Specifying, measuring and reducing noise levels of pumps to meet Health and Safety regulations

Legal requirements

There are various health and safety regulations around the world that set the maximum continuous noise levels workers can be subject to, but all are broadly in agreement. For example, the European Union Machinery Directive (2006/42/EC) establishes the essential health and safety requirements for free movements of goods within the EU and details the mandatory essential health and safety (EHSRs) which must be followed including:

- eliminate or reduce risks as far as possible (inherently safe machinery design and construction),
- take the necessary protective measures in relation to risks that cannot be eliminated,
- inform users of the residual risks due to any shortcomings of the protective measures adopted, indicate whether any particular training is required and specify any need to provide personal protective equipment.

The machinery directive is implemented in the countries by each government's regulations and enforced by its health and safety body. For example, in the UK the machinery directive is implemented by "The Supply of Machinery (Safety) Regulations 2008 (SI 2008 No. 1597)" and enforced by the Health and Safety Executive (HSE) alongside the Control of Noise at Work Regulations 2005.

A supplier of machinery must:

- provide machinery that is safe and without risk to health, with the necessary information and instructions to ensure those aims can be met during installation, use and maintenance;
- design and construct machinery so that the noise produced is as low as possible;
- provide information about the noise the machinery produces, including descriptions of the operating conditions under which the noise was measured.

Prosecution is activated on usage, i.e. employers use of noisy equipment and failing to provide adequate noise protection for their employees, rather than supply which is not currently restricted by specific limits in the legalisation. The level at which employers must take action (such as providing hearing protection or hearing protection zones) is 85 decibels (daily or weekly average exposure) and 137 decibels (Maximium Level) for peak sound pressure, and the level at which employers must assess the risk to workers' health and provide them with information and training is 80 decibels.

In practice, the implementation of noise exposure is more complicated as workers are often subjected to different levels of noise for various periods of time whilst undertaking their duties. As such, an exposure points-based system is used to sum different noise levels and exposure times which enable a calculation of overall noise exposure for a given period and which can then be compared to an exposure table to see if the worker is operating within regulations (see Figure 1 for an example).

Sound pressure level, L_{Aeq} (dB)	Duration of exposure (hours)							
	1/4	1/2	1	2	4	8	10	12
95	32	65	125	250	500	1000		
94	25	50	100	200	400	800		
93	20	40	80	160	320	630		
92	16	32	65	125	250	500	625	
91	12	25	50	100	200	400	500	600
90	10	20	40	80	160	320	400	470
89	8	16	32	65	130	250	310	380
88	6	12	25	50	100	200	250	300
87	5	10	20	40	80	160	200	240
86	4	8	16	32	65	130	160	190
85		6	12	25	50	100	125	150
84		5	10	20	40	80	100	120
83		4	8	16	32	65	80	95
82			6	12	25	50	65	75
81			5	10	20	40	50	60
80			4	8	16	32	40	48
79				6	13	25	32	38
78				5	10	20	25	30
75					5	10	13	15

Total exposure points	Noise exposure $L_{EP,d}$ (dB)
800	94
630	93
500	92
400	91
320	90
250	89
200	88
160	87
130	86
100	85
80	84
65	83
50	82
40	81
32	80
25	79
20	78
16	77

Figure 1 – Worked example of a daily noise exposure ready-reckoner

Specification driven pump requirements

With differing health and safety regulations around the world and the onus being on the employer to protect their employees from damaging noise levels, customers may specify the maximum noise levels for individual items of equipment, such as pumps. The specified noise levels should be set by the customer to take in to account the summation of other noise within the environment where the pump will be placed so that the overall noise level does not exceed local regulations.

However, customers often deliver a variety of information when specifying the equipment and will often give the manufacturer documents such as their own internal noise level tables within the specification which may detail a whole range of maximum permissible noise levels in, for example, onshore, offshore production and process plant and the permissible levels within the various buildings, manned and unmanned, in those locations.

