BLASTING VIBRATION DAMAGE AND NUISANCE IN CORNWALL

R T F Vanstone

Cornwall County Council, Truro.

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Introduction.

Cornwall County Council created the full time post of a Noise Control Officer in 1974, to deal with development control and highway noise problems. The first allegation of damage and nuisance due to quarry blasting was received in the winter of 1978-79.

Today in 1989 there are several complaints being investigated from the vicinity of eight quarries across the County plus two areas near china clay pits.

Why?

It would be easy to say "increased environmental awareness", but for this to be a reason it would be necessary for complaints to originate now from persons who had experienced similar vibration levels for a number of years without complaint. This is not so. Virtually all complainents had,
(1) Recently moved into the County or,
(2) Recently retired.
That is, they were at home, possibly with time on their hands, when blasting took place.

Another reason or perhaps complimentary reasons are the increased mobility of quarry labour and increased mechanisation within the quarry. Mechanisation has increased the size of mobile equipment with consequent increase in noise and reduced the labour force. This has lead to a number of quarrymen's houses coming on to the open market, reinforced by the increased mobility of the workforce allowing them to live much further from their place of employment. In Cornwall many of these houses are in picturesque rural and coastal settings - most attractive to those seeking "The Good Life".

Substance of Complaints.

The overriding reason for complaints is the fear of structural damage. There are always new cracks to be observed following a bad blast! Externally these are found frequently to have been caused by poor building practice, such as add on features having been incorrectly keyed in or not keyed in at all to the original structure. Internally the installation of central heating will result in considerable shrinkage of woodwork with cracking of paint around door and window architraves.

Another reason for complaint is the startle effect. Elderly people do not always hear the warning siren and so complaints refer to minor domestic accidents, such as spilling a cup of tea, resulting from reaction to an unexpected noise or vibration.

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Devaluation of property due to the general proximity of a quarry is frequently deduced as being the real reason for complaint. "The quarry was not working on the Saturday afternoon we bought it". "I retired to Cornwall for peace and quiet so that quarry has to stop". Pointing out to such complainants that the purchase price of their dwelling reflected the proximity of the quarry is taken as additional provocation.

Damage and Nuisance.
Buildings are mixtures of many materials such as wood, glass, metal, concrete, stone and plastic resulting in complex built-in stresses according to temperature and other physical effects. Damage will occur only when the sum total of blasting vibration induced stress plus the built-in stress exceeds some critical level for the particular material in question. Considerable variation will be found in the level of blasting vibration at which damage occurs due to this unknown built-in stress. Thus the problem can be approached only in a statistical manner.

We are all familiar with the nuisance definition of "inconvenience materially interfering with physical comfort not merely according to elegant or dainty modes of living ....." Essentially this means that nuisance must be judged upon the reaction of the statistical average person.

What to do about it?
A literature survey introduces us to square root and cube root scaled distances and to Peak Particle Velocity, PPV which correlates best with both damage and nuisance. Reference 1 would suggest that the possibility of threshold damage to domestic structures is unlikely below 12 mms/sec.

In terms of nuisance, Reference 2 would imply that the minimum PPV inside a dwelling likely to cause adverse comment would be about 8.5 mms/sec.

Figures 1a, 1b and 2 summarise the damage and nuisance aspects of blasting vibration and air overpressure with the typical range encompassing 98% of all vibration measurements in Cornwall. Figure 1b also shows a night time threshold obtained from underground mining complaints.

The next step is to measure vibration and air overpressure at a complainant's dwelling. Their first question on seeing the seismograph is to ask what it measures. On being told "Peak Particle Velocity" their reaction is predictable - Why can't it measure something they can understand like displacement. In Cornwall we have a ready explanation. The tide already causes the County to move up and down twice a day over about a centimetre and no-one feels it at all. What is important is how fast the ground moves up and down. This explanation is grudgingly accepted.
Then comes the blast. Standing alongside the complainant, you know that he felt it to be a movement of the best part of a centimetre but the printout shows the displacement to be a fraction of a millimetre. Instant and total loss of credibility! Why is it not a well known fact that the human perception of a suddenly applied vibration is to sub-consciously multiply it by a factor of 10 to 15 times? or to pose another question - what exactly has been felt?

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A Particular Case.

Extreme care needs to be exercised in using Figure 1 to forecast PPV from distance and charge weight when the geology of an area is not uniform. Metamorphic conditioning of the rock overlying the fringes of the main bodies of granite result in complex diffraction, reflection, interference and focussing of vibration. Within the main unweathered granite mass more uniform conditions exist.

Fifteen results from three quarries on the same granite mass are also shown on Figure 1a. The mean line for these results is different to that for the County as a whole and the smaller scatter allows a mere accurate forecast of vibration levels to be made.

Airblast measurements for these blasts are plotted in Figure 2. The sealed stemming depths for these varies from 1.3 to 2.0.

