

ISB Cam and Tappet Test Industry Report Packet



Warren Totten
July 2004



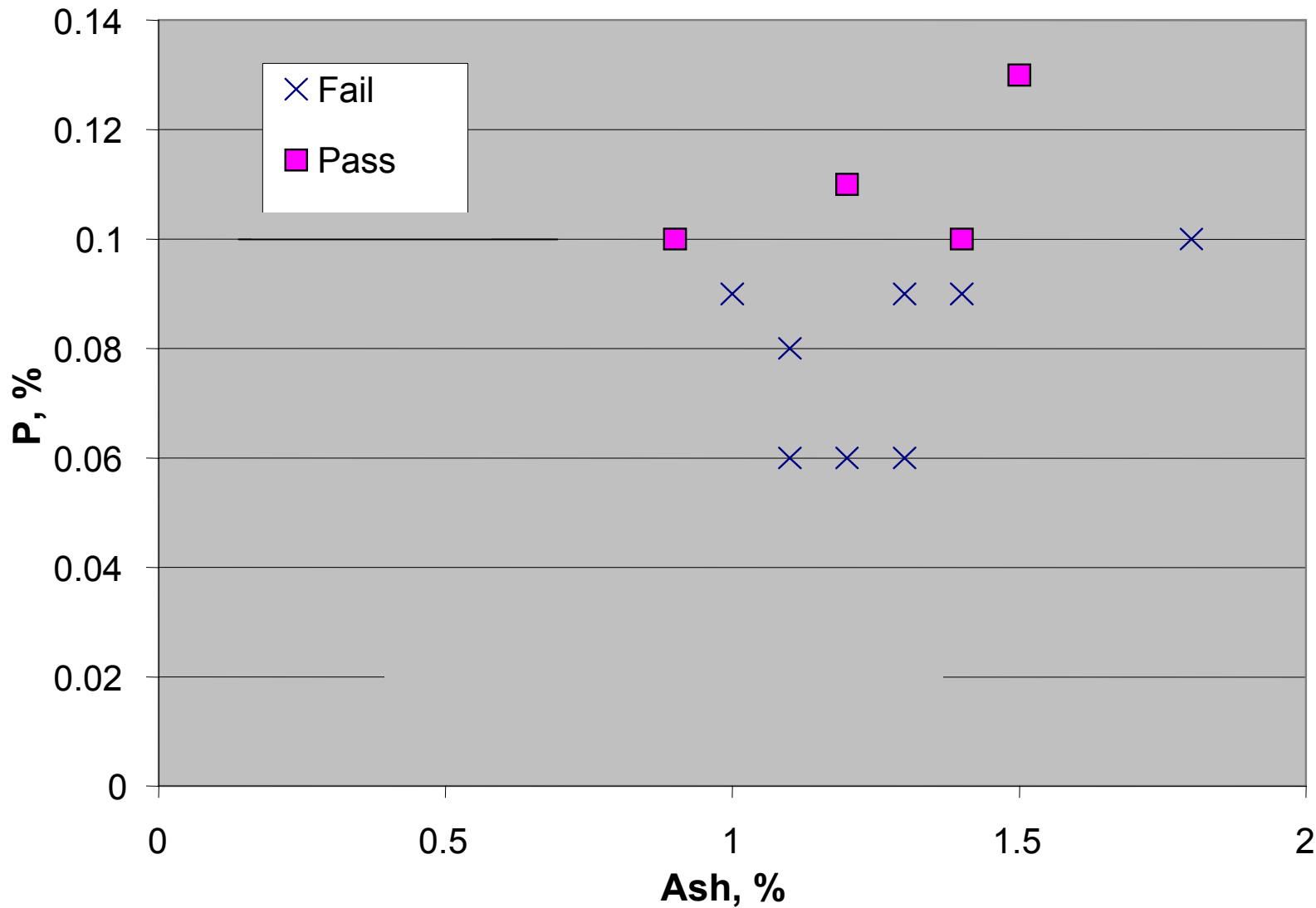
Test History

The ISB Valvetrain Wear Test was developed and based upon a Cummins, internal accelerated camshaft and tappet test used to evaluate the performance of engine hardware with various grades of engine oil. During the course of the development of the accelerated test it was found that cam lobe pitting and tappet wear directly correlated with the quality of an engine oil. The end of test results were evaluated on a visual inspection basis for pitting and wear severity. The cam lobes and tappets were rated on a 5 point scale from good condition down to strong pitting observed.

