Noise in hydraulic systems

Theory and installation guidelines

Bulletin MSG30-9000 UK

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This document is divided into two parts.

Theoretical background:

Surface vibrations

A surface vibrates when acted upon by a dynamic force. These surface vibrations create periodic compressions in the air, which are perceived as noise by our ears.

This is illustrated below where excitation energy is delivered by a hammer to the response surface that vibrates and produces sound as a result.

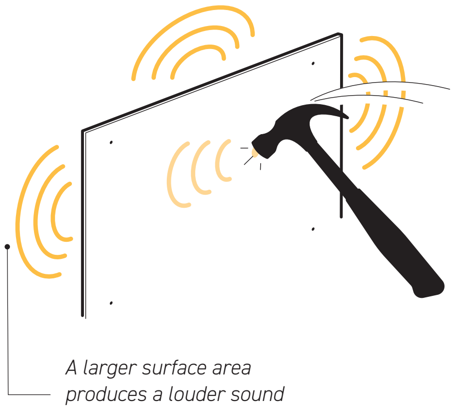
Response surface

The radiated sound power is directly proportional to the area of the response surface.

As illustrated below, a larger area will produce a louder sound as compared to a smaller area in response to the hammer exciting the same vibration velocity.

A good standard procedure is thus to minimize the surface area.

A small surface area produces low sound



A larger surface area produces a louder sound

Isolation

Mechanical isolation between the source of vibration and the response surface(s) reduces the amount of vibration energy transmitted to the response surface(s), hence lowering the amplitude of the surface vibrations and consequently the radiated sound power. It should be noted that vibration isolation also affects the frequency spectrum of the vibrations in the response surface.

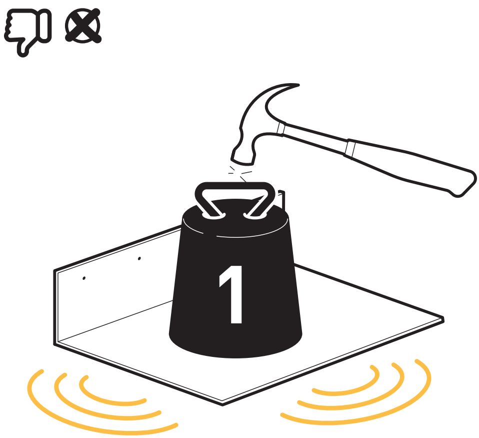
Similarly, mechanical isolation between different response surfaces helps reducing transmission of energy and results in reduction of radiated sound power.

There are three main methods of isolation:

1. Mass blocking; the same function as increased mass. A heavier object gets less vibration velocity for a given force impulse than a lighter object, irrespective of its stiffness.

Introducing a mass between the vibration source and the rest of the system reduces the transmitted vibration energy.

The mass needs to be large relative to the mass of the exciting source. A diesel engine is a good mass blocker for a hydraulic pump.



2. Mass-spring vibration isolation; surface vibration velocity is reduced through inserting a mass-spring system between the exciting force and the response surface(s).

The vibration velocity is strongly reduced for all frequencies well above the mass-spring system's resonance frequency given by:

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

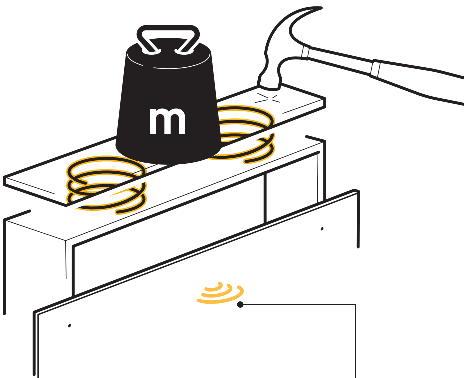
where k is the spring constant and m is the vibrating mass.

The spring constant shall be chosen so that the resonance frequency is lower than half of the lowest exciting frequency.

A high mass and/or a soft spring is needed to get a low resonance frequency. Most often the excitation source has sufficient mass and no additional mass is needed.

