Test Monitoring Center
6555 Penn Avenue
Pittsburgh, PA 15206-4489
(412) 365-1000

Memorandum: 01-052

Date: May 10, 2001

To: William M. Nahumck, Chairman, Sequence IIIF Surveillance Panel

From: Michael T. Kasimirsky

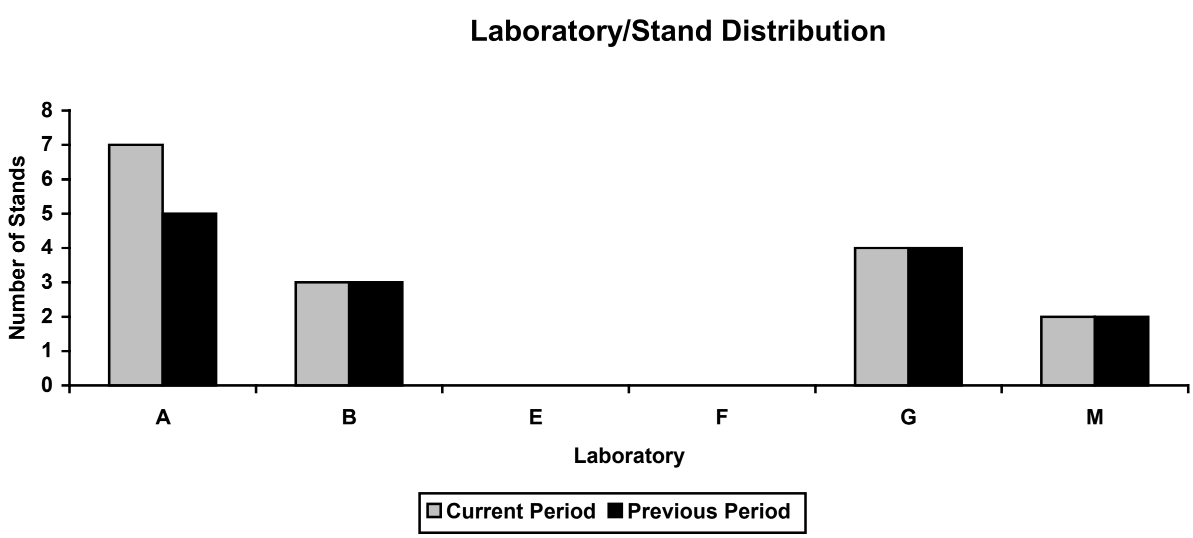
Subject: Sequence IIIF Semiannual Report: October 1, 2000 through March 31, 2001

The following is a summary of Sequence IIIF reference tests that were reported to the Test Monitoring Center during the period October 1, 2000 through March 31, 2001.

Lab/Stand Distribution

	Reporting Data	Calibrated as of September 30, 2000
Number of Laboratories:	4	4
Number of Test Stands:	16	13

The following chart shows the laboratory/stand distribution:

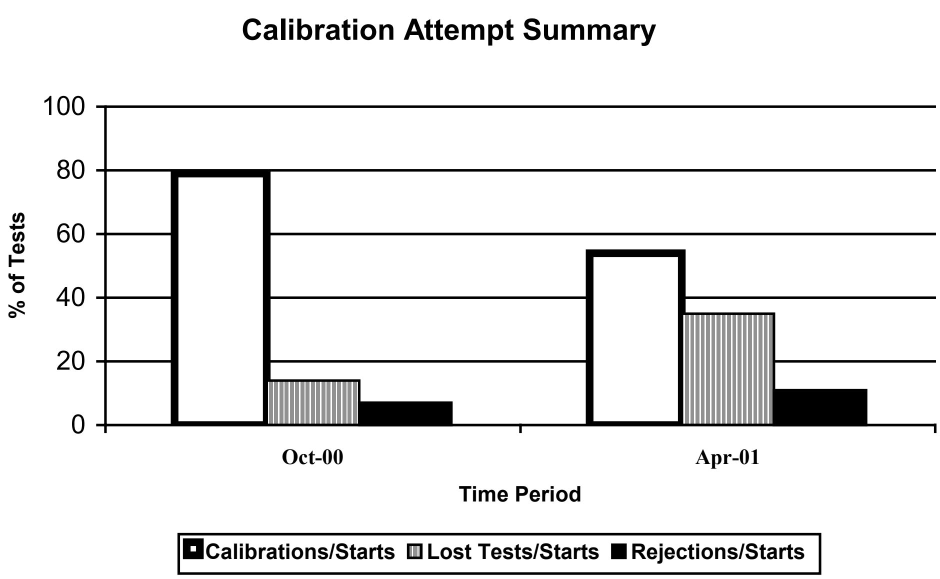


The following summarizes the status of the reference oil tests reported to the TMC:

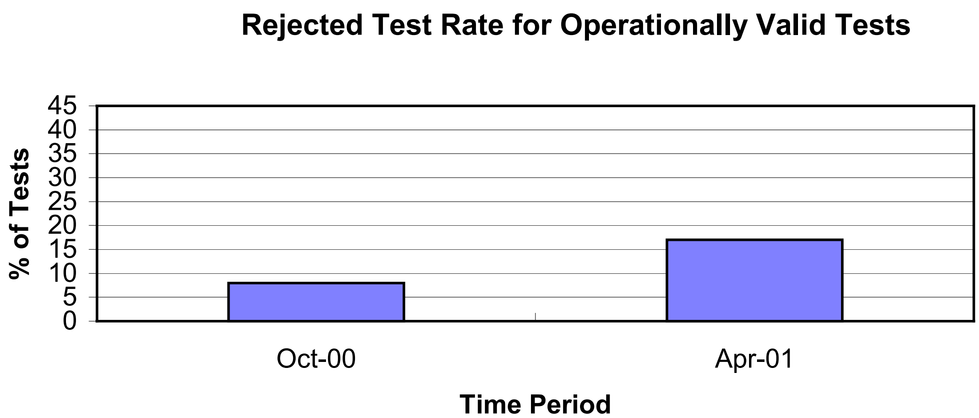
Calibration Start Outcomes	**TMC Validity Codes**	**No. of Tests**
Operationally and Statistically Acceptable	AC	34
Failed Acceptance Criteria	OC	7
Operationally Invalid (Laboratory Judgment)	LC	11
Operationally Invalid (Lab & TMC Judgment)	RC	2
Stand Failed Reference Sequence – data pulled	MC	6
Aborted	XC	3
Total		63

Donated & Industry Support Outcomes	**TMC Validity Codes**	**No. of Tests**
Decoded Runs for Stand Severity Investigation	NI	1
Total		1

Calibrations per start, lost tests per start and rejection rates are summarized below:

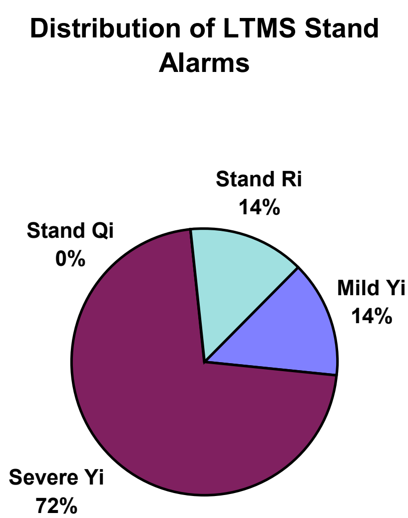


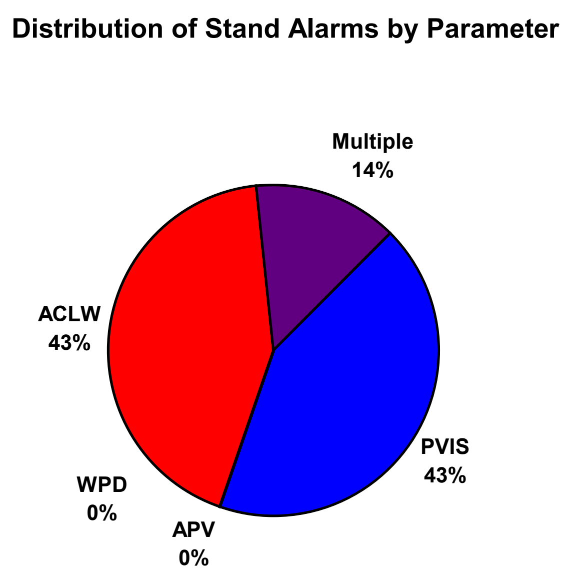
The calibration per start rate is worse than last period. The lost test rate is higher than last period. The rejected test rate is also slightly worse than last period.



