ADA

FEASIBILITY OF A SINGLE COMMON POWERTRAIN LUBRICANT-TRANSMISSION BENCH TESTING

INTERIM REPORT
TFLRF No. 417

by
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and

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Force Projection Technologies
Warren, Michigan

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14. ABSTRACT

The goal of the Army Single Common Powertrain Lubricant (SCPL) program is to develop an all-season (arctic to desert), fuel efficient, multifunctional powertrain fluid with extended drain capabilities. SCPL must be able to properly function in various mechanical applications including engine crankcase lubrication, powershift transmission operation, and some hydraulic system operation. Several diesel engine crankcase oils were evaluated in powershift fluid bench tests to determine the feasibility of using engine oil in this application. While none of the engine oils passed all the bench tests, overall technical feasibility was demonstrated as evidenced by passing or near passing results with the slate of engine oils tested.

15. SUBJECT TERMS

Single Common Powertrain Lubricant, SCPL, Transmission, Caterpillar TO-4, Cat TO-4, Dexron, Dexron VI, SAE No. 2, Clutch, Allison, Allison C4

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EXECUTIVE SUMMARY

The goal of the Army Single Common Powertrain Lubricant program SCPL is to develop an all-season (arctic to desert), fuel efficient, multifunctional powertrain fluid with extended drain capabilities. This program seeks to leverage state-of-the-art base oil and additive technologies to significantly improve upon current military lubricant products, and act as an enabler for future powertrain technologies. Due to the versatility desired in the SCPL program, candidate fluids must be able to properly function in various mechanical applications including engine crankcase lubrication, powershift transmission operation, and some hydraulic system operation. It is desired that SCPL meet or exceed minimum performance requirements when used in all of the above systems in operating environments varying from arctic to desert type conditions. Various test programs have been initiated to quantify candidate SCPL performance in each of the above applications. This report covers testing relating to the feasibility of incorporating powershift transmission performance in SCPL. Overall, the performance of various diesel engine oils tested in a variety of friction bench tests was determined. The results indicate that use of engine oils in military automatic/ powershift transmission applications is technically feasible as evidenced by passing or near passing friction bench test results with the slate of engine oils tested. This will enable the marriage of diesel engine oil performance with military automatic/powershift transmission performance in a SCPL.

FOREWORD/ACKNOWLEDGMENTS

The U.S. Army TARDEC Fuel and Lubricants Research Facility (TFLRF) located at Southwest Research Institute (SwRI), San Antonio, Texas, performed this work during the period January 2008 through January 2009 under Contract No. DAAE-07-99-C-L053. The U.S. Army Tank-Automotive RD&E Center, Force Projection Technologies, Warren, Michigan administered the project. Mr. Luis Villahermosa (RDTA-SIE-ES-FPT) served as the TARDEC contracting officer's technical representative.

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ACRONYMS AND ABBREVIATIONS

CAT – Caterpillar

FRRET – friction retention

kPa – kilopascals

m/s – meters per second

N-m – Newton Meters

OEA – Oil Engine Arctic

QPL – Qualified Products List

SAE – Society of Automotive Engineers

SCPL – Single Common Powertrain Lubricant

sec- seconds

SEQ - sequence

SwRI – Southwest Research Institute

TARDEC – Tanks Automotive Research and Development Engineering Center

TFLRF – TARDEC Fuels and Lubricants Research Facility

1.0 INTRODUCTION AND BACKGROUND

The US Army TARDEC Fuels and Lubricants Research Facility (TFLRF) located at Southwest Research Institute (SwRI) in San Antonio, TX, was tasked to determine the technical and economic feasibility of developing and implementing a Single Common Powertrain Lubricant (SCPL) for use in all combat tactical equipment currently using MIL-PRF-2104 [1] and MIL-PRF-46167D [2] lubricants. The project goal for the SCPL program is to develop an all-season (arctic to desert), fuel efficient, multi functional powertrain fluid with extended drain capabilities. This program seeks to leverage state-of-the-art base oil and additive technologies to significantly improve upon current military lubricant products, and act as an enabler for future powertrain technologies.

2.0 OBJECTIVE

Due to the versatility desired in the SCPL program, candidate fluids must be able to properly function in various mechanical applications including engine crankcase lubrication, powershift transmission operation, and some hydraulic system operation. Candidate oils must meet or exceeded minimum performance requirements when used in all of the above systems in operating environments varying from arctic to desert type conditions. Various test programs have been initiated at TFLRF to quantify candidate oil performance in each of the above applications. This report covers the feasibility testing relating to engine oil performance in powershift transmission applications.

3.0 APPROACH

To determine engine oil performance in powershift transmission applications, several oils were subjected to various commercial transmission oil testing procedures. Six initial engine oils were chosen for testing. Engine Oil viscosities ranged from SAE15W-40 grades consistent with MIL-

PRF-2104 oils, to OEA-30 MIL-PRF-46167 arctic grade oils. Each candidate oil and its qualified products list (QPL) number, where applicable, are listed below.

Description	**Code No.**
MIL-PRF-2104G, SAE 15W-40, QPL NO. PRI EO 0058 (S)	AL-27793
MIL-PRF-2104H, SAE 15W-40, EO 0068 (L)	AL-27876
MIL-PRF-2104G, SAE 5W-40,QPL NO. PRI EO 0067 (E)	AL-27252
MIL-PRF-46167D, OEA 30, QPL NO. ME-35 (C)	AL-27637
MIL-PRF-46167D, OEA 30 (New)	AL-27877
Experimental SAE 5W-40 (L)	AL-27875

The following tests were performed on each oil:

- Caterpillar TO-4 Friction Test
    - TO-4 SEQ 1219 (Elastomeric)
    - TO-4 SEQ 1221 (Steering Brake Paper)
    - TO-4 SEQ 1222 (Wheel Brake Paper)
    - TO-4 SEQ 1223 (Transmission Paper)
    - TO-4 SEQ 1224 (Elastomeric)
    - TO-4 SEQ 1220 (OEA 30 (New) and Experimental 5W-40 (L) only)
    - TO-4 SEQ FRRET (OEA 30 (New) and Experimental 5W-40 (L) only)
- DEXRON-VI (OEA-30 ME-35 (C) and OEA 30 (New) only)
    - Band Clutch Friction
    - Plate Clutch Friction
    - Low Speed Clutch Friction and Torque Capacity
- John Deere JDQ-96 Brake Torque Retention & Friction (1000 cycles)
- Allison C4 Friction Test (Paper and Graphite, OEA 30 (New) only)

4.0 RESULTS/DISCUSSIONS

Top-level details of each testing procedure, and individual oil performance results are discussed in the following sections.

4.1 CAT TO-4

CAT TO-4 tests are designed to evaluate oils to determine if minimum performance requirements are met for fluids that are intended for use in CAT equipment. CAT specifies that the primary use for these types of fluids would be found in powershift transmissions, final drives, hydrostatic transmissions, torque converters, wheel brakes, steering brakes, and steering clutches. The TO-4 testing apparatus consists of a flywheel with a known inertial value, a variable speed AC motor, a stationary reaction plate, and a load cell to measure application forces. Various friction materials are attached to the flywheel and brought up to a specified speed with the variable speed motor. After reaching the desired speed, the kinetic energy is then absorbed by engaging the flywheel with the stationary reaction plate at various application pressures. The reaction plate is fitted with a complimentary steel plate of similar dimensions as the tested friction disk. The lubrication oil is applied to the friction surface from a feed line mounted on the reaction plate. A diagram of the testing apparatus is presented in Figure 1. The apparatus is used to measure the dynamic and static coefficient of friction, energy capability, wear resistance, and friction retention of each material and test fluid combination [3].

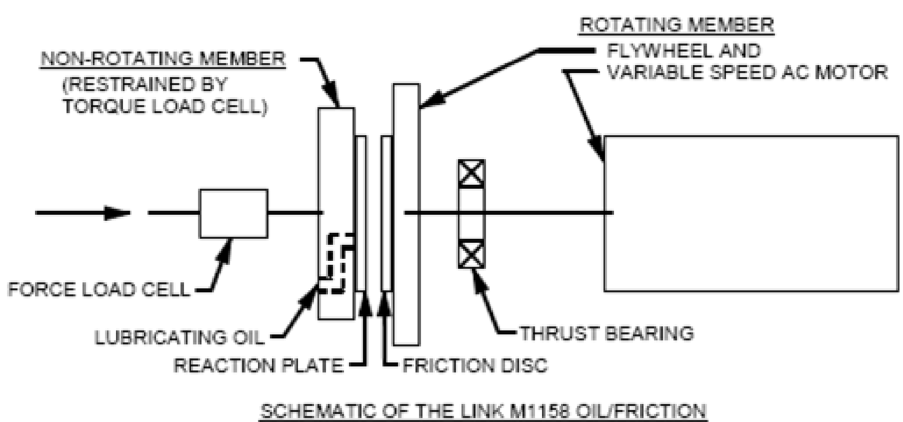

Figure 1. CAT TO-4 VC70 Testing Apparatus

The CAT TO-4 test is divided up into multiple sequences, with each sequence representing a different friction material being tested. Listed below are the seven sequences of the TO-4 test and their respective tested friction material:

- CAT TO-4 SEQ 1219 (Elastomeric)
- CAT TO-4 SEQ 1221 (Steering Brake Paper)
- CAT TO-4 SEQ 1222 (Wheel Brake Paper)
- CAT TO-4 SEQ 1223 (Transmission Paper)
- CAT TO-4 SEQ 1224 (CAT F37 Elastomeric)
- CAT TO-4 SEQ 1220*
- CAT TO-4 SEQ FRRET*

*Note – CAT TO-4 SEQ 1220 and FRRET are required testing procedures for all military spec oils, and were completed on the OEA 30 (New) and Experimental 5W-40 (L) oils only.

A torque versus time plot is generated for each friction material as the rotating flywheel is accelerated from its initial speed to a stop, and is used to calculate the coefficient of friction. The coefficient of friction is a dimensionless value that describes the ratio of frictional forces between two surfaces versus the force applying the two surfaces together. An example friction curve is presented in Figure 2.   where rotational speed is the speed of the flywheel, and clutch pressure is the pressure applied between the friction disk and reaction plate. The resulting torque values can then be used to calculate the coefficient of friction between the two surfaces as a function of relative velocity, and application pressure. The dynamic coefficient of friction is the component of friction present when the two acting surfaces have a differential velocity between them. This can be seen in the flat portion of the torque curve as the rotational velocity decreases from its initial speed to zero. The static coefficient of friction is the component of friction immediately present when the differential velocity between the two acting surfaces goes to zero. This can be seen at the final torque spike towards the end of the torque curve.

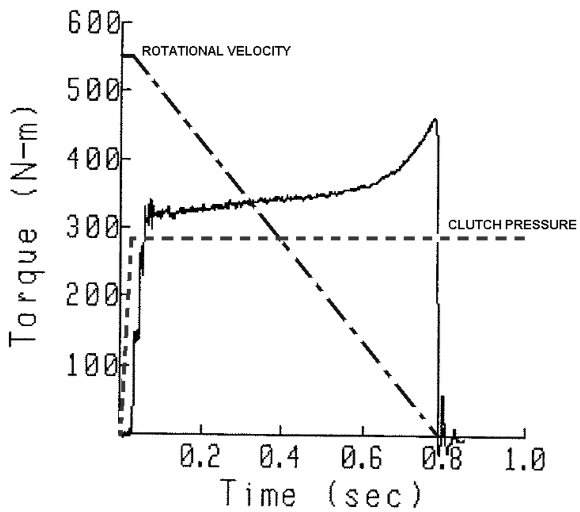

Figure 2. Typical TO-4 Test Torque Response Curve

The importance of the torque curve is to determine the consistency of coefficient of friction over a wide variety of relative velocities and application pressures. If a flat torque curve exists in the dynamic range, the coefficient of friction remains relatively constant and the resulting behavior of the driveline components remain consistent. If the torque drastically shifts in the dynamic region, this means the dynamic coefficient of friction has changed and the driveline behavior can become inconsistent. This effect can be realized through a sudden grabbing or slipping during engagement or disengagement. An example curve showing this behavior is presented in Figure 3.

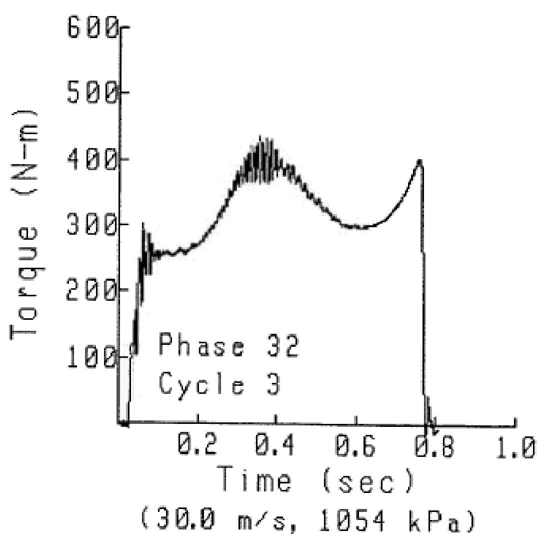

Figure 3. Non-typical TO-4 Torque Response Curve

From experience gained through testing, it has been found that multipurpose engine oils typically yield lower overall coefficient of friction values than transmission fluids. This should be taken into consideration when comparing engine oil performance in these tests. While some of the candidate oils failed to meet minimum coefficient of friction specifications, their overall behavior was consistent and yielded values only slightly lower than approved transmission fluids. In these types of situations, it is possible that the candidate oils performance would not prohibit its use in transmission applications. In addition, all candidate oils were only subjected to one round of TO-4 testing yielding single point data. Due to inherent variation in this testing, some borderline failures could be deemed passing with continued testing to gain more statistical significance in the results.

The resulting data for sequences 1219, 1221, 1222, 1223, and 1224 for each candidate oil was examined for trends by:

- Comparing the relative performance of oils by each sequence
- Comparing the relative performance of oils by similar viscosity grade

4.1.1 Performance by Test Sequence

Table 1 and Table 2 lists CAT TO-4 test results of each candidate oils and approximate magnitude of failure where applicable.

Table 1. TO4 Test Results

	OEA 30 ME-35 (C) AL-27637-L	5W-40 EO 0067 (E) AL-27252-L	15W-40 EO 0058 (S) AL-27793-L	Experimental 5W-40 (L) AL-27875-L	15W-40 EO 0068 (L) AL-27876-L	OEA 30 (New) AL-27877-L
Caterpillar TO-4	27637-L	AL-27252-L	AL-27793-L	AL-27875-L	AL-27876-L	AL-27877-L
SEQ 1219 (Elastomeric)	Test No. VC70-A-77-I	Test No. VC70-A-70-I	Test No. VC70-A-84-I	Test No. VC70-A-85-1	Test No. VC70-A-86-1	Test No. VC70-A-75-I
	Date Requested: 7/17/2007	Date Requested: 7/17/2007	Date Requested: 8/2/2007	Date Requested: 9/13/2007	Date Requested: 9/13/2007	Date Requested: 9/7/2007
	Date Started: 10/7/2007	Date Started: 8/8/07	Date Started: 11/8/07	Date Started: 11/16/07	Date Started: 11/24/2007	Date Started: 9/27/2007
	*Date Finished: 10/11/2007**	Date Finished: 8/13/2007 *	Date Finished: 11/15/2007 *	Date Finished: 11/20/2007 *	Date Finished: 11/28/2007*	Date Finished: 10/2/2007*
Dynamic Coeficient vs Cycle	Fail - Approx min coef: 0.105 Approx test coef: 0.100	Fail - Approx min coef: 0.105 Approx test coef: 0.099	Fail - Approx min coef: 0.105 Approx test coef: 0.097	Fail - Approx min coef: 0.105 Approx test coef: 0.098	Fail - Approx min coef: 0.104 Approx test coef: 0.098	Fail - Approx min coef: 0.104 Approx tested coef: 0.097
Dynamic Coeficient vs Load	Fail - Approx min coef: 0.105 Approx test coef: 0.103	Fail - Approx min coef: 0.105 Approx test coef: 0.099	Fail - Approx min coef: 0.105 Approx test coef: 0.095	Fail - Approx min coef: 0.104 Approx test coef: 0.095	Fail - Approx min coef: 0.104 Approx test coef: 0.098	Fail - Approx min coef: 0.104 Approx test coef: 0.095
Dynamic Coeficient vs Speed	Fail - Below spec until tested speed increases above approx 35 m/s	Fail - Below spec until tested speed increases above approx 36 m/s	Fail - Below spec until tested speed increases above approx 36 m/s	Fail - Below spec until tested speed increases above approx 38 m/s	Fail - Below spec until tested speed increases above approx 36 m/s	Fail - Below spec until tested speed increases above approx 36 m/s
Energy Limit	Pass	Pass	Pass	Pass	Pass	Pass
Static Coeficient vs Load	Pass	Pass	Pass	Pass	Pass	Pass
Static Coeficient vs Speed	Pass	Pass	Pass	Pass	Pass	Pass
Energy Limit	Pass	Pass	Pass	Pass	Pass	Pass
Total Wear	0.033	0.026	0.022	0.015	0.013	0.007
Wear Limit	0.030	0.03	0.030	0.030	0.030	0.030
Caterpillar TO-4	27637-L	AL-27252-L	AL-27793-L	AL-27875-L	AL-27876-L	AL-27877-L
SEQ 1221 (Steering Brake Paper)	Test No. VC70-A-77-I	Test No. VC70-A-70-I	Test No. VC70-A-84-I	Test No. VC70-A-85-1	Test No. VC70-A-86-1	Test No. VC70-A-75-I
	Date Requested: 7/17/2007	Date Requested: 7/17/2007	Date Requested: 8/2/2007	Date Requested: 9/13/2007	Date Requested: 9/13/2007	Date Requested: 9/7/2007
	Date Started: 10/7/2007	Date Started: 8/8/07	Date Started: 11/8/07	Date Started: 11/16/07	Date Started: 11/24/2007	Date Started: 9/27/2007
	*Date Finished: 10/11/2007**	Date Finished: 8/13/2007 *	Date Finished: 11/15/2007 *	Date Finished: 11/20/2007 *	Date Finished: 11/28/2007*	Date Finished: 10/2/2007*
Dynamic Coeficient vs Cycle	Pass	Pass	Pass	Pass	Pass	Pass
Dynamic Coeficient vs Load	Pass	Pass	Pass	Pass	Pass	Pass
Dynamic Coeficient vs Speed	Fail - Coef. within limits until tested speed increases above approx 24 m/s	Pass	Pass	Pass	Pass	Fail - Coef. within limits until tested speed increases above approx 21 m/s
Energy Limit	Pass	Pass	Pass	Pass	Pass	Pass
Static Coeficient vs Load	Pass	Pass	Pass	Pass	Pass	Fail - Borderline, marginally below spec throughout test duration (<0.005)
Static Coeficient vs Speed	Fail - Coef. within limits briefly at start of test then falls out of spec at approx 14 m/s	Pass	Pass	Pass	Pass	Fail - Coef. below limits at start of test and steadily decreases
Energy Limit	Pass	Pass	Pass	Pass	Pass	Pass
Total Wear	0.029	0.037	0.032	0.020	0.046	0.040
Wear Limit	0.070	0.070	0.070	0.070	0.070	0.070
Caterpillar TO-4	27637-L	AL-27252-L	AL-27793-L	AL-27875-L	AL-27876-L	AL-27877-L
SEQ 1222 (Wheel Brake Paper)	Test No. VC70-A-77-I	Test No. VC70-A-70-I	Test No. VC70-A-84-I	Test No. VC70-A-85-1	Test No. VC70-A-86-1	Test No. VC70-A-75-I
	Date Requested: 7/17/2007	Date Requested: 7/17/2007	Date Requested: 8/2/2007	Date Requested: 9/13/2007	Date Requested: 9/13/2007	Date Requested: 9/7/2007
	Date Started: 10/7/2007	Date Started: 8/8/07	Date Started: 11/8/07	Date Started: 11/16/07	Date Started: 11/24/2007	Date Started: 9/27/2007
	*Date Finished: 10/11/2007**	Date Finished: 8/13/2007 *	Date Finished: 11/15/2007*	Date Finished: 11/20/2007 *	Date Finished: 11/28/2007*	Date Finished: 10/2/2007*
Dynamic Coeficient vs Cycle	Pass	Pass	Pass	Pass	Fail - Borderline, marginally below min spec throughout entire test (<0.005)	Pass
Dynamic Coeficient vs Load	Pass	Pass	Pass	Pass	Fail - Coef within limits at start of test, quickly falls below min spec through remainder of test	Pass
Dynamic Coeficient vs Speed	Pass	Pass	Fail - Coef. within limits at start of test, quickly falls below min spec through remainder of test	Fail - Coef. within limits at start of test, quickly falls below min spec through remainder of test	Fail - Coef below limits throughout test	Fail - Coef. within limits until tested speed increases above approx 19 m/s
Energy Limit	Pass	Pass	Pass	Pass	Pass	Pass
Static Coeficient vs Load	Fail - Coef. within limits at start of test and falls below after approx 1600 kPa	Pass	Pass	Fail - Coef. within limits at start of test, falls below limits after 800 kPa	Fail - Borderline, Coef. within limits at start of test and falls below after 900 kPA (<0.005)	Fail - Coef. within limits at start of test, falls below limits after approx 700 kPa
Static Coeficient vs Speed	Fail - Coef. at start below min spec and steadily decreases throughout test	Pass	Pass	Fail - Coef. at start below min spec. Coef increases at approx 20 m/s and satisfies limits at approx 24 m/s through remainder of test	Pass	Fail - Coef. at start below min spec. Coef increases at approx 21 m/s and satisfies limits at approx 25 m/s through remainder of test
Energy Limit	Pass	Pass	Pass	Pass	Pass	Pass
Total Wear	0.047	0.039	0.029	0.054	0.038	0.033
Wear Limit	0.070	0.07	0.070	0.070	0.070	0.070

Table 2. TO4 Test Results Continued

	OEA 30 ME-35 (C) AL-27637-L	5W-40 EO 0067 (E) AL-27252-L	15W-40 EO 0058 (S) AL-27793-L	Experimental 5W-40 (L) AL-27875-L	15W-40 EO 0068 (L) AL-27876-L	OEA 30 (New) AL-27877-L
Caterpillar TO-4	27637-L	AL-27252-L	AL-27793-L	AL-27875-L	AL-27876-L	AL-27877-L
SEQ 1223 (Transmission Paper)	Test No. VC70-A-77-I	Test No. VC70-A-70-I	Test No. VC70-A-84-I	Test No. VC70-A-85-1	Test No. VC70-A-86-1	Test No. VC70-A-75-I
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Dynamic Coeficient vs Cycle	Pass	Fail - Coef. below limits at start of test, Coef. meets limits after approx 75 cycles	Fail - Approx min spec: 0.105 Approx tested spec 0.103	Fail - Approx min spec 0.108 Approx tested spec: 0.100	Fail - Borderline below test at start and finish (<0.005)	Fail - Approx min spec 0.110 Approx tested spec: 0.101
Dynamic Coeficient vs Load	Pass	Fail: Tested coef. approx 0.005 below min at start and below 0.002 at end of test	Fail - Tested coef. approx 0.007 below min at start and below 0.004 at end of test	Fail - Tested coef. approx 0.02 below min at start and below 0.005 at end of test	Fail - Tested coef. approx 0.004 below min at start and marginally below at end of test	Fail - Tested coef. approx 0.015 below at start and 0.005 at end of test
Dynamic Coeficient vs Speed	Fail - Coef within limits at start of test, falls below min limit at approx 21 m/s	Fail - Coef. below limits at start of test and steadily decreases. Coef. begins to increase after 25 m/s, but still below spec	Fail - Coef. below limits at start of test and steadily decreases.	Fail - Coef below limits at start of test and steadily decreases	Fail - Coef below limits at start of test and steadily decreases	Fail - Coef below limits at start of test and steadily decreases
Energy Limit	Pass	Pass	Pass	Pass	Pass	Pass
Static Coeficient vs Load	Fail - Approx min coef 0.150 Approx tested coef: 0.135	Fail - Coef. below limits at start of test, Coef. meets limits after approx 1400 kPa	Fail - Approx min coef: 0.150 Approx tested coef: 0.140	Fail - Approx min coef: 0.150 Approx tested coef: 0.130	Fail - Approx min coef: 0.150 Approx tested coef: 0.140	Fail - Approx min coef: 0.150 Approx tested coef: 0.134
Static Coeficient vs Speed	Fail - Coef. at start below min limit and steadily decreases through out test	Fail - Borderline below spec until after 25 m/s	Fail - Coef. below limits for approx first half of test, meets limits at approx 24 m/s	Fail - Coef. below limits at start of test. Coef. increases at approx 22 m/s but remains below limits through duration of test	Fail - Coef. below limits at start of test, meets limits at approx 23 m/s	Fail - Coef below limits at start of test. Coef. increases at approx 25 m/s but remains below limits through duration of test
Energy Limit	Pass	Pass	Pass	Pass	Pass	Pass
Total Wear	0.044	0.022	0.035	0.032	0.037	0.033
Wear Limit	0.070	0.07	0.070	0.070	0.070	0.070
Caterpillar TO-4	27637-L	AL-27252-L	AL-27793-L	AL-27875-L	AL-27876-L	AL-27877-L
SEQ 1224 (Elastomeric)	Test No. VC70-A-77-I	Test No. VC70-A-70-I	Test No. VC70-A-84-I	Test No. VC70-A-85-1	Test No. VC70-A-86-1	Test No. VC70-A-75-I
	Date Requested: 7/17/2007	Date Requested: 7/17/2007	Date Requested: 8/2/2007	Date Requested: 9/13/2007	Date Requested: 9/13/2007	Date Requested: 9/7/2007
	Date Started: 10/7/2007	Date Started: 8/8//07	Date Started: 11/8//07	Date Started: 11/16//07	Date Started: 11/24/2007	Date Started: 9/27/2007
	Date Finished - 10/11/2007*	Date Finished: 8/13/2007 *	Date Finished: 11/15/2007 *	Date Finished: 11/20/2007 *	Date Finished: 11/28/2007*	Date Finished: 10/2/2007*
Dynamic Coeficient vs Cycle	Fail - Coef. within limits at start of test, falls below min limit near end at approx 450 cycles	Pass	Pass	Fail - Borderline, Coef. slightly below limits at start of test and is satisfactory after approx 180 cycles	Pass	Fail - Borderline, Coef. slightly below limits at start of test and is satisfactory after approx 170 cycles
Dynamic Coeficient vs Load	Fail - Coef. below limits for approx first quarter of test, meets limits after approx 800 kPa	Pass	Pass	Pass	Pass	Fail - Borderline, Coef. slightly below limits during middle of test (<0.005)
Dynamic Coeficient vs Speed	Pass	Pass	Pass	Pass	Pass	Fail - Borderling, Coef. marginally below at start of test, satisfactory throughout remainder (<0.005)
Energy Limit	Pass	Pass	Pass	Pass	Pass	Pass
Static Coeficient vs Load	Pass	Pass	Pass	Pass	Pass	Pass
Static Coeficient vs Speed	Pass	Fail - Coef within limits until increasing above max value at approx 37 m/s	Fail - Coef within limits until increasing above max value at approx 36 m/s	Fail - Coef. within limits until increasing above max value at approx 38 m/s	Fail - Coef. within limits until increasing above max value at approx 36 m/s	Fail - Coef within limits until increasing above max value at approx 35 m/s
Energy Limit	Pass	Pass	Pass	Pass	Pass	Pass
Total Wear	0.027	0.029	0.011	0.019	0.016	0.000
Wear Limit	0.040	0.040	0.040	0.040	0.040	0.040

Below are some generalizations from the data in shown Table 1 and Table 2 based on sequence number.

<u>Seq. 1219 (Raybestos Elastomeric)</u> – All candidate oils performed in a similar manner. Dynamic coefficient versus load and cycle values were slightly below spec but consistent between all candidate oils. Dynamic coefficient versus speed for all oils was below spec until relative speeds increased to 35-38 m/s. All static coefficients measured within reference fluid ranges.

<u>Seq. 1221 (Steering Brake Paper)</u> – All oils except arctic grades passed within reference oil specs. OEA 30 ME-35 (C) and OEA 30 (New) shared similar failures in the dynamic and static coefficient versus speed measurements.

<u>Seq. 1222 (Wheel Brake Paper)</u> – No failure patterns were identified within this sequence. 5W-40 EO 0067 (E) was the only oil to pass all tests.

<u>Seq. 1223 (Transmission Paper)</u> – All candidate oils performed in a similar manner. OEA 30 ME-35 (C) measured slightly better than other tested grades. Measured coefficient of friction values for dynamic versus load and cycle are slightly below reference oil specs for all remaining oils.

<u>Seq. 1224 (CAT F37 Elastomeric)</u> – All candidate oils with the exception of OEA 30 ME-35 (C) failed in a similar manner. Experimental 5W-40 (L) and OEA 30 (New) had some additional failures from the group, but were borderline in magnitude.

4.1.2 Performance by Viscosity Grade

Below lists the individual comparisons between candidate oils by viscosity grade.

<u>5W-40 EO 0067 (E) and Experimental 5W-40 (L) in TO-4 sequences 1219, 1221–24:</u>

- Seq. 1219 (Raybestos Elastomeric)—Nearly identical failures and error margins.
- Seq. 1221 (Steering Brake Paper)—Both passed all tests

- Seq. 1222 (Wheel Brake Paper)— 5W-40 EO 0067 (E) passed all tests with Experimental 5W-40 (L) falling out of error limits during three tests (static coefficient vs. load, static and dynamic coefficient vs. speed)
- Seq. 1223 (Transmission Paper)—Similar failures for both oils
- Seq. 1224 (CAT F37 Elastomeric)—Nearly identical failures and error margins. Experimental 5W-40 (L) had additional borderline failure of dynamic coefficient vs. cycle

<u>15W-40 EO 0058 (S) and 15W-40 EO 0068 (L) in TO-4 sequences 1219, 1221-24:</u>

- Seq. 1219 (Raybestos Elastomeric)—Nearly identical failures and error margins.
- Seq. 1221 (Steering Brake Paper)—Both oils passed all tests.
- Seq. 1222 (Wheel Brake Paper)— 15W-40 EO 0058 (S) failed dynamic coefficient vs. speed. 15W-40 EO 0068 (L) failed both dynamic coefficient vs. speed and load, with additional borderline failures in dynamic coefficient vs. cycle, and static coefficient vs. load.
- Seq. 1223 (Transmission Paper)—Nearly identical failures and error margins.
- Seq. 1224 (CAT F37 Elastomeric)—Nearly identical failures and error margins

<u>OEA 30 ME-35 (C) and OEA 30 (New) in TO-4 sequences 1219, 1221–24:</u>

- Seq. 1219 (Raybestos Elastomeric)—Nearly identical failures and error margins.
- Seq. 1221 (Steering Brake Paper)—Failures similar with the exception of OEA 30 (New) borderline failure in static coefficient vs. load.
- Seq. 1222 (Wheel Brake Paper)—OEA 30 (New) failed dynamic coefficient vs. speed but OEA 30 ME-35 (C) passed. Both oils failed the static coefficient vs. load test, but OEA 30 (New) failed at a lower 700kPa compared to 1600kPa for the OEA 30 ME-35 (C). Both oils start below limits for static coefficient vs. speed, but OEA 30 (New) increases within limits through test duration while OEA 30 ME-35 (C) remains below.
- Seq. 1223 (Transmission Paper)—OEA 30 (New) failed both dynamic coefficient vs. cycle and load, which OEA 30 ME-35 (C) oil passed. Remainder of failures nearly identical.

- Seq. 1224 (CAT F37 Elastomeric)—OEA 30 (New) did better with all of its failures except one being borderline. OEA 30 (New) failed static coefficient vs. speed after 35 m/s.

SEQ 1220 and FRRET were completed on the Experimental 5W-40 (L) and OEA 30 (New) in accordance to standard mil-spec oil testing requirements. Test results are presented in the same format as previously discussed TO-4 results. See Table 3 below for Seq. 1220 and FRRET results.

Table 3. Seq. 1220 and FRRET Results

		Sequence	Dynamic Coefficient vs. Cycle	Dynamic Coefficient vs. Load	Static Coefficient vs. Load	Dynamic Coefficient vs. Speed	Static Coefficient vs. Speed	Energy Limit [P/CycleNo.]
OEA 30 (New)	**AL--27877**	1220	FAIL	FAIL	PASS	FAIL	PASS	PASS
		FRRET	PASS					
Experimental 5W-40 (L)	**AL-27875**	1220	PASS	PASS	PASS	PASS	PASS	PASS
		FRRET	FAIL					

4.2 DEXRON VI

Both arctic oil blends, OEA 30 ME-35 (C) and OEA 30 (New), were tested in Dexron VI friction tests as a basis to compare oil performance when used in automatic transmission applications requiring Dexron approved fluids. These tests included the Dexron VI band clutch, plate clutch, and low speed clutch friction tests. All of these tests are carried out using an SAE No. 2 friction test machine. An SAE No. 2 friction machine is similar in concept to the previously discussed CAT TO-4 test apparatus, whereas rotating clutch disks are engaged into a stationary reaction plate while recording the resulting torque value, clutch rotation speed, and application pressure.

The SAE No. 2 friction test machine can be operated in two different ways. The first option is to bring the clutch disks up to speed using the drive motor, then turning the motor off and engaging the disks to the stationary reaction plate. The second option is to engage the clutch disks to the reaction plate with the motor off, then turning on the motor and recording the static break away torque. The Dexron VI band and plate clutch tests follow the first format, while the low speed clutch test incorporates both formats.

Test results from the Dexron VI friction tests are presented in Table 4. Both oils passed the band and low speed clutch tests with satisfactory performance results meeting the Dexron VI specifications. For the plate clutch friction test, both oils failed to meet the required Dexron VI specifications.

Table 4. Dexron VI Friction Test Results

	OEA 30 ME-35 (C) AL-27637	**OEA 30 (New) AL-27877-L**
DEXRON-VI Band Clutch Friction	Test No. BH3-4-164	Test No. BH3-8-169
	Date Requested: 7/17/2007	Date Requested: 9/7/2007
	Date Started: 7/30/2007	Date Started: 9/14/2007
	Date Finished: 8/6/2007*	Date Finished: 9/21/2007 *
	Pass	Pass
DEXRON-VI Plate Clutch Friction	AL-27637	AL-27877-L
	Test No. HC-11-24-80	Test No. HC11-1-82
	Date Requested: 7/17/2007	Date Requested: 9/7/2007
	Date Started: 7/30/2007	Date Started: 9/11/2007
	Date Finished: 8/7/2007*	Date Finished: 9/19/2007 *
	Fail	Fail
DEXRON-VI Low Speed Clutch Friction	AL-27637	AL-27877-L
	Test No. 12-5-0363	Test No. LS12-5-0374
	Date Requested: 7/17/2007	Date Requested: 9/7/2007
	Date Started: 7/30/2007	Date Started: 9/10/2007
	Date Finished: 7/31/2007*	Date Finished: 9/11/2007 *
	Pass	Pass

Similar to CAT TO-4 testing, further investigation was needed to quantify the oils relative performance. It was found that the low speed clutch failures were due to both oils not meeting the specified maximum torque of >90 Nm required by the plate clutch friction test. From the test results, it was found that both oils maintained a steady range of maximum torque, with values falling between 85-88 Nm. Although this torque value lies below the specifications set forth by the Dexron VI standards, it should be adequate to ensure functionality and durability when used in military equipment. Analysis of the torque capacity plots versus speed and clutch pressure shows the oils tested do not have any undesirable characteristics. Over the duration of testing, the overall clutch performance does not change with steady maximum torque values and a smooth transition from dynamic to static friction as the speed approaches zero. If the plots were to have shown substantial variation of the maximum torque measured throughout the test duration, or large torque spikes during the dynamic to static transition, the use of these oils could be problematic. Neither of the tested oils displays these negative characteristics and should be considered capable to adequately perform in drivelines requiring the Dexron VI rated fluids.

4.3 JOHN DEERE JDQ-96

The John Deere JDQ-96 test procedure is used to determine brake noise (or chatter) and capacity of an immersed brake system provided by a candidate oil compared to a baseline reference oil. Testing is carried out using a John Deere 1400 series industrial axle powered by a full sized modified John Deere 4640 tractor. The sun pinion shaft is equipped with strain gauges to measure dynamic torque changes throughout a total of 30,000 braking cycles. Chatter tests are run after 1,000, 10,000, 20,000, and 30,000 braking cycles. Torque data is acquired for a variety of axle speeds and loads. Chatter is evaluated over 32°, 49°, 60°, and 71°C fluid temperatures with varying brake application pressures and wheel speeds.

Each candidate oil was subjected to the first 1,000 cycles of the standard 30,000-cycle test. Results are presented in Table 5. Torque variation is defined as the greatest difference between the maximum and minimum torque over a 0.2 second portion of the engagement event. SwRI torque variation is defined as the sum of all the differences between the maximum and minimum torque for each engagement. Relative capacity is the average torque value during the middle of an engagement.

Table 5. John Deere JDQ-96 Test Results

	Reference Oil Range	OEA 30 ME-35 (C) AL-27637-L	OEA 30 (New) AL-27677-L
Torque Variation	59,000-100,00 Nm	85,000 Nm	158,000 Nm
SwRI Tq. Variation	750,000-1,250,000 Nm	1,115,000 Nm	2,200,000 Nm
Relative Capacity	330,000-350,000 Nm	365,000 Nm	345,000 Nm
Disk Thickness	Approx 7.5 mm	In Spec	In Spec
	Reference Oil Range	**5W-40 EO 0067 (E) AL-27252-L**	**Experimental 5W-40 (L) AL-27875-L**
Torque Variation	59,000-100,00 Nm	205,000 Nm	180,000 Nm
SwRI Tq. Variation	750,000-1,250,000 Nm	2,600,000 Nm	2,150,000 Nm
Relative Capacity	330,000-350,000 Nm	370,000 Nm	350,000 Nm
Disk Thickness	Approx 7.5 mm	In Spec	In Spec
	Reference Oil Range	**15W-40 EO 0058 (S) AL-27793-L**	**15W-40 EO 0068 (L) AL-27876-L**
Torque Variation	59,000-100,00 Nm	DNF-Testing stopped due to excessive chatter	200,000 Nm
SwRI Tq. Variation	750,000-1,250,000 Nm		2,500,000 Nm
Relative Capacity	330,000-350,000 Nm		335,000 Nm
Disk Thickness	Approx 7.5 mm		In Spec

Since testing only included the first 1,000 cycles of the standard JDQ test, all oils met the standard set by the reference oil for disk thickness. (*Note – The JDQ96 test with oil 15W-40 EO 0058 (S) was terminated early due to excessive chatter. Further investigation is needed to determine overall compatibility with equipment requiring fluids that meet JDQ96 specifications)

4.4 ALLISON C4

Similar to the Dexron VI friction tests, the Allison C4 paper and graphite high-energy friction tests are carried out in an SAE No.2 Friction Test Machine. This testing was carried out on the OEA 30 (New) fluid only. A pass-fail criterion for each fluid is based on a maximum allowed slip time and a minimum mid-point coefficient of friction value. Results for the OEA 30 (New) are presented in Table 6. The OEA 30 (new) passed both the paper and graphite tests.

Table 6. Allison C4 Friction Test (Graphite & Paper), OEA 30 (new)

Allison C4 Paper Test				
Property	**Spec**	**Result @ 100N**	**Result @ 10,000N**	**P/F**
Slip Time (Max)	0.600	0.530	0.460	P
Mid-Point Fric. Coef. (Min)	0.085	0.095	0.110	P

Allison C4 Graphite Test				
Property	**Spec**	**Result @ 100N**	**Result @ 10,000N**	**P/F**
Slip Time (Max)	0.81	0.73	0.78	P
Mid-Point Fric. Coef. (Min)	0.093	0.101	0.097	P

5.0 CONCLUSIONS

In addition to engine crankcase applications, a multifunctional lubricant must be capable of being used in military automatic/powershift transmission applications. To assess the feasibility of a SCPL, several engine oils were evaluated in industry standard transmission test procedures including selected: Allison C4, Caterpillar TO-4, and John Deere JDQ test procedures. Many of these industry transmission frictional tests utilize an SAE No. 2 friction testing machine. This machine measures the engagement properties of friction and reaction plates and test fluid over a wide range of speeds and application forces. It instantaneously records multiple parameters including load applied, torque transmitted, and plate speed to determine overall torque capacity, dynamic and static coefficients of friction, and slip time. Results are then compared to a baseline fluid which brackets desired performance and determines pass or fail of a candidate fluid.

While the engine oils tested resulted in a mixture of passing and failing results, overall the performance was generally favorable. The most difficult requirement for any multifunctional oil is compatibility with the large variety of friction materials being used in transmission applications. The level of friction developed between the friction material and reaction plates determines the feel of the shift (i.e., harshness) and amount of torque that can be transmitted without the clutch slipping. Clutch damage can occur if the coefficient of friction between the friction material and the reaction plate is too low. Low friction during a clutch engagement results in long slip times and excessive heat buildup which can cause deposit formation on the friction and reaction plate surfaces (i.e., glazing). If the friction is too high, the result will be very short, abrupt shifts. Passenger car ATFs use friction modifiers to ensure smooth shifts. The downside of friction modification is that it can reduce the clutch holding capacity. Given the large mass and high torque of heavy-duty equipment, heavy-duty automatic/powershift transmission fluids are typically not friction modified. In fact, it is more typical to look for ways to maximize the friction in these transmissions. Formulators of multifunctional oils like those developed for military use must choose a formulation strategy that does not result in excessively low dynamic and static coefficients of friction.

The testing matrix consisted of 6 engine oils that were evaluated in 5 Caterpillar TO-4 test sequences (1219, 1221, 1222, 1223, and 1224). One arctic oil and an SAE 5W40 oil were tested in Caterpillar Sequence 1220 and FRRET. Six engine oils were tested for 1000 cycles of the JDQ-96 procedure. Two arctic engine oils were evaluated for friction performance by Dexron VI methods. Finally, one of the arctic engine oils was tested against the friction retention requirements of Allison C4 Paper and Graphitic materials. The summarized results were:

- None of the engine oils evaluated was able to pass all of the TO-4 requirements for sequences 1219, 1221, 1222, 1223, and 1224.
- All engine oils passed the wear limits of sequences 1219, 1221-1224.

- All engine oils passed the static friction requirements of sequence 1219.
- Oil E, SAE 5W40, passed all requirements for sequences 1221 and 1222.
- Except for the two arctic engine oils, all engine oils passed sequence 1222.
- Most engine oils failed all friction requirements of sequence 1223.
- Overall, TO-4 performance of engine oils could not be predicted by viscosity alone.
- Oil S, SAE 15W40, was not able to complete the initial 1000 cycles of JDQ-96 test. The test was terminated early because of excessive brake chatter.
- The two arctic oils passed the band clutch friction and low speed clutch friction of Dexron VI. Their clutch plate friction was stable, but slightly below the maximum required by Dexron VI.
- Oil OEA 30 (new) failed sequence 1220 and passed FRRET.
- Oil L (SAE 5W40) passed sequence 1220 and failed FRRET.
- Oil OEA 30 (new) passed the Allison C4 friction tests, both paper and graphite.

Overall, the friction bench tests indicate that use of engine oils in military automatic/ powershift transmission applications is technically feasible as evidenced by passing or near passing results with the slate of engine oils tested. This means it is feasible to combine diesel engine performance and military automatic/ powershift transmission performance in an SCPL.

6.0 REFERENCES

[1] MIL-PRF-2104J, “Lubricating Oil, Internal Combustion Engine, Combat/Tactical Service”, 11 February 2014.

[2] MIL-PRF-46167D, “Lubricating Oil, Internal Combustion Engine, Arctic”, 27 January 2005.

[3] TO-4, Caterpillar Inc. Transmission and Drivetrain Fluid Requirements, 23 June 2005.

APPENDIX A

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

FUELS AND LUBRICANTS RESEARCH DIVISION

Report on

CATERPILLAR TO-4 FRICTION PROPERTIES, VC-70

Conducted for

ARMY LAB

Oil Code:
AL-27252-L

Test Number:
VC70-A-70-I

August 13, 2007

Submitted by:

Brian Koehler
Principal Engineer
Specialty & Driveline Fluids
Evaluations

CATERPILLAR TO-4 FRICTION PROPERTIES, VC-70

Summary Sheet

Company: ARMY LAB

Test start date: August 8, 2007
End of test date: August 13, 2007
Oil Code: AL-27252-L

Sequence Number	1219	N/A	1221	1222	1223	1224	Friction Retention
Dynamic Coefficient Vs. Cycle:	F	N/A	P	P	F	P	N/A
Dynamic Coefficient Vs. Load:	F	N/A	P	P	F	P	
Dynamic Coefficient Vs. Speed:	F	N/A	P	P	F	P	
Energy Limit:	P	N/A	P	P	P	P	
Static Coefficient Vs. Cycle:							N/A
Static Coefficient Vs. Load:	P	N/A	P	P	F	P	
Static Coefficient Vs. Speed:	P	N/A	P	P	F	F	
Energy Limit:	P	N/A	P	P	P	P	
Total Wear:	0.026	N/A	0.037	0.039	0.022	0.029	
Wear Limit:	0.030	N/A	0.070	0.070	0.070	0.040	

Comments:

The limit lines shown in each sequences' report were generated using the CAT single grade reference oil.

F = Fail
P = Pass
N/A = Not Applicable

SOUTHWEST RESEARCH INSTITUTE
I MACHINE OIL TEST AL-27252-L / LO-222424

Test name:	A-70-I
Test date:	08/8/07
Test description:	AL-27252-L
Oil type:	AL-27252-L LO-222424
Viscosity:	SAE 5W-40
Miscellaneous:	
Software version:	1.40

Run name & desc:	I0706076 - AL-27252-L
Run date:	08/08/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	HC
Remarks:	"I" MACHINE OIL TEST AL-27252-L / LO-222424
Sequence name:	SEQ1219
Remarks:	Use 1Y0708 Disc and 1Y3610 Plate
Number of cycles run:	1080

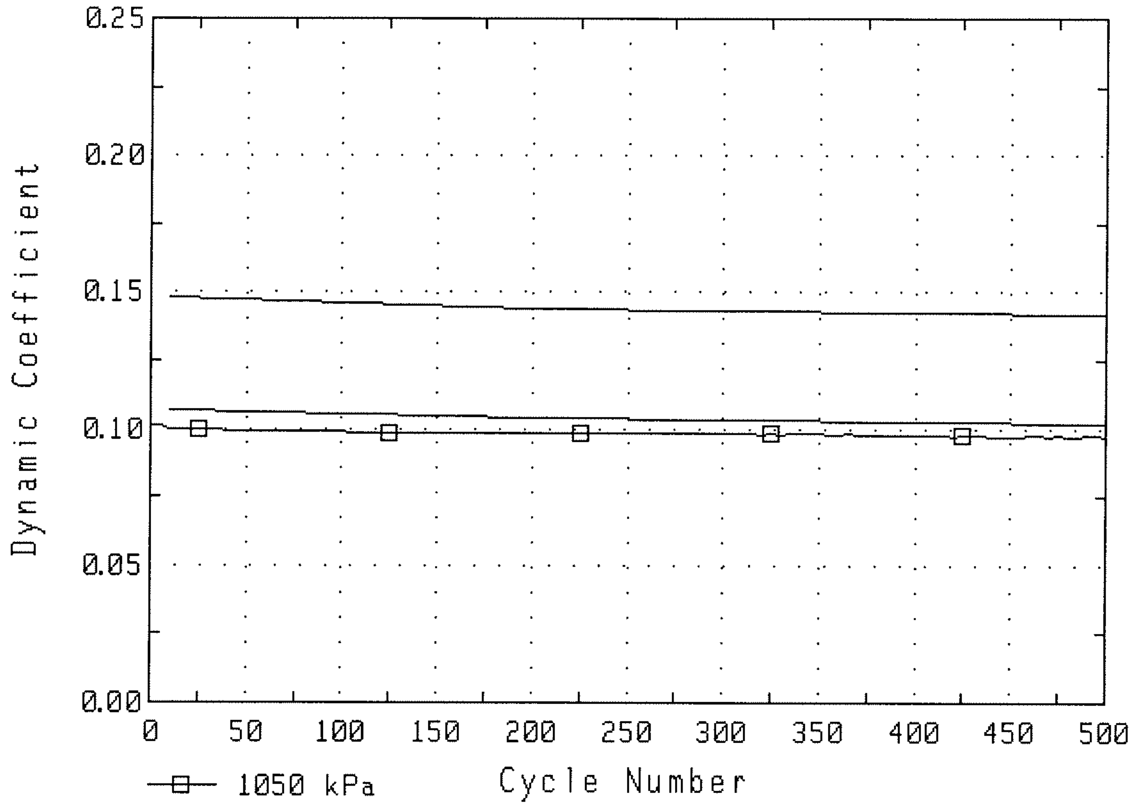
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 $N\text{-}m\text{-}s^2$

Disc name & desc:	1Y0708 - Elastomeric Disc
Material:	Raybestos 6475-4 Rayflex
Groove pattern:	Single Lead Spiral - 12 Radial
Miscellaneous:	Use with 1Y3610 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	14JA1-00005
Remarks:	ELASTOMERIC

Plate name & desc:	1Y3610 - Steel Plate
Surface:	0.70 to 1.30 micron Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	14JA1-00005
Remarks:	0.86 SURFACE FINISH

Report limit name:	LIM1219 - Reference run: I0706001
Limit file generated:	07/26/06
Report format name:	REP1219 - ELASTOMERIC, RAYFLEX

Test: A-70-I Run: I0706076 Started on 08/08/07 at 08:45

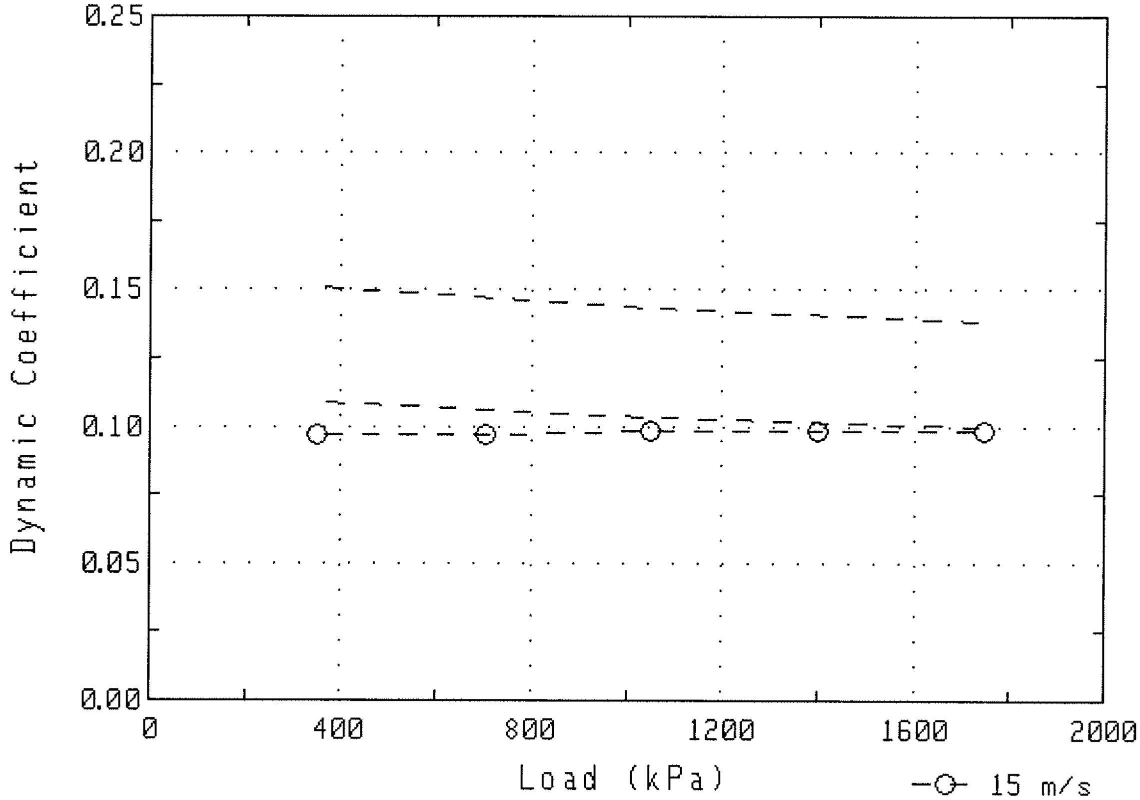


1Y0708 DISC
THICKNESS

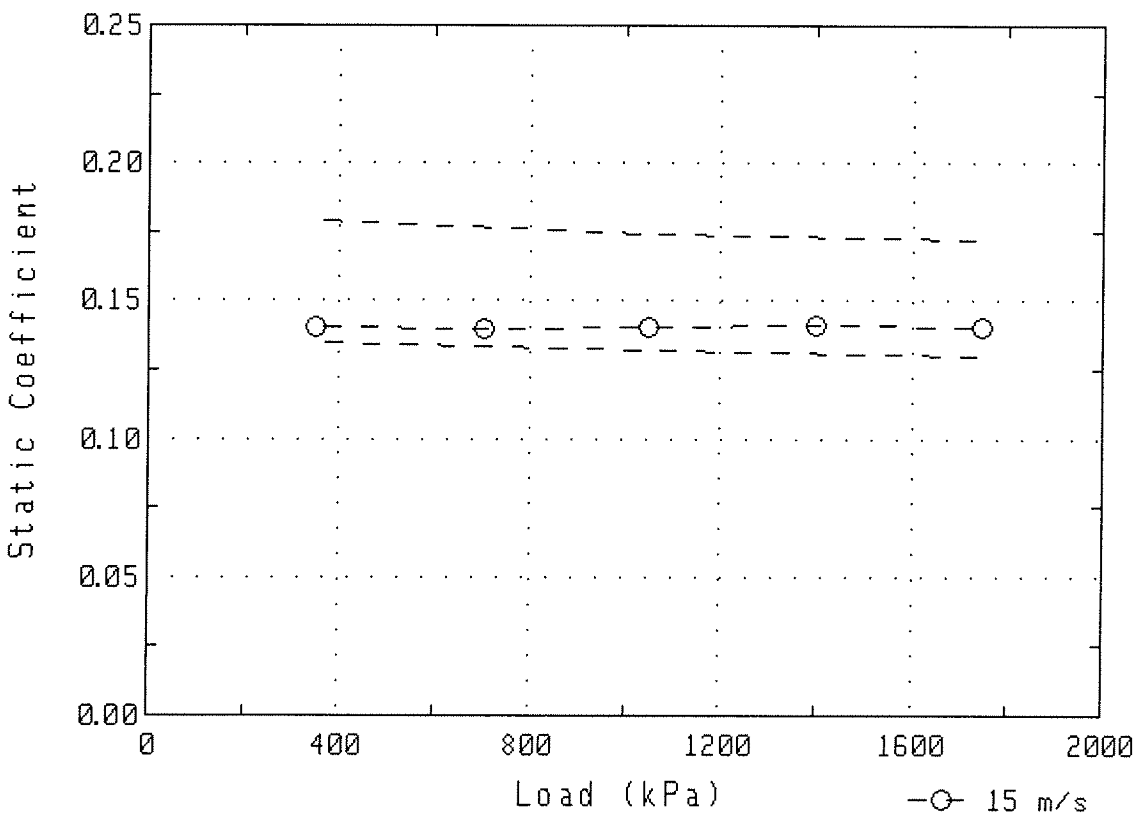
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	4.98	4.97	4.96	4.98	4.97	4.96
2	4.98	4.97	4.96	4.98	4.97	4.96
3	4.98	4.97	4.96	4.99	4.97	4.96
4	4.98	4.96	4.95	4.98	4.96	4.95
5	4.98	4.96	4.95	4.98	4.96	4.95
6	4.98	4.96	4.95	4.98	4.96	4.95
Avg	4.98	4.96	4.96	4.98	4.96	4.96

Compression set average wear: 0.016
M2 - M3 average Wear: 0.010

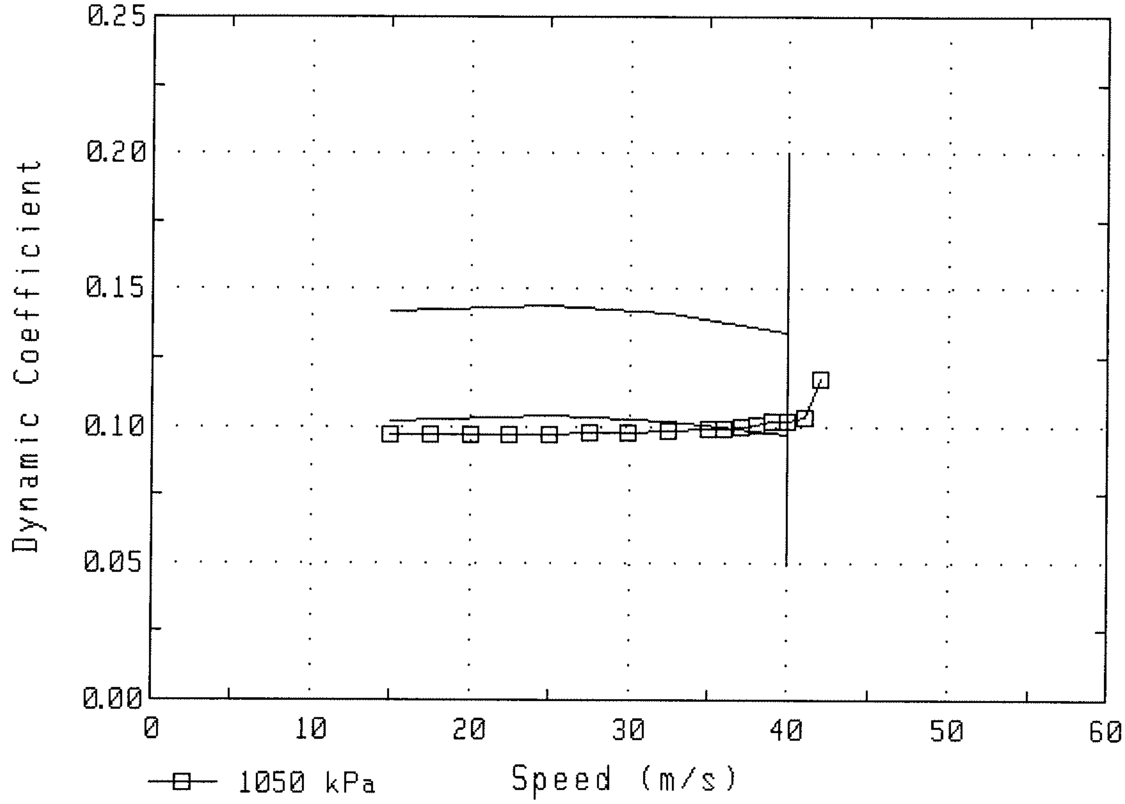
Total Wear (all measurements in mm): 0.026

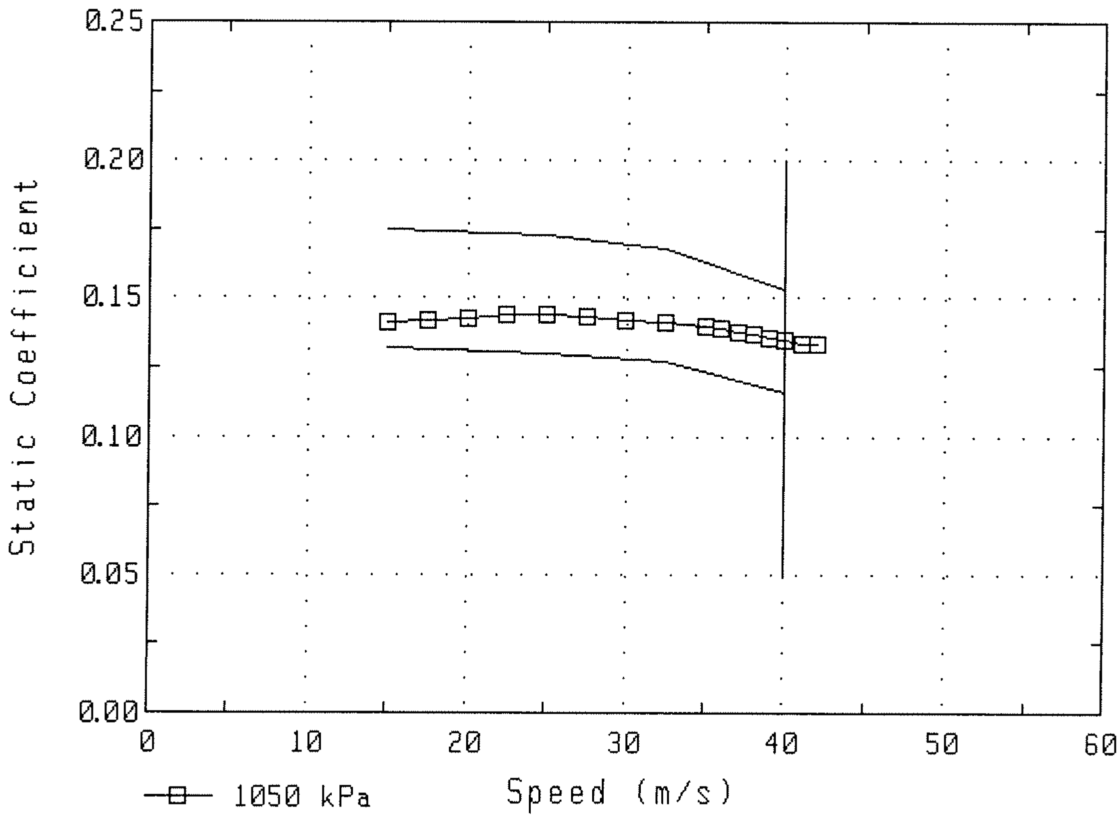


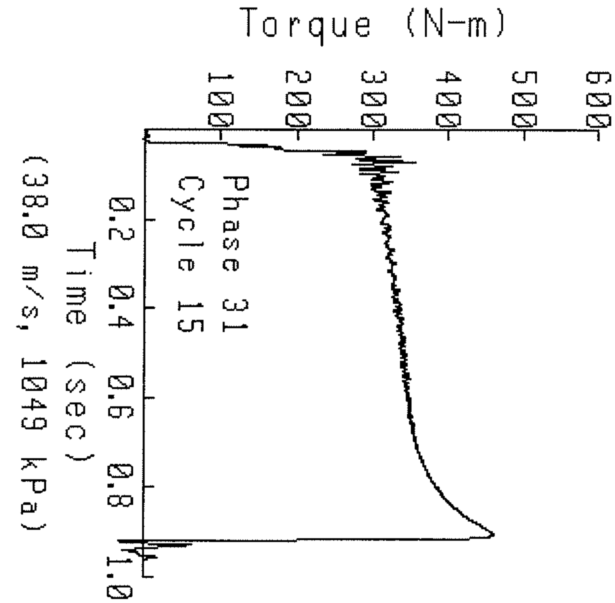
0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

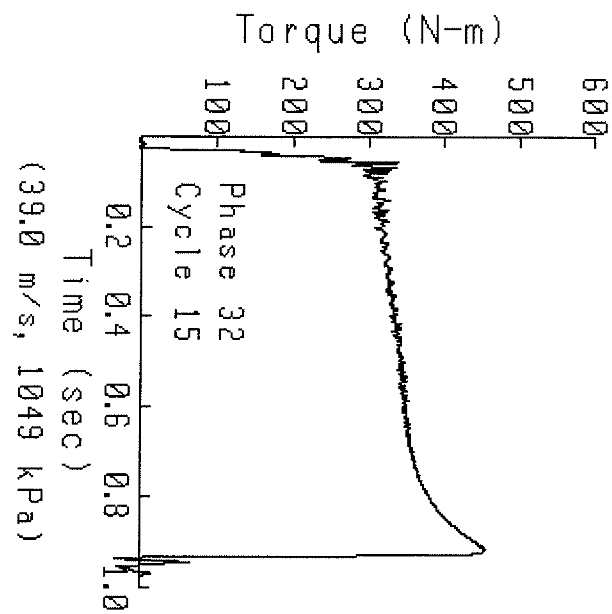


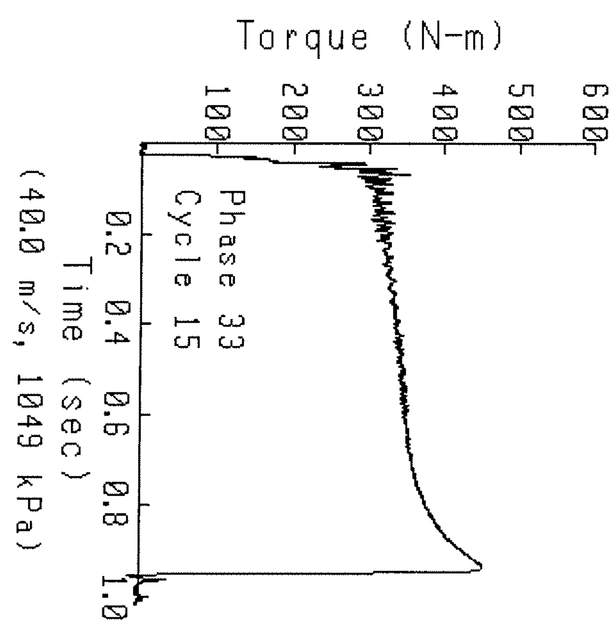
0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

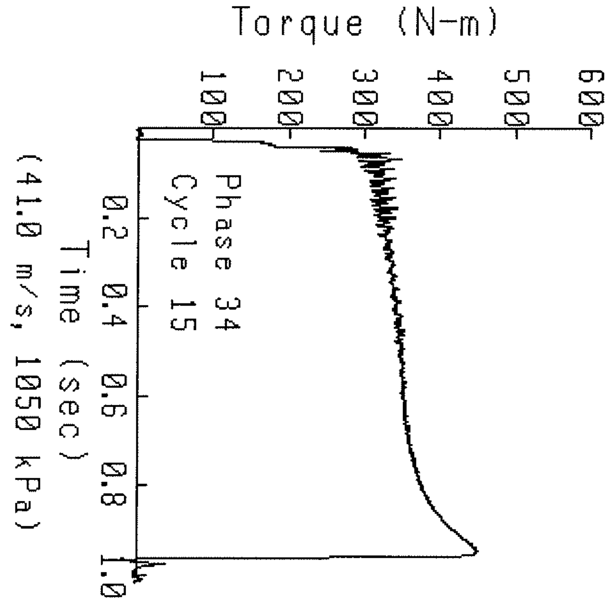

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

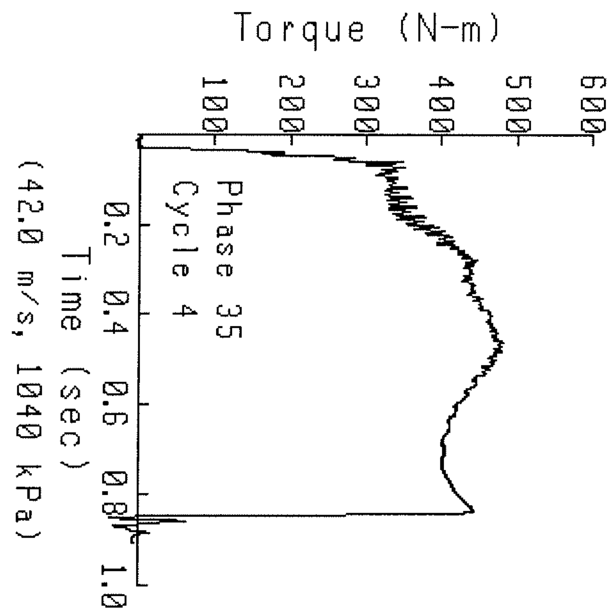

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

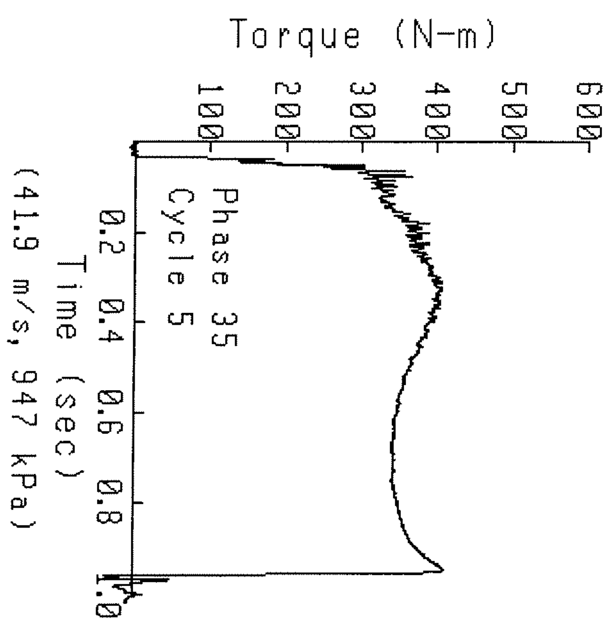

Torque (N-m)
100 200 300 400 500 600
Phase 31
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(38.0 m/s, 1049 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 32
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(39.0 m/s, 1049 kPa)

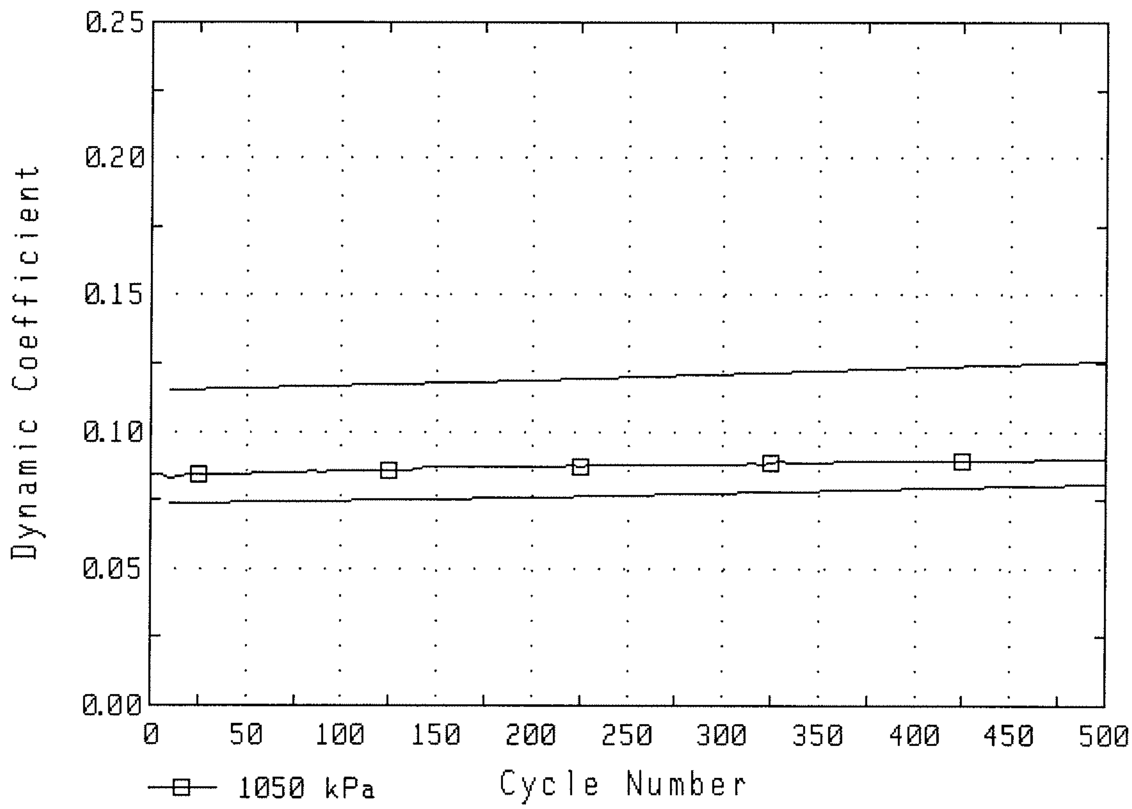

Torque (N-m)
100 200 300 400 500 600
Phase 33
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(40.0 m/s, 1049 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 34
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(41.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 35
Cycle 4
0.2 0.4 0.6 0.8 1.0
Time (sec)
(42.0 m/s, 1040 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 35
Cycle 5
0.2 0.4 0.6 0.8 1.0
Time (sec)
(41.9 m/s, 947 kPa)

Test name:	A-70-I
Test date:	08/8/07
Test description:	AL-27252-L
Oil type:	AL-27252-L LO-222424
Viscosity:	SAE 5W-40
Miscellaneous:	
Software version:	1.40
Run name & desc:	I0706078 - AL-27252-L
Run date:	08/09/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	HC
Remarks:	"I" MACHINE OIL TEST AL-27252-L / LO-222424
Sequence name:	SEQ1221
Remarks:	Use 1Y0710 Disc and 1Y3610 Plate.
Number of cycles run:	1057
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 $N\text{-}m\text{-}s^2$
Disc name & desc:	1Y0710 - Steering Brake Paper
Material:	Raybestos 7894-4 Paper
Groove pattern:	2 - 37 Multiple Parallel
Miscellaneous:	Use with 1Y3610 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	23MR9-00001
Remarks:	STEERING BRAKE PAPER
Plate name & desc:	1Y3610 - Steel Plate
Surface:	0.70 to 1.30 micron Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	23MR9-00001
Remarks:	0.98 SURFACE FINISH
Report limit name:	LIM1221 - Reference run: I0706003
Limit file generated:	07/26/06
Report format name:	REP1221 - STEERING BRAKE PAPER

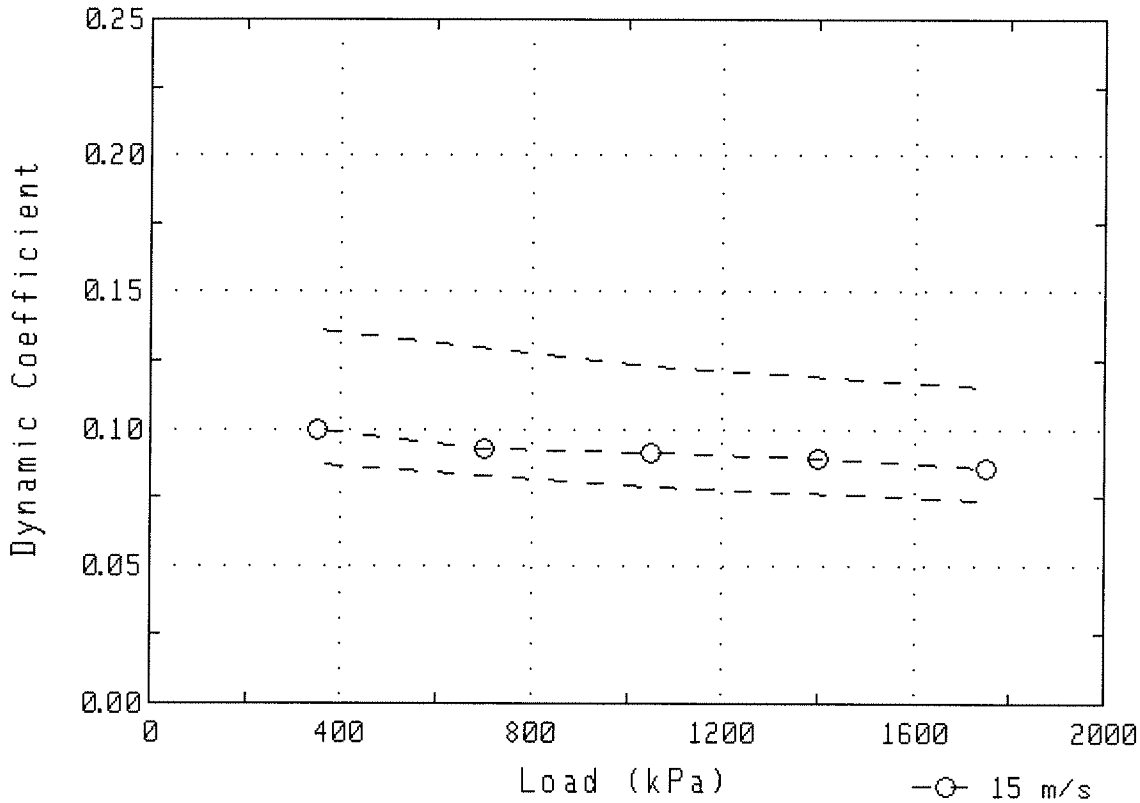


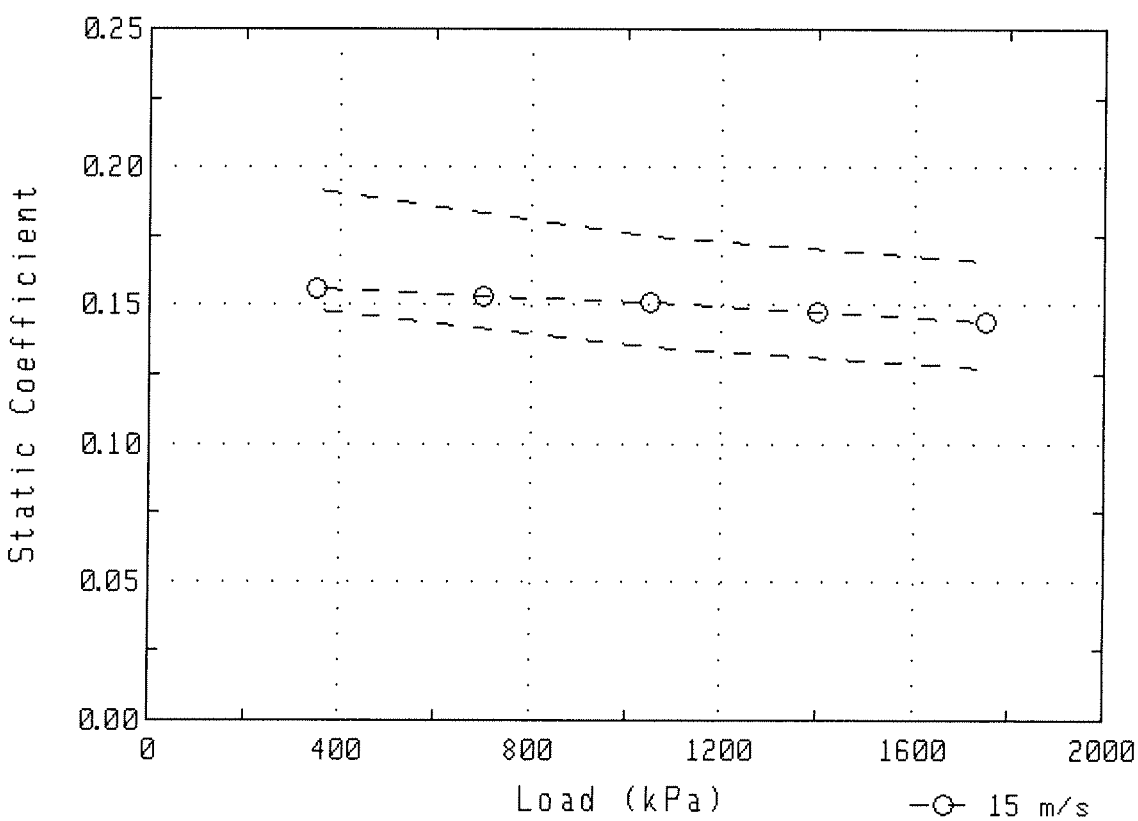
1Y0710 DISC
THICKNESS

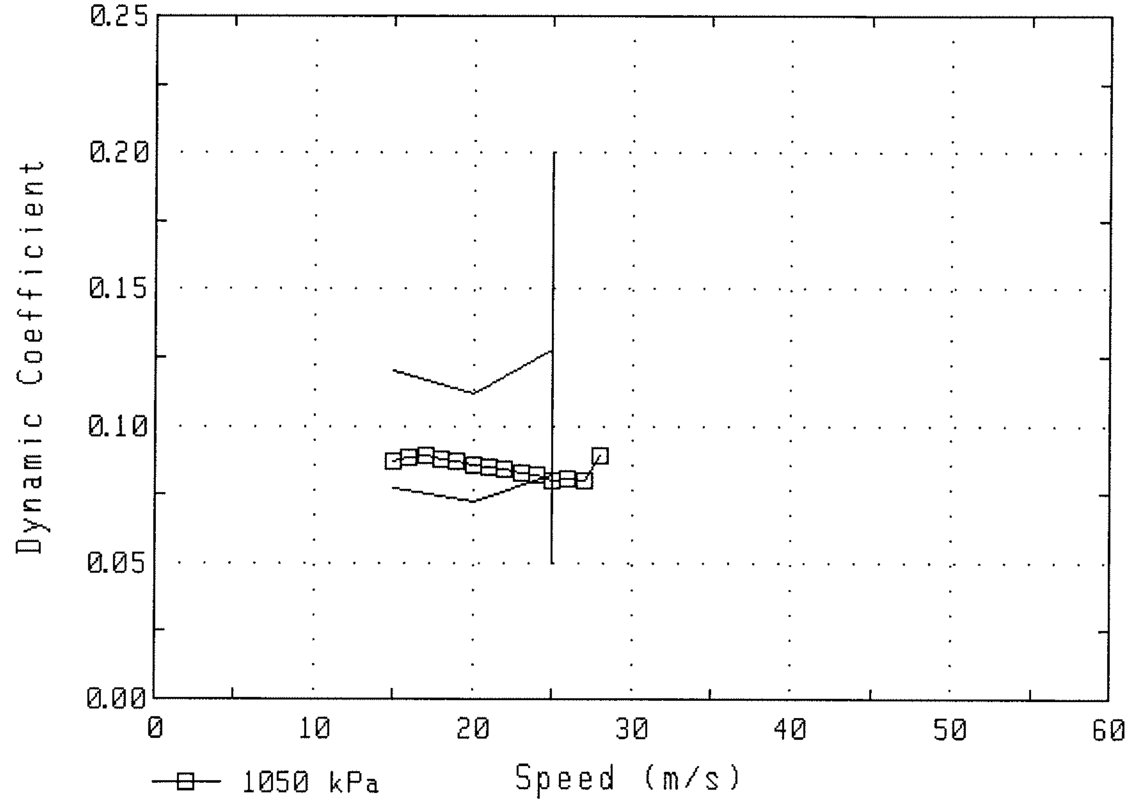
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	5.04	5.01	5.00	5.04	5.01	5.00
2	5.04	5.01	5.00	5.04	5.01	5.00
3	5.03	5.01	5.00	5.03	5.01	5.00
4	5.03	5.00	4.99	5.03	5.00	4.99
5	5.03	5.01	4.99	5.03	5.00	4.99
6	5.02	5.00	4.99	5.02	5.00	4.99
Avg	5.03	5.01	4.99	5.03	5.01	4.99

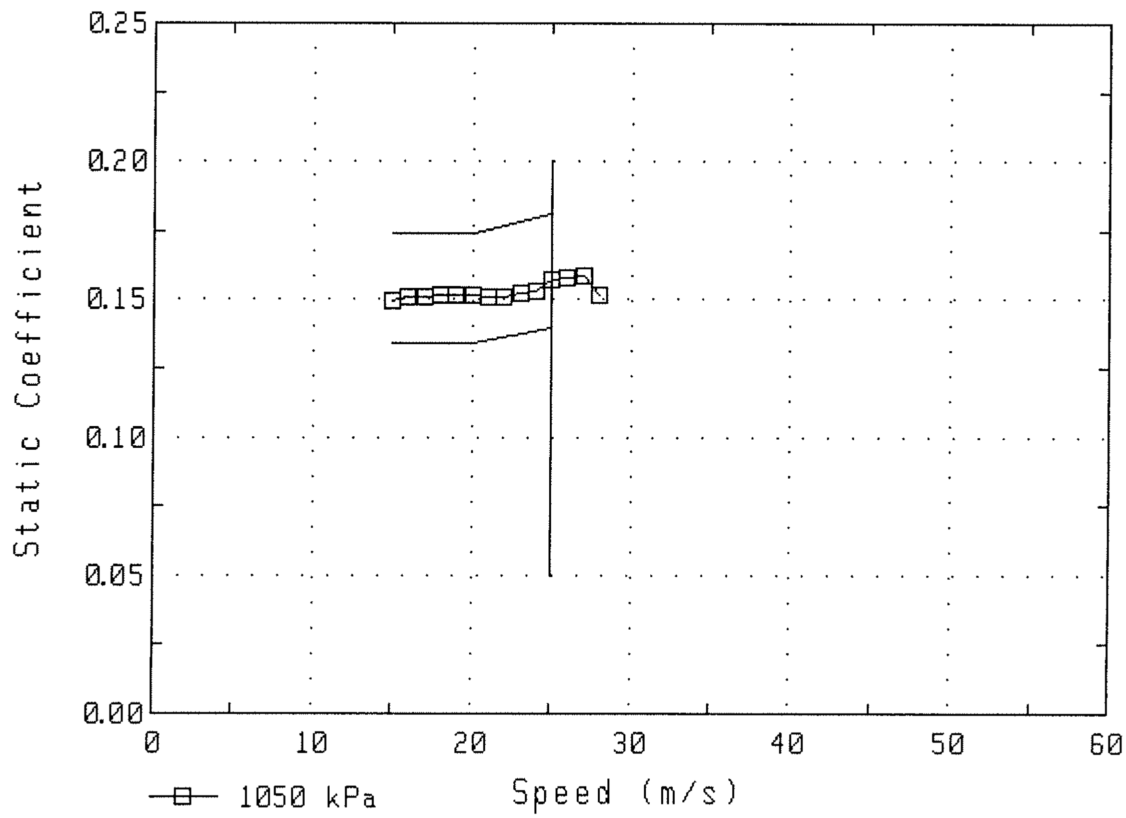
Compression set average wear: 0.026
M2 - M3 average Wear: 0.011

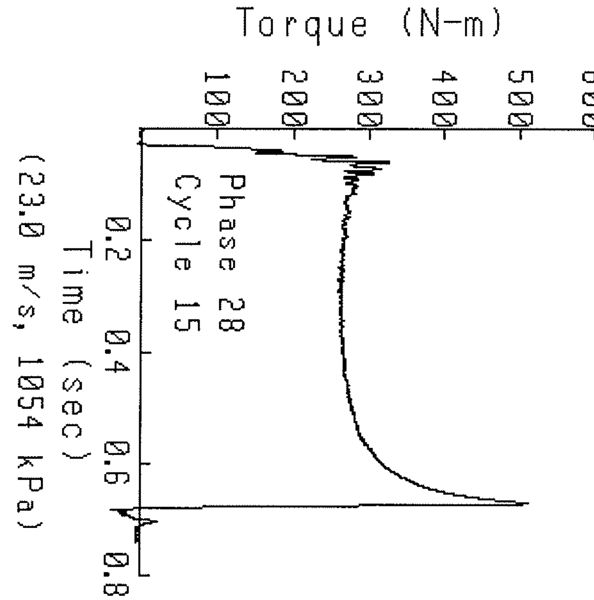
Total Wear (all measurements in mm): 0.037

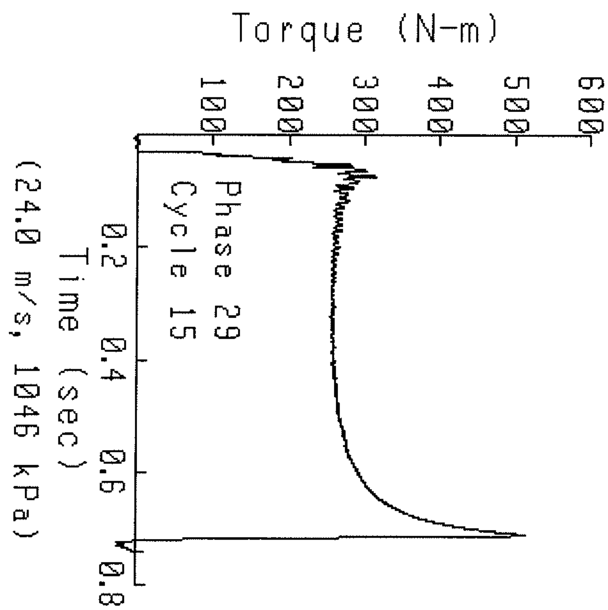

Dynamic Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

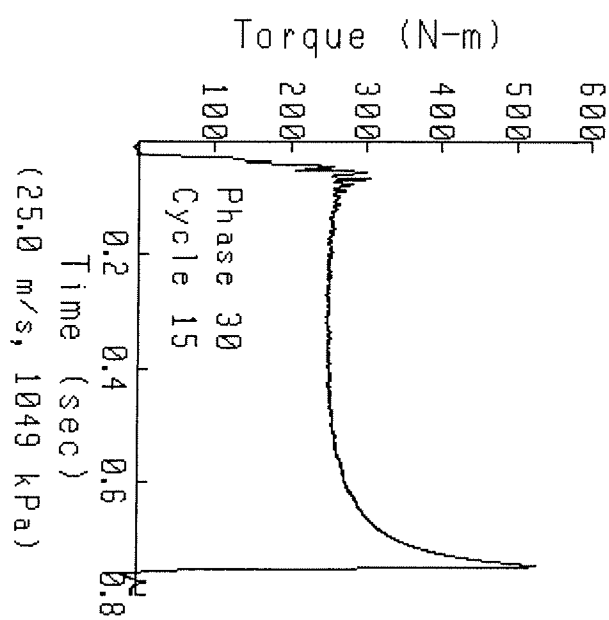

Static Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

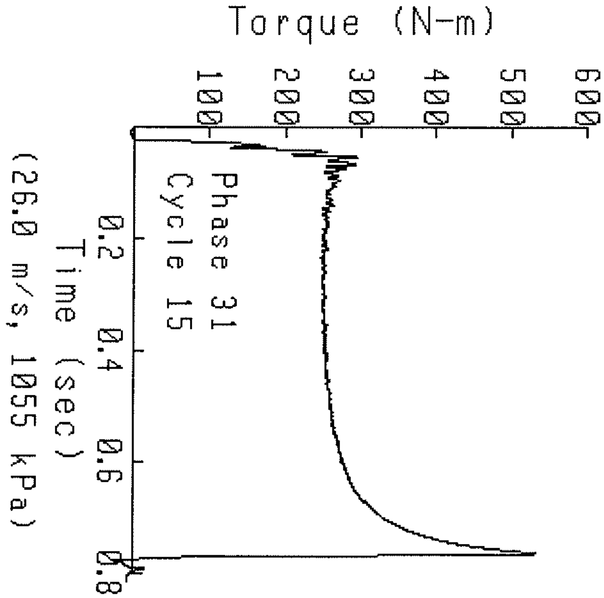

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

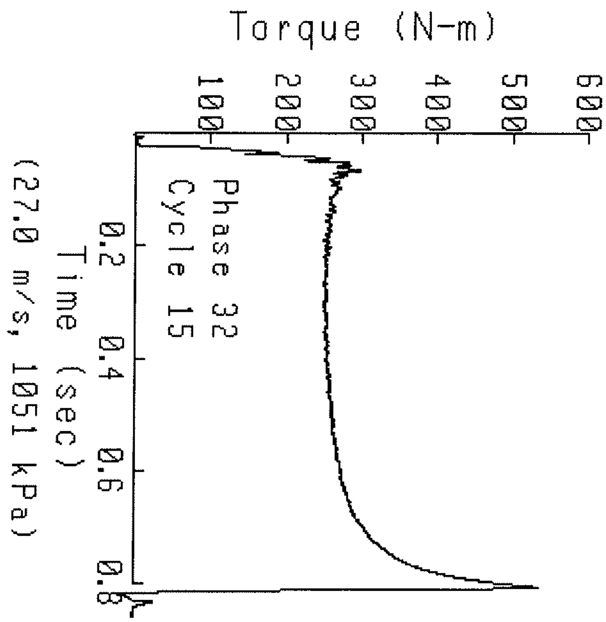

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

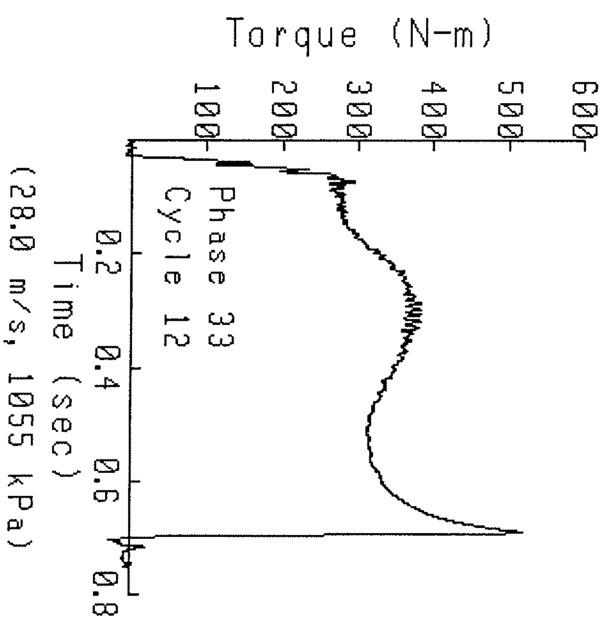

Torque (N-m)
100 200 300 400 500 600
Phase 28
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(23.0 m/s, 1054 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 29
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(24.0 m/s, 1046 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 30
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(25.0 m/s, 1049 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 31
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(26.0 m/s, 1055 kPa)

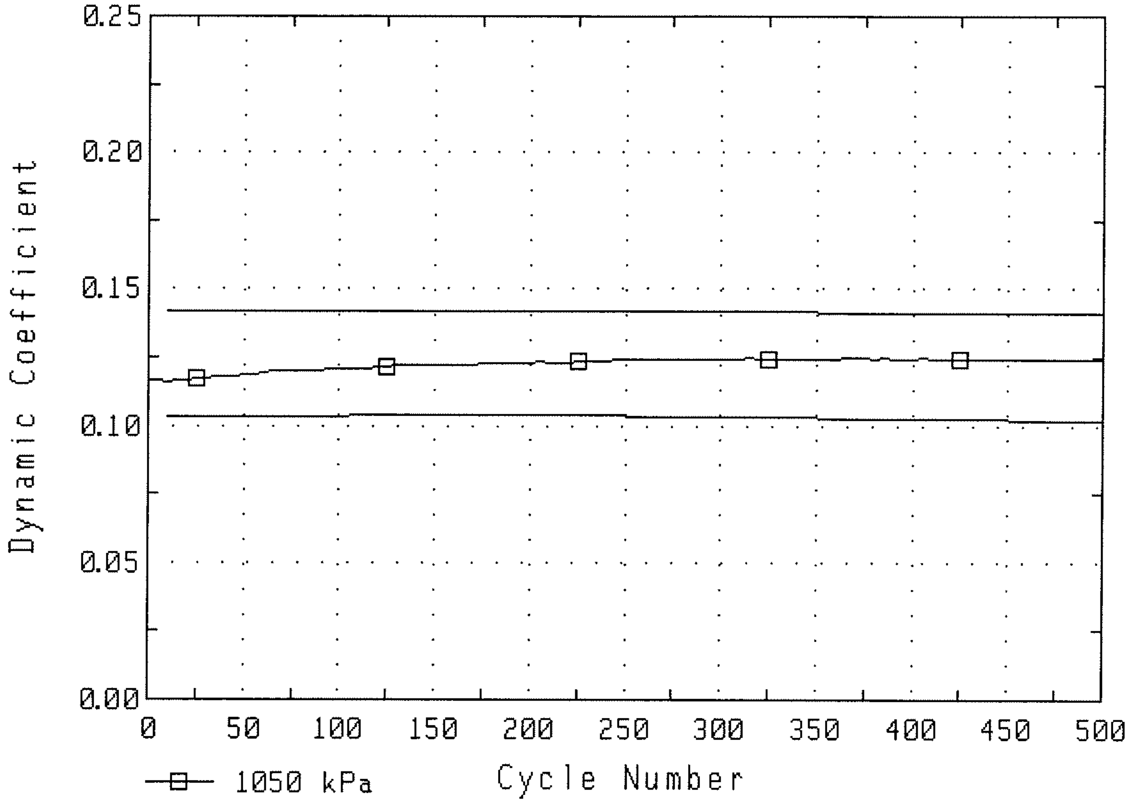

Torque (N-m)
100 200 300 400 500 600
Phase 32
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(27.0 m/s, 1051 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 33
Cycle 12
0.2 0.4 0.6 0.8
Time (sec)
(28.0 m/s, 1055 kPa)

SOUTHWEST RESEARCH INSTITUTE
I MACHINE OIL TEST AL-27252-L / LO-222424

Test name:	A-70-I
Test date:	08/8/07
Test description:	AL-27252-L
Oil type:	AL-27252-L LO-222424
Viscosity:	SAE 5W-40
Miscellaneous:	
Software version:	1.40
Run name & desc:	I0706079 - AL-27252-L
Run date:	08/10/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	HC
Remarks:	"I" MACHINE OIL TEST AL-27252-L / LO-222424
Sequence name:	SEQ1222
Remarks:	Use 1Y0711 Disc and 1Y0726 Plate
Number of cycles run:	1155
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 $N\text{-}m\text{-}s^2$
Disc name & desc:	1Y0711 - Wheel Brake Paper
Material:	Raybestos 7902-1 Paper
Groove pattern:	2 - 37 Multiple Parallel
Miscellaneous:	Use with 1Y0726 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	24FE9-00001
Remarks:	WHEEL BRAKE PAPER
Plate name & desc:	1Y0726 - Steel Plate
Surface:	0.30 micron Maximum Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	24FE9-00001
Remarks:	0.23 SURFACE FINISH
Report limit name:	LIM1222 - Reference run: I0706004
Limit file generated:	07/26/06
Report format name:	REP1222 - WHEEL BRAKE PAPER

Test: A-70-I Run: I0706079 Started on 08/10/07 at 08:43



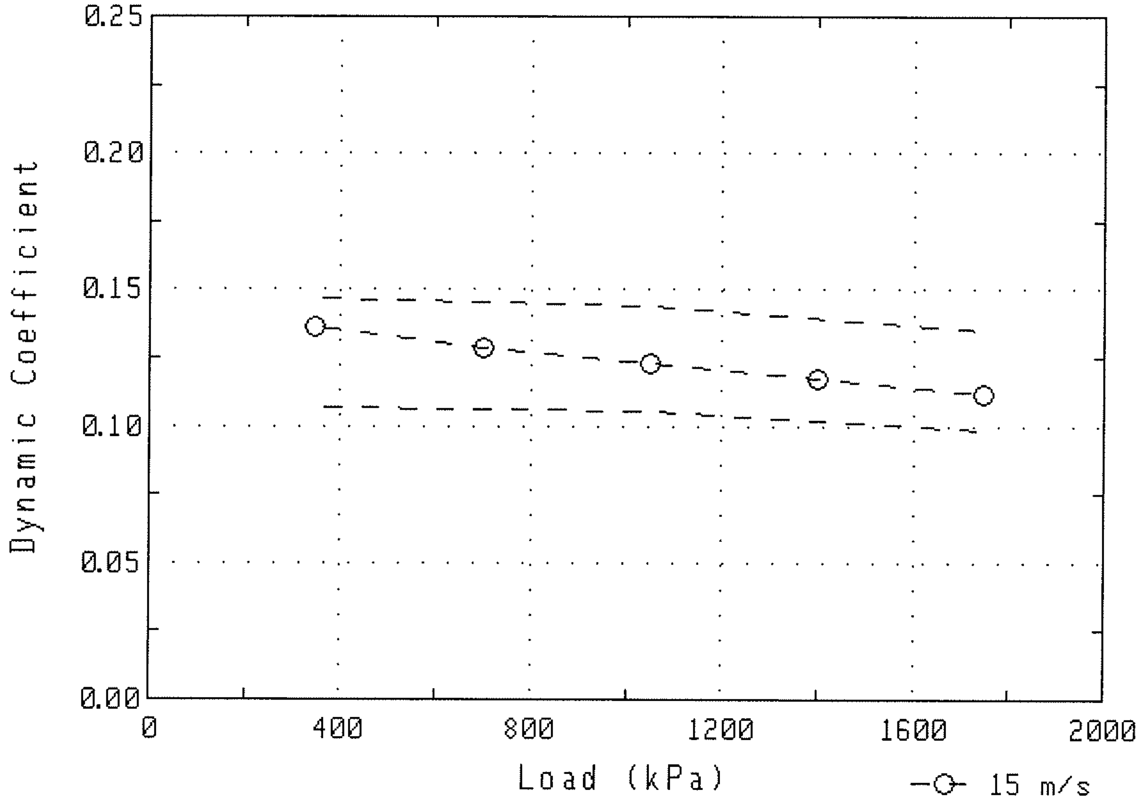
1Y0711 DISC
THICKNESS

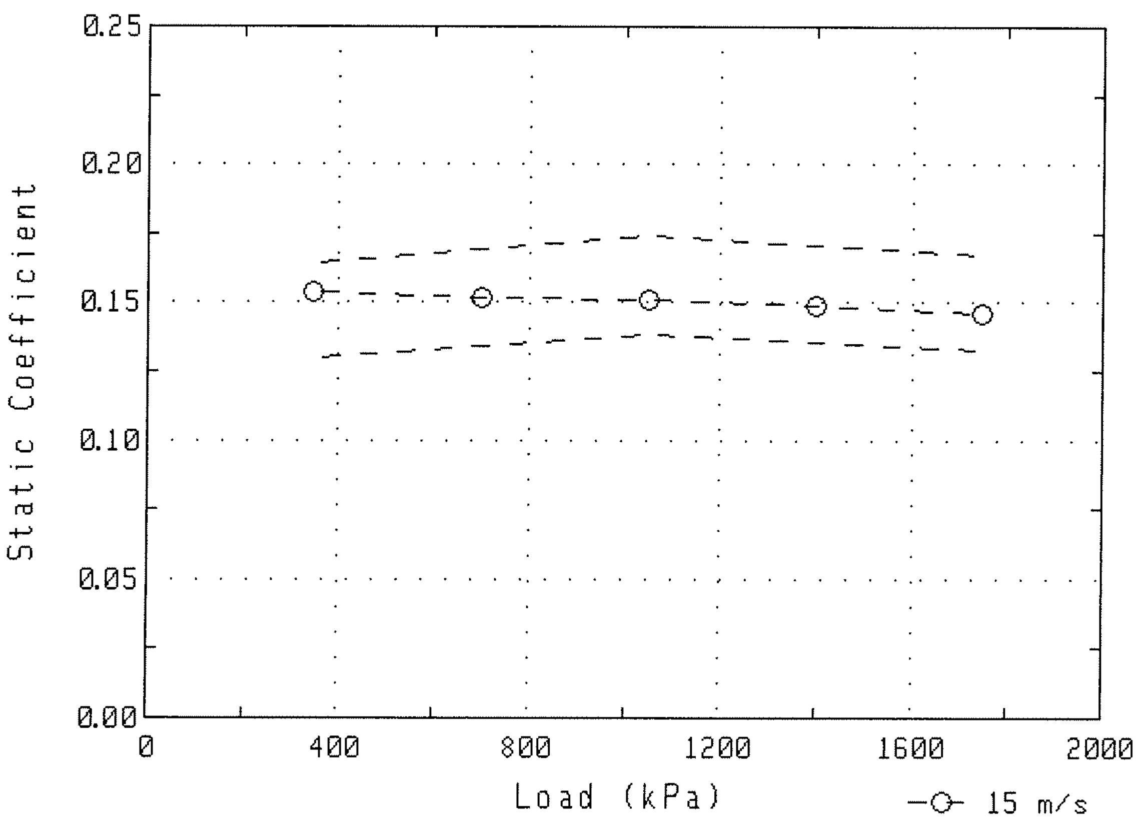
Loc	Outer Diameter M1	M2	M3	Inner Diameter M1	M2	M3
1	5.00	4.96	4.95	5.00	4.96	4.95
2	4.99	4.96	4.95	4.99	4.96	4.95
3	5.00	4.97	4.96	4.99	4.97	4.96
4	5.00	4.97	4.96	5.00	4.97	4.96
5	4.98	4.94	4.94	4.98	4.95	4.94
6	4.97	4.95	4.94	4.97	4.94	4.94
Avg	4.99	4.96	4.95	4.99	4.96	4.95

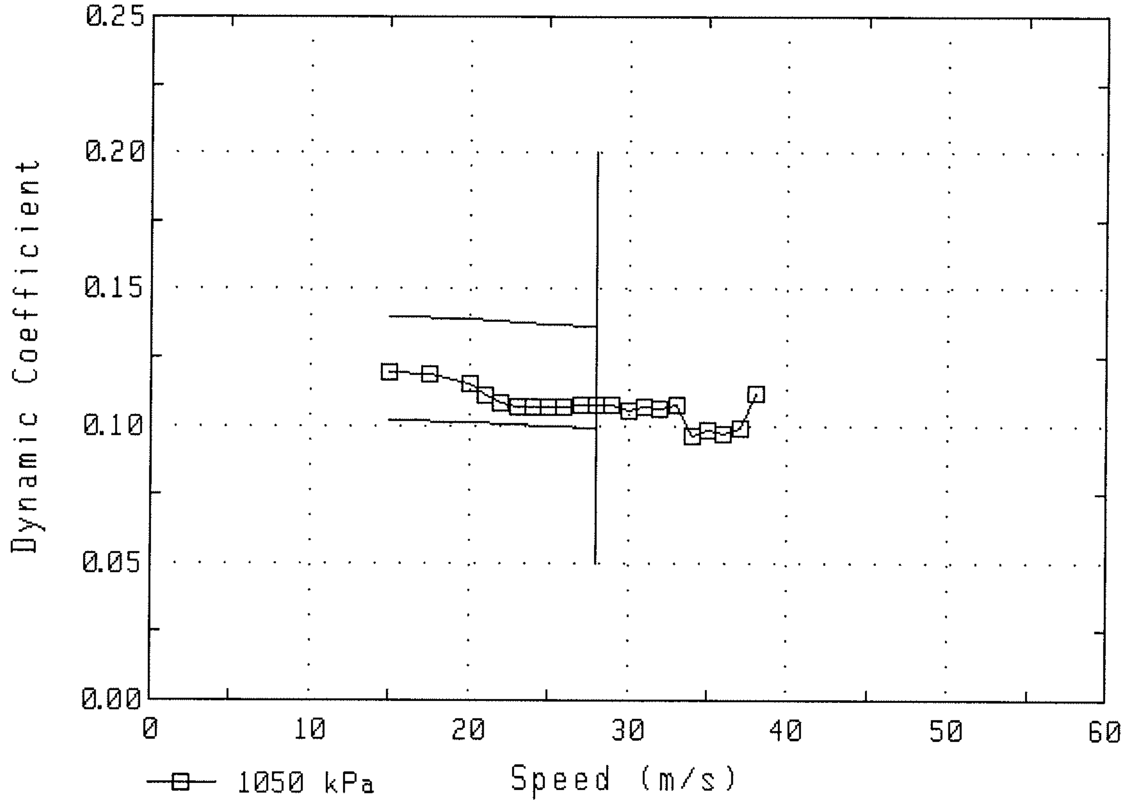
Compression set average wear: 0.031
M2 - M3 average Wear: 0.008

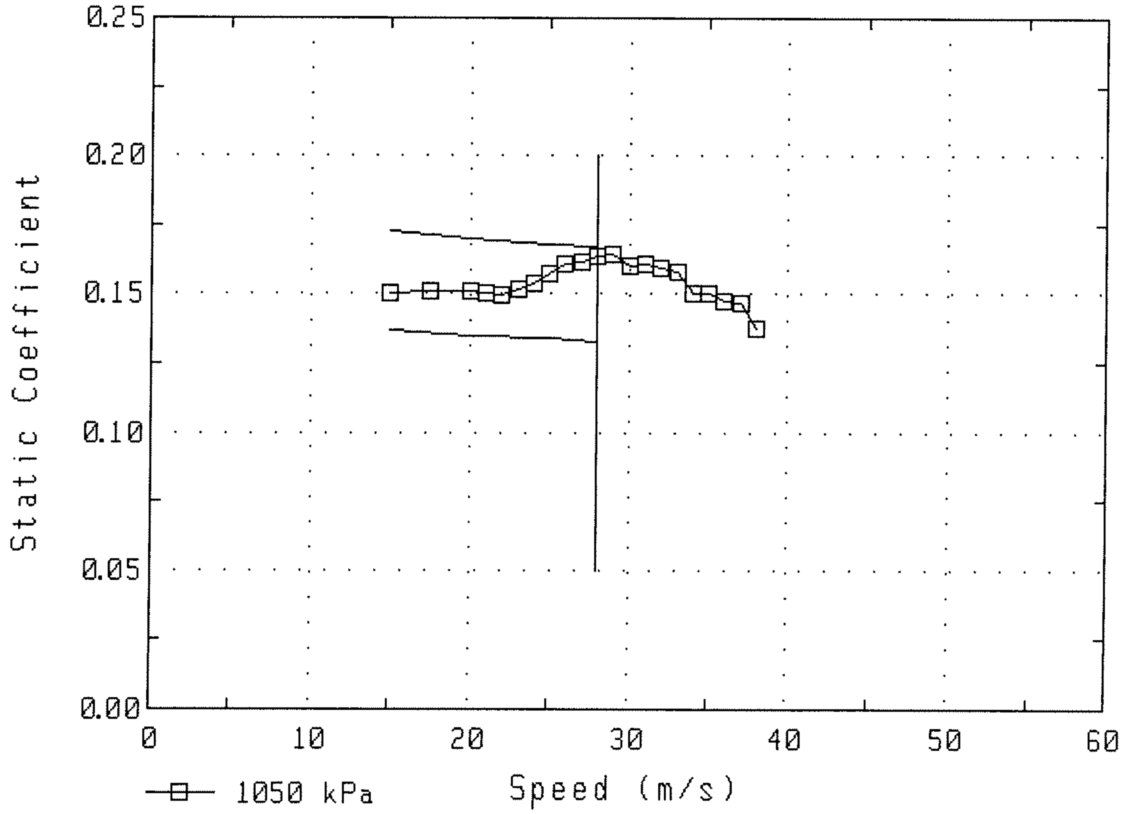
Total Wear (all measurements in mm): 0.039

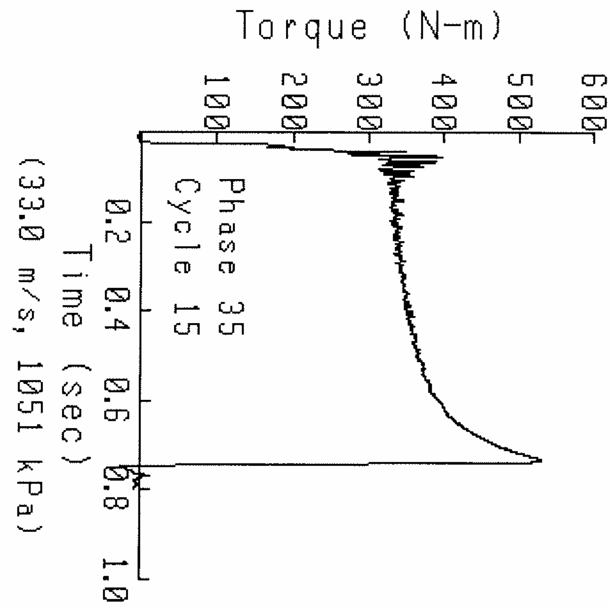
Test: A-70-I Run: I0706079 Started on 08/10/07 at 08:43

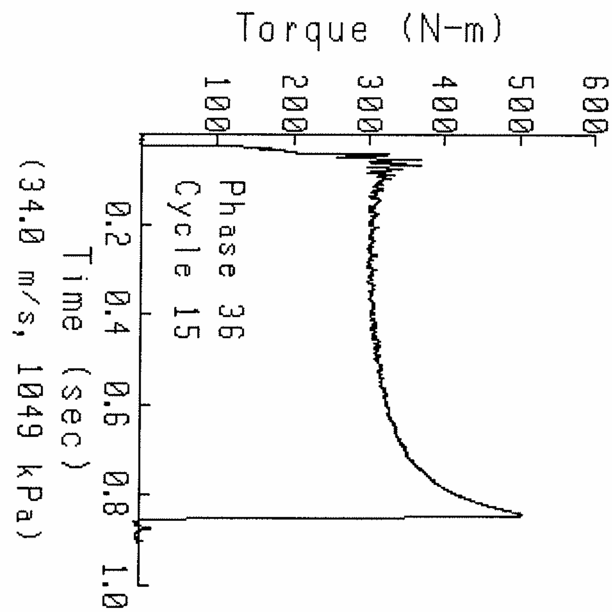


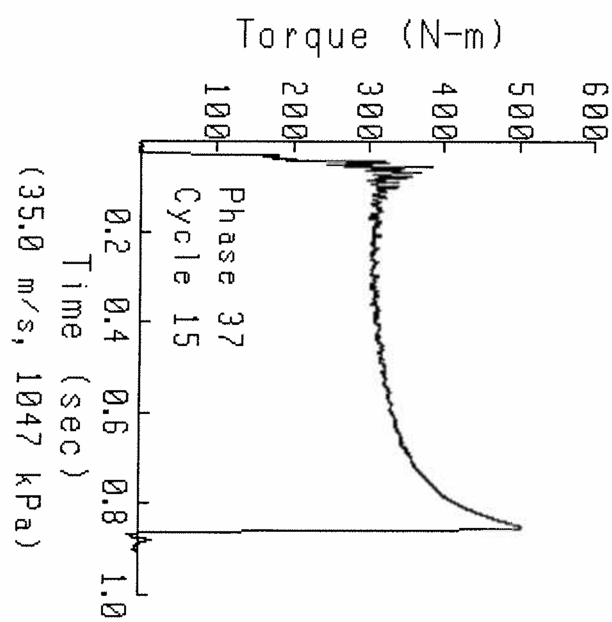


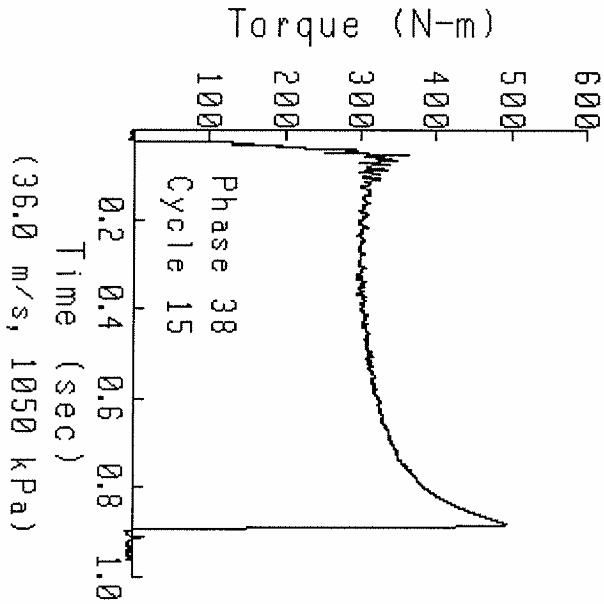

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

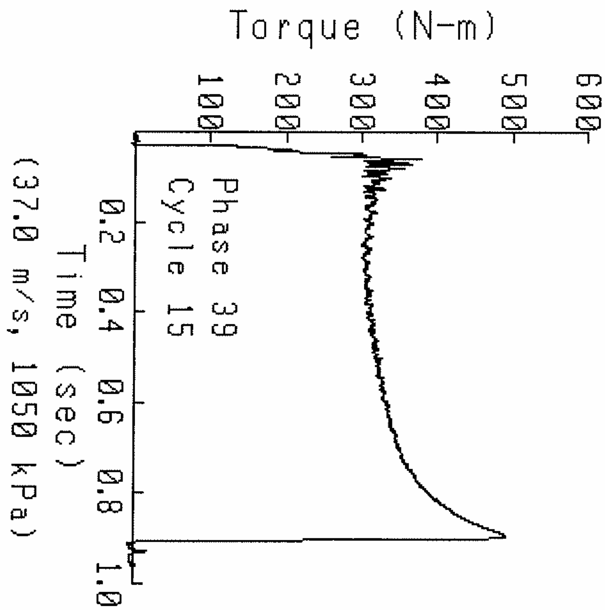

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

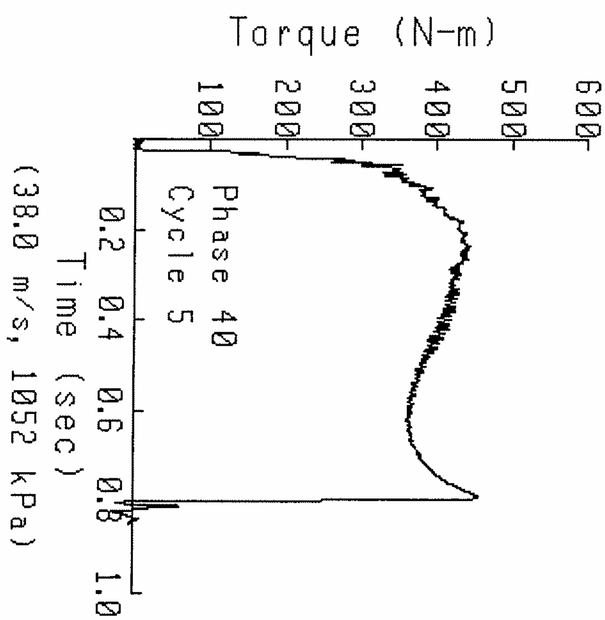

Torque (N-m)
100 200 300 400 500 600
Phase 35
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(33.0 m/s, 1051 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 36
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(34.0 m/s, 1049 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 37
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(35.0 m/s, 1047 kPa)

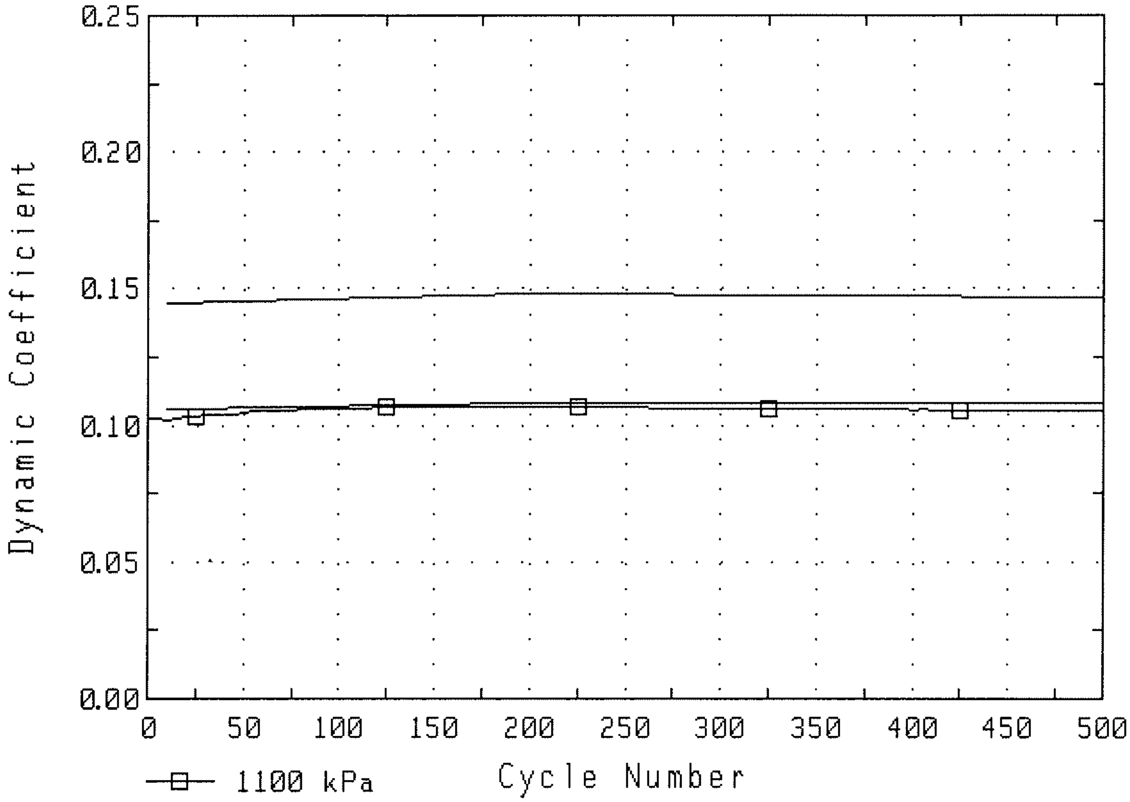

Torque (N-m)
100 200 300 400 500 600
Phase 38
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(36.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 39
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(37.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 40
Cycle 5
0.2 0.4 0.6 0.8 1.0
Time (sec)
(38.0 m/s, 1052 kPa)

SOUTHWEST RESEARCH INSTITUTE
I MACHINE OIL TEST AL-27252-L / LO-222424

Test name:	A-70-I
Test date:	08/8/07
Test description:	AL-27252-L
Oil type:	AL-27252-L LO-222424
Viscosity:	SAE 5W-40
Miscellaneous:	
Software version:	1.40
Run name & desc:	I0706080 - AL-27252-L
Run date:	08/11/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	JG
Remarks:	"I" MACHINE OIL TEST AL-27252-L / LO-222424
Sequence name:	SEQ1223
Remarks:	Use 1Y0712 Disc and 1Y0726 Plate
Number of cycles run:	1040
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 $N\text{-}m\text{-}s^2$
Disc name & desc:	1Y0712 - Transmission Paper
Material:	Raybestos 7901-2 Paper
Groove pattern:	2 - 37 Multiple Parallel
Miscellaneous:	Use with 1Y0726 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	27MR9-00001
Remarks:	TRANSMISSION PAPER
Plate name & desc:	1Y0726 - Steel Plate
Surface:	0.30 micron Maximum Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	27MR9-00001
Remarks:	0.18 SURFACE FINISH
Report limit name:	LIM1223 - Reference run: I0706006
Limit file generated:	07/26/06
Report format name:	REP1223 - TRANSMISSION PAPER

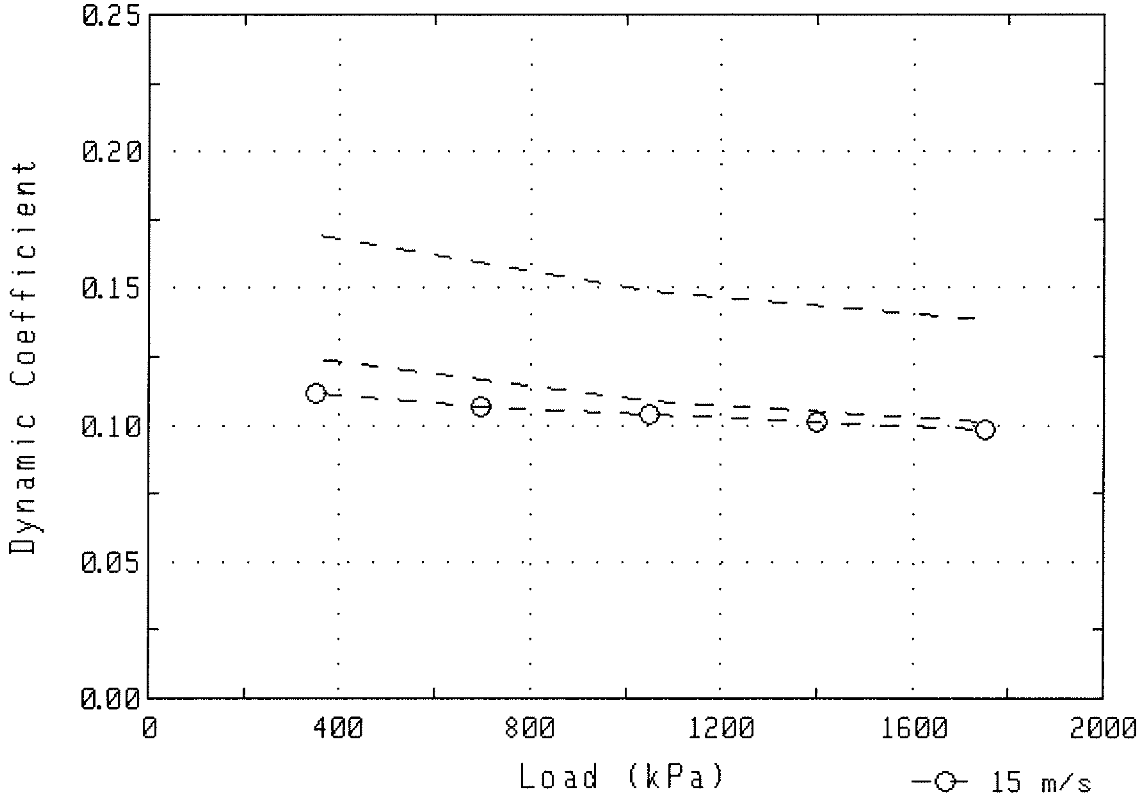


1Y0712 DISC
THICKNESS

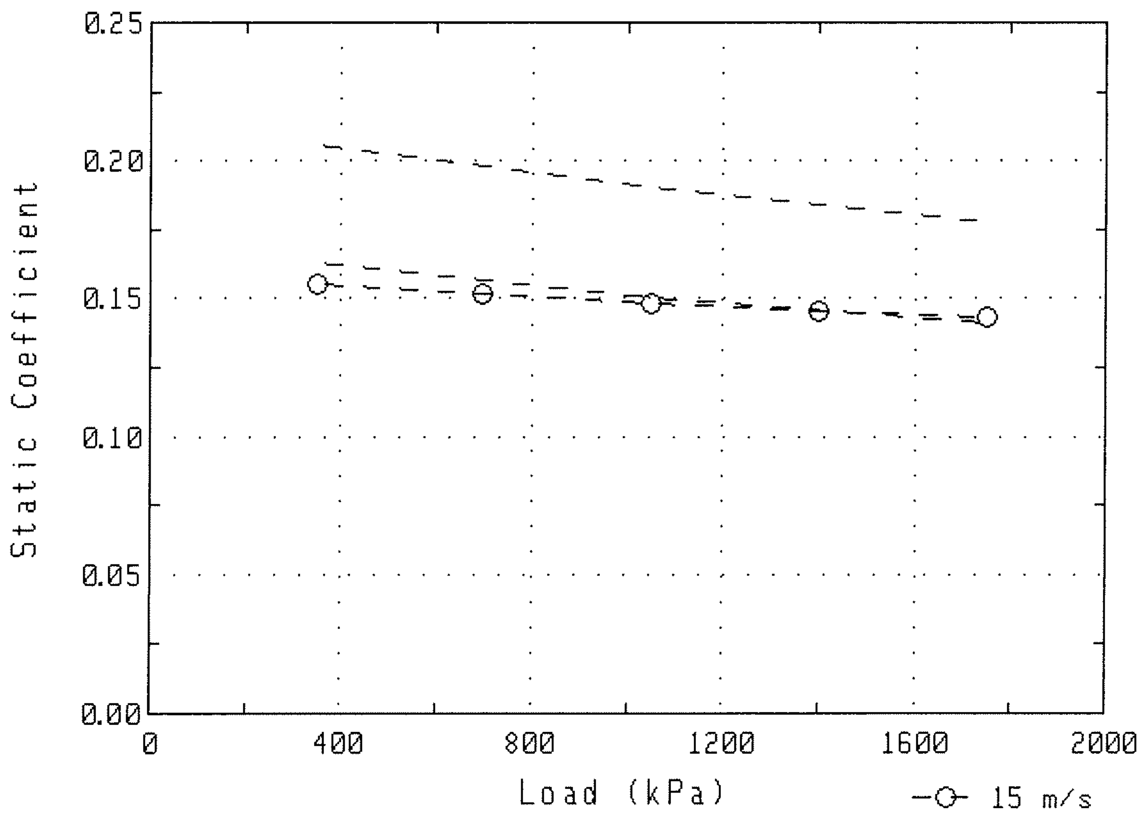
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	5.04	5.02	5.02	5.04	5.03	5.02
2	5.04	5.02	5.01	5.03	5.02	5.01
3	5.02	5.01	5.00	5.02	5.01	5.00
4	5.02	5.01	5.00	5.02	5.01	5.00
5	5.02	5.01	5.00	5.02	5.01	5.00
6	5.03	5.02	5.00	5.02	5.02	5.00
Avg	5.03	5.01	5.00	5.03	5.02	5.00

Compression set average wear: 0.011
M2 - M3 average Wear: 0.011

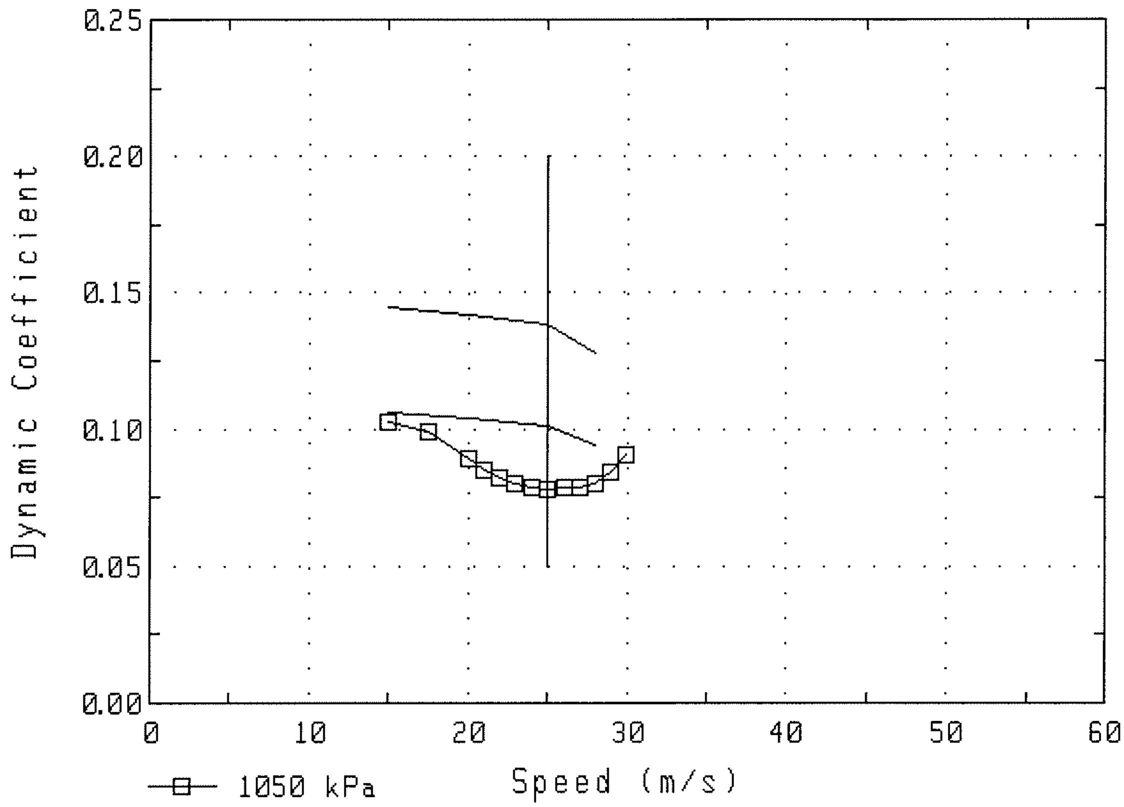
Total Wear (all measurements in mm): 0.022

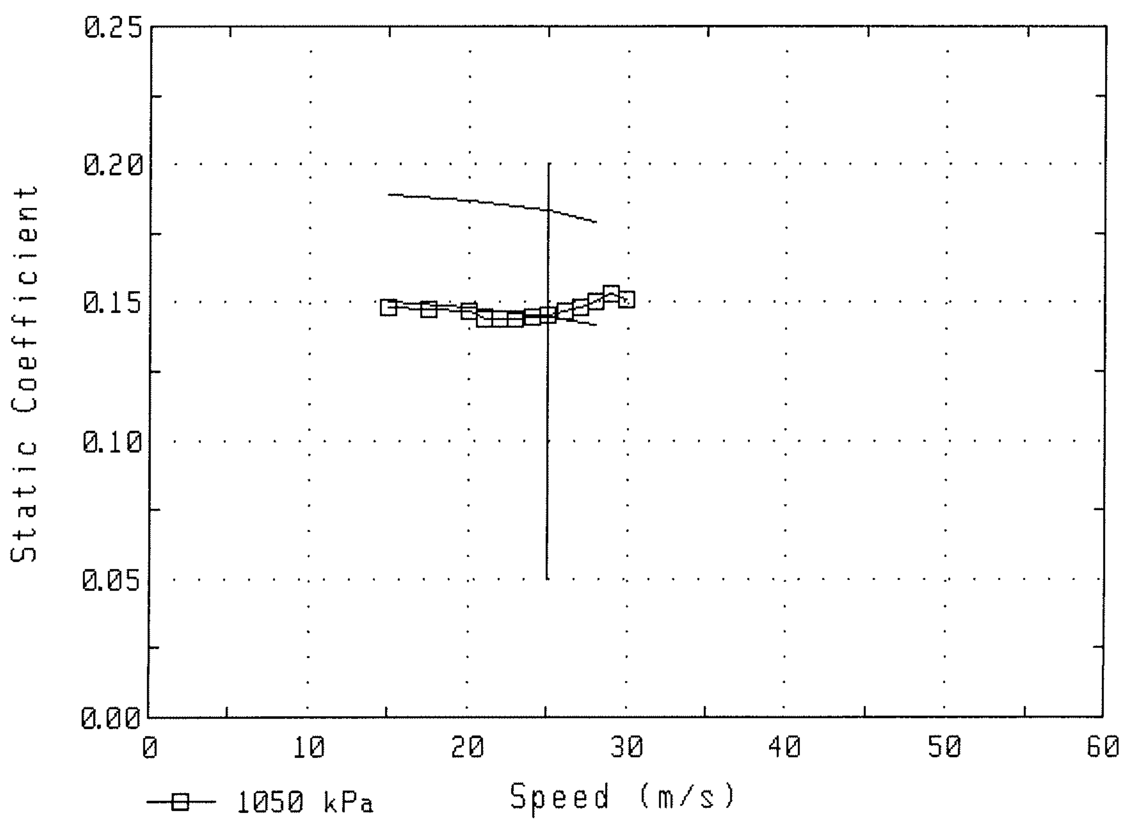


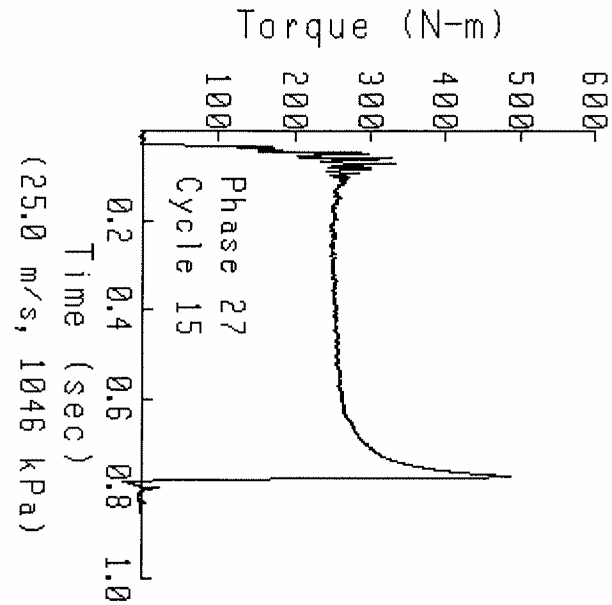
0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

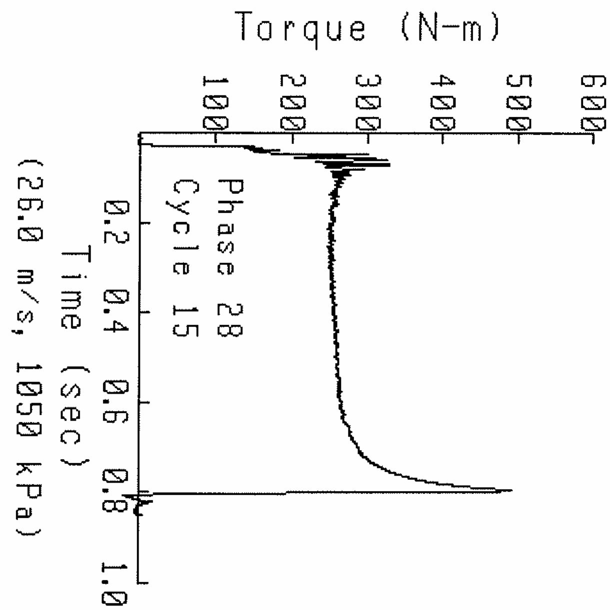


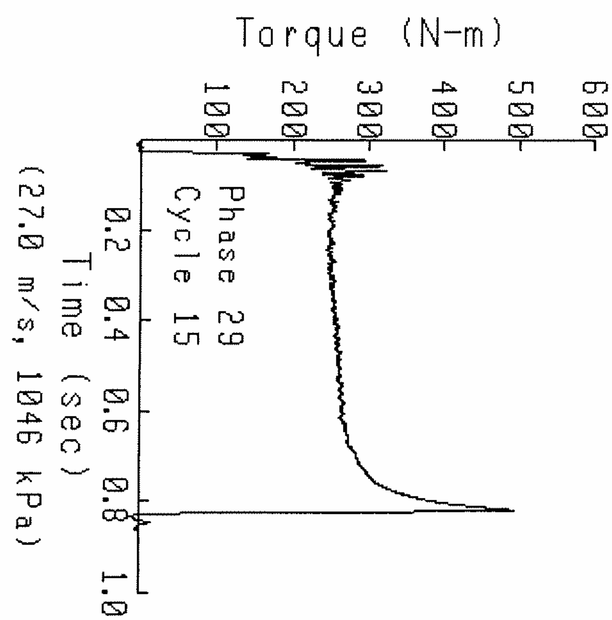
0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

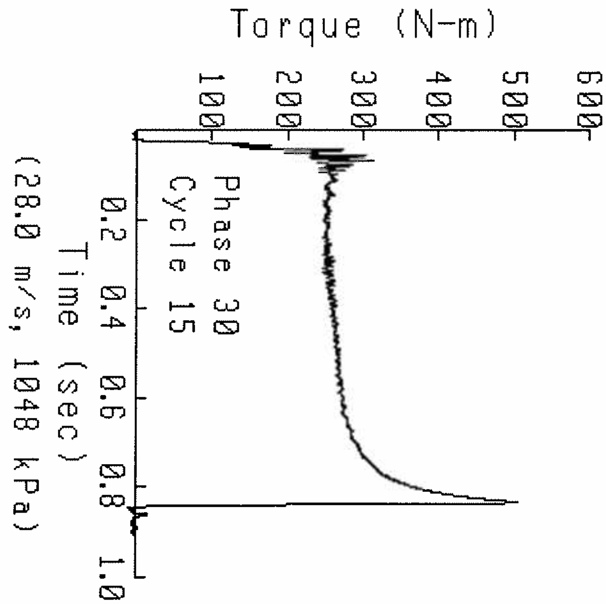

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

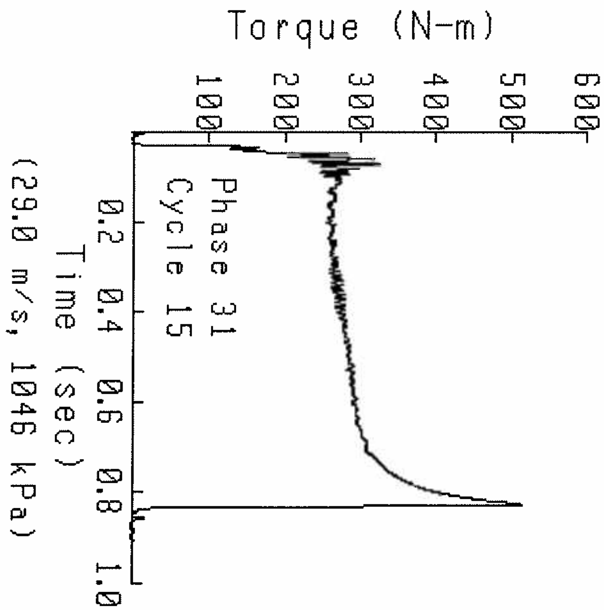

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

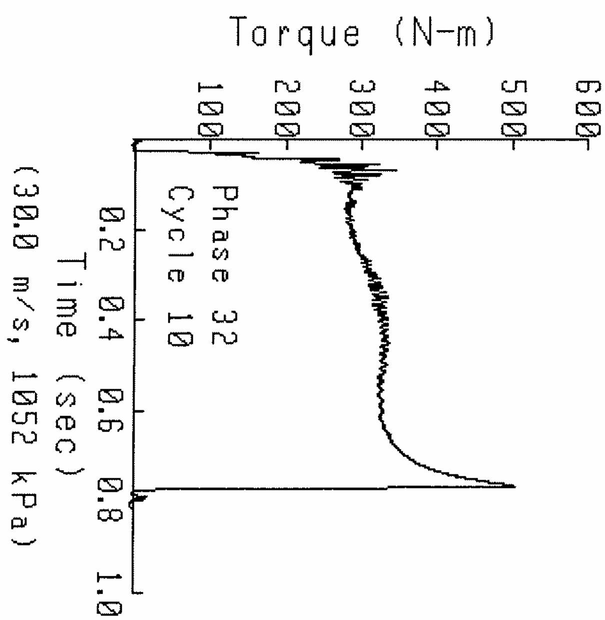

Torque (N-m)
100 200 300 400 500 600
Phase 27
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(25.0 m/s, 1046 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 28
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(26.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 29
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(27.0 m/s, 1046 kPa)

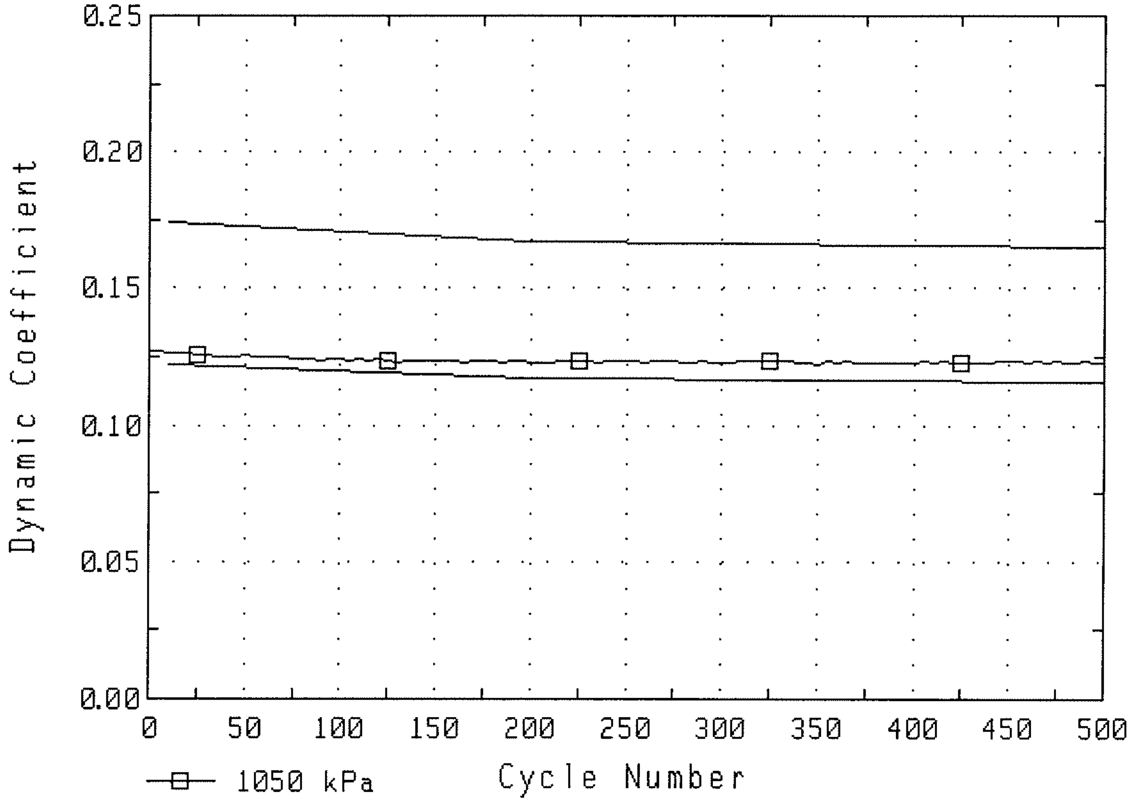

Torque (N-m)
100 200 300 400 500 600
Phase 30
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(28.0 m/s, 1048 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 31
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(29.0 m/s, 1046 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 32
Cycle 10
0.2 0.4 0.6 0.8 1.0
Time (sec)
(30.0 m/s, 1052 kPa)

SOUTHWEST RESEARCH INSTITUTE
I MACHINE OIL TEST AL-27252-L / LO-222424

Test name:	A-70-I
Test date:	08/8/07
Test description:	AL-27252-L
Oil type:	AL-27252-L LO-222424
Viscosity:	SAE 5W-40
Miscellaneous:	
Software version:	1.40
Run name & desc:	I0706081 - AL-27252-L
Run date:	08/13/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	JG
Remarks:	I MACHINE OIL TEST AL-27252-L / LO-222424
Sequence name:	SEQ1224
Remarks:	Use 1Y0713 Disc and 8E4095 Plate
Number of cycles run:	1093
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 N-m-s^2
Disc name & desc:	1Y0713 - Elastomeric Disc
Material:	Caterpillar F37
Groove pattern:	Single Lead Spiral - 12 Radial
Miscellaneous:	Use with 8E4095 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	C63007FE1
Remarks:	ELASTOMERIC
Plate name & desc:	8E4095 - Steel Plate
Surface:	0.70 to 1.00 micron Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	C63007FE1
Remarks:	0.82 SURFACE FINISH
Report limit name:	LIM1224 - Reference run: I0706007
Limit file generated:	07/26/06
Report format name:	REP1224 - ELASTOMERIC, F37



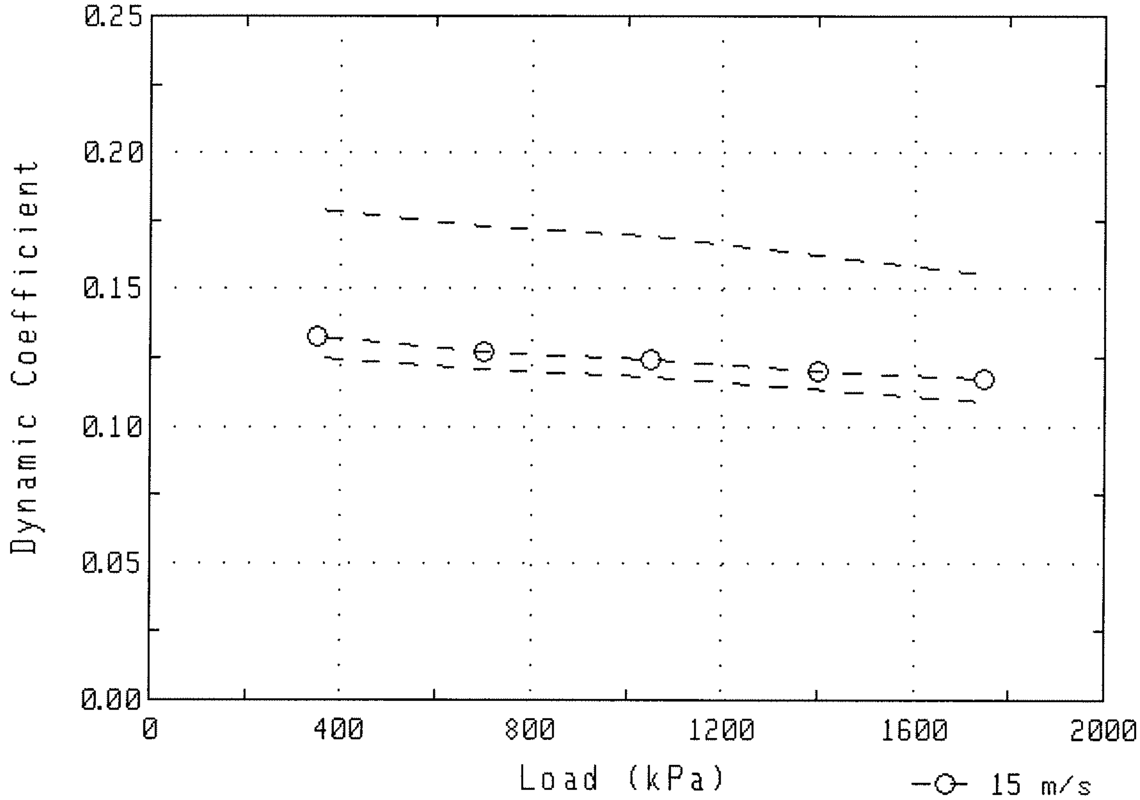
1Y0713 DISC
THICKNESS

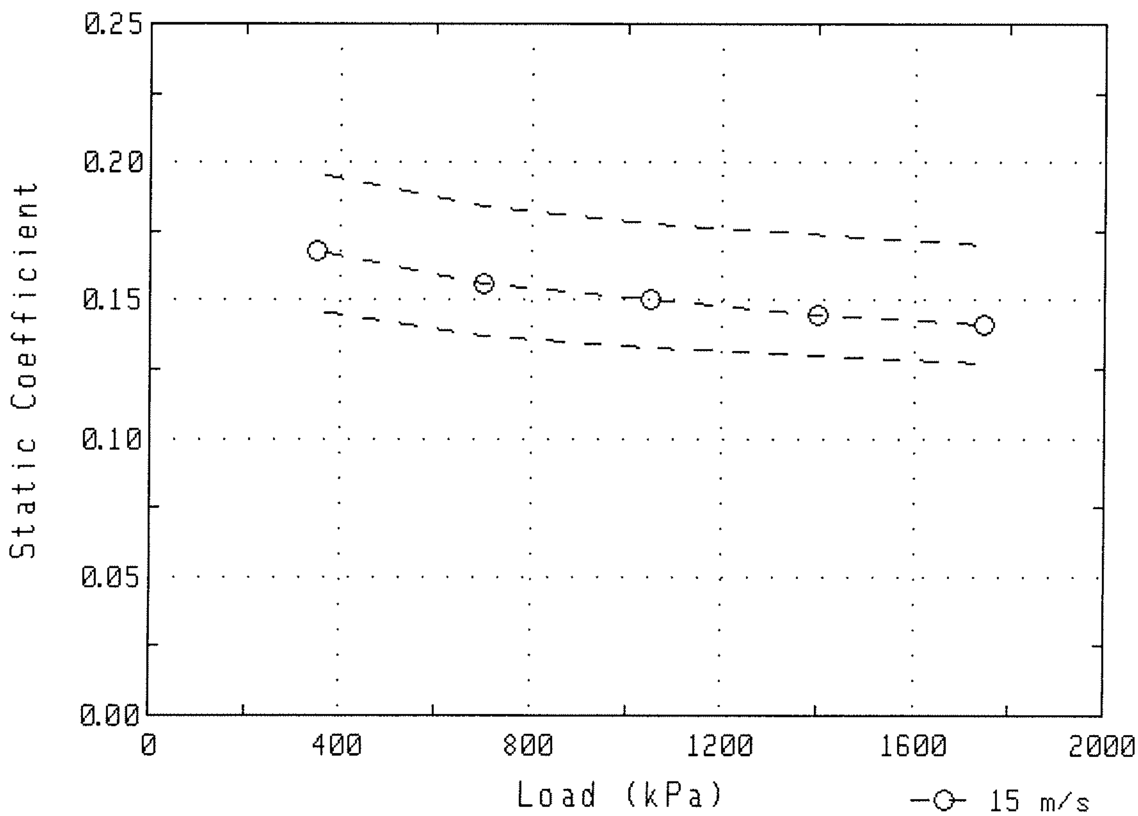
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	5.06	5.04	5.03	5.06	5.04	5.03
2	5.06	5.04	5.03	5.06	5.04	5.03
3	5.05	5.04	5.03	5.06	5.04	5.03
4	5.06	5.04	5.03	5.06	5.04	5.03
5	5.06	5.04	5.03	5.06	5.04	5.03
6	5.06	5.04	5.03	5.06	5.04	5.03
Avg	5.06	5.04	5.03	5.06	5.04	5.03

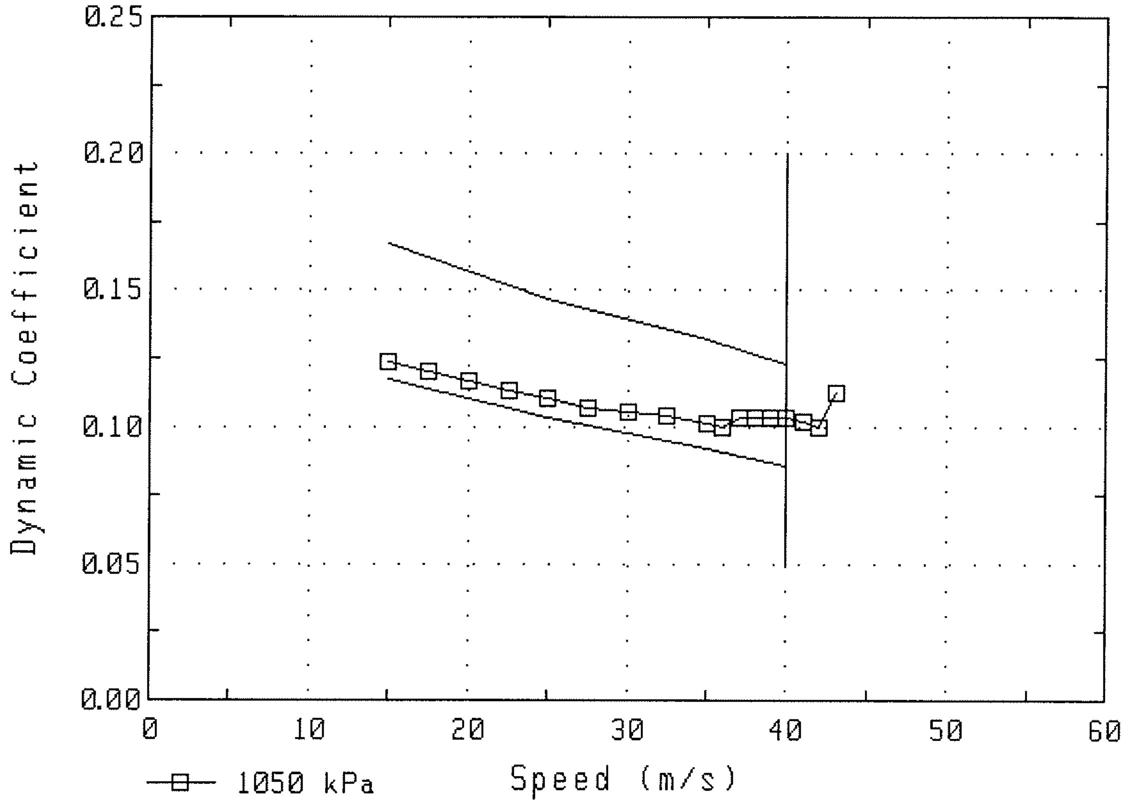
Compression set average wear: 0.019
M2 - M3 average Wear: 0.010

Total Wear (all measurements in mm): 0.029

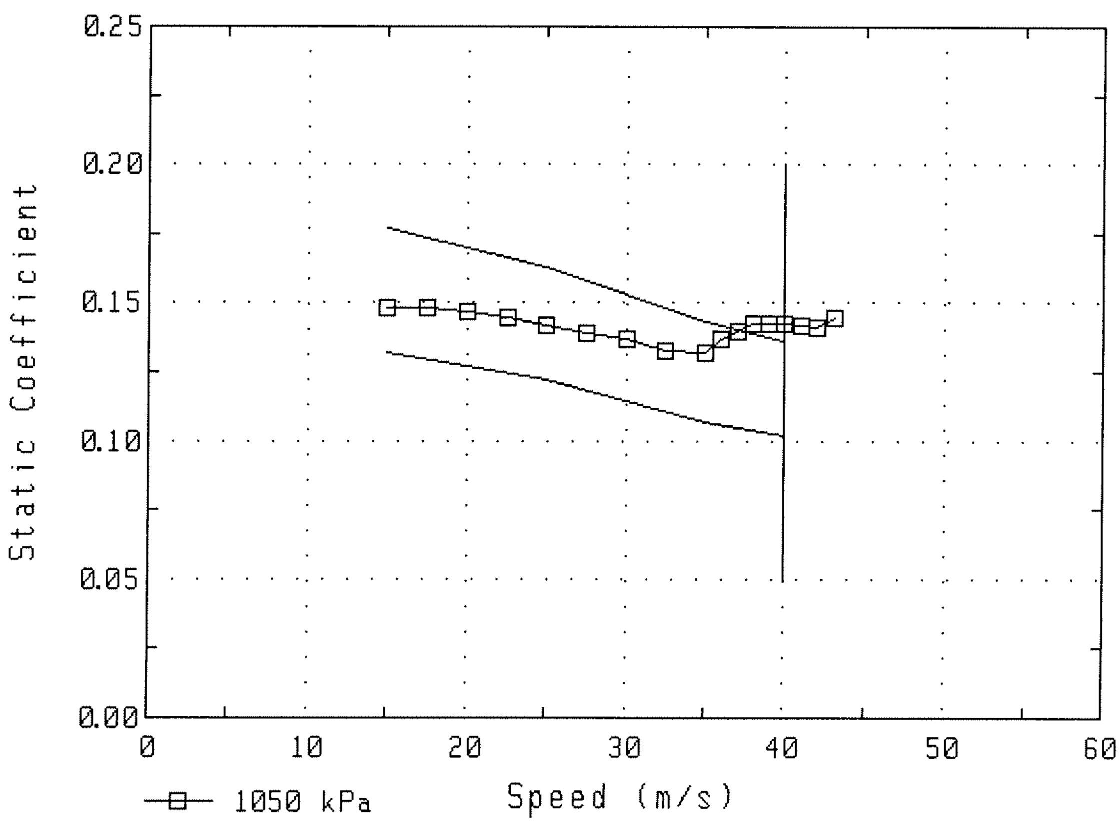
Test: A-70-I Run: I0706081 Started on 08/13/07 at 09:15



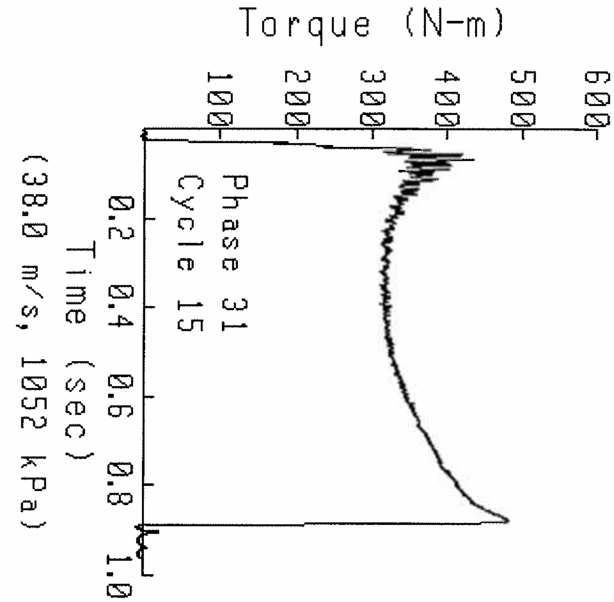


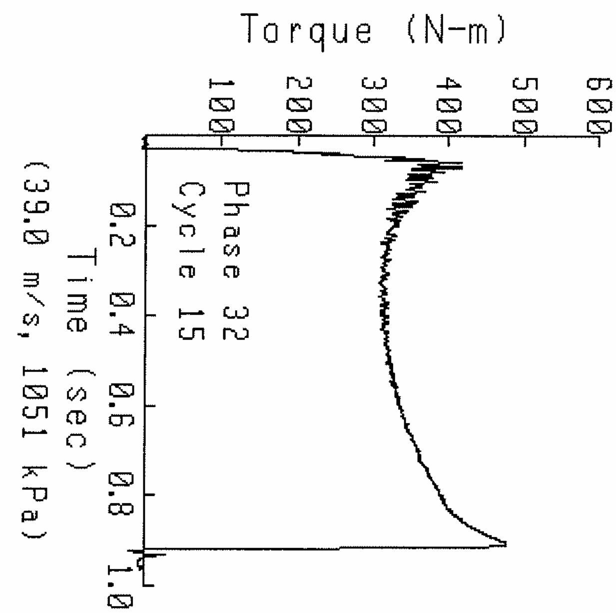


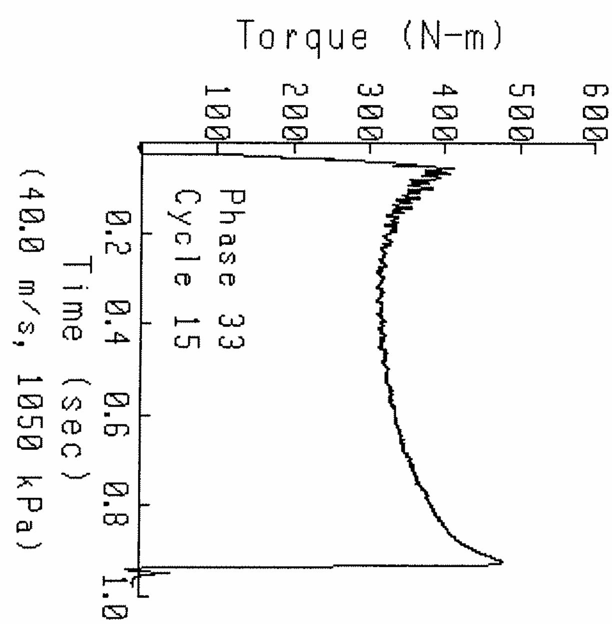
0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

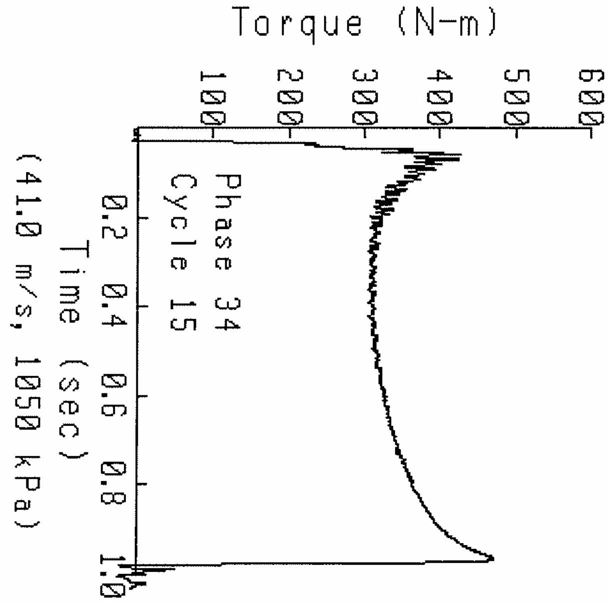


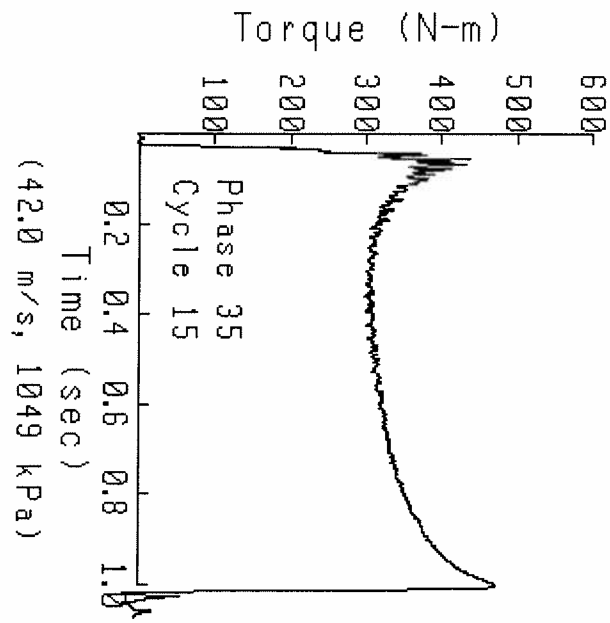
0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

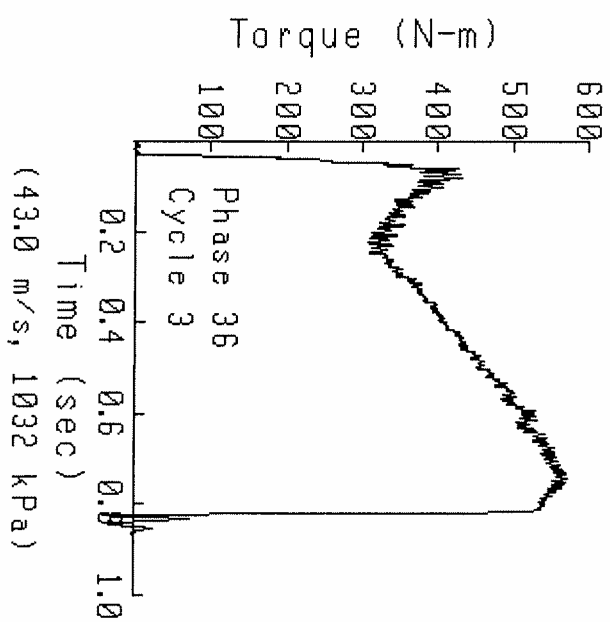

Torque (N-m)
100 200 300 400 500 600
Phase 31
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(38.0 m/s, 1052 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 32
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(39.0 m/s, 1051 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 33
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(40.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 34
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(41.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 35
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(42.0 m/s, 1049 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 36
Cycle 3
0.2 0.4 0.6 0.8 1.0
Time (sec)
(43.0 m/s, 1032 kPa)

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

Fuels and Lubricants Research Division

Report on

John Deere JDQ-96
Performed using 1400 Series Axle

Conducted for

ARMY LAB

AL-27252-L

Test Number
07804

October 11, 2007

Submitted by:

Michael D. Lochte
Manager
Specialty & Driveline Fluids
Evaluations

John Deere JDQ-96 Performed using 1400 Series Axle

General Information

Oil Code: AL-27252-L	E.O.T. Date: October 11, 2007

Purpose

The purpose of this test was to evaluate the anti-chatter properties of this oil on the brakes of a 1400 series John Deere Inboard Planetary Axle.

Test Procedure

The test was performed as specified by John Deere Product Engineering. The only changes made to the Deere procedure were those necessary to compensate for a different spiral bevel gear ratio. This procedure is proprietary to Deere and Company.

Data Interpretation

The capacity for each engagement is the average torque during the middle of the engagement. The torque variation is the greatest difference between the maximum and minimum torque recorded during any 0.2-second portion of the engagement. The SwRI variation is the sum of all differences between the maximum torque and minimum torque for each engagement. It is obtained by summing all torque variations of each 0.2-second time block of all engagements.

Test Number

The run number listed on this report is a random number and is not sequential. Only SwRI® can link this run number to JDQ-96, AL-27252-L, October 11, 2007.

John Deere JDQ-96 Performed using 1400 Series Axle

Results

Oil Code: AL-27252-L	E.O.T. Date: October 11, 2007

The candidate results can be compared to the baseline reference average. Pass or fail decisions are only made by John Deere Product Engineering. The current reference baseline average is the average of the five most recent tests.

Current Reference Baseline Average (N · m)					
	1,000 Cycles	**10,000 Cycles**	**20,000 Cycles**	**30,000 Cycles**	**TOTAL**
Relative Capacity	338,535	338,534	341,629	343,274	1,361,972
Torque Variation	79,214	84,272	79,152	74,708	317,346

Results From Test Candidate AL-27252-L					
	1,000 Cycles	**10,000 Cycles**	**20,000 Cycles**	**30,000 Cycles**	**TOTAL**
Relative Capacity	369,909				
Torque Variation	206,360				

Tables 1 of the Appendix contains chatter test results from 1,000cycles. Table 2 contains results of the five current baseline reference tests. Figures 1 through 4 are graphic presentations of candidate oil performance compared to baseline reference data.

Figure 5 is a graphic presentation of 1000-cycle reference results and AL-27252-L. Table 3 contains the history of reference tests.

John Deere JDQ-96 Performed using 1400 Series Axle

Oil Code: AL-27252-L	**E.O.T. Date:** October 11, 2007

Appendix

Tables

1. Table 1 – Durability results 1,000 cycles Candidate Oil
2. Table 2 – Reference Data Compared to Candidate Data
3. Figure 1 & Figure 2 - Torque Variation Chart
4. Figure 3 & Figure 4 – Relative Capacity & Average Disk Thickness Chart
5. Figure 5 - Graphic presentation of 1000 cycle reference results & Candidate
6. Table 3 - History of reference tests

October 11, 2007

TABLE 1: JDQ-96 DURABILITY TEST RESULTS 1,000 CYCLES

SwRI Oil Code LO-222424 Sponsor Oil Code AL-27252-L

Axle Speed (rpm)	Brake Press. (kPa)	TORQUE VARIATION TEST RESULTS (TORQUE and VARIATION in Nm)											
		Oil Temp. 32°C			Oil Temp. 49°C			Oil Temp. 60°C			Oil Temp. 71°C		
		Torque	Variation	Temp.	Torque	Variation	Temp.	Torque	Variation	Temp.	Torque	Variation	Temp.
8	3831	4083	3620	29	4398	2190	50	4689	3320	61	4992	2670	72
10	3831	4281	2550	29	4622	2360	49	4545	2780	60	4670	4190	70
15	3831	4233	2920	29	4230	2890	49	4310	3420	59	4381	3140	69
20	3831	4325	1090	29	4231	3320	49	4234	3880	59	4595	3810	72
25	3831	4358	1060	29	4492	1460	50	4161	4250	60	4344	4630	72
30	3831	4398	1330	30	4492	1770	50	4453	1920	60	4655	2080	72
35	3831	4389	1210	31	4447	1610	51	4453	1740	61	4545	1940	72
40	3831	4497	1420	31	4523	1740	51	4572	2190	61	4681	2290	73
45	3831	4434	1310	33	4240	1420	50	4357	1860	61	4477	1970	72
50	3831	4079	1070	32	4215	1570	51	4397	2110	61	4443	2220	72
55	3831	4251	960	32	4396	1490	50	4470	1870	59	4738	2770	73
60	3831	4230	1050	33	4290	1380	51	4341	1530	60	4477	2090	72
15	1532	1786	580	34	1800	740	50	1846	900	61	1897	980	71
15	2300	2657	700	33	2684	950	49	2725	1070	59	2728	1320	70
15	3065	3545	750	33	3245	2750	49	3397	2950	60	3403	2820	70
15	3831	4248	2810	33	4257	3080	49	4386	3050	60	4406	3140	70
15	4598	5158	3070	33	5189	3080	49	5359	3340	59	5543	3750	71
15	5364	6142	3120	33	6182	3260	49	6319	3770	59	6434	6100	71
15	6130	7152	3440	33	7274	4410	49	7262	4100	59	7383	6240	70
15	7050	8280	3760	33	8302	5690	49	8285	6640	59	8528	6540	71

Temp (°C)	Relative Capacity (Nm)	Torque Variation (Nm)	SwRI Variation (Nm)
32	90,524	37,820	557,440
49	91,506	47,160	649,060
60	92,561	56,690	728,540
71	95,319	64,690	774,330
TOTAL	369,909	206,360	2,709,370

TABLE 2: JDQ-96 REFERENCE DATA COMPARED TO CANDIDATE DATA

EOT Date: October 11, 2007

Oil Code : AL-27252-L

Reference Oil Coded : 69X31111i	Cycles	Relative Capacity	Torque Variation	SwRI Variation	Average Facing Thickness (millimeters)
First Reference Run					
	1,000	326,304	57,420	730,050	7.60
	10,000	331,809	64,900	804,030	7.50
	20,000	345,325	69,500	899,880	7.44
	30,000	341,770	66,210	810,190	7.39
	Total	1,345,208	258,030	3,244,150	
Second Reference Run					
	1,000	337,791	66,660	848,580	7.60
	10,000	338,055	92,240	1,129,330	7.55
	20,000	343,166	77,010	1,001,920	7.49
	30,000	350,470	73,280	863,980	7.44
	Total	1,369,482	309,190	3,843,810	
Third Reference Run					
	1,000	339,375	100,390	1,204,240	7.56
	10,000	335,754	106,780	1,079,450	7.52
	20,000	334,120	84,770	1,030,270	7.49
	30,000	335,614	79,620	1,021,190	7.47
	Total	1,344,863	371,560	4,335,150	
Fourth Reference Run					
Run on new backing pla	1,000	343,906	79,990	1,020,120	7.48
and piston	10,000	343,056	72,520	893,570	7.30
	20,000	342,668	69,920	885,870	7.07
	30,000	345,315	70,360	833,920	6.90
	Total	1,374,945	292,790	3,633,480	
Invalid test run on same	*1,000*	*348,860*	*132,110*	*1,721,010*	
backing plate and pistor	*10,000*	*323,093*	*153,860*	*1,919,720*	
as test above was run on					
Fifth Reference Run					
most recent run	**1,000**	**345,296**	**91,610**	**1,125,260**	**7.50**
Run on new backing	**10,000**	**343,999**	**84,920**	**1,019,400**	**7.33**
plate and piston	**20,000**	**342,864**	**94,560**	**1,264,070**	**7.22**
	30,000	**343,201**	**84,070**	**1,052,400**	**7.11**
	Total	**1,375,360**	**355,160**	**4,461,130**	
AL-27252-L		Candidate Oil Test Results			
	1,000	369,909	206,360	2,709,370	
	10,000				
	20,000				
	30,000				
	Total	369,909	206,360	2,709,370	

Figure 1

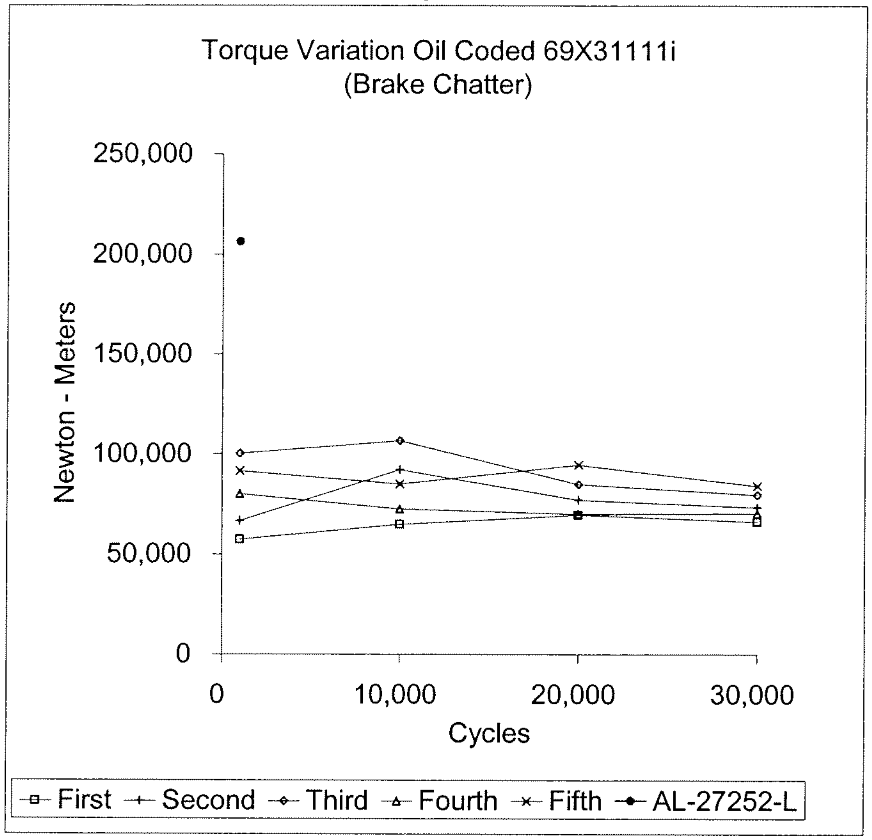


Figure 2

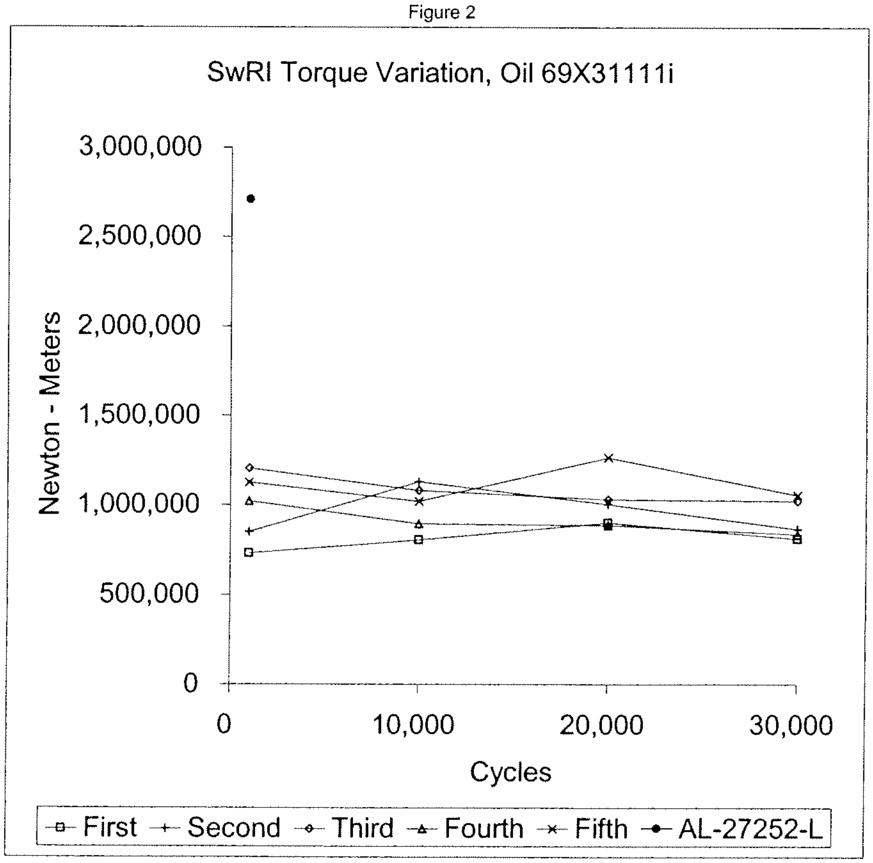


Figure 3

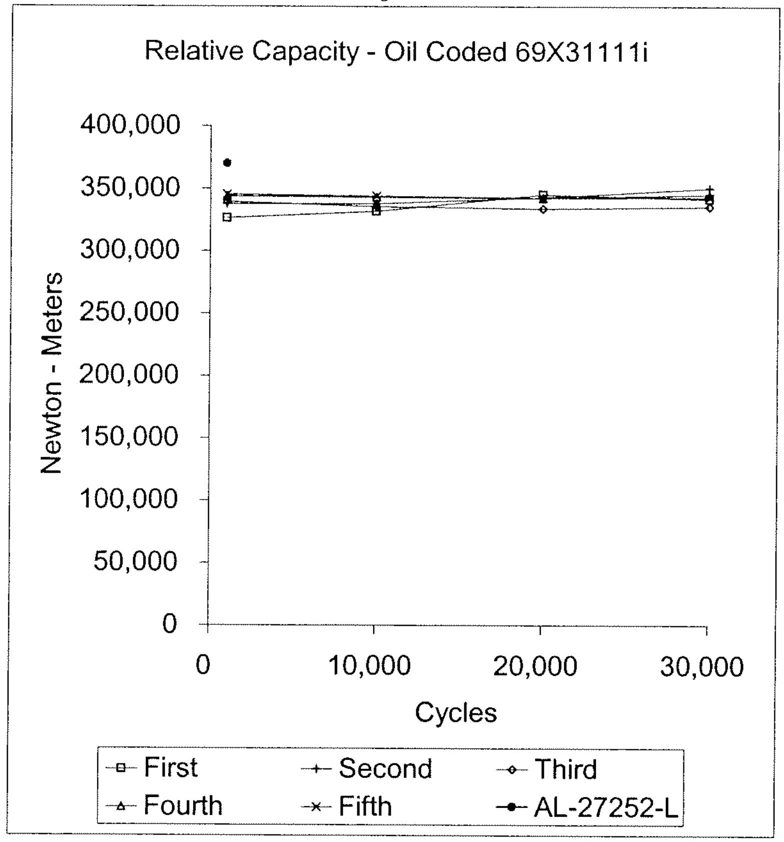


Figure 4

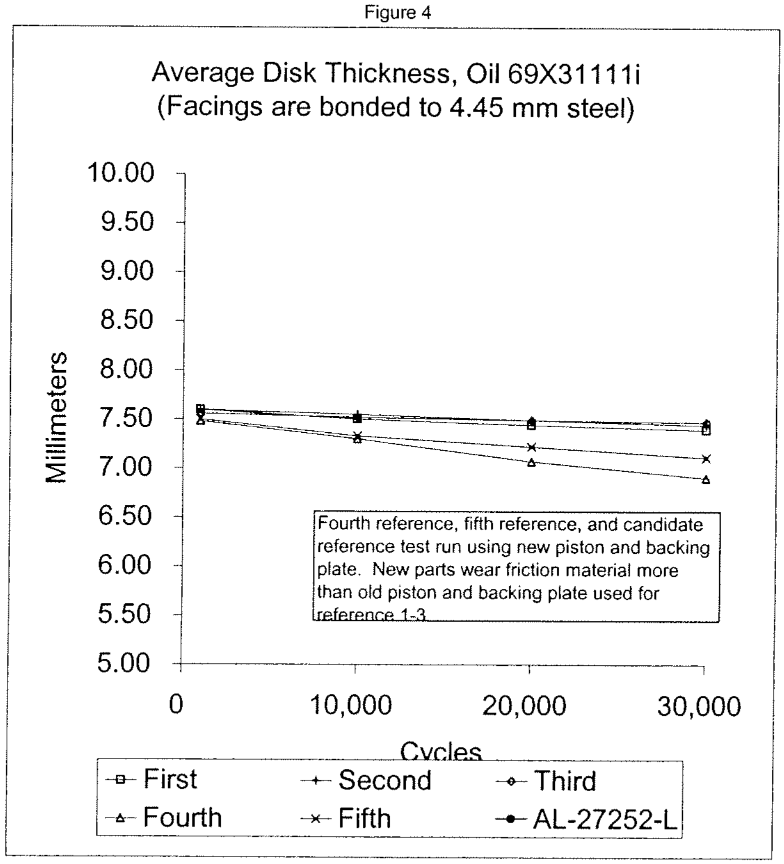
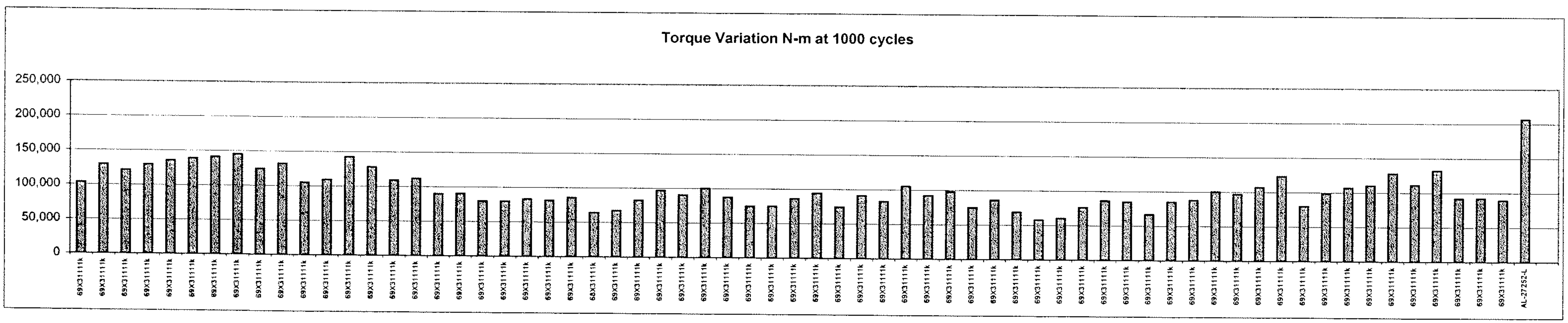


Table 3

AL-27252-L October 11, 2007

History of 1000 cycle reference tests.

		Torque variation at 1000 cycles
69X31111k	1999 brake disk	103,360
69X31111k	1997 brake disk	129,540
69X31111k	2000 brake disk	121,120
69X31111k	2000 brake disk	129,620
69X31111k	2000 brake disk	135,700
69X31111k	2000 brake disk	138,760
69X31111k	2000GDD brake di	140,830
69X31111k	2000GDD brake	144,820
69X31111k	2000GDD brake	124,310
69X31111k	2000 GDD brake	131,860
69X31111k	2000 GDD brake	105,010
69X31111k	2000 GDD brake	109,220
69X31111k	2000 GDD brake	142,510
69X31111k	2000 GDD brake	128,080
69X31111k	2000 GDD brake	109,100
69X31111k	2000 GDD brake	111,800
69X31111k	2000 GDD brake	90,070
69X31111k	2000 GDD brake	90,810
69X31111k	2000 GDD brake	79,930
69X31111k	2000 GDD brake	79,930
69X31111k	2000 GDD brake	83,190
69X31111k	2000 GDD brake	81,220
69X31111k	2000 GDD brake	85,570
68X31111k	2000 GDD brake	64,170
69X31111k	2000 GDD brake	67,390
69X31111k	2000 GDD brake	82,410
69X31111k	2000 GDD brake	96,730
69X31111k	2000 GDD brake	90,390
69X31111k	2000 GDD brake	99,960
69X31111k	2000 GDD brake	87,380
69X31111k	2000 GDD brake	74,720
69X31111k	2000 GDD brake	74,940
69X31111k	2000 GDD brake	85,980
69X31111k	2000 GDD brake	94,410
69X31111k	2000 GDD brake	74,300
69X31111k	2000 GDD brake	90,950
69X31111k	2000 GDD brake	83,190
69X31111k	2000 GDD brake	105,210
69X31111k	2000 GDD brake	91,960
69X31111k	2000 GDD brake	97,320
69X31111k	2000 GDD brake	75,040
69X31111k	2000 brake disk	86,060
69X31111k	2000 brake disk	68,590
69X31111k	2003 brake disk	57,420
69X31111k	2003 brake disk	60,330
69X31111k	2003 brake disk	76,260
69X31111k	2003 brake disk	86,210
69X31111k	2003 brake disk	84,550
69X31111k	2003 brake disk	66,660
69X31111k	2003 brake disk	84,760
69X31111k	2003 brake disk	87,800
69X31111k	2003 brake disk	100,390
69X31111k	2003 brake disk	96,620
69X31111k	2003 brake disk	106,710
69X31111k	2003 brake disk	123,110
69X31111k	NEW BACKING PI	79,990
69X31111k		98,440
69X31111k		106,370
69X31111k		110,040
69X31111k		127,550
69X31111k		111,280
69X31111k	invalid run	132,110
69X31111k	NEW BACKING Plate and piston	91,610
69X31111k	NEW BACKING Plate and piston	92,230
69X31111k	plate used for 1 test	89,200
AL-27252-L	same brake plate and piston as above	206,360



AL-27252-L

October 11, 2007

Figure 5

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

FUELS AND LUBRICANTS RESEARCH DIVISION

Report on

CATERPILLAR TO-4 FRICTION PROPERTIES, VC-70

Conducted for

SwRI ARMY LAB

Oil Code:
AL-27637-L

Test Number:
VC70-A-77-I

October 11, 2007

Submitted by:

Brian Koehler
Principal Engineer
Specialty & Driveline Fluids
Evaluations

CATERPILLAR TO-4 FRICTION PROPERTIES, VC-70

Summary Sheet

Company: SwRI Army Lab
Test Number: VC70-A-77-I
Test start date: October 7, 2007
End of test date: October 11, 2007
Oil Code: AL-27637-L

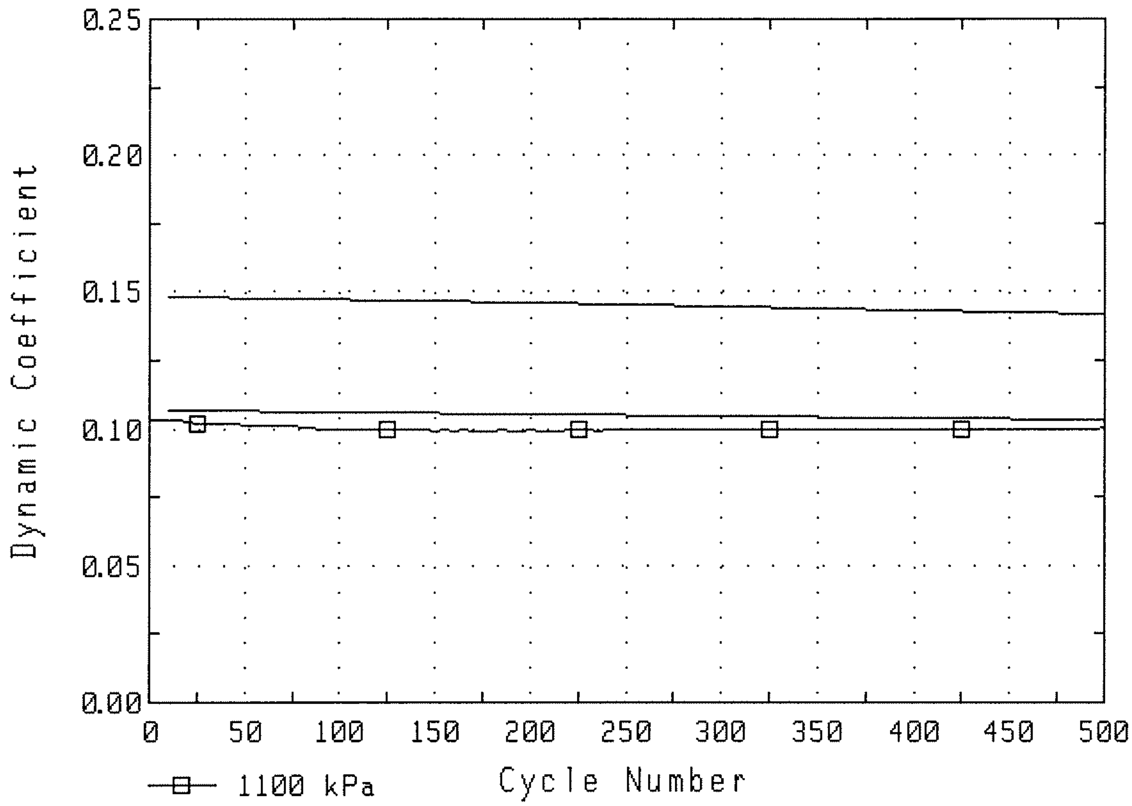
Sequence Number	1219	N/A	1221	1222	1223	1224	Friction Retention
Dynamic Coefficient Vs. Cycle:	F	N/A	P	P	P	F	N/A
Dynamic Coefficient Vs. Load:	F	N/A	P	P	P	F	
Dynamic Coefficient Vs. Speed:	F	N/A	F	P	F	P	
Energy Limit:	P	N/A	P	P	P	P	
Static Coefficient Vs. Cycle:							N/A
Static Coefficient Vs. Load:	P	N/A	P	F	F	P	
Static Coefficient Vs. Speed:	P	N/A	F	F	F	P	
Energy Limit:	P	N/A	P	P	P	P	
Total Wear:	0.033	N/A	0.029	0.047	0.044	0.027	
Wear Limit:	0.030	N/A	0.070	0.070	0.070	0.070	

Comments:

F = Fail
P = Pass
N/A = Not Applicable

Southwest research institute
I machine oil test AL-27637-L/LO-224425

Test name:	A-77-I
Test date:	10/06/07
Test description:	I Machine AL-27637-L
Oil type:	AL-27637-L/LO-224425
Viscosity:	30
Miscellaneous:	
Software version:	1.40
Run name & desc:	I0706098 - AL-27637-L / LO-224425
Run date:	10/07/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	mtd
Remarks:	I machine oil test AL-27637-L / LO-224425
Sequence name:	SEQ1219
Remarks:	Use 1Y0708 Disc and 1Y3610 Plate
Number of cycles run:	1139
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 N-m-s^2
Disc name & desc:	1Y0708 - Elastomeric Disc
Material:	Raybestos 6475-4 Rayflex
Groove pattern:	Single Lead Spiral - 12 Radial
Miscellaneous:	Use with 1Y3610 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	26NO0-00004
Remarks:	Elastomeric
Plate name & desc:	1Y3610 - Steel Plate
Surface:	0.70 to 1.30 micron Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	26NO0-00004
Remarks:	0.90 surface finish
Report limit name:	LIM1219 - Reference run: I0706090
Limit file generated:	09/24/07
Report format name:	REP1219 - ELASTOMERIC, RAYFLEX

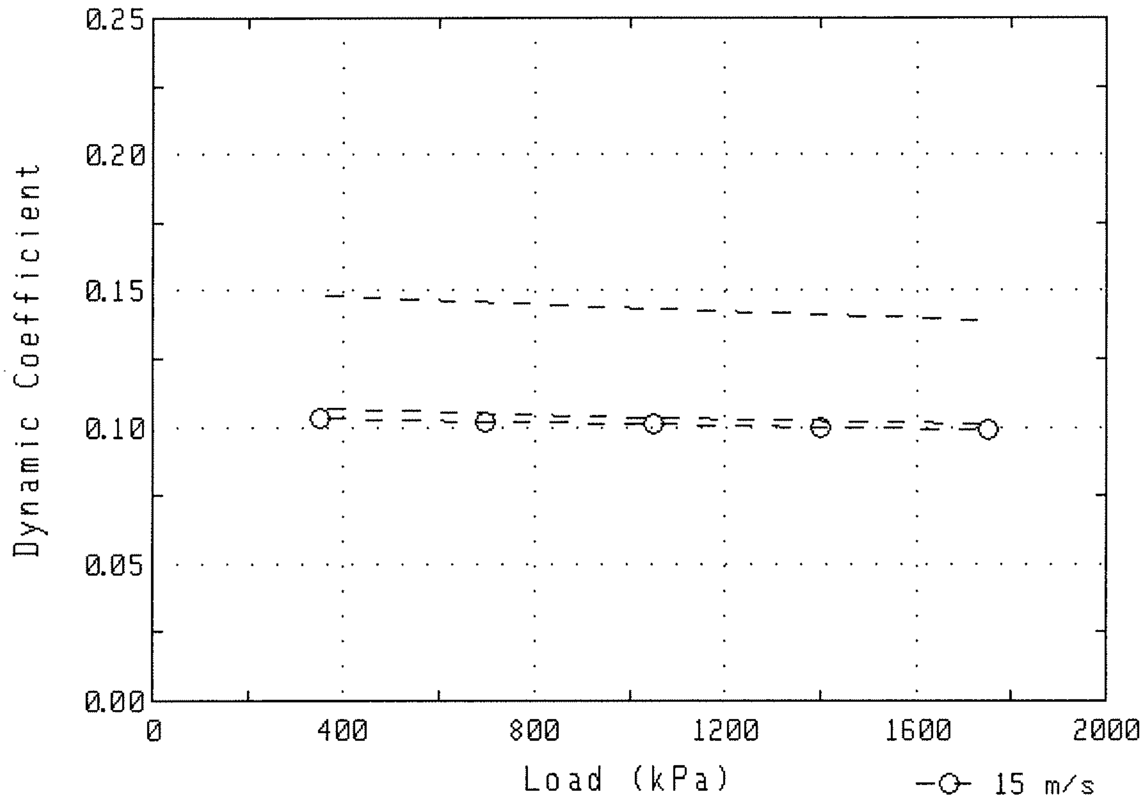


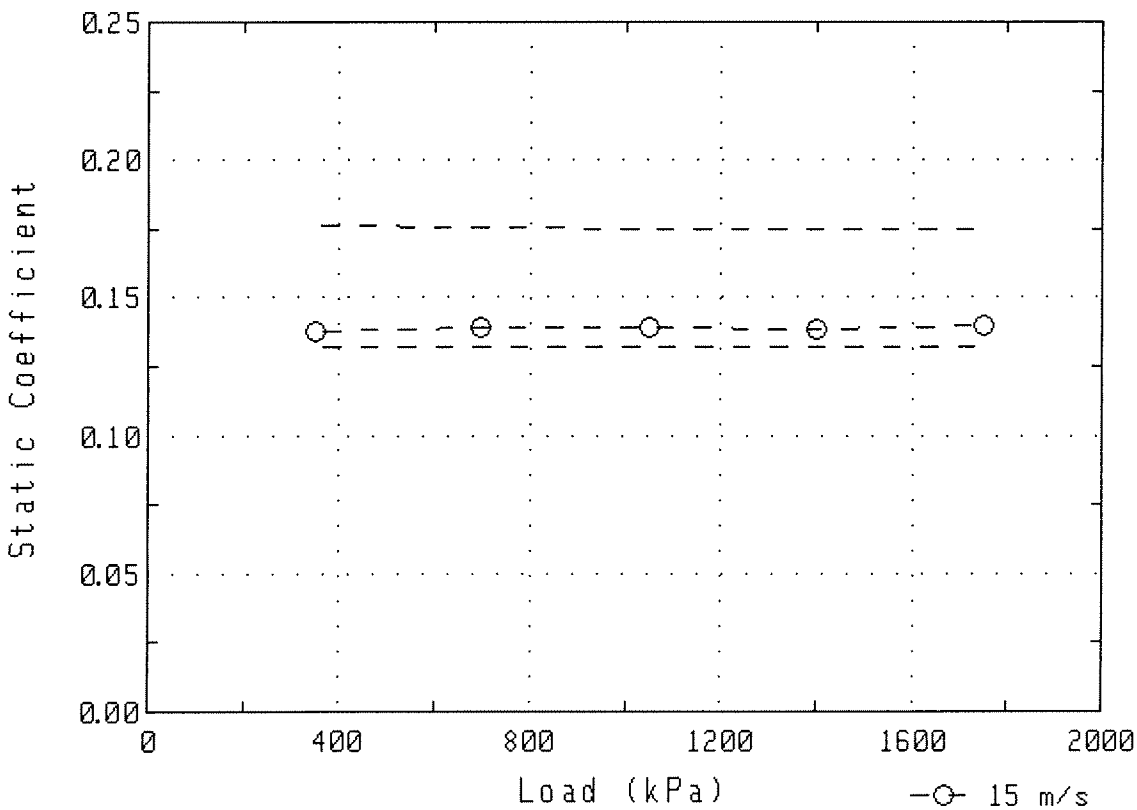
1Y0708 DISC
THICKNESS

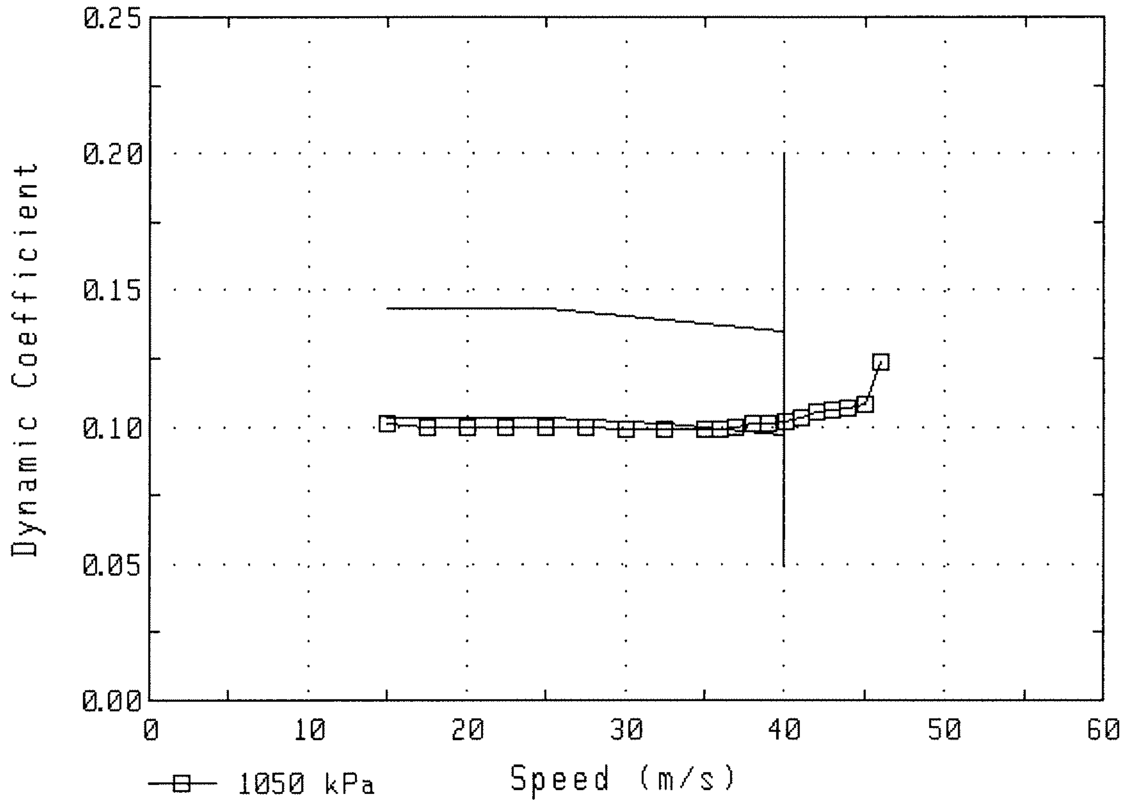
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	4.99	4.96	4.95	4.98	4.95	4.95
2	4.99	4.97	4.96	4.98	4.95	4.94
3	4.99	4.96	4.95	4.98	4.96	4.95
4	4.99	4.95	4.95	4.98	4.95	4.95
5	4.98	4.95	4.95	4.98	4.95	4.95
6	4.98	4.95	4.95	4.98	4.95	4.95
Avg	4.99	4.96	4.95	4.98	4.95	4.95

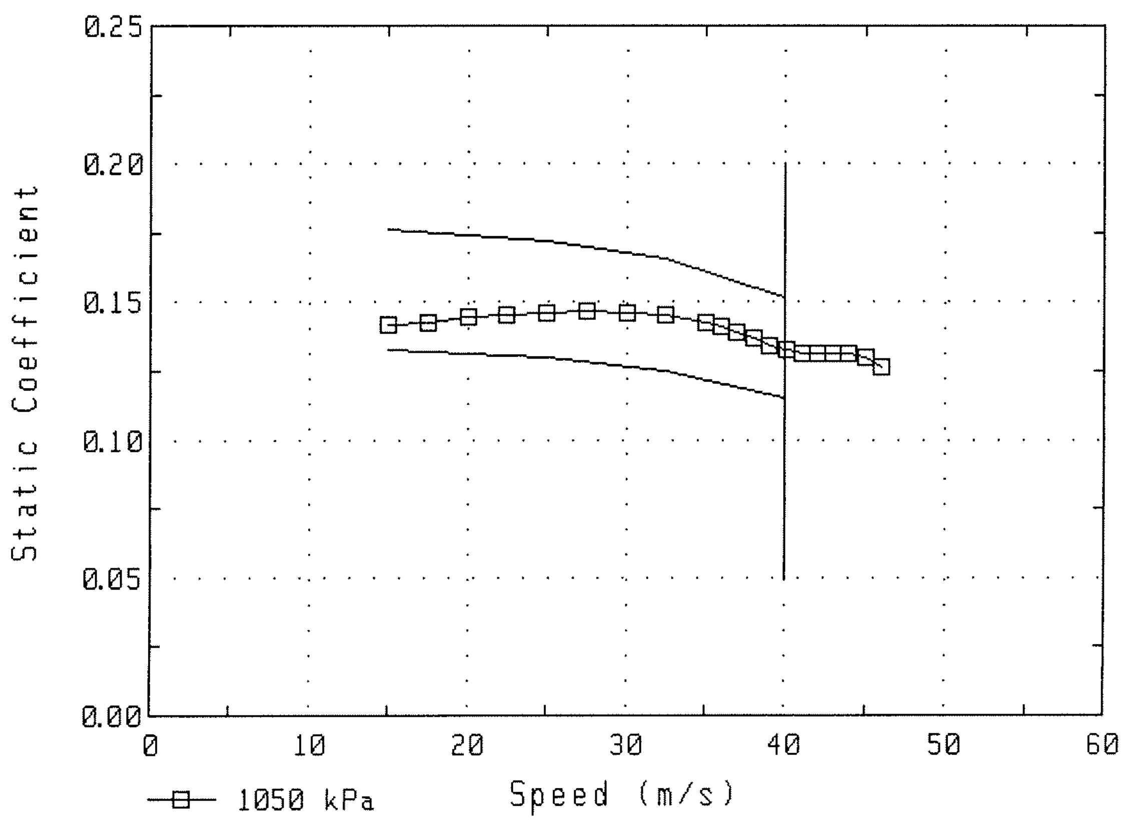
Compression set average wear: 0.029
M2 - M3 average Wear: 0.004

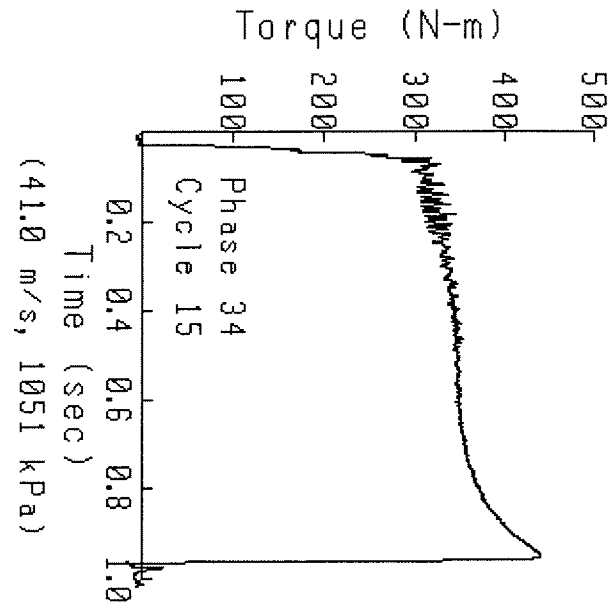
Total Wear (all measurements in mm): 0.033

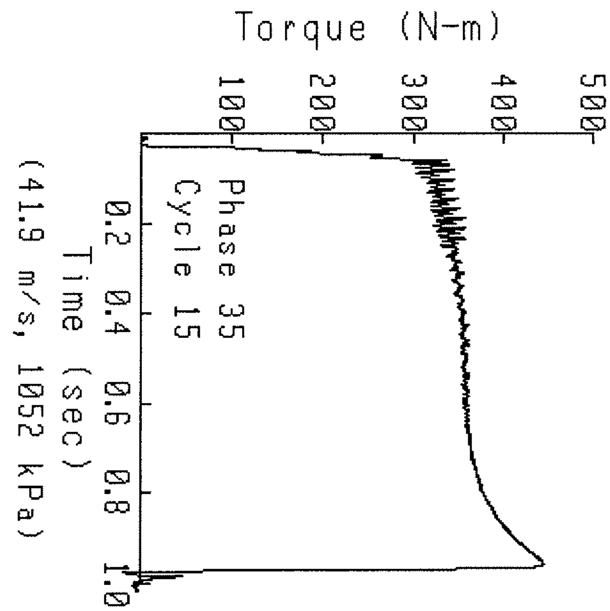

Dynamic Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

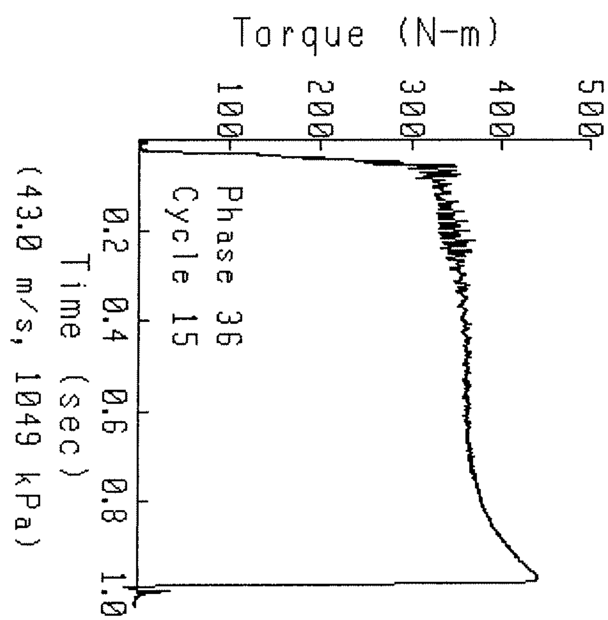

Static Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

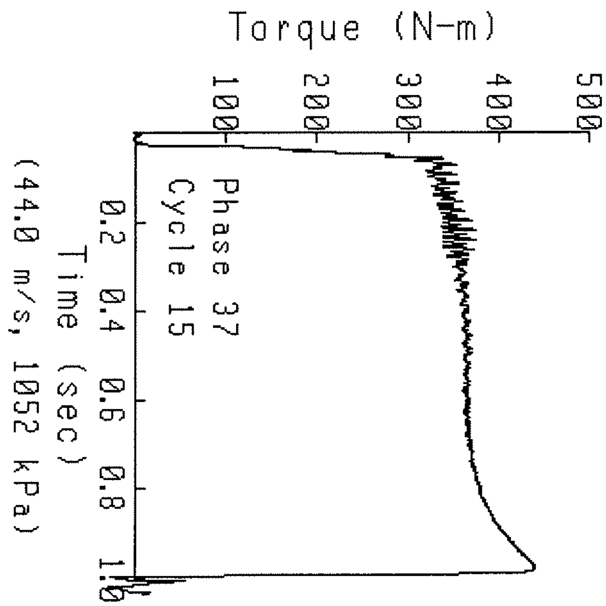

Dynamic Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

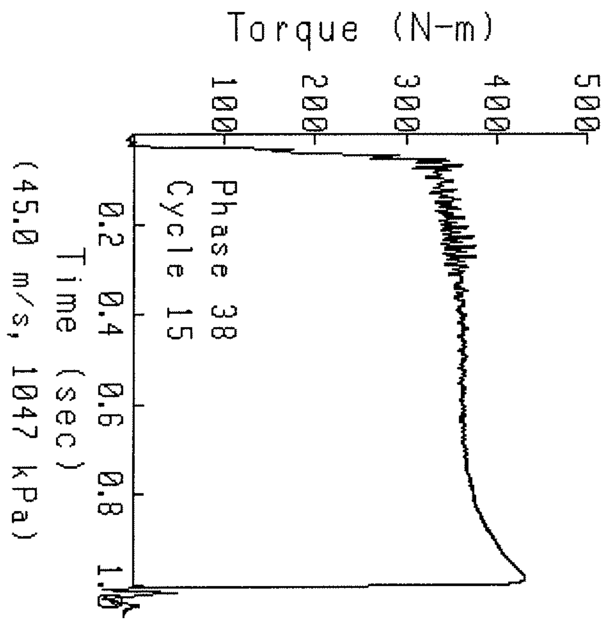

Static Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

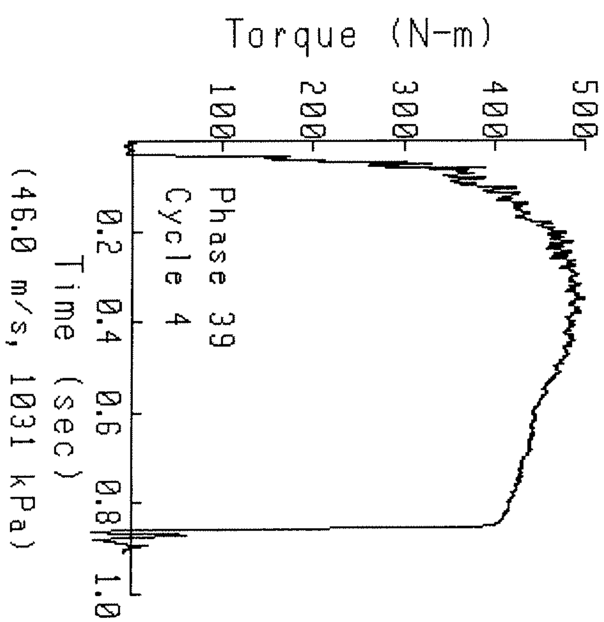

Torque (N-m)
100 200 300 400 500
Phase 34
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(41.0 m/s, 1051 kPa)


Torque (N-m)
100 200 300 400 500
Phase 35
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(41.9 m/s, 1052 kPa)


Torque (N-m)
100 200 300 400 500
Phase 36
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(43.0 m/s, 1049 kPa)

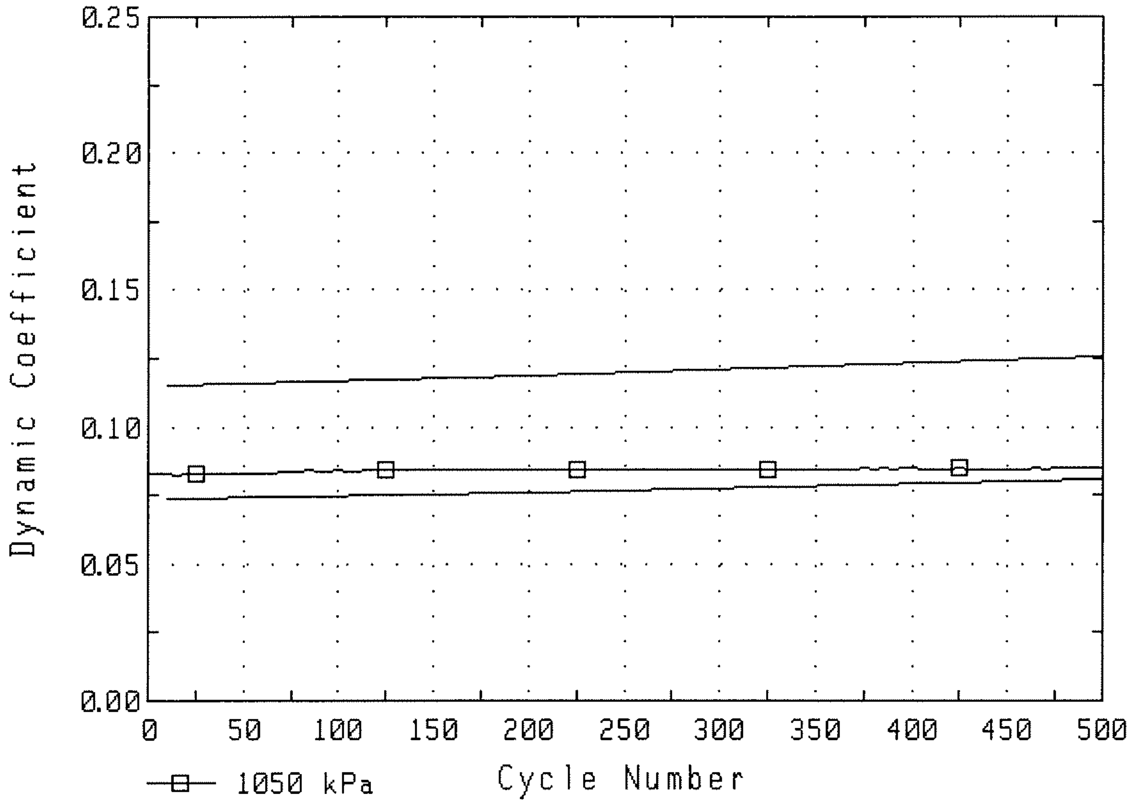

Torque (N-m)
100 200 300 400 500
Phase 37
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(44.0 m/s, 1052 kPa)


Torque (N-m)
100 200 300 400 500
Phase 38
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(45.0 m/s, 1047 kPa)


Torque (N-m)
100 200 300 400 500
Phase 39
Cycle 4
0.2 0.4 0.6 0.8 1.0
Time (sec)
(46.0 m/s, 1031 kPa)

Southwest research institute
I machine oil test AL-27637-L/LO-224425

Test name:	A-77-I
Test date:	10/06/07
Test description:	I Machine AL-27637-L
Oil type:	AL-27637-L/LO-224425
Viscosity:	30
Miscellaneous:	
Software version:	1.40
Run name & desc:	I0706099 - AL-27637-L / LO-224425
Run date:	10/08/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	HC
Remarks:	"I" machine oil test AL-27637-L / LO-224425
Sequence name:	SEQ1221
Remarks:	Use 1Y0710 Disc and 1Y3610 Plate.
Number of cycles run:	1018
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 N-m-s^2
Disc name & desc:	1Y0710 - Steering Brake Paper
Material:	Raybestos 7894-4 Paper
Groove pattern:	2 - 37 Multiple Parallel
Miscellaneous:	Use with 1Y3610 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	23MR9-00001
Remarks:	Steering Brake Paper
Plate name & desc:	1Y3610 - Steel Plate
Surface:	0.70 to 1.30 micron Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	23MR9-00001
Remarks:	0.83 Surface Finish
Report limit name:	LIM1221 - Reference run: I0706003
Limit file generated:	07/26/06
Report format name:	REP1221 - STEERING BRAKE PAPER

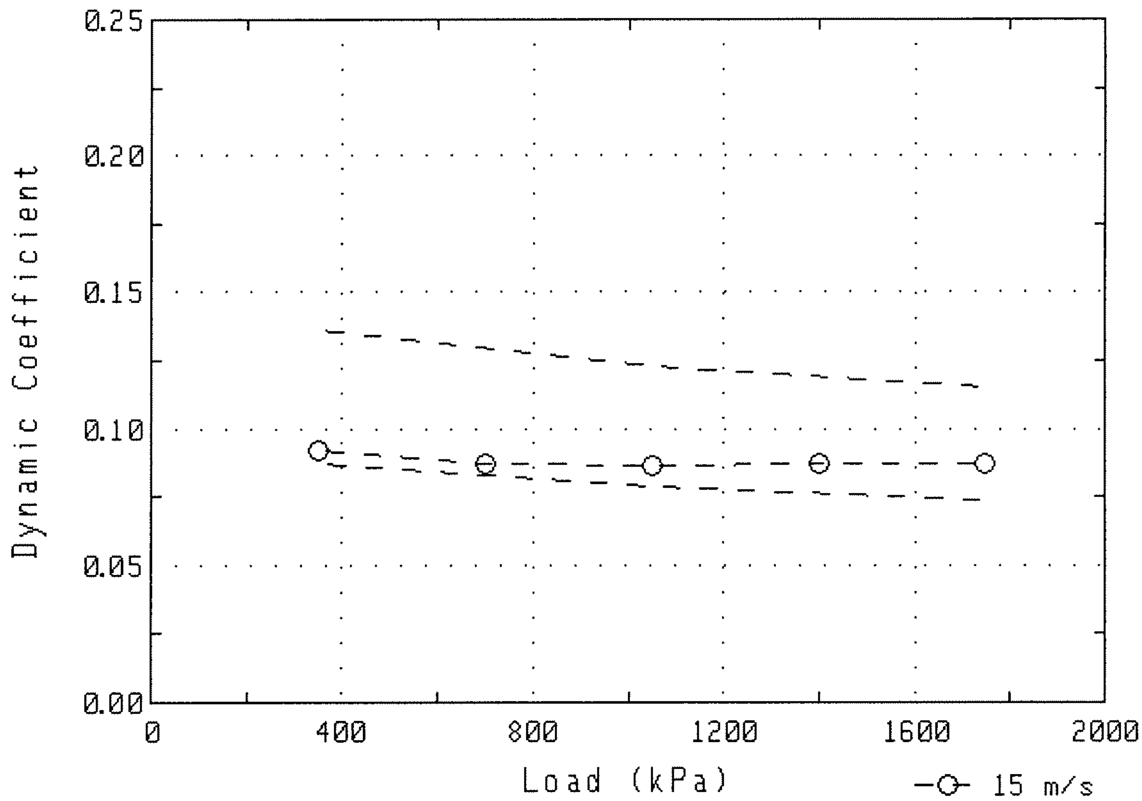


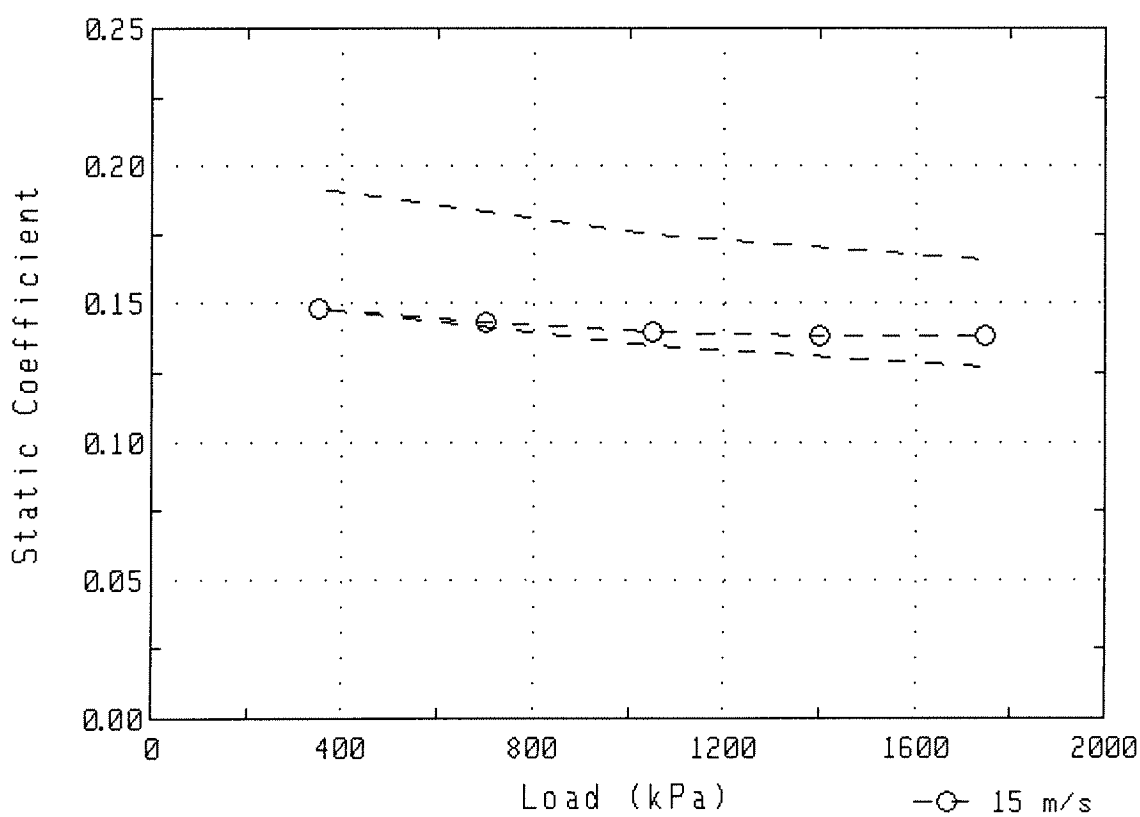
1Y0710 DISC
THICKNESS

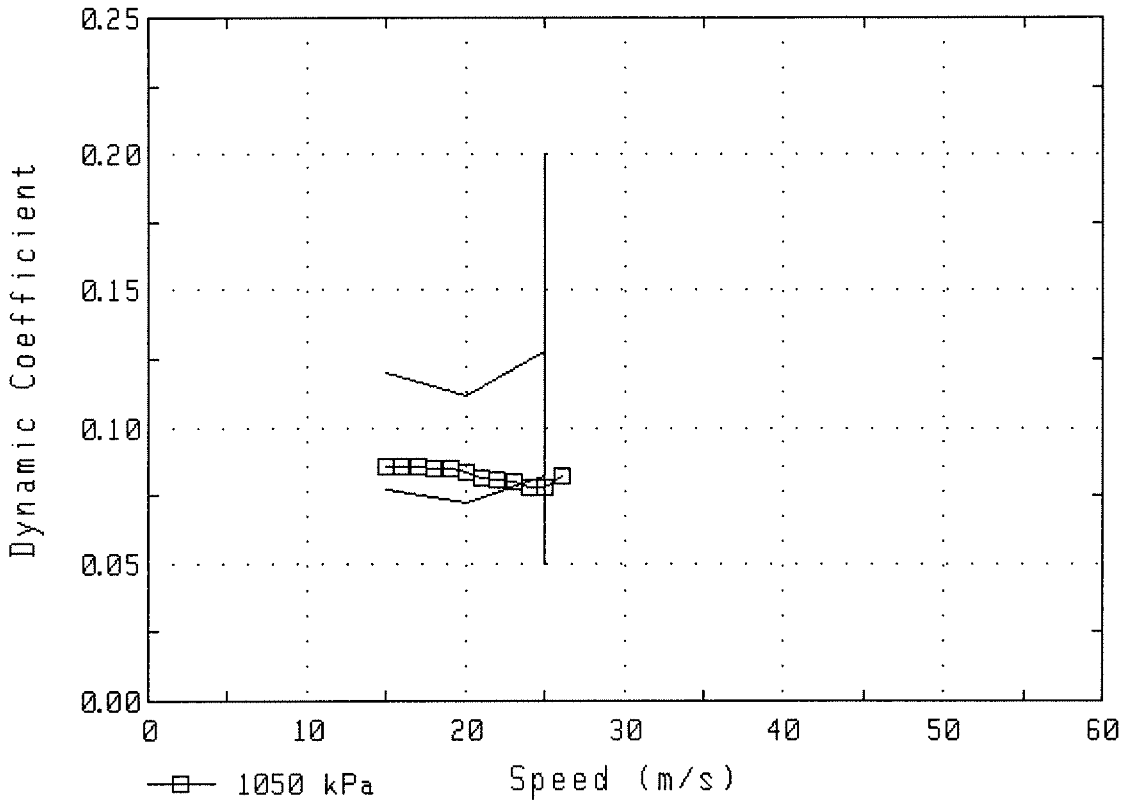
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	5.04	5.02	5.01	5.04	5.02	5.01
2	5.05	5.02	5.01	5.05	5.02	5.01
3	5.03	5.02	5.01	5.03	5.01	5.01
4	5.03	5.01	5.00	5.03	5.01	5.00
5	5.02	5.01	5.00	5.03	5.01	5.00
6	5.04	5.02	5.01	5.04	5.02	5.01
Avg	5.04	5.02	5.01	5.04	5.01	5.01

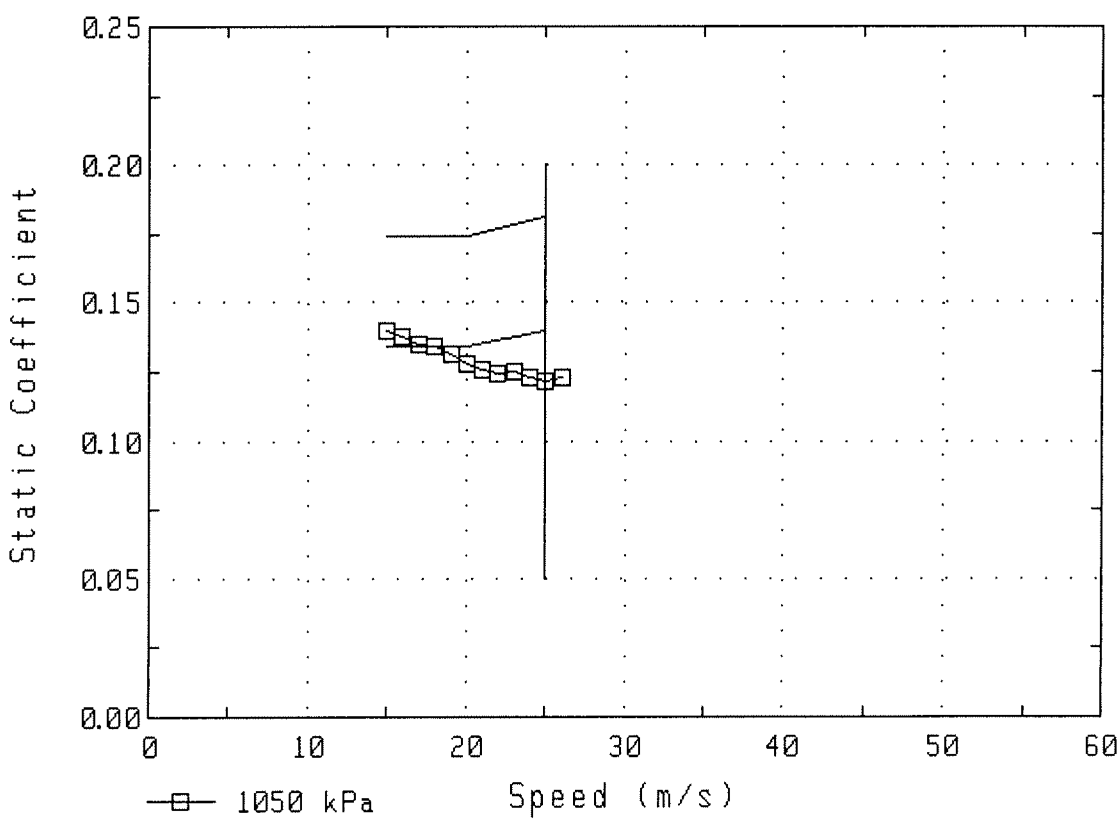
Compression set average wear: 0.020
M2 - M3 average Wear: 0.009

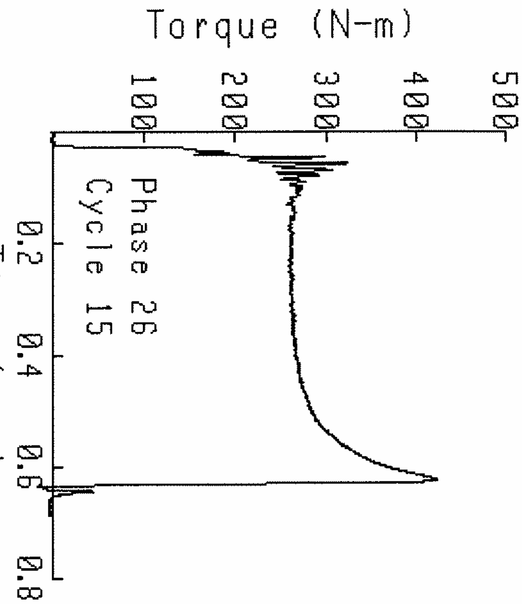
Total Wear (all measurements in mm): 0.029

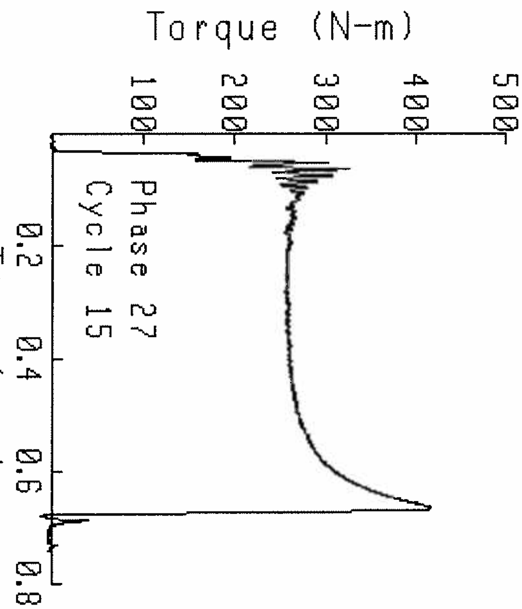

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

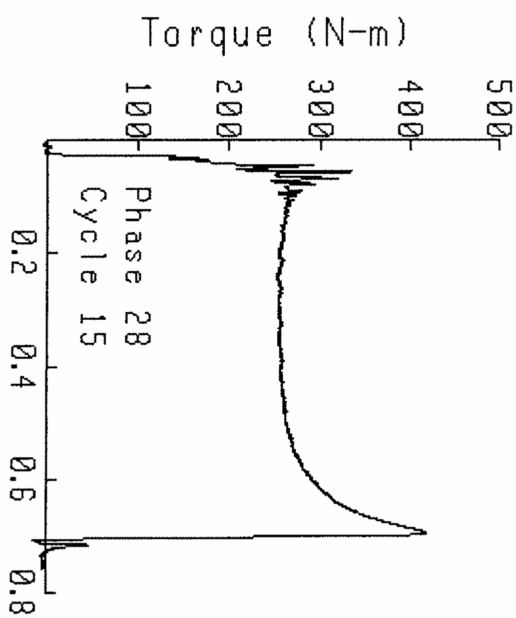

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

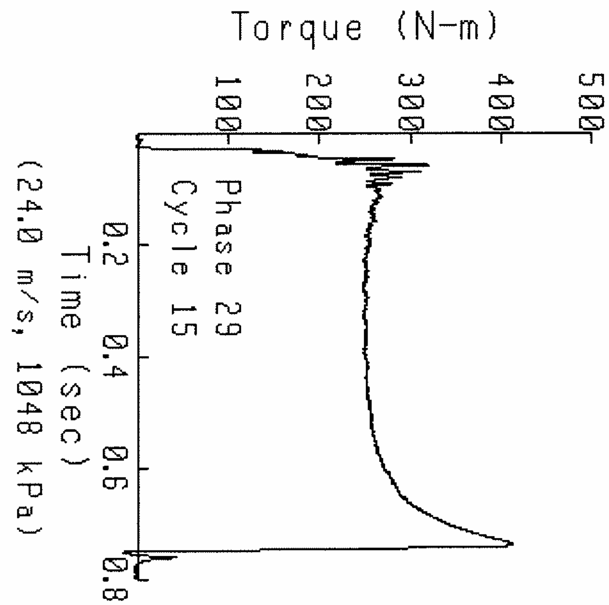

Dynamic Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

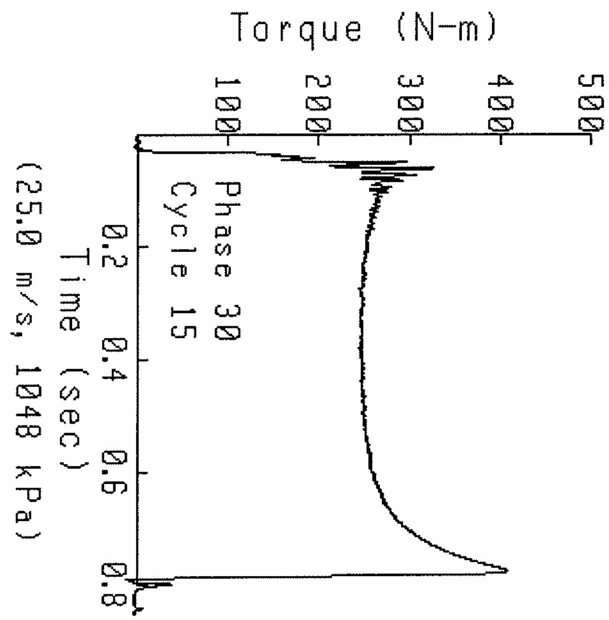

Static Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

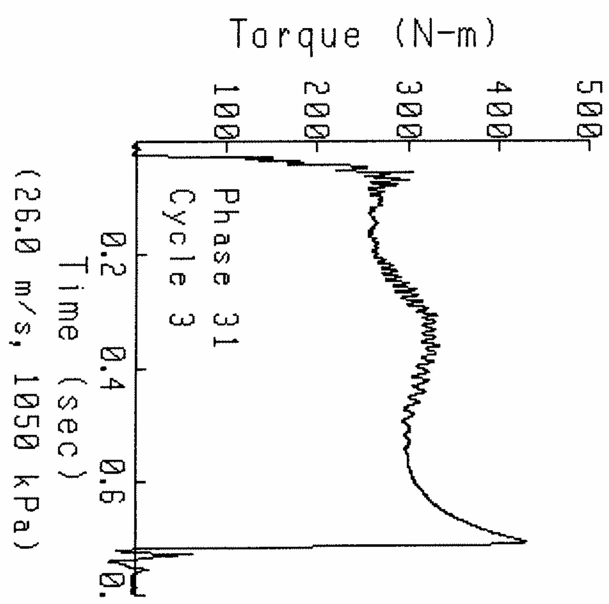

Torque (N-m)
100 200 300 400 500
Phase 26
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(21.0 m/s, 1047 kPa)


Torque (N-m)
100 200 300 400 500
Phase 27
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(22.0 m/s, 1048 kPa)


Torque (N-m)
100 200 300 400 500
Phase 28
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(23.0 m/s, 1047 kPa)


Torque (N-m)
100 200 300 400 500
Phase 29
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(24.0 m/s, 1048 kPa)

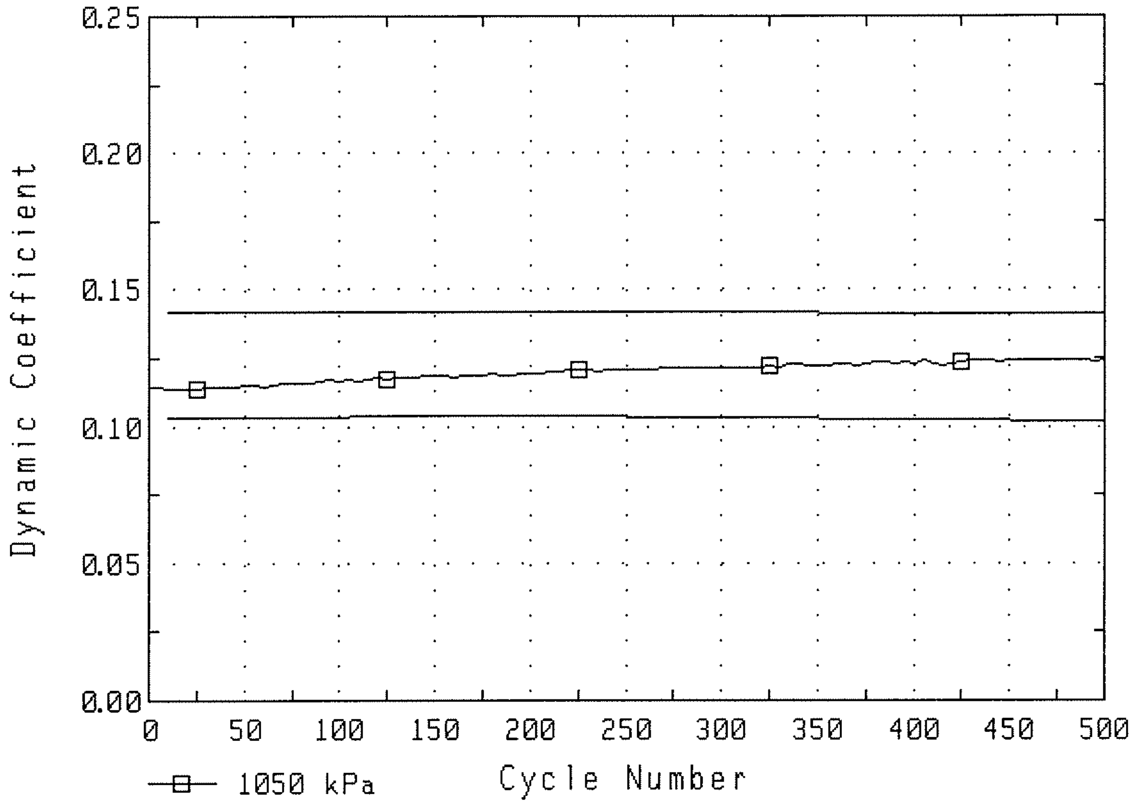

Torque (N-m)
100 200 300 400 500
Phase 30
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(25.0 m/s, 1048 kPa)


Torque (N-m)
100 200 300 400 500
Phase 31
Cycle 3
0.2 0.4 0.6 0.8
Time (sec)
(26.0 m/s, 1050 kPa)

Southwest research institute
I machine oil test AL-27637-L/LO-224425

Test name:	A-77-I
Test date:	10/06/07
Test description:	I Machine AL-27637-L
Oil type:	AL-27637-L/LO-224425
Viscosity:	30
Miscellaneous:	
Software version:	1.40
Run name & desc:	I0706100 - AL-27637-L
Run date:	10/09/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	HC
Remarks:	"I" machine oil test AL-27637-L / LO-224425
Sequence name:	SEQ1222
Remarks:	Use 1Y0711 Disc and 1Y0726 Plate
Number of cycles run:	1117
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 N-m-s^2
Disc name & desc:	1Y0711 - Wheel Brake Paper
Material:	Raybestos 7902-1 Paper
Groove pattern:	2 - 37 Multiple Parallel
Miscellaneous:	Use with 1Y0726 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	24FE9-00001
Remarks:	Wheel Brake Paper
Plate name & desc:	1Y0726 - Steel Plate
Surface:	0.30 micron Maximum Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	24FE9-00001
Remarks:	0.23 Surface Finish
Report limit name:	LIM1222 - Reference run: I0706004
Limit file generated:	07/26/06
Report format name:	REP1222 - WHEEL BRAKE PAPER

Test: A-77-I Run: I0706100 Started on 10/09/07 at 08:55

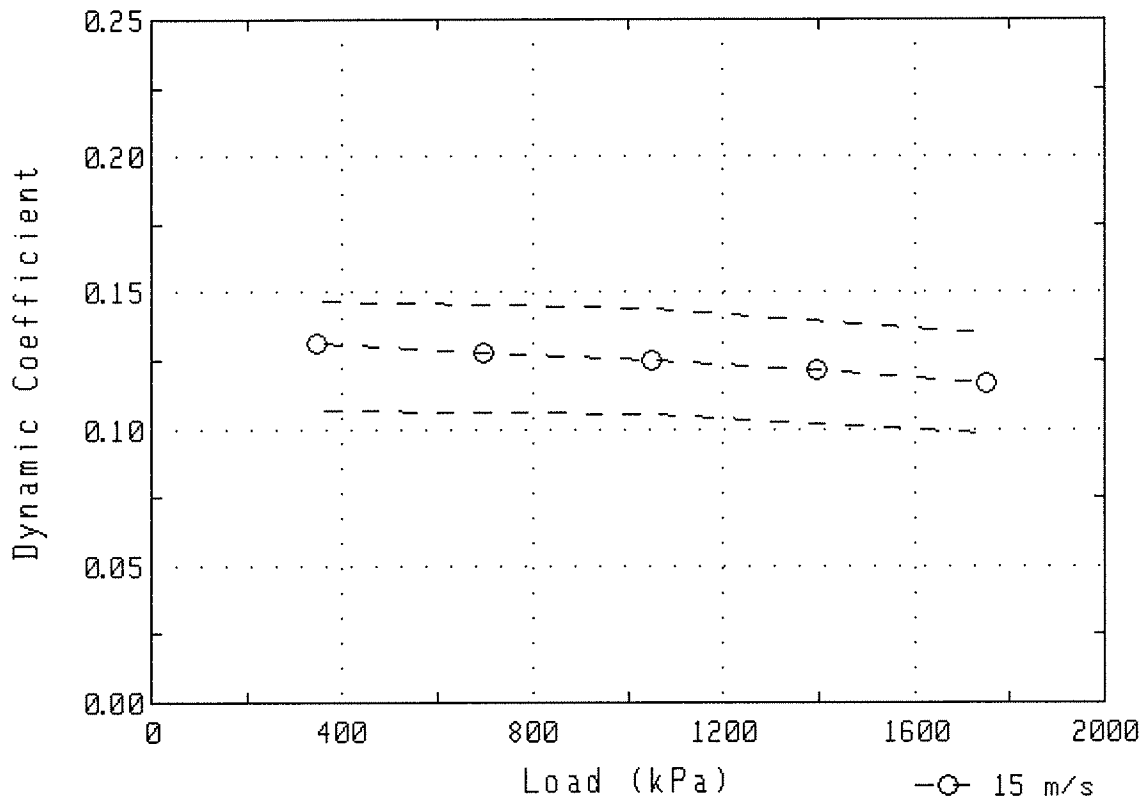


1Y0711 DISC
THICKNESS

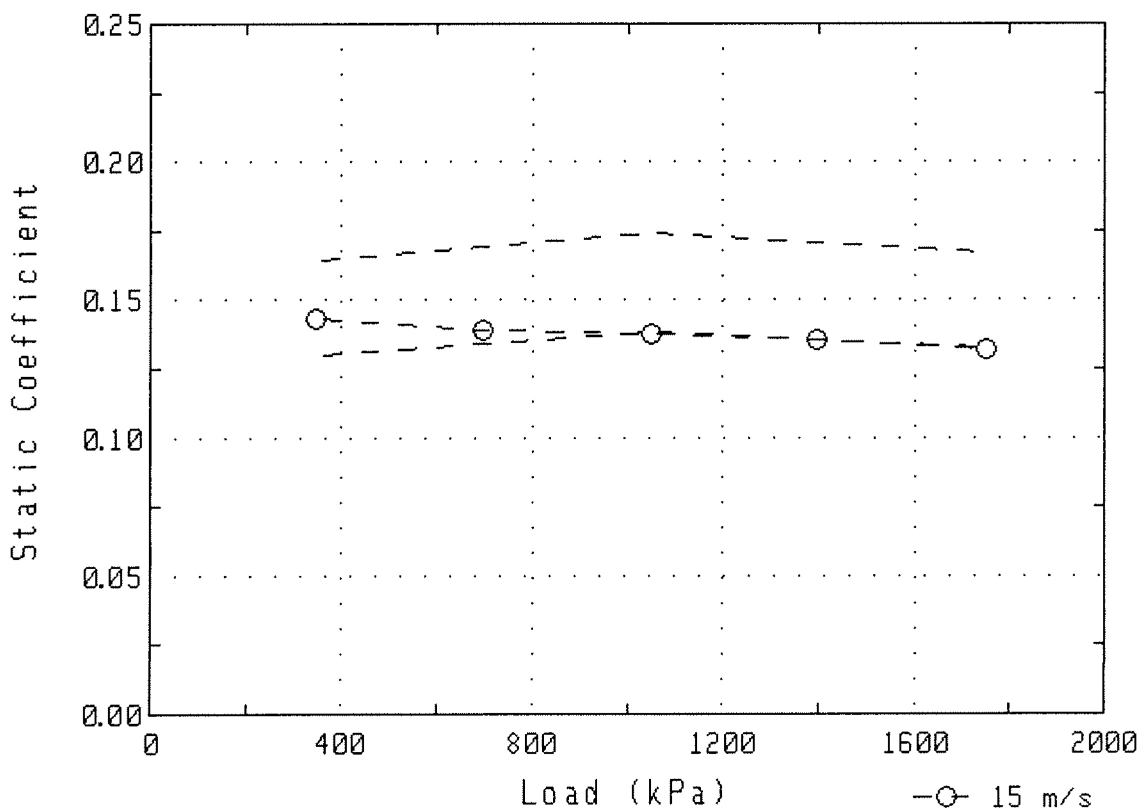
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	4.99	4.95	4.94	4.99	4.96	4.95
2	4.99	4.96	4.94	4.99	4.96	4.95
3	4.99	4.96	4.94	4.99	4.96	4.95
4	4.99	4.96	4.94	4.99	4.96	4.94
5	4.99	4.96	4.94	4.99	4.96	4.95
6	4.99	4.95	4.93	4.98	4.94	4.94
Avg	4.99	4.96	4.94	4.99	4.96	4.95

Compression set average wear: 0.032
M2 - M3 average Wear: 0.014

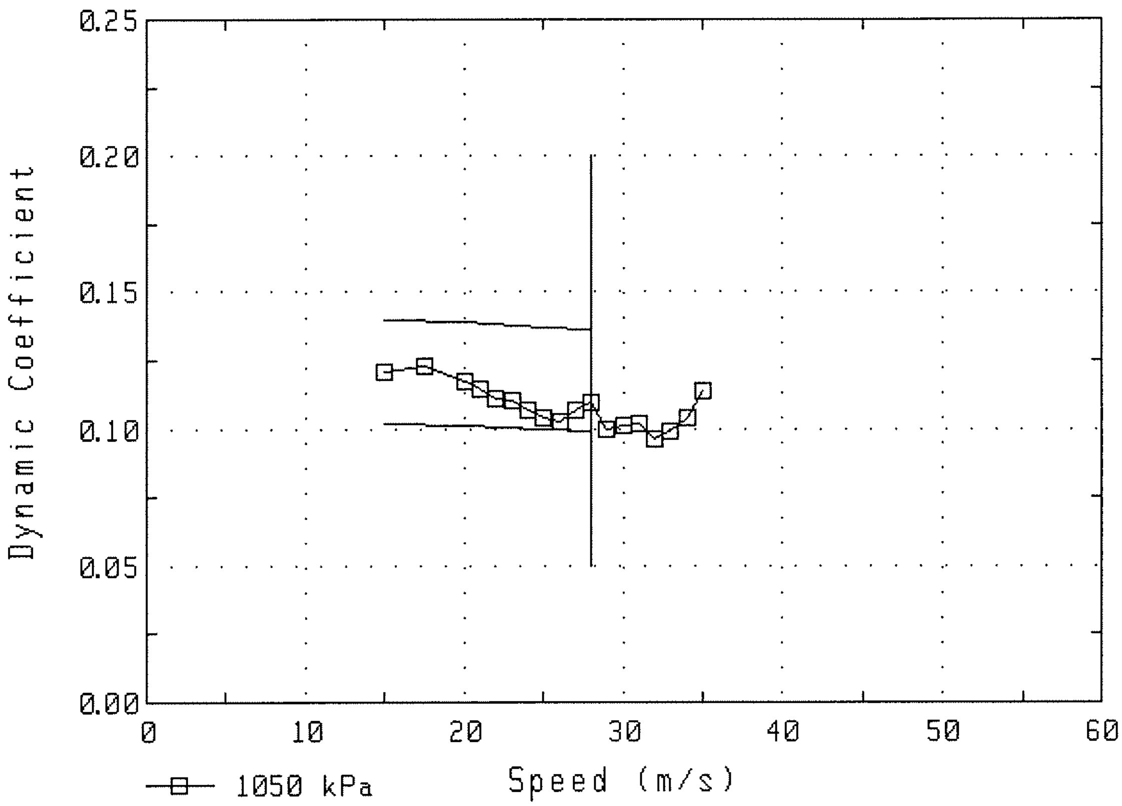
Total Wear (all measurements in mm): 0.047

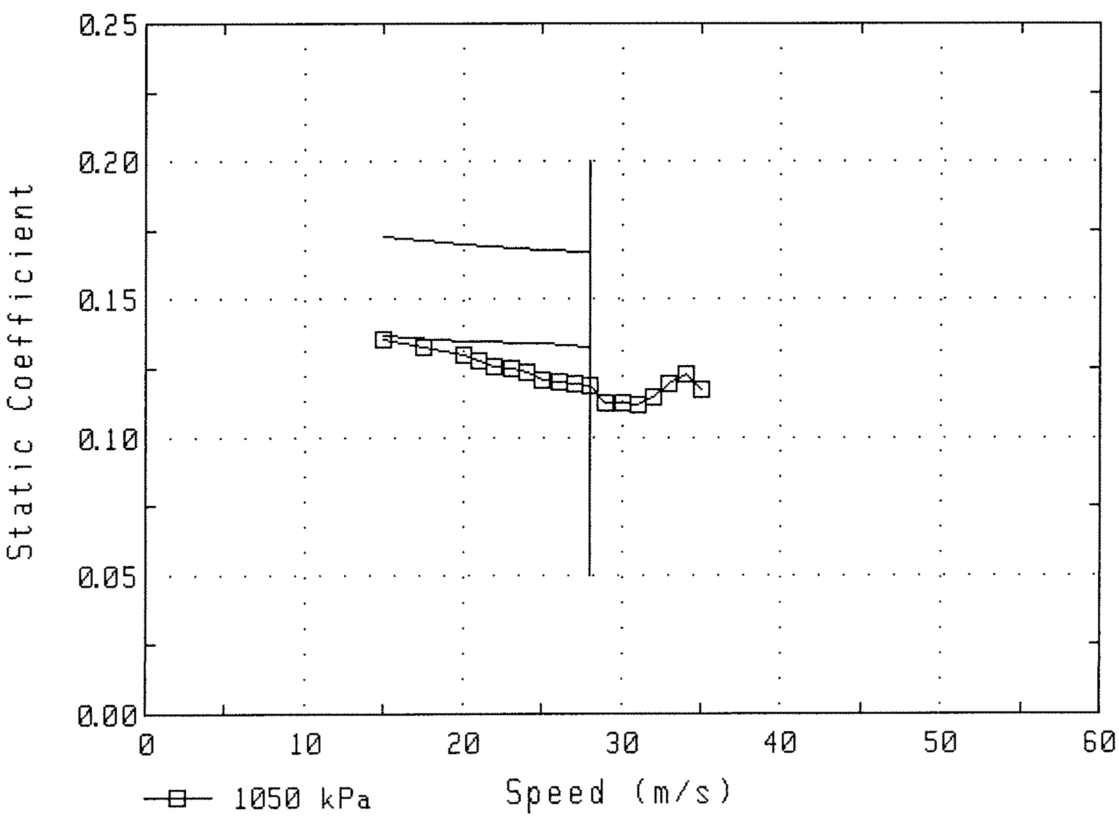


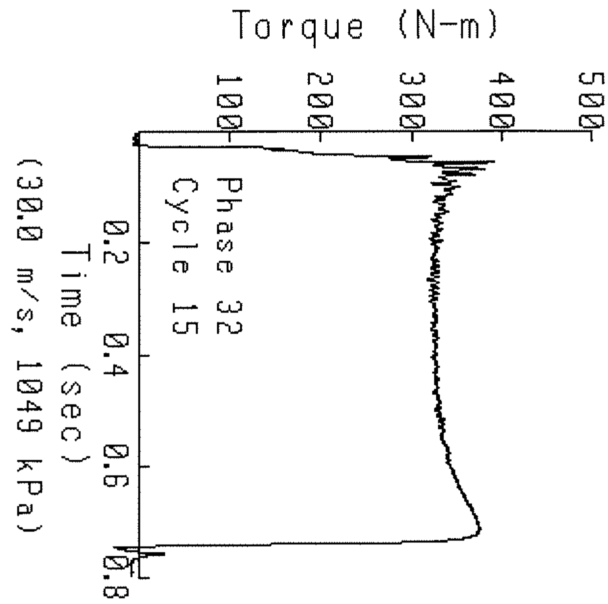
Dynamic Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

