Sargent-Welch Rotary Vane Pump Maintenance Information

Checklist version

Introduction

The Sargent-Welch Duo-Seal Rotary Vane pumps used throughout the lab are some of the most dependable and forgiving vacuum pumps we have, provided they receive a little bit of attention now and then. This document, along with the accompanying checklist version, has been written to assist experimenters in providing that attention. Please read the complete version fully before employing the checklist.

I have tried to make this document comprehensive in nature so that anyone who wishes to attempt repairs has, at the very least, a place to start. Some of the items on this list are maintenance actions that are not necessarily expected of the experimenter, but are intended to be helpful in getting an experiment back on-line at 3:00 am, on a dark and stormy night...

Writing technical procedures and checklists is not always simple. It can be difficult to anticipate every question, remember each step, and then to accurately convey that knowledge to someone else. This document will undoubtedly undergo constant revision. Consequently, please always obtain the latest version prior to performing any of the maintenance actions listed.

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Periodic Inspection

Checklist Version | Contents

If possible, a complete inspection should be performed at least monthly. When this is not practical, the pump should be examined for as many inspection points as possible. Even with a running pump one can check the oil level and inlet vacuum hose, look for signs of leakage and listen for ugly noises.

- Periodic Inspection - Oil Level

Most Welch Duo-Seal pumps have two oil level sight glasses located on the main sump opposite one another. Each window is covered with a metal disk indicating the full and low marks for oil. The best and easiest way to check the oil level is to shine a flashlight in one window while inspecting the oil level in the other. *It is extremely easy to be fooled by the film that forms on the inside of the window. Often this film is perceived to be the oil level itself when, in fact, the true oil level is not visible in the window. If it is not obvious that you are looking at the actual oil level, shake or bump the pump. The oil will slosh back and forth whereas the film will remain stationary.* On pumps that have only one window, the 'slosh' method is even more critical.

Improper oil level can affect the pump in many ways. When the oil level is low, the second stage exhaust valves as well as the first stage exhaust and blowby valves can become uncovered. Since these pumps are oil sealed, these valves cease to function properly. This is almost always accompanied by a measurable loss in performance as indicated by higher inlet pressures. Too much oil can cause the sump to become over pressured during periods of high gas loads resulting in excess oil mist, oil frothing, and, in extreme cases, oil being violently ejected from the discharge. Having been the victim of a 'gusher', I recommend against overfilling.

Fresh oil can be obtained either from the 1 gallon container that stays in Room 15 (I am eternally hopefull) or from the 55 gallon drum in the northeast corner of the gas handling room. The drum has a hand pump for filling small containers. This hand pump works on the upstroke, that is, it flows when the handle is pulled up. It can be slow to prime. Pump smoothly and carefully until oil starts flowing. Allow for some extra oil flow after the last stroke. Push the handle all the way down, and move the spout over the top of the oil drum when done--it keeps the floor clean. Contents

- Periodic Inspection - Oil Condition

The condition of the oil determines when it must be changed. Depending on how the pump is used, the time between oil changes can vary dramatically. Pumps used for high gas load or caustic vapor operations must have their oil changed far more often than pumps used to back cryostat turbos for example. A small amount of oil can be drained off, even while the pump is running. The color, clarity, and quantity of particulate can then be assessed. A chemistry test tube can be used for comparison. I hope to have a set of standard tubes available for comparison soon.

Fresh oil is amber in color and quite clear, resembling a good, hearty ale. As the oil ages, the clarity can fall off quickly, but the color is slower to change. When the oil begins to look more like a stout (especially with head) than an ale, it's time for an oil change. (I am honestly convinced that the beer analogies are about the best frame of reference to use)

White, frothy foam (the head on the beer) is often an indication that the oil contains a great deal of water. This will often be the case when doing an initial pumpdown on a system that has been open to atmosphere for some time or pumping on some porous device, such as a charcoal adsorber in a cryopump. If the oil is good in color or known to be fairly new, the gas ballast may be employed to try to clean it up. If after pumping several hours with the gas ballast open no improvement is observed, the oil should be changed. Additionally, very high gas loads (especially something like blowing down the slow tuners) can cause oil froth. Froth created by high gas loads usually dissipates much more quickly than when caused by water vapor.

