LTMS Task Force Meeting
January 28-29, 2009
Southwest Research Institute
Bldg 209, Room 103, 8:00 to 5:00
San Antonio, TX

Unapproved Minutes of the January 28 and 29, 2009 LTMS Task Force Meeting.

Introductions

Dan Worcester, Chairman (SwRI) welcomed everyone to the meeting of the LTMS Task Force at SwRI, San Antonio, Texas and called the meeting to order at 8:00am on 28th January 2009.

The attendees introduced themselves and the proposed Agenda (Attachment 1) was accepted.

Attendance sign-in sheet distribution

The Attendance Sheet (Attachment 2) was circulated.

Voting Members

Phil Scinto	Lubrizol
Bill Buscher	Southwest Research Institute
Frank Farber	ASTM TMC
Jim Rutherford	Chevron Oronite
Elisa Santos	Infineum
Todd Dvorak	Afton
Martin Chadwick	Intertek

Non-Voting Members

Dan Worcester	Southwest Research Institute
Richard Grundza	ASTM TMC
Chris Castanien	Lubrizol
Fred Gerhart	Southwest Research Institute

Motion and action recorder

Bill Buscher volunteered to record the Motions and Actions (Attachment 3) for this meeting. Raham Kirkwood was Secretary.

History

There was a conference call on December 18, 2008 at 11:00am Central Time. During this call it was determined this task force would apply to all tests affected by the LTMS system, but that the IIIG would be covered on one full day.

The email for minutes and feedback would be extended to TGC membership and B3. Chairs of the Surveillance Panels were requested to distribute to their membership to request input or suggested improvements for the existing LTMS system.

Phil Scinto (Lubrizol) provided and gave a presentation of "LTMS Re-Overview" (Attachment 4), which covered:

- LTMS Introduction
- LTMS Methodology
- Current Issues and Concerns
- LTMS Moving Forward

He also presented "LTMS Issues", (Attachment 5), which listed 17 considerations that for the Task Force. Each item was discussed in detail, but no decisions made on specific issues. The list will be sent out for feedback.

> Action Item – Invite Driveline/Gears and Bench Test surveillance panel chairs and the chair of B3 to join this group.

> Action Item – Task force members to review Phil Scinto's LTMS Issues document (17 issues) within their companies prior to the next LTMS task force meeting.

The question was raised where the new LTMS Task Force stood with respect to the previous LTMS Task Forces and it was determined that the current Task Force supercedes all of the preceding LTMS Task Forces.

Richard Grundza (TMC) suggested that representatives from the gear and driveline testing panels should be represented in future meetings since changes made to LTMS could affect them.

> Action Item – Create a subgroup to review the current LTMS document for a possible rewrite.

> Action Item – Invite Driveline/Gears and Bench Test surveillance panel chairs and the chair of B3 to join this group.

The meeting adjourned at 5:00 PM on the first day.

The second day started at 8:00 AM to focus on IIIG issues.

LTMS by Test Type

David Glaenzer (Afton) presented “Seq III Goals”(Attachment 6).

Richard Grundza (TMC) informed the groups that there is 4 tests of Oil 434 and ~25 tests of Oil 435 left in inventory.

Considerations and Recommendations

The group recommended that the remaining quantity of Oil 434 be withheld for future testing and start reference testing on the re-blend of Oil 434. It was also recommended not to introduce the re-blend for Oil 435 until sufficient data has been collected on the Oil 434 re-blend. 434-1 would be evaluated against existing 434 targets until 8 test are completed on the re-blend.

The introduction of 435-1 would be on hold until either a GF-5 level oil become available, or the re-blend of 434-1 introduction was completed.

Todd Dvorak (Afton) presented “Enhancements to the IIIG LTMS”(Attachment 7), which suggested that Reference Oil 438 should be discontinued since it does not represent current technology. The procedure also gave alternatives for a transformation on WPD ratings. He also had a discussion on the Rules of Eight, and has provided a representative sample as Attachment 8.

Jo Martinez (Oronite) presented graphs showing another transform to normalize WPD data.

There was also discussion on the Rule of Eights, which would apply in conditions where industry data showed a consistent severe or mild trend. It was decided to add this as Issue #18 for consideration as follows:

Consider modifications to IIIG LTMS that deals with trigger value for application of severity adjustments. Continue with the “normal” application of severity adjustment following the exceeding of the Zi threshold value. If the SP believes the test is in a severe or mild state and a lab has 5 (or some SP determined) number of Yi data in a row in the same direction of shift, reduce the K value for application of severity to 0 for that parameter until such time as the 5 in a row number is no longer satisfied or the SP deems the test parameter is no longer in the severe or mild state.

Future Activity

A sub-group to review the LTMS document for possible rewrite will be created and report back to this Task Force. Review by the larger group would lead to guidelines to report to the TGC and Surveillance Panels

David Glaenzer (Afton) will also report back to the Task Force any comments provided by the IIIG Surveillance Panel. That group will hold a conference call.

The Scope and Objectives generated at this meeting are included as Attachment 9.

Next Meeting

The next Task Force meeting will be contingent on the timeline and findings of the sub-group Task Force.

Adjourn

Dan Worcester, Chairman (SWRI) adjourned the meeting at 2:07pm.

ATTACHMENT

ONE

ASTM LTMS Task Force Meeting

San Antonio, TX
SwRI, Building 209, Conference Room 103
January 28-29, 2009
8:00 a.m. - 5:00 p.m.

A G E N D A

1. Introductions.
2. Attendance sign-in sheet distribution.
3. Motion and action recorder and Secretary.
4. History
   a. LTMS Review and History — PS
   b. Review of the 2008 Task Force Report
5. LTMS by Test Type
6. Recommendations
7. New business.
8. Future Activity
9. Next meeting.
10. Adjourn.

ATTACHMENT

TWO

SIGN-IN SHEET
ASTM LTMS TASK FORCE

January 28-29, 2009

NAME	COMPANY-ADDRESS-PHONE-FAX-EMAIL	SIGNATURE
Phil Scinto	Lubrizol Phone No.: 440-347-2161 Fax No.: Email: phil.scinto@lubrizol.com	PRS Day 2 M
Chris Castanier	Lubrizol Phone No.: 440 347 2973 Fax No.: Email: CCA@LUBRIZOL.com	M
Ryan D. Johnson	Southwest Research Institute Phone No.: 210-522-2892 Fax No.: Email: ryan.johnson@swri.org	Day 1 & Day 2
Raham Kirkwood	Southwest Research Institute Phone No.: 210-522-5905 Fax No.: Email: Raham.Kirkwood@swri.org	Day 1 & 2
Bill Buscher	SwRI Phone No.: 210-522-6802 Fax No.: Email: william.buscher@swri.org	WAB III M
Richard Grundza	ASTM TMC 6555 Penn Ave Pittsburgh, PA 15206 Phone No.: 412-365-1031 Fax No.: 412-365-1047 Email: reg@astmtmc.cmu.edu	Day 1 & Day 2 M
FRANK FARBER	TMC Phone No.: 412-365-1030 Fax No.: Email: fmf@astmtmc.cmu.edu	1/28 1/29 M
Mark Cooper	Chevron Oronite Co. 4502 Centerview Dr. Ste 210 San Antonio, TX 78228 Phone No.: 210-731-5506 Fax No.: Email: mawc@chevron.com	

SIGN-IN SHEET
ASTM LTMS TASK FORCE

January 28-29, 2009

NAME	COMPANY-ADDRESS-PHONE-FAX-EMAIL	SIGNATURE
Scott Richards	SWRI Phone No.: 210-522-3567 Fax No.: Email: Scott.Richards@SWRI.org	1/28 1/29
Jim Rutherford	Chevron Oronite Company LLC 100 Chevron Way Richmond CA 94802 Phone No.: 5102423410 Fax No.: NA Email: JARU@CHEVRON.COM	182 M
Elisa Santos	Infineum Phone No.: 908 474 3335 Fax No.: Email: Elisa.Santos@Infineum.com	1/28 1/29 M
Doyle Boese	Infineum Phone No.: 908 474-3176 Fax No.: Email: Doyle.Boese@Infineum.com	1/28 + 1/29
Charlie Leverett	Intertek Phone No.: Fax No.: Email: charlie.leverett@intertek.com	
JIM MORITZ	INTERTEK Phone No.: Fax No.: Email: JIM.MORITZ@INTERTEK.COM	1/29
Fred Gerhart	SwRI Phone No.: (210) 522-3842 Fax No.: Email: fgerhart@swri.org	
DAVID GLAENZER	Afton Chemical Phone No.: 804-788-5214 Fax No.: Email: dave.glaenzer@aftonchemical.com	M 2

SIGN-IN SHEET
ASTM LTMS TASK FORCE

January 28-29, 2009

Todd Dvorak	Afton Chemical Phone No.: 804-788-6367 Fax No.: Email: todd.dvorak@AftonChemical.com	1/29 M
Bob Campbell	AFTON Phone No.: Fax No.: Email:	RLC
MARTIN CHADWICK	INTERTEK Phone No.: Fax No.: Email:	M
DAN WORCESTER	SWRI DAY 2 Phone No.: Fax No.: Email:	M
JIM GUTZWILLER	INFINEUM USA LP 4241 PIEDRAS DRIVE EAST SUITE 111 SATX 78228 Phone No.: 210 732-8123 Fax No.: 210 732-8480 Email: JAMES.GUTZWILLER@INFINEUM.COM	1/28 1/29
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	

SIGN-IN SHEET
ASTM LTMS TASK FORCE

January 28-29, 2009

NAME	COMPANY-ADDRESS-PHONE-FAX-EMAIL	SIGNATURE
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	

SIGN-IN SHEET
ASTM LTMS TASK FORCE

January 28-29, 2009

NAME	COMPANY-ADDRESS-PHONE-FAX-EMAIL	SIGNATURE
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	

SIGN-IN SHEET
ASTM LTMS TASK FORCE

January 28-29, 2009

	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	
	Phone No.: Fax No.: Email:	

ATTACHMENT

THREE

LTMS Task Force
January 28, 2009
8:00AM – 5:00PM
SwRI, Building 209, Conference Room 103
San Antonio, TX

Motions and Action Items
As Recorded at the Meeting by Bill Buscher

1. Action Item – Create a subgroup to review the current LTMS document for a possible rewrite.

2. Action Item – Invite Driveline/Gears and Bench Test surveillance panel chairs and the chair of B3 to join this group.

3. Action Item – Task force members to review Phil Scinto's LTMS Issues document (17 issues) within their companies prior to the next LTMS task force meeting.

