Considerations when installing centrifugal pumps to minimise vibration and ensure reliable operation

technical bulletin

Amarinth pumps are tested comprehensively before they leave the factory to ensure they perform to customer specification. The correct handling and installation of centrifugal pumps is however crucial if they are to to operate to specification and reliably for their design life. The end user specifying a pump may place the order on a contractor, who orders the pump from the manufacturer and possibly then has it installed by a third-party sub-contractor, who may not be a pump specialist. Throughout this supply chain it is therefore important that all parties have access to the relevant specifications and information to ensure that the pumps are handled, installed and commissioned according to industry standards and manufacturers' recommendations.

After providing a pump, we are occasionally contacted by customers reporting that the pump is exhibiting problems, sometimes reported as excessive vibration directly after commissioning, or as an issue later such as a seal or bearing failing prematurely. On further investigation, we invariably identify that either the wrong machinery standard has been used as the basis for comparison during testing or that after leaving the factory the pump was not properly handled during shipment, was not installed correctly, or commissioned inappropriately.

Below are some of the common reasons Amarinth has identified as to why a pump may not appear to be operating to specification or suffer from premature failure.

Use the correct machinery standard

There are three main standards that are used when measuring vibration of equipment, only one of which should be used for evaluating vibration in rotodynamic pumps. See Figure 1:

✗	**IEC 60034-14:2004 Rotating Electrical Machines - Part 14:** Mechanical vibration of certain machines with shaft heights of 56mm and higher – Measurement, evaluation and limits of vibration severity This standard specifies acceptance vibration test procedures and vibration limits for certain electrical machines under specified (test) conditions. Although an electrical motor may be part of the pump assembly, this standard **is not applicable** to machines mounted in-situ and **should only be applied** to the free-standing motors. As such, any data in this standard is **not valid for a rotodynamic pump assembly**.
✗	**ISO 10816-3:2009 Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts – Part 3:** Industrial machines with power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured in-situ This standard specifies criteria for assessing vibration levels of motors when measurements are made after installation - so in-situ. However, although this standard is for industrial machines it is **not applicable to rotodynamic pumps** which have their own standard.
✓	**ISO 10816-7:2009 Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts – Part 7:** Rotodynamic pumps for industrial applications, including measurements on rotating shafts **This standard is the only one that should be used** when evaluating vibration of rotodynamic pumps for industrial applications with nominal power above 1kW.

Red = Not-applicable	*Green = Applicable*

Figure 1 – Use of the correct machinery standard for measuring vibration in rotodynamic pumps

However, it should also be noted that API 610 sets a maximum allowable vibration and so for the Oil & Gas industry the API 610 standard should be applied. See Figure 2 for comparisons.

Applicable to pumps	Standard	Allowable Vibration	
		Displacement (µm)	Velocity (mm/s)
✗	**IEC 60034-14:2004** (Rigid mounting, Shaft Height 132mm to 280mm)	35	2.2
✗	**ISO 10816-3:2009** (Rigid mounting, Shaft Height 160mm to 315mm, Power 15kW to 300kW)	22	1.4
✓	**ISO 10816-7:2009** (Rigid mounting, Power 1kW to 200kW, Category I Pumps – High Reliability)	80	4.0
✓	**API 610 11th edition** (Rigid mounting, End suction, Horizontal, Under 300kW)	50	3.0

Red = Non-applicable standard to pumps *Green = Applicable standard to pumps*

Figure 2 – Example comparisons of allowable vibration in the different standards for newly commissioned machines

Shipment and storage

Pumps are carefully protected and packed for transportation with anti-corrosion fluid applied to all machined surfaces. If air or sea transport will be used, longer term storage required, or if arduous conditions will be encountered, it is important that Amarinth is made aware of these by the customer so that suitable precautions can be taken to prevent damage to the pump or ancillary equipment during shipment. Transporting pumps without protective packaging should be avoided and motors with cylindrical roller and/or contact bearing must be fitted with locking devices to prevent damage.

After unpacking and inspecting pumps, if they are to be stored for longer than three weeks then care must be taken to ensure that they are stored on a hard, clean and dry surface away from any sources of vibration. Pumps should also be protected from dust sand, heat or excessive cold, moisture or corrosive vapours, preferably resealed in their original packaging. They should also be stored in the orientation as marked and not stacked one over another.

During longer term storage and to prevent damage to the pump bearings and mechanical seal faces, it is crucial that the pump/motor shafts are turned clockwise by hand 2¼ rotations every month when in warehouse storage and every week if stored on an active site. At the same time machined surfaces should be checked for corrosion and protection applied as appropriate.

After several months in storage, pumps will need to be inspected, drained and rust/dewatering fluid applied to the suction and discharge and all covers, gaskets, plugs etc. re-installed and the pump re-packaged. Full details of the storage maintenance schedule for each pump is in the documentation that accompanies each pump and so it is crucial that any contractor looking after the pump is given this information. If storage will be for longer than 12-months, then additional storage precautions will be necessary and Amarinth should be consulted for advice.

