www.costeffectiveequipment.com

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Operations Manual

Apogee® 450 Spin Coater

Model: A-B-SC3-2

Cost Effective Equipment

1 Introduction

1.1 Confidentiality Statement

Information supplied is for the use in the operation and/or maintenance of Cee® equipment. Neither this document nor the information it contains shall be disclosed to others for manufacturing or any other purpose without written authorization from Cost Effective Equipment, LLC.

1.2 Warranty

Cost Effective Equipment, LLC warrants to the original purchaser (Buyer) that equipment is free from defects in material and workmanship under normal use and service in accordance with Cee® instructions and specifications. Buyer shall promptly notify Cee® of any claim against this warranty, and any item to be returned to Cee® shall be sent with transportation charges prepaid by Buyer, clearly marked with a Return Authorization (RMA) number obtained from Cee® Customer Support. Cee's obligation under this warranty is limited to the repair or replacement, at Cee® option, of any equipment, component or part which is determined by Cee® to be defective in material or workmanship. This obligation shall expire one (1) year after the initial shipment of the equipment from Cee®. This warranty shall be void if:

- Any failure is due to the misuse, neglect, improper installation of, or accident to the equipment.
- Any major repairs or alterations are made to equipment by anyone other than a duly authorized representative of Cee®. Representatives of Buyer will be authorized to make repairs to the equipment without voiding warranty, on completion of the Cee® training program.
- Replacement parts are used other than those made or recommended by Cee®.

CEE® MAKES NO OTHER WARRANTIES, EXPRESSED OR IMPLIED, WITH RESPECT TO EQUIPMENT. NO WARRANTY IS MADE AS TO THE MERCHANTABILITY OF THE EQUIPMENT NOR ITS FITNESS FOR ANY PARTICULAR PURPOSE. In no event shall Cee® be liable for consequential loss or damages, however caused. No person or representative of Cee® is authorized to assume for Cee® any liability in connection with equipment nor to make any change to this warranty unless such change or modification is put in writing and approved by an authorized representative of Cee® in writing.

This warranty shall be governed by the laws of the state of Missouri, U.S.A.

1.3 Returned Materials

Any materials, parts, or equipment returned to Cost Effective Equipment; LLC must be clearly labeled with a Return Material Authorization (RMA) number.

To obtain an RMA number, contact:

Cee® Customer Support
Telephone ..... +1-573-466-4300
Email ..... support@costeffectiveequipment.com
Web Address ..... www.costeffectiveequipment.com

1.4 Model and Revisions

The model and serial number information for the Cee® Apogee® 450 Spin Coater are located on the rear panel. Software version information can be found on the *About* screen. See *DataStream™ Manual* for screen shots and a detailed explanation of the system software.

1.5 Environmental Considerations

Cee® fosters sustainability through innovation in the durability and reliability of our precision tools and equipment. Individual component modules are engineered for serviceability ensuring long lasting performance. Processes are designed to minimize use & consumption of chemical compounds ensuring accurate, replicable, industry-leading results every time.

Cee® diligently screens suppliers to ensure conflict-free sourcing of minerals and product components are constructed of recycled materials wherever possible.

Cee® equipment operates without the use of ozone depleting substances (ODSs) including chlorofluorocarbons (CFCs), methyl chloroform, hydrochlorofluorocarbons (HCFCs), carbon tetrachloride, perfluoro compounds (PFCs), or other volatile compounds/organic solvents.

1.6 General Safety Hazards / Precautions

Read this manual in its entirety before operating or servicing the machine.

The unit is very heavy and proper precautions should be taken when handling the machine to minimize the risk of injury. Labels are placed on the machine to identify areas where caution is needed during operation.

Sound pressure measurements greater than 80dB(A) are considered hazardous. The following sound pressure measurements were obtained from the Cee® Apogee® 450 Spin Coater at a distance of 3 ft (0.9 m) from the system:

Stand-by Mode ..... 54dB(A)

Normal Operations ..... 70dB(A)

1.7 Electrical

High voltage is present in the machine. Disconnect power before servicing.

Stored electrical energy is present in the machine. Before servicing allow sufficient time for discharge. The servo amp contains a charge light. Do not service the machine until this light has been extinguished.

This unit must be connected to an outlet with proper grounding.

1.8 Mechanical

This machine may contain compressed gases which can provide motive force for components and can expand violently upon decompression. Disconnect N_2 or CDA before removing any panels.

Spin Coaters and Developers are capable of very high-speed rotation. Ensure all lids and panels are in place before rotating these devices.

Ensure that all panels are on and in their correct locations before powering up or operating.

When opening lids be aware of the pinch point at the hinge cover. Open lids only by using the handles on the lids.

1.9 Chemical

Cee® does not supply or dictate chemicals to be used in conjunction with the Cee® Apogee® 450 Spin Coater. Enclosure material data will be reviewed during equipment design and configuration to ensure compatibility with the customer's proprietary process.

Prior to introducing new chemicals, refer to your chemical supplier's factory specifications and MSDS. Material Safety Data Sheets (MSDS) contain crucial information regarding chemical safety, including details about hazardous components, physical properties, spill and leak procedures, waste disposal guidelines, and personal protective equipment requirements for handling.

Ensure chemical compatibility of all chemicals and materials being used inside the machine. This includes all wetted parts of the storage, supply, dispense, and waste systems.

All dispensed materials are held in one common waste storage tank. Ensure chemical compatibility and verify potential for negative interactions between chemicals before use.

Flammable Chemicals. No open flames/sparks.

Avoid the use of materials with an auto-ignition point ≤30°C.

Relieve pressure before opening canisters, tanks, cartridges, or syringes to refill.

Relieve pressure and shut off chemical valves before servicing supply lines, dispense valves or other components such as EBR/BSR tubes, dispense nozzles, spray tips, or spinner lid.

Flush tubing and valves with an appropriate solvent and drain system before servicing.

When draining the waste tank, use appropriate containers and connection methods.

Ensure proper ventilation/exhaust is always used.

Always wear appropriate Personal Protective Equipment. This includes safety glasses, gloves, and other equipment, as needed, to protect from mechanical and chemical hazards.

Exhaust and fume management is important to prevent the release of hazardous materials and ensure a safe working environment. Users should assume that all fumes are hazardous and take appropriate precautions to ensure system exhaust is functional per the guidelines outlined in section 7 of this operations manual.

1.10 Lockout/Tagout Procedures and Information

Before servicing, turn off the machine and remove the power inlet cord by disconnecting the plug where it enters the machine.

Note: There are no LOTO (Lock Out/Tag Out) facilities supplied with the Cee® Apogee® Spin Coater. It is the responsibility of the customer/installer/end-user to ensure that the suitable LOTO devices are provided on utilities being supplied to the Cee® Apogee® Spin Coater in accordance with applicable laws, regulations, and/or company policies.

For more information, please contact Cee® Customer Support.

1.11 Intended Use of Machine

The Cee® Apogee® 450 Spin Coater is intended for use as a semiconductor/optical application machine.

The Cee® Apogee® 450 Spin Coater is not intended for use in food or medical applications or for use in hazardous locations.

The Cee® Apogee® 450 Spin Coater is intended for use only by trained personnel wearing the proper personal protective equipment. Anyone not trained in the proper use of the Cee® Apogee® Spin Coater and having not fully read this manual, should not operate the equipment.

The Cee® Apogee® 450 Spin Coater is intended for use in a cleanroom environment to provide the proper processing conditions for the substrates. If it is used outside of a cleanroom environment, substrate cleanliness may be compromised.

The Cee® Apogee® 450 Spin Coater is not intended for use in a hazardous or explosive environment.

Normal Operating Conditions

The Cee® Apogee® 450 Spin Coater is designed for indoor use only.

Ambient Temperature.....10˚C - 30˚C

Relative Humidity.....≤80%

Altitude.....up to 3000 m

Pollution Degree.....2

Overvoltage Category.....II

Permissible Voltage Fluctuations .....208-230VAC ±10%

If the Cee® Apogee® 450 Spin Coater is used in a manner not specified by Cee® or with accessories not provided by Cee® the protection provided by the equipment may be impaired.

2 Equipment Description

The Cee® Apogee® 450 Spin Coater delivers track-quality performance, with revolutionary interface capabilities and the utmost in chemical compatibility, in an efficient, space-saving design. The Apogee® 450 Spin Coater combines precision spin speed control and a high torque drive for wafers up to 450mm and LCD squares up to 14” x 14” (355.6mm x 355.6mm).

Fully programmable and user-friendly, this precision spin coater features the accuracy and repeatability needed to eliminate processing variability from critical experiments. With its convenient compact footprint, wide array of chemical compatibility, and durability, this easy-to-use benchtop system will provide years of high-performance operation, making the Cee® Apogee® 450 Spin Coater purchase a smart and cost-effective decision.