ATTACHMENT

FOUR

Overview of the Lubricant Test Monitoring System

AND

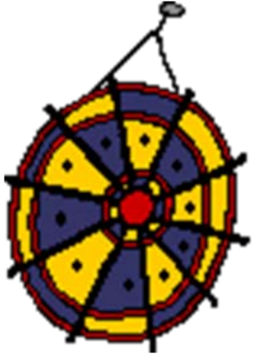
LTMS Moving Forward

Scinto: January 2009

AGENDA

- LTMS Introduction
- LTMS Methodology
- Current Issues and Concerns
- LTMS Moving Forward

LTMS Introduction



- What is LTMS?
  - Control Charting System that Monitors Both Bias and Precision for Both Abrupt Changes and Consistent Trends
  - Accuracy = Function(Bias, Precision)

- Why LTMS?
  - Maintain Calibration ➔ Protect Quality
  - X Special Causes ➔ Reduce Time/Cost

  - LTMS is a major prerequisite to fair, unbiased, cost effective candidate testing

LTMS Introduction

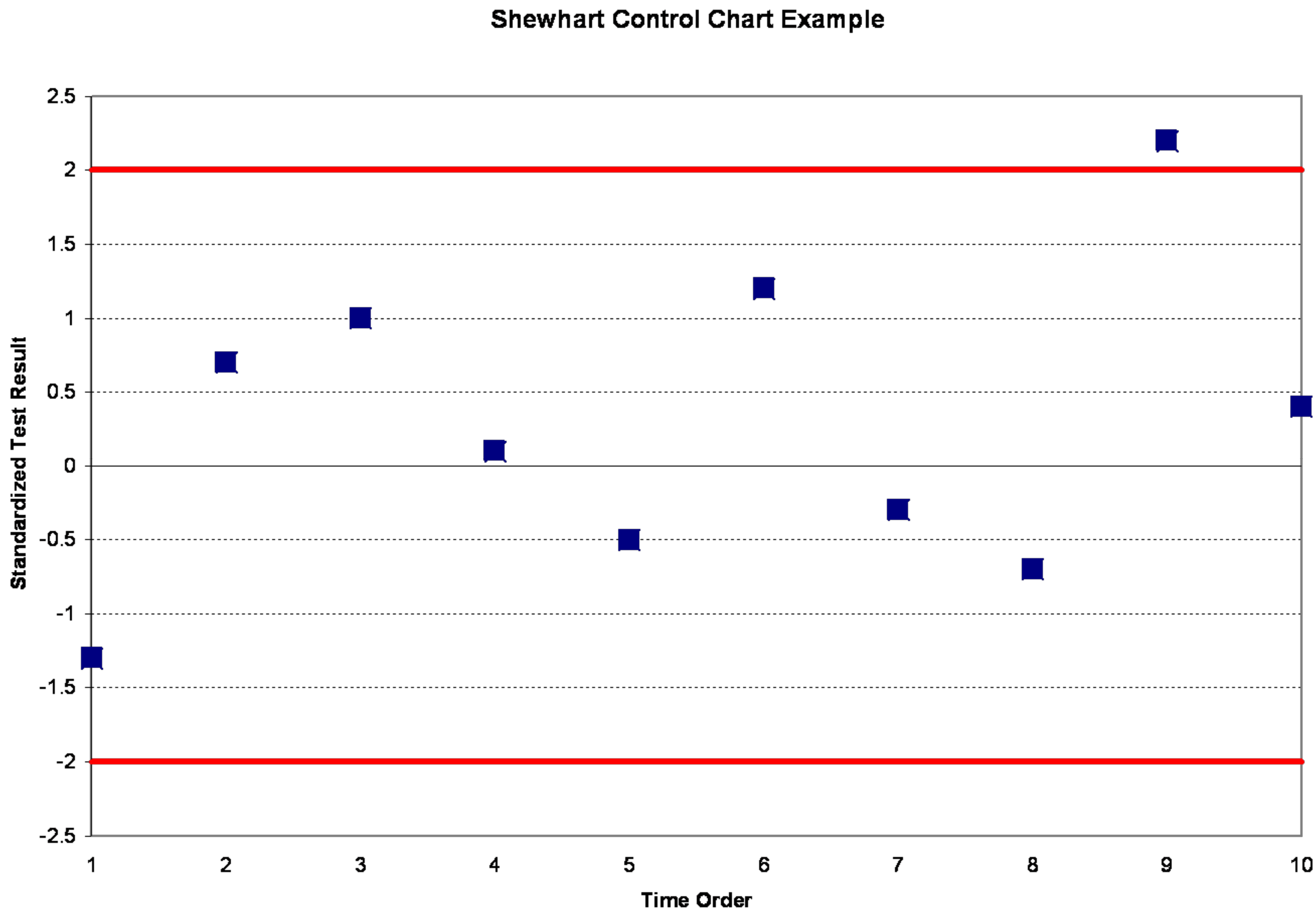
- Important Notes
  - LTMS does not solve problems
    - It is a tool to help solve problems
    - It is a tool to facilitate ‘fair’ testing
  - LTMS is at the mercy of bad practices
    - LTMS more effective under sound practices
  - LTMS should serve its purpose and should not be altered to accommodate poorly developed and administered tests
  - LTMS is not for all tests
    - Some tests have ‘priced’ themselves out of LTMS

LTMS Introduction

- Elements of LTMS
  - Increase value of reference tests
    - Test to generate necessary data, NOT as punishment
  - Use of ALL operationally valid data
  - Actions = Function (Control Chart)
  - Use of fixed reference oil targets
  - Use of reference oils that mimic candidates
  - Standardized control charts
  - Near real time severity adjustments
  - Monitoring of different levels of severity (Engine, Stand, Lab, Industry)

LTMS Introduction

- What is a Control Chart?
  - Critical tool in LTMS process



Shewhart Control Chart Example
Standardized Test Result
Time Order
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
1
2
3
4
5
6
7
8
9
10

LTMS Introduction

- LTMS Prerequisites
  - Consistent, managed parts supply
  - Consistent, managed fuel supply
  - Consistent test operation and hardware
  - Consistent, managed supply of reference oils that mimic the performance of candidate oils
  - Approximate data normality (transformations)
  - Sufficient reference testing per lab
  - Baseline matrix or round robin or data history

LTMS Introduction

- Perspective
  - Why Do all This?
    - An Investment
    - Cost Effective Testing
    - Poor Oils Must Fail and Good Oils Must Pass

LTMS Methodology

- Four Control Chart Types
  - Shewhart – Bias/Severity
  - Shewhart - Precision
  - EWMA – Bias/Severity
  - EWMA Precision
- Appropriate chart levels
  - Lab, Stand, Engine, Industry, Other?
- Appropriate actions
  - Shewhart and EWMA charts working together
  - Additional reference testing should NOT be a punishment, but a means of gathering necessary information in times of uncertainty

LTMS Methodology

- Notation
  - k = Standard Deviation Multiplier for Control Chart Limit
  - X_i = Test Result at Test/Time i
  - T_i = Transformed Test Result at Test/Time i
    - Example: $T_i = LN(Y_i)$
  - Y_i = Standardized Test Result at Time/Test i
    - $$Y_i = \frac{(T_i - \text{Reference Oil Mean})}{\text{Reference Oil Standard Deviation}}$$
  - R_i = Standardized Range at Time/Test I
    - $$R_i = \frac{SQRT(|Y_i - Y_{i-1}|) - 0.969}{0.416}$$

LTMS Methodology

- Notation
  - Z_i = Exponentially Weighted Moving Average of Y_i
    - $Z_i = (\lambda) Y_i + (1 - \lambda) Z_{i-1}$
  - Q_i = Exponentially Weighted Moving Average of R_i
    - $Q_i = (\lambda) R_i + (1 - \lambda) Q_{i-1}$
  - Lambda = λ = Tuning parameter for EWMA

LTMS Methodology

- The Exponentially Weighted Moving Average (EWMA)

$Z_i \quad = \qquad (\lambda)\, Y_i \;+\; (1 \;-\; \lambda)\, Z_{i-1}$

where: $0 < = \lambda < = 1$, $Z_0 = 0$

Z_i has a Memory, it Captures Process History

Z_i is the One-Step-Ahead Predictor of the Process

$VAR(Z_i) = (\lambda \,/\, (2 \;-\; \lambda)) \times VAR(Y_i)$

LTMS Methodology

- EWMA Example (Set $\lambda = 0.3$)

