Minutes from 3/22/2011 Sequence VG Surveillance Panel Conference Call

Attendees:

Andrew Ritchie, Gordon Farnsworth, Mike McMillan, Doyle Boese – Infineum

Jo Martinez, Mark Sutherland – Chevron

Tom Wingfield – ChevronPhillips

Ron Romano – Ford

Jim Linden - Toyota

Raham Kirkwood, Bill Buscher, Janet Buckingham – SwRI

Al Lopez, Charlie Leverett, Martin Chadwick – Intertek

Ed Altman – Afton

Rich Grundza – TMC

Jerry Brys, George Szappanos, Alison Rajakumar , Chris Castinean – Lubrizol

Mark Overaker, Jim Carter, Wayne Petersen – Haltermann

Timothy Caudill – Ashland

Timothy Miranda, Irwin Goldblatt – BP Castrol

Jason Bowden, Adam Bowden, Dwight Bowden, Mathew Bowden – OHT

Zack Bishop, Clayton Knight – TEI

1) The minutes from the March 15, 2011 conference call were approved with no additions or corrections. Motion made by Jason Bowden and seconded by Ed Altman.
2) Chairman Ritchie summarized the agenda for today's meeting. The 2 main items to be discussed are the following:

a. Engineers VG Precision Task Force report and recommendations
b. Haltermann report on rationale and supporting data for next test fuel(s) and test plan update

3) Jerry Brys went through the report generated by the VG Precision Task Force (see attached). The report covers what was found during the round robin VG laboratory visits conducted over the last month in an attempt to improve the precision of the VG test. As a result of these visits, 5 main recommendations, all of which were unanimously approved by the Task Force members from 7 different organizations, were made. These 5 recommendations, which are recommended by the Task Force for incorporation in the procedure to be used in conducting the next fuel matrix, are as follows:
   a. Labs to install cam sensor failure detection sensor
   b. Install either a spark meter, or validate that spark timing is correct at each oil check with a timing light.
   c. Standardize blowby orifice size at 5/16", and 4" incline manometer.
   d. Insure that labs are measuring blowby at 45 minutes before the end of stage 2
   e. Standardize the calculation for blowby

   These recommendations were based in part on findings that 2 of the labs were interpreting blowby measurement and calculation requirements differently than the other 2 labs.
4) Because of the time constraints under which one of the Panel members(Wayne Petersen from Haltermann) was operating, it was recommended by Chairman Ritchie that completion of the Precision Task Force report be deferred until either later in this call or until next week's call. After some discussion, it was agreed to do so.
5) Mark Overaker began his fuel supplier report by providing additional clarification on how the statisticians provided input to Haltermann, stating that the data from the last fuel test matrix was reviewed, and based on this review it was determined which labs showed the largest variation in results. The statisticians then recommended what they believed to be the best path forward, which included 2 possible options. The first option was for 3 labs (SwRI, Afton, Lubrizol) to run tests with Reference Oil 925-3 on the proposed modification to the rejected fuel batch; the second option was for this testing to be conducted in 2 labs only (SwRI and Afton). The Statistical Group decided that the first of these two options (3 labs) was their preferred choice, because this would provide a larger number of comparisons between the previous matrix fuel and the new test fuel as well as a larger amount of data in a shorter amount of time upon which to make a decision on the suitability of the pilot reblend. In further discussion of

these possibilities, it was pointed out that, if changes to the VG procedure were to be made based on the recommendations included in the Precision Task Force report, it is possible that the Statistical Group would want to reconvene to discuss how these changes might impact their recommendations. Dwight Bowden pointed out that none of the proposed recommendations actually changes the VG procedure. Ed Altman went through the 5 recommendations again to further support this. Al Lopez and Ron Romano countered by saying they believed it would be best if the statisticians knew what changes were going to be made in what labs, particularly with blowby, before affirming their recommendations. George Szappanos pointed out that unless all 4 labs participate in the evaluation of the pilot reblend, we won't really know where we stand when the actual VG fuel approval matrix is run on the full reblend of the entire rejected fuel batch.