2.1 User Controls

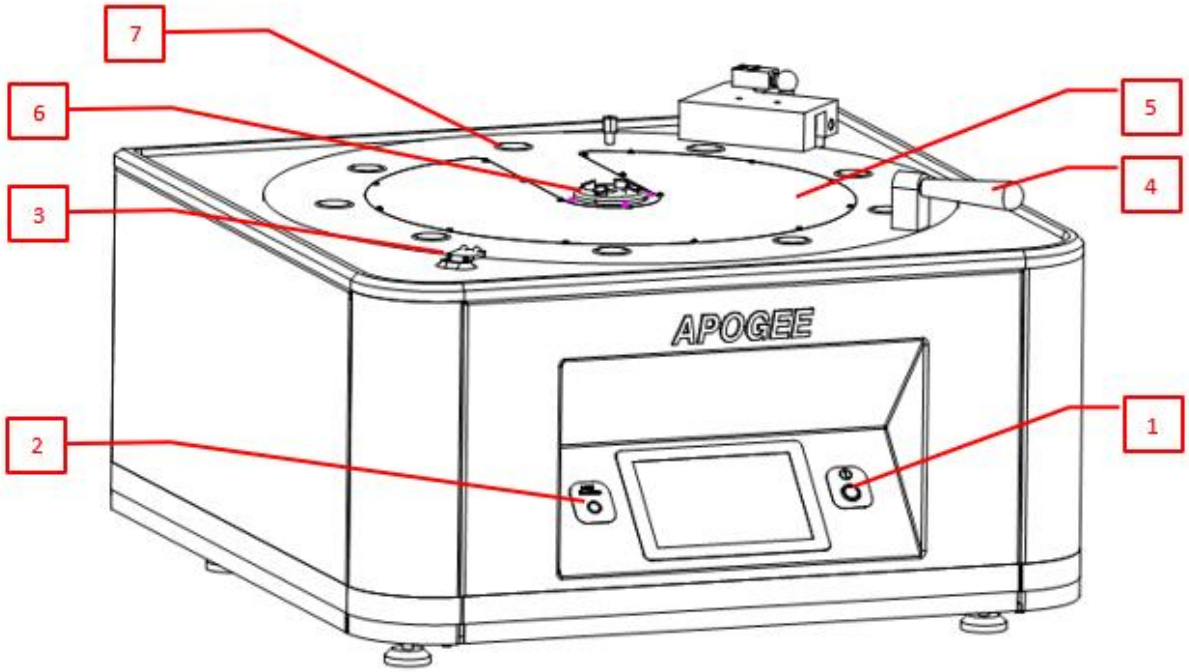


Figure 1: Cee® Apogee® 450 Spin Coater User Controls

1. power button ..... used to turn the equipment off and on
2. local presence button[1] ..... used for remote access
3. lid latch ..... latches and locks lid when spinning
4. lid handle ..... used to safely open and close the lid
5. spin coater lid ..... cover for the spin bowl
6. 5-hole dispense hub ..... allows for materials to be dispensed onto the substrate
7. lid plugs ..... used to adjust airflow and solvent vapor in the spin bowl

2.2 Dimensions

27 $^{5}/_{8}$” (702mm) W x 30 ¾” (781mm) D x 15 3/4” (400mm) H[2]
machine weight 85lb (38.6kg)

[1] Refer to the DataStream™ Manual for more detailed information.
[2] H is with lid closed. Open H is 29 ¼ ” (743mm)

2.3 Features & Programmability

- vacuum and lid interlock
- full-color touchscreen graphical user interface (GUI)
- supports unlimited user-defined program steps for each recipe
- 0.1 second step time resolution (9,999.9 seconds maximum step time)
- spin speeds up to 6000 rpm
- spin speed acceleration up to 30,000 rpm/s unloaded
- up/download DataStream™ process parameters via native USB and Ethernet ports
- multiple simultaneous automated dispense capability
- in-process dynamic speed & acceleration control
- substrate sizes of <10mm to 450mm round; 14” x14” square *(max)*

2.4 Precision

spin speed repeatability ..... < 0.2 rpm

spin speed resolution ..... < 0.2 rpm

acceleration resolution ..... < 0.2 rpm/s

- 0 to 30,000 rpm/s unloaded
- 0 to 23,000 rpm/s with a typical 30mm silicon wafer
- 0 to 3,000 rpm/s with a 350mm x 6mm round recessed spin chuck
- 0 to 400 rpm/s with a 14” x 14” x 0.05” photomask in a recessed chuck

2.5 Reliability

- indirect drive system protects the spin motor from contact with process chemicals and solvents
- industry-leading reliability and uptime
- low maintenance design
- one-year full warranty on parts and labor
- complimentary remote technical support for the life of the product
- application process assistance for life of the product

2.6 Bowl Design

- high-density polyethylene (HDPE) spin bowl for material compatibility
- optional polyethylene disposable liners available
- versatile lid design allows process flexibility and repeatability
- optional nitrogen purge for an inert spin environment
- integrated drain and exhaust ports

2.7 NRTL

Beginning in February of 2024, all standard Cee® Apogee® Benchtop Spin Coater models will proudly showcase the Intertek ETL mark, a testament to our commitment to safety and quality.

Intertek's ETL Mark signifies compliance with North American safety standards, providing assurance of product safety and quality. Recognized by Authorities Having Jurisdiction (AHJs) and code officials throughout the US and Canada, the ETL Mark is featured on millions of products sold nationwide. Customers can trust that products bearing the ETL Mark meet rigorous safety standards established by independent testing and ongoing inspections.

2.8 Utilities

voltage ranges ..... 208-230 VAC, single phase, 50/60Hz
power requirements ..... 1440 Watts (6A)
drain port..... ¾” OD
exhaust port ..... 1 ½” OD, 0.4” H2O @ 30CFM (100Pa @ 50CMH)
vacuum ..... <20” Hg (33kPa abs)
nitrogen/CDA (automated dispense) ..... 70 psi (482kPa)

3 Installation

3.1 Clearance Requirements

The Cee® Apogee® 450 Spin Coater is a benchtop unit requiring a table or benchtop for location. In most cases the supporting structure will be larger than the unit itself.

Clearance Requirements
Adherence to these requirements ensures adequate spacing, ventilation, and access to the detachable MAINs[3] supply cords as needed.

device rear[4] ..... 12” (304.8mm)
device sides ..... 3” (76.2mm)

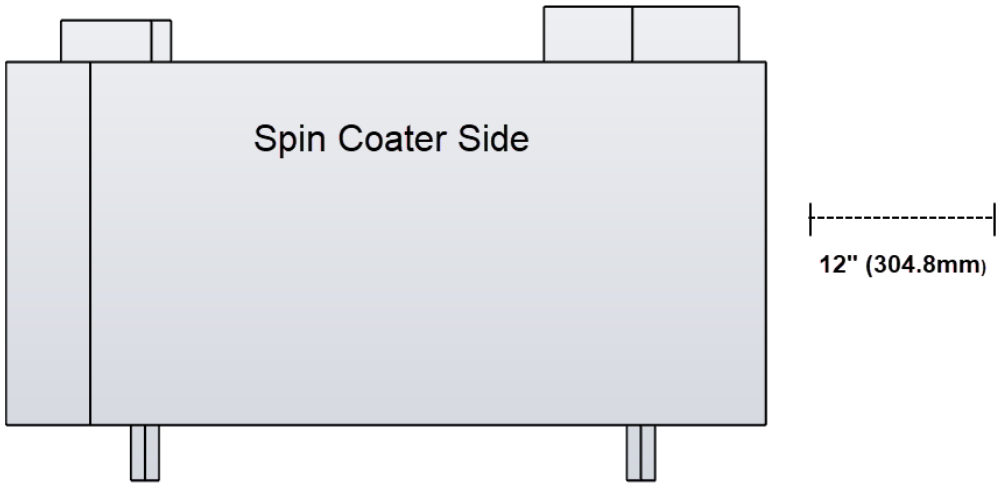


Figure 2: Cee® Apogee® 450 Spin Coater Rear Clearance Requirements

[3] The tool should only be operated with the MAINs supply cord provided by Cee®.
[4] When equipped with optional Programmable Exhaust, rear clearance requirement is 18” (457.2mm).

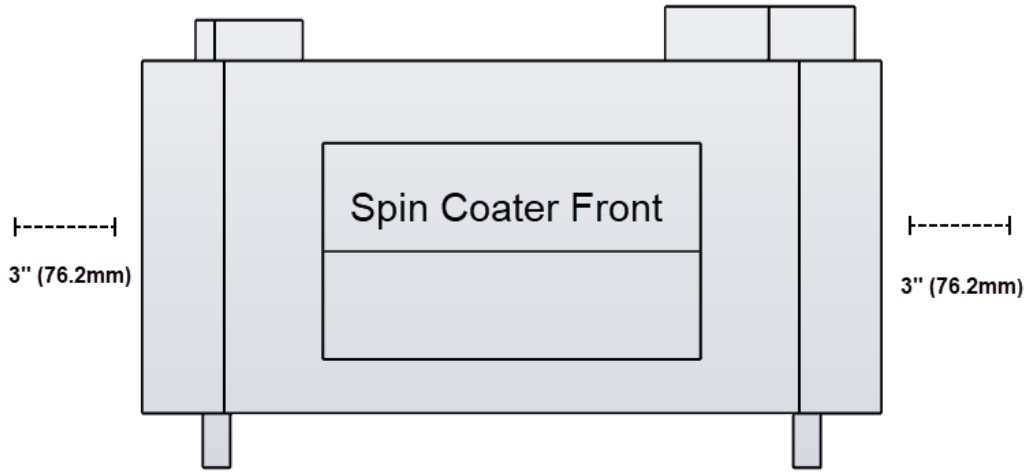


Figure 3: Cee® Apogee® 450 Spin Coater Side Clearance Requirements

3.2 Facilities Requirements

The Cee® Apogee® 450 Spin Coater requires the following utilities for operation.

