

Analysis of API CH-4 and CI-4 Testing Levels

ACC PAPTG

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Introduction

- ACC has analyzed the RSI database to determine the testing activity levels for the major API CH-4 and CI-4 engine tests
- Quarterly analysis was conducted, rather than monthly analysis, to reduce clutter

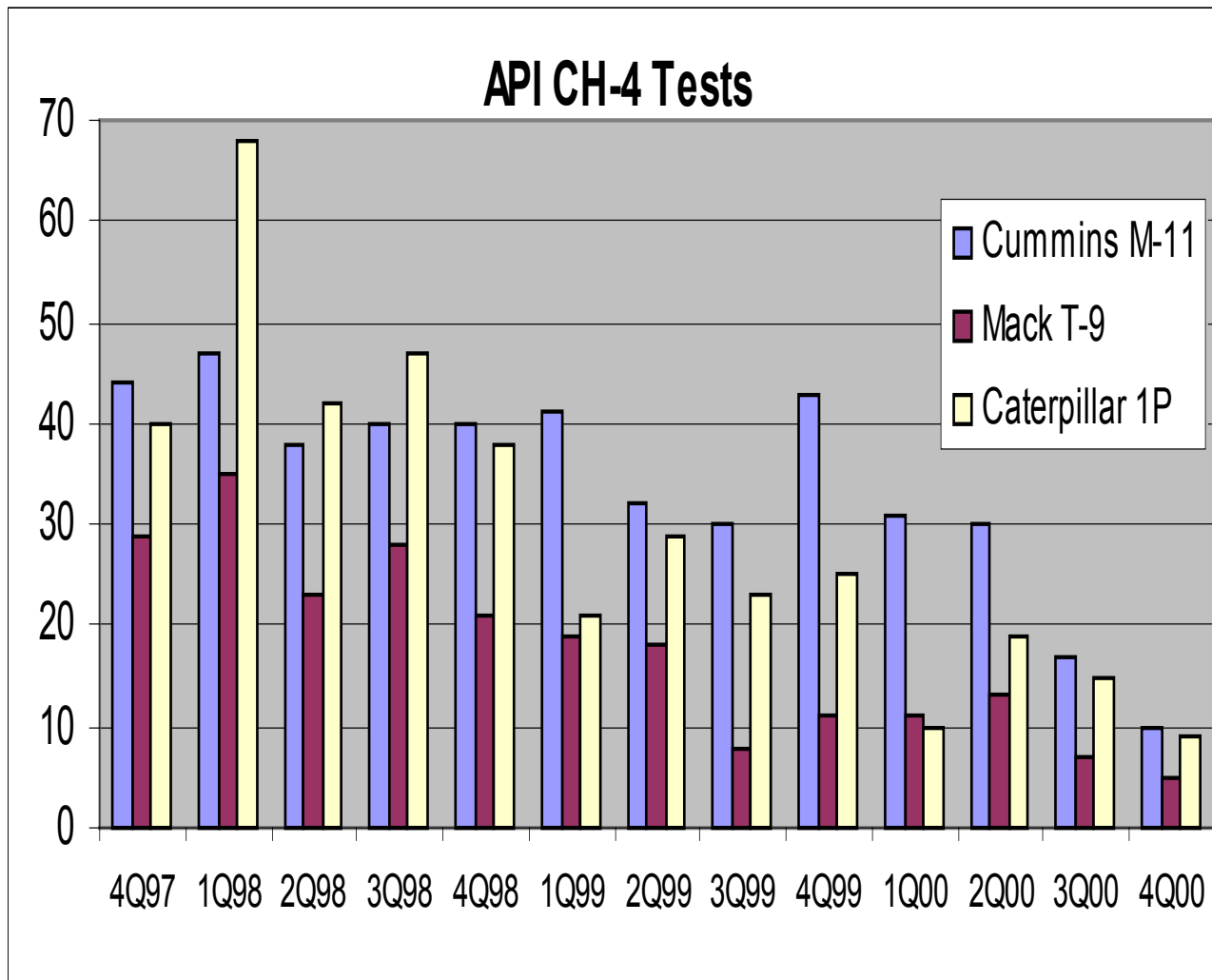
Details

- API CH-4 Specification
 - The high level of testing activity is protracted, probably due to evolving OEM specs
 - Difficult to draw any conclusions
 - Commencement of RSI registrations occurred in mid-October 1997 (almost a full quarter)