One round of testing, including 8 engine oils representing North America and SE Asia regions, found 6 of the oils tested failed to meet the wear criteria. A note of interest was that of the cam lobe failures 20% were represented by intake cam lobes the remaining were represented by the exhaust lobes.

Test History – B Camshaft Pitting

Phosphorus and Ash Effects



Test History

Lessons Learned

- Increase in stress and the presence of an edge stress on the tappet face are accompanied by a reduction in the velocity of lubricant flowing into the contact. It is solely a function of the cam lobe profile. The lubricant entrainment velocity for the cam lobe and sliding tappet systems is nearly zero when the pitch lift velocity is a maximum.
- The distance between the cam lobe center and the line of contact is equal to the instantaneous pitch lift velocity.
- Pre-sooting the oil prior to the Cummins ISB Valvetrain Wear Test provides for the most severe wear scenario.

Test Development

The intent of the ISB Valvetrain Wear Test is to take the internal accelerated cam and tappet test forward by allowing the end of test results to be evaluated on a mostly objective basis. Using previous experience with test development on heavy-duty engines for ASTM, the test procedure was proposed, drafted and supported internally. This procedure is now being finalized with the help of the industry through the ASTM ISB Test Development Task Force. Currently there are 6 labs participating on the task force. Of the six, one lab ran evaluation tests and is now upgrading hardware, two labs will be prepared to run evaluation tests in July and the remaining three should be running in August.

