DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1973/8

VIBRATION MEASUREMENT AT CURRARONG, N.S.W., 1972

by

F.J. Taylor

RESTRICTED

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SUMMARY

Vibration measurements were taken at Currarong township, adjacent to the Navy shelling range on the N.S.W. coast during September 1972. The object of the measurements was to compare the ground disturbances produced by two different types of shell.

The vibration measurements were requested by the Defence Standards Laboratories who were evaluating the effectiveness of a 'special practice bombardment round' (S.P.B.R.) which contains a much smaller high explosive content than the normal high explosive shell. This shell (S.P.B.R.) was designed to replace the genuine high explosive shell during practice shooting and hence reduce the associated noise and ground vibrations.

Measurements taken show that the sonic boom from the shell produces the greatest disturbance at Currarong township and that the ground-induced vibrations from the explosion are not measureable at this location. The vibration levels recorded from either the sonic boom or the noise from the explosion are in the order of one thousanth of that amplitude which can cause damage to domestic buildings.

INTRODUCTION

Vibrations measurements were taken at Currarong township in N.S.W. in order to compare the relative effects of two types of R.A.N. shells. Currarong is a small township situated approximately 25 km southeast of Nowra on the N.S.W. coast. It is situated adjacent to the R.A.N. bombardment range. The Defence Standards Laboratories have developed a special practice bombardment round (S.P.B.R.) which is the same weight and size as the normal high explosive shell (H.E.) but contains only 10 per cent of the normal amount of explosives. The two types of shells (H.E. and S.P.B.R.) were fired onto the bombardment range from an R.A.N. ship located some 12 km off-shore. The shells were fused to detonate on impact (direct action) as well as in the air (air bursts). The object of the test was to determine whether the S.P.B.R. shell produces less noise and ground disturbance than the normal H.E. shell.

Recordings were made at two locations - Currarong township and the Navy observation post (Plate 1). These recordings sites were 2.7 km and 1.4 km respectively from the impact area. It was not possible to record at closer sites because of the necessary safety distance. The recordings were made using a three-component Sprengnether Seismograph system together with a sound detector on 18, 19, and 20 September 1972 by F.J. Taylor (geophysicist) assisted by staff of the Defence Standards Laboratories. The noise levels from these experiments were monitored by staff from the Defence Standards Laboratories and the Commonwealth Accoustic Laboratories.

GEOLOGY

The area is part of the Sydney Basin and consists of Jervis Bay Sandstone of Permian age as well as Quaternary beach sediments and aeolian sand dunes. The geology of the region has been mapped by the Geological Branch of BMR (Jackson, 1969). Typical seismic refraction profiles of the weathering for this region are given in seismic survey reports by Taylor (1969), and Polak & Hill (1970). A brief description of the geology is given here but the reader is referred to the literature for further details.

The Jervis Bay Sandstone is a gently dipping, well jointed Permian sandstone overlain in places by unconsolidated Quaternary beach and dune sands. The latter contain lagoonal marsh sediments in some areas. The fine-grained Quaternary quartz sands vary in thickness from a few centimetres to 100 m.

The recording site near Currarong was on weathered sandstone, and the site adjacent to the observation post was on a large sand dune of unknown thickness.

METHODS AND EQUIPMENT

A Sprengnether Seismograph system was used to monitor the vibrations. This system measures the absolute level of vibrations (in terms of particle velocity) for the transverse, vertical, and radial components. The system also incorporates a sound detector. All shells were fired by an R.A.N. ship and an observer in the observation post relayed the impact instant to all personnel operating recorders. A total of 80 shell bursts were recorded. This number was made up of 30 H.E. shells, 45 S.P.B.R. shells and 5 white phosphorus marker shells.