Details

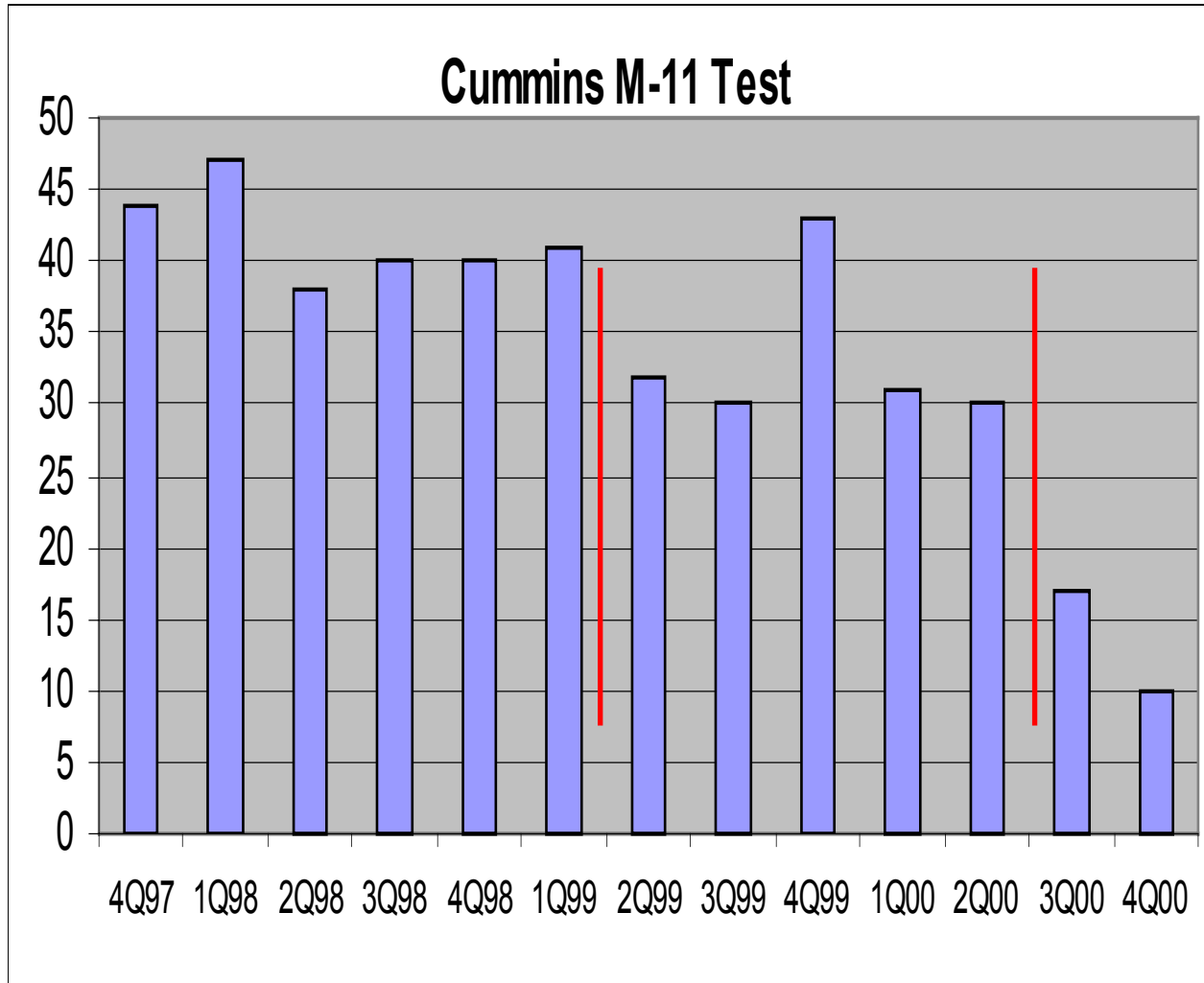
- API CI-4 Specification
 - The high level of testing activity is clear-cut
 - Duration is 15-18 months
 - Commencement of RSI registrations
 - Cummins M-11 EGR and Mack T-10, August 2001 (partial quarter)
 - Caterpillar 1R, October 2001 (full quarter)
 - Delay was due to the Caterpillar 1Q/1R matrix