With no international standard for noise, there is room for misinterpretation over what the customer is specifying for permissible noise levels and in the use and location of the equipment. Judicious questioning of the specifications may be necessary to fully understand the requirements so that it can be met cost-effectively. For example, without an understanding of the noise exposure over the course of day or a week any given employee has to the equipment it could be over or under designed with regards to noise attenuation, which could significantly change both the initial and through life cost of the equipment.

Measuring noise

The noise level received by the human ear depends on the environment. For example, a single pump in a large smooth walled enclosure will give a different sound level than the same pump installed in a small steel-clad shed surrounded by other machinery. To allow for this, test standards define set environment conditions so that tests can be repeated within a noise tolerance range of acceptability. In reality, this narrows down to either an anechoic chamber (large room fitted with sound deadening foam), hemi-anechoic or open field (rectangular room with smooth hard walls) or non-anechoic (e.g. a machinery room). If certain conditions are known or can be calculated, then it is possible to compare or reduce (attenuate) noise levels between environments. This however must be done with expert knowledge to prevent use and acceptance of inaccurate or incorrect information and assumptions.

Pump manufacturers are legally required to comply with the European Union Machinery Directive EHSRs but do not have to use standards to do this. However, to assist manufacturers in meeting the standard a pump test code, BS EN ISO 20361, has been designed specifically for pumps and this harmonised standard has been accepted by the EC. The main points of BS EN ISO 20361 are:

1. Measurement positions (dependent on the pump size).
2. A minimum of 5 measurement positions for small pumps (1m long) up to 11 positions for large pumps (4m long).
3. Pump conditions (best efficiency with rated or other positions if customer specified).
4. Declaration (a weighted sound power and sound pressure and uncertainty level).
5. Sound power levels to be calculated using methods stated in BS EN ISO 3746.

BS EN ISO 20361 cross references BS EN ISO 3746 “Acoustics – Determination of sound power levels of noise sources using sound pressure” which specifies methods for determining the sound power level or sound energy level of a noise source from sound pressure levels measured on a surface enveloping a noise source (machinery or equipment) in a test environment for which requirements are given.

To certify that a pump design meets the customer specified noise level, Amarinth tests to BS EN ISO 20361 or BS EN ISO 3746, adapting the test procedures to suit customer specific requirements. See Figure 2 for an example of the noise measurement points used on a horizontal pump.

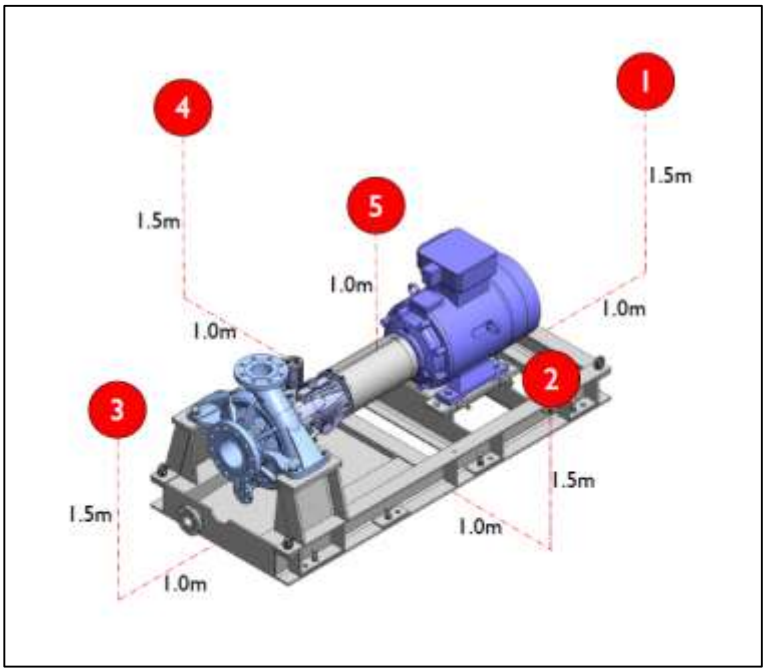

Figure 2 – Noise measurement positions

Reducing noise levels

If the overall noise level of the equipment is greater than required, then steps must be taken to reduce this. A quick fix adopted by some pump manufacturers is to use an acoustic enclosure over the whole pump assembly. However, this brings problems with:

- On-going monitoring of such items as oil levels.
- Maintenance and replacement of items such as impellers.
- Removal of the enclosure with associated pipework and for example in restricted spaces such as on oil platform there may be little space available to remove and store the enclosure.
- Human factors of access into and around the enclosure when in place and when removed.
- The cost of an acoustic enclosure over the whole pump can be cost-prohibitive.
- The additional time to design and test a full acoustic enclosure may impact delivery times.