  $Z_i = (\lambda) Y_i + (1 - \lambda) Z_{i-1}$

$Y_1 = 0.5$

$Z_1 = (0.3)(0.5) + (0.7)(0) = 0.15$

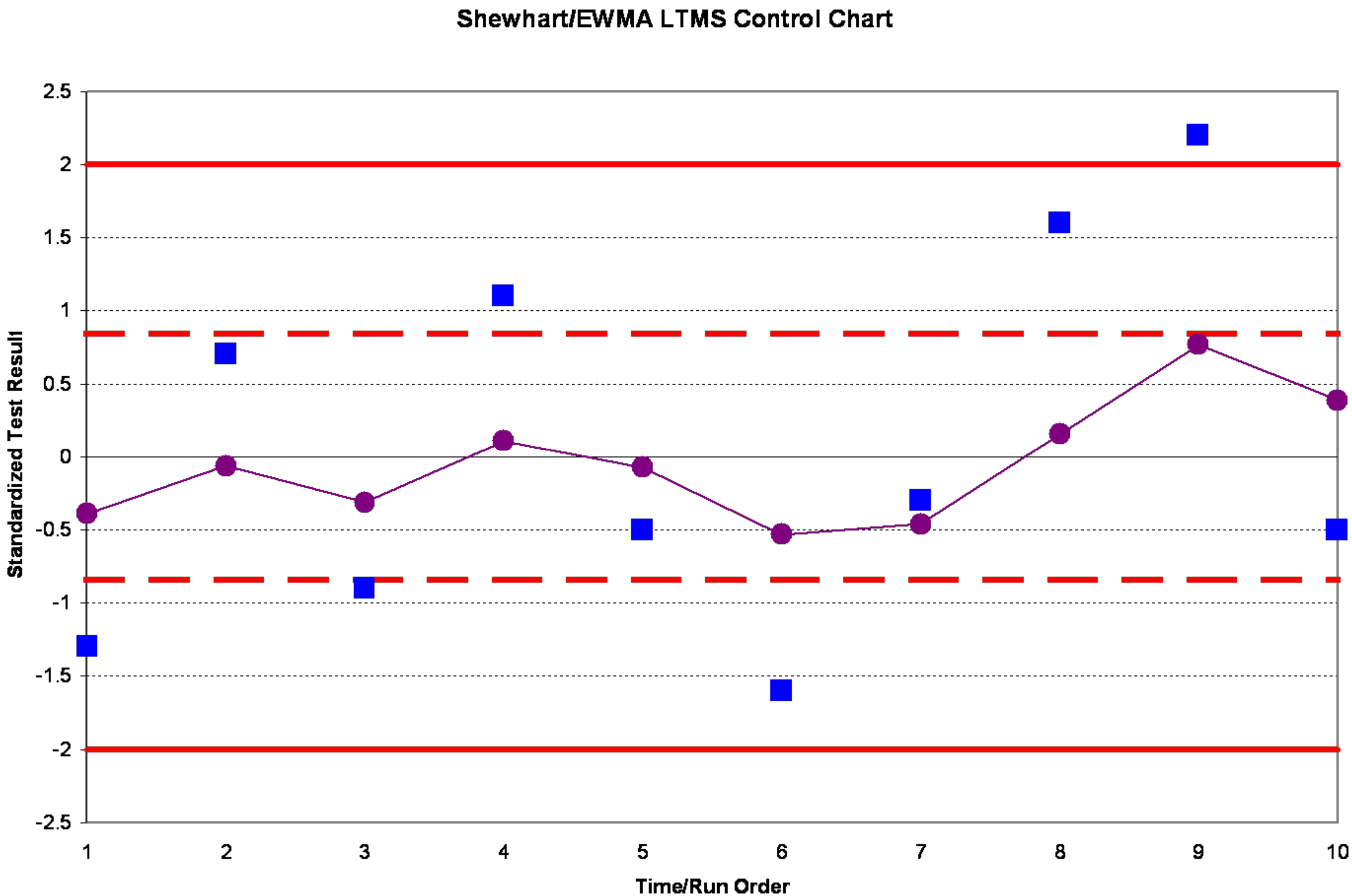
$Y_2 = 1.0$

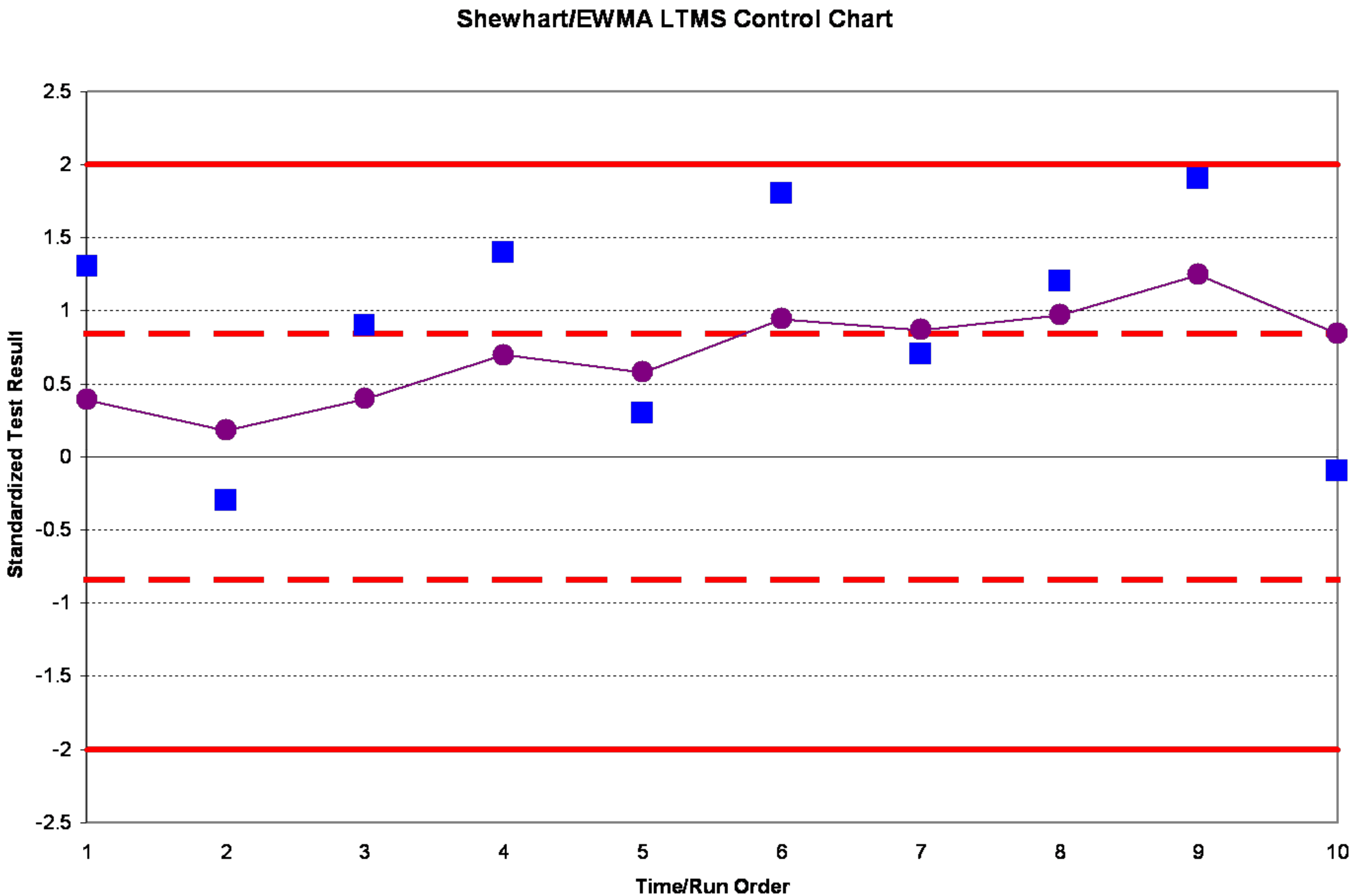
$Z_2 = (0.3)(1.0) + (0.7)(1.15) = 0.405$

$Y_3 = 0.75$

$Z_3 = (0.3)(0.75) + (0.7)((0.405) = 0.5085$

$Z_3 = (0.3)(Y_3) + (0.3)(0.7)Y_2 + (0.3)(0.7)(0.7)(Y_1) + (0.7)(0.7)(0.7)(Z_0)$


Shewhart/EWMA LTMS Control Chart
Standardized Test Result
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
1
2
3
4
5
6
7
8
9
10
Time/Run Order


Shewhart/EWMA LTMS Control Chart
Standardized Test Result
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
1
2
3
4
5
6
7
8
9
10
Time/Run Order

LTMS Methodology

	Typical Corrective Actions for Lab Chart	
	Shewhart Chart	EWMA Chart
Severity	Run Another Reference Test	Apply EWMA as Severity Adjustment
Precision	~~Run Another Reference Test~~	~~Cease Candidate Testing (2 Tests to Restart)~~

LTMS Methodology

- Determination of λ and k for the EWMA

False Alarm Error Rate	Average Run Length for 0.0s Shift		
	$\lambda = 0.1$	$\lambda = 0.2$	$\lambda = 0.3$
9%	38.55	24.52	18.56
7%	45.14	29.57	23.31
5%	62.47	41.13	32.22
3%	89.04	60.77	48.31
1%	141.2	116.2	103.6

LTMS Methodology

- Determination of λ and k for the EWMA

False Alarm Error Rate	Average Run Length for 0.5s Shift		
	$\lambda = 0.1$	$\lambda = 0.2$	$\lambda = 0.3$
9%	12.17	10.22	9.25
7%	13.11	11.11	10.19
5%	14.78	12.72	12.11
3%	17.65	15.91	15.51
1%	25.64	25.16	25.08

LTMS Methodology

- Determination of λ and k for the EWMA

False Alarm Error Rate	Average Run Length for 1.0s Shift		
	$\lambda = 0.1$	$\lambda = 0.2$	$\lambda = 0.3$
9%	5.48	4.54	4.07
7%	5.86	4.86	4.40
5%	6.48	5.46	4.98
3%	7.31	6.14	5.80
1%	9.06	7.88	7.82

Current Issues and Concerns

- Lack of training
  - All involved trained together in 1991
  - Several generations have passed without training
  - There is a basic lack of understanding of LTMS
- Deviation from LTMS elements, focus and philosophy
  - Ex: Request for poor failing oil
  - Ex: Change k value to turn fail into pass
  - Ex: Limited to no accountability for poor variability
- Setting reference oil targets
  - Need ‘sufficient data’ in a short time frame
  - New blends should take old data into account
- Reference frequency and minimum tests

Current Issues and Concerns

- Normality and transformations
- Selection of false alarms error rate, detection power and λ
  - Select and standardize based on LTMS philosophy
- Lab vs stand based systems
  - Should not be based on financials
- Use of precision charts
  - Old methodology was flawed, but can develop new
- Providing better incentives for “good” lab behavior
- Providing less opportunity to “trick” the system
- LTMS worth given today’s time and money

LTMS Moving Forward

- Need buy in and agreement to philosophy and elements
- Need to examine the system as a whole and on a test by test basis
- Need to be committed to periodic reviews
- Need to provide training to engineers and formulators

ATTACHMENT

FIVE

Goal

Standardize LTMS across test types and provide a consistent template for all test types. LTMS guidelines are suggested in order to provide the best possible basis for level-playing-field, unbiased, cost-effective candidate testing.

Issue 1: Reference Oils

Reference Oils are requested and selected by the ASTM Surveillance Panel and Classification Panel.

Important guidelines for reference oil selection:

- Strive for reference oils that "mimic" candidate oil behavior.
- Reference oils should meet the chemical and physical limits of the category.
- Reference oils do not need to pass every parameter for the test, but they should be "around" the pass/fail limit. Oils that are more than 2 standard deviations above or 1 standard deviation below any pass/fail parameters are not desirable.

Issue 2: Test Targets

Test targets are developed by the Surveillance Panel. However, given the importance of test targets to the success of LTMS, it is worth considering target development as a responsibility of the LTMS Task Force or ACC.

Important guidelines for target development:

- Strive for a homogeneous dataset to set targets.
- Outliers should not be removed from the target dataset unless special cause can be identified. In other words, if outlier test results can be attributed to a set of parts, a certain lab practice, or a certain lab, then the outlier results may be removed or adjusted through statistical regression analysis..
- Target development dataset should be developed within as short a timeframe as possible.
- Time effect should be checked in every target development dataset. If time is a factor, then it needs to be accounted for and corrected.
- Issues involving oil by lab interactions should be resolved before final targets are set.

- Mean and standard deviation targets should be based on data that is as close to normally (Gaussian) distributed as possible. In order to achieve this, use of a data transformation may be necessary. In addition, a transformation may also be necessary to eliminate any relationships between oil means and standard deviations. The assumption of normality is very important to the appropriateness of the LTMS control charts.
- Test standard deviation estimates should be developed based on the process monitored. For example, if the data permits a variance components analysis, an estimate of the within engine standard deviation should be used for monitoring test engines. An estimate of the within lab (between stand/engine) standard deviation should be used for monitoring labs, and an estimate of the within industry (between labs) standard deviation should be used for monitoring Industry.
- A minimum of 10 tests should be used to set targets. If this is not possible, the targets should be recalculated at 10 tests and 30 tests.
- If targets are being developed for a re-blend of an oil, the old targets should be used until there are 10 tests on the re-blend. Any time effects should be incorporated into the re-blend targets. It is worth considering using the old targets as a prior, and updating the prior with the re-blend data to set the re-blend targets.
- Keep in mind that targets are developed to enable LTMS to achieve the best possible basis for level-playing-field, unbiased, cost-effective candidate testing.

Issue 3: Determine Major Source of Variability

For each test type, the major source of variability needs to be determined in order to set the appropriate calibration requirements and source of severity adjustments. The major source of variability should be determined by the Surveillance Panel.

Major Source: Lab
In this situation, test parts and lab practice are the major sources of variation for test results. The actual test engine or test stand might have an impact, but the influence is less likely. The test operation should be largely static (steady-state) as opposed to dynamic. There is typically a rebuild after each test.

Reference intervals and frequency would be based on time/candidates in the lab as opposed to the stand, although requirements may be placed on the stand as well. Precision requirements and severity adjustments would apply to the lab.

Major Source: Lab/Stand or Lab/Engine
In this situation, test parts and lab practice are the major sources of variation for test results, but the variability of the stand and/or engine cannot be discounted. In this situation, while there might be a rebuild after each test, the rebuild does not consist of all major parts. The test operation might also have more of a dynamic component.

Reference intervals and frequency would be based on time/candidates in the stand or engine, although additional requirements may be placed on the lab as well. Precision requirements would apply to the stand or the engine as well as the lab and severity adjustments would be on a lab basis.

Major Source: Engine
In this situation, the specific test engine is the major sources of variation for test results. This is typically a flush and run test and/or a test with a large dynamic component.

Reference intervals and frequency would be based on time/candidates in the engine, although additional requirements may be placed on the lab as well. Precision requirements and severity adjustments would apply to the engine.

Issue 4: New Calibration

For a system in which the major source of variation is considered to be the Lab, consider a 4 test, reference test requirement to calibrate the lab (at a minimum, more may be warranted), and a 1 test, reference test requirement to calibrate each stand. Reduced K does not apply.

For all other system types (Lab/Stand, Lab/Engine, Stand/Engine, Stand, Engine), consider 4 reference tests to calibrate the first Stand or Engine in the lab, 3 reference tests to calibrate the second, and 2 reference tests to calibrate each new, subsequent stand or engine (at a minimum, more may be warranted). Since the calibration requirement is on the stand/engine, reduced K should apply for each new stand in a lab that has completed at least 6 reference tests and does not currently have any precision alarms. The reduced K requirement should be for severity only as the precision in the 1 test case is redundant. The reduced K is set such that the probability of a successful calibration under the reduced K scenario is equivalent to two consecutive successful calibrations under the original K scenario. A full table is provided in the ‘Reduced K Calculations’ and ‘Reduced K Table’ tabs in Appendix A.