Looking Forward

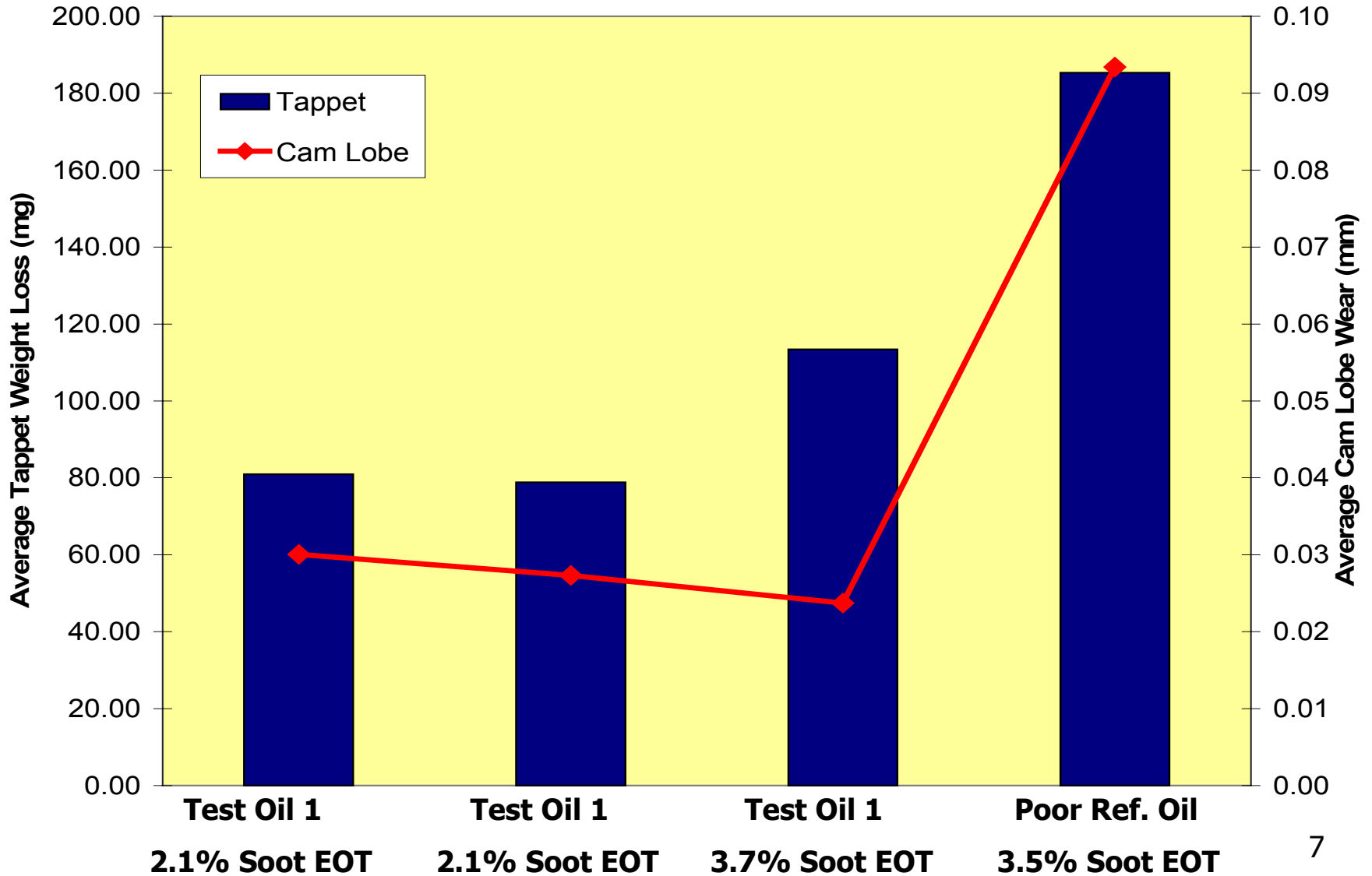
Meeting the Timing

Cummins proposes that the precision matrix testing begin on the ISB test as soon as the test is ready. However, before the matrix can begin, proof of concept data indicating the ability of the test to discriminate and repeat must be presented to the HDEOCP. This data is included in the presentation.

Once the remaining engine labs have ISB test stands on-line and the Operation and Hardware subgroup of the ISB Test Development Task Force provides positive feedback on the all test stands participating in the matrix, Cummins will move that the ISB matrix begin.

