Thomas Schrüllkamp and Jan-Welm Biermann, Aachen with Karl-Hans Kromer, Bonn

Noise from farm machinery

Presented using the Amazone Airplanter ED 451 K

An analysis of noise created by pneumatic precision drills gave values of 96 dB (A) at 3 m distance. The suction fan was identified cause of the noise. The highest level of noise intensity was measured at the fan outlet. The noise emission increased with increasing fan speed and the dominant frequencies could be traced back to the multiples of the pto revolution frequency. Currently, noise reduction measures, and their applicability for other implements, are being investigated within a research project supported by the Federal German Environmental Foundation.

Dipl..Ing. Thomas Schrüllkamp is a member of the scientific staff and section leader at the Institute for Powered Vehicle Studies (ika), RWTH Aachen, 52056 Aachen; e-mail: schruellkamp@ika.rwth-aachen.de
Priv.-Doz. Dr.-Ing. Jan-Welm Biermann is academic director and director of the educational sector Vehicle Accoustics at ika.
Prof. Dr.-Ing. Karl-Hans Kromer is director of the Institute for Agricultural Engineering, Bonn University.

Keywords
NVH, sound emission, acoustic, air spacing seeders

Up until now, emissions in agricultural production and land utilisation have almost entirely been investigated as materialistic emissions, in solid, gaseous and liquid form and defined as damaging according to the exceeding of threshold values, and thresholds determined according to evidence. Remaining, to a large extent, unconsidered up until now are non-material emissions in the form of noise and electromagnetic radiation. Of greater importance here is noise emission in that often long periods of noise production at levels above long-term noise level of 80 dB (A) determined by health authorities occur during agricultural operations. The long pauses of quiet necessary for the recovery of the human hearing system are not conformed with because of the long working periods involved in farm work. Thus noise emission is often the source of tiredness, poor performance and health stresses for the labour personnel as well as others in the countryside.

The effect of noise on organisms is mainly judged through its interaction with humans. Regarding the damaging results, basically the dose-effect principle is applied whereby the dose is the product of noise pressure and its length of time and the effect represents the resultant damage.

This report concerns noise emission and the analysis of noise from farm machinery based on the example of a pneumatic precision drill. In standardised farm tractor, implement and equipment test procedures the noise emission is determined only within the framework of the OECD-test for tractors and the DLG fan noise test. According to these, the fan noise with pneumatic sowing implements (compressed air principle) is 78 to 83 dB (A), for cereal precision drills (vacuum principle) 83 to 95 dB (A), for vegetables 78 to 88 dB (A), and for pneumatic drills 79 to 92 dB (A). Alongside the absolute noise stress level, its effective duration (DIN 45645), and the duration of the associated quiet period for the recovery effect (EG guideline 77/311, EWG noise level) is problematical.

A comprehensive noise analysis of farm implements is required for noise reduction. For the noise analysis, a difference is made basically between oscillations in the air (air noise) and in solid objects (object noise). The noise can be emitted from source as direct air noise, or over neighbouring constructional parts as indirect air noise. In the case of indirect air noise the oscillations are transferred further as object noise and, e.g., radiated from large areas of sheet metal. In general, for the assessment of noise emissions the noise variation effect p is measured and given as evaluated noise effect level in dB (A) (decibel-A). The calculation takes place thus:

$L_P = 20 \cdot \log p/p_0$

with $p_0 = 2 \cdot 10^{-5}$ Pa

Hereby, p_0 is the noise effect delivered at the point of hearing. The human ear recognises noise signals not only as amplitude but also much more according to their frequencial composition. Hearing is especially sensitive in the frequency range from 3500 Hz to 4000 Hz within which noise effects with the same effective noise level at low frequencies are

