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Operations Manual

Apogee® Spin Developer

Models: A-B-SD2-1

A-B-SD2-2



Cost Effective Equipment

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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
Physical Address..... 6 Industrial Drive; St. James, Missouri 65559

1.4. Model and Revisions

The model and serial number information for the Cee® Apogee® Developer 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® tools and equipment operate 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 to 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® Spin Developer 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 N₂ or CDA before removing any panels.



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



This device is equipped with a safety lid interlock safety feature which will immediately decelerate the spindle motor if the lid is opened at speeds greater than 60rpm.



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® Spin Developer. 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 $\leq 30^{\circ}\text{C}$.



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 developer lid.



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



When draining 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® Developer. 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® Developer 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® Developer is intended for use as a semiconductor/optical application machine.

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

The Cee® Apogee® Developer 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® Developer and having not fully read this manual, should not operate the equipment.

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

Normal Operating Conditions

The Cee® Apogee® Developer is designed for indoor use only.

Ambient Temperature.....10 °C - 30 °C

Relative Humidity.....≤80%

Altitude.....up to 3000 m

Pollution Degree2

Overvoltage Category.....II

Permissible Voltage Fluctuations100-120; 208-230 ±10%



If the Cee® Apogee® Spin Developer 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® Developer delivers track-quality performance, with revolutionary interface capabilities and the utmost in chemical compatibility, in an efficient and space-saving design.

Fully programmable and user-friendly, this precision developer 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® Developer purchase a smart and cost-effective decision.

2.1. User Controls

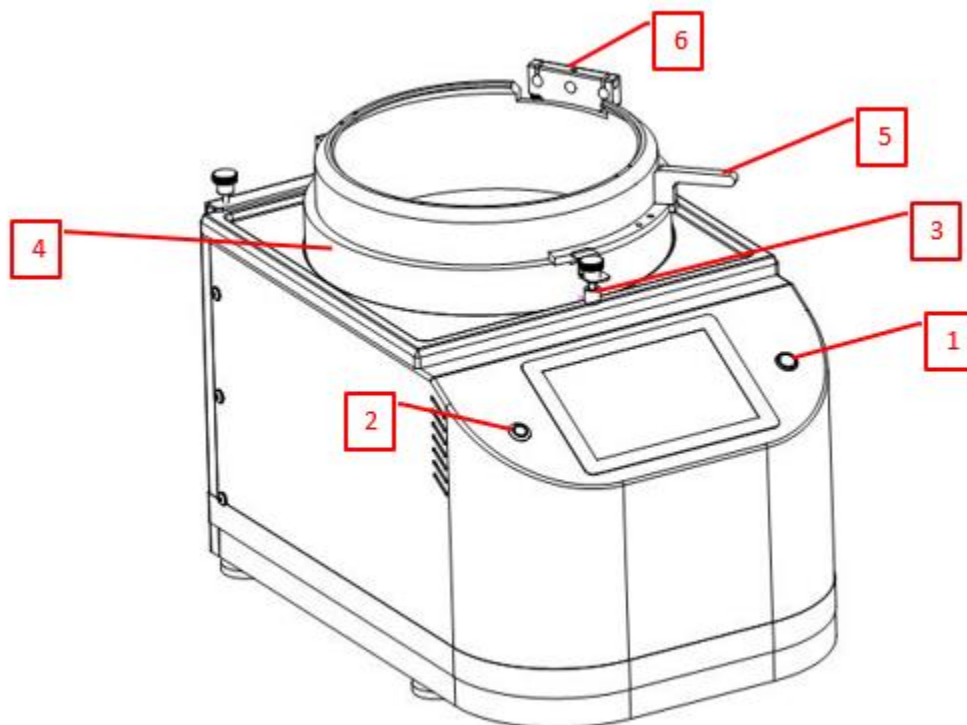


Figure 1: Cee® Apogee® Developer User Controls

1. power button used to turn the tool off and on
2. local presence button¹ used for remote access
3. lid sensor detects when the lid is closed
4. developer lid cover for the spin bowl
5. lid handle used to safely open and close the lid
6. dispense bracket used to hold dispense nozzles

2.2. Dimensions

13.25" (337mm) W x 19" (483mm) D x 12" (305mm) H²
Machine Weight 40lb (18kg)

¹ Refer to the [DataStream™ Manual](#) for more detailed information.

