Airborne noise, structure-borne sound (vibration) and vacuum stability of milking systems

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ABSTRACT: Problems with milking and udder health can be attributed to the following causes: (1) sound intensity level (noise) > 65 dB in the milking area, (2) transmission of oscillation (vibration) > 0.3 m/s^2 to the body of the cow in the milking parlour, (3) transmission of severe oscillation (vibration) into the vacuum system, (4) assembly and installation faults causing fluid flow problems and hence pressure fluctuations in the vacuum system. By combining technical alterations to a practical unit with the fitting of the Vibrations-schlucker®, it was possible to significantly improve vacuum stability. At the same time noise dropped to one quarter of the original level and vibration was reduced by a factor of five. A significantly reduced working time requirement testified to more pleasant conditions for humans and animals. The results show that the installation requirements according to ISO 5707 (1996) have gaps here. Further studies should specifically define the comfort limits for humans and animals in milking parlours.

Keywords: milking; stress; milking machine; air-borne noise; structure-borne noise; vacuum stability

Cows achieve their full yield potential only in the environment where they feel comfortable. The milking parlour plays an essential role in shaping this environment. Even when milking machines are installed according to ISO 5707 (1996), operators of new milking parlours often notice not only the advantages but also signs indicative of unfavourable conditions:

– Cows are unwilling to enter the milking parlour.
– Cows defecate before entering the milking parlour or during milking.
– Cows are restless and knock the milking units off.
– Cows do not allow their udders to be emptied completely.
– The milker feels unwell and stressed during and after milking.

The results of our measurements and studies over the past two years show that these behavioural changes can be caused by airborne noise and structure-borne sound (vibration) – phenomena to which little attention has been paid until now (Nosal and Bilgery, 2001a,b).

Noise and vibration can be unpleasant for humans and animals and can even have a negative influence on the vacuum stability of the milking system.

MATERIAL AND METHODS

Tolerance limits of noise and vibration

Limit values in the human sphere are minutely regulated by standards and regulations to meet particular needs (ISO 2631-1, 1997). However, no information is available in the sphere of farm animals at all. Vets and ethologists agree that animals are just as sensitive as humans. Sensitivity in animals assumes even greater importance when optimum yield is at stake.

Art. 34, paragraph 2 of the Swiss Ordinance on Accident and Occupational Disease Prevention

Table 1. Activity-related standard values according to the Swiss National Accident Insurance Organisation (Suva, 1997)

Activity	Equivalent continuous sound intensity level L_{eq} in dB (A)	
	minimum requirement	increased requirement
Group 1: Industrial and commercial activities	85	75
Group 2: General office activities and comparable production and supervisory activities	65	55
Group 3: Predominantly intellectual activities demanding a high degree of concentration	50	40

stipulates (Suva, 1997) that: "Technical installations and equipment must be designed, fitted, arranged, maintained and operated so as to preclude any risk to health or safety from noise or vibration".

Table 1 shows that the equivalent continuous sound intensity level for a milker working in a milking parlour would have to be below 75 dB (A).

With reference to vibration (structure-borne sound), ISO Standard 2631-1 (1997) gives the following standard values for the human sphere:

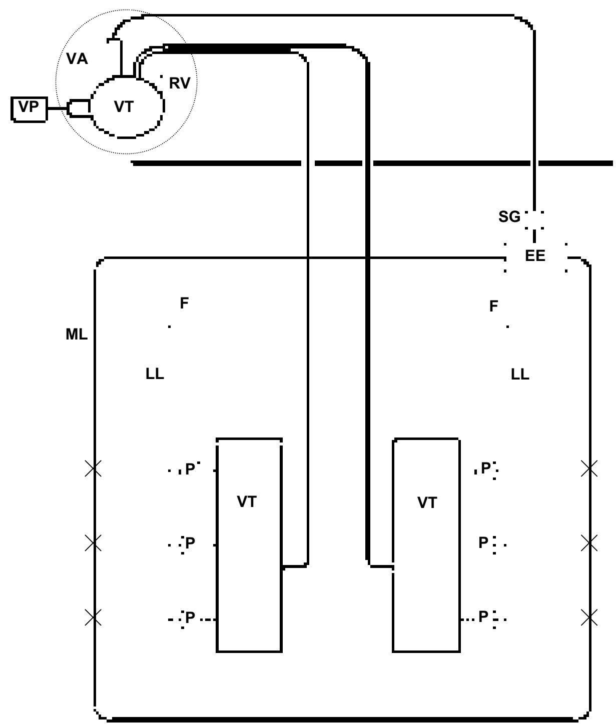
below 0.315 m/s^2	not uncomfortable
0.315 to 0.63 m/s^2	very slightly uncomfortable
0.5 to 1 m/s^2	slightly uncomfortable
0.8 to 1.6 m/s^2	uncomfortable
1.25 to 2.5 m/s^2	very uncomfortable
above 2 m/s^2	extremely uncomfortable

Therefore the maximum values for structure-borne sound should not exceed 1.6 m/s^2.

