

# CASE STUDY

## Using vibration diagnostics for consumer goods reliability — The Vaillant Group

Spain

Household and consumer goods

PULSE, transducers, modal vibration and analysis software

*Ensuring the reliability of heating and refrigeration circuits, the Vaillant Group's Center of Competence uses vibration diagnostics to understand and predict damaging resonances in systems and components such as piping and compressors.*

*Photos courtesy of Vaillant Group*



## The company

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The core business of the Vaillant Group is heating technology, which it sells in over 80 countries, primarily through its own sales offices. About 12,400 employees develop and manufacture products at 14 sites in eight countries.

Located in Vitoria-Gasteiz in Spain, the Vaillant Group's Center of Competence develops and approves Refrigerant Circuit Modules (RCMs)



With annual sales of €3 billion, the Vaillant Group is the second-largest European company in the area of heating technology, and is also active in the branches of ventilation and air-conditioning technology.

The Vaillant Group is an international family-owned company with more than 136 years of experience. Based in Remscheid, Germany, it owns brands throughout Europe.

### The Vaillant Group's brands are:

Vaillant (Germany), Saunier Duval (France), AWB (Netherlands), Bulex (Belgium), DemirDöküm (Turkey), Glow-worm (UK), Hermann (Italy) and Protherm (Czech Republic).

**“When we decided to buy equipment to measure and analyse vibration signals, our partner the University of Mondragón recommended Brüel & Kjær's vibration systems to us”**

Javier Oleaga, Development and Innovation Engineer

## Center of Competence

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Located in Vitoria-Gasteiz in Spain, the Vaillant Group's Center of Competence (CoC) develops and approves Refrigerant Circuit Modules (RCMs). These RCMs are the core of both the aerothermal and geothermal heat pumps manufactured by the Vaillant Group. Heat pumps are one of the key product segments for the Vaillant Group's renewable energy strategy.

When it came to ensuring the reliability of their RCMs, the CoC chose a vibration analysis system from Brüel & Kjær. As Development and Innovation Engineer Javier Oleaga says, “We were looking for an instrument which would enable us to accurately characterise the vibration of a refrigerant circuit module, in order to assure the quality and lifetime of the heat pump. When we decided to buy equipment to measure and analyse vibration signals, our partner the University of Mondragón recommended Brüel & Kjær's vibration systems to us.”

## Investigating vibration in refrigerant circuits

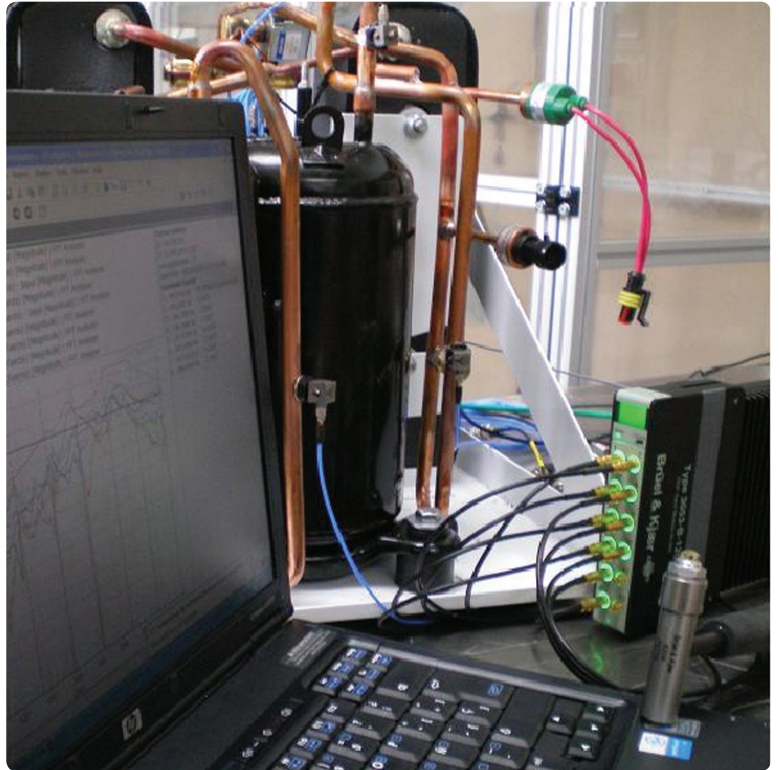
### Experimental determination of the modal frequencies in a refrigerant circuit

In this test procedure, the objective is to find the frequencies at which the excitation frequencies of the compressor can generate resonances (large-amplitude displacements), which cause fatigue and breakdowns.