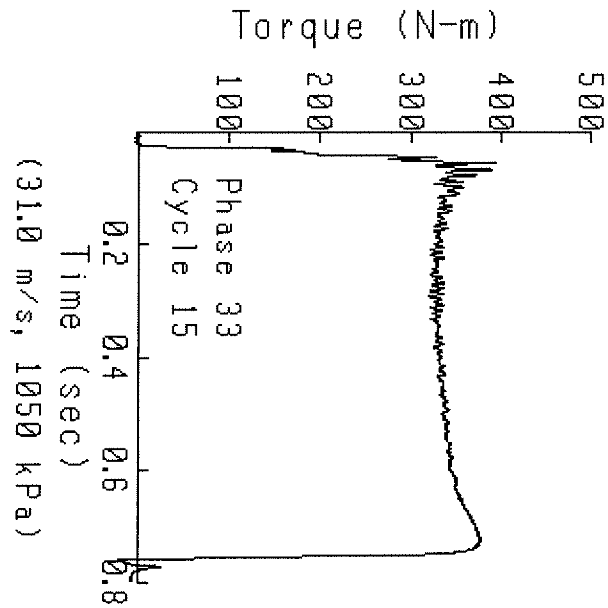


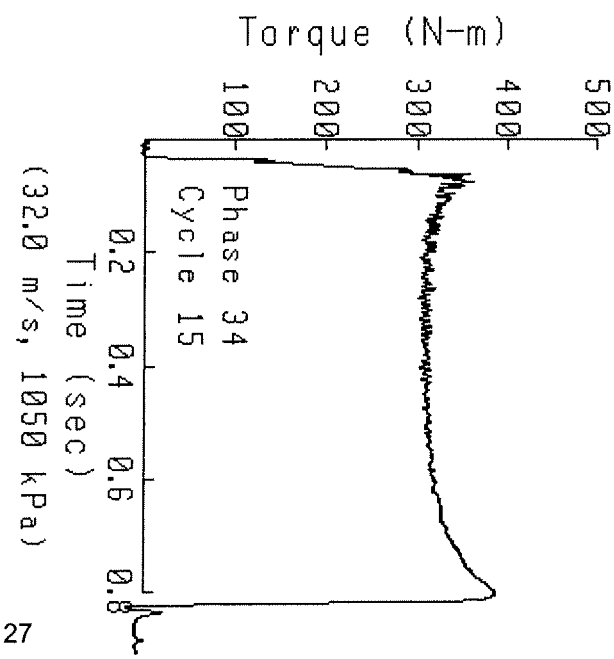
Static Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

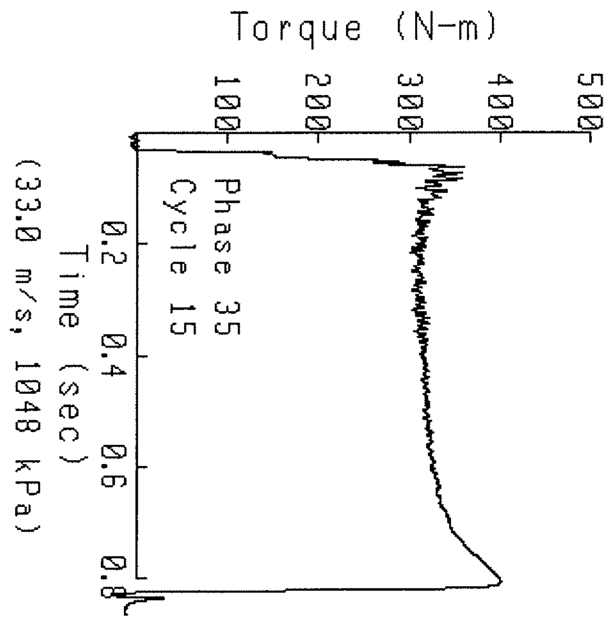

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

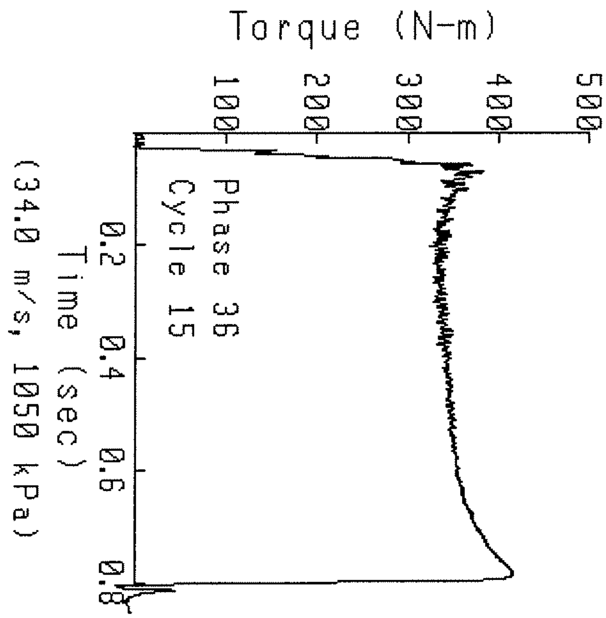

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

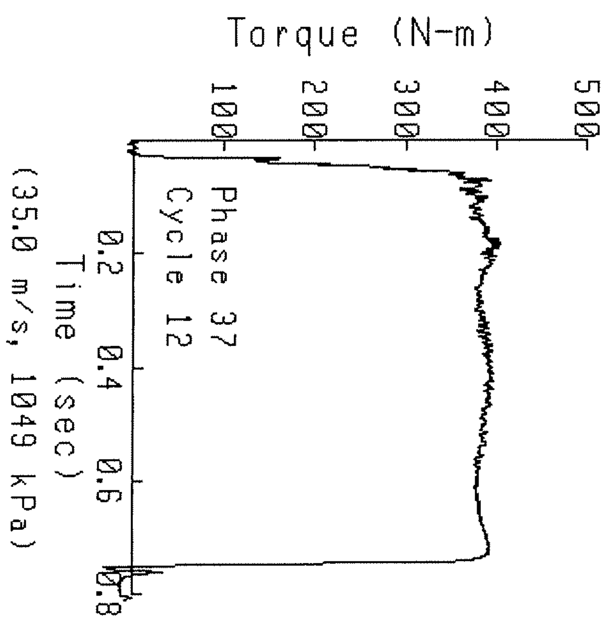

Torque (N-m)
100 200 300 400 500
Phase 32
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(30.0 m/s, 1049 kPa)


Torque (N-m)
100 200 300 400 500
Phase 33
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(31.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500
Phase 34
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(32.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500
Phase 35
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(33.0 m/s, 1048 kPa)


Torque (N-m)
100 200 300 400 500
Phase 36
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(34.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500
Phase 37
Cycle 12
0.2 0.4 0.6 0.8
Time (sec)
(35.0 m/s, 1049 kPa)

Southwest research institute
I machine oil test AL-27637-L/LO-224425

Test name:	A-77-I
Test date:	10/06/07
Test description:	I Machine AL-27637-L
Oil type:	AL-27637-L/LO-224425
Viscosity:	30
Miscellaneous:	
Software version:	1.40

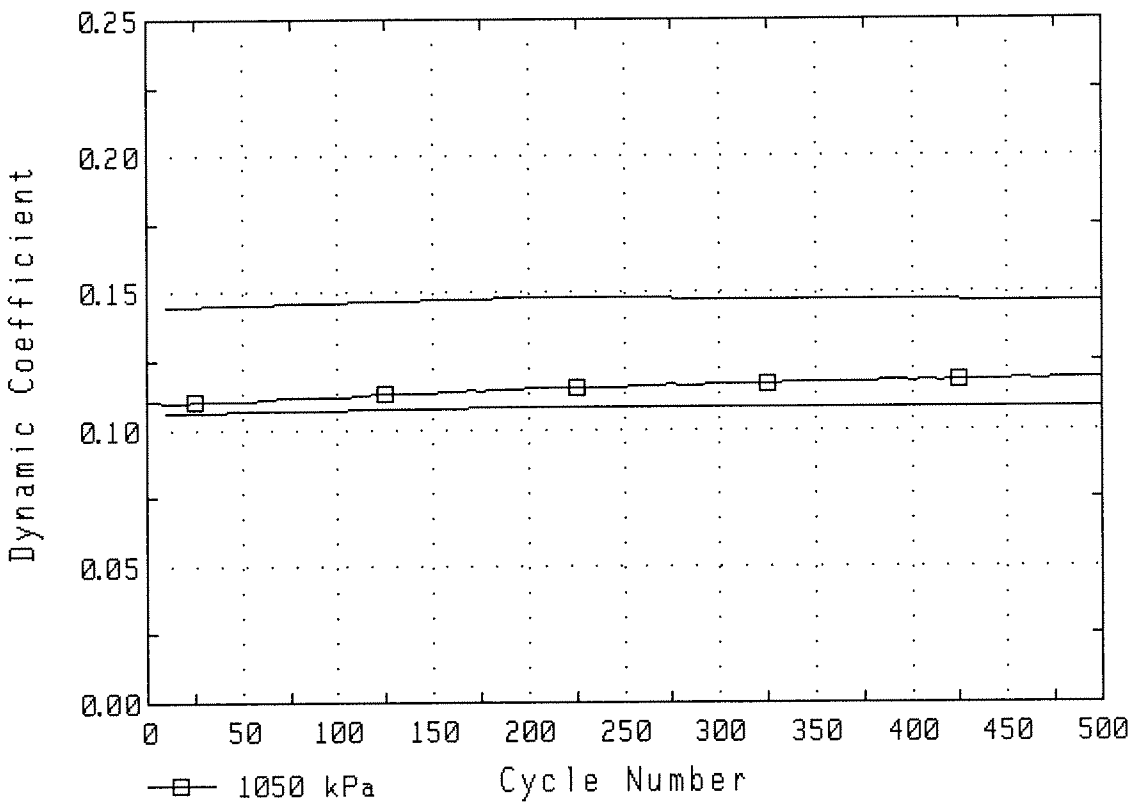
Run name & desc:	I0706101 - AL-27637-L
Run date:	10/10/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	HC
Remarks:	"I" machine oil test AL-27637-L / LO-224425
Sequence name:	SEQ1223
Remarks:	Use 1Y0712 Disc and 1Y0726 Plate
Number of cycles run:	1006

Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 N-m-s^2

Disc name & desc:	1Y0712 - Transmission Paper
Material:	Raybestos 7901-2 Paper
Groove pattern:	2 - 37 Multiple Parallel
Miscellaneous:	Use with 1Y0726 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	27MR9-00001
Remarks:	Transmission Paper

Plate name & desc:	1Y0726 - Steel Plate
Surface:	0.30 micron Maximum Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	27MR9-00001
Remarks:	0.20 Surface Finish

Report limit name:	LIM1223 - Reference run: I0706006
Limit file generated:	07/26/06
Report format name:	REP1223 - TRANSMISSION PAPER

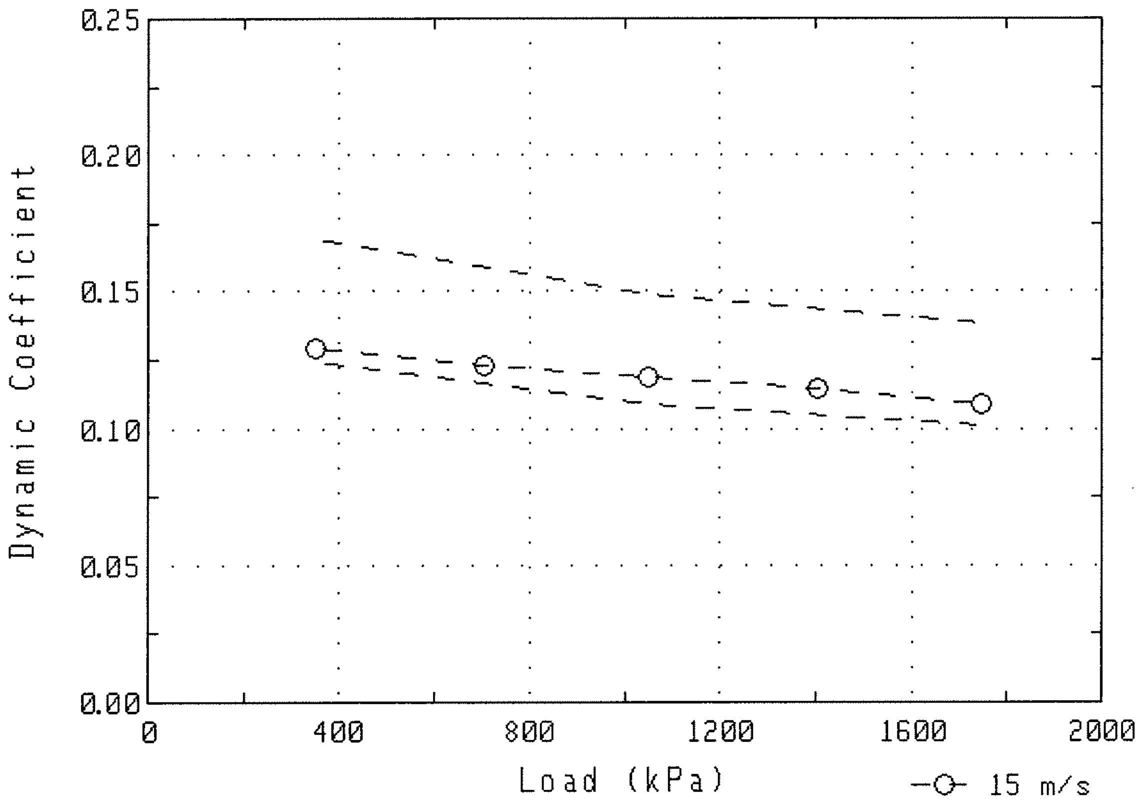


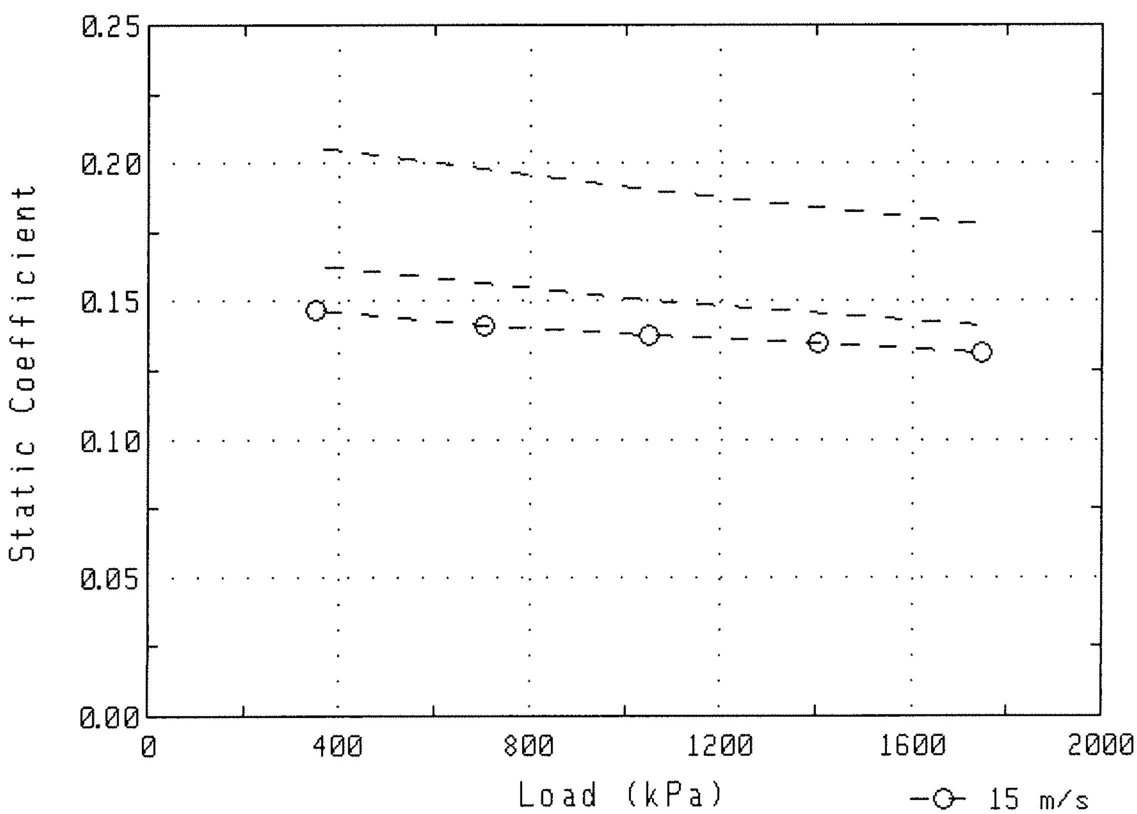
1Y0712 DISC
THICKNESS

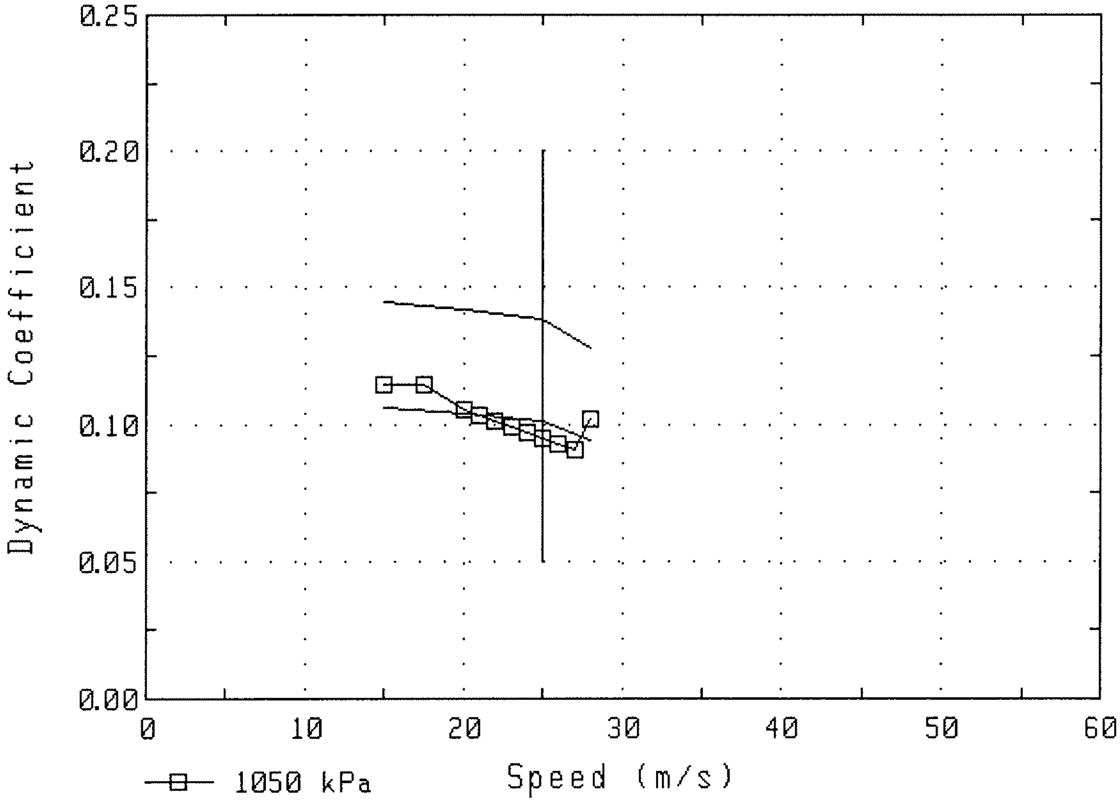
Loc	Outer Diameter M1	M2	M3	Inner Diameter M1	M2	M3
1	5.00	4.97	4.95	5.00	4.98	4.96
2	4.99	4.96	4.95	4.99	4.96	4.95
3	4.98	4.95	4.94	4.98	4.95	4.94
4	4.99	4.95	4.94	4.99	4.95	4.94
5	4.98	4.95	4.94	4.98	4.95	4.94
6	5.00	4.96	4.95	5.00	4.96	4.95
Avg	4.99	4.96	4.94	4.99	4.96	4.95

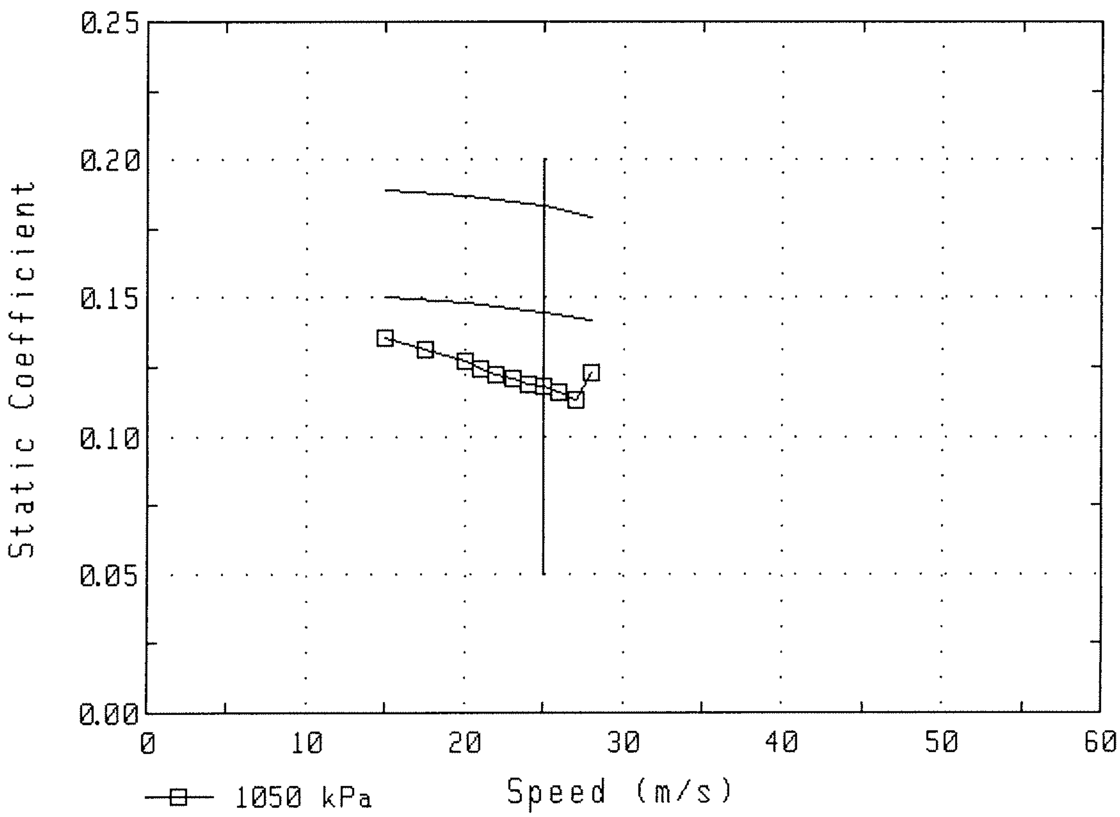
Compression set average wear: 0.033
M2 - M3 average Wear: 0.012

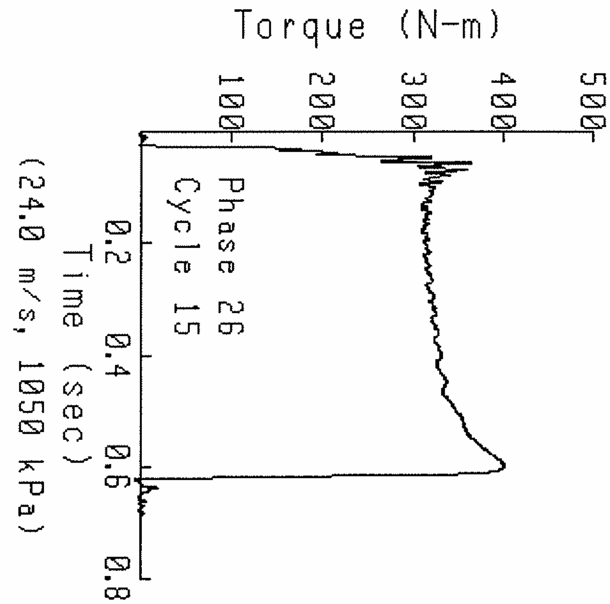
Total Wear (all measurements in mm): 0.044

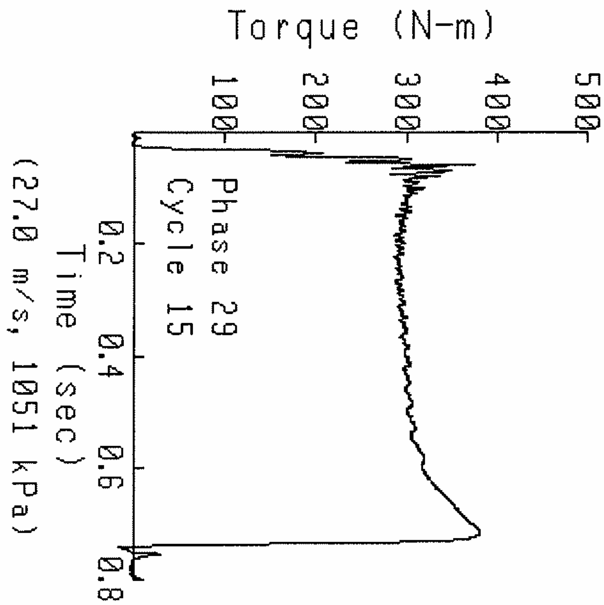

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

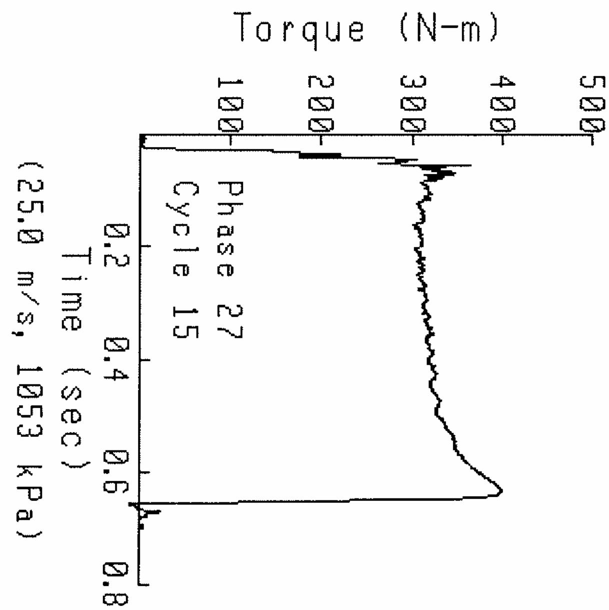

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

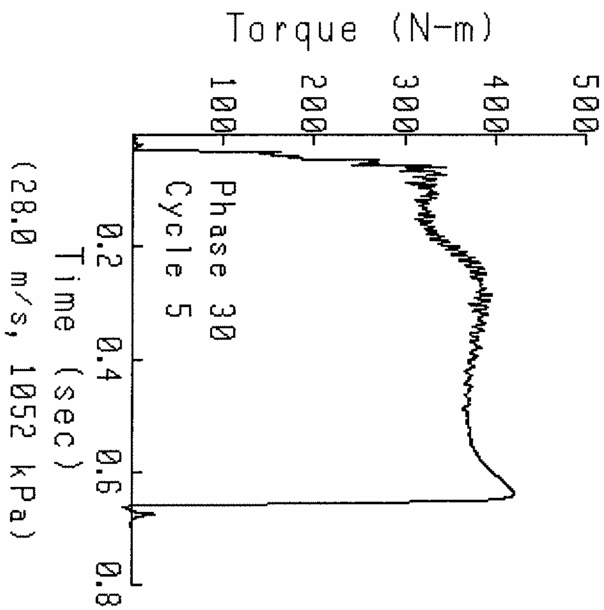

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

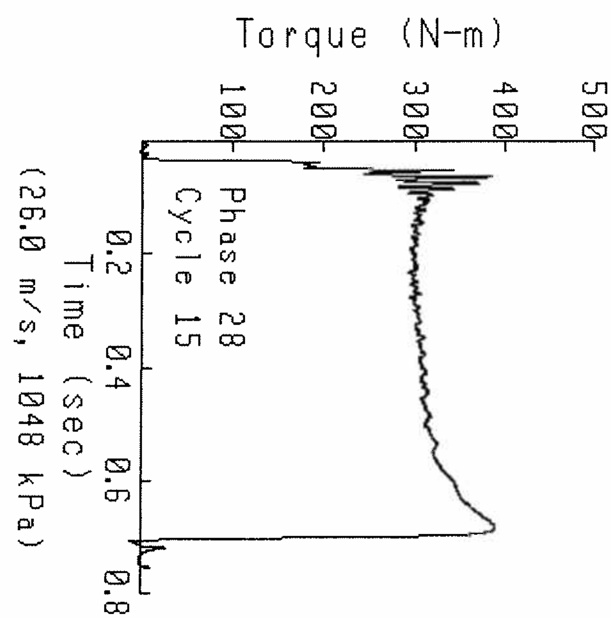

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

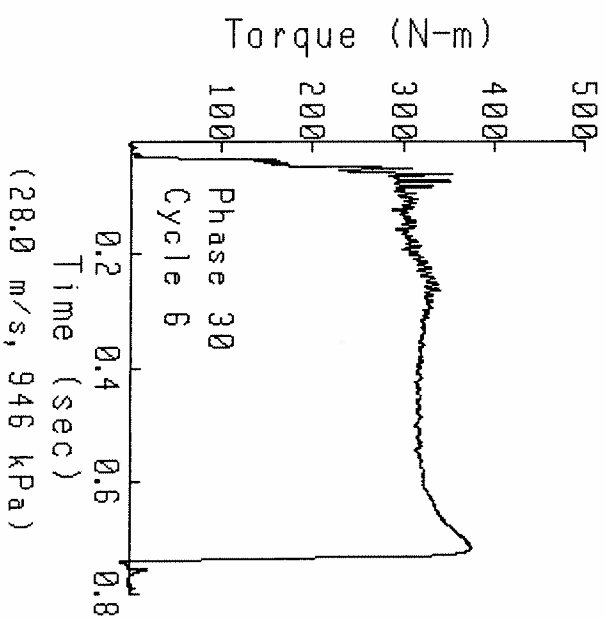

Torque (N-m)
100
200
300
400
500
Phase 26
Cycle 15
0.2
0.4
0.6
0.8
Time (sec)
(24.0 m/s, 1050 kPa)


Torque (N-m)
100
200
300
400
500
Phase 29
Cycle 15
0.2
0.4
0.6
0.8
Time (sec)
(27.0 m/s, 1051 kPa)


Torque (N-m)
100
200
300
400
500
Phase 27
Cycle 15
0.2
0.4
0.6
0.8
Time (sec)
(25.0 m/s, 1053 kPa)


Torque (N-m)
100
200
300
400
500
Phase 30
Cycle 5
0.2
0.4
0.6
0.8
Time (sec)
(28.0 m/s, 1052 kPa)


Torque (N-m)
100
200
300
400
500
Phase 28
Cycle 15
0.2
0.4
0.6
0.8
Time (sec)
(26.0 m/s, 1048 kPa)


Torque (N-m)
100
200
300
400
500
Phase 30
Cycle 6
0.2
0.4
0.6
0.8
Time (sec)
(28.0 m/s, 946 kPa)

Southwest research institute
I machine oil test AL-27637-L/LO-224425

Test name:	A-77-I
Test date:	10/06/07
Test description:	I Machine AL-27637-L
Oil type:	AL-27637-L/LO-224425
Viscosity:	30
Miscellaneous:	
Software version:	1.40

Run name & desc:	I0706102 - AL-27637-L
Run date:	10/11/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	HC
Remarks:	I machine oil test AL-27637-L / LO-224425
Sequence name:	SEQ1224
Remarks:	Use 1Y0713 Disc and 8E4095 Plate
Number of cycles run:	1126

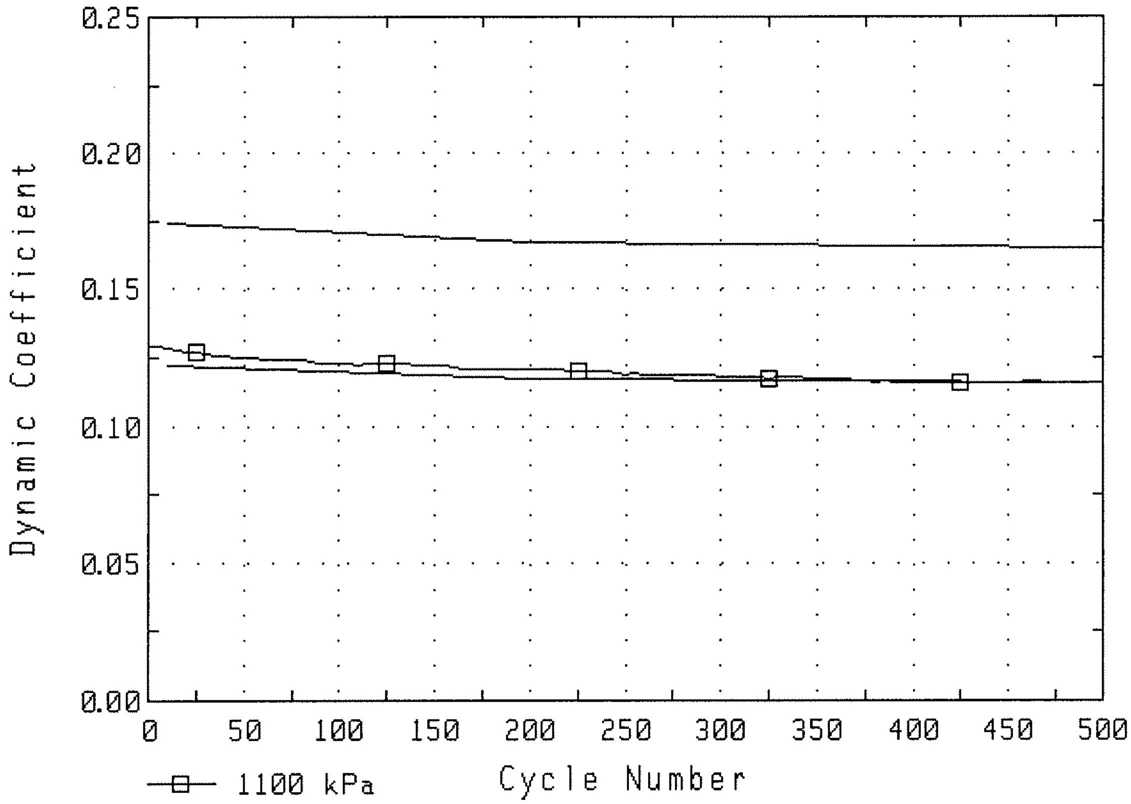
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 N-m-s^2

Disc name & desc:	1Y0713 - Elastomeric Disc
Material:	Caterpillar F37
Groove pattern:	Single Lead Spiral - 12 Radial
Miscellaneous:	Use with 8E4095 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	C63007FE1
Remarks:	Elastomeric

Plate name & desc:	8E4095 - Steel Plate
Surface:	0.70 to 1.00 micron Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	C63007FE1
Remarks:	0.87 Surface Finish

Report limit name:	LIM1224 - Reference run: I0706007
Limit file generated:	07/26/06
Report format name:	REP1224 - ELASTOMERIC, F37

Test: A-77-I Run: I0706102 Started on 10/11/07 at 08:58



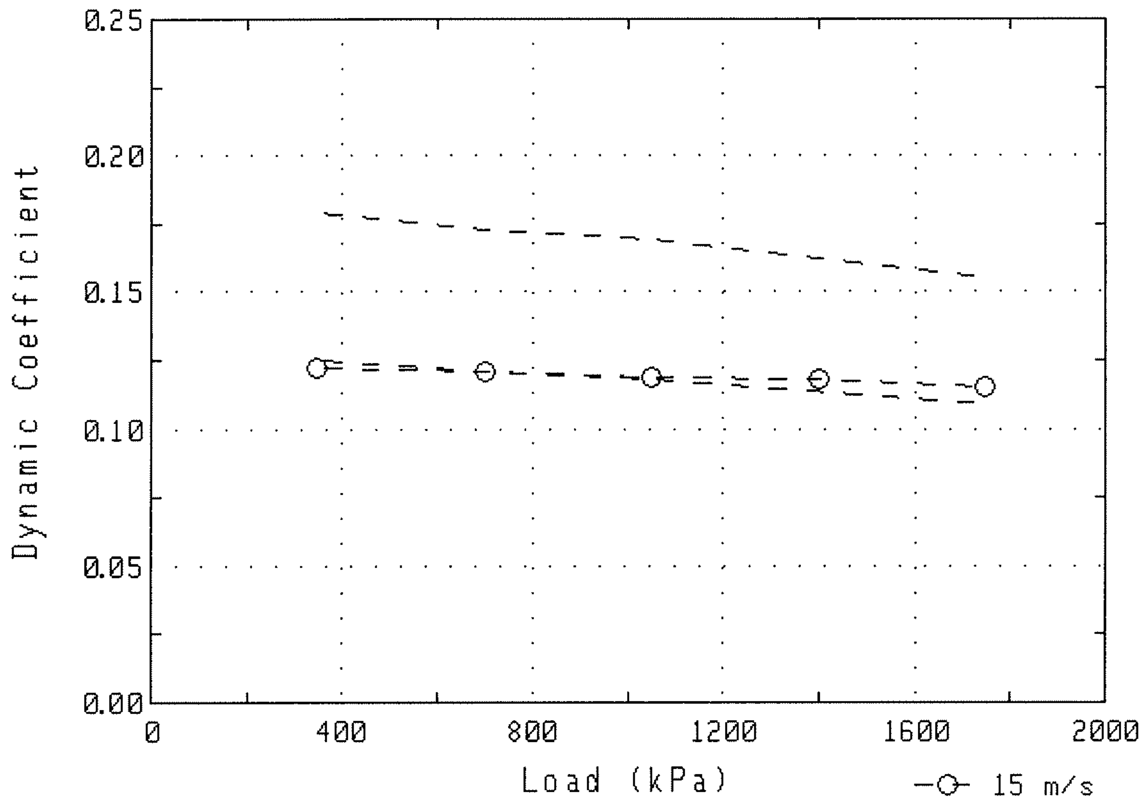
1Y0713 DISC
THICKNESS

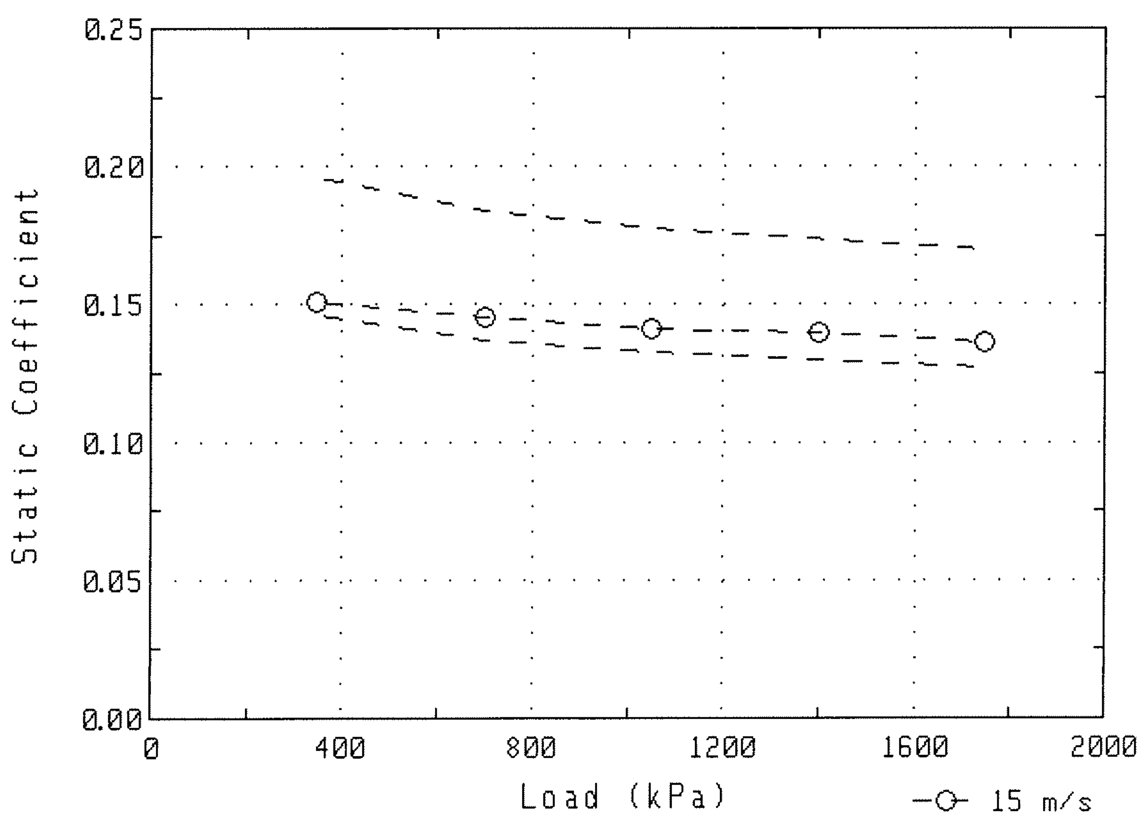
Loc	Outer Diameter M1	M2	M3	Inner Diameter M1	M2	M3
1	5.03	5.03	4.99	5.03	5.03	5.01
2	5.03	5.03	5.00	5.03	5.03	5.00
3	5.03	5.03	5.00	5.03	5.03	5.01
4	5.03	5.03	5.00	5.03	5.03	5.01
5	5.03	5.03	5.00	5.03	5.03	5.01
6	5.03	5.03	5.00	5.03	5.03	5.00
Avg	5.03	5.03	5.00	5.03	5.03	5.01

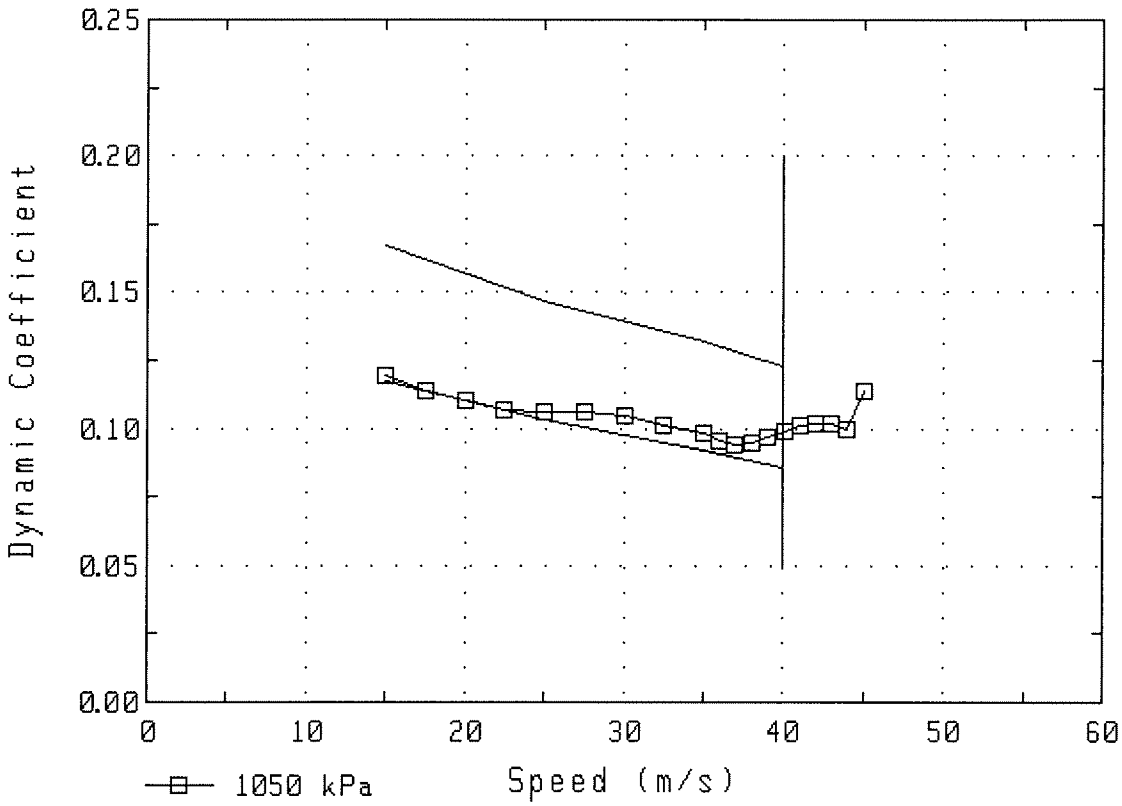
Compression set average wear: 0.000
M2 - M3 average Wear: 0.027

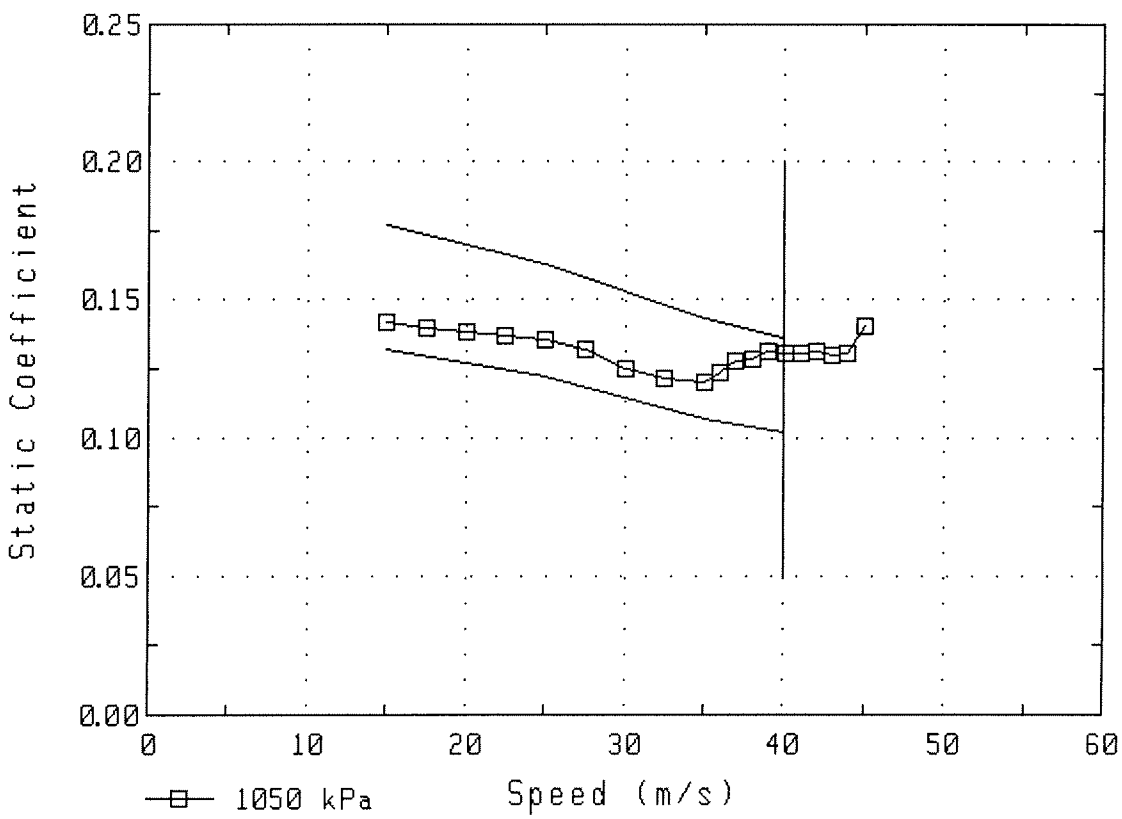
Total Wear (all measurements in mm): 0.027

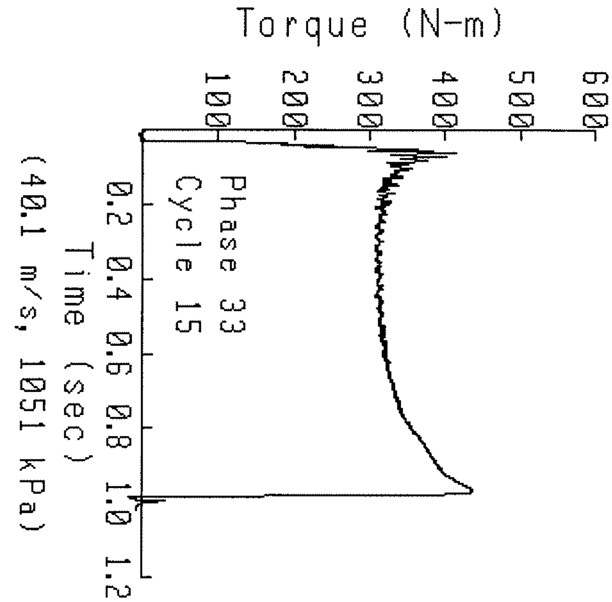
Test: A-77-I Run: I0706102 Started on 10/11/07 at 08:58

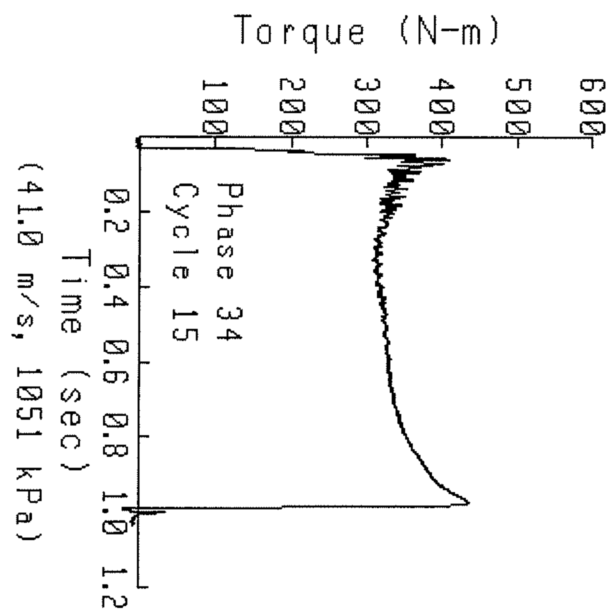


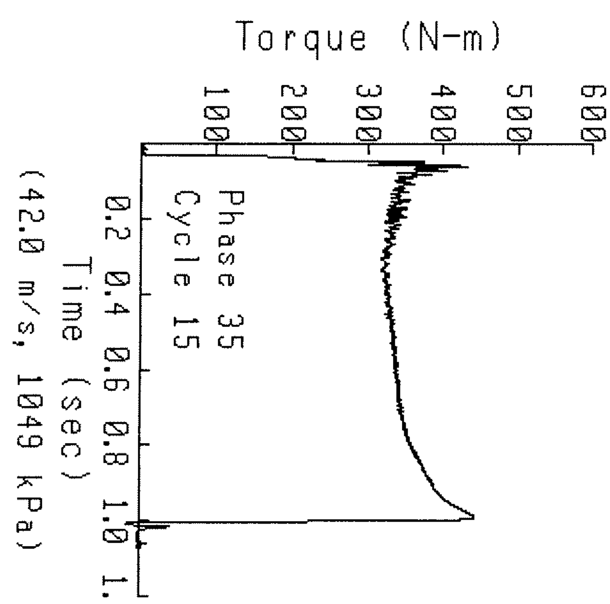


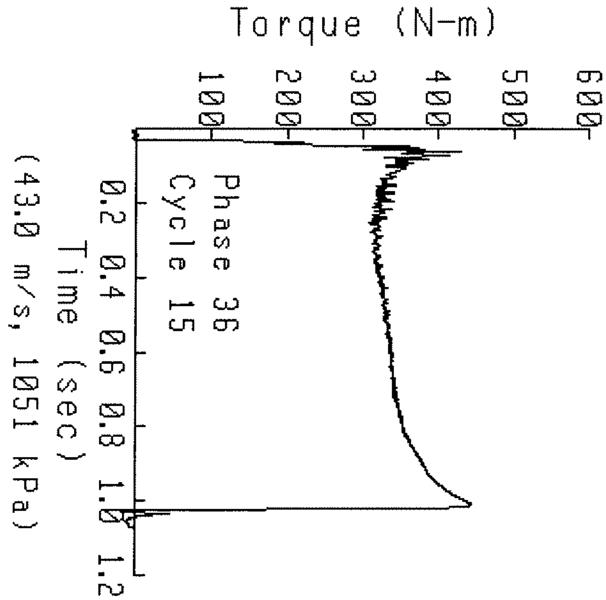

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

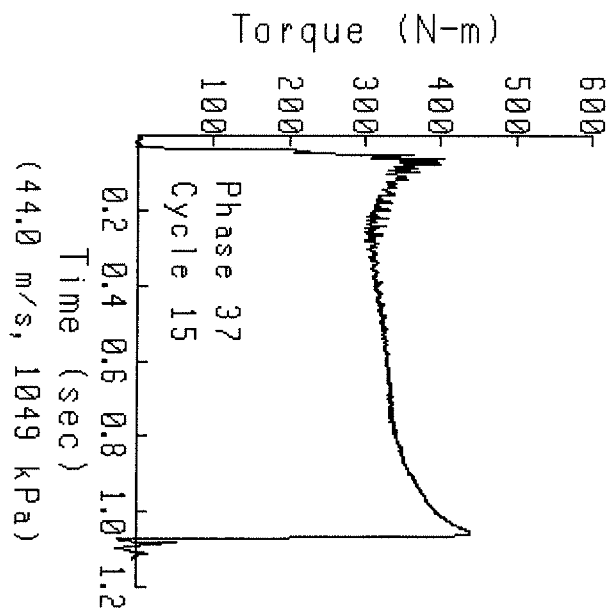

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

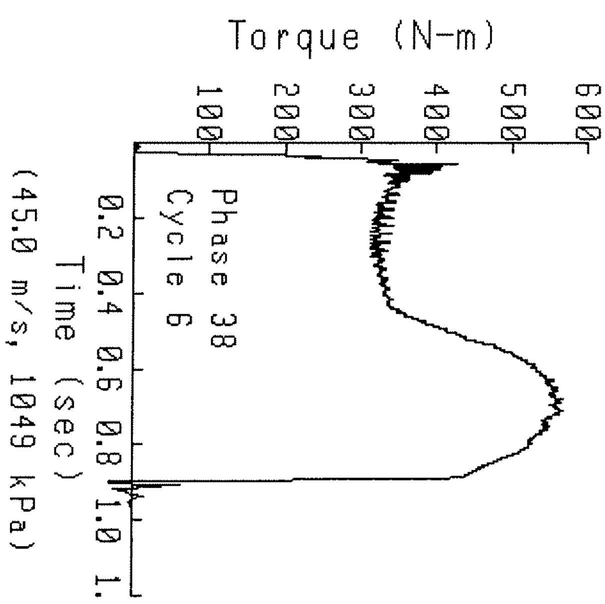

Torque (N-m)
100 200 300 400 500 600
Phase 33
Cycle 15
0.2 0.4 0.6 0.8 1.0 1.2
Time (sec)
(40.1 m/s, 1051 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 34
Cycle 15
0.2 0.4 0.6 0.8 1.0 1.2
Time (sec)
(41.0 m/s, 1051 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 35
Cycle 15
0.2 0.4 0.6 0.8 1.0 1.2
Time (sec)
(42.0 m/s, 1049 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 36
Cycle 15
0.2 0.4 0.6 0.8 1.0 1.2
Time (sec)
(43.0 m/s, 1051 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 37
Cycle 15
0.2 0.4 0.6 0.8 1.0 1.2
Time (sec)
(44.0 m/s, 1049 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 38
Cycle 6
0.2 0.4 0.6 0.8 1.0 1.2
Time (sec)
(45.0 m/s, 1049 kPa)

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

Fuels And Lubricants Research Division

Report on

DEXRON® VI BAND CLUTCH FRICTION TEST

Conducted For

SwRI ARMY LAB

Oil Code:
AL-27637-L

Test Number:
BH3-4-164

August 6, 2007

Submitted by:

Christopher Barker
Research Engineer
Specialty & Driveline Fluids Evaluation

DEXRON®-VI Band Friction - 150 HOURS

Program Code: AL-27637-L
Status: EOT
Test Cycles: 36,000
Test Performance:

Start Date: 7/30/2007
EOT Date: 8/6/2007
Run Number: BH3-4-164
EOT Parts Condition:

Band: 4L60
Drum: 4L60

Test Time [h]	Cycles	Stop Time [s] 0.35	0.55	Midpoint Torque [N·m] 180	290	Max Torque [N·m] Report	End Torque [N·m] > 200		Max - Mid Torque [N·m] < 120		Shift Energy [kJ] (15.7-16.3)
0	10	0.40		260		335	308		75		16.0
1	240	0.43		213		355	352		142		16.0
2	480	0.43		210		341	335		131		16.0
3	720	0.44	Three	208	Three	305	299	Three	97	Three	16.0
4	960	0.45	Point	203	Point	312	282	Point	109	Point	16.0
5	1,200	0.45	Average	202	Average	320	312	Average	118	Average	16.0
10	2,400	0.47	0.46	202	200	313	312	306	111	112	16.0
15	3,600	0.47	0.47	196	202	302	295	306	106	108	16.0
20	4,800	0.46	0.46	208	206	316	312	290	108	91	16.2
25	6,000	0.46	0.46	215	213	274	262	271	59	73	16.2
30	7,200	0.46	0.46	215	215	267	239	253	52	55	16.2
35	8,400	0.46	0.46	216	216	271	257	252	55	53	16.1
40	9,600	0.46	0.46	216	213	269	260	246	53	54	16.2
45	10,800	0.46	0.46	207	209	262	220	232	55	53	16.2
50	12,000	0.46	0.46	204	205	253	217	217	50	51	16.3
55	13,200	0.47	0.47	205	203	254	215	216	48	49	16.3
60	14,400	0.47	0.47	201	205	248	216	224	48	50	16.4
65	15,600	0.47	0.47	210	205	262	243	224	53	51	16.5
70	16,800	0.47	0.47	206	207	257	213	235	52	56	16.6
75	18,000	0.48	0.47	207	205	271	249	227	64	56	16.7
80	19,200	0.48	0.48	203	205	254	217	242	51	61	16.8
85	20,400	0.48	0.48	206	206	274	259	240	69	62	16.9
90	21,600	0.48	0.48	210	208	278	244	248	67	71	17.1
95	22,800	0.49	0.49	209	209	285	241	242	76	67	17.2
100	24,000	0.49	0.49	208	202	266	242	243	58	71	17.5

DEXRON®-VI Band Friction - 150 HOURS

Program Code: AL-27637-L
Status: EOT
Test Cycles: 36,000
Test Performance:

Start Date: 7/30/2007
EOT Date: 8/6/2007
Run Number: BH3-4-164
EOT Parts Condition:

Band: 4L60
Drum: 4L60

Test Time [h]	Cycles	Stop Time [s]		Midpoint Torque [N·m]		Max Torque [N·m]	End Torque [N·m]		Max - Mid Torque [N·m]		Shift Energy [kJ]
		0.35	0.55	180	290	Report	> 200		< 120		(15.7-16.3)
105	25,200	0.48	0.49	190	195	270	246	237	80	67	16.0
110	26,400	0.50	0.49	187	188	251	224	227	64	75	15.8
115	27,600	0.49	0.50	188	189	270	210	220	82	62	15.8
120	28,800	0.50	0.50	192	189	233	226	216	41	70	15.8
125	30,000	0.50	0.50	188	190	276	213	221	87	61	15.8
130	31,200	0.50	0.50	189	187	245	223	213	56	77	15.7
135	32,400	0.50	0.50	183	187	270	205	216	87	67	15.7
140	33,600	0.50	0.50	188	184	247	219	217	59	75	15.8
145	34,800	0.50	0.50	182	184	260	226	224	78	65	15.7
150	36,000	0.51	0.50	182	182	240	228	227	57	68	15.7

Southwest Research Institute®

Test Number: BH3-4-164	Energy: 16.38 KJ	Band : 4L60	Start of Test: 7/30/2007
Fluid Code: AL-27637-L	Temp.: 137.1 C	Drum : 4L60	End of Test : 8/6/2007
	Apply: 303.2 KPa	Air Flow: 50 ml/min	

Test Hour	Total Cycles	Engagement Time (Sec) (0.35 -0.55)		Midpoint Torq.(Nm) (180-290)		Max-Mid Torq.(Nm) <120		End-Mid Torq.(Nm) <120		Maximum Torq.(Nm) (Report)	End Torq.(Nm) >200		Energy (KJ) (15.7-16.3)
0	10	0.40		260		75		48		335	308		16.0
1	240	0.43		213		142		139		355	352		16.0
2	480	0.43		210		131		125		341	335		16.0
3	720	0.44	Three	208	Three	97	Three	91	Three	305	299	Three	16.0
4	960	0.45	Point	203	Point	109	Point	79	Point	312	282	Point	16.0
5	1,200	0.45	Average	202	Average	118	Average	110	Average	320	312	Average	16.0
10	2,400	0.47	0.46	202	200	111	112	110	107	313	312	306	16.0
15	3,600	0.47	0.47	196	202	106	108	99	104	302	295	306	16.0
20	4,800	0.46	0.46	208	206	108	91	104	84	316	312	290	16.2
25	6,000	0.46	0.46	215	213	59	73	47	59	274	262	271	16.2
30	7,200	0.46	0.46	215	215	52	55	24	37	267	239	253	16.2
35	8,400	0.46	0.46	216	216	55	53	41	36	271	257	252	16.1
40	9,600	0.46	0.46	216	213	53	54	44	33	269	260	246	16.2
45	10,800	0.46	0.46	207	209	55	53	14	24	262	220	232	16.2
50	12,000	0.46	0.46	204	205	50	51	14	12	253	217	217	16.3
55	13,200	0.47	0.47	205	203	48	49	10	13	254	215	216	16.3
60	14,400	0.47	0.47	201	205	48	50	15	19	248	216	224	16.4
65	15,600	0.47	0.47	210	205	53	51	33	19	262	243	224	16.5
70	16,800	0.47	0.47	206	207	52	56	8	28	257	213	235	16.6
75	18,000	0.48	0.47	207	205	64	56	42	21	271	249	227	16.7
80	19,200	0.48	0.48	203	205	51	61	14	37	254	217	242	16.8
85	20,400	0.48	0.48	206	206	69	62	53	34	274	259	240	16.9
90	21,600	0.48	0.48	210	208	67	71	34	40	278	244	248	17.1
95	22,800	0.49	0.49	209	209	76	67	32	33	285	241	242	17.2
100	24,000	0.49	0.49	208	202	58	71	33	41	266	242	243	17.5

Southwest Research Institute®

Test Number: BH3-4-164	Energy: 16.38 KJ	Band : 4L60	Start of Test: 7/30/2007
Fluid Code: AL-27637-L	Temp.: 137.1 C	Drum : 4L60	End of Test : 8/6/2007
	Apply: 303.2 KPa	Air Flow: 50 ml/min	

Test Hour	Total Cycles	Engagement Time (Sec) (0.35 -0.55)		Midpoint Torq.(Nm) (180-290)		Max-Mid Torq.(Nm) <120		End-Mid Torq.(Nm) <120		Maximum Torq.(Nm) (Report)	End Torq.(Nm) >200		Energy (KJ) (15.7-16.3)
105	25,200	0.48	0.49	190	195	80	67	57	42	270	246	237	16.0
110	26,400	0.50	0.49	187	188	64	75	37	38	251	224	227	15.8
115	27,600	0.49	0.50	188	189	82	62	22	31	270	210	220	15.8
120	28,800	0.50	0.50	192	189	41	70	35	27	233	226	216	15.8
125	30,000	0.50	0.50	188	190	87	61	24	31	276	213	221	15.8
130	31,200	0.50	0.50	189	187	56	77	34	27	245	223	213	15.7
135	32,400	0.50	0.50	183	187	87	67	22	29	270	205	216	15.7
140	33,600	0.50	0.50	188	184	59	75	31	32	247	219	217	15.8
145	34,800	0.50	0.50	182	184	78	65	44	40	260	226	224	15.7
150	36,000	0.51	0.50	182	182	57	68	46	45	240	228	227	15.7

Southwest Research Institute ®

DEXRON® VI Band Friction Test Parts Rating

Sponsor Code: AL-27637-L
Run Number: BH3-4-164
EOT Date: 08-06-07
Cycles: 36,000
Hours: 150

Band: The fiber area is completely darkened with light glazing and trace/light stress cracks. Handling marks are also visible. Fiber material is damaged at one end of the band

Drum: There are no cracks. Dark gray tracking marks and light discoloration is also visible.

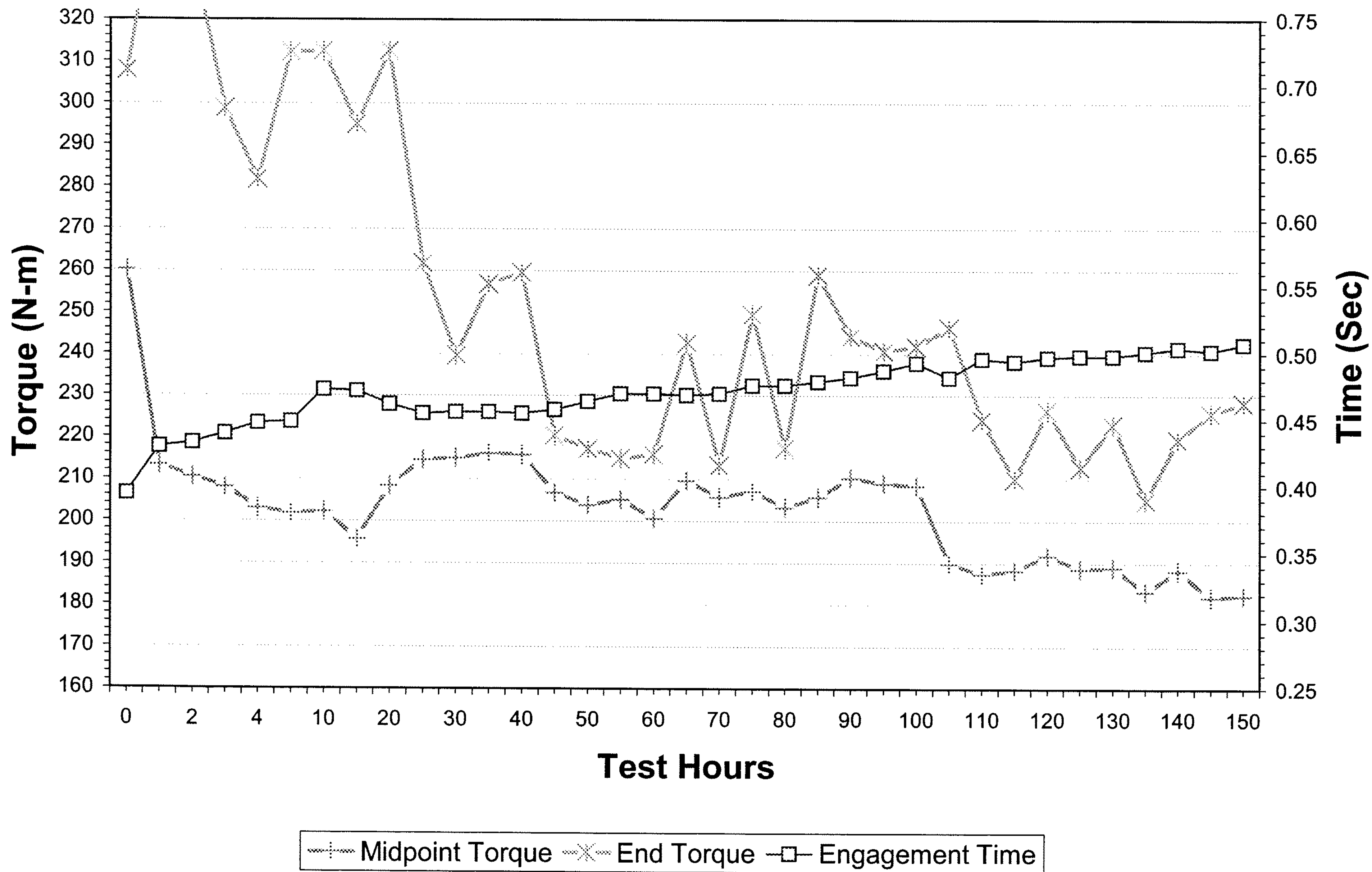
SwRI Rating: Pass

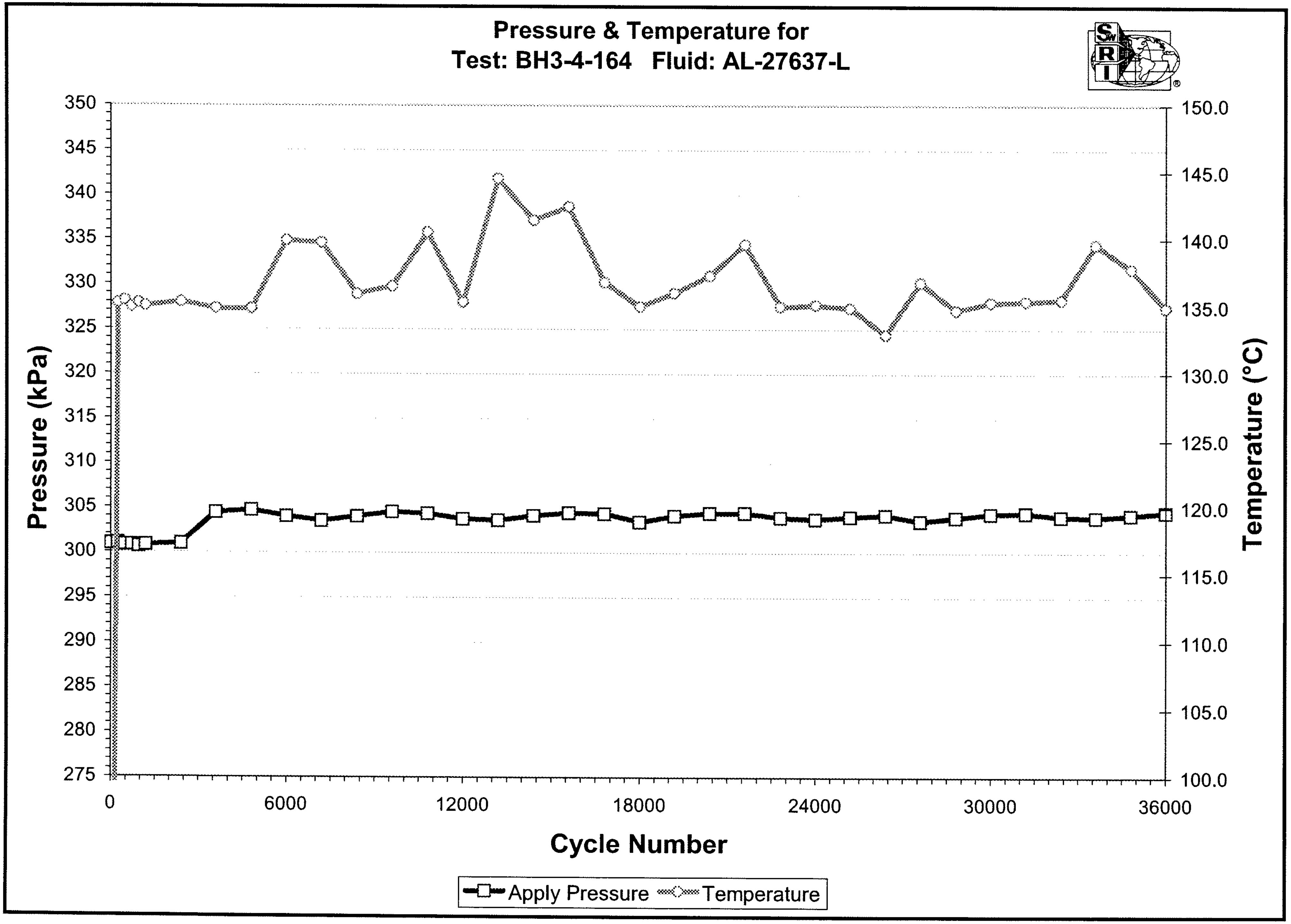
Rater: Art Sanchez
Date: 08-07-2007

Comments: This test was conducted using 4L60 Drum And 4L60 Band.

*Pending GM ATF Committee approval

Fluid Performance Summary of AL-27637-L




Pressure & Temperature for
Test: BH3-4-164 Fluid: AL-27637-L
Pressure (kPa)
Temperature (°C)
Cycle Number
Apply Pressure
Temperature
350
345
340
335
330
325
320
315
310
305
300
295
290
285
280
275
150.0
145.0
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
0
6000
12000
18000
24000
30000
36000

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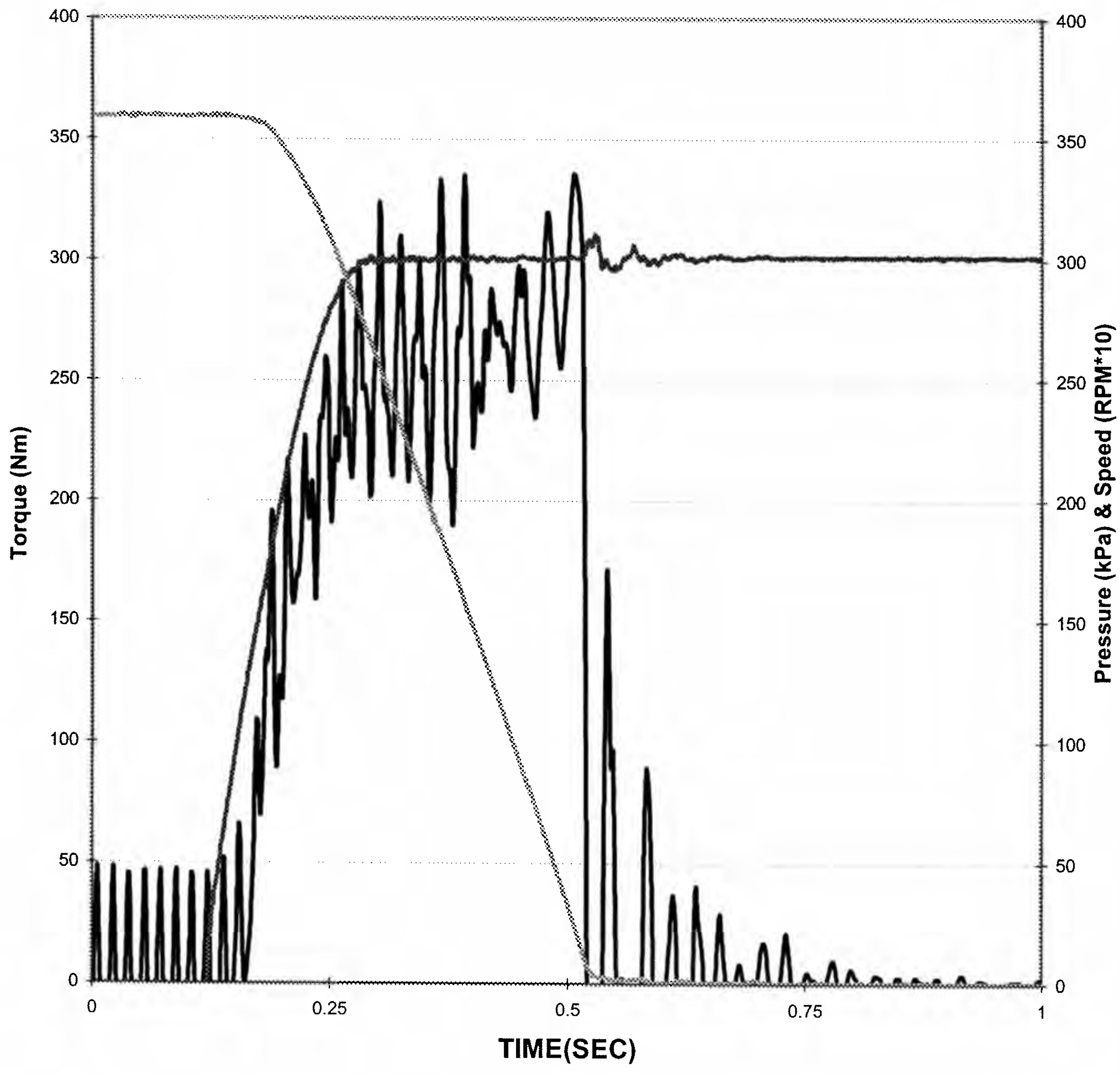

Date of Test:	7/30/2007
Time of Test:	12:04:59
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	0
Cycle Number:	10
Temperature:	58.0 °C *(129 - 141)*
Apply Pressure:	301 kPa (295 - 305)
Energy:	16.0 KJ *(15.7-16.3)*
Engage Time:	0.40 Sec *(0.35 -0.55)*

Torque

Maximum:	335 N*m (Report)
Midpoint:	260 N*m *(180-290)*
Max - Mid:	75 N*m *<120*
End - Mid:	48 N*m *<120*
End:	308 N*m *>200*

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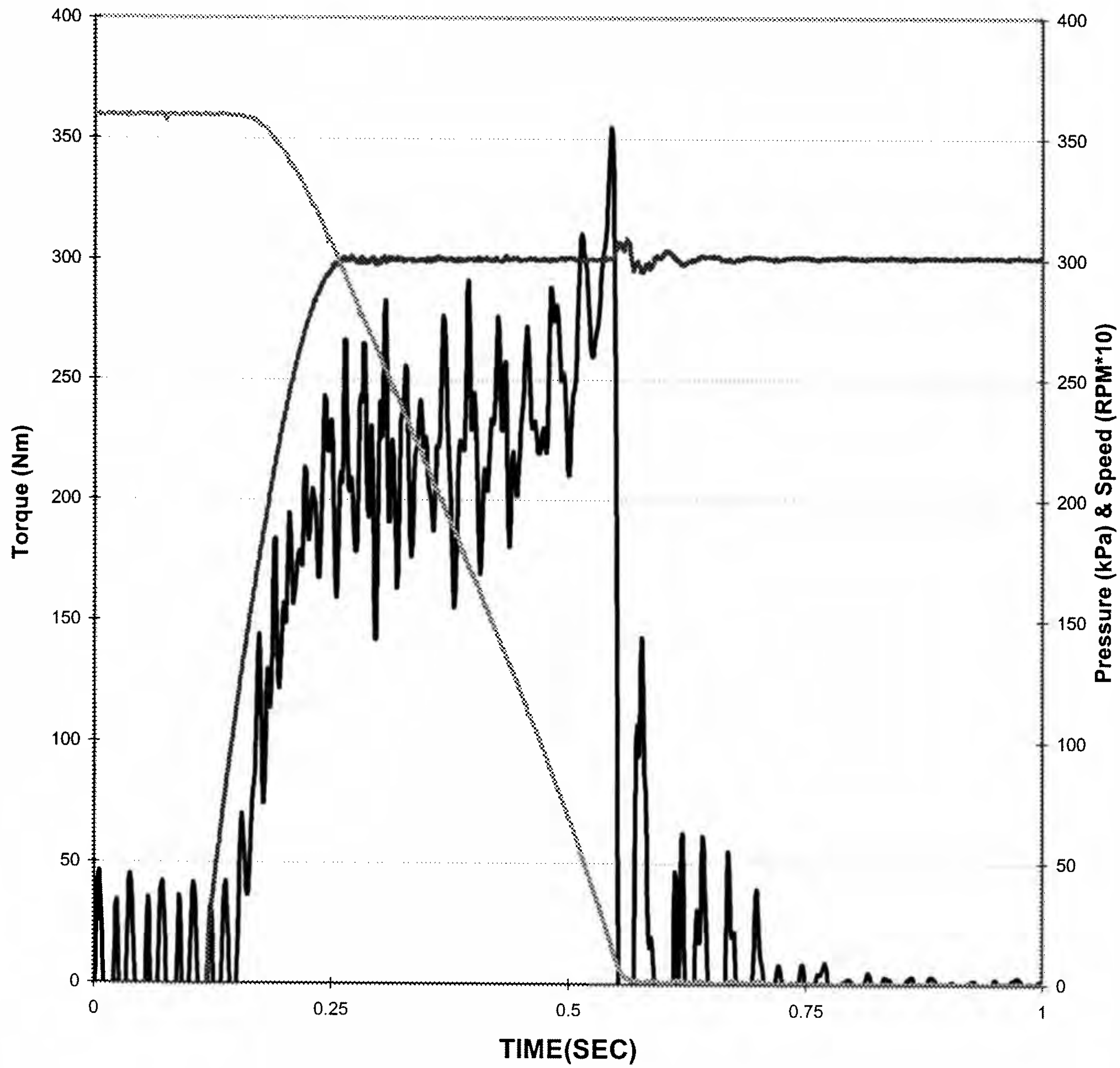

Date of Test:	7/30/2007
Time of Test:	13:02:29
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	1
Cycle Number:	240
Temperature:	135.2 °C *(129 - 141)*
Apply Pressure:	301 kPa (295 - 305)
Energy:	16.0 KJ *(15.7-16.3)*
Engage Time:	0.43 Sec *(0.35 -0.55)*

Torque

Maximum:	355 N*m (Report)
Midpoint:	213 N*m *(180-290)*
Max - Mid:	142 N*m *<120*
End - Mid:	139 N*m *<120*
End:	352 N*m *>200*

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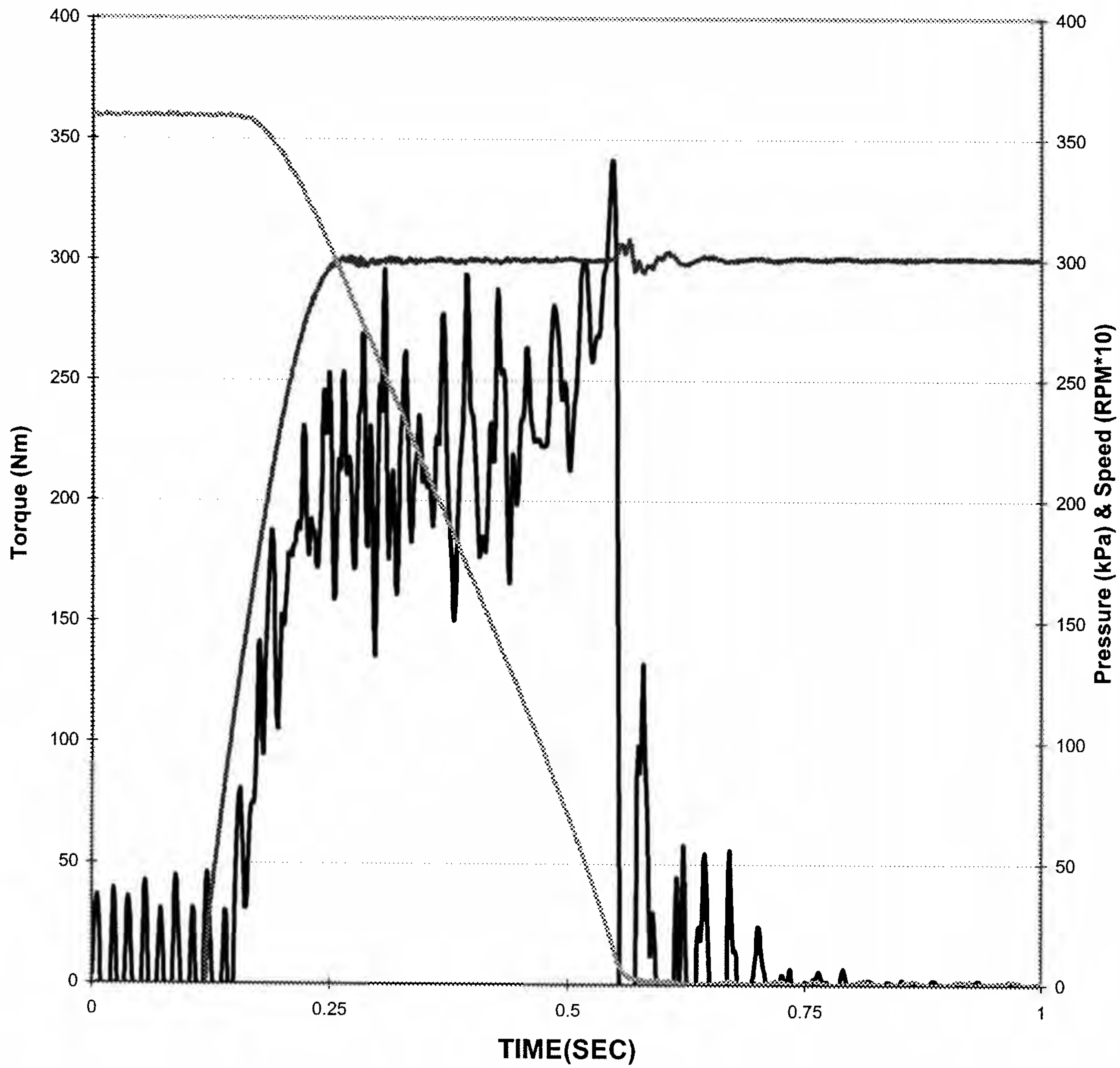

Date of Test:	7/30/2007
Time of Test:	14:02:29
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	2
Cycle Number:	480
Temperature:	135.4 °C
	(129 - 141)
Apply Pressure:	301 kPa
	(295 - 305)
Energy:	16.0 KJ
	(15.7-16.3)
Engage Time:	0.43 Sec
	(0.35 -0.55)

Torque

Maximum:	341 N*m
	(Report)
Midpoint:	210 N*m
	(180-290)
Max - Mid:	131 N*m
	<120
End - Mid:	125 N*m
	<120
End:	335 N*m
	>200

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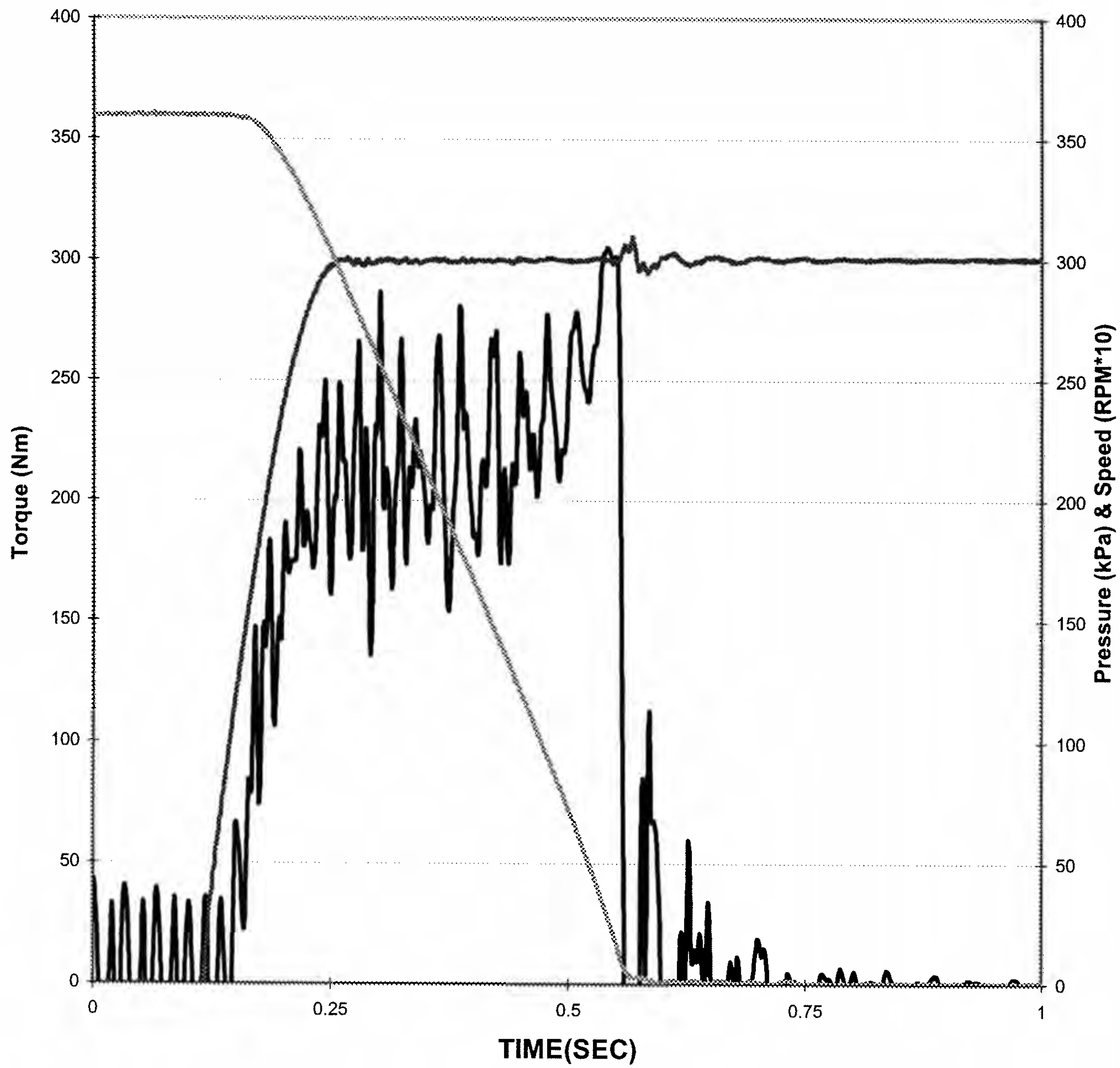

Date of Test:	7/30/2007
Time of Test:	15:02:29
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	3
Cycle Number:	720
Temperature:	134.9 °C *(129 - 141)*
Apply Pressure:	301 kPa (295 - 305)
Energy:	16.0 KJ *(15.7-16.3)*
Engage Time:	0.44 Sec *(0.35 -0.55)*

Torque

Maximum:	305 N*m (Report)
Midpoint:	208 N*m *(180-290)*
Max - Mid:	97 N*m *<120*
End - Mid:	91 N*m *<120*
End:	299 N*m *>200*

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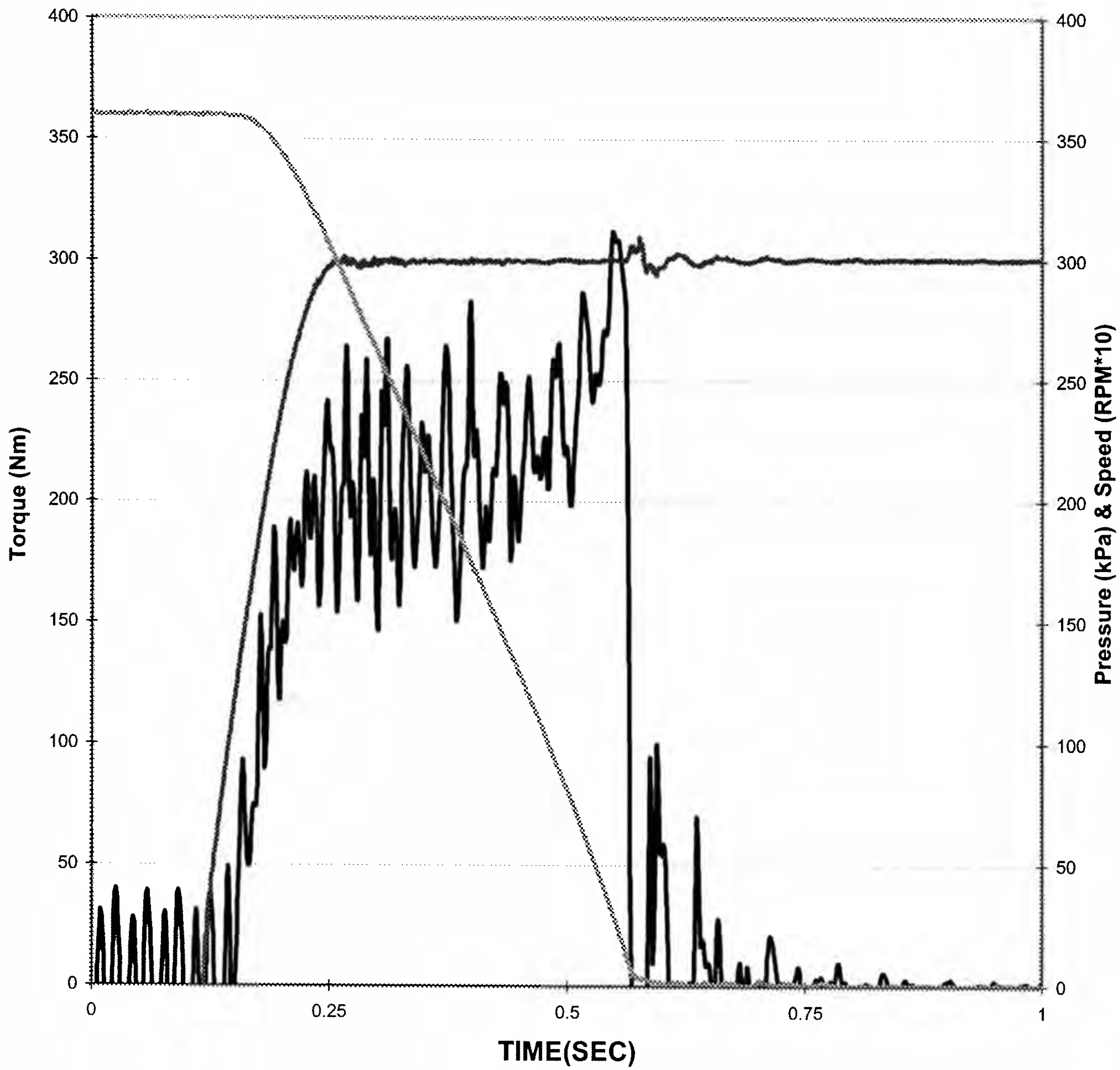

Date of Test:	7/30/2007
Time of Test:	16:02:30
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	4
Cycle Number:	960
Temperature:	135.2 °C *(129 - 141)*
Apply Pressure:	301 kPa (295 - 305)
Energy:	16.0 KJ *(15.7-16.3)*
Engage Time:	0.45 Sec *(0.35 -0.55)*

Torque

Maximum:	312 N*m (Report)
Midpoint:	203 N*m *(180-290)*
Max - Mid:	109 N*m *<120*
End - Mid:	79 N*m *<120*
End:	282 N*m *>200*

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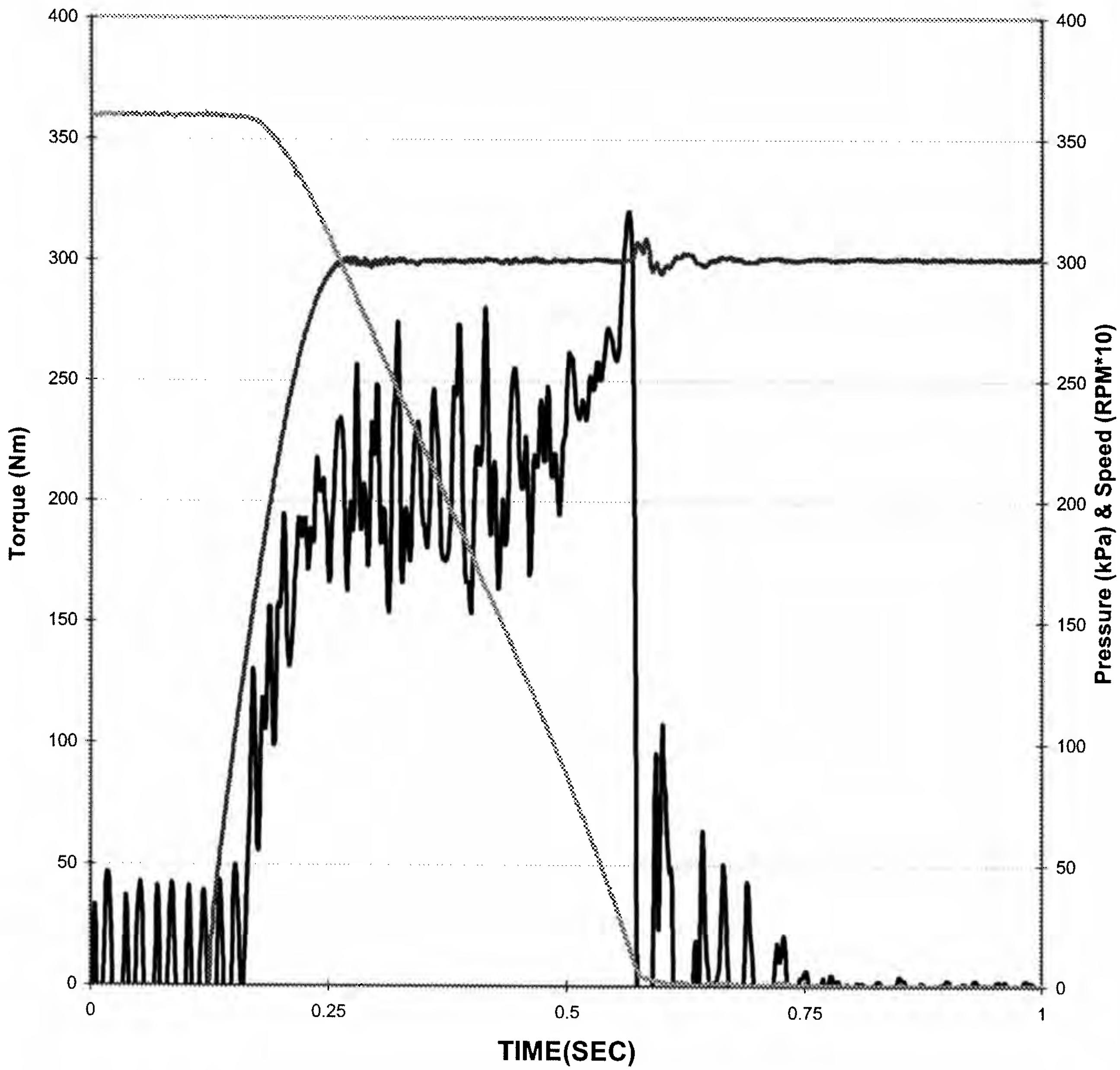

Date of Test:	7/30/2007
Time of Test:	17:02:30
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	5
Cycle Number:	1200
Temperature:	135.0 °C *(129 - 141)*
Apply Pressure:	301 kPa (295 - 305)
Energy:	16.0 KJ *(15.7-16.3)*
Engage Time:	0.45 Sec *(0.35 -0.55)*

Torque

Maximum:	320 N*m (Report)
Midpoint:	202 N*m *(180-290)*
Max - Mid:	118 N*m *<120*
End - Mid:	110 N*m *<120*
End:	312 N*m *>200*

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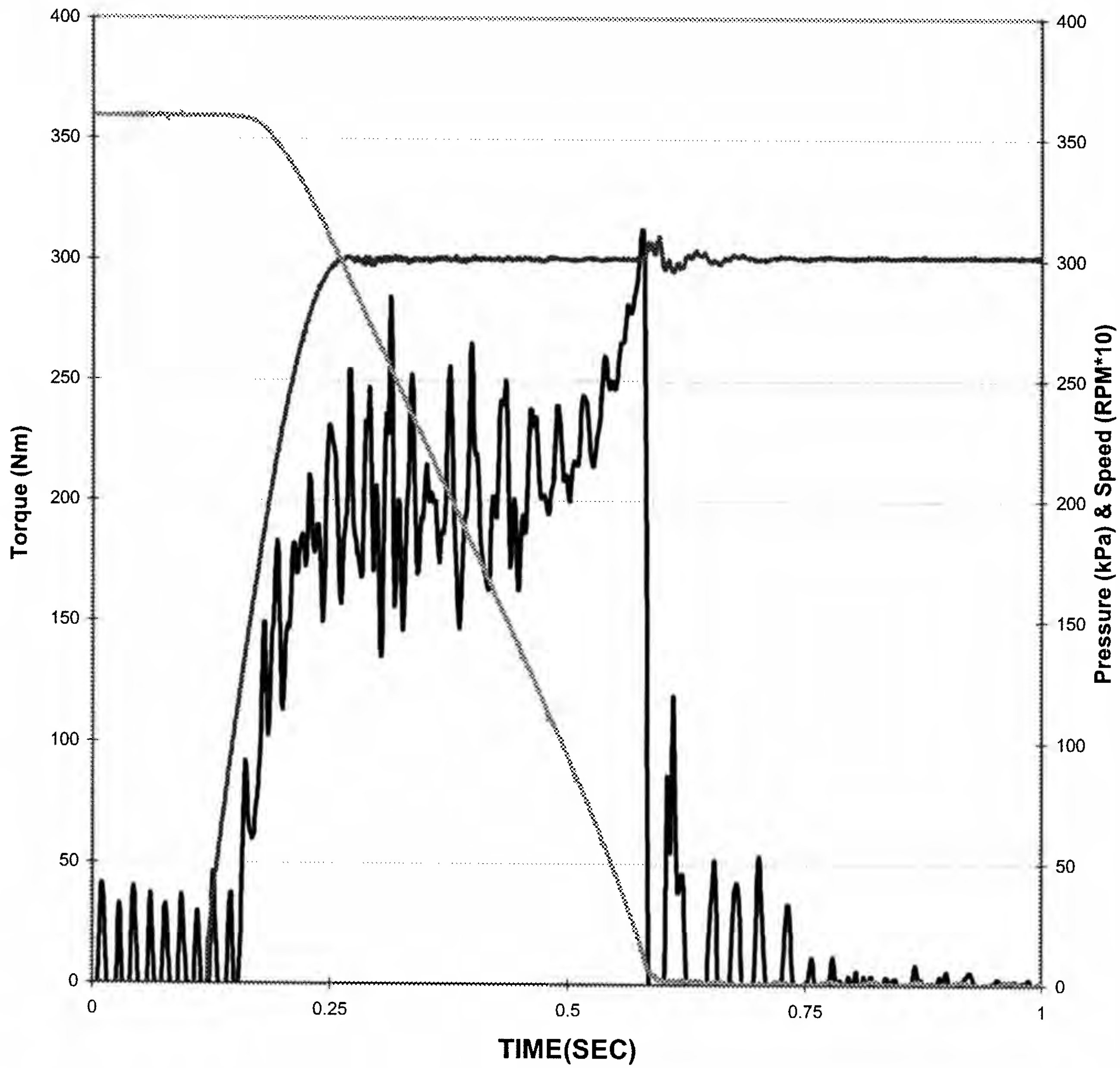

Date of Test:	7/30/2007
Time of Test:	22:02:30
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	10
Cycle Number:	2400
Temperature:	135.3 °C *(129 - 141)*
Apply Pressure:	301 kPa (295 - 305)
Energy:	16.0 KJ *(15.7-16.3)*
Engage Time:	0.47 Sec *(0.35 -0.55)*

Torque

Maximum:	313 N*m (Report)
Midpoint:	202 N*m *(180-290)*
Max - Mid:	111 N*m *<120*
End - Mid:	110 N*m *<120*
End:	312 N*m *>200*

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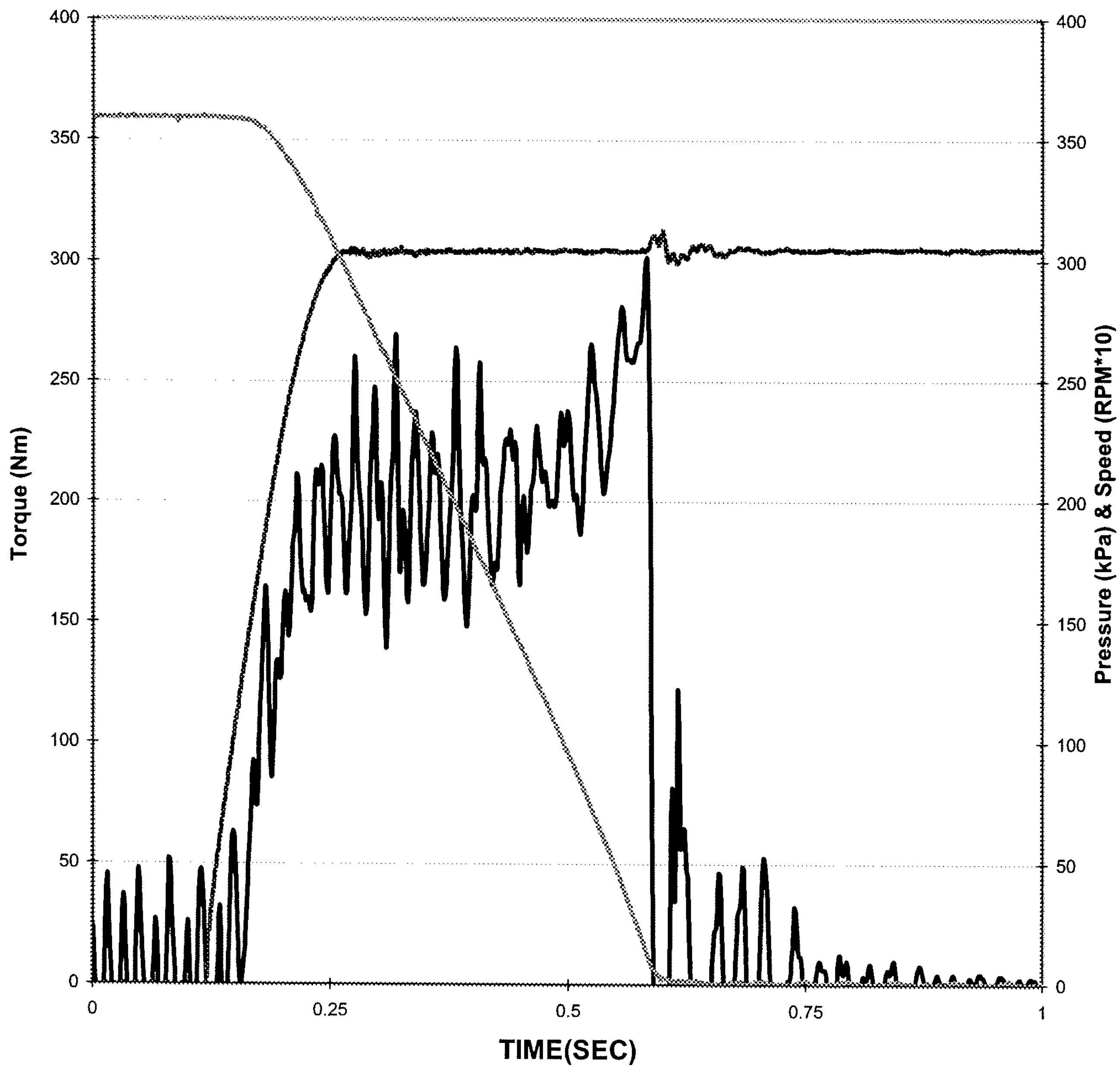

Date of Test:	7/31/2007
Time of Test:	3:02:31
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	15
Cycle Number:	3600
Temperature:	134.8 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	16.0 KJ
	(15.7-16.3)
Engage Time:	0.47 Sec
	(0.35 -0.55)

Torque

Maximum:	302 N*m
	(Report)
Midpoint:	196 N*m
	(180-290)
Max - Mid:	106 N*m
	<120
End - Mid:	99 N*m
	<120
End:	295 N*m
	>200

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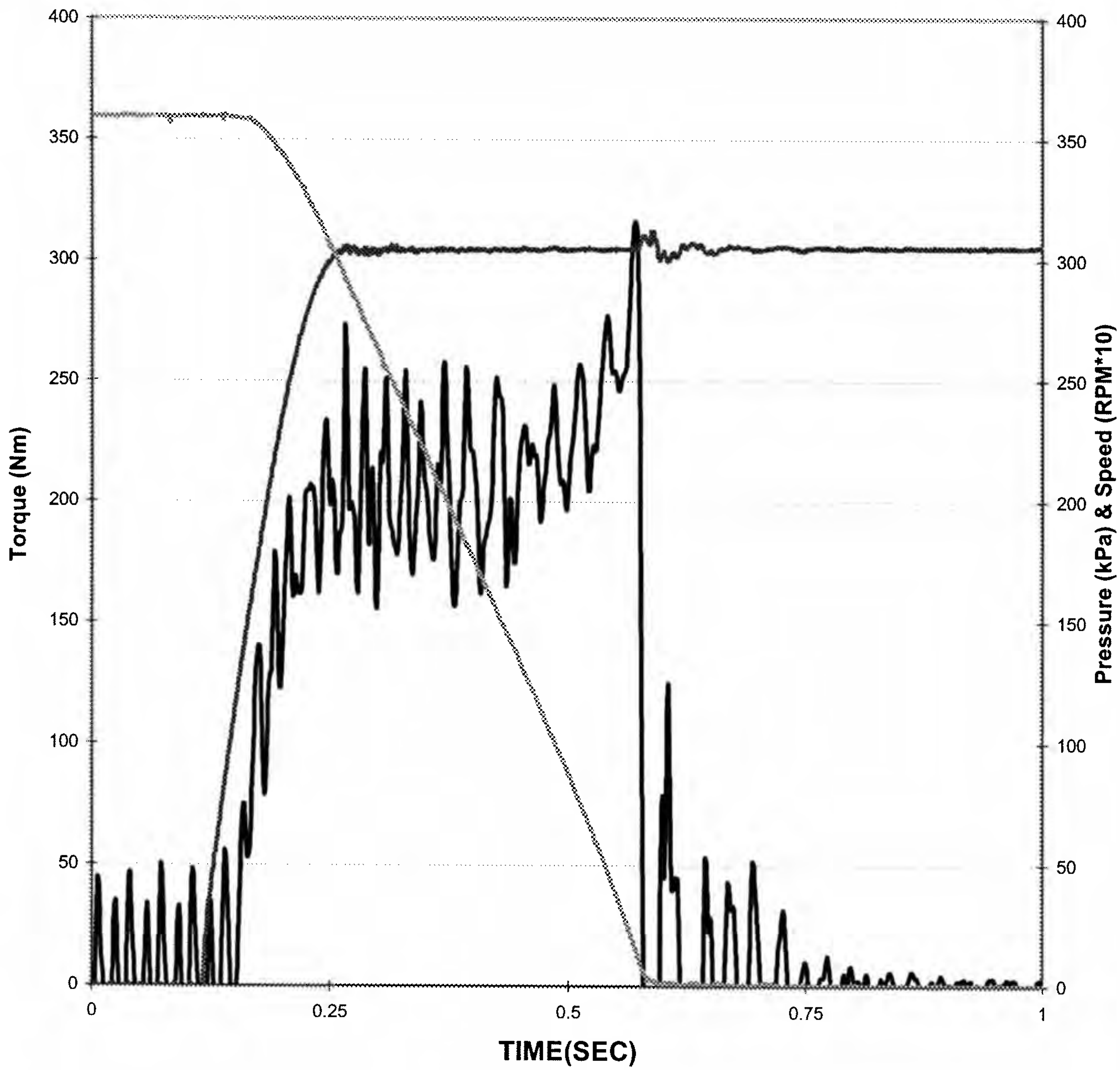

Date of Test:	7/31/2007
Time of Test:	8:02:32
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	20
Cycle Number:	4800
Temperature:	134.8 °C
	(129 - 141)
Apply Pressure:	305 kPa
	(295 - 305)
Energy:	16.2 KJ
	(15.7-16.3)
Engage Time:	0.46 Sec
	(0.35 -0.55)

Torque

Maximum:	316 N*m
	(Report)
Midpoint:	208 N*m
	(180-290)
Max - Mid:	108 N*m
	<120
End - Mid:	104 N*m
	<120
End:	312 N*m
	>200

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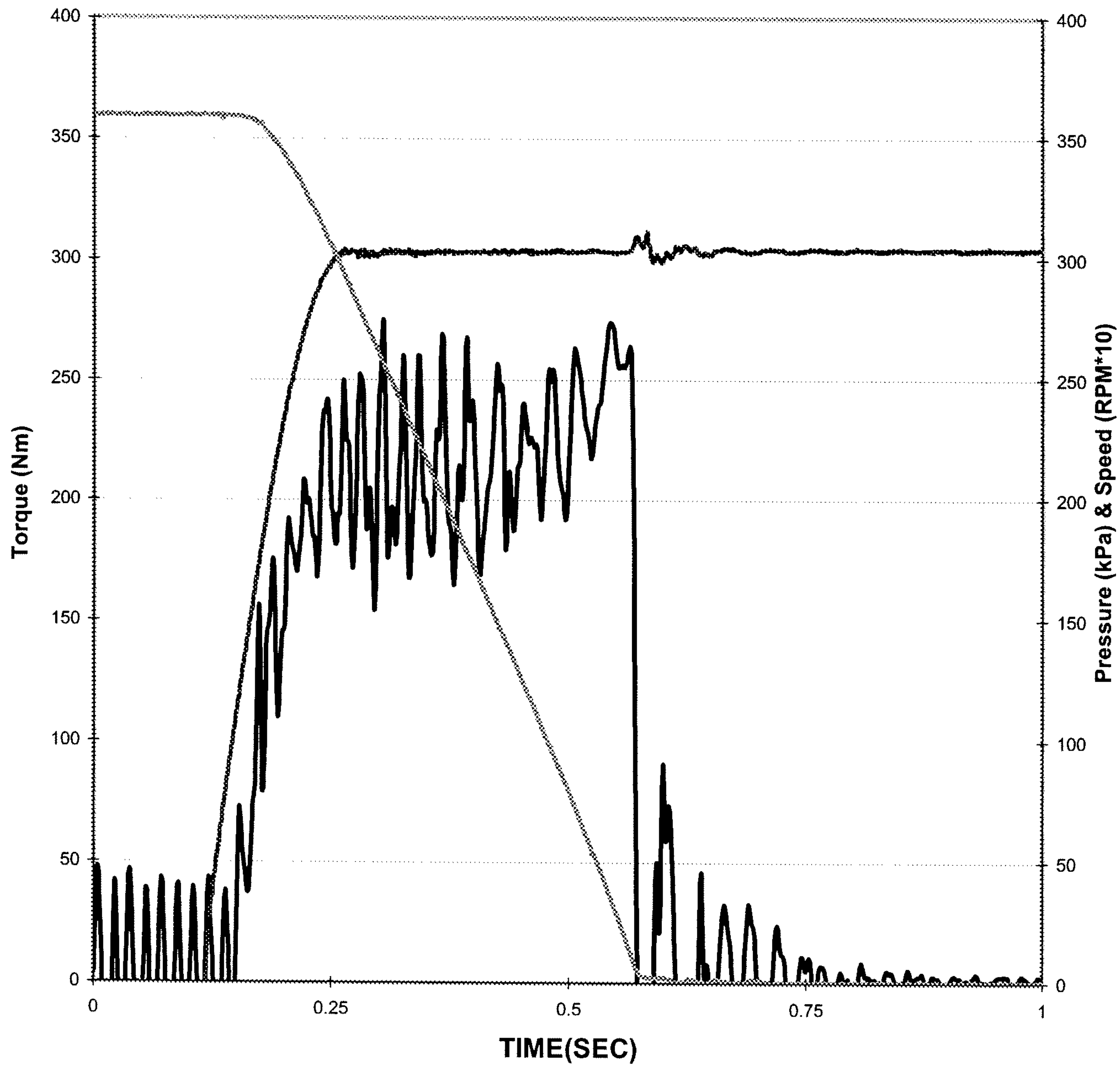

Date of Test:	7/31/2007
Time of Test:	13:02:33
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	25
Cycle Number:	6000
Temperature:	139.9 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	16.2 KJ
	(15.7-16.3)
Engage Time:	0.46 Sec
	(0.35 -0.55)

Torque

Maximum:	274 N*m
	(Report)
Midpoint:	215 N*m
	(180-290)
Max - Mid:	59 N*m
	<120
End - Mid:	47 N*m
	<120
End:	262 N*m
	>200

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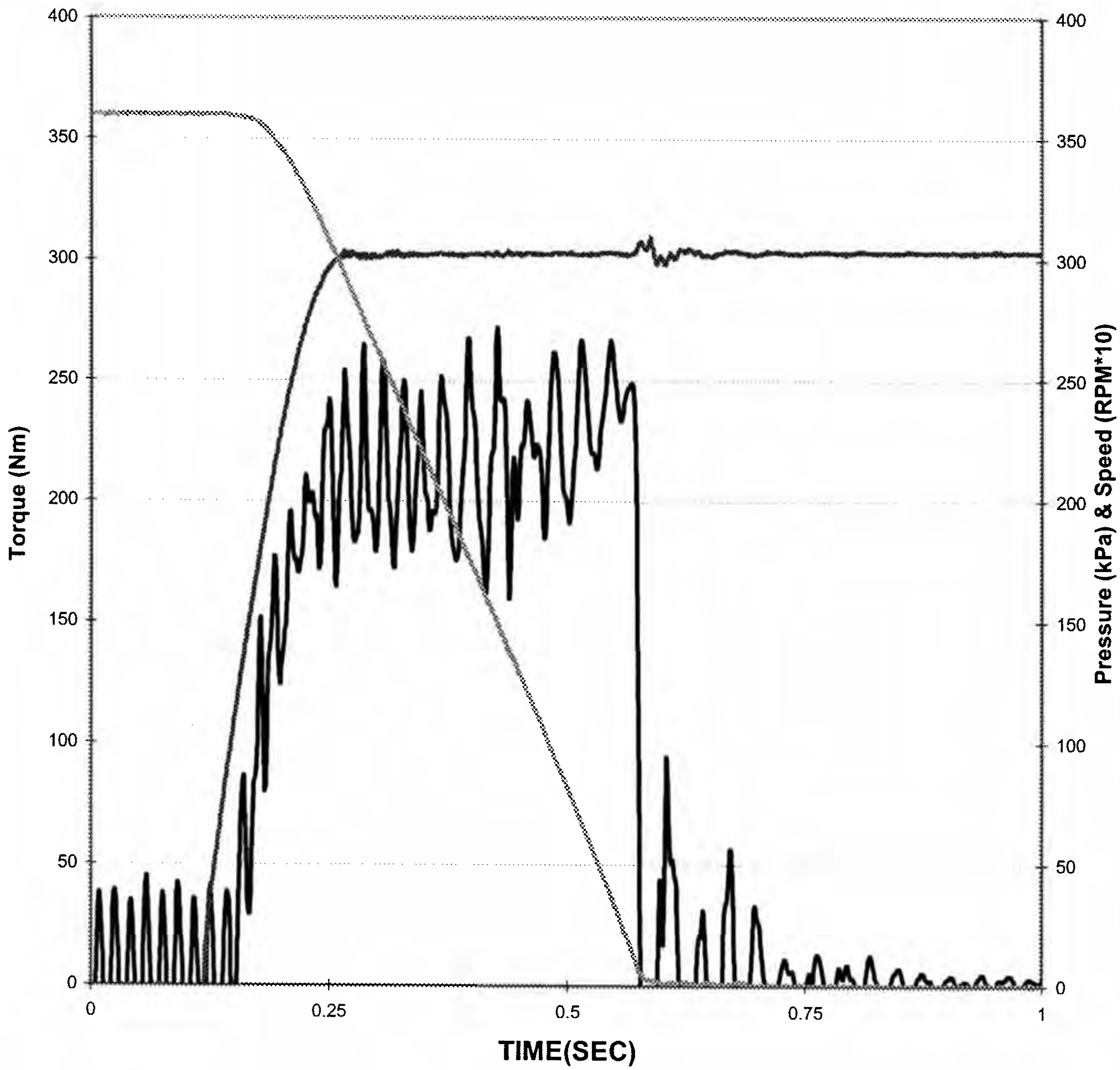

Date of Test:	7/31/2007
Time of Test:	18:02:34
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	30
Cycle Number:	7200
Temperature:	139.7 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	16.2 KJ
	(15.7-16.3)
Engage Time:	0.46 Sec
	(0.35 -0.55)

Torque

Maximum:	267 N*m
	(Report)
Midpoint:	215 N*m
	(180-290)
Max - Mid:	52 N*m
	<120
End - Mid:	24 N*m
	<120
End:	239 N*m
	>200

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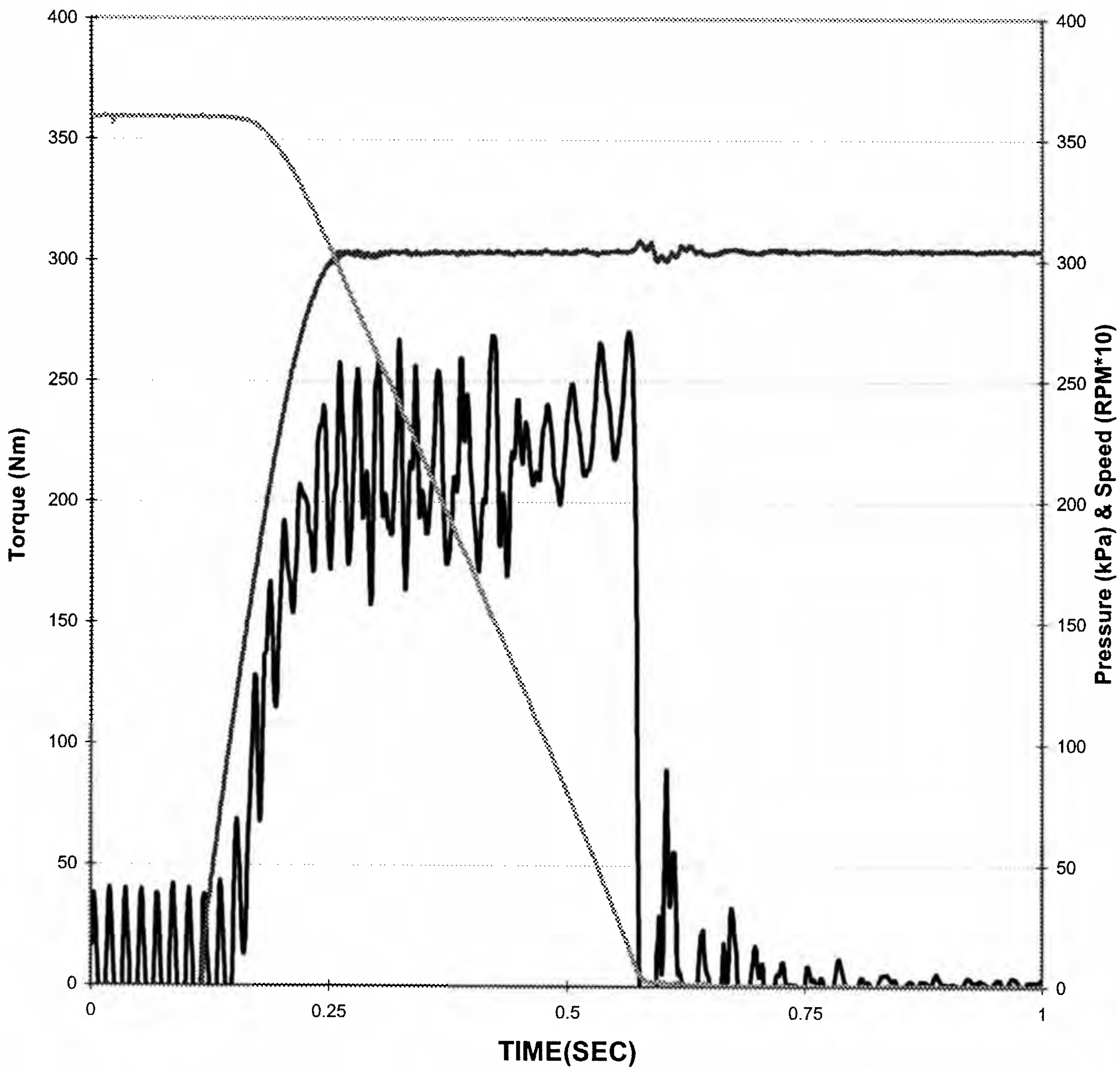

Date of Test:	7/31/2007
Time of Test:	23:02:34
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	35
Cycle Number:	8400
Temperature:	135.9 °C *(129 - 141)*
Apply Pressure:	304 kPa (295 - 305)
Energy:	16.1 KJ *(15.7-16.3)*
Engage Time:	0.46 Sec *(0.35 -0.55)*

Torque

Maximum:	271 N*m (Report)
Midpoint:	216 N*m *(180-290)*
Max - Mid:	55 N*m *<120*
End - Mid:	41 N*m *<120*
End:	257 N*m *>200*

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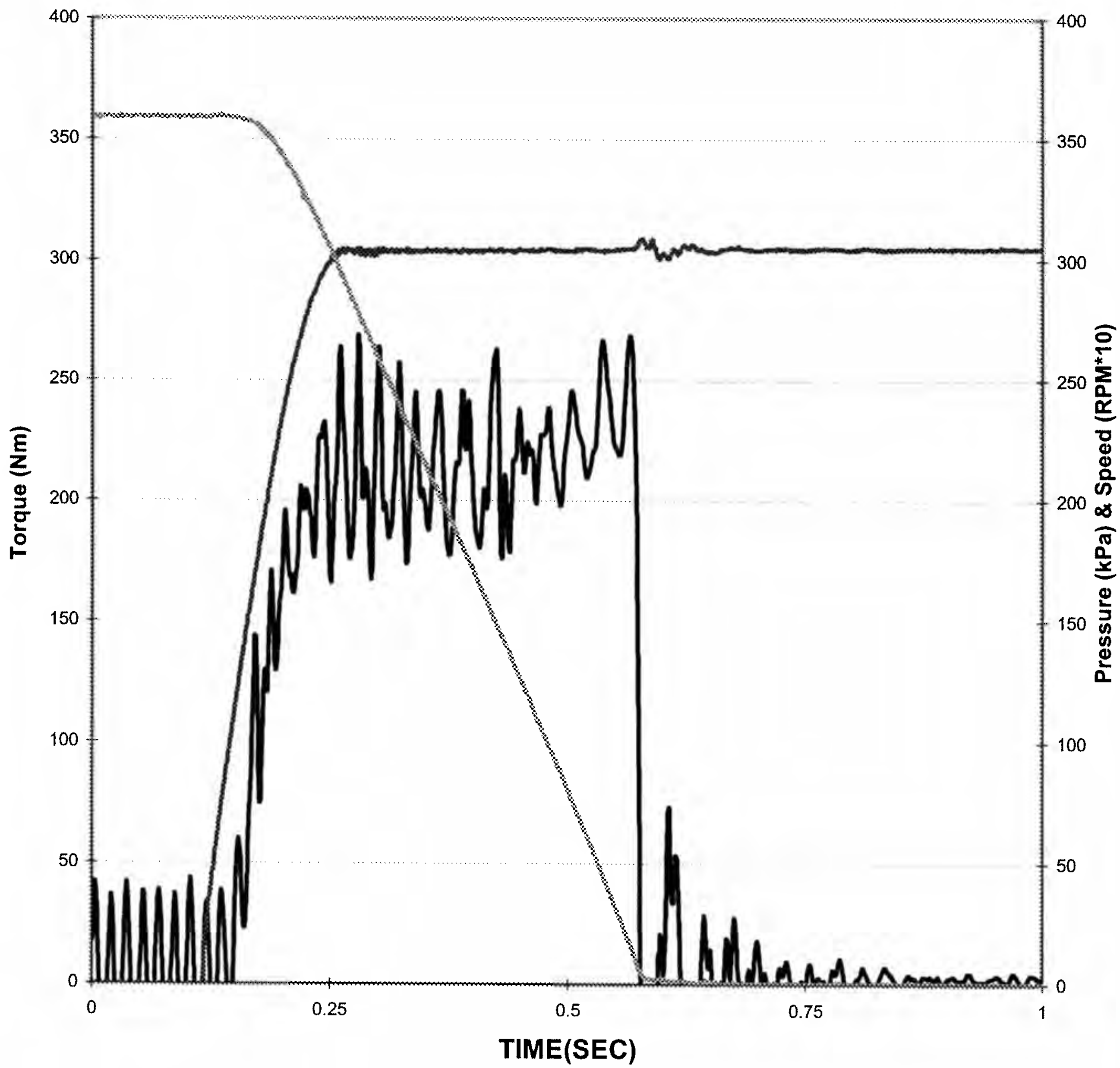

Date of Test:	8/1/2007
Time of Test:	4:02:35
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	40
Cycle Number:	9600
Temperature:	136.5 °C
	(129 - 141)
Apply Pressure:	305 kPa
	(295 - 305)
Energy:	16.2 KJ
	(15.7-16.3)
Engage Time:	0.46 Sec
	(0.35 -0.55)

Torque

Maximum:	269 N*m
	(Report)
Midpoint:	216 N*m
	(180-290)
Max - Mid:	53 N*m
	<120
End - Mid:	44 N*m
	<120
End:	260 N*m
	>200

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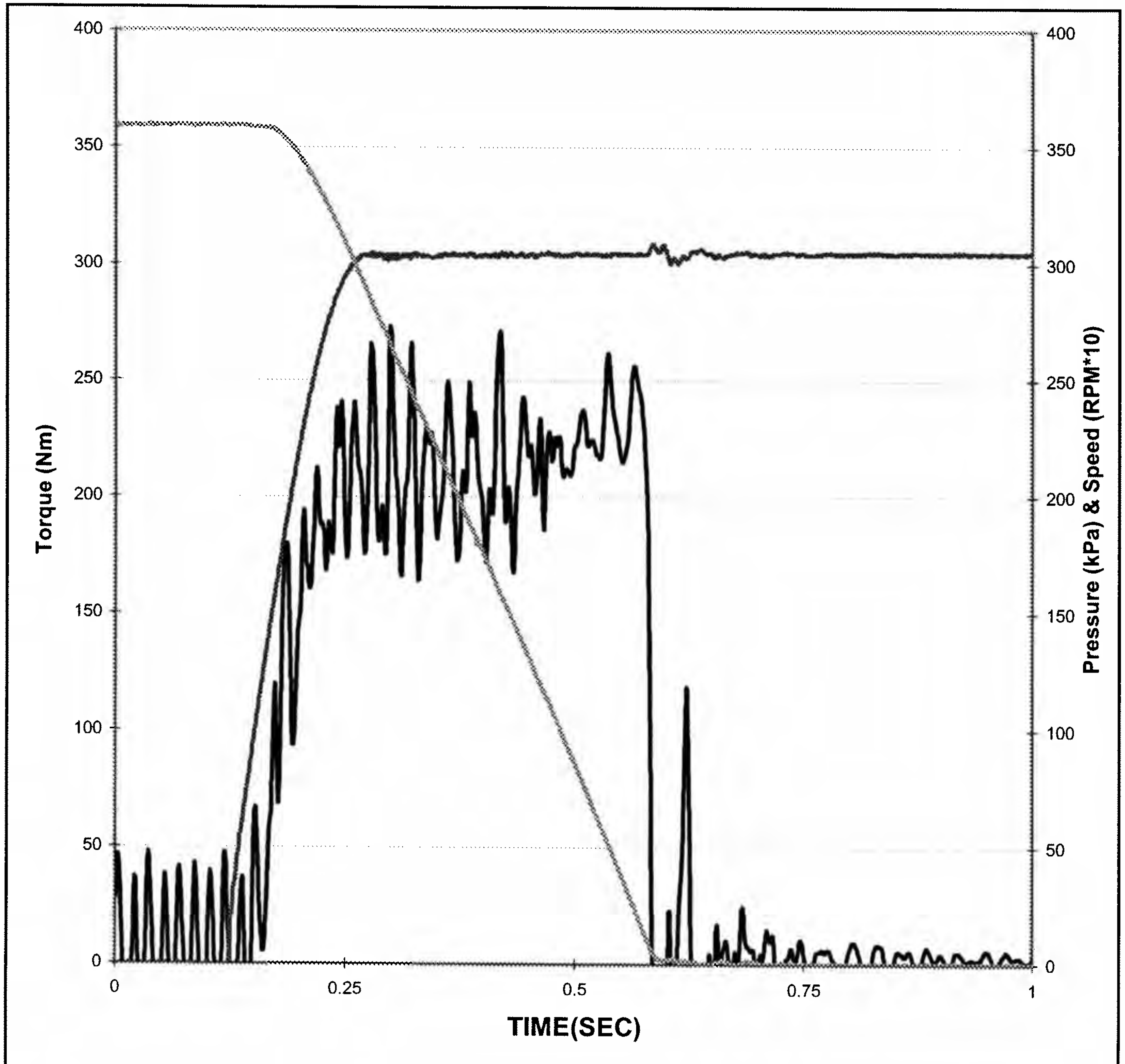

Date of Test:	8/1/2007
Time of Test:	9:02:36
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	45
Cycle Number:	10800
Temperature:	140.5 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	16.2 KJ
	(15.7-16.3)
Engage Time:	0.46 Sec
	(0.35 -0.55)

Torque

Maximum:	262 N*m
	(Report)
Midpoint:	207 N*m
	(180-290)
Max - Mid:	55 N*m
	<120
End - Mid:	14 N*m
	<120
End:	220 N*m
	>200

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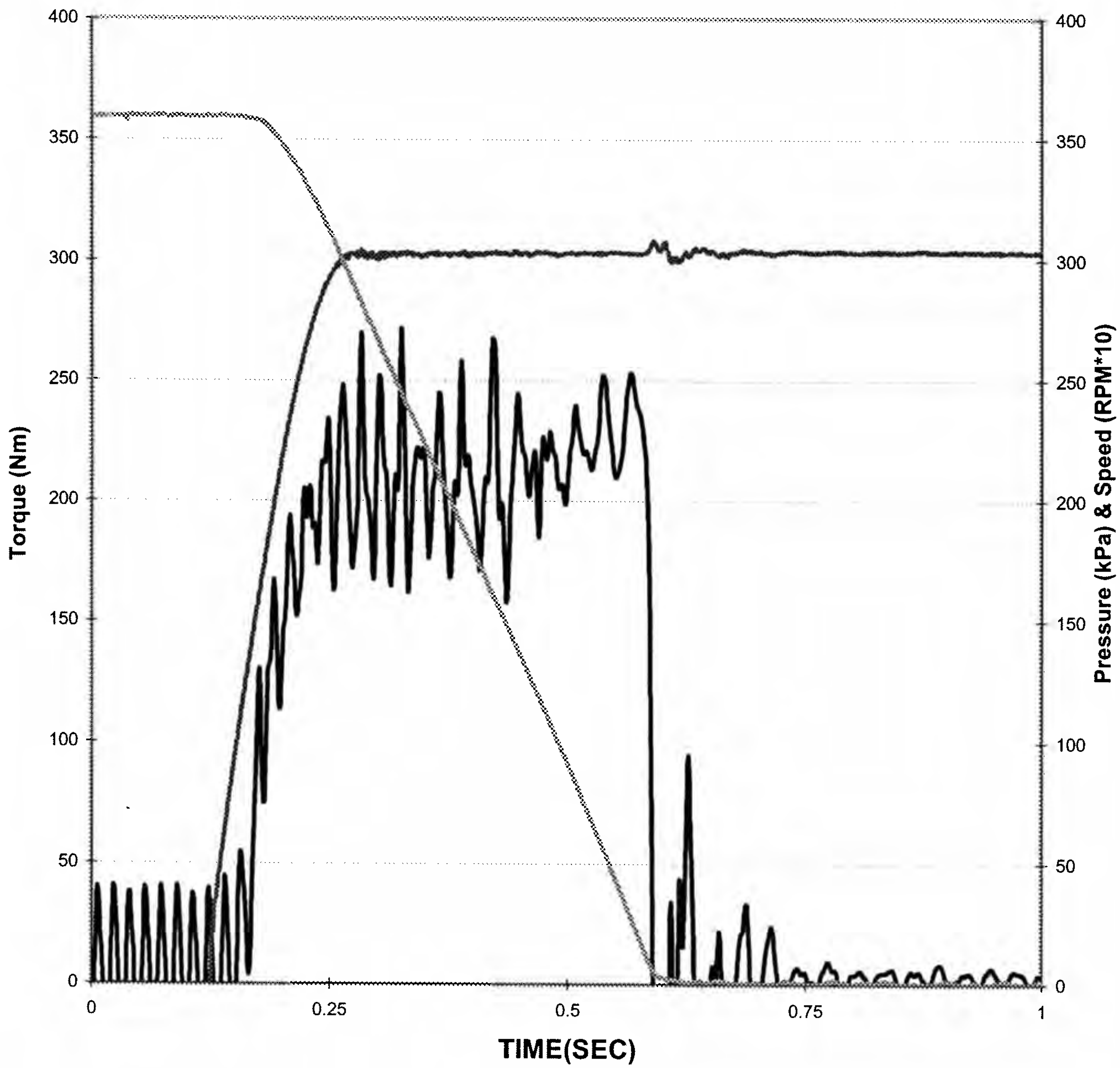

Date of Test:	8/1/2007
Time of Test:	14:45:57
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	50
Cycle Number:	12000
Temperature:	135.3 °C *(129 - 141)*
Apply Pressure:	304 kPa (295 - 305)
Energy:	16.3 KJ *(15.7-16.3)*
Engage Time:	0.46 Sec *(0.35 -0.55)*

Torque

Maximum:	253 N*m (Report)
Midpoint:	204 N*m *(180-290)*
Max - Mid:	50 N*m *<120*
End - Mid:	14 N*m *<120*
End:	217 N*m *>200*

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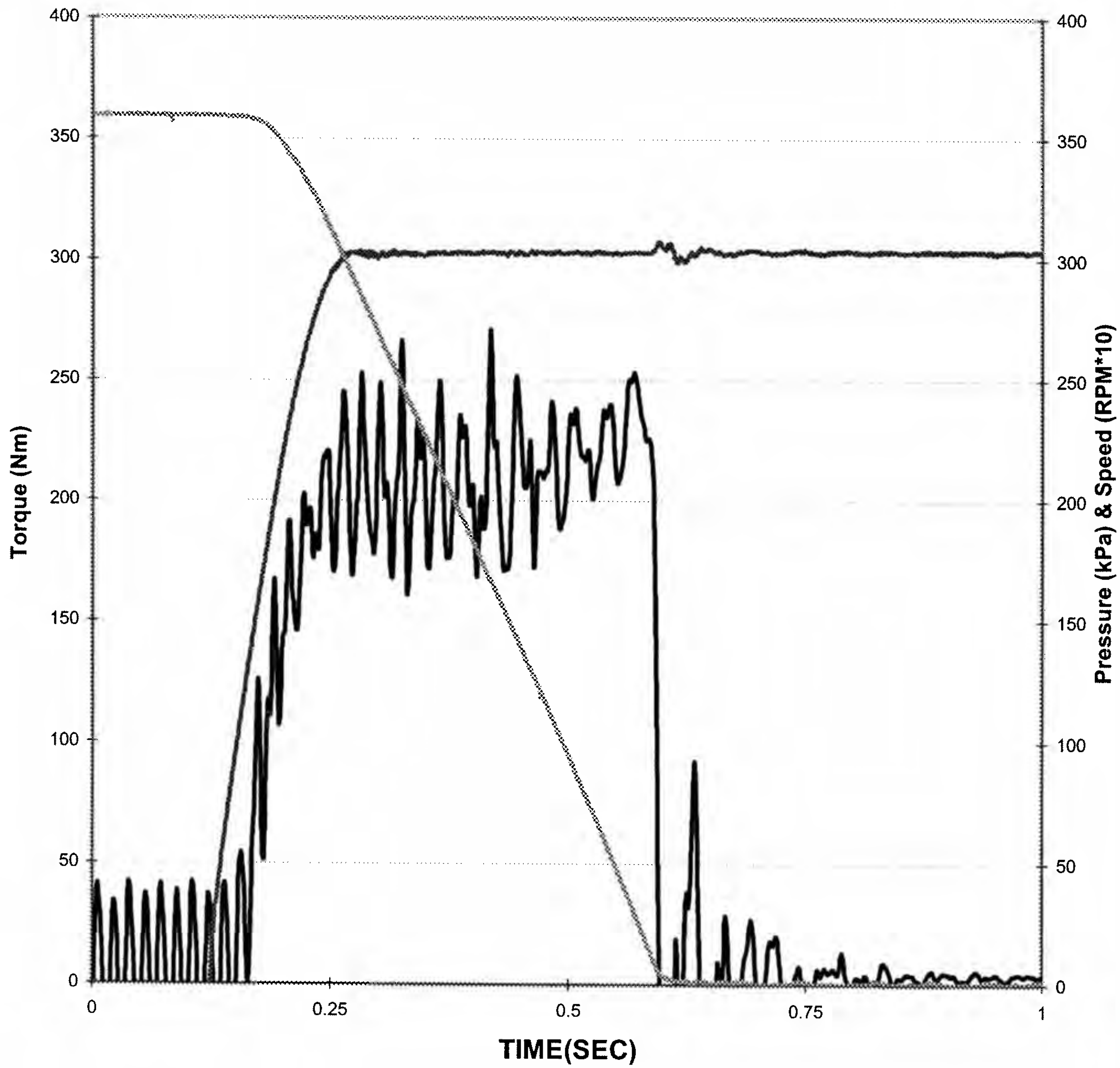

Date of Test:	8/1/2007
Time of Test:	19:45:58
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	55
Cycle Number:	13200
Temperature:	144.5 °C *(129 - 141)*
Apply Pressure:	304 kPa (295 - 305)
Energy:	16.3 KJ *(15.7-16.3)*
Engage Time:	0.47 Sec *(0.35 -0.55)*

Torque

Maximum:	254 N*m (Report)
Midpoint:	205 N*m *(180-290)*
Max - Mid:	48 N*m *<120*
End - Mid:	10 N*m *<120*
End:	215 N*m *>200*

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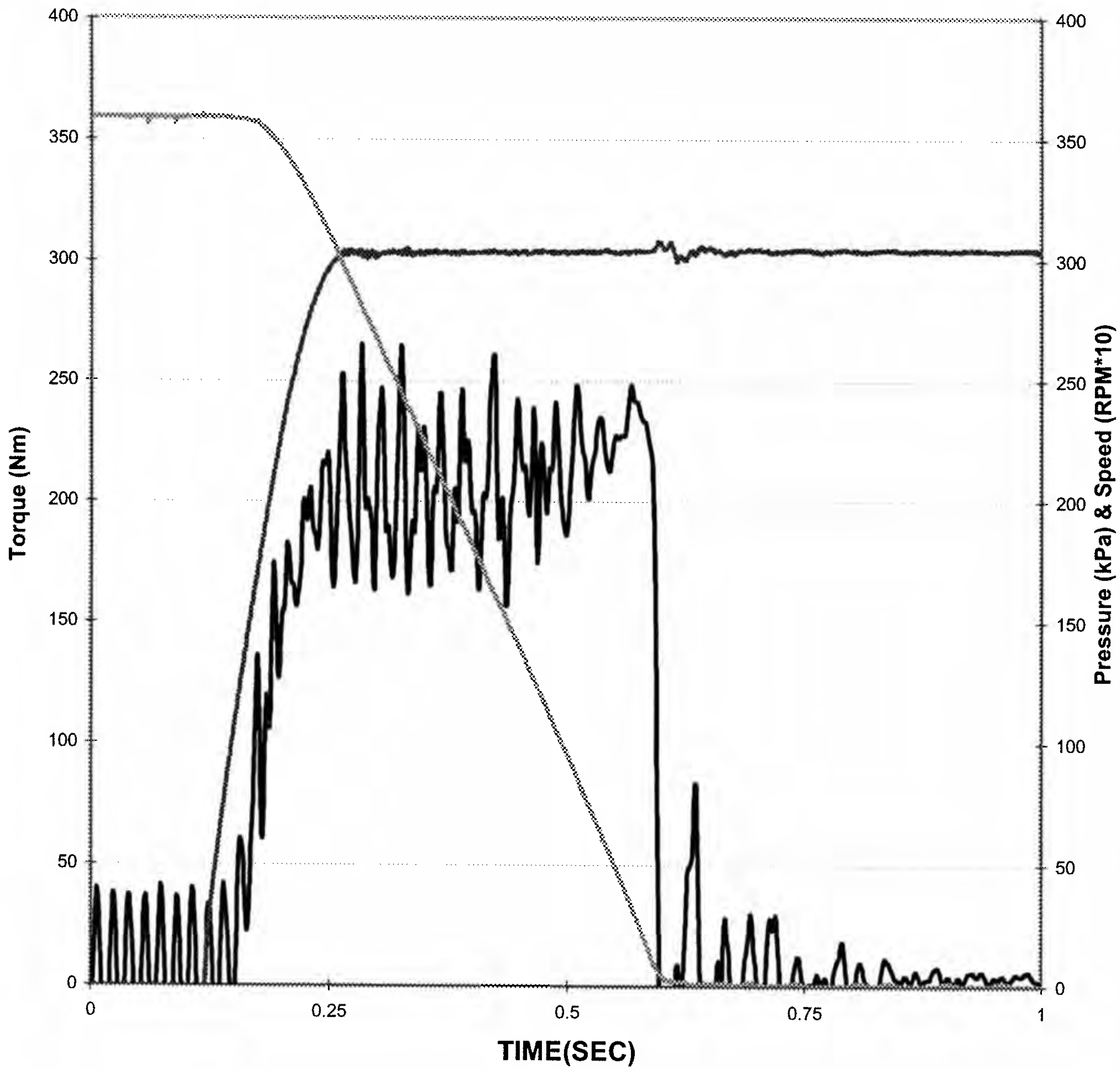

Date of Test:	8/2/2007
Time of Test:	0:45:58
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	60
Cycle Number:	14400
Temperature:	141.4 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	16.4 KJ
	(15.7-16.3)
Engage Time:	0.47 Sec
	(0.35 -0.55)

Torque

Maximum:	248 N*m
	(Report)
Midpoint:	201 N*m
	(180-290)
Max - Mid:	48 N*m
	<120
End - Mid:	15 N*m
	<120
End:	216 N*m
	>200

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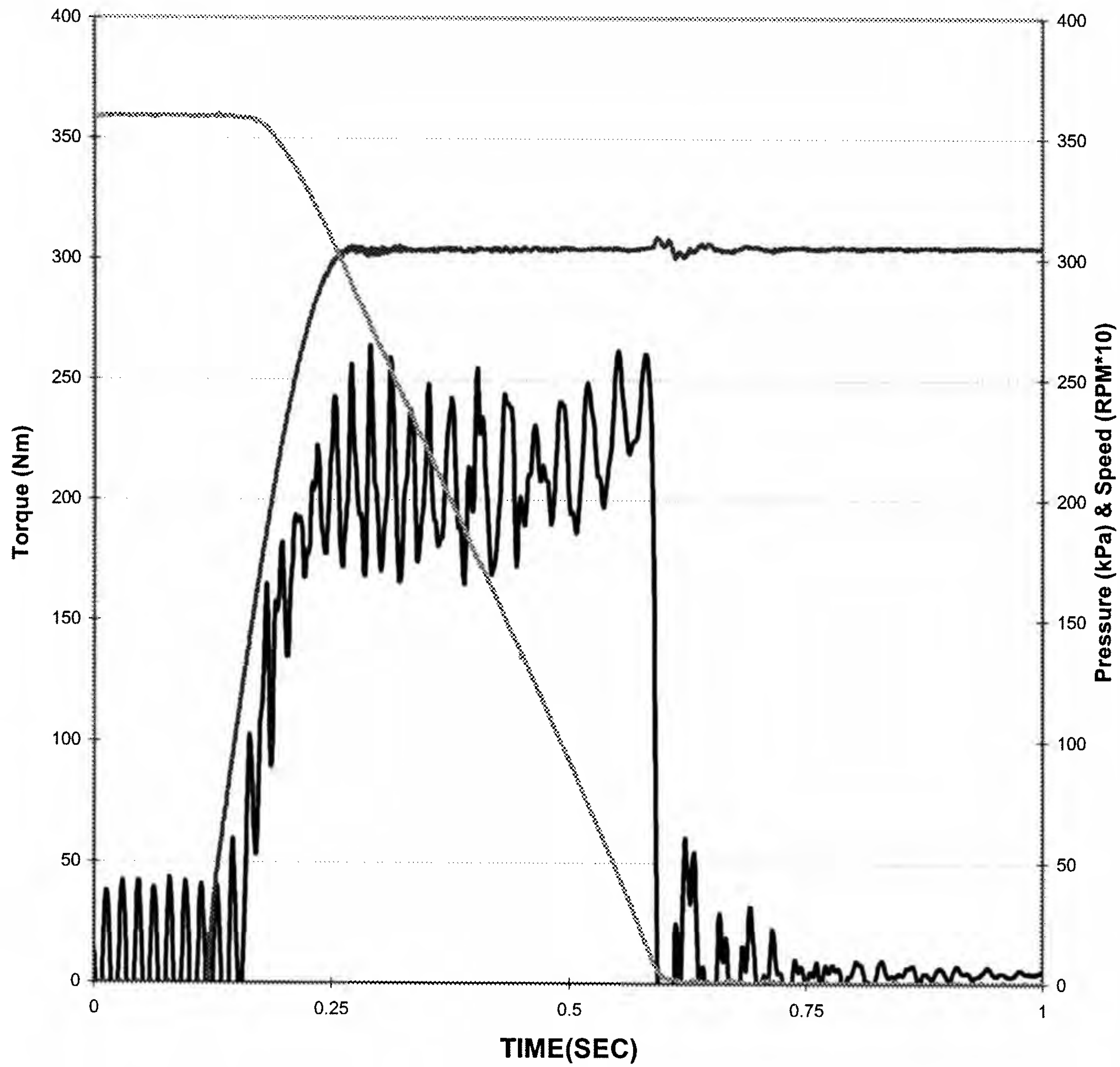

Date of Test:	8/2/2007
Time of Test:	5:45:59
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	65
Cycle Number:	15600
Temperature:	142.4 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	16.5 KJ
	(15.7-16.3)
Engage Time:	0.47 Sec
	(0.35 -0.55)

Torque

Maximum:	262 N*m
	(Report)
Midpoint:	210 N*m
	(180-290)
Max - Mid:	53 N*m
	<120
End - Mid:	33 N*m
	<120
End:	243 N*m
	>200

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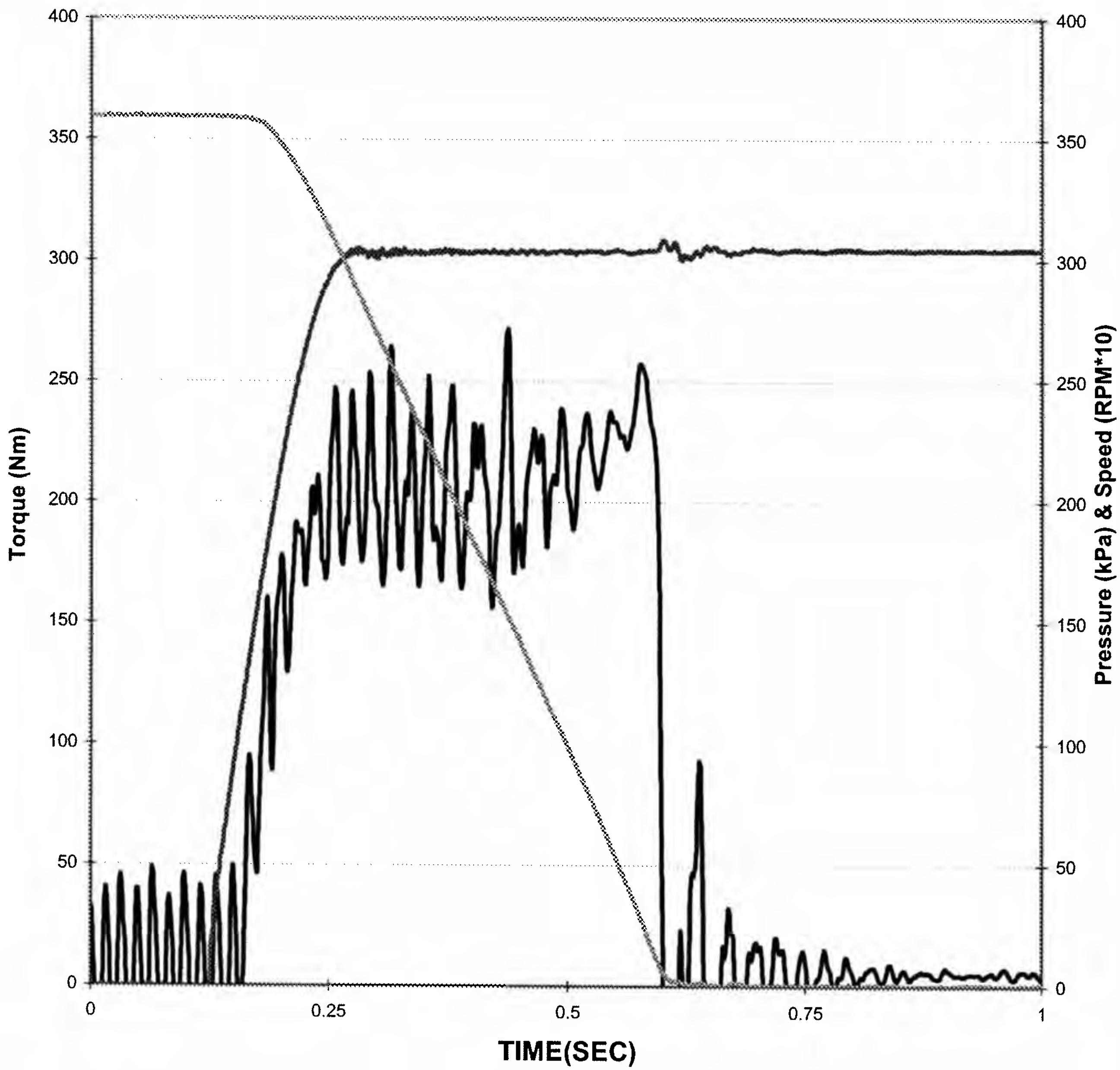

Date of Test:	8/2/2007
Time of Test:	10:46:00
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	70
Cycle Number:	16800
Temperature:	136.8 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	16.6 KJ
	(15.7-16.3)
Engage Time:	0.47 Sec
	(0.35 -0.55)

Torque

Maximum:	257 N*m
	(Report)
Midpoint:	206 N*m
	(180-290)
Max - Mid:	52 N*m
	<120
End - Mid:	8 N*m
	<120
End:	213 N*m
	>200

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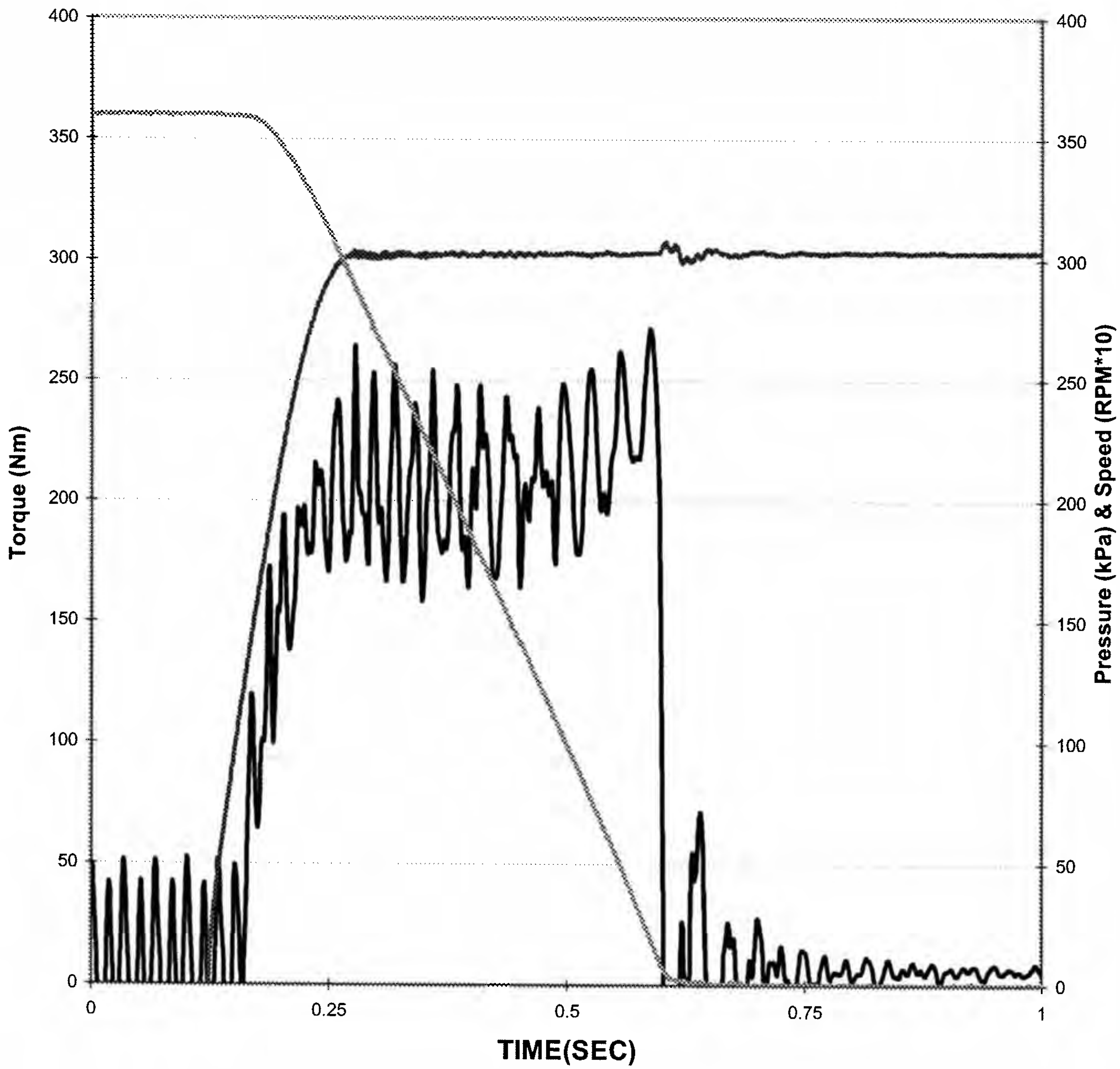

Date of Test:	8/2/2007
Time of Test:	15:46:01
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	75
Cycle Number:	18000
Temperature:	135.0 °C
	(129 - 141)
Apply Pressure:	303 kPa
	(295 - 305)
Energy:	16.7 KJ
	(15.7-16.3)
Engage Time:	0.48 Sec
	(0.35 -0.55)

Torque

Maximum:	271 N*m
	(Report)
Midpoint:	207 N*m
	(180-290)
Max - Mid:	64 N*m
	<120
End - Mid:	42 N*m
	<120
End:	249 N*m
	>200

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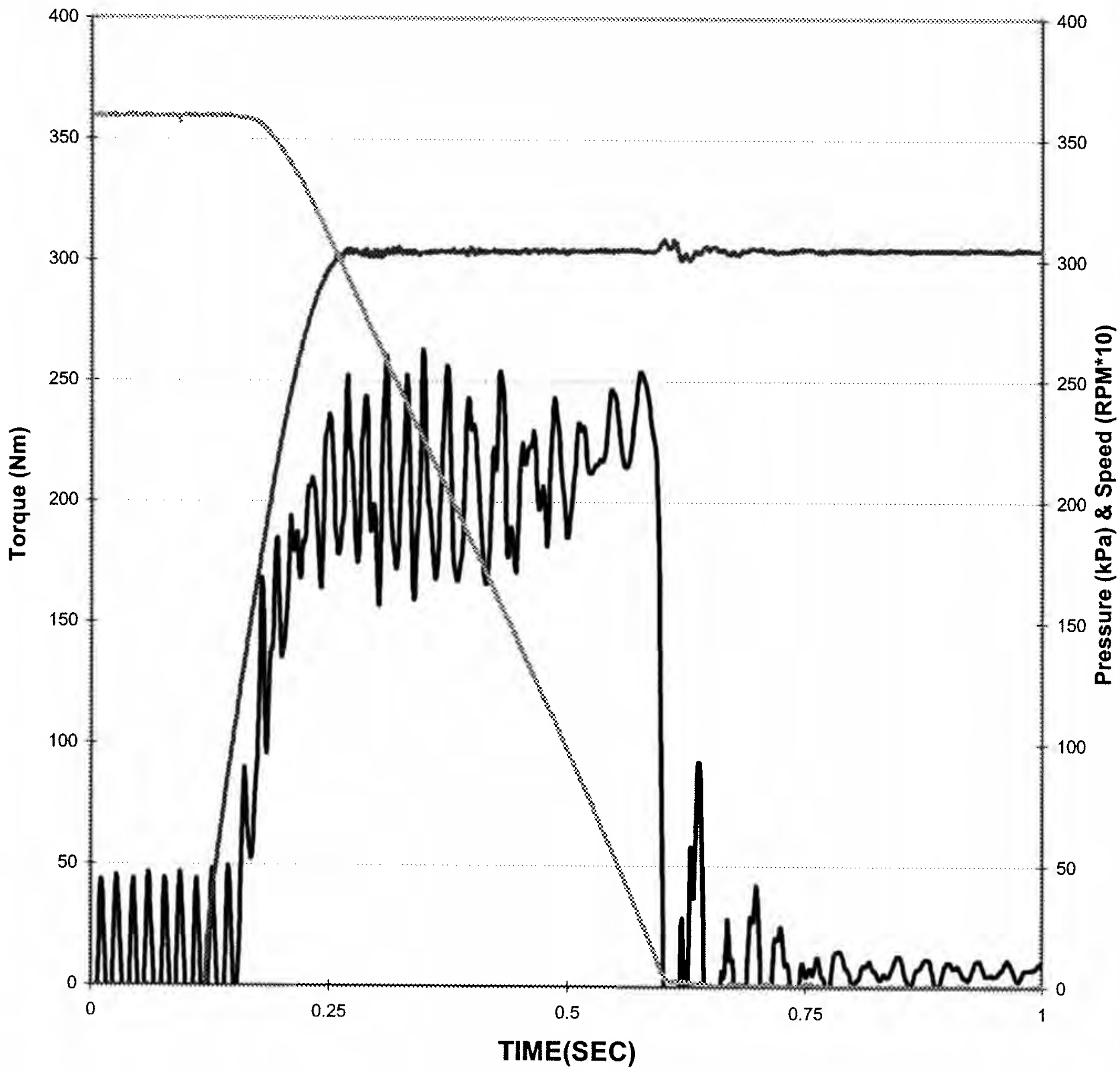

Date of Test:	8/2/2007
Time of Test:	20:46:01
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	80
Cycle Number:	19200
Temperature:	136.0 °C *(129 - 141)*
Apply Pressure:	304 kPa (295 - 305)
Energy:	16.8 KJ *(15.7-16.3)*
Engage Time:	0.48 Sec *(0.35 -0.55)*

Torque

Maximum:	254 N*m (Report)
Midpoint:	203 N*m *(180-290)*
Max - Mid:	51 N*m *<120*
End - Mid:	14 N*m *<120*
End:	217 N*m *>200*

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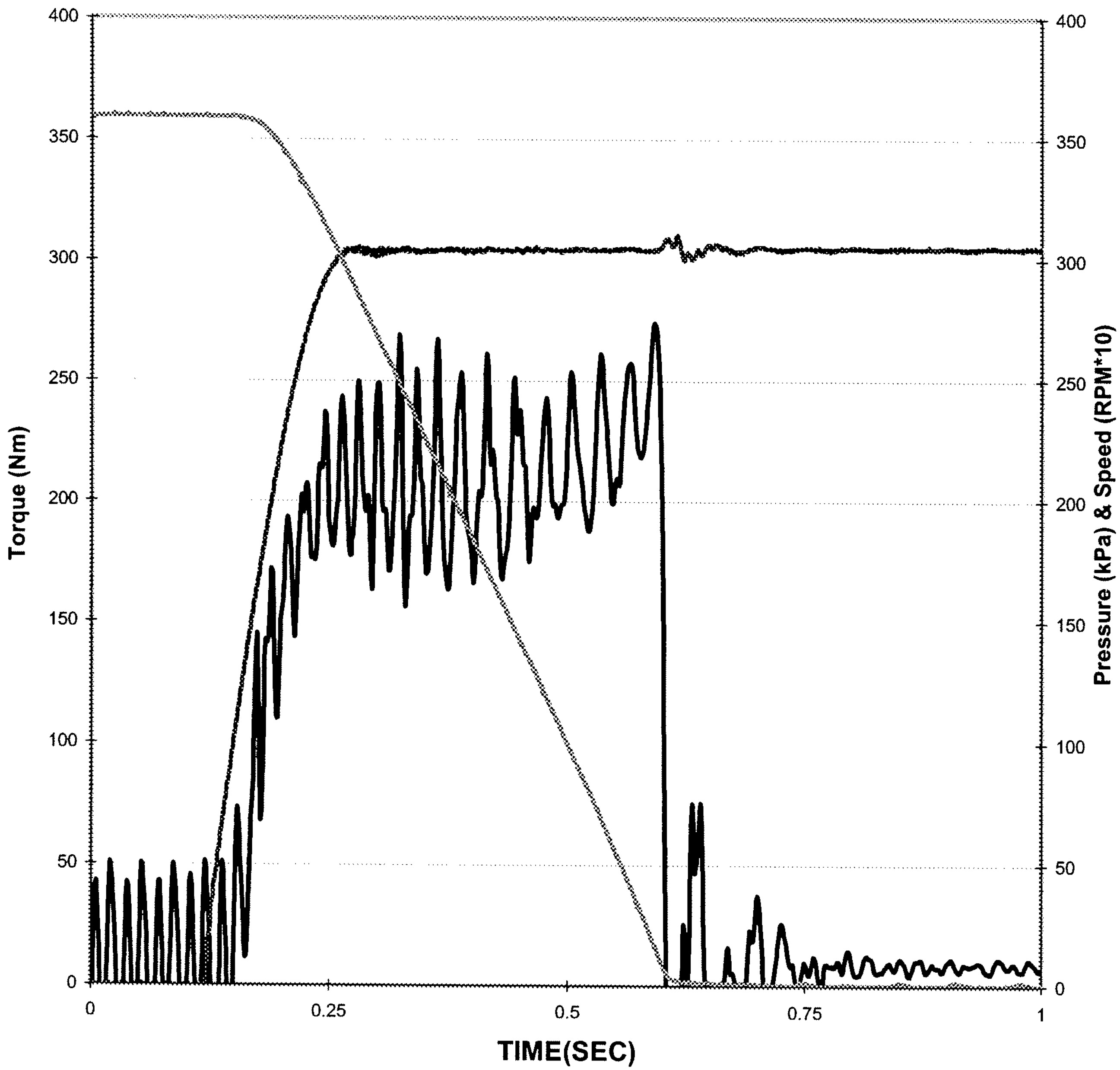

Date of Test:	8/3/2007
Time of Test:	1:46:02
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	85
Cycle Number:	20400
Temperature:	137.3 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	16.9 KJ
	(15.7-16.3)
Engage Time:	0.48 Sec
	(0.35 -0.55)

Torque

Maximum:	274 N*m
	(Report)
Midpoint:	206 N*m
	(180-290)
Max - Mid:	69 N*m
	<120
End - Mid:	53 N*m
	<120
End:	259 N*m
	>200

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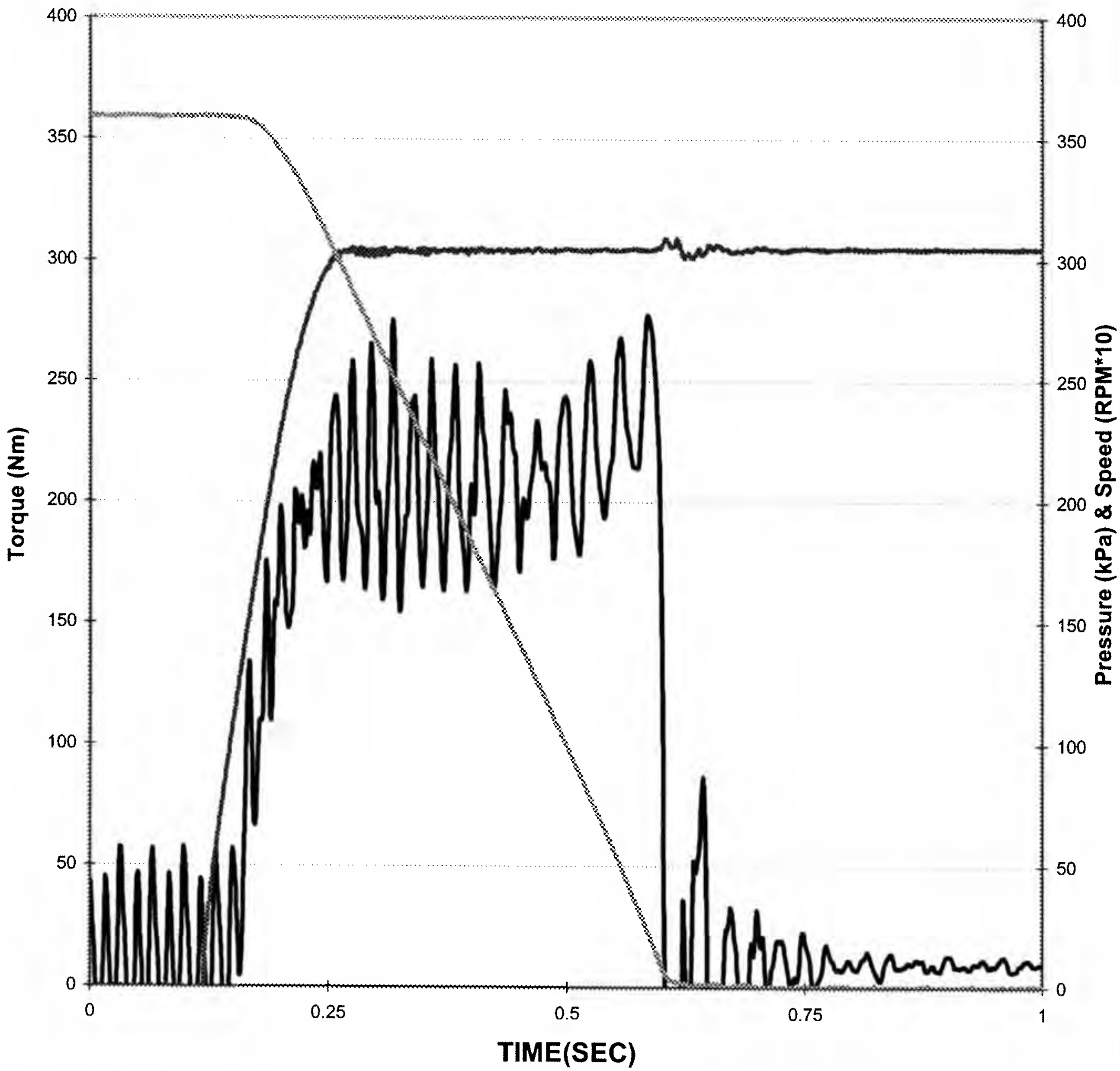

Date of Test:	8/3/2007
Time of Test:	6:46:03
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	90
Cycle Number:	21600
Temperature:	139.6 °C *(129 - 141)*
Apply Pressure:	304 kPa (295 - 305)
Energy:	17.1 KJ *(15.7-16.3)*
Engage Time:	0.48 Sec *(0.35 -0.55)*

Torque

Maximum:	278 N*m (Report)
Midpoint:	210 N*m *(180-290)*
Max - Mid:	67 N*m *<120*
End - Mid:	34 N*m *<120*
End:	244 N*m *>200*

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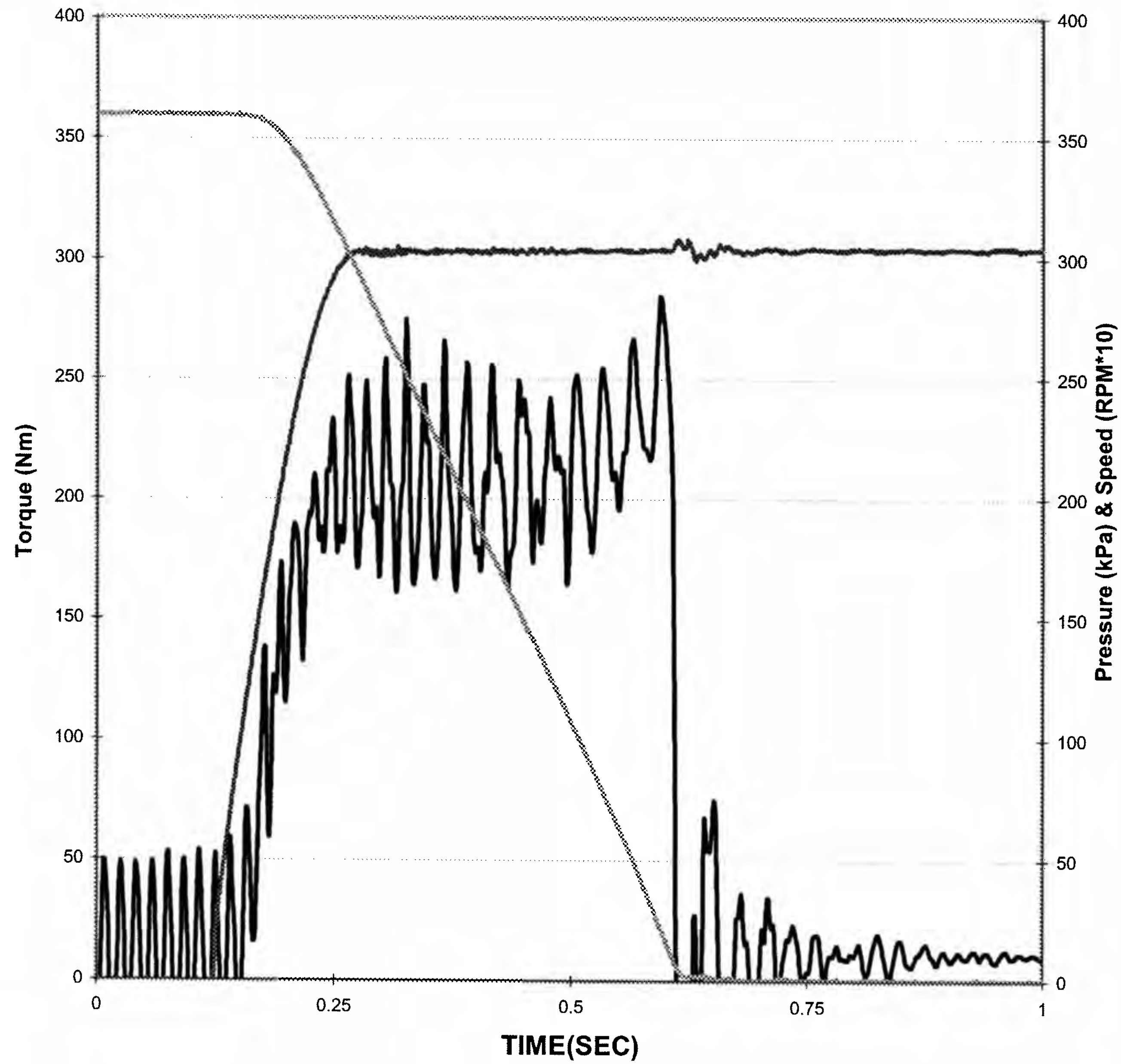

Date of Test:	8/3/2007
Time of Test:	11:46:04
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	95
Cycle Number:	22800
Temperature:	135.0 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	17.2 KJ
	(15.7-16.3)
Engage Time:	0.49 Sec
	(0.35 -0.55)

Torque

Maximum:	285 N*m
	(Report)
Midpoint:	209 N*m
	(180-290)
Max - Mid:	76 N*m
	<120
End - Mid:	32 N*m
	<120
End:	241 N*m
	>200

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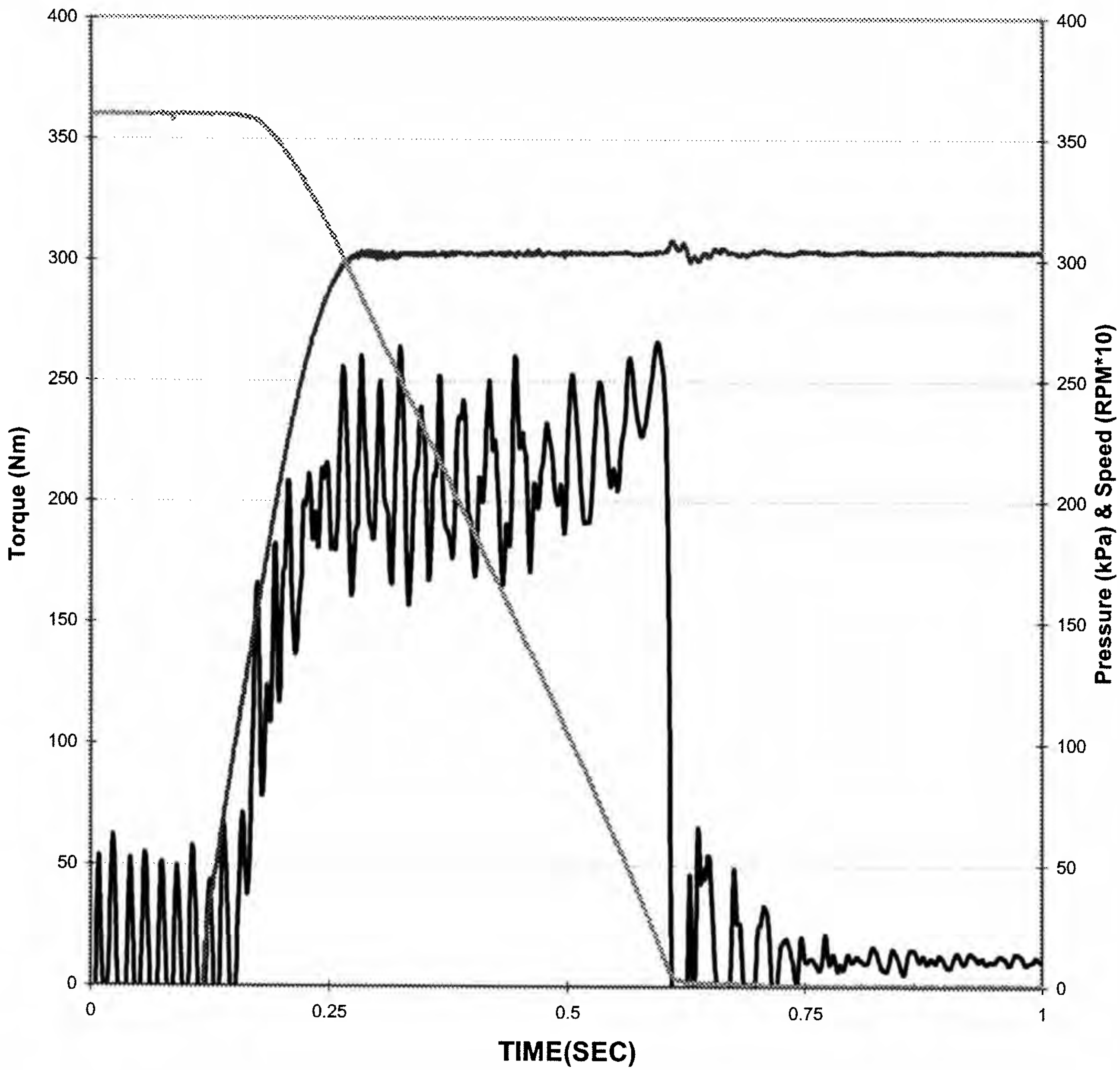

Date of Test:	8/3/2007
Time of Test:	17:04:35
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	100
Cycle Number:	24000
Temperature:	135.1 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	17.5 KJ
	(15.7-16.3)
Engage Time:	0.49 Sec
	(0.35 -0.55)

Torque

Maximum:	266 N*m
	(Report)
Midpoint:	208 N*m
	(180-290)
Max - Mid:	58 N*m
	<120
End - Mid:	33 N*m
	<120
End:	242 N*m
	>200

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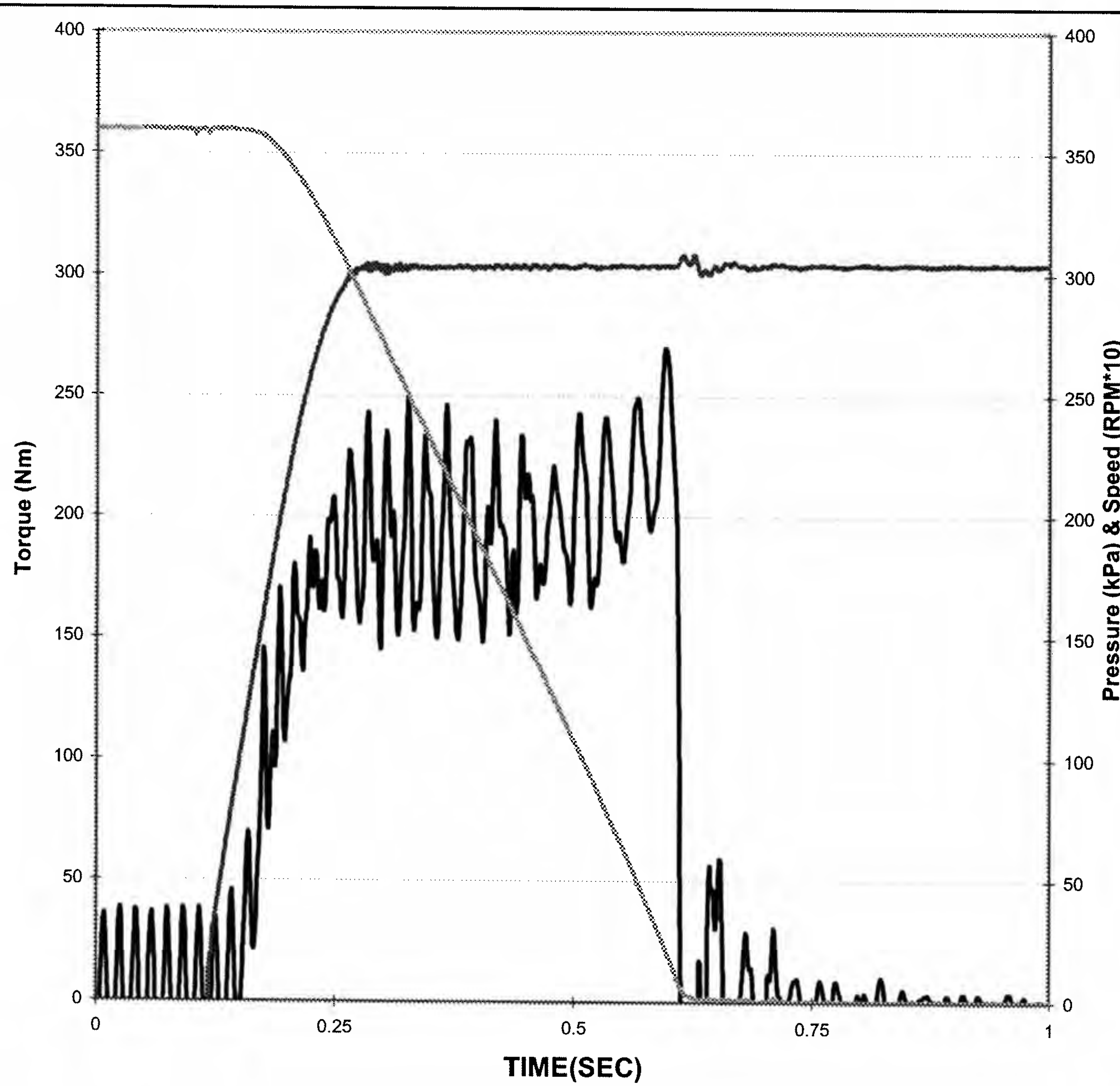

Date of Test:	8/3/2007
Time of Test:	23:23:48
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	105
Cycle Number:	25200
Temperature:	134.9 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	16.0 KJ
	(15.7-16.3)
Engage Time:	0.48 Sec
	(0.35 -0.55)

Torque

Maximum:	270 N*m
	(Report)
Midpoint:	190 N*m
	(180-290)
Max - Mid:	80 N*m
	<120
End - Mid:	57 N*m
	<120
End:	246 N*m
	>200

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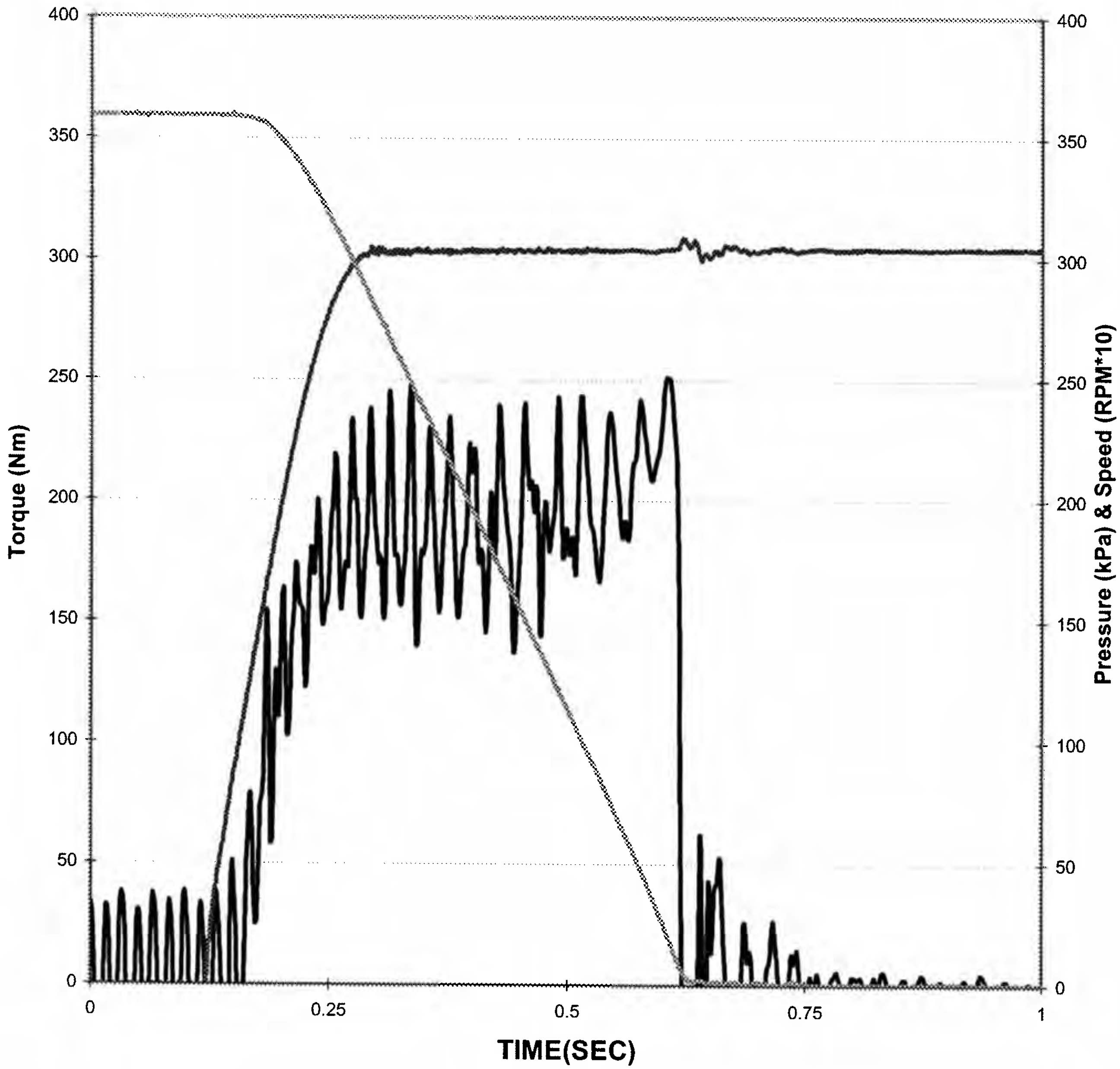

Date of Test:	8/4/2007
Time of Test:	11:10:41
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	110
Cycle Number:	26400
Temperature:	132.9 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.50 Sec
	(0.35 -0.55)

Torque

Maximum:	251 N*m
	(Report)
Midpoint:	187 N*m
	(180-290)
Max - Mid:	64 N*m
	<120
End - Mid:	37 N*m
	<120
End:	224 N*m
	>200

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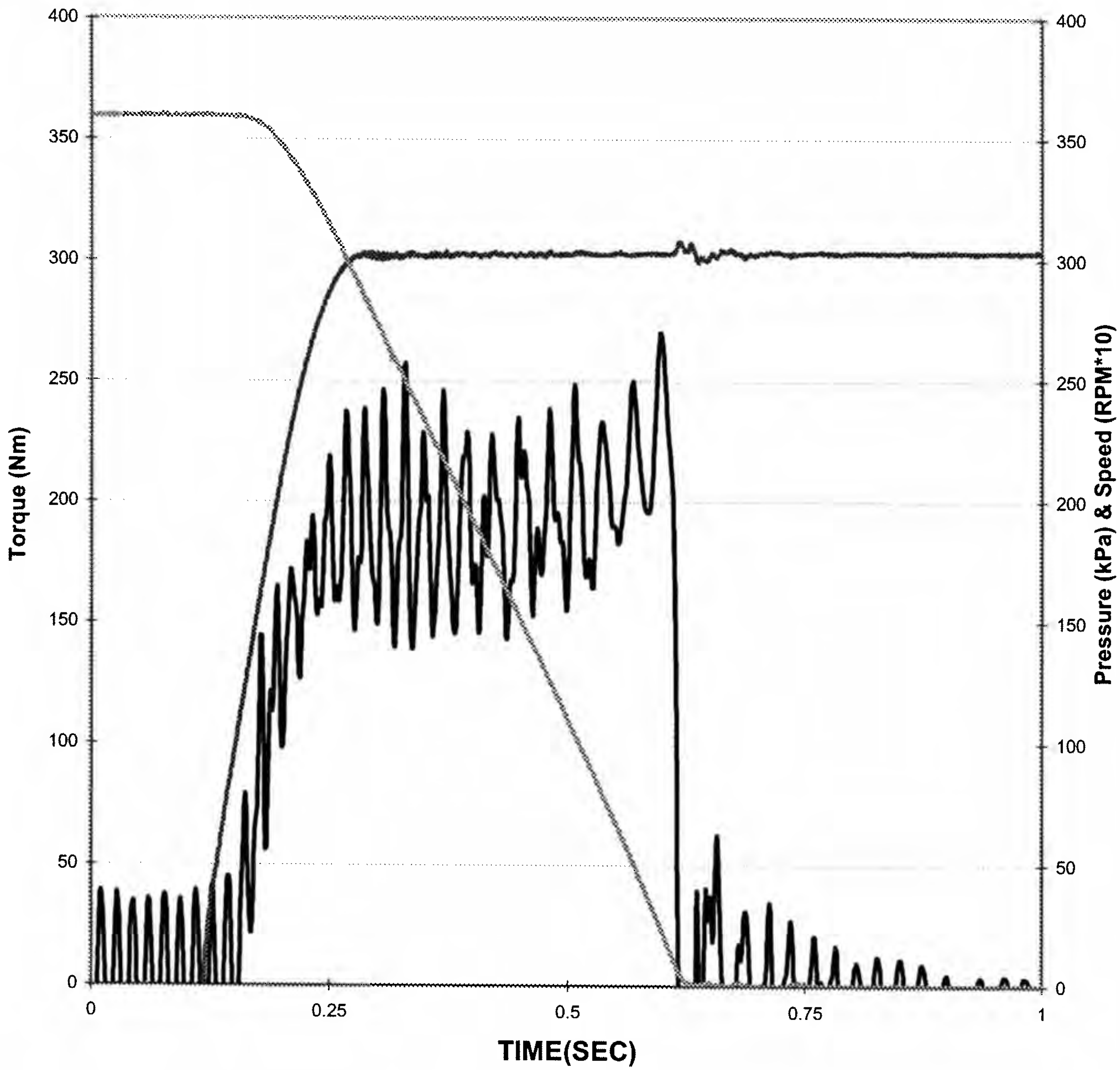

Date of Test:	8/4/2007
Time of Test:	16:10:31
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	115
Cycle Number:	27600
Temperature:	136.8 °C *(129 - 141)*
Apply Pressure:	304 kPa (295 - 305)
Energy:	15.8 KJ *(15.7-16.3)*
Engage Time:	0.49 Sec *(0.35 -0.55)*

Torque

Maximum:	270 N*m (Report)
Midpoint:	188 N*m *(180-290)*
Max - Mid:	82 N*m *<120*
End - Mid:	22 N*m *<120*
End:	210 N*m *>200*

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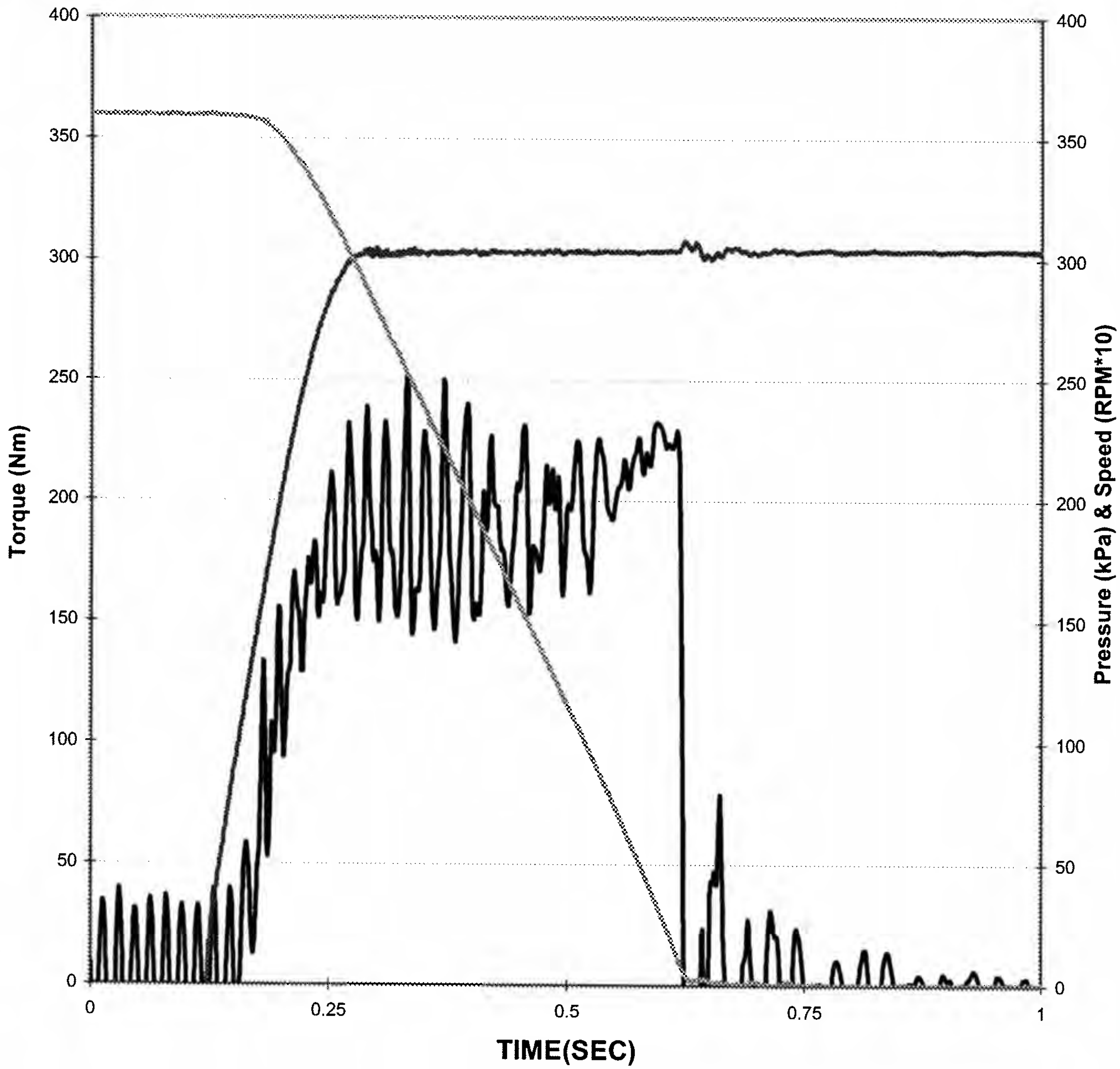

Date of Test:	8/4/2007
Time of Test:	21:10:32
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	120
Cycle Number:	28800
Temperature:	134.7 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.50 Sec
	(0.35 -0.55)

Torque

Maximum:	233 N*m
	(Report)
Midpoint:	192 N*m
	(180-290)
Max - Mid:	41 N*m
	<120
End - Mid:	35 N*m
	<120
End:	226 N*m
	>200

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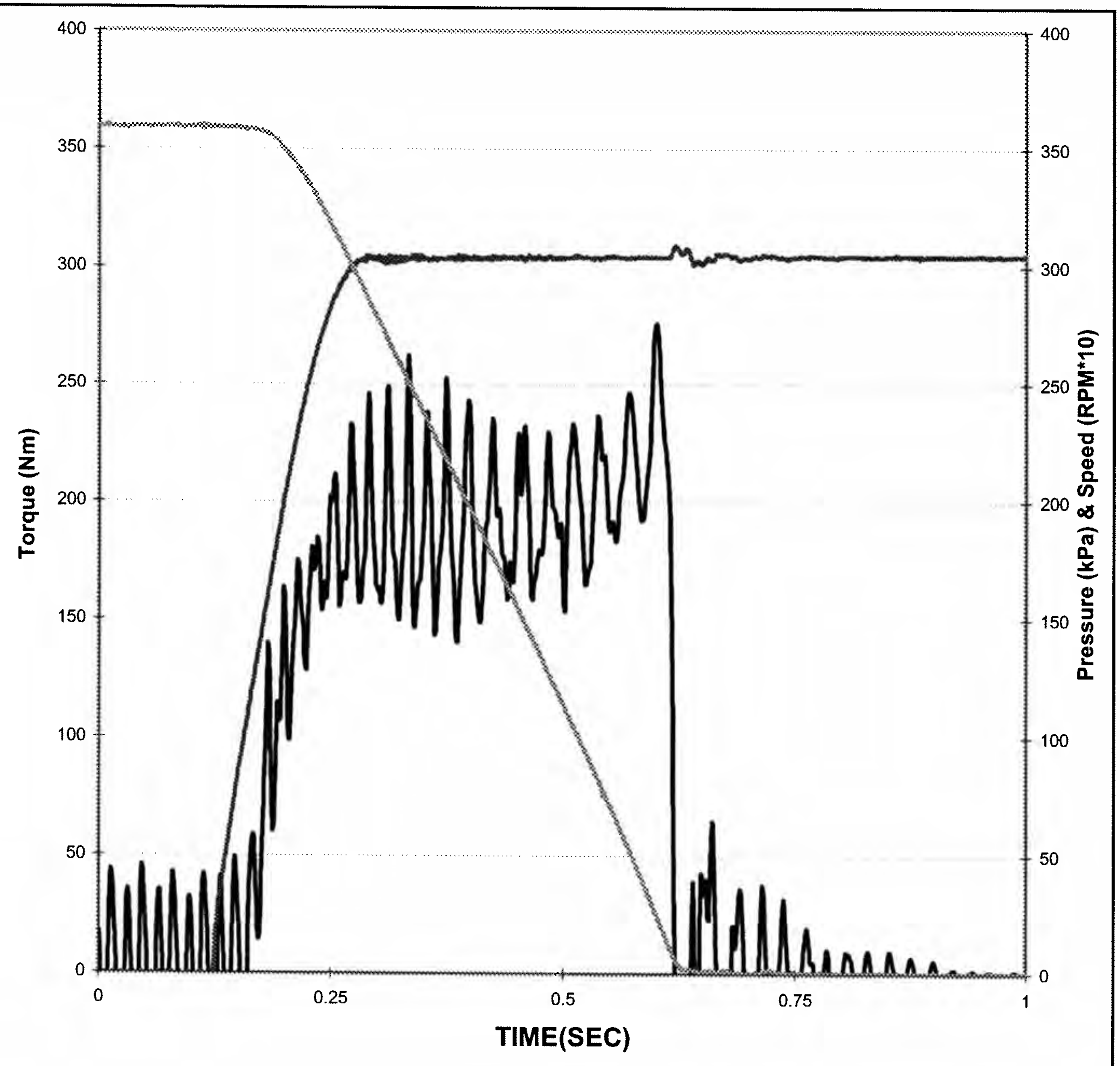

Date of Test:	8/5/2007
Time of Test:	2:10:33
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	125
Cycle Number:	30000
Temperature:	135.3 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.50 Sec
	(0.35 -0.55)

Torque

Maximum:	276 N*m
	(Report)
Midpoint:	188 N*m
	(180-290)
Max - Mid:	87 N*m
	<120
End - Mid:	24 N*m
	<120
End:	213 N*m
	>200

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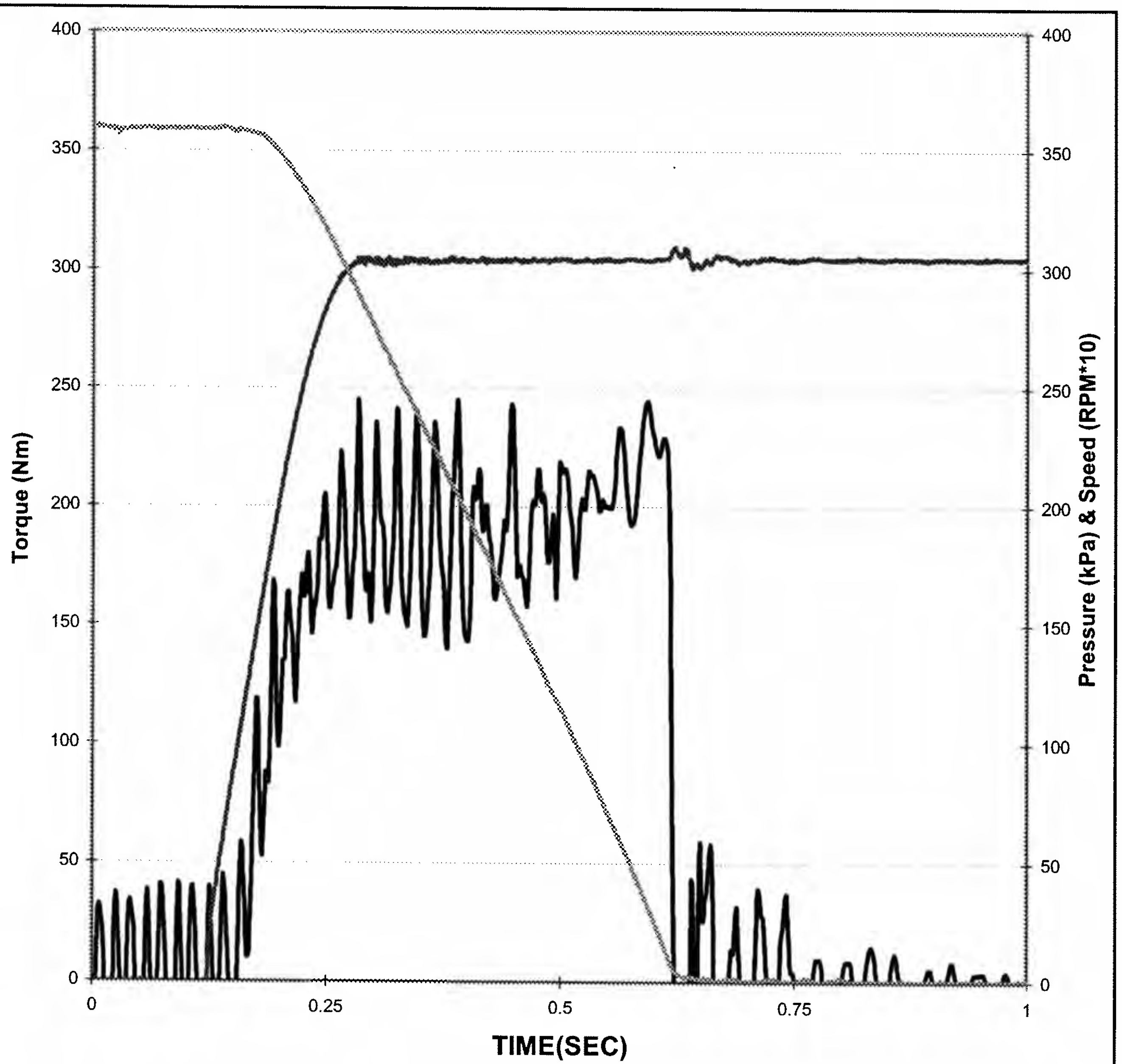

Date of Test:	8/5/2007
Time of Test:	7:10:34
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	130
Cycle Number:	31200
Temperature:	135.4 °C (129 - 141)
Apply Pressure:	304 kPa (295 - 305)
Energy:	15.7 KJ *(15.7-16.3)*
Engage Time:	0.50 Sec *(0.35 -0.55)*

Torque

Maximum:	245 N*m (Report)
Midpoint:	189 N*m *(180-290)*
Max - Mid:	56 N*m *<120*
End - Mid:	34 N*m *<120*
End:	223 N*m *>200*

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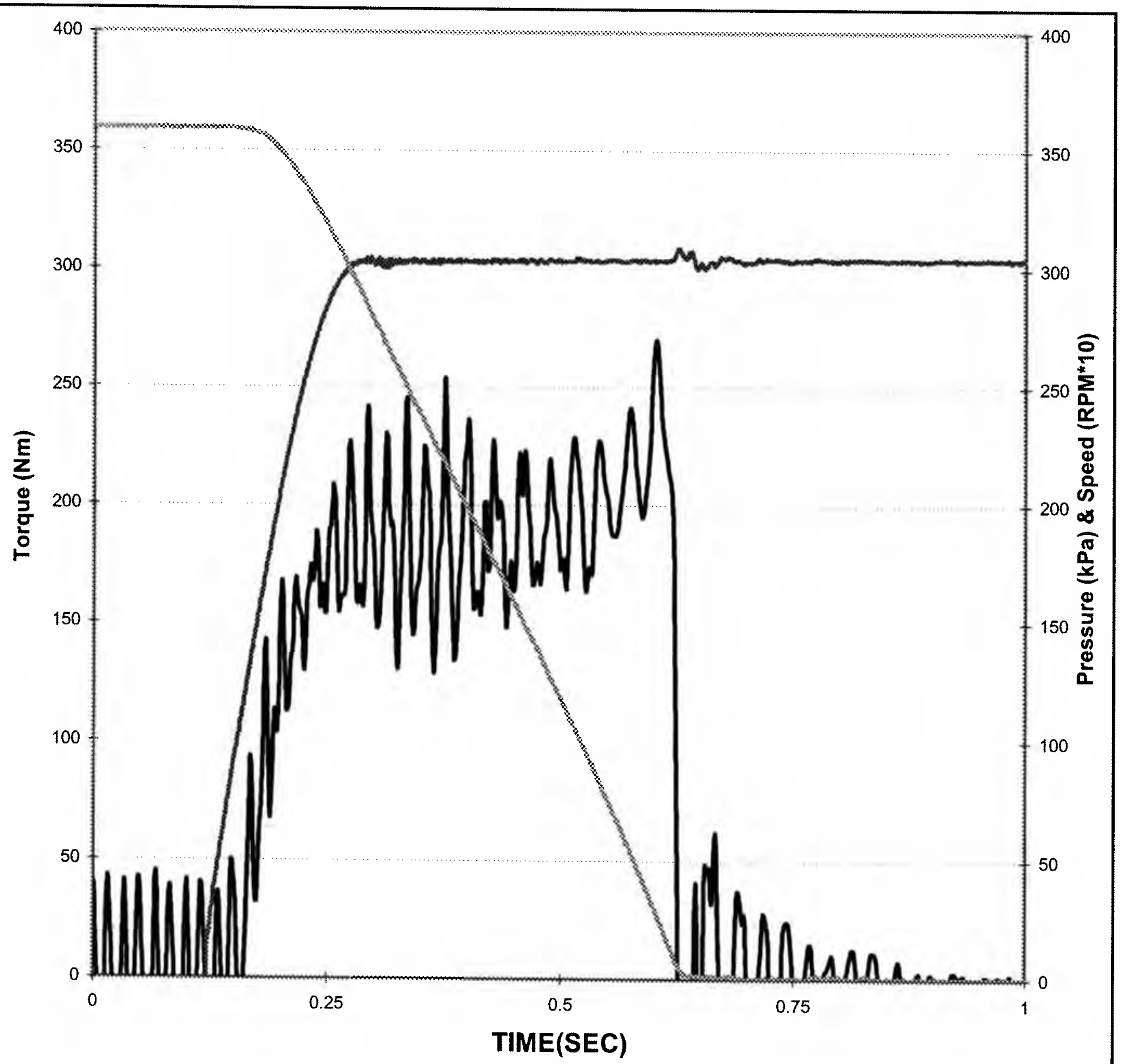

Date of Test:	8/5/2007
Time of Test:	12:10:35
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	135
Cycle Number:	32400
Temperature:	135.5 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	15.7 KJ
	(15.7-16.3)
Engage Time:	0.50 Sec
	(0.35 -0.55)

Torque

Maximum:	270 N*m
	(Report)
Midpoint:	183 N*m
	(180-290)
Max - Mid:	87 N*m
	<120
End - Mid:	22 N*m
	<120
End:	205 N*m
	>200

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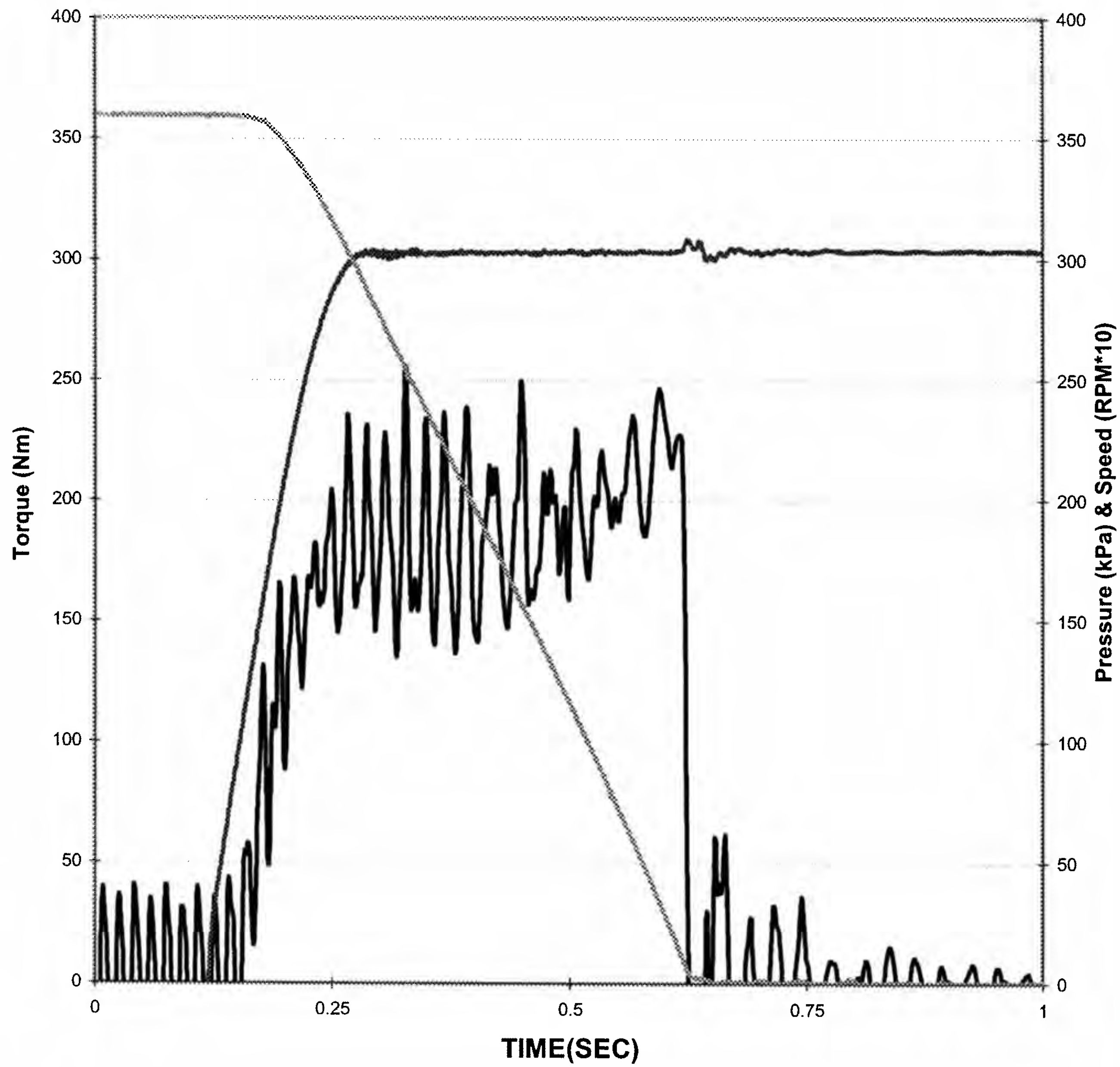

Date of Test:	8/5/2007
Time of Test:	17:10:35
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	140
Cycle Number:	33600
Temperature:	139.6 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.50 Sec
	(0.35 -0.55)

Torque

Maximum:	247 N*m
	(Report)
Midpoint:	188 N*m
	(180-290)
Max - Mid:	59 N*m
	<120
End - Mid:	31 N*m
	<120
End:	219 N*m
	>200

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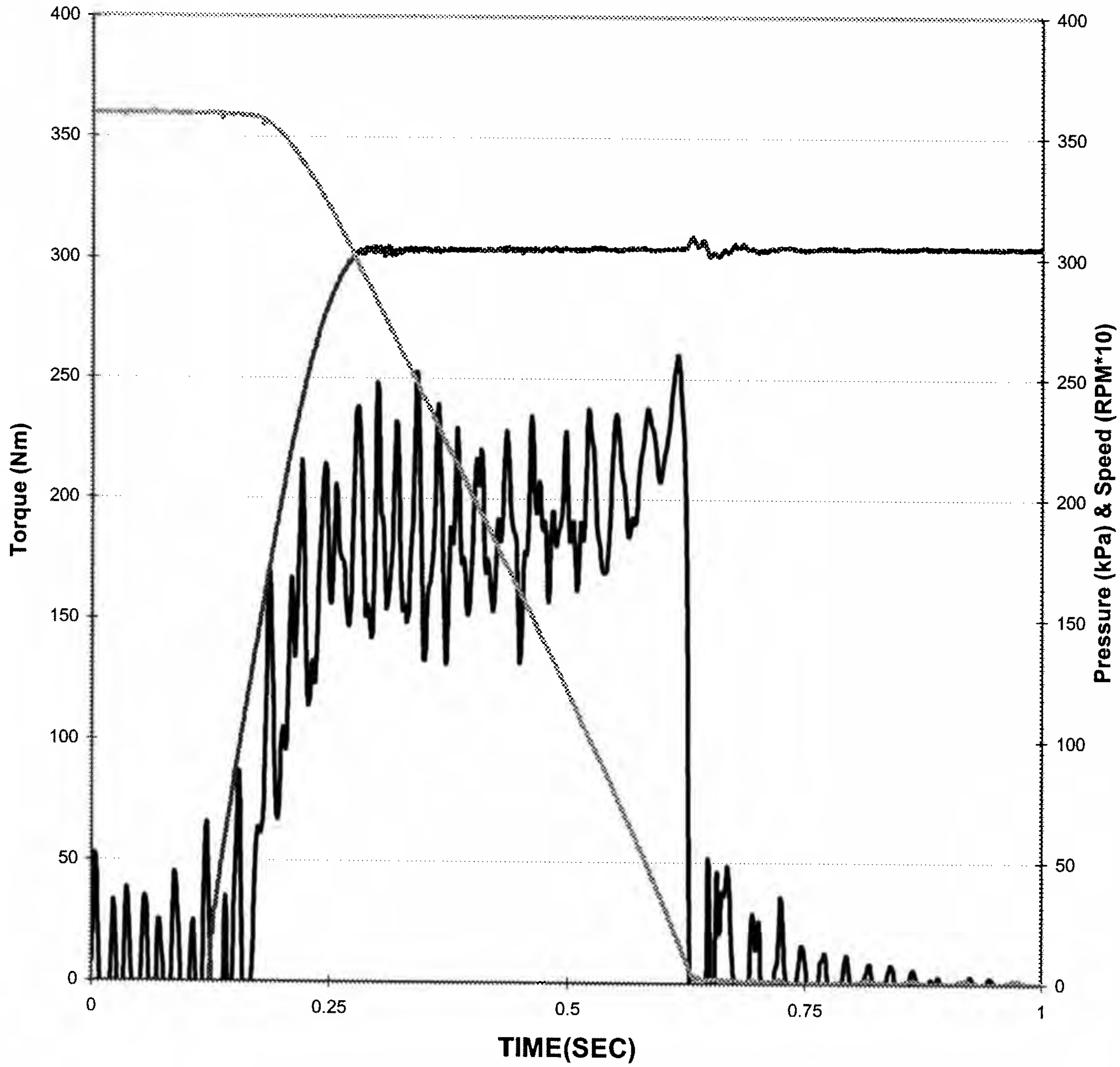

Date of Test:	8/5/2007
Time of Test:	22:10:36
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	145
Cycle Number:	34800
Temperature:	137.8 °C *(129 - 141)*
Apply Pressure:	304 kPa (295 - 305)
Energy:	15.7 KJ *(15.7-16.3)*
Engage Time:	0.50 Sec *(0.35 -0.55)*

Torque

Maximum:	260 N*m (Report)
Midpoint:	182 N*m *(180-290)*
Max - Mid:	78 N*m *<120*
End - Mid:	44 N*m *<120*
End:	226 N*m *>200*

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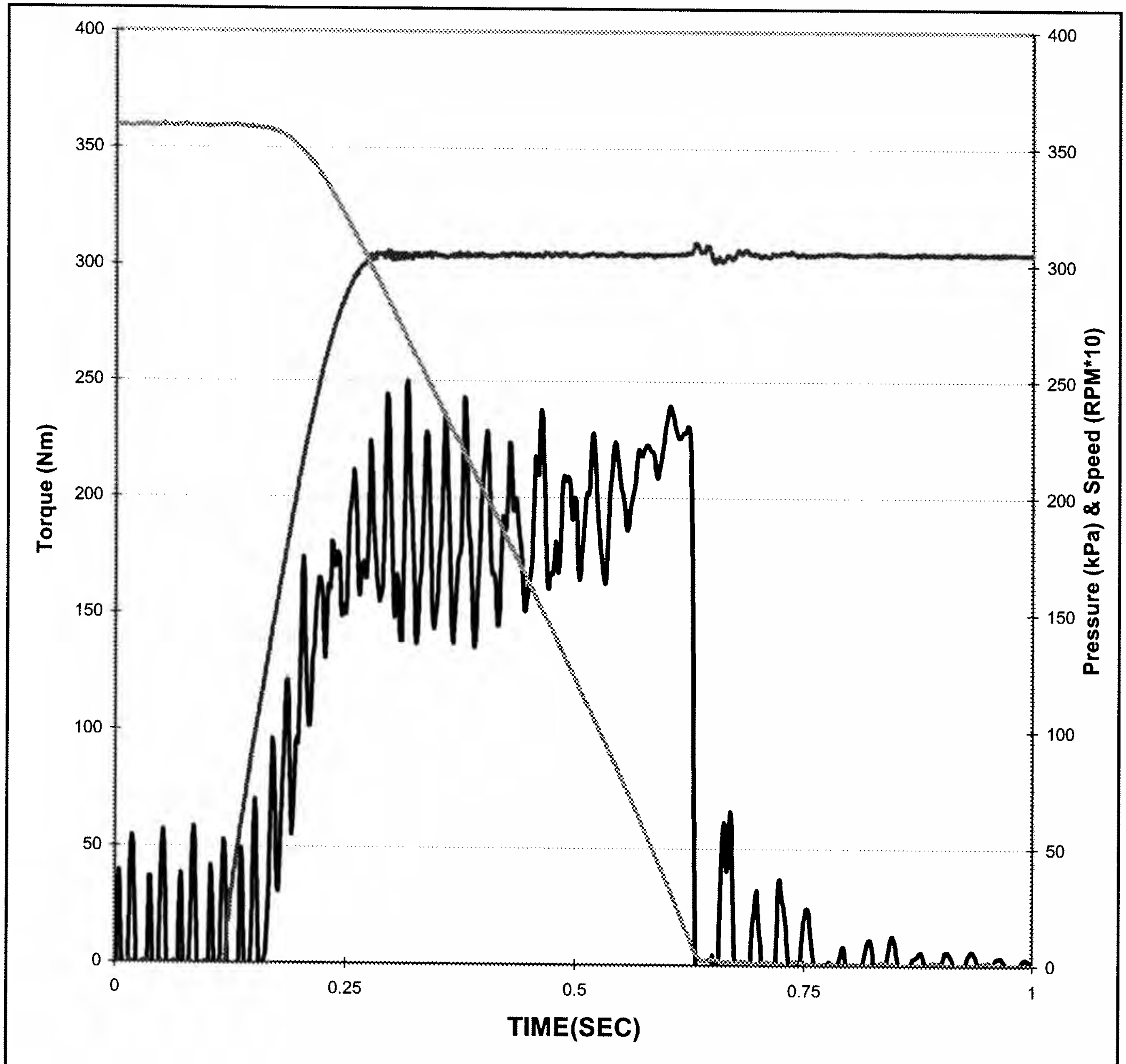


Date of Test:	8/6/2007
Time of Test:	3:10:37
Test Type:	BAND
Test Number:	BH3-4-164
Fluid Code:	AL-27637-L
Hour Number:	150
Cycle Number:	36000
Temperature:	134.9 °C (129 - 141)
Apply Pressure:	305 kPa (295 - 305)
Energy:	15.7 KJ (15.7-16.3)
Engage Time:	0.51 Sec (0.35 -0.55)

Torque

Maximum:	240 N*m (Report)
Midpoint:	182 N*m (180-290)
Max - Mid:	57 N*m <120
End - Mid:	46 N*m <120
End:	228 N*m >200

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

FUELS AND LUBRICANTS RESEARCH DIVISION

Report on
DEXRON® VI LOW SPEED CLUTCH FRICTION AND TORQUE CAPACITY CHARACTERIZATION

Conducted for

ARMY LAB

Oil Code:

AL-27637-L

Test Numbers:
LS12-5-0363

July 31, 2007

Submitted by:

Matthew Jackson
Principal Engineer
Specialty & Driveline Fluids
Evaluation

DEXRON® VI - LOW SPEED - NEW OIL

Program Code:	AL-27637-L	Start Date:	7/30/2007
Status:	EOT	EOT Date:	7/31/2007
Test Cycles:	306	Run Number:	LS12-5-0363
Test Performance:	Pass	EOT Parts Condition:	Pass

Slip Speed	Sliding Speed	40°C Coefficients			90°C Coefficients			120°C Coefficients		
		Apply Pressure [kPa]			Apply Pressure [kPa]			Apply Pressure [kPa]		
[r/min]	[m/s]	273	683	1044	273	683	1044	273	683	1044
1	0.007	0.129	0.131	0.130	0.114	0.117	0.114	0.107	0.107	0.107
2	0.014	0.133	0.134	0.132	0.118	0.119	0.117	0.110	0.110	0.110
4	0.028	0.136	0.136	0.134	0.122	0.121	0.120	0.114	0.113	0.112
8	0.056	0.139	0.138	0.135	0.126	0.125	0.122	0.117	0.116	0.115
16	0.112	0.140	0.139	0.136	0.128	0.127	0.124	0.120	0.119	0.117
24	0.168	0.142	0.139	0.137	0.130	0.127	0.126	0.122	0.121	0.119
30	0.210	0.142	0.139	0.136	0.131	0.128	0.125	0.123	0.122	0.119
40	0.280	0.141	0.139	0.136	0.132	0.128	0.126	0.124	0.122	0.119
70	0.490	0.142	0.136	0.133	0.132	0.127	0.125	0.125	0.122	0.119
80	0.560	0.141	0.135	0.132	0.132	0.127	0.124	0.125	0.122	0.119
100	0.700	0.140	0.134	0.131	0.132	0.127	0.123	0.126	0.122	0.118
135	0.946	0.139	0.132	0.128	0.132	0.125	0.121	0.126	0.121	0.116
170	1.191	0.138	0.130	0.126	0.132	0.124	0.119	0.126	0.119	0.115
235	1.646	0.136	0.127	0.122	0.130	0.121	0.116	0.125	0.118	0.112

DEXRON® VI - LOW SPEED - USED CYCLING TEST OIL

Program Code:		Start Date:	
Status:		EOT Date:	
Test Cycles:		Run Number:	
Test Performance:		EOT Parts Condition:	

Slip Speed	Sliding Speed	40°C Coefficients			90°C Coefficients			120°C Coefficients		
		Apply Pressure [kPa]			Apply Pressure [kPa]			Apply Pressure [kPa]		
[r/min]	[m/s]	273	683	1044	273	683	1044	273	683	1044
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
70	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
80	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
135	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
170	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
235	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Test Rig Overview

The GM Low Speed Clutch Friction Test Rig utilizes a 30 hp variable speed electric drive that provides input power to a Greening SAE No. 2 Universal Wet Friction Material Test Machine through a speed-reducing gearbox. Test fluid is drawn from the bottom of the test head, externally circulated using a small gear pump, and returned at the clutch centerline. This is done to more closely simulate fluid flow within a transmission.

Since the clutch cannot be slipped to achieve heating between engagements, an external heat source is employed to achieve the high fluid temperatures required by the test procedure. Silicon oil from an external bath is circulated through the test head "water jacket" chamber (in place of the normal cooling water). Temperature control of the silicon bath is achieved using immersion heaters and a shell-and-tube heat exchanger.

Procedure Overview

A clutch pack consists of one fiber plate installed between two steel plates. Both steel plates are instrumented with thermocouples to record plate interface temperatures during the clutch engagements. Once the test rig is assembled and filled with test fluid, the clutch is applied three times (at a rotational speed of 0 rpm) to ensure saturation of the friction plate.

Discrete Data

The clutch is slipped at fourteen discrete rotational speeds, repeated for nine different pressure and temperature combinations. The discrete conditions for SAE Standard clutch plates are listed below.

<table>
<tr><th>Rotational Speed (rpm)</th><th>Apply Pressure (kPa)</th><th>Fluid Temperature (°C)</th></tr>
<tr><td>1</td><td rowspan="4">273</td><td rowspan="5">40</td></tr>
<tr><td>2</td></tr>
<tr><td>4</td></tr>
<tr><td>8</td></tr>
<tr><td>16</td><td rowspan="5">683</td></tr>
<tr><td>24</td><td rowspan="5">90</td></tr>
<tr><td>30</td></tr>
<tr><td>40</td></tr>
<tr><td>70</td></tr>
<tr><td>80</td><td rowspan="5">1044</td></tr>
<tr><td>100</td><td rowspan="4">120</td></tr>
<tr><td>135</td></tr>
<tr><td>170</td></tr>
<tr><td>235</td></tr>
</table>

(Note: The use of different clutch plates will necessitate adjustment of the speed and pressure conditions to match the slip speeds and surface pressures encountered by the SAE Standard plates.)

At each discrete speed condition, the clutch is slipped for three seconds following stabilization of the apply force. Target times for data collection are 0.3, 1.0, and 2.9 seconds. The clutch pack is then rotated at 100 rpm (with the apply pressure released) until the separator plate temperatures are stabilized within 3 °C of the bulk fluid temperature.

Sweep Data

Once all speed data has been recorded for a given pressure and temperature combination, sweep data is collected. During a sweep, the clutch is applied and the rotational speed is ramped from 0 rpm to maximum in 20 seconds. The clutch is then held at maximum speed for 5 seconds, then ramped to 0 rpm in 20 seconds. One sweep is performed for every pressure and temperature combination.

Breakaway Data

At the conclusion of each sweep, two static breakaways are performed. In each breakaway, speed is set at 0 rpm and the clutch applied at the given pressure condition. The electric drive then increases power to the test head until the clutch "breaks away." Immediately following breakaway, the clutch is slipped for 3 seconds at 5 rpm. The first breakaway is performed immediately following the conclusion of the sweep, with the second following after the separator plate temperatures are stabilized within 3 °C of the bulk fluid temperature.

Friction Map

Completion of the 126 speed-pressure-temperature clutch slip combinations and their associated sweeps and breakaways constitutes a friction map.

Break-In

Following the initial friction map, a break-in procedure is performed. Break-in consists of continuously slipping the clutch for ten minutes at 120 °C, 683 kPa, and 100 rpm. (Note that break-in conditions must also be adjusted when using plates other than SAE standard.) The ten-minute engagement is performed three times with a one minute release period between each apply cycle.

Post Break-In

Upon completion of the break-in, a complete friction map is performed (as described above). This results in two complete sets of data – an initial "pre-break-in" friction map and a final "post-break-in" map.

New and Used Fluid

Two full tests are conducted on each fluid. The first test is conducted on new, unused fluid. The second test is conducted on identical fluid that was previously run in another test (typically the GM Cycling test).

Upon completion of the initial test on new fluid, the rig is allowed to drain for a minimum of 30 minutes. Since the used fluid test is conducted on the same clutch pack used to test the new fluid, the test head is not disassembled between runs. (For this reason, clutch pack measurements give an indication of overall wear only, as final measurements are not conducted until the completion of the second test.)

After the rig has been fully drained, the used fluid (which has been filtered to remove any debris from previous testing) is installed and the test repeated.

Data Interpretation

A friction coefficient is calculated for each discrete data combination. The coefficient is calculated according to the following equation:

$$\mu = \frac{T}{PARN}$$

where

T = Torque (Nm)
P = Pressure (kPa)
A = Apply Piston Area (m^2)
R = Mean Friction Radius (m)
N = Active Friction Surfaces

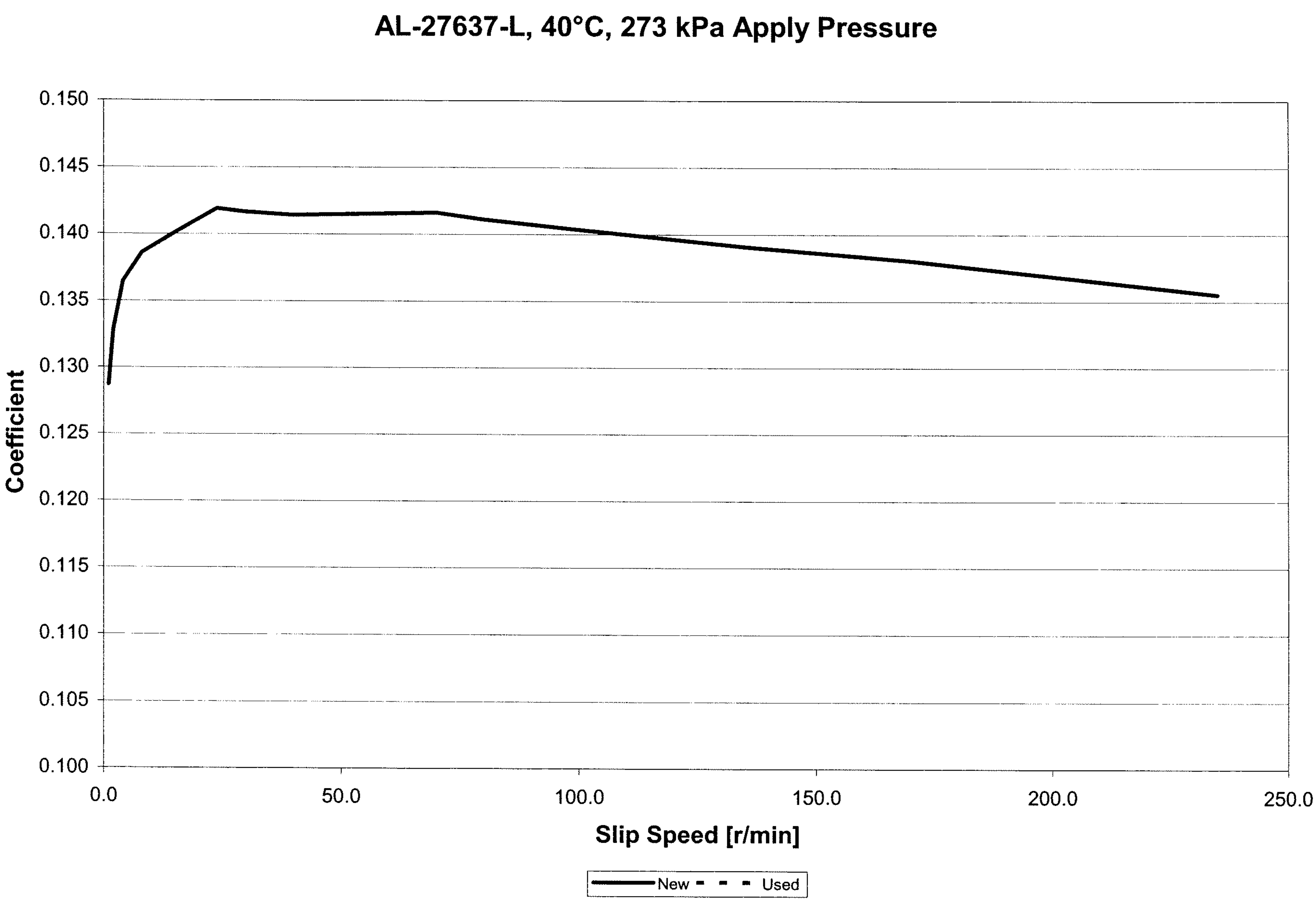
Test Report

Per sponsor request, only the new fluid portion of the test was conducted. The test report consists of nine plots displaying the variation of coefficient with slip speed at each temperature and pressure combination, two charts summarizing friction map data from the new and used fluid tests (not run in this case), and clutch pack wear measurements.

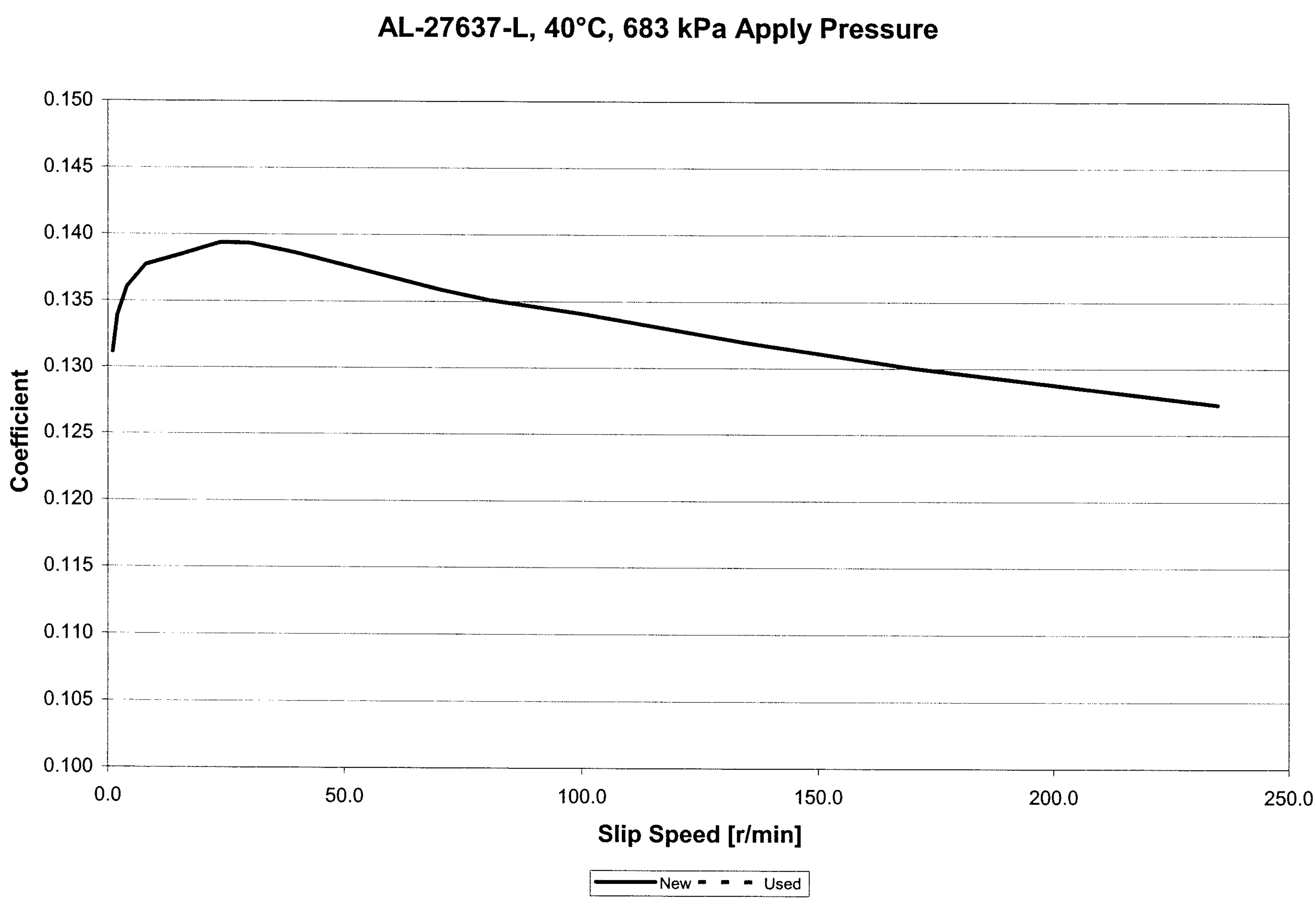
Appendix

1. Coefficient vs. Slip Speed Plot: 40 °C / 273 kPa
2. Coefficient vs. Slip Speed Plot: 40 °C / 683 kPa
3. Coefficient vs. Slip Speed Plot: 40 °C / 1044 kPa
4. Coefficient vs. Slip Speed Plot: 90 °C / 273 kPa
5. Coefficient vs. Slip Speed Plot: 90 °C / 683 kPa
6. Coefficient vs. Slip Speed Plot: 90 °C / 1044 kPa
7. Coefficient vs. Slip Speed Plot: 120 °C / 273 kPa
8. Coefficient vs. Slip Speed Plot: 120 °C / 683 kPa
9. Coefficient vs. Slip Speed Plot: 120 °C / 1044 kPa
10. Clutch Pack Wear Measurements

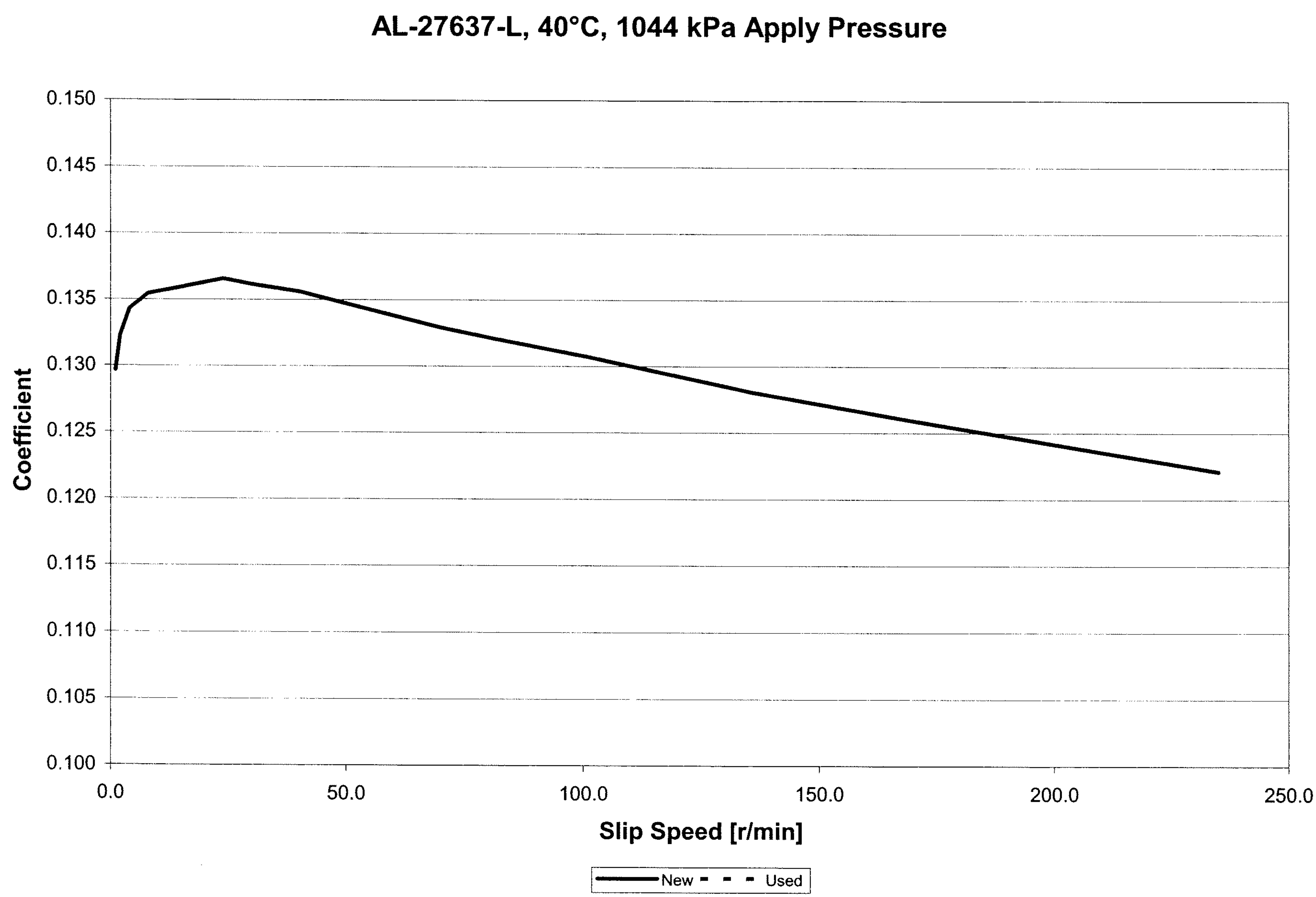
New Fluid Test Number: LS12-5-0363



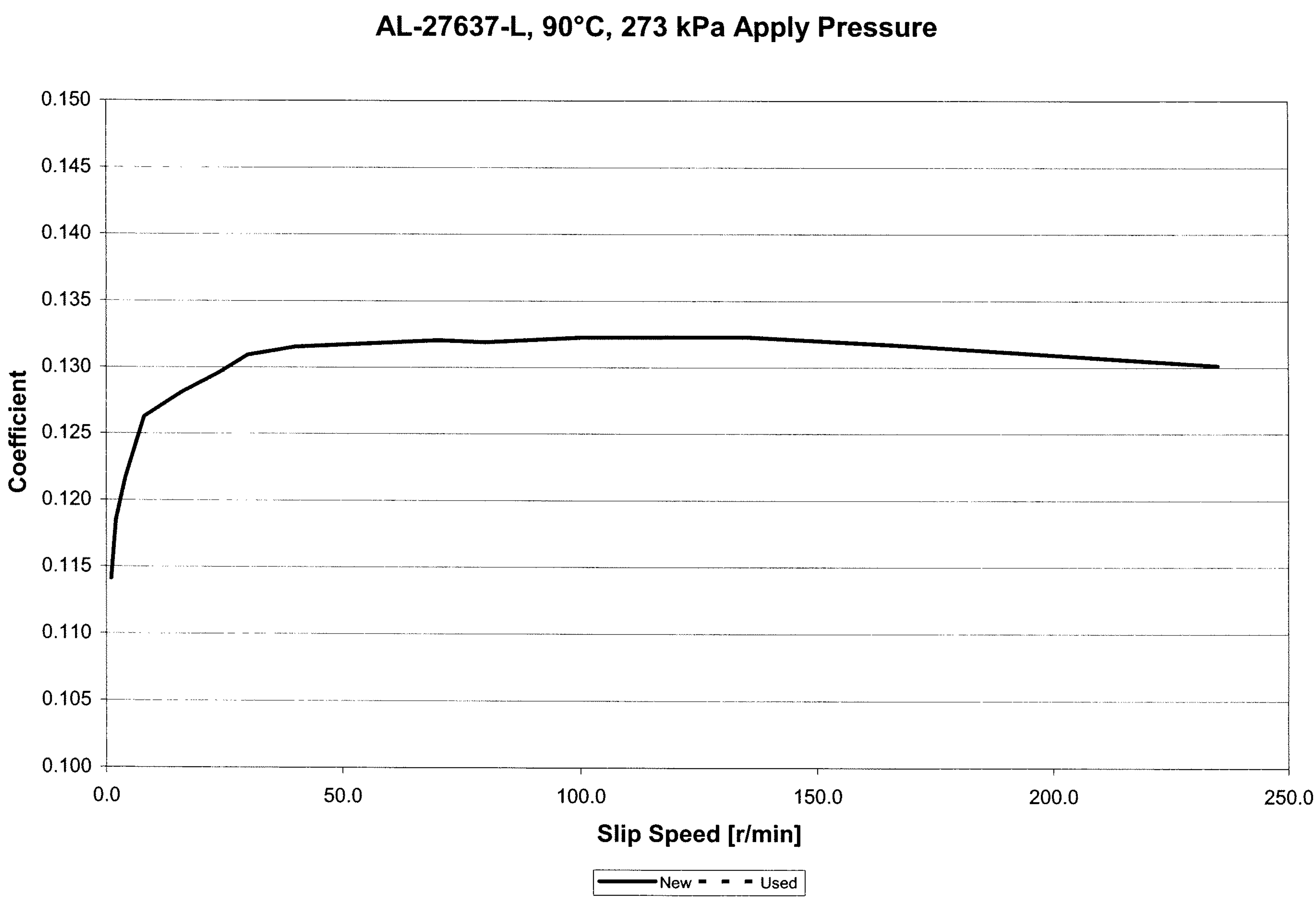
New Fluid Test Number: LS12-5-0363



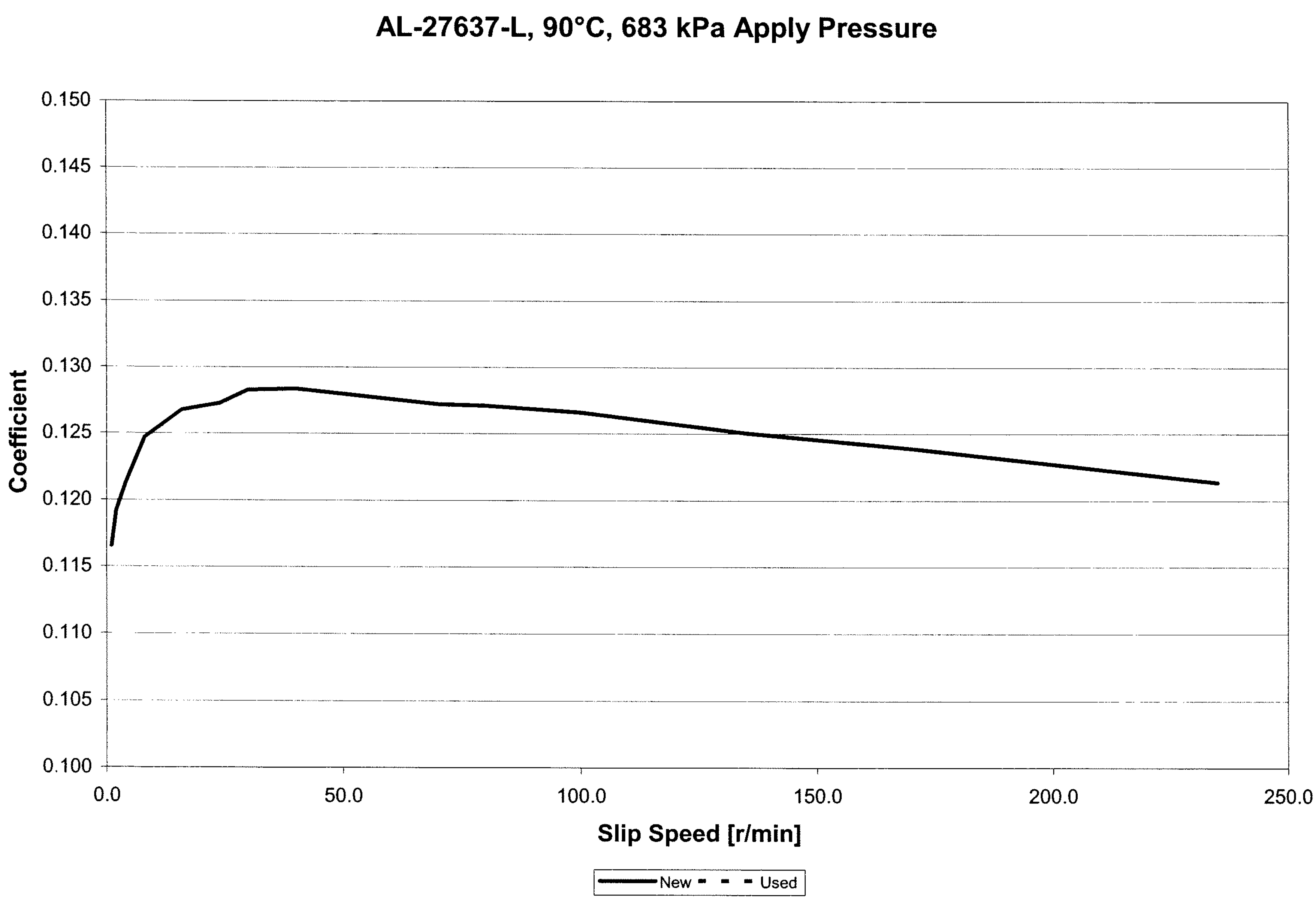
New Fluid Test Number: LS12-5-0363



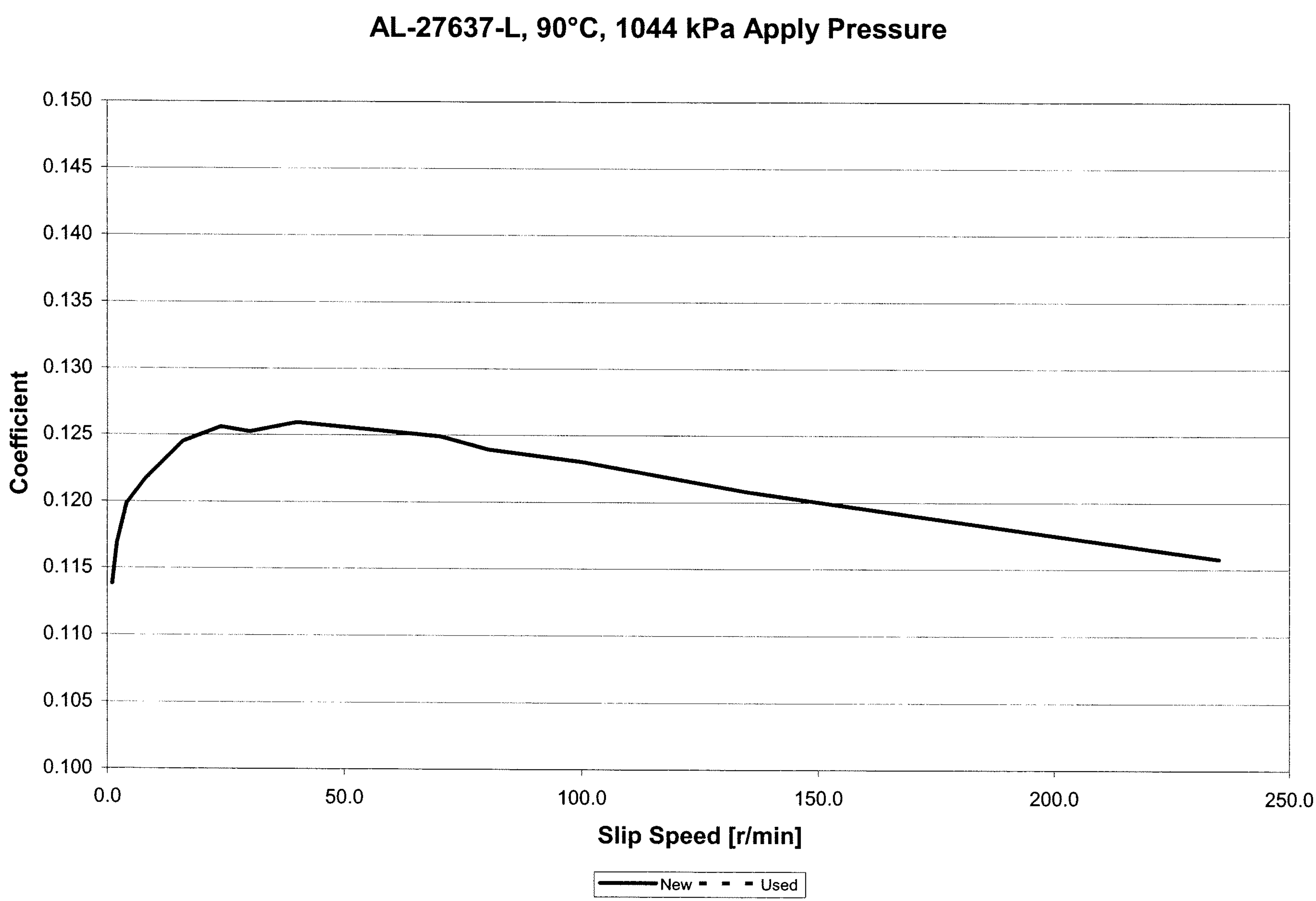
New Fluid Test Number: LS12-5-0363



New Fluid Test Number: LS12-5-0363

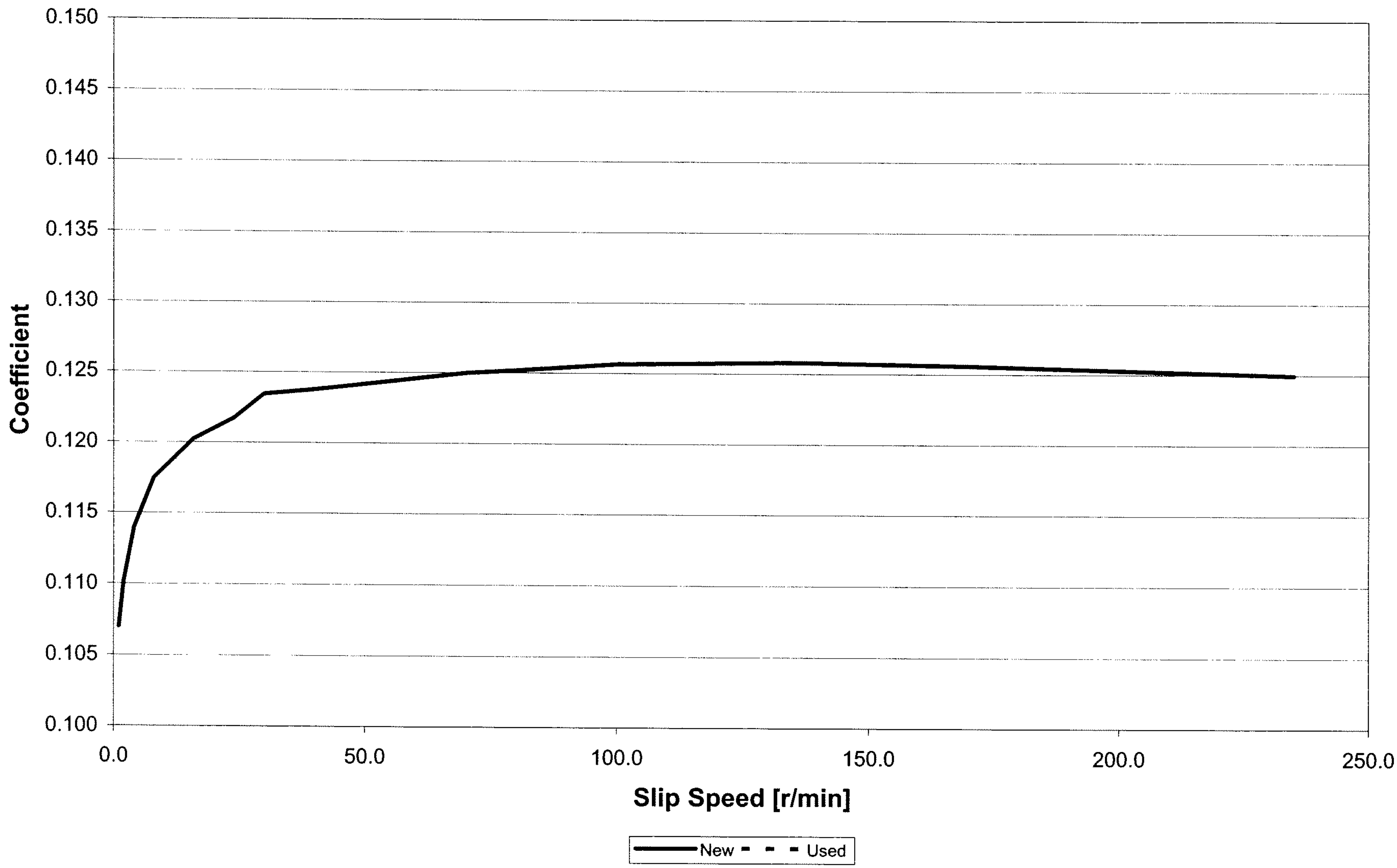


New Fluid Test Number: LS12-5-0363



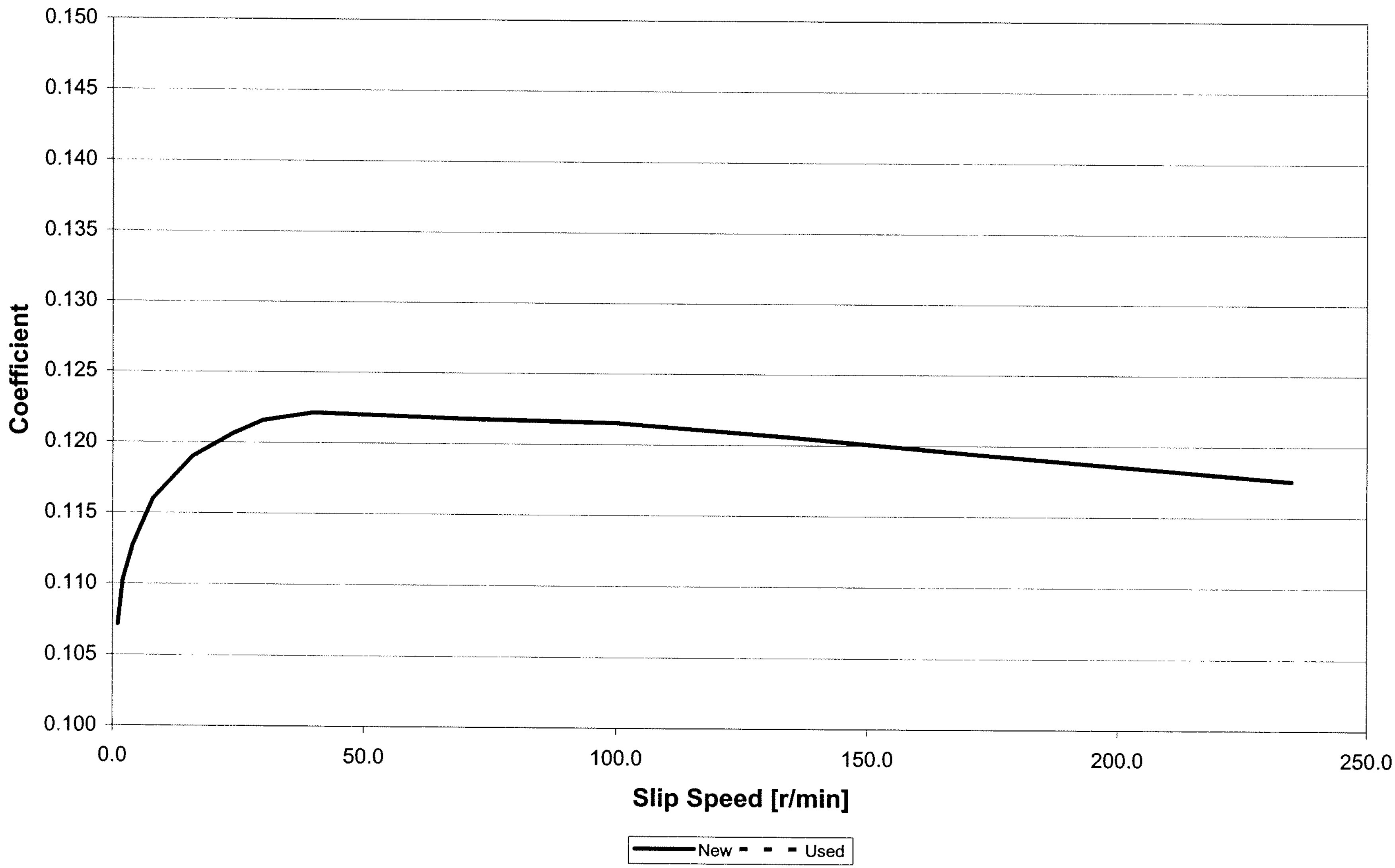
New Fluid Test Number: LS12-5-0363

AL-27637-L, 120°C, 273 kPa Apply Pressure

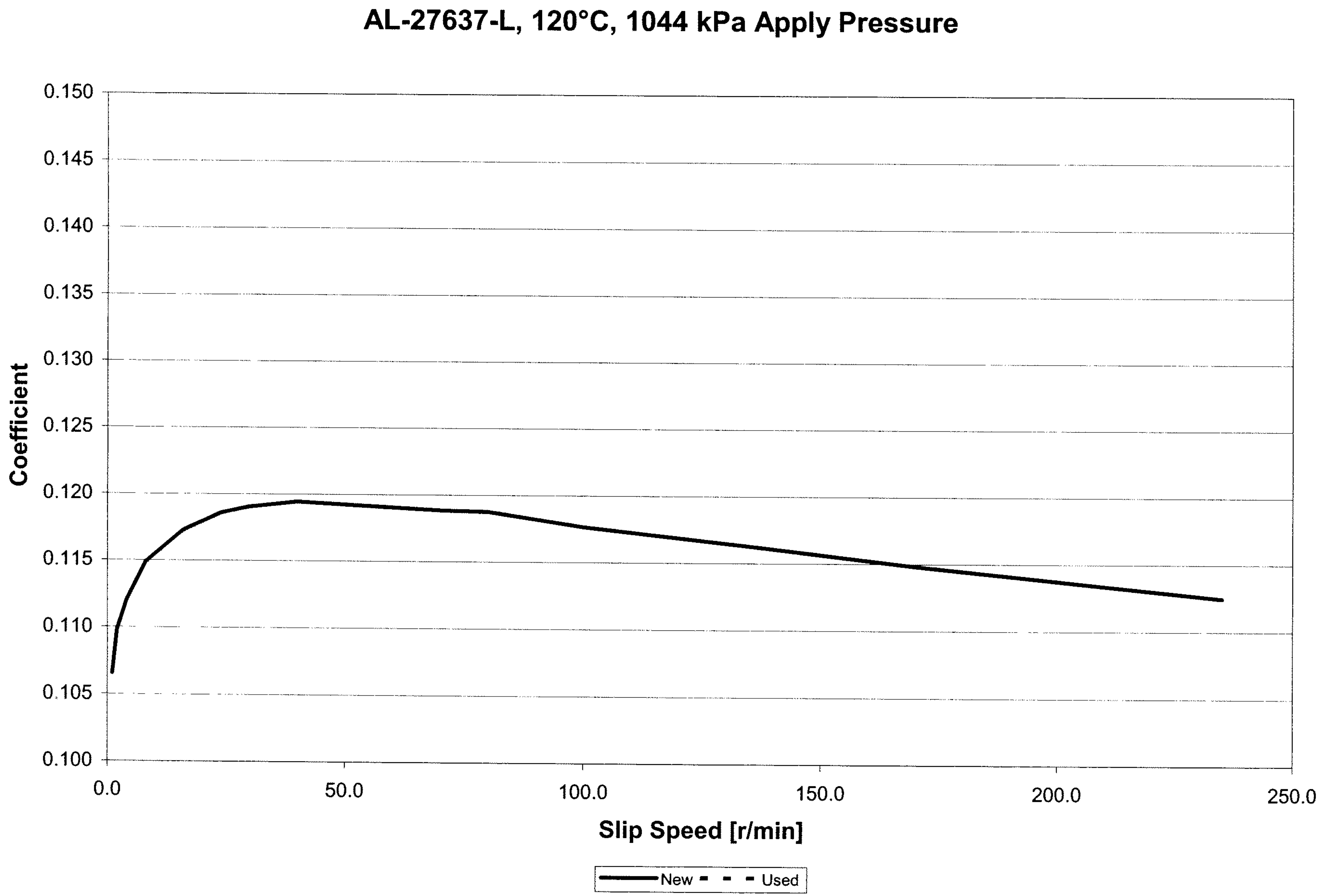


New Fluid Test Number: LS12-5-0363

AL-27637-L, 120°C, 683 kPa Apply Pressure



New Fluid Test Number: LS12-5-0363



SOUTHWEST RESEARCH INSTITUTE®

GM LOW SPEED CLUTCH FRICTION AND TORQUE CAPACITY CHARACTERIZATION

Candidate Fluid: AL-27637-L | **Test Number : LS12-5-0363** | **Completion Date : 7/31/2007**

Lab Fluid Code : ATF-222425 | **Steel Plate Batch: 11-7-03 AXOD** | **Fric Plate Batch : 0505-001CARBON**

Plates	Location of Tooth (Clockwise)	Near Inner Diameter Before	Near Inner Diameter After	Near Outer Diameter Before	Near Outer Diameter After	Inner Diameter Change	Average Overall Change	Outer Diameter Change
FRICTION MATERIAL								
2	Top	1.7630	1.6580	1.7650	1.7020	0.1050		0.0630
	120	1.7660	1.6710	1.7640	1.7070	0.0950		0.0570
	240	1.7690	1.6780	1.7690	1.7090	0.0910		0.0600
	Average					0.0970	0.0785	0.0600
STEEL SEPARATORS								
1	Top	1.7480	1.7480	1.7480	1.7480	0.0000		0.0000
	120	1.7510	1.7510	1.7510	1.7500	0.0000		0.0010
	240	1.7530	1.7530	1.7530	1.7530	0.0000		0.0000
	Average					0.0000	0.0002	0.0003
3	Top	1.7460	1.7460	1.7460	1.7460	0.0000		0.0000
	120	1.7460	1.7460	1.7460	1.7460	0.0000		0.0000
	240	1.7420	1.7420	1.7420	1.7420	0.0000		0.0000
	Average					0.0000	0.0000	0.0000

PLATE CONDITION AT E.O.T.: PLATES IN GOOD CONDITION WITH NO UNUSUAL DISCOLORATION
(Anything Unusual)

Test Date: 4/11/2007

Operator's Name: MARK HOLMES

Reviewed By (Signature and Date)

8/8/07

Pack ID#: 4000

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

Fuels And Lubricants Research Division

Report on

DEXRON® VI PLATE CLUTCH FRICTION TEST

Conducted For

SwRI ARMY LAB

Oil Code:
AL-27637-L

Test Number:
HC11-24-80

August 7, 2007

Submitted by:

Christopher Barker
Research Engineer
Specialty & Driveline Fluids Evaluation

The results of this report relate only to the fluid tested.

