Test Monitoring Center
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Memorandum: 02-034

Date: May 6, 2002

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

From: Michael T. Kasimirsky

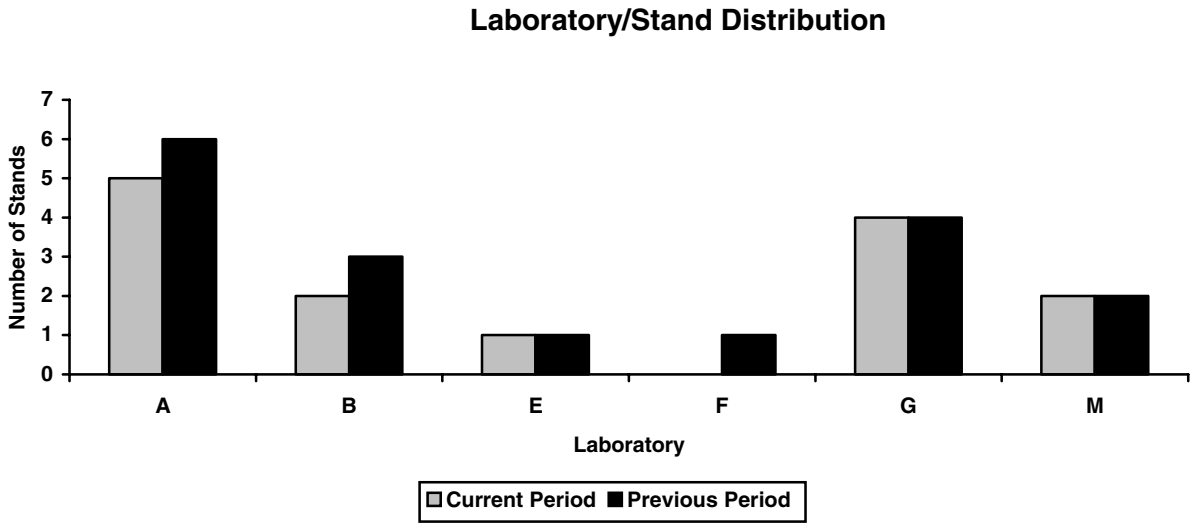
Subject: Sequence IIIF Semiannual Report: October 1, 2001 through March 31, 2002

The following is a summary of Sequence IIIF reference tests that were reported to the Test Monitoring Center during the period October 1, 2001 through March 31, 2002.

Lab/Stand Distribution

	Reporting Data	Calibrated as of March 31, 2002
Number of Laboratories:	5	5
Number of Test Stands:	14	12

The following chart shows the laboratory/stand distribution:

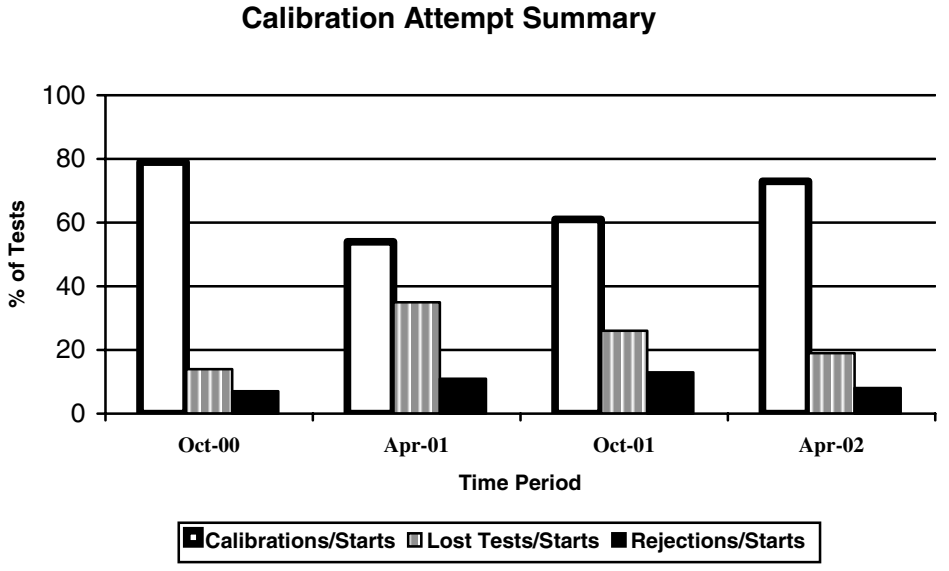


The following summarizes the status of the reference oil tests reported to the TMC:

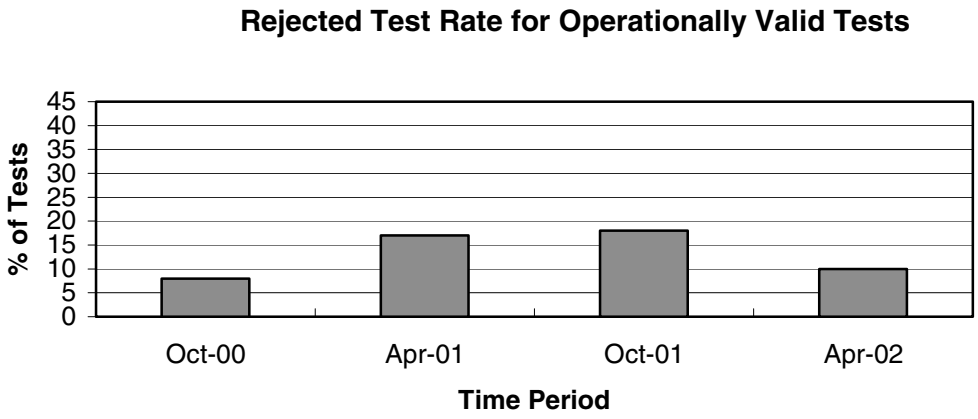
Calibration Start Outcomes	TMC Validity Codes	No. of Tests
Operationally and Statistically Acceptable	AC	19
Failed Acceptance Criteria	OC	2
Operationally Invalid (Laboratory Judgment)	LC	3
Operationally Invalid (Lab & TMC Judgment)	RC	0
Stand Failed Reference Sequence – data pulled	MC	2
Aborted	XC	0
Total		26

Donated & Industry Support Outcomes	TMC Validity Codes	No. of Tests
Decoded Runs for Wear Investigation run by OH Technologies, Inc.	NI	4
Decoded Runs for laboratory internal severity investigation on WPD	NI	1
Total		5

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

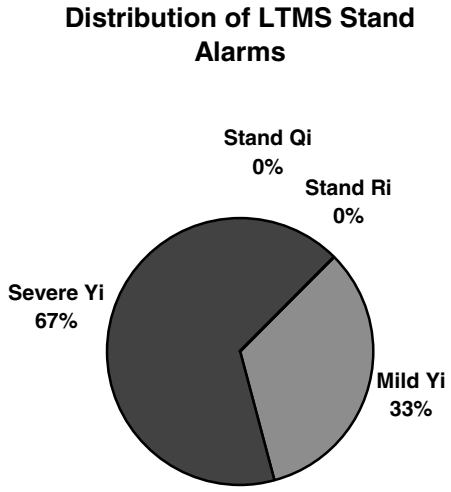


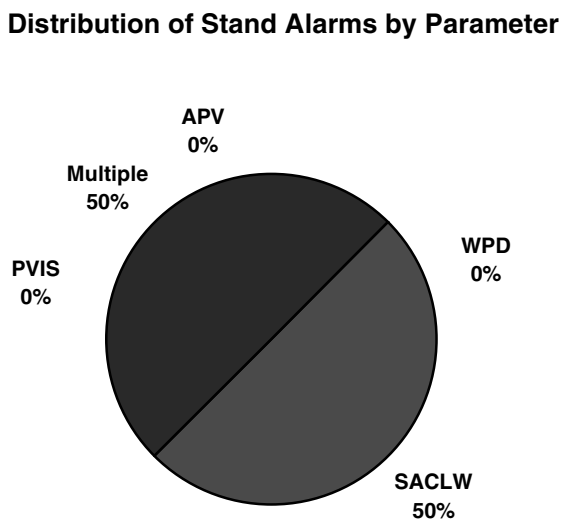
The calibration per start rate is higher than last period. The lost test rate is lower than last period. The rejected test rate is slightly lower than last period.



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

There were two 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 have been two deviations from the LTMS since its introduction in June of 2000.

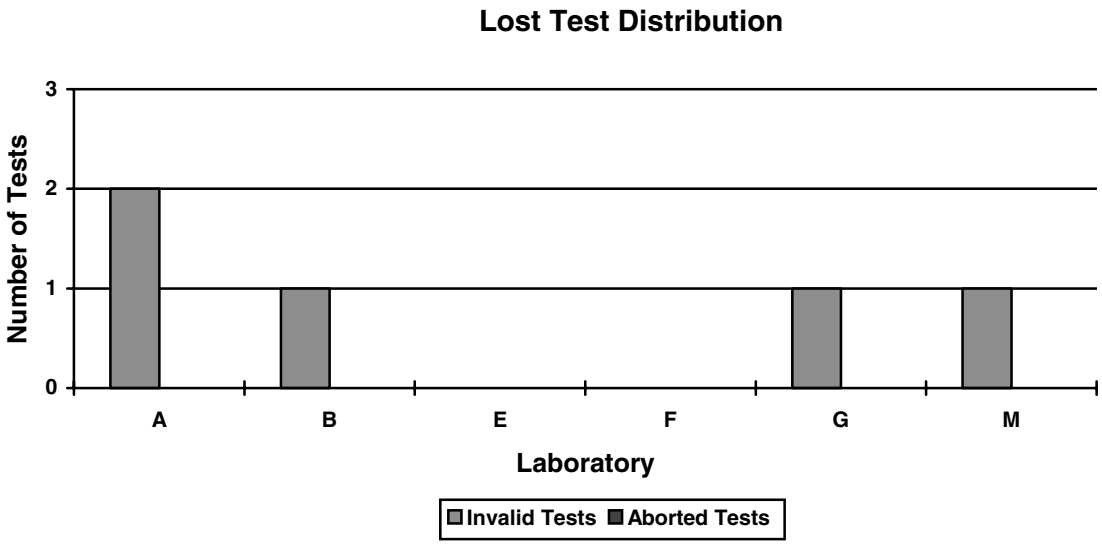
No lab visits were performed during the period.

