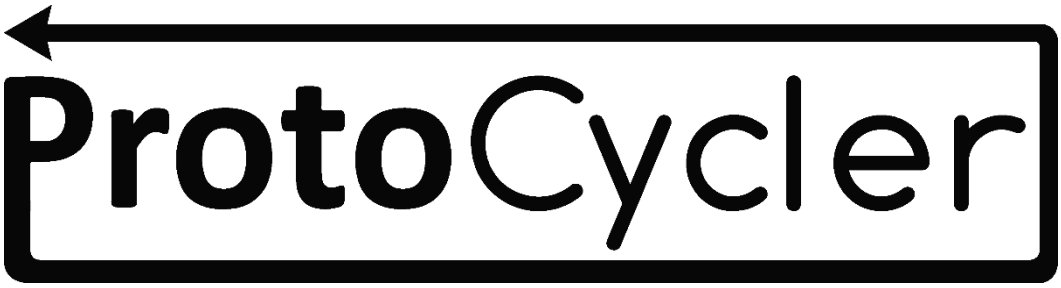


Operations Manual

Rev. 1.3

ReDeTec

Table of Contents

1.0 Introduction to the ProtoCycler

Welcome and thank you for joining the ProtoCycler community! ProtoCycler is designed to provide an easy to use experience and automatically take care of the extrusion process for you, using an advanced control system to monitor and control operation.

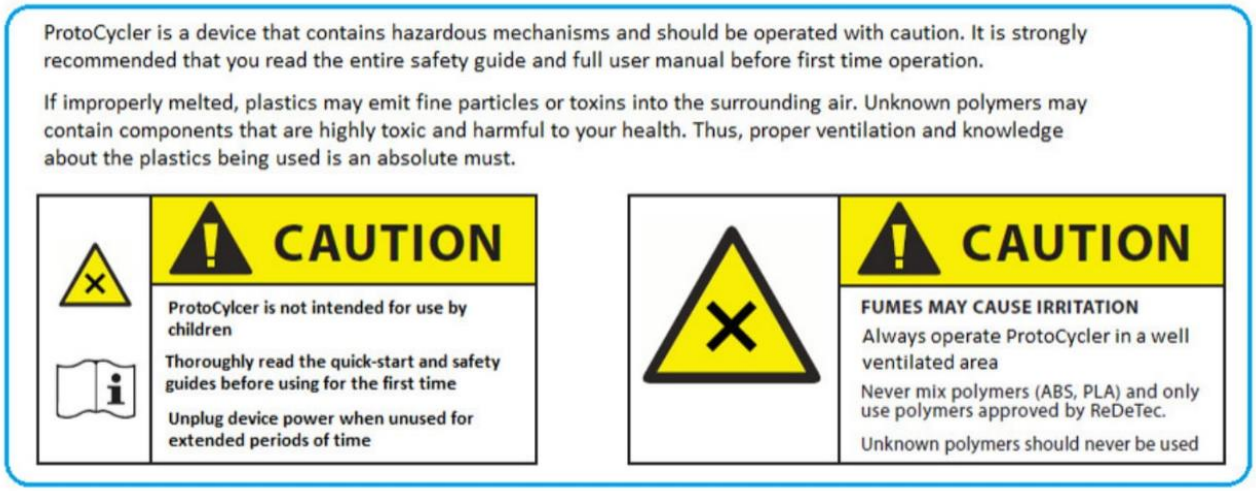
This manual will guide you to unlocking the operations and extrusion potential of your ProtoCycler extrusion system. Depending on what operating mode you become accustomed to, you may wish to have the **"ProtoCycler Command Center Overview"** document handy or already open. This operations manual details basic setup and operation of ProtoCycler, including key limitations such as constraints on the size of ground particles for extrusion, and safety warnings. To avoid bodily harm or damage to your machine, it is recommended that you read this entire document before proceeding with operation. For further troubleshooting and documentation, please check out http://www.redetec.com/support.

This guide is intended as a comprehensive reference and is somewhat long - though we do encourage you to read it fully. As a recycling business, we encourage you to keep a digital copy handy at all times on the computer on which PCC is installed, rather than printing the full manual.

1.1 Safety

As always, safety first when operating equipment of this caliber. **Please thoroughly review the safety precautions before proceeding with ProtoCycler operation. Failure to do so may result in damage to your device or bodily harm.**

1.1.1 General Safety:



1.1.2 Extrusion Safety:

The Extruder nozzle and emitted molten plastic may reach tempuratures up to 260° C, which can cause severe burns to body parts. Always use the supplied tools and exercise extreme caution while interacting with the nozzle or molten plastic during normal operation and while changing nozzles.

Never extrude PVC or any plastic whose type is unknown. The fumes could be lethal! ProtoCycler currently supports PLA and ABS. An exciting experience the ProtoCycler provides is the ability to experiment with new materials and colours through our software. It is important that you understand the material you are extruding and what is released when thermally broken down. If the material will release toxic fumes then you should not extrude it. For instance PVC will release chlorine gas and under no circumstances should you try to extrude it with the ProtoCycler. ABS on the other hand is commonly used in 3D printing – but, for safety reasons, still requires proper ventilation to the outside.

1.2 ProtoCycler Layout

Before we go any further, let's learn some key terminology that will be used throughout this guide. The following images outline the key areas of importance. Many of the terms are intuitive in meaning.

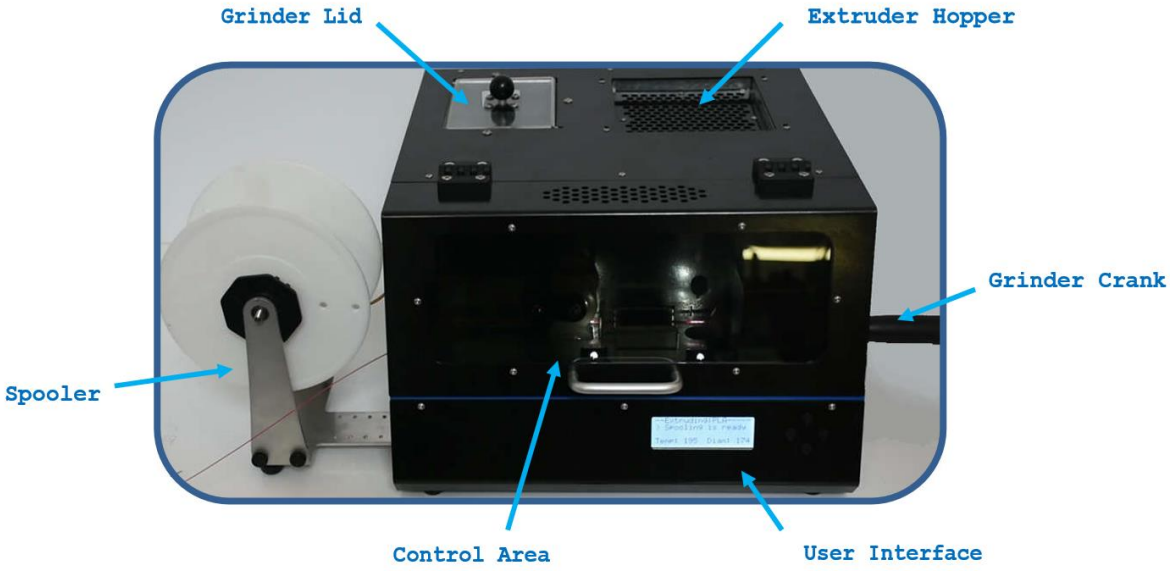


Figure 1: Above shows a general overview of ProtoCycler's anatomy (Front View).

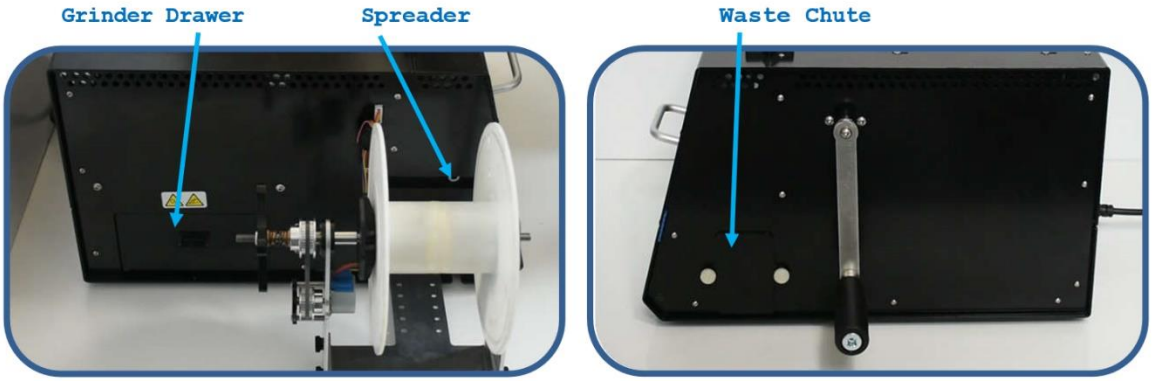
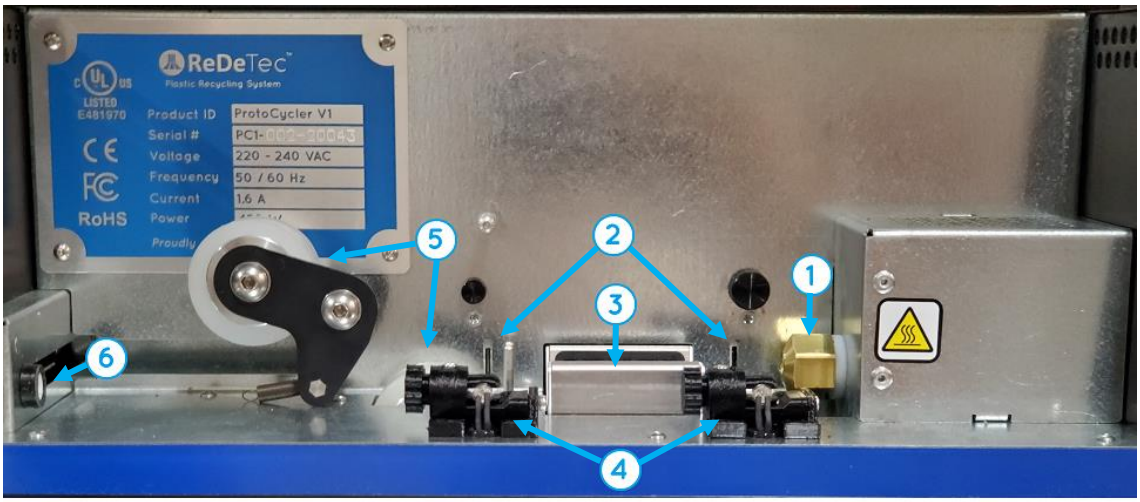