The K value of reference test acceptance (K values are the control chart limits and represent the number of standard deviations from target) may be set based upon a fixed 5% false alarm error rate (a higher false alarm error rate may be warranted, for example, for tests in which the reference frequency is very low) for each critical test parameter. Non-critical test parameters (the definition of non-critical is, at the time being, at the determination of the appropriate Surveillance Panel) may be adjusted to an overall 5% false alarm error rate (once again, a higher false alarm error rate may be warranted) based upon the number of independent test parameters in the test. Principal components that explain at least 90% of the test variation should be used to determine the number of independent parameters from which to set the overall 5% false alarm error rate for non-critical parameters only. Until the principal components analysis can be performed, minimum of 10 test results to perform the analysis, the individual, critical parameter, false alarm error rate shall apply. The attached table in the 'False Alarm Error Rates' tab (see Appendix A) lists the false alarm error rates as a function of K, the number of parameters, and whether or not the control chart has a one-sided or two-sided limit.

Issue 5: Exceed EWMA Lab Precision Alarm

For a system with lab based severity adjustments, perform the following actions.

- Special K and Reduced K no longer apply for the parameter.
- There are to be no lab severity adjustments for being severe for the parameter with the precision issue.
- Lab severity adjustments would continue for being mild in the parameter.
- Reduce the reference interval for the next scheduled reference test (whether or not it is the same stand or engine) by three candidate tests, or the number of days equivalent to three candidate tests. This might be a percentage of the calibration period.

For a system with stand or engine based severity adjustments, perform the following actions.

- None, but notify TMC.

Issue 6: Exceed EWMA Stand/Engine Precision Alarm

For a system with stand or engine based severity adjustments, perform the following actions.

- Special K and Reduced K no longer apply for the parameter.
- There are to be no stand/engine severity adjustments for being severe for the parameter with the precision issue.
- Severity adjustments would continue for being mild in the parameter.
- Reduce the reference interval for the next scheduled reference test in the offending stand/engine by three candidate tests, or the number of days equivalent to three candidate tests. This might be a percentage of the calibration period.

For a system with lab based severity adjustments, perform the following actions.

- Special K and Reduced K no longer apply for the parameter.
- Reduce the reference interval for the next scheduled reference test in the offending stand/engine by three candidate tests, or the number of days equivalent to three candidate tests. This might be a percentage of the calibration period.

Issue 7: Exceed Shewhart Lab Precision Warning Alarm

For a system with lab based severity adjustments, perform the following actions.

- Special K and Reduced K no longer apply for the parameter.
- Reduce the reference interval for the next scheduled reference test (whether or not it is the same stand or engine) by one candidate test, or the number of days equivalent to one candidate test. This might be a percentage of the calibration period.

For a system with stand or engine based severity adjustments, perform the following actions.

- None, but notify TMC.

Issue 8: Exceed Shewhart Lab Precision Action Alarm

For a system with lab based severity adjustments, perform the following actions.

- Special K and Reduced K no longer apply for the parameter.
- Reduce the reference interval for the next scheduled reference test (whether or not it is the same stand or engine) by four candidate tests, or the number of days equivalent to four candidate tests. This might be a percentage of the calibration period.

For a system with stand or engine based severity adjustments, perform the following actions.

- None, but notify TMC.

Issue 9: Exceed Shewhart Stand/Engine Precision Warning Alarm

For a system with stand or engine based severity adjustments, perform the following actions.

- Special K and Reduced K no longer apply for the parameter.
- Reduce the reference interval for the next scheduled reference test in the offending stand/engine by one candidate test, or the number of days equivalent to one candidate test. This might be a percentage of the calibration period.

For a system with lab based severity adjustments, perform the following actions.

- Special K and Reduced K no longer apply for the parameter.
- Reduce the reference interval for the next scheduled reference test in the offending stand/engine by one candidate test, or the number of days equivalent to one candidate test. This might be a percentage of the calibration period.

Issue 10: Exceed Shewhart Stand/Engine Precision Action Alarm

For a system with stand or engine based severity adjustments, perform the following actions.

- Special K and Reduced K no longer apply for the parameter.
- Reduce the reference interval for the next scheduled reference test in the offending stand/engine by four candidate tests, or the number of days equivalent to four candidate tests.

For a system with lab based severity adjustments, perform the following actions.

- Special K and Reduced K no longer apply for the parameter.

- Reduce the reference interval for the next scheduled reference test in the offending stand/engine by four candidate tests, or the number of days equivalent to four candidate tests.

Issue 11: Exceed EWMA Lab Severity Alarm

For a system with lab based severity adjustments, perform the following actions.

- Calculate and apply lab based severity adjustments to all candidates in the lab completed after the alarm after following rules for precision alarms.

For a system with stand or engine based severity adjustments, perform the following actions.

- None, but notify TMC.

Issue 12: Exceed EWMA Stand/Engine Severity Alarm

For a system with stand or engine based severity adjustments, perform the following actions.

- Calculate and apply stand/engine based severity adjustments to all candidates in that particular stand/engine completed after the alarm after following rules for precision alarms.

For a system with lab based severity adjustments, perform the following actions.

- None, but notify TMC.

Issue 13: Exceed Shewhart Severity Alarm

For a system with lab as the major source of variation (note that this is a subset of systems with lab based severity adjustments), perform the following actions.

- Immediately conduct an additional calibration test in the offending stand/engine. However, if a severity adjustment existed in the lab prior to the reference test, and the alarm is in the direction of the severity adjustment, then an additional calibration test need not be run as long as the test result is within the Special K control chart limit. However, if the Special K control chart limit is utilized, reduce the reference interval for the next scheduled reference test by two candidate tests, or the number of days equivalent to two candidate tests.
- If a test stand fails two consecutive calibration tests on the same parameter but on different reference oils, the stand must generate two (2) operationally valid calibration tests, with no Shewhart severity alarms (all parameters).

For a system with stand or engine based severity adjustments, perform the following actions.

- Immediately conduct an additional calibration test in the offending stand/engine. However, if a severity adjustment existed in the stand/engine prior to the reference test, and the alarm is in the direction of the severity adjustment, then an additional calibration test need not be run as long as the test result is within the Special K control chart limit. However, if the Special K control chart limit is utilized ,reduce the reference interval for the next scheduled reference test in that particular stand/engine by two candidate tests, or the number of days equivalent to two candidate tests.

Issue 14: Operationally Invalid Reference Tests

For every 2 invalid reference tests in a calibration attempt, reduce the reference interval of the next available stand by one candidate, or the number of days equivalent to one candidate test, whether or not the original stand remains in the system.

Issue 15: Setting K and Lambda Values

There is certainly a tradeoff in setting K values between detecting shifts and minimizing false alarms. The larger the K, the smaller the false alarm error rate, and the longer the Average Run Length (ALR) of reference tests until an alarm. While that is a positive, the downside is a smaller alarm rate and longer ARL when trying to detect shifts, trends and problems. The error rates and Average Run Lengths for the Shewhart control charts are included in the ‘Probability of an Alarm’, and ‘Shewhart ARL’ tabs in Appendix A. The plot of ARL as a function of K and the actual shift in severity is found in the ‘ARL Plot’ tab. One can clearly see the tradeoff between false alarms and shift detection in this plot. It may be wise to consider consequences of false alarms, consequences of not detecting shifts, and the number of reference tests that a lab or stand is expected to run in its lifetime when selecting a K value.

While calculating the Shewhart theoretical alarm error rates and the ARL are simple and straightforward using the normal distribution (assuming that the data is normal, that is), the calculations are a little bit more difficult for the EWMA because the calculations involve lambda and the data are correlated. Therefore, simulation is used to calculate the ARL in the ‘EWMA ARL’ tab. The concept of the higher the lambda, the more weight on the most recent data point in the EWMA control chart is not too difficult to understand, but setting lambda is not easy. Given that the Shewhart charts are already an EWMA with lambda equal to one (1), we begin at 0.3 and below for lambda considerations. Once again it may be wise to consider consequences of false alarms, consequences of not detecting shifts, and the number of reference tests that a lab or stand is expected to run in its lifetime when selecting a lambda and K value for the EWMA charts. For example, given the importance of precision, but the consequences of an EWMA precision alarm, plus the influence of outlier results on precision alarms (an outlier greatly affects two data points for monitoring precision) it may be a good idea to use a lower K (1.645, for example), and a lower lambda (0.1, for example).

Issue 16: Template for Lambda and K

It is important to establish a general, standardized template for Lambda and K values from which to discuss any possible deviations for specific engine tests. Suggestions for a starting point may be found in the 'Generic Lambda and K' tab in Appendix A.

Issue 17: Deviations Based on Lab Size and/or Reference Frequency

While it appears that LTMS guidelines should be adjusted based on lab size and/or reference frequency, this is not necessarily the case. There will always be inherent advantages and disadvantages to being a lab with many stands or being a lab with one stand. If you are a lab with many stands, you are more likely to encounter a false alarm than a lab with a single stand. However, the impact of a false alarm on overall lab economics is not as large. If you are a lab with many stands, you are more likely to get that severity adjustment when the Industry is severe than a lab with one stand. However, you are also more likely to get that severity adjustment when the Industry is mild. Therefore, although there are easy to see advantages to being a large lab or a small lab, overall, the system is fair. A large lab or a small lab may catch a bad break, and that is unfortunate, but the system is fair, and it would be unwise and detrimental to adjust the system for every perceived bad break.

In the past, we have been reluctant to use severity adjustments for tests with very low reference frequencies. The point was that it may take several years to get 4 to 5 test results in order to generate a severity adjustment, and the relatively high weights on test results from years ago may not be relevant. While this point is well taken, we may still use the same system for tests with a lower reference frequency that we do for a test with a higher reference test frequency. Once again, there are tradeoffs, but the tradeoffs are fair. A test with a higher reference test frequency is more likely to encounter a false alarm than a test with a lower reference test frequency. However, the impact of a false alarm on a test with a higher reference test frequency is not as large. A test with a higher reference test frequency is more likely to get those severity adjustments when the Industry is severe, but will also get those severity adjustments when the Industry is mild.

Large or small labs, high or low reference frequency, we have said that the system is fair. However, there are points at which the system will not even work approximately well. It may be argued that there are several test types currently in LTMS that fit this description, but it will not be argued here. The point is that if a test generates results that are not approximately normally distributed, are not well behaved, cannot be well characterized beyond descriptions like 'fail-safe', exhibit test apparatus by oil interactions, and rarely see multiple repeats on batches of parts and/or fuel, then that test should not monitored using LTMS, and candidate oils in the test should not be subject to registration or Multiple Test Evaluation Procedures.

Issue 18: Rule of 8's

Consider modifications to IIIG LTMS that deals with trigger value for application of severity adjustments. Continue with the "normal" application of severity adjustment following the exceeding of the Zi threshold value. If the SP believes the test is in a severe or mild state and a lab has 5 (or some SP determined) number of Yi data in a row in the same direction of shift, reduce the K value for application of severity to 0 for that parameter until such time as the 5 in a row number is no longer satisfied or the SP deems the test parameter is no longer in the severe or mild state.

Summary

While each test type and Surveillance Panel is unique with different needs, it appears that structure, logic, and purpose have been absent in setting up LTMS for new test types. Therefore it is suggested, in this document, to standardize LTMS across test types and provide a consistent template for all test types. LTMS guidelines are suggested in order to provide the best possible basis for level-playing-field, unbiased, cost-effective candidate testing. Will use of these guidelines ever produce a false alarm? Yes. Will use of these guidelines ever fail to capture a true shift in severity? Yes. Will the guidelines ever favor a lab with many stands? Yes. Will the guidelines ever favor a lab with one stand? Yes. However, the guidelines still do represent the best possible basis for level-playing-field, unbiased, cost-effective candidate testing.