API CH-4 Tests – Composite



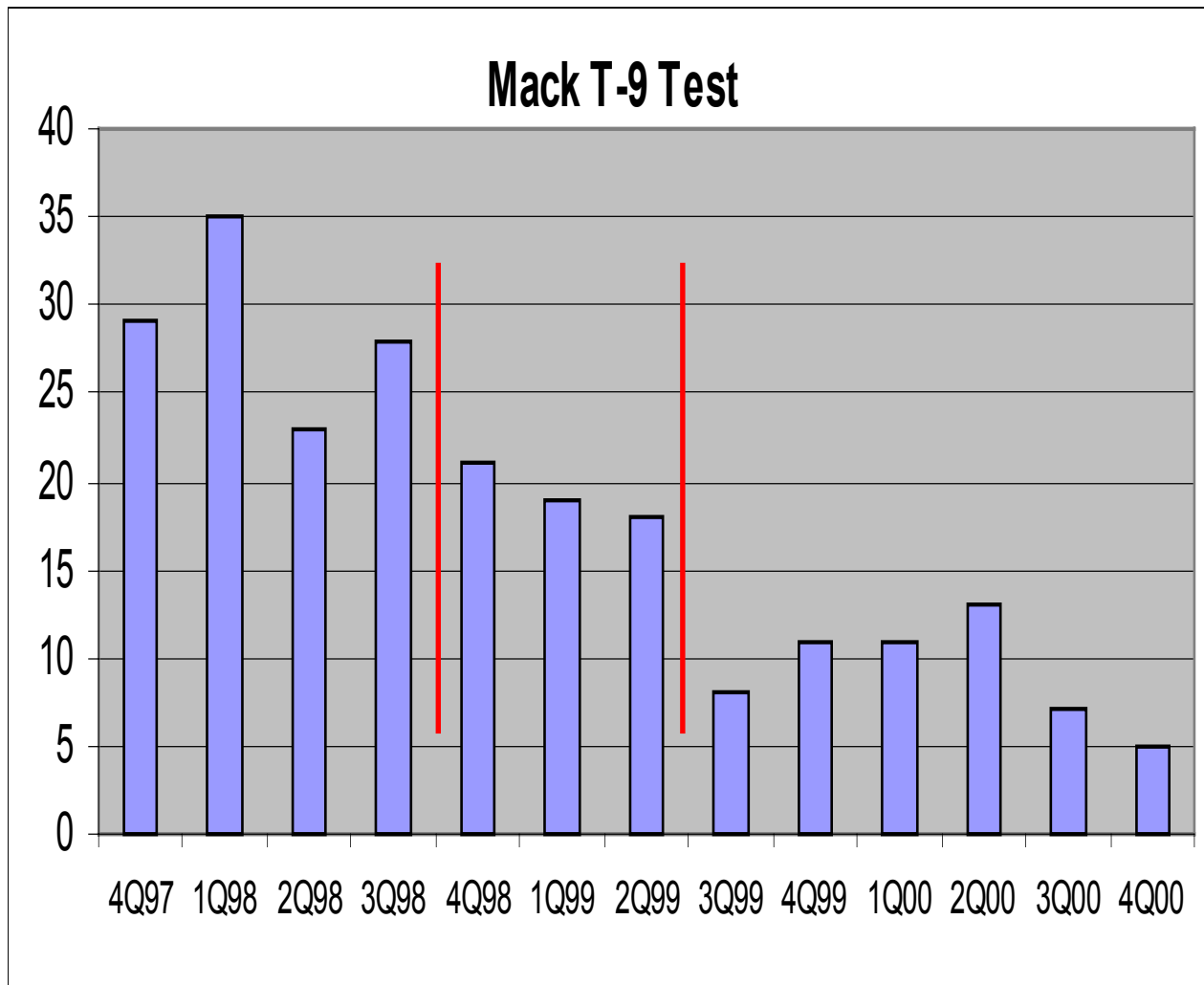
- Protracted, elongated testing period, almost three years
- Difficult to draw any conclusions
- Examine individual tests for more information