Figure 2: Above shows general overviews of the left and right sides, respectively, of the ProtoCycler



1. Extruder Nozzle
2. Diameter Sensors
3. Cooling Fan
4. Light Guides
5. Puller
6. Spreader

Figure 3: Above shows a general overview of the user interface (UI) of ProtoCycler. TODO FIX THIS

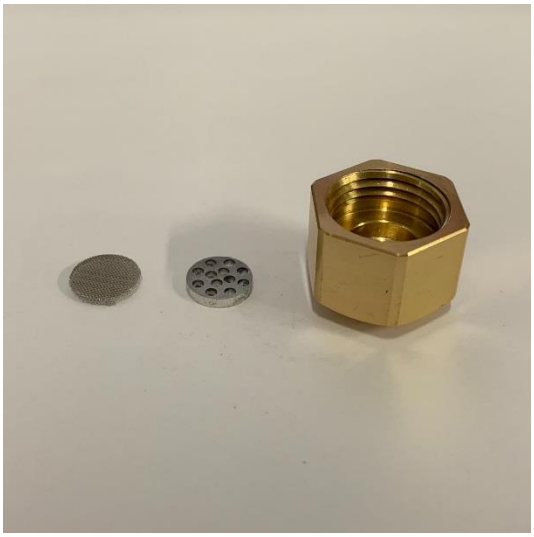


Figure 4: From left to right - Nozzle Screen, Nozzle Breaker Plate, Nozzle Cap.

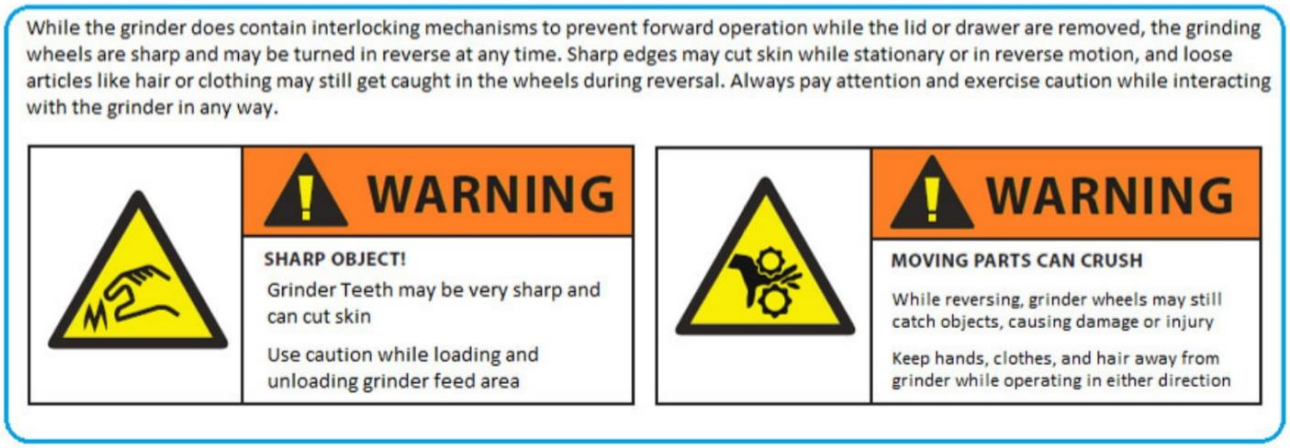
2.0 Grinding

2.1 Grinder Operation

The ProtoCycler must be powered on at all times to operate the grinder! The grinder relies on an electromagnet interlock that engages the grinder drive train only when supplied with power. The electromagnet is calibrated to disengage the interlock at set torque limit value to prevent damage to the gear train. Lastly, the grinder will only work if the two interlock switches are engaged while the unit is powered on. One switch is engaged by the grinder lid, and the other, by the grinder drawer.

2.1.1 Grinder Safety:

Please thoroughly review the safety precautions before proceeding with grinder operation. Failure to do so may result in serious injury or irreparable damage to your device.



2.1.2 Grinder First Time Setup:

1. Remove the Crank Arm and Allen Key from the packaging.
2. Use the Allen Key to remove the screw and washer from the Grinder Crankshaft.
3. Place the support washer onto the crankshaft.
4. Install the Crank Arm over the hex on the Crankshaft with the handle facing outwards
    - **Note: the hex size is 5/16".**
5. Replace the screw with the washer under it, and tighten until snug.

2.1.3 Operation:

Note: It is not advised to operate the Grinder while the Extruder is running. Grinder operation may shift or vibrate the unit which may affect filament quality.

1. Power on your ProtoCycler
2. Remove the Grinder Lid and place the part you wish to grind into the grinder hopper. Place the lid back in the hopper. The lid and drawer must be correctly installed in order to operate the Grinder.

    While the lid only needs to be partially in, the drawer must be fully seated against the back wall. Particulates may block this, and so it is necessary to make sure the drawer slot is clean of debris before reinserting the drawer.
3. To grind, first rotate the Grinder Handle counter-clockwise to ensure the interlock is engaged. Then press down on the Grinder Lid Plunger and rotate the Grinder Handle clockwise. Viewing through the clear area of the Grinder Lid you will see the Grinder Teeth spin inwards.
4. During operation, if at any time the load on the Grinder Teeth exceeds the maximum, the Grinder Interlock will disengage. Reverse the grinder all the way until the part is pulled off of the teeth by the clearers, and

then attempt grinding again. If unsuccessful, you may need to fully remove the part and reduce its size by other means, or otherwise reduce the number of parts you are grinding at once.

5. When you are done grinding, remove the Grinder Drawer to retrieve the regrind. Sort the particulates and re-grind the oversized bits. See the following section on sorting regrind for extrusion.

2.2 Sorting Ground Material:

When grinding, depending on the material type, density and shape, it may be necessary to sort the regrind using the provided sorting mechanism, and re-grind the ground material that isn't small enough. The sorting mechanism lives inside of the grinder drawer. It is a liner comprised of two levels of offset holes used to sift through the ground material and only allow ground material of appropriate extrusion size through.

1. Review section on desired regrind size, below.
2. Lift the sorting mechanism most of the way out of the drawer, and hold it so they are still overlapping.
3. Shake the two side to side, up and down, until it seems the only particles left in the sorter are too large to fall through.
4. You may also wish to shake the sorter over a large pan or bucket to allow a little more freedom of motion. Make sure whatever you choose for your "catch container", it is clean of contaminants. Rubbing alcohol is an excellent choice for cleaning your container as it dissolves and cleans surface contaminants while evaporating quickly! Using soap and water is fine, but make sure your grinder drawer/container is fully dry before using it with your ProtoCycler system.
5. Remove the sorting mechanism and pour the large particles that remain in the sorter back into a container for regrind or back into the Grinder Hopper. Pour the small particles that made it into the drawer (or catch container of your choice) into a container or plastic bag to save for extrusion.
6. You will want to collect regrind and dry it as a large batch before packaging or using it for extrusion. See section on wet/dry plastic.

2.3 Regrind Size & Extruding Recycled Plastic

The size of pellets/regrind particles entering your extruder is very important. If the plastic media is too large in any dimension, it can jam your extruder. Using 100% regrind can also lead to jamming. De-jamming is a difficult process which may require partial disassembly of your unit.

1. The appropriate pellet size that can be used in your ProtoCycler's Extruder is 0.125" to 0.2" in diameter. Pellets that do not fit in this size range will not pass through the Extruder Hopper Filter. Particles over 0.2" in any dimension may jam your extruder. While having some portion of pellets be undersized is fine, the extruder hasn't been tested with high concentration of small particles yet.

   WARNING: The Extruder Hopper Filter does not replace the act of proper pre-sorting. The Extruder Hopper Filter is a final protection for the Extruder to reduce the chances of issues. It is your responsibility to ensure proper sorting before using ground recycled plastic.

   Use the sorting mechanism to ensure all of your regrind particles are small enough. See section on sorting in the Grinder section, above.
2. **Regrind must be mixed with virgin pellets.** 50% recycled plastic is the recommended regrind ratio, though up to 70% with well ground regrind has been successful. Extruding 100% regrind may jam your extruder! High consistency in size of your regrind will improve filament quality.
3. Note that 50% is a statistically proven percentage and subject to vary depending on material and regrind size.

3.0 Important Things to Know Before Extruding

3.1 Puller Wheel Storage

The plastic is pulled from the extruder nozzle using 2 wheels. These 2 wheels have soft silicone tires, and use a spring to hold force between them for gripping the filament. **If left stationary in one position for an extended period of time, the tires can develop a flat! Therefore, it is important to disengage the spring and rotate the puller idler wheel out of position when not un use to avoid developing a flat.** The following images clearly depict Puller operation and Puller storage positions.

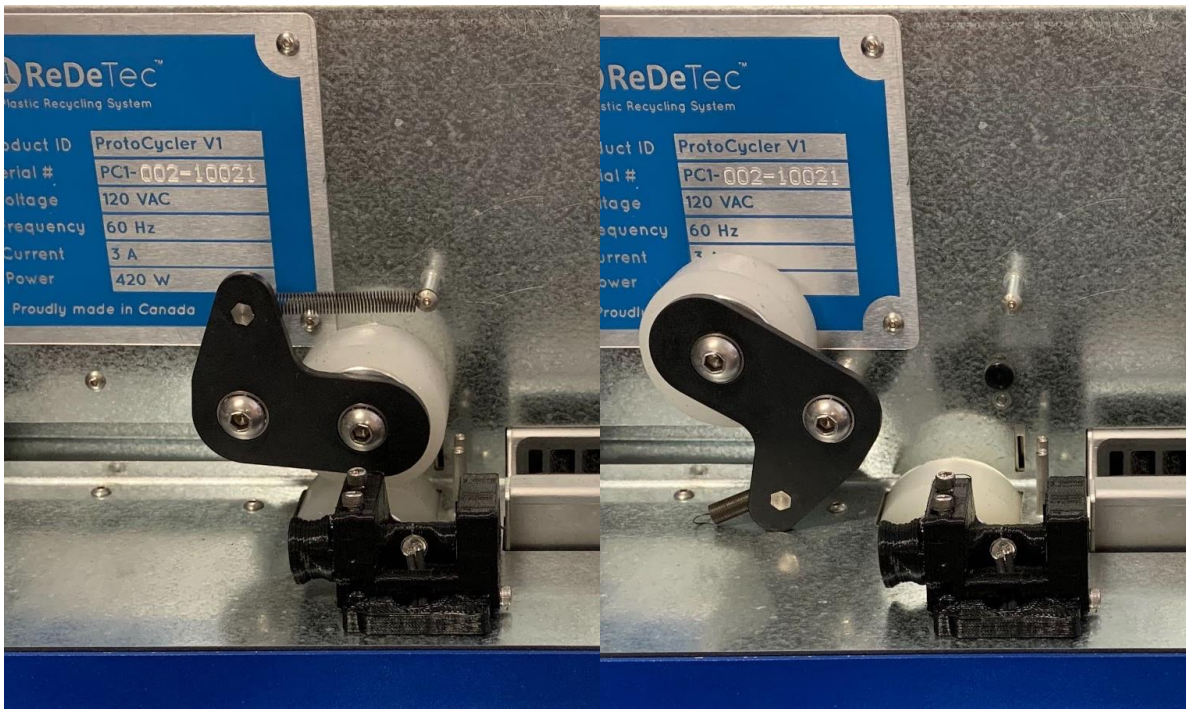


Figure 5: Shows the puller idler wheel spring engaged (left image), and disengaged (right image).