DEXRON®-VI Plate Friction - 200 HOURS

Program Code: AL-27637-L
Status: EOT
Test Cycles: 36,000
Test Performance:

Start Date: 7/30/2007
EOT Date: 8/7/2007
Run Number: HC11-24-80
EOT Parts Condition:

Fiber Plates: GMPT-0506
Steel Plates: GMPT-0506
Delta Travel [mm]: 0.356 mm

Test Time [h]	Cycles	Stop Time [s] 0.85	1.05	Midpoint Torque [N·m] 80	105	End Torque [N·m] Report	Maximum Torque [N·m] > 90		Max - Mid Torque [N·m] < 30		Shift Energy [kJ] 15.4 - 16.0
0.1	10	1.02	Three Point Average	88	Three Point Average	81	89	Three Point Average	0	Three Point Average	15.6
1	180	0.96		91		62	90		-2		15.7
2	360	0.93		94		99	109		14		15.7
3	540	0.91		98		101	109		11		15.8
4	720	0.91		98		98	108		10		15.8
5	900	0.90		98		99	107		9		15.8
10	1,800	0.91	0.91	97	98	91	102	102	5	5	15.8
15	2,700	0.92	0.92	97	97	83	97	98	0	1	15.8
20	3,600	0.94	0.94	96	96	77	93	94	-3	-2	15.8
25	4,500	0.96	0.95	94	94	73	91	91	-3	-3	15.8
30	5,400	0.95	0.97	92	92	70	89	89	-3	-3	15.8
35	6,300	0.99	0.98	91	91	72	88	88	-2	-2	15.8
40	7,200	0.99	0.99	90	90	69	88	88	-2	-2	15.8
45	8,100	1.00	1.00	89	89	69	87	87	-2	-2	15.8
50	9,000	1.00	0.99	88	88	71	87	87	-1	-2	15.8
55	9,900	0.99	1.00	88	88	68	87	87	-1	-1	15.7
60	10,800	1.01	1.00	88	88	69	86	87	-1	-1	15.8
65	11,700	1.00	1.00	88	88	69	87	87	-1	-1	15.7
70	12,600	1.00	1.00	87	88	69	87	87	-1	-1	15.8
75	13,500	1.00	1.00	87	87	70	87	87	-1	-1	15.8
80	14,400	1.00	1.01	87	87	69	87	87	-1	-1	15.7
85	15,300	1.01	1.01	87	87	71	87	87	0	0	15.8
90	16,200	1.01	1.02	87	87	71	86	87	0	0	15.7
95	17,100	1.03	1.02	86	86	70	86	86	0	0	15.8
100	18,000	1.03	1.03	86	86	71	86	86	0	0	15.7

DEXRON®-VI Plate Friction - 200 HOURS

Program Code: AL-27637-L
Status: EOT
Test Cycles: 36,000
Test Performance:

Start Date: 7/30/2007
EOT Date: 8/7/2007
Run Number: HC11-24-80
EOT Parts Condition:

Fiber Plates: GMPT-0506
Steel Plates: GMPT-0506
Delta Travel [mm]: 0.356 mm

Test Time [h]	Cycles	Stop Time [s]		Midpoint Torque [N·m]		End Torque [N·m]	Maximum Torque [N·m]		Max - Mid Torque [N·m]		Shift Energy [kJ]
		0.85	1.05	80	105	Report	> 90		< 30		15.4 - 16.0
105	18,900	1.02	1.03	86	85	71	86	86	0	1	15.7
110	19,800	1.03	1.03	85	85	71	86	86	1	1	15.8
115	20,700	1.03	1.03	85	85	71	86	86	1	2	15.7
120	21,600	1.04	1.04	85	85	71	86	86	2	2	15.8
125	22,500	1.04	1.04	84	84	71	86	86	2	2	15.8
130	23,400	1.04	1.05	84	84	72	86	86	2	2	15.7
135	24,300	1.06	1.05	83	83	71	86	86	2	2	15.7
140	25,200	1.06	1.06	83	83	71	86	86	3	3	15.8
145	26,100	1.07	1.06	83	83	72	86	86	3	3	15.7
150	27,000	1.06	1.06	83	83	73	85	86	3	3	15.8
155	27,900	1.05	1.06	83	83	73	86	86	3	3	15.8
160	28,800	1.07	1.06	83	83	73	86	86	3	3	15.7
165	29,700	1.06	1.07	83	83	71	87	86	3	3	15.8
170	30,600	1.09	1.06	84	84	70	87	87	3	3	15.8
175	31,500	1.05	1.06	84	84	74	88	87	4	3	15.8
180	32,400	1.06	1.05	84	84	71	86	87	2	3	15.7
185	33,300	1.05	1.05	84	84	73	87	87	3	3	15.7
190	34,200	1.06	1.05	85	85	73	88	88	3	3	15.8
195	35,100	1.05	1.05	85	85	73	88	88	3	3	15.8
200	36,000	1.05	1.05	86	85	73	88	88	3	3	15.8

GM Plate Clutch Friction Test Summary

Southwest Research Institute®

Test Number: HC11-24-80
Fluid Code: AL-27637-L

Energy: 15.8 KJ
Temp.: 140.0 C
Apply: 349 KPa

Fibers : GMPT-0506
Steels : GMPT-0506
Air Flow: 50 ml/min

Start of Test: 7/30/2007
End of Test : 8/7/2007
Delta Travel: 0.356 mm

Test Hour	Total Cycles	Engagement Time (Sec) (0.85 to 1.05)	Engagement Time Three Point Average	Midpoint Torq.(Nm) (80-105)	Midpoint Three Point Average	Max-Mid Torq.(Nm) (<30)	Max-Mid Three Point Average	End-Mid Torq.(Nm)	End-Mid Three Point Average	Maximum Torq.(Nm) (>90)	Maximum Three Point Average	End Torq.(Nm) (Report)	Energy (KJ) (15.4 - 16.0)
0	10	1.02		88		0		-7		89		81	15.6
1	180	0.96		91		-2		-29		90		62	15.7
2	360	0.93		94		14		5		109		99	15.7
3	540	0.91		98		11		4		109		101	15.8
4	720	0.91		98		10		0		108		98	15.8
5	900	0.90		98		9		1		107		99	15.8
10	1,800	0.91	0.91	97	98	5	5	-7	-7	102	102	91	15.8
15	2,700	0.92	0.92	97	97	0	1	-14	-14	97	98	83	15.8
20	3,600	0.94	0.94	96	96	-3	-2	-19	-18	93	94	77	15.8
25	4,500	0.96	0.95	94	94	-3	-3	-21	-21	91	91	73	15.8
30	5,400	0.95	0.97	92	92	-3	-3	-22	-21	89	89	70	15.8
35	6,300	0.99	0.98	91	91	-2	-2	-19	-20	88	88	72	15.8
40	7,200	0.99	0.99	90	90	-2	-2	-20	-20	88	88	69	15.8
45	8,100	1.00	1.00	89	89	-2	-2	-20	-19	87	87	69	15.8
50	9,000	1.00	0.99	88	88	-1	-2	-17	-19	87	87	71	15.8
55	9,900	0.99	1.00	88	88	-1	-1	-21	-19	87	87	68	15.7
60	10,800	1.01	1.00	88	88	-1	-1	-19	-20	86	87	69	15.8
65	11,700	1.00	1.00	88	88	-1	-1	-20	-19	87	87	69	15.7
70	12,600	1.00	1.00	87	88	-1	-1	-18	-18	87	87	69	15.8
75	13,500	1.00	1.00	87	87	-1	-1	-18	-18	87	87	70	15.8
80	14,400	1.00	1.01	87	87	-1	-1	-18	-17	87	87	69	15.7
85	15,300	1.01	1.01	87	87	0	0	-16	-17	87	87	71	15.8
90	16,200	1.01	1.02	87	87	0	0	-16	-16	86	87	71	15.7
95	17,100	1.03	1.02	86	86	0	0	-17	-16	86	86	70	15.8
100	18,000	1.03	1.03	86	86	0	0	-15	-15	86	86	71	15.7

GM Plate Clutch Friction Test Summary

Southwest Research Institute®

Test Number: HC11-24-80
Fluid Code: AL-27637-L

Energy: 15.8 KJ
Temp.: 140.0 C
Apply: 349 KPa

Fibers : GMPT-0506
Steels : GMPT-0506
Air Flow: 50 ml/min

Start of Test: 7/30/2007
End of Test : 8/7/2007
Delta Travel: 0.356 mm

Test Hour	Total Cycles	Engagement Time (Sec) (0.85 to 1.05)		Midpoint Torq.(Nm) (80-105)		Max-Mid Torq.(Nm) (<30)		End-Mid Torq.(Nm)		Maximum Torq.(Nm) (>90)		End Torq.(Nm) (Report)	Energy (KJ) (15.4 - 16.0)
105	18,900	1.02	1.03	86	85	0	1	-15	-15	86	86	71	15.7
110	19,800	1.03	1.03	85	85	1	1	-14	-14	86	86	71	15.8
115	20,700	1.03	1.03	85	85	1	2	-14	-14	86	86	71	15.7
120	21,600	1.04	1.04	85	85	2	2	-14	-14	86	86	71	15.8
125	22,500	1.04	1.04	84	84	2	2	-13	-13	86	86	71	15.8
130	23,400	1.04	1.05	84	84	2	2	-12	-13	86	86	72	15.7
135	24,300	1.06	1.05	83	83	2	2	-12	-12	86	86	71	15.7
140	25,200	1.06	1.06	83	83	3	3	-12	-12	86	86	71	15.8
145	26,100	1.07	1.06	83	83	3	3	-11	-11	86	86	72	15.7
150	27,000	1.06	1.06	83	83	3	3	-10	-10	85	86	73	15.8
155	27,900	1.05	1.06	83	83	3	3	-10	-10	86	86	73	15.8
160	28,800	1.07	1.06	83	83	3	3	-10	-11	86	86	73	15.7
165	29,700	1.06	1.07	83	83	3	3	-12	-12	87	86	71	15.8
170	30,600	1.09	1.06	84	84	3	3	-13	-12	87	87	70	15.8
175	31,500	1.05	1.06	84	84	4	3	-10	-12	88	87	74	15.8
180	32,400	1.06	1.05	84	84	2	3	-13	-11	86	87	71	15.7
185	33,300	1.05	1.05	84	84	3	3	-12	-12	87	87	73	15.7
190	34,200	1.06	1.05	85	85	3	3	-12	-12	88	88	73	15.8
195	35,100	1.05	1.05	85	85	3	3	-12	-12	88	88	73	15.8
200	36,000	1.05	1.05	86	85	3	3	-13	-13	88	88	73	15.8

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DEXRON®VI Plate Friction Test Parts Condition Rating

Sponsor Code: AL-27637-L
Run Number: HC11-24-80
EOT Date: 08-7-2007
Cycles: 36,000
Hours: 200

Fiber Plates: The inner and outer facing areas are completely darkened with light glazing and medium wear. Outer facing area has heavy flaking and the inner facing area has light/medium flaking.

Steel Plates: Outer steel plate shows light heat discoloration and light scratching and light wear and no hot spots. Inner steel plate shows medium heat discoloration and light wear and light scratching and no hot spots.

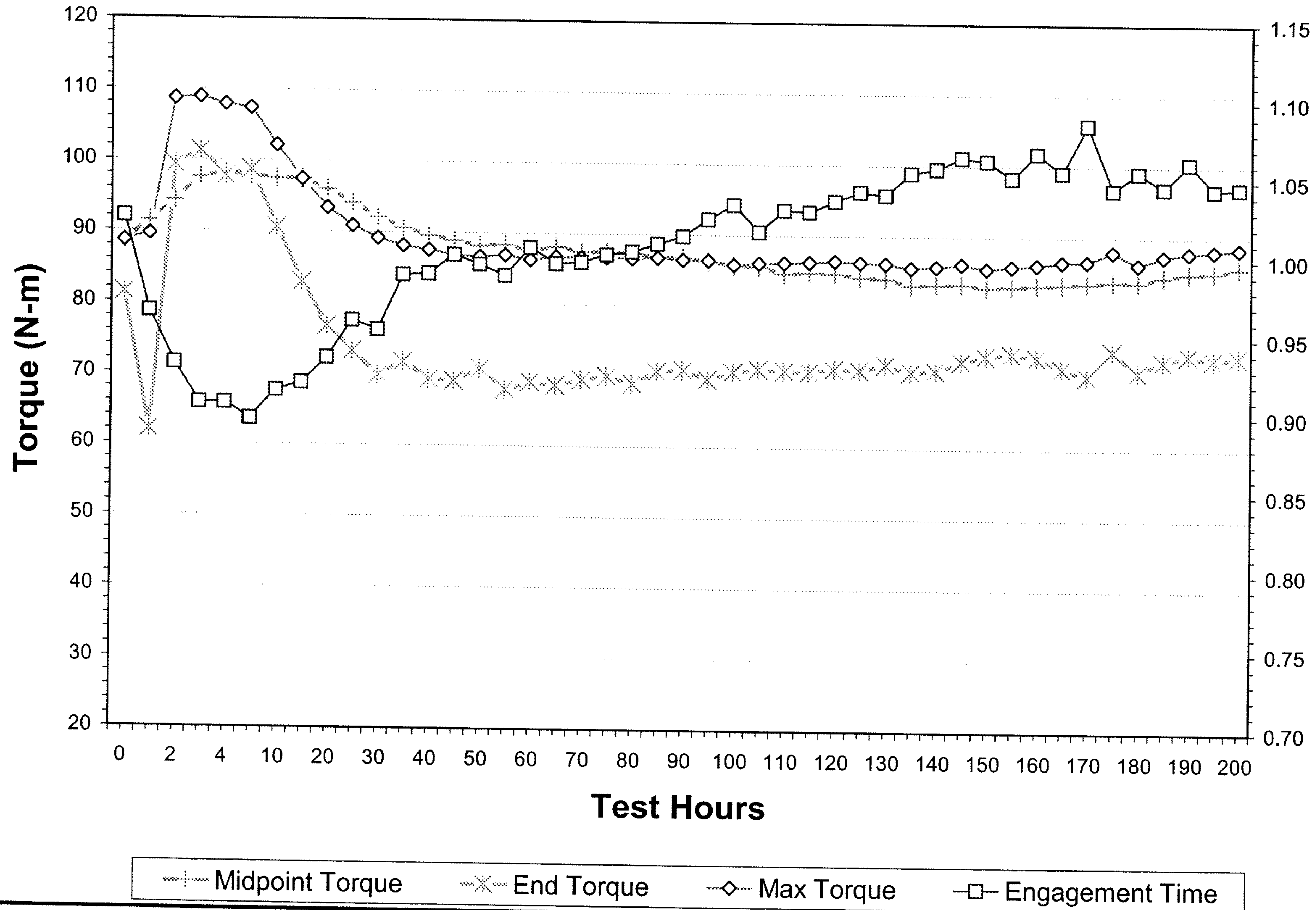
SwRI Rating: Fail

Rater: Art Sanchez
Date: 08-09-2007

Comments: This test was conducted using GMPT 0506 test kit.

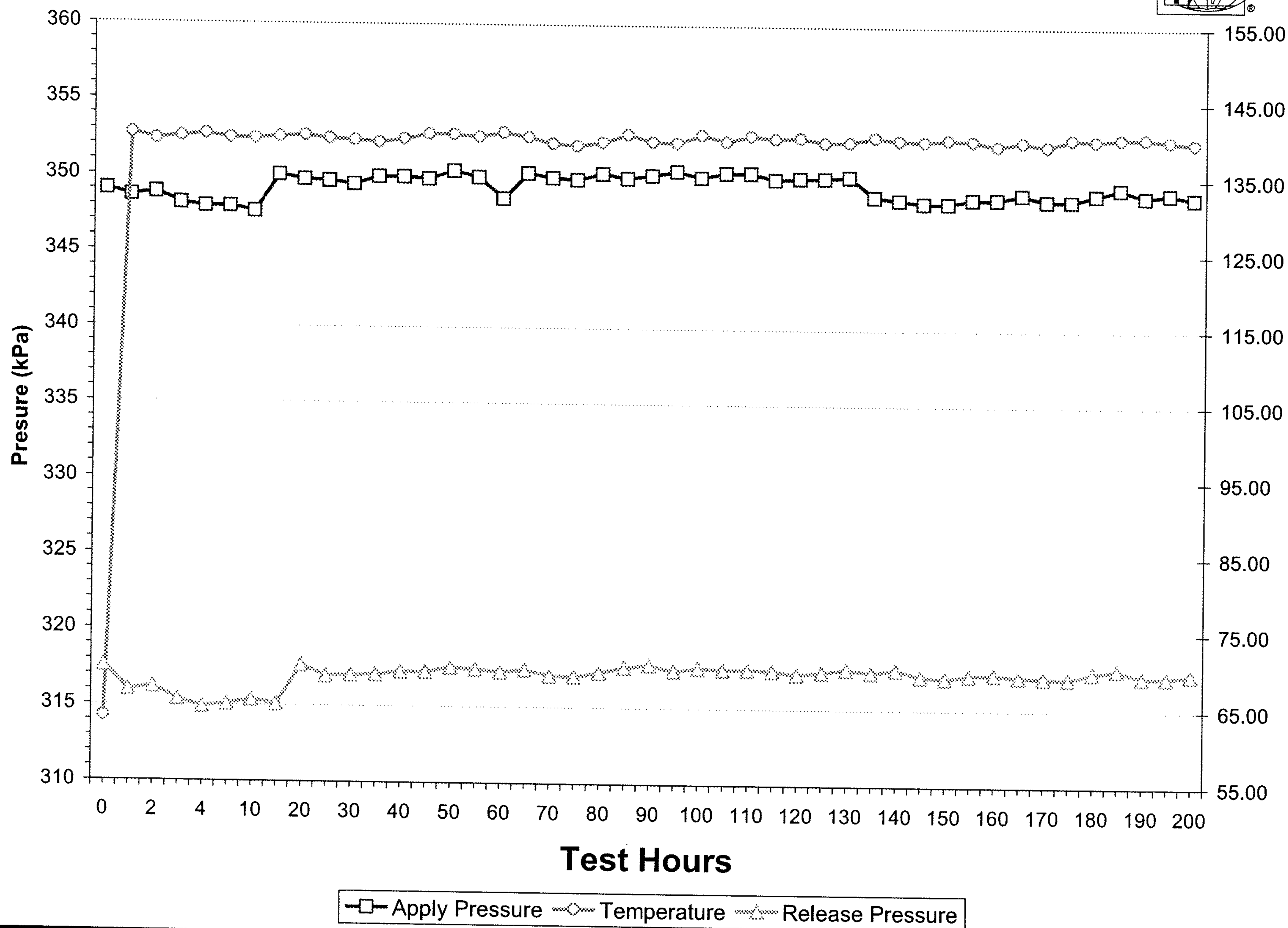
*Pending GM ATF committee approval

Fluid Performance Summary of
Test: HC11-24-80 Fluid: AL-27637-L



200 Hr. Extended Plate Test Ver. 1.0.0.0

Pressure & Temperature for
Test: HC11-24-80   Fluid: AL-27637-L



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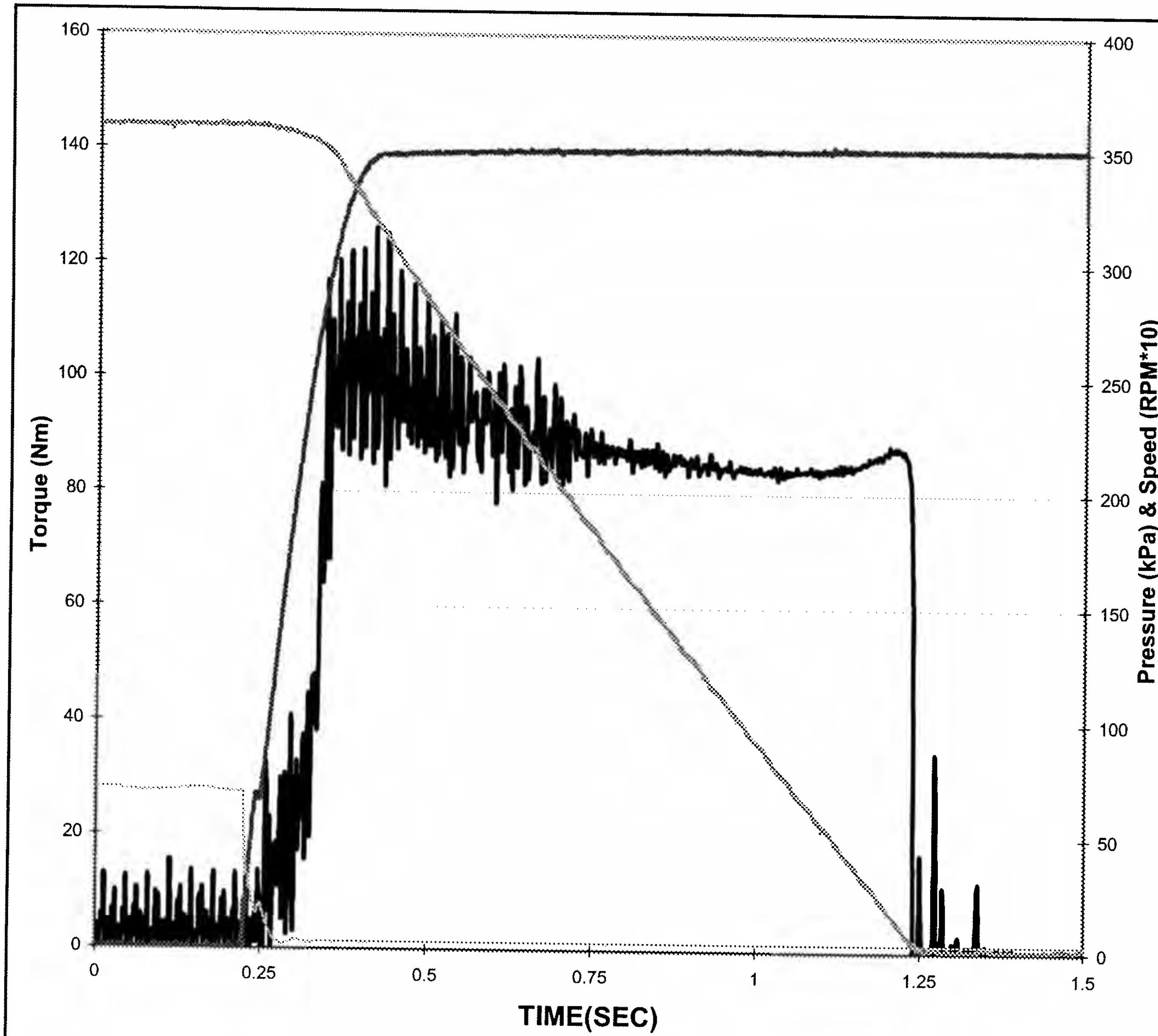

Date of Test:	**7/30/2007**
Time of Test:	**16:00:40**
Test Type:	**PLATE**
Test Number:	**HC11-24-80**
Fluid Code:	**AL-27637-L**
Hour Number:	**0**
Cycle Number:	**10**
Temperature:	**63 °C** *(134 - 146)*
Apply Pressure:	**349 kPa** *(340 - 350)*
Energy:	**15.6 KJ** *(15.4 - 16.0)*
Engage Time:	**1.02 Sec** *(0.85 - 1.05)*

Torque

Maximum:	**89 N*m** *(>90)*
Midpoint:	**88 N*m** *(80 - 105)*
Max - Mid:	**0 N*m** *(<30)*
End - Mid:	**-7 N*m**
End:	**81 N*m** *(Report)*

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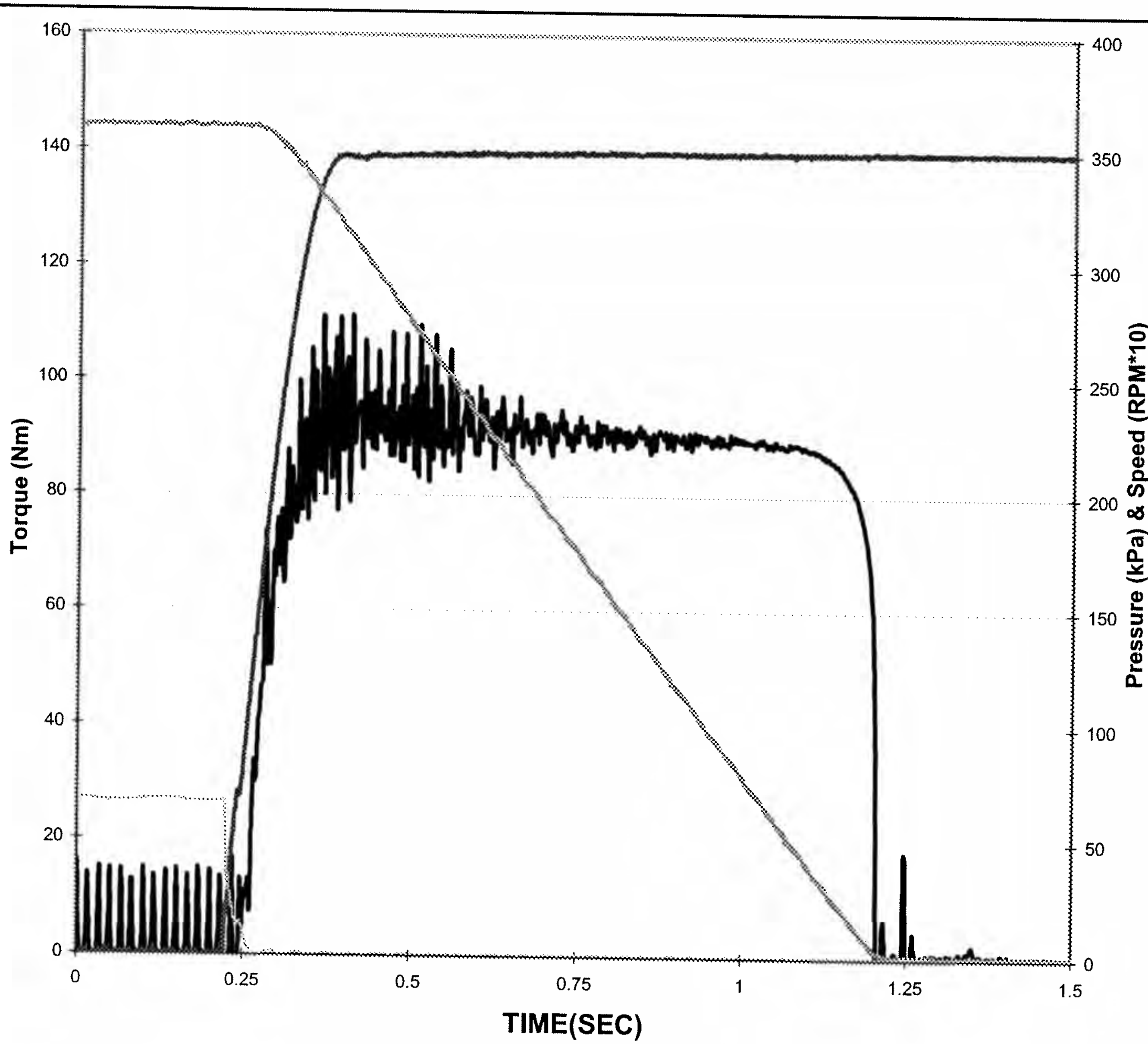

Date of Test:	7/30/2007
Time of Test:	16:57:20
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	1
Cycle Number:	180
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	0.96 Sec *(0.85 - 1.05)*

Torque

Maximum:	90 N*m *(>90)*
Midpoint:	91 N*m *(80 - 105)*
Max - Mid:	-2 N*m *(<30)*
End - Mid:	-29 N*m
End:	62 N*m *(Report)*

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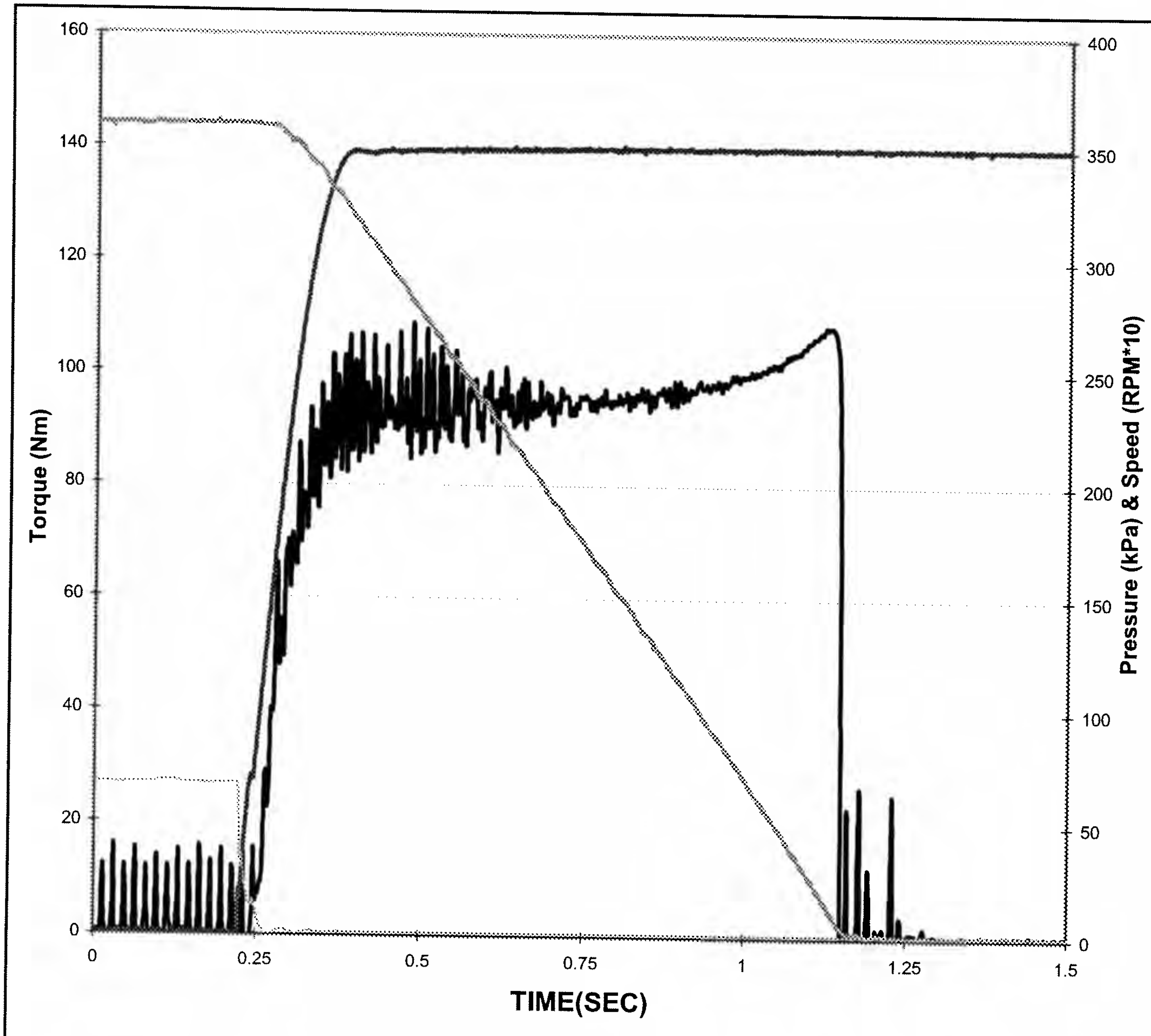

Date of Test:	7/30/2007
Time of Test:	17:57:20
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	2
Cycle Number:	360
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	0.93 Sec *(0.85 - 1.05)*

Torque

Maximum:	109 N*m *(>90)*
Midpoint:	94 N*m *(80 - 105)*
Max - Mid:	14 N*m *(<30)*
End - Mid:	5 N*m
End:	99 N*m *(Report)*

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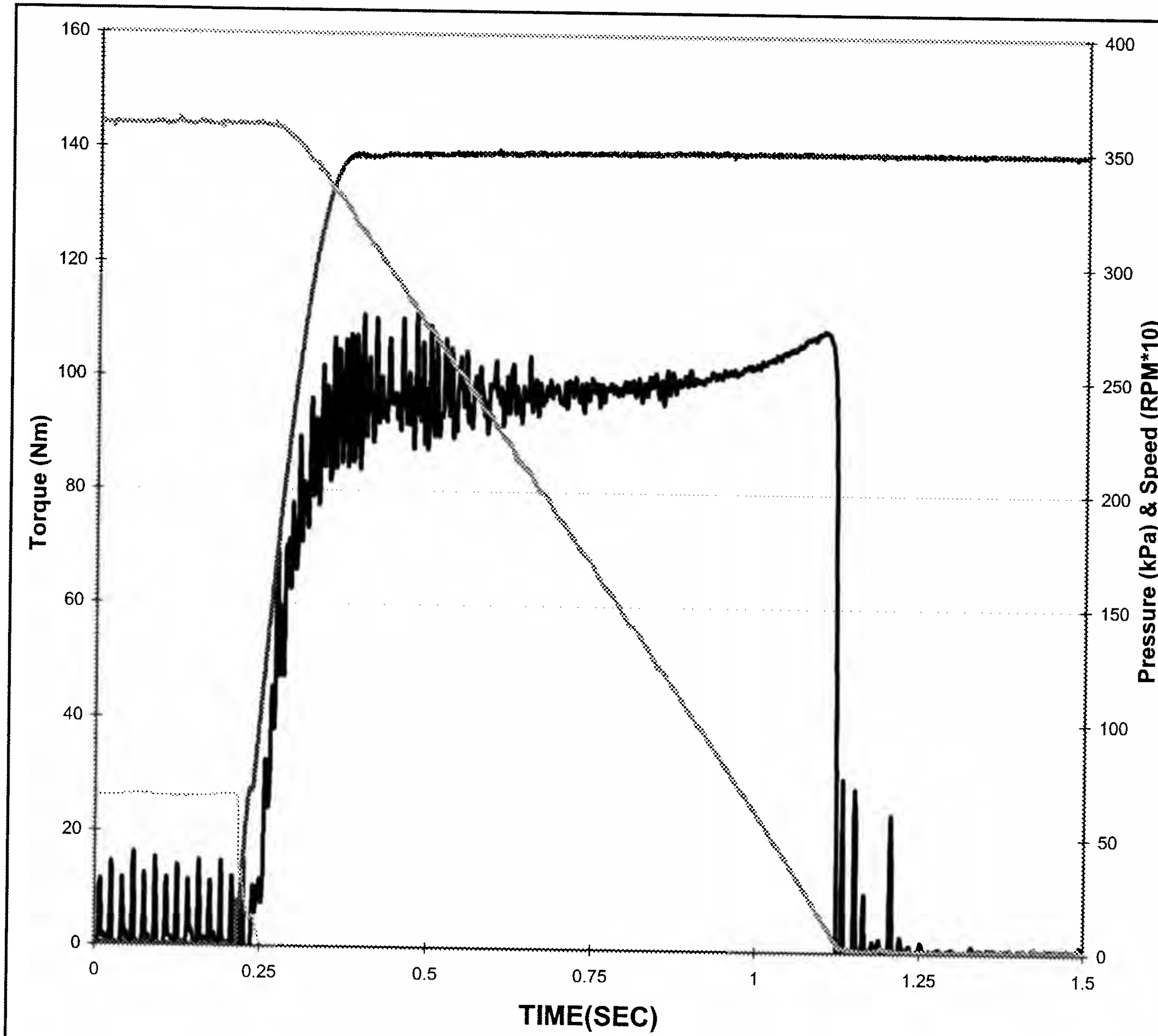

Date of Test:	7/30/2007
Time of Test:	18:57:20
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	3
Cycle Number:	540
Temperature:	140 °C
	(134 - 146)
Apply Pressure:	348 kPa
	(340 - 350)
Energy:	15.8 KJ
	(15.4 - 16.0)
Engage Time:	0.91 Sec
	(0.85 - 1.05)

Torque

Maximum:	109 N*m
	(>90)
Midpoint:	98 N*m
	(80 - 105)
Max - Mid:	11 N*m
	(<30)
End - Mid:	4 N*m
End:	101 N*m
	(Report)

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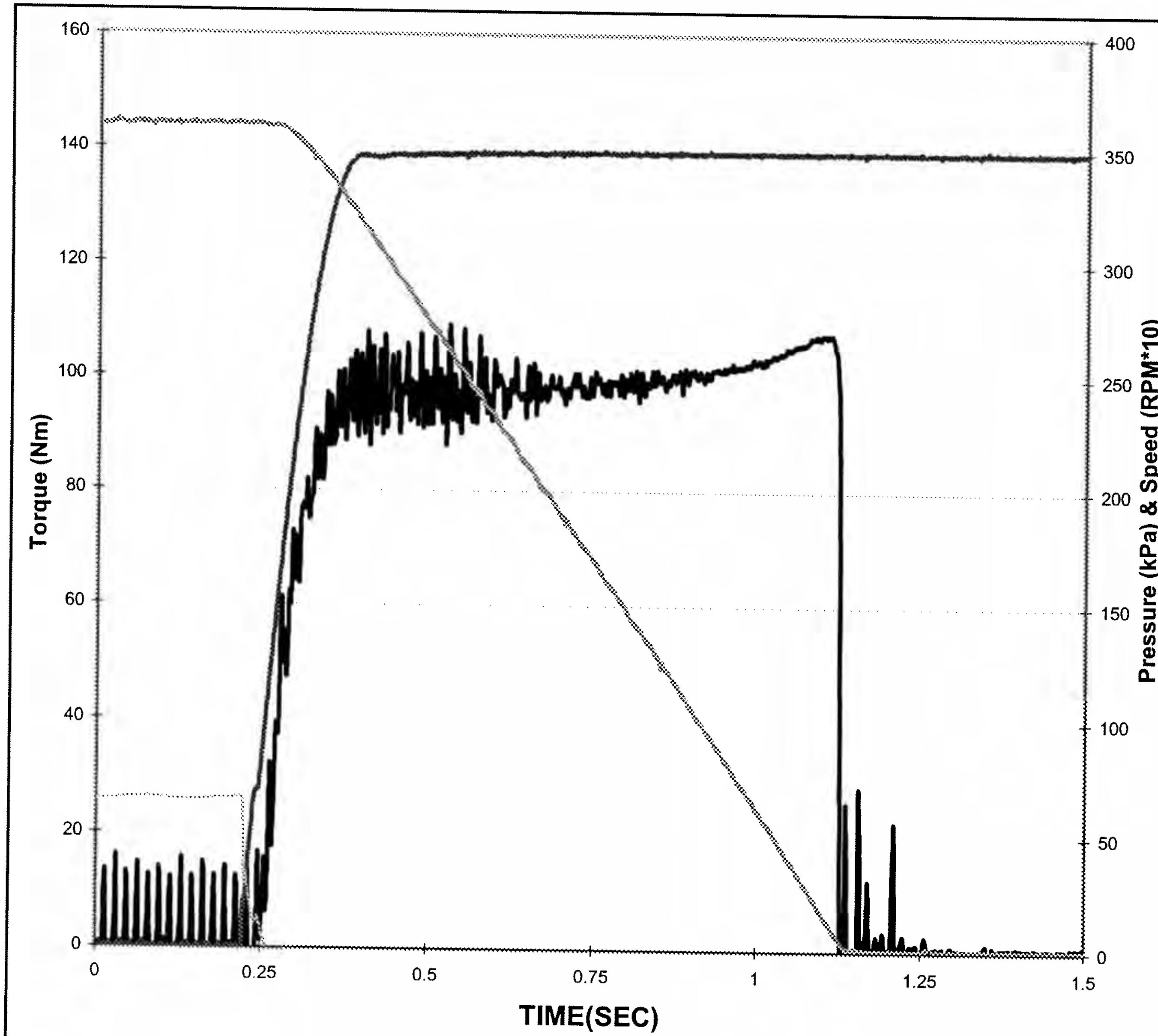

Date of Test:	7/30/2007
Time of Test:	19:57:20
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	4
Cycle Number:	720
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	348 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	0.91 Sec *(0.85 - 1.05)*

Torque

Maximum:	108 N*m *(>90)*
Midpoint:	98 N*m *(80 - 105)*
Max - Mid:	10 N*m *(<30)*
End - Mid:	0 N*m
End:	98 N*m *(Report)*

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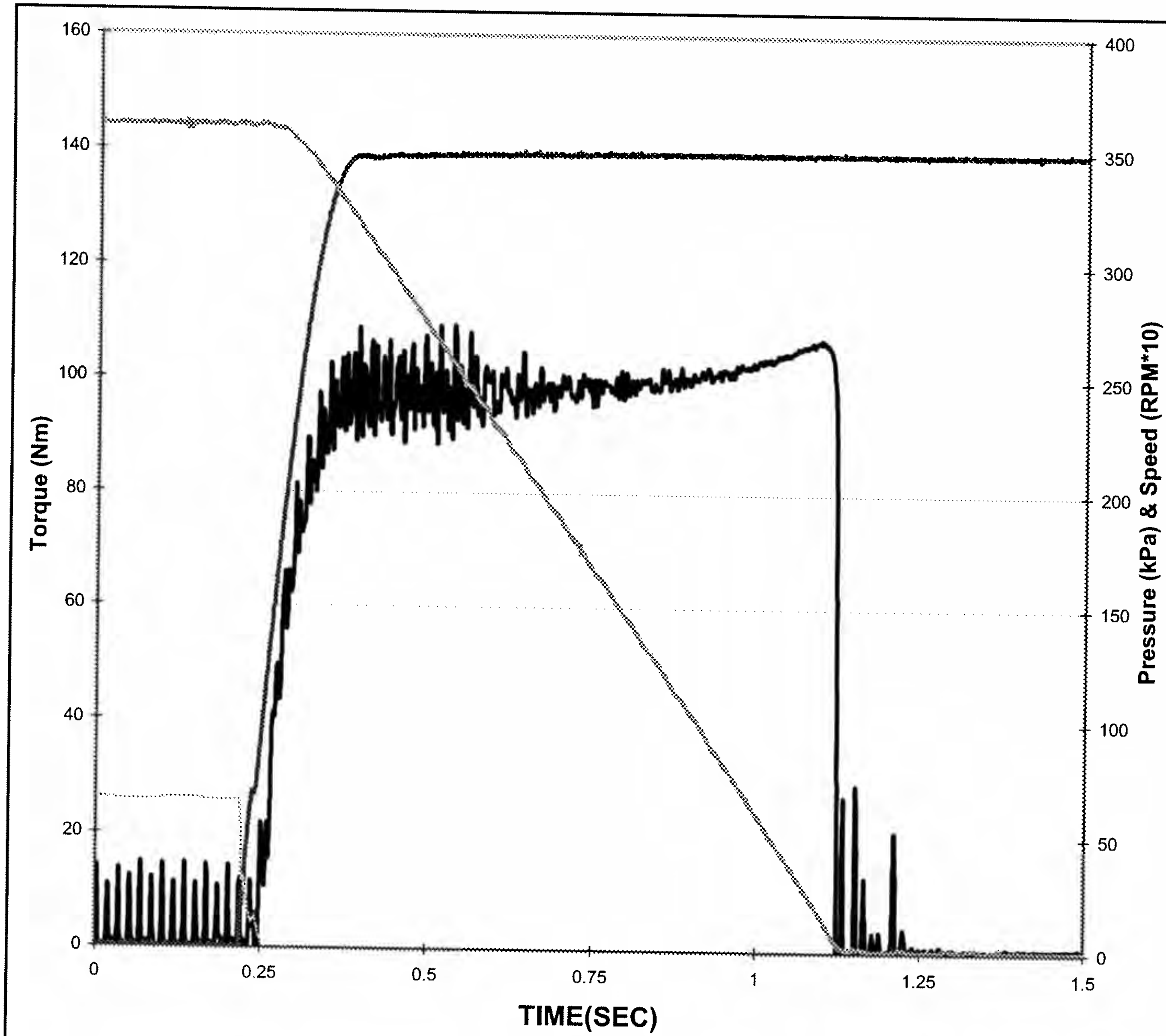

Date of Test:	7/30/2007
Time of Test:	20:57:21
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	5
Cycle Number:	900
Temperature:	140 °C (134 - 146)
Apply Pressure:	348 kPa (340 - 350)
Energy:	15.8 KJ (15.4 - 16.0)
Engage Time:	0.90 Sec (0.85 - 1.05)

Torque

Maximum:	107 N*m (>90)
Midpoint:	98 N*m (80 - 105)
Max - Mid:	9 N*m (<30)
End - Mid:	1 N*m
End:	99 N*m (Report)

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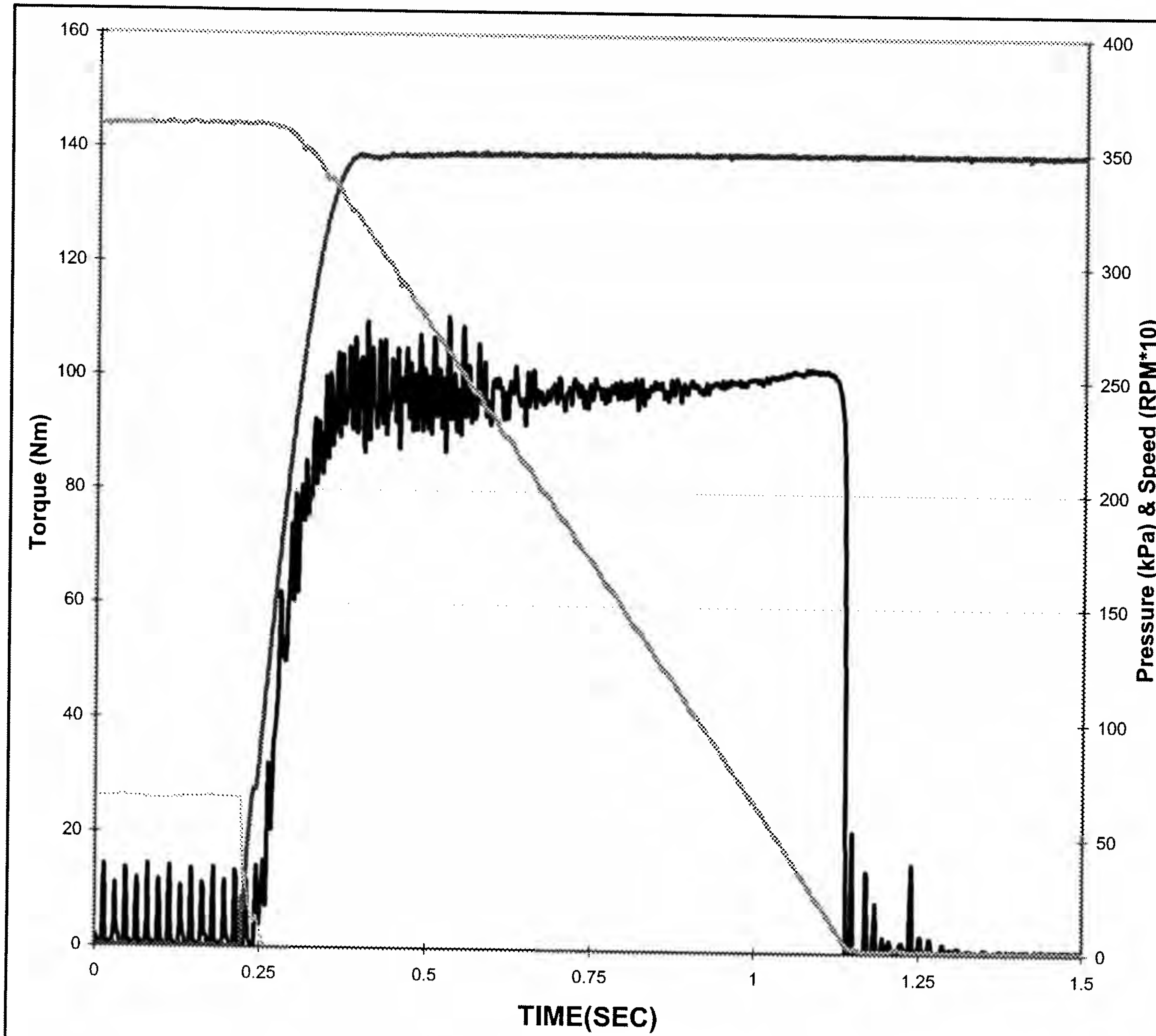

Date of Test:	7/31/2007
Time of Test:	1:57:21
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	10
Cycle Number:	1800
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	348 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	0.91 Sec *(0.85 - 1.05)*

Torque

Maximum:	102 N*m *(>90)*
Midpoint:	97 N*m *(80 - 105)*
Max - Mid:	5 N*m *(<30)*
End - Mid:	-7 N*m
End:	91 N*m *(Report)*

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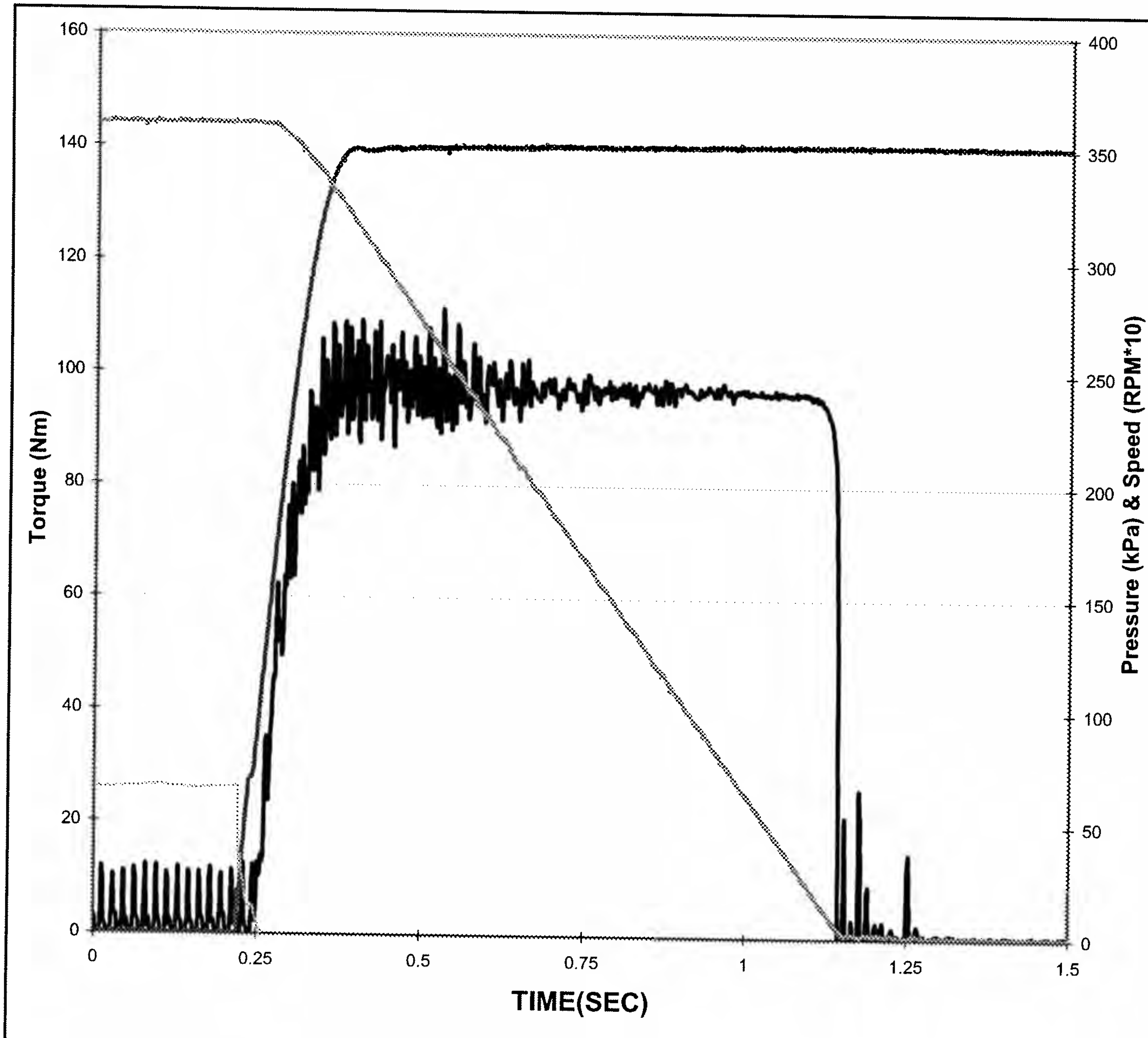

Date of Test:	7/31/2007
Time of Test:	6:57:22
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	15
Cycle Number:	2700
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	0.92 Sec *(0.85 - 1.05)*

Torque

Maximum:	97 N*m *(>90)*
Midpoint:	97 N*m *(80 - 105)*
Max - Mid:	0 N*m *(<30)*
End - Mid:	-14 N*m
End:	83 N*m *(Report)*

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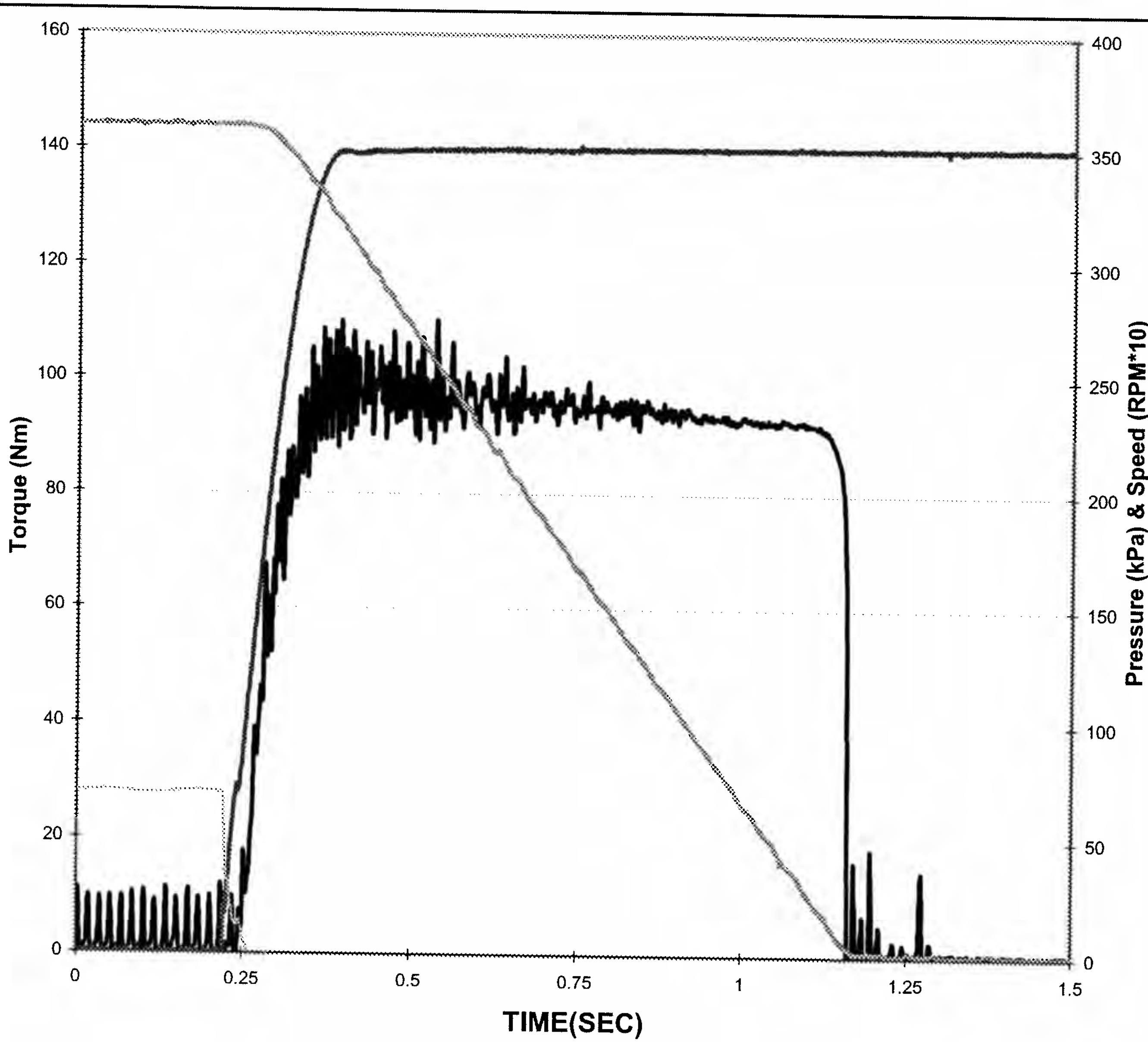

Date of Test:	7/31/2007
Time of Test:	11:57:23
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	20
Cycle Number:	3600
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	0.94 Sec *(0.85 - 1.05)*

Torque

Maximum:	93 N*m *(>90)*
Midpoint:	96 N*m *(80 - 105)*
Max - Mid:	-3 N*m *(<30)*
End - Mid:	-19 N*m
End:	77 N*m *(Report)*

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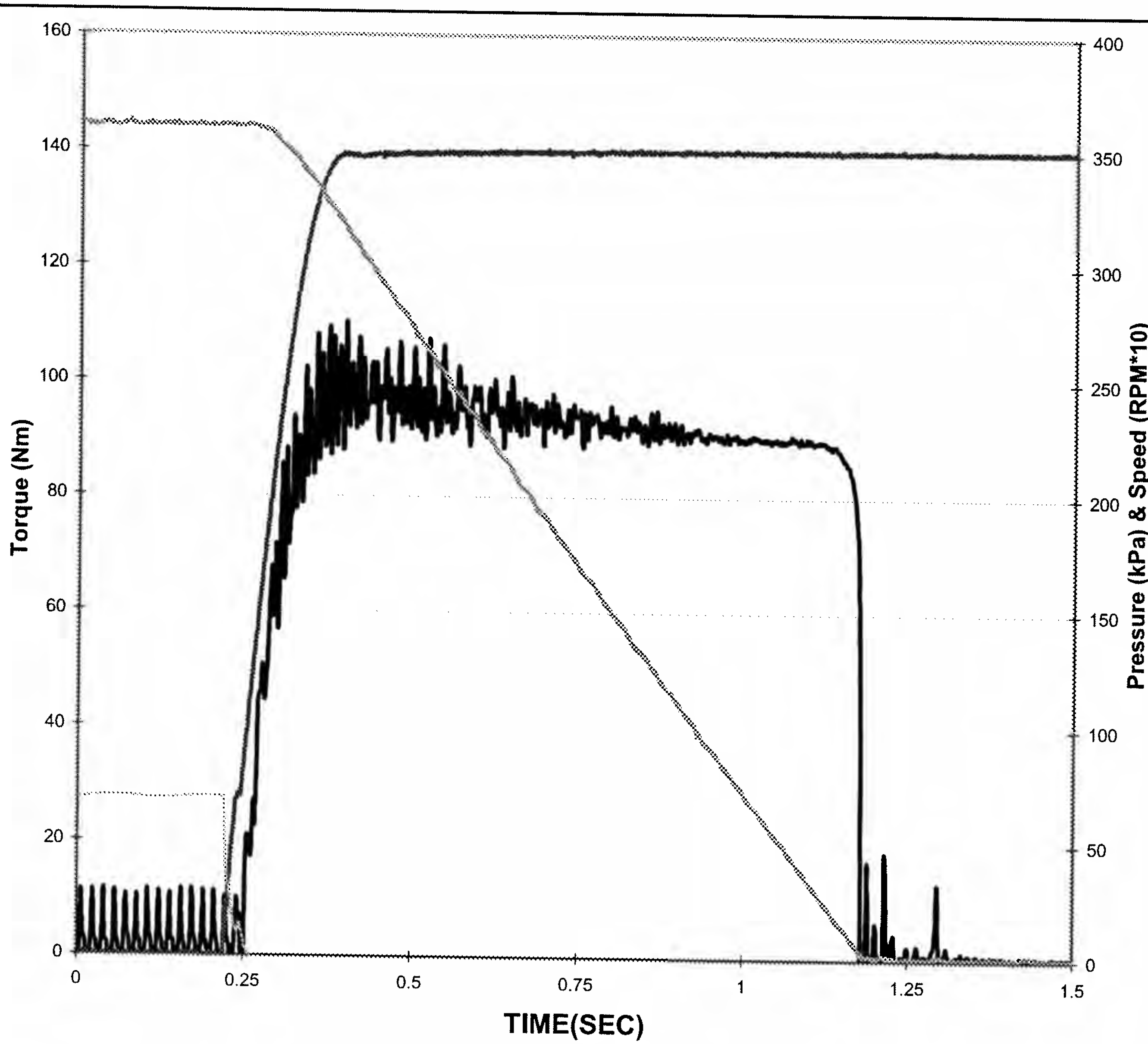

Date of Test:	7/31/2007
Time of Test:	16:57:24
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	25
Cycle Number:	4500
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	0.96 Sec *(0.85 - 1.05)*

Torque

Maximum:	91 N*m *(>90)*
Midpoint:	94 N*m *(80 - 105)*
Max - Mid:	-3 N*m *(<30)*
End - Mid:	-21 N*m
End:	73 N*m *(Report)*

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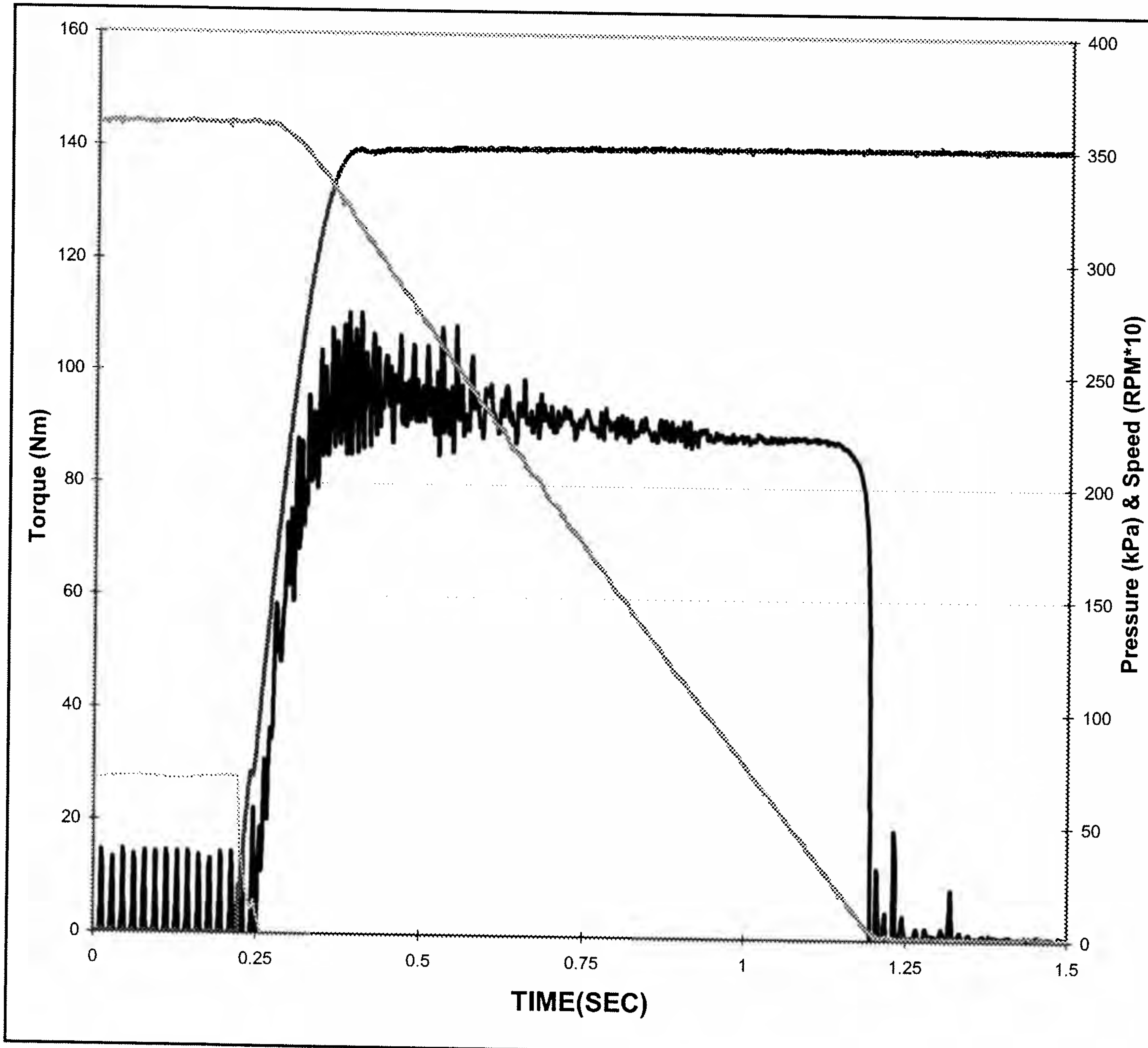

Date of Test:	7/31/2007
Time of Test:	21:57:25
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	30
Cycle Number:	5400
Temperature:	140 °C (134 - 146)
Apply Pressure:	349 kPa (340 - 350)
Energy:	15.8 KJ (15.4 - 16.0)
Engage Time:	0.95 Sec (0.85 - 1.05)

Torque

Maximum:	89 N*m (>90)
Midpoint:	92 N*m (80 - 105)
Max - Mid:	-3 N*m (<30)
End - Mid:	-22 N*m
End:	70 N*m (Report)

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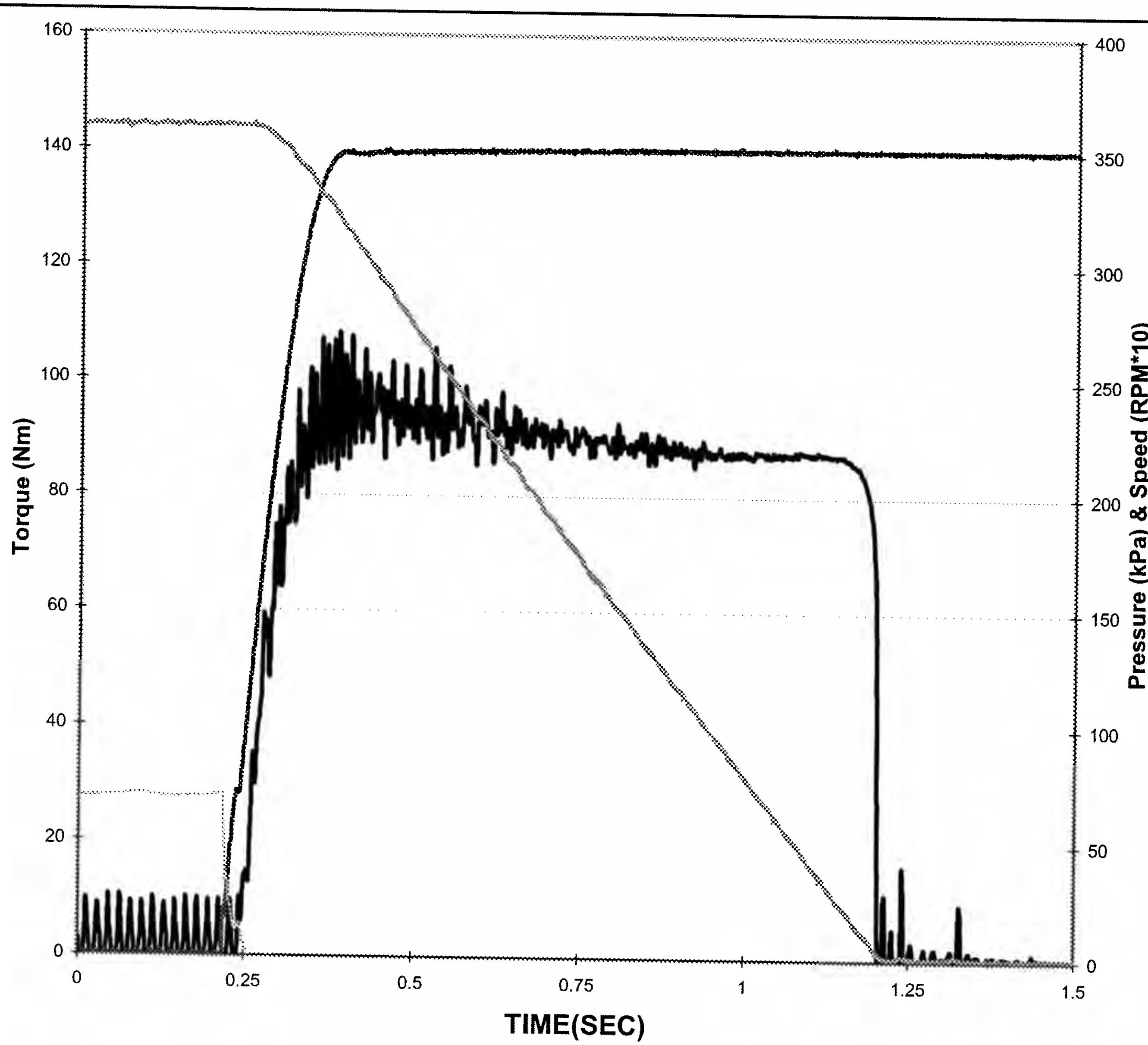

Date of Test:	8/1/2007
Time of Test:	2:57:26
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	35
Cycle Number:	6300
Temperature:	139 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	0.99 Sec *(0.85 - 1.05)*

Torque

Maximum:	88 N*m *(>90)*
Midpoint:	91 N*m *(80 - 105)*
Max - Mid:	-2 N*m *(<30)*
End - Mid:	-19 N*m
End:	72 N*m *(Report)*

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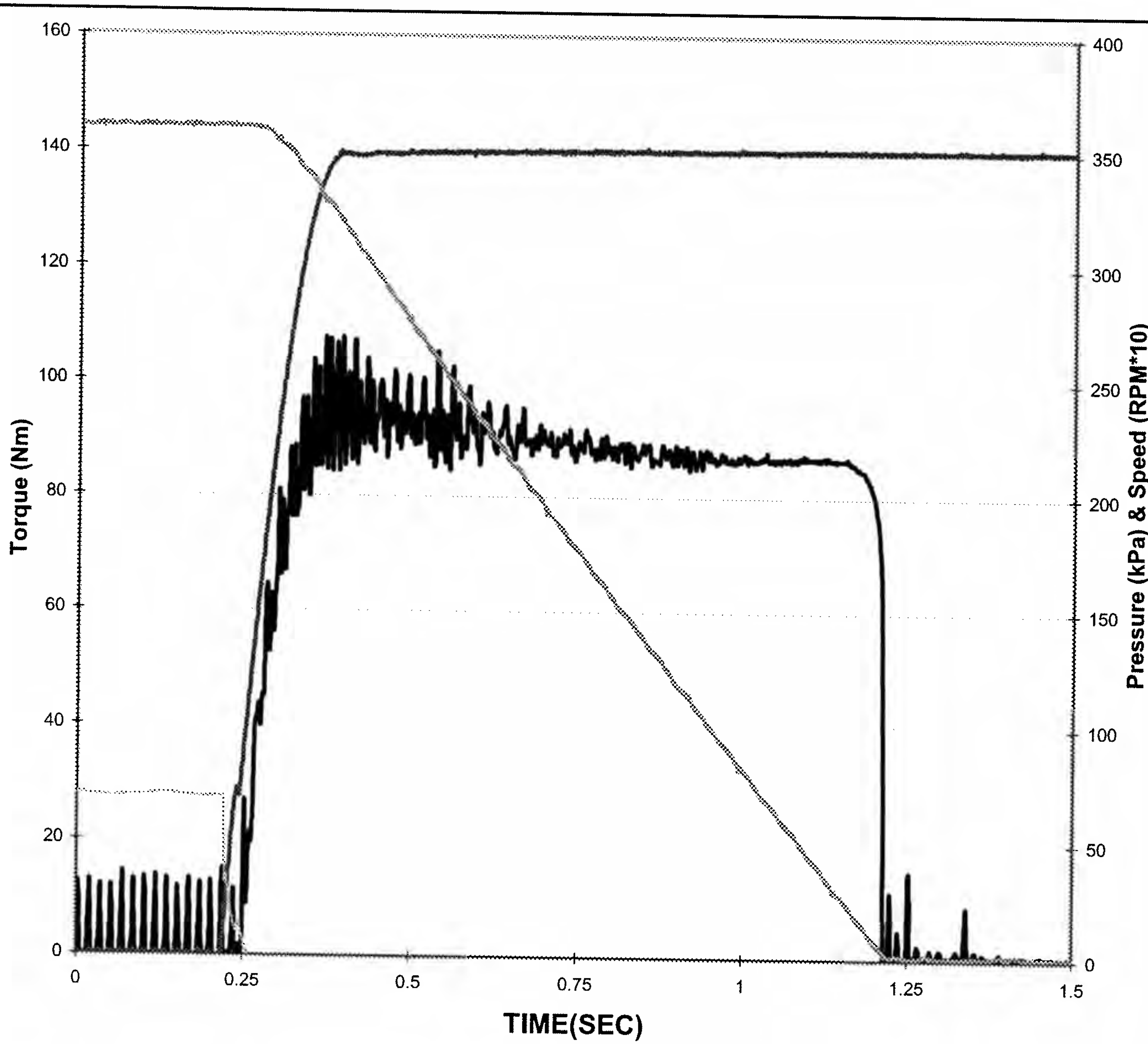

Date of Test:	8/1/2007
Time of Test:	7:57:27
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	40
Cycle Number:	7200
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	0.99 Sec *(0.85 - 1.05)*

Torque

Maximum:	88 N*m *(>90)*
Midpoint:	90 N*m *(80 - 105)*
Max - Mid:	-2 N*m *(<30)*
End - Mid:	-20 N*m
End:	69 N*m *(Report)*

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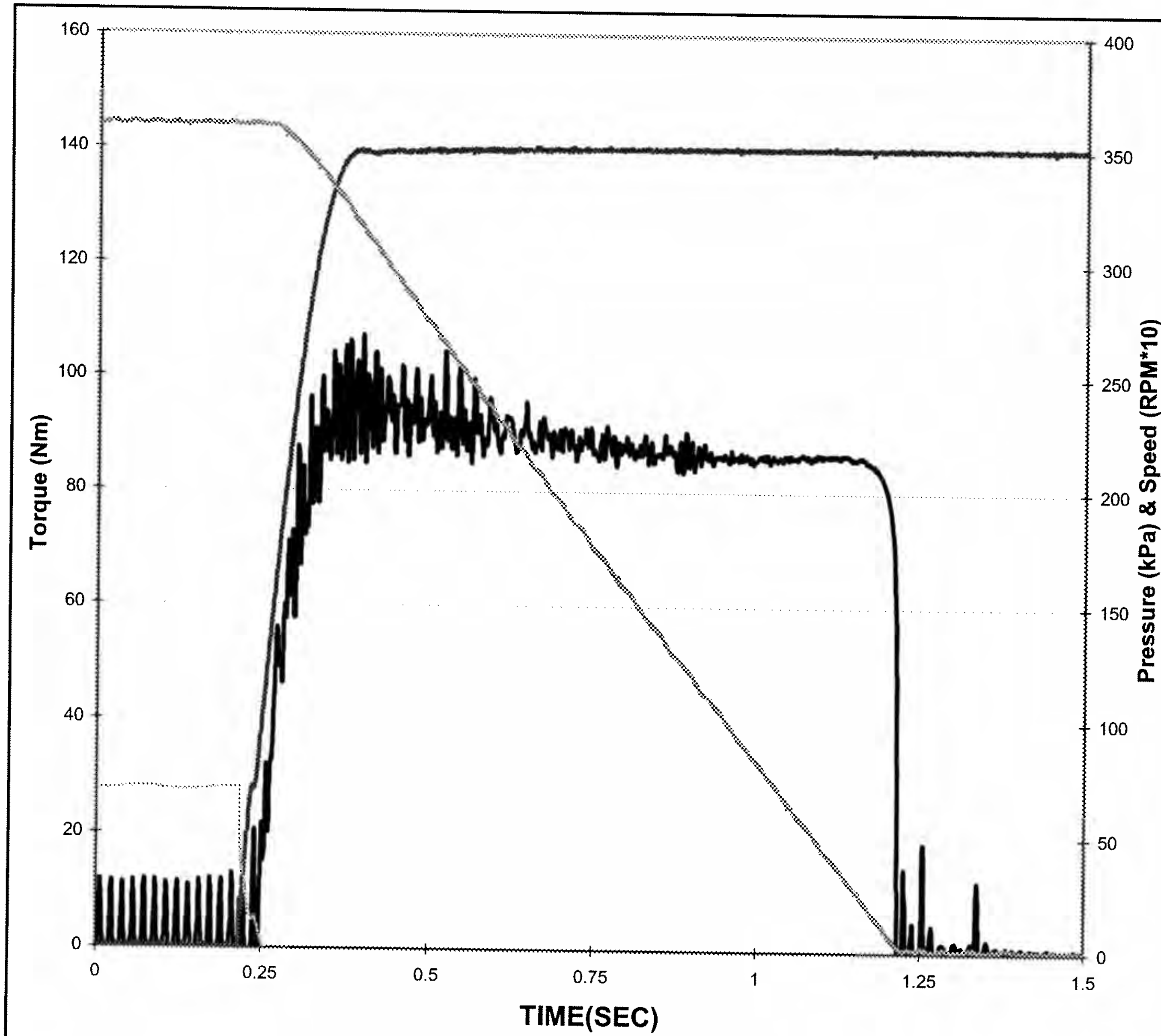

Date of Test:	8/1/2007
Time of Test:	12:57:27
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	45
Cycle Number:	8100
Temperature:	141 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	1.00 Sec *(0.85 - 1.05)*

Torque

Maximum:	87 N*m *(>90)*
Midpoint:	89 N*m *(80 - 105)*
Max - Mid:	-2 N*m *(<30)*
End - Mid:	-20 N*m
End:	69 N*m *(Report)*

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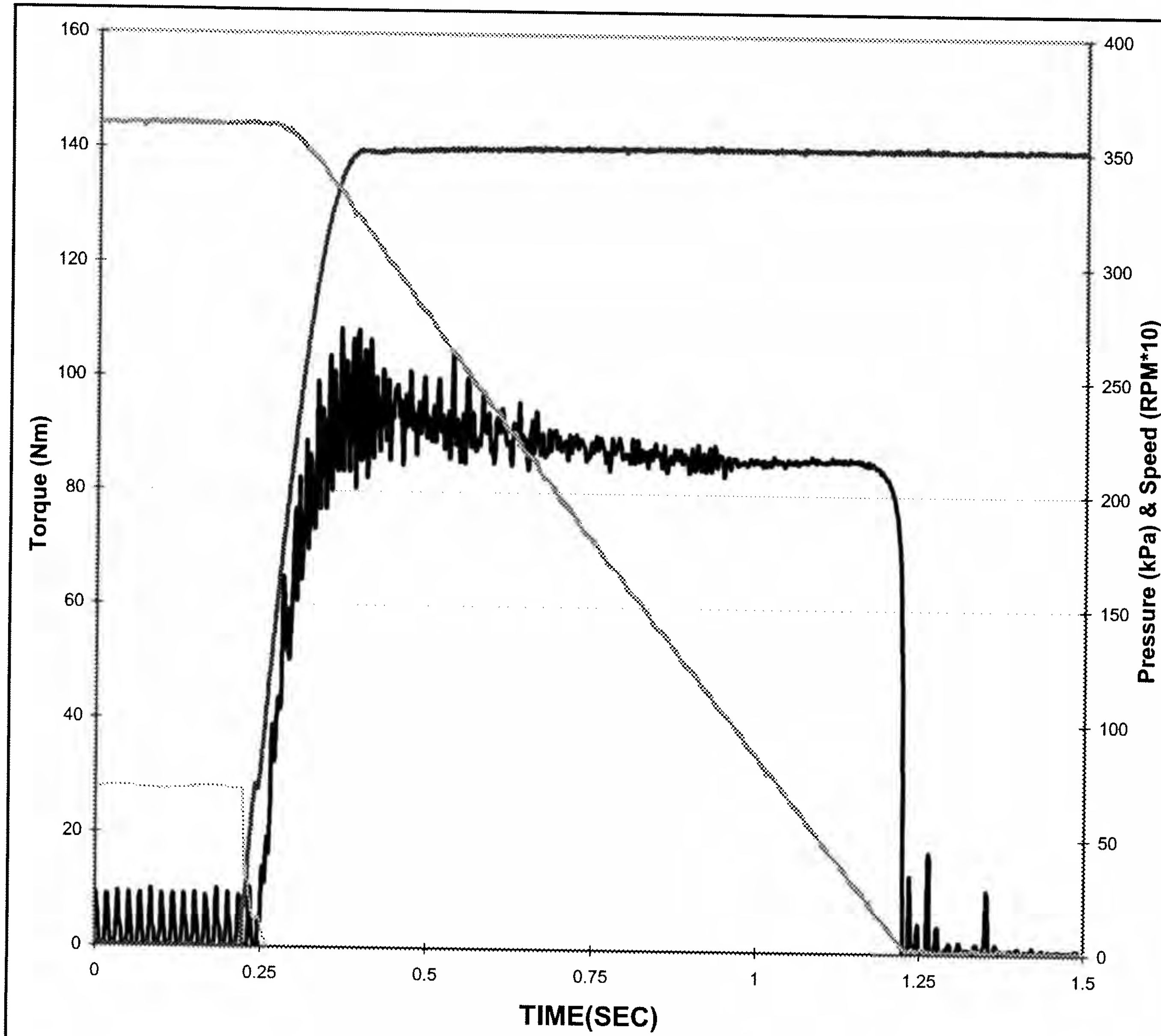

Date of Test:	8/1/2007
Time of Test:	17:57:28
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	50
Cycle Number:	9000
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	1.00 Sec *(0.85 - 1.05)*

Torque

Maximum:	87 N*m *(>90)*
Midpoint:	88 N*m *(80 - 105)*
Max - Mid:	-1 N*m *(<30)*
End - Mid:	-17 N*m
End:	71 N*m *(Report)*

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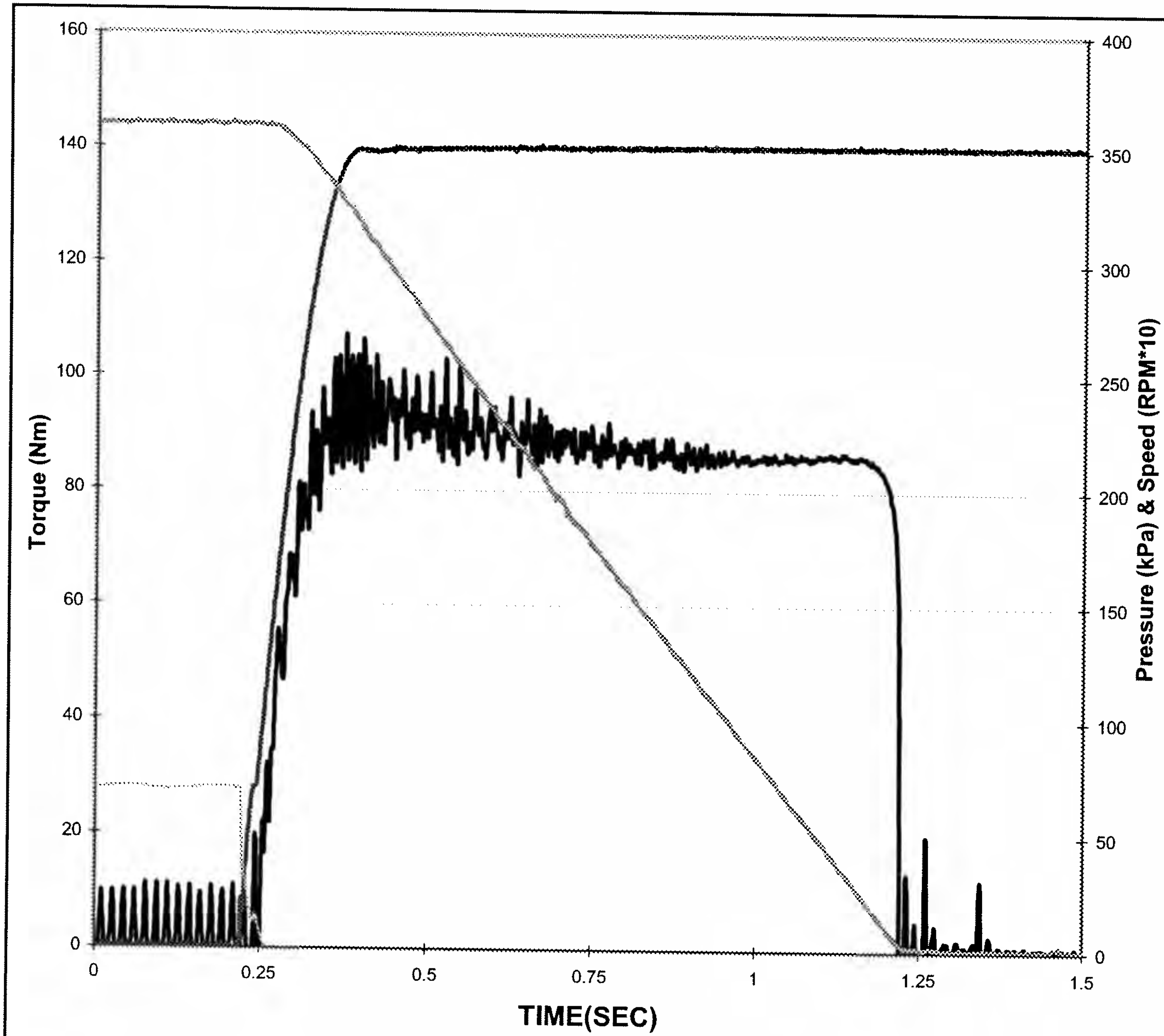

Date of Test:	8/1/2007
Time of Test:	22:57:29
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	55
Cycle Number:	9900
Temperature:	140 °C (134 - 146)
Apply Pressure:	350 kPa (340 - 350)
Energy:	15.7 KJ (15.4 - 16.0)
Engage Time:	0.99 Sec (0.85 - 1.05)

Torque

Maximum:	87 N*m (>90)
Midpoint:	88 N*m (80 - 105)
Max - Mid:	-1 N*m (<30)
End - Mid:	-21 N*m
End:	68 N*m (Report)

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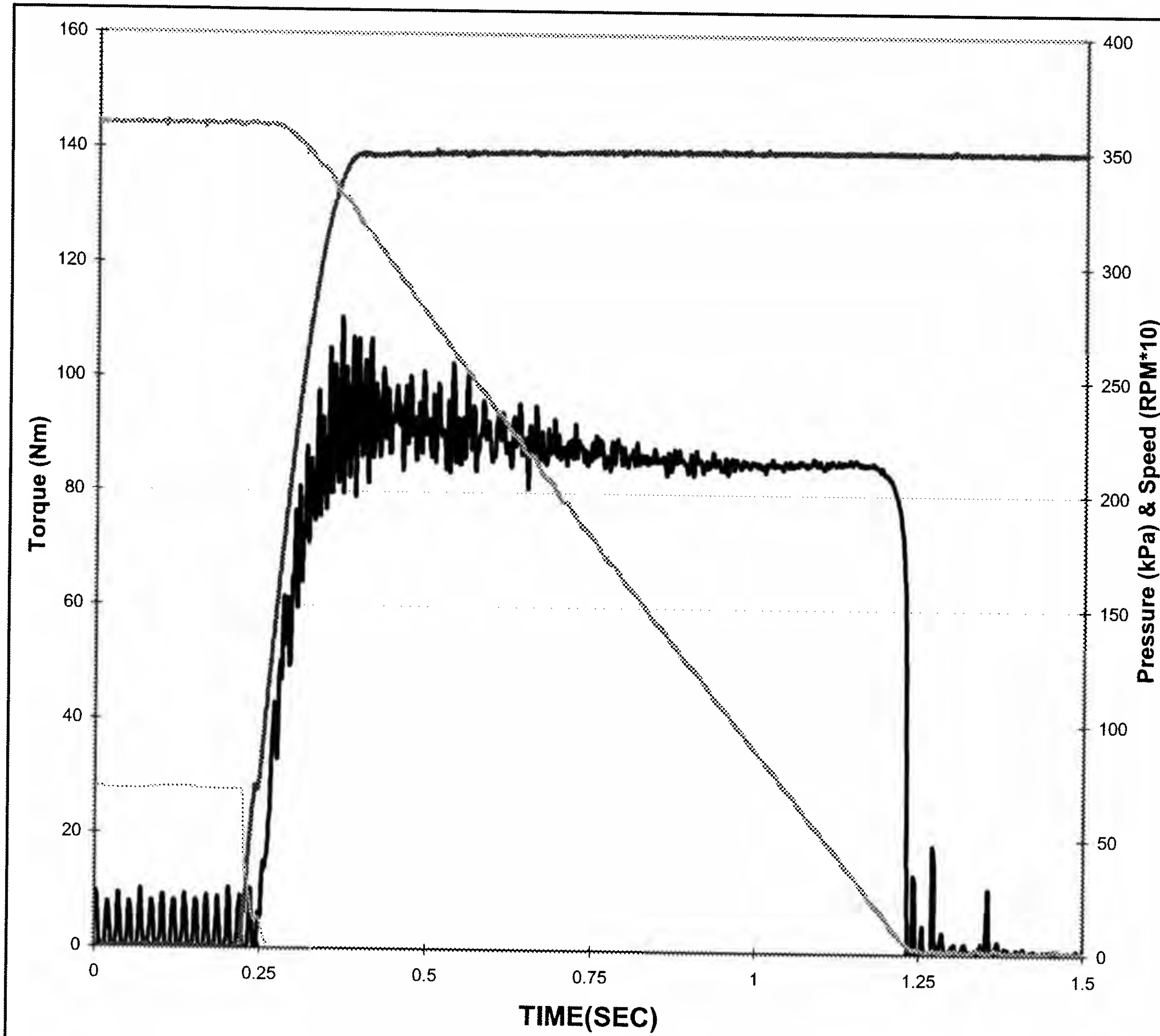

Date of Test:	8/2/2007
Time of Test:	3:57:30
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	60
Cycle Number:	10800
Temperature:	141 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	1.01 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	88 N*m *(80 - 105)*
Max - Mid:	-1 N*m *(<30)*
End - Mid:	-19 N*m
End:	69 N*m *(Report)*

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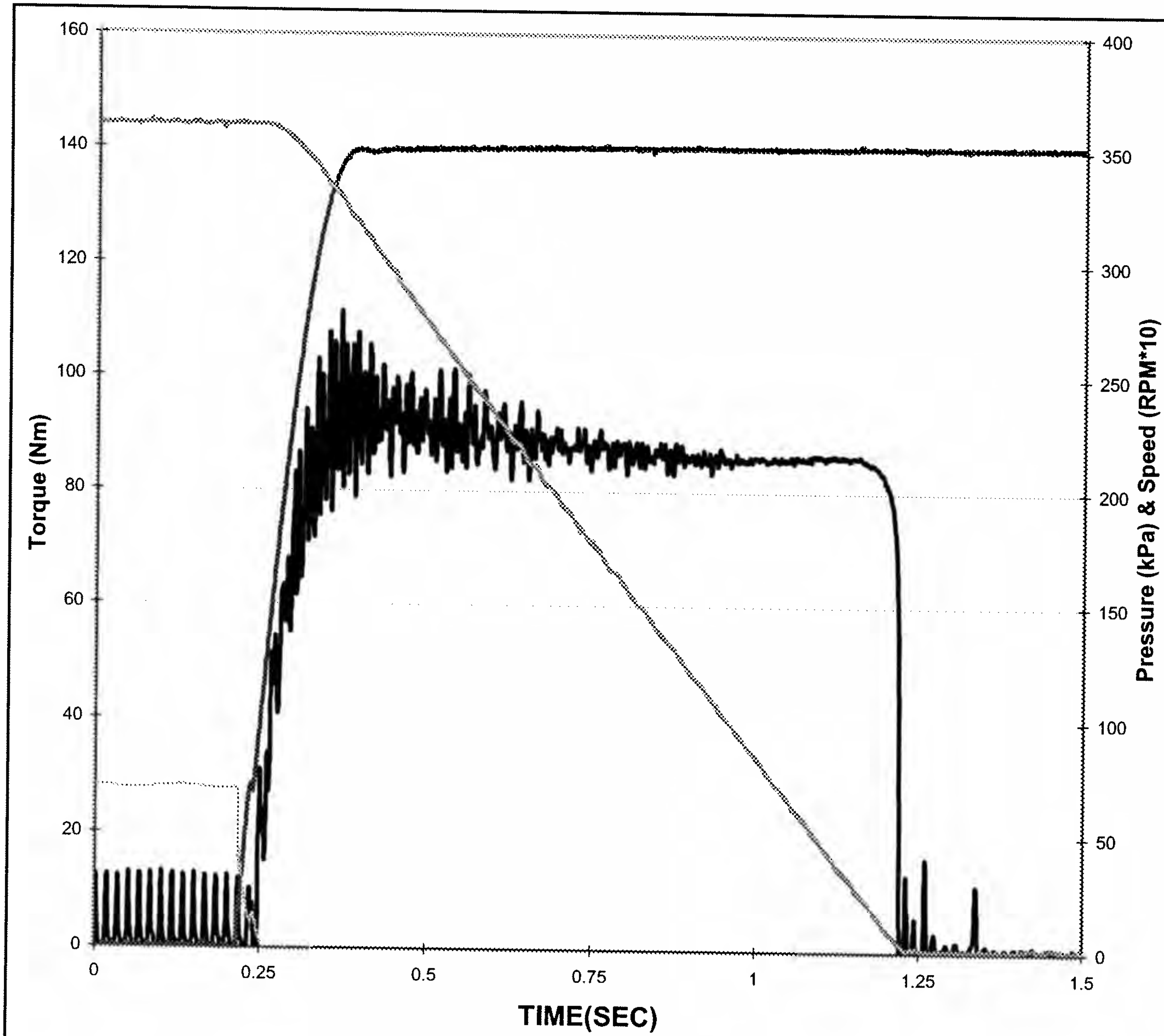

Date of Test:	8/2/2007
Time of Test:	8:57:31
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	65
Cycle Number:	11700
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.00 Sec *(0.85 - 1.05)*

Torque

Maximum:	87 N*m *(>90)*
Midpoint:	88 N*m *(80 - 105)*
Max - Mid:	-1 N*m *(<30)*
End - Mid:	-20 N*m
End:	69 N*m *(Report)*

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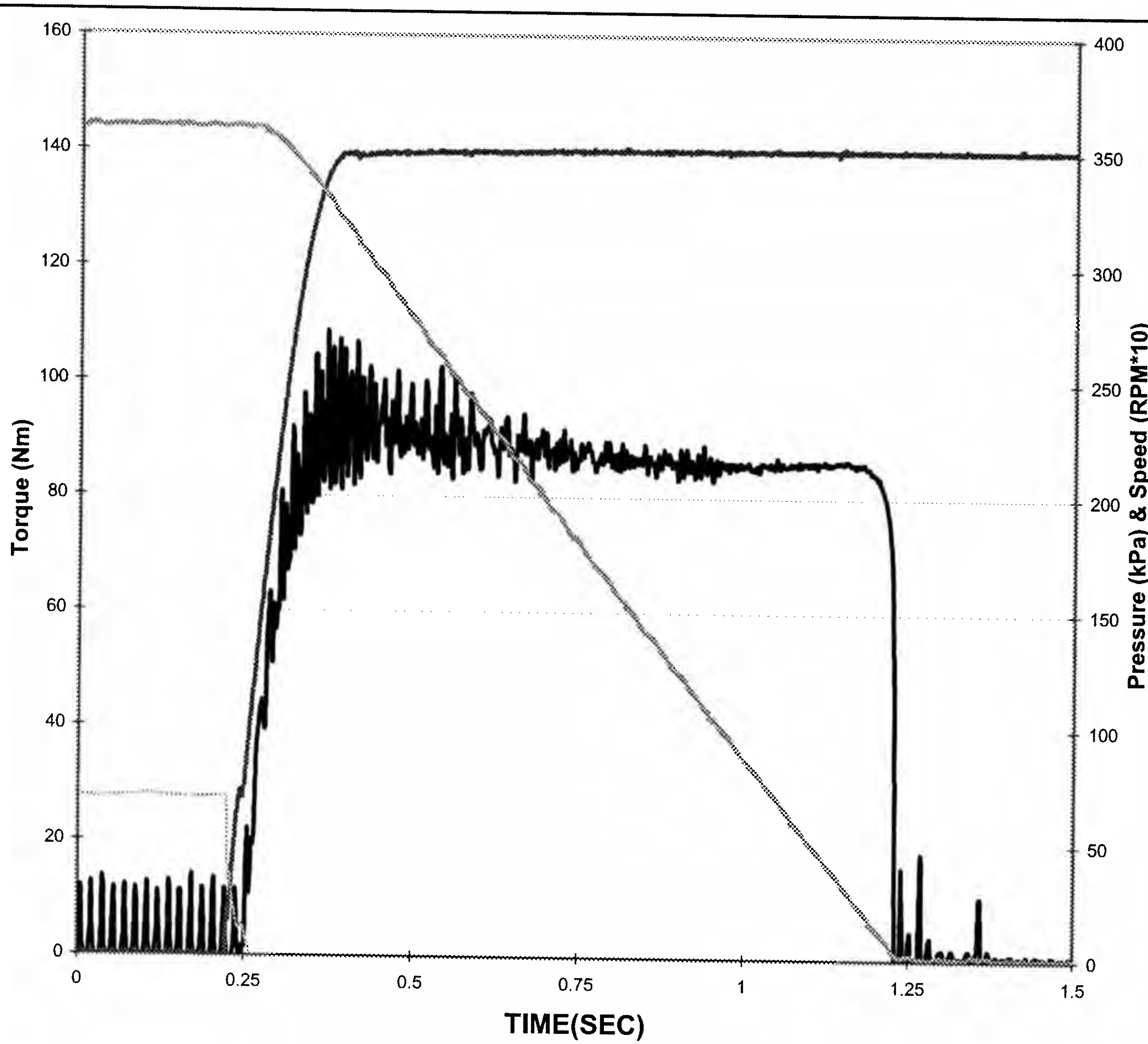

Date of Test:	8/2/2007
Time of Test:	13:57:32
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	70
Cycle Number:	12600
Temperature:	139 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	1.00 Sec *(0.85 - 1.05)*

Torque

Maximum:	87 N*m *(>90)*
Midpoint:	87 N*m *(80 - 105)*
Max - Mid:	-1 N*m *(<30)*
End - Mid:	-18 N*m
End:	69 N*m *(Report)*

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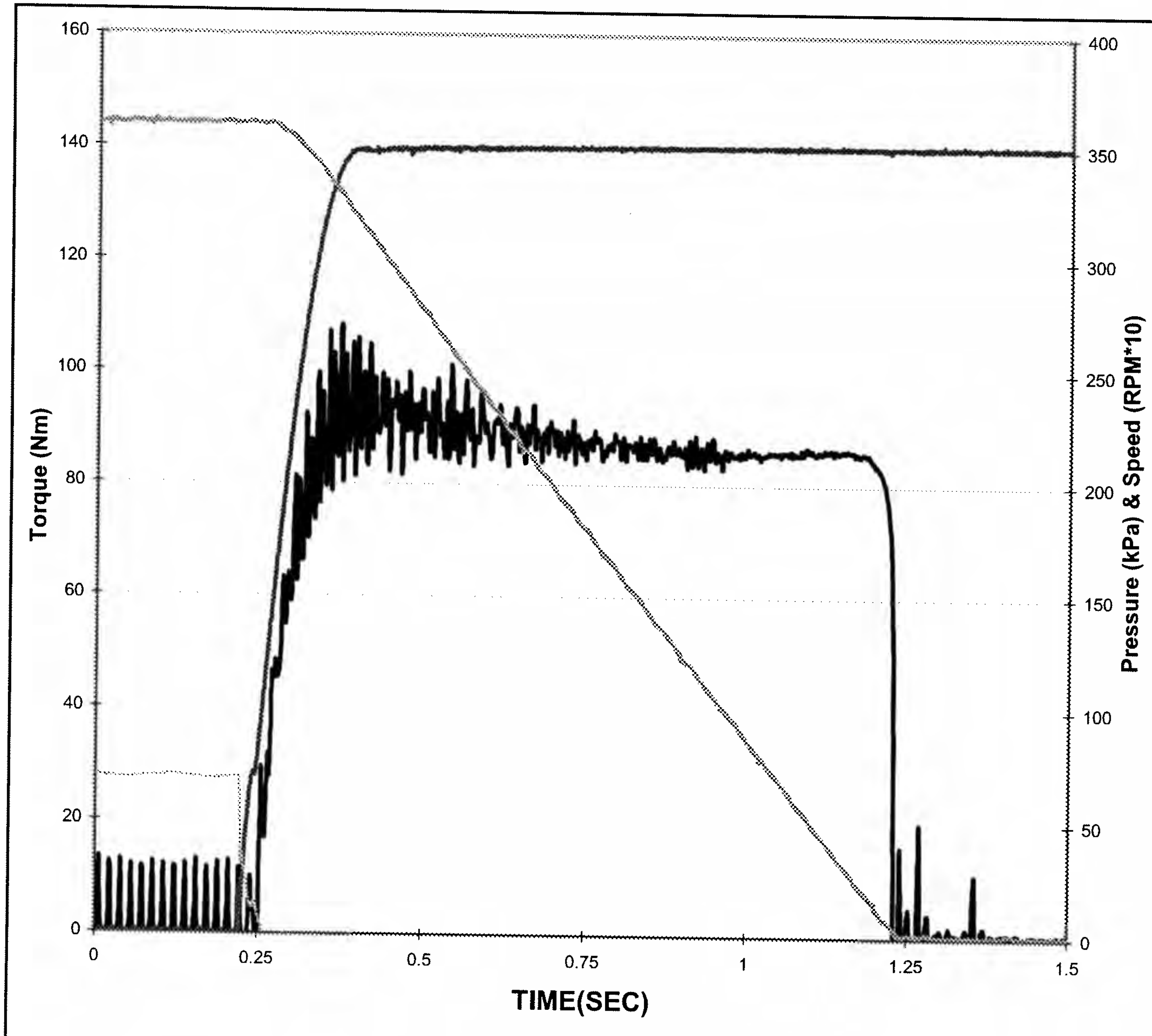

Date of Test:	8/2/2007
Time of Test:	18:57:33
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	75
Cycle Number:	13500
Temperature:	139 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	1.00 Sec *(0.85 - 1.05)*

Torque

Maximum:	87 N*m *(>90)*
Midpoint:	87 N*m *(80 - 105)*
Max - Mid:	-1 N*m *(<30)*
End - Mid:	-18 N*m
End:	70 N*m *(Report)*

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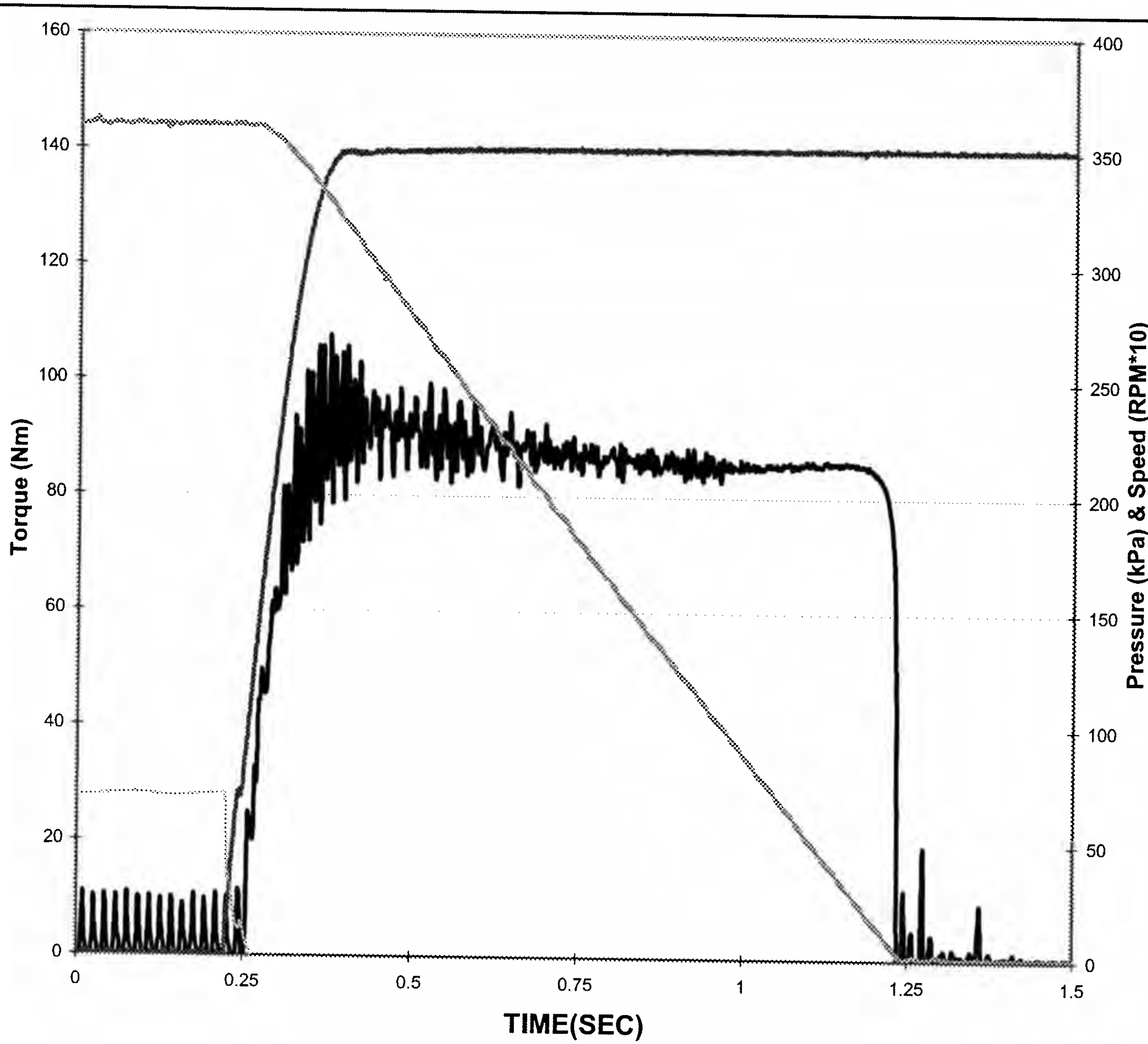

Date of Test:	8/2/2007
Time of Test:	23:57:33
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	80
Cycle Number:	14400
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.00 Sec *(0.85 - 1.05)*

Torque

Maximum:	87 N*m *(>90)*
Midpoint:	87 N*m *(80 - 105)*
Max - Mid:	-1 N*m *(<30)*
End - Mid:	-18 N*m
End:	69 N*m *(Report)*

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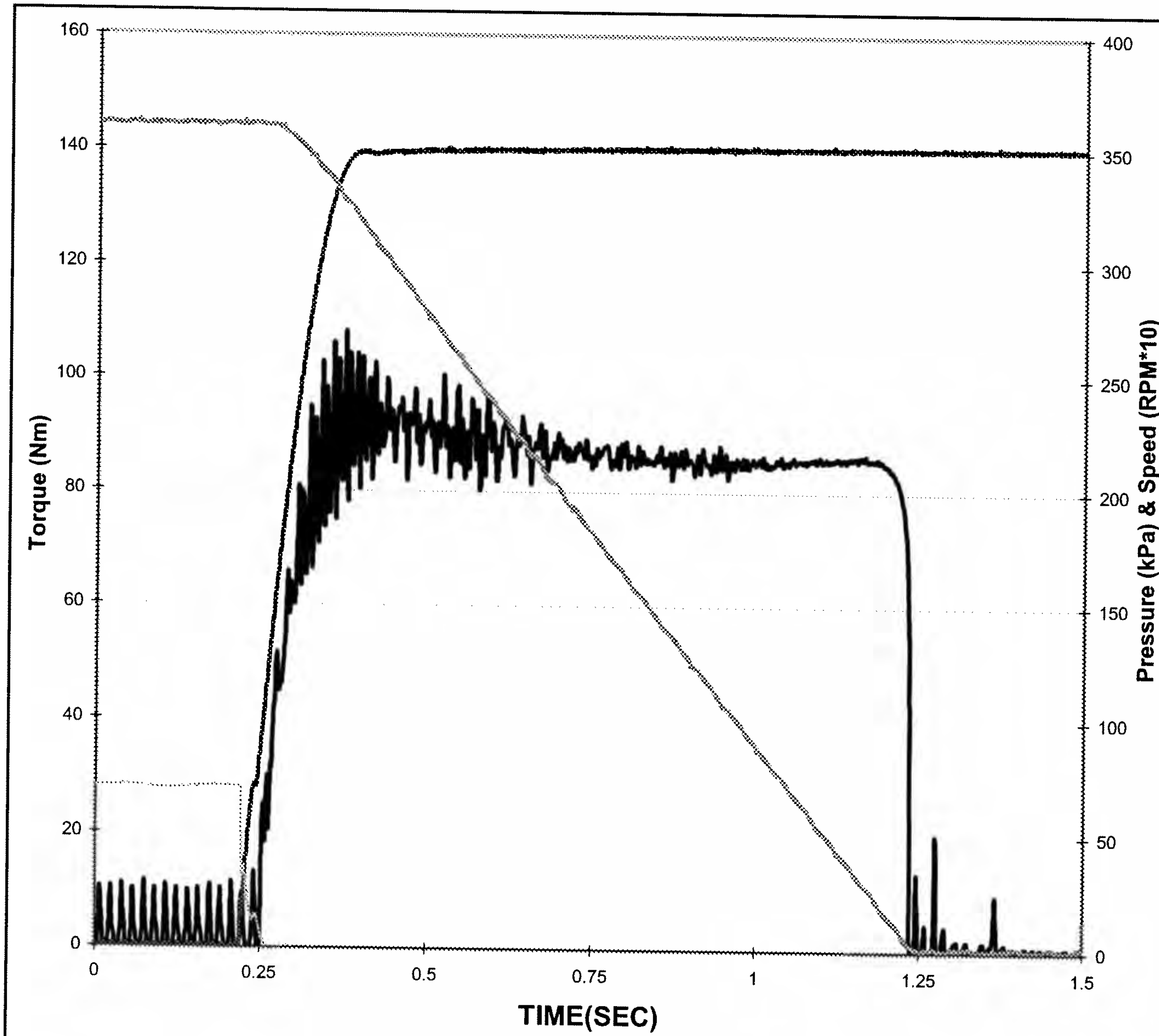

Date of Test:	8/3/2007
Time of Test:	4:57:34
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	85
Cycle Number:	15300
Temperature:	141 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	1.01 Sec *(0.85 - 1.05)*

Torque

Maximum:	87 N*m *(>90)*
Midpoint:	87 N*m *(80 - 105)*
Max - Mid:	0 N*m *(<30)*
End - Mid:	-16 N*m
End:	71 N*m *(Report)*

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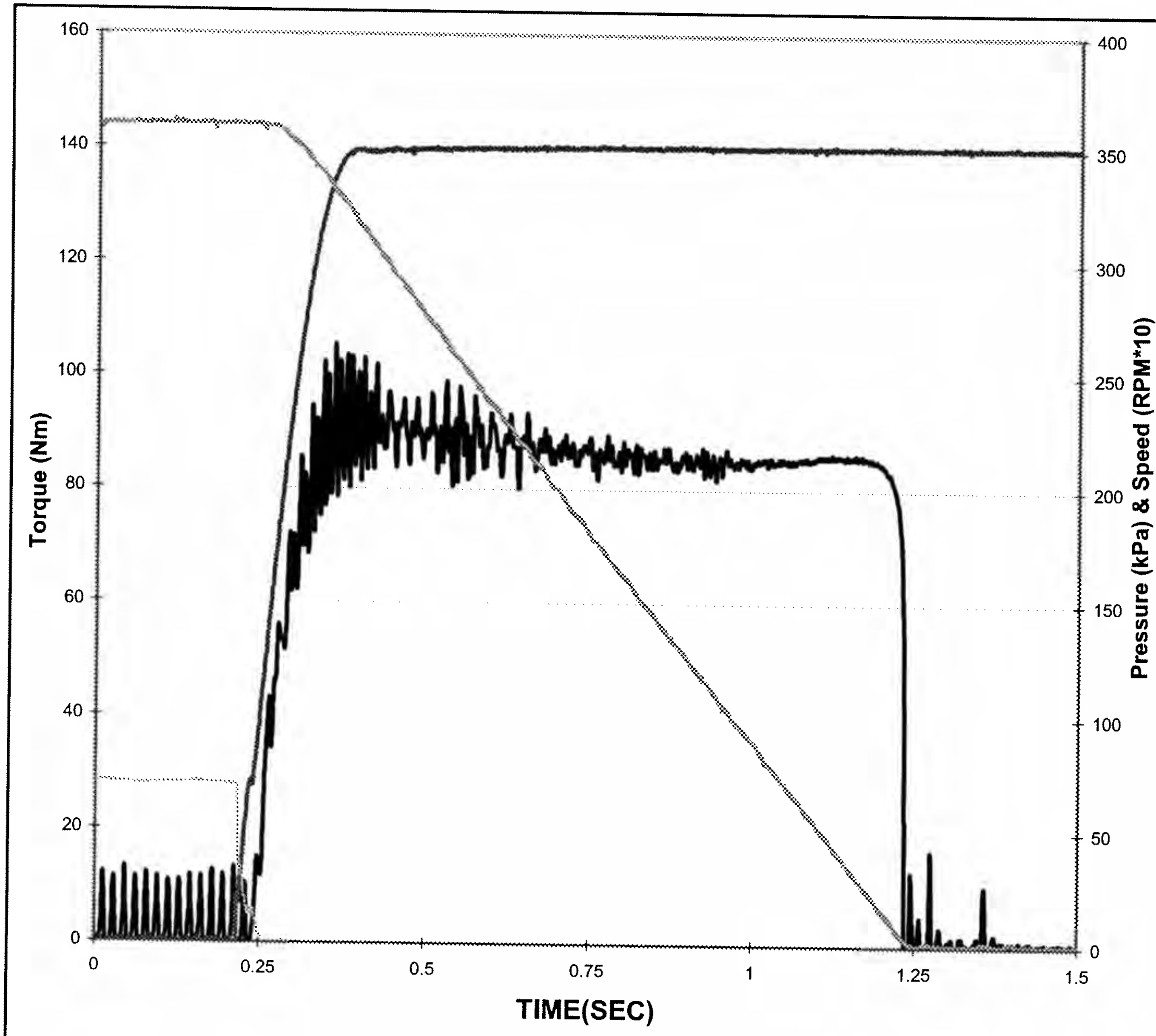

Date of Test:	8/3/2007
Time of Test:	9:57:35
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	90
Cycle Number:	16200
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.01 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	87 N*m *(80 - 105)*
Max - Mid:	0 N*m *(<30)*
End - Mid:	-16 N*m
End:	71 N*m *(Report)*

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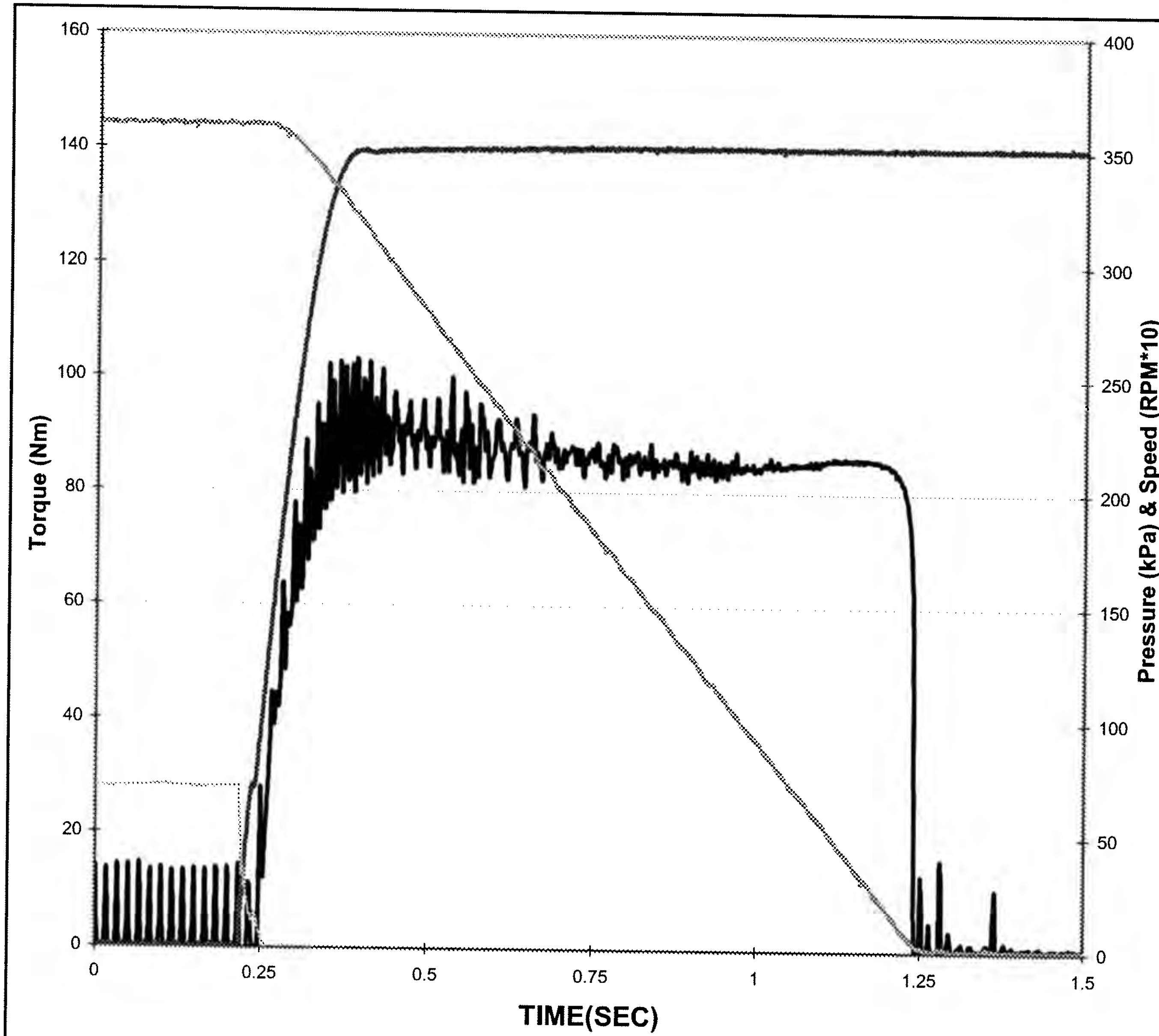

Date of Test:	8/3/2007
Time of Test:	14:57:36
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	95
Cycle Number:	17100
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	1.03 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	86 N*m *(80 - 105)*
Max - Mid:	0 N*m *(<30)*
End - Mid:	-17 N*m
End:	70 N*m *(Report)*

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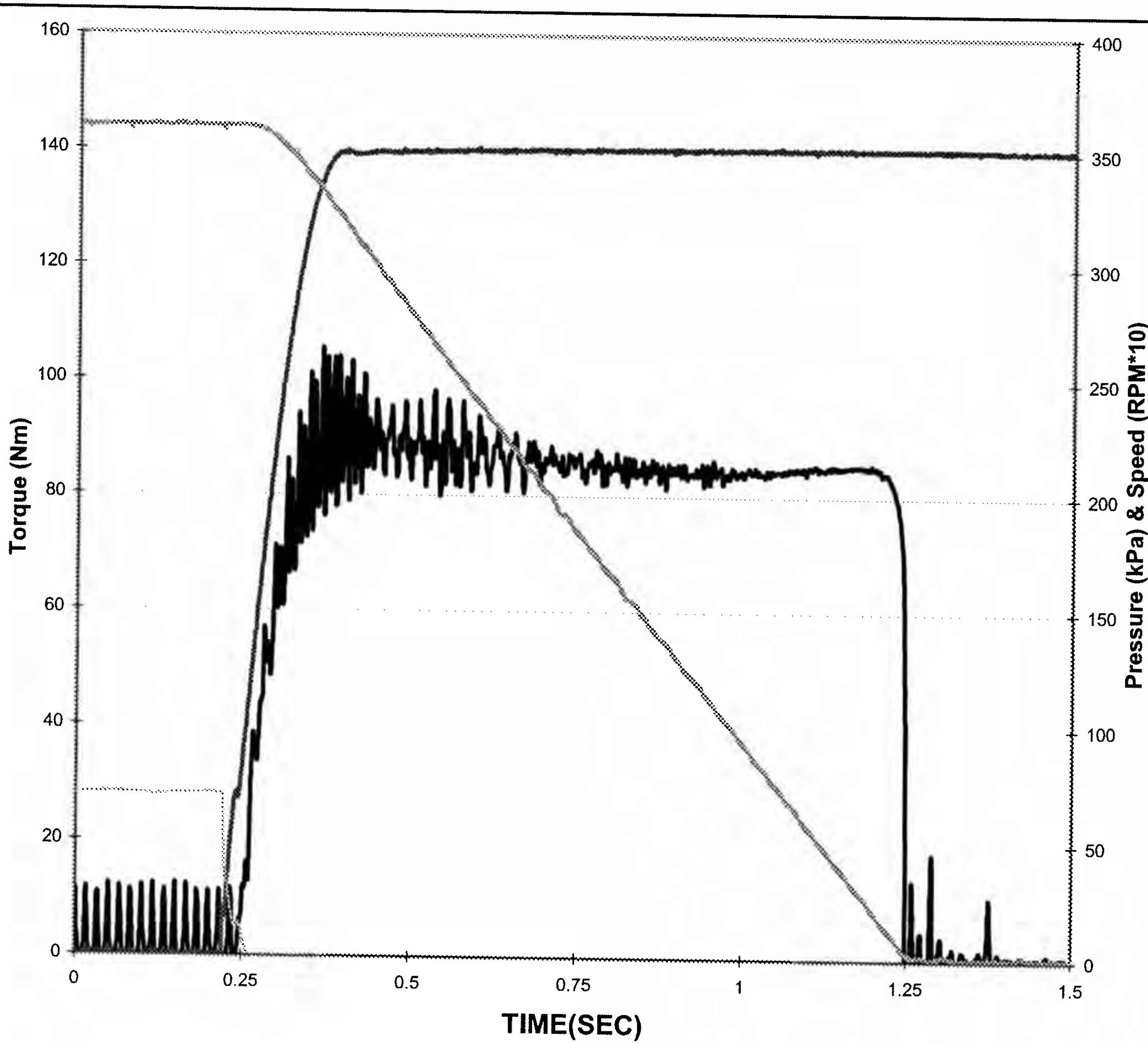

Date of Test:	8/3/2007
Time of Test:	19:57:37
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	100
Cycle Number:	18000
Temperature:	141 °C
	(134 - 146)
Apply Pressure:	350 kPa
	(340 - 350)
Energy:	15.7 KJ
	(15.4 - 16.0)
Engage Time:	1.03 Sec
	(0.85 - 1.05)

Torque

Maximum:	86 N*m
	(>90)
Midpoint:	86 N*m
	(80 - 105)
Max - Mid:	0 N*m
	(<30)
End - Mid:	-15 N*m
End:	71 N*m
	(Report)

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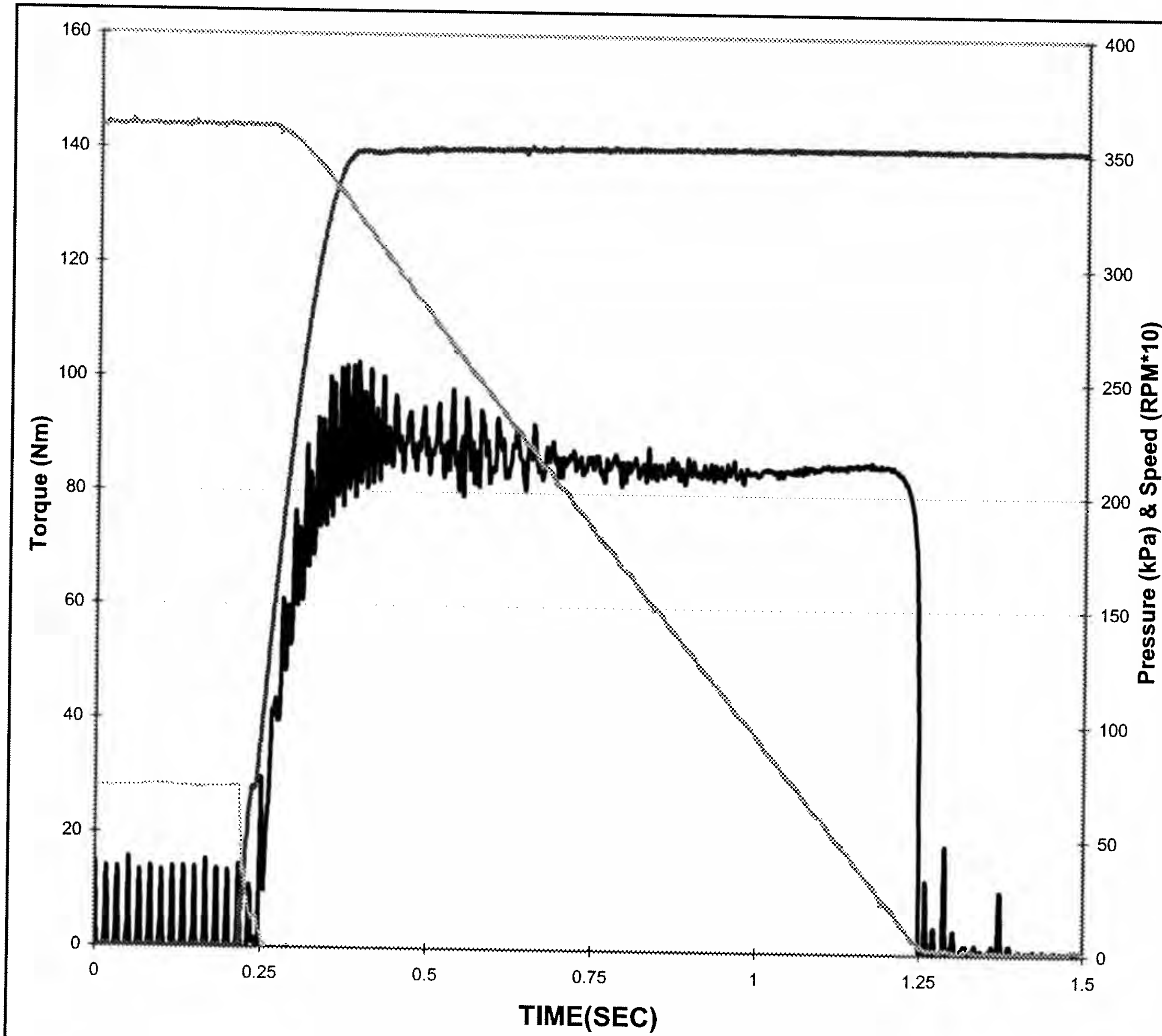

Date of Test:	8/4/2007
Time of Test:	0:57:38
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	105
Cycle Number:	18900
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.02 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	86 N*m *(80 - 105)*
Max - Mid:	0 N*m *(<30)*
End - Mid:	-15 N*m
End:	71 N*m *(Report)*

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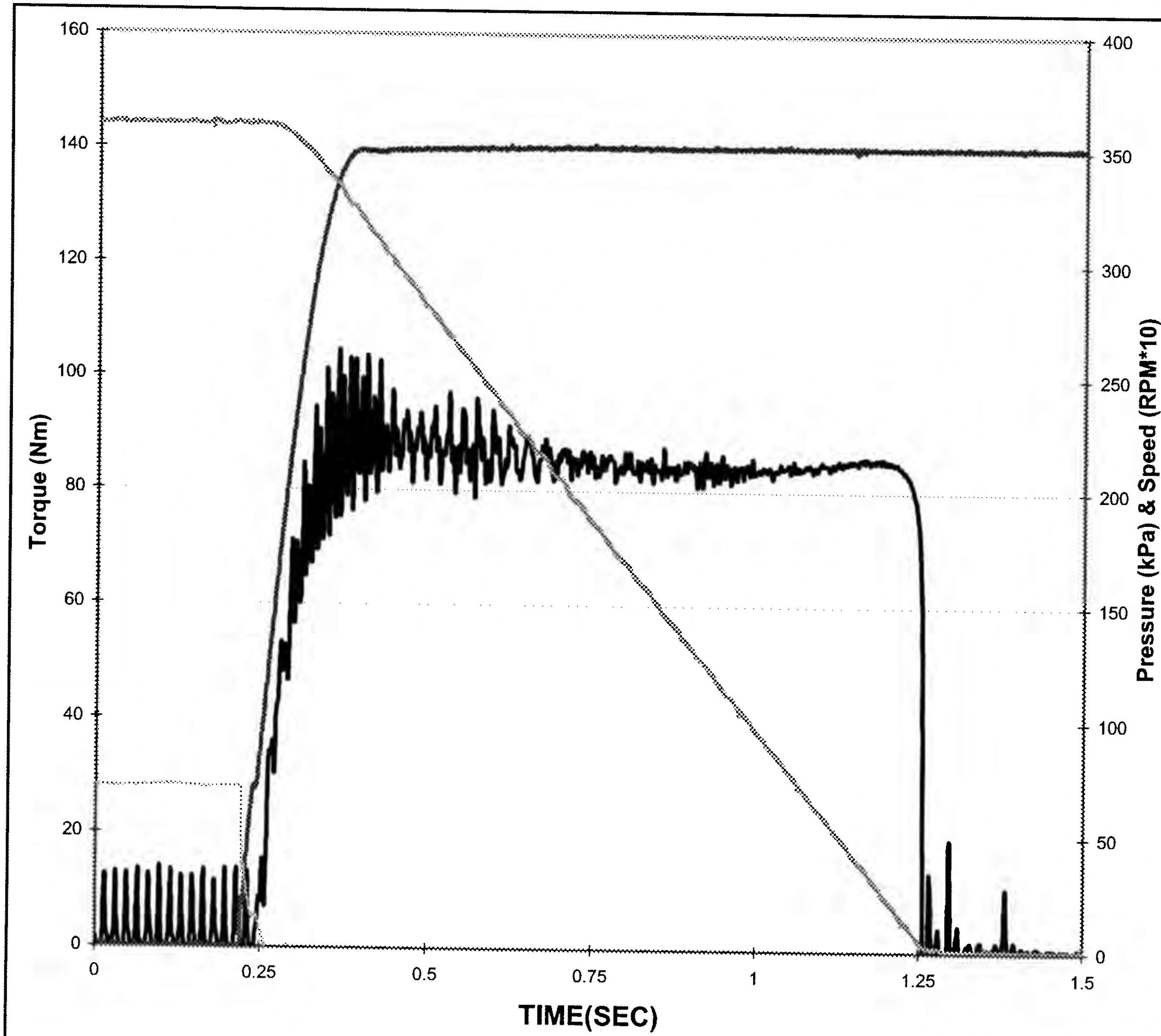

Date of Test:	8/4/2007
Time of Test:	5:57:39
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	110
Cycle Number:	19800
Temperature:	141 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	1.03 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	85 N*m *(80 - 105)*
Max - Mid:	1 N*m *(<30)*
End - Mid:	-14 N*m
End:	71 N*m *(Report)*

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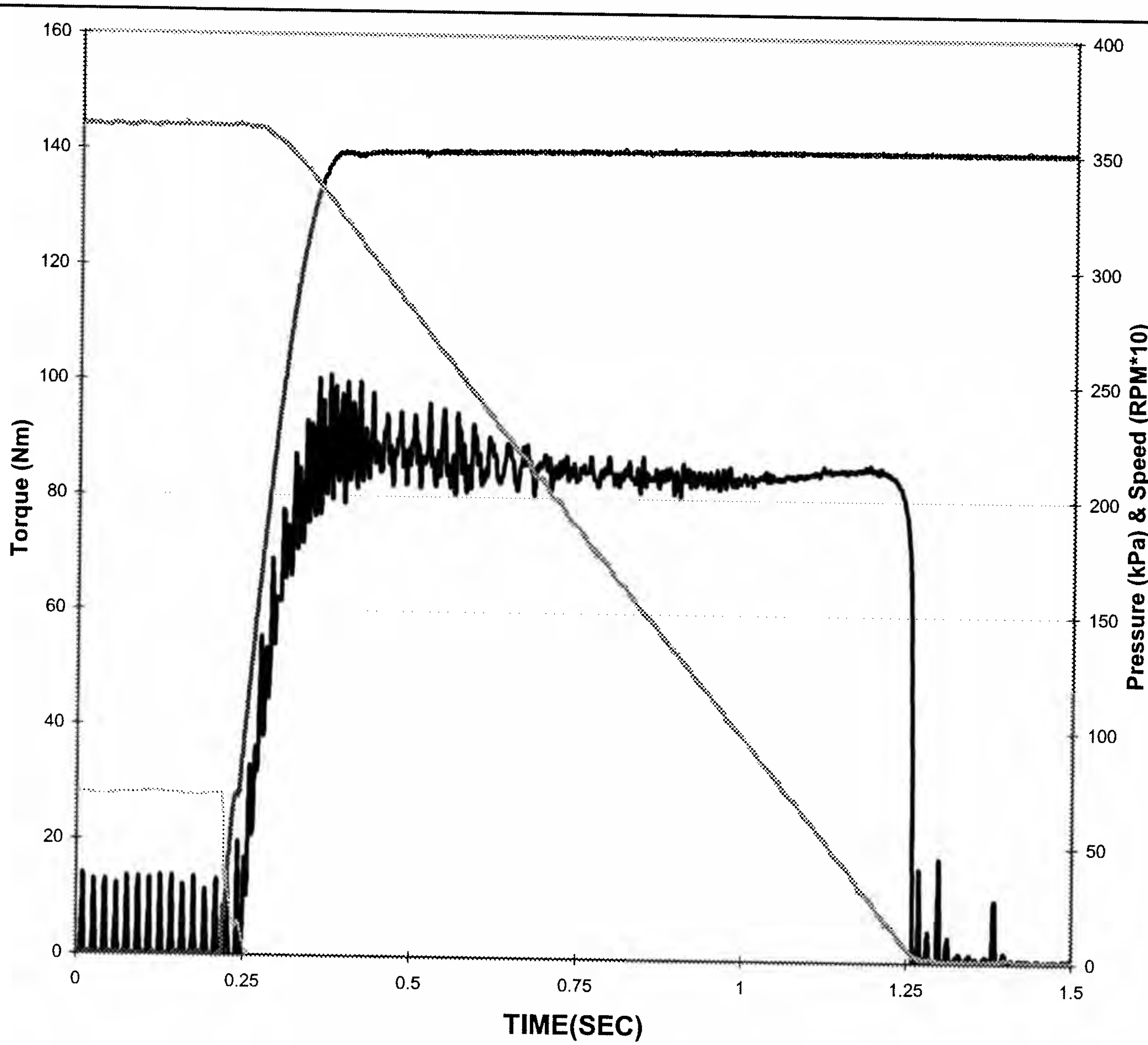

Date of Test:	8/4/2007
Time of Test:	10:57:39
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	115
Cycle Number:	20700
Temperature:	140 °C
	(134 - 146)
Apply Pressure:	350 kPa
	(340 - 350)
Energy:	15.7 KJ
	(15.4 - 16.0)
Engage Time:	1.03 Sec
	(0.85 - 1.05)

Torque

Maximum:	86 N*m
	(>90)
Midpoint:	85 N*m
	(80 - 105)
Max - Mid:	1 N*m
	(<30)
End - Mid:	-14 N*m
End:	71 N*m
	(Report)

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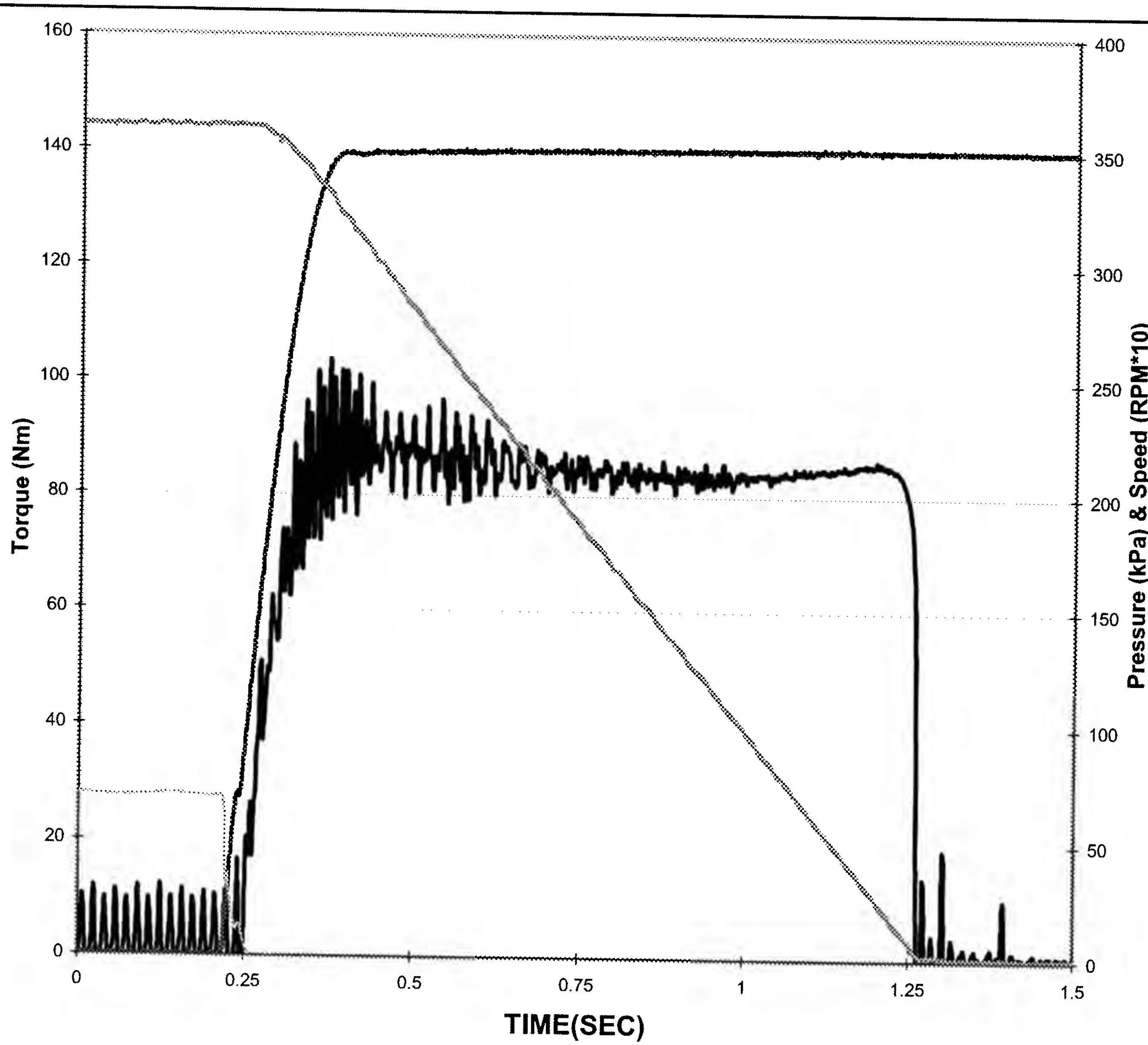

Date of Test:	8/4/2007
Time of Test:	15:57:40
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	120
Cycle Number:	21600
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	1.04 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	85 N*m *(80 - 105)*
Max - Mid:	2 N*m *(<30)*
End - Mid:	-14 N*m
End:	71 N*m *(Report)*

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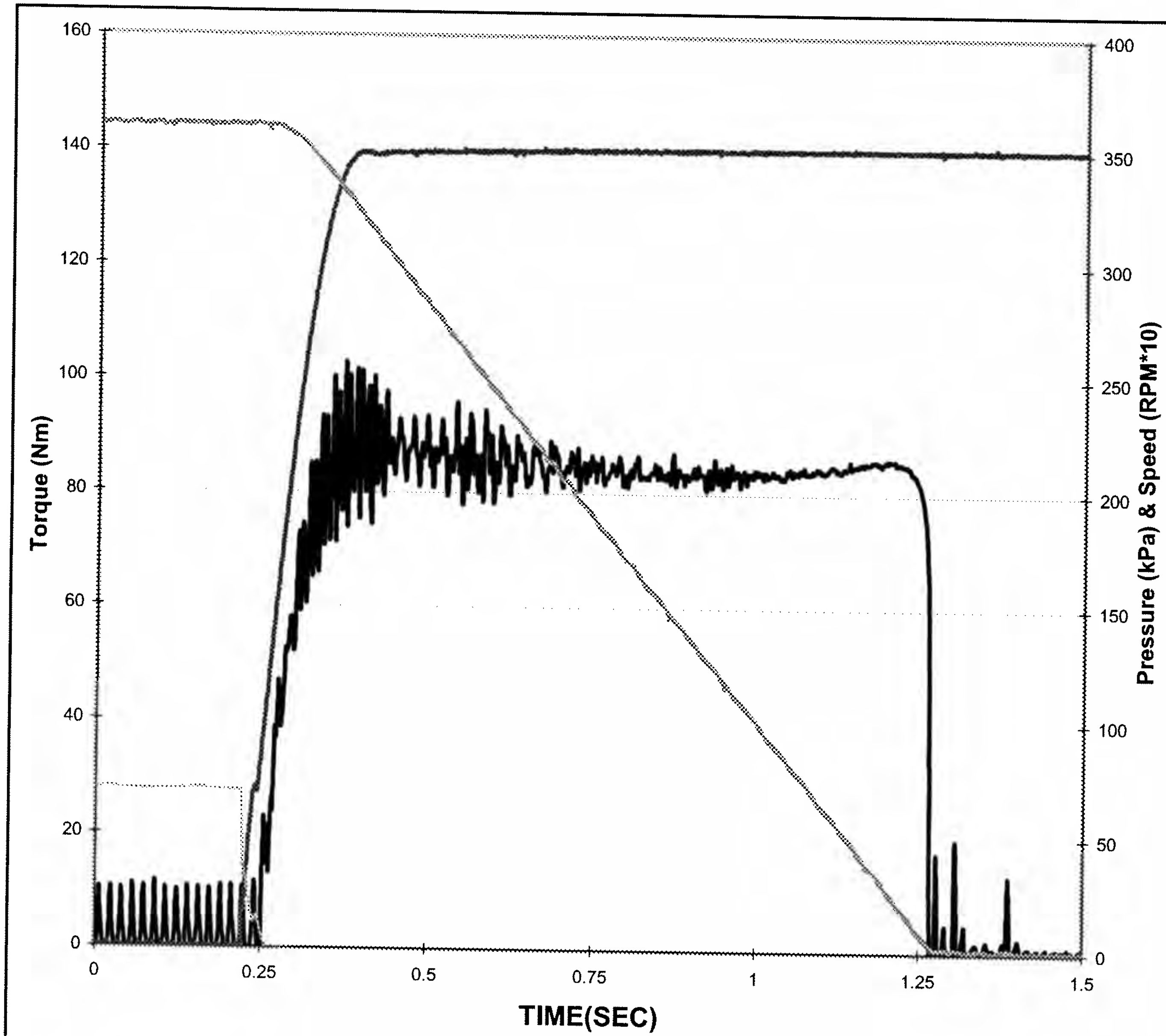

Date of Test:	8/4/2007
Time of Test:	20:57:41
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	125
Cycle Number:	22500
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	1.04 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	84 N*m *(80 - 105)*
Max - Mid:	2 N*m *(<30)*
End - Mid:	-13 N*m
End:	71 N*m *(Report)*

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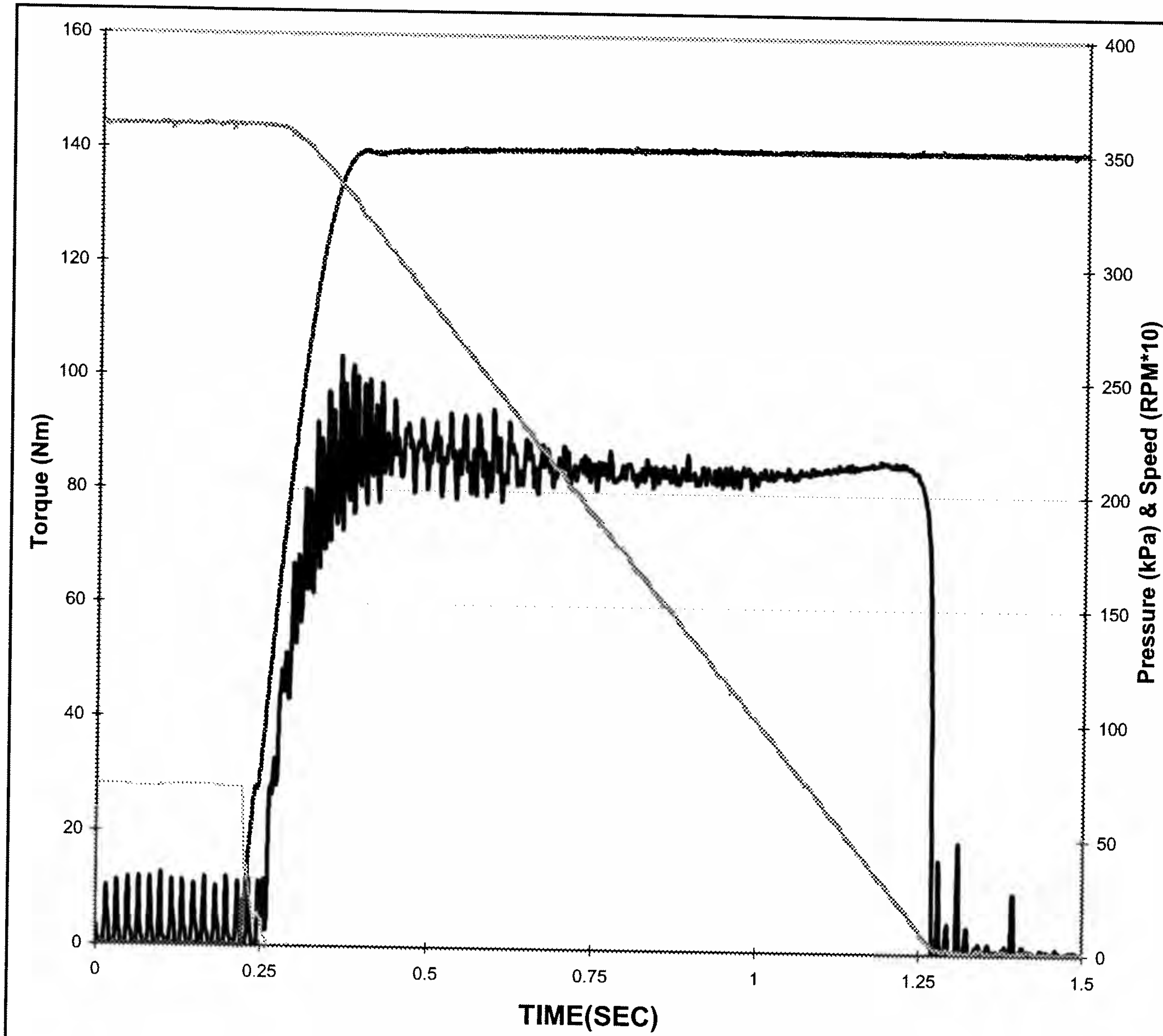

Date of Test:	8/5/2007
Time of Test:	1:57:42
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	130
Cycle Number:	23400
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.04 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	84 N*m *(80 - 105)*
Max - Mid:	2 N*m *(<30)*
End - Mid:	-12 N*m
End:	72 N*m *(Report)*

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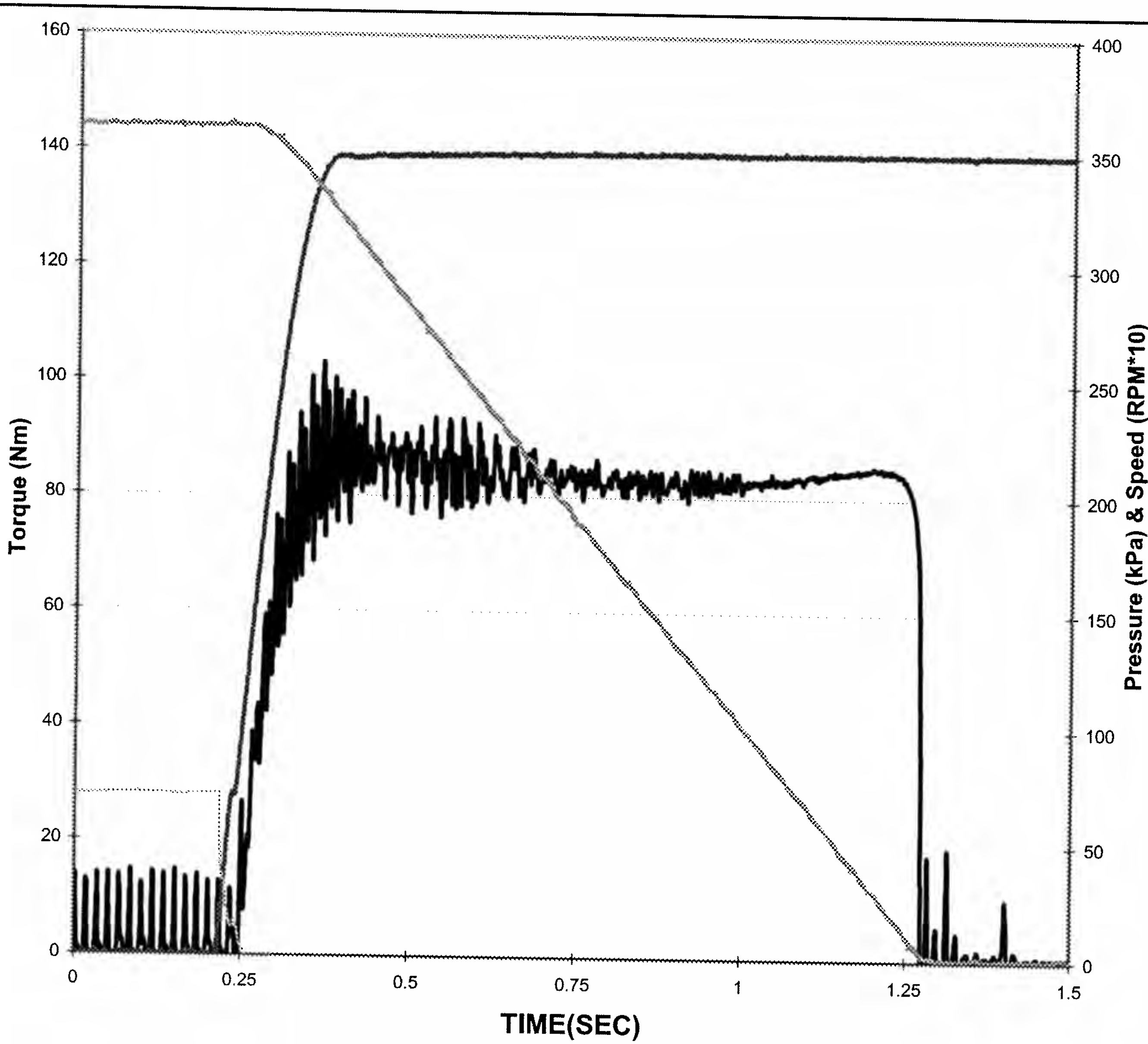

Date of Test:	8/5/2007
Time of Test:	6:57:43
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	135
Cycle Number:	24300
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.06 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	83 N*m *(80 - 105)*
Max - Mid:	2 N*m *(<30)*
End - Mid:	-12 N*m
End:	71 N*m *(Report)*

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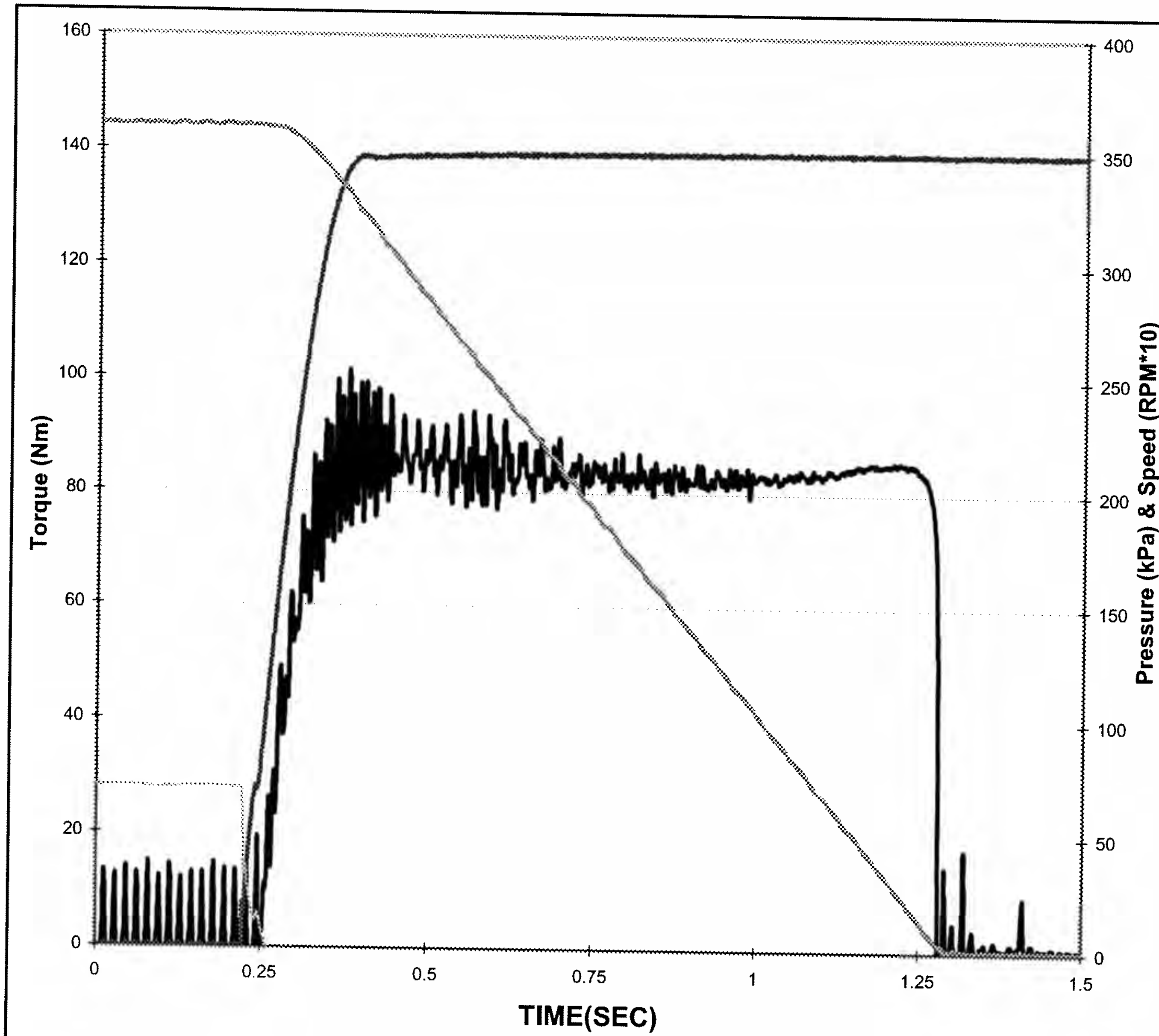

Date of Test:	8/5/2007
Time of Test:	11:57:44
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	140
Cycle Number:	25200
Temperature:	140 °C
	(134 - 146)
Apply Pressure:	349 kPa
	(340 - 350)
Energy:	15.8 KJ
	(15.4 - 16.0)
Engage Time:	1.06 Sec
	(0.85 - 1.05)

Torque

Maximum:	86 N*m
	(>90)
Midpoint:	83 N*m
	(80 - 105)
Max - Mid:	3 N*m
	(<30)
End - Mid:	-12 N*m
End:	71 N*m
	(Report)

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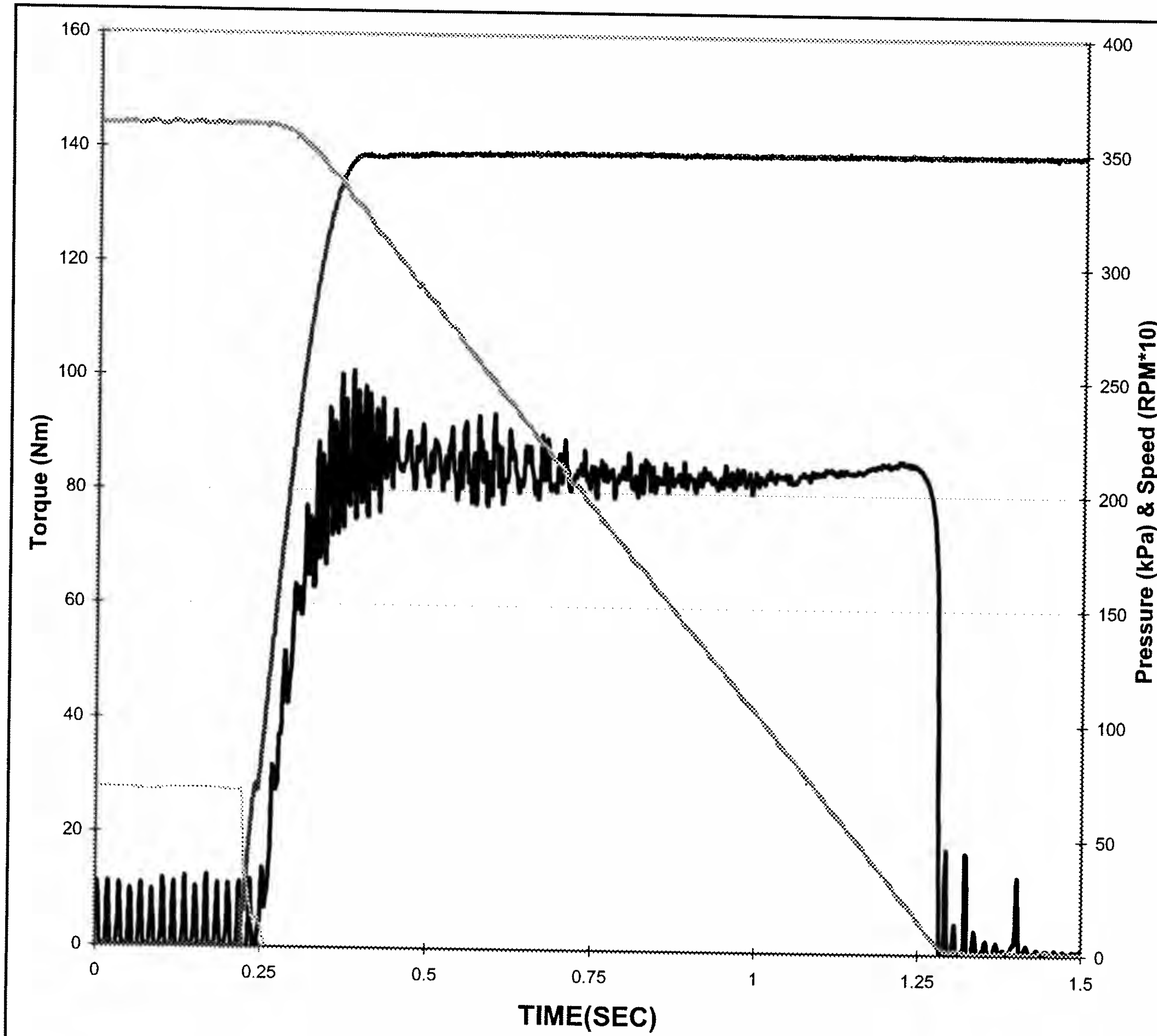

Date of Test:	8/5/2007
Time of Test:	16:57:45
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	145
Cycle Number:	26100
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	348 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.07 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	83 N*m *(80 - 105)*
Max - Mid:	3 N*m *(<30)*
End - Mid:	-11 N*m
End:	72 N*m *(Report)*

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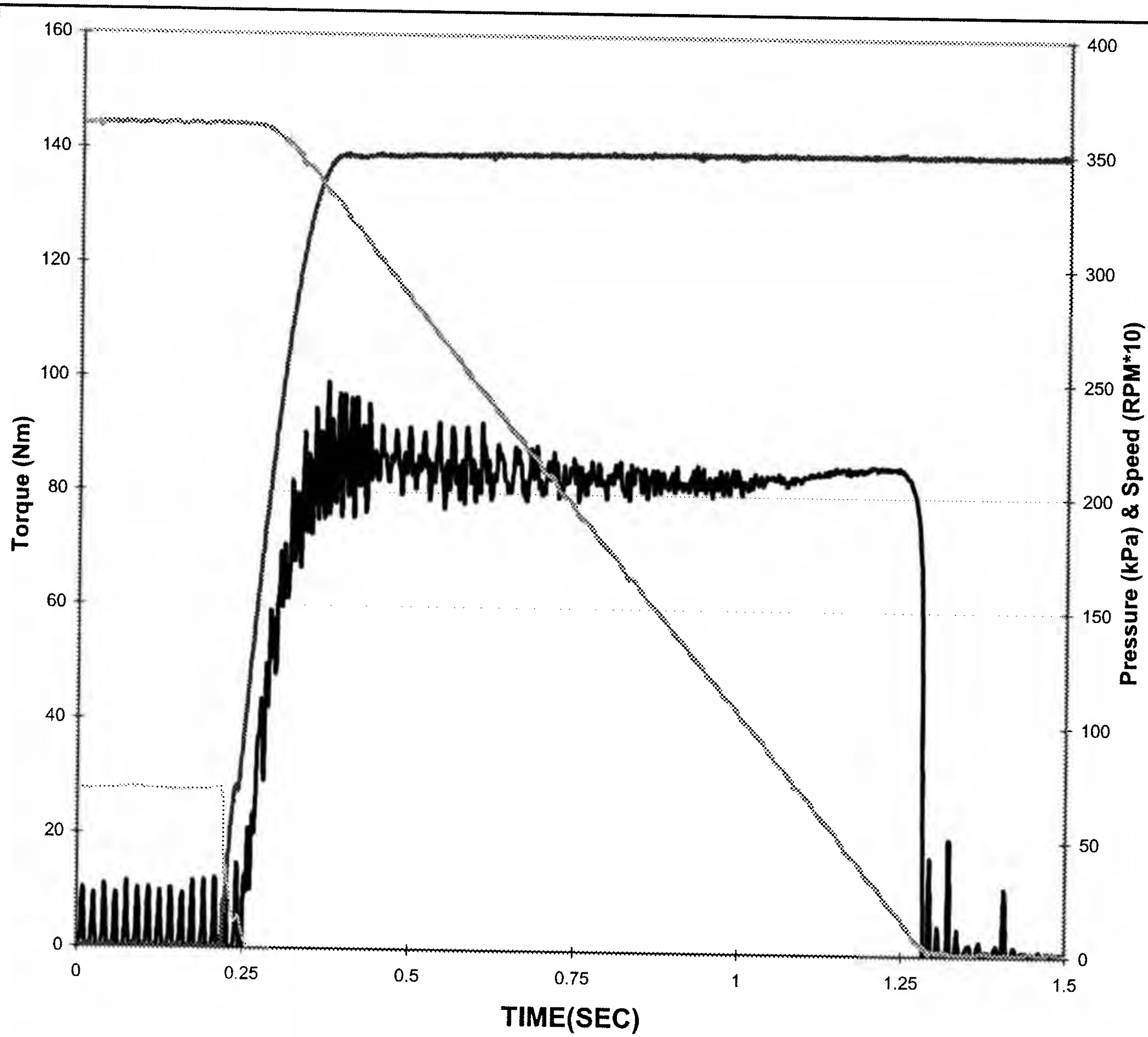

Date of Test:	8/5/2007
Time of Test:	21:57:45
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	150
Cycle Number:	27000
Temperature:	140 °C (134 - 146)
Apply Pressure:	348 kPa (340 - 350)
Energy:	15.8 KJ (15.4 - 16.0)
Engage Time:	1.06 Sec (0.85 - 1.05)

Torque

Maximum:	85 N*m (>90)
Midpoint:	83 N*m (80 - 105)
Max - Mid:	3 N*m (<30)
End - Mid:	-10 N*m
End:	73 N*m (Report)

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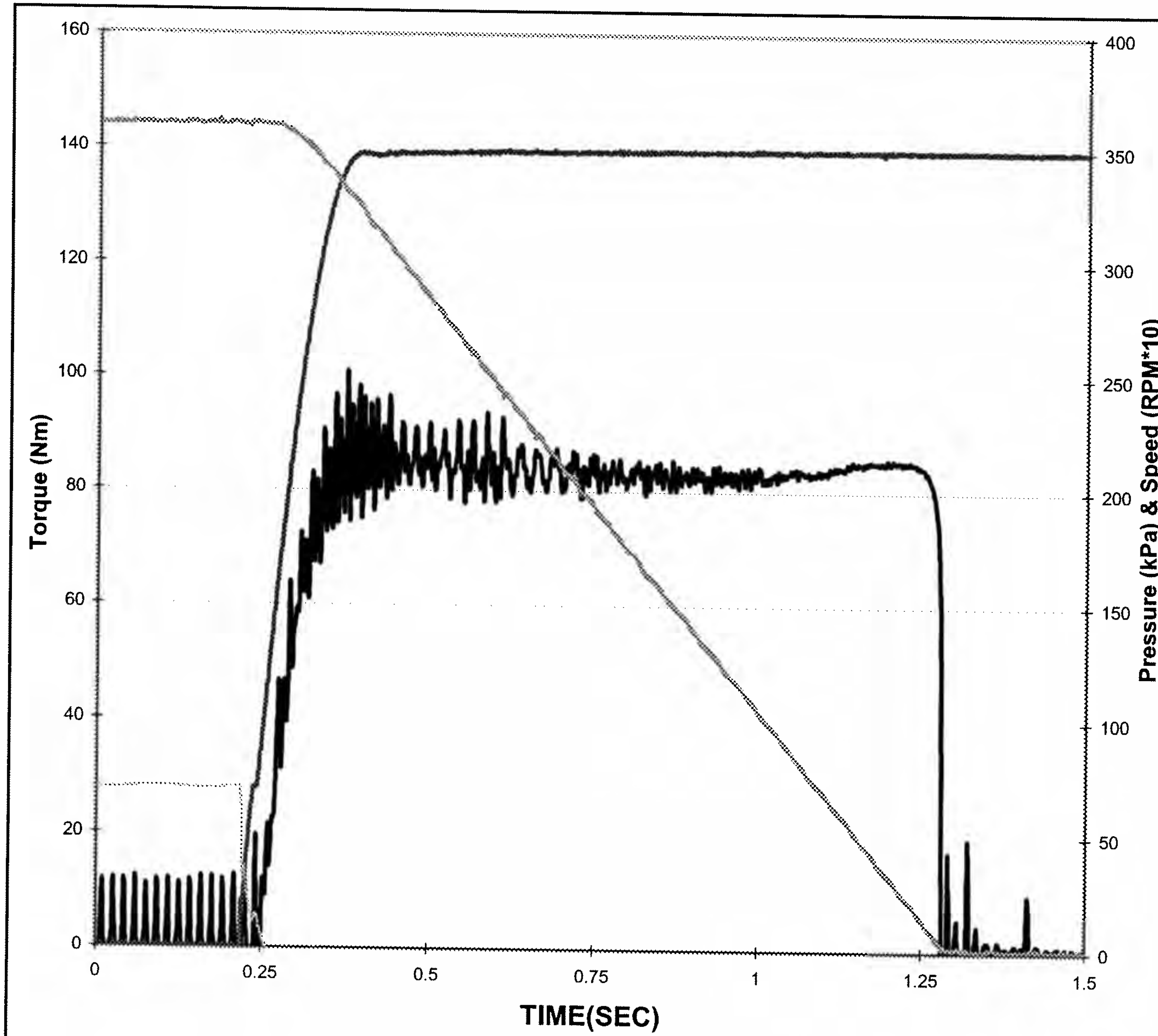

Date of Test:	8/6/2007
Time of Test:	2:57:46
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	155
Cycle Number:	27900
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	1.05 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	83 N*m *(80 - 105)*
Max - Mid:	3 N*m *(<30)*
End - Mid:	-10 N*m
End:	73 N*m *(Report)*

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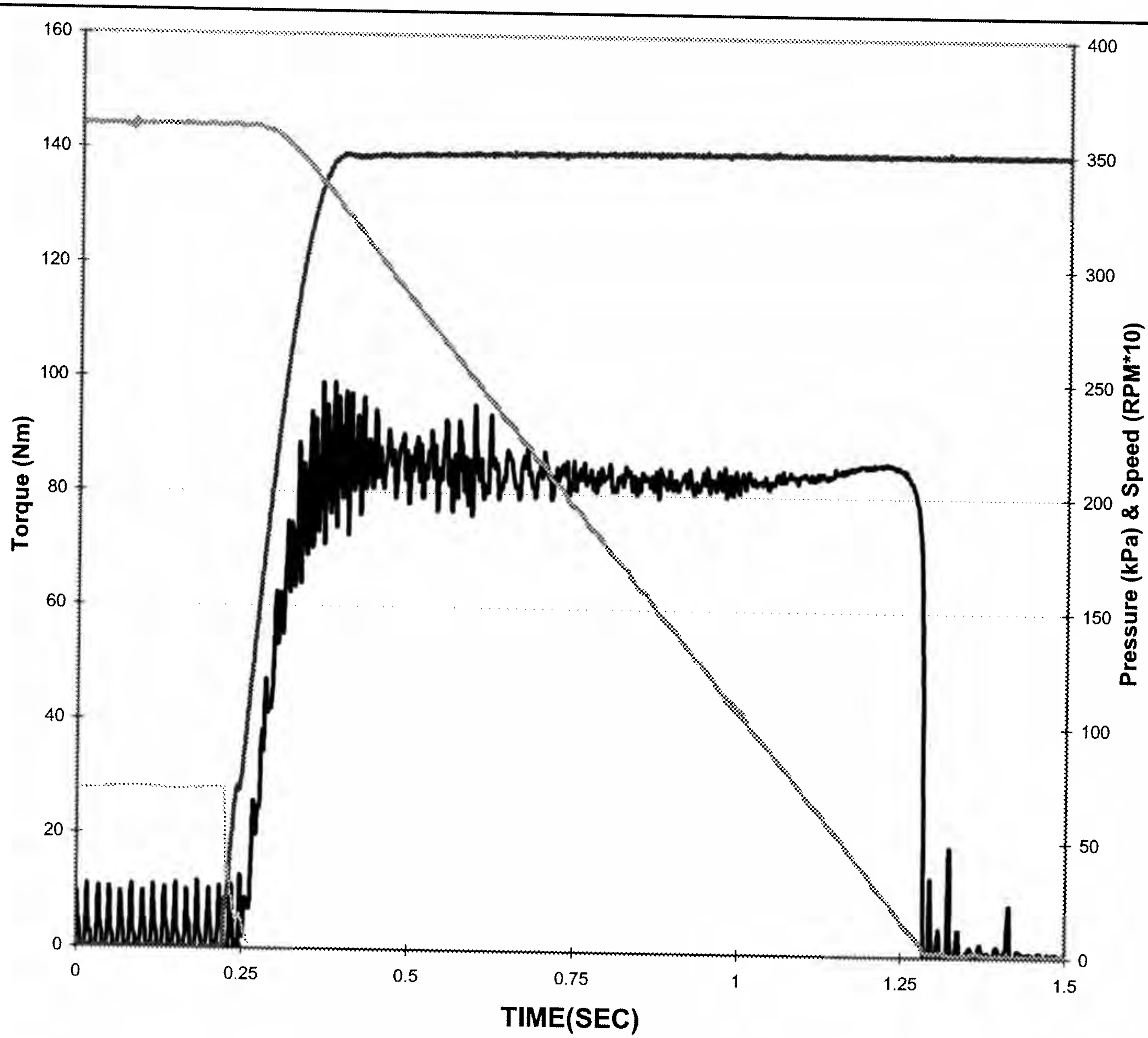

Date of Test:	8/6/2007
Time of Test:	7:57:47
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	160
Cycle Number:	28800
Temperature:	139 °C (134 - 146)
Apply Pressure:	349 kPa (340 - 350)
Energy:	15.7 KJ (15.4 - 16.0)
Engage Time:	1.07 Sec (0.85 - 1.05)

Torque

Maximum:	86 N*m (>90)
Midpoint:	83 N*m (80 - 105)
Max - Mid:	3 N*m (<30)
End - Mid:	-10 N*m
End:	73 N*m (Report)

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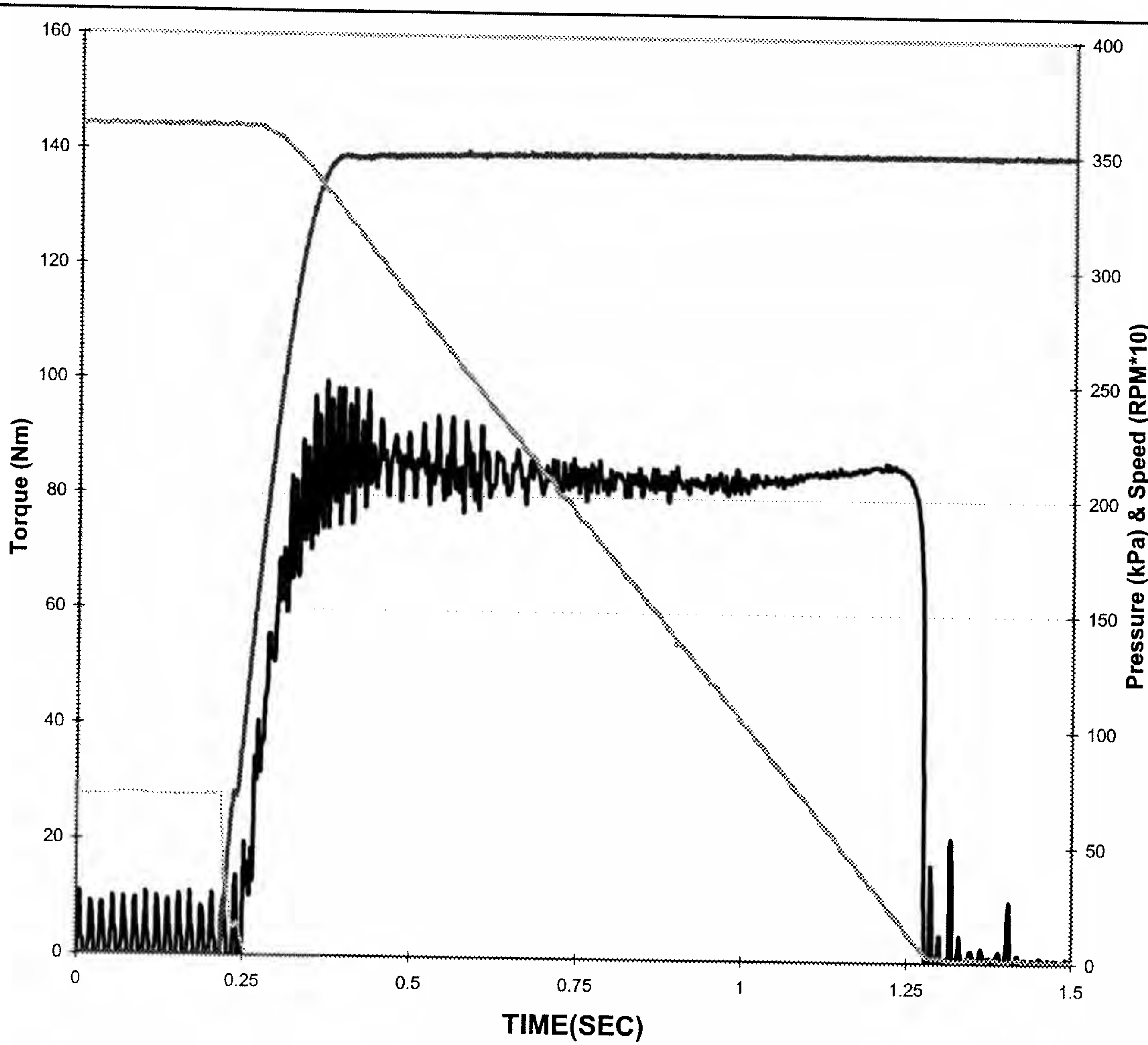

Date of Test:	8/6/2007
Time of Test:	12:57:48
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	165
Cycle Number:	29700
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	1.06 Sec *(0.85 - 1.05)*

Torque

Maximum:	87 N*m *(>90)*
Midpoint:	83 N*m *(80 - 105)*
Max - Mid:	3 N*m *(<30)*
End - Mid:	-12 N*m
End:	71 N*m *(Report)*

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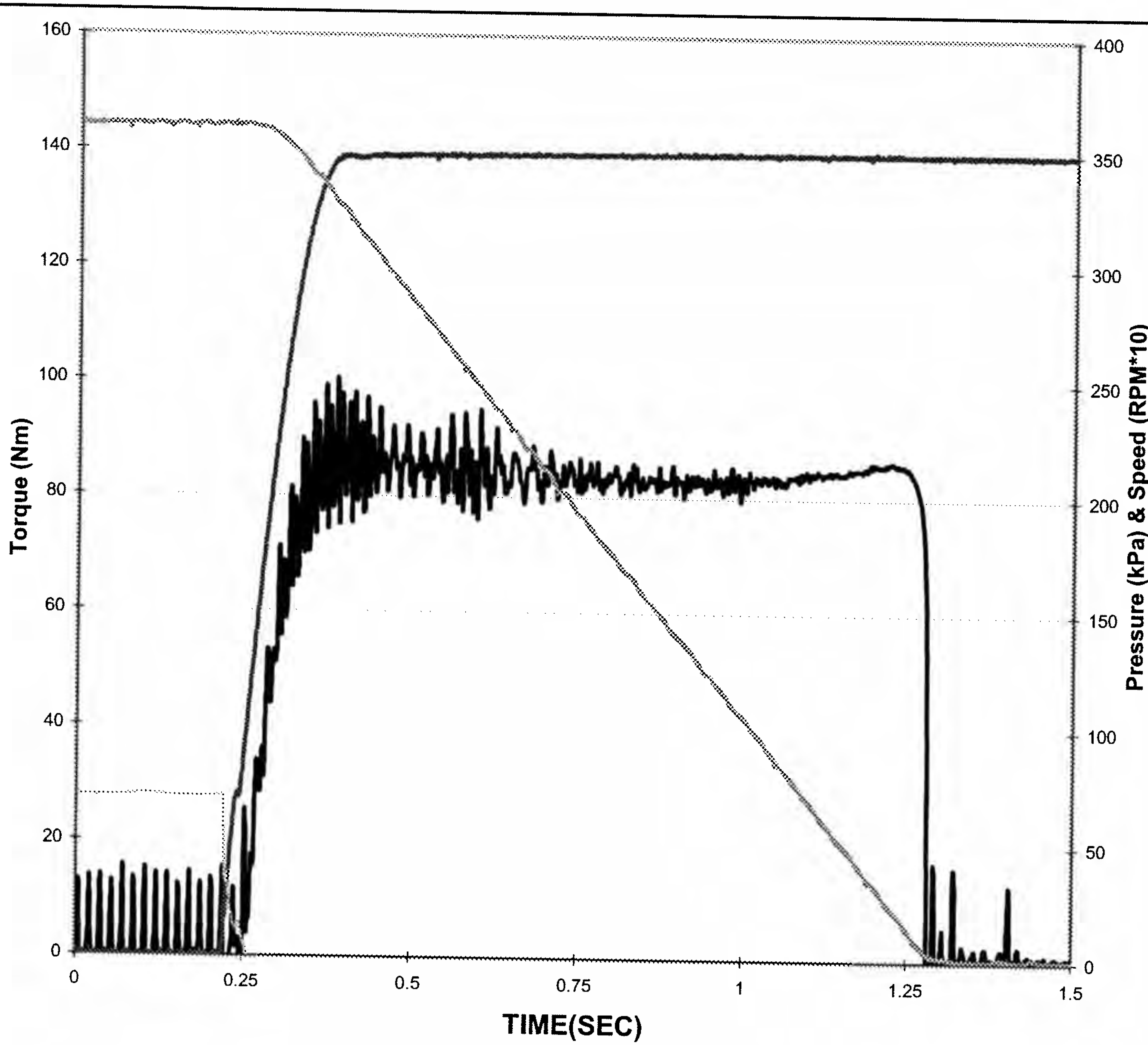

Date of Test:	8/6/2007
Time of Test:	17:57:49
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	170
Cycle Number:	30600
Temperature:	139 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	1.09 Sec *(0.85 - 1.05)*

Torque

Maximum:	87 N*m *(>90)*
Midpoint:	84 N*m *(80 - 105)*
Max - Mid:	3 N*m *(<30)*
End - Mid:	-13 N*m
End:	70 N*m *(Report)*

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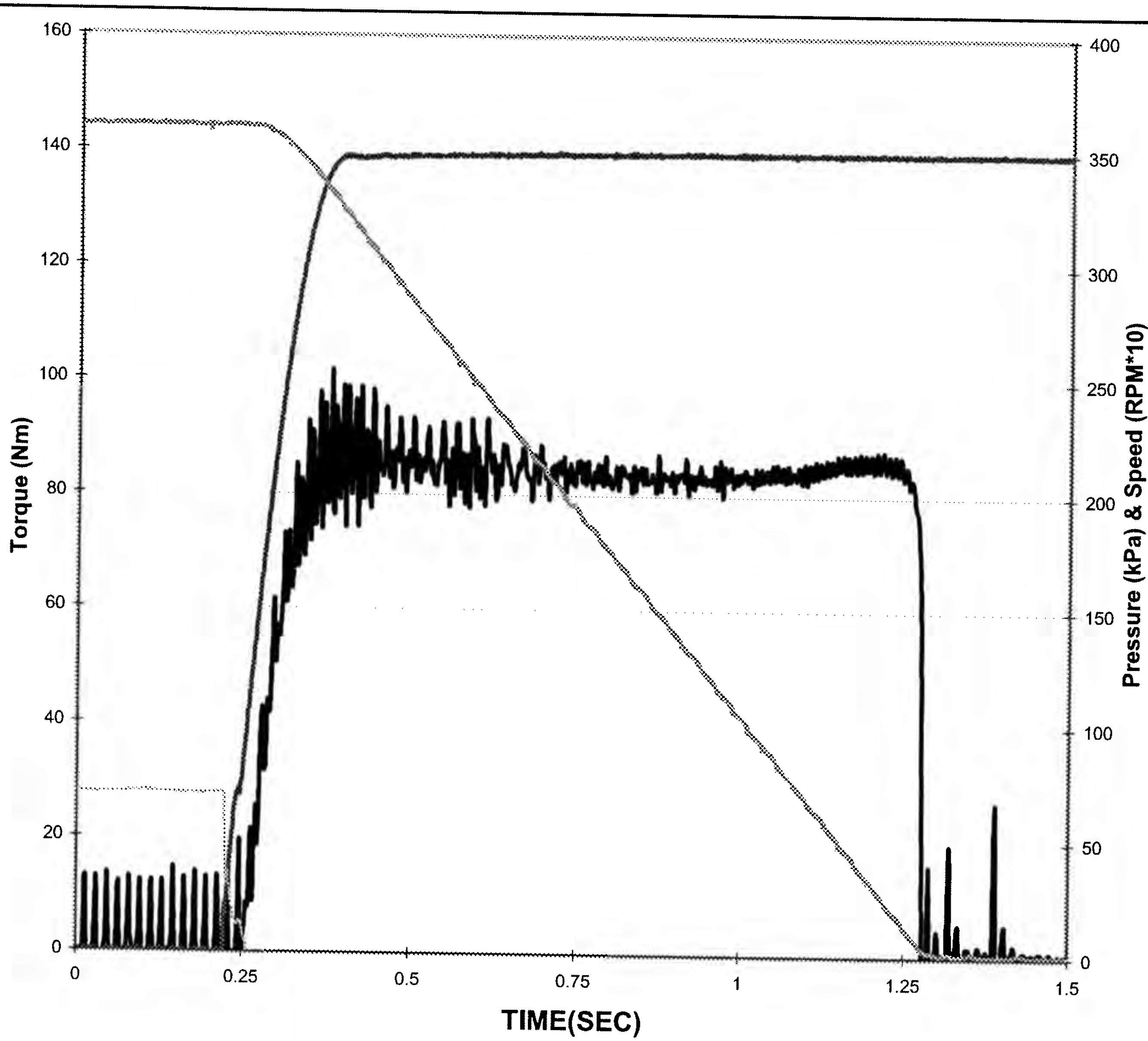

Date of Test:	8/6/2007
Time of Test:	22:57:50
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	175
Cycle Number:	31500
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	1.05 Sec *(0.85 - 1.05)*

Torque

Maximum:	88 N*m *(>90)*
Midpoint:	84 N*m *(80 - 105)*
Max - Mid:	4 N*m *(<30)*
End - Mid:	-10 N*m
End:	74 N*m *(Report)*

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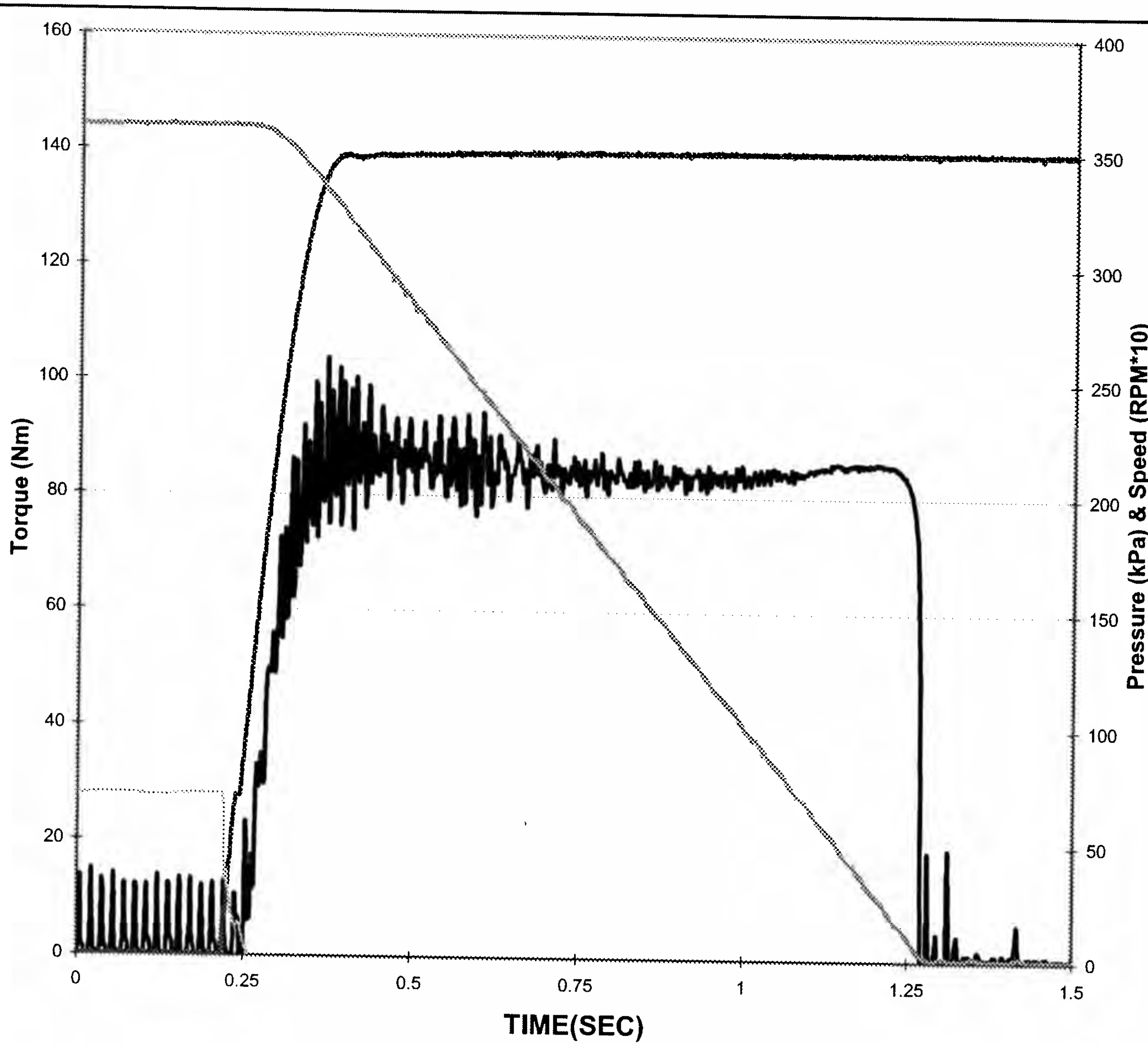

Date of Test:	8/7/2007
Time of Test:	3:57:51
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	180
Cycle Number:	32400
Temperature:	140 °C
	(134 - 146)
Apply Pressure:	349 kPa
	(340 - 350)
Energy:	15.7 KJ
	(15.4 - 16.0)
Engage Time:	1.06 Sec
	(0.85 - 1.05)

Torque

Maximum:	86 N*m
	(>90)
Midpoint:	84 N*m
	(80 - 105)
Max - Mid:	2 N*m
	(<30)
End - Mid:	-13 N*m
End:	71 N*m
	(Report)

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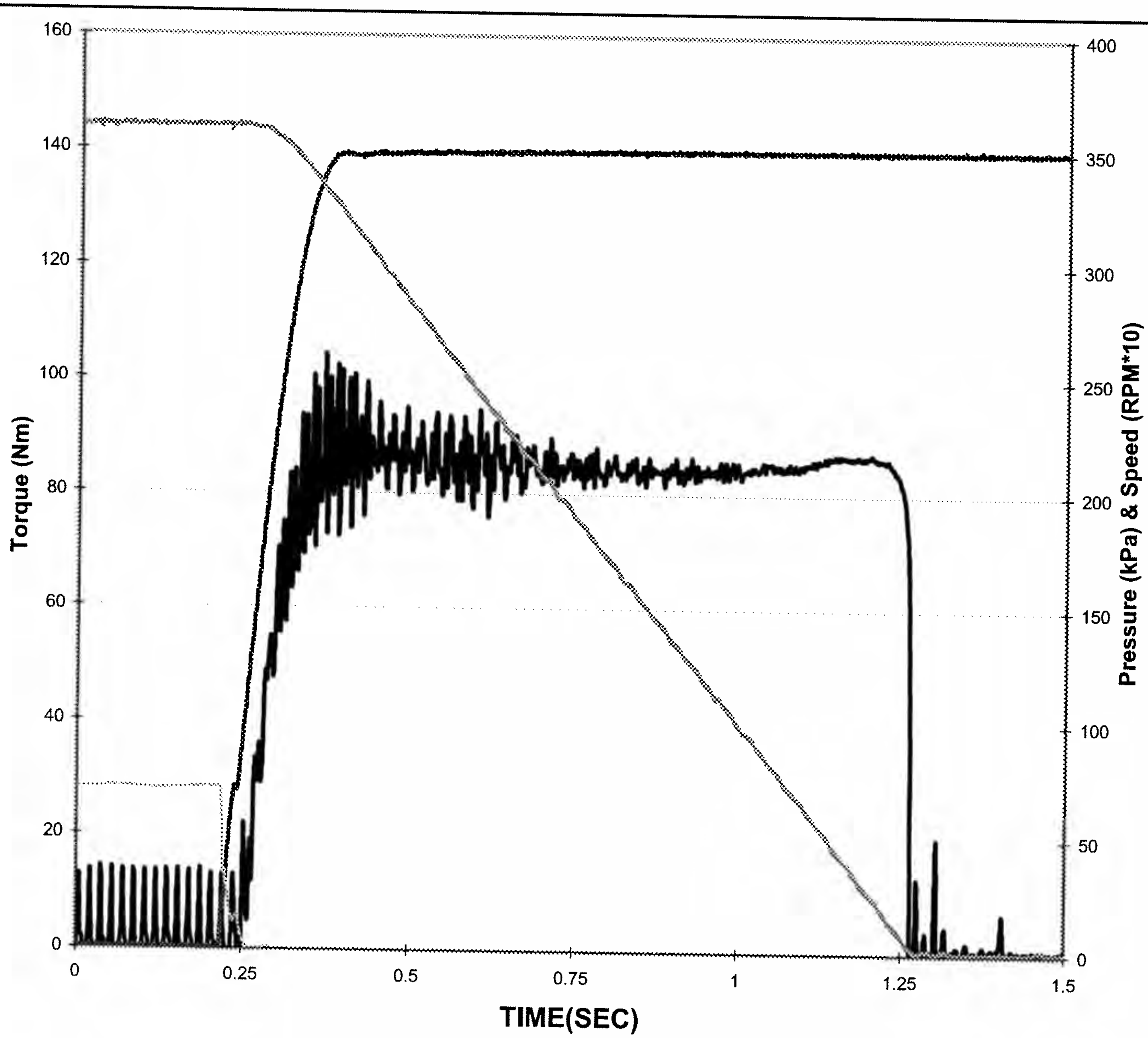

Date of Test:	8/7/2007
Time of Test:	8:57:51
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	185
Cycle Number:	33300
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.05 Sec *(0.85 - 1.05)*

Torque

Maximum:	87 N*m *(>90)*
Midpoint:	84 N*m *(80 - 105)*
Max - Mid:	3 N*m *(<30)*
End - Mid:	-12 N*m
End:	73 N*m *(Report)*

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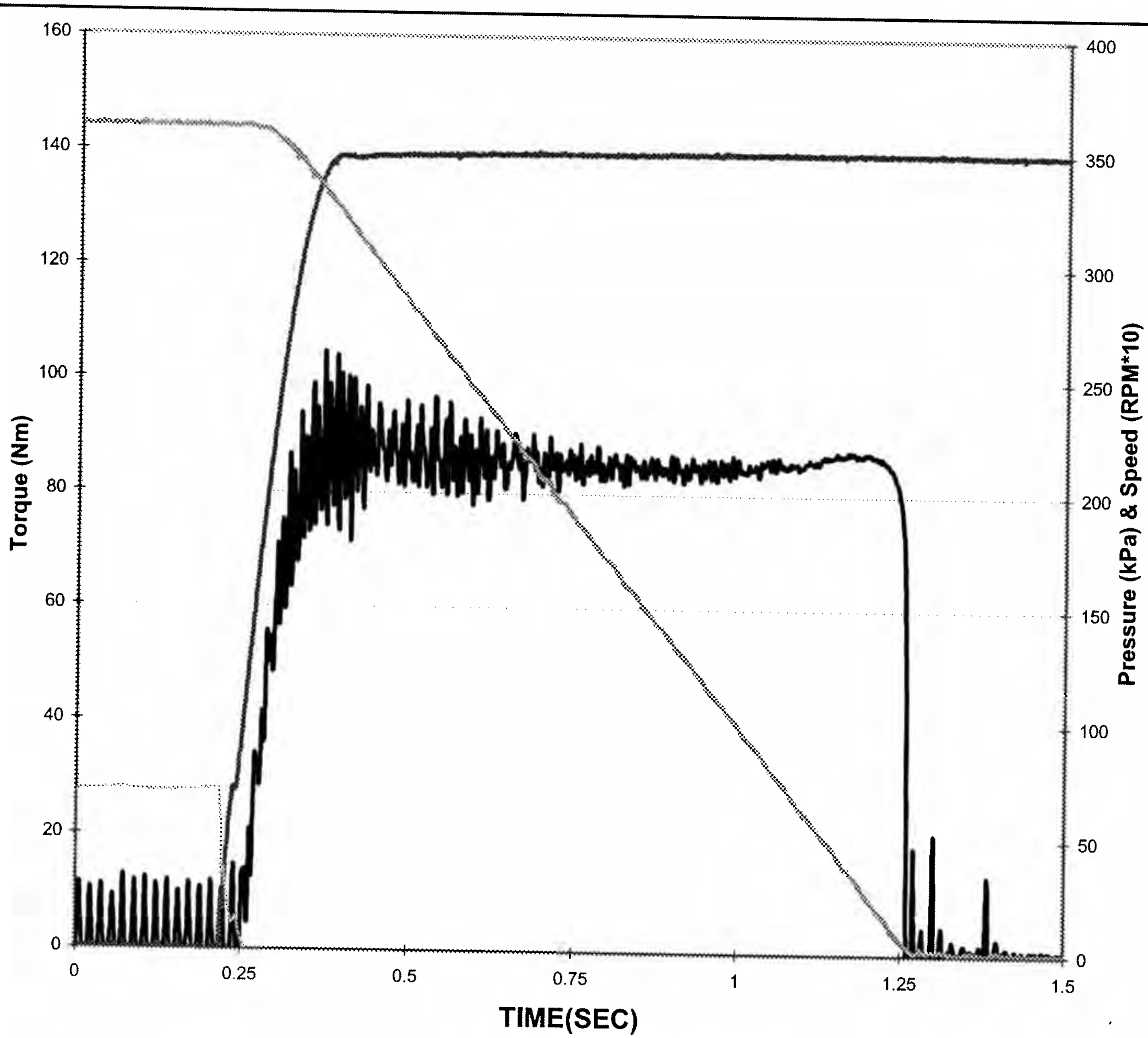

Date of Test:	8/7/2007
Time of Test:	13:57:52
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	190
Cycle Number:	34200
Temperature:	141 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	1.06 Sec *(0.85 - 1.05)*

Torque

Maximum:	88 N*m *(>90)*
Midpoint:	85 N*m *(80 - 105)*
Max - Mid:	3 N*m *(<30)*
End - Mid:	-12 N*m
End:	73 N*m *(Report)*

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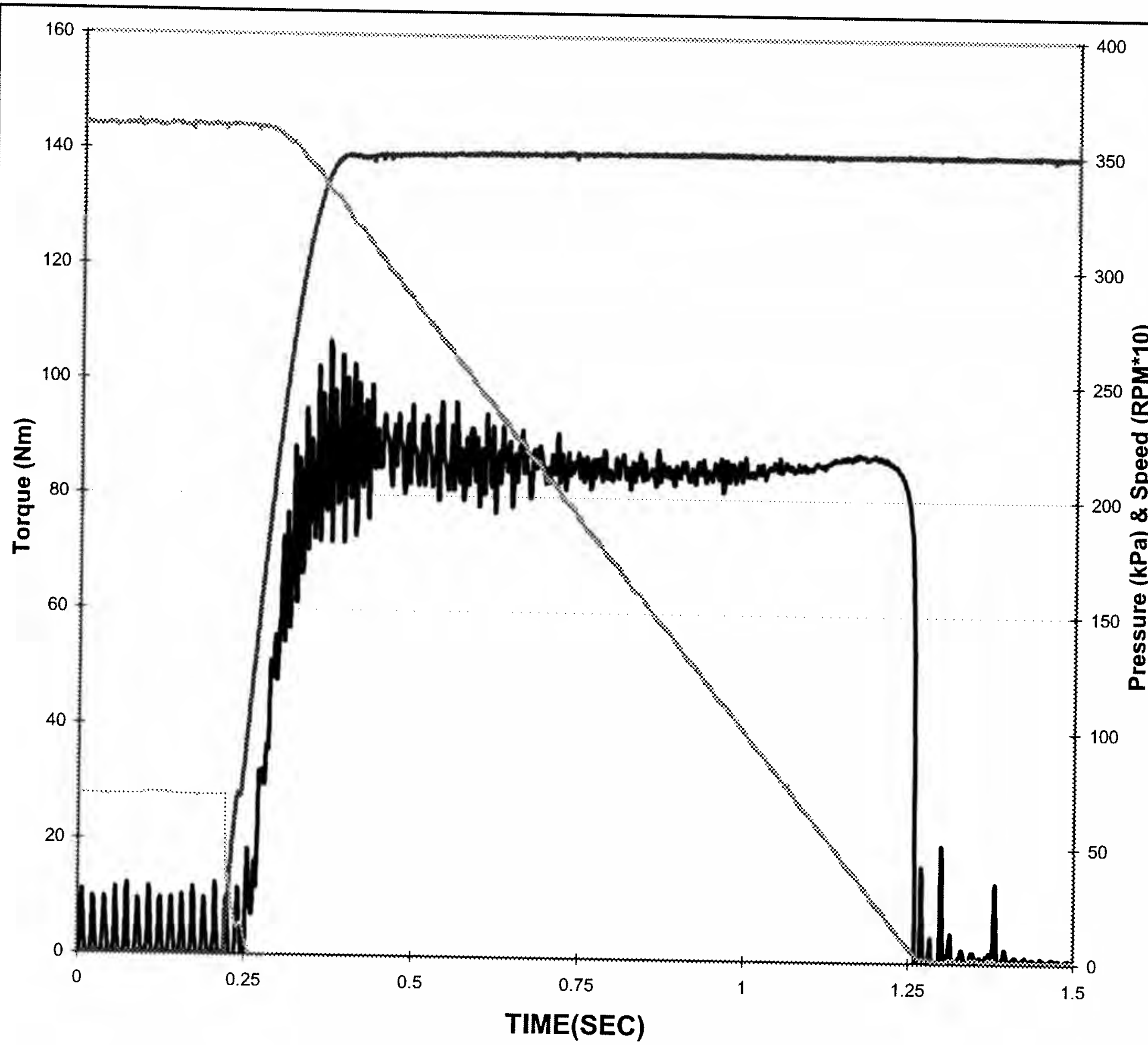

Date of Test:	8/7/2007
Time of Test:	18:57:53
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	195
Cycle Number:	35100
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	1.05 Sec *(0.85 - 1.05)*

Torque

Maximum:	88 N*m *(>90)*
Midpoint:	85 N*m *(80 - 105)*
Max - Mid:	3 N*m *(<30)*
End - Mid:	-12 N*m
End:	73 N*m *(Report)*

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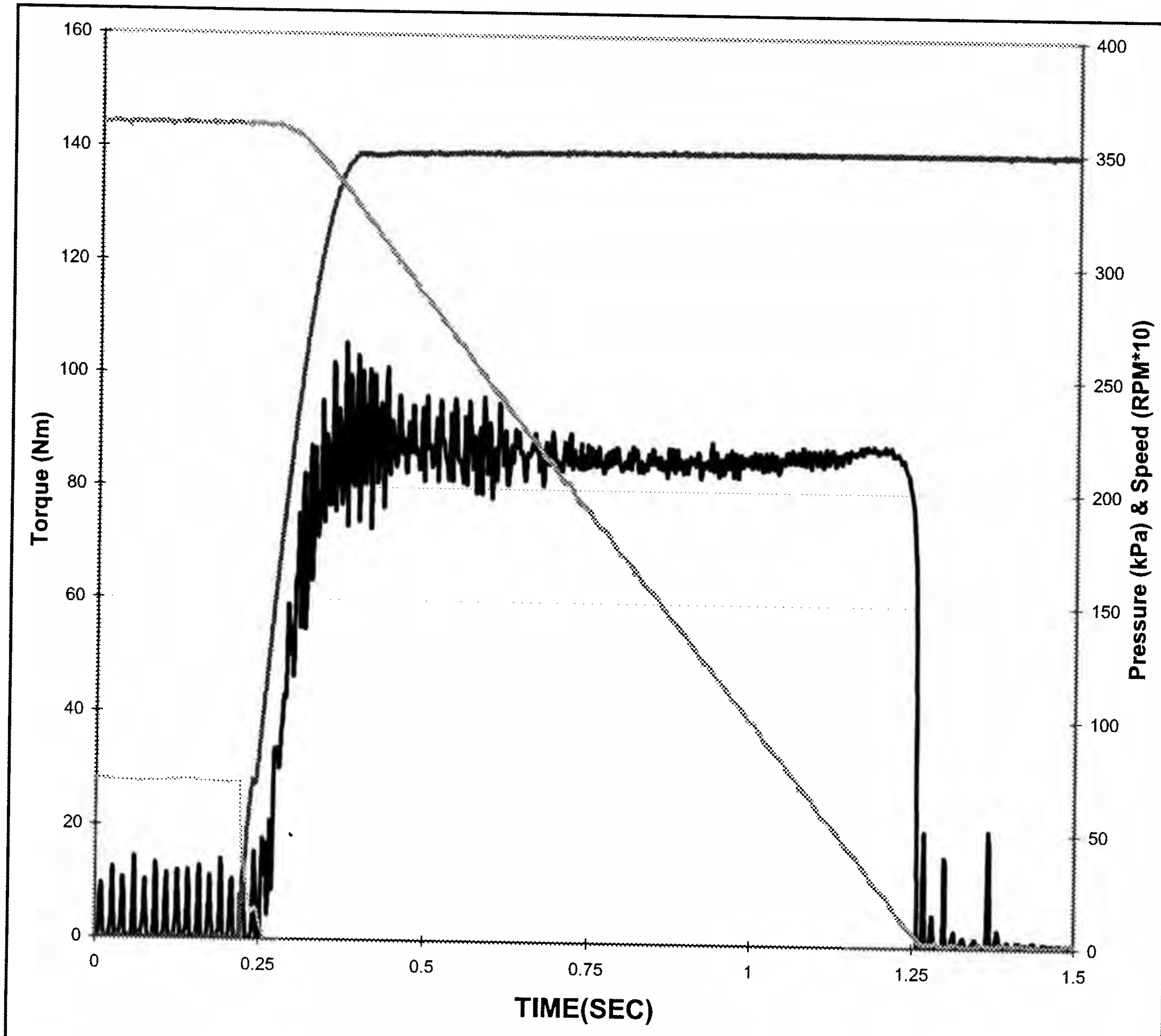


Date of Test:	8/7/2007
Time of Test:	23:57:54
Test Type:	PLATE
Test Number:	HC11-24-80
Fluid Code:	AL-27637-L
Hour Number:	200
Cycle Number:	36000
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	1.05 Sec *(0.85 - 1.05)*

Torque

Maximum:	88 N*m *(>90)*
Midpoint:	86 N*m *(80 - 105)*
Max - Mid:	3 N*m *(<30)*
End - Mid:	-13 N*m
End:	73 N*m *(Report)*

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

Fuels and Lubricants Research Division

Report on

John Deere JDQ-96
Performed using 1400 Series Axle

Conducted for

ARMY LAB

AL-27637-L

Test Number
07649

October 15, 2007

Submitted by:

Michael D. Lochte
Manager
Specialty & Driveline Fluids
Evaluations

John Deere JDQ-96 Performed using 1400 Series Axle

General Information

Oil Code: AL-27637-L	E.O.T. Date: October 15, 2007

Purpose

The purpose of this test was to evaluate the anti-chatter properties of this oil on the brakes of a 1400 series John Deere Inboard Planetary Axle.

Test Procedure

The test was performed as specified by John Deere Product Engineering. The only changes made to the Deere procedure were those necessary to compensate for a different spiral bevel gear ratio. This procedure is proprietary to Deere and Company.

Data Interpretation

The capacity for each engagement is the average torque during the middle of the engagement. The torque variation is the greatest difference between the maximum and minimum torque recorded during any 0.2-second portion of the engagement. The SwRI variation is the sum of all differences between the maximum torque and minimum torque for each engagement. It is obtained by summing all torque variations of each 0.2-second time block of all engagements.

Test Number

The run number listed on this report is a random number and is not sequential. Only SwRI® can link this run number to JDQ-96, AL-27637-L, October 15, 2007.

John Deere JDQ-96 Performed using 1400 Series Axle

Results

Oil Code: AL-27637-L	**E.O.T. Date:** October 15, 2007

The candidate results can be compared to the baseline reference average. Pass or fail decisions are only made by John Deere Product Engineering. The current reference baseline average is the average of the five most recent tests.

Current Reference Baseline Average (N · m)					
	1,000 Cycles	**10,000 Cycles**	**20,000 Cycles**	**30,000 Cycles**	**TOTAL**
Relative Capacity	338,535	338,534	341,629	343,274	1,361,972
Torque Variation	79,214	84,272	79,152	74,708	317,346

Results From Test Candidate AL-27637-L					
	1,000 Cycles	**10,000 Cycles**	**20,000 Cycles**	**30,000 Cycles**	**TOTAL**
Relative Capacity	367,565				
Torque Variation	86,470				

Tables 1 of the Appendix contains chatter test results from 1,000cycles. Table 2 contains results of the five current baseline reference tests. Figures 1 through 4 are graphic presentations of candidate oil performance compared to baseline reference data.

Figure 5 is a graphic presentation of 1000-cycle reference results and AL-27637-L. Table 3 contains the history of reference tests.

John Deere JDQ-96 Performed using 1400 Series Axle

Oil Code: AL-27637-L	**E.O.T. Date:** October 15, 2007

Appendix

Tables

1. Table 1 – Durability results 1,000 cycles Candidate Oil
2. Table 2 – Reference Data Compared to Candidate Data
3. Figure 1 & Figure 2 - Torque Variation Chart
4. Figure 3 & Figure 4 – Relative Capacity & Average Disk Thickness Chart
5. Figure 5 - Graphic presentation of 1000 cycle reference results & Candidate
6. Table 3 - History of reference tests

October 15, 2007

TABLE 1: JDQ-96 DURABILITY TEST RESULTS 1,000 CYCLES

SwRI Oil Code LO-222425 Sponsor Oil Code AL-27637-L

Axle Speed (rpm)	Brake Press. (kPa)	TORQUE VARIATION TEST RESULTS (TORQUE and VARIATION in Nm)											
		Oil Temp. 32°C			Oil Temp. 49°C			Oil Temp. 60°C			Oil Temp. 71°C		
		Torque	Variation	Temp.	Torque	Variation	Temp.	Torque	Variation	Temp.	Torque	Variation	Temp.
8	3831	4608	2450	26	4627	460	51	4673	1060	61	4620	130	72
10	3831	4490	2460	26	4633	780	50	4649	1130	60	4554	490	70
15	3831	4457	2970	26	4493	900	49	4314	470	59	3955	120	70
20	3831	4602	1080	26	4444	1070	49	4385	870	60	4194	300	71
25	3831	4509	1060	27	4389	1120	49	4392	840	61	4290	650	72
30	3831	4484	1100	28	4386	1210	50	4380	950	61	4256	1080	71
35	3831	4403	980	28	4303	1130	50	4330	1080	59	4349	1080	71
40	3831	4471	1080	30	4374	1170	50	4361	1180	59	4357	1070	71
45	3831	4344	1010	30	4295	1250	50	4322	1200	60	4262	1120	71
50	3831	4289	960	31	4244	1160	51	4330	1030	61	4263	1250	71
55	3831	4381	850	33	4366	1180	49	4286	1100	61	4281	1030	71
60	3831	4286	880	33	4302	1130	49	4270	1030	61	4234	1000	71
15	1532	1973	720	31	2026	750	49	2043	740	61	2012	690	70
15	2300	2843	870	31	2882	930	48	2868	910	59	2766	660	71
15	3065	3677	930	31	3667	1020	47	3643	1140	58	3644	850	70
15	3831	4539	2460	31	4503	930	48	4516	1210	57	4517	950	69
15	4598	5509	2460	31	5353	1030	48	5242	750	59	5280	610	71
15	5364	6371	2430	31	6222	1090	48	5747	630	58	6062	820	70
15	6130	7242	2370	31	6981	1170	49	6682	880	59	6939	630	70
15	7050	8191	2200	31	7897	1160	49	7643	1140	59	7601	640	70

Temp (°C)	Relative Capacity (Nm)	Torque Variation (Nm)	SwRI Variation (Nm)
32	93,669	31,320	390,060
49	92,386	20,640	285,560
60	91,075	19,340	249,820
71	90,436	15,170	182,130
TOTAL	367,565	86,470	1,107,570

TABLE 2: JDQ-96 REFERENCE DATA COMPARED TO CANDIDATE DATA

EOT Date: October 15, 2007

Oil Code : AL-27637-L

Reference Oil Coded : 69X31111i	Cycles	Relative Capacity	Torque Variation	SwRI Variation	Average Facing Thickness (millimeters)
First Reference Run					
	1,000	326,304	57,420	730,050	7.60
	10,000	331,809	64,900	804,030	7.50
	20,000	345,325	69,500	899,880	7.44
	30,000	341,770	66,210	810,190	7.39
	Total	1,345,208	258,030	3,244,150	
Second Reference Run					
	1,000	337,791	66,660	848,580	7.60
	10,000	338,055	92,240	1,129,330	7.55
	20,000	343,166	77,010	1,001,920	7.49
	30,000	350,470	73,280	863,980	7.44
	Total	1,369,482	309,190	3,843,810	
Third Reference Run					
	1,000	339,375	100,390	1,204,240	7.56
	10,000	335,754	106,780	1,079,450	7.52
	20,000	334,120	84,770	1,030,270	7.49
	30,000	335,614	79,620	1,021,190	7.47
	Total	1,344,863	371,560	4,335,150	
Fourth Reference Run					
Run on new backing pla	1,000	343,906	79,990	1,020,120	7.48
and piston	10,000	343,056	72,520	893,570	7.30
	20,000	342,668	69,920	885,870	7.07
	30,000	345,315	70,360	833,920	6.90
	Total	1,374,945	292,790	3,633,480	
Invalid test run on same	*1,000*	*348,860*	*132,110*	*1,721,010*	
backing plate and pistoı	*10,000*	*323,093*	*153,860*	*1,919,720*	
as test above was run on					
Fifth Reference Run					
most recent run	**1,000**	**345,296**	**91,610**	**1,125,260**	**7.50**
Run on new backing	**10,000**	**343,999**	**84,920**	**1,019,400**	**7.33**
plate and piston	**20,000**	**342,864**	**94,560**	**1,264,070**	**7.22**
	30,000	**343,201**	**84,070**	**1,052,400**	**7.11**
	Total	**1,375,360**	**355,160**	**4,461,130**	
AL-27637-L		Candidate Oil Test Results			
	1,000	367,565	86,470	1,107,570	
	10,000				
	20,000				
	30,000				
	Total	367,565	86,470	1,107,570	

Figure 1

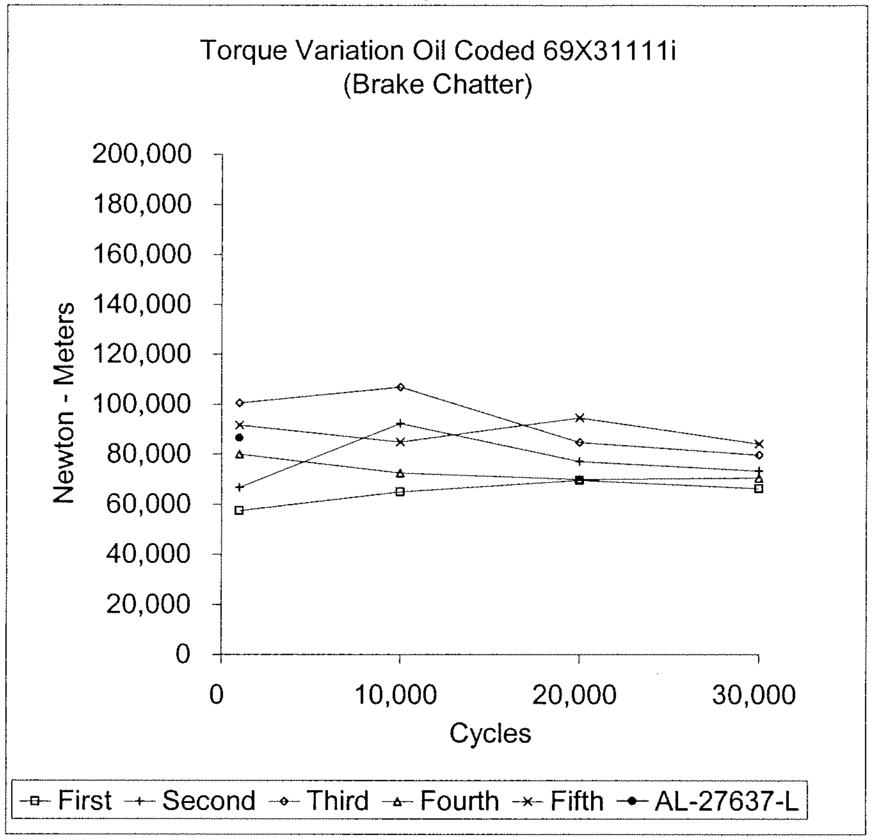


Figure 2

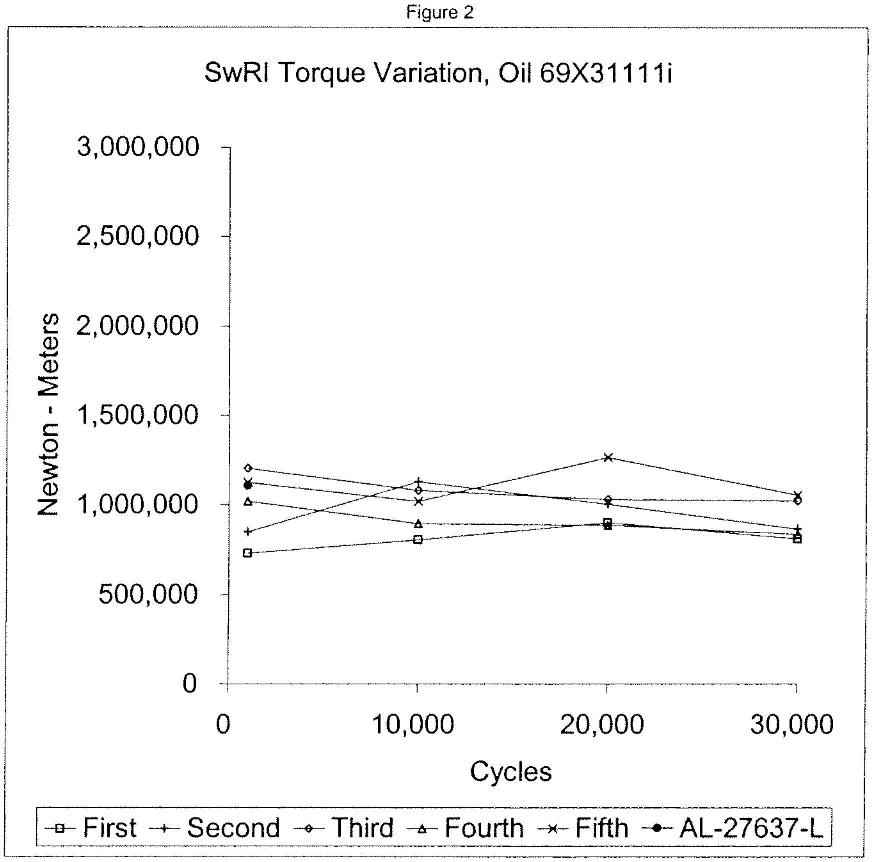


Figure 3

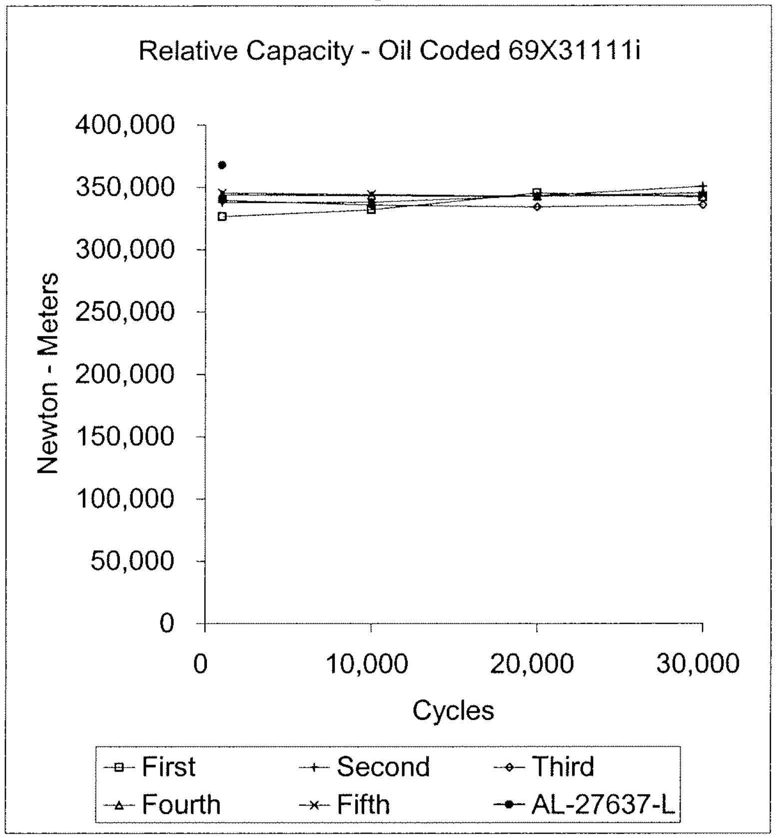


Figure 4

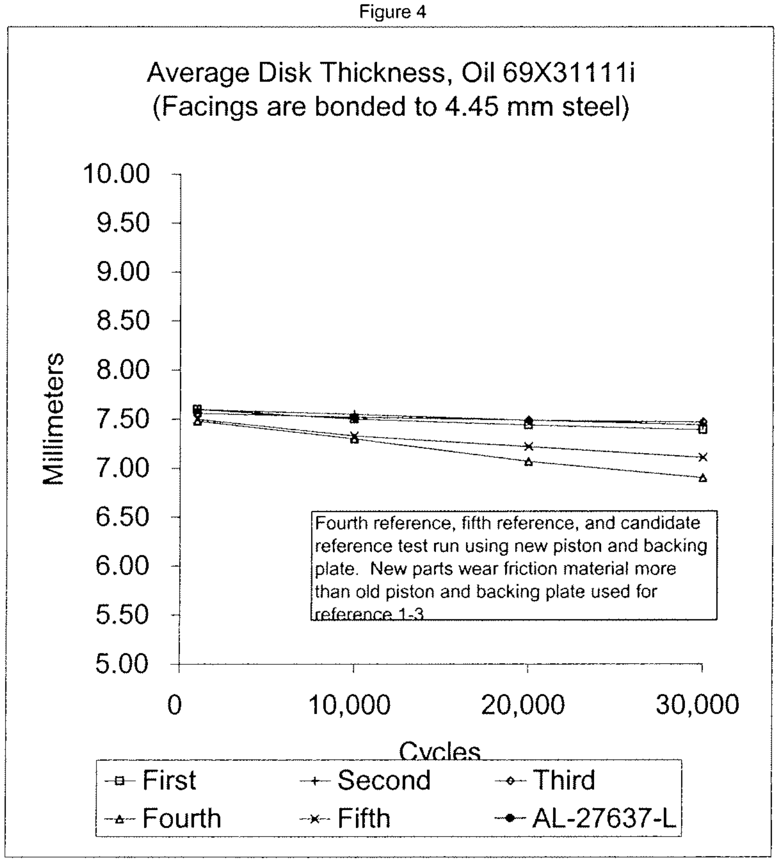
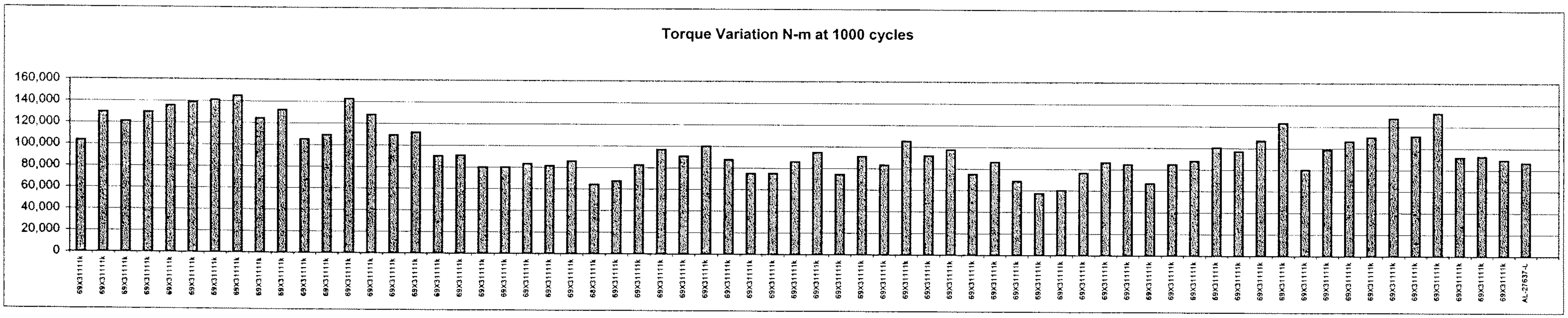


Table 3

AL-27637-L October 15, 2007

History of 1000 cycle reference tests.

		Torque variation at 1000 cycles
69X31111k	1999 brake disk	103,360
69X31111k	1997 brake disk	129,540
69X31111k	2000 brake disk	121,120
69X31111k	2000 brake disk	129,620
69X31111k	2000 brake disk	135,700
69X31111k	2000 brake disk	138,760
69X31111k	2000GDD brake di	140,830
69X31111k	2000GDD brake	144,820
69X31111k	2000GDD brake	124,310
69X31111k	2000 GDD brake	131,860
69X31111k	2000 GDD brake	105,010
69X31111k	2000 GDD brake	109,220
69X31111k	2000 GDD brake	142,510
69X31111k	2000 GDD brake	128,080
69X31111k	2000 GDD brake	109,100
69X31111k	2000 GDD brake	111,800
69X31111k	2000 GDD brake	90,070
69X31111k	2000 GDD brake	90,810
69X31111k	2000 GDD brake	79,930
69X31111k	2000 GDD brake	79,930
69X31111k	2000 GDD brake	83,190
69X31111k	2000 GDD brake	81,220
69X31111k	2000 GDD brake	85,570
68X31111k	2000 GDD brake	64,170
69X31111k	2000 GDD brake	67,390
69X31111k	2000 GDD brake	82,410
69X31111k	2000 GDD brake	96,730
69X31111k	2000 GDD brake	90,390
69X31111k	2000 GDD brake	99,960
69X31111k	2000 GDD brake	87,380
69X31111k	2000 GDD brake	74,720
69X31111k	2000 GDD brake	74,940
69X31111k	2000 GDD brake	85,980
69X31111k	2000 GDD brake	94,410
69X31111k	2000 GDD brake	74,300
69X31111k	2000 GDD brake	90,950
69X31111k	2000 GDD brake	83,190
69X31111k	2000 GDD brake	105,210
69X31111k	2000 GDD brake	91,960
69X31111k	2000 GDD brake	97,320
69X31111k	2000 GDD brake	75,040
69X31111k	2000 brake disk	86,060
69X31111k	2000 brake disk	68,590
69X31111k	2003 brake disk	57,420
69X31111k	2003 brake disk	60,330
69X31111k	2003 brake disk	76,260
69X31111k	2003 brake disk	86,210
69X31111k	2003 brake disk	84,550
69X31111k	2003 brake disk	66,660
69X31111k	2003 brake disk	84,760
69X31111k	2003 brake disk	87,800
69X31111k	2003 brake disk	100,390
69X31111k	2003 brake disk	96,620
69X31111k	2003 brake disk	106,710
69X31111k	2003 brake disk	123,110
69X31111k	NEW BACKING Pl	79,990
69X31111k		98,440
69X31111k		106,370
69X31111k		110,040
69X31111k		127,550
69X31111k		111,280
69X31111k	invalid run	132,110
69X31111k	NEW BACKING Plate and piston	91,610
69X31111k	NEW BACKING Plate and piston	92,230
69X31111k	plate used for 1 test	89,200
AL-27637-L	same brake plate and piston as above	86,470



AL-27637-L

October 15, 2007

Figure 5

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

Fuels and Lubricants Research Division

Report on

John Deere JDQ-96
Performed using 1400 Series Axle

Conducted for

ARMY LAB

AL-27793-L

Test Number
07981

October 12, 2007

Submitted by:

Michael D. Lochte
Manager
Specialty & Driveline Fluids
Evaluations

John Deere JDQ-96 Performed using 1400 Series Axle

General Information

Oil Code: AL-27793-L	E.O.T. Date: October 12, 2007

Purpose

The purpose of this test was to evaluate the anti-chatter properties of this oil on the brakes of a 1400 series John Deere Inboard Planetary Axle.

Test Procedure

The test was performed as specified by John Deere Product Engineering. The only changes made to the Deere procedure were those necessary to compensate for a different spiral bevel gear ratio. This procedure is proprietary to Deere and Company.

Data Interpretation

The capacity for each engagement is the average torque during the middle of the engagement. The torque variation is the greatest difference between the maximum and minimum torque recorded during any 0.2-second portion of the engagement. The SwRI variation is the sum of all differences between the maximum torque and minimum torque for each engagement. It is obtained by summing all torque variations of each 0.2-second time block of all engagements.

Test Number

The run number listed on this report is a random number and is not sequential. Only SwRI® can link this run number to JDQ-96, AL-27793-L, October 12, 2007.

John Deere JDQ-96 Performed using 1400 Series Axle

Results

Oil Code: AL-27793-L	**E.O.T. Date:** October 12, 2007

The candidate results can be compared to the baseline reference average. Pass or fail decisions are only made by John Deere Product Engineering. The current reference baseline average is the average of the five most recent tests.

Current Reference Baseline Average (N · m)					
	1,000 Cycles	**10,000 Cycles**	**20,000 Cycles**	**30,000 Cycles**	**TOTAL**
Relative Capacity	338,535	338,534	341,629	343,274	1,361,972
Torque Variation	79,214	84,272	79,152	74,708	317,346

Results From Test Candidate AL-27793-L					
	1,000 Cycles	**10,000 Cycles**	**20,000 Cycles**	**30,000 Cycles**	**TOTAL**
Relative Capacity					
Torque Variation					

Tables 1 of the Appendix contains chatter test results from 1,000cycles.

John Deere JDQ-96 Performed using 1400 Series Axle

Oil Code: AL-27793-L	**E.O.T. Date:** October 12, 2007

Appendix

Tables

1. Table 1 – Durability results 1,000 cycles Candidate Oil

October 12, 2007

TABLE 1: JDQ-96 DURABILITY TEST RESULTS 1,000 CYCLES

This oil created too much noise and vibration in the axle. The test was suspended after 441 cycles out of intended 1000 cycles. No Torque variation data was taken for fear of damaging the equipment.

SwRI Oil Code swri code

Sponsor Oil Code AL-27793-L

Axle Speed (rpm)	Brake Press. (kPa)	TORQUE VARIATION TEST RESULTS (TORQUE and VARIATION in Nm)											
		Oil Temp. 32°C			Oil Temp. 49°C			Oil Temp. 60°C			Oil Temp. 71°C		
		Torque	Variation	Temp.	Torque	Variation	Temp.	Torque	Variation	Temp.	Torque	Variation	Temp.
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0

Temp (°C)	Relative Capacity (Nm)	Torque Variation (Nm)	SwRI Variation (Nm)
32	0	0	0
49	0	0	0
60	0	0	0
71	0	0	0
TOTAL	0	0	0

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

FUELS AND LUBRICANTS RESEARCH DIVISION

Report on

CATERPILLAR TO-4 FRICTION PROPERTIES, VC-70

Conducted for

SWRI ARMY LAB

Oil Code:
AL-27875-L

Test Number:
VC70-A-85-I

November 20, 2007

Submitted by:

Brian Koehler
Principal Engineer
Specialty & Driveline Fluids
Evaluations

CATERPILLAR TO-4 FRICTION PROPERTIES, VC-70

Summary Sheet

Company: SWRI ARMY LAB
Test Number: VC70-A-85-I
Test start date: November 16, 2007
End of test date: November 20, 2007
Oil Code: AL-27875-L

Sequence Number	**1219**	**1220**	**1221**	**1222**	**1223**	**1224**	**Friction Retention**
Dynamic Coefficient Vs. Cycle:	F	N/A	P	P	F	F	N/A
Dynamic Coefficient Vs. Load:	F	N/A	P	P	F	P	
Dynamic Coefficient Vs. Speed:	F	N/A	P	F	F	P	
Energy Limit:	P	N/A	P	P	P	P	
Static Coefficient Vs. Cycle:							N/A
Static Coefficient Vs. Load:	P	N/A	P	F	F	P	
Static Coefficient Vs. Speed:	P	N/A	P	F	F	F	
Energy Limit:	P	N/A	P	P	P	P	
Total Wear:	0.015	N/A	0.020	0.054	0.032	0.019	
Wear Limit:	0.030	0.040	0.070	0.070	0.070	0.040	

Comments: The limit lines shown are from the last time the straight grade CAT reference oil was run in this stand.

