HEARING DAMAGE BY COCKPIT NOISE IN MOTOR GLIDERS

"From motor glider to hearing aid"

By Uwe Stüben, M.D.
Deutsche Akademie für Flugmedizin
Akademische Fliegergruppe FrankfurVMain
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SUMMARY:

Background: Over the past fifteen years touring motor gliders and gliders with retractable propulsion units have developed with incredible speed. More than 1/3 of the annual glider production is delivered by the manufacturers with retractable propulsion units. These glider constructions in particular are equipped with two stroke engines resulting high frequency sound emissions. Due to the requirements of the sound insulation regulations, all powered gliders are optimized to avoid sound emissions especially with regards to the anti-noise lobby living near airfields but they are not optimized to avoid noise in the cockpit. To find out the noise level in the cockpit of those powered gliders and how it affects the hearing of the pilots, the cockpit noise of 6 touring motor gliders and 8 gliders with retractable propulsion units were measured.

Results: Both types of motor gliders are too loud for pilots and may become hazardous to their hearing if they are not equipped with personal noise protection. In extreme cases an exposure time of 20 seconds to the cockpit noise of a glider with retractable propulsion unit may cause permanent hearing damage.

Conclusion: Pilots must be warned to not fly motor gliders without personal noise protection.

INTRODUCTION:

Over the past fifteen years self launching gliders with retractable propulsion units have developed with incredible speed. More than 1/3 of the annual glider production is delivered by the main manufacturers with retractable propulsion units. These glider constructions in particular are equipped with two stroke engines resulting in high frequency sound emissions. Due to the requirements of the sound insulation regulations, all powered gliders are optimized to avoid sound emissions especially with regards to the anti-noise lobby living near airfields but they are not optimized to avoid noise in the cockpit. The negative and painful effects which I experienced with my own powered gliders since 1981 have led me, over the past two years, to analyze a representative cross section of 14 motor gliders from various manufacturers for their cockpit noise and to assess the result for the pilots.

METHOD:

This analysis measured the interior noise level in the cockpit of 6 most common motor touring gliders and 8 powered gliders with retractable propulsion units.

Cockpit noise of motor touring gliders was measured for the following designs. Grob 109 B - Motorfalke SF 25 C - Dimona HK36 MR2 - Taifun 17 E Super Dimona HK 36 – ASK-16

Fig. 1 - Motor touring glider

In these motor touring gliders the pilots sit in dual seats beside each other. The propeller and engine are situated in the nose in front of the pilots. The propeller is approximately 1 m away from the pilots ear. The engines are either 4-stroke Limbach engines or 2-stroke Rotax 91 2S.

The noise in the cockpit was measured at the level of the pilot's ear at various values of engine power: idling, cruising speed and starting level.

In the same way, interior noise was measured in 8 powered gliders with retractable propulsion units, of which one was a self sustaining "Discus CT". All the others were powered gliders with retractable propulsion units and self launching capability.

Cockpit noise was measured for the following designs: ASW-22 BE – ASW-24 E – ASH-25 M – ASH-26 E - Nimbus 4 M - Ventus 2 CM DG-400 - Discus CT.

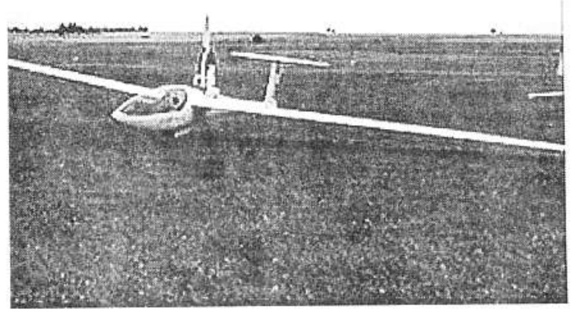


Fig. 2

It is a particular characteristic of gliders with retractable propulsion units that the engine is situated either immediately behind the back of the pilot's seat and the propeller disc area is only a few centimeters behind and above the pilot's head when the engine is running. In older models, such as ASW-22 BE, Nimbus 4 M or DG-400, the engine is also unfolded and located together with the propeller area, directly above and behind the pilot's head.

