Brüel & Kjær application notes

Vibration Analysis at a Ski Resort

The Portable Vibration Analyzer Type 2515 is a rugged, sophisticated analysis tool for identifying and diagnosing vibration problems. This Application Note outlines how the Type 2515 was used at a Rocky Mountain ski resort to monitor the condition of chairlift bearings, to test lift chairs for structural flaws, and to record and examine vibration spectra from final gear drives and from snow-making equipment.

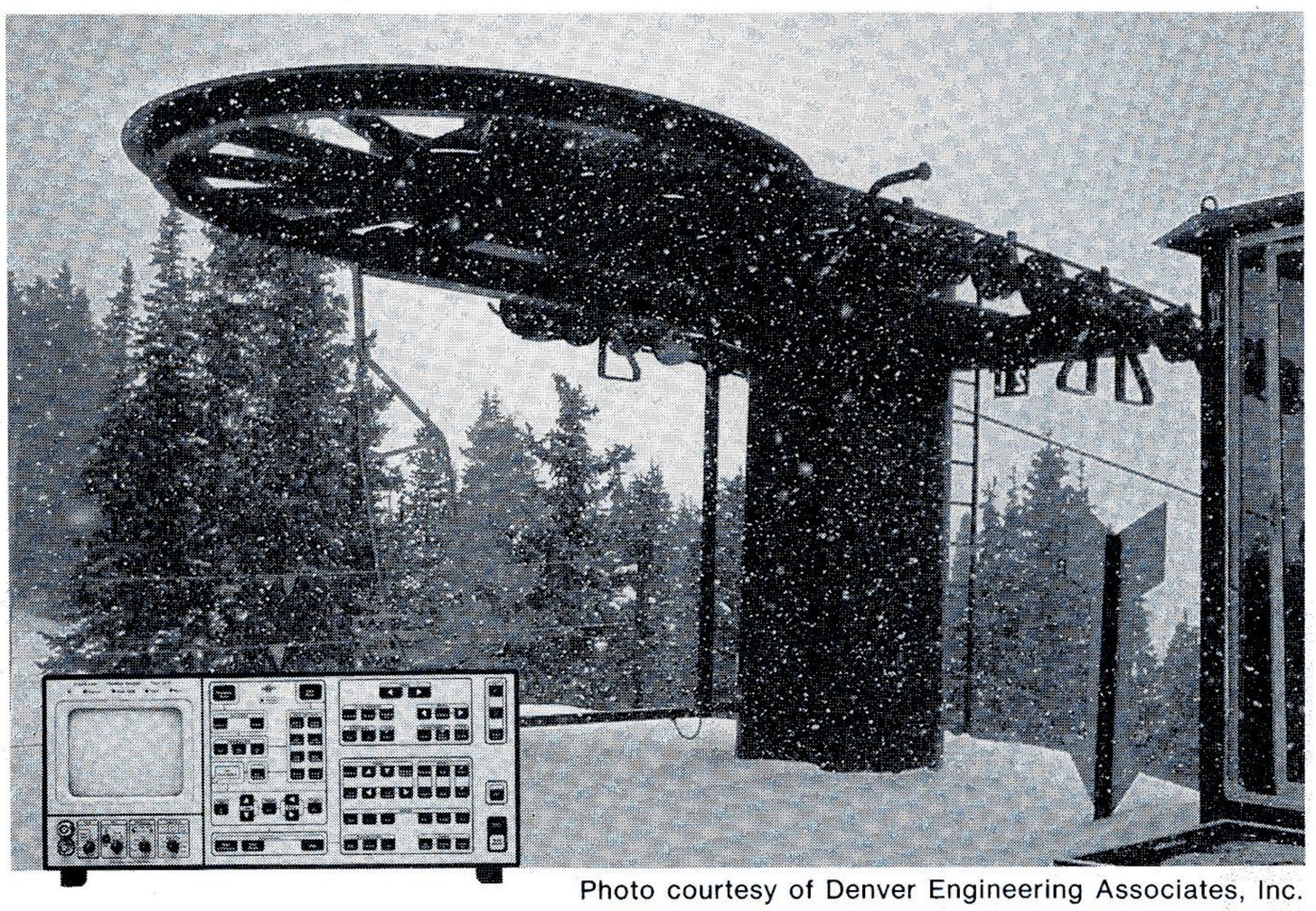


Photo courtesy of Denver Engineering Associates, Inc.

A typical bullwheel at a ski resort. Monitoring the bullwheel bearing-vibration with the Type 2515 Vibration Analyzer can give early warning of bearing faults

Introduction

Mr. Kenneth B. Simons, P.E., of Denver Engineering Associates, Inc. has used their Type 2515 successfully in the harsh environment of a Rocky Mountain ski resort, where temperatures, moisture, and rough terrain are limiting factors for most vibration analyzers. Safety is a major concern for all resort operators, especially on critical systems such as chairlifts, and vibration analysis can help identify potential problems. Denver Engineering Associates have experimented with the Type 2515 as a tool for rapidly checking each chair on a chairlift for faults and for monitoring the condition of bearings on bullwheels, the final gear drives for the chairlift, and for snow-making equipment.

Lift Bearings

One of the critical spots on a chairlift is the bullwheel bearing. A typical bullwheel is shown in the photo above. Denver Engineering Associates used the Type 2515 to measure the vibration spectrum of this bearing. This spectrum can give an accurate picture of the condition of the bearing. A monitoring programme can easily be set up to check the condition of the bearing on a permanent basis.