Cummins M-11 Test



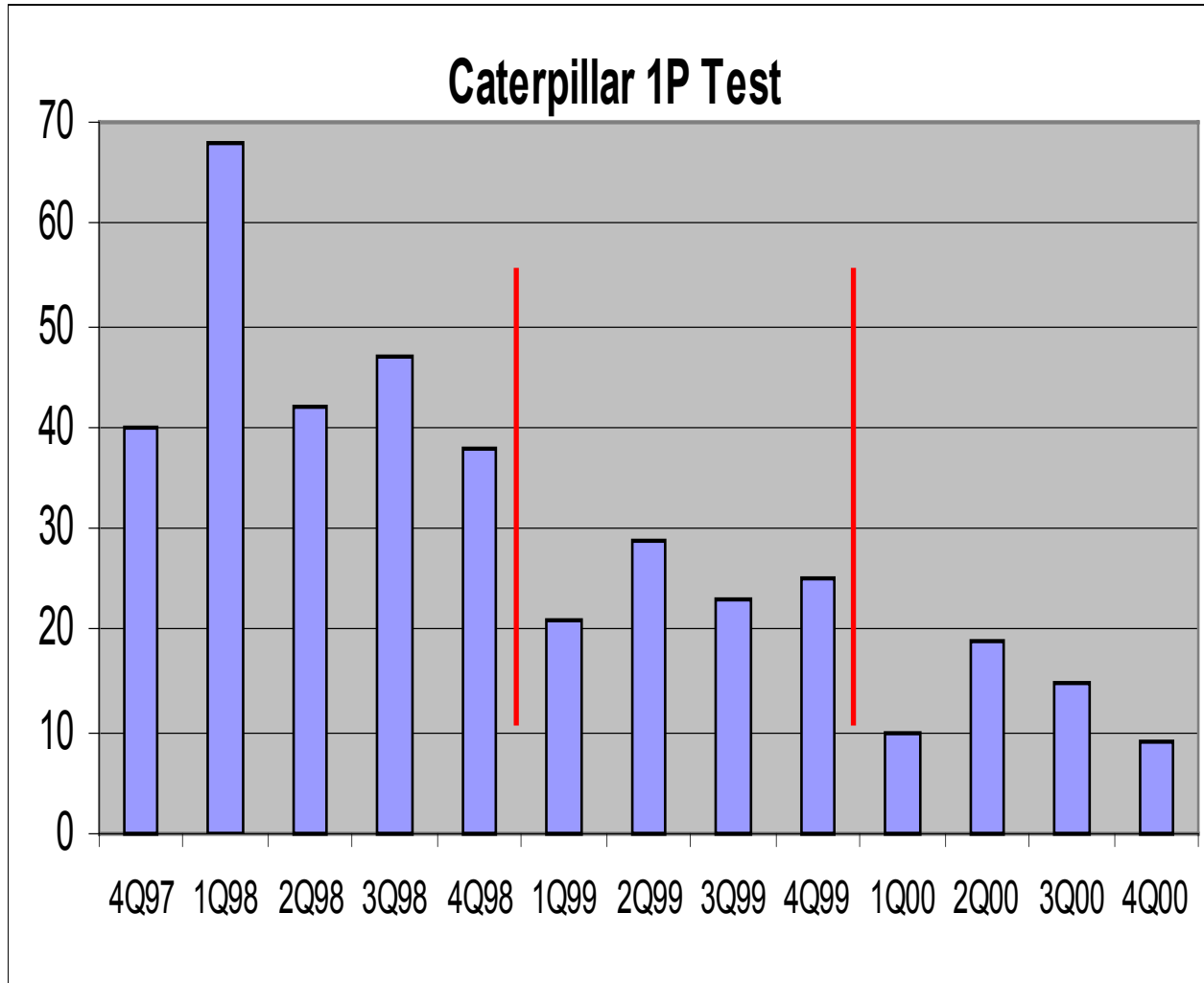
- 200-hour test
- Six quarters, ~42 tests/quarter
- Five quarters, ~33 tests/quarter
- Likely due to Cummins CES 20076 spec (300-hour test)
- Thereafter, less than 10 tests/quarter

Mack T-9 Test



- 500-hour test
- Four quarters, ~29 tests/quarter
- Three quarters, ~19 tests/quarter
- Thereafter, less than 10 tests/quarter