F = Fail
P = Pass
N/A = Not Applicable

Southwest research institute
I machine oil test AL-27875-L/L)-224036

Test name:	A-85-I
Test date:	11/15/07
Test description:	IMachineAL-27875-l
Oil type:	AL-27875-L/LO-224036
Viscosity:	5W-40
Miscellaneous:	
Software version:	1.40

Run name & desc:	I0706119 - AL-27875-L
Run date:	11/16/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	JG
Remarks:	I Machine oil test AL-27875-L / LO-224036
Sequence name:	SEQ1219
Remarks:	Use 1Y0708 Disc and 1Y3610 Plate
Number of cycles run:	1169

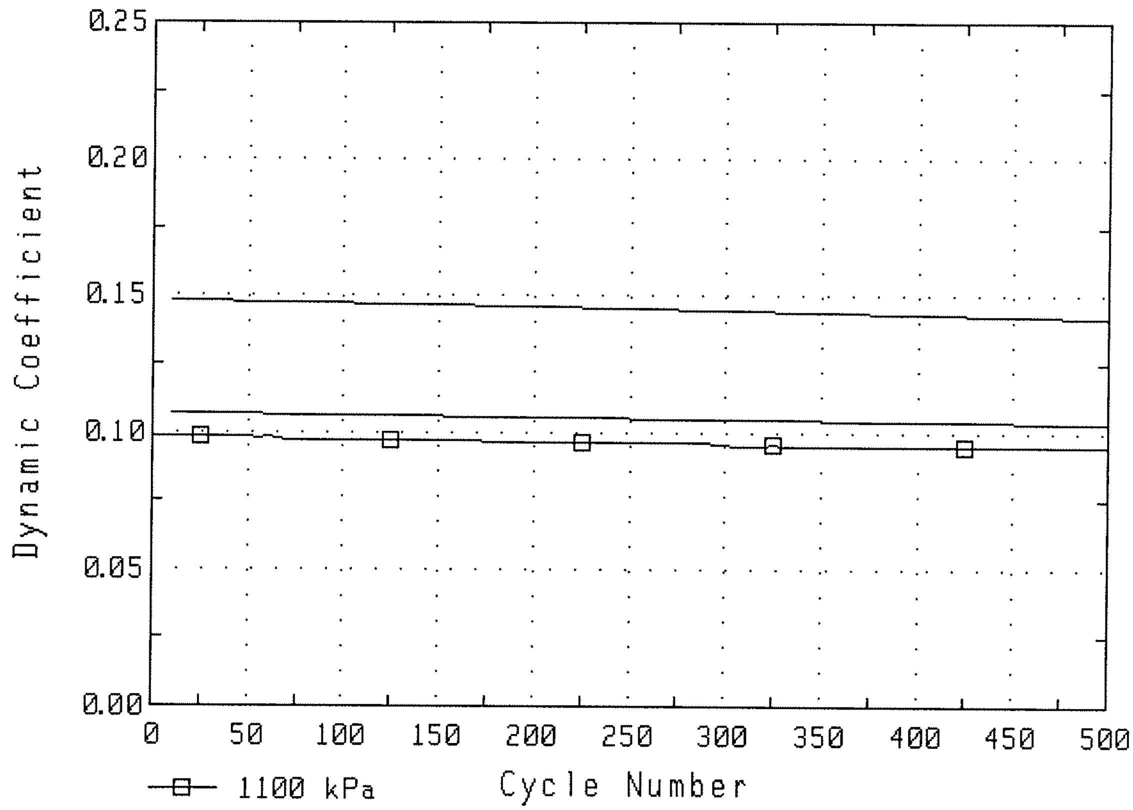
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 $N\text{-}m\text{-}s^2$

Disc name & desc:	1Y0708 - Elastomeric Disc
Material:	Raybestos 6475-4 Rayflex
Groove pattern:	Single Lead Spiral - 12 Radial
Miscellaneous:	Use with 1Y3610 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	26NO0-00004
Remarks:	Elastomeric

Plate name & desc:	1Y3610 - Steel Plate
Surface:	0.70 to 1.30 micron Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	26NO0-00004
Remarks:	1.02 Surface finish

Report limit name:	LIM1219 - Reference run: I0706090
Limit file generated:	09/24/07
Report format name:	REP1219 - ELASTOMERIC, RAYFLEX

Test: A-85-I Run: I0706119 Started on 11/16/07 at 06:59



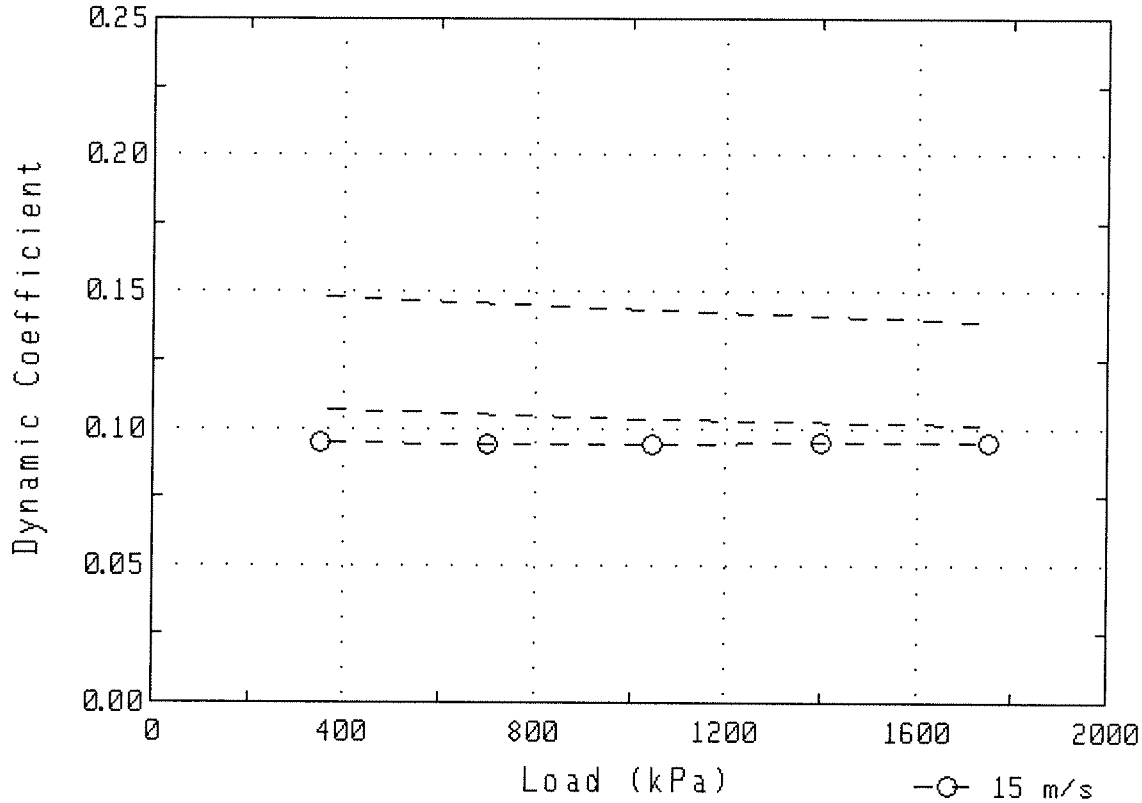
1Y0708 DISC
THICKNESS

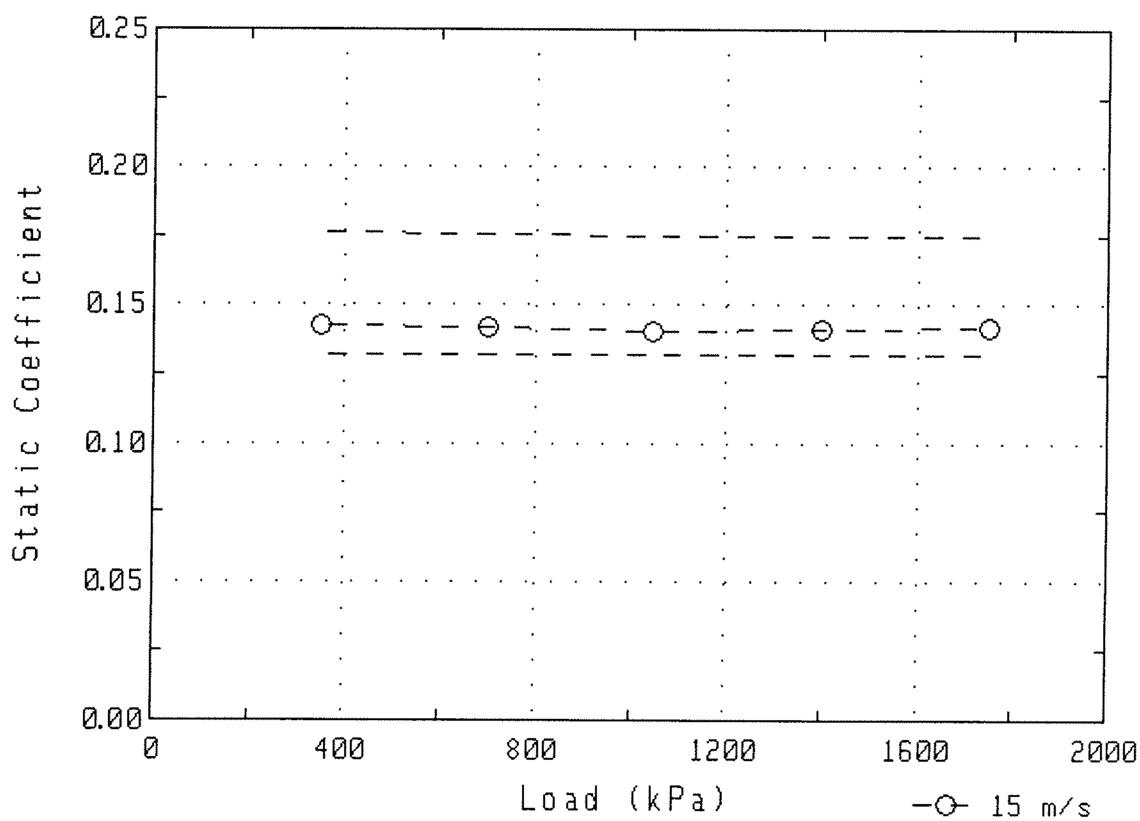
Loc	Outer Diameter M1	M2	M3	Inner Diameter M1	M2	M3
1	4.96	4.95	4.94	4.95	4.95	4.94
2	4.97	4.96	4.95	4.96	4.95	4.94
3	4.96	4.96	4.95	4.96	4.95	4.94
4	4.96	4.96	4.95	4.96	4.95	4.94
5	4.96	4.96	4.95	4.95	4.95	4.94
6	4.96	4.96	4.94	4.95	4.95	4.94
Avg	4.96	4.96	4.95	4.96	4.95	4.94

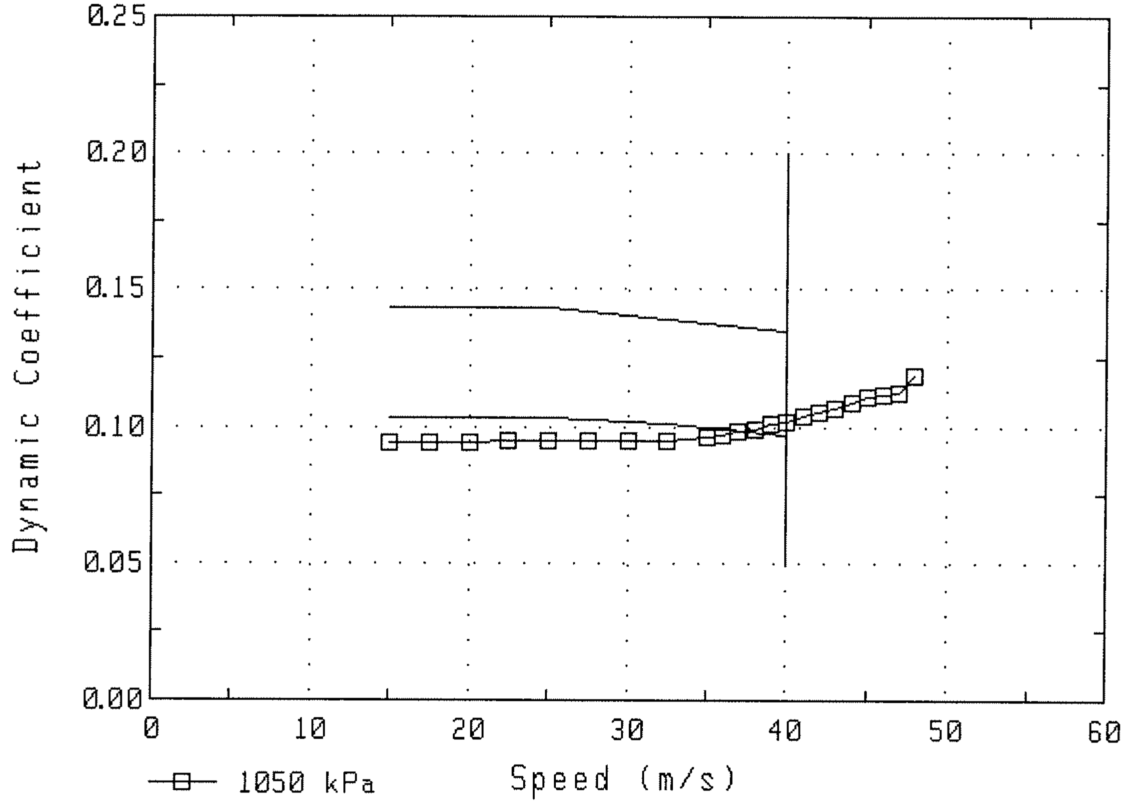
Compression set average wear: 0.004
M2 - M3 average Wear: 0.011

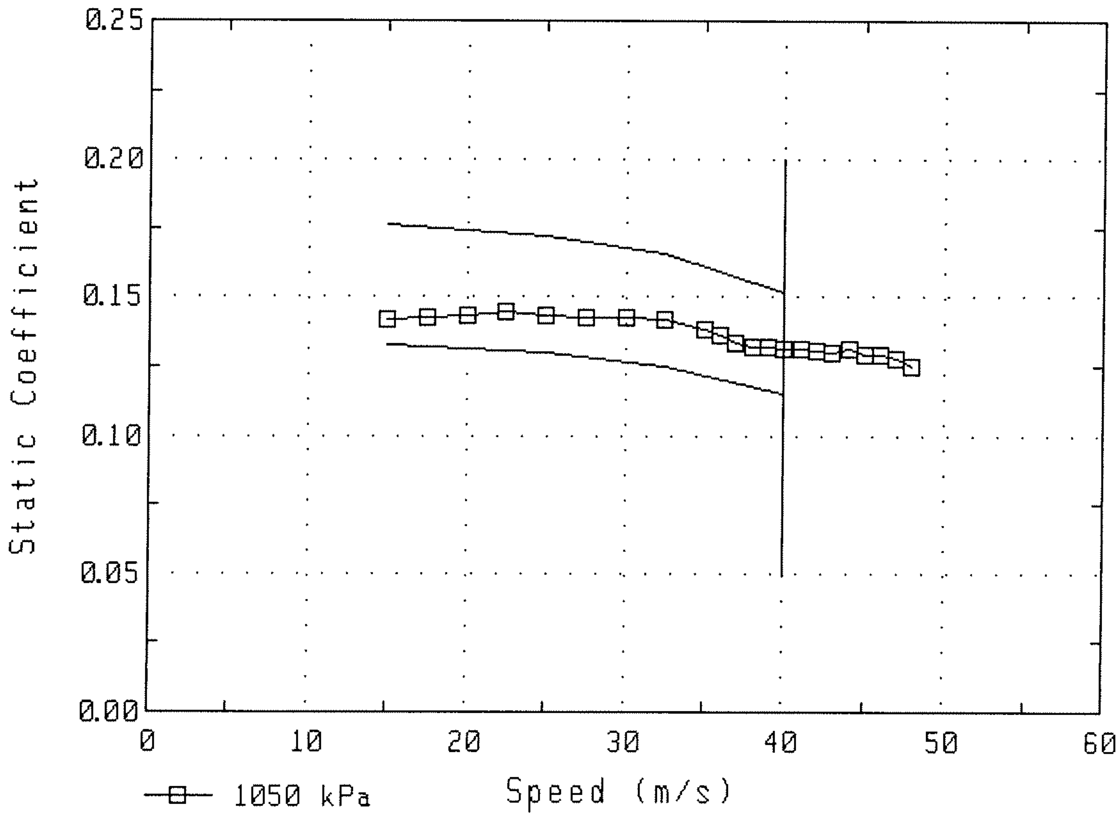
Total Wear (all measurements in mm): 0.015

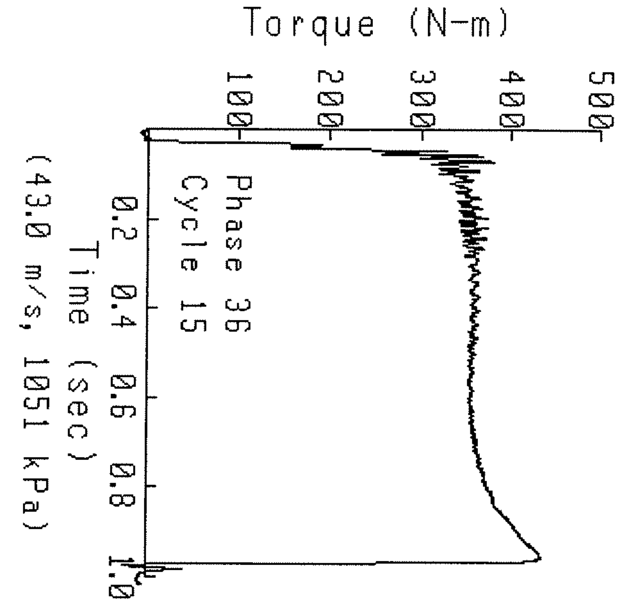
Test: A-85-I Run: I0706119 Started on 11/16/07 at 06:59

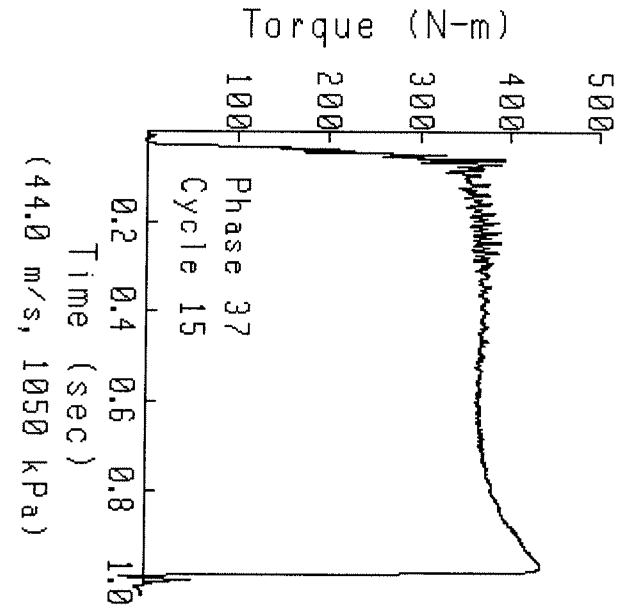


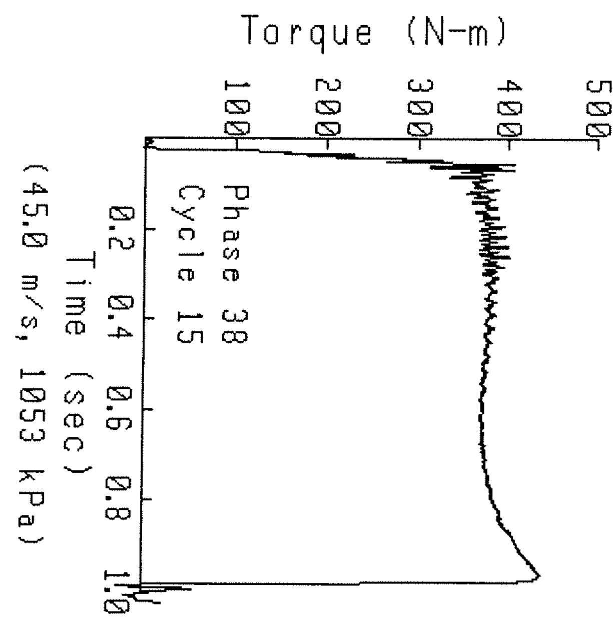


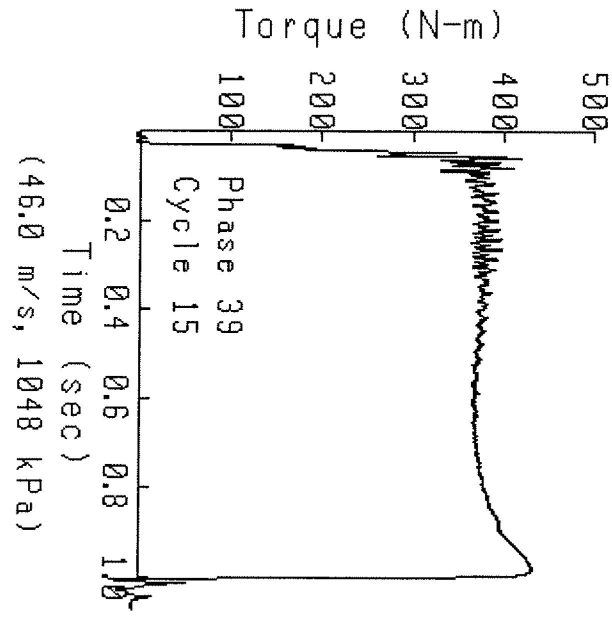

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

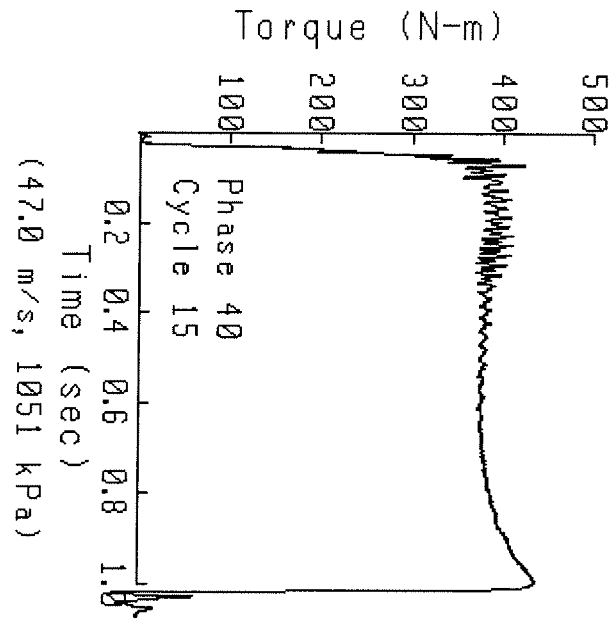

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

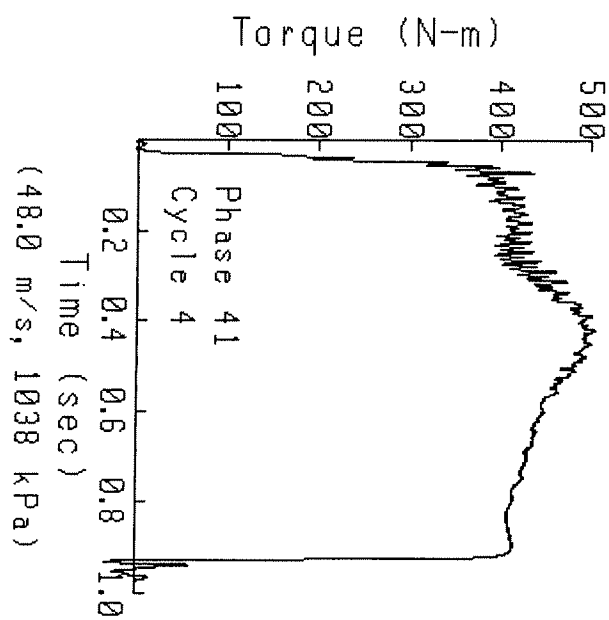

Torque (N-m)
100 200 300 400 500
Phase 36
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(43.0 m/s, 1051 kPa)


Torque (N-m)
100 200 300 400 500
Phase 37
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(44.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500
Phase 38
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(45.0 m/s, 1053 kPa)


Torque (N-m)
100 200 300 400 500
Phase 39
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(46.0 m/s, 1048 kPa)

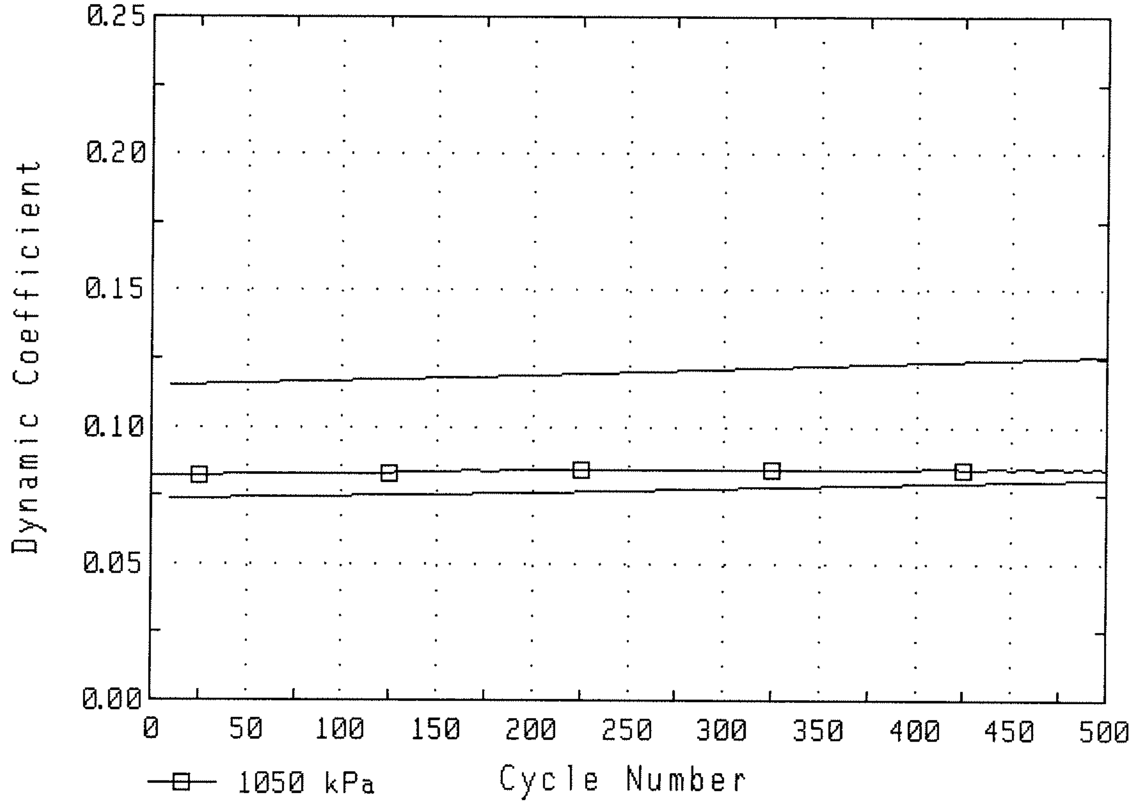

Torque (N-m)
100 200 300 400 500
Phase 40
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(47.0 m/s, 1051 kPa)


Torque (N-m)
100 200 300 400 500
Phase 41
Cycle 4
0.2 0.4 0.6 0.8 1.0
Time (sec)
(48.0 m/s, 1038 kPa)

Southwest research institute
I machine oil test AL-27875-L/L)-224036

Test name:	A-85-I
Test date:	11/15/07
Test description:	IMachineAL-27875-l
Oil type:	AL-27875-L/LO-224036
Viscosity:	5W-40
Miscellaneous:	
Software version:	1.40
Run name & desc:	I0706120 - AL-27875-L
Run date:	11/17/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	MTD
Remarks:	"I" MACHINE OIL TEST AL-27875-L / LO-224036
Sequence name:	SEQ1221
Remarks:	Use 1Y0710 Disc and 1Y3610 Plate.
Number of cycles run:	1085
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 N-m-s^2
Disc name & desc:	1Y0710 - Steering Brake Paper
Material:	Raybestos 7894-4 Paper
Groove pattern:	2 - 37 Multiple Parallel
Miscellaneous:	Use with 1Y3610 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	23MR9-00001
Remarks:	STEERING BRAKE PAPER
Plate name & desc:	1Y3610 - Steel Plate
Surface:	0.70 to 1.30 micron Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	23MR9-00001
Remarks:	0.93 Surface Finish
Report limit name:	LIM1221 - Reference run: I0706003
Limit file generated:	07/26/06
Report format name:	REP1221 - STEERING BRAKE PAPER

Test: A-85-I Run: I0706120 Started on 11/17/07 at 06:05

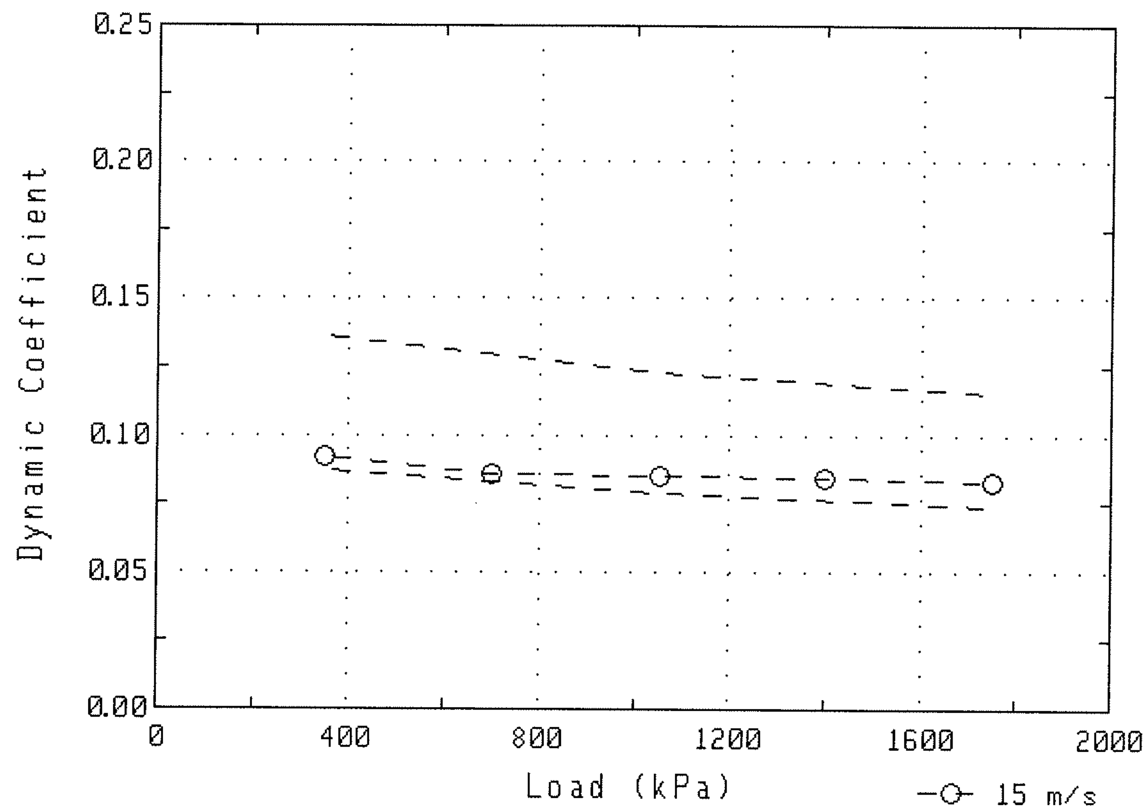


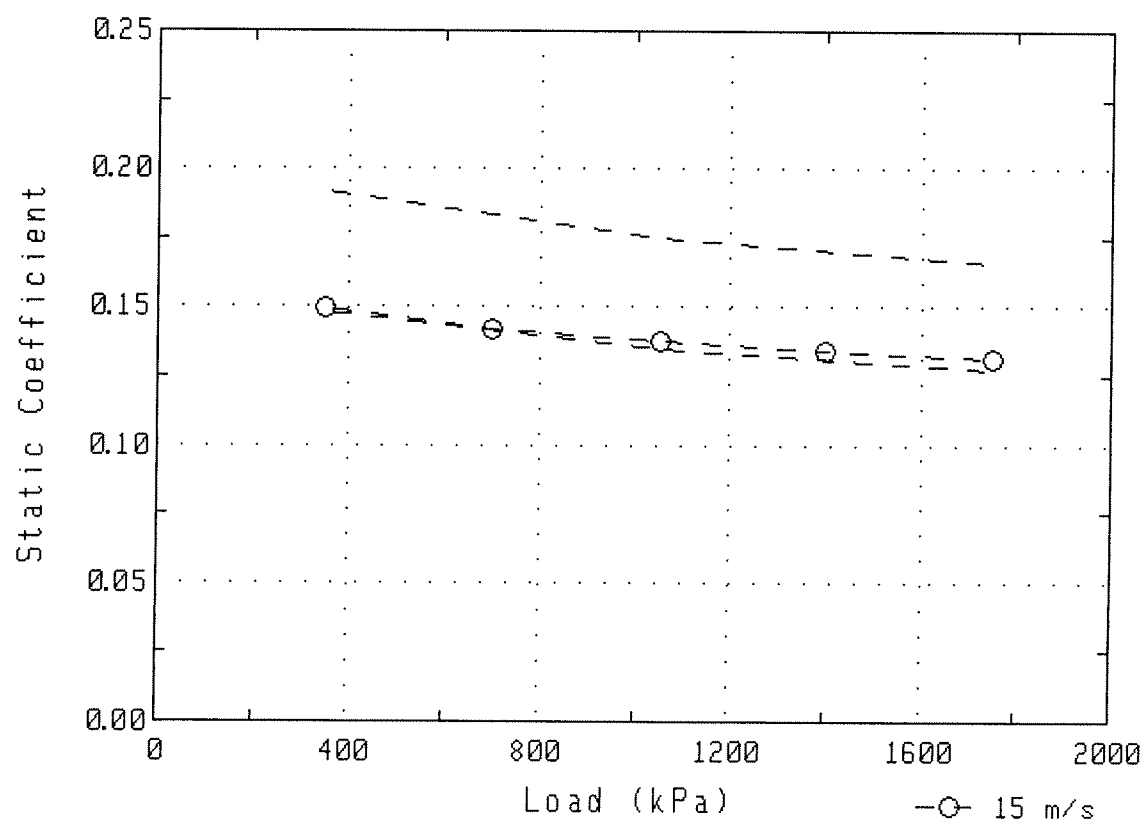
1Y0710 DISC
THICKNESS

Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	5.01	4.99	4.99	5.01	5.00	5.00
2	5.02	5.00	4.99	5.02	5.00	4.99
3	5.02	5.01	5.00	5.02	5.01	5.00
4	5.02	5.01	5.01	5.02	5.01	5.00
5	5.01	5.00	4.99	5.01	5.00	4.99
6	5.01	5.00	4.99	5.01	5.00	4.99
Avg	5.02	5.00	4.99	5.02	5.00	5.00

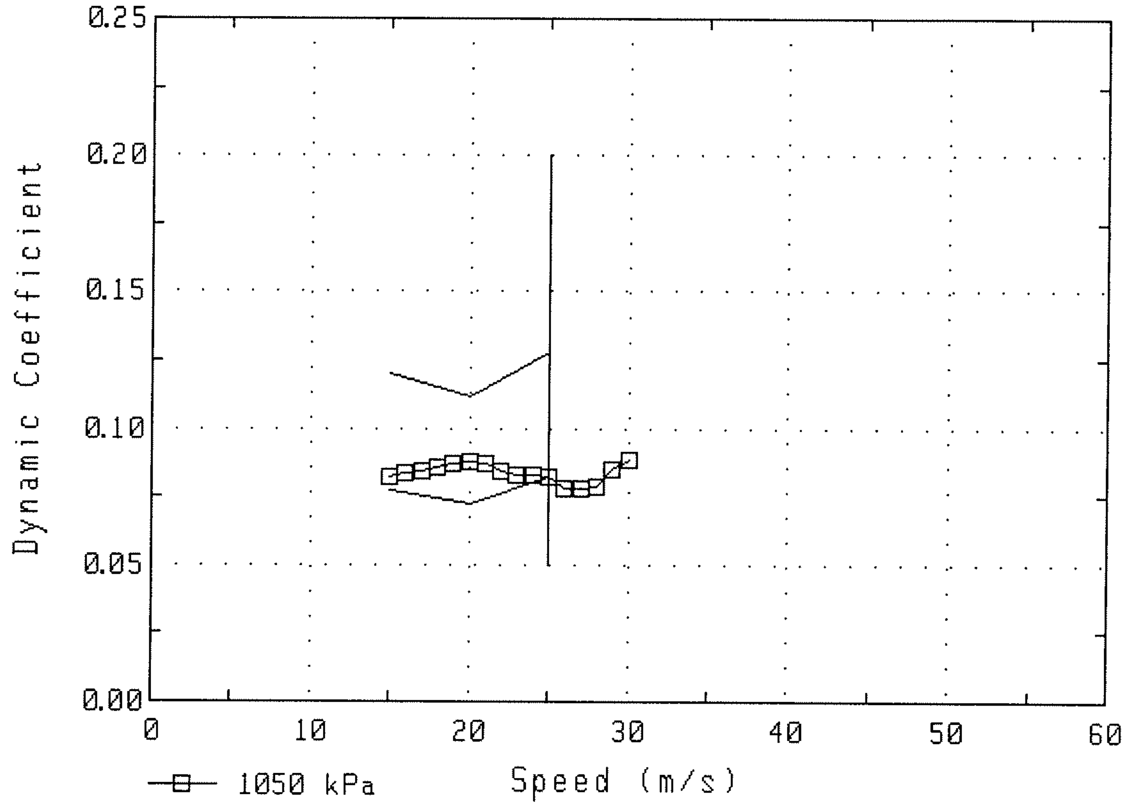
Compression set average wear: 0.013
M2 - M3 average Wear: 0.008

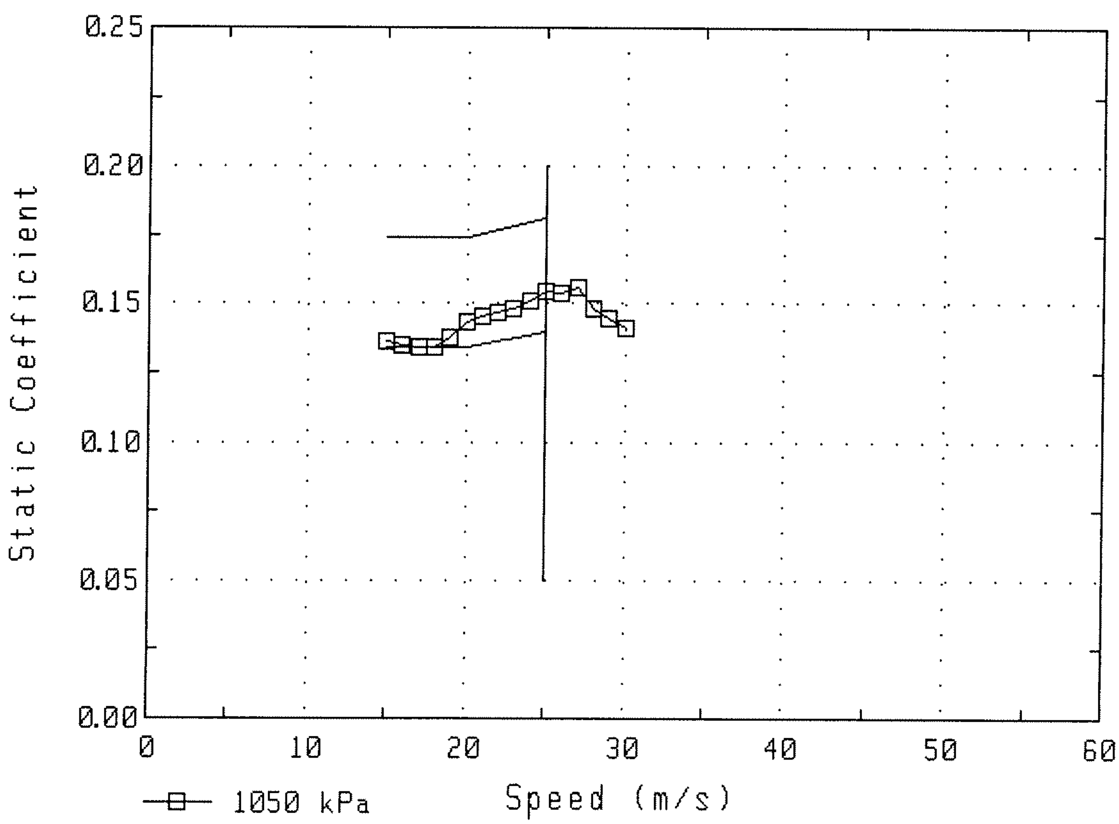
Total Wear (all measurements in mm): 0.020

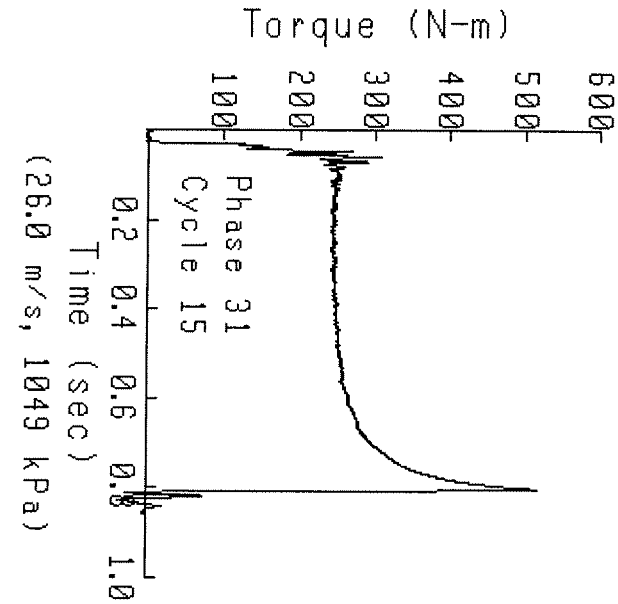

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

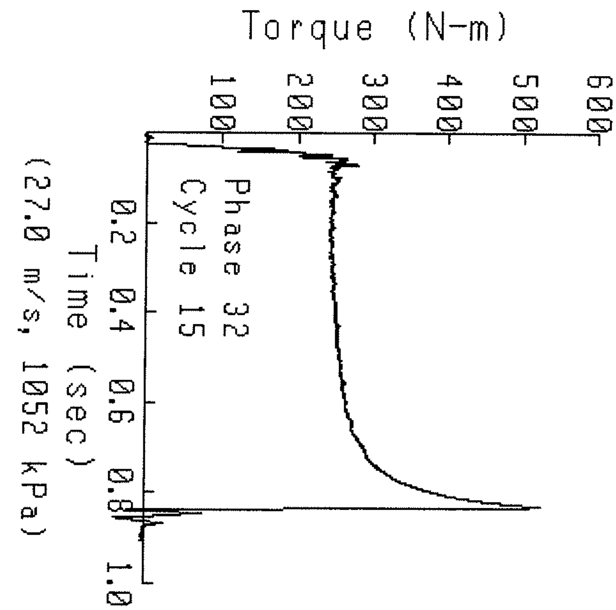

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

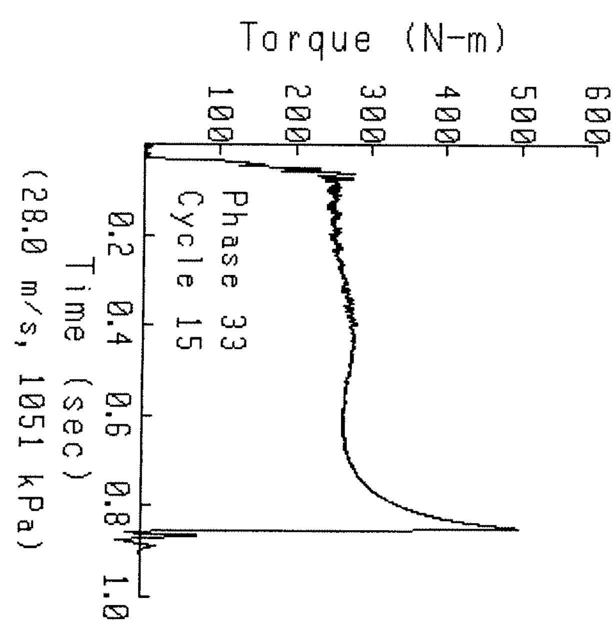
Test: A-85-I Run: I0706120 Started on 11/17/07 at 06:05

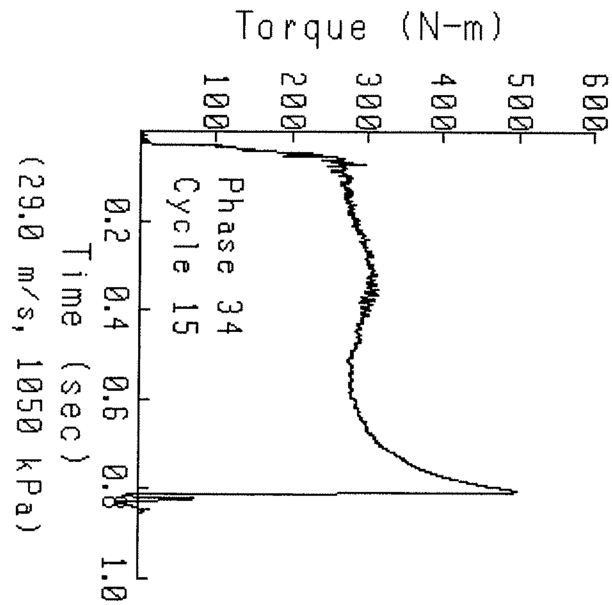


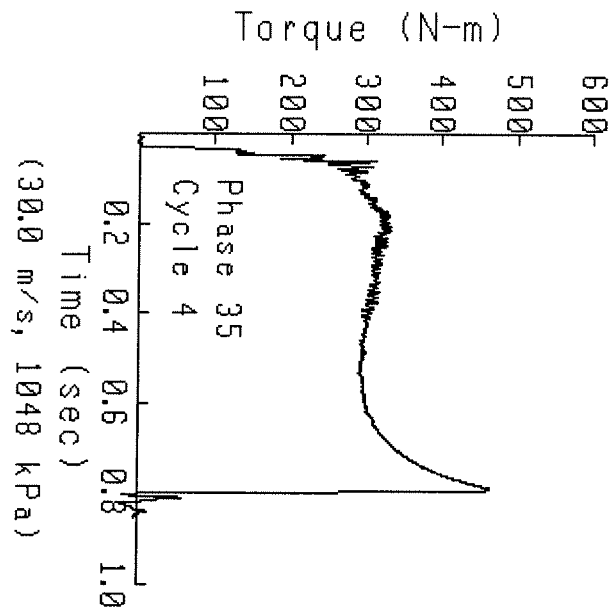


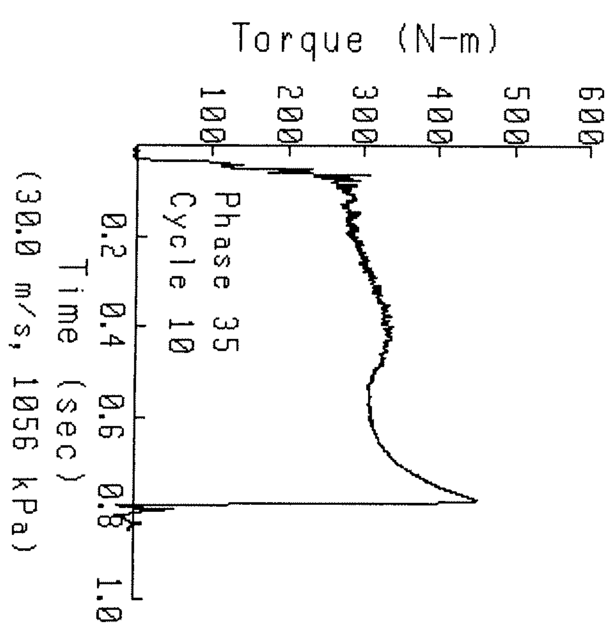

Torque (N-m)
100
200
300
400
500
600
Phase 31
Cycle 15
0.2
0.4
0.6
0.8
1.0
Time (sec)
(26.0 m/s, 1049 kPa)


Torque (N-m)
100
200
300
400
500
600
Phase 32
Cycle 15
0.2
0.4
0.6
0.8
1.0
Time (sec)
(27.0 m/s, 1052 kPa)


Torque (N-m)
100
200
300
400
500
600
Phase 33
Cycle 15
0.2
0.4
0.6
0.8
1.0
Time (sec)
(28.0 m/s, 1051 kPa)


Torque (N-m)
100
200
300
400
500
600
Phase 34
Cycle 15
0.2
0.4
0.6
0.8
1.0
Time (sec)
(29.0 m/s, 1050 kPa)


Torque (N-m)
100
200
300
400
500
600
Phase 35
Cycle 4
0.2
0.4
0.6
0.8
1.0
Time (sec)
(30.0 m/s, 1048 kPa)


Torque (N-m)
100
200
300
400
500
600
Phase 35
Cycle 10
0.2
0.4
0.6
0.8
1.0
Time (sec)
(30.0 m/s, 1056 kPa)

Southwest research institute
I machine oil test AL-27875-L/L)-224036

Test name:	A-85-I
Test date:	11/15/07
Test description:	IMachineAL-27875-l
Oil type:	AL-27875-L/LO-224036
Viscosity:	5W-40
Miscellaneous:	
Software version:	1.40

Run name & desc:	I0706121 - AL-27875-L
Run date:	11/18/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	JG
Remarks:	Machine I Oil Test AL-27875-L / LO-224036
Sequence name:	SEQ1222
Remarks:	Use 1Y0711 Disc and 1Y0726 Plate
Number of cycles run:	1195

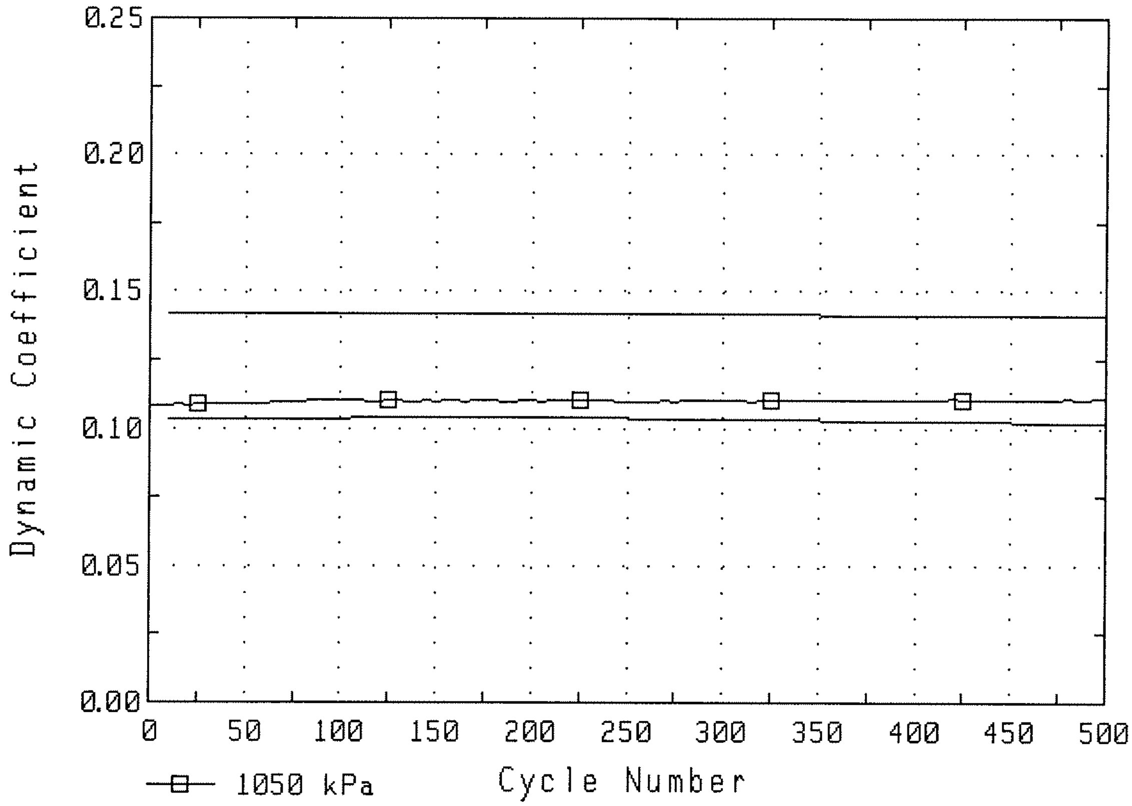
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 N-m-s^2

Disc name & desc:	1Y0711 - Wheel Brake Paper
Material:	Raybestos 7902-1 Paper
Groove pattern:	2 - 37 Multiple Parallel
Miscellaneous:	Use with 1Y0726 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	24FE9-00001
Remarks:	Wheel brake paper

Plate name & desc:	1Y0726 - Steel Plate
Surface:	0.30 micron Maximum Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	24FE9-00001
Remarks:	0.20 Surface Finish

Report limit name:	LIM1222 - Reference run: I0706004
Limit file generated:	07/26/06
Report format name:	REP1222 - WHEEL BRAKE PAPER

Test: A-85-I Run: I0706121 Started on 11/18/07 at 06:57



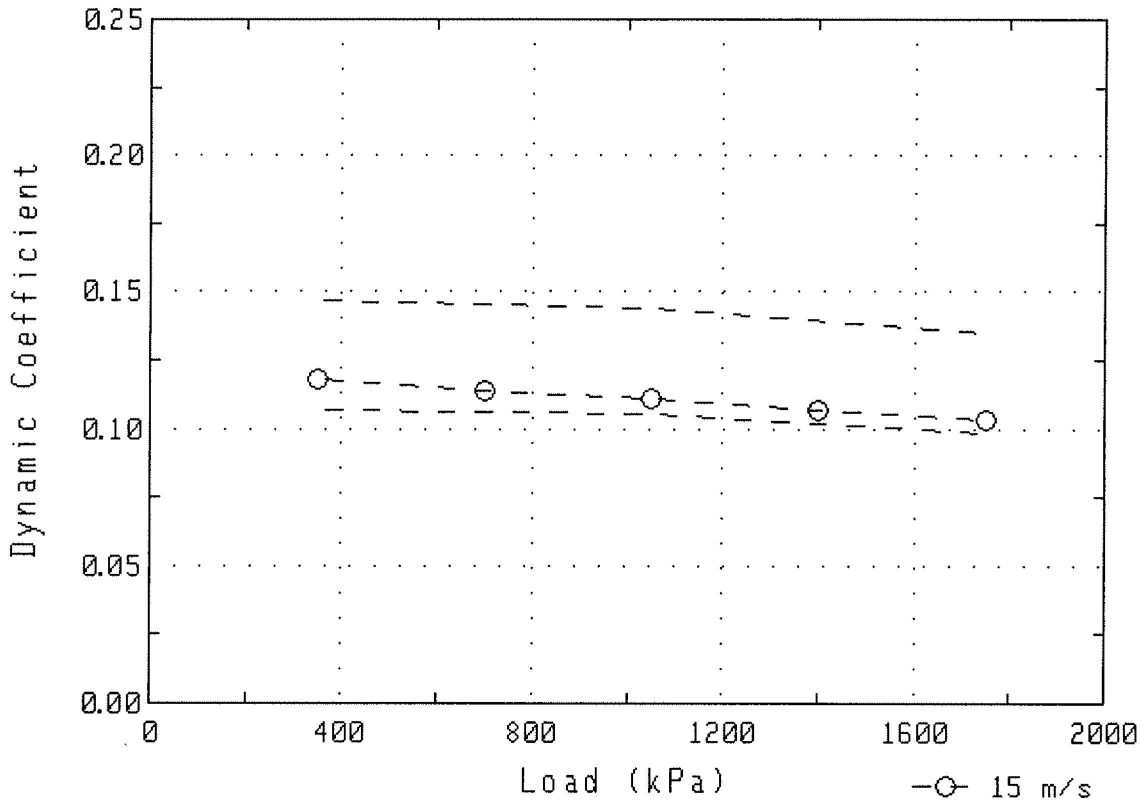
1Y0711 DISC
THICKNESS

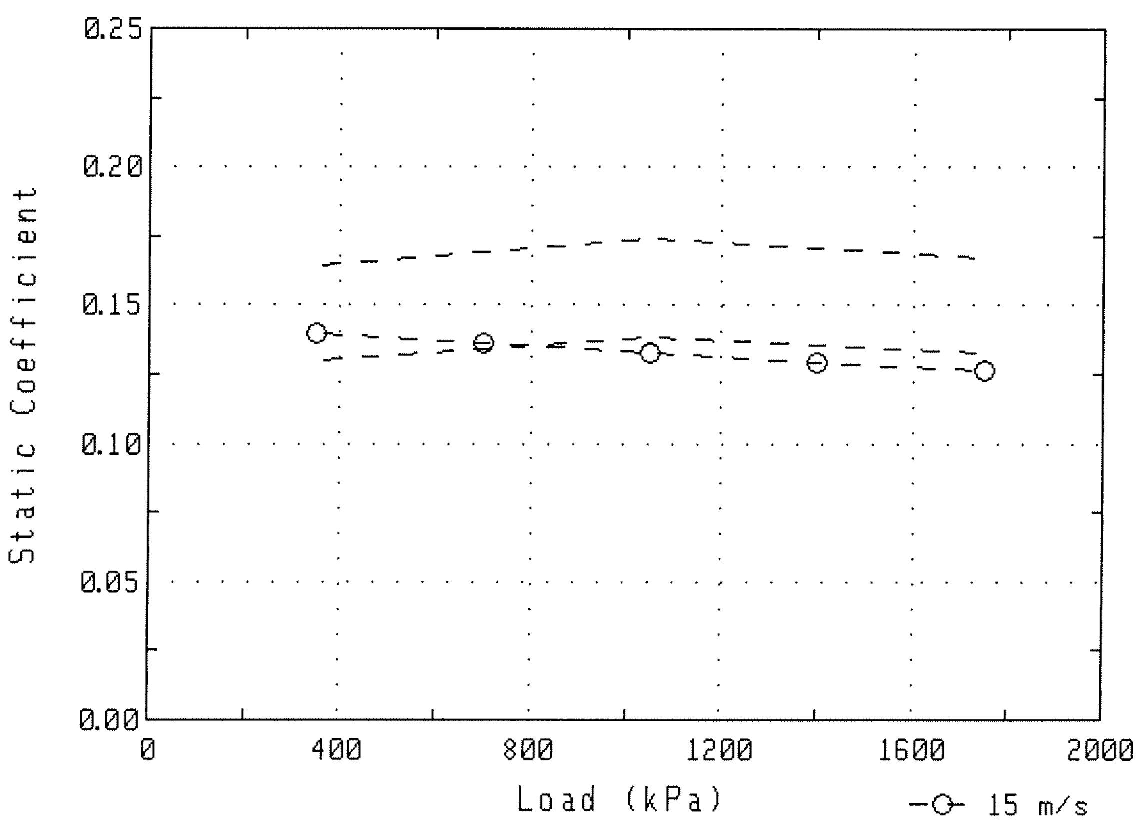
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	4.90	4.85	4.84	4.90	4.86	4.85
2	4.89	4.84	4.83	4.89	4.85	4.84
3	4.89	4.84	4.83	4.89	4.85	4.84
4	4.91	4.86	4.85	4.91	4.86	4.86
5	4.91	4.87	4.86	4.91	4.87	4.87
6	4.91	4.86	4.85	4.91	4.86	4.85
Avg	4.90	4.85	4.84	4.90	4.86	4.85

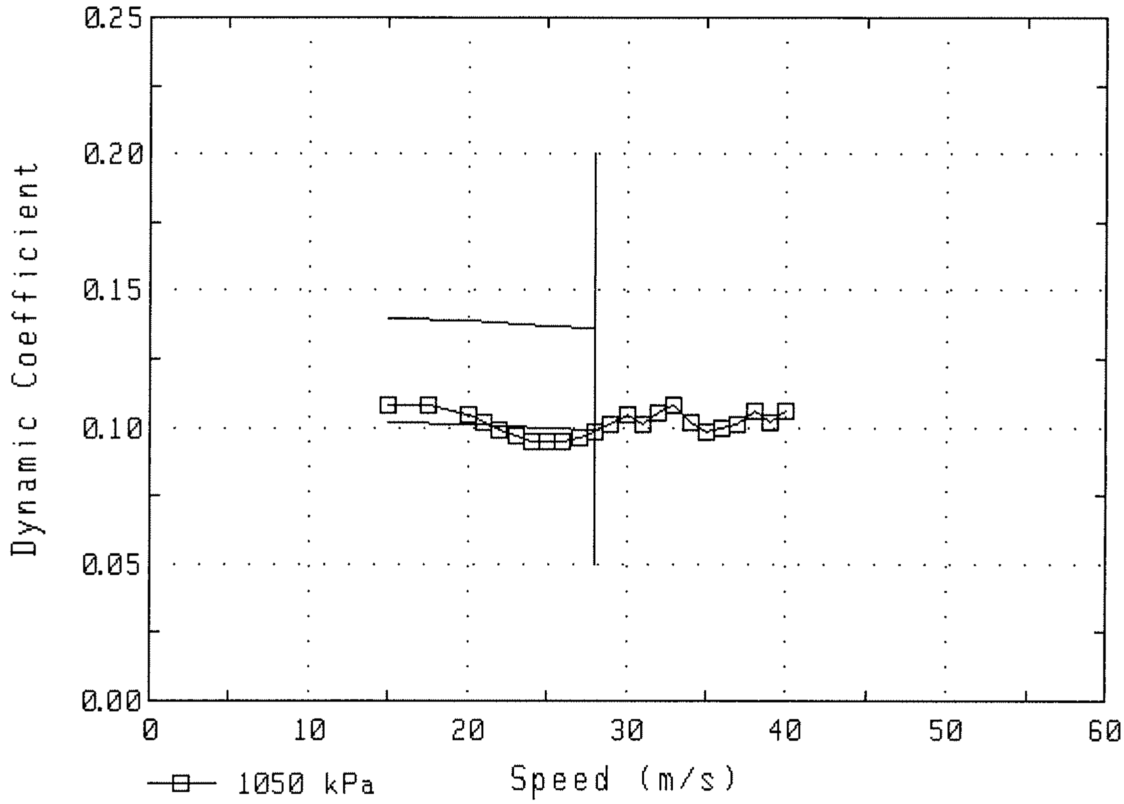
Compression set average wear: 0.046
M2 - M3 average Wear: 0.008

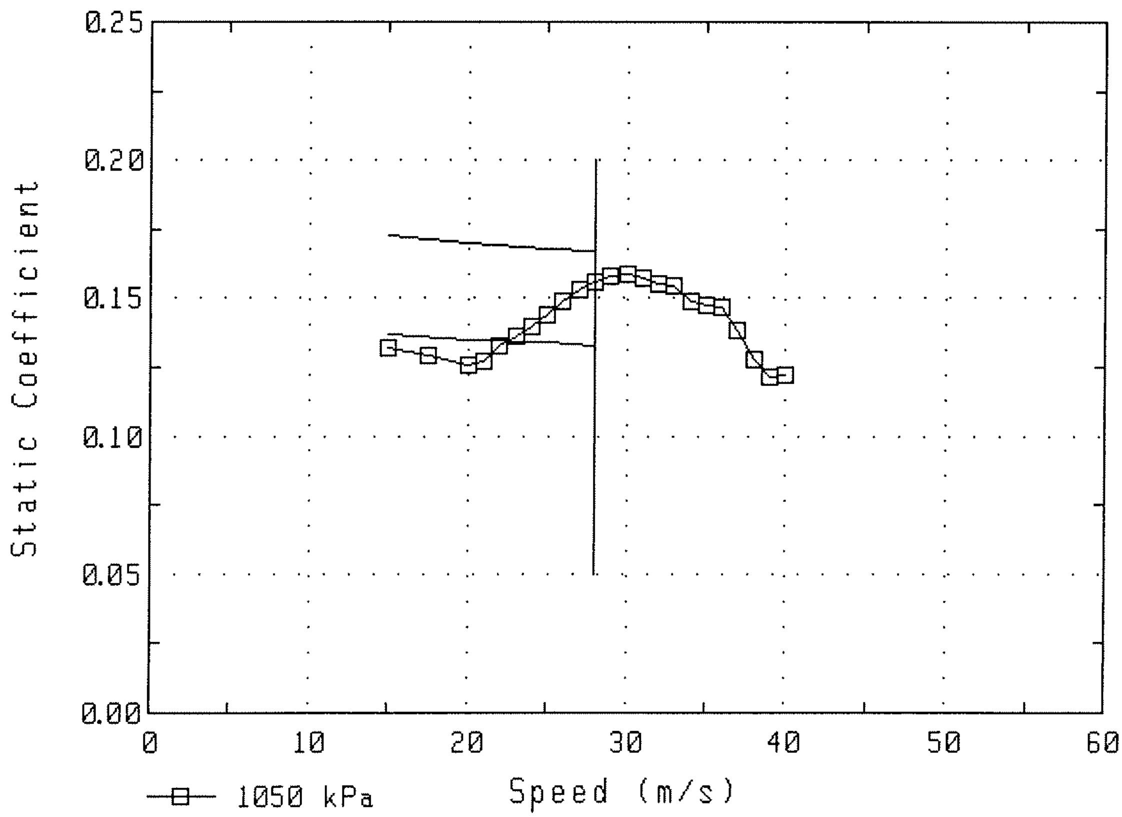
Total Wear (all measurements in mm): 0.054

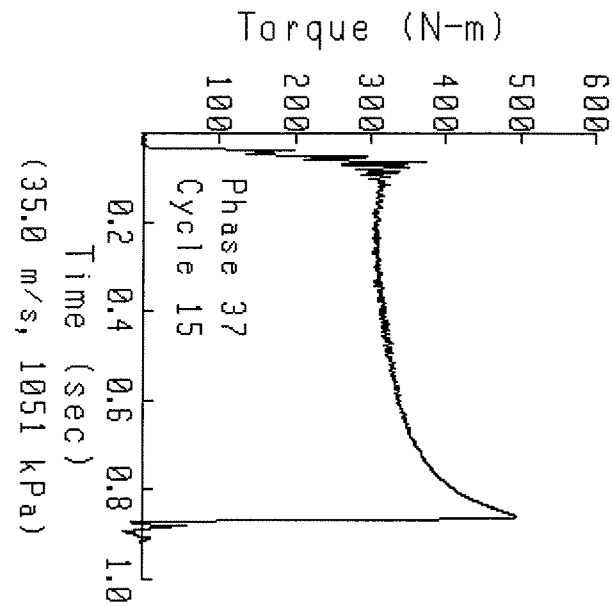
Test: A-85-I Run: I0706121 Started on 11/18/07 at 06:57

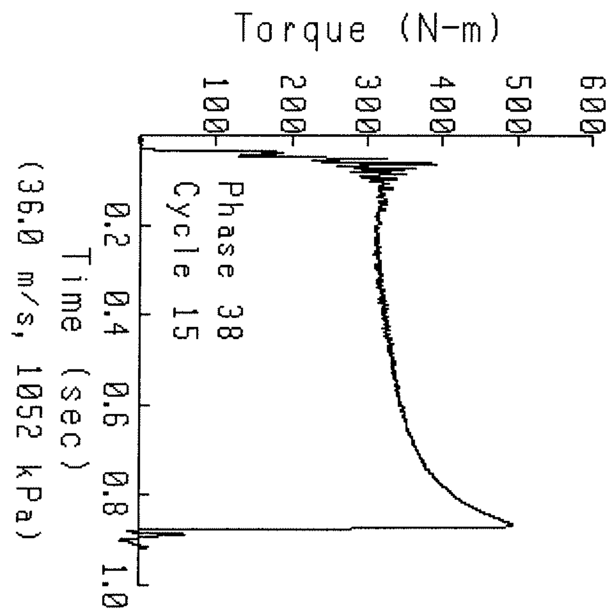


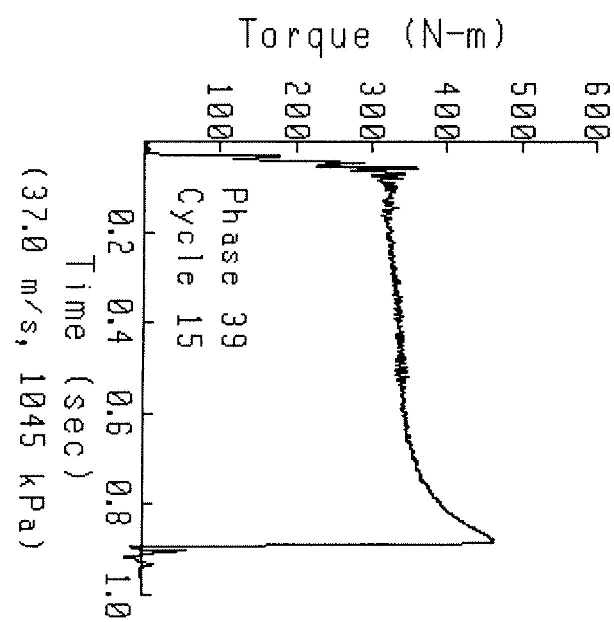


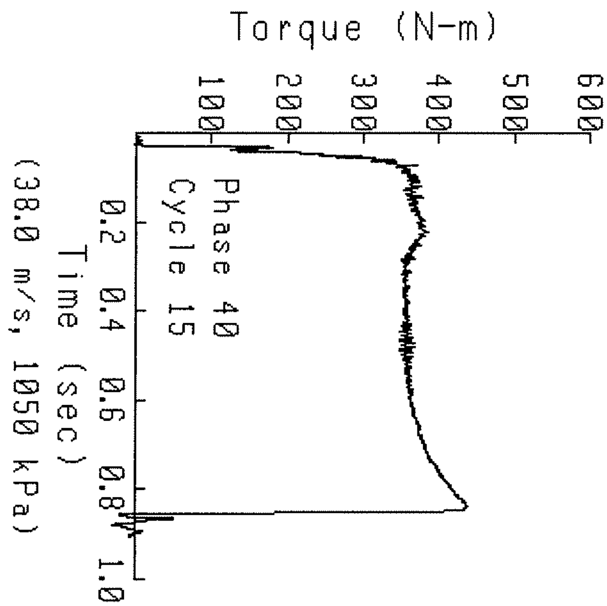

Dynamic Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

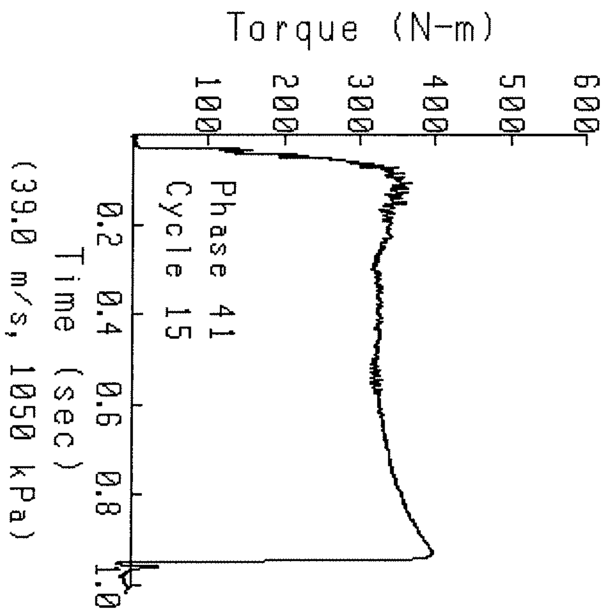

Static Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

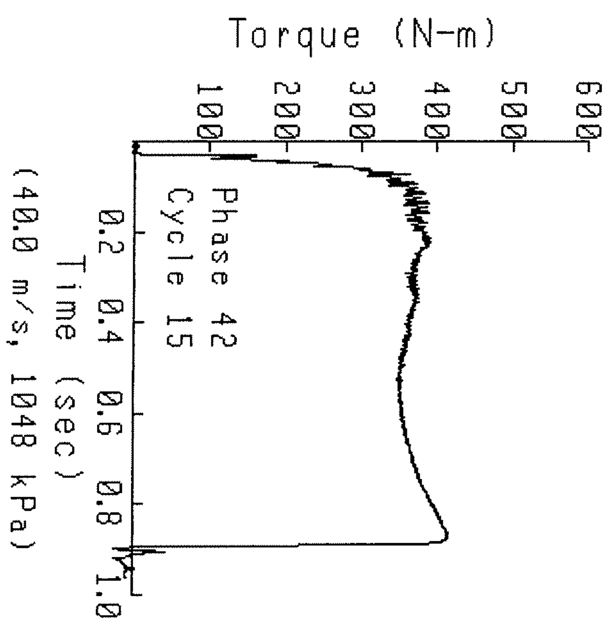

Torque (N-m)
100 200 300 400 500 600
Phase 37
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(35.0 m/s, 1051 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 38
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(36.0 m/s, 1052 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 39
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(37.0 m/s, 1045 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 40
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(38.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 41
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(39.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 42
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(40.0 m/s, 1048 kPa)

Southwest research institute
I machine oil test AL-27875-L/L)-224036

Test name:	A-85-I
Test date:	11/15/07
Test description:	IMachineAL-27875-1
Oil type:	AL-27875-L/LO-224036
Viscosity:	5W-40
Miscellaneous:	
Software version:	1.40

Run name & desc:	I0706122 - AL-27875-L
Run date:	11/19/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	JG
Remarks:	"I" MACHINE OIL TEST AL-27875-L / LO-224036
Sequence name:	SEQ1223
Remarks:	Use 1Y0712 Disc and 1Y0726 Plate
Number of cycles run:	1006

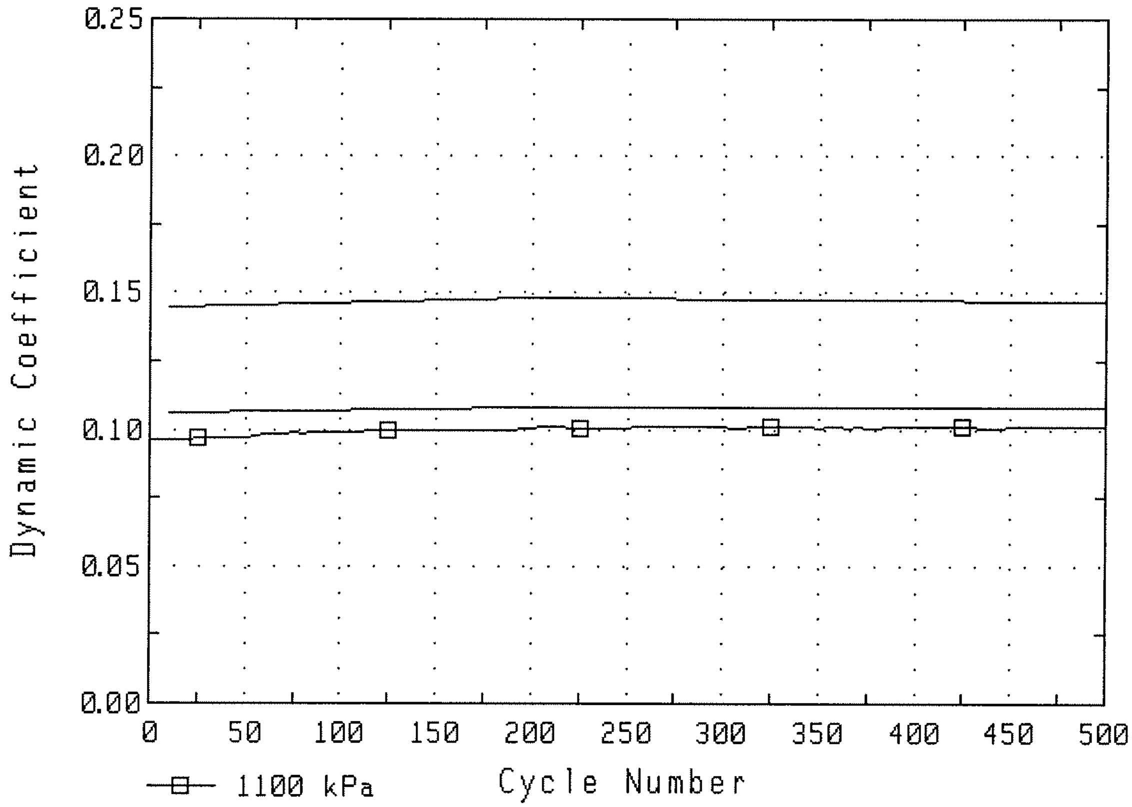
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 N-m-s^2

Disc name & desc:	1Y0712 - Transmission Paper
Material:	Raybestos 7901-2 Paper
Groove pattern:	2 - 37 Multiple Parallel
Miscellaneous:	Use with 1Y0726 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	27MR9-00001
Remarks:	TRANSMISSION PAPER

Plate name & desc:	1Y0726 - Steel Plate
Surface:	0.30 micron Maximum Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	27MR9-00001
Remarks:	0.21 Surface Finish

Report limit name:	LIM1223 - Reference run: I0706006
Limit file generated:	07/26/06
Report format name:	REP1223 - TRANSMISSION PAPER

Test: A-85-I Run: I0706122 Started on 11/19/07 at 08:58



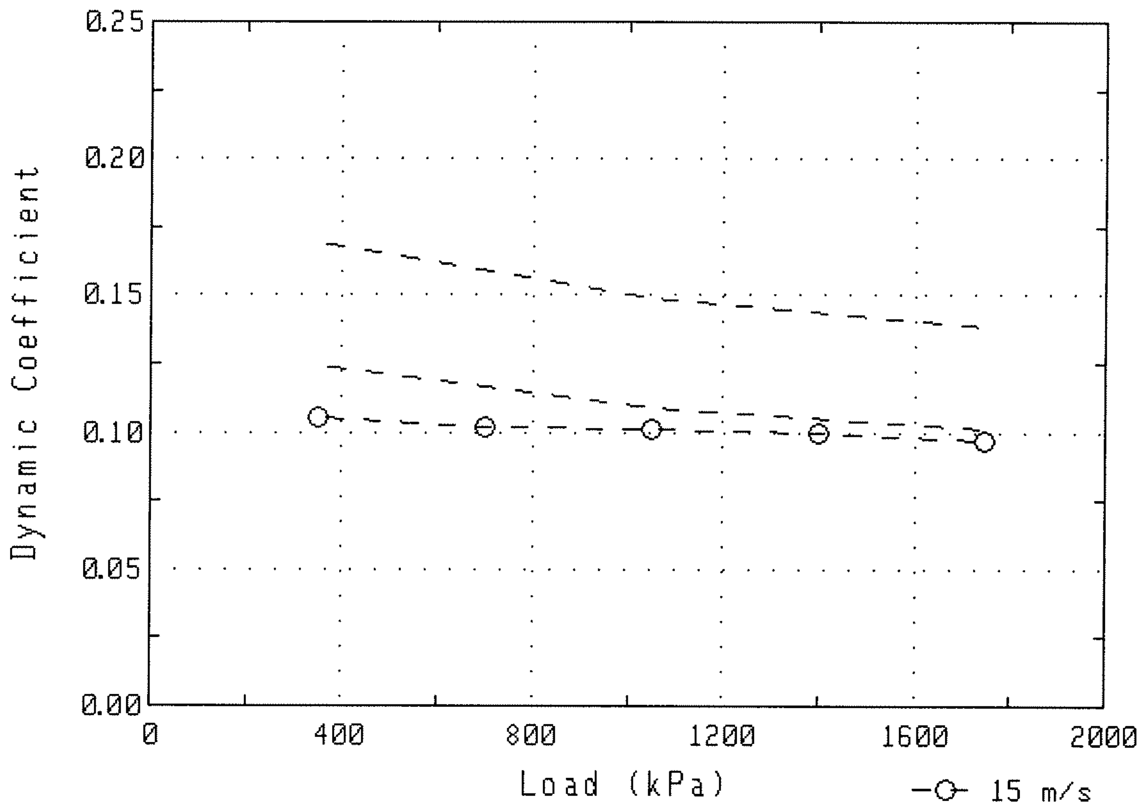
1Y0712 DISC
THICKNESS

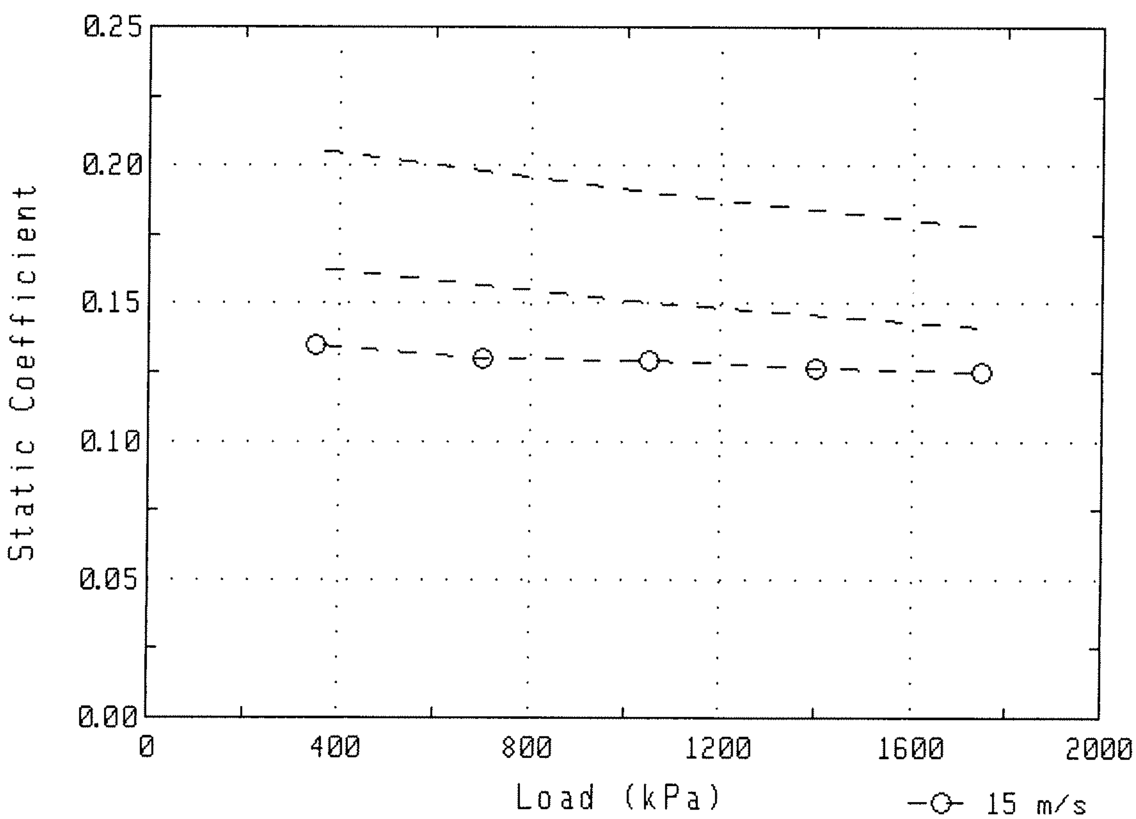
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	5.01	4.99	4.98	5.01	4.99	4.98
2	5.02	4.99	4.98	5.02	4.99	4.98
3	5.03	5.01	5.00	5.03	5.01	4.99
4	5.02	5.00	4.99	5.02	5.00	4.99
5	5.01	4.98	4.98	5.01	4.99	4.98
6	5.01	4.99	4.98	5.01	4.99	4.98
Avg	5.02	4.99	4.99	5.02	5.00	4.98

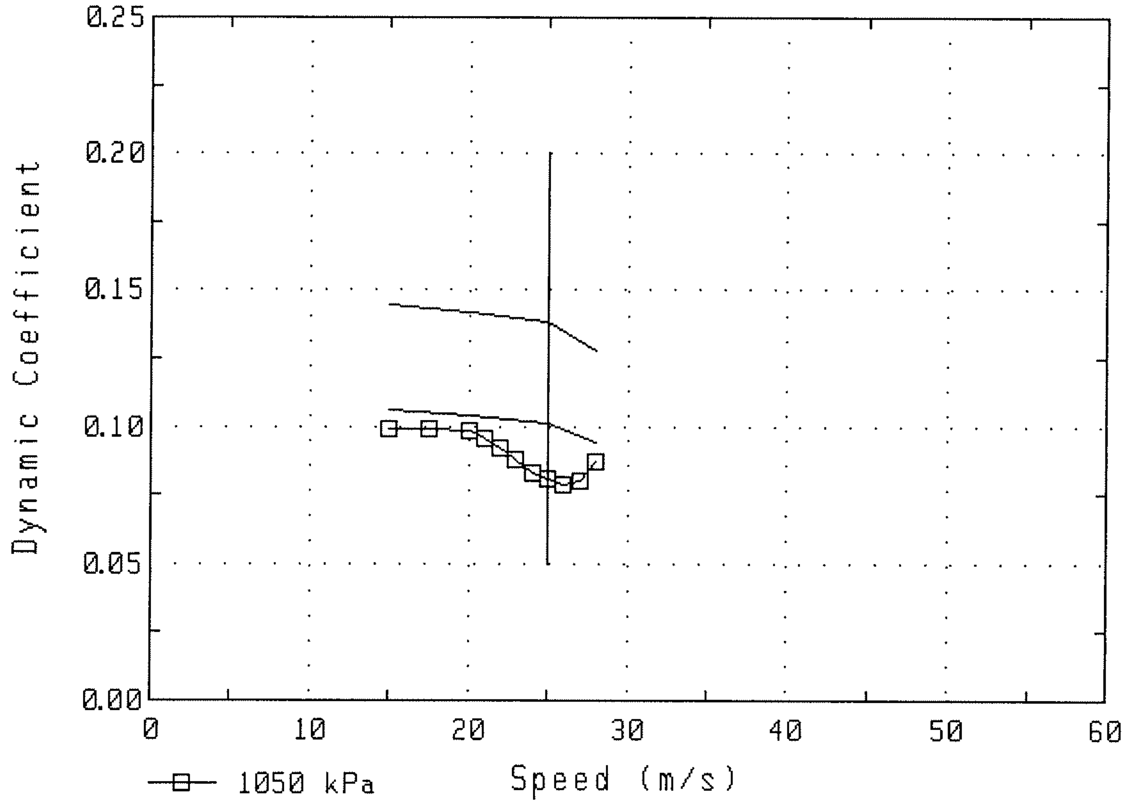
Compression set average wear: 0.022
M2 - M3 average Wear: 0.010

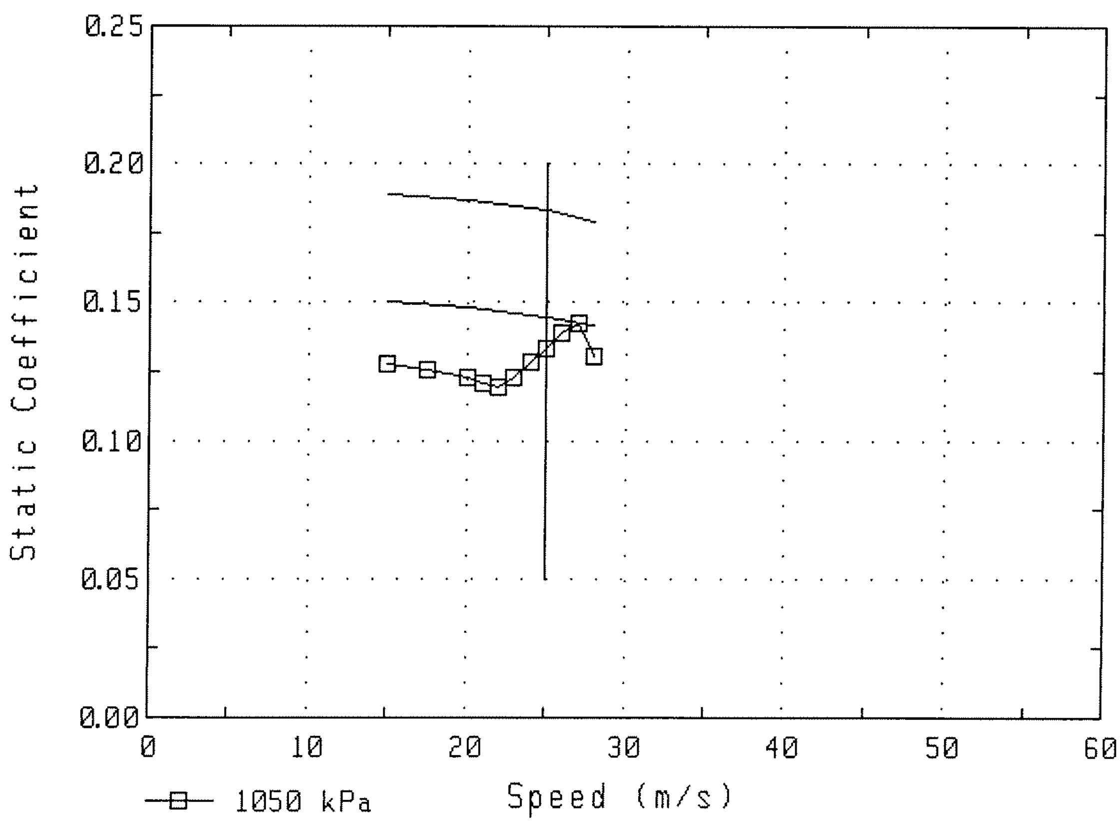
Total Wear (all measurements in mm): 0.032

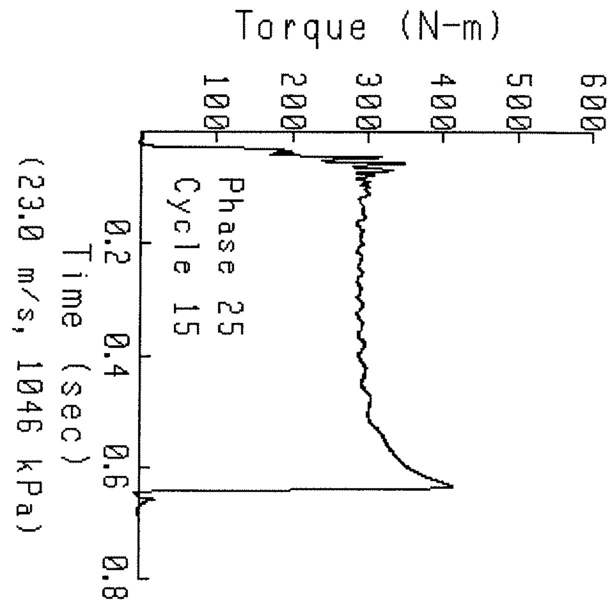
Test: A-85-I Run: I0706122 Started on 11/19/07 at 08:58

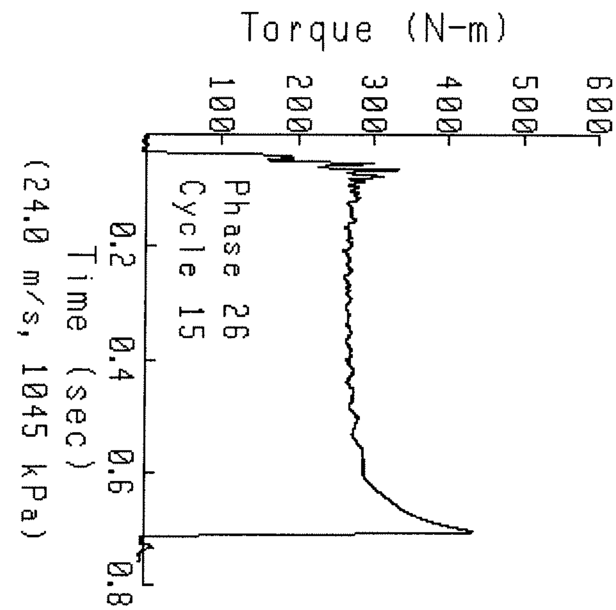


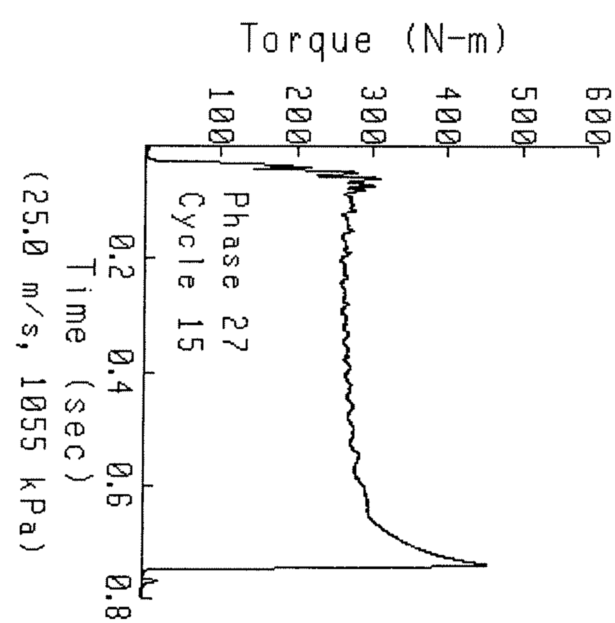


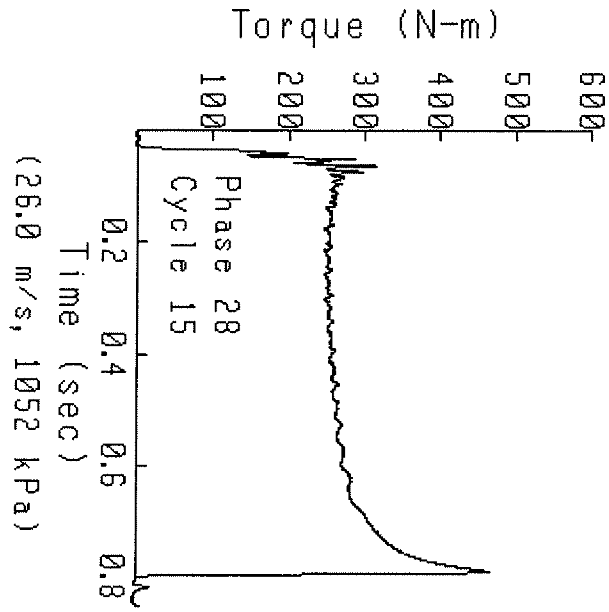

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

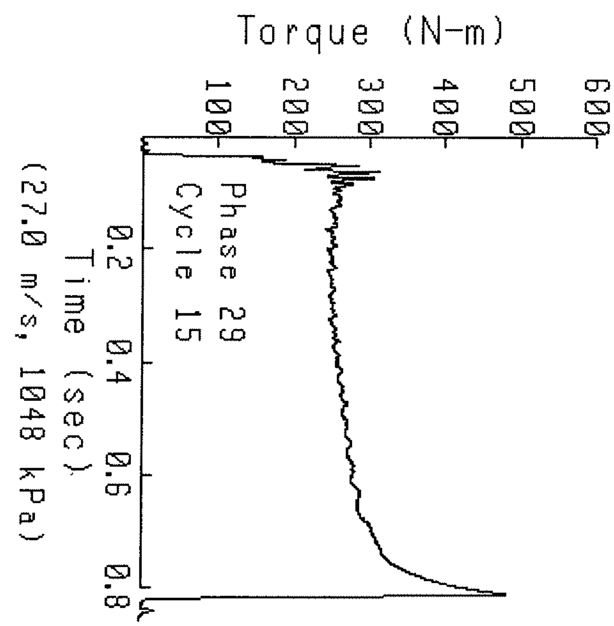

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

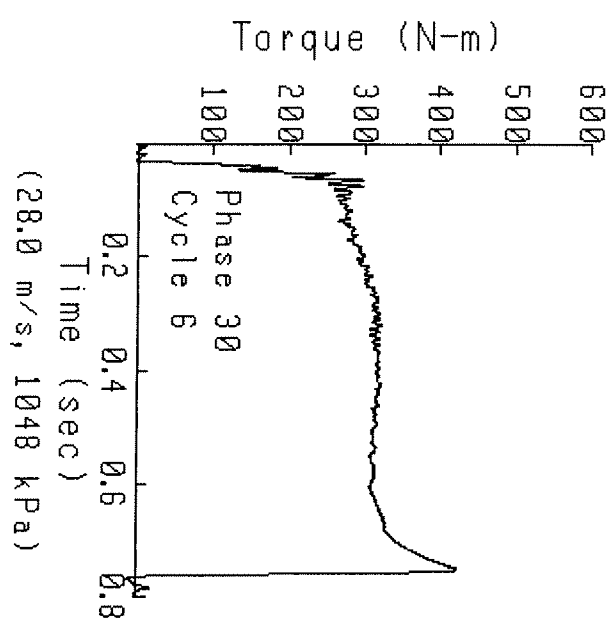

Torque (N-m)
100 200 300 400 500 600
Phase 25
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(23.0 m/s, 1046 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 26
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(24.0 m/s, 1045 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 27
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(25.0 m/s, 1055 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 28
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(26.0 m/s, 1052 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 29
Cycle 15
0.2 0.4 0.6 0.8
Time (sec)
(27.0 m/s, 1048 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 30
Cycle 6
0.2 0.4 0.6 0.8
Time (sec)
(28.0 m/s, 1048 kPa)

Southwest research institute
I machine oil test AL-27875-L/L)-224036

Test name:	A-85-I
Test date:	11/15/07
Test description:	IMachineAL-27875-l
Oil type:	AL-27875-L/LO-224036
Viscosity:	5W-40
Miscellaneous:	
Software version:	1.40

Run name & desc:	I0706123 - AL-27875-L
Run date:	11/20/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	hc
Remarks:	"I" MACHINE OIL TEST AL-27875-L / LO-224036
Sequence name:	SEQ1224
Remarks:	Use 1Y0713 Disc and 8E4095 Plate
Number of cycles run:	1085

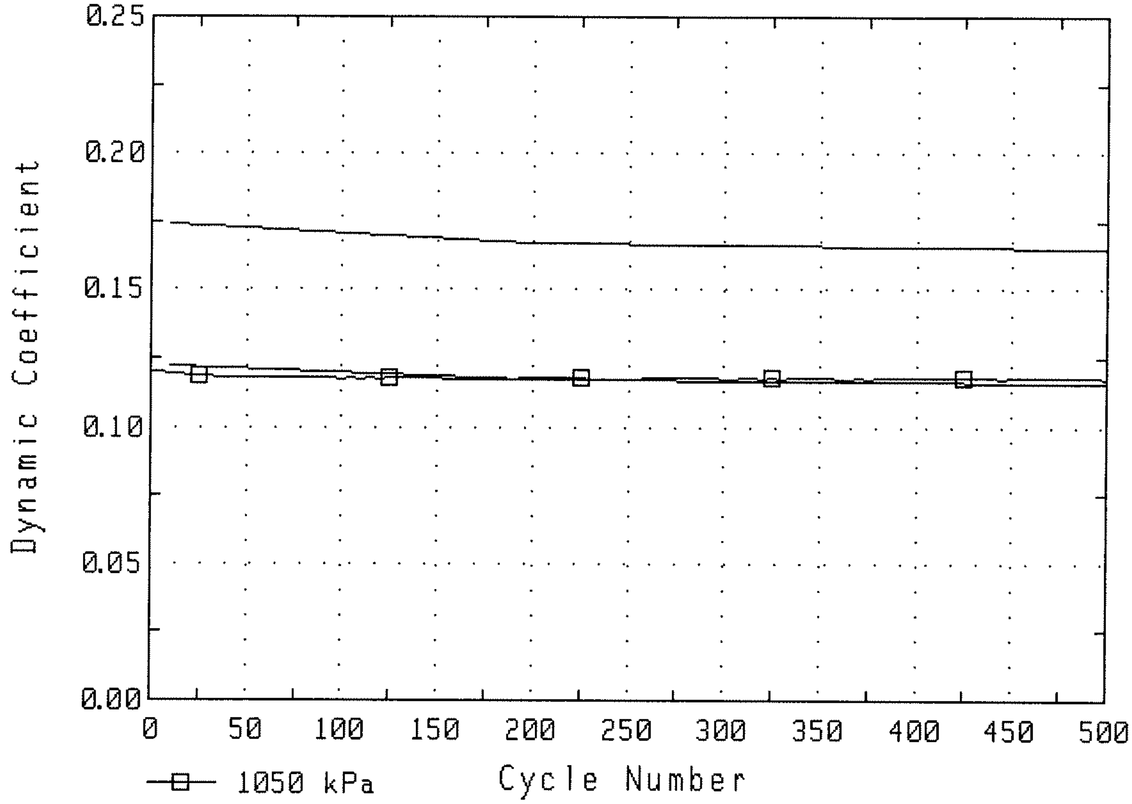
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 N-m-s^2

Disc name & desc:	1Y0713 - Elastomeric Disc
Material:	Caterpillar F37
Groove pattern:	Single Lead Spiral - 12 Radial
Miscellaneous:	Use with 8E4095 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	C63007FE1
Remarks:	ELASTOMERIC

Plate name & desc:	8E4095 - Steel Plate
Surface:	0.70 to 1.00 micron Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	C63007FE1
Remarks:	0.89 SURFACE FINISH

Report limit name:	LIM1224 - Reference run: I0706007
Limit file generated:	07/26/06
Report format name:	REP1224 - ELASTOMERIC, F37

Test: A-85-I Run: I0706123 Started on 11/20/07 at 08:57



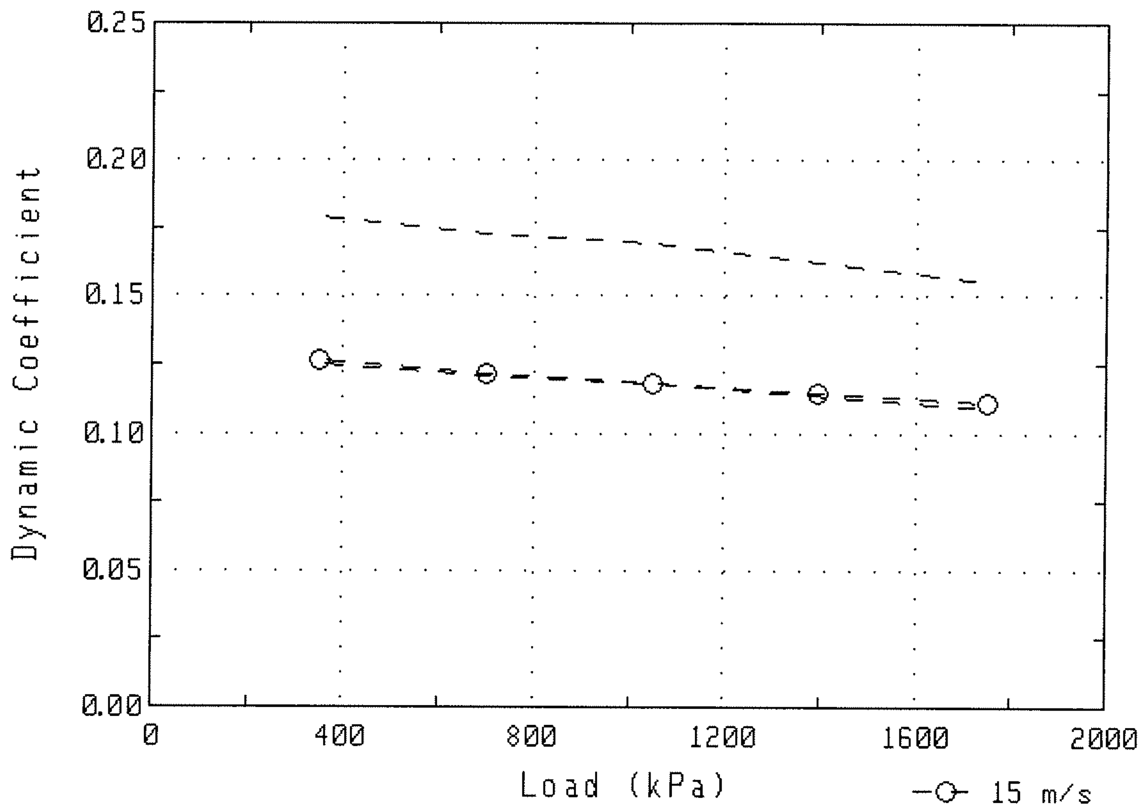
1Y0713 DISC
THICKNESS

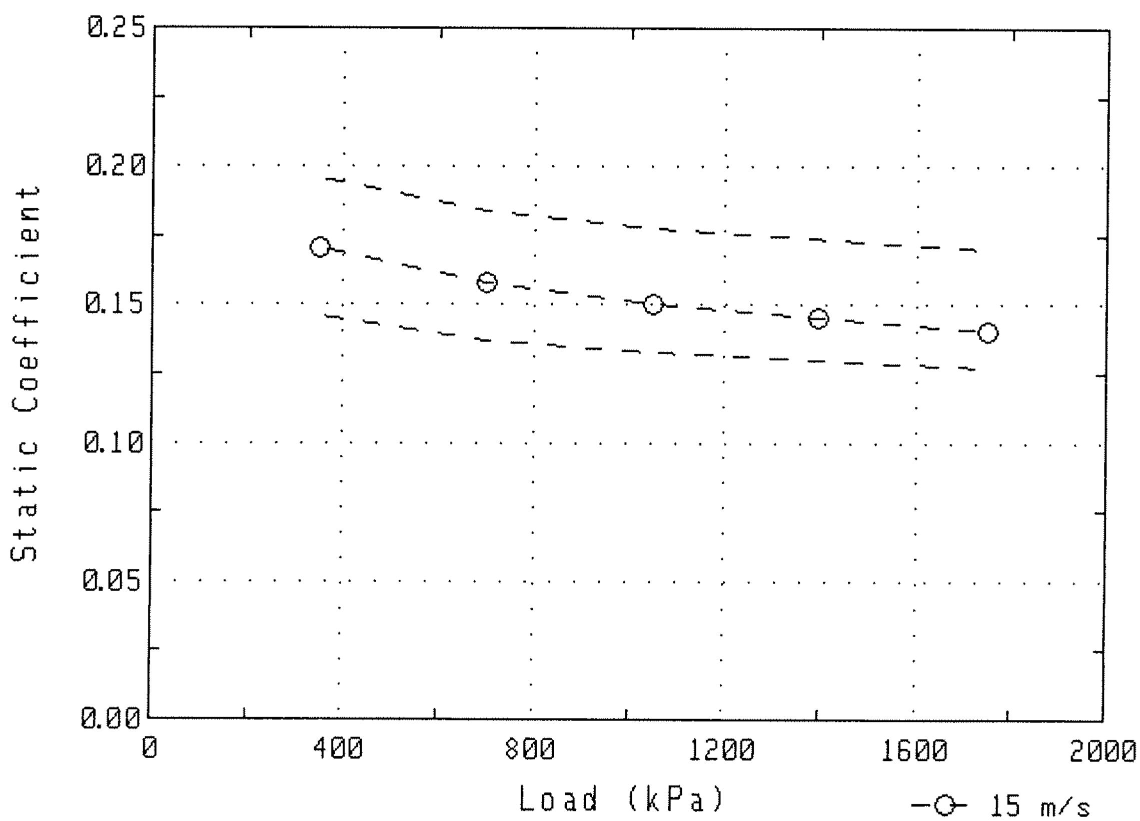
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	5.05	5.04	5.03	5.05	5.04	5.03
2	5.05	5.04	5.03	5.05	5.04	5.03
3	5.05	5.04	5.03	5.05	5.04	5.03
4	5.05	5.04	5.03	5.05	5.04	5.03
5	5.04	5.04	5.03	5.05	5.04	5.03
6	5.05	5.04	5.03	5.05	5.04	5.03
Avg	5.05	5.04	5.03	5.05	5.04	5.03

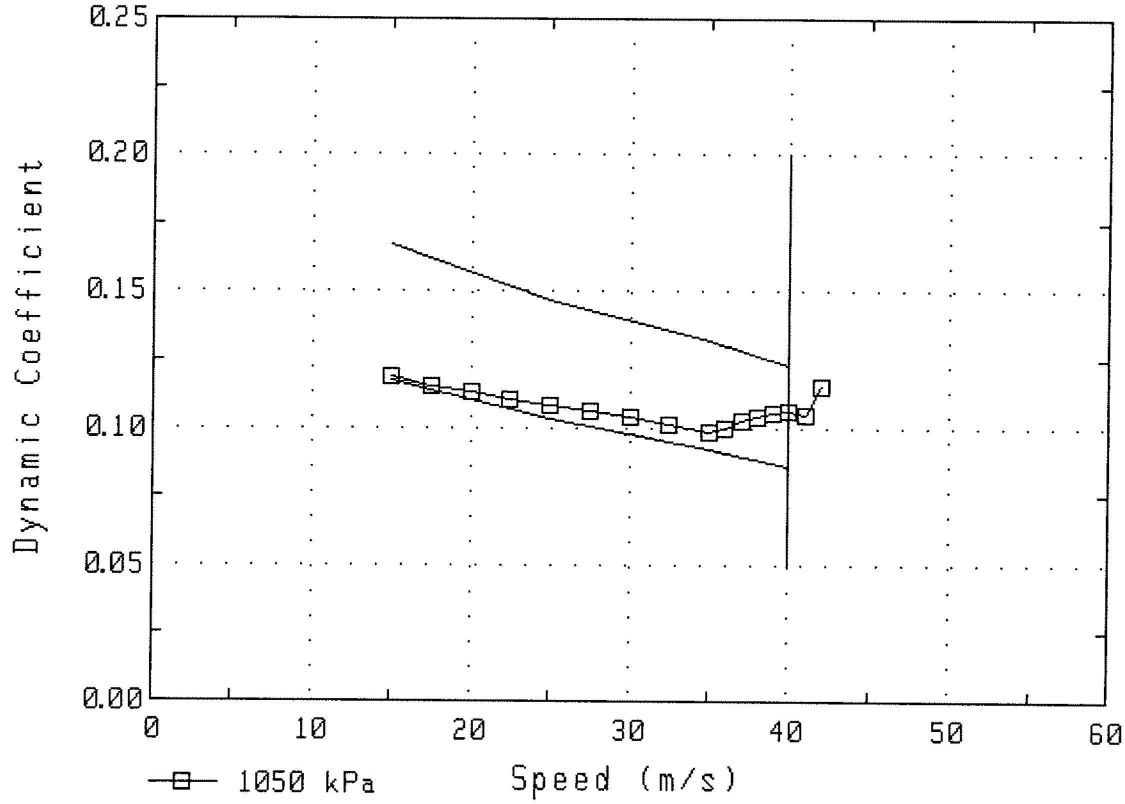
Compression set average wear: 0.009
M2 - M3 average Wear: 0.010

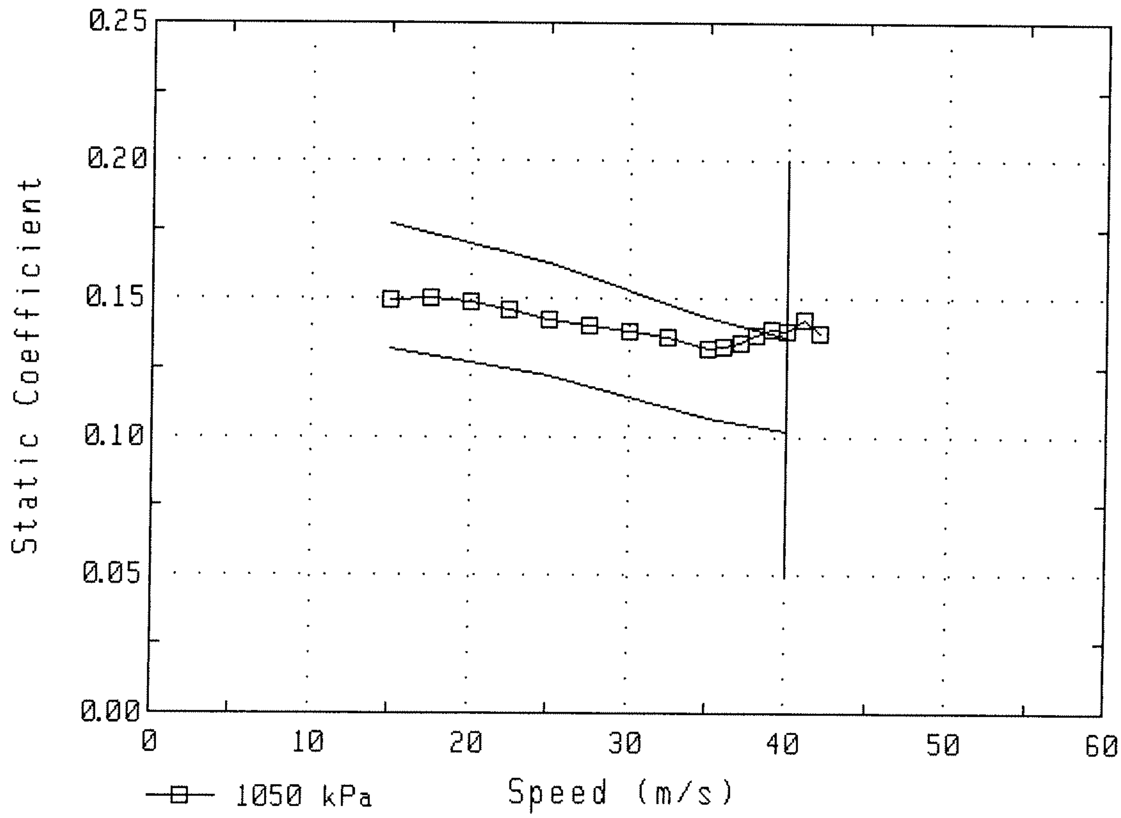
Total Wear (all measurements in mm): 0.019

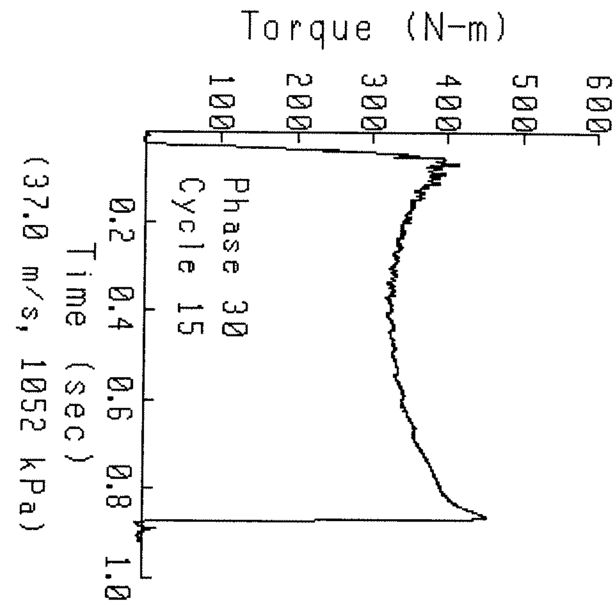
Test: A-85-I Run: I0706123 Started on 11/20/07 at 08:57

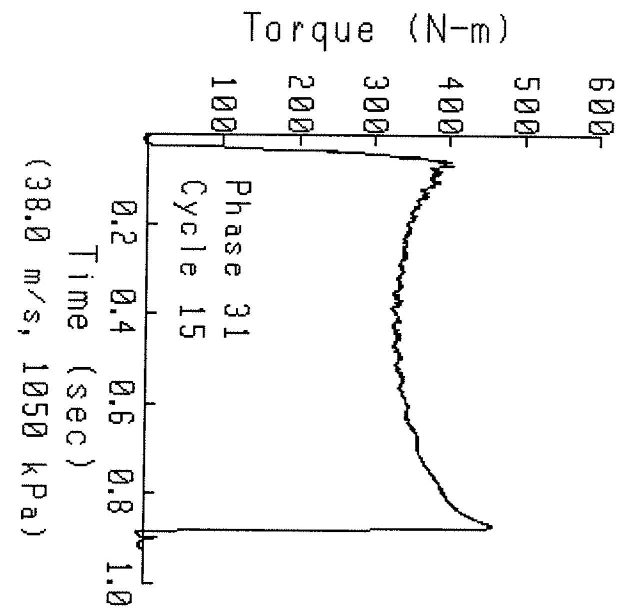


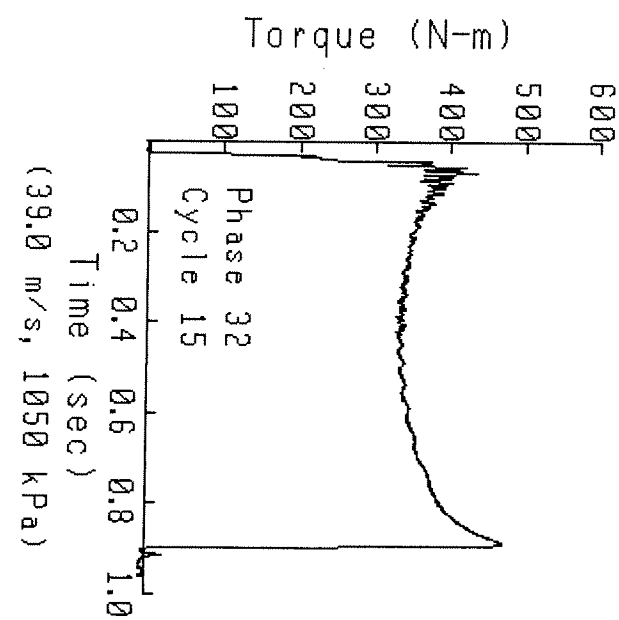


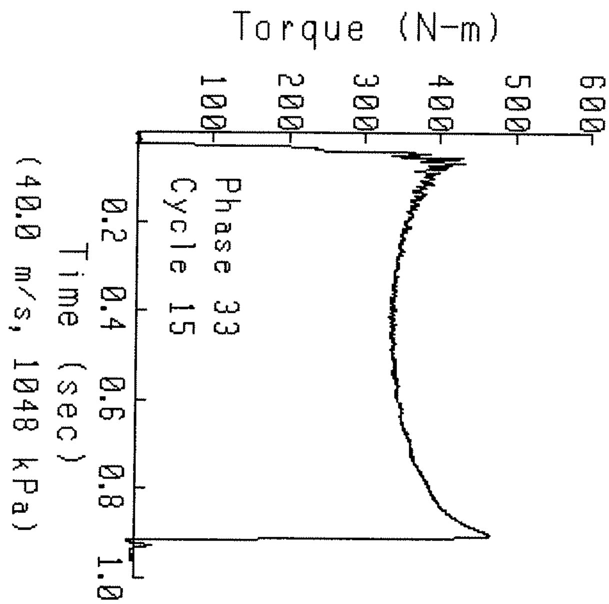

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

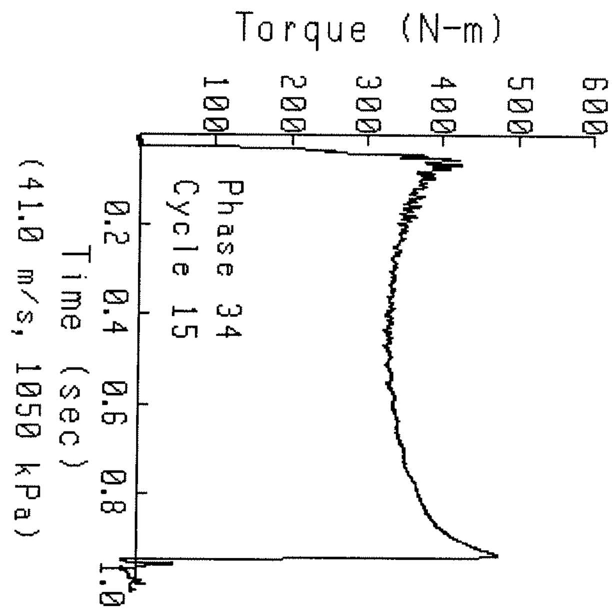

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

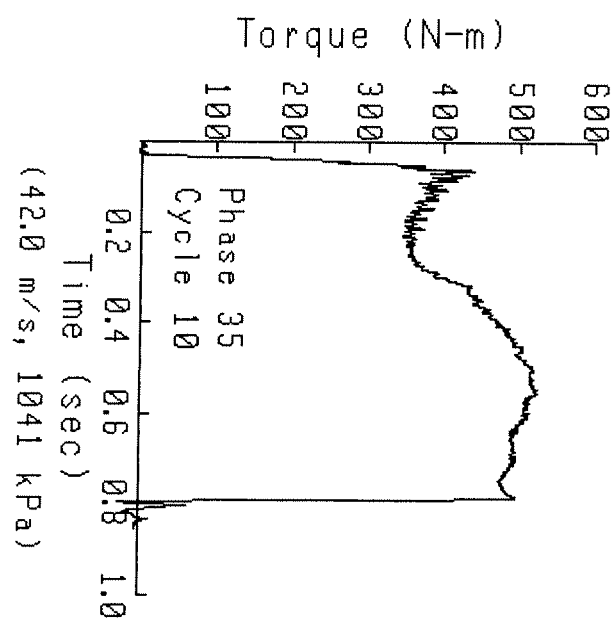

Torque (N-m)
100 200 300 400 500 600
Phase 30
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(37.0 m/s, 1052 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 31
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(38.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 32
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(39.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 33
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(40.0 m/s, 1048 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 34
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(41.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 35
Cycle 10
0.2 0.4 0.6 0.8 1.0
Time (sec)
(42.0 m/s, 1041 kPa)

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

Fuels and Lubricants Research Division

Report on

CATERPILLAR TO-4 FRICTION PROPERTIES, VC-70

Conducted for

SWRI-ARMY LAB

Oil Code:
AL-27875-L

Test Number:
VC70-A-100-I

January 24, 2008

Submitted by:

Brian Koehler
Principal Engineer
Specialty & Driveline Fluids Evaluations

CATERPILLAR TO-4 FRICTION PROPERTIES, VC-70

Summary Sheet

Company: SWRI-ARMY LAB
Test Number: VC70-A-100-I
Test start date: January 19, 2008
End of test date: January 24, 2008
Oil Code: AL-27875-L

Sequence Number	**N/A**	**1220**	**N/A**	**N/A**	**N/A**	**N/A**	**Friction Retention**
Dynamic Coefficient Vs. Cycle:	N/A	P	N/A	N/A	N/A	N/A	F
Dynamic Coefficient Vs. Load:	N/A	P	N/A	N/A	N/A	N/A	
Dynamic Coefficient Vs. Speed:	N/A	P	N/A	N/A	N/A	N/A	
Energy Limit:	N/A	P	N/A	N/A	N/A	N/A	
Static Coefficient Vs. Cycle:							N/A
Static Coefficient Vs. Load:	N/A	P	N/A	N/A	N/A	N/A	
Static Coefficient Vs. Speed:	N/A	P	N/A	N/A	N/A	N/A	
Energy Limit:	N/A	P	N/A	N/A	N/A	N/A	
Total Wear:	N/A	0.015	N/A	N/A	N/A	N/A	
Wear Limit:	N/A	0.040	N/A	N/A	N/A	N/A	

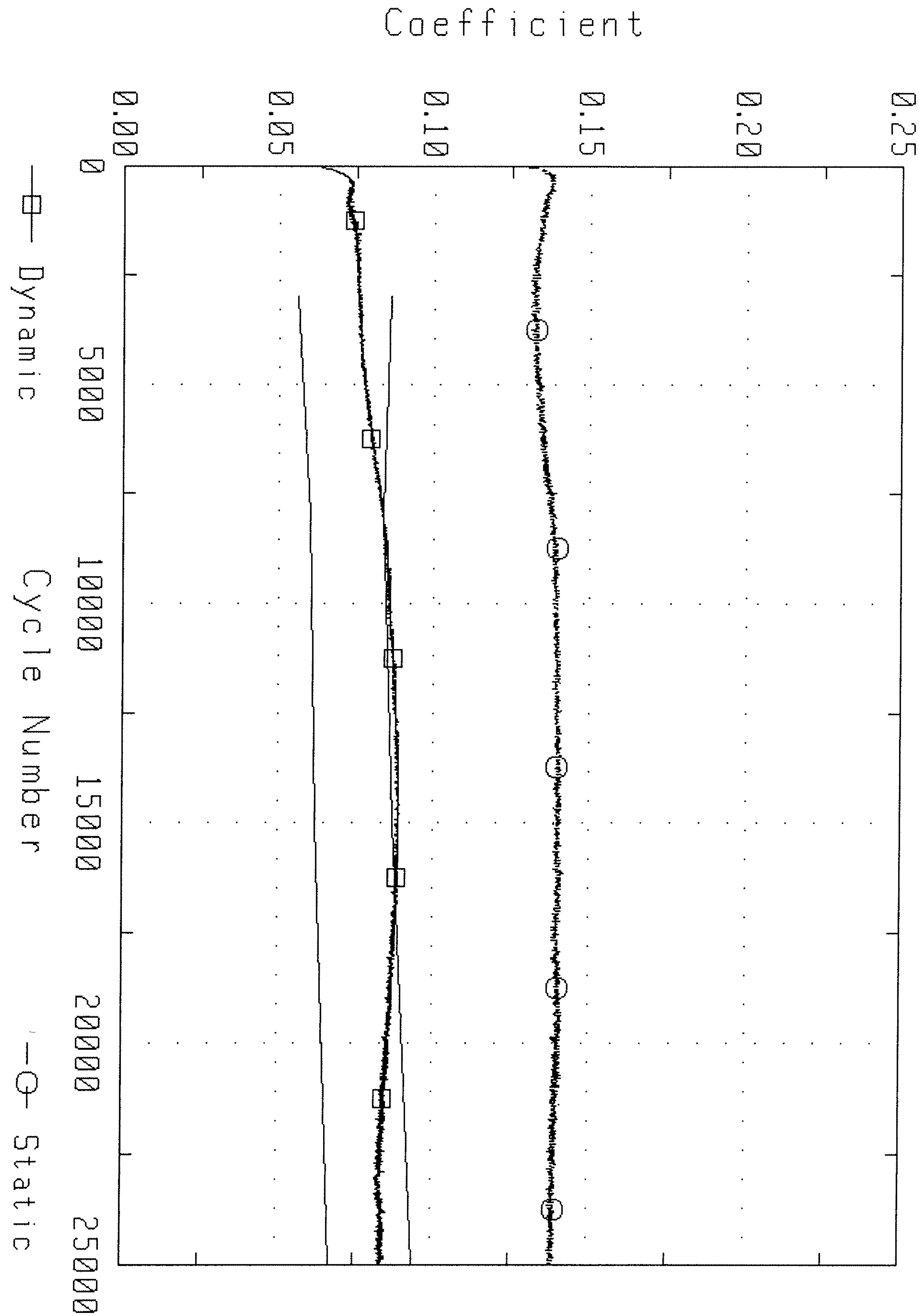
Comments: The limits shown are for the last time the CAT TO-4 straight grade reference oil was run.

F = Fail
P = Pass
N/A = Not Applicable

Southwest Research Institute
I machine oil test AL-27875-L / LO-224036

Test name:	A-100-I
Test date:	01/19/08
Test description:	AL-27875-L
Oil type:	AL-27875-L /LO-224036
Viscosity:	5W-40
Miscellaneous:	
Software version:	1.40
Run name & desc:	I0706163 - AL-27875-L / LO-224036
Run date:	01/19/08
Oil temperature:	115 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	JG
Remarks:	I Machine oil test AL-27875-L / LO-224036
Sequence name:	SEQFRRET
Remarks:	USE 1Y0709 DISC AND 1Y0726 PLATE (8E7351 GROUP)
Number of cycles run:	25100
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 N-m-s^2
Disc name & desc:	1Y0709 - Sintered Bronze
Material:	Raybestos 1349-ET Bronze
Groove pattern:	Single Lead Spiral - 12 Radial
Miscellaneous:	Use with 8E4095 Steel Plate for performance run
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	12FE1-00010
Remarks:	Sintered bronze
Plate name & desc:	1Y0726 - Steel Plate
Surface:	0.30 micron Maximum Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	12FE1-00010
Remarks:	0.14 surface finish
Report limit name:	LIMFRRET - Reference run: I0706151
Limit file generated:	01/14/08
Report format name:	REPFRRET - FRICTION RETENTION

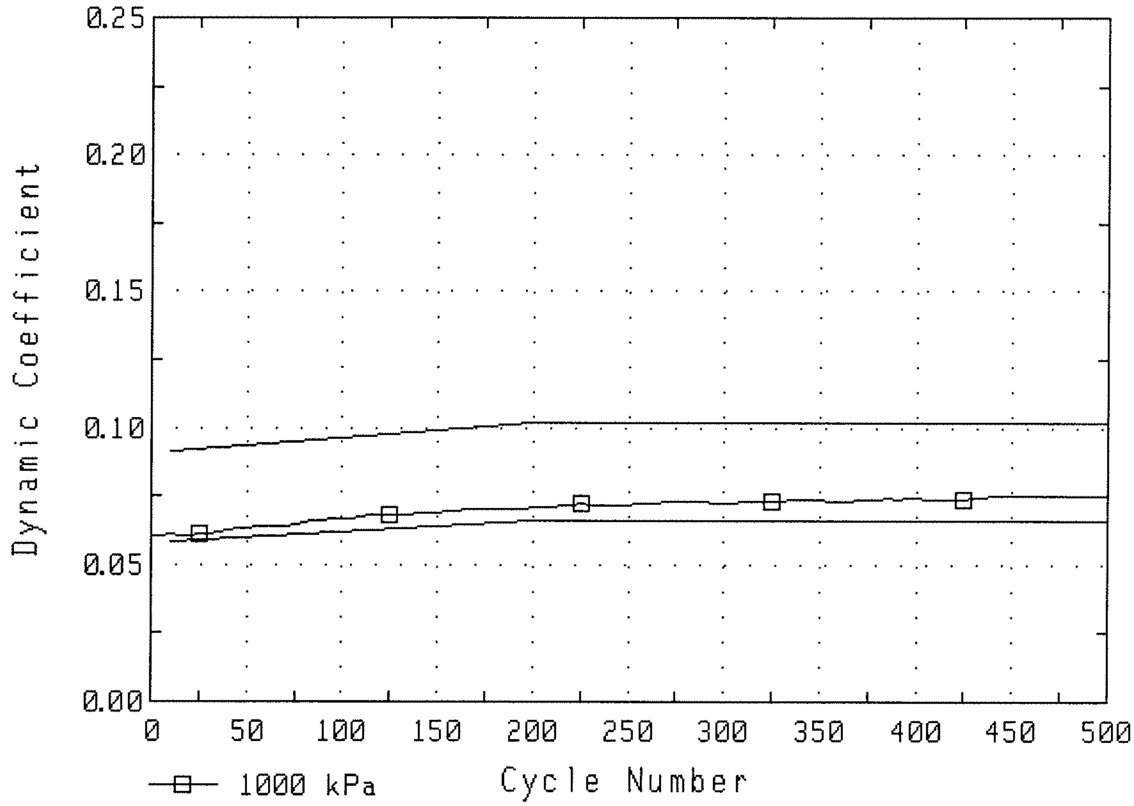
Test: A-100-I Run: I0706163 Started on 01/19/08 at 11:29



Southwest Research Institute
I machine oil test AL-27875-L / LO-224036

Test name:	A-100-I
Test date:	01/19/08
Test description:	AL-27875-L
Oil type:	AL-27875-L /LO-224036
Viscosity:	5W-40
Miscellaneous:	
Software version:	1.40
Run name & desc:	I0706164 - AL-27875-L
Run date:	01/24/08
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	mtd
Remarks:	AL-27875-L / LO-224036
Sequence name:	SEQ1220
Remarks:	Use 1Y0709 Disc and 8E4095 Plate
Number of cycles run:	1079
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 N-m-s^2
Disc name & desc:	1Y0709 - Sintered Bronze
Material:	Raybestos 1349-ET Bronze
Groove pattern:	Single Lead Spiral - 12 Radial
Miscellaneous:	Use with 8E4095 Steel Plate for performance run
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	12FE1-00010
Remarks:	Sintered bronze
Plate name & desc:	8E4095 - Steel Plate
Surface:	0.70 to 1.00 micron Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	12FE1-00010
Remarks:	0.87 surface finish
Report limit name:	LIM1220 - Reference run: I0706159
Limit file generated:	01/15/08
Report format name:	REP1220 - SINTERED BRONZE

Test: A-100-I Run: I0706164 Started on 01/24/08 at 05:40

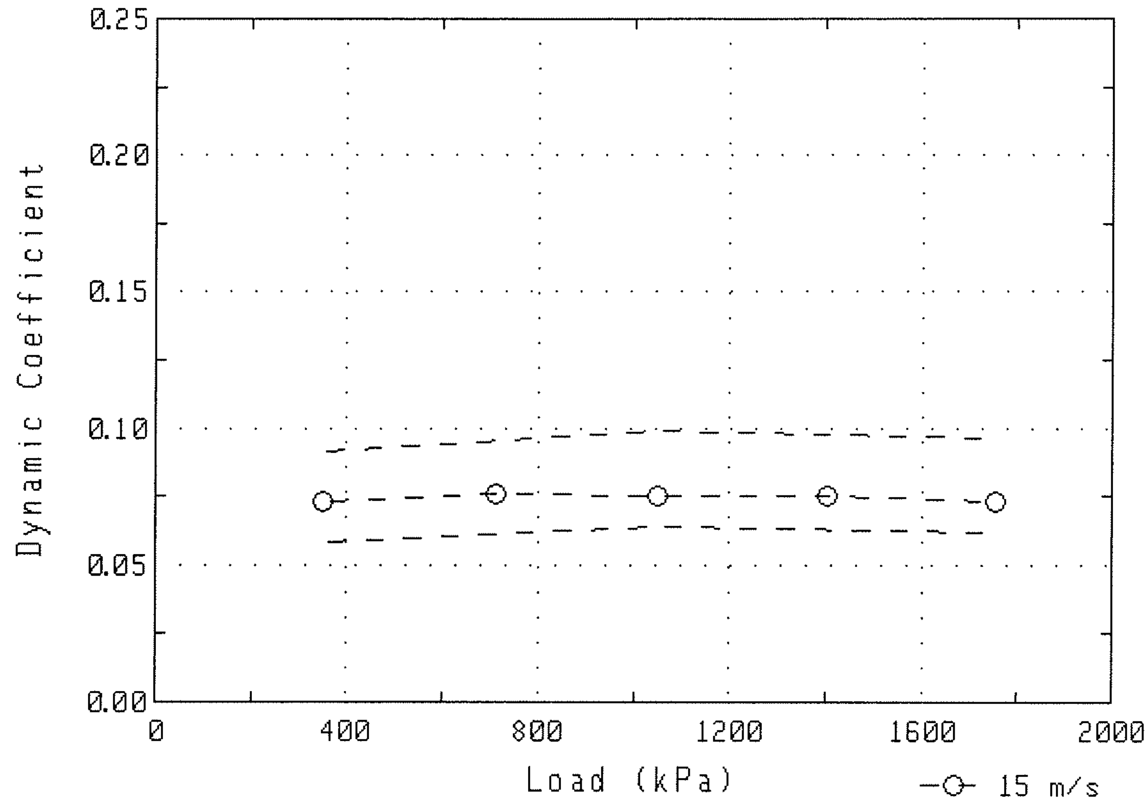


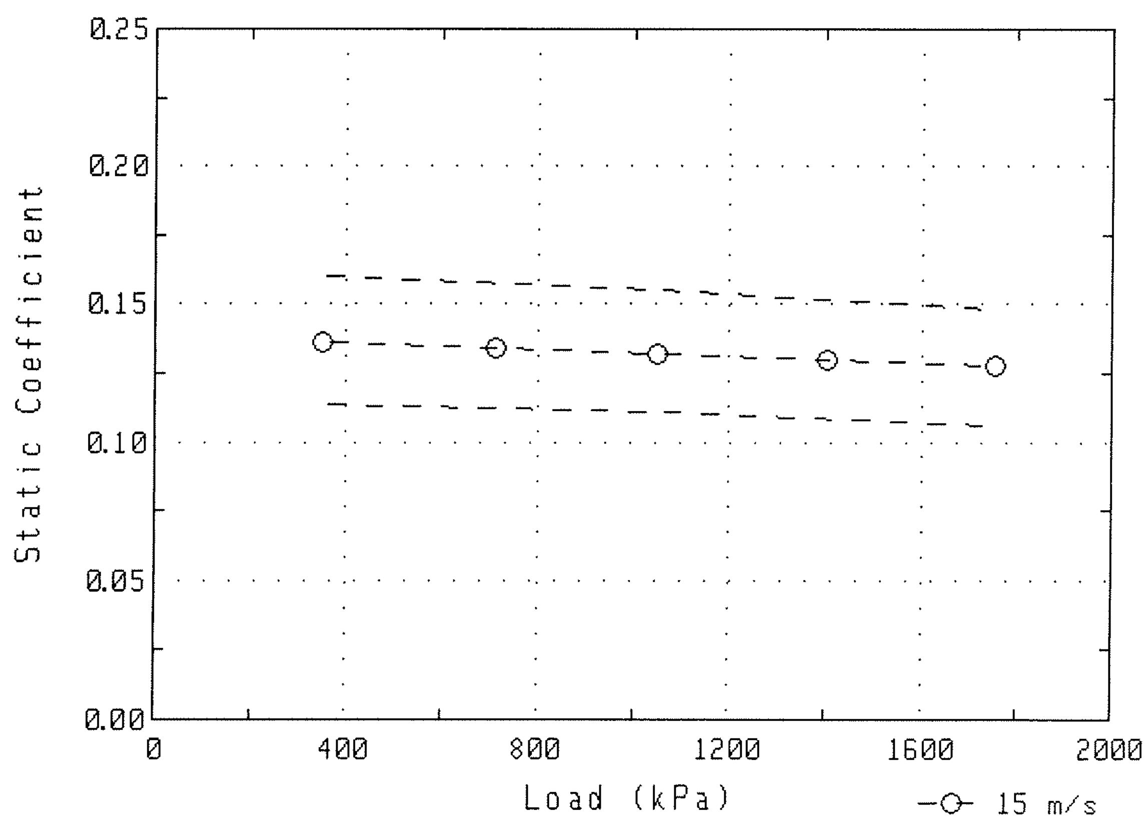
1Y0709 DISC
THICKNESS

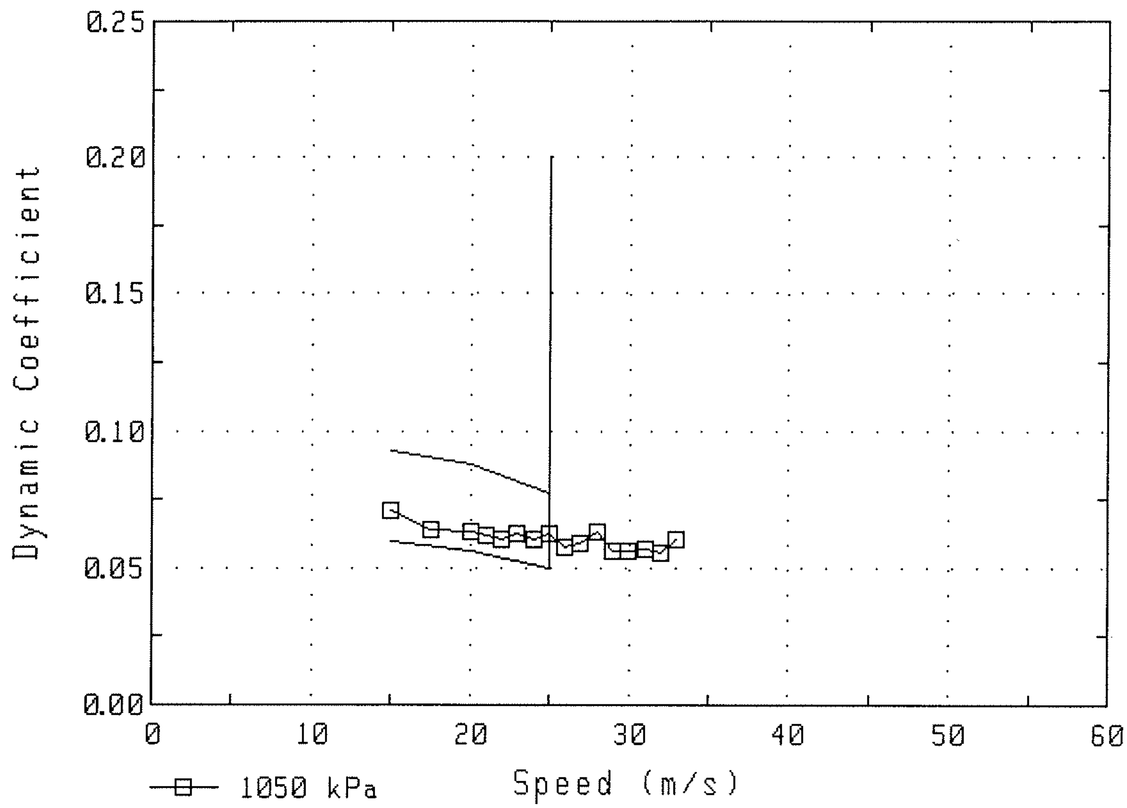
	Outer Diameter			Inner Diameter		
Loc	M1	M2	M3	M1	M2	M3
1	5.01	4.99	4.99	5.01	5.00	4.99
2	5.00	4.99	4.99	5.01	4.99	4.99
3	5.00	4.99	4.99	5.01	5.00	4.99
4	4.99	4.98	4.98	4.99	4.98	4.98
5	5.00	5.00	4.99	5.01	5.00	5.00
6	5.01	5.00	4.99	5.01	4.99	4.99
Avg	5.00	4.99	4.99	5.01	4.99	4.99

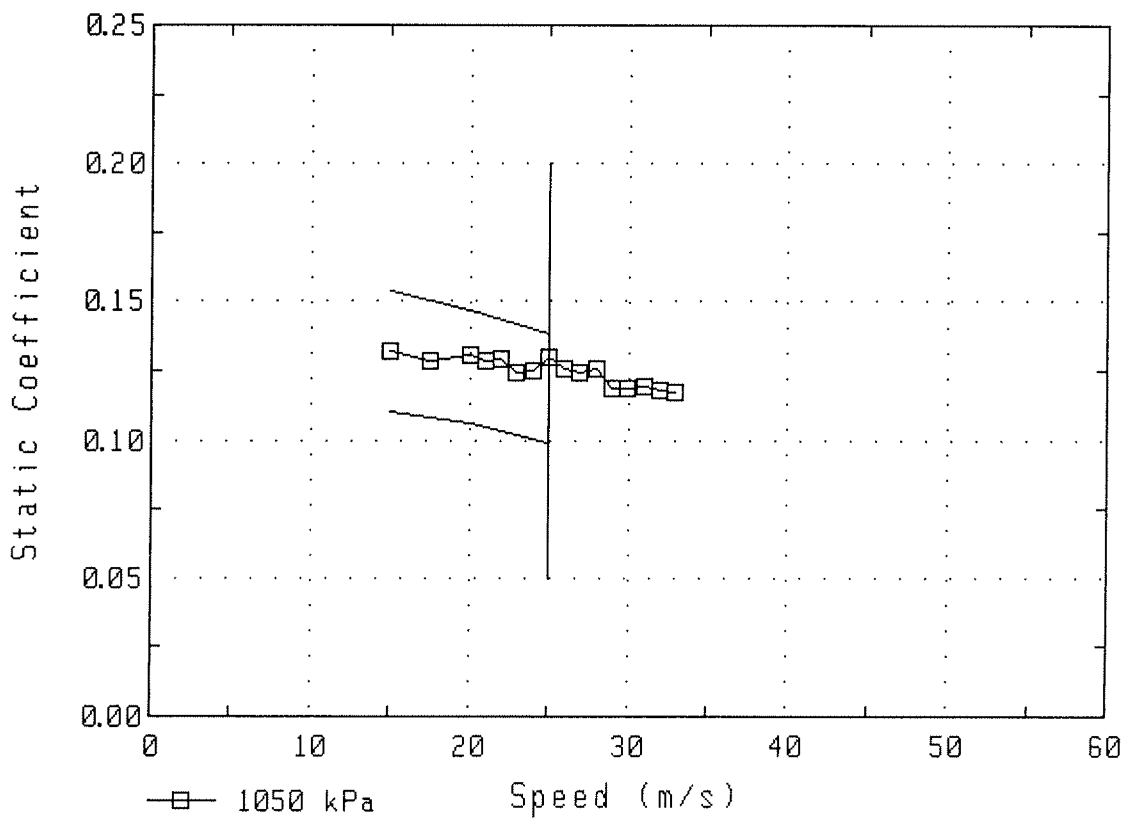
Compression set average wear: 0.012
M2 - M3 average Wear: 0.003

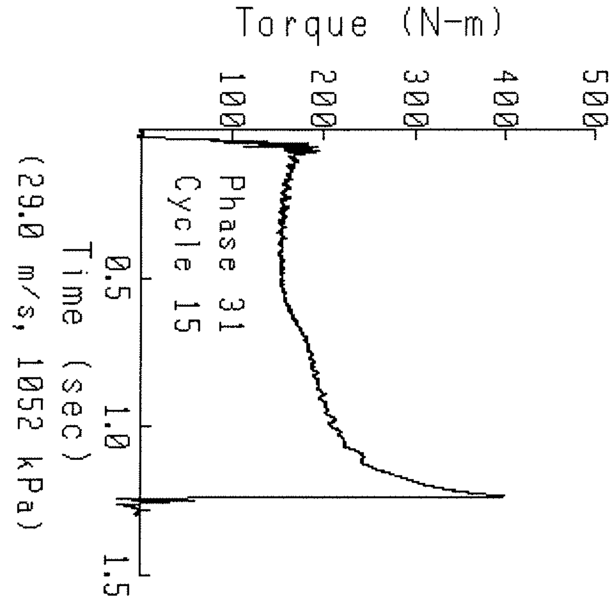
Total Wear (all measurements in mm): 0.015

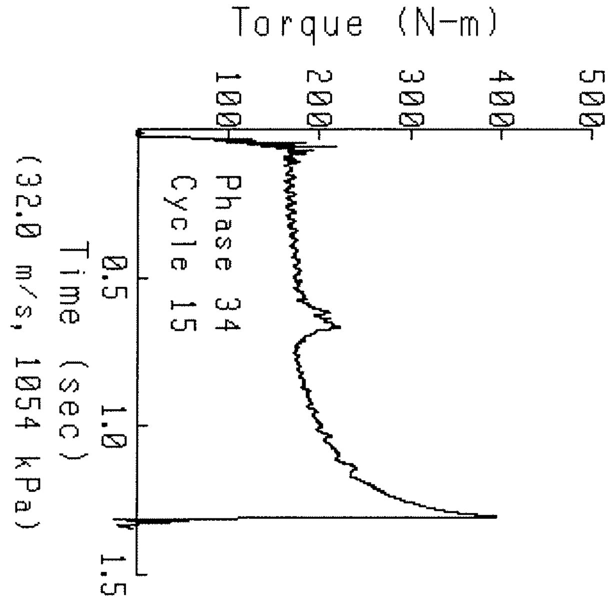

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

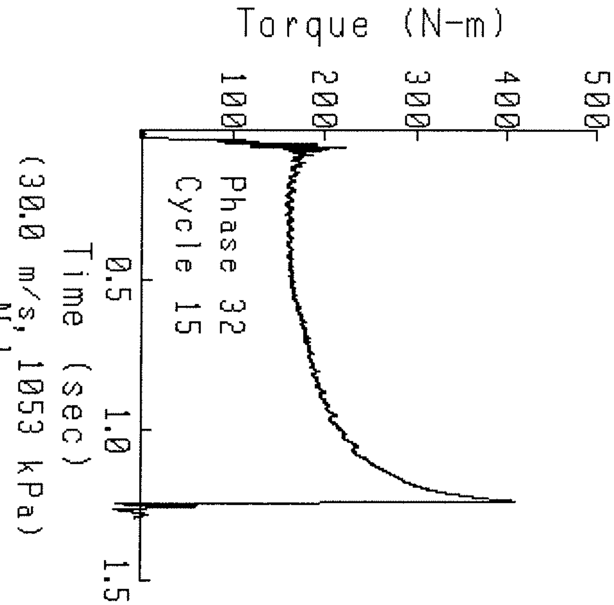

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

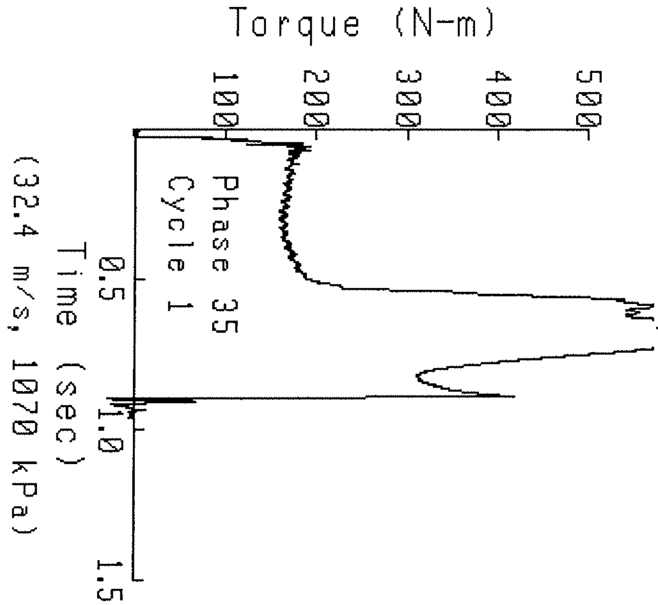

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

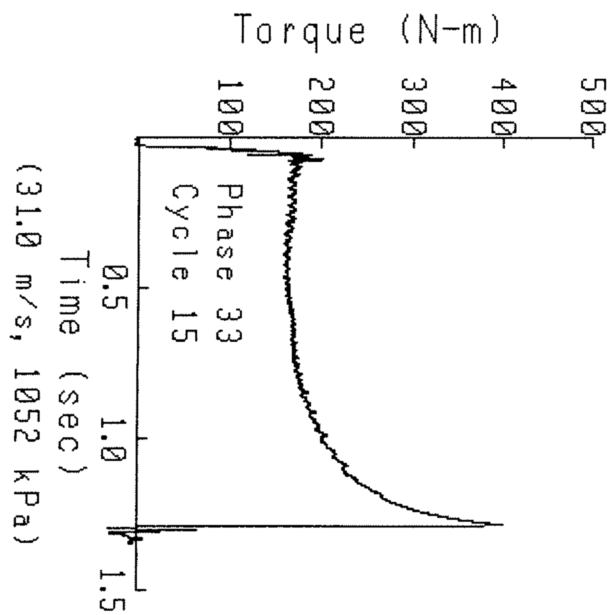

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

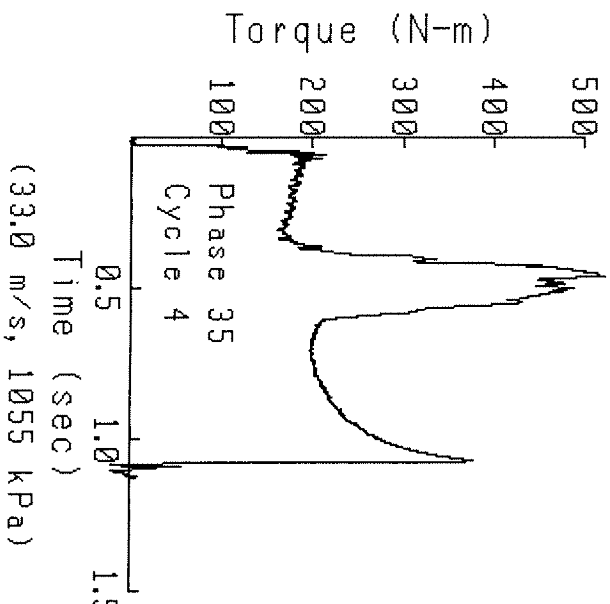

Torque (N-m)
100 200 300 400 500
Phase 31
Cycle 15
Time (sec)
0.5 1.0 1.5
(29.0 m/s, 1052 kPa)


Torque (N-m)
100 200 300 400 500
Phase 34
Cycle 15
Time (sec)
0.5 1.0 1.5
(32.0 m/s, 1054 kPa)


Torque (N-m)
100 200 300 400 500
Phase 32
Cycle 15
Time (sec)
0.5 1.0 1.5
(30.0 m/s, 1053 kPa)


Torque (N-m)
100 200 300 400 500
Phase 35
Cycle 1
Time (sec)
0.5 1.0 1.5
(32.4 m/s, 1070 kPa)


Torque (N-m)
100 200 300 400 500
Phase 33
Cycle 15
Time (sec)
0.5 1.0 1.5
(31.0 m/s, 1052 kPa)


Torque (N-m)
100 200 300 400 500
Phase 35
Cycle 4
Time (sec)
0.5 1.0 1.5
(33.0 m/s, 1055 kPa)

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

Fuels and Lubricants Research Division

Report on

John Deere JDQ-96
Performed using 1400 Series Axle

Conducted for

ARMY LAB

AL-27875-L

Test Number
07019

October 16, 2007

Submitted by:

Michael D. Lochte
Manager
Specialty & Driveline Fluids
Evaluations

John Deere JDQ-96 Performed using 1400 Series Axle

General Information

Oil Code: AL-27875-L	E.O.T. Date: October 16, 2007

Purpose

The purpose of this test was to evaluate the anti-chatter properties of this oil on the brakes of a 1400 series John Deere Inboard Planetary Axle.

Test Procedure

The test was performed as specified by John Deere Product Engineering. The only changes made to the Deere procedure were those necessary to compensate for a different spiral bevel gear ratio. This procedure is proprietary to Deere and Company.

Data Interpretation

The capacity for each engagement is the average torque during the middle of the engagement. The torque variation is the greatest difference between the maximum and minimum torque recorded during any 0.2-second portion of the engagement. The SwRI variation is the sum of all differences between the maximum torque and minimum torque for each engagement. It is obtained by summing all torque variations of each 0.2-second time block of all engagements.

Test Number

The run number listed on this report is a random number and is not sequential. Only SwRI® can link this run number to JDQ-96, AL-27875-L, October 16, 2007.

John Deere JDQ-96 Performed using 1400 Series Axle

Results

Oil Code: AL-27875-L	**E.O.T. Date:** October 16, 2007

The candidate results can be compared to the baseline reference average. Pass or fail decisions are only made by John Deere Product Engineering. The current reference baseline average is the average of the five most recent tests.

Current Reference Baseline Average (N · m)					
	1,000 Cycles	**10,000 Cycles**	**20,000 Cycles**	**30,000 Cycles**	**TOTAL**
Relative Capacity	338,535	338,534	341,629	343,274	1,361,972
Torque Variation	79,214	84,272	79,152	74,708	317,346

Results From Test Candidate AL-27875-L					
	1,000 Cycles	**10,000 Cycles**	**20,000 Cycles**	**30,000 Cycles**	**TOTAL**
Relative Capacity	348.512				
Torque Variation	179,060				

Tables 1 of the Appendix contains chatter test results from 1,000cycles. Table 2 contains results of the five current baseline reference tests. Figures 1 through 4 are graphic presentations of candidate oil performance compared to baseline reference data.

Figure 5 is a graphic presentation of 1000-cycle reference results and AL-27875-L. Table 3 contains the history of reference tests.

John Deere JDQ-96 Performed using 1400 Series Axle

Oil Code: AL-27875-L	**E.O.T. Date:** October 16, 2007

Appendix

Tables

1. Table 1 – Durability results 1,000 cycles Candidate Oil
2. Table 2 – Reference Data Compared to Candidate Data
3. Figure 1 & Figure 2 - Torque Variation Chart
4. Figure 3 & Figure 4 – Relative Capacity & Average Disk Thickness Chart
5. Figure 5 - Graphic presentation of 1000 cycle reference results & Candidate
6. Table 3 - History of reference tests

October 16, 2007

TABLE 1: JDQ-96 DURABILITY TEST RESULTS 1,000 CYCLES

SwRI Oil Code LO-224036 Sponsor Oil Code AL-27875-L

Axle Speed (rpm)	Brake Press. (kPa)	TORQUE VARIATION TEST RESULTS (TORQUE and VARIATION in Nm)											
		Oil Temp. 32°C			Oil Temp. 49°C			Oil Temp. 60°C			Oil Temp. 71°C		
		Torque	Variation	Temp.	Torque	Variation	Temp.	Torque	Variation	Temp.	Torque	Variation	Temp.
8	3831	3914	4030	25	4280	2270	51	4464	2340	62	4564	2320	72
10	3831	4235	4260	26	4212	2290	49	4250	2310	60	4314	2340	71
15	3831	4055	3120	26	3998	2920	49	3962	2900	59	4405	2870	71
20	3831	4051	720	26	4000	3610	48	3931	3400	58	4248	3640	72
25	3831	4104	760	26	3948	3720	48	3865	3940	59	4125	4390	72
30	3831	4125	780	26	4189	1100	49	4080	1210	60	4464	1700	73
35	3831	4103	710	27	4113	960	49	4044	1170	60	4340	1590	73
40	3831	4138	790	28	4178	1030	50	4071	1330	61	4358	1630	72
45	3831	4093	770	29	4084	1130	50	3952	1360	61	4223	1610	72
50	3831	4049	740	30	4048	1100	51	3934	1330	61	4177	1560	72
55	3831	4052	690	31	3943	990	48	4125	1260	61	4346	1540	73
60	3831	4062	780	33	3920	1000	49	4016	1200	61	4194	1520	72
15	1532	1633	450	32	1740	740	50	1751	800	60	1805	900	72
15	2300	2463	630	31	2606	880	49	2409	1760	59	2614	1030	71
15	3065	3108	2780	31	3168	2800	47	3189	2750	59	3186	2570	71
15	3831	3963	2990	31	4135	2840	50	4132	2830	60	4075	2950	70
15	4598	4925	3080	31	5106	2780	50	5076	3000	60	5026	2920	70
15	5364	5944	2940	31	5970	3090	50	5944	3230	60	6255	5190	71
15	6130	6908	4460	31	6921	4420	50	6893	3740	60	7214	3770	71
15	7050	7911	4820	32	7875	3300	50	7932	3640	60	8289	4250	71

Temp (°C)	Relative Capacity (Nm)	Torque Variation (Nm)	SwRI Variation (Nm)
32	85,836	40,300	537,410
49	86,434	42,970	489,820
60	86,019	45,500	525,270
71	90,222	50,290	584,580
TOTAL	348,512	179,060	2,137,080

TABLE 2: JDQ-96 REFERENCE DATA COMPARED TO CANDIDATE DATA

EOT Date: October 16, 2007

Oil Code : AL-27875-L

Reference Oil Coded : 69X31111i	Cycles	Relative Capacity	Torque Variation	SwRI Variation	Average Facing Thickness (millimeters)
First Reference Run					
	1,000	326,304	57,420	730,050	7.60
	10,000	331,809	64,900	804,030	7.50
	20,000	345,325	69,500	899,880	7.44
	30,000	341,770	66,210	810,190	7.39
	Total	1,345,208	258,030	3,244,150	
Second Reference Run					
	1,000	337,791	66,660	848,580	7.60
	10,000	338,055	92,240	1,129,330	7.55
	20,000	343,166	77,010	1,001,920	7.49
	30,000	350,470	73,280	863,980	7.44
	Total	1,369,482	309,190	3,843,810	
Third Reference Run					
	1,000	339,375	100,390	1,204,240	7.56
	10,000	335,754	106,780	1,079,450	7.52
	20,000	334,120	84,770	1,030,270	7.49
	30,000	335,614	79,620	1,021,190	7.47
	Total	1,344,863	371,560	4,335,150	
Fourth Reference Run					
Run on new backing pla	1,000	343,906	79,990	1,020,120	7.48
and piston	10,000	343,056	72,520	893,570	7.30
	20,000	342,668	69,920	885,870	7.07
	30,000	345,315	70,360	833,920	6.90
	Total	1,374,945	292,790	3,633,480	
Invalid test run on same	*1,000*	*348,860*	*132,110*	*1,721,010*	
backing plate and pistor	*10,000*	*323,093*	*153,860*	*1,919,720*	
as test above was run on					
Fifth Reference Run					
most recent run	**1,000**	**345,296**	**91,610**	**1,125,260**	**7.50**
Run on new backing	**10,000**	**343,999**	**84,920**	**1,019,400**	**7.33**
plate and piston	**20,000**	**342,864**	**94,560**	**1,264,070**	**7.22**
	30,000	**343,201**	**84,070**	**1,052,400**	**7.11**
	Total	**1,375,360**	**355,160**	**4,461,130**	
AL-27875-L		Candidate Oil Test Results			
	1,000	348,512	179,060	2,137,080	
	10,000				
	20,000				
	30,000				
	Total	348,512	179,060	2,137,080	

Figure 1

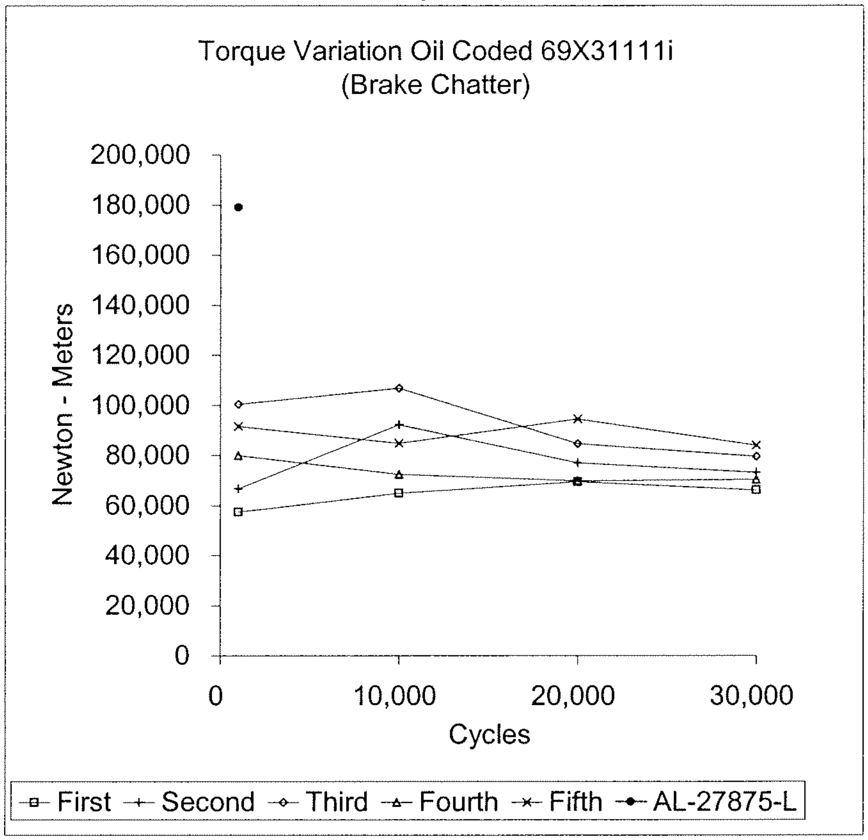


Figure 2

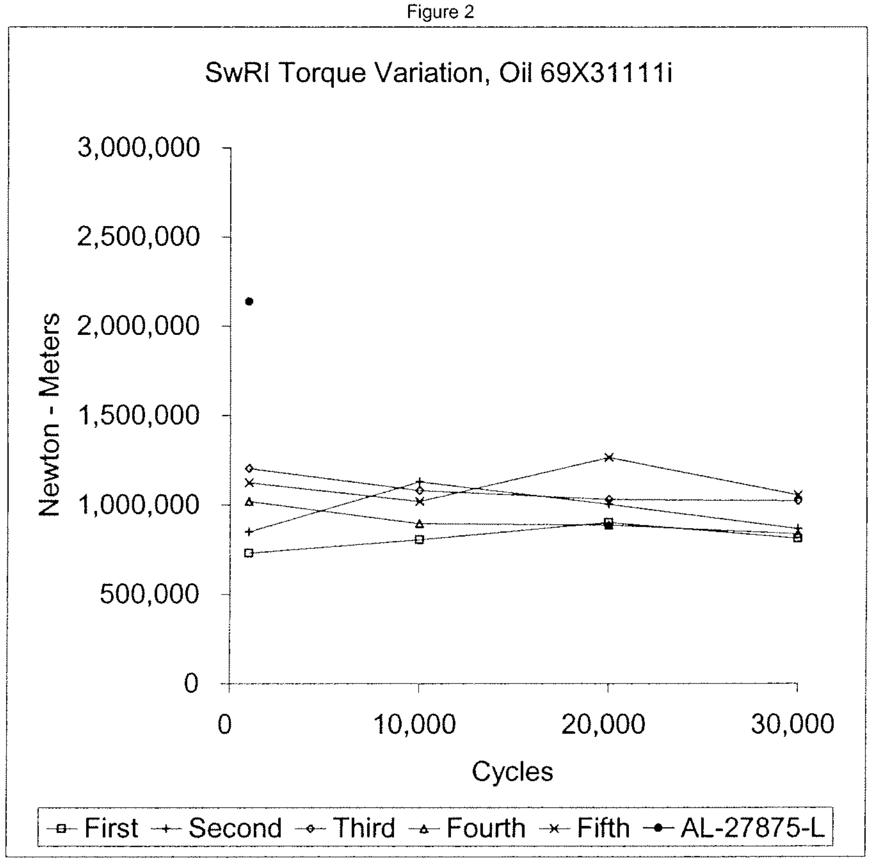


Figure 3

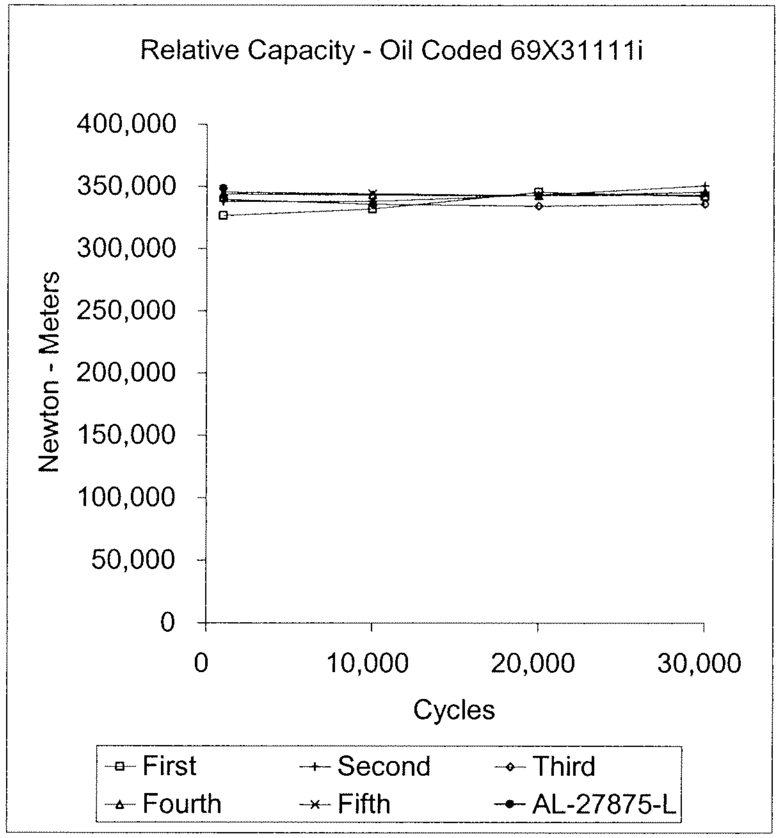


Figure 4

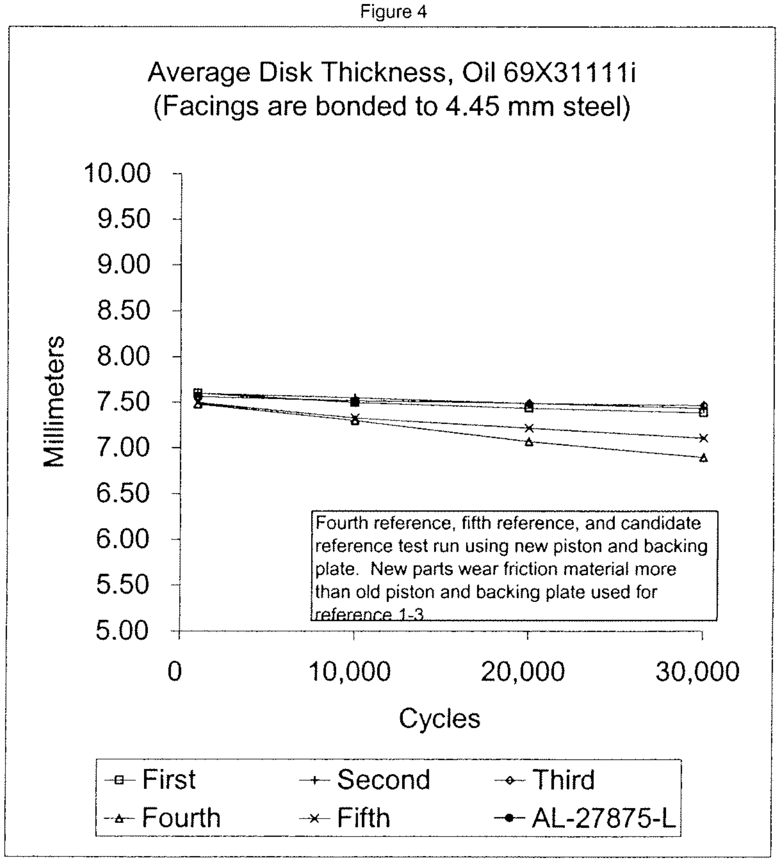
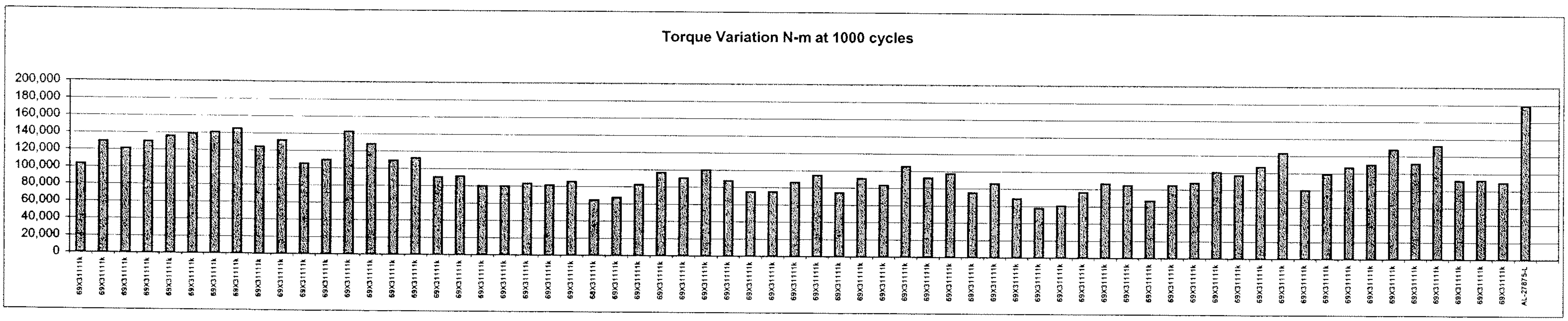


Table 3

AL-27875-L October 16, 2007

History of 1000 cycle reference tests.

		Torque variation at 1000 cycles
69X31111k	1999 brake disk	103,360
69X31111k	1997 brake disk	129,540
69X31111k	2000 brake disk	121,120
69X31111k	2000 brake disk	129,620
69X31111k	2000 brake disk	135,700
69X31111k	2000 brake disk	138,760
69X31111k	2000GDD brake di	140,830
69X31111k	2000GDD brake	144,820
69X31111k	2000GDD brake	124,310
69X31111k	2000 GDD brake	131,860
69X31111k	2000 GDD brake	105,010
69X31111k	2000 GDD brake	109,220
69X31111k	2000 GDD brake	142,510
69X31111k	2000 GDD brake	128,080
69X31111k	2000 GDD brake	109,100
69X31111k	2000 GDD brake	111,800
69X31111k	2000 GDD brake	90,070
69X31111k	2000 GDD brake	90,810
69X31111k	2000 GDD brake	79,930
69X31111k	2000 GDD brake	79,930
69X31111k	2000 GDD brake	83,190
69X31111k	2000 GDD brake	81,220
69X31111k	2000 GDD brake	85,570
68X31111k	2000 GDD brake	64,170
69X31111k	2000 GDD brake	67,390
69X31111k	2000 GDD brake	82,410
69X31111k	2000 GDD brake	96,730
69X31111k	2000 GDD brake	90,390
69X31111k	2000 GDD brake	99,960
69X31111k	2000 GDD brake	87,380
69X31111k	2000 GDD brake	74,720
69X31111k	2000 GDD brake	74,940
69X31111k	2000 GDD brake	85,980
69X31111k	2000 GDD brake	94,410
69X31111k	2000 GDD brake	74,300
69X31111k	2000 GDD brake	90,950
69X31111k	2000 GDD brake	83,190
69X31111k	2000 GDD brake	105,210
69X31111k	2000 GDD brake	91,960
69X31111k	2000 GDD brake	97,320
69X31111k	2000 GDD brake	75,040
69X31111k	2000 brake disk	86,060
69X31111k	2000 brake disk	68,590
69X31111k	2003 brake disk	57,420
69X31111k	2003 brake disk	60,330
69X31111k	2003 brake disk	76,260
69X31111k	2003 brake disk	86,210
69X31111k	2003 brake disk	84,550
69X31111k	2003 brake disk	66,660
69X31111k	2003 brake disk	84,760
69X31111k	2003 brake disk	87,800
69X31111k	2003 brake disk	100,390
69X31111k	2003 brake disk	96,620
69X31111k	2003 brake disk	106,710
69X31111k	2003 brake disk	123,110
69X31111k	NEW BACKING Pl	79,990
69X31111k		98,440
69X31111k		106,370
69X31111k		110,040
69X31111k		127,550
69X31111k		111,280
69X31111k	invalid run	132,110
69X31111k	NEW BACKING Plate and piston	91,610
69X31111k	NEW BACKING Plate and piston	92,230
69X31111k	plate used for 1 test	89,200
AL-27875-L	same brake plate and piston as above	179,060



AL-27875-L

October 16, 2007

Figure 5

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

FUELS AND LUBRICANTS RESEARCH DIVISION

Report on

CATERPILLAR TO-4 FRICTION PROPERTIES, VC-70

Conducted for

SWRI ARMY LAB

Oil Code:
AL-27876-L

Test Number:
VC70-A-86-I

November 28, 2007

Submitted by:

Brian Koehler
Principal Engineer
Specialty & Driveline Fluids
Evaluations

CATERPILLAR TO-4 FRICTION PROPERTIES, VC-70

Summary Sheet

Company: SWRI ARMY LAB
Test Number: VC70-A-86-I
Test start date: November 24, 2007
End of test date: November 28, 2007
Oil Code: AL-27876-L

Sequence Number	1219	1220	1221	1222	1223	1224	Friction Retention
Dynamic Coefficient Vs. Cycle:	F	N/A	P	F	F	P	N/A
Dynamic Coefficient Vs. Load:	F	N/A	P	F	F	P	
Dynamic Coefficient Vs. Speed:	F	N/A	P	F	F	P	
Energy Limit:	P	N/A	P	P	P	P	
Static Coefficient Vs. Cycle:							N/A
Static Coefficient Vs. Load:	P	N/A	P	F	F	P	
Static Coefficient Vs. Speed:	P	N/A	P	P	F	F	
Energy Limit:	P	N/A	P	P	P	P	
Total Wear:	0.013	N/A	0.046	0.038	0.037	0.016	
Wear Limit:	0.030	0.040	0.070	0.070	0.070	0.040	

Comments: The limits shown on these report pages are from the last time the test stand was referenced with the single grade CAT reference oil.

F = Fail
P = Pass
N/A = Not Applicable

Test name:	A-86-I
Test date:	11/21/07
Test description:	I MACHINE AL-27876-L
Oil type:	
Viscosity:	
Miscellaneous:	
Software version:	1.40

Run name & desc:	I0706124 - AL-27876-L
Run date:	11/24/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	JG
Remarks:	"I" MACHINE OIL TEST AL-27876-L / LO-224037
Sequence name:	SEQ1219
Remarks:	Use 1Y0708 Disc and 1Y3610 Plate
Number of cycles run:	1094

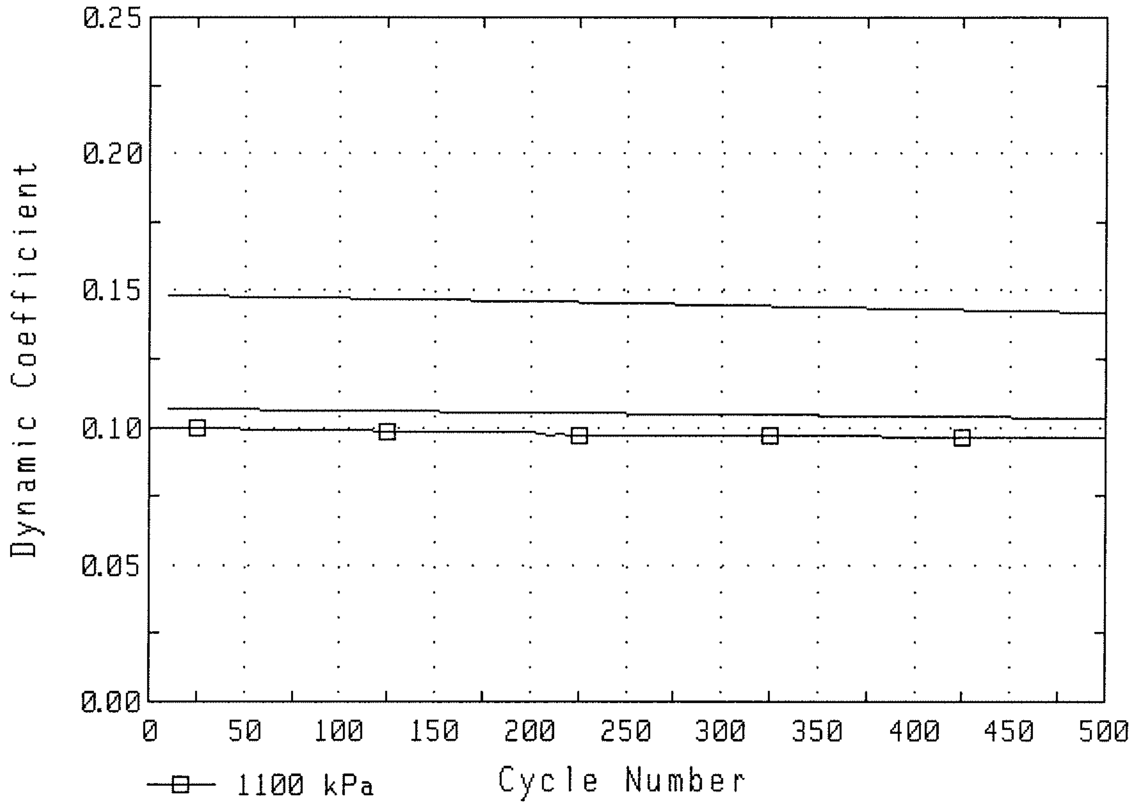
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 N-m-s^2

Disc name & desc:	1Y0708 - Elastomeric Disc
Material:	Raybestos 6475-4 Rayflex
Groove pattern:	Single Lead Spiral - 12 Radial
Miscellaneous:	Use with 1Y3610 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	26NO0-00004
Remarks:	ELASTOMERIC

Plate name & desc:	1Y3610 - Steel Plate
Surface:	0.70 to 1.30 micron Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	26NO0-00004
Remarks:	0.88 SURFACE FINISH

Report limit name:	LIM1219 - Reference run: I0706090
Limit file generated:	09/24/07
Report format name:	REP1219 - ELASTOMERIC, RAYFLEX

Test: A-86-I Run: I0706124 Started on 11/24/07 at 07:56

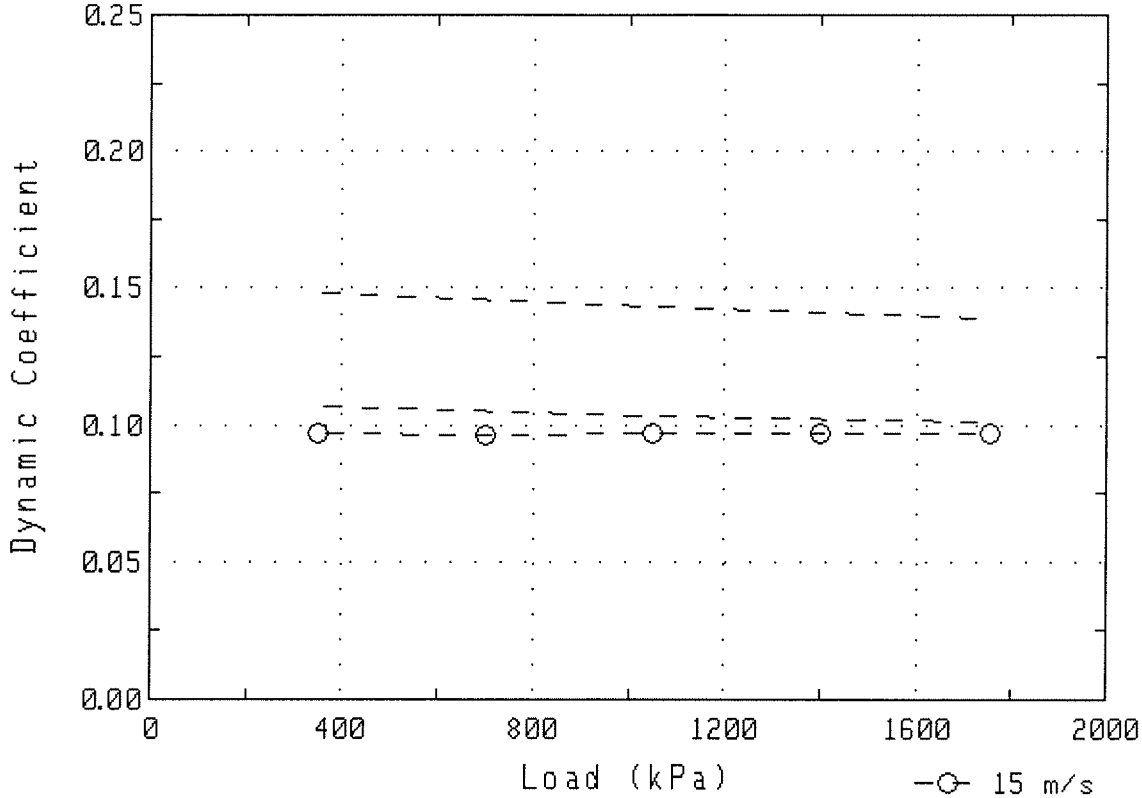


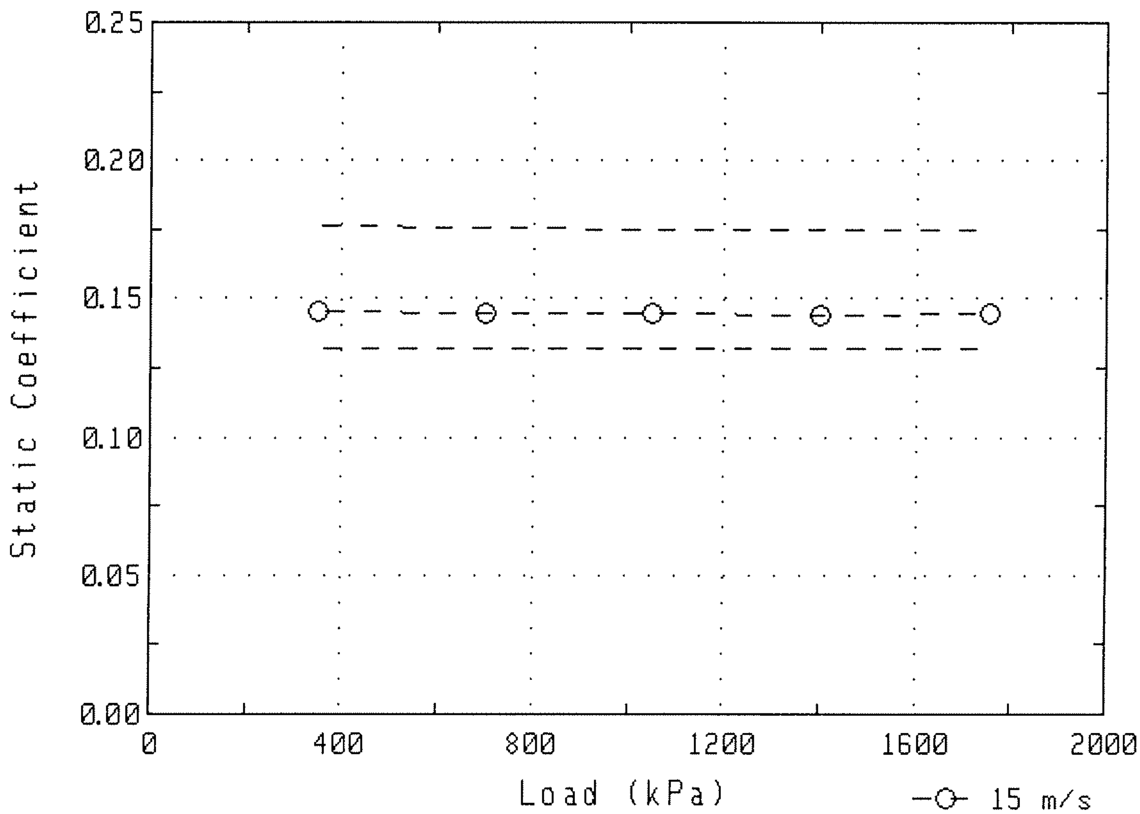
1Y0708 DISC
THICKNESS

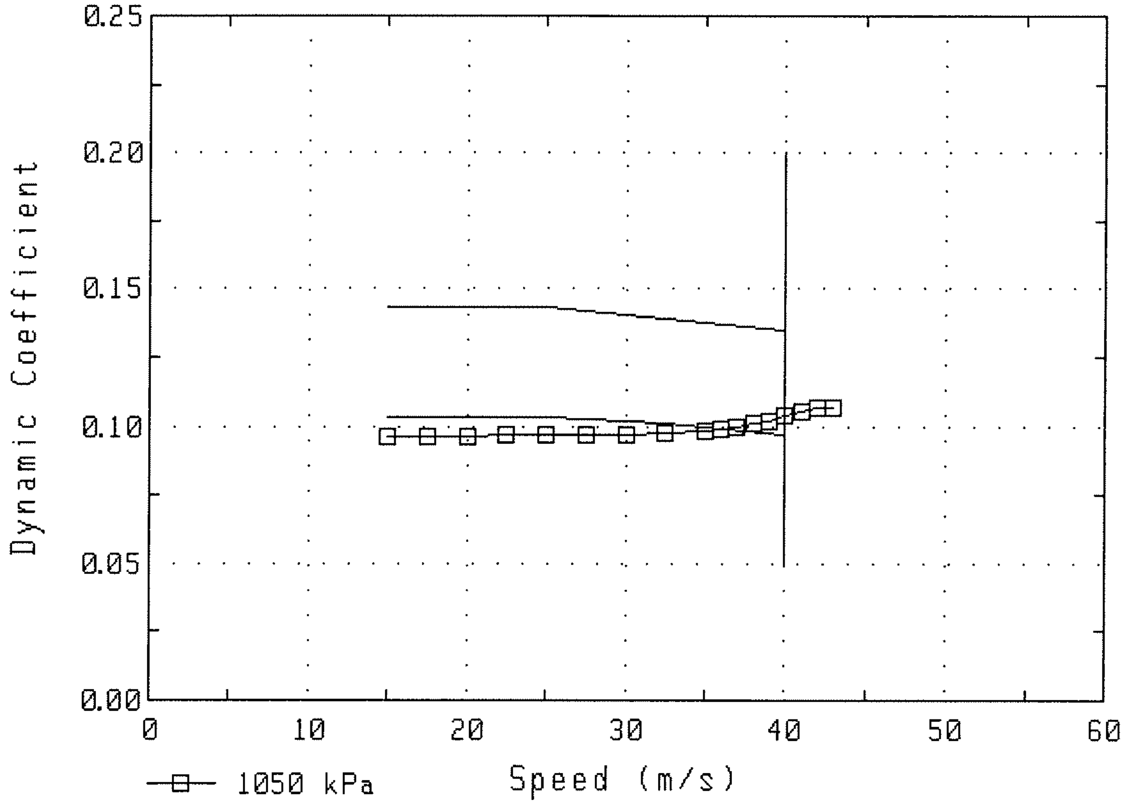
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	4.96	4.95	4.95	4.96	4.94	4.94
2	4.96	4.95	4.95	4.96	4.94	4.94
3	4.96	4.95	4.95	4.96	4.95	4.95
4	4.97	4.96	4.96	4.97	4.96	4.96
5	4.97	4.96	4.96	4.97	4.96	4.96
6	4.97	4.96	4.96	4.97	4.95	4.95
Avg	4.97	4.95	4.95	4.97	4.95	4.95

Compression set average wear: 0.013
M2 - M3 average Wear: 0.000

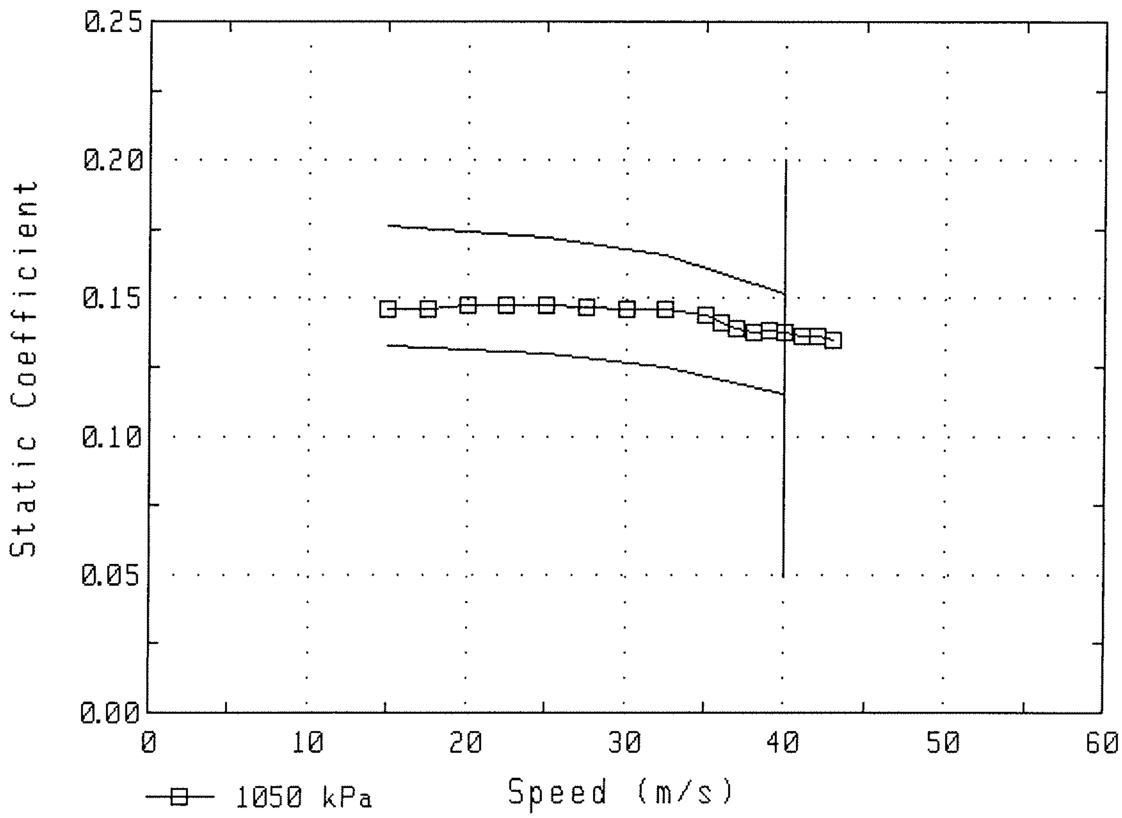
Total Wear (all measurements in mm): 0.013


0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

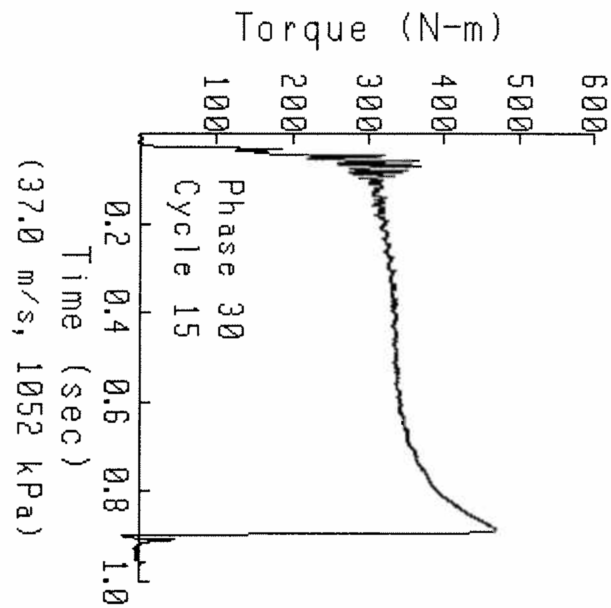

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

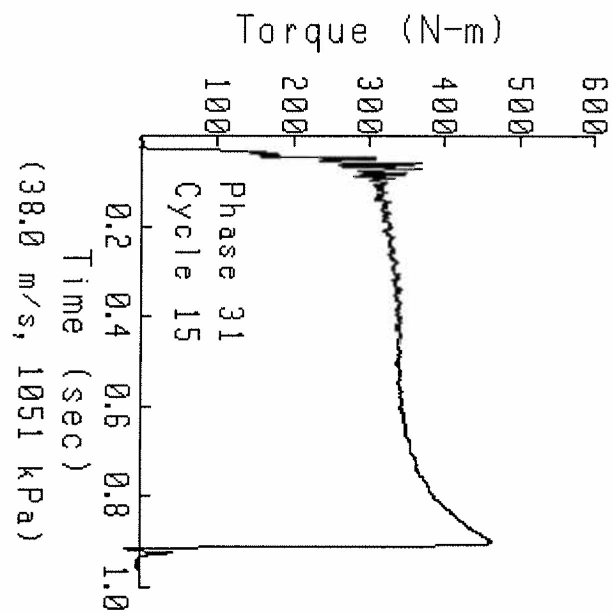


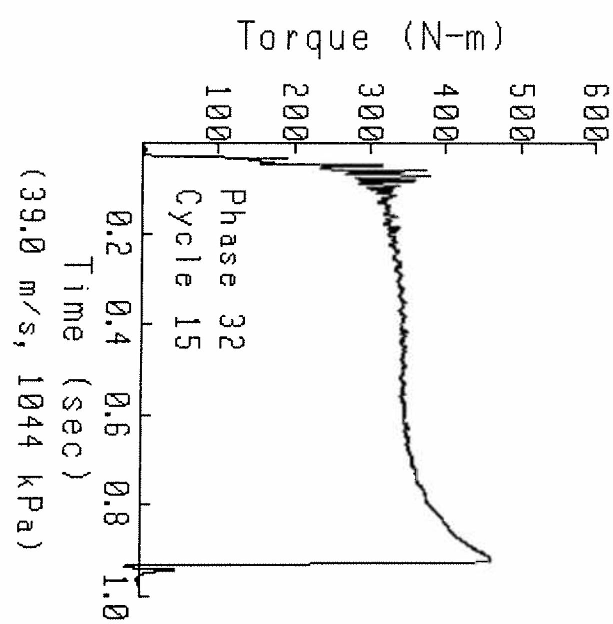
0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

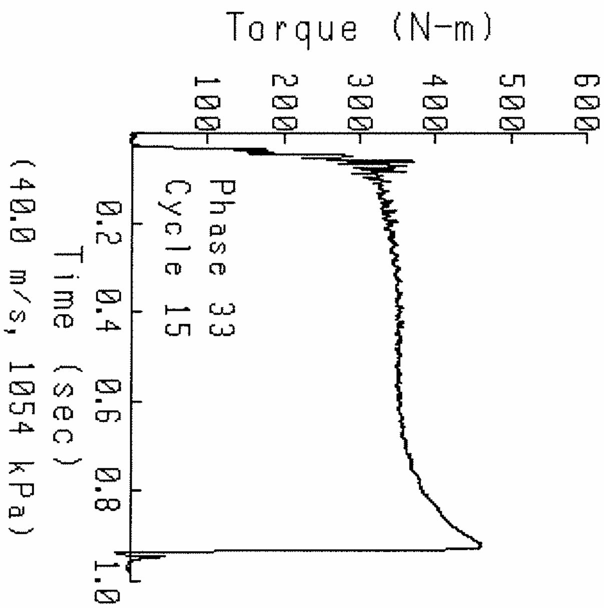


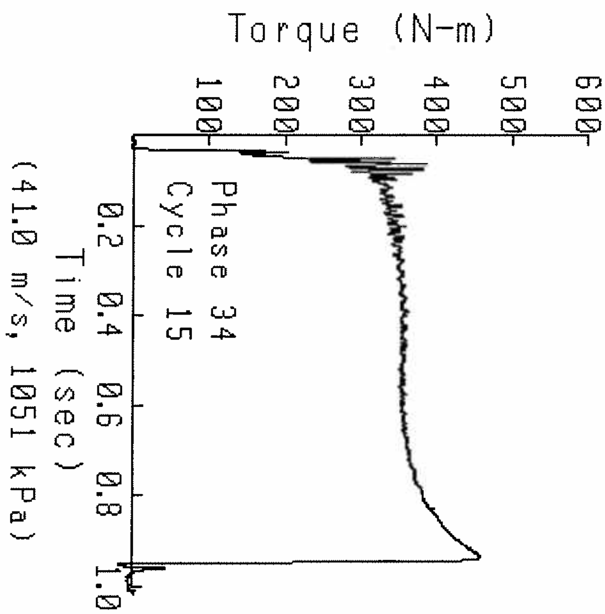
0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

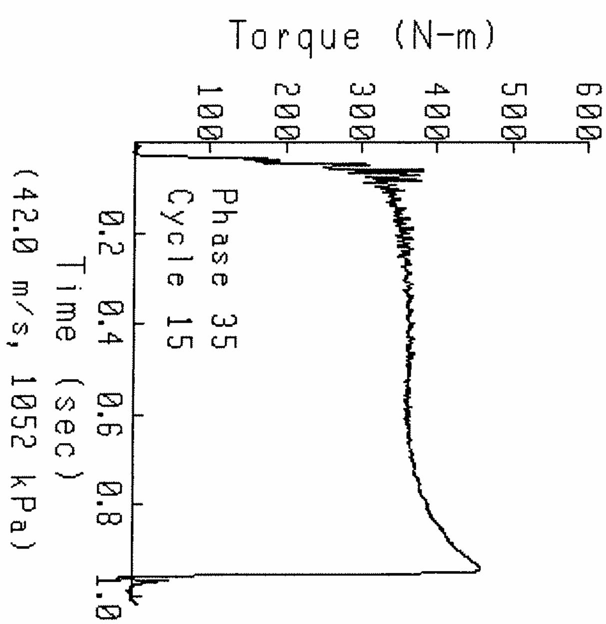

Torque (N-m)
Phase 30
Cycle 15
Time (sec)
(37.0 m/s, 1052 kPa)


Torque (N-m)
Phase 31
Cycle 15
Time (sec)
(38.0 m/s, 1051 kPa)


Torque (N-m)
Phase 32
Cycle 15
Time (sec)
(39.0 m/s, 1044 kPa)

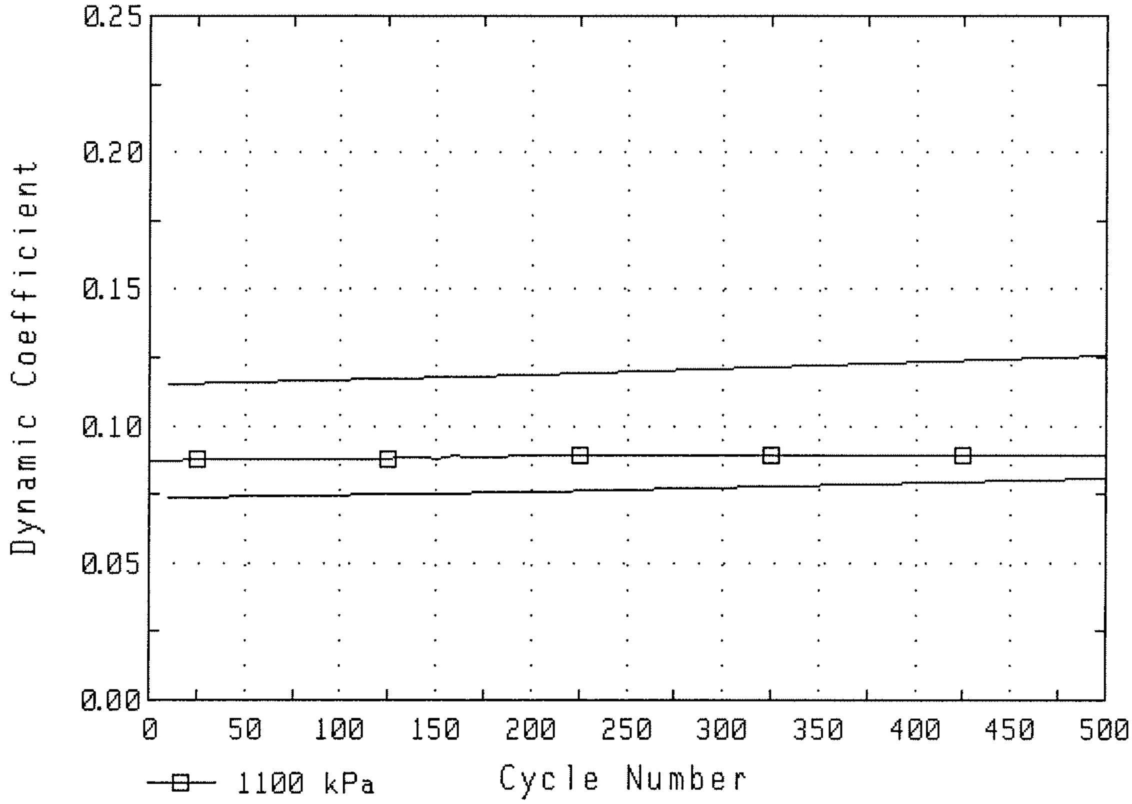

Torque (N-m)
Phase 33
Cycle 15
Time (sec)
(40.0 m/s, 1054 kPa)


Torque (N-m)
Phase 34
Cycle 15
Time (sec)
(41.0 m/s, 1051 kPa)


Torque (N-m)
Phase 35
Cycle 15
Time (sec)
(42.0 m/s, 1052 kPa)

Test name:	A-86-I
Test date:	11/21/07
Test description:	I MACHINE AL-27876-L
Oil type:	
Viscosity:	
Miscellaneous:	
Software version:	1.40
Run name & desc:	I0706125 - AL-27876-L
Run date:	11/25/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	JG
Remarks:	"I" MACHINE OIL TEST AL-27876-L / LO-224037
Sequence name:	SEQ1221
Remarks:	Use 1Y0710 Disc and 1Y3610 Plate.
Number of cycles run:	1113
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 N-m-s^2
Disc name & desc:	1Y0710 - Steering Brake Paper
Material:	Raybestos 7894-4 Paper
Groove pattern:	2 - 37 Multiple Parallel
Miscellaneous:	Use with 1Y3610 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	23MR9-00001
Remarks:	STEERING BRAKE PAPER
Plate name & desc:	1Y3610 - Steel Plate
Surface:	0.70 to 1.30 micron Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	23MR9-00001
Remarks:	0.87 SURFACE FINISH
Report limit name:	LIM1221 - Reference run: I0706003
Limit file generated:	07/26/06
Report format name:	REP1221 - STEERING BRAKE PAPER

Test: A-86-I Run: I0706125 Started on 11/25/07 at 08:52

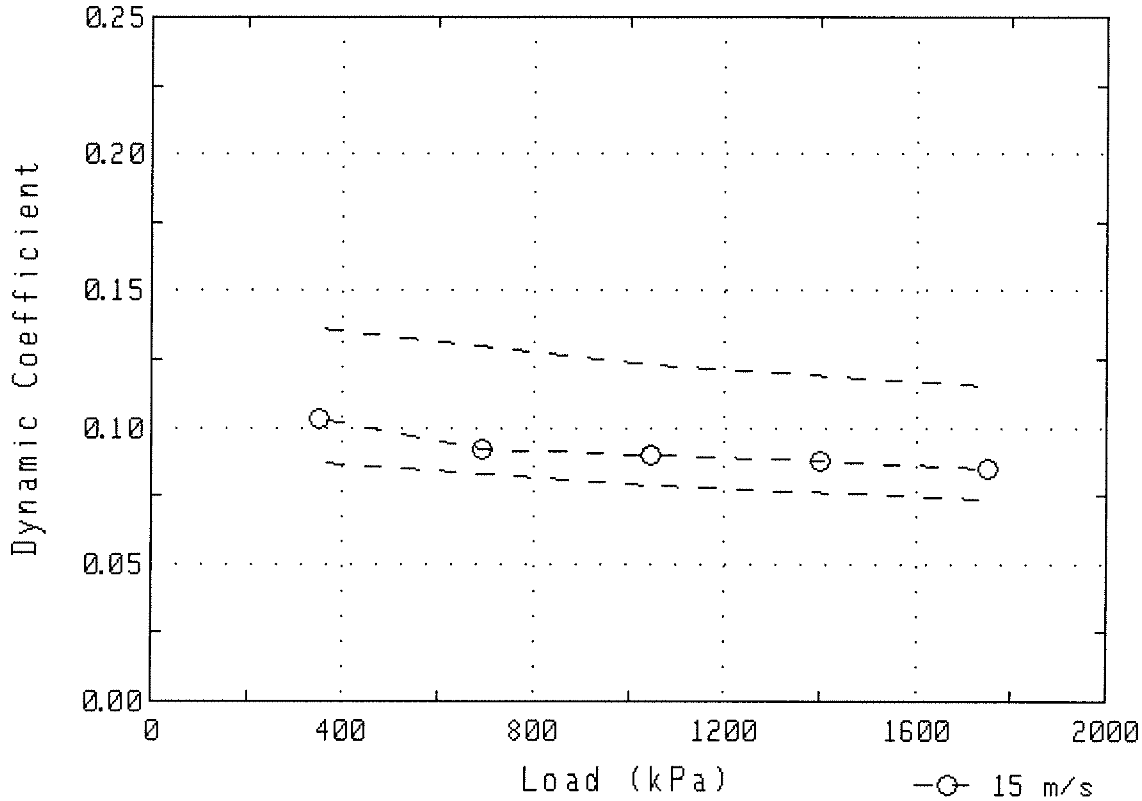


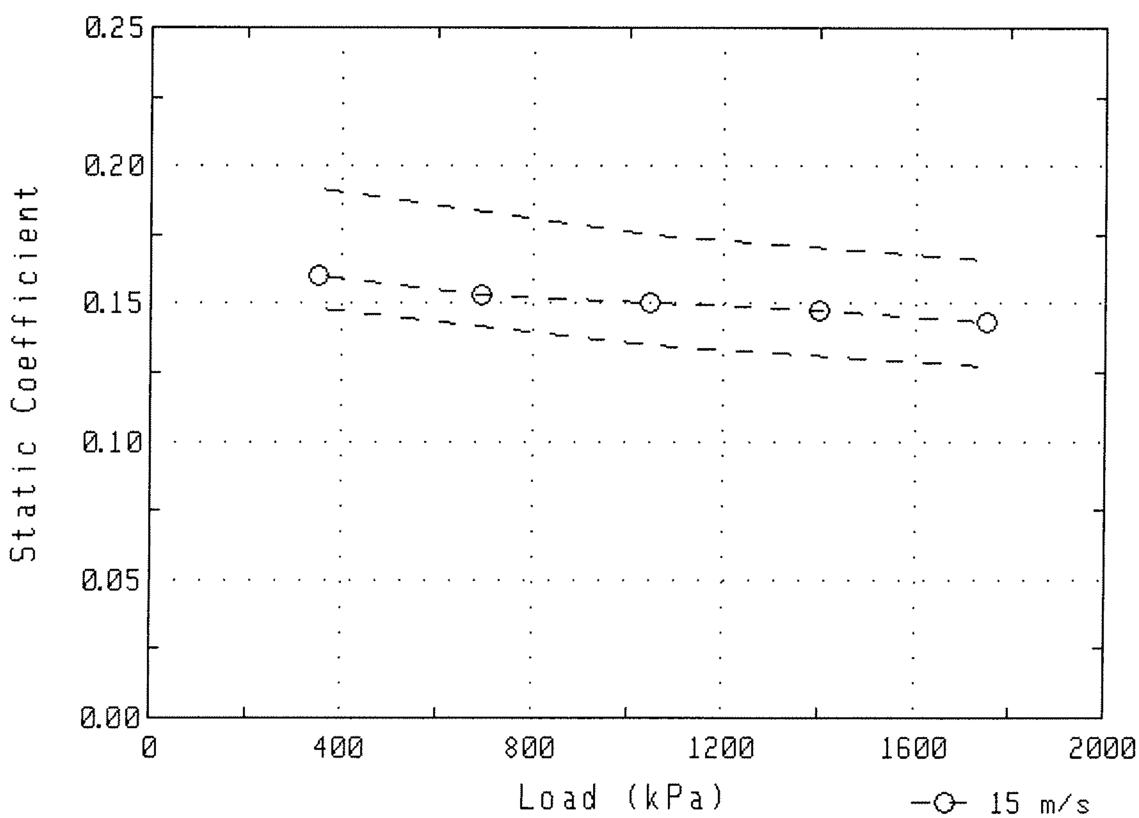
1Y0710 DISC
THICKNESS

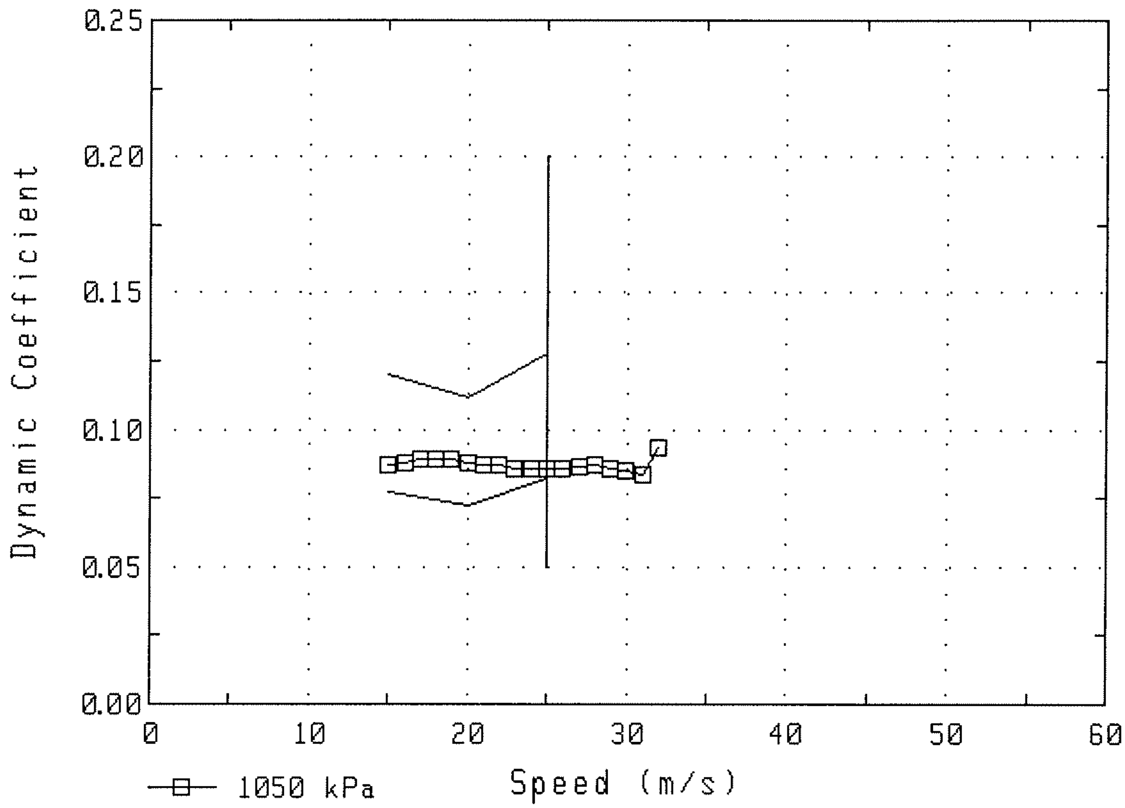
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	5.06	5.02	5.01	5.06	5.03	5.02
2	5.06	5.02	5.01	5.06	5.02	5.01
3	5.06	5.02	5.01	5.06	5.02	5.01
4	5.05	5.02	5.01	5.05	5.02	5.01
5	5.06	5.03	5.02	5.06	5.03	5.02
6	5.07	5.03	5.02	5.07	5.03	5.02
Avg	5.06	5.02	5.01	5.06	5.03	5.01

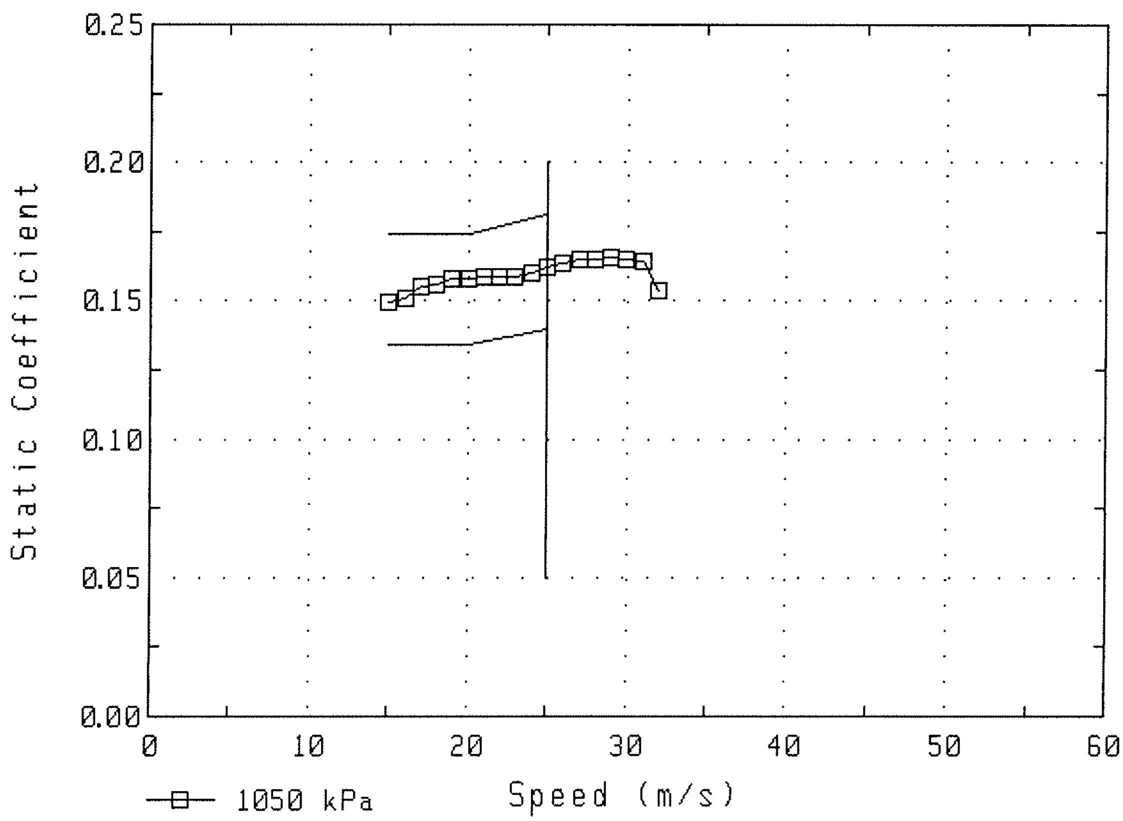
Compression set average wear: 0.036
M2 - M3 average Wear: 0.010

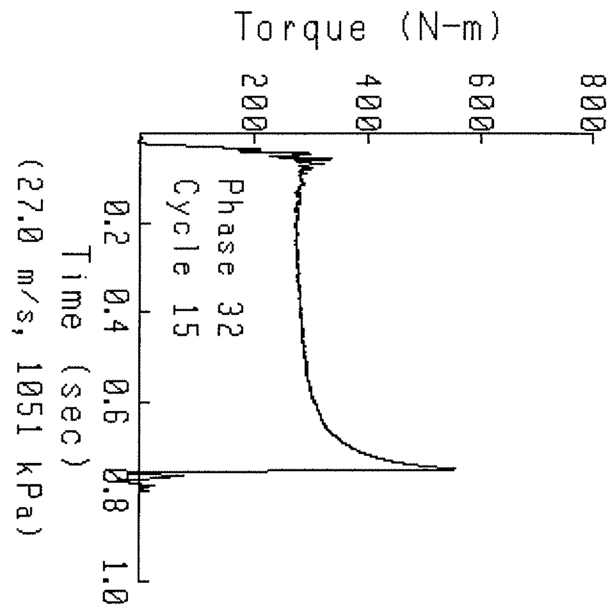
Total Wear (all measurements in mm): 0.046

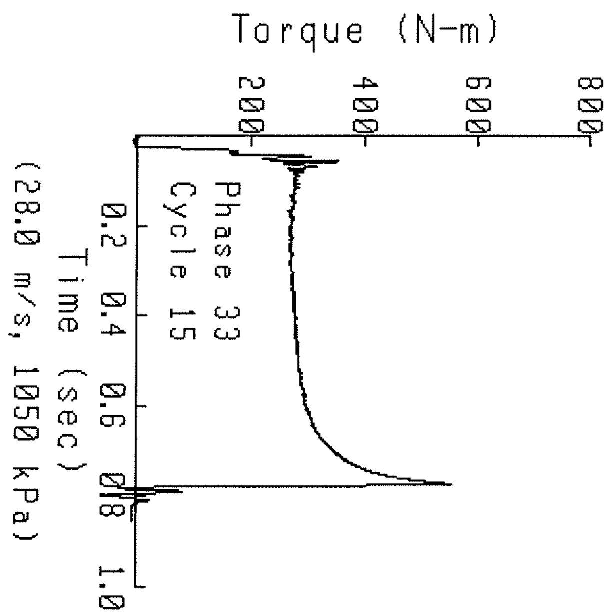

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

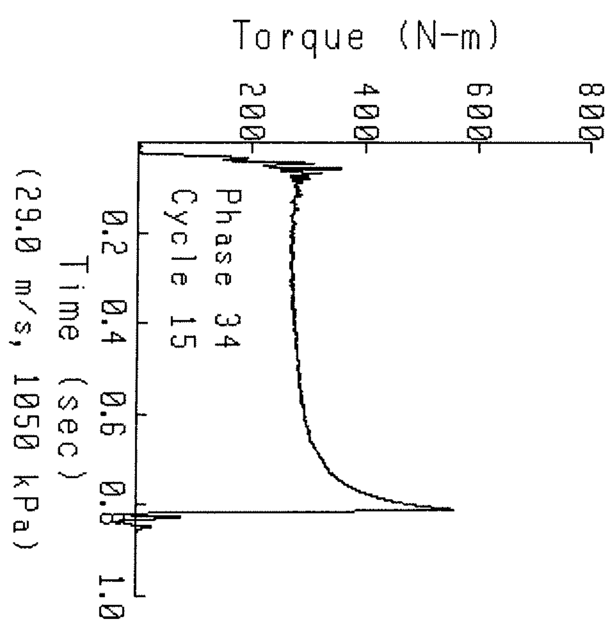

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

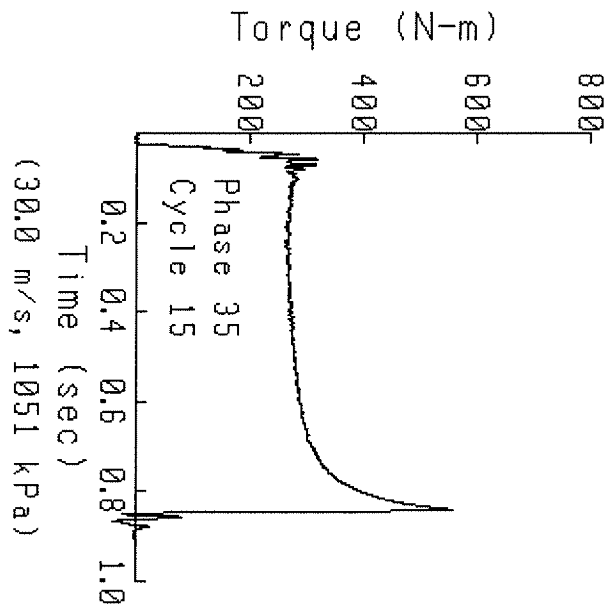

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

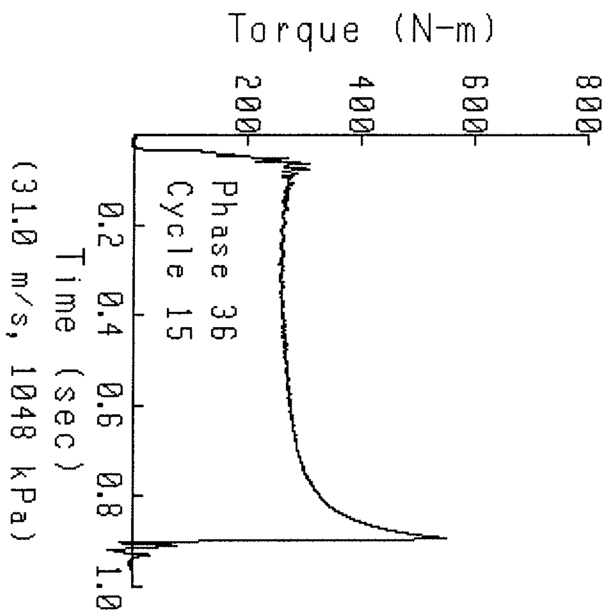

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

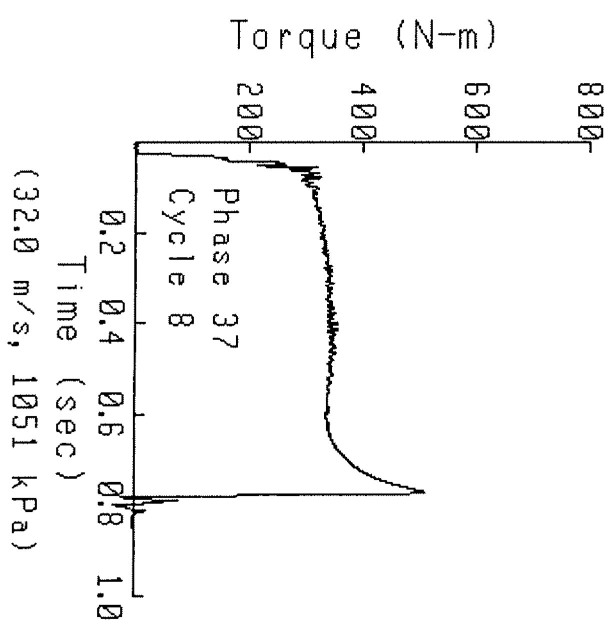

Torque (N-m)
200
400
600
800
Phase 32
Cycle 15
0.2
0.4
0.6
0.8
1.0
Time (sec)
(27.0 m/s, 1051 kPa)


Torque (N-m)
200
400
600
800
Phase 33
Cycle 15
0.2
0.4
0.6
0.8
1.0
Time (sec)
(28.0 m/s, 1050 kPa)


Torque (N-m)
200
400
600
800
Phase 34
Cycle 15
0.2
0.4
0.6
0.8
1.0
Time (sec)
(29.0 m/s, 1050 kPa)


Torque (N-m)
200
400
600
800
Phase 35
Cycle 15
0.2
0.4
0.6
0.8
1.0
Time (sec)
(30.0 m/s, 1051 kPa)


Torque (N-m)
200
400
600
800
Phase 36
Cycle 15
0.2
0.4
0.6
0.8
1.0
Time (sec)
(31.0 m/s, 1048 kPa)


Torque (N-m)
200
400
600
800
Phase 37
Cycle 8
0.2
0.4
0.6
0.8
1.0
Time (sec)
(32.0 m/s, 1051 kPa)

Test name:	A-86-I
Test date:	11/21/07
Test description:	I MACHINE AL-27876-L
Oil type:	
Viscosity:	
Miscellaneous:	
Software version:	1.40

Run name & desc:	I0706126 - AL-27876-L
Run date:	11/26/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	JG
Remarks:	"I" MACHINE OIL TEST AL-27876-L / LO-224037
Sequence name:	SEQ1222
Remarks:	Use 1Y0711 Disc and 1Y0726 Plate
Number of cycles run:	1142

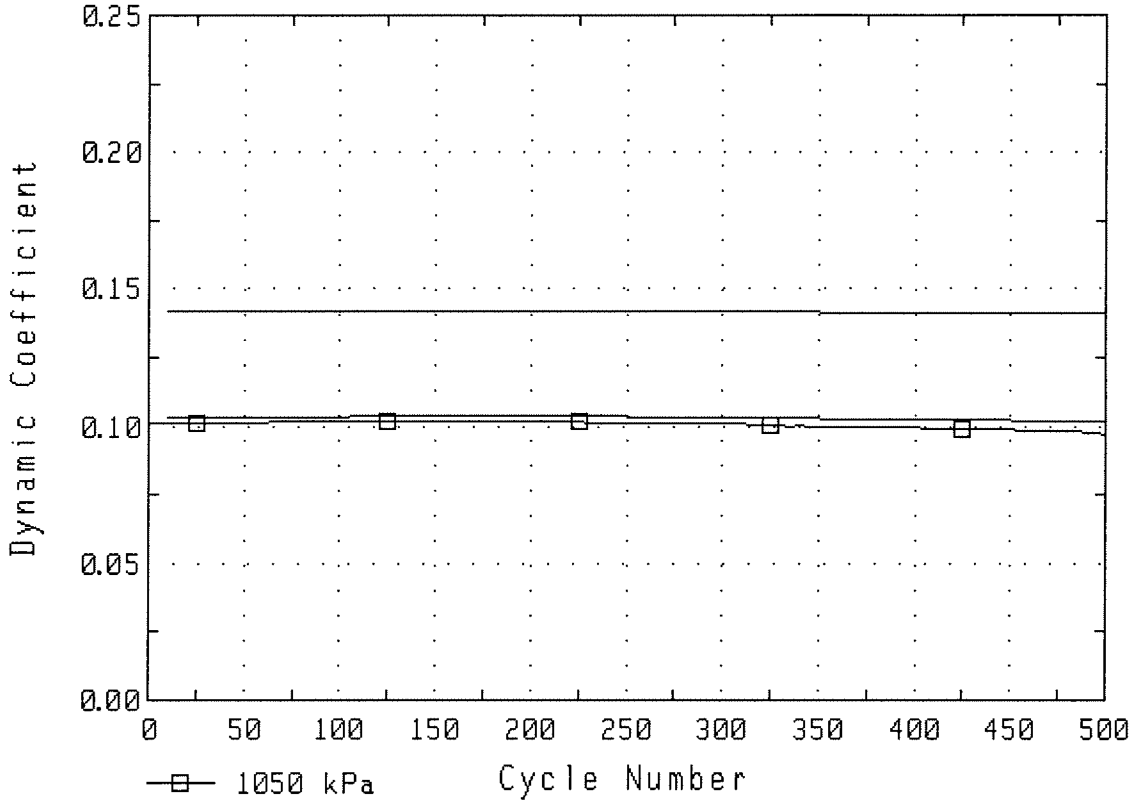
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 $N\text{-}m\text{-}s^2$

Disc name & desc:	1Y0711 - Wheel Brake Paper
Material:	Raybestos 7902-1 Paper
Groove pattern:	2 - 37 Multiple Parallel
Miscellaneous:	Use with 1Y0726 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	24FE9-00001
Remarks:	WHEEL BRAKE PAPER

Plate name & desc:	1Y0726 - Steel Plate
Surface:	0.30 micron Maximum Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	24FE9-00001
Remarks:	0.19 SURFACE FINISH

Report limit name:	LIM1222 - Reference run: I0706004
Limit file generated:	07/26/06
Report format name:	REP1222 - WHEEL BRAKE PAPER

Test: A-86-I Run: I0706126 Started on 11/26/07 at 09:31

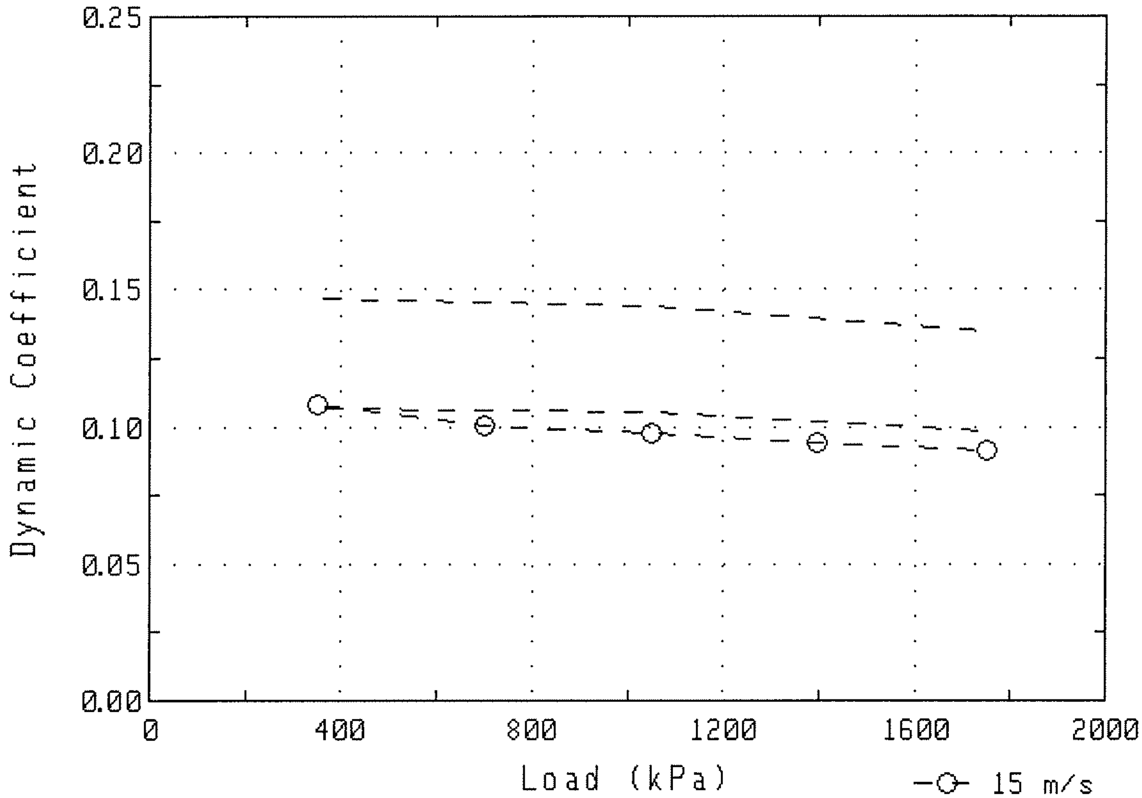


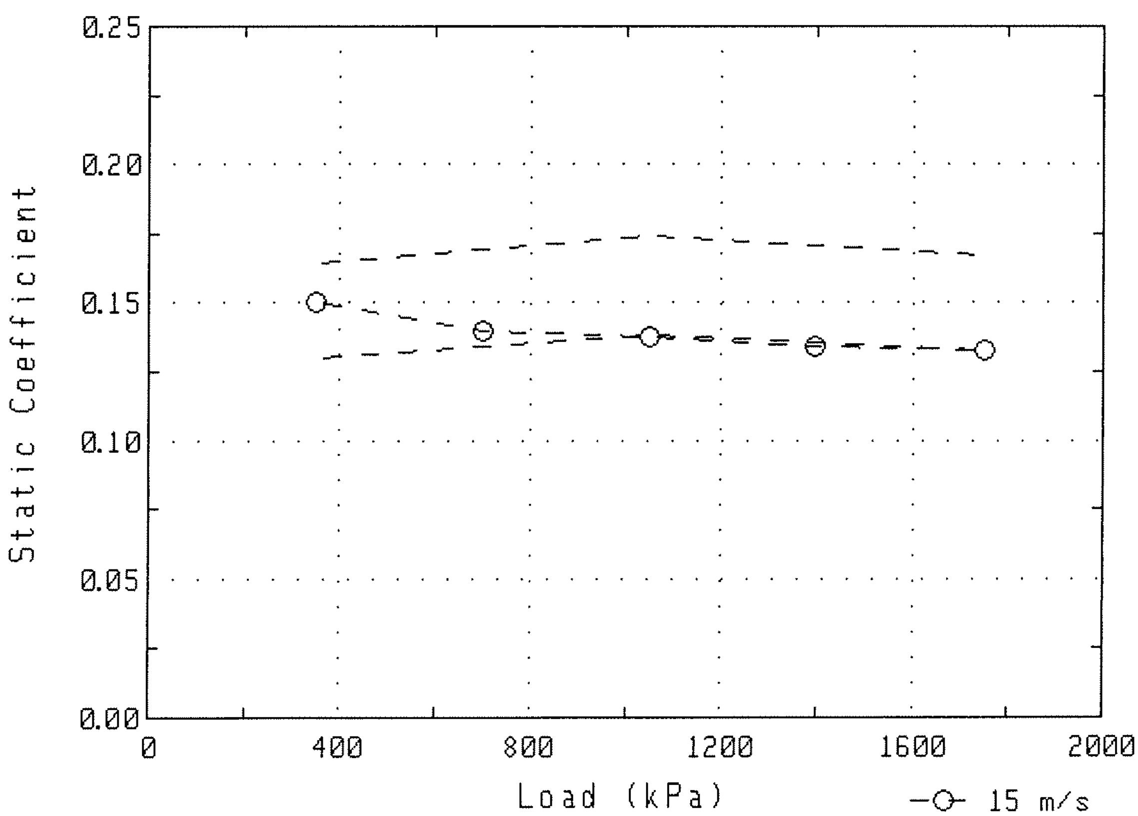
1Y0711 DISC
THICKNESS

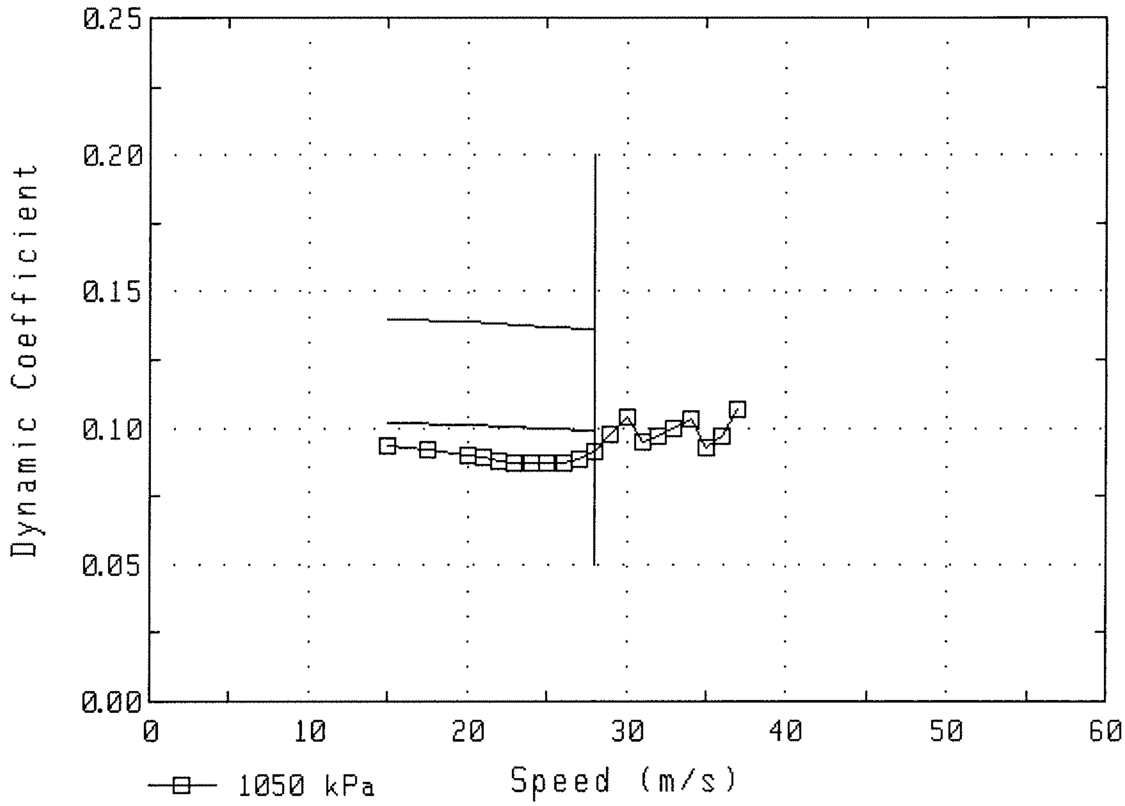
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	4.88	4.84	4.84	4.88	4.85	4.84
2	4.87	4.84	4.83	4.87	4.84	4.83
3	4.88	4.85	4.84	4.88	4.85	4.84
4	4.88	4.86	4.85	4.89	4.85	4.85
5	4.88	4.85	4.85	4.88	4.86	4.85
6	4.89	4.86	4.85	4.89	4.85	4.85
Avg	4.88	4.85	4.84	4.88	4.85	4.84

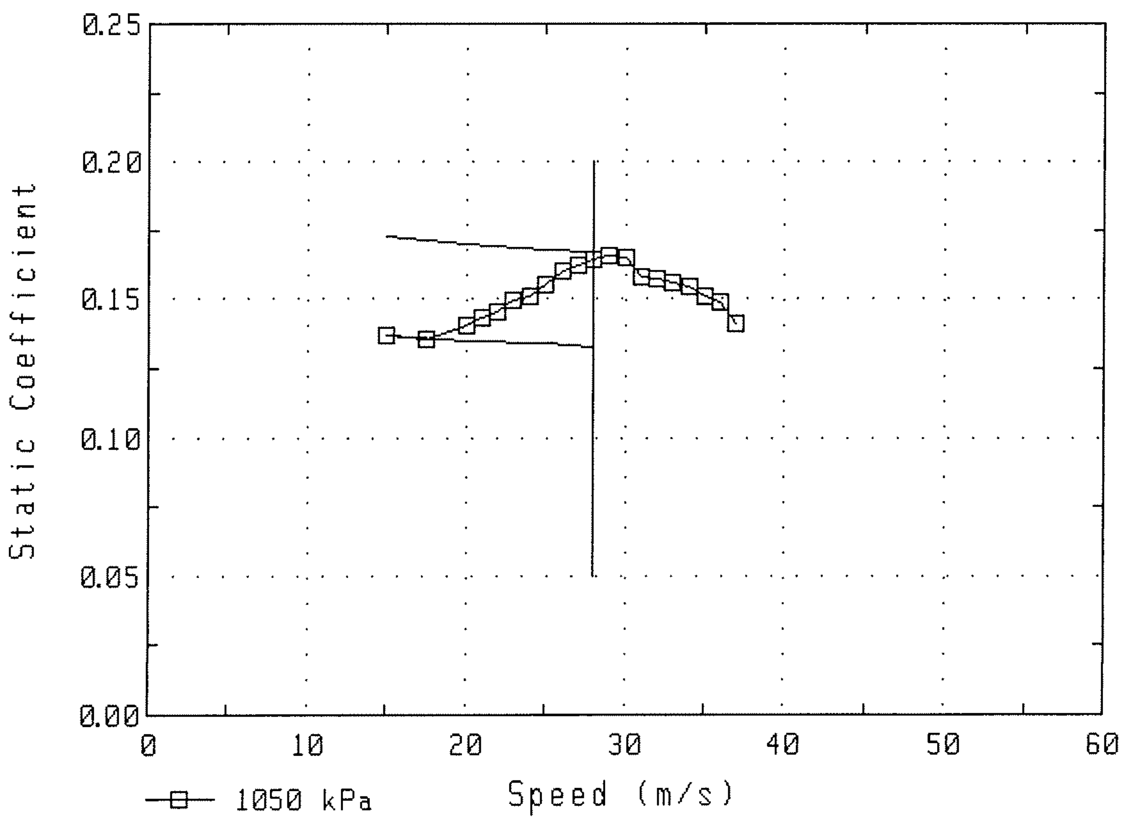
Compression set average wear: 0.031
M2 - M3 average Wear: 0.007

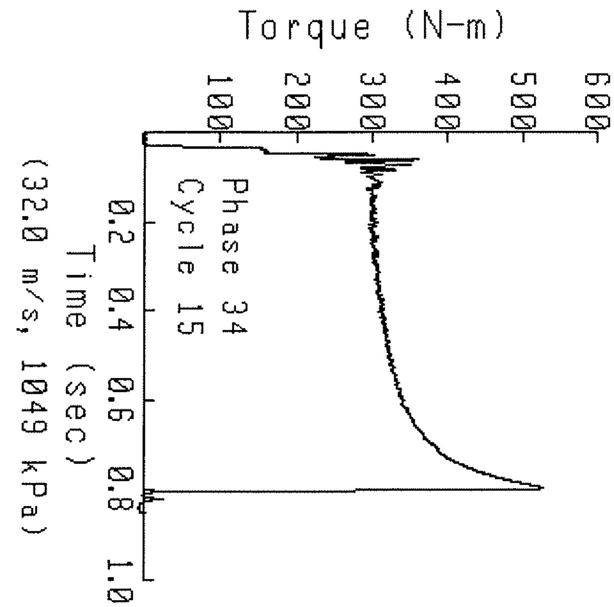
Total Wear (all measurements in mm): 0.038

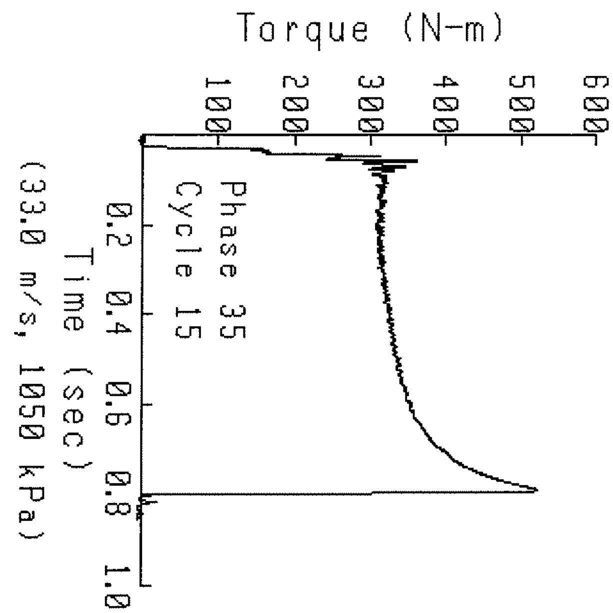

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

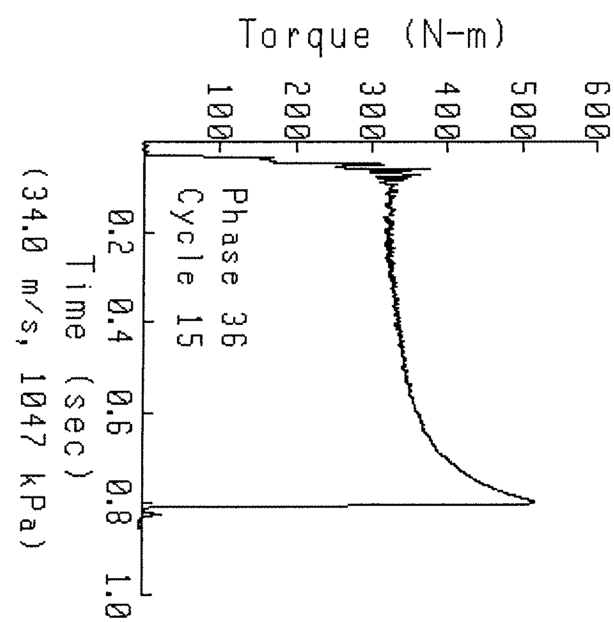

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

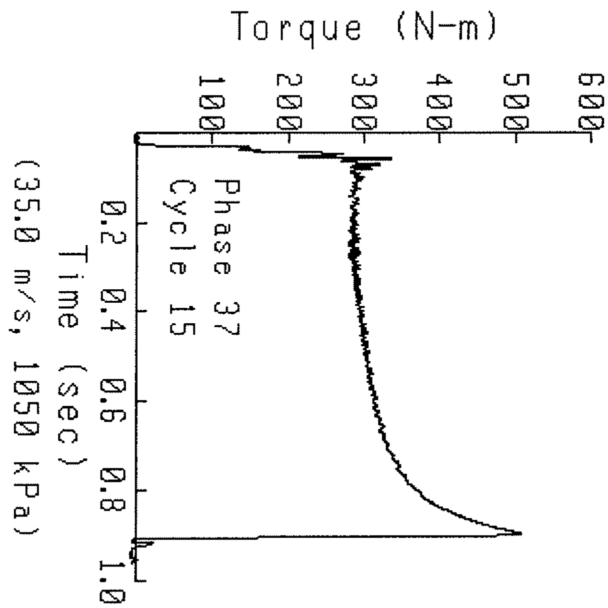

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

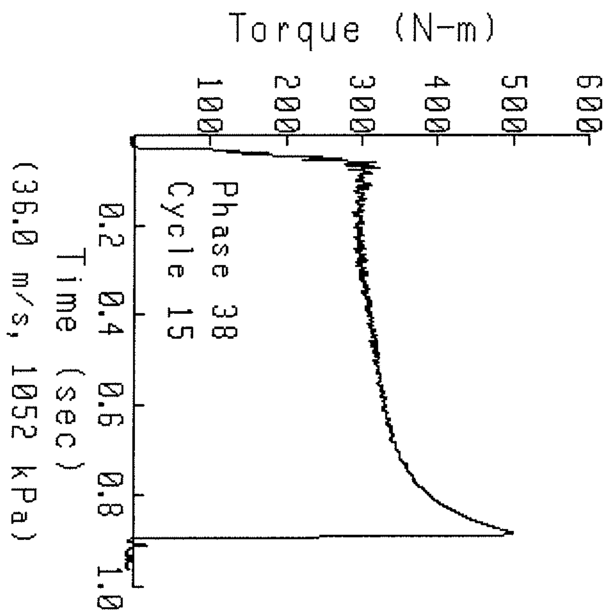

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

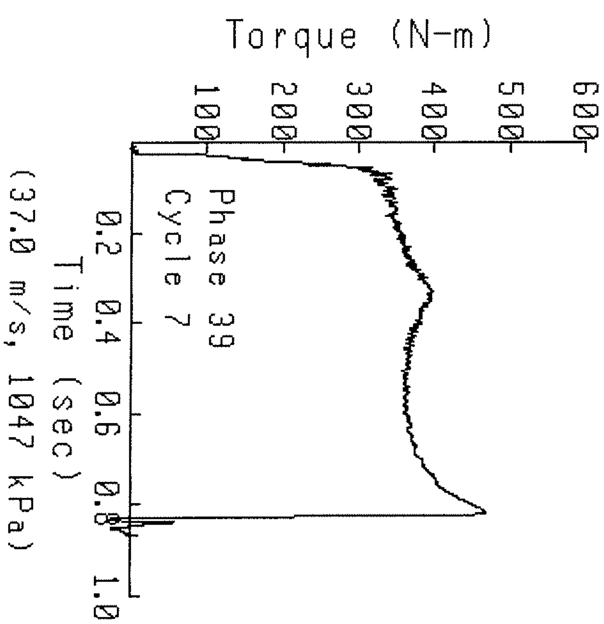

Torque (N-m)
100 200 300 400 500 600
Phase 34
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(32.0 m/s, 1049 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 35
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(33.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 36
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(34.0 m/s, 1047 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 37
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(35.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 38
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(36.0 m/s, 1052 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 39
Cycle 7
0.2 0.4 0.6 0.8 1.0
Time (sec)
(37.0 m/s, 1047 kPa)

Test name:	A-86-I
Test date:	11/21/07
Test description:	I MACHINE AL-27876-L
Oil type:	
Viscosity:	
Miscellaneous:	
Software version:	1.40

Run name & desc:	I0706127 - AL-27876-L
Run date:	11/27/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	HC
Remarks:	"I" MACHINE OIL TEST AL-27876-L / LO-224037
Sequence name:	SEQ1223
Remarks:	Use 1Y0712 Disc and 1Y0726 Plate
Number of cycles run:	1054

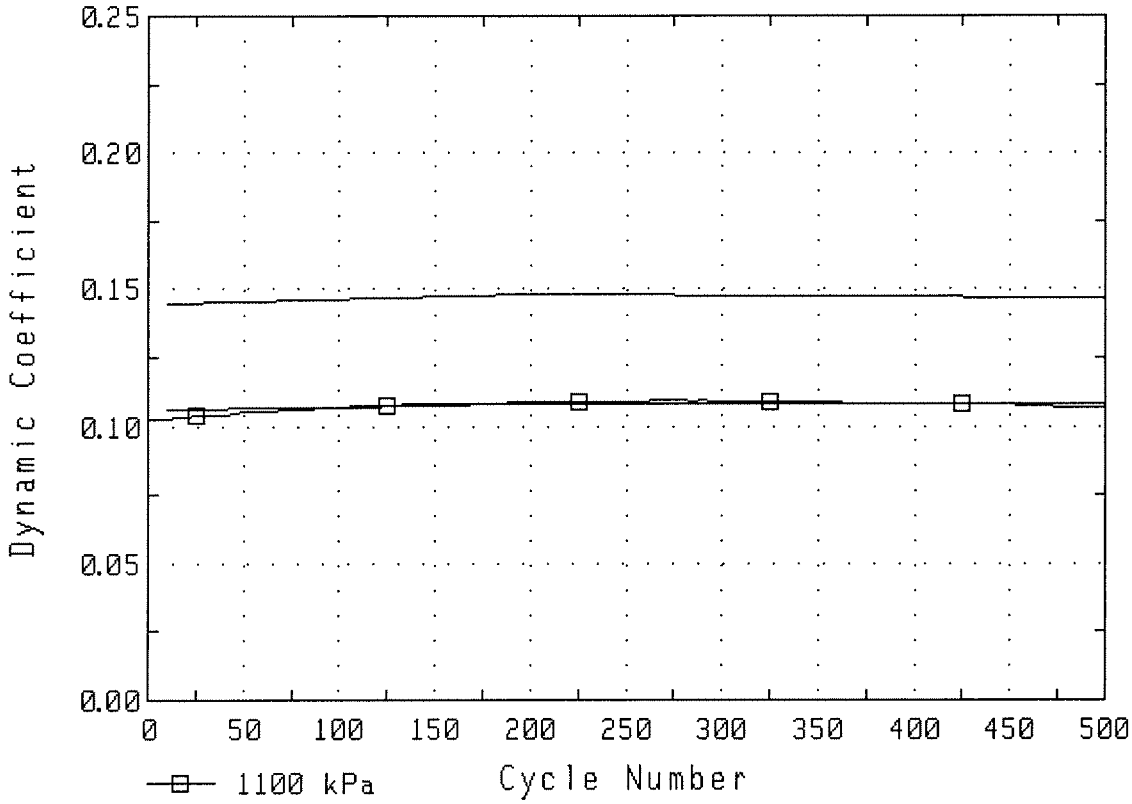
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 N-m-s^2

Disc name & desc:	1Y0712 - Transmission Paper
Material:	Raybestos 7901-2 Paper
Groove pattern:	2 - 37 Multiple Parallel
Miscellaneous:	Use with 1Y0726 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	27MR9-00001
Remarks:	TRANSMISSION PAPER

Plate name & desc:	1Y0726 - Steel Plate
Surface:	0.30 micron Maximum Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	27MR9-00001
Remarks:	0.25 SURFACE FINISH

Report limit name:	LIM1223 - Reference run: I0706006
Limit file generated:	07/26/06
Report format name:	REP1223 - TRANSMISSION PAPER

Test: A-86-I Run: I0706127 Started on 11/27/07 at 09:06

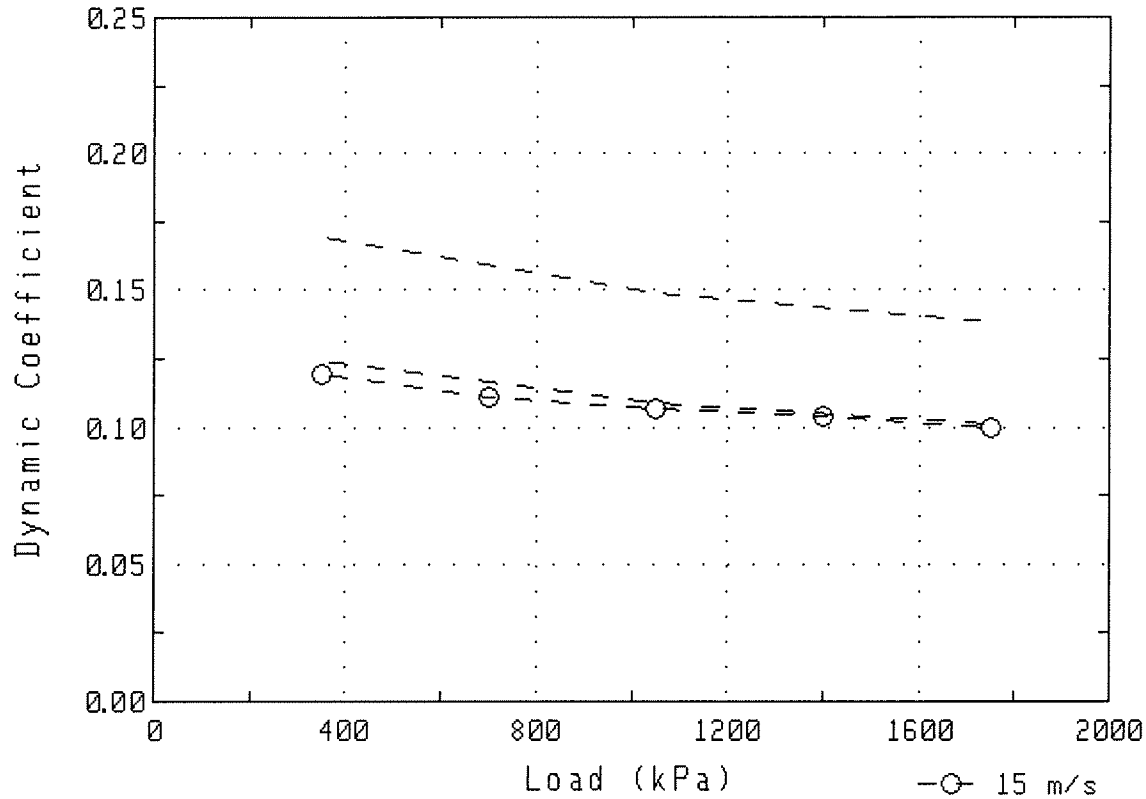


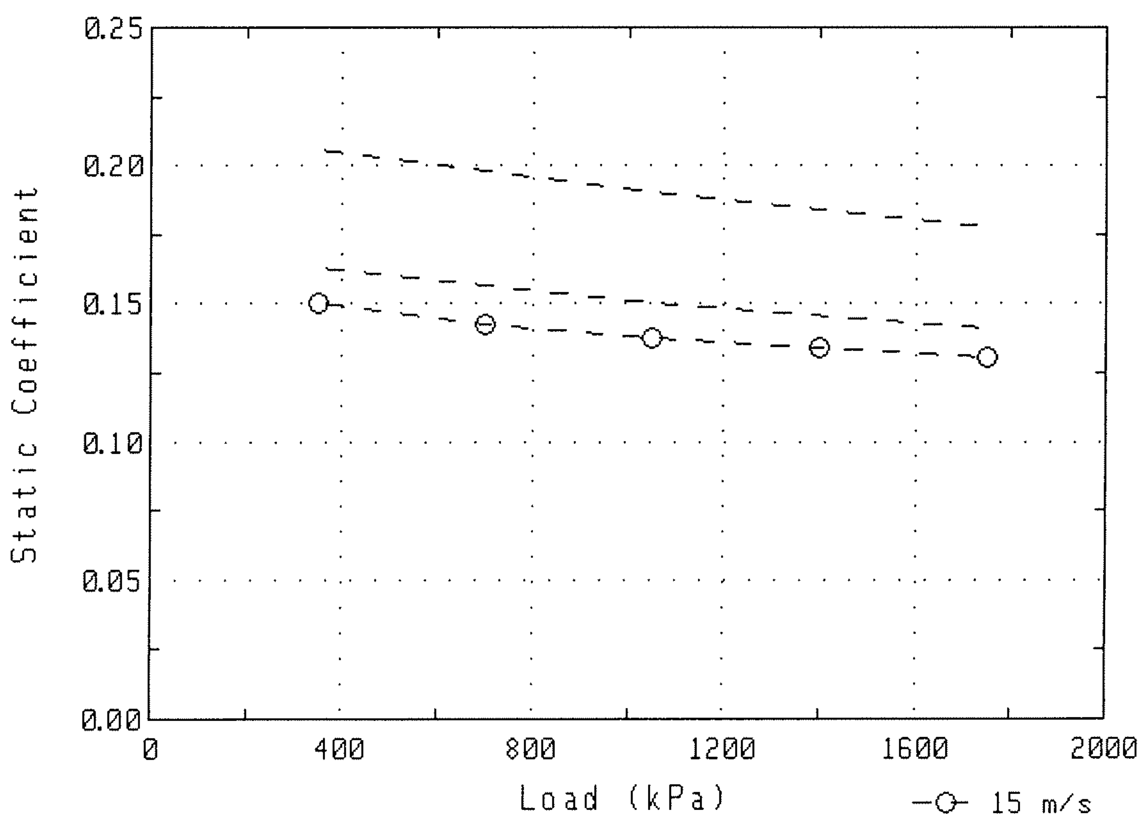
1Y0712 DISC
THICKNESS

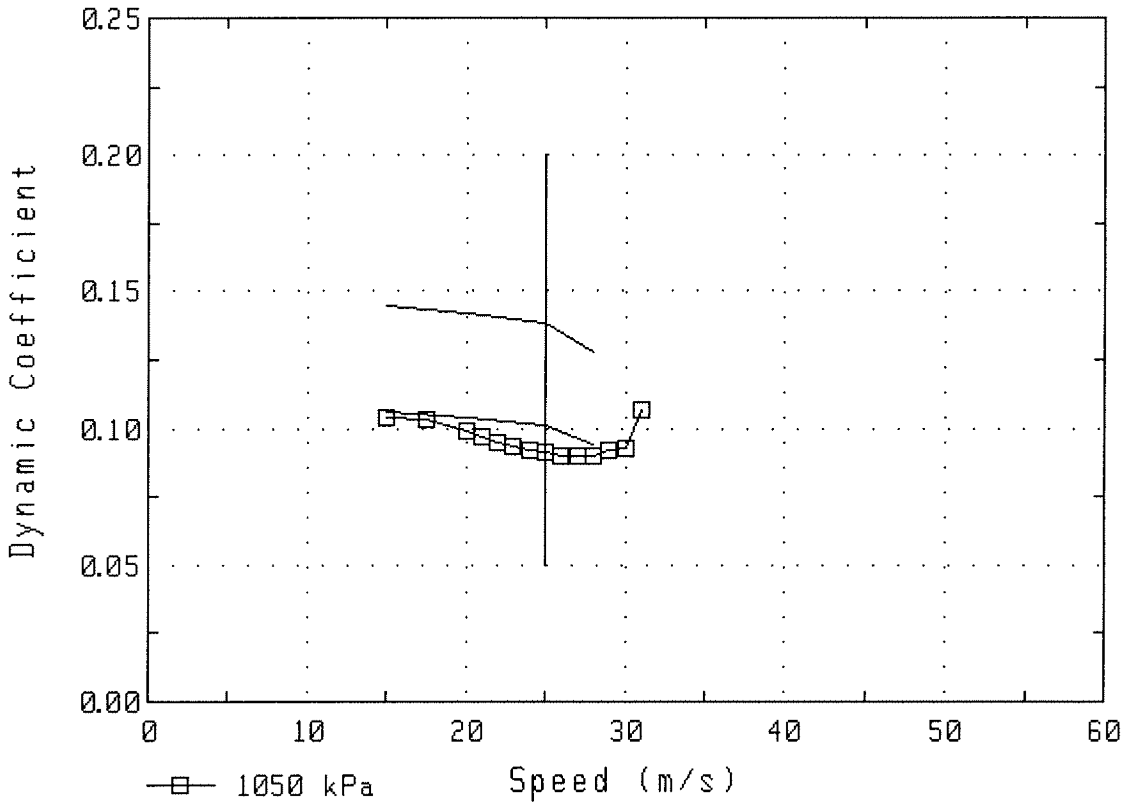
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	5.00	4.98	4.95	5.00	4.98	4.96
2	5.00	4.98	4.97	5.00	4.98	4.96
3	5.00	4.98	4.97	5.00	4.98	4.97
4	5.01	4.98	4.97	5.01	4.98	4.97
5	5.00	4.98	4.97	5.00	4.98	4.97
6	5.00	4.98	4.96	5.00	4.98	4.96
Avg	5.00	4.98	4.97	5.00	4.98	4.97

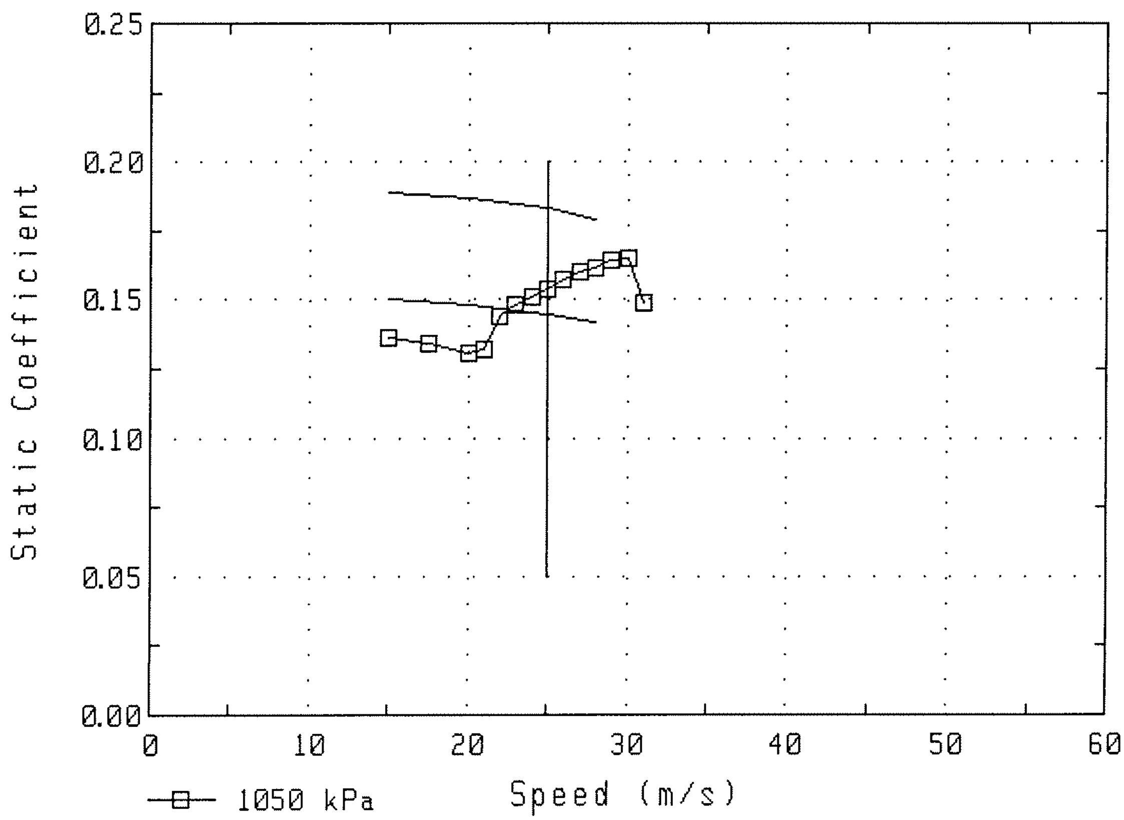
Compression set average wear: 0.022
M2 - M3 average Wear: 0.015

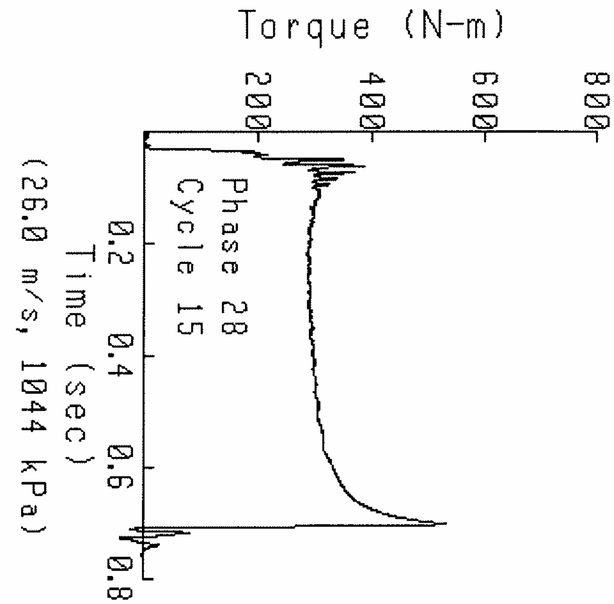
Total Wear (all measurements in mm): 0.037

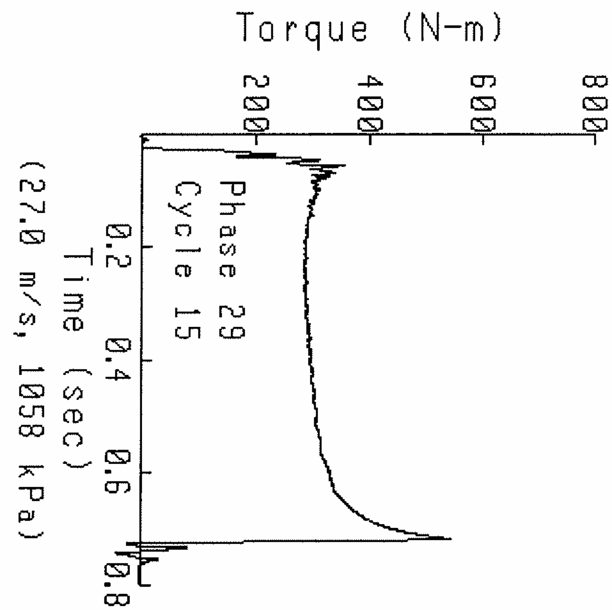

Dynamic Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

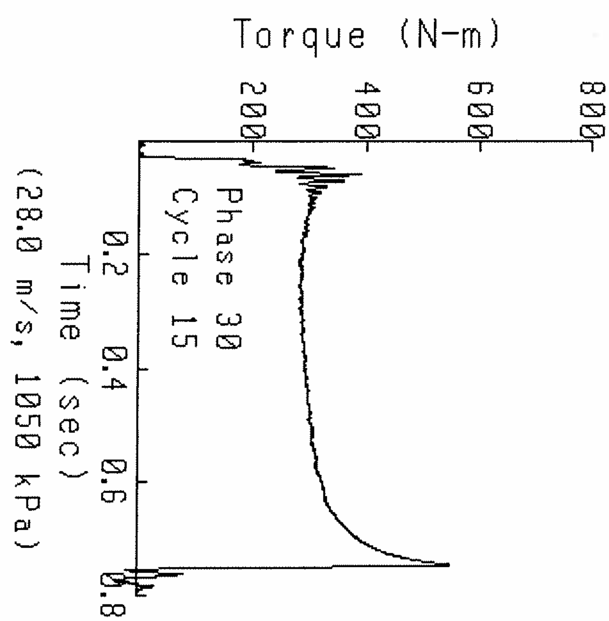

Static Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

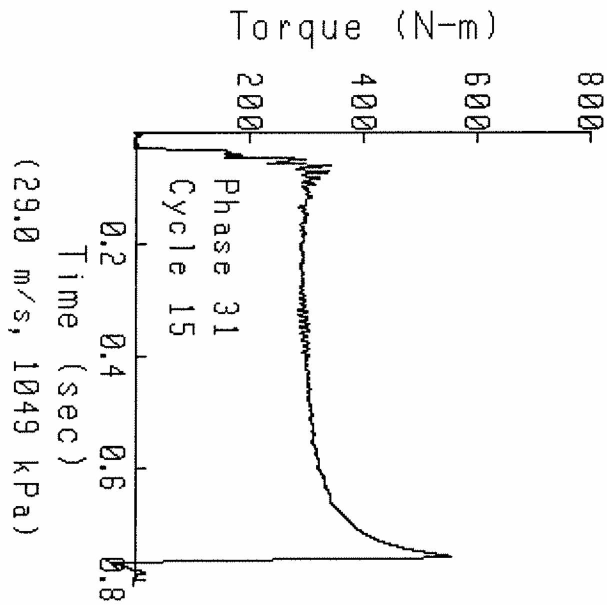

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

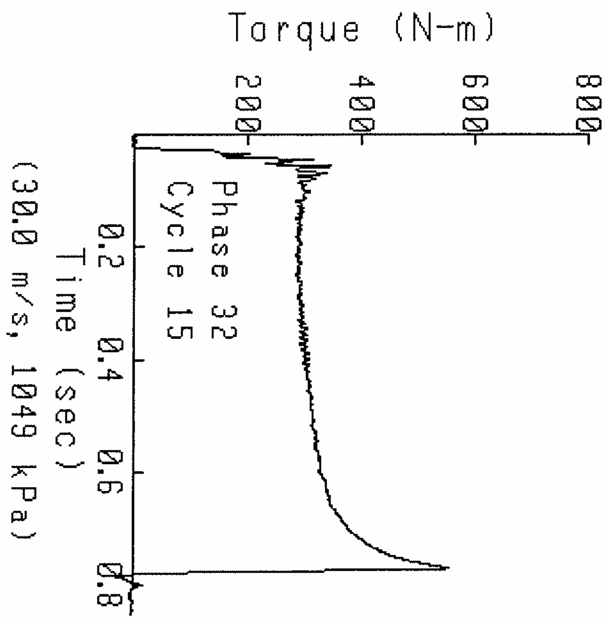

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

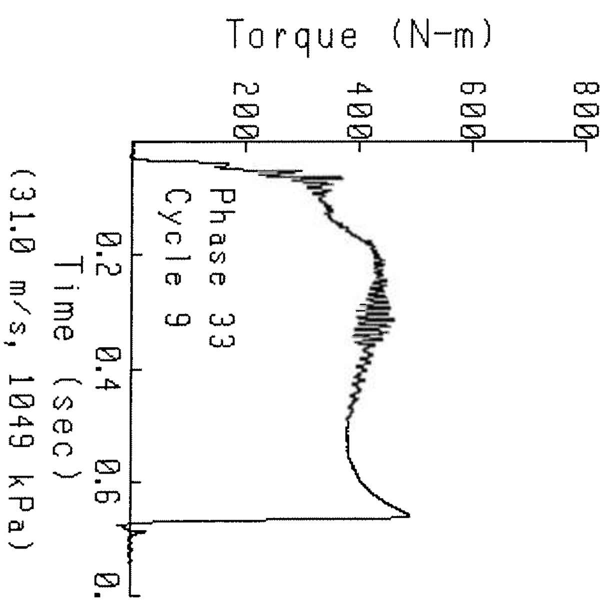

Torque (N-m)
200
400
600
800
Phase 28
Cycle 15
0.2
0.4
0.6
0.8
Time (sec)
(26.0 m/s, 1044 kPa)


Torque (N-m)
200
400
600
800
Phase 29
Cycle 15
0.2
0.4
0.6
0.8
Time (sec)
(27.0 m/s, 1058 kPa)

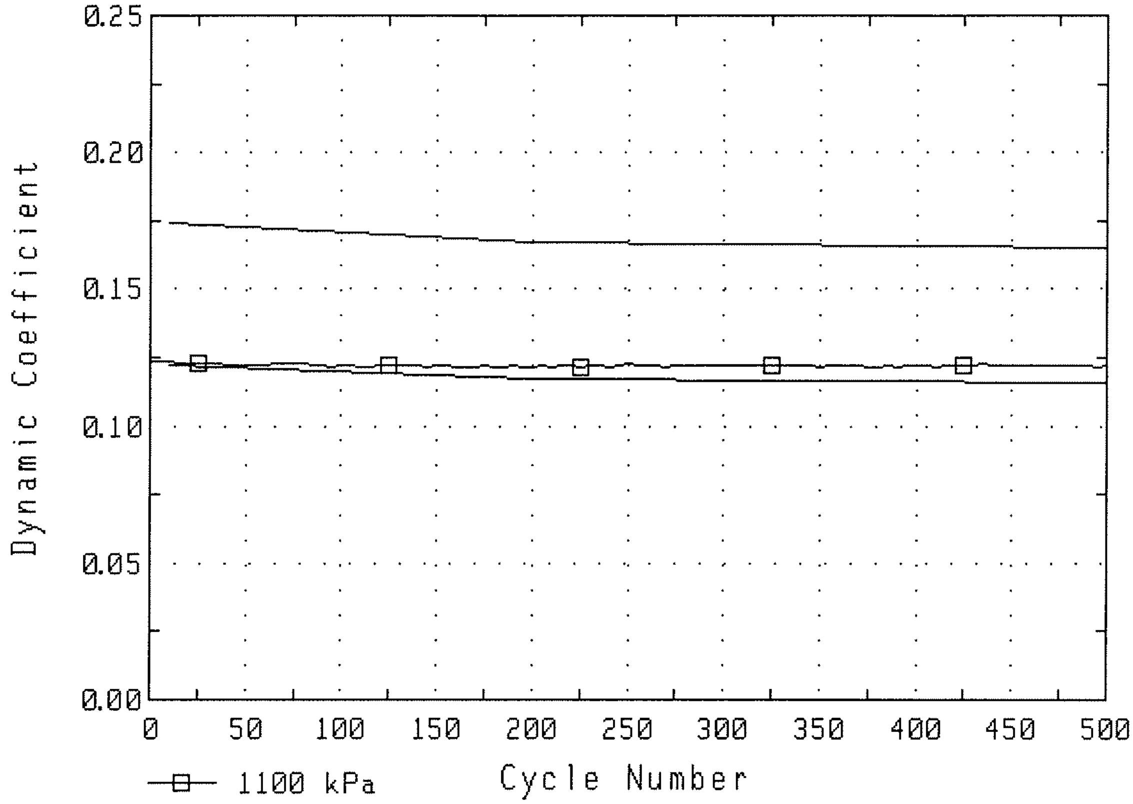

Torque (N-m)
200
400
600
800
Phase 30
Cycle 15
0.2
0.4
0.6
0.8
Time (sec)
(28.0 m/s, 1050 kPa)


Torque (N-m)
200
400
600
800
Phase 31
Cycle 15
0.2
0.4
0.6
0.8
Time (sec)
(29.0 m/s, 1049 kPa)


Torque (N-m)
200
400
600
800
Phase 32
Cycle 15
0.2
0.4
0.6
0.8
Time (sec)
(30.0 m/s, 1049 kPa)


Torque (N-m)
200
400
600
800
Phase 33
Cycle 9
0.2
0.4
0.6
0.8
Time (sec)
(31.0 m/s, 1049 kPa)

Test name:	A-86-I
Test date:	11/21/07
Test description:	I MACHINE AL-27876-L
Oil type:	
Viscosity:	
Miscellaneous:	
Software version:	1.40
Run name & desc:	I0706128 - AL-27876-L
Run date:	11/28/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	HC
Remarks:	"I" MACHINE OIL TEST AL-27876-L / LO-224037
Sequence name:	SEQ1224
Remarks:	Use 1Y0713 Disc and 8E4095 Plate
Number of cycles run:	1109
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 $N\text{-}m\text{-}s^2$
Disc name & desc:	1Y0713 - Elastomeric Disc
Material:	Caterpillar F37
Groove pattern:	Single Lead Spiral - 12 Radial
Miscellaneous:	Use with 8E4095 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	C63007FE1
Remarks:	ELASTOMERIC
Plate name & desc:	8E4095 - Steel Plate
Surface:	0.70 to 1.00 micron Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	C63007FE1
Remarks:	0.82 SURFACE FINISH
Report limit name:	LIM1224 - Reference run: I0706007
Limit file generated:	07/26/06
Report format name:	REP1224 - ELASTOMERIC, F37

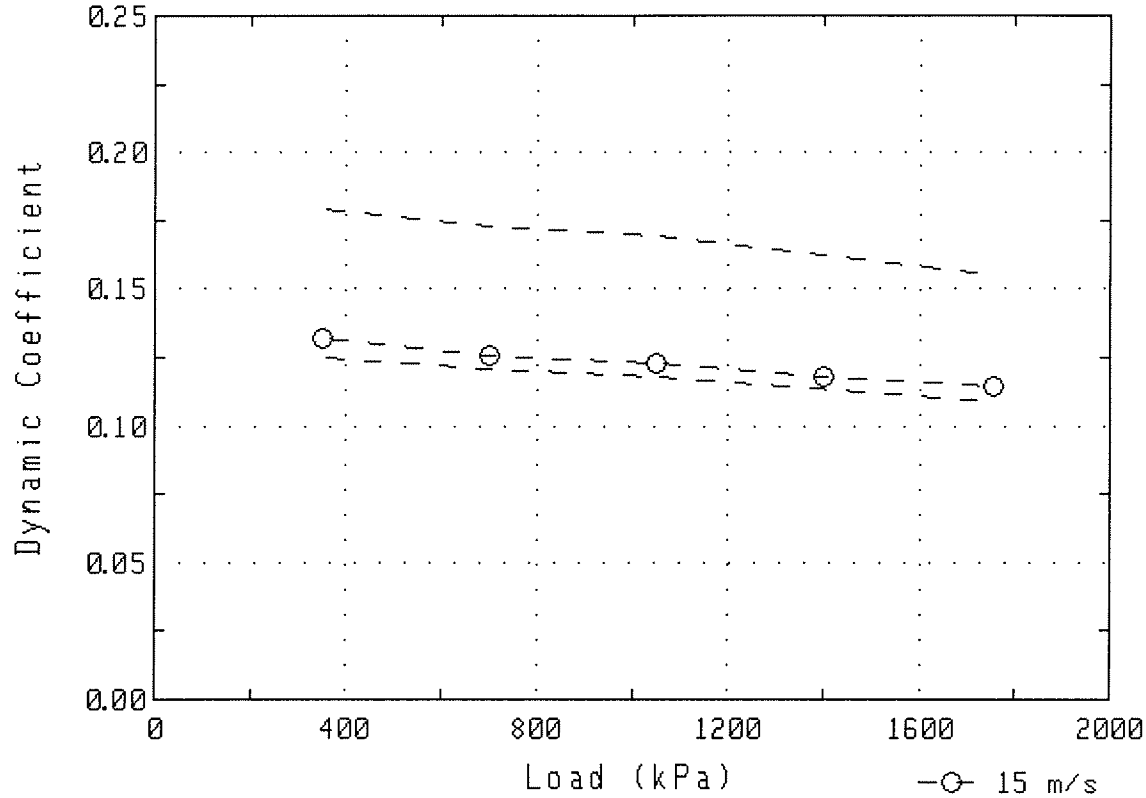


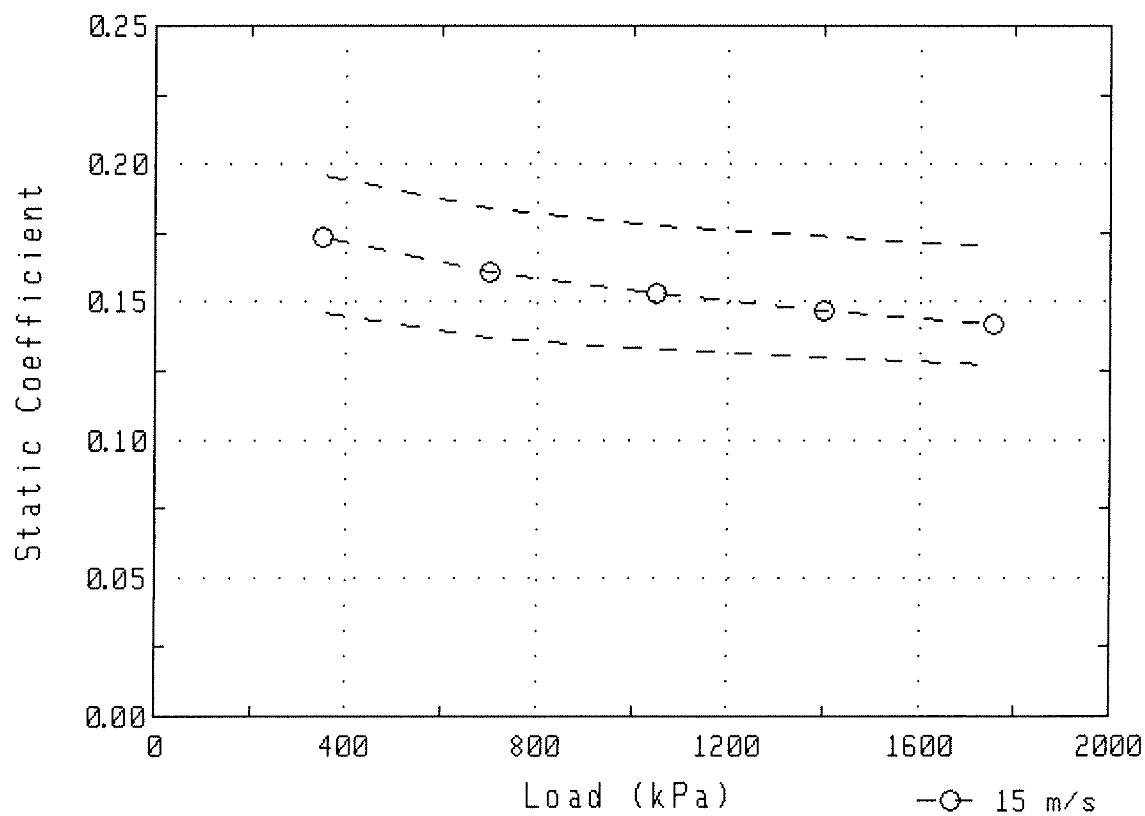
1Y0713 DISC
THICKNESS

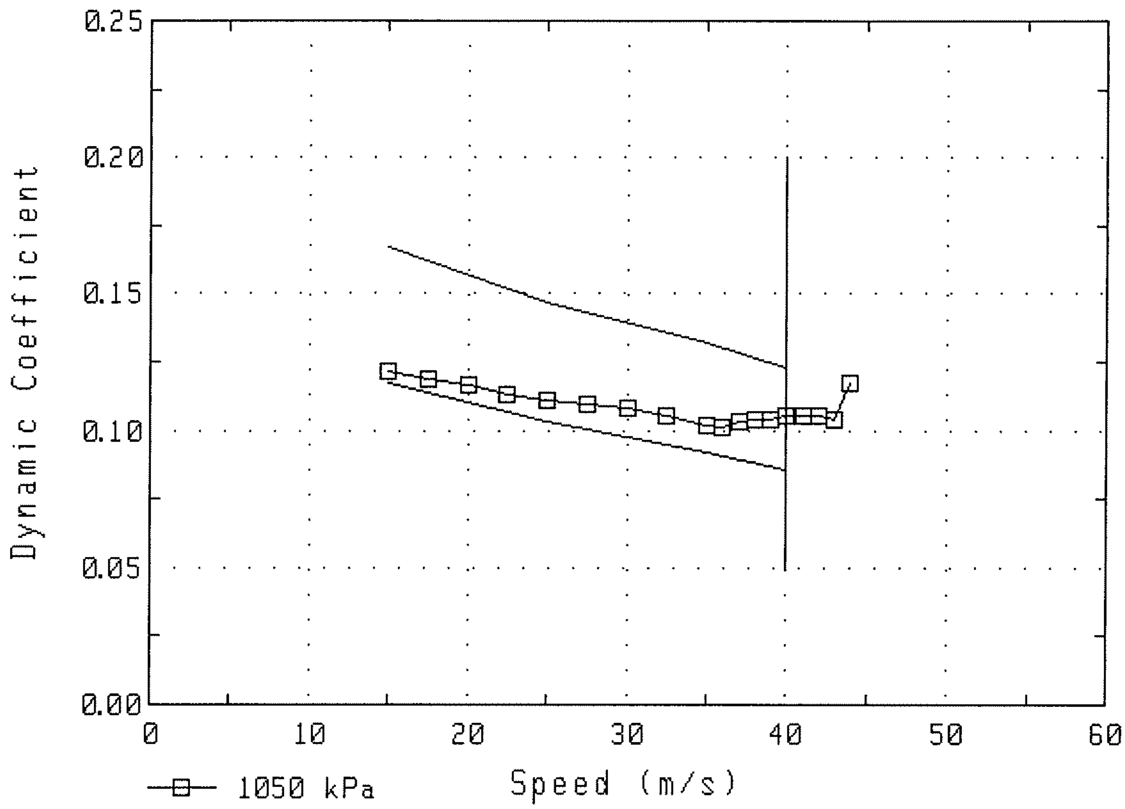
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	5.05	5.04	5.03	5.05	5.04	5.03
2	5.05	5.03	5.03	5.04	5.03	5.03
3	5.05	5.04	5.03	5.04	5.04	5.03
4	5.05	5.04	5.03	5.04	5.04	5.03
5	5.05	5.04	5.03	5.04	5.04	5.03
6	5.04	5.03	5.03	5.04	5.03	5.02
Avg	5.05	5.04	5.03	5.04	5.04	5.03

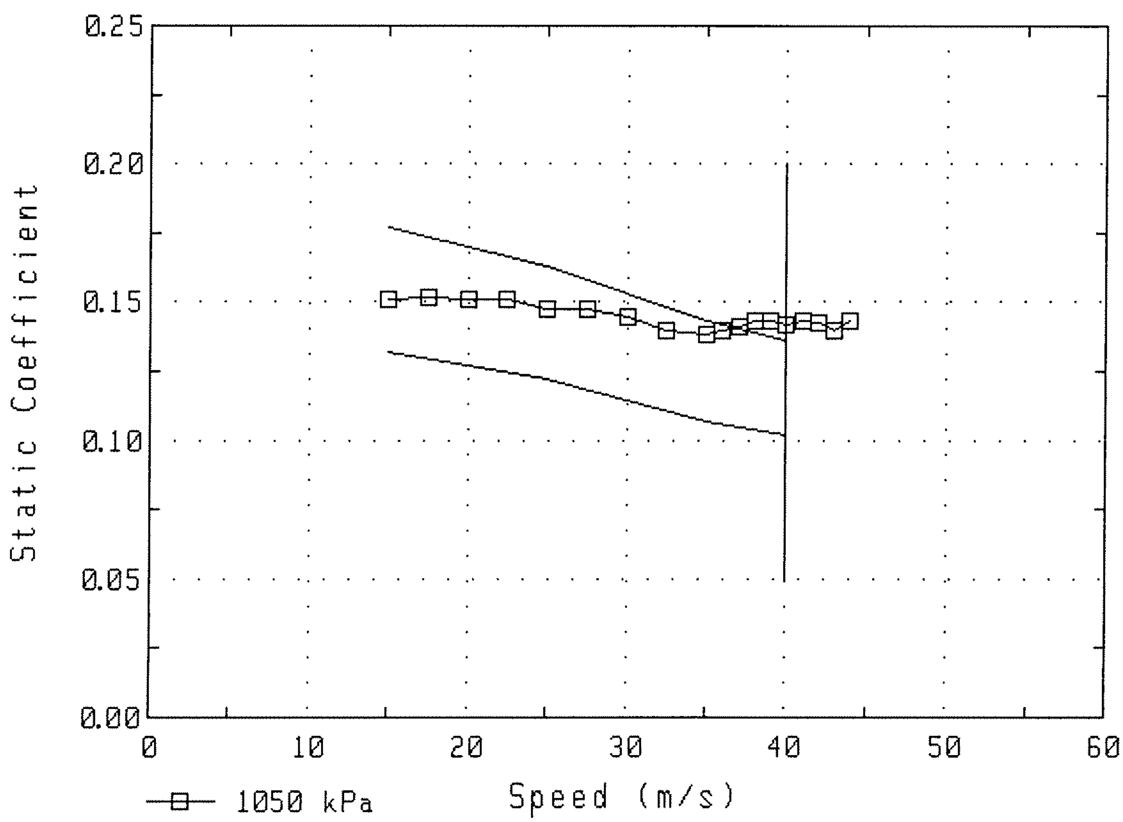
Compression set average wear: 0.008
M2 - M3 average Wear: 0.008

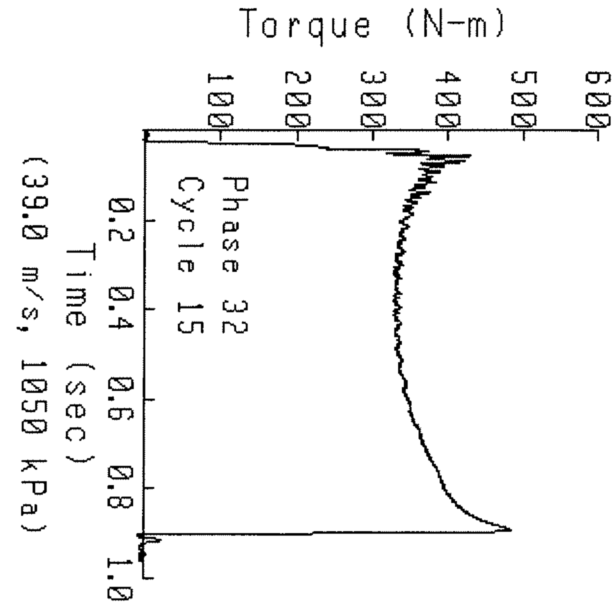
Total Wear (all measurements in mm): 0.016

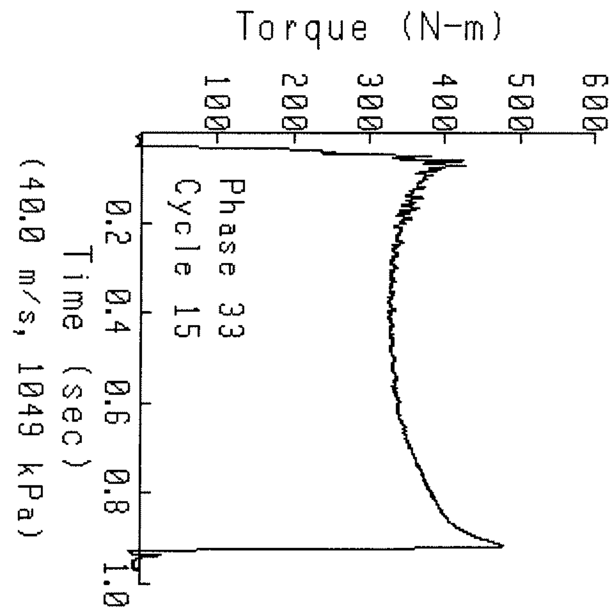

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

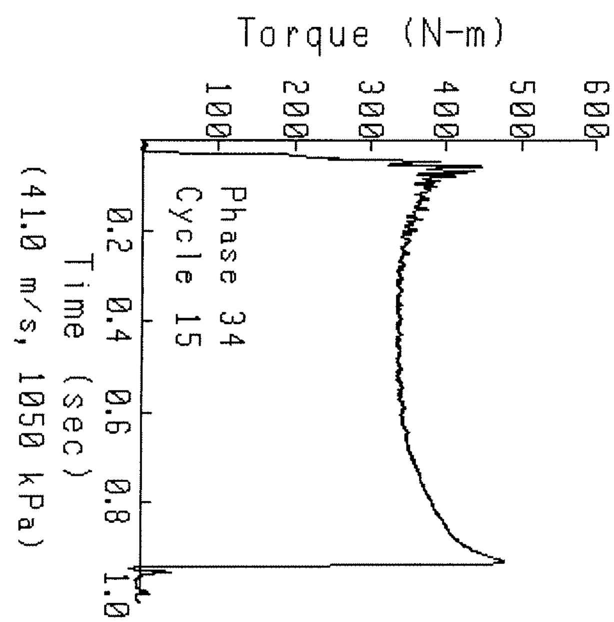

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

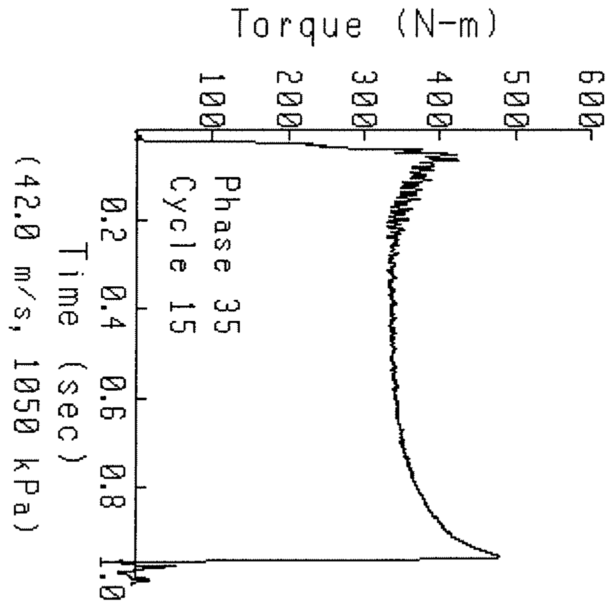

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

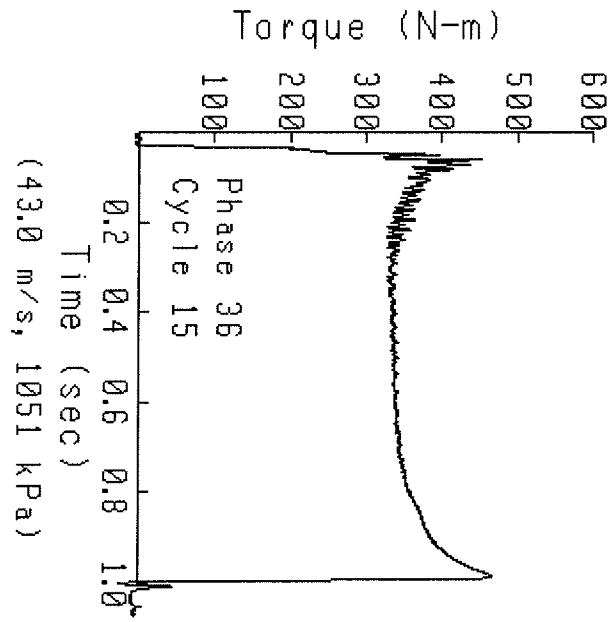

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

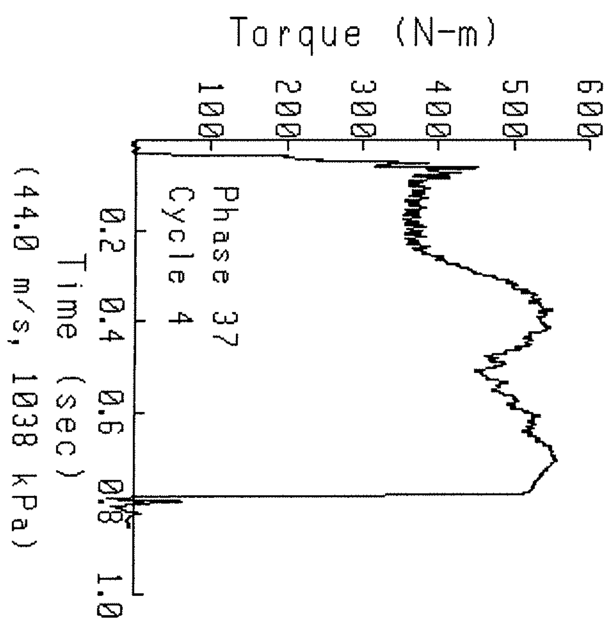

Torque (N-m)
100 200 300 400 500 600
Phase 32
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(39.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 33
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(40.0 m/s, 1049 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 34
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(41.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 35
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(42.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 36
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(43.0 m/s, 1051 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 37
Cycle 4
0.2 0.4 0.6 0.8 1.0
Time (sec)
(44.0 m/s, 1038 kPa)

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

Fuels and Lubricants Research Division

Report on

John Deere JDQ-96
Performed using 1400 Series Axle

Conducted for

ARMY LAB

AL-27876-L

Test Number
07498

October 17, 2007

Submitted by:

Michael D. Lochte
Manager
Specialty & Driveline Fluids
Evaluations

The results of this report relate only to the items tested.