Since the tower that the bullwheel is mounted on experiences many types of vibration, including the loading and unloading of the chairs, measurements should be taken at the same point in the rotation cycle of the bullwheel. Synchronous sampling reduces such extraneous noise while retaining important bearing information. This can be done using a trigger source such as B&K's Photoelectric Tachometer Probe MM 0024, which is powered directly from the Type 2515.

Powerful memory functions in the Type 2515 can be used to store baseline vibration data for each bearing. This data can be compared with new measurements on a regular basis. Using an accelerometer, the Type 2515 can easily detect the small changes in high frequency vibration typically associated with early stages of bearing fault development.

Testing Lift Chairs

A simplified one-channel form of modal analysis was used to check the condition of each chair on a lift. The chair was struck by a small object and the frequency response of the chair was recorded on the Type 2515. The process is very similar to ringing a bell; the higher-frequency components present in an intact bell are shifted in a cracked bell to lower frequencies and the ringing dies away rapidly. This gives a cracked bell a hollow, "dead" sound. The same principles apply to testing the lift chairs.

To test this process, a measurement was made on a chair with no known defects (Fig. 1 left) and on a chair with a known defect (Fig. 1 right). The spectrum from the "good" chair shows a large peak at 4200 Hz, while in the spectrum from the cracked chair the peak is absent.

This form of testing was used to detect faults and defect welds in areas of chairs which are covered with rubber boots or are otherwise hidden from other inspection procedures. The test procedure is relatively fast: several hundred chairs could be tested in only a few hours.

Using the Type 2515's built-in non-volatile memory, an averaged vibration spectrum of a "good" chair can be stored and used as a reference when testing similar chairs. A reference spectrum can be stored for each type of chair in use at the resort. Since the Type 2515 stores the entire set-up needed for the measurement, the comparison process is very simple and can be carried out by relatively unskilled personnel.

Final Gear Drives

Chairlifts are generally driven by diesel or electric motors through a complex final gear drive. Denver Engineering Associates used the Type 2515 to provide information as to what is happening inside the gear drive. This information can be used to order spares and schedule timely shutdowns for repairs.

Each element in a final gear drive produces its own unique vibration pattern. These elements include the shaft speed and its harmonics, gear meshing frequencies and harmonics, and ball bearing vibration and harmonics. Knowing the geometry (number of gear teeth, ball bearing dimensions, etc.) of each element allows the element to be identified in a frequency spectrum.

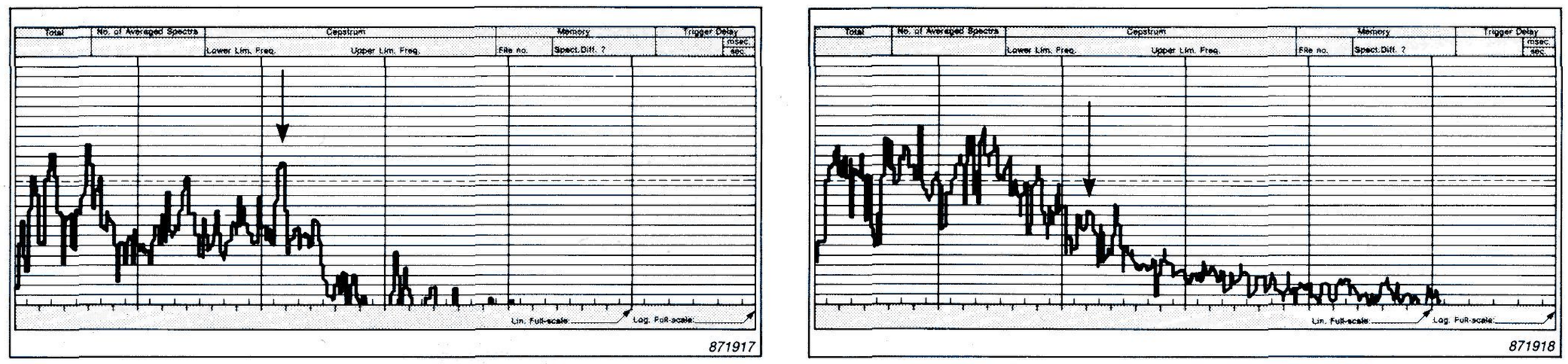
This process of measuring and identifying the condition of specific elements in a machine such as a final gear drive is known as "On-Condition Maintenance". Instead of fixed-interval servicing or run-to-breakdown practices, on-condition maintenance allows the drive to be serviced only when it needs it. Knowing what element is going wrong well in advance of breakdown allows timely ordering of spare parts, which reduces the need for a large and expensive spare parts inventory.

Snow-making Equipment

Vibration analysis was also performed on the motors, pumps, and compressors of the snow-making equipment. The vibration spectra from these machines contains enough information to diagnose many of the faults that are common to them, such as unbalance, misalignment, and developing bearing faults. The advantages of machine health monitoring described above are equally applicable to these important machines.

Conclusion

Preliminary measurements taken by Denver Engineering Associates, Inc. on the lift chairs, drive mechanisms, and snow-making equipment prove that the Portable Vibration Analyzer Type 2515 is ideally suited to make measurements in the conditions found at a typical ski resort. Its tough, sealed construction and environmental stability allow it to go on-site to make measurements critical to the safety and operation of the lifts. Its built-in memories can store up to 100 field measurements as well as allow fast comparison of new data with stored reference spectra. The built-in charge amplifier eliminates the need for separate charge amplifiers: accelerometers can be connected directly to the Type 2515.



Data courtesy of Denver Engineering Associates, Inc.

Fig. 1. Spectrum of a good lift chair (left) versus a cracked chair (right). Note the large peak in the good chair (arrowed), indicating a clear, bell-like tone

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Printed in Denmark: K. Larsen & Søn A/S · DK-2600 Glostrup