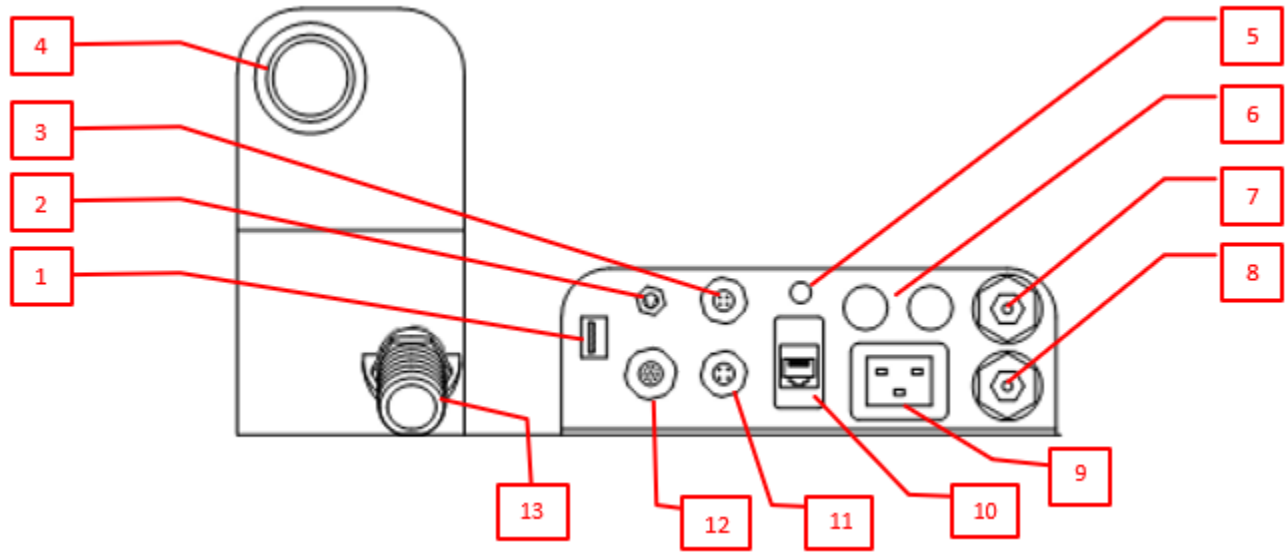


Figure 4: Cee® Apogee® Spin Coater Facilities Connections

1. USB port[5] ..... facilitates data transfer
2. programmable exhaust..... *(optional)* M8, 4pin female port, 24VDC
3. light tree ..... *(optional)* light tree port, M12 4pin, female, 24VDC
4. spin bowl exhaust port..... exhaust port for spin bowl vapors (20-50cfm @ 0.2" water)
5. backside rinse (BSR)..... *(optional)* dispense material fitting for backside rinse
6. fuses ..... system protection fuses *(Replacement: BK/MDA-15-R)*
7. system vacuum[6] ..... ¼" NPT port, <33kPa abs
8. nitrogen/CDA..... *(optional)* system nitrogen/CDA 70psi *(482 kPa)*
9. AC power in ..... single phase 208-230 VAC, 6A
10. Ethernet ..... facilitates remote recipe writing and remote device control
11. accessory port..... as needed, M12 4pin, male, 24VDC
12. dispense trigger..... *(optional)* connection for automated dispense control box
13. spin bowl drain ..... port via which liquid waste is removed from the tool

3.3 Environment

The Cee® Apogee® 450 Spin Coater should be operated in a clean, low humidity environment.

3.4 Unpackaging/Inspection

1. Lifting from the bottom of the unit, carefully remove from the packing crate. Do not lift by any of the top covers or protrusions. Do not roll or turn the unit on its sides.
2. Remove packing foam and plastic wrap.
3. Place the Cee® Apogee® 450 Spin Coater on a table of proper height and strength so that the controls and spin chuck are at the proper ergonomic height.

[5] see DataStream™ Manual for more information
[6] Tools through July 2022 include ¼" barb connect as standard/ post-July 2022 tools are supplied with a ¼" push connect fitting as standard. Connection fittings may vary based on customer request.

4. Thoroughly check machine for shipping damage. If physical damage is seen, **DO NOT APPLY POWER!** Contact Cee® Customer Support immediately.

The following items are included with shipment:

- Cee® Apogee® 450 Spin Coater
- temperature & humidity sensor
- power cord
- operations manual (USB thumb drive)

Optionally Included Items:

- dispense systems and related components
- spin chucks with screws
- programmable exhaust
- substrate centering equipment
- waste systems
- vacuum pump

3.5 System Installation & Setup

1. Using (x2) 9/16” wrenches, turn the adjustable feet until there is 1 ¼” – 1 ¾” between the tabletop and bottom of the equipment. The Apogee® must also be level from side-to-side and front-to-back. See section 4.7, Leveling Setup. Once level is achieved, tighten the jam nuts to secure the feet in place.
2. Thoroughly clean the spin bowl and spin chuck.
3. Connect utilities per the reference diagram in section 3.2 Facilities Requirements.
4. Connect the temperature & humidity sensor to the CAN terminal.
5. Connect the vacuum supply to the vacuum fitting. (System vacuum <33kPa abs)
6. Connect the drain to the drain port.
7. Connect exhaust lines to the exhaust port. (System exhaust flow rate of 20-50cfm)
8. Connect the (optional) dispense box (if equipped) to the dispense triggers.
9. Connect the (optional) programmable exhaust (if equipped) to the programmable exhaust terminal.
10. Connect any dispense as indicated on the supplied USB dispense diagrams.
11. Plug in the machine using the supplied Cee® shielded cables and note that only the cooling fan should be powered, not the display.

3.6 Start Up

Turn the machine on by pressing the lighted power switch. The display will cycle through a series of boot screens before arriving at the main login screen.

Enter default administrative login credentials:

Username: ..... admin
Password: admin2

3.7 System Checks

On the ***Process*** screen, navigate to ***Tools>Manual Control*** and perform the following system checks for initial validation of the Cee® Apogee® 450 Spin Coater.

Vacuum:

Turn the vacuum on and verify that vacuum is pulling through the hole of the spin shaft. Turn the vacuum off and verify that vacuum ceased at the hole of the spin shaft.

Spin Speed:

Close the lid and set spin speed to 1000 rpm. Verify that the shaft spins and that the tool reads 1000rpm.

Lid Interlock:

Attempt to open the spin bowl lid to test the lid interlock functionality. If properly functioning, you will *NOT* be able to open the lid while the shaft is spinning.

Temperature & Humidity Sensor:

On the left side of the ***Process*** screen, confirm that temperature and humidity readings are present.

Automated Dispense (optional):

If equipped with automated dispenses, navigate to ***Tools>Manual Control>Dispenses***, tap ***Dispense 1*** to select, then tap ***Apply*** to validate that Dispense Triggers are operational. Repeat as needed for additional dispense triggers.

Programmable Exhaust (optional):

If equipped with programmable exhaust, navigate to ***Tools>Manual Control>Programmable Exhaust***, enter 100 into the field and tap ***Apply***. Verify that the valve is fully open. Next enter 0 and tap ***Apply*** to verify that the valve closes completely.

Spin Chuck(s):

Aligning the spin chuck slot with the pin or key on the spin shaft, firmly press the chuck onto the shaft ensuring the pin or key is fully engaged. If equipped, insert chuck screw, and tighten.

Place substrate on the spin chuck.

Navigate to ***Tools>Manual Control>Vacuum*** and set vacuum threshold to 64kPa.

If the vacuum is less than 64kPa, the chuck passes inspection.

Turn off the vacuum and remove the substrate. Spin chuck removal is reverse of installation.

Once operations have been validated, the Cee® Apogee® 450 Spin Coater is ready for use. Begin by creating a recipe. See the DataStream™ Manual for more information.

In the event of a fault condition, power cycle the tool to restore function

4 DataStream™ Technology

This section covers information *specific to Apogee® Spin Coaters* and is intended as a companion to the DataStream™ Technology Software Manual. ***Please review the DataStream™ Operations Manual*** for detailed guidance on software usage.

4.1 System Parameters

Parameter	Actual	Set Point	Status
Spin Speed	0 rpm	0 rpm	In Range
Spin Acceleration	500 rpm/s	500 rpm/s	In Range
Active Dispenses	None	None	In Range
Dispense Source Empty	None		In Range
Chuck Vac	98.8 kPa	101.3 kPa	In Range
Waste Bottle Full	False		In Range
Ambient Temperature	27.9 °C		In Range
Humidity	44.4 %		In Range
Vibration	3		In Range

Spin Speed---------- measured rotational speed of the spin chuck in revolutions per minute (rpm)

Spin Acceleration[7]---------- dictates how fast the spin chuck will accelerate in revolutions per minute per second (rpm/s)

Percent Exhaust---------- displays the valve opening percentage of the optionally equipped programmable exhaust module

Active Dispenses---------- indicates which dispenses are enabled

Dispense Source Empty--- indicates when dispense sources are low or empty

Chuck Vac---------- measurement of the vacuum pressure holding the substrate against the spin chuck in kPa

Waste Bottle Full---------- indicates whether the sensors detect a full waste bottle

Ambient Temperature------ the air temperature of the environment where the equipment is housed

Humidity[8]---------- the ambient relative humidity in the environment where the equipment is housed

Vibration---------- unitless measurement of g-forces at the spindle block; can be used to detect off-center substrates at high speeds

