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MEMORANDUM: 08-003

DATE: February 5, 2008

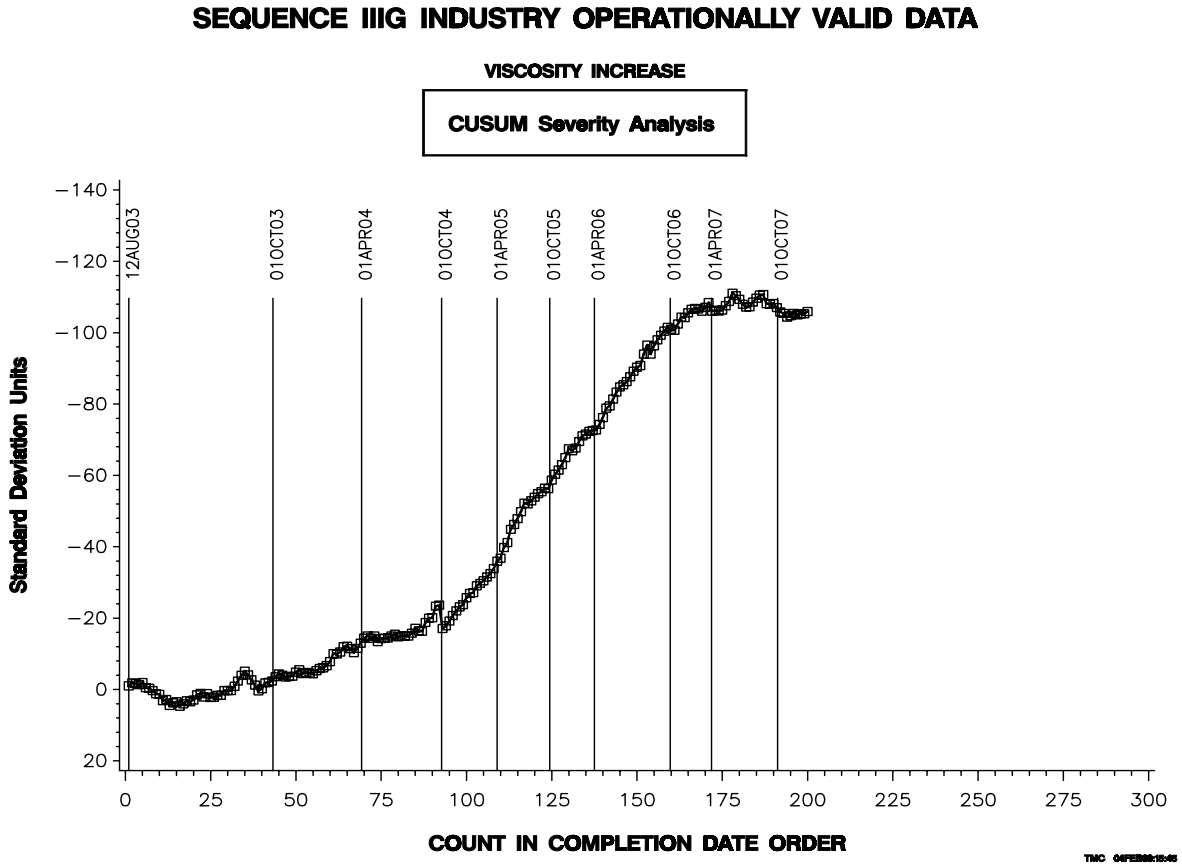
TO: Sequence III Surveillance Panel

FROM: Richard Grundza

SUBJECT: Results of Analysis of PVIS Trend Abatement

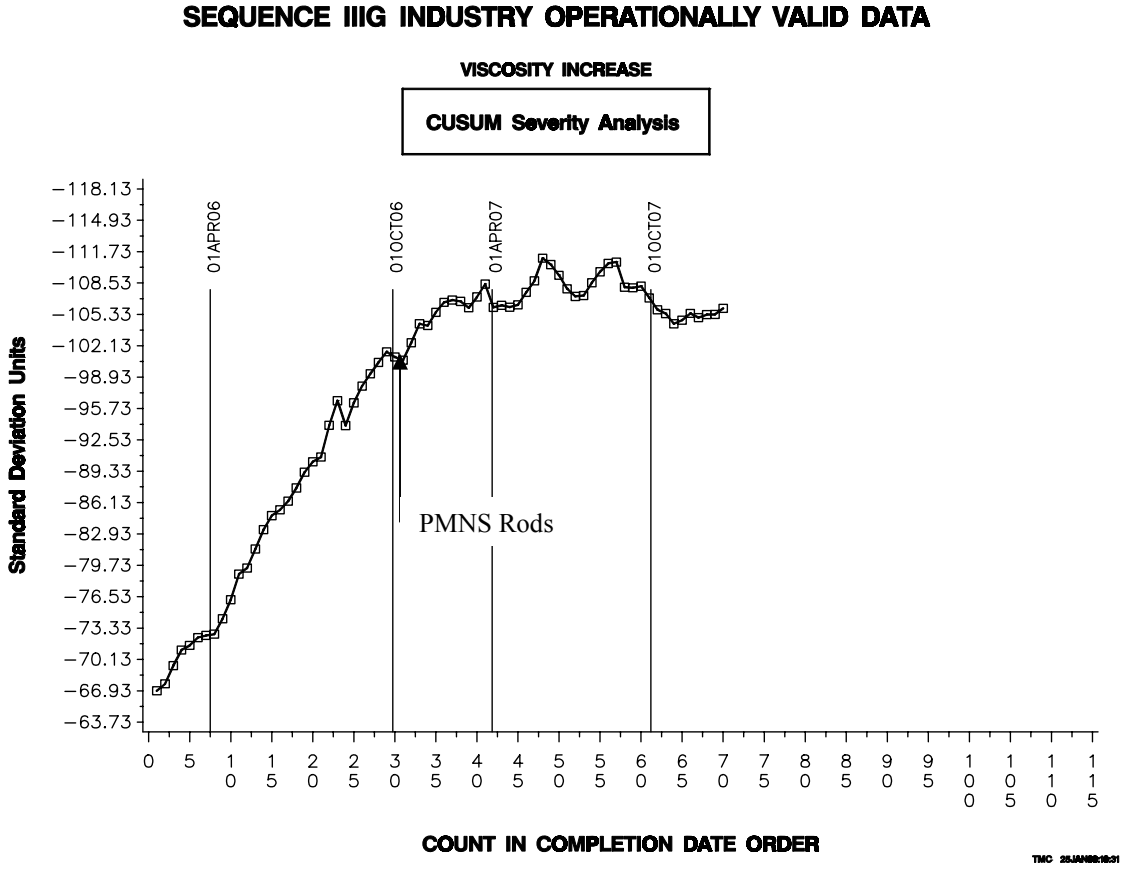
At the November 13, 2007 Sequence III Surveillance Panel meeting, the TMC was tasked with attempting to identify the reason for the leveling in the mild trend