6) In an effort to move toward reaching a decision, Chairman Ritchie asked the Panel for concurrence that the 5 changes recommended by the Precision Task Force should be made. All Panel members agreed. Mark Overaker asked for clarification that it was intended that all of these changes would be made before the new fuel approval matrix is run. It was acknowledged by all that this was the case. Chairman Ritchie then asked if we could simplify things by simply deciding whether we should run 4, 3, 2 or 1 test on Oil 925-3. It was agreed that this might be one possibility. Another might be to go with the 2 labs (Lubrizol and Afton) that seemed to be running closest to target on Oil 925-3 in the previous matrix. A third possibility might be to proceed with the Statistical Group recommendation (3 labs). Ron Romano pointed out that there were cost implications with any decision we make. Doyle Boese pointed out that more tests are better in trying to determine if there is a lab-oil interaction. He further noted that the magnitude of the fuel change relative to the variation among those labs decided upon for inclusion in the testing is also an important consideration. Mark Overaker noted that enough fuel to run whatever number of tests the Panel decides upon will be made available. Ron asked if we'd be better off to run 2 repetitive tests at 2 labs, rather than 1 test at 4 different labs. Doyle answered that in his opinion we'd be better off with more labs, but that, again, it depends on how large the fuel difference (AES rating of revised blend – AES rating of original blend) turns out to be. If this difference is approximately 0.8 merit or greater, we will probably be able to see a difference between the revised and original blends with 1 round of testing (though not necessarily a statistically significant difference). At a

difference of 0.3 or 0.4 merits, we probably won't be able to see the fuel effect to any high level of significance with a single round of testing.

7) Chairman Ritchie again asked for a motion to adopt the 5 recommendations made by the Precision Task Force. Ron Romano made this motion, and it was seconded by Lubrizol. Jason Bowden asked whether the blowby would be changed with what is being recommended; Jerry Brys answered that 2 of the labs would have ~2 LPM higher blowby with the change – this is illustrated in Slide 10 of the Task Force report. Further discussion highlighted the point that large differences in ring gaps do not necessarily result in large blowby differences. Dwight Bowden noted that large differences in ring gaps can be caused by differences in how rings are cut (based on Sequence IIIE experience). Chairman Ritchie at this point called for a vote on the motion, and it passed with 12 Affirmatives, 0 Negatives, and 1Waive. Timothy Caudill then made the motion that 1 test/lab be conducted on the same stands used in the original fuel approval matrix in each of the 4 VG test labs (SwRI, Intertek, Afton, Lubrizol), with the new procedure including the 5 recommendations made by the Precision Task Force. This motion was seconded by Al Lopez. The motion carried with 10 Affirmatives, 1 Negative, and 3 Waives.
8) The next conference call will be Tuesday, March 29, at 2:00 pm EST. Items of business will include completion of the Precision Task Force report presentation, a report on the status of VG testing of the revised fuel pilot blend, and discussion of a possible face-to-face VG Panel meeting.

VG Precision Task Force Report

Objective:

Improve the precision of the VG Test

March 22, 2011

VG Precision Task Force Recommendations for the Next Round of VG Fuel Evaluation Tests

1. Labs to install cam sensor failure detection sensor
2. Install either a spark meter, or validate that spark timing is correct at each oil check with a timing light.
3. Standardize blowby orifice size at 5/16”, and 4” incline manometer.
4. Insure that labs are measuring blowby at 45 minutes before the end of stage 2
5. Standardize the calculation for blowby

- All unanimously approved by Task Force members from 7 organizations.

- regarding “recommended action” column:
- Items in italic and in parentheses are still being considered
- Items in red color text are suggested to be included in the next matrix of tests

Engine build

Area of investigation	Discovery	Task force investigation	Recommended action
Hardware	Labs running on same blocks, Same cylinder heads, LZ on FM pistons, others on India pistons (two batches)	Chamfers on India pistons very similar	none
Ring gaps	IAR had smaller ring gaps compared to rest of labs (50% smaller than SWRI); IAR says 0.001" --> 2 LPM, whereas other labs are 1:1	Engine measurement "round robin" – OK	Engine build workshop, which may reveal differences related to ring cutting practices etc. also, see blowby measurement slide
Honing	No apparent differences	inspection of labs' procedures; oil change intervals	none
Cylinder-bore clearance	SWRI slightly smaller than IAR (0.0002" avg on matrix builds)	Engine measurement "round robin"	none
Cylinder head decking	There is a wide variety of heads in service	Measure the combustion chamber "button heights" of heads and determine impact on Compression Ratio [(1)]	*(Heads that are decked beyond "X" (TBD) should no longer be used.?)* *(Use thicker head gasket?)* *(use similar heads on each engine build?)*
Engine cleaning	No differences noticed		

