CASE STUDY

LINK Engineering Company Inc.

United States of America

Automotive

PULSE

Resolving Customers' Brake Noise Issues

Since its foundation, Link Engineering Company has focused on the design and manufacture of state-of-the-art test systems for the automotive, aerospace, railway and general industries. Today, with special emphasis on brake testing solutions, Link Engineering is a global leader and delivers complete turnkey projects to many of the world's major automotive manufacturers and their suppliers.

Link Model 3900 Brake Noise Dynamometer has become an industry standard. Brüel & Kjær's PULSE™ data acquisition and analysis system is Link's preferred NVH analyzer platform, and more than 50 systems have been delivered during the past five years.

This case study describes the testing, data analysis, and ultimate resolution of a customer's brake noise issue. Since both the Link Model 3501 Vehicle Data Acquisition System, and the Model 3900 use PULSE and the same format for storing data, it was easy to find the critical conditions and make direct comparisons between the two sets of results.

Link Engineering's Model 3900 Brake Noise Dynamometer

Brake Testing Expertise – A Global Leader

For more than 70 years, Link Engineering Company has been deeply involved in the design and manufacture of test systems for the automotive, aerospace, railway and general industries. Its solutions are used by many of the world's major vehicle manufacturers and their component suppliers.

Link's experience includes the development and manufacture of a wide range of NVH (Noise, Vibration and Harshness) test systems. Brake NVH testing is one of Link's specialities and it is the world leader in the development of NVH brake test systems and brake analysis.

Brüel & Kjær PULSE Platform

Fig. 1
Dr. James Thompson, is Link Engineering's Executive Director of NVH, Sales and Marketing

Dr. James Thompson, Link's Executive Director of NVH, Sales and Marketing says, "Brüel & Kjær's PULSE system is our preferred NVH data acquisition and analysis platform and we have ordered more than 50 systems in the last six years. The constantly evolving PULSE platform is a major factor in the development and marketing of our NVH solutions.

"Our partnership with Brüel & Kjær over the last six years has been highly successful. Both companies are fastidious about the use of state-of-the-art technology and product quality. This factor, combined with Brüel & Kjær's outstanding local service, back-up and support from the Detroit office has led to our success".

Jim continues, "Our customers demand ever more sophistication in NVH testing and our growth comes from constantly offering new and innovative products. Brake noise is one of the most important warranty issues for automotive manufacturers throughout the world, it's a critical product differentiator, and brake repairs and replacement are hugely expensive. Noise makes a customer aware of the vehicle's brakes and affects the customers perception of the vehicle because brake noise immediately causes safety concerns".

Brake NVH Test Procedure

Fig. 2
The interior of General Motors' Link Model 3900 Brake Testing Dynamometer

Developed by the US Working Group on Brake NVH, the SAE J2521 procedure has led to a standardised apparatus for brake noise testing and the adoption of this standard has been so widespread that it has lead to a standard dynamometer configuration.

In the US, General Motors developed its own test procedure based on SAE J2521. This procedure was developed from General Motors' experience with their NVH dynamometer and key aspects of this dynamometer design are prescribed in the test procedure.

Link Engineering's Model 3900 Brake Noise Dynamometer has become the standard configuration and is used by the brake industry around the world.

Solving a Customer's Brake Noise Issue

Jim explains, "The strong cooperative relationship between Brüel & Kjær and Link Engineering was a key to providing a rapid solution to a difficult problem".

Problem Description

A major brake material supplier came to Link Testing Laboratories requesting assistance with a noise problem that they were having on a new vehicle application. The vehicle was soon to go into production and they needed rapid response.

On a ten point scale, brake noise on the vehicle was rated at five points and this was considered to be commercially unacceptable. The customer needed to improve the subjective rating to at least eight points and preferably nine points to keep the placement on the vehicle.

Fig. 3
Initial SAE J2521 test results summary page 1

Test Program

The first step of this test program was to assess the nature of the noise exhibited by the brake system. The most expedient way to perform this test was to mount a vehicle corner on a Link Model 3900 Brake Noise Dynamometer and run a full noise assessment. In this case the problem brake assembly was run using the SAE J2521 test procedure. This brake squeal test matrix performs a very thorough evaluation of the brake's propensity to generate squeal noise.