noted in the PVIS summation Δ/s charts. A copy of the current chart is included as Figure 1 (below).

Figure 1



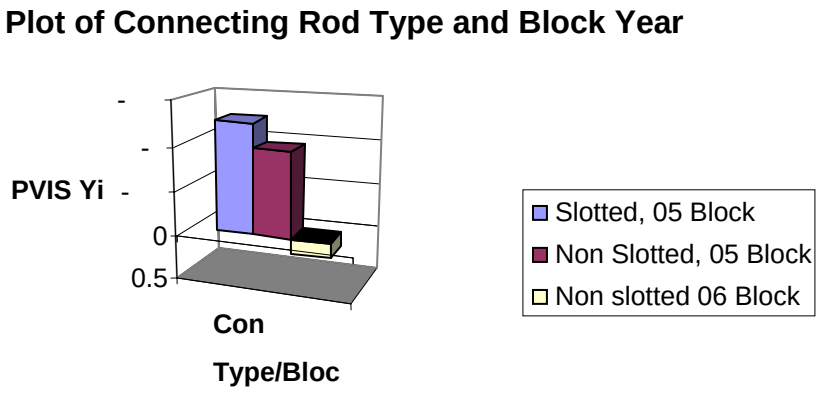
The charts begin to level between December 2006 and January 2007. The following summation Δ/s chart (Figure 2) shows the leveling. On October 8, 2006 the first test on the Powdered Metal Rods, without the oil slinger slots (designated PMNS) was reported. This point is identified on the chart.

