# Reduction of Hand Transmitted Vibration in Rock Drills

**E.M. De Souza**
Department of Mining Engineering
**T.N. Moore**
Department of Mechanical Engineering
Queen's University
Kingston, Ontario, K7L 3N6

## INTRODUCTION

It has long been known that operators of vibration producing hand tools, such as rock drills, chain saws and chipping hammers, often suffer from tingling, numbness and blanching of their fingers (1). This complex of "vibration-induced white finger" and the various associated symptoms occurring in other systems, in addition to the arterial systems, are known as the Hand-Arm Vibration (HAV) Syndrome, to distinguish them from disorders caused by whole-body vibration (2). The mining industry has recognized its obligation to minimize operator exposure to sources of vibration that could produce HAV syndrome. In particular, efforts have focused on the reduction of hand-transmitted vibration associated with the use of jack-leg rock drills. This type of drill, see Figure 1, is used extensively in the mining industry.

In previous work developed by the authors (3, 4), a research program, was undertaken to determine the effectiveness of using elastomer covered (cushioned) handles in place of the standard steel design. This paper presents an investigation of the long term effectiveness of the elastomer covered handle (cushioned handle) to minimize hand-transmitted vibration under different conditions underground and its applicability to mine production. In this study, five identical cushioned handles were quantitatively and qualitatively tested in different operating mines.

## THE TEST HANDLE

The cushioned handle employs a material known as HD Damped Elastomer, with a durometer of 56. The handle was approximately 4.1 cm in diameter. The cushioned handle was designed to provide "motorcycle grip" control of the jack leg air pressure, that is, the pressure was controlled by twisting the handle. This is in contrast to the steel handle which is fixed, and control of the jack leg pressure is achieved by adjusting a thumbwheel located in one end of the handle.

## FIELD TESTING PROGRAM

The actual test data was obtained from a number of underground operations. In each mine, the standard steel handle used was monitored using the vibration measuring techniques developed by the authors (3, 4) and then replaced by the cushioned handle. The cushioned handle was monitored and the operator was interviewed and evaluated. A questionnaire was also submitted to the operator to develop a data base on acceptance of the drill handle. The handles were used underground under normal production conditions for approximately six months, during which a log book containing all pertinent drill data was filled out daily by the operator. During this time, progress of the field application was closely followed. At the end of this period of application, the cushioned handles were re-evaluated by monitoring the reduction in vibration level experienced by the operators. The operators were interviewed and re-evaluated, and the handles were evaluated in terms of durability, performance and effectiveness (4).

The basic field test approach was to drill a series of holes under simulated production conditions, with the standard steel handle and the cushioned handle. In this manner, the measured vibration provides a direct comparison of the isolation performance of the cushioned handle relative to the steel handle. In all cases, the operators were experienced drillers. They did not use gloves during drilling sequences. The fixture used, fabricated from aluminum, had three accelerometers mounted in three orthogonal directions, as shown in Figure 2.

The upper frequency limit of the measuring system was fixed by the tape recorder at approximately 8000 Hz for direct recording and 900 Hz for fm recording. All data was tape recorded for later laboratory analysis. For each test condition approximately 45 seconds of acceleration data was recorded.

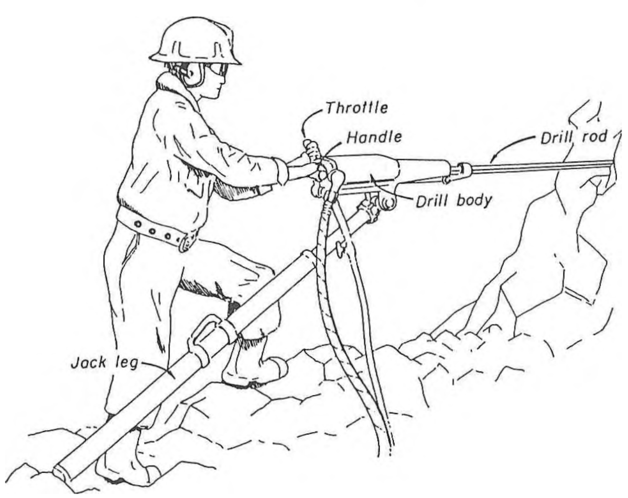


Figure 1 Jack-Leg Rock Drill

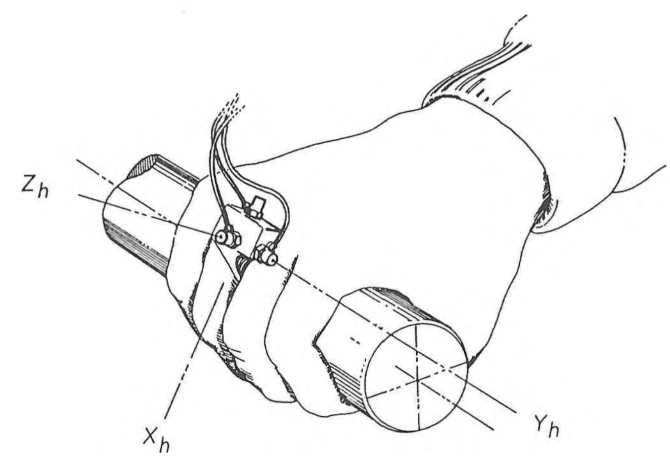


Figure 2 Mounting Fixture And Coordinate Measuring System

VIBRATION DATA ANALYSIS

The vibration data presented in this paper were obtained using the vibration measurement protocol previously developed by the authors (3, 4) and based upon procedures detailed in ISO 5349-1986 (5). For the purposes of evaluating the long-term field performance of the cushioned handle, it was felt that determination of overall vibration levels and narrowband frequency analysis were sufficient. For this series of tests the analog data were obtained for two different frequency bandwidths. The first was from DC to 900 Hz and the second was from 50 Hz to 8000 Hz. These will be referred to as the *low frequency* range and *high frequency* range results, respectively. In this manner, it is possible to assess both the low and high frequency performance of the cushioned handle. Table 1 summarizes the averaged relative reduction in overall vibration level when the steel handle was replaced by the cushioned handle. This represents the data from the five mine sites, a total of 85 individual drilling sequences, for both initial installation of the handles and after six month's service. Narrowband spectra were obtained for frequency ranges of 0 to 2000 Hz and 0 to 8000 Hz. All spectra were 400-line resolution and were averaged using five ensembles. Figure 3 shows a typical spectrum for the z-direction. The results in the x and y directions were very similar.