Lost Test Summary

Five 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	Negative Coolant Flow QI Results	1	1/0/0
	Low Boron in ICP Metals Results	1	1/0/0
B	Negative Coolant Out Temperature QI Results due to coolant temperature control problem	1	1/0/0

In addition, a total of two data points from two labs were pulled from the LTMS data set and given an "MC" validity code. Lab G pulled one stand from the system due to mild viscosity increase problems, resulting in the one pulled data point. In addition, Lab M pulled one data point from the LTMS after the laboratory took corrective action to address laboratory WPD performance problems and this test did not reflect those changes.



Information Letters

Sequence IIIF Information Letter No. 01-3, Sequence No. 6, dated November 28, 2001 was issued during the period and contained the Sequence IIIF-HD Test Procedure.

Sequence IIIF Information Letter No. 02-1, Sequence No. 7, dated March 1, 2002 was issued during the period and contained the Revised Sequence IIIF Test Procedure.

Sequence IIIF Information Letter No. 02-2, Sequence No. 8, dated March 15, 2002 was issued during the period and contained the Sequence IIIFHD Test Procedure and the Revised Sequence IIIF Test Procedure.

Sequence IIIF Information Letter No. 02-3, Sequence No. 9, dated April 23, 2002 was issued since the last semiannual report and contained Oil Filter and Oil Cooler Replacement guidelines.

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	0.122	0.024 (df=17)	24.9% Viscosity Increase[1]
APV	0.006	0.229 (df=17)	0.001 merits
WPD	-0.578	0.637 (df=17)	-0.37 merits
PV60[2]	0.610	0.198 (df=17)	37.9% Viscosity Increase[3]

[1] At the GF-3 Pass Limit of 275% Viscosity Increase
[2] Not a pass/fail parameter in the Sequence IIIF test; Sequence IIIFHD use only
[3] At the CH-4 Pass Limit of 295% Viscosity Increase @ 60 Hours; Sequence IIIFHD use only.

Average Δ/s Results, by Laboratory				
Laboratory	PVIS	APV	WPD	PV60
A	0.26	-0.11	-0.57	0.22
B	-0.21	-0.37	-0.67	0.16
E	0.69	-0.18	-0.58	-1.41
F	No Data	No Data	No Data	No Data
G	-0.34	0.01	-0.93	2.11
M	0.67	0.64	0.18	-0.23

Percent Viscosity Increase (PVIS)

The industry was within limits for both severity and precision during the period (see figure 1). The industry was much closer to target than the previous two periods with an average Δ/s value of 0.122 for the period (see figure 5). Precision for the period, however, has degraded and this period compared to historical performance (see figure 9).

Weighted Piston Deposits (WPD)

The industry experienced a severity alarm of seven data points during the period (see figure 2). The industry was severe for the period with an average Δ/s value of –0.578 for an average Δ of –0.37 merits (see figure 6), which is more severe than any previous period in history. Precision for the period was comparable to historical performance (see figure 10). The alarm period also coincided with the introduction of reference oil 1006-2 and the group of tests run to establish test targets for this oil. At that time, one laboratory was performing differently on WPD and was much more mild than other laboratories in industry. Subsequent investigations by the laboratory brought those WPD results into question and that data point has since been excluded from the test target data set for future target updates. Later tests by this laboratory, on reference oil 1006-2, have been in line with the remainder of industry. However, some questions have been raised about WPD performance on non-reference oils so further investigation was warranted.

The WPD data was examined for laboratory differences in an effort to determine a cause for the severity shift. The data was first examined across all reference oils by examining the Y_i values to remove

any reference oil effects. Both WPD and APV data was compared in this manner. Two laboratories were found to be different from one another on overall WPD performance (all oils combined) while two other laboratories were found to be different on APV performance (also all oils combined). Both of these analysis results looked at the overall engine average results for both Weighted Piston Deposits as well as Piston Skirt Varnish.

The data was then analyzed by reference oil to look for laboratory differences. In this analysis, laboratory differences on both APV and WPD performance were found only in the reference oil 1008 data. However, the laboratory differences that were found on reference oil 1008, on both APV and WPD, did not span both parameters, i.e. the same laboratories were not found to be different on both APV and WPD performance. In fact, no two laboratories that were found to be different on WPD performance were also found to be different from one another on APV performance. No differences were found in the data on all other reference oil blends. Reference oil 1008 is the mildest reference oil on WPD performance, with the exception of reference oil 433, with a target value of 4.52 merits. However, reference oil 433 has limited data available on it compared to reference oil 1008 (19 data points vs. 50 data points) so there may be insufficient data on reference oil 433 to show any differences in laboratory performance. The WPD test targets for all reference oils are shown in the table below, for comparison purposes:

Weighted Piston Deposit Test Targets		
Reference Oil	Mean	Standard Deviation
1006	3.32	0.327
1006-2	4.18	0.417
1008	4.52	0.773
433	4.96	0.697
433-1	4.27	0.557

So the absolute performance level of a particular reference oil may play a role in the overall variability of the WPD rating results.

Next, the individual ratings that make up the WPD rating were examined. The individual ratings used to determine WPD, along with the weighting factors of each individual rating area, are shown in the table below:

WPD Rating Weighting Factors	
Location	Weighting Factor
Groove 1	0.05
Groove 2	0.10
Groove 3	0.20
Land 2	0.15
Land 3 (Oil Ring Land)	0.30
Undercrown	0.10
Piston Skirt Varnish (average of thrust and anti-thrust)	0.10

As you can see, there are seven different positions that make up the WPD rating. In addition, there are six different pistons in the engine, five different reference oils, and four or five different test laboratories represented in the data. To reduce these factors to a manageable size, the six different piston locations were ignored in the data. The data was analyzed for differences in laboratory performance, broken down by reference oil and rated position, with the data from that location on all six pistons compared together, i.e. all the data on groove 1 and reference oil 1006 was analyzed for laboratory differences, etc. The results of this analysis are summarized in the following table:

Laboratory differences found, individual WPD ratings, by reference oil					
Position\Oil	1006	1006-2	1008	433	433-1
Groove 1	No	Yes	No	Yes	No
Groove 2	No	No	Yes	No	Yes
Groove 3	Yes	Yes	Yes	Yes	Yes
Land 2	Yes	Yes	Yes	No	Yes
ORLD	No	No	Yes	No	Yes
Undercrown	Yes	No	Yes	No	Yes
PSV, thrust[*#]	No	Yes	Yes	Yes	Yes
PSV, anti-thrust[*#]	Yes	No	Yes	Yes	Yes
PSV, average[*]	Yes	Yes	Yes	Yes	Yes

[*] These results are based on an analysis of the individual thrust, anti-thrust, or piston average value, not overall engine value. For example, one set of test results would contribute six data points to the analysis, rather than one data point.

[#] The thrust and anti-thrust PSV ratings are not a direct part of the WPD rating; only the average PSV rating for a piston is part of the WPD rating for that individual piston.

In the above table, the differences found were not consistent across the board, i.e. the laboratories found to be different on groove 1 on reference oil 1006-2 were not the same as those found to be different on groove 1 on reference oil 433. As such, a definitive cause for these differences, or any differences in overall WPD performance, is not readily apparent.

However, the relative influence of the individual positions is worth considering at this point. Of all the positions, Groove 3 accounts for 20%, Land 2 for 15%, and Land 3 (the Oil Ring Land) for 30% of the WPD rating value. All the other positions account for 10% of the WPD rating, with the exception of Groove 1, which is only 5% of the WPD rating value. As such, these four parts only account for 35% of the WPD rating value. From the above chart, Groove 3, which is 20% of the WPD rating, shows a difference across all reference oils between at least some laboratories.

Early in the development of the Sequence IIIF test, the subject of groove rating was discussed at a Light Duty Rating Task Force meeting and Light Duty Rating Workshop. At that time, there were some concerns raised over rating deposits in the grooves of Sequence IIIF pistons because the piston ring grooves are so narrow. From this limited information, further investigation into the groove ratings is probably warranted. At this time, the reference oil data does not show a problem with WPD performance but the TMC will continue to investigate this issue to see if further refinements can be made and to determine if a real problem exists in the WPD rating procedures.

Average Piston Skirt Varnish (APV)

The industry was within limits for both severity and precision during the period (see figure 3). The industry was on target for the period with an average Δ/s value of 0.006 for the period (see figure 7). Precision for the period has degraded slightly for this period compared to historical performance, but it still comparable to previous periods (see figure 11).

Average Camshaft-plus-Lifter Wear (ACLW)/Screened Average Camshaft-plus-Lifter Wear (SACLW)

Both failing reference oil tests for the period failed due to severe SACLW performance. No explanation for the severe SACLW results has been found at this time. Investigations into Sequence IIIF wear performance are ongoing but to date no solutions to the problem have been found.

Percent Viscosity Increase at 60 Hours

The industry control chart for PV60 is shown in figure 4. The average Δ/s and pooled standard deviation for this period, and previous report periods, are shown in figures 8 and 12 respectively. This parameter is not a pass-fail parameter in the Sequence IIIF test and is used only in Sequence IIIFHD testing.