RESULTS

There are three possible sources of ground disturbances from a shell firing. The first disturbance to arrive at the site is the sonic boom generated by the projectile when exceeding the speed of sound. This sound wave induces ground vibrations as it passes over the site. Secondly, the explosion on the firing range generates ground vibrations which travel out from the point of impact via the ground at velocities in the order of 3000 m/s. Thirdly, the sound wave from the explosion induces ground vibrations as it passes over the site. At a shot-to-recorder distance of about 3 km the latter vibrations are expected to arrive some 8 seconds after the ground vibrations from the explosion.

The effects of the sonic boom on the Currarong site are summarized in Table 1. This table and subsequent tables give the range of maximum ground motions and sound level for the various types of shells fired.

TABLE 1. EFFECTS OF SONIC BOOM AT CURRARONG RECORDING SITE

Shell Type	Particle velocity cm/s			Sound - peak over pressure
	Transverse	Vertical	Radial	Newtons/m^2 (Pascal)
White phosphorus	.0008 - .0024	.0004 .0013	.0002- .002	1.0 - 2.4
High explosive	.0008 - .004	.0003- .0020	.0002- .0027	1.0 - 4.5
Special practice	.0015- .0032	.0006- .0016	.0005- .0015	2.0 - 3.4
Inert shell	.0028	.0019	.0011	4.1

The effect of the noise from the explosions on the Currarong site are summarized in Table 2. (Includes both direct action and variable time fuses.)

TABLE 2. EFFECTS OF EXPLOSIONS AT CURRARONG RECORDING SITE

Shell Type	Particle velocity cm/s			Sound - maximum overpressure
	Transverse	Vertical	Radial	Newtons/m^2 (Pascal)
White Phosphorus	Nil	Nil	Nil	Nil
High Explosive	.0006- .002	.0004- .0022	.0004- .001	4.8
Special Practice (Single)	.0003	.0002	.0002	1.1
Special Practice (Twin)	.0004	.0004	.0002	1.3

Table 2 shows a maximum overpressure of 4.8 Newtons/m^2 was recorded for the sound from a high explosive shell. This level is greater than the sound level from the sonic boom. However, the high explosive shell in this instance had a variable time fuse which detonated prematurely while at a relatively high altitude. Under normal circumstances the sound level from the sonic boom is always greater than that from the exploding shell.

Vibrations conducted by the ground direct from the explosive source were recorded at the Currarong site from one shot only. This shot was the static test involving the detonation on ground of two special practice rounds. For all other shots the level of this vibration was below the level of natural ground vibration. The results of this solitary explosion are shown in Table 3.

TABLE 3. GROUND VIBRATIONS AT CURRARONG RECORDING SITE

Component	Velocity cm/s
Transverse	.0004
Vertical	.0001
Radial	.0004

The second recording site was located at the observation post on the firing range. The approximate shot to recorder distance was 1.4 km. The effectsof the sonic boom at this location are shown in Table 4.

TABLE 4. EFFECTS OF SONIC BOOM AT FIRING RANGE

Shell Type	Particle Velocity cm/s			Sound - maximum overpressure
	Transverse	Vertical	Radial	Newtons/m^2 (Pascals)
High Explosive	.003 - .006	.005 - .008	.003 - .008	11.0
Special Practice	.002 - .007	.001 - .009	.002 - .007	9.0

The effect of the explosion for this same site is greater than that of the sonic boom. The results are shown in Table 5.

TABLE 5. EFFECTS OF EXPLOSIONS AT FIRING RANGE

Shell Type	Particle velocity cm/s			Sound - maximum overpressure
	Traverse	Vertical	Radial	Newtons/m^2 (Pascals)
High explosive	.017 - .02	.012 - .015	.005 - .10	8.0 - 10.0
Special Practice	.002 - .015	.001 - .007	.001 .008	5.0 - 10.0

CONCLUSIONS

The particle velocities recorded are all very much lower than levels necessary to cause damage. The generally accepted criterion for damage is a ground velocity exceeding 5 cm/s. The level of vibrations produced by the exploding shells are so low that it is not possible to give measured relative levels of disturbance produced by the two different types of shells. As expected, the effects of the sonic boom are independent of the shell type since all shells are approximately the same size and weight and all are fired at approximately the same velocity.