² H is with lid closed. Open H is 33" (83.8cm) or with optional chimney hood, H is 24 ¾" (628.7mm) closed and 36" (914.4mm) open

2.3. Features and Programmability

- vacuum and lid interlock
- touch screen interface and display
- full-color alphanumeric-capable 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 12,000rpm (max rpm varies with substrate size)
- spin speed acceleration
 - 0 to 30,000 rpm/s unloaded
 - 0 to 23,000 rpm/s with a typical 200mm substrate
 - 0 to 3,000 rpm/s with a 6" x 6" x 0.250" photomask in a recessed chuck
- bidirectional speed control/oscillating chuck
- up/download process parameters using DataStream™ technology via native USB/Ethernet ports
- multiple simultaneous automated dispense capability
- in-process dynamic speed & acceleration control

2.4. Precision

| | |
|-------------------------------|-----------------------------------|
| Spin Speed Repeatability..... | 0.2rpm (per standard spin module) |
| Spin Speed Resolution | 0.2rpm (per standard spin module) |
| Substrate Sizes | 200mm round; 7" x 7" square (max) |

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
- optional closed or open lid design for process flexibility and repeatability
- direct fan-jet spray, side angle puddle, and stream dispense options
- optional nitrogen blow-off nozzle
- integrated drain and exhaust ports
- optional automatic drain separator (aqueous/solvent)

2.7. NRTL

Beginning in February of 2024, all standard Cee® Apogee® Benchtop Spin Developer 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 | 100-120, 208-230VAC, single phase, 50/60Hz |
| Power Requirements | 655 watts, 6A |
| Drain Port | 3/4" OD |
| Exhaust Port | 1" OD |
| Vacuum | <33kPa abs |
| Exhaust | 20-50cfm at 0.2" water |
| Nitrogen/CDA (automated dispense) | 70 psi (482kPa) |
| DI water ³ | < 30psi (206.8kPa) |

³ for developer spray and backside rinse (if hard-plumbed)

3. Installation

3.1. Clearance Requirements

The Cee® Apogee® Developer 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 MAINS⁴ supply cords as needed.

Device Rear⁵ 12" (304.8mm)
Device Sides 3" (76.2mm)

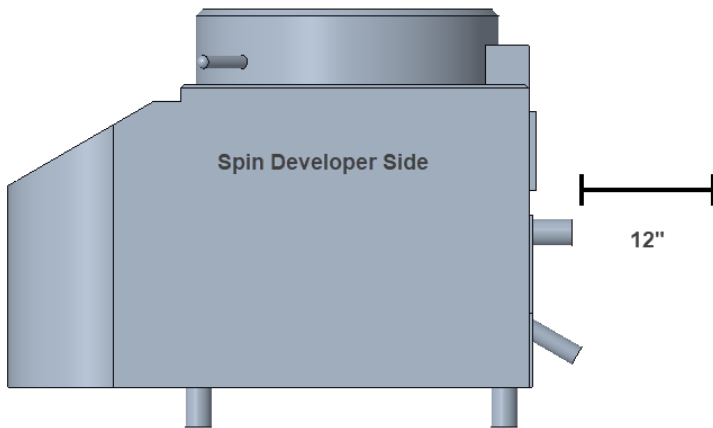


Figure 2: Cee® Apogee® Developer Rear Clearance Requirements

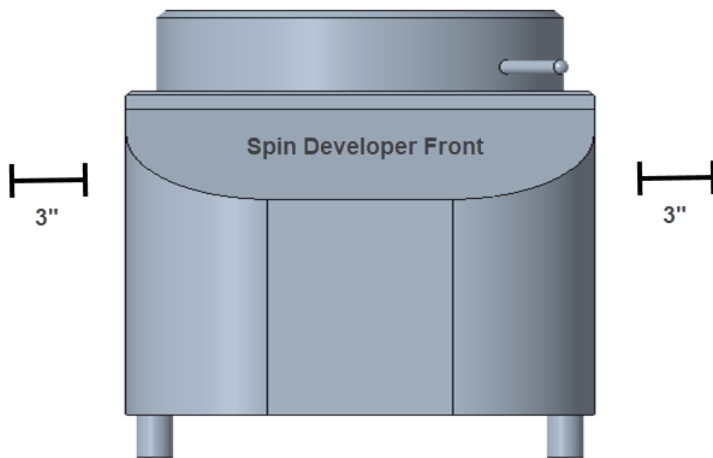


Figure 3: Cee® Apogee® Developer Side Clearance Requirements

3.2. Facilities Requirements

⁴ The tool should only be operated with the MAINS supply cord provided by Cee®.