Undertaking detailed investigations into the specific noise levels various assemblies are contributing, such as the motor, the wetted-end, the seal support system and pipework, and making appropriate design changes could yield the necessary reduction in noise without resorting to a full acoustic enclosure and its associated problems. Noise levels may be reduced through:

- Operating as close to BEP and full impeller as possible.
- Ensuring pipework diameter is one or two sizes larger than the pump connections.
- Designing pipework runs to be straight for a length of 5x suction diameter.
- Using full-bore isolating valves if possible.
- Avoiding air pockets by sloping pipework and correct orientation of reducers.
- Avoiding water hammer effects by pressure regulators.

The wetted-end of a pump often produces the most noise and so if the noise level of the overall pump assembly is still outside specification after other design changes have been considered, it could be brought into specification by designing an acoustic enclosure for just the wetted-end, rather than enclosing the whole pump assembly. The benefits of such an acoustic closure over a full enclosure are:

- Easier on-going monitoring of such items as oil levels which can then be placed outside of the acoustic enclosure or can be accessed through maintenance or removable flaps
- Where space is restricted, such as on an oil platform, the smaller enclosure means that access around the enclosure or when removing the enclosure entirely are eased and the space needed for total removal of the enclosure can be significantly reduced
- The cost of an acoustic enclosure over only the wetted-end of the pump is considerable less than designing one for the whole assembly even if some changes to the layout on the baseplate are needed to accommodate it
- The electric motor is not thermally restricted as can be the case with a full enclosure
- A smaller acoustic enclosure should have less impact on delivery times than a full enclosure

Sound travels through a system

In fluid systems noise is usually generated by mechanical noises such as motors, gears, heat exchangers or can be particles trapped in the fluid. Rapid changes in fluid properties such as flowrate, pressure or density (e.g. crystallisation) can also produce noise.

If the individual process items have been made as quiet as possible then attention should be given to the design of the pipework so that is does not amplify process disruptions, for example avoid sharp bends and reduced diameters so that the flow velocity is as low and as laminar (smooth) as possible. This will also help reduce gas generation due to reducing pressure drops. Thermal expansion should also be allowed for when fixing pipework using methods to isolate one piece of equipment from another such as AV mounts, spring tension brackets and expansion vessels (arrestors). A sound attenuation blanket should only be used as a last resort due to the high cost of wrapping.

Measurement of noise levels from pipework is undertaken in a similar way to that of the pumps with measurement positions of 1m from the pipework. For some environments, the noise levels of the whole system, i.e. pump, motor, ancillaries and pipework, needs to be carefully managed as a whole system if noise levels are to remain within given levels.

Predictive noise

Reducing noise late in the manufacturing or testing process can be expensive and lead to less than ideal solutions, such as full acoustic enclosures, and so manufacturers must strive to accurately predict and take measures to decrease specific noise levels early in the design.

Amarinth has amassed a detailed library of historical noise data from its multiple and repeatable pump testing that allows it to predict the noise levels for any given pump system. Computer simulation allows its engineers to try different combinations of pumps and equipment and accurately predict the overall noise level. This enables the company to deliver the system that most cost-effectively meets the customer's duty and specification whilst meeting the stated noise threshold.

Summary

The control of noise in the workplace is a primary responsibility of employers and since equipment may be used in any environment and staff can be exposed for different periods of time, customers should always specify the noise levels that manufacturers must design the equipment to. However, there are various ways in which noise levels can be measured and controlled and so those equipment manufacturers that understand and can accurately predict noise levels and take the time to fully understand the customer requirements are best able to design a solution that meets the specification in the most cost-effective manner, either by designing out the noise at source or providing suitable acoustic enclosures to attenuate the precise cause of excess noise.