GPD Global
Precision Dispensing Systems

NCM7500 Pump Maintenance Guide

P/N 22293249M, v1.0

GPD Global
611 Hollingsworth Street
Grand Junction, CO 81505 USA

Phone: +1.970-245-0408
Web: www.gpd-global.com
E-mail: request@gpd-global.com

Contents

Safety Guidelines

The described fluid applicator and controller are resources for use in industrial environments.

GPD Global products are manufactured according to currently valid engineering standards and are operationally safe. Hazards may arise if handled improperly by unqualified personnel. It is recommended that operating personnel thoroughly review these operating instructions.

1. Introduction and Specifications

1.1 NCM7500 Jet Overview

GPD Global NCM7500 non-contact jetting technology is a major leap in liquid dispensing. The jet dispenser features a patented diaphragm design: a single, easily replaceable diaphragm eliminates the many dynamic fluid seals common in all other jets. The inherent advantages of this design are significant:

- The diaphragm's very low mass allows very fast cycle rates, since there isn't a large sliding valve stem slowing down the process.
- With the novel diaphragm design, the energy needed to eject a drop can be adjusted, providing wider process windows. As a result, the NCM7500 can dispense a wide range of fluids and applications.
- The non-contact jetting is fast, allowing dispensing rates up to 300Hz.
- Drop size can be adjusted ± 20% from the nominal size, allowing a wide range of adjustability.
- The simplicity of the diaphragm design is most beneficial in its ease of cleaning, since the two parts that touch the fluid are quickly and easily removed for cleaning/replacement.

The NCM7500 is designed specifically for standalone operation and does not require an external controller. The jet responds to a rectangular 24V trigger signal that fires as fast as 2.5 msec. When the jet is idle, smart electronics inside the pneumatic valve closes the jet and reduces the voltage to minimize heating effects.

1.2 NCM7500 Jet Specifications

PARAMETER	SPECIFICATION
Size NCM7500 Jet (without mounting bracket)	Width: 57.2 mm (2.3 in) Height: 119.6 mm (4.7 in) Depth: 97.5 mm (3.8 in) Weight: 530 grams (1.2lb)
Viscosity Range	1 - 400K mPa·s (cps)
Fluid Syringes	10, 30 and 55 cc
Nozzle Sizes	
Standard Carbide Nozzle	64 µm, 75 µm, 100 µm, 125 µm, 150 µm, 200 µm, 300 µm, 400 µm
Standard Ceramic Nozzle	75 µm, 100 µm, 125 µm, 200 µm
Ceramic Capillary (6mm)	75 µm, 100 µm, 125 µm, 150 µm, 200 µm, 250 µm
Carbide Capillary (2mm)	125 µm, 200 µm
Carbide Capillary (6mm)	75 µm, 125 µm, 200 µm
Nozzle Heater	Heating up to 75°C Max
Fluid Pressure	.27 MPa (40 PSI) Max
Jet Pressure	.24 MPa (35 PSI) Min .45 MPa (65 PSI) Max
Input/Output	TTL level triggers
Operating Temperature	10^{o}C to 50^{o}C

1.3 Technical Assistance

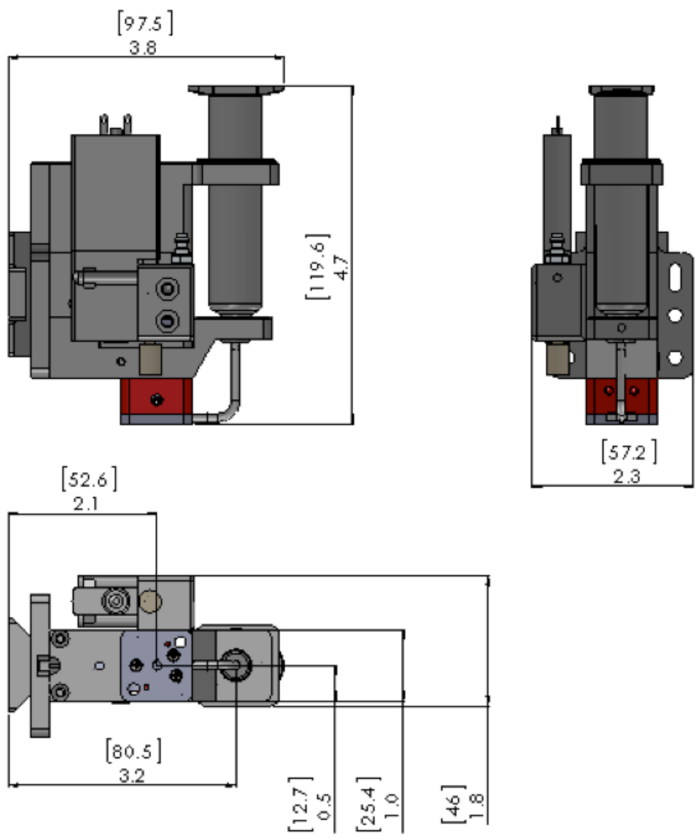
GPD Global
611 Hollingsworth Street
Grand Junction, CO 81505
USA