Handling, shipment and storage, as directed by Amarinth in the documentation provided with the pumps, will ensure that pumps and ancillary equipment do not sustain any damage whilst awaiting installation and will be in the same condition and perform to the same specification as when they left the factory.

Installation

Many of the problems that are reported to Amarinth come from poor installation of the pumps. There are several key points that must be observed if the pumps are to operate as per specification:

Lifting

Pumps should only be lifted using the designated lifting points and appropriate eye bolts by the methods detailed in the documentation. For vertical pumps, particularly those over 7m, additional care must be taken when lifting out of the packing and into a vertical position to avoid damage to the shaft and bearings.

Foundations

The foundation is where we trace most of the problems to when out of specification vibration of a pump is reported. Foundations must be level and flat providing a rigid support for the pump and substantial enough to absorb vibration.

For vertical pumps, a shimmed mounting plate (sole plate) is always recommended levelled to within 0.25mm/m. A mounting plate also allows easy subsequent removal of a vertical pump and eliminates the problems we have seen of a pump not being fully tightened when mounted directly to a concrete surface due to imperfections and voids in the foundation under the pump base plate resulting in looseness and subsequent vibration.

For horizontal pumps, baseplates must be levelled using shims to within 0.4mm/m. For grouted baseplates, the baseplate shall be levelled using levelling screws. Once the grout is set the levelling screws should be withdrawn to ensure the pump is supported by the grouting. Baseplate fixing nuts should be tightened evenly in the order as set out in the documentation and torqued to the given specification to ensure the frame is not distorted which would cause pump misalignment.

See Figure 3 for an example of a poor installation. There is an increasing gap between the frame and baseplate (to the right in the image). The frame is therefore not seated squarely on the shims that sit between the baseplate and frame at each corner and is only being supported by one edge of each of the shims. See Figure 3 for an exaggerated illustration of one corner. In this case the result was a significant vibration of the pump assembly.

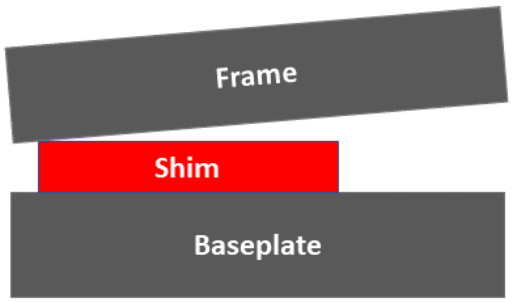

Figure 3 – Exaggerated illustration of how the frame will only touch one side of the shim

Alignment

Horizontal pumps are aligned during manufacture. However, after installation and every time pump and/or motor are moved, or the pipework disconnected and reconnected, **the alignment must be precisely checked in both the vertical and horizontal axes** to ensure optimum performance.

Coupling manufacturers state permitted mis-alignment tolerances and these are provided with the documentation for each pump assembly and the alignment must be checked using one of three methods:

- ***Preferred*** – laser alignment which can achieve high accuracy with less time spent on the procedure.
- ***Acceptable*** – dial indicators to adjust concentric and angular displacement.
- ***Basic*** – straight edge / engineers square used across the outside diameter of the coupling hubs to ensure the two halves are concentric and parallel.

Alignment is a two-stage process. After an initial alignment has been achieved a "soft foot" check should be carried out to ensure all mounting feet surfaces of the motor are in **complete contact** with the baseplate mount surfaces and then final alignment of the pump motor can be carried out. It is important that a final alignment check is then carried out following installation of pump pipework as the pipework can subsequently pull the pump out of alignment.

See Figure 4 for the most common pump and motor mis-alignments.

