Rotary Pump Startups

A pre-startup guide that will help keep gremlins away *from your system.*

By James R. Brennan

Many pump startups are the culmination of months if not years of work designing the process, machine or system, specifying components, instrumentation, protective devices, and reviewing and qualifying suppliers. It is also the most vulnerable time for any pump. This article describes cautions, reviews and inspections that should be conducted before startup to help insure that all those many gremlins of pumping systems are found out and eliminated in time.

Thoroughly read the technical manuals and instructions from the pump, driver and all auxiliary equipment suppliers to learn of requirements that may be specific to their equipment design. While this is the easiest method to protect the system, it is overlooked more often than not.

PIPE AND VALVES

Piping and valving installation (Figure 1) should probably be considered first.

Be sure all required valves have been installed. Verify that none is installed backwards. An absent or reverse mounted check valve, foot valve or relief valve can cause very serious damage. Piping should have been inspected during fabrication to insure that weld bead, weld rod and scale have been completely removed. Such hard particles can cause catastrophic pump failure should they lodge in the wrong pump clearance. Temporary, if not permanent, pump inlet strainers should be considered if not present. They should start in a clean condition so that accumulation of dirt can be monitored.

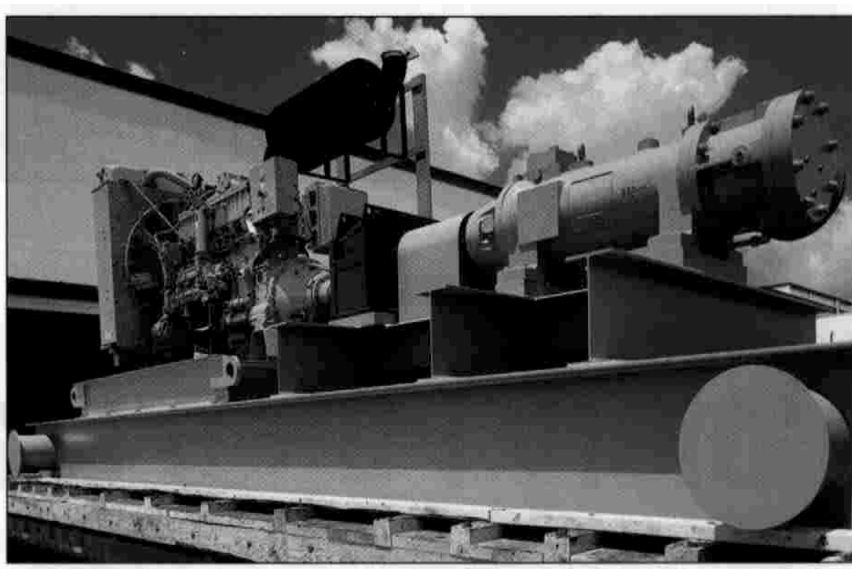
The piping system should be pressure tested. Avoid imposing on any system component pressures in excess of its design limits. Many pumps can withstand discharge pressure only on their discharge side.

Inlet piping systems are frequently suitable only for low pressure. The pressure test medium should be compatible with the components/ system to be tested. Don't use water if the system is not a water system. A low pressure (15 psig, 1 Bar g) compressed air test may be adequate to find missing flange gaskets or other obvious leak sources.

Check and tighten all flange bolts to specified torque. Pump inlet and discharge piping should have been made up from the pump for a distance of perhaps 20 ft (6 meters) to minimize pipe strain on the pump. Piping should be independently supported. Close internal clearance positive displacement rotary pumps do not make very good pipe anchors. When pipe flanges are unbolted from the pump, flange bolts should be able to be installed/removed without forcing piping into position. There should be a flange-to-pump gap not exceeding the greater of twice the flange gasket thickness or 1/16" (3 mm). If the gap is greater than either of these values, rework the piping until the gap is this width or less.