Figure 2



On first glance, it appears that the leveling might be associated with the PMNS rods, but the charts begin to level six tests after the introduction of these rods. The following bar charts shows mean Δ/s by connecting rod type and oil. Statistical analysis shows a significant difference between the slotted and non slotted rods. However, upon further investigation, there may be a block effect. The blocks prefixed 1F6, 2F6, 3F6 and 1H7 are physically different from previous batches of blocks. The newer blocks have freeze plugs which are threaded, while previous batches were the more traditional press in freeze plug. Analysis was limited to test results on Batch 6 rings, since these rings were introduced using build practices established at the Unified Engine Build Workshop. Figure 3 plots the mean delta/s for both connecting rod and block type. For the purpose of further analysis, the blocks with press in plugs were designated as 05 blocks and the batches with screw in plugs were designated as 06 blocks.

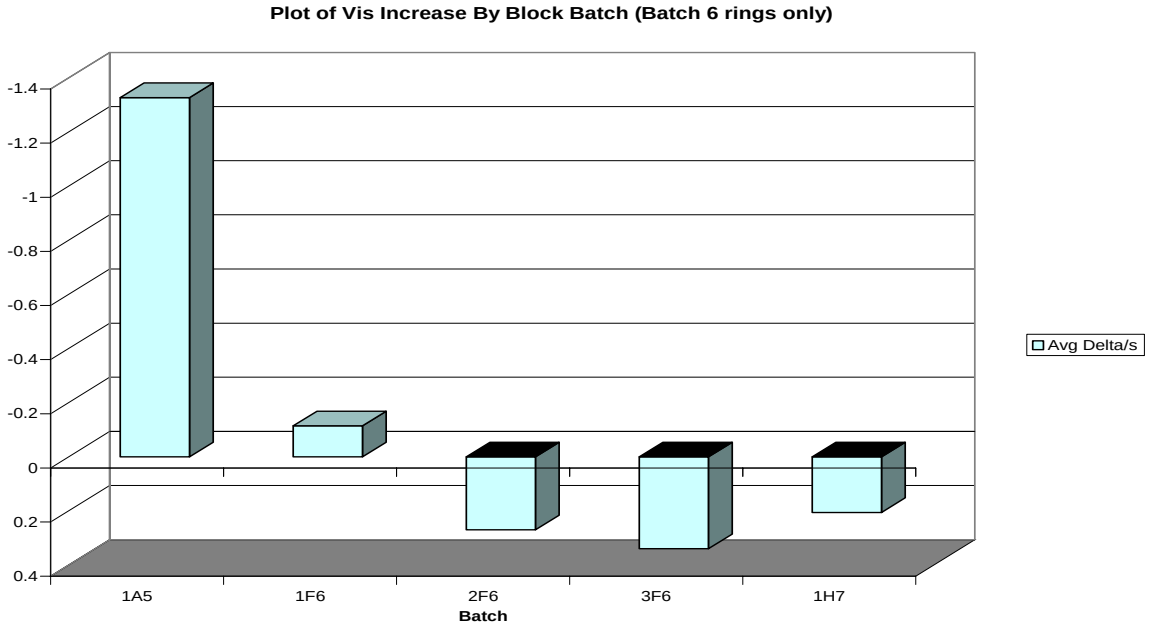
Figure 3



One observation that should be noted is that no slotted connecting rods were used with the latest (06) batch of blocks. When the connecting rod differences are tested in the 05 blocks, the difference between connecting rod types is not significant.

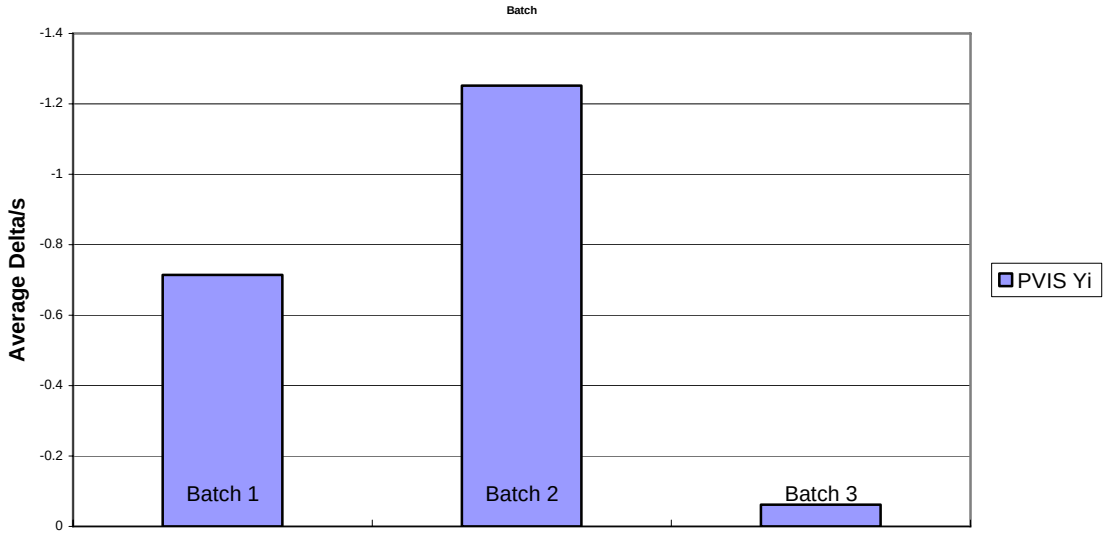
The average delta/s for each block batch is plotted in Figure 4. The 1A5 blocks appear to be much milder than the XF6 and 1H7 blocks. As previously mentioned, the 1A5 blocks have a press in freeze plug, while 1F6 and later blocks have the screw in type. How this change in freeze plug installation impacts performance is not clear.

