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Influence of Drive Level on the Fundamental Vibrator Signal

R.P. Noorlandt* (Delft University of Technology), G.G. Drijkoningen (Delft University of Technology) & C.A.M. Faber (ION Geophysical)

SUMMARY

In this abstract we show the influence of vibrator drive level on the signal it produces. For that purpose a field survey was carried out using an INOVA's AHV-IV vehicle with a modified 266kN (60.000 lbf) vibrator. A single linear sweep was repeated at 10 different drive levels ranging from 5 to 90% at two locations. Each drive level was repeated 10 times and each run was repeated twice per location. In total 400 sweeps were carried out. From this data set we conclude that; the vibrator signal is very repeatable for a given setting; the repeatability is less comparing different runs with the same setting; the ground-base plate interaction depends on the drive level in a non-linear way and not taking these effects into account produce arrival time and amplitude errors in seismic records.

Figure 2 dB Spectra of different source measurements. Colour indicates drive level percentage.

The experiment was repeated at the same spot to see the impact of first 100 sweeps on the coupling and the repeatability of the experiment. Figure 3 shows the spectra of the signals belonging to the vibrator at the first location for the first and second run. Again it is clear that, except for the 5% drive level, the controller was able to fix the output amplitude. In the second run, especially for the higher frequencies, the influence is shifted from base plate to reaction mass for all drive levels. At the second location, not shown here, the opposite effect was found, i.e. the base plate gained more importance over the reaction mass signal. The difference between the runs becomes smaller for larger drive levels.

Figure 3 dB Spectra of different source measurements. First run results are plotted with solid lines, second run results are plotted with dashed lines. Colour indicates drive level percentage.

Ground filtering of the signal

The spectra shown in figure 2 and 3 show that this vibrator experiment does not scale in a linear way, but it is hard to discriminate between effects produced by the mechanics and/or hydraulics of the vibrator and those produced by the base plate ground interaction. If we consider the interactions shown in figure 1 as one-dimensional forces, we see that the base plate experiences five different forces from; gravity, the hold down system, the driving engine, the reaction mass support system and the ground force. If we now ignore gravity and the hold down system, since both act below the frequency of interest, we see that the weighted sum ground force is just the filtered version of the force acting on the reaction mass. Figure 4 shows the spectra of the weighted sum ground force divided by the reaction mass acceleration to be able to see the ground force spectra as if the mechanics would have generated a flat force spectrum. From these graphs it is clear that if we correct for the variability of the mechanical force on the base plate, i.e. correct for the controller, the response varies considerable with drive level.

Figure 4 Weighted sum ground force corrected for reaction mass acceleration spectra. Colour indicates drive level percentage.

Influence on seismic records

The influence of the drive level on seismic data is larger than might be expected from the flat spectra of the weighted sum ground force. We plotted common receiver gathers of the different drive levels for the first location and first run in figure 5 after being correlated with the pilot signal and scaled per trace maximum. Within each constant force panel there is little variation in the signals, but from panel to panel the signals do change. In more detail we see that the positive time ground force signal is more affected than the negative time. The near field geophone shows a shift of about 10 ms and amplitude and bandwidth variations. The far field and borehole geophone also show time, amplitude and bandwidth variations. Not all events seem to be effected equally strong, some events present at low drive level are vanish with larger drive level and vice versa, while others are persistent for all drive levels.

Conclusions

We have shown from field data that

- For a given setting the vibrator signal is very repeatable. (figure 2 and 5)
- The vibrator signal spectra depend on the history of sweeps. (figure 3)
- The ground - base plate interaction depends on drive level. (figure 4)
- Not taking these effects into account results in arrival time and amplitude errors in seismic records. (figure 5)

Figure 5 Common receiver gathers for four different signals, correlated with the pilot signal. The plots show 10 panels with drive levels at 5,10,20,30,40,50,60,70,80 and 90 % from left to right. Each panel contains 10 consecutive sweeps. The top two plots have a time axis from -125 to 125ms, while the lower two plots contain 250 to 1700ms. Colour indicates signal amplitude.

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