3.2 Cleanliness

It is important to make sure your device is clean before use. We make sure to thoroughly clean each ProtoCycler before shipping, but over time dust can accumulate. Before extruding, inspect your extruder hopper for dust and other contaminants. **If material other than the plastic you wish to process makes it through the system then you risk defects in the output filament.**

ProtoCycler also uses two light sensors to read filament diameter output. We recommend using a canister of dry compressed air ("computer duster") to blow-out any dust or particles that may block the light sensor. We will show you how to know if there is dust getting in the way of the LED or photoresistor in the "Light Guide Alignment" section of this manual. If compressed air doesn't do the trick then we also recommend using a softer material (a skinny piece of PLA filament works very well) to clean the photoresistor "slot" on the UI panel where the LED shines light into. **Never use metal or anything sharp to clean the diameter sensors, as permanent damage can occur.**

Lastly, if other un-meltable materials or dissimilar materials with higher melting temperature than your plastic of choice enter your system, you may find over time that your nozzle becomes clogged. Referring to **Fig 4** (Nozzle parts), inside of the Nozzle Cap there is a breaker plate and screen whose purposes are to aid in building stable pressure, and to act as a last line of defence against contaminants entering your filament. In the event that your screen becomes clogged, please contact ReDeTec support for assistance in how to clean your screen! This process requires special care and safety when executing and a trained specialist will be happy to advise.

3.3 Plastic Care: Dry vs Wet - Clean vs Dirty

Similar to filament, you want to make sure your plastic is dry and kept clean prior to use. All plastic is inherently "hygroscopic", meaning it readily absorbs moisture from the air into its molecular structure. This moisture is your enemy when it comes to extrusion! Extruding with wet plastic will cause the moisture to be vaporized during extrusion, causing bubbles in the output and vastly changing the extrusion properties. In most cases this will prevent you from achieving high quality consistent filament.

Extruding wet plastic will likely produce unusable filament! Depending on the grade, the plastic may absorb moisture from the air very quickly. Thus it is very important to follow a strict regimen of properly drying, and managing your dried plastic before extrusion.

The drying process is simple and may be done using an oven, toaster oven, or food dehydrator. If using an oven or toaster oven the moist air must be removed for proper drying. Plastic manufacturers will give specific recommendations on drying temperatures and times. Temperatures and times used for ABS and PLA are shown in Table 1.

Table 1 below shows the Drying Guide for ReDeTec Supported Plastics.

Plastic (grade)	Temperature	Time (hours)
PLA (4043D)	80°C (175°F)	4
ABS (250-X10)	80-90°C (175-194°F)	4

Make sure your drying system is already preheated before starting the timer for the drying times stated in Table 1.

Note, ReDeTec currently supports PLA and ABS. If you have a specific plastic type and grade that you would like us to focus on next, please do not hesitate to reach out to us with requests.

After drying, plastic must immediately be stored in an air-tight container or bag with desiccants until extrusion, otherwise it will quickly reabsorb moisture from the air again.

All pellets purchased from ReDeTec inc. come pre-dried with desiccants in a sealed bag. This ensures that the plastic is dry and ready to extrude right away. However, while exposed to air the plastic will be absorbing moisture, and if left out for too long will need to be re-dried. Absorption rate is fully dependent on the ambient humidity, so you can slow this process by operating in a dry environment.

Ground plastic parts on the other hand, will have had plenty of time exposed to the environment, and must always be dried for best results. Best practice is to collect sorted, ground bits in a bag or container until you have enough to dry and extrude a full batch.

Just as your extruder should be kept clean of contaminants prior to and during operation, the same applies to the plastic itself. We take special care to avoid contaminants entering the plastic supply. If dirt or a higher melting temperature plastic makes its way into the plastic you are extruding, you may encounter inconsistencies in the melt output and/or irregularities in the consistency of your filament diameter. Clean-dry plastic will yield a smooth and consistent output if all other conditions are correct as well.

3.4 Opaque vs Transparent Plastic

Due to the nature of the diameter sensors used for control, ProtoCycler does not currently support extruding transparent filaments. For a naturally transparent plastic such as PLA, colorants must be added to make the filament opaque.

Included with ProtoCycler is a sample of colorants to use with the included plastic, and additional colorants may be purchased from ReDeTec along with plastic pellets.

3.5 Spooler Set Up

Before setting up your spooler, please check to ensure all of the parts in the image below are included with your ProtoCycler.

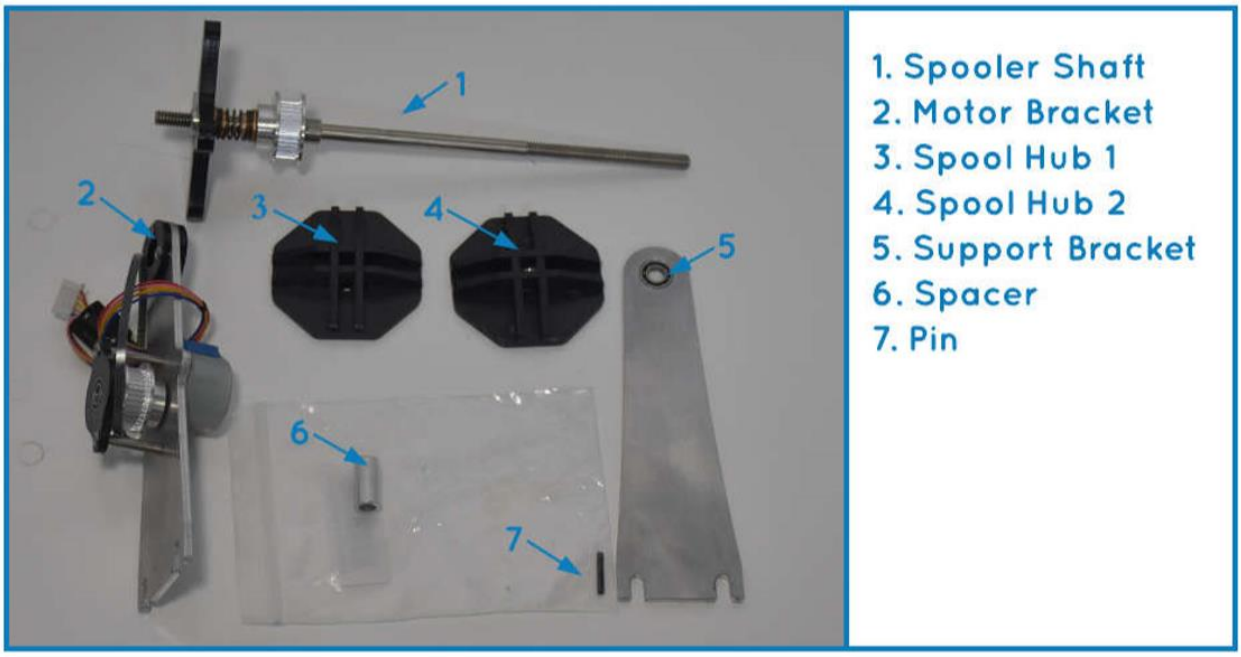


Figure 6: Spooler Kit Parts

In addition to the above parts, you will need to retrieve the spooler base that slides out from the side of the ProtoCycler as shown in the image below.

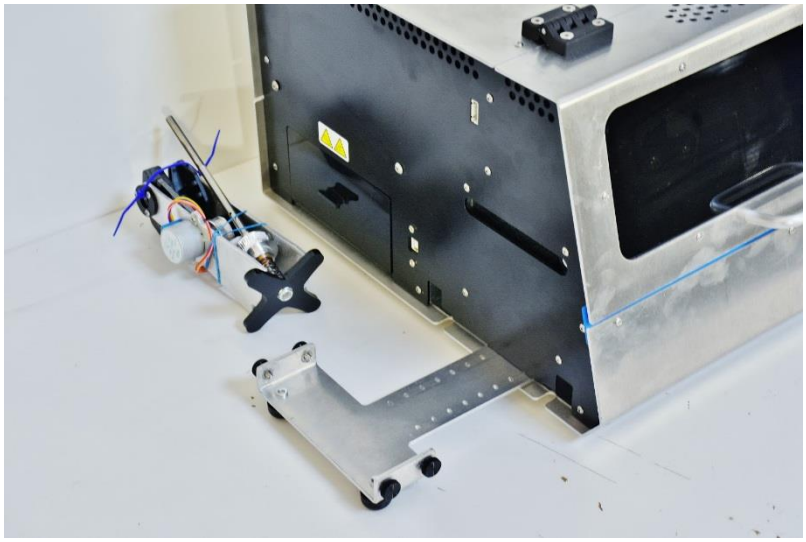


Figure 7: Spooler parts bundle and spooler base shown pulled out from its recess.

The following illustrations in **Fig 8** below outline how to assemble the spooler and correspond to the set of written instructions that follow it.