John Deere JDQ-96 Performed using 1400 Series Axle

General Information

Oil Code: AL-27876-L	**E.O.T. Date:** October 17, 2007

Purpose

The purpose of this test was to evaluate the anti-chatter properties of this oil on the brakes of a 1400 series John Deere Inboard Planetary Axle.

Test Procedure

The test was performed as specified by John Deere Product Engineering. The only changes made to the Deere procedure were those necessary to compensate for a different spiral bevel gear ratio. This procedure is proprietary to Deere and Company.

Data Interpretation

The capacity for each engagement is the average torque during the middle of the engagement. The torque variation is the greatest difference between the maximum and minimum torque recorded during any 0.2-second portion of the engagement. The SwRI variation is the sum of all differences between the maximum torque and minimum torque for each engagement. It is obtained by summing all torque variations of each 0.2-second time block of all engagements.

Test Number

The run number listed on this report is a random number and is not sequential. Only SwRI® can link this run number to JDQ-96, AL-27876-L, October 17, 2007.

John Deere JDQ-96 Performed using 1400 Series Axle

Results

Oil Code: AL-27876-L	**E.O.T. Date:** October 17, 2007

The candidate results can be compared to the baseline reference average. Pass or fail decisions are only made by John Deere Product Engineering. The current reference baseline average is the average of the five most recent tests.

Current Reference Baseline Average (N · m)

	1,000 Cycles	10,000 Cycles	20,000 Cycles	30,000 Cycles	TOTAL
Relative Capacity	338,535	338,534	341,629	343,274	1,361,972
Torque Variation	79,214	84,272	79,152	74,708	317,346

Results From Test Candidate AL-27876-L

	1,000 Cycles	10,000 Cycles	20,000 Cycles	30,000 Cycles	TOTAL
Relative Capacity	330,895				
Torque Variation	200,980				

Tables 1 of the Appendix contains chatter test results from 1,000cycles. Table 2 contains results of the five current baseline reference tests. Figures 1 through 4 are graphic presentations of candidate oil performance compared to baseline reference data.

Figure 5 is a graphic presentation of 1000-cycle reference results and AL-27876-L. Table 3 contains the history of reference tests.

John Deere JDQ-96 Performed using 1400 Series Axle

Oil Code: AL-27876-L	E.O.T. Date: October 17, 2007

Appendix

Tables

1. Table 1 – Durability results 1,000 cycles Candidate Oil
2. Table 2 – Reference Data Compared to Candidate Data
3. Figure 1 & Figure 2 - Torque Variation Chart
4. Figure 3 & Figure 4 – Relative Capacity & Average Disk Thickness Chart
5. Figure 5 - Graphic presentation of 1000 cycle reference results & Candidate
6. Table 3 - History of reference tests

October 17, 2007

TABLE 1: JDQ-96 DURABILITY TEST RESULTS 1,000 CYCLES

SwRI Oil Code LO-224037 Sponsor Oil Code AL-27876-L

Axle Speed (rpm)	Brake Press. (kPa)	TORQUE VARIATION TEST RESULTS (TORQUE and VARIATION in Nm)											
		Oil Temp. 32°C			Oil Temp. 49°C			Oil Temp. 60°C			Oil Temp. 71°C		
		Torque	Variation	Temp.	Torque	Variation	Temp.	Torque	Variation	Temp.	Torque	Variation	Temp.
8	3831	3924	4150	29	4155	2510	51	4165	3780	61	4282	3720	72
10	3831	3947	2610	29	4060	2470	50	4112	4060	60	4233	3890	72
15	3831	3761	3160	29	3892	3000	49	3867	3080	59	3954	3210	71
20	3831	4006	700	29	3926	3570	49	3832	3590	58	3882	3860	71
25	3831	4001	680	29	3798	4140	49	3808	4230	59	3779	5030	71
30	3831	4014	770	30	3918	1030	50	3906	1320	59	3947	1700	71
35	3831	3992	730	32	3849	1010	50	3823	1190	60	3862	1520	71
40	3831	4041	770	33	3851	1040	50	3821	1260	60	3852	1490	71
45	3831	3983	780	33	3759	1000	51	3739	1190	61	3750	1500	71
50	3831	3943	760	35	3732	980	51	3695	1190	61	3773	1450	71
55	3831	3730	720	33	3650	910	48	3811	1170	61	3897	1440	71
60	3831	3730	770	34	3630	1020	49	3632	1170	61	3838	1510	72
15	1532	1554	210	32	1667	750	49	1641	880	59	1659	880	70
15	2300	2315	640	32	2334	2440	48	2408	1050	58	2472	1110	69
15	3065	3185	2830	32	3089	3000	48	3086	2860	58	3126	2790	70
15	3831	3932	3280	32	3910	3070	48	4058	3020	59	4004	3080	70
15	4598	4774	3380	32	4762	3440	48	4791	3490	59	5050	3480	70
15	5364	5727	3350	32	5638	3500	48	5743	3460	59	5972	3610	70
15	6130	6738	3520	33	6444	5730	48	6638	5650	59	6964	4620	70
15	7050	7613	5660	33	7456	5960	48	7678	6270	59	7915	7140	70

Temp (°C)	Relative Capacity (Nm)	Torque Variation (Nm)	SwRI Variation (Nm)
32	82,912	39,470	539,920
49	81,518	50,570	661,660
60	82,254	53,910	637,060
71	84,211	57,030	679,650
TOTAL	330,895	200,980	2,518,290

TABLE 2: JDQ-96 REFERENCE DATA COMPARED TO CANDIDATE DATA

EOT Date: October 17, 2007

Oil Code : AL-27876-L

Reference Oil Coded : 69X31111i	Cycles	Relative Capacity	Torque Variation	SwRI Variation	Average Facing Thickness (millimeters)
First Reference Run					
	1,000	326,304	57,420	730,050	7.60
	10,000	331,809	64,900	804,030	7.50
	20,000	345,325	69,500	899,880	7.44
	30,000	341,770	66,210	810,190	7.39
	Total	1,345,208	258,030	3,244,150	
Second Reference Run					
	1,000	337,791	66,660	848,580	7.60
	10,000	338,055	92,240	1,129,330	7.55
	20,000	343,166	77,010	1,001,920	7.49
	30,000	350,470	73,280	863,980	7.44
	Total	1,369,482	309,190	3,843,810	
Third Reference Run					
	1,000	339,375	100,390	1,204,240	7.56
	10,000	335,754	106,780	1,079,450	7.52
	20,000	334,120	84,770	1,030,270	7.49
	30,000	335,614	79,620	1,021,190	7.47
	Total	1,344,863	371,560	4,335,150	
Fourth Reference Run					
Run on new backing pla	1,000	343,906	79,990	1,020,120	7.48
and piston	10,000	343,056	72,520	893,570	7.30
	20,000	342,668	69,920	885,870	7.07
	30,000	345,315	70,360	833,920	6.90
	Total	1,374,945	292,790	3,633,480	
Invalid test run on same	*1,000*	*348,860*	*132,110*	*1,721,010*	
backing plate and pistor	*10,000*	*323,093*	*153,860*	*1,919,720*	
as test above was run on					
Fifth Reference Run					
most recent run	**1,000**	**345,296**	**91,610**	**1,125,260**	**7.50**
Run on new backing	**10,000**	**343,999**	**84,920**	**1,019,400**	**7.33**
plate and piston	**20,000**	**342,864**	**94,560**	**1,264,070**	**7.22**
	30,000	**343,201**	**84,070**	**1,052,400**	**7.11**
	Total	**1,375,360**	**355,160**	**4,461,130**	
AL-27876-L		Candidate Oil Test Results			
	1,000	330,895	200,980	2,518,290	
	10,000				
	20,000				
	30,000				
	Total	330,895	200,980	2,518,290	

Figure 1

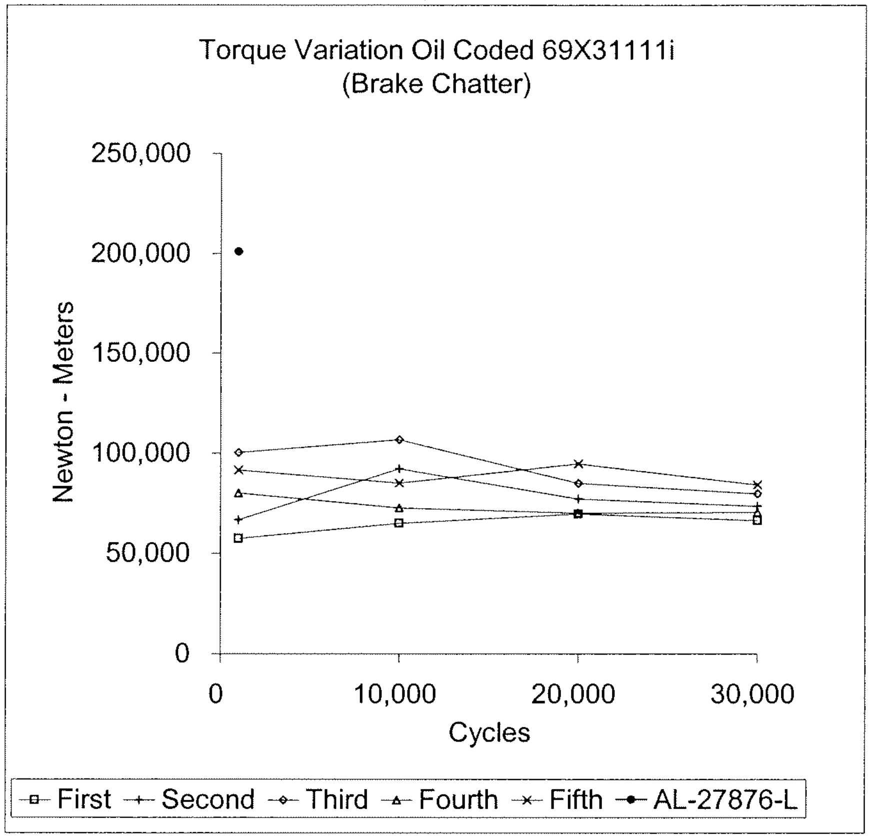


Figure 2

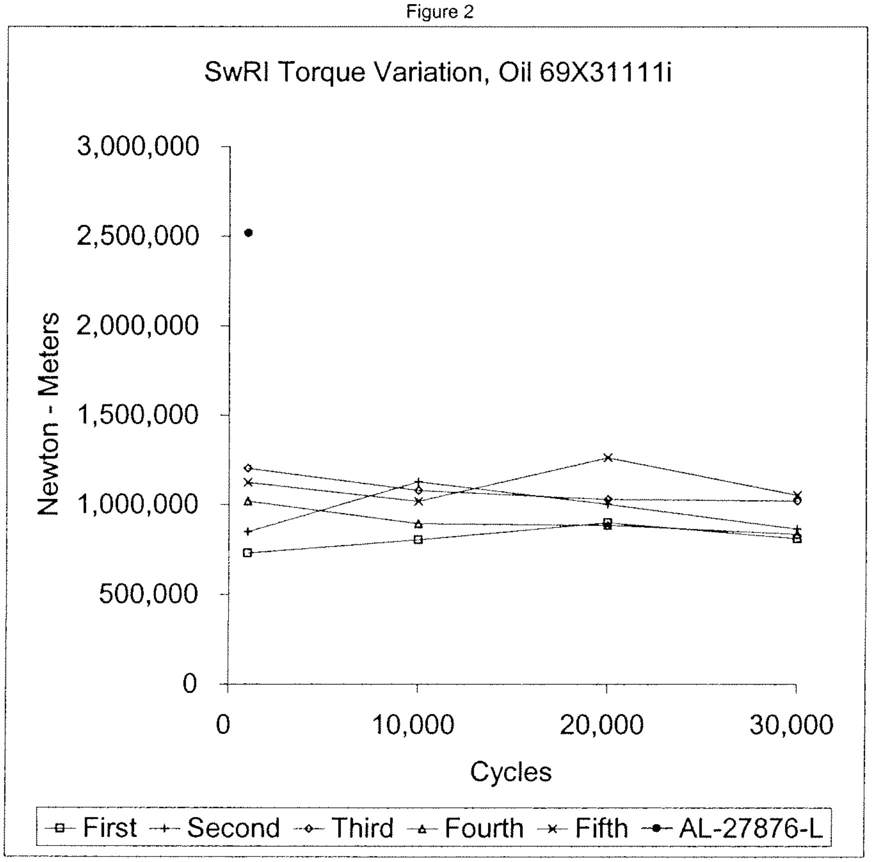


Figure 3

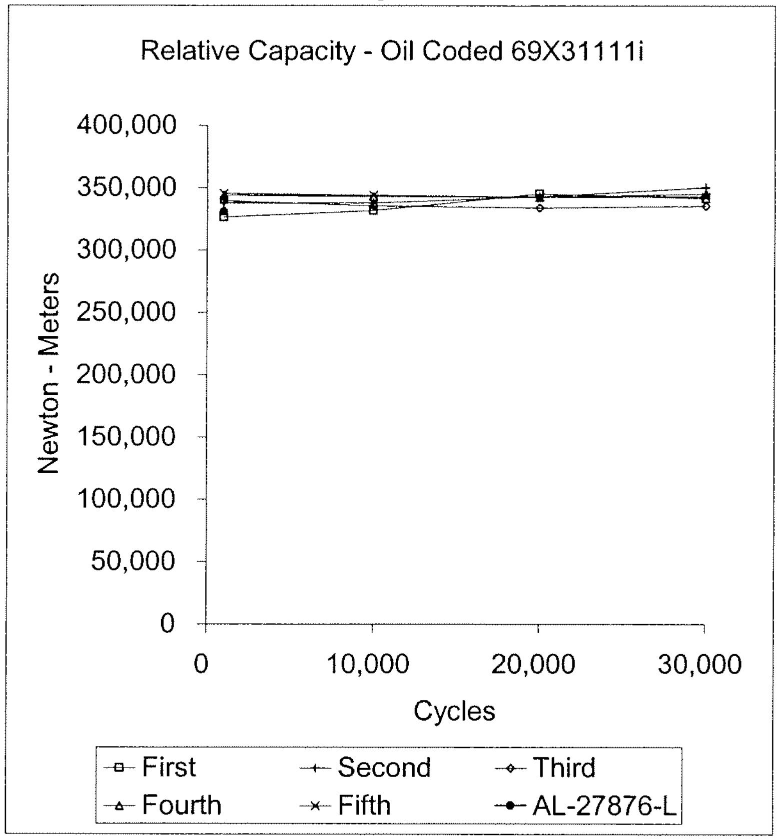


Figure 4

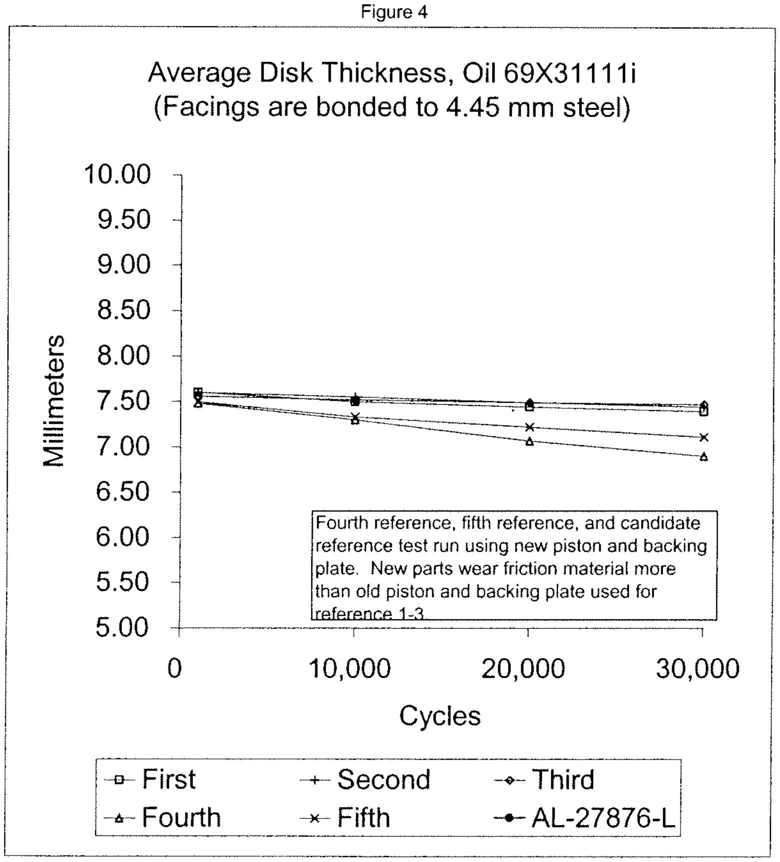
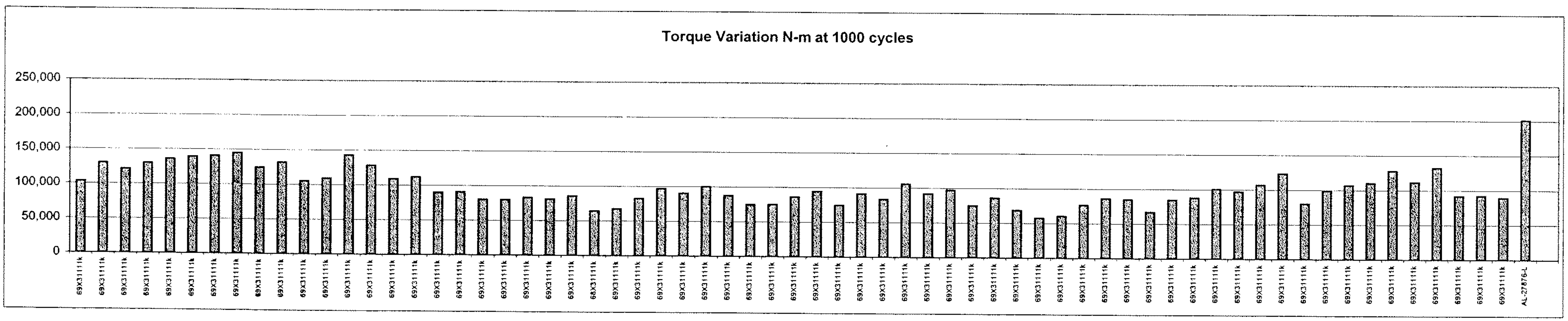


Table 3

AL-27876-L October 17, 2007

History of 1000 cycle reference tests.

		Torque variation at 1000 cycles
69X31111k	1999 brake disk	103,360
69X31111k	1997 brake disk	129,540
69X31111k	2000 brake disk	121,120
69X31111k	2000 brake disk	129,620
69X31111k	2000 brake disk	135,700
69X31111k	2000 brake disk	138,760
69X31111k	2000GDD brake di	140,830
69X31111k	2000GDD brake	144,820
69X31111k	2000GDD brake	124,310
69X31111k	2000 GDD brake	131,860
69X31111k	2000 GDD brake	105,010
69X31111k	2000 GDD brake	109,220
69X31111k	2000 GDD brake	142,510
69X31111k	2000 GDD brake	128,080
69X31111k	2000 GDD brake	109,100
69X31111k	2000 GDD brake	111,800
69X31111k	2000 GDD brake	90,070
69X31111k	2000 GDD brake	90,810
69X31111k	2000 GDD brake	79,930
69X31111k	2000 GDD brake	79,930
69X31111k	2000 GDD brake	83,190
69X31111k	2000 GDD brake	81,220
69X31111k	2000 GDD brake	85,570
68X31111k	2000 GDD brake	64,170
69X31111k	2000 GDD brake	67,390
69X31111k	2000 GDD brake	82,410
69X31111k	2000 GDD brake	96,730
69X31111k	2000 GDD brake	90,390
69X31111k	2000 GDD brake	99,960
69X31111k	2000 GDD brake	87,380
69X31111k	2000 GDD brake	74,720
69X31111k	2000 GDD brake	74,940
69X31111k	2000 GDD brake	85,980
69X31111k	2000 GDD brake	94,410
69X31111k	2000 GDD brake	74,300
69X31111k	2000 GDD brake	90,950
69X31111k	2000 GDD brake	83,190
69X31111k	2000 GDD brake	105,210
69X31111k	2000 GDD brake	91,960
69X31111k	2000 GDD brake	97,320
69X31111k	2000 GDD brake	75,040
69X31111k	2000 brake disk	86,060
69X31111k	2000 brake disk	68,590
69X31111k	2003 brake disk	57,420
69X31111k	2003 brake disk	60,330
69X31111k	2003 brake disk	76,260
69X31111k	2003 brake disk	86,210
69X31111k	2003 brake disk	84,550
69X31111k	2003 brake disk	66,660
69X31111k	2003 brake disk	84,760
69X31111k	2003 brake disk	87,800
69X31111k	2003 brake disk	100,390
69X31111k	2003 brake disk	96,620
69X31111k	2003 brake disk	106,710
69X31111k	2003 brake disk	123,110
69X31111k	NEW BACKING PI	79,990
69X31111k		98,440
69X31111k		106,370
69X31111k		110,040
69X31111k		127,550
69X31111k		111,280
69X31111k	invalid run	132,110
69X31111k	NEW BACKING Plate and piston	91,610
69X31111k	NEW BACKING Plate and piston	92,230
69X31111k	plate used for 1 test	89,200
AL-27876-L	same brake plate and piston as above	200,980



AL-27876-L

October 17, 2007

Figure 5

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

Fuels And Lubricants Research Division

Report on

ALLISON HYDRAULIC TRANSMISSION FLUID, TYPE C-4 GRAPHITE CLUTCH FRICTION TEST

Conducted For

SWRI ARMY LAB

Oil Code:
AL-27877-L

Test Number:
C4-2-1189

September 11, 2007

Submitted by:

Matthew Jackson
Principal Engineer
Specialty & Driveline Fluids Evaluation

VIII. Graphite Clutch Friction Test

Test Laboratory: SWRI
Test Number: C4-2-1189
Friction Plate Batch: LOT 43
Steel Plate Batch: 9/11/2005

Lab Fluid Code: ATF-223703
Sponsor Fluid Code: AL-27877-L
Completion Date: 09/11/07

Clutch Wear Data

	Maximum	Average
Steel Plates	0.0010	0.0002
Clutch Plate	0.0820	0.0735

	Before	After
Pack Clearance	0.4064	0.6350

Reference Tests

Test Number	Test Date	Test Fluid
C4-0-1163	01/19/07	PASS REF-L-06-04
C4-0-1176	05/05/07	PASS REF-L-06-04
C4-0-1187	8/30/2007	PASS REF-L-06-04

	New	EOT
Viscosity at 40°C, cSt	58.17	42.61
Viscosity at 100°C, cSt	10.62	8.06
Iron Content, ppm	2	71

D5185	New Fluid (ppm)
Ba	<1
B	1
Ca	3595
Mg	10
P	1302
Si	4
Na	<5
Zn	1444

Name: Matthew Jackson
Title: Principal Engineer

Signature:
Date: 9/17/07

ALLISON C- 4 GRAPH FRICTION TEST SUMMARY

(Torque in Ft-Lbs)

Sponsor Fluid Code: **AL-27877-L**	Test Number: **C4-2-1189**
Lab Fluid Code: **ATF-223703**	Fric. Plate Batch: **LOT 43**
Completion Date: **9/11/2007**	Steel Plate Batch: **9/11/2005**

PHASE A

CYCLE	SLIP TIME	TORQUE (MIDPOINT)	TORQUE STATIC PEAK	TORQUE (.2 Second)	STATIC PEAK - 0.2 TORQUE	LOW SPEED STATIC PEAK	LOWSPEED STATIC TORQUE
500	1.11	55	62	52	10	68	60
1000	1.10	56	64	51	13	67	61

PHASE B

CYCLE	SLIP TIME	TORQUE (MIDPOINT)	TORQUE STATIC PEAK	TORQUE (0.2 Second)	STATIC PEAK - 0.2 TORQUE	LOW SPEED STATIC PEAK	LOWSPEED STATIC TORQUE
1500	0.73	108	130	104	26	145	129
2000	0.75	106	129	100	29	142	129
2500	0.75	106	128	100	28	141	127
3500	0.76	104	123	95	28	135	128
4000	0.76	105	123	96	27	138	125
4500	0.78	103	120	95	25	141	126
5000	0.77	104	118	96	22	136	126
5500	0.78	103	117	96	21	135	125

	Limits		**Results**			
	Max	Max Change	1,500 N	5,500 N	% Change	P/F
Slip Time Max.	0.81	N/A	0.73	0.78	6.85	**P**
0.2 Second Dynamic Coeff.	N/A	N/A	0.097	0.090	-7.216	
Mid-Point Fric. Coeff. Min.	0.093	N/A	0.101	0.097	-3.960	**P**
Static Friction Coeff.	N/A	N/A	0.122	0.110	-9.836	
Low Speed Peak Fric. Coeff.	N/A	N/A	0.136	0.126	-7.353	
0.25 Second Low Speed Coeff.	N/A	N/A	0.121	0.117	-3.306	

SOUTHWEST RESEARCH INSTITUTE®

ALLISON C4-GRAPHITE FRICTION TEST

Candidate Fluid: AT-27877-L **Test Number : C4-2-1189** **Completion Date : 9/11/2007**

Lab Fluid Code : ATF-223703 **Steel Plate Batch: 09/11/2005** **Fric Plate Batch : LOT 43**

Plates	Location of Tooth (Clockwise)	Near Inner Diameter Before	Near Inner Diameter After	Near Outer Diameter Before	Near Outer Diameter After	Inner Diameter Change	Average Overall Change	Outer Diameter Change
FRICTION MATERIAL								
2	Top	2.2200	2.1510	2.2200	2.1540	0.0690		0.0660
	120	2.2260	2.1440	2.2280	2.1540	0.0820		0.0740
	240	2.2230	2.1420	2.2190	2.1500	0.0810		0.0690
	Average					0.0773	0.0735	0.0697
STEEL SEPARATORS								
1	Top	1.7520	1.7510	1.7520	1.7520	0.0010		0.0000
	120	1.7520	1.7520	1.7520	1.7520	0.0000		0.0000
	240	1.7500	1.7500	1.7500	1.7490	0.0000		0.0010
	Average					0.0003	0.0003	0.0003
3	Top	1.7480	1.7480	1.7480	1.7480	0.0000		0.0000
	120	1.7500	1.7500	1.7500	1.7500	0.0000		0.0000
	240	1.7500	1.7500	1.7500	1.7500	0.0000		0.0000
	Average					0.0000	0.0000	0.0000

PLATE CONDITION AT E.O.T.: PLATES IN GOOD CONDITION WITH NO UNUSUAL DISCOLORATION
(Anything Unusual)

Test Date: 9/11/2007

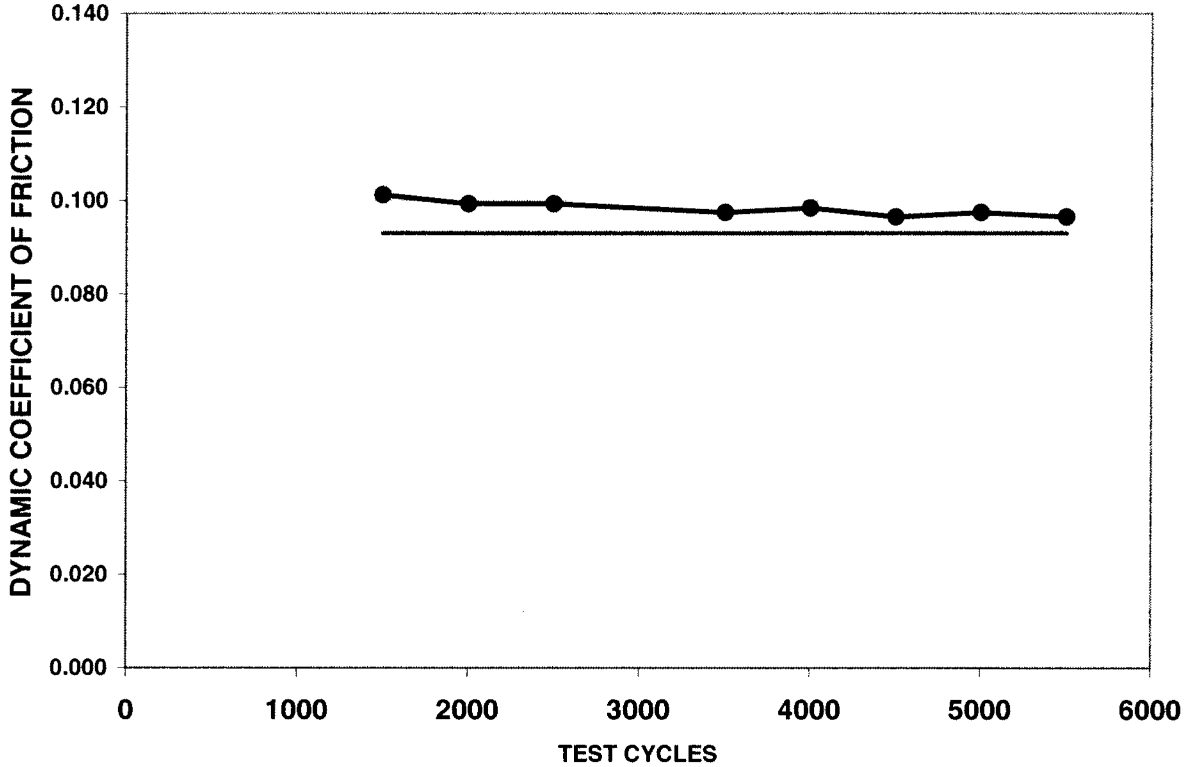
Operator's Name: RAUL VALDEZ

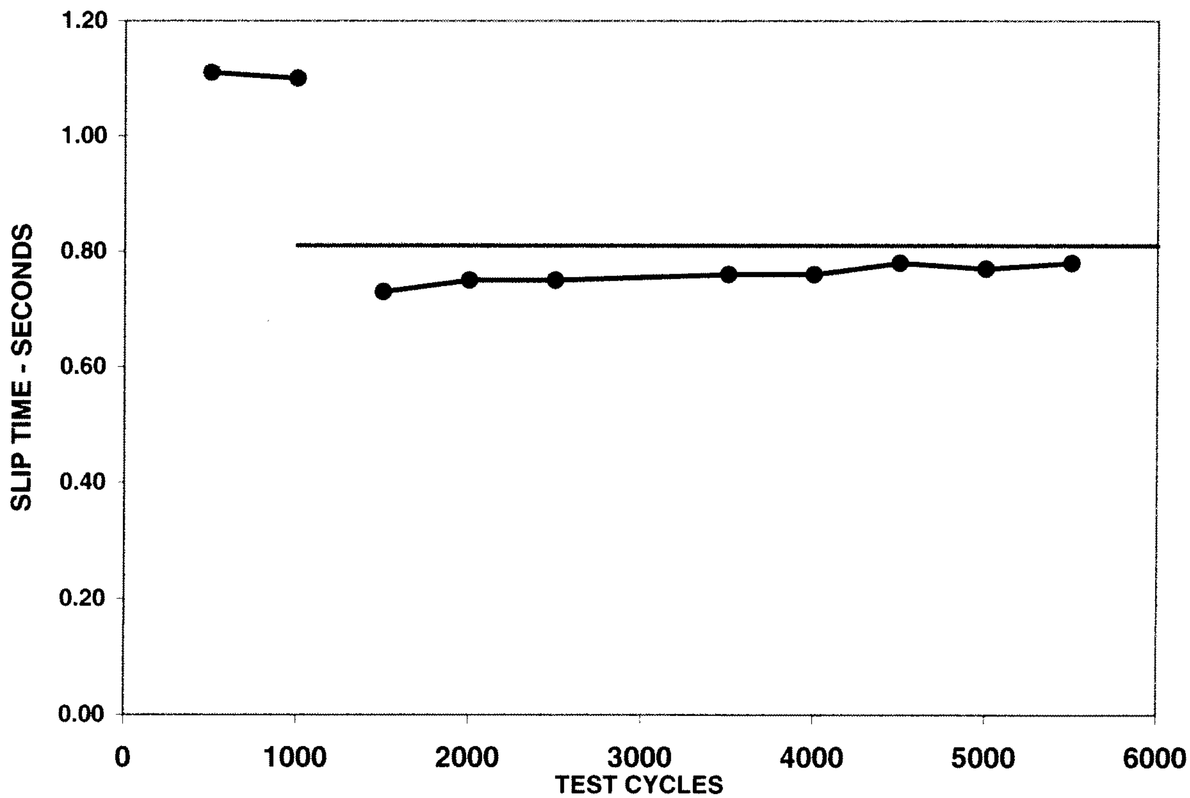
Reviewed By (Signature and Date) 9/14/07

Pack ID#: 4068

ALLISON HYDRAULIC TRANSMISSION FLUID
TYPE C-4 GRAPHITE FRICTION TEST

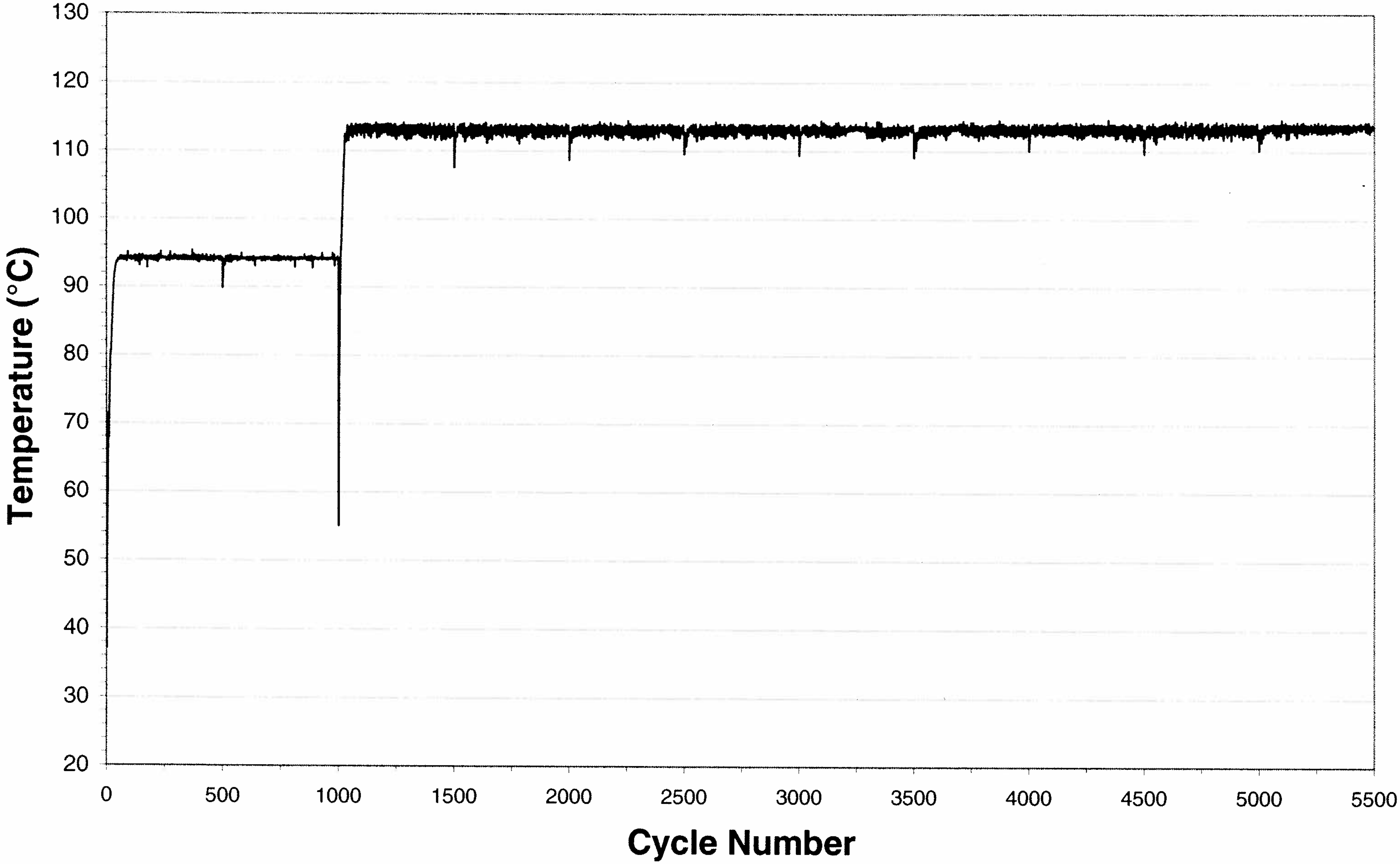
EOT Date: 9/11/2007 **Fluid Code:** AL-27877-L
Test Number: C4-2-1189 **Plate Batch:** LOT 43
Steel Batch: 9/11/2005





C4-2-1189 AL-27877-L

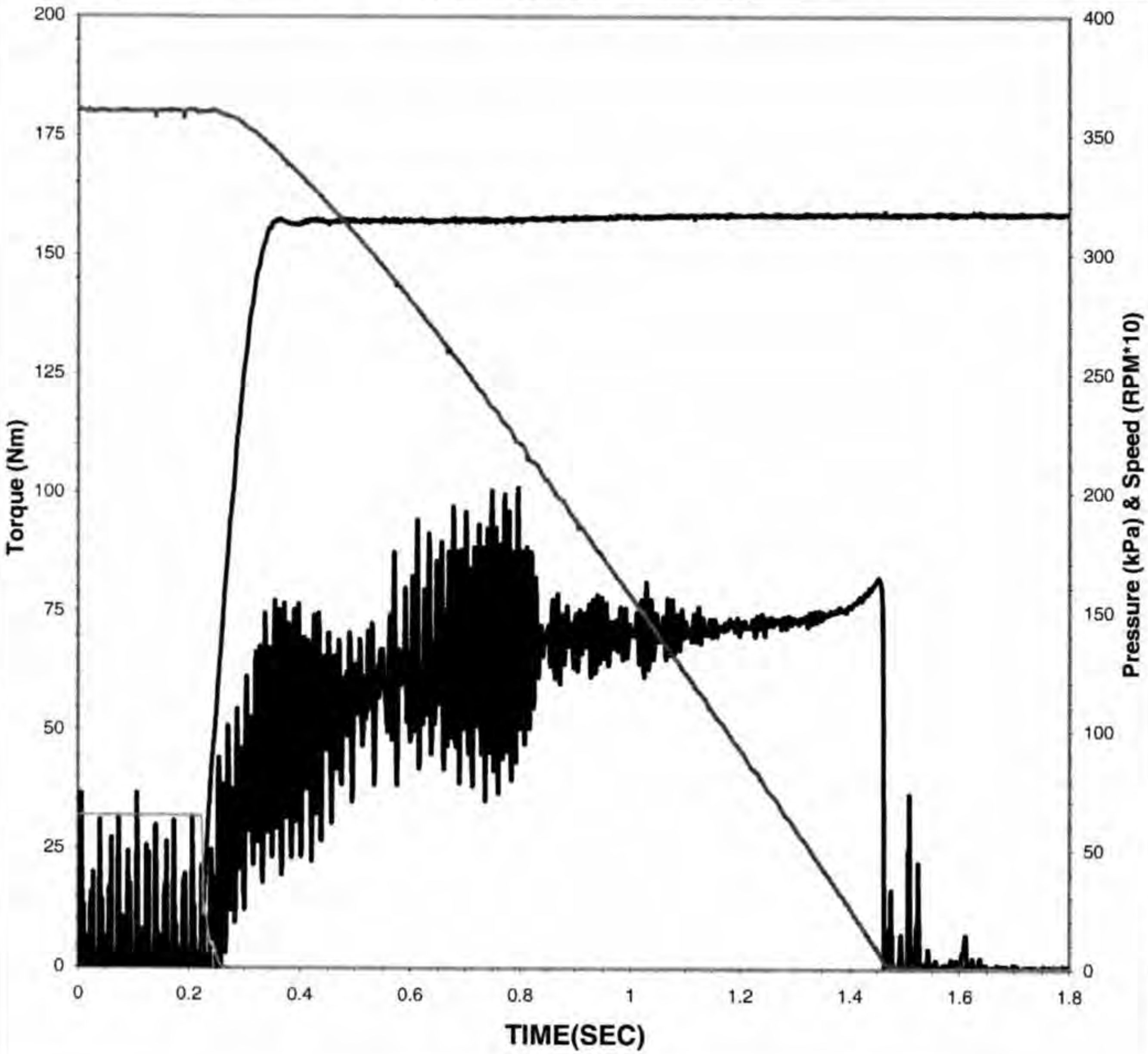
AVG: Phase A = 93.4 °C, Phase B = 112.8 °C



DYNAMIC TRACES

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE A



Date of Test:	9/10/2007
Time of Test:	20:07:38
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	10
Temperature:	71.4 °C (93.3 ± 3.0 °C)
Apply Pressure:	315 kPa (345 ± 7 KPa)
Apply Rate:	0.12 Sec (0.15 ± 0.02 Sec)
Energy:	14.4 KJ (14.50 ± 0.40 KJ)
Engage Time:	1.239 Sec

Torque

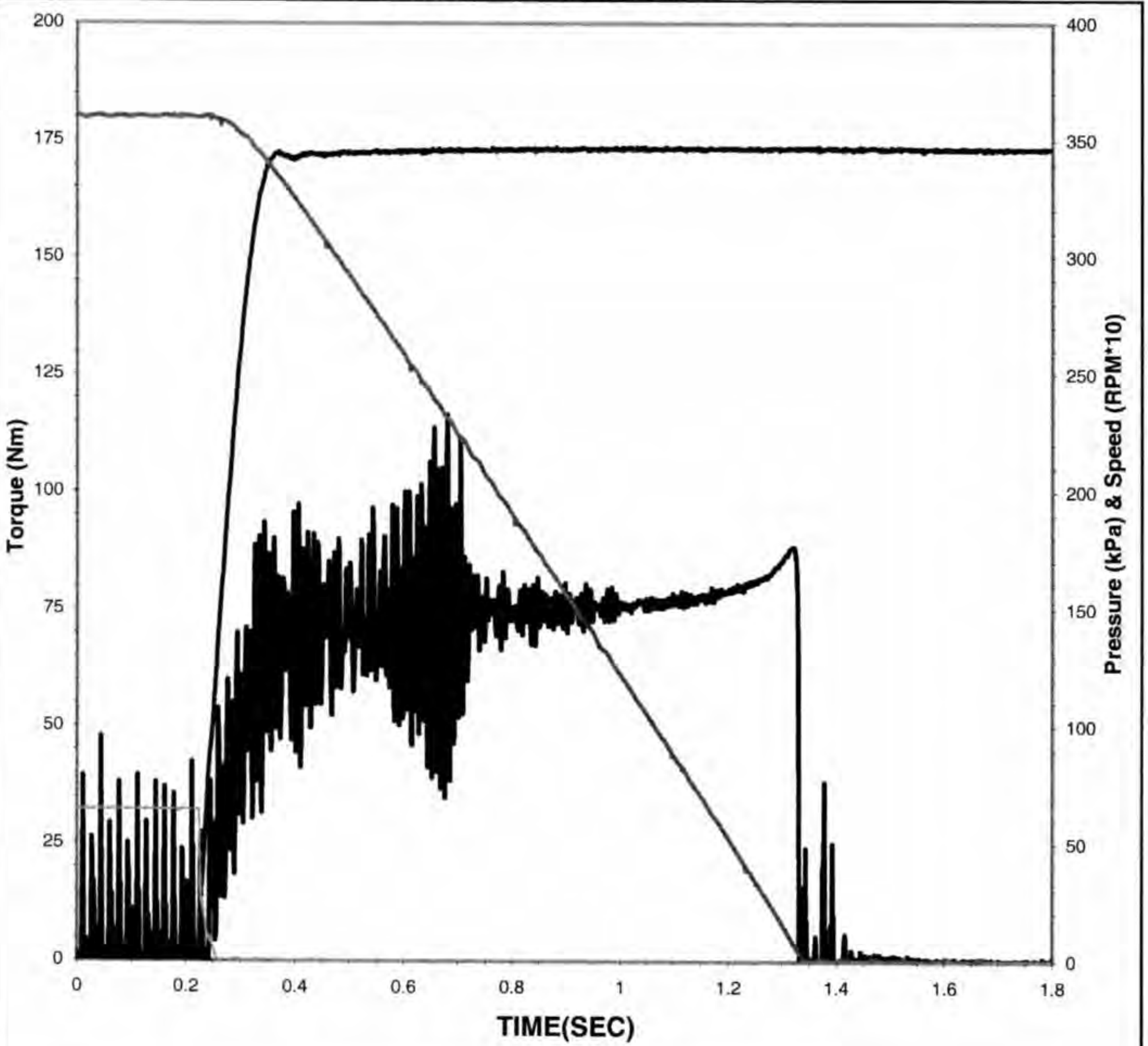
0.2 Sec Dyn:	50 N*m
Midpoint Dyn:	69 N*m
LwSpd Dynamic:	79 N*m

Coefficient of Friction

.2 Sec Dyn:	0.084
Midpoint Dyn:	0.115
LwSpd Dynamic:	0.131

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE A



Date of Test:	9/10/2007
Time of Test:	22:10:05
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	499
Temperature:	94.1 °C
	(93.3 ± 3.0 °C)
Apply Pressure:	347 kPa
	(345 ± 7 KPa)
Apply Rate:	0.13 Sec
	(0.15 ± 0.02 Sec)
Energy:	14.4 KJ
	(14.50 ± 0.40 KJ)
Engage Time:	1.106 Sec

Torque

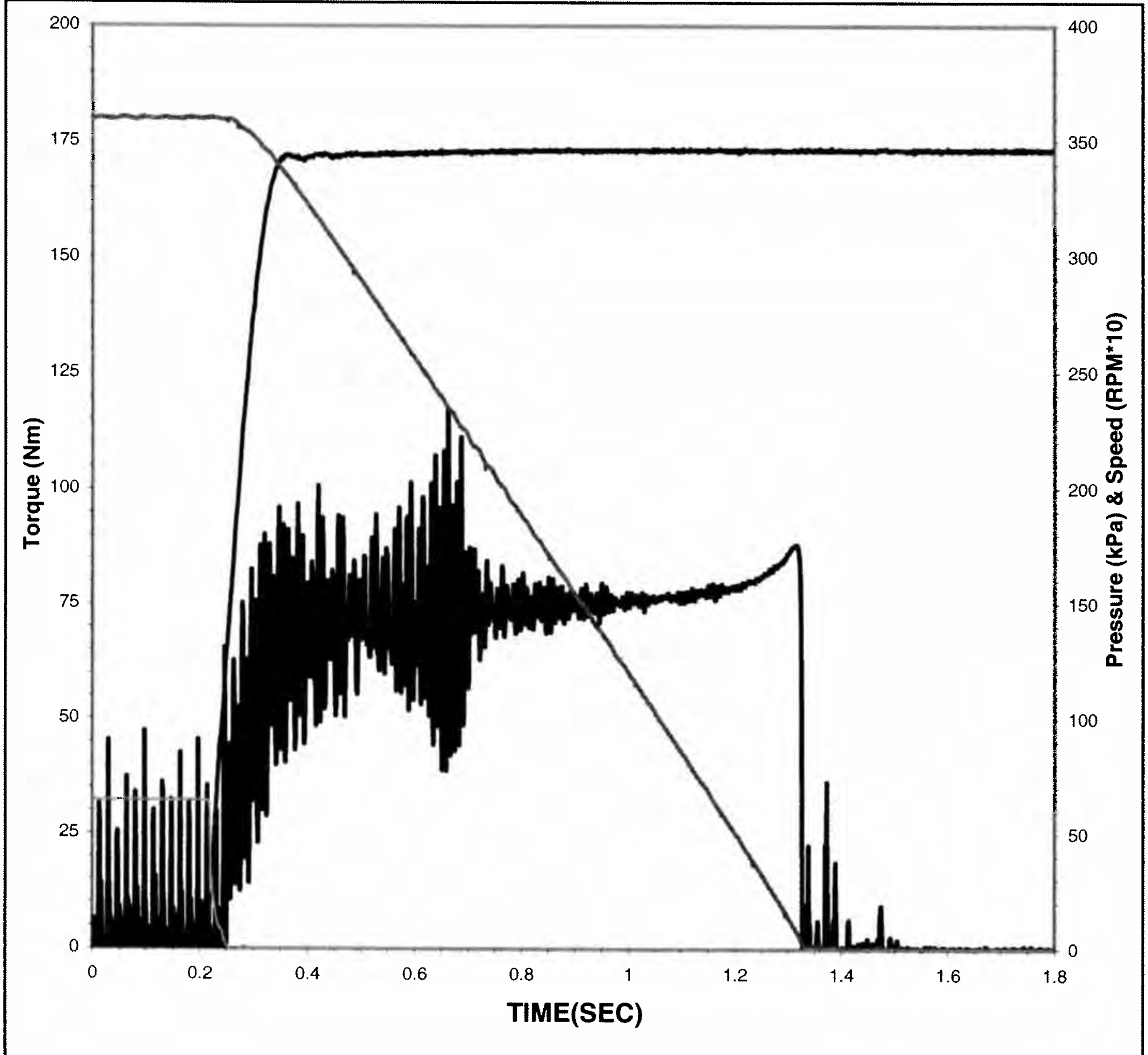
0.2 Sec Dyn:	69 N*m
Midpoint Dyn:	75 N*m
LwSpd Dynamic:	84 N*m

Coefficient of Friction

.2 Sec Dyn:	0.114
Midpoint Dyn:	0.124
LwSpd Dynamic:	0.139

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE A



Date of Test:	9/10/2007
Time of Test:	22:10:20
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	500
Temperature:	94.2 °C (93.3 ± 3.0 °C)
Apply Pressure:	346 kPa (345 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	14.4 KJ (14.50 ± 0.40 KJ)
Engage Time:	1.108 Sec

Torque

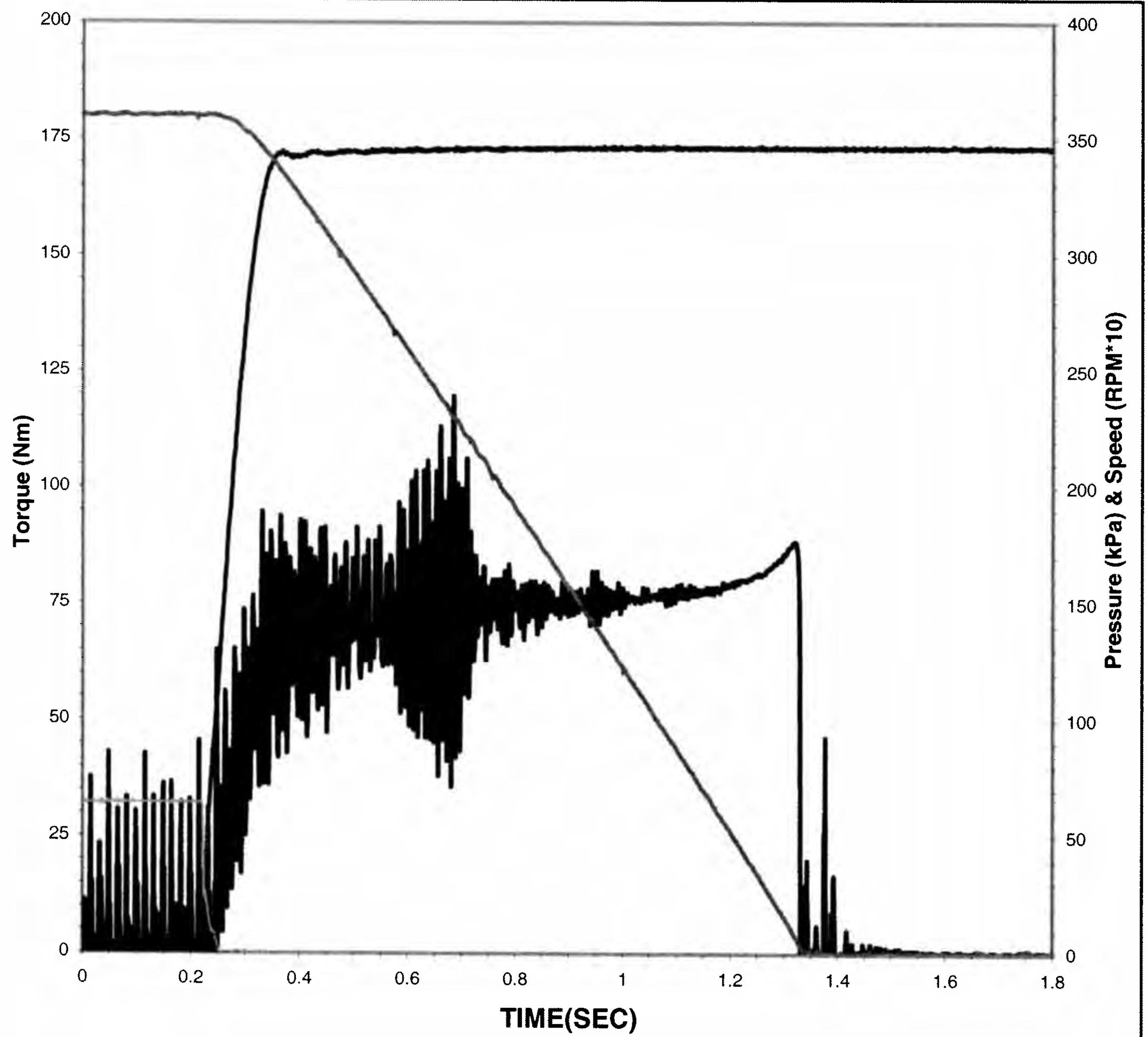
0.2 Sec Dyn:	70 N*m
Midpoint Dyn:	74 N*m
LwSpd Dynamic:	83 N*m

Coefficient of Friction

.2 Sec Dyn:	0.116
Midpoint Dyn:	0.123
LwSpd Dynamic:	0.138

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE A



Date of Test:	9/10/2007
Time of Test:	22:10:47
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	501
Temperature:	89.8 °C (93.3 ± 3.0 °C)
Apply Pressure:	346 kPa (345 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	14.4 KJ (14.50 ± 0.40 KJ)
Engage Time:	1.109 Sec

Torque

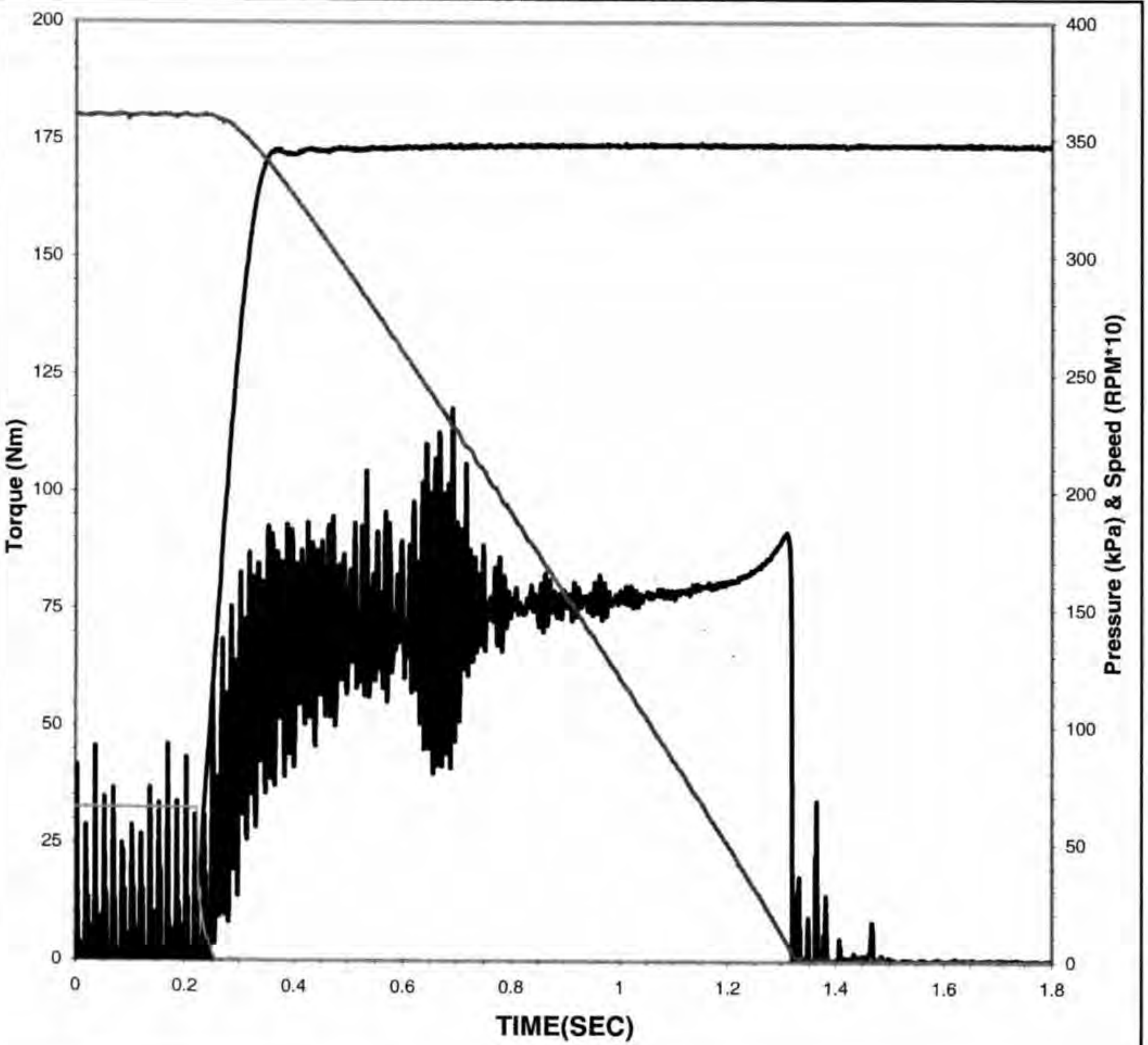
0.2 Sec Dyn:	71 N*m
Midpoint Dyn:	74 N*m
LwSpd Dynamic:	84 N*m

Coefficient of Friction

.2 Sec Dyn:	0.119
Midpoint Dyn:	0.124
LwSpd Dynamic:	0.139

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE A



Date of Test:	9/11/2007
Time of Test:	0:15:02
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	998
Temperature:	94.1 °C (93.3 ± 3.0 °C)
Apply Pressure:	347 kPa (345 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	14.4 KJ (14.50 ± 0.40 KJ)
Engage Time:	1.096 Sec

Torque

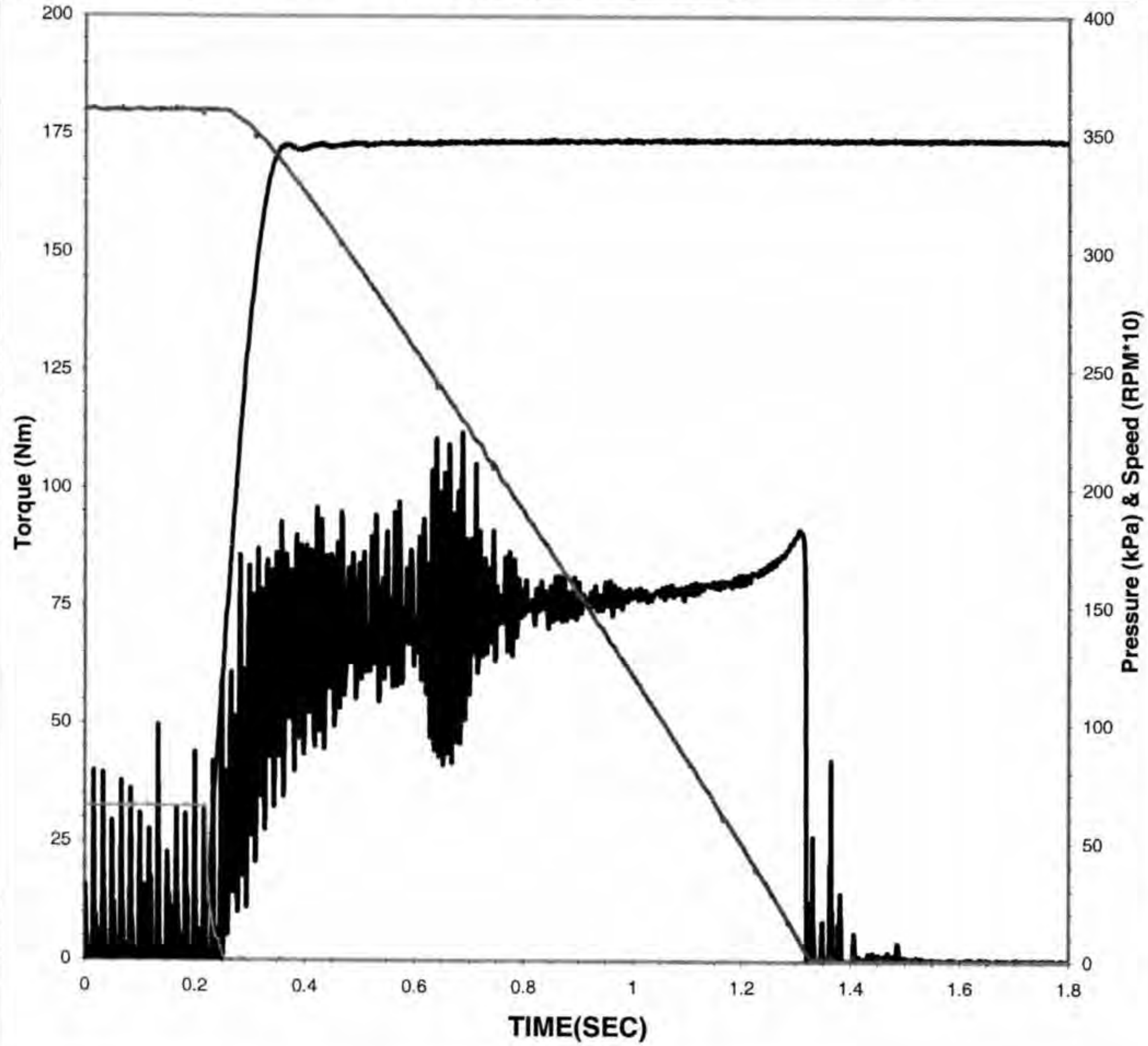
0.2 Sec Dyn:	68 N*m
Midpoint Dyn:	75 N*m
LwSpd Dynamic:	87 N*m

Coefficient of Friction

.2 Sec Dyn:	0.112
Midpoint Dyn:	0.125
LwSpd Dynamic:	0.145

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE A



Date of Test:	9/11/2007
Time of Test:	0:15:17
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	999
Temperature:	94.0 °C (93.3 ± 3.0 °C)
Apply Pressure:	347 kPa (345 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	14.4 KJ (14.50 ± 0.40 KJ)
Engage Time:	1.097 Sec

Torque

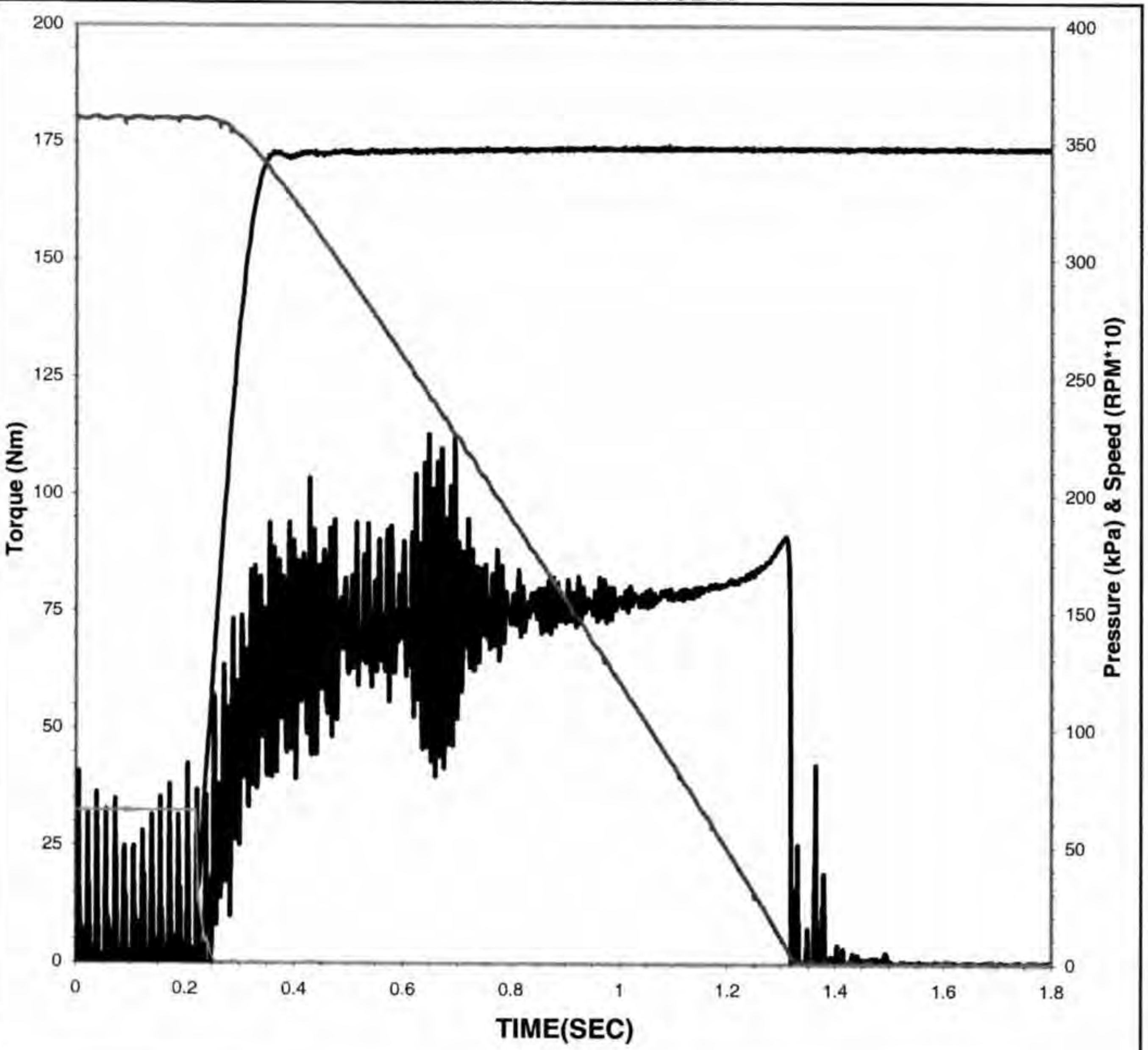
0.2 Sec Dyn:	69 N*m
Midpoint Dyn:	75 N*m
LwSpd Dynamic:	87 N*m

Coefficient of Friction

.2 Sec Dyn:	0.114
Midpoint Dyn:	0.124
LwSpd Dynamic:	0.144

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE A



Date of Test:	9/11/2007
Time of Test:	0:15:32
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	1000
Temperature:	93.9 °C (93.3 ± 3.0 °C)
Apply Pressure:	347 kPa (345 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	14.4 KJ (14.50 ± 0.40 KJ)
Engage Time:	1.097 Sec

Torque

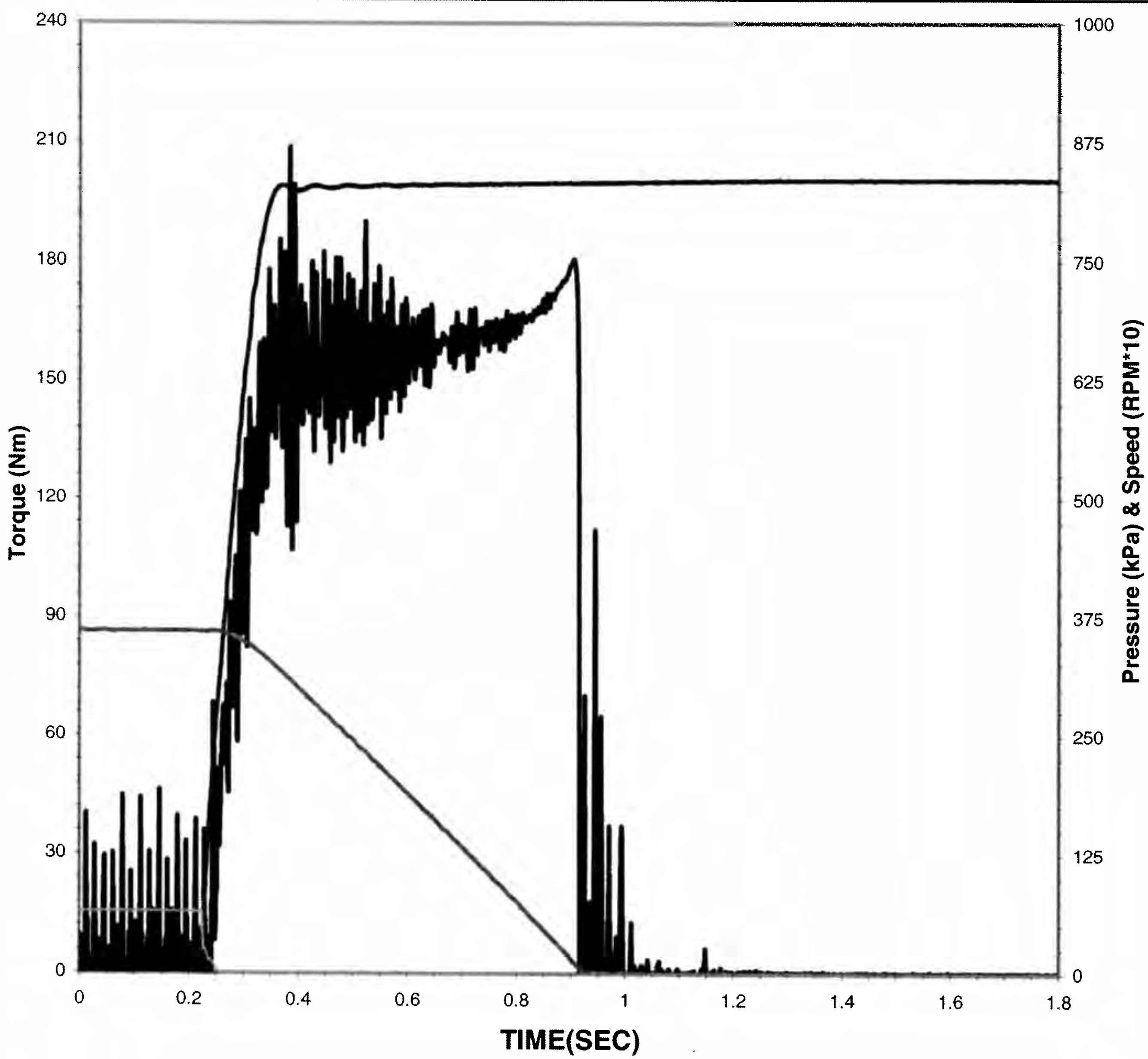
0.2 Sec Dyn:	70 N*m
Midpoint Dyn:	76 N*m
LwSpd Dynamic:	87 N*m

Coefficient of Friction

.2 Sec Dyn:	0.117
Midpoint Dyn:	0.125
LwSpd Dynamic:	0.145

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	0:43:45
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	1010
Temperature:	94.4 °C
	(112.7 ± 3.0 °C)
Apply Pressure:	828 kPa
	827 ± 7 KPa)
Apply Rate:	0.14 Sec
	(0.15 ± 0.02 Sec)
Energy:	18.5 KJ
	(18.71 ± 0.40 KJ)
Engage Time:	0.694 Sec

Torque

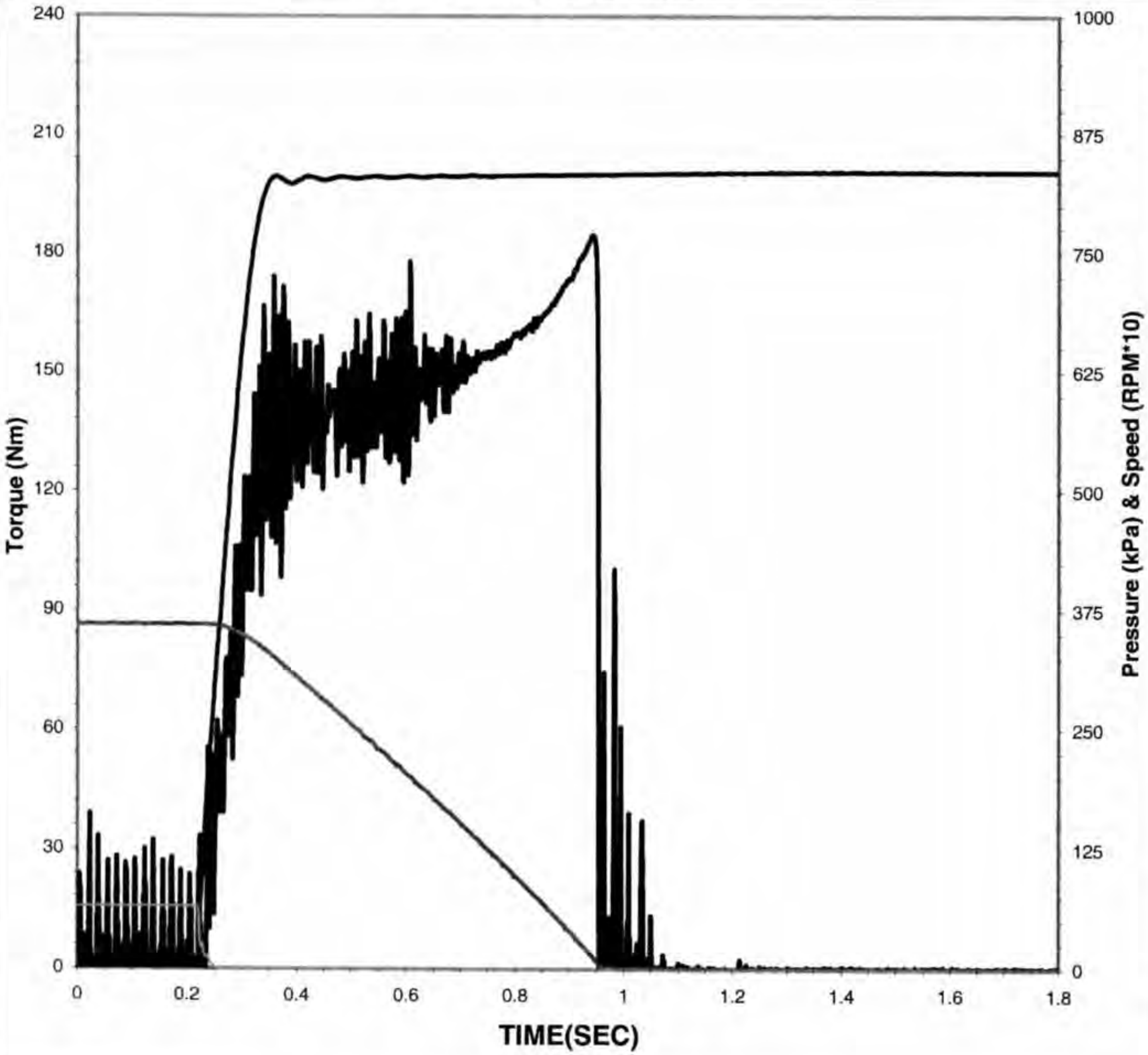
0.2 Sec Dyn:	155 N*m
Midpoint Dyn:	157 N*m
LwSpd Dynamic:	171 N*m

Coefficient of Friction

.2 Sec Dyn:	0.107
Midpoint Dyn:	0.109
LwSpd Dynamic:	0.118

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	2:46:00
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	1499
Temperature:	113.6 °C (112.7 ± 3.0 °C)
Apply Pressure:	830 kPa 827 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	18.5 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.735 Sec

Torque

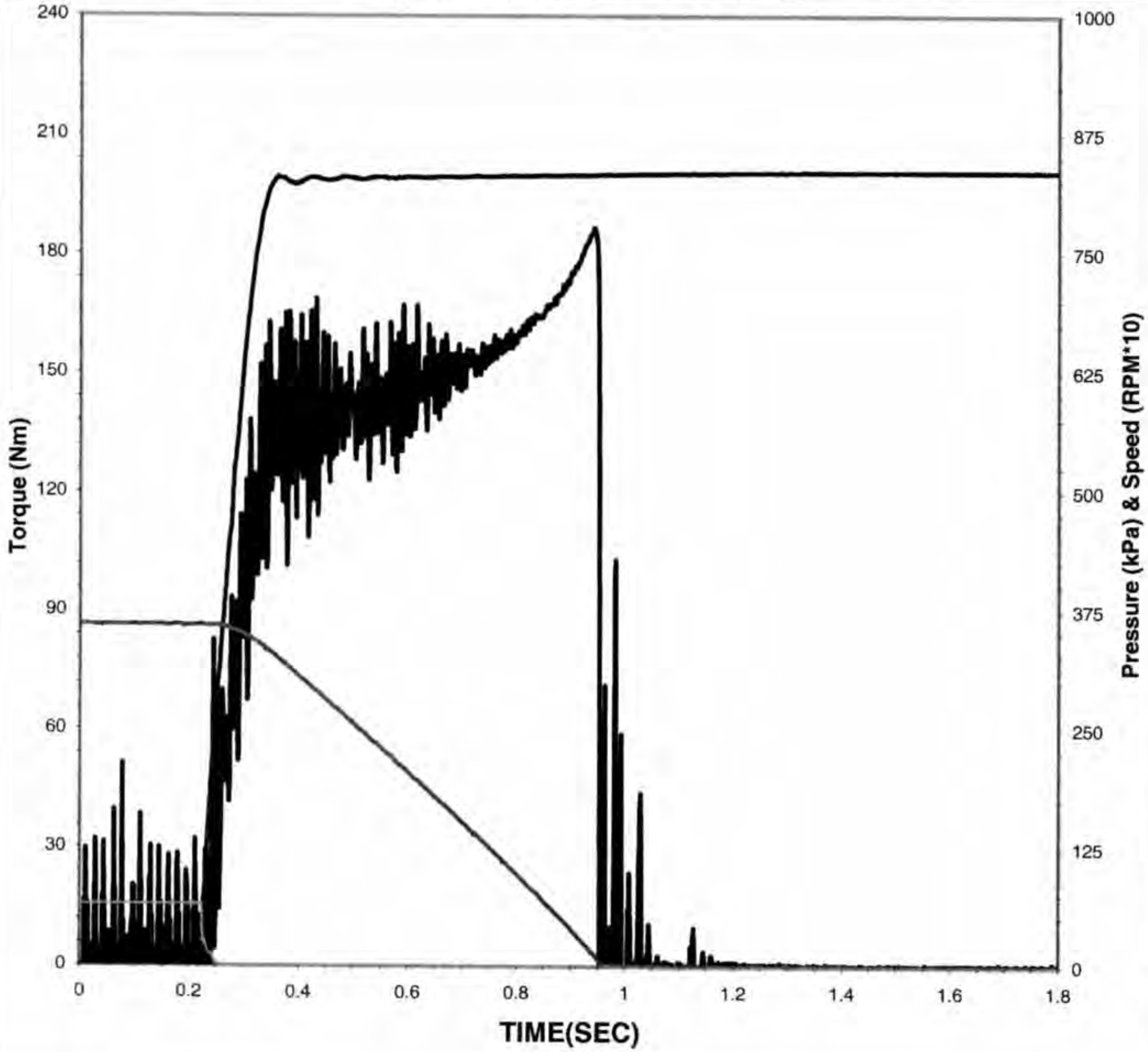
0.2 Sec Dyn:	142 N*m
Midpoint Dyn:	145 N*m
LwSpd Dynamic:	174 N*m

Coefficient of Friction

.2 Sec Dyn:	0.098
Midpoint Dyn:	0.100
LwSpd Dynamic:	0.121

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	2:46:15
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	1500
Temperature:	112.9 °C (112.7 ± 3.0 °C)
Apply Pressure:	829 kPa 827 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.4 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.732 Sec

Torque

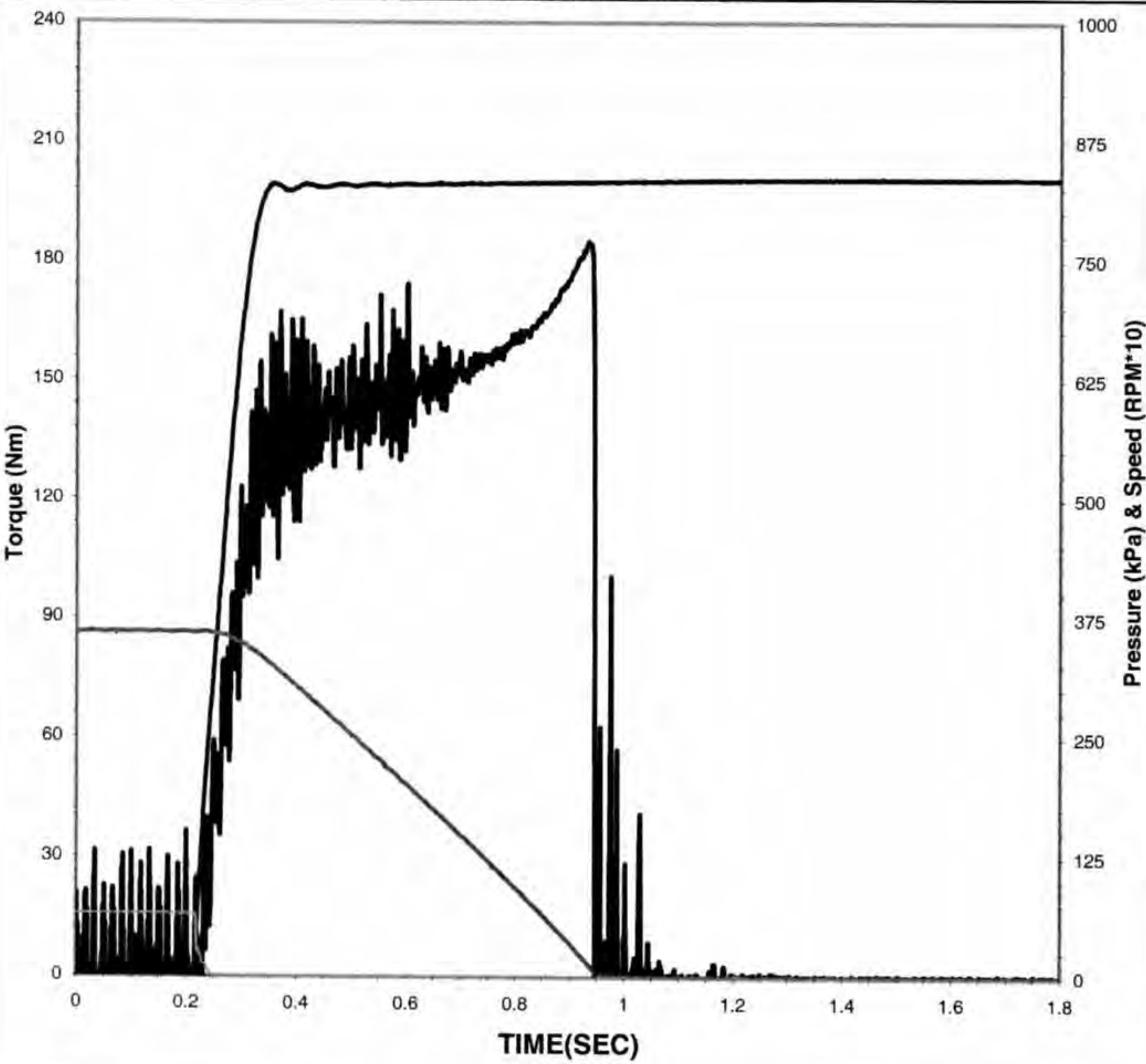
0.2 Sec Dyn:	139 N*m
Midpoint Dyn:	146 N*m
LwSpd Dynamic:	179 N*m

Coefficient of Friction

.2 Sec Dyn:	0.096
Midpoint Dyn:	0.101
LwSpd Dynamic:	0.124

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	2:46:42
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	1501
Temperature:	107.5 °C (112.7 ± 3.0 °C)
Apply Pressure:	829 kPa 827 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.5 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.731 Sec

Torque

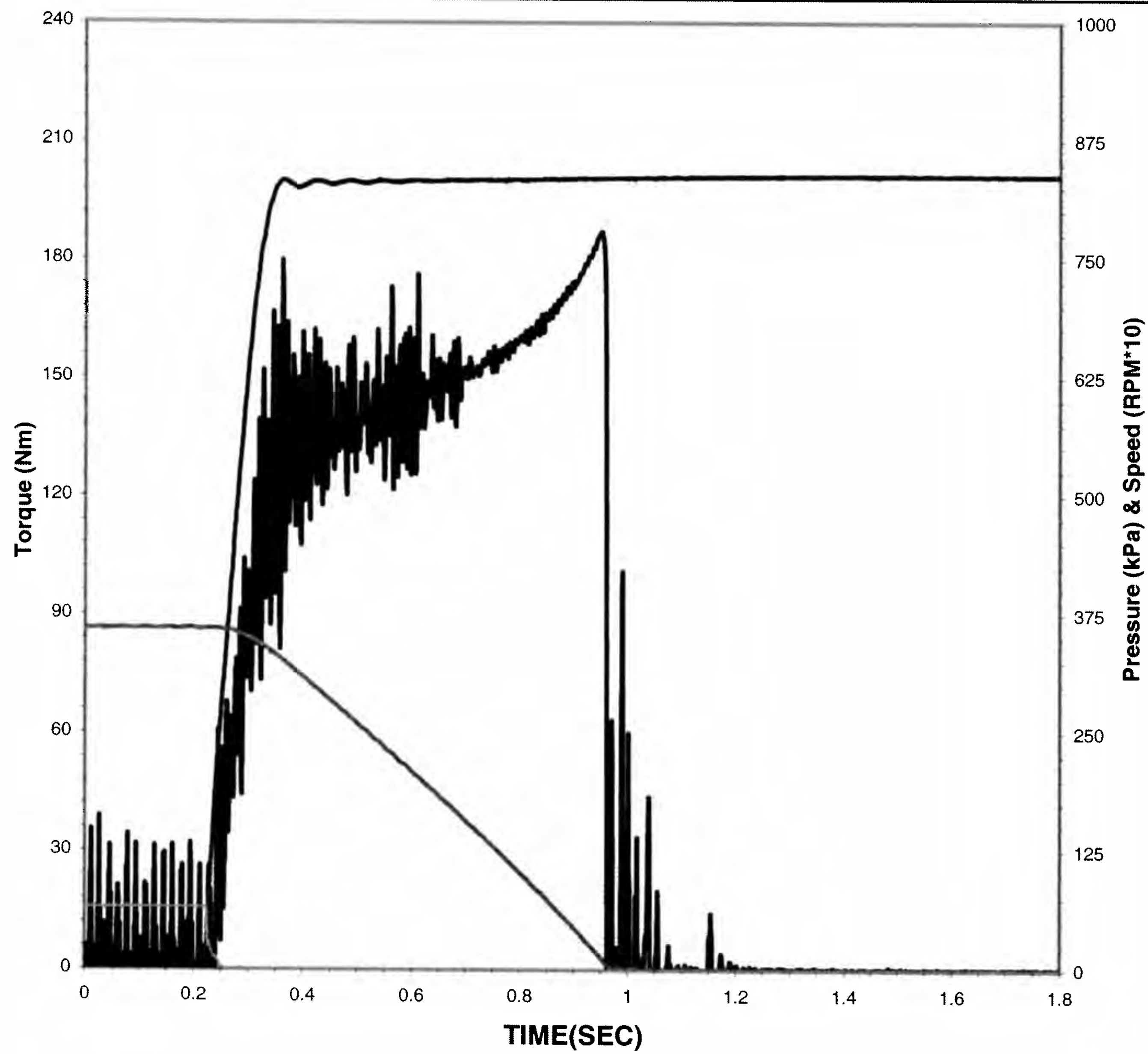
0.2 Sec Dyn:	141 N*m
Midpoint Dyn:	147 N*m
LwSpd Dynamic:	176 N*m

Coefficient of Friction

.2 Sec Dyn:	0.098
Midpoint Dyn:	0.102
LwSpd Dynamic:	0.121

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	**9/11/2007**
Time of Test:	**4:51:12**
Test Number:	**C4-2-1189**
Fluid Code:	**AL-27877-L**
Cycle Number:	**1999**
Temperature:	**112.6 °C** (112.7 ± 3.0 °C)
Apply Pressure:	**831 kPa** 827 ± 7 KPa)
Apply Rate:	**0.13 Sec** (0.15 ± 0.02 Sec)
Energy:	**18.5 KJ** (18.71 ± 0.40 KJ)
Engage Time:	**0.739 Sec**

Torque

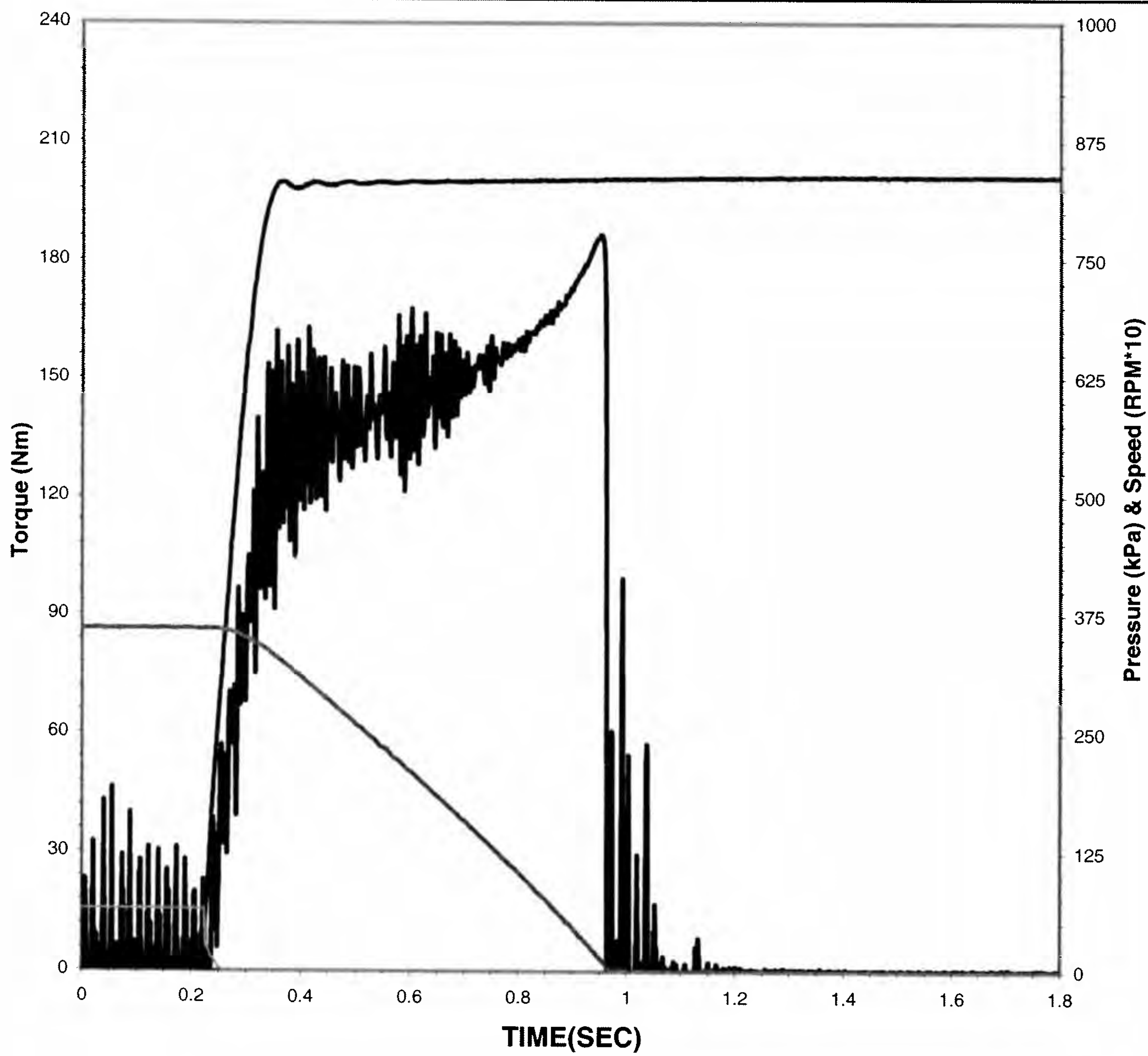
0.2 Sec Dyn:	**139 N*m**
Midpoint Dyn:	**145 N*m**
LwSpd Dynamic:	**178 N*m**

Coefficient of Friction

.2 Sec Dyn:	**0.096**
Midpoint Dyn:	**0.100**
LwSpd Dynamic:	**0.123**

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	4:51:27
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	2000
Temperature:	112.4 °C (112.7 ± 3.0 °C)
Apply Pressure:	831 kPa 827 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	18.5 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.741 Sec

Torque

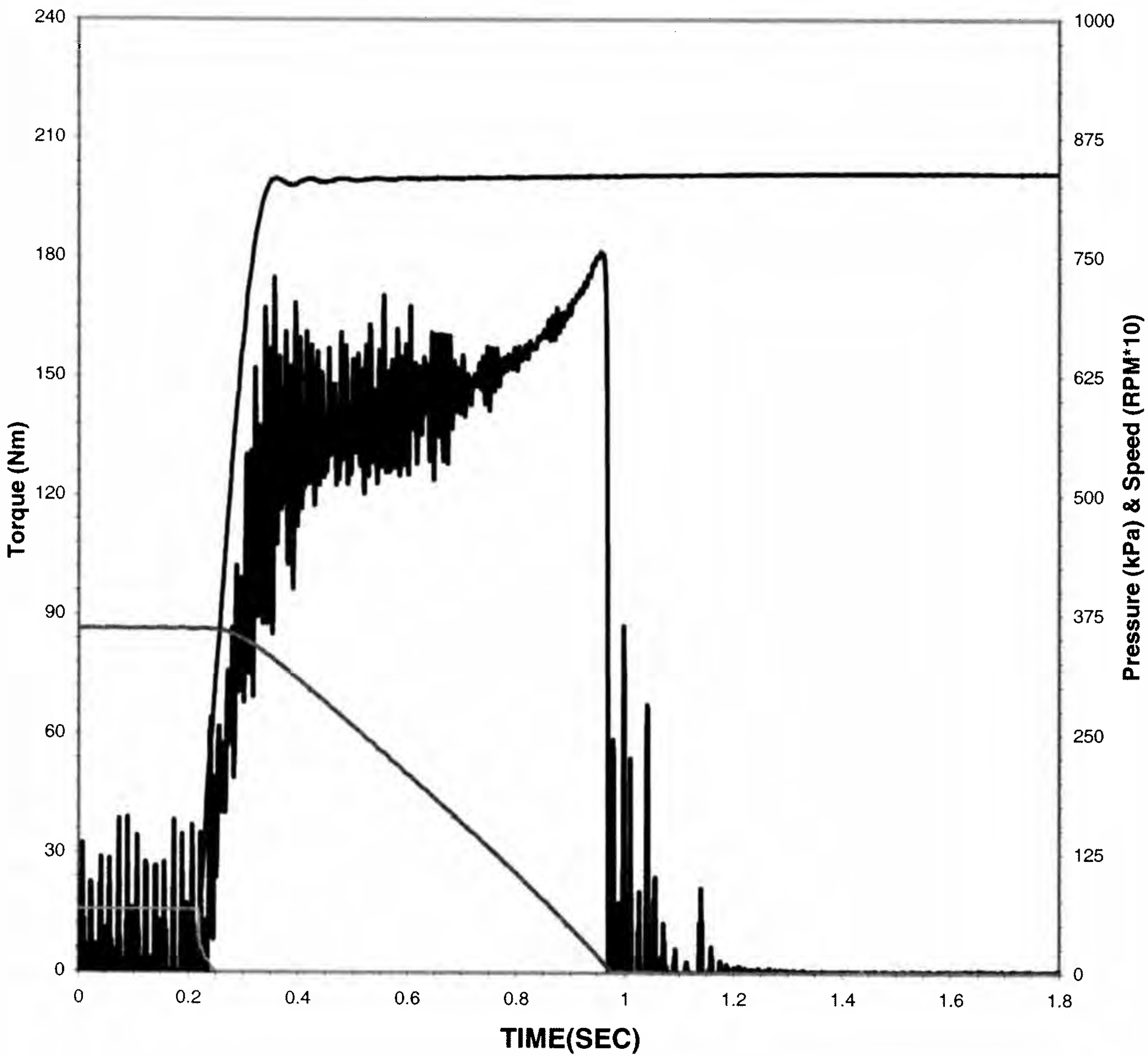
0.2 Sec Dyn:	134 N*m
Midpoint Dyn:	144 N*m
LwSpd Dynamic:	178 N*m

Coefficient of Friction

.2 Sec Dyn:	0.092
Midpoint Dyn:	0.100
LwSpd Dynamic:	0.123

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	4:51:54
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	2001
Temperature:	108.6 °C (112.7 ± 3.0 °C)
Apply Pressure:	831 kPa 827 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.5 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.752 Sec

Torque

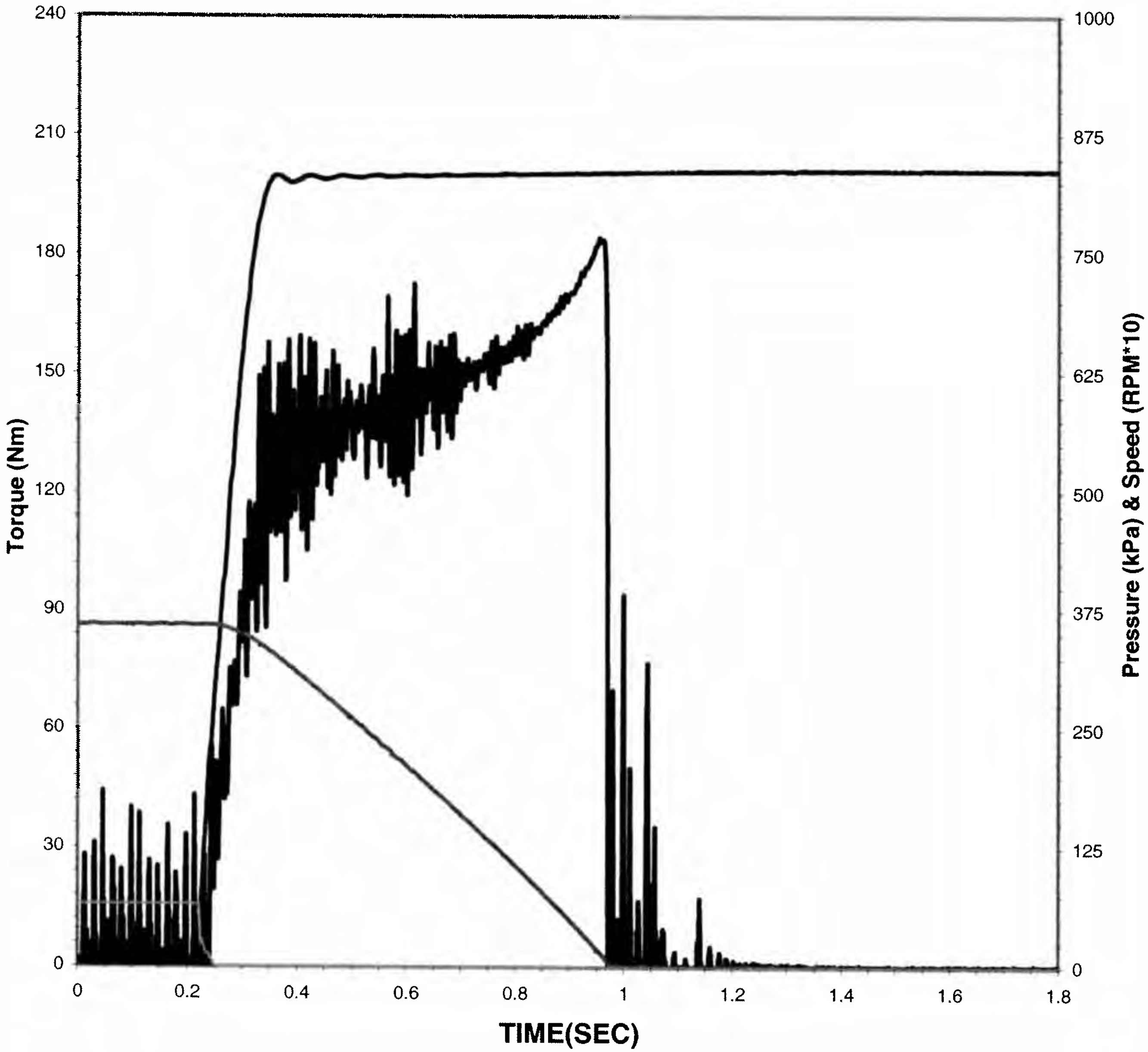
0.2 Sec Dyn:	138 N*m
Midpoint Dyn:	143 N*m
LwSpd Dynamic:	171 N*m

Coefficient of Friction

.2 Sec Dyn:	0.095
Midpoint Dyn:	0.099
LwSpd Dynamic:	0.118

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	6:56:24
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	2499
Temperature:	112.3 °C (112.7 ± 3.0 °C)
Apply Pressure:	832 kPa 827 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.4 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.75 Sec

Torque

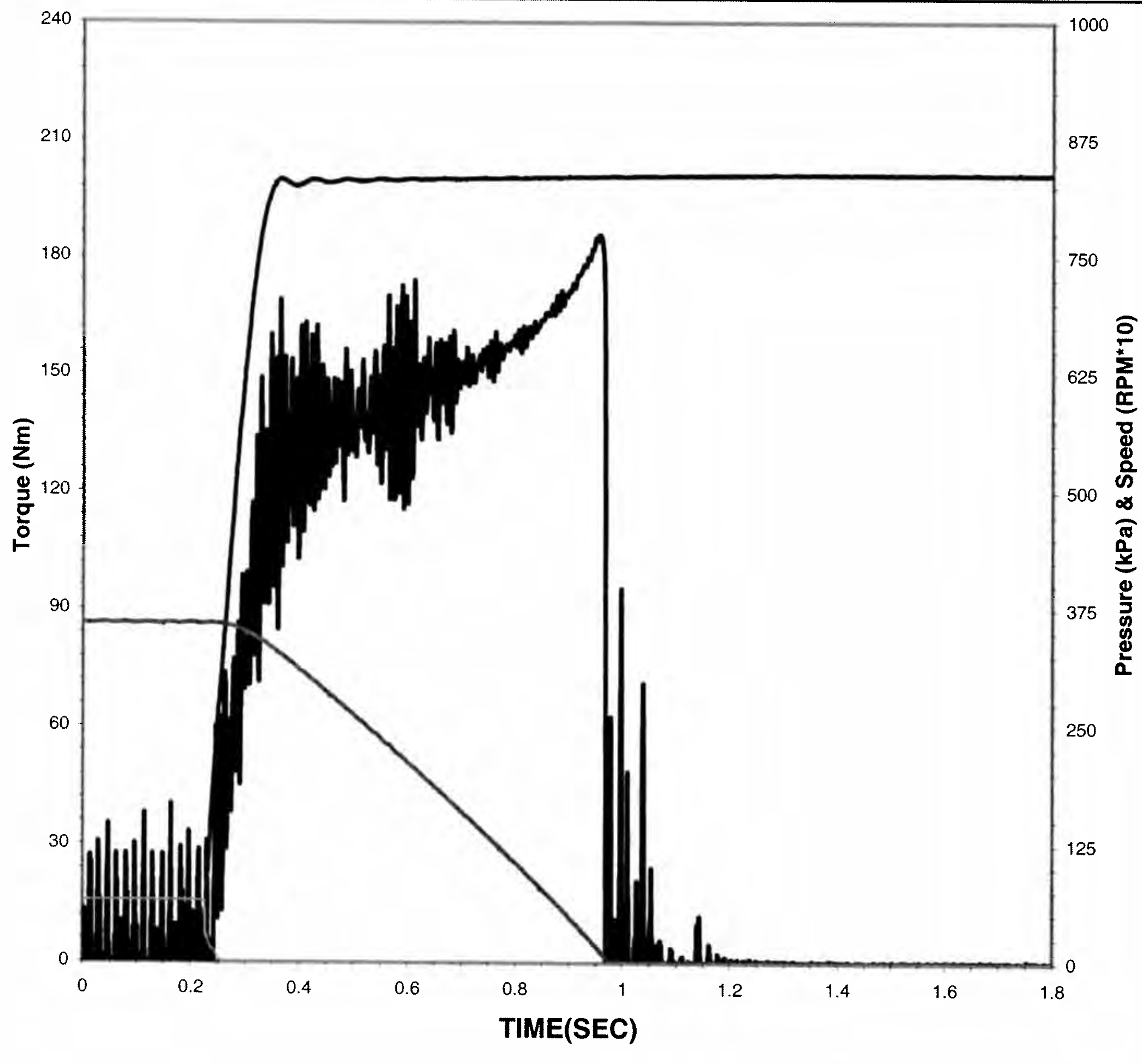
0.2 Sec Dyn:	132 N*m
Midpoint Dyn:	143 N*m
LwSpd Dynamic:	174 N*m

Coefficient of Friction

.2 Sec Dyn:	0.091
Midpoint Dyn:	0.099
LwSpd Dynamic:	0.120

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	6:56:39
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	2500
Temperature:	112.3 °C
	(112.7 ± 3.0 °C)
Apply Pressure:	832 kPa
	827 ± 7 KPa)
Apply Rate:	0.13 Sec
	(0.15 ± 0.02 Sec)
Energy:	18.5 KJ
	(18.71 ± 0.40 KJ)
Engage Time:	0.745 Sec

Torque

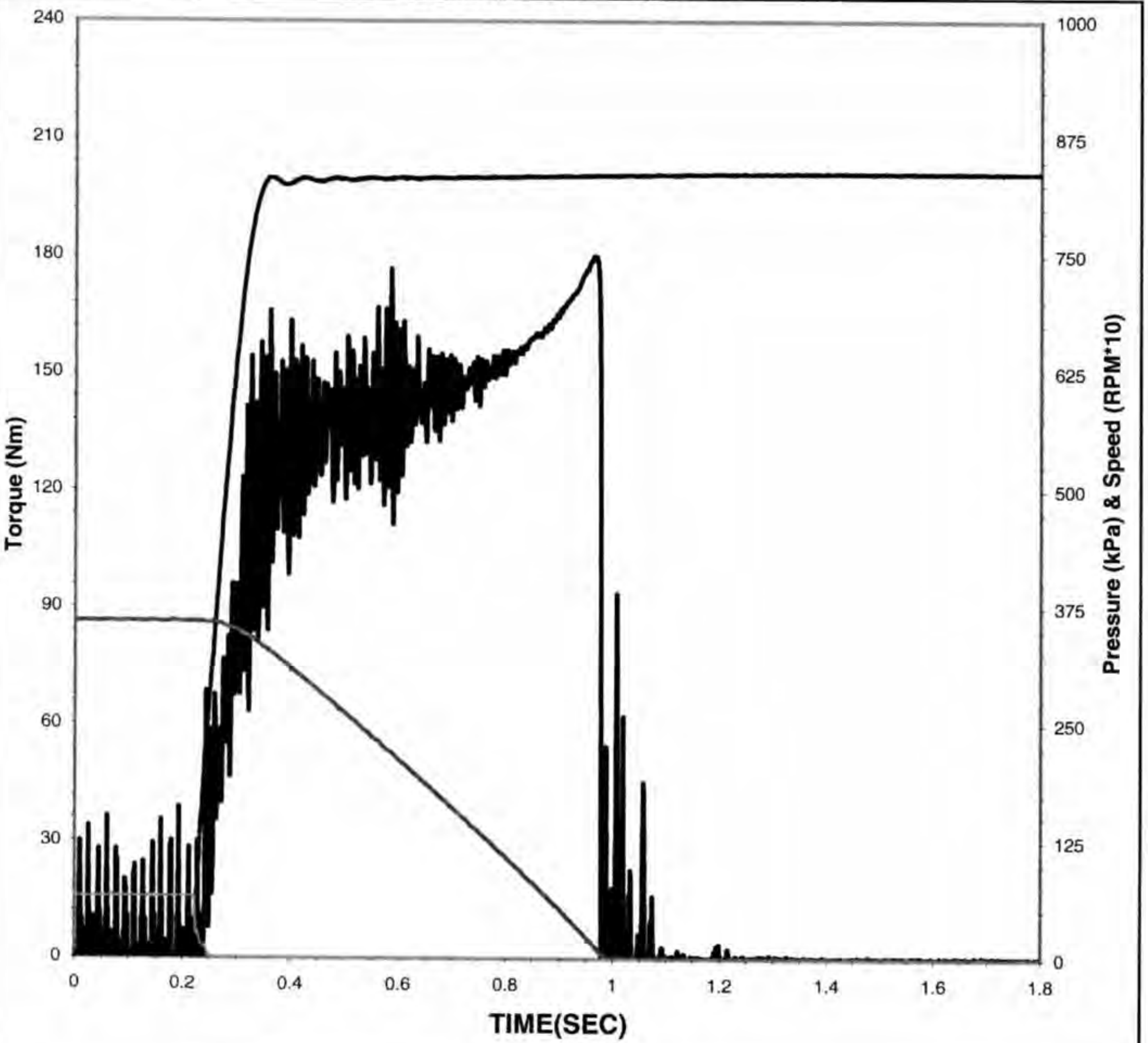
0.2 Sec Dyn:	136 N*m
Midpoint Dyn:	144 N*m
LwSpd Dynamic:	177 N*m

Coefficient of Friction

.2 Sec Dyn:	0.094
Midpoint Dyn:	0.099
LwSpd Dynamic:	0.122

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	6:57:06
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	2501
Temperature:	109.5 °C (112.7 ± 3.0 °C)
Apply Pressure:	832 kPa 827 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.4 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.758 Sec

Torque

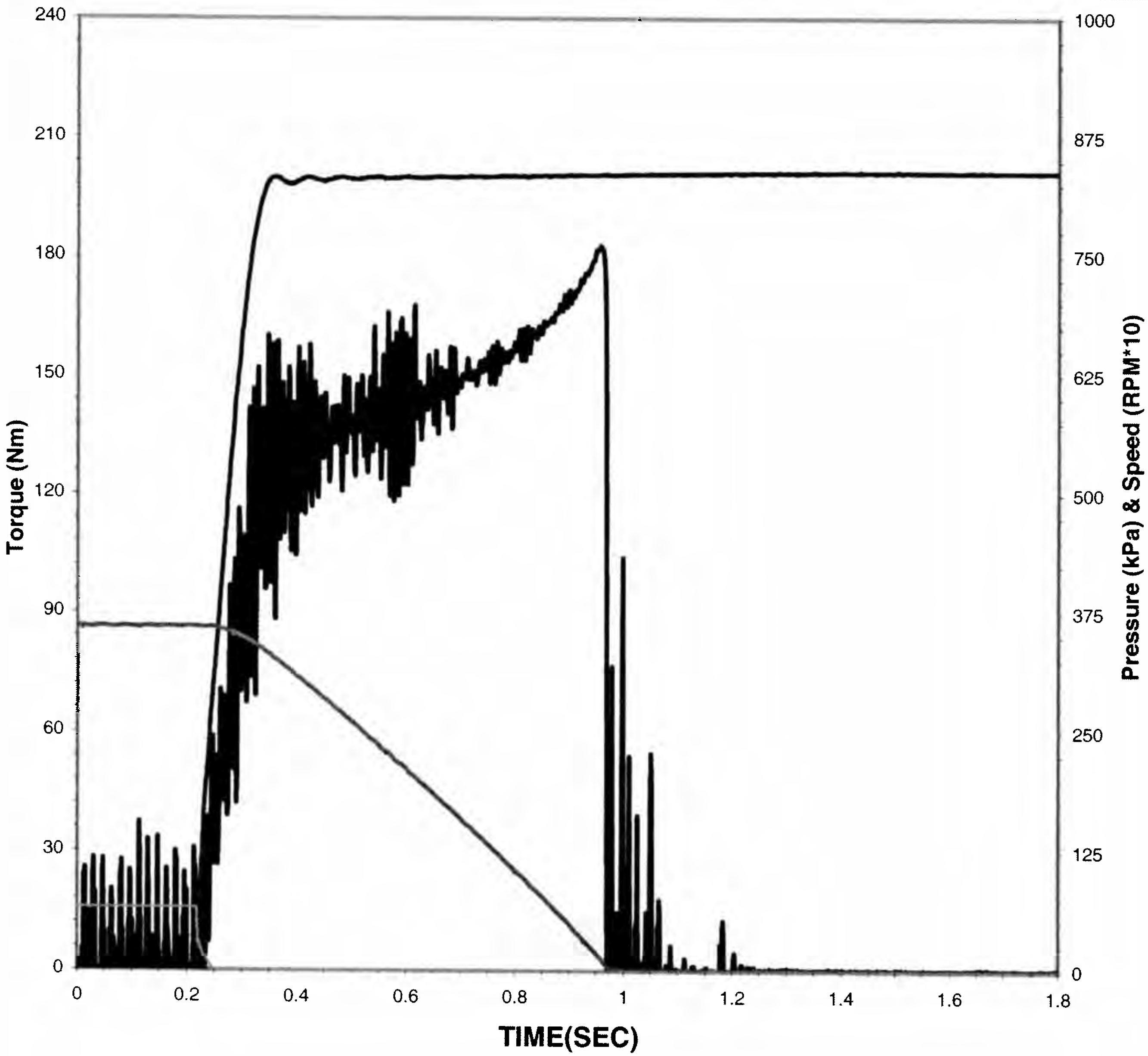
0.2 Sec Dyn:	135 N*m
Midpoint Dyn:	143 N*m
LwSpd Dynamic:	169 N*m

Coefficient of Friction

.2 Sec Dyn:	0.093
Midpoint Dyn:	0.098
LwSpd Dynamic:	0.117

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	9:01:36
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	2999
Temperature:	113.8 °C
	(112.7 ± 3.0 °C)
Apply Pressure:	831 kPa
	827 ± 7 KPa)
Apply Rate:	0.13 Sec
	(0.15 ± 0.02 Sec)
Energy:	18.4 KJ
	(18.71 ± 0.40 KJ)
Engage Time:	0.753 Sec

Torque

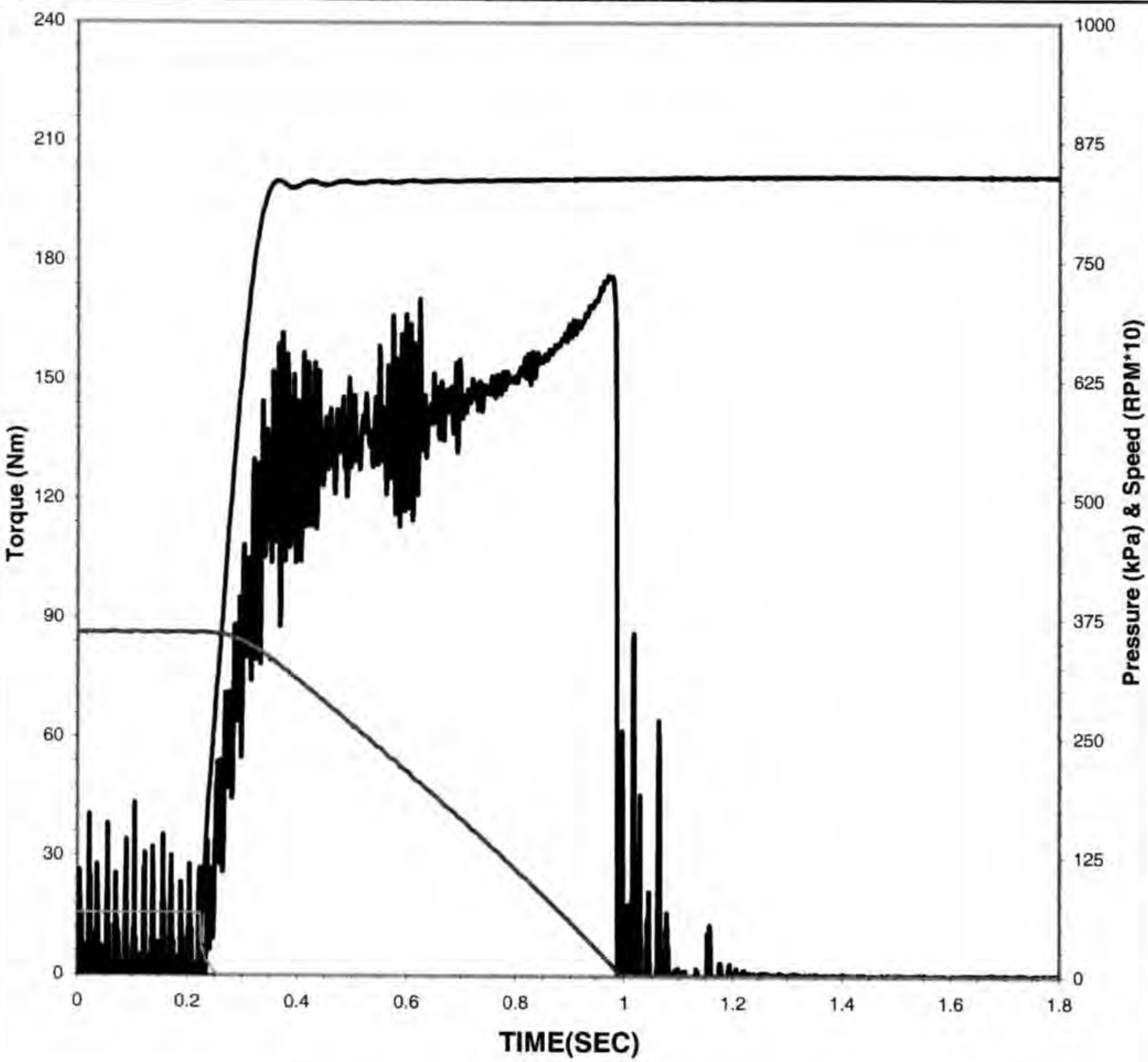
0.2 Sec Dyn:	134 N*m
Midpoint Dyn:	142 N*m
LwSpd Dynamic:	173 N*m

Coefficient of Friction

.2 Sec Dyn:	0.092
Midpoint Dyn:	0.098
LwSpd Dynamic:	0.119

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	9:01:51
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	3000
Temperature:	113.4 °C (112.7 ± 3.0 °C)
Apply Pressure:	832 kPa 827 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.4 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.765 Sec

Torque

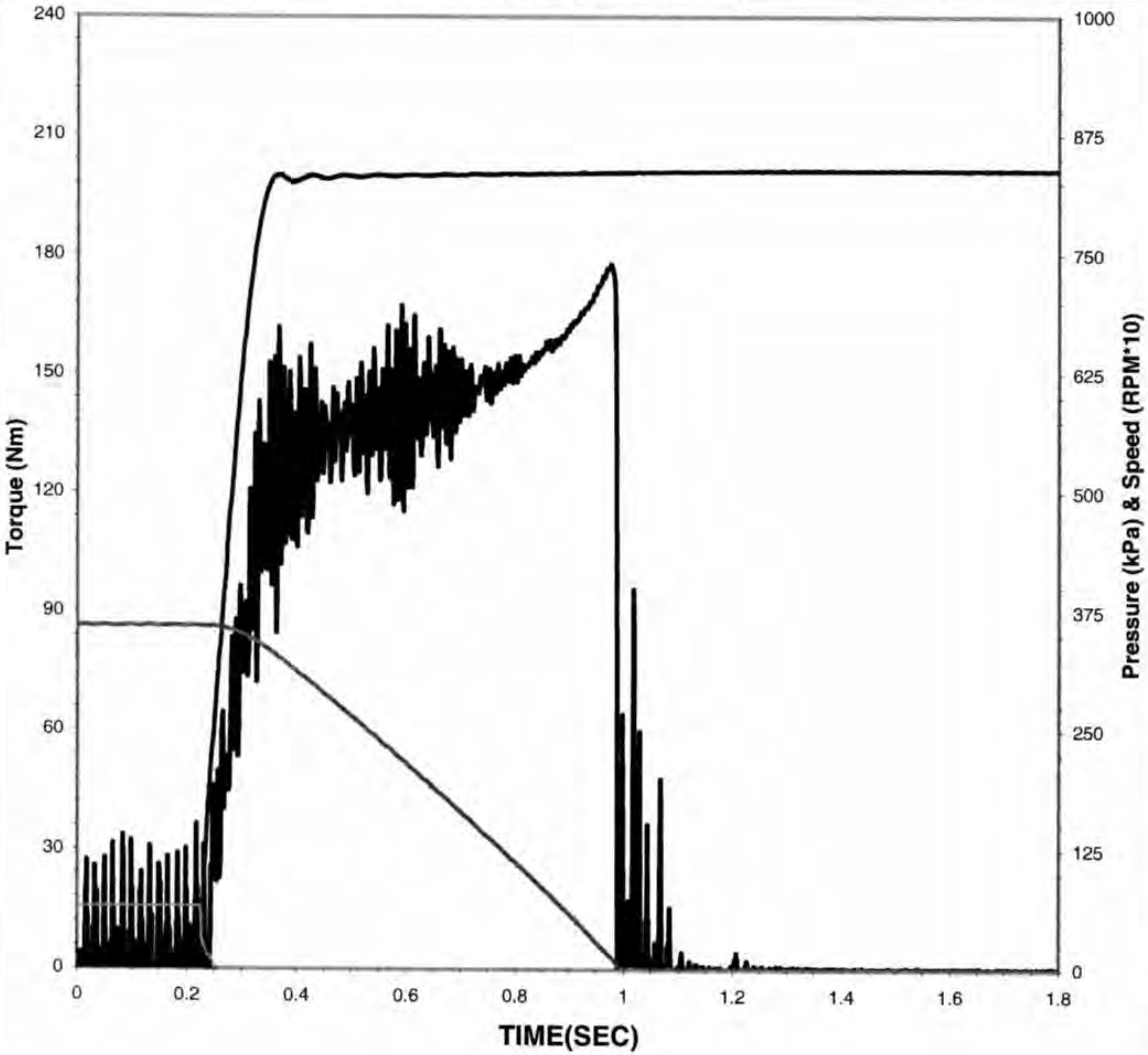
0.2 Sec Dyn:	132 N*m
Midpoint Dyn:	140 N*m
LwSpd Dynamic:	165 N*m

Coefficient of Friction

.2 Sec Dyn:	0.091
Midpoint Dyn:	0.097
LwSpd Dynamic:	0.114

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	9:02:18
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	3001
Temperature:	109.3 °C (112.7 ± 3.0 °C)
Apply Pressure:	832 kPa 827 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	18.5 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.765 Sec

Torque

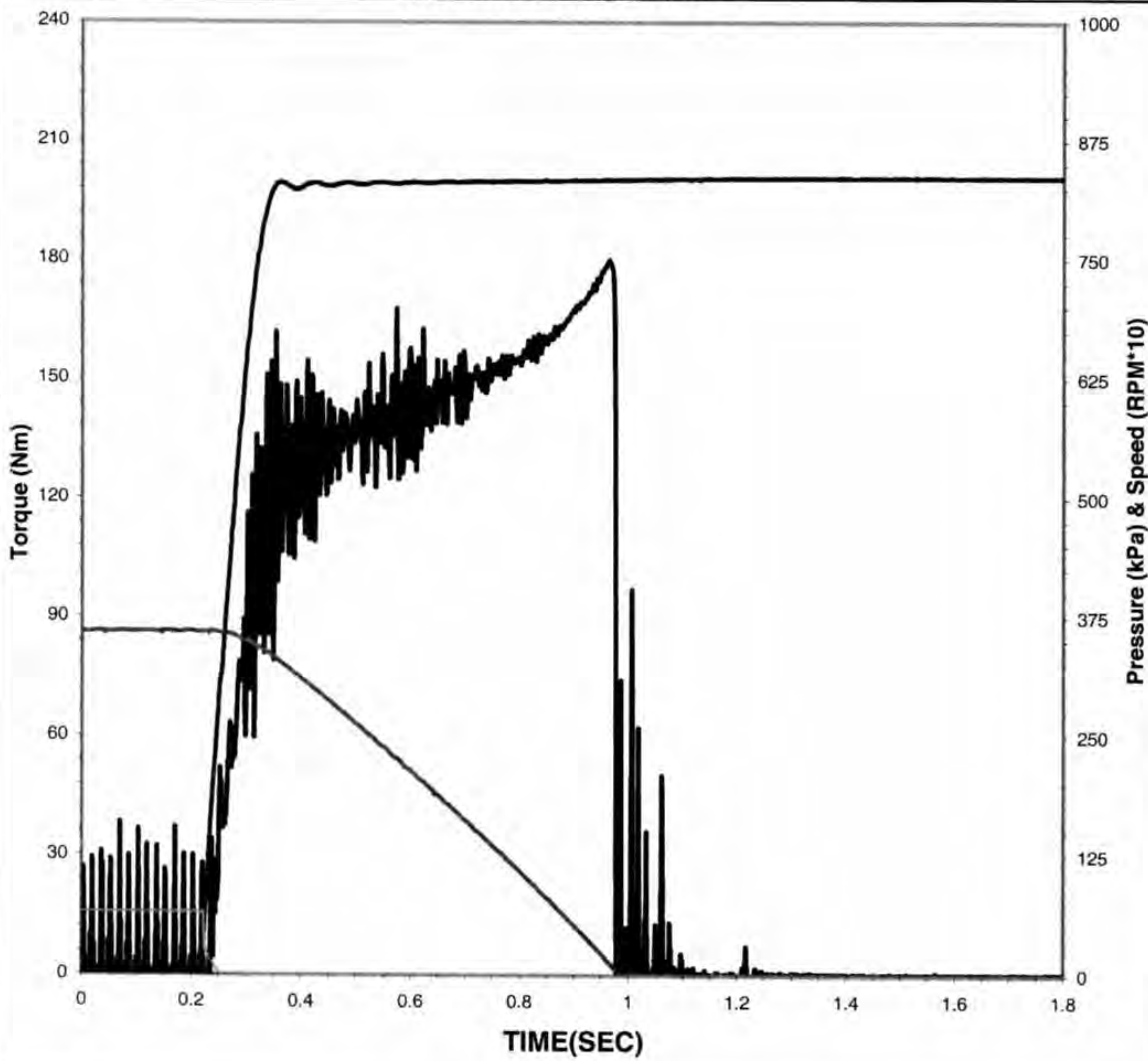
0.2 Sec Dyn:	131 N*m
Midpoint Dyn:	142 N*m
LwSpd Dynamic:	170 N*m

Coefficient of Friction

.2 Sec Dyn:	0.090
Midpoint Dyn:	0.098
LwSpd Dynamic:	0.117

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	11:06:49
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	3499
Temperature:	112.5 °C (112.7 ± 3.0 °C)
Apply Pressure:	831 kPa 827 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.4 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.757 Sec

Torque

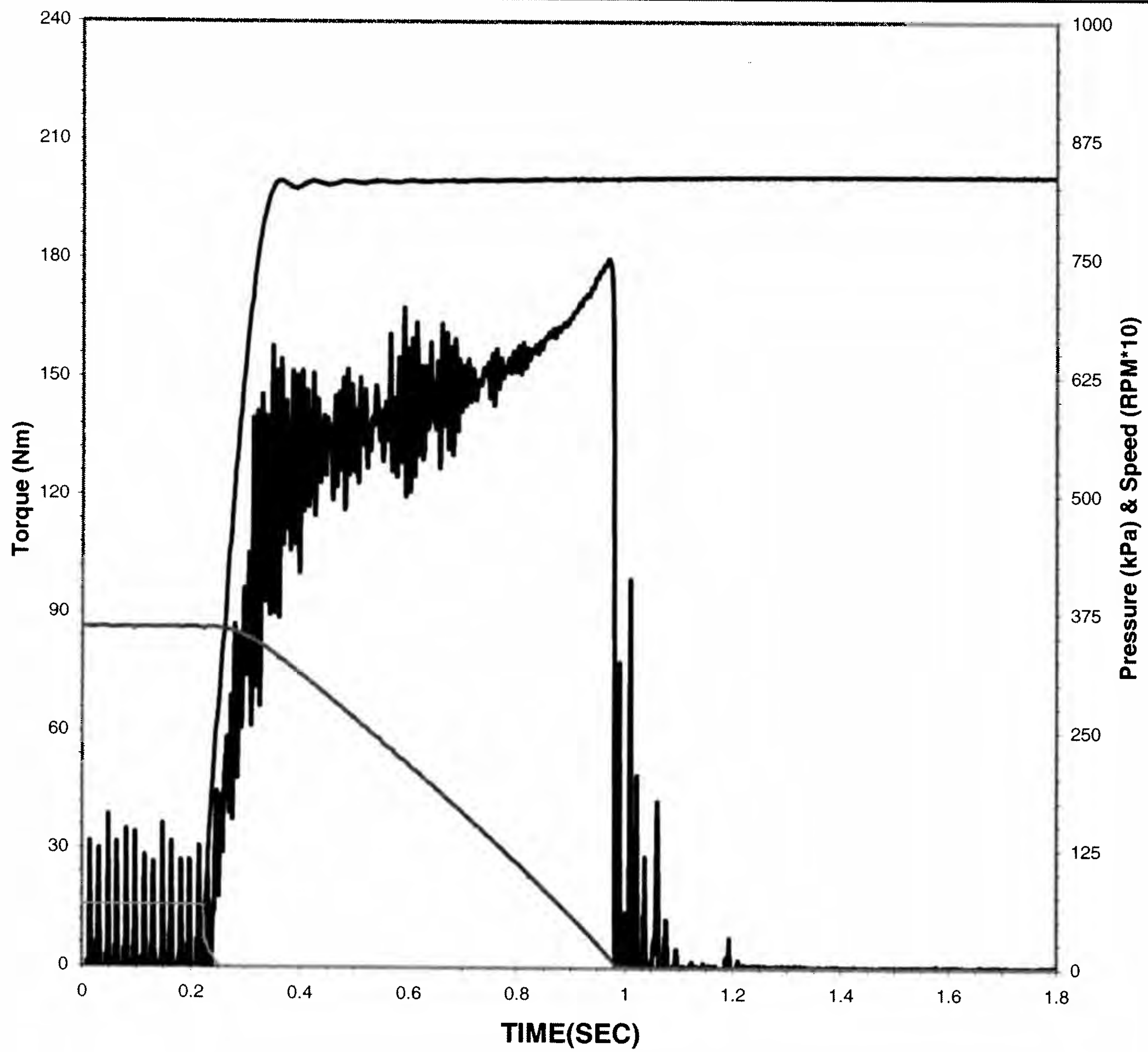
0.2 Sec Dyn:	130 N*m
Midpoint Dyn:	142 N*m
LwSpd Dynamic:	170 N*m

Coefficient of Friction

.2 Sec Dyn:	0.090
Midpoint Dyn:	0.098
LwSpd Dynamic:	0.117

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	11:07:04
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	3500
Temperature:	112.3 °C (112.7 ± 3.0 °C)
Apply Pressure:	832 kPa 827 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	18.4 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.76 Sec

Torque

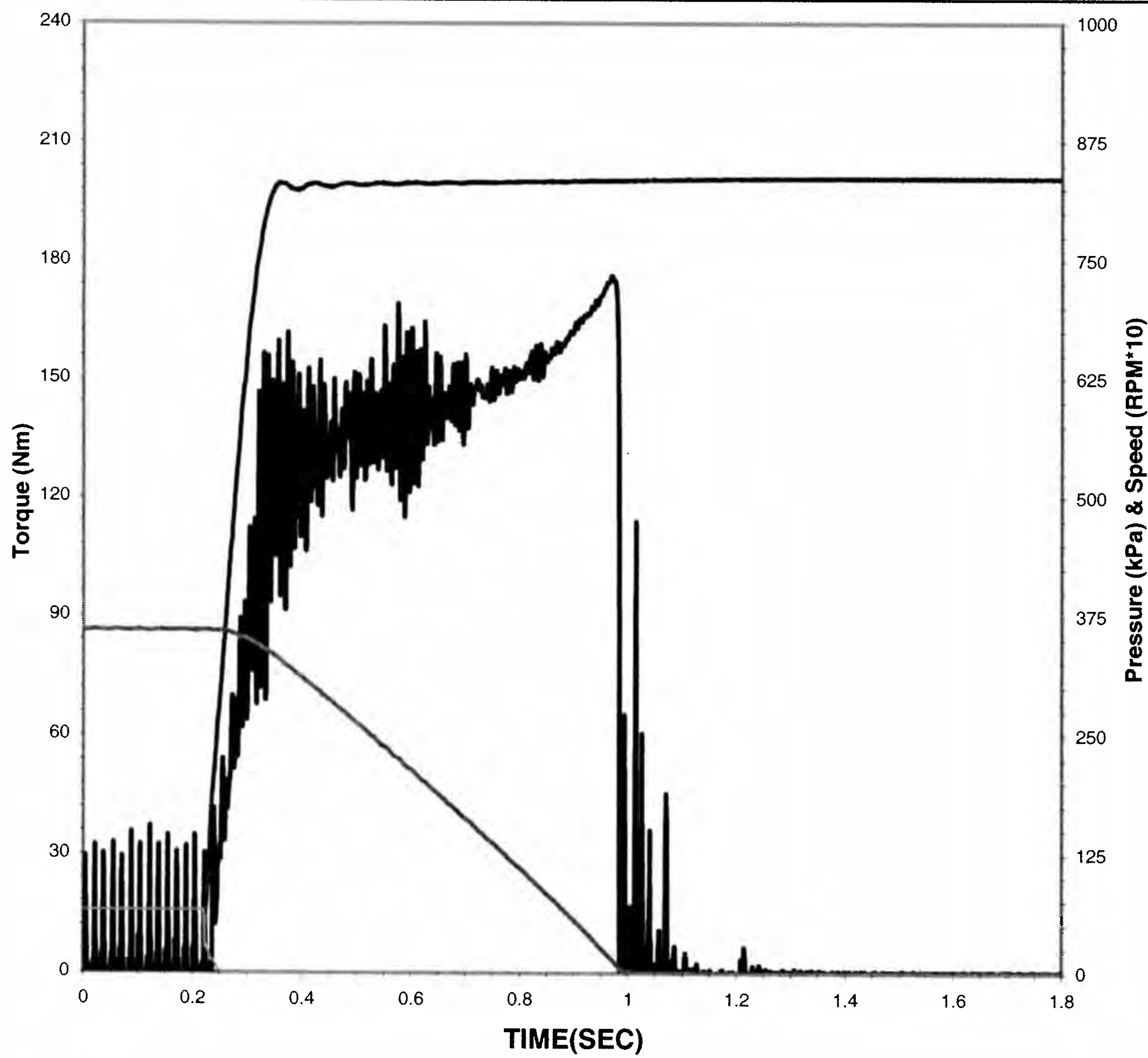
0.2 Sec Dyn:	129 N*m
Midpoint Dyn:	142 N*m
LwSpd Dynamic:	169 N*m

Coefficient of Friction

.2 Sec Dyn:	0.089
Midpoint Dyn:	0.098
LwSpd Dynamic:	0.117

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	11:07:30
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	3501
Temperature:	109.0 °C
	(112.7 ± 3.0 °C)
Apply Pressure:	832 kPa
	827 ± 7 KPa)
Apply Rate:	0.13 Sec
	(0.15 ± 0.02 Sec)
Energy:	18.4 KJ
	(18.71 ± 0.40 KJ)
Engage Time:	0.765 Sec

Torque

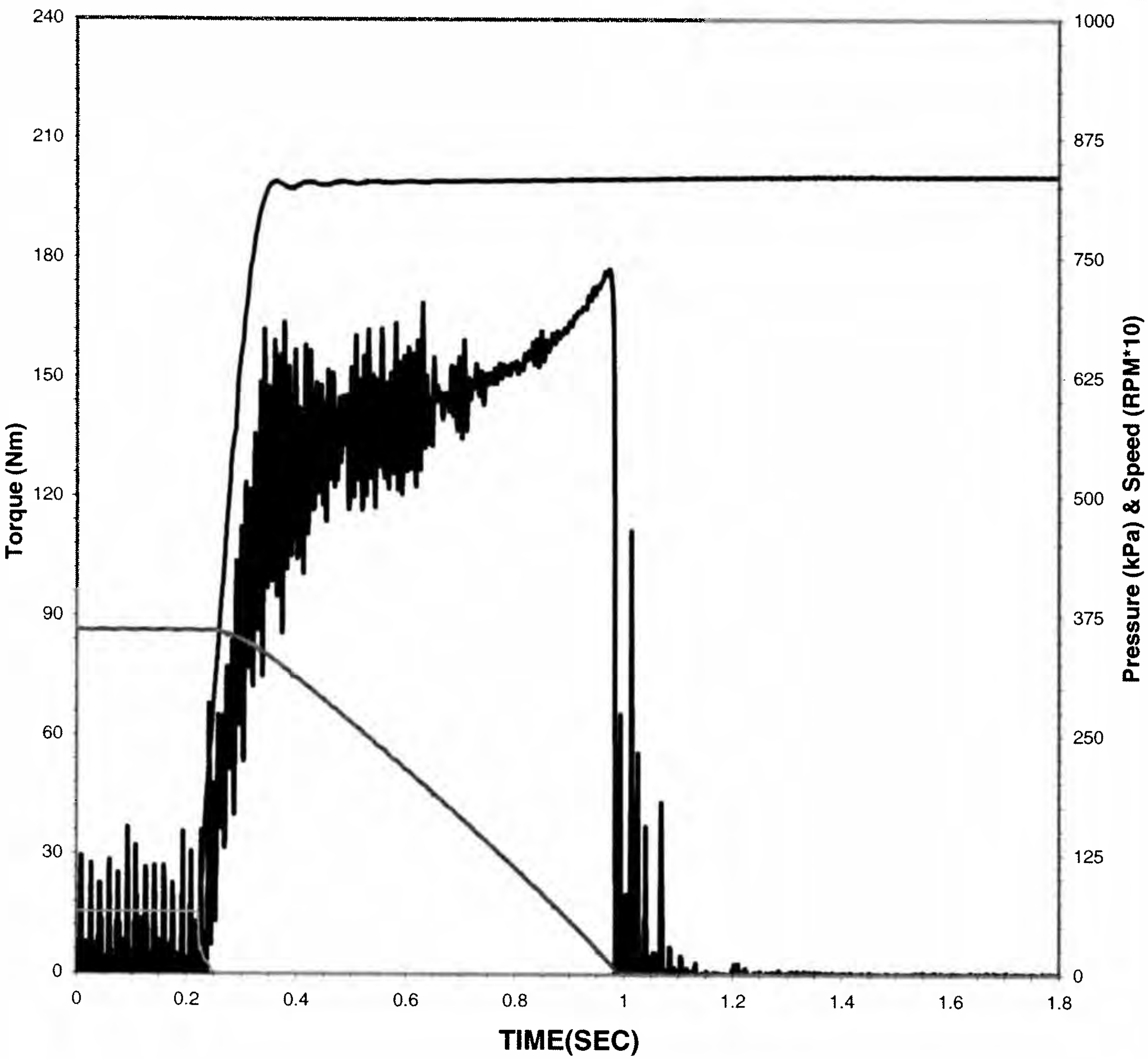
0.2 Sec Dyn:	130 N*m
Midpoint Dyn:	141 N*m
LwSpd Dynamic:	164 N*m

Coefficient of Friction

.2 Sec Dyn:	0.090
Midpoint Dyn:	0.097
LwSpd Dynamic:	0.113

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	13:12:01
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	3999
Temperature:	113.6 °C (112.7 ± 3.0 °C)
Apply Pressure:	830 kPa 827 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.5 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.764 Sec

Torque

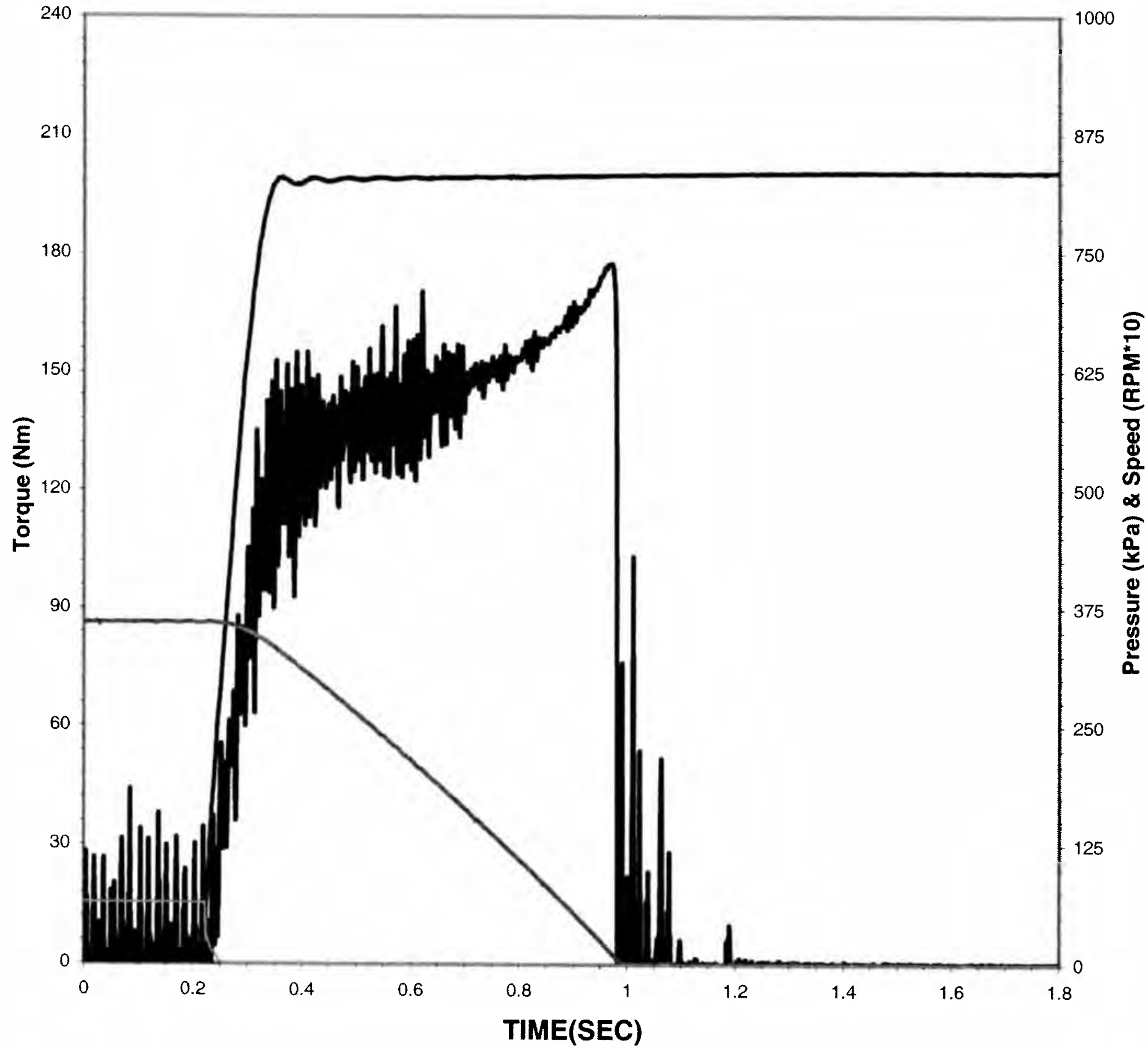
0.2 Sec Dyn:	133 N*m
Midpoint Dyn:	142 N*m
LwSpd Dynamic:	168 N*m

Coefficient of Friction

.2 Sec Dyn:	0.092
Midpoint Dyn:	0.098
LwSpd Dynamic:	0.116

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	13:12:16
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	4000
Temperature:	114.0 °C
	(112.7 ± 3.0 °C)
Apply Pressure:	829 kPa
	827 ± 7 KPa)
Apply Rate:	0.13 Sec
	(0.15 ± 0.02 Sec)
Energy:	18.4 KJ
	(18.71 ± 0.40 KJ)
Engage Time:	0.761 Sec

Torque

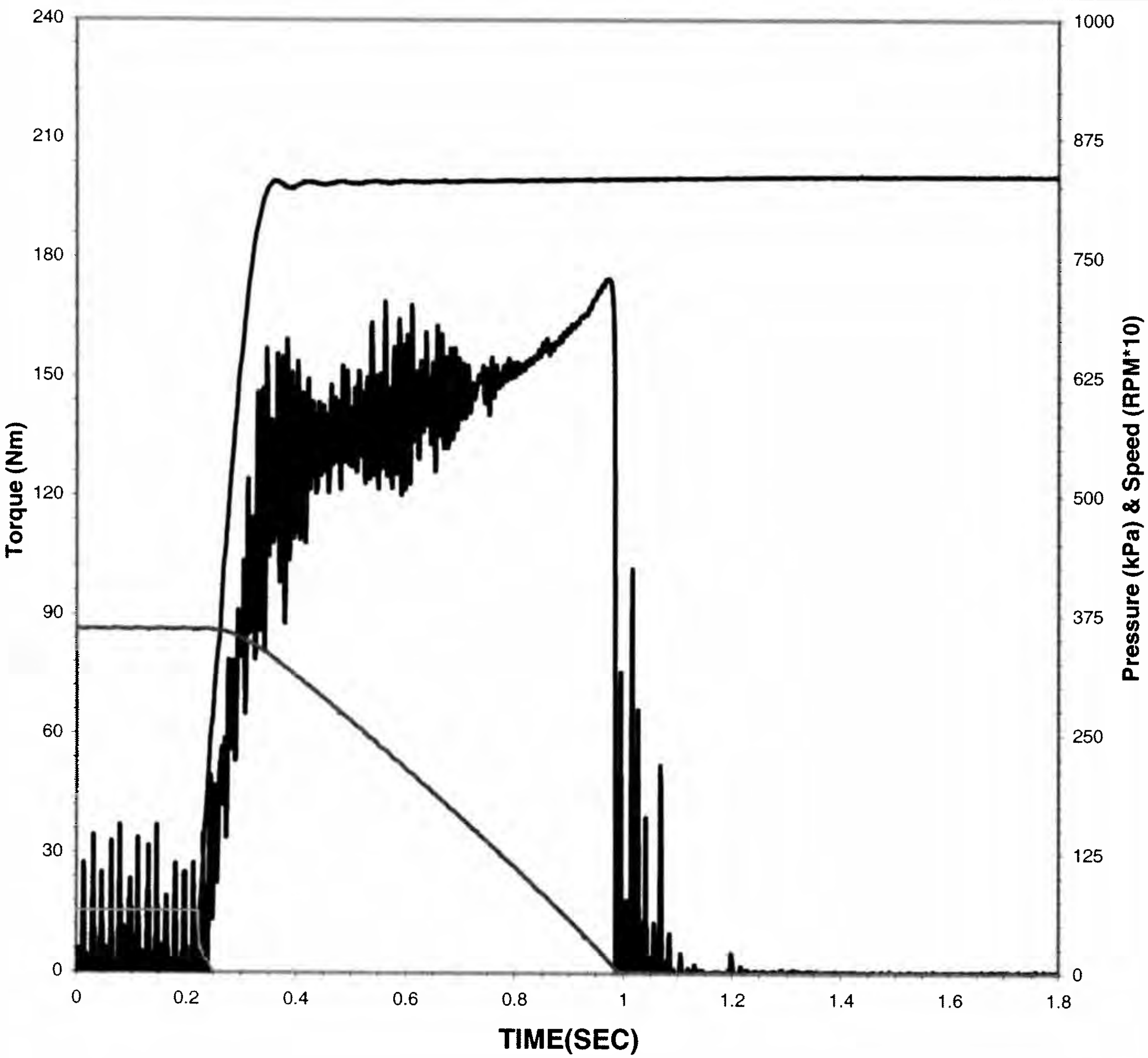
0.2 Sec Dyn:	131 N*m
Midpoint Dyn:	142 N*m
LwSpd Dynamic:	166 N*m

Coefficient of Friction

.2 Sec Dyn:	0.090
Midpoint Dyn:	0.098
LwSpd Dynamic:	0.115

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	13:12:42
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	4001
Temperature:	110.0 °C (112.7 ± 3.0 °C)
Apply Pressure:	830 kPa 827 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.4 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.765 Sec

Torque

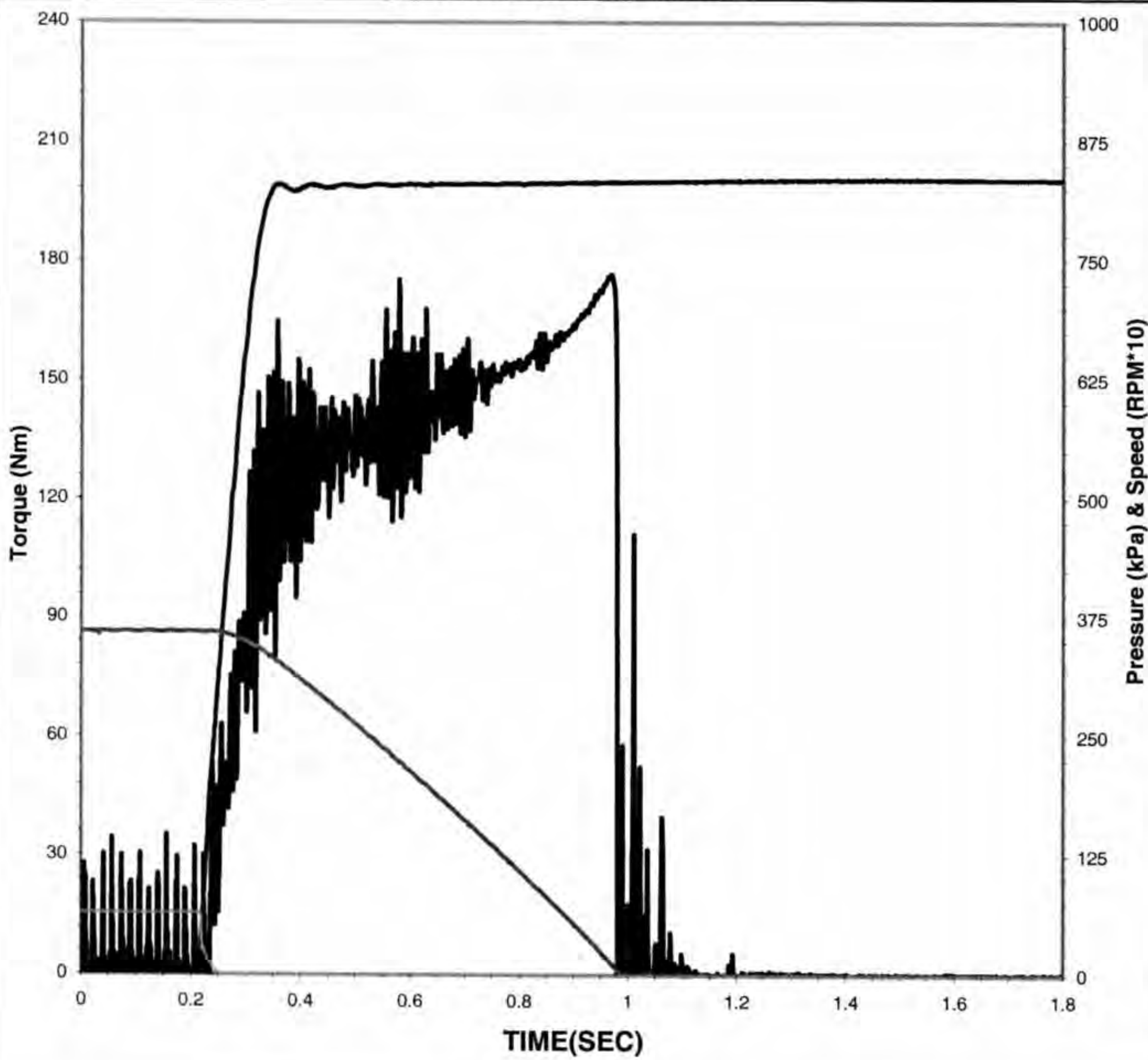
0.2 Sec Dyn:	129 N*m
Midpoint Dyn:	142 N*m
LwSpd Dynamic:	166 N*m

Coefficient of Friction

.2 Sec Dyn:	0.089
Midpoint Dyn:	0.098
LwSpd Dynamic:	0.115

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	15:17:13
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	4499
Temperature:	113.2 °C (112.7 ± 3.0 °C)
Apply Pressure:	829 kPa 827 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.5 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.763 Sec

Torque

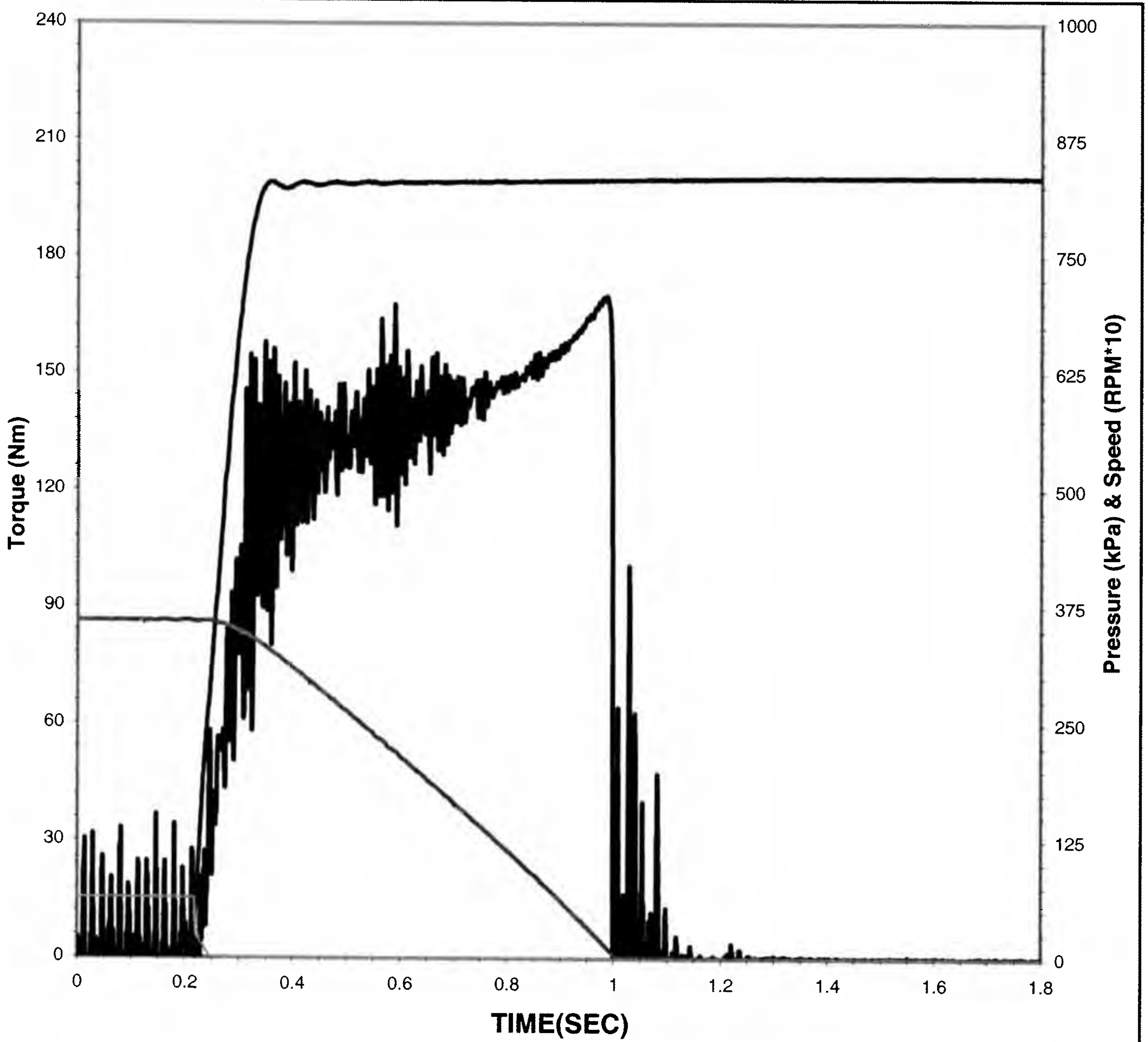
0.2 Sec Dyn:	131 N*m
Midpoint Dyn:	142 N*m
LwSpd Dynamic:	168 N*m

Coefficient of Friction

.2 Sec Dyn:	0.091
Midpoint Dyn:	0.098
LwSpd Dynamic:	0.116

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	15:17:28
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	4500
Temperature:	113.2 °C (112.7 ± 3.0 °C)
Apply Pressure:	829 kPa 827 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.4 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.782 Sec

Torque

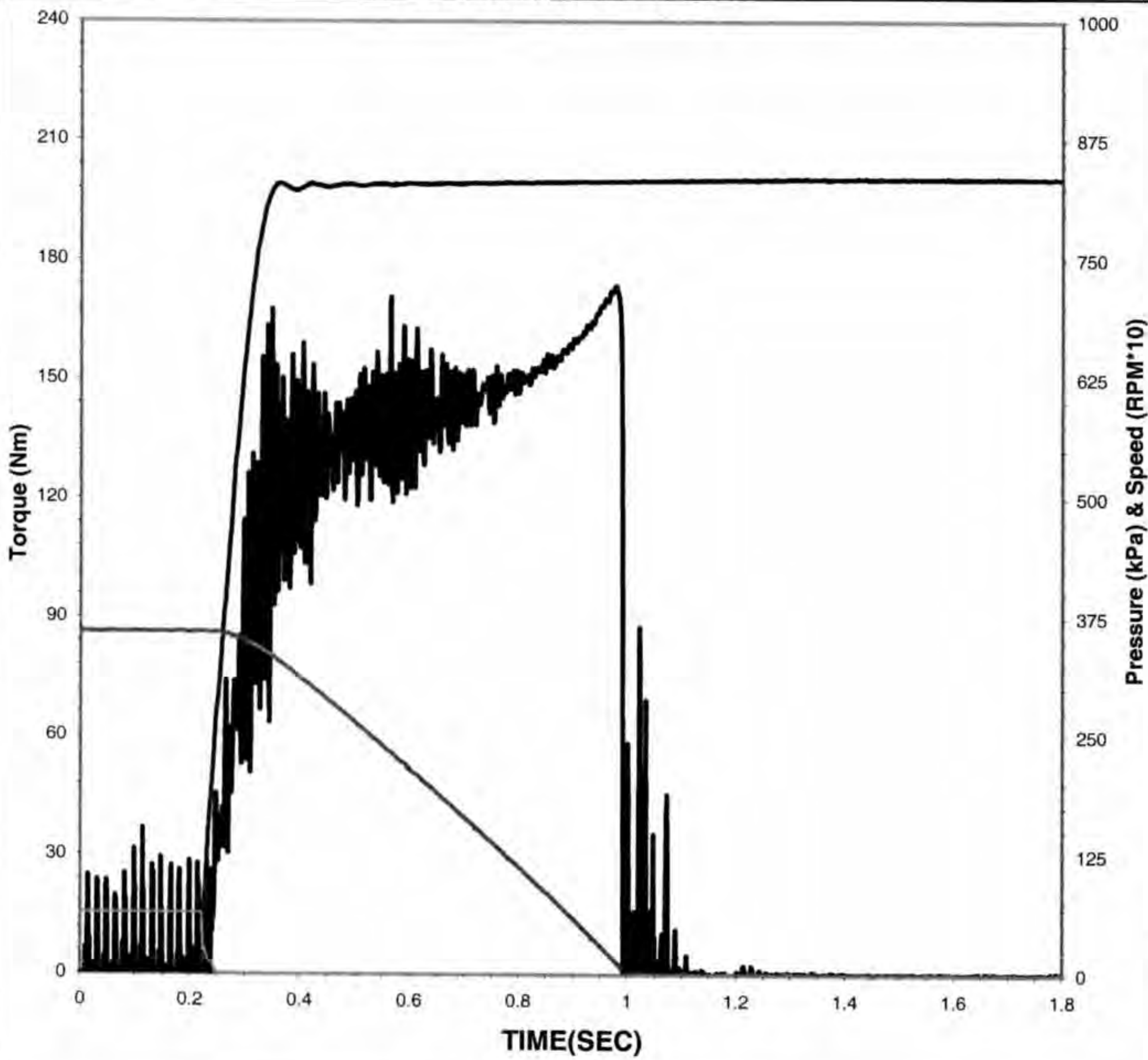
0.2 Sec Dyn:	129 N*m
Midpoint Dyn:	137 N*m
LwSpd Dynamic:	163 N*m

Coefficient of Friction

.2 Sec Dyn:	0.089
Midpoint Dyn:	0.095
LwSpd Dynamic:	0.112

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	15:17:54
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	4501
Temperature:	109.6 °C (112.7 ± 3.0 °C)
Apply Pressure:	829 kPa 827 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.4 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.772 Sec

Torque

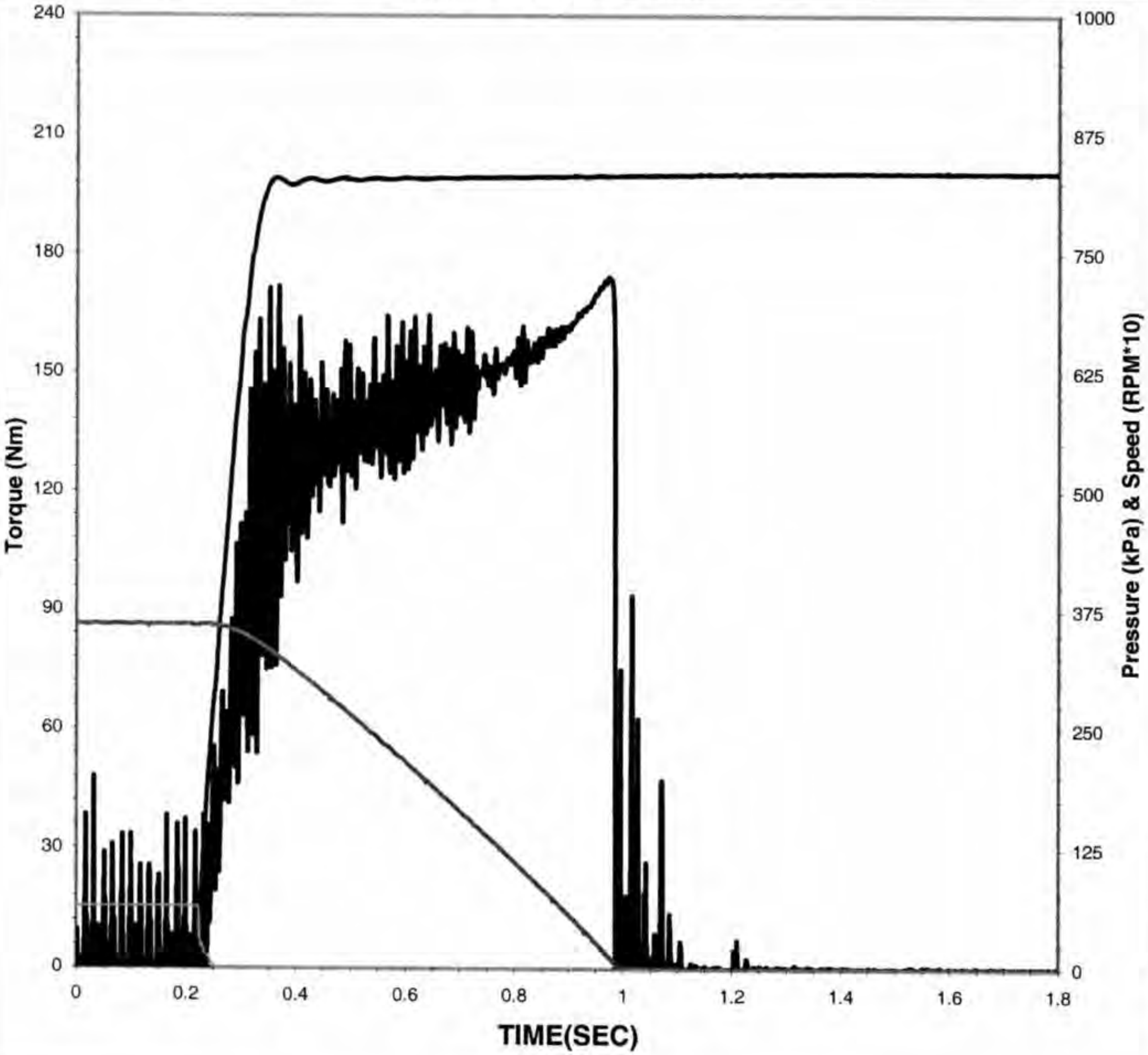
0.2 Sec Dyn:	128 N*m
Midpoint Dyn:	141 N*m
LwSpd Dynamic:	162 N*m

Coefficient of Friction

.2 Sec Dyn:	0.088
Midpoint Dyn:	0.097
LwSpd Dynamic:	0.112

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	17:22:25
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	4999
Temperature:	112.6 °C (112.7 ± 3.0 °C)
Apply Pressure:	829 kPa 827 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.4 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.765 Sec

Torque

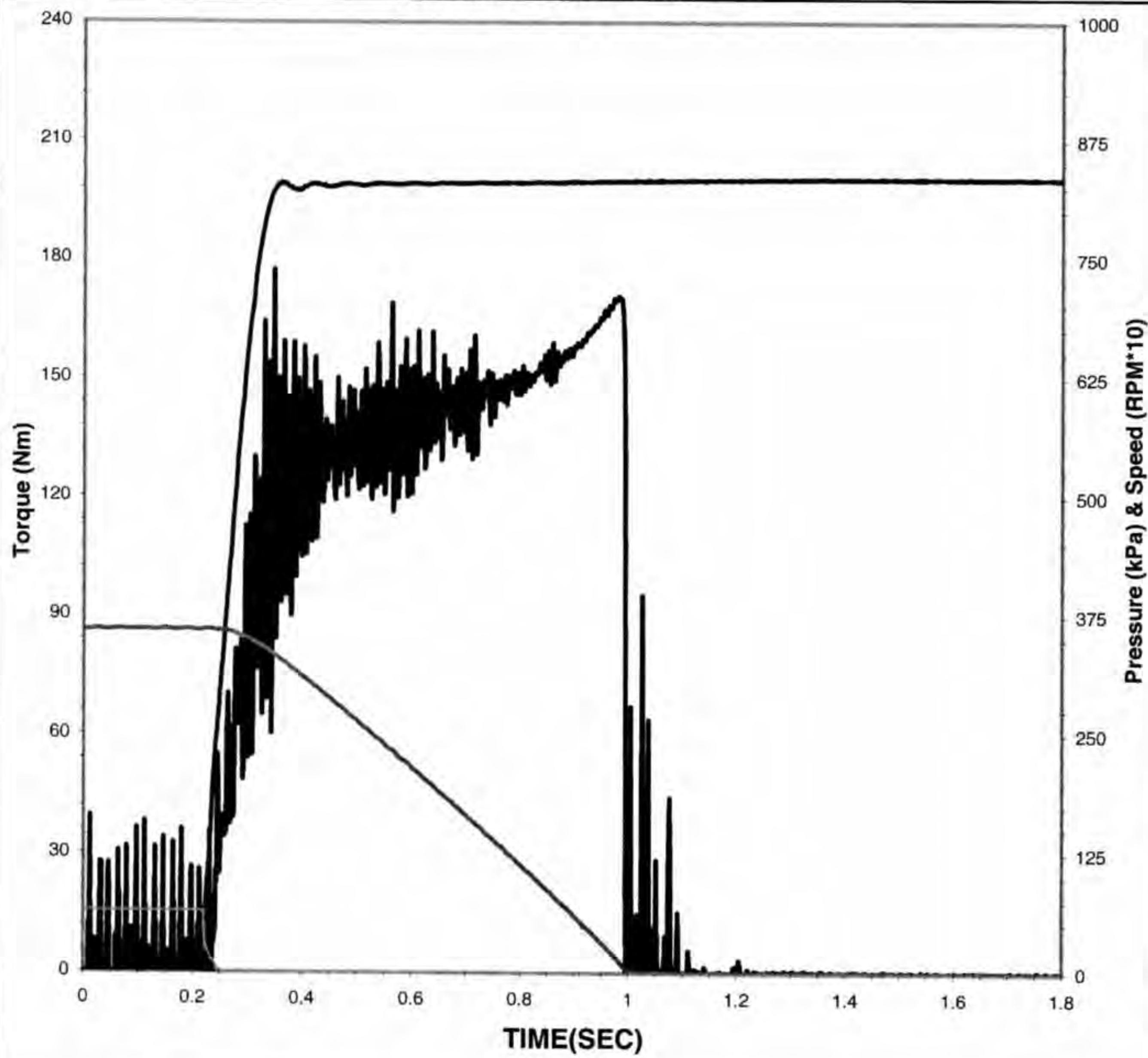
0.2 Sec Dyn:	129 N*m
Midpoint Dyn:	143 N*m
LwSpd Dynamic:	167 N*m

Coefficient of Friction

.2 Sec Dyn:	0.089
Midpoint Dyn:	0.099
LwSpd Dynamic:	0.116

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	17:22:40
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	5000
Temperature:	113.2 °C (112.7 ± 3.0 °C)
Apply Pressure:	829 kPa 827 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.5 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.777 Sec

Torque

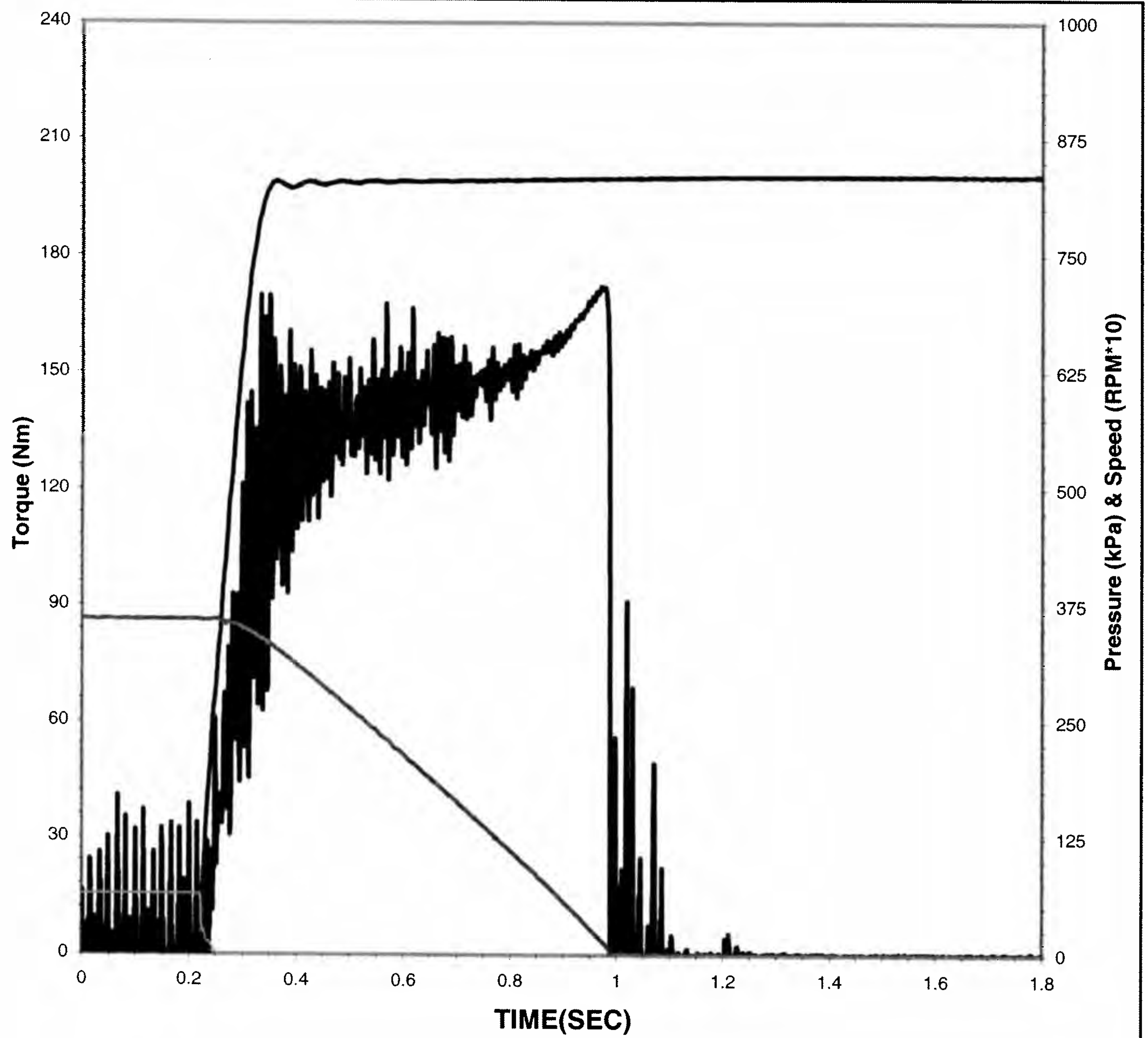
0.2 Sec Dyn:	128 N*m
Midpoint Dyn:	139 N*m
LwSpd Dynamic:	159 N*m

Coefficient of Friction

.2 Sec Dyn:	0.088
Midpoint Dyn:	0.096
LwSpd Dynamic:	0.110

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	17:23:07
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	5001
Temperature:	110.1 °C
	(112.7 ± 3.0 °C)
Apply Pressure:	829 kPa
	827 ± 7 KPa)
Apply Rate:	0.13 Sec
	(0.15 ± 0.02 Sec)
Energy:	18.4 KJ
	(18.71 ± 0.40 KJ)
Engage Time:	0.769 Sec

Torque

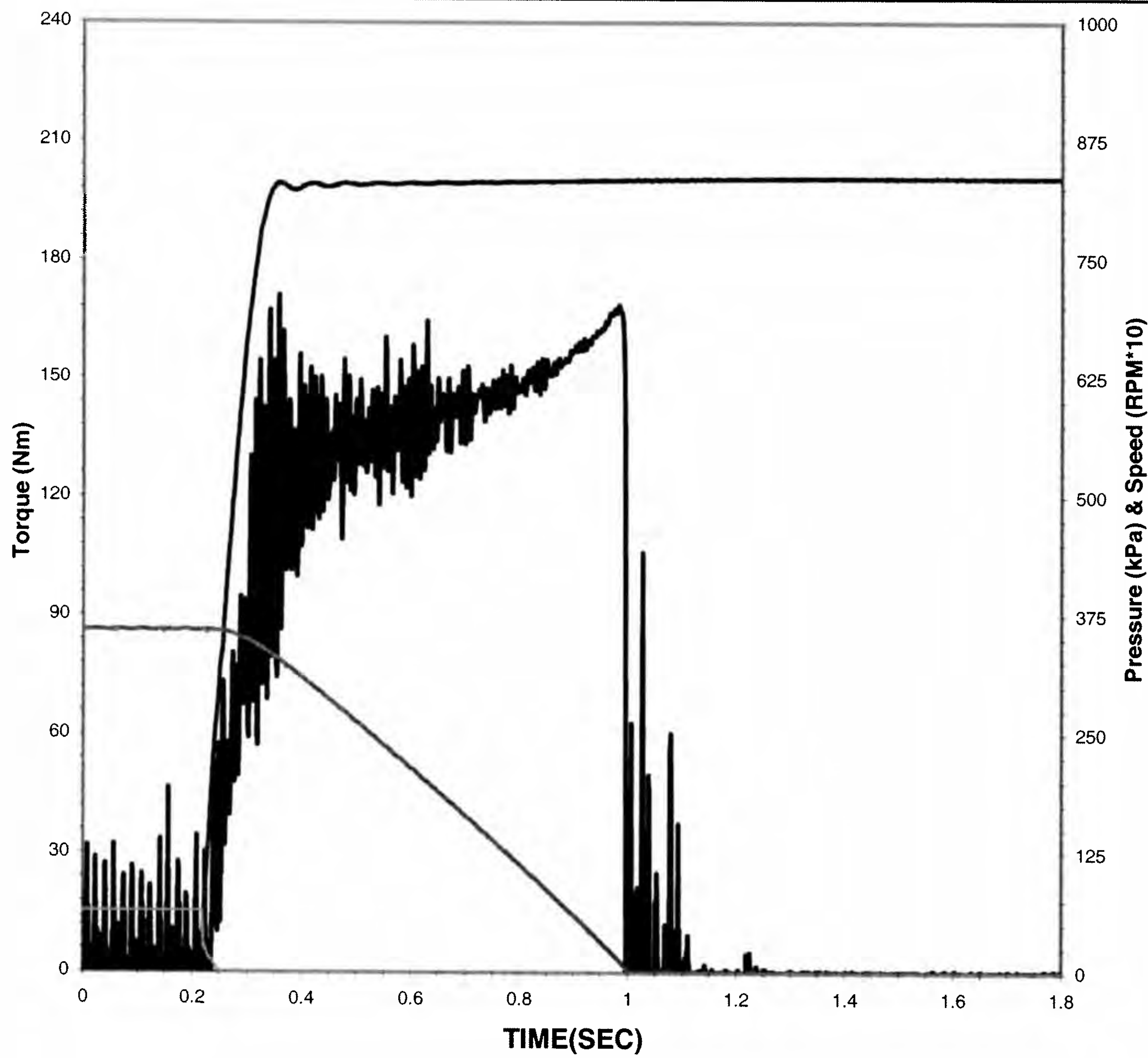
0.2 Sec Dyn:	132 N*m
Midpoint Dyn:	142 N*m
LwSpd Dynamic:	161 N*m

Coefficient of Friction

.2 Sec Dyn:	0.091
Midpoint Dyn:	0.098
LwSpd Dynamic:	0.111

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	19:27:22
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	5498
Temperature:	113.3 °C (112.7 ± 3.0 °C)
Apply Pressure:	830 kPa 827 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.5 KJ (18.71 ± 0.40 KJ)
Engage Time:	0.779 Sec

Torque

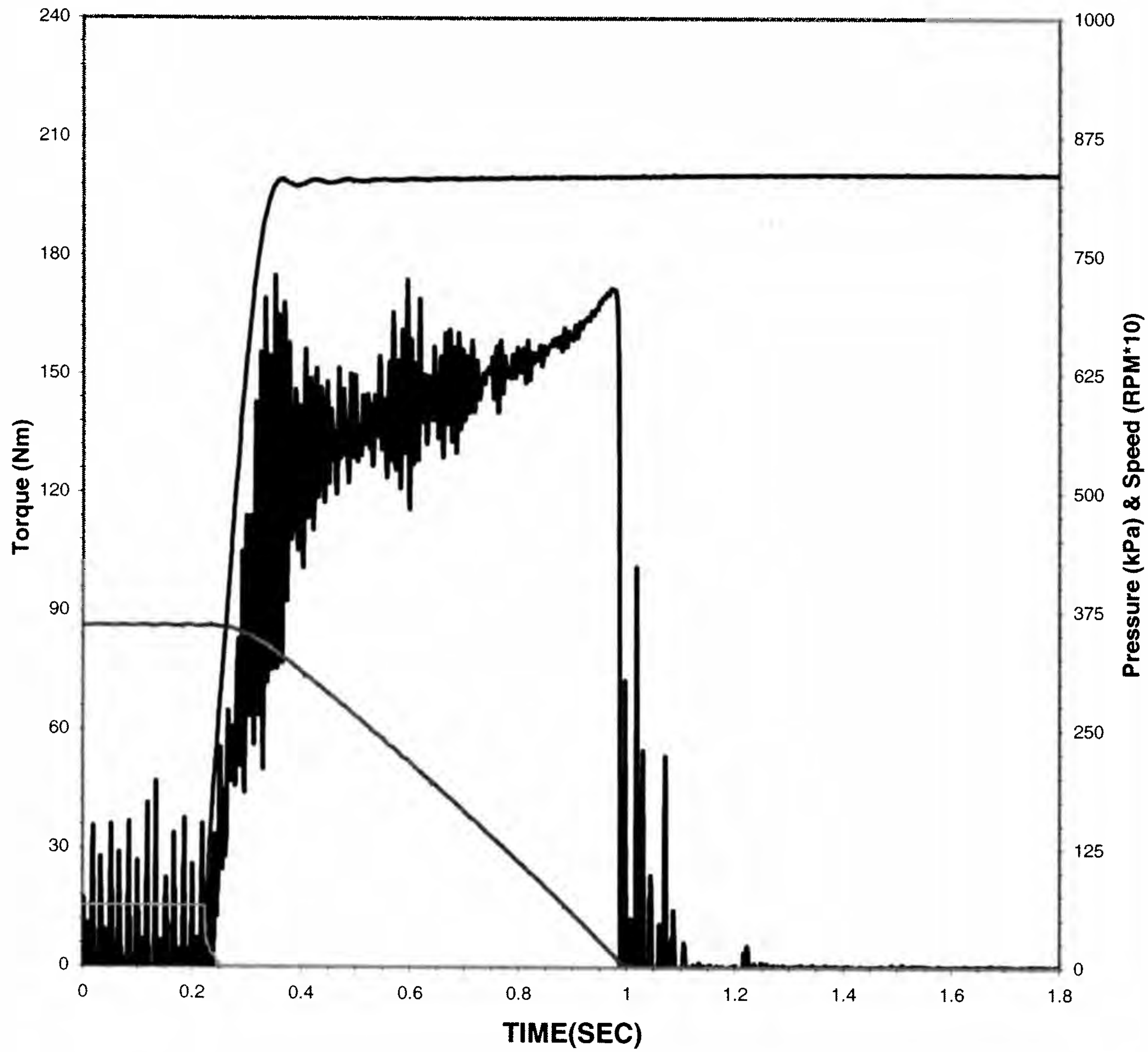
0.2 Sec Dyn:	131 N*m
Midpoint Dyn:	139 N*m
LwSpd Dynamic:	158 N*m

Coefficient of Friction

.2 Sec Dyn:	0.091
Midpoint Dyn:	0.096
LwSpd Dynamic:	0.109

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	19:27:37
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	5499
Temperature:	113.6 °C
	(112.7 ± 3.0 °C)
Apply Pressure:	830 kPa
	827 ± 7 KPa)
Apply Rate:	0.13 Sec
	(0.15 ± 0.02 Sec)
Energy:	18.4 KJ
	(18.71 ± 0.40 KJ)
Engage Time:	0.766 Sec

Torque

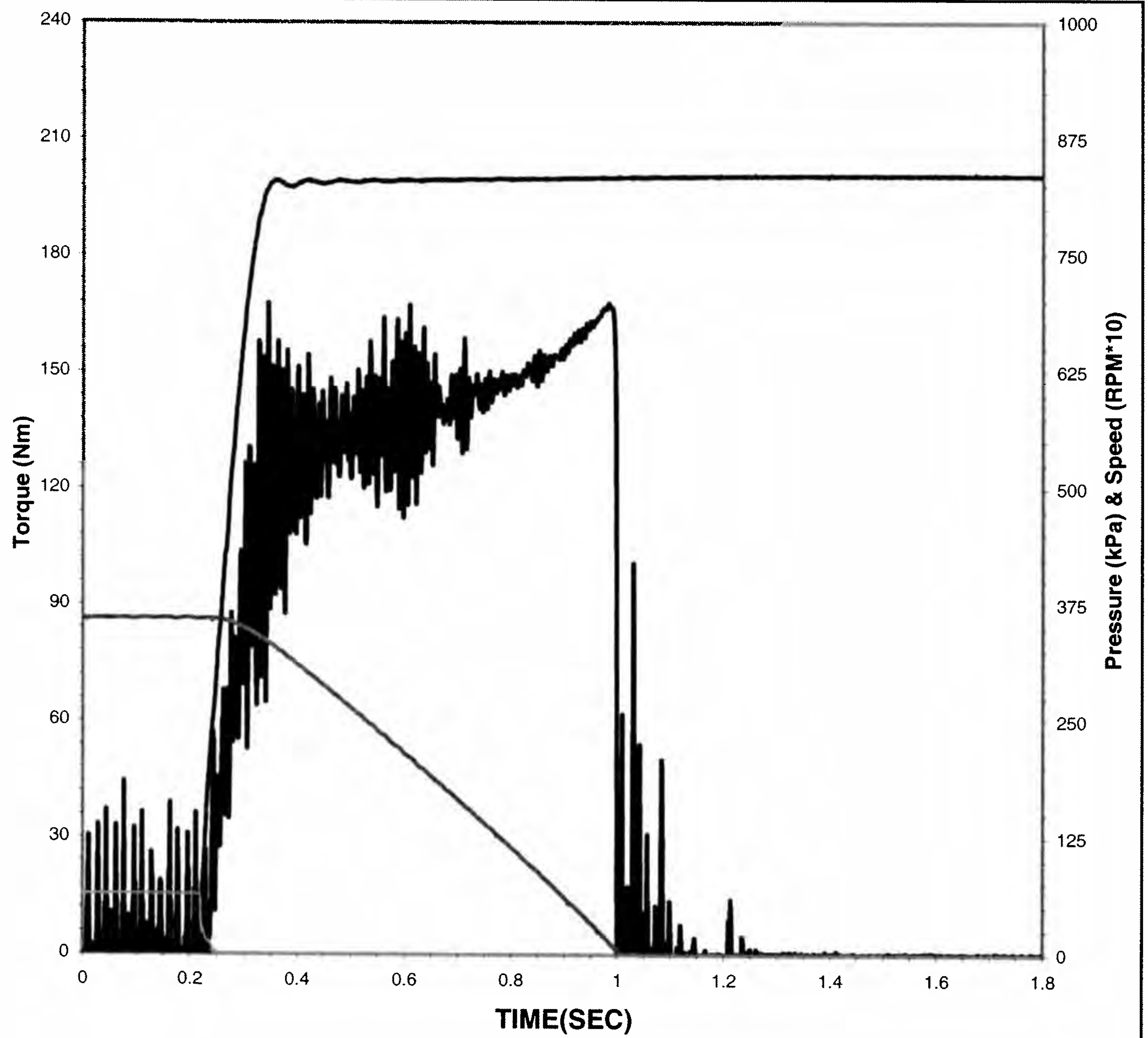
0.2 Sec Dyn:	130 N*m
Midpoint Dyn:	143 N*m
LwSpd Dynamic:	160 N*m

Coefficient of Friction

.2 Sec Dyn:	0.090
Midpoint Dyn:	0.098
LwSpd Dynamic:	0.111

ALLISON C4 GRAPHITE DATA

DYNAMIC CYCLE PHASE B



Date of Test:	9/11/2007
Time of Test:	19:27:52
Test Number:	C4-2-1189
Fluid Code:	AL-27877-L
Cycle Number:	5500
Temperature:	113.1 °C
	(112.7 ± 3.0 °C)
Apply Pressure:	830 kPa
	827 ± 7 KPa)
Apply Rate:	0.14 Sec
	(0.15 ± 0.02 Sec)
Energy:	18.5 KJ
	(18.71 ± 0.40 KJ)
Engage Time:	0.782 Sec

Torque

0.2 Sec Dyn:	127 N*m
Midpoint Dyn:	139 N*m
LwSpd Dynamic:	157 N*m

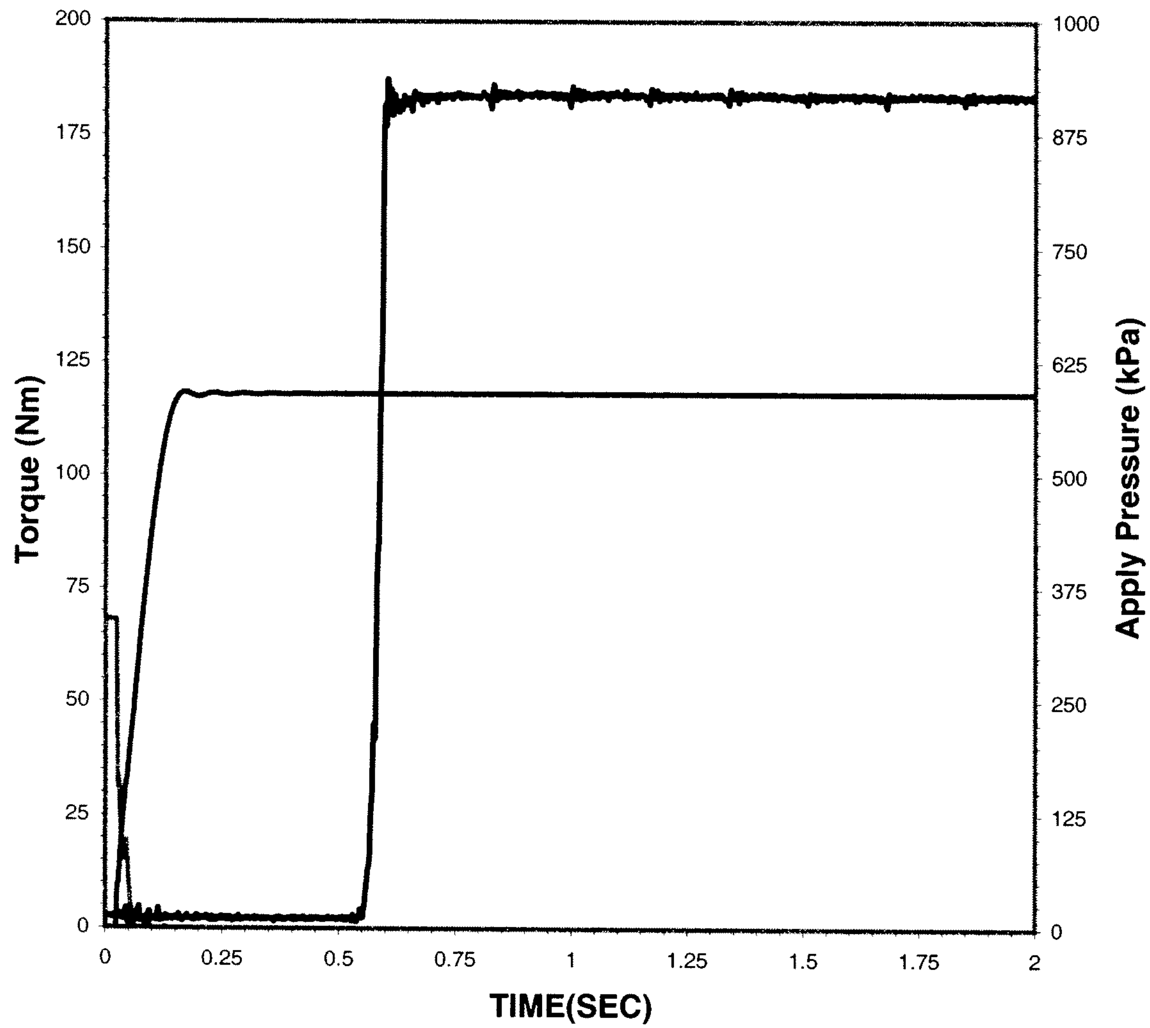
Coefficient of Friction

.2 Sec Dyn:	0.088
Midpoint Dyn:	0.096
LwSpd Dynamic:	0.108

STATIC TRACES

ALLISON C4 GRAPHITE DATA

STATIC CYCLE



Date of Test: 9/10/2007

Time of Test: 20:07:49

Test Number: C4-2-1189

Fluid Code: AL-27877-L

Cycle Number: 10

PHASE A

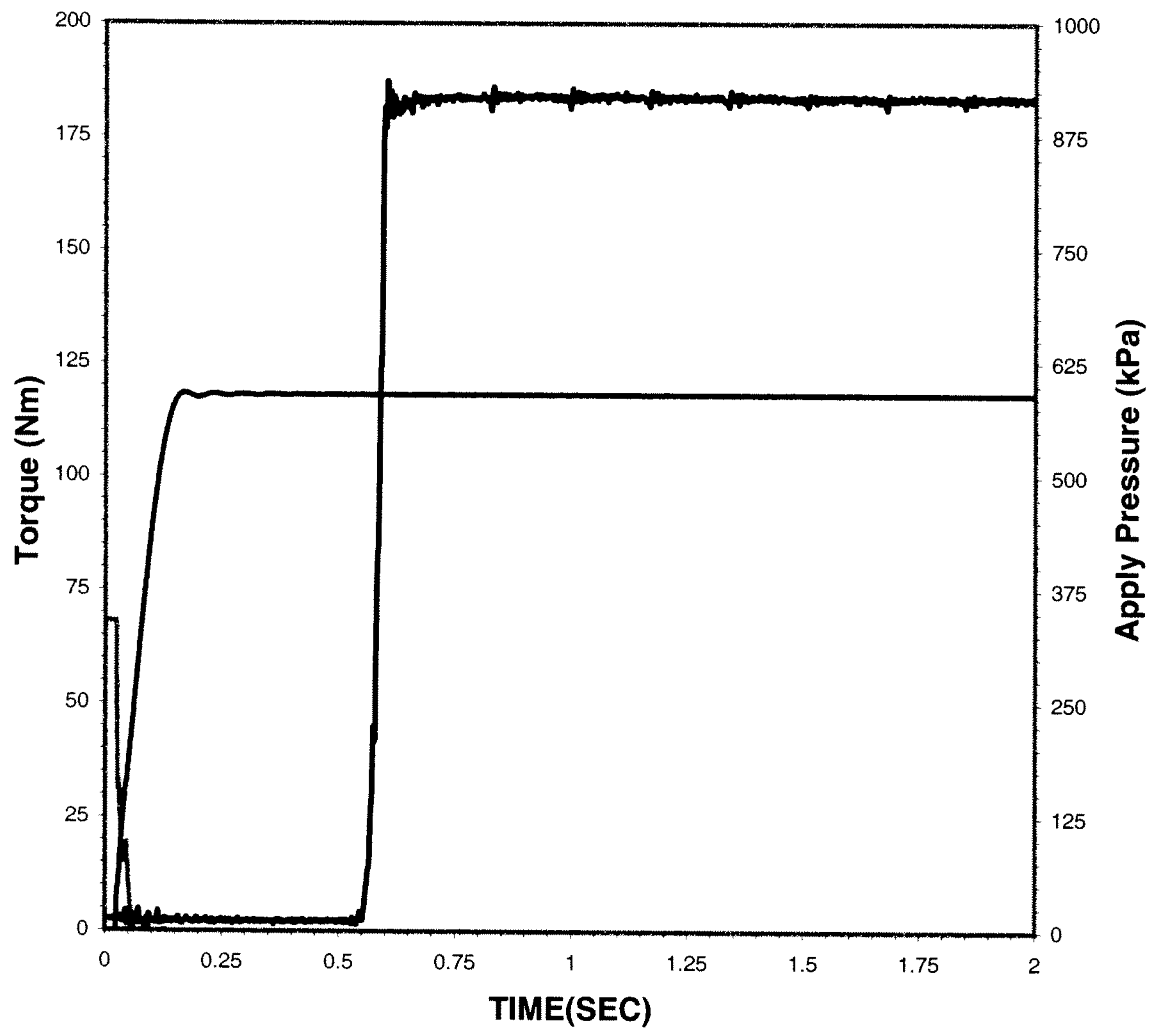
Apply Pressure:
At .25 Second: 315 kPa

Torque
Static Peak: 93 Nm
.25 Second: 79 Nm

Coefficient of Friction
Static Peak: 0.154
.25 Second: 0.131

ALLISON C4 GRAPHITE DATA

STATIC CYCLE



Date of Test: 9/10/2007

Time of Test: 22:10:31

Test Number: C4-2-1189

Fluid Code: AL-27877-L

Cycle Number: 500

PHASE A

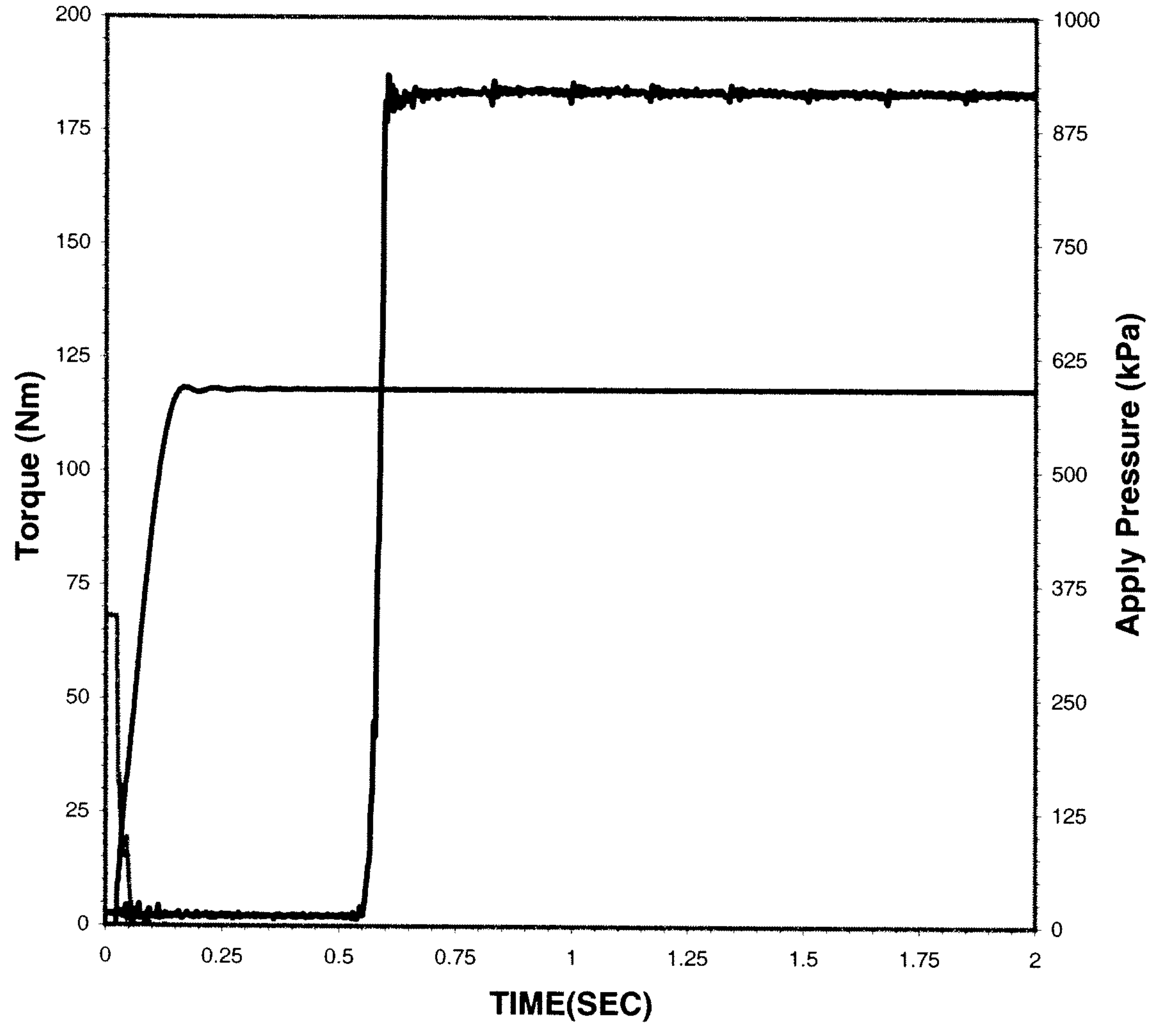
Apply Pressure:
At .25 Second: 346 kPa

Torque
Static Peak: 92 Nm
.25 Second: 81 Nm

Coefficient of Friction
Static Peak: 0.152
.25 Second: 0.135

ALLISON C4 GRAPHITE DATA

STATIC CYCLE



Date of Test: 9/11/2007

Time of Test: 0:15:44

Test Number: C4-2-1189

Fluid Code: AL-27877-L

Cycle Number: 1000

PHASE A

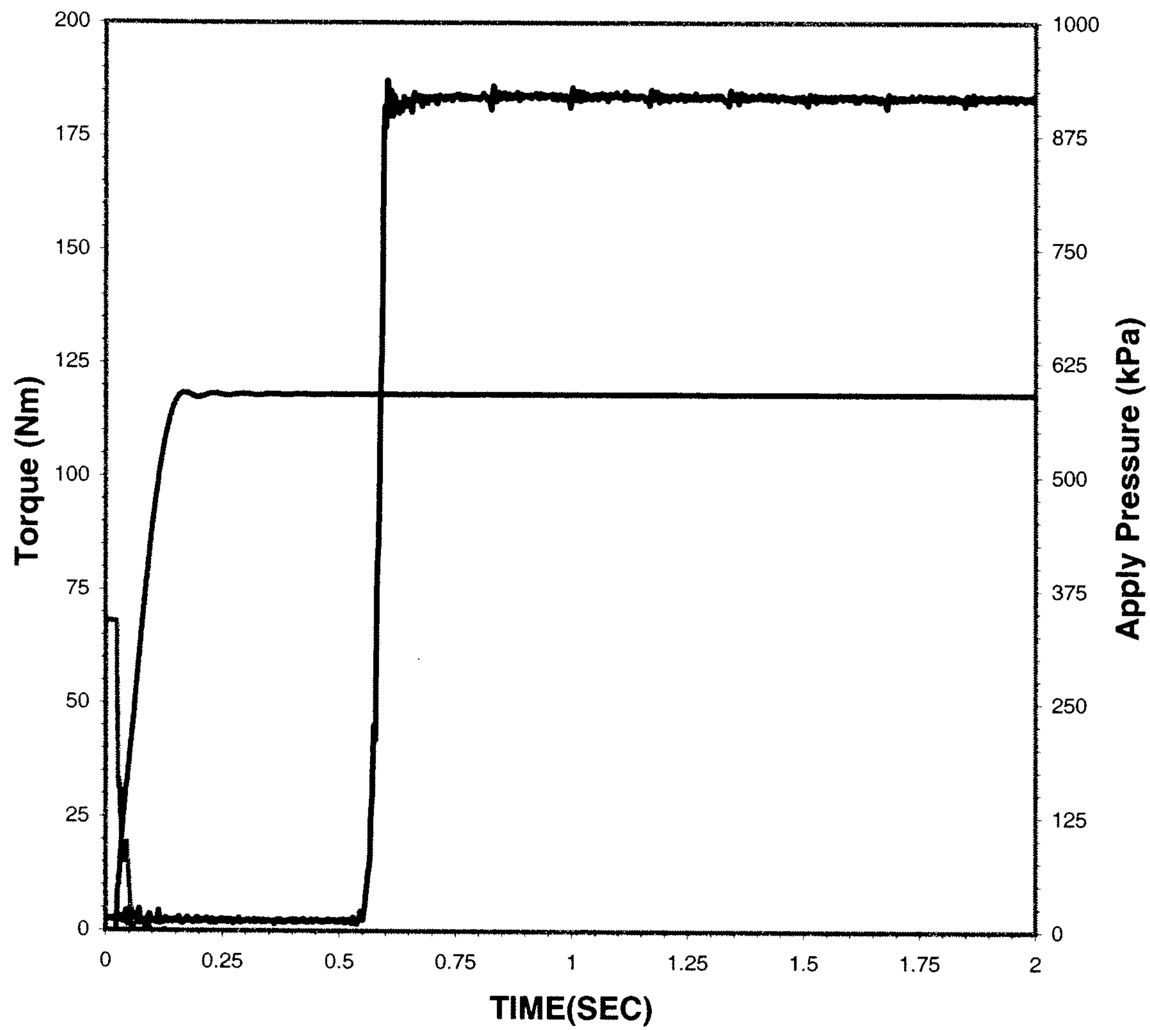
Apply Pressure:
At .25 Second: 347 kPa

Torque
Static Peak: 91 Nm
.25 Second: 83 Nm

Coefficient of Friction
Static Peak: 0.151
.25 Second: 0.138

ALLISON C4 GRAPHITE DATA

STATIC CYCLE



Date of Test: 9/11/2007

Time of Test: 2:46:27

Test Number: C4-2-1189

Fluid Code: AL-27877-L

Cycle Number: 1500

PHASE B

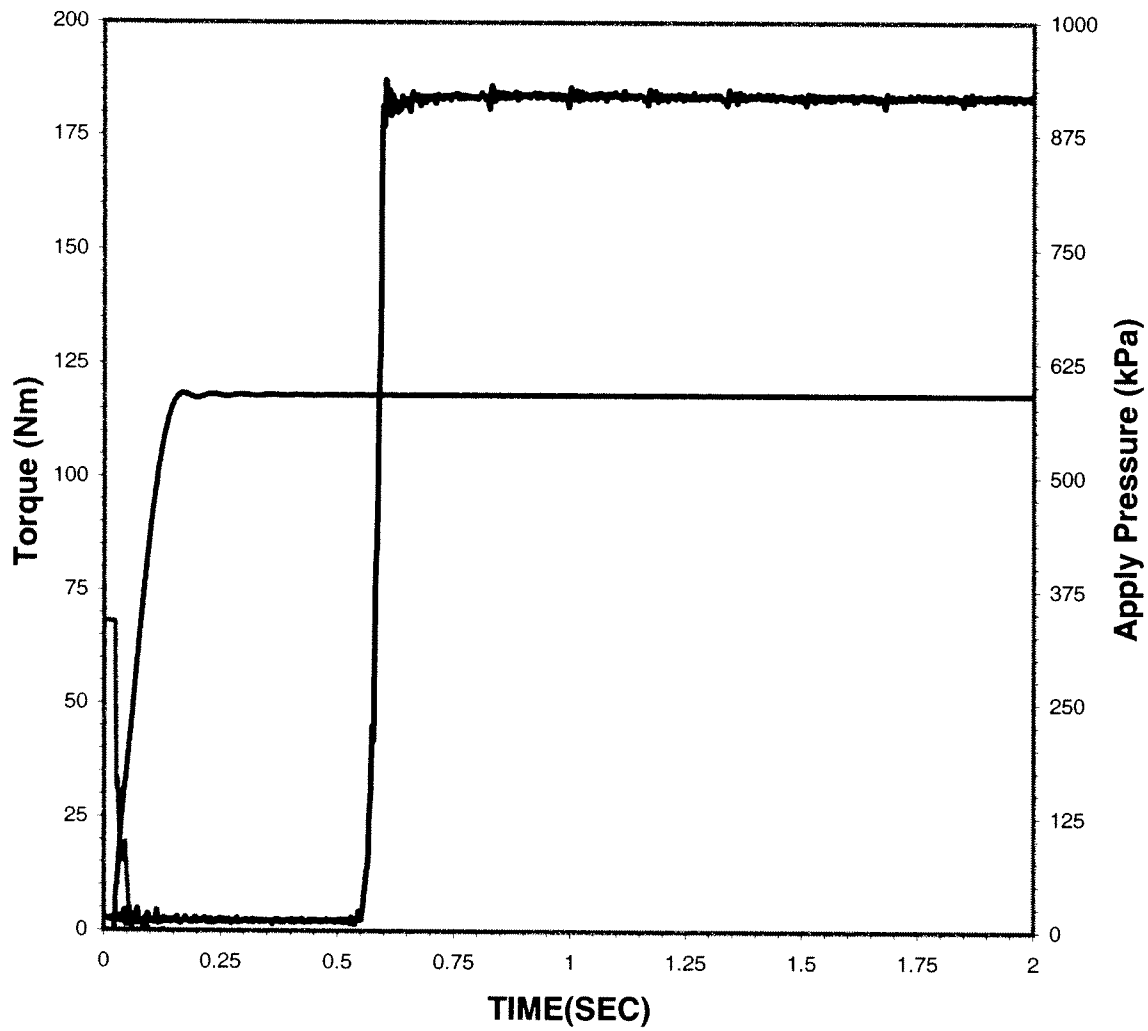
Apply Pressure:
At .25 Second: 829 kPa

Torque
Static Peak: 197 Nm
.25 Second: 176 Nm

Coefficient of Friction
Static Peak: 0.136
.25 Second: 0.121

ALLISON C4 GRAPHITE DATA

STATIC CYCLE



Date of Test: 9/11/2007

Time of Test: 4:51:39

Test Number: C4-2-1189

Fluid Code: AL-27877-L

Cycle Number: 2000

PHASE B

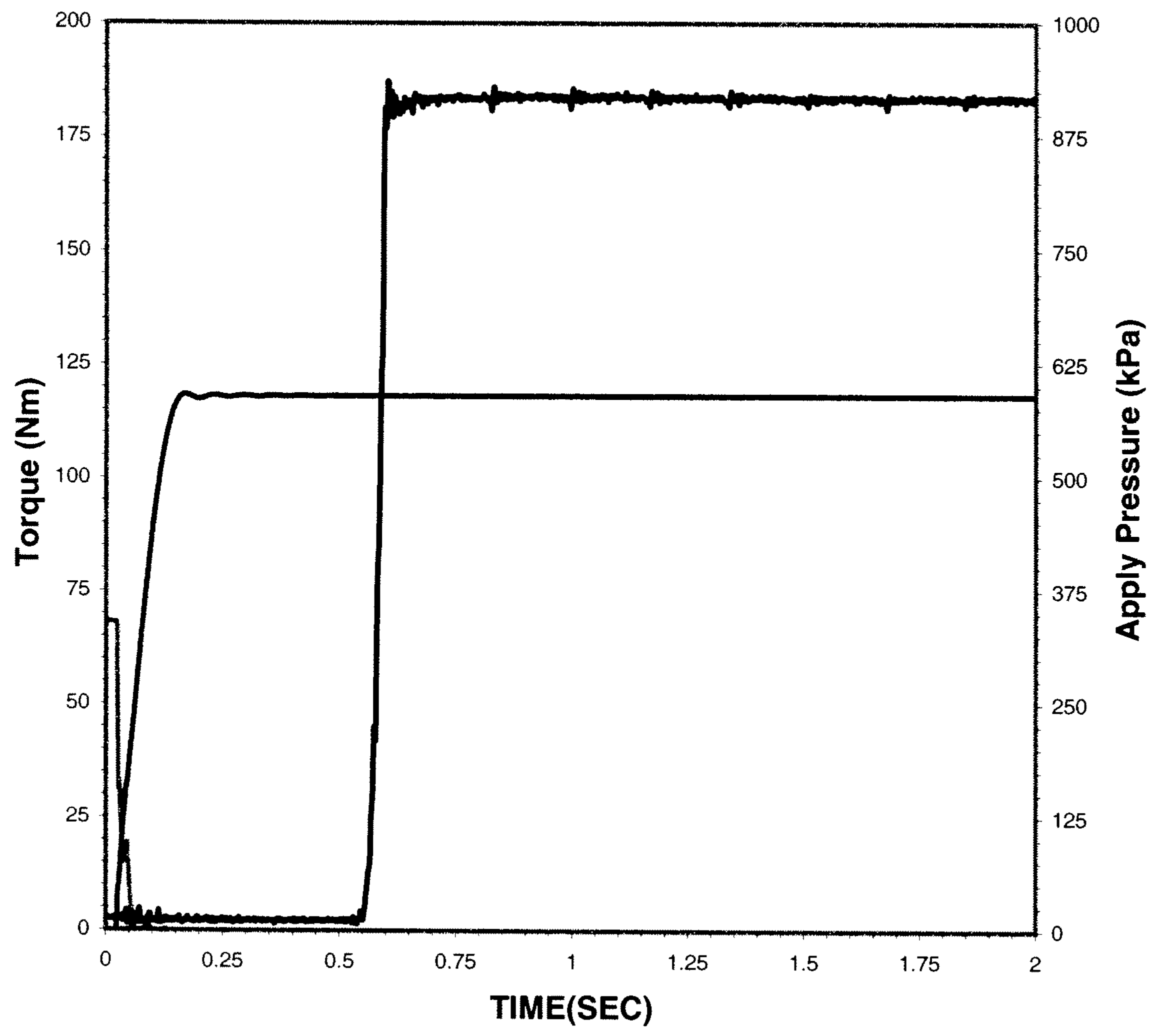
Apply Pressure:
At .25 Second: 831 kPa

Torque
Static Peak: 192 Nm
.25 Second: 175 Nm

Coefficient of Friction
Static Peak: 0.133
.25 Second: 0.121

ALLISON C4 GRAPHITE DATA

STATIC CYCLE



Date of Test: 9/11/2007

Time of Test: 6:56:51

Test Number: C4-2-1189

Fluid Code: AL-27877-L

Cycle Number: 2500

PHASE B

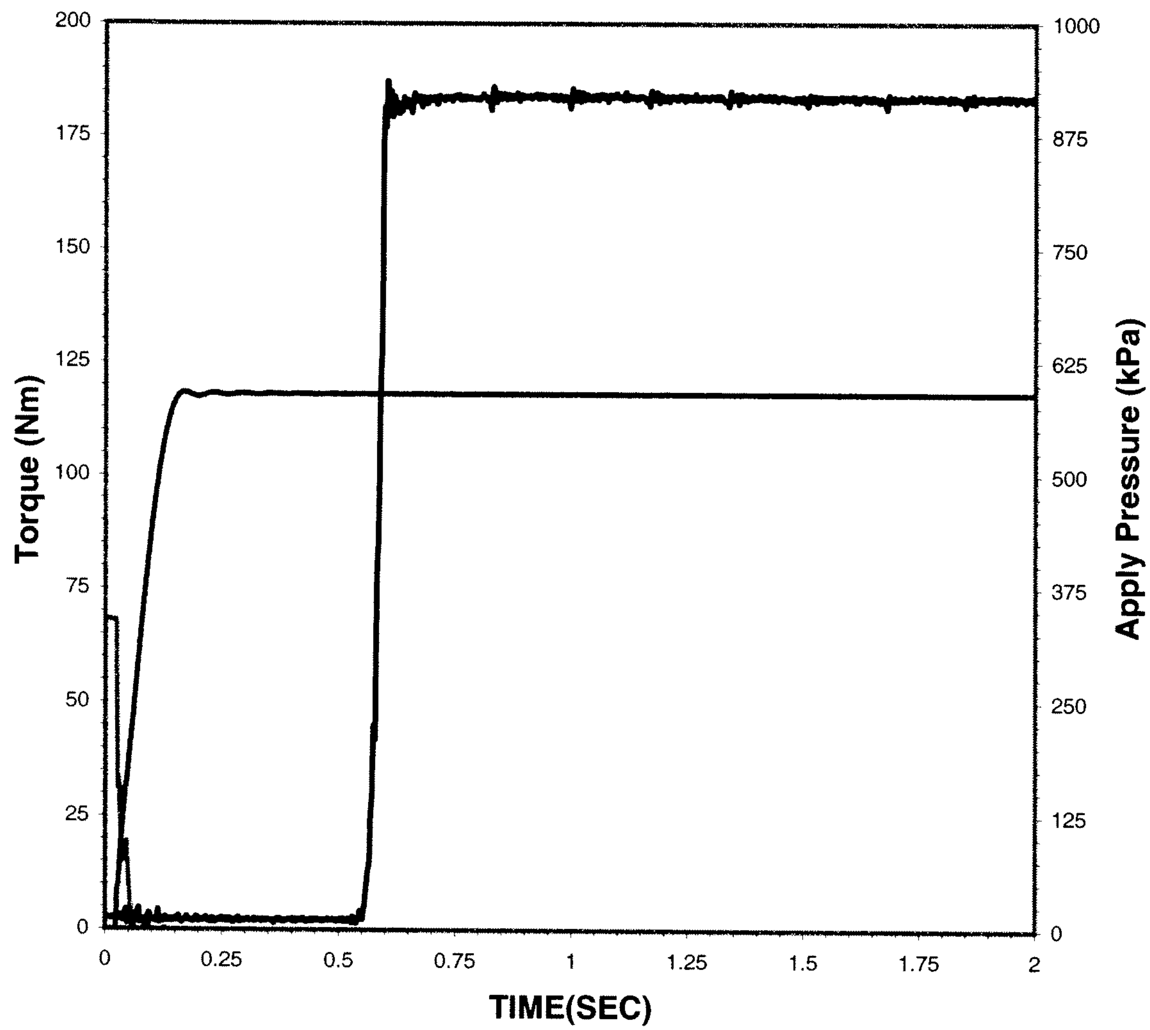
Apply Pressure:
At .25 Second: 832 kPa

Torque
Static Peak: 191 Nm
.25 Second: 172 Nm

Coefficient of Friction
Static Peak: 0.132
.25 Second: 0.119

ALLISON C4 GRAPHITE DATA

STATIC CYCLE



Date of Test: 9/11/2007

Time of Test: 9:02:03

Test Number: C4-2-1189

Fluid Code: AL-27877-L

Cycle Number: 3000

PHASE B

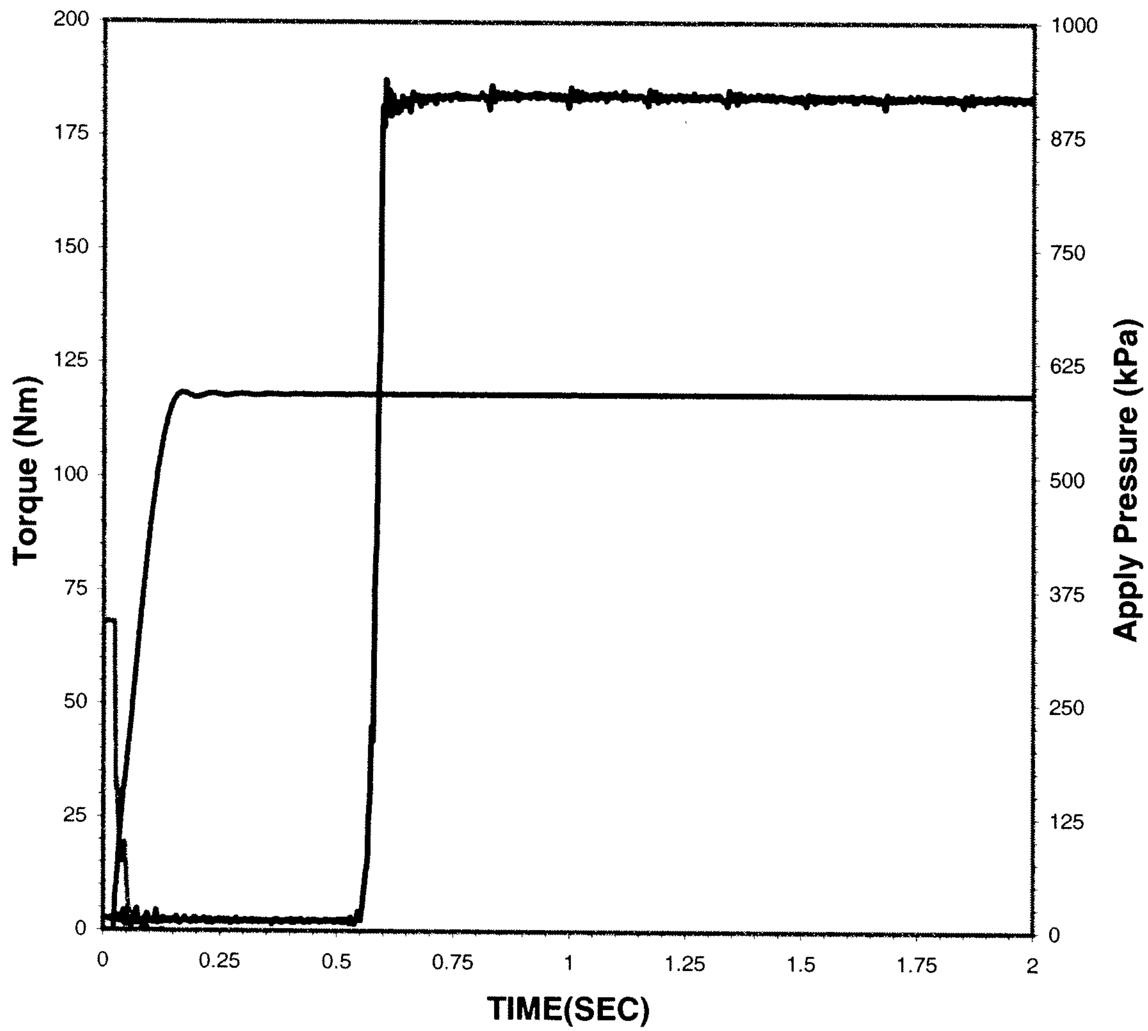
Apply Pressure:
At .25 Second: 832 kPa

Torque
Static Peak: 194 Nm
.25 Second: 174 Nm

Coefficient of Friction
Static Peak: 0.134
.25 Second: 0.120

ALLISON C4 GRAPHITE DATA

STATIC CYCLE



Date of Test: 9/11/2007

Time of Test: 11:07:15

Test Number: C4-2-1189

Fluid Code: AL-27877-L

Cycle Number: 3500

PHASE B

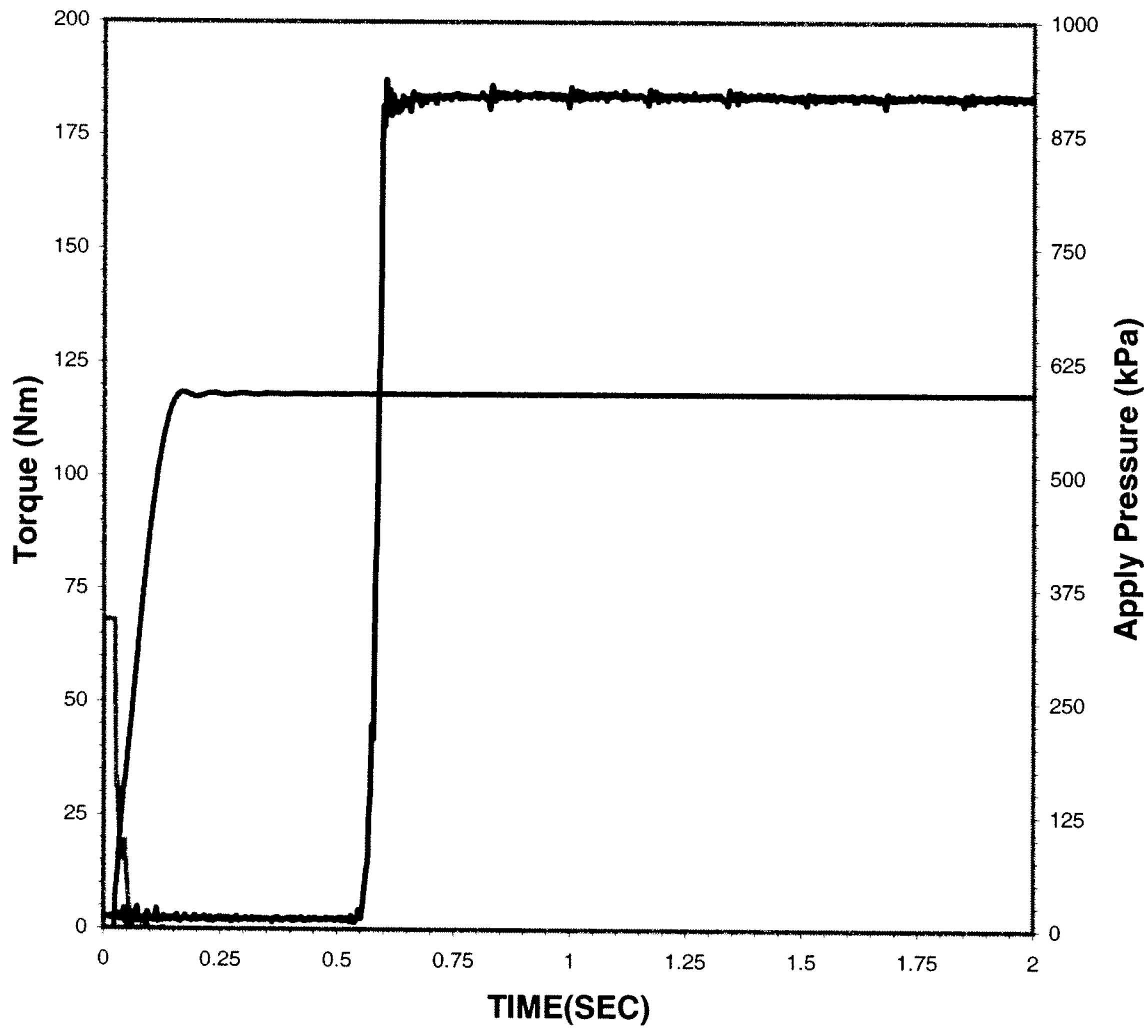
Apply Pressure:
At .25 Second: 832 kPa

Torque
Static Peak: 183 Nm
.25 Second: 173 Nm

Coefficient of Friction
Static Peak: 0.126
.25 Second: 0.120

ALLISON C4 GRAPHITE DATA

STATIC CYCLE



Date of Test: 9/11/2007

Time of Test: 13:12:27

Test Number: C4-2-1189

Fluid Code: AL-27877-L

Cycle Number: 4000

PHASE B

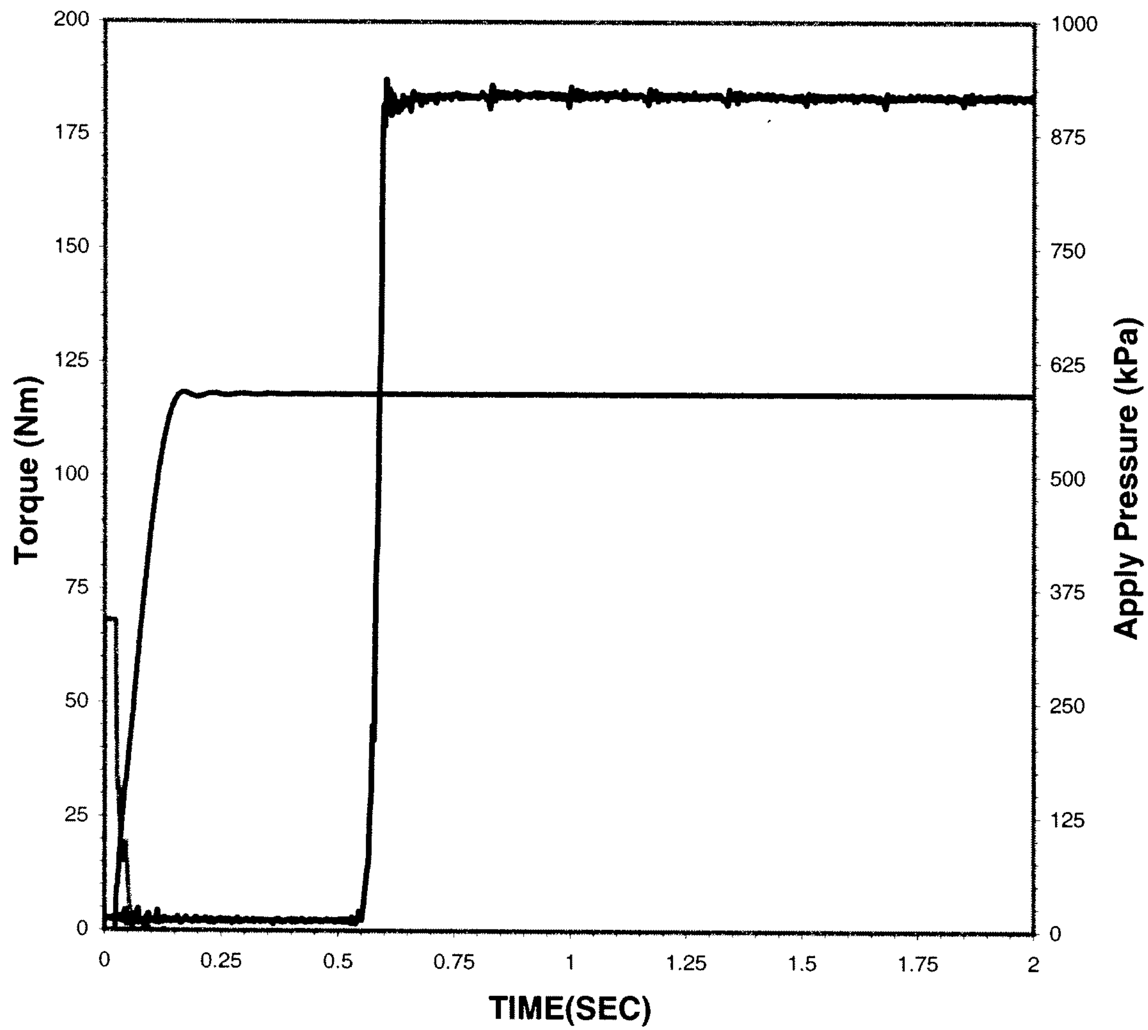
Apply Pressure:
At .25 Second: 829 kPa

Torque
Static Peak: 187 Nm
.25 Second: 170 Nm

Coefficient of Friction
Static Peak: 0.130
.25 Second: 0.117

ALLISON C4 GRAPHITE DATA

STATIC CYCLE



Date of Test: 9/11/2007

Time of Test: 15:17:39

Test Number: C4-2-1189

Fluid Code: AL-27877-L

Cycle Number: 4500

PHASE B

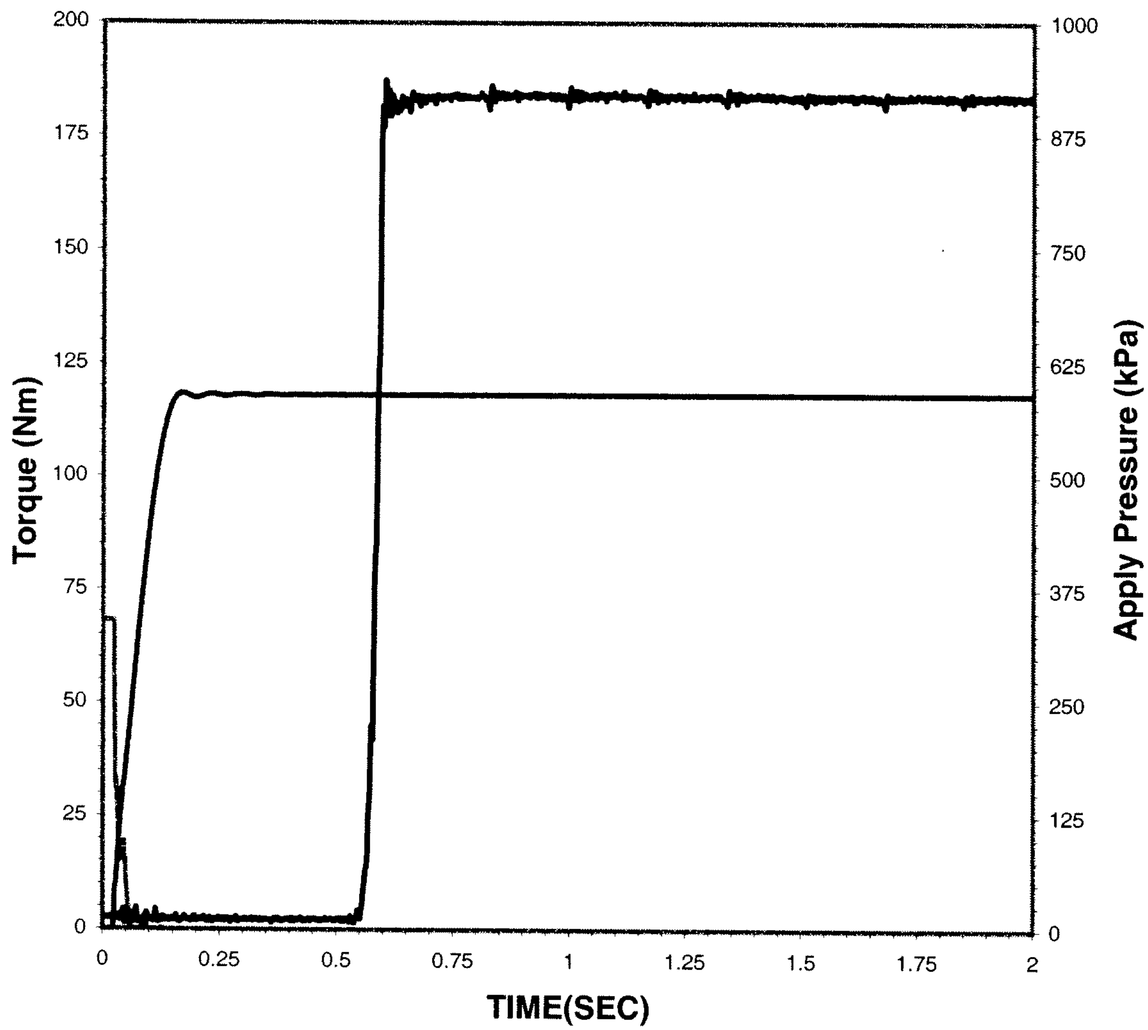
Apply Pressure:
At .25 Second: 829 kPa

Torque
Static Peak: 192 Nm
.25 Second: 171 Nm

Coefficient of Friction
Static Peak: 0.132
.25 Second: 0.118

ALLISON C4 GRAPHITE DATA

STATIC CYCLE



Date of Test: 9/11/2007

Time of Test: 17:22:52

Test Number: C4-2-1189

Fluid Code: AL-27877-L

Cycle Number: 5000

PHASE B

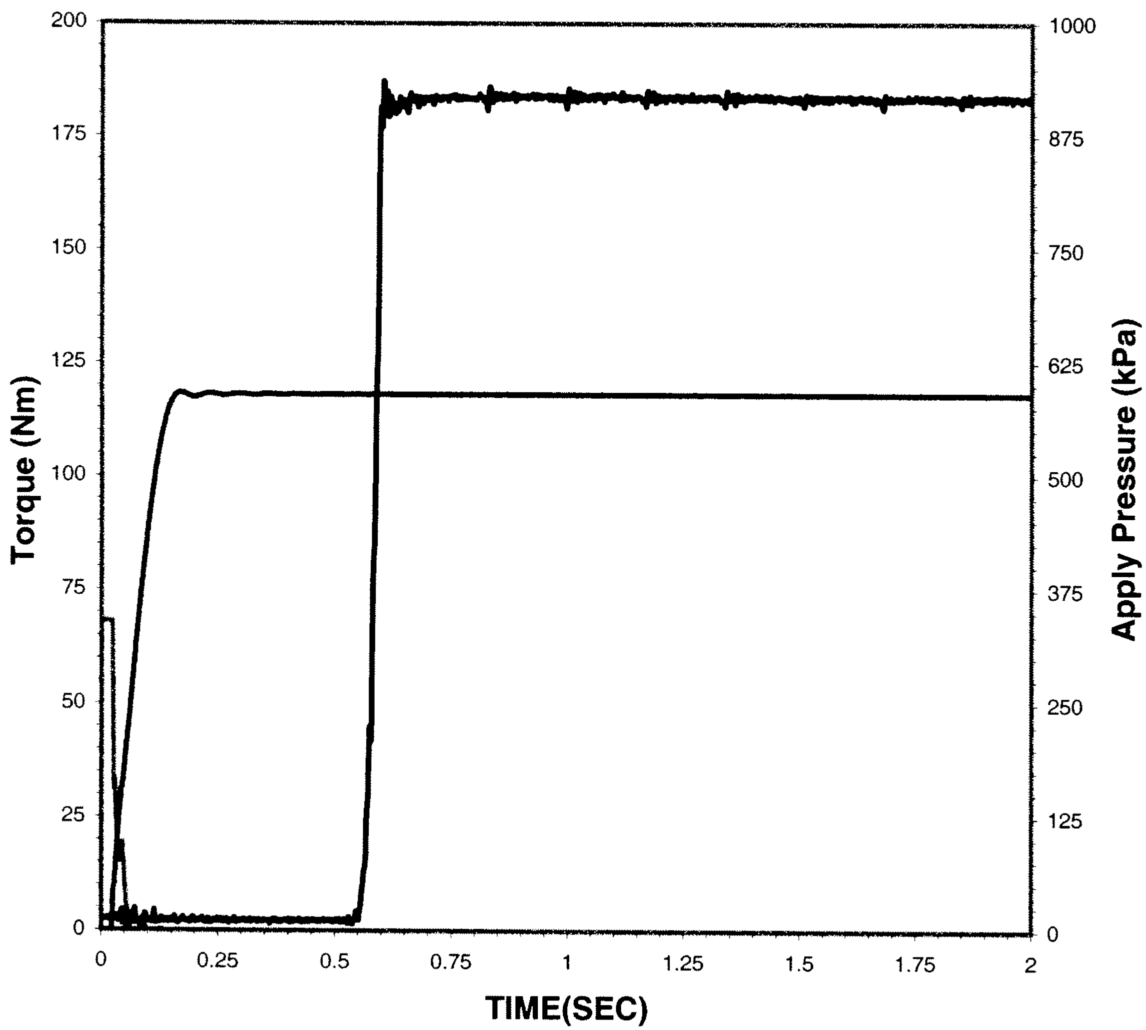
Apply Pressure:
At .25 Second: 829 kPa

Torque
Static Peak: 185 Nm
.25 Second: 171 Nm

Coefficient of Friction
Static Peak: 0.128
.25 Second: 0.118

ALLISON C4 GRAPHITE DATA

STATIC CYCLE



Date of Test: 9/11/2007

Time of Test: 19:28:04

Test Number: C4-2-1189

Fluid Code: AL-27877-L

Cycle Number: 5500

PHASE B

Apply Pressure:
At .25 Second: 830 kPa

Torque
Static Peak: 183 Nm
.25 Second: 169 Nm

Coefficient of Friction
Static Peak: 0.126
.25 Second: 0.117

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

Fuels And Lubricants Research Division

Report on

ALLISON HYDRAULIC TRANSMISSION FLUID, TYPE C-4 PAPER CLUTCH FRICTION TEST

Conducted For

SWRI ARMY LAB

Oil Code:
AL-27877-L

Test Number:
C2-2-1484

September 12, 2007

Submitted by:

Matthew Jackson
Principal Engineer
Specialty & Driveline Fluids Evaluation

IX. Paper Clutch Friction Test

Test Laboratory: SWRI
Test Number: C2-2-1484
Friction Plate Batch: LOT 4D
Steel Plate Batch: 9/11/2005

Lab Fluid Code: ATF-223703
Sponsor Fluid Code: AL-27877-L
Completion Date: 09/12/07

Clutch Wear Data

	Maximum	Average
Steel Plates	0.0010	0.0001
Clutch Plate	0.1110	0.1060

	Before	After
Pack Clearance	1.0922	1.3462

Reference Tests

Test Number	Test Date	Test Fluid
C2-0-1460	11/19/06	RDL-2746 08-05
C2-0-1471	03/17/07	RDL-2746 08-05
C2-0-1482	08/31/07	RDL-2746 07-06

	New	EOT
Viscosity at 40°C, cSt	58.24	44.16
Viscosity at 100°C, cSt	10.6	8.37
Iron Content, ppm	2	227

D5185	New Fluid (ppm)
Ba	<1
B	2
Ca	3593
Mg	12
P	1298
Si	5
Na	<5
Zn	1441

Name: Matthew Jackson
Title: Principal Engineer

Signature:
Date: 9/21/07

ALLISON C- 4 PAPER FRICTION TEST

(Torque in N*m)

Sponsor Fluid Code:	**AL-27877-L**	Test Number:	**C2-2-1484**
Lab Fluid Code:	**ATF-223703**	Fric. Plate Batch:	**LOT 4D**
Completion Date:	**09/12/2007**	Steel Plate Batch:	**9/11/2005**

TORQUE

CYCLE	SLIP TIME	TORQUE (MIDPOINT)	TORQUE STATIC PEAK	STATIC PEAK - MIDPOINT	LOW SPEED STATIC PEAK	LOWSPEED STATIC TORQUE
100	0.53	195	232	37	259	243
500	0.55	181	302	121	321	295
1000	0.51	196	318	122	340	316
2500	0.49	207	308	101	348	315
5000	0.47	220	298	78	325	307
7500	0.46	224	287	63	314	302
10000	0.46	225	274	49	309	289

COEFFICIENT OF FRICTION

CYCLE	SLIP TIME	TORQUE (MIDPOINT)	TORQUE STATIC PEAK	STATIC PEAK - MIDPOINT	LOW SPEED STATIC PEAK	LOWSPEED STATIC TORQUE
100	0.53	0.095	0.113	0.018	0.126	0.118
500	0.55	0.088	0.147	0.059	0.156	0.144
1000	0.51	0.095	0.155	0.060	0.166	0.154
2500	0.49	0.101	0.150	0.049	0.169	0.153
5000	0.47	0.107	0.145	0.038	0.158	0.150
7500	0.46	0.109	0.140	0.031	0.153	0.147
10000	0.46	0.110	0.133	0.023	0.150	0.141

	Limits		Results			
	Value	% Change	100 N	10,000 N	% Change	P/F
Slip Time Max.	0.600	N/A	0.530	0.460	-13.21	P
Mid-Point Fric. Coeff. Min.	0.085	N/A	0.095	0.110	15.79	P
Static Friction Coeff.	N/A	N/A	0.113	0.133	17.70	
Low Speed Peak Fric. Coeff.	N/A	N/A	0.126	0.150	19.05	
0.25 Second Low Speed Coeff.	N/A	N/A	0.118	0.141	19.49	

SOUTHWEST RESEARCH INSTITUTE®

ALLISON C4-PAPER FRICTION TEST

Candidate Fluid: AL-27877-L **Test Number : C2-2-1484** **Completion Date : 9/12/2007**
Lab Fluid Code : ATF-223703 **Steel Plate Batch: 09/11/2005** **Fric Plate Batch : LOT 4D**

Plates	Location of Tooth (Clockwise)	Near Inner Diameter Before	Near Inner Diameter After	Near Outer Diameter Before	Near Outer Diameter After	Inner Diameter Change	Average Overall Change	Outer Diameter Change
FRICTION MATERIAL								
2	Top	1.7670	1.6600	1.7670	1.6640	0.1070		0.1030
	120	1.7670	1.6650	1.7660	1.6630	0.1020		0.1030
	240	1.7670	1.6560	1.7650	1.6550	0.1110		0.1100
	Average					0.1067	0.1060	0.1053
5	Top	1.7670	1.6570	1.7670	1.6650	0.1100		0.1020
	120	1.7630	1.6550	1.7670	1.6620	0.1080		0.1050
	240	1.7660	1.6580	1.7670	1.6640	0.1080		0.1030
	Average					0.1087	0.1060	0.1033
STEELS SEPARATORS								
1	Top	1.7540	1.7540	1.7530	1.7530	0.0000		0.0000
	120	1.7520	1.7520	1.7540	1.7540	0.0000		0.0000
	240	1.7550	1.7550	1.7550	1.7550	0.0000		0.0000
	Average					0.0000	0.0000	0.0000
3	Top	1.7440	1.7440	1.7440	1.7430	0.0000		0.0010
	120	1.7450	1.7440	1.7430	1.7430	0.0010		0.0000
	240	1.7440	1.7440	1.7440	1.7440	0.0000		0.0000
	Average					0.0003	0.0003	0.0003
4	Top	1.7470	1.7470	1.7470	1.7470	0.0000		0.0000
	120	1.7480	1.7480	1.7480	1.7480	0.0000		0.0000
	240	1.7430	1.7420	1.7420	1.7420	0.0010		0.0000
	Average					0.0003	0.0002	0.0000
6	Top	1.7510	1.7510	1.7510	1.7510	0.0000		0.0000
	120	1.7510	1.7510	1.7500	1.7500	0.0000		0.0000
	240	1.7490	1.7490	1.7480	1.7480	0.0000		0.0000
	Average					0.0000	0.0000	0.0000

PLATE CONDITION AT E.O.T.: PLATES IN GOOD CONDITION WITH LIGHT DISCOLORATION ON INNER STEEL PLATES
(Anything Unusual)

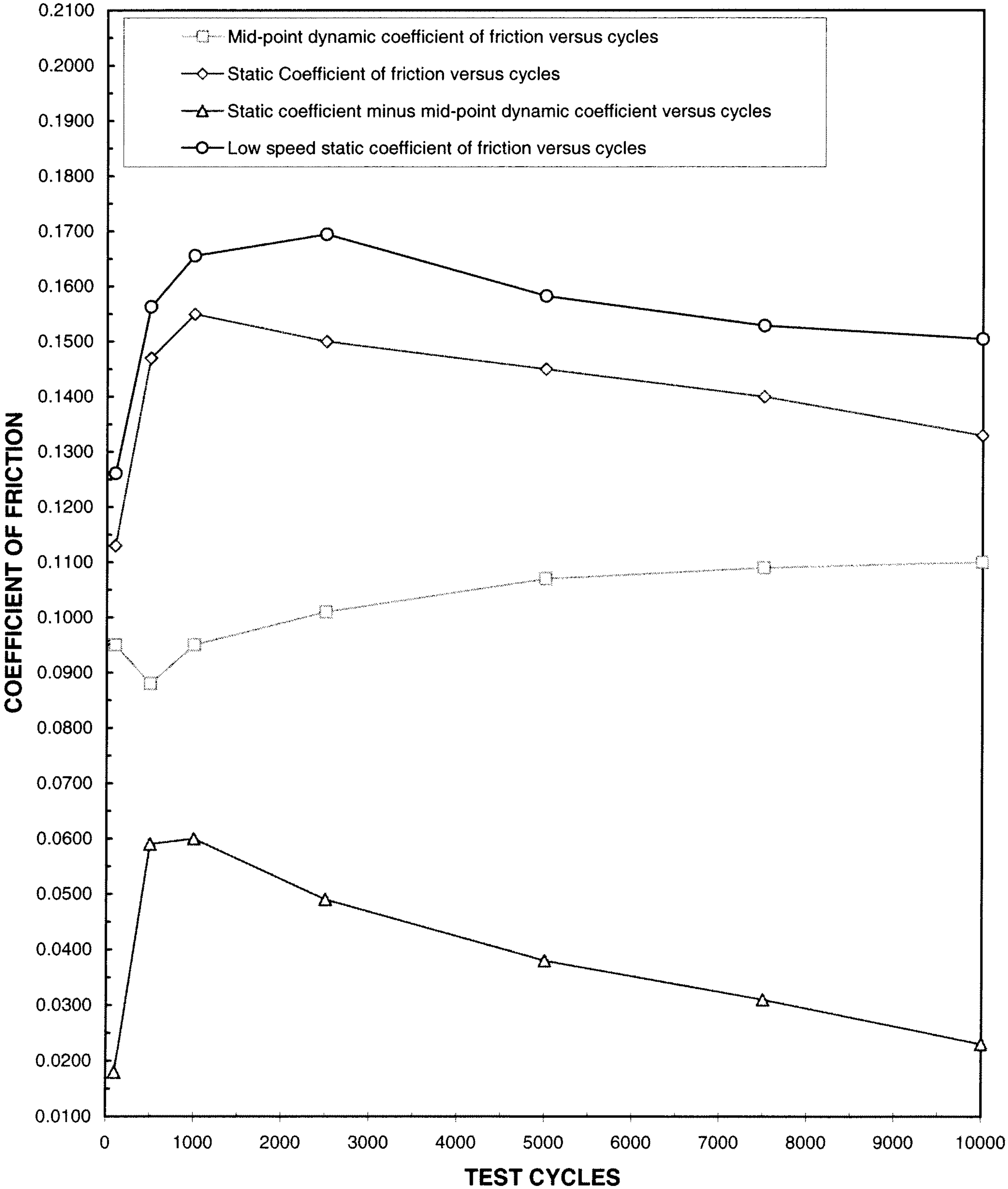
Test Date and Operator's Name: 9/12/2007 EDWARD TIJERINA

Reviewed By (Signature and Date)
9/14/07

Pack ID#: 4072

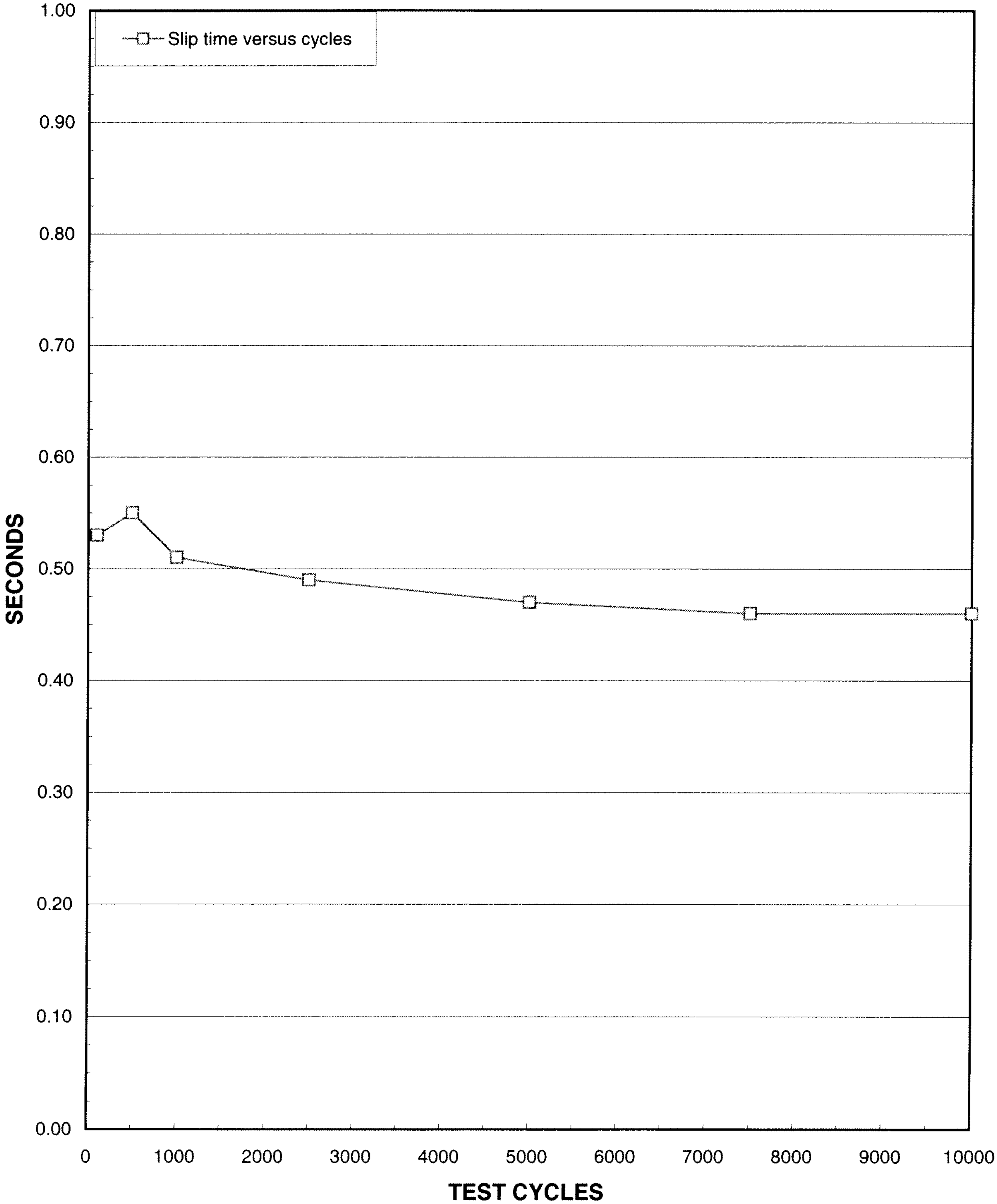
ALLISON HYDRAULIC TRANSMISSION FLUID
TYPE C-4 PAPER FRICTION TEST

Fluid Code: AL-27877-L **Test Number: C2-2-1484**



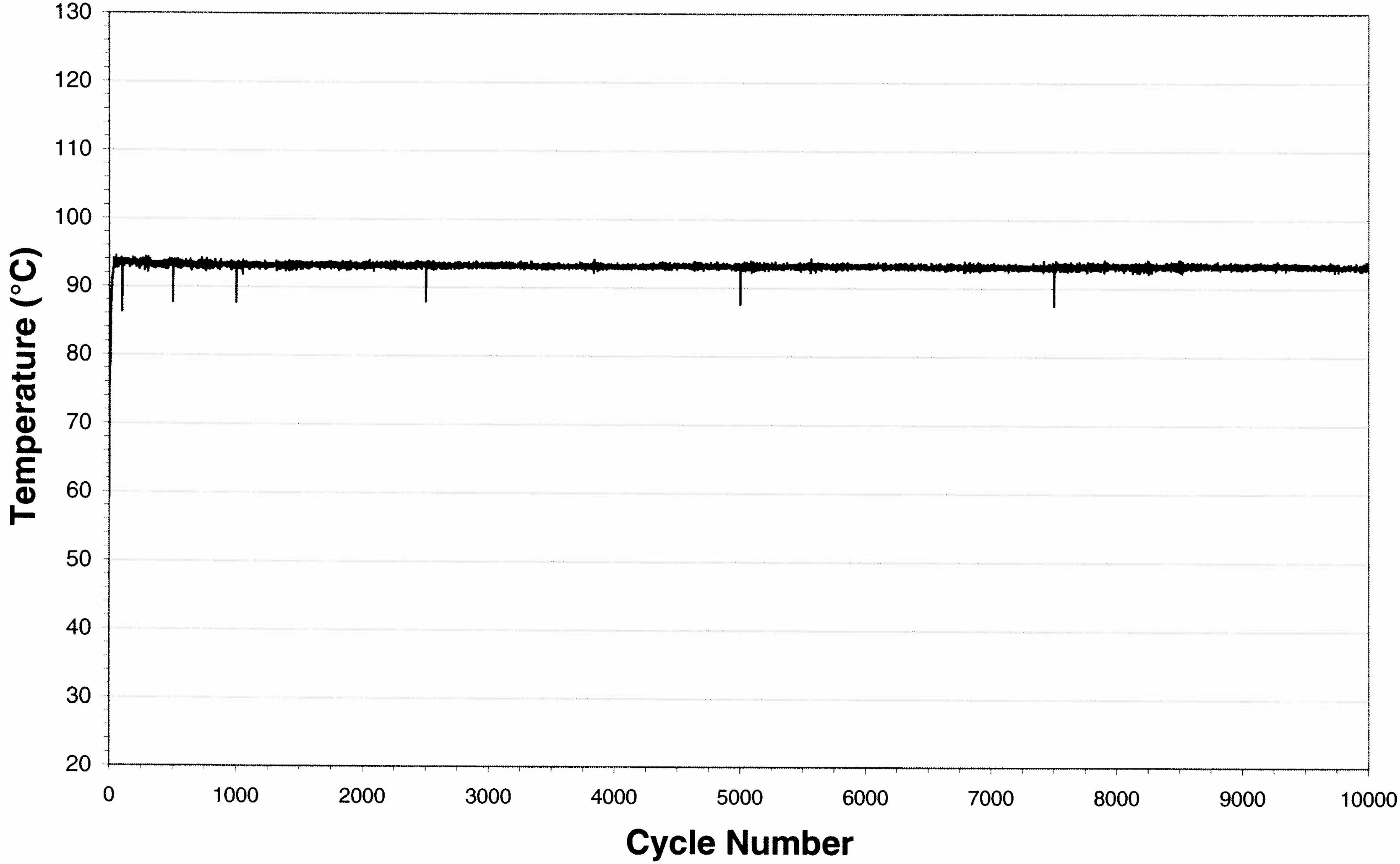
ALLISON HYDRAULIC TRANSMISSION FLUID
TYPE C-4 PAPER FRICTION TEST

Fluid Code: AL-27877-L **Test Number: C2-2-1484**



C2-2-1484 AL-27877-L

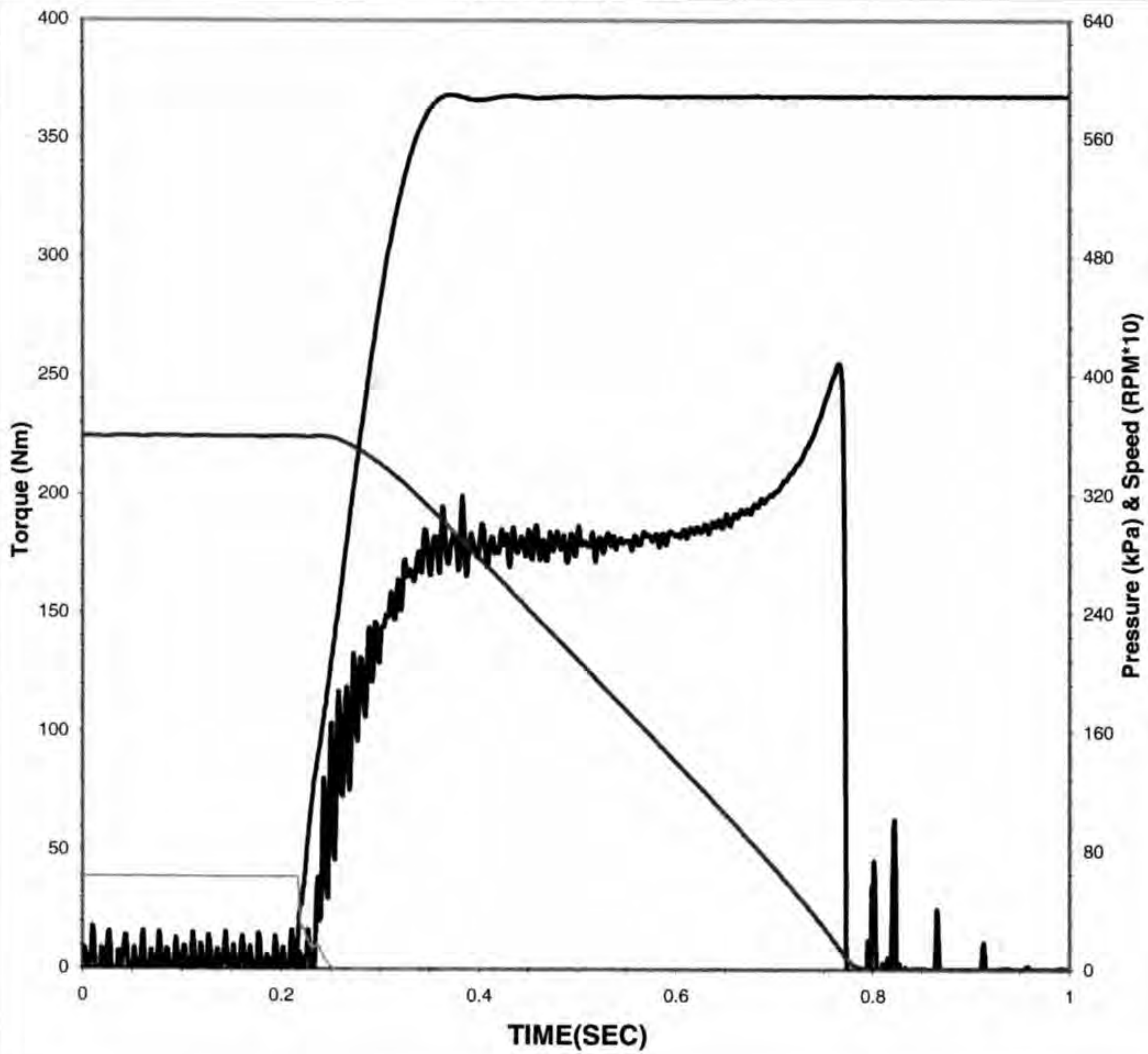
Temp: Max=94.5°C Min=59.2°C Avg=93.1°C



DYNAMIC TRACES

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/10/2007
Time of Test:	21:53:24
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	10
Temperature:	82.4 °C (93.3 ± 3.0 °C)
Apply Pressure:	589 kPa (586 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	18.3 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.557 Sec

Torque

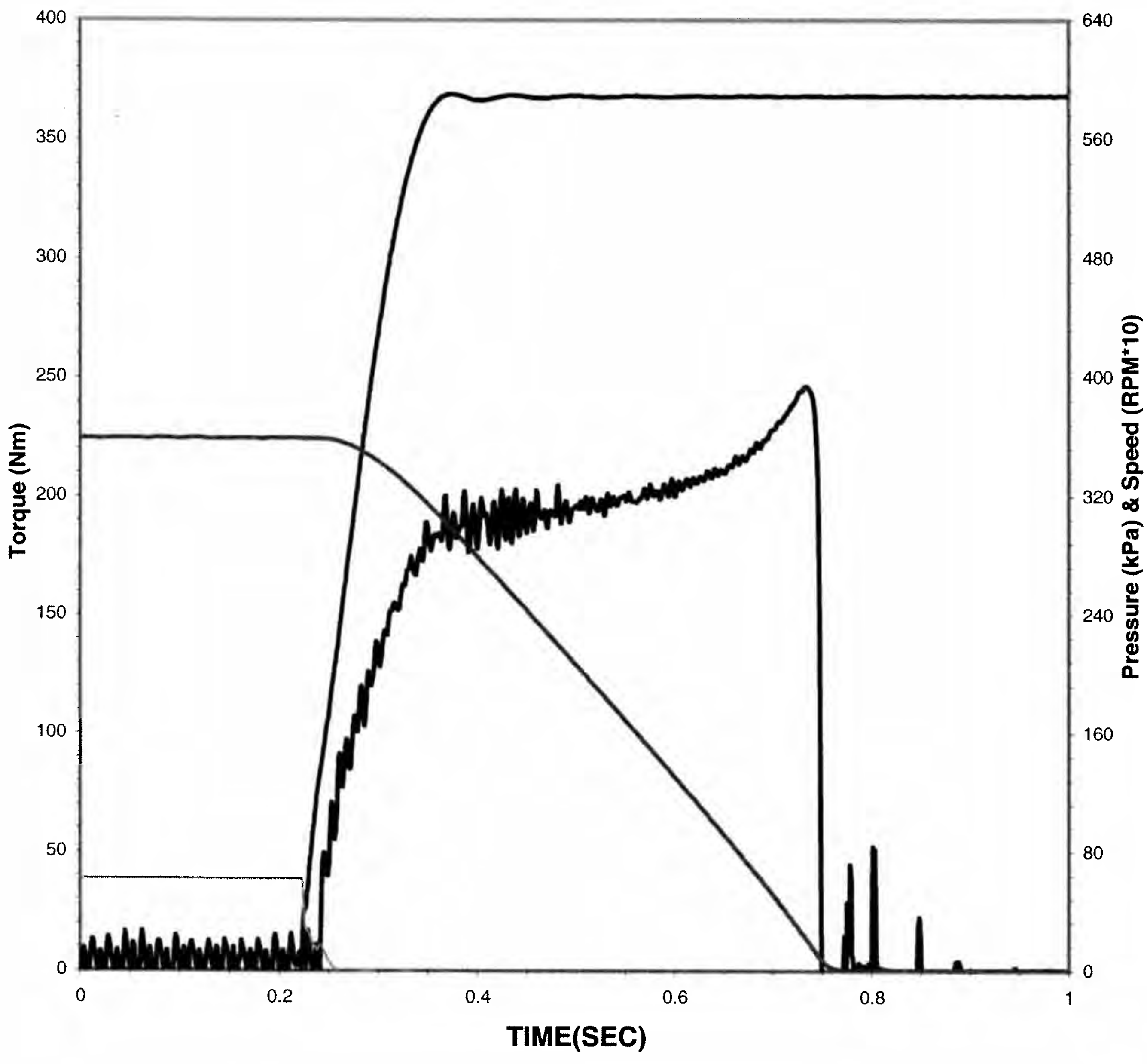
0.2 Sec Dyn:	180 N*m
Midpoint Dyn:	180 N*m
LwSpd Dynamic:	246 N*m

Coefficient of Friction

.2 Sec Dyn:	0.088
Midpoint Dyn:	0.088
LwSpd Dynamic:	0.120

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/10/2007
Time of Test:	22:15:55
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	99
Temperature:	93.8 °C (93.3 ± 3.0 °C)
Apply Pressure:	589 kPa (586 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	18.4 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.526 Sec

Torque

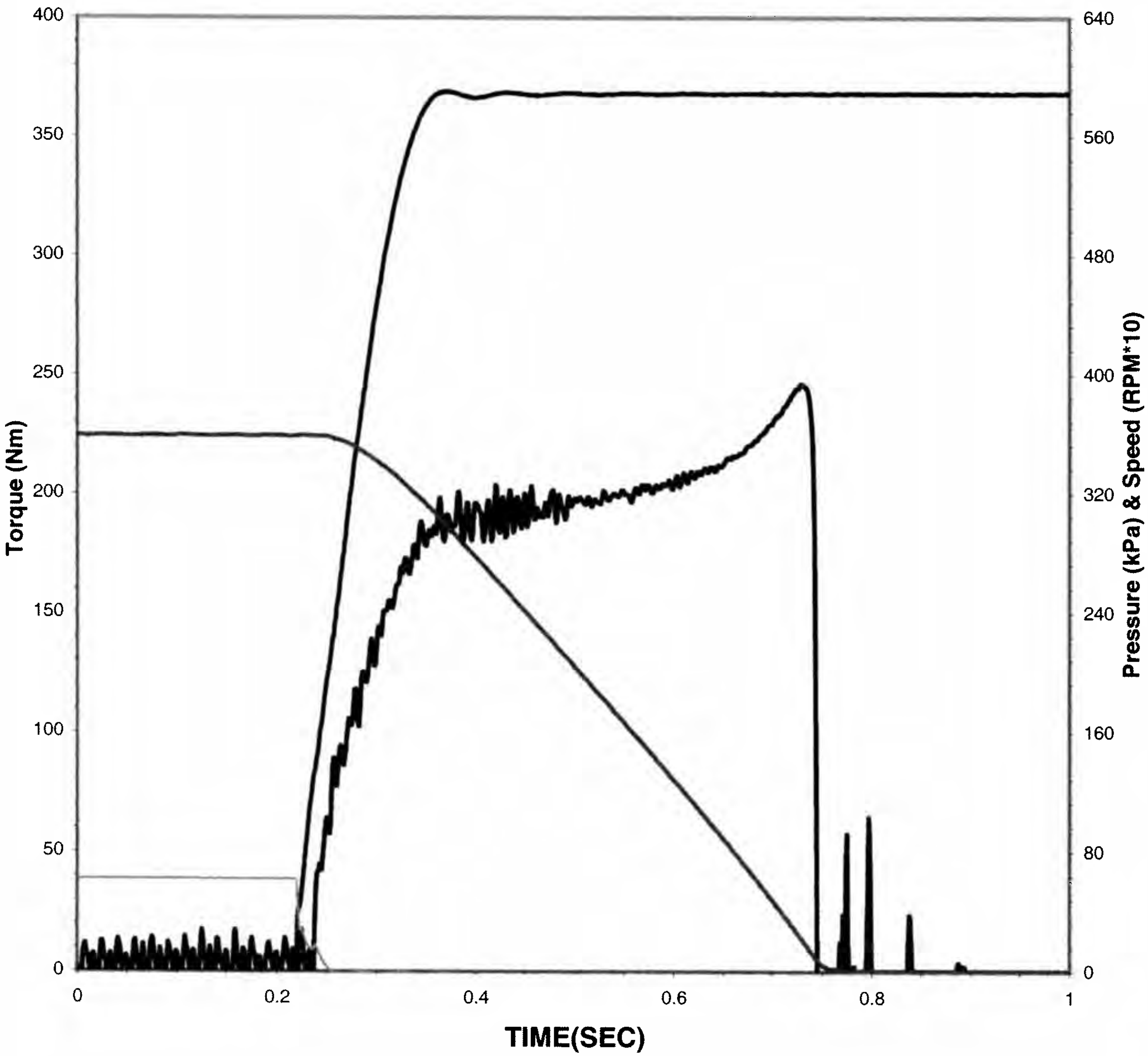
0.2 Sec Dyn:	192 N*m
Midpoint Dyn:	195 N*m
LwSpd Dynamic:	230 N*m

Coefficient of Friction

.2 Sec Dyn:	0.094
Midpoint Dyn:	0.095
LwSpd Dynamic:	0.112

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/10/2007
Time of Test:	22:16:10
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	100
Temperature:	93.7 °C (93.3 ± 3.0 °C)
Apply Pressure:	590 kPa (586 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	18.4 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.525 Sec

Torque

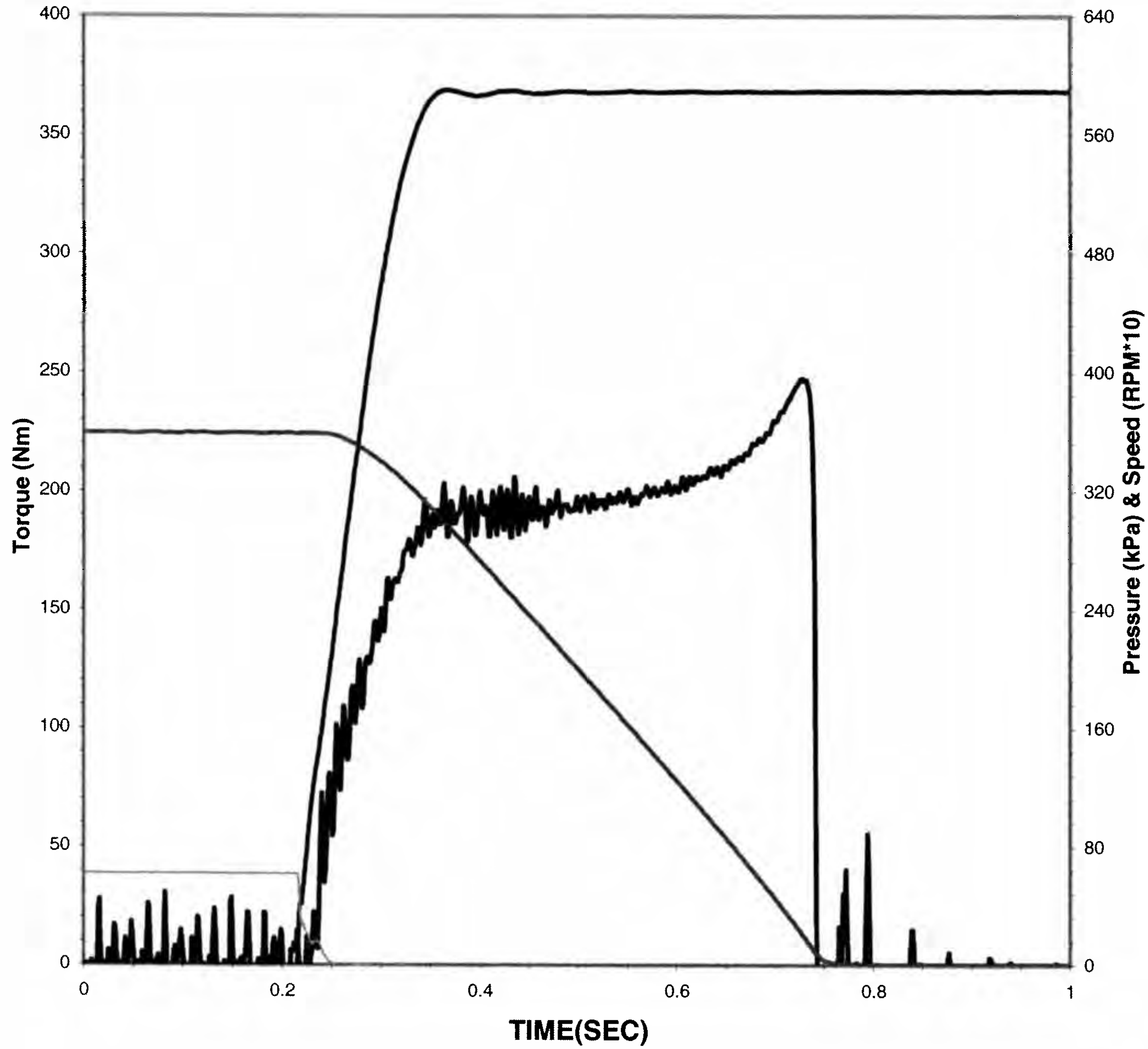
0.2 Sec Dyn:	192 N*m
Midpoint Dyn:	195 N*m
LwSpd Dynamic:	230 N*m

Coefficient of Friction

.2 Sec Dyn:	0.094
Midpoint Dyn:	0.095
LwSpd Dynamic:	0.112

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/10/2007
Time of Test:	22:16:41
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	101
Temperature:	86.2 °C (93.3 ± 3.0 °C)
Apply Pressure:	589 kPa (586 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	18.4 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.527 Sec

Torque

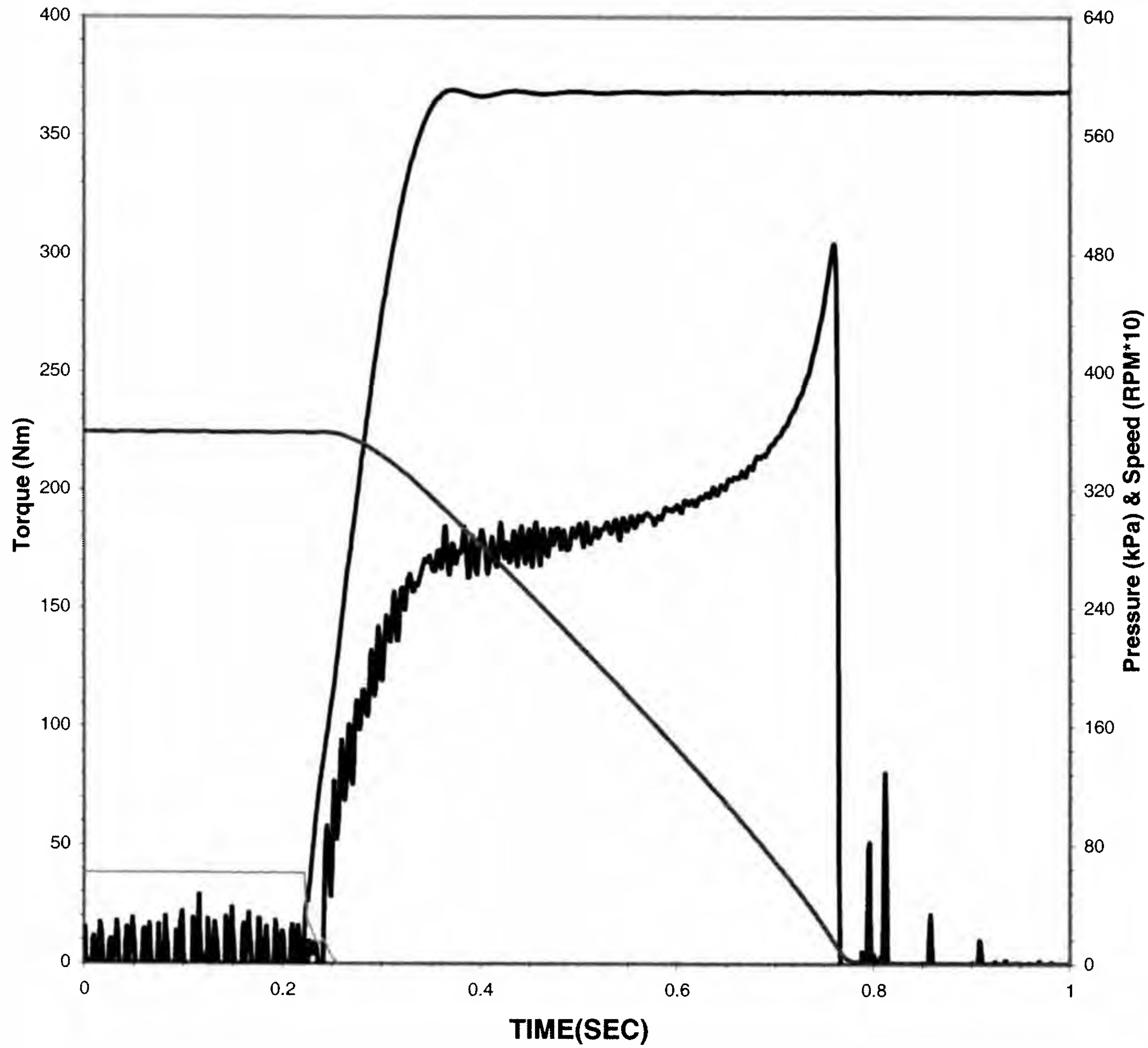
0.2 Sec Dyn:	191 N*m
Midpoint Dyn:	194 N*m
LwSpd Dynamic:	237 N*m

Coefficient of Friction

.2 Sec Dyn:	0.093
Midpoint Dyn:	0.094
LwSpd Dynamic:	0.115

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/10/2007
Time of Test:	23:56:11
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	499
Temperature:	93.7 °C (93.3 ± 3.0 °C)
Apply Pressure:	590 kPa (586 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	18.4 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.545 Sec

Torque

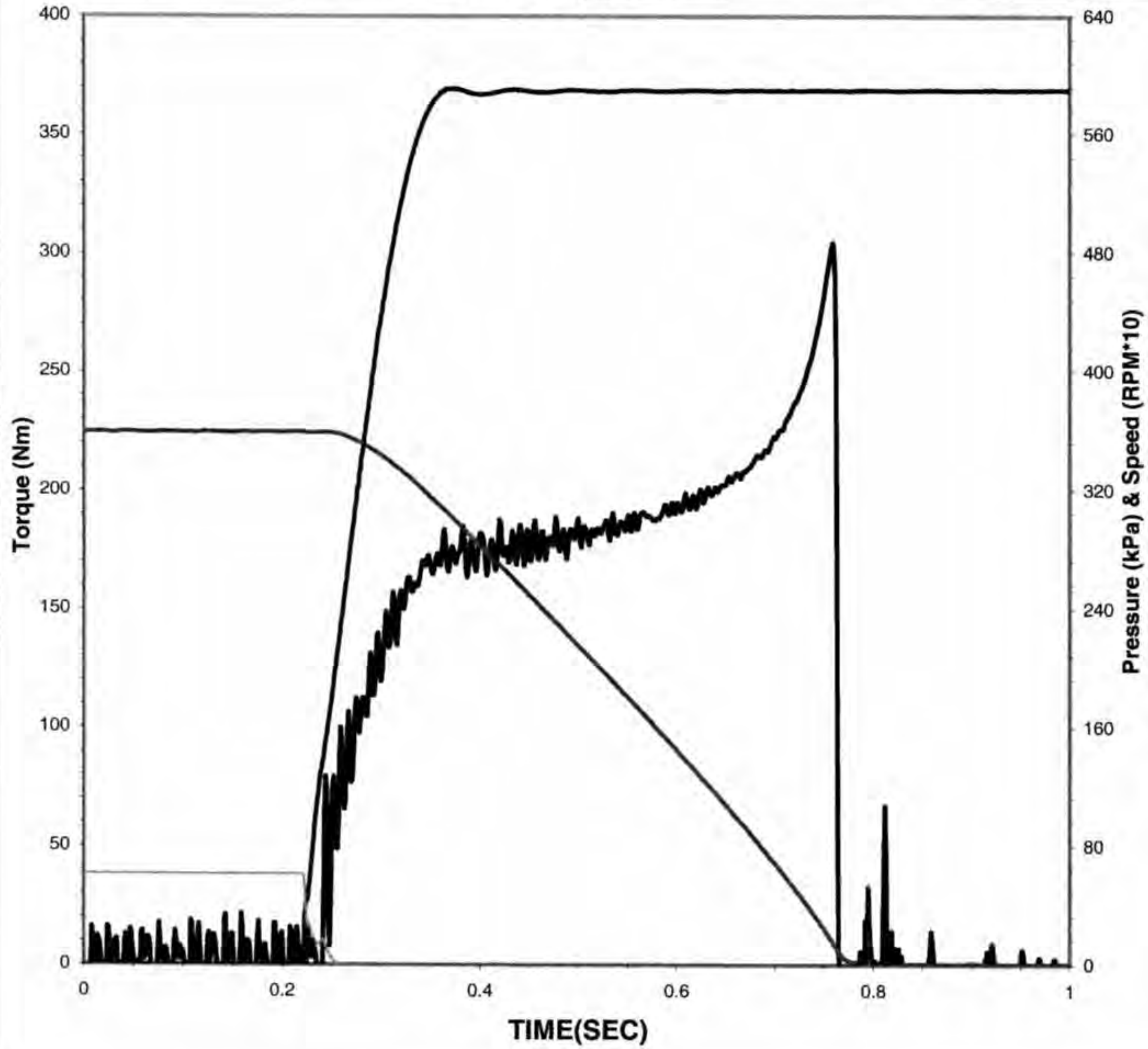
0.2 Sec Dyn:	176 N*m
Midpoint Dyn:	181 N*m
LwSpd Dynamic:	302 N*m

Coefficient of Friction

.2 Sec Dyn:	0.085
Midpoint Dyn:	0.088
LwSpd Dynamic:	0.147

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/10/2007
Time of Test:	23:56:26
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	500
Temperature:	93.0 °C (93.3 ± 3.0 °C)
Apply Pressure:	590 kPa (586 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	18.4 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.544 Sec

Torque

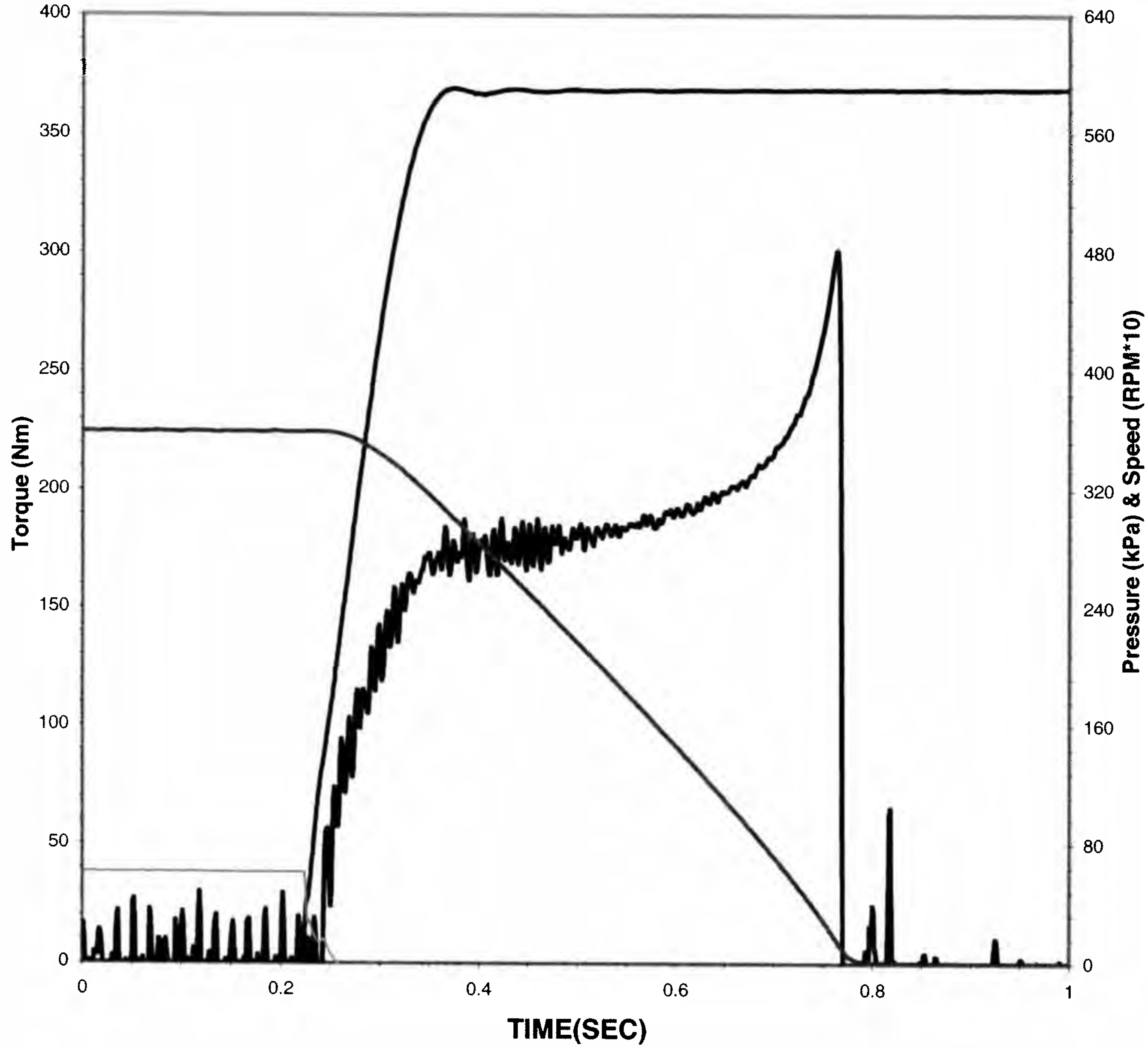
0.2 Sec Dyn:	176 N*m
Midpoint Dyn:	182 N*m
LwSpd Dynamic:	303 N*m

Coefficient of Friction

.2 Sec Dyn:	0.086
Midpoint Dyn:	0.088
LwSpd Dynamic:	0.147

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/10/2007
Time of Test:	23:56:58
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	501
Temperature:	87.6 °C (93.3 ± 3.0 °C)
Apply Pressure:	590 kPa (586 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	18.4 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.547 Sec

Torque

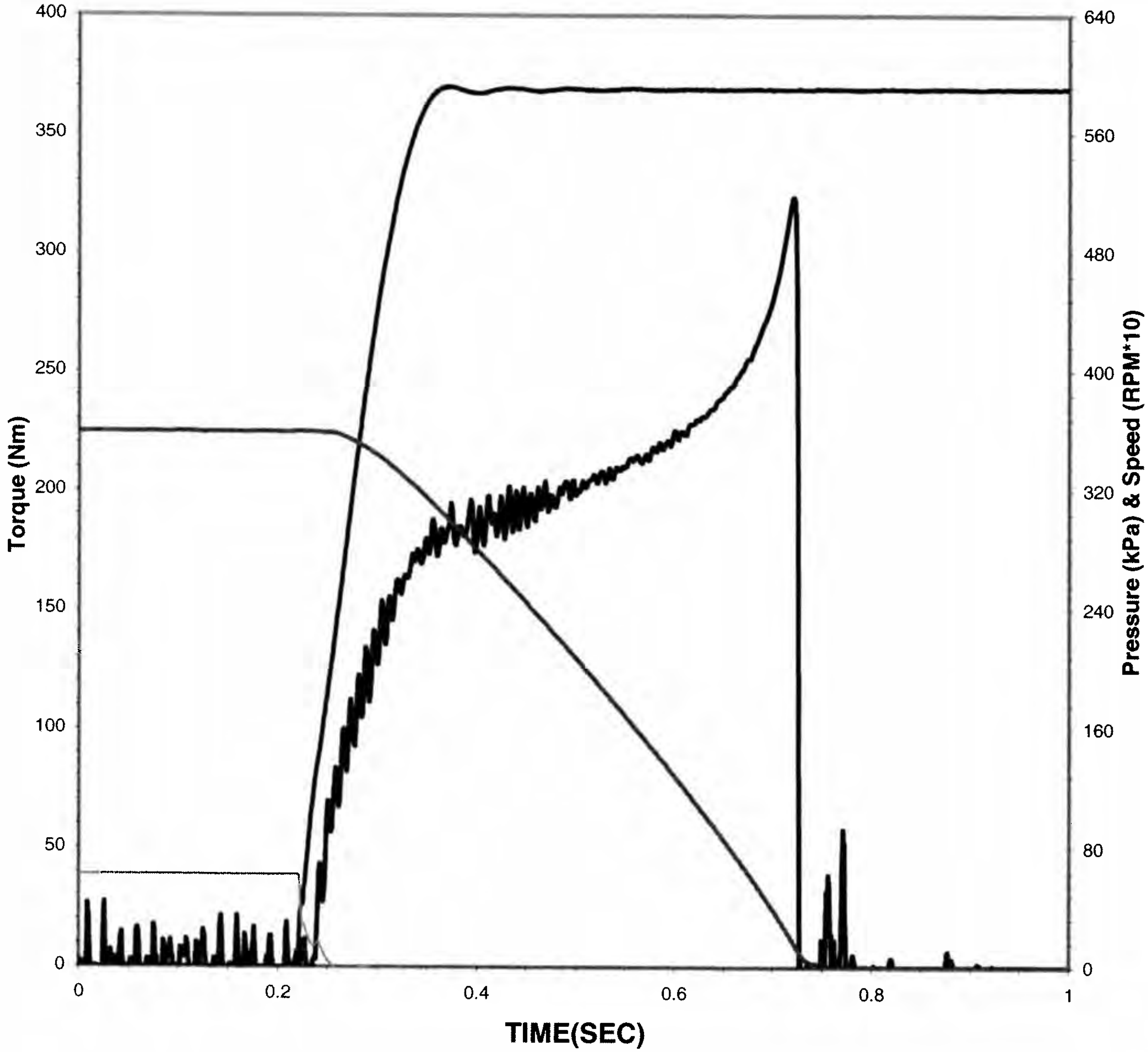
0.2 Sec Dyn:	175 N*m
Midpoint Dyn:	181 N*m
LwSpd Dynamic:	300 N*m

Coefficient of Friction

.2 Sec Dyn:	0.085
Midpoint Dyn:	0.088
LwSpd Dynamic:	0.146

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/11/2007
Time of Test:	2:01:28
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	999
Temperature:	93.1 °C (93.3 ± 3.0 °C)
Apply Pressure:	591 kPa (586 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	18.6 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.506 Sec

Torque

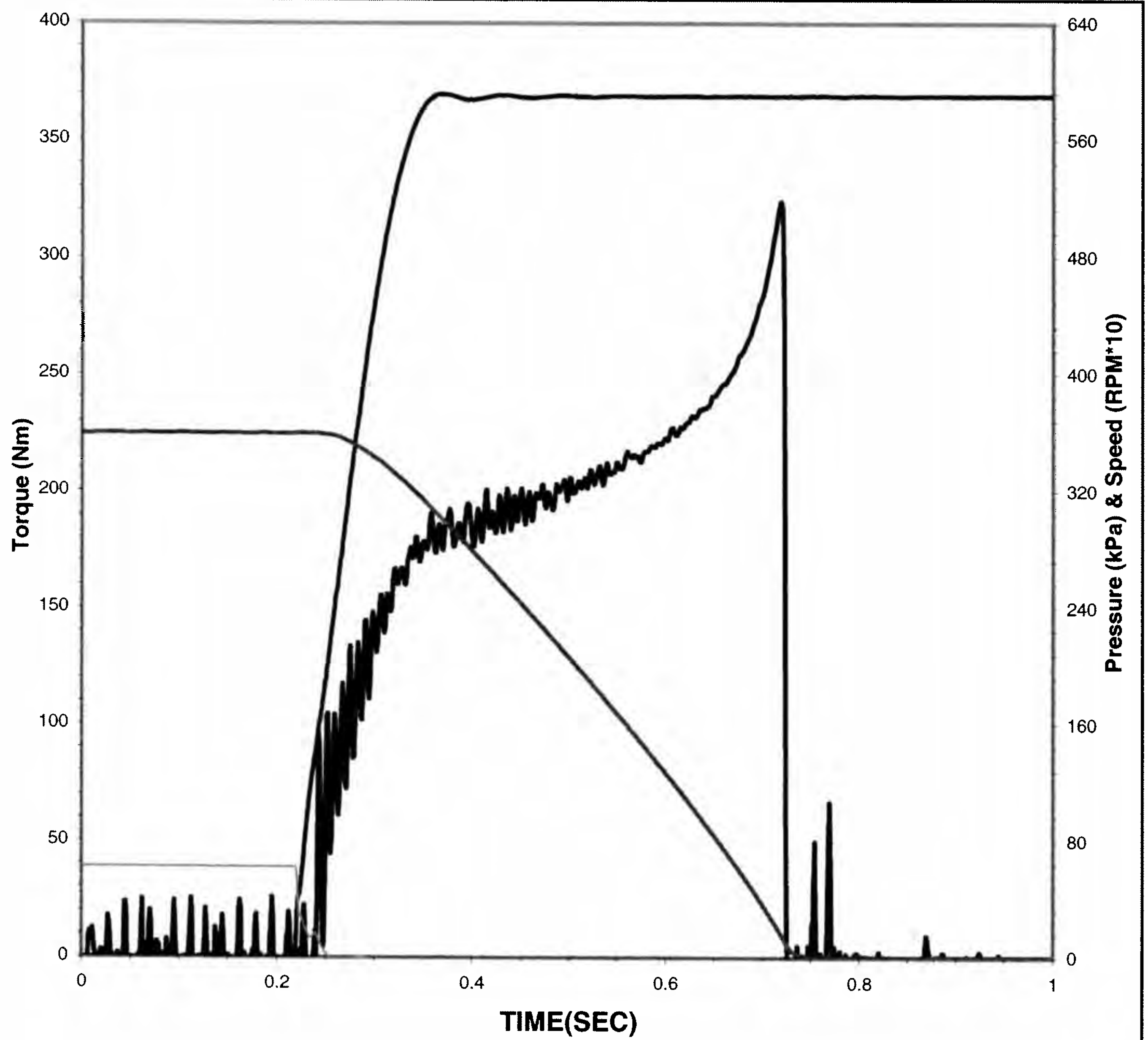
0.2 Sec Dyn:	188 N*m
Midpoint Dyn:	197 N*m
LwSpd Dynamic:	315 N*m

Coefficient of Friction

.2 Sec Dyn:	0.092
Midpoint Dyn:	0.096
LwSpd Dynamic:	0.153

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/11/2007
Time of Test:	2:01:43
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	1000
Temperature:	93.1 °C (93.3 ± 3.0 °C)
Apply Pressure:	590 kPa (586 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	18.5 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.507 Sec

Torque

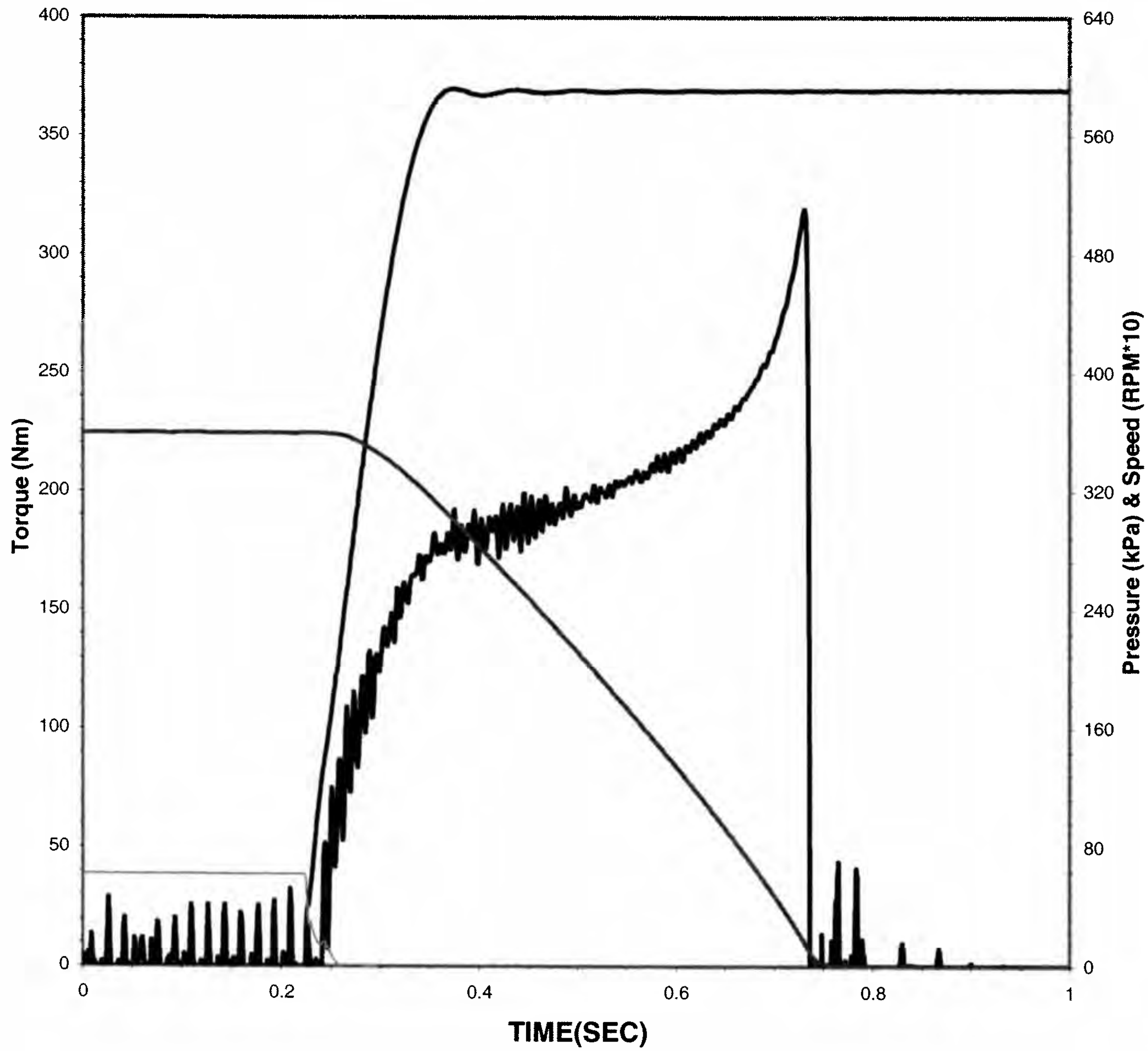
0.2 Sec Dyn:	191 N*m
Midpoint Dyn:	197 N*m
LwSpd Dynamic:	322 N*m

Coefficient of Friction

.2 Sec Dyn:	0.093
Midpoint Dyn:	0.096
LwSpd Dynamic:	0.157

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/11/2007
Time of Test:	2:02:14
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	1001
Temperature:	87.6 °C (93.3 ± 3.0 °C)
Apply Pressure:	591 kPa (586 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	18.5 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.512 Sec

Torque

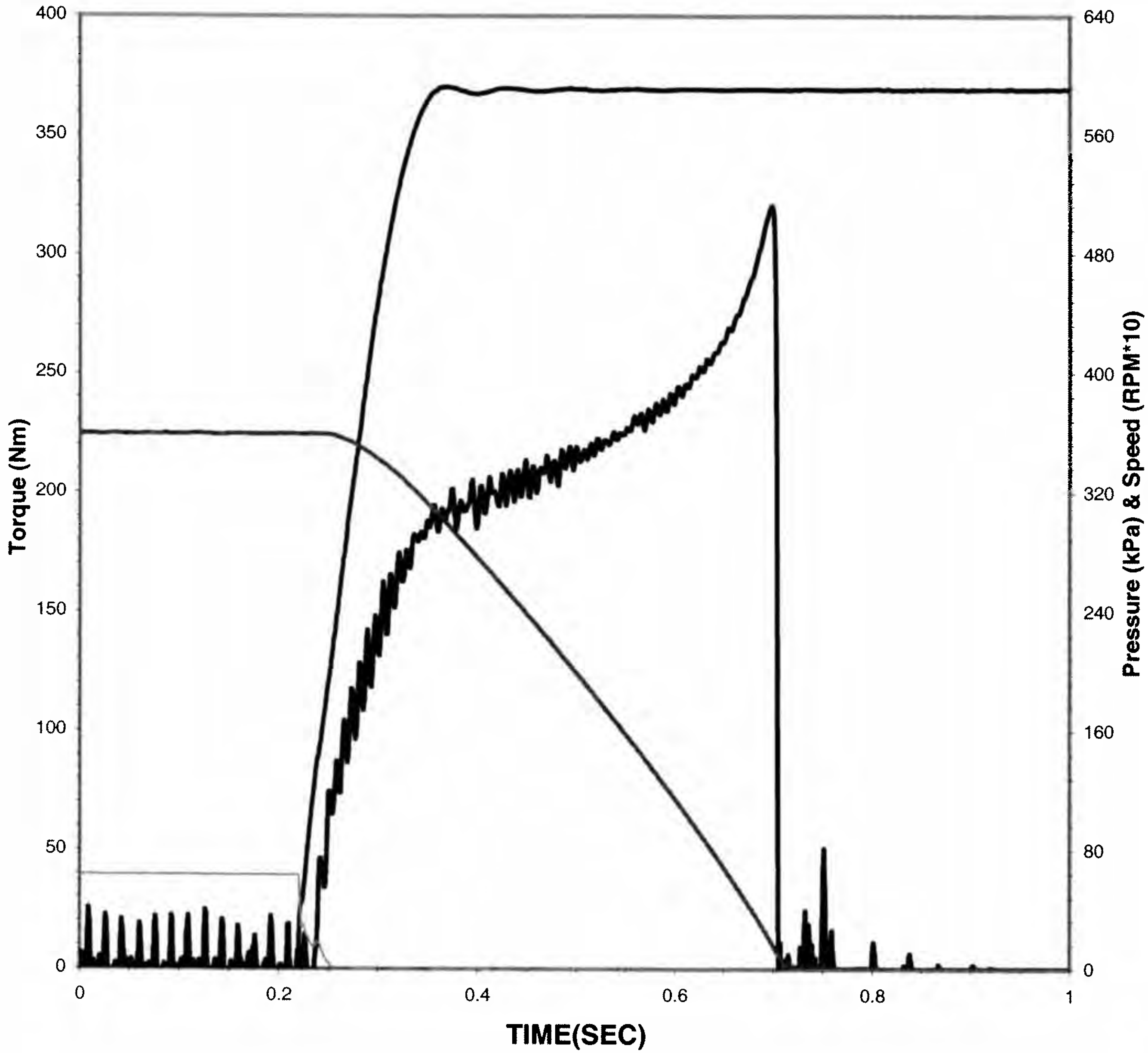
0.2 Sec Dyn:	186 N*m
Midpoint Dyn:	193 N*m
LwSpd Dynamic:	316 N*m

Coefficient of Friction

.2 Sec Dyn:	0.091
Midpoint Dyn:	0.094
LwSpd Dynamic:	0.154

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/11/2007
Time of Test:	8:16:45
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	2499
Temperature:	93.6 °C (93.3 ± 3.0 °C)
Apply Pressure:	591 kPa (586 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	18.6 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.485 Sec

Torque

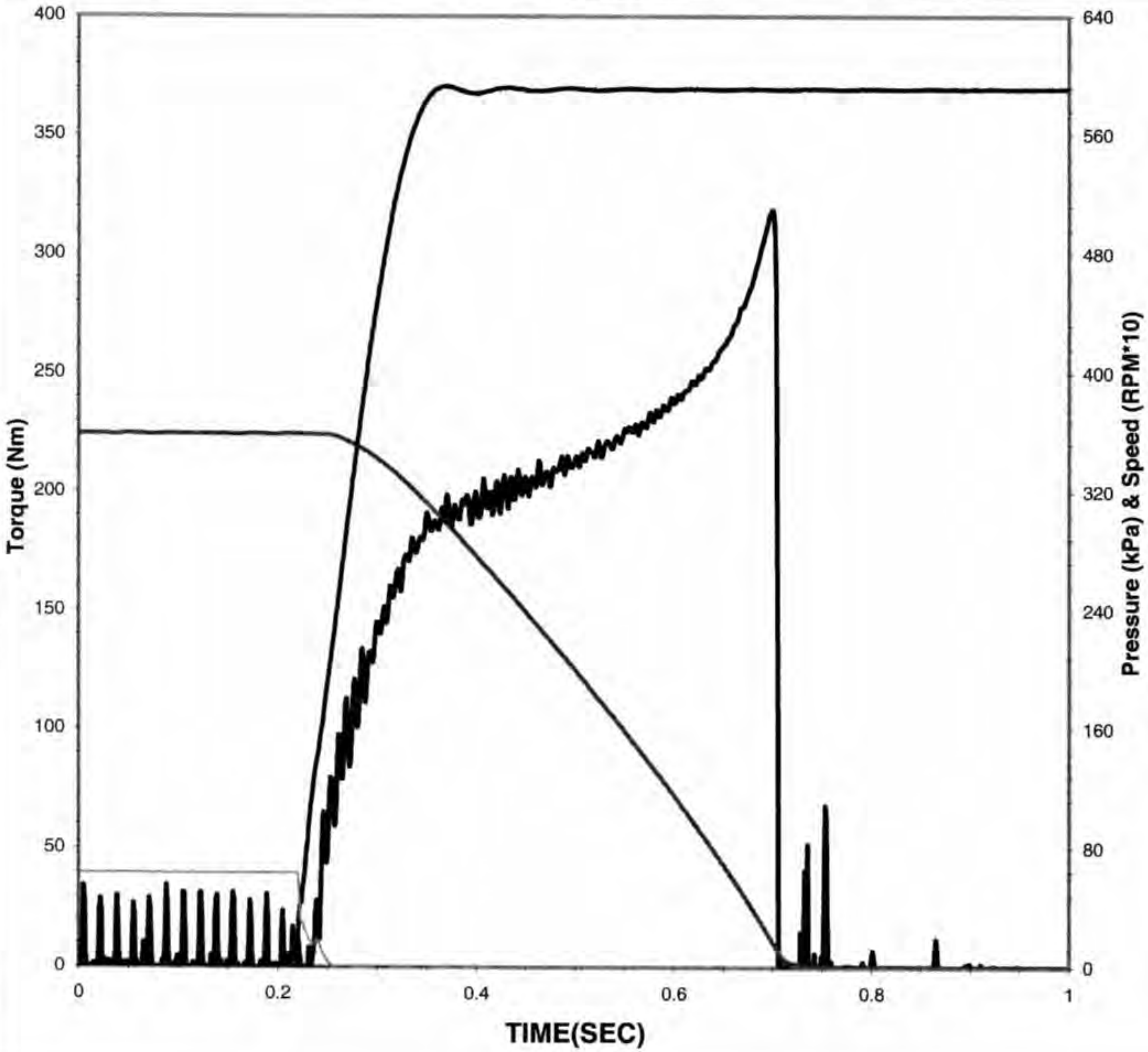
0.2 Sec Dyn:	201 N*m
Midpoint Dyn:	208 N*m
LwSpd Dynamic:	310 N*m

Coefficient of Friction

.2 Sec Dyn:	0.098
Midpoint Dyn:	0.101
LwSpd Dynamic:	0.151

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	**9/11/2007**
Time of Test:	**8:17:00**
Test Number:	**C2-2-1484**
Fluid Code:	**AL-27877-L**
Cycle Number:	**2500**
Temperature:	**93.3 °C** (93.3 ± 3.0 °C)
Apply Pressure:	**591 kPa** (586 ± 7 KPa)
Apply Rate:	**0.13 Sec** (0.15 ± 0.02 Sec)
Energy:	**18.4 KJ** (18.7 ± 0.40 KJ)
Engage Time:	**0.486 Sec**

Torque

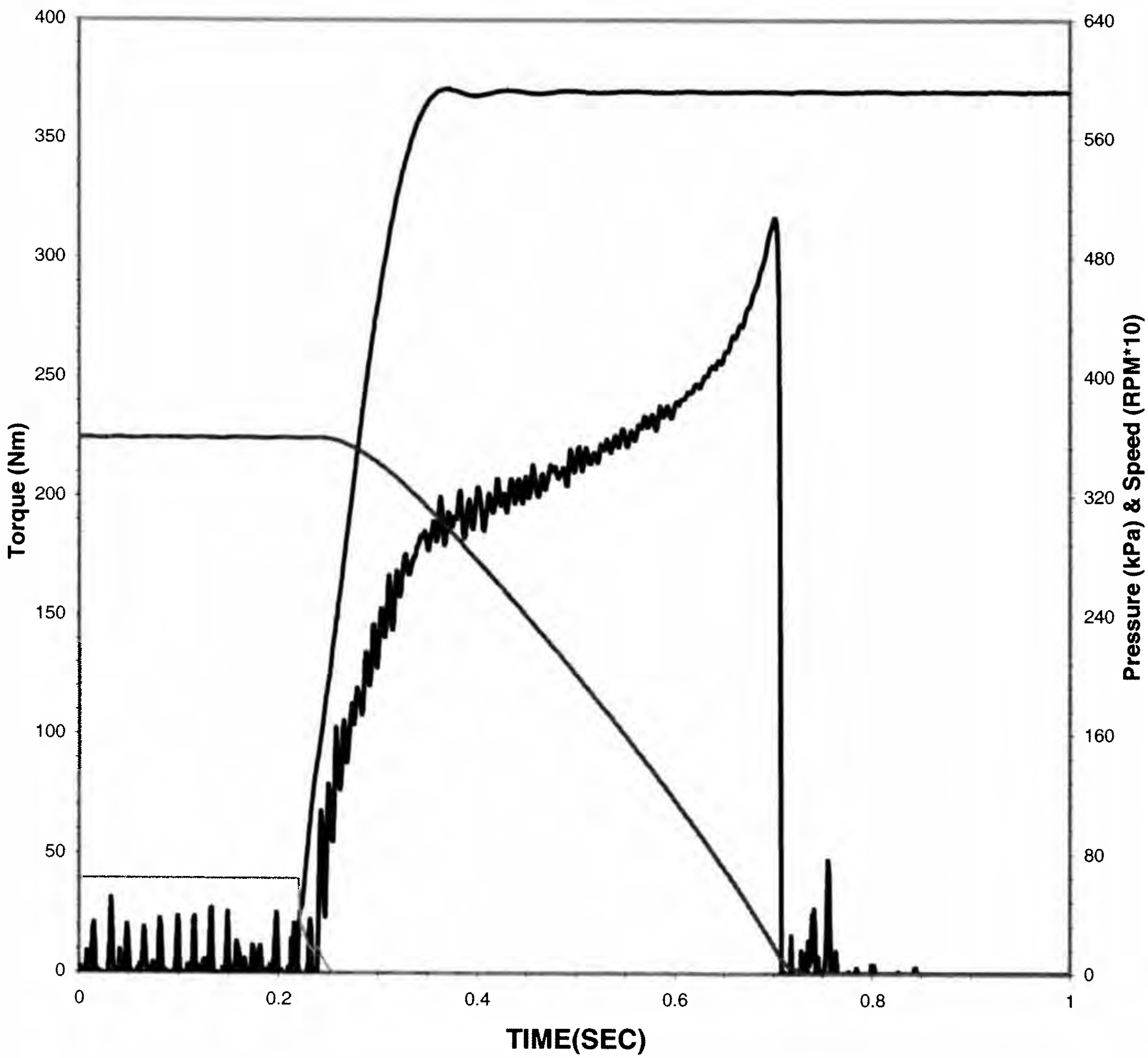
0.2 Sec Dyn:	**200 N*m**
Midpoint Dyn:	**206 N*m**
LwSpd Dynamic:	**309 N*m**

Coefficient of Friction

.2 Sec Dyn:	**0.097**
Midpoint Dyn:	**0.100**
LwSpd Dynamic:	**0.151**

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/11/2007
Time of Test:	8:17:31
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	2501
Temperature:	87.8 °C (93.3 ± 3.0 °C)
Apply Pressure:	592 kPa (586 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.6 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.488 Sec

Torque

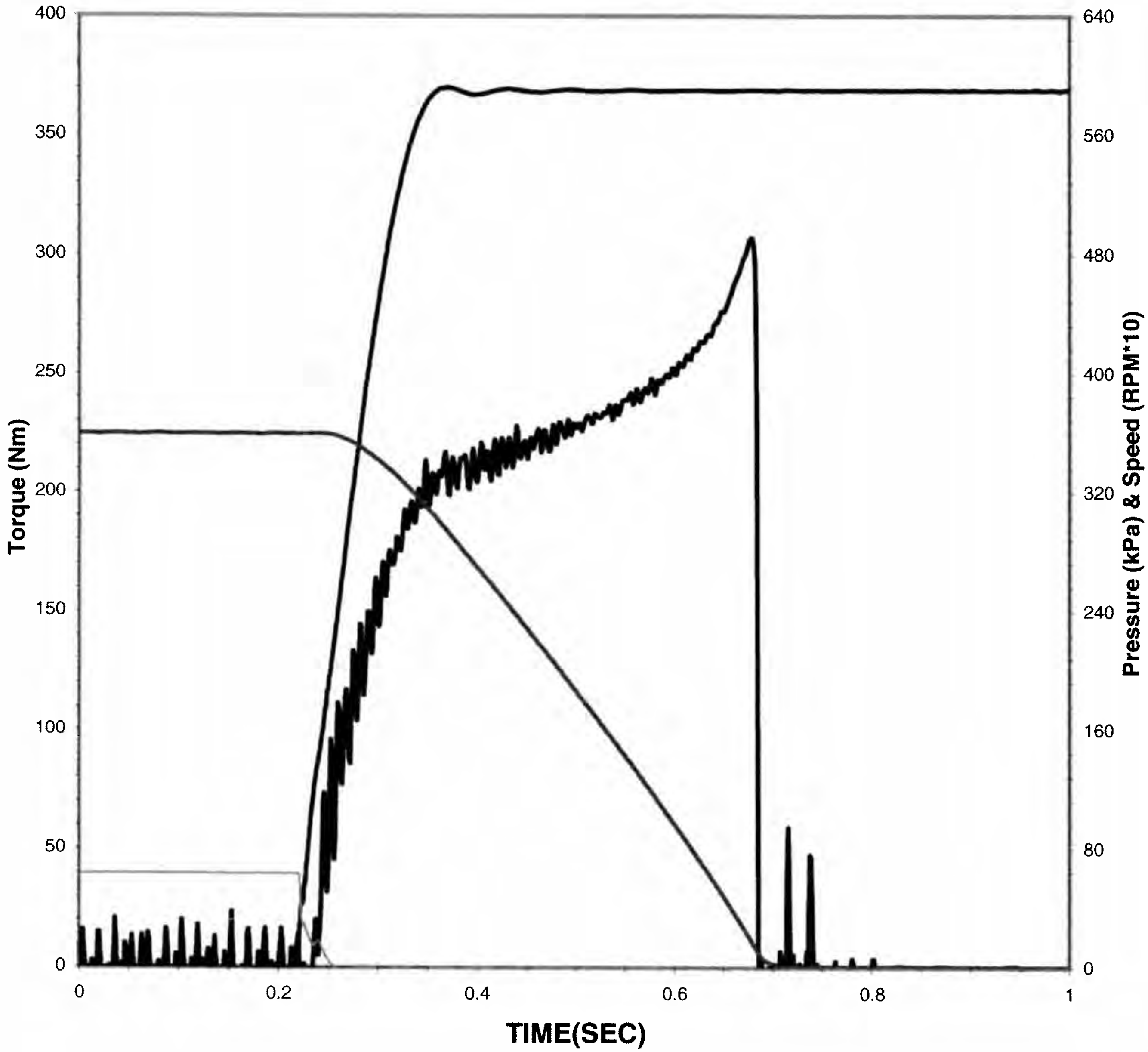
0.2 Sec Dyn:	199 N*m
Midpoint Dyn:	207 N*m
LwSpd Dynamic:	306 N*m

Coefficient of Friction

.2 Sec Dyn:	0.097
Midpoint Dyn:	0.101
LwSpd Dynamic:	0.149

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/11/2007
Time of Test:	18:42:03
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	4999
Temperature:	93.3 °C (93.3 ± 3.0 °C)
Apply Pressure:	590 kPa (586 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.5 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.465 Sec

Torque

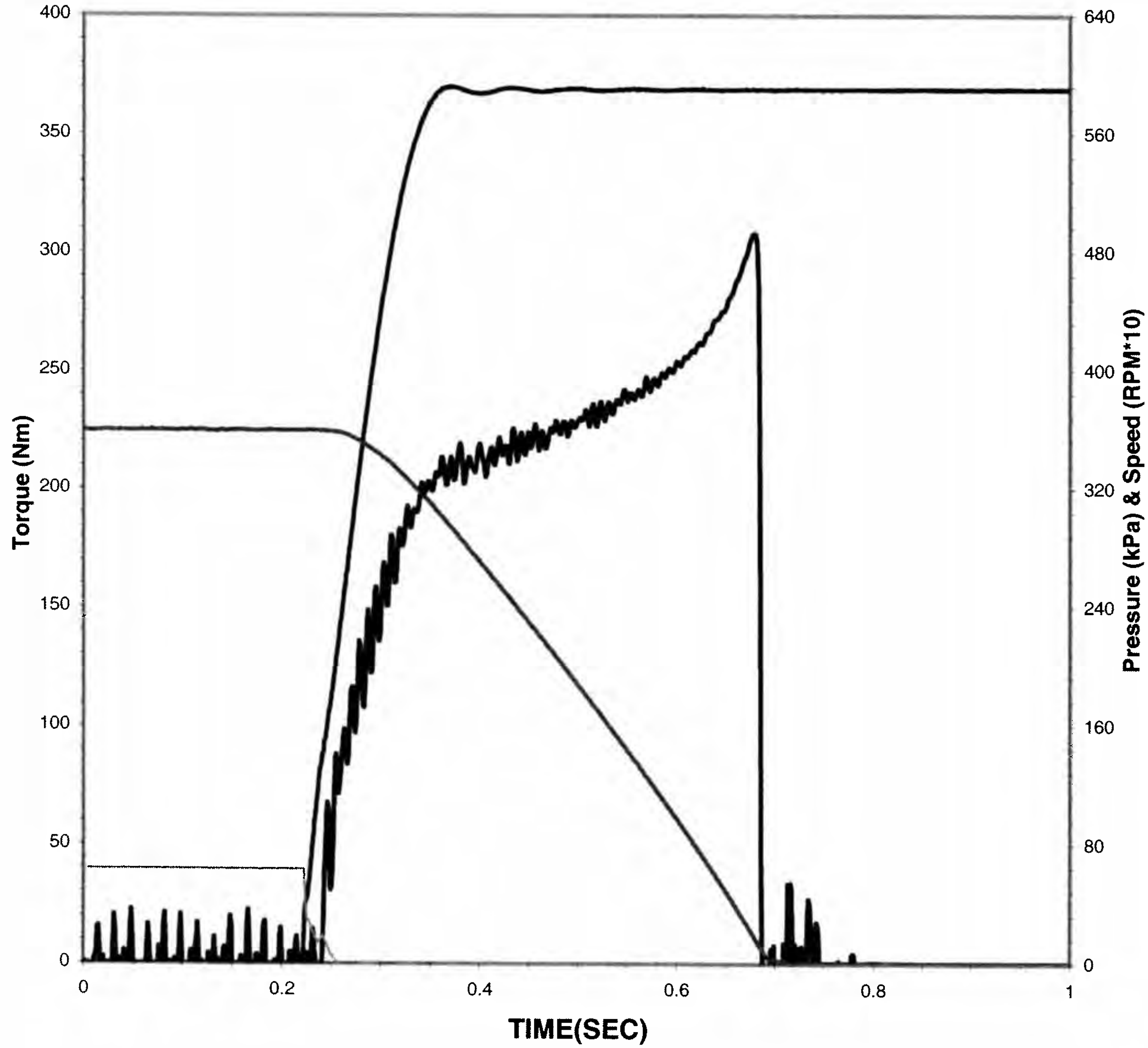
0.2 Sec Dyn:	216 N*m
Midpoint Dyn:	221 N*m
LwSpd Dynamic:	297 N*m

Coefficient of Friction

.2 Sec Dyn:	0.105
Midpoint Dyn:	0.108
LwSpd Dynamic:	0.145

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/11/2007
Time of Test:	18:42:18
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	5000
Temperature:	93.0 °C (93.3 ± 3.0 °C)
Apply Pressure:	591 kPa (586 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	18.6 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.465 Sec

Torque

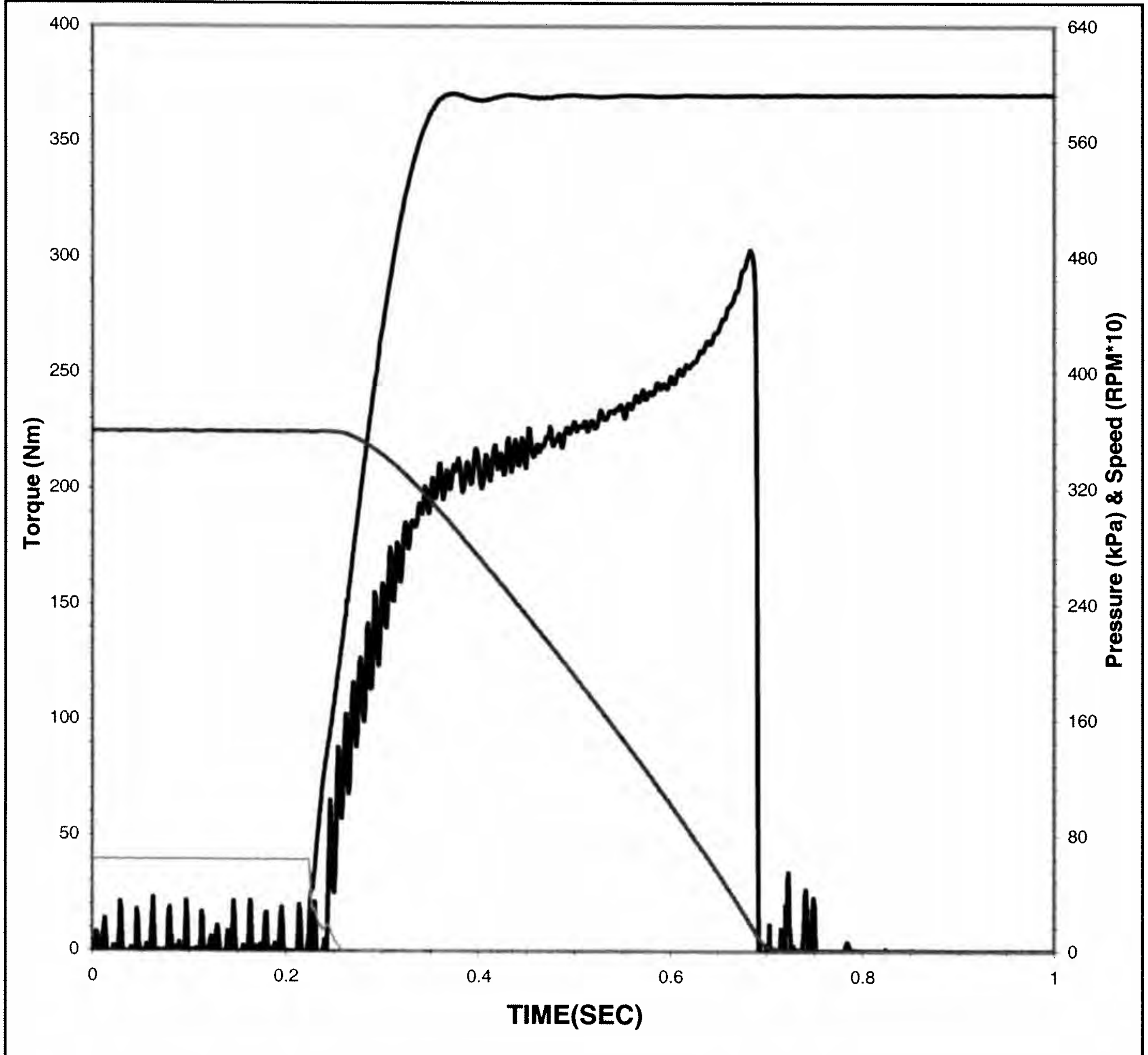
0.2 Sec Dyn:	217 N*m
Midpoint Dyn:	222 N*m
LwSpd Dynamic:	301 N*m

Coefficient of Friction

.2 Sec Dyn:	0.106
Midpoint Dyn:	0.108
LwSpd Dynamic:	0.147

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/11/2007
Time of Test:	18:42:49
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	5001
Temperature:	87.5 °C (93.3 ± 3.0 °C)
Apply Pressure:	592 kPa (586 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.5 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.468 Sec

Torque

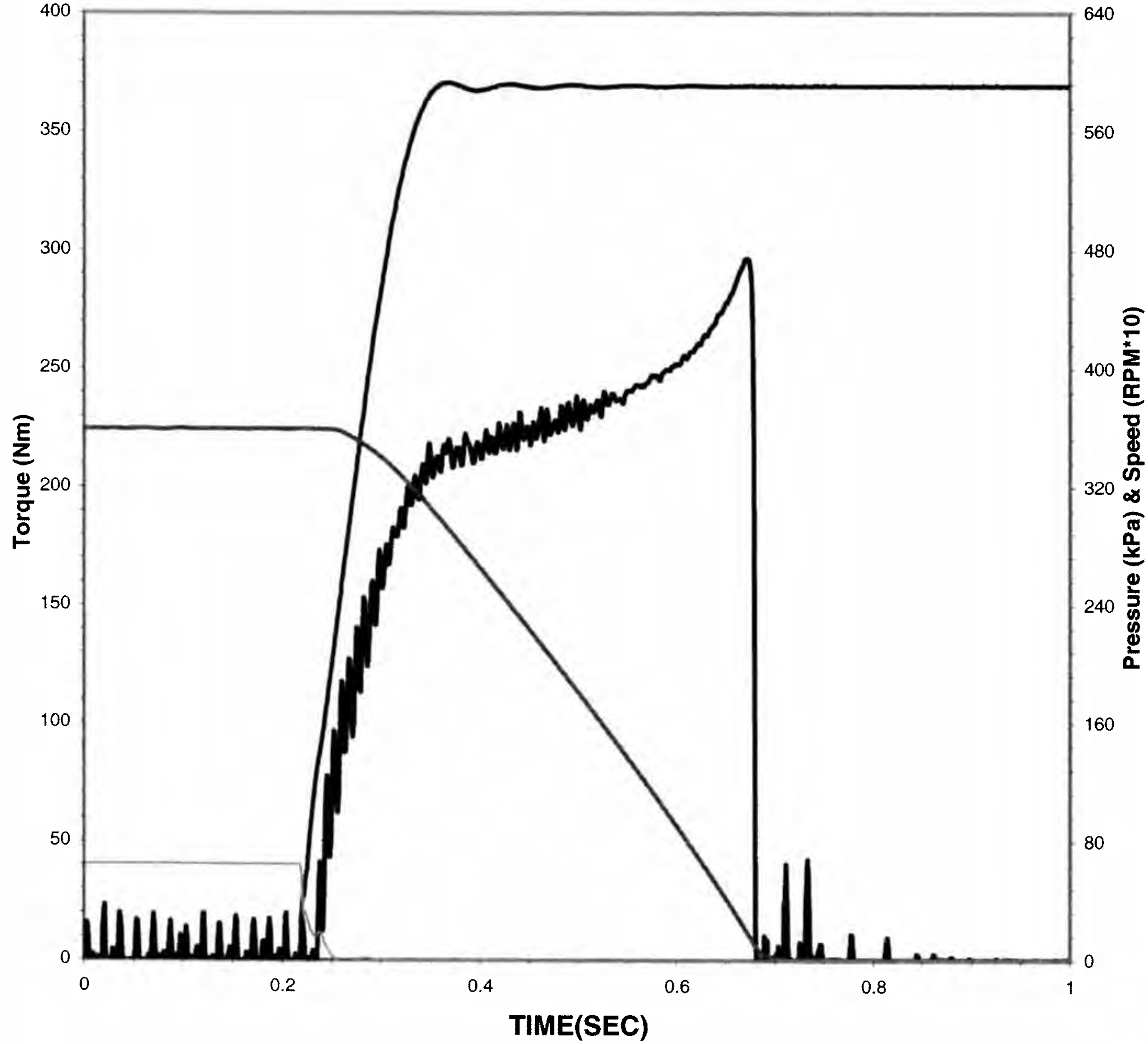
0.2 Sec Dyn:	214 N*m
Midpoint Dyn:	219 N*m
LwSpd Dynamic:	297 N*m

Coefficient of Friction

.2 Sec Dyn:	0.104
Midpoint Dyn:	0.107
LwSpd Dynamic:	0.145

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/12/2007
Time of Test:	5:07:21
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	7499
Temperature:	93.2 °C (93.3 ± 3.0 °C)
Apply Pressure:	592 kPa (586 ± 7 KPa)
Apply Rate:	0.14 Sec (0.15 ± 0.02 Sec)
Energy:	18.6 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.463 Sec

Torque

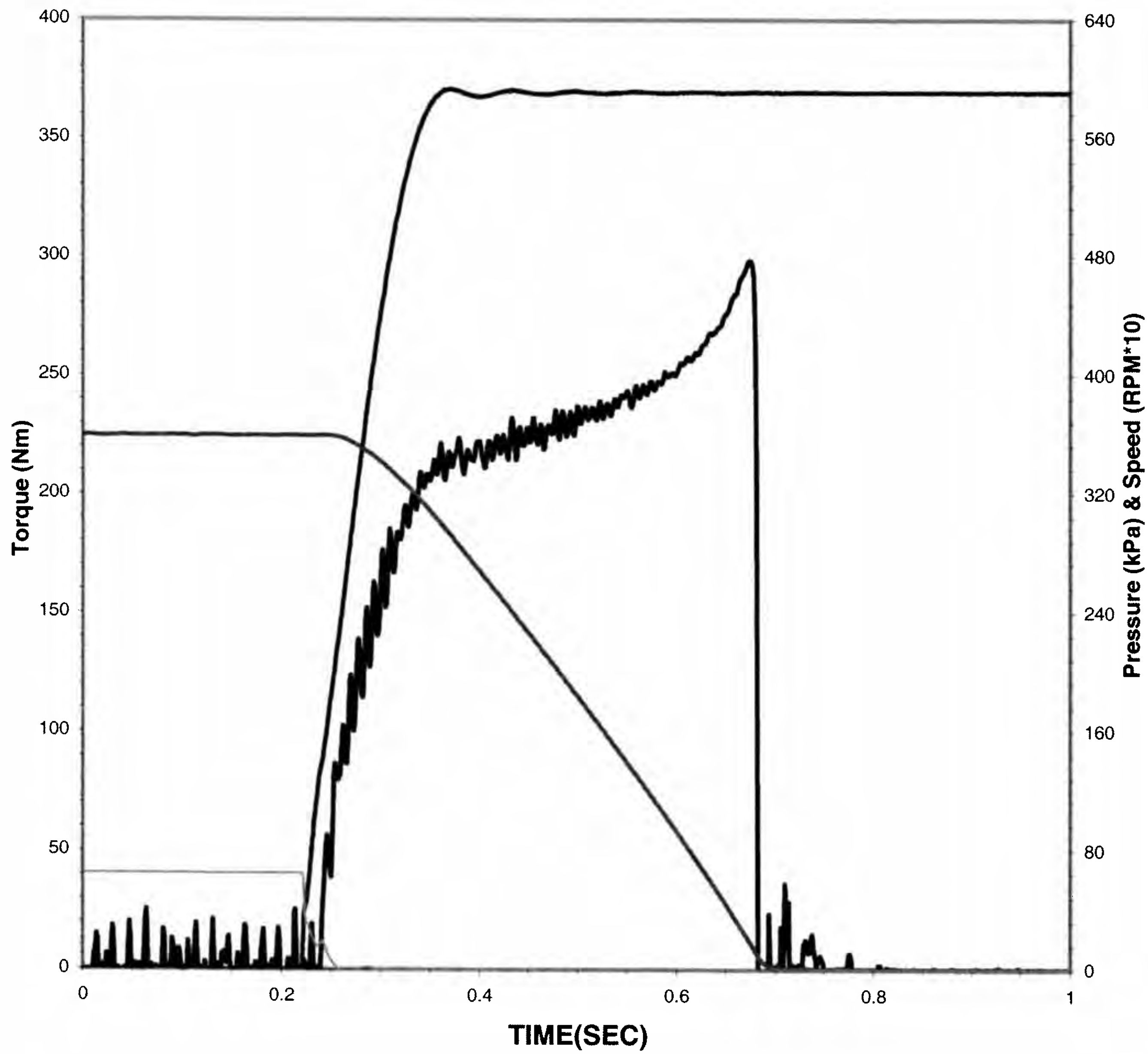
0.2 Sec Dyn:	220 N*m
Midpoint Dyn:	224 N*m
LwSpd Dynamic:	283 N*m

Coefficient of Friction

.2 Sec Dyn:	0.107
Midpoint Dyn:	0.109
LwSpd Dynamic:	0.138

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/12/2007
Time of Test:	5:07:36
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	7500
Temperature:	93.4 °C (93.3 ± 3.0 °C)
Apply Pressure:	592 kPa (586 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.6 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.462 Sec

Torque

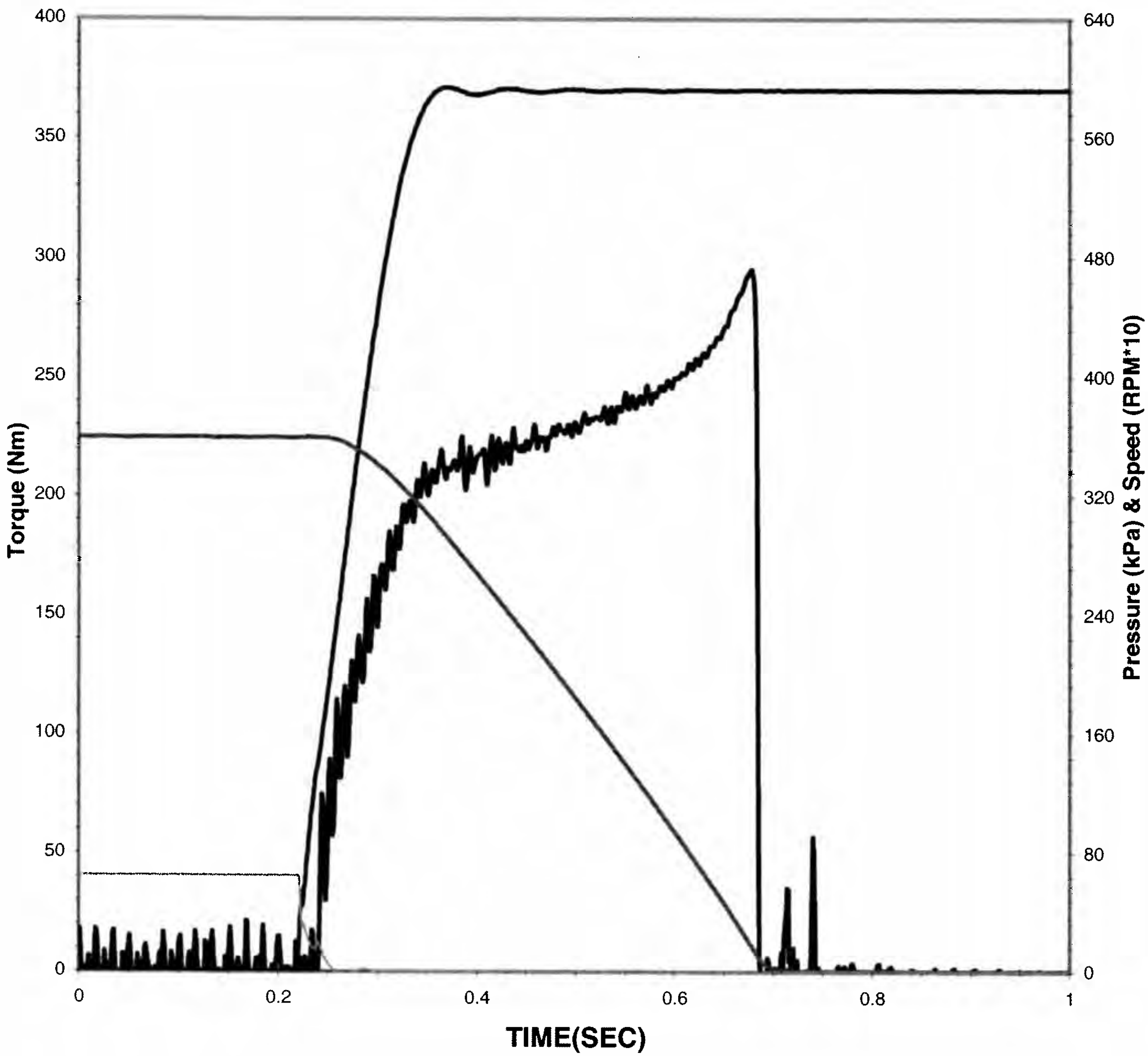
0.2 Sec Dyn:	220 N*m
Midpoint Dyn:	224 N*m
LwSpd Dynamic:	292 N*m

Coefficient of Friction

.2 Sec Dyn:	0.107
Midpoint Dyn:	0.109
LwSpd Dynamic:	0.142

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/12/2007
Time of Test:	5:08:07
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	7501
Temperature:	87.4 °C (93.3 ± 3.0 °C)
Apply Pressure:	592 kPa (586 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.5 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.466 Sec

Torque

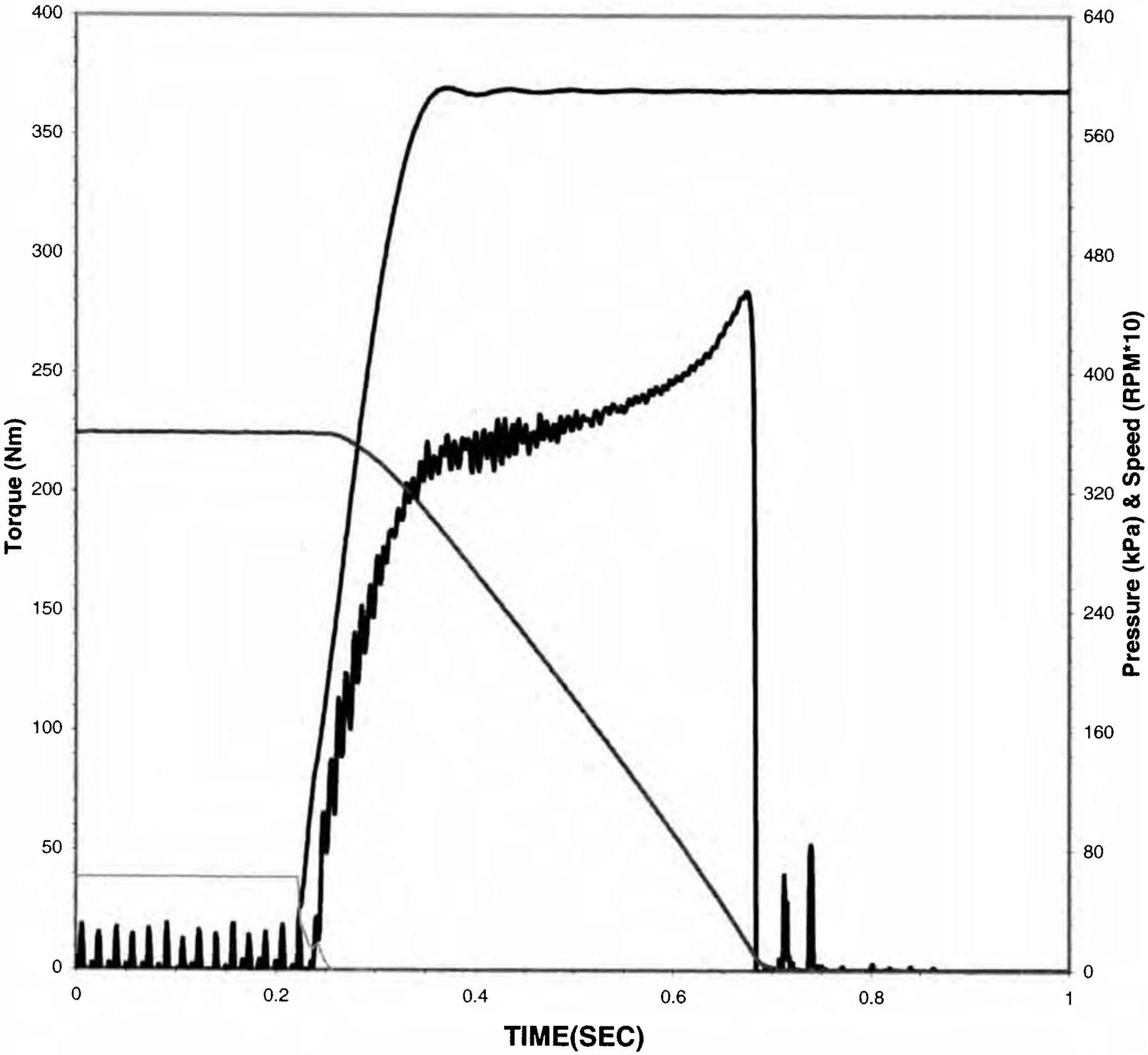
0.2 Sec Dyn:	219 N*m
Midpoint Dyn:	222 N*m
LwSpd Dynamic:	285 N*m

Coefficient of Friction

.2 Sec Dyn:	0.107
Midpoint Dyn:	0.108
LwSpd Dynamic:	0.139

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/12/2007
Time of Test:	15:32:24
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	9998
Temperature:	93.4 °C (93.3 ± 3.0 °C)
Apply Pressure:	590 kPa (586 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.5 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.462 Sec

Torque

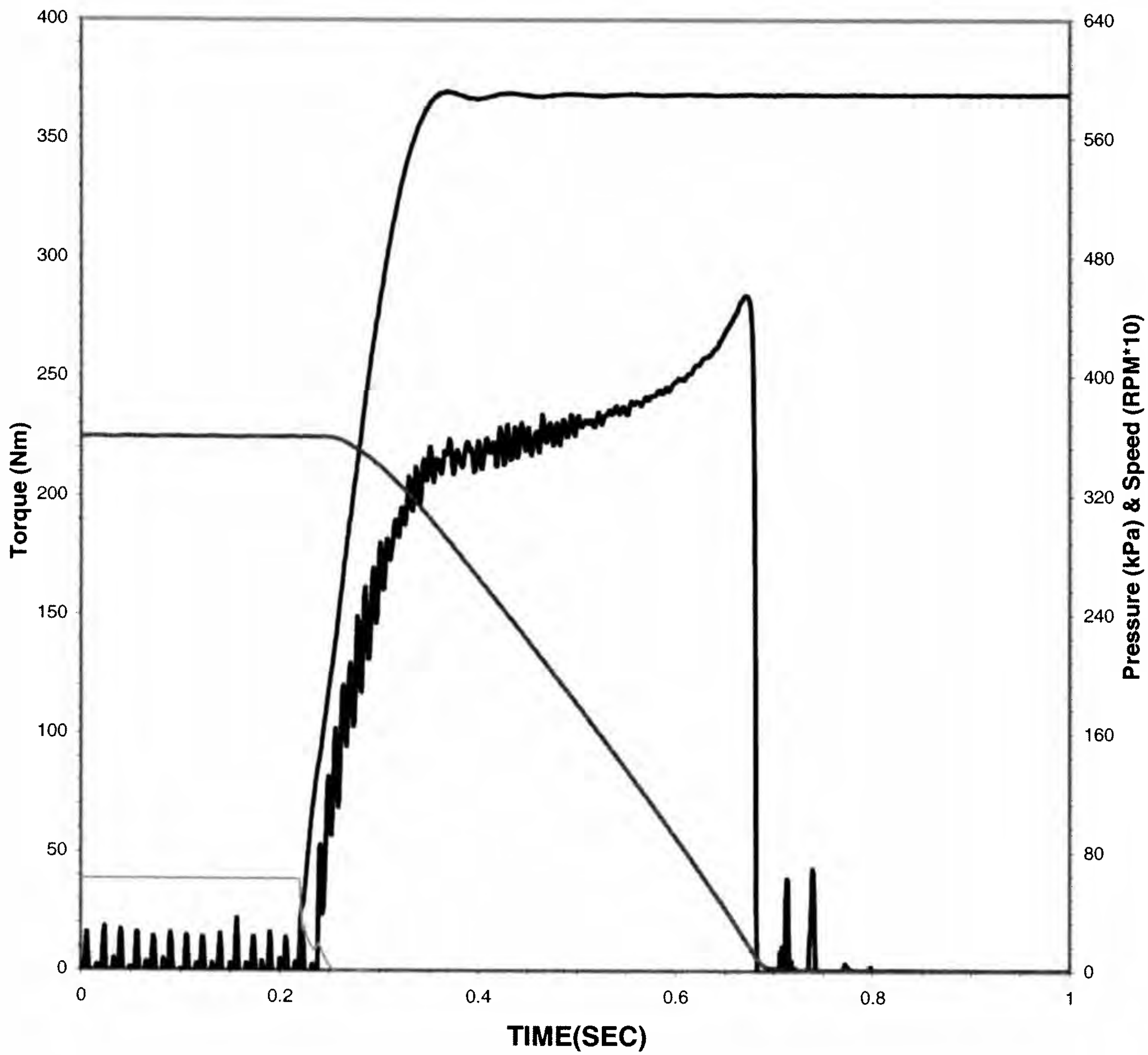
0.2 Sec Dyn:	222 N*m
Midpoint Dyn:	225 N*m
LwSpd Dynamic:	272 N*m

Coefficient of Friction

.2 Sec Dyn:	0.108
Midpoint Dyn:	0.110
LwSpd Dynamic:	0.133

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/12/2007
Time of Test:	15:32:39
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	9999
Temperature:	92.9 °C (93.3 ± 3.0 °C)
Apply Pressure:	590 kPa (586 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.6 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.463 Sec

Torque

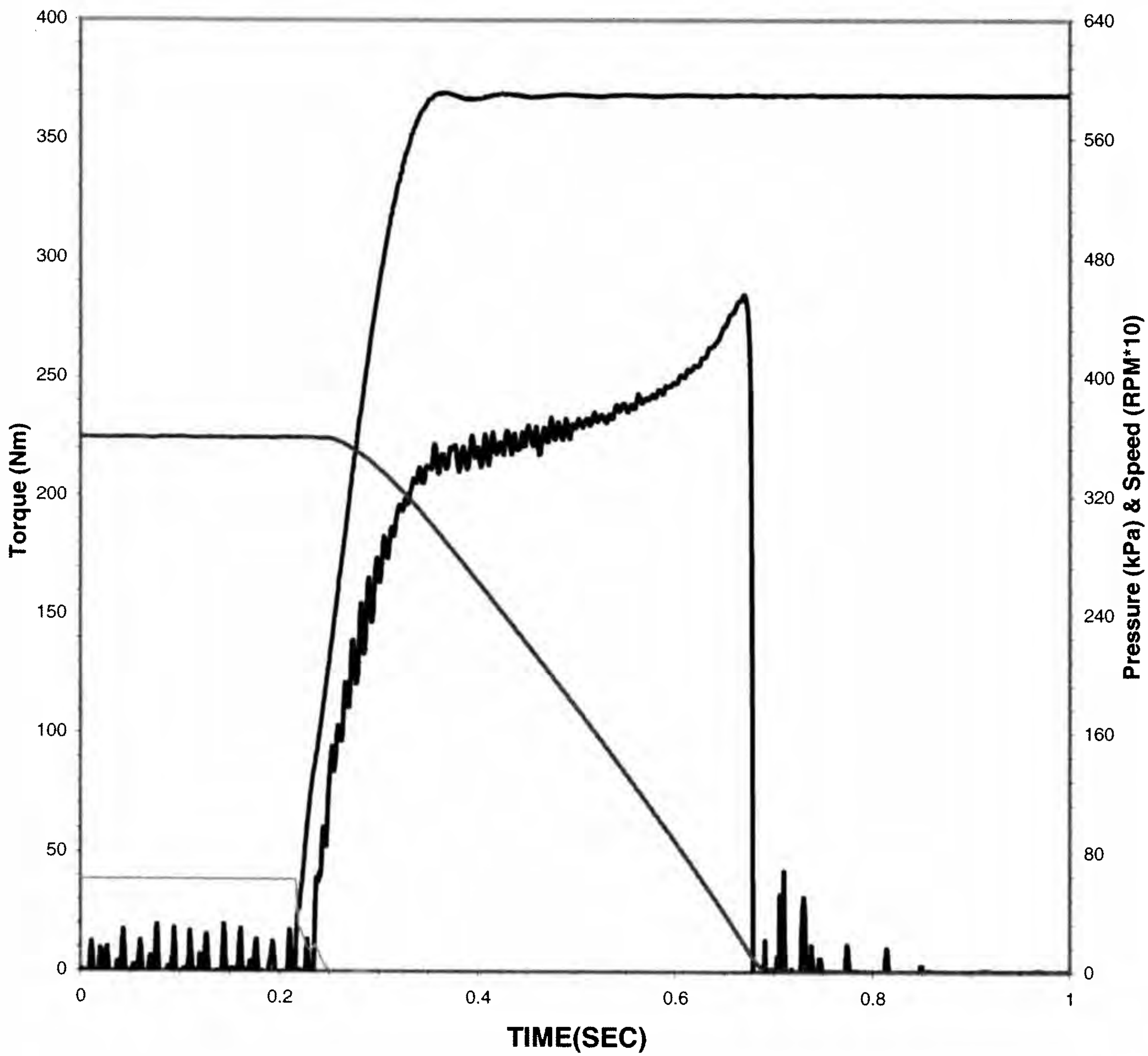
0.2 Sec Dyn:	222 N*m
Midpoint Dyn:	225 N*m
LwSpd Dynamic:	276 N*m

Coefficient of Friction

.2 Sec Dyn:	0.108
Midpoint Dyn:	0.110
LwSpd Dynamic:	0.135

ALLISON C4 PAPER DATA

DYNAMIC CYCLE



Date of Test:	9/12/2007
Time of Test:	15:32:54
Test Number:	C2-2-1484
Fluid Code:	AL-27877-L
Cycle Number:	10000
Temperature:	92.6 °C (93.3 ± 3.0 °C)
Apply Pressure:	590 kPa (586 ± 7 KPa)
Apply Rate:	0.13 Sec (0.15 ± 0.02 Sec)
Energy:	18.6 KJ (18.7 ± 0.40 KJ)
Engage Time:	0.463 Sec

Torque

0.2 Sec Dyn:	222 N*m
Midpoint Dyn:	225 N*m
LwSpd Dynamic:	275 N*m

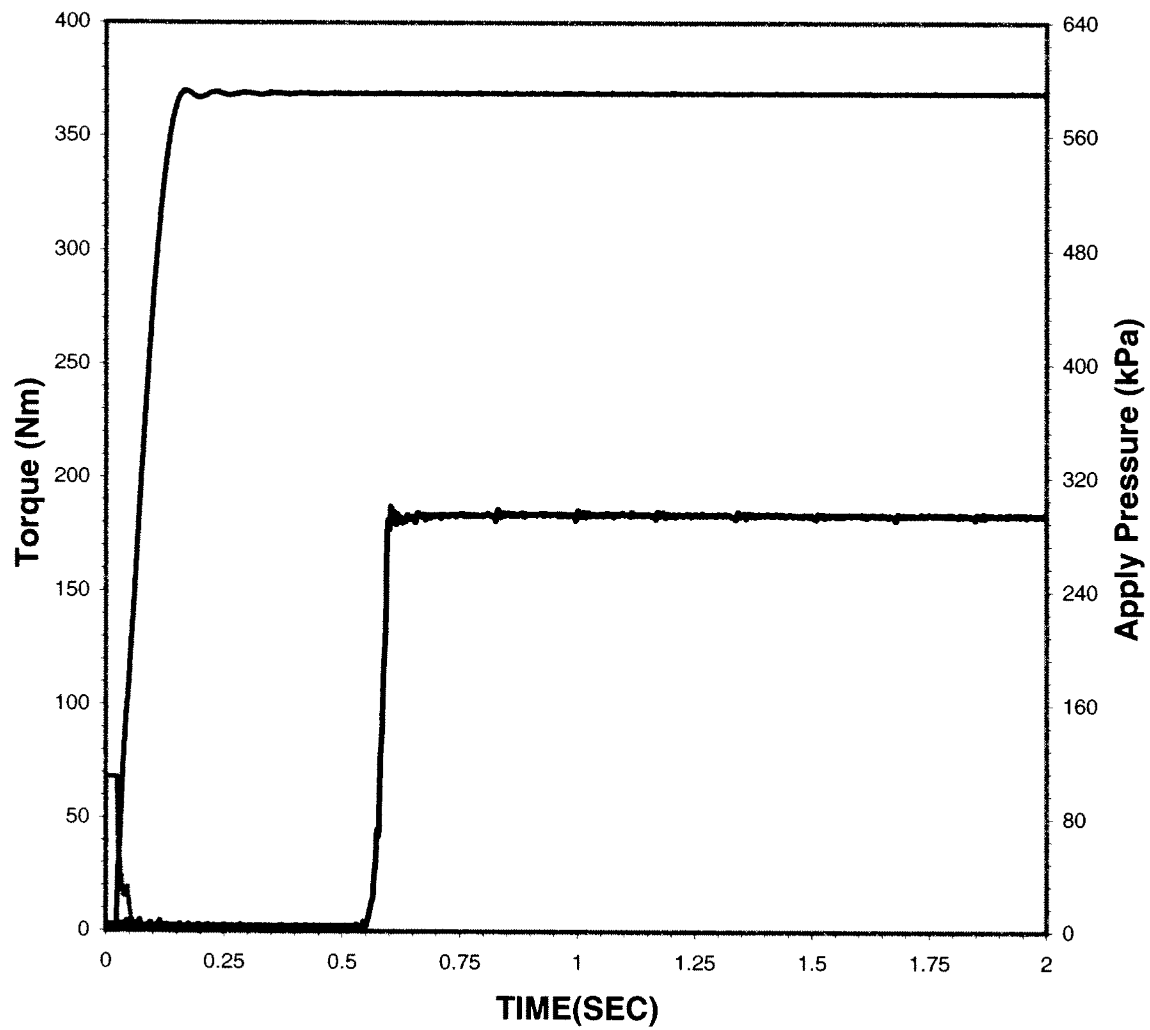
Coefficient of Friction

.2 Sec Dyn:	0.108
Midpoint Dyn:	0.110
LwSpd Dynamic:	0.134

STATIC TRACES

ALLISON C4 PAPER DATA

STATIC CYCLE



Date of Test: 9/10/2007

Time of Test: 21:53:40

Test Number: C2-2-1484

Fluid Code: AL-27877-L

Cycle Number: 10

STATIC CYCLE

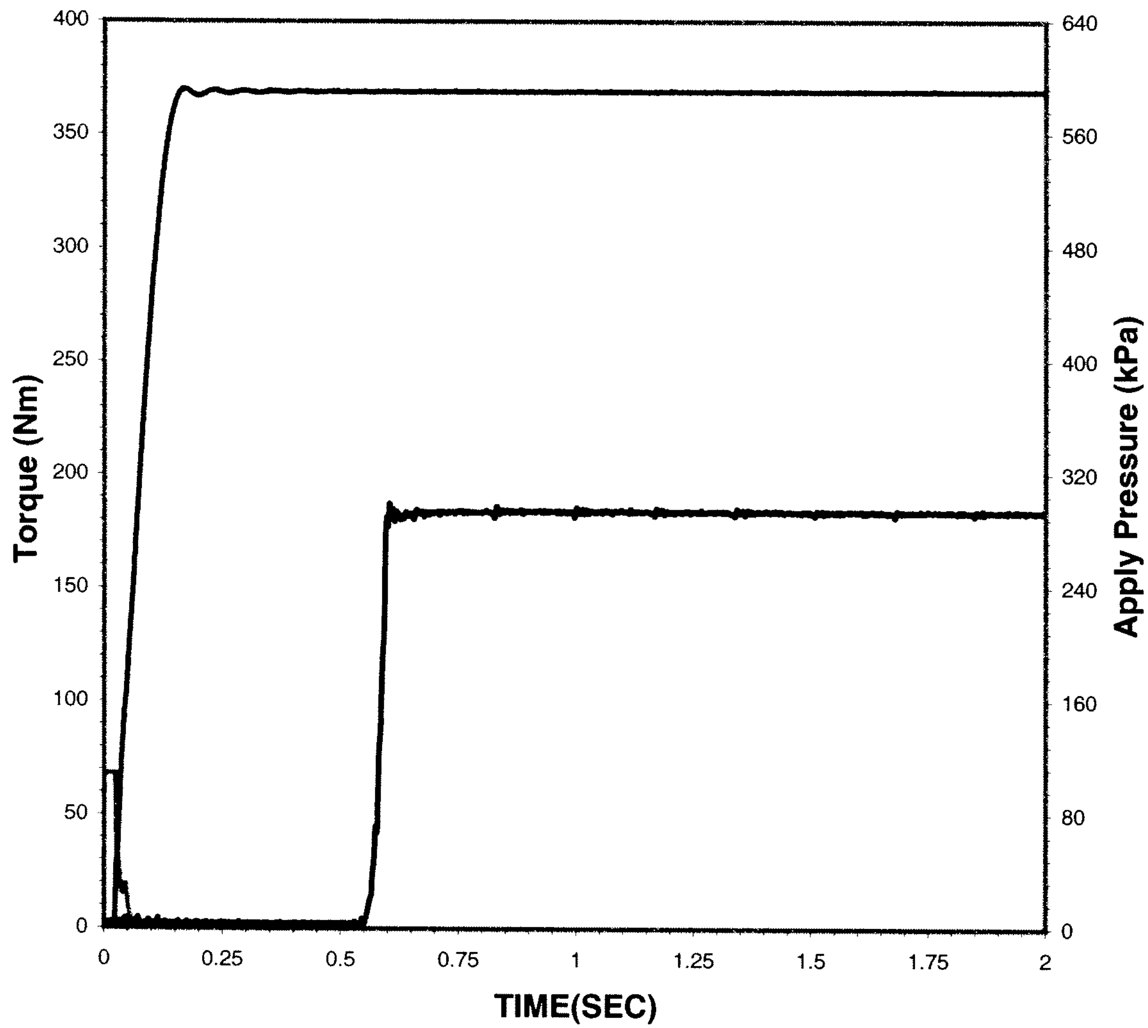
Apply Pressure:
At .25 Second: 589 kPa

Torque
Static Peak: 276 Nm
.25 Second: 255 Nm

Coefficient of Friction
Static Peak: 0.134
.25 Second: 0.124

ALLISON C4 PAPER DATA

STATIC CYCLE



Date of Test: 9/10/2007

Time of Test: 22:16:26

Test Number: C2-2-1484

Fluid Code: AL-27877-L

Cycle Number: 100

STATIC CYCLE

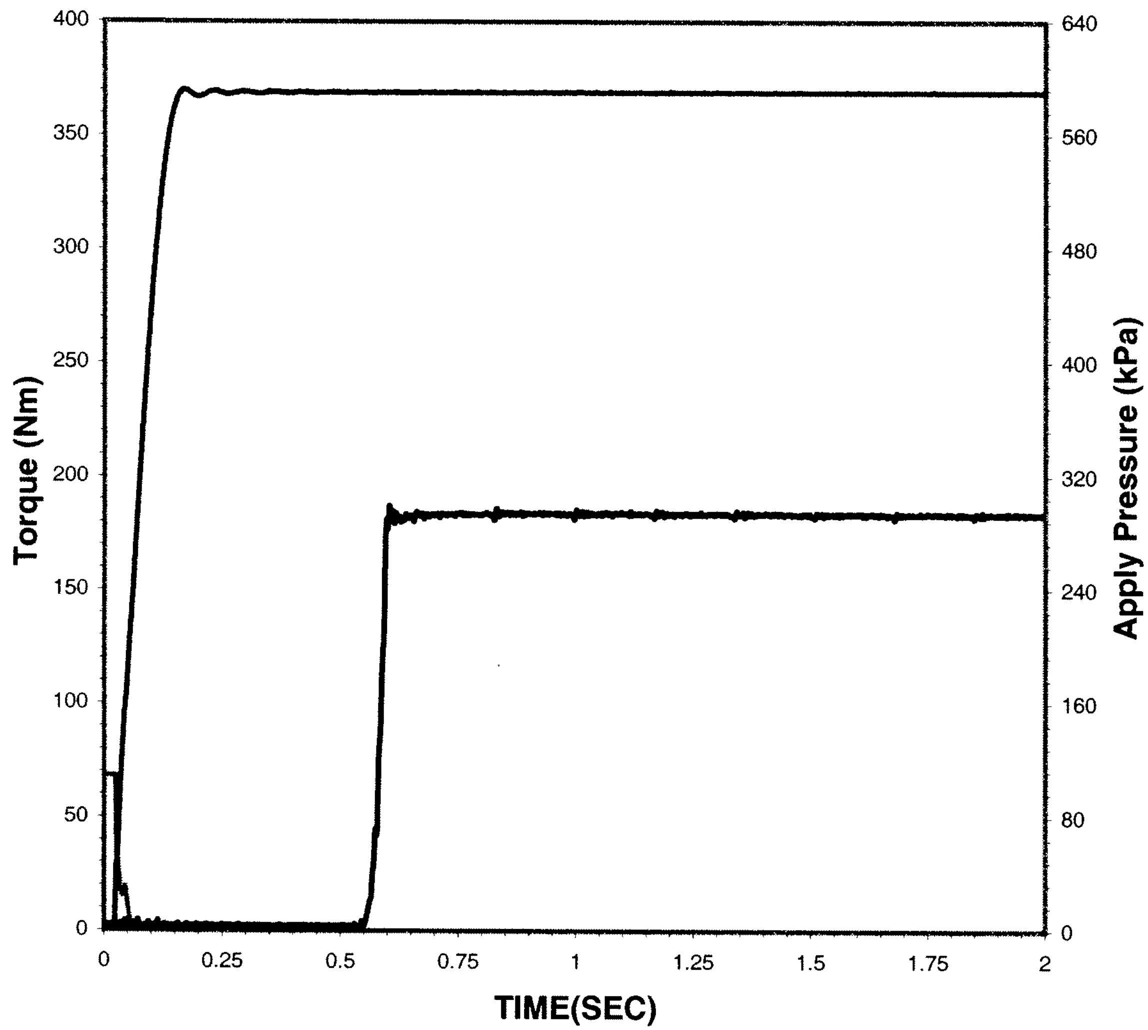
Apply Pressure:
At .25 Second: 590 kPa

Torque
Static Peak: 259 Nm
.25 Second: 243 Nm

Coefficient of Friction
Static Peak: 0.126
.25 Second: 0.118

ALLISON C4 PAPER DATA

STATIC CYCLE



Date of Test: 9/10/2007

Time of Test: 23:56:42

Test Number: C2-2-1484

Fluid Code: AL-27877-L

Cycle Number: 500

STATIC CYCLE

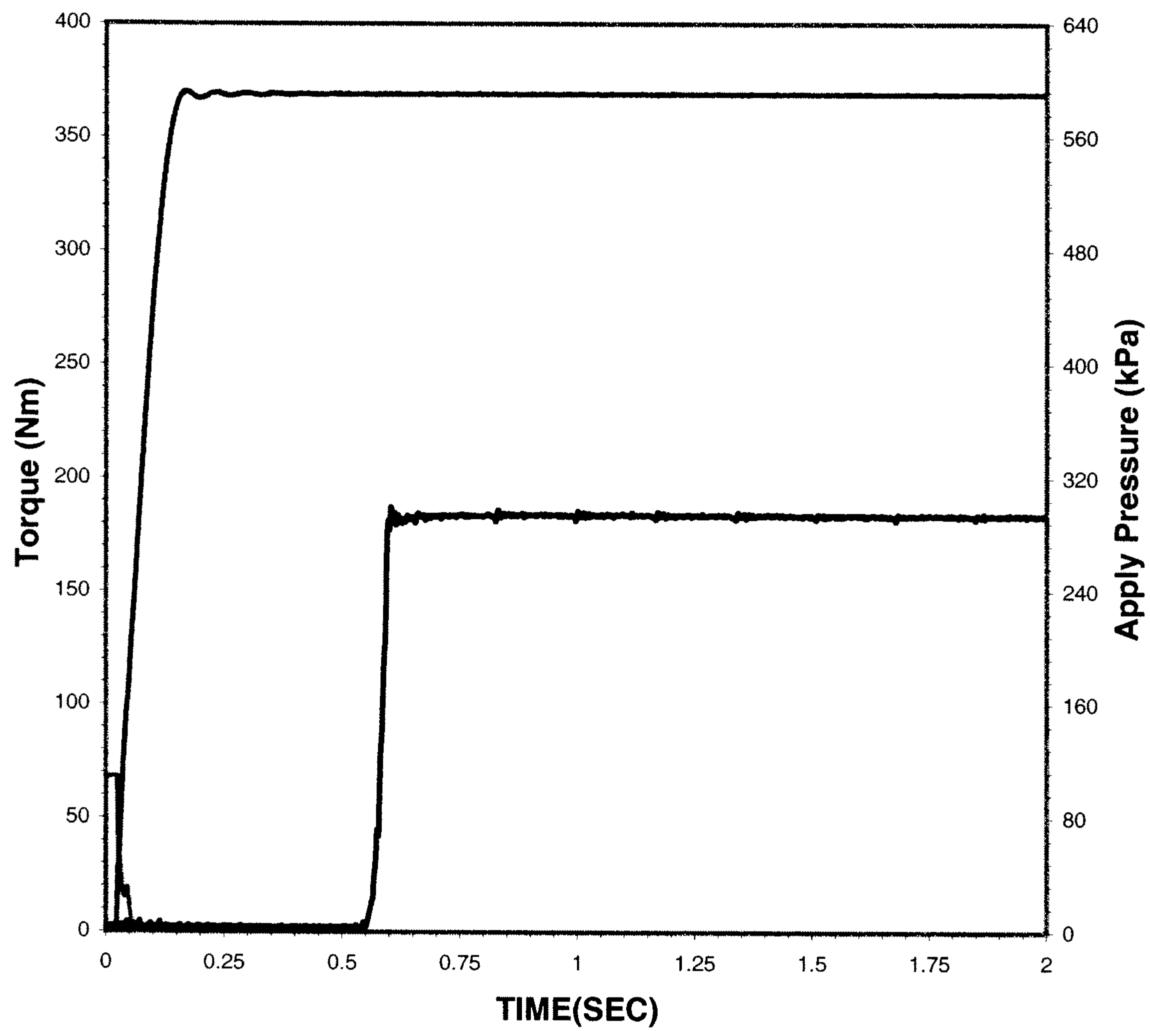
Apply Pressure:
At .25 Second: 590 kPa

Torque
Static Peak: 321 Nm
.25 Second: 295 Nm

Coefficient of Friction
Static Peak: 0.156
.25 Second: 0.144

ALLISON C4 PAPER DATA

STATIC CYCLE



Date of Test: 9/11/2007

Time of Test: 2:01:59

Test Number: C2-2-1484

Fluid Code: AL-27877-L

Cycle Number: 1000

STATIC CYCLE

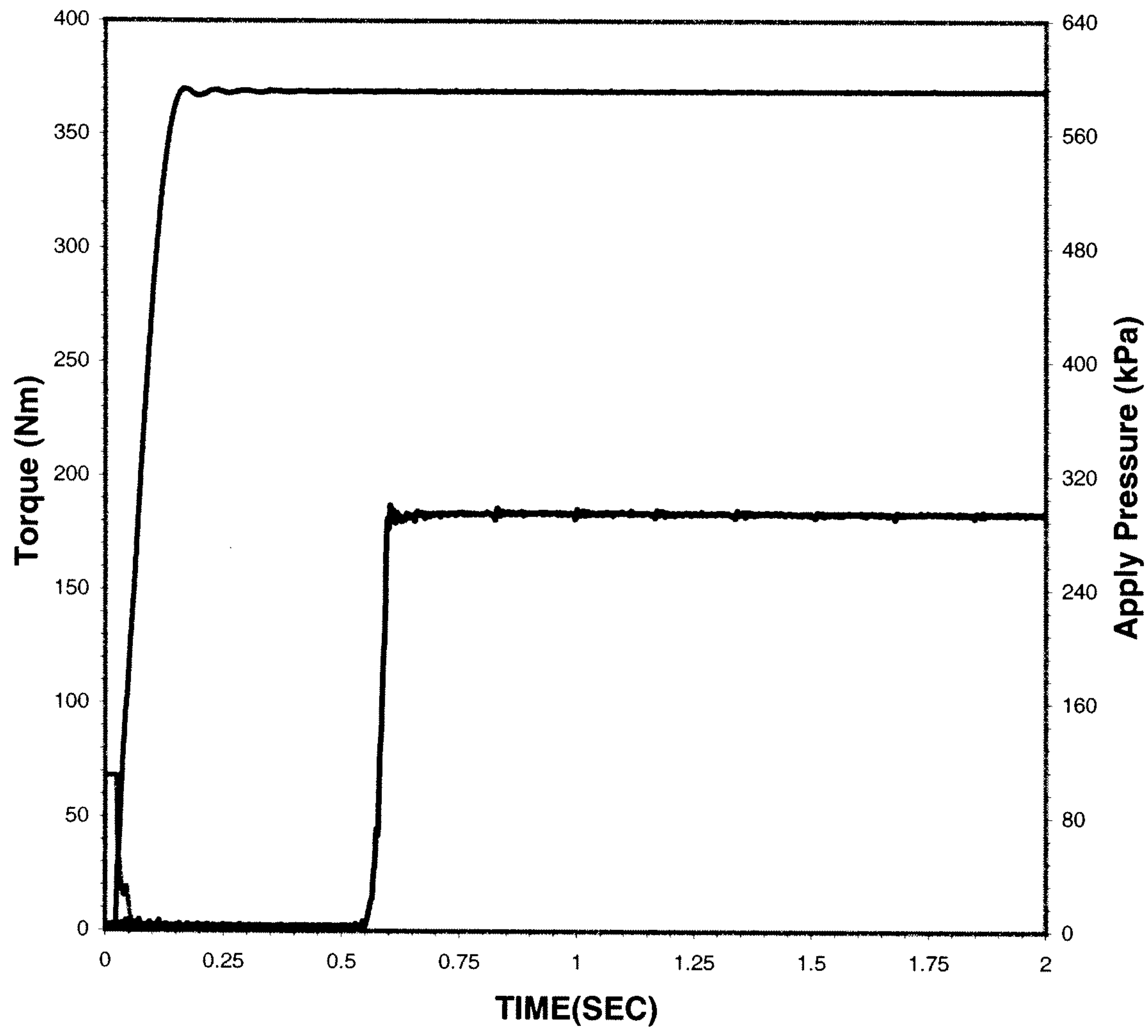
Apply Pressure:
At .25 Second: 590 kPa

Torque
Static Peak: 340 Nm
.25 Second: 316 Nm

Coefficient of Friction
Static Peak: 0.166
.25 Second: 0.154

ALLISON C4 PAPER DATA

STATIC CYCLE



Date of Test: 9/11/2007

Time of Test: 8:17:16

Test Number: C2-2-1484

Fluid Code: AL-27877-L

Cycle Number: 2500

STATIC CYCLE

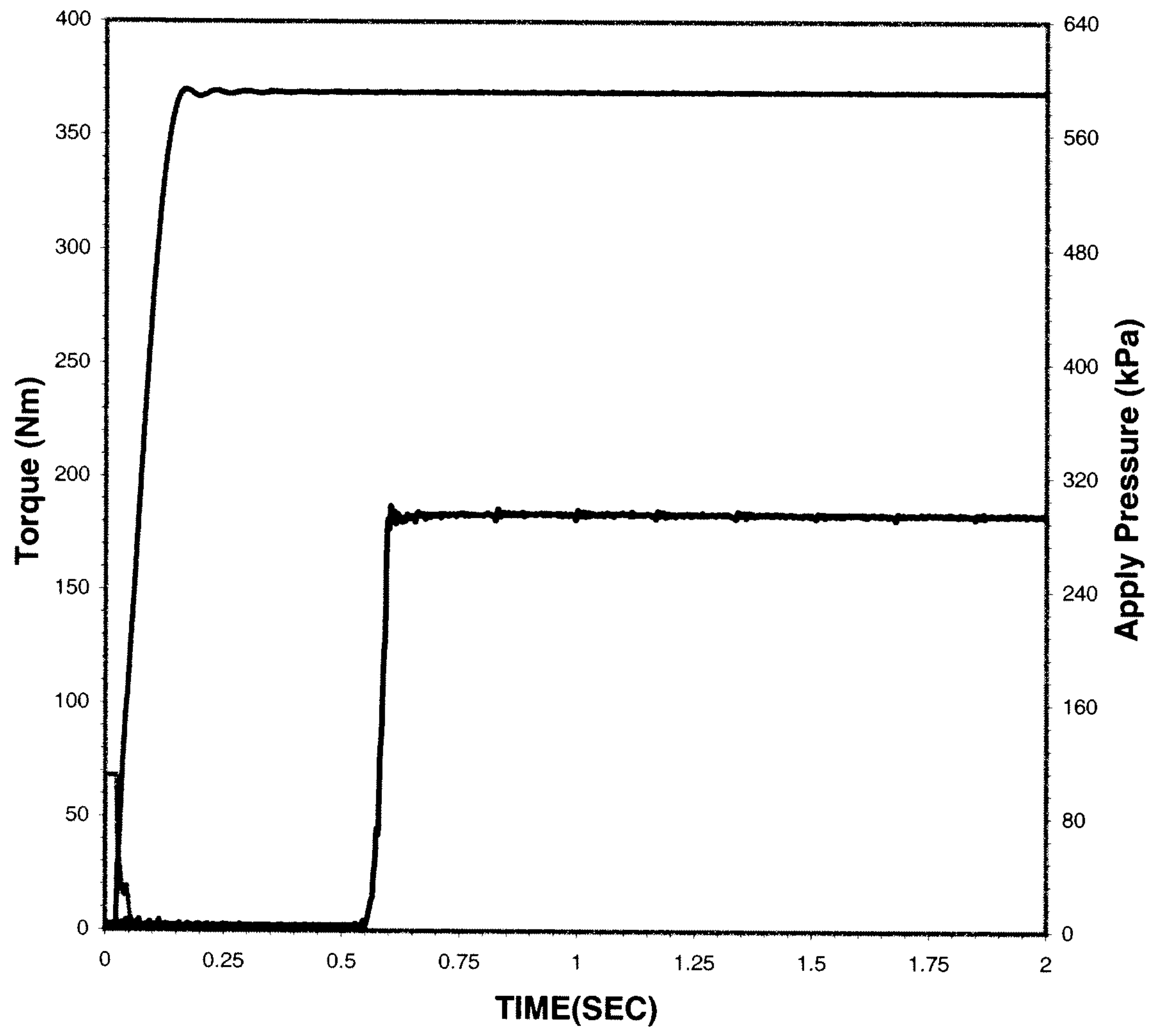
Apply Pressure:
At .25 Second: 591 kPa

Torque
Static Peak: 348 Nm
.25 Second: 315 Nm

Coefficient of Friction
Static Peak: 0.170
.25 Second: 0.153

ALLISON C4 PAPER DATA

STATIC CYCLE



Date of Test: 9/11/2007

Time of Test: 18:42:34

Test Number: C2-2-1484

Fluid Code: AL-27877-L

Cycle Number: 5000

STATIC CYCLE

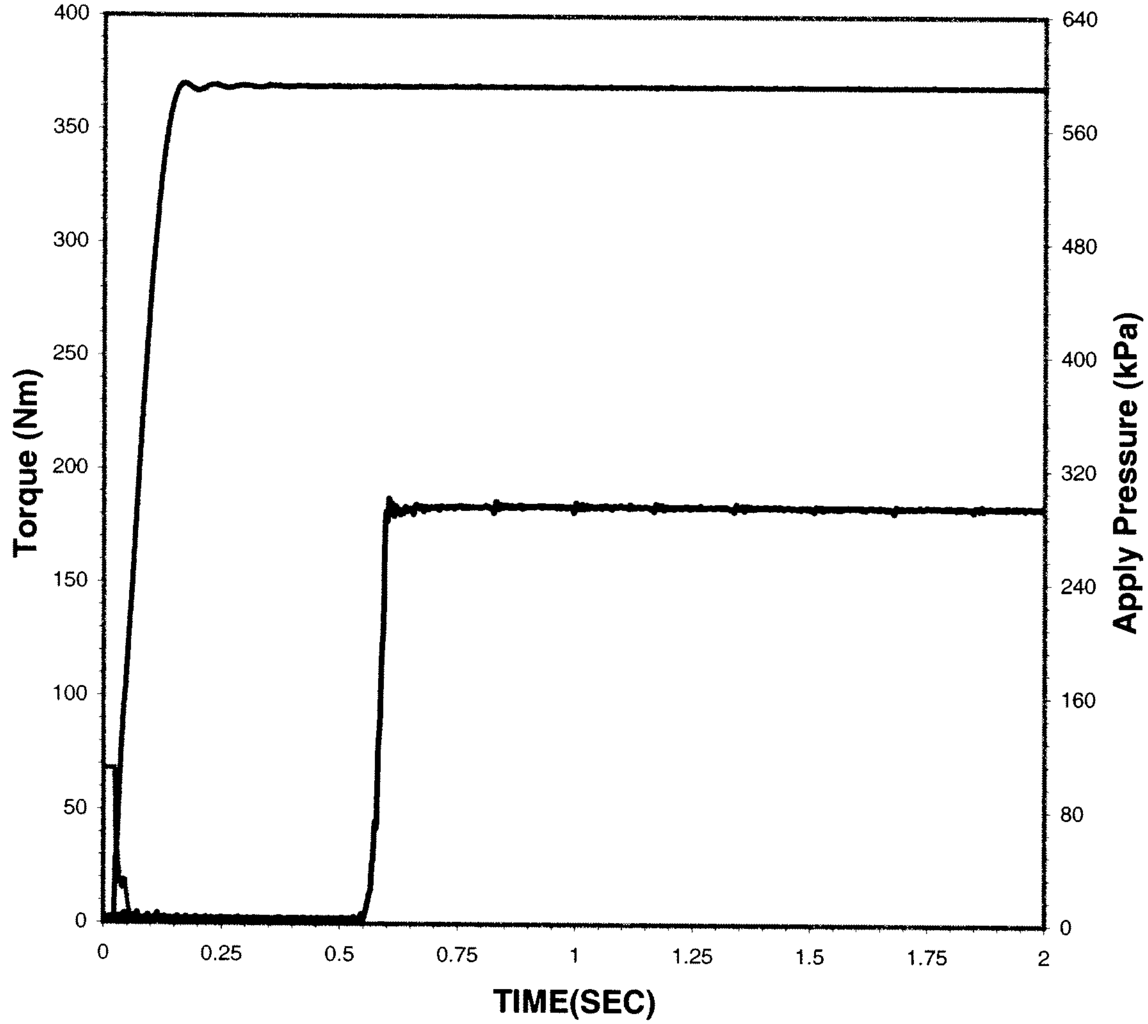
Apply Pressure:
At .25 Second: 591 kPa

Torque
Static Peak: 325 Nm
.25 Second: 307 Nm

Coefficient of Friction
Static Peak: 0.158
.25 Second: 0.149

ALLISON C4 PAPER DATA

STATIC CYCLE



Date of Test: 9/12/2007

Time of Test: 5:07:52

Test Number: C2-2-1484

Fluid Code: AL-27877-L

Cycle Number: 7500

STATIC CYCLE

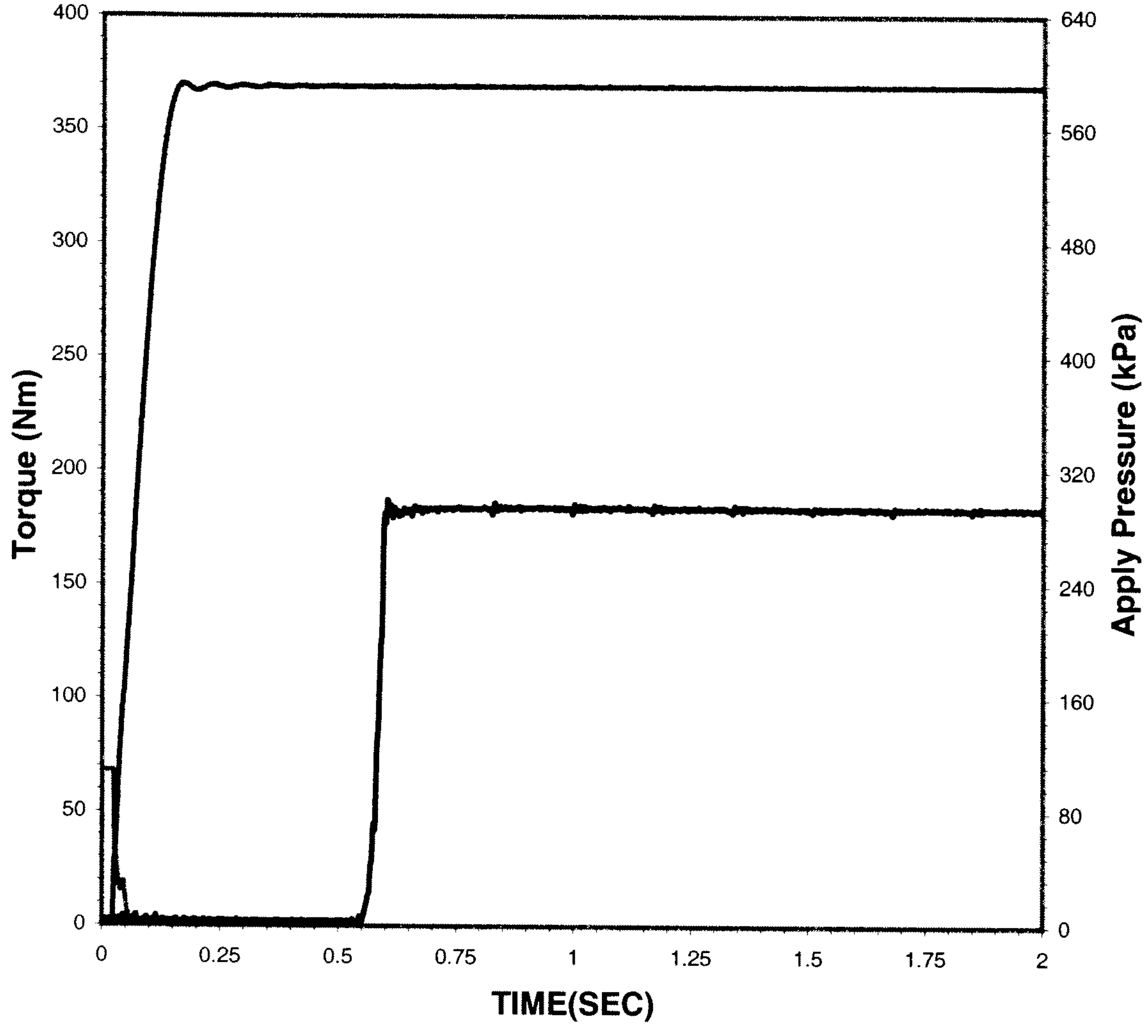
Apply Pressure:
At .25 Second: 592 kPa

Torque
Static Peak: 314 Nm
.25 Second: 302 Nm

Coefficient of Friction
Static Peak: 0.153
.25 Second: 0.147

ALLISON C4 PAPER DATA

STATIC CYCLE



Date of Test: 9/12/2007

Time of Test: 15:33:10

Test Number: C2-2-1484

Fluid Code: AL-27877-L

Cycle Number: 10000

STATIC CYCLE

Apply Pressure:
At .25 Second: 590 kPa

Torque
Static Peak: 309 Nm
.25 Second: 289 Nm

Coefficient of Friction
Static Peak: 0.151
.25 Second: 0.141

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

FUELS AND LUBRICANTS RESEARCH DIVISION

Report on

CATERPILLAR TO-4 FRICTION PROPERTIES, VC-70

Conducted for

ARMY LAB

Oil Code:
AL-27877-L

Test Number:
VC70-A-75-I

October 2, 2007

Submitted by:

Brian Koehler
Principal Engineer
Specialty & Driveline Fluids
Evaluations

CATERPILLAR TO-4 FRICTION PROPERTIES, VC-70

Summary Sheet

Company: ARMY LAB

Test start date: September 28, 2007
End of test date: October 2, 2007
Oil Code: AL-27877-I

Sequence Number	1219	N/A	1221	1222	1223	1224	Friction Retention
Dynamic Coefficient Vs. Cycle:	F	N/A	P	P	F	F	N/A
Dynamic Coefficient Vs. Load:	F	N/A	P	P	F	F	
Dynamic Coefficient Vs. Speed:	F	N/A	F	F	F	F	
Energy Limit:	P	N/A	P	P	P	P	
Static Coefficient Vs. Cycle:							N/A
Static Coefficient Vs. Load:	P	N/A	F	F	F	P	
Static Coefficient Vs. Speed:	P	N/A	F	F	F	F	
Energy Limit:	P	N/A	P	P	P	P	
Total Wear:	0.007	N/A	0.040	0.033	0.033	0.000	
Wear Limit:	0.030	N/A	0.070	0.070	0.070	0.040	

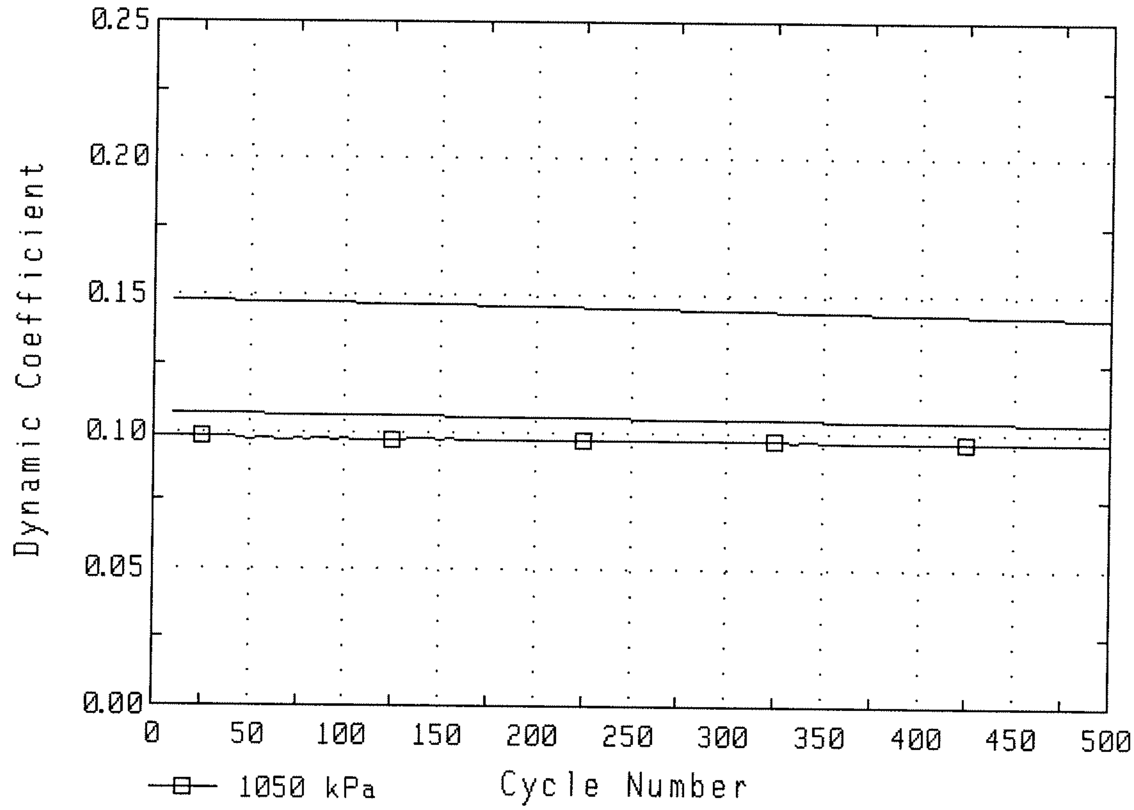
Comments:
Acceptance bands shown are for the last time each sequence was referenced using the TO-4 CAT. Category reference oil.

F = Fail
P = Pass
N/A = Not Applicable

Southwest Research Institute
"I"machine oil test AL-27877-L / LO-223703

Test name:	A-75-I
Test date:	09/28/07
Test description:	AL-27877-L
Oil type:	AL-27877-L / LO-223703
Viscosity:	OW-30
Miscellaneous:	
Software version:	1.40
Run name & desc:	I0706091 - AL-27877-L
Run date:	09/25/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	HC
Remarks:	"I" machine oil test AL-27877-L / LO-223703
Sequence name:	SEQ1219
Remarks:	Use 1Y0708 Disc and 1Y3610 Plate
Number of cycles run:	1155
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 $N\text{-}m\text{-}s^2$
Disc name & desc:	1Y0708 - Elastomeric Disc
Material:	Raybestos 6475-4 Rayflex
Groove pattern:	Single Lead Spiral - 12 Radial
Miscellaneous:	Use with 1Y3610 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	26NO0-00004
Remarks:	Elastomeric
Plate name & desc:	1Y3610 - Steel Plate
Surface:	0.70 to 1.30 micron Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	26NO0-00004
Remarks:	0.99 Surface Finish
Report limit name:	LIM1219 - Reference run: I0706090
Limit file generated:	09/24/07
Report format name:	REP1219 - ELASTOMERIC, RAYFLEX

Test: A-75-I Run: I0706091 Started on 09/25/07 at 09:00

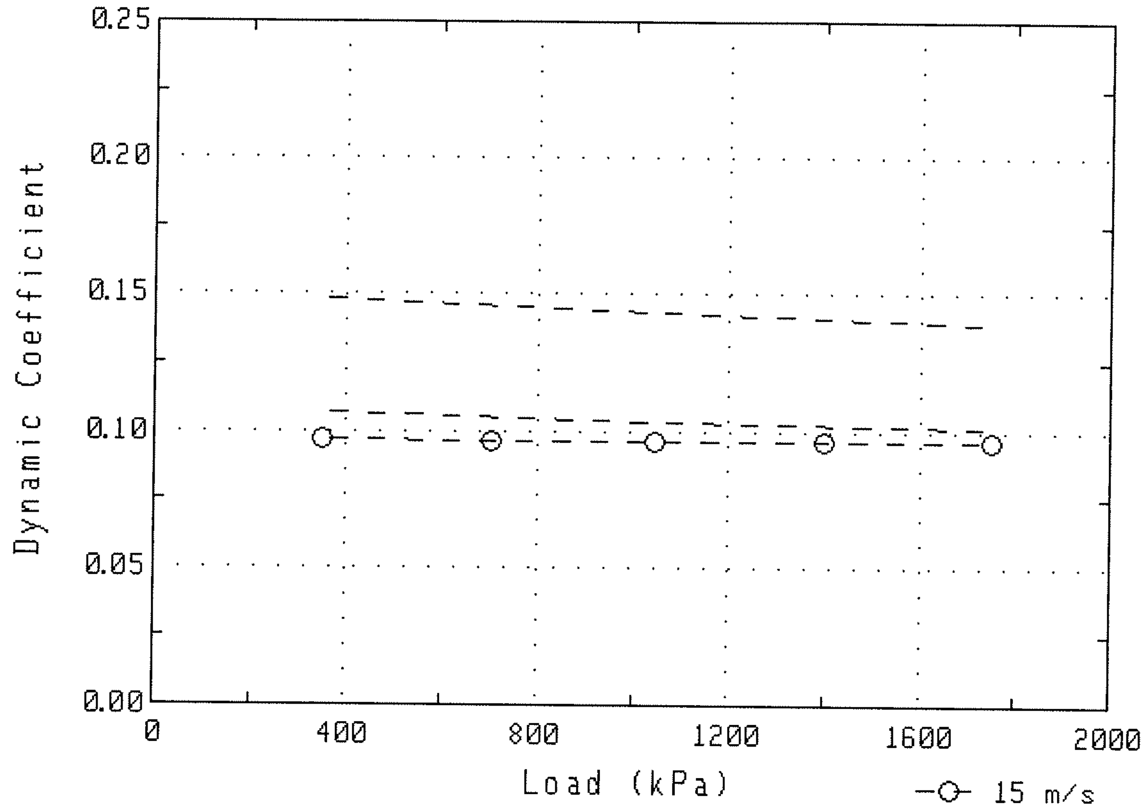


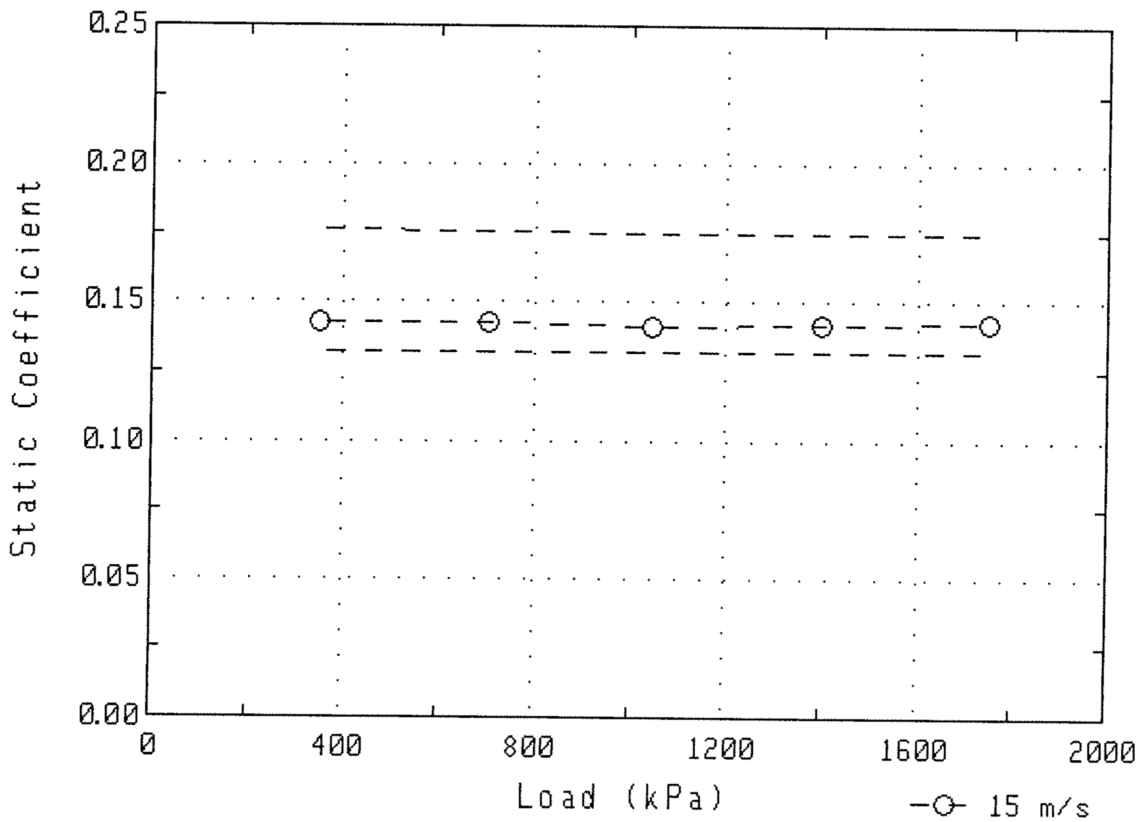
1Y0708 DISC
THICKNESS

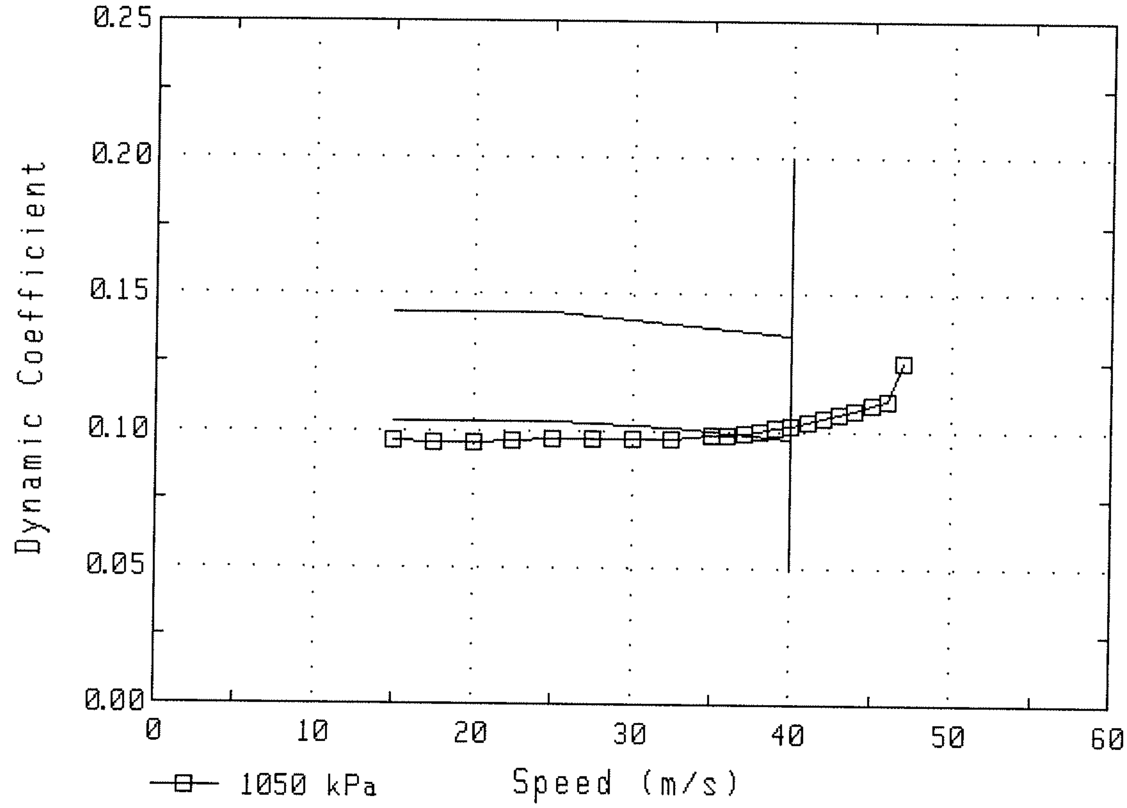
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	4.95	4.95	4.95	4.94	4.93	4.93
2	4.96	4.96	4.95	4.95	4.94	4.94
3	4.95	4.94	4.94	4.95	4.94	4.94
4	4.95	4.95	4.95	4.95	4.94	4.94
5	4.95	4.94	4.94	4.93	4.93	4.93
6	4.95	4.95	4.94	4.94	4.94	4.94
Avg	4.95	4.95	4.94	4.94	4.94	4.94

Compression set average wear: 0.005
M2 - M3 average Wear: 0.002

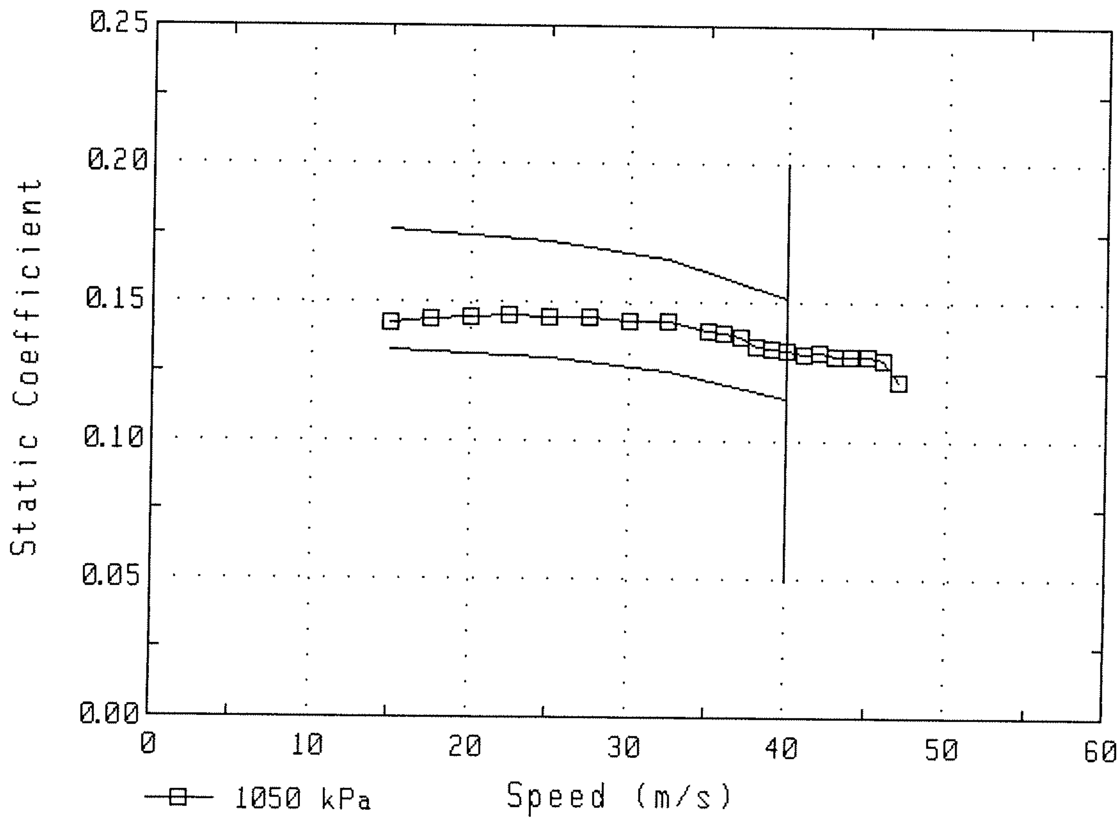
Total Wear (all measurements in mm): 0.007


0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

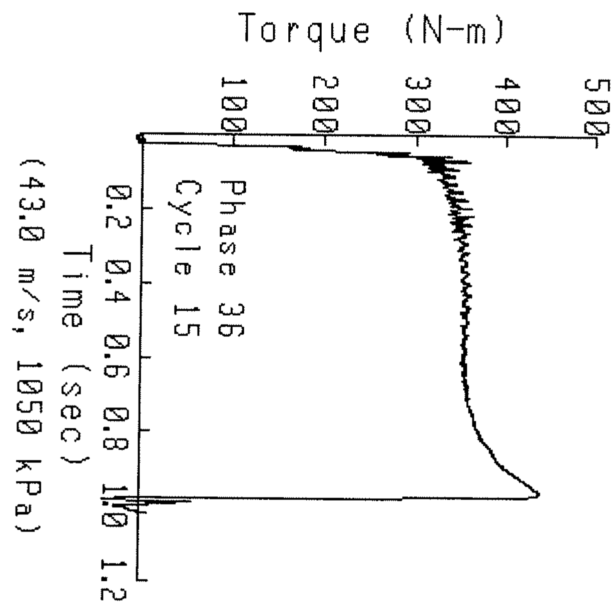

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

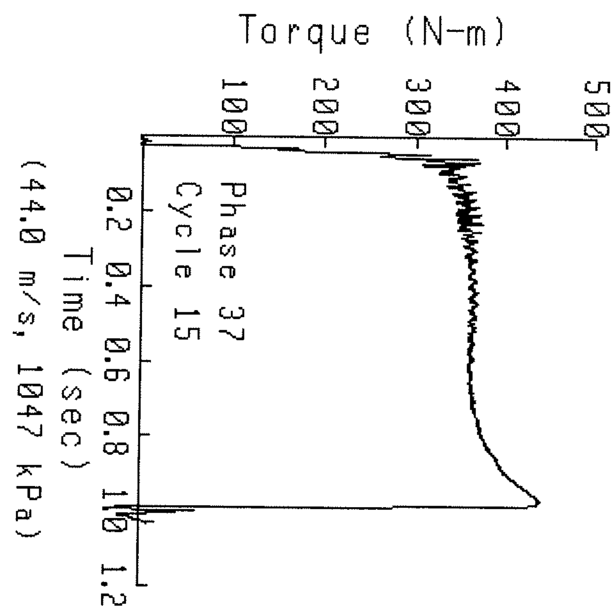


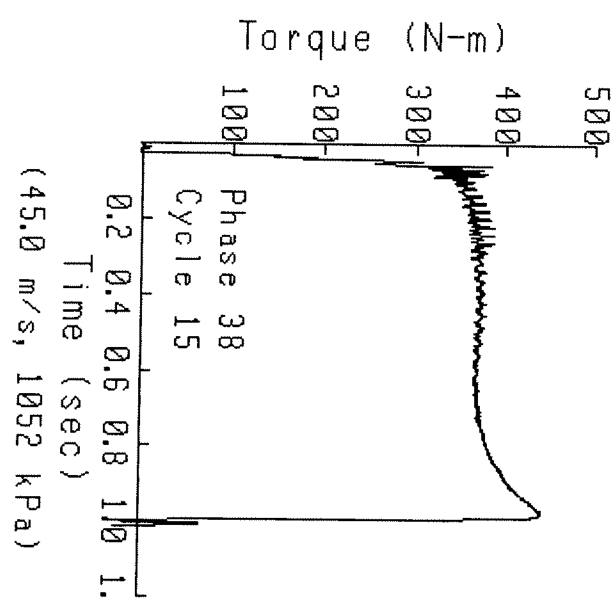
0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

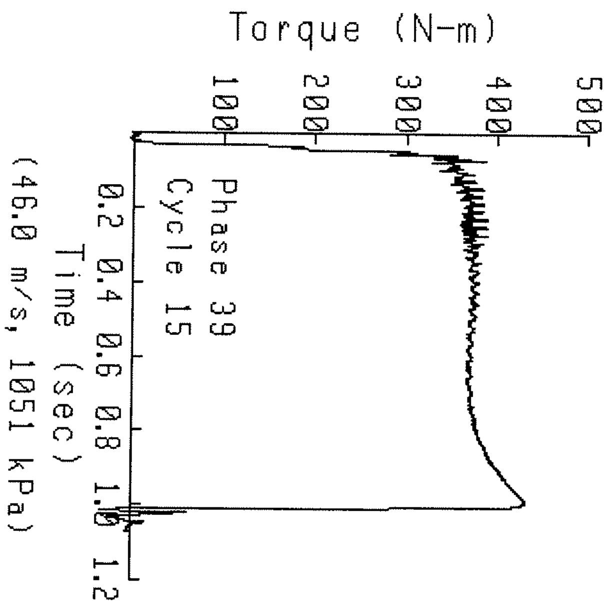


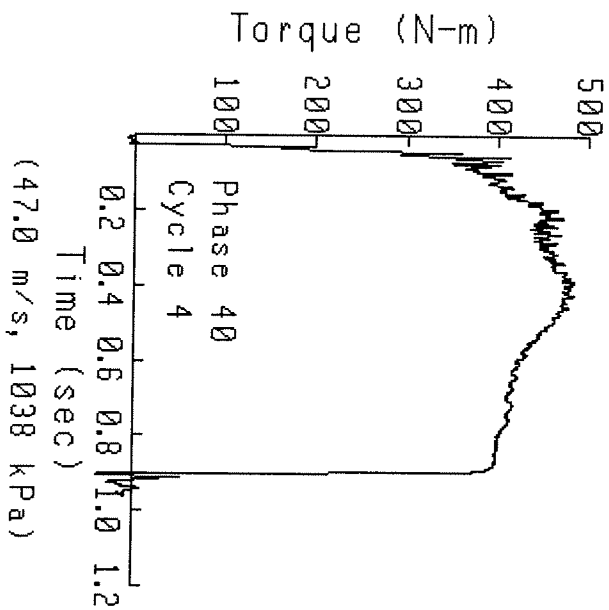
0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

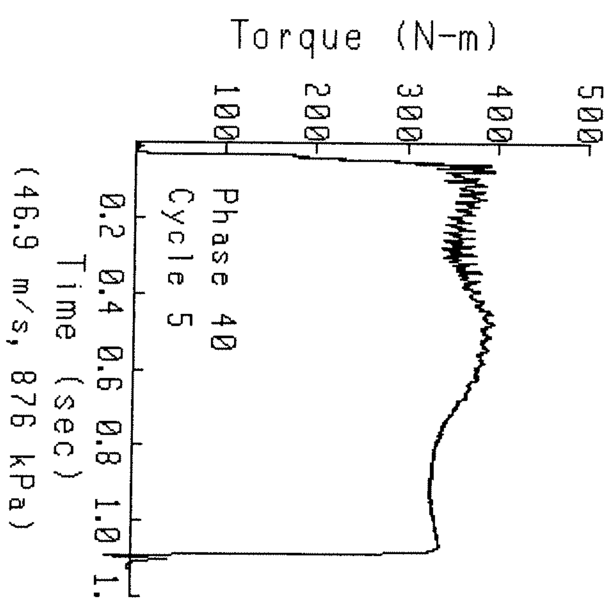

Torque (N-m)
100 200 300 400 500
Phase 36
Cycle 15
0.2 0.4 0.6 0.8 1.0 1.2
Time (sec)
(43.0 m/s, 1050 kPa)


Torque (N-m)
100 200 300 400 500
Phase 37
Cycle 15
0.2 0.4 0.6 0.8 1.0 1.2
Time (sec)
(44.0 m/s, 1047 kPa)


Torque (N-m)
100 200 300 400 500
Phase 38
Cycle 15
0.2 0.4 0.6 0.8 1.0 1.2
Time (sec)
(45.0 m/s, 1052 kPa)


Torque (N-m)
100 200 300 400 500
Phase 39
Cycle 15
0.2 0.4 0.6 0.8 1.0 1.2
Time (sec)
(46.0 m/s, 1051 kPa)

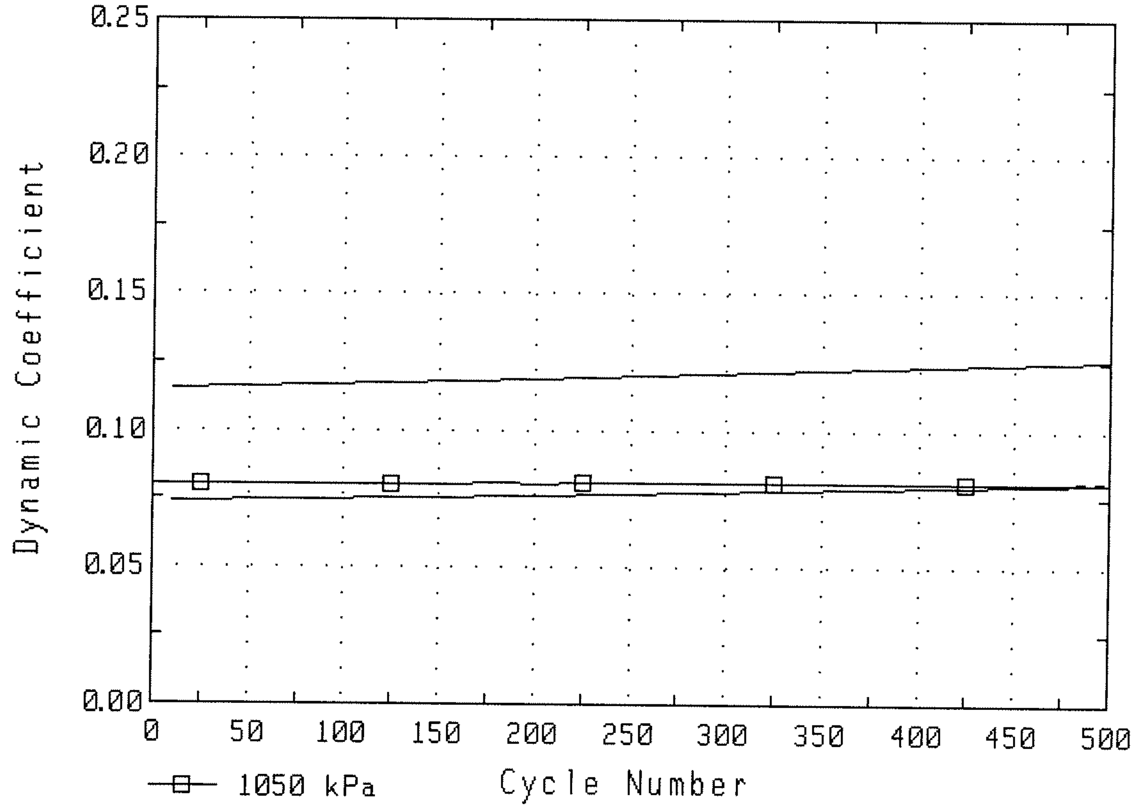

Torque (N-m)
100 200 300 400 500
Phase 40
Cycle 4
0.2 0.4 0.6 0.8 1.0 1.2
Time (sec)
(47.0 m/s, 1038 kPa)


Torque (N-m)
100 200 300 400 500
Phase 40
Cycle 5
0.2 0.4 0.6 0.8 1.0 1.2
Time (sec)
(46.9 m/s, 876 kPa)

Southwest Research Institute
"I"machine oil test AL-27877-L / LO-223703

Test name:	A-75-I
Test date:	09/28/07
Test description:	AL-27877-L
Oil type:	AL-27877-L / LO-223703
Viscosity:	OW-30
Miscellaneous:	
Software version:	1.40
Run name & desc:	I0706092 - AL-27877-L / LO-223703
Run date:	09/29/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	mtd
Remarks:	I machine oil test AL-27877-L / LO-223703
Sequence name:	SEQ1221
Remarks:	Use 1Y0710 Disc and 1Y3610 Plate.
Number of cycles run:	1087
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 $N\text{-}m\text{-}s^2$
Disc name & desc:	1Y0710 - Steering Brake Paper
Material:	Raybestos 7894-4 Paper
Groove pattern:	2 - 37 Multiple Parallel
Miscellaneous:	Use with 1Y3610 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	23MR9-00001
Remarks:	Steering brake paper
Plate name & desc:	1Y3610 - Steel Plate
Surface:	0.70 to 1.30 micron Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	23MR9-00001
Remarks:	0.72 surface finish
Report limit name:	LIM1221 - Reference run: I0706003
Limit file generated:	07/26/06
Report format name:	REP1221 - STEERING BRAKE PAPER

Test: A-75-I-1 Run: I0706092 Started on 09/29/07 at 07:27

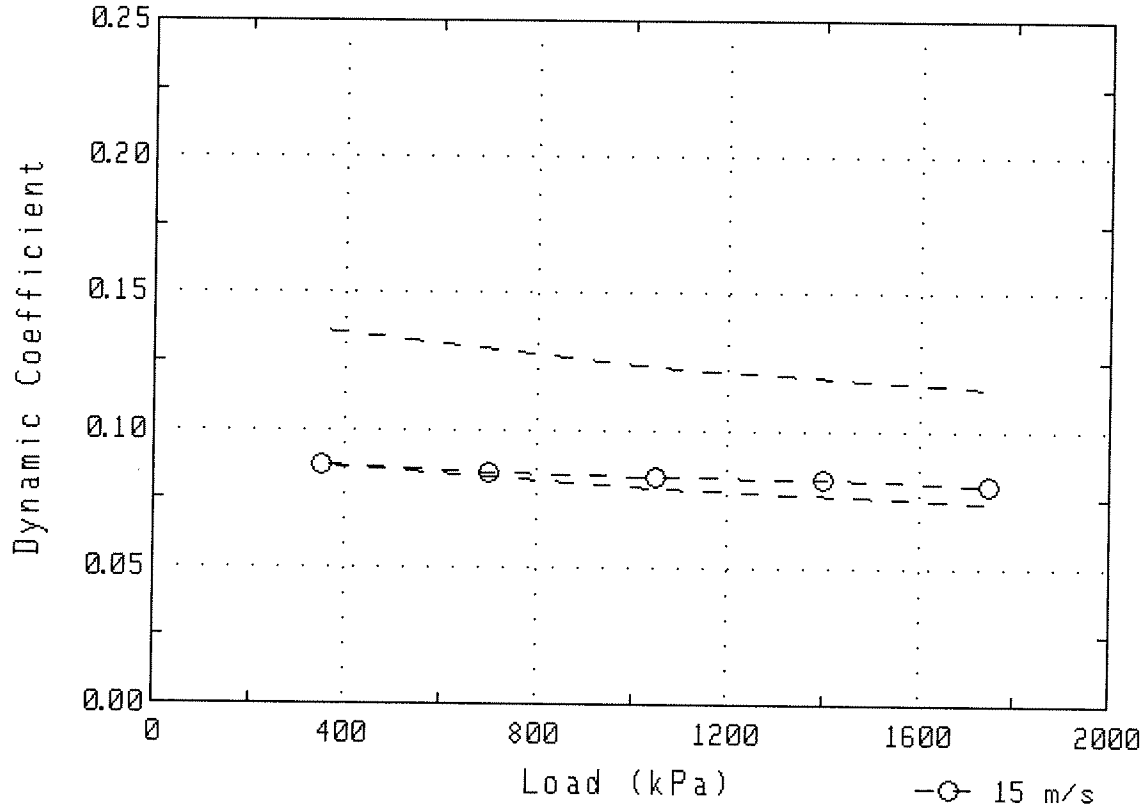


1Y0710 DISC
THICKNESS

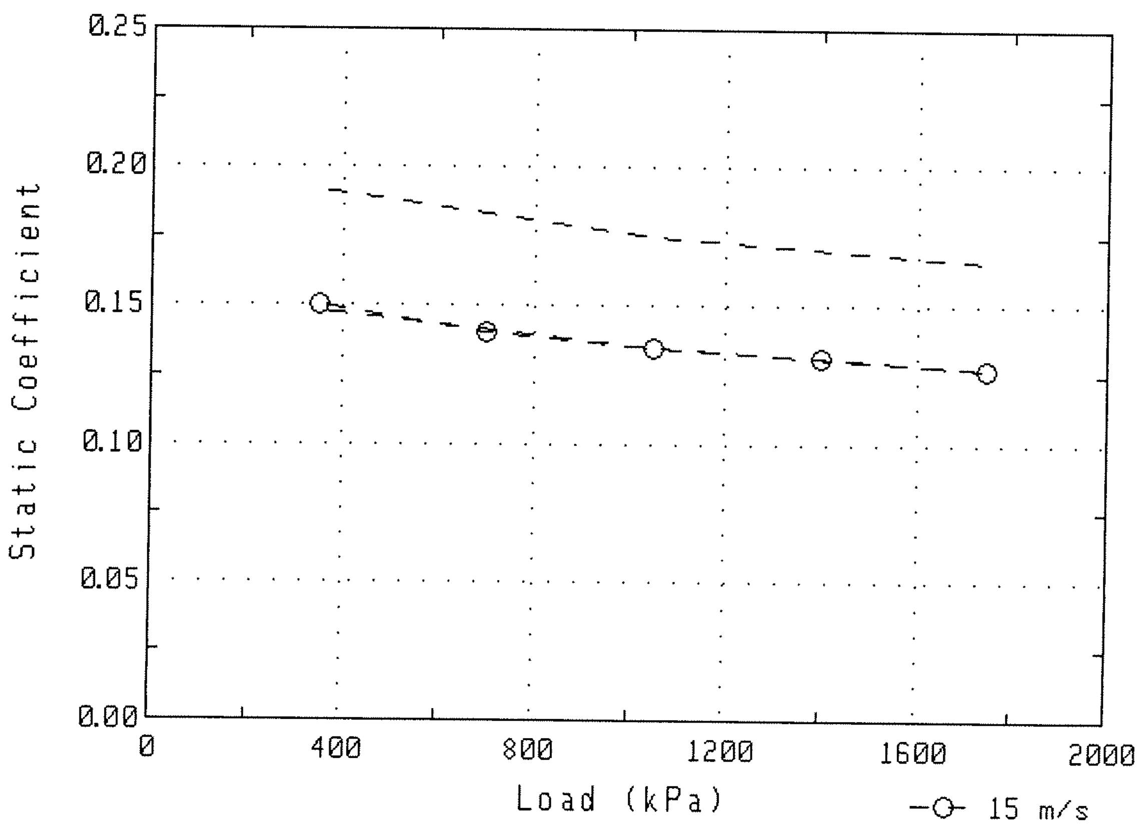
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	5.03	5.00	4.99	5.02	5.00	4.99
2	5.04	5.02	5.00	5.03	5.01	4.99
3	5.05	5.02	5.00	5.05	5.02	5.01
4	5.04	5.02	5.00	5.04	5.01	4.99
5	5.03	5.01	5.00	5.03	5.01	5.00
6	5.03	5.00	4.99	5.03	5.00	4.98
Avg	5.04	5.01	5.00	5.03	5.01	4.99

Compression set average wear: 0.025
M2 - M3 average Wear: 0.015

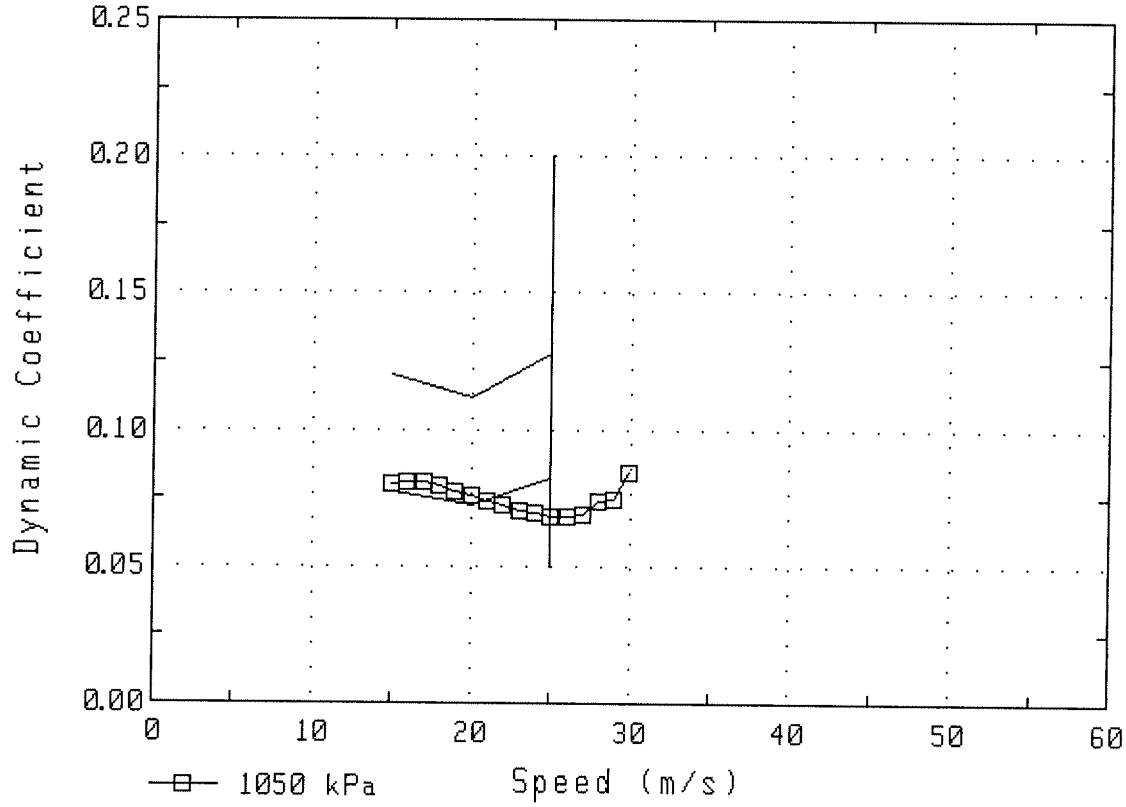
Total Wear (all measurements in mm): 0.040

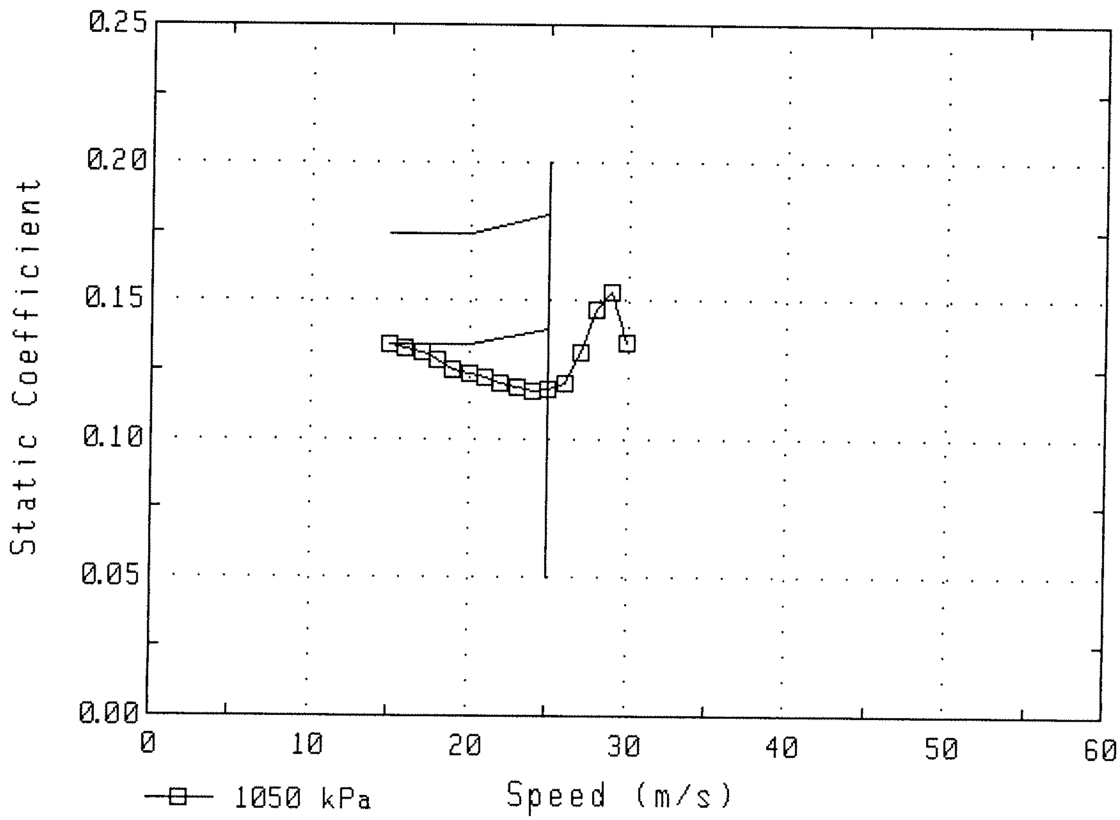


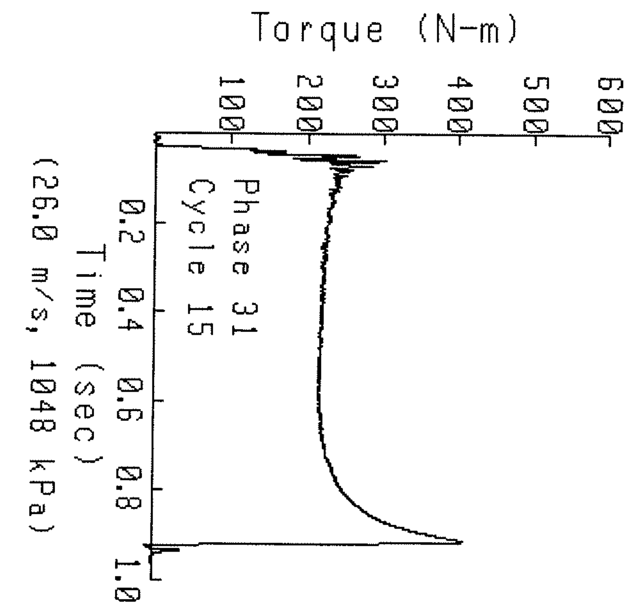
0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

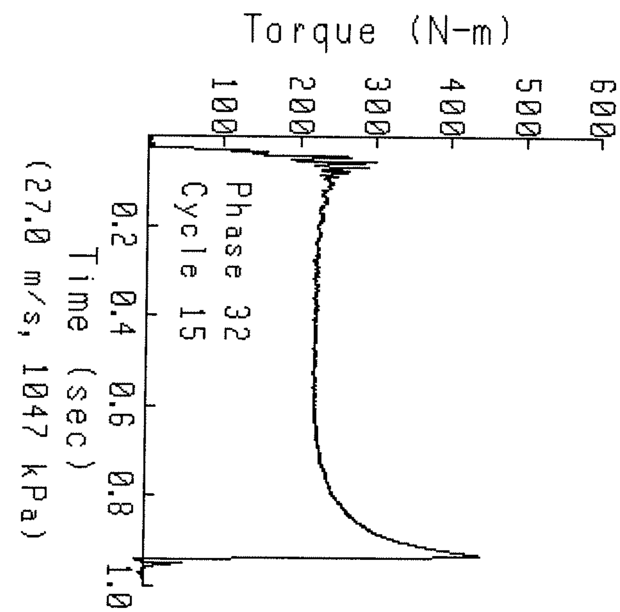


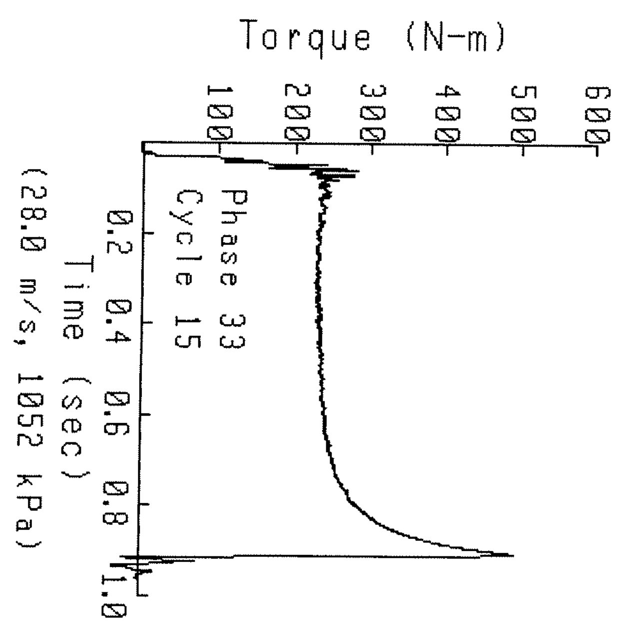
0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

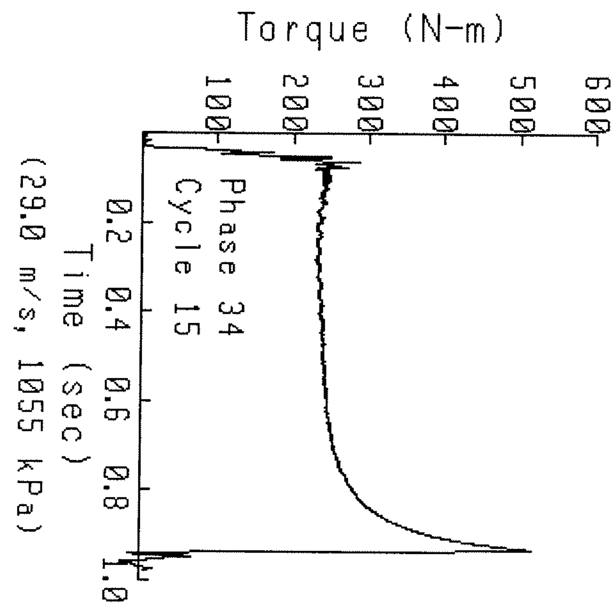

Dynamic Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

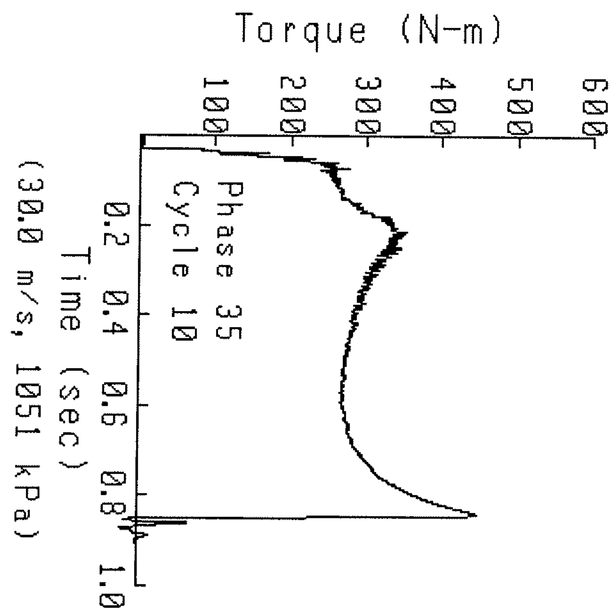

Static Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

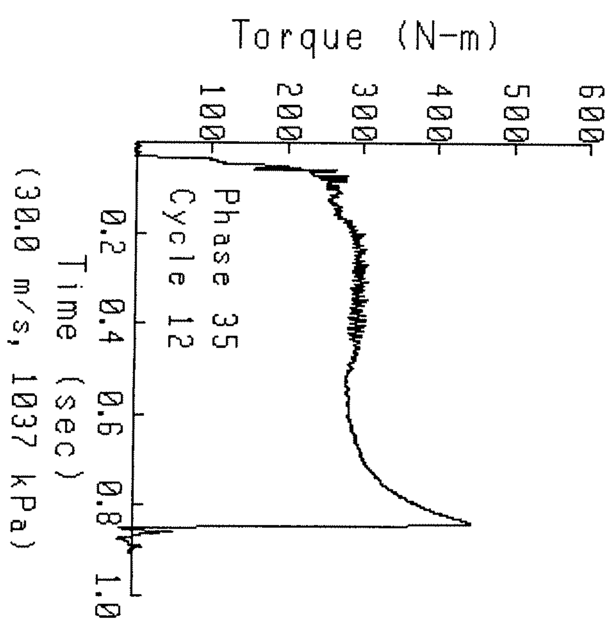

Torque (N-m)
100 200 300 400 500 600
Phase 31
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(26.0 m/s, 1048 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 32
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(27.0 m/s, 1047 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 33
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(28.0 m/s, 1052 kPa)

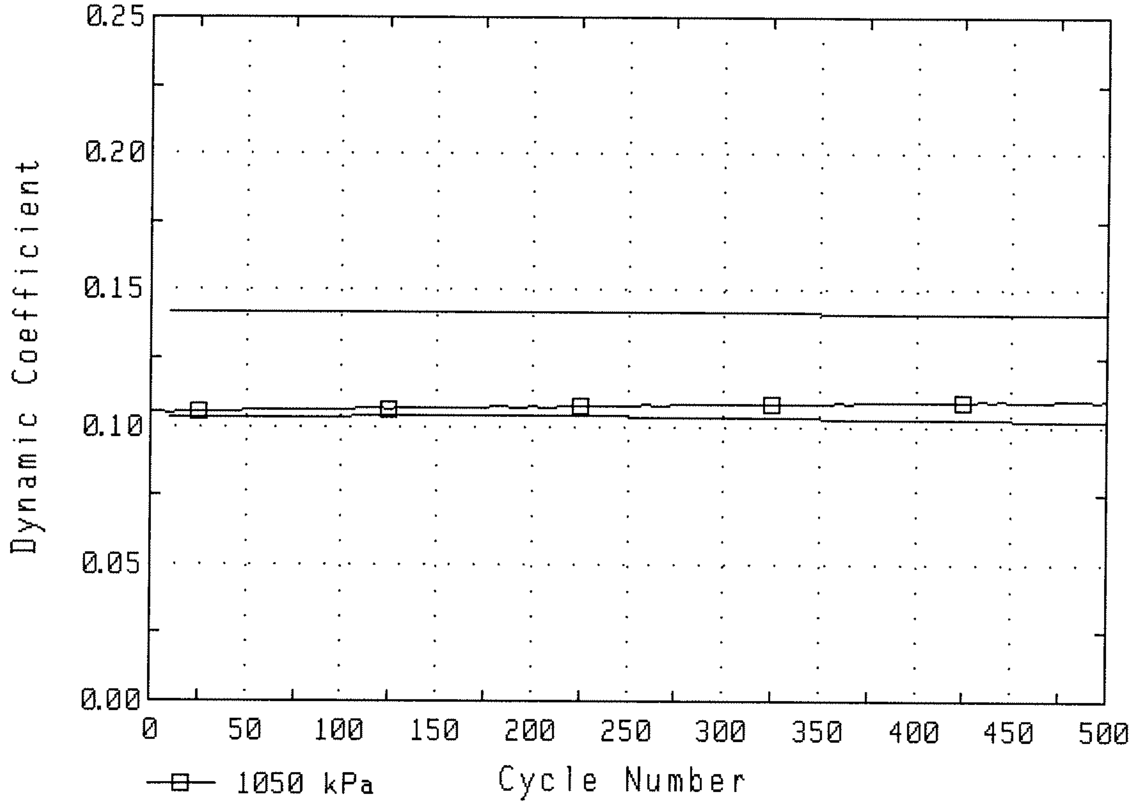

Torque (N-m)
100 200 300 400 500 600
Phase 34
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(29.0 m/s, 1055 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 35
Cycle 10
0.2 0.4 0.6 0.8 1.0
Time (sec)
(30.0 m/s, 1051 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 35
Cycle 12
0.2 0.4 0.6 0.8 1.0
Time (sec)
(30.0 m/s, 1037 kPa)

Southwest Research Institute
"I"machine oil test AL-27877-L / LO-223703

Test name:	A-75-I
Test date:	09/28/07
Test description:	AL-27877-L
Oil type:	AL-27877-L / LO-223703
Viscosity:	OW-30
Miscellaneous:	
Software version:	1.40
Run name & desc:	I0706093 - AL-27877-L
Run date:	09/30/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	mtd
Remarks:	I machine oil test AL-27877-L / LO-223703
Sequence name:	SEQ1222
Remarks:	Use 1Y0711 Disc and 1Y0726 Plate
Number of cycles run:	1164
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 N-m-s^2
Disc name & desc:	1Y0711 - Wheel Brake Paper
Material:	Raybestos 7902-1 Paper
Groove pattern:	2 - 37 Multiple Parallel
Miscellaneous:	Use with 1Y0726 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	24FE9-00001
Remarks:	wheel brake paper
Plate name & desc:	1Y0726 - Steel Plate
Surface:	0.30 micron Maximum Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	24FE9-00001
Remarks:	0.21 surface finish
Report limit name:	LIM1222 - Reference run: I0706004
Limit file generated:	07/26/06
Report format name:	REP1222 - WHEEL BRAKE PAPER

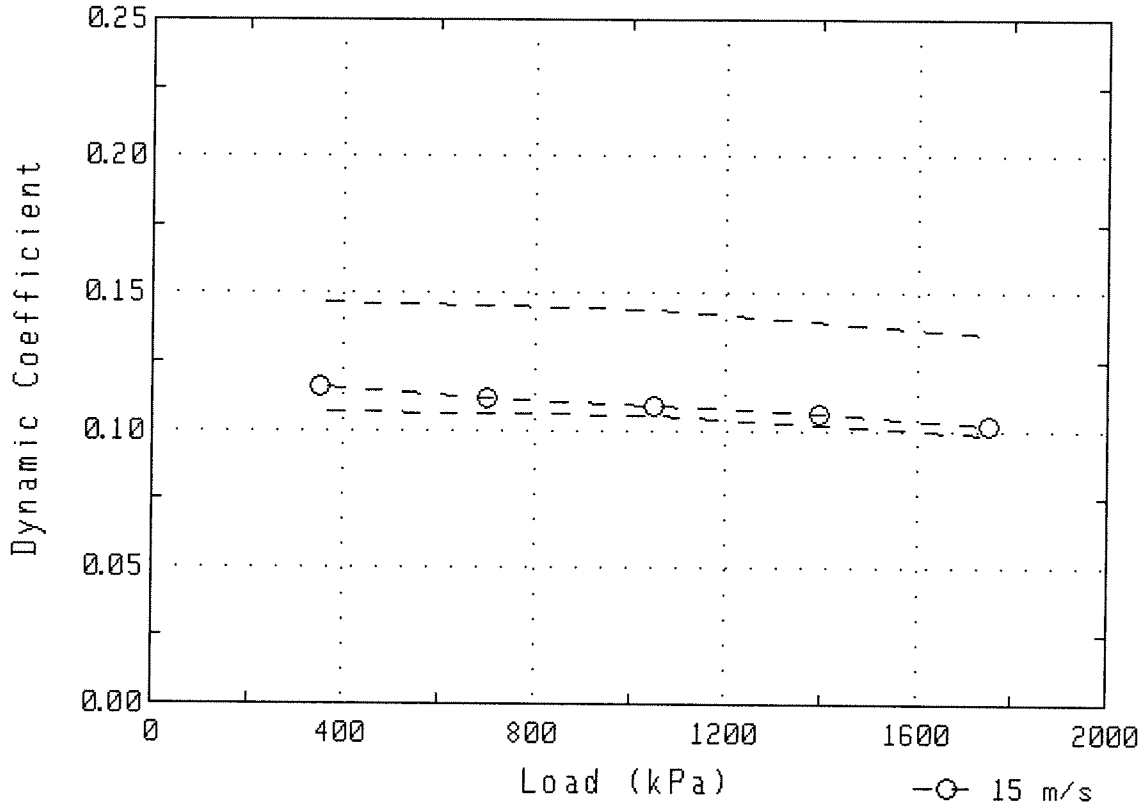


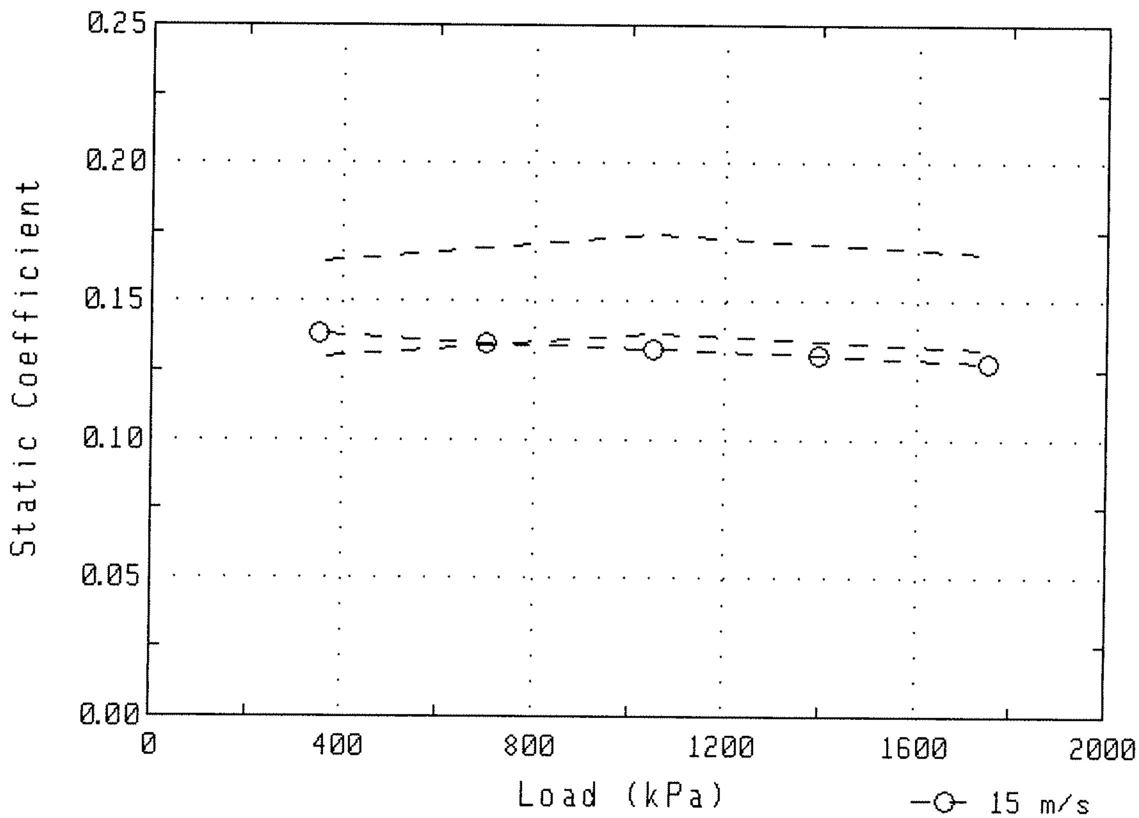
1Y0711 DISC
THICKNESS

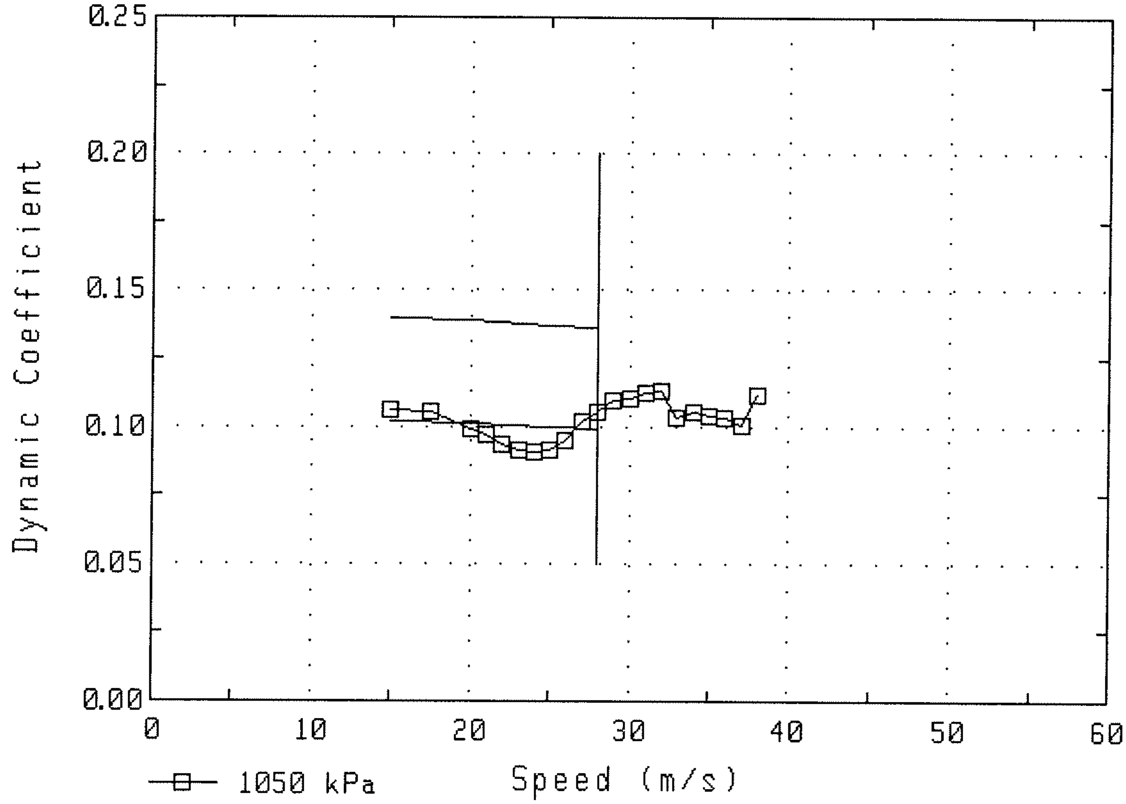
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	5.00	4.98	4.96	4.99	4.97	4.96
2	4.98	4.96	4.95	4.97	4.96	4.95
3	4.98	4.96	4.95	4.98	4.96	4.95
4	4.99	4.97	4.95	4.99	4.96	4.95
5	4.98	4.96	4.95	4.98	4.96	4.95
6	4.99	4.97	4.96	4.99	4.96	4.95
Avg	4.99	4.97	4.95	4.98	4.96	4.95

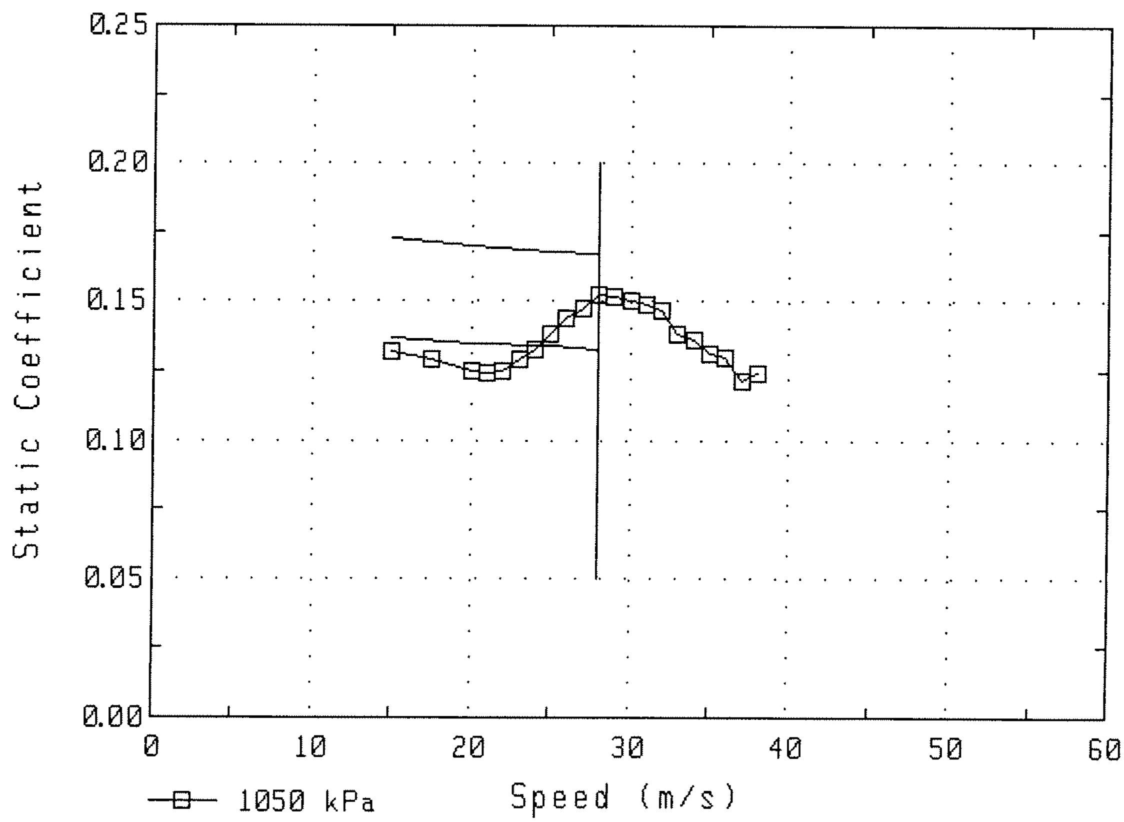
Compression set average wear: 0.021
M2 - M3 average Wear: 0.012

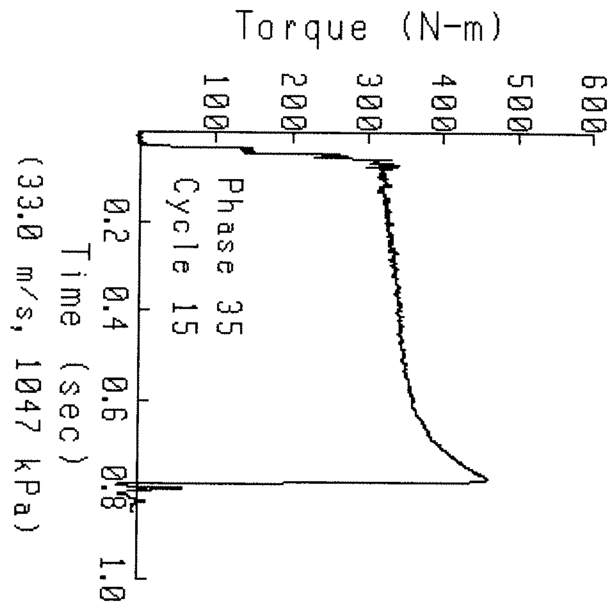
Total Wear (all measurements in mm): 0.033

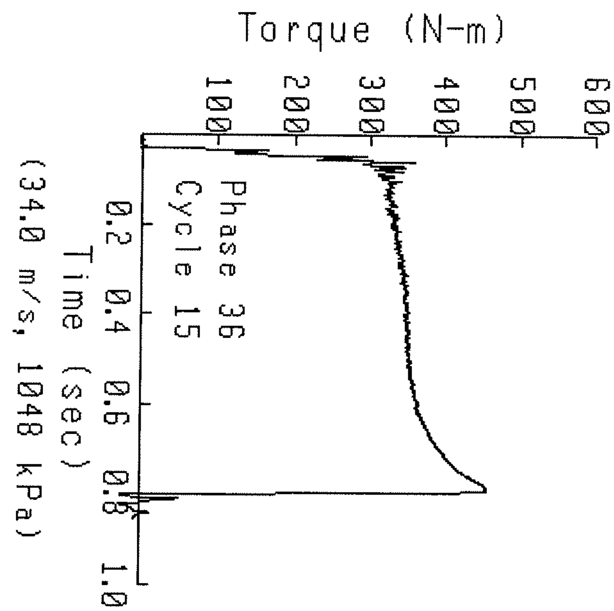

Dynamic Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

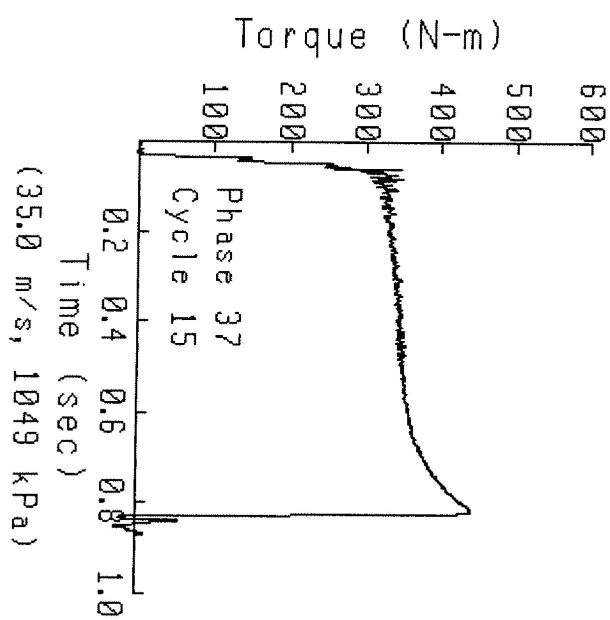

Static Coefficient
0.25
0.20
0.15
0.10
0.05
0.00
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

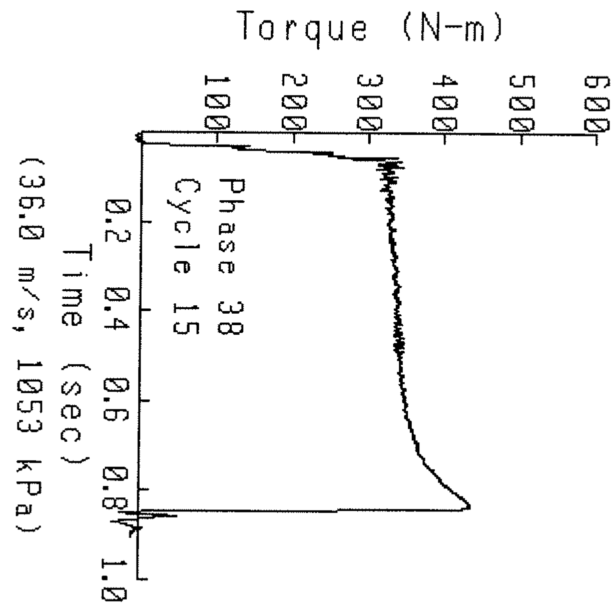

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

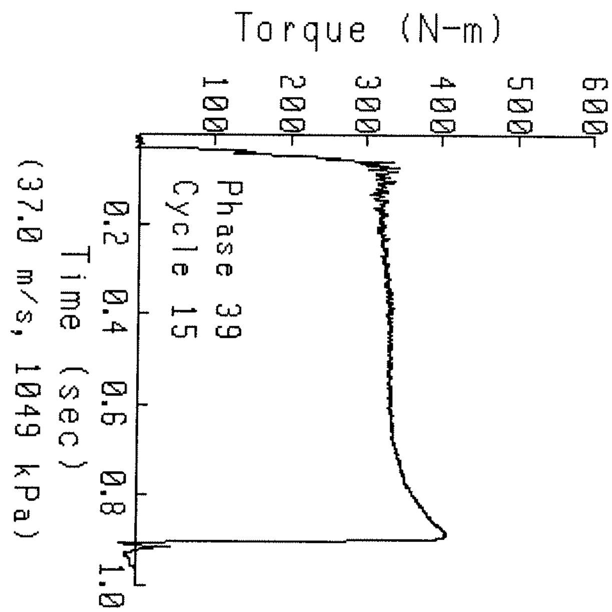

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

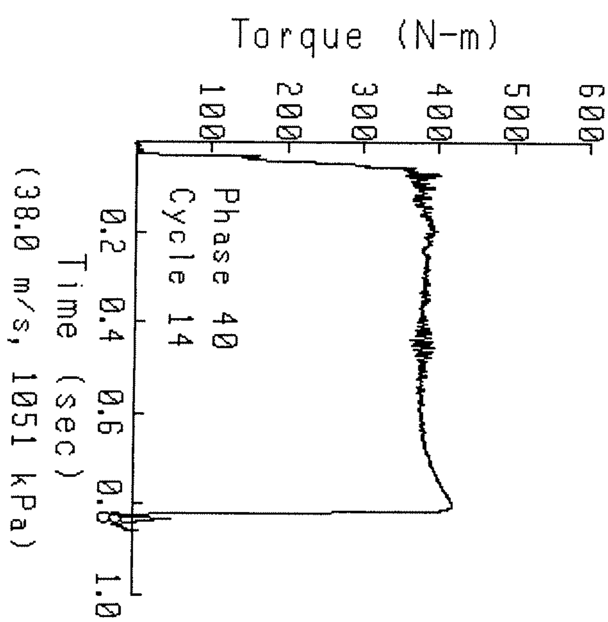

Torque (N-m)
100 200 300 400 500 600
Phase 35
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(33.0 m/s, 1047 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 36
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(34.0 m/s, 1048 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 37
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(35.0 m/s, 1049 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 38
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(36.0 m/s, 1053 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 39
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(37.0 m/s, 1049 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 40
Cycle 14
0.2 0.4 0.6 0.8 1.0
Time (sec)
(38.0 m/s, 1051 kPa)

Test name:	A-75-I
Test date:	09/28/07
Test description:	AL-27877-L
Oil type:	AL-27877-L / LO-223703
Viscosity:	OW-30
Miscellaneous:	
Software version:	1.40

Run name & desc:	I0706094 - AL-27877-L
Run date:	10/01/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	HC
Remarks:	"I" machine oil test AL-27877-L / LO-223703
Sequence name:	SEQ1223
Remarks:	Use 1Y0712 Disc and 1Y0726 Plate
Number of cycles run:	1033

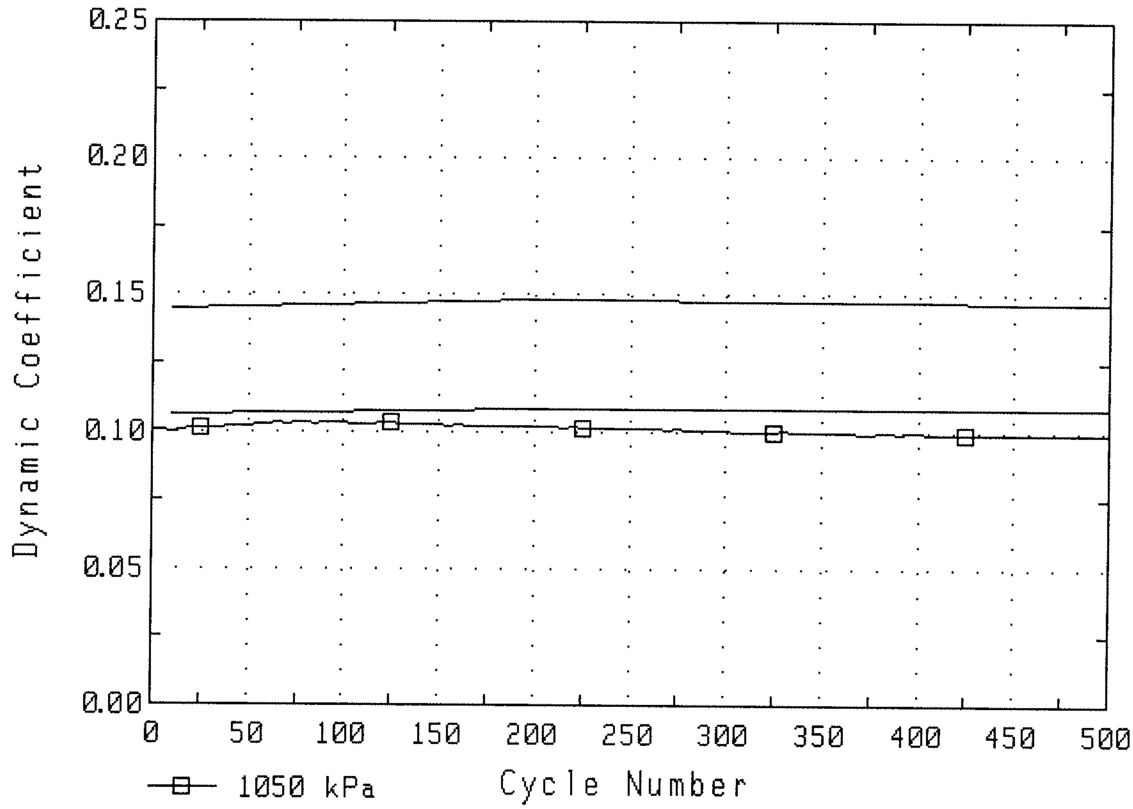
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 $N\text{-}m\text{-}s^2$

Disc name & desc:	1Y0712 - Transmission Paper
Material:	Raybestos 7901-2 Paper
Groove pattern:	2 - 37 Multiple Parallel
Miscellaneous:	Use with 1Y0726 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	27MR9-00001
Remarks:	Transmission Paper

Plate name & desc:	1Y0726 - Steel Plate
Surface:	0.30 micron Maximum Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	27MR9-00001
Remarks:	0.18 Surface Finish

Report limit name:	LIM1223 - Reference run: I0706006
Limit file generated:	07/26/06
Report format name:	REP1223 - TRANSMISSION PAPER

Test: A-75-I Run: I0706094 Started on 10/01/07 at 09:00

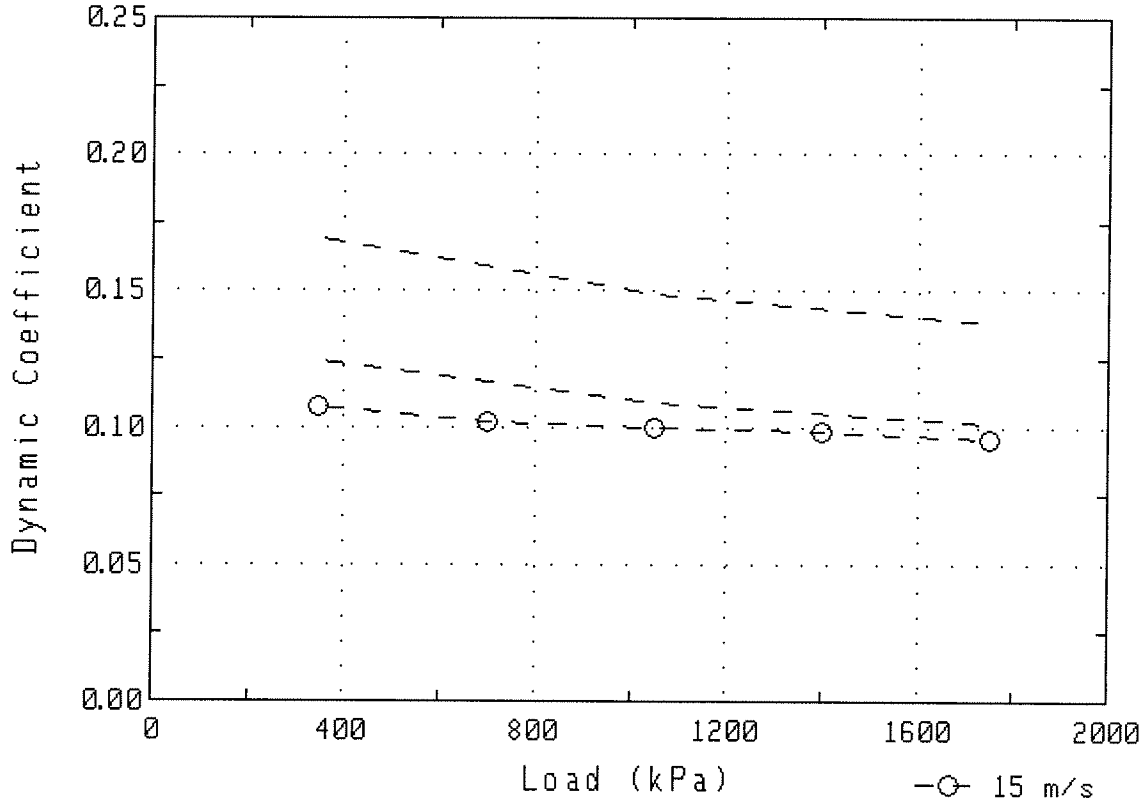


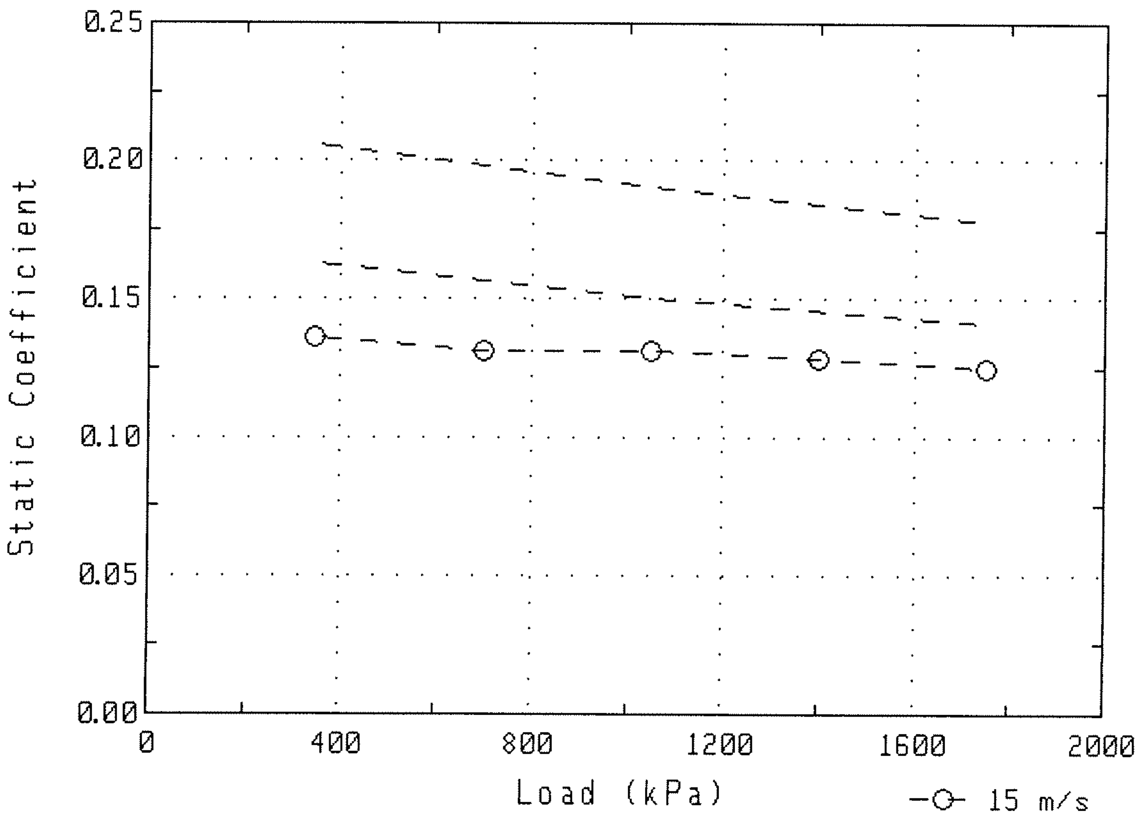
1Y0712 DISC
THICKNESS

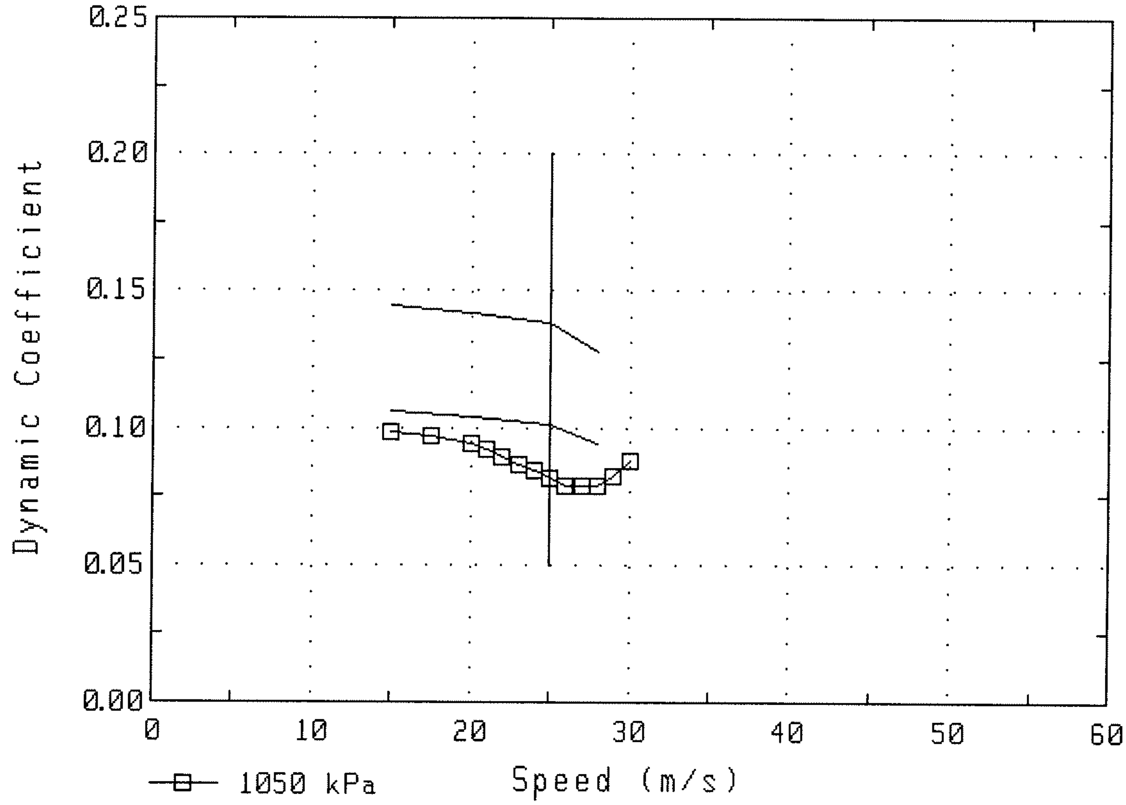
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	4.99	4.97	4.96	4.98	4.97	4.95
2	4.98	4.96	4.95	4.98	4.96	4.95
3	4.98	4.95	4.95	4.98	4.96	4.95
4	4.99	4.96	4.95	4.98	4.96	4.95
5	5.00	4.97	4.96	5.00	4.97	4.96
6	5.00	4.97	4.96	4.99	4.97	4.96
Avg	4.99	4.96	4.95	4.99	4.97	4.95

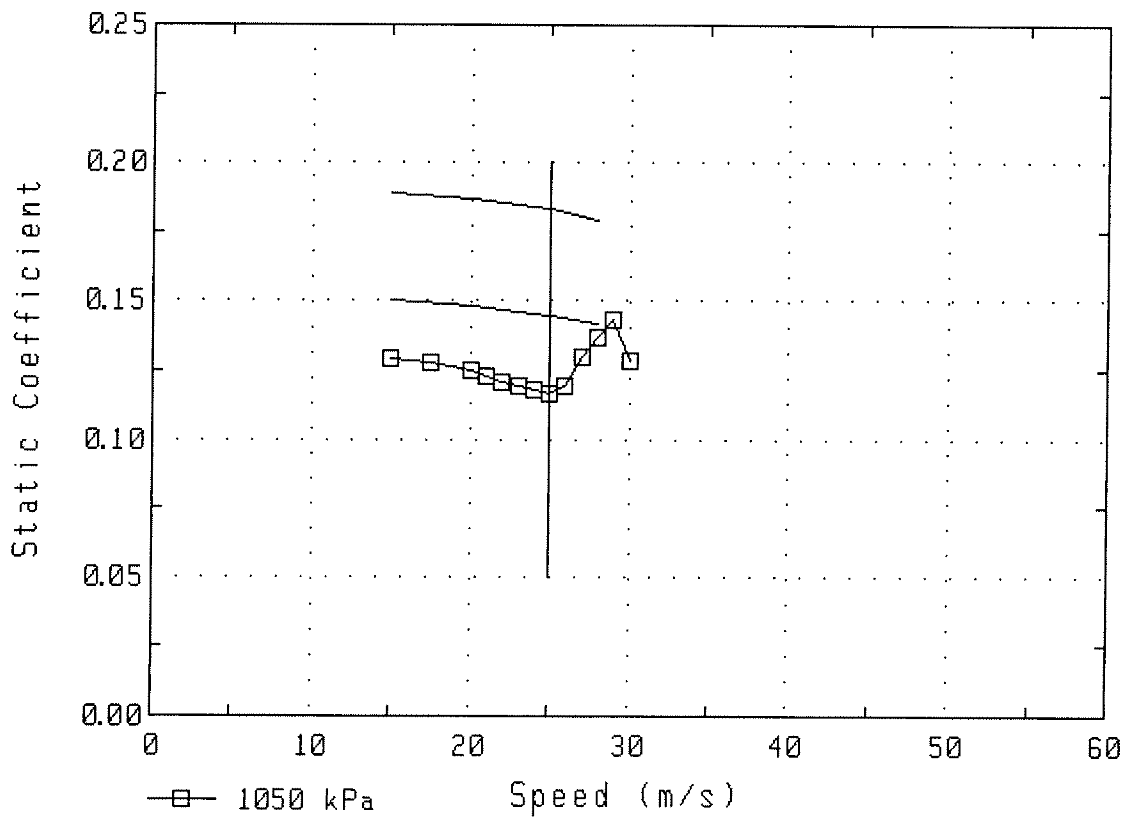
Compression set average wear: 0.023
M2 - M3 average Wear: 0.010

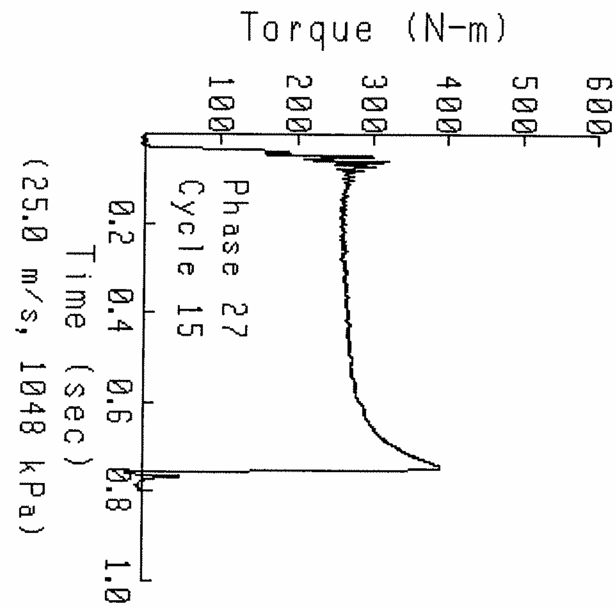
Total Wear (all measurements in mm): 0.033

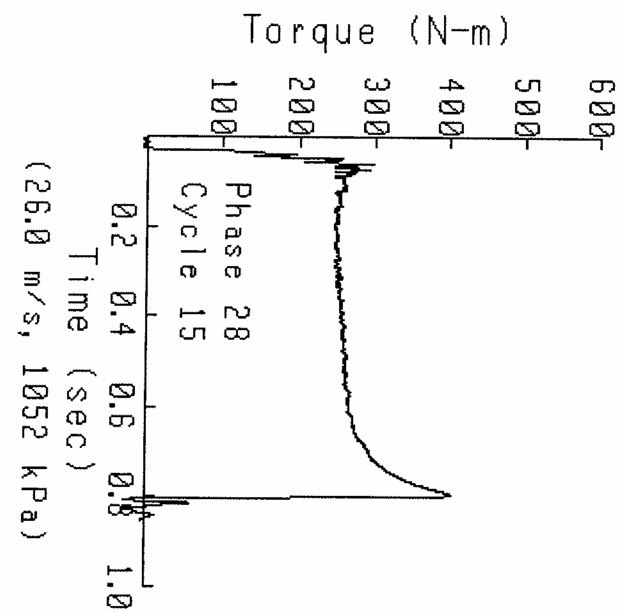

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

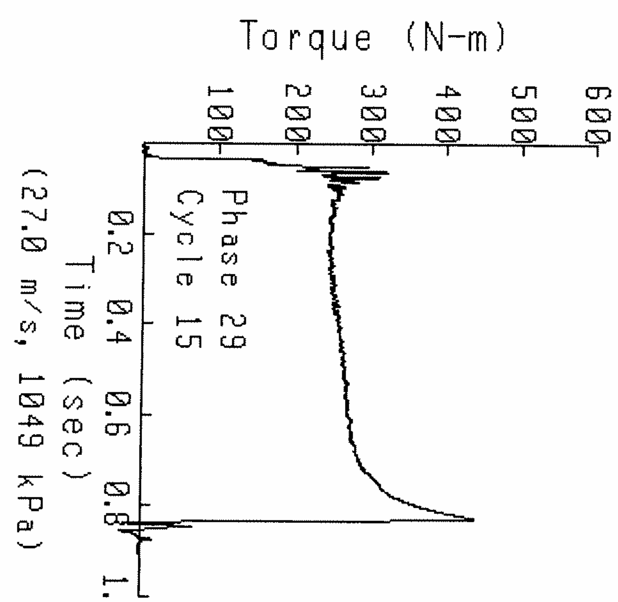

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

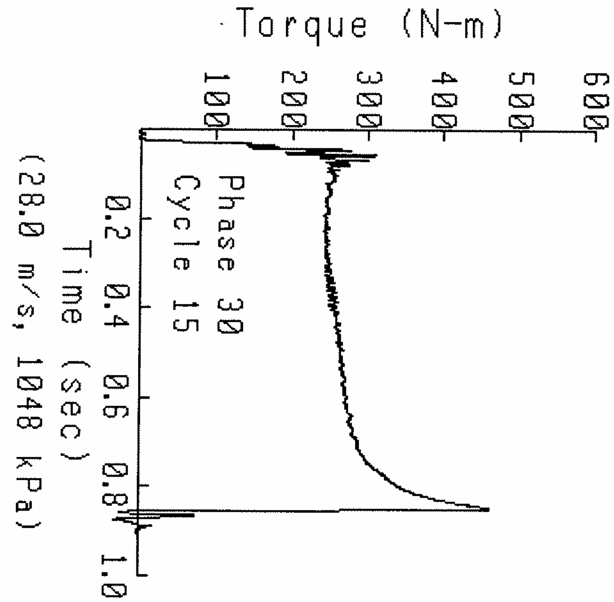

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

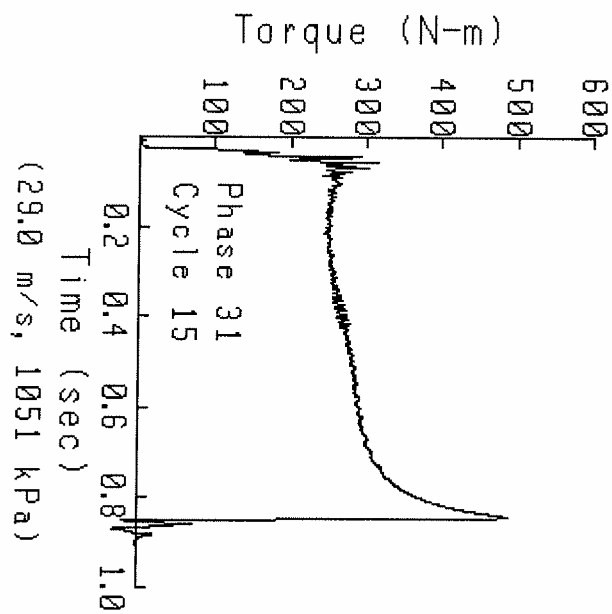

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

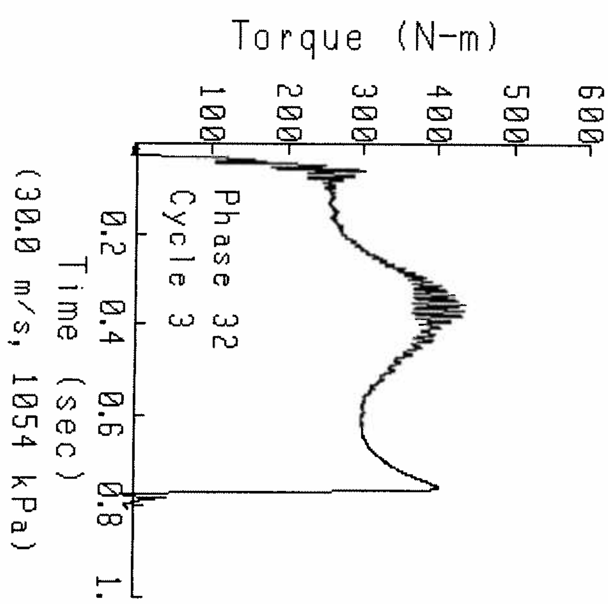

Torque (N-m)
100 200 300 400 500 600
Phase 27
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(25.0 m/s, 1048 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 28
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(26.0 m/s, 1052 kPa)

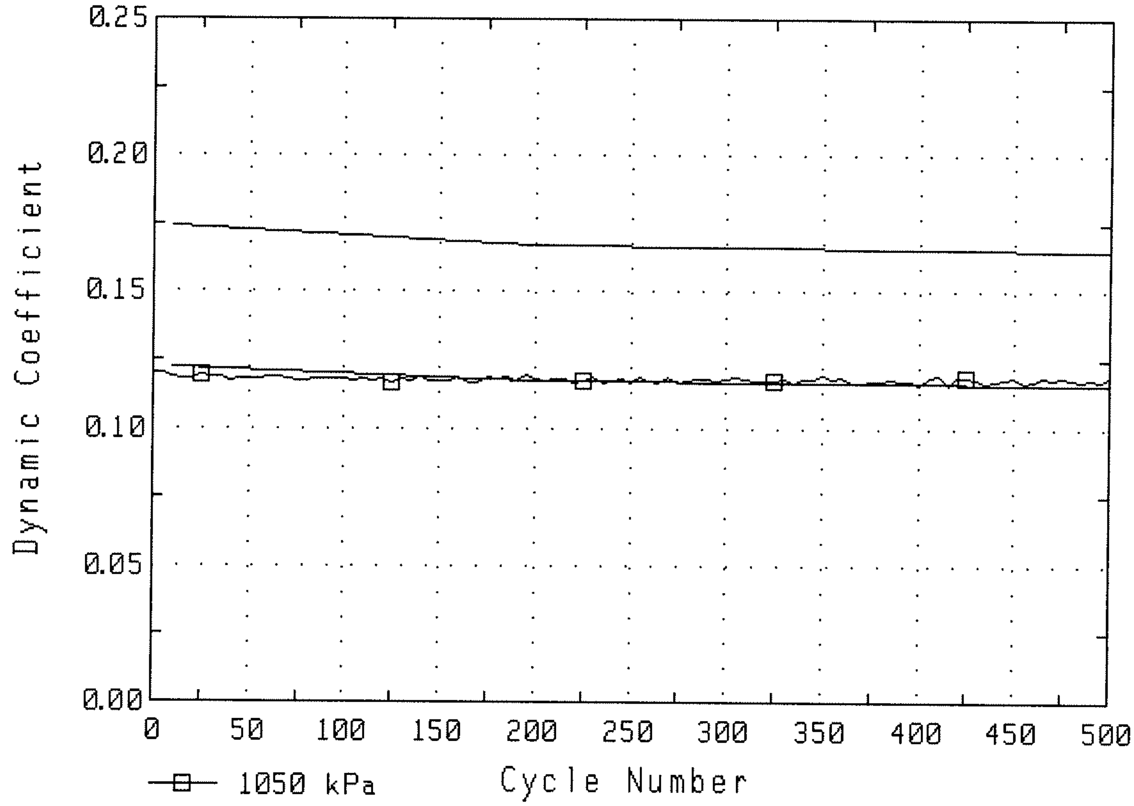

Torque (N-m)
100 200 300 400 500 600
Phase 29
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(27.0 m/s, 1049 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 30
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(28.0 m/s, 1048 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 31
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(29.0 m/s, 1051 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 32
Cycle 3
0.2 0.4 0.6 0.8 1.0
Time (sec)
(30.0 m/s, 1054 kPa)

Test name:	A-75-I
Test date:	09/28/07
Test description:	AL-27877-L
Oil type:	AL-27877-L / LO-223703
Viscosity:	OW-30
Miscellaneous:	
Software version:	1.40
Run name & desc:	I0706095 - AL-27877-L
Run date:	10/02/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	HC
Remarks:	"I" machine oil test AL-27877-L / LO-223703
Sequence name:	SEQ1224
Remarks:	Use 1Y0713 Disc and 8E4095 Plate
Number of cycles run:	1096
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 N-m-s^2
Disc name & desc:	1Y0713 - Elastomeric Disc
Material:	Caterpillar F37
Groove pattern:	Single Lead Spiral - 12 Radial
Miscellaneous:	Use with 8E4095 Steel Plate
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	C63007FE1
Remarks:	Elastomeric
Plate name & desc:	8E4095 - Steel Plate
Surface:	0.70 to 1.00 micron Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	C63007FE1
Remarks:	0.88 Surface Finish
Report limit name:	LIM1224 - Reference run: I0706007
Limit file generated:	07/26/06
Report format name:	REP1224 - ELASTOMERIC, F37

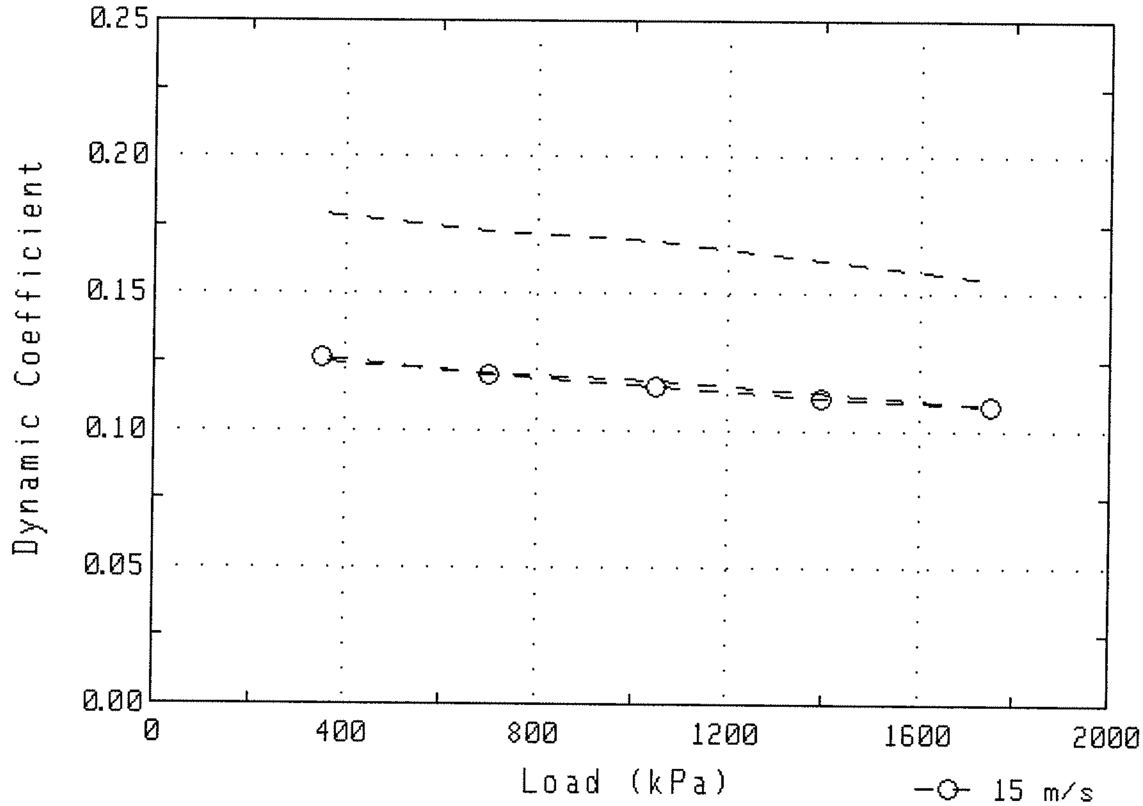


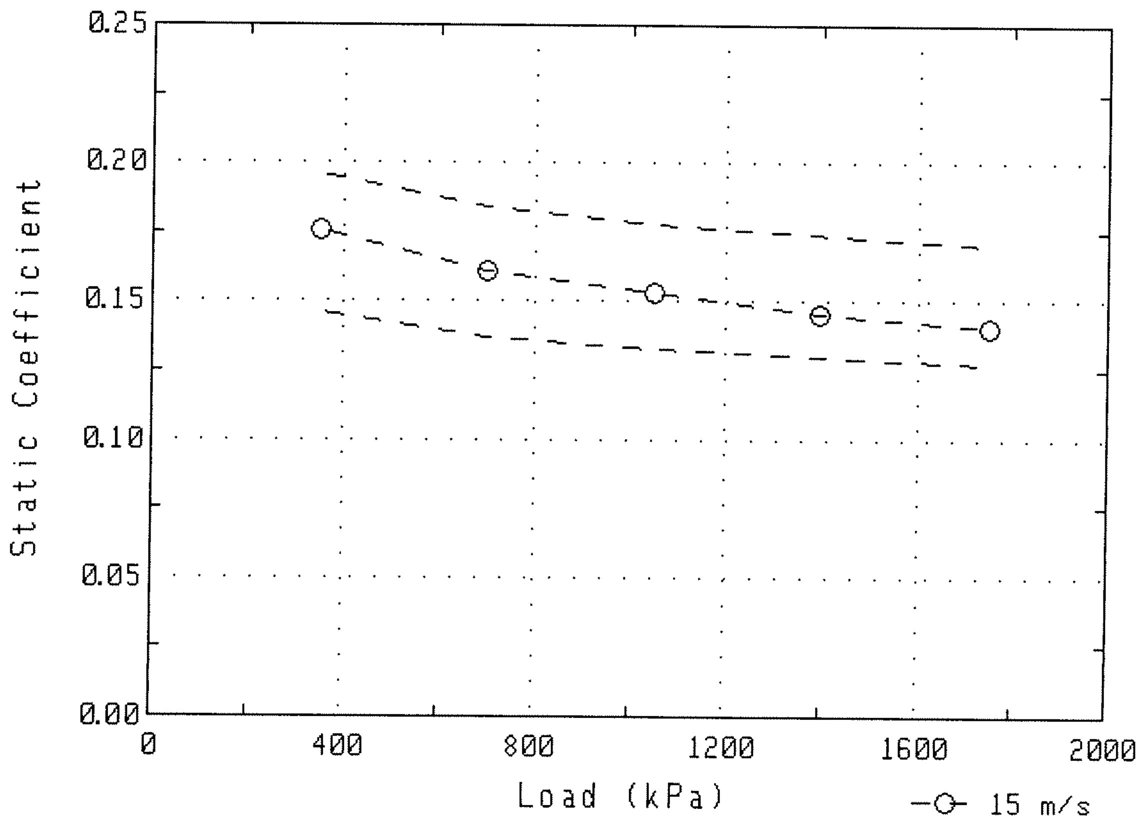
1Y0713 DISC
THICKNESS

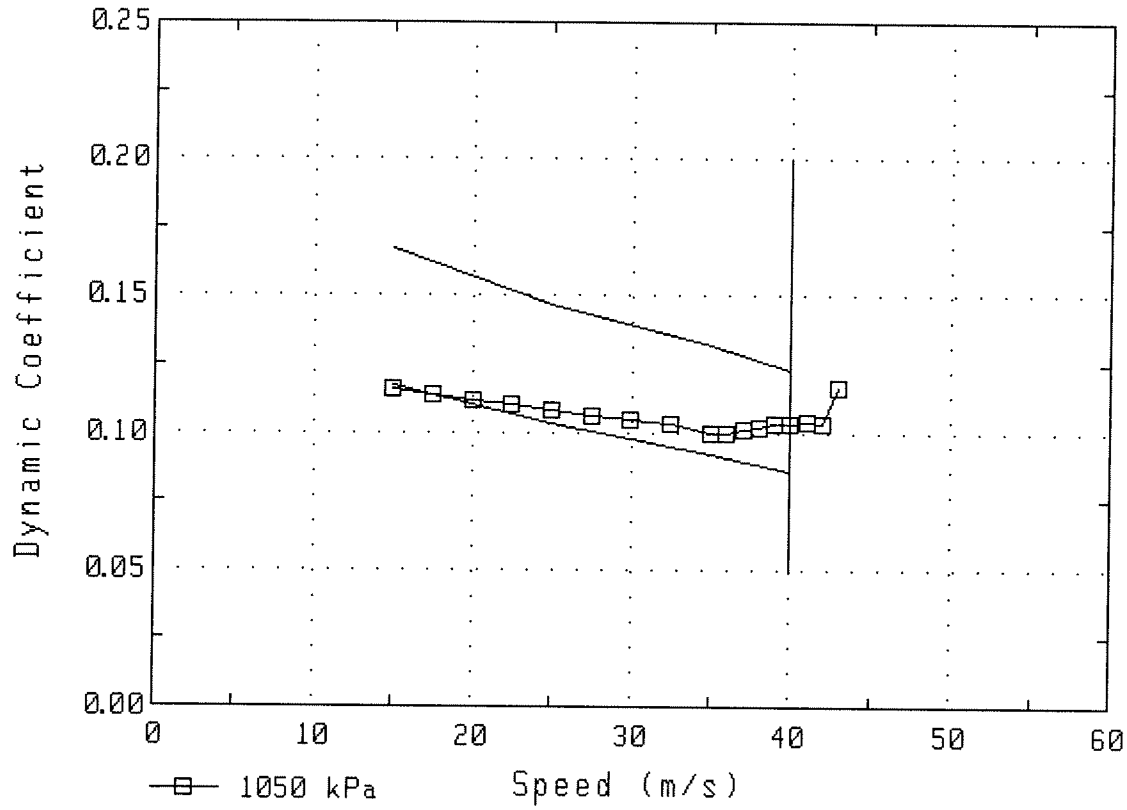
Loc	Outer Diameter M1	M2	M3	Inner Diameter M1	M2	M3
1	5.04	5.04	5.04	5.04	5.04	5.04
2	5.04	5.04	5.04	5.04	5.04	5.04
3	5.04	5.04	5.04	5.04	5.04	5.04
4	5.04	5.04	5.04	5.04	5.04	5.04
5	5.04	5.04	5.04	5.04	5.04	5.04
6	5.04	5.04	5.04	5.04	5.04	5.04
Avg	5.04	5.04	5.04	5.04	5.04	5.04

Compression set average wear: 0.000
M2 - M3 average Wear: 0.000

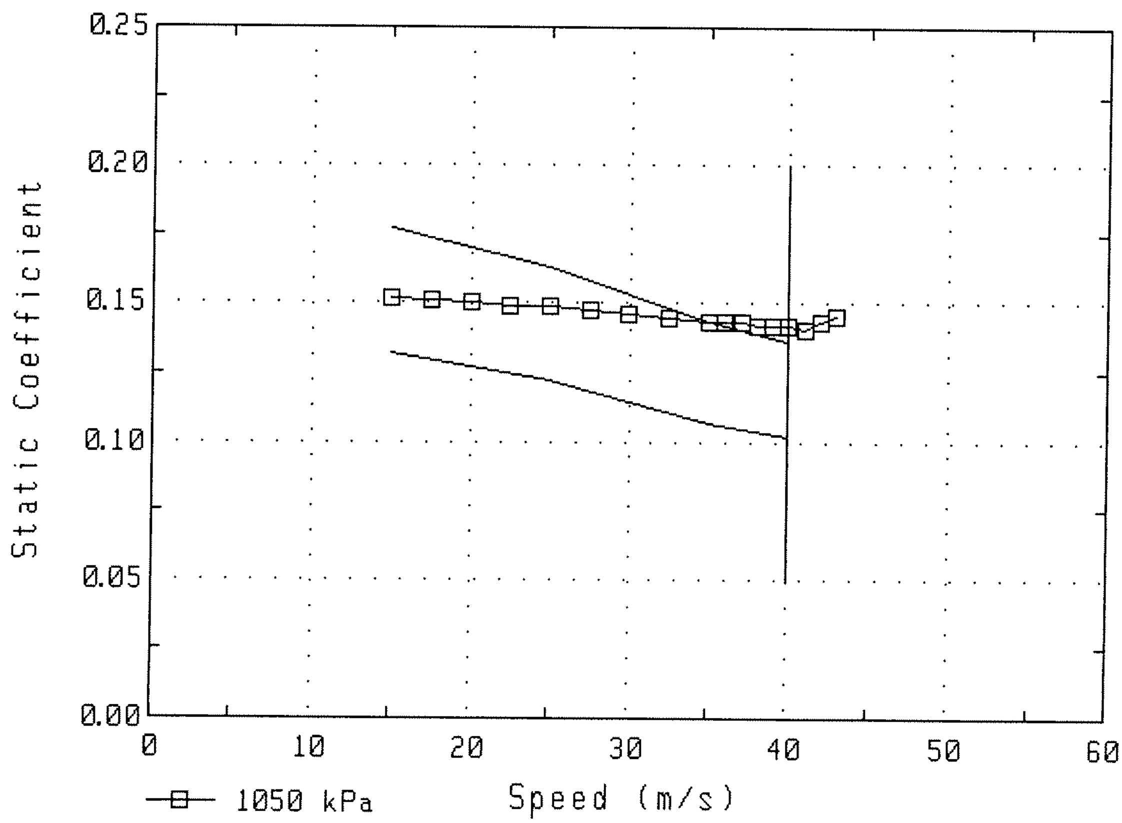
Total Wear (all measurements in mm): 0.000


0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

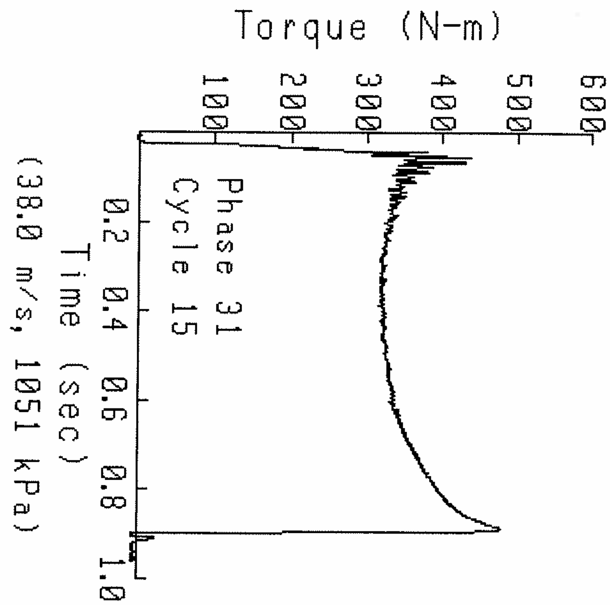

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
400
800
1200
1600
2000
Load (kPa)
15 m/s

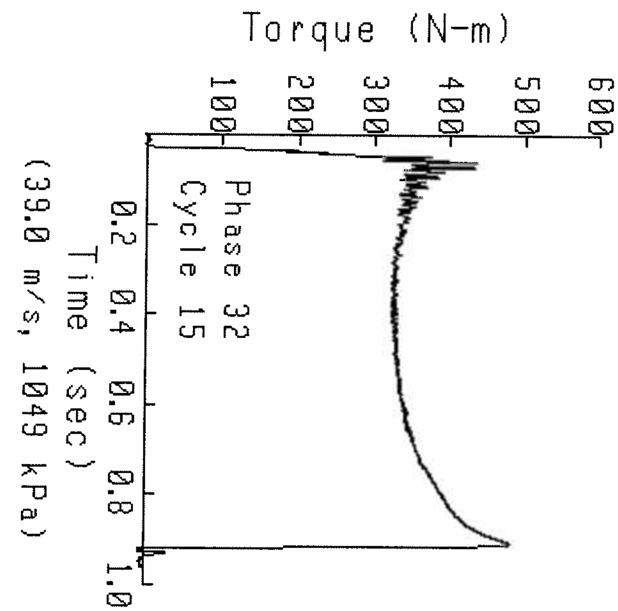


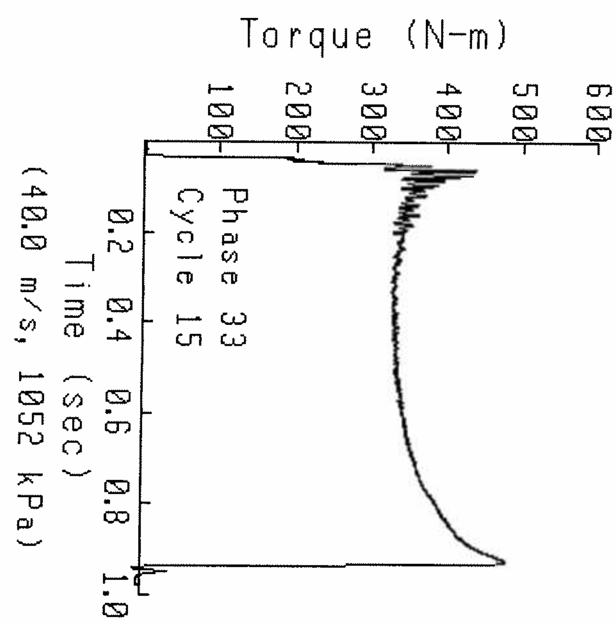
0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

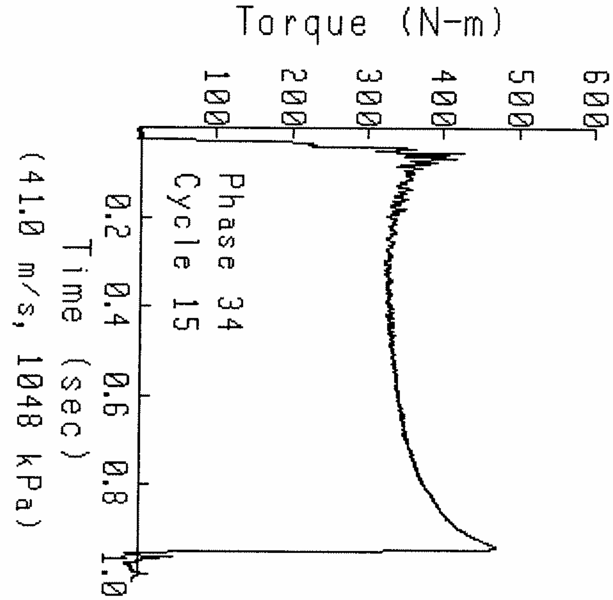


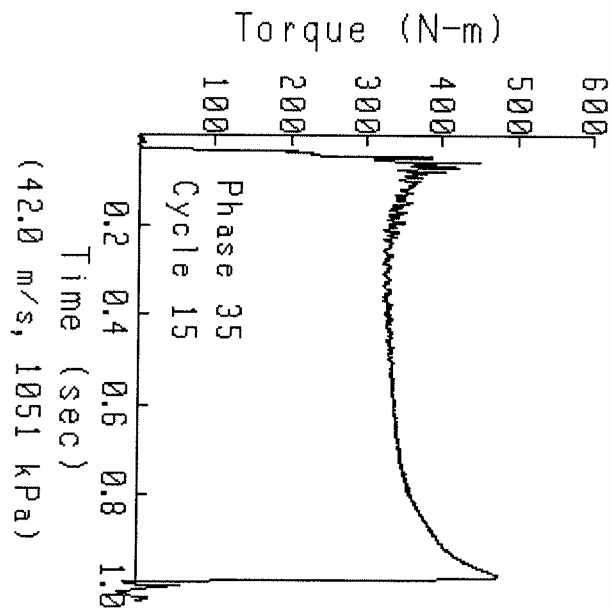
0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
1050 kPa
Speed (m/s)

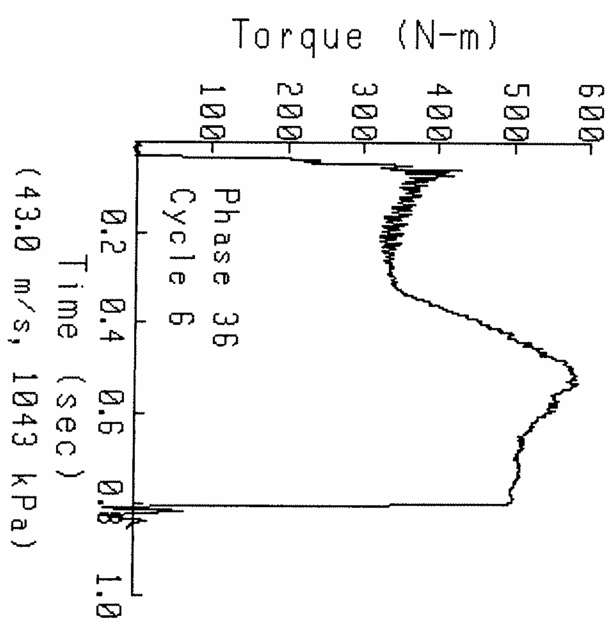

Torque (N-m)
100 200 300 400 500 600
Phase 31
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(38.0 m/s, 1051 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 32
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(39.0 m/s, 1049 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 33
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(40.0 m/s, 1052 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 34
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(41.0 m/s, 1048 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 35
Cycle 15
0.2 0.4 0.6 0.8 1.0
Time (sec)
(42.0 m/s, 1051 kPa)


Torque (N-m)
100 200 300 400 500 600
Phase 36
Cycle 6
0.2 0.4 0.6 0.8 1.0
Time (sec)
(43.0 m/s, 1043 kPa)

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

FUELS AND LUBRICANTS RESEARCH DIVISION

Report on

CATERPILLAR TO-4 FRICTION PROPERTIES, VC-70

Conducted for

SWRI – ARMY LAB

Oil Code:
AT-27877-L

Test Number:
VC70-A-73-I

September 20, 2007

Submitted by:

Brian Koehler
Principal Engineer
Specialty & Driveline Fluids
Evaluations

CATERPILLAR TO-4 FRICTION PROPERTIES, VC-70

Summary Sheet

Company: SWRI – ARMY LAB

Test start date: September 13, 2007
End of test date: September 20, 2007
Oil Code: AL-27877-L

Sequence Number	N/A	1220	N/A	N/A	N/A	N/A	Friction Retention
Dynamic Coefficient Vs. Cycle:	N/A	F	N/A	N/A	N/A	N/A	P
Dynamic Coefficient Vs. Load:	N/A	F	N/A	N/A	N/A	N/A	
Dynamic Coefficient Vs. Speed:	N/A	F	N/A	N/A	N/A	N/A	
Energy Limit:	N/A	P	N/A	N/A	N/A	N/A	
Static Coefficient Vs. Cycle:							N/A
Static Coefficient Vs. Load:	N/A	P	N/A	N/A	N/A	N/A	
Static Coefficient Vs. Speed:	N/A	P	N/A	N/A	N/A	N/A	
Energy Limit:	N/A	P	N/A	N/A	N/A	N/A	
Total Wear:	N/A	0.030	N/A	N/A	N/A	N/A	
Wear Limit:	N/A	0.040	N/A	N/A	N/A	N/A	

Comments:
The sequence FRRET had a shutdown at about 3500 cycles. The dynamic values where shifted upward while the oil temperature stabilized.