Figure 4



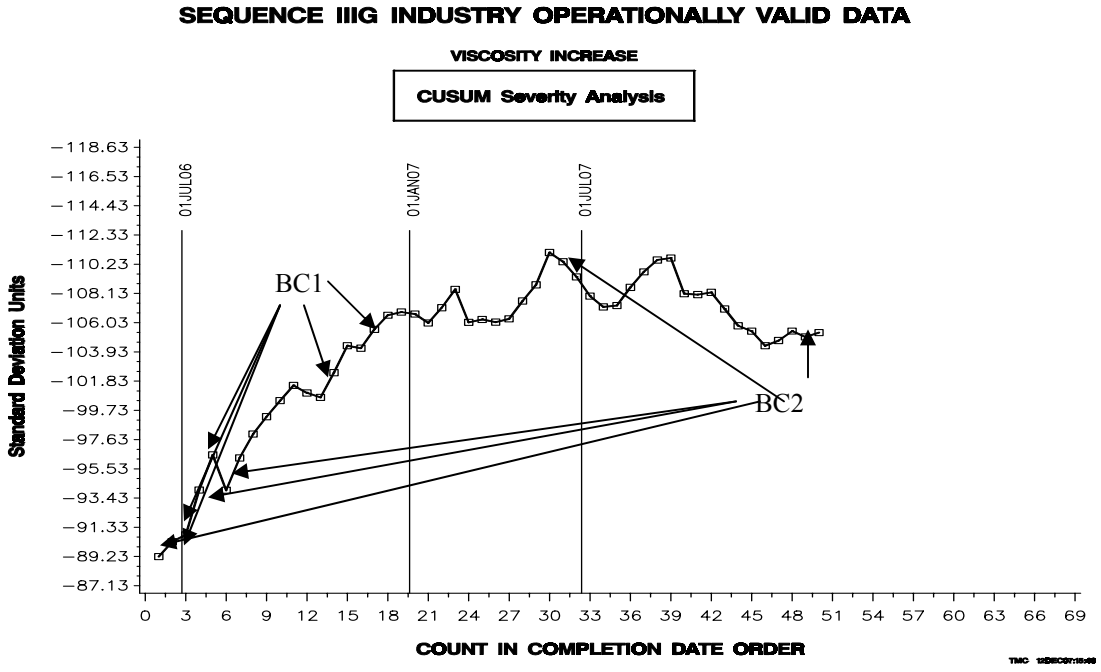
There are currently only three batch codes of intake valve seals in the reference test data base. Mean delta/s by batch is charted below.