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Engine electronics / ECU

Area of investigation	Discovery	Task force investigation	Recommended action
AFR control	Stage 2-3 control similar; stage 3-1 seems variable and affected by rpm, temp, MAF sensor variability, and/or engine load	Attempt to minimize variability by installing resistor to simulate coolant temp[2]	Investigation not complete; labs to test as stand availability permits to determine impact on 3-1 AFR transition
MAP / Baro sensor	Some labs do not connect to manifold pressure	Ran several cycles with and without, and made no difference	None
Cam sensor failure	It is difficult to detect this sensor failure, which has significant impact on fuel dilution[3]	Sensor is needed to determine state of sensor	Labs to install cam sensor failure detection sensor. [6]
Spark timing	If the "SPOUT" circuit is disconnected (or fuse is blown), then the engine will run at timing retarded by 14°	Breaking this circuit can impact blowby flow by 2.6 LPM [5]	Installation of either a spark meter, or validation that spark timing is correct at each oil check with a timing light.

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Blowby measurement

Area of investigation	Discovery	Task force investigation	Recommended action
Accuracy of Blowby test rig	Large difference in ring gaps	Blowby flow test rig "round robin" – Intertek found to be 1-2 LPM higher than SWRI	Intertek is building a new blowby rig with 4" manometer
Manometer accuracy		Manometer calibration at each lab is underway	*(manometers should be included when doing a stand calibration)*
Orifice size	Using either 5/16" or 3/8"	Small size should lead to better accuracy and consistency	standardize size at 5/16", and 4" incline manometer.
Calculation consistency	Slight variability in formulas	Survey of labs' formulas	Standardize the calculation for LPM vs delta P [(7)]
Time at which blowby is taken	Some labs are taking blowby at 50min vs 30min into stage 2	A difference of 2 LPM was observed on a non-test engine [(4)]	Modify wording in procedure to eliminate any misinterpretation. Proposed wording: "45 minutes before the end of stage 2"

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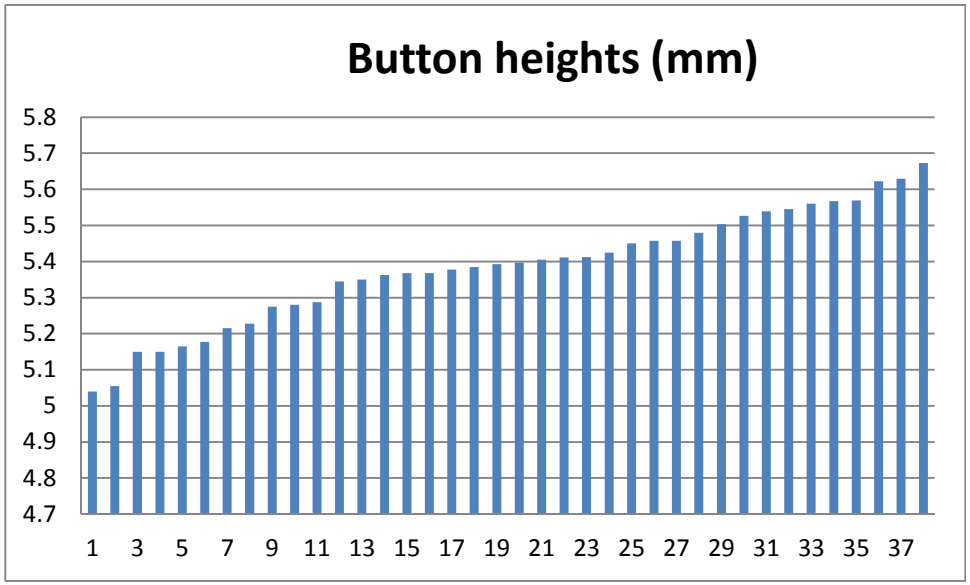
Appendix: (1) CR vs button heights

Button height is the measurement of a cast-in feature of the combustion chamber. Measuring the depth of this feature from the deck face is a good indicator of chamber volume.