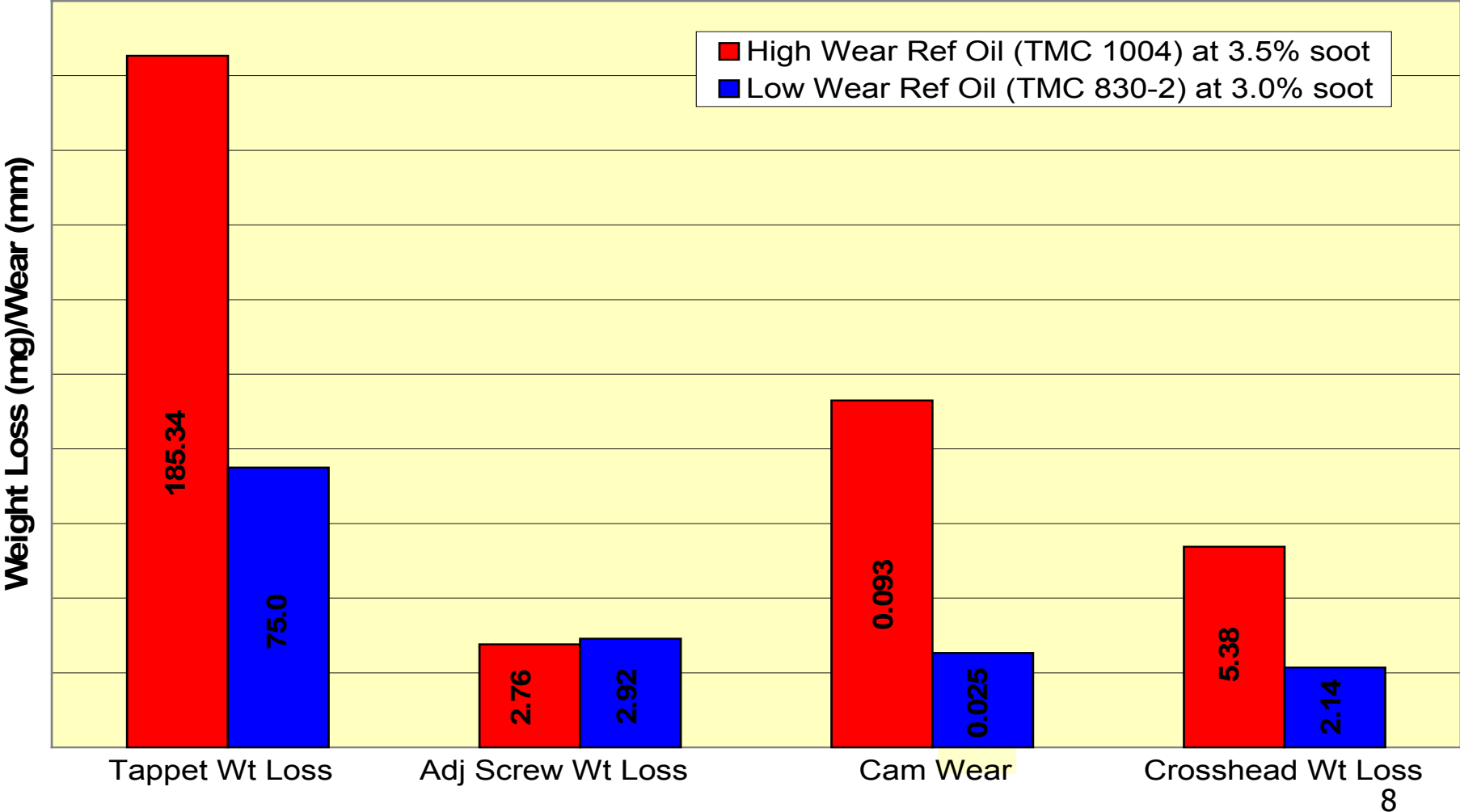
B Engine Camshaft and Tappet Testing

Repeatability and Discrimination



ISB '02 Camshaft and Tappet Data Discrimination

ISB Cam Cycle Test Data



ISB Test Overview

The ISB Valvetrain Wear Test is based upon a 2004 EPA Compliant engine rated at 300 HP and 600 lbf-ft torque. Prior to starting the test, the engine is run through a series of warm-up cycles to flush the engine oil with reference or candidate oil. After the final engine oil flush, the first portion of test cycle begins. This portion (Stage I) consists of a 100 hour soot generation steady-state cycle at 1600 RPM and 325 lbf-ft torque. The timing is artificially retarded using electronic engine control hardware to hit a soot window of 3.25 +/- 0.25%. The oil level is verified as full. The test then continues repeating a 28 second accelerated wear cycle for 250 hours. The wear components and other test parameters are evaluated upon successful test completion.

Scope

To develop a lubricant performance test on a Cummins ISB test platform that can discriminate and provide a quality assessment of motor oils in a sliding tappet engine under cyclic conditions. The ISB test development will consider the following parameters for lubricant quality evaluation:

Primary Parameters

Tappet Weight Loss

Cam Lobe Wear

Cam Journal Wear

Secondary Parameters

Push tube scuffing

Sludge

Oil filter delta P

Adjusting screw wt. loss

Crosshead weight loss

Objectives

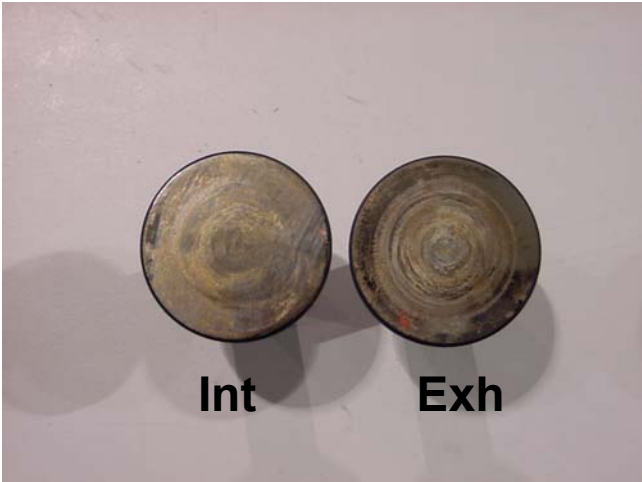
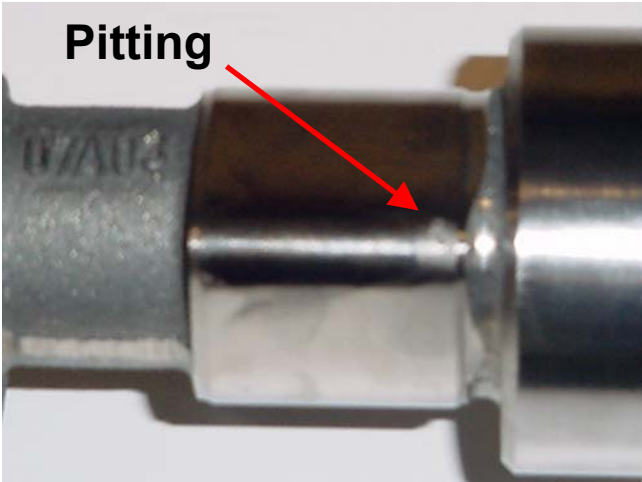
- Draft of test procedure 12/03
 - **Preliminary draft completed 01/04**
 - **Work continues within the ISB Test Development Task Force to refine and standardize the procedure**

- Test engines to six labs 1/04
 - ExxonMobil, Lubrizol, PerkinElmer, SwRI, Valvoline
 - Ethyl engine 6/04

- 3. Initiate matrix design 1/04
 - **Preliminary proposal based upon 4 labs attached**

