AVAS VIBRATION MONITORING SYSTEM

Universal Vibration Solutions

1. Overview of the "Mill Module" Software

The AVAS Mill Module performs a "front-line" warning activity, which monitors vibration continuously, giving the operator a constant indication of the levels of vibration in the 3rd and 5th –octave frequency ranges, as well as a continually-updating spectrum. The operator is alerted to changes in the vibration generated by the rolling process, which might occur as rolling conditions such as speed, or bending forces are changed during a coil. The operator can use the system to judge the maximum "safe" speed for running surface-critical material.

A level alarm facility is also incorporated, which can be used to automatically slow the mill down if self-excited vibration, such as 3rd-Octave mode chatter, should suddenly build up.

A Coil Quality Index (CQI) is calculated (see below for description) which is essentially a simple numeric indicator describing the severity of the vibration suffered by a particular coil during rolling – and hence an indication of the likelihood of their being chatter marks in the surface of the strip.

The Mill Module is normally configured with 1 - 3 vibration sensors per stand, usually located somewhere on the mill frame or load blocks ("Mae West blocks"), and one speed signal per stand. More sensors can be monitored if desired, however.

The Mill Module stores detailed vibration histories for each coil as data-files. The data-files can be searched by time-and-date and coil number, and can be recalled and viewed at any time without disturbing the monitoring activity. The data-files are readily available for export to an external database, if required. The number of data-files which can be stored is specified during configuration. A typical working maximum allows for 10,000 coils for a single stand mill. When this number is reached the data-files are overwritten, oldest first.

2. Description of the operation of the Mill Module

2.1 Location of sensors

The Mill Module vibration monitoring software is normally used to monitor the signals from upto three transducers per stand, though more can be monitored if required. A typical transducer, junction box and cable supplied with an AVAS system is shown in Figure 1. These transducers need to be mounted somewhere on the mill frame which is adequately sensitive to self-excited chatter instability (3rd – Octave Mode chatter), and which is also reasonably sensitive to the 5th – Octave Mode vibration generated by marks beginning to be worn into the back-up rolls.

If no such position can be found on the frame, then positions on the load blocks or (if practical) on the back-up roll chocks could be used. In theory, upto 15 sensors can be monitored, but in practice two or three sensors per stand is normally sufficient as the system is primarily designed to provide general indication of the vibration levels occurring while rolling. The unused channels can be used to monitor other process parameters, such as load, tension etc., if desired.

Where a limited number (2-3) of sensors are involved, an enclosure in which the transducer signal conditioning units are housed is normally provided. Where the number of sensors is greater, it has generally been found more practical to supply all the hardware mounted on a chassis plate of dimensions specified by the client that will then fit into one of his existing control cabinets – see Figure 2 for an example of a 16-channel signal conditioning panel.

Each signal conditioning unit incorporates two vibration-measuring and one speed-measuring channel. Each of the two vibration channels incorporates a transducer power source, signal amplifier and integrator and an anti-aliasing filter.

2.2 Operation of the Mill Module software

A computer incorporating a data-acquisition card running the AVAS “Mill Module” software is connected to the enclosure and acquires the vibration and speed data from the signal conditioning unit/s.

The AVAS Mill Module display, an example of which is shown in Figure 3, continuously updates as a coil is rolled. The software provides bandpass-filtering of the vibration in the 3rd and 5th - Octave band, and in any other band of interest. These bandpass-filtered vibration levels are shown in the form of a scrolling graph of the most recent 10 minutes of data. Mill speed is also displayed in the same format. A continuously-updated spectrum of the vibration is presented, as shown in the example in Figure 4.

To minimise clutter, the display shows the *detailed* data for one stand and for one transducer attached to that stand, only. Where several sensors are used to monitor the vibration of various components of a single stand, the display can be toggled between the different transducers. Additionally, where the system is applied to a multi-stand mill, the display can be toggled between stands, as well as between transducers for each stand.