Plot of Average % Vis Increase Yi by Intake Valve Seal Batch



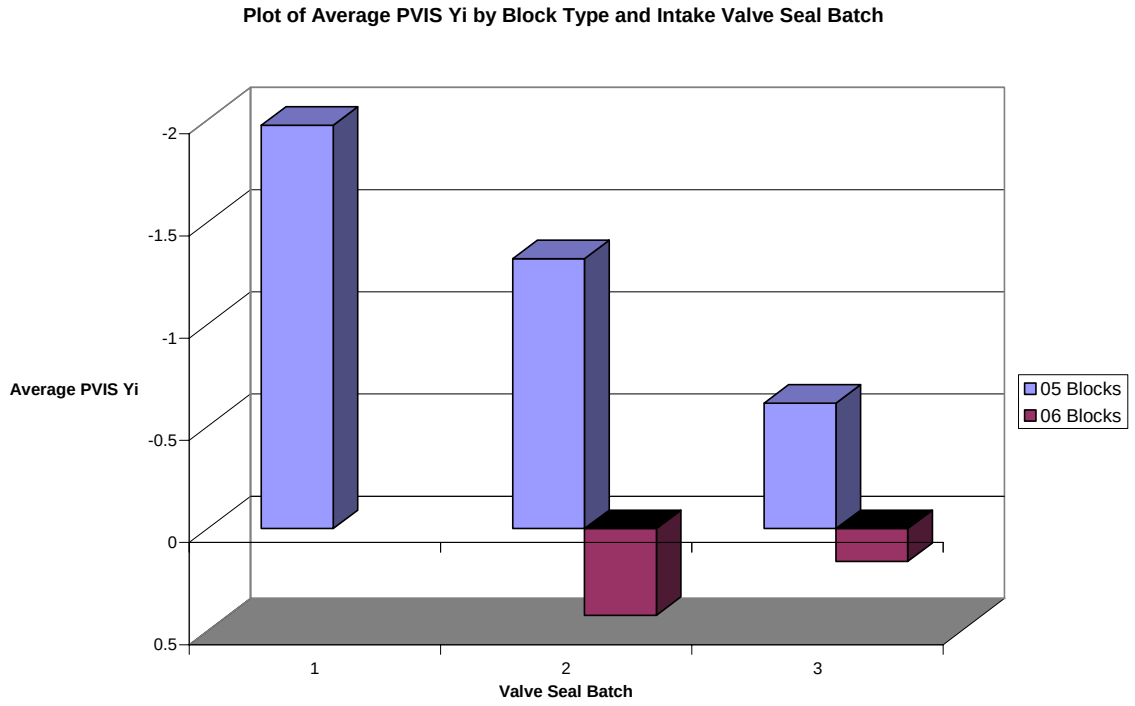
Plots show both Batch codes 1 and 2 were mild, while Batch 3 was near target. The last 50 data points in the reference test data contain primarily batch 3 results. The following plot (Figure 5) shows where other batch codes are represented.

Figure 5



No one batch code appears to provide consistent results during this period, though batch code 3 is by far the most prevalent during the abatement. It should be further noted that with the exception of one result, all of the results on the 1F6 and later blocks were on batch 3 intake valve seals. The following chart (Figure 6) shows average delta/s by block group and intake valve seal batch.

Figure 6



There are some anomalies in the data that bear mentioning. For example, there are 6 results on batch 1 using 05 blocks, which on average were -1.97 Δ/s from target. Five results from one lab averaged -2.16 Δ/s mild, while the remaining lab was -1.02 Δ/s mild. Batch 2 seals with 06 blocks consist of only one data point, making it difficult to show any difference between batch 2 and batch 3 seals with the 06 blocks. Figure 7 plots the mean performance PVISYi performance by lab, intake valve seal batch and block type.