Positive displacement pumps will normally have a system pressure relief valve installed from the discharge piping to either the source of the pumped liquid, such as a supply tank, or to the pump inlet piping (a less desirable point due to the potential for temperature buildup during relief valve operation). This valve will usually be set slightly higher than the maximum anticipated normal system operating pressure. If possible, verify that it has been properly set. If this cannot be verified, consider adjusting the relief valve to a very low pressure and changing it upward after pump startup. Consult relief valve vendor's technical data to be sure valve adjustment is done in the correct (to lower pressure) direction.

Ideally, the entire piping and valve system will be thoroughly flushed to remove all dirt and fabrcation debris. This is customarily done using a flush pump - not the normal system pump. Strainers and or filters are installed at appropriate locations, and their dirt accumulation is monitored until they show no accumulation for a period of 24 hours. Flushing usually uses light, fairly hot (150°F, 65°C) oil delivered



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A Caterpillar diesel drives a three screw pump via a reduction gear. The pump operates at 1,200 rpm, 200 gpm, 14,000 psig and 10,200 SSU. It was recently placed in service on a new crude oil pipeline at Xan, Guatemala.

at flow rates higher than system design. The higher flow rates cause higher liquid velocities within the piping system and are more likely to dislodge debris. Some systems will use vibration equipment to impose mechanical "shaking" on the piping, again to maximize the dislodging of dirt. Very extensive piping systems have been known to show debris accumulation even after 30 days of flushing. Because of their long distances and relatively huge holding volumes, pipeline systems will frequently use "pigs," bullet shaped devices, sometimes equipped with wire bristles, which are propelled ahead of a flush or initial product batch of liquid to scrub debris and dirt from the inside of the pipe.

Before final startup, be sure valves are open or closed as required. Pump inlet and discharge valves are normally left fully open. Manual pump bypass valves are also normally left open on startup. An air bleed valve in the discharge piping at a high point near the pump will significantly improve the pump's ability to self prime. The valve is left open during startup until liquid flows. It is then shut. Be sure to know where this flow will be directed to avoid inadvertent discharge to atmosphere or spillage. Steam turbine steam valving is very important. Turbine startup procedures should be thoroughly reviewed as there are personal injury issues associated with this equipment if it is started or operated improperly.

FOUNDATEON, ALIGNMENT AND ROTATION

If horizontal pumps are used, be sure the foundation is level, that hold-down bolts are tight and that grouting, if used, has completely filled the baseplate (no hollows or voids) and has cured. If the pump will be handling liquid above about 150^{0}F (65^{0}C) or a steam turbine is used as the driver, an estimate of the centerline growth in height of the hot machine must be made. Shaft to shaft alignment (cold) should incorporate a deliberate, compensating offset, so that alignment is more nearly correct when equipment is up to operating temperature. Coefficients of thermal expansion for common pump case materials are provided in Table 1.

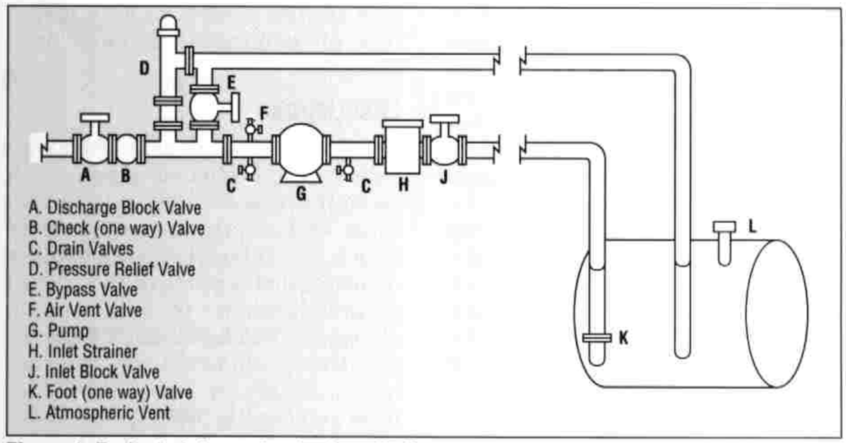

Figure 1. Typical piping and valve installation

Material	inches/inch/F°*	mm/mm/°C*
Cast Iron	6.0	11.0
Ductile Iron	6.6	12.0
Cast Steel	6.5	12.1
316 Stainless Steel	9.4	17.0

Table 1. Thermal growth coefficients (*x10^{-6})

The coefficient is applied to the centerline height of
the shafts and the difference in temperature between that at which the unit was aligned and temperature of expected operation. The cold machine should be shimmed high by this calculated amount.