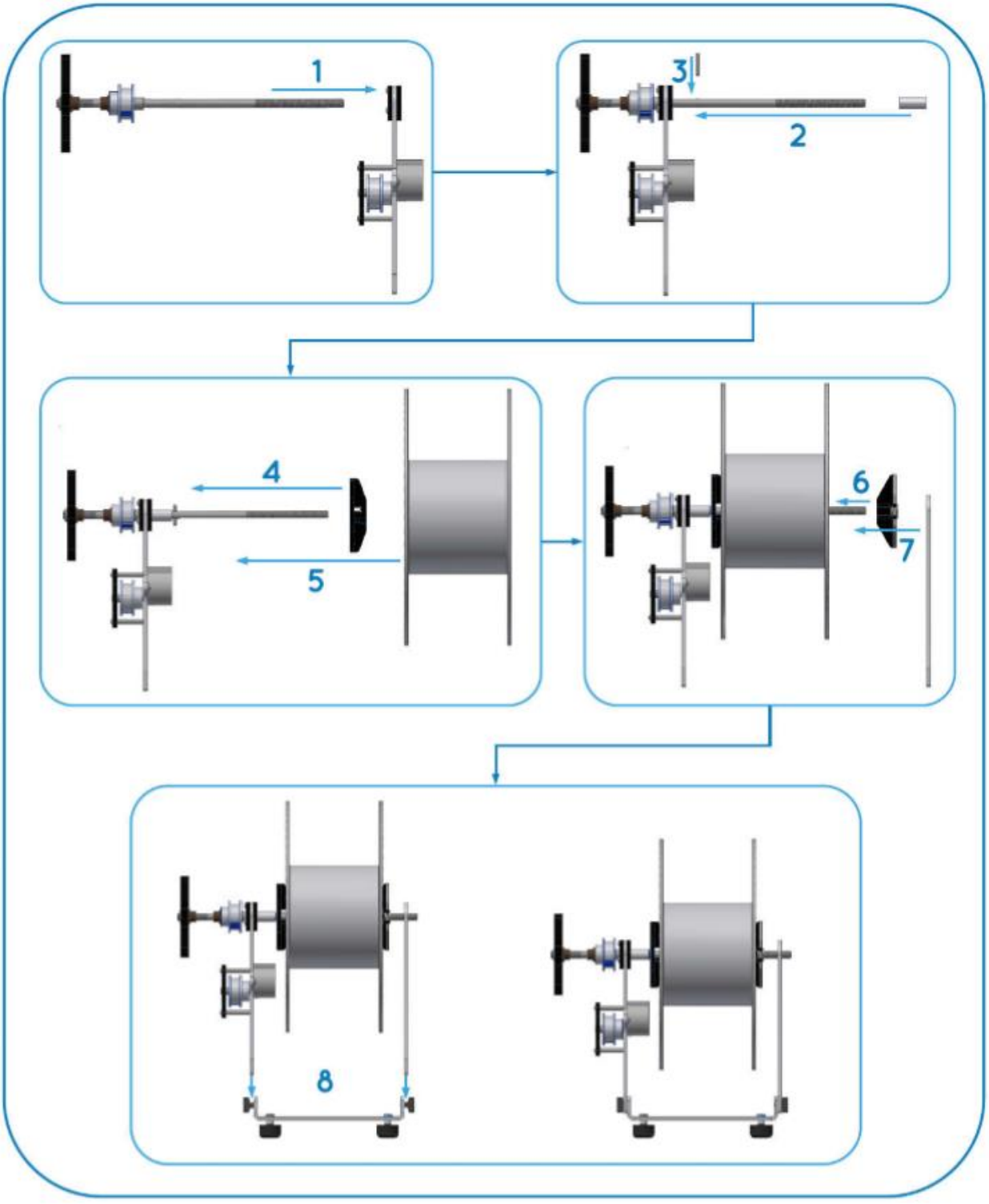


Figure 8: Step by step numbered illustrative guide to assembling the spooler.

3.5.1 Spooler Assembly Instructions:

Warning: The ProtoCycler must be powered-off when installing and plugging in the spooler. Unplugging or plugging in the spooler while ProtoCycler is powered can permanently damage the main circuit board!

1. Slide the Spooler Shaft through the bearing in the motor mount bracket in the direction shown.
2. Slide the Spacer onto the shaft so it rests against the bearing and is clear of the pin hole in the shaft.
3. Slide the Pin into the hole in the shaft and hold it there.
4. Slide Spool Hub 1 onto the shaft as shown, ensure the pin seats properly into its groove. NOTE: Spool Hub 1 does NOT have a nut in it!
5. Place a spool over the shaft so it rests against the tapered face of Hub 1.
6. Thread Hub 2 onto the shaft and spin until it is contacting the spool. Now tighten until the hubs are tightly holding the spool, while ensuring that the spool is being held straight.
7. Slide the shaft into the bushing in the Support Bracket.
8. Ensure the thumb screws in the Spooler Base are as loose as possible, then place the assembly into the base as shown. Tighten the screws so they are nice and snug.
9. Insert the Spooler Base back into the side of the ProtoCycler and plug the stepper motor into its receptacle, also located on the left side of the unit.
10. Now it is time to turn on your ProtoCycler and set the spool geometry settings in ProtoCycler's User Interface.

    Failure to correctly set spool geometry may result in improper spreading of filament onto the spool.

    i) Plug ProtoCycler's power cord into a grounded outlet and turn on the main power switch.
    ii) From the UI Home, select "Settings" and then "Spool size".
    iii) In the SPOOL SIZE window, you may now set the width and diameter of the spool. The width figure is the width contained inside the spool (ie the width filament will be spread over) and the diameter is the inner diameter that filament will be spooled on. Change these values by using the left and right buttons.
    iv) Return to the top and push the right button to save the spool geometry settings.

The spooler is now set up and ready for extrusion!

3.6 Light Guide Alignment

Light guide alignment is key to your ProtoCycler's vision system to verify and maintain filament diameter! Every ProtoCycler is aligned and tested for performance before shipping, but sometimes things are bumped and moved between when the ProtoCycler ships to the next time it is turned on again by you, the owner. Taking care and patience to assure your light guides are properly aligned will pay off in the long run.

Depending on when your ProtoCycler was built you may have one of two 3D printed variants! Neither is better in terms of function. They both work to align the LED beam of light, but an iteration was made to improve fabrication and assembly time internally. The following image details the two types of Light guides.

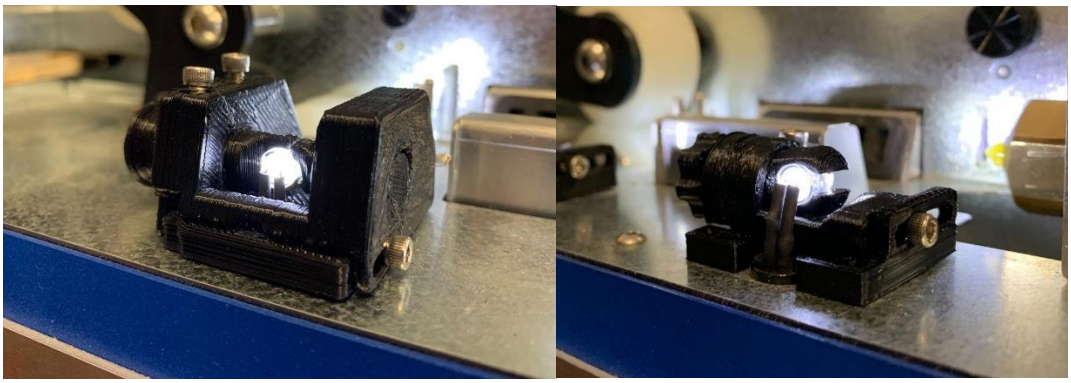


Figure 9: Light Guide V1.0 (left). Light Guide V1.1 (right).

3.6.1 What you need to check Light Guide Alignment:

- You'll need two sizes of dowels. Drill bit shafts are an excellent option (use the smooth shank, not the cutting flutes side). **It's very important that the dowels are a consistent, known size - DO NOT use extruded filament!**
- ReDeTec uses a 1.83mm and a 2.56mm dowel to align the light guides, but you can use anything close within +/- 0.1mm. The larger dowel size is used for the sensor closest to the nozzle, and the smaller dowel size is used for the sensor closest to the puller wheel. For reference we will call these the Puller Sensor and the Nozzle Sensor.
- You will also need to be connected to a computer, to use ProtoCycler Command Center ("PCC").

3.6.2 Light Guide Alignment Overview:

With ProtoCycler connected to PCC, start manual mode extrusion via the ProtoCycler U.I. (For guidance, refer to the ProtoCycler Command Center Overview). You will see a screen that looks like this upon manual mode startup:

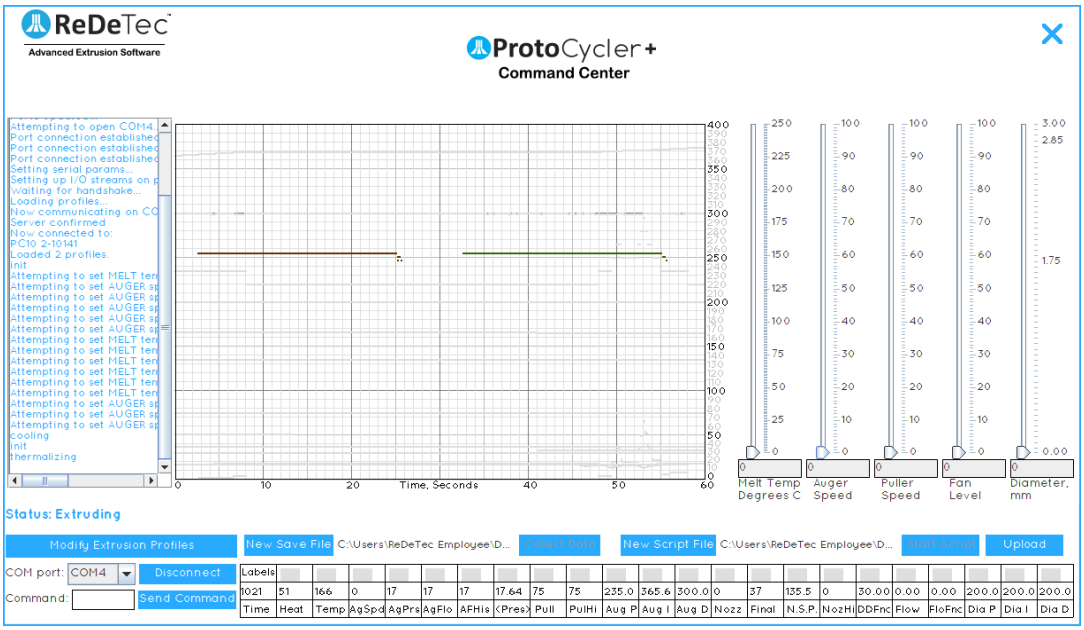


Figure 10a: Startup screen of manual extrusion with all readings toggled off (by clicking the "Labels" button above the "Time" readout).

