CASE STUDY

Liebherr-Werk Ehingen GmbH
EU Directive Compliance, R&D Testing

Germany

Automotive

PULSE, Transducers

Liebherr-Werk Ehingen GmbH, a wholly owned subsidiary of the Liebherr Group, is a market leader in the production of mobile cranes. Brüel & Kjær PULSE™ systems and transducers are used extensively – both for R&D investigations, and for sound power measurements to ensure that Liebherr cranes comply with the EU Directive 2000/14/EC.

History

Originally founded in 1949, Liebherr is a group of companies with activities throughout the world and an extensive range of products and services. Its excellent reputation has been built on the dedication and technical expertise of more than 20 000 employees.

Liebherr technology is firmly established in the world of building construction and civil engineering. Its program of construction machinery includes:

- construction cranes
- mobile and crawler cranes
- hydraulic excavators
- mining trucks
- hydraulic rope excavators
- wheeled loaders
- crawler tractors and loaders
- pipe layers
- concrete mixing plants
- truck mixers

The Liebherr Group is also active in other markets. These include shipping, container and cargo board cranes, machine tools material handling systems, transportation and aerospace, domestic freezers and refrigerators, and an interest in the tourist industry with hotels in Ireland, Austria and Germany.

Cranes

Fig. 1
The Liebherr-Werk Ehingen factory. The site extends to 535 000 square metres

Liebherr-Werk Ehingen GmbH is a wholly owned subsidiary of the Liebherr Group and was established in 1969. The factory is located some 90 km south-east of Stuttgart, Germany and is a market leader in the production of mobile and crawler cranes. The total Ehingen site extends to 535 000 square metres and the new covered hall is 123 000 square metres – it's the world's most modern crane factory.

Fig. 2
The final assembly area extends to 123 000 square metres

With 2200 employees, Liebherr-Werk Ehingen manufactures up to 1400 mobile cranes each year that are sold throughout the world. The main markets are Europe, North America and Asia. The product range is wide, with lifting capacities from 30 to 1200 tonnes and lifting heights up to 232 metres. There is also a repair centre at Ehingen. This was established in 1983 and, to date, more than 5 000 used cranes have been fully overhauled by Liebherr and resold.

Advanced Technology

Liebherr-Werk Ehingen has developed state-of-the-art technologies. Examples include the LICCON programmable computer system for the control and monitoring of mobile and crawler cranes – it's the most modern in the world. The TELEMATIK automatic

rapid-cycle telescoping system quickly selects and adjusts the boom length for optimum functionality and efficiency.

Continuous innovation in the processing of special steels and the development of hydraulic, electric and electronic drive and control systems are necessary in order to meet the high demands that are placed on mobile and crawler cranes during different operations. Features in modern mobile crane technology include weight-optimised and torsion-resistant frames, hyrdopneumatic suspension, advanced axle and steering concepts, and an efficient and economic travelling drive.

Testing Expertise

Fig. 3
Hartmut Erbarth is a Testing Engineer. He has worked at Liebherr for 12 years

Mr. Hartmut Erbarth, Dipl.-ing. (TU), has worked at Liebherr-Werk Ehingen for 12 years. He's the Test Engineer responsible for all noise and vibration testing on mobile cranes – and he's an expert. He plans the test programs and has a team of three technicians to set up the tests, operate the cranes and assist him with the data acquisition.

Mr. Erbarth says, "We started testing in 1990. In those days we used sound level meters but it was obvious that a better solution was needed. So we bought our first 16-channel PULSE multi-analyzer in 1996 for sound power testing and it's been used daily ever since. We bought from Brüel & Kjær because of their reputation for quality, accuracy and reliability – I think we were the second PULSE customer in Germany. We get excellent service and support, both from the local office here in Germany but also from Brüel & Kjær's application experts in Denmark".

EU Directive

With increasing demands for noise and vibration testing, the company recently purchased a 30-channel PULSE system with 100 Mbit LAN module. Mr. Erbarth explains, "We carry out noise testing to verify that the sound power of our cranes complies with EU Directive 2000/14/EC".

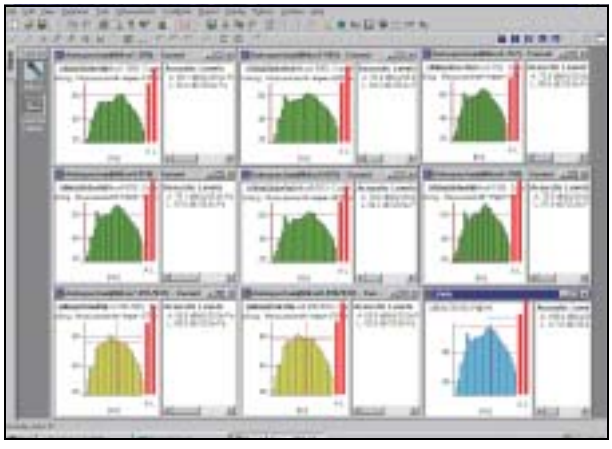

Fig. 4
In this example of 1/3-octave CPB data, 6/8 channels are measured and displayed simultaneously

Owing to their size, complete cranes have to be tested outside and, subject to acceptable weather conditions (maximum wind speed is 3 metres per second), testing takes place throughout the year. There is very quiet area, far away from any other activities, which is used for this work. For the EU Directive test, there must be no reflecting material within approximately 100 metres of the

test object. Six Brüel&Kjær Type 4190 microphones are placed 16 metres from the midpoint of the crane.

