A Comprehensive Guide to Decanter Centrifuge Operation, Service, Maintenance, and Repair

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What is a Decanter Centrifuge and How Does it Work?

Description of a Decanter Centrifuge

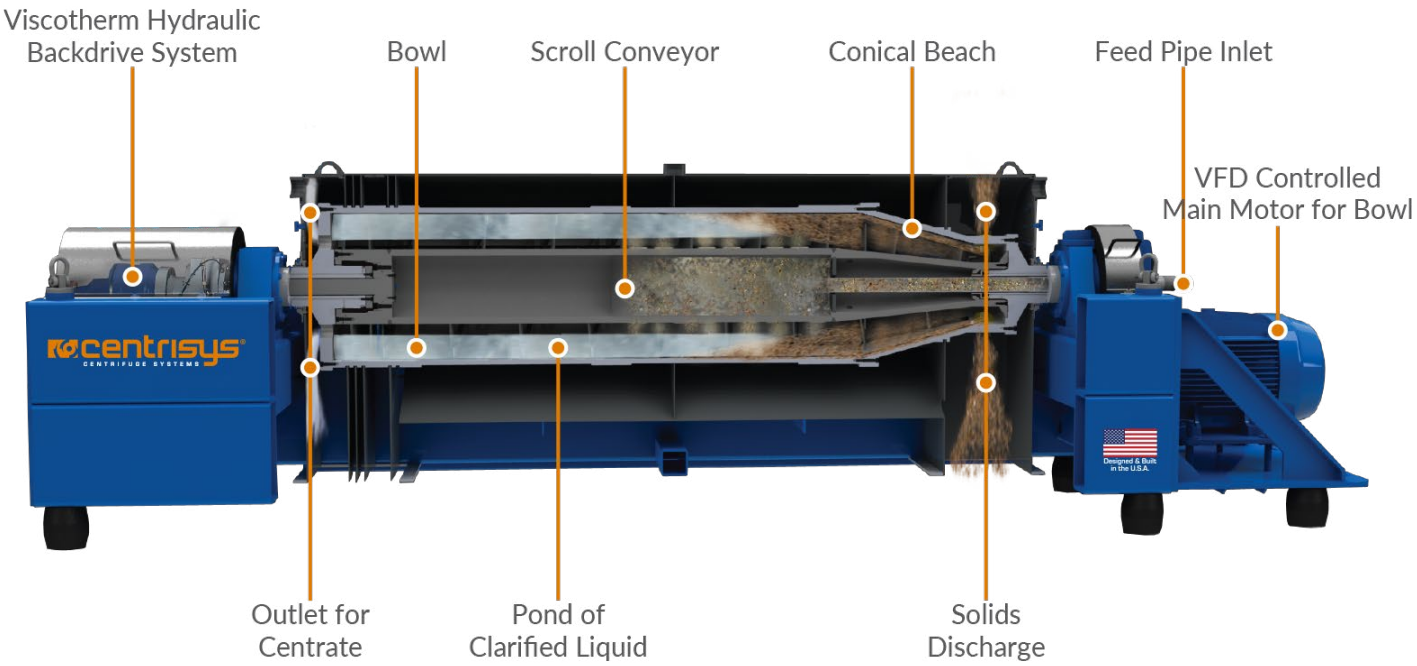
A decanter centrifuge, also known as a horizontal bowl centrifuge, solid bowl centrifuge or scroll centrifuge, is a machine used to separate a solid material from a liquid(s) using a high-speed and continual rotational process. While wastewater treatment of biosolids is a primary application, the separation of one solid material from one liquid (2-phase dewatering) in a slurry is also important for a number of industries including chemical, food, oil, and mining to name a few.

How it Works

The separation of a solid and liquid(s) in a decanter centrifuge system work on the principle of gravitational forces. It takes considerable time for the gravitational separation of a muddy mixture (to fall to the bottom) and water (to rise to the top) in separation technologies based on 1xG separation such as, a static container, clarifier or lamal separator, the rapid rotation of a centrifuge greatly speeds up this gravitational principle.

