

**EA02-025**

**FORD 10/27/03**

**APPENDIX N**

**BOOK 24 OF 61**

**PART 4 OF 5**

Sample	VIN	Date Code	Condition	Hexport, Washer, Converter, and Spacer	Seals	Cup	Base/Switch Cavity/Terminals
Reddick (Memphis, 1993 Town Car)	1LNLM82W0P	F2VC/2056	Partially burned.	Black residue containing glycol based material (probably brake fluid) and a metal oxalate. Indicates presence of brake fluid on fluid and switch sides of seals.	Environmental seal and gasket intact and appear to have had good sealing. All three Kapton seals are buckled and exhibit brittle cracks which most likely formed leak path. Damage appears to have initiated in seal closest to washer. Damaged Kapton darkened and embrittled by unknown mechanism.	Green Deposits on face of cup contain elements from brass contacts indicating transfer of contact material to cup probably as oxide, sulfide, or corrosion product. Glycol based material (probably brake fluid) also detected in this area.	Base separated below crimp ring. Transfer pin and movable contact missing. Stationary contact exhibits loss of material due to corrosion, evidence of dezincification, stress corrosion cracking. Base of movable contact melted back into bulkhead between switch and terminal cavities. Appears to have occurred in later stages of event. Surfaces of terminals covered with black and green deposits which appear to be sulfur compounds of the terminal materials.
A (1993 Town Car, Houston)	1LNLM82W1P	????/2281	Burned	Elements from contact material detected at fitting end of hexport. Indicate possible flow of fluid back through seals. Traces of silicone detected.	Gasket and environmental seal missing. Charred fragments Kapton seals remain.	Deposits on face of cup contain elements from brass contacts indicating transfer of contact material to cup probably as oxide, sulfide, or corrosion product.	Base, stationary contact, movable contact, and terminals missing.
B (1992 Town Car, Houston)	1LNLM83W5N	F2VC/2114	Burned	Elements from contact material detected at fitting end of hexport. Indicate possible flow of fluid back through seals.	Not permitted to disassemble switch.	Deposits on face of cup contain elements from brass contacts indicating transfer of contact material to cup probably as oxide, sulfide, or corrosion product.	Transfer pin and movable contact missing. Stationary contact exhibits crack in similar location as that in Reddick sample.
C (1992 Town Car, Houston)	1LNLM81W2N	F2VC/2003	Burned	Elements from contact material detected at fitting end of hexport. Indicate possible flow of fluid back through seals. Black deposit in cavity contains traces of hydrocarbon and silicone.	Gasket appears charred. Environmental seal missing. Damage to Kapton seals currently being evaluated.	Deposits on face of cup contain elements from brass contacts indicating transfer of contact material to cup probably as oxide, sulfide, or corrosion product.	Base, stationary contact, movable contact, and terminals missing.
D (1987 Crown Victoria)	2FALP71W1V	F2AC/???	Apparent leakage.	Black residue containing glycol based material (probably brake fluid) and a metal oxalate. Indicates presence of brake fluid on fluid and switch sides of seals.	Environmental seal and gasket intact and appear to have had good sealing. Kapton seals exhibit damage similar to that found in Reddick sample. All three exhibit brittle cracks which most likely formed a leak path.	Dark green deposits on face of cup contain elements from brass contacts indicating transfer of contact material to cup probably as oxide, sulfide, or corrosion product. Deposits appear to have formed a bridge between movable contact and cup. Liquid in interior and on face of cup is glycol based (probably brake fluid).	Switch cavity and terminal cavity contain glycol based material (probably brake fluid). Contacts appear intact. Dark green deposits on movable and stationary contacts contain elements from brass contact material. Terminals appear clean (no apparent deposits or corrosion).
E (#11 from survey)		F2AC/2137	No leaks or other apparent problems.	Black residue containing glycol based material (probably brake fluid) and a metal oxalate. Indicates presence of brake fluid on fluid and switch sides of seals.	Environmental seal and gasket intact and appear to have had good sealing. Kapton seals exhibit deformation and buckling similar to that found in Reddick sample. Creasing on surfaces suggest incipient damage is occurring.	Face of cup appears clean and dry.	Switch cavity and terminal cavity appear clean and dry. No apparent deposits or corrosion.
F	1LNLM82W1N	F2VC/2126	Apparent leakage	Black residue containing glycol based material (probably brake fluid) and a metal oxalate. Indicates presence of brake fluid on fluid and switch sides of seals.	Environmental seal and gasket intact and appear to have had good sealing. Kapton seals exhibit damage similar to that found in Reddick sample. All three exhibit brittle cracks which most likely formed a leak path.	Dark green deposits on face of cup contain elements from brass contacts indicating transfer of contact material to cup probably as oxide, sulfide, or corrosion product. Liquid in interior and on face of cup is glycol based (probably brake fluid).	Switch cavity and terminal cavity contain glycol based material (probably brake fluid). Stationary contact is intact, but does show stress corrosion cracking in progress in bridge area (same location as in Reddick switch). Movable contact appears to have separated as a result of loss of material (~50% of thickness) due to corrosion. No evidence of heating or arc damage. Dark green deposits on movable and stationary contacts contain elements from brass contact material, as well as sulfur. Terminals exhibit green deposits (currently being analyzed). Deposits extend in from both sides of bulkhead between switch and terminal cavities, but do not meet.

" KAPTON "

## Brake Pressure Switch Questions

### Competitive Vehicles

How is switch packaged?

Is it always Powered ( HOT\_ALL\_TIME ) ?

Are the contacts opened when pressure applied?

What is fuse limit?

What is being switched?

Is it a redundant switch?

Stewart Salter by 2/16/99

What are descriptions from AWS and CQIS?

Joe Neme/ Bill Abramczyk by 2/16/99

Are the switch materials compatible with brake fluid?

Greg Stevens by 2/16/99

Are the switch materials compatible with brake fluid in an electric field?

Greg Stevens by 2/16/99

Are the switch materials compatible with brake fluid and contaminants?

Greg Stevens by 2/16/99

Are the switch materials compatible with contaminated brake fluid in an electric field?

Greg Stevens by 2/16/99

What are we seeing in returned Speed control modules (FRACAS)?

Fred Kohl/ Dan Budzynski by 2/12/99

What does TI DFEMA say about this failure mode?

Rob Sharpe by 2/10/99

What are TI in-process test failures?

Rob Sharpe by 2/10/99

What does Speed control FMEA say about Brake Switch ?

Fred Kohl by 2/9/99

## Brake Pressure Switch Questions

When was non-Pressure actuated switched introduced?  
Steve Reimers by 2/9/99

Is the Circuit drive hi-side or low-side? Fred Kohl by 2/8/99

Results of Central Lab analysis Steve LaRouch by 2/12/99

Analysis of harness pig-tails Joe Kafati by 2/16/99

If a switch is contaminated can it start the event?  
Fred Porter by 2/16/99

Flash points for all materials? Greg Stevens by 2/16/99

What heat is conducted internally? By  
Don't understand this questions!!!!!!!!!!!!!!

Provide color photos of Econoline? Rob Sharpe by 2/8/99

What is the difference in the base materials that look different?  
Rob Sharpe by 2/16/99

TI analysis results of the Memphis parts ( crease marks in diaphragm, etc) ?  
Rob Sharpe by 2/9/99

What are the material call-outs for 1992 and 1993?  
Rob Sharpe by 2/9/99

Results of testing with corrosion simulation? Fred Porter by 2/16/99

What does it take to start an event? Fred Porter by 2/16/99

How does speed control use this switch? Fred Kohl by 2/11/99

Do all Ford applications use switch between fuse and load? YES  
Fred Kohl by complete

Do all Ford applications have switch connected to HOT-ALL-TIMES?  
Joe Kafati by 2/16/99

## Brake Pressure Switch Questions

**Why is this switch connected to HOT-ALL-TIMES?**

Fred Kohl by Complete

*Because the SDS requires it to be connected to the same fuse as the stoplamp.*

**What is SDS requirement number?**

Fred Kohl by 2/16/99

**Can the switch act as a fuse?**

Team by complete

*No.*

**Is it feasible to disconnect the switch as immediate containment?**

*Yes. The customer will not have use of the speed control.*

**Is it acceptable to Jumper out the switch as immediate containment?**

Fred Kohl by 2/16/99

**Other recommendations for immediate containment?**

All by on-going

**Can Brake Pressure Switch function be removed from power feed circuit and placed in ground return circuit?**

Fred Kohl by tbd



The Dow Chemical Company  
P.O. Box 150  
Birmingham, Louisiana 70780-0150

January 25, 1999

Mr. Greg Stevens  
Ford Motor Company  
FAX: 313-323-6686

Dear Mr. Stevens:

The following is in response to request from Mr. F.J. Porter for information on the conductivity of brake fluid (HDSO-4) supplied to Ford Motor by The Dow Chemical Company. We have completed a search of our research database and no data on conductivity of HDSO-4 was found.

Please call me at (225) 353-6343 if you have questions or comments.

Sincerely,

A handwritten signature in cursive script that reads "Michael Kitt".

Michael Kitt  
Business Quality Leader  
Oxygenated Solvents



The Dow Chemical Company  
P.O. Box 160  
Plaquemine, Louisiana 70760-0160

January 13, 1999

Mr. Greg Stevens  
Ford Motor Company  
FAX: 313-323-6686

Dear Mr. Stevens:

The following is in response to your request for information concerning physical properties and process modifications on brake fluid (HD50-4) supplied to Ford Motor by The Dow Chemical Company. Our records indicate the addition of a new additive for improved zinc corrosion protection was added to the HD50-4 formulation during the second quarter of 1995. The modification was communicated to Ford engineering at that time.

The flash point and autoignition temperature are available on the Material Safety Data Sheet for our brake fluids. The data for HD50-4 are as follows:

Flash Point	312 degrees F
Autoignition Temperature	606 degrees F

Please call me at (225) 353-6343 if you have questions or comments.

Sincerely,

Michael Kitt  
Business Quality Leader  
Oxygenated Solvents



Central Laboratory  
15000 Century Drive  
Dearborn, MI 48120-1257

January 15, 1999

**Preliminary Findings:**

The cup is partially covered with a greenish residue. Residue appears to be primarily an oxide of the brass contact material with possibly a sulfur compound. This suggests transfer of oxide or corrosion product from the brass contacts to the cup.

The stationary contact exhibits intergranular cracks which indicate stress corrosion cracking (SCC). SCC is caused by combination of a specific corrosive environment and a sustained tensile stress (can be localized). Ammonia, ammonia compounds, sulfur compounds, and moisture are known to cause SCC in brass. The contact material has been reported to be 360 brass, which is highly susceptible to SCC.

The presence of brake fluid on the switch side of the diaphragm has been determined. Black residues in the hex port and on the cup, converter, and disc appear to be compounds which may have formed from a reaction between decomposition products (acids) of the polyester base, the brake fluid, and metals in the switch. This suggests that the brake fluid was present on both sides of the diaphragm during the thermal event.

All three diaphragms exhibit what appears to be mechanical damage. The damage does not match up with any mating parts of the switch. This suggests that damage may have occurred prior to assembly. The diaphragm has become brittle and cracked in the vicinity of the damage. Brake fluid has become entrained between the layers (Teflon and capton) of the diaphragms.

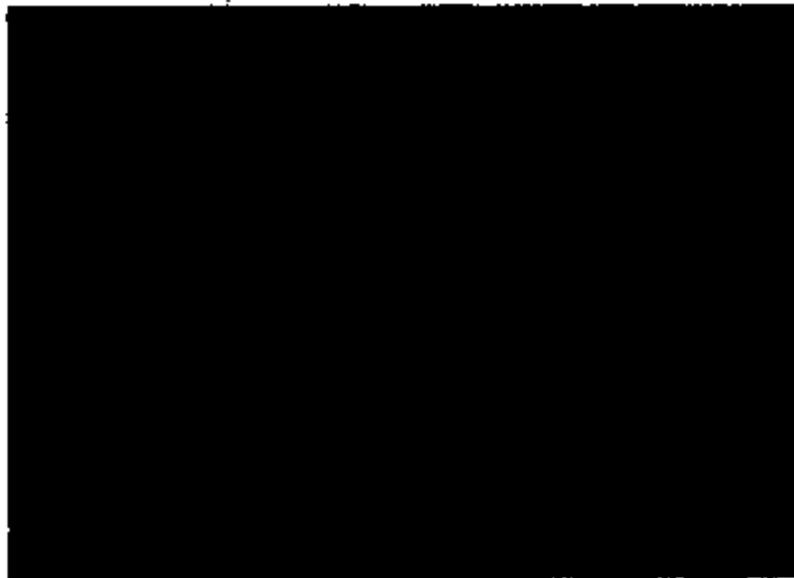
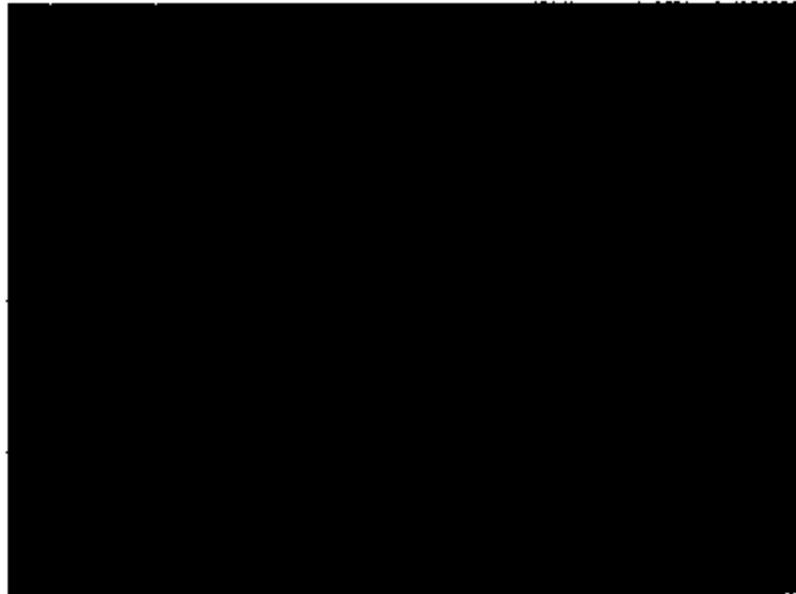
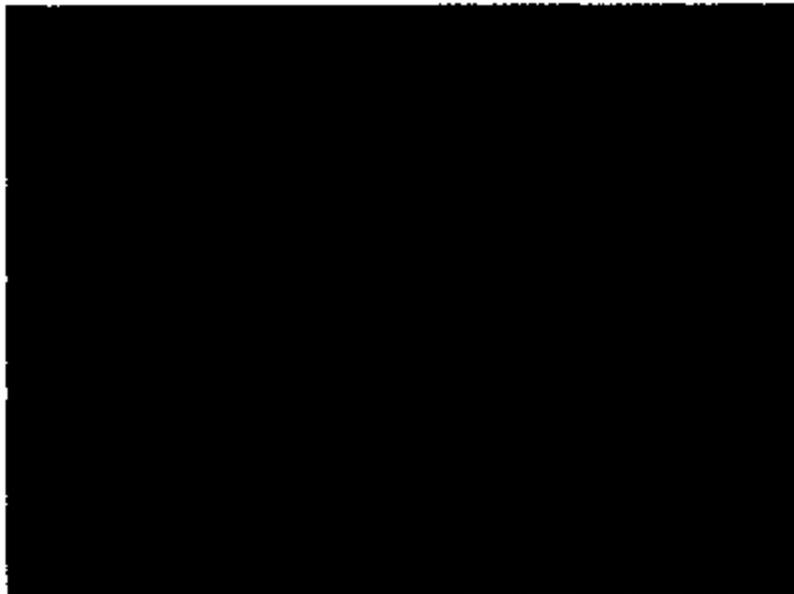
The post of the movable contact melted back into the bulkhead between the switch and terminal cavities of the base. There is also arc damage (localized melting) to one corner of the bridge of the stationary contact. This damage appears fresh (surfaces bright and shiny) which suggests that it may have occurred in the later stages of the thermal event.

The terminals exhibit deposits which appear to be primarily sulfur compounds of the terminal material (tin plated brass). Although these deposits appear visually similar to the deposit found on the cup, they appear to be of different composition.

The white residue found in the connector cavity contains elements found in dry chemical fire extinguishers (Muscovite and phosphorus)

Steve LaRouche

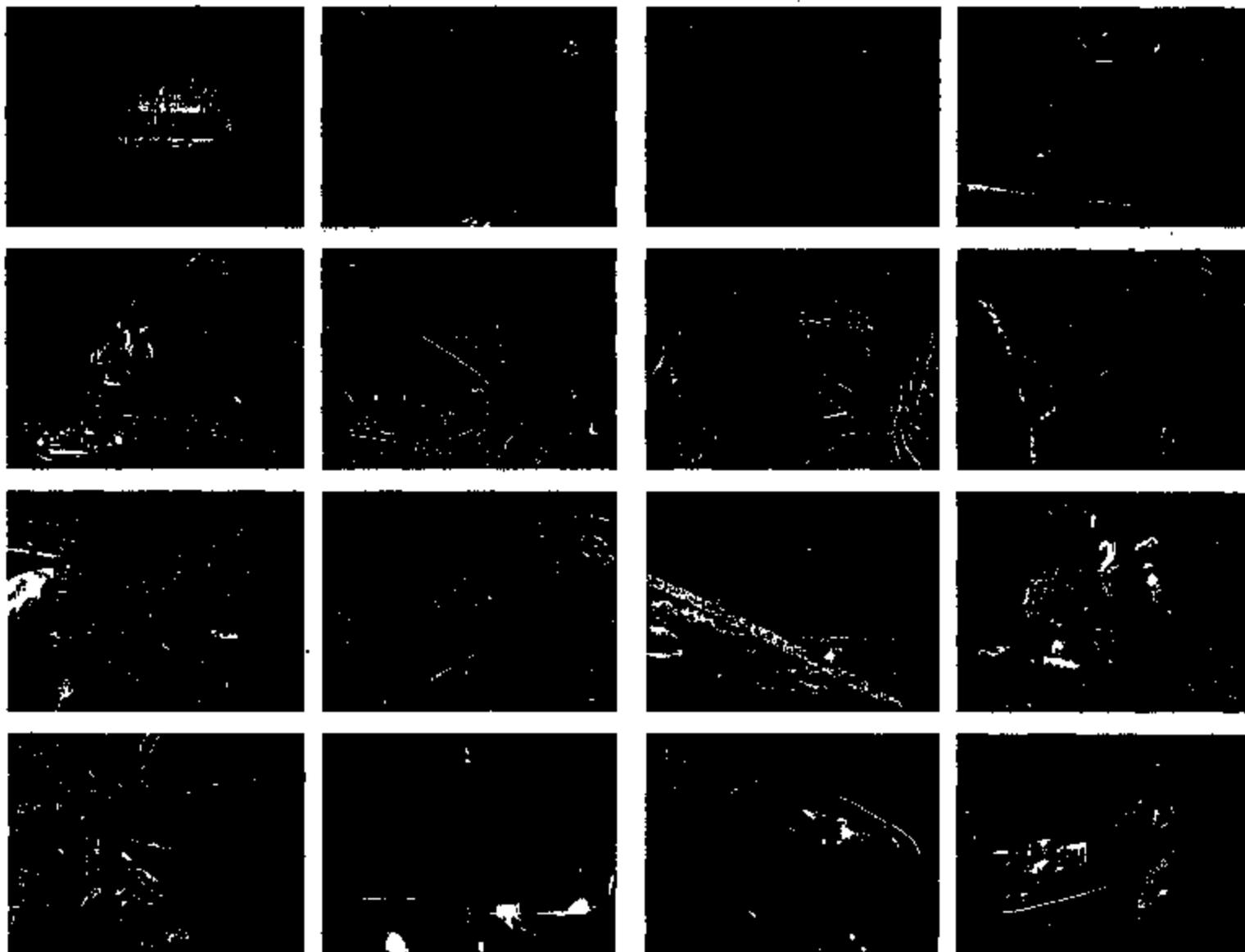
3713 6025



Switch A

F2VC-9F924-AB 2281

3713 6026



3713 6027

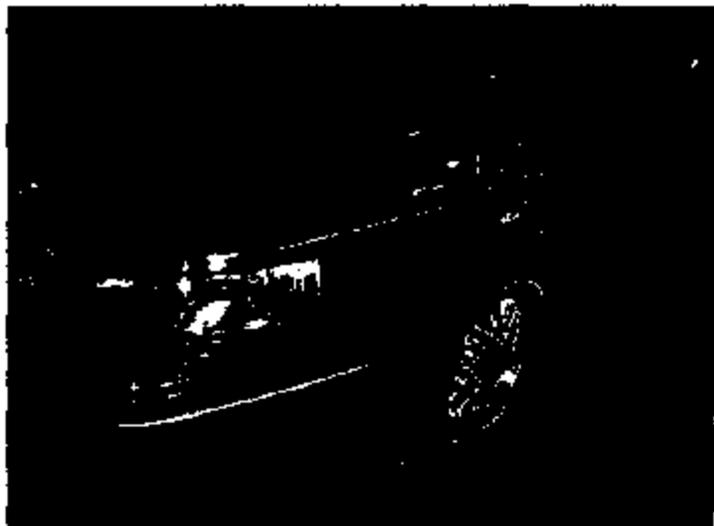
1LNLM92WXNY [REDACTED] 1992 Lincoln Town Car - Dallas, TX, 99-Jan-13

pg 98-055

3719 6028

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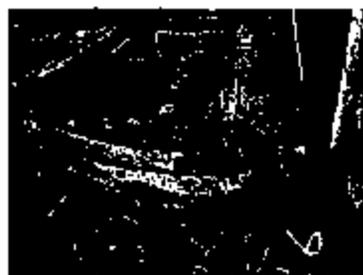
DE 98-655



3713 6029

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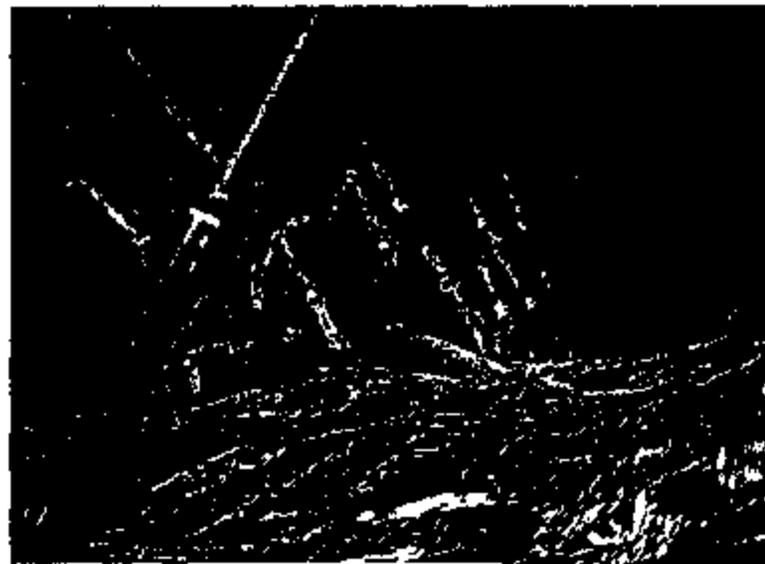
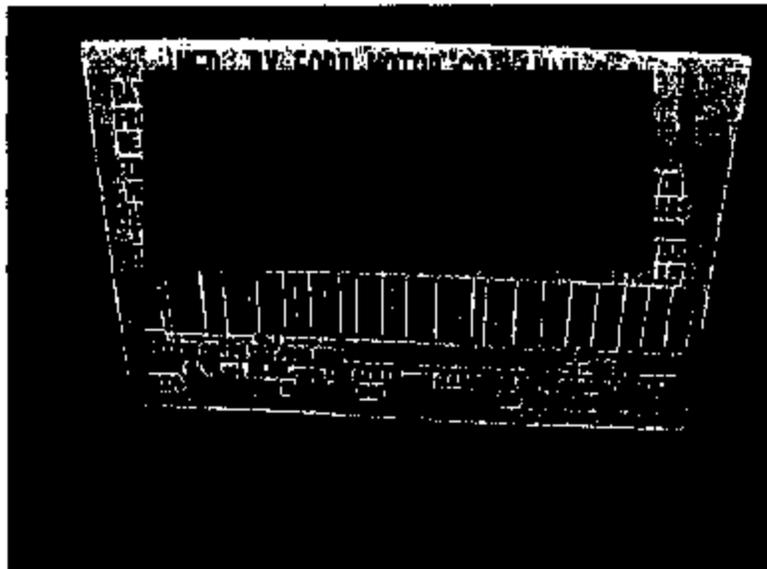
PE98-055