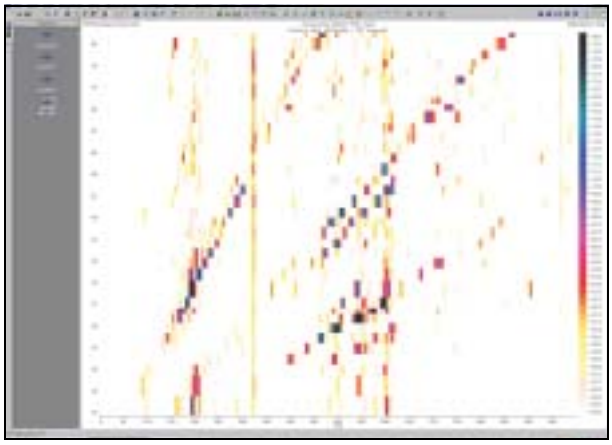

Fig. 5
This contour plot displays the run-up of a winder between 0 and 85 rpm

Mr. Erbarth explains, "Including the setup, it usually takes us one day to make a sound power test for the EU Directive. The crane engine must be fixed to run at three-quarters of its specified speed. The crane must be operated as fast as possible. The formula of weightings and other factors is laid down in the Directive".

Mr. Erbarth continues, "The 16-channel system runs under Windows NT® while our new 30-channel analyzer runs under Windows® 2000. We use the facility in PULSE to export the test data to Microsoft® Word. The printed reports are submitted to our external "auditor" and he verifies that the sound power of our cranes conforms to the EU Directive. The reports are also sent to our management, to development and the production department. It's a close circle and speed is essential".

The test data is saved on a database that runs on Liebherr's network.

Research and Development

Fig. 6
A Liebherr crane hard at work

"However, noise and vibration in general are very important issues and we extensively investigate these parameters of our cranes", says Mr. Erbarth. "We use our PULSE systems and transducers extensively for R&D investigations, and the data acquisition must be fast and totally accurate. For example, we don't only test the complete crane but many of its components. These includeelectric and hydraulic motors, pumps, diesel engines etc."

Liebherr-Werk Ehingen sources many of these components from Liebherr Group companies. For example, hydraulic pumps are produced by a sister company in Switzerland as are the diesel engines (up to 600 hp). Small cranes use one motor while the larger models use two. Sound insulation products and materials to reduce shock and vibration are also tested.

Mr. Erbarth explains, "We are involved in testing prototypes of new models right through the development process and the data we collect is widely used in R&D applications to optimise crane performance. For these tests, the large number of channels available

with our newest PULSE analyzer is very useful. We use Brüel&Kjær Type 4190 microphones and different accelerometers. In fact all our transducers are supplied by them". Mr. Erbarth calibrates the microphones before each test using a Brüel&Kjær Type 4231 Calibrator.

The Future

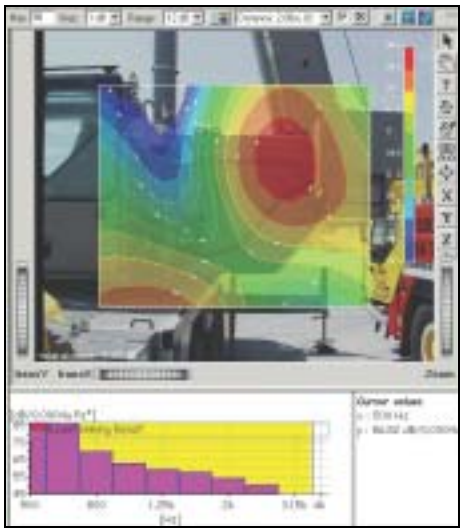

Fig. 7
An example of beamforming – the acoustic data (range 500 Hz – 3.6 kHz) was acquired during a lowering test

Liebherr-Werk Ehingen's technology is state-of-the-art. Mr. Erbarth says, "We are continually looking at new ways to test individual components and complete cranes. It's a major part of our work to constantly improve the quality of our cranes. In the future we intend to expand our PULSE applications to include, for example, modal analysis. I'm also very interested in PULSE Beamforming and we recently invited Brüel&Kjær's application experts to visit us at Ehingen to make some trials, and the results were impressive".

Beamforming is a remote acoustic source location measurement technique. Measurements are made with a specially arranged microphone array in the far field. This enables identification of different sound sources (including ranking) from a machine surface such as the crane lift/lowering unit, as shown in the example in Fig. 7.

Mr. Erbarth concludes, "With Brüel&Kjær you get a solution – not just a product".

Key Facts

- The Liebherr Group was founded in 1949 – it has activities throughout the world and an extensive range of products and services
- Liebherr-Werk Ehingen GmbH is a wholly owned subsidiary of the Liebherr Group. Established in 1969, it is a market leader in the production of mobile and crawler cranes and manufactures up to 1400 mobile cranes each year
- Liebherr-Werk Ehingen bought its first PULSE multi-analyzer in 1996
- The company recently purchased a 30-channel PULSE system with 100 Mb module
- Testing is carried out to verify that the sound power of cranes complies with the EU Directive 2000/14/EC
- Noise and vibration in general are very important issues
- PULSE systems and transducers are used extensively for R&D investigations
- Brüel&Kjær transducers are used exclusively
- Liebherr-Werk Ehingen gets excellent service and support from Brüel&Kjær
- "With Brüel&Kjær you get a solution – not just a product"

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