In fact, the G-force generated by a decanter centrifuge can be well in excess of three-thousand times greater than gravity reducing the separation process from hours to mere seconds. Today's centrifuges are a counter-current type technology. The separation process in a 2-phase decanter centrifuge results in the denser solid particles to be compacted and settled out in the inner drum and then transported and removed via solids discharge end of the decanter. The centrate is routed to the opposite end of the centrifuge and removed via the centrate outlet. In a 3-phase centrifuge, the baffle system is built inside the centrifuge. The baffle system blocks the oil from being discharged with the water. The oil (the lighter phase fluid) is collected between the two baffles and skimmed off the top.

Decanter Centrifuge Operational Diagram



The basic operation includes the following centrifuge parts and how they function:

1. The feed material enters the centrifuge via the **feed pipe** on one end of the centrifuge
2. Due to **centrifugal force**, the heavier particles are pushed through the liquid and collected on the inner wall of the bowl; the high speed rotation of the bowl separates the solids and liquid materials
3. The continuous rotation of the **bowl** can be accomplished by a VFD (Variable Frequency Drive)
4. The **scroll conveyor (scroll)** inside the bowl rotates at a slightly different speed than the bowl (differential speed)
5. The scroll conveyor continuously scrapes the solids off the inner bowl wall and moves the solids in the direction of the centrifuge conical's **solids discharge** area
6. The liquid (centrate) moves in the opposite direction from the solids due to Pascal's Law (or a system of combined piping) and because the solids discharge end is sealed by the solids
7. The differential speed of the centrifuge controls the **solids retention time**; the longer the solids are under G-force the drier the solids become in the dewatering process

Decanter Centrifuges for Sludge Thickening and Dewatering

The cost of biosolids storage, transportation, and end-use or disposal can significantly impact the choice of decanter centrifuges to perform thickening or dewatering functions. Generally speaking, sludge thickening before dewatering will reduce the tankage needed for storage by removing water; dewatering works to remove more water producing a drier cake material (source: EPA - Centrifuge Thickening and Dewatering of Biosolids).

Sludge Thickening

According to ScienceDirect, Sludge thickening commonly produces sludge solids concentrations in the 3% to 7% range, which results in an 80% volume reduction. Several factors determine whether a sludge thickening system is sufficient in the treatment of biosolids. These include:

- The type of sludge
- Transportation costs based on tonnages
- Landfill percent of solids concentration requirements
- Whether the sludge can be disposed in a sludge lagoon

Sludge thickening using a decanter centrifuge before a digestion treatment process will reduce the size of the digester, and can be used before sludge storage and liquid land applications. Depending on the utilization of the sludge product (landfilled, land applied or dried) the drier the product the more cost effective it will be for storage, transportation and disposal.

Types of Sludge:

Waste Activated Sludge (WAS) / Secondary Sludge (0.8-1.3% TS)	Primary Sludge (1.5-5% TS)	Digested Sludge (1.5-3% TS)
▪ Has natural separation of free water (floc) and is easily settable ▪ Little to no polymer is required. (*)(**)	▪ Solids are heavy and settable but laden with colloidal material (hazy) ▪ Hard to remove fine particles ▪ Polymer is usually required	▪ Not easily settable; ▪ Polymer is usually required

* *Traditional decanter centrifuges used for sludge thickening can work using little to no polymer but require higher energy consumption or the capacity of the equipment is limited. Other thickening technologies (rotary drum, gravity belt, DAF) need polymer to produce 4-5% solids concentration*

** *The Centrisys THK Sludge Thickener will achieve 4-5% solids concentration using no polymer, with 50% less energy consumption and increased capacity compared to traditional decanter centrifuges.*

Click to read the **Centrisys** Sludge Thickener THK Series for more details and advantages of this type of a decanter centrifuge for sludge thickening.

Sludge Dewatering

Mechanical dewatering with a decanter centrifuge can result in a 95% reduction in volume and a concentration of between 15% to 35% dry solids, compared with 80% volume reduction and solids concentration of 3% to 7% with a sludge thickening-only operation. By removing more water and thereby producing a drier cake product, dewatering will offer significant savings in treatment, handling, and disposal costs.