Vacuum stability

The ultimate objective of any milking unit is a stable vacuum from the air line to the claw and the teat end.

Vacuum stability is influenced chiefly by the dimensioning, installation and functional efficiency of the individual components – vacuum pump, line system, regulator, pulsators and milking unit. No better result can be expected at the teat end or in the teat cup if the desired vacuum stability is not first achieved in the vacuum and milking system.



Legend:
LL – air line
ML – milking line
SG – safety glass
EE – end unit
RV – control valve
VT – vacuum tank
VP – vacuum pump
P – pulsators
F – filter
VA – vibration absorber
× – connection points for milking units

Figure 1. Schematic representation of the redesigned milking system

The same sources (vacuum pump, regulator, pulsators) are often responsible for milking parlour noise, structural vibration and the formation of pressure waves, vibration and noise in the vacuum and milking system, thus negatively affecting vacuum stability.

A 2 × 3 herringbone milking parlour with six milking units was used to demonstrate the effect on noise, vibration and vacuum stability achieved by adapting the installation and a newly developed functional milking unit component, the "Vibrationsschlucker" (a vibration absorber invented by E. Bilgery) (Nosal and Bilgery, 2001a, b).

The original milking unit was dimensioned and installed in accordance with ISO 5707 (1996) (Milking Unit Design and Performance) and the internal guidelines of the installation company (Nosal, 2000). It should be noted that to date ISO 5707 (1996) includes no instructions or data defining the connection between installation and design with noise and vibration or giving the tolerance values.

Figure 2. The invention of E. Bilgery: Der Vibrationsschlucker

RESULTS AND DISCUSSION

Figure 1 shows the redesigned milking unit. Vacuum stability was improved and noise and vibration were reduced by taking the following measures:

- using flexible hoses to connect the vacuum pump to the vacuum tank
- fitting a special device called the "Vibrationsschlucker" (vibration absorber) after the vacuum tank. This special device incorporates the control unit *inter alia,* and supplies vacuum to the terminal unit and one or more pulsator buffer tanks (Figure 2)
- fitting separate buffer tanks between the air line and pulsator
- vibration-damping suspension of the air line and suspending the buffer tank/s on straps
- securing the pulsators with flexible, damping hoses

Before modification the noise in the milking box reached values of 78.7 dB(A) with the pulsators running. Following the design innovations and modifications to the installation, airborne sound (noise) in the milking box was reduced by around 20 dB to 59.6. A 10 dB reduction in airborne sound means halving the original noise.

In the milking parlour surfaces coming into contact with cows (excrement plate, neck pipe etc.), vibration in the original installation reached values of 0.48 m/s^2. Maximum values of 0.15 m/s^2 were measured in the redesigned unit. The measurements were taken with a Brüel + Kjaer "Integrating Vibration Meter", using software specially made for frequency analysis.

The redesign of the milking unit also significantly affected vacuum stability. Figure 3 shows the changes in the range of vacuum stability in the air line (ISO 6690, 1996). The milking line also presented a similar picture. Taking the air line as an example, Figure 4 shows the vibration amplitudes at different frequencies before and after modification of the milking unit. Frequency analysis (Fourier) helps to ascertain the problem sources.

It can be assumed that the milker's behaviour, peace of mind and contentment decisively influence the milking process and hence the well-being of the cows, their amenability to milking and the quality of their milk.

Milking on the experimental farm was carried out very professionally, even prior to technical optimisation.

However, the milker felt uneasy going into the milking parlour, felt his cows to be ill at ease, and

