



# CASE STUDY

Bosch Rexroth AG  
Hydraulics for the Automotive Industry  
Sound and Vibration R&D

Germany  
Automotive

PULSE™, customised software, transducers

*Bosch Rexroth AG is a 100% subsidiary of Robert Bosch GmbH. It was created in May 2001 as a result of a merger of the Automation Division of Robert Bosch GmbH and Mannesmann Rexroth AG. The company employs 26400 people throughout the world and had global sales of 4.079 thousand million Euros in 2004. In the technology field, Bosch Rexroth offers a vast range of products in the area of axial position pumps, external gear pumps, control systems and electronics.*

*Noise is an important factor in the development of hydraulic pumps and a new, state-of-the-art noise testing facility has been commissioned at Bosch Rexroth's site at Schwieberdingen, near Stuttgart, Germany. A PULSE data acquisition and analysis system, with customised software, is used for noise measurement and analysis.*

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## Bosch Rexroth – The Drive and Control Company

**Fig. 1**  
An aerial view of the impressive Bosch facility at Schwieberdingen, 25 km northwest of Stuttgart. The daughter company, Bosch Rexroth, supplies components, modules and systems needed to drive and control mobile machines mechanically, hydraulically and electronically

Bosch Rexroth has worked with hydraulics for more than 50 years. With 18 locations and six regional sales centres in Germany, subsidiaries in 38 countries and a dealer and service network in 80 countries around the world, it is ideally positioned as a global partner.

Its vast portfolio of hydraulic products is subdivided into several product sectors – axial piston pumps, external gear pumps, control systems, electronics and service. Market segments include:

- Excavators
- Wheel loaders
- Fork lift trucks
- Tracked vehicles
- Road rollers
- Concrete pumps
- Telehandlers
- Mobile concrete mixers
- Cranes
- Drilling equipment
- Surface repair machinery
- Pavers
- Agricultural machinery
- Forestry machinery
- Commercial vehicles
- Municipal vehicles
- Wind turbines

For mobile applications, Bosch Rexroth supplies components, modules, systems, as well as service and engineering services in the fields of working hydraulics, driving hydraulics, planetary gears, braking and steering systems. Its products and services satisfy the most stringent quality standards.

Bosch Rexroth is globally accredited to ISO 9001.



**Fig. 2**  
Bosch Rexroth pumps are used in a wide variety of applications



## Research and Development

**Fig. 3**

*Dr. Dietmar Schwuchow is Group Leader within Bosch Rexroth's development department*

Dr. Dietmar Schwuchow is Group Leader within Bosch Rexroth's development department for external gear machines. He has a Masters's Degree in Mechanical Engineering from the University of Stuttgart and, in 1990, began a research project for his Doctorate, supported by Bosch. His thesis subject was 'Low Pulsation Gear Pumps'. Dr. Schwuchow joined Bosch Rexroth in January, 1996.

He explains, "The facility here at Schwieberdingen is the main Bosch R&D centre. About 5500 people are employed here, of more than 200 work in Bosch Rexroth.

Bosch Rexroth has a large global customer base, and is the market leader in external gear pumps. The company currently produce about 1.1 million units each year in different size ranges.



**Fig. 4**

*Bosch Rexroth gear pumps are manufactured in a wide range of sizes and combinations*



Dr. Schwuchow continues, "Our aim is to make our pumps as quiet as possible. Even as internal combustion engines used in machines continue to become quieter, and cabin and sound insulation parameters improve, so pump noise becomes more critical".

"Hydraulic pumps are in continuous use and so the level and quality of the sound improves comfort for the vehicle driver. As the overall noise level of machines is decreasing, our customers are driving the demand for quieter pumps and this is becoming a product differentiator."

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## Test Facility

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**Fig. 5**

*Jürgen Breuninger, in the control room of the noise test cell, is a test engineer at Bosch Rexroth's R&D facility. The test system is used for noise monitoring of hydraulic pumps during research and development*

Noise measurement tests are carried out in a new and specially designed test facility. This comprises a control room, semi-anechoic test cell, and the necessary motors, pumps and control equipment used to drive a pump under test. The semi-anechoic chamber is  $4 \times 7 \times 4$  metres and has a cut-off frequency of 125 Hz.

Six Brüel & Kjær microphones and one tacho signal are connected to an 8-channel PULSE data acquisition system. No signal conditioning is used.



It takes about one hour to set up a typical test. In the test cell, the horizontal reflecting plane is placed one centimetre below the underside of the pump under test.