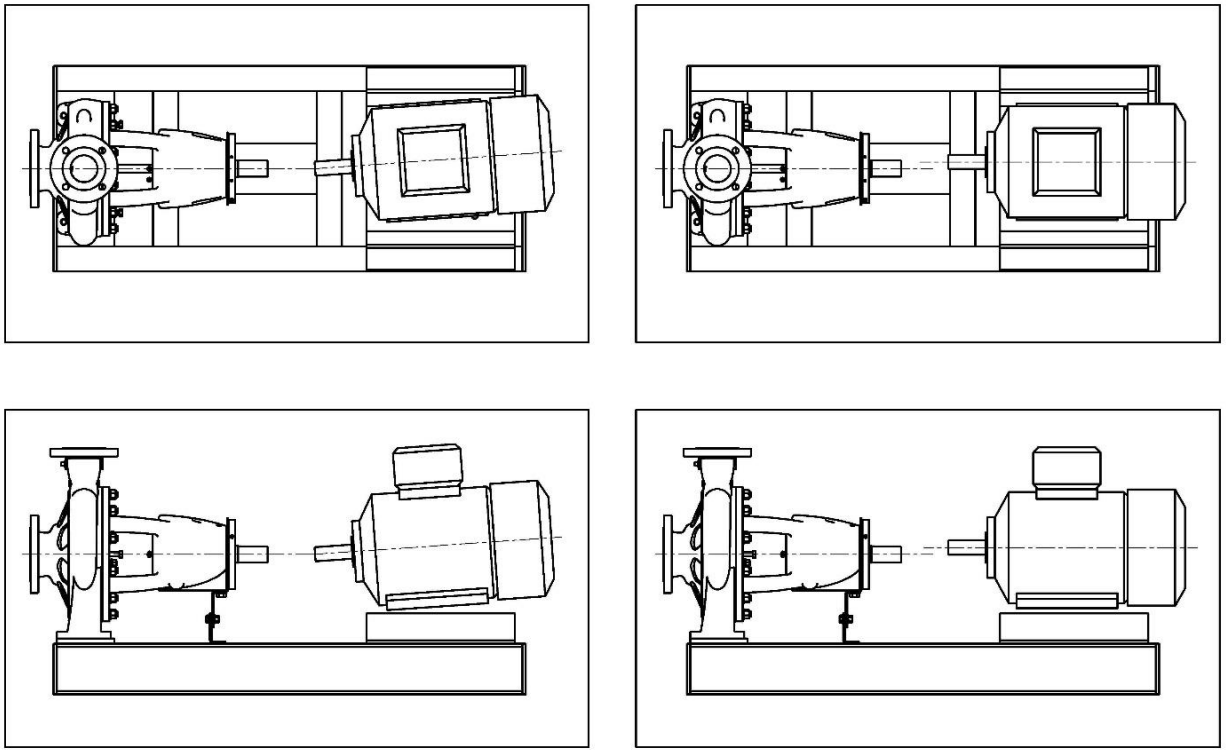

Figure 4 – Common pump and motor mis-alignments

Piping and ancillary equipment

Pipework runs should be as short as possible avoiding high loss fittings, such as short radius elbows, to minimise frictional and pressure losses, achieve low velocities and smooth flow within the suction and discharge pipework. It is recommended that the diameter of pipework should be should be two times larger than the pump flange sizes to reduce pipework velocities. See Figure 5 for an example of tight radius elbows close to suction and discharge which caused vibration problems with the pumps after installation.

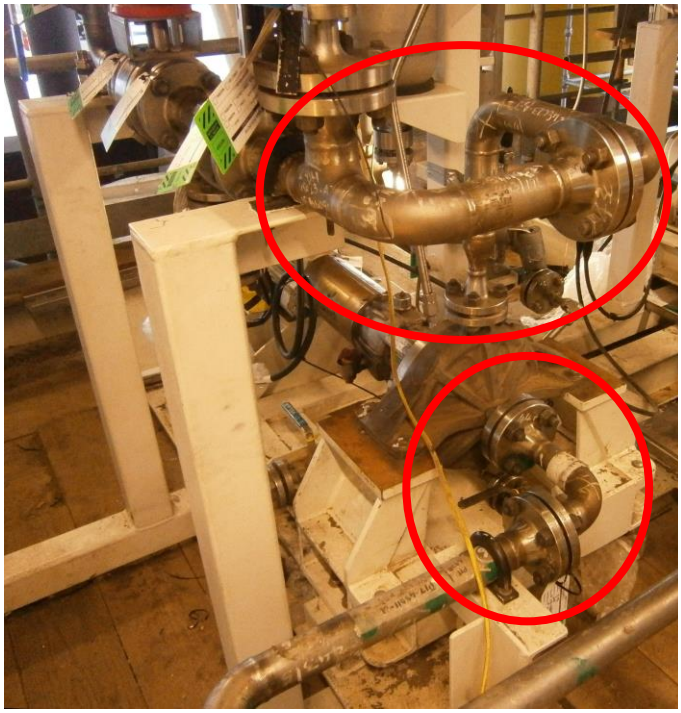

Figure 5 – Example of poor piping arrangement (in red)

Pipework materials should be equal or superior to pump materials whilst considering any potential for galvanic corrosion. Correct flange gaskets must be installed, and all joints must be airtight. All pipework should be clean and free from scale welding residues and other obstructions.

Pipework attached to the pump must be independently supported so that any forces or moments transmitted to the pump flanges do not exceed specifications laid down by industry standards or specified. The pipework should always be connected square and in line with the pump flanges and never be forced into position otherwise the resulting strain on the pump can cause misalignment. Valves, vents, interlocks and filters must be fitted as per the specification.

Installation, as directed by Amarinth in the documentation provided with the pumps, will ensure that pumps and ancillary equipment perform to the same specification as tested at the factory.

Customer acceptance manuals

Large organisations, particularly those in the Oil & Gas industry, may have developed their own installation documents based on industry standards and qualitative knowledge gathered from many years of experience. Third parties involved in the installation of pumps should follow these guidelines, alongside the documentation provided by Amarinth.

Summary

In most cases, when the issue of a pump not performing to specification is raised with Amarinth, the underlying cause is due to one or more of the issues above – i.e. wrong machinery standard being used; shipment and storage guidelines not followed; poor foundations or alignment during installation.

Amarinth take great care in developing documentation (in-line with industry standards as appropriate, such as API 686) which details all the steps necessary to ensure that after the pump leaves our factory that, if installed correctly, it will perform reliably for its expected life to the same specification to which it was tested and certified. For a pump to perform to specification however, it is crucial that all parties throughout the supply chain involved with handling and installation of the pump have access to and undertake their duties in accordance with the documentation.