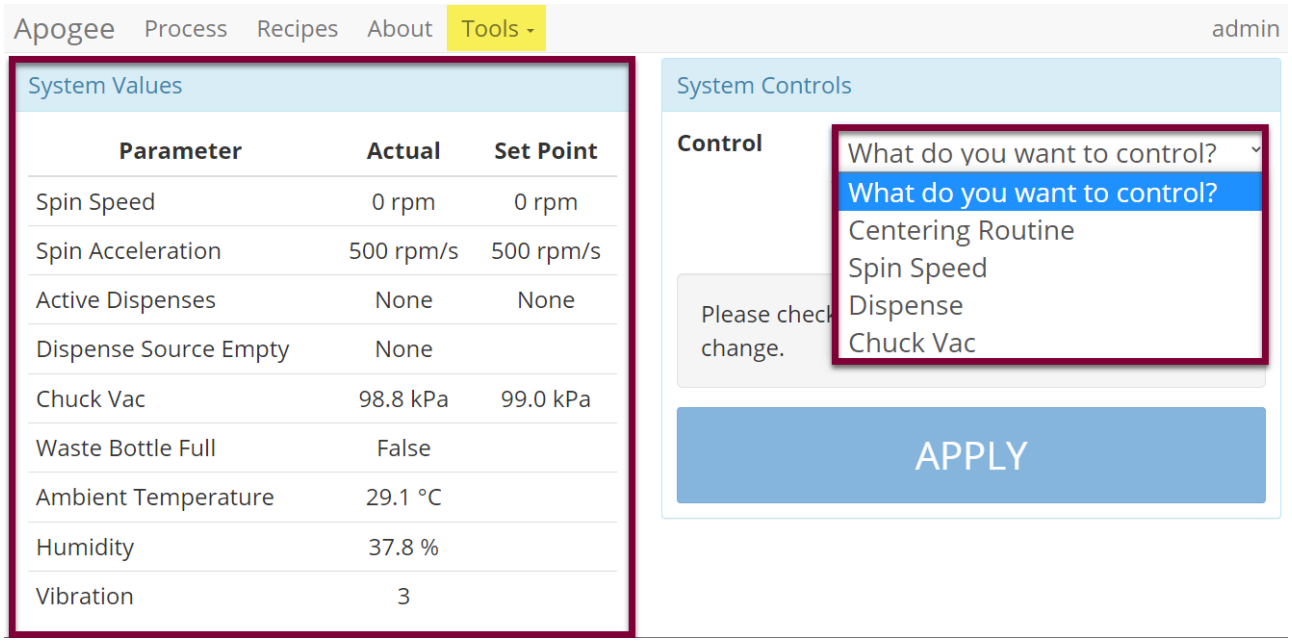
4.2 Manual Controls – Apogee® Spin Coater

The Manual Control activity is an advanced feature that allows users to run most operating processes outside of a recipe. This mode is useful for tasks such as prototyping processes, verifying equipment

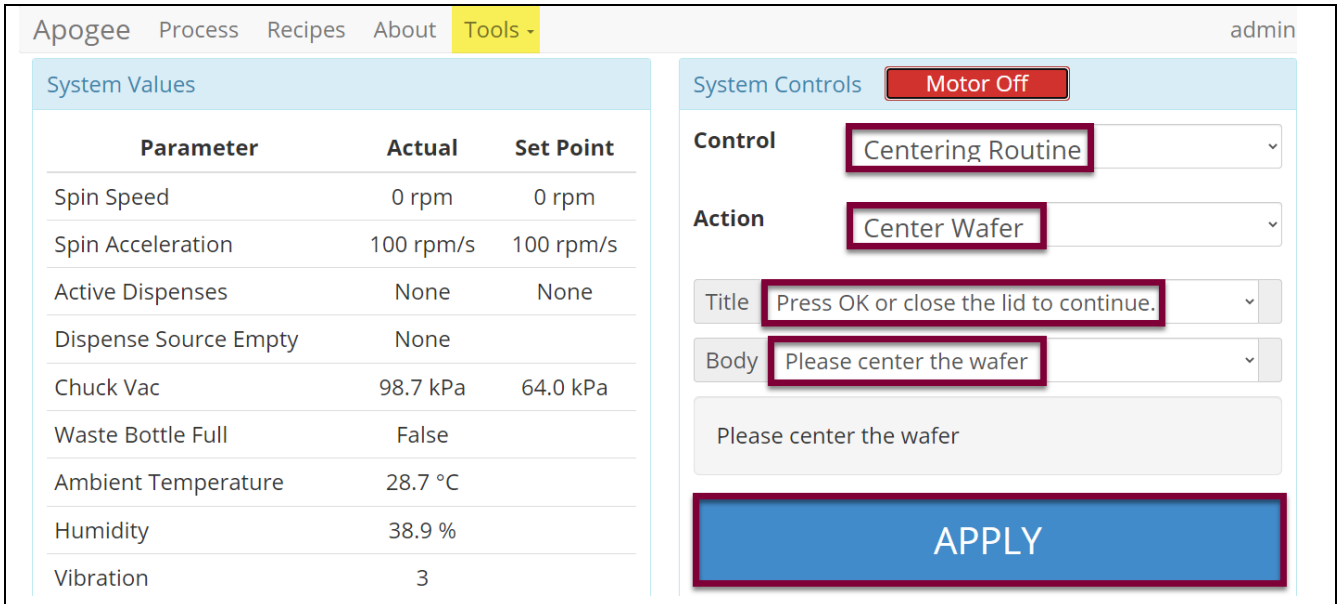
[7] ***Spin Acceleration*** settings are dependent on the presence of a ***Spin Speed*** set point.
[8] Both Ambient Temperature and Humidity are measured via a custom sensor board mounted next to a ventilation inlet inside the tool. If the sensor is disconnected, a default of -1.1 is displayed.

operation, and recovering from aborted processes. To access the activity, navigate to ***Tools > Manual Control***. Actual and set point parameter values are displayed on the left. A drop-down menu of available controls is located on the right.

If using remote feature, the user must confirm local presence to execute manual commands. *Refer to the DataStream™ Manual for guidance on the Local Presence feature.*



Centering Routine



Select a Control of *Centering Routine* and the Action will default to *Center Wafer*.

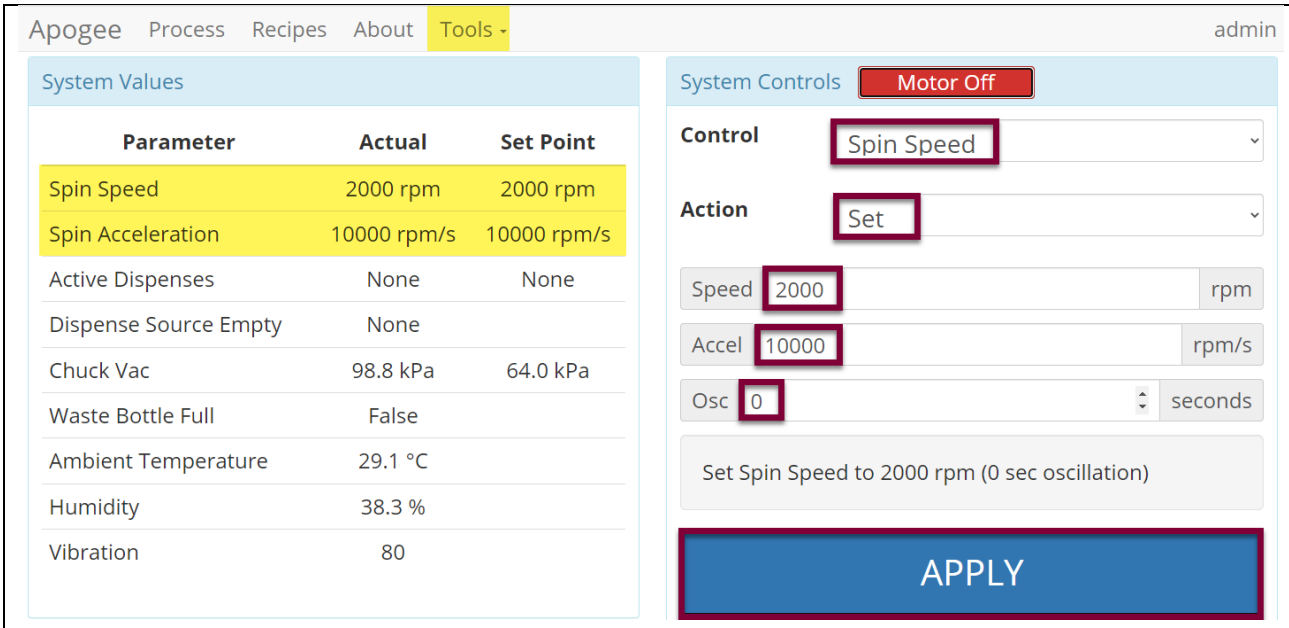
Select an option from the Title dropdown menu.

Select an option from the Body dropdown menu.

Click APPLY

Allows users to test and view configuration of the Centering Routine Display window outside of the Advanced Recipe Editor Activity.

Spin Speed:



Select a Control of *Spin Speed*

*T*he Action will default to *Set*.

Close the spinner lid and enter desired values for spin speed, acceleration, and oscillation within the supported range for each setting:

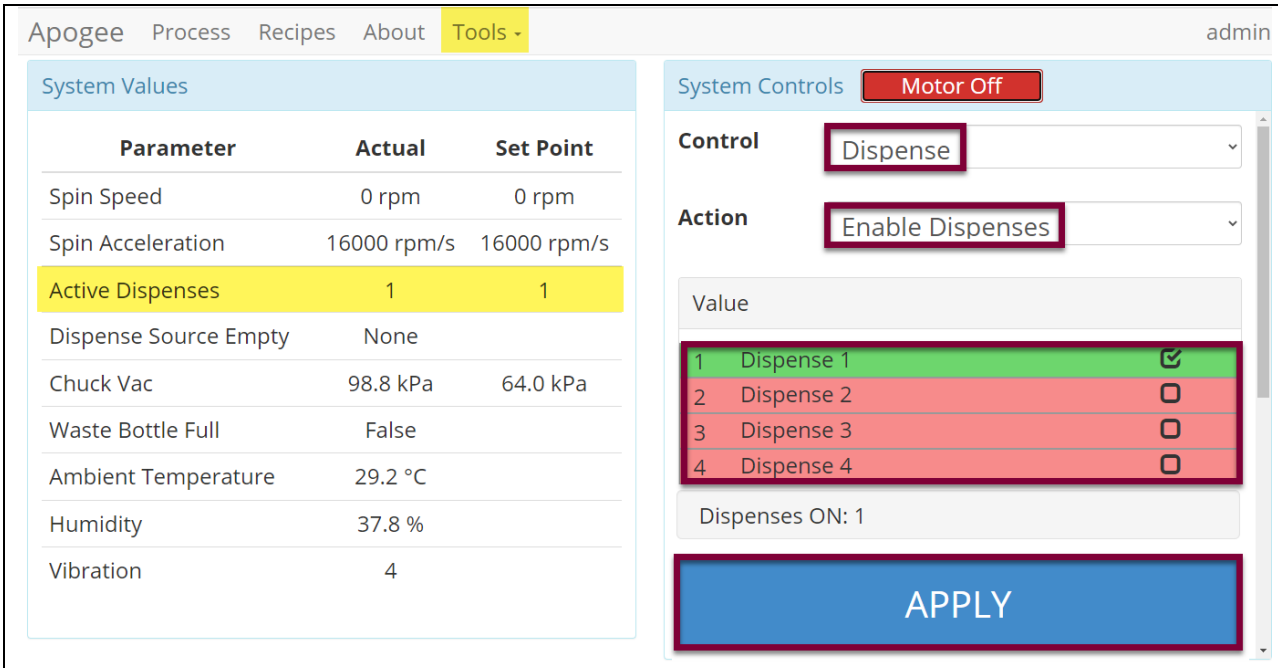
Speed	1-12,000 rpm (standard spinner) 1-6,000 rpm (450 spinner)
Acceleration	1-30,000 rpm/s
Oscillation[9]	0-99 seconds

Click APPLY

Note that the actual and set point values have populated on the system values list.