Advantages of dewatering include the following (source: EPA - Biosolids Technology Fact Sheet on Centrifuge Thickening and Dewatering):

- Reduces volume, saving money on storage and transportation
- Eliminates free liquids before landfill disposal
- Reduces fuel requirements if the residuals are to be incinerated or heat dried
- Eliminates ponding and runoff
- Optimizes air drying and many stabilization processes

With a Centrisys **Dewatering Centrifuge CS Series**, the more the equipment runs, the more fine-tuned the set-up becomes. Not only does the centrifuge controller automatically start the centrifuge system, the control package also allows the operator to preselect what mode the centrifuge should operate in. A Centrisys decanter centrifuge is typically 95% optimized within 45 minutes of start-up. The Rotodiff® hydraulic backdrive gives instant feedback (via a pressure correlation) of the cake solids level more accurately than can be determined by visual observation. Once the desired pressure is achieved, the Rotodiff hydraulic backdrive maintains the cake solids level in spite of changing feed concentration via an integral proportional controller. A plant operator will need to occasionally observe the centrate and adjust the polymer accordingly, but the system stays optimized with very little operator attention.

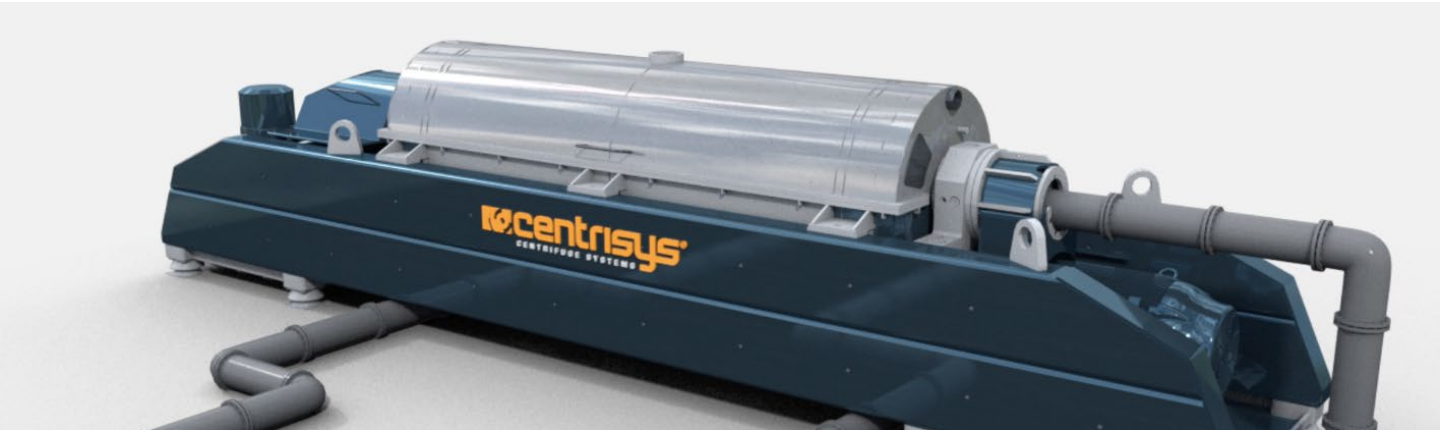
Process Performance. Municipal sludge and performance expectations are difficult to fully classify due to wide-ranging variations of different processes as well as domestic and industrial contributions to the biomass.

There is a need to:

- Define sludge characteristics
- Characterize optimum performance levels expected on the equipment

Sludge definitions. To better quantify performance, limits need to be set and terms better qualified. All sludge types as defined below assume industrial contributions are less than 20% of the final dewatered solids concentration and that conventional wastewater treatment processes are employed. Chemical additives (such as potassium permanganate used in odor control) are assumed not to significantly affect sludge conditioning.

Raw Primary	The feed solids are assumed to come off the bottom of a primary clarifier and therefore have a consistency of 2 – 7% ts. For thickening before anaerobic digestion or tanker hauling, cake at 5 – 10% ts is specified at +95% recovery and is easily obtainable.
Waste Activated Sludge (WAS)	Most feed solids vary from 0.4 – 2.0% tss. Sludge thickening without polymer yields a 4 – 6 % cake for recovery specs of 85 – 90%. Polymer is required at higher level of recoveries and/or while thickening at 7 – 10%. Dewatering and high solids dewatering typically occurs at 90 – 95% recovery levels.
Raw Mixed Primary / Secondary Sludge	Various combinations of mixed primary and secondary sludge are usually found at a concentration between 3 – 6% tss. This analysis assumes a 50:50 blend of sludge types. Recovery levels of +95% are typically achieved using polymer for all modes of separation.
Mixed Anaerobically Digested Sludge	Assuming a 50:50 blend of primary and secondary sludge to the digester, feed solids at 2 – 4% tss typically result in specifications at +95% recovery with polymer.
Aerobically Digested Sludge	For aerobically digested sludge, feed solids at 1 – 2.5% tss typically result. Polymer is used to effect separations at 90 – 95% recovery.