Conclusions.

Forecasting vibration levels for a given situation is much more difficult than forecasting noise levels due to the effects of local geology. A reasonable range of possible PPVs may be calculated once a sufficient range of measurement experience is available.

No known damage can be attributed directly to blasting vibration but with few measurements in excess of 10mm/sec this is to be expected.

Nuisance threshold occurs at a mean level of 2.25 mm/sec for quarry blasting, much lower than the minimum level for average response of 8.5 mm/sec thought to result in adverse comment for BS6472.

References.

1. D. E. Siskind et al — US Bu Mines R1 8507
2. British Standard 6472 — Guide to evaluation of human exposure to vibration in buildings.

Other useful References.

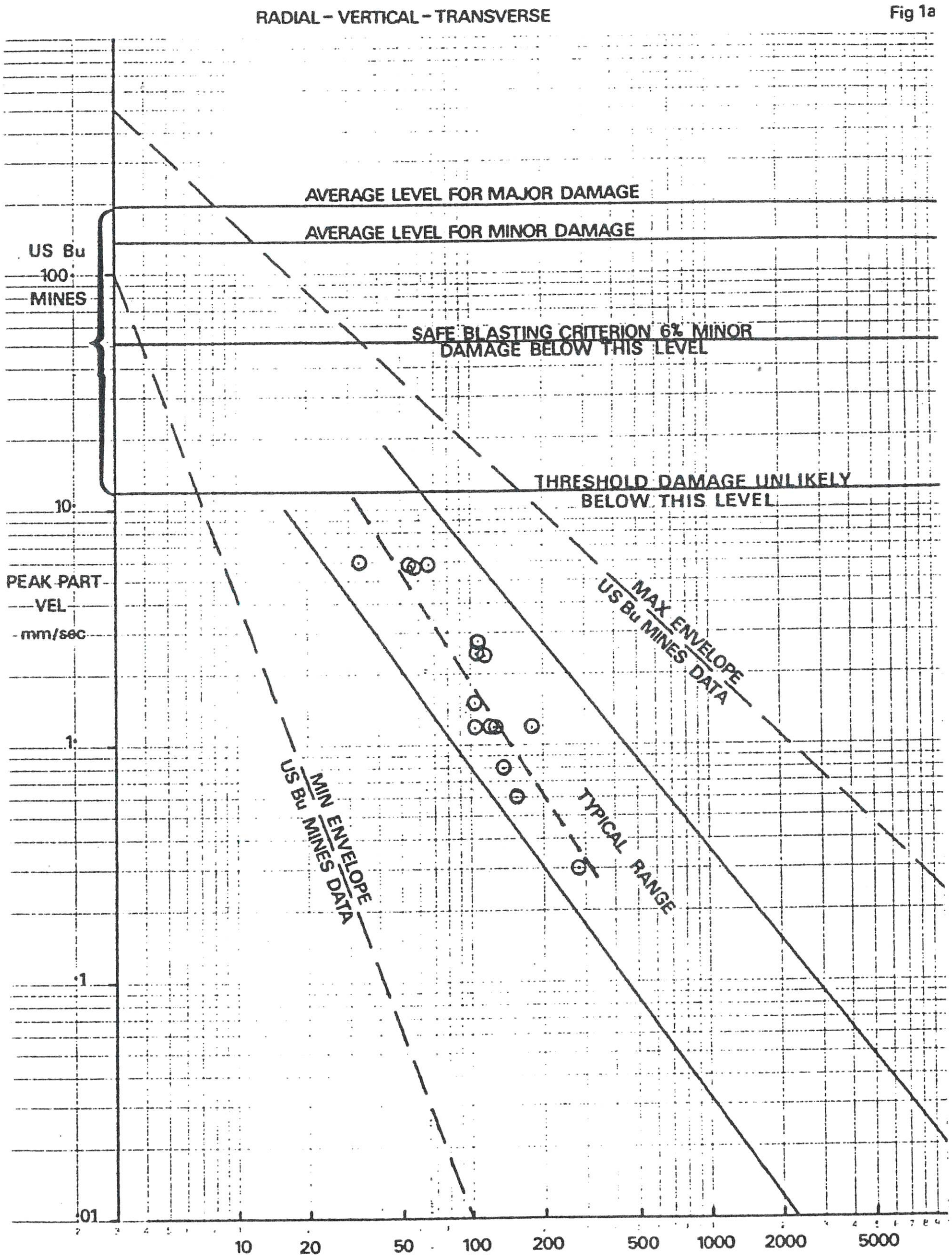
H. R. Nicholls et al — US Bu Mines — Bulletin 656