A triaxial accelerometer measures the natural frequencies of the piping of a refrigerant circuit. Note the impact hammer at bottom right, which contains an integral accelerometer.

This requires measurement of the natural frequencies of the pipes, which move in three dimensions. Triaxial accelerometers are used, and are placed in key positions on the critical pipes. Then the piping is excited with a purpose-designed impact hammer made by Brüel & Kjær.

The obtained result is a series of Frequency Response Functions (FRFs), showing the natural resonant frequencies and the amplitudes of the piping at those frequencies. The acceptance criteria are to check the correct shape of the time signals (force and acceleration), the autospectrum of the force, and the shape of the coherence in each measurement. If they are correct, the measurement is validated and the results are considered reliable.

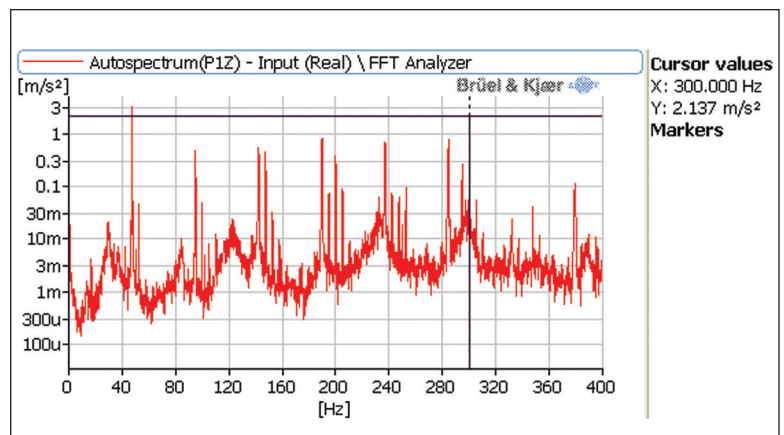


### Experimental signal analysis to obtain the excitation frequencies of the main vibration source

The objective of this test is to obtain the excitation frequencies of the main vibration source (the compressor) from the measured acceleration signals. This is to understand how it will excite the piping, and determine if the design is robust enough, and if it will avoid natural frequencies becoming excited.

Example of the autospectrum of the acceleration vibration in one point with the main excitation frequencies pointed out

In this test, the compressor is switched on and configured to work in standard conditions, and the test is begun once these conditions have been reached. The result obtained is a list of the excitation frequencies of the compressor, and the acceptance criterion is to check and compare these values with the rotation speed of the compressor and its harmonics.



## Results – piping feasibility

Once the results are available from the previous two analyses, an overall analysis is done to link all the results and obtain general conclusions, and to validate or reject the refrigerant circuit.

- From the measured FRFs, a list of the natural frequencies and the amplitudes of the FRFs at those natural frequencies is available.
- From operational measurements of the vibration frequencies in a refrigerant circuit, the excitation frequencies of the main vibration source (the compressor) and other possible excitation frequencies are known.

The next step is to compare the values of the natural frequencies and the excitation frequencies. If there is a match between both values at a certain frequency, there is the potential danger of large displacements in the piping, and consequently fatigue and failure.

## The future

The Center of Competence envisages continuing their studies into the vibration analysis of refrigerant systems, and hope to achieve more complete results on different systems and machines. As each of these different types have their own dynamic behaviour, the CoC are interested in making more measurements and building up a database. This would contain the values of the vibrations, excitation frequencies, and the natural frequencies of the different pipes used in their refrigerant circuits, and help them to evaluate new designs against older ones and establish thresholds for admissible values.

Choosing a 12-channel LAN-XI data acquisition module gives high potential scalability to cover future testing requirements

Looking forward, the next natural step after measuring the natural frequencies is to perform experimental modal analysis, to find the natural modes of vibration of the pipes of a refrigerant circuit, which would be helpful to propose design rules.

In addition, a final and much more demanding step would be to carry out a simulation of the dynamic behaviour of the pipes of a refrigerant circuit, in order to predict this behaviour before the system is manufactured. Such a simulation process would still need to be validated through a good correlation with the experimental data.

Such ambitions are the reason that Javier Oleaga and his team chose Brüel & Kjær equipment. "That's why we decided to select a modular and scalable instrument that guaranteed the coherence and quality of our investigation processes, with the potential to offer a wide range of reliable solutions now and in the future," he says. "After our work experience with Brüel & Kjær, we can confirm that we have purchased high quality equipment and we can rely on expert technical service that guarantees the achievement of successful results."