All noise measurements were made with an integrating impulse sound-level meter DIN IEC 651 Class 2, Brüel & Kjaer, type 226, using the slow mode measurement procedure. The permissible variation of a sound-level meter of this kind is a maximum of ± 1,0 dB, thus allowing a reliable reading as to the sound hazard in the cockpit (2; 5).

For the purpose of medical assessment, noise is defined as sound consisting of a mixture of frequencies, which may damage the hearing or lead to particular accident hazards (4; 7). Such sound is expressed as an instantaneous value of sound-pressure levels measured in decibels A. A is the corresponding DIN-IEC 651 frequency level of sound. It is necessary because a person's hearing ability is less for very low and very high frequencies, compared with the middle range of the audible frequency spectrum.

The sound-level meter used is fitted with a built-in measurement Filter A analogous to this lowering of auditory capability. By means of this filtering characteristic, the objective sound-pressure measurement produced by the meter is adapted to a person's auditory impression (1;4;5).

Since not all motor gliders available on the market were measured, the results of these measurements cannot be generalized. Due to the same type of construction it can be assumed that the results of the cockpit noise of those motor gliders, which were not measured, are very similar.

RESULTS AND DISCUSSION:

Touring motor glider

type	reg.-no.	motor	rev/min	cockpit noise	
Grob G 109 B	D-KDBA	Limbach 80 PS	1500 U/min 2200 U/min 2500 U/min	 + radio	85 dB(A) 92 dB(A) 95 dB(A) 110 dB(A)
				seat left	seat right
Super Dimona HK 36	D-KAWS	Rotax 912 80 PS	1500 U/min 2200 U/min 2500 U/min	90,0 dB(A) 95,0 dB(A) 100,0 dB(A)	89,5 dB(A) 95,0 dB(A) 102,0 dB(A)
Dimona HK 36 MK 2	D-KADA	Limbach 2000 80 PS	1500 U/min 2500 U/min 2700 U/min	87,0 dB(A) 95,0 dB(A) 98,0 dB(A)	87,0 dB(A) 97,0 dB(A) 105,0 dB(A)
Scheibe C - Falke	D-KAMM	Limbach 80 PS	1500 U/min 2700 U/min	90,0 dB(A) 103,5 dB(A)	91,5 dB(A) 101,5 dB(A)
Taifun 17 E	D-KGAN	Limbach L 420 00 EB1B 80 PS	1000 U/min 2600 U/min 3000 U/min	77,5 dB(A) 93,0 dB(A) 100,0 dB(A)	77,5 dB(A) 95,0 dB(A) 105,0 dB(A)
ASK 16	D-KFWP	Limbach 80 PS	1300 U/min 2300 U/min 2700 U/min	85,0 dB(A) 99,5 dB(A) 106,0 dB(A)	85,0 dB(A) 99,5 dB(A) 106,0 dB(A)

Table 1

Motor glider with retractable propulsion unit

type	reg.-no	motor	rev/min	cockpit noise	
				front seat	rear seat
ASH 25 M	D-KONI	Midwest 50 PS	5000 U/min 6800 U/min 7200 U/min	98 dB(A) 100 dB(A) 102 dB(A)	102 dB(A) 104 dB(A) 106 dB(A)
ASH 26 E	D-KWST	Midwest 50 PS	4000 U/min 6300 U/min		97,5 dB(A) 103,5 dB(A)
ASW 22 BE	D-KWES	Rotax 505 A	6700 U/min		109 dB(A)
ASW 24 E	D-KIMK	Rotax 24 PS 275 MK/TW, 7188	2800 U/min 7000 U/min		98,5 dB(A) 106 dB(A)
Nimbus 4 M	D-KOJO	Rotax 505 A	6300 U/min		117 dB(A)
Ventus 2CM	D-KBVB	Solo	idle full power		100 dB(A) 110 dB(A)
DG 400	D-KOBE	Rotax 505	3000 U/min 5800 U/min 6100 U/min		92 dB(A) 106 dB(A) 111 dB(A)
Discus CT	D-KKAX	Solo	full power		103 dB(A)

Table 2

Results showed noise pollution levels at the level of the pilot's ears in the cockpits of all motor gliders with retractable propulsion units amounting to more than 100 dB (A). The noisiest of these gliders produced 117 dB (A) in starting mode, even the quietest produced 103 dB (A). Only in the front seat of the ASH-25 M were lower levels of 100 dB (A) measured at starting speed.