Figure 7

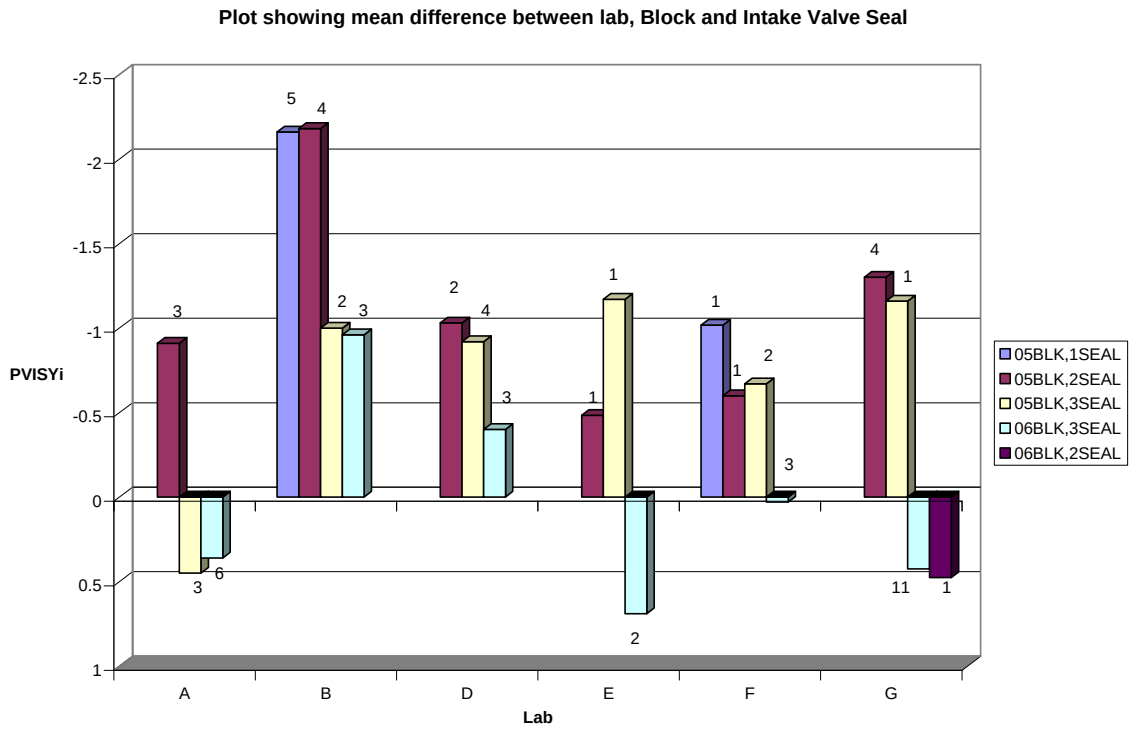


Figure 7 is further confounded by the introduction of lab into the mix. For example, Lab G shows a difference in performance between 05 and 06 blocks, but not much difference between seal batches, with limited data on 3 of the 4 combinations. Lab B shows about a 1 standard deviation difference between both batches 1 and 2 when compared to 3, yet 05 and 06 blocks appear to perform the same on batch 3 seals. Lab F is near target with the 06 blocks and batch 3 seals, but mild on all 3 seal batches with the 05 blocks.

Analysis of Oil Consumption

Because of some correlation with viscosity increase, oil consumption was also analyzed in a similar manner as viscosity increase. Oil consumption targets were derived from the same data used to generate the viscosity increase targets for each reference oil and Δ/s for all of the tests analyzed for viscosity increase were also analyzed for oil consumption. Figure 8 shows the plot of mean Δ/s for con rod type and block batch. Similar results to the viscosity increase analysis were obtained.

Figure 8 shows lower oil consumption with the 05 blocks and PM rods. With PMNS and 05 blocks, oil consumption is close to target. The PMNS and 06 blocks provided higher oil consumption than the other two configurations.

Figure 8

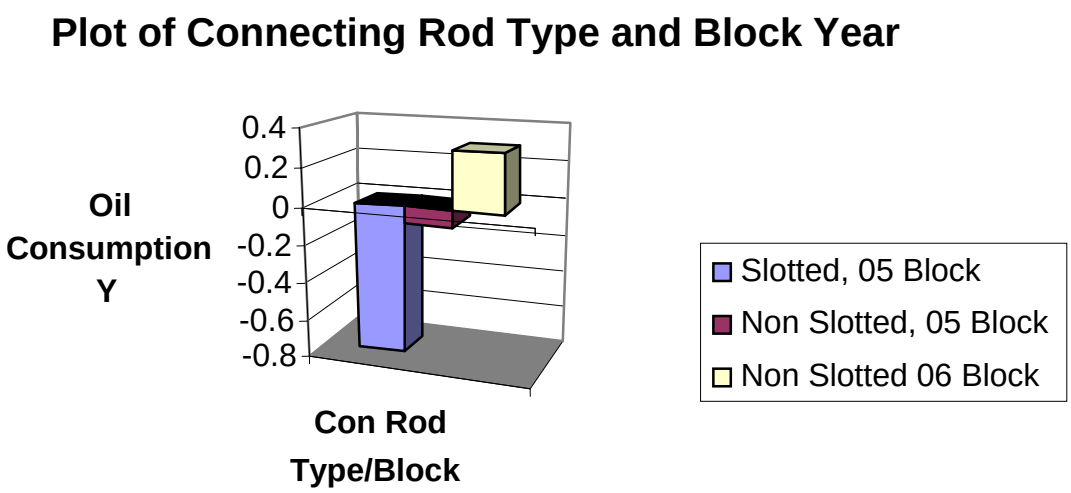


Figure 9 shows the lowest oil consumption with the 1A5 blocks, while oil consumption for the 1F6 is still slightly mild and the remaining batches tending to be severe. There are only 2 results on the 1H7 blocks and both results were obtained in the same lab.

