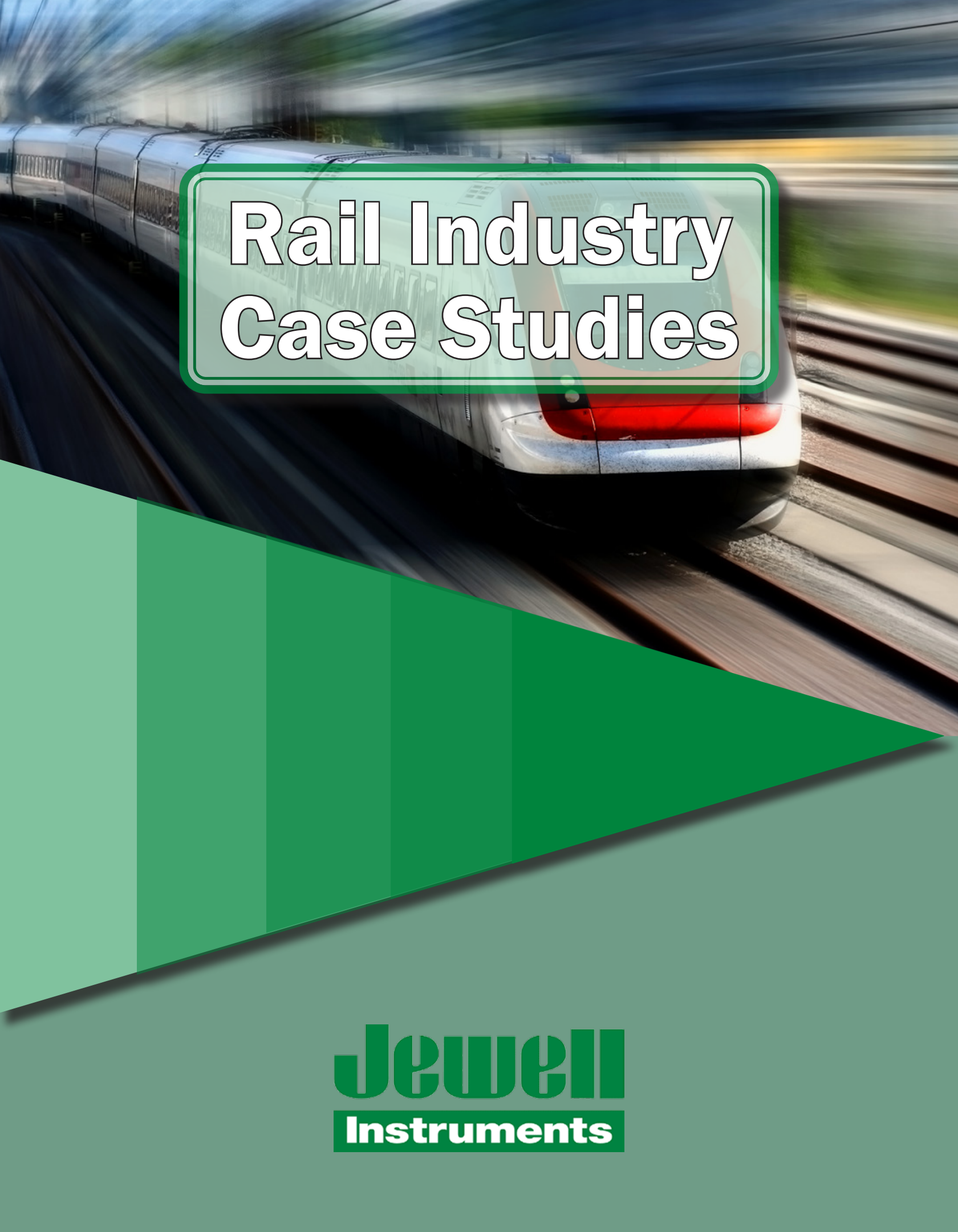


A high-speed train, possibly a Shinkansen, is shown in motion on a track, blurred to indicate speed. The train is silver with a red stripe. The background is a blurred landscape. A green rectangular box with a white border is overlaid on the train, containing the title text.

Rail Industry Case Studies

A large green geometric graphic consisting of several vertical bars of increasing height from left to right, forming a triangular shape, is positioned on the left side of the page.

Jewell
Instruments



Passenger Comfort And Safety At High Speeds

- **Objectives:** Provide the best passenger comfort and safety
- **Solution:** Jewell Instruments **LSMP-2**
- **Benefits:** High-precision and fast response time
- **Results:** Safe and smooth trips at high speeds

Overview

China is home to the largest and most extensively used network of high-speed trains in the world. Based in Beijing, the Chinese Academy of Railway Sciences (CARS) is the leading research and development institute, supporting this important industry. CARS offers scientific and technological education as well as strategic consultation and certification services for

the Chinese railway industry. A focal theme is research and the testing of new materials, products, and technology. Founded on March 1, 1950, CARS is the only comprehensive research institute that is multidisciplinary and multi-specialty in the China Railway industry.