Running under the ProLink software package, all data collected is integrated together to permit a thorough analysis of the noise which occurred.

All noise measurements were made using a Brüel & Kjær PULSE system which also runs under the direction of the ProLink software package.

Fig. 4
Link Model 3501 Modular Data Acquisition System

Using the ReportAssist feature in ProLink, a report of the SAE J2521 test results was generated automatically in electronic format and conveyed to the customer by email. Examples of these results are shown in Fig.3.

Fig.3 shows the there were several squeal frequencies detected between 5000 to 12000 Hz. It was clear that there was a squeal noise issue and that it occurred at temperatures above 100°C. It appeared that the 9600 Hz peak represented the most prevalent squeal. There was also squeal noise at 5000, 6500, 7600, 9000, 10500, and 11500 Hz.

The next step in this test program was to confirm the same noise on the vehicle and to determine the conditions at which the noise occurred. There was only one vehicle available with the proper hardware for these tests.

So, a full set of instrumentation was applied to this vehicle. A Link Model 3501 Modular Data Acquisition System was used to acquire a complete set of data for some basic tests performed to identify the occurrence of the problem noise. The parameters measured with this system included inner and outer pad temperature, brake line pressure, vehicle speed, acceleration at the brake, and interior noise

Fig. 5
Instrumented Vehicle Corner

The Brüel & Kjær PULSE NVH module was used in the Model 3501 to acquire and analyse the noise and vibration data channels.

From these tests it was determined that the noise could be excited at low speeds and with relatively low deceleration levels if the brake temperature was kept above 100°C.

Since both the Link Model 3501 and the Model 3900 use the same format for storing data, it was easy to find the critical conditions and make direct comparisons between the two sets of results. All further vehicle tests were made keeping the speed above 40 km/h (25 mph) and the deceleration levels between 0.1 to 0.3 g while maintaining the brake temperature above 100°C.

To study possible solutions proposed by the customer, one of the corners of the vehicle was fully instrumented to capture the critical data. Fig.5 shows the corner being instrumented.

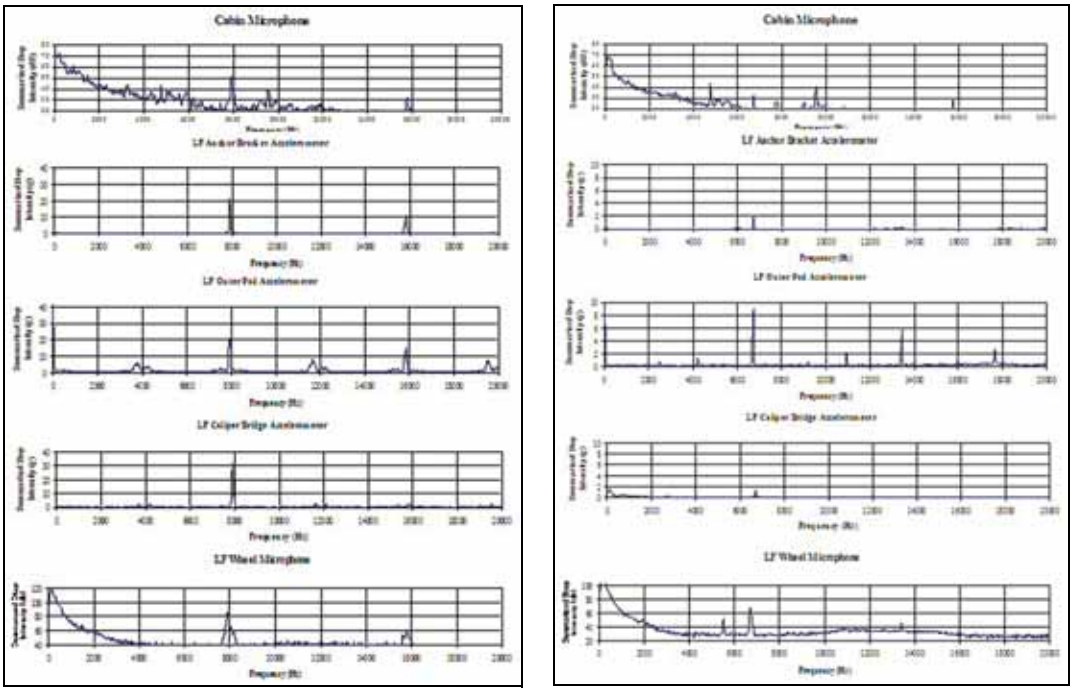


Fig. 6
Left: Initial Vehicle NVH measurement spectra
Right: Final Vehicle NVH measurement spectra

The complete set of NVH instrumentation on the vehicle is described in Fig.7. An example of the noise data obtained from the vehicle in the initial state is shown in Fig.6.