A summary of the alarm status for all stands is shown in the top right hand corner of the screen. This summary includes for each stand:

- a large bar to indicate the *current* alarm status on each stand
- a smaller bar to indicate whether any alarms have been activated at any stage during rolling of the current coil.
- the current value of the cumulative “CQI” for each individual stand (see below)

Configuration of the alarms is completely flexible. In most applications, however, the status bar for a particular stand is set to turn red if the thresholds are exceeded in any of the filter bands for any of the transducers monitoring on that stand.

If the mill operator sees that the status bar for one of the stands not being displayed has turned red, he can quickly toggle the display to show the detailed analysis for that stand.

In order to provide the user with some kind of simple numeric indicator of the severity of the vibration occurring while rolling, a “quality index” has been developed. This comprises firstly a "local CQI" that is calculated and displayed for *each individual stand*, as can be seen in the top right of the screen in Figure 3. This is a number on a scale 0-99 which represents the percentage of the coil length in which the vibration level exceeded the pre-set threshold, in that stand. It can be configured to work with any one of the individual frequency bands, or to use a combination of several. In most applications, however, the CQI calculation is configured to work from the status of the 5th-Octave band alarm threshold status, since marking of the strip is most commonly associated with excitation of the 5th-Octave Mode of the roll stack.

A main "**Coil CQI**" is also displayed in a larger format in this part of the display. This is the *key* quality index that is calculated and stored for the coil being rolled, and is normally a simple duplicate of the CQI recorded on just one of the stands – normally, that stand deemed most influential to coil quality (usually the final stand of a tandem mill). It's value could, however, be derived from a combination of the individual local CQI's of any of the stands - Stands 4 and 5 of a tandem mill, for example – if desired.

The idea behind the CQI is that it provides a simple numeric indicator of the severity of the vibration suffered by a coil during rolling, and hence an indicator of the likelihood of there being marks rolled into the surface of the strip as a result. If the vibration histories are eventually stored in a database application, it becomes a convenient parameter by which the histories can be searched for those coils whose surfaces may be marked.

For maximum effectiveness the system needs to be linked by serial interface to the mill controller, then the coil number, width, gauge, and other information can also be displayed, as can be seen at the top of the example screen display in Figure 3.

The system includes a digital alarm status output. Configuration of the alarm output is completely flexible. For example, the system can be configured so that the alarm is triggered only if the threshold is exceeded in the 3rd-Octave band for transducer number 1 on Stand 5. This would be useful for minimising the damaging effects of 3rd-Octave Mode chatter instability, since the mill controller can monitor this digital output so that the mill speed can be automatically reduced if the onset of chatter is detected. Alternatively, the alarm might be configured to activate if the CQI level falls below a pre-set figure. In this case, the alarm could be used to initiate a written warning message on one of the main mill control displays, to reinforce the warning to the operator that the strip is in danger of being marked by 5th-Octave vibration.

2.3 Interpretation of displayed information

In the example shown in Figure 3, which shows the detailed analysis for Stand 4 of a tandem mill, there are unusually high levels of vibration in the 3rd-Octave band caused by a number of close peaks in the spectrum around 160Hz, and because the threshold is being exceeded in this band the alarm status bar for this stand is red in colour. This indicates to the presence of abnormal vibration to the mill operator. However, vibration of this magnitude at this frequency is unlikely to lead to any visible marks in the surface of the strip and the CQI for this stand, which is set only to respond to the levels in the 5th-Octave band, remains at 99 – the highest level. The stand alarm status summary at the top right of the screen shows that the vibration levels in Stand 2 are also abnormally high, but in this case the levels are being exceeded in the frequency band in which the CQI calculation has been set to operate – hence the low CQI value for that stand. The strip is unlikely to be marked by high vibration levels in Stand 2 and, in this example, the main Coil CQI has been configured to be the same as the local CQI for Stand 5 hence its value remains at 99.

As a result of the information presented to him in the display shown in Figure 3, the mill operator should:

- take no immediate action with respect to Stand 4 , however, remain vigilant and keep a close eye on the vibration levels over the next few coils.
- toggle the display to Stand 2, to take a closer look, and possibly consider change of work rolls. If this action brings about a reduction in vibration levels, the operator should make a recommendation to the technician that the “Tracking and Trending” system be used to check for chock bearing vibration in the original Stand 2 work roll chocks.