The two flat lines seen in **Fig 10a** above represent the raw data read by the light sensor photoresistor array for the diameter of filament at the nozzle (left - brown line) and the final diameter of the filament at the puller wheel (right

- dark green line). These lines being flat at a value of 255 (with a small amount of "drop-off" on the right) is a good sign that your light guides are well aligned. If the light guides are lower than 255 or have severe angle to them, such as **Fig 10b** below, alignment is required.

Note that "Alignment" refers to two separate tasks. The first is to ensure the light is evenly lighting the sensor. The second is to ensure that the readings are accurate.

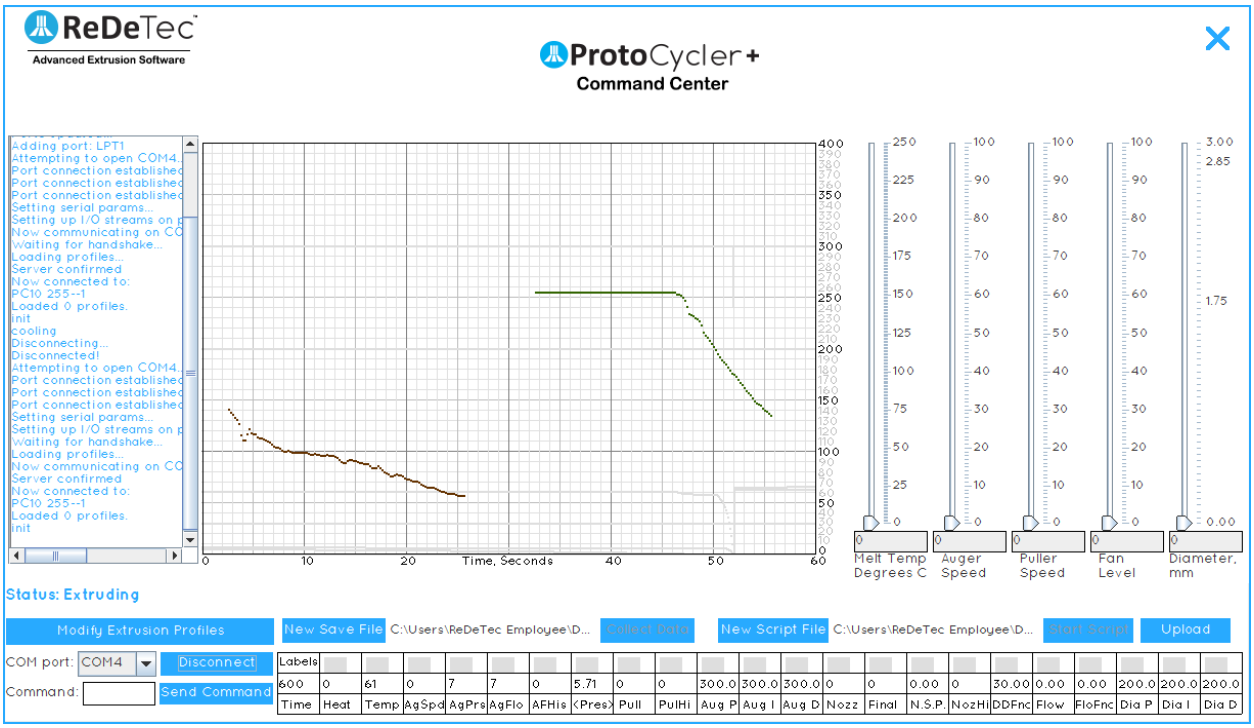


Figure 10b: Two examples of incorrectly aligned light guides – the nozzle is very bad, but the puller still has far too much drop off on the right side to work.

3.6.3 Step 1 - Adjusting the sensor height

1. The first step is to ensure the sensors themselves are aligned. Each sensor has a thumbscrew that, if loosened, permits the sensor to move up and down, as shown below in **Fig 11**. **The sensors are adjusted from the factory and neither sensor should be adjusted unless the filament is seen to be frequently "falling off the edge" of the sensor, as shown in Fig 19 (see "Extrusion - Automatic Mode")**

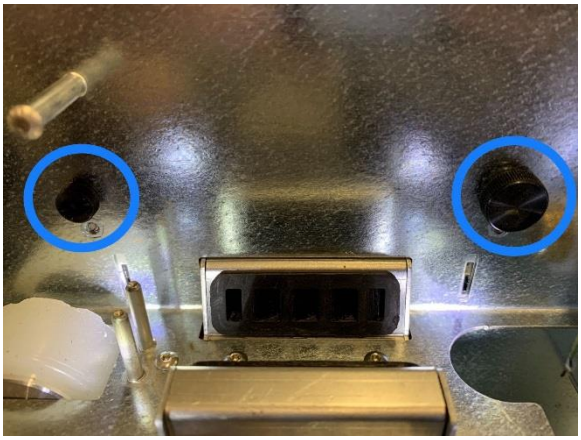


Figure 11: UI Thumbscrews for adjusting the height position of the photoresistors.

2. Typically the puller sensor's photoresistor will be positioned all the way at the bottom range of its movement for best results. It has been adjusted this way from the factory, and should not need adjustment!
3. The nozzle sensor is a little more tricky depending on what material is being extruded and at what diameter; both of which will affect how the filament passes the first diameter sensor at the nozzle. Typically, the nozzle diameter sensor's photoresistor will be positioned ~1mm (~0.04") above the midpoint of its range of motion. The nozzle sensor's photoresistor height can also be fine tuned during operation; this will be addressed in the extrusion instructions of this manual.
4. If adjustment is required, loosen the thumbscrew holding that sensor, and move the sensor up and down. **Take extreme care to ensure the sensor remains correctly oriented in its slot - it cannot be angled or offset sideways, or it will be impossible to align the LED lights.**

3.6.4 Step 2 - Evenly lighting the sensor

1. If the sensor is not evenly lit (**Fig 10b**), the LED needs to be re-aimed to ensure that the response curve shown in **Fig 10a** is obtained. The process is the same for both the Nozzle and Puller sensors.
2. Both light guide versions 1.0 and 1.1 allow the LED to be angled up or down, to ensure the light guide is evenly lit. Their operation differs however - see step 3 for version 1.0 and step 4 for version 1.1
3. Version 1.0 has two screws facing "up", which push on opposite sides of a lever to angle the LED shaft. To aim the LED up, first loosen the front screw (farther from the user), then tighten the back screw (closer to the user). To aim the LED down, first loosen the rear screw, then tighten the front screw. Adjust the LED incrementally, monitoring the response pattern shown on the screen until it is an even response as shown in **Fig 10a**. Finally, ensure both screws are snugged down to prevent further movement. **Always loosen one screw before tightening the other. Also, be sure to not overtighten the screws - they should just be snug.**
4. Version 1.1 has only one screw facing "up", that clamps the LED shaft in position. To adjust the LED, first loosen the screw. Then use the shaft knob on the left side of the light guide to adjust the angle of the LED. You may want to support the other end of the shaft with your thumb for more control - see **Fig 12** below for reference. When the desired response pattern as shown in **Fig 10a** is obtained, simply re-tighten the screw.

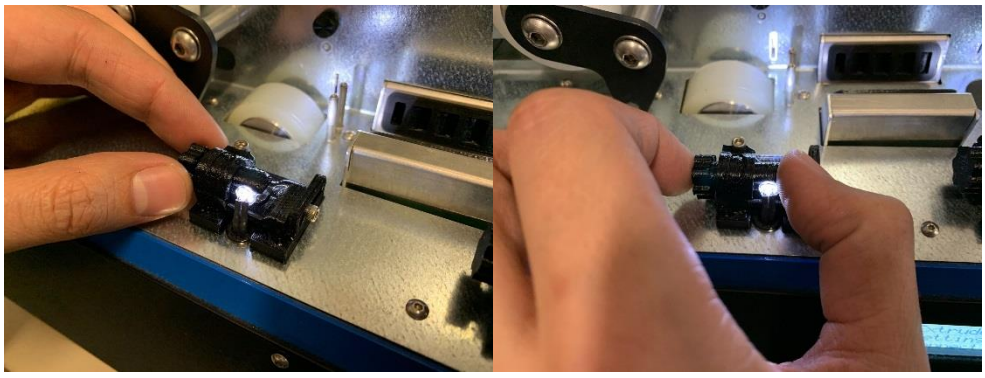


Figure 12: How to grip the light guide shaft to adjust LED angle.

3.6.5 Step 3 - Calibrating the readings

1. Finally, we need to ensure the light guide readings are accurate. This is where we'll use the dowels. The procedure is the same for both the puller and nozzle sensor, with minor differences that will be noted as required.
2. Place the ~1.83mm "dowel" in between the puller wheels as shown in **Figure 13**. Similarly, check the nozzle sensor using your ~2.56mm dowel of choice. Do your best to align the dowel with the nozzle output as seen in **Figure 13**. **Make sure the puller idler wheel's spring is attached! This will effectively position the dowel at the right height as it *squishes* the puller wheel into position.**

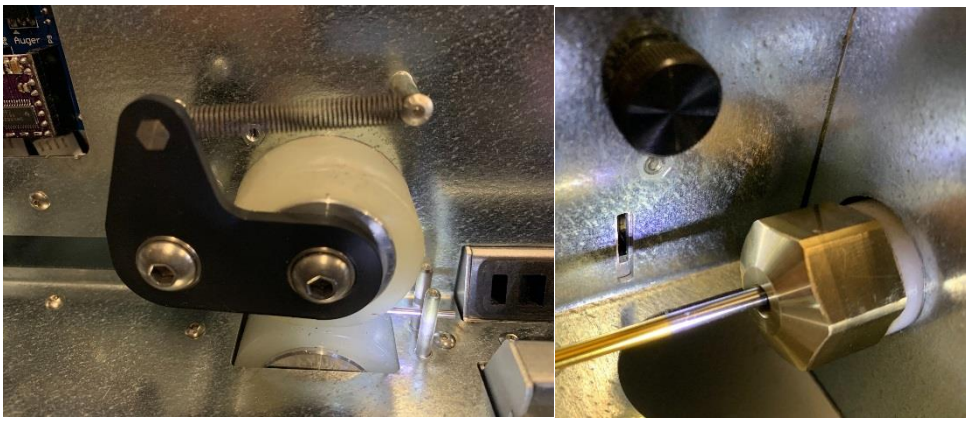


Figure 13 shows the light guide alignment dowel positioned in between the puller wheels on the left, and aligned with the nozzle on the right, in preparation for light guide alignment.