Therefore, the industry control charts are presented for information purposes only and any alarms shown on those charts do not require action by the Sequence IIIF Surveillance Panel. A review of figure 4 shows that the industry has been consistently mild of target on this parameter since it's introduction into the test. As a result, the Surveillance Panel may wish to consider a revision of the test targets used for this parameter.

QI Deviations

There was one QI Deviation for the period. There have been 22 deviations from the QI Limits since the test was introduced in June of 2000.

The lone QI Deviation written this period was due to a negative QI result on engine load. The test experienced a few short periods of erratic control that resulted in a final QI value of –0.041 for the test. No cause for the periods of erratic control was found in the laboratory's investigation of the problem. The TMC's opinion of this test was that the operational conditions of this test did not deviate enough from the expected norm to cause it to be considered invalid. If this test were used to recalculate U & L values for this parameter, in all likelihood this test would result in the same U & L limits after the new limits were rounded according to past practice. However, the laboratory was urged to strive to improve it's control capabilities so that this problem did not recur in the future.

Hardware

No hardware changes were made this period.

Reference Oils

Oil	TMC Inventory, in gallons	TMC Inventory, in tests (4 gal/test)	Laboratory Inventory, in tests	Estimated life
1006	46	11	13	depleted[1]
1006-2	5,246	1,311	12	~3+ years[1]
1007	509	127	11	not currently used in IIIF[2]
1008	74	18	15	~1 year[1]
432	118	29	13	not currently used in IIIF
433	10	2	2	depleted
433-1	782	195	13	~3 years

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

The test targets on reference oil 1006 were updated and frozen during the period, based on 35 data points. 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:

Final reference oil 1006 test targets		
Parameter	Mean	Standard Deviation
PVIS	0.0167362	0.0086503
APV	9.23	0.213
WPD	3.32	0.327
PV60	5.41732	0.230855

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

Reference oil 1008 supplies at the TMC are almost depleted. A reblend of this oil, 1008-1, has been procured by the TMC at this time and is awaiting analytical results. If no problems are found, it will then be available for shipment.

At the November 15, 2001 meeting of the Sequence IIIF Surveillance Panel, the panel approved a plan to run a series of five simultaneous reference oil tests on reference oil 1006-2 for the purposes of both stand calibration and test target generation. The initial targets for reference oil 1006-2, based on the five data points from the matrix, are shown below:

Initial Reference Oil 1006-2 Test Targets		
Parameter	Mean	Standard Deviation
PVIS	0.0496678	0.0090039
APV	9.35	0.283
WPD	4.18	0.417
PV60	5.30933	0.168340

Any applicable severity adjustments were applied to the data prior to target generation. Future updates to the targets will also be severity adjusted according to past practice. The Surveillance Panel has approved a plan to update these targets when the TMC has 10, 20, and 30 data points on this reference oil.

During the period, the TMC received 11 data points on reference oil 433-1 and as such had sufficient data to update the test targets at this time. The updated test targets, based on the 11 available data points on this reference oil, are shown below:

Updated Reference Oil 433-1 Test Targets		
Parameter	Mean	Standard Deviation
PVIS	0.1684402	0.0402156
APV	9.27	0.281
WPD	4.27	0.557
PV60	3.55682	0.298299

Any applicable severity adjustments were applied to the data prior to target generation. These targets will be updated again when the TMC has 20 and 30 data points available on this reference oil. These new targets are effective for all tests completed on or after March 1, 2002.

The GF-3 Category Reference Oil, reference oil 1009, is now at the TMC and has been mixed at this time and it too is awaiting analytical results. If no problems are found, it will then be available for shipment.

MTK/mtk

Attachments

c: F. M. Farber, TMC
Sequence IIIF Surveillance Panel
ftp://ftp.astmtmc.cmu.edu/docs/gas/sequenceiii/semiannualreports/IIIF-04-2002.pdf

Distribution: Electronic Mail

List of Figures

- Figures 1, 2, 3, and 4 are EWMA severity and precision control charts and also the CUSUM Δ/s plots of PVIS, WPD, APV, and PV60, annotated with date lines, using the same data set as the EWMA severity and precision control charts. Transformed units are used, when appropriate.

- Figures 5, 6, 7, and 8 are bar charts of average Δ/s, by report period, for PVIS, WPD, APV, and PV60.

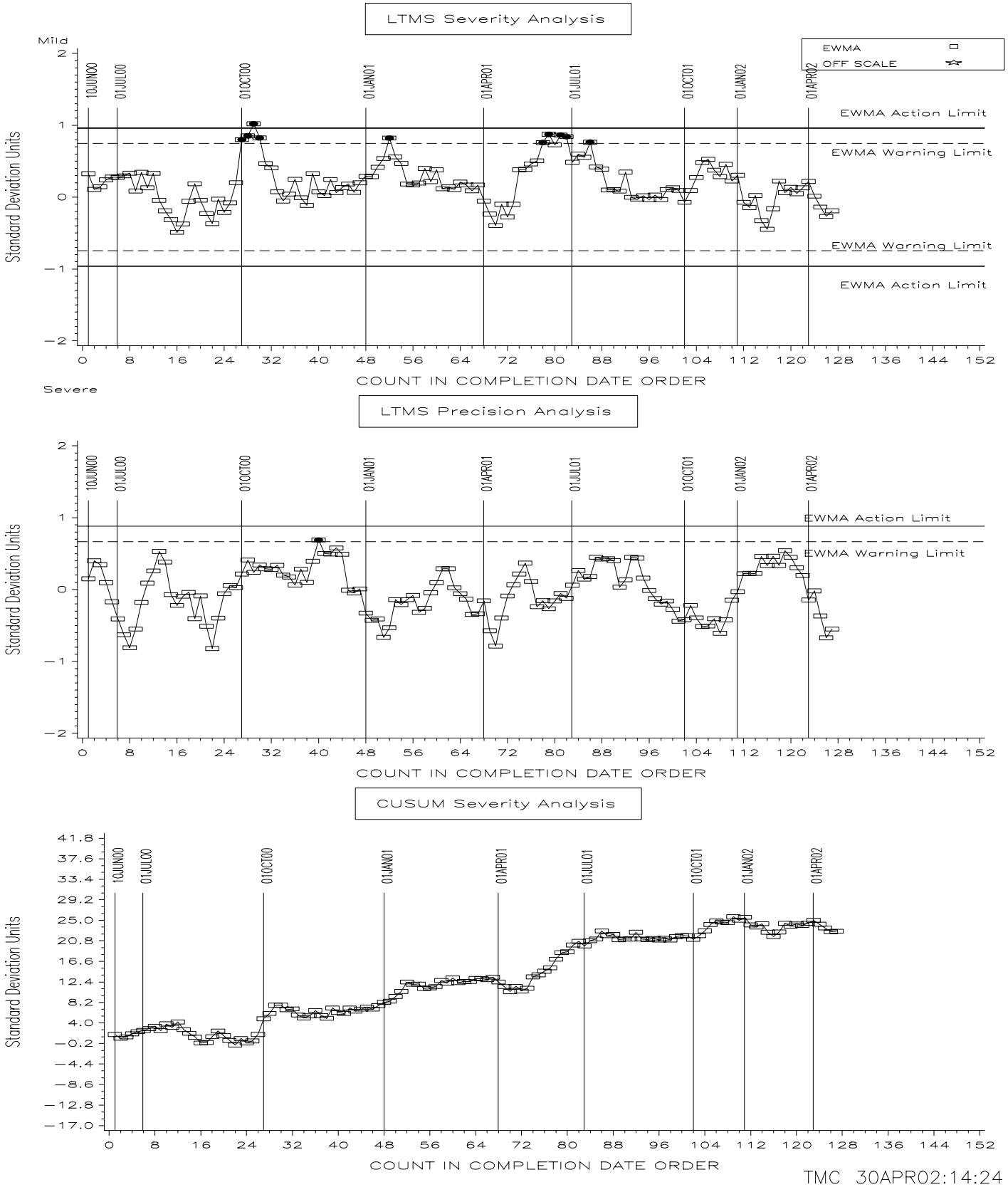
- Figures 9, 10, 11, and 12 are bar charts of pooled standard deviation, by report period, for PVIS, WPD, APV, and PV60.

- Figure 13 is the Sequence IIIF Timeline.