Phone: +1 970-245-0408
Web: www.gpd-global.com
E-mail: request@gpd-global.com

1.4 NCM7500 Jet Dimensions

Shown below are the mechanical dimensions of the NCM7500.

- The NCM7500 can be mounted to a variety of robots when X-Y-Z motion is desired. It can also be mounted rigidly over a transporting mechanism like a conveyor belt or shuttle table.
- The NCM7500 provides two mounting holes located on the rear mounting plate for rigid attachment to a robot's X-Y-Z stage. Additionally, the rear mounting plate allows the jet to be mounted in a channel which allows adjustment of the dispense tip to the dispensing surface.
- The dispense tip relative to the mounting holes and the rear mounting plate dimensions are shown in the figure below. It is highly recommended that any mounting scheme allow for vertical adjustment so the dispensing tip to dispensing surface can be easily adjusted.



2. Installation and Setup

2.1 Dispensing Components

Figure 2-1 below shows the NCM7500 components that are in contact with the fluid: the nozzle plate, diaphragm, O-ring, and the feed tube. The materials of these components are listed in the table below. The NCM7500 dispensing components can be easily disassembled with two screws, cleaned and reused (see Section 4). The diaphragm should be inspected each time the nozzle plate is removed. If there are signs of wear or deformation, the diaphragm should be replaced.

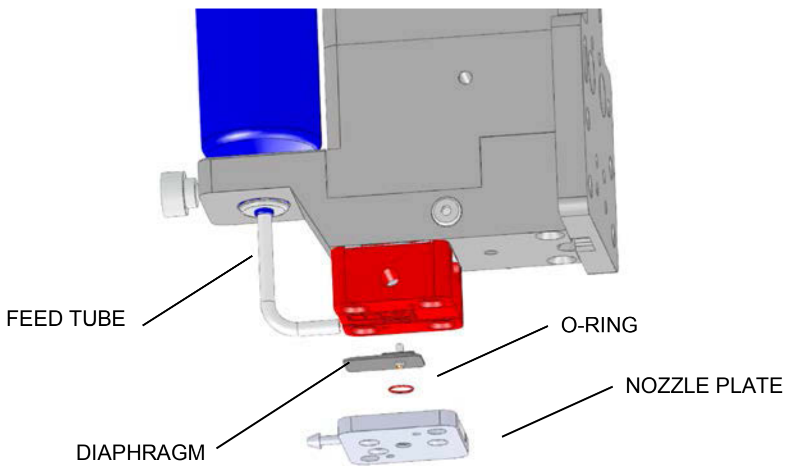


Figure 2-1: NCM7500 Nozzle Plate, O-ring, Diaphragm, and feed tube

CAUTION!	***AVERTISSEMENT!***
Important: *Fluids that could damage the jet's wetted parts (17-4 Stainless Steel, Tungsten Carbide, Ceramic, FFKM, Silicone) should not be dispensed or used for cleaning.* *Not recommended are pre-mixed 2-part adhesives with a short pot life as these can harden in the nozzle plate.* *Cyanoacrylates are not recommended.*	***Important****: Les liquides de contact pouvant endommager certaines pièces du jet telles que l'acier inoxydable 17-4, carbure de tungstène, EPDM, FFKM, ou Silicone ne doit pas être utilisées pour le nettoyage.* *Non recommandé pré-mélangés en 2 parties adhésifs avec une durée de conservation courte et ceux-qui durcissent dans la buse.* *Cyanoacrylates peut pas être dosés.*

