Analysis of Rolling Resistance Data for Passenger Car Tires

prepared for the
Rubber Manufacturers Association

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Objectives

- To compile a comprehensive data set that represents the RRC values of passenger car tires sold in the domestic replacement tire market
- To assess the market coverage provided by the comprehensive RRC data set
- To characterize the distribution of RRC values in the domestic replacement tire market
- To evaluate the sources of variation and uncertainty associated with RRC values

Available Data Sets

1. California Energy Commission (CEC) tested 5 replicates for each of 149 passenger car tires; rolling resistance force and other tire characteristics are reported, RRC must be calculated

2. Transportation Research Board (TRB) reported RRC values and other tire characteristics for 196 passenger car tires (162 reported by RMA members, 34 reported by Ecos)

3. RMA members reported RRC values and other tire characteristics for 662 passenger car tires

Combining these data sets provides 1,007 RRC test values with varying numbers of replicates and other information on the tested tires

Relevant Variables

- Tire Identification: manufacturer, brand, model, market, class, load index, speed rating, size (prefix, rim diameter, section width, aspect ratio)
- Rolling Resistance: RRC value (computed from RRF for CEC tests)
- Other Tire Characteristics: UTQG ratings (traction, temperature, tread wear), tire weight, tread depth, outside diameter

Combining the Data Sets

- Data sets distributed by TRB are used with minor errors corrected and specific values for speed rating (SR) and load index added
- Data set provided by CEC is used with 149 RRC values calculated from 745 tests (5 replicates per test)
- Additional data sets are used as provided by RMA members; number of replicates per RRC value ranges from 1 to 8
- Excluded all LT tires and winter/traction tread tires
- Included original equipment tires (also available as replacement tires)
- Current count is 1,007 RRC values with identifying information
- Extent of additional information provided varies substantially from one RRC test value to another

Market Characterization

- Market coverage is evaluated using 2006 domestic replacement market tire shipments by RMA members
- Sales data are not available for specific tire brands, models, SKUs, or states (e.g. California only)
- The RMA shipment data provide estimates of the percentage of the 2006 domestic passenger car replacement tire market accounted for by specific combinations of tire size and speed rating
- The percentage estimates are based on shipments by RMA members, which account for approximately 90% of the domestic replacement tire market

Market Coverage

- The combined RRC data set includes tests on approximately 150 different sizes of tires with various speed rating (SR) codes
- Many sizes are produced with only a few SR codes
- Speed ratings are related to tire construction characteristics that can influence RRC. These characteristics suggest four SR groups: H, V, ZR, and other (T and lower)
- Size and speed rating are often related; higher speed ratings are more commonly found in sizes with larger rim diameters and lower aspect ratios
- RRC data are available for more than 200 combinations of size and SR group sold in the domestic replacement tire market

Market Coverage (continued)

- The tire sizes represented by RRC tests account for more than 92% of the 2006 domestic replacement tire market
- The 200+ combinations of size and SR group represented by RRC tests account for almost 88% of this market
- None of the untested combinations account for as much as 0.5% of this market
- The distribution of RRC tests across the size/SR group combinations is not always proportional to the percentage of sales; some combinations with very low sales percentages have more than one RRC test