The equivalent system for rotation is moment of inertia-torsional spring e.g. flexible flange.

The use of a soft spring inevitably leads to vibration displacements; i.e. the isolated object must have the possibility to move in all directions to get vibration isolation. At the resonance frequency the vibration velocity is higher than without the mass-spring system!



Possible reduction > 10 dB!

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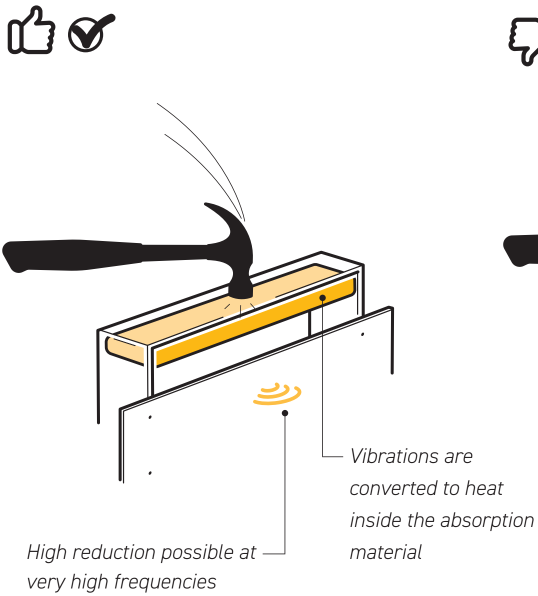
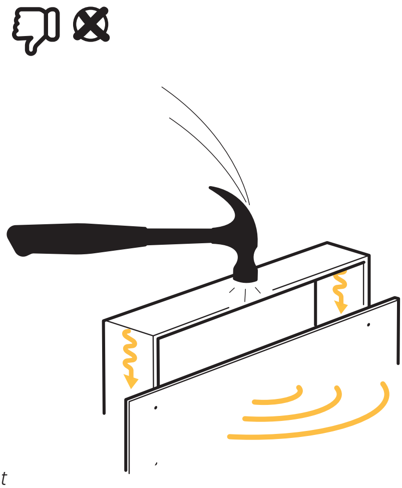
3. Increased internal vibration damping;
The usual way to accomplish this is to attach vibration absorption material on the surface.

Vibrations are converted to heat inside the absorption material, e.g. due to internal viscous friction. This process only works at relatively high frequencies which makes this approach rather ineffective for noise reduction in many hydraulic systems.

However, to attach material onto an existing surface increases the surface mass and gives hence a vibration reduction which, in turn leads to reduced radiated sound power.



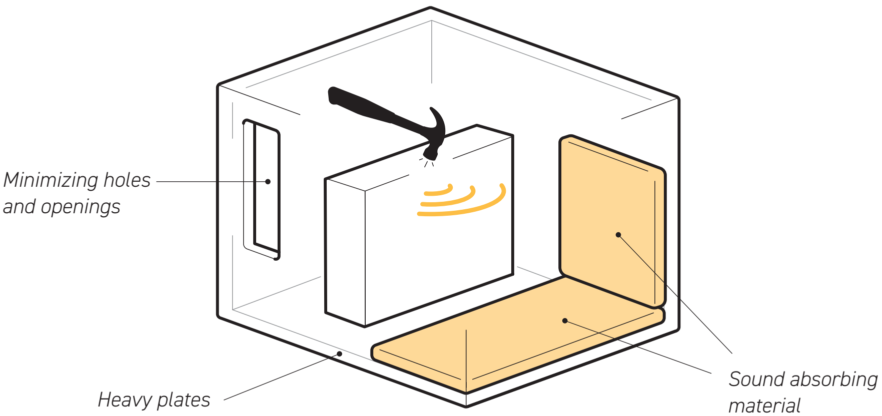


Encapsulation

Encapsulating the response surface(s) attenuates the radiated sound power by blocking its propagating to the outside.