Glossary of Terms Used in this Section:

Biosolids	Organic matter recycled from sewage especially for us in agriculture as fertilizer. Treated sewage sludge.
Cake	The dried substance (sludge solids) from a decanter centrifuge operation.
Centrate	The liquid discharged from a centrifuge after most of the solids have been removed.
Centrifugal Force	The force (non-real force) that is needed to make things work as you would think in a reference frame that is accelerating.
Countercurrent Technology	In countercurrent flow, the two flows move in opposite directions. Under high centrifugal force, the heavier solids migrate radially outwards towards the bowl, displacing the lighter liquid to the pool surface at a smaller radius.
G-force	An outward force acting on a body rotating about an axis.
Million Gallons per Day (MGD)	The measurement of water a facility processes each day.
Sludge	The semi-solid residual material which is left behind from the treatment of wastewater.
Slurry	A muddy mixture of a liquid and a solid; a watery mixture of insoluble matter.
STP	Sewage treatment plant.
Total Solids (TS)	The combination of total dissolved solids and total suspended solids in a liquid.
Total Suspended Solids (TSS)	The portion of fine particles, these do not dissolve, that remains suspended in water.
Variable Frequency Drive (VFD)	Motor controller that drives an electric motor by varying the frequency and voltage of its power supply. The VFD also has the capacity to control ramp-up and ramp-down of the motor during start or stop.
Waste Activated Sludge (WAS)	The excess quantity of microorganisms that must be removed from the biological wastewater treatment process to keep the ration of biomass and incoming pollutant load in balance.

Servicing and Maintaining a Decanter Centrifuge

In this section, we'll discuss some routine maintenance procedures a plant operator can undertake. We'll also offer details on Centrisys' Suggested Plant Maintenance Guidelines, and the Centrisys Service Inspection Program (CSI).

Routine Centrifuge Predictive and Preventative Maintenance

A decanter centrifuge maintenance schedule should include daily, weekly, monthly, and annual measures. A trained plant operator can perform many if not most of these. Some more critical centrifuge service issues may require the equipment and expertise of a dedicated centrifuge service and repair facility or a Centrisys field service technician to evaluate the centrifuge at your plant - more on this later.

Our 30+ years of manufacturing, servicing, and repairing all brands of centrifuges qualifies us to share the following routine centrifuge preventive inspection and maintenance items. For complete details and a list of all centrifuge inspection and maintenance checks, download a copy of Centrisys' Suggested Plant Maintenance Guidelines.

Daily Maintenance

Operators should **perform a daily centrifuge walk around. Here are s**ome essential parts and functions to check for:

- Fasteners & Guards: Visually check external bolts for looseness and guards for cracking
- Discharge Hoppers & Piping: Check for leaks
- Noise & Vibration: Observe noise and vibration levels on the panel

Monthly Maintenance

Here are a few of the suggested centrifuge maintenance items to perform monthly:

- Inspection for Wear: Inspect rotor and housing for wear
- Wiring, Electrical Components: Check for wear or damage
- Discharge Areas: Check solids and liquid discharge areas for wear and obstruction

Weekly Maintenance

See your operations and maintenance manual for information on the recommended weekly maintenance tasks involving the following:

- Grease Internal Bearings
- Check Belt Tension
- Check Lubricant & Oil Levels

Annual Maintenance

Conduct a function check to verify the operation of interlocks and system controls. Also, check the PLC battery. The centrifuges main and internal bearings should be replaced every 15,000 hours. Other centrifuge wear components such as feed and discharge nozzles and tiles should also be inspected and replaced if needed.