If the 5^{th}-Octave band alarms were being exceeded in Stand 5, and the main coil CQI was falling in magnitude as a result, the mill operator ought to take more immediate action, because if the system has been properly set up, this is a strong indication that marks are being rolled into the strip. First, he should, if possible, reduce mill speed to try to bring about an immediate increase in the CQI for the coil. Second, he should change work rolls at the end of the current coil.

2.4 Setting of frequency bands and alarm thresholds during commissioning

If the AVAS system is to be successful in preventing degradation of the quality of the rolled strip, without creating any significant number of false alarms, then it is clear that the setting of the frequency bands and the alarm thresholds is of critical importance. This is usually achieved during a visit to site by UNIVIB’s measurement and test engineers, with the assistance of their portable instrumentation. This instrumentation is used to compare the levels measured by the AVAS sensors with those measured on the work roll chocks themselves (the nearest that the true vibration of the work rolls can be measured) to determine the effective transmissibility between the two positions, and thus help set the sensitivities of the system. An instrumented hammer is often used to help measure the actual 3^{rd} and 5^{th} Octave resonances of the roll stack.

2.5 Searching and retrieving vibration histories

When the coil is finished, the completed display, including all the information shown in Figure 3, is stored in a data-file as a vibration history for each stand for that coil.

By switching to “history” mode, the datafiles can be searched (on a time-and-date basis, by stand number, and by coil number), and the vibration history of any particular coil can be retrieved for each stand of the mill (see the example in Figure 5). Working in history mode does not interrupt the monitoring process, so no data is lost.

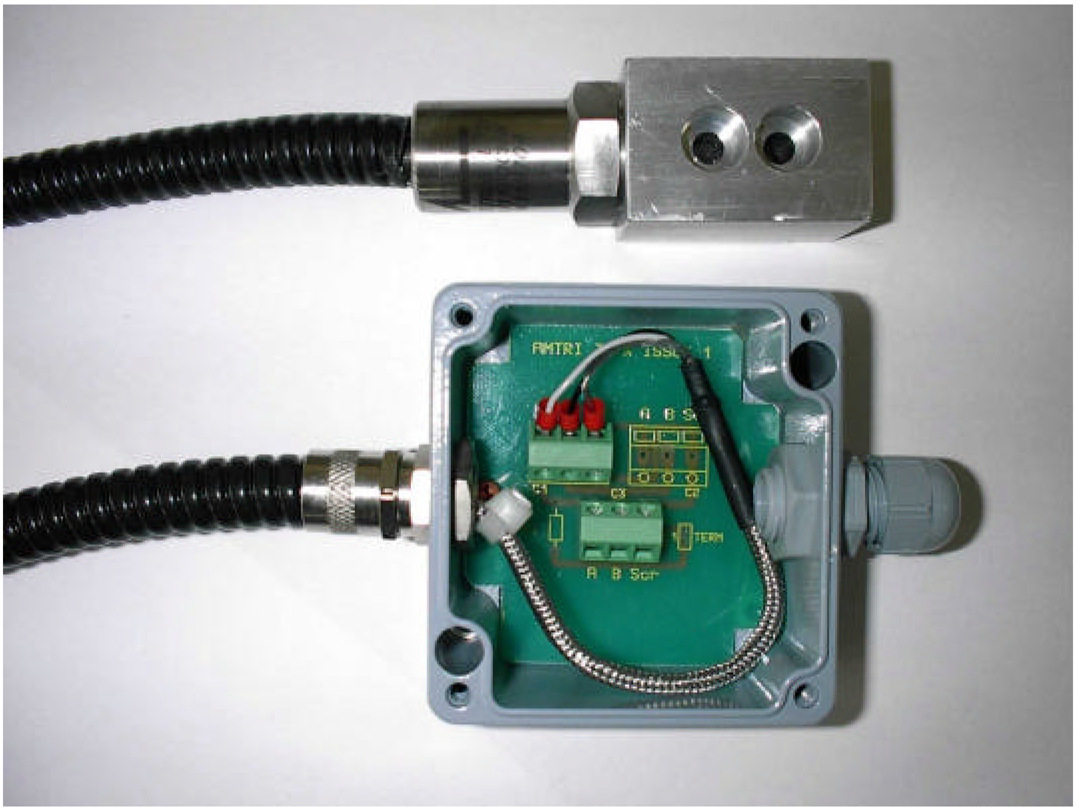

Figure 1 – Typical accelerometer, junction box and cable supplied with AVAS system