SEQUENCE IIIF INDUSTRY OPERATIONALLY VALID DATA

VISCOSITY INCREASE FINAL ORIG UNIT RES

Figure 1



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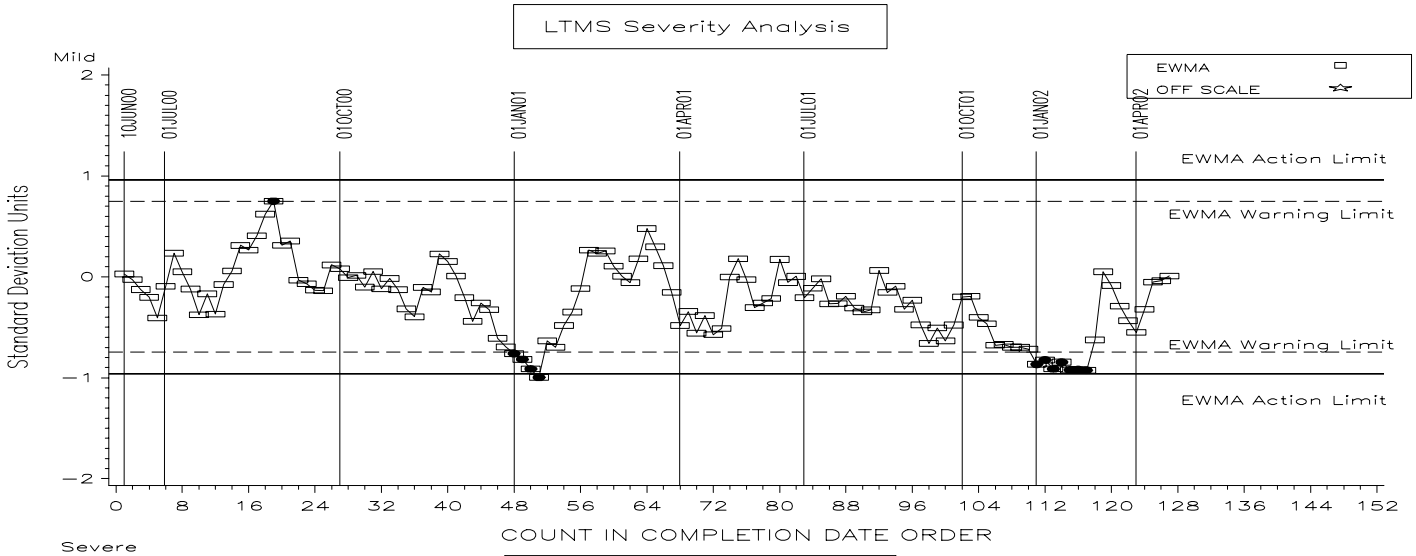
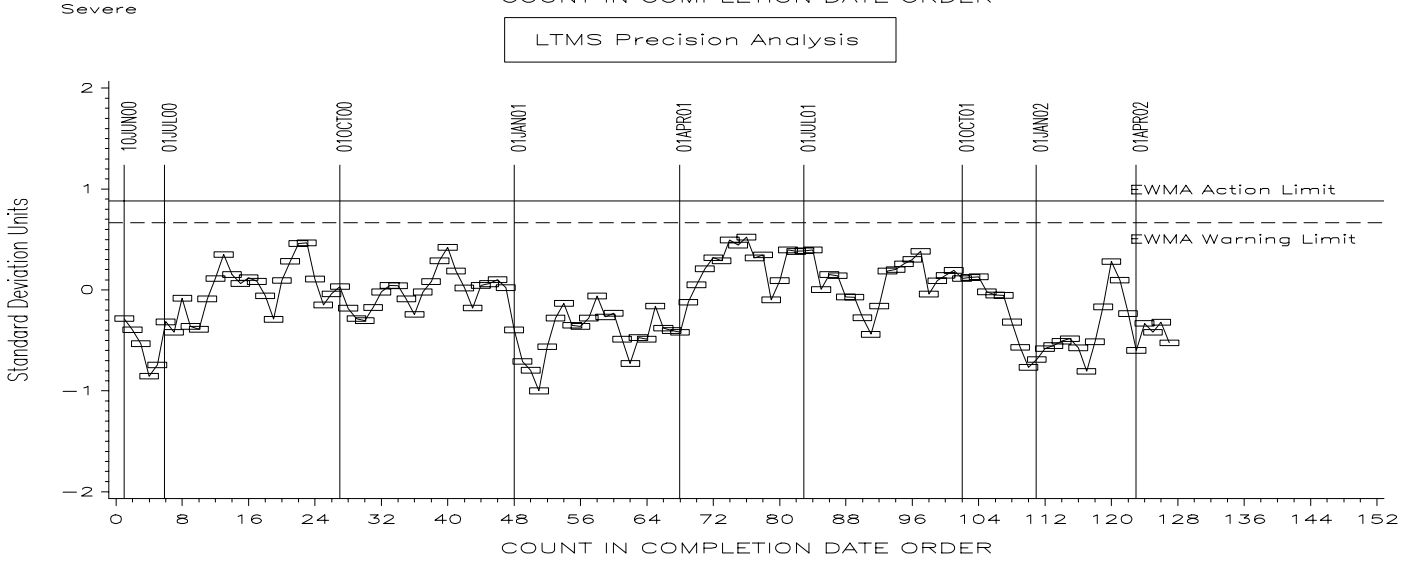
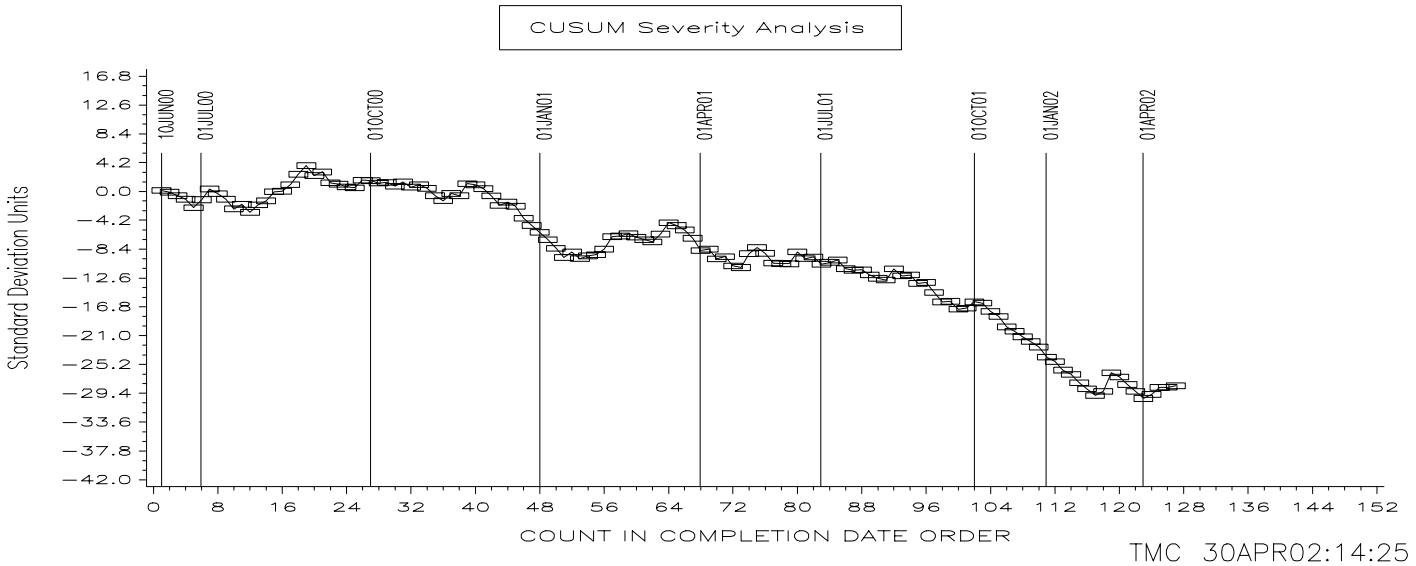
SEQUENCE IIIF INDUSTRY OPERATIONALLY VALID DATA

AVERAGE WEIGHTED PISTON DEPOSITS FNL ORIG UNIT RES

Figure 2







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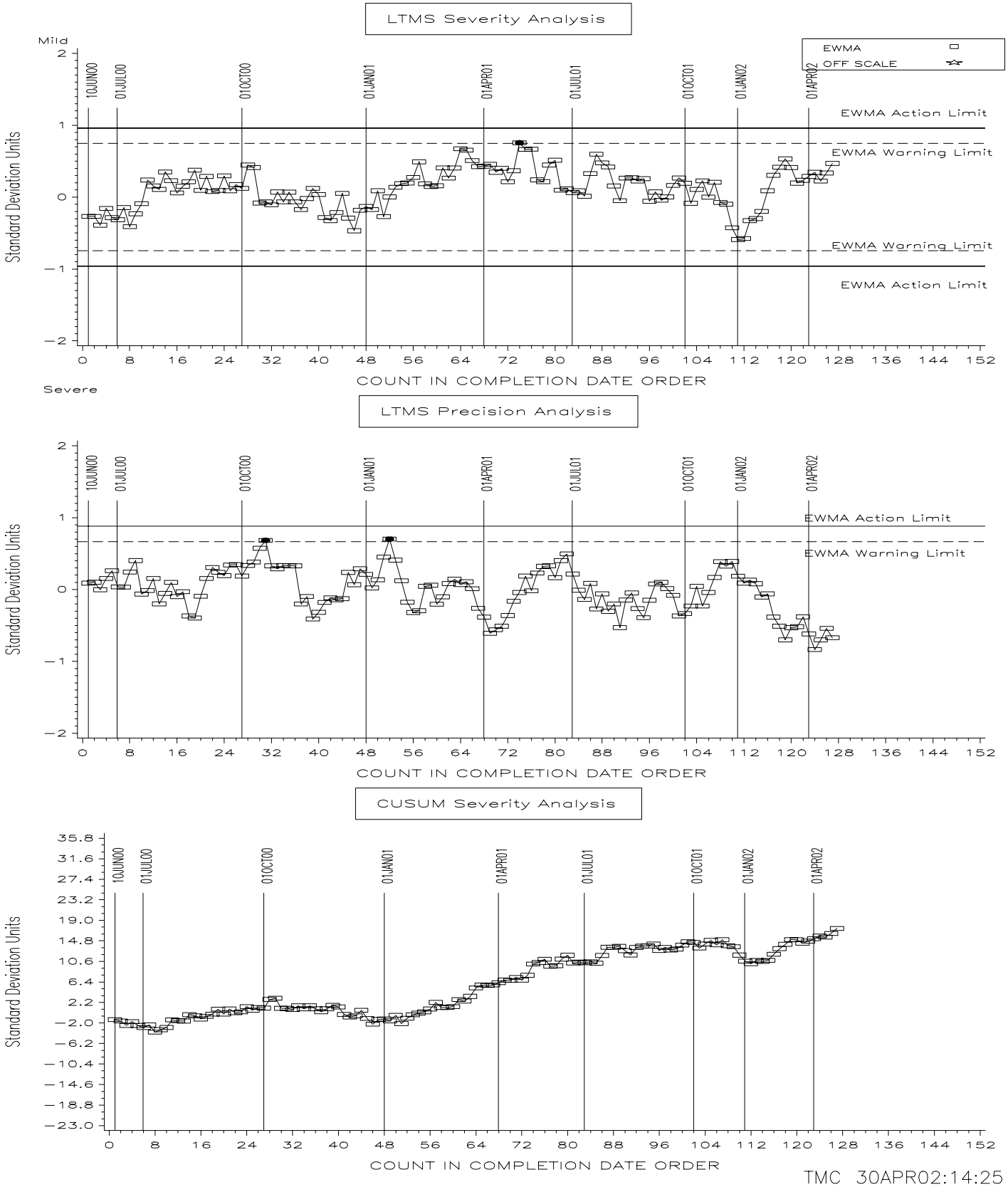
SEQUENCE IIIF INDUSTRY OPERATIONALLY VALID DATA