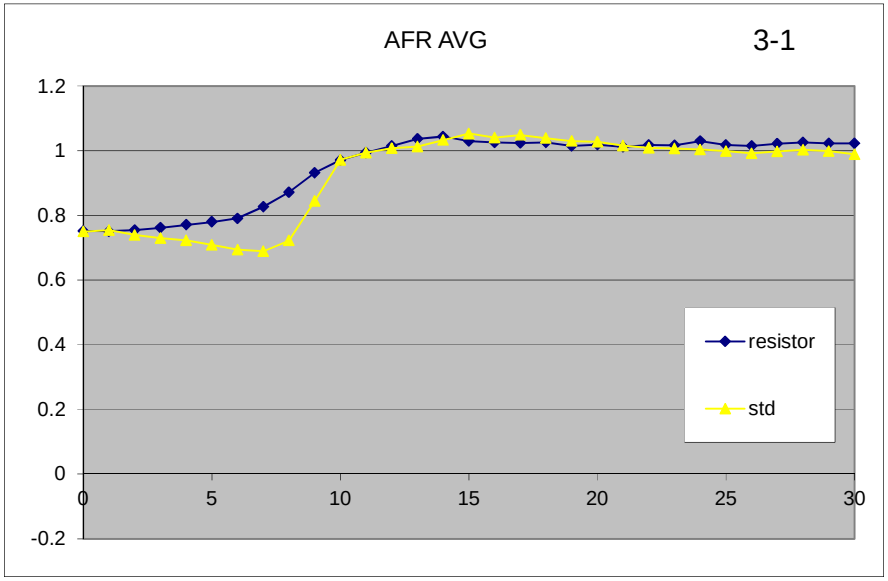
Given the current range of “button heights” (cylinder head averages), the range of compression ratios is on the order of 0.4

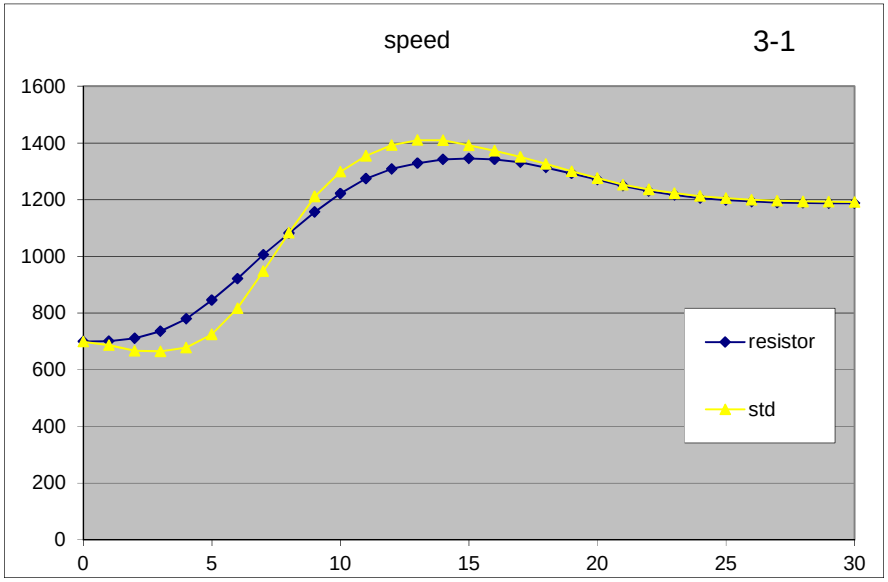
CR		
displacement volume	575	cc
nominal CR	9	:1
nominal clear volume	71.875	cc
button height range	0.63	mm
volume correction	80%	
volume range	3.22	cc
new CR	9.38	



(2) Using resistor in place of ECT

AFR transition is much “cleaner”, and Speed transition occurs without as much overshoot.