3. Looking at the GUI (graphical user interface) of your PCC, you should notice that the flat raw data line (representing light being read by the photoresistor) is now a "U-shaped" trough. This is representative of the shadow cast by the LED shining on the dowel, and is shown below in **Figure 14.**

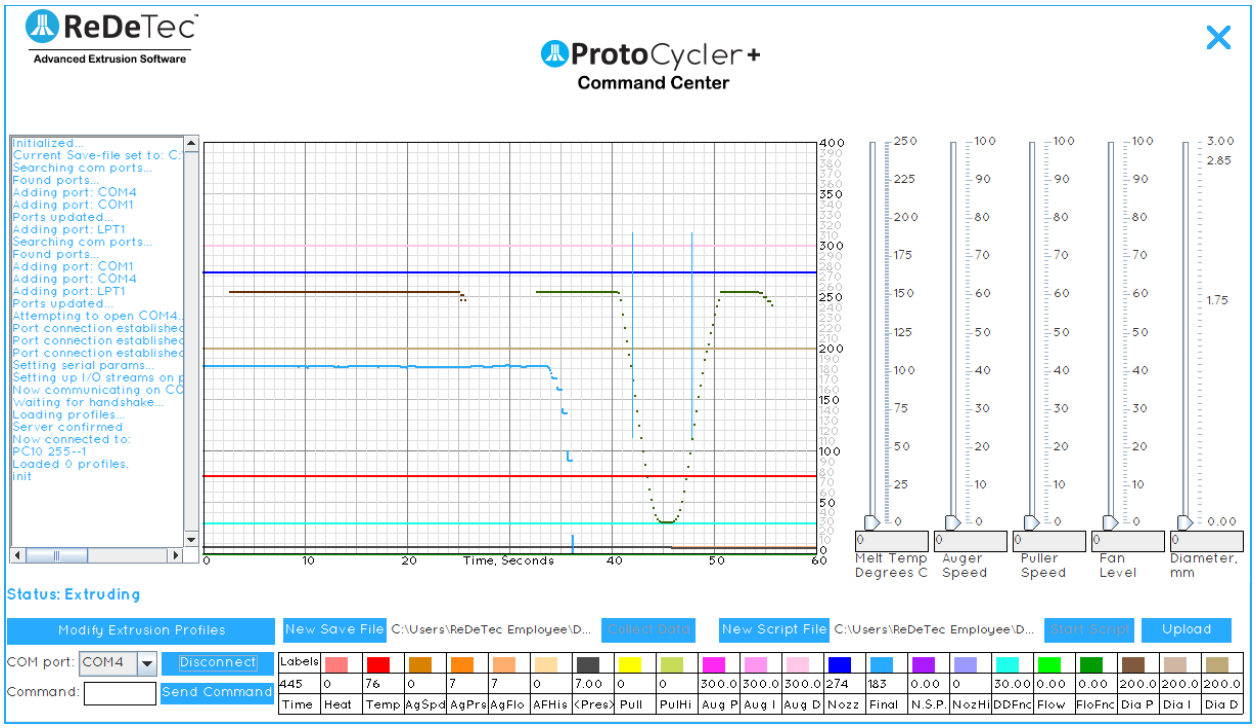


Figure 14: Puller sensor raw data reading with 1.83mm dowel.

4. If either light sensor is not reading the correct value in the Raw Data Stream ("Nozz" and "Final" diameter readings) then the light guides require adjustment by sliding them forward and aft.
5. Both light guides V1.0 and V1.1 have a screw on their side, facing to the users right. In both cases, loosening this screw allows the light guide to be slid fore and aft, which in turn decreases or increases the reading respectively. To be clear, sliding the LED mount back towards the user increases the diameter reading. Conversely, the diameter reading will decrease as you move the slider carriage closer to the sensor. This is how you achieve nominal reading based on your dowel's true diameter. This is only effective if the angle of the LED is correctly aligned.

In all likelihood you will only have to adjust the LED's angle. This is more subject to movement if accidentally bumped compared to the slider position.

Note the nozzle sensor's reading can be a little "off" from nominal - up to 0.1mm - and still operate just fine. The software will adjust the puller speed accordingly. What is critical is that the final diameter sensor's reading be as accurate and precise as possible.

Diameter sensor alignment can be a bit of an iterative process. Sliding the LED mount forward or backwards may necessitate repeating Step 2, evenly lighting the sensor. Similarly, If the sensor itself is moved up or down, and adjustments are required to evenly light the sensor, the sensor should be re calibrated (Step 3) to ensure a correct reading. **Ultimately, you want to achieve Figure 14's response for both sensors - the key points are that the shadow is right in the middle of the sensor response pattern, that the pattern is a flat line at 255 where it's not blocked by the filament, and that the diameter reading is exactly accurate as reported.**

4.0 Extrusion Operational Instructions

4.1 Overview

Now that we are all tuned up and have assured our ProtoCycler is clean and diameter sensors are aligned, we can extrude filament! We will guide you through Automatic Mode Extrusion and Manual Mode.

Before starting either automatic or manual extrusion, please make sure you've setup your Spooler correctly, including Step 10 of Spooler Set Up (setting spool dimensions on the ProtoCycler). If this step is not taken then the filament will not spool nicely.

Please be sure to operate your ProtoCycler in a clean, dry environment, at ambient air temperature (~23C is ideal temperature for your room to be). We recommend you maintain ambient room temperature conditions as that is the average temperature ReDeTec calibrates each ProtoCycler in.

Note every unit is primed with plastic (PLA or ABS depending on what you purchased) and calibrated before leaving ReDeTec. This means there is plastic already in your melt section! Depending on how much time has passed since the ProtoCycler was calibrated, the plastic in the melt section may have absorbed moisture from the air. If too much moisture has been absorbed into the melt section plastic, purging may be required - simply run the unit for ~10 minutes to flush out the old plastic with new, dried plastic.

4.2 Initial Extrusion Steps for both Manual and Automatic:

1. Fill your hopper with dry plastic and colourant of your choosing (if any). Remember colourant is critical if the plastic you are processing is naturally clear when melted (PLA extrudes transparent for example). Mix 1 tablespoon of colourant for every 500g of plastic.
2. After powering on ProtoCycler, choose whether you would like to connect to your computer or not.

Automatic extrusion does not require a computer connection, but it is useful for experimentation and/or troubleshooting with new materials or different ambient conditions. To connect to a computer, follow the procedure in the ProtoCycler Command Center guide. Note that for manual extrusion, you *must* be connected to ProtoCycler Command Center.

3. Navigate to the "Extrude" screen using the d-pad on the ProtoCycler. Press the right button to select Extrude and then either "Automatic" or "Manual. Finally, select "Begin Extrusion" – and proceed to the corresponding section below.

4.3 Automatic Extrusion

ProtoCycler comes with two preloaded extrusion profiles - PLA and ABS. It is important that you have the most recent firmware and EEPROM loaded onto your ProtoCycler for these profiles to work optimally. Automatic mode also allows you to upload and run your own custom profiles via the PCC. Please refer to the ProtoCycler Command Center Overview manual for guidance on what all the different variables are. Custom profiles must be created and uploaded via the PCC. We suggest creating, testing, and uploading in manual mode extrusion before proceeding with custom automatic profile extrusion.

4.3.1 Automatic Extrusion Steps

1. After completing steps 1-3 in "Initial Steps for Extrusion", above, your ProtoCyler will begin preheating to thermalization temperature. Once up to temperature, the extruder will hold here for 100 seconds to thermalize the melt section. This allows the hot (melt) section of your device to reach a uniform temperature throughout before initiating the rest of the extrusion start-up sequence. This may take a few minutes depending on ambient conditions and the type of plastic you are using.
2. Following thermalization, the extruder will preheat to the extrusion temperature of your selected plastic. By default this will be either PLA or ABS processing temperatures.
3. Once up to extrusion temperature, you will hear a chime and a prompt on your ProtoCycler's UI screen saying "Filament Ready". At this time, you can now use tweezers or needle nose pliers to feed the plastic from the nozzle in between and through the puller wheels. **Be careful! - The nozzle is extremely hot at this point in the startup sequence; follow safety guidelines to avoid personal injury or harm. Make sure you have engaged the puller wheel idler spring! See Figure 15 for reference.** Once the filament is being correctly pulled through the puller wheels, select "Filament Ready" on the D-pad to confirm to ProtoCycler that it may begin stabilization. Note that for safety concerns, there is a 2 minute timeout feature, and if you fail to select "Filament Ready" within this time, ProtoCycler will automatically begin cooldown.

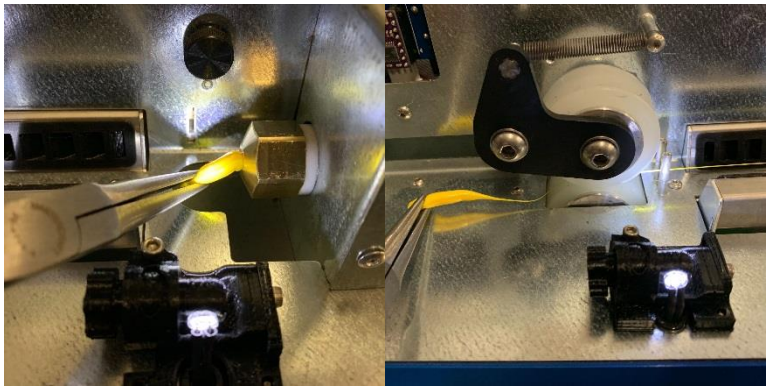


Figure 15: Using tweezers or pliers to feed the filament from the nozzle to the puller wheels.

4. ProtoCycler will now enter the "Stabilization" phase. No action is required here. Your ProtoCycler control system will wait for the filament diameter to become consistent enough to proceed to the spooling phase. In the meantime, just let the filament "dump" off the front-side of the UI. Stabilization may take a few

minutes (3-5) depending on material and ambient condition influences. **During this time, prepare a small piece of tape for Step 7-8: "Spooler Ready".**

5. Once the output filament has stabilized you will hear another chime and a prompt on the UI screen saying "Spooler Ready". The fan speed will reduce to allow the filament to soften to a point that it is able to start spooling. Using the yellow handle snips that come with every ProtoCycler, snip the excess filament that has been extruding off the front side of your UI. Now feed the filament through the spreader guide. See **Figure 16** for reference.

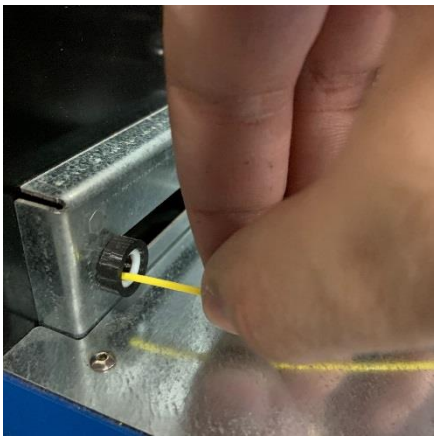


Figure 16: Feeding filament through the Spreader Guide.