If noise issues still remain after mass blocking and isolation, a correctly designed encapsulation of the response surface(s) attenuates a great portion of the radiated sound power.
A correctly designed encapsulation means:

- **Maximizing mass per area (e.g. heavy plates)**
- **Minimizing the holes and opening of the encapsulation 10 % of open surface (holes) limits the possible reduction to 10 dB, irrespective of the sound insulation of the encapsulation construction, and 1 % open surface limits the possible reduction to 20 dB.**
- **Dress the inner surface with absorbing material.**



Possible reduction 20 dB!

Specific hydraulic system issues

In a hydraulic system, the pump or motor and its prime mover (e.g. electric motor, diesel engine) or load, are sources of excitation energy in form of dynamic forces, torques and flow ripple. Dynamic forces result in vibrations which causing noise from the system surfaces. Flow ripples give rise to dynamic forces at flow restrictions in the system such as valve blocks, filters and angled connectors. In this kind of system, it might also be possible to reduce the flow ripple in several ways, similar to mechanical isolation.

Bad suction conditions which give cavitation noise might also be a noise problem.

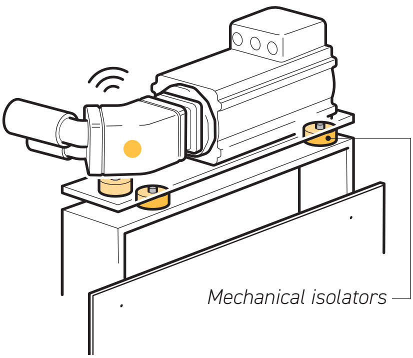
Surfaces contributing much to the noise level are most often on the chassis (e.g. vehicle) on which the hydraulic system is mounted!

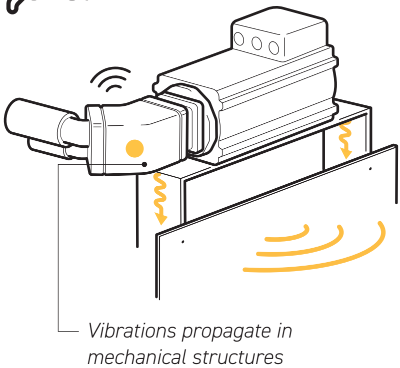
By using mass blocking, isolation and encapsulation in systems design, noise issues can be eliminated!

Practical installation guidelines

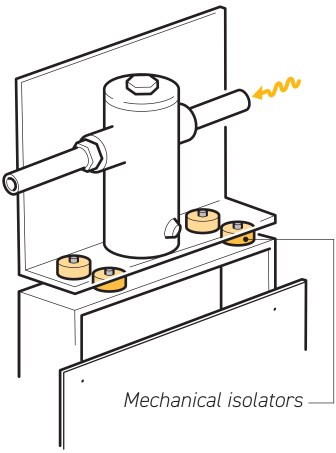
Some practical guidelines for installation of a hydraulic system which should help minimize noise.

1. Use mechanical isolators to prevent vibrations from sources such as electric motor, hydraulic pump/motor, valve block, filter block, hydraulic hoses, pipes and connectors etc, to propagate in mechanical structures.