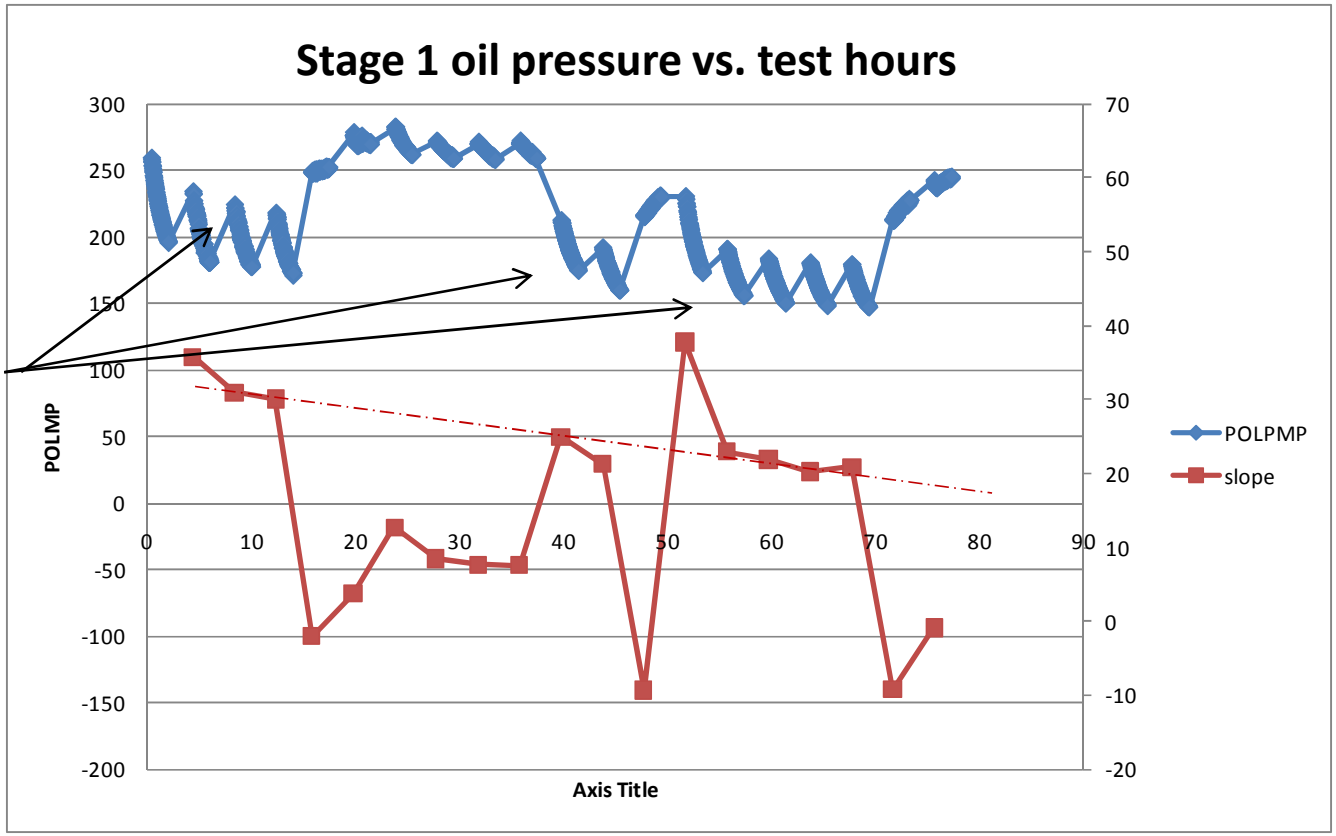


Lubrizol data on non-test engine.

(3) Fuel dilution during test cycle

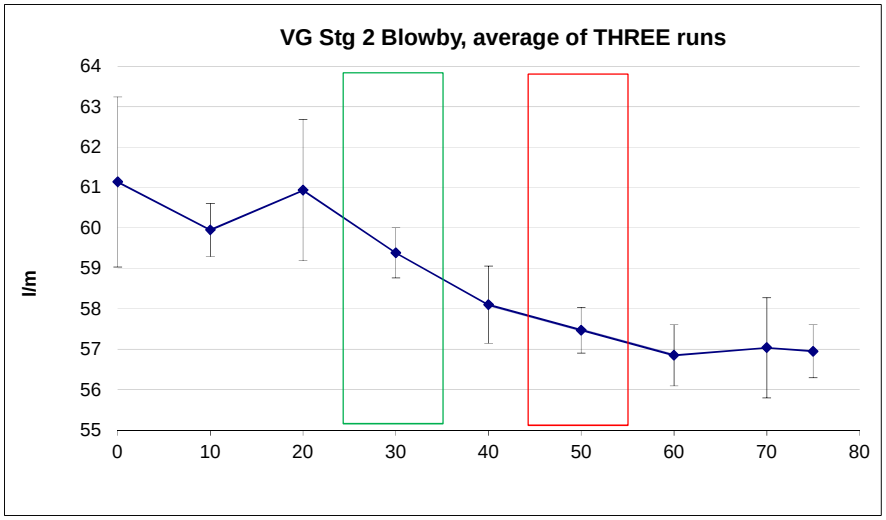
When the cam sensor is faulty or disconnected (prior to a restart), fuel dilution is much lower due to fuel injection timing that is randomly timed rather than just prior to the intake valve opening event (which minimizes fuel vaporization time and maximizes fuel dilution). Oil pressure during stage 1 is a good indicator of fuel dilution.