⁵ When equipped with optional Programmable Exhaust, rear clearance requirement is 18" (457.2mm).

The Apogee® Developer requires the following utilities for operation.

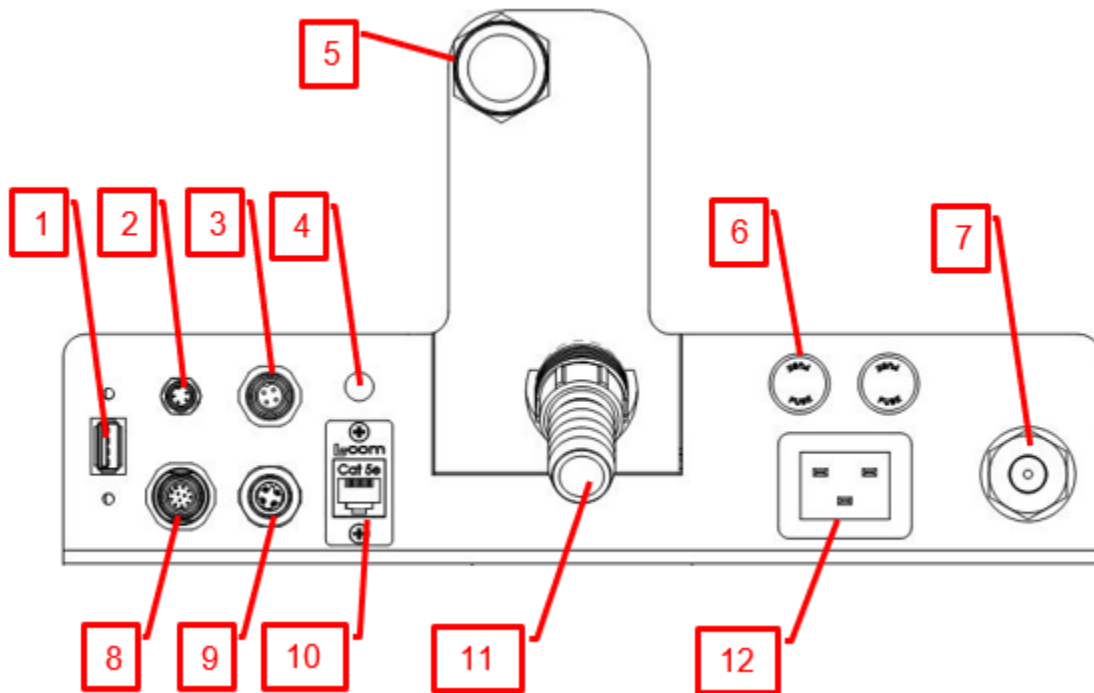


Figure 4: Cee® Apogee® Developer Facilities Connections

1. USB port⁶ facilitates software updates and log file downloads
2. programmable exhaust..... (optional) M8, 4pin female port, 24VDC
3. light tree (optional) light tree port, M12 4pin, female, 24VDC
4. backside rinse (BSR)..... (optional) dispense material fitting for backside rinse
5. spin bowl exhaust port..... exhaust port for spin bowl vapors (20-50cfm @ 0.2" water)
6. fuses system protection fuses (Replacement: BK/MDA-15-R)
7. system vacuum⁷ 1/4" NPT, <33kPa abs
8. dispense trigger..... (optional) connection for automated dispense control box
9. accessory port..... as needed, M12 4pin, male, 24VDC
10. Ethernet facilitates remote recipe writing and remote device control
11. spin bowl drain port via which liquid waste is removed from the tool
12. AC power in⁸ single phase 100-120VAC at 655 watts, 6A

⁶ see [DataStream™ Manual](#) for more information

⁷ Tools through July 2022 include 1/4" barb connect as standard/ post-July 2022 tools are supplied with a 1/4" push connect fitting as standard. Your connection fitting may vary based on customer request.