Distribution of RRC Values in the Replacement Tire Market

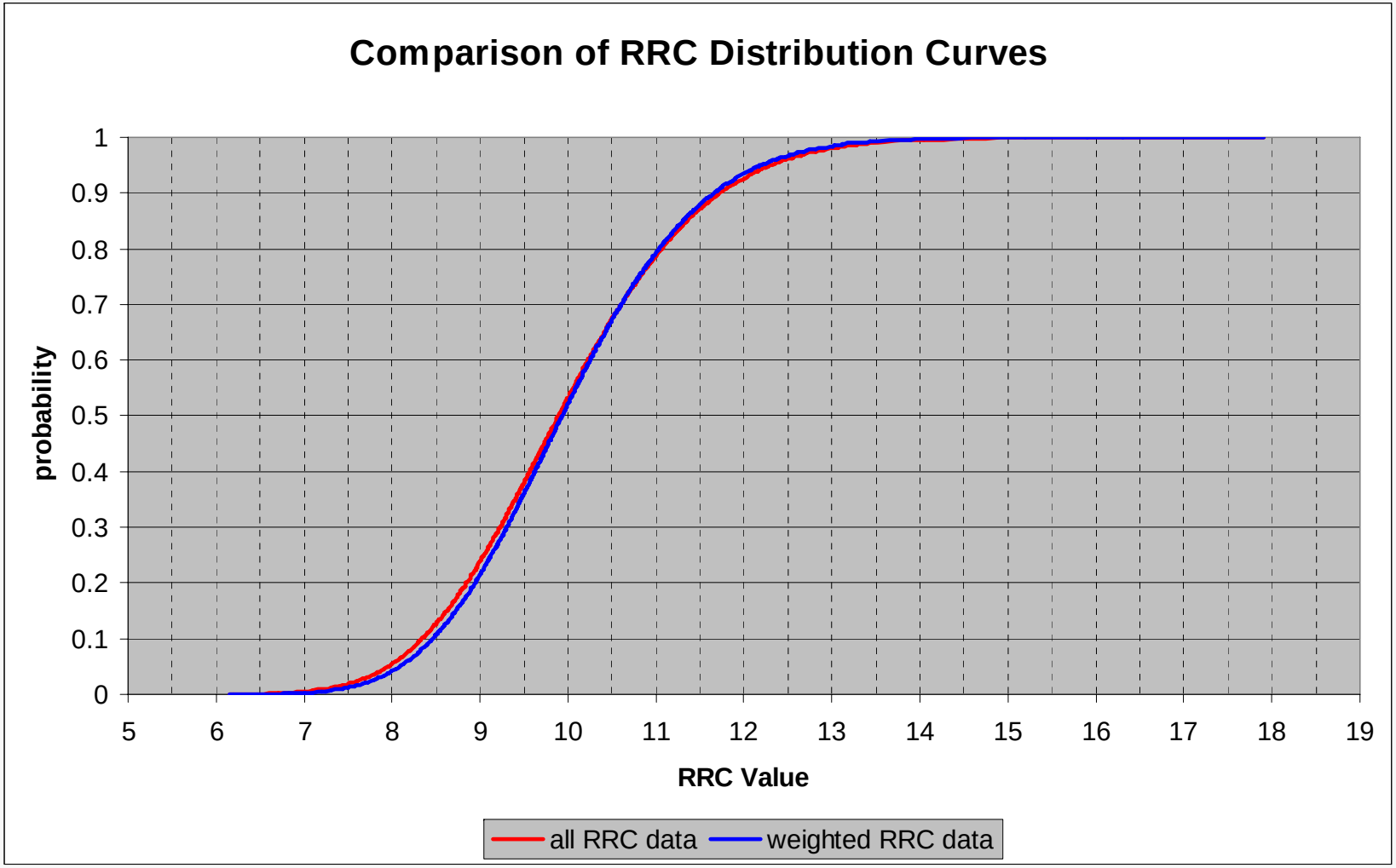
Two approaches to characterizing the distribution:

1. using available RRC test values alone
2. using tire shipment/sales data to assign weights to the RRC values

Each approach provides a curve that represents the distribution of RRC values in the replacement tire market

As shown in the figure (next page), the curves are nearly identical

Distribution of RRC Values



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Sources of Variation in RRC Values