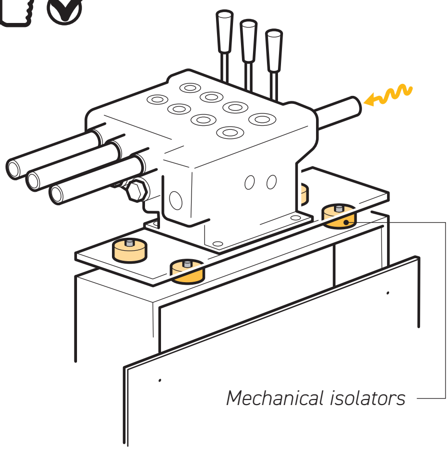




Hydraulic pump/motor

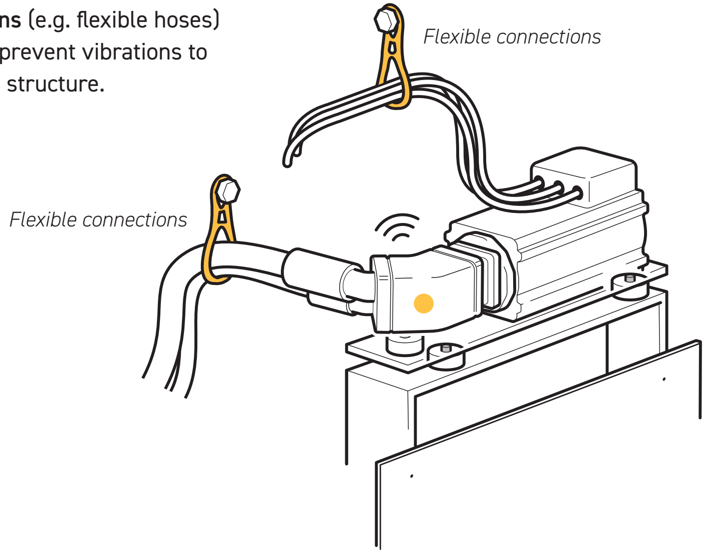


Filter block

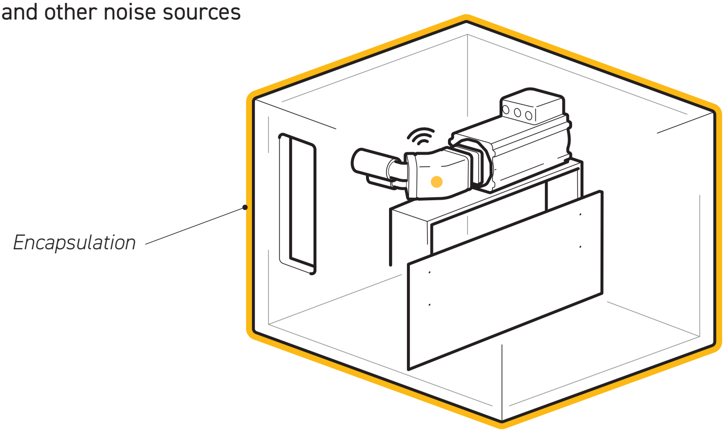


Valve block

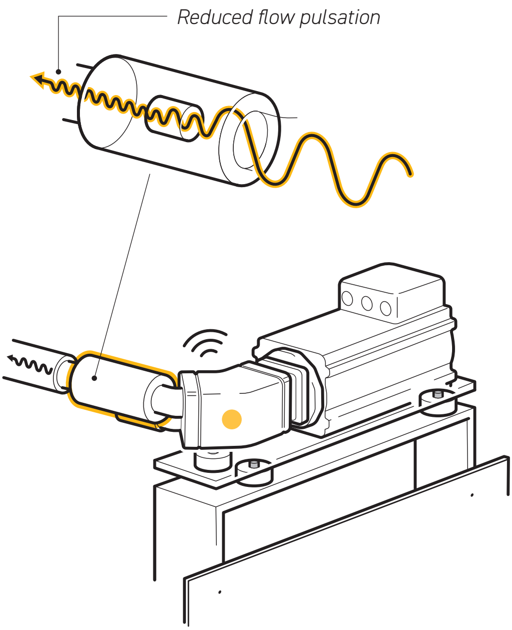
2. Use flexible connections (e.g. flexible hoses) and flexible fastening to prevent vibrations to propagate to mechanical structure.



3. Encapsulate the hydraulic pump/motor and its prime mover/load (e.g. electric motor, compressor) and other noise sources whenever feasible.



4. Use flow pulsation-reducing components if necessary.



5. Ensure good suction conditions. Consider pump self-priming speed limit and proper suction line dimensions for your flow.

For technical guidance, please contact Parker.

More technical information at:
https://discover.parker.com/noiseandvibration

Notes

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