⁸ (208-230V A/C option available, see back to verify).

3.3. Environment

The Cee® Apogee® Developer should be operated in a clean, climate-controlled 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® Developer on a table of proper height and strength so that the controls and spin chuck are at the proper ergonomic height.
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® Developer
- temperature & humidity sensor
- power cord
- operators manual (USB)

Optionally included items:

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

3.5. System Installation & Setup

Please refer to the quick reference card supplied with the tool and visit the [Cee® YouTube Channel](#) for a video on installation.

1. Using the adjustable feet, adjust the Cee® Apogee® Developer so that it is level from side-to-side and front-to-back.
2. Thoroughly clean the spin bowl and spin chuck.
3. Connect utilities per the reference diagram in *Figure 4: Cee® Apogee® Developer Facilities Connections*.
4. Connect the temperature & humidity sensor to the CAN terminal.
5. Connect the vacuum supply to the vacuum fitting. (System vacuum <20inHg (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

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

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 1000rpm. Verify that the shaft spins and that the tool reads 1000rpm.

Lid Interlock⁹:

Open the spin bowl lid to confirm lid interlock functionality. The tool will decelerate immediately.

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 hit **Apply** to validate that Dispense Triggers are operational. Repeat as needed for additional dispense triggers.

Programmable Exhaust (optional):

If equipped with programmable exhaust, ensure that it is working properly

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® Developer is ready for use. Begin by creating a recipe. See [DataStream™ Manual](#) for more information.

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

****In the event that power to the machine is unintentionally interrupted and then restored, the spin coater will attempt to reboot, but the process will not resume automatically.***

⁹ To ensure that the wafer centering routine can be performed with the lid open, the lid interlock feature is triggered at speeds above 60rpm.

4. DataStream™ Technology

This section covers information specific to Apogee® Developers 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**¹⁰----- 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**¹¹----- 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® Developer

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 operation, and recovering from aborted processes. To access the activity, navigate to **Tools > Manual**

¹⁰ **Spin Acceleration** settings are dependent on the presence of a **Spin Speed** set point.

¹¹ Both Ambient Temperature and Humidity are measured via a custom sensor board mounted next to a ventilation inlet inside the tool. If sensor is disconnected, default of -1.1 is displayed.

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.

Apogee Process Recipes About Tools - admin

| Parameter | Actual | Set Point |
|-----------------------|-----------|-----------|
| Spin Speed | 0 rpm | 0 rpm |
| Spin Acceleration | 500 rpm/s | 500 rpm/s |
| Active Dispenses | None | None |
| Dispense Source Empty | None | |
| Chuck Vac | 98.8 kPa | 99.0 kPa |
| Waste Bottle Full | False | |
| Ambient Temperature | 29.1 °C | |
| Humidity | 37.8 % | |
| Vibration | 3 | |

System Controls

Control: What do you want to control? (dropdown menu)

Please check change.

APPLY

Centering Routine

Apogee Process Recipes About Tools - admin

| Parameter | Actual | Set Point |
|-----------------------|-----------|-----------|
| Spin Speed | 0 rpm | 0 rpm |
| Spin Acceleration | 100 rpm/s | 100 rpm/s |
| Active Dispenses | None | None |
| Dispense Source Empty | None | |
| Chuck Vac | 98.7 kPa | 64.0 kPa |
| Waste Bottle Full | False | |
| Ambient Temperature | 28.7 °C | |
| Humidity | 38.9 % | |
| Vibration | 3 | |

System Controls **Motor Off**

Control: Centering Routine (dropdown menu)

Action: Center Wafer (dropdown menu)

Title: Press OK or close the lid to continue. (dropdown menu)

Body: Please center the wafer (dropdown menu)

Please center the wafer

APPLY

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 assess and view configuration of the Centering Routine Display window outside of the Advanced Recipe Editor Activity.

Spin Speed:

Apogee Process Recipes About Tools - admin

System Values

| Parameter | Actual | Set Point |
|-----------------------|-------------|-------------|
| Spin Speed | 2000 rpm | 2000 rpm |
| Spin Acceleration | 10000 rpm/s | 10000 rpm/s |
| Active Disposes | None | None |
| Dispense Source Empty | None | |
| Chuck Vac | 98.8 kPa | 64.0 kPa |
| Waste Bottle Full | False | |
| Ambient Temperature | 29.1 °C | |
| Humidity | 38.3 % | |
| Vibration | 80 | |

System Controls

Motor Off

Control: Spin Speed

Action: Set

Speed: 2000 rpm

Accel: 10000 rpm/s

Osc: 0 seconds

Set Spin Speed to 2000 rpm (0 sec oscillation)

APPLY

Select a Control of *Spin Speed*

The Action will default to *Set*.