Appendix A

Setting K and
Lambda.xls

Appendix B

For additional history and information on LTMS, please read SAE Paper 2004_01_1891.

SAE Paper
2004_01_1891.pdf

ATTACHMENT

SIX

IIIG SP Chairman will schedule conference call for the week of Feb 9 to discuss items pertaining to IIIG LTMS.

Consider using only oils 434, 435 and their respective reblends. Do not assign remainder of 434. Hold 434 for potential future comparison testing. In light of two oils in system, SP should consider rescinding current LTMS section 3.B.3 dealing with the reassignment of the same oil as the potential for becoming calibrated using only one oil may exist.

Consider modifications to IIIG LTMS that deals with trigger value for application of severity adjustments. Continue with the "normal" application of severity adjustment following the exceeding of the Zi threshold value. If the SP believes the test is in a severe or mild state and a lab has 5 (or some SP determined) number of Yi data in a row in the same direction of shift, reduce the K value for application of severity to 0 for that parameter until such time as the 5 in a row number is no longer satisfied or the SP deems the test parameter is no longer in the severe or mild state.

Consider transforming WPD data. The use of transforms for WPD may reduce variability among the reference oils. Statisticians to investigate.

SP is using existing targets for the introduction of 434-1 and 435-1 and currently plans to establish initial 434-1 targets after 8 tests. SP is encouraged to investigate difference between current (recent months) 434 performance, 434 targets and 434-1 performance. Consider adjusting 434-1 targets by delta difference with 434. Add 434-1 data to lab charts after review. Data to be added to lab charts following acceptable reference, not during reference period.

Do not introduce 435-1 until 434-1 is complete and then intermix 435-1 with 435 assignments to lab. Consider same mechanism for establishing initial 435-1 targets as recommended for 434-1 targets. If GF-5 oil is available, secure "gimmie" test from each lab to generate data to be used for initial targets. Mechanism to determine appropriate targets for GF-5 oil will need to be established if test is still deemed to be at severity warning limit for WPD.

After IIIG conference call, feedback period and SP action, IIIG SP chairman will report back to LTMS TF on the actions taken.

ATTACHMENT

SEVEN

Enhancements to IIIG LTMS

By: Todd Dvorak

01-29-09

Background

– The LTMS Severity charts indicate that the test is severe and at the warning limit.

– An analysis of the industry data indicates that there is statistical difference in current WPD parameter test results as compared to the period when the test was established.

– The Industry Severity Adjusted results for the WPD parameter are also below the established reference oil target values

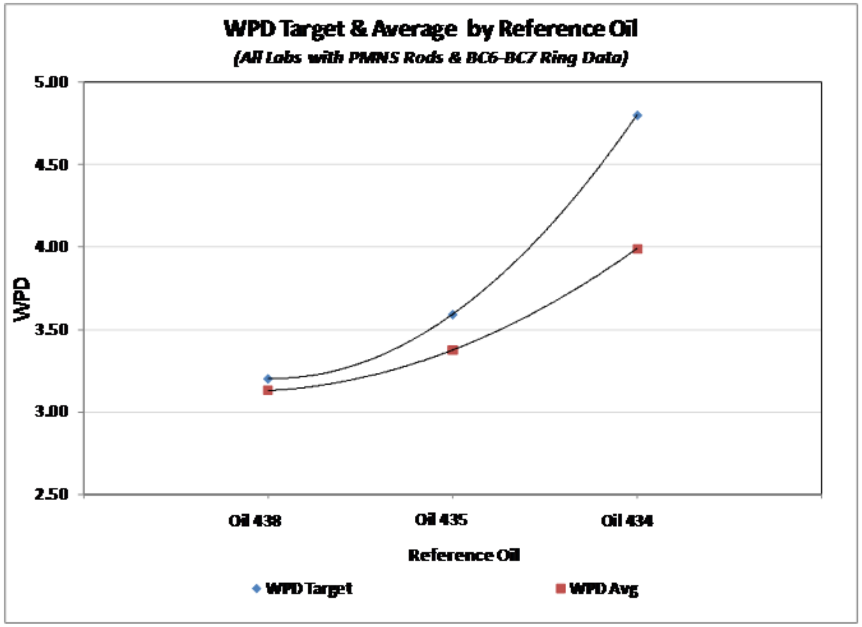
– LTMS enhancements and WPD transforms should be explored to bring the test closer to on target performance.

– The enhancements and transformations explored in this presentation include:
  - Reference Oil selection (Section 1)
  - Changing LTMS factors (Section 2)
  - Applying WPD transforms (Section 3)

Section I – Reference Oil Selection

Reference Oil Selection

- A plot of the WPD means by reference oil suggests that the performance is more severe with reference oils 434 and 435. *(Means based on PMNS & BC6-BC7 ring data)*
- Eliminating 438 will result in severity adjustments that are better matched to the performance level of a passing candidate test oil.
- It would be advantageous to include a GF5 capable reference oil and/or change the reference oil frequency mix. (i.e. 2 x 434's for each 435 reference, etc.)



Reference Oil Selection

- The following summarize the Severity Adjusted results with each of the reference oil mix combinations.
  - Severity Adjusted results for reference oil 434, 435, and 438

Industry Data Summary (2007 & 2008 Data)				
	SA Adj WPD	*WPD Stdev*	*Prop ≥ Target*	*N*
Oil 434 (Target = 4.80)	*4.25*	*0.46*	*0*	*15*
Oil 435 (Target= 3.59)	*3.62*	*0.32*	*0.65*	*23*
Oil 438 (Target = 3.20)	*3.34*	*0.23*	*0.71*	*21*

  - Severity Adjusted results for reference oil 434 and 435 *(Pooled S for reference oil selection ~ 0.62)*

Industry Data Summary (2007 & 2008 Data)				
	SA Adj WPD	*WPD Stdev*	*Prop ≥ Target*	*N*
Oil 434 (Target = 4.80)	*4.28*	*0.47*	*0*	*15*
Oil 435 (Target = 3.59)	*3.60*	*0.34*	*0.61*	*23*
Oil 438 (Target = 3.20)				

  - Severity Adjusted results for reference oil 434 *(Pooled S for reference oil selection ~ 0.76)*

Industry Data Summary (2007 & 2008 Data)				
	SA Adj WPD	*WPD Stdev*	*Prop ≥ Target*	*N*
Oil 434 (Target = 4.80)	*4.44*	*0.47*	*0.13*	*15*
Oil 435 (Target= 3.59)				
Oil 438 (Target = 3.20)				

Reference Oil Selection

- Reference Oil Selection summary:
  - Severity adjusted results are affected by the reference oil selection
  - Eliminating reference oil 438 will have a favorable affect on laboratory based SAs
  - Changing the reference oil mix will have a favorable effect on Laboratory based SA's:
    - Increase 434 reference frequency mix (recommend a minimum of 2 x 434's for each 435)
    - Add a GF5 capable reference oil

Section II – LTMS Modifications

LTMS Modifications

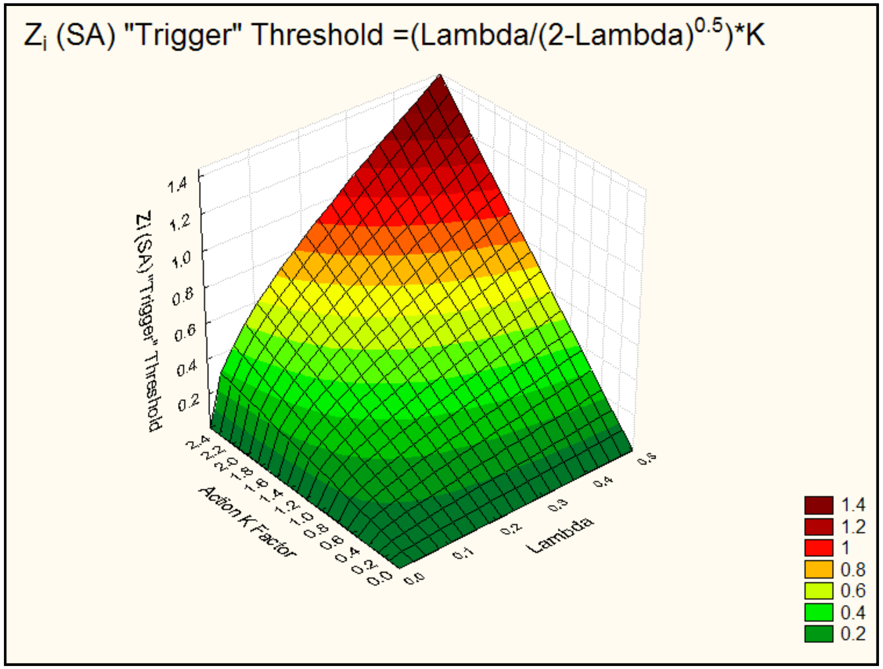
- The previous section concluded that the laboratory based severity adjustments remain severe of target – even with modifications to the reference oil selection.
- Additional Changes to LTMS will be explored to determine if improvements can be made to bring the Severity Adjusted WPD results closer to the target values.
- The LTMS changes to be evaluated include analyzing the effects of (Action) K factor, Lambda, and SPC “8 in a row” rule changes.
- All changes will be evaluated with reference oils 434 & 435, exclusively.

LTMS Modifications

- The "Action Limit" for a laboratory based severity adjustment is a function of both λ and the K value.

$$Action\ limit = 0 \pm K\sqrt{\frac{\lambda}{2-\lambda}}$$

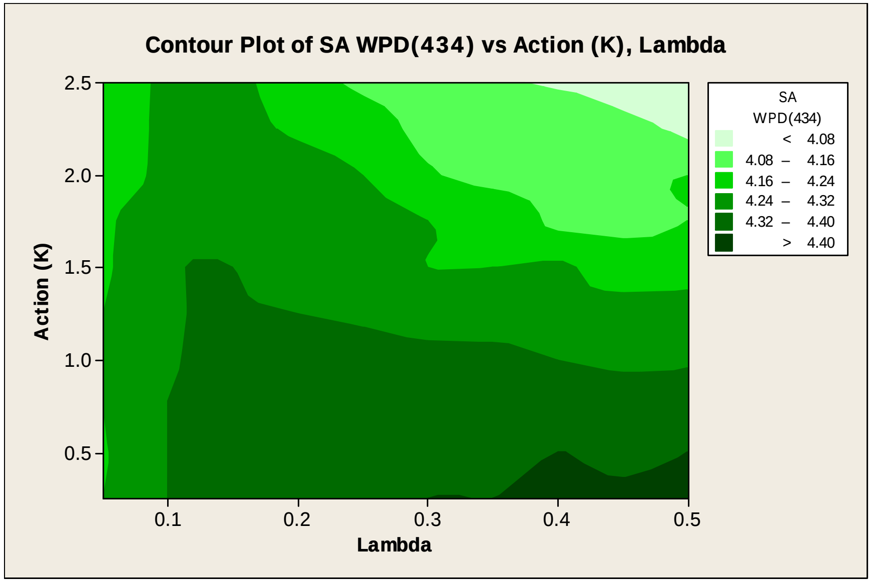
- As shown in the below response plot, both λ and K values have an equivalent effect on the severity adjustment "Action Limit."

