

Noise emissions from model aircraft can be divided into four major sources:

Propeller

Exhaust

Airframe

Engine

On a poorly silenced, under-propped aircraft, this is the order of importance of their contribution to the overall noise output.

The most successful approach when attempting to reduce noise is to tackle the dominant source of noise first. When this source has been controlled, the next most important source should be tackled. It makes no sense to try and reduce overall noise by tackling a source responsible for only 5% of the total noise output. Far better to reduce the source of 90% of the noise, if only by half.

The ideas presented in this section are deliberately given in outline, as the detail has been covered in several magazine articles over the years.

Controlling the RPM

Selection of the correct propeller is important for two reasons. Firstly, the faster the engine runs, the more exhaust, engine and airframe noise is produced. Secondly, high propeller speeds produce more noise. Although it is difficult to lay down strict criteria for calculating ideal propeller sizes, as a rule of thumb, the following target RPMs need to be approached if noise emissions are not to exceed 82dBA at 7 metres:

0.40 cu.in 2 strokes:	10000-11000 RPM
0.60 cu.in 2 strokes:	9000-10000 RPM
0.90 cu.in 2 strokes:	7000-8000 RPM

Some commentators have suggested that the propeller tip speed should be kept below 350 mph to achieve the same effect. It is true that if the propeller tip speed becomes too high, the tips will emit a very significant amount of noise. This is not usually a problem on model aircraft unless large propellers running at very high RPMs are used. Tip speeds approaching the speed of sound are required for this effect to become significant, and a 12 inch propeller will not approach this speed even when running at 15000 RPM.

Pitch vs Diameter

Whichever rule is followed, the correct way to reduce RPM is to run coarse pitch propellers rather than large diameter propellers. This prevents RPM from rising dramatically in a dive or at high speed (this would negate any benefit of reducing RPM on the ground, leading to increased noise output). Incidentally, a coarse pitch propeller will often result in higher achievable airspeeds - think of it as an aerodynamic gearbox; coarse pitch equals a higher gear ratio. Some useful prop sizes are given below:

0.40 cu.in. 2 strokes:	11x6, 11x7, 11x8, 10x9, 10x10
0.50 cu.in. 2 strokes:	11x9, 11x10
0.60 cu.in. 2 strokes:	11x11, 12x10, 12x11
0.90 cu.in. 2 strokes:	14x11, 15x10

Similar principles can be applied to 4 stroke engines.

Multibladed propellers

Multibladed propellers have a place, especially for very large, fast running engines. Where unacceptably high tip speeds would occur with the diameter of a two bladed prop necessary to absorb

the power, an extra blade can be used to absorb the power at a more modest tip speed. For most engines however, a multibladed propeller offers no advantages over a coarse pitch two bladed prop.

Torque

The other point to note is that the torque peak for most model aircraft engines lies quite near the above recommended RPM ranges. This means that a comparatively large propeller can be turned, and benefits result by virtue of moving a larger mass of air over the wings and control surfaces. Thus although the power output of the engine at these lower RPMs is lower than the BHP peak, more of the available power is converted into thrust

What makes a good silencer?

There are now several effective exhaust silencers available on the market for a range of engine sizes. These come in two basic types: an integrated primary silencer, or an add-on secondary silencer. All good silencers incorporate internal structures to break up the sharp pressure wave that is produced by rapidly expanding hot exhaust gases. It is this pressure wave that is responsible for the vast majority of exhaust noise. The flow of exhaust gas is usually very quiet; this can be illustrated by exhaling very quickly. The noise produced by this simple act is far less than that produced by any model aircraft engine exhaust, despite the volume of gas moved per second by your lungs being more than by a 0.90 cu.in 2 stroke running at 10000 RPM !

Silencers and power loss

An add-on silencer should not cause any power loss when attached to a primary silencer. Power loss is caused by back pressure - a result of exhaust gas not being able to exit the silencer quickly enough. If all the holes in a silencer are large enough, back pressure does not occur to an appreciable extent and power is not lost. The best way to measure power is by using maximum RPM as a surrogate measure. The maximum RPM should be measured both before and after fitting the silencer, with no other changes, except that a minor degree of retuning may be needed after fitting the silencer. If the RPM has remained within 200 RPM (allowance for experimental error), no power loss or gain has occurred.

Tuned pipes

Tuned pipes can be used very effectively as silencers, provided that they have a suitable internal structure ('quiet' tuned pipes), and that any increase in power provided by using such a device is not used to increase the RPM. Instead, a propeller with increased pitch should be used to absorb the increased power whilst maintaining a constant RPM.