The rate of rejection of operationally valid tests has increased from last period.

There were seven failing tests for the period. The following charts summarize the reasons and breakdown by parameter for the failed test:





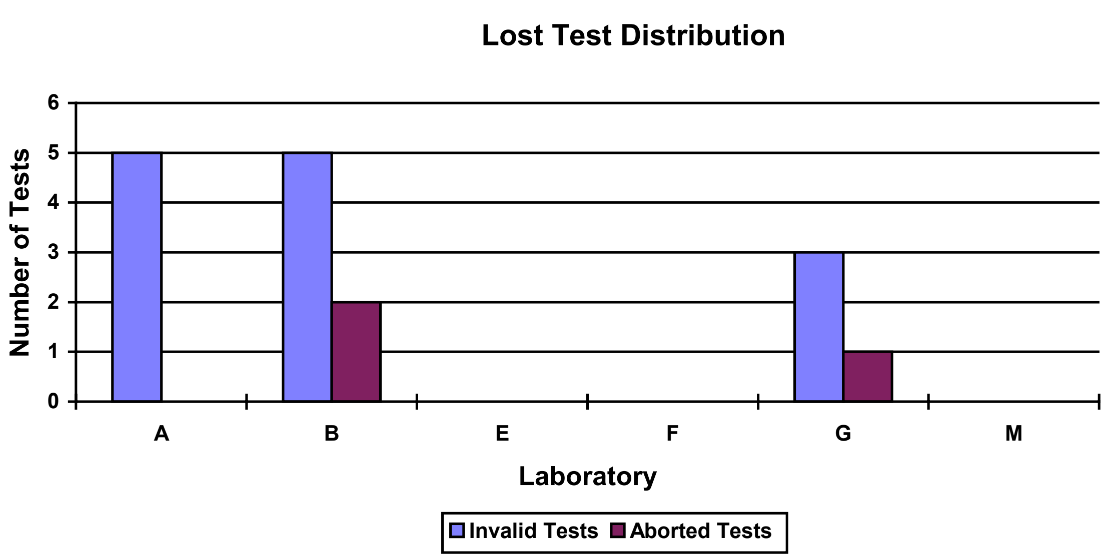
There was one LTMS Deviation written this period. There has been one deviation from the LTMS since its introduction in 2000.

<u>Lost Test Summary</u>

Nineteen tests were lost this period. The reasons for the lost tests are shown in the following table:

Lab	Reason for Lost Test	Number of Tests	Breakdown of Tests (LC/RC/XC)
A	Oil Sample Contamination	1	1/0/0
	Coolant Control Problems	1	1/0/0
	Coolant Flow Calibration Problems	3	2/1/0
B	Exhaust Back Pressure Control Problems	1	1/0/0
	Speed & Load Control Problems	1	1/0/0
	Intake Vacuum Sensor Problems	1	1/0/0
	Coolant Flow Reversed	1	0/0/1
	Exhaust Back Pressure Control Problems and Abnormal Mechanical Wear on Bearings	1	1/0/0
	Coolant Flow Problems	1	0/0/1
	Operational Data Missing	1	1/0/0
G	Down Time	1	1/0/0
	Oil Filter Block Temperature QI below zero	1	0/1/0
	Connecting Rod Bearing Failure	1	0/0/1
	Load Calibration Shift	1	1/0/0

In addition, a total of six data points from three different labs were pulled from the LTMS data set and given an "MC" validity code. Lab A pulled one stand from the LTMS due to mild viscosity increase problems, resulting in two pulled data points. Lab B pulled one stand from the system due to mild viscosity increase problems, resulting in two pulled data points. Lab G also pulled one stand from the system due to mild viscosity increase problems, resulting in two pulled data points.



Information Letters

Sequence IIIF Information Letter No. 00-2, Sequence No. 2, dated October 13, 2000 was issued during the period and contained Used Oil Sample Testing, Revised Quality Index U&L Values, Revised Ring Sticking Definitions, Using Test Oil to Assemble Test Engines, and Revised Oil Consumption Limits on Test Validity

Sequence IIIF Information Letter No. 00-3, Sequence No. 3, dated December 21, 2000 was issued during the period and contained Non-reference Oil Test Interpretability Criteria.

Severity and Precision Analysis

Below is a summary of the average Δ/s, pooled standard deviation, and average Δ in reported units for the tests reported during this period. Also below is a summary of the average Δ/s value, by parameter, for all laboratories reporting data during this period.

Industry Severity Summary			
Parameter	Average Δ/s	Pooled standard deviation (degrees of freedom)	Average Δ, in reported units
PVIS	0.285	0.011 (df=38)	26.5% Viscosity Increase[1]
APV	0.113	0.189 (df=38)	0.03 merits
WPD	-0.206	0.589 (df=38)	-0.18 merits

[1] At the GF-3 Pass Limit of 275% Viscosity Increase

Average Δ/s Results, by Laboratory			
Laboratory	PVIS	APV	WPD
A	0.16	0.09	-0.41
B	0.86	0.12	0.17
E	-	-	-
F	-	-	-
G	0.28	0.35	-0.19
M	-0.36	-0.40	-0.32

Percent Viscosity Increase (PVIS)

The industry experienced two severity and one precision alarm during the period (see figures 1, 4, and 7). The severity alarms were of three and one data point in duration. The three-point alarm was caused by a test that returned a result of 3.2 standard deviations mild of target, causing the industry alarm. Subsequent testing cleared that alarm. The single-point alarms were both caused by failing test results (approximately 2 standard deviations from target in both cases) and were cleared by subsequent testing in industry.

At the last meeting of the Surveillance Panel, the TMC was tasked with investigating if elevated lead and copper levels in the test oil were impacting viscosity severity. To this end, the TMC analyzed the ICP analysis of the used oil samples for iron, copper, and lead to determine what effect, if any, these factors had on test severity. The data was analyzed in several different ways. The percent viscosity increase results were compared to a "total iron" number (generated by summing the individual used oil sample results into an overall test composite value) as well as comparing the viscosity results to individual

10-hour sample results. The process was then repeated in a similar manner for both copper and lead content.

The results of the analysis showed that while the relation between EOT iron, copper, and lead levels and percent viscosity increase results are significant, there is not a strong correlation between the them. EOT iron content had the strongest relationship with an R^2 value of 0.36, compared to 0.14 for copper and 0.10 for lead. The analyses of the individual 10-hour results for iron, copper, and lead showed an even weaker correlation and many of the relationships were not significant at the 95% confidence level.