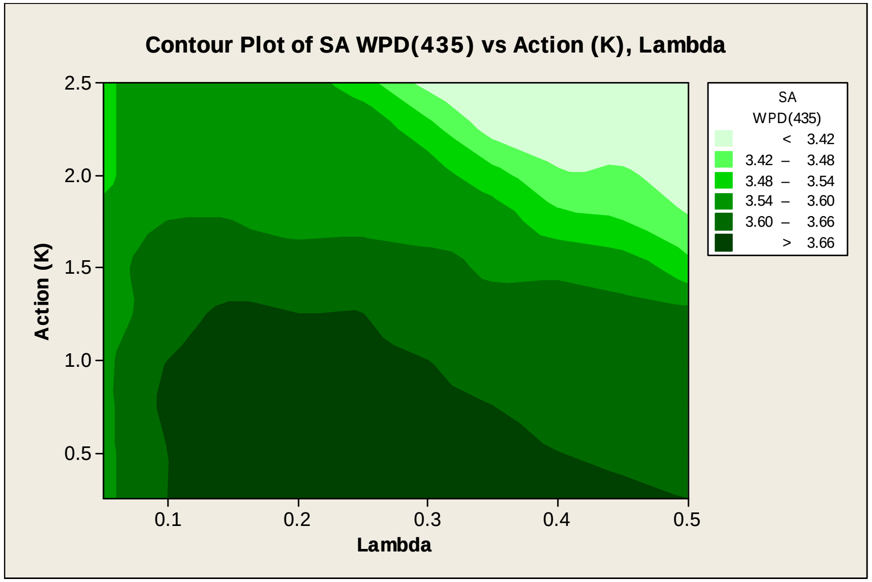


LTMS Modifications

- A computer program evaluated a series of Lambda and K value combinations - using reference oils 434 & 435. The results are summarized in the below contour plots.

- The plots indicate that a reduced (Action) K and Lambda solution set of {1.5, 0.15}, respectively will result in a more favorable (WPD) SA.

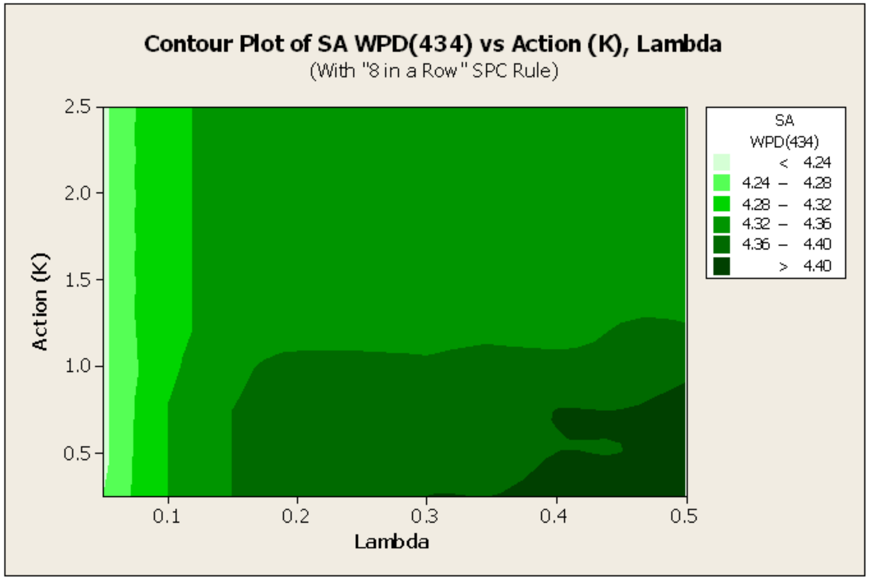


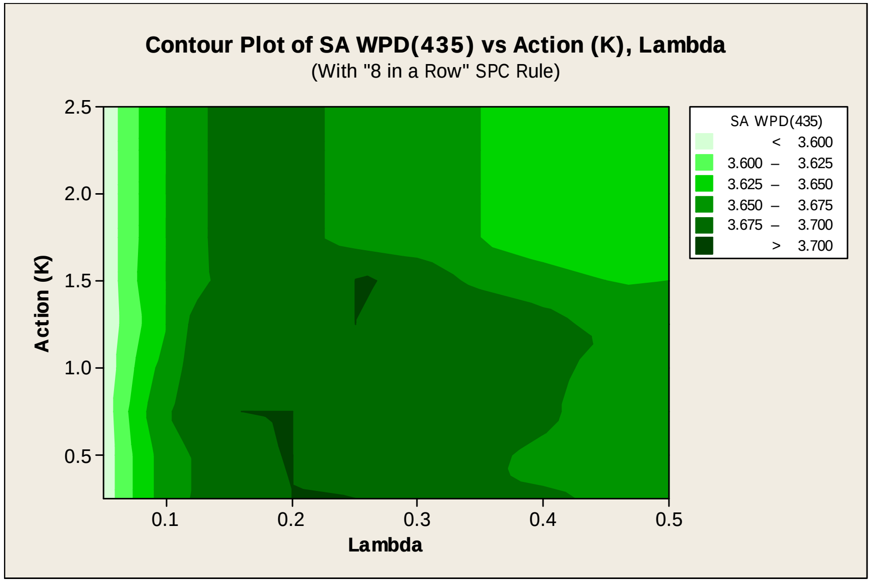


LTMS Modifications

- One SPC rule indicates that a process mean change may have occurred if 8 observations occur above or below the centerline[1]. The effects of adding this rule to trigger a laboratory based severity adjustment are summarized below.

- The plots indicate that a reduced (Action) K and Lambda solution set of {1.0, 0.2}, respectively, will result in a more favorable (WPD) SA.





Note 1: "Statistical Quality Design and Control", DeVor, Change, Sutherland, 1992.

LTMS Modifications

- The below following summarizes the LTMS Severity Adjusted results for the selected λ and K factors:

Industry Data Summary (2007-2008)

K Value	Lambda	Reference Oil	SA Adj WPD	WPD Stdev	Prop > Target	N	8 in A Row Rule
1.00	0.20	434	4.37	0.51	0.20	15	No
1.00	0.20	435	3.68	0.29	0.74	23	No
1.00	0.20	434	4.37	0.51	0.20	15	Yes
1.00	0.20	435	3.70	0.29	0.74	23	Yes
1.50	0.15	434	4.32	0.50	0.13	15	No
1.50	0.15	435	3.62	0.33	0.70	23	No
1.50	0.15	434	4.33	0.52	0.20	15	Yes
1.50	0.15	435	3.68	0.34	0.78	23	Yes

- Conclusions:
  - With selected Lambda's and K values, the lower K value solution sets have a slight advantage.
  - The λ and K of 0.15 and 1.5, respectively, may be more preferable solution set – since it is more similar to the current LTMS factor settings.
  - There appears to be no practical difference in the Severity Adjusted results with the "8 in a Row" SPC rule.

LTMS Modifications

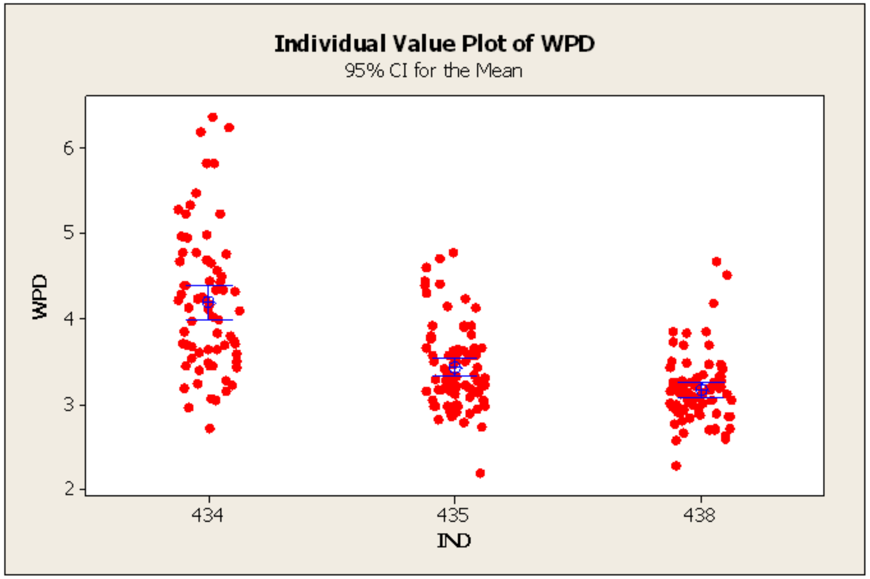
- Supplemental thought for discussion:
  - If the industry data indicates that the test is severe, then there is some justification for a reduced K value for Laboratory based Severity Adjustments.

Section III – WPD Transforms

WPD Transforms

- Industry data suggests that the WPD variability is a function of the reference Oil mean.

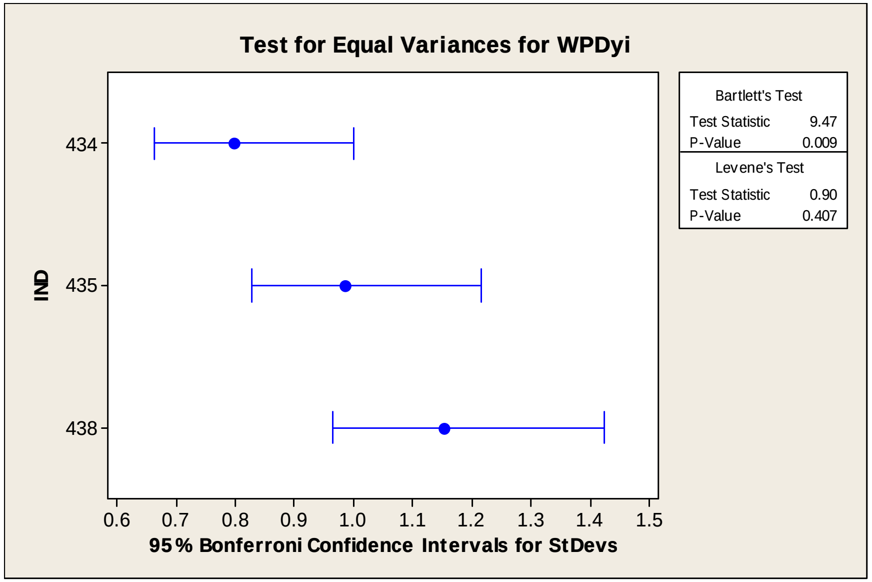
WPD Performance & Variability Relationship



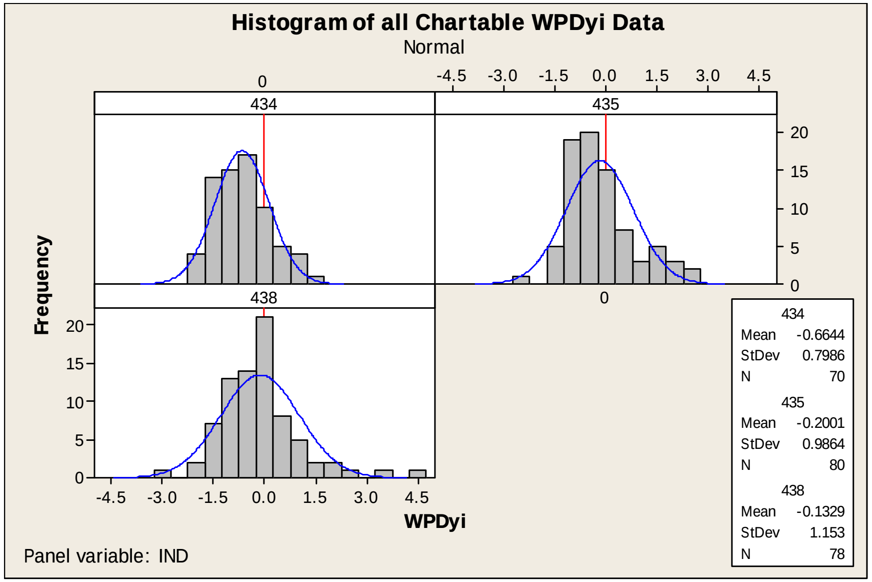
WPD Transforms for Control Charts

- Two assumptions of Shewhart Control charts are constant mean and variance.
  - Multiple comparisons of WPD Yi data (with lab & oil factors) suggests statistical differences between reference oil Yi means
- The descriptive statistics of Yi data by reference oil also suggest that it may be advantageous to explore WPD transforms.