2.2 Pneumatic System

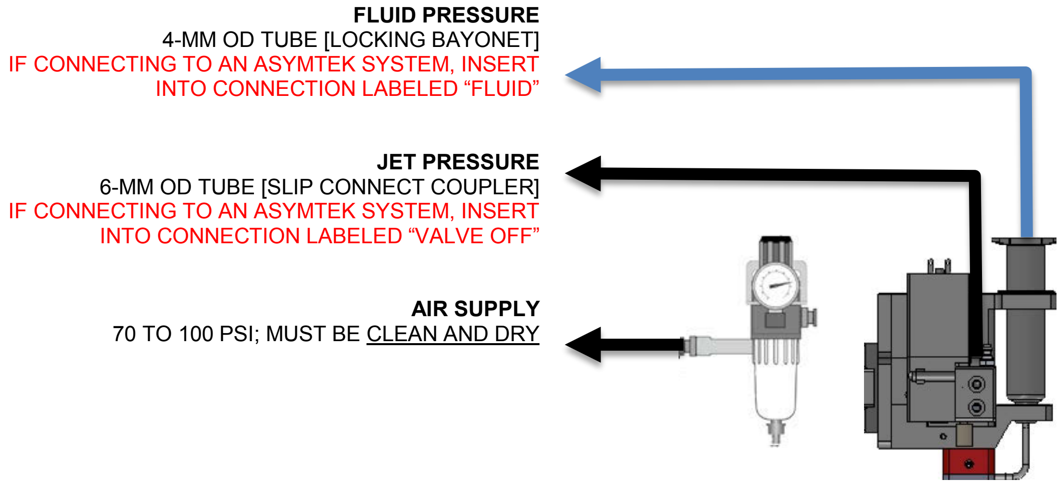


Figure 2-2: NCM7500 Pneumatic Connections

Referring to Figure 2-2**,** connect an independently regulated and filtered main air source (at least a 40-micron filter) to the jet. The air supply must be clean and dry and at a pressure of 70 to 100 psi. Normal jet air operation is usually between 40 and 60 psi. The NCM7500 jet is supplied with a 6-mm OD air tube that terminates with a slip connect coupler.

The NCM7500 is supplied with a syringe mount that can accommodate a 30-cc or 55-cc syringe. Adapters are available for 3-cc, 5-cc, and 10-cc syringes. A receiver head attaches to the syringe. If a syringe is not desired, fluid can be connected directly to the feed tube using a luer lock connector. Maximum fluid pressure is 40 psi. However, normal operation is usually between 5 and 30 psi. Pressure variations in the fluid pressure source can adversely affect the consistency of the drop size.

CAUTION!	***AVERTISSEMENT!***
It is imperative that the air supplied to the NCM7500 is clean and dry, free from debris and water. A 40-micron filter, a water separator, and an overpressure relief valve set at around 120 psi are highly recommended. If the air is not clean and dry, serious damage can occur to the air solenoid valves. The air supply pressure should be between 70 and 100 psi.	*Il est impératif que l'air alimenté dans le NCM7500 soit propre, sec et dépourvu de tous débris et d'eau. Un filtre de 40 micron, une membrane de séparation d'eau et une valve sous pression à 120 psi sont recommandés. Si l'air n'est pas propre et sec, des dommages peuvent se produire dans les solénoïdes des valves. La pression d'air doit être entre 70 et 100 psi.*

2.3 Jet Cable Input/Output

The NCM7500 Jet cable should be attached directly to the jet and the user's controller.

The table at right describes the cable pin assignments.

- Pins 1 and 2 are for the Solenoid
- Pins 4 and 5 are for the Heater
- Pins 6 and 7 are RTD
- Pin 3 and pins 8-28 are not used

Figure 2-3: 28-pin Jet Cable and Quick-Disconnect Jet Pressure Connector

28-PIN and 7-PIN JET CABLE PIN ASSIGNMENTS	
PIN	
1	Solenoid
2	Solenoid
3	--
4	Heater
5	Heater
6	RTD
7	RTD
8 - 28	--

3. Assembling the NCM7500 Jet

The NCM7500 is shipped fully assembled except for a diaphragm and nozzle plate. A specific diaphragm material and nozzle plate orifice diameter should be chosen based on the application and dispensing fluid (see Appendix 1: Jet Dispensing Parameters). The steps required to correctly assemble the diaphragm and nozzle plate on the jet body are listed below.

3.1 NCM7500 Jet Assembly Overview

Figure 3-1 below shows the fit and alignment of the NCM7500 heater block, diaphragm, O-ring, and nozzle plate.