One last warning. There are two basic types of oil drain on the Welch pump. One is a valve, which makes obtaining an oil sample quite easy. The other type is a screw-on cap which must be nearly removed in order to get oil flow, especially when the sump contains heavy particulate. *Great care should be exercised when trying to obtain a sample from a running pump when this type of drain is used. If the cap is dropped, the oil drain cannot be stopped and the pump will run dry, spoiling the vacuum. Additionally, the oil can be quite hot making the 'Dutch-boy' method of stopping the oil drain impractical (if not painful!)* Contents

- Periodic Inspection - Oil Leakage

Because these pumps are oil sealed, a significant amount of oil can build up on and around the pump, especially if they experience high gas loads frequently. Consequently, it is common for the pump to have a light film of oil on it. It is important, however, to ensure that there are no leaks. The obvious tip-off is, of course, a low oil level. Common locations for leaks include the shaft seal, oil level windows, and drain valve/cap. Leaking at the windows will usually leave a stain trailing down the pump case. While all leaks should be dealt with as

soon as possible, *it is particularly important to ensure that leaking shaft seals are repaired quickly, as a bad shaft seal can damage the shaft, requiring its replacement at considerable cost. A shaft seal costs between $55 - $75, whereas shaft replacement runs $750 - $1000.* Ideally, the pump should be turned off and the shaft seal, pulleys, belts, and belt guard interior surfaces inspected for signs of oil. An oil 'sling' on the interior guard surfaces is a strong indication of a leaking shaft seal, since the oil for a sling must originate at the center of the pulley. If the pump cannot be turned off, look for localized oil film originating from under the belt guards. If pooled oil is found and the source can not be localized with the pump running, it is strongly suggested that arrangements be made to shut down the pump and examine the shaft seal at the soonest opportunity. Contents

- Periodic Inspection - Belt Condition

With the pump turned off and unplugged, the condition of the belts should be examined. The belt surfaces should be dry and free of oil. The inside diameter of the belt should be free of cracks and glazing (shiny areas which have been polished by the motor pulley spinning against a stationary belt). The inside surfaces of the belt guards should have minimal belt dust on them.

Belts with oil or glazed areas are indicators of a leaking shaft seal. *Do not simply replace the belts - address the shaft seal as well.* Belts that have no oil but have cracks, strings, delaminations or other problems should be replaced if they are dry. Belt replacement requires motor adjustment in most cases. Contents

- Periodic Inspection - Belt Tension

If the belt condition is good, then belt tension should be checked. There are two basic methods that I recommend; deflection and rotation. Both methods require that the pump be shut down and unplugged. For deflection, press the belt toward the center at the halfway point between the two pulleys. It should deflect no more than about one belt width before significant resistance is encountered. For rotation, grasp the belt between the thumb and forefinger about halfway between the two pulleys and try to rotate it. Significant resistance to rotation should be encountered by about 90 degrees rotation but certainly before 180 degrees rotation. Again, this is judgment call. If multiple belts are used on a pump, they should have more of less the same tension. If

one belt seems much tighter than the other, change both.

The belts should also be checked for too much tension. The inability to deflect or rotate a belt without extreme force is an indicator of too much tension. A final check is to sight down on the motor from above. If the belts have too much tension, the axis of the motor shaft will not be perpendicular to the plane that the belts are in, indicating that the belts are pulling the motor too hard against its resilient mounts. *This is serious problem which will lead to premature bearing failure in the motor.* Contents

- Periodic Inspection - Motor Power Cord Condition

All of the Welch rotary-vane pumps that we have use 120VAC, Capacitor Start, Drip-proof motors. Typically, there is a 14/3 Neoprene power cord of not more than 6 feet attached to the motor. This cord should be inspected for damage. Typical problems include cracks in the insulation, external insulation pulling free from strain relief devices, loose strain relief devices at the motor, and loose or missing motor plates. Additionally, some of the pumps that I haven't overhauled yet may have old plugs which use a cardboard insulator. This insulator can often come out exposing the user to 120VAC. Contents

- Periodic Inspection - Inlet Vacuum Hose Condition

Pumps that have been installed at the same location for long periods of time frequently develop problems with the inlet vacuum hose. These rubber hoses (usually red) can become brittle and hard. They sometimes develop cracks or simply fail to seal because they are no longer resilient. Moreover, the hoses can take a set where hose clamps are used. Hard and brittle hoses should be replaced. Contents

- Periodic Inspection - Belt Guard Installation

As pumps have come in to me for overhaul or repair, I have replaced the old banjo case style belt guards with newer, integrated belt guards and bases that meet OSHA requirements (and are simply much, much, much, better).