[9] Reverses spin direction for the period specified.

Dispense *(*if equipped)*



Select a Control of *Dispense*

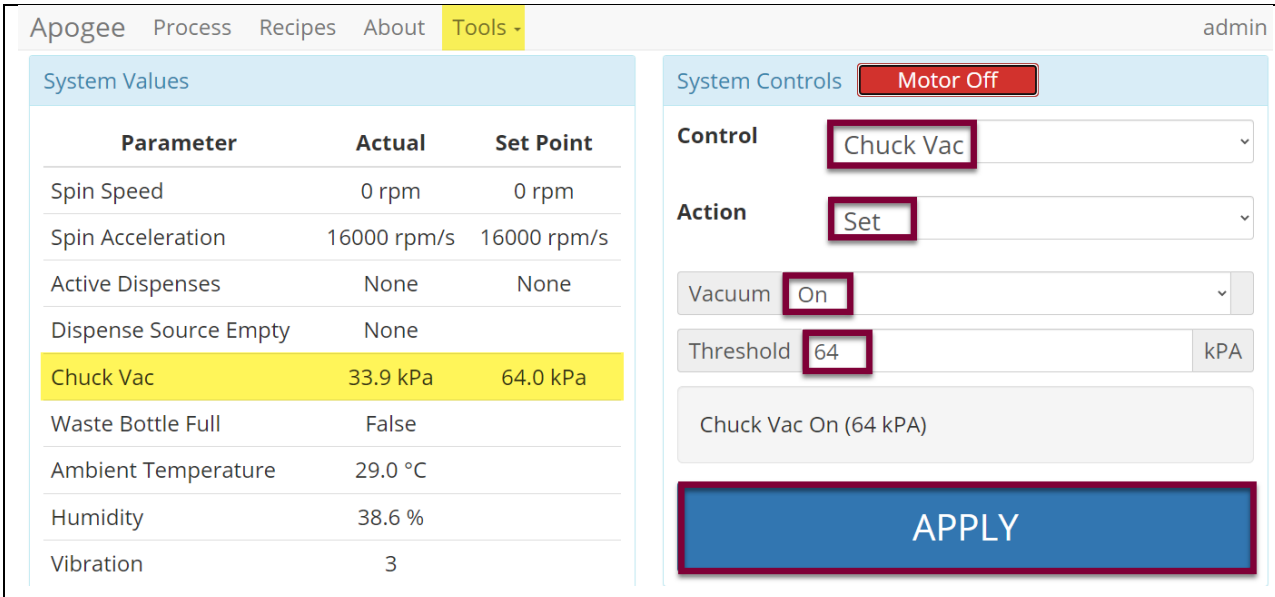
The Action will default to *Enable Dispenses*.

Check the box for the desired dispenses - selections are rendered in green

Click APPLY

Note that the actual and set point values for enabled dispenses have populated on the system values list.

Chuck Vac **ensure source vacuum is on*



Select a Control of *Chuck Vac*

The Action will default to *Set*.

Set Vacuum to *On* or *Off.*

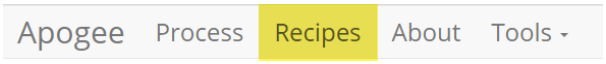
Set Threshold to the desired value in kPa.

Click APPLY

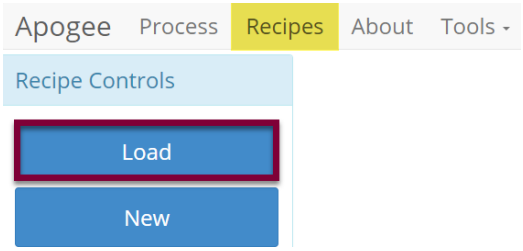
Note that the actual and set point values have populated on the system values list.

4.3 Running Recipes

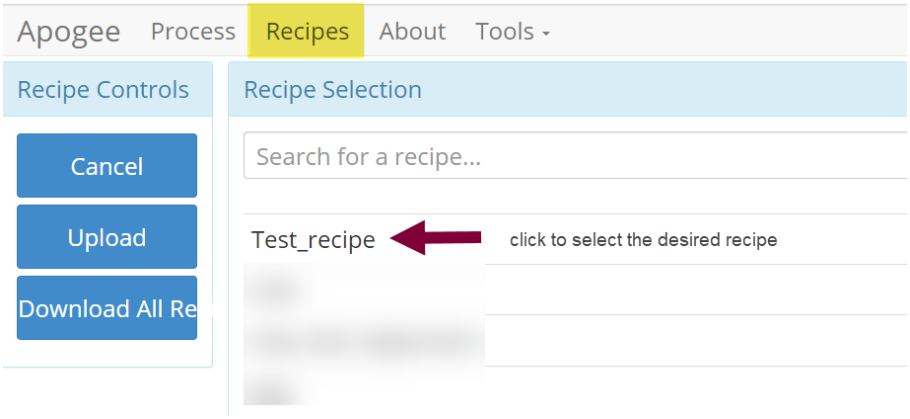
1. Navigate to the *Recipes* page.



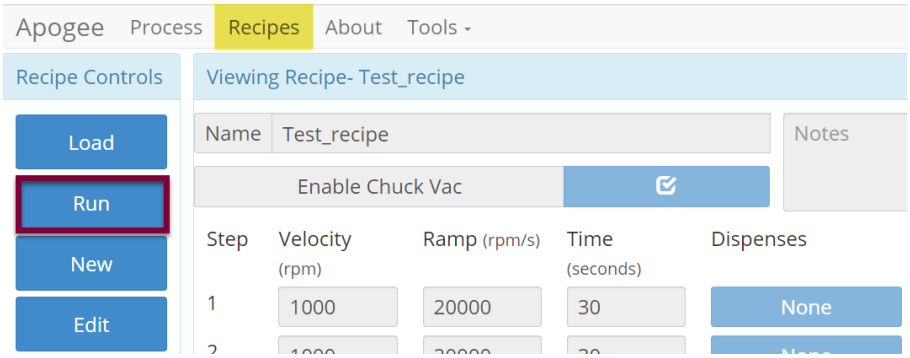
2. Click ***Load*** to access the recipes list.



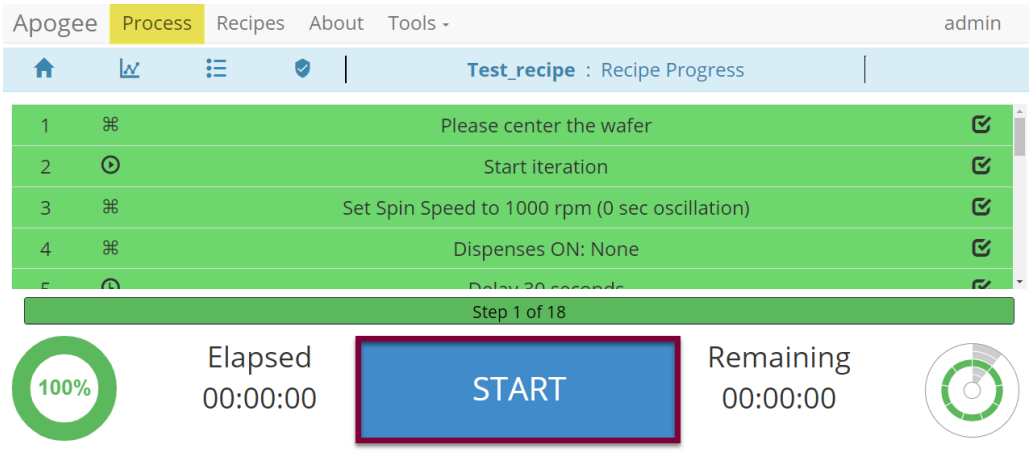
3. Search for, identify, & select the preferred recipe.



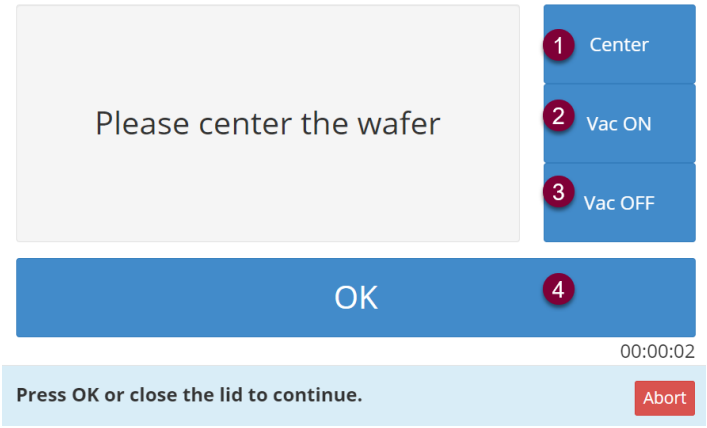
4. Click ***Run***.