The purpose of any shaft aligning procedure is to align the centers

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of the machine shafts with each other, NOT to align the flexible coupling hubs. At temperature, alignment should be within 0.003 inches (0.076 mm) Total Indicator Reading (TIR), both angular and parallel. Consult a good aligning procedure to achieve or verify this degree of precision. The fact that the coupling may be rated to a much greater misalignment capability has nothing to do with the shaft-to-shaft alignment of the equipment. Survival and longevity of the machinery, NOT the coupling, are the objectives. If hot pumps and/or drivers are used, after they are at nominal operating temperature long enough for thermal growth to have stabilized (probably one hour or more), shut down the equipment and verify that alignment is within prescribed limits.

Never rely on the alignment that was produced where the pump and drive train were assembled. Transportation, lifting and handling as well as foundation irregularities will impact alignment, always in an undesirable direction. Final alignment should be achieved as nearly the last step before actual starting of the pump. If equipment is to be dowelled in place, do so to the pump ONLY after several hours, if not days, of good operation and hot alignment checks.

The use of resilient mounts is sometimes desirable to reduce vibration being transmitted into the underlying foundation. If used, such mounts must not be deployed beneath the pump or driver but between the pump/driver baseplate or bracket and the foundation. The pump and driver must be rigidly aligned, not resiliently aligned, since the resilient mounts will not maintain adequate alignment under torsional reactions from the transmitted torque.

Direction of rotation is critical for most equipment. It is usually indicated by arrow nameplates. Remember that some gearing will reverse rotation from input shaft to output shaft. Most engines and turbines must be purchased for a specific direction of rotation. This is also true of most pumps. Standard AC electric motors are frequently bi-drectional; their direction of rotation will depend upon how the power cables are connected. It is normally not possible to predict their direction of rotation before- hand. It is recommended that the flexible coupling at the motor shaft be disconnected and the motor momentarily energized (jogged on, then immediately off) to see if its rotation is correct for the rest of the driven equipment. If not, two of the electric power cables will need to have their connections reversed. Verify correct rotation after reversing, if necessary, before re-engaging the flexible coupling.

LUBRICATION

Most rotating machinery has some form of lubrication for its bearing systems (Figure 2). It may be as simple as a permanently grease packed, sealed ball bearing or as complicated as a separate lubricating oil pump system complete with cooler, filter and instrumentation. Be sure to verify that any lubrication required has been addressed. Equipment that has been in storage may require draining and addition of fresh lubricant or even flushing out. Any gearing present (pump timing gears or reduction drive gears, for example) should be reviewed for the presence of the correct type and quantity of lubricant. Constant level oilers should be filled to their mark with clean, fresh lubricant of the correct type. Some flexible couplings are grease lubricated and should also be checked. Most electric motors will have grease lubricated antifriction bearings that should be checked as well.