AVERAGE PISTON SKIRT VARNISH FINAL ORIG UNIT RES

Figure 3



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SEQUENCE IIIF INDUSTRY OPERATIONALLY VALID DATA

% VISCOSITY INCREASE @ 060 HOURS

Figure 4

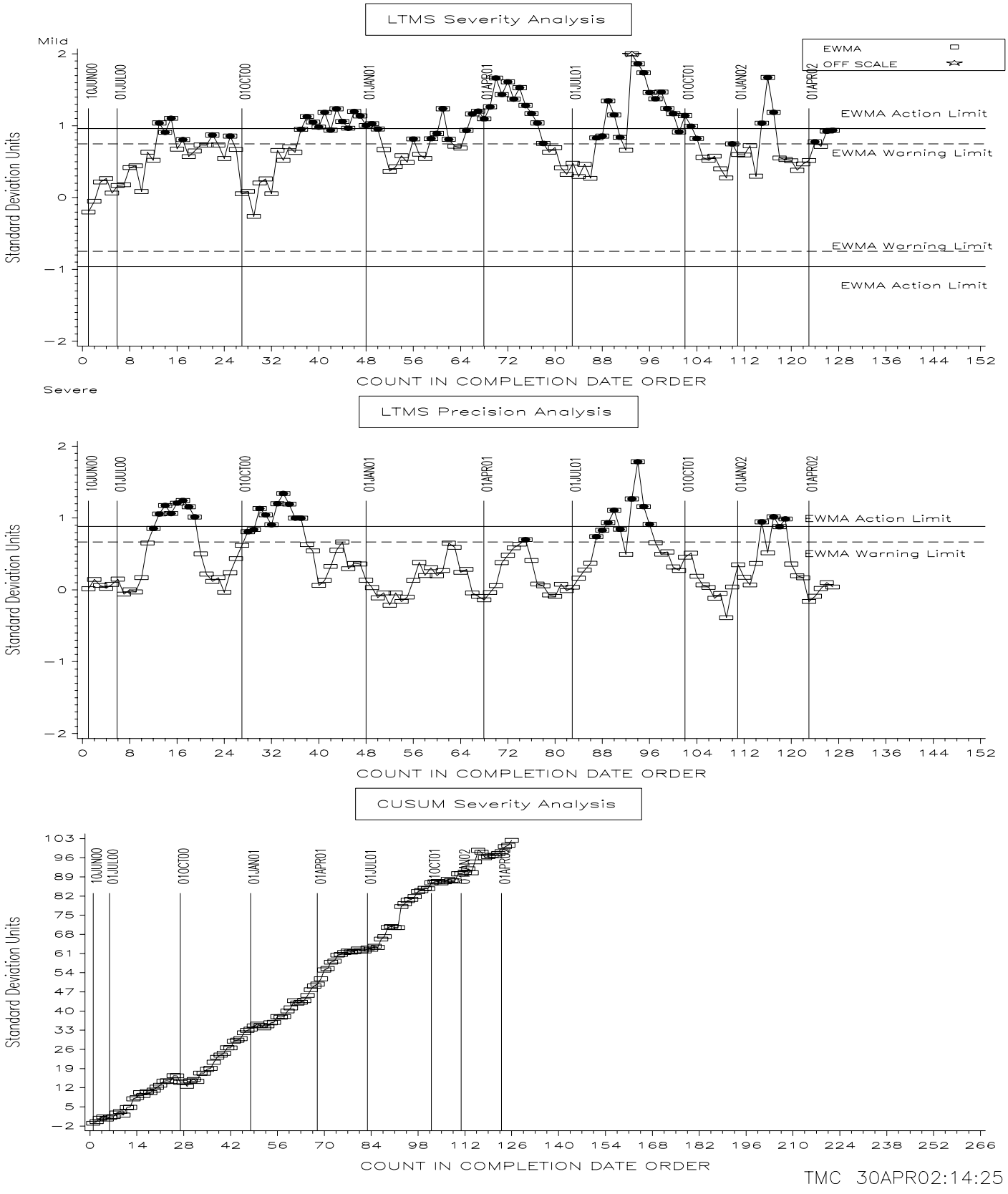

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Figure 5 - Percent Viscosity Increase, Average Delta/s

