New Dynamometers at Application Research Center

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The Application Research Center (ARC) in Canton, MI, represents a cooperative agreement between Material Sciences Corporation, Brüel & Kjær, and Link Engineering. There are two new brake dynamometers and one new chassis dynamometer in the facility. Operated by Link Engineering, these dynamometers are designed to reproduce brake noise and provide a means to quantify and understand the generation of noise at specific vehicle operating conditions.

Brake Dynamometers. A sketch of the major components of a Model 3900 NVH Dynamometer is shown in Figure 1. The system provides the capability for noise and vibration testing of corner and axle-type brake fixtures. It can reproduce a wide range of brake noise issues for optimal correlation to actual operating conditions.

The dynamometer controls are designed to enable close correlation with existing certification test protocols including SAE J2521. The advanced features of the ProLink™ controls offer operator-dependent control or fully automatic unattended operation. All primary operating functions are performed at the dynamometer station including selection of test parameters, control modes, display of pertinent data, monitoring of all test functions, and execution of desired test sequences.

The double-wall dynamometer enclosure provides high levels of transmission loss and thermal insulation that allow for precise environmental and background noise control. This walk-in unit will accommodate full vehicle corner sections and axle fixtures as well as conventional fixtures. Figure 2 shows a photograph of the Model 3900 enclosure. The enclosure provides a free-field sound environment over the 900-18,000 Hz frequency range for brake squeals. It also contains brake noise emanating from the test to prevent it from contaminating other tests or the general environment room exterior. The enclosure is fully isolated from the dynamometer drive and support systems to provide minimum interior background noise and vibration. The background sound level is less than 55 dBA.

The NVH module is based on the Brüel & Kjær PorTable PULSE™ system. The base configuration provides 6 channels for noise and vibration measurement. The system runs under the ProLink software package to maximize ease of use while providing a full set of noise and vibration analysis capabilities.

An environmental control system is provided on each unit to allow environmental testing, with temperature ranges from –20º C to 50º C and humidity from 20 to 90%. The primary mechanical specifications of the dynamometer are shown in Table 1.

Brake Dynamometer Operation and Capabilities. To perform realistic simulations of stopping a vehicle, inertia effects of the vehicle must be represented. In the Model 3900, an electric motor is used to simulate the inertia of the vehicle. Although it is desirable to have at least one inertia disc on the dynamometer for a number of reasons, it is now possible to provide extremely fine inertia increments with electric simulation. One can simply enter the required inertia, and the control system takes care of everything else.

It is also necessary to match other operating conditions of the braking system. One such condition is the application pressure of the brake. It is not only necessary to match the application pressure using the same brake fluid as employed in the vehicle, but to provide the same rates of application pressure. In some instances, squeal can be sensitive to the rate of brake application or release.

Of course all the same brake components must be used in dynamometer squeal testing as are used on the vehicle. The issue is in defining how far this match must extend. There is clear agreement that the principal brake hardware must be the same. This includes the brake pads or shoes, the caliper or drum, and all related components.

The need to match the rest of the vehicle corner depends on the particular frequency range of interest. Therefore, this dynamometer is designed to permit testing with only the corner knuckle or it will support the full vehicle corner including suspension and structural attachment bushings. A wide range of tests can be conducted over frequency ranges as broad as from 1 to 20 kHz.

The environment in which the brake is operating is also important to reproduce the noise found on the vehicle. This includes both the acoustical environment and environmental conditions. Acoustically, the environment of the vehicle operating on the road must be reproduced. This means an essentially free acoustical field above a reflecting plane. At the frequencies of concern, the road surfaces act much like a reflecting plane; otherwise the brake sound energy is free to radiate with little impedance in all other directions. To approximate the free acoustic field in which a vehicle operates, the walls of the test enclosure are lined with an acoustically absorptive material. Since squeal noise occurs at frequencies of 1 kHz and higher, the absorption of these treatments are most important above this frequency.

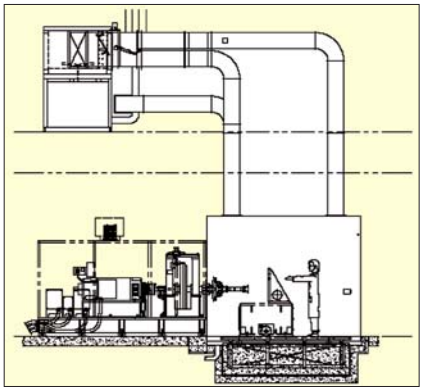

Figure 1. Model 3900 brake NVH dynamometer.

Figure 2. Model 3900 test enclosure.

Table 1. Model 3900 specifications.