Switch A

3713 8090

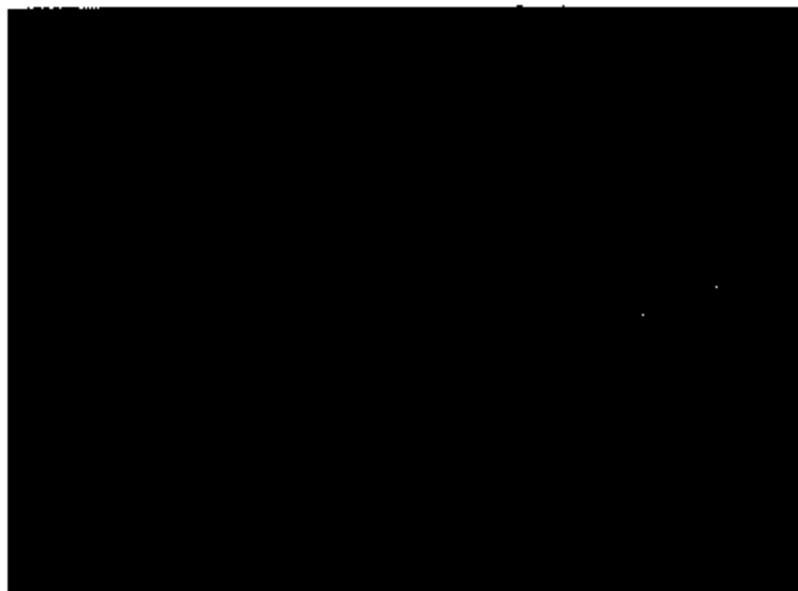
1LNLM92WIPY [REDACTED] 1993 Lincoln Town Car - Houston, Tx 99-Jan-14 PE98-055



3713 8031

1LNLM92W1PY

1993 Lincoln Town Car - Houston, Tx 99-Jan-14 PE98-055



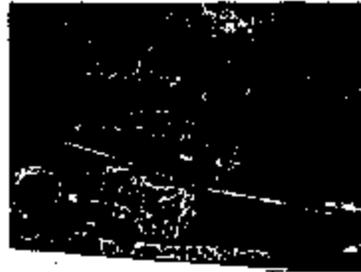
Switch A

F2VC-9F924-AB 2281

9713 6032



Switch B



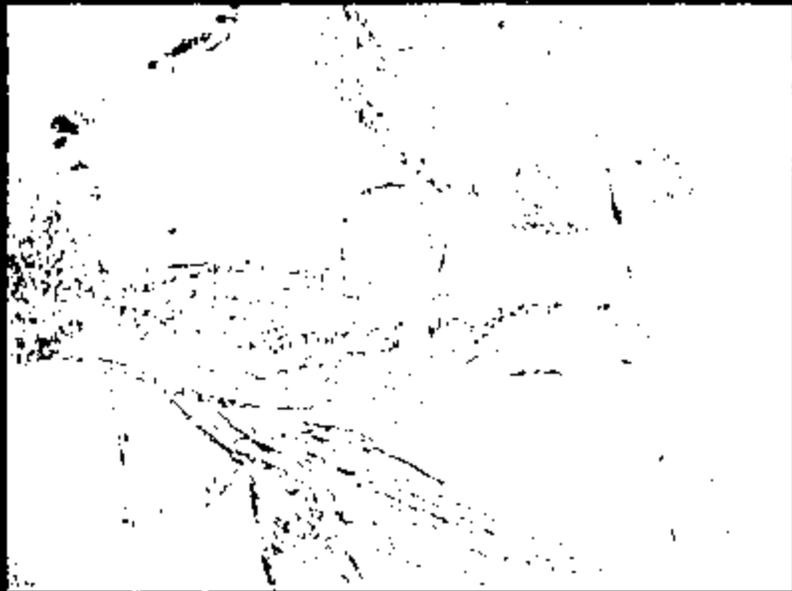
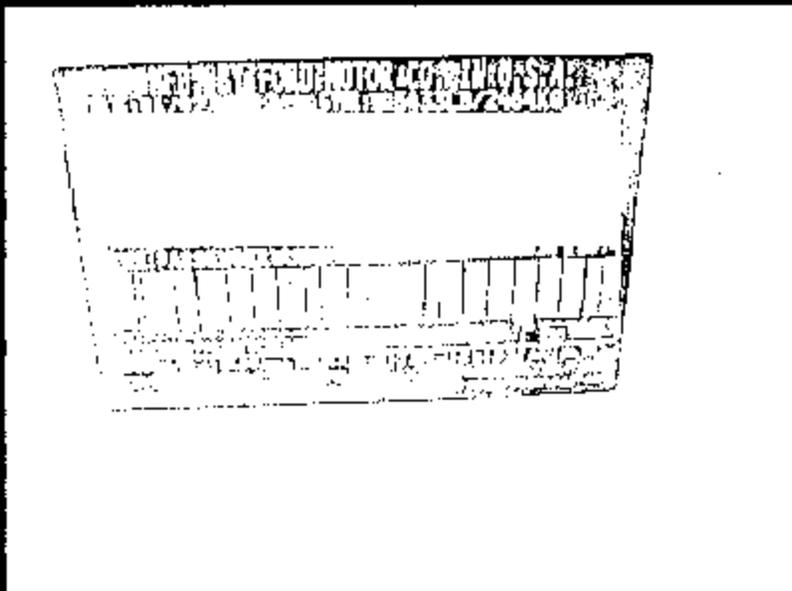
3713 6033

1LNLM83W5NY [REDACTED] 992 Lincoln Town Car - Houston, TX 99-Jan-14 PE98-055



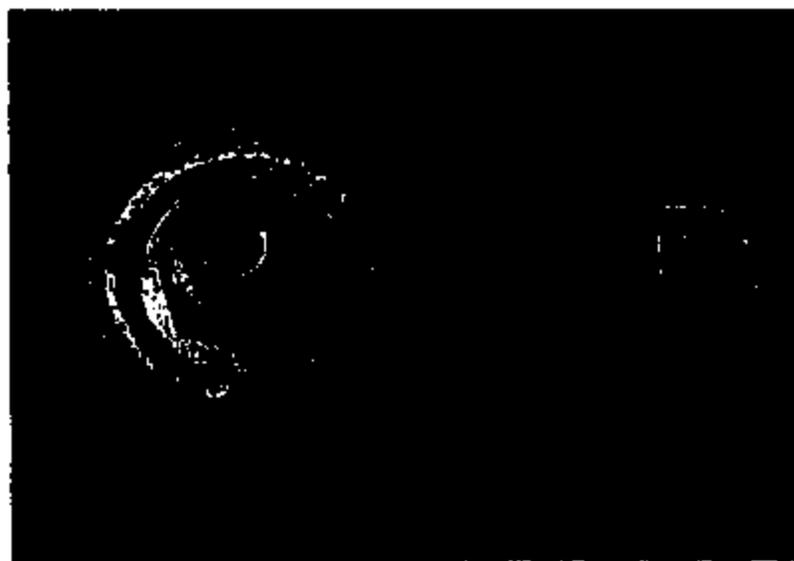
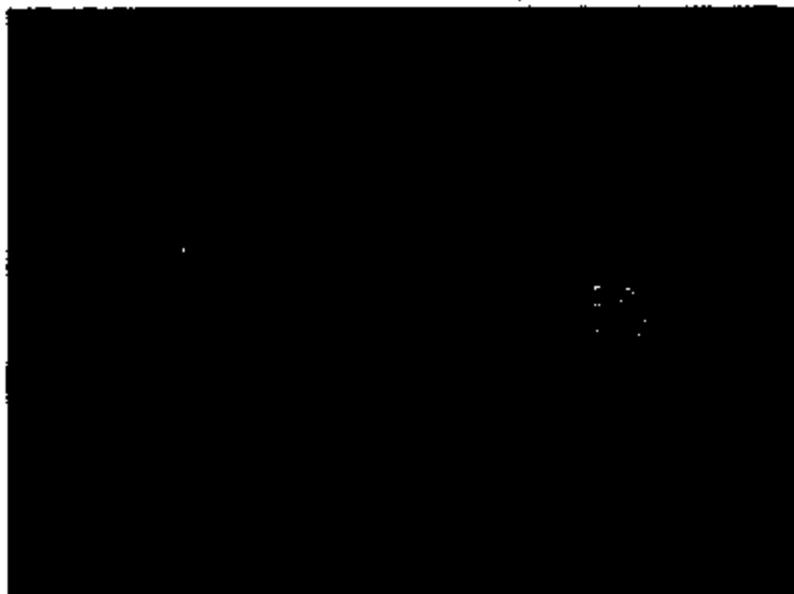
3719 8094

1LNLM83W5NY [REDACTED] 1992 Lincoln Town Car - Houston, TX 99-Jan-14 PE98-055



3713 8035

1LNLM83W5NY [REDACTED] 992 Lincoln Town Car - Houston, TX 99-Jan-14 PE98-055



Switch B

F2VC-9F924-AB 2114

3713 8036

1LNLM83W5NY [REDACTED] 1992 Lincoln Town Car - Houston, TX 99-Jan-14 PE98-055

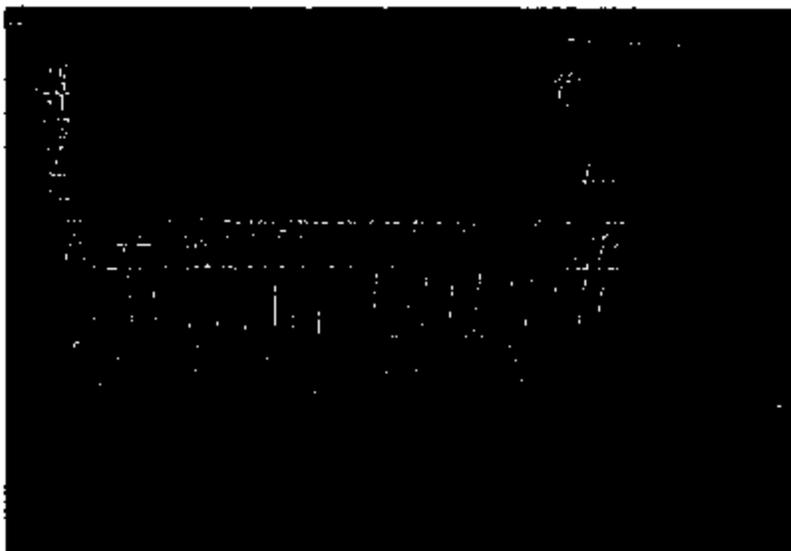
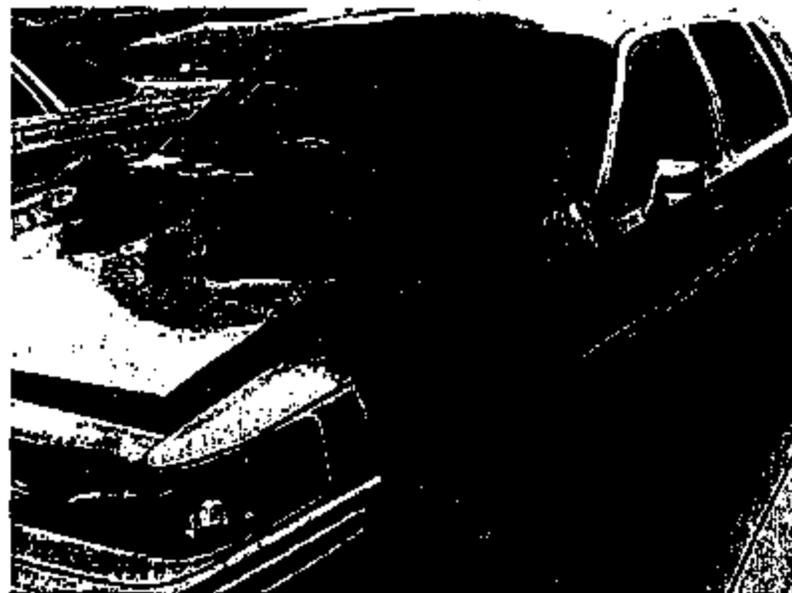


Switch B

F2VC-9F924-AB 2114

3713 6037

1LNLM83W5NY [REDACTED] 1992 Lincoln Town Car - Houston, TX 99-Jan-14 PE98-055



Switch C

3713 6036

1LNLM81W2NY [REDACTED] 1992 Lincoln Town Car - Houston, TX 99-Jan-14 PE98-055

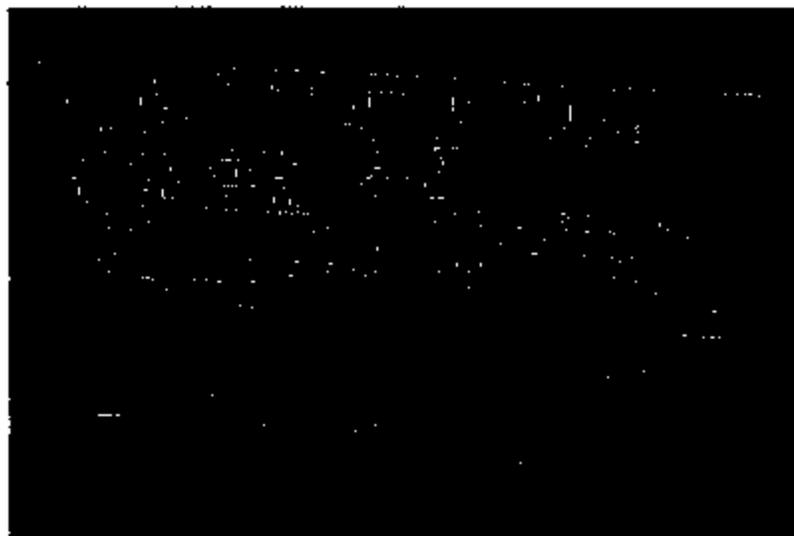


Switch C

F2VC-9F924-AB 2003

9713 8039

1LNLM81W2NY [REDACTED] 1992 Lincoln Town Car - Houston, TX 99-Jan-14 PE98-055



3713 8040

1LNLM82W7NY [REDACTED] 1992 Lincoln Town Car - Houston, TX 99-Jan-14

7E98-055

**OUR EXPENSE. THANK YOU.**



February 22, 1999

The Dow Chemical Company  
P.O. Box 160  
Plaquemine, Louisiana 70765-0160

Ford Motor Company  
FAX: 313-323-6686

Dear Sir/Madame:

The following is a summary of the questions that The Dow Chemical Company has been asked by Ford Motor to address :

1. How can a fire start with the switch given the following constraints;
  - continuous battery voltage applied between switch electrical components and the hydraulic connection
  - circuit fused at 15 amps
  - inductive load current of 0.5 amps switched when speed control is turned off
  - the switch cavity contains a black material containing at least copper, zinc, sulfur and brake fluid (probably containing water)
2. Are the switch materials compatible with brake fluid?
3. Are the switch materials compatible with brake fluid in an electric field?
4. Are the switch materials compatible with brake fluid and contaminants?
5. Are the switch materials compatible with contaminated brake fluid in an electric field?
6. Is brake fluid a possible source of sulfur found in the Memphis switch?
7. Is brake fluid conductive enough to explain the finding of a transfer of the brass contact material to the steel cap?

As we stated in our prior response, we do not have data to address these questions. The questions you've raised were not considered as reasonable failure modes during our design or manufacturing evaluations. Therefore, testing required to address your questions were not conducted.

Due to the complexity of this problem, we recommend that a series of test are designed and conducted. We also suggest that this work be performed by an independent laboratory with the appropriate area of expertise. We at Dow would be more than happy to provide assistance in interpreting the results from such tests and the impact on future brake fluid performance requirements.

As the sole supplier of brake fluid to Ford Motor in North America, we are very aware of our role as a knowledgeable contact when these issues arise. We are committed to providing data and analysis of issues in all cases where our experience and knowledge add value for our customers. However, we have neither the data or experience with the switch involved in the current issue. Therefore, we do not believe we can contribute and add value in meetings addressing these issues and will abstain from attending.

Sincerely,

Michael Kitz  
Business Quality Leader  
Oxygenated Solvents

3713 6041

971007

# Improved Methods for Testing the Durability of Corrosion Protection in Brake Fluids

Garry L. Jackson  
Delphi Chassis Systems

Pierre Lévesque  
Union Carbide Corp.

Frederick T. Wagner  
General Motors Research & Development Center

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## ABSTRACT

Present corrosion testing procedures for brake fluids assess the properties of fresh fluids under some forms of environmental stress (e.g., water content, elevated temperature). These tests may not accurately predict corrosion protection properties of fluid after the years of continuous service typical of North American practice. This paper describes the development of laboratory accelerated aging procedures which reproduce the chemical changes occurring in brake fluids during long-term service. Short-duration vehicular tests with these lab-aged fluids have reproduced specific modes of corrosion previously observed only after long-term customer use.

## INTRODUCTION

Brake fluid reliably transmits full boosted pedal pressure throughout the braking system. Brake fluid also serves to protect against corrosion the brake system materials it contacts. While in Europe the brake fluid in a vehicle is typically changed every few years, in North America brake fluids are not routinely changed. Therefore, it is important to assess the long-term corrosion protection of brake fluid used in cars and trucks sold in North America.

The minimum levels of corrosion protection required for brake fluids are set by laboratory test procedures embodied in FMVSS 116<sup>1</sup>, a regulation based on the primary brake fluid standard for the automotive industry, SAE J1703<sup>2</sup>. The corrosion tests required by these standards are performed on fresh samples of brake fluid and may not be a reliable

indicator of the level of corrosion protection afforded by the fluid after several years in a vehicle. A fluid compounded from high-quality base materials, but containing no corrosion inhibitors whatsoever, can pass the weight change requirements (see Table 1). Corrosion is on occasion still observed within brake systems filled with fluids which were fully compliant with SAE J1703 and FMVSS 116 when fresh. Chemical analysis of used brake fluids suggests reasons why corrosion could occur in these circumstances.

Table 1: J1703 corrosion test (section 4.6) weight changes for an unleaded brake fluid base.

metal	J1703 max. wt. change (mg/cm <sup>2</sup> )	measured wt. change (mg/cm <sup>2</sup> )
Tinned Iron	±0.2	-0.06
Steel	±0.2	-0.04
Aluminum	±0.1	+0.01
Cast Iron	±0.2	+0.00
Brass	±0.4	-0.02
Copper	±0.4	+0.00
Zinc	±0.4	+0.06

Note: J1703 4.8 requirements on coupon and fluid appearance, sediment, and rubber interactions also passed

This paper first characterizes, through chemical analysis, the changes which can occur in brake fluids during vehicular use. Then, building upon this database, we develop new aging and testing procedures which can measure the durability of the corrosion protection provided by a fully-formulated fluid. The primary corrosion inhibitors used in most brake fluids are amines, organic bases which both provide general buffering

capacity against the deleterious effects of acidic breakdown products and provide specific protection of particular metals, presumably through adsorption. Amides both work well as inhibitors and fulfill the extended solubility constraints imposed by the need for the brake fluid to remain a single phase system over wide ranges of temperature and water content. This paper will therefore concentrate upon the amine components of the total inhibitor package.

**SPECIAL STRESSES AND REQUIREMENTS OF ANTILOCK BRAKE SYSTEMS** - Modern antilock brake systems pose new challenges to the proper formulation of formulated brake fluids. New wheel brake system designs for chassis performance. The increased circulation of brake fluid associated with ABS (e.g., through low-pressure return lines to the master cylinder reservoir) may increase the chances of loss of brake fluid components from the fluid, either by direct evaporation, permeation through polymers, or corrosion into polymer. The forced circulation can also facilitate the transport of corrosion products and/or thermal degradation products, if they are present, from one point in the brake system to another.

#### CHANGES IN BRAKE FLUID CHEMISTRY DURING VEHICULAR SERVICE

**DROP IN RESERVE ALKALINITY** - The major inhibitors which provide the primary corrosion protection in most brake fluids are organic bases. A simple approximate measurement of their total concentration (and the stability thereof) in a formulated brake fluid can be obtained by acid-base titration similar to those called out for engine coolants by ASTM standard D 1121<sup>1</sup>. The Reserve Alkalinity (RA) of a brake fluid is defined as the number of milliliters of 0.100 M hydrochloric acid needed to titrate 50 ml of brake fluid down to a pH of 3.5<sup>2</sup> (in contrast, the D 1121 definition of RA for engine coolant is ml HCl / 10 ml coolant concentrate). In an attempt to keep all brake fluid components in solution during the titration, the brake fluid is prediluted with a solution of 80% deionized alcohol and 20% deionized water (in this work, ~2ml of brake fluid [quantified by weight] was diluted to 60 ml total volume before starting titration with 0.100 M HCl). RA's of fresh brake fluids in recent commercial production range from about 3 to about 120.

Figure 1 shows the residual RA (as % of initial value) of a brake fluid in matched vehicles 0-3.5 years old, plotted as a function of the age of the fluid. By 30 months (about 50,000 km) the RA has dropped to as low as 9% of its initial value, and about half of this small residual RA arises from components other than the amines. The titration data therefore suggest a 20-fold reduction in primary inhibitor concentration over 2-3 years of service.

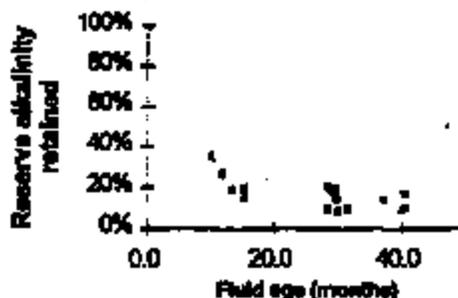


Figure 1: Decrease in reserve alkalinity of a brake fluid during vehicular use.

Table 2 shows %RA (vs. fresh values for appropriate OEM brake fluids) for a number of fluid samples taken from randomly-selected vehicles produced by a range of manufacturers. Some loss of RA during vehicular service is universally observed, but the % retained varies widely for different fluids. In the absence of further data, no conclusions about the quality of corrosion protection afforded by a fluid should be drawn from absolute RA values, since it may be possible to formulate effective fluids with a wide range of initial RA's. However, the evolution of the RA over time of use gives a general picture of the stability of the inhibitor package. If the material retains a smaller percentage of its initial RA over time, one can have less confidence that the initial level of corrosion protection implied by J1703 compliance will be continued through the service life of the vehicle.

Table 2: Retained reserve alkalinity for a number of OEM fluids after vehicular use.

OEM fluid	Kilometers	Months (approx.)	% Initial RA retained
I	73270	36	9%
II	71067	36	21%
III	47818	na	35%
IV	117762	36	49%
V	60780	na	52%

**DROP IN AMINE INHIBITOR CONCENTRATIONS, BUILDUP OF INHIBITOR REACTION PRODUCTS, AND LOSS OF TOTAL NITROGEN** - Determination of RA, while simple, usually measures only general buffering capacity, not the concentrations of particular inhibitors. To properly characterize the chemical evolution of brake fluids in use and to prevent misinterpretation of RA data, it is necessary to be able to quantify the concentrations of individual inhibitors. The capillary gas chromatographic (GC) techniques employing flame ionization detectors (FID's) commonly used in quality control of the glycol ether and polyglycol components of brake fluid base oils, if carried out with unusually high resolution, quantify the presence of at least some of the common amine inhibitors. However, since the

amines constitute only a small fraction of the total fluid and the chromatographic properties of some important amines are less than optimal for clean separation. Full characterization of amines content requires methods which are more selective for nitrogen compounds.

