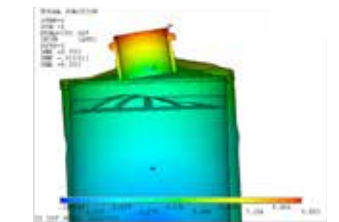
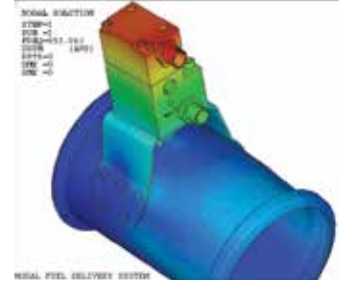
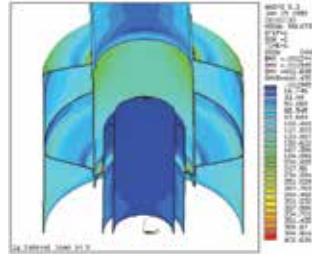


PRODUCT DURABILITY

Accurate Prediction Using Simulation

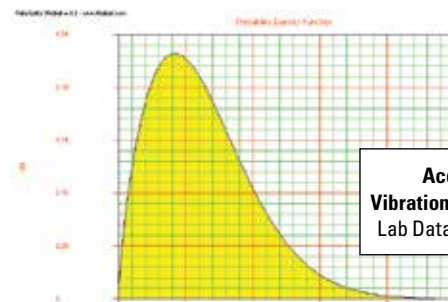
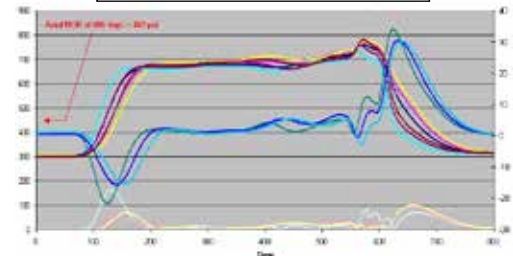
- Finite Element Analysis
 - Models stress on components and assemblies
 - Capable of dynamic analysis to determine resonance frequencies and modes
- Experimental Modal Analysis Software
 - Determines modal properties of structures
- Cost Advantageous