- There is a grooved pattern on the bottom face of the heater block that matches with the raised embossments on the diaphragm. The grooves position the diaphragm correctly on the heater block.
- The diaphragm also has a metal insert with a post that must be inserted into the central hole on the heater block.
- Although a diaphragm can be inserted without the jet connected to an air source, it will not sit flat on the heater. It is recommended to OPEN the jet before assembling the diaphragm. Detailed instructions are in Section 3.5.

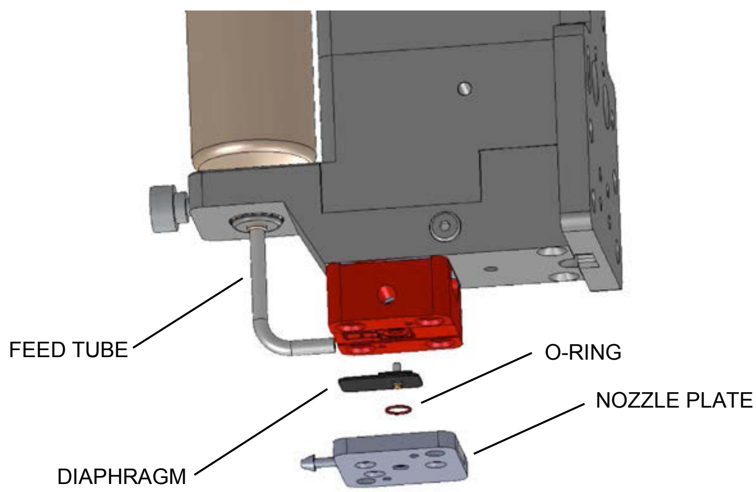


Figure 3-1: NCM7500 Heater Block, Diaphragm, O-ring and Nozzle Plate

The following sections provide detailed instructions for assembling the NCM7500 Jet.

> ⚠ ***IMPORTANT!***
> *It is important that the nozzle plate and diaphragm are clean and free of debris before installing onto the jet. If the nozzle plate is not clean, it could affect the dispensing quality, or in the worst case, could plug the nozzle orifice.*

3.2 Connect the Jet

Before assembling the jet, make the necessary pneumatic and input/output connections to the jet as described in Sections 2.2 and 2.3.

3.3 Inspect the Nozzle Plate for Cleanliness

It is important to inspect the nozzle plate for debris before mounting it onto the Jet. If the nozzle plate is not clean, it could affect the dispensing quality. These dispensing problems are symptoms of a contaminated jet:

- Unclean or uneven dispensing
- Drops become irregular or vary in size
- Residual flow or drooling out of the tip when the jet is in the closed position
- Interrupted dispensing (places where fluid no longer is dispensed)
- Splatter or satellites

In the worst case, contamination could plug the nozzle orifice, as pictured below.

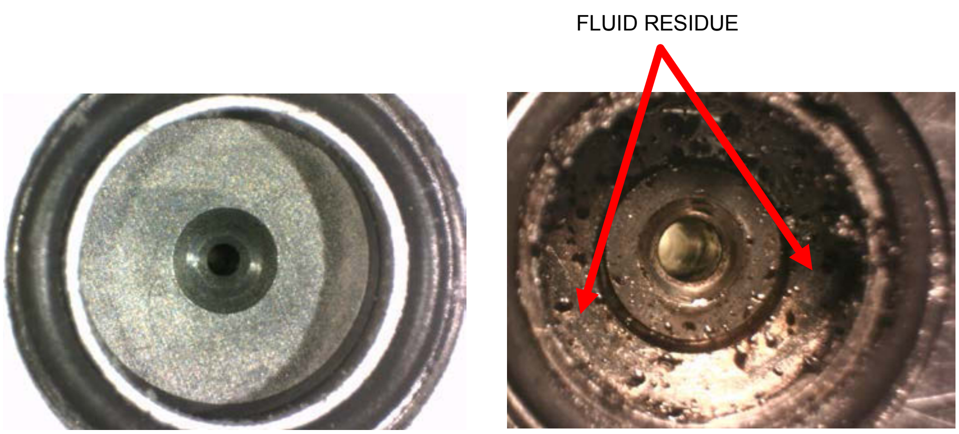


Figure 3-2: Clean Nozzle (left) Compared to Contaminated Nozzle (right)

Refer to Section 4 for complete instructions on cleaning the jet.