Caterpillar 1P Test

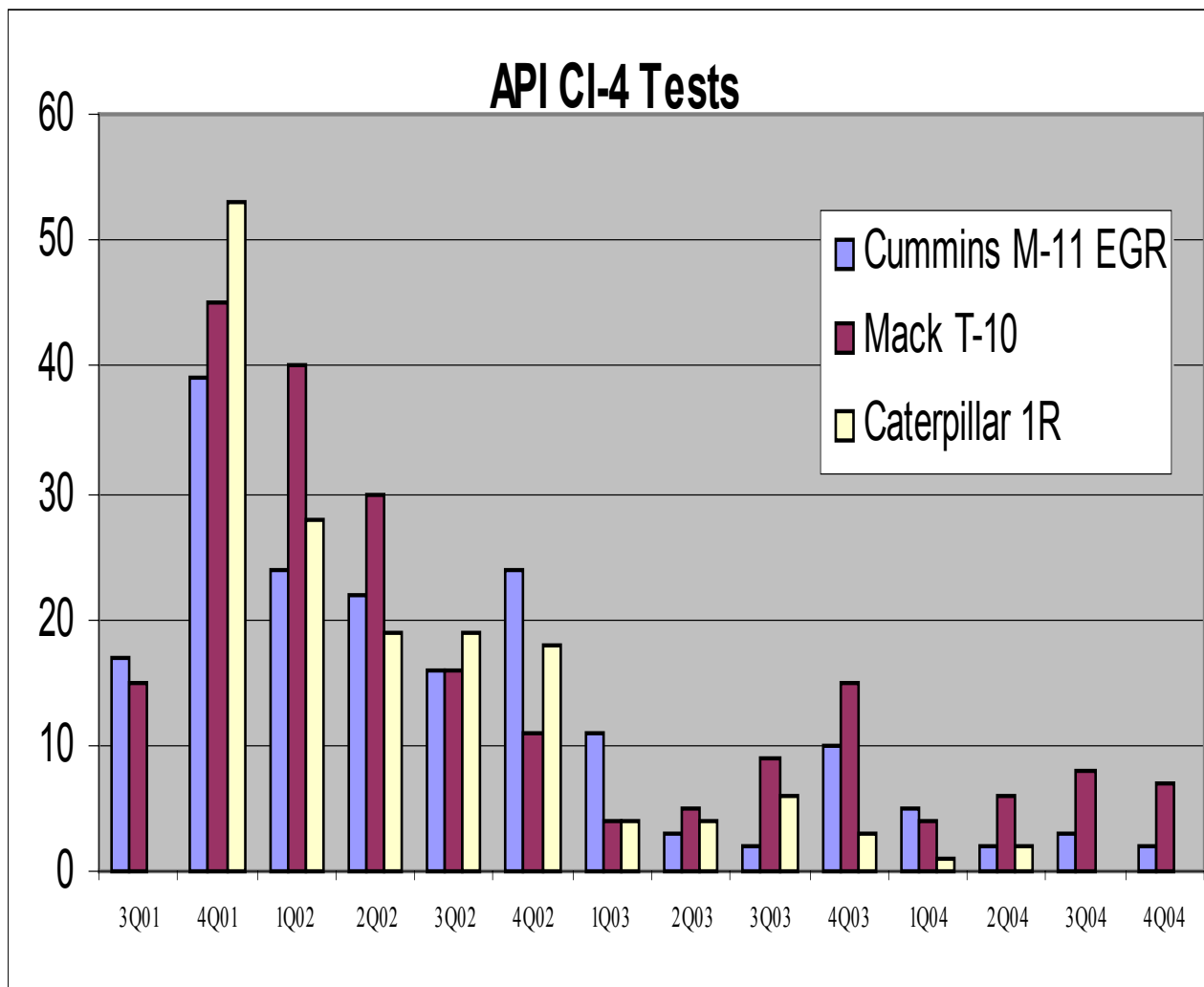


- 360-hour test
- Many tests terminated
- Low passing rate
- Five quarters, ~47 tests/quarter
- Four quarters, ~25 tests/quarter
- Thereafter, less than 15 tests/quarter