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

| | |
|---------------------------------|--|
| Speed | 1-12,000 rpm (standard developer) 1-6,000 rpm (450 developer) |
| Acceleration | 1-30,000 rpm/s |
| Oscillation¹² | 0-99 seconds |

Click APPLY

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

¹² reverses spin direction for the period specified

Dispense (*if equipped)

Apogee Process Recipes About Tools - admin

System Values

| Parameter | Actual | Set Point |
|-----------------------|-------------|-------------|
| Spin Speed | 0 rpm | 0 rpm |
| Spin Acceleration | 16000 rpm/s | 16000 rpm/s |
| Active Disperses | 1 | 1 |
| Dispense Source Empty | None | |
| Chuck Vac | 98.8 kPa | 64.0 kPa |
| Waste Bottle Full | False | |
| Ambient Temperature | 29.2 °C | |
| Humidity | 37.8 % | |
| Vibration | 4 | |

System Controls

Motor Off

Control: Dispense

Action: Enable Disperses

Value

| | | |
|---|------------|-------------------------------------|
| 1 | Dispense 1 | <input checked="" type="checkbox"/> |
| 2 | Dispense 2 | <input type="checkbox"/> |
| 3 | Dispense 3 | <input type="checkbox"/> |
| 4 | Dispense 4 | <input type="checkbox"/> |

Disperses ON: 1

APPLY

Select a Control of Dispense
The Action will default to *Enable Disperses*.
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

Apogee Process Recipes About Tools - admin

System Values

| Parameter | Actual | Set Point |
|-----------------------|-------------|-------------|
| Spin Speed | 0 rpm | 0 rpm |
| Spin Acceleration | 16000 rpm/s | 16000 rpm/s |
| Active Disperses | None | None |
| Dispense Source Empty | None | |
| Chuck Vac | 33.9 kPa | 64.0 kPa |
| Waste Bottle Full | False | |
| Ambient Temperature | 29.0 °C | |
| Humidity | 38.6 % | |
| Vibration | 3 | |

System Controls

Motor Off

Control: Chuck Vac

Action: Set

Vacuum: On

Threshold: 64 kPa

Chuck Vac On (64 kPa)

APPLY

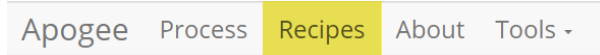
Select a Control of Chuck Vac
The Action will default to *Set*.
Set Vacuum to *On* or *Off*.
Set Threshold to the desired value in kPa.

Click APPLY

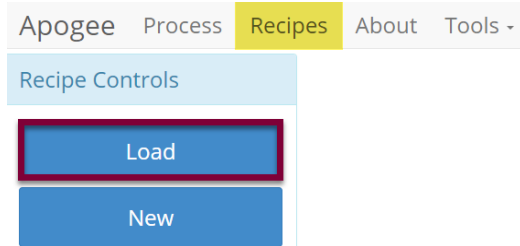
Note that the actual and set point values have populated on the system values list.

4.3. Running Recipes

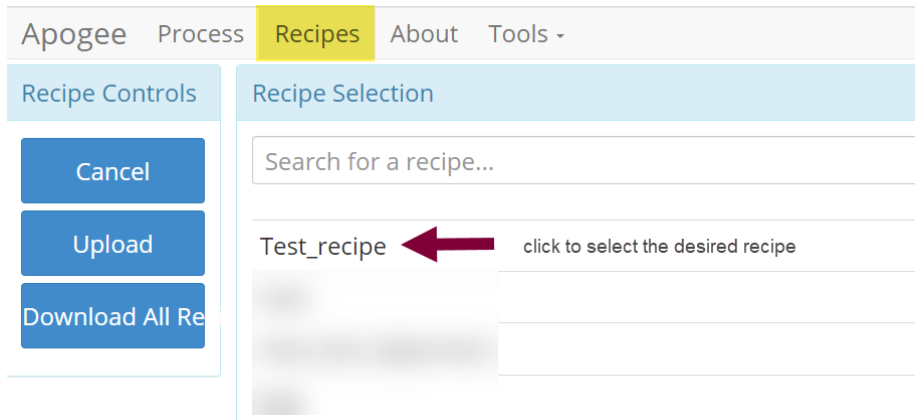
1. Navigate to the *Recipes* page.