However, there are still some of the older style belt guards out there. Regrettably, in one or two cases, there are still pumps running with no belt guards at all. Regardless of the style, the belt guard installation should be inspected to ensure that it is functional. This is especially important in cases where the guard is removed for inspection or service. The pump should be tested again after the guard is reinstalled. Occasionally, a pulley will rub against the guard. Minor adjustment in guard placement will correct this. On some pumps pulley alignment necessitates creative guard installations. Contents

- Periodic Inspection - Audio

Yes, audio. Listen to the pump. One of the most common complaints I receive about pumps is that they don't sound right. Many common problems have noises associated with them. Scraping sounds are common when pulleys rub against belt guards. Gurgling and bubbling noises often indicate a leak (or the gas ballast is on). A sound something like marbles in a coffee can typically precedes motor bearing failure. Slapping noise means sticking vanes. Note any noises that aren't typical. A good Welch pump running at low gas loads is almost silent.

I should point out that many of our pumps have had their rubber feet replaced by castors. This not only makes them much easier to roll around, but it makes them much louder as well. Contents

Oil Changes

Checklist Version | Oil Capacities by Pump Model | Contents

Oil Changes are very important for two reasons. First, the quality of the oil determines pump performance in the near term. As the oil breaks down, the ultimate pressure that the pump is capable of reaching deteriorates because of the accumulation of contaminants and by-products from the oil. Second, the lifetime of the pump is decreased when bad oil is used. With age, the oil becomes less viscous and can become gummy. In the extreme, this can cause the pump to run hotter, which accelerates this process.

As stated above, the condition of the oil determines when it should be changed. However, a pump in continuous operation should have its oil changed every six months or so at the outside.

The following procedure indicates what I do when changing the oil. Note that if there is time to change the oil, then an opportunity exists to perform a complete inspection as outlined above. Fresh pump oil for the Welch Rotary Vane pumps can be found in a 55 gal drum in the northwest corner of the Gas Handling Room. Please ask for assistance locating the correct oil if necessary. A waste oil drum with a large funnel on the inlet can be found in

the same location. This drum should be clearly marked as waste oil. Once again, ask if necessary.

1. Ensure that the pump oil is warm by running the pump for at least 20 minutes prior to draining. Blank off the pump inlet with a large rubber stopper or bung.
2. With the pump stopped and level and a suitable container in place, open the pump's drain valve or remove the drain cap and allow the oil to drain. This can take a few minutes. The process can be somewhat accelerated by *briefly* running the pump with the inlet open and covering the outlet of the pump with the hand. As the outlet is covered, the escaping pressure will force oil out of the drain. *This should be done for no more than 30 seconds or so and care should be used because the discharge from the drain can be somewhat violent.* This technique also creates a great deal of oil mist.
3. Shut the drain valve or recap as appropriate.
4. Add about 4 ounces of fresh oil (1/2 cup) to the pump discharge and about 2 tablespoons to the pump inlet.
5. Run the pump for about 30 seconds using the rubber bung to burp the pump inlet. This creates turbulence in the pump. The air let in with each burp entrains the oil trapped in the voids and recesses of the pump causing it to be delivered to the sump.
6. Drain the pump again as above.
7. Repeat the three steps above until the color of the oil being drained is the same as the fresh oil. Allow for the froth created by the turbulence when making this determination. This may have to be repeated several times for pumps having very dirty oil.
8. Shut the drain valve or recap as appropriate.
9. Fill the pump with fresh oil to the correct level as indicated on the sight glass. Use care to prevent oil spills while filling. These spills can lead to misdiagnosed shaft seal leaks during future inspections.
10. Discard used oil in the appropriate waste oil container located in the gas handling room.

Pumps that are extremely dirty may require the use of a flushing fluid. This flushing fluid is useful for removing particularly bad oil contamination from a pump. If the pump had very poor oil condition prior to service and does not reach its normal ultimate pressure after service, it *may* be a candidate for flushing. Please consult me prior to using the flushing fluid.

Belt Replacement

Checklist Version | Belt Selection by Pump Model | Contents

Sargent Welch Rotary Vane vacuum pumps are belt driven and run at relatively slow rotational speed when compared to direct drive pumps. As belts become worn, they can begin to slip. This can cause belt overheating, glazing, and reduced rotational speed, thus affecting the performance of the pump. *It is very important that pumps with oily belts be*

examined for a leaking shaft seal. It the shaft seal is leaking, it is futile to replace the belts without repairing the seal.