DISCUSSION OF VIBRATION RESULTS

In terms of overall vibration levels, it is apparent that the cushioned handle provides significant reduction in overall hand/handle interface vibration (Table 1). The reduction in overall level is approximately 10 dB in each coordinate direction for the high frequency range. This represents a reduction of the transmitted vibration by a factor of 3. For the low frequency range the reduction is on the order of 5 dB (although the y-direction shows a surprisingly high 10 dB). This confirms that much of the effectiveness of the cushioned handle is based on reduction of higher frequencies. The results for the cushioned handle measured 6 months after initial introduction show no significant change in performance. If anything, there seems to be a slight improvement in performance, although this is not considered to be statistically significant.

A review of the narrowband frequency analyses indicates that the reduction in overall vibration level noted for the cushioned handle occurs as a result of attenuation of higher frequency components of the vibration. This is clearly shown in Figure 3. Generally, significant reduction in acceleration components is noted above 500 Hz. The frequency content of the vibration signals was not noticeably modified for the measurements made 6 months after initial field introduction.

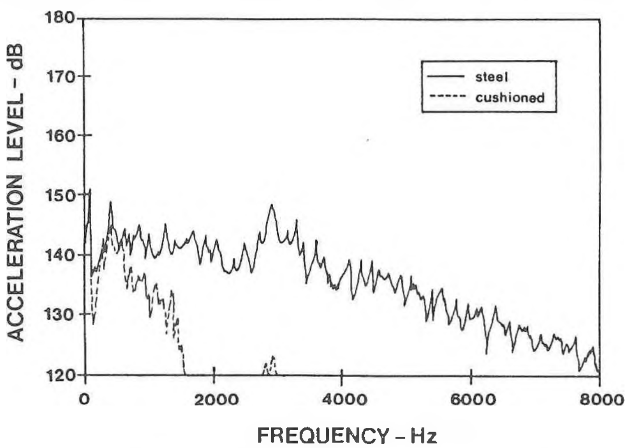


Figure 3 Typical Narrowband Spectra for the Z-Direction

QUALITATIVE EVALUATION OF HANDLES

A qualitative assessment of the cushioned handles by the drill operators indicated an increase in comfort over the standard steel handle. The assessment program, however, did not indicate preference for the cushioned handle as a number of required design modifications have been identified. The concept of the motorcycle grip to control the jack leg air pressure, was well accepted and given some preference to the standard thumbwheel control. In all mines, the handle was found to be slippery and that, to ensure safe operation, it should be covered with an anti-skid material. An end cap was also found necessary to minimize handle twist. Other minor design modifications were also identified for incorporation in future designs. The above results were based on interviews performed on site and on responses to a questionnaire administered to the drillers at handle installation, and again at the end of the field testing program during re-testing of the handles.

CONCLUSIONS

Measured hand-transmitted vibration levels were used to evaluate the performance of an elastomer based handle, relative to the standard, solid steel handle. It was found that this cushioned handle reduced overall vibration levels (over the frequency range 0 to approximately 8000 Hz) by a factor of 3. These reductions were consistent for all three coordinate directions. Relative to the steel handle, the cushioned handle was found to provide vibration reductions for frequencies above approximately 500 Hz. Isolation performance improved with increasing frequency, up to approximately 8000 Hz. A qualitative assessment of the cushioned handle by the drill operators indicated some improvement in comfort over the steel handle.

REFERENCES

(1) Wasserman, D.E., *Human Aspects of Occupational Vibration*, Elsevier, Amsterdam, p. 9, 1987.

(2) Brammer, A.J., "Exposure of the Hand to Vibration in Industry", Associate Comm. on Scientific Criteria for Environmental Quality, National Research Council Canada, NRCC No. 22844, 63 p., 1984.

(3) De Souza, E.M. and Moore, T.N., "Quantitative Vibration Evaluation of Modified Rock Drill Handles". *Mining Engineering*, Vol. 43, No. 3, pp. 319-324, 1991.

(4) De Souza, E.M. and Moore, T.N., "Long Term Field Performance Evaluation of a Rock Drill Handle Design." Final report submitted to Mining Industry Research Organization of Canada, Queen's University, pp. 50, 1990.

(5) Mechanical Vibration - Guidelines for the Measurement and the Assessment of Human Exposure to Hand-Transmitted Vibration. International Standard ISO5349-1986(E), 12p, 1986.

| DIRECTION | INITIAL (dB) | FINAL (6 months) (dB) |
|---|---|---|
| | LOW FREQUENCY RANGE | |
| X | 5 | 4 |
| Y | 10 | 12 |
| Z | 4 | 5 |
| | HIGH FREQUENCY RANGE | |
| X | 9 | 10 |
| Y | 10 | 14 |
| Z | 9 | 11 |

Table 1 Summary of Relative Reduction in Vibration Level