F = Fail
P = Pass
N/A = Not Applicable

southwest Research Institute
"I" machine AL-27877-L / LO-223703

Test name:	A-73-I
Test date:	09/13/07
Test description:	I machine AL27877-L
Oil type:	AL-27877-L /LO223703
Viscosity:	OW-30
Miscellaneous:	
Software version:	1.40

Run name & desc:	I0706087 - AL-27877-L
Run date:	09/14/07
Oil temperature:	115 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	HC
Remarks:	"I" machine oil test AL-27877-L / LO-223703
Sequence name:	SEQFRRET
Remarks:	USE 1Y0709 DISC AND 1Y0726 PLATE (8E7351 GROUP)
Number of cycles run:	25100

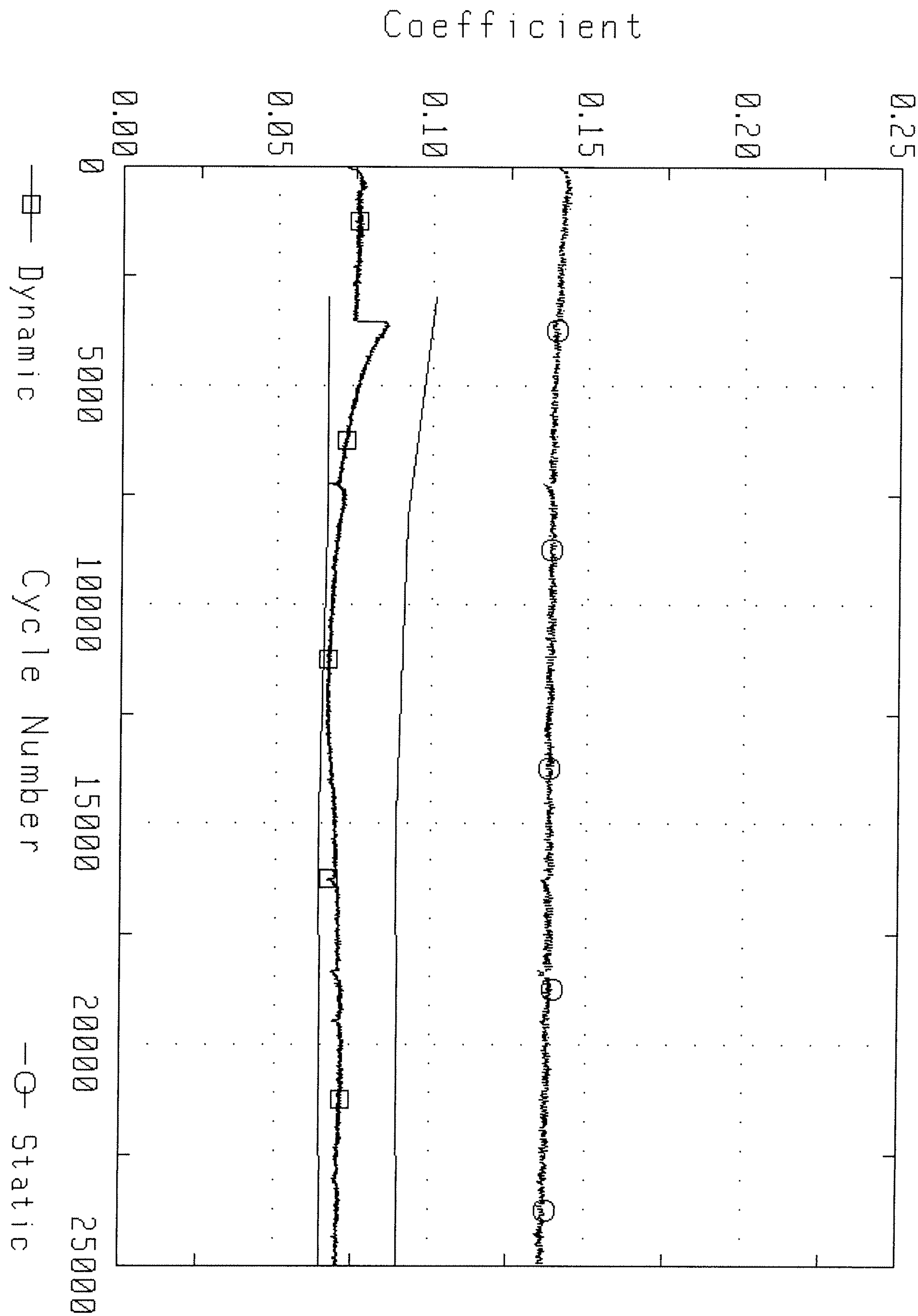
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 $N\text{-}m\text{-}s^2$

Disc name & desc:	1Y0709 - Sintered Bronze
Material:	Raybestos 1349-ET Bronze
Groove pattern:	Single Lead Spiral - 12 Radial
Miscellaneous:	Use with 8E4095 Steel Plate for performance run
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	12FE1-00008
Remarks:	Sintered Bronze

Plate name & desc:	1Y0726 - Steel Plate
Surface:	0.30 micron Maximum Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	12FE1-00008
Remarks:	0.16 Surface Finish

Report limit name:	LIMFRRET - Reference run: I0706005
Limit file generated:	07/26/06
Report format name:	REPFRRET - FRICTION RETENTION

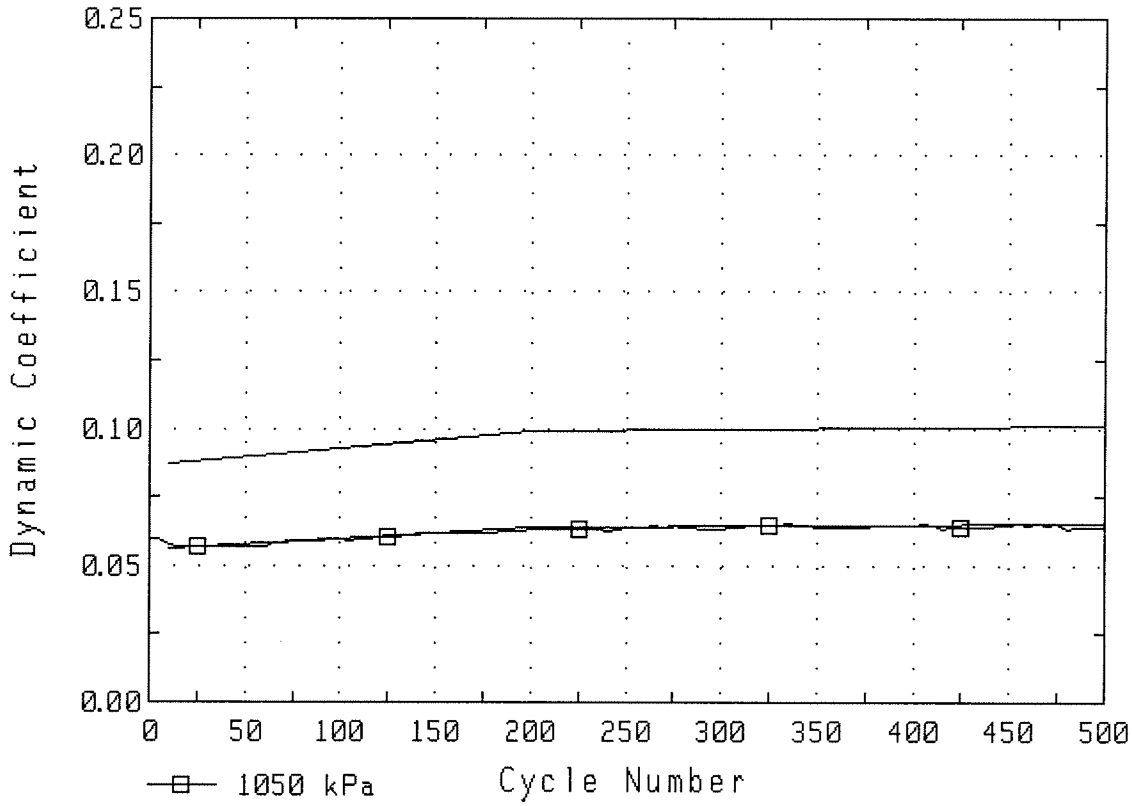
Test: A-73-I Run: I0706087 Started on 09/14/07 at 10:20



southwest Research Institute
"I" machine AL-27877-L / LO-223703

Test name:	A-73-I
Test date:	09/13/07
Test description:	I machine AL27877-L
Oil type:	AL-27877-L /LO223703
Viscosity:	OW-30
Miscellaneous:	
Software version:	1.40
Run name & desc:	I0706088 - AT-27877-L
Run date:	09/20/07
Oil temperature:	82 degrees C
Oil flow rate:	3.78 liter/minute
Operator:	HC
Remarks:	"I" machine oil test AT-27877-L / LO-223703
Sequence name:	SEQ1220
Remarks:	Use 1Y0709 Disc and 8E4095 Plate
Number of cycles run:	974
Machine:	I
Coast down check run:	07/19/02
Result:	151.76 seconds
Inertia check run:	07/19/02
Result:	1.0288 $N\text{-}m\text{-}s^2$
Disc name & desc:	1Y0709 - Sintered Bronze
Material:	Raybestos 1349-ET Bronze
Groove pattern:	Single Lead Spiral - 12 Radial
Miscellaneous:	Use with 8E4095 Steel Plate for performance run
Outer diameter (mm):	285.80
Inner diameter (mm):	223.20
Mean radius (mm):	128.21
Batch number:	12FE1-00009
Remarks:	Sintered Bronze
Plate name & desc:	8E4095 - Steel Plate
Surface:	0.70 to 1.00 micron Roughness
Miscellaneous:	Install the side marked with the average roughness
Batch number:	12FE1-00009
Remarks:	0.87 Surface Finish
Report limit name:	LIM1220 - Reference run: I0706002
Limit file generated:	07/26/06
Report format name:	REP1220 - SINTERED BRONZE

Test: A-73-I Run: I0706088 Started on 09/20/07 at 09:22



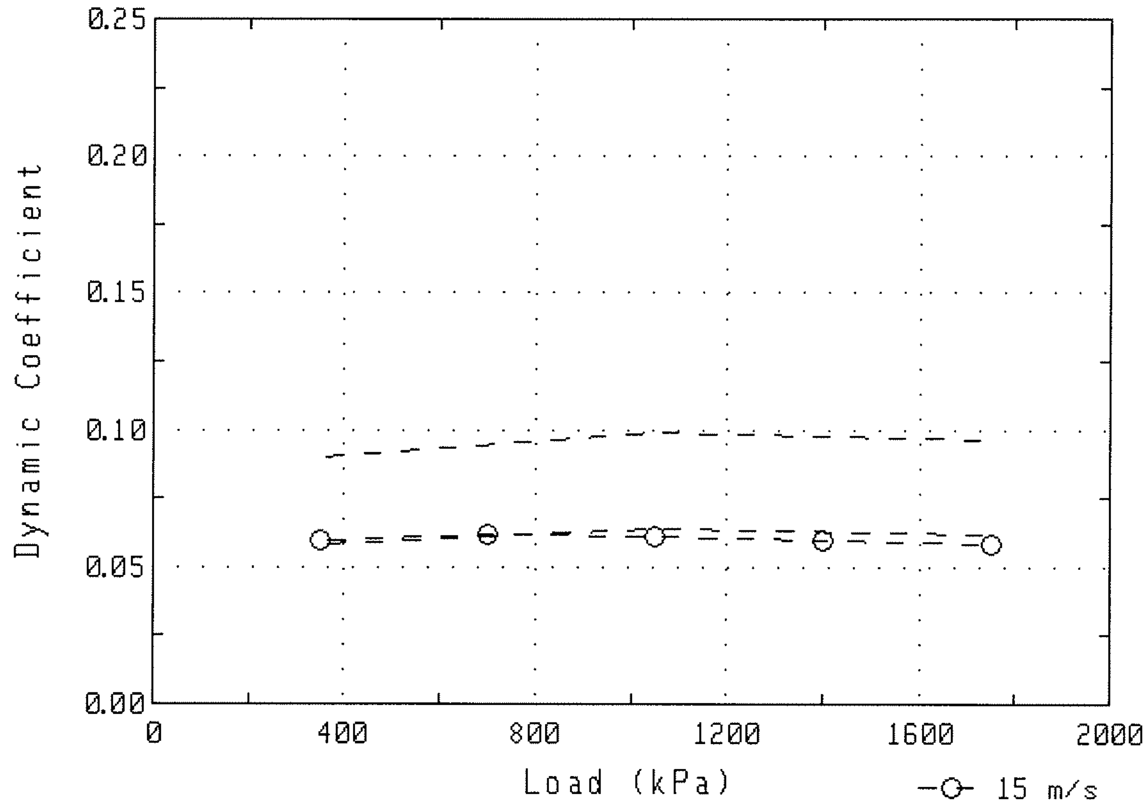
1Y0709 DISC
THICKNESS

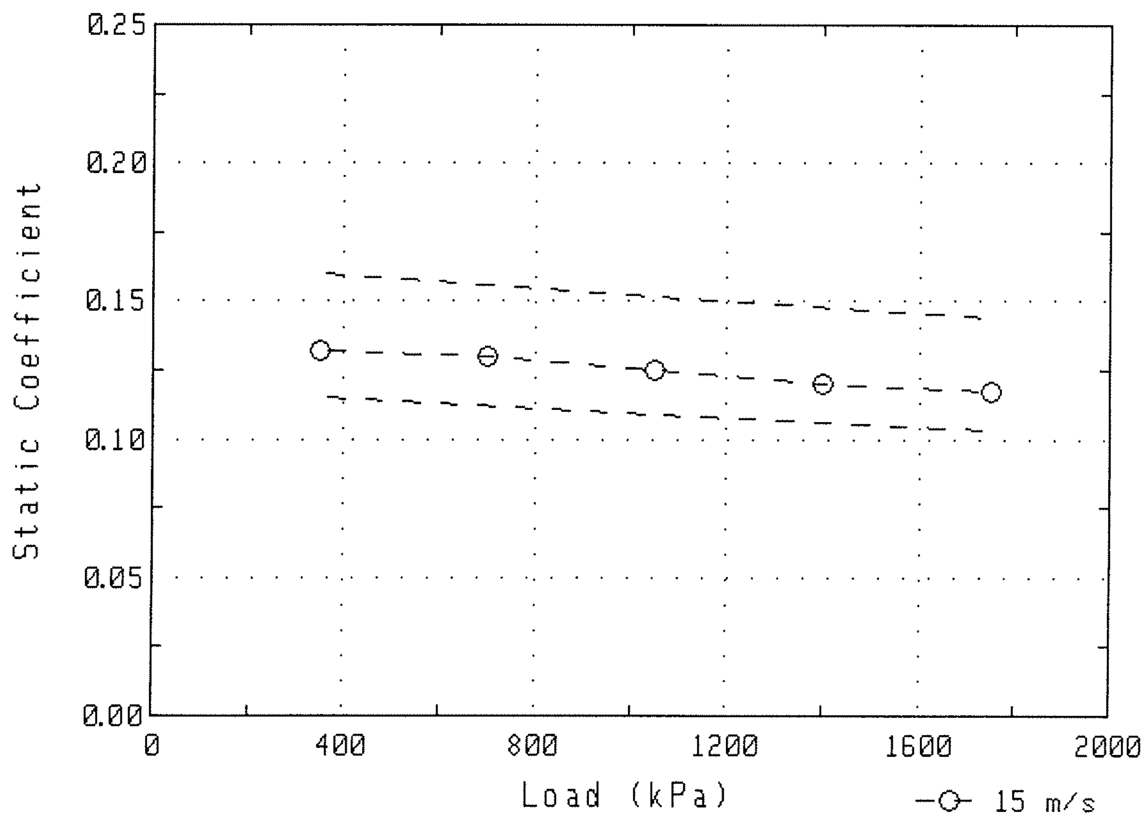
Loc	Outer Diameter M1	Outer Diameter M2	Outer Diameter M3	Inner Diameter M1	Inner Diameter M2	Inner Diameter M3
1	4.99	4.97	4.96	5.00	4.98	4.96
2	4.97	4.96	4.95	4.98	4.97	4.95
3	4.99	4.98	4.96	4.99	4.97	4.96
4	5.00	4.97	4.97	5.00	4.97	4.97
5	5.00	4.98	4.97	4.99	4.97	4.97
6	5.00	4.98	4.97	5.00	4.98	4.96
Avg	4.99	4.97	4.96	4.99	4.97	4.96

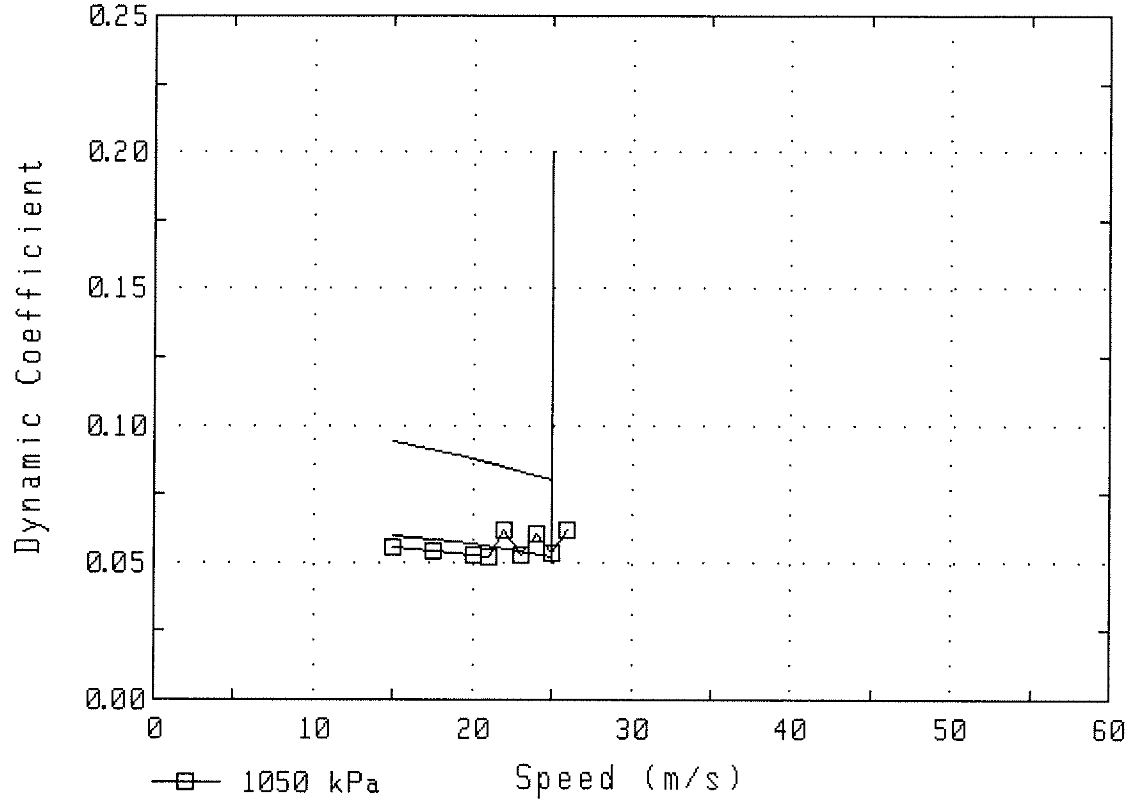
Compression set average wear: 0.019
M2 - M3 average Wear: 0.011

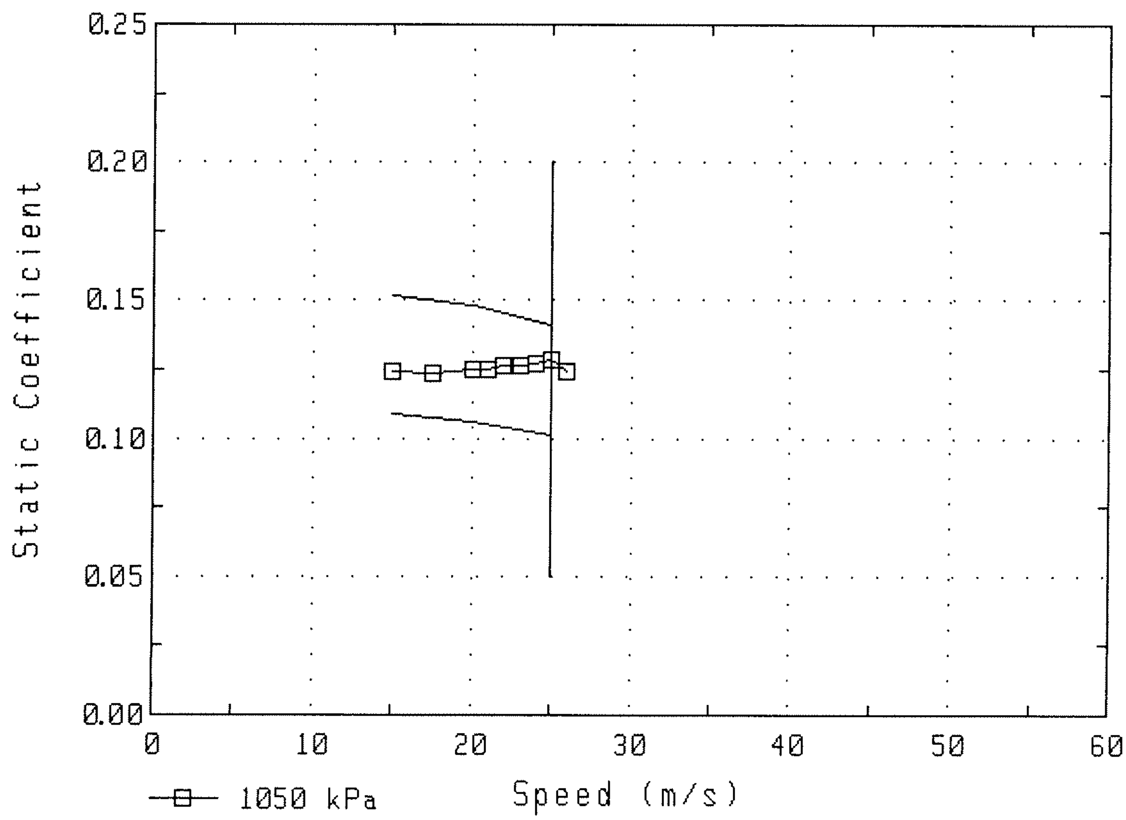
Total Wear (all measurements in mm): 0.030

Test: A-73-I Run: I0706088 Started on 09/20/07 at 09:22

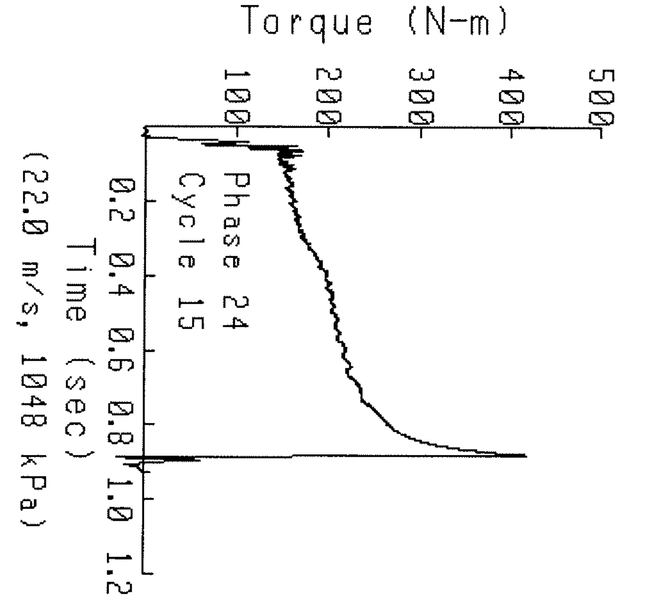


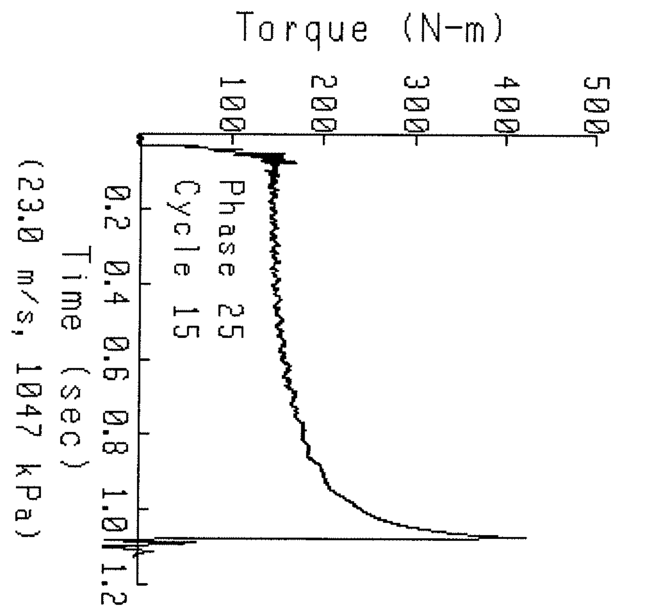


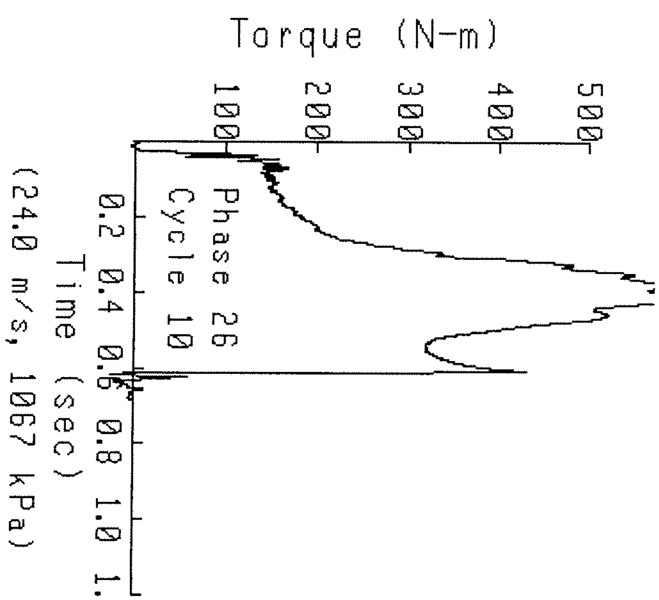

0.25
0.20
0.15
0.10
0.05
0.00
Dynamic Coefficient
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

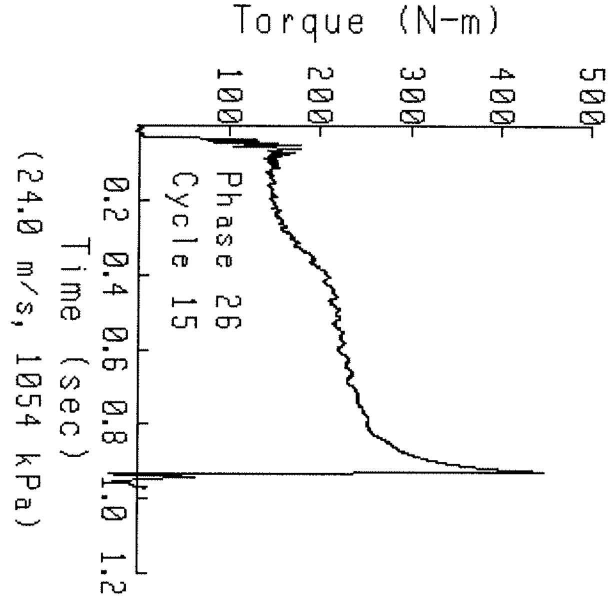

0.25
0.20
0.15
0.10
0.05
0.00
Static Coefficient
0
10
20
30
40
50
60
Speed (m/s)
1050 kPa

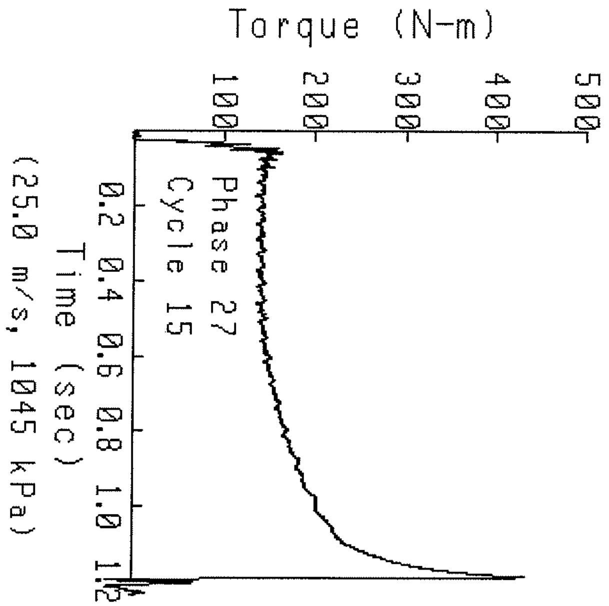
Test: A-73-I Run: I0706088 Started on 09/20/07 at 09:22

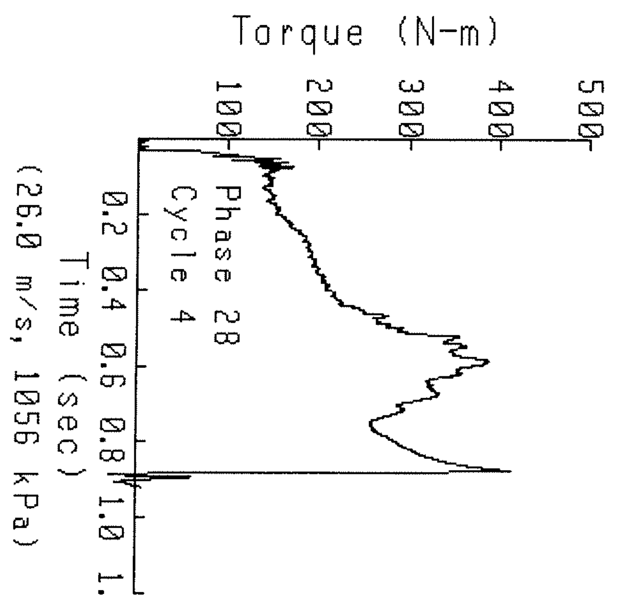












SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

Fuels And Lubricants Research Division

Report on

DEXRON® VI BAND CLUTCH FRICTION TEST

Conducted For

SWRI ARMY LAB

Oil Code:
AL-27877-L

Test Number:
BH3-8-169

September 21, 2007

Submitted by:

Christopher Barker
Research Engineer
Specialty & Driveline Fluids Evaluation

DEXRON®-VI Band Friction - 150 HOURS

Program Code: AL-27877-L
Status: *
Test Cycles: 36,000
Test Performance: *

Start Date: 9/14/2007
EOT Date: 9/21/2007
Run Number: BH3-8-169
EOT Parts Condition: *

Band: 4L60
Drum: 4L60

Test Time [h]	Cycles	Stop Time [s] 0.35	0.55	Midpoint Torque [N·m] 180	290	Max Torque [N·m] Report	End Torque [N·m] > 200		Max - Mid Torque [N·m] < 120		Shift Energy [kJ] (15.7-16.3)
0	10	0.39		233		340	333		106		15.9
1	240	0.41		230		313	309		83		15.8
2	480	0.42		218		331	315		113		15.8
3	720	0.43	Three	218	Three	319	311	Three	101	Three	15.8
4	960	0.42	Point	215	Point	323	318	Point	108	Point	15.8
5	1,200	0.43	Average	216	Average	315	310	Average	99	Average	15.8
10	2,400	0.44	0.44	200	206	314	304	304	114	105	15.7
15	3,600	0.45	0.45	202	202	303	299	296	101	102	15.8
20	4,800	0.45	0.45	204	204	294	286	290	90	91	15.8
25	6,000	0.45	0.45	206	206	287	285	279	81	79	15.8
30	7,200	0.45	0.45	208	209	275	268	267	67	65	15.8
35	8,400	0.44	0.44	212	211	257	249	247	46	49	15.8
40	9,600	0.44	0.45	212	209	246	223	233	34	44	15.8
45	10,800	0.46	0.45	202	208	255	228	227	53	45	15.8
50	12,000	0.44	0.44	209	206	258	229	231	49	52	15.8
55	13,200	0.44	0.44	206	208	261	236	232	54	48	15.8
60	14,400	0.44	0.44	209	207	251	229	229	42	48	15.8
65	15,600	0.44	0.44	205	208	254	222	224	49	43	15.8
70	16,800	0.44	0.44	210	207	248	222	227	37	45	15.8
75	18,000	0.45	0.45	205	207	255	237	228	50	44	15.8
80	19,200	0.45	0.45	205	204	248	225	234	43	47	15.8
85	20,400	0.45	0.45	200	204	250	239	234	49	46	15.8
90	21,600	0.45	0.45	205	203	251	238	238	46	47	15.8
95	22,800	0.45	0.45	205	205	251	238	239	46	45	15.8
100	24,000	0.45	0.45	206	206	249	242	238	43	42	15.8

DEXRON®-VI Band Friction - 150 HOURS

Program Code: AL-27877-L
Status: *
Test Cycles: 36,000
Test Performance: *

Start Date: 9/14/2007
EOT Date: 9/21/2007
Run Number: BH3-8-169
EOT Parts Condition: *

Band: 4L60
Drum: 4L60

Test Time [h]	Cycles	Stop Time [s]		Midpoint Torque [N·m]		Max Torque [N·m]	End Torque [N·m]		Max - Mid Torque [N·m]		Shift Energy [kJ]
		0.35	0.55	180	290	Report	> 200		< 120		(15.7-16.3)
105	25,200	0.45	0.45	207	204	245	233	239	38	46	15.8
110	26,400	0.45	0.45	200	204	258	240	232	58	47	15.8
115	27,600	0.44	0.45	205	203	250	222	236	45	50	15.8
120	28,800	0.45	0.45	205	204	251	244	237	46	47	15.8
125	30,000	0.46	0.45	200	203	250	243	237	50	50	15.8
130	31,200	0.46	0.45	202	201	255	225	232	53	52	15.8
135	32,400	0.45	0.45	200	202	254	227	231	54	53	15.8
140	33,600	0.45	0.45	203	202	256	242	236	53	54	15.8
145	34,800	0.45	0.45	203	203	258	238	236	55	53	15.8
150	36,000	0.44	0.45	204	204	254	229	234	50	52	15.7

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Test Number: BH3-8-169 Energy: 15.80 KJ Band : 4L60 Start of Test: 9/14/2007

Fluid Code: AL-27877-L Temp.: 135.1 C Drum : 4L60 End of Test : 9/21/2007

Apply: 304.2 KPa Air Flow: 50 ml/min

Test Hour	Total Cycles	Engagement Time (Sec) (0.35 -0.55)		Midpoint Torq.(Nm) (180-290)		Max-Mid Torq.(Nm) <120		End-Mid Torq.(Nm) <120		Maximum Torq.(Nm) (Report)	End Torq.(Nm) >200		Energy (KJ) (15.7-16.3)
0	10	0.39		233		106		100		340	333		15.9
1	240	0.41		230		83		79		313	309		15.8
2	480	0.42		218		113		97		331	315		15.8
3	720	0.43	Three	218	Three	101	Three	93	Three	319	311	Three	15.8
4	960	0.42	Point	215	Point	108	Point	103	Point	323	318	Point	15.8
5	1,200	0.43	Average	216	Average	99	Average	94	Average	315	310	Average	15.8
10	2,400	0.44	0.44	200	206	114	105	103	98	314	304	304	15.7
15	3,600	0.45	0.45	202	202	101	102	97	94	303	299	296	15.8
20	4,800	0.45	0.45	204	204	90	91	82	86	294	286	290	15.8
25	6,000	0.45	0.45	206	206	81	79	79	73	287	285	279	15.8
30	7,200	0.45	0.45	208	209	67	65	60	59	275	268	267	15.8
35	8,400	0.44	0.44	212	211	46	49	37	36	257	249	247	15.8
40	9,600	0.44	0.45	212	209	34	44	11	24	246	223	233	15.8
45	10,800	0.46	0.45	202	208	53	45	25	19	255	228	227	15.8
50	12,000	0.44	0.44	209	206	49	52	20	25	258	229	231	15.8
55	13,200	0.44	0.44	206	208	54	48	30	24	261	236	232	15.8
60	14,400	0.44	0.44	209	207	42	48	20	22	251	229	229	15.8
65	15,600	0.44	0.44	205	208	49	43	17	16	254	222	224	15.8
70	16,800	0.44	0.44	210	207	37	45	11	20	248	222	227	15.8
75	18,000	0.45	0.45	205	207	50	44	32	21	255	237	228	15.8
80	19,200	0.45	0.45	205	204	43	47	20	30	248	225	234	15.8
85	20,400	0.45	0.45	200	204	49	46	39	30	250	239	234	15.8
90	21,600	0.45	0.45	205	203	46	47	33	35	251	238	238	15.8
95	22,800	0.45	0.45	205	205	46	45	33	34	251	238	239	15.8
100	24,000	0.45	0.45	206	206	43	42	37	32	249	242	238	15.8

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Test Number: BH3-8-169 | Energy: 15.80 KJ | Band : 4L60 | Start of Test: 9/14/2007

Fluid Code: AL-27877-L | Temp.: 135.1 C | Drum : 4L60 | End of Test : 9/21/2007

Apply: 304.2 KPa | Air Flow: 50 ml/min

Test Hour	Total Cycles	Engagement Time (Sec) (0.35 -0.55)		Midpoint Torq.(Nm) (180-290)		Max-Mid Torq.(Nm) <120		End-Mid Torq.(Nm) <120		Maximum Torq.(Nm) (Report)	End Torq.(Nm) >200		Energy (KJ) (15.7-16.3)
105	25,200	0.45	0.45	207	204	38	46	26	34	245	233	239	15.8
110	26,400	0.45	0.45	200	204	58	47	41	28	258	240	232	15.8
115	27,600	0.44	0.45	205	203	45	50	17	32	250	222	236	15.8
120	28,800	0.45	0.45	205	204	46	47	39	33	251	244	237	15.8
125	30,000	0.46	0.45	200	203	50	50	43	35	250	243	237	15.8
130	31,200	0.46	0.45	202	201	53	52	22	31	255	225	232	15.8
135	32,400	0.45	0.45	200	202	54	53	27	29	254	227	231	15.8
140	33,600	0.45	0.45	203	202	53	54	39	34	256	242	236	15.8
145	34,800	0.45	0.45	203	203	55	53	35	33	258	238	236	15.8
150	36,000	0.44	0.45	204	204	50	52	25	30	254	229	234	15.7

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DEXRON® VI Band Friction Test Parts Rating

Sponsor Code: AL-27877-L
Run Number: BH3-8-169
EOT Date: 09-21-07
Cycles: 36,000
Hours:150

Band: The fiber area is completely darkened with light/medium glazing and no stress cracks. One medium to heavy flake at one end of the band. Handling marks are also visible.

Drum: There are no cracks. Dark gray tracking marks and light debris denting and medium and heavy scratching is also visible.

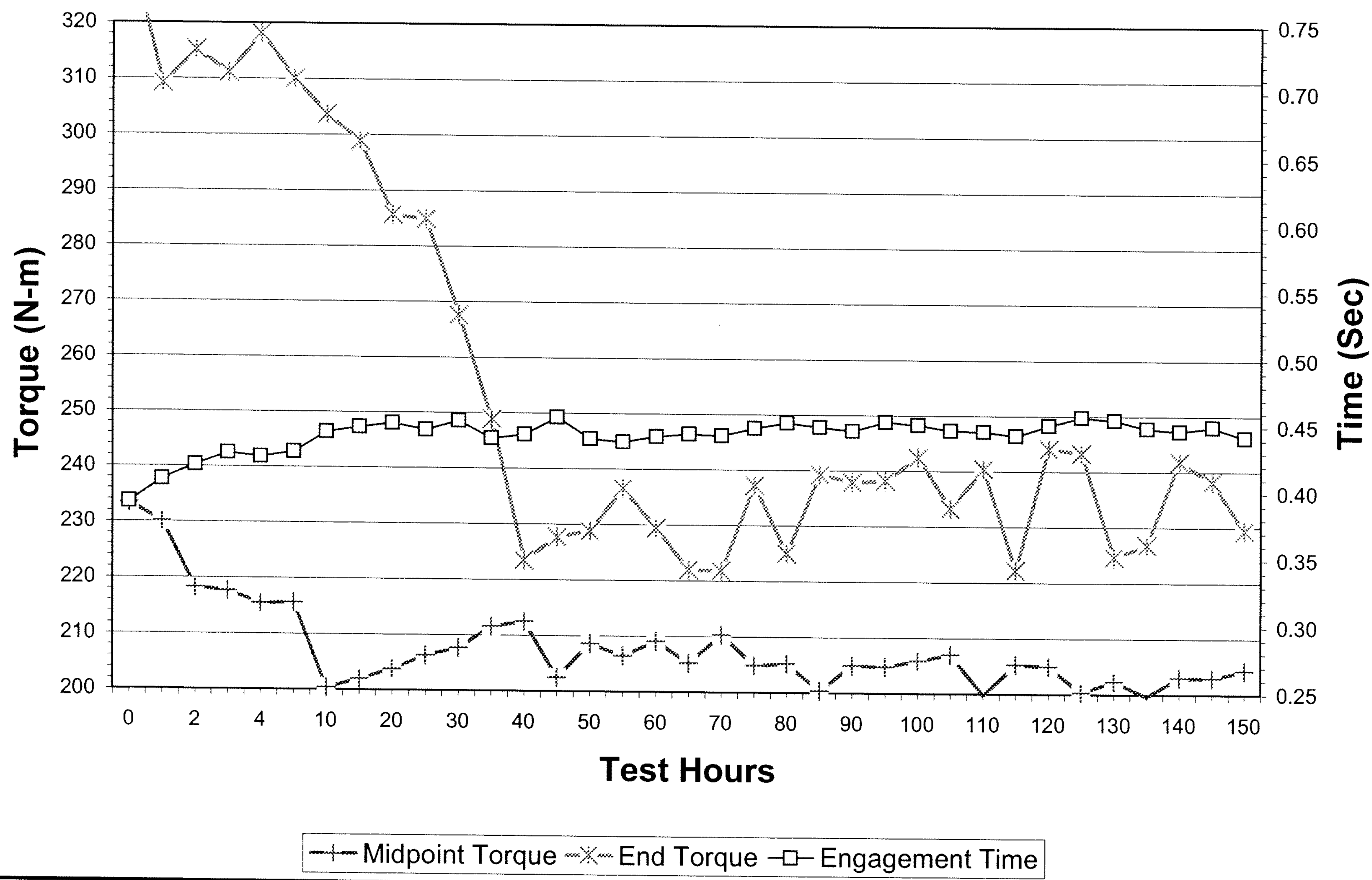
SwRI Rating: Pass

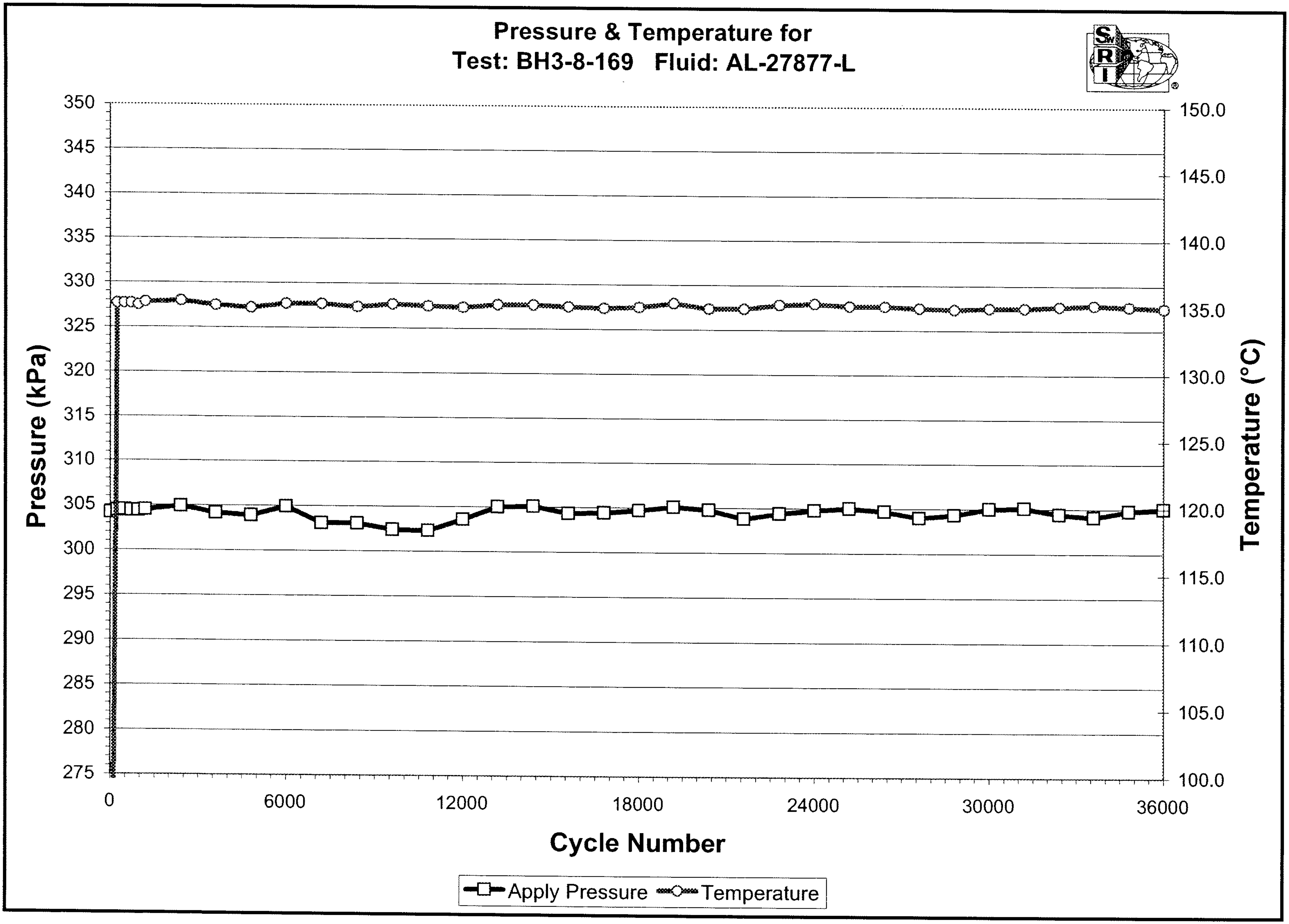
Rater: Art Sanchez
Date: 09-26-2007

Comments: This test was conducted using 4L60 Drum And 4L60 Band.

*Pending GM ATF Committee approval

Fluid Performance Summary of AL-27877-L





Pressure & Temperature for
Test: BH3-8-169 Fluid: AL-27877-L
350
345
340
335
330
325
320
315
310
305
300
295
290
285
280
275
Pressure (kPa)
150.0
145.0
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
Temperature (°C)
0
6000
12000
18000
24000
30000
36000
Cycle Number
Apply Pressure
Temperature

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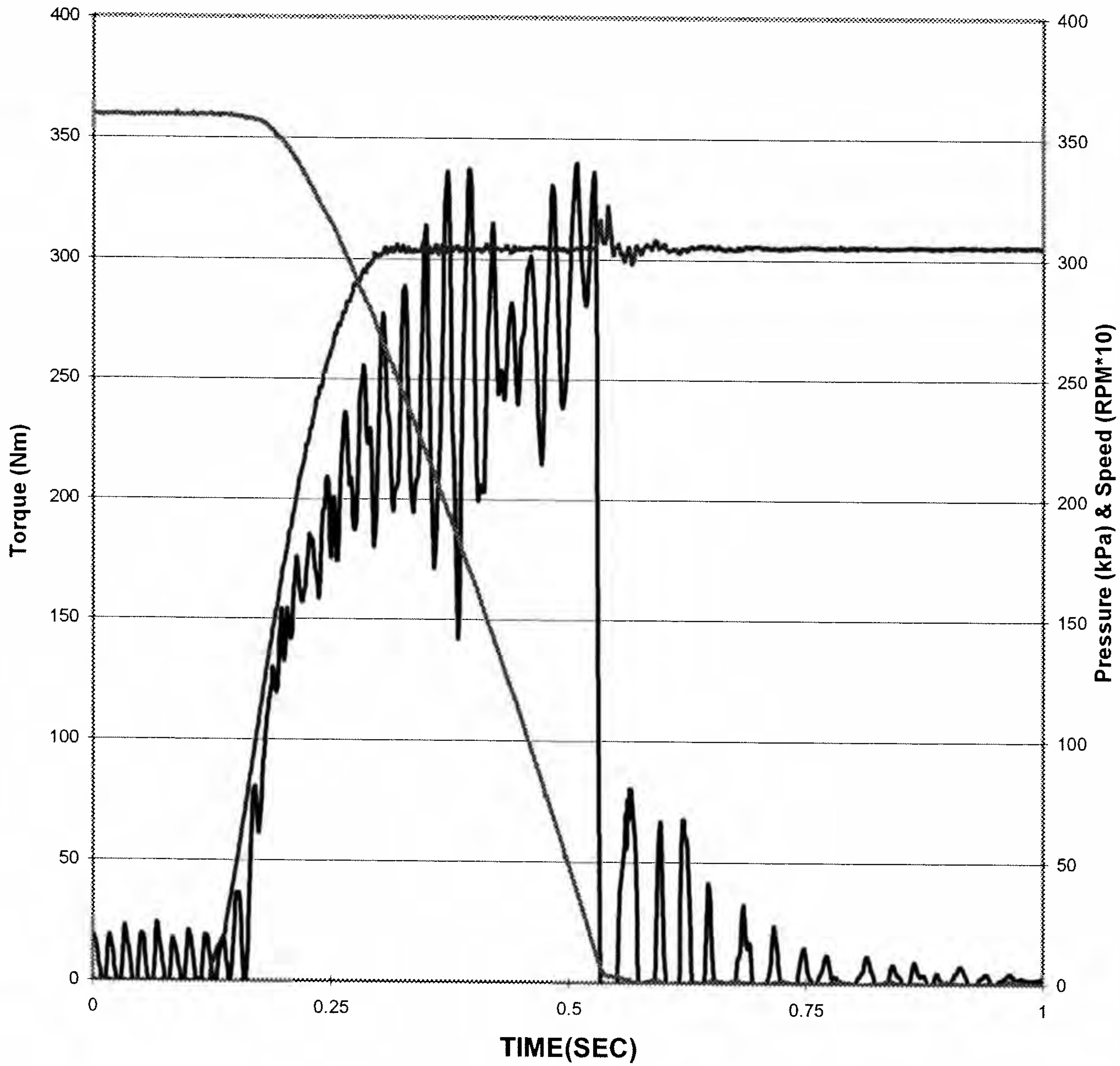

Date of Test:	9/14/2007
Time of Test:	21:53:09
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	0
Cycle Number:	10
Temperature:	66.5 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	15.9 KJ
	(15.7-16.3)
Engage Time:	0.39 Sec
	(0.35 -0.55)

Torque

Maximum:	340 N*m
	(Report)
Midpoint:	233 N*m
	(180-290)
Max - Mid:	106 N*m
	<120
End - Mid:	100 N*m
	<120
End:	333 N*m
	>200

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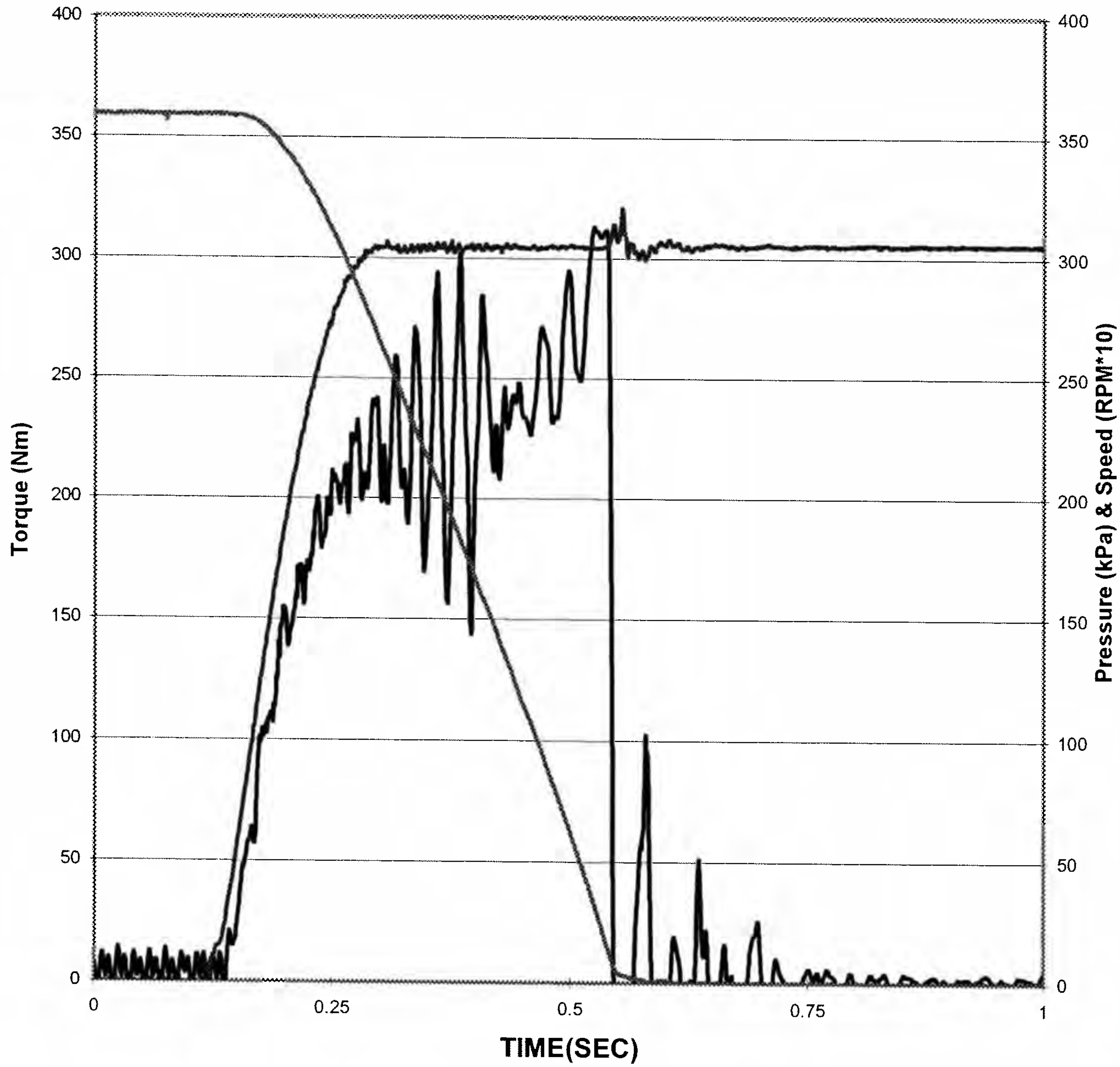

Date of Test:	9/14/2007
Time of Test:	22:50:39
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	1
Cycle Number:	240
Temperature:	135.1 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.41 Sec
	(0.35 -0.55)

Torque

Maximum:	313 N*m
	(Report)
Midpoint:	230 N*m
	(180-290)
Max - Mid:	83 N*m
	<120
End - Mid:	79 N*m
	<120
End:	309 N*m
	>200

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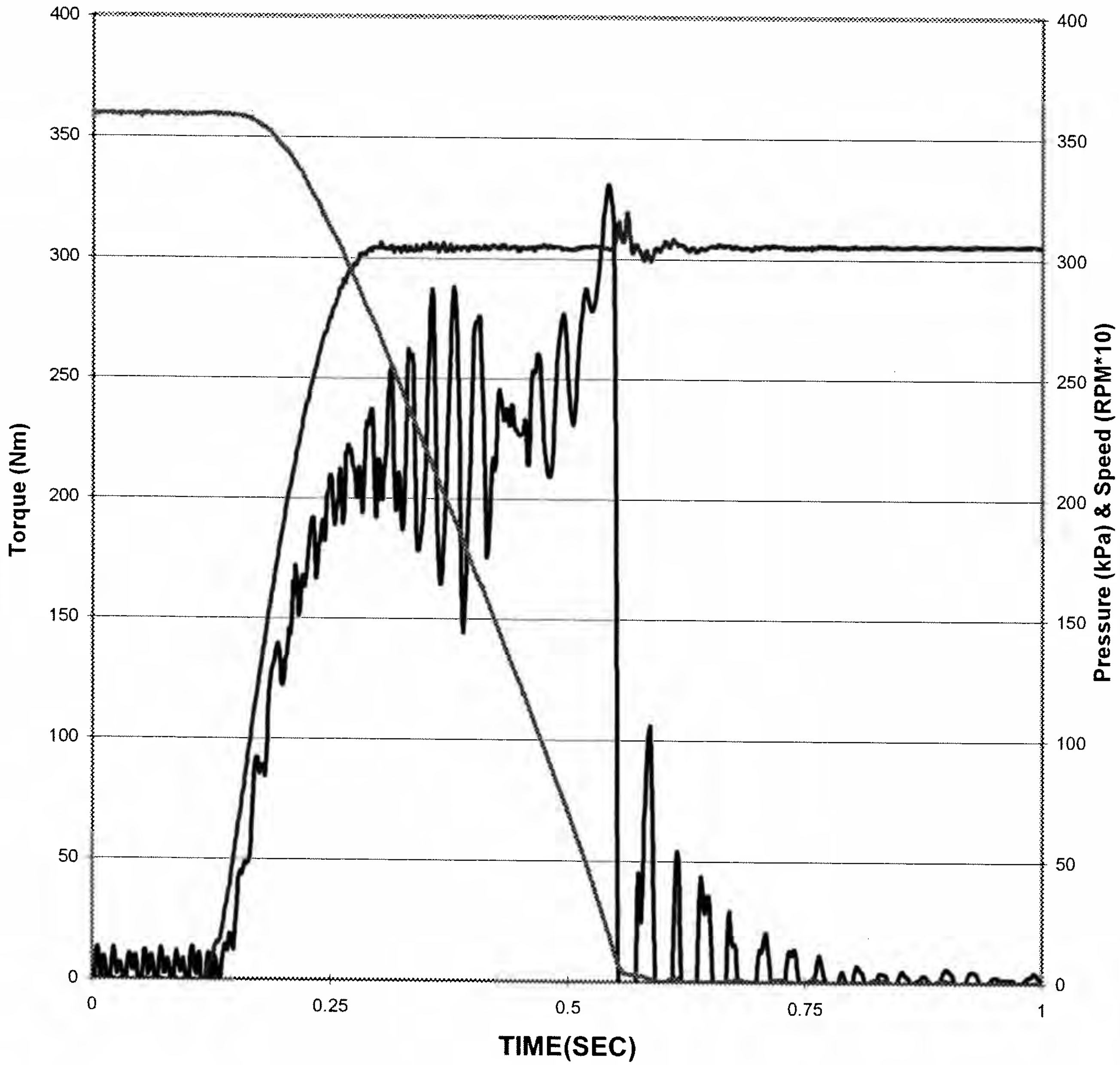

Date of Test:	9/14/2007
Time of Test:	23:50:39
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	2
Cycle Number:	480
Temperature:	135.1 °C
	(129 - 141)
Apply Pressure:	305 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.42 Sec
	(0.35 -0.55)

Torque

Maximum:	331 N*m
	(Report)
Midpoint:	218 N*m
	(180-290)
Max - Mid:	113 N*m
	<120
End - Mid:	97 N*m
	<120
End:	315 N*m
	>200

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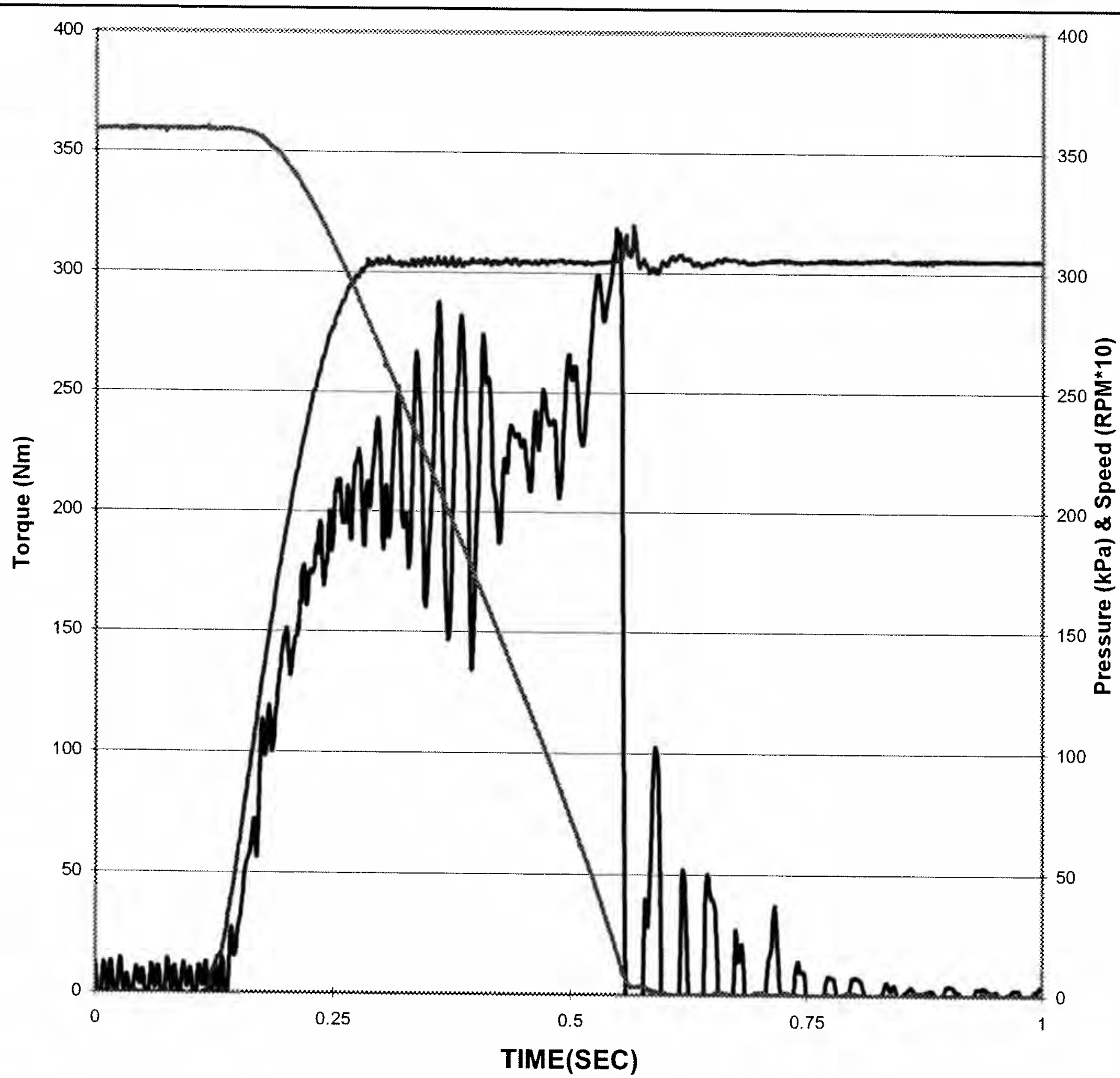

Date of Test:	9/15/2007
Time of Test:	0:50:39
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	3
Cycle Number:	720
Temperature:	135.1 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.43 Sec
	(0.35 -0.55)

Torque

Maximum:	319 N*m
	(Report)
Midpoint:	218 N*m
	(180-290)
Max - Mid:	101 N*m
	<120
End - Mid:	93 N*m
	<120
End:	311 N*m
	>200

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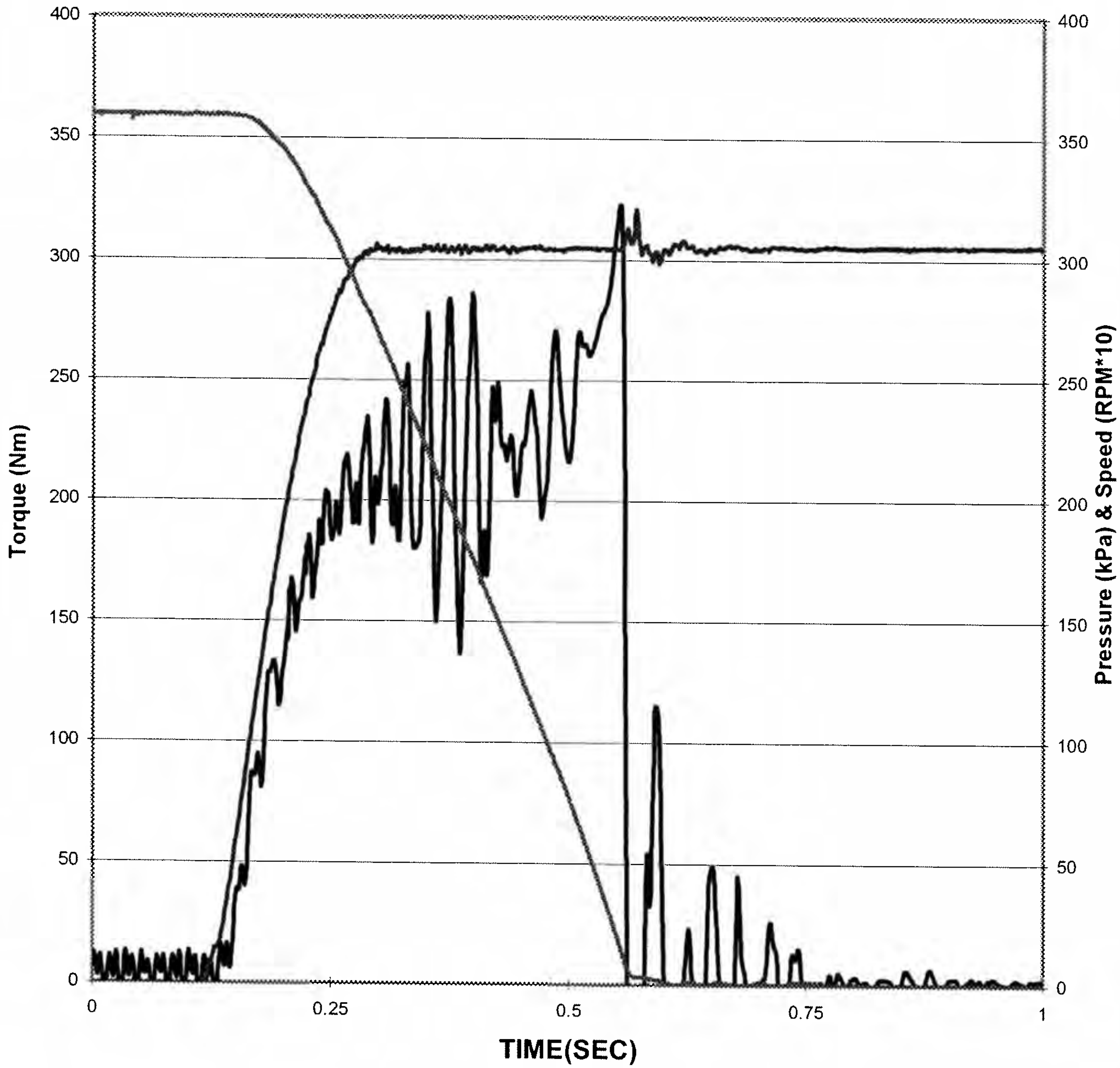

Date of Test:	9/15/2007
Time of Test:	1:50:39
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	4
Cycle Number:	960
Temperature:	135.0 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.42 Sec
	(0.35 -0.55)

Torque

Maximum:	323 N*m
	(Report)
Midpoint:	215 N*m
	(180-290)
Max - Mid:	108 N*m
	<120
End - Mid:	103 N*m
	<120
End:	318 N*m
	>200

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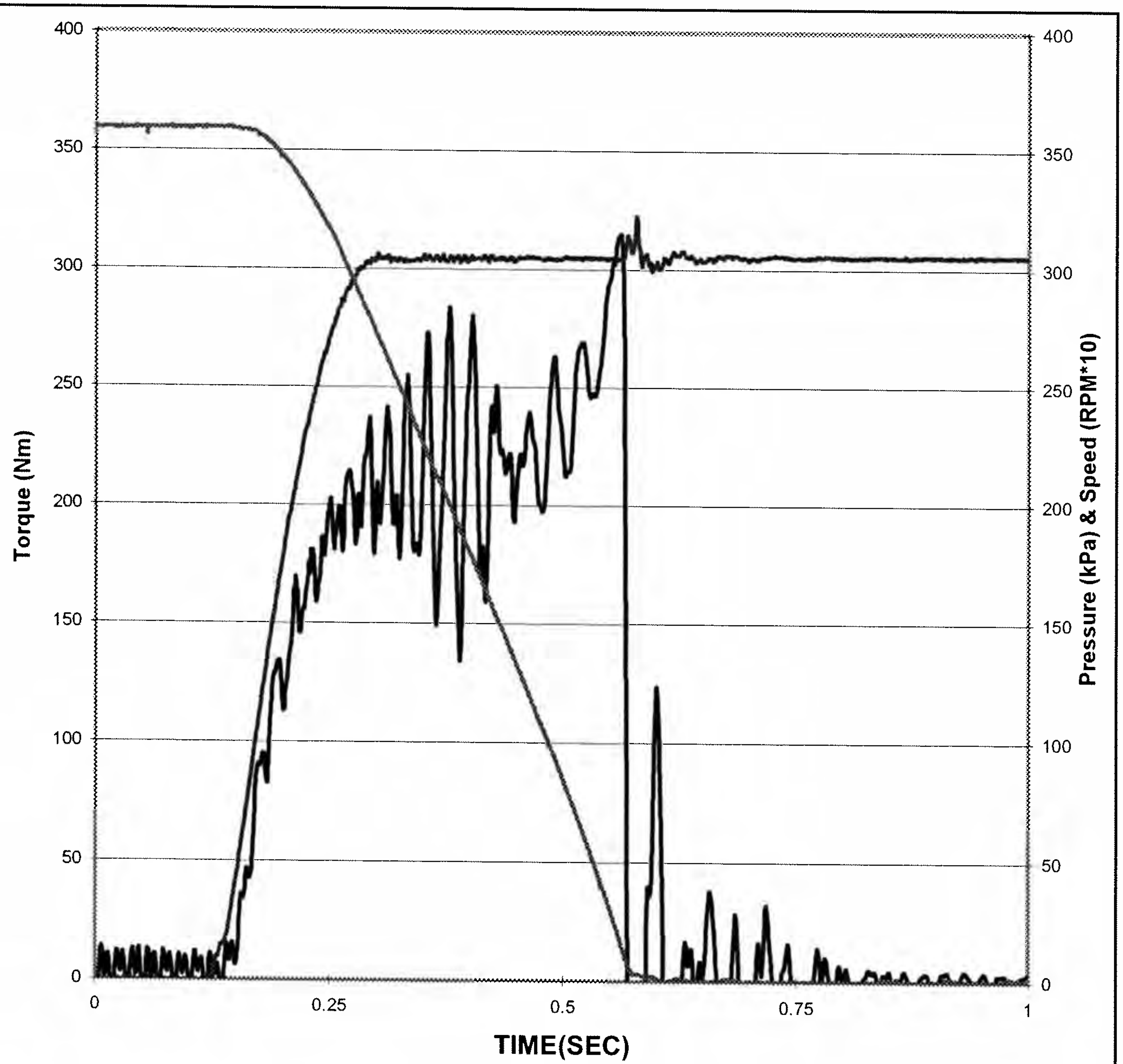

Date of Test:	9/15/2007
Time of Test:	2:50:39
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	5
Cycle Number:	1200
Temperature:	135.2 °C
	(129 - 141)
Apply Pressure:	305 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.43 Sec
	(0.35 -0.55)

Torque

Maximum:	315 N*m
	(Report)
Midpoint:	216 N*m
	(180-290)
Max - Mid:	99 N*m
	<120
End - Mid:	94 N*m
	<120
End:	310 N*m
	>200

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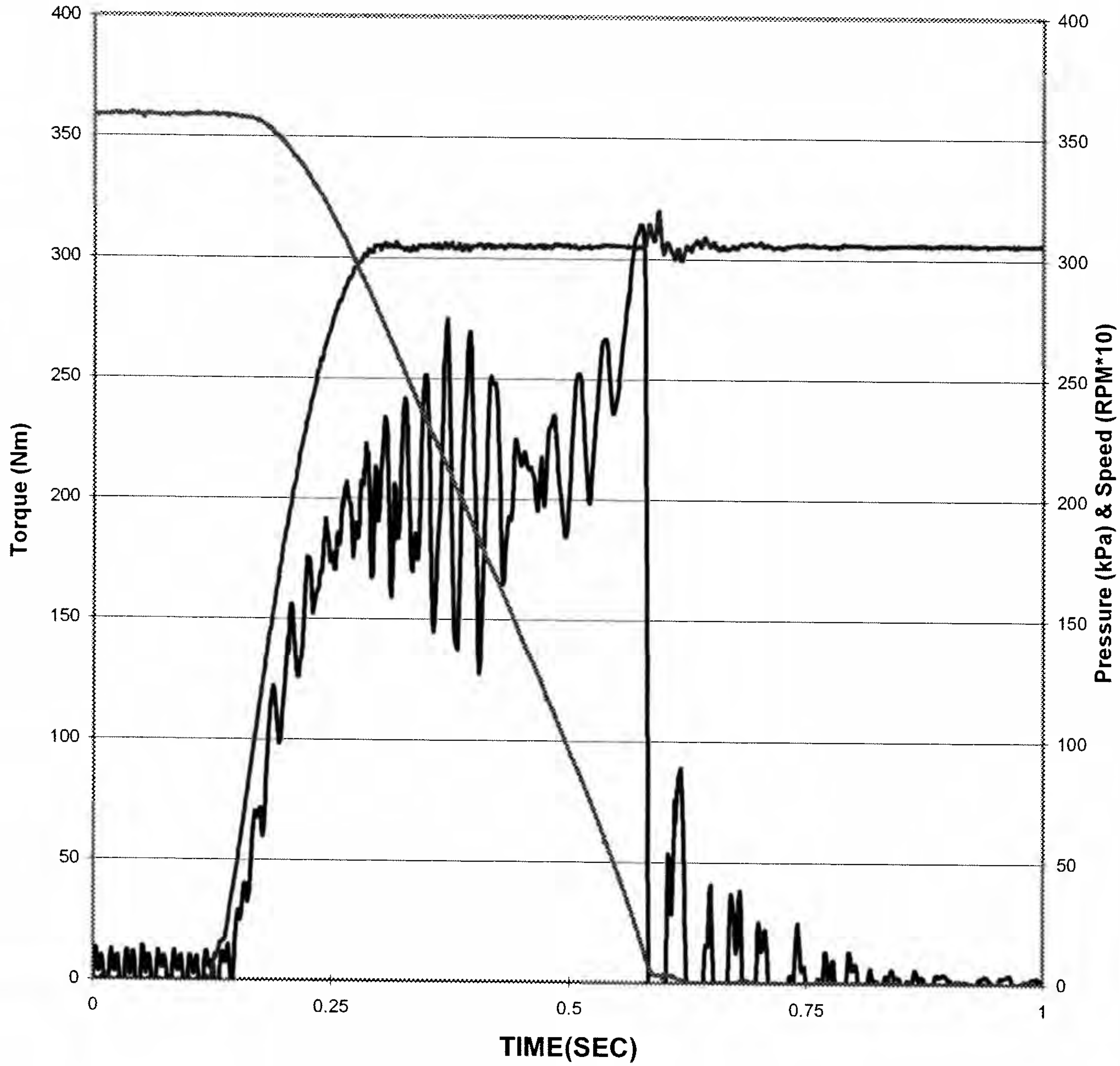

Date of Test:	9/15/2007
Time of Test:	7:50:55
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	10
Cycle Number:	2400
Temperature:	135.3 °C *(129 - 141)*
Apply Pressure:	305 kPa (295 - 305)
Energy:	15.7 KJ *(15.7-16.3)*
Engage Time:	0.44 Sec *(0.35 -0.55)*

Torque

Maximum:	314 N*m (Report)
Midpoint:	200 N*m *(180-290)*
Max - Mid:	114 N*m *<120*
End - Mid:	103 N*m *<120*
End:	304 N*m *>200*

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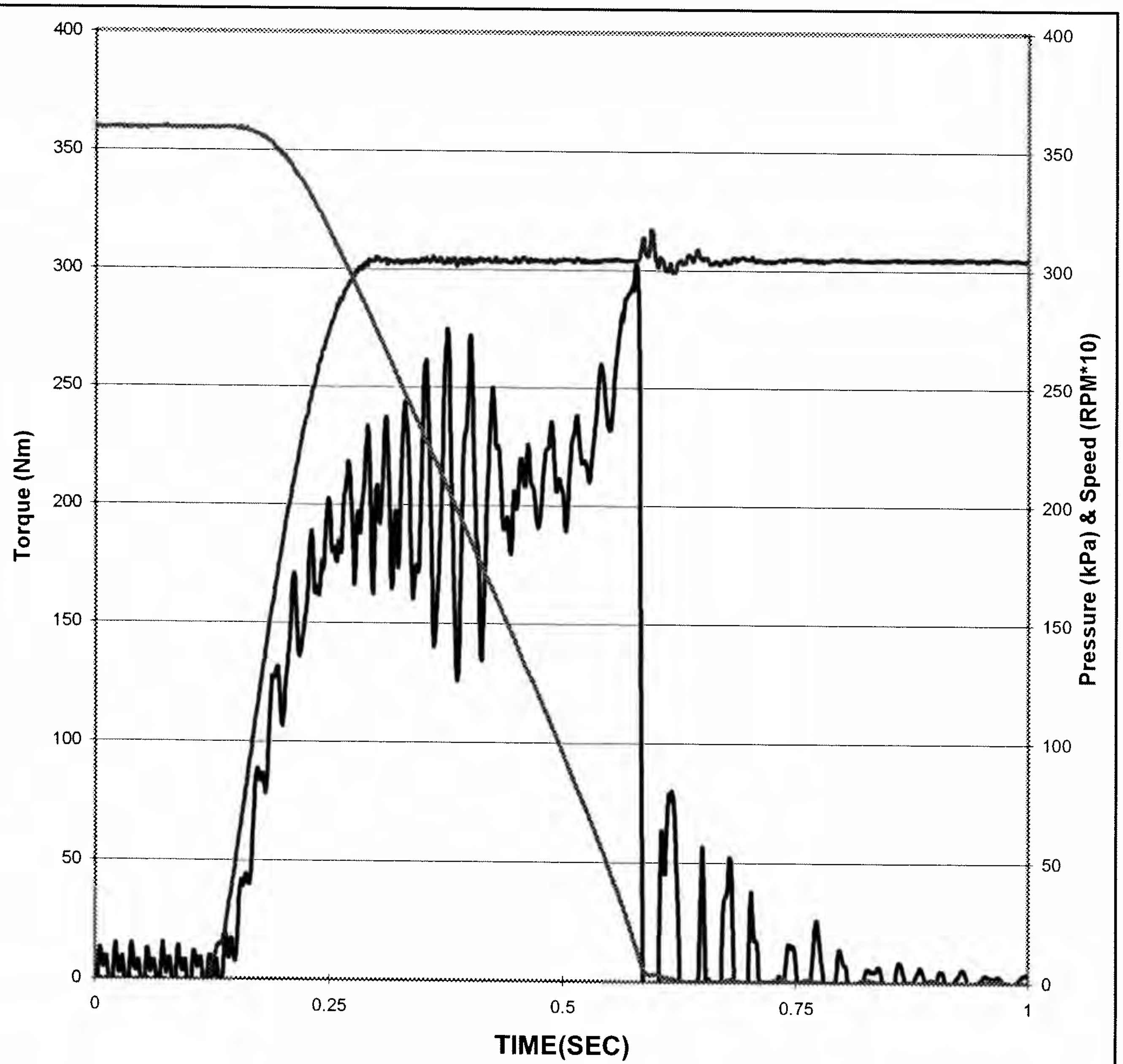

Date of Test:	9/15/2007
Time of Test:	12:50:56
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	15
Cycle Number:	3600
Temperature:	135.0 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.45 Sec
	(0.35 -0.55)

Torque

Maximum:	303 N*m
	(Report)
Midpoint:	202 N*m
	(180-290)
Max - Mid:	101 N*m
	<120
End - Mid:	97 N*m
	<120
End:	299 N*m
	>200

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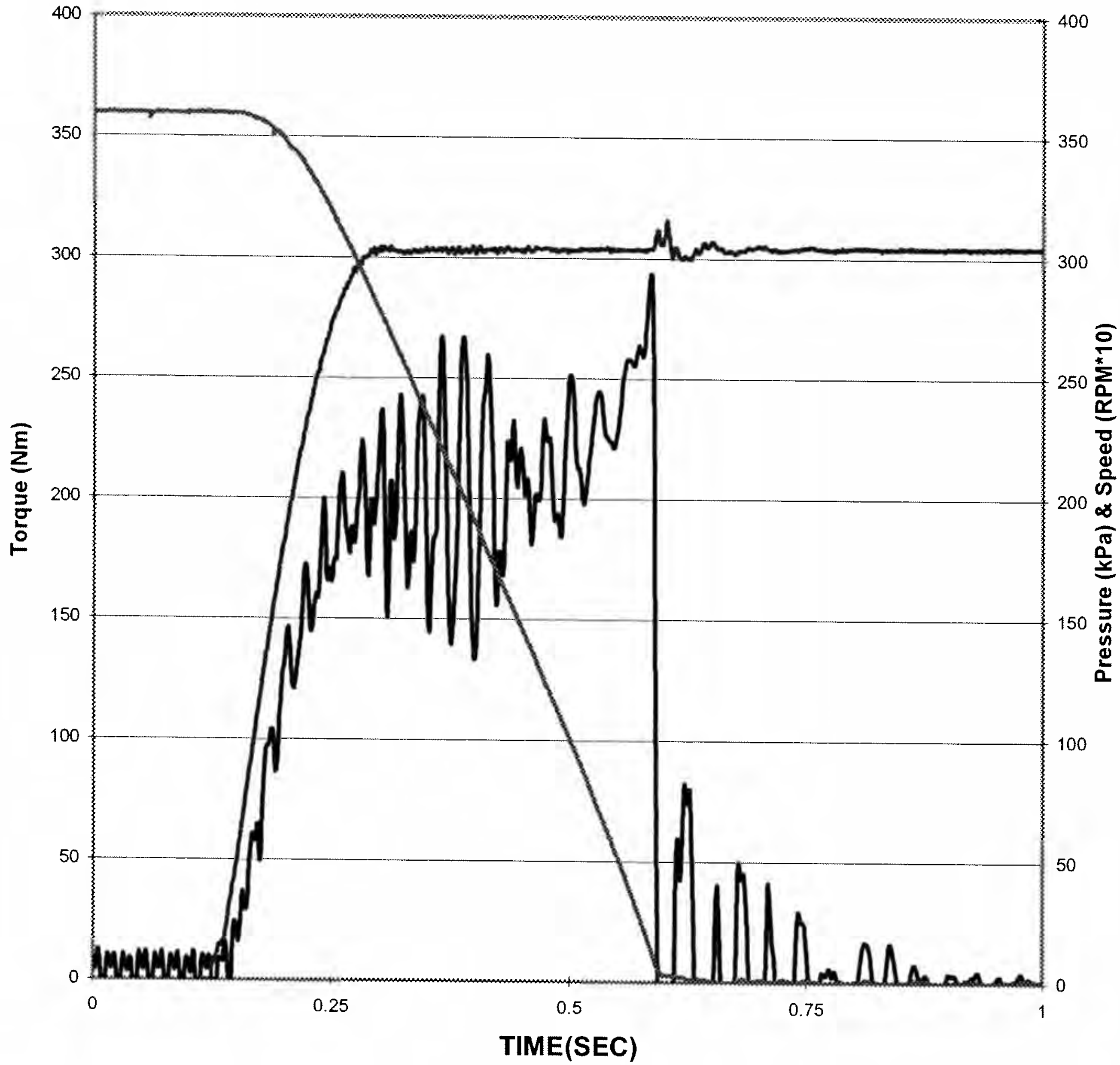

Date of Test:	9/15/2007
Time of Test:	17:50:57
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	20
Cycle Number:	4800
Temperature:	134.8 °C *(129 - 141)*
Apply Pressure:	304 kPa (295 - 305)
Energy:	15.8 KJ *(15.7-16.3)*
Engage Time:	0.45 Sec *(0.35 -0.55)*

Torque

Maximum:	294 N*m (Report)
Midpoint:	204 N*m *(180-290)*
Max - Mid:	90 N*m *<120*
End - Mid:	82 N*m *<120*
End:	286 N*m *>200*

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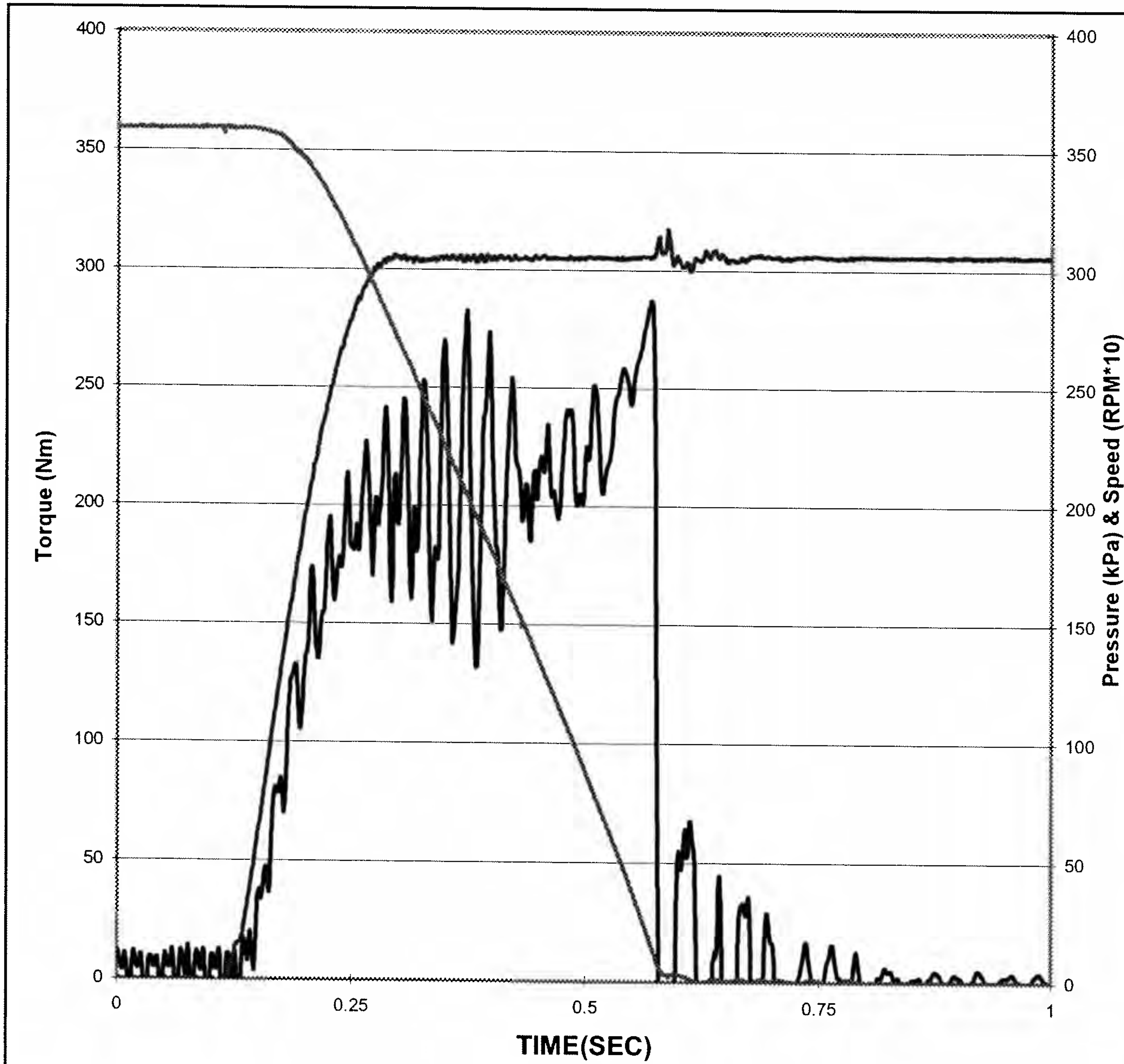

Date of Test:	9/15/2007
Time of Test:	22:50:58
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	25
Cycle Number:	6000
Temperature:	135.1 °C
	(129 - 141)
Apply Pressure:	305 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.45 Sec
	(0.35 -0.55)

Torque

Maximum:	287 N*m
	(Report)
Midpoint:	206 N*m
	(180-290)
Max - Mid:	81 N*m
	<120
End - Mid:	79 N*m
	<120
End:	285 N*m
	>200

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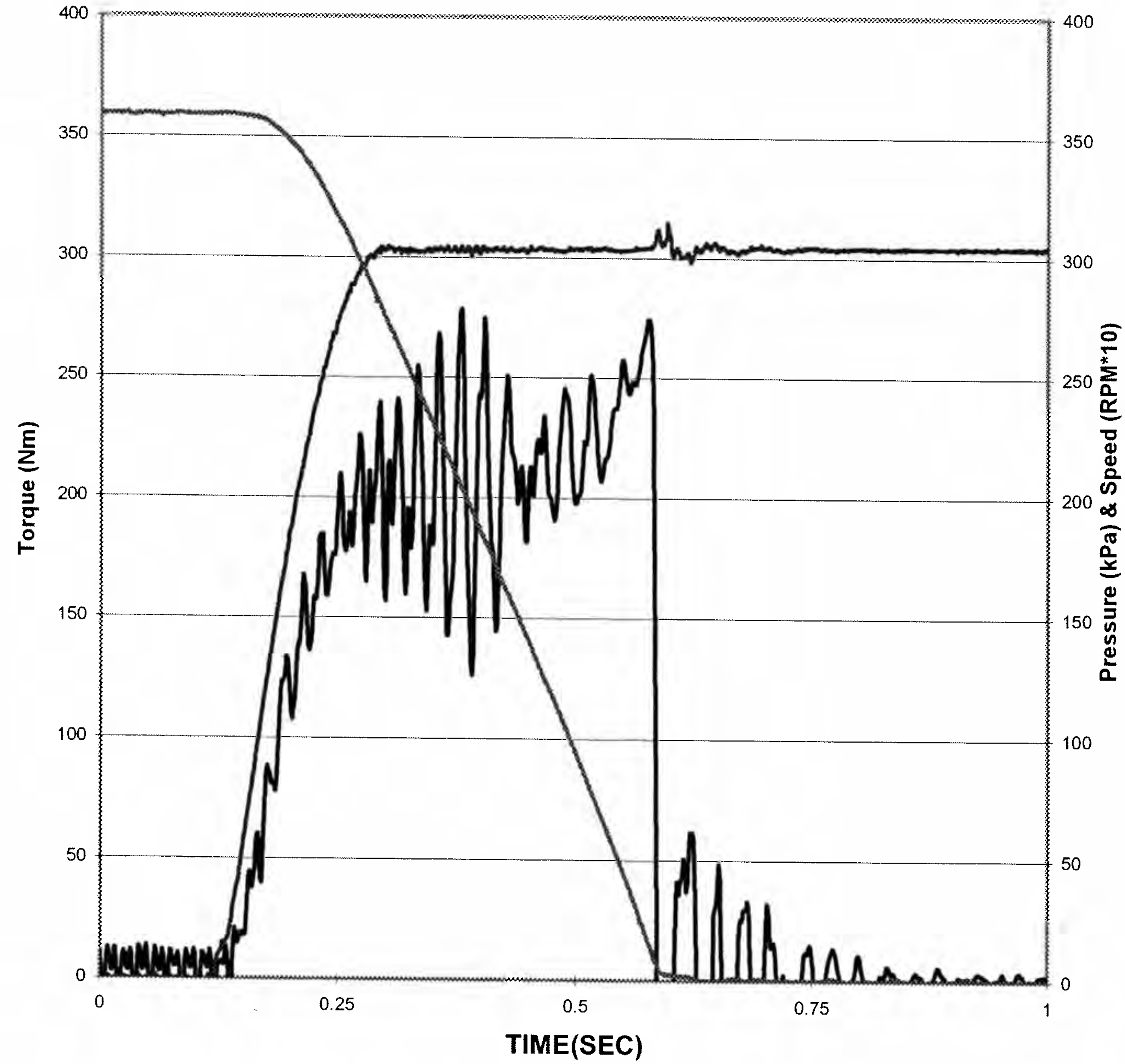

Date of Test:	9/16/2007
Time of Test:	3:50:58
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	30
Cycle Number:	7200
Temperature:	135.1 °C
	(129 - 141)
Apply Pressure:	303 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.45 Sec
	(0.35 -0.55)

Torque

Maximum:	275 N*m
	(Report)
Midpoint:	208 N*m
	(180-290)
Max - Mid:	67 N*m
	<120
End - Mid:	60 N*m
	<120
End:	268 N*m
	>200

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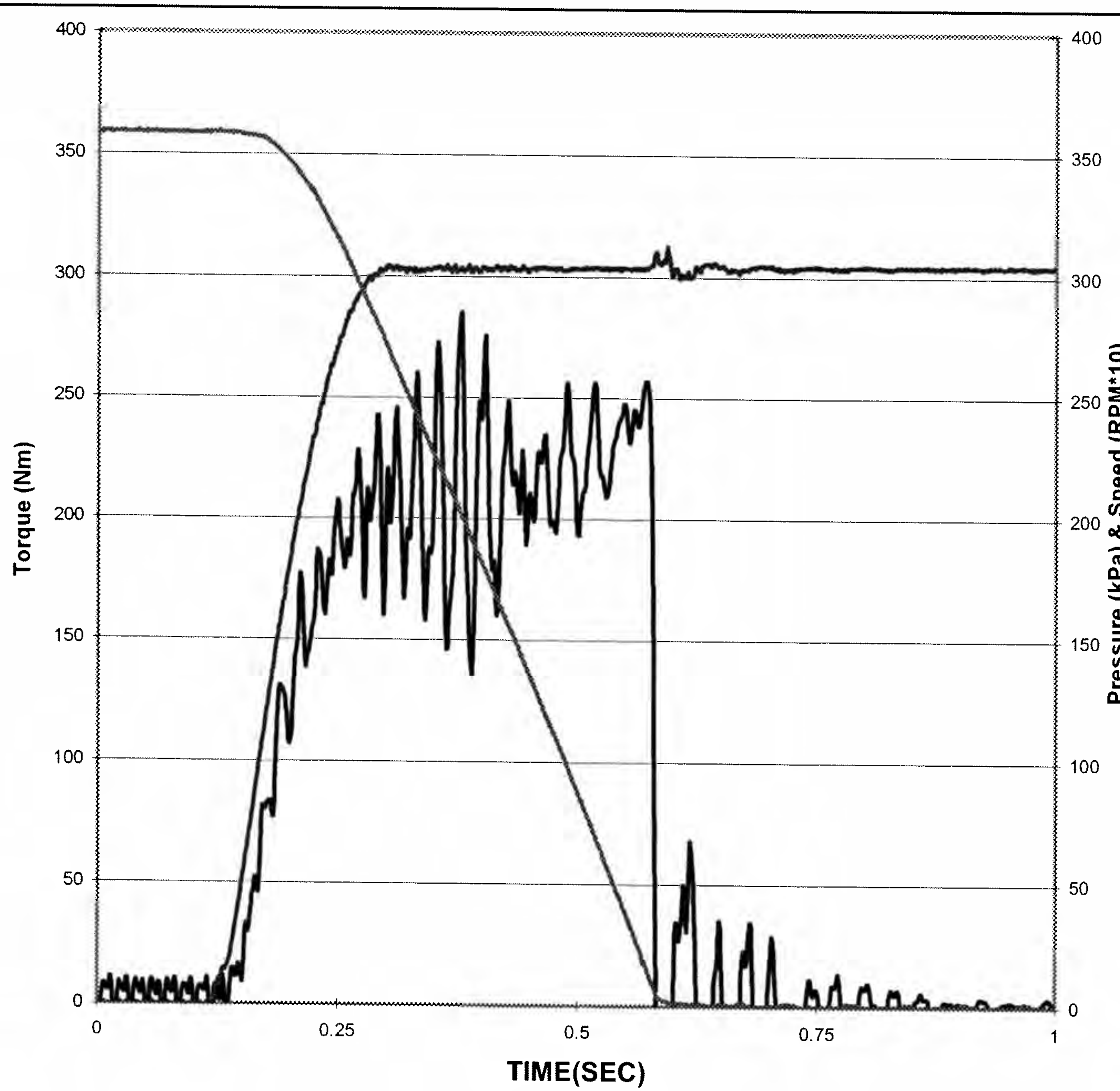

Date of Test:	9/16/2007
Time of Test:	8:50:59
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	35
Cycle Number:	8400
Temperature:	134.9 °C *(129 - 141)*
Apply Pressure:	303 kPa (295 - 305)
Energy:	15.8 KJ *(15.7-16.3)*
Engage Time:	0.44 Sec *(0.35 -0.55)*

Torque

Maximum:	257 N*m (Report)
Midpoint:	212 N*m *(180-290)*
Max - Mid:	46 N*m *<120*
End - Mid:	37 N*m *<120*
End:	249 N*m *>200*

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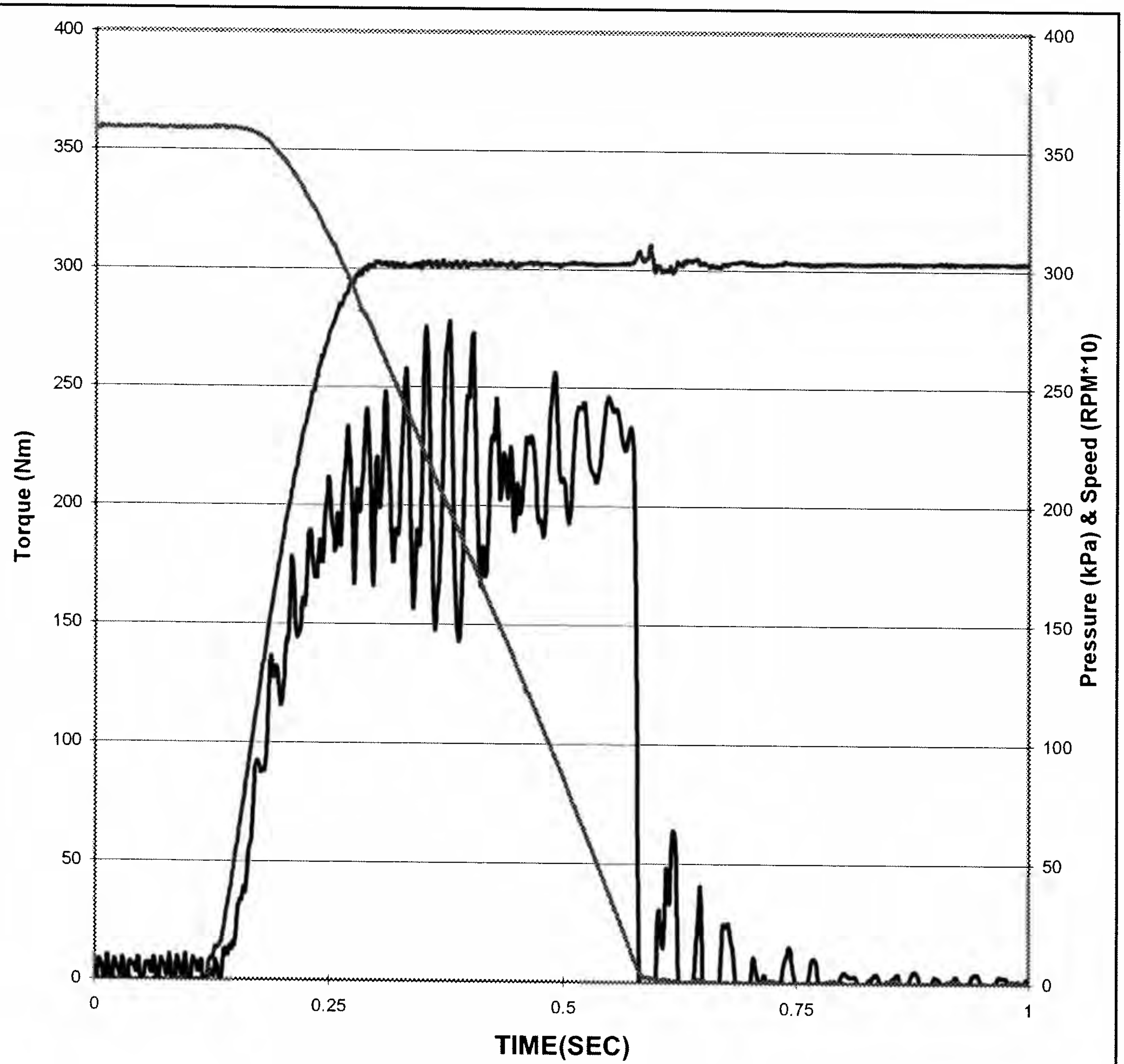

Date of Test:	9/16/2007
Time of Test:	13:51:00
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	40
Cycle Number:	9600
Temperature:	135.1 °C
	(129 - 141)
Apply Pressure:	302 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.44 Sec
	(0.35 -0.55)

Torque

Maximum:	246 N*m
	(Report)
Midpoint:	212 N*m
	(180-290)
Max - Mid:	34 N*m
	<120
End - Mid:	11 N*m
	<120
End:	223 N*m
	>200

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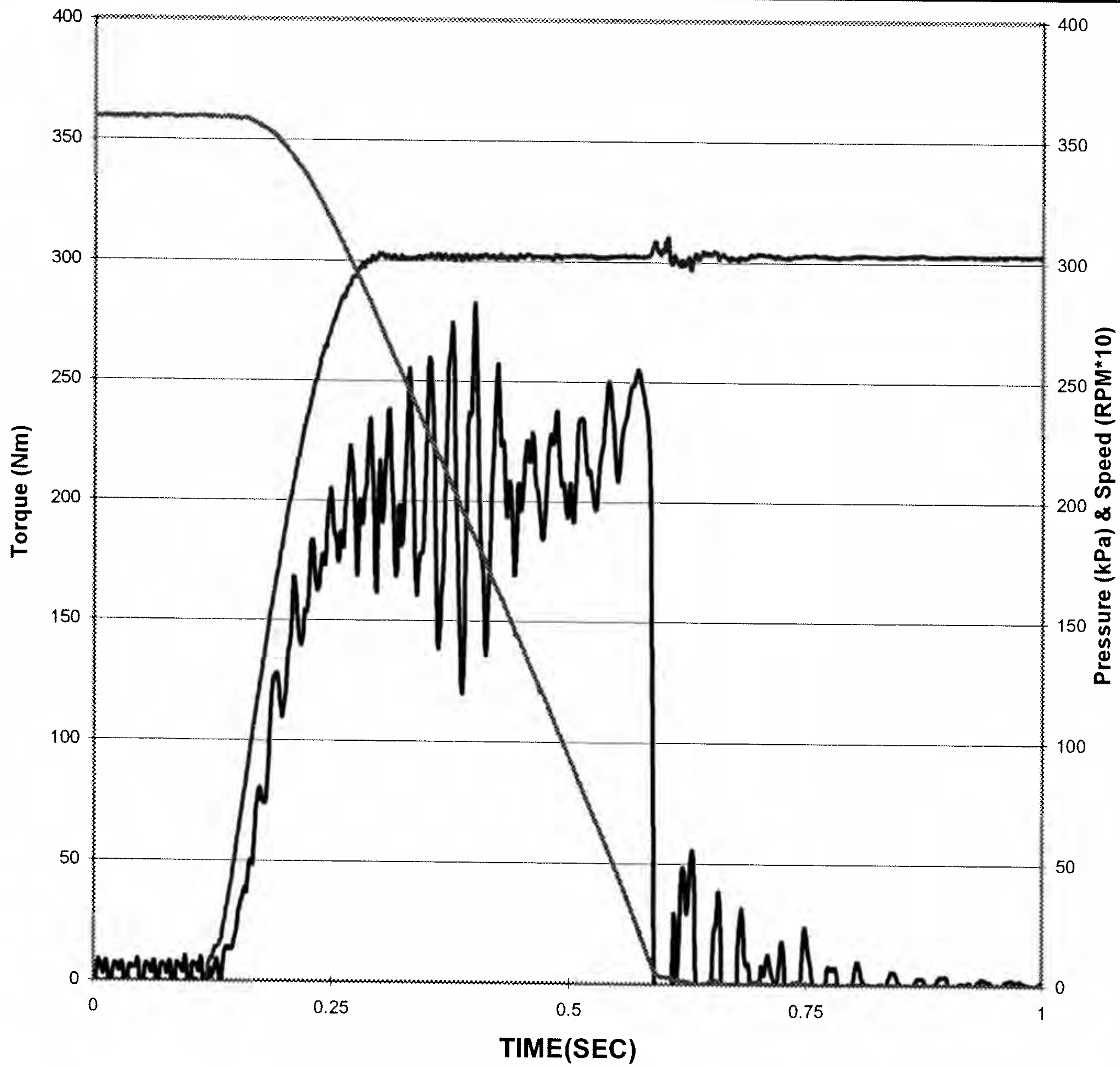

Date of Test:	9/16/2007
Time of Test:	18:51:01
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	45
Cycle Number:	10800
Temperature:	135.0 °C *(129 - 141)*
Apply Pressure:	302 kPa (295 - 305)
Energy:	15.8 KJ *(15.7-16.3)*
Engage Time:	0.46 Sec *(0.35 -0.55)*

Torque

Maximum:	255 N*m (Report)
Midpoint:	202 N*m *(180-290)*
Max - Mid:	53 N*m *<120*
End - Mid:	25 N*m *<120*
End:	228 N*m *>200*

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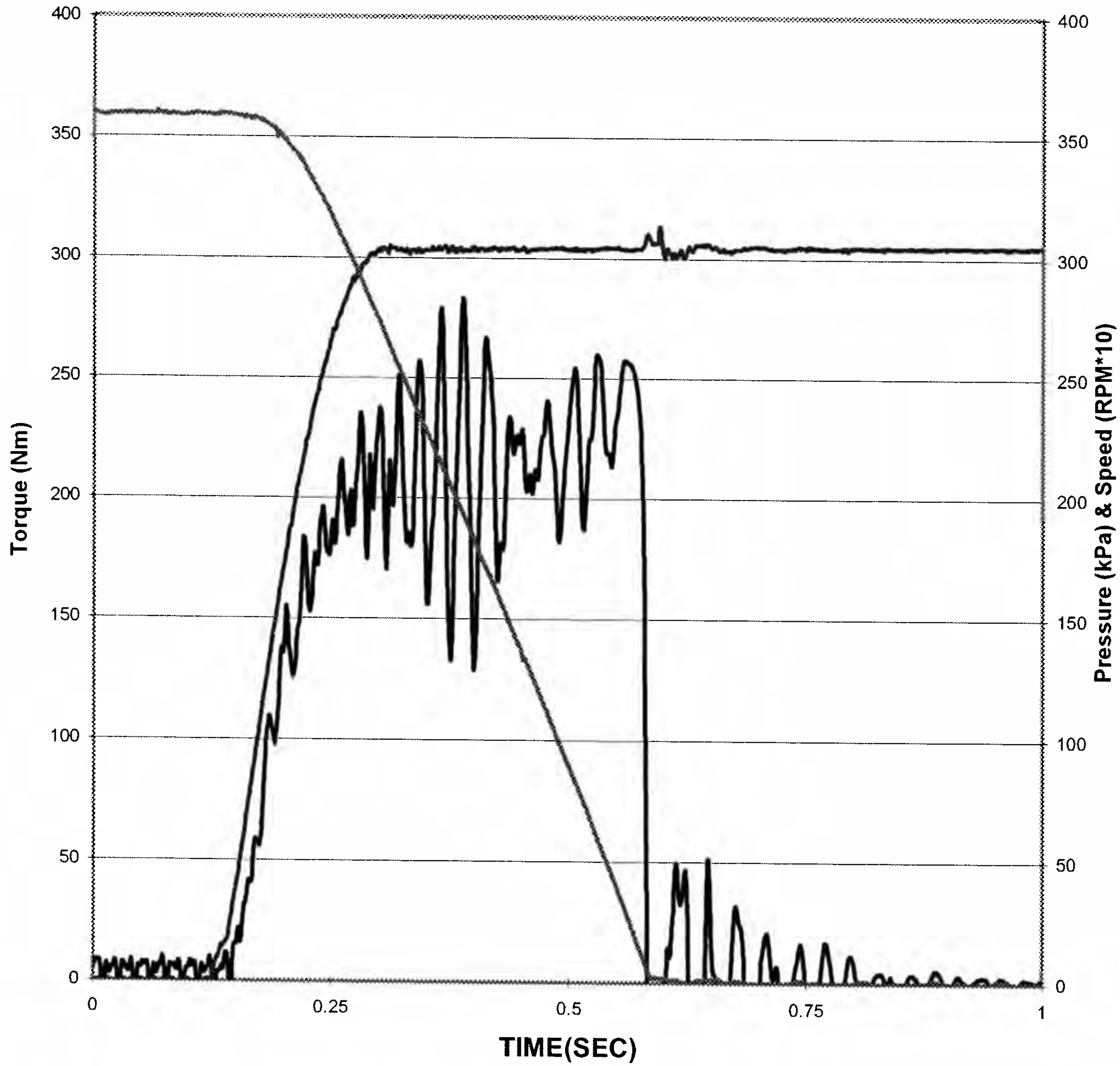

Date of Test:	9/16/2007
Time of Test:	23:51:01
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	50
Cycle Number:	12000
Temperature:	134.9 °C *(129 - 141)*
Apply Pressure:	304 kPa (295 - 305)
Energy:	15.8 KJ *(15.7-16.3)*
Engage Time:	0.44 Sec *(0.35 -0.55)*

Torque

Maximum:	258 N*m (Report)
Midpoint:	209 N*m *(180-290)*
Max - Mid:	49 N*m *<120*
End - Mid:	20 N*m *<120*
End:	229 N*m *>200*

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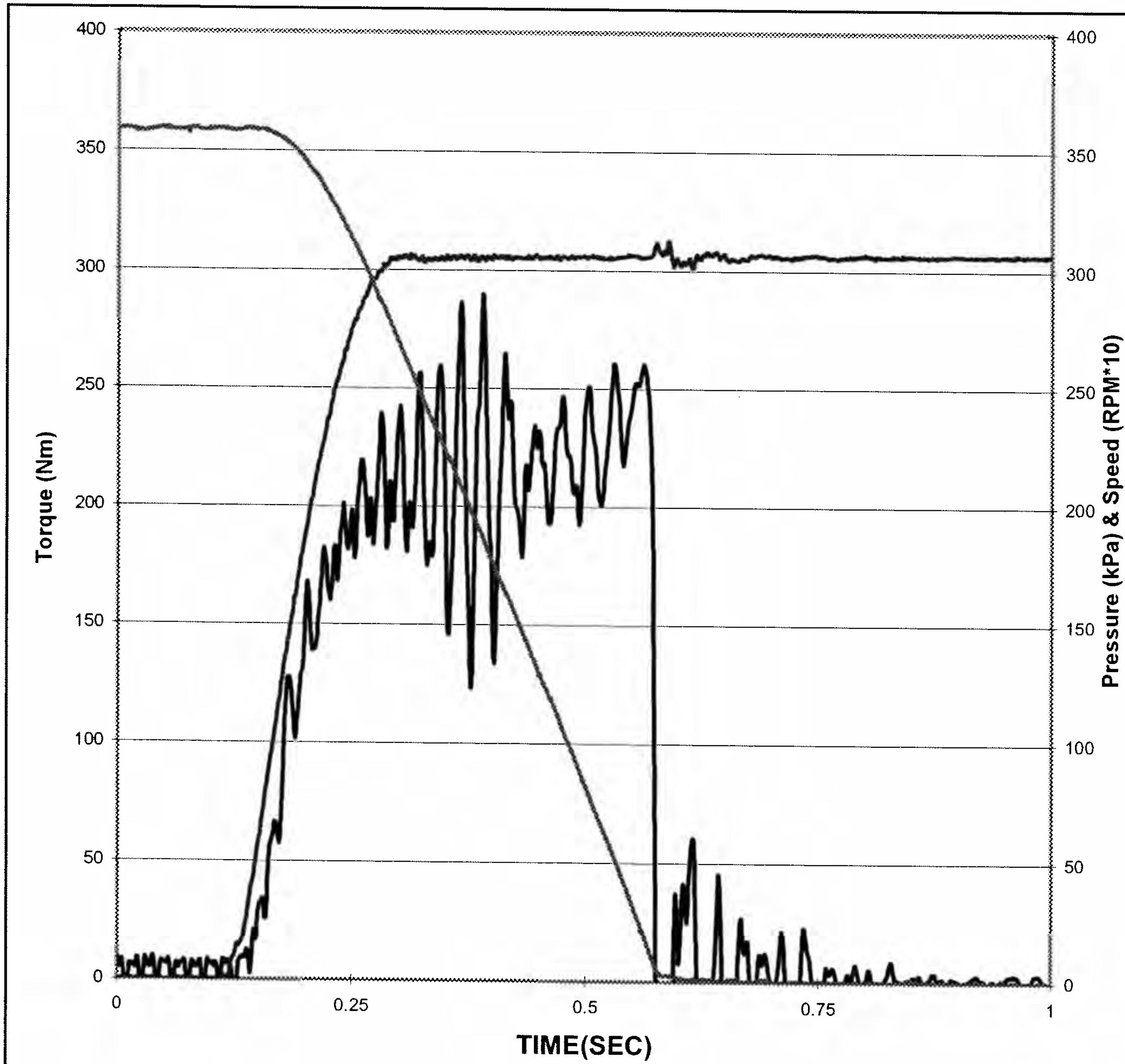

Date of Test:	9/17/2007
Time of Test:	4:51:02
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	55
Cycle Number:	13200
Temperature:	135.1 °C
	(129 - 141)
Apply Pressure:	305 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.44 Sec
	(0.35 -0.55)

Torque

Maximum:	261 N*m
	(Report)
Midpoint:	206 N*m
	(180-290)
Max - Mid:	54 N*m
	<120
End - Mid:	30 N*m
	<120
End:	236 N*m
	>200

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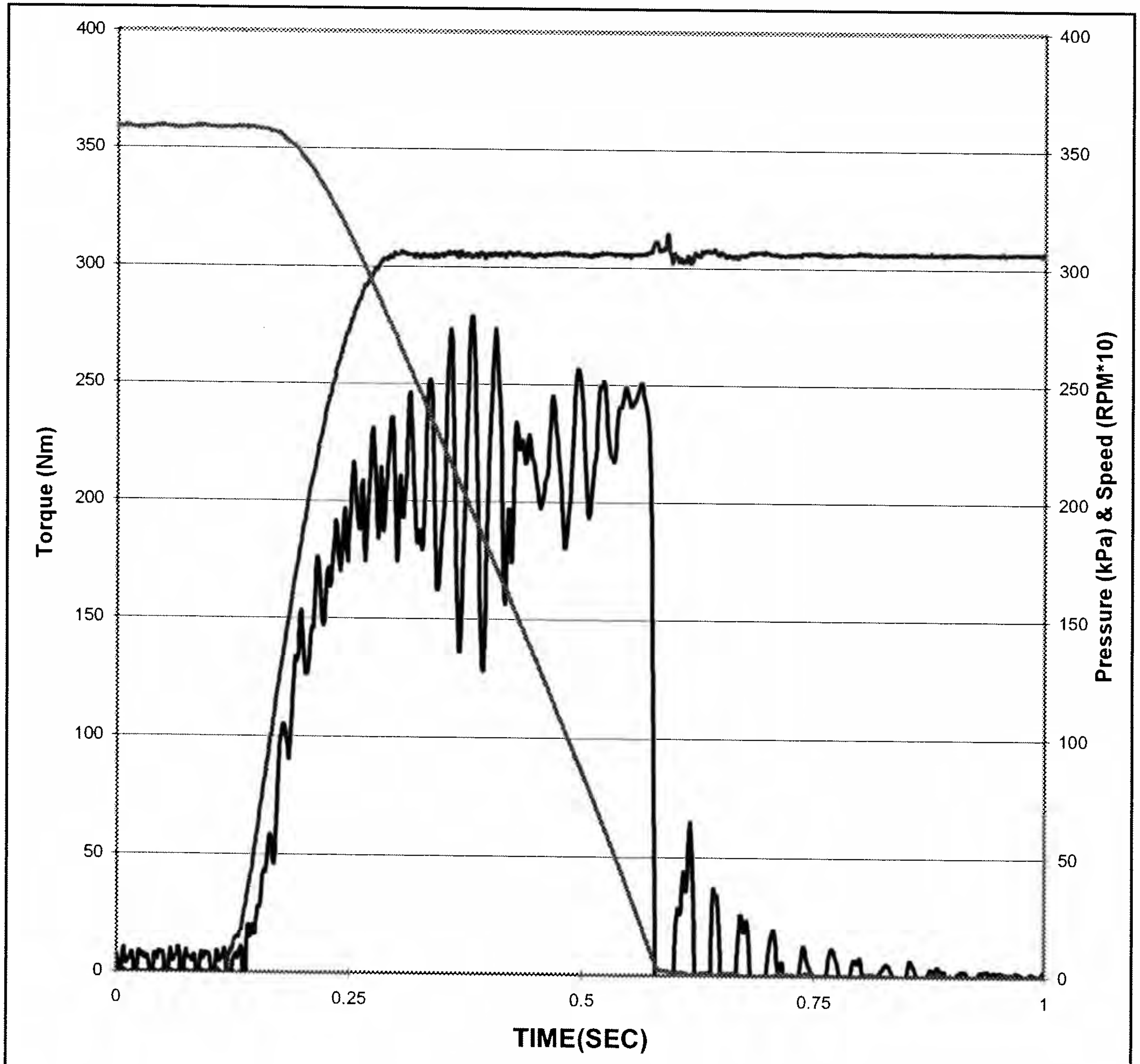

Date of Test:	9/17/2007
Time of Test:	9:51:03
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	60
Cycle Number:	14400
Temperature:	135.1 °C
	(129 - 141)
Apply Pressure:	305 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.44 Sec
	(0.35 -0.55)

Torque

Maximum:	251 N*m
	(Report)
Midpoint:	209 N*m
	(180-290)
Max - Mid:	42 N*m
	<120
End - Mid:	20 N*m
	<120
End:	229 N*m
	>200

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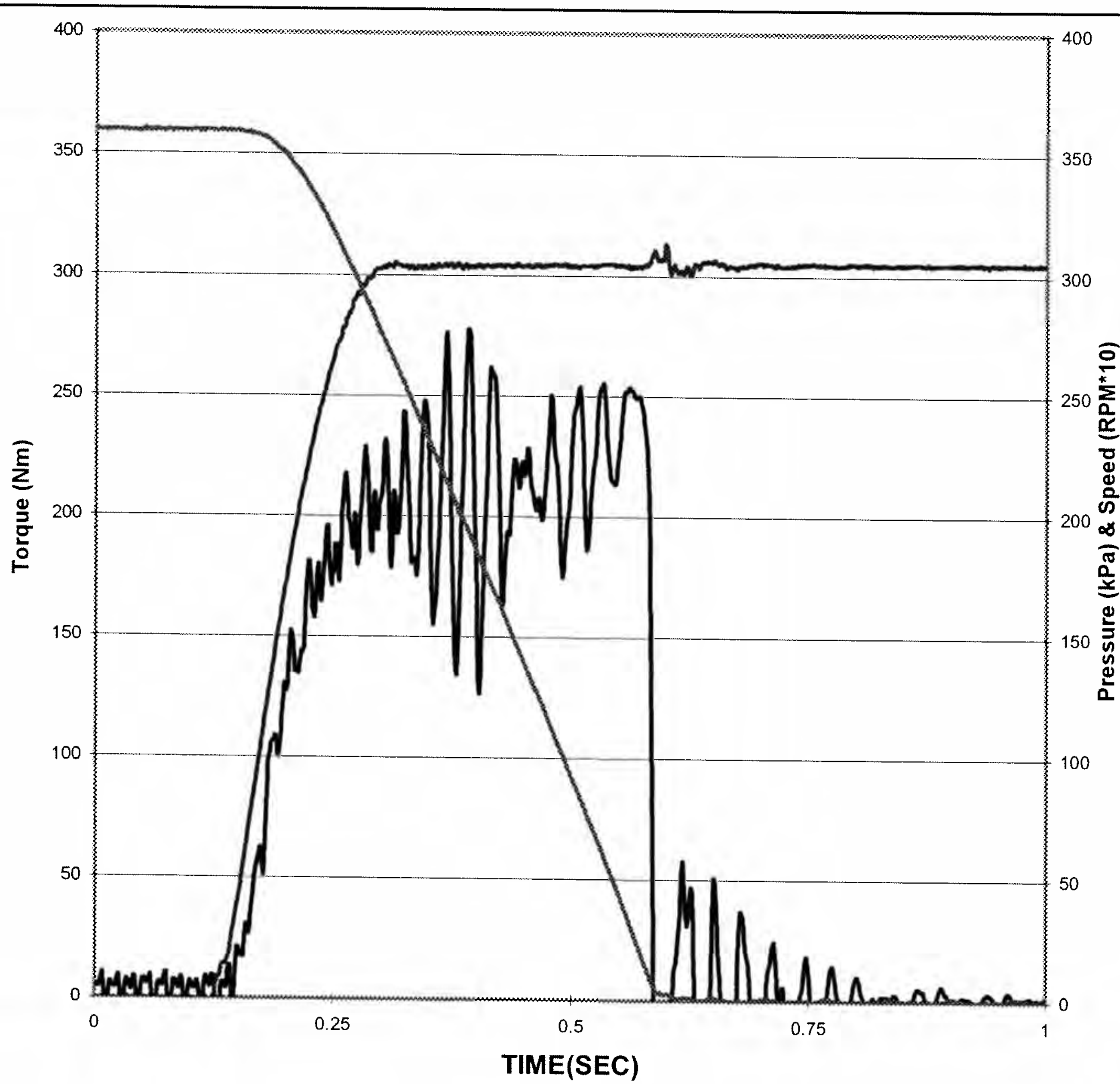

Date of Test:	9/17/2007
Time of Test:	14:51:04
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	65
Cycle Number:	15600
Temperature:	135.0 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.44 Sec
	(0.35 -0.55)

Torque

Maximum:	254 N*m
	(Report)
Midpoint:	205 N*m
	(180-290)
Max - Mid:	49 N*m
	<120
End - Mid:	17 N*m
	<120
End:	222 N*m
	>200

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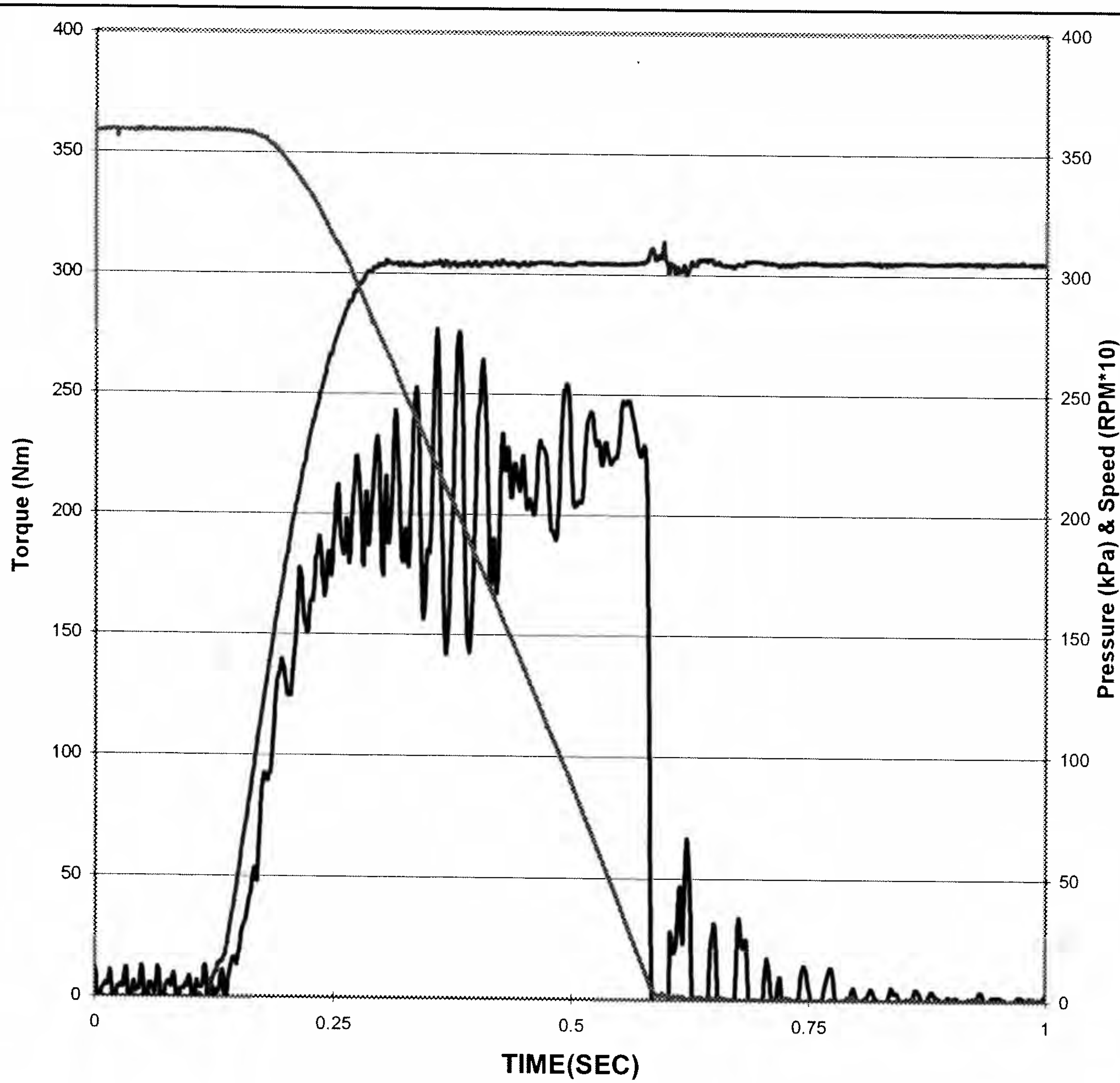

Date of Test:	9/17/2007
Time of Test:	19:51:04
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	70
Cycle Number:	16800
Temperature:	134.9 °C *(129 - 141)*
Apply Pressure:	304 kPa (295 - 305)
Energy:	15.8 KJ *(15.7-16.3)*
Engage Time:	0.44 Sec *(0.35 -0.55)*

Torque

Maximum:	248 N*m (Report)
Midpoint:	210 N*m *(180-290)*
Max - Mid:	37 N*m *<120*
End - Mid:	11 N*m *<120*
End:	222 N*m *>200*

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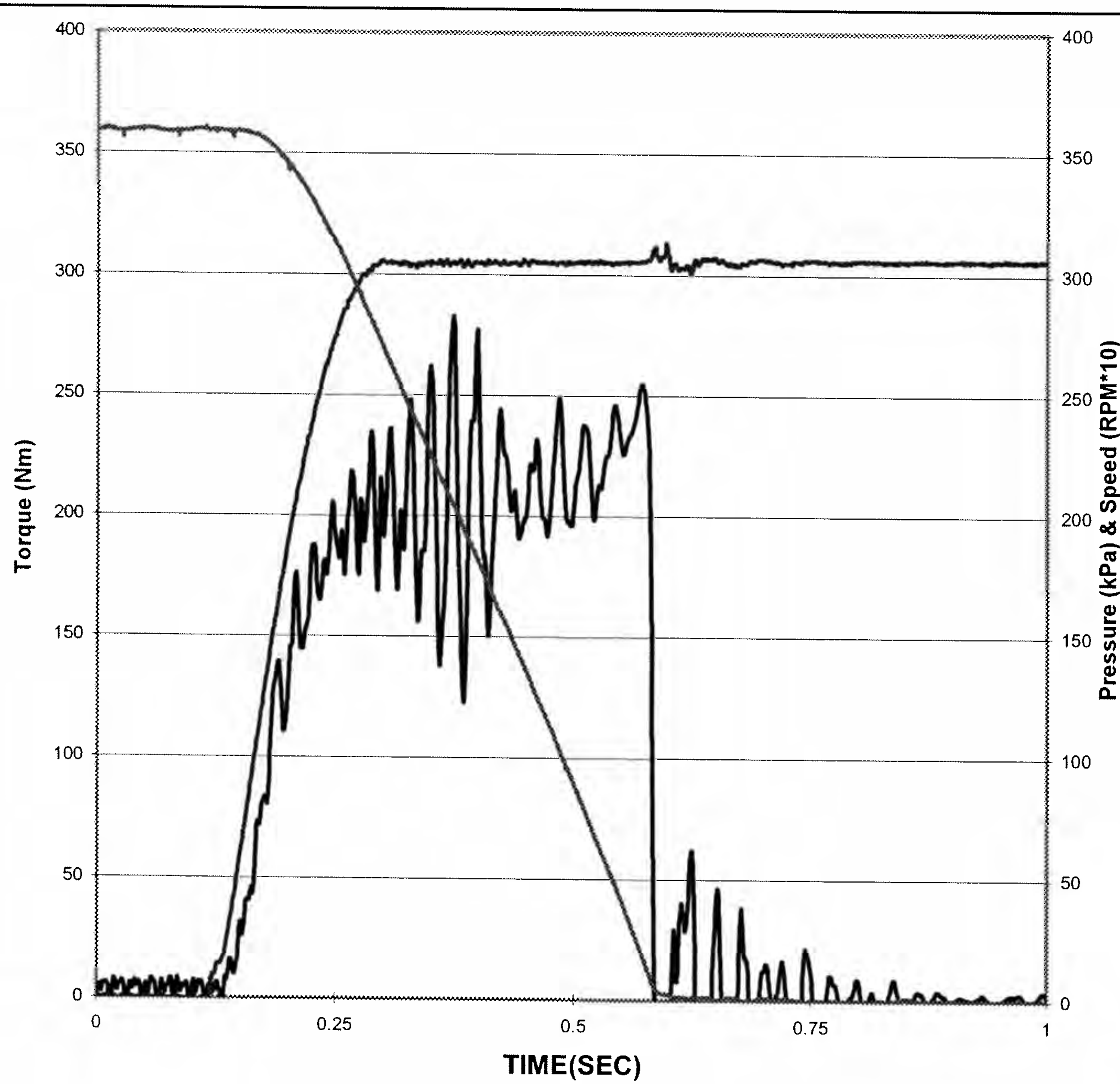

Date of Test:	9/18/2007
Time of Test:	0:51:05
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	75
Cycle Number:	18000
Temperature:	135.0 °C
	(129 - 141)
Apply Pressure:	305 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.45 Sec
	(0.35 -0.55)

Torque

Maximum:	255 N*m
	(Report)
Midpoint:	205 N*m
	(180-290)
Max - Mid:	50 N*m
	<120
End - Mid:	32 N*m
	<120
End:	237 N*m
	>200

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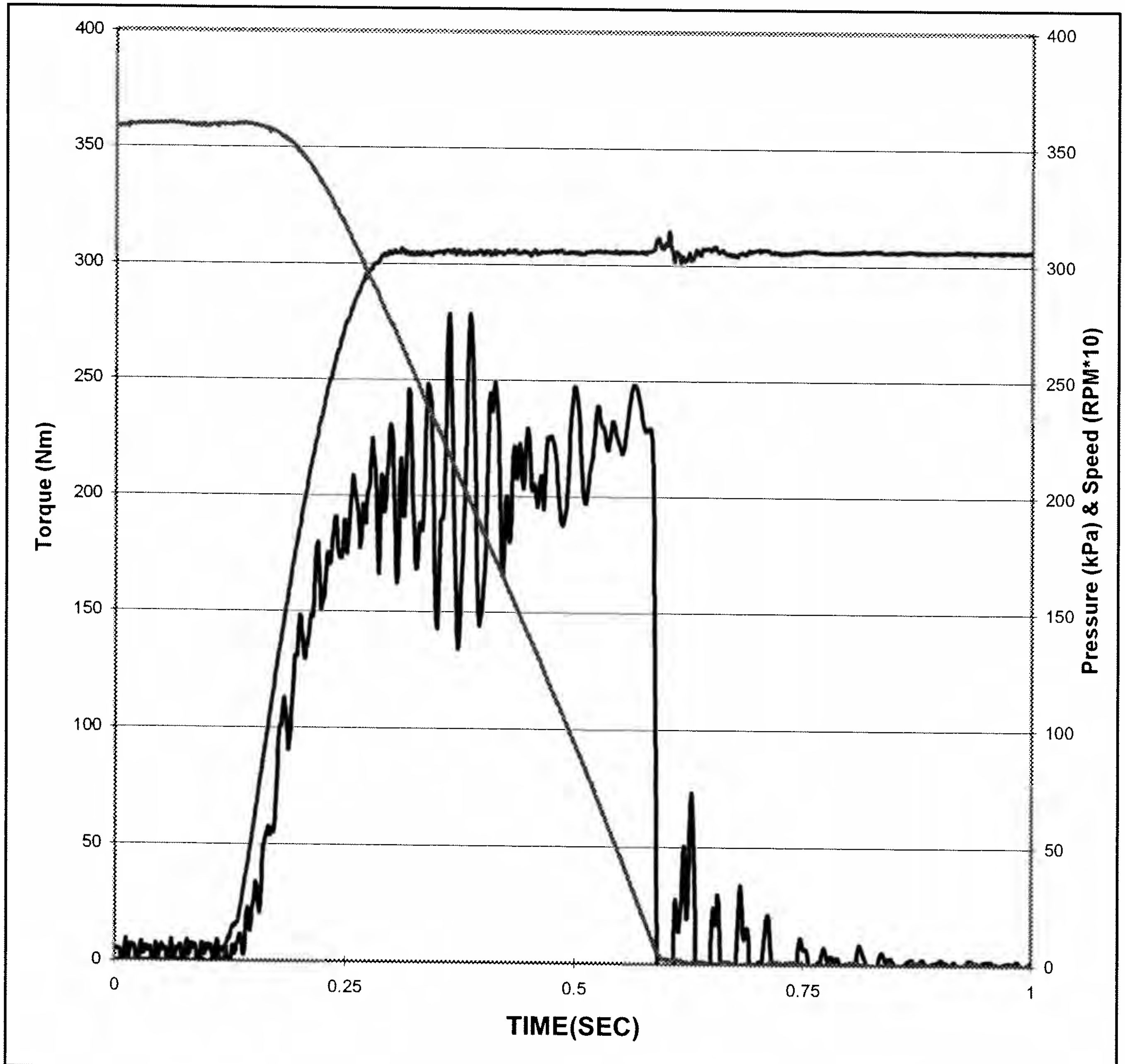

Date of Test:	9/18/2007
Time of Test:	5:51:06
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	80
Cycle Number:	19200
Temperature:	135.3 °C *(129 - 141)*
Apply Pressure:	305 kPa (295 - 305)
Energy:	15.8 KJ *(15.7-16.3)*
Engage Time:	0.45 Sec *(0.35 -0.55)*

Torque

Maximum:	248 N*m (Report)
Midpoint:	205 N*m *(180-290)*
Max - Mid:	43 N*m *<120*
End - Mid:	20 N*m *<120*
End:	225 N*m *>200*

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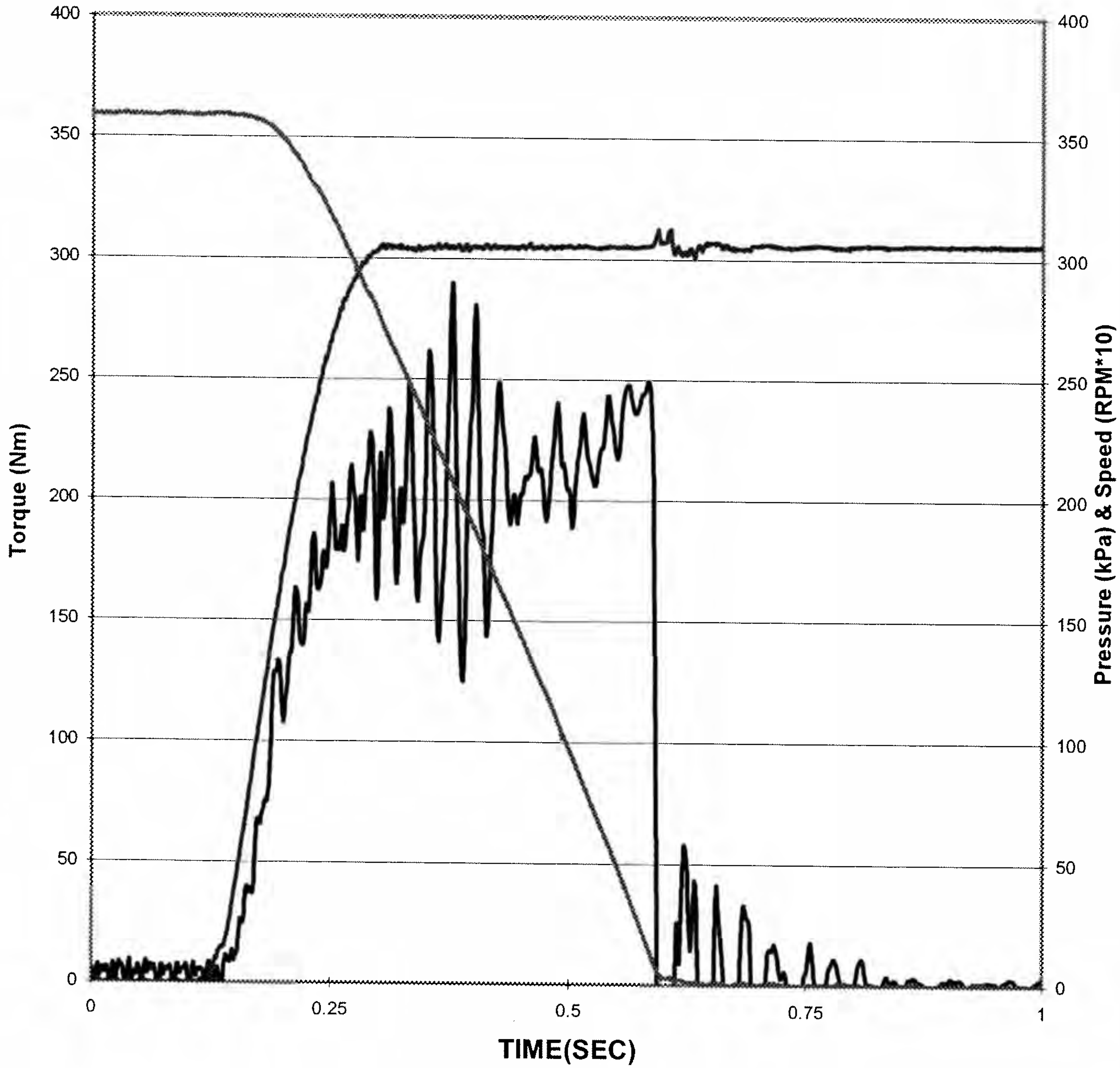

Date of Test:	9/18/2007
Time of Test:	10:51:07
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	85
Cycle Number:	20400
Temperature:	134.9 °C *(129 - 141)*
Apply Pressure:	305 kPa (295 - 305)
Energy:	15.8 KJ *(15.7-16.3)*
Engage Time:	0.45 Sec *(0.35 -0.55)*

Torque

Maximum:	250 N*m (Report)
Midpoint:	200 N*m *(180-290)*
Max - Mid:	49 N*m *<120*
End - Mid:	39 N*m *<120*
End:	239 N*m *>200*

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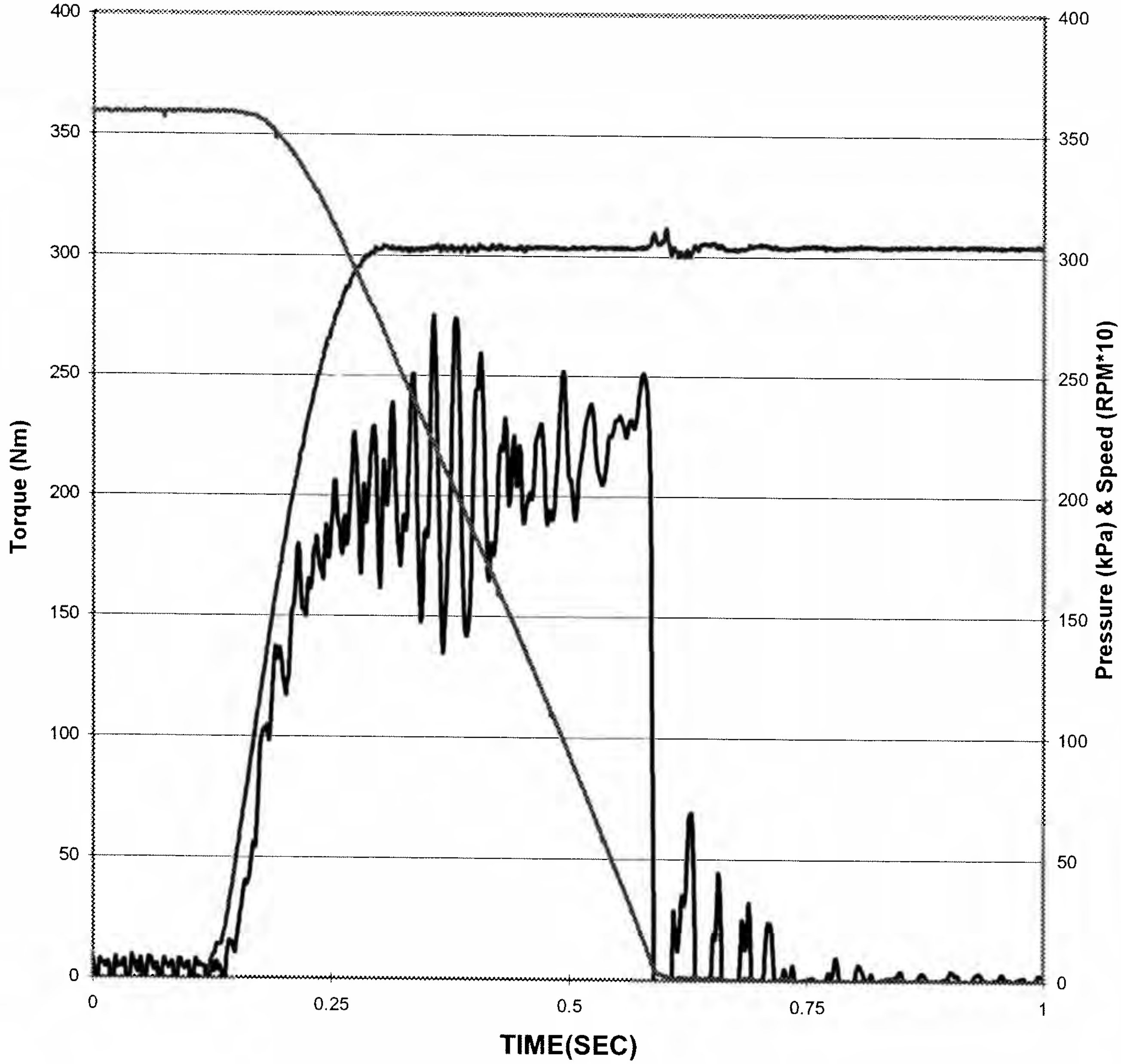

Date of Test:	9/18/2007
Time of Test:	15:51:08
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	90
Cycle Number:	21600
Temperature:	134.9 °C *(129 - 141)*
Apply Pressure:	304 kPa (295 - 305)
Energy:	15.8 KJ *(15.7-16.3)*
Engage Time:	0.45 Sec *(0.35 -0.55)*

Torque

Maximum:	251 N*m (Report)
Midpoint:	205 N*m *(180-290)*
Max - Mid:	46 N*m *<120*
End - Mid:	33 N*m *<120*
End:	238 N*m *>200*

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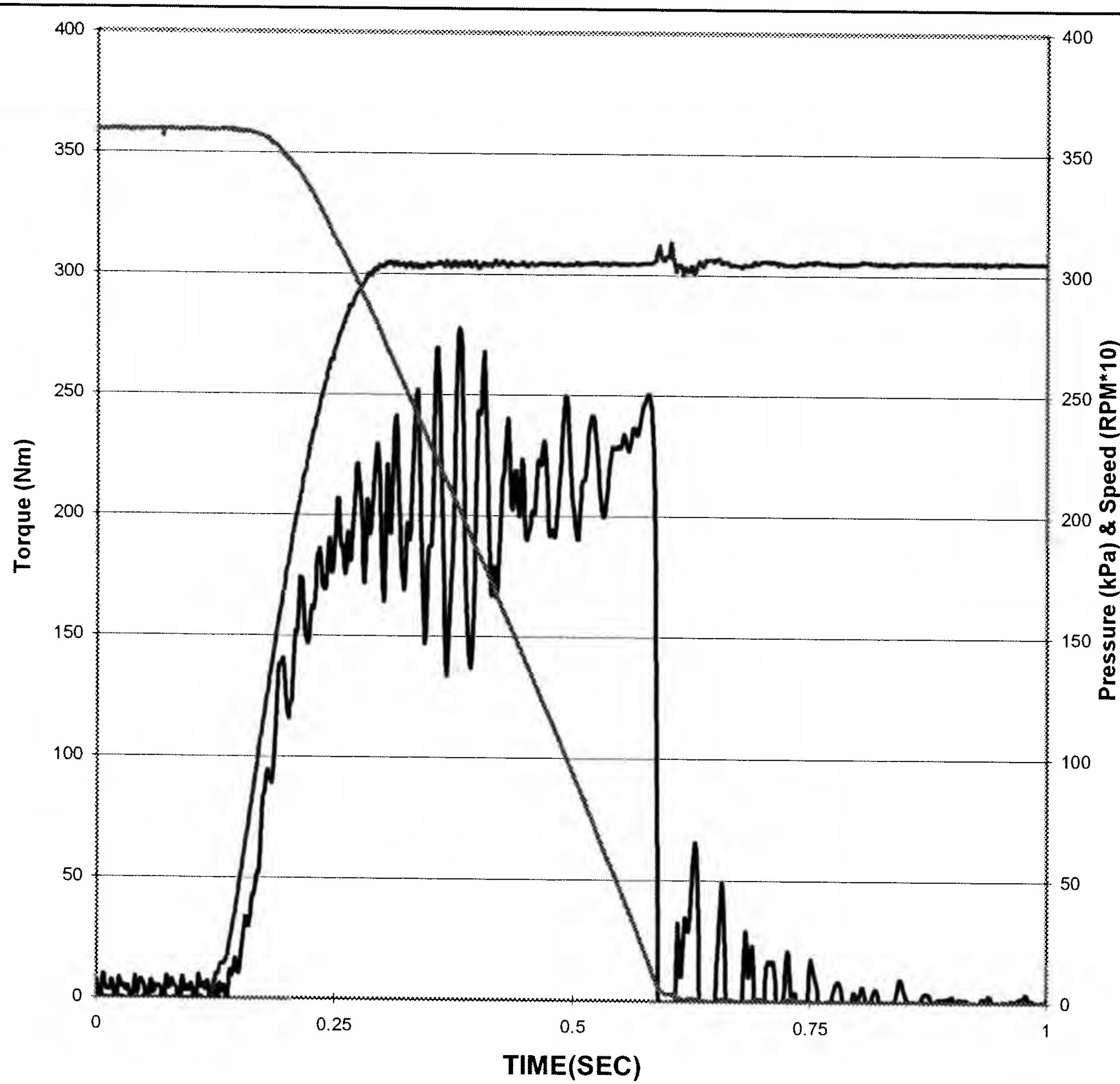

Date of Test:	9/18/2007
Time of Test:	20:51:08
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	95
Cycle Number:	22800
Temperature:	135.2 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.45 Sec
	(0.35 -0.55)

Torque

Maximum:	251 N*m
	(Report)
Midpoint:	205 N*m
	(180-290)
Max - Mid:	46 N*m
	<120
End - Mid:	33 N*m
	<120
End:	238 N*m
	>200

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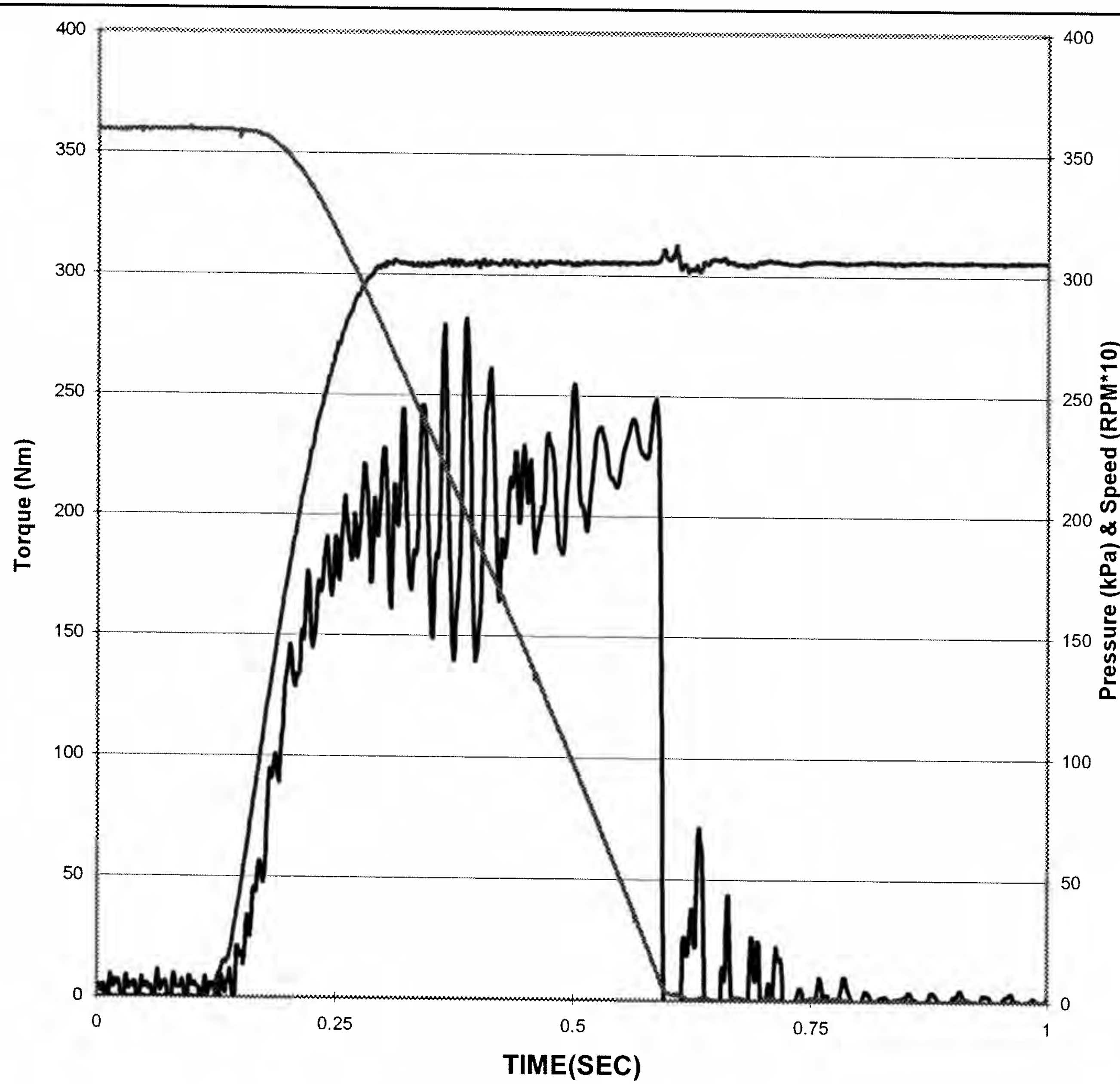

Date of Test:	9/19/2007
Time of Test:	1:51:09
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	100
Cycle Number:	24000
Temperature:	135.3 °C *(129 - 141)*
Apply Pressure:	305 kPa (295 - 305)
Energy:	15.8 KJ *(15.7-16.3)*
Engage Time:	0.45 Sec *(0.35 -0.55)*

Torque

Maximum:	249 N*m (Report)
Midpoint:	206 N*m *(180-290)*
Max - Mid:	43 N*m *<120*
End - Mid:	37 N*m *<120*
End:	242 N*m *>200*

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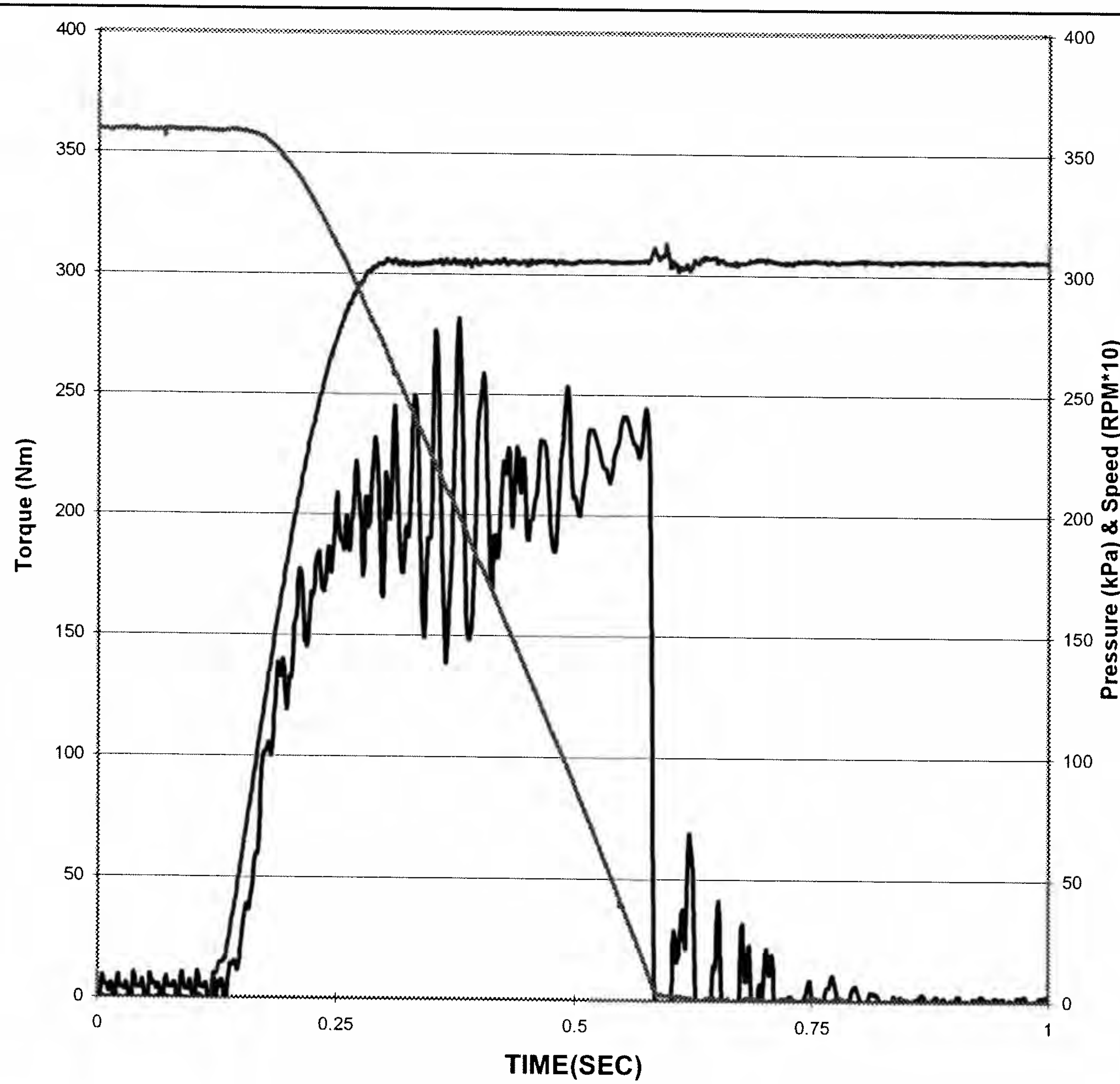

Date of Test:	9/19/2007
Time of Test:	6:51:10
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	105
Cycle Number:	25200
Temperature:	135.1 °C *(129 - 141)*
Apply Pressure:	305 kPa (295 - 305)
Energy:	15.8 KJ *(15.7-16.3)*
Engage Time:	0.45 Sec *(0.35 -0.55)*

Torque

Maximum:	245 N*m (Report)
Midpoint:	207 N*m *(180-290)*
Max - Mid:	38 N*m *<120*
End - Mid:	26 N*m *<120*
End:	233 N*m *>200*

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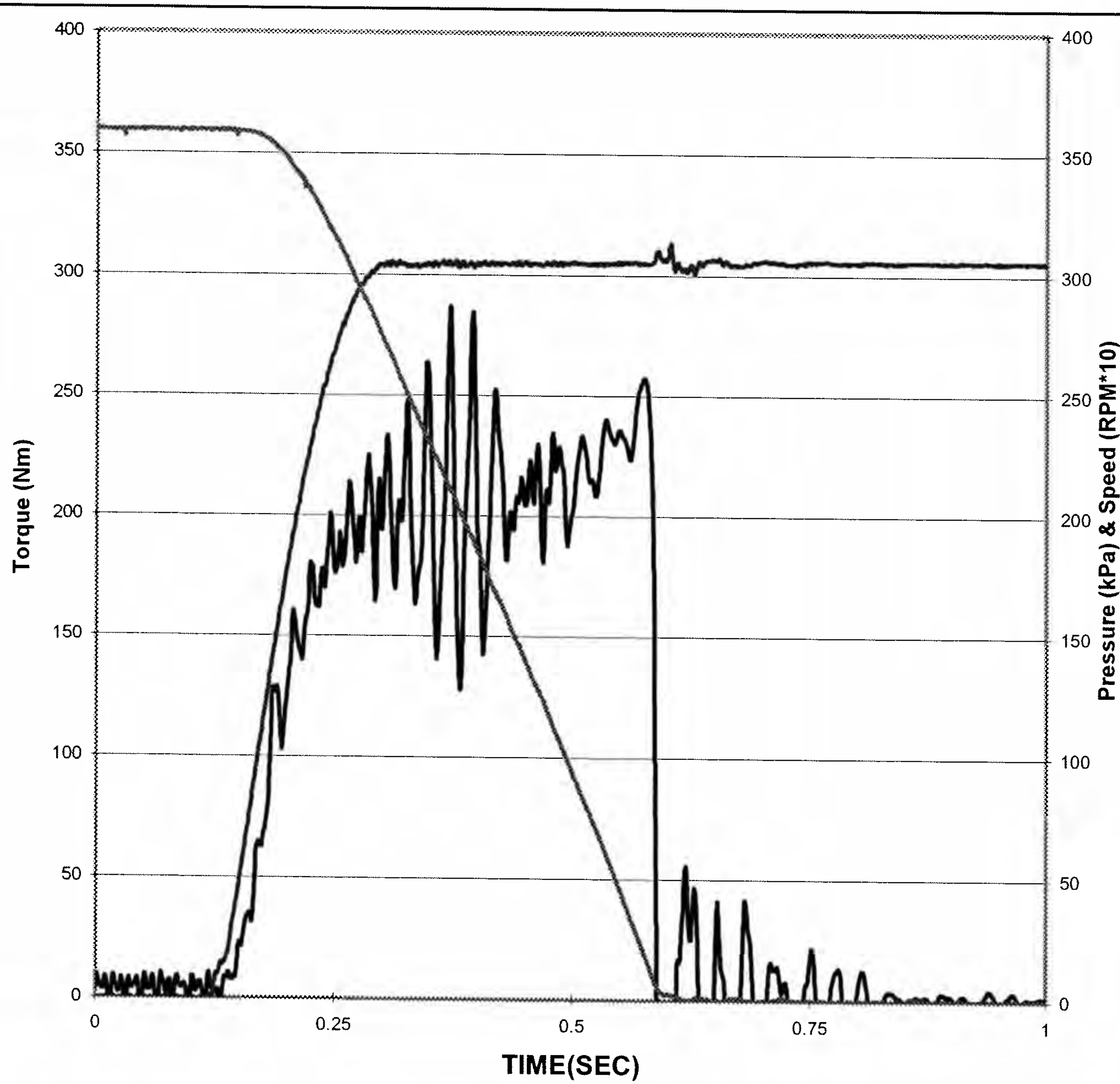

Date of Test:	9/19/2007
Time of Test:	11:51:11
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	110
Cycle Number:	26400
Temperature:	135.1 °C *(129 - 141)*
Apply Pressure:	305 kPa (295 - 305)
Energy:	15.8 KJ *(15.7-16.3)*
Engage Time:	0.45 Sec *(0.35 -0.55)*

Torque

Maximum:	258 N*m (Report)
Midpoint:	200 N*m *(180-290)*
Max - Mid:	58 N*m *<120*
End - Mid:	41 N*m *<120*
End:	240 N*m *>200*

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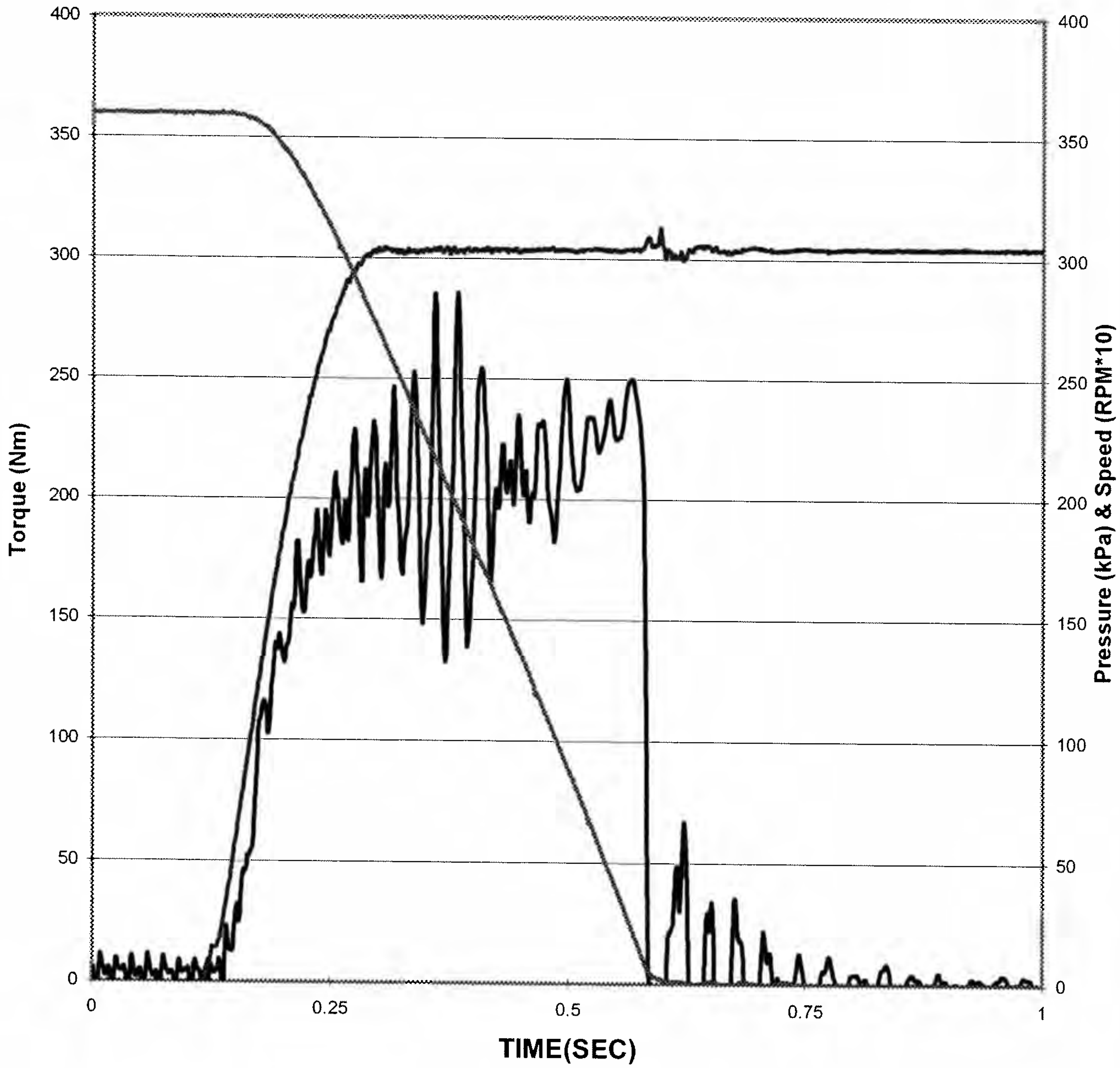

Date of Test:	9/19/2007
Time of Test:	16:51:11
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	115
Cycle Number:	27600
Temperature:	135.0 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.44 Sec
	(0.35 -0.55)

Torque

Maximum:	250 N*m
	(Report)
Midpoint:	205 N*m
	(180-290)
Max - Mid:	45 N*m
	<120
End - Mid:	17 N*m
	<120
End:	222 N*m
	>200

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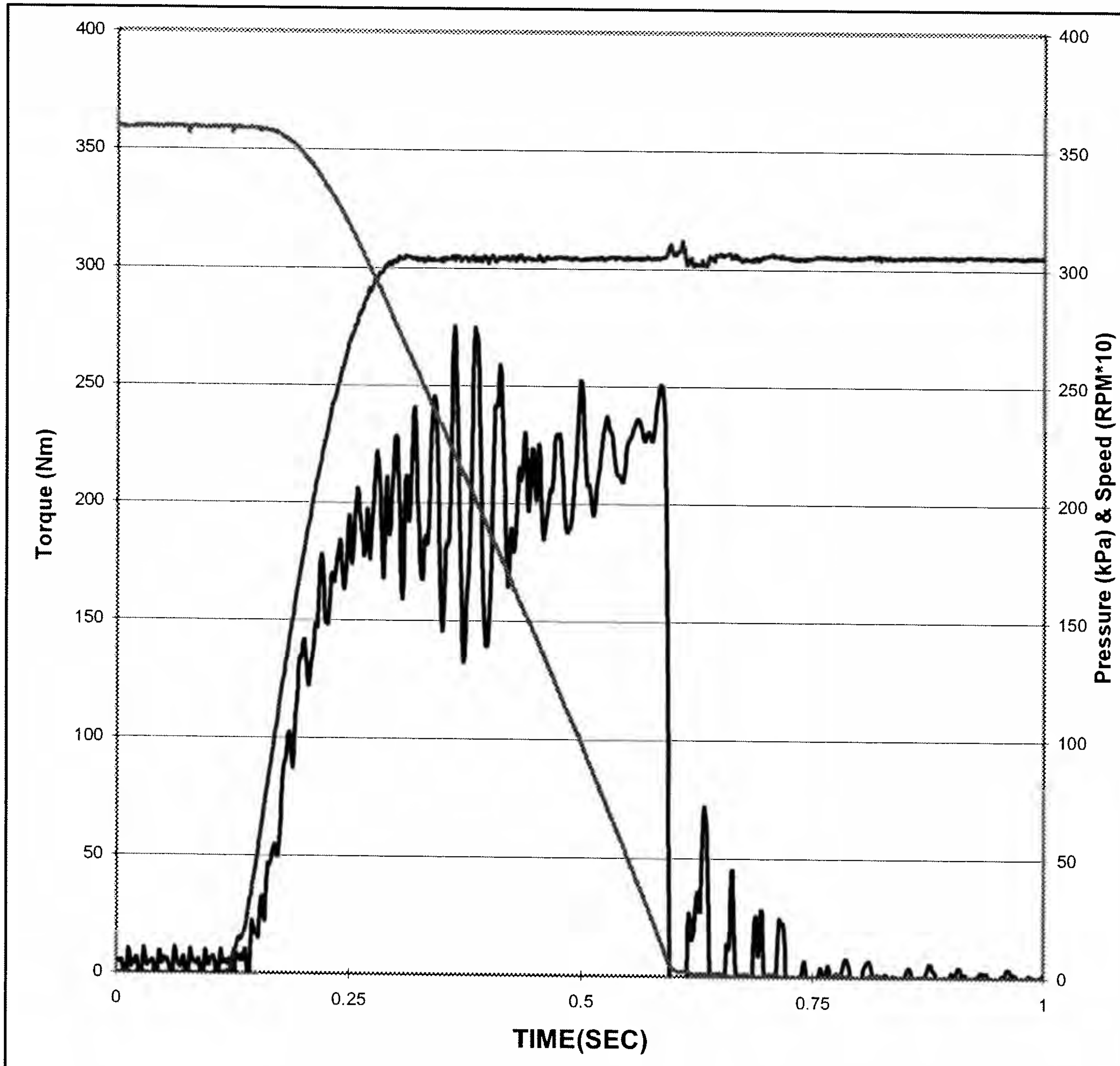

Date of Test:	9/19/2007
Time of Test:	21:51:12
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	120
Cycle Number:	28800
Temperature:	134.9 °C
	(129 - 141)
Apply Pressure:	304 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.45 Sec
	(0.35 -0.55)

Torque

Maximum:	251 N*m
	(Report)
Midpoint:	205 N*m
	(180-290)
Max - Mid:	46 N*m
	<120
End - Mid:	39 N*m
	<120
End:	244 N*m
	>200

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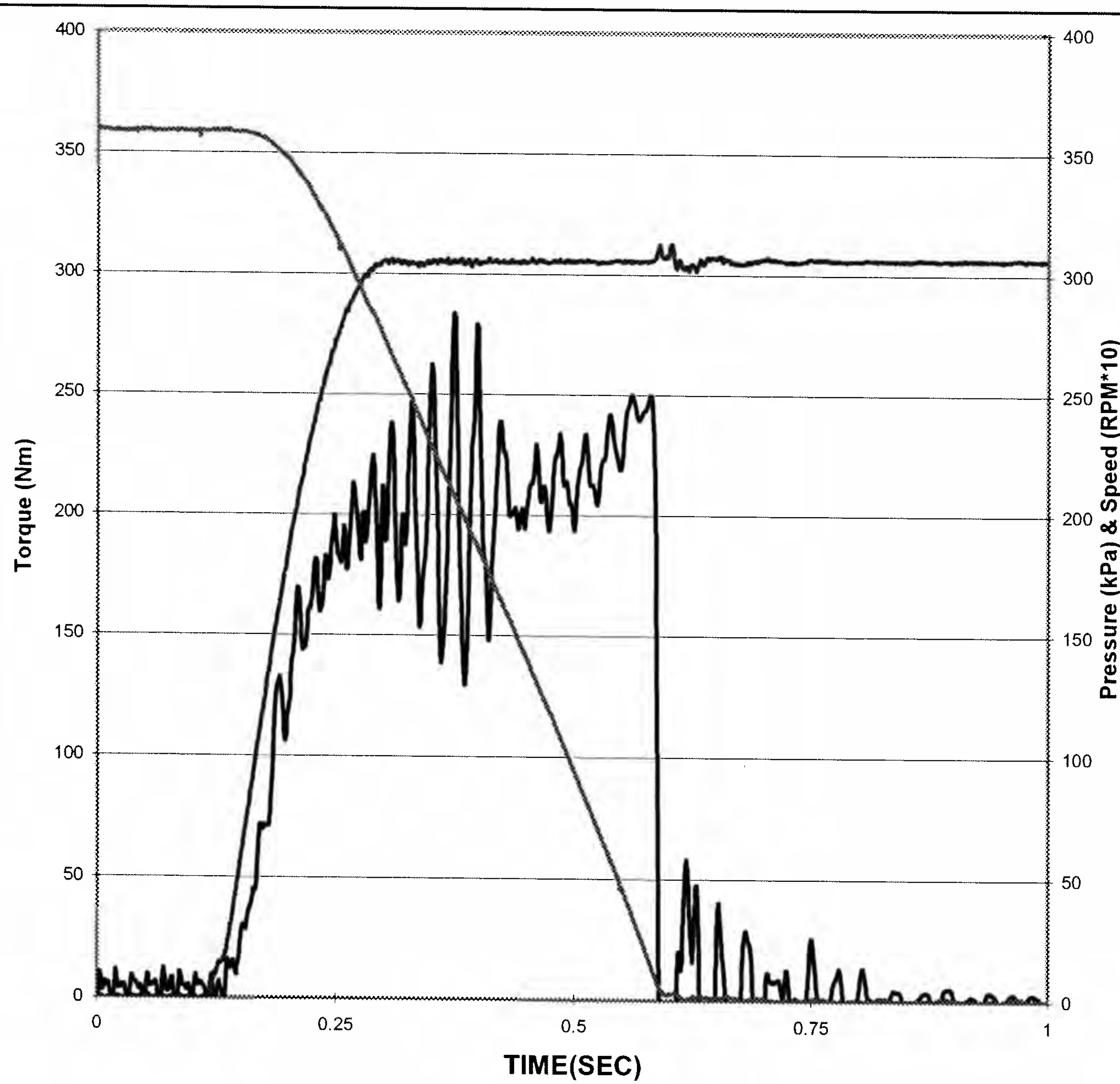

Date of Test:	9/20/2007
Time of Test:	2:51:13
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	125
Cycle Number:	30000
Temperature:	135.0 °C *(129 - 141)*
Apply Pressure:	305 kPa (295 - 305)
Energy:	15.8 KJ *(15.7-16.3)*
Engage Time:	0.46 Sec *(0.35 -0.55)*

Torque

Maximum:	250 N*m (Report)
Midpoint:	200 N*m *(180-290)*
Max - Mid:	50 N*m *<120*
End - Mid:	43 N*m *<120*
End:	243 N*m *>200*

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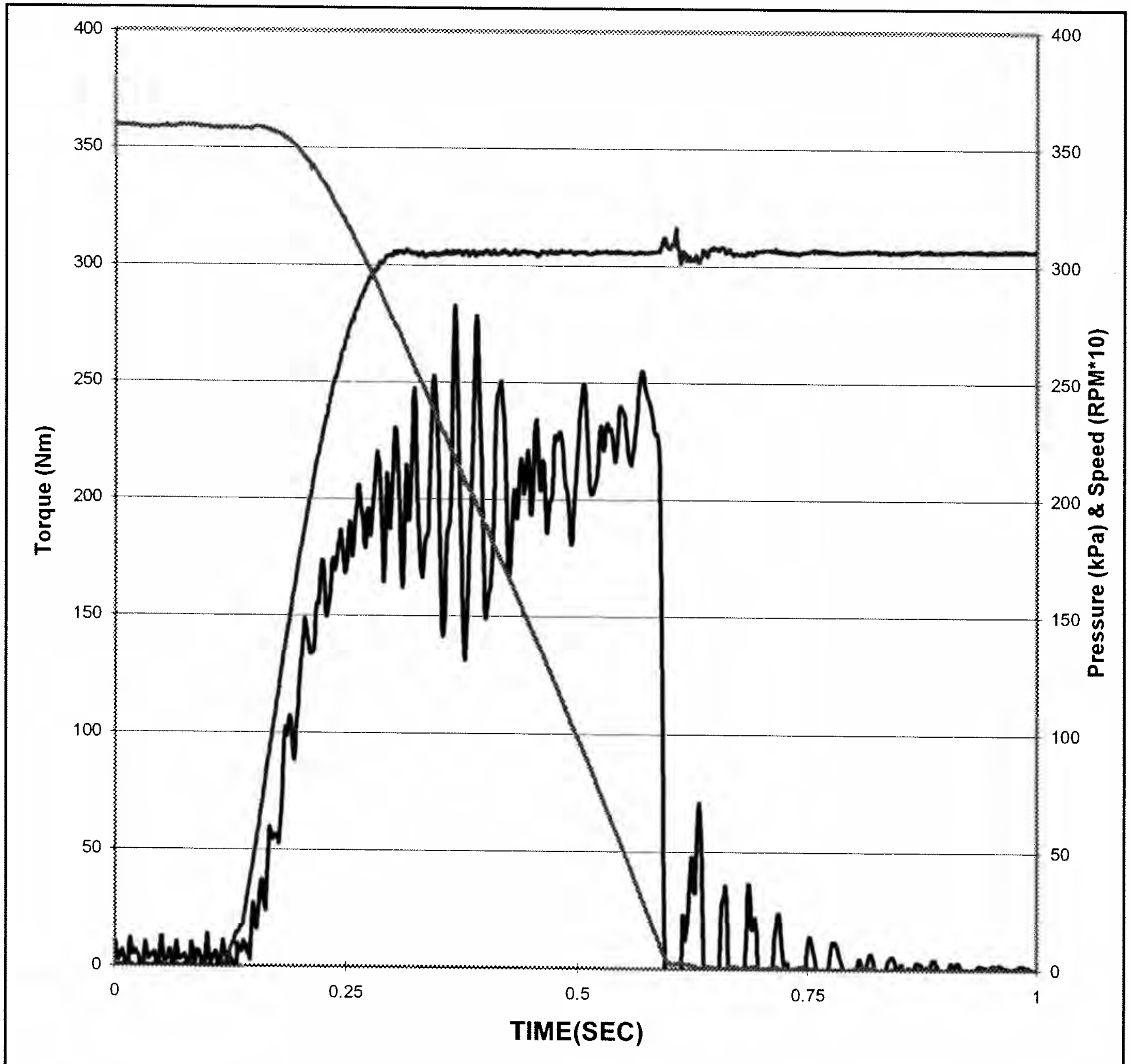

Date of Test:	9/20/2007
Time of Test:	7:51:14
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	130
Cycle Number:	31200
Temperature:	135.0 °C
	(129 - 141)
Apply Pressure:	305 kPa
	(295 - 305)
Energy:	15.8 KJ
	(15.7-16.3)
Engage Time:	0.46 Sec
	(0.35 -0.55)

Torque

Maximum:	255 N*m
	(Report)
Midpoint:	202 N*m
	(180-290)
Max - Mid:	53 N*m
	<120
End - Mid:	22 N*m
	<120
End:	225 N*m
	>200

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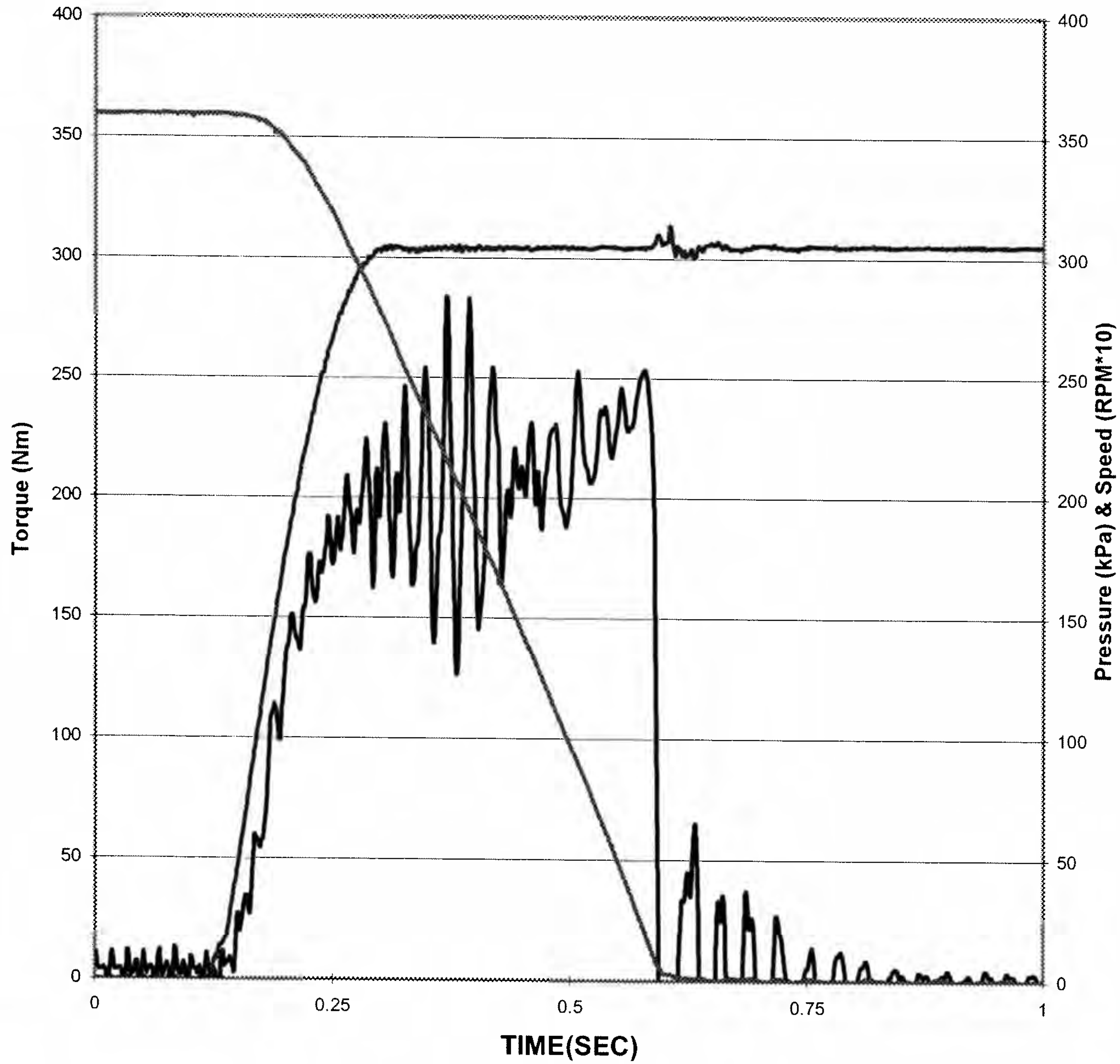

Date of Test:	9/20/2007
Time of Test:	12:51:14
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	135
Cycle Number:	32400
Temperature:	135.1 °C *(129 - 141)*
Apply Pressure:	304 kPa (295 - 305)
Energy:	15.8 KJ *(15.7-16.3)*
Engage Time:	0.45 Sec *(0.35 -0.55)*

Torque

Maximum:	254 N*m (Report)
Midpoint:	200 N*m *(180-290)*
Max - Mid:	54 N*m *<120*
End - Mid:	27 N*m *<120*
End:	227 N*m *>200*

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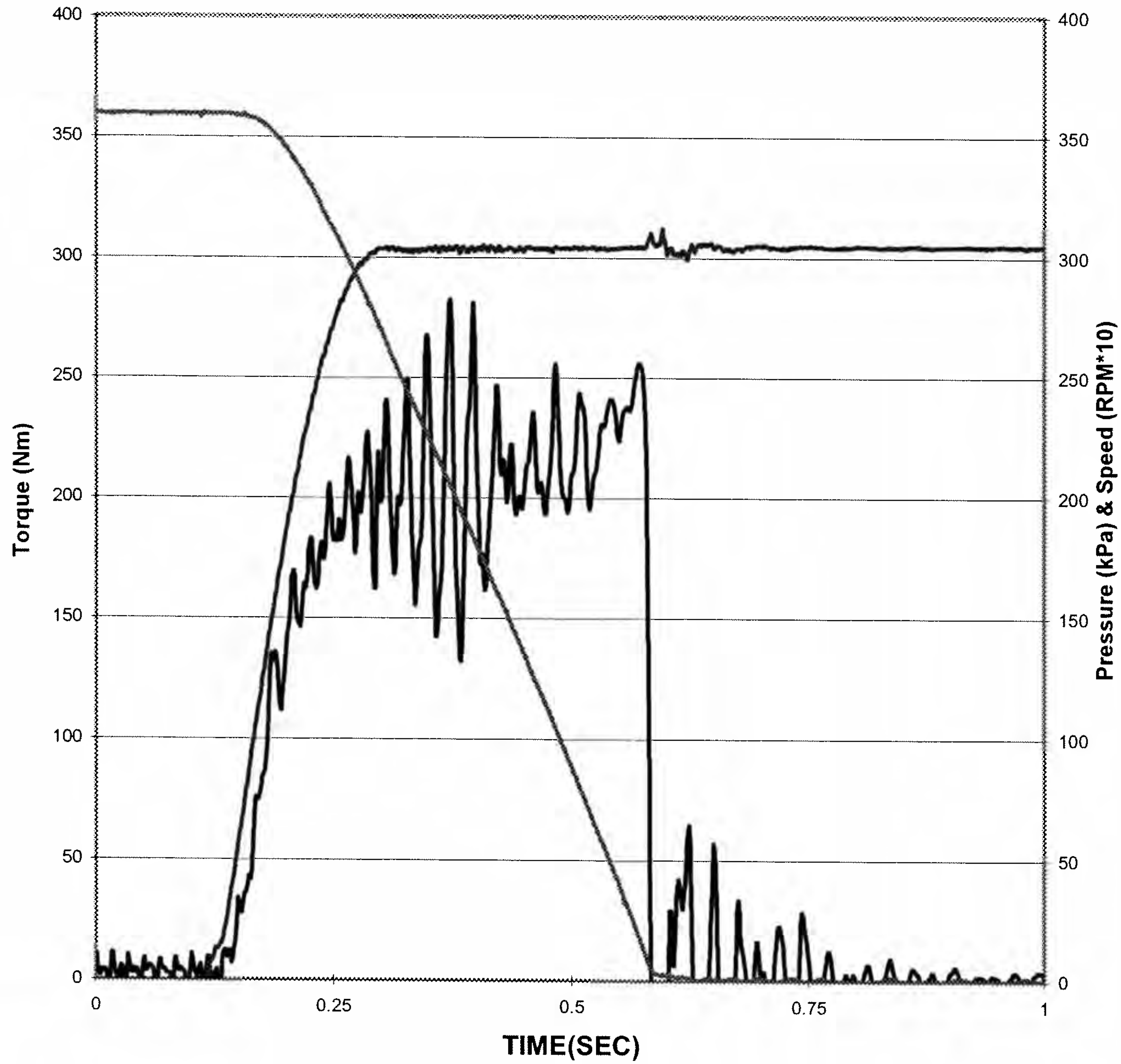

Date of Test:	9/20/2007
Time of Test:	17:51:15
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	140
Cycle Number:	33600
Temperature:	135.2 °C *(129 - 141)*
Apply Pressure:	304 kPa (295 - 305)
Energy:	15.8 KJ *(15.7-16.3)*
Engage Time:	0.45 Sec *(0.35 -0.55)*

Torque

Maximum:	256 N*m (Report)
Midpoint:	203 N*m *(180-290)*
Max - Mid:	53 N*m *<120*
End - Mid:	39 N*m *<120*
End:	242 N*m *>200*

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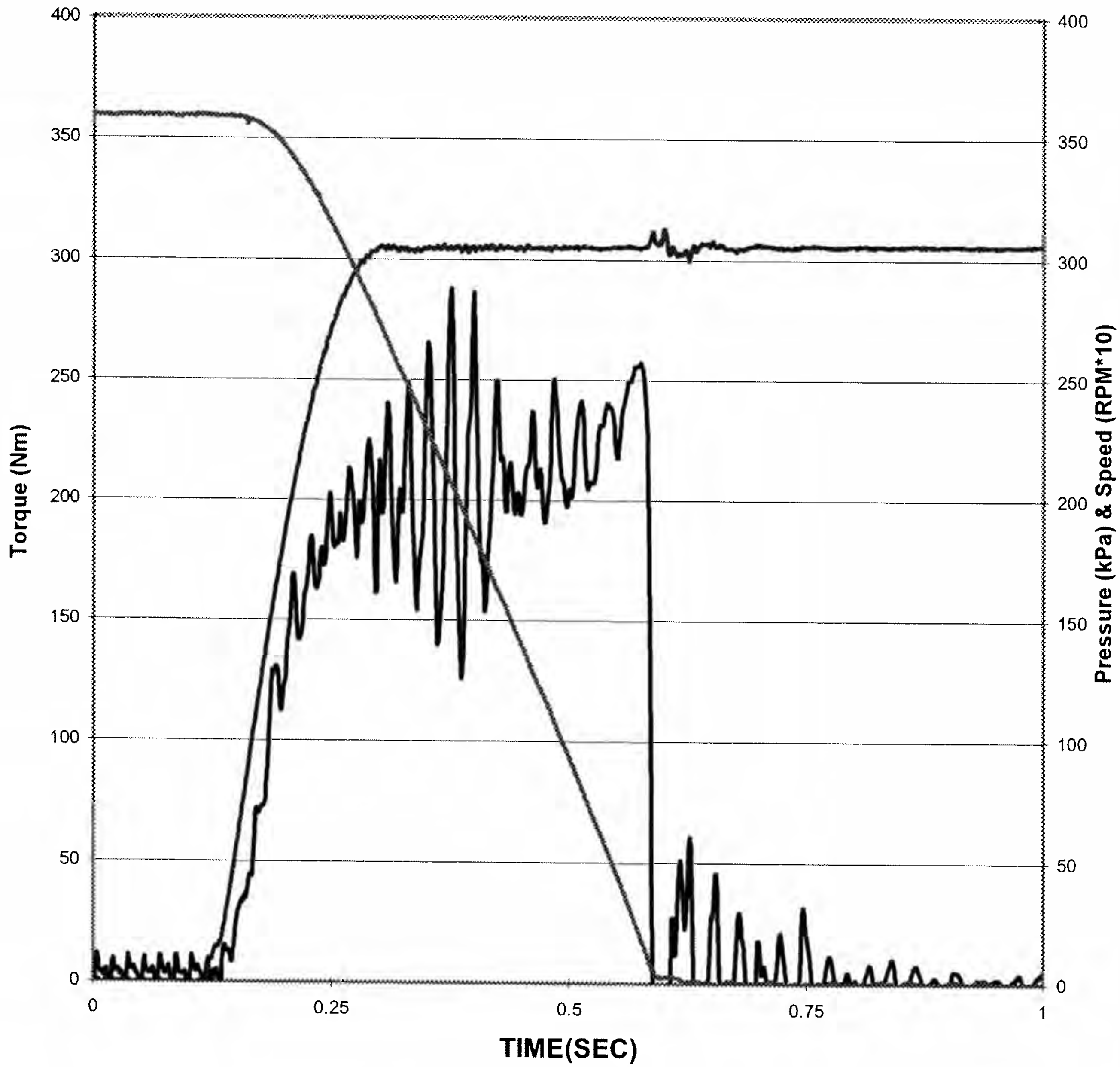

Date of Test:	9/20/2007
Time of Test:	22:51:16
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	145
Cycle Number:	34800
Temperature:	135.1 °C *(129 - 141)*
Apply Pressure:	305 kPa (295 - 305)
Energy:	15.8 KJ *(15.7-16.3)*
Engage Time:	0.45 Sec *(0.35 -0.55)*

Torque

Maximum:	258 N*m (Report)
Midpoint:	203 N*m *(180-290)*
Max - Mid:	55 N*m *<120*
End - Mid:	35 N*m *<120*
End:	238 N*m *>200*

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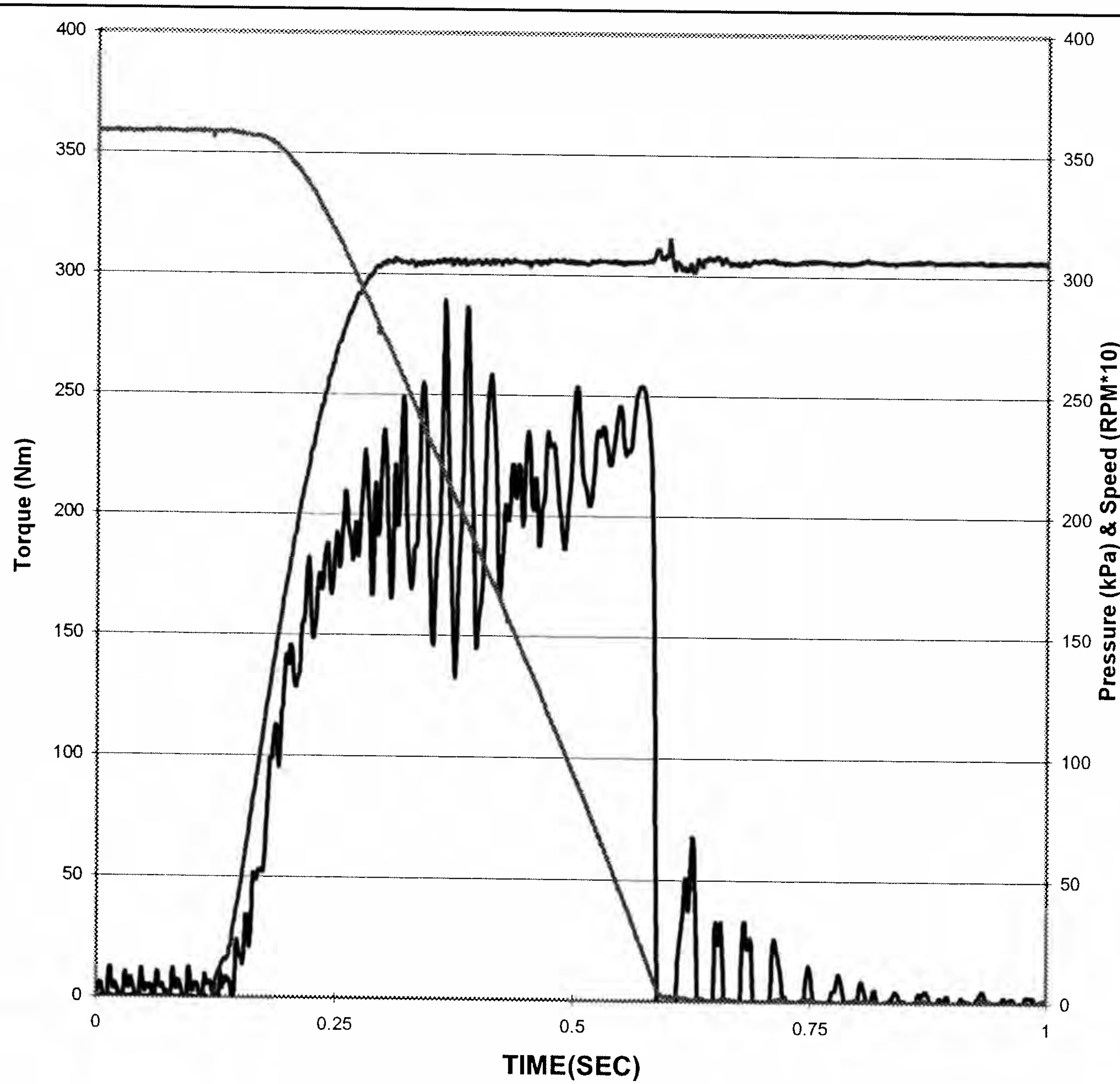


Date of Test:	9/21/2007
Time of Test:	3:51:17
Test Type:	BAND
Test Number:	BH3-8-169
Fluid Code:	AL-27877-L
Hour Number:	150
Cycle Number:	36000
Temperature:	135.0 °C *(129 - 141)*
Apply Pressure:	305 kPa (295 - 305)
Energy:	15.7 KJ *(15.7-16.3)*
Engage Time:	0.44 Sec *(0.35 -0.55)*

Torque

Maximum:	254 N*m (Report)
Midpoint:	204 N*m *(180-290)*
Max - Mid:	50 N*m *<120*
End - Mid:	25 N*m *<120*
End:	229 N*m *>200*

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

FUELS AND LUBRICANTS RESEARCH DIVISION

Report on

DEXRON® VI LOW SPEED CLUTCH FRICTION AND TORQUE CAPACITY CHARACTERIZATION

Conducted for

ARMY LAB

Oil Code:

AL-27877-L

Test Numbers:
LS12-5-0374

September 11, 2007

Submitted by:

Matthew Jackson
Principal Engineer
Specialty & Driveline Fluids
Evaluation

DEXRON® VI - LOW SPEED - NEW OIL

Program Code: AL-27877-L
Status: EOT
Test Cycles: 306
Test Performance:

Start Date: 9/10/2007
EOT Date: 9/11/2007
Run Number: LS12-5-0374
EOT Parts Condition:

Slip Speed [r/min]	Sliding Speed [m/s]	40°C Coefficients Apply Pressure [kPa]			90°C Coefficients Apply Pressure [kPa]			120°C Coefficients Apply Pressure [kPa]		
		273	683	1044	273	683	1044	273	683	1044
1	0.007	0.134	0.134	0.131	0.119	0.118	0.117	0.112	0.109	0.111
2	0.014	0.136	0.136	0.134	0.123	0.121	0.119	0.116	0.113	0.112
4	0.028	0.140	0.138	0.136	0.127	0.125	0.122	0.120	0.116	0.115
8	0.056	0.140	0.139	0.137	0.130	0.128	0.124	0.123	0.119	0.118
16	0.112	0.141	0.139	0.136	0.133	0.129	0.126	0.127	0.122	0.120
24	0.168	0.143	0.138	0.136	0.133	0.130	0.127	0.127	0.123	0.121
30	0.210	0.141	0.138	0.136	0.134	0.130	0.126	0.128	0.124	0.120
40	0.280	0.141	0.137	0.135	0.134	0.129	0.126	0.128	0.124	0.121
70	0.490	0.140	0.134	0.132	0.133	0.128	0.125	0.128	0.123	0.120
80	0.560	0.140	0.134	0.131	0.133	0.127	0.125	0.127	0.123	0.120
100	0.700	0.140	0.133	0.130	0.133	0.126	0.123	0.128	0.122	0.120
135	0.946	0.139	0.131	0.128	0.132	0.125	0.121	0.128	0.121	0.118
170	1.191	0.139	0.130	0.126	0.132	0.124	0.119	0.127	0.120	0.116
235	1.646	0.137	0.127	0.123	0.130	0.121	0.117	0.126	0.118	0.114

DEXRON® VI - LOW SPEED - USED CYCLING TEST OIL

Program Code:
Status:
Test Cycles:
Test Performance:

Start Date:
EOT Date:
Run Number:
EOT Parts Condition:

Slip Speed [r/min]	Sliding Speed [m/s]	40°C Coefficients Apply Pressure [kPa]			90°C Coefficients Apply Pressure [kPa]			120°C Coefficients Apply Pressure [kPa]		
		273	683	1044	273	683	1044	273	683	1044
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
70	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
80	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
135	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
170	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
235	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Test Rig Overview

The GM Low Speed Clutch Friction Test Rig utilizes a 30 hp variable speed electric drive that provides input power to a Greening SAE No. 2 Universal Wet Friction Material Test Machine through a speed-reducing gearbox. Test fluid is drawn from the bottom of the test head, externally circulated using a small gear pump, and returned at the clutch centerline. This is done to more closely simulate fluid flow within a transmission.

Since the clutch cannot be slipped to achieve heating between engagements, an external heat source is employed to achieve the high fluid temperatures required by the test procedure. Silicon oil from an external bath is circulated through the test head "water jacket" chamber (in place of the normal cooling water). Temperature control of the silicon bath is achieved using immersion heaters and a shell-and-tube heat exchanger.

Procedure Overview

A clutch pack consists of one fiber plate installed between two steel plates. Both steel plates are instrumented with thermocouples to record plate interface temperatures during the clutch engagements. Once the test rig is assembled and filled with test fluid, the clutch is applied three times (at a rotational speed of 0 rpm) to ensure saturation of the friction plate.

Discrete Data

The clutch is slipped at fourteen discrete rotational speeds, repeated for nine different pressure and temperature combinations. The discrete conditions for SAE Standard clutch plates are listed below.

<table>
<tr><th>Rotational Speed (rpm)</th><th>Apply Pressure (kPa)</th><th>Fluid Temperature (°C)</th></tr>
<tr><td>1</td><td rowspan="4">273</td><td rowspan="5">40</td></tr>
<tr><td>2</td></tr>
<tr><td>4</td></tr>
<tr><td>8</td></tr>
<tr><td>16</td><td rowspan="5">683</td></tr>
<tr><td>24</td><td rowspan="5">90</td></tr>
<tr><td>30</td></tr>
<tr><td>40</td></tr>
<tr><td>70</td></tr>
<tr><td>80</td><td rowspan="5">1044</td></tr>
<tr><td>100</td><td rowspan="4">120</td></tr>
<tr><td>135</td></tr>
<tr><td>170</td></tr>
<tr><td>235</td></tr>
</table>

(Note: The use of different clutch plates will necessitate adjustment of the speed and pressure conditions to match the slip speeds and surface pressures encountered by the SAE Standard plates.)

At each discrete speed condition, the clutch is slipped for three seconds following stabilization of the apply force. Target times for data collection are 0.3, 1.0, and 2.9 seconds. The clutch pack is then rotated at 100 rpm (with the apply pressure released) until the separator plate temperatures are stabilized within 3 °C of the bulk fluid temperature.

Sweep Data

Once all speed data has been recorded for a given pressure and temperature combination, sweep data is collected. During a sweep, the clutch is applied and the rotational speed is ramped from 0 rpm to maximum in 20 seconds. The clutch is then held at maximum speed for 5 seconds, then ramped to 0 rpm in 20 seconds. One sweep is performed for every pressure and temperature combination.

Breakaway Data

At the conclusion of each sweep, two static breakaways are performed. In each breakaway, speed is set at 0 rpm and the clutch applied at the given pressure condition. The electric drive then increases power to the test head until the clutch "breaks away." Immediately following breakaway, the clutch is slipped for 3 seconds at 5 rpm. The first breakaway is performed immediately following the conclusion of the sweep, with the second following after the separator plate temperatures are stabilized within 3 °C of the bulk fluid temperature.

Friction Map

Completion of the 126 speed-pressure-temperature clutch slip combinations and their associated sweeps and breakaways constitutes a friction map.

Break-In

Following the initial friction map, a break-in procedure is performed. Break-in consists of continuously slipping the clutch for ten minutes at 120 °C, 683 kPa, and 100 rpm. (Note that break-in conditions must also be adjusted when using plates other than SAE standard.) The ten-minute engagement is performed three times with a one minute release period between each apply cycle.

Post Break-In

Upon completion of the break-in, a complete friction map is performed (as described above). This results in two complete sets of data – an initial "pre-break-in" friction map and a final "post-break-in" map.

New and Used Fluid

Two full tests are conducted on each fluid. The first test is conducted on new, unused fluid. The second test is conducted on identical fluid that was previously run in another test (typically the GM Cycling test).

Upon completion of the initial test on new fluid, the rig is allowed to drain for a minimum of 30 minutes. Since the used fluid test is conducted on the same clutch pack used to test the new fluid, the test head is not disassembled between runs. (For this reason, clutch pack measurements give an indication of overall wear only, as final measurements are not conducted until the completion of the second test.)

After the rig has been fully drained, the used fluid (which has been filtered to remove any debris from previous testing) is installed and the test repeated.

Data Interpretation

A friction coefficient is calculated for each discrete data combination. The coefficient is calculated according to the following equation:

$$\mu = \frac{T}{PARN}$$

where

T = Torque (Nm)
P = Pressure (kPa)
A = Apply Piston Area (m^2)
R = Mean Friction Radius (m)
N = Active Friction Surfaces

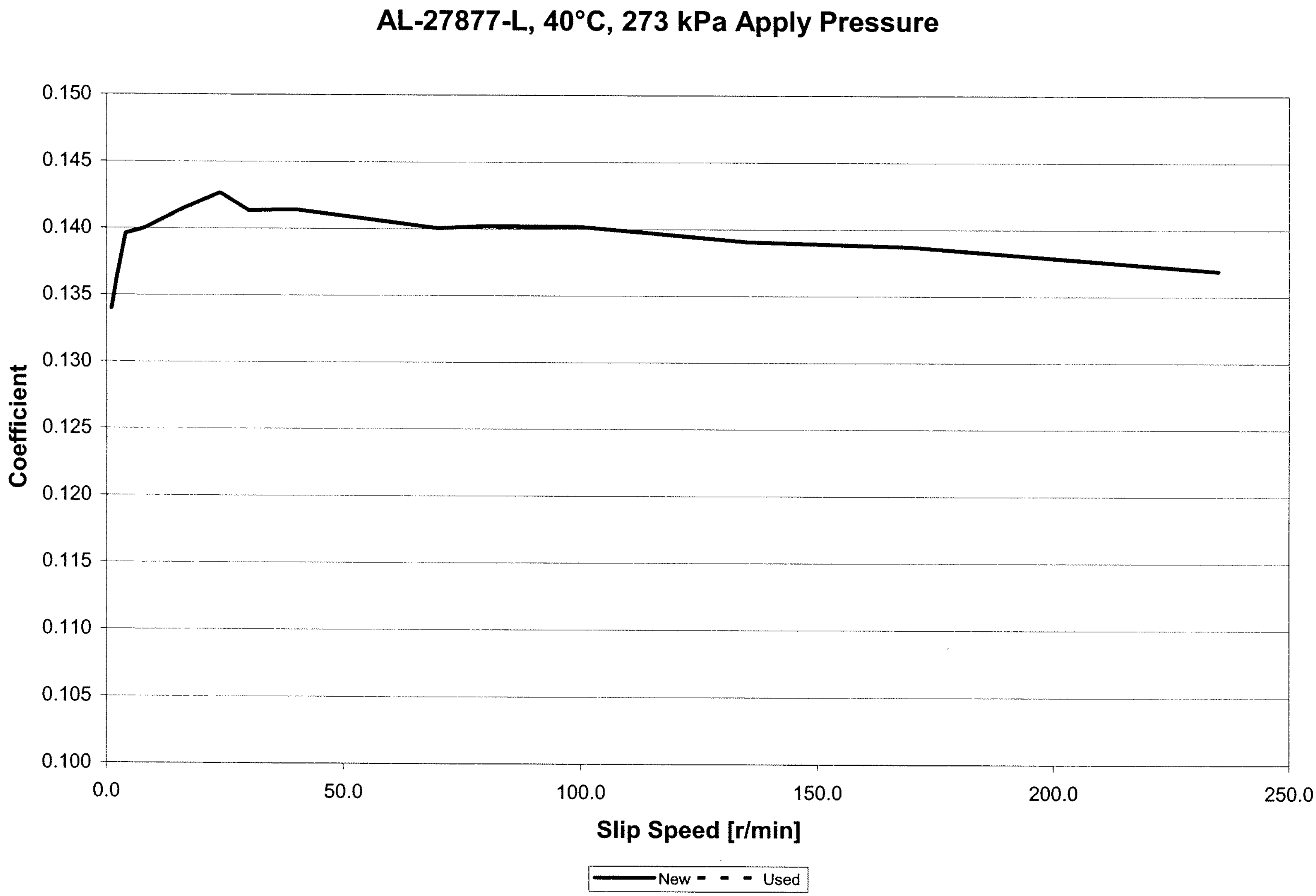
Test Report

Per sponsor request, only the new fluid portion of the test was conducted. The test report consists of nine plots displaying the variation of coefficient with slip speed at each temperature and pressure combination, two charts summarizing friction map data from the new and used fluid tests (not run in this case), and clutch pack wear measurements.