If the belts are not oily, the belts may be replaced using the procedure given below. Pumps with multiple belts should have all belts replaced at the same time. Because a pump which has only one belt will cease to run if that belt breaks, I will usually replace single belts at the most minimal sign of damage. Bear in mind, however, that if one belt of a double belt system fails, the second belt, which is usually just as old as the first, must serve double duty and consequently will often fail very soon after the first.

Belt replacement usually requires adjusting the motor mounts. The vast majority of the Welch pumps that we have use a NEMA 56 motor mount which has slots allowing for adjustment of the distance between the motor and pump shafts. Since belts almost always stretch, the new belts will often require this distance be shortened. I typically try the existing motor position and then adjust from there. Also, most of our pumps have nut bars installed. Some genius devised these things! The bolts that hold the motor in place don't have normal nuts under the base. Instead, the have metal bars with two threaded holes in them. One need only loosen each bolt, move the motor, and then tighten the bolts. When tightening one bolt, the other prevents the nut bar from rotating.

The method I use to install and remove the belts is simple. I call it the bicycle method, because it is the same way I used to put my bike chain on when I was a kid. With my left hand, I hold the belt against the motor pulley in the groove that I want it to end up in. Then, with my right hand, I place the belt in the outermost groove of the pump pulley at the top of the pulley. Holding the belt against the pump pulley, I rotate the pump pulley slowly clockwise. As the right hand progresses from the 12:00 o'clock position to the 6:00 o'clock position, the belt will fall into the groove. To move the belt to an inner groove, repeat the process. *Mind the fingers using this method--it can be quite painful to get them between the belt and the pulley.* Belts can be removed by reversing this procedure.

Use this table to determine what belt is used for each model pump. The belts are located in room 15, on the east wall above the shelves. Note that different belt manufacturers use different nomenclatures for their belts. Typically though, the last 3 digits of the belt number indicate the belt circumference, in inches. Thus a 2490 and a 4L490 are both a 49.0" belt. A 4L415 is a 41.5" belt. As a future endeavor, I'll try to get the belts marked by pump model number so that it will be simpler to locate the correct belt.

The belt tension can be checked with a single belt installed. There are two basic methods that I recommend; deflection and rotation. Both methods require that the pump be shut down and unplugged. For deflection, press the belt toward the center at the halfway point between the two pulleys. It should deflect no more than about one belt width before significant resistance is encountered. For rotation, grasp the belt between the thumb and forefinger about halfway between the two pulleys and try to rotate it. Significant resistance to rotation should be encountered by about 90 degrees rotation but certainly before 180 degrees rotation. Again, this is judgment call. If multiple belts are used on a pump, they should have more of less the same tension. If one belt seems much tighter than the other, change both.

The belts should also be checked for too much tension. The inability to deflect or rotate a belt without extreme force is an indicator of too much tension. A final check is to sight down on the motor from above. If the belts have too much tension, the axis of the motor

shaft will not be perpendicular to the plane that the belts are in, indicating that the belts are pulling the motor too hard against its resilient mounts. *This is serious problem which will lead to premature bearing failure in the motor.*

Belt Replacement Procedure

1. Ensure pump is turned off and unplugged.
2. Remove belt guard assembly, noting how it is installed.
3. Remove the old belts, if they are still on the pump.
4. Degrease the pulleys using a lab towel moistened with a solvent such as ethanol.
5. Install a single new belt.
6. Check for belt tension.
7. If tension is not correct, remove belt, make motor mount adjustment, and try again until correct tension is obtained.
8. Verify belt tension is not too high by checking motor shaft axis is perpendicular to belt plane.
9. Install belt guard assembly.
10. Run and test pump. Ensure pulleys are not rubbing against belt guard assembly.

As a courtesy, please let me know if the belt inventory is low after replacing belts so that I can order more. Contents

Shaft Seal Replacement

Checklist Version | Pic-Tutorial | Shaft Seal Selection by Pump Model | Contents

The shaft seal is one of the most troublesome components of this type of pump. Its job is to form an oil tight seal between the shaft, which rotates at several hundred rpm, to the pump housing, which is stationary. The manufacturer supplied seals that consisted of two precision-ground, spring-loaded graphite rings which rotated against one another. In a two part design, each half would use rubber to form the first part of the seal and the carbon ring to form the second. The carbon rings wear with use and at some point become thin, break, and allow the springs and other internal bits to damage the shaft. Once the shaft is scored, it can be difficult to get the rubber side to seal to the shaft, hence requiring shaft replacement. *This is the reason that it is so important to replace leaking shaft seals early.*