CARS was responsible for the evaluation and performance testing of the CRH380 for Bombardier. The CRH380A is an electric high-speed train that was developed by CSR Corporation Limited (CSR) and is currently manufactured by CRRC Qingdao Sifang. The CRH380A is designed to operate at a cruise speed of 350 km/h (217 mph) and a maximum speed of 380 km/h (236 mph) in commercial service. The original 8-car train-set recorded a top speed of 416.6 km/h (258.9 mph) during a trial run. The longer 16-car train-set reached 486.1 km/h (302.0 mph).

CRH380A is one of four Chinese train series which have been designed for the new standard operating speed of 380 km/h (236 mph) on the newly constructed Chinese high-speed main lines.

The Bombardier train version of the CRH380



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is called the Zefiro 380. Zefiro is a family of high-speed passenger trains designed by Bombardier Transportation (now Alstom) whose variants have top operating speeds of between 250 km/h (160 mph); 380 km/h (240 mph) and 400 km/h (250 mph). The family consists of the Zefiro 250, the Zefiro 300, and the Zefiro 380, which has a top operating speed of 350 km/h (220 mph) and design speed up to 380 km/h (240 mph).

To provide the very best in passenger safety and comfort, CARs has implemented almost 300 units of a custom Jewell [LSMP-2](#) (2g) high precision accelerometer for over a decade to measure acceleration, deceleration, and side to side motion. Space was a concern, and the Jewell LSMP Series accelerometers is an elegant solution.

The 1" cube linear accelerometers have 100,000 hour MTBF reliability and up to 20g full-scale sensing range. The [LSMP](#) sensors provide a wide input range and bandwidth features that meet the demanding needs of a variety of Rail as well as aerospace applications.

CARS has also utilized more than 100 units of custom [DXA-100](#) accelerometers to measure acceleration and deceleration of magnetic levitation (Maglev) trains in China +140 km/h (+87 mph) high speed train signal control system & Automatic Train Operation. Our engineering team has the technical expertise and over 50 years of experience designing custom products tailored to meet your exact needs. Contact us today to find out more!



About Jewell Instruments

Jewell Instruments is a world leader in the design, manufacture, and distribution of high-precision products. Our expertise includes acceleration and tilt sensors, electronic compasses, avionics components, solenoids, and panel meters. The extensive application knowledge we have obtained through decades of experience allows us to provide custom solutions for a diverse group of industries. In fact, customers from all over the globe contact us for solutions to aerospace, medical, industrial, and telecommunications applications - to name a few.

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CSRL3 Rev. A



Track Stabilization Using Jewell Inclinometer



- **Objectives:** Measure rail track displacement
- **Solution:** Jewell Instruments **LSOC**
- **Benefits:** High-precision and shock-resistant
- **Results:** Extended and accurate detection of track faults

Overview

Track stabilization is an important part of most track surfacing projects. Proper track stabilization can provide up to 85 percent recovery of the original track lateral stability. Train stabilization can reduce slow orders and get trains back to running at track speed quicker, after tie change-out or undercutting operations.

The Harsco Model TS-30 is designed to increase the longevity of track balance by stabilizing the track through inserting controlled and accurate force directly into the track structure. The operator can set the desired down-feed pressure for each rail and

the machine maintains that constant pressure until the operator changes it.

The TS-30's work head produces a horizontal force of 50 tons at 45 Hz and a vertical down force of 50,000 lbs. The Jupiter control system provides diagnostic capabilities, which minimizes trouble-shooting time. It is also equipped with pre- and post-cross level data collection. Additionally, the TS-30 is engineered with "large, comfortable control cabs that are fully enclosed, and climatized with excellent track visibility," the company said, adding that the cab is accessible from either side of the machine via a rear platform and rear entry door.

The TS-50 Track Stabilizer is equipped with a high precision inclinometer on the front axle, an inclinometer on the rear axle, and two LVDT's mounted between the vibrating buggy and the main frame measuring the displacement relationship of each rail to the main frame.