An analysis of blowby results, both average and total (calculated using a methodology similar to the "total iron" value calculated above) also did not yield any useful information.

Weighted Piston Deposits (WPD)

The industry was within limits for both severity and precision for the period, with the exception of a severity alarm of four data points (see figures 2, 5, and 8). Precision for the period was within limits. The alarm was caused by several severe, but passing, reference oil tests in a row. Nothing noteworthy regarding these tests was found and the industry returned within limits with subsequent testing.

Average Piston Skirt Varnish (APV)

The industry was within limits for the period on both severity and precision with the exception of two single-point precision alarms (see figures 3, 6, and 9). The first was caused by a severe failing reference oil test and the second was caused by a severe but passing reference oil test. In both cases, the industry returned within limits with the next test result.

Average Camshaft-plus-Lifter Wear (ACLW)

There has been some concern in industry regarding wear performance in the Sequence IIIF test, specifically related to the number of wear failures (43% of all failing reference oil tests this period). This is alarming for no other reason than the fact that the ACLW was set at 20 µm because it was thought that this level would be far above the expected wear levels.

The TMC was asked to examine several factors relating to this situation. One factor to be considered was the change to the engine build procedure made as part of Information Letter 00-2 eliminating the use of test oil in favor of build-up oil in assembling the valve train of a Sequence IIIF test engine. Another factor was the camshaft batch change from Pour Code 4 camshafts (*JBxxxx* serial numbered camshafts) to Pour Code 5 camshafts (*LCxxxx* serial numbered camshafts). Unfortunately, these two changes took place almost simultaneously in that the LC camshafts were introduced in August 2000 and by October 2000 all test engines were being built with build-up oil. No JB camshaft runs were made with engines assembled with build-up oil and only seven runs were made with LC camshafts on engines built with test oil; the remaining ones were built with build-up oil. As a result, there is only limited data to examine relating to these two factors. A comparison of the two camshaft batches, performed by reference oil to eliminate the difference in reference oil performance level, shows no significant differences between the JB and LC camshafts. The following table shows the average wear performance of the two camshaft batches, calculated by reference oil:

Average Camshaft-plus-Lifter Wear Results		
Reference Oil	JB Camshaft Mean (N size)	LC Camshaft Mean (N size)
1006	6.867 (9)	8.125 (16)
1008	7.383 (6)	10.756 (18)
433	9.400 (5)	15.043 (14)

At the request of the Central Parts Distributor, the TMC prepared plots of wear performance, by position, of the reference oil data. These plots were prepared by reference oil and then also by reference oil and camshaft pour code. The wear results were also broken down, with plots prepared for camshaft wear, lifter wear, and then camshaft-plus-lifter wear. The result was a set of 27 plots, which is too much to include in this document, so the plots have been loaded on the TMC Web Page. They are located in the same directory as the industry LTMS plots in a Microsoft® Word® file called *IIIF Wear Plots.doc* if you would like to review them. From these plots there is at least some indication that there are differences in the hardware, but the difference is not significant at the 95% confidence level.

QI Deviations

There were twelve QI Deviations for the period. There have been fifteen deviations from the QI Limits since the test was introduced in 2000.

Three deviations were written due to Condenser Coolant Flow problems. This parameter is one that has been discussed repeatedly for revision to the QI limits or removal from the QI requirements completely. In all cases, the Condenser Coolant Out Temperature QI result was above zero.

One deviation was written due to Condenser Coolant Flow problems and also Intake Air Pressure problems. In this case, the Condenser Coolant Out Temperature QI result was also above zero. The intake air pressure problems were related to the addition of an air filter assembly to the intake air stream, changing the system dynamics and throwing the control system tuning off. The filter was added to address a lab-wide particulate problem not specifically related to Sequence IIIF testing.

Another deviation was written for Intake Air Pressure problems. This test was run on the same stand that experienced the Condenser Coolant Flow and Intake Air Pressure problems listed above. The corrective actions taken by the lab improved the situation but did not address it completely. This test was an acceptable reference oil test so the laboratory provided operational data from the next candidate test on that run to show that the problem had been solved.

One deviation was written for Engine Speed control problems. This test had control problems that were traced to a problem with the dynamometer during the test. The dyno was replaced and control improved but not enough to return the QI results above zero. This type of problem was not an issue in the Sequence IIIE test but the IIIF test is more sensitive to these types of problems. As such, the initial laboratory maintenance practices were not sufficient to prevent it. Since being identified, the problem has not recurred due to more frequent dyno replacement.

Two deviations were written for Coolant Out Temperature control problems. One was due to an air leak on the control valve causing coolant temperature to drift low for approximately 12 minutes. The test was shut down and the leak repaired. The second deviation was due to a tuning problem present when the test was started. The problem was identified and corrected within the first 15 hours of the test but the QI results did not recover.

One deviation was written for Condenser Coolant Flow problems and also Left Exhaust Back Pressure problems. The former is a known issue, as was described above. The latter was due to the loss of a control channel on the stand computer that could not be rectified during the test. As a result, that parameter had to be manually controlled during the test, resulting in poor control.

One deviation was written for Oil Filter Block Temperature control problems. This test was conducted on reference oil 1006 and this is a known problem with this oil. As the oil thickens, the filter goes into bypass mode and oil temperature control is lost.

One deviation was written for Left Exhaust Back Pressure Control problems. The problems began at 36 hours and at 40 hours the exhaust valve was replaced in an attempt to improve control. At hour 41, the problem recurred and the exhaust drain valves were opened in an attempt to drain the exhaust system of condensed water. This resulted in several large excursions in the EBP data. Removal of these few excursions returned the QI results to almost zero, although still negative. The problem was not solved during the test. An appropriate corrective action for the problem was never found. A review of operational data from subsequent candidate showed the problem was corrected after completion of the test.

Finally, one deviation was written for Engine Coolant Flow problems. The problems were traced to a scored and sticking flow control valve that was replaced after the test completed.

Percent Viscosity Increase at 60 Hours

At the last meeting of the Surveillance Panel, the TMC was tasked with creating LTMS charts for percent viscosity increase at 60 hours. This parameter would be used for utilizing the Sequence IIIF test in place of the Sequence IIIE test for product approval against current performance categories. It would not be used for stand calibration purposes. The parameter would also have severity adjustments calculated for candidate test adjustment. This action has been completed. However, one issue remains to be settled: what to use for test targets for this parameter. A possible set of targets, based on all industry data available to date, is shown in the following table:

Test Targets for Percent Viscosity Increase at 60 Hours			
Oil	N size	Mean	Standard Deviation
1006	26	248.78	53.51
1008	24	77.53	10.61
433	19	30.99	4.51

Another issue is what standard deviation to use for severity adjustment purposes. One possible value would be a pooled standard deviation based on all oils. From the above data, that value would be 33.61.

Hardware

No hardware changes were made this period.