Decanter Centrifuge Service and Maintenance Resources

Give your centrifuge some love by learning from the experience of others and by following these service and maintenance tips:

- Decanter Centrifuge Case Studies and Service Tips
- Do's and Don'ts of Cleaning a Decanter Centrifuge
- Visual Inspection: Centrifuge Solids Discharge Nozzle
- Protect Your Centrifuge from Environmental Elements

Preparing and Operating a Decanter Centrifuge for Extreme Weather Conditions

Your centrifuge may be subject to severe weather: rain, snow, and freezing temperatures. If so, the following service tips can help:

- How to Winterize Your Decanter Centrifuge
- Video: How to Prevent Decanter Centrifuge Bearing Damage During Storage
- How to Prepare a Decanter Centrifuge for Extreme Weather Change
- Decanter Centrifuge Service Tips Following Extreme Weather

A Proactive Approach to Ensure More Centrifuge Uptime

Centrifuge inspections shouldn't be viewed as a burden. Knowing the condition of your centrifuge or sludge thickener will reduce repair costs and enhance performance reliability. Not only that, but a forward-thinking centrifuge maintenance plan allows for proactive budgeting and a safer environment for your plant operators.

For these reasons and more, Centrisys has developed the Centrifuge Service Inspection (CSI) Program, a 40+ point inspection for your decanter centrifuge or sludge thickener.

What is the CSI Program?

It's a one day, one decanter centrifuge on-site inspection performed by Centrisys. The CSI Program is available for all brands of decanter centrifuges. The centrifuge evaluation includes a summarized report outlining the condition of 40+ critical areas and recommended actions to prevent the consequences of poor performance or centrifuge failure.

Why 40+ Points?

After 30 years of servicing all makes and models of decanter centrifuges, the Centrisys service team has the experience to identify those areas of a centrifuge that are critical for performance, reliability, and safety. Plants find this evaluation to be a useful reference for forecasting maintenance budgets

Download our free CSI: 40+ Point Inspection Program Fact Sheet for more information on what the inspection report covers along with the Centrisys 365 Support plan.

Maintaining the Optimal Differential Speed of a Decanter Centrifuge

In most cases, the differential speed of a decanter centrifuge is set by the manufacturer or service provider based on the customer's application for dewatering or sludge thickening. Optimization of the differential speed of the bowl and scroll may be necessary to achieve optimal solids removal and the driest cake.

In this section, we'll cover the differential speeds at which a centrifuge is running along with its impact on both dewatering and sludge thickening. We'll also discuss steps to verify a decanter centrifuge's differential speed is optimized.

What is the Differential Speed of a Centrifuge?

The differential speed of a centrifuge is the difference between the bowl speed and the speed of the scroll.

- Assuming the bowl speed is at 3000 RPM
- If the scroll is leading at 1 RPM of differential speed - the scroll speed is 3001
- If the scroll is lagging at 1 RPM of differential speed - the scroll speed is 2999

A Centrisys decanter centrifuge has the ability to operate both as a leading and lagging scroll. A leading scroll runs faster than the bowl. A lagging scroll runs slower than the bowl. This innovative scroll design prolongs the life of the discharge nozzles on both the bowl and the scroll. The benefit to our customers is less maintenance since a scroll can operate as both leading and lagging.

Why is the Differential Speed of a Centrifuge Necessary for Dewatering Sludge?

Assuming the scroll has 15 sets of flights and a differential speed of 1, the solids that are pushed through the centrifuge (from the feed inlet to the solids discharge) will stay in the centrifuge for a maximum of 15 minutes under G-force. The solids retention time is determined by the differential speed. The longer the solids remain in the centrifuge, the drier they will be. A lower differential speed results in drier cake.

By increasing the differential speed from 1 RPM to 2 RPM , the solids retention time is halved. So now, instead of the solids staying 15 minutes in the centrifuge under the G-force, they're only staying 7½ minutes, theoretically resulting in a wetter cake but a cleaner centrate. By doubling the differential speed the solids inventory inside the centrifuge is halved; there is more available room for clarification, resulting in a cleaner centrate.

Differential speed of a centrifuge is vital for dewatering when calculating the desired dryness level of the cake versus the overall throughput of the critical operation. Again, a lower differential means more time in the centrifuge and results in a dryer cake. Whereas, a higher differential means less time in the centrifuge, a wetter solid, but a cleaner centrate and more gallons per minute (gpm) capacity.

What's the Quickest Way to Verify the Differential Speed is Set Properly on a Decanter Centrifuge?