Harsco selected the Jewell Instruments [LSOC-14.5](#) high precision inclinometer. The Jewell LSOC Series inclinometers are a fluid damped, flexure suspension, servo inclinometer. The LSOC is a precision internal grade sensing instrument, and it is Jewell's most robust solution designed to meet the needs



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of a variety of commercial, industrial, and aerospace applications. Units are available with a 6-pin connector, or pin-terminals and in $\pm 5V$

The LSOC sensor provides:

- Extremely high resolution and low hysteresis of less than 0.0005% of full range output.
- Extremely robust designed to withstand shocks in excess of 1500g and vibration of 20 grams.
- Responds to changes of slope as small as 0.000006"/ft.
- High accuracy closed-loop force balanced sensor technology.
- Low white noise spectral density of better than 0.15 μV /Sq. Root HZ

The [LSOC](#) series has been successfully implemented in countless projects throughout the past decades, and with due to its phenomenal success and our customers continued satisfaction in mind, we're glad to inform that we recently designed an upgraded version of this product called [LSOX](#) with an optical module that offers improved linearity, less noise, and greater operating & storage temperature ranges. In addition, we're offering this exceptional [LSOX](#) inclinometer at a lower-cost and better lead time in comparison to our legacy LSOC series. [Contact our team today](#) to experience for yourself what our LSOX can do for you!



[Jewell Instruments LSOX](#)

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CSRL4 Rev. A



Jewell on the Cutting Edge of Asia's Rail Development

- **Objectives:** Detect acceleration shifts at high speed
- **Solution:** Jewell Instruments **LSMP-2**
- **Benefits:** High-precision and fast response time
- **Results:** Broke the world rail travel speed record

Overview

Jewell Instruments has played a key role in the success of China's newly developed high-speed train, which the Shanghai Daily newspaper reported on Saturday, December 4, 2010. During a test run on the new rail line between Shanghai and Beijing the previous week, the train broke the world rail

travel speed record, achieving speeds of up to 486.1 kilometers per hour (302 miles per hour). The flagship rail line is between Shanghai and Beijing and would cut the travel time of the conventional rail system in half, reducing the journey from 8 hours to 4.

Jewell Instruments supplies the key acceleration sensing component crucial to the control of the train. Jewell's custom model LSMP-2 linear accelerometer electronically supplies the information to the trains automatic control system required for the control of the acceleration and deceleration of the train. Jewell's sensors also supply the side-to-side movement information which allows the trains control systems to automatically adjust for wind buffeting and minimize these effects for customer safety and ride comfort.

Jewell's products are fully designed, assembled, and tested at Jewell manufacturing facility in Manchester, NH USA. In a meeting in Beijing during that period, officials of the China Academy of Railway Sciences



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(Locomotive and Car Research Institute) reported that “Jewell accelerometers were key in the success of the test” and that they were “very pleased at the operation of the Jewell products.”

Jewell also supplies this type of sensor throughout China and companies world-wide for use in metro systems and subways. Asia is vastly expanding its Metro and high-speed

rail systems and presents excellent growth potential for Jewell in this business sector. At the time of this Shanghai newspaper report, China alone planned to expand its high-speed rail service utilizing this system with 13,000 kilometers (8,077 miles) of new service at a cost of \$120B USD with new projects to be initiated or implemented by 2012.

“Jewell accelerometers were key in the success of the test, and [we are] very pleased at the operation of the Jewell products.”

- Officials of the China Academy of Railway Sciences/Locomotive and Car Research Institute



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CSRL2 Rev. A



Communication-Based Train Control

- **Objectives:** Eliminate distorted data due to vibrations
- **Solution:** Jewell Instruments **LCA-165** and **LCF-500**
- **Benefits:** High-precision and ruggedness
- **Results:** Reliable and precise measurements

Overview

High-speed train systems require precision measurements for efficiency, accuracy, and most importantly: the passengers' safety and comfort. To this end, train control systems normally require multiple sensors (and in this case from two different manufacturers) for redundancy and ensuring any failure and/or incorrect measurement will not jeopardize the reliability of the entire system.



Jewell Instruments LCA-165

Background Of Issue

When the outputs of the redundant sensors do not match, the control system reads this result as a fault and essentially locks. In this situation, there were control systems in two different trains that had experienced a lock situation.

1) The 3 sets of accelerometers had unusually high lock counters in these control systems. The limit of 300 could be reached after a dozen of hours by any of three couples. Other control systems of the line reached 0 to 70 in 24 hours.

2) Train #1 also had a failure of another manufacturer's sensor in January 2016 that was fixed.

3) The problem was not related to calibration of accelerometers. They were correctly calibrated when it happened.

4) The problem was not a hardware failure of accelerometer or any piece of hardware in the sensor. The problem was still there after hardware replacement. After swapping the complete sensor with another in the same train or another accelerometer from another train, the problem remained.

5) The issue came from a phenomenon at train level or sensor installation level, which impacts all accelerometers, but has differing impacts on the two types (Jewell accelerometer with pendulum in air vs another supplier's sensor with pendulum in oil) leading to differences in data.