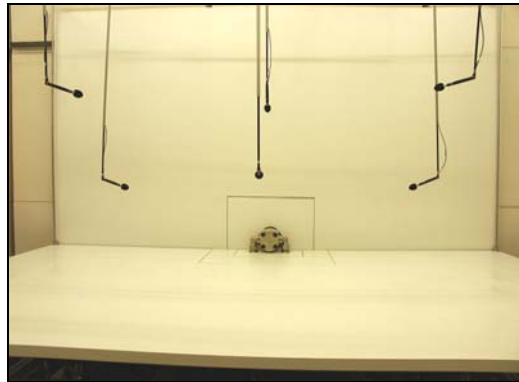
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## HyTest Automated Control System

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**Fig. 6**

*Interior views of the test cell. Left: Six Brüel & Kjær microphones are used for sound power measurements. Right: The reflecting plane can be positioned to be placed one centimetre below the pump under test*



Following the specification determined by Bosch Rexroth, the HyTest customised software was developed by the German consultant company Akustec, based near Munster. HyTest uses Brüel & Kjær's PULSE data acquisition and analysis platform. The relevant DIN and ISO standards specify how measurements are to be made. HyTest automatically controls the complete test process of external gear pumps, gear motors and power packs.

### Measurement Modes

The first stage is the Monitoring Mode. This is used to initially examine pump noise and to check that the data acquisition system is operating correctly. The HyTest software also monitors other pump operating parameters such as pressure, pump and fluid temperatures, flow, suction pressure, etc.

The second stage, with the system in stationary mode, adds the metadata and additional factors such as a test cell correction factor, the influence of external noise, etc.

A typical test uses six pump speeds in the range from 500 to 3000 rpm, and nine pressure levels. Once the test matrix is correctly set up, HyTest is placed in automatic mode and controls the whole test process including pump speed and pressure.

In dynamic mode, the pump is run up to a predetermined speed or pressure, and the varying factors are measured and recorded.

**Fig. 7**  
This display shows from top-left to bottom-right – dB(A) vs. frequency, speed signal input, overall display of six microphones and tachometer, HyTest Monitor Control parameters

In stationary mode, CPB and FFT measurements are made automatically. In dynamic mode, CPB and FFT trigger points can be set. There is also an in-built alert function that informs the operator if the predetermined values are exceeded. For subjective testing, a recording of the audio signal can be selected if required.

Dr. Schwuchow explains, “We determine sound power using CPB analysis and usually measure dB (A-weighted) vs. frequency, measured from 125 Hz to 20 kHz. The measurement time at each point is normally 10 seconds. It takes between 5 and 10 seconds to change to a new measurement point. Any overload is displayed on the screen and reported in the saved data. We can also use FFT analysis when making dynamic measurements. This is a basic type of sound quality measurement as we can see the frequency ranges of noise and determine those that are important and uncomfortable.”

If required, Zwicker loudness can be obtained as a cursor value from CPB analysis. The complete analysis display comprises nine windows.

**Fig. 8**  
A typical display in the HyTest software made in automatic mode. CPB analysis of dB (A) vs. frequency

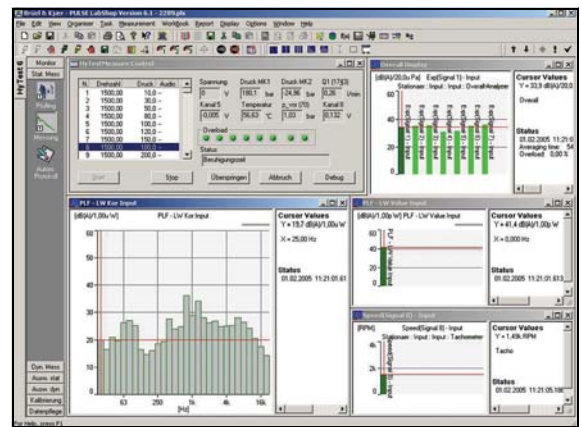
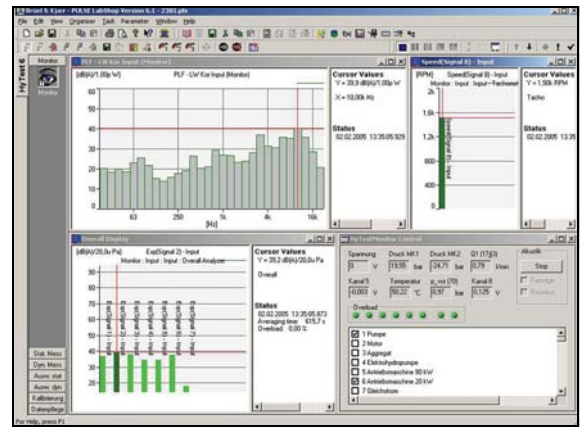
Following completion, the main test data is automatically exported to Excel and then copied into a Bosch Rexroth specified report template. The data is saved to a Microsoft® Access database on the PC. All test data is permanently backed-up on CDs.