Mounting silencers

A couple of other points are worth making on the subject of silencers. Firstly, silencers should not be hard mounted to the fuselage or wing of the aircraft. This increases the amount of vibration transmitted to the fuselage and hence airframe noise (see [flexible mounts and engine noise](#)).

Use of the noise meter

Secondly, the noise meter can be a useful tool in determining the comparative effectiveness of silencers. A series of tests should be carried out, all at the same RPM with the same propeller, changing nothing but the silencer. In this way, meaningful comparisons of silencer effectiveness can be achieved. You will often notice that the reading most affected by adding a silencer is not that taken with the exhaust facing the meter, but that taken with the starboard side of the aircraft facing the meter (on an aircraft with an upright or side-mounted engine with side exhaust)

This fact can provide a useful pointer as to whether the exhaust is the dominant source of noise. If the starboard reading is higher than the others, the exhaust is usually the dominant source

Flexible mounting systems

An important point to remember about flexible engine mounting systems is that airframe noise is not usually the most important noise source. Propeller and exhaust noise should be adequately tackled first.

Having said this, flexible mounting systems can make a significant difference, and often turn a reasonably quiet aircraft into a very quiet aircraft. The quality of the sound is often improved markedly, being perceived as much less harsh. There are many different systems available, with some evidence that a soft rubber is preferable to a hard grade of rubber in damping vibrations transmitted to the fuselage.

The idea behind all the systems used is to prevent vibration from being transmitted from the engine to the fuselage and thus causing the fuselage to act like a drum, amplifying the vibration and emitting it as noise. A successful system must ensure that no part of the engine or silencer is in contact with the fuselage or wing without a layer of rubber in between.

'Lord' mounts are a good option, and are readily available, as are other fixings to be found in DIY outlets. Consider retrofitting existing aircraft with rubber mounts, and always plan to include them when constructing new aircraft.

Engine Noise.

The mechanical noise produced by an engine in relatively good condition is relatively small compared to the other components discussed above. Note however that out of balance propellers can lead to a lot of vibration - always ensure propellers are balanced prior to use - and worn bearings can similarly generate a lot of noise.

Mechanical noise is difficult to tackle, and the most practical solution is usually to encase the engine in a decent cowling; even a cheap plastic cowling can have an effect on reducing noise emission.

Large Engines and Four strokes.

The same principles of limiting RPM and fitting effective silencing and flexible engine mounts work for four strokes and larger 2 strokes. Four strokes are easier to silence in some ways, as the active pumping of exhaust gases by the exhaust stroke makes them resistant to the effects of back pressure when a silencer is added, and the number of exhaust strokes is less. Thus a smaller silencer can be used, e.g. a silencer used for a 0.51 cu.in 2 stroke can be used on a 0.90 cu.in 4 stroke.

Large engines, although producing more noise than a small engine, will be run at much lower RPM's. This offsets the higher noise levels usually associated with such engines, and may provide a qualitative bonus, as low frequency sounds tend to be less irritating. Larger engines therefore provide an opportunity to be exploited. It is a mistake to think that moving to smaller engines must automatically reduce the noise problem and lead to fewer complaints

RPM and Thrust

Although static maximum thrust as measured on the ground is not an exact measure of performance in the air, it does give an indication of how an aircraft will perform on takeoff and in a climb.

We measured maximum RPM, noise emission and static maximum thrust using a spring balance:

Aircraft: Wot 4

Engine: Super Tigre 45 ABC

Silencer: Standard

(All propellers are Graupner)

Propeller	RPM	Noise				Thrust (lbs)
		F	L	B	R	
10x6	13000	86	83	76	82	5.6
11x6	11100	86	81	76	80	5.7
11x7	10000	83	76	74	80	6.1
11x8	8900	81	75	72	75	5.0
12x6	9400	83	75	70	76	5.0
12x7	8500	80	75	70	75	5.1

Flexible mount data

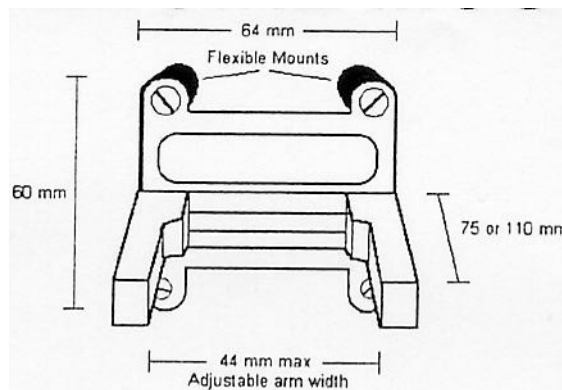
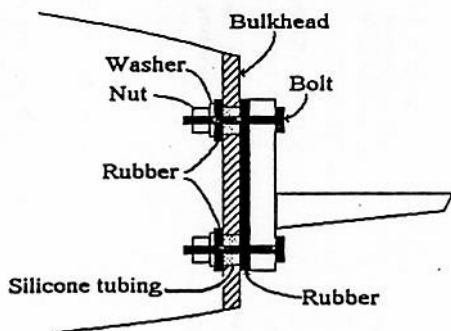
A simple system for retrofitting rubber mounts where there is insufficient room for 'Lord' mounts. Note that no part of the engine or bolts is allowed to contact the fuselage directly. 2mm rubber sheet was used on the prototype