5. Click ***Start*** to initiate the recipe process.



6. Use the centering activity to center the substrate.



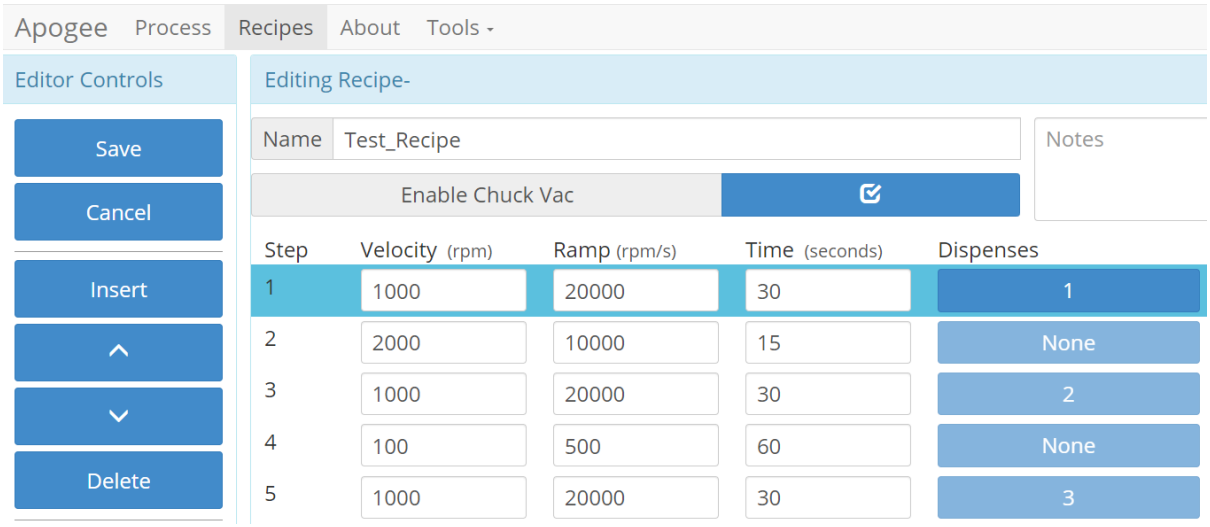
1. spin chuck rotates slowly with vacuum on then stops rotation & vents vacuum
2. toggle chuck vacuum on
3. toggle chuck vacuum off
4. resume recipe

7. Recipe execution.

*Users may be required to follow prompts on the screen during recipe execution.

4.4 Editing Recipes

Spin coater recipes may enlist an unlimited number of steps, each capable of defining spin speed, acceleration, spin time, percent exhaust opening, and dispense triggers. Users can easily insert new steps, reorder existing steps, and/or delete a selected step via the *Step Context Menu*.



Name---------- recorded in log files and used as criteria when searching for recipes

Enable Chuck Vac[10]--------- used when the substrate requires vacuum to remain on the spin chuck. *If disabled, the centering step does not occur.

Step Velocity[11]---------- speed in rpm the spin chuck will achieve on a given step

Step Ramp---------- rate in rpm/s the spin chuck will ramp on a given step

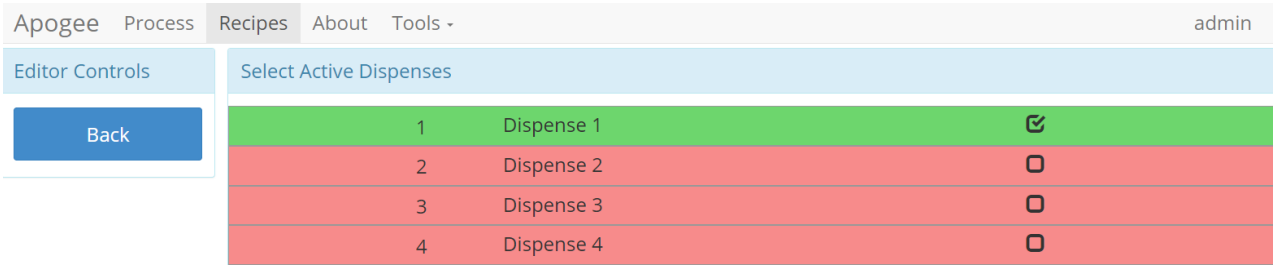
Step Time---------- the duration in seconds for a given step

Exhaust[12]---------- percent of exhaust opening

Dispense---------- the dispense triggered during a given step

4.5 Editing Dispense Selection

Enabled dispenses are rendered in green and display a checkmark. Multiple dispenses may be selected within the same step.



4.6 Tool Specific Settings – Apogee® Spin Coater

Vac Threshold (kPa)---------- Minimum vacuum threshold that must be reached before spinning a substrate.

Centering Speed (rpm) ---------- How fast the substrate spins during a centering routine

Centering Time (milliseconds) -------- How long the substrate spins during a centering routine

Idle Exhaust (%)[13] ---------- Default exhaust position when not running a process.

[10] Only available to users with advanced recipe editor permissions.
[11] preconditions default to ± 5% of the target speed
[12] field is only present on tools equipped with optional programmable exhaust
[13] Idle Exhaust does not apply to tools not equipped with Programmable Exhaust

4.7 Leveling Setup

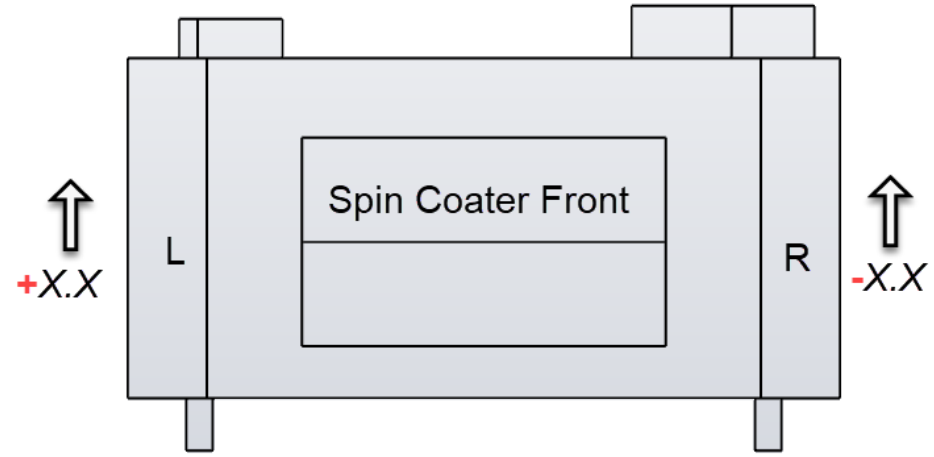
Navigate to ***Tools>Diagnostics*** and scroll to *Accelerometer Leveling Data*.

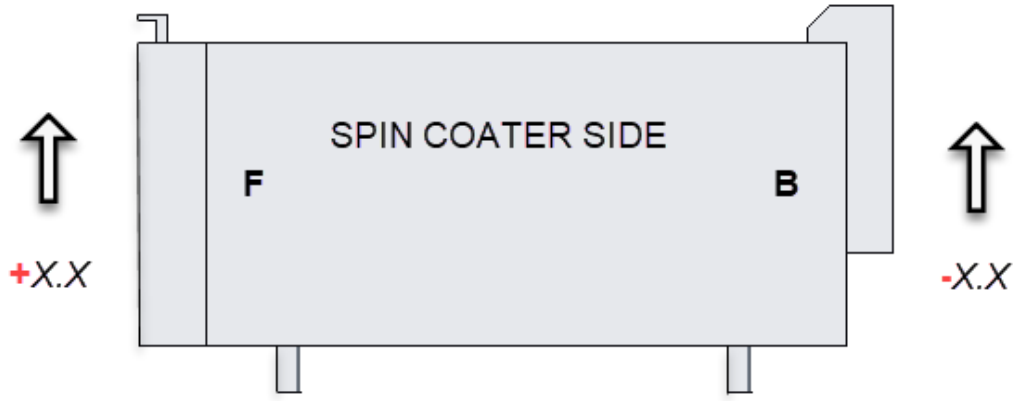
When leveled properly the tool will sit between 1 ¼” – 1 ¾” above table height and accelerometer values will read 0.0.

```
Accelerometer Leveling Data
Left/Right=+0.3
Forward/Back=-0.2
```

Adjusting the left and/or front of the equipment in an upward direction will produce movement toward the positive range.

Adjusting the right and/or back of the equipment in an upward direction will produce movement toward the negative range.





Accelerometer data is responsive in real time. Monitor adjustment readings to confirm level.

5 Spin Coater Use & Operation

5.1 Spin Chuck Installation and/or Removal

1. In the center of the vacuum chuck, locate the spin chuck flat head cap screw.
2. Using a hex wrench, remove the chuck screw from the spindle.
3. Grasp the spin chuck and lift vertically for removal.
4. Align the new spin chuck slot with spin shaft pin and firmly press chuck onto shaft.
5. Use a hex wrench to tighten the chuck screw and secure the spin chuck to the shaft.

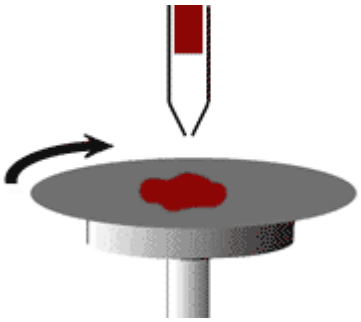
5.2 Five-Hole Dispense Nozzle Hub

All Cee® Apogee® Spin Coaters utilize a multi-nozzle dispense center hub. This design allows for up to five centrally positioned dispense nozzles to be mounted into the lid simultaneously and triggered independently in any sequence or combination. Auto-dispense nozzles are oriented to the center of the substrate and utilize precision suck-back control. Additionally, each nozzle features a female luer adapter housing a disposable tip to be placed at point of use. Tips are easily changed to clear dried material residue and/or to manipulate the volume of dispense flow.