The strong noise peak is clear at 7800 Hz and is seen in both the measurements at the brake and in the vehicle interior. There was no doubt that this was the primary noise of concern.

Results

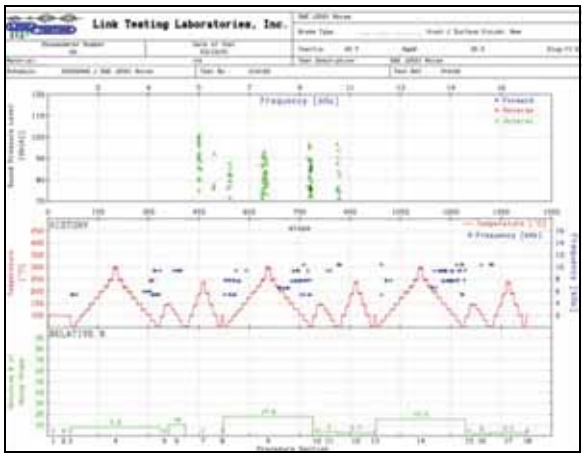
To optimize the noise solution, with the vehicle instrumented in this way, several tests were conducted with different brake pads made by the customer, and, after trying a few potential solutions, the final design change was selected.

Fig. 7
NVH transducer locations

Channel No.	Transducer	Location
1	Microphone	Vehicle Interior
2	Accelerometer	Left Front Anchor Bracket
3	Accelerometer	Left Front Outer Pad
4	Accelerometer	Left Front Inner Pad
5	Microphone	Left Front Wheel Well

To confirm that sufficient improvement was achieved, a new set of tests was conducted on the vehicle and reported in Fig.6 right. It was clear that a major improvement had been achieved. In fact there, was a 7 dB reduction in the vehicle interior noise level and the subjective rating rose from 5 to 8 or 9 on the ten point scale.

Fig. 8
Final hardware SAE J2521 results page 1



As a final confirmation, the solution brake hardware was run on the dynamometer using the SAE J2521 procedure to be sure that there were no negative effects to the changes made to the design.

Solving one noise problem to create another at some other set of conditions would not be acceptable. Fortunately, as shown in Fig.8, the results indicated good noise performance throughout the operational range.

Conclusions

This programme resulted in the best possible outcome. The customer was very pleased with the support provided and his brake pads were maintained on the vehicle. Using a combination of vehicle and dynamometer testing, a solution to this noise issue was found quickly, in a matter of a few weeks, and the robustness of the solution was checked with a comprehensive dynamometer evaluation.

Jim says, “Link’s partnership with Brüel & Kjær provided the opportunity to perform precision analyses rapidly and to use as many channels as were necessary to understand the noise sources and causes”.

He concludes, “In the future, the best situation for vehicle manufacturers will be that brake noise will be a non-issue. Our solutions are helping them and their suppliers to achieve this goal”.

Key Facts

- Link is a world leader in the development of NVH brake test systems
- The Brüel & Kjær PULSE system is Link's preferred NVH data acquisition and analysis platform
- More than 50 PULSE systems have been delivered in the last six years as part of Link Engineering test systems
- Noise is the leading brake related customer issue for automotive manufacturers
- Model 3900 is preferred by a wide range of vehicle manufacturers and brake suppliers – it has become the standard configuration
- Since both the Link Model 3501 and Model 3900 use PULSE, and the same format for storing data, it was easy to find the critical conditions and make direct comparisons between the two sets of results
- The customer was very pleased with the support provided and his brake pads were maintained on the vehicle
- "Link's partnership with Brüel & Kjær provided the opportunity to perform precision analyses rapidly and to use as many channels as were necessary to understand the noise sources and causes"
- "In the future, the best situation for vehicle manufacturers will be that brake noise will be a non-issue. Our solutions are helping them and their suppliers to achieve this goal"

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