Appendix

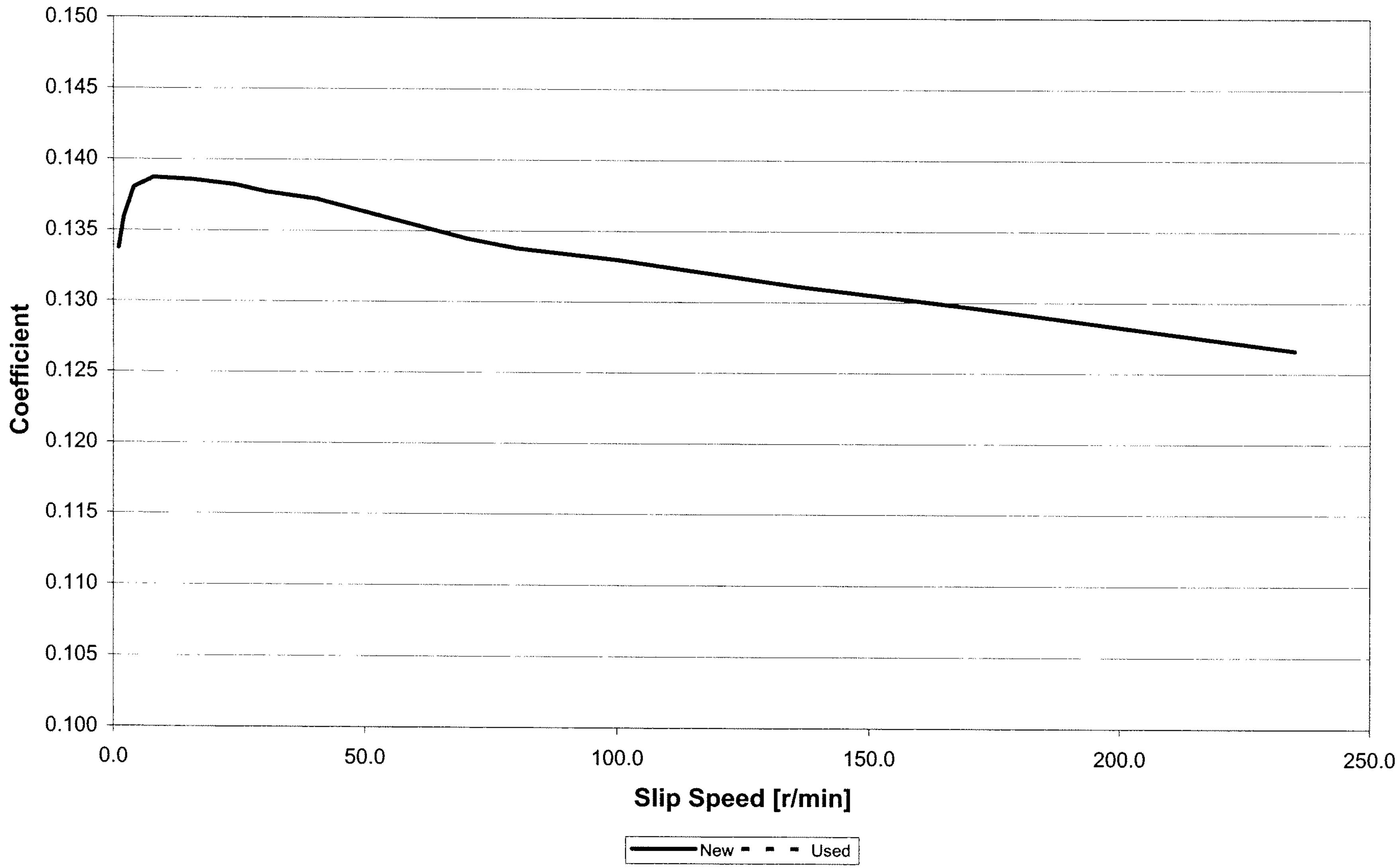
1. Coefficient vs. Slip Speed Plot: 40 °C / 273 kPa
2. Coefficient vs. Slip Speed Plot: 40 °C / 683 kPa
3. Coefficient vs. Slip Speed Plot: 40 °C / 1044 kPa
4. Coefficient vs. Slip Speed Plot: 90 °C / 273 kPa
5. Coefficient vs. Slip Speed Plot: 90 °C / 683 kPa
6. Coefficient vs. Slip Speed Plot: 90 °C / 1044 kPa
7. Coefficient vs. Slip Speed Plot: 120 °C / 273 kPa
8. Coefficient vs. Slip Speed Plot: 120 °C / 683 kPa
9. Coefficient vs. Slip Speed Plot: 120 °C / 1044 kPa
10. Clutch Pack Wear Measurements

New Fluid Test Number: LS12-5-0374



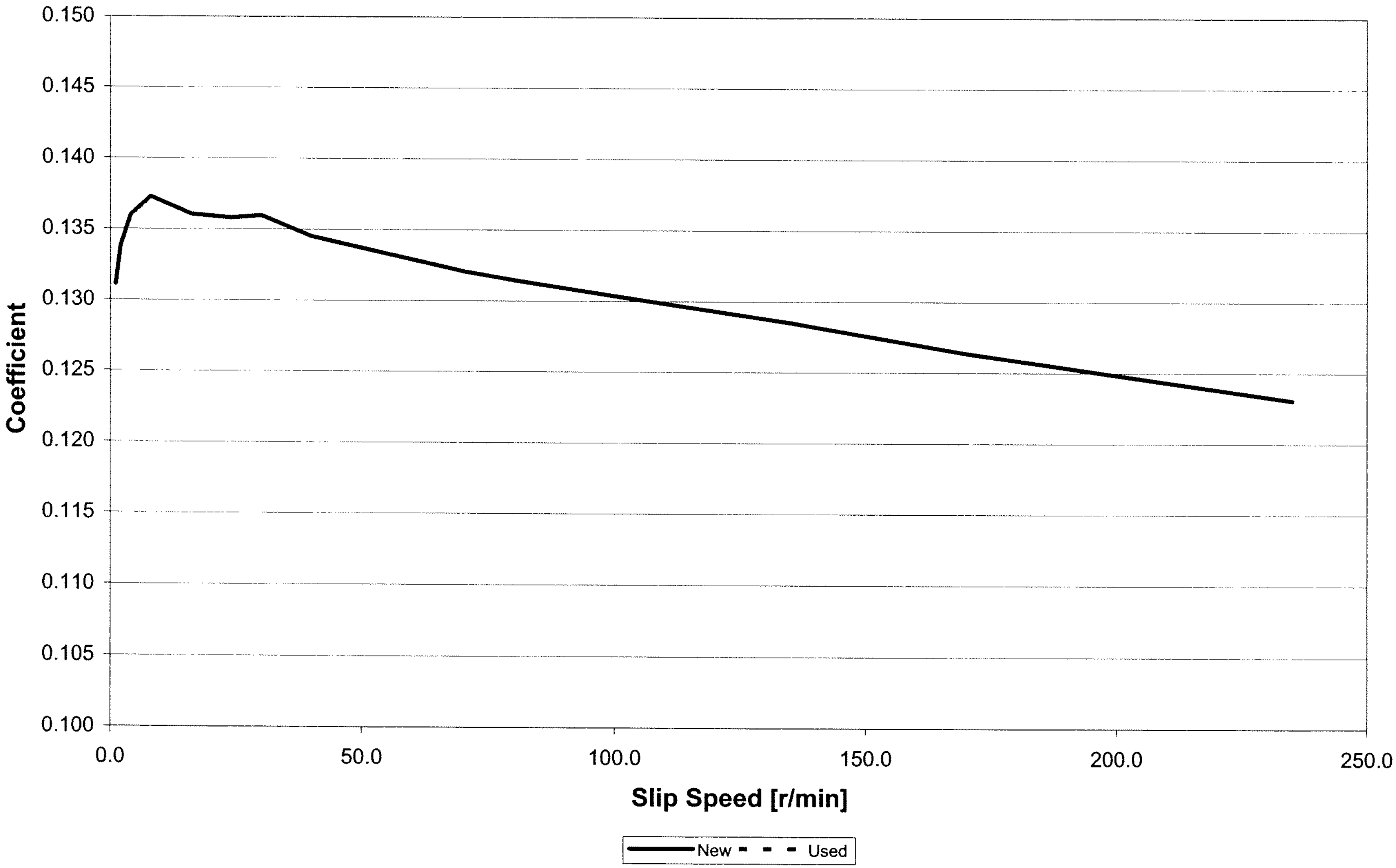
New Fluid Test Number: LS12-5-0374

AL-27877-L, 40°C, 683 kPa Apply Pressure

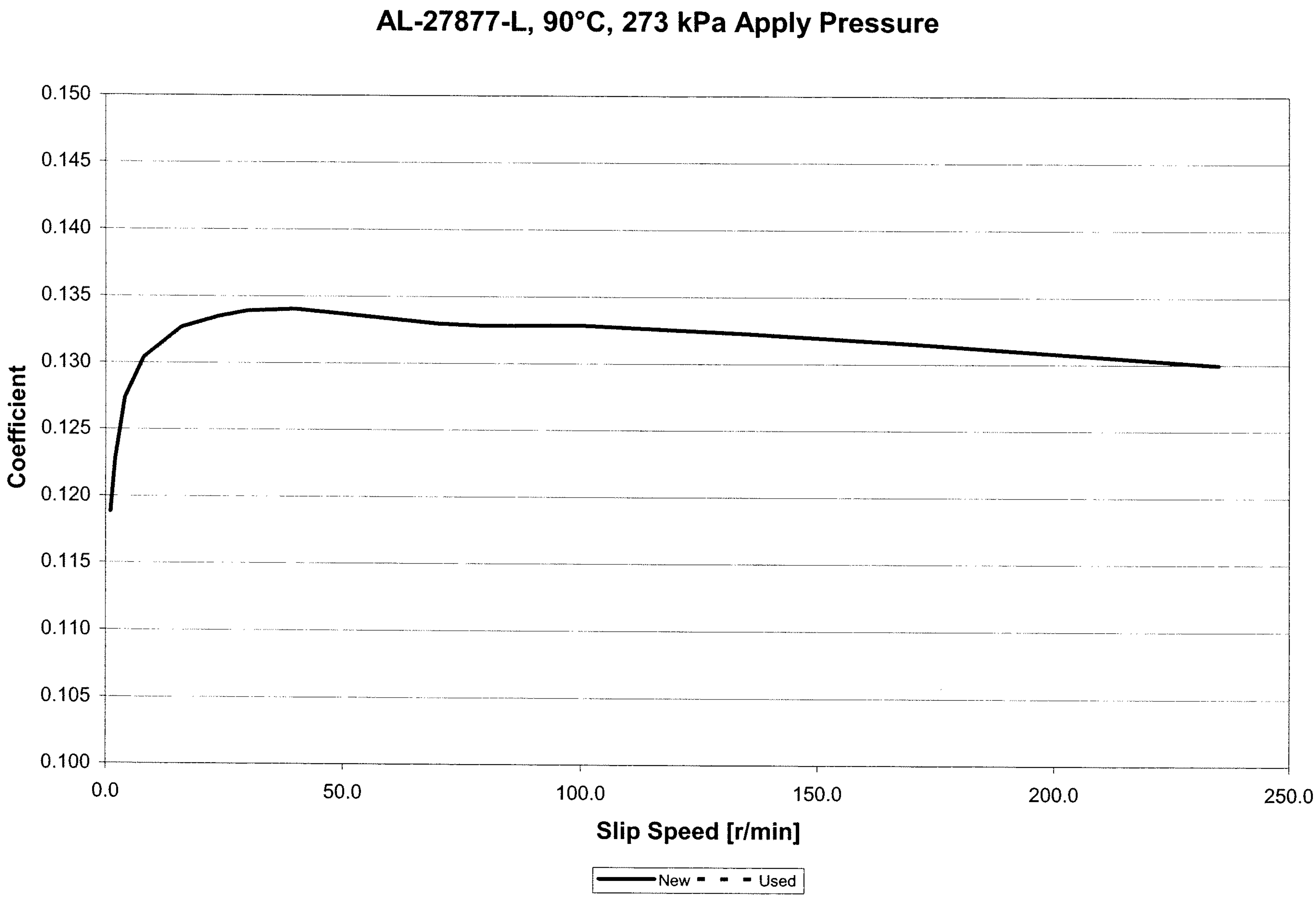


New Fluid Test Number: LS12-5-0374

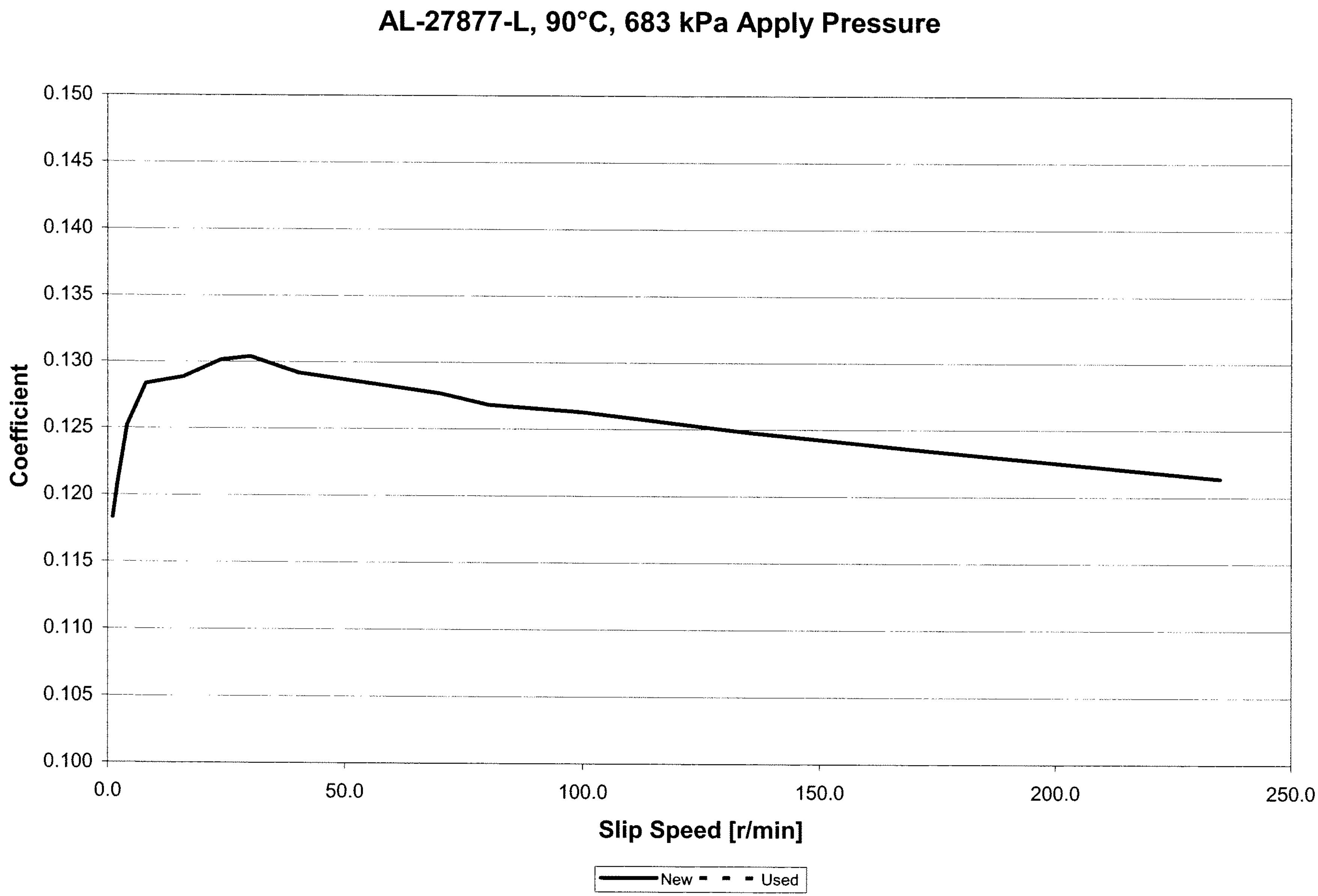
AL-27877-L, 40°C, 1044 kPa Apply Pressure



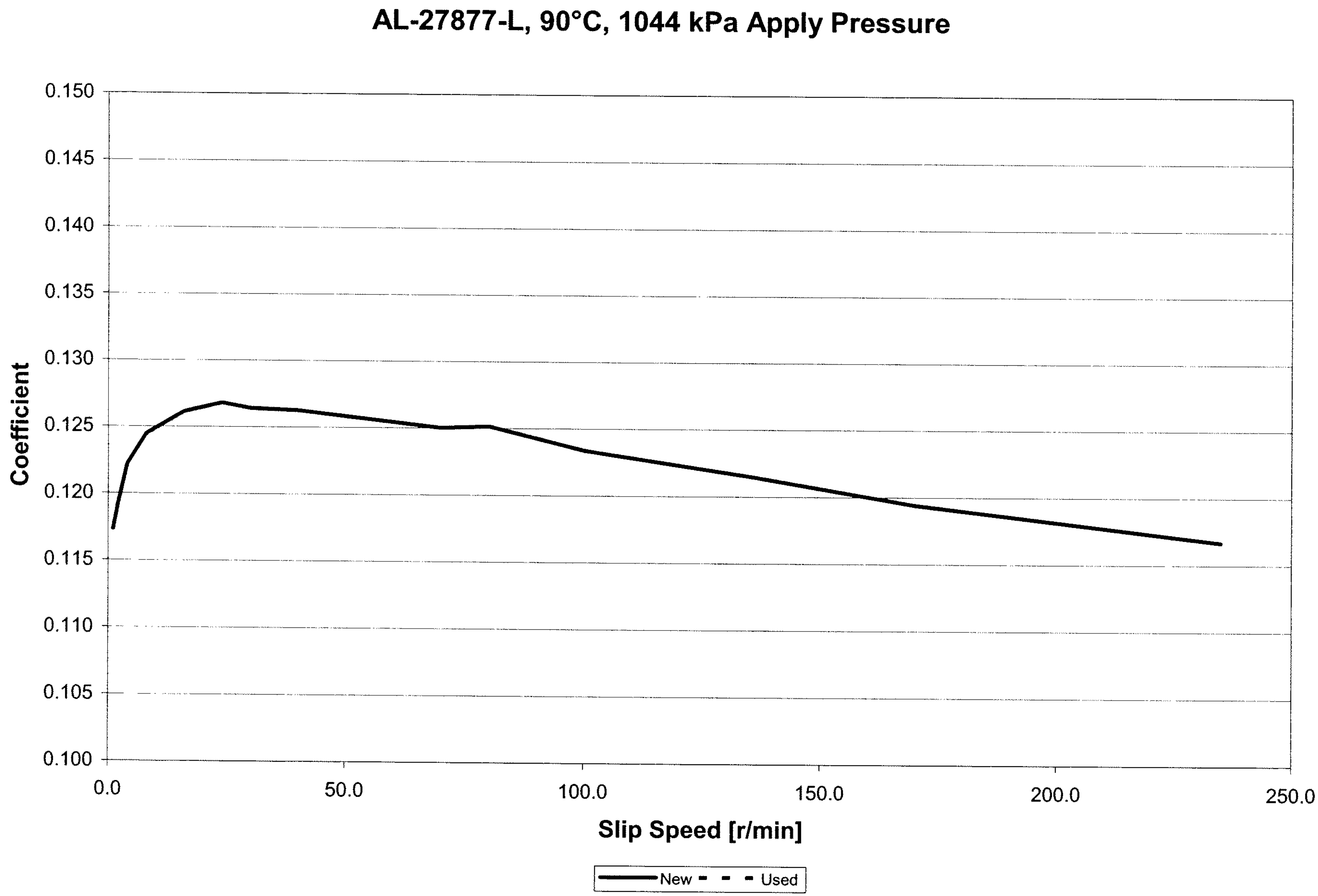
New Fluid Test Number: LS12-5-0374



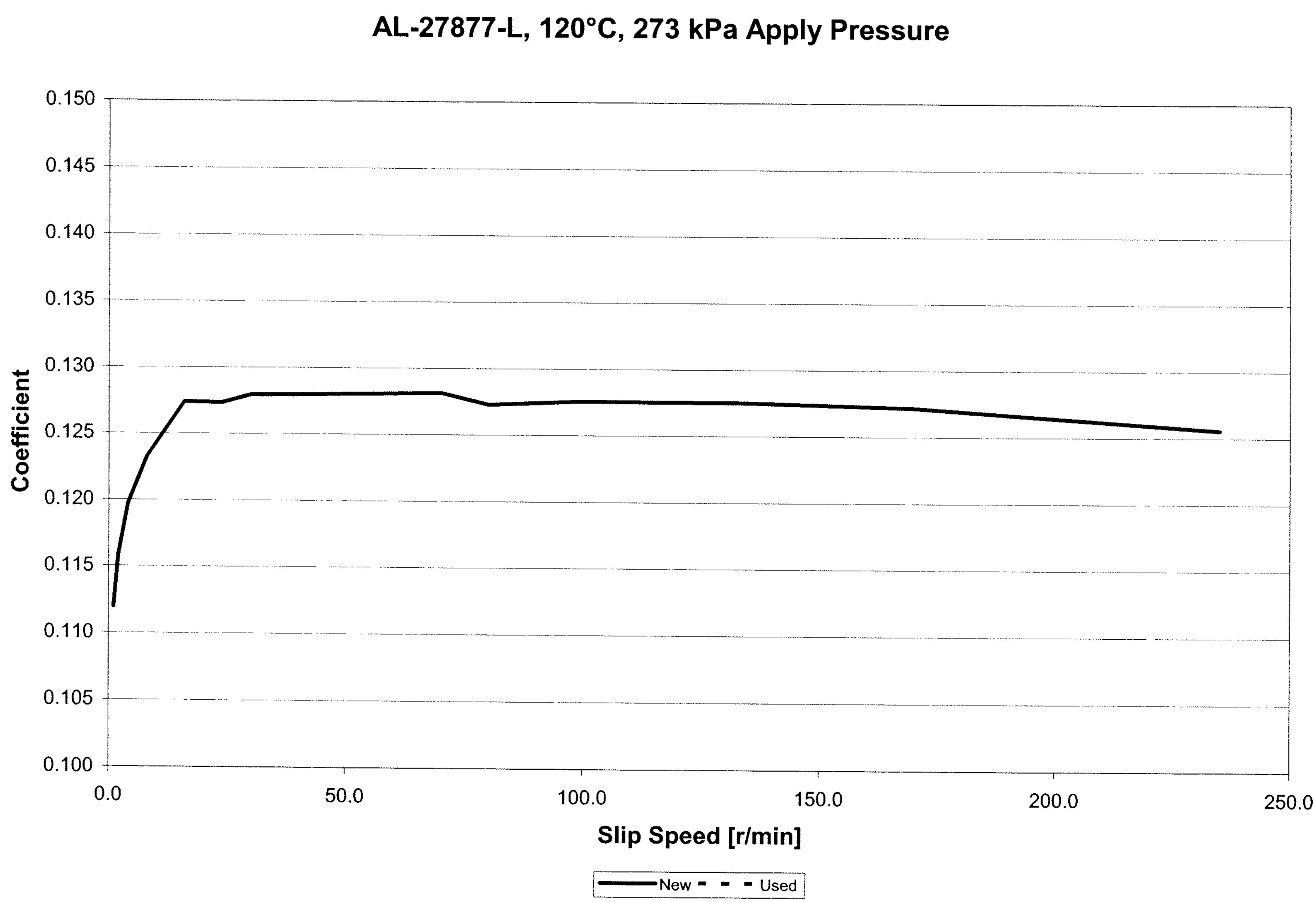
New Fluid Test Number: LS12-5-0374



New Fluid Test Number: LS12-5-0374



New Fluid Test Number: LS12-5-0374



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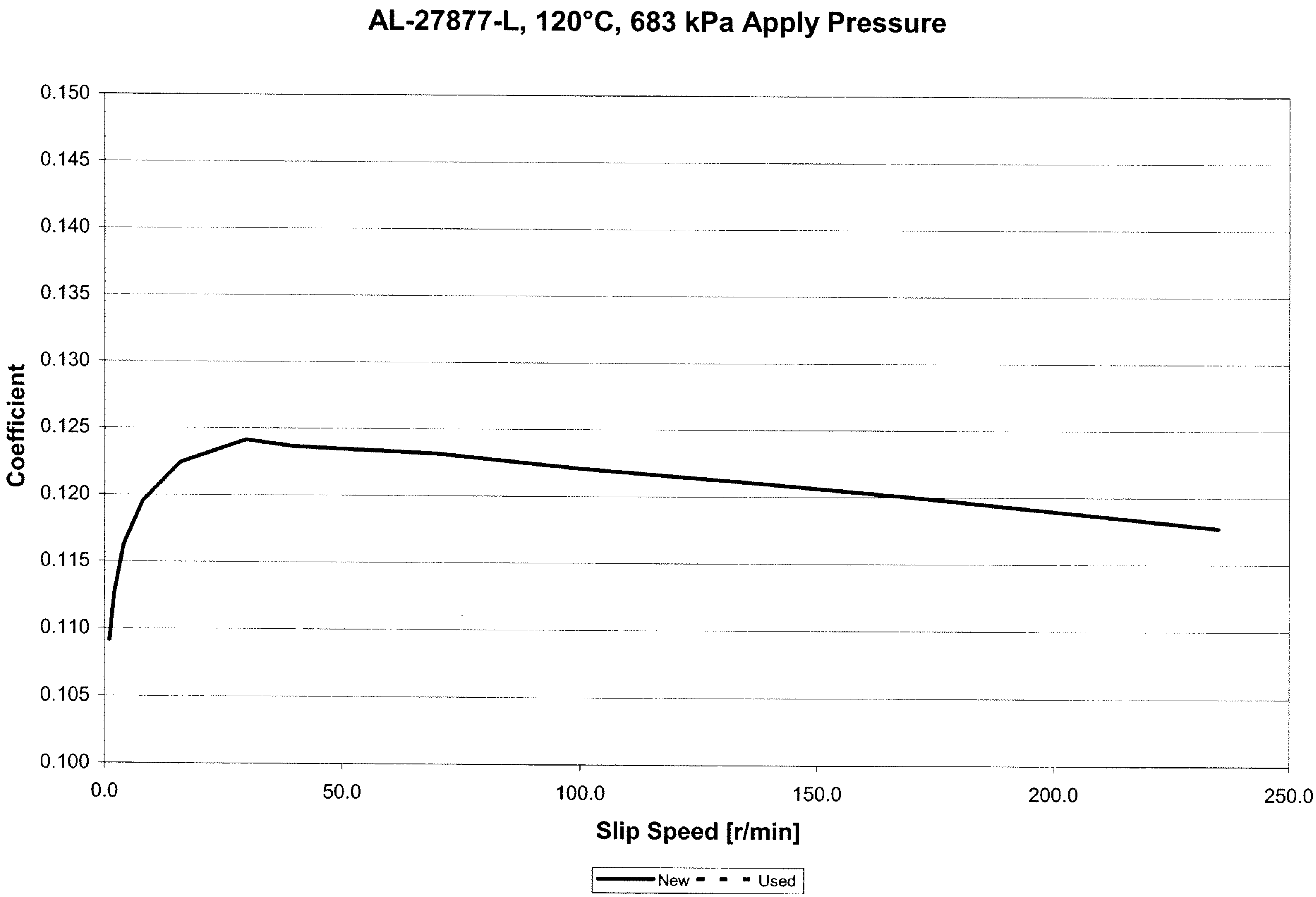

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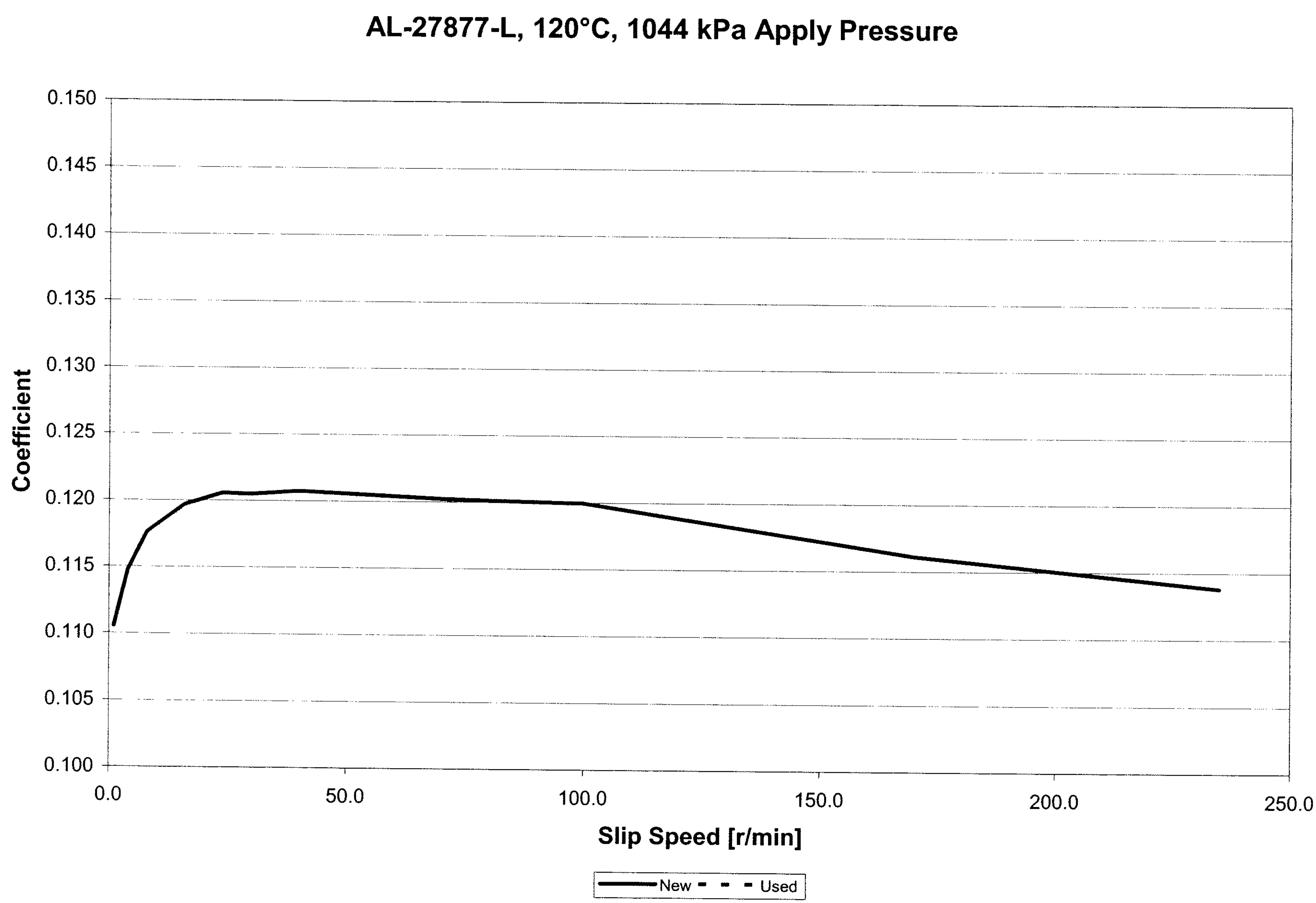


SOUTHWEST RESEARCH INSTITUTE®

GM LOW SPEED CLUTCH FRICTION AND TORQUE CAPACITY CHARACTERIZATION

Candidate Fluid: AL-27877-L | **Test Number : LS12-5-0374** | **Completion Date : 9/11/2007**

Lab Fluid Code : ATF-223703 | **Steel Plate Batch: 8-07 AXOD** | **Fric Plate Batch : 0505-001CARBON**

Plates	Location of Tooth (Clockwise)	Near Inner Diameter Before	Near Inner Diameter After	Near Outer Diameter Before	Near Outer Diameter After	Inner Diameter Change	Average Overall Change	Outer Diameter Change
FRICTION MATERIAL								
2	Top	1.7720	1.6800	1.7740	1.7080	0.0920		0.0660
	120	1.7600	1.6780	1.7590	1.7070	0.0820		0.0520
	240	1.7660	1.6690	1.7680	1.6970	0.0970		0.0710
	Average					0.0903	0.0767	0.0630
STEEL SEPARATORS								
1	Top	1.7450	1.7440	1.7460	1.7460	0.0010		0.0000
	120	1.7460	1.7460	1.7460	1.7460	0.0000		0.0000
	240	1.7460	1.7460	1.7450	1.7450	0.0000		0.0000
	Average					0.0003	0.0002	0.0000
3	Top	1.7330	1.7330	1.7330	1.7330	0.0000		0.0000
	120	1.7290	1.7290	1.7280	1.7280	0.0000		0.0000
	240	1.7270	1.7270	1.7280	1.7280	0.0000		0.0000
	Average					0.0000	0.0000	0.0000

PLATE CONDITION AT E.O.T.: PLATES IN GOOD CONDITION WITH NO UNUSUAL DISCOLORATION
(Anything Unusual)

Test Date: 9/11/2007

Operator's Name: JOE MARTINEZ

Reviewed By (Signature and Date)

9/19/07

Pack ID#: 4088

GM LVFA Version 1.0 April 30, 2002

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

Fuels And Lubricants Research Division

Report on

DEXRON® VI PLATE CLUTCH FRICTION TEST

Conducted For

SWRI ARMY LAB

Oil Code:
AL-27877-L

Test Number:
HC11-1-82

September 19, 2007

Submitted by:

Christopher Barker
Research Engineer
Specialty & Driveline Fluids Evaluation

DEXRON®-VI Plate Friction - 200 HOURS

Program Code: AL-27877-L
Status: *
Test Cycles: 36,000
Test Performance: *

Start Date: 9/11/2007
EOT Date: 9/19/2007
Run Number: HC11-1-82
EOT Parts Condition: *

Fiber Plates: GMPT-0506
Steel Plates: GMPT-0506
Delta Travel [mm]: 0.069 mm

Test Time [h]	Cycles	Stop Time [s]		Midpoint Torque [N·m]		End Torque [N·m]	Maximum Torque [N·m]		Max - Mid Torque [N·m]		Shift Energy [kJ]
		0.85	1.05	80	105	Report	> 90		< 30		15.4 - 16.0
0.1	10	1.06		81		75	82		1		15.5
1	180	0.95		90		102	112		22		15.6
2	360	0.92		95		104	114		19		15.7
3	540	0.92	Three	95	Three	99	112	Three	18	Three	15.7
4	720	0.92	Point	95	Point	101	110	Point	15	Point	15.7
5	900	0.91	Average	94	Average	99	109	Average	15	Average	15.7
10	1,800	0.95	0.94	91	92	97	104	104	13	13	15.8
15	2,700	0.95	0.95	91	91	92	101	100	10	8	15.7
20	3,600	0.95	0.96	93	91	81	95	95	2	4	15.7
25	4,500	0.99	0.98	90	90	73	90	91	0	0	15.7
30	5,400	1.00	1.00	88	88	71	87	88	-1	-1	15.7
35	6,300	1.01	1.01	87	88	70	86	87	-1	-1	15.7
40	7,200	1.01	1.01	87	87	70	87	87	0	-1	15.6
45	8,100	1.00	1.01	88	87	71	87	87	-1	0	15.6
50	9,000	1.01	1.01	87	87	70	88	87	0	0	15.7
55	9,900	1.01	1.01	87	87	71	86	86	-1	0	15.7
60	10,800	1.02	1.01	86	86	71	86	86	0	0	15.7
65	11,700	1.02	1.02	86	86	71	86	86	0	0	15.7
70	12,600	1.04	1.02	85	85	72	85	86	0	0	15.6
75	13,500	1.02	1.02	85	85	71	85	85	0	0	15.6
80	14,400	1.00	1.02	85	85	70	86	85	1	1	15.6
85	15,300	1.04	1.03	84	84	70	85	85	1	1	15.7
90	16,200	1.05	1.04	83	84	69	85	85	1	1	15.6
95	17,100	1.04	1.04	84	83	69	85	85	2	2	15.7
100	18,000	1.05	1.04	83	83	71	86	86	2	2	15.7

DEXRON®-VI Plate Friction - 200 HOURS

Program Code: AL-27877-L
Status: *
Test Cycles: 36,000
Test Performance: *

Start Date: 9/11/2007
EOT Date: 9/19/2007
Run Number: HC11-1-82
EOT Parts Condition: *

Fiber Plates: GMPT-0506
Steel Plates: GMPT-0506
Delta Travel [mm]: 0.069 mm

Test Time [h]	Cycles	Stop Time [s] 0.85	1.05	Midpoint Torque [N·m] 80	105	End Torque [N·m] Report	Maximum Torque [N·m] > 90		Max - Mid Torque [N·m] < 30		Shift Energy [kJ] 15.4 - 16.0
105	18,900	1.04	1.05	83	83	70	86	86	3	2	15.7
110	19,800	1.05	1.04	83	83	71	86	86	2	2	15.7
115	20,700	1.04	1.05	83	83	70	85	85	2	2	15.7
120	21,600	1.06	1.05	83	83	71	86	85	2	2	15.6
125	22,500	1.07	1.06	84	84	71	86	86	2	2	15.6
130	23,400	1.05	1.05	84	84	70	85	85	1	2	15.7
135	24,300	1.05	1.04	84	84	70	85	85	1	1	15.7
140	25,200	1.03	1.04	85	84	70	86	86	1	1	15.7
145	26,100	1.05	1.04	84	84	71	86	86	2	1	15.6
150	27,000	1.05	1.05	84	84	72	86	86	2	2	15.7
155	27,900	1.05	1.04	84	85	70	86	86	2	2	15.6
160	28,800	1.03	1.04	85	85	70	86	86	1	2	15.6
165	29,700	1.04	1.03	85	85	71	86	86	1	1	15.6
170	30,600	1.01	1.03	84	85	73	86	86	2	1	15.7
175	31,500	1.05	1.04	85	84	71	86	86	1	1	15.7
180	32,400	1.05	1.04	84	85	72	86	86	1	1	15.7
185	33,300	1.03	1.03	85	85	70	86	86	1	1	15.7
190	34,200	1.02	1.03	85	85	71	86	86	1	1	15.7
195	35,100	1.03	1.03	84	85	70	86	86	2	1	15.7
200	36,000	1.04	1.03	84	84	71	86	86	2	2	15.7

GM Plate Clutch Friction Test Summary

Southwest Research Institute®

Test Number:	HC11-1-82	Energy:	15.7 KJ	Fibers :	GMPT-0506	Start of Test:	9/11/2007
Fluid Code:	AL-27877-L	Temp.:	140.1 C	Steels :	GMPT-0506	End of Test :	9/19/2007
		Apply:	349 KPa	Air Flow:	50 ml/min	Delta Travel:	0.069 mm

Test Hour	Total Cycles	Engagement Time (Sec) (0.85 to 1.05)		Midpoint Torq.(Nm) (80-105)		Max-Mid Torq.(Nm) (<30)		End-Mid Torq.(Nm)		Maximum Torq.(Nm) (>90)		End Torq.(Nm) (Report)	Energy (KJ) (15.4 - 16.0)
			Three Point Average		Three Point Average		Three Point Average		Three Point Average		Three Point Average		
0	10	1.06		81		1		-6		82		75	15.5
1	180	0.95		90		22		12		112		102	15.6
2	360	0.92		95		19		9		114		104	15.7
3	540	0.92		95		18		4		112		99	15.7
4	720	0.92		95		15		6		110		101	15.7
5	900	0.91		94		15		5		109		99	15.7
10	1,800	0.95	0.94	91	92	13	13	6	4	104	104	97	15.8
15	2,700	0.95	0.95	91	91	10	8	1	-2	101	100	92	15.7
20	3,600	0.95	0.96	93	91	2	4	-12	-9	95	95	81	15.7
25	4,500	0.99	0.98	90	90	0	0	-17	-15	90	91	73	15.7
30	5,400	1.00	1.00	88	88	-1	-1	-17	-17	87	88	71	15.7
35	6,300	1.01	1.01	87	88	-1	-1	-17	-17	86	87	70	15.7
40	7,200	1.01	1.01	87	87	0	-1	-18	-17	87	87	70	15.6
45	8,100	1.00	1.01	88	87	-1	0	-17	-17	87	87	71	15.6
50	9,000	1.01	1.01	87	87	0	0	-17	-17	88	87	70	15.7
55	9,900	1.01	1.01	87	87	-1	0	-16	-16	86	86	71	15.7
60	10,800	1.02	1.01	86	86	0	0	-15	-15	86	86	71	15.7
65	11,700	1.02	1.02	86	86	0	0	-15	-14	86	86	71	15.7
70	12,600	1.04	1.02	85	85	0	0	-13	-14	85	86	72	15.6
75	13,500	1.02	1.02	85	85	0	0	-14	-14	85	85	71	15.6
80	14,400	1.00	1.02	85	85	1	1	-15	-14	86	85	70	15.6
85	15,300	1.04	1.03	84	84	1	1	-14	-14	85	85	70	15.7
90	16,200	1.05	1.04	83	84	1	1	-14	-14	85	85	69	15.6
95	17,100	1.04	1.04	84	83	2	2	-14	-14	85	85	69	15.7
100	18,000	1.05	1.04	83	83	2	2	-13	-13	86	86	71	15.7

GM Plate Clutch Friction Test Summary
Southwest Research Institute®

Test Number: HC11-1-82
Fluid Code: AL-27877-L

Energy: 15.7 KJ
Temp.: 140.1 C
Apply: 349 KPa

Fibers : GMPT-0506
Steels : GMPT-0506
Air Flow: 50 ml/min

Start of Test: 9/11/2007
End of Test : 9/19/2007
Delta Travel: 0.069 mm

Test Hour	Total Cycles	Engagement Time (Sec) (0.85 to 1.05)		Midpoint Torq.(Nm) (80-105)		Max-Mid Torq.(Nm) (<30)		End-Mid Torq.(Nm)		Maximum Torq.(Nm) (>90)		End Torq.(Nm) (Report)	Energy (KJ) (15.4 - 16.0)
105	18,900	1.04	1.05	83	83	3	2	-13	-12	86	86	70	15.7
110	19,800	1.05	1.04	83	83	2	2	-12	-13	86	86	71	15.7
115	20,700	1.04	1.05	83	83	2	2	-13	-13	85	85	70	15.7
120	21,600	1.06	1.05	83	83	2	2	-13	-13	86	85	71	15.6
125	22,500	1.07	1.06	84	84	2	2	-13	-13	86	86	71	15.6
130	23,400	1.05	1.05	84	84	1	2	-14	-14	85	85	70	15.7
135	24,300	1.05	1.04	84	84	1	1	-14	-14	85	85	70	15.7
140	25,200	1.03	1.04	85	84	1	1	-15	-14	86	86	70	15.7
145	26,100	1.05	1.04	84	84	2	1	-13	-14	86	86	71	15.6
150	27,000	1.05	1.05	84	84	2	2	-13	-13	86	86	72	15.7
155	27,900	1.05	1.04	84	85	2	2	-15	-14	86	86	70	15.6
160	28,800	1.03	1.04	85	85	1	2	-15	-15	86	86	70	15.6
165	29,700	1.04	1.03	85	85	1	1	-14	-14	86	86	71	15.6
170	30,600	1.01	1.03	84	85	2	1	-12	-13	86	86	73	15.7
175	31,500	1.05	1.04	85	84	1	1	-14	-13	86	86	71	15.7
180	32,400	1.05	1.04	84	85	1	1	-13	-14	86	86	72	15.7
185	33,300	1.03	1.03	85	85	1	1	-15	-14	86	86	70	15.7
190	34,200	1.02	1.03	85	85	1	1	-14	-14	86	86	71	15.7
195	35,100	1.03	1.03	84	85	2	1	-14	-14	86	86	70	15.7
200	36,000	1.04	1.03	84	84	2	2	-14	-14	86	86	71	15.7

Southwest Research Institute ®

DEXRON®VI Plate Friction Test Parts Condition Rating

Sponsor Code: AL-27877-L
Run Number: HC11-1-82
EOT Date: 09-19-2007
Cycles: 36,000
Hours: 200

Fiber Plates: The inner and outer facing areas are completely darkened with light/medium glazing and medium wear and heavy flaking.

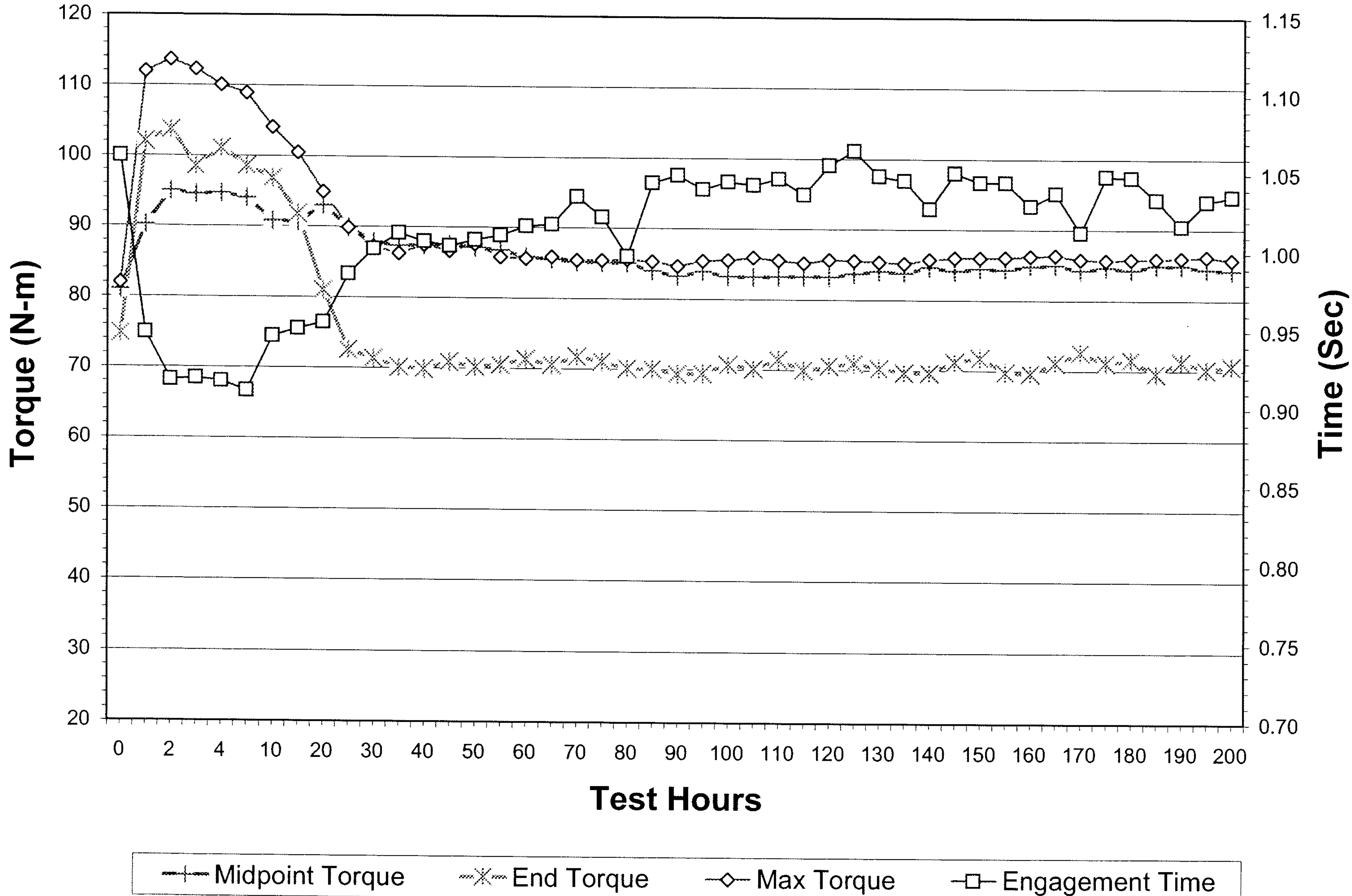
Steel Plates: Outer steels show light/medium heat discoloration and trace/light scratching and no hot spots. Inner steels show medium heat discoloration and light scratching and light wear and not hot spots.

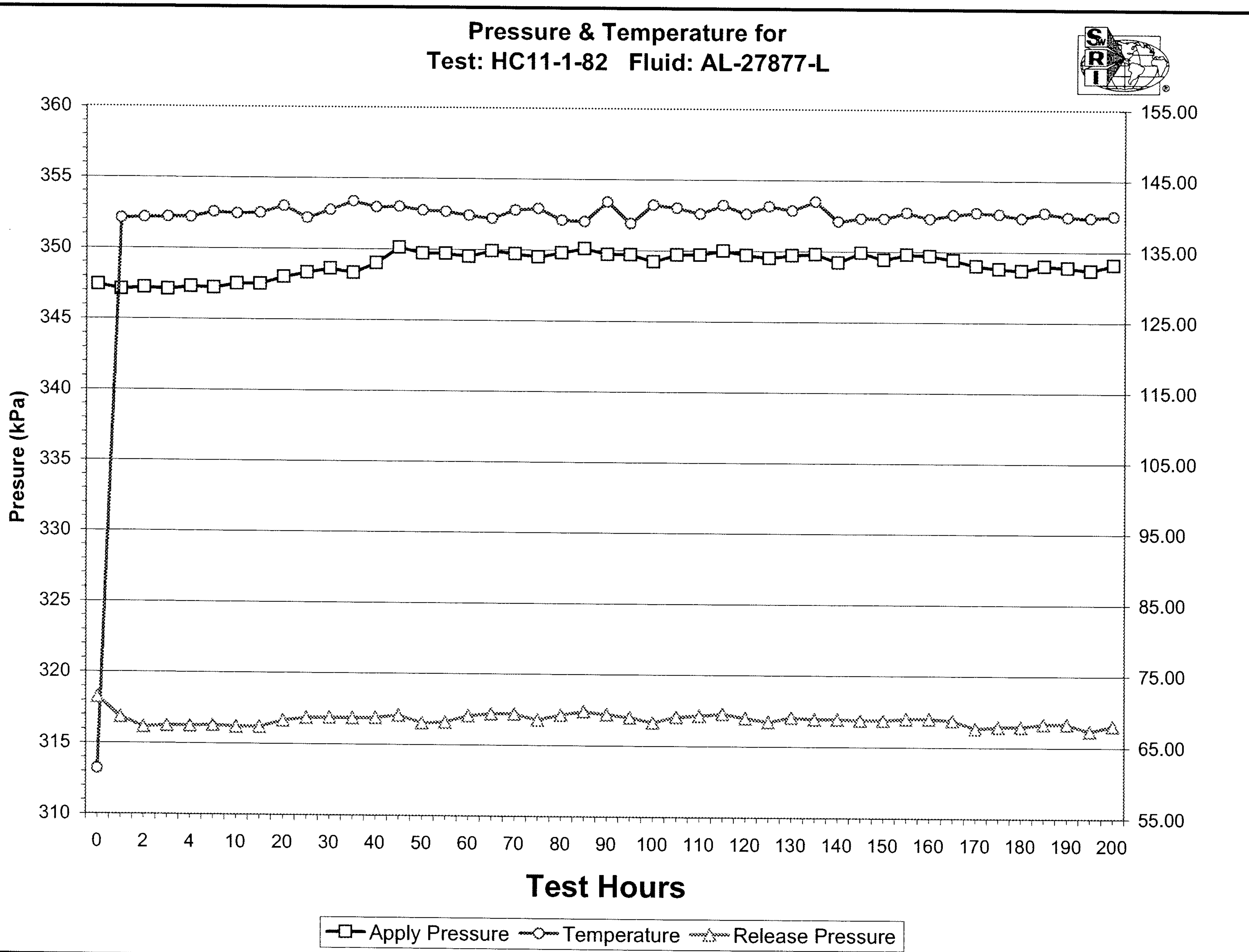
SwRI Rating: Fail

Rater: Art Sanchez
Date: 09-20-2007

Comments: This test was conducted using GMPT 0506 steel plates and GMPT 0506 fibers.

Fluid Performance Summary of
Test: HC11-1-82   Fluid: AL-27877-L





Pressure & Temperature for
Test: HC11-1-82 Fluid: AL-27877-L
Presure (kPa)
360
355
350
345
340
335
330
325
320
315
310
155.00
145.00
135.00
125.00
115.00
105.00
95.00
85.00
75.00
65.00
55.00
0 2 4 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
Test Hours
Apply Pressure
Temperature
Release Pressure

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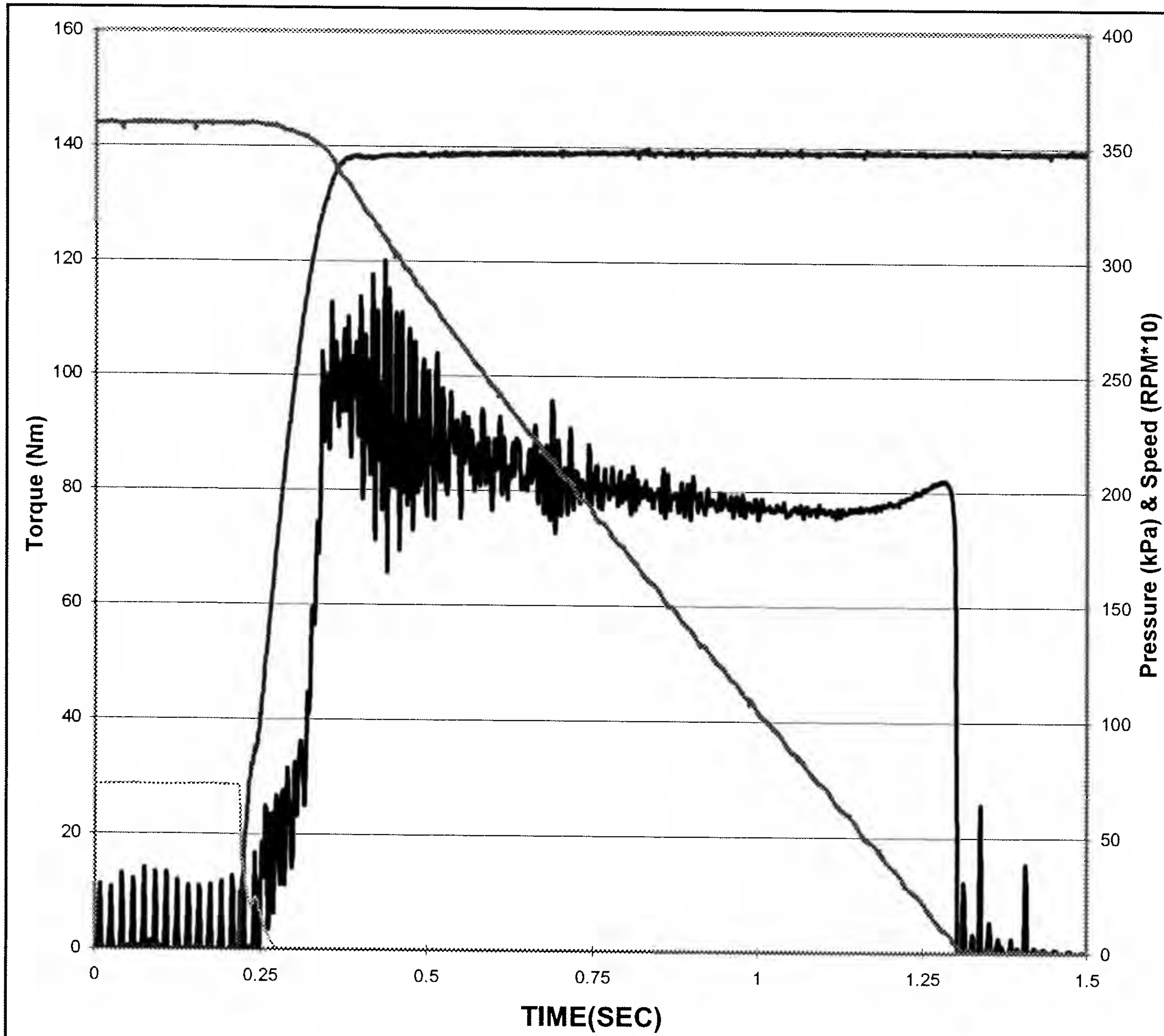

Date of Test:	9/11/2007
Time of Test:	14:10:54
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	0
Cycle Number:	10
Temperature:	61 °C *(134 - 146)*
Apply Pressure:	347 kPa *(340 - 350)*
Energy:	15.5 KJ *(15.4 - 16.0)*
Engage Time:	1.06 Sec *(0.85 - 1.05)*

Torque

Maximum:	82 N*m *(>90)*
Midpoint:	81 N*m *(80 - 105)*
Max - Mid:	1 N*m *(<30)*
End - Mid:	-6 N*m
End:	75 N*m *(Report)*

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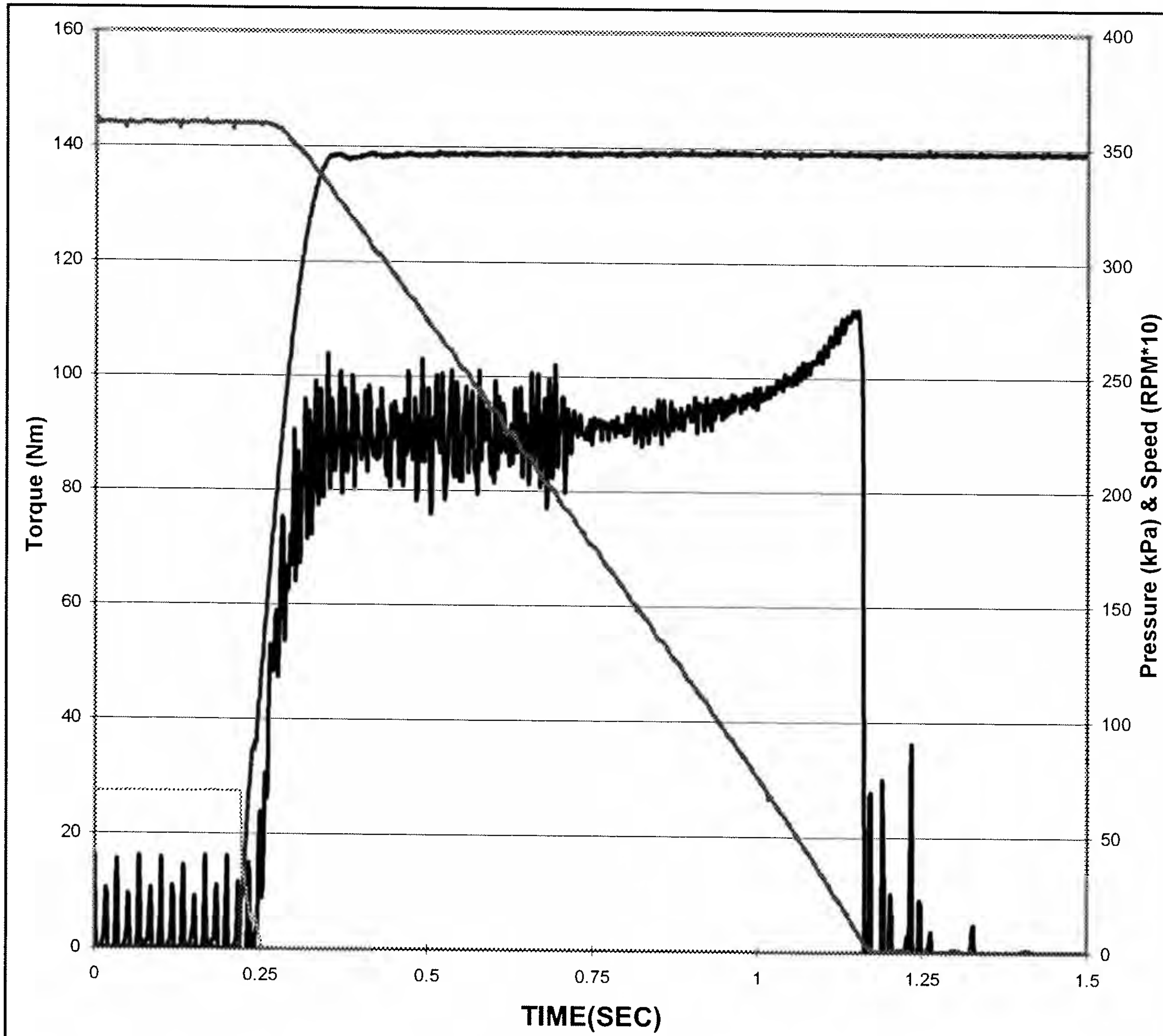

Date of Test:	9/11/2007
Time of Test:	15:07:34
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	1
Cycle Number:	180
Temperature:	139 °C *(134 - 146)*
Apply Pressure:	347 kPa *(340 - 350)*
Energy:	15.6 KJ *(15.4 - 16.0)*
Engage Time:	0.95 Sec *(0.85 - 1.05)*

Torque

Maximum:	112 N*m *(>90)*
Midpoint:	90 N*m *(80 - 105)*
Max - Mid:	22 N*m *(<30)*
End - Mid:	12 N*m
End:	102 N*m *(Report)*

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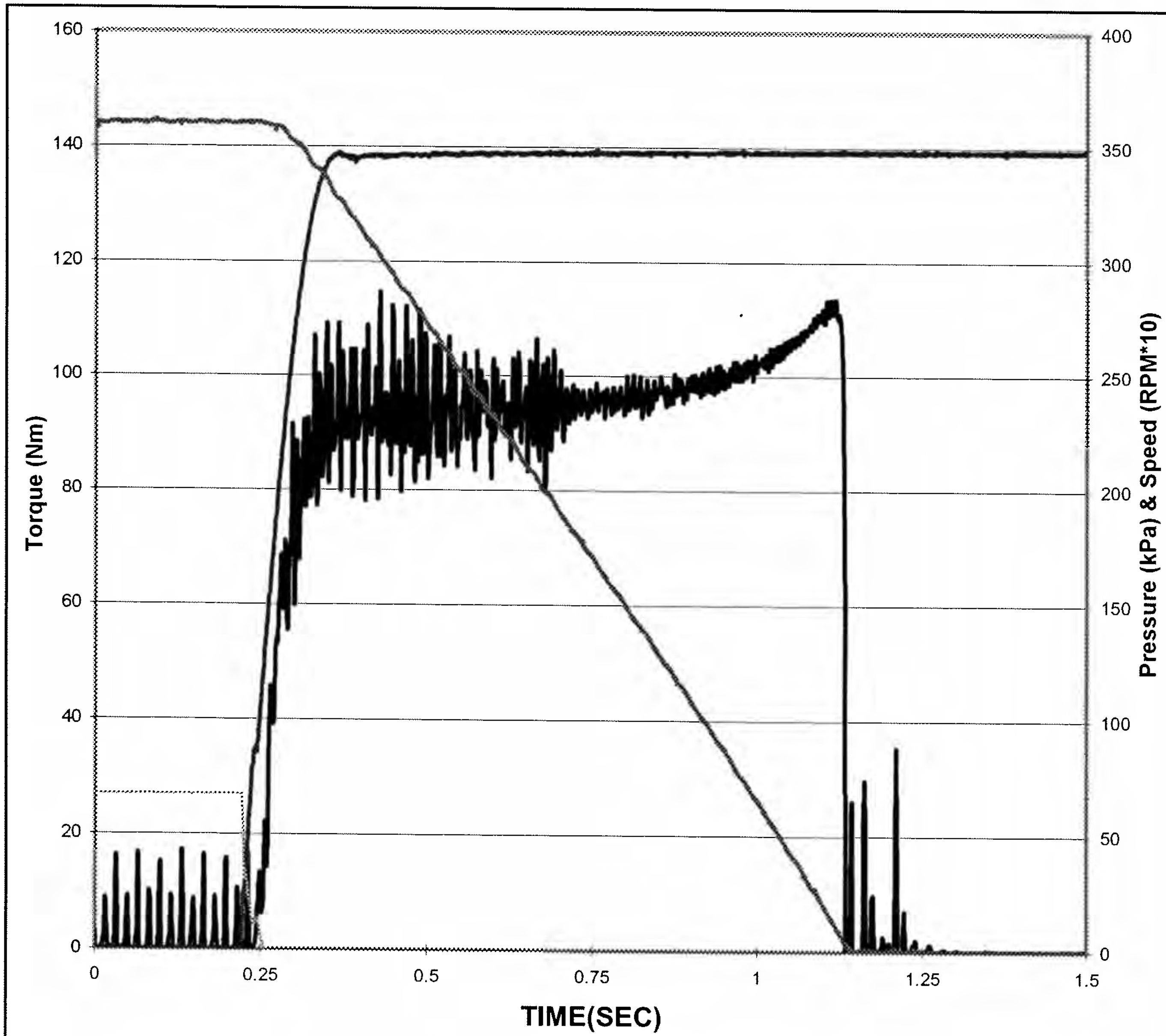

Date of Test:	9/11/2007
Time of Test:	16:07:34
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	2
Cycle Number:	360
Temperature:	139 °C *(134 - 146)*
Apply Pressure:	347 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	0.92 Sec *(0.85 - 1.05)*

Torque

Maximum:	114 N*m *(>90)*
Midpoint:	95 N*m *(80 - 105)*
Max - Mid:	19 N*m *(<30)*
End - Mid:	9 N*m
End:	104 N*m *(Report)*

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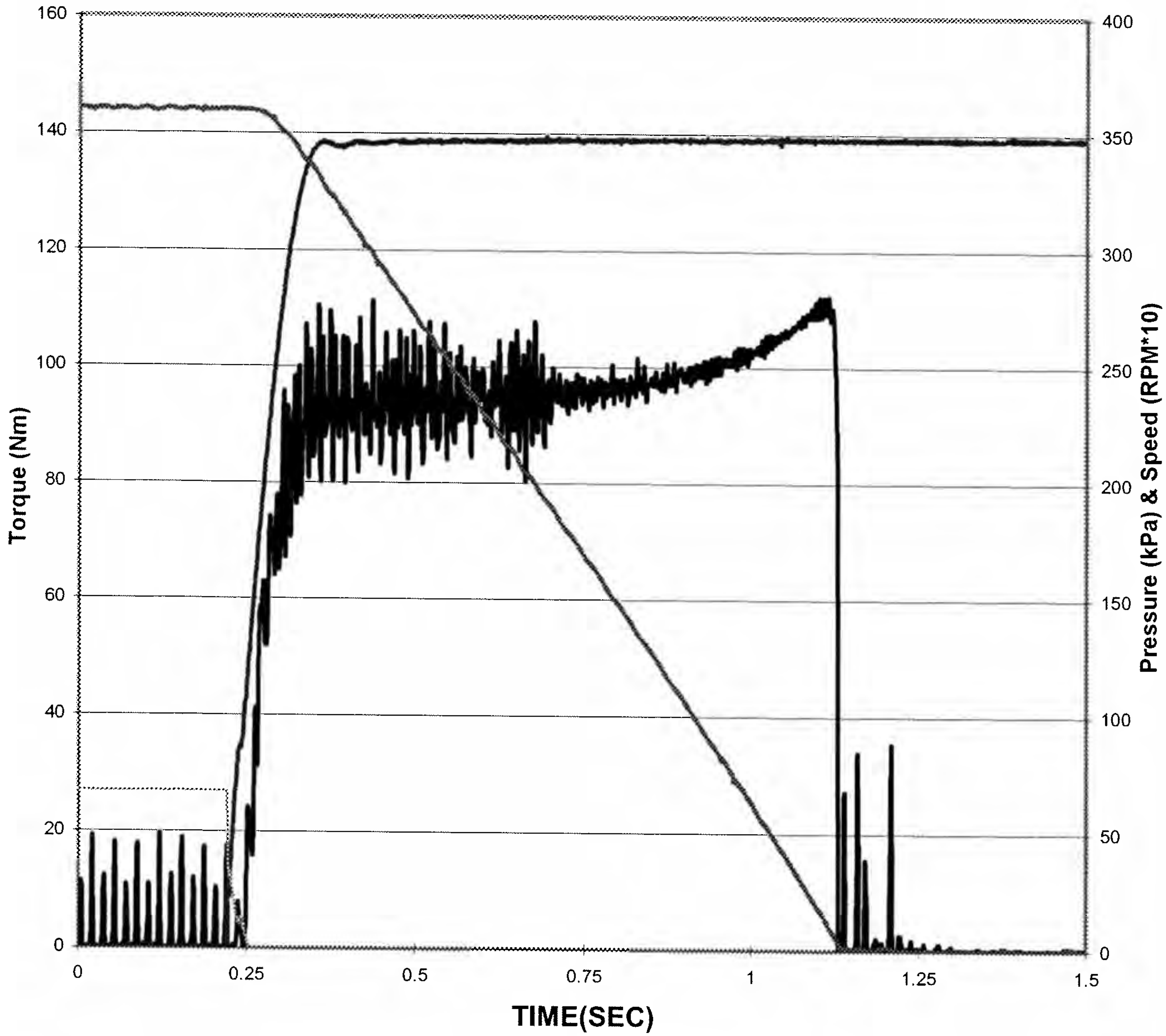

Date of Test:	9/11/2007
Time of Test:	17:07:34
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	3
Cycle Number:	540
Temperature:	139 °C
	(134 - 146)
Apply Pressure:	347 kPa
	(340 - 350)
Energy:	15.7 KJ
	(15.4 - 16.0)
Engage Time:	0.92 Sec
	(0.85 - 1.05)

Torque

Maximum:	112 N*m
	(>90)
Midpoint:	95 N*m
	(80 - 105)
Max - Mid:	18 N*m
	(<30)
End - Mid:	4 N*m
End:	99 N*m
	(Report)

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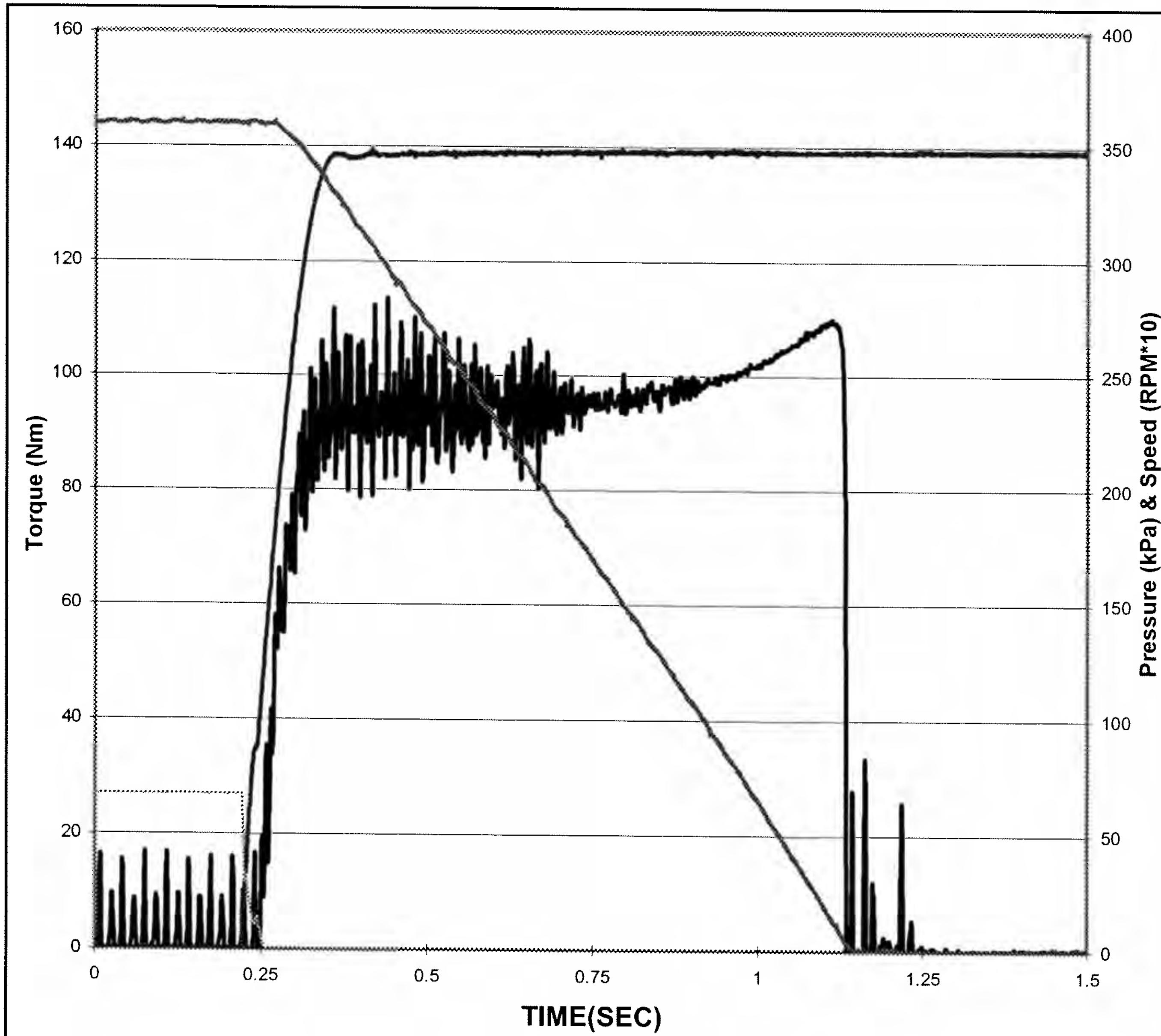

Date of Test:	9/11/2007
Time of Test:	18:07:34
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	4
Cycle Number:	720
Temperature:	139 °C *(134 - 146)*
Apply Pressure:	347 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	0.92 Sec *(0.85 - 1.05)*

Torque

Maximum:	110 N*m *(>90)*
Midpoint:	95 N*m *(80 - 105)*
Max - Mid:	15 N*m *(<30)*
End - Mid:	6 N*m
End:	101 N*m *(Report)*

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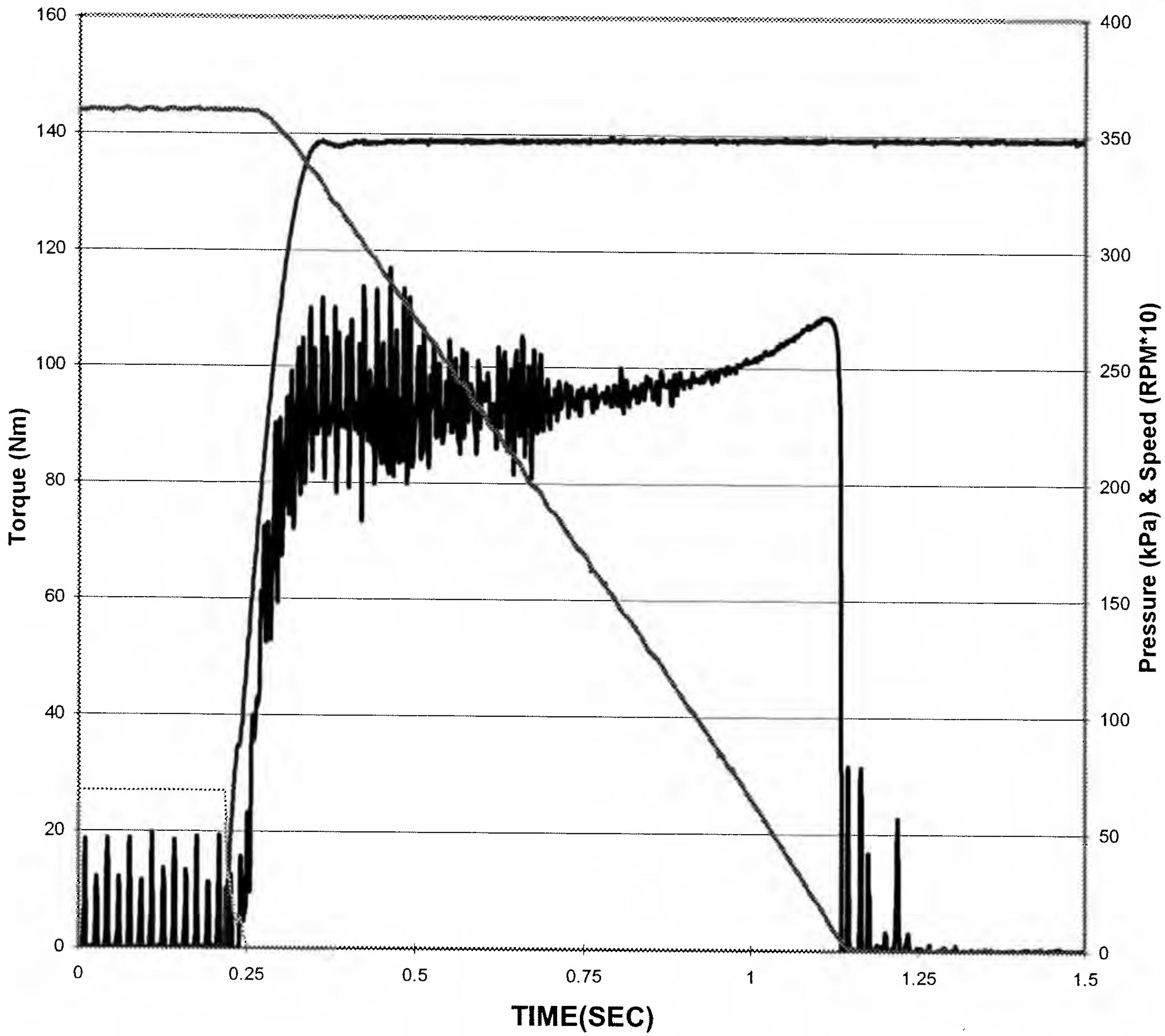

Date of Test:	9/11/2007
Time of Test:	19:07:34
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	5
Cycle Number:	900
Temperature:	140 °C
	(134 - 146)
Apply Pressure:	347 kPa
	(340 - 350)
Energy:	15.7 KJ
	(15.4 - 16.0)
Engage Time:	0.91 Sec
	(0.85 - 1.05)

Torque

Maximum:	109 N*m
	(>90)
Midpoint:	94 N*m
	(80 - 105)
Max - Mid:	15 N*m
	(<30)
End - Mid:	5 N*m
End:	99 N*m
	(Report)

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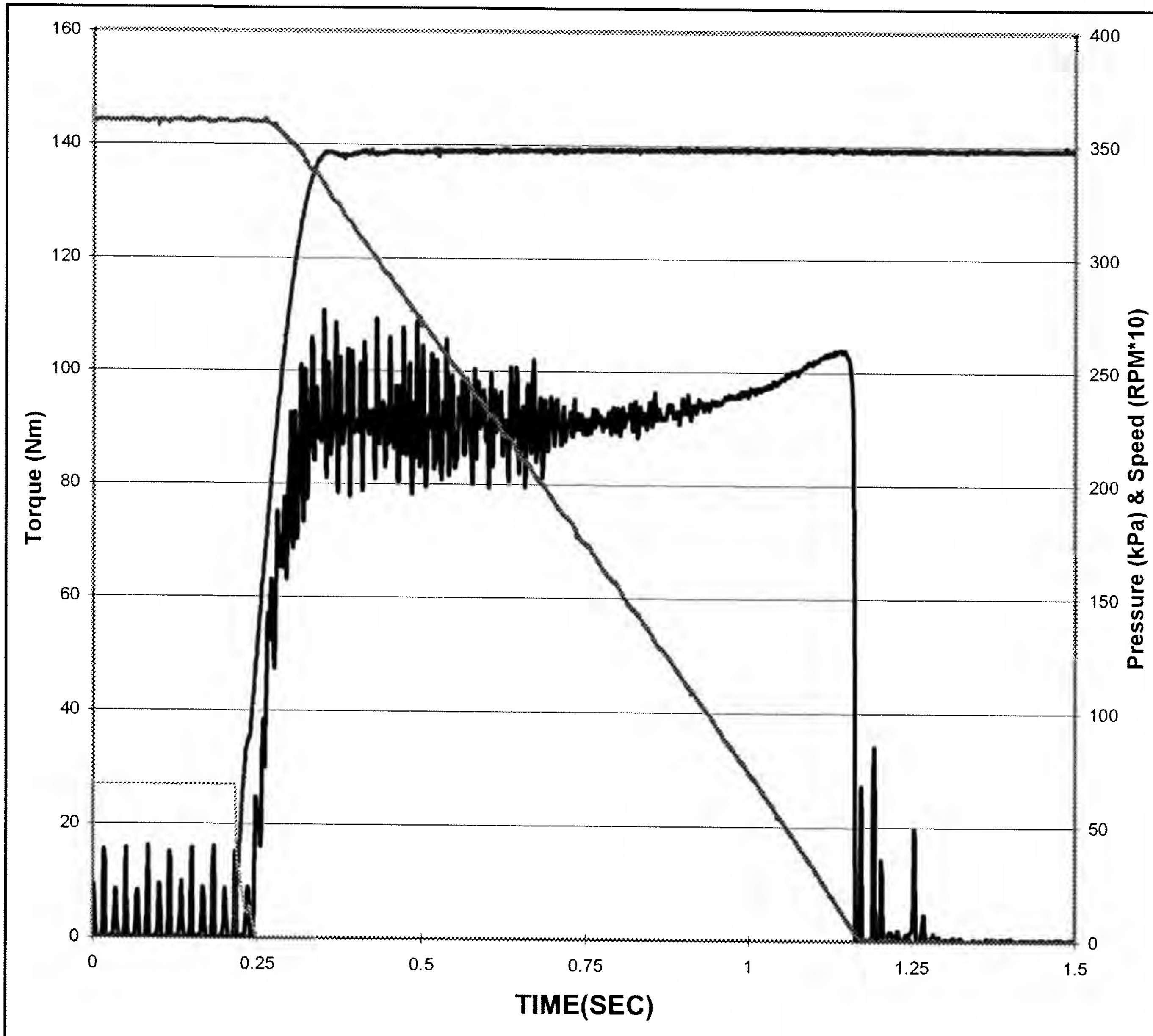

Date of Test:	9/12/2007
Time of Test:	0:07:35
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	10
Cycle Number:	1800
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	348 kPa *(340 - 350)*
Energy:	15.8 KJ *(15.4 - 16.0)*
Engage Time:	0.95 Sec *(0.85 - 1.05)*

Torque

Maximum:	104 N*m *(>90)*
Midpoint:	91 N*m *(80 - 105)*
Max - Mid:	13 N*m *(<30)*
End - Mid:	6 N*m
End:	97 N*m *(Report)*

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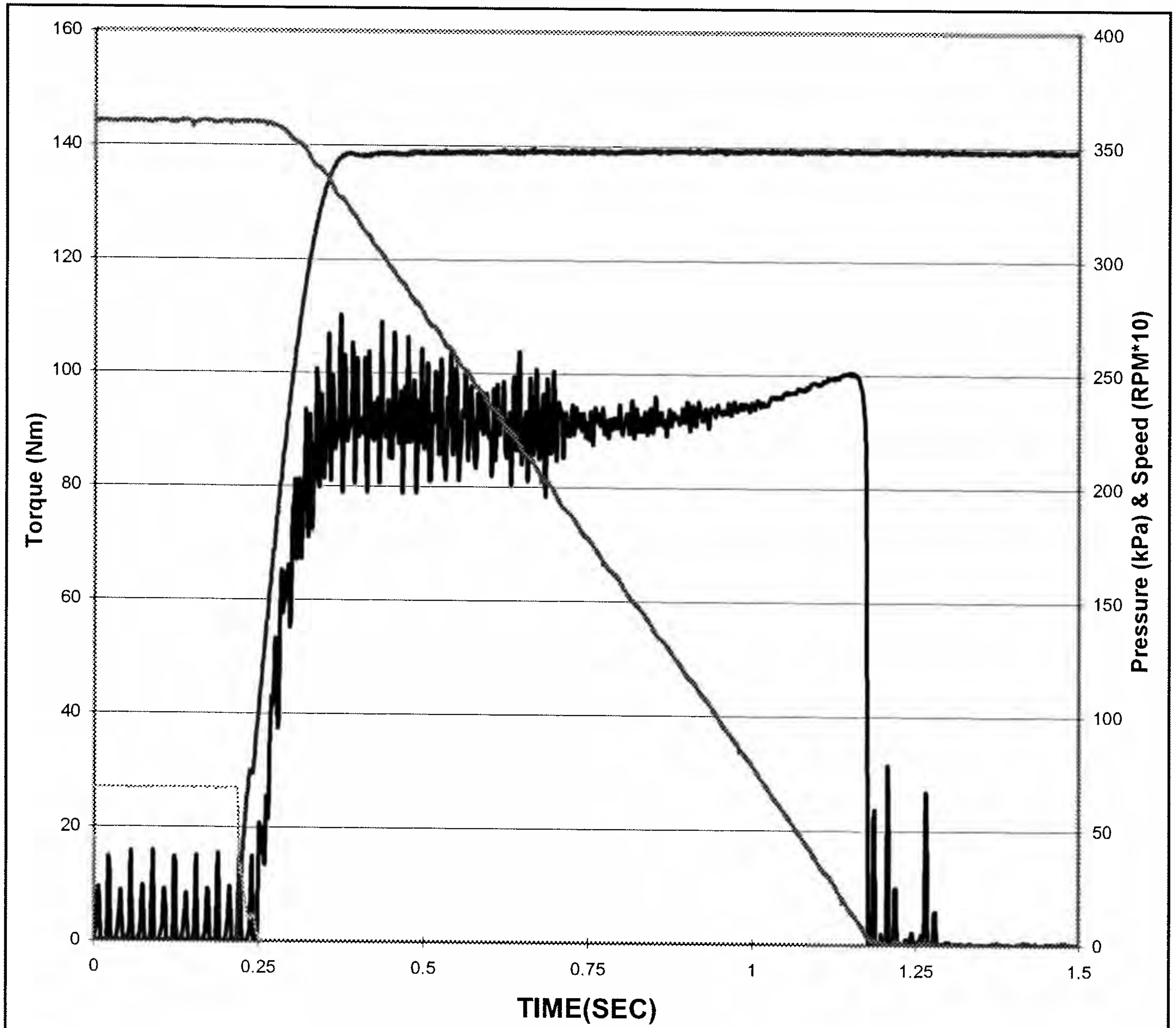

Date of Test:	9/12/2007
Time of Test:	5:07:36
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	15
Cycle Number:	2700
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	348 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	0.95 Sec *(0.85 - 1.05)*

Torque

Maximum:	101 N*m *(>90)*
Midpoint:	91 N*m *(80 - 105)*
Max - Mid:	10 N*m *(<30)*
End - Mid:	1 N*m
End:	92 N*m *(Report)*

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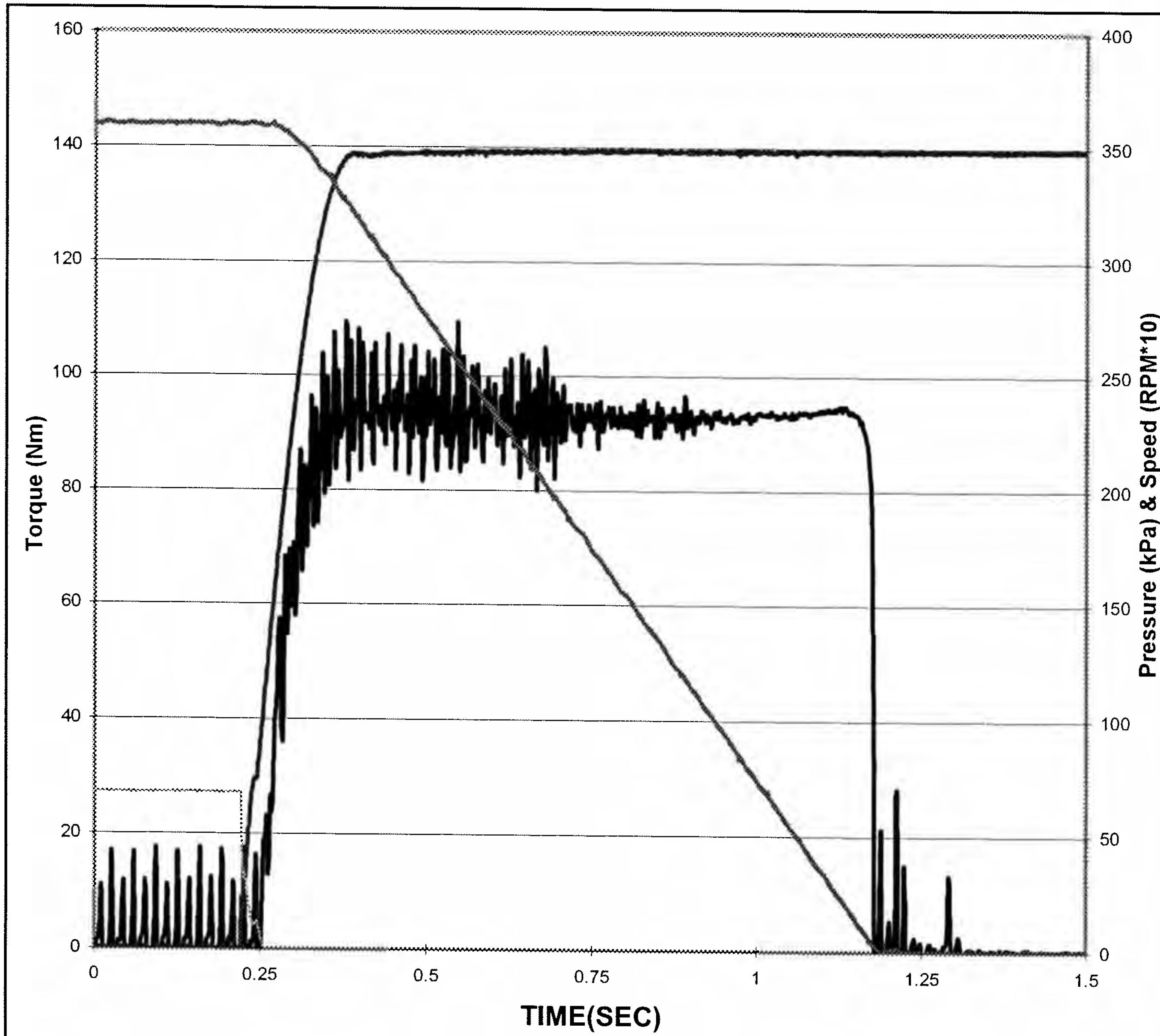

Date of Test:	**9/12/2007**
Time of Test:	**10:07:37**
Test Type:	**PLATE**
Test Number:	**HC11-1-82**
Fluid Code:	**AL-27877-L**
Hour Number:	**20**
Cycle Number:	**3600**
Temperature:	**141 °C**
	(134 - 146)
Apply Pressure:	**348 kPa**
	(340 - 350)
Energy:	**15.7 KJ**
	(15.4 - 16.0)
Engage Time:	**0.95 Sec**
	(0.85 - 1.05)

Torque

Maximum:	**95 N*m**
	(>90)
Midpoint:	**93 N*m**
	(80 - 105)
Max - Mid:	**2 N*m**
	(<30)
End - Mid:	**-12 N*m**
End:	**81 N*m**
	(Report)

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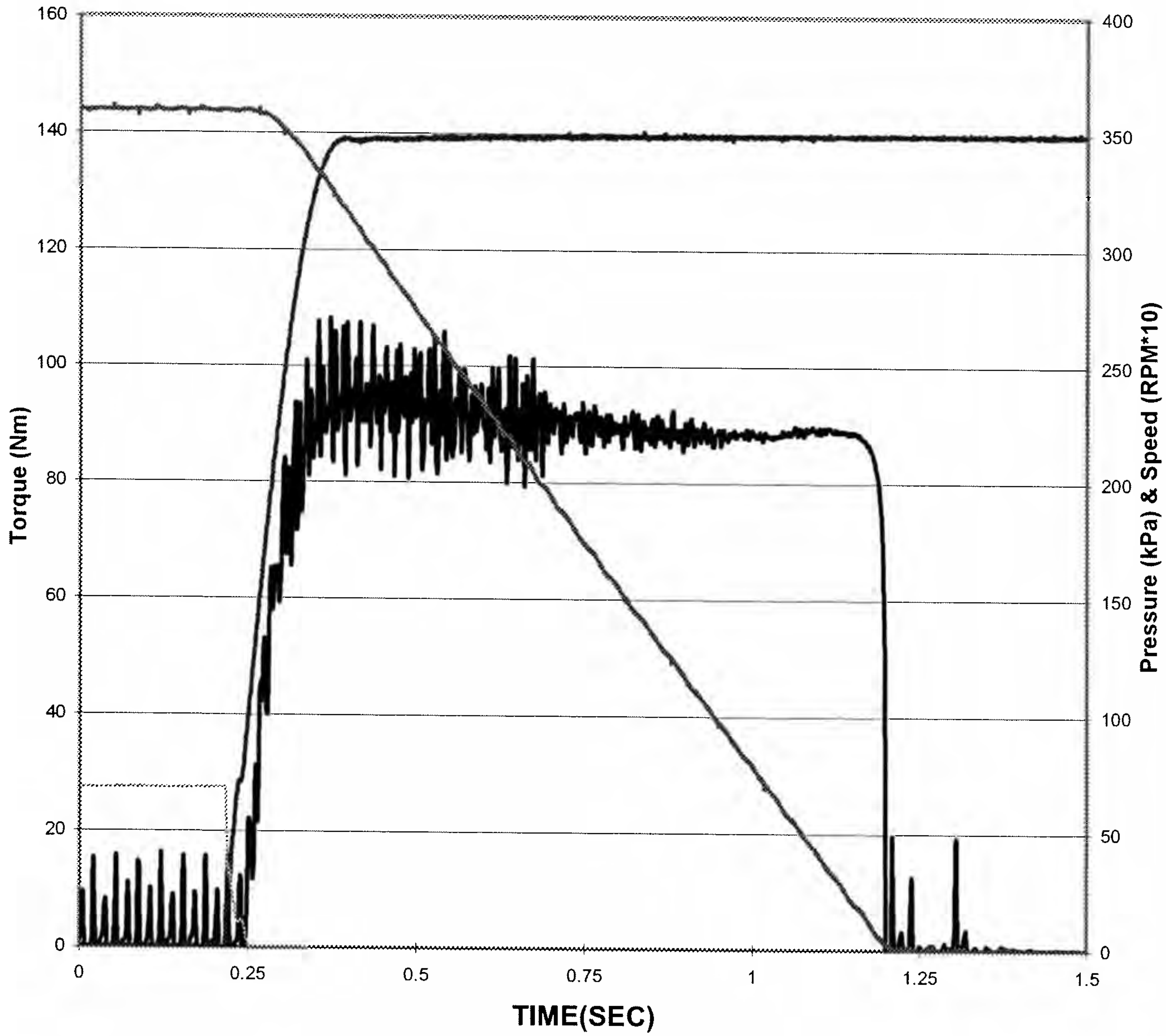

Date of Test:	9/12/2007
Time of Test:	15:07:38
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	25
Cycle Number:	4500
Temperature:	139 °C *(134 - 146)*
Apply Pressure:	348 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	0.99 Sec *(0.85 - 1.05)*

Torque

Maximum:	90 N*m *(>90)*
Midpoint:	90 N*m *(80 - 105)*
Max - Mid:	0 N*m *(<30)*
End - Mid:	-17 N*m
End:	73 N*m *(Report)*

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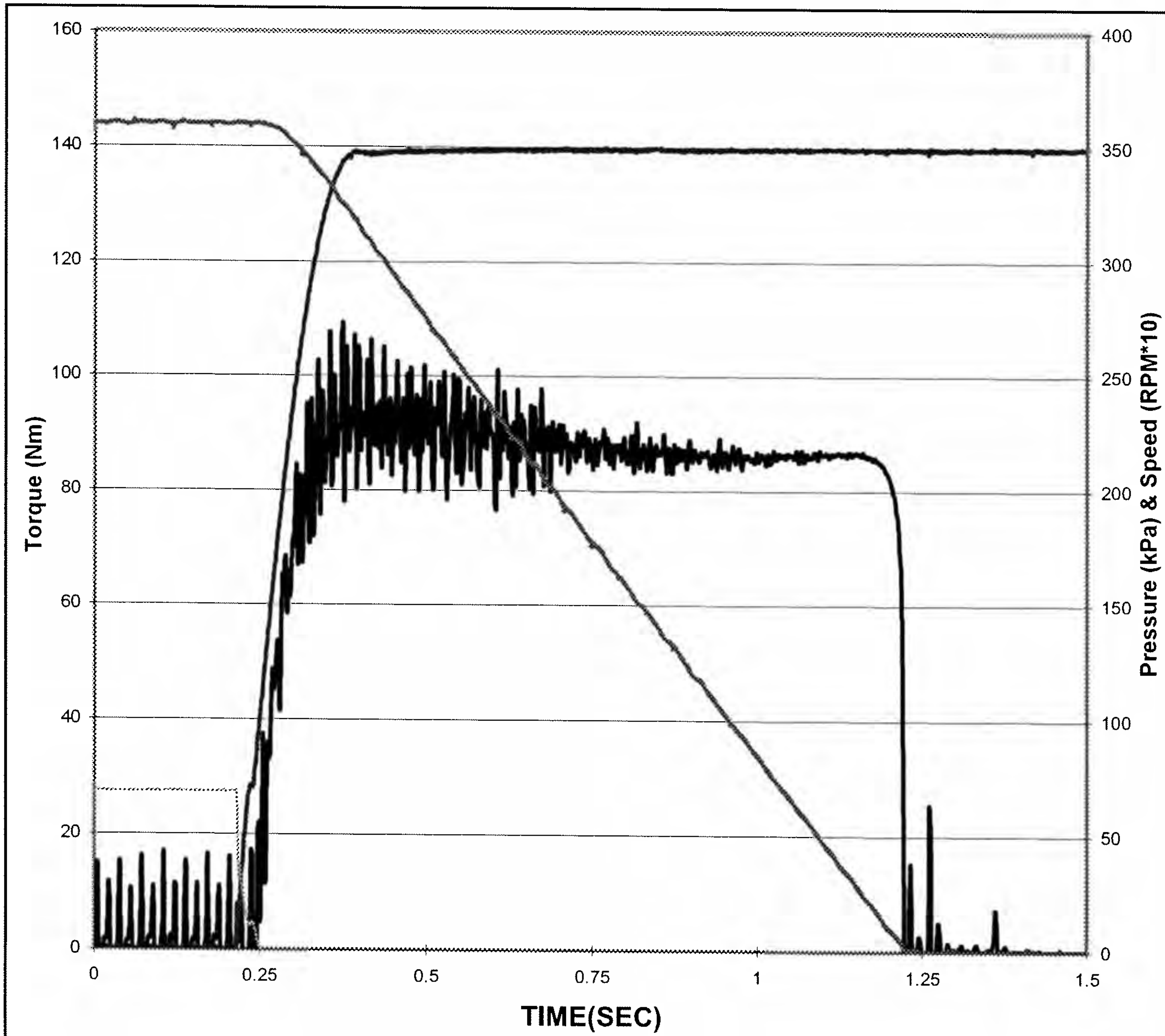

Date of Test:	9/12/2007
Time of Test:	20:07:39
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	30
Cycle Number:	5400
Temperature:	141 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.00 Sec *(0.85 - 1.05)*

Torque

Maximum:	87 N*m *(>90)*
Midpoint:	88 N*m *(80 - 105)*
Max - Mid:	-1 N*m *(<30)*
End - Mid:	-17 N*m
End:	71 N*m *(Report)*

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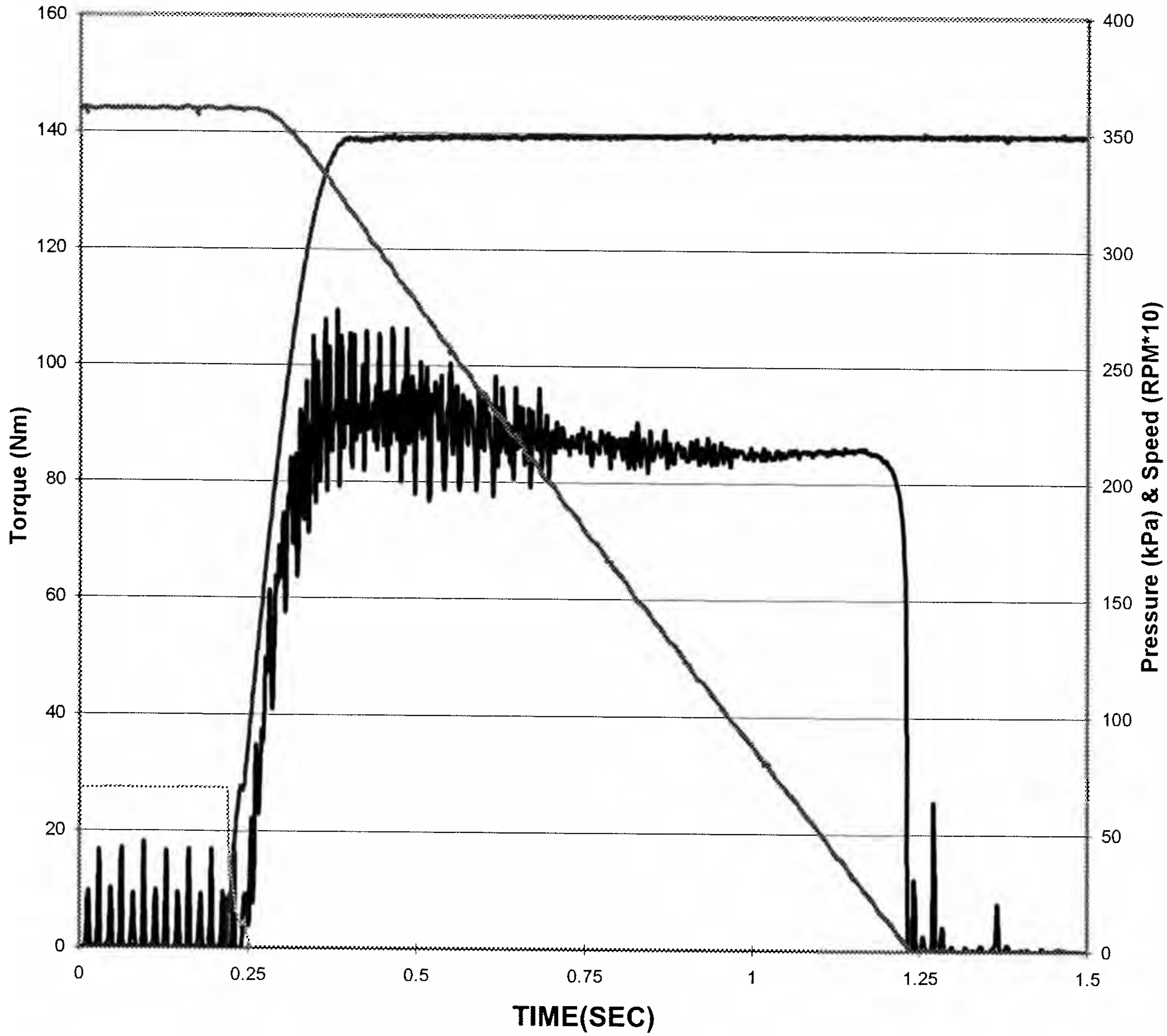

Date of Test:	9/13/2007
Time of Test:	1:07:40
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	35
Cycle Number:	6300
Temperature:	142 °C *(134 - 146)*
Apply Pressure:	348 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.01 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	87 N*m *(80 - 105)*
Max - Mid:	-1 N*m *(<30)*
End - Mid:	-17 N*m
End:	70 N*m *(Report)*

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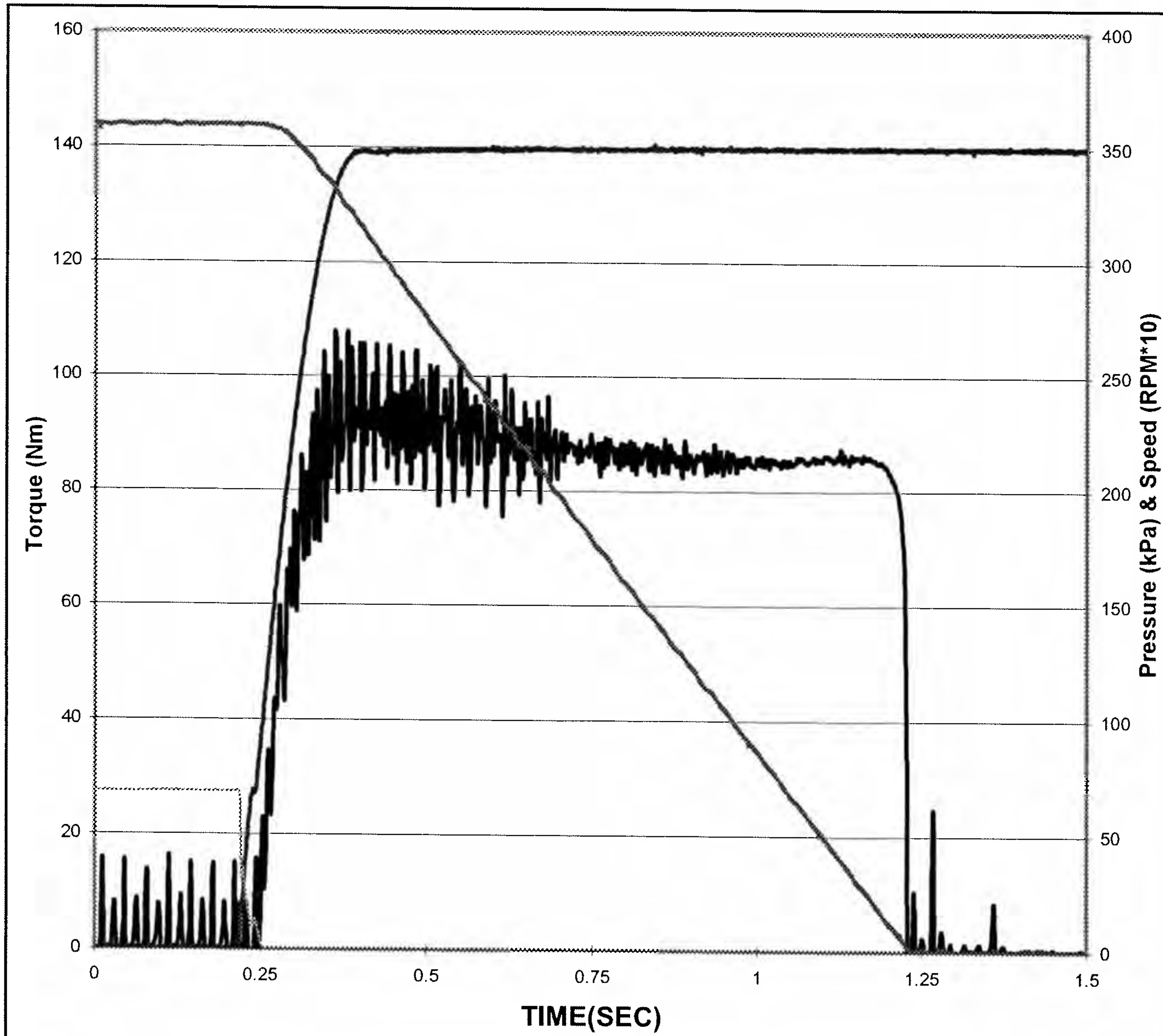

Date of Test:	9/13/2007
Time of Test:	6:07:40
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	40
Cycle Number:	7200
Temperature:	141 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.6 KJ *(15.4 - 16.0)*
Engage Time:	1.01 Sec *(0.85 - 1.05)*

Torque

Maximum:	87 N*m *(>90)*
Midpoint:	87 N*m *(80 - 105)*
Max - Mid:	0 N*m *(<30)*
End - Mid:	-18 N*m
End:	70 N*m *(Report)*

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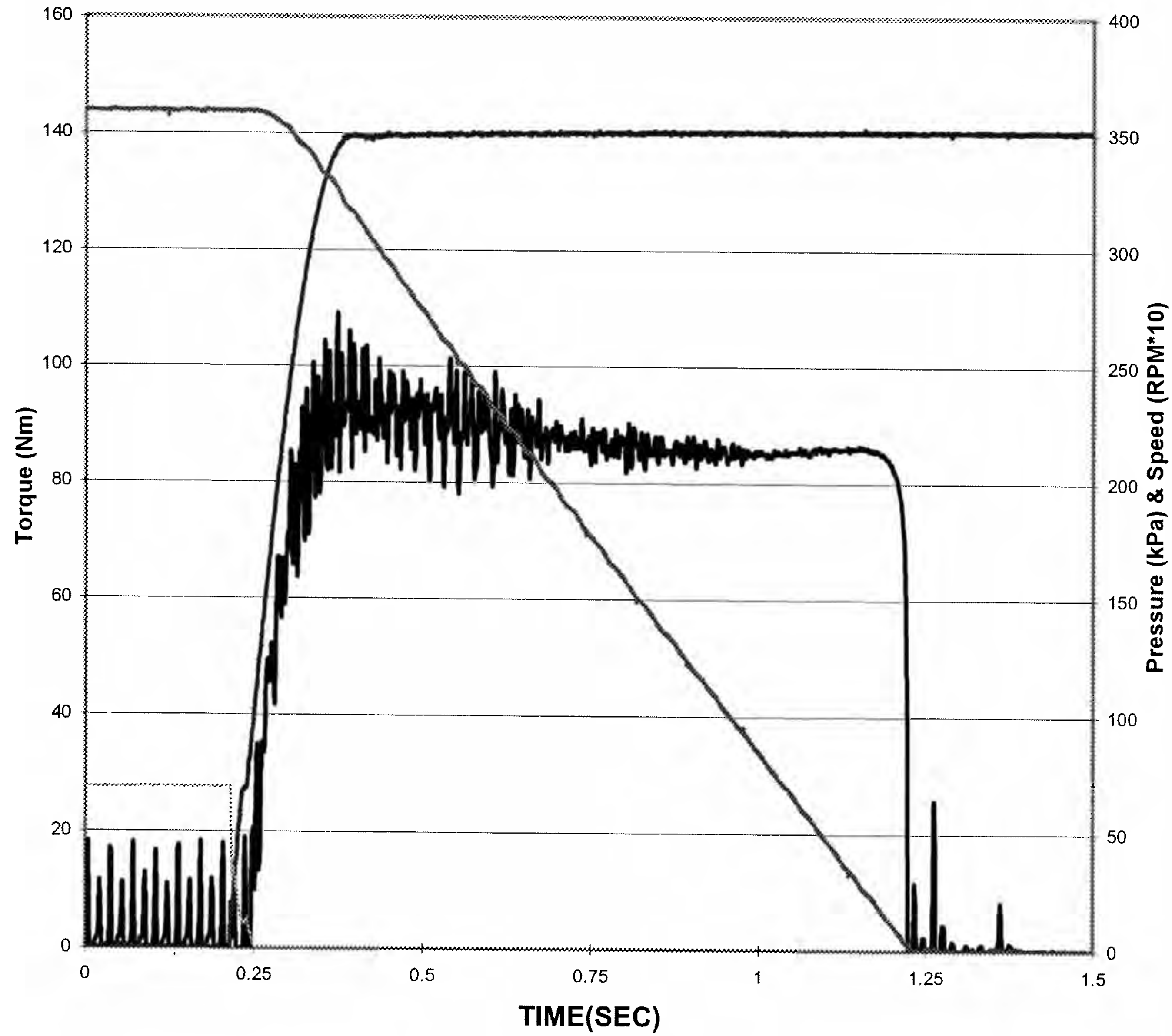

Date of Test:	9/13/2007
Time of Test:	11:07:41
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	45
Cycle Number:	8100
Temperature:	141 °C
	(134 - 146)
Apply Pressure:	350 kPa
	(340 - 350)
Energy:	15.6 KJ
	(15.4 - 16.0)
Engage Time:	1.00 Sec
	(0.85 - 1.05)

Torque

Maximum:	87 N*m
	(>90)
Midpoint:	88 N*m
	(80 - 105)
Max - Mid:	-1 N*m
	(<30)
End - Mid:	-17 N*m
End:	71 N*m
	(Report)

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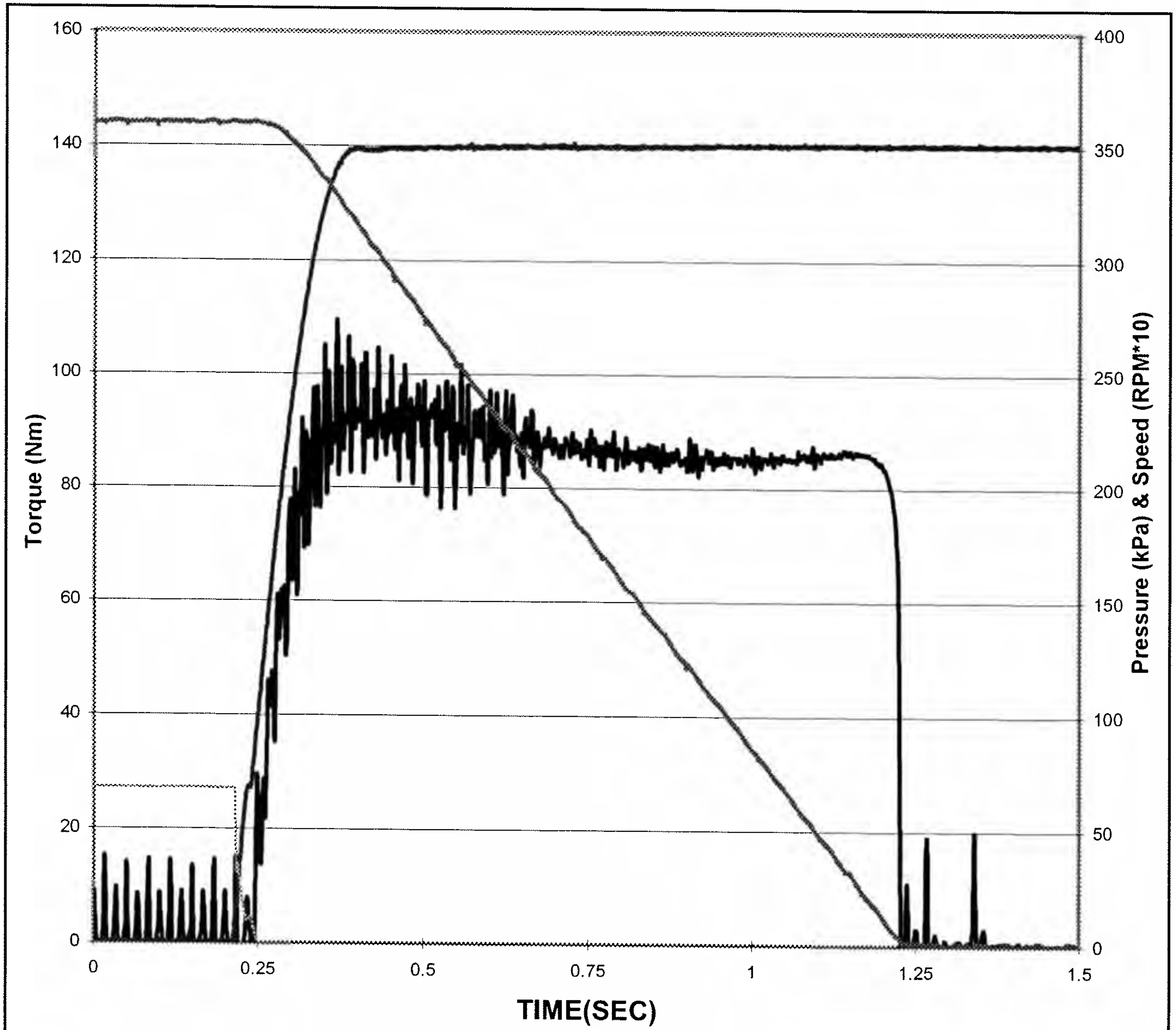

Date of Test:	9/13/2007
Time of Test:	16:07:42
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	50
Cycle Number:	9000
Temperature:	141 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.01 Sec *(0.85 - 1.05)*

Torque

Maximum:	88 N*m *(>90)*
Midpoint:	87 N*m *(80 - 105)*
Max - Mid:	0 N*m *(<30)*
End - Mid:	-17 N*m
End:	70 N*m *(Report)*

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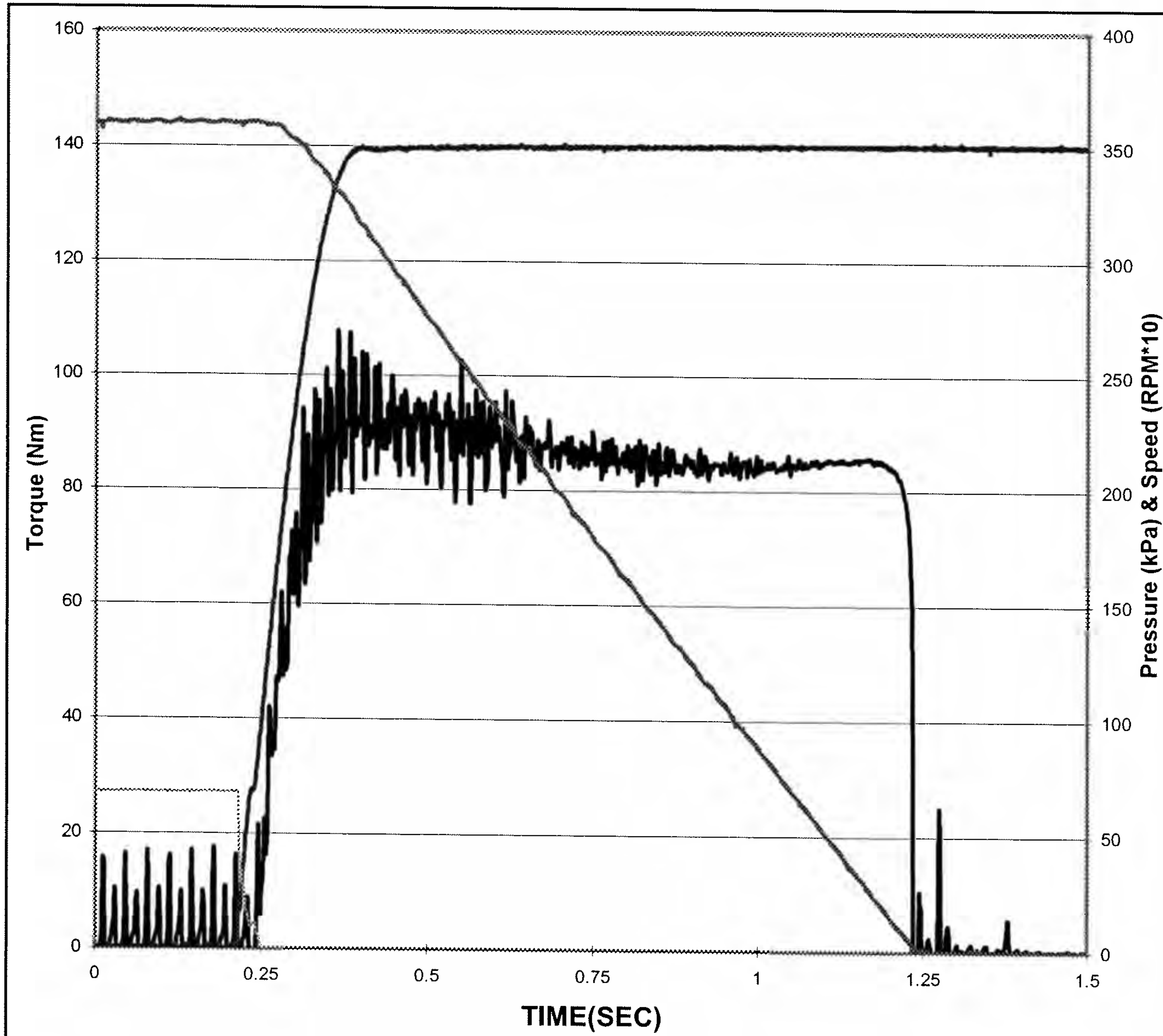

Date of Test:	9/13/2007
Time of Test:	21:07:43
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	55
Cycle Number:	9900
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.01 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	87 N*m *(80 - 105)*
Max - Mid:	-1 N*m *(<30)*
End - Mid:	-16 N*m
End:	71 N*m *(Report)*

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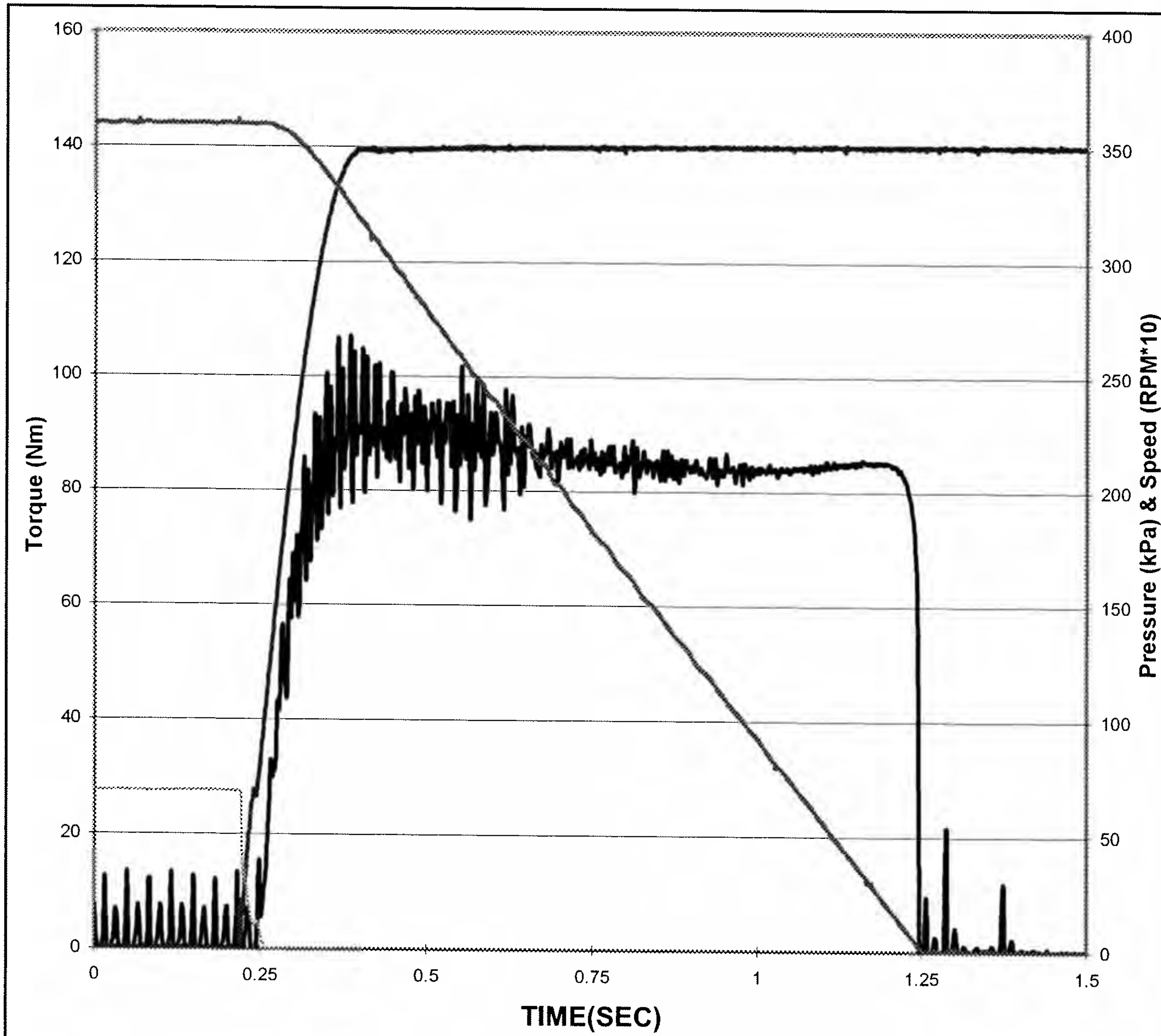

Date of Test:	9/14/2007
Time of Test:	2:07:44
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	60
Cycle Number:	10800
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.02 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	86 N*m *(80 - 105)*
Max - Mid:	0 N*m *(<30)*
End - Mid:	-15 N*m
End:	71 N*m *(Report)*

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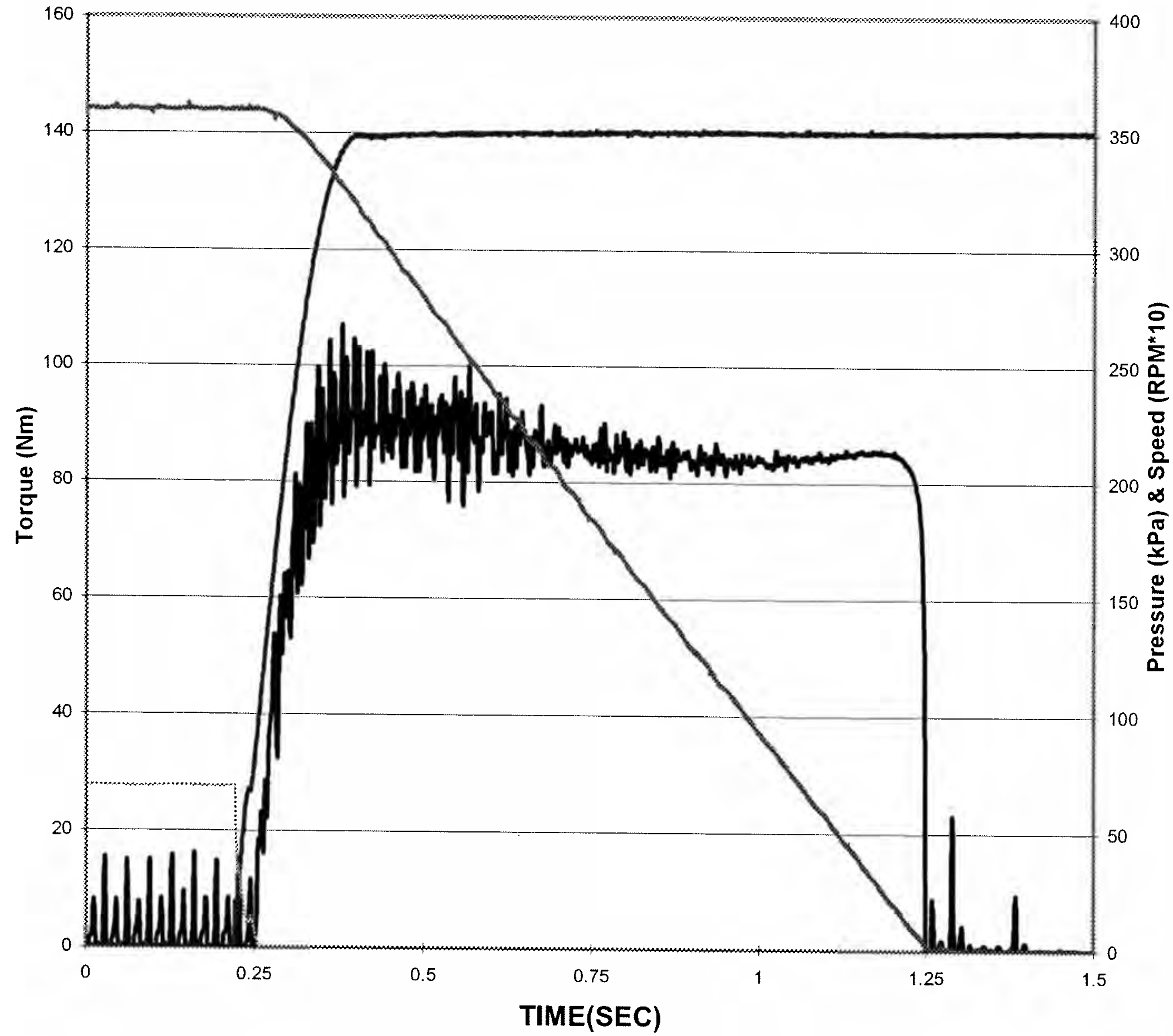

Date of Test:	9/14/2007
Time of Test:	7:07:45
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	65
Cycle Number:	11700
Temperature:	139 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.02 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	86 N*m *(80 - 105)*
Max - Mid:	0 N*m *(<30)*
End - Mid:	-15 N*m
End:	71 N*m *(Report)*

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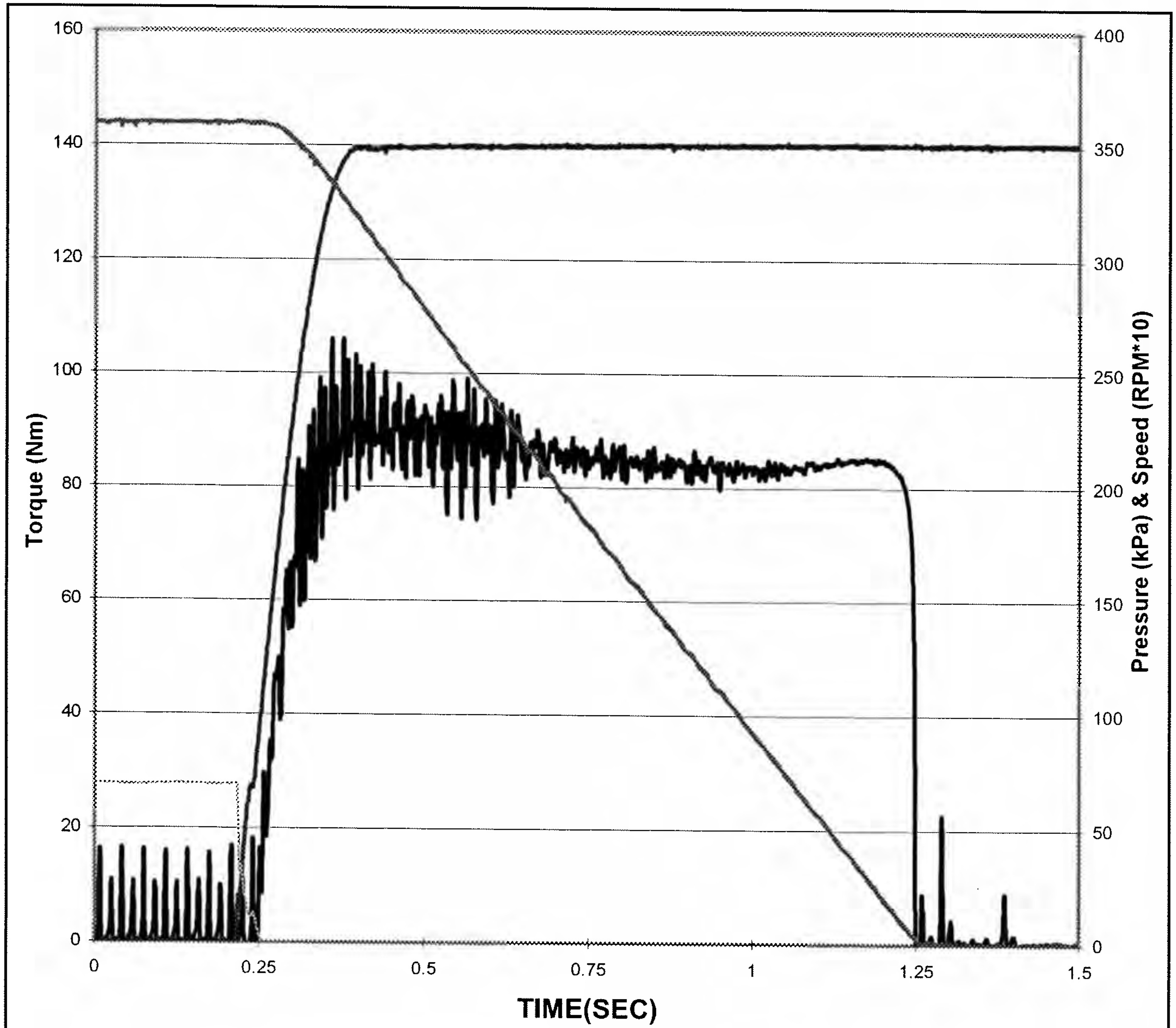

Date of Test:	9/14/2007
Time of Test:	12:07:46
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	70
Cycle Number:	12600
Temperature:	141 °C (134 - 146)
Apply Pressure:	350 kPa (340 - 350)
Energy:	15.6 KJ (15.4 - 16.0)
Engage Time:	1.04 Sec (0.85 - 1.05)

Torque

Maximum:	85 N*m (>90)
Midpoint:	85 N*m (80 - 105)
Max - Mid:	0 N*m (<30)
End - Mid:	-13 N*m
End:	72 N*m (Report)

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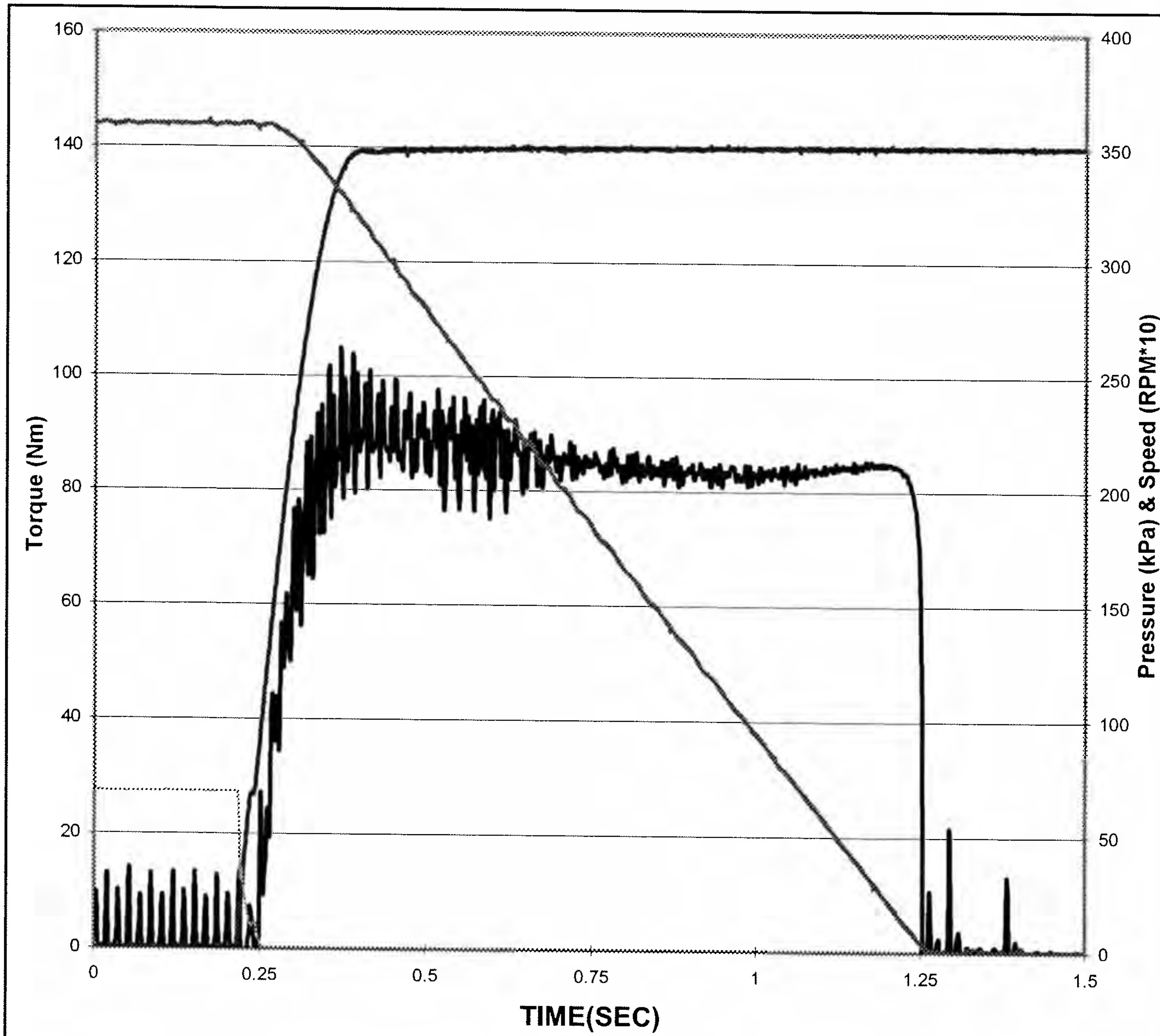

Date of Test:	9/14/2007
Time of Test:	17:07:46
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	75
Cycle Number:	13500
Temperature:	141 °C
	(134 - 146)
Apply Pressure:	350 kPa
	(340 - 350)
Energy:	15.6 KJ
	(15.4 - 16.0)
Engage Time:	1.02 Sec
	(0.85 - 1.05)

Torque

Maximum:	85 N*m
	(>90)
Midpoint:	85 N*m
	(80 - 105)
Max - Mid:	0 N*m
	(<30)
End - Mid:	-14 N*m
End:	71 N*m
	(Report)

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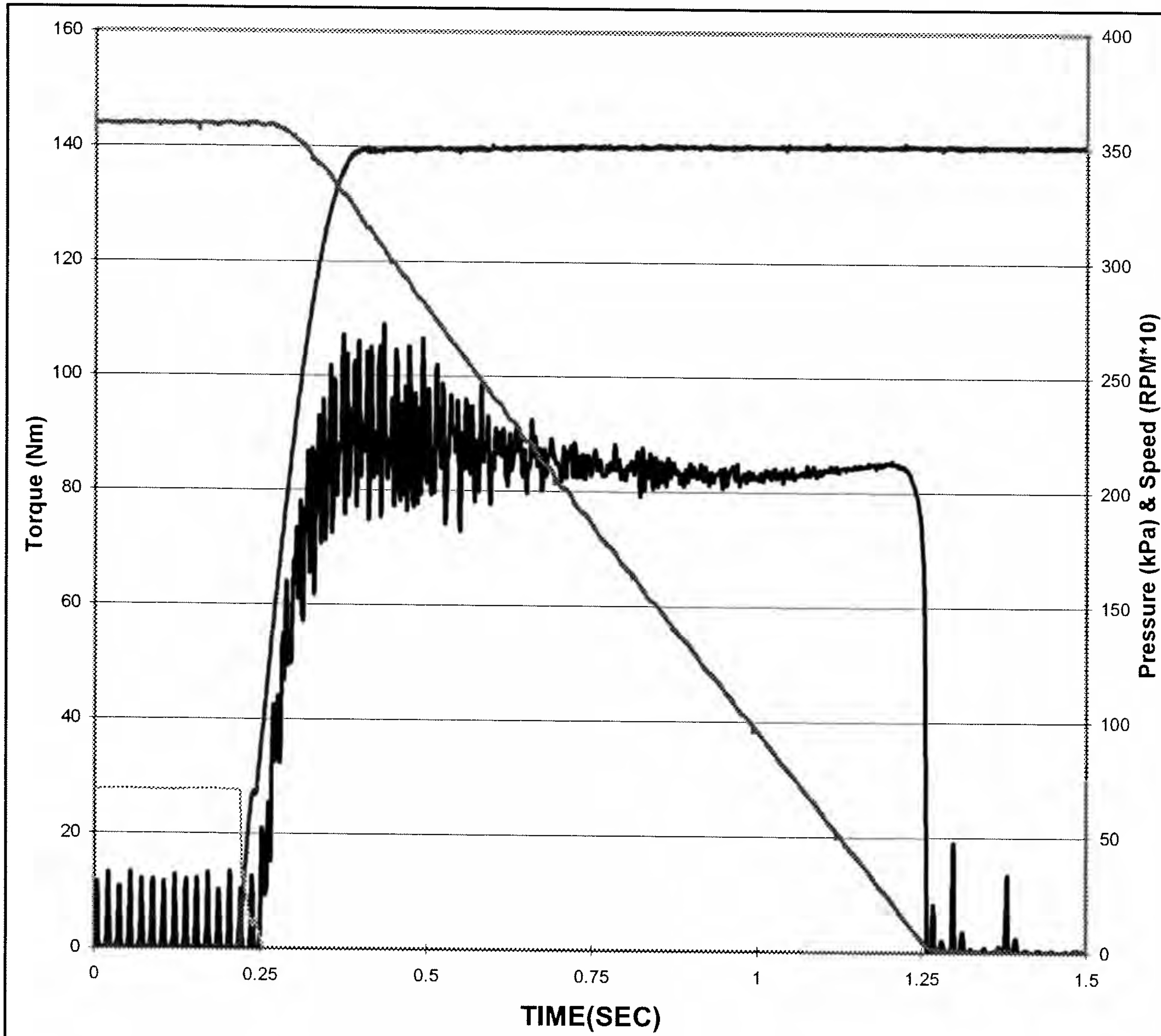

Date of Test:	9/14/2007
Time of Test:	22:07:47
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	80
Cycle Number:	14400
Temperature:	139 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.6 KJ *(15.4 - 16.0)*
Engage Time:	1.00 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	85 N*m *(80 - 105)*
Max - Mid:	1 N*m *(<30)*
End - Mid:	-15 N*m
End:	70 N*m *(Report)*

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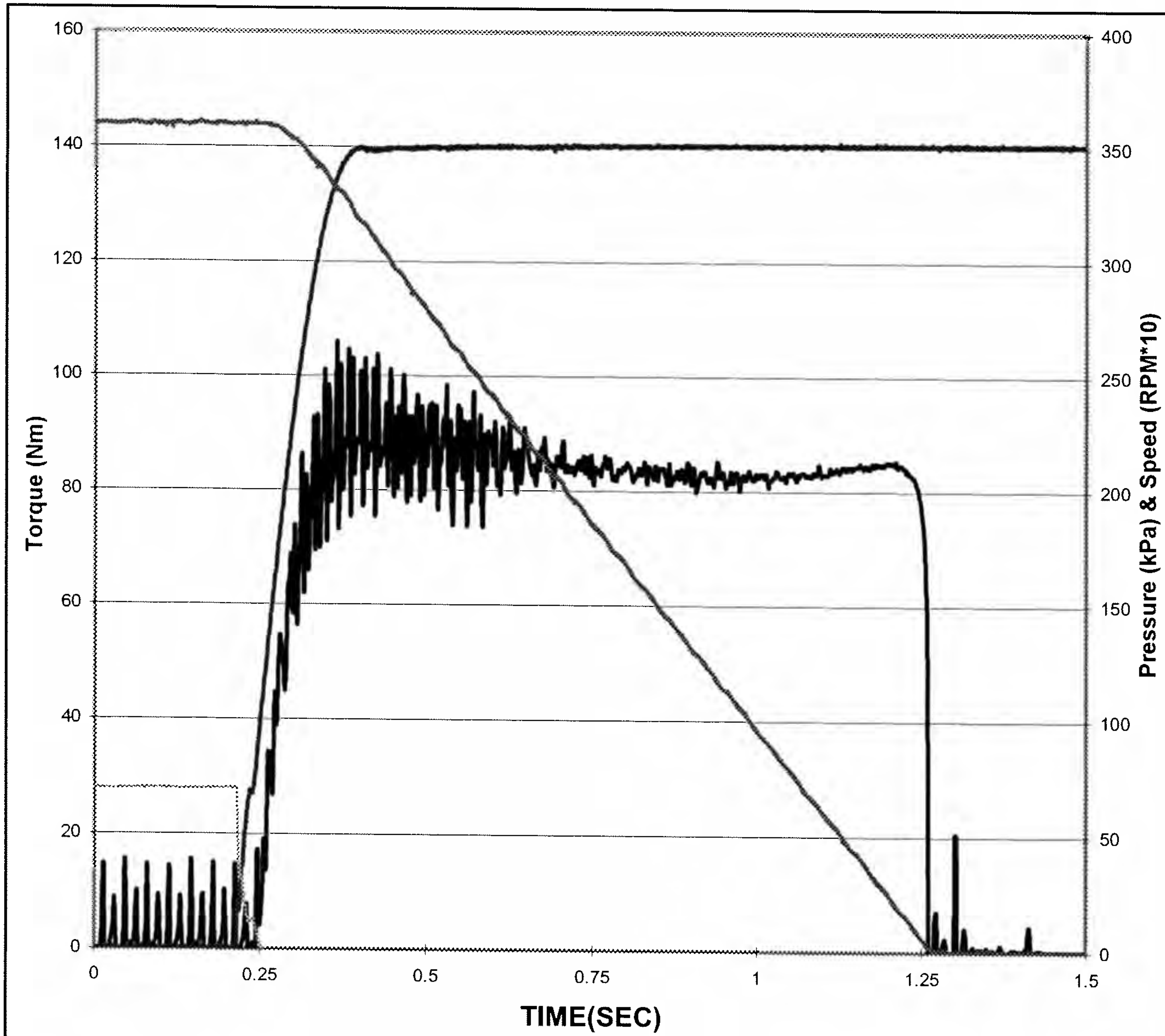

Date of Test:	9/15/2007
Time of Test:	3:07:48
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	85
Cycle Number:	15300
Temperature:	139 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.04 Sec *(0.85 - 1.05)*

Torque

Maximum:	85 N*m *(>90)*
Midpoint:	84 N*m *(80 - 105)*
Max - Mid:	1 N*m *(<30)*
End - Mid:	-14 N*m
End:	70 N*m *(Report)*

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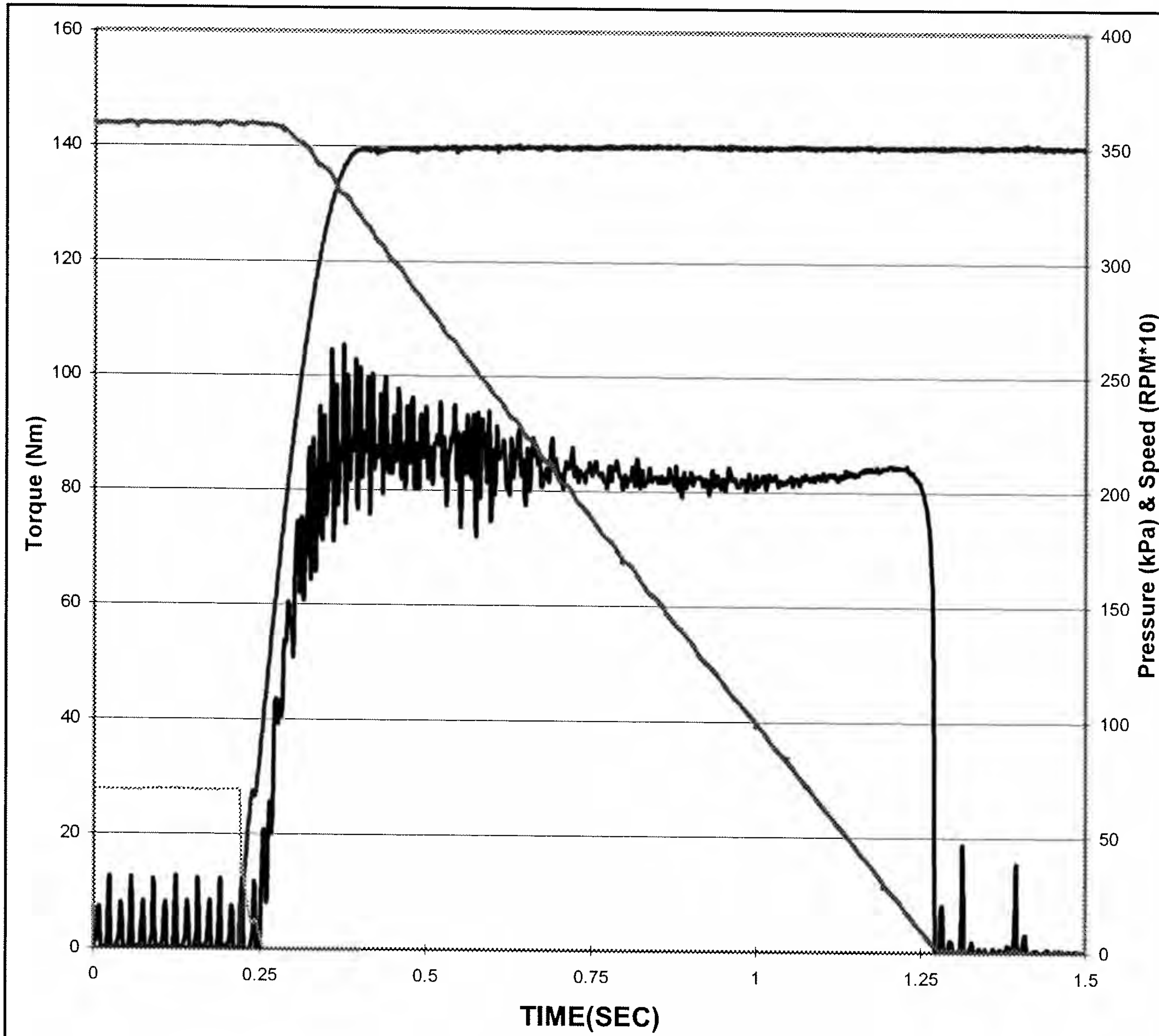

Date of Test:	9/15/2007
Time of Test:	8:07:49
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	90
Cycle Number:	16200
Temperature:	142 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.6 KJ *(15.4 - 16.0)*
Engage Time:	1.05 Sec *(0.85 - 1.05)*

Torque

Maximum:	85 N*m *(>90)*
Midpoint:	83 N*m *(80 - 105)*
Max - Mid:	1 N*m *(<30)*
End - Mid:	-14 N*m
End:	69 N*m *(Report)*

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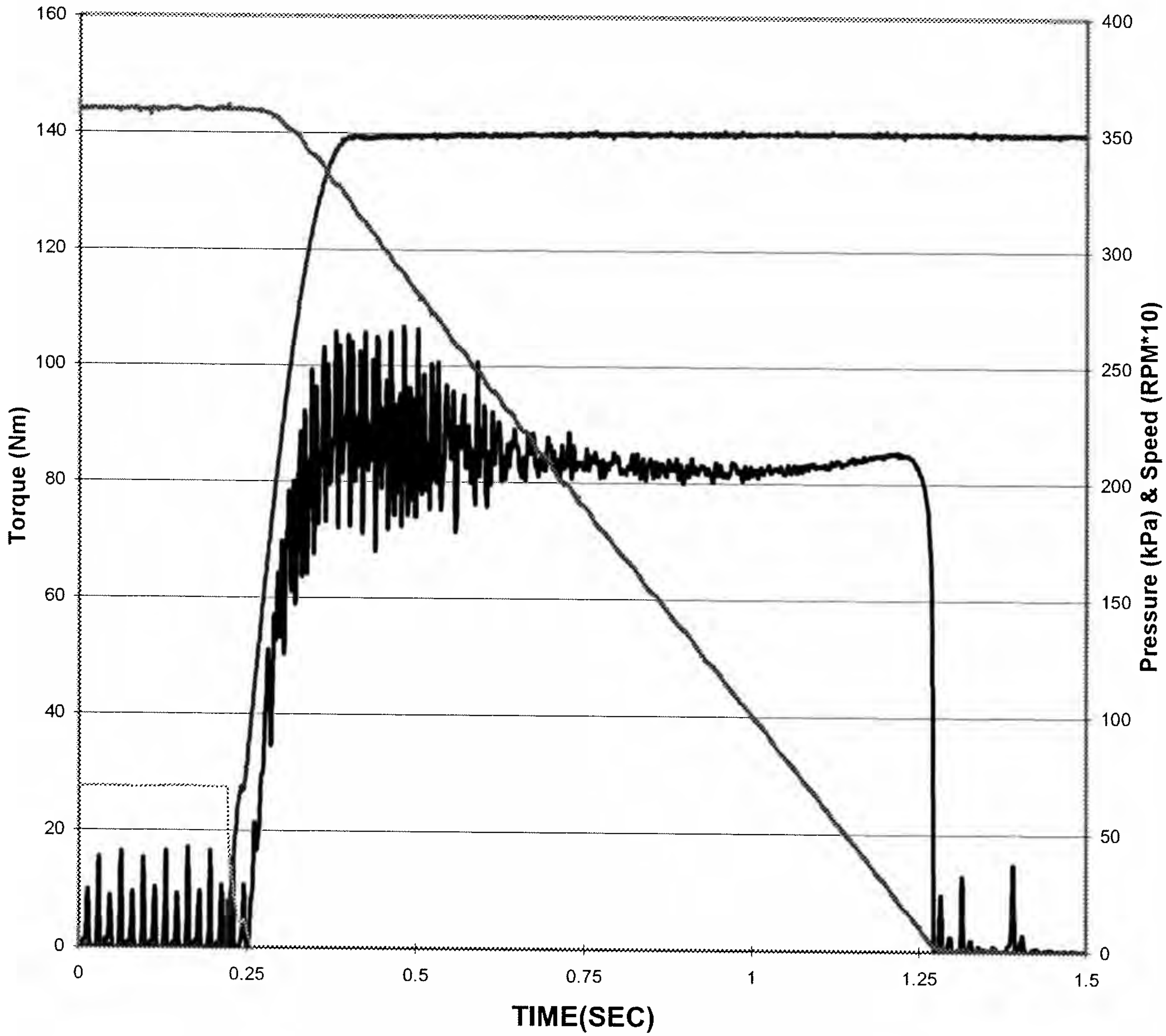

Date of Test:	9/15/2007
Time of Test:	13:07:50
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	95
Cycle Number:	17100
Temperature:	139 °C
	(134 - 146)
Apply Pressure:	350 kPa
	(340 - 350)
Energy:	15.7 KJ
	(15.4 - 16.0)
Engage Time:	1.04 Sec
	(0.85 - 1.05)

Torque

Maximum:	85 N*m
	(>90)
Midpoint:	84 N*m
	(80 - 105)
Max - Mid:	2 N*m
	(<30)
End - Mid:	-14 N*m
End:	69 N*m
	(Report)

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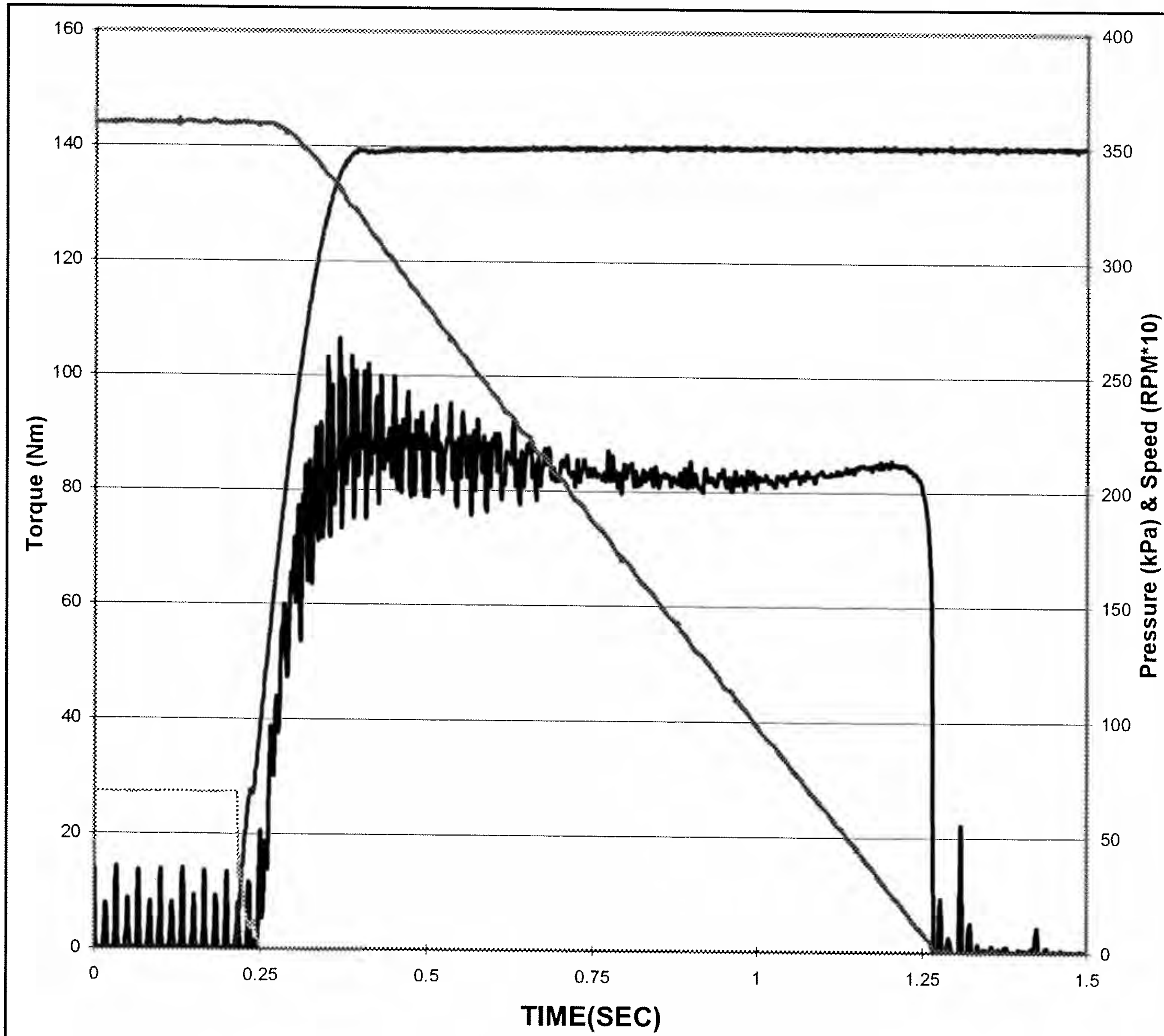

Date of Test:	**9/15/2007**
Time of Test:	**18:07:51**
Test Type:	**PLATE**
Test Number:	**HC11-1-82**
Fluid Code:	**AL-27877-L**
Hour Number:	**100**
Cycle Number:	**18000**
Temperature:	**141 °C**
	(134 - 146)
Apply Pressure:	**349 kPa**
	(340 - 350)
Energy:	**15.7 KJ**
	(15.4 - 16.0)
Engage Time:	**1.05 Sec**
	(0.85 - 1.05)

Torque

Maximum:	**86 N*m**
	(>90)
Midpoint:	**83 N*m**
	(80 - 105)
Max - Mid:	**2 N*m**
	(<30)
End - Mid:	**-13 N*m**
End:	**71 N*m**
	(Report)

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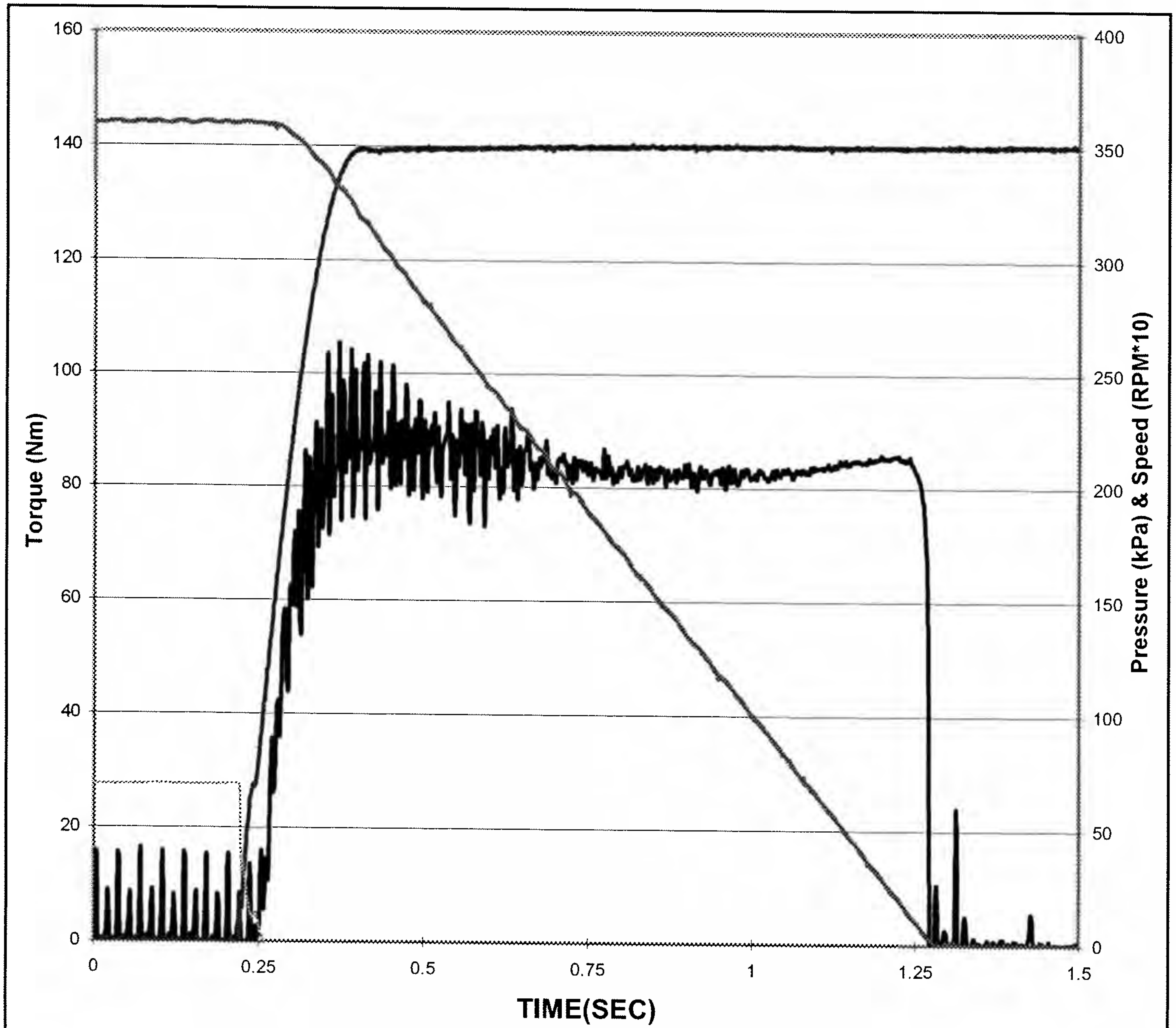

Date of Test:	9/15/2007
Time of Test:	23:07:52
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	105
Cycle Number:	18900
Temperature:	141 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.04 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	83 N*m *(80 - 105)*
Max - Mid:	3 N*m *(<30)*
End - Mid:	-13 N*m
End:	70 N*m *(Report)*

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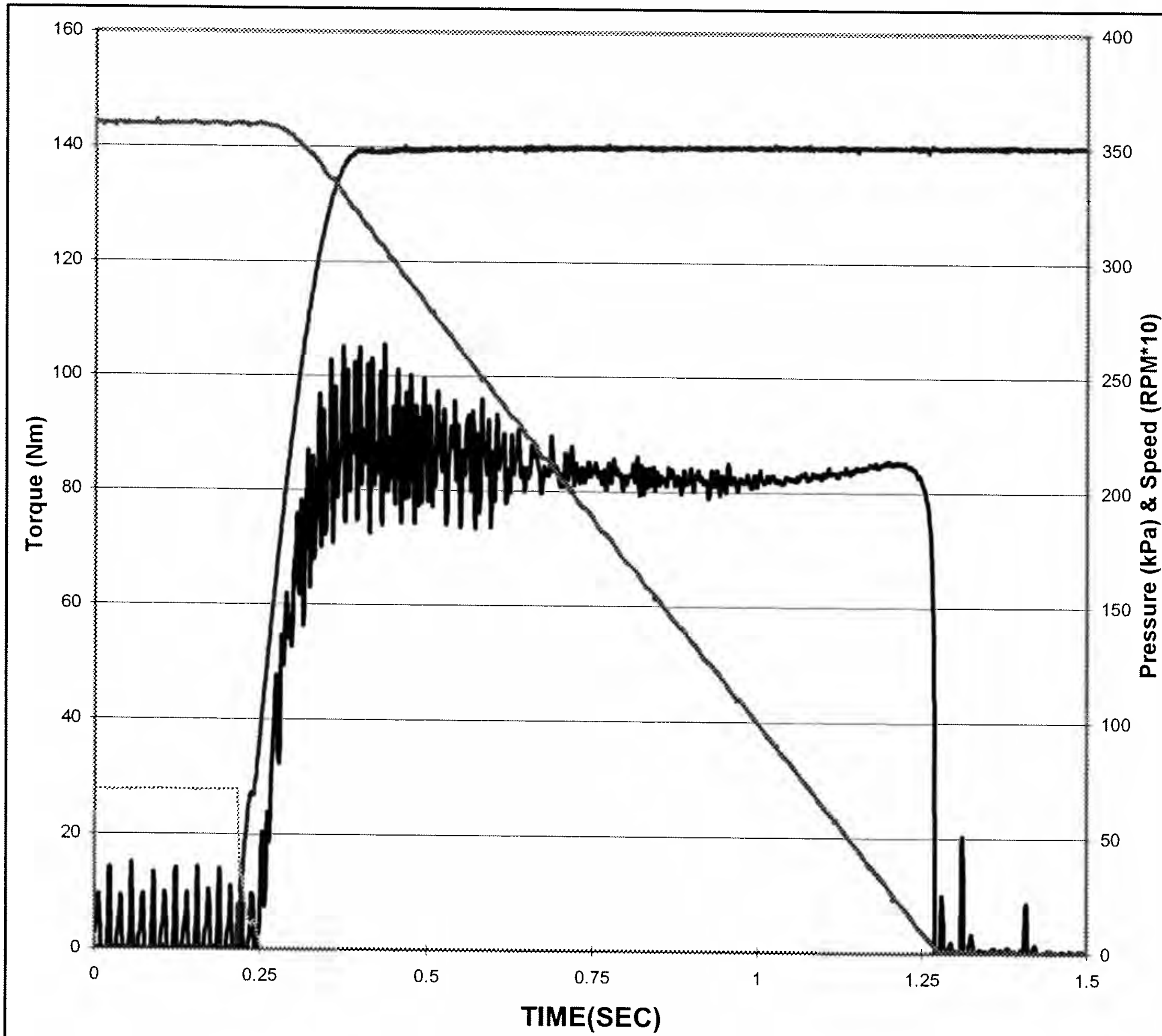

Date of Test:	9/16/2007
Time of Test:	4:07:52
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	110
Cycle Number:	19800
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.05 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	83 N*m *(80 - 105)*
Max - Mid:	2 N*m *(<30)*
End - Mid:	-12 N*m
End:	71 N*m *(Report)*

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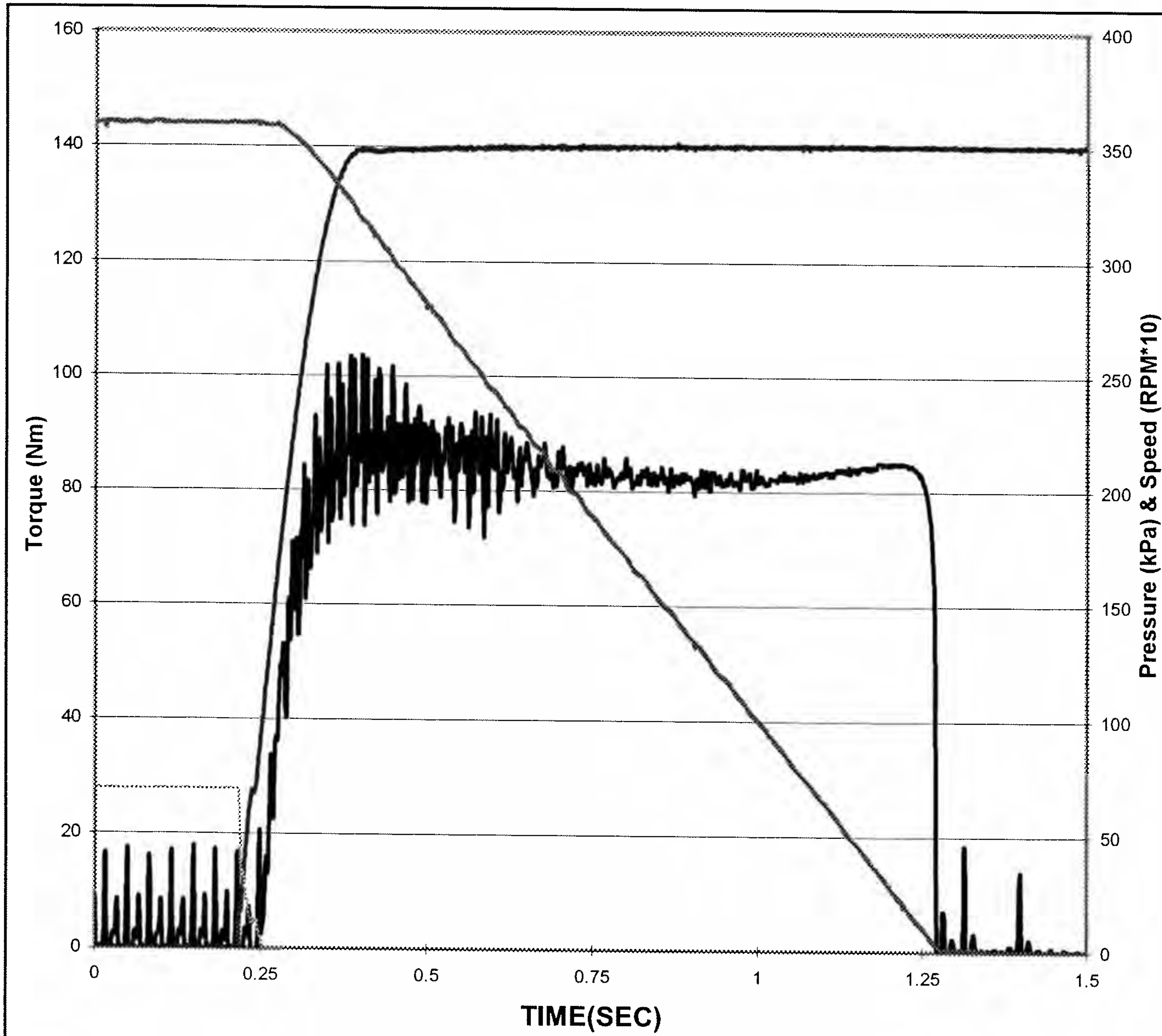

Date of Test:	9/16/2007
Time of Test:	9:07:53
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	115
Cycle Number:	20700
Temperature:	141 °C
	(134 - 146)
Apply Pressure:	350 kPa
	(340 - 350)
Energy:	15.7 KJ
	(15.4 - 16.0)
Engage Time:	1.04 Sec
	(0.85 - 1.05)

Torque

Maximum:	85 N*m
	(>90)
Midpoint:	83 N*m
	(80 - 105)
Max - Mid:	2 N*m
	(<30)
End - Mid:	-13 N*m
End:	70 N*m
	(Report)

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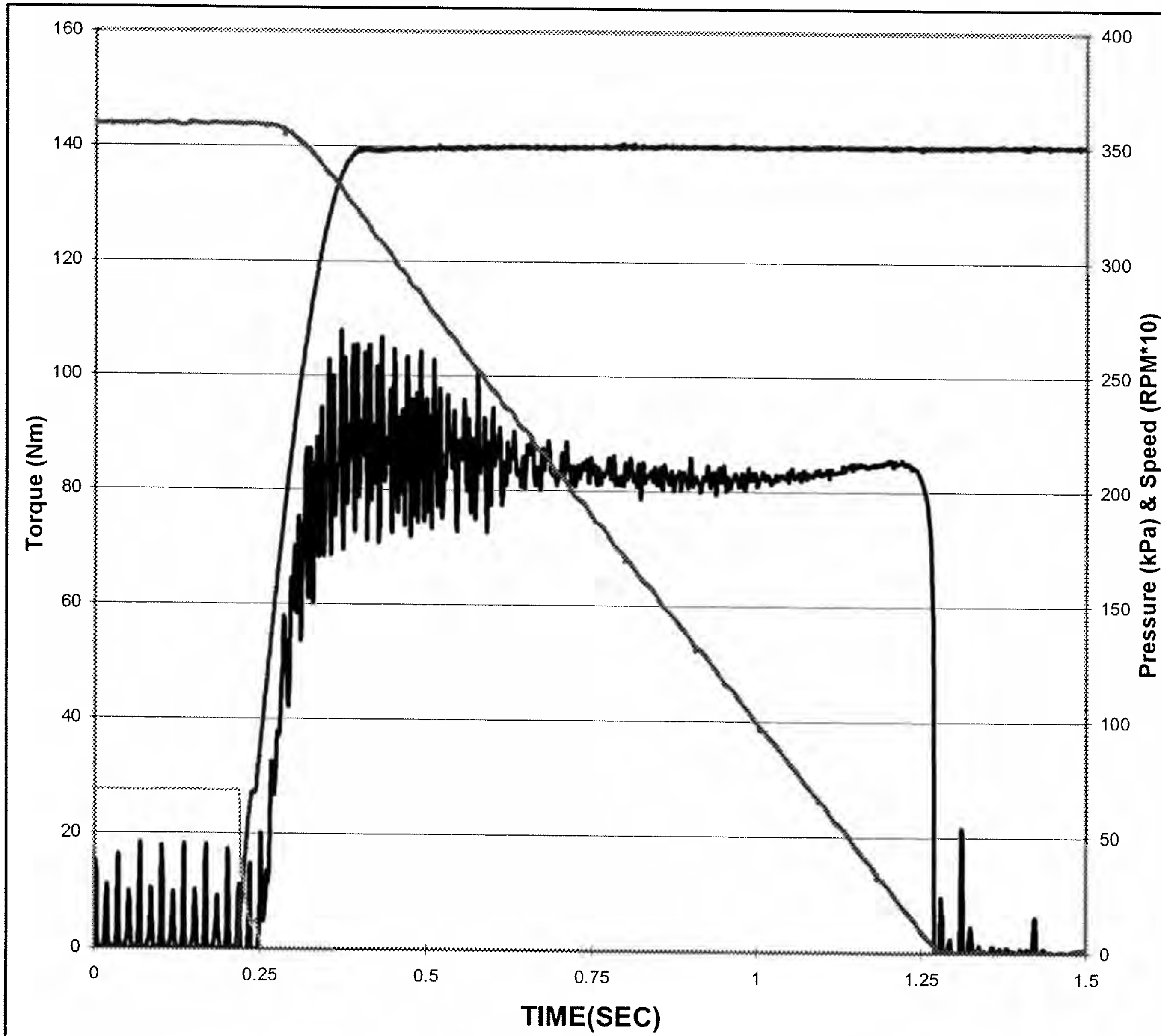

Date of Test:	9/16/2007
Time of Test:	14:07:54
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	120
Cycle Number:	21600
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.6 KJ *(15.4 - 16.0)*
Engage Time:	1.06 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	83 N*m *(80 - 105)*
Max - Mid:	2 N*m *(<30)*
End - Mid:	-13 N*m
End:	71 N*m *(Report)*

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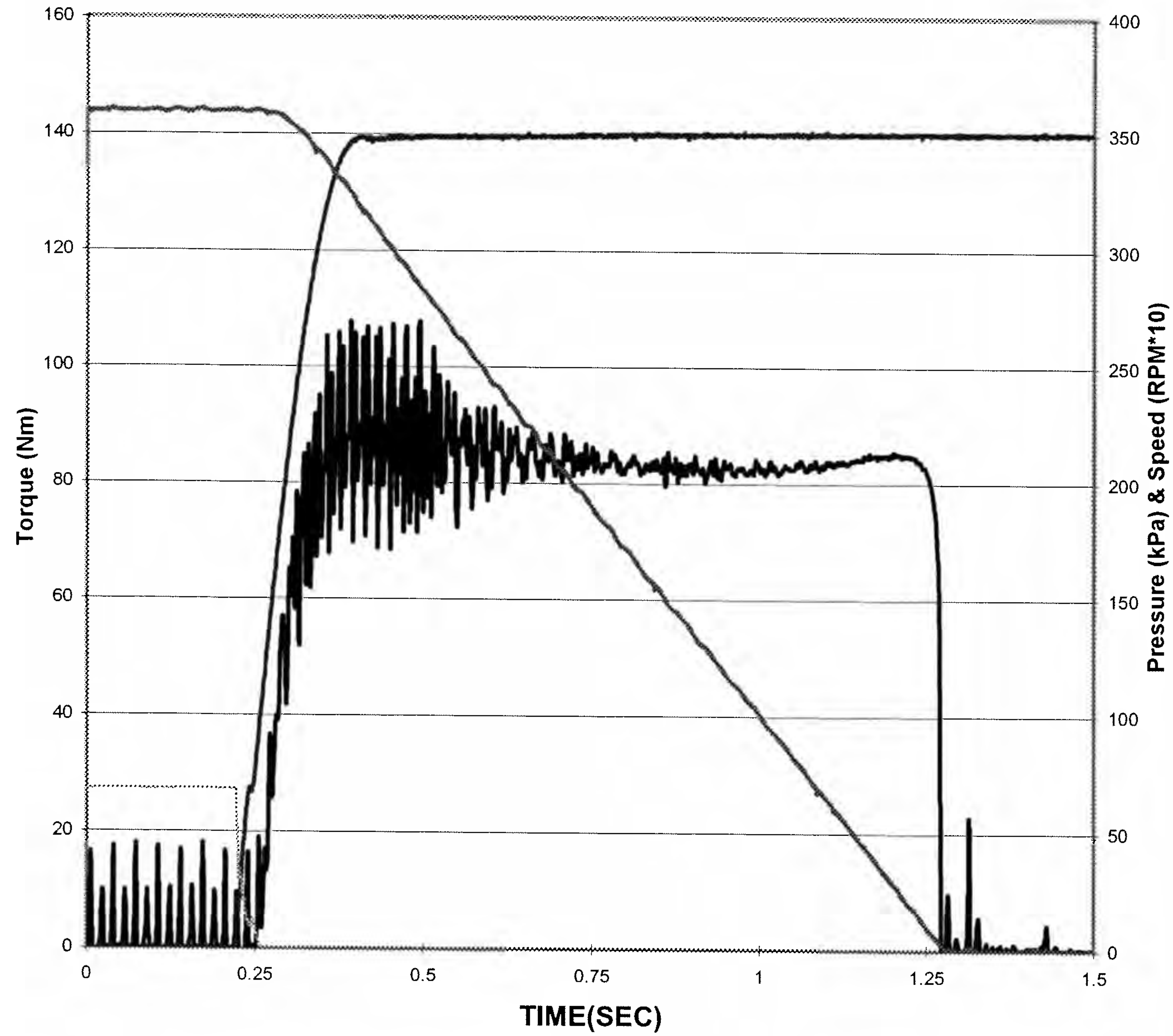

Date of Test:	9/16/2007
Time of Test:	19:07:55
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	125
Cycle Number:	22500
Temperature:	141 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.6 KJ *(15.4 - 16.0)*
Engage Time:	1.07 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	84 N*m *(80 - 105)*
Max - Mid:	2 N*m *(<30)*
End - Mid:	-13 N*m
End:	71 N*m *(Report)*

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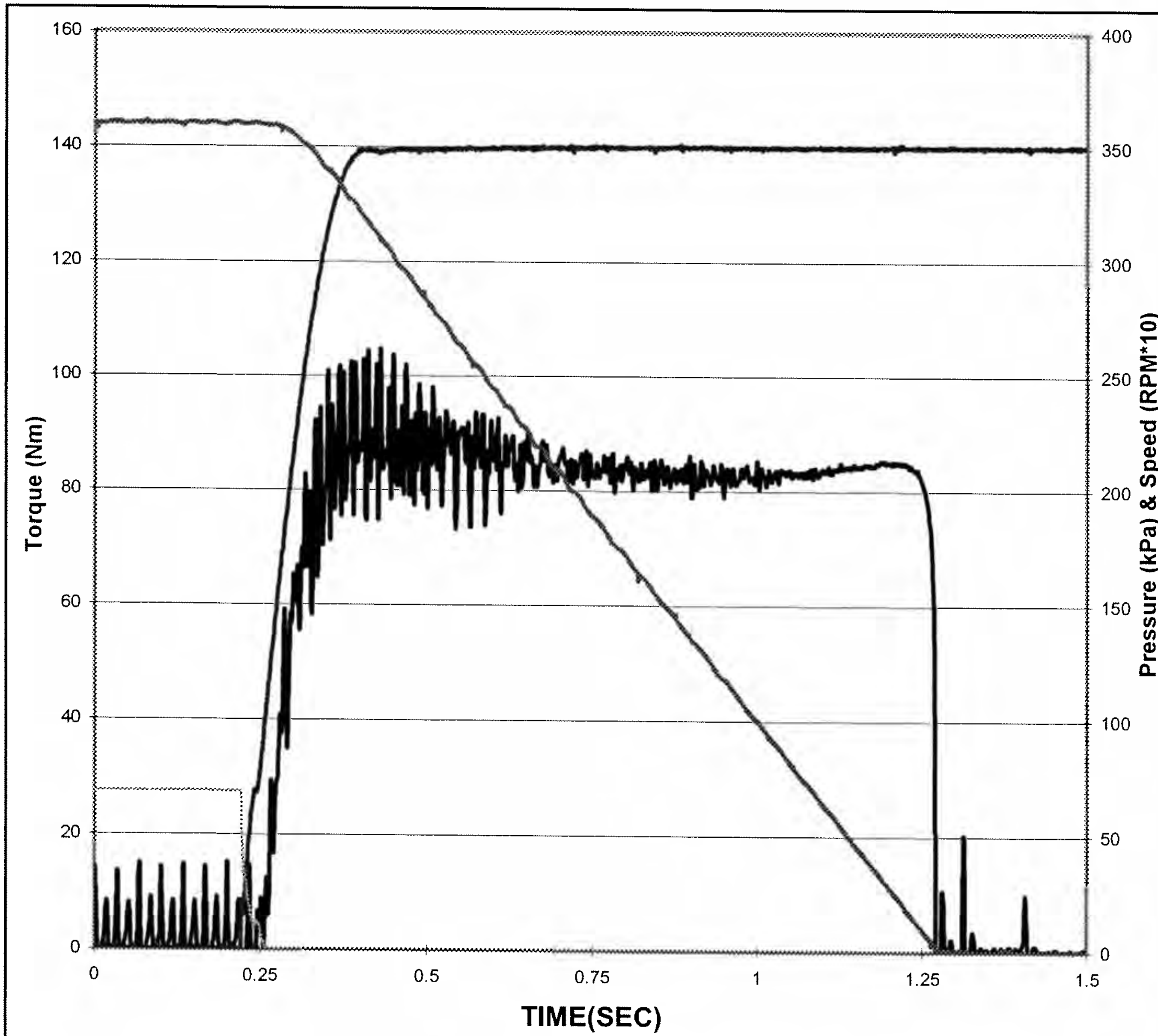

Date of Test:	9/17/2007
Time of Test:	0:07:56
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	130
Cycle Number:	23400
Temperature:	141 °C
	(134 - 146)
Apply Pressure:	350 kPa
	(340 - 350)
Energy:	15.7 KJ
	(15.4 - 16.0)
Engage Time:	1.05 Sec
	(0.85 - 1.05)

Torque

Maximum:	85 N*m
	(>90)
Midpoint:	84 N*m
	(80 - 105)
Max - Mid:	1 N*m
	(<30)
End - Mid:	-14 N*m
End:	70 N*m
	(Report)

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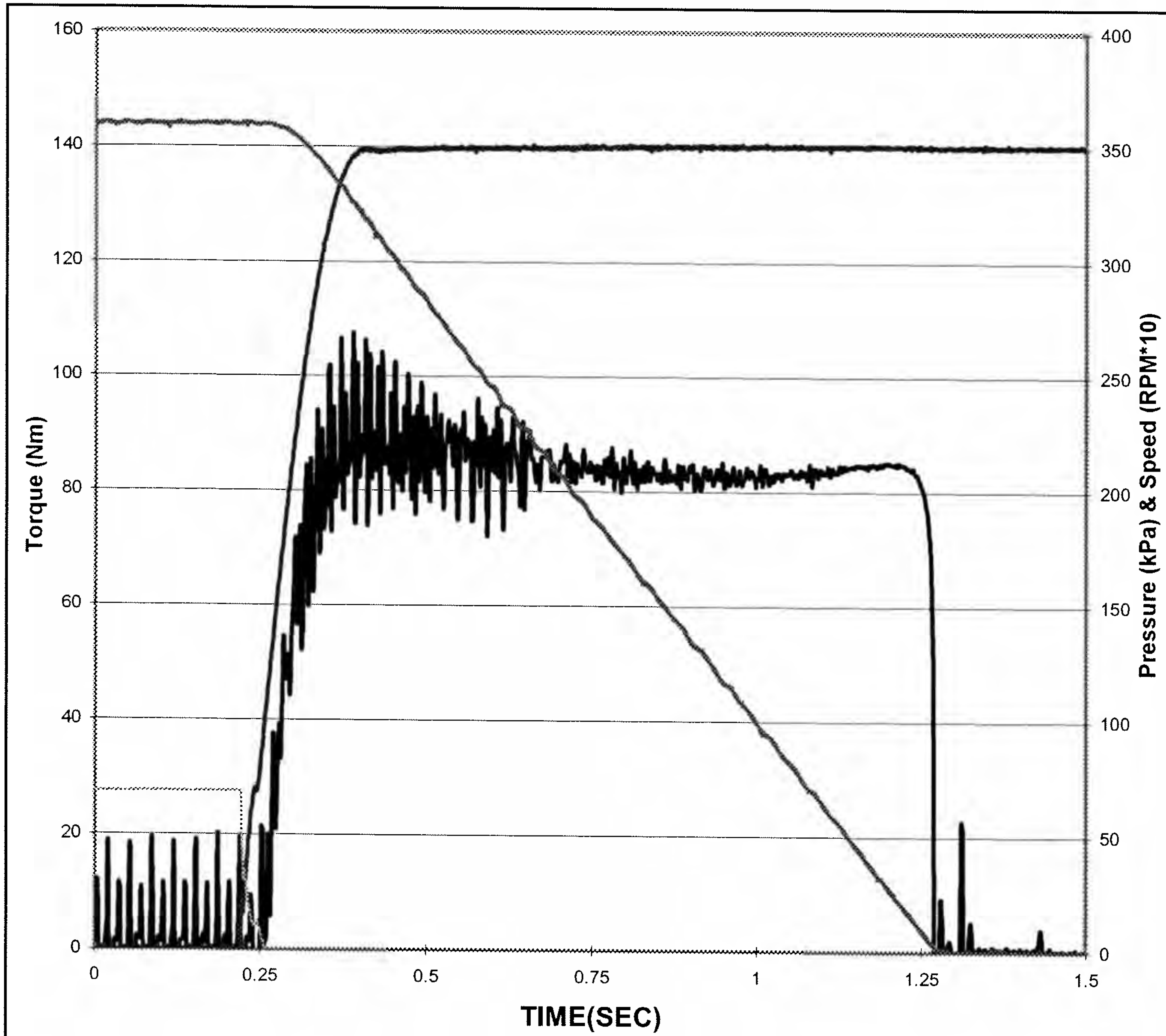

Date of Test:	9/17/2007
Time of Test:	5:07:57
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	135
Cycle Number:	24300
Temperature:	142 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.05 Sec *(0.85 - 1.05)*

Torque

Maximum:	85 N*m *(>90)*
Midpoint:	84 N*m *(80 - 105)*
Max - Mid:	1 N*m *(<30)*
End - Mid:	-14 N*m
End:	70 N*m *(Report)*

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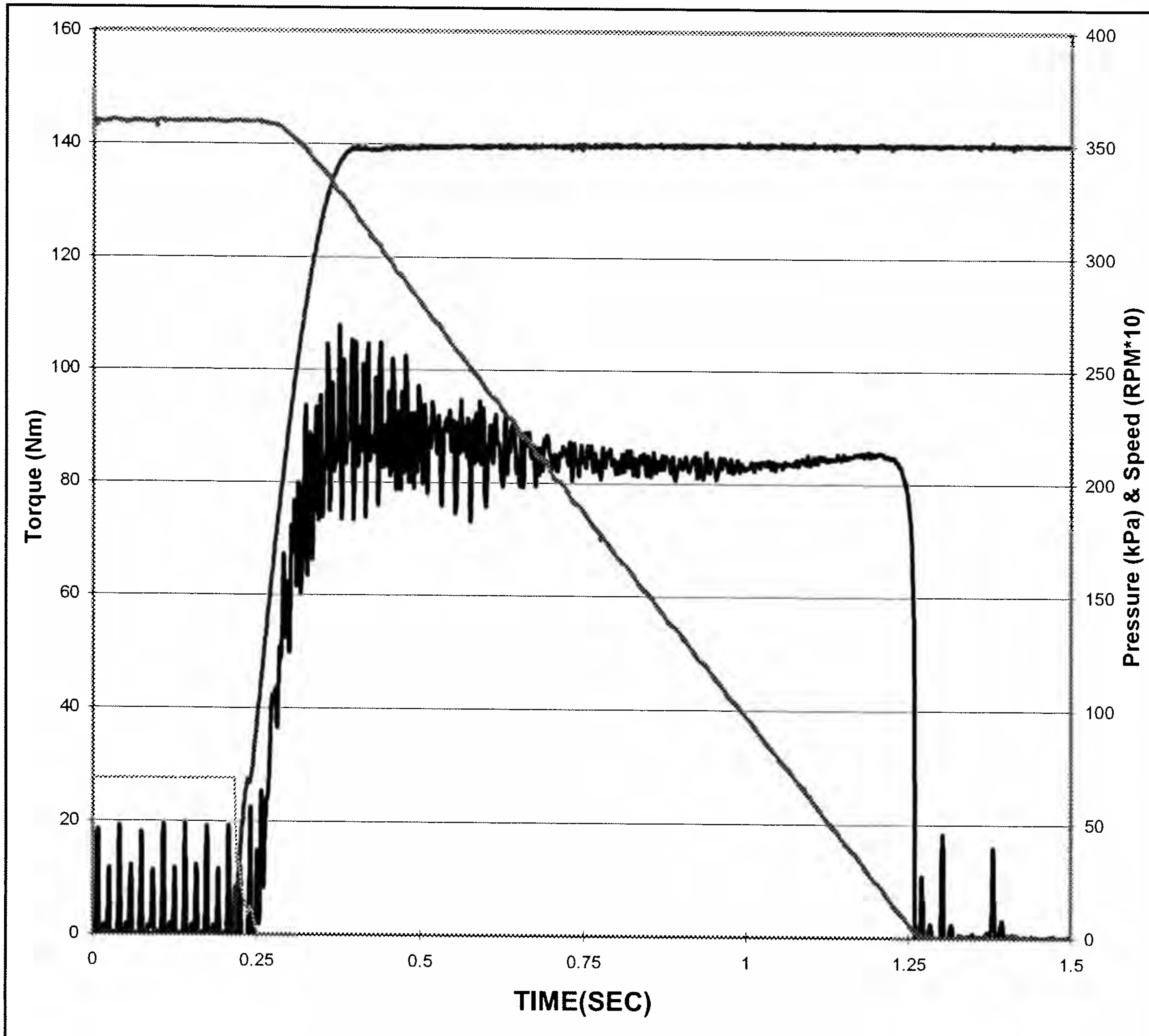

Date of Test:	9/17/2007
Time of Test:	10:07:58
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	140
Cycle Number:	25200
Temperature:	139 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.03 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	85 N*m *(80 - 105)*
Max - Mid:	1 N*m *(<30)*
End - Mid:	-15 N*m
End:	70 N*m *(Report)*

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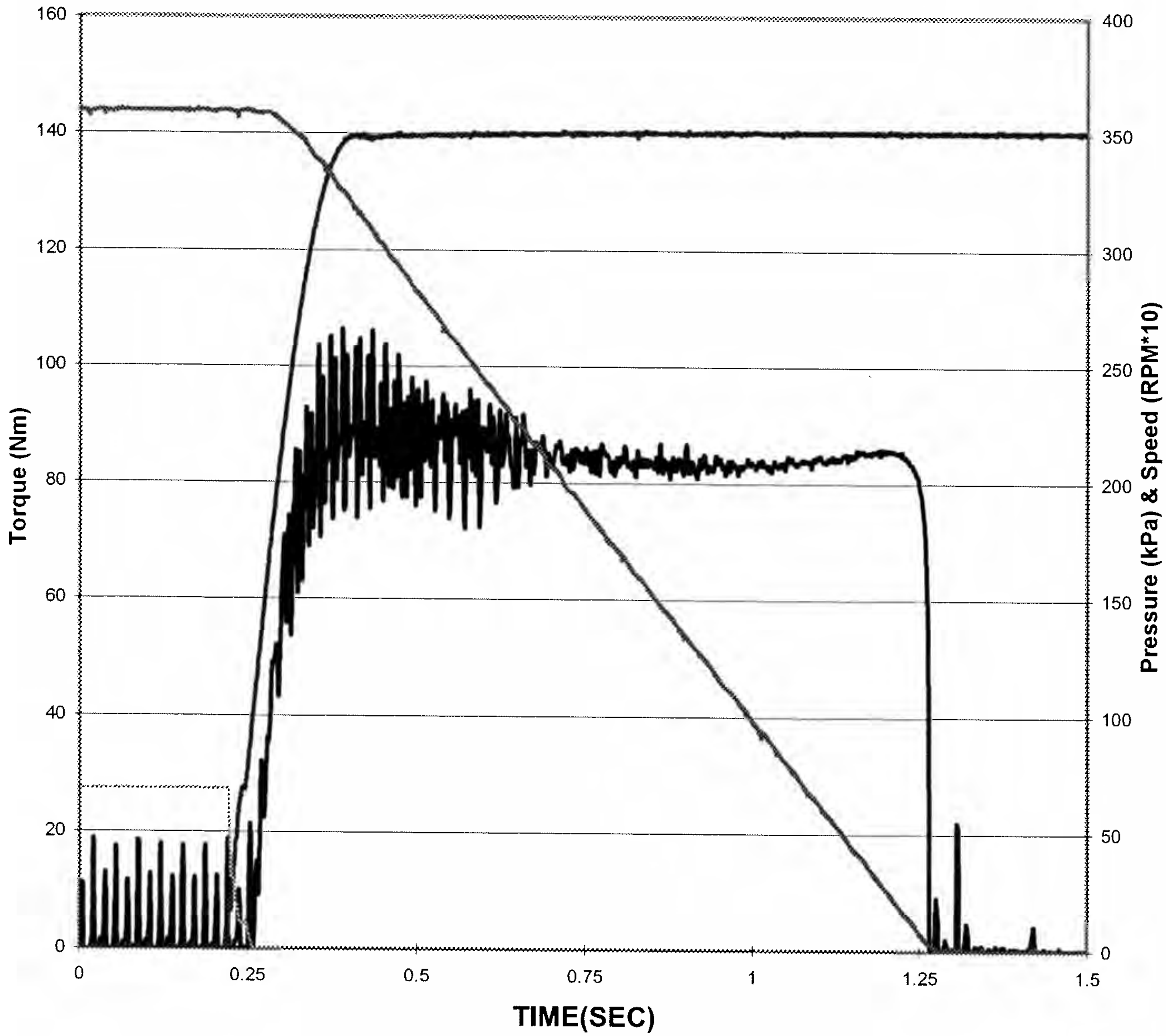

Date of Test:	9/17/2007
Time of Test:	15:07:58
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	145
Cycle Number:	26100
Temperature:	140 °C
	(134 - 146)
Apply Pressure:	350 kPa
	(340 - 350)
Energy:	15.6 KJ
	(15.4 - 16.0)
Engage Time:	1.05 Sec
	(0.85 - 1.05)

Torque

Maximum:	86 N*m
	(>90)
Midpoint:	84 N*m
	(80 - 105)
Max - Mid:	2 N*m
	(<30)
End - Mid:	-13 N*m
End:	71 N*m
	(Report)

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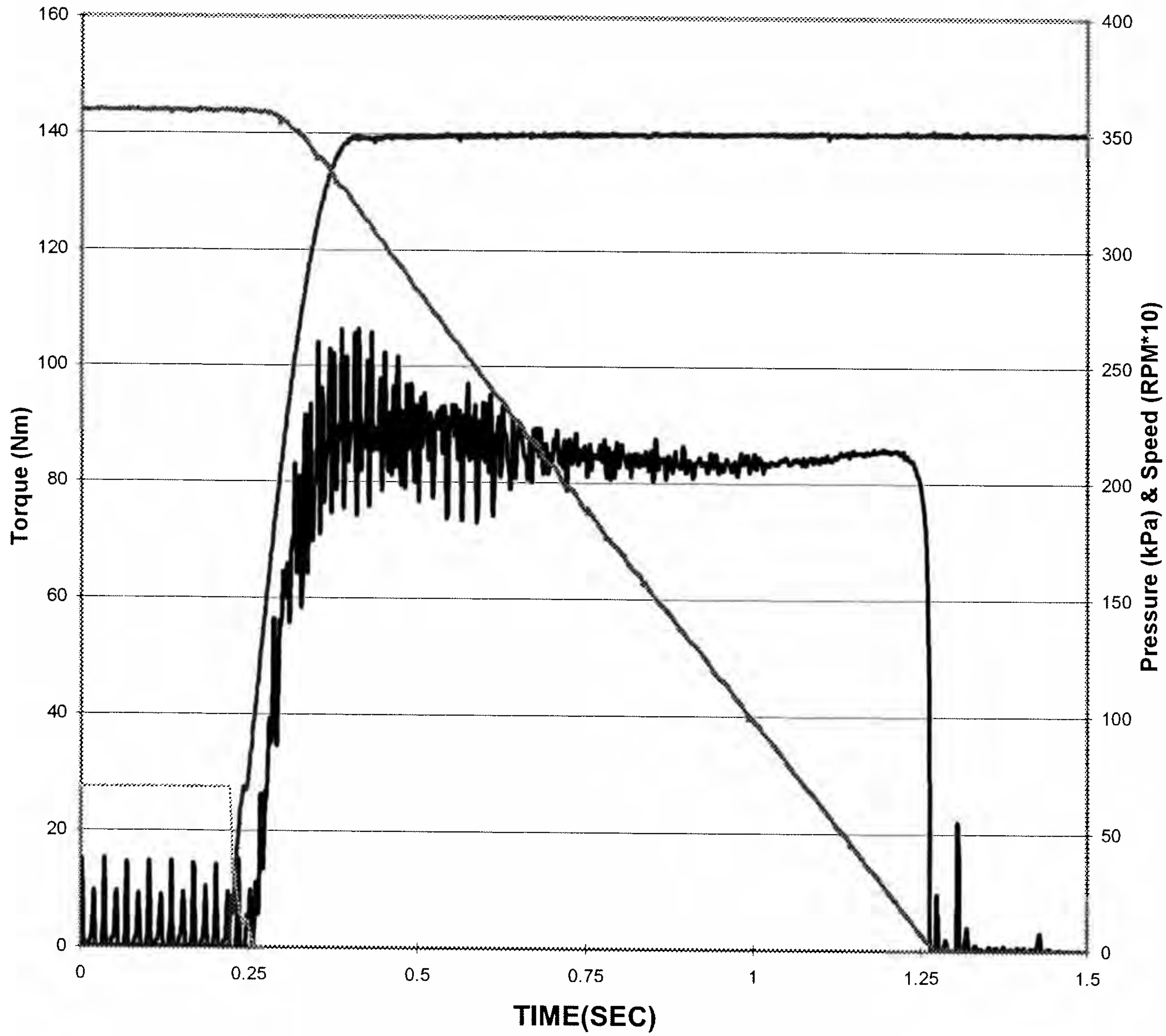

Date of Test:	9/17/2007
Time of Test:	20:07:59
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	150
Cycle Number:	27000
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.05 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	84 N*m *(80 - 105)*
Max - Mid:	2 N*m *(<30)*
End - Mid:	-13 N*m
End:	72 N*m *(Report)*

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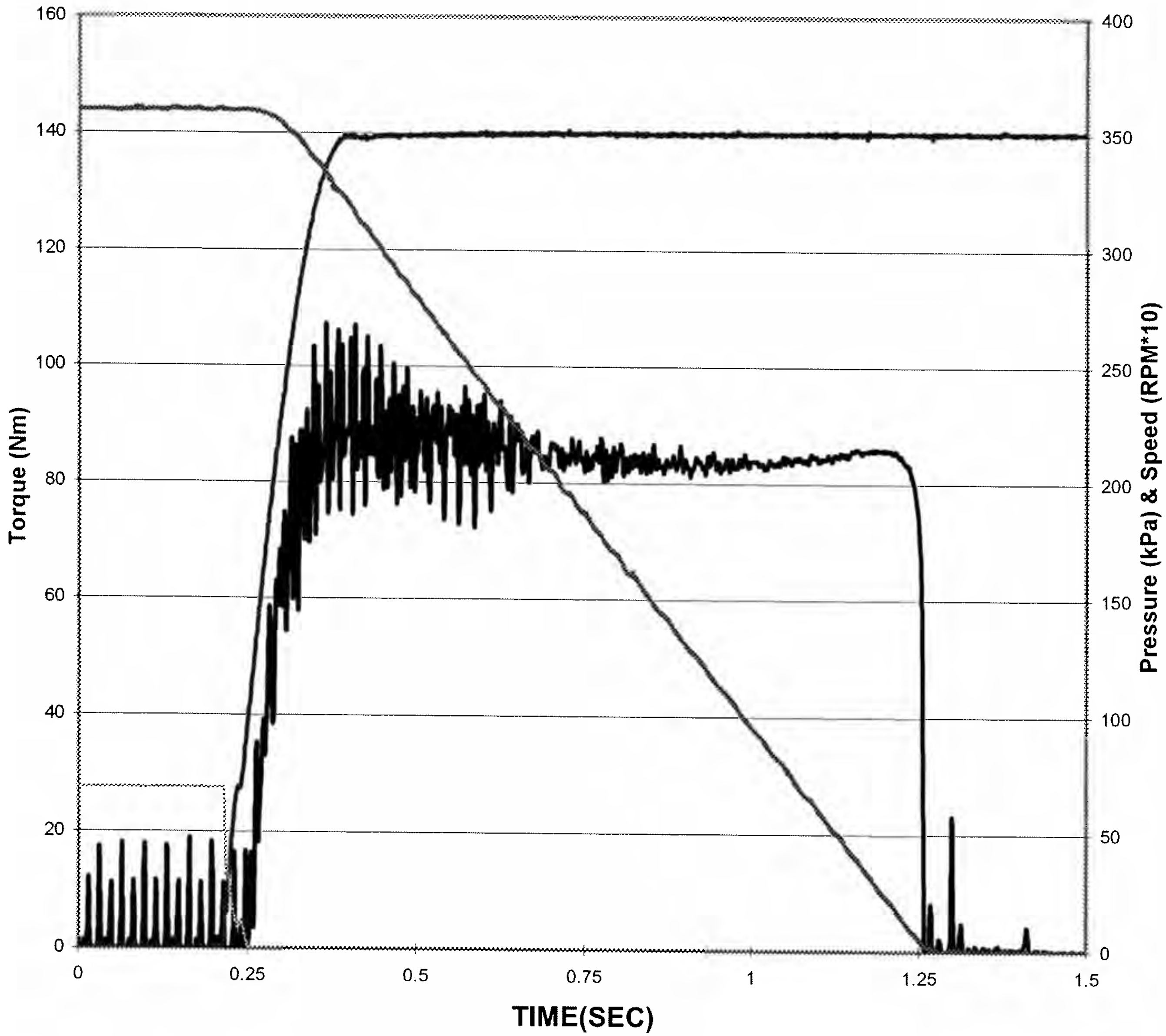

Date of Test:	9/18/2007
Time of Test:	1:08:00
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	155
Cycle Number:	27900
Temperature:	141 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.6 KJ *(15.4 - 16.0)*
Engage Time:	1.05 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	84 N*m *(80 - 105)*
Max - Mid:	2 N*m *(<30)*
End - Mid:	-15 N*m
End:	70 N*m *(Report)*

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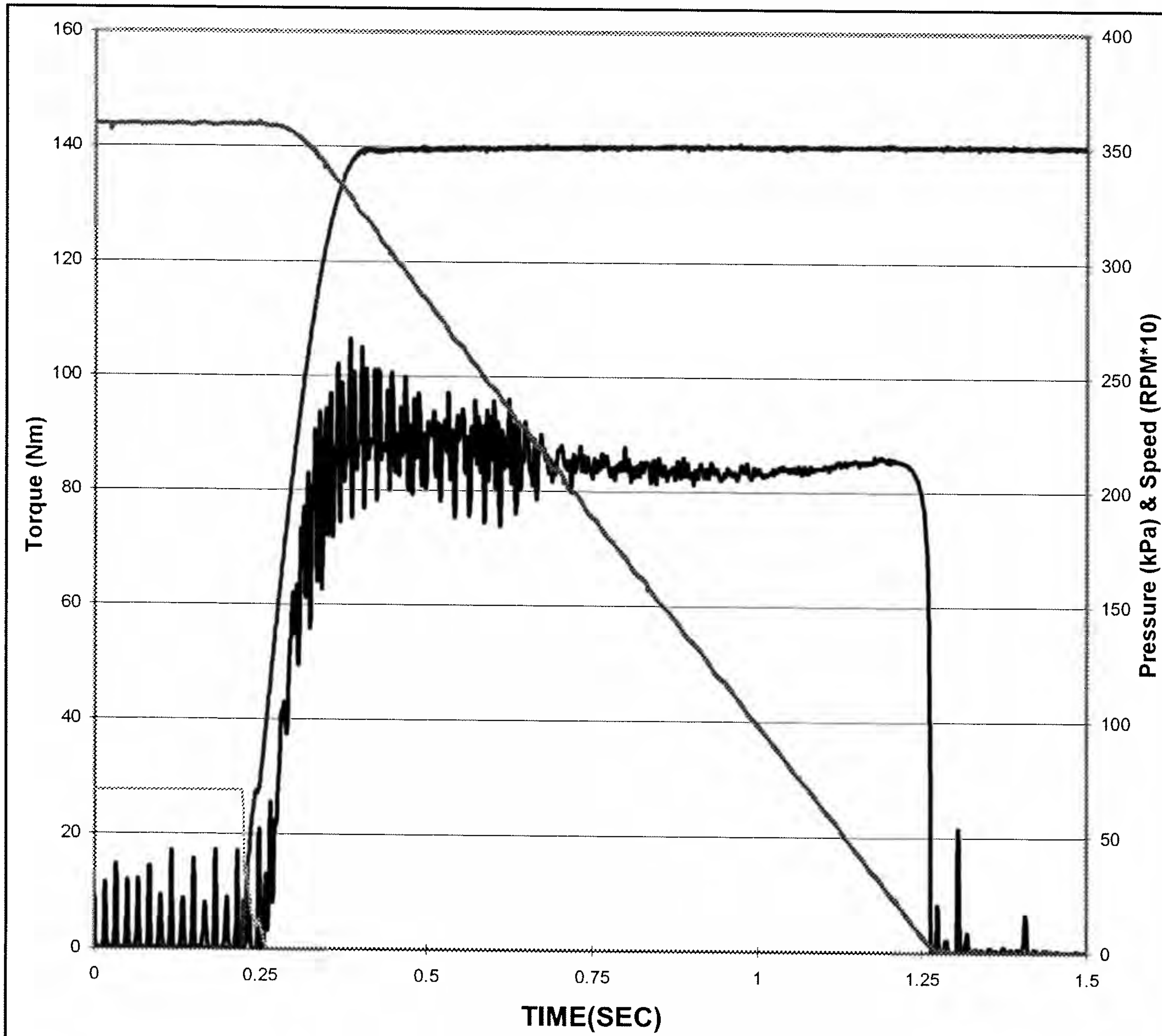

Date of Test:	9/18/2007
Time of Test:	6:08:01
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	160
Cycle Number:	28800
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	350 kPa *(340 - 350)*
Energy:	15.6 KJ *(15.4 - 16.0)*
Engage Time:	1.03 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	85 N*m *(80 - 105)*
Max - Mid:	1 N*m *(<30)*
End - Mid:	-15 N*m
End:	70 N*m *(Report)*

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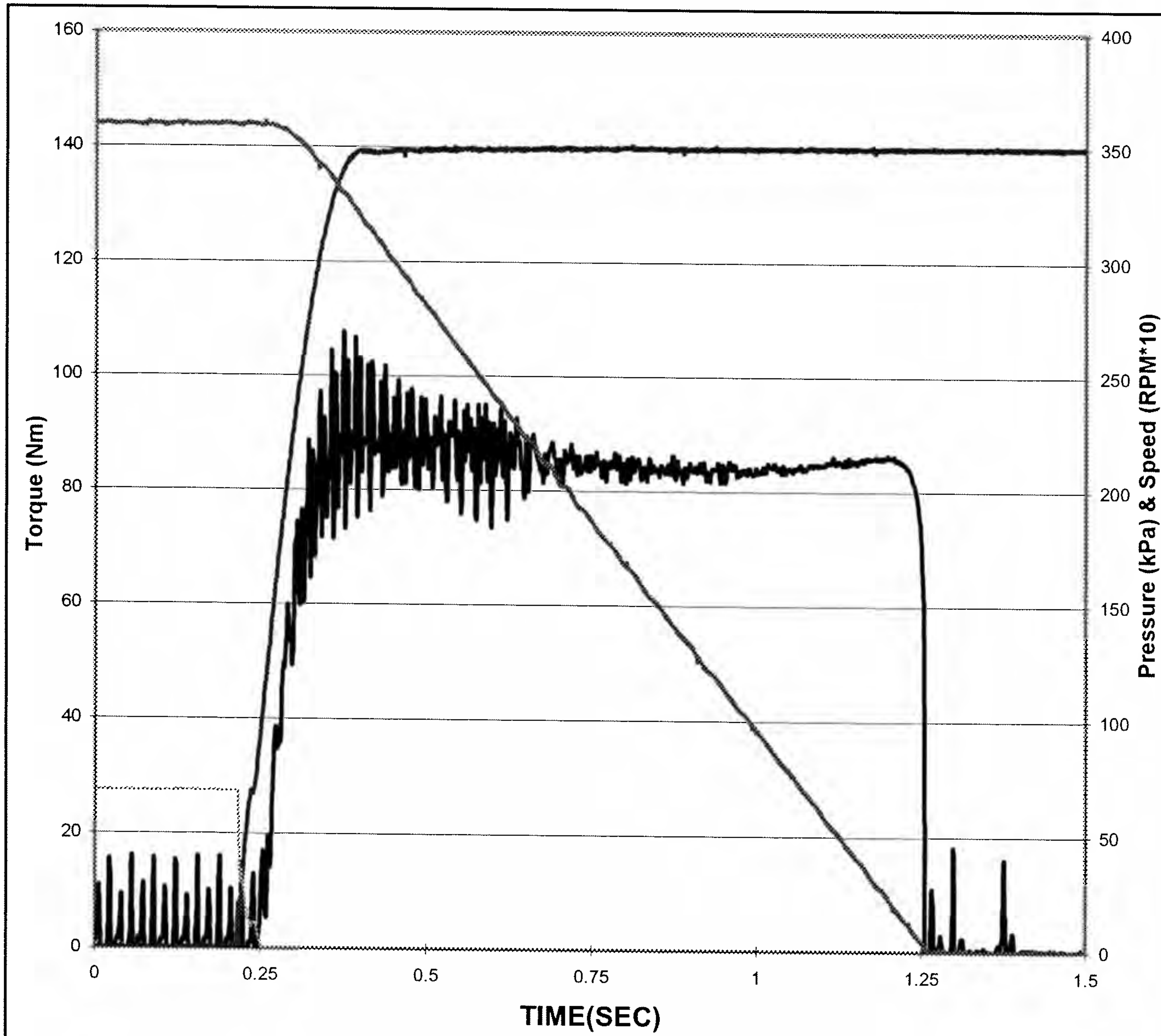

Date of Test:	9/18/2007
Time of Test:	11:08:02
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	165
Cycle Number:	29700
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.6 KJ *(15.4 - 16.0)*
Engage Time:	1.04 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	85 N*m *(80 - 105)*
Max - Mid:	1 N*m *(<30)*
End - Mid:	-14 N*m
End:	71 N*m *(Report)*

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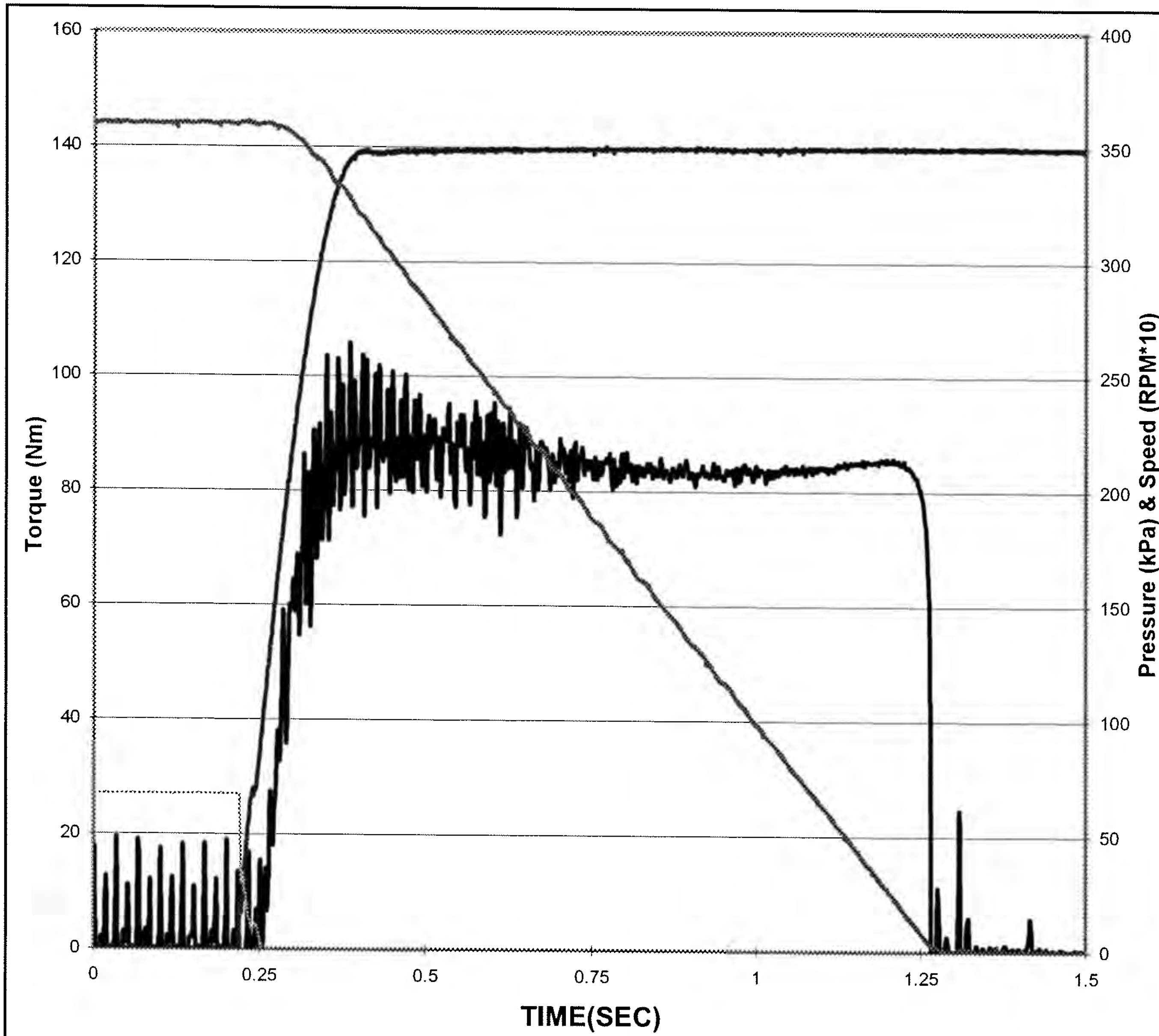

Date of Test:	9/18/2007
Time of Test:	16:08:03
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	170
Cycle Number:	30600
Temperature:	141 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.01 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	84 N*m *(80 - 105)*
Max - Mid:	2 N*m *(<30)*
End - Mid:	-12 N*m
End:	73 N*m *(Report)*

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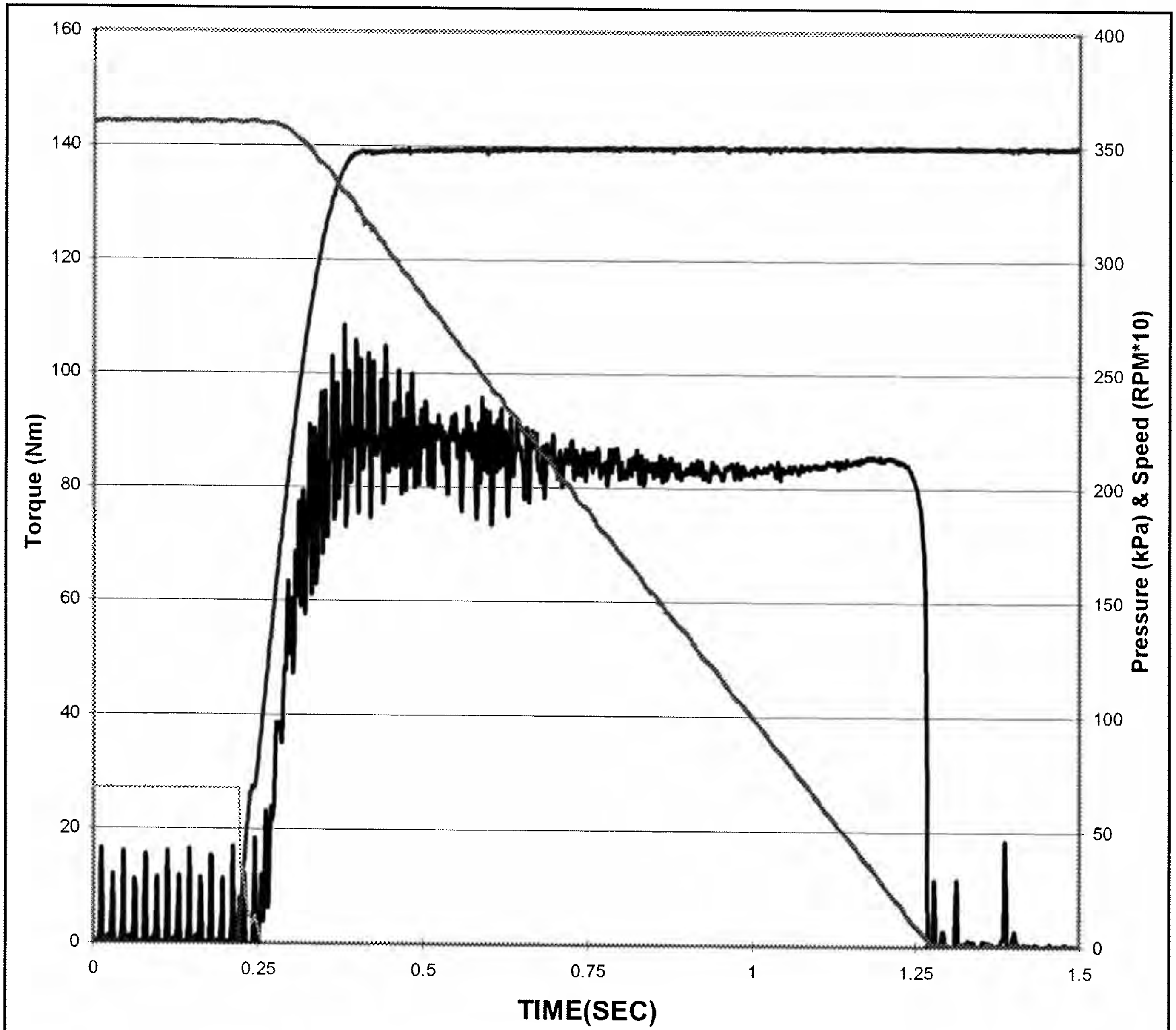

Date of Test:	9/18/2007
Time of Test:	21:08:04
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	175
Cycle Number:	31500
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.05 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	85 N*m *(80 - 105)*
Max - Mid:	1 N*m *(<30)*
End - Mid:	-14 N*m
End:	71 N*m *(Report)*

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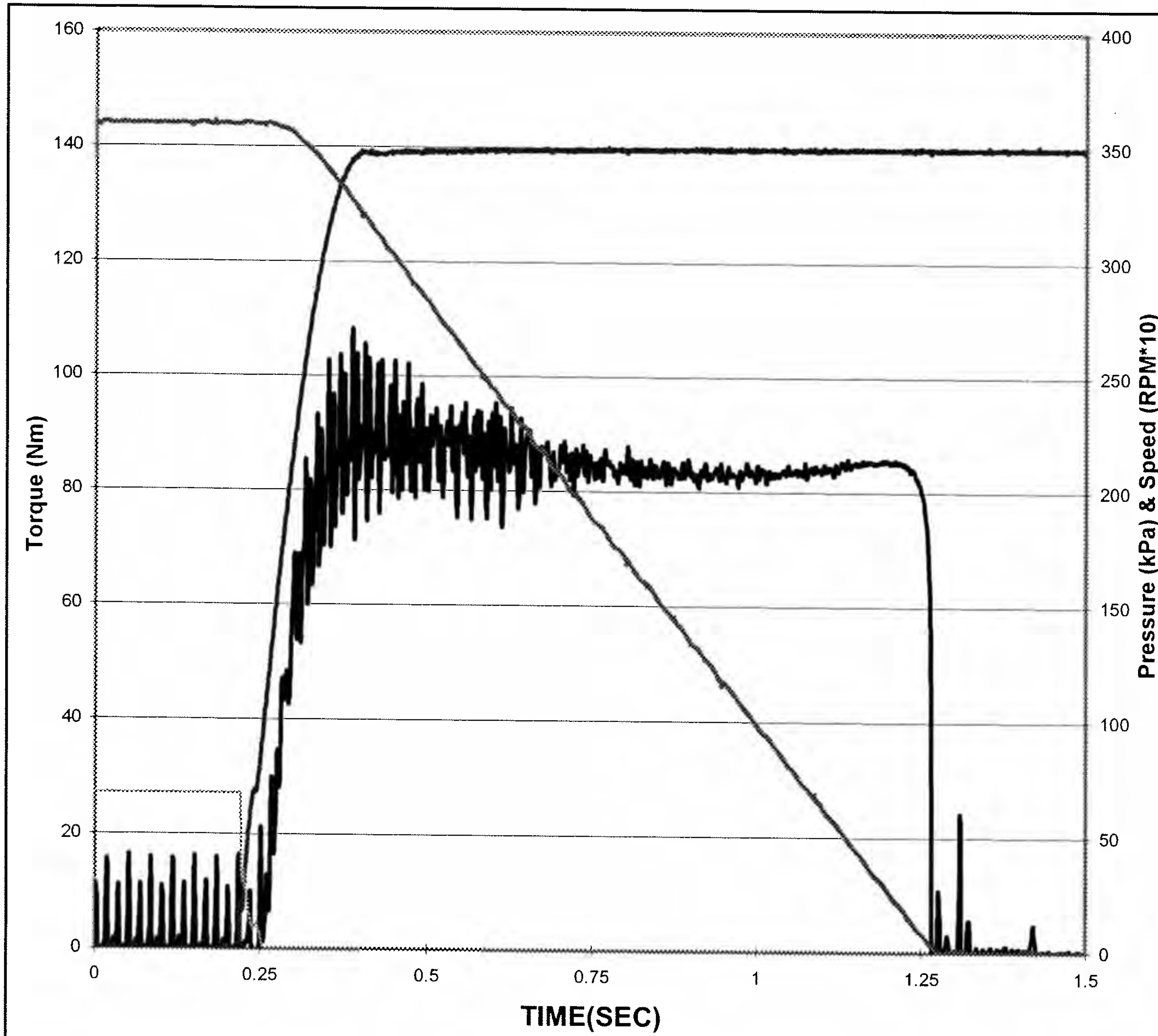

Date of Test:	9/19/2007
Time of Test:	2:08:04
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	180
Cycle Number:	32400
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.05 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	84 N*m *(80 - 105)*
Max - Mid:	1 N*m *(<30)*
End - Mid:	-13 N*m
End:	72 N*m *(Report)*

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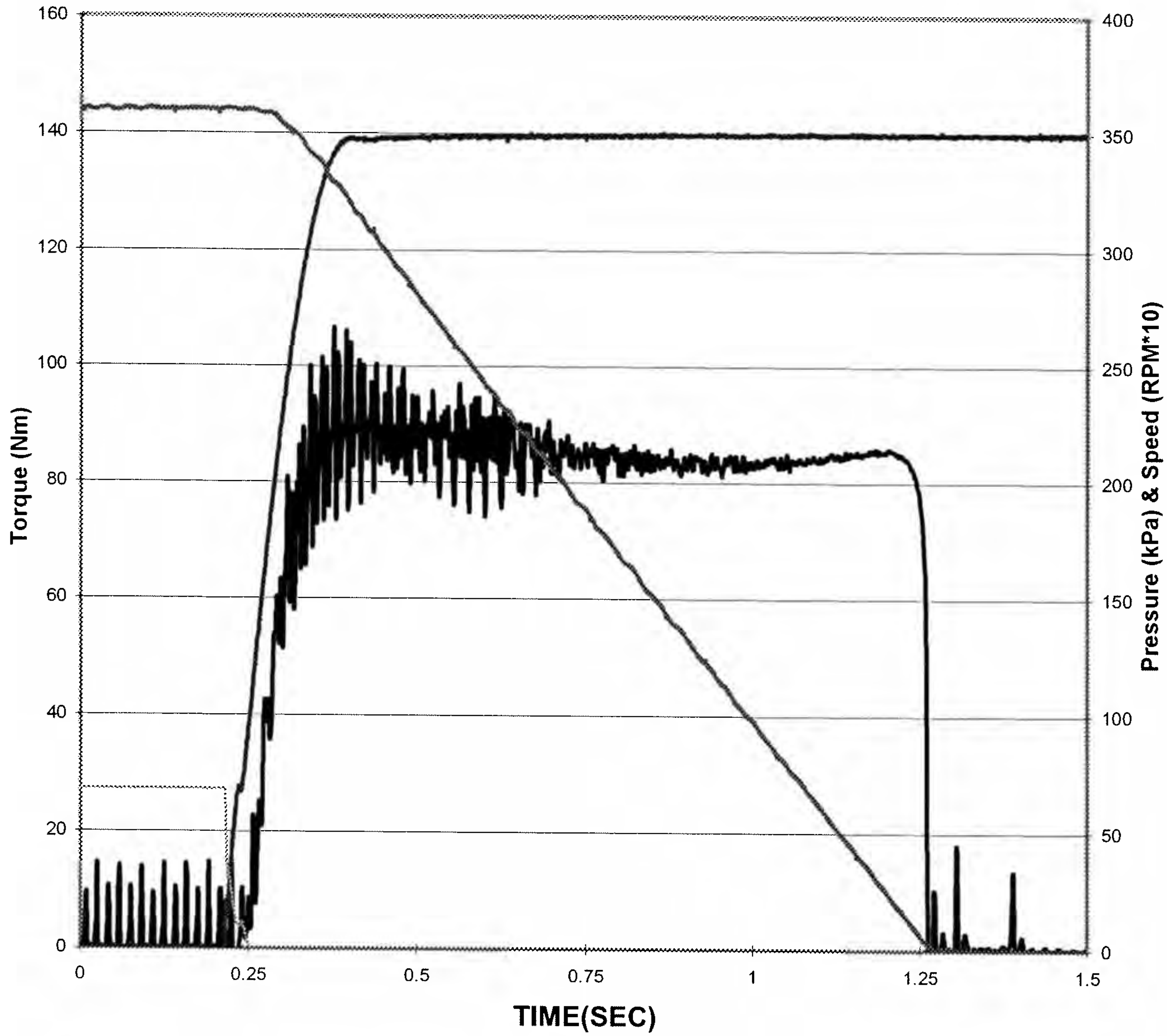

Date of Test:	9/19/2007
Time of Test:	7:08:05
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	185
Cycle Number:	33300
Temperature:	141 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.03 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	85 N*m *(80 - 105)*
Max - Mid:	1 N*m *(<30)*
End - Mid:	-15 N*m
End:	70 N*m *(Report)*

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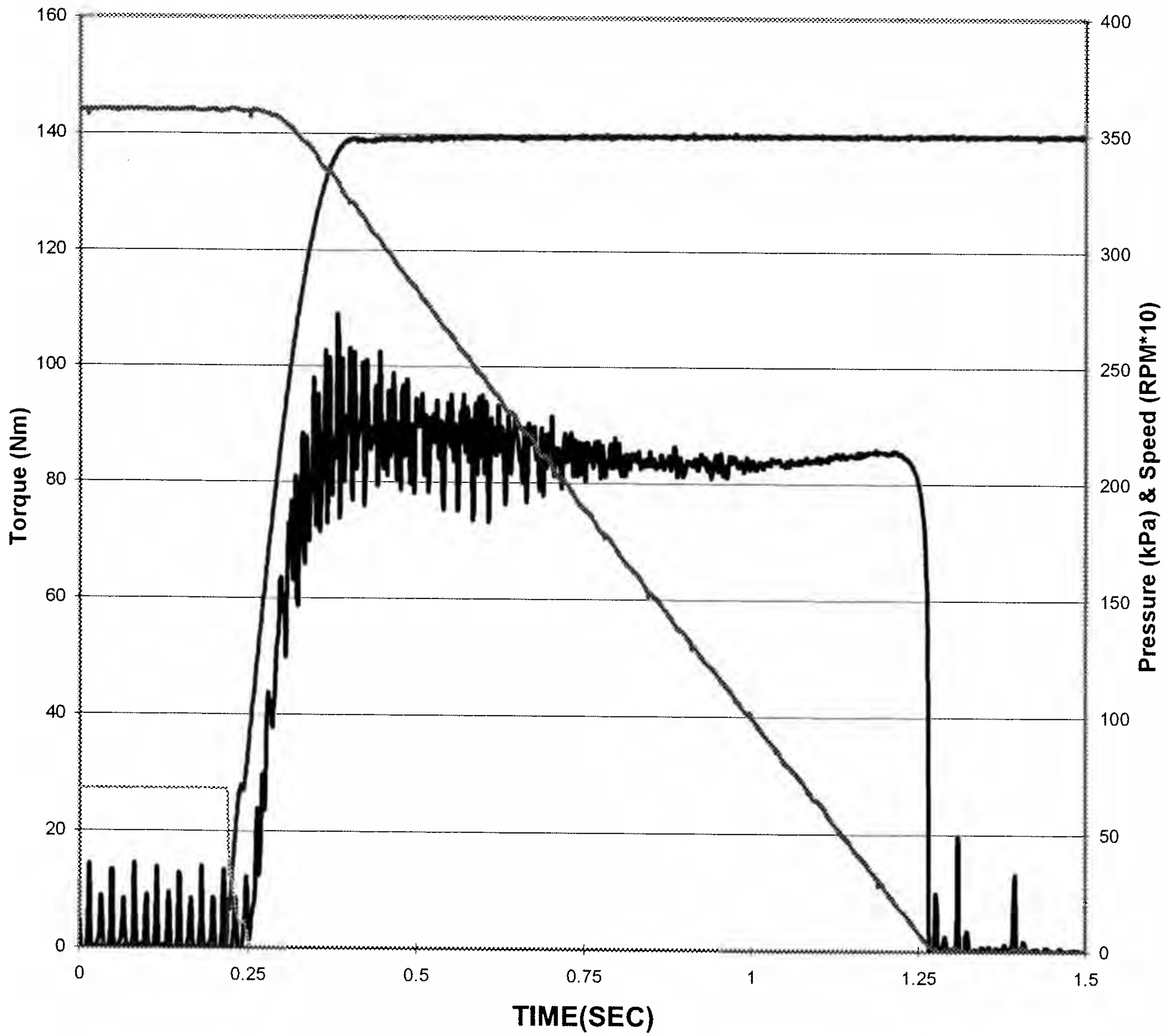

Date of Test:	9/19/2007
Time of Test:	12:08:06
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	190
Cycle Number:	34200
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.02 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	85 N*m *(80 - 105)*
Max - Mid:	1 N*m *(<30)*
End - Mid:	-14 N*m
End:	71 N*m *(Report)*

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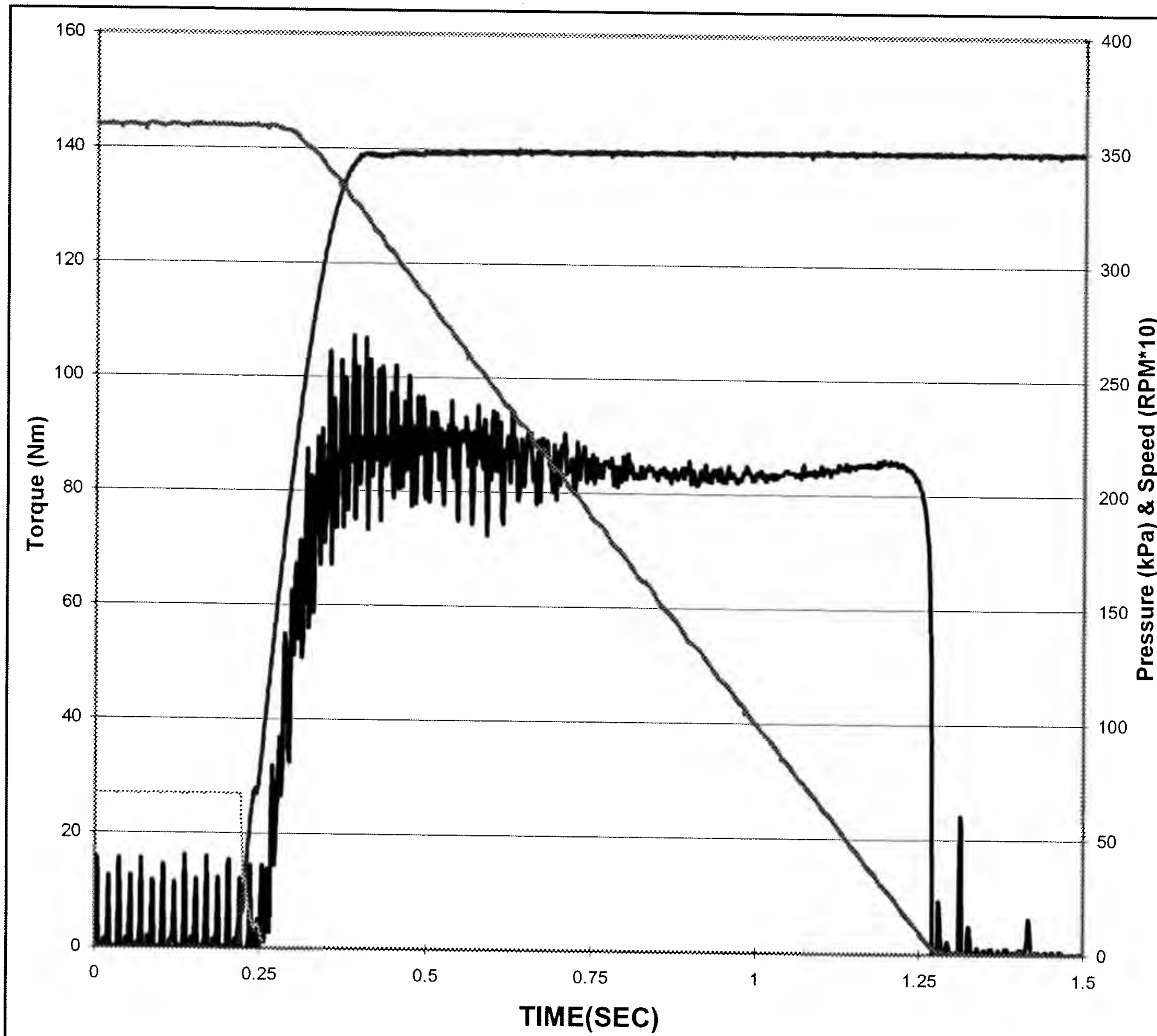

Date of Test:	9/19/2007
Time of Test:	17:08:07
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	195
Cycle Number:	35100
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.03 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	84 N*m *(80 - 105)*
Max - Mid:	2 N*m *(<30)*
End - Mid:	-14 N*m
End:	70 N*m *(Report)*

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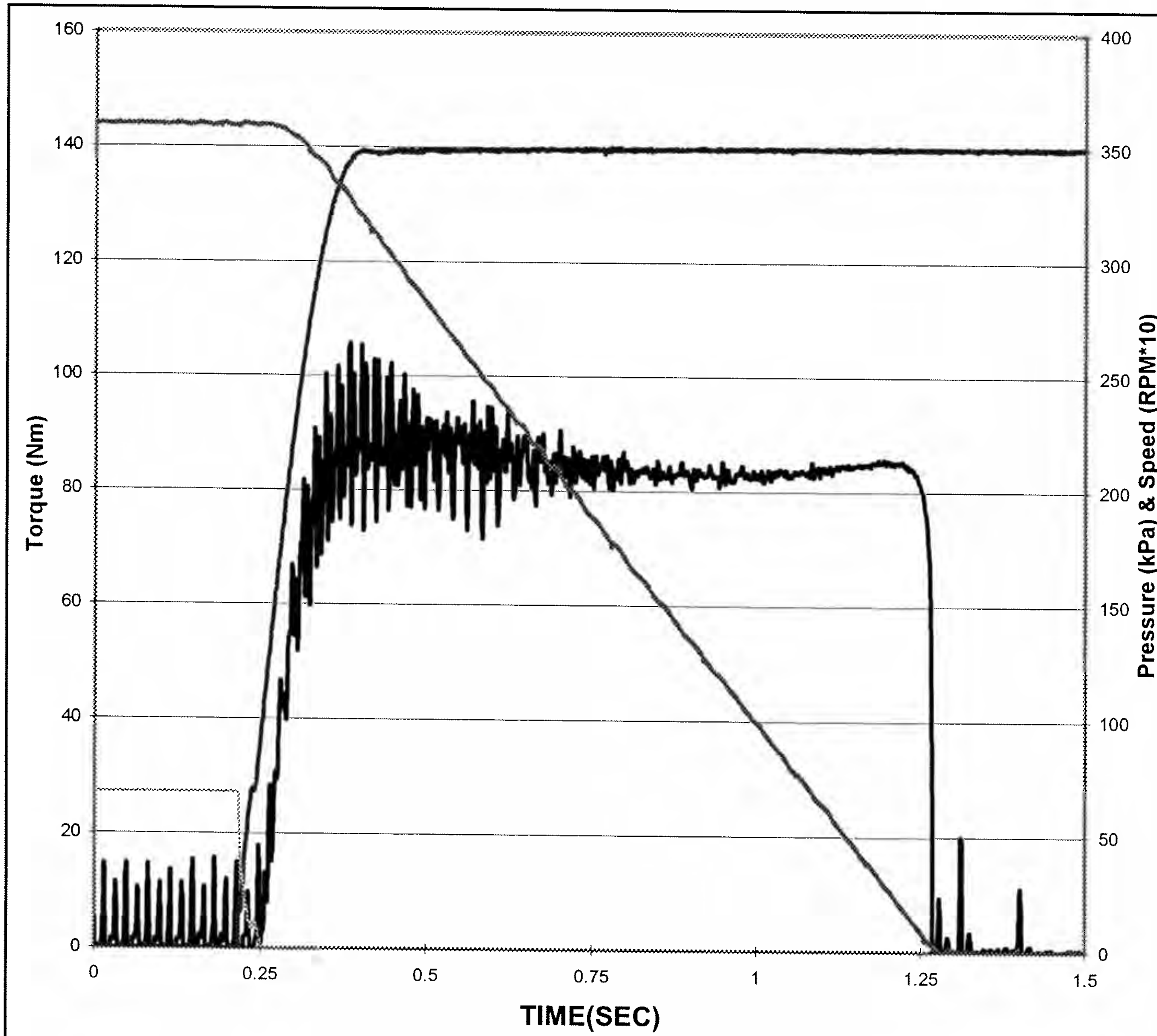

Date of Test:	9/19/2007
Time of Test:	22:08:08
Test Type:	PLATE
Test Number:	HC11-1-82
Fluid Code:	AL-27877-L
Hour Number:	200
Cycle Number:	36000
Temperature:	140 °C *(134 - 146)*
Apply Pressure:	349 kPa *(340 - 350)*
Energy:	15.7 KJ *(15.4 - 16.0)*
Engage Time:	1.04 Sec *(0.85 - 1.05)*

Torque

Maximum:	86 N*m *(>90)*
Midpoint:	84 N*m *(80 - 105)*
Max - Mid:	2 N*m *(<30)*
End - Mid:	-14 N*m
End:	71 N*m *(Report)*

SOUTHWEST RESEARCH INSTITUTE®
San Antonio, Texas

Fuels and Lubricants Research Division

Report on

John Deere JDQ-96
Performed using 1400 Series Axle

Conducted for

ARMY LAB

AL-27877-L

Test Number
07793

October 10, 2007

Submitted by:

Michael D. Lochte
Manager
Specialty & Driveline Fluids Evaluations

The results of this report relate only to the items tested.
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John Deere JDQ-96 Performed using 1400 Series Axle

General Information

Oil Code: AL-27877-L	E.O.T. Date: October 10, 2007

Purpose

The purpose of this test was to evaluate the anti-chatter properties of this oil on the brakes of a 1400 series John Deere Inboard Planetary Axle.

Test Procedure

The test was performed as specified by John Deere Product Engineering. The only changes made to the Deere procedure were those necessary to compensate for a different spiral bevel gear ratio. This procedure is proprietary to Deere and Company.

Data Interpretation

The capacity for each engagement is the average torque during the middle of the engagement. The torque variation is the greatest difference between the maximum and minimum torque recorded during any 0.2-second portion of the engagement. The SwRI variation is the sum of all differences between the maximum torque and minimum torque for each engagement. It is obtained by summing all torque variations of each 0.2-second time block of all engagements.

Test Number

The run number listed on this report is a random number and is not sequential. Only SwRI® can link this run number to test type, oil code, and end-of test date.

John Deere JDQ-96 Performed using 1400 Series Axle

Results

Oil Code: OR-97584	E.O.T. Date: October 10, 2007

The candidate results can be compared to the baseline reference average. Pass or fail decisions are only made by John Deere Product Engineering. The current reference baseline average is the average of the five most recent tests.

Current Reference Baseline Average (N · m)					
	1,000 Cycles	**10,000 Cycles**	**20,000 Cycles**	**30,000 Cycles**	**TOTAL**
Relative Capacity	338,535	338,534	341,629	343,274	1,361,972
Torque Variation	79,214	84,272	79,152	74,708	317,346

Results From Test Candidate AL-27877-L					
	1,000 Cycles	**10,000 Cycles**	**20,000 Cycles**	**30,000 Cycles**	**TOTAL**
Relative Capacity	345,338				
Torque Variation	154,990				

Tables 1 of the Appendix contains chatter test results from 1,000cycles. Table 2 contains results of the five current baseline reference tests. Figures 1 through 4 are graphic presentations of candidate oil performance compared to baseline reference data.

Figure 5 is a graphic presentation of 1000-cycle reference results and AL-27877-L. Table 3 contains the history of reference tests.

John Deere JDQ-96 Performed using 1400 Series Axle

Oil Code: AL-27877-L	**E.O.T. Date:** October 10, 2007

Appendix

Tables

1. Table 1 – Durability results 1,000 cycles Candidate Oil
2. Table 2 – Reference Data Compared to Candidate Data
3. Figure 1 & Figure 2 - Torque Variation Chart
4. Figure 3 & Figure 4 – Relative Capacity & Average Disk Thickness Chart
5. Figure 5 - Graphic presentation of 1000 cycle reference results & Candidate
6. Table 3 - History of reference tests

October 10, 2007

TABLE 1: JDQ-96 DURABILITY TEST RESULTS 1,000 CYCLES

SwRI Oil Code LO-223703 Sponsor Oil Code AL-27877-L

Axle Speed (rpm)	Brake Press. (kPa)	TORQUE VARIATION TEST RESULTS (TORQUE and VARIATION in Nm)											
		Oil Temp. 32°C			Oil Temp. 49°C			Oil Temp. 60°C			Oil Temp. 71°C		
		Torque	Variation	Temp.	Torque	Variation	Temp.	Torque	Variation	Temp.	Torque	Variation	Temp.
8	3831	3995	4280	29	4346	1670	50	4388	1610	61	4341	1390	72
10	3831	4138	4430	29	4288	1930	49	4278	1990	60	4251	1670	71
15	3831	3943	3250	29	4160	2420	48	4161	2130	59	4190	1790	70
20	3831	4171	1310	29	4073	2870	48	4223	1580	59	4152	1770	70
25	3831	4140	1280	29	4158	1410	49	4167	1640	60	4064	1720	71
30	3831	4140	1330	30	4113	1570	50	4120	1760	60	4026	1790	71
35	3831	4115	1270	31	4029	1410	50	4029	1670	61	3960	1680	71
40	3831	4119	1340	32	4065	1460	50	4059	1660	61	3954	1720	71
45	3831	4085	1270	33	3975	1570	50	3963	1710	61	3872	1740	71
50	3831	4023	1290	34	3926	1510	51	3899	1660	61	3840	1670	71
55	3831	3977	1180	32	4057	1390	52	4041	1560	62	3966	1690	71
60	3831	3901	1090	29	3855	1420	48	3841	1540	58	3901	1620	71
15	1532	1701	680	31	1786	860	49	1805	890	58	1832	890	71
15	2300	2523	830	31	2599	1060	48	2641	1120	58	2597	1170	71
15	3065	3290	2670	31	3176	2640	48	3196	2120	58	3381	1410	71
15	3831	4136	3040	31	4098	2920	48	4165	2770	58	4247	1840	71
15	4598	5049	3140	31	5029	3010	48	5078	2840	58	5089	1970	71
15	5364	5954	3470	31	5926	2980	48	5925	2790	58	5854	2130	71
15	6130	6922	3240	31	6833	2570	48	6834	2380	60	6835	2250	71
15	7050	7954	3210	32	7799	2510	49	7778	2350	60	7832	2530	71

Temp (°C)	Relative Capacity (Nm)	Torque Variation (Nm)	SwRI Variation (Nm)
32	86,275	43,600	610,080
49	86,291	39,180	498,700
60	86,589	37,770	515,000
71	86,183	34,440	516,040
TOTAL	345,338	154,990	2,139,820

TABLE 2: JDQ-96 REFERENCE DATA COMPARED TO CANDIDATE DATA

EOT Date: October 10, 2007

Oil Code : AL-27877-L

Reference Oil Coded : 69X31111i	Cycles	Relative Capacity	Torque Variation	SwRI Variation	Average Facing Thickness (millimeters)
First Reference Run					
	1,000	326,304	57,420	730,050	7.60
	10,000	331,809	64,900	804,030	7.50
	20,000	345,325	69,500	899,880	7.44
	30,000	341,770	66,210	810,190	7.39
	Total	1,345,208	258,030	3,244,150	
Second Reference Run					
	1,000	337,791	66,660	848,580	7.60
	10,000	338,055	92,240	1,129,330	7.55
	20,000	343,166	77,010	1,001,920	7.49
	30,000	350,470	73,280	863,980	7.44
	Total	1,369,482	309,190	3,843,810	
Third Reference Run					
	1,000	339,375	100,390	1,204,240	7.56
	10,000	335,754	106,780	1,079,450	7.52
	20,000	334,120	84,770	1,030,270	7.49
	30,000	335,614	79,620	1,021,190	7.47
	Total	1,344,863	371,560	4,335,150	
Fourth Reference Run					
Run on new backing pla	1,000	343,906	79,990	1,020,120	7.48
and piston	10,000	343,056	72,520	893,570	7.30
	20,000	342,668	69,920	885,870	7.07
	30,000	345,315	70,360	833,920	6.90
	Total	1,374,945	292,790	3,633,480	
Invalid test run on same	*1,000*	*348,860*	*132,110*	*1,721,010*	
backing plate and pistor	*10,000*	*323,093*	*153,860*	*1,919,720*	
as test above was run on					
Fifth Reference Run					
most recent run	**1,000**	**345,296**	**91,610**	**1,125,260**	**7.50**
Run on new backing	**10,000**	**343,999**	**84,920**	**1,019,400**	**7.33**
plate and piston	**20,000**	**342,864**	**94,560**	**1,264,070**	**7.22**
	30,000	**343,201**	**84,070**	**1,052,400**	**7.11**
	Total	**1,375,360**	**355,160**	**4,461,130**	
AL-27877-L		Candidate Oil Test Results			
	1,000	345,338	154,990	2,139,820	
	10,000				
	20,000				
	30,000				
	Total	345,338	154,990	2,139,820	

Figure 1

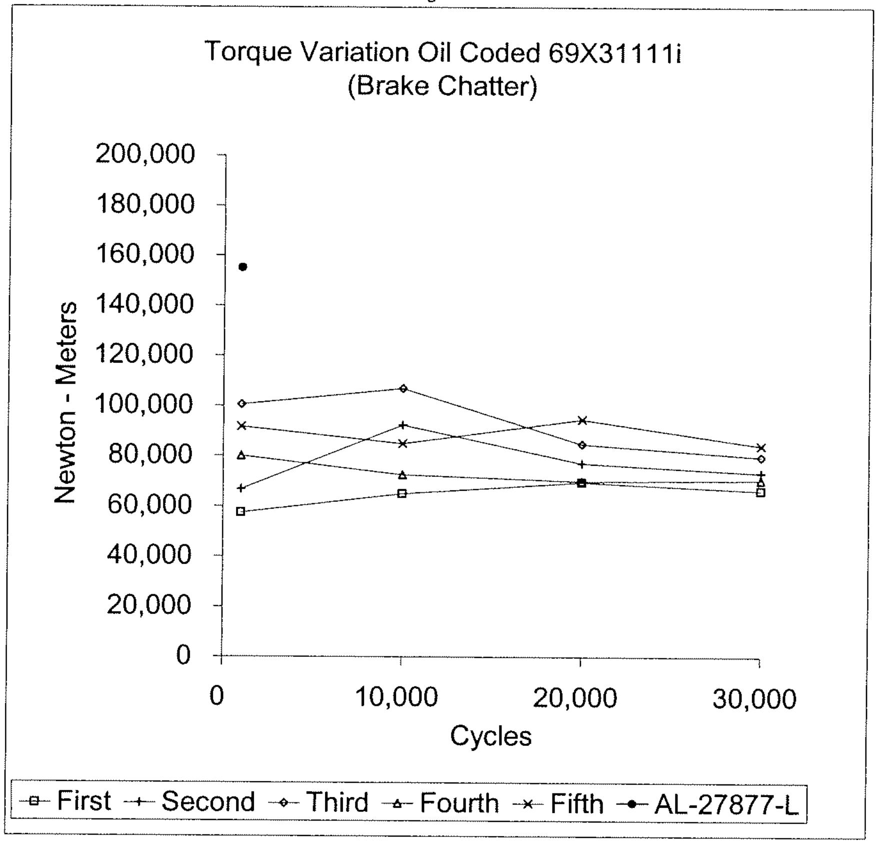


Figure 2

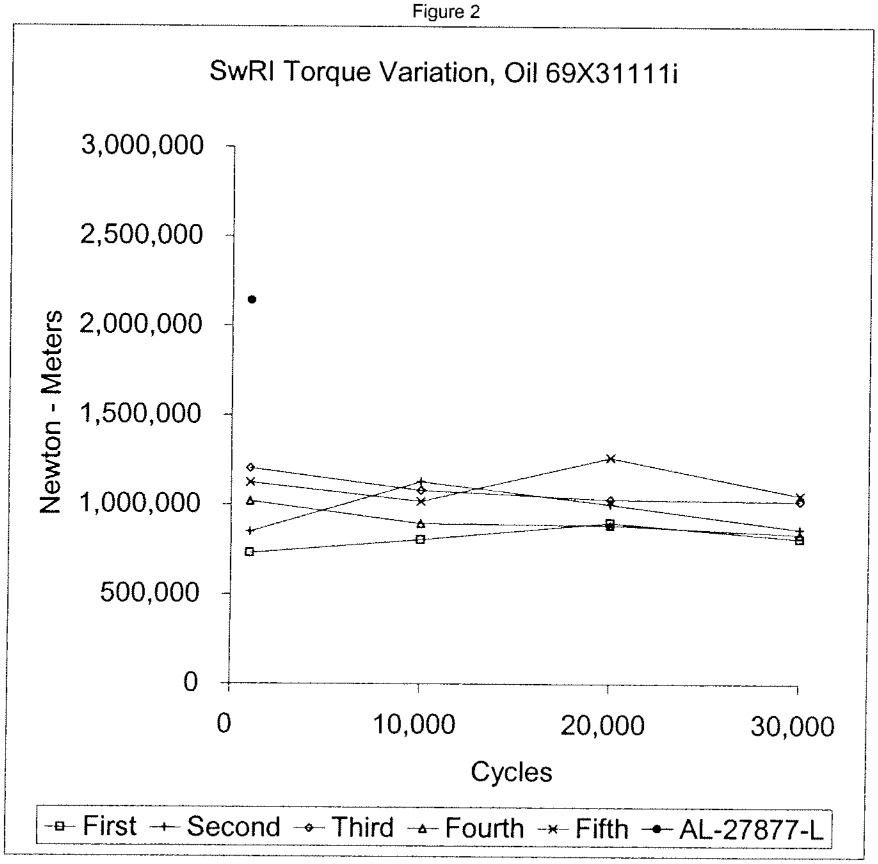


Figure 3

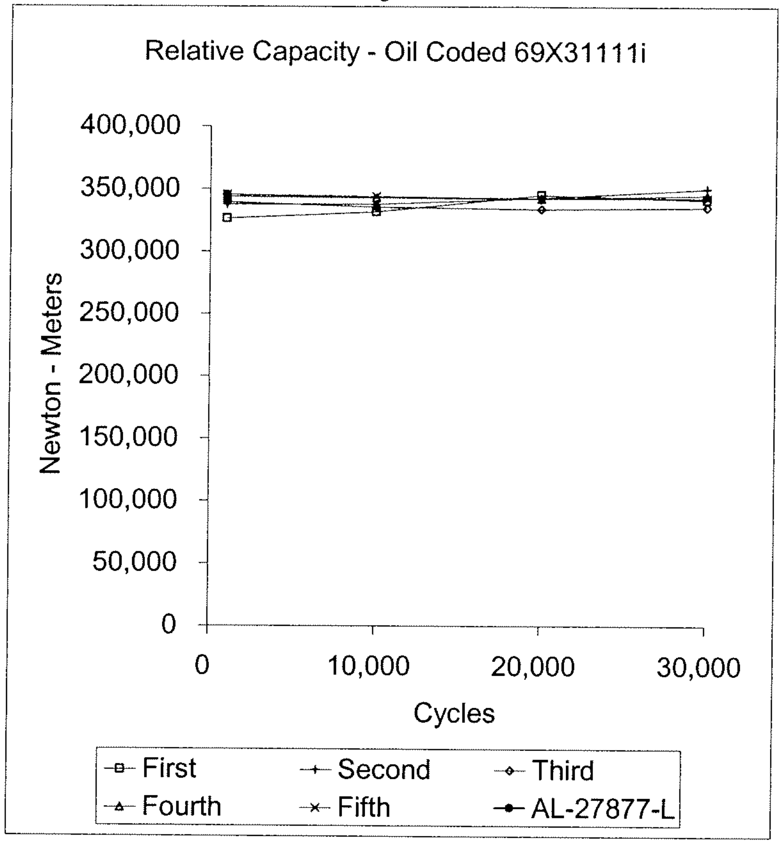
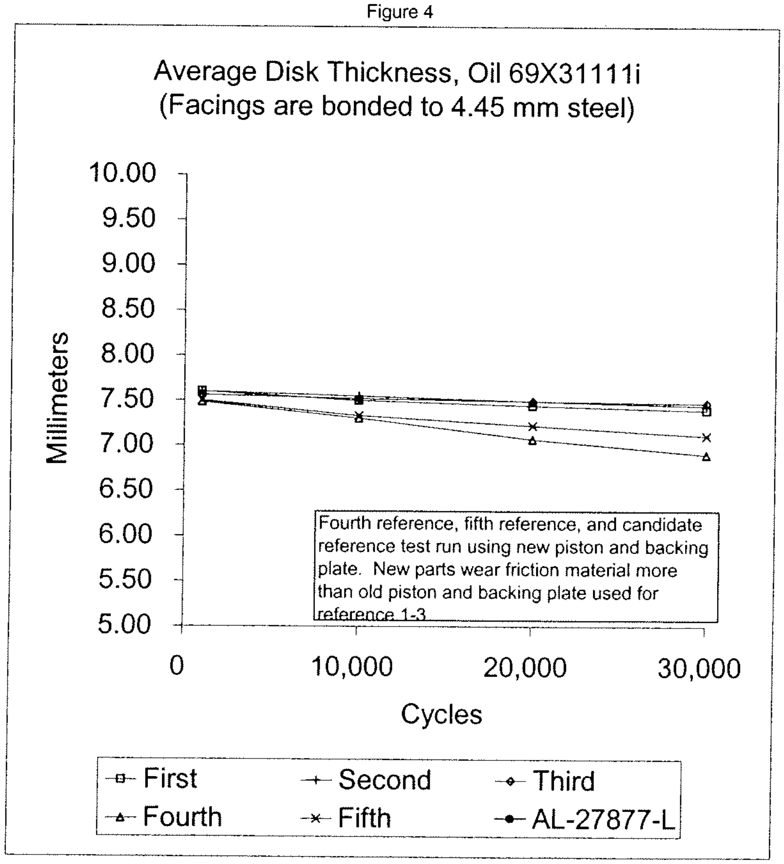
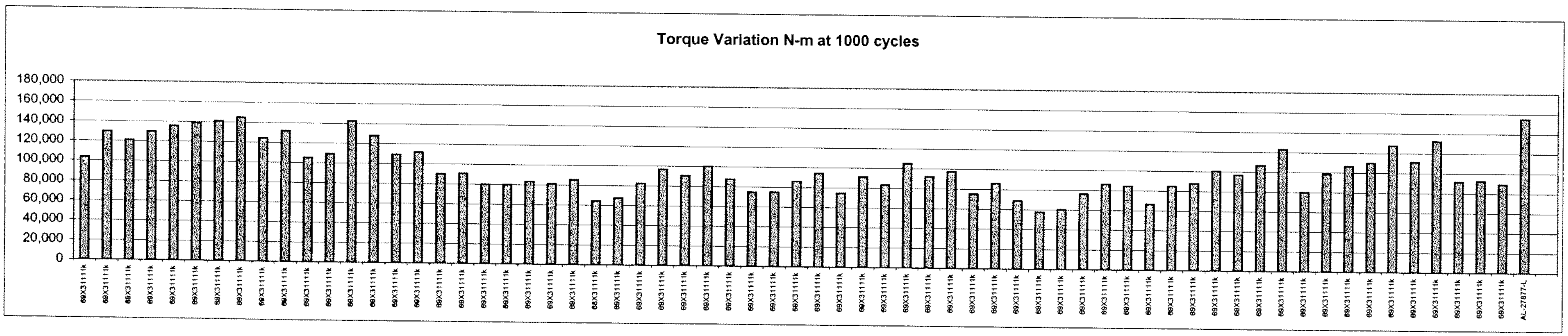


Figure 4





AL-27877-L

October 10, 2007

Figure 5

Table 3

AL-27877-L October 10, 2007

History of 1000 cycle reference tests.

		Torque variation at 1000 cycles
69X31111k	1999 brake disk	103,360
69X31111k	1997 brake disk	129,540
69X31111k	2000 brake disk	121,120
69X31111k	2000 brake disk	129,620
69X31111k	2000 brake disk	135,700
69X31111k	2000 brake disk	138,760
69X31111k	2000GDD brake	140,830
69X31111k	2000GDD brake	144,820
69X31111k	2000GDD brake	124,310
69X31111k	2000 GDD brak	131,860
69X31111k	2000 GDD brak	105,010
69X31111k	2000 GDD brak	109,220
69X31111k	2000 GDD brak	142,510
69X31111k	2000 GDD brak	128,080
69X31111k	2000 GDD brak	109,100
69X31111k	2000 GDD brak	111,800
69X31111k	2000 GDD brak	90,070
69X31111k	2000 GDD brak	90,810
69X31111k	2000 GDD brak	79,930
69X31111k	2000 GDD brak	79,930
69X31111k	2000 GDD brak	83,190
69X31111k	2000 GDD brak	81,220
69X31111k	2000 GDD brak	85,570
68X31111k	2000 GDD brak	64,170
69X31111k	2000 GDD brak	67,390
69X31111k	2000 GDD brak	82,410
69X31111k	2000 GDD brak	96,730
69X31111k	2000 GDD brak	90,390
69X31111k	2000 GDD brak	99,960
69X31111k	2000 GDD brak	87,380
69X31111k	2000 GDD brak	74,720
69X31111k	2000 GDD brak	74,940
69X31111k	2000 GDD brak	85,980
69X31111k	2000 GDD brak	94,410
69X31111k	2000 GDD brak	74,300
69X31111k	2000 GDD brak	90,950
69X31111k	2000 GDD brak	83,190
69X31111k	2000 GDD brak	105,210
69X31111k	2000 GDD brak	91,960
69X31111k	2000 GDD brak	97,320
69X31111k	2000 GDD brak	75,040
69X31111k	2000 brake disk	86,060
69X31111k	2000 brake disk	68,590
69X31111k	2003 brake disk	57,420
69X31111k	2003 brake disk	60,330
69X31111k	2003 brake disk	76,260
69X31111k	2003 brake disk	86,210
69X31111k	2003 brake disk	84,550
69X31111k	2003 brake disk	66,660
69X31111k	2003 brake disk	84,760
69X31111k	2003 brake disk	87,800
69X31111k	2003 brake disk	100,390
69X31111k	2003 brake disk	96,620
69X31111k	2003 brake disk	106,710
69X31111k	2003 brake disk	123,110
69X31111k	NEW BACKING	79,990
69X31111k		98,440
69X31111k		106,370
69X31111k		110,040
69X31111k		127,550
69X31111k		111,280
69X31111k	invalid run	132,110
69X31111k	BACKING Plate and	91,610
69X31111k	BACKING Plate and	92,230
69X31111k	plate used for 1 test	89,200
AL-27877-L	same brake plate and piston as	154,990