Motor size/type:	186 kW (250 HP) / DC
Speed Range:	0 - 2000 rpm
Constant torque:	0 - 850 rpm
Constant HP:	851 - 2000 rpm
Speed control:	±0.25% FS
Speed measurement accuracy:	±0.25% FS
Overload capacity:	150%
Drive:	Six-pulse system

To provide a sufficiently low background sound level to detect squeals, the walls of this enclosure are also designed to provide high sound transmission loss. These rooms provide background levels below 55 dBA. Double-wall construction is used to assure sufficient transmission loss. The enclosure for the Model 3900 is isolated from the rest of the dynamometer and building in which it is placed. The entire test section rests on a large seismic mass that is isolated from the rest of the building. In addition, the enclosure sits on vibration isolators and is not directly connected to the test section.

Chassis Dynamometer. One of the most important laboratories in the ARC is the four wheel drive chassis dynamometer. The LINK Model 4900 Dynamometer shown in Figure 3 has the capability to evaluate a wide range of vehicles and features a full set of tools for control and measurement. Typical applications include power train, brake, tire, and interior trim evaluations. Teamed with the Brüel & Kjær PULSE analyzer, the Model 4900 provides a state-of-the-art system

Figure 3. Model 4900 chassis dynamometer at ARC facility.

for vehicle measurement and analysis.

With an automated system for wheelbase adjustment, the Model 4900 can accommodate a wide range of vehicles. Typical configurations range from wheel bases of 2.29 to 4.06 m (90 to 160 in.). This range incorporates the smallest passenger cars to light trucks and small commercial vehicles. The result is a very versatile test apparatus for many applications.

A key criterion in the Model 4900 is keeping the background noise levels as low as possible to assure high-quality noise and vibration measurements. To this end the rolls are completely enclosed except for the running surface in the room above. The drive motors and other related power equipment are isolated in a separate room and placed in high-transmission-loss noise enclosures. The result is a background level that is low enough to permit the most sensitive noise measurements.

Table 2. Model 4900 specifications.

Installation:	Isolated subframe foundation
Noise acquisition:	Six-channel system
Maximum axle load:	5443 kg
Minimum axle load:	907 kg
Roadwheel diameter:	1829 mm (72 in)
Roadwheel width:	711 mm (28 in)
Maximum road speed:	200 kph (130 mph)
Drive motor size:	224 kW per axle (300 HP)
Vehicle wheelbase:	2.29 - 4.06 m (85 - 175 in)
Motor speed (base/top):	300 / 653 rpm

Included with the Model 4900 is a complete control and measurement system. The core of this system is the ProLink software package that integrates all control, measurement, analysis, and reporting functions.

ProLink has been cited as one of the most versatile and easy to use test software packages in the industry. By integrating all the major control and data acquisition functions, ProLink makes automated test programs easy to define and deploy.

Noise measurements are done with the Brüel & Kjær PULSE analyzer, which is controlled by the ProLink package for maximum ease of use. ProLink systems can accommodate up to 300 data acquisition channels. The collected data are easily interrogated by Excel macros, MATLAB, and other Microsoft Windows tools. Developing and running a test with the Model 4900 is very easy, and the processing of results can be fully automated, with reports delivered electronically.

Chassis Dynamometer Operation and Capabilities. The Link Model 4900 dynamometer can be used for a wide array of NVH evaluations. The control system permits automated operation of a vehicle for power-train, tire, and brake noise testing. With the hemi-anechoic room having a lower cut-off frequency of 90 Hz, a wide range of noise issues can be evaluated. Table 2 provides an overview of the mechanical specifications.

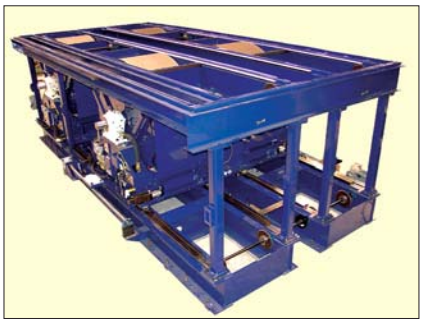

Figure 4. Link Model 4900 chassis dynamometer mechanical assembly.

The 224-kW electric motors on each axle provide the capability to test a wide range of vehicles. This high power level also permits brake NVH testing, since a vehicle's brake can absorb much more power than the engine can deliver.

To provide optimum background noise levels in the test chamber, the motors and rolls are isolated from the chamber. The motors are located in a separate room beyond the test chamber, with care taken to provide high transmission loss between this room and the test chamber and the room containing the rolls. In addition, the motors are located on a separate seismic mass that is isolated from the rest of the building structure. The actual rolls are each completely enclosed in a high-transmission-loss enclosure, with the only opening being in the test chamber where the vehicle tires contact the rolls (see Figure 4). Here too, the whole mechanical roll system is located on a separate seismic block with low frequency vibration isolators separating this mass from the building and its foundation. The result is a background level of 20 dBA in the test chamber while the rolls are operating.

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