The quickest indicator of a correctly adjusted differential speed is the cleanliness of the centrate. As long as the centrate is clear and clean, the differential speed can be reduced to optimize the dryness of the cake solids.

It's impossible to see the dryness of the cake solids, but it's visually possible to immediately see the clarity of the centrate and adjust based on how clean or dirty the centrate becomes while optimizing. When adjusting the differential, if the centrate becomes dirty or cloudy, that's the indicator that the actual differential speed is too low. Too many solids are being stored in the centrifuge which results in the centrate becoming cloudy and dirty.

You may have noticed the centrifuge is not performing as expected, or the solids are too wet, the centrate is too cloudy. As noted in our video, Verifying Calibration of Differential Speed, you can make temporary changes and verify differential speed without shutting your process down by following these steps:

1. Start your centrifuge and put the feed system in manual
2. Make sure BAR pressure is low, under 20 BAR
3. Go to curve control page on the control panel
4. Select Delta N and enter a higher value, press enter
5. Make sure the actual value you entered is accepted

6. The actual differential should change to the set value within 30 seconds
7. Set the value back to one RPM
8. Make sure the differential speed changes to the set value (a small variation like 0.5 RPM is okay)
9. This confirms that the control valve and hydraulic system are responding
10. If the actual RPM does not respond, the centrifuge will need to be recalibrated
11. Reset value Delta N to the original setting

Contact Centrisys with any questions on recalibrating the speed of your decanter centrifuge.

Balancing a Decanter Centrifuge at Operational Speed in a Bunker

Just as a centrifuge's differential speed needs to be recalibrated if it's running outside its normal operating parameters, a centrifuge bowl and scroll will need to be rebalanced under certain conditions. This section will cover the ins and outs of balancing a centrifuge and why it's important to balance at operational speed.

Why Balance a Decanter Centrifuge?

An out-of-balance decanter centrifuge is like having unbalanced car tires. When a tire is out of balance, it bounces against the road, which results in multiple performance problems involving steering, speed, safety, and the premature wear and tear of parts.

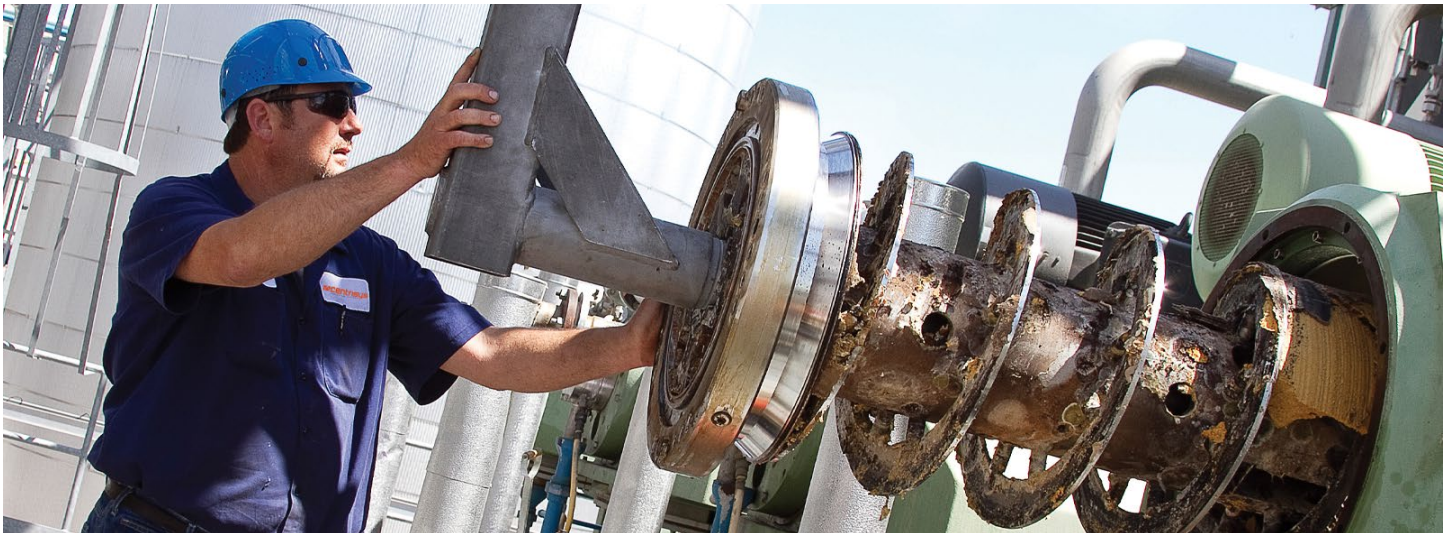
Underestimating the power of accurate centrifuge balancing is a big mistake. High vibrations cause premature damage and wear to centrifuge parts and structural components, creating more expensive repair costs and unnecessary process downtime.

