Many extreme pressure (EP) additives are activated under severe contact conditions in which traditional antiwear additives are ineffective. As a result, EP additives are normally graded according to the contact load required for scuffing failure, rather than their ability to minimize material loss by wear. The ruggedly built-four ball EP test apparatus produces the severe contact conditions needed to evaluate these chemistries while maintaining accurately controlled test conditions. The contact geometry and test specimens are identical to those used in the more lightly loaded four-ball friction and wear tests.

Typical Test Conditions for ASTM D 2783 for Lubricating Fluids
Temperature:
- 18 - 35°C (65 - 95°F)
Speed
- 1760 +/- 40 rpm
Duration
- 10 seconds
Load
- 6 - 800 kgf

Typical Test Conditions for ASTM D 2596 for Greases
Temperature:
- 27 +/- 8°C (80 +/- 15°F)
Speed
- 1770 +/- 60 rpm
Duration
- 10 seconds
Load
- 6 - 800 kgf

Related Test Methods:
The most widely used test methods for the EP Four-Ball test are ASTM D 2783 for liquid lubricants and ASTM D 2596 for greases.
ASTM D-2783 "Measurement of Extreme Pressure Properties of Lubricating Fluids (Four Ball Method)"
Three 1/2 inch 52100 steel balls are locked into a pot containing the fluid which is forced against a fourth rotating ball (1800 rpm) at increasing loads and run for 10 seconds. The wear scars on the stationary balls are measured and the load is increased until lubrication breaks down completely causing the balls to weld together (Weld Load). By mathematical treatment of the scar sizes at the increasing loads an indexing value which characterizes the load carrying capacity of the fluid is obtained and reported as the Load Wear Index (LWI) along with the Weld Load. Most fluids exhibit a load at which metal to metal contact is minimal and the amount of wear produced on the basis of scar diameter is no more than 5% greater than the impression diameter (the plastic deformation of the balls under point contact load without turning the machine on). This is termed as the 'Last Non-Seizure Load'. Greater loads which are termed 'Seizure load' typically produce much larger scars with scoring due to heavy metal to metal contact. The Last Non-Seizure Load is sometimes of interest for comparative purposes as well as an indicator of the upper limits of transition from elastohydrodynamic to boundary modes of lubrication in terms of the test conditions. If desired, the Last Non Seizure Load and scar size can be reported as well as the Last Seizure Load and scar (Load just prior to the Weld Load).

**Description:** Film strength
**Test method:** ASTM D 2783
**Test result values, what they mean:** Uses 4-ball method to determine load-carrying properties of lubricating fluid. The higher number the better.

**Description:** Weld point
**Test method:** ASTM D 2783
**Test result values, what they mean:** Measures the lowest applied load in kilograms at which the rotating ball welds to the three stationary balls. The higher the number the better extreme pressure characteristics.

**Description:** Load wear index
**Test method:** ASTM D 2783
**Test result values, what they mean:** An index of the ability of a lubricant to minimize wear at applied loads. The higher the better.

**Description:** Timken method
**Test method:** ASTM D 2782
**Test result values, what they mean:** Line contact, similar to roller bearing, the higher the number the greater load carrying capabilities.
February 9, 2017

Mark W. Pushnick
Steel Shield Technologies
3351 Industrial Blvd
Bethel Park, PA 15102-2543
Phone: 1-800-390-1535
Email: mwpushnick@steelsheildtech.com

Re: Fuel Analysis Results
Purchase Order# 147
SwRI WO# 76231

Dear Mr. Pushnick:

Analyses have been completed on your samples in accordance with the tests requested. Two samples were received in good condition on January 10, 2017 in good condition. The samples were received in 1-gallon and quart plastic containers. Testing took place by February 7, 2017. Test results and sample identifications are shown in the table attached.

Analyses were performed according to the listed ASTM test procedures with no modifications or deviations. Precision should be consistent with those stated in the ASTM test procedures. Sample aliquots were taken in accordance with the various ASTM test procedures. The analyses above pertain only to the sample received by Southwest Research Institute and represent only that sampling lot. This report shall not be reproduced except in full without the express written permission of Southwest Research Institute.

If there are any questions concerning these analyses, or if you need any additional testing on the samples, please contact me at (210) 522-2071. We appreciate the opportunity to be of service to your firm.

Sincerely,

Robert R. Legg
Director
Fuels & Lubricants Research Department
Office of Automotive Engineering

WO-76231 (OPAJABI-17) PO-147
Test Summary Report

Steel Shield Technologies
PO# 147

Sample Code:
Truck Shield Metal Treatment for Trucking Industries

Test Results:

ASTM D2782
Extreme-Pressure Properties of Lubricating Fluids
(Timken Method)

- OK Load (lbs) ................................................................. 85
- Fail Value (lbs) ............................................................... 90
- Temperature ................................................................. 38°C

ASTM D2783
Extreme-Pressure Properties of Lubricating Fluids
(Four-Ball Method)

- Corrected Load (kgf) ....................................................... N/A
- Load Wear Index (kgf) .................................................... N/A
- Weld Point (kgf) .............................................................. *
- LNSL (kgf) ................................................................. N/A

* No weld point – applied load exceeds the scope of the method.

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WO-76231 (OPA-JAB-17) PO-147