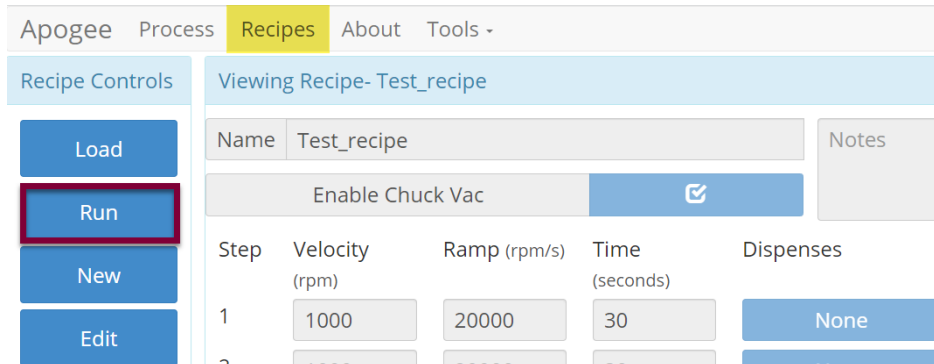
2. Click **Load** to access the recipes list.



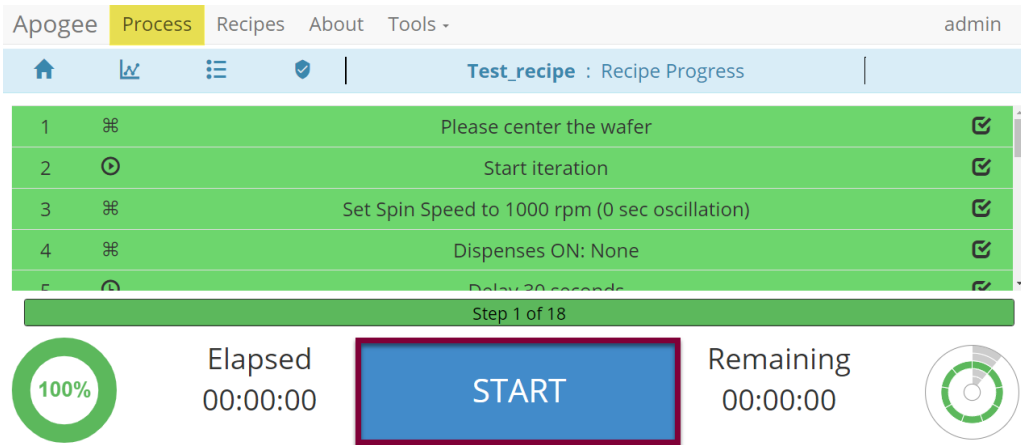
3. Search for, identify, & select the preferred recipe.



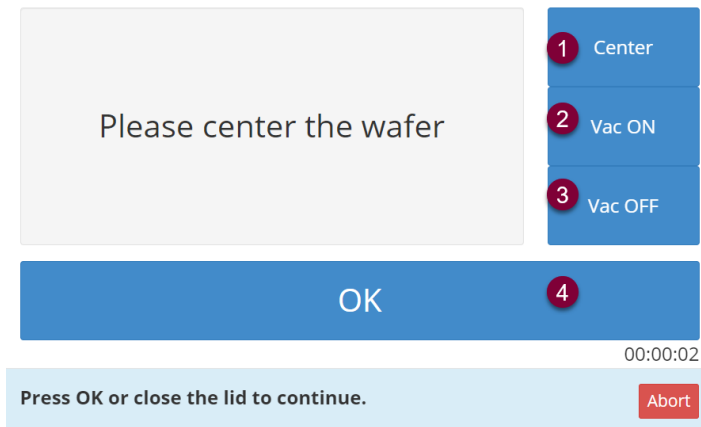
4. Click **Run**.



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



- Use the centering activity to center the substrate.