One successful approach has been to use capillary GC with a thermionic emission detector (or nitrogen-phosphorus detector (NPD)) which has a sensitivity for nitrogen atoms in molecules which is over 3000-fold greater than its sensitivity for carbon atoms<sup>21</sup>. This high selectivity for N allows not only ready identification of the chromatographic peaks due to the original amines but also allows use to determine the fate of nitrogen atoms as the original amines react to form new nitrogen-containing compounds during vehicular use. This ability to monitor nitrogen in the fluid even after it has been incorporated into reaction products which may no longer provide buffering capacity has proven particularly useful in using laboratory aging procedures to accurately reproduce the effects of extended vehicular use.

Total nitrogen in the brake fluid was also measured with a standard N/S elemental analyzer. Since this technique is sensitive to nitrogen in any relevant form, the drop of total nitrogen as seen by this method allows determination of what fraction of initial nitrogen completely left the fluid. In the primary fluids under study here, the overwhelming preponderance of original nitrogen in the fluid was in the form of the amine inhibitor(s).

Capillary electrophoresis was found to be another successful analytical approach for the amines in most of the inhibitor packages<sup>22</sup>. The technique relies on the fact that ions move with different velocities through a capillary tube filled with buffer solution when an electric field is applied across the length of the tube. Amines in aqueous solutions of brake fluid were separated and detected as their ammonium cations in a pyridinium sulfate buffer at pH 4.4. When they passed through the UV absorbance detector on the Capillary Ion Analysis (CIA) instrument, amine cations were detected as a decrease in absorbance at 254 nm because they displaced some of the pyridinium cations which absorb light at that wavelength<sup>23</sup>. For many fluids, this procedure detects all of the original amines and any reaction products thereof which retain basicity. However, it will not detect other nitrogen-containing reaction products which do not still contribute to the buffering capacity of the used fluid. The limited aqueous solubilities of the ammonium ions derived from the inhibitors in some fluids can lead to irreproducible CIA results. Consequently, the NPD GC and CIA methods were used together to generate corroborative and complementary data.

The mechanisms by which the amine content decreases over time can be inferred by comparison of several metrics of a fluid after vehicular use: the % RA retained, the % retained of total original amine species (by NPD GC), the % of total nitrogen retained (by N/S), and the % buildup of known N-containing reaction products which do not provide buffering capacity (by NPD GC). While the RA and the concentrations of the original amines drop away after approximately 75000 km to <10% of their initial values, more than a third of the original total nitrogen remains in the fluid. Essentially all of this residual N is in a form other than the original amines, and most of the residual N is in a form which does not provide

significant buffering against addition of acid. Of this inactivated but still-present portion of the N, approximately half can be identified as a particular reaction product, the formamide of an inhibitor originally present in the fluid. Cast iron readily rusts when placed in contact with uninhibited brake fluid base to which an appropriate level of this formamide, 3% water, and 50 ppm chloride were added. When the original amine replaced the formamide in control experiments, no rusting was observed at all. The formamide reaction product thus serves neither as a buffer nor as a corrosion inhibitor. However, it does provide a readily-analyzed signature for the severity of thermal oxidation to which a fluid has been subjected while being used in a vehicle.

**INCREASE IN DISSOLVED METALS** - Measurements of dissolved metals in brake fluid (here, done by inductively-coupled plasma atomic emission spectroscopy) provide an indirect indicator of corrosion activity within the brake system. If such measurements are to be a useful guide to the functional durability of the fluid, they must both be interpreted with some care and be accompanied by detailed inspection of brake system components to establish whether the presence of the dissolved metals in the fluid is in fact indicative of a condition which could eventually decrease brake system performance. A low rate of general corrosion over a large surface area of a metal may lead to apparently significant levels of that metal dissolved in the fluid but may pose no threat to system performance. Conversely, a very high rate of localized corrosion of a metal could produce only a small dissolved metal content in the fluid but eventually lead to significant loss of brake system function. A case of correlation between metals uptake in the fluid and component corrosion with a potential for functional significance over an extended service life will be given in later sections of this paper.

Figure 2 shows the pickup of metals by a fluid in vehicular service as a function of fluid age, corresponding to distance traveled of 0-100,000 km. In all vehicles in this figure and for all fluid ages, the metal at highest concentration in solution is copper. This is in part due to the (perhaps surprisingly) large preponderance of the system surface area exposed to the brake fluid which is copper. The interior of typical 2-layer steel brake pipe is completely covered by the copper bearing alloy. A typical light-duty vehicle uses 14 m of such pipe, with an internal diameter of ~2.5 mm, giving an internal geometric surface area of 1200 cm<sup>2</sup>. Atomic force microscopy scans of the interior copper surface of the pipe yield a roughness factor of 1.5, so that the ~900 ml of brake fluid in a vehicle (including that in the master cylinder reservoir) is exposed to 1800 cm<sup>2</sup> of copper. The approximately 300 ppm of Cu used in the brake fluid after ~36 months corresponds to dissolution of ~0.1 mg/cm<sup>2</sup> copper in 3 years of service, compared with the 0.4 mg/cm<sup>2</sup> copper allowed in a 5 day laboratory test to comply with J1703. The copper corrosion, which appears to be general (rather than localized) in morphology, poses a direct threat to system integrity.

The significance of Figure 2 lies not in the relatively large dissolved copper levels but in the more subtle levels of dissolved iron. No dissolved iron at all is seen until around 30 months, after which 50-100 ppm of dissolved iron becomes typical. Cast iron components removed from some vehicles after such times show some level of pitting of the iron, with pits typically surrounded by metallic copper.

Dissolved iron appears in the brake fluid after the initial zinc corrosion inhibitors are significantly depleted and dissolved copper levels rise to around 200 ppm. The apparent induction period for iron corrosion has presented difficulties in testing technological changes designed to maintain this effect; no test protocol employing fresh brake fluid had succeeded in reproducing the iron corrosion observed at times in vehicles after several years' service. Later sections of this paper will show that attention to the chemical changes in brake fluid during use has led to test procedures which reproduce the field vehicular effects within 6 months.

The dissolved zinc levels in Figure 2 show no evidence of the induction time seen for iron. Since testing for corrosion protection of zinc in brake fluid is known to be problematic even in fresh brake fluids<sup>11</sup> (it is not yet a requirement of FMVSS116), it would not be entirely surprising if some Zn corrosion is occurring even after relatively short service. Another possible source of the observed zinc is extraction of Zn compounds from hoses.

Table 3 shows dissolved metal data for different fluids after extended use in vehicles built by a number of manufacturers. Analytically significant levels of dissolved metals are a common, but not completely universal, characteristic of brake fluids in vehicular service. Between different vehicles, the metals dissolved in brake fluid can be expected to vary with the metals exposed to brake fluid and the service conditions, as well as with the properties of the brake fluids used.

Table 3: Dissolved metals for a number of OEM fluids after use in vehicles.

Fluid	km	months (approx)	Cu (ppm)	Fe (ppm)	Zn (ppm)
a	4391	21	38	<10	10
a	37783	21	150	10	0
a	77371	40	250	110	58
β	6134	12	38	<10	10
β	69717	na	800	<10	130
β	na	60	530	38	200
γ	47619	na	260	30	140
δ	71904	36	18	2	49
ε	106612	24	16	3	33

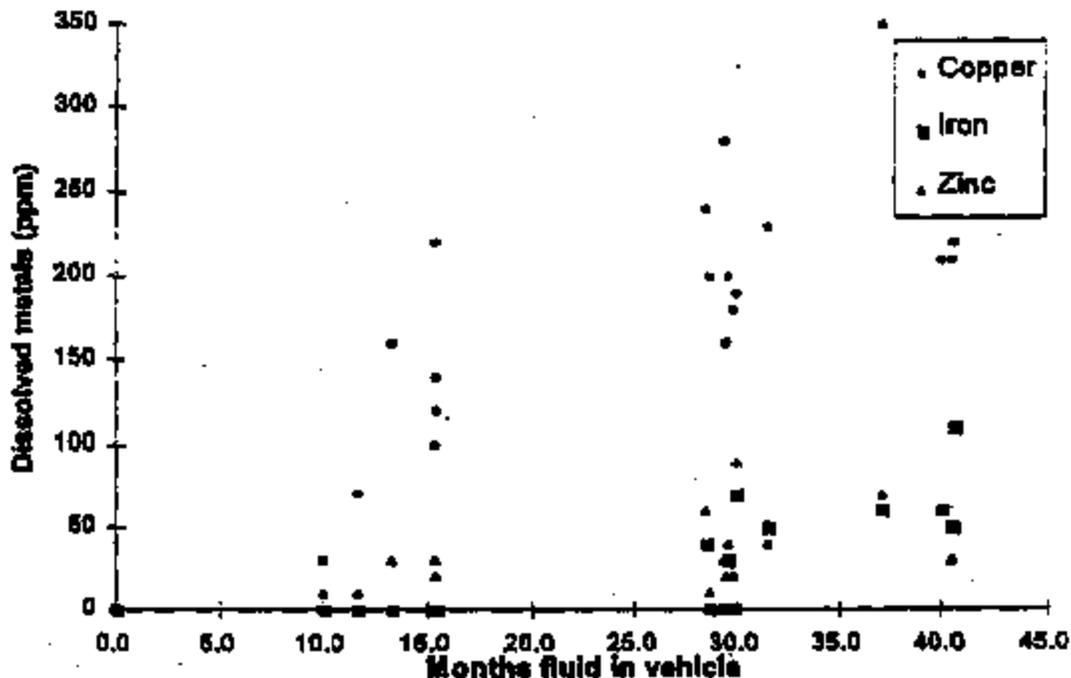


Figure 2: Dissolved metals in a fluid as fraction of time of use.

## LABORATORY AGING PROCEDURES

Analysis of changes in reserve alkalinity, concentrations of initial amines, concentrations of identifiable nitrogen-containing reaction products, and total nitrogen with vehicular use point to at least two pathways for loss of buffering capacity and amine inhibitor action in brake fluids over time. Under conditions where the buffering capacity is almost completely lost, total nitrogen measurements show retention of 35-45% of the original nitrogen in the fluid (in a formulation for which the vast majority of initial nitrogen is in the amine inhibitor). Thus 1/3-1/2 of the initial nitrogen remains in the fluid but has been converted to non-buffering compounds which are also not good inhibitors. About half of this non-inactive nitrogen can be accounted for by the growth of the formamide derived from an initial amine inhibitor. The chemical path to a formamide is reasonably clear. One end of a glycol ether base fluid molecule can electrostatically oxidize, breaking off one carbon atom to yield formalin, a common oxidation product of glycols and glycol ethers. The formalin can then react with amine molecules to form inactive formamide molecules. The large concentrations of formamide products which develop during vehicular service thus point to formalin oxidation as one significant cause of the changes of brake fluid chemistry seen in vehicles.

The other significant change in fluid amine chemistry involved not conversion of nitrogen to an inactive form, but loss of nitrogen (in any form) from the brake fluid. The selective loss of various amines from brake systems suggested that volatility, either directly from the fluid surface in the master cylinder reservoir or indirectly via permeation through hoses, could be the second major pathway to the loss of amine inhibitor activity in vehicles. These two pathways to amine loss were incorporated into a laboratory aging procedure designed to mimic vehicular behavior.

**THERMAL OXIDATION** - The thermal oxidation aspect of brake fluid aging was emulated in the laboratory by an 18 hour air-sparged reflux of the fluid at 132° C in the presence of copper powder. To gain maximum acceleration of the aging process, it was desirable to run at the highest temperature which fluid was likely to see anywhere in vehicular brake systems under conditions occurring during normal driving. The chosen 132° C is the highest temperature allowed for fluid during a standard vehicular service test. Copper powder (at >2 cm<sup>2</sup> Cu per ml brake fluid) was incorporated into the procedure because of the similarity high Cu surface / brake fluid volume ratio in real brake systems, the observed dissolution of Cu into fluids during use, and the known behavior of Cu as a catalyst for the oxidation of organic compounds<sup>11</sup>. The duration of the laboratory vehicular treatment was sufficient to approximate the levels of formamide reaction products seen in vehicular brake fluid samples after 3 years' service.

Refluxing of 2 liter quantities of fluid was carried out in a 5000 ml round-bottomed flask with three 24440 tapered glass joints (two fixed and one adapted), warmed with a heating mantle. A water-cooled 300 ml - long Graham (co2) condenser in series with a 300 rpm - long Atlas (bulk)

condenser (the latter on top) proved adequate to keep total weight losses for the fluids below 0.5% during this procedure. Air (free of carbon dioxide and hydrocarbons) was sparged through the fluid at 10 ml/s through a fluorinated ethylene-propylene (FEP) tube drawn out in the hot air of a heat gun to give a ca. 1 mm opening. Temperature was measured by a 0.13 mm thermocouple within the fluid and was controlled with an Omega 889401 temperature controller switching the power to a variable transformer set at 70 V (for steady-state operation) which in turn supplied power to the heating mantle. The fluid and 20 g of copper powder (Baker 1728-01) were continuously stirred with a magnetic stirrer directly below the heating mantle. A 10-20 cm<sup>2</sup> piece of cast iron brake cylinder was used as a stir bar and provided a quick visual check of any corrosive effects generated during the thermal oxidation; a second standard polystyrene-coated stir bar was also put in the flask to improve stirring. The fluid was refluxed in the flow of air for 18 hr at 132° C in this apparatus. Then the fluid was decanted from above the copper powder and transferred to a 4 liter borosilicate glass beaker for the next step of the laboratory aging process.

The white columns of Figure 3 show the % RA retained after SAE compatibility fluid RM-66-04 and a number of commercially available brake fluids were subjected to this thermal oxidation procedure. Results range from >90% retention of buffering capacity to complete destruction of buffering capacity (pH below 5.5 after thermal oxidation (not shown)). While DOT 4 fluids taken as a class were more resistant to loss of amines and buffering capacity by thermal oxidation, some DOT 4 fluids showed some of the lowest levels of thermal stability seen in any fluids.

Significantly smaller RA losses were observed when argon was substituted for air in this procedure or when fluid was simply sealed into brake pipe and heated. Nitrogen analysis of fluids subjected to this air-sparged reflux procedure showed very little loss of total nitrogen. The primary mechanism of loss of buffering capacity tested by this procedure therefore appears to in fact be thermal oxidation.

**VOLATILIZATION** - The simplest process which could explain the observed 55-65% loss of total nitrogen from some brake fluids during vehicular service is volatilization of amines either from the free surface in the master cylinder reservoir or after permeation through hoses. Another possibility is simple absorption into hose materials without evaporation off of the hose outer surface. Since simple volatilization of the amines off of the free fluid surface can be performed most reproducibly in the laboratory, direct evaporation was chosen as the initial laboratory procedure to emulate the observed vehicular loss of total nitrogen from the fluid.

The tendency of fresh fluids towards loss of amine inhibitors through volatilization can be quickly measured largely in isolation of other effects by placing 100 ml of fluid in a standard SAE corrosion test jar which is then placed, uncovered, in an oven at 100° C for 16 hours (temperature chosen for convenience to a lab running standard corrosion tests). Figure 4 shows how the RA drops for various fluids as a function of time under these conditions. However, this simple volatilization experiment alone does not accurately

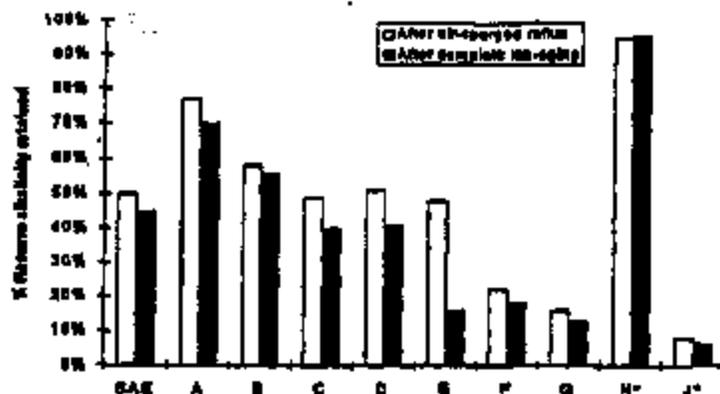


Figure 3: % Reserve alkalinity retained after thermal oxidation and after complete lab-aging procedures were applied to SAE compatibility fluid RM-66-04 and commercially available fluids (\* indicates DOT 4 fluid).

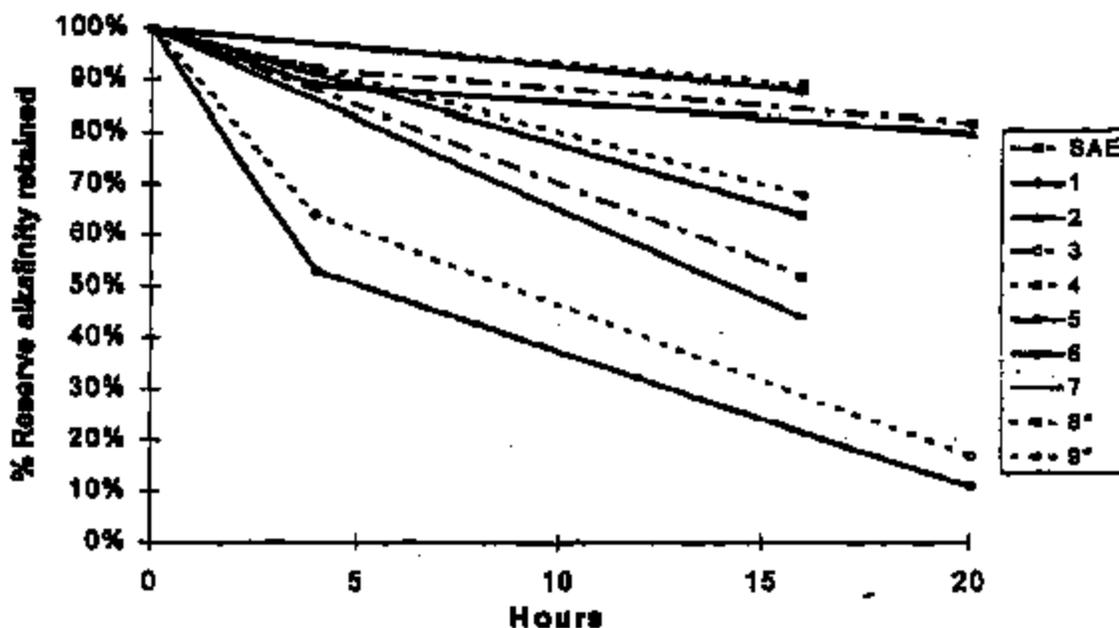


Figure 4: Reserve alkalinity retention as function of heating time (uncovered) at 100° C for SAE compatibility fluid RM-66-04 and various commercially available fluids (\* indicates DOT 4 fluid).

reproduce the chemical changes observed during vehicle use, particularly the production of formamide oxidation products.

**OVERALL AGING: COMBINED PROCESSES** - The best fit of lab-treated fluid composition to vehicle-aged fluids has been obtained if the volatilization step is performed after the air-sparged refluxing procedure previously described. A lower temperature is used for volatilization in this combined procedure because (1) fluid temperatures at the location of volatilization (reservoir or hose) will be lower than the maximum system temperature used for the thermal oxidation step and (2) volatilization at higher temperatures could cause changes in the relative concentrations of base fluid components which have not been observed in vehicles.

The 2 liters of previously reduced fluid are decanted into a 4 liter beaker, which is then held, uncovered, at 80° C (thermocouple in the fluid 2.5 cm above the bottom) for 64 hours on a hotplate regulated by a temperature controller. The fluid is then cooled and filtered through 2.5 µm paper (Whatman 42) to remove suspended copper powder, taking care in pouring to capture any condensate on the sides of the beaker along with the liquid. Weight losses from the fluid during this volatilization step range from about 3 to 5%.

The black column of Figure 3 shows the %EA (vs. fresh fluid) remained after both the thermal oxidation and volatilization steps for a number of fluids. For most, but not all, fluids, almost all of the loss of buffering capacity occurs during the thermal oxidation step of the laboratory aging procedure.

Table 4 compares chemical parameters for fresh, laboratory-aged and vehicle-aged fluids. By design, the dissolved metals contents of lab-aged fluids are significantly lower than those of fluids used in vehicular service. The low metal contents in the lab-aged fluids simplify detection of corrosion when lab-aged fluid is put into the brake systems of new vehicles.

Table 4: Comparison of chemical properties of a fluid in vehicular-aged and laboratory-aged forms.

km	% RA	% amines	formamide % of amines	Cu ppm	Fe ppm	Zn ppm
77371	17 %	3%	17%	220	110	50
83245	5%	3%	17%	210	60	60
77100	13 %	<3%	30%	320	160	120
lab-aged	13 %	2%	10%	22	3	<5

## BEHAVIOR OF LABORATORY-AGED FLUIDS IN VEHICLES

**DISSOLVED METALS** - To test the correlation of expectations from laboratory work with true vehicular behavior, an experiment was run in matched new vehicles using two brake fluid formulations (I and II), each in both fresh and lab-aged conditions. Table 5 shows dissolved metal content after 6 months fluid use for the individual vehicles, grouped by fluid type. The clear difference between the four groups is that the lab-aged fluid I led to significantly higher dissolved iron levels than seen in the other three groups. Since repeat analysis confirmed an essentially null iron content for the lab-aged fluids at the time they were put into vehicles, it was clear that the laboratory-aged form of fluid I had initiated some form of iron corrosion during 6 months vehicular exposure. No iron corrosion was detected during this brief vehicular exposure for the non-aged form of I or for either the fresh or lab-aged forms of II. Comparison of the results of Table 5 with the non-field dissolved metal timeline of Figure 2 suggests that the laboratory aging procedure appears to have accelerated the relevant fluid about 30 months down the timeline. In contrast, fluid II showed no increase in 6 month vehicular dissolved iron after the same laboratory stress prior to installation in new matched vehicles, suggesting improved durability of iron corrosion protection.

**CORROSION OF COMPONENTS** - Figure 5 compares the interior surfaces of cast iron wheel cylinders which ran 6 months (top) and 12 months (bottom) with lab-aged fluids I (left) and II (right) in the vehicular experiment. The non-corroded appearance on the right duplicates all previous testing experience with fresh brake fluids - no corrosion of cast iron components occurs before several years of vehicular exposure. The rusting seen on the left with lab-aged I is similar to corrosion sometimes seen in wheel cylinders of vehicles after several years in the field - a patch of rust builds at the bottom of the cylinder. Electron microscopy of the rust patch shows, again in agreement with long-term vehicular experience, deposition of significant levels of copper in the corroded region. The appearance of this corrosion correlates with the elevated dissolved iron levels seen in laboratory-aged fluid I within 6 months of the start of service. No corrosion was seen in wheel cylinders running fresh fluid I or II or lab-aged fluid II, again in agreement with the dissolved iron data. It should be noted that the difference in dissolved Fe and observed cylinder corrosion was observed despite the similar levels of dissolved copper in all four groups of vehicles. While copper is implicated in the iron corrosion by its deposition in the rusted areas, the data suggest that it is necessary to have severely depleted the iron corrosion inhibitors (amines) before the dissolved copper can accelerate the corrosion of iron.

Table 5: Dissolved metals for fresh and lab-aged fluids I and II, before and after 6 months service in matched vehicles.