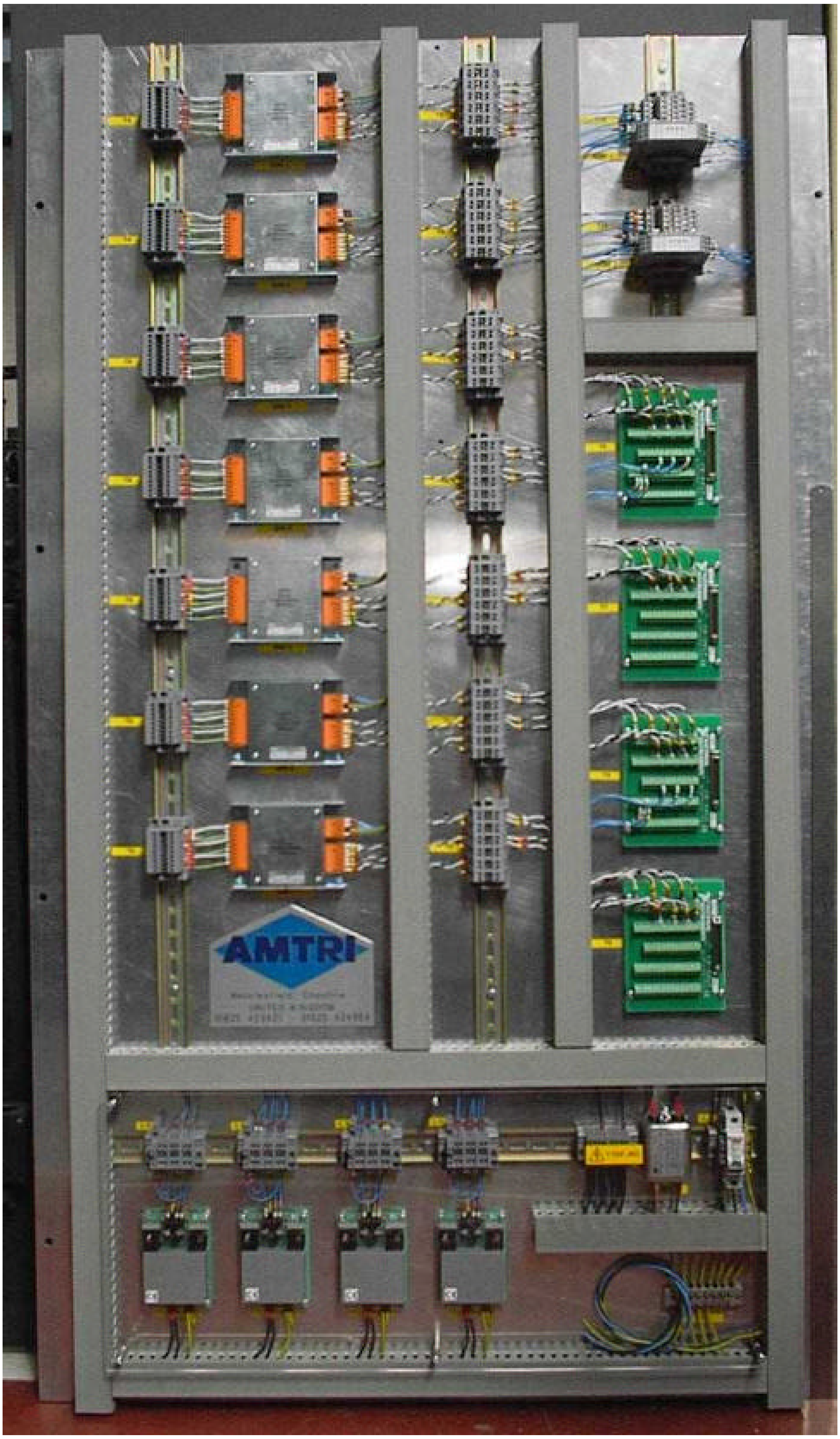

Figure 2 Signal conditioning panel for a 16-channel AVAS system mounted on a chassis plate, ready for installation inside a standard mill control cabinet

