PRODUCT DURABILITY

Accurate Prediction Using Simulation

- Finite Element Analysis
  - Models stress on components and assemblies
  - Capable of dynamic analysis to determine resonance frequencies and modes
- Experimental Modal Analysis Software
  - Determines modal properties of structures
- Cost Advantageous

Evaluation Through Physical Testing

- Vibration Tables
  - Use shakers to excite hardware to assess durability
  - Can apply sine, random, or shock vibration input
  - Capable of hot or cold tests
  - Multiple tests cells (U.S. and Europe)
- Thermal Aging Test Bench
  - Allows transient flow and temperature control for thermal aging and durability analysis
  - Ability to simulate full flow engine conditions
  - Multiple benches (U.S. and Europe)
- Ultrasound Analyzer
  - Allows non-destructive evaluation of filter integrity
- Tensile/Compression Tester
  - Used to test material properties
- Environmental Chambers
  - Allows testing at hot or cold temperature with humidity control and salt spray
- Field Data Acquisition System
  - Collects data from field tests
  - Allows analysis of acceleration, strain and pressure to develop vibration test profiles
- Correlation to Simulation

Accurate correlation of Vibration Tests to Field Test Results
Lab Data (left); Field Data (bottom)
FLOW AND THERMAL

Precise Prediction Through Simulation

- Fluid Modeling
  - Predicts performance of components
  - Predicted characteristics are fluid flow, pressure loss, flow distribution, velocity ranges, thermal gradients and dispersion

- Fluid Flow
  - Predicts performance of systems by component
  - Predicted characteristics are fluid flow, pressure loss, flow velocity, flow rates and heat transfer rates
  - Considers transient and steady-state flow

- Backpressure Modelling
  - Predicts pressure drop of muffler designs due to internal component changes
  - In-house proprietary software

- Cost Advantageous

Validation by Evaluation

- Flow Test Bench
  - Allows measurement of the flow distribution or backpressure for an emissions device
  - Allows calculation of device backpressure at varying flows and temperatures

- Engine Dynamometers
  - Used to validate performance and durability of emissions devices

- Infrared Imaging
  - Analyzes effect of insulation on surface temperatures
  - Allows thermal analysis of an object’s surface

- Correlation to Simulation
ACOUSTIC

Simulation of Prediction

• Linear Acoustic Analysis
  - Engine simulation tool
  - Enables prediction of transmission loss (noise reduction) of a given design
  - Reduces development time and prototype costs

• Finite Element Acoustic Analysis
  - Enables prediction of transmission loss of a given design
  - Includes the impact of shell noise from muffler surfaces
  - Works in conjunction with ANSYS for 3D analysis

• Cost Advantageous

Physical Evaluation of Engineered Solutions

• Hemi-anechoic Chambers (2)
  - Used for transmission loss analysis
  - LMS sound quality software

• HEAD® Acoustics
  - Used for sound quality analysis
  - Evaluates sound for human hearing subjective noise analysis
  - Allows analysis of in-cab noise based on cab design
  - Considers affects of noise frequency

• Acoustic Test Cell
  - Evaluates “on engine” performance of acoustic products
  - Simulates SAE J366 Drive-by Test
  - Accommodates customer engines
  - Offers steady-state or transient control

• Correlation to Simulation