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Project

The differences in the Jewell unit and the second sensor's bandwidth validated the theories discussed with the customer. Based on further observation, there was a shock (or high-level vibration) that caused a spike in the Jewell Instruments' sensor's bandwidth that could be seen by the second sensor. The spike occurred in both sensors' sensitive axis along the train's moving axis. The customer mentioned that anomalies almost always occur at a switcher in the track but not at one specific switcher.

The customer mentioned that the train sets were > 4 years old and there could be mechanical wear in

the bogie's suspension (or possibly car to car coupler) that was being exaggerated at the switchers. They were going to re-test performance after installing a new bogie on the front of the lead car that contains the equipment rack with the accelerometers. If the anomaly was coupler-related, changing the rear bogie (or replacing the coupler) would potentially be a solution, but that was not the case. A quick test was run to insert a Sallen Key low pass filter in line with our unit that would emulate the second sensor's response of 2 to 3 Hz.



“Jewell accelerometers have been used for nearly 50 years in rapid transit and people-mover systems as crucial components in safety and control systems providing a secure, controlled ride by providing train acceleration, deceleration, and position information.”

LCA-165's Performance

The custom [LCA-165-0.5](#) had no output filter. The servo output is the unit output and has a nominal frequency response of 60 Hz. The servo output will clip somewhere around 2g, or 4x the 0.5 g range, so we suspected the problem in the metro train was not from output clipping. The units built by Jewell had 86 Hz bandwidth and 0.6 damping ratio. Figure 1 shows the response bode plot.

The theoretical plots for the second sensor with 3 Hz bandwidth, 2nd order response bode plot is below. Obviously, the output from the LCA would look much different from second sensor at higher frequencies, and signal processing in the train's control system had an important role in analyzing the sensor's response with respect to the other.

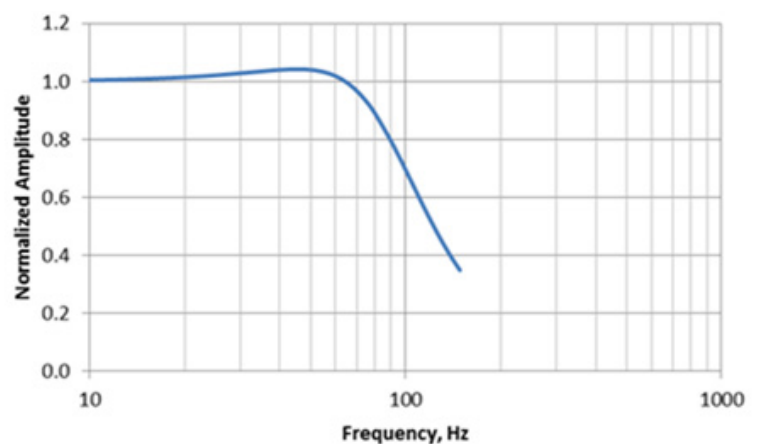


Figure 1



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Samples were fabricated to emulate the second sensor's response and solved the problem. As a result, the customer was very satisfied with the performance of our custom [LCA-165](#) with the same dynamic response as the other sensor, which proves Jewell technical expertise and application experience to work with customers to develop a custom solution that meets your needs.

Jewell's successful analysis further demonstrates the expertise that has led to more than 30,000 Jewell Instruments accelerometers have been used in the rail industry, of which 8,000 have been [LCA-165](#) or [LCF-500](#) servicing 807 stations over one thousand kilometers worldwide including China, France, USA, Canada, Saudi Arabia, India, UK, Italy, Denmark, Turkey, Peru, Greece and Belgium.

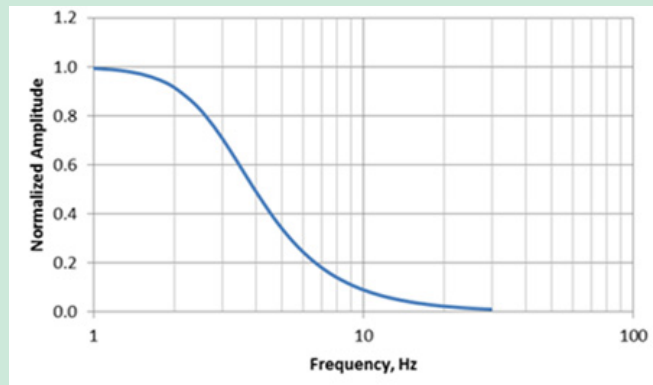


Figure 2 shows Jewell Instruments' LCA-165's performance



**“...more than 30,000
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accelerometers have been
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