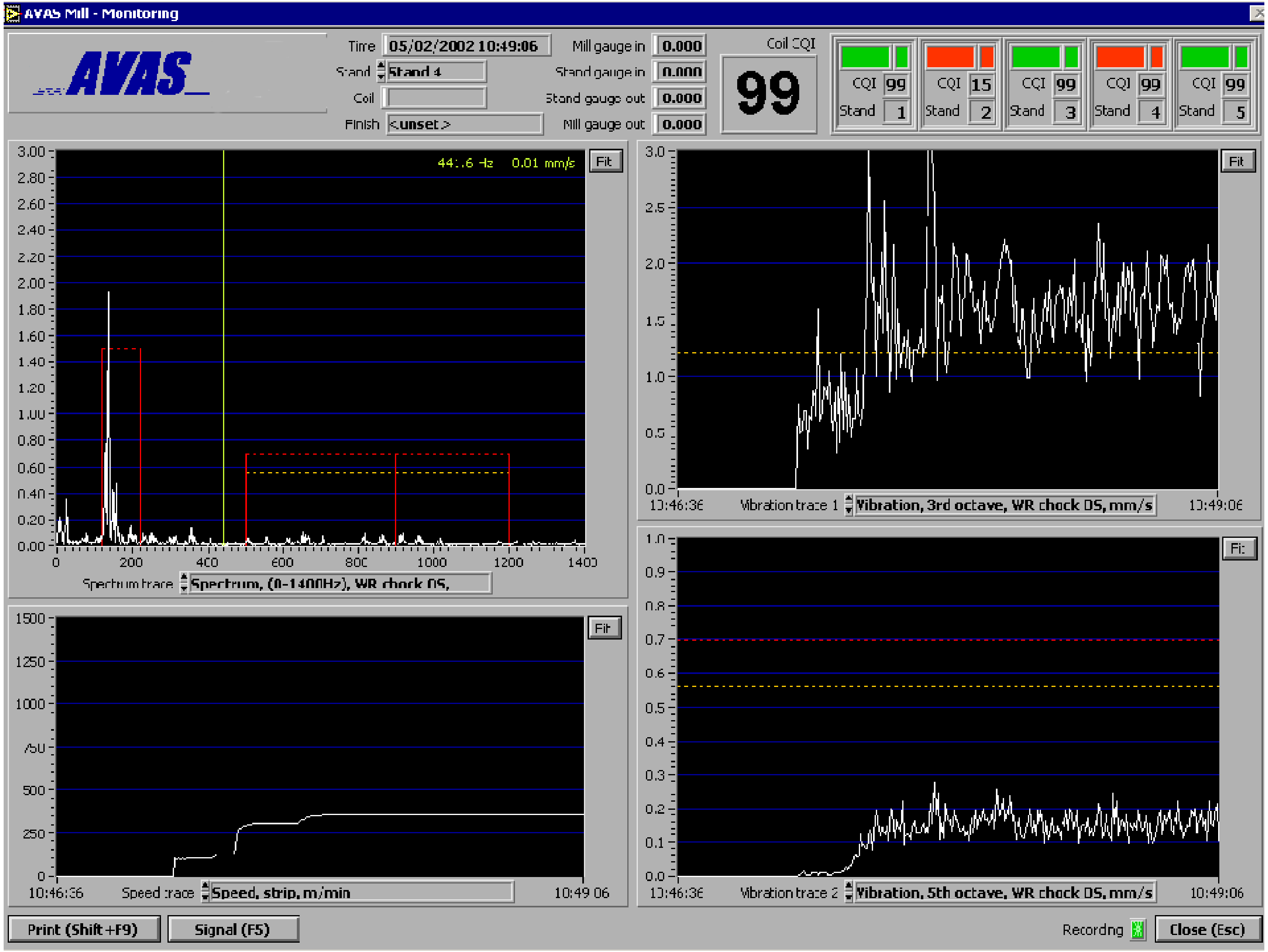

Figure 3 Example of operator display of AVAS Mill Module