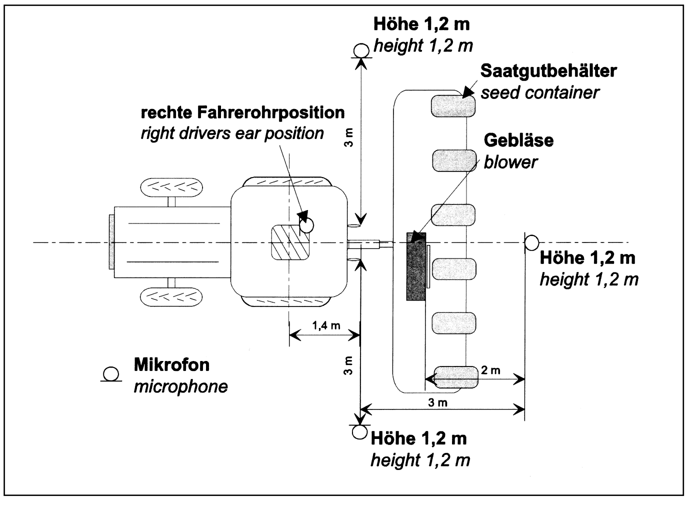

Fig. 1: Construction stationary measurement

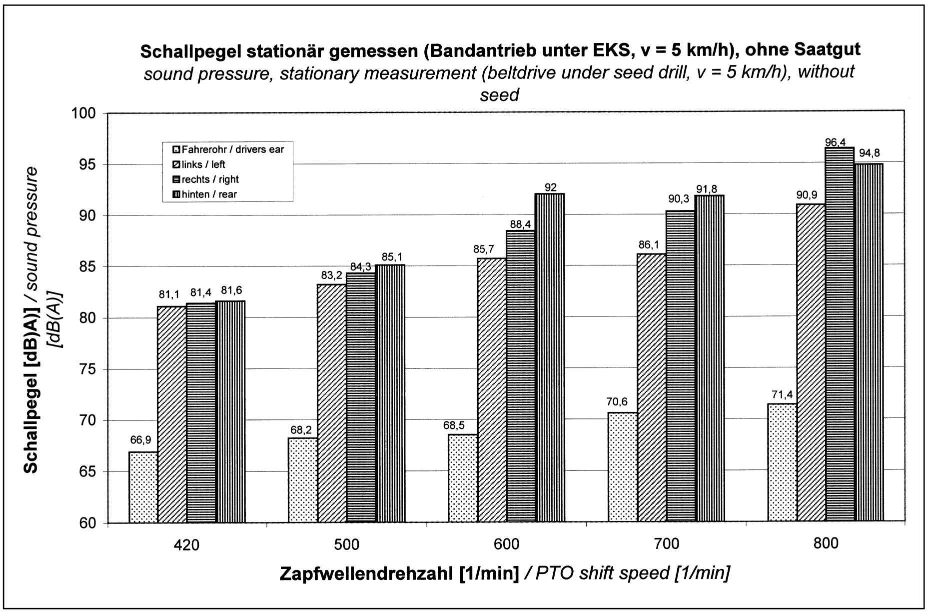

Fig. 2: Soundpressure influenced by PTO-shift-speed

experienced as less loud. These frequency-associated properties of the human ear are taken account of through the A-evaluation. The noise nuisance-effect is dependant on the noise pressure as well as from the frequencial composition. The dose depends on the length of time of the effect. In this sector of work science, physical effects already appear from 65 dB (A) and temporary reduction in hearing occurs at over 85 dB (A). Working places with a noise pressure of over 85 dB (A) put hearing at risk ear protection is mandatory under injury prevention regulations.

With this background, a research project supported by the Federal German Environmental Foundation and the agricultural machinery industry was initiated with the aim of reducing farm machinery noise emission and its associated stress for humans and the environment. As a first step in the noise analysis, the noise emission of a stationary precision drill linked to a tractor was measured. The noise pressure in association with pto speed and driving speed was recorded by tape from different positions (*figure 1*). Here, the filling of the seed hopper was also taken account of.