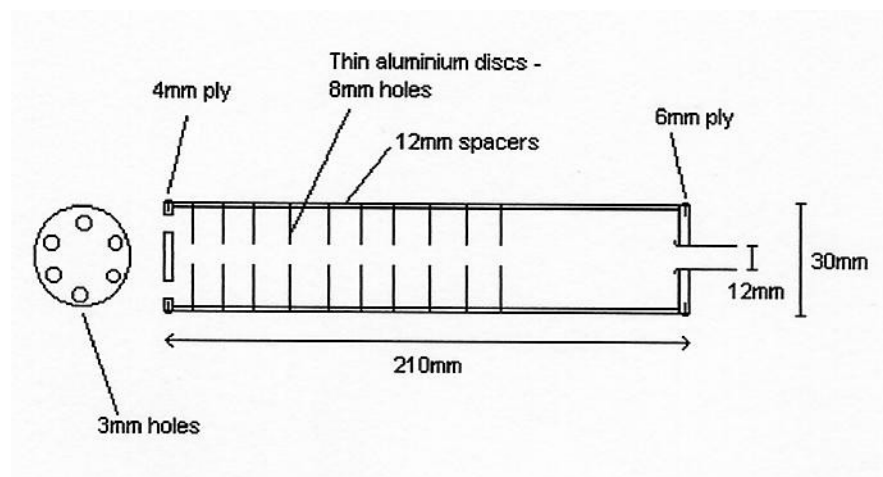
Effectiveness of Lord mounts:

Meaningful comparisons of rubber mounts vs no rubber mounts are difficult to achieve, given the need for remounting the engine in between tests.

Aircraft: Wot 4 fuselage
 Engine: Super Tigre 45 ABC
 Silencer: Standard
 Propeller: 11x7 Graupner

Mounting	Noise				RPM
	F	L	B	R	
Without rubber mounts	83	81	78	84.5	10500
With rubber mounts	82	76	76	81	10300





The S13a was the first really successful design that we encountered in the research project. It is derived from the design of a gun silencer,

Engine size range:

Up to 0.51 cu.in 2 stroke

Up to 0.90 cu.in 4 stroke

The original design utilised 30mm (1 1/4 in) PVC tubing, a brass front pipe, and spacers made with split segments of 30mm PVC tubing. The silencer cannot be used on 4 stroke engines in this original format, as the high exhaust temperature melts the PVC tubing. Metal versions are fine, however.

The silencer is designed to be used as a second-stage silencer, not straight from the exhaust manifold.

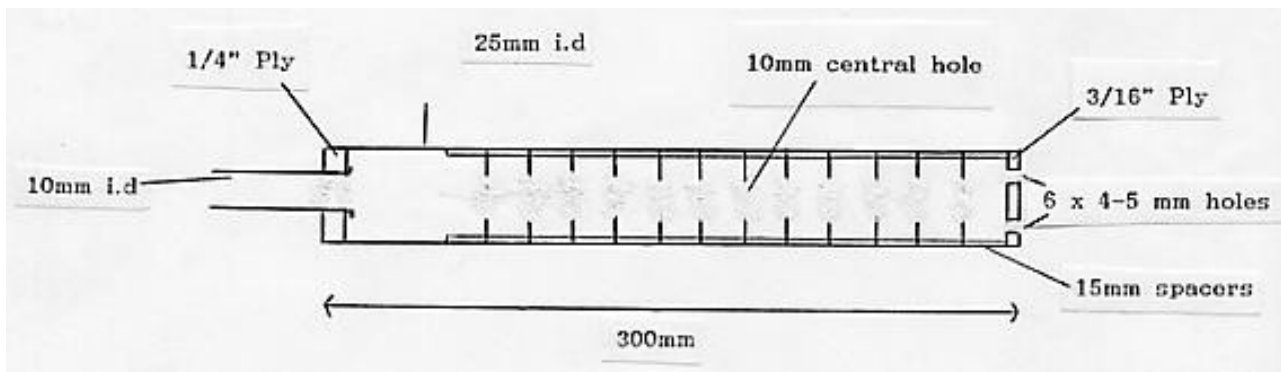
Although not a small silencer, I recommend this silencer if you really want to get on top of exhaust noise for 2 strokes up to 0.50 size.