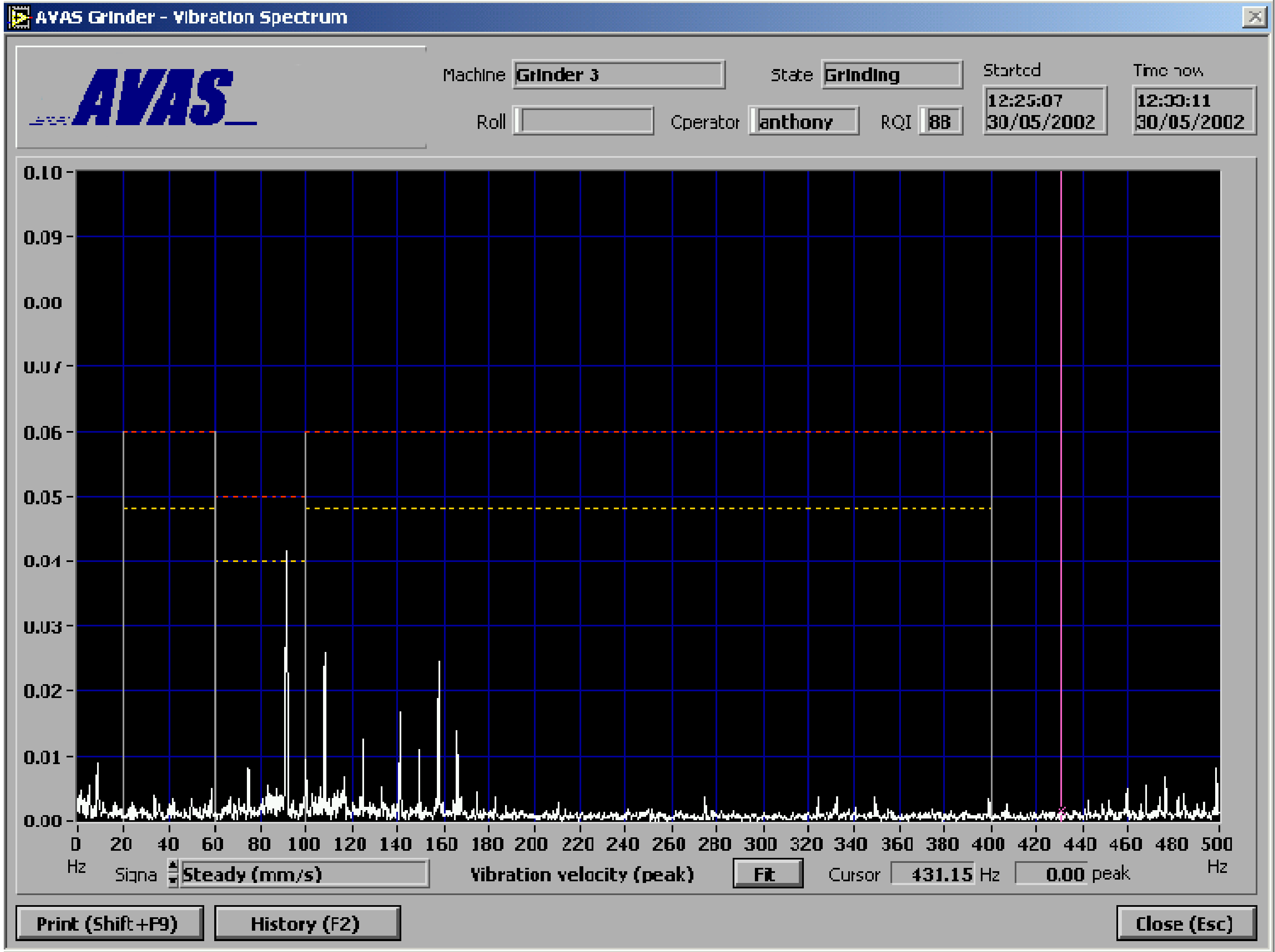

Figure 4 Example of spectrum display of Mill Module