Vibration of the pump under test is not currently measured using HyTest but this is being investigated and may be incorporated in the future.

Dr. Schwuchow continues, “Of course, we do a lot of data comparison. During the R&D stages of a new product, as changes are made, we check how the noise parameters vary. We also analyse noise from pumps that have been in use to check if the sound power level increases with age, and of course we do benchmark our pumps against the products of our competitors”.

### Calibration

There is a dedicated calibration facility in the HyTest software. Using a Brüel & Kjær Sound Level Calibrator Type 4231, all microphones are calibrated before starting each series of measurements. The calibration values for each microphone are saved in the database.



## PULSE

Dr. Schwuchow says, “While developing the specification for the test system, we considered the available options concerning data acquisition and analysis. There were three names on our final shortlist. The name Brüel & Kjær is well-known and we had the immediate impression that they were highly competent in the area of noise and vibration analysis, and knew the business. With so many PULSE systems sold, we felt that we could benefit from the experiences of other users.”

Dr. Schwuchow concludes, “The solution was competitively priced and was commissioned by Akustec and Brüel & Kjær as a turnkey project. The complete test function performs very efficiently, and in accordance with our specification. It gives both us and our customers confidence and it is a great advantage to be able to say that we measure with Brüel & Kjær. We are very pleased”.

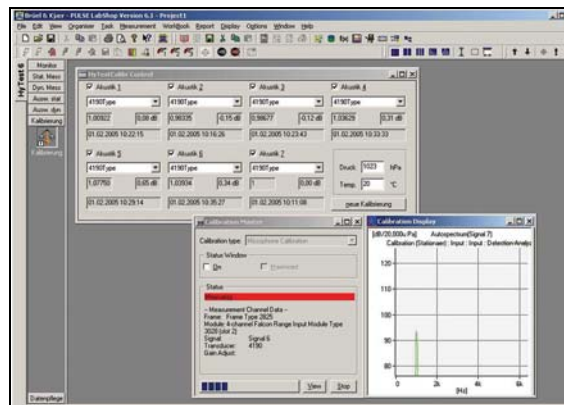
## Akustec

**Fig. 9**

*There is a dedicated calibration display in the HyTest software*

Akustec is a consultancy company that was founded by Mr. Wolfgang Metzen in 1990. Akustec works with many companies in the area of sound and vibration and, among others, specialises in the automotive industry. Akustec has recommended the PULSE data acquisition and analysis platform since it was first introduced in 1996 and has implemented many customised test solutions.

Mr. Metzen states, “My goal is to provide effective and efficient NVH test solutions for our customers. Although Akustec provides consultancy in a number of areas, we work only with Brüel & Kjær in acoustics and vibration. I want to be a partner with the world-market leader and I have total confidence in recommending their solutions to our customers”.



## Key Facts

- Bosch Rexroth AG is a 100% subsidiary of Robert Bosch GmbH
- The company manufactures components, modules and systems in the fields of hydraulics, pneumatics, electric drives and controls, linear motion and assembly technologies
- Bosch Rexroth is globally accredited to ISO 9001
- “Our aim is to make our hydraulic gear pumps as quiet as possible – as internal combustion engines become quieter, and cabin and sound insulation parameters improve, so pump noise becomes more critical”
- Noise measurement tests are carried out in a new and specially designed test facility
- Six Brüel & Kjær microphones are connected to an 8-channel PULSE system
- The complete noise measurement testing process is fully automated using the HyTest customised software developed by the German consultant company Akustec
- Sound power, dB (A-weighted), is determined using CPB analysis from 125 Hz to 20 kHz
- “The name Brüel & Kjær is well-known and we had the immediate impression that they were highly competent in the area of noise and vibration analysis”
- “With so many PULSE system sold, we felt that we could benefit from the experiences of other users”
- It gives both us and our customers confidence and it is a great advantage to be able to say that we measure with Brüel & Kjær”

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