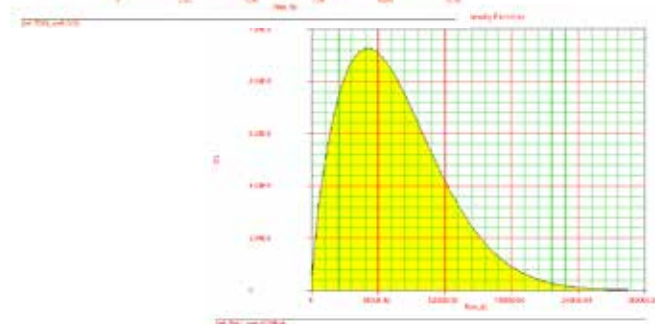
Evaluation Through Physical Testing

- 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

DPF Temperature and Stress Profiles



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



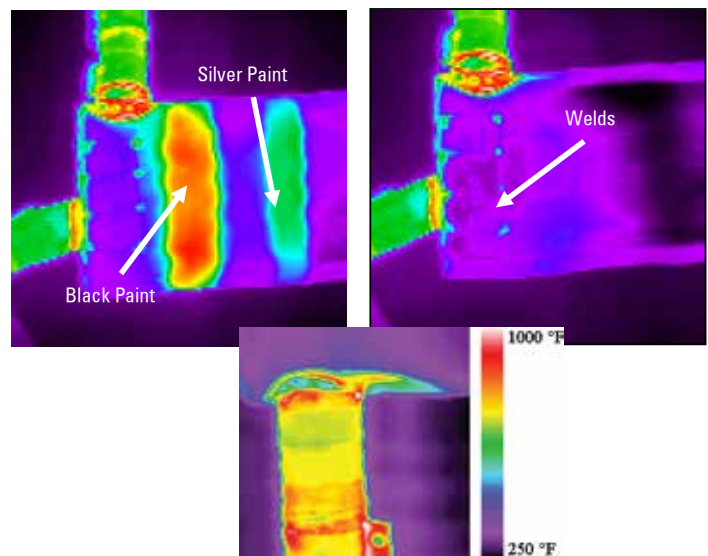
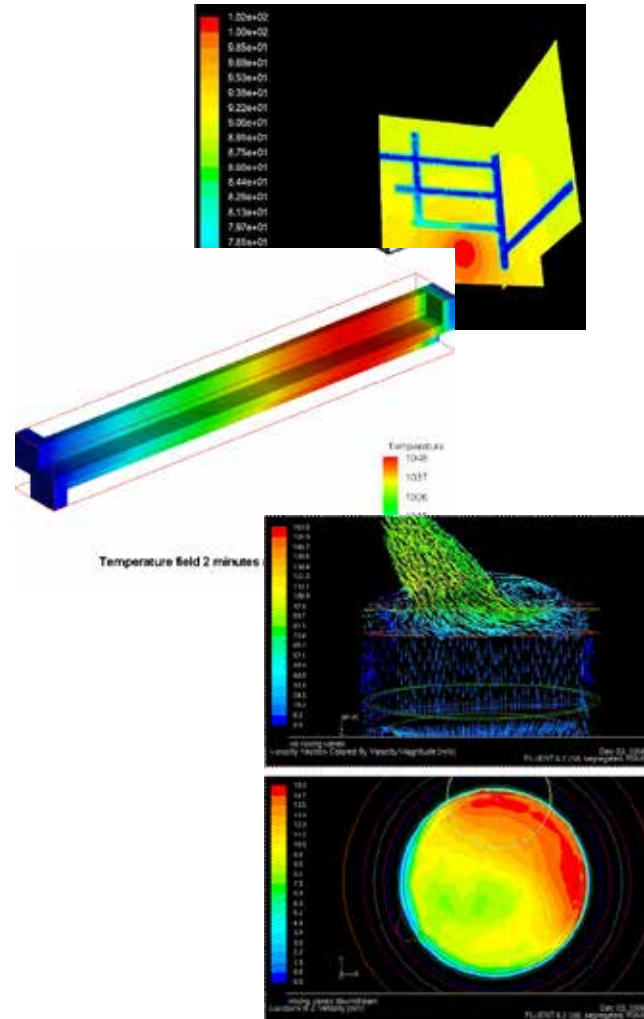
FLOW AND THERMAL

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



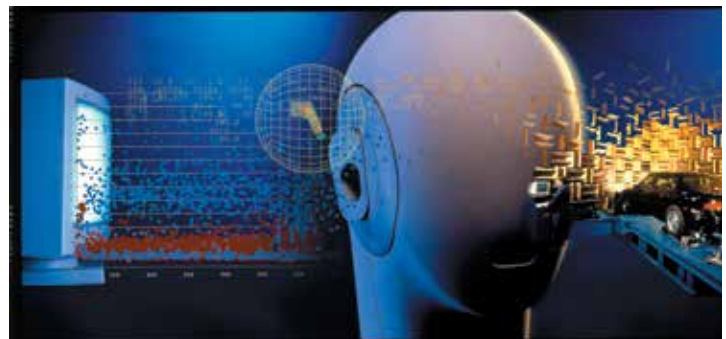
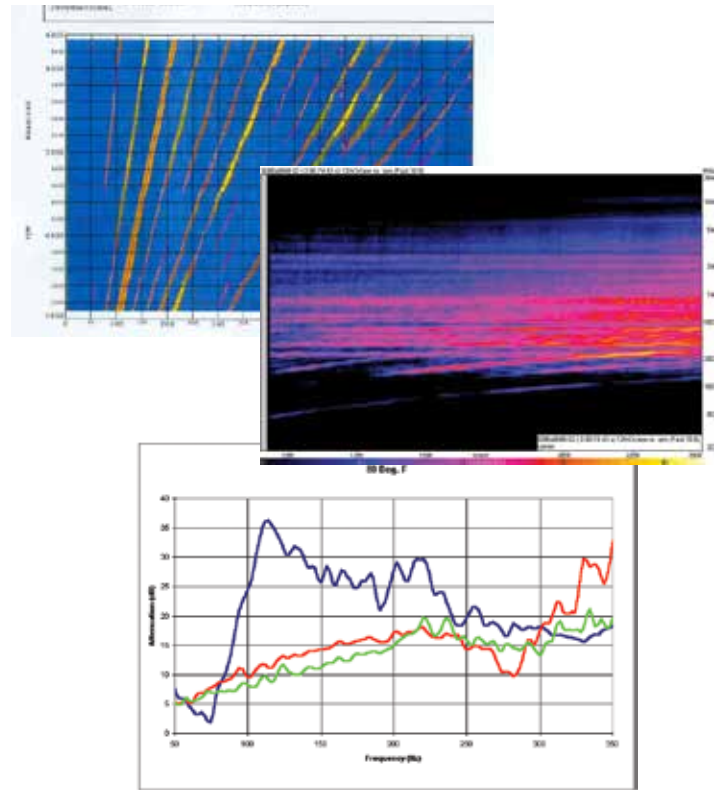
ACOUSTIC

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





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