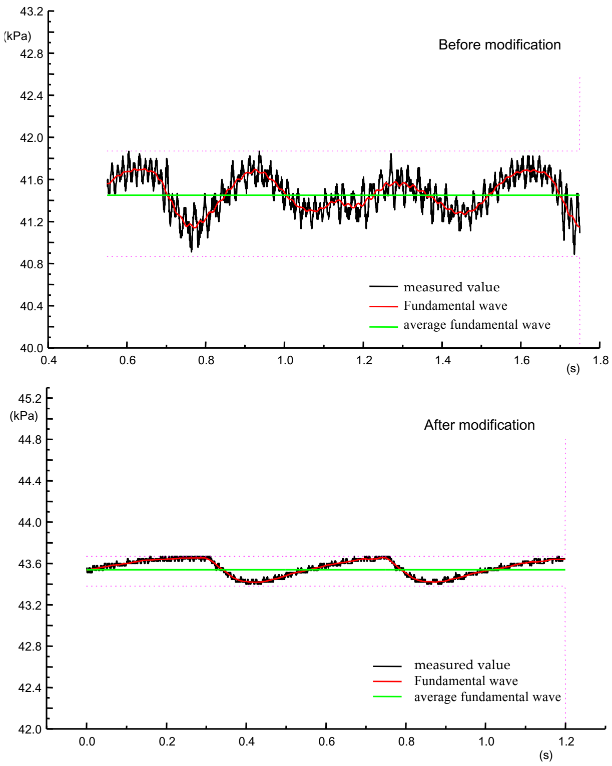


Figure 3. Vacuum stability in the air line before and after modification of the milking system

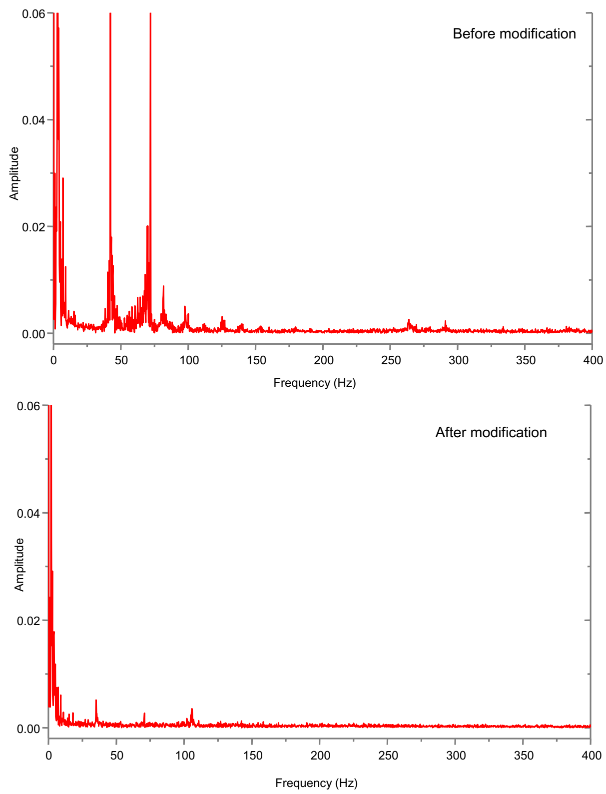


Figure 4. Vibration amplitudes at different frequencies before and after modification of the milking unit

was hardly able to talk to anyone in the milking parlour. The positive change in the milker's well-being is also supported by work organisation studies.

Before the modification the milker put a lot of effort into fore-milking and preparation, the total time required for routine work being 1.6 man-min while 37 cows per hour were milked.

After the modification the time required for fore-milking and preparation, i.e. the total time required for the routine work, fell significantly to 1.5 manpower-min (MP-min) and the number of cows milked increased to 39 per hour. This means that the technical optimisation made the cows more amenable to milking.

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ABSTRAKT

Hluk šířený vzduchem, zvuk šířený pevnou hmotou (vibrace) a stabilita podtlaku v dojicích zařízeních

Problémy kolem dojení a zdravotního stavu mléčné žlázy lze připisovat těmto příčinám: (1) hladina intenzity zvuku (hluk) v dojicím prostoru > 65 dB, (2) přenos chvění (vibrací) na tělo dojnice v dojírně > 0,3 m/s^2, (3) přenos silného chvění (vibrací) do sacího potrubí, (4) montážní a instalační nedostatky, které způsobují problémy s průtokem kapaliny, a tedy kolísání tlaku v sacím potrubí. Kombinací technických změn na dojicím stroji a namontováním tlumiče vibrací Vibrationsschlucker® se podařilo významně zvýšit stabilitu podtlaku v sacím potrubí. Hluk zároveň klesl na jednu čtvrtinu původní hladiny a vibrace se snížily o koeficient 5. Významně nižší potřeba pracovního času dokumentovala příjemnější podmínky pro lidi i zvířata. Výsledky naznačily, že v požadavcích na instalaci podle ISO 5707 (1996) jsou mezery. Další studie by měly podrobněji definovat hranice komfortu pro lidi i zvířata v dojírnách.

Klíčová slova: dojení; stres; dojicí stroj; hluk šířený vzduchem; hluk šířený pevnou hmotou; stabilita podtlaku

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