On the other hand, the motor touring gliders had somewhat quieter cockpits. However, at starting speed none of these motor gliders showed a noise level of less than 100 dB (A). Levels for the quietest motor touring glider at starting speed were 100 dB (A), those of the noisiest 106 dB (A). At cruising speed, noise pollution in these motor gliders dropped to 92 dB (A) for the quietest and to 99.5 for the noisiest.

To assess the effect of the noise level on the pilot, account must be taken of the different way in which motor gliders with retractable propulsion units and motor touring gliders are flown. Gliders with retractable propulsion units and self launching capability are mainly designed for gliding. A start using the engine lasts on average 10 minutes. Intermediate engine use in the case of thermal calms as a rule only lasts a few minutes, in order to find thermal again. Longer engine running times are as a rule only for home flights, following abandoned gliding exercises in the evening, after thermal lift is no longer available, or for longer transfer flights. In this process, flight is by "saw-tooth flying," i.e. the engine is only needed for climbing. When the machine has reached the necessary height under power, the subsequent flight is made in gliding mode without the engine, in order to exploit the good aerodynamic properties of a glider for a maximum flight time and distance. If the pilot uses a glider with a retractable propulsion unit reasonably, the ratio of time under power to gliding time will be about 1: 10. In this way permanent exposure times to cockpit noise for a pilot in a glider with retractable propulsion unit will be relatively short, as a rule between 5 and 20 minutes.

A motor touring glider, on the other hand, is primarily designed for motor flight and is flown relatively seldom in pure glider mode. For this reason permanent noise exposure times for the pilot in the cockpit are relatively long, between 1 and 4 hours, depending on the flight.

According to the current regulations of the industrial accident insurance companies, a 'noisy area' is defined as a place with a noise level where there is a risk of damage to hearing, because the worker at this place is exposed to a permanent sound level of 90 dB (A) or more for over 8 hours (1; 5).

Human hearing, from sound just audible to the human ear (auditory threshold) up to the level of sound just bearable without pain (level of pain), covers an enormous area of intensity (4).

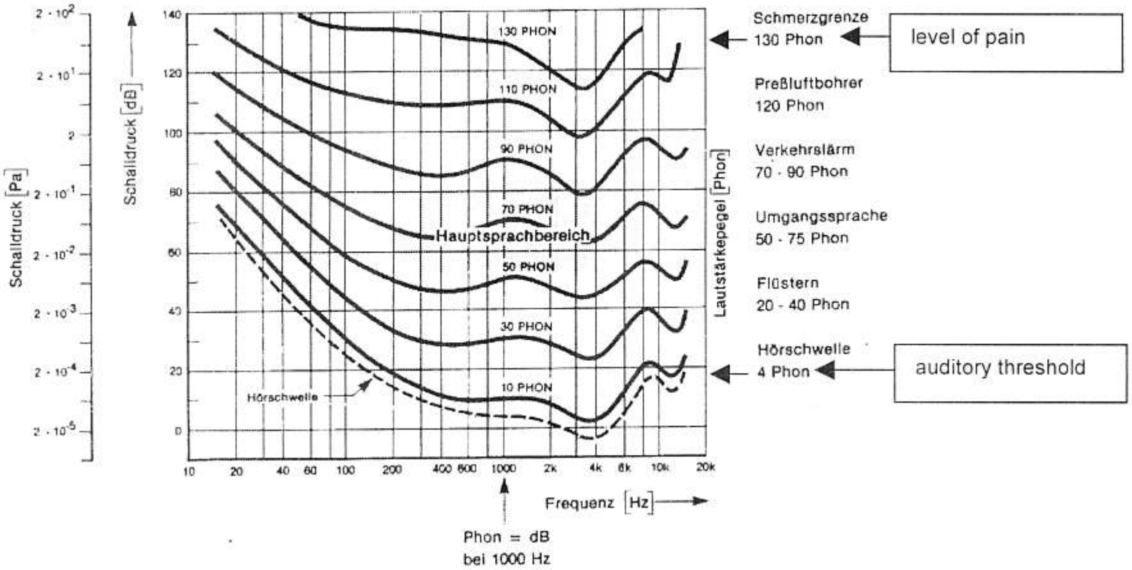


Figure 3. Human hearing from the auditory threshold to the level of pain.