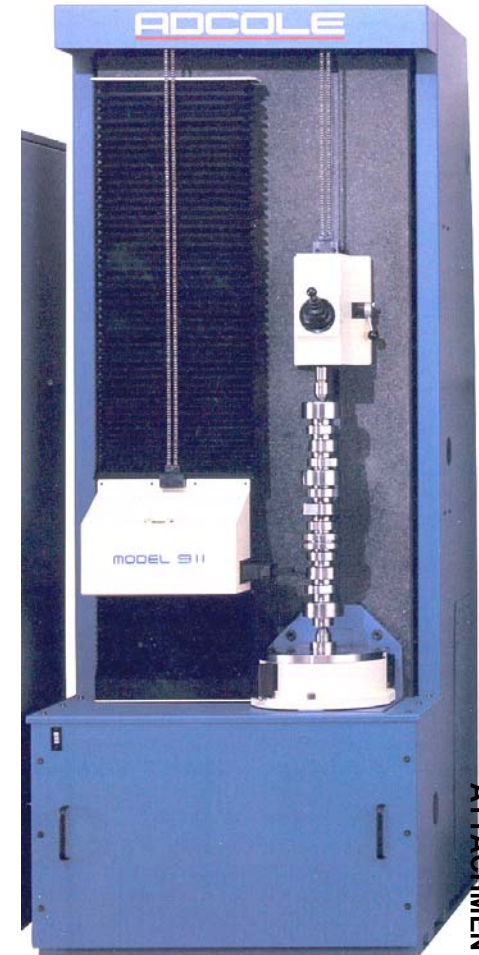
- 4. Begin matrix testing third quarter, 2004

Cam and Tappets After Test



ISB Test Parameters

- Parameters to be rated
 - Primary Parameters
 - Tappet Wear
 - mg wt loss
 - Cam lobe wear
 - mm wear
 - » ADCOLE measurement
 - » Cams will be pre and post measured by CPD
 - » The O&H Sub-group is evaluating alternative wear measurement methods
 - Cam journal wear
 - mm wear
 - » ADCOLE measurement



ISB Test Parameters

- Parameters to be rated
 - Secondary Parameters
 - Overhead wear
 - Crosshead Weight Loss, mg loss
 - Adjusting Screw Weight Loss, mg loss
 - Push Tube Scuffing
 - Other parameters
 - Oil Filter Delta Pressure, kPa
 - Sludge, rocker cover and oil pan

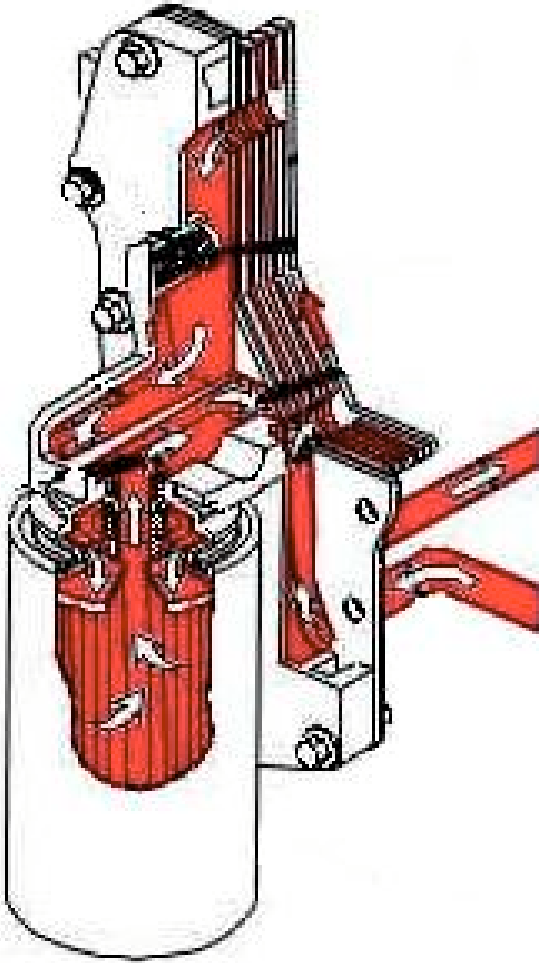
Precision ISB Matrix Design

Reducing the costs

Ideas

- Each test stand will generate similar wear performance as the Cummins test stand based upon historical data (mean and standard deviation)
- 3 DI/VI combinations, 1 base oil, and 1 Reference Oil
- Each successful test generates 12 tappet, cam and crosshead wear points
- No VGRA or BOI included in matrix design

Hardware Modifications



Remote
Oil filter

Remote
Oil Cooler