API CH-4 Testing Summary

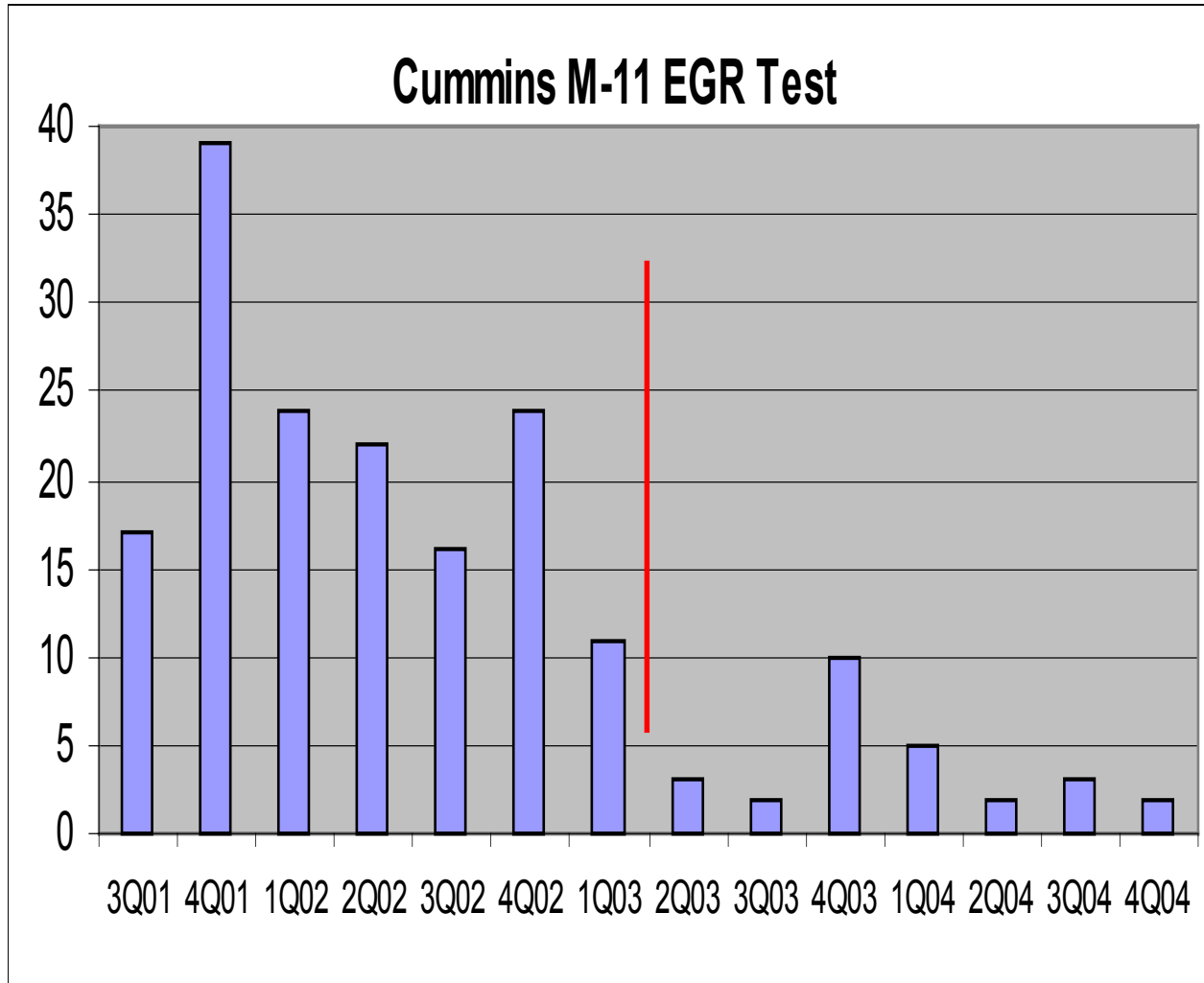
- An extended duration of high engine testing activity levels occurred for API CH-4 plus subsequent OEM approvals
- Best estimate is five to eleven quarters, or about 15 to 33 months
- Difficult to draw any conclusions, except that the lower limit is about 15 months (based on the 1P)