Figure 9

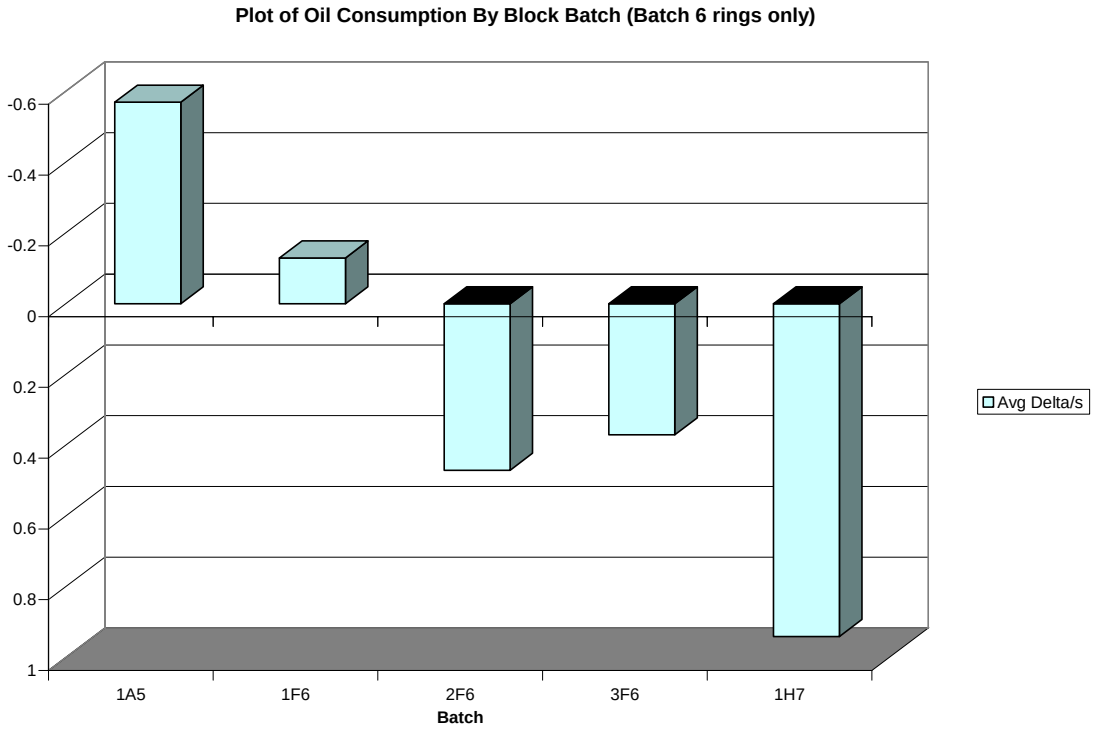


Figure 10 charts the oil consumption delta/s by block type and valve seal batch. There appears to be difference between batch 2 and 3 intake valve seals. Blocks also show a difference with batch 2 seals,

but the block difference is not as pronounced with the 06 blocks. It should be noted that there is only one result on batch 2 seals and 06 blocks.