Figure 2 indicates the related noise level values. Whereas the highest noise level (up to 96 dB (A)) were recorded behind and to the right of the fan outlet, the sound-insulated cabin meant that the lowest values (~70 dB (A)) occurred at the driver position. The noise level was to the largest extent independent of speed of travel, and increased with increasing pto revolutions. Filling the seed hopper resulted in a noise level increase of around 2 dB (A).

For more intensive investigations of noise levels during practical application, field trials were carried out in the form of measurements made with the implements driving past a recording point. Here, the results of the stationary measurements were confirmed. In actual working conditions, the drill had a higher noise level compared with the tractor. Here, the main noise source at the precision drill was the vacuum fan. The results of the measurements with and without the fan indicate that, without the fan, the noise level at both sides were almost identical at around 72 dB (A). If the fan was activated, the level at the left rose to around 81 dB (A) and around 88 dB (A) at the right hand side. Additionally, the fan had also a special effect in the noise level at the driver's ears which means that the reduction of the fan noise emissions is of great importance not only in relation to the environment but also especially in relation to protection during work.

Main source fan outlet

In order to be able to analyse the fan noise emission more intensively, further measurements of noise pressure levels and noise intensity were carried out with the disconnected fan unit in ika's low-reflection noise measurement laboratory. The test station investigations showed that the noise level increased in association with increasing revolutions. The fan covering was dismantled in four sequential steps in this trial series. The noise level, however, was only slightly altered so that one can assume that parts of the covering oscillating in sympathy with the noise do not apply as reasons for the extremely high noise level. The different noise sources of the vacuum fan were investigated by intensity measurements. These showed that the highest intensity value was reached at the fan outlet canal, and this point was able to be identified as the main noise source. The canal is situated on the right hand side of the fan which also explains the higher noise levels measured on the right side of the implement during the field trials.

From the frequency analyses of the noise pressure measurements in working conditions (n_{zw} = 700 min^{-1}) were determined the dominating frequencies of 681 Hz, 1366 Hz, 2034 Hz and 2709 Hz (*figure 3*). The frequencies can be attributed to the rpm speeds of the fan blades. The vacuum fan had a 10-blade fan ($n_{Flügel}$ = 10) which, with a translation ration of i = 3.88 is driven via the pto. Typical operational frequencies were:

$f = f_{zw} \cdot i \cdot n_{Flügel}$

with $f_{zw} = n_{zw}/60$ (Hz) pto revolution frequency

The dominant frequencies represented the multiples of the fan operational frequency f; these are in the order of 1.5, 3.0, 4.5 and 6.0. Thus the noise emissions of the drill could definitely be attributed to the air noise emission of the vacuum fan. The current noise reduction actions which concentrate on the fan are based on this result. The aim is to reduce the noise level by at least 7 dB (A) through selective alterations on the fan.

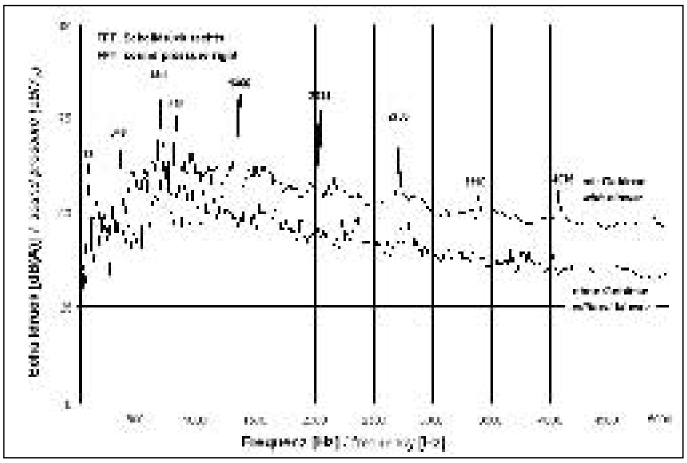

Fig. 3: Fequency analyisis sound pressure right side