We also tested a cut down version, 110mm long with only 5 baffles, referred to as **S13e**. This performed only slightly less well; about a decibel worse on average

S13a comparative tests

Model	Engine	Prop	Exhaust	Noise				RPM
				F	L	B	R	
Hi Boy	OS 35	10x6	Std	81	77	73	82	10500
			Std+S13a	77	72.5	68.5	75.5	10700
Wot 4	Super Tigre 45 ABC	11x7	Std	83	81	78	84.5	10500
			Std+S13a	80	77.5	75	78	10500
Wot 4	Super Tigre 45 ABC	11x7	Std	82	84	75	82.5	9600
			Std+S13a	78.5	79.5	72	77	9500
Magician	OS 40 SF	11x6	Std	79.5	77	73.5	77	10600
			Std+S13a	77.5	76	72	76.5	10500
Wot 4	Super Tigre 45 ABC	11x7	Std	84	80	81	83	10400
			Std+S13a	76.5	75	72.5	75.5	10300

S13h is a design based on the S13a design. The outer tube is aluminium, with the spacers being made of thin aluminium strip.



Engine size range:

2 strokes of 0.51 cu.in to 0.90 cu.in

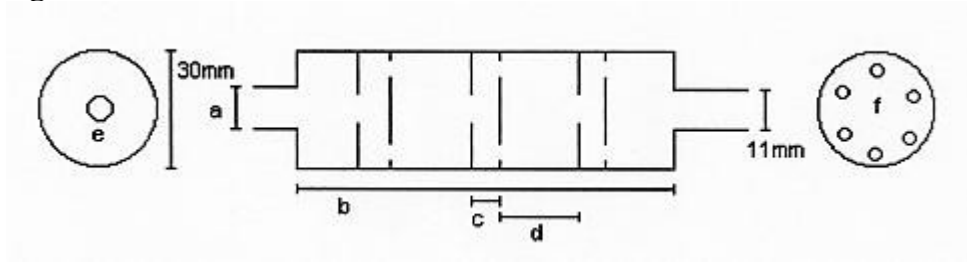
4 strokes of 0.60 cu.in to 1.20 cu.in

Although designed for use as an add-on silencer, it has been used as a primary silencer for an 0.50 size 2 stroke and for a Super Tigre 2500 with some success

S13h comparative data

Model	Engine	Prop	Exhaust	Noise				RPM
				F	L	B	R	
Wot 4	OS 61 FS-R	11x11	Std	81.5	82	81	82	9400
			Std+S13h	78	75	74	78.5	9400
Dalotel	Super Tigre 90	15x10	Std	80	81.5	78	83	7500
			Std+S13h	78.5	77	72	78.5	7500
Joker	SC 91	15x10	Std	83	83	73	84	7100
			Std+S13h	79.5	74	70	79	7000
Gangster 63	Super Tigre 61 ABC	12x11	Std+affle	81	80.5	74	79.5	8200
			Std+affle+S13h	78	77	71	78	8000
-	Fox 61	11x11	Std OS	82.5	80	82	85.5	8900
			Std OS+S13h	81	79	80.5	83.5	8400
Magister	Super Tigre 2500	18x8	Open	88	88	78	89	6400
			S13h	80	78	78	80	6400

silencer design s60/s62



Dimensions:

	S60	S62
a	11mm	13mm
b	65mm	100mm
c	3mm	4mm
d	12mm	15mm
e	10mm	11mm
f	4mm	5mm

The S60 and S62 were all-metal silencers designed for larger engines. The S62 was marketed as the NRD 2090. Spacers can be made from thin aluminium tube or from strips of sheet aluminium.

S60 recommended for use on:

0.45 to 0.61 cu.in 2 strokes

S62 recommended for use on:

0.51 to 1.08 cu.in 2 strokes

Model	Engine	Prop	Exhaust	Noise				RPM
				F	L	B	R	
Dalotel	Super Tigre 90	15x10	Std	83.5	80	75	84	7400
			Std+S62	79	78	75	80	7100
Joker	SC 91	15x10	Std	83	83	73	84	7100
			Std+S62	81	79	72	80	7000
Wot 4	Irvine Q72	13x8	Std	84	83	81	85	9300
			Std+S62	81	79	77	79.5	9000
Wot 4	Super Tigre 45 ABC	11x8	Std	80.5	75.5	74	82	9200
			Std+S60	76.5	74	68.5	75	9200
Panic	ASP 75	13x6	Std	85	83	73	83	9500
			Std+S60	76	75	67	75	9500
Wot 4	Magnum 61	11x10	Std	82	84.5	75	80.5	9900
			Std+S60	80	78	72	80	9800