Reference Oils

Oil	TMC Inventory, in gallons	TMC Inventory, in tests	Laboratory Inventory, in tests	Estimated life
1006	498	124	12	~3 years[1]
1007	619	154	12	not currently used in IIIF[2]
1008	491	122	14	~3 years[1]
432	118	29	13	not currently used in IIIF
433	10	2	2	~1 month
433-1	869	217	15	To be introduced

[1] Multiple test area reference oil; total TMC inventory shown
[2] Not reblendable

The test targets on reference oil 1008 were updated during the period, based on 24 data points. The old targets are listed below for comparison purposes:

Original Reference Oil 1008 Test Targets		
Parameter	Mean	Standard Deviation
PVIS	0.0872279	0.0087680
APV	9.73	0.115
WPD	4.66	0.861

The data on this reference oil was adjusted using the severity adjustments, if any, generated as a result of the previous reference oil test. The new test targets, based upon this methodology, are shown below:

Updated Reference Oil 1008 Test Targets		
Parameter	Mean	Standard Deviation
PVIS	0.0895442	0.0098604
APV	9.75	0.102
WPD	4.57	0.803

These new targets are effective for all tests completed on or after April 1, 2001.

Reference oil 1008 supplies at the TMC are also getting low. At this time, the oil is reblendable. However, there is no long-term guarantee that this situation will not change. If a reblend is desired, the Surveillance Panel should take action as soon as possible and task the TMC with beginning the reblend process.

Reference oil 1006 has sufficient data for a target update at this time. However, there are some questions regarding how to handle tests that become too viscous to measure on viscosity increase. The test labs are currently handling this issue differently and as a result have reported widely varying numbers for the final percent viscosity increase as a result. This will have a significant impact on the targets generated from this data. The Operations & Hardware Subpanel has a proposal for addressing this issue and hopefully it can be approved and the targets reset based upon that, or some other, protocol.

Reference oil 433 is nearly depleted in industry, with only four samples of that oil remaining. Currently the TMC has 19 data points on this oil and could update targets when one more data point becomes available. However, given the limited supply of this oil, this may not be desirable. The current targets are shown below:

Original Reference Oil 433 Test Targets		
Parameter	Mean	Standard Deviation
PVIS	0.1601833	0.0204379
APV	9.41	0.257
WPD	4.96	0.697

Revised test targets for this oil, based on the above calculation methodology, are shown below.

Potential Update to Reference Oil 433 Test Targets		
Parameter	Mean	Standard Deviation
PVIS	0.1640265	0.0137085
APV	9.35	0.250
WPD	4.74	0.607

These targets are not currently effective in the Sequence IIIF test.

Introduction of the reblend of reference oil 433, oil 433-1, is still a topic of business for the Surveillance Panel. The search for donated tests for test target generation has proved fruitless so some other method, such as simultaneous reference oil tests or running under the new oil under the old targets, will be necessary.

MTK/mtk

Attachments

c: F. M. Farber, TMC
Sequence IIIF Surveillance Panel
ftp://tmc.astm.cmri.cmu.edu/docs/gas/sequenceiii/semiannualreports/IIIF-04-2001.pdf

List of Figures

- Figures 1, 2, and 3 are EWMA severity and precision control charts and also the CUSUM Δ/s plots of PVIS, WPD, and APV, annotated with date lines, using the same data set as the EWMA severity and precision control charts. Transformed units are used, when appropriate.

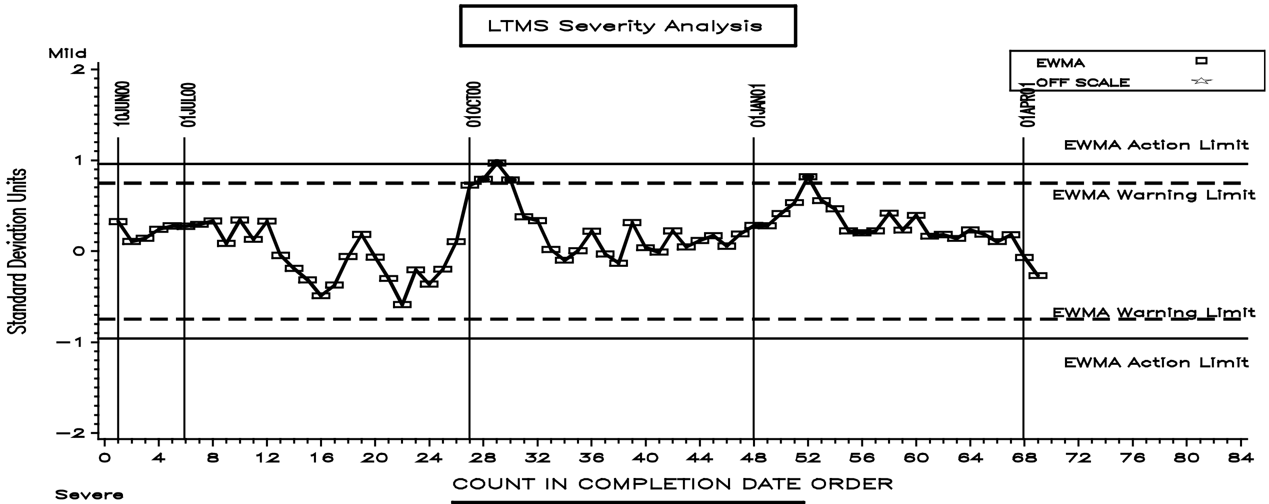
- Figures 4, 5, and 6 are bar charts of average Δ/s, by report period, for PVIS, WPD, and APV.

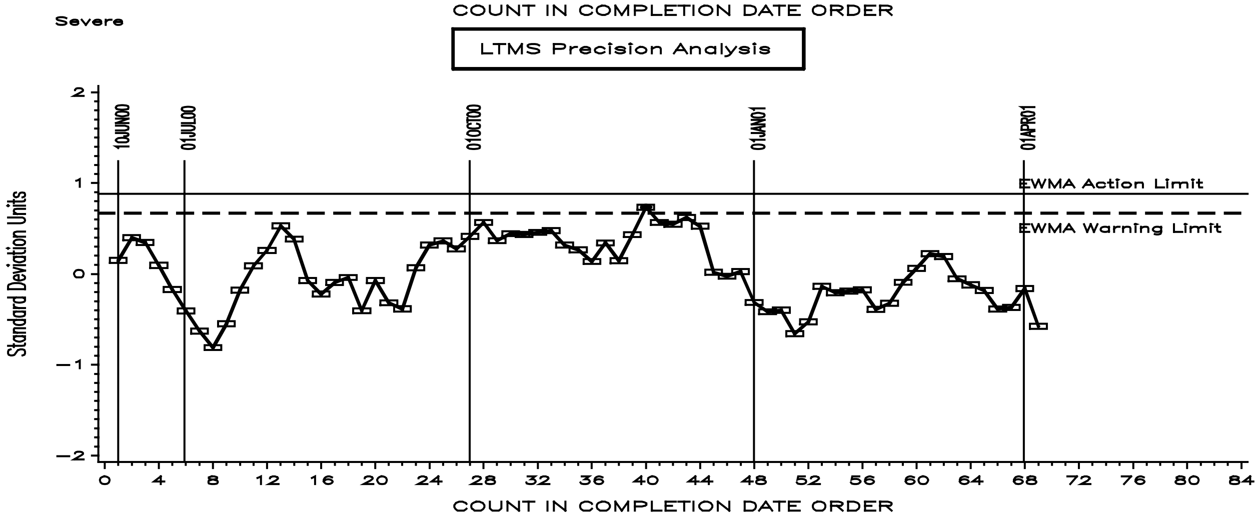
- Figures 7, 8, and 9 are bar charts of pooled standard deviation, by report period, for PVIS, WPD, and APV.