The peak overpressures shown here correspond to a noise level in the range of 90 to 120 lb, and, generally speaking, the sonic boom makes the greatest noise at Currarong. However, premature explosions in the air can give noise levels greater in amplitude than that of the sonic boom.

ACKNOWLEDGEMENTS

The author acknowledges the assistance given by staff of the Defence Standards Laboratories and by personnel of the Royal Australian Navy.

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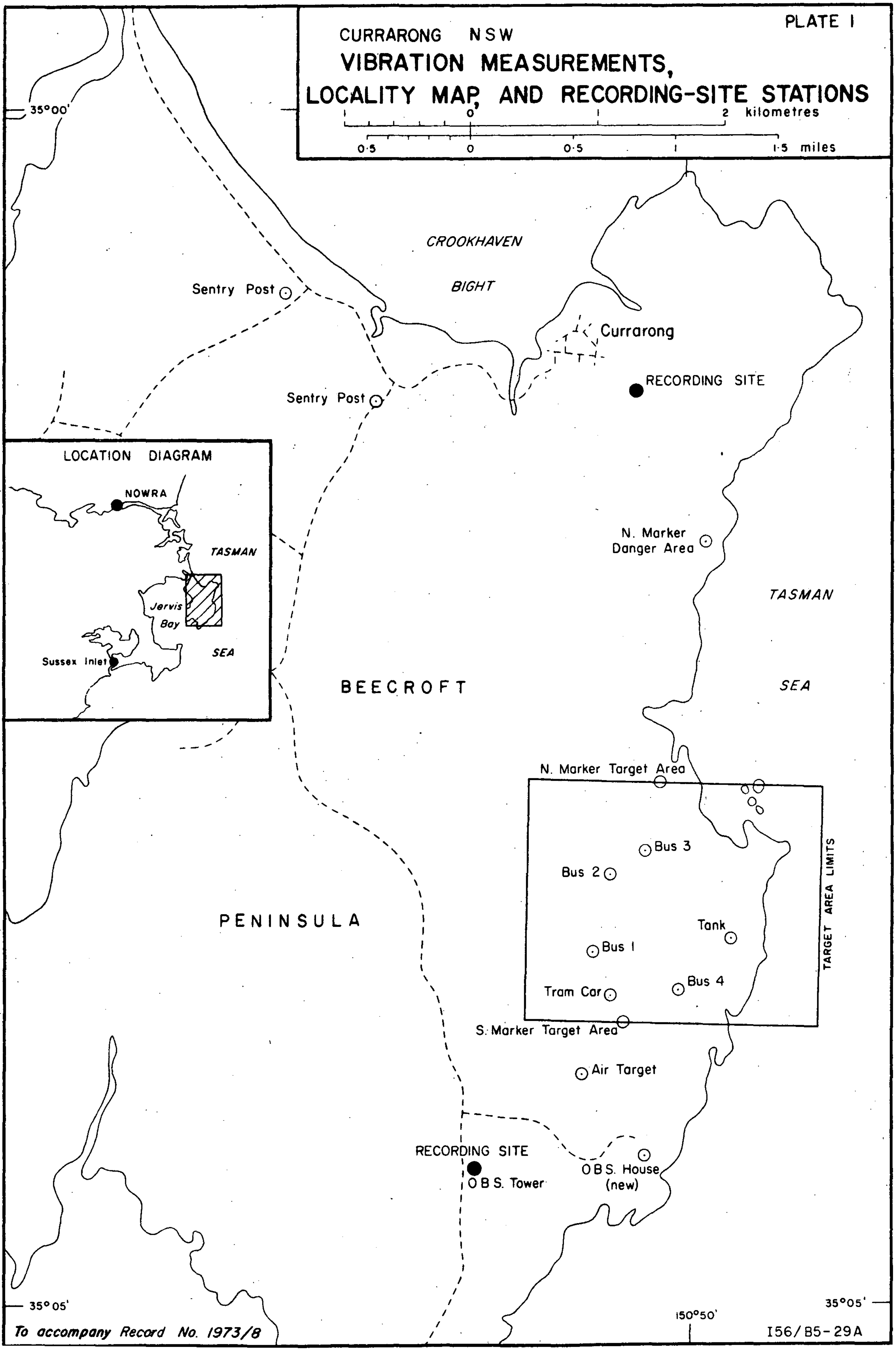
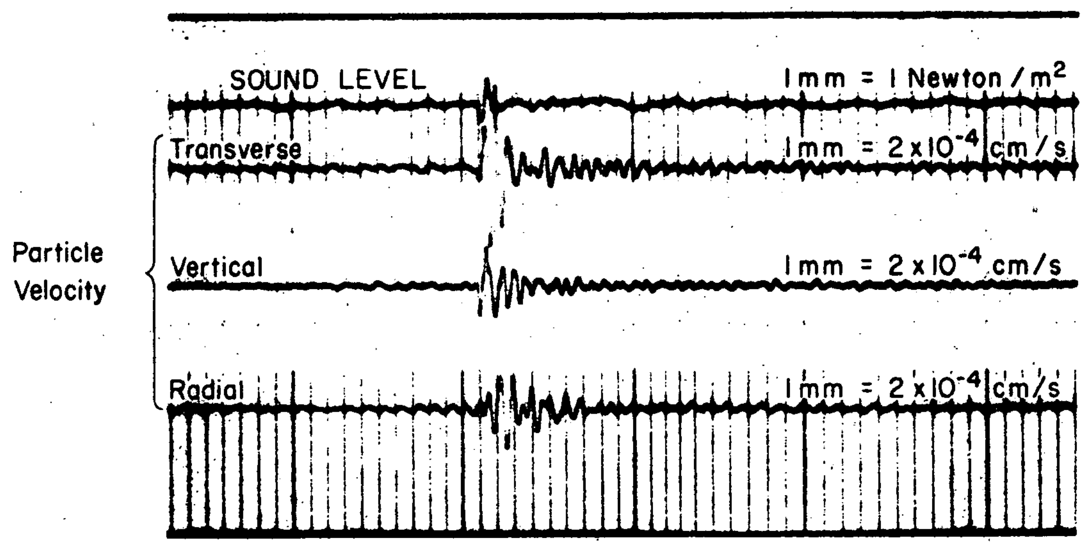


PLATE I
CURRARONG NSW
VIBRATION MEASUREMENTS,
LOCALITY MAP AND RECORDING-SITE STATIONS
0 2 kilometres
0·5 0 0·5 1 1·5 miles
35°00'
CROOKHAVEN
BIGHT
Sentry Post
Sentry Post
Currarong
RECORDING SITE
LOCATION DIAGRAM
NOWRA
TASMAN
Jervis
Bay
SEA
Sussex Inlet
N. Marker
Danger Area
TASMAN
SEA
BEECROFT
N. Marker Target Area
Bus 3
Bus 2
TARGET AREA LIMITS
PENINSULA
Tank
Bus 1
Bus 4
Tram Car
S. Marker Target Area
Air Target
RECORDING SITE
O B S. Tower
O B S. House
(new)
35°05'
35°05'
150°50'
To accompany Record No. 1973/8
I56/B5-29A



IDENTIFICATION OF RECORD

Transverse trace moves down – ground moves to right (looking at the shot)
Vertical trace moves down – ground moves down
Radial trace moves down – ground moves towards shot

SPRENGNETHER RECORD OF SONIC BOOM FROM HIGH EXPLOSIVE SHELL