API CI-4 Tests – Composite



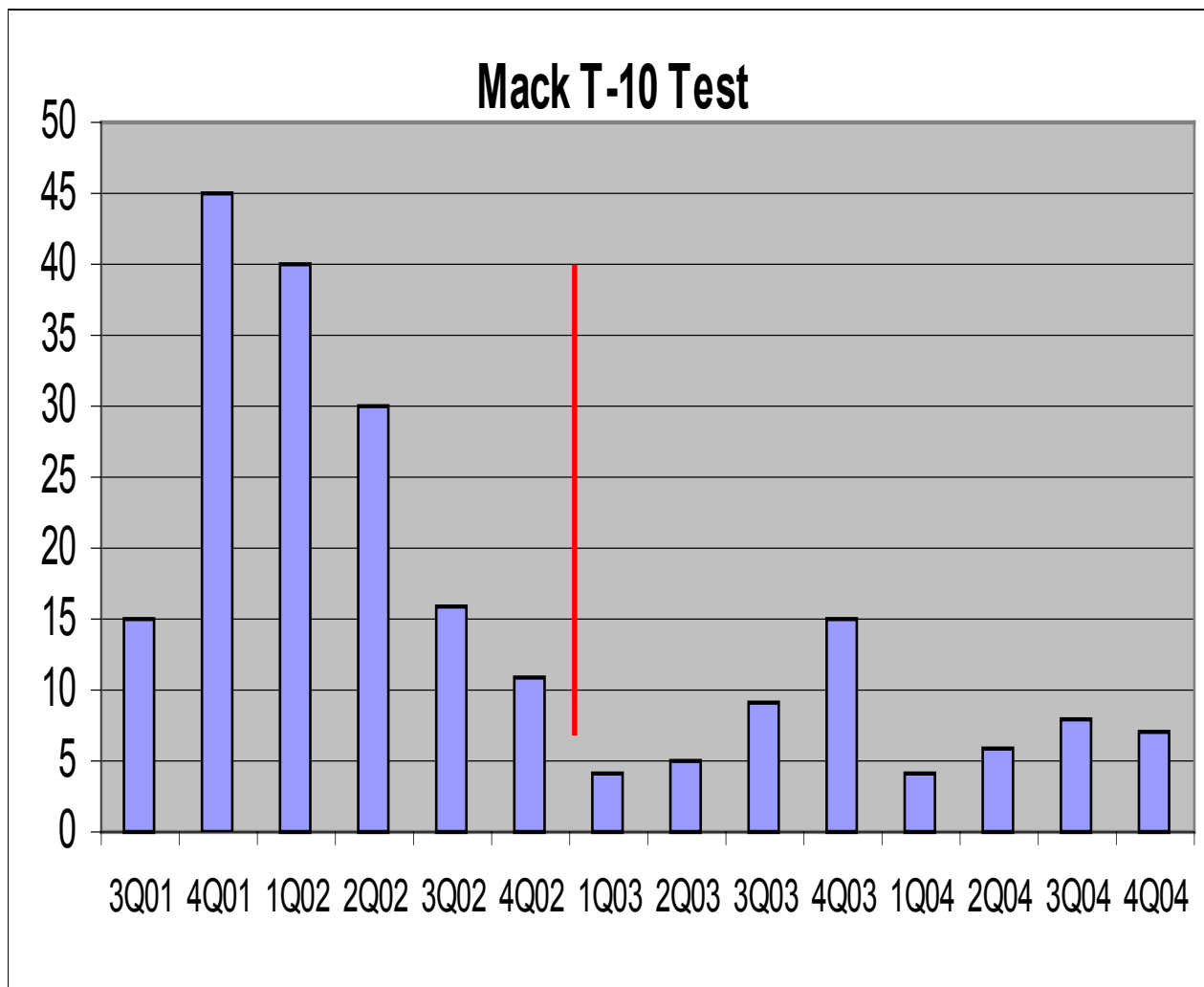
- Shorter testing period, about 18 months
- Easier to draw conclusions
- Examine individual tests for more information