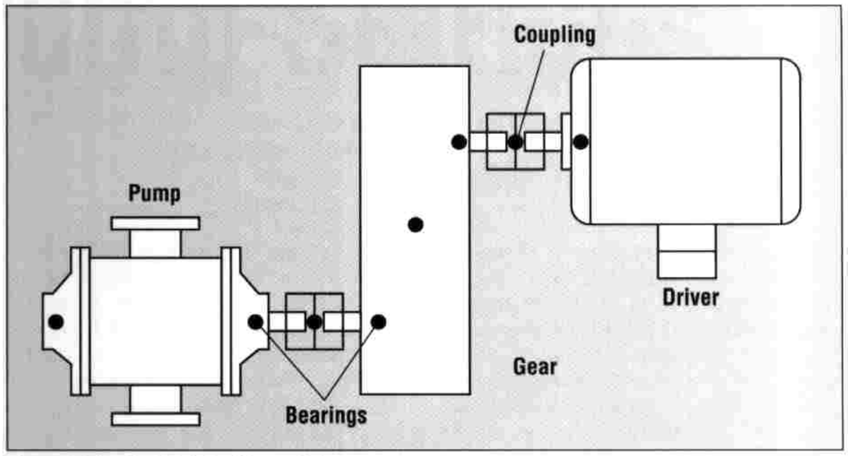
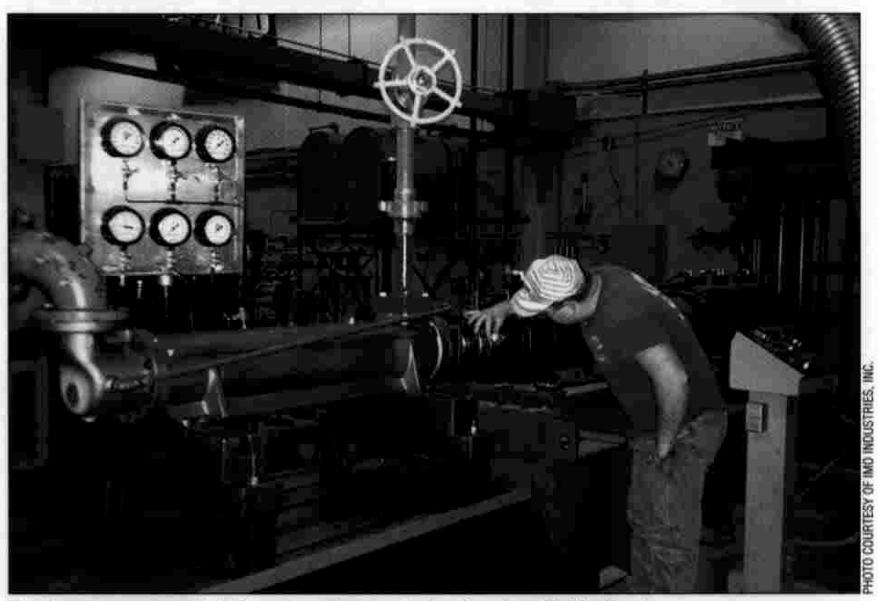