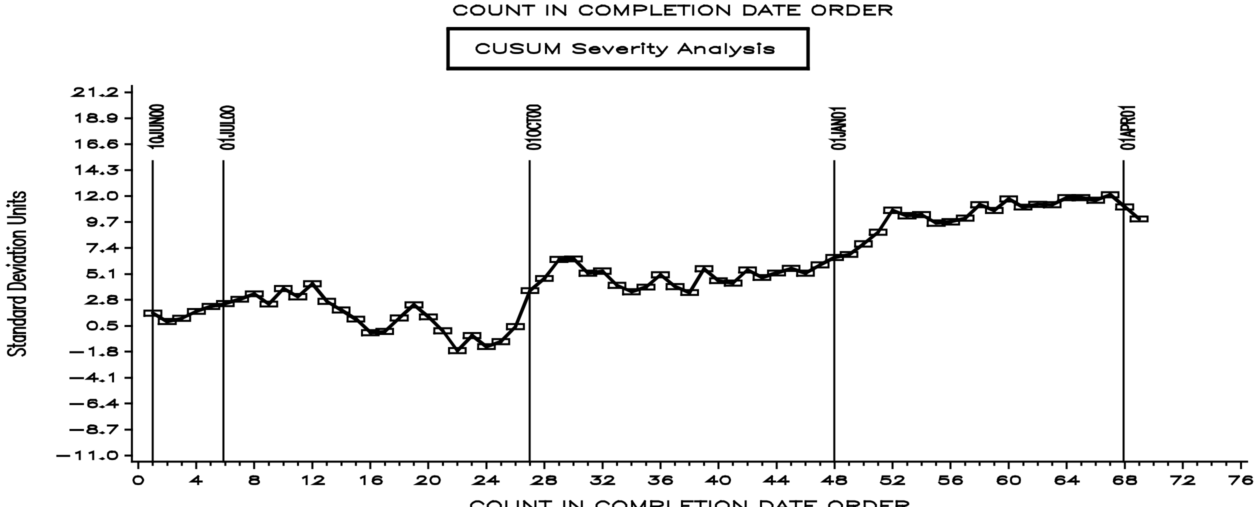
SEQUENCE IIIF INDUSTRY OPERATIONALLY VALID DATA

VISCOSITY INCREASE FINAL ORIG UNIT RES (%)

Figure 1







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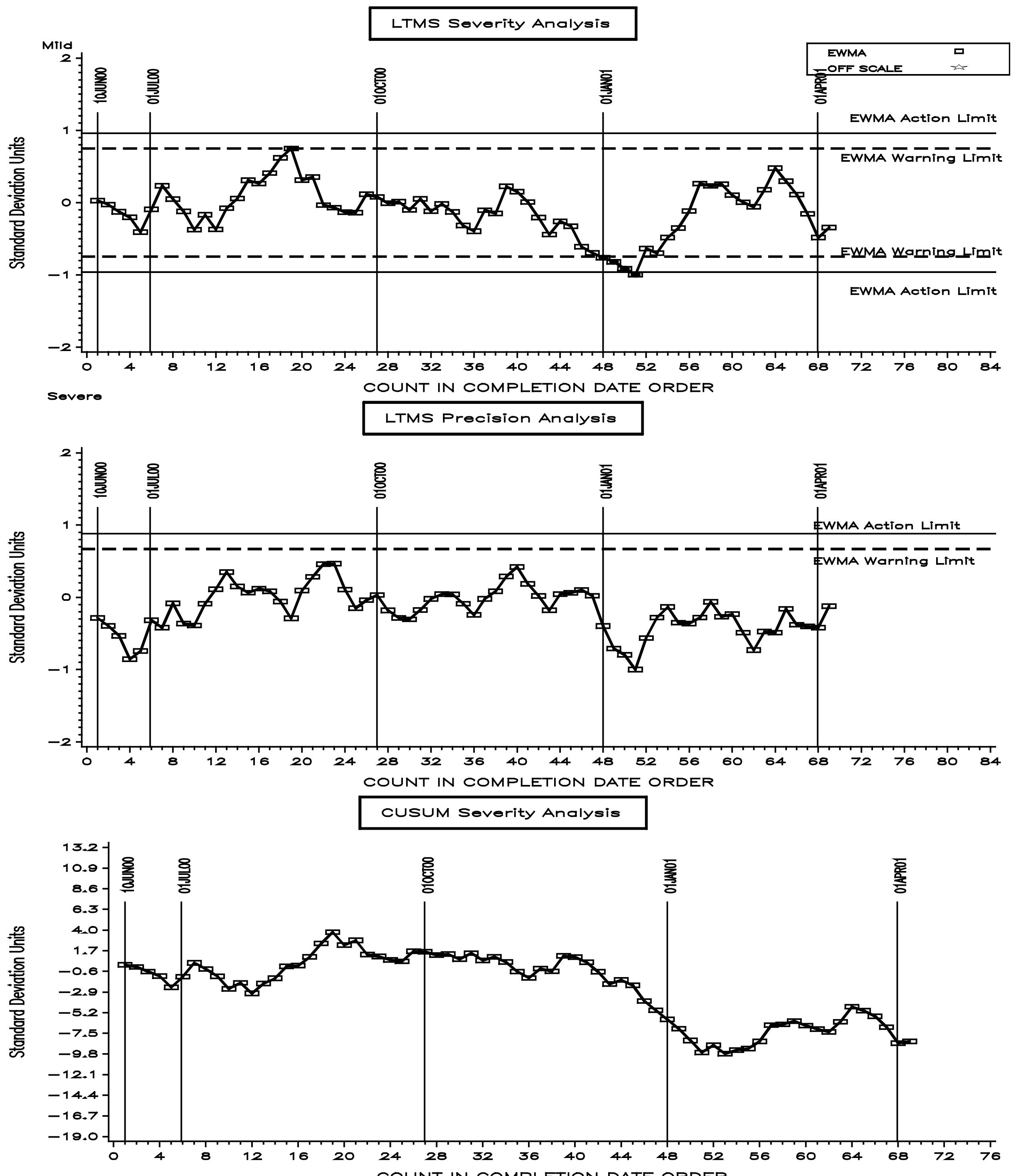
SEQUENCE IIIF INDUSTRY OPERATIONALLY VALID DATA