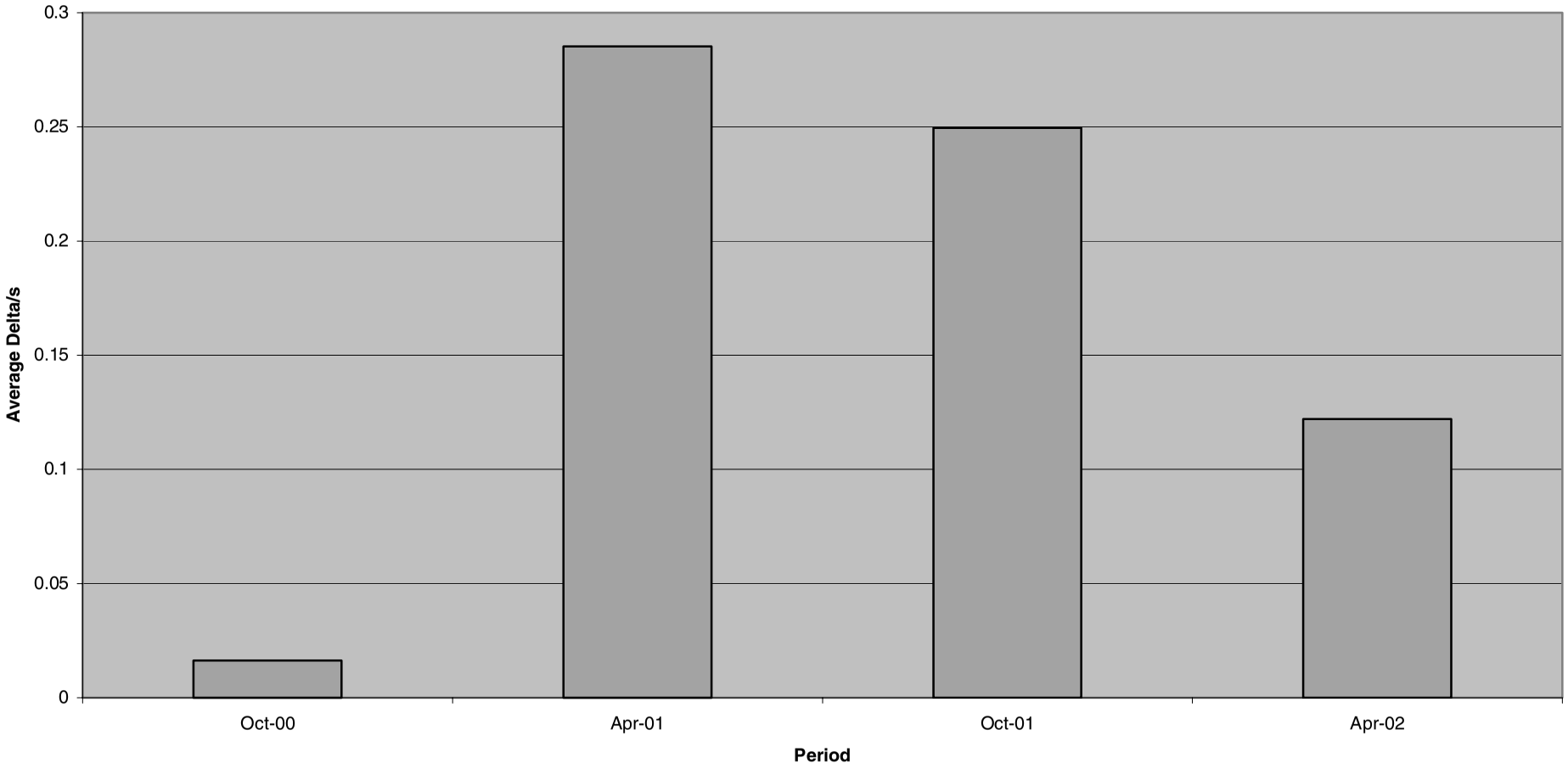

Figure 6 - Weighted Piston Deposits, Average Delta/s

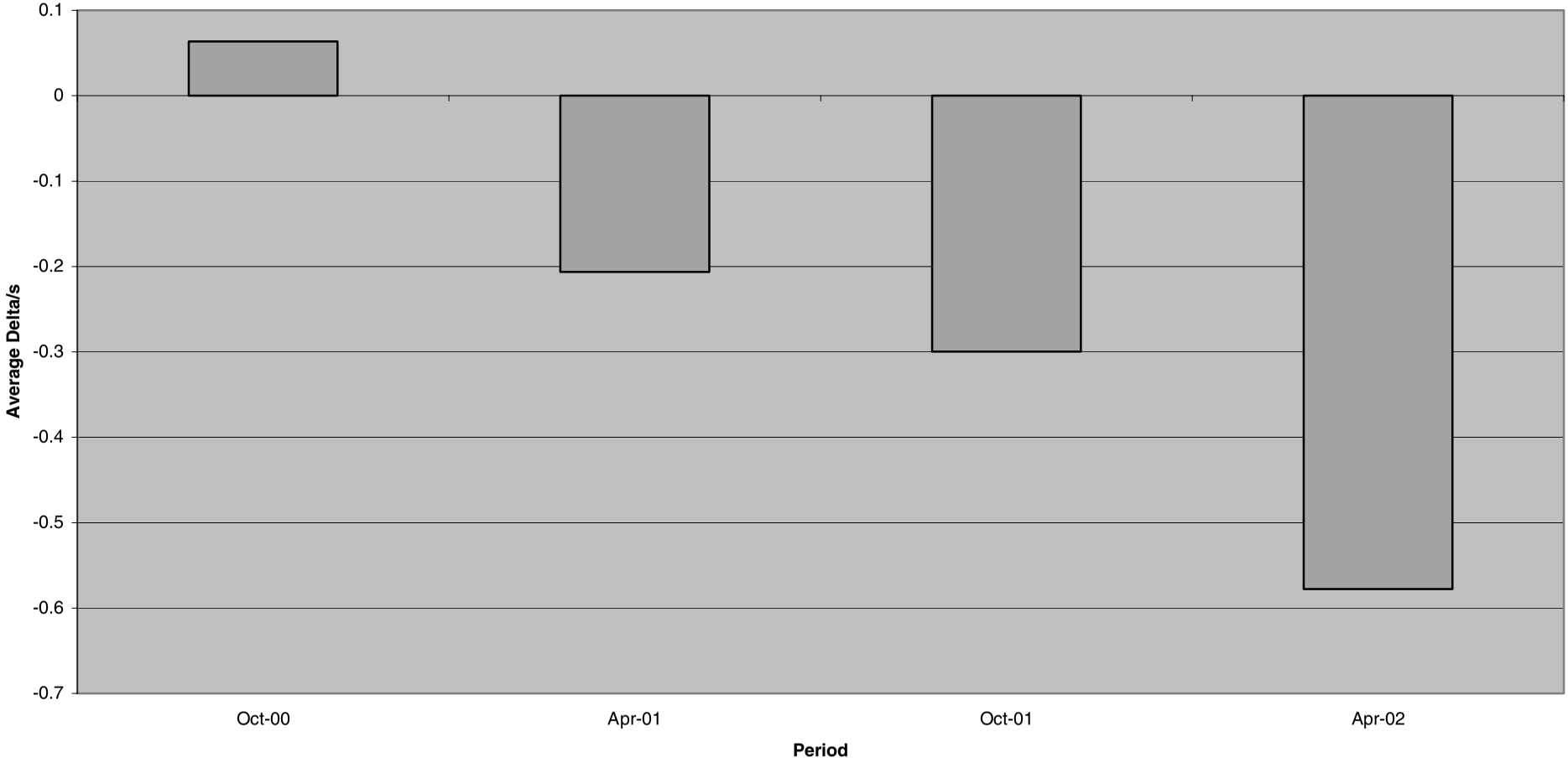

Figure 7 - Average Piston Varnish, Average Delta/s

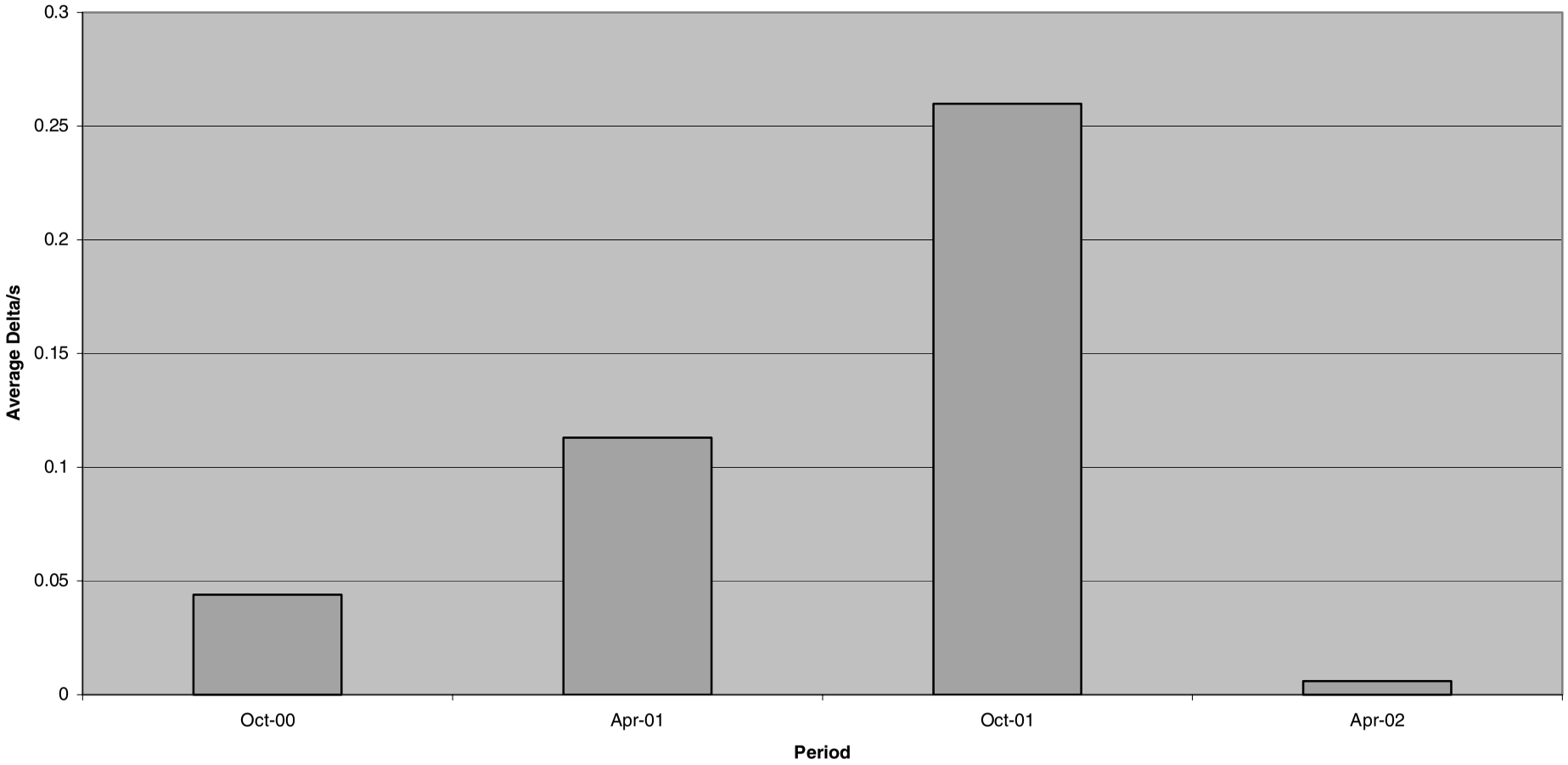

Figure 8 - Percent Viscosity Increase @ 60 Hours (Sequence IIIFHD), Average Delta/s