Diagnostics of Y_i Metric for each Reference Oil



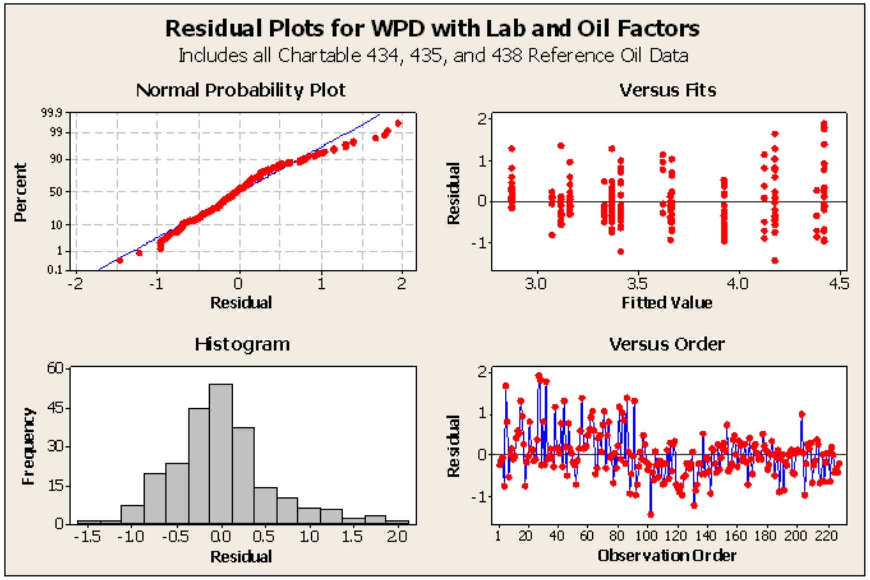
Histogram Plot of Y_i by Reference Oil Type



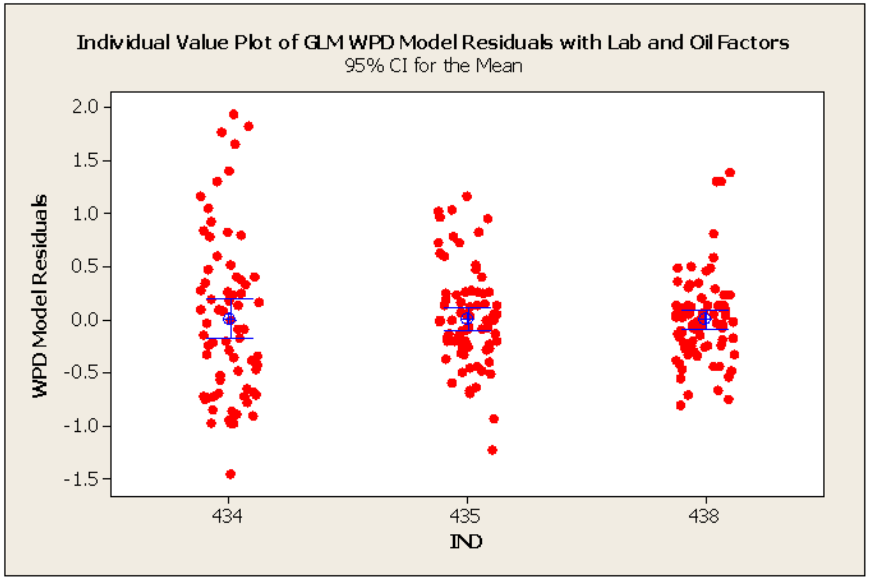
WPD Transforms for General Linear Models

- Severity Adjustments are based on General Linear Model (GLM) Pooled S
    - Two of the GLM assumptions require a constant variance and normal distribution of the errors.
    - The residual diagnostics of a fitted model also suggest that it may be advantageous to explore WPD transforms to better satisfy GLM assumptions.

(WPD, Lab, & Ref Oil) - GLM Residual Diagnostics



Model Fit Residuals Plot by Reference Oil Type



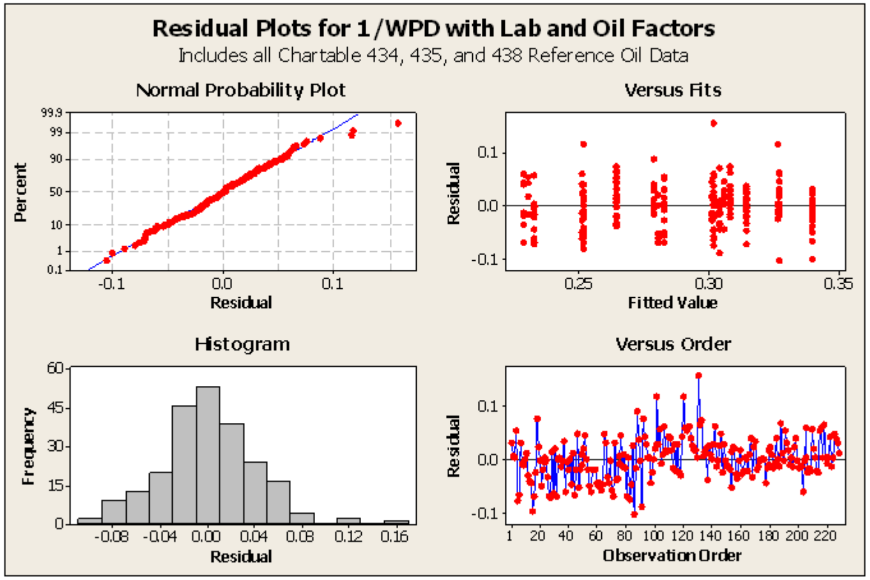
WPD Transforms

- Several types of WPD transformations were explored to help satisfy GLM and control charting assumptions.
- Two possible transforms are based on a natural log and inverse of the WPD parameter.
- A summary of both transforms are provided on the following slides.

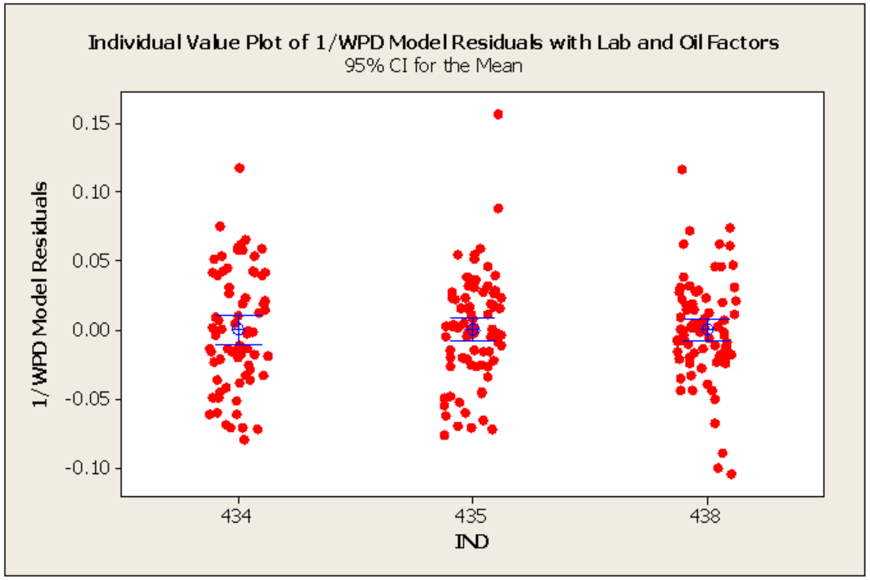
Inverse WPD Transform

- The first evaluated transform is based on the WPD inverse: $WPD' = \dfrac{1}{WPD}$
- The residual diagnostics indicate that this transform better satisfies the GLM assumptions.
  - Multiple comparisons of 1/WPD Yi data (with lab & oil factors) indicates statistical differences between reference oil Yi means
- The model fit diagnostics of the LTMS Industry data are summarized below.

(1/WPD, Lab, & Ref Oil) - GLM Residual Diagnostics



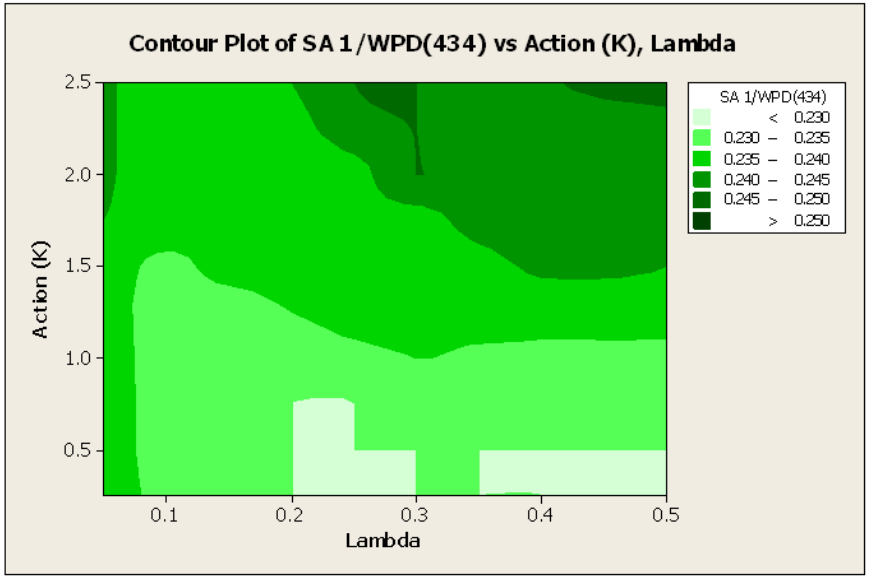
Model Fit Residuals Plot by Reference Oil Type

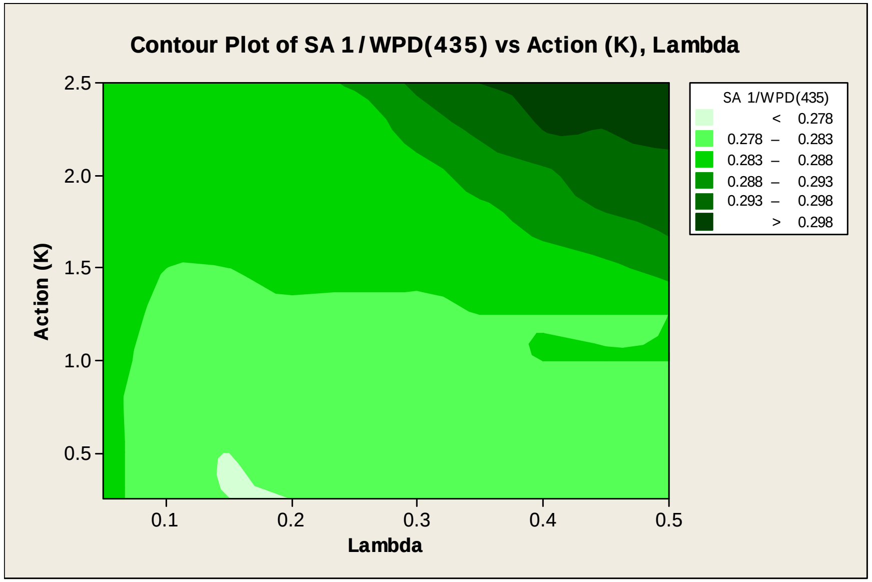


LTMS Modifications with WPD Inverse Transform

- With the WPD Inverse Transform, a computer program evaluated a series of Lambda and K value combinations - using reference oils 434 & 435. The results are summarized in the below contour plots.

- Similar to the untransformed results, the plots indicate that a reduced (Action) K and Lambda value of {1.0, 0.2} or {1.5, 0.15}, respectively, will result in a more favorable (WPD) SA.