AVERAGE WEIGHTED PISTON DEPOSITS FNL ORIG UNIT RES

Figure 2



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SEQUENCE IIIF   INDUSTRY OPERATIONALLY VALID DATA

AVERAGE PISTON SKIRT VARNISH FINAL ORIG UNIT RES (

Figure 3

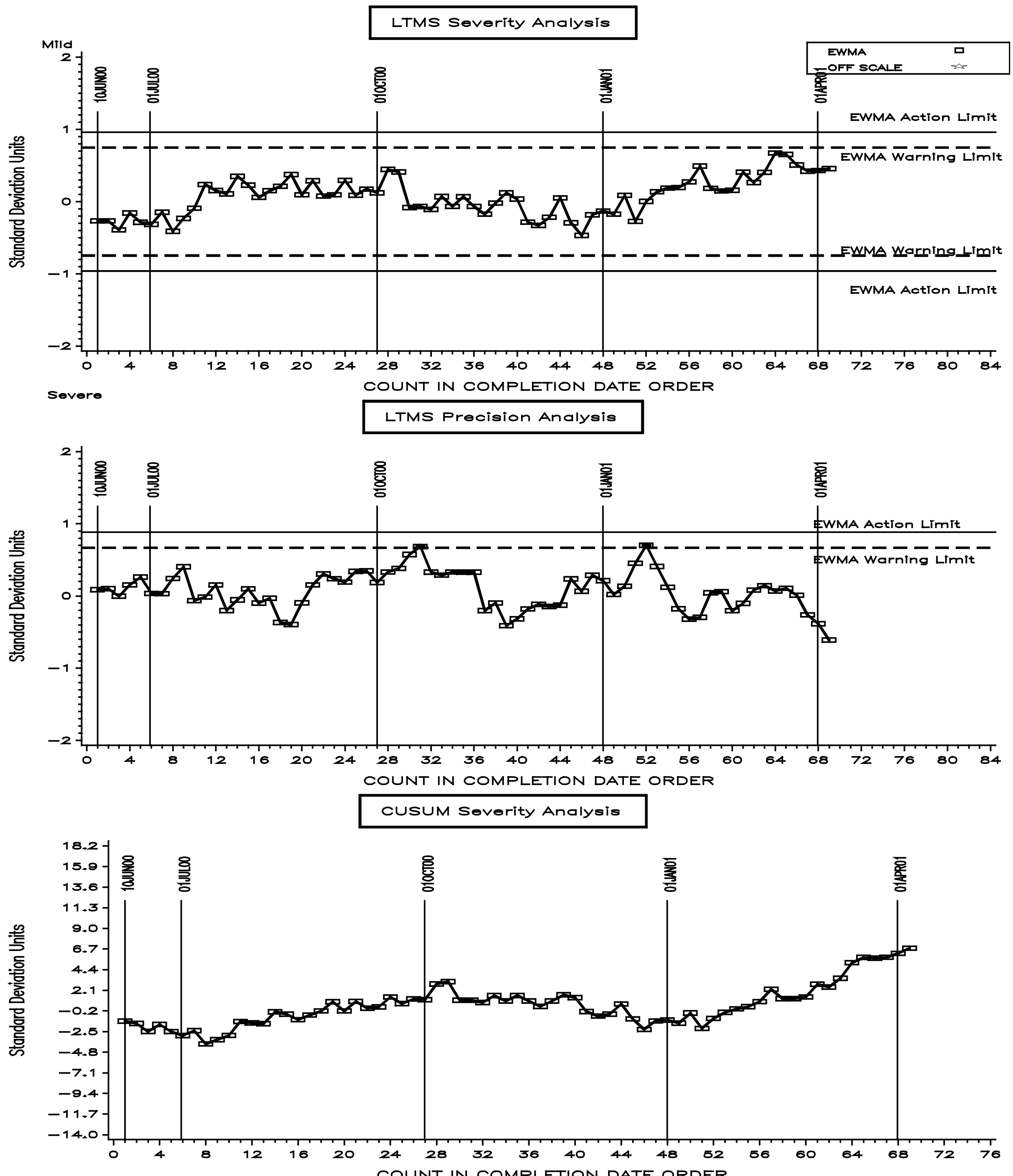

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Figure 4 - Percent Viscosity Increase, Average Delta/s