Cummins M-11 EGR Test



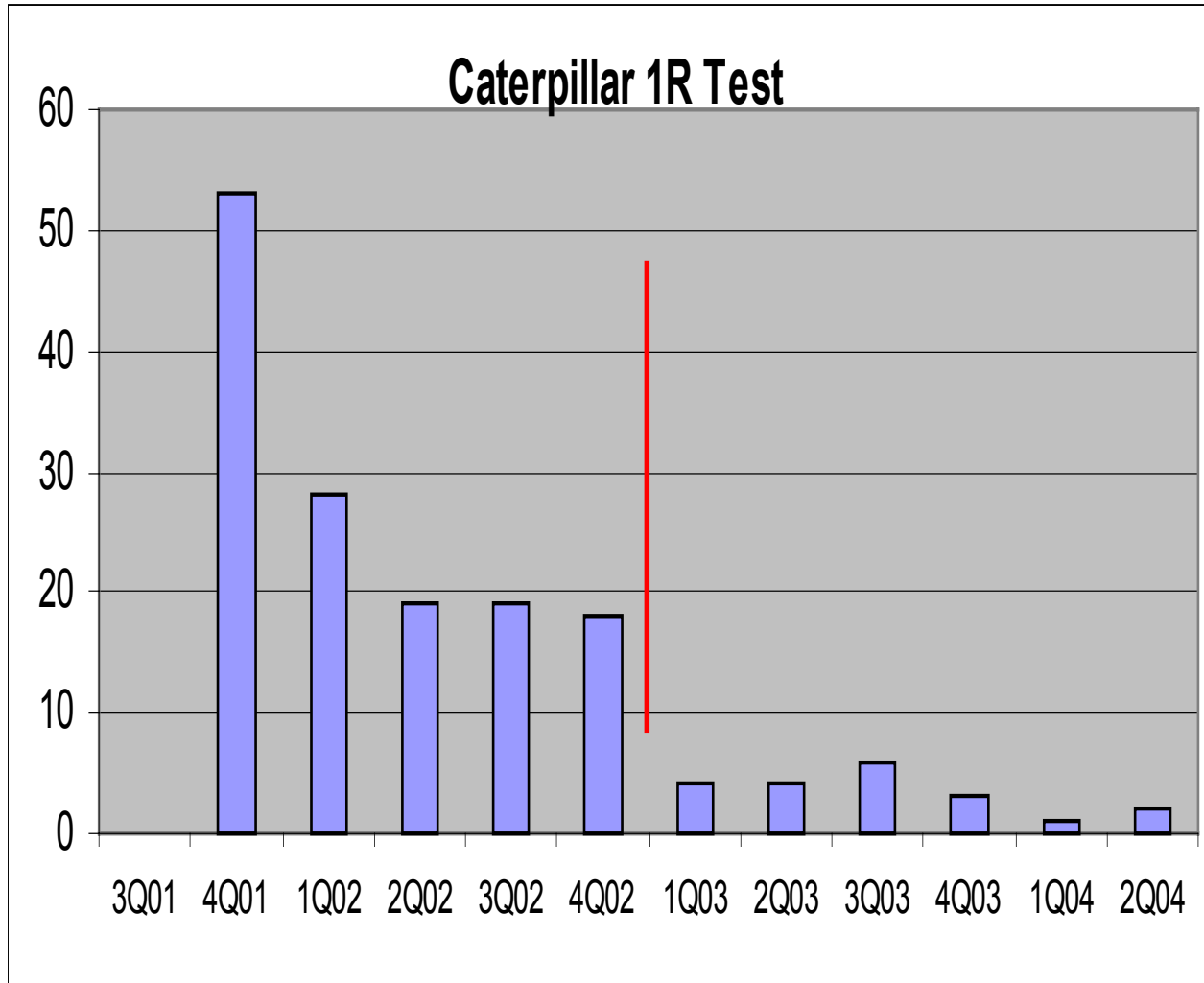
- 300-hour test
- Seven quarters, ~22 tests/quarter
- (perhaps a bit less, 19 months)
- Middle five quarters, 25 tests/month
- Thereafter, less than 5 tests/quarter

Mack T-10 Test



- 300-hour test
- Six quarters, ~26 tests/quarter (perhaps a bit less, 16 months)
- Thereafter, less than 10 tests/quarter

Caterpillar 1R Test



- 504-hour test
- Very high passing rate
- Registration delayed
- Five quarters, ~27 tests/ quarter
- Thereafter, less than 5 tests/ quarter

API CI-4 Testing Summary

- A shorter duration of high engine testing activity levels occurred for API CI-4 than for API CH-4
- For each test, five-seven quarters was required
- Overall conclusion, fifteen months was required

Critical Considerations

- The CI-4 process was not satisfactory and resulted in CI-4 Plus
- There is higher complexity/greater uncertainty in PC-10
- Test capacity, pass/fail ratio, and invalid test frequency is unknown
- One more test in PC-10 than in CI-4
 - PC-10: Cummins ISM and ISB, Mack T-11 and T-12, Caterpillar C-13
 - CI-4: Cummins M-11 EGR, Mack T-8E and T-10, Caterpillar 1R
- Advent of PC-10 chemical box requires establishment of new core technology and limits formulating flexibility

Test Capacity Concerns

- Caterpillar 1R
 - 504 hours, two-day turnaround (ca. 23 days total)
 - Very high passing rate (>75%?)
 - 137 tests run in first 15 months, about 9/month
 - 75% passing rate, about 103 passes
- Caterpillar C-13
 - 500 hours, six-day turnaround (ca. 27 days total)
 - Passing rate unknown
 - With a 50% passing rate, 200 tests are needed
 - Assuming there are 10-13 C-13 stands in the industry, each runs about one test/month, about 15-20 months is required

ACC Viewpoint

- PC-10 is revolutionary (more challenging, more uncertainty), while API CH-4 and CI-4 were evolutionary (less challenging)
- API CI-4 required fifteen months
- Historical data and test differences for PC-10 indicate the current PC-10 process can not be compressed below that of API CI-4
- **PC-10 will take fifteen months from end of matrix**