- spin chuck rotates slowly with vacuum on then stops rotation & vents vacuum
- toggle chuck vacuum on
- toggle chuck vacuum off
- resume recipe

- Recipe execution.



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

4.4. Editing Recipes

Developer 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*.

Apogee Process Recipes About Tools -

Editor Controls

Editing Recipe-

Name Test_Recipe Notes

Enable Chuck Vac

| Step | Velocity (rpm) | Ramp (rpm/s) | Time (seconds) | Dispenses |
|------|----------------|--------------|----------------|-----------|
| 1 | 1000 | 20000 | 30 | 1 |
| 2 | 2000 | 10000 | 15 | None |
| 3 | 1000 | 20000 | 30 | 2 |
| 4 | 100 | 500 | 60 | None |
| 5 | 1000 | 20000 | 30 | 3 |

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

Enable Chuck Vac¹³----- used when the substrate requires vacuum to remain on the spin chuck; the user must center the substrate prior to spinning

Step Velocity¹⁴----- speed in rpms 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

Exhaust¹⁵----- 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.

Apogee Process Recipes About Tools - admin

Editor Controls

Select Active Dispenses

Back

| | | |
|---|------------|-------------------------------------|
| 1 | Dispense 1 | <input checked="" type="checkbox"/> |
| 2 | Dispense 2 | <input type="checkbox"/> |
| 3 | Dispense 3 | <input type="checkbox"/> |
| 4 | Dispense 4 | <input type="checkbox"/> |

4.6. Tool Specific Settings - Apogee® Developer

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 (%)¹⁶ ----- Default exhaust position when not running a process.

¹³ Only available to users with ARE permissions.

¹⁴ preconditions default to ± 5% of the target speed

¹⁵ field is only present on tools equipped with optional programmable exhaust

¹⁶ Idle Exhaust does not apply to tools not equipped with Programmable Exhaust

5. Apogee® Developer 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 3/32" 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 3/32" hex wrench to tighten the chuck screw and secure the spin chuck to the shaft.

5.2. Starting Recipe

Developer recipes will vary based on materials being developed, thickness of the coating, and aspect ratios. Below is a basic starting recipe for the Apogee® Developer .

Below is an explanation of the steps of this recipe and how they can be optimized for each individuals substrate.

Step 1: This step dispenses developer across the substrate. This is done with the substrate spinning. This creates an agitation at the surface and will allow the developer to penetrate the coating. For most processes the spin speed ranges from 50-75 rpm. If the velocity is less than 50 rpm, material will wick around the backside of the substrate. The Time value should be set so that the substrate is flooded with material. Typically, 15 sec is more than enough but for larger substrates it may take more time.

Step 2: This step is to allow the developer to fully react with the material. Performing only Step 1 during a develop process will waste a lot of material. By dispensing material and then letting it soak, we allow the developer to react to its fullest potential.

Step 3: This step spins off the developer waste. The wafer does not have to be fully dry at this step but must not have a lot of liquid still on the wafer. If the wafer is not fully developed after this step, repeat step 1-3 for as many times as is necessary to fully develop the substrate. Many people must repeat this process 2 or 3 times for a total of 8-11 process steps.

Step 4: After the last spin off of developer waste, the wafer needs to be rinsed. This is typically done at a lower RPM than the spin off step but can be done at the same RPM as well. The time can be altered based on process needs. A larger substrate will generally take longer than a smaller substrate. This step can also include the back side rinse dispense if the option is available on the tool.

Step 5: This is the drying step. The velocity of the substrate is usually at least 1000 rpm for this step for 30 seconds to 1 minute. Typically, larger substrates will be spun at a lower velocity than smaller substrates. The velocity and time can be optimized for the process.

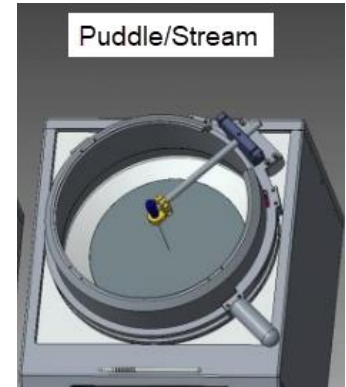
6. Developer Configurations

Development of features is a critical process step in photolithography. There are several processes to perform this step such as tank (bath) immersion and spin developing.