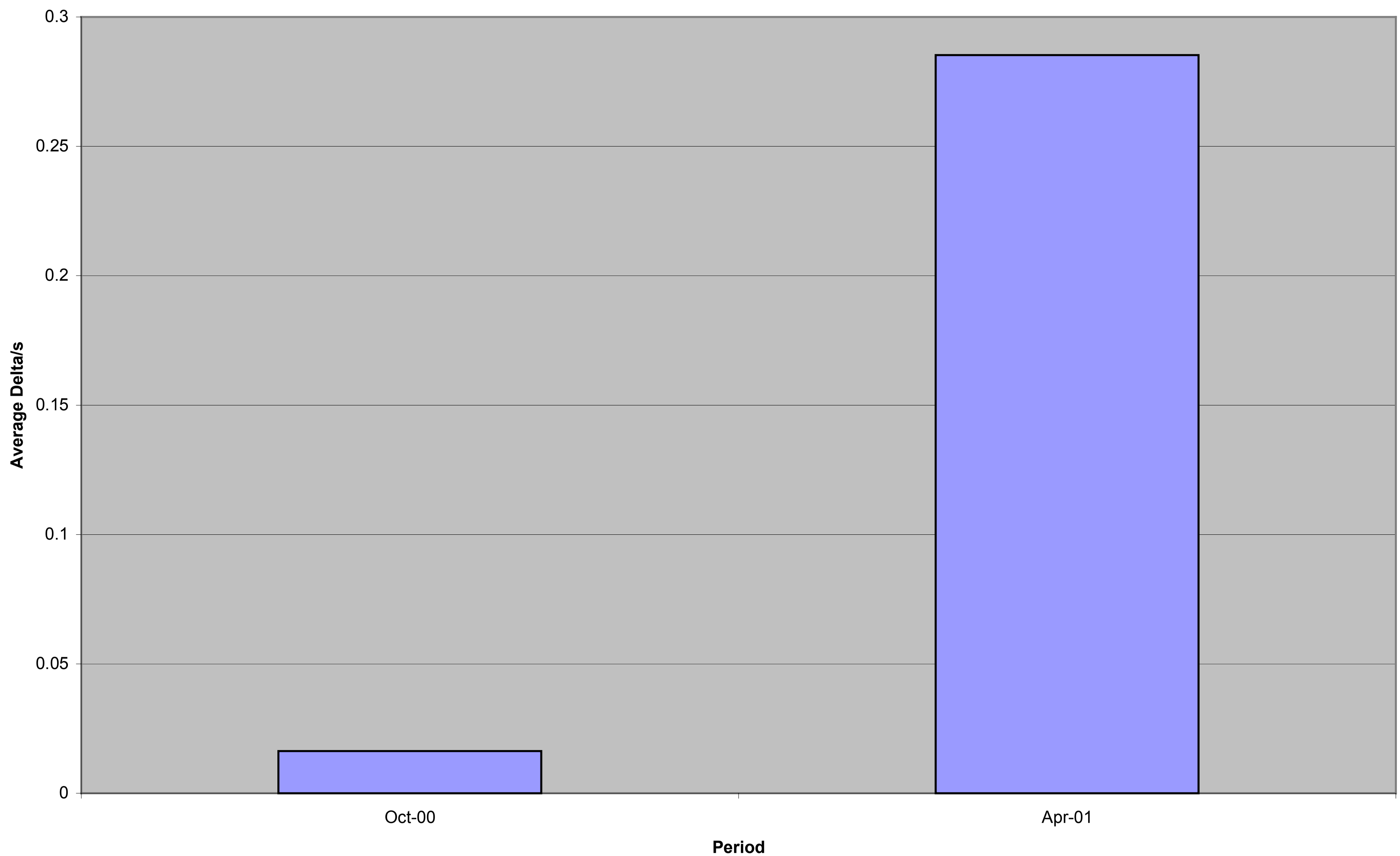

Figure 5 - Weighted Piston Deposits, Average Delta/s

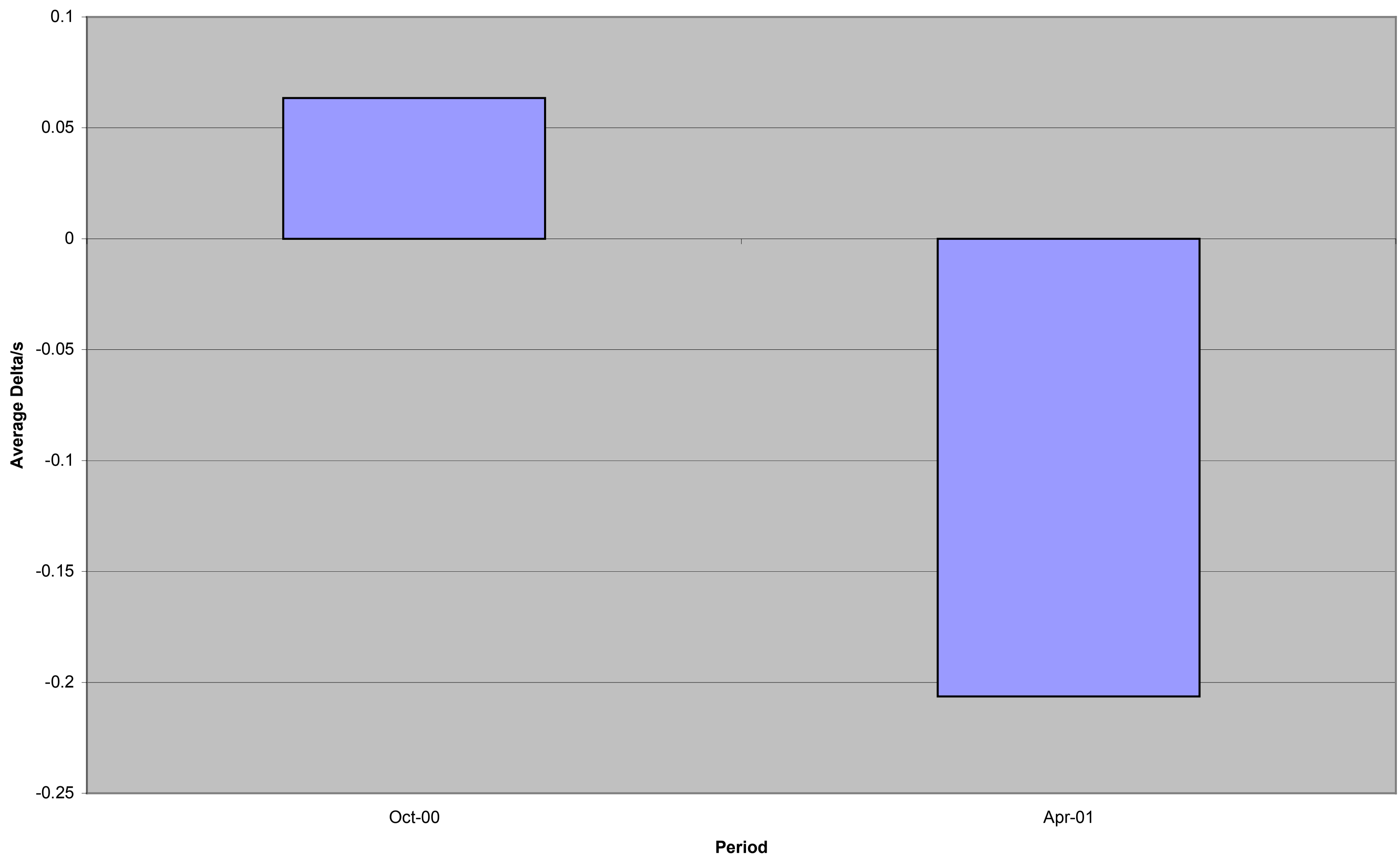

Figure 6 - Average Piston Varnish, Average Delta/s

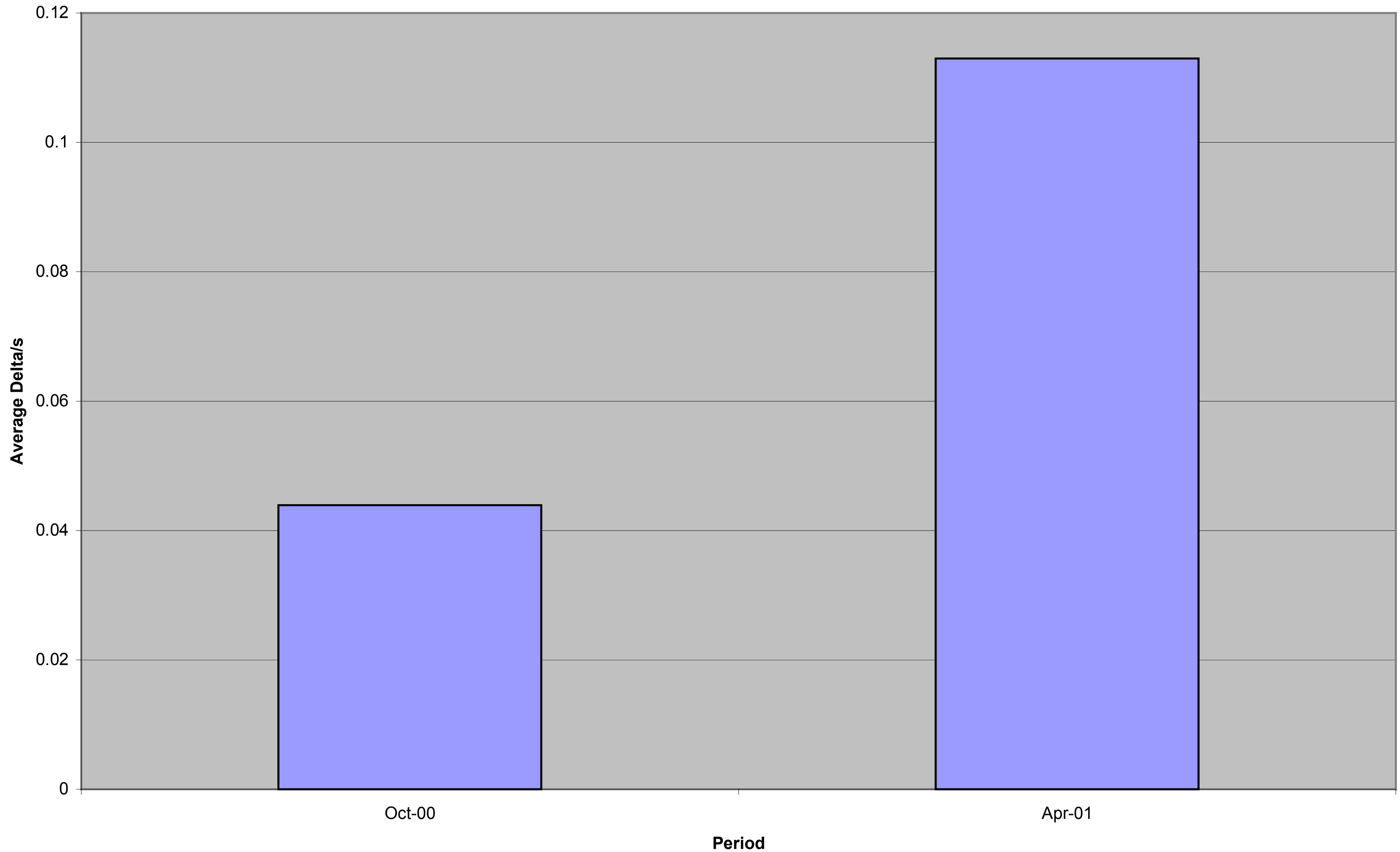