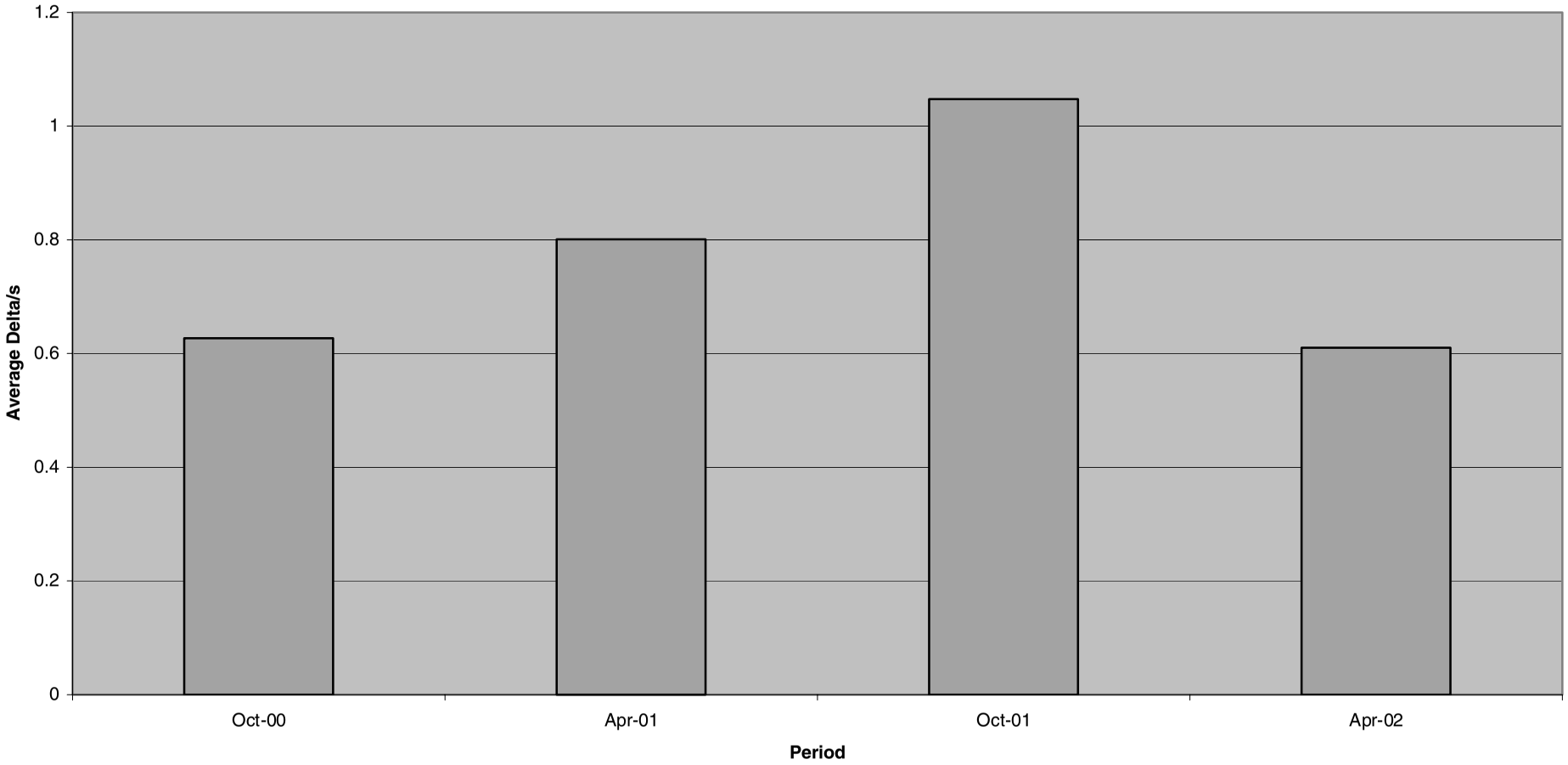

Figure 9 - Percent Viscosity Increase, Pooled Standard Deviation

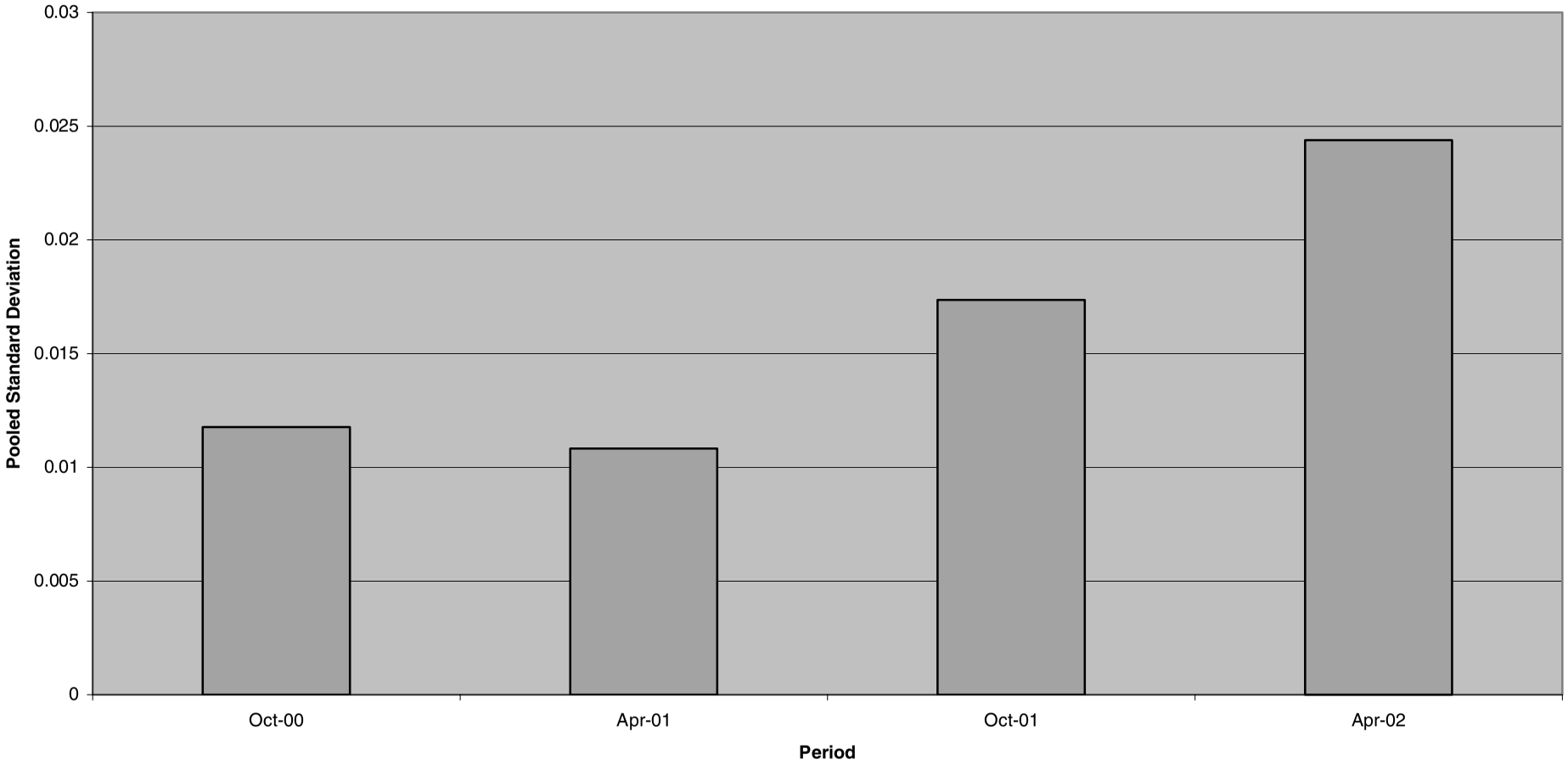

Figure 10 - Weighted Piston Deposits, Pooled Standard Deviation

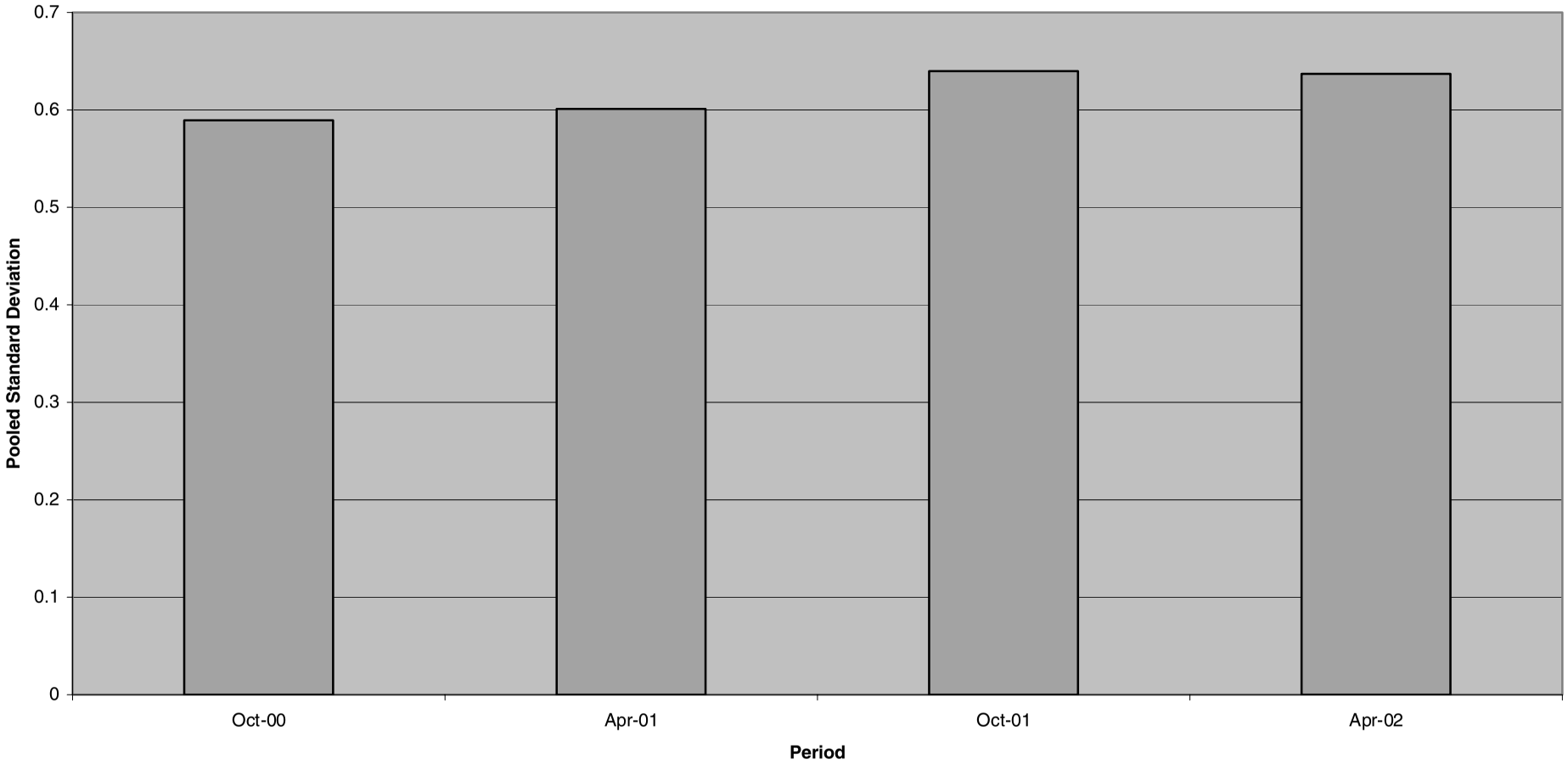

Figure 11 - Average Piston Skirt Varnish, Pooled Standard Deviation

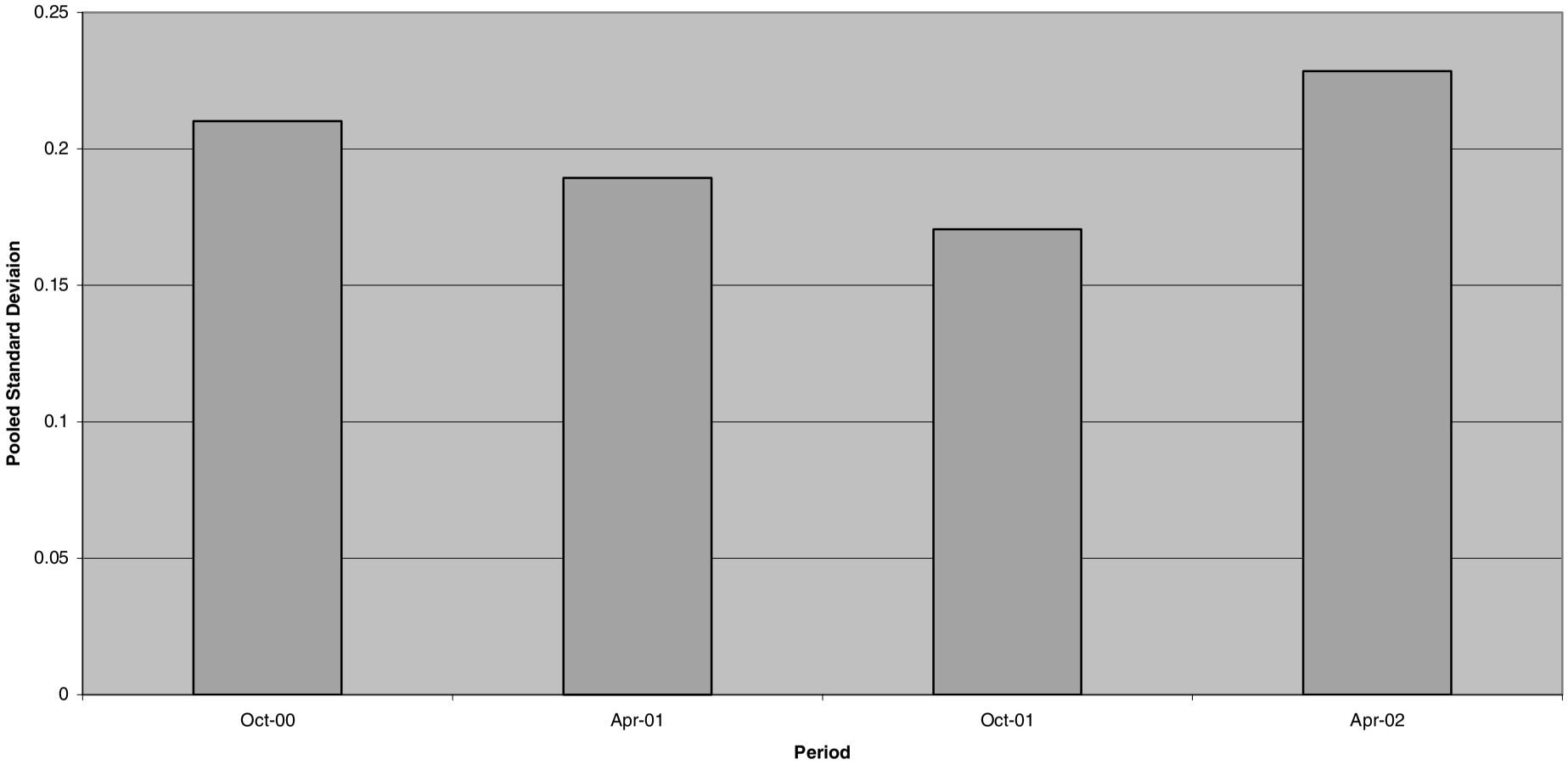

Figure 12 - Percent Viscosity Increase @ 60 Hours (Sequence IIIFHD), Pooled Standard Deviation

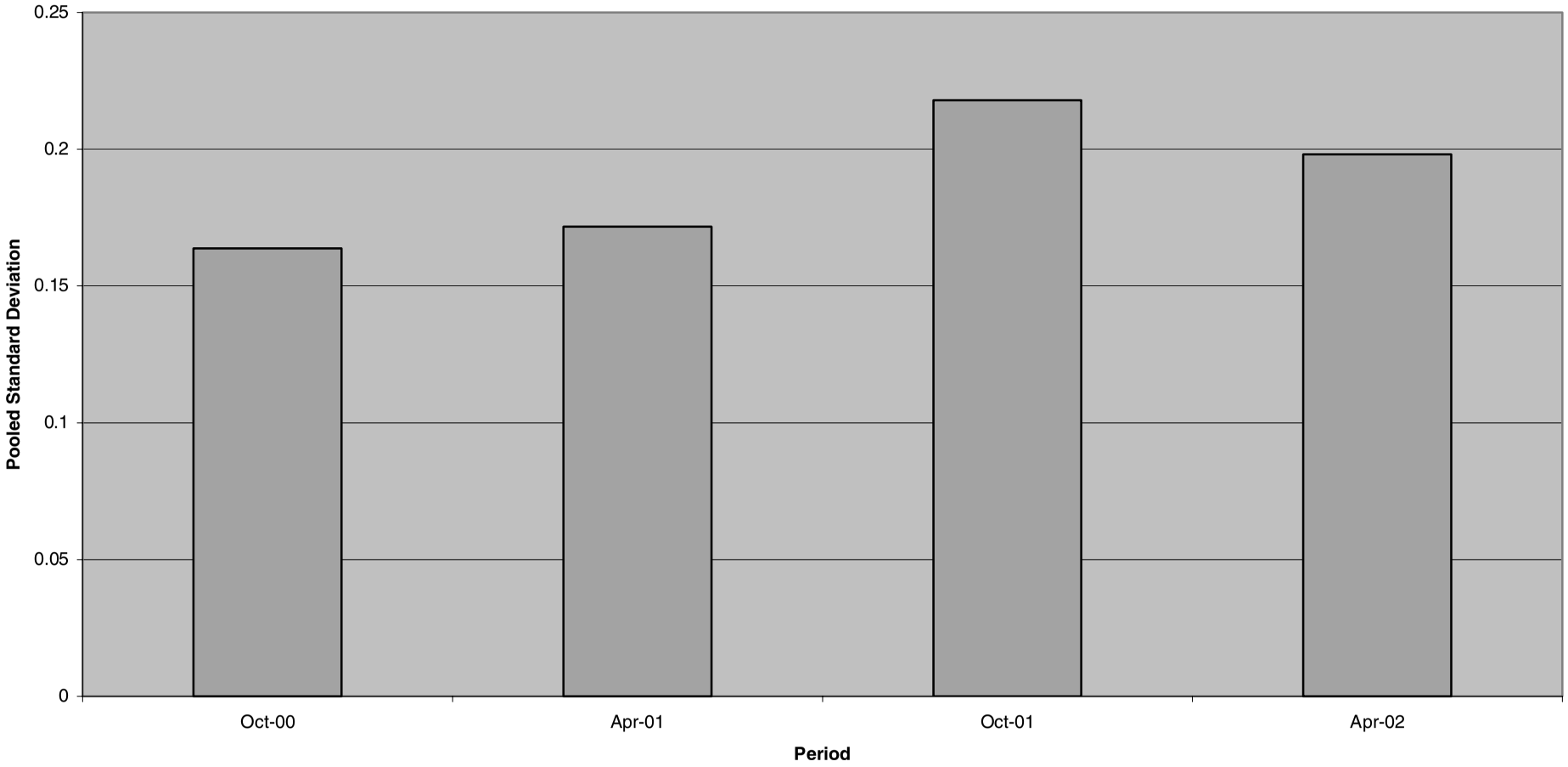

Figure 13 – Sequence IIIF Timeline

Date	Topic	Information Letter
6/10/2000	IIIF Test Released from Redevelopment	
9/8/2000	Draft 3 of the Sequence IIIF Test Procedure released	00-1
9/27/2000	MRV & CCS Testing of used oil samples added	00-2
10/4/2000	New QI U&L Values implemented	00-2
6/10/2000	Revised Ring Sticking definitions implemented	00-2
7/25/2000	Oil Consumption as a test validity criteria dropped	00-2
9/27/2000	Valve train assembly using build up oil implemented	00-2
10/8/2000	First occurrence of Valve train assembly using build up oil in LTMS	00-2
12/6/2000	Oil Consumption as a test interpretability criteria added	00-3
8/28/2000	First occurrence of LC camshafts in LTMS data	