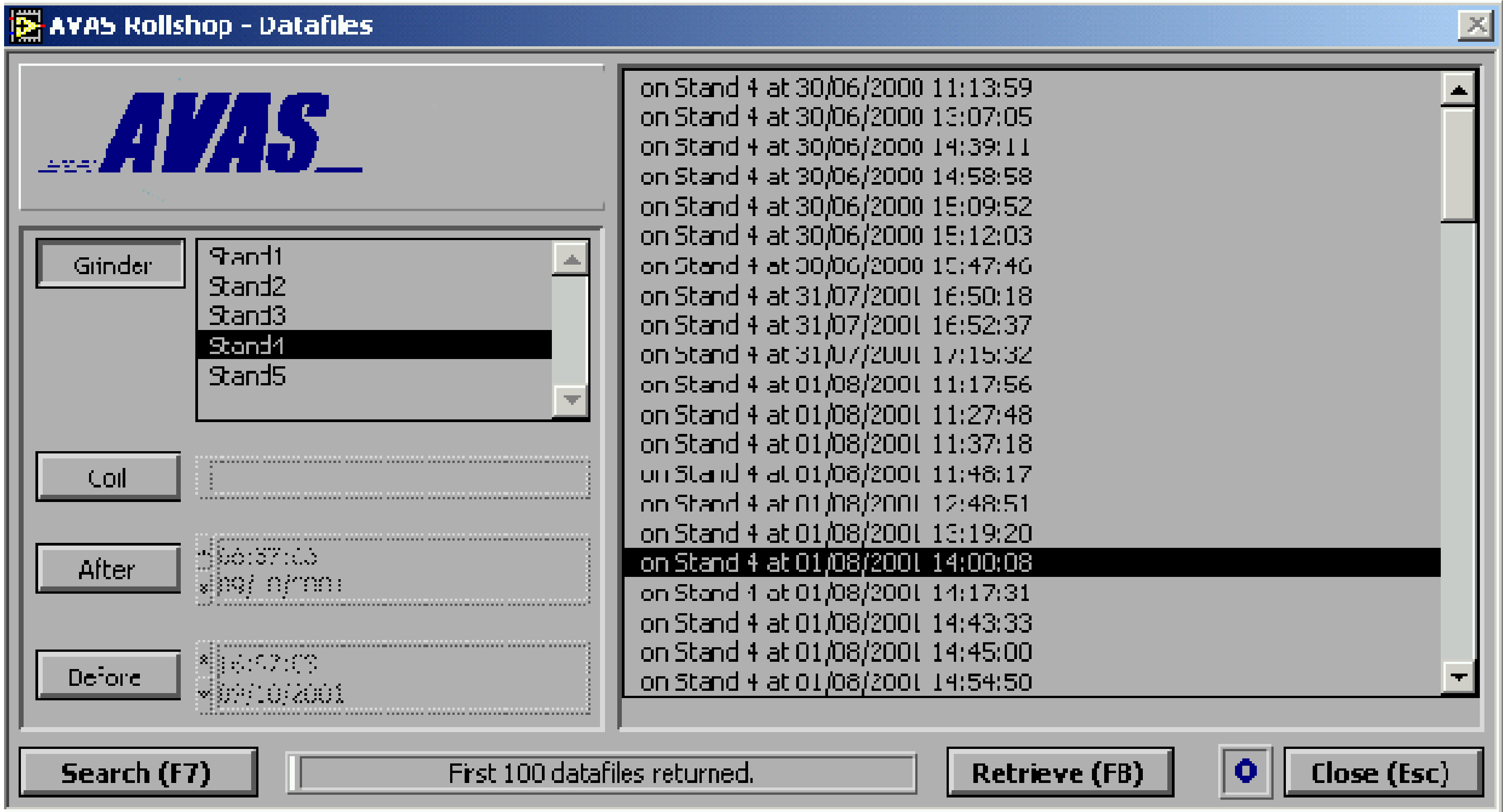

Figure 5 Example of data-file search screen when working in history mode