> ***IMPORTANT!***
> *Never submerge the diaphragm in solvents as they might be damaged.*
>
> *Diaphragms can be cleaned successfully with a small amount of solvent and a soft brush and cotton swab.*
>
> *Do not submerge the diaphragm into the ultrasonic cleaner because it will deteriorate the diaphragm and shorten its life.*

3.4 Install a Nozzle Insert (Optional)

When the nozzle becomes damaged or plugged, a new nozzle insert may be required. Installation is simple, but correct and careful assembly is important.

NOZZLE PLATE O-RING P/N		NOZZLE INSERT O-RING P/N	
SILICONE	FKM	SILICONE	FKM
2650-0246	2650-0305	2650-0247	2650-0306

1. Disassemble the nozzle plate by removing the three screws.

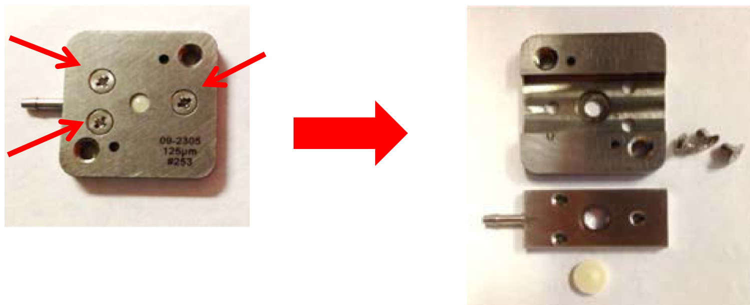


Figure 3-3: Disassemble the Nozzle Plate

2. Mount the supplied O-ring on the Nozzle Insert.

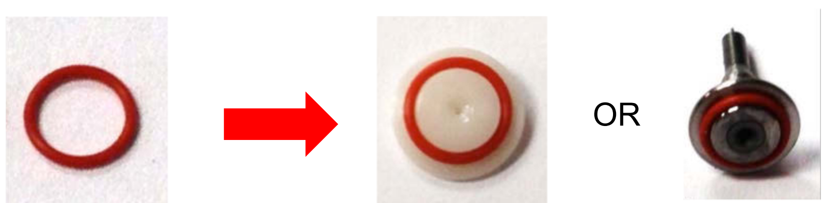


Figure 3-4: Mount the O-ring on the Nozzle Insert

3. Set the Nozzle Insert tip down on the inside face of the nozzle plate bottom. Replace the nozzle plate top and insert and tighten the three screws.

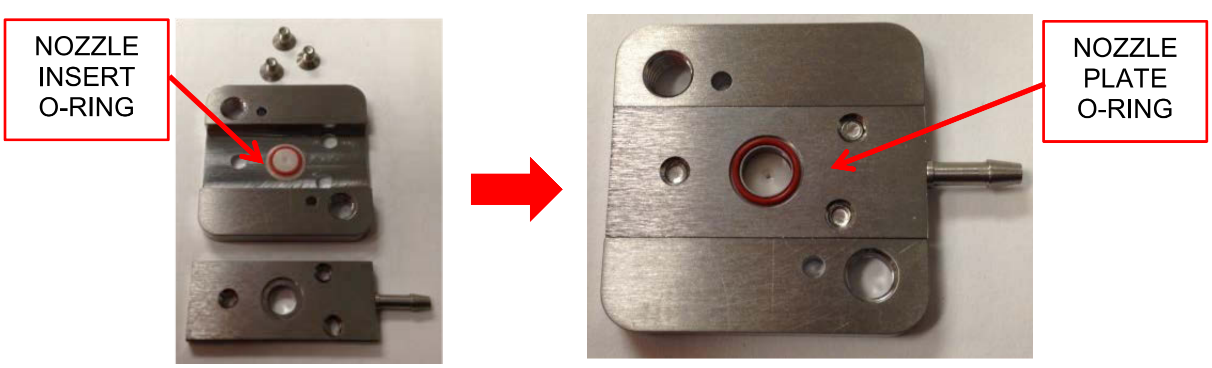


Figure 3-5: Set the Nozzle Insert in the Nozzle Plate

Important! *The nozzle plate top with the groove for the nozzle plate O-ring must face up. Note that the O-ring for the insert is smaller than the O-ring for the nozzle plate.*

3.5 Install the Diaphragm and Nozzle Plate

1. Attach the pneumatic and electrical connections as described in Sections 2.2 and 2.3.
2