MAP Fuel/Fluids Subcommittee
Brake Fluid
**Component**: Brake Fluid

- At or beyond OEM service interval Suggest service
- Brake fluid type incorrect Require flushing
- Contaminated Require flushing
- **Corrosion inhibitors depleted** Require flushing

⚠️ A copper content of 200 ppm or greater indicates a depletion of corrosion inhibitors in the brake fluid

- Hydraulic component overhaul or replacement Suggest flushing
Information Sources


Information Sources


Functions of BRAKE FLUID

1. Apply hydraulic pressure to brake components to slow the vehicle

2. Protect the Brake System from CORROSION
The #1 concern is CORROSION

- Corrosion inhibitors deplete
  - Depletion results in corrosion
  - Copper is an indicator of depleted corrosion inhibitors
  - Copper effects ABS valving

Jackson et al. [2] studied the changes that occur in brake fluid chemistry during vehicular service. In their extensive study they found that the buffer capacity and inhibitor concentrations dropped to as low as 9% of their initial levels after only 30 months of service.
Corrosion Inhibitors

Buffering Amines

- Reduces the acid level

Filming Amines

- Protective film on metals

Note: Flush brake fluid when replacing calipers.
Factors effecting Brake Fluid

• Brake fluid chemical & thermal stability
• Brake system design, ABS
• Operator driving habits
• Temperature
• Road surface
  – Dr. Ricker et al.
Evidence of Corrosion from NIST Report

• Visual evidence of corrosion damage is observed on iron alloy components

• The damage observed usually consisted of shallow pitting.

• In most cases when corrosion pits were found on iron, copper deposits were also found.
More Evidence

• Small copper particles were found both inside and outside of the shallow pits on the iron.

• The copper sponge and the copper nugget morphology were found in the shallow pits associated with and usually under the gel-like substance.
TEVES VI Body Passages
Proportioning Valve Insert
TEVES VI Solenoid Valve
Copper

- Early Warning for iron corrosion
- Indicator of losted buffering capability
- Causes iron to corrode rapidly
- 30 months of service copper reached 200ppm
TABLE 1. Copper and iron levels versus the age of brake fluid. Each pair of iron/copper symbols represents a single vehicle.
More Recent Information
March 22, 2013

ABIC Testing Laboratories
Dr. Len Mackowiak
Listed by the DOT for testing and evaluating brake fluid.

Members of the SAE Brake Fluid committee

Certified by Automotive Equipment Compliance Agency
Water is required for iron to corrode. Copper does not need water to corrode (form ions). Copper is an oxidizer and will corrode iron.
Fun Facts

Copper can deactivate corrosion inhibitors.

In the DOT test PH can be no less than 7% or higher than 11.5%.

Most vehicle have 2%-3% moisture in the brake fluid.
The following series of corrosion tests were performed:

• Corrosion test on commercially available brake fluid
• Brake fluid with 50 ppm copper added
• Brake fluid with 100 ppm copper added
The following series of corrosion tests were performed:

- Brake fluid with 200 ppm copper added
- Used brake fluid with 300 ppm copper
- Brake fluid with 200 ppm copper added and 2% water added
Corrosion Test, FMVSS-116 standard.

The following 5 metals are used

1. Tinned iron
2. Steel
3. Aluminum
4. Cast iron
5. Brass
6. Copper
Two sets of metals are put in separate jars containing 400 milliliters of a combination of brake fluid with 5% water added.

The jars are kept at 212°F for 5 days.
Metals are removed, cleaned and reweighed after the 5 day period. The weight losses are calculated as milligrams/square millimeter. The final values are compared to the limits specified in the FMVSS-116 standard.
The same test procedures were repeated using a 2% moisture absorption level instead of a 5% moisture absorption level as required by the Corrosion Test, S5.1.6
Exhibit XIII: 200 ppm Copper Added and Baseline Brake Fluid Comparison

New Brake Fluid (Baseline) After Corrosion Test
0 ppm Copper
Results: PASS

1: Tinned Iron
2: Steel
3: Aluminum
4: Cast Iron
5: Brass
6: Copper

New Brake Fluid After Corrosion Test
200 ppm Copper
Results: FAIL
Exhibit XII: 200 ppm Copper Added Close-up

1: Tinned Iron
2: Steel
3: Aluminum
4: Cast Iron
5: Brass
6: Copper

FAIL
Commercial Brake Fluid + 200 ppm Copper Added 2% Water Corrosion test Metals

Exhibit XV

1: Tinned Iron
2: Steel
3: Aluminum
4: Cast Iron
5: Brass
6: Copper

2% Water Instead of 5%

FAIL
### Exhibit III

**Phoenix Systems**

**Brake Fluid Corrosion Test: Commercial Brake Fluid + 100 ppm copper added**

**Method:** FMVSS-116, Para S6.6

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**pH after test: 6.54**

**Source:** ABIC Testing Laboratories
# Exhibit IV

Phoenix Systems  
Brake Fluid Corrosion test: Commercial Brake Fluid + 200 ppm copper added

**Method: FMVSS 116, Para S6.6**

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**pH after test: 5.36**

Source: ABIC Testing Laboratories
### Exhibit VII

**Phoenix Systems**

**Commercial Brake Fluid Corrosion test: 200 ppm copper + 2 % Water**

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**pH 5.48 after test**

Source: ABIC Testing Laboratories, Inc
1. As levels of copper ions increased so did the levels of corrosion.

2. As the copper level increased so did the corrosivity.

3. Determined that the visual threshold for corrosion test failure is approximately 200 ppm copper.
ABIC LAB TEST RESULTS

SUMMARY

4. This type of reaction within a brake fluid system can lead to corrosion and malfunction of ABS components.

5. As brake fluid ages, levels of copper increase.

6. Using 200 ppm copper and 2% water proved to be enough water for copper ions to cause surfaces to become pitted and show rusting failing the corrosion test.
Jon,

Thank you for taking the time to come out to the Bureau and meet with the new Management team being assembled. I found your research and testing of your product to be quite comprehensive. As to the “Consumer Disclosures” listed in your email, I believe them to be right in line with the Automotive Repair Act and what your product tests. I see no reason why they should not be implemented ASAP. Again, thank you for your efforts to come speak with us and good luck.

Dan Povey
Deputy Chief
Bureau of Automotive Repair

9/4/2013
BrakeStrip Copper Brake Fluid Testing Consumer Disclosures ©
1. Openly and honestly communicate with your customer.
2. Obtain authorization, test and inspect vehicle before making service recommendation.
3. Inform customer that a copper based recommendation is different from their vehicle manufacturer scheduled brake fluid maintenance recommendation which is based on time/mileage or provides no recommendation.
4. Provide customer with reason/justification for service: Brake fluid with 200 ppm or higher copper levels will not pass Department of Transportation (DOT) FVMSS-116 corrosion test standards.
5. Communicate test results to customer
6. Provide customer with expectation for service: The brake flush service will not remove all of the copper, but will reduce copper below the 200 ppm level to help protect the brake system from corrosion.
Can you get the copper out?
YES;

With good brake flush techniques

• Clean the brake fluid reservoir
• Use enough fluid to flush
  • 2 quarts in a 1 quart system