Figure 7 - Percent Viscosity Increase, Pooled Standard Deviation

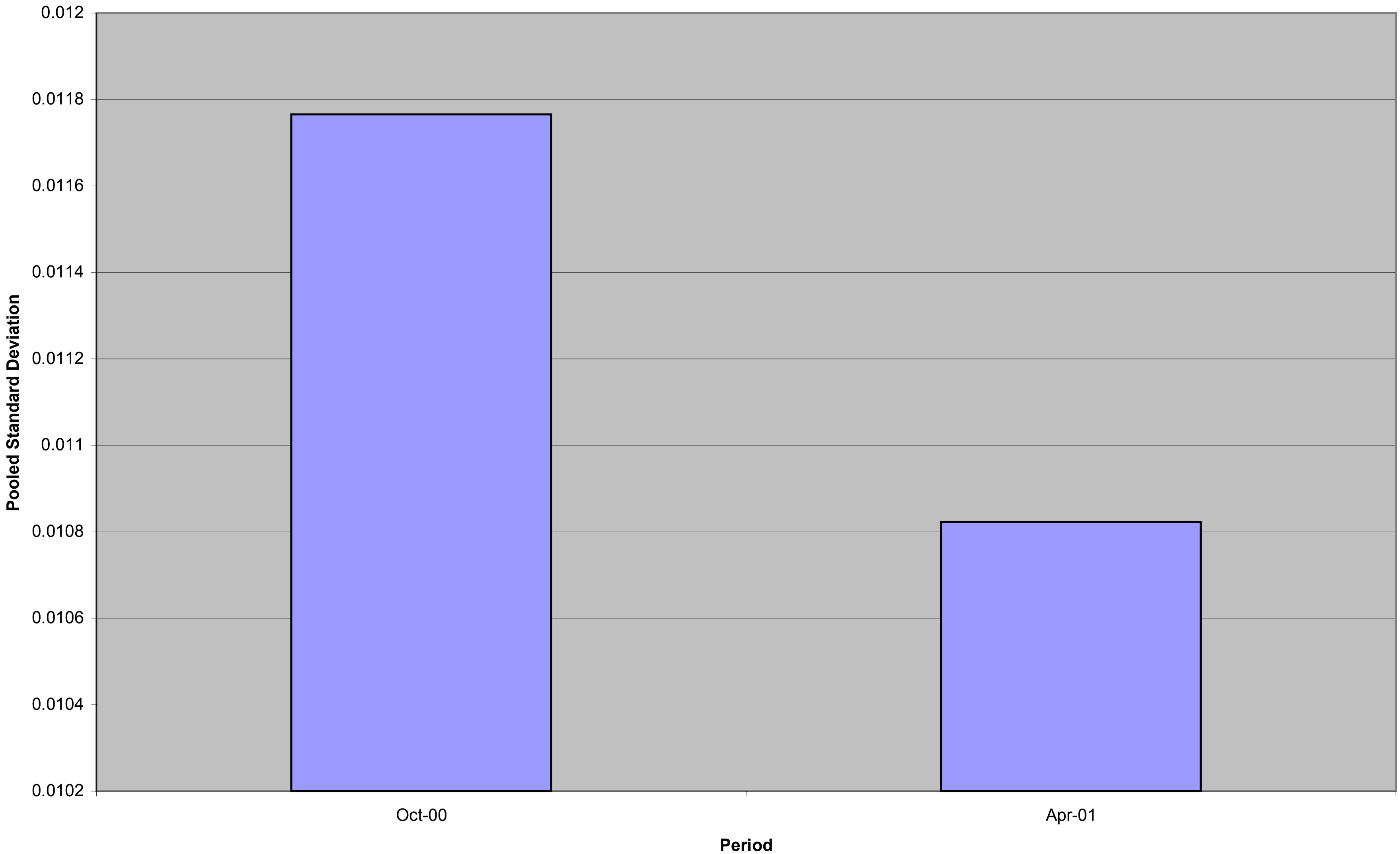

Figure 8 - Weighted Piston Deposits, Pooled Standard Deviation

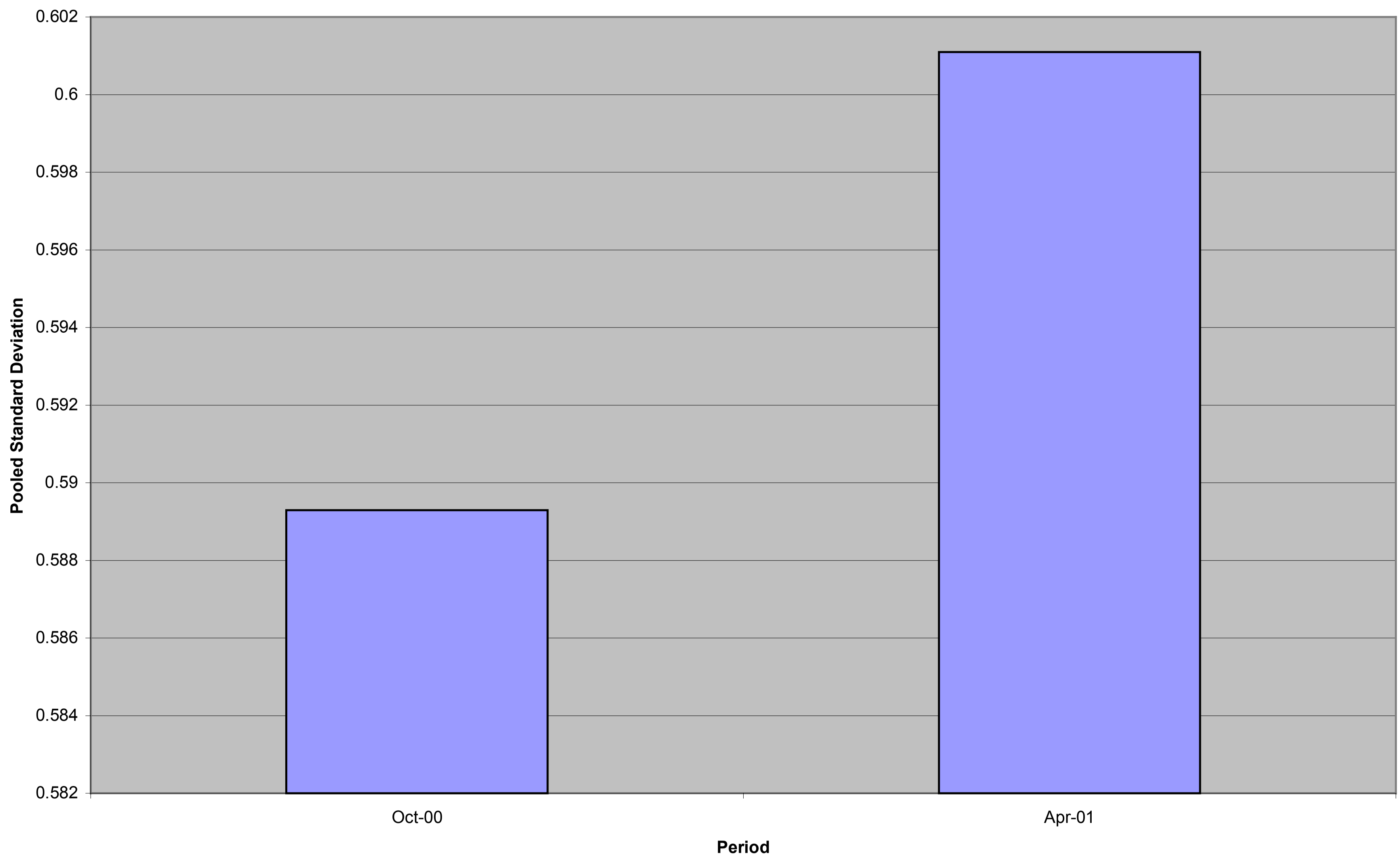

Figure 9 - Average Piston Skirt Varnish, Pooled Standard Deviation