When Should a Decanter Centrifuge be Balanced?

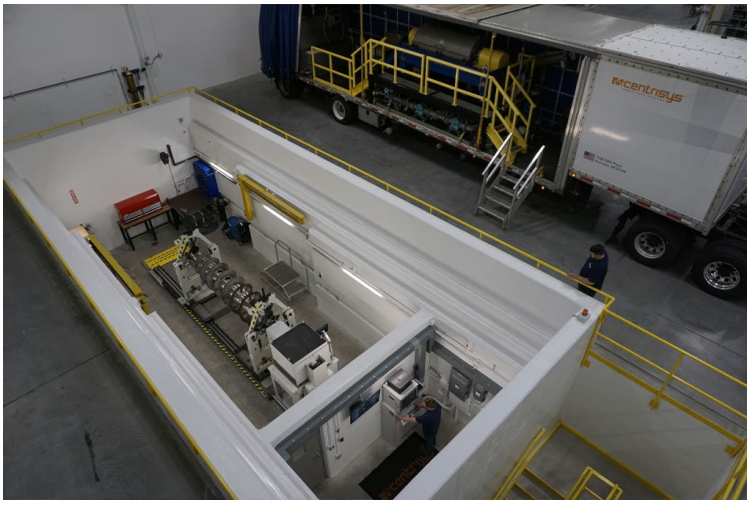
A decanter centrifuge balancing should be performed, after a major repair or rebuild following 15,000 to 20,000 hours, or anytime you have excess noise and vibration during operation.

What Parts of a Decanter Centrifuge Need to be Balanced?

Typically the centrifuge bowl and scroll are balanced. Each is going to be balanced separately. But then they'll be balanced and tested together to make sure they run smoothly and are within the operational specifications required.



Where and How Should a Decanter Centrifuge be Balanced?



It's important to balance a centrifuge at operating speed. Centrifuges can run at very high speeds: 2000 to 4000 times the speed of gravity (what is referred to as G-force). The only way to accurately balance a centrifuge bowl and scroll is to balance them at their normal operating speeds.

Balancing equipment at high speeds, as you can imagine, is not advised without proper protection and protocols. This is why at Centrisys, we've created an innovative approach with our state of the art balancing bunker.

Centrifuges sent to Centrisys for repair or rebuild and which then require balancing are done so in our Centrifuge Balancing Bunker. This dedicated shop space provides the necessary safety and protection of employees and customers who come to witness the operation. It not only provides for noise reduction during high-speed balancing, but it affords a much-needed measure of safety for our operators and service technicians.

Beyond the safety of our team, our centrifuge balancing bunker pit is 13' deep, 20' wide and 40' long. Sixteen truckloads of concrete were used to pour the bunker to insure the strongest base possible. Two 15-ton cranes move the centrifuge bowls and scrolls in and out of the pit. A retractable steel and concrete roof encloses the bunker when the balancer is operating.

The Schenck HM7U balancing machine can balance on and over operating speeds on centrifuges with a diameter of 44" or greater and handle larger heavier rotors. Creating this state of the art balancing bunker is the natural step for manufacturing and servicing the next generation of centrifuges.

Customers who do not wish to be present for balancing at our service facility can have the balancing readings sent directly to them via access to a web interface.

Accurate, at or above, operational speed centrifuge balancing is the first critical step to execute a well planned preventative maintenance program. This will keep a decanter centrifuge running smoothly and minimize repairs and unnecessary downtime.

Centrisys/CNP provides low-maintenance equipment and process needs backed by expert service staff stationed throughout the USA We are ready to answer your questions and help you maximize performance today.

Contact Us with Your Equipment and Process Needs

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