5.3 Airflow Adjustment

The Cee® Apogee® 450 Spin Coater is furnished with 9 holes along the perimeter of the lid. This allows the operator to regulate the exhaust flow through the bowl region. Removal of the plugs can be a variable in optimizing coating results. Results vary depending on coating materials.

6 Spin Coater Theory

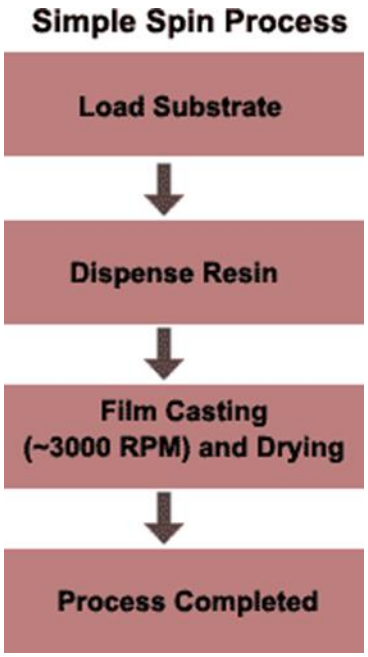


Spin coating has been used for several decades as a method for applying thin films. A typical process involves depositing a small puddle of a fluid material onto the center of a substrate and then spinning the substrate at high speed (typically around 3000 rpm). Centripetal acceleration will cause most of the resin to spread to, and eventually off, the edge of the substrate leaving a thin film of material on the surface. Final film thickness and other properties will depend on the nature of the fluid material (viscosity, drying rate, percent solids, surface tension, etc.) and the parameters chosen for the spin process. Factors such as final rotation speed, acceleration, and fume exhaust affect the properties of the coated films. One of the most important factors in spin coating is repeatability, as subtle variations in the parameters that define a spin-coating process can result in drastic variations in the coated film.

6.1 Spin Coater Process Description

A typical spin process consists of a dispense step in which the resin fluid is deposited onto the substrate surface, a high-speed spin step to thin the fluid, and a drying step to eliminate excess solvents from the resulting film. Two common methods of dispense are Static dispense, and Dynamic dispense.

Static dispense is simply depositing a small puddle of fluid on or near the center of the substrate. This can range from 1 to 10cc depending on the viscosity of the fluid and the size of the substrate to be coated. Higher viscosity and or larger substrates typically require a larger puddle to ensure full coverage of the substrate during the high-speed spin step. Dynamic dispense is the process of dispensing while the substrate is turning at low speed. A speed of about 500 rpm is commonly used during this step of the process. This serves to spread the fluid over the substrate and can result in less waste of resin material since it is usually not necessary to deposit as much to wet the entire surface of the substrate. This is a particularly advantageous method when the fluid or substrate itself has poor wetting abilities and can eliminate voids that may otherwise form.

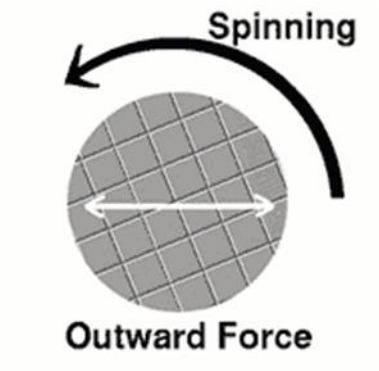


After the dispense step, it is common to accelerate to a relatively high speed to thin the fluid to near its final desired thickness. Typical spin speeds for this step range from 1500-6000 rpm, again depending on the properties of the fluid as well as the substrate. This step can take from 10 seconds to several minutes. The combination of spin speed and time selected for this step will generally define the final film thickness.

In general, higher spin speeds and longer spin times create thinner films. The spin coating process involves many variables that tend to cancel and average out during the spin process, and it is best to allow sufficient time for this to occur.

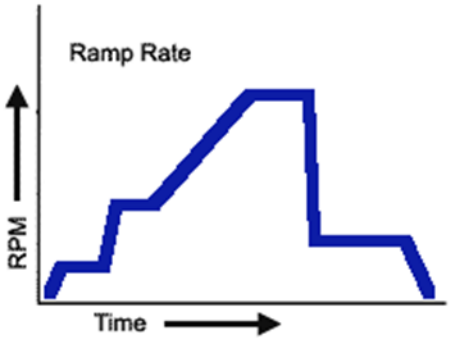
A separate drying step is sometimes added after the high-speed spin step to further dry the film without substantially thinning it. This can be advantageous for thick films since long drying times may be necessary to increase the physical stability of the film before handling. Without the drying step problems can occur during handling, such as pouring off the side of the substrate when removing it from the spin bowl. In this case a moderate spin speed of about 25% of the high-speed spin will generally suffice to aid in drying the film without significantly changing the film thickness. Each program on a Cee® spin coater may contain up to ten separate process steps. While most spin processes require only two or three, this allows the maximum amount of flexibility for complex spin coating requirements.

6.2 Spin Speed



Spin speed is one of the most important factors in spin coating. The speed of the substrate (rpm) affects the degree of radial (centrifugal) force applied to the liquid resin as well as the velocity and characteristic turbulence of the air immediately above it. The high-speed spin step generally defines the final film thickness. Relatively minor variations of Â±50 rpm at this stage can cause a resulting thickness change of 10%. Film thickness is largely a balance between the force applied to shear the fluid resin towards the edge of the substrate and the drying rate which affects the viscosity of the resin. As the resin dries, the viscosity increases until the radial force of the spin process can no longer appreciably move the resin over the surface. At this point, the film thickness will not decrease significantly with increased spin time. All Cee® spin coating systems are specified to be repeatable to within Â±5 rpm at all speeds. Typical performance is Â±1 rpm. Also, all programming and display of spin speed is given with a resolution of 1 rpm.

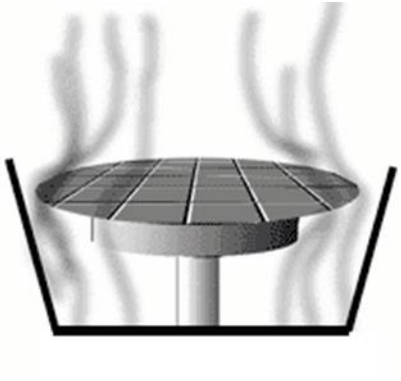
6.3 Acceleration



The acceleration of the substrate towards the final spin speed can also affect the coated film properties. Since the resin begins to dry during the first part of the spin cycle, it is important to accurately control acceleration. In some processes, 50% of the solvents in the resin will be lost to evaporation in the first few seconds of the process.

Acceleration also plays a large role in the coat properties of patterned substrates. In many cases the substrate will retain topographical features from previous processes; it is therefore important to uniformly coat the resin over and through these features. While the spin process in general provides a radial (outward) force to the resin, it is the acceleration that provides a twisting force to the resin. This twisting aids in the dispersal of the resin around topography that might otherwise shadow portions of the substrate from the fluid. Acceleration of Cee® spinners is programmable with a resolution of 1 rpm/second. In operation, the spin motor accelerates (or decelerates) in a linear ramp to the final spin speed.

6.4 Fume Exhaust



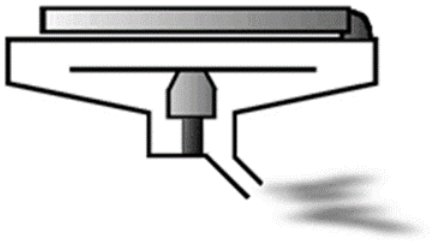
The drying rate of the resin fluid during the spin process is defined by the nature of the fluid itself (volatility of the solvent systems used) as well as by the air surrounding the substrate during the spin process. Just as a damp cloth will dry faster on a breezy dry day than during damp weather, the resin will dry depending on the ambient conditions around it. It is well known that such factors as air temperature and humidity play a large role in determining coated film properties. It is also very important that the airflow and associated turbulence above the substrate itself be minimized, or at least held constant, during the spin process.

All Cee® spin coaters employ a "closed bowl" design. While not actually an airtight environment, the exhaust lid allows only minimal exhaust during the spin process. Combined with the bottom exhaust port located beneath the spin chuck, the exhaust lid becomes part of a system to minimize unwanted

random turbulence. There are two distinct advantages to this system: slowed drying of the fluid resin and minimized susceptibility to ambient humidity variations.

The slower rate of drying offers the advantage of increased film thickness uniformity across the substrates. The fluid dries out as it moves toward the edge of the substrate during the spin process. This can lead to radial thickness non-uniformities since the fluid viscosity changes with distance from the center of the substrate. By slowing the rate of drying, it is possible for the viscosity to remain more constant across the substrate.

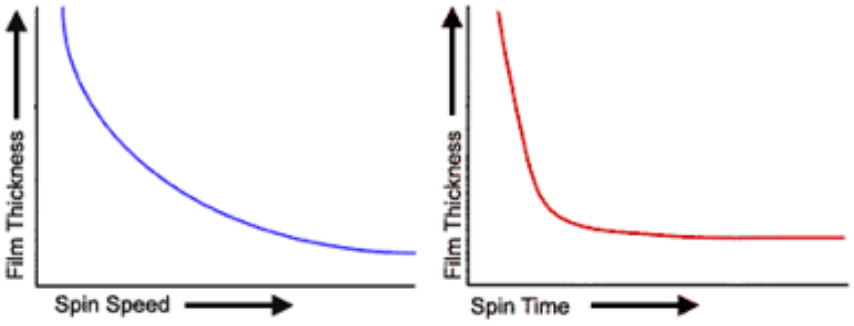
Drying rate and hence final film thickness is also affected by ambient humidity. Variations of only a few percent relative humidity can result in large changes in film thickness. By spinning in a closed bowl, the vapors of the solvents in the resin itself are retained in the bowl environment and tend to overshadow the effects of minor humidity variations. At the end of the spin process, when the lid is lifted to remove the substrate, full exhaust is maintained to contain and remove solvent vapors.