Man's hearing assesses any change in sound on a logarithmic ratio. For this reason, when measuring noise affecting the hearing of a person at his or her workplace, a noise level is calculated using logarithms for the ratio of sound intensity measured to a defined reference sound-intensity (sound intensity at auditory threshold (1; 4; 5).

On this scheme the sound intensity level is

$$L_I = 10 \bullet \log \frac{I}{Io} \text{ dB}$$

I = measurement sound intensity Io = reference sound intensity of auditory threshold

From this definition of the sound-intensity level it can be deduced that, if the sound intensity is doubled, the level will rise by 3 dB.

$$L_{I\,ges} = L_{I\,M1} + L_{I\,M2}$$

$$= 10 \bullet \log \frac{I_{M1}}{Io} + 10 \bullet \log \frac{I_{M2}}{Io}$$

$$= 10 \bullet \log \frac{I_{M1} + I_{M2}}{Io}$$

at

$$L_{IM1} = 90 \text{ dB (Engine I)}$$
$$L_{IM2} = 90 \text{ dB (Engine II)}$$

$$L_{Iges} = 10 \bullet \log \frac{2 \cdot I_{M1}}{Io}$$

$$= 10 \bullet \log 2 + 10 \bullet \log \frac{I_{M1}}{Io}$$

$$= 10 \bullet 0{,}3 + 10 \bullet \log \frac{I_{M1}}{Io}$$

$$L_{Iges} = 3 + L_{M1}$$

$$= 3 + 90$$

$$= 93 \text{ dB}$$

For example, if the first engine is started in a twin-engined aircraft, developing a sound intensity M1 with 90 dB, when the second engine is started, adding M_2 = 90 dB at the same number of revolutions, then the total noise level rises to 93 dB.

And vice versa: if, in the same way, the sound intensity is halved, then the sound level decreases by 3 dB.

If it is asked whether a particular noise effect is hazardous to the hearing or not, then - given the relatively constant cockpit noise in the aircraft measured reference can be made in a rough way to assessment tables from occupational medicine.

These tables assume that a constant noise exposure of 85 dB (A) at the workplace, during full shift work over 8 hours per day and five days a week, will very probably lead to permanent hearing damage. On a basis of energy equivalence for the assessment threshold of 85 dB (A), the table shows assessment-level time-exposure coordinates, demonstrating the same risk of hearing damage at higher sound intensities (1; 5).

Assessment level	**Permitted exposure time**	
dB (A)	min	sec
85	480	
88	240	
91	120	
94	60	
97	30	
100	15	
103	7	:30
106	3	:45
109	1	:50
112	0	:56
115	0	:28
118	0	:14

Table 3 - Assessment level - Time exposure coordinates

From this it can be seen that, if the sound intensity is doubled, i.e. if the assessment level rises by 3 dB (A), permitted exposure time is halved in each case.

If we use these assessment-level time-exposure coordinates to analyze the measurements for the different motor gliders, then it will be seen that, because of the noise exposure in the cockpit, the hearing of the pilot exposed to such noise is undergoing a considerable hazard if he is not wearing ear protectors (1; 5; 6).

Accordingly, for the most noisy glider with retractable propulsion unit, showing 117 dB (A) of cockpit noise, an exposure time of 20 seconds without ear protectors would be enough to lead to permanent hearing damage. Given a starting time of ten minutes, such hazardous noise exposure would be thirty times too high and would be associated with immediate permanent hearing damage to the pilot. Even the most silent retractable-propulsion glider has 103 dB (A) of cockpit noise, and pilots in this cockpit must expect permanent hearing damage after a constant exposure of about 15 minutes.

Therefore, as regards normal ranges of use for gliders with retractable propulsion units, it can be seen that these machines may seem quiet and environmentally friendly from the outside, with their emission levels of around 60 dB (A), but in the cockpit for pilots flying without ear protectors they are very dangerous and are almost certain to cause permanent hearing damage.

There is a similar hazard for pilots of motor touring gliders, which, it is true, have quieter cockpits, but which, by virtue of their type, are flown under power for considerably longer.