4/25/2001	First occurrence of MB camshafts in LTMS data	
9/12/2001	First occurrence of engine builds using test oil for valvetrain lubrication in LTMS	
5/23/2001	Condenser Flow QI requirements dropped	01-1
5/23/2001	New oil addition at EOT dropped	01-1
5/23/2001	Condenser part number corrected	01-1
5/23/2001	Revised dipstick calibration curve implemented	01-1
5/23/2001	Revised MRV & CCS test procedures	01-1
5/23/2001	Upper limit of 8000cSt for viscosity measurements established	01-1
5/23/2001	Reexamination of Engine Speed and Condenser Coolant Out Temperature QI U&L values performed; no changes made	01-1
9/8/2001	Screened Average Cam-plus-lifter Wear (SACLW) replaces Average Cam-plus-lifter Wear (ACLW) as pass/fail parameter	01-2
9/8/2001	Valve train assembly using test oil reintroduced into IIIF test	01-2
11/28/2001	Sequence IIIF-HD Test Procedure Published	01-3
3/1/2002	Revised Sequence IIIF Test Procedure Published	02-1
3/15/2002	Sequence IIIFHD Test Procedure added to Revised Sequence IIIF Test Procedure. Editorial changes to IIIF Test Procedure also made and document republished	02-2
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