Figure 2. Typical lubrication points

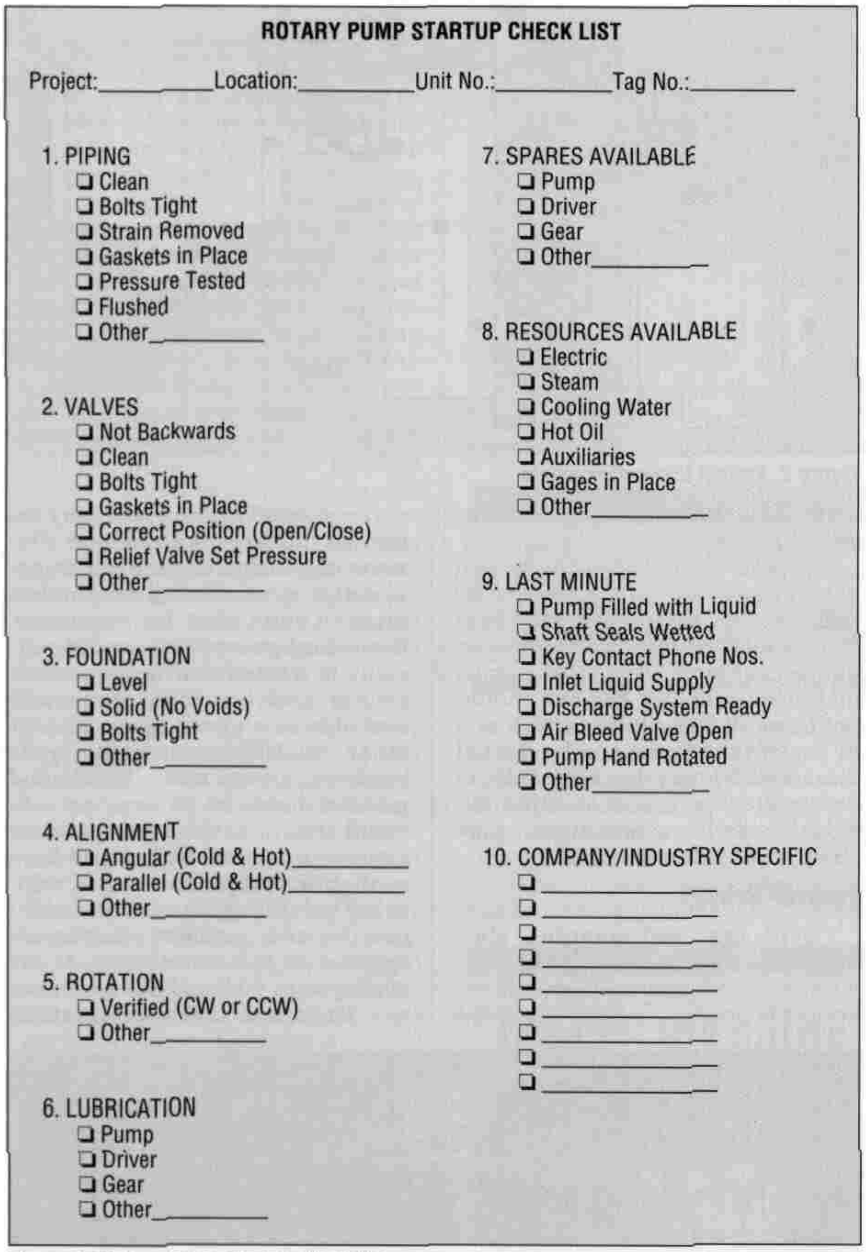
A person should be able to turn over almost all rotary pumps by hand. Pumps should generally turn over smoothly, with no catches or uneven rubbing. Very large pumps may need a helper bar but should not be at all difficult to turn. If one is, consult the pump vendor Partial disassembly may be advisable to determine the cause of difficulty encountered (foreign material, pipe strain, rust) before starting.

STARTUP SPARES

With care and planning, startups will generally go smoothly, without significant problems. However, it is prudent to have key spare
parts on hand in the event they are needed quickly for correction after some unanticipated problem, minor damage, or need to disassemble a piece of equipment for inspection. For rotary pumps this would normally be a set of shaft seals, gaskets, o-rings and bearings, frequently available as a minor repair kit. For other rotating equipment, spare bearings, grease and oil seals and gaskets should be on hand so as to avoid delay in the startup. More extensive spares will depend on availability from the vendor, criticality of pump operation, plant practice and, perhaps, other issues specific to the installation. If the startup goes well and the spares are not consumed, it is appropriate to



Twelve stage pump to DC motor alignment check using dial indicator



ROTARY PUMP STARTUP CHECK LIST

Project:________Location:________Unit No.:________Tag No.:________

1. PIPING
   - ❑ Clean
   - ❑ Bolts Tight
   - ❑ Strain Removed
   - ❑ Gaskets in Place
   - ❑ Pressure Tested
   - ❑ Flushed
   - ❑ Other________

2. VALVES
   - ❑ Not Backwards
   - ❑ Clean
   - ❑ Bolts Tight
   - ❑ Gaskets in Place
   - ❑ Correct Position (Open/Close)
   - ❑ Relief Valve Set Pressure
   - ❑ Other________