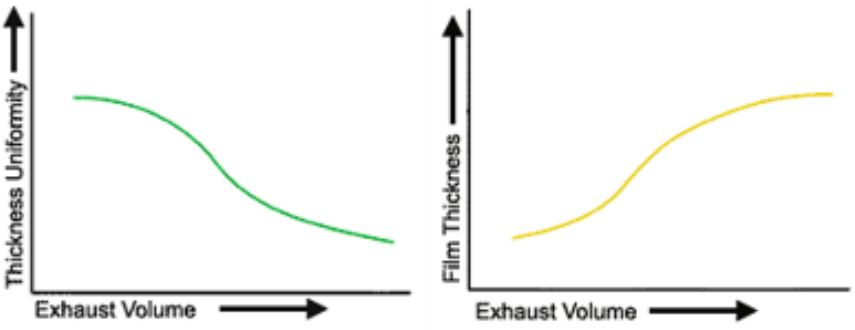


Another advantage to this "closed bowl" design is the reduced susceptibility to variations in air flow around the spinning substrate. In a typical clean room, for instance, there is a constant downward flow of air at about 100 feet per minute (30m/min). Various factors affect the local properties of this air flow. Turbulence and eddy currents are common results of this high degree of air flow. Minor changes in the environment can create drastic alteration in the downward flow of air. By closing the bowl with a smooth lid surface, variations and turbulence caused by the presence of operators and other equipment are eliminated from the spin process.

6.5 Process Trend Charts

These charts represent general trends for the various process parameters. For most resin materials, the final film thickness will be inversely proportional to the spin speed and spin time. Final thickness will also be somewhat proportional to the exhaust volume although uniformity will suffer if the exhaust flow is too high since turbulence will cause non-uniform drying of the film during the spin process.





6.6 Spin-Coating Process Troubleshooting

Film too Thin

spin speed too high ..... select lower speed
spin time too long ..... decrease time during high-speed step
inappropriate choice of resin material ..... contact resin manufacturer

Film too Thick

spin speed too low ..... select higher speed
spin time too short ..... increase time during high-speed step
exhaust volume too low ..... adjust exhaust lid or house exhaust damper
inappropriate choice of resin material ..... contact resin manufacturer

Poor Reproducibility

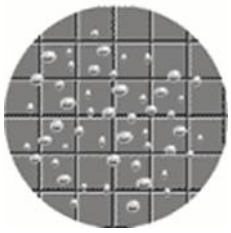
variable exhaust or ambient conditions ..... adjust exhaust lid to fully closed
substrate not centered properly ..... center substrate before operation
insufficient dispense volume ..... increase dispense volume
inappropriate application of resin material ..... contact resin manufacturer
unstable balance in speed/time parameters ..... increase speed/decrease time or vice versa

Poor Film Quality

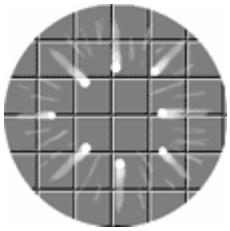
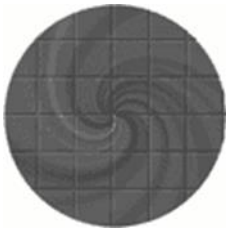
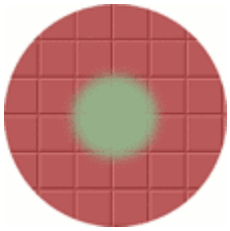
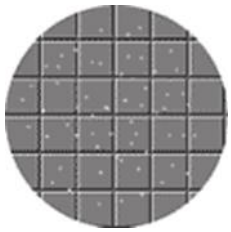
exhaust volume too high ..... adjust exhaust lid or house exhaust damper
acceleration too high ..... select lower acceleration
unstable balance in speed/time parameters ..... increase speed/decrease time or vice-versa
insufficient dispense volume ..... increase dispense volume
inappropriate application of resin material ..... contact resin manufacturer

Other Findings

Air Bubbles on Wafer Surface



Air bubbles in dispensed fluid (resin).
Dispense tip is cut unevenly.

Comets, streaks, or flares		Fluid velocity (dispense rate) is too high. Spin bowl exhaust rate is too high. Resist sits on wafer too long prior to spin. Spin speed and acceleration setting is too high. Particles exist on substrate surface prior to dispense. Fluid is not being dispensed at the center of the substrate surface.
Swirl pattern		Spin bowl exhaust rate is too high. Fluid is striking substrate surface off center. Spin speed and acceleration setting is too high. Spin time too short.
Center circle *(chuck mark)*		If the circle is the same size as the spin chuck, switch to a Delrin spin chuck.
Uncoated areas		Insufficient dispense volume.
Pinholes		Air bubbles in dispensed fluid (resin). Particles in dispensed fluid (resin). Particles exist on substrate surface prior to dispense.

7 Preventative Maintenance

This maintenance manual provides personnel with procedures and guidelines for conducting routine maintenance on a Cee® Apogee® 450 Spin Coater. Below is a chart of recommend maintenance scheduling.

7.1 Service and Repairs

Safety Notice: Important Repair Information for Cee® Equipment

⚠ In order to maintain safety and performance standards, only authorized representatives of Cee® are permitted to conduct repairs or alterations on Cee® equipment.

⚠ When servicing the machine, use only replacement parts made or recommended by Cee®.

⚠ Use only Cee® supplied shielded cables with this machine.

⚠ Unauthorized repairs may lead to serious risks such as equipment malfunction, damage, personal injury, or even death.

7.2 Fault Condition

In the event of a fault condition, power cycle the tool to restore function.

7.3 Safety Checks

Inspect spin coater lid for the following defects each day prior to use:

- loose assemblies
- improper closure
- improper bowl ring placement

7.4 Mechanical/Utilities Checklist

Evaluate	Frequency	Detail
Pressure Range	Daily	Check all pressures for ranges specified in tool manual.
Drains	Daily	Verify that there is a proper drain facility.
Exhaust	Daily	Verify that the exhaust is functioning at a range of 20-50cfm @ 0.2” water
Spin Chuck Cleanliness	Daily	A dirty spin chuck could cause vacuum errors. Wipe the spin chuck clean with isopropyl alcohol or acetone. For major buildup of material, a glass slide can be used to gently scrape the material away and then wipe clean. See the Cleaning section for more detailed instructions.
Spin Chuck Flatness	Quarterly	A non-uniform spin chuck can cause vacuum errors. Inspect visually against a straight edge. Small uniformity issues such as a burr can be gently removed with a glass slide. Larger deformations can be removed with fine sandpaper. Contact Cee Customer Support if the above methods are not successful.

Bearing Wear	Quarterly	Bad bearings can cause erratic spin speed and acceleration. When rotating the spindle shaft by hand, the shaft should spin easily with little noise. If the shaft does not spin easily or if a grinding noise is heard during a process, the bearing should be replaced.
Vacuum at Spindle	Quarterly	<33kPa abs - If low vacuum is present, check system supply. If supply is in spec and problems persist, contact Cee Customer Support for more information.
Axial Spindle Shaft Play	Bi-Annually	Axial play will cause excess bearing wear and possible vacuum error. There should be no axial play in the shaft.
Connections	Bi-Annually	Inspect all connections for proper installation.
Power	Bi-Annually	Verify that AC power is connected and of the proper voltage.

7.5 Cleaning

The Cee® Apogee® 450 Spin Coater should be cleaned following daily use. When cleaning the spin chuck, remove it from the equipment to keep solvent from getting into the spin coater vacuum system. It is good practice to use the mildest solvent possible such as acetone or isopropyl alcohol. ***Do not use caustic acids or bases.***

When cleaning the spin bowl, a small substrate should be on the spin chuck to keep solvent from getting into the vacuum system. Spin the wafer at approximately 100 rpm and use solvent in a wash bottle to flush out the spin bowl. Keep solvent from going down the spin shaft or the spin shaft tube. Shields and seals will protect the bearings from a small amount of solvent, but they will not tolerate large doses. Do not direct the solvent stream down the shaft or tube.

Use only water-based cleaner on the labels on the rear of the machine. Use only isopropyl or water-based cleaner on the *Power*, *Cee*® logo, *Caution ... Eye Protection*, and the *Cee® model/serial number* labels. The display may be cleaned with glass cleaner, water, or isopropyl alcohol.

8 Table of Revisions

Doc Rev #	Author	Description of Change(s)	Reviewed/Approved By	Date
2.2	J. Adams	- Added Section 2.7 NRTL - Update Apogee® branding	B. Waterworth	2/13/2024
2.1	J. Adams	- Update Section 1.7 Electrical - Update Section 1.9 Chemical to include auto-ignition point - Update Section 1.11 Intended Use of Machine - Update Section 2.7 Utilities - Update Section 3.2 Facilities Requirements - Update Section 3.5 System Installation & Setup - Update Section 3.7 System Checks - Add Section 7.1 Service and Repairs - Add Section 7.2 Fault Condition -	B. Waterworth	6/14/2023
2.0	J. Adams	- Update format - Add Section 1.5 *Environmental Considerations* - Remove shipping weight from Section 2.2 due to potential for variance - Add Section 3.1, *Clearance Requirements* - Add Doc Rev for DCIF and append document with explanation of rev	B. Waterworth J. Strothmann	09/22/2022