6. Remember that piece of tape we prepped at the end of Step 4? After feeding the filament through the spreader guide, stick the piece of tape to the end of the filament (if you need a little more runway, snip the filament a little more after feeding through the spreader guide before sticking tape to it). Now, stick the taped filament to the bottom side of your spool. Note, it is best to stick the filament as close to the front (starting side) of your spooler as possible. See **Figure 17** for reference.

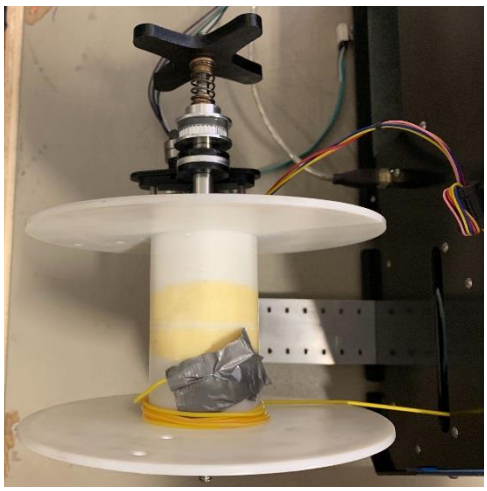


Figure 17: Above view of starting spool using tape.

7. Once filament is taped to the spool, select "Spooler Ready" using the d-pad. If you don't do this, the extrusion cycle will timeout and we will have to restart this process by disconnecting the ProtoCycler (if connected to your computer) and quickly power cycling the unit.
8. Now that we've accomplished all of the setup work required to begin extrusion, the control system will take over fully. Before the diameter control engages, the ProtoCycler waits 60 seconds to allow filament to reach

steady state while spooling. At which point the puller wheel speed and fan speed will constantly adapt to changes in output and disturbances to the system to maintain consistent filament diameter.

Note: For best results, close the door to the UI to avoid any cross-wind affecting your filament output - i.e. if a cross-wind cools the filament at the nozzle too quickly, the puller wheel won't be able to draw-down the filament to its desired final diameter.

9. And there we have it! You are now off to the races and creating your very own filament!

If connected to a computer, now is a good time to check how your diameter sensors are doing. In particular, your nozzle sensor alignment may need tweaking. Depending on the rate of output, you may find that your filament is a little high or low relative to the diameter sensor. From the alignment process, the nozzle sensor is positioned approximately half way in its range of motion. **Figure 18** shows ideal light sensor positioning. Notice the two troughs (representing the shadow of the filament) are relatively centred without falling off to either side. Whereas in **Figure 19** we see the filament is too far off one side of the sensor for the nozzle sensor. If you find that your filament shadow is too far off one side that the sensor can no longer see the full "width" (diameter) of the filament's shadow, we can fix this by adjusting the height of the light sensor. Using the thumb screw in the UI (**Figure 11** for reference), loosen and adjust the height of the photoresistor so the shadow is centred within the range of measurement similar to **Figure 18.** When you have achieved this positioning, tighten the thumbscrew to fix position.

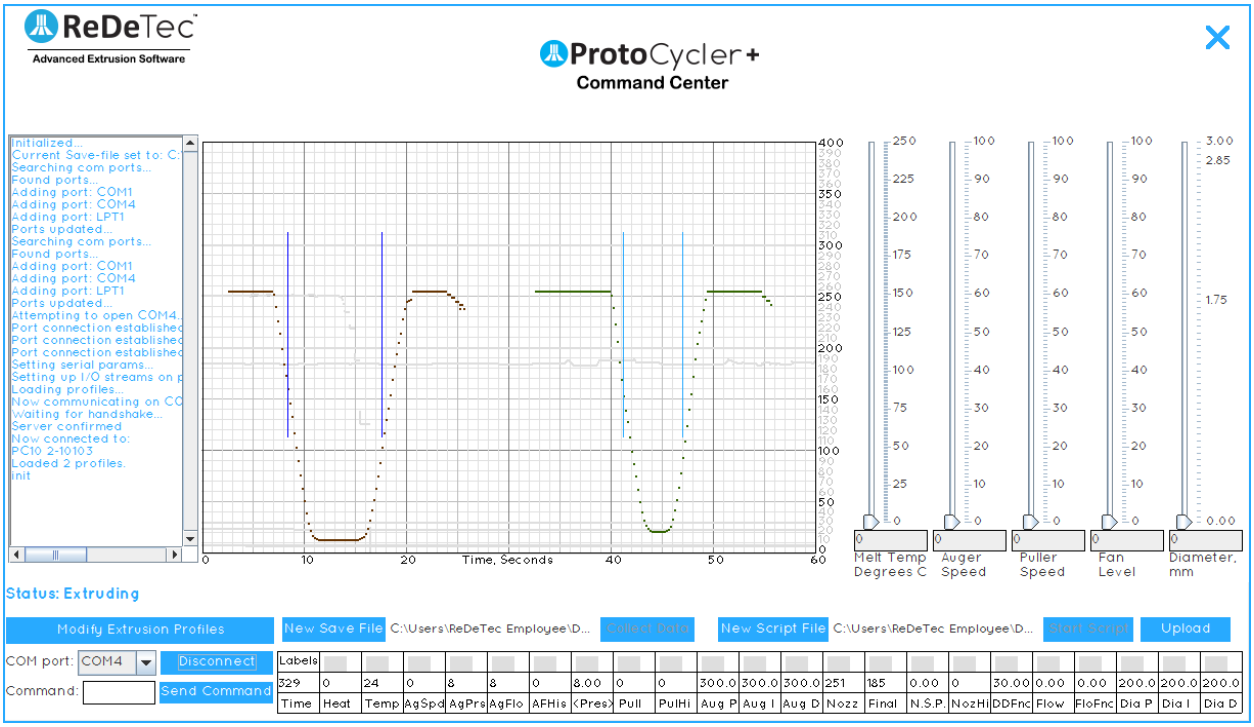


Figure 18: Nozzle Diameter Sensor raw data ideal reading example.

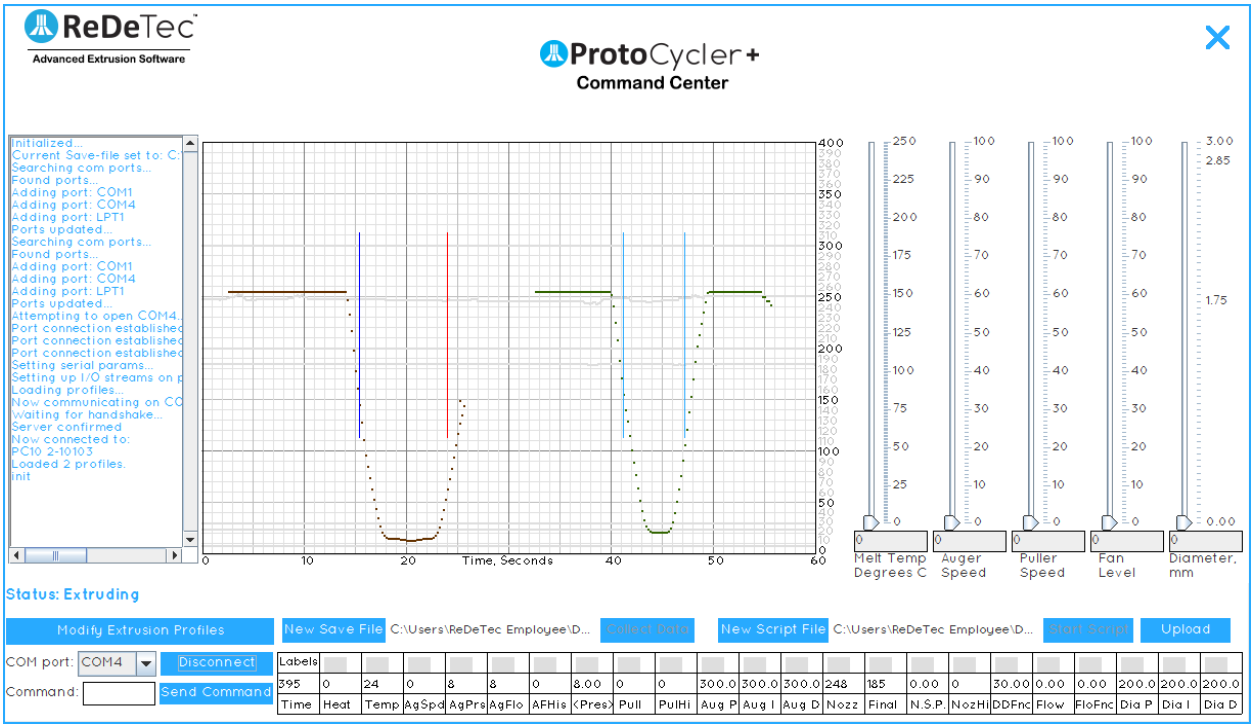


Figure 19: Nozzle Diameter Sensor raw data misaligned reading. Notice the rid vertical line indicating the shadow of the filament has completely fallen outside the bounds of the sensor reading range.

4.4 Manual Extrusion

For greater control and the ability to experiment with extrusion settings and materials, we have enabled a manual mode control. This is excellent for discovering new materials or adjusting existing plastics processing settings based on your ambient conditions.

A lot of these instructions are going to be similar if not identical to the Automatic Mode instructions. We copied a few of them here for ease of reference.

4.4.1 Manual Extrusion Steps:

1. Once you've clicked "Begin Extrusion" (see "Initial Extrusion Steps", above)...nothing will happen. ProtoCycler is now awaiting your commands to do pretty much anything. You'll have to heat up and begin the extrusion process, well, manually!
2. Note that there are *lot* of different things happening in automatic extrusion, and you have to set and control *all* of them in manual mode. It is not easy! Please ensure you have fully read and understood the ProtoCycler Command Center Overview - particularly the sections and appendices on how to extrude manually, and what all the commands do - before attempting manual extrusion on your own. Note as well that this guide is *very* brief, but should at least get you up and running.
3. Begin the thermalization process by sliding the temperature sensor to the desired setting.
    a) For PLA we recommend 175C.
    b) For ABS we recommend 210C.

4. Before turning on your auger feed, we need to disable the lower pressure bound by entering in the command line: "pl000000", no quotes, and clicking "send command". This will prevent *stalling* during the preheat and priming phase.
5. Now set your auger speed to 30 via the slider.
6. Allow the melt section to thermalize for 100 seconds once up to temperature (set in step 4).