D. E. Siskind et al — US Bu Mines — R1 8485

C. H. Dowding — "Blast Vibration Monitoring and Control" Prentiss-Hall.

MINE & QUARRY BLASTING VIBRATION

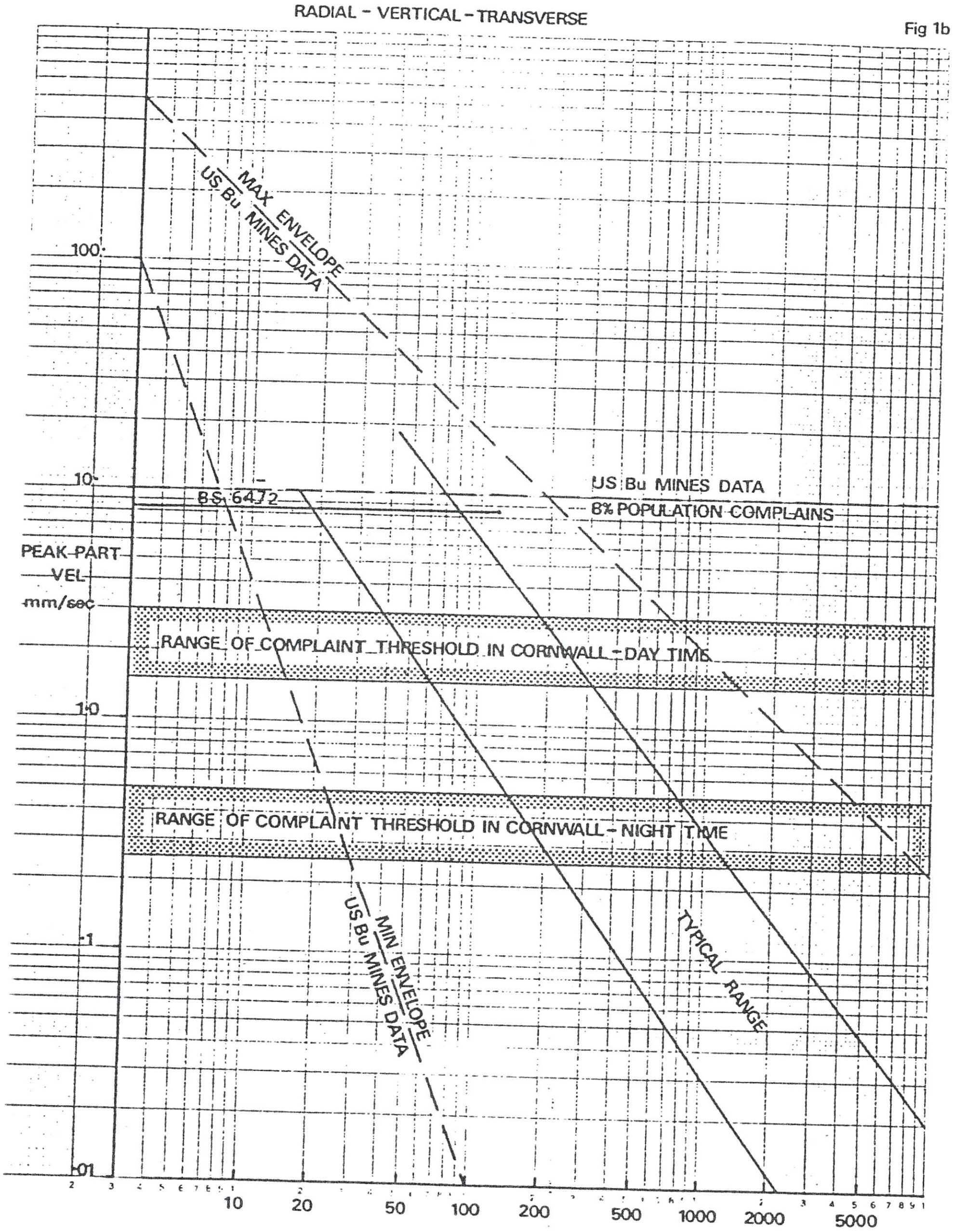
DAMAGE CRITERIA AND TYPICAL RANGE OF MEASURED LEVELS IN CORNWALL



$$\text{SCALED DISTANCE} = \frac{\text{SOURCE - RECEIVER DIST}}{\sqrt{\text{INST CHARGE WT}}} \quad \frac{\text{ft}}{\sqrt{\text{lb}}} \text{ or } \frac{2{\cdot}21\text{m}}{\sqrt{\text{kg}}}$$

MINE & QUARRY BLASTING VIBRATION

COMPLAINT THRESHOLDS AND TYPICAL RANGE OF MEASURED LEVELS IN CORNWALL



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QUARRY BLASTING
AIR BLAST LEVEL AND EFFECT ON STRUCTURES

TEMP INVERSION AND/OR WIND GRADIENT CAN INCREASE LEVELS BY UP TO 40dB. LESSER VARIATION A COMMON OCCURRENCE

Fig 2