For the most noisy motor touring gliders considered in these measurements, showing 106 dB (A) in the cockpit at starting speed, a maximum exposure time of 7.5 minutes would apply, and at 99.5 dB (A) when cruising a maximum exposure time of about 20 minutes. For a flight of only 1 hour these exposure thresholds will be three times higher and certainly causing hearing damage to the pilot.

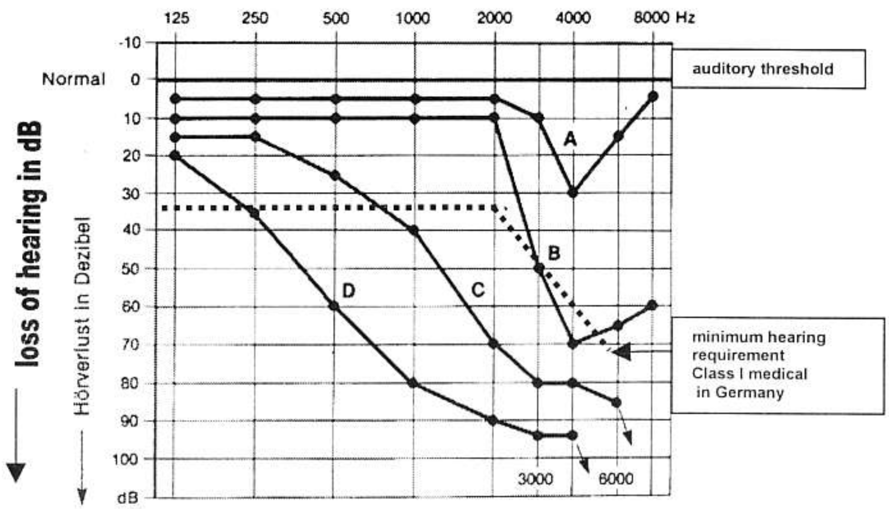
For even the most silent motor touring glider, showing 100 dB (A) in the cockpit at starting speed, the maximum noise exposure time should still be no more than 10 minutes, and at 92 dB (A) during cruising a maximum exposure time of 100 minutes.

A flight lasting two hours in this motor glider will certainly exceed the threshold and the pilot must expect permanent hearing damage.

In the most silent motor glider additional maximum noise levels of up to 110 dB (A) were measured during radio reception via the cockpit loudspeaker. The pilot had to turn up the volume control of the radio to high so that the radio messages could be understood properly and clearly distinguished from the cockpit noise. It would take only 3 minutes of radio communication under these conditions during a long flight to reach the maximum noise exposure time for the pilot.

Hearing damage can be shown in the cases of pilots who have undergone lengthy noise exposure by using sound-threshold audiometry, of the kind prescribed for commercial pilots at every medical in Germany.

If permanent hearing damage has occurred, then one finds typical reductions of the auditory threshold in the frequency ranges concerned (5; 3).



Hearing ability with audiogram

Hearing loss in decibels

A) Normal hearing

B) Initial signs of deafness

C + D) Pronounced deafness

Figure 4

In cases of repeated damage, the consequence is extreme deafness of the pilot, making the use of a hearing aid a necessity (1; 5; 6).

In such cases, the flying capability of even private pilots is severely endangered.

CONCLUSION:

As long as only outward noise emissions are subject to statutory regulation for these motor gliders, and there is no licensing criterion for acceptable noise production in the cockpit, this research shows that all pilots must be warned not to fly these machines without personal ear protectors (1; 6).

For optimum personal noise protection among pilots "active noise reduced headsets" as found in flight equipment stores, are to be recommended. By encapsulating the ears and providing an active counter-sound these can reduce noise exposure levels by up to 30 dB (A). If this solution is too expensive, the pilot should buy earplugs at the nearest supplier.

Earplugs have a noise insulation level of 33 dB. Earplugs are cheap and provide sufficient protection, so that the pilot should not only use them himself, but provide them for his passengers as well, in order to avoid hearing-damage. Anyone who fears that, with plugs in his ears, he will not hear radio conversations so well, need not be alarmed. The fact that the surrounding noise level in the cockpit is dampened by the earplugs means that conversation on the radio will be even more clear when the pilot has plugs in his ears. However, you have to get comfortable with earplugs first.

In conclusion, I suggest that manufacturers should write a warning message in the manual of their motor gliders indicating that it could be hazardous for the pilot's hearing if flying the motor glider without ear protection.

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