The use of immersion tank processes has steadily declined in MEMS fabrication and advanced lithography over the past decade due to excessive material consumption, non-uniform resolution, and poor clearing from high-aspect-ratio features. Additionally, increased throughput requirements and smaller features have further shifted mainstream applications to spin developing. As the popularity of the spin developing has grown, three main methods have emerged.

6.1. Puddle/Stream Dispense

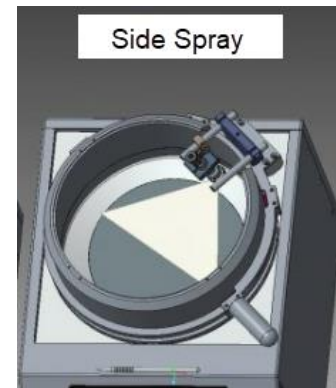
The most common and oldest process is the stream/puddle dispense. Developer is dispensed into a puddle at the center of the wafer. The wafer is then spun at low speed (0-50 rpm) long enough for the developer to cover the entirety of the wafer. The rotation is then stopped allowing the chemical reaction to dissolve the soluble areas of the patterned film. This process is very popular for thin films $\leq 1 \mu\text{m}$ thick and/or for small wafer applications. For thick films and/or high-aspect-ratio features, the stream puddle step may be repeated over several iterations to reapply fresh developer. However, this method is problematic for many of today's process requirements. Often features along the wafer perimeter are underdeveloped, and center features are over-developed due to the inherent over exposure of a puddle dispense.



6.2. Side Spray Dispense

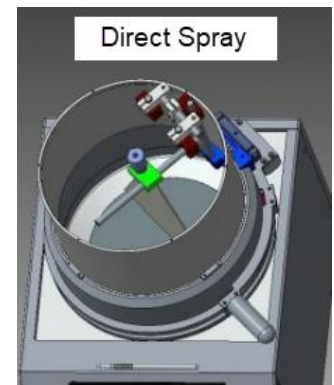
The use of side-angle spray nozzles (45°) significantly enhances fluid deposition uniformity. The standard configuration utilizes two side-spray nozzles to evenly apply developer solution across the substrate. These nozzles are positioned to spray from the center of the wafer out. The side spray nozzles are factory positioned outside the wafer plane and ensure uniform deposition for many substrate sizes. Cee® recommends the side spray dispense option for aspect ratios up to 5:1.

Over the years, the side spray dispense has become the most popular option as it allows for a variety of wafers sizes, materials, and feature sizes. Cee® Developers use side spray dispense as the standard setup configuration.



6.3. Direct Spray Dispense

Direct-angle nozzles (90°) are often used for continuous-spray applications and allow accelerated development of thick films ($5\text{-}100 \mu\text{m}$) with features having high aspect ratios greater than 5:1. The direct angle provides sufficient agitation to penetrate the film and remove soluble material.



7. Preventative Maintenance

This maintenance manual provides personnel with procedures and guidelines for maintaining a Cee® Apogee® Developer. 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 developer lid for the following defects each day prior to use:

- loose assemblies
- improper closure
- improper bowl ring placement

7.4. Mechanical/Utilities Checklist

| <u>Evaluate</u> | <u>Frequency</u> | <u>Detail</u> |
|-------------------------------|------------------|--|
| 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 | <20inHG (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 Apogee® Developer should be cleaned following daily use. When cleaning the spin chuck, remove it from the equipment to keep solvent from getting into the developer 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 | B. Waterworth | 2/13/2024 |
| 2.1 | J. Adams | <ul style="list-style-type: none"> - Updated Section 1.9 Chemical - Updated Section 1.11 Intended Use of Machine - Updated Section 3.2 Facilities Requirements - Updated Section 3.7 System Checks - Added Section 7.1 Service and Repairs - Added Section 7.2 Fault Condition | B. Waterworth | 6/12/2023 |
| 2.0 | J. Adams | <ul style="list-style-type: none"> - Update format - Add Section 1.5 <i>Environmental Considerations</i> - Add Section 3.1 <i>Clearance Requirements</i> - Remove shipping weight from Section 2.2 due to potential for variance - Add Section 6 <i>Developer Configurations</i> - Add Doc Rev for DCIF and append document with explanation of rev | B. Waterworth J. Strothmann | 10/27/2022 |