Natural Log based WPD Transform

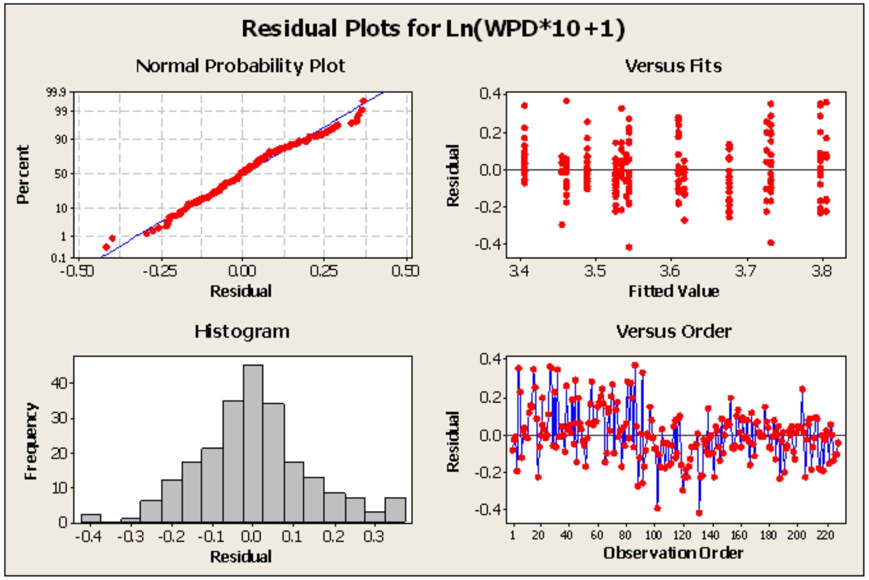
- The second evaluated transform is based on the natural log of WPD:

$$WPD' = Ln\ (WPD*10+1)$$

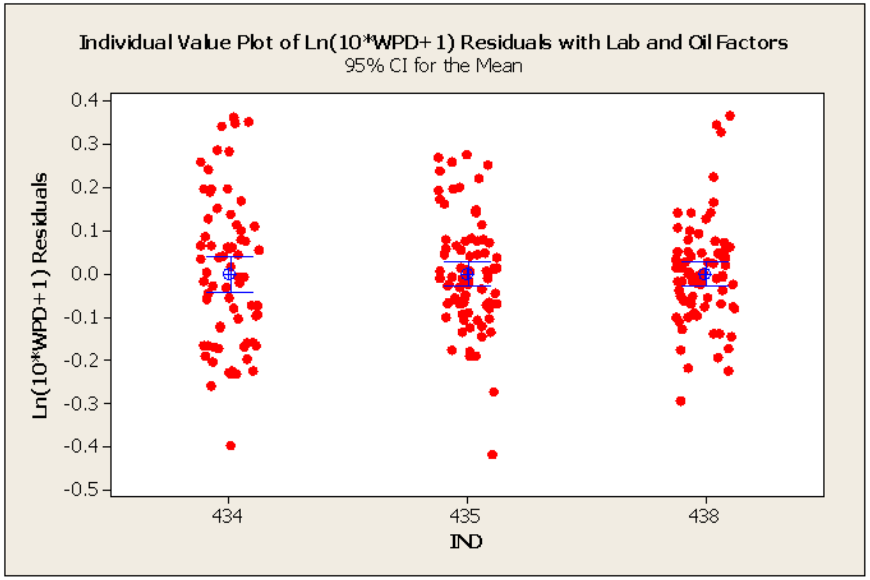
- The residual diagnostics indicate that this transform also helps to satisfy the GLM assumptions.

- The model fit diagnostics of the LTMS Industry data are summarized below.

*(Ln(WPD*10+1), Lab, & Ref Oil) - GLM Residual Diagnostics*



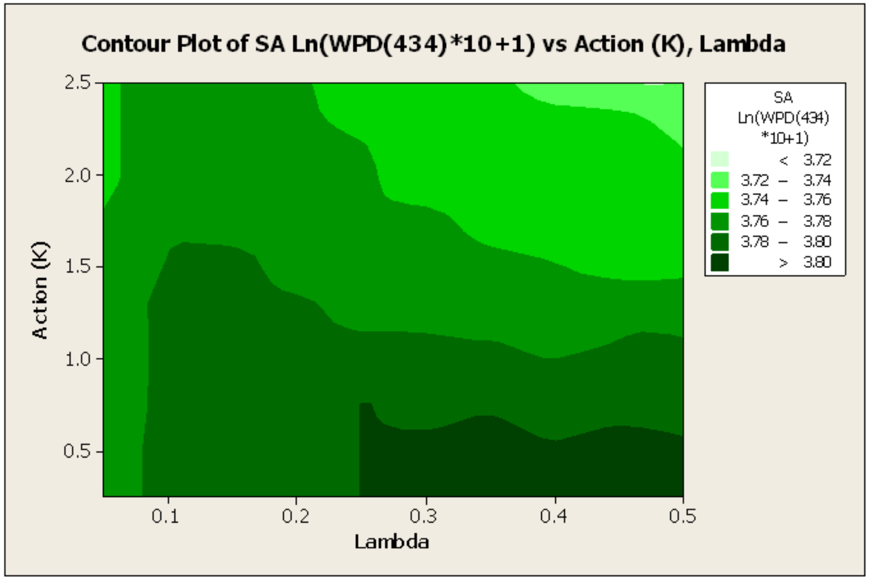
Model Fit Residuals Plot by Reference Oil Type

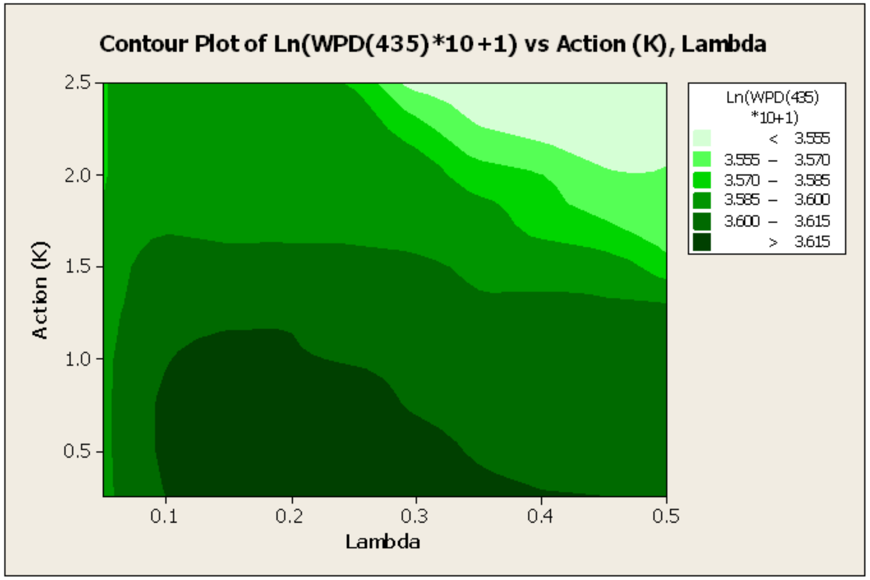


LTMS Modifications with Ln(WPD*10+1) Transform

- The below summarizes the Severity Adjusted results for reference oils 434 and 435 of all combinations of λ and K factors with the Ln(WPD*10+1) Transform.

- Similar to the untransformed results, the plots indicate that a reduced (Action) K and Lambda value of {1.0, 0.2} or {1.5, 0.15}, respectively, will result in a more favorable (WPD) SA.





LTMS Summary with WPD Transforms

- The below summarizes the severity adjusted results of the analyzed WPD transforms and the LTMS based λ, K, and "8 in a row" change proposals:

Industry Data Summary (2007-2008) for Selected Transform, Lambda, K Value, & 8 In a Row Rule

K Value	Lambda	Reference Oil	Transform Type	Severity Adj. Trans WPD	Untrans Severity Adj. WPD Result	WPD Severity Adj. Stdev	Prop > Target	N	8 in A Row Rule
1.00	0.20	434	*1/WPD*	0.233	4.29	0.032	0.20	15	No
1.00	0.20	435	*1/WPD*	0.280	3.57	0.023	0.61	23	No
1.00	0.20	434	*1/WPD*	0.232	4.31	0.033	0.27	15	Yes
1.00	0.20	435	*1/WPD*	0.278	3.60	0.023	0.61	23	Yes
1.50	0.15	434	*1/WPD*	0.236	4.24	0.031	0.13	15	No
1.50	0.15	435	*1/WPD*	0.283	3.53	0.027	0.52	23	No
1.50	0.15	434	*1/WPD*	0.232	4.31	0.034	0.27	15	Yes
1.50	0.15	435	*1/WPD*	0.280	3.57	0.027	0.57	23	Yes
1.00	0.20	434	*Ln(10*WPD+1)*	3.79	4.33	0.13	0.27	15	No
1.00	0.20	435	*Ln(10*WPD+1)*	3.62	3.62	0.08	0.70	23	No
1.00	0.20	434	*Ln(10*WPD+1)*	3.79	4.33	0.13	0.27	15	Yes
1.00	0.20	435	*Ln(10*WPD+1)*	3.62	3.65	0.08	0.70	23	Yes
1.50	0.15	434	*Ln(10*WPD+1)*	4.32	4.31	0.50	0.13	15	No
1.50	0.15	435	*Ln(10*WPD+1)*	3.62	3.63	0.33	0.70	23	No
1.50	0.15	434	*Ln(10*WPD+1)*	3.79	4.32	0.13	0.20	15	Yes
1.50	0.15	435	*Ln(10*WPD+1)*	3.62	3.61	0.09	0.70	23	Yes
1.00	0.20	434	*WPD*		4.37	0.51	0.20	15	No
1.00	0.20	435	*WPD*		3.68	0.29	0.74	23	No
1.00	0.20	434	*WPD*		4.37	0.51	0.20	15	Yes
1.00	0.20	435	*WPD*		3.70	0.29	0.74	23	Yes
1.50	0.15	434	*WPD*		4.32	0.50	0.13	15	No
1.50	0.15	435	*WPD*		3.62	0.33	0.70	23	No
1.50	0.15	434	*WPD*		4.33	0.52	0.20	15	Yes
1.50	0.15	435	*WPD*		3.68	0.34	0.78	23	Yes

LTMS Change Proposal Conclusions

- Transformation of WPD Summary:
  - Transforms help to better satisfy GLM modeling assumptions
  - With the selected λ values, K factors, the untransformed WPD results are closer to the reference oil targets than the transformed WPD results.
  - Regardless of the WPD transform or changes to K or λ factors, a large majority of the Industry wide severity adjusted WPD results remain below the reference oil target values.

Recommendations

Summary

- Recommend eliminating oil 438, establishing a new reference oil mix (2 or more 434 reference tests for each 435), and adding a GF5 capable oil.
- Recommend changing the IIIG WPD K and λ to be set to 1.5 and 0.15, respectively.
  - The K and λ changes to be applied to the WPD parameter, exclusively.
- Recommend a reduced K (i.e. K = 1 λ=0.2) when the industry is severe
- The addition of a new "8 in a Row" rule has a small effect on the LTMS severity adjusted results. (It is optional.)
- The application of a WPD transform is optional.
  - It has a minimal effect the Industry Wide Severity Adjusted (WPD) results.
- None of the proposed changes will result in a laboratory based SA

Summary

- None of the proposed changes will result in a laboratory based SA that has an "on target" performance.
  - It would be advantageous that a 434 reference test would result in an adjusted WPD of 4.8

ATTACHMENT

EIGHT

Statistical Process Control

- Checking for “Out of Control” conditions:
  - 8 or more successive points above or below centerline