3. FOUNDATION
   - ❑ Level
   - ❑ Solid (No Voids)
   - ❑ Bolts Tight
   - ❑ Other________

4. ALIGNMENT
   - ❑ Angular (Cold & Hot)________
   - ❑ Parallel (Cold & Hot)________
   - ❑ Other________

5. ROTATION
   - ❑ Verified (CW or CCW)
   - ❑ Other________

6. LUBRICATION
   - ❑ Pump
   - ❑ Driver
   - ❑ Gear
   - ❑ Other________

7. SPARES AVAILABLE
   - ❑ Pump
   - ❑ Driver
   - ❑ Gear
   - ❑ Other________

8. RESOURCES AVAILABLE
   - ❑ Electric
   - ❑ Steam
   - ❑ Cooling Water
   - ❑ Hot Oil
   - ❑ Auxiliaries
   - ❑ Gages in Place
   - ❑ Other________

9. LAST MINUTE
   - ❑ Pump Filled with Liquid
   - ❑ Shaft Seals Wetted
   - ❑ Key Contact Phone Nos.
   - ❑ Inlet Liquid Supply
   - ❑ Discharge System Ready
   - ❑ Air Bleed Valve Open
   - ❑ Pump Hand Rotated
   - ❑ Other________

10. COMPANY/INDUSTRY SPECIFIC
   - ❑ ________
   - ❑ ________
   - ❑ ________
   - ❑ ________
   - ❑ ________
   - ❑ ________
   - ❑ ________
   - ❑ ________
   - ❑ ________

Figure 3. Rotary pump startup checklist

keep them on hand for future routine inspections and service.

RESOURCES

Be sure electric power, steam, cooling water, hot oil, instrumentation power or air or any other auxiliary resources are available and ready before start. Be sure adequate pressure and temperature gages are in place so observations can be made during startup. Without them, you are working blind.

Speed indication (tachometers) may also be needed if the drive is not a fixed speed one such as an AC electric motor. If the pump will be handling hot liquid, preheat the pump as necessary so it is not exposed to thermal shock when otherwise hot liquid reaches an ambient temperature pump. Rotary pumps may be somewhat more sensitive to thermal shock due to their close internal running clearances.

LAST MINUTE

It is good practice to fill the pump with the liquid to be pumped and pump and as much of the inlet piping system as possible with the liquid to be pumped. This will assist in priming and reduce the risk of pump damage during an otherwise dry start. A rotary pump will prime more quickly if internal pumping elements are at least wetted. Priming is nothing more than pumping air from the inlet system to the discharge system. The ability of a rotary positive displacement pump to act as an air compressor is very much related to having some liquid present internally.

Pump shaft seals, especially mechanical seals, should never be operated dry. Immediate, or at best premature, seal failure is the inevitable result. Again, filling the

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hand rotating the pump a few times helps insure that liquid is present at the shaft sealing mechanism to carry away frictional heat during startup. If the particular pump has a seal chamber access plug, remove the plug, fill the chamber with liquid and reinstall the plug.

Have phone numbers on hand of key vendor service departments, fire brigade and medical emergency services in the event they are needed. When handling petroleum and other flammable liquids, there are both pollution and fire hazards present.

Insure that there is an adequate supply of liquid in the pump inlet system (no half empty supply oil tanks or the like). It is also prudent to confirm where pump discharge flow will be going to be sure the discharge system is ready.

Loud or erratic noise at startup is an indication of cavitation (inadequate pump inlet pressure) or air being drawn into the pump inlet system. It is frequently accompanied by increases in or excessive vibration. If mild, troubleshoot the cause. If severe, shut down the pump and find the source of the problem.

Use the Rotary Pump Startup Check List accompanying this article
or a similar control to help insure that all contingencies have been addressed.

CONCLUSION

Our discussion cannot be considered all-inclusive since each pumping system has unique features and requirements, some of which may interact with each other or with other aspects of the overall plant operation. In addition, no allowance has been made here for regulatory requirements, specialized industry or company guidelines and the like. Where values are recommended, they are intended for use in the absence of vendor or specifically engineered information. Always use the more stringent of either the recommendations herein or the vendor or engineering guidelines. E

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