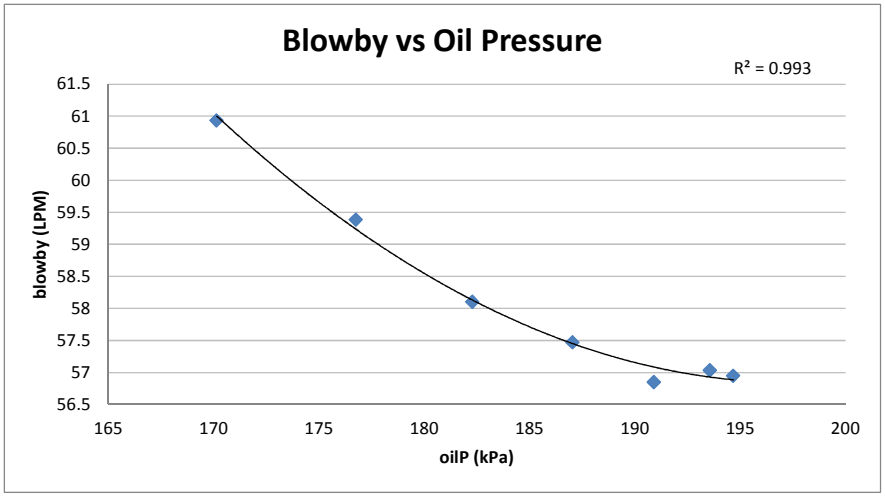
Normal Fuel dilution levels



(4) Blowby vs stage time

Test conducted at Lubrizol using a non-test engine and 5w30 oil.





There is a ~2 LPM difference between the blowby rate measured at 30 min vs. 50 min.

The difference is likely due to the increase of oil viscosity, which occurs as the fuel vaporizes from the oil as the stage progresses.

The strong relationship between oil pressure (viscosity affected) and blowby supports that theory.

(5) Spark vs blowby

Experimentation on a non-test engine revealed a ~2.6 LPM difference in blowby flow when the SPOUT connector is disconnected.

slope	engine speed	delta P	blowby
1.319	2900	2.3	59.8
LPM / 100 rpm	2700	2.0	55.8
	3100	2.4	61.1
slope	**load (MAP kpa)**	**delta P**	**blowby**
1.30	66	2.3	59.8
LPM / kpa	60	1.7	50.7
	70	2.6	63.5
slope	**spark**	**delta P**	**blowby**
0.19	24	2.3	59.8
LPM / deg	10	2.1	57.2

(6) Cam sensor sensor

- Brentek Watchdog timer module
  - WDT5 model
  - If the unit does not see a changing signal after 2 secs, then its contact changes state from closed to open (or open to closed)
  - Use as a digital input to detect presence of cam signal (5v pulse every 2 crank revolutions)

(7) Calculation for LPM from in-wat

Taking data from the official GM paper chart for orifice flow vs delta P, a 4th order polynomial curve is fitted.

from GM chart, for 25C and 100 kPa				
in Wat	CFM	LPM	LPM-calc	diff%
5.9	3.35	94.9	94.8	0.0%
4.7	3	85.0	85.0	-0.1%
3.8	2.7	76.5	76.4	0.1%
3.25	2.5	70.8	70.7	0.1%
2.5	2.2	62.3	62.3	-0.1%
2.05	2	56.6	56.6	0.0%
1.85	1.9	53.8	53.9	-0.1%
1.65	1.8	51.0	50.9	0.1%
1.4	1.65	46.7	46.9	-0.4%
1.15	1.5	42.5	42.5	0.0%
1	1.4	39.6	39.6	0.1%
0.85	1.3	36.8	36.6	0.7%
0.6	1.1	31.1	31.0	0.5%
0.5	1	28.3	28.6	-1.0%
coefficients, in-wat to LPM				
	4th	-0.0684		
	3rd	1.1027		
	2nd	-7.0495		
	1st	30.8158		
	0th	14.8102