7. Follow thermalization, you may begin the extrusion temperature preheat. Using the slider set to the desired temperature.
    a) For PLA we recommend 181-187C depending on material grade and ambient conditions.
    b) For ABS we recommend 220-230C depending on material grade and ambient conditions.

8. Once the plastic has reached its correct temperature and is correctly flowing out of the nozzle, we can now set the lower pressure bound back to its default. Enter "pl000050" in the command line, no quotes, and click "Send command".
9. Turn on your fan using the slider. This may vary depending on what material you are processing. Essentially, we want the plastic to be soft enough to start spooling easily. If the plastic is too cool then it will be very stiff and difficult to begin spooling with.
    a) For PLA set to 40.
    b) For ABS, keep turned off. ABS will cool quite quickly on its own.

10. Attach your puller wheel idler arm spring if you haven't already. Set your pull speed slider to ~30-40 depending on material throughput. This will set the puller wheel to spin at a constant speed that is easy to work with during setup.
11. Use tweezers or needle nose pliers to feed the plastic from the nozzle in between and through the puller wheels. **Be careful! - The nozzle is extremely hot at this point in the startup sequence; follow safety guidelines to avoid personal injury or harm**. **Make sure you have engaged the puller wheel idler wheel spring! See Figure 15 for reference.**
12. If spooling is desired, Follow the steps below. If not (because your filament isn't usable), skip to step 13.
    a) Prep a piece of tape to fasten the filament to the spool. Using the yellow handle snips that come with every ProtoCycler, snip the excess filament that has been extruding off the front side of your UI.
    b) Now feed the filament through the spreader guide. See **Figure 16** for reference.
    c) Remember that piece of tape we prepped? After feeding the filament through the spreader guide, stick the piece of tape to the end of the filament (if you need a little more runway, snip the filament a little more after feeding through the spreader guide before sticking tape to it). Now, stick the taped filament to the bottom side of your spool. Note, it is best to stick the filament as close to the front (starting side) of your spooler as possible. See **Figure 17** for reference.
    d) Once filament is taped to the spool, we are ready to start spooling. To do so, enter the command: "ss000000" to start spreading the filament evenly across the spool. This is the command for "start spooling"; hence the "ss" part of the command. Allow the filament to wind around the spool a few times (2 to 3 should suffice) before increasing your fan speed.
13. Now that extrusion is well underway, increase your fan speed slider to 100% for PLA, or 50% for ABS.
14. Finally, enable diameter control. To do so, slide the diameter slider to the desired filament size (measured in mm). Note that diameter control may fail irrecoverably if the filament is too far away from the desired size, if the extrusion flow is too low (or too high), or if any of the parameters are incorrectly set.

    Similar to Automatic operation, now is a good time to check how your diameter sensors are doing. In particular, your nozzle sensor. Depending on the rate of output, you may find that your filament is a little high or low relative to the diameter sensor. From the alignment process, the nozzle sensor is positioned approximately half way in its range of motion. In order to check your diameter sensors, you'll need to be connected to the PCC software on a computer. **Figure 18** shows ideal light sensor positioning. Notice the two troughs (representing the shadow of the filament) are relatively centred without falling off to either side. Whereas in **Figure 19** we see the filament is too far off one side of the sensor. If you find that your filament shadow is too far off one side that the sensor can no longer see the full "width" (diameter) of the filament's shadow, we can fix this by adjusting the height of the light sensor. Using the thumb screw in the UI (**Figure 11** for reference), loosen and adjust the height of the photoresistor so the shadow is centred within the range of measurement similar to **Figure 18**. When you have achieved this positioning, tighten the thumbscrew to fix position.

Note: For best results, close the door to the UI to avoid any cross-wind affecting your filament output - i.e. if a cross-wind cools the filament at the nozzle too quickly, the puller wheel won't be able to draw-down the filament to its desired final diameter.

15. And there we have it! You are now off to the races and creating your very own filament!

5.0 Intro to the ProtoCycler Purge Procedure (PPP)

When purging your ProtoCycler's extrusion system there are two types of purging depending on what you wish to achieve. They are:

1. **Short Purge:** Required when transitioning between wet and dry plastic or colour changes. Please see Section 2.1 for instructions on how to conduct a Short Purge.
2. **Disco Purge:** Required when conducting a materials change. Please refer to Section 2.2 for instructions on how to Disco Purge.

Please be sure to abide by all safety precautions outlined in the main user manual.

For further details on different purge conditions and temperature settings please refer to the Appendix in Section 7.0, Table 1 of this document.

5.1 Purging

The following steps will guide you through **purging from a cold-powered-down-hopper empty ProtoCycler state**. Be sure to have a set of pliers or tweezers and nozzle wrench (if needed) ready.

All temperature settings for purging are found in the Appendix, Section 7.0 of this document.

5.1.1 Short Purge

1. Power on your ProtoCycler and connect to the PCC software. Pour the new plastic you wish to extrude into your Extruder Hopper. While connected to the PCC begin manual extrusion.
2. Enter the command pl000000 in the command line and click "Enter Command". This will assure the lower auger speed limit has been disabled.
3. Manually set the temperature using the PCC slider to the preheat temperature (in accordance with Table 1).
4. Set the auger speed to 50 using the PCC slider.
5. When the preheat temperature is achieved, wait 100 seconds for the melt section to reach a uniform temperature and viscosity.
6. Once Step 5 is complete, increase temperature slider to the appropriate Purge Temperature.
7. When Purge Temperature is achieved increase auger speed to 75 on the slider. Purge for ~10-15 minutes at the designated purge temperature and auger speed until fully transitioned to new plastic. Purge time may take longer depending on the material.
8. Material will start flowing and dump into the Garbage Shoot. Remove the side door to clear the material inside. Careful, the melted plastic is quite hot if it does not have time to cool. Take proper precaution with PPE and pliers when removing the plastic from the Garbage Shoot to avoid injury.
9. From here you may proceed into regular manual extrusion operation or choose to shutdown following manual mode shutdown procedure as outlined in the Operations Manual.

5.1.2 Disco Purge

Disco Purging means we are going to thermal cycle the ProtoCycler to help transition from one material to another. It is strongly recommended to remove nozzles for the duration of a disco purge and replace it only when purging is complete with a new nozzle. Removing nozzle will require preheating in order to soften the plastic inside to release the nozzle. Please refer to Table 1 for nozzle removal temperatures.

Steps:

1. Remove nozzle and follow steps 1-8 of section 2.1 (Short Purge).
2. After your first 10 minute cycle, immediately set your temperature slider to 0°C and auger speed to 50. The auger will limit its speed as the extruder cools and material melt resistance increases.
3. Once the extruder reaches the temperature of the "Lower Temperature" material's nozzle removal temperature (see Table 1 for reference), increase temperature back up to the Purge Temperature. **Do not** increase the auger speed until the temperature has reached (the minimum) Preheat Temperature to avoid stalling the motor.
4. When up to Preheat Temperature, increase auger speed back up to 75 on the slider.
5. Purge for 10 minutes.
6. Repeat steps 2-5 until completely transitioned to the new material.

5.3 Purge Tips

1. Purging plastic – especially from a warmer temperature plastic to a cooler temperature plastic – can take a long time. It is recommended that you avoid or mitigate the need for switching plastics as much as possible.
2. Use different colorants as an indicator when purging to distinguish between old and new plastic.
3. When purging dissimilar materials, the general rule is to look at the MSDS documentation to see where the extrusion (purge) temperatures overlap. Importantly, do not increase temperature so high that you burn the old or new material inside of the extruder. But what if there is no overlap in the two materials' processing temperatures? If this is the case, please contact Technical Support immediately for assistance, stating what plastics you are transitioning from and to. ReDeTec will advise further.
4. Having an extra nozzle (with breaker plate and screen) is especially useful when switching between materials to not contaminate the new material!

6.0 Congratulations!

As with any process there is a bit of a learning curve, and the ProtoCycler is a complex system to learn inside and out. Making it to the end of this instructions manual and learning all of its ins and outs hopefully means we are well underway to producing your very own filament. So, congratulations on your new ProtoCycler and taking the first steps towards accomplishing your recycling and filament creation goals!

If there is anything we can help with please contact our technical support channel via the following email: techsupport@redetec.com

All the best and happy extruding,

Team ReDeTec

7.0 Appendix

Table 1: Below summarizes possible purge scenarios, their respective temperature settings, and what type of purge they require.

	Old Material to be Purged	New Material to be Primed	Purge Type	Nozzle State	Nozzle Removal Temperature [C]	Preheat Temperature [C]	Purge Temperature [C]	Notes
1	PLA	ABS	Disco Purge	Off	150 C [PLA]	175 C	200 C	-
2	ABS	PLA	Disco Purge	Off	200 C [ABS]	200 C	210 C	-
3	Low Temperature Material	High Temperature Material	Disco Purge	Off	Low temperature material preheat temperature minus 25C. Temperature can vary depending on material type and grade. Special exception to ABS where the removal temperature is the same as the preheat temperature.	Low temperature material extrusion temperature minus ~10C. Temperature can vary depending on material type and grade.	Low temperature maximum extrusion temperature specified in manufacturer's MSDS document.	Cross reference materials extrusion temperatures when purging dissimilar materials. If the minimum extrusion temperature for the high temperature material is higher than the maximum extrusion temperature of the low temperature material then you will risk burning the low temperature material and clogging your extruder. If there is no overlap in material processing temperatures, you may require an intermediary purge material.

4	High Temperature Material	Low Temperature Material	Disco Purge	Off	High temperature material preheat temperature minus 25C. Temperature can vary depending on material type and grade. Special exception to ABS where the removal temperature is the same as the preheat temperature.	High temperature material extrusion temperature minus ~10C. Temperature can vary depending on material type and grade.	High temperature minimum extrusion temperature specified in manufacturer's MSDS document.	Cross reference materials extrusion temperatures when purging dissimilar materials. If the minimum extrusion temperature for the high temperature material is higher than the maximum extrusion temperature of the low temperature material then you will risk burning the low temperature material and clogging your extruder. If there is no overlap in material processing temperatures, you may require an intermediary purge material.
5	Colour 1	Colour 2	Short Purge	On	Material Dependent.	Material Dependent.	Material Dependent.	Run extruder in manual mode until purged of previous colour and fully transitioned to the new colour. Colour can also be switched at any time during regular extrusion.
6	Wet Plastic	Dry Plastic	Short Purge	On	Material Dependent.	Material Dependent.	Material Dependent.	Run extruder in manual mode until purged. Plastic may be wet if you notice necking or bubbles (or pockets) in extrusion. You can leave nozzle on for wet to dry plastic conditions.