My last purchase of shaft seals for the 3/4 inch shafts, such as those used on the model 1402 pump, were of a different design. These newer shaft seals consist of a double lip seal made of elastomer which is stationary relative to the pump housing and wears against the shaft. Presumably, an oil bearing is established between the two lip seals. At the moment (Jan, 2000) I intend to reserve judgment on this design, since I have little experience with them. However, I can see one dramatic advantage to this design. The newer seal is much simpler in design, having only two parts: an elastomeric sealing surface bonded to an aluminum mounting ring. Should the elastomer become damaged, an oil leak will result, but the mounting ring will remain in place. *There are no internal metal bits to damage the shaft upon seal failure.* I hope that these seals are effective, because they may cut down on the number of unnecessary rebuilds that we have to perform due to scored shafts.

It is rare that a leaking shaft seal is the immediate cause of pump failure. Usually, the belts fail and shut down the pump. Consequently, shaft seal replacement is not a repair that

should be attempted in a 3:00 am bid to get the experiment going again. Either clean off the pulleys and throw on some new belts or, instead, tag the bad pump and leave it in or near room 15, steal someone else's pump to get going again, and make the necessary apologies in the morning. Then send me e-mail so I know to get to it.

The proceedure for replacing the new-style shaft seal is covered in this Pic-Tutorial , which demonstrates the new-style shaft seal being installed on a Welch 1402 pump.

Oil Mist Separator Replacement

Checklist Version | Contents

Replacement of the Oil Mist Separators can be difficult, but is generally trivial. Until I find the filters that Jason purchased, this section is on hold. Contact me for help with these until then.

Rotational Speed Assessment

Rotational Speed by Pump Model | Contents

Each model of Welch pump has a specified rotational speed for the pump pulley and shaft in order to obtain manufacturer's performance specifications. Because they are belt driven, the condition of the belts plays the major part in determining whether the pump is up to spec or not. Conditions leading to belt slip will cause the rotational speed of the pump to drop, decreasing pump performance. When a leaking shaft seal is the cause, pump performance can deteriorate significantly before belt failure occurs.

All of our Welch pumps use a 60Hz, 120VAC motor with a rotational speed of 1725 RPM. This, in conjunction with the ratio of the pulley diameters determines the rotational speed of the pump. *Please note that this means that the pulleys are critical to pump performance. Incorrect pulley replacement can cause poor pump performance or premature failure.*

Determination of rotational speed is accomplished using a strobe light. A light colored mark is made on the pulley--I typically use chalk. With the pump running, the strobe illuminates the mark. The strobe period is adjusted until the mark appears stationary. It is rare that pump pulley speed differs by a factor of two from spec so the multiples can usually be disregarded as false readings.

It is important to ensure that the motor speed is correct prior to condeming the pump. If the pump seems visibly slow or severly loaded, remove the belts and measure the motor speed. The motor speed may be measured with the belts on, however, it should be confirmed with the belts off if it reads low-out-of-spec.

Once it has been determined that the motor speed is correct, the pump speed should be tested. Refer to the table for correct speeds. If the pump runs slow and the belt condition is good, contact me. Possible reasons for slow speeds with good belts include incorrect pulley size and excessive pump friction. High pump pulley speeds are almost always due to incorrect pulley size. Contents

Vendor Information for Vacuum Pump Repair Parts and Accessories

Contents

My primary supplier for repair parts is Precision Plus Vacuum Parts, Inc., in Niagra Falls, NY. They are good for internal repair parts and buying a pump piece-by-piece. They also have good rebuild kits, if you are so inclined. Other items, such as rubber vacuum hose, gauges, hand valves and such I purchase from Duniway Stockroom Corp., in Mountain View, CA. These folks also supply the OSHA supplied base and belt guard assembly that I've been migrating to. I just purchased a 55 gal drum of MP-43 belt-drive pump oil from Vacuum System Specialists, which should last at least a couple of years, depending on how well the pumps are maintained. I believe that they sell direct-drive oil as well. Call Dawn and ask.

The best place to go for pump rebuilds is Vacuum Systems Specialists. Contact Dawn Doyle or Jim Harper at (800) 354-8177 voice, (904) 964-5348 fax. Their address is P.O. Box 1257, 402 E. Brownlee St, Starke, FL 32091-1257. They are a factory authorized Welch repair facility, and their service is *absolutely superb.*

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