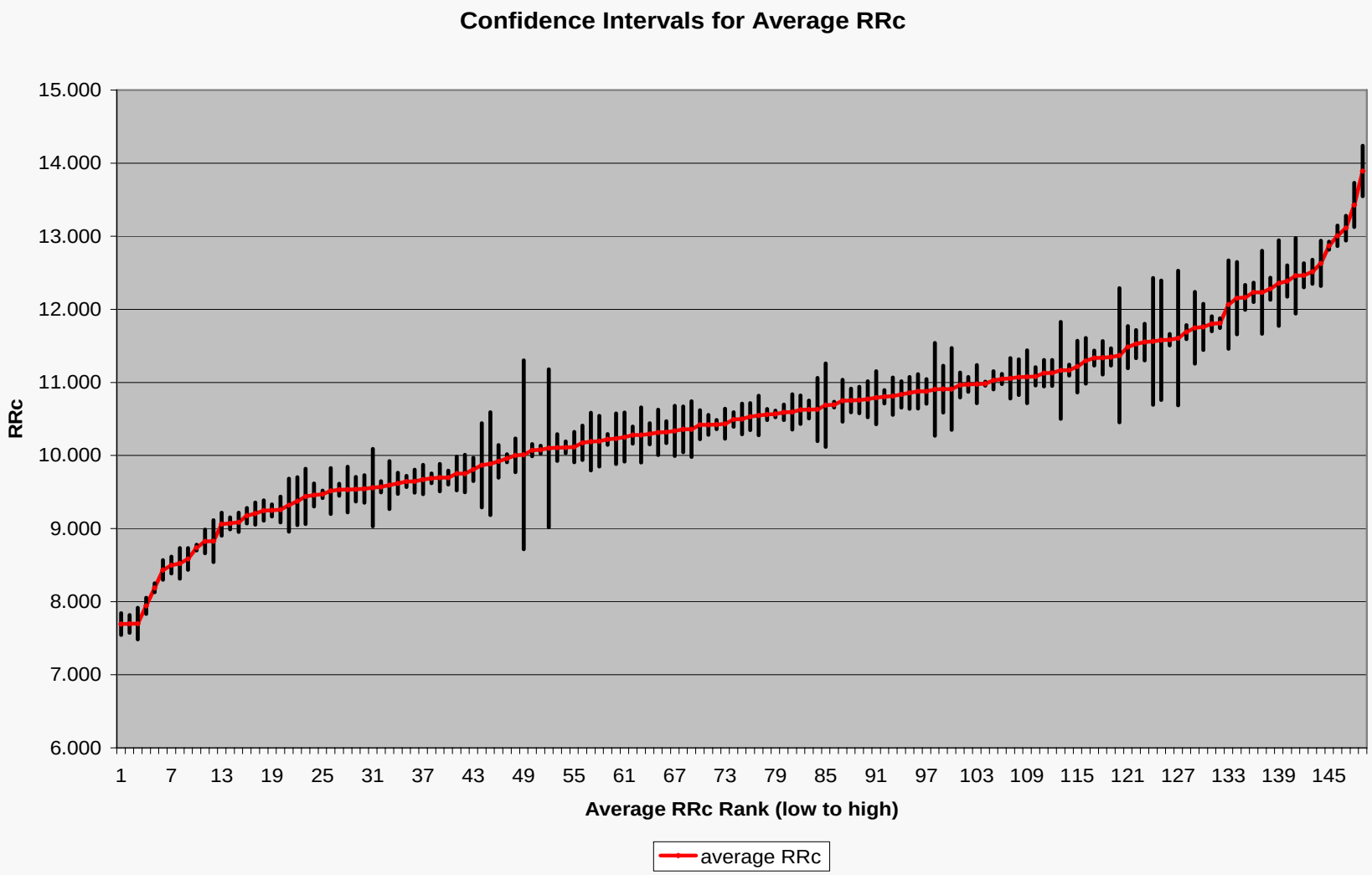
Two primary sources of variation in RRC values within a specific SKU have been identified:

1. Item-to-item variability between replicates
2. Variability due to differences between test machines

Variability from both sources should be considered in evaluating the uncertainty associated with RRC values

Differences in RRC values between SKUs are not strongly related to other variables in the combined data set (size, UTQG ratings, load index, tire weight, tread depth, outside diameter)

Item-to-Item Variability in CEC Data (all from one laboratory)



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Confidence Intervals for CEC Data

- 95% confidence intervals for the population mean were computed for each tire tested for CEC (5 replicates from one laboratory)
- Half-width is a function of sample size and test-to-test variation
- Half-widths computed from 5 replicates range from 0.03 to 1.3, with an average half-width of 0.26

Item-to-Item variability alone can cause substantial uncertainty in RRC values (e.g., 10 ± 1.3)

The level of variation among the 5 replicates varies substantially from one tire (SKU) to another

In pair-wise comparisons, many of the mean RRC values estimated from the CEC data are not significantly different

Points for Discussion

- Data sets
- Market coverage
- Distribution of RRC values
- Sources of Variation