Figure 10

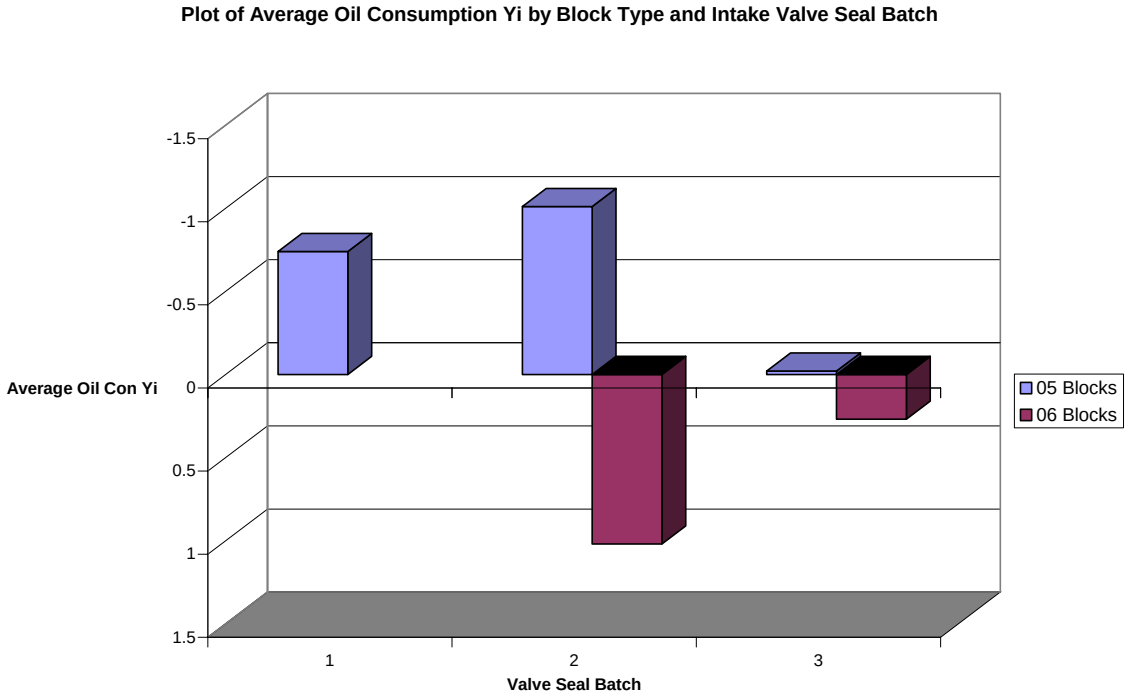
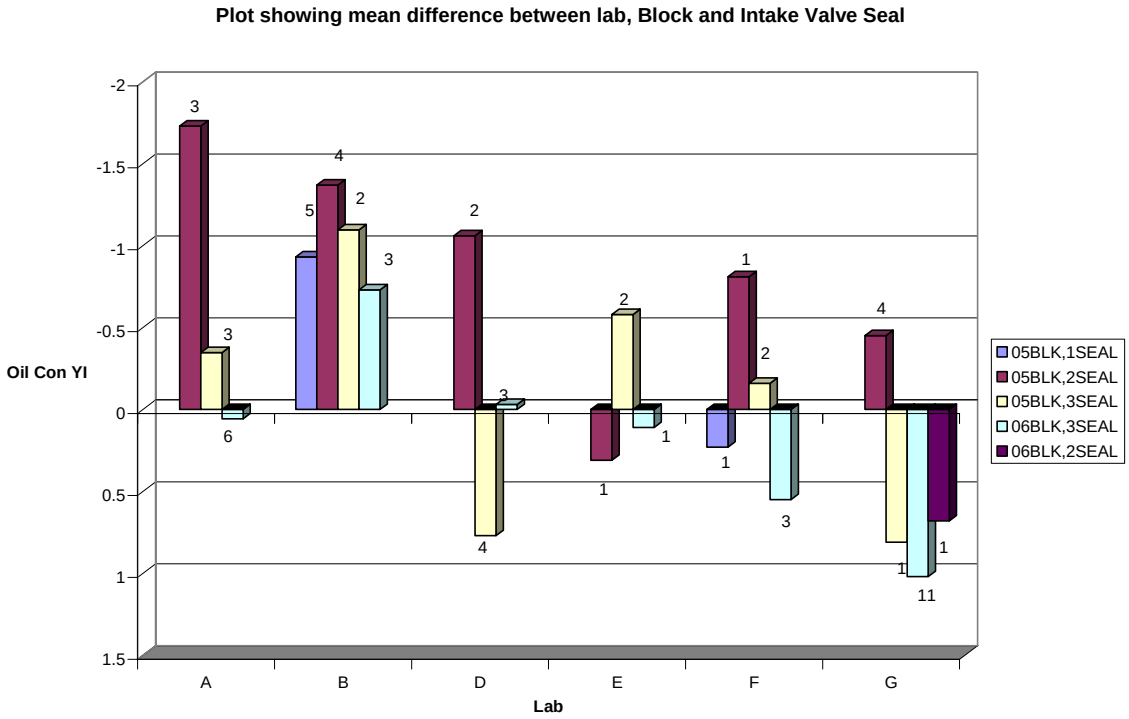


Figure 11 charts average oil consumption Δ/s for a given lab, block and intake valve seal batch. Though most labs seem to show some difference between batch 2 and batch 3 intake valve seals, the magnitude and significance are varied. In many cases though, the amount of data to compare is limited, making the ability to draw meaningful conclusions difficult.

Figure 11



Summary

There does not appear to be one single component that can be identified as the cause of the return to near target performance since late 2006, early 2007. Blocks and intake valve seals may have contributed to the abatement, but the lack of data across block types and seal batches makes drawing meaningful conclusions difficult to impossible. In addition, potential lab difference may also influence some of these results.

REG/reg

Attachments

c: Frank Farber, TMC
John L. Zalar, TMC

ftp://ftp.astmtmc.cmu.edu/docs/gas/sequenceiii/memos/mem08-003.pdf

Distribution: email