Fluid	Fresh / lab-aged	km	Cu ppm	Fe ppm	Zn ppm
I	fresh	0	0	0	0
II	fresh	0	0	0	0
I	aged	0	82	3	<3
II	aged	0	89	3	<3
I	fresh	16261	130	<3	11
I	fresh	30910	320	<3	27
I	fresh	18463	460	3	26
I	fresh	9746	150	<3	16
I	aged	35305	210	50	20
I	aged	11350	240	33	49
I	aged	24975	260	57	61
I	aged	20060	270	50	23
II	fresh	13384	110	2	12
II	fresh	26333	180	<3	16
II	fresh	7501	54	<3	5
II	fresh	34828	160	11	13
II	aged	17260	240	5	64
II	aged	19742	250	5	74
II	aged	12613	230	5	42
II	aged	11779	360	5	81

#### BEHAVIOR OF LAB-AGED COMMERCIAL BRAKE FLUIDS IN SAE J1703 LABORATORY CORROSION TESTS

Internal corrosion of brake system components has been observed in some vehicles after several years' service in brake fluids which easily pass the corrosion tests in the J1703 standard. One cannot, therefore, have confidence that the standard corrosion tests performed on fresh fluids adequately predict the durability of corrosion protection for the life of the vehicle. Laboratory-aging of fluids prior to vehicle fill has reproduced long-term vehicular effects after much shorter vehicular exposure. In an attempt to develop a laboratory corrosion test which does have predictive power for the durability of corrosion protection, standard corrosion tests were run on a number of commercial brake fluids in both fresh and laboratory-aged (thermal oxidation + volatilization) conditions. In this application, the ca. 100 ppm copper level in some lab-aged fluids complicates the interpretation of weight-loss measurements. Copper deposition can accompany corrosion, (most noticeably on zinc, iron, and aluminum coupons) and decrease the magnitude (or even invert the apparent sign) of real corrosive weight losses. Lab-aged fluids were therefore analyzed for metals after being used in the corrosion test, and the dissolved metals contents were

Table 6 shows standard J1703 corrosion test weight changes for SAE compatibility fluid RM-66-04 and for 9 commercially available fluids tested both in fresh and laboratory-aged conditions. A number of fluids showed significant zinc weight losses and/or etching when tested in lab-aged form. Otherwise no weight losses or gains outside the SAE limits were induced by lab-aging prior to the standard J1703 corrosion test. It should be noted that used fluid from vehicles can also show no objectionable weight losses in the standard J1703 corrosion tests, even when the used fluid is drawn from vehicles after service intervals which sometimes produce visible corrosion of components. It appears that the conditions of the corrosion test in J1703 are not severe enough to produce visible corrosion even from aged fluids which do allow visible internal brake system corrosion in severe vehicular service.

Table 7 shows preliminary results on weight changes for metals tested in lab-aged fluids by the J1703 method modified by addition of 50 ppm chloride to the test fluid. With the addition of chloride, not only zinc but also dissolved iron, steel and/or aluminum showed pitting or etching with some lab-aged fluids.

Modifying the J1703 corrosion test both by lab-aged fluid and by addition of 50 ppm chloride clearly increases its severity and its ability to distinguish between fluids, at least in regards to coupon appearance. However, even this doubly-modified version of the SAE corrosion test does not reproduce the effect in one iron observed in vehicles.

To minimize the future necessity of vehicular testing, even with lab-aged fluids, more stringent laboratory corrosion tests must be developed. Additional factors which may contribute to the more aggressive corrosion environment in vehicles compared to the standard J1703 corrosion test include details of the time/temperature history of the fluid and further changes in brake fluid chemistry induced by interactions with elastomers in the system (particularly hose materials). Further modifications to the standard J1703 corrosion test procedure, as applied to lab-aged fluids, are being investigated to determine the simplest possible laboratory corrosion test conditions which best reproduce the worst-case behavior of fluids in severe vehicular service.

#### SUMMARY AND CONCLUSIONS

Constantly increasing expectations for durability of automotive components on the part of both consumers and manufacturers suggests the desirability of improved methods to ensure the durability of corrosion protection in brake fluids. Chemical analysis of used brake fluids has shown that the anions which are often the primary corrosion inhibitors can be lost over time both through thermal oxidation and by another process which completely removes nitrogen from the fluid. A two-step laboratory aging procedure was developed to reproduce these vehicular changes in brake fluid chemistry. Fluids subjected to this laboratory aging process typically still missed all of the corrosion weight change requirements of the

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# Improved Methods for Testing the Durability of Corrosion Protection in Brake Fluids

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## ABSTRACT

Present corrosion testing procedures for brake fluids assess the properties of fresh fluids under some forms of environmental stress (e.g. water contact, elevated temperature). These tests may not accurately predict corrosion protection properties of fluid after the years of continuous service typical of North American practice. This paper describes the development of laboratory accelerated aging procedures which reproduce the chemical changes occurring in brake fluids during long-term service. Short-duration vehicular tests with these lab-aged fluids have reproduced specific modes of corrosion previously observed only after long-term customer use.

## INTRODUCTION

Brake fluid reliably transmits full boosted pedal pressure throughout the braking system. Brake fluid also serves to protect against corrosion the brake system materials it contacts. While in Europe the brake fluid in a vehicle is typically changed every few years, in North America brake fluids are not routinely changed. Therefore, it is important to assess the long-term corrosion protection of brake fluid used in cars and trucks sold in North America.

The minimum levels of corrosion protection required for brake fluids are set by laboratory test procedures embodied in FMVSS 116<sup>1</sup>, a regulation based on the primary brake fluid standard for the automotive industry, SAE J1703<sup>2</sup>. The corrosion tests required by these standards are performed on fresh samples of brake fluid and may not be a reliable

indicator of the level of corrosion protection afforded by the fluid after several years in a vehicle. A fluid compounded from high-quality base materials, but containing no corrosion inhibitors whatsoever, can pass the weight change requirements (see Table 1). Corrosion is on occasion still observed within brake systems filled with fluids which were fully compliant with SAE J1703 and FMVSS 116 when fresh. Chemical analysis of used brake fluids suggests reasons why corrosion could occur in these circumstances.

Table 1: J1703 corrosion test (section 4.6) weight changes for an uninhibited brake fluid base.

metal	J1703 max. wt. change (mg/cm <sup>2</sup> )	measured wt. change (mg/cm <sup>2</sup> )
Tinned Iron	±0.2	-0.04
Steel	±0.2	-0.04
Aluminum	±0.1	+0.01
Cast Iron	±0.2	+0.00
Brass	±0.4	-0.03
Copper	±0.4	-0.00
Zinc	±0.4	+0.06

Note: J1703 4.6 requirements on copper and fluid appearance, sediment, and rubber interaction also passed

This paper first characterizes, through chemical analysis, the changes which can occur in brake fluids during vehicular use. Then, building upon this database, we develop new aging and testing procedures which can measure the durability of the corrosion protection provided by a fully-formulated fluid. The primary corrosion inhibitors used in most brake fluids are amines, organic bases which both provide general buffering

capacity against the deleterious effects of acidic breakdown products and provide specific protection of particular metals, preferably through adsorption. Amines both work well as inhibitors and fulfill the extended solubility constraints imposed by the need for the brake fluid to remain a single phase system over wide ranges of temperature and water content. This paper will therefore concentrate upon the amine components of the total inhibitor package.

**SPECIAL STRESSES AND REQUIREMENTS OF ANTILOCK BRAKE SYSTEMS** - Modern antilock brake systems pose new challenges to the proper integration of formulated brake fluids into total brake system design for durable performance. The increased circulation of brake fluid associated with ABS (e.g., through low-pressure return lines to the master cylinder reservoir) may increase the chances of loss of brake fluid components from the fluid, either by direct evaporation, permeation through polymers, or sorption into polymers. The forced circulation can also facilitate the transport of corrosion products and/or thermal degradation products, if they are present, from one point in the brake system to another.

#### CHANGES IN BRAKE FLUID CHEMISTRY DURING VEHICULAR SERVICE

**DROP IN RESERVE ALKALINITY** - The amine inhibitors which provide the primary corrosion protection in most brake fluids are organic bases. A simple approximate measurement of their total concentration (and the stability thereof) in a formulated brake fluid can be obtained by acid-base titration similar to those called out for engine coolants by ASTM standard D 1121<sup>2</sup>. The Reserve Alkalinity (RA) of a brake fluid is defined as the number of milliliters of 0.100 M hydrochloric acid needed to titrate 50 ml of brake fluid down to a pH of 5.5<sup>3</sup> (in contrast, the D 1121 definition of RA for engine coolant is ml HCl / 10 ml coolant concentrate). In an attempt to keep all brake fluid components in solution during the titration, the brake fluid is prediluted with a solution of 80% denatured alcohol and 20% deionized water (in this work, ~2ml of brake fluid [quantified by weight] was diluted to 60 ml total volume before starting titration with 0.100 M HCl). RA's of fresh brake fluids in recent commercial production range from about 3 to about 120.

Figure 1 shows the residual RA (as % of initial value) of a brake fluid in matched vehicles 0-3.5 years old, plotted as a function of the age of the fluid. By 30 months (about 50,000 km) the RA has dropped to as low as 9% of its initial value, and about half of this small residual RA arises from components other than the amines. The titration data therefore suggest a 20-fold reduction in primary inhibitor concentration over 2-3 years of service.

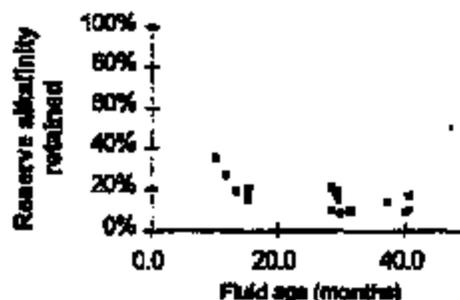


Figure 1: Decrease in reserve alkalinity of a brake fluid during vehicular use.

Table 2 shows %RA (vs. fresh values for appropriate OEM brake fluids) for a number of fluid samples taken from randomly-selected vehicles produced by a range of manufacturers. Some loss of RA during vehicular service is universally observed, but the % retained varies widely for different fluids. In the absence of further data, no conclusions about the quality of corrosion protection afforded by a fluid should be drawn from absolute RA values, since it may be possible to formulate effective fluids with a wide range of initial RA's. However, the evolution of the RA over time of use gives a general picture of the stability of the inhibitor package. If the material retains a smaller percentage of its initial RA over time, one can have less confidence that the initial level of corrosion protection implied by 11703 compliance will be continued through the service life of the vehicle.

Table 2: Retained reserve alkalinities for a number of OEM fluids after vehicular use.

OEM fluid	Kilometers	Months (approx.)	% Initial RA retained
I	71830	36	5%
II	71067	36	21%
III	47618	28	33%
IV	117763	36	49%
V	60780	28	52%

**DROP IN AMINE INHIBITOR CONCENTRATIONS, BUILDUP OF INHIBITOR REACTION PRODUCTS, AND LOSS OF TOTAL NITROGEN** - Determination of RA, while simple, actually measures only general buffering capacity, not the concentrations of particular inhibitors. To properly characterize the chemical evolution of brake fluids in use and to prevent misinterpretation of RA data, it is necessary to be able to quantify the concentrations of individual inhibitors. The capillary gas chromatography (GC) techniques employing flame ionization detectors (FID's) commonly used in quality control of the glycol ether and polyglycol components of brake fluid base oils, if carried out with unusually high resolution, quantify the presence of at least some of the common amine inhibitors. However, since the

amines contribute only a small fraction of the total fluid and the chromatographic properties of some important amines are less than optimal for clean separation, full characterization of amines content requires methods which are more selective for nitrogen compounds.

One successful approach has been to use capillary GC with a thermionic amine detector (or nitrogen-phosphorus detector [NPD]) which has a sensitivity for nitrogen atoms in molecules which is over 5000-fold greater than its sensitivity for carbon atoms<sup>24</sup>. This high selectivity for N allows not only ready identification of the chromatographic peaks due to the original amines but also allows one to determine the fate of nitrogen atoms as the original amines react to form new nitrogen-containing compounds during vehicular use. This ability to monitor nitrogen in the fluid even after it has been incorporated into reaction products which may no longer provide buffering capacity has proven particularly useful in testing laboratory aging procedures to accurately reproduce the effects of extended vehicular use.

Total nitrogen in the brake fluid was also measured with a standard N/S elemental analyzer. Since this technique is sensitive to nitrogen in any relevant form, the drop of total nitrogen as seen by this method allows determination of what fraction of initial nitrogen completely left the fluid. In the primary fluids under study here, the overwhelming preponderance of original nitrogen in the fluid was in the form of the amine inhibitor(s).

Capillary electrophoresis was found to be another successful analytical approach for the amines in most of the inhibitor packages<sup>25</sup>. The technique relies on the fact that ions move with different velocities through a capillary tube filled with buffer solution when an electric field is applied across the length of the tube. Amines in aqueous solutions of brake fluid were separated and detected as their ammonium cations in a pyridinium sulfate buffer at pH 4.4. When they passed through the UV absorbance detector on the Capillary Ion Analysis (CIA) instrument, amine cations were detected as a decrease in absorbance at 254 nm because they displaced some of the pyridinium cations which absorb light at that wavelength<sup>9</sup>. For many fluids, this procedure detects all of the original amines and any reaction products thereof which retain basicity. However, it will not detect other nitrogen-containing reaction products which do not still contribute to the buffering capacity of the used fluid. The limited aqueous solubilities of the ammonium ions derived from the inhibitors in some fluids can lead to irreproducible CIA results. Consequently, the NPD GC and CIA methods were used together to generate corroborative and complementary data.

The mechanisms by which the amines content decreases over time can be inferred by comparison of several metrics of a fluid after vehicular use: the % RA retained, the % retained of total original amine species (by NPD GC), the % of total nitrogen retained (by N/S), and the % buildup of known N-containing reaction products which do not provide buffering capacity (by NPD GC). While the RA and the concentrations of the original amines drop away after approximately 75000 km to <10% of their initial values, more than a third of the original total nitrogen remains in the fluid. Essentially all of this residual N is in a form other than the original amines, and most of the residual N is in a form which does not provide

significant buffering against addition of acid. Of this inactivated but still-present portion of the N, approximately half can be identified as a particular reaction product, the formamide of an inhibitor originally present in the fluid. Cast iron readily rusts when placed in contact with un inhibited brake fluid base to which an appropriate level of this formamide, 5% water, and 50 ppm chloride were added. When the original amines replaced the formamide in control experiments, no rusting was observed at all. The formamide reaction product thus serves neither as a buffer nor as a corrosion inhibitor. However, it does provide a readily-analyzed signature for the severity of thermal oxidation to which a fluid has been subjected while being used in a vehicle.

**INCREASE IN DISSOLVED METALS** - Measurements of dissolved metals in brake fluid (here, done by inductively-coupled plasma atomic emission spectroscopy) provide an indirect indicator of corrosion activity within the brake system. If such measurements are to be a useful guide to the functional durability of the fluid, they must both be interpreted with some care and be accompanied by detailed inspection of brake system components to establish whether the presence of the dissolved metals in the fluid is in fact indicative of a condition which could eventually decrease brake system performance. A low rate of general corrosion over a large surface area of a metal may lead to apparently significant levels of that metal dissolved in the fluid but may pose no threat to system performance. Conversely, a very high rate of localized corrosion of a metal could produce only a small dissolved metal content in the fluid but eventually lead to significant loss of brake system function. A case of correlation between metal uptake in the fluid and component corrosion with a potential for functional significance over an extended service life will be given in later sections of this paper.

Figure 2 shows the pickup of metals by a fluid in vehicular service as a function of fluid age, corresponding to distances traveled of 0-100,000 km. In all vehicles in this figure and for all fluid ages, the most or highest concentration in solution is copper. This is in part due to the (perhaps surprisingly) huge preponderance of the system surface area exposed to the brake fluid which is copper. The interior of typical 2-layer steel brake pipe is completely covered by the copper braze alloy. A typical light-duty vehicle uses 14 m of such pipe, with an internal diameter of ~2.5 mm, giving an internal geometric surface area of 1200 cm<sup>2</sup>. Atomic force microscopy scans of the interior copper surface of the pipe yield a roughness factor of 1.5, so that the ~900 ml of brake fluid in a vehicle (including that in the master cylinder reservoir) is exposed to 1800 cm<sup>2</sup> of copper. The approximately 300 ppm of Cu seen in the brake fluid after ~36 months corresponds to dissolution of ~0.1 mg/cm<sup>2</sup> copper in 3 years of service, compared with the 0.4 mg/cm<sup>2</sup> copper allowed in a 5 day laboratory test to comply with J1703. The copper corrosion, which appears to be general (rather than localized) in morphology, poses no direct threat to system integrity.

The significance of Figure 2 lies not in the relatively large dissolved copper levels but in the more subtle levels of dissolved iron. No dissolved iron at all is seen until around 10 months, after which 50-100 ppm of dissolved iron becomes typical. Cast iron components removed from some vehicles after such times show some level of pitting of the iron, with pits typically surrounded by metallic copper.

Dissolved iron appears in the brake fluid after the initial anodic corrosion inhibitors are significantly depleted and dissolved copper levels rise to around 200 ppm. The apparent induction period for iron corrosion has presented difficulties in testing technological changes designed to minimize this effect; no test protocol employing fresh brake fluid had succeeded in reproducing the iron corrosion observed at times in vehicles after several years' service. Later sections of this paper will show that attention to the chemical changes in brake fluid during use has led to test procedures which reproduce the field vehicular effects within 6 months.

The dissolved zinc levels in Figure 2 show no evidence of the induction time seen for iron. Since testing for corrosion protection of zinc in brake fluid is known to be problematic even in fresh brake fluids<sup>16</sup> (it is not yet a requirement of FMVSS116), it would not be entirely surprising if some Zn corrosion is occurring even after relatively short service. Another possible source of the observed zinc is extraction of Zn compounds from hoses.

Table 3 shows dissolved metal data for different fluids after extended use in vehicles built by a number of manufacturers. Analytically significant levels of dissolved metals are a common, but not completely universal, characteristic of brake fluids in vehicular service. Between different vehicles, the metals dissolved in brake fluid can be expected to vary with the metals exposed to brake fluid and the service conditions, as well as with the properties of the brake fluids used.

Table 3: Dissolved metals for a number of OEM fluids after use in vehicles.

Fluid	Rm	months (approx)	Cu (ppm)	Fe (ppm)	Zn (ppm)
$\alpha$	4591	28	30	<10	10
$\alpha$	57785	28	130	10	0
$\alpha$	77371	40	220	110	50
$\beta$	6134	12	30	<10	10
$\beta$	60717	na	800	<10	130
$\beta$	na	60	550	30	200
$\gamma$	47618	na	260	30	140
$\delta$	71004	36	18	2	49
$\epsilon$	106612	24	16	3	33

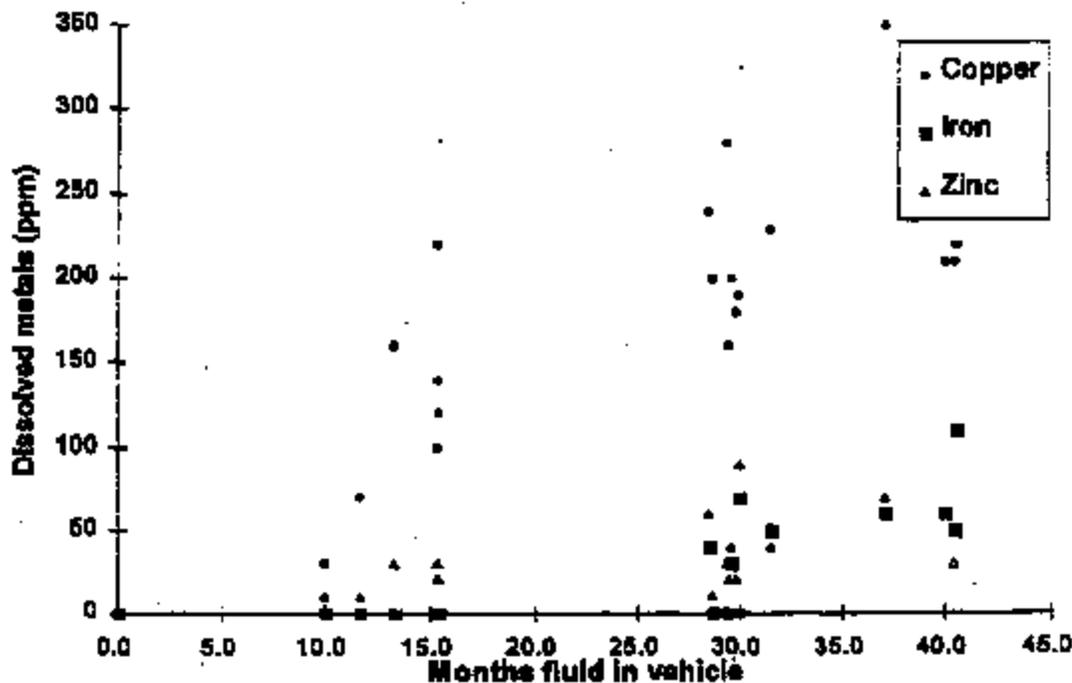


Figure 3: Dissolved metals in a fluid as function of time of use.

## LABORATORY AGING PROCEDURES

Analysis of changes in reserve alkalinity, concentrations of initial amines, concentrations of identifiable nitrogen-containing reaction products, and total nitrogen with vehicular use point to at least two pathways for loss of buffering capacity and amine inhibitor action in brake fluids over time. Under conditions where the buffering capacity is almost completely lost, total nitrogen measurements show retention of 35-45% of the original nitrogen in the fluid (in a formulation for which the vast majority of initial nitrogen is in the amine inhibitors). Thus 1/3-1/2 of the initial nitrogen remains in the fluid but has been converted to non-buffering compounds which are also not good inhibitors. About half of this non-inactive nitrogen can be accounted for by the growth of the formamide derived from an initial amine inhibitor. The chemical path to a formamide is reasonably clear. One end of a glycol ether base fluid molecule can dimethylatively oxidize, breaking off one carbon atom to yield formate, a common oxidation product of glycols and glycol ethers. The formate can then react with amine molecules to form inactive formamide molecules. The large concentrations of formamide products which develop during vehicular service thus point to thermal oxidation as one significant cause of the changes of brake fluid chemistry seen in vehicles.

The other significant change is fluid amine chemistry involved not conversion of nitrogen to an inactive form, but loss of nitrogen (in any form) from the brake fluid. The selective loss of various amines from brake systems suggested that volatility, either directly from the fluid surface in the master cylinder reservoir or indirectly via permeation through hoses, could be the second major pathway to the loss of amine inhibitor activity in vehicles. These two pathways to amine loss were incorporated into a laboratory aging procedure designed to mimic vehicular behavior.

**THERMAL OXIDATION** - The thermal oxidation aspect of brake fluid aging was emulated in the laboratory by an 18 hour air-sparged reflux of the fluid at 132° C in the presence of copper powder. To gain maximum acceleration of the aging process, it was desirable to run at the highest temperature which fluid was likely to see anywhere in vehicular brake systems under conditions occurring during normal driving. The chosen 132° C is the highest temperature allowed for fluid during a standard vehicular service test. Copper powder (at >2 cm<sup>3</sup> Cu per ml brake fluid) was incorporated into the procedure because of the similarly high Cu surface / brake fluid volume ratio in real brake systems, the observed dissolution of Cu into fluids during use, and the known behavior of Cu as a catalyst for the oxidation of organic compounds<sup>11</sup>. The duration of the laboratory oxidation treatment was sufficient to approximate the levels of formamide reaction products seen in vehicular brake fluid samples after 3 years' service.

Refluxing of 2 liter quantities of fluid was carried out in a 5000 ml round-bottomed flask with three 24/40 tapered glass joints (two fixed and one adapted), wrapped with a heating mantle. A water-cooled 300 ml - long Graham (coil) condenser in series with a 300 mm - long Allihn (bulb)

condenser (the latter on top) proved adequate to keep total weight losses for the fluids below 0.5% during this procedure. Air (free of carbon dioxide and hydrocarbons) was sparged through the fluid at 10 ml/s through a fluorinated ethylene-propylene (FEP) tube drawn out in the hot air of a heat gun to give a ca. 1 mm opening. Temperature was measured by a 0.13 mm thermocouple within the fluid and was controlled with an Omega BSS601 temperature controller switching the power to a variable transformer set at 70 V (for steady-state operation) which in turn supplied power to the heating mantle. The fluid and 80 g of copper powder (Baker 172E-01) were continuously stirred with a magnetic stirrer directly below the heating mantle. A 10-20 cm<sup>3</sup> piece of cast iron brake cylinder was used as a stir bar and provided a quick visual check of any corrosive effects generated during the thermal oxidation; a second standard polytetrafluoroethylene-coated stir bar was also put in the flask to improve stirring. The fluid was refluxed in the flow of air for 18 hr at 132° C in this apparatus. Then the fluid was decanted from above the copper powder and transferred to a 4 liter borosilicate glass beaker for the next step of the laboratory aging process.

The white columns of Figure 3 show the % RA retained after SAE compatibility fluid RM-65-04 and a number of commercially available brake fluids were subjected to this thermal oxidation procedure. Results range from >90% retention of buffering capacity to complete destruction of buffering capacity (pH below 5.5 after thermal oxidation (not shown)). While DOT 4 fluids taken as a class were more resistant to loss of amines and buffering capacity by thermal oxidation, some DOT 4 fluids showed some of the lowest levels of thermal stability seen in any fluids.

Significantly smaller RA losses were observed when argon was substituted for air in this procedure or when fluid was simply sealed into brake pipe and heated. Nitrogen analysis of fluids subjected to this air-sparged reflux procedure showed very little loss of total nitrogen. The primary mechanism of loss of buffering capacity tested by this procedure therefore appears to in fact be thermal oxidation.

**VOLATILIZATION** - The simplest process which could explain the observed 55-65% loss of total nitrogen from some brake fluids during vehicular service is volatilization of amines either from the free surface in the master cylinder reservoir or after permeation through hoses. Another possibility is simple absorption into hose materials without evaporation off of the hose outer surface. Since simple volatilization of the amines off of the free fluid surface can be performed more reproducibly in the laboratory, direct evaporation was chosen as the initial laboratory procedure to emulate the observed vehicular loss of total nitrogen from the fluid.

The tendency of fresh fluids towards loss of amine inhibitors through volatilization can be quickly measured largely in isolation of other effects by placing 100 ml of fluid into a standard SAE corrosion test jar which is then placed, covered, in an oven at 100° C for 16 hours (temperature chosen for convenience to a lab running standard corrosion tests). Figure 4 shows how the RA drops for various fluids as a function of time under these conditions. However, this simple volatilization experiment alone does not accurately

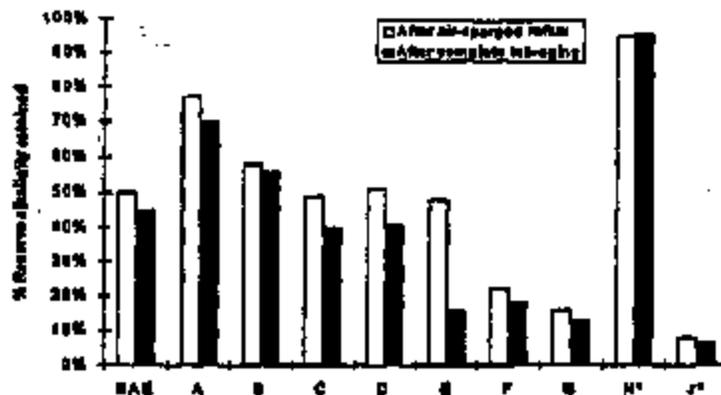


Figure 3: % Reserve alkalinity retained after thermal oxidation and after complete lab-aging procedure were applied to SAE compatibility fluid RM-66-04 and commercially available fluids (\* indicates DOT 4 fluid).

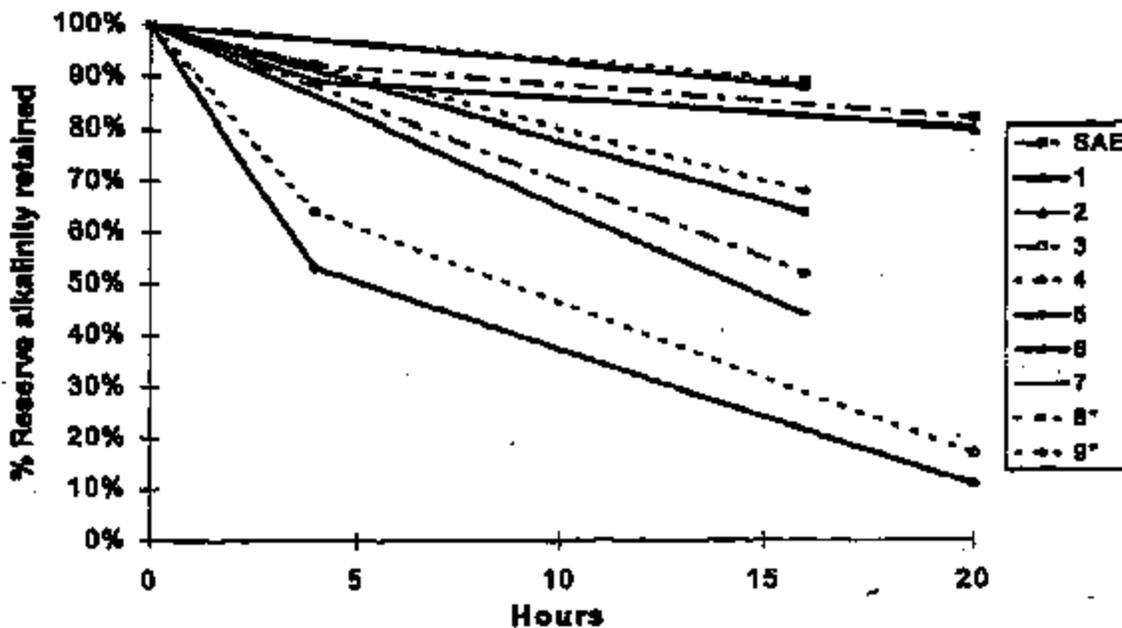


Figure 4: Reserve alkalinity retention as function of heating time (uncovered) at 100° C for SAE compatibility fluid RM-66-04 and various commercially available fluids (\* indicates DOT 4 fluid).

reproduces the chemical changes observed during vehicle use, particularly the production of formamide oxidation products.

**OVERALL AGING: COMBINED PROCESSES** - The best fit of lab-treated fluid composition to vehicle-aged fluids has been obtained if the volatilization step is performed after the air-saturated refluxing procedure previously described. A lower temperature is used for volatilization in this combined procedure because (1) fluid temperatures at the location of volatilization (reservoir or hose) will be lower than the maximum system temperature used for the thermal oxidation step and (2) volatilization at higher temperatures could cause changes in the relative concentrations of base fluid components which have not been observed in vehicles.

The 2 liters of previously refluxed fluid are decanted into a 4 liter beaker, which is then held, uncovered, at 80° C (thermocouple in the fluid 2.5 cm above the bottom) for 64 hours on a hotplate regulated by a temperature controller. The fluid is then cooled and filtered through 2.5 µm paper (Whatman 42) to remove suspended copper powder, taking care in pouring to capture any condensate on the sides of the beaker along with the liquid. Weight losses from the fluid during this volatilization step range from about 2 to 3%.

The block columns of Figure 3 show the %RA (vs. fresh fluid) retained after both the thermal oxidation and volatilization steps for a number of fluids. For most, but not all, fluids, almost all of the loss of buffering capacity occurs during the thermal oxidation step of the laboratory aging procedure.

Table 4 compares chemical parameters for fresh, laboratory-aged and vehicle-aged fluids. By design, the dissolved metal contents of lab-aged fluids are significantly lower than those of fluids used in vehicular service. The low metal contents in the lab-aged fluids simplify detection of corrosion when lab-aged fluid is put into the brake systems of new vehicles.

Table 4: Comparison of chemical properties of a fluid in vehicular-aged and laboratory-aged forms.

Run	% RA	% amine	Form- amide % of amine	Cu ppm	Fe ppm	Zn ppm
77371	11 %	5%	17%	220	110	50
85245	9%	3%	17%	210	60	60
77198	12 %	<5%	20%	320	160	120
lab- aged	13 %	5%	10%	81	3	<3

## BEHAVIOR OF LABORATORY-AGED FLUIDS IN VEHICLES

**DISSOLVED METALS** - To test the correlation of expectations from laboratory work with true vehicular behavior, an experiment was run in matched new vehicles using two brake fluid formulations (I and II), each in both fresh and lab-aged conditions. Table 5 shows dissolved metals content after 6 months fluid use for the individual vehicles, grouped by fluid type. The clear difference between the four groups is that the lab-aged fluid I led to significantly higher dissolved iron levels than seen in the other three groups. Since repeat analysis confirmed an essentially null iron content for the lab-aged fluids at the time they were put into vehicles, it was clear that the laboratory-aged form of fluid I had initiated some form of iron corrosion during 6 months vehicular exposure. No iron corrosion was detected during this brief vehicular exposure for the non-aged form of I or for either the fresh or lab-aged forms of II. Comparison of the results of Table 5 with the new-fluid dissolved metals timeline of Figure 2 suggests that the laboratory aging procedure appears to have accelerated the relevant fluid about 30 months down the timeline. In contrast, fluid II showed no increase in 6 month vehicular dissolved iron after the same laboratory stress prior to installation in new matched vehicles, suggesting improved durability of iron corrosion protection.

**KORROSION OF COMPONENTS** - Figure 3 compares the interior surfaces of cast iron wheel cylinders which ran 6 months (top) and 12 months (bottom) with lab-aged fluids I (left) and II (right) in the vehicular experiment. The non-corroded appearance on the right duplicates all previous testing experience with fresh brake fluids - no corrosion of cast iron components occurs before several years of vehicular exposure. The rusting seen on the left with lab-aged I is similar to corrosion sometimes seen in wheel cylinders of vehicles after several years in the field - a patch of rust builds at the bottom of the cylinder. Electron microscopy of the rust patch shows, again in agreement with long-term vehicular experience, deposition of significant levels of copper in the corroded region. The appearance of this corrosion correlates with the elevated dissolved iron levels seen in laboratory-aged fluid I within 6 months of the start of service. No corrosion was seen in wheel cylinders running fresh fluids I or II or lab-aged fluid II, again in agreement with the dissolved iron data. It should be noted that the difference in dissolved Fe and observed cylinder corrosion was observed despite the similar levels of dissolved copper in all four groups of vehicles. While copper is implicated in the iron corrosion by its deposition in the rusted areas, the data suggest that it is necessary to have severely depleted the iron corrosion inhibitors (amines) before the dissolved copper can accelerate the corrosion of iron.

**Table 5: Dissolved metals for fresh and lab-aged fluids I and II, before and after 6 months service in matched vehicles.**

fluid	fresh / lab-aged	Iron	Cu ppm	Pb ppm	Zn ppm
I	fresh	0	0	0	0
II	fresh	0	0	0	0
I	aged	0	82	3	<3
II	aged	0	69	3	<3
I	fresh	16261	130	<2	11
I	fresh	30910	320	<3	37
I	fresh	18463	460	3	26
I	fresh	9746	130	<3	16
I	aged	35305	210	30	20
I	aged	11350	240	33	49
I	aged	24975	260	57	61
I	aged	20080	270	50	23
II	fresh	13384	110	2	12
II	fresh	26333	180	<3	16
II	fresh	7501	34	<3	5
II	fresh	34128	160	11	13
II	aged	17260	240	5	64
II	aged	19742	250	5	74
II	aged	12613	230	3	42
II	aged	11779	360	3	81

#### BEHAVIOR OF LAB-AGED COMMERCIAL BRAKE FLUIDS IN SAE J1703 LABORATORY CORROSION TESTS

Internal corrosion of brake system components has been observed in some vehicles after several years' service in brake fluids which easily pass the corrosion tests in the J1703 standard. One cannot, therefore, have confidence that the standard corrosion tests performed on fresh fluids adequately predict the durability of corrosion protection for the life of the vehicle. Laboratory-aging of fluids prior to vehicle fill has reproduced long-term vehicular effects after much shorter vehicular exposure. In an attempt to develop a laboratory corrosion test which does have predictive power for the durability of corrosion protection, standard corrosion tests were run on a number of commercial brake fluids in both fresh and laboratory-aged (thermal oxidation + volatilization) conditions. In this application, the ca. 100 ppm copper level in some lab-aged fluids complicates the interpretation of weight-loss measurements. Copper deposition can accompany corrosion, (most noticeably on zinc, iron, and aluminum coupons) and decrease the magnitude (or even invert the apparent sign) of real corrosive weight losses. Lab-aged fluids were therefore analyzed for metals after being used in the corrosion test, and the dissolved metals contents were

Table 6 shows standard J1703 corrosion test weight changes for SAE compatibility fluid RM-66-04 and for 9 commercially available fluids tested both in fresh and laboratory-aged conditions. A number of fluids showed significant zinc weight losses and/or etching when used in lab-aged form. Otherwise no weight losses or gains outside the SAE limits were induced by lab-aging prior to the standard J1703 corrosion test. It should be noted that used fluid from vehicles can also show no objectionable weight losses in the standard J1703 corrosion tests, even when the used fluid is drawn from vehicles after service intervals which sometimes produce visible corrosion of components. It appears that the conditions of the corrosion test in J1703 are not severe enough to produce visible corrosion even from aged fluids which do allow visible internal brake system corrosion in severe vehicular service.

Table 7 shows preliminary results on weight changes for metals tested in lab-aged fluids by the J1703 method modified by addition of 50 ppm chloride to the test fluid. With the addition of chloride, not only zinc but also dissolved iron, steel and/or aluminum showed pitting or etching with some lab-aged fluids.

Modifying the J1703 corrosion test both by lab-aged fluid and by addition of 50 ppm chloride clearly increases its severity and its ability to distinguish between fluids, at least in regards to coupon appearance. However, even this doubly-modified version of the SAE corrosion test does not reproduce the effect on cast iron observed in vehicles.

To minimize the future necessity of vehicular testing, even with lab-aged fluids, more stringent laboratory corrosion tests must be developed. Additional factors which may contribute to the more aggressive corrosion environment in vehicles compared to the standard J1703 corrosion test include details of the time-temperature history of the fluid and further changes in brake fluid chemistry induced by interactions with elastomers in the system (particularly hose materials). Further modifications to the standard J1703 corrosion test procedures, as applied to lab-aged fluids, are being investigated to determine the simplest possible laboratory corrosion test conditions which best reproduce the worst-case behavior of fluids in severe vehicular service.

#### SUMMARY AND CONCLUSIONS

Constantly increasing expectations for durability of automotive components on the part of both consumers and manufacturers suggests the desirability of improved methods to ensure the durability of corrosion protection in brake fluids. Chemical analysis of used brake fluids has shown that the additives which are often the primary corrosion inhibitors can be lost over time both through thermal oxidation and by another process which completely removes nitrogen from the fluid. A two-step laboratory aging procedure was developed to reproduce these vehicular changes in brake fluid chemistry. Fluids subjected to this laboratory aging process typically still passed all of the corrosion weight change requirements of the

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\* Note printed by GSTEVENI on 12 Apr 1999 at 07:27:04 \*  
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From: SREIMERS--DRBN007 Date and time 04/10/99 13:18:02  
To: GSTEVENI--DRBN005 REPORTER --DRBN007 Portez, F.J.

FROM: Steve Reimers USAET(UTC -04:00)  
Subject: Re: Zytel Sample to TI  
fyi

Steve Reimers building 5 3E008  
RVT Chassis E/E System Applications mail drop 3C11  
39-03286 SREIMERS sreimers@ford.com fax 39-04145 ;>  
\*\*\* Forwarding note from PAPCSHBU--EXTERNAL 04/09/99 13:23 \*\*\*  
To: SREIMERS--FORDMAIL Steve Reimers

From: Paul J Kane  
Subject: Re: Zytel Sample to TI

From: "Paul J Kane"<Paul.J.Kane@usa.dupont.com>  
cc: A-mcguirk@ti.com,  
swalters@ti.com

The V-0(flame retardant) high temperature Zytel HTW FR52G3EHL NCG10  
(natural color) will arrive at TI on Monday April 12. I talked with Andy  
McGuirk and Steve Walters (molding responsibility) about this product and  
have fax'd the processing guidelines to Steve. This product will have a  
160F higher melt point over the Celanax 4300 and a 100F higher melt point  
over the Noryl GTX 830 (a nylon alloy). It will also have much better flow  
and dimensional stability over the Noryl GTX 830. Paul 248-583-8107

**Subject: Materials Recommendations for Flammability Issues**

**Date: Thu, 1 Apr 1999 09:44:08 -0500**

**From: "Paul J Kane" <Paul.J.Kane@USA.dupont.com>**

**To: GSTEVENI@ford.com, SREIMERS@ford.com**

**CC: "Michael J Bauhof" <Michael.J.Bauhof@USA.dupont.com>**

Greg, I recommend the Zenite 6140L (used at Ford in a wiper motor to solve similar concern where high amperage going through when motor was in stall torque condition). The DuPont Zenite LCP is a liquid crystal polymer that is V-0 (flame retardant) down to .031 inch thickness and has a melt point of 635F. The Calanex PBT grades have a melt point of 431F and the Noryl GTX 830 which is just a nylon alloy has a melt point of 497 F.

My experience is that in these situations, going to higher melt point is the only hope for solving it from a polymer standpoint.

The other material I recommended is Zytel HTR FR52G30BL which has a melt point of 590 F and is flame retardant. This would be lower cost resin.

I have fax'd data sheet to you and we can rush samples to TI for molding if you want, Paul Kane....248-583-8107

\*\*\*\*\*  
\* Note printed by GSTEVEN1 on 20 Mar 1999 at 09:15:11 \*  
\*\*\*\*\*

From: SREIMERS--DRBN007 Date and time 03/18/99 08:40:32  
To: GSTEVEN1--DRBN005

FROM: Steve Reimers USAFT(UTC -08:00)  
Subject: B/P Switch USAFT(UTC -05:00)  
Greg, I will get you a connector and switch. If you don't need the switch please  
a return it to me. Can we also put a sample of the new plastic and the current  
model plastic in this test too?

Steve Reimers building 5 3E008  
AVT Chassis E/E System Applications mail drop 5011  
39-03286 SREIMERS sreimers@ford.com fax 39-03286 ;>  
\*\*\* Forwarding note from GSTEVEN1--DRBN005 03/18/99 06:39 \*\*\*  
To: SREIMERS--DRBN007  
cc: XGRIBBLE--DRBN005

From: Greg Stevens USAFT(UTC -05:00)  
Subject: B/P Switch USAFT(UTC -05:00)  
Steve: I talked to Fred regarding a test we might want to perform on the  
switch based on Joe Evans comments in the meeting yesterday. I was thinking  
on submerging the switch in brake fluid (old fluid) at an elevated temp. for  
70 to 120 hrs, then checking the components for evidence of damage. Let me  
know what you think. I will need a switch to do test.

Regards,  
Greg Stevens

*\* Ignition temp of new vs exposed (in BF) plastic housing  
\* Leroy Sheppard*

\*\*\*\*\*  
\* Note printed by GSTEVEN1 on 16 Mar 1999 at 06:45:46 \*  
\*\*\*\*\*

From: HPEASE --DRBN005  
To: KGRIBBLE--DRBN005  
cc: SREIMERS--DRBN007

Date and time 03/15/99 16:34:17  
GSTEVEN1--DRBN005  
FRORTER --DRBN007

FROM: Bruce Pease (BPEASE)  
Subject: Non Conductor

USAET(UTC -05:00)

In reviewing the speed control switch issue, it occurs to me that the switch might be isolated (not grounded) to the prop valve if we were to put an insulating spacer between the switch and valve in the form of a double threaded bushing. This bushing would have to have strength similar to steel and yet be a non conductor. I checked Marks Handbook and the resistance for steel (switch) is 99.8 (cir mil per foot), for aluminum (valve) is 17.01, and for cast iron is 448-588. Can a resistance path of 5x resistance cut the current back to an acceptable heating in dead short situation? The cast iron would be fairly easy to machine into bushings. My question is: in the exotic world of materials, are there other candidates for bushing material? non-metallic?

Regards, Bruce Pease  
R&VT-Adv. Brake Systems, 84-54774, fax 39-04145

\*\*\*\*\*  
\* Note printed by GSTEVEN1 on 20 Mar 1999 at 09:15:45 \*  
\*\*\*\*\*

From: SBALZER1--DRENO06 Date and time 03/17/99 14:52:26  
To: GSTEVEN1--DRENO05

FROM: Stacy Balzer USAET(UTC -05:00)  
Subject: Town Car Brake Pressure Switch USAET(UTC -05:00)  
Greg, I discussed the Brake Parts Cleaner with the supplier. They confirmed that there is NO oxalic acid in the product. We do not have any samples at our facility, we are planning on ordering some. The fastest way to receive would be to purchase from a Ford dealership. The part number is: F6AE-2C410-AB. If you have any additional questions, please feel free to contact me. Also, the MSDS is available in MATS under tox numer: 147124.

Regards,  
Stacy Balzer PROPS ID: SBALZER1 Internet: sbalzer1@ford.com  
FCSD Repair Product Planning Phone: (313) 39-05765  
Product Engineer-Service Chemicals Fax: (313) 39-00770  
\*\*\* Forwarding note from GSTEVEN1--DRENO05 03/10/99 09:09 \*\*\*  
To: SBALZER1--DRENO06  
cc: SRIMERS--DRENO07 SLAROUCH--FORDNA1  
KORIBBLE--DRENO05

From: Greg Stevens USAET(UTC -05:00)  
Subject: Town Car Brake Pressure Switch USAET(UTC -05:00)  
Stacy: I don't know if you have heard anything about the problems we are experiencing with this switch (PIES) but a question has been raised concerning the compatibility of a brake parts cleaner (F6AE-2C410-AB) with this switch. Do you know if the cleaner contains oxalic acid which could be damaging to our switch? If not, do you have a couple of quarts of this cleaner available that our central lab and Texas Instruments can analyze?

Regards,  
Greg Stevens

\*\*\*\*\*  
\* Note printed by GSTEVEN1 on 17 Mar 1999 at 06:40:07 \*  
\*\*\*\*\*

From: SREIMERS--DRBN007 Date and time 03/16/99 17:27:25  
To: FEORTER --DRBN007 Porter, F.J. GSTEVEN1--DRBN005  
SLAROUCB--FORDNA1

FROM: Steve Reimers USAET(UTC -05:00)  
Subject: RE: Ford Braka Fluid Questions  
fyi

Steve Reimers building 5 38008  
AVT Chassis E/E System Applications mail drop 5011  
39-03286 SREIMERS sreimers@ford.com fax 39-03286 ?>  
\*\*\* Forwarding note from OWOELQSP--EXTERNAL 03/16/99 15:28 \*\*\*  
To: SREIMERS--FORDMAIL Reimers, Steve  
cc: 02421WPI--EXTERNAL Kitt, Michael

From: Urbiha, Scott (SA)  
Subject: RE: Ford Brake Fluid Questions

From: "Urbiha, Scott (SA)"<surbuha@dow.com>  
cc: "Kitt, Michael"<mkitt@dow.com>

Steve, I know that Mike was out today and is on vacation tomorrow. I  
will follow up with him on your request as well.

A few comments....

1. It was my understanding from our recent meeting that it was unknown  
as to what brake fluid was in the vehicles in question. From a testing  
standpoint, is Ford wanting to look at the "world" of brake fluids that  
are in the market. The reason I ask this is that the brake fluid GM  
uses for factory fill is different from Chrysler which is different from  
Ford. In fact, the Japanese all use different fluids and chemistries as  
well. I had mentioned this to several folks after our meeting was over.  
There are several producers of brake fluids (some for OEM and others for  
aftermarket) and these all use different formulation chemistry.

2. Conductivity of brake fluid will be contingent upon a number of  
factors including the chemistry of the "neat" (unused/unadulterated)  
fluid, water content, and whether or not any impurities have entered the  
fluid (i.e.: metals from the brake system, etc.)

3. I'll let Mike address this. I am aware of the paper although I  
don't have a copy of it. The comments I made in number one are valid  
for this test as well.

I'm sorry if this seems to be confusing or muddies up anything Ford was  
looking at. It's important, though, to recognize that due to the  
various fluids in the market that it's difficult to come up with a test  
procedure. Once a vehicle leaves the assembly plant the type and  
"mixture" of brake fluid is up in the air. While brake fluid  
chemistries are "similar" they are not the same...and I don't just mean  
for corrosion inhibitors, etc. The actual base chemistry can be very  
different.

Let me know of any questions you may have and anything I can do to help  
further. Again, I'll put a call into Mike to help on this request.

Scott A. Urbina  
Account Manager  
Dow Automotive  
Phone: 248-351-5557  
Fax: 248-948-1706  
surbiha@dow.com

> -----  
> From: Steve Reimers SMTP:sreimers@ford.com  
> Sent: Tuesday, March 16, 1999 11:23 AM  
> To: Urbina, Scott (SA)  
> Subject: Ford Brake Fluid Questions  
>  
> TO: surbiha@dow.com  
>  
> This is text of message I sent to Mike Kitt today.  
> Subject: Ford Brake Fluid questions  
> 1. When will Brake Fluid without inhibitors be available?  
> 2. Need to know conductivity of Brake Fluid?  
> 3. SAE 971007 describes a way to lab-age brake fluid. Can DOW help  
> Ford get some  
> of this lab-aged Brake Fluid? ( Is this the SAE paper you referred  
> to in our  
> meeting in Dearborn on 2/24/99? )  
> thanks,  
>  
> Steve Reimers building 5 3E008  
> AVT Chassis H/E System Applications mail drop 5011  
> 39-03286 SREIMERS sreimers@ford.com fax 39-03286 ;>  
>

\*\*\*\*\*  
\* Note printed by GSTEVEN1 on 10 Mar 1999 at 09:09:16 \*  
\*\*\*\*\*

From: GSTEVEN1--DREN005 Date and time 03/10/99 09:09:03  
To: SBALZER1--DREN006  
CC: SREIMERS--DREN007 SLAROUCH--FORDNA1  
KGRIBBLE--DREN005

From: Greg Stevens USAST(UTC -05:00)  
Subject: Town Car Brake Pressure Switch USAST(UTC -05:00)  
Stacy: I don't know if you have heard anything about the problems we are  
experiencing with this switch (FIRES) but a question has been raised concerning  
the compatability of a brake parts cleaner (FSAZ-2CH10-AB) with this switch.  
Do you know if the cleaner contains oxalic acid which could be damaging to our  
switch ? If not, do you have a couple of quarts of this cleaner available that  
our central lab and Texas Instruments can analyze ?

Regards,  
Greg Stevens

\*\*\*\*\*  
\* Note printed by GSTEVEN1 on 10 Mar 1999 at 07:12:23 \*  
\*\*\*\*\*

From: SREIMERS--DRBN007 Date and time 03/08/99 15:08:38  
To: GSTEVEN1--DRBN005  
cc: SLAROUCH--FORDWA1 YPORTER --DRBN007 Porter, F.J.

FROM: Steve Reimers USAET(UTC -05:00)  
Subject: RE: Town Car Testing  
Greg, the brake cleaning fluid should be checked for contents that may be harmful to the BP switch. At MPG last week I observed the mechanic using it to clean the master cylinder reservoir exterior and the area around the BP switch where the brake fluid had been dripping. Oxylate source?

Steve Reimers building 5 3E008  
AVT Chassis E/E System Applications mail drop 5011  
39-03286 SREIMERS sreimers@ford.com fax 39-03286 ;>  
\*\*\* Forwarding note from JMORRIS6--FORDWA2 03/08/99 10:35 \*\*\*  
To: SREIMERS--FORDMAIL Reimers, Steve (S.  
cc: JGWISDAL--FORDWA2 Gwisdalla, Joe (J.

From: Morris, John (J.M.)  
Subject: RE: Town Car Testing

I just FTP 27 test files to you and 1 excel sheet describing the test runs. MPG will try to perform the low mu testing on Tuesday morning.

The brake parts cleaner # is  
F6A2-2CH10-AB

Ford internal Ref. # is  
147124

John Morris  
Michigan Proving Ground  
Phone: 810-752-8770 Fax: 810-752-8656  
jmorris6@ford.com

-----Original Message-----  
From: Steve Reimers mailto:sreimers@gw.ford.com  
Sent: Saturday, March 06, 1999 6:41 PM  
To: Gwisdalla, Joe  
Cc: jmorris6@mail.ford.com  
Subject: Town Car Testing

Joe,  
I will need more test runs. The 16 data sets I have so far do not have much ABS event data. The transducer at the HCU must be checked to be absolutely sure it is connected to the Prop-valve that has the Brake pressure switch. I need some data from a low mu surface so that the rear has a long ABS event. If this means testing on snow then I can do without the fifth wheel channel so you don't have to ruin it. I would like to see two data sets run at 40 mph on low mu. If the data looks good I will probably need 3 more similar runs. If using a split mu surface helps go ahead, but be sure the low mu is on the brake side that has the brake pressure switch.

Stacy Balzer SBALZER1 06765

\*\*\*\*\*  
Also, I need the Ford Part number for the brake cleaning fluid that Tom H.  
used  
on the car. We need to get this for chemical analysis of contaminants we  
are  
seeing in the field.  
\*\*\*\*\*  
thanks,

Steve Reimers	building 5 3E008
AVT Chassis E/E System Applications	mail drop 5011
39-03286 SRIMERS areimers@ford.com	fax 39-03286 ;>

\*\*\*\*\*  
\* Note printed by GSTEVEN1 on 10 Mar 1999 at 07:12:34 \*  
\*\*\*\*\*

From: SREIMERS--DRBN007 Date and time 03/09/99 09:57:38  
To: GSTEVEN1--DRBN005

FROM: Steve Reimers USAET(UTC -05:00)  
Subject: RE: Town Car Testing  
Buy some.

Steve Reimers building 5 3E008  
AVT Chassis E/E System Applications mail drop 5011  
39-03286 SREIMERS sreimers@ford.com fax 39-03286 ;>  
\*\*\* Forwarding note from GSTEVEN1--DRBN005 03/09/99 07:10 \*\*\*  
To: SREIMERS--DRBN007

\*\*\* Reply to note of 03/08/99 15:08  
From: Greg Stevens USAET(UTC -05:00)  
Subject: RE: Town Car Testing  
Steve: I am not familiar with the brake cleaning fluid. Do you have a sample  
of it or do you want us to purchase some of it at a dealership? Both TI and the  
lab should analyze it. I will not be at Wednesday's meeting, so let me know  
what you decide.

Regards,  
Greg Stevens

\*\*\*\*\*  
\* Note printed by GSTEVEN1 on 3 Mar 1999 at 07:00:17 \*  
\*\*\*\*\*

From: FPORTER --DRBN007 Date and time 03/02/99 08:55:06  
To: GSTEVEN1--DRBN005 Stevens, Gregory

FROM: F. J. Porter USAET(UTC -05:00)  
Subject: (U) Brake Fluid

Greg,

Can we get a barrel (or two) of brake fluid without rust inhibitors?

Regards,  
Fred Porter OV - fporter fporter@ford.com  
Chassis E/E Systems Applications (313)845-3722  
Bldg 5 - Mail Drop 5030 - Cubicle 3E004 fax: 390-4145

\*\*\*\*\*  
\* Note printed by GSTEVEN1 on 3 Mar 1999 at 10:40:44 \*  
\*\*\*\*\*

From: GSTEVEN1--DEBN005 Date and time 03/03/99 09:47:31  
To: FPORTER --DEBN007  
Cc: EGRIEBLE--DEBN005

\*\*\* Reply to note of 01/02/99 08:55  
From: Greg Stevens USAST(UTC -05:00)  
Subject: (U) Brake Fluid  
Fred: It would be almost impossible. Dows' material production process is for 20,000 gallons of brake fluid per batch. They could possibly make a 1 gallon sample for you in their lab. If this would work, call Mike Kitt on 225-353-6343.

Regards,  
Greg Stevens

\*\*\*\*\*  
\* Note printed by GSTEVENI on 3 Mar 1999 at 09:47:49 \*  
\*\*\*\*\*

From: FPORTER --DRBN007 Date and time 03/02/99 08:55:06  
To: GSTEVENI--DRBN005 Stevens, Gregory

FROM: F. J. Porter USAET(UTC -05:00)  
Subject: (U) Brake Fluid

Greg,

Can we get a barrel (or two) of brake fluid without rust inhibitors?

Regards,  
Fred Porter OV - fporter fporter@ford.com  
Chassis S/E Systems Applications (313) 845-3722  
Bldg 5 - Mail Drop S030 - Cubicle 3E004 fax: 390-4145

\*\*\*\*\*  
\* Note printed by GSTEVEN1 on 15 Feb 1999 at 12:38:31 \*  
\*\*\*\*\*

From: SREIMERS--DRBN007 Date and time 02/15/99 08:59:40  
To: GSTEVEN1--DRBN005

FROM: Steve Reimers USAET(UTC -05:00)  
Subject: RE: Brake Pressure Switch Sulfur  
Another question for DOW.

Steve Reimers building 5 3C043  
AVT Chassis E/E System Applications mail drop 5011  
39-03286 SREIMERS sreimers@ford.com fax 39-03286 ;>  
\*\*\* Forwarding note from SLAROUCH--FORDMAIL 02/15/99 08:30 \*\*\*  
To: SREIMERS--FORDMAIL Reimers, Steve (S.)

From: LaRouche, Steve (S.)  
Subject: RE: Brake Pressure Switch Sulfur

Steve: We have found sulfur in all the other switches. We haven't identified a source yet. I hope that Dow or DuPont can give us some ideas.

Steve LaRouche (SLAROUCH)  
Metallurgy Section, Central Laboratory, Room M410  
(313) 845-4876 (313) 322-1614 FAX

-----Original Message-----

From: Steve Reimers mailto:sreimers@gw.ford.com  
Sent: Monday, February 15, 1999 8:15 AM  
To: LaRouche, Steve  
Subject: Brake Pressure Switch Sulfur

You mentioned sulfur as one of the contaminants found in the Memphis switch. Did you find sulfur in any others? Have you identified the likely source? thanks,

Steve Reimers building 5 3C043  
AVT Chassis E/E System Applications mail drop 5011  
39-03286 SREIMERS sreimers@ford.com fax 39-03286 ;>

\*\*\*\*\*  
\* Note printed by GSTEVEN1 on 15 Feb 1999 at 08:03:55 \*  
\*\*\*\*\*

From: FPORTER --DRBN007 Date and time 02/13/99 16:33:31  
To: GSTEVEN1--DRBN005 Stevens, Gregory  
cc: SREIMERS--DRBN007

FROM: F. J. Porter USAET(UTC -05:00)  
Subject: (U) Dow Meeting

Greg,

One of the things that became abundantly clear was that we need to have a meeting with Dow to consider the requirements to cause a thermal event given the materials we have in the brake pressure switch. I know that it is short notice but this meeting should happen the week of 2/15/99 (preferably 2/16).

Please work with Steve Reiners. He can invite the other team members to the meeting when we can get someone from Dow here.

Regards,  
Fred Porter OV - fporter fporter@ford.com  
Chassis E/E Systems Applications (313)845-3722  
Bldg 8 - Mail Drop 5020 - Cubicle 3E004 fax: 390-4145

\*\*\*\*\*  
\* Note printed by GSTEVEN1 on 15 Feb 1999 at 08:04:03 \*  
\*\*\*\*\*

From: SREIMERS--DRSN007  
To: GSTEVEN1--DRSN005

Date and time 02/13/99 15:55:19

FROM: Steve Reimers

USANT(UTC -05:00)

Subject: Assistance from Dow Chemical

In several of the Brake Pressure Switch team meetings it has been suggested that we get Dow to assist us. I believe you may have already contacted them. Let's get them on-board by Tuesday if they aren't already. Ask them how a fire can be started with this switch given the following constraints; 1. Constant Battery voltage applied, circuit fused at 15 amps, switch hydraulic connection constantly connected to ground potential, vehicle underhood temperature, switching an inductive load of about 0.5 amps, load current flows only when speed control is active, the switch cavity contains a black material containing at least copper, zinc, sulfur, and brake fluid (probably containing water). Let me know if there are any roadblocks to getting Dow here.

Steve Reimers  
AVT Chassis E/E System Applications  
39-03286 SREIMERS sreimers@ford.com

building 5 3C043  
mail drop 5011  
fax 39-03286 ;>

\*\*\*\*\*  
\* Note printed by GSTEVEN1 on 15 Feb 1999 at 13:07:07 \*  
\*\*\*\*\*

From: SLAROUCH--FORDMAIL Date and time 02/03/99 12:56:24  
To: GSTEVEN1--FORDMAIL, Stevens, Gregory (

From: LaRouche, Steve (S.)  
Subject: Speed Control Cutoff Switches

Greg: Gayle Gullen said that you were going to contact someone at Dow concerning brake fluid. I was wondering if you found out any information regarding its conductivity. We are finding transfer of the brass contact material to the steel cup, which suggests that a cell may be being set up. If you have any info on this, I'd appreciate it. Thanks.

Steve LaRouche (SLAROUCH)  
Metallurgy Section, Central Laboratory, Room M410  
(313) 845-4876 (313) 322-1614 FAX

\*\*\*\*\*  
\* Note printed by GSTEVEN1 on 16 Jan 1999 at 07:51:28 \*  
\*\*\*\*\*

From: GGULLEN --FORDMAIL Date and time 01/22/99 08:12:47  
To: CTHOMAS5--FORDMAIL Thomas, Clark (C.D MRAGA --FORDMAIL Haga, Mary (M.C.)  
GGULLEN --FORDMAIL Gullen, Gayle (G.D  
cc: FPORTER --FORDMAIL Porter, Fred (F.J. GSTEVEN1--FORDMAIL Stevens, Gregory (R  
KGRIBBLE--FORDMAIL Kowalczyk, Richard

From: Gullen, Gayle (G.D.)  
Subject: RE: (U) Brake Fluid Questions

I just talked to Mike Kitt at Dow and he informed me that Greg Stevens is faxing him a list of questions to answer. The one that Mike can't answer is regarding whether or not brake fluid reacts with copper/brass. The answer to that is yes, under some circumstances. We have seen several instances over the years in various assembly plants where brake fluids have formed an organometallic copper complex. This only occurs after there has been some type of welding repair to the delivery system. Dow does not add anything copper based to their system and they have never been able to assist us in determining the exact nature of the copper complex formed. Eventually this material flushes from the plant system, however, in an enclosed system like a switch I suspect we could have flocculating particulates.

-----Original Message-----

From: Clark Thomas mailto:cthomas5@ccmail.dearborn.ford.com  
Sent: Thursday, January 21, 1999 5:27 PM  
To: mhaga@mail.ford.com; ggullen@mail.ford.com  
Cc: fporter@gw.ford.com; gsteven1@gw.ford.com; kgribble@gw.ford.com  
Subject: (U) Brake Fluid Questions

Gayle/Mary: Can you comment on this? It is in reference to the issue of fires possibly caused by the Texas Instrument Cruise Control Switch being looked at by NHTSA and our Legal Staff. Thanks.

Regards, Clark Thomas  
AVT Materials (Plastics/Elastomers)  
313-59-41313 (Bld5); 313-32-23188 (POEE)  
\*\*\* Forwarding note from FPORTER --DRBN007 01/21/99 10:13 \*\*\*  
To: CTHOMAS5--DRBN005 GSTEVEN1--DRBN005

FROM: F. J. Porter USAFT(UTC -05:00)  
Subject: (U) Brake Fluid Questions

Two questions:

Is brake fluid conductive? How much?

Will brake fluid react with copper or brass? Will an electric field or current cause a reaction?

Regards,  
Fred Porter OV - fporter fporter@ford.com  
Chassis E/E Systems Applications (313)845-3722  
Bldg 5 - Mail Drop 8030 - Cubicle 1E004 fax: 390-4145

To: MIKE KITT

\*\*\*\*\*  
\* Note printed by GSTEVEN1 on 22 Jan 1999 at 07:23:57 \*  
\*\*\*\*\*

From: FPORTER --DRBN007  
To: CTEOMASS--DRBN005

Date and time 01/21/99 10:13:51  
GSTEVEN1--DRBN005

FROM: F. J. Porter  
Subject: (U) Brake Fluid Questions

USANT(UTC -05:00)

Two questions:

Is brake fluid conductive? How much?

Will brake fluid react with copper or brass? Will an electric field or current cause a reaction?

Regards,  
Fred Porter OV - fporter fporter@ford.com  
Chassis E/E Systems Applications (313)845-3722  
Bldg 5 - Mail Drop 5030 - Cubicle 3E004 fax: 390-4145

3713 6077

\*\*\*\*\*  
\* Note printed by GSTEVEN1 on 5 Jan 1999 at 08:26:22 \*  
\*\*\*\*\*

From: FPORTER --DRBN007	Date and time	12/23/98 10:33:16
To: WARRAMCE--DRBN005	ZDEERING--DRBN005	
BHGEN --DRBN007	BENGLISI--DRBN005	
JEVANS9 --DRBN005	DGOML --DRBN005	
JGREGOIR--DRBN005	KGRIBBLE--DRBN005	
MLAPOINT--DRBN005	SLAROUCH--FORDNA1	
JMCINERN--DRBN005	JNEME --DRBN005	
RNEVI --DRBN005	GSTEVEN1--DRBN005	
CTHOMAS5--DRBN005	HWELPER3--DRBN005	

FROM: F. J. Porter USAET(UTC -05:00)  
Subject: (U) Part Analysis

Dr. Al Hopkins from TI suggests that representatives from Ford travel to Attleboro, MA via Providence, RI the evening of January 5, 1999 for a full day of analysis on January 6, 1999.

Can some find out the type of material used in the extinguisher? This will aid in the analysis.

It would also be helpful to understand the weather conditions at the time of the event. I don't have the date and dealership from this part.

Thanks.

Regards,  
Fred Porter OV - fporter fporter@ford.com  
Chassis E/E Systems Applications (313)845-3722  
Bldg 5 - Mail Drop 5030 - Cubicle 3R004 fax: 390-4145

\*\*\*\*\*  
 \* Note printed by GSTEVEN1 on 5 Jan 1999 at 08:26:50 \*  
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From: FPORTER --DRBN007 Date and time 12/18/98 17:04:06  
 To: WABRAMCZ--DRBN005 BEGEN --DRBN007  
 RENGLISI--DRBN005 JEVANS8 --DRBN005  
 DGOEL --DRBN005 JGREGOIR--DRBN005  
 KRIBBLE--DRBN005 NLAPOINT--DRBN005  
 SLAROUCH--FORDNA1 JMCINERN--DRBN005  
 JNEWE --DRBN005 RNEVI --DRBN005  
 GSTEVEN1--DRBN005 CTHOMAS5--DRBN005  
 RWELFER3--DRBN006

FROM: F. J. Porter USAFT(UTC -05:00)  
 Subject: 9F924 Update (19981218)

1992-1993 Town Car F2VC-9F924-A Brake Pressure Switch Investigation

TEAM:

-----  
 AVT ESE Chassis Electronics: Fred Porter x84-53722 fporter  
 AVT Chassis Engineering: Joe Evans x32-23832 jevans8  
 Barry Egan x32-39512 begen  
 AVT ESE EOS: Rob English x33-73225 renglis1  
 AVT Design Analysis: Norm LaPointe x59-42686 nlapoint  
 AVT ESE OPE: Jim Gregoire x33-79962 jgregoir  
 ESE Prod. Veh. Safety: William Abramczyk x32-23284 wabramcz  
 Ray Nevi x59-47688 rnevi  
 Large Luxury VC Safety: John McInerney x32-30276 jmcinern  
 Joe Newe x39-08133 jnewe  
 AVT Materials Engineering: Greg Stevens x32-36686 gsteven1  
 Ken Gribble x32-38658 kgribble  
 Clark Thomas x59-41313 cthomas5  
 Central Lab Services: Steve LaRouche x84-54876 slarouch

INFORMATION:

-----  
 NHTSA letter: PE98-055

Vehicles identified: 21 initially identified.  
 20 additional vehicles reported since publication of  
 the investigation.

Warranty: A total of 89 warranty claims are identified in AWS on the  
 F2VY-9F924-A for 1992 and 1993 Town Cars.

Two CQIS reports (WJIAA135 & VDUA322) mention underhood fire  
 in connection with the brake pressure switch.  
 WJIAA135 occurred at 51,500 miles.  
 VDUA322 occurred at 56,802 miles.

Supplier: The pressure switch was manufactured by Texas Instruments. The  
 switch was purchased in assembly with the brake proportioning  
 valve bought from Surfaces.

Contacts: Surfaces - Mike Thomas (248)543-6520 HILITE Industries  
 TI - Rob Sharp (248)305-3729

TI - Russ Baumann (508)236-3314  
TI - Charlie Douglas (508)236-3657

Function: The brake pressure switch is a redundant switch for turning off the speed control function.

X-Rays: Taken by Steve LaRouche, Norm LaPointe & Clark Thomas on 12/17/1998. Original photographs and part are in Steve LaRouche's possession.

ON-GOING ACTIVITY:

2 service parts have been ordered from Fairlane Ford for X-ray and other testing by Central Lab Services.

Meeting with representatives of TI is planned for 12/22/1998 to discuss intended operation of the switch. The meeting will be at the Central Laboratory Conference room off of the lobby.

QUESTIONS: (in no particular order)

- 1) What is the normal current in the brake pressure switch?
- 2) Was cruise control standard on Town Car in 1992 and 1993?
- 3) Under what circumstances is brake fluid flammable?

According to Clark Thomas & Mary Haga, brake fluid is flammable at approximately 300 degrees F.

- 4) What is the repair history for vehicles that have exhibited a problem? Repair history for the two CQIS vehicles are being gathered by Fred Porter.
- 5) What other vehicles use this brake pressure switch? What are their electrical configurations?

MODEL YEAR	92	93	94	95	96	97	98
Town Car	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	
Crown Vic	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	
Grand Marquis	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	
Escort	XXXXX						
Club Wagon	XXXXX						
F-Series		XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX
Bronco		XXXXX	XXXXX	XXXXX	XXXXX		
Taurus SHO		XXXXX	XXXXX	----			
Capri			XXXXX	XXXXX	----		
Windstar			XXXXX	XXXXX	XXXXX	XXXXX	XXXXX
Falcon				XXXXX	XXXXX	XXXXX	XXXXX
Explorer					----	XXXXX	XXXXX
Ranger					----	XXXXX	XXXXX
Expedition						XXXXX	XXXXX
Navigator							XXXXX

XXXXX = used in model year

---- = may have been used in model year

6) Is this switch still in use? If not, why not? If so, what design changes have been implemented since 1992/1993?

Charlie Douglas of TI is investigating the design changes that may have been implemented on the brake pressure switch beginning in 1992.

7) What fault codes are stored if the brake pressure switch fails?

Regards,  
Fred Porter                      OV - fporter                      fporter@ford.com  
Chassis E/E Systems Applications                      (313)848-3712  
Bldg 5 - Mail Drop 5030 - Cubicle 3E004                      fax: 390-4145

\*\*\*\*\*  
\* Note printed by JLOTT on 21 Dec 1998 at 14:58:31 \*  
\*\*\*\*\*

From: OBSAMAR1--DRBN005 Date and time 12/18/98 13:19:10  
Subject: ANAY Facility/VM messages  
This note was generated by the ANAY Facility/VM 5799-FLP (c) IBM Corp.  
DO NOT REPLY TO THIS NOTE

ANAL101 This mail item is being routed to you from FPORTER at DRBN007  
on behalf of KGRIBBLE at DRBN005.

To: WABRANCE--DRBN005 BEGEN --DRBN007 Barry Egen  
RENGLISI--DRBN005 JEVANS8 --DRBN005  
DGOHL --DRBN005 JGREGOIR--DRBN005  
KGRIBBLE--DRBN005 NLAPOINT--DRBN005  
SLAROUCH--FORDMA1 JMCINERN--DRBN005  
JNEME --DRBN005 RNEVI --DRBN005  
GSTEVEN1--DRBN005 CTHOMAS5--DRBN005  
HWELFER3--DRBN006

FROM: F. J. Porter USAET(UTC -05:00)

Requester: Frederick J. Porter  
Date to be scheduled: 12/22/98  
Starting time: 10:00AM USAET  
Ending time: 12:00PM USAET

Location: Central Labs - Lobby Conference Room

Subject: Brake Pressure Switch Analysis

Purpose: Review brake pressure switch operation with Texas Instrument  
Review available data and determine next steps.

\*\*\*\*\*  
Regards,  
Fred Porter OV - fporter fporter@ford.com  
Chassis E/E Systems Applications (313)845-3722  
Bldg 5 - Mail Drop 5030 - Cubicle 3E004 fax: 390-4143

- If brake fluid gets into the cavity - the brake fluid itself is fairly inert, but if it  
has some water or other contaminants, that's when you might get corrosion.  
- designed to handle 3-5 amp load

Product Information



# Zenite™ LCP

liquid crystal polymer resin

## PRELIMINARY DATA

### Zenite™ 6140L BK010

A Lubricated 40% Glass Reinforced Liquid Crystal Polymer Resin

Zenite™ 6140L BK010 is a lubricated 40% glass reinforced black LCP resin with excellent toughness and a heat deflection temperature of 282 C. It is well suited for use in the automotive, electrical/electronic, telecommunications, and aerospace industries.

Property	Test Method	Units	Value
<b>Mechanical</b>			
Tensile Strength	ASTM D 638	MPa (ksi)	137 (19.8)
Elongation at Break	ASTM D 638	%	3
Flexural Modulus	ASTM D 790	MPa (ksi)	16000 (2400)
Flexural Strength	ASTM D 790	MPa (ksi)	194 (28.1)
Impact	ASTM D 256	Jm (ft.lbf/in)	101 (1.9)
<b>Thermal</b>			
Heat Deflection Temperature 1.8MPa (260psi)	ASTM D 648	°C (°F)	272 (540)
Melting Point	ASTM D 3416	°C (°F)	335 (639)
<b>Flammability</b>			
UL94 Rating at Min. Thickness	UL94		V-0
UL94 Min. Thickness Tested	UL94	mm (in)	0.79 (0.031)
<b>Other</b>			
Specific Gravity	ASTM D 792		1.71
<b>Processing</b>			
Melt Temperature Range		°C (°F)	350-360 (660-680)
Mold Temperature Range		°C (°F)	30-95 (85-200)
Processing Moisture Content		%	<0.01

Mechanical properties measured at 23°C (73°F)

Contact DuPont for MSDS, general questions and/or additional information about ventilation, handling, purging, drying, etc.

During molding, use protective equipment and clothing. Skin contact with molten Zenite™ resins can cause severe burns. Be particularly alert during purging.

The above data are preliminary and are subject to change as additional data are developed on subsequent lots.

B00691

This data sheet lists only the general range of product properties but they should not be used as a substitute specification for a particular resin used in the design of a part. The DuPont Company assumes no obligation or liability for any advice furnished by it or for results obtained with respect to this information. All such advice is given and accepted at the buyer's risk. The disclosure of information herein is not a license to operate under or a promise of performance in violation of any patent of DuPont or others. DuPont warrants that the use or sale of any material which is described herein and is offered for sale by DuPont does not infringe any patent covering the material herein, but does not warrant against infringement by others of the use thereof in combination with or on other elements or in the operation of any process. **CAUTION:** Do not use in medical applications involving permanent implantation in the human body. For other medical applications, see "DuPont Medical Grades Statement", H-30042.

Dist DuPont First (800) 441-0876 • Automotive Inquiries (800) 533-1313

Product Information



# Zytel® HTN

high temperature nylon resin

## PRELIMINARY DATA

### Zytel® HTNFR52G30BL NC010

A 30% Glass Reinforced, Flame Retardant High Temperature Nylon Resin

Zytel® HTNFR52G30BL is a 30% glass reinforced, lubricated, flame retardant high temperature nylon resin that has been developed for connector applications.

Property	Test Method	Units	Value
			BAM
<b>Mechanical</b>			
Tensile Strength	ASTM D 634	MPa (ksi)	172 (25)
Elongation at Break	ASTM D 634	%	2.2
Flexural Modulus	ASTM D 790	MPa (ksi)	11400 (1650)
Flexural Strength	ASTM D 790	MPa (ksi)	240 (34.5)
Notched Impact	ASTM D 256	J/m (ft lb/in)	115 (2.3)
Unnotched Impact	ASTM D 4812	J/m (ft lb/in)	800 (15)
<b>Thermal</b>			
Heat Deflection Temperature	ASTM D 648	°C (°F)	
0.45MPa (65psi)			286 (545)
1.1MPa (160psi)			278 (532)
<b>Flammability</b>			
UL94 Rating at Min. Thickness	UL94		V0
UL94 Min. Thickness Tested	UL94	mm	0.85
<b>Other</b>			
Specific Gravity	ASTM D 790		1.62
Mold Shrinkage		%	
Flow, 1.6mm (0.063in)			0.2
Transverse, 1.6mm (0.063in)			0.3

Consult DuPont for MSDS, general guidelines and additional information about ventilation, handling, storage, drying, etc.  
 Mechanical properties measured at 23°C (73°F) unless otherwise stated.

During molding, use proper protective equipment and adequate ventilation. Avoid exposure to fumes and limit the hold up time and temperature of the resin in the machine. Purge degraded resin carefully with HDPE.

The above data are preliminary and are subject to change as additional data are developed on subsequent lots.

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The data listed here are preliminary and are subject to change as additional data are developed on subsequent lots. The DuPont Company assumes no obligation or liability for any advice furnished by it or for results obtained with respect to this information. All such advice is given and accepted at the buyer's risk. The disclosure of information herein is not a license to operate under or a recommendation to infringe, any patent of DuPont or others. DuPont warrants that the use or sale of any material which is developed hereby and is offered for sale by DuPont does not infringe any patent covering the material herein. We do not warrant against infringement by reason of its use thereof in combination with the other material or in the operation of any process. **CAUTION:** Do not use in medical applications involving permanent implantation in the human body. For other medical applications, see "DuPont Medical Catheter Systems", H-25702.

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**Zytel® HTNFR52G30BL NC010**

Property	Test Method	Units	Value
			DAM
<b>Processing</b>			
Melt Temperature Range		°C (°F)	325-340 (615-644)
Mold Temperature Range		°C (°F)	60-130 (140-265)
Drying Time, Dehumidified Dryer		h	6-8
Drying Temperature		°C (°F)	100 (210)
Air Dew Point		°C (°F)	<-20 (<-4)
Processing Moisture Content		%	<0.1

Contact DuPont for MSDS, general guidelines and/or additional information about ventilation, handling, curing, drying, etc.  
Mechanical properties measured at 30°C (75°F) unless otherwise stated.

The above data are preliminary and are subject to change as additional data are developed on subsequent lots.

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**NOT FOR USE IN OR WITH THE HUMAN BODY OR FOR ANY OTHER MEDICAL APPLICATIONS UNLESS SPECIFICALLY INDICATED BY DU PONT.**  
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**CALIFORNIA:** Do not use in medical applications involving permanent implantation in the human body.  
For other medical applications, see "DuPont Medical Contact Statement", H-30182.

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1992-93 LINCOLN TOWN CAR  
UNDERHOOD FIRES

PE58-055

NO.	OWNER NAME	ADDRESS	CITY	STATE	ZIP CODE	TELEPHONE NUMBER	VIN	MODEL YEAR	MODEL	BUILD DATE	SALE DATE	REPORT DATE	REPORT TYPE	MI/LEAGE	ISSUE REPORTED	POSSIBLE PROBLEM DESCRIPTION
			Lujo	OK	NA	NA	1LNLM81W7W	1992	Town Car	03/11/92	03/02/92	06/17/94	CODE/ MORS	84,503	Fire	Lines leaked an exhaust manifold and caused a fire.
			Evergreen Park	IL	NA	NA	1LNLM81W7W	1992	Town Car	10/09/91	02/27/92	06/28/95	CODE	220,246	Fire	Brakes.
			Chicgo	IL	NA	NA	1LNLM81W7W	1992	Town Car	12/18/91	01/05/92	07/20/93	CODE	21,250	Melted	Brake lines.
			Los Angeles	CA	NA	NA	1LNLM81W7W	1992	Town Car	01/15/92	02/02/92	08/20/95	CODE	37,442	Fire	Brake lines.
			Dearborn	MI	NA	NA	1LNLM81W7W	1992	Town Car	08/27/91	08/23/91	04/25/96	CODE/ MORS	317,000	Fire	Alternator start-down issue
			Gainesville	FL	NA	NA	1LNLM81W7W	1992	Town Car	12/19/91	01/01/92	06/09/93	CODE	18,172	Headlight	Overheated, drive belt broke, A/C leaked, fuses.
			Memphis	TN	NA	NA	1LNLM81W7W	1992	Town Car	08/10/92	02/08/95	10/09/98	CODE	51,699	Fire	Brake lines.
			FL Lauderdale	FL	NA	NA	1LNLM81W7W	1992	Town Car	04/07/92	10/02/92	04/21/97	CODE	86,802	Smoke	Brake pressure switch caught on fire and burned the wiring.
			San Diego	CA	NA	NA	1LNLM81W7W	1992	Town Car	07/25/92	08/28/92	12/21/94	CODE	35,637	Melted wires	Overheated, melted wires
			Peekskill	NY	NA	NA	1LNLM81W7W	1992	Town Car	06/22/92	08/22/92	01/26/95	CODE	42,115	Overheated	Spark plug wires melted.
			Troy	OH	NA	NA	1LNLM81W7W	1992	Town Car	07/29/92	11/23/92	08/23/94	CODE	14,822	Fire	Brakes.
			Northbrook	IL	NA	NA	1LNLM81W7W	1992	Town Car	08/05/92	11/08/92	07/26/95	MORS	40,880	Burned	Electrical wiring.
			Alpena	IL	NA	NA	1LNLM81W7W	1992	Town Car	06/27/92	09/15/92	08/14/98	MORS	83,888	Fire	Unknown.
			Englewood	NJ	NA	NA	1LNLM81W7W	1992	Town Car	08/18/92	12/18/92	07/26/94	MORS	12,000	Fire	Unknown.
			New Orleans	LA	NA	NA	1LNLM81W7W	1992	Town Car	09/25/92	07/18/93	08/30/93	MORS	8,508	Fire	Unknown.
			San Antonio	TX	NA	NA	1LNLM81W7W	1992	Town Car	04/01/93	04/16/93	08/24/94	MORS	25,911	Fire	Unknown.
			Pittsburgh	PA	NA	NA	1LNLM81W7W	1992	Town Car	12/04/92	01/20/93	03/23/96	MORS	12,898	Fire	Wiring harness.
			Rochester	NY	NA	NA	1LNLM81W7W	1992	Town Car	02/05/92	06/05/92	08/10/95	MORS	29,000	Fire	Unknown.
			Manassas	VA	NA	NA	1LNLM81W7W	1992	Town Car	11/25/91	12/21/91	02/27/96	MORS	48,000	Fire	Unknown.
			Malbourne	FL	NA	NA	1LNLM81W7W	1992	Town Car	07/30/92	09/15/92	01/28/97	MORS/ VOD	80,000	Fire	Unknown.
			Deer Park	LA	NA	NA	NA	1992	Unknown	Unknown	Unknown	Unknown	80,000	Fire	Unknown.	
			Indianapolis	IN	NA	NA	1LNLM81W7W	1992	Town Car	05/11/92	07/30/92	08/23/93	MORS	65,000	Fire	Unknown.
			Jackson	MS	NA	NA	1LNLM81W7W	1992	Town Car	06/28/92	08/21/92	07/8/95	MORS	86,000	Fire	Unknown.
			St. Martinville	LA	NA	NA	1LNLM81W7W	1992	Town Car	05/13/92	01/21/93	08/11/97	MORS	95,000	Fire	Unknown.
			Port St. Lucie	FL	NA	NA	1LNLM81W7W	1992	Town Car	03/11/92	10/08/92	01/09/95	MORS/ VOD	61,000	Fire	Unknown.
			Sevierville	FL	NA	NA	1LNLM81W7W	1992	Town Car	04/09/92	04/17/92	12/03/97	MORS	1	Fire	Unknown.

3713 8096

1992-93 LINCOLN TOWN CAR  
UNDERHOOD FIRES

PE98-055

NO.	OWNER NAME	ADDRESS	CITY	STATE	ZIP CODE	TELEPHONE NUMBER	VIN	MODEL YEAR	MODEL	BUILD DATE	SALE DATE	REPORT DATE	REPORT TYPE	MILEAGE	ISSUE REPORTED	POSSIBLE PROBLEM DESCRIPTION
21			Dayton	TX			LNLM82V3YH	1992	Town Car	1008/91	09/09/92	09/17/94	MORS	37,000	Fire	Unknown.
22			Severy Hills	CA			LNLM82V3WV	1992	Town Car	03/19/92	06/12/92	09/14/92	MORS	125	Fire	Unknown.
23			San Bern	LA			LNLM82V3VH	1992	Town Car	10/11/91	11/14/91	01/12/92	MORS	18,000	Fire	Unknown.
24			Springfield	TX			LNLM82V2YH	1992	Town Car	02/18/92	07/24/92	04/30/97	MORS	88,080	Fire	Unknown.
25			Aples	FL			LNLM81W1VH	1992	Town Car	05/23/92	08/10/92	12/23/98	MORS	62,040	Fire	Engine compartment, gas leak.
26			Waynes	GA			LNLM81V1CH	1992	Town Car	02/28/92	04/10/92	06/28/93	MORS	28,000	Fire	Unknown.
27			Winston	IL			LNLM82V2VH	1992	Town Car	07/28/92	08/17/92	10/12/95	MORS	80,212	Fire	Brakes.
28			Sydney	NY			LNLM82V7VH	1992	Town Car	02/20/92	04/19/92	07/08/92	MORS	11,000	Fire	Brakes.
29			Crosby	TX			LNLM81W001	1992	Town Car	09/04/92	06/25/92	12/23/97	MORS	72,880	Fire	Unknown.
30			Kearns	TX			LNLM81V4M8	1992	Town Car	03/03/92	05/22/92	09/01/97	MORS	98,990	Fire	Fire started above the left front tire.
31			Lawrence	NY			LNLM81V4M8	1992	Town Car	07/18/92	07/21/92	09/29/96	MORS	1	Fire	Engine compartment.
32			Highwood	MS			LNLM82V4M8	1992	Town Car	04/28/92	09/14/92	05/04/98	MORS/VOI	87,864	Fire	Wiring harness in engine compartment.
33			Robey	FL			LNLM82V7VH	1992	Town Car	02/27/92	10/30/92	07/28/98	MORS	47,800	Fire	Motor.
34			Belmont	TX			LNLM82V7VH	1992	Town Car	03/05/92	08/21/92	12/07/98	MORS	120,008	Fire	Under the hood - catalytic converter assembly for the ABS.
35			Remondine	FL			LNLM81V4M8	1992	Town Car	09/18/92	04/18/92	06/08/94	MORS	1	Fire	Unknown.
36			E. Amherst	NY			LNLM82V4M8	1993	Town Car	10/21/92	05/17/93	08/21/97	MORS	90,000	Fire	Under the hood.
37			Wilmington	NC			Unknown	1990	Unknown	Unknown	Unknown	12/08/91	MORS	56,000	Fire	Under the hood.
38			Alant	FL			LNLM81V4M8	1993	Town Car	11/18/92	12/05/92	01/02/97	MORS	40,000	Fire	Under the car.
39			Good Point	FL			LNLM82V1VH	1992	Town Car	02/25/92	09/14/92	12/23/97	MORS	47,800	Fire	Under the engine.
40			Farmville	NY			LNLM82V5M8	1992	Town Car	12/04/91	12/24/91	03/13/94	MORS	1	Fire	Electrical short.
41			Charwell	KS			LNLM82V1VH	1992	Town Car	08/27/91	09/18/91	02/26/97	MORS	84,006	Fire	Front suspension.
42			Labanon	OH			LNLM81V4M8	1992	Town Car	09/14/92	04/01/92	11/01/96	MORS/VOI	100,000	Fire	Ignition or electrical system.
43			Evans	GA			LNLM81V3M8	1992	Town Car	02/21/92	03/10/92	04/28/96	MORS	63,637	Fire	Unknown.
44			Kansas City	MO			LNLM81V4M8	1992	Town Car	05/23/92	09/18/92	10/08/96	MORS	72,000	Fire	Electrical system.
45			Houston	TX			LNLM80V7VH	1992	Town Car	08/27/91	11/02/91	04/28/96	MORS	83,000	Fire	Electrical.
46			Lee's Summit	MO			LNLM82V3M8	1992	Town Car	10/22/91	11/14/91	06/20/98	MORS	71,000	Fire	Brake system sensor.

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1992-93 LINCOLN TOWN CAR  
UNDERHOOD FIRES

PE98-065

NO.	OWNER NAME	ADDRESS	CITY	STATE	ZIP CODE	TELEPHONE NUMBER	VIN	MODEL YEAR	MODEL	BUILD DATE	SALE DATE	REPORT DATE	REPORT TYPE	MILEAGE	ISSUE REPORTED	POSSIBLE PROBLEM DESCRIPTION
53			Green Beach	FL			LNLM81W9NY	1992	Town Car	12/11/91	01/14/92	03/18/92	MORS	70,000	Fire	Electrical
54			Nesbit	LA			LNLM81W9NY	1992	Town Car	08/28/92	07/11/92	01/13/93	MORS/VOQ	98,700	Fire	Unknown
55			Ridgely	LA			LNLM81W9NY	1992	Town Car	05/15/92	06/02/92	12/08/92	MORS/VOQ	60,800	Fire	Electrical short
56			West Palm Beach	FL			LNLM81W9NY	1992	Town Car	01/22/92	02/11/92	10/14/92	MORS	78,800	Fire	Electrical
57			Weytown	TX			LNLM81W9NY	1992	Town Car	03/16/92	04/01/92	09/29/92	MORS/VOQ	87,800	Fire	Electrical system
58			Woods	TX			LNLM81W9NY	1992	Town Car	08/03/92	08/01/92	08/28/92	MORS	83,000	Fire	Engine
59			Wesley	TX			LNLM81W9NY	1992	Town Car	12/7/91	04/23/92	08/18/92	MORS	100,000	Fire	Unknown
60			Wills Park	IL			LNLM81W9NY	1992	Town Car	12/05/91	01/29/92	09/28/92	MORS	85,000	Fire	Left hand side
61			Winston	TX			LNLM81W9NY	1992	Town Car	08/05/92	11/22/92	01/08/93	MORS	86,000	Fire	Unknown
62			Worchester	FL			LNLM81W9NY	1992	Town Car	08/28/92	08/28/92	08/20/92	MORS	36,000	Fire	Unknown
63			Woods Beach	FL			LNLM81W9NY	1992	Town Car	08/10/91	08/20/91	08/18/92	MORS/VOQ	70,000	Fire	Left hand wheel area
64			Wylie	TX			LNLM81W9NY	1992	Town Car	04/02/92	04/21/92	06/08/92	MORS	90,900	Fire	Engine
65			Wytheville	VA			LNLM81W9NY	1992	Town Car	04/27/92	05/13/92	04/23/92	MORS	111,300	Fire	Unknown
66			Wynnton	TX			LNLM81W9NY	1992	Town Car	04/18/92	05/01/92	03/17/93	MORS	100,000	Fire	Under the hood
67			Yates	VA			LNLM81W9NY	1992	Town Car	08/28/91	11/08/91	08/18/92	MORS	78,000	Fire	Unknown
68			Yazoo	TN			Unknown	1992	Unknown	Unknown	Unknown	03/02/92	MORS	1	Fire	Under the hood
69			Unknown	HR			LNLM81W9NY	1992	Town Car	05/04/92	08/08/92	04/21/93	MORS	47,000	Fire	Electrical short
70			Yonkers	LA			LNLM81W9NY	1992	Town Car	07/31/92	09/01/92	10/24/92	MORS	80,000	Fire	Electrical
71			Mount Holly	MI			LNLM81W9PY	1992	Town Car	10/13/92	10/28/92	09/22/92	MORS	88,000	Fire	Electrical
72			West Columbia	SC			Unknown	1993	Unknown	Unknown	Unknown	03/08/94	MORS	8,000	Burned	Brakes
73			Cunning	GA			LNLM81W9NY	1992	Town Car	08/28/92	09/11/92	04/21/93	MORS	84,000	Fire	Catalytic converter
74			Durham	OH			LNLM81W9NY	1992	Town Car	03/18/92	03/26/92	07/02/92	MORS/VOQ	110,500	Fire	Spark plug/wire
75			Verde Beach	FL			2HEC479P9110	1992	Gr Marq	04/02/92	05/08/92	08/11/92	CO2S	90,000	Fire	Disconnect switch
76			Unknown	MA			LNLM81W9NY	1992	Town Car	11/05/91	11/27/91	Unknown	VOQ	Unknown	Fire	Unknown
77			Unknown	MA			LNLM81W9NY	1992	Town Car	08/20/92	08/20/92	Unknown	VOQ	Unknown	Fire	Unknown
78			Unknown	MA			LNLM81W9NY	1992	Town Car	07/19/92	08/21/92	Unknown	VOQ	Unknown	Fire	Unknown

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1992-83 LINCOLN TOWN CAR  
UNDERHOOD FIRES

PE98-056

NO.	OWNER NAME	ADDRESS	CITY	STATE	ZIP CODE	TELEPHONE NUMBER	VIN	MODEL YEAR	MODEL	BUILD DATE	SALE DATE	REPORT DATE	REPORT TYPE	MILEAGE	BSRM REPORTED	POSSIBLE PROBLEM DESCRIPTION
79	Unknown	Unknown	Unknown	MA	NA	Unknown	1LNLM81W2WY	1992	Town Car	04/07/92	08/20/92	Unknown	VOC	Unknown	Fire	Unknown.
80	Unknown	Unknown	Unknown	MA	NA	Unknown	1LNLM82W7WY	1992	Town Car	02/06/92	02/18/92	Unknown	VOC	Unknown	Fire	Unknown.
81	Unknown	Unknown	Unknown	MA	NA	Unknown	1LNLM81W0WY	1992	Town Car	07/17/92	07/31/92	Unknown	VOC	Unknown	Fire	Unknown.
82	Unknown	Unknown	Unknown	MA	NA	Unknown	1LNLM81W8WY	1992	Town Car	04/27/92	05/13/92	Unknown	VOC	Unknown	Fire	Unknown.
83	Unknown	Unknown	Unknown	MA	NA	Unknown	1LNLM82W4WY	1992	Town Car	03/10/92	04/23/92	Unknown	VOC	Unknown	Fire	Unknown.
84	Unknown	Unknown	Unknown	MA	NA	Unknown	1LNLM82V1WY	1992	Town Car	05/15/92	07/10/92	Unknown	VOC	Unknown	Fire	Unknown.
85	Unknown	Unknown	Unknown	MA	NA	Unknown	1LNLM81W2WY	1992	Town Car	08/29/91	08/29/91	Unknown	VOC	Unknown	Fire	Unknown.
86	Unknown	Unknown	Unknown	MA	NA	Unknown	1LNLM81W0WY	1992	Town Car	04/30/92	08/28/92	Unknown	VOC	Unknown	Fire	Unknown.
87	Unknown	Unknown	Unknown	MA	NA	Unknown	1LNLM81W0WY	1992	Town Car	10/20/92	11/05/92	Unknown	VOC	Unknown	Fire	Unknown.
88	Unknown	Unknown	Unknown	FL	NA	Unknown	1LNLM82W4WY	1992	Town Car	02/02/92	05/11/92	08/11/92	VOC	Unknown	Fire	Engine.
89	Unknown	Unknown	Unknown	MD	NA	Unknown	1LNLM81W8WY	1992	Town Car	08/15/92	09/03/92	10/01/92	VOC	Unknown	Fire	Underhood.
90	Unknown	Unknown	Unknown	TX	NA	Unknown	1LNLM82W0WY	1992	Town Car	05/23/92	09/20/92	Unknown	VOC	Unknown	Fire	Engine compartment.
91	Unknown	Unknown	Unknown	TX	NA	Unknown	1LNLM82W8WY	1992	Town Car	05/18/92	08/14/92	11/01/92	VOC	Unknown	Fire	Engine compartment.
92	Unknown	Unknown	Unknown	TX	NA	Unknown	1LNLM82W0WY	1993	Town Car	11/24/92	12/07/92	11/01/92	VOC	Unknown	Fire	Engine compartment.
93	Unknown	Unknown	Unknown	NY	NA	Unknown	1LNLM82W0WY	1993	Town Car	11/03/92	11/20/92	08/01/92	VOC	Unknown	Fire	Engine compartment.
94	Unknown	Unknown	Unknown	CA	NA	Unknown	1LNLM81W0WY	1993	Town Car	10/13/92	10/29/92	02/04/93	VOC	Unknown	Fire	Underhood.
95	Unknown	Unknown	Unknown	FL	NA	Unknown	1LNLM81W0WY	1992	Town Car	01/13/92	11/20/92	11/01/92	VOC	Unknown	Fire	Underhood.
96	Unknown	Unknown	Unknown	SE	NA	Unknown	1LNLM81W0WY	1992	Town Car	02/24/92	03/03/92	10/01/92	VOC	Unknown	Fire	Underhood.
97	Unknown	Unknown	Unknown	TX	NA	Unknown	1LNLM82W0WY	1992	Town Car	09/24/92	07/12/92	10/01/92	VOC	Unknown	Fire	Engine compartment.
98	Unknown	Unknown	Unknown	MA	NA	Unknown	1LNLM81W0WY	1992	Town Car	03/28/92	03/27/92	08/01/92	VOC	Unknown	Fire	Engine.
99	Unknown	Unknown	Unknown	MA	NA	Unknown	1LNLM81W0WY	1992	Town Car	05/05/92	10/08/92	08/01/92	VOC	Unknown	Fire	Engine.
100	Unknown	Unknown	Unknown	MA	NA	Unknown	1LNLM82W0WY	1992	Town Car	05/13/92	07/28/92	01/01/93	VOC	Unknown	Fire	Engine compartment.
101	Unknown	Unknown	Unknown	MA	NA	Unknown	1LNLM81W0WY	1992	Town Car	04/24/92	03/12/92	08/01/92	VOC	Unknown	Fire	Lift front fender area.
102	Unknown	Unknown	Unknown	TX	NA	Unknown	1LNLM82W0WY	1992	Town Car	11/21/91	02/03/92	05/01/92	VOC	Unknown	Fire	Engine compartment.
103	Unknown	Unknown	Unknown	FL	NA	Unknown	1LNLM82W0WY	1992	Town Car	04/06/92	05/07/92	10/01/92	VOC	Unknown	Fire	Engine compartment.
104	Unknown	Unknown	Unknown	MA	NA	Unknown	24E0A78W4WY	1992	Dr. Long	08/27/91	08/19/91	05/01/92	VOC	Unknown	Fire	Stake booster.

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1992-93 LINCOLN TOWN CAR  
UNDERHOOD FIRES

PE98-065

NO.	OWNER NAME	ADDRESS	CITY	STATE	ZIP CODE	TELEPHONE NUMBER	VIN	YEAR	MODEL	BUILD DATE	SALE DATE	REPORT DATE	REPORT TYPE	MILEAGE	ISSUE REPORTED	POSSIBLE PROBLEM DESCRIPTION
105	Unknown	Unknown	Unknown	FL	NA	Unknown	25ECM27W610	1992	Gr Marq	03/03/92	05/22/92	09/01/92	VOC	Unknown	Fire	Under hood.
106	Unknown	Unknown	Unknown	FL	NA	Unknown	1LNLM30R1Y	1992	Town Car	05/04/92	10/20/92	02/01/93	VOC	Unknown	Fire	Engine compartment.
107	Unknown	Unknown	Unknown	FL	NA	Unknown	1LNLM32AD1N	1992	Town Car	04/25/92	05/12/92	07/01/92	VOC	Unknown	Fire	Engine compartment.
108	Unknown	Unknown	Unknown	FL	NA	Unknown	1LNLM31W6Y	1992	Town Car	03/30/92	04/15/92	12/11/92	VOC	Unknown	Fire	Left edge of hood and fender
109	Unknown	Unknown	Unknown	NC	NA	Unknown	1LNLM32V6N	1993	Town Car	05/04/92	08/25/92	08/01/93	VOC	Unknown	Fire	Under hood.
110	Unknown	Unknown	Unknown	FL	NA	Unknown	1LNLM31W6Y	1992	Town Car	09/18/92	07/25/92	11/20/92	VOC	Unknown	Fire	Under hood.
111	Unknown	Unknown	Unknown	FL	NA	Unknown	1LNLM31W6Y	1992	Town Car	04/15/92	04/25/92	02/01/93	VOC	Unknown	Fire	Under hood.

3713 6090



- Commissions
- Journal Entry
- Therapist & Meds
- Agencies
- Conventions

All wish to know, but none want to pay the fee.  
— Decimus Junius

3/1/97

~~28~~

MPG 92 TOWN CAR

Sunday

February 1999

990 Day 308 Let Week 1

Daily Record of Events

Carroll Bolton 8918 74-98E00510-8918 G

DTG U U U O

Wt	Balance	LR	1142	RF	1119	2250
	Setup	LR	899	RF	905	1804

NOTE: BP Switch was ~~not~~  
ONLY Finger tight when  
Mechanic (@ MPG) removed it.

BP SWITCH F2VC-9F924-BB  
DATE CODE 1280A

John Joyce 82241 Brake Pad Temp? Don't need Pad Temp. Keep 1 mile between stops.

- RAN FIRE EXPERIMENT ON BP SWITCH hanging from harness
- RAN FIRE Experiment on harness hanging from BP SWITCH.
- PHOTOS OF TC 92 before Instrumenting
- DISCONNECTED BATTERY when leaving for the day.

## February 1988 Business Expenses

Day	Business Purpose Where, Why, Who, etc.	Odometer		Miles Traveled	Gas	Auto Other	Travel Fares	Meals	Lodging	Other
		Beginning	End							
1										
2										
3										
4										
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31										
<b>TOTAL</b>										

Copy table to Annual Summary of Business Expenses in Finance section.

Original-Nonverbal

© 1988 Franklin Covey Co. Printed in the U.S.A.



- Compendiums
- Journal Entry
- Thoughts & Ideas
- Agendas
- Conversations

The desire of knowledge, like the thirst of riches,  
increases ever with the acquisition of it.  
— Laurence Sterne

2

Tuesday  
March 1989

Daily Record of Events

© 1989 Franklin Covey Co.

- AV MPG - TOWN CAR 92 INSTRUMENTATION
- ESTIMATE THAT 26 OZ OF brake fluid was added to replace fluid lost while instrumenting and bleeding brakes.
- RAN PARKED PRESSURE TEST 30 & 40 MPH NORMAL BRAKING
- 2 each 30 & 40 MPH ABS BRAKING
- 2 (Per) 40 MPH ABS PANIC STOPS
- Photos of TC 92 with Instrumentation
- DISCONNECTED BATTERY WHEN LEAVING FOR THE DAY.

# 3

## Wednesday March 1989

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

February 1989							April 1989						
S	M	T	W	T	F	S	S	M	T	W	T	F	S
1	2	3	4	5	6	7	1	2	3	4	5	6	7
8	9	10	11	12	13	14	8	9	10	11	12	13	14
15	16	17	18	19	20	21	15	16	17	18	19	20	21
22	23	24	25	26	27	28	22	23	24	25	26	27	28
29	30						29	30					

- ✓ Task Completed
- Planned Forward
- X Task Deleted
- BD Delegated Task
- In Progress

### ↓ ABC Prioritized Daily Task List

<del>Update LD Record</del>	
Find VCR & Monitor for VHS Tape.	

### Appointment Schedule

7	
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### Daily Expenses


3713 6097



- Compositions
- Journal Entry
- Thoughts & Ideas
- Agendas
- Conversations

The most wasted day of all is that in  
which we have not laughed.  
— Sébastien-Roch Nicolas Chamfort

3

Wednesday  
March 1999

Wed Day 30 Left Week 4

Daily Record of Events

f/ Tele Ron Brumback - Update Leadership  
Development form to include 17 pre-  
ferred years of experience.

- Tele Mike (Bucaga?) MPG INSTRUMENTATION  
 (92 Town Car) = Brake Fluid leaking out of reservoir  
 was evident on outer surface.  
 • Reservoir was filled above max line.  
 • ~~Mike~~ Tom has reduced it down to max.

# 4

## Thursday March 1999

- ✓ Task Completed
- Planned Forward
- x Task Deleted
- ⊞ Delegated Task
- In Progress

**S M T W T F S**

	1	2	3	4	5	6	7
7	8	9	10	11	12	13	
14	15	16	17	18	19	20	
21	22	23	24	25	26	27	
28	29	30	31				

February 1999

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

April 1999

S	M	T	W	T	F	S
						1
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9	10	11	12	13	14	15
16	17	18	19	20	21	22

### Appointment Schedule

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### ↓ ABC Prioritized Daily Task List


### Daily Expenses




5

Friday  
March 1999

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7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

February 1999							April 1999						
S	M	T	W	T	F	S	S	M	T	W	T	F	S
1	2	3	4	5	6		1	2	3	4	5	6	
7	8	9	10	11	12	13	1	2	3	4	5	6	7
14	15	16	17	18	19	20	8	9	10	11	12	13	14
21	22	23	24	25	26	27	15	16	17	18	19	20	21
28	29	30	31				22	23	24	25	26	27	28

- ✓ Task Completed
- Planned Forward
- X Task Deleted
- @ Delegated Task
- In Progress

**Appointment Schedule**

7	
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10	GARY METZ & COL DIXON - CONNECTOR SEAL IMPROVEMENT
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**↓ ABC Prioritized Daily Task List**


**Daily Expenses**




- Comments
- Journal Entry
- Thoughts & Ideas
- Agenda
- Conversations

Poverty is hard, but debt is horrible.  
— Charles H. Spurgeon

5

Friday  
March 1999

Daily Record of Events

9:00 Day 201 Let Week 3

WIL DIXON WILL LOOK INTO EXISTING CONNECTORS THAT MAY PROVIDE BETTER SEALING. HE WILL ALSO ASK UTA TO ~~FORWARD~~ ~~EXPLORE~~ LOOK FOR SAME.  
Given the time-line there is not enough time to re-tool for a new connector.

Wil - Will to provide list of connectors

Mo - Need to GET SAMPLES & RUN ENVIRONMENTAL TEST TO SHOW IMPROVEMENT OVER ORIGINAL.

SIT for BP Switch - will meet with ERL TEAM (NOT USER GROUP) next Wed/Thurs.

CS Will call with meeting time.

Jerry Andritsis 89524 ~~89524~~  
Application Engr 2 DISCIPLINES  
8D & DVP  
Statistical Measuring

# 6

Saturday  
March 1999

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	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

- ✓ Task Completed
- Planned Forward
- X Task Deleted
- ☉ Delegated Task
- In Progress

February 1999							April 1999						
S	M	T	W	T	F	S	S	M	T	W	T	F	S
1	2	3	4	5	6	7	1	2	3	4	5	6	7
8	9	10	11	12	13	14	8	9	10	11	12	13	14
15	16	17	18	19	20	21	15	16	17	18	19	20	21
22	23	24	25	26	27	28	22	23	24	25	26	27	28
29							29	30	31				

↓ ABC **Prioritized Daily Task List**


**Daily Expenses**


**Appointment Schedule**

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- Conference
- Journal Entry
- Thoughts & Ideas
- Agenda
- Conversation

Opportunities are seldom labeled.  
— John A. Shedd

12

Friday

March 1989

Daily Record of Events

7th Day 2nd Last Week

NOTE

Shield or Boot for RP Switch

CONNECTOR ~~is~~ <sup>can</sup> be made EASILY EITHER WAY  
WHICH WOULD SCREW-UP THE REVERSING  
OF THE HOT & LOAD TERMINALS.

A UTA - BOOT & IN-LINE DRIP LOOP

EN114 - Battery Ht Sensor

VCEDEN KINGEL

LINA  
HARL-AWAY

~~EN114 COST - ASSUMPTION  
- U152 LOAD LEVELING  
- IN V.S.S.  
- FROM 2001~~

A Me - EN114 DOOR ATAR ~~see~~ George Kants  
HISHAM & Dennis Olette to review  
Hi-Side mark-up for validity.

ARZ Software - U152 ok  
desired + EN145 features  
- EVO ok  
desired EVO ~~ok~~  
- DIAGNOSTIC NGS





- Commitments
- Journal Entry
- Thoughts & Ideas
- Agendas
- Conversations

They also serve who only stand and wait.  
— John Milton

15

Monday  
March 1999

Daily Record of Events

7th Day 28th Week 11

Me RANGER ELECTRIC VEHICLE HAS  
A GEE. FIND CONTACT  
— John Mc?

Where is TI on Brake Fluid Corrosion?

Me WATER SPLASH ENVIRONMENT—  
RWD VIDEO AT MPG?

BOB SWITCH WARRANTY NUMBERS?





- Commitments
- Journal Entry
- Thoughts & Ideas
- Agenda
- Conversations

It is better to ask some of the questions  
than to know all the answers.  
— James Thurber

19

Friday

March 1999

7th Day 27th Week 11

Daily Record of Events

Central has litg oxalate from oxalic acid  
Metal cleaners  
Tarnish Remover  
Typically Not Rust Preventer

BY-PRODUCT OF BURNING PLASTIC  
w/ POLY ESTERS

N2O2L POLYESTER?  
PPL - will not have OXYLIC ACID

Terminal cleaning process - does it include  
OXYLIC ACID TO clean metals

ABS HCU cleaning process

Brake system flush?

CONDUCTIVITY of Brake Fluid - CSL will look into it.

# 20

Saturday  
March 1999

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7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

February 1999							April 1999						
S	M	T	W	T	F	S	S	M	T	W	T	F	S
1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	16	17	18	19	20	21	22	23	24	25	26	27	28
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- ✓ Task Completed
- Planned Forward
- x Task Deleted
- BD Delegated Task
- In Process

### Appointment Schedule

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### ↓ ABC Prioritized Daily Task List


### Daily Expenses




- Commitments
- Journal Entry
- Thoughts & Ideas
- Agenda
- Conversations

*There is only one corner of the universe you can be certain of improving, and that's your own self.*  
— Aldous Huxley

**22**

**Monday**

**March 1999**

81st Day 294 Left Week 12

### Daily Record of Events

DO NOREL BF SWITCHES SHOW ANY OXYLATES?

Brake Fluid Reservoir Leakage: T/C Issue?





- Commitment
- Journal Entry
- Thoughts & Ideas
- Agenda
- Conversations

Humor is an affirmation of dignity, a declaration of  
man's superiority to all that befalls him.  
— Roman Gary

7

Wednesday  
April 1989

17th Day 28th Week 14

Daily Record of Events

CAMEXAS - KEITH FRASER, HARVEY STINGER

3/27/89

to BARRY to TIM

For vehicle locate parts, VIN, seal material, connector seal material, photos - overall layout + 2/12/89 - 90. Orientation, denotation around seal examination from switch, proximity of other (available) (plastic & rubber).

? Is sound padding available

? Are we recommending replacing BP switches in a Re-call.

# 8

## Thursday April 1999

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March 1999

May 1999

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22	23	24	25	26	27	28
29	30	31				

S	M	T	W	T	F	S
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22	23	24	25	26	27	28
29	30	31				

- ✓ Task Completed
- Planned Forward
- ✕ Task Deleted
- Ⓜ Delegated Task
- ⦿ In Progress

### Appointment Schedule

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### ↓ ABC Prioritized Daily Task List


### Daily Expenses




- Comments
- Journal Entry
- Thoughts & Ideas
- Agenda
- Conversations

What is liberty without wisdom and without virtue?  
— Edmund Burke

8

Thursday  
April 1989

Daily Record of Events

8 1/2" Day 2 1/2" Let. 1 1/2" Wk. 1 1/2"

ENVIRON - John Vitale, Alan Janotik, Ron Colombo  
 clearance ZAVES or GEE Chris Goss  
 CONTACT - Chrissy Downey 26 325  
 Supv - Susan McCarty 26 344  
 Security - Mike Duffoe 59645  
 Charley Alongi - 59655

85-0296





- Commitments
- Journal Entry
- Thoughts & Ideas
- Agendas
- Conversations

The greatest glory of a freeborn people is to transmit  
that freedom to their children.  
→ William Howard

14

Wednesday  
April 1999

Wed Day 21st Week 13

Daily Record of Events

DOES DTFSA Ltr - include SVIS  
- include attended

see 4 charts from Joe

SPLASH CATEGORIES

SWITCH ORIENTATION CATEGORIES

# 15

**Thursday**  
**April 1999**

S M T W T F S

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18	19	20	21	22	23	24
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March 1999

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20	21	22	23	24	25	26
27	28	29	30	31		

May 1999

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20	21	22	23	24	25	26
27	28	29	30	31		

### Appointment Schedule

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- ✓ Task Completed
- Planned Forward
- X Task Deleted
- Ⓜ Delegated Task
- In Progress

### ↓ ABC Prioritized Daily Task List


### Daily Expenses




- Commitments
- Journal Entry
- Thoughts & Ideas
- Agendas
- Conversations

Chance is a word void of sense; nothing  
can exist without a cause.  
— Voltaire

16

Friday

April 1999

1025 Day 228 Left Week 15

Daily Record of Events

ABS / BRAKE CHANGES

NOVA 92/93 TOWN CAR / CVT/CA

PRODUCTION BUILD RATE IMPLEMENTED

TI - QUALITY RECORD, CHANGE RECORDS  
AUTO-LINE HISTORY  
for design & process

Likewise # for Hi-lite Industries

PROCESS QUALITY RECORDS  
CHANGE RECORDS





- Commitments
- Journal Entry
- Thoughts & Ideas
- Agenda
- Conversations

Life is too short to be little.  
— Benjamin Disraeli

19

Monday  
April 1999

Daily Record of Events

10:00 Day 28:14 Week 14

TECH REVIEW

KAPTON effect from <sup>higher</sup> temperature

DISPONT how can case embrittle KAPTON?  
~~What DISPONT is what changed~~

Field Returns at WINDSTAR Leakers

Brake light on WINDSTAR due to PAD wear

What determines temperature of switch?  
(AMBIENT)

Field returns on other vehicles.









- Commitments
- Journal Entry
- Thoughts & Ideas
- Agenda
- Conversations

Never spend your money before you have it.  
— Thomas Jefferson

3

Monday  
May 1999

Daily Record of Events

123rd Day 242nd Week 18

JOE HARPER Mtg EN/FN 2002

MY2002 EN114 WILL HAVE ABS STANDARD.

ROTARY HT Sensor  
SCP RASM  
EEVO

(MY2002 EN145 WILL HAVE IVD<sup>STD</sup> OPTIONAL)

~~STEERING MSG SCP MESSAGE RATE~~

ME CAN VISION SUPPORT A BROADCAST  
MESSAGE TO ABS @ 50 msec?

What messages steering info is available?

(in RASM already calculated)

o HARDWARE OUTPUT OF STEERING

o <sup>ADP</sup> FIND CENTER ROUTINE

o CAN RASM USE STEERING RATE SCP MSG.

BP SW Mtg 3:30 PM

Justify ~~the~~ redundant Deactivation.

Failure rate on BCO.

4

Tuesday  
May 1999

S M T W T F S

29	30	31				1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

April 1999

June 1999

4	5	6	7	8	9	
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

- ✓ Task Completed
- Passed Forward
- X Task Deleted
- DD Delegated Task
- In Progress

Appointment Schedule

7 \_\_\_\_\_  
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↓ ABC Prioritized Daily Task List


Daily Expenses




- Commitments
- Journal Entry
- Thoughts & Ideas
- Agendas
- Conversations

Kindness is produced by kindness.  
- Marcus Tullius Cicero

11

Tuesday  
May 1999

Daily Record of Events

131st Day 234 Left Week 19

C. SUTTON Mtg

U152 - Air Susph volume down to 5-8 K  
because of handling concerns  
\* Usage will be European only

U231 - CVSA will be standard. Precludes  
using air suspension. 40K

A Craig, Jay, Me handle spec. CVSA  
Set up Meeting FRS spec. CVSA

Early to Mid-August Need 10 Modules AP2  
from U152 CP.

DUPER & <sup>(157)</sup>EMEA SYSTEM LEVEL NEEDS  
TO BE DEVELOPED. (ANYTHING AVAILABLE FROM DEW78?)  
START ROUGH DRAFT - RAAD/HERMAN

Len Brown to Ray Shalcraft <sup>disclosure</sup> ~~disclosure~~ agreement  
for CVSA strategy (per S. Herman)

A FIND BP SWITCH BUYER - REQUEST STA VISIT  
TO EOR PROCESS  
REVIEW & CONTROL  
HISTORY.

# 12

**Wednesday  
May 1998**

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30	31					1
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9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

April 1998							June 1998						
S	M	T	W	T	F	S	S	M	T	W	T	F	S
			1	2	3				1	2	3	4	
4	5	6	7	8	9		5	6	7	8	9	10	
10	11	12	13	14	15		11	12	13	14	15	16	
16	17	18	19	20	21		17	18	19	20	21	22	
22	23	24	25	26	27		23	24	25	26	27	28	
28	29	30					29	30					

- ✓ Task Completed
- Planned Forward
- × Task Deleted
- Ⓧ Delegated Task
- In Progress

**↓ ABC Prioritized Daily Task List**


**Appointment Schedule**

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**Daily Expenses**




- Commitments
- Journal Entry
- Thoughts & Ideas
- Agenda
- Conversations

Since everything is in our heads,  
we had better not lose them.

— Coco Chanel

Conf. Call with Steve Beringhaas  
& Brian Daigh  
Daily Record of Events

12

Wednesday  
May 1999

132nd Day 231 Left Week 18

- Auto Crimp Part Testing began in 12/91  
completed in 1/92.
- SPC data still not located at TI.
- 57PS MANUAL Next 4 Crimp Die  
changed per Steve  
B.
- 77PS AUTO
- Same crimper still being used today as 77PS.  
Crimper sup to hex-part.
- Samples to Ford but no production parts  
until resolved.
- Wrinkle (Memphis) characteristic not what TI  
was seeing in Auto-crimp issue. (Tear-drop shape)
- A - TI, try to create an image of Tear-drop  
or an illustration.
- Corrosion research at TI - on going  
No plastics breaking down.
- SUGGESTIONS FOR INCREASING LIFE
  - ADD'L KADION LAYER (Gives ~ 25% more life)
  - SOLID STATE SWITCH
  - Optimize Crimp Pressure Range
- TI Looking for 8D for Auto-crimp issue.  
Before Crimp Pressure DOE data exists.
- \* CRIMP Height is SPC parameter at TI.  
Is springback an issue.





- Commitments
- Journal Entry
- Thoughts & Ideas
- Agenda
- Conversations

*Happiness makes up for in height what it lacks in length.*  
— Robert Frost

**27**

**Thursday**

**May 1989**

**Daily Record of Events**

1478 Day 218 (of 365)

*APR*  
FOIL TYRA - SORT 9F924 CLAIMS  
FILE FOR ALL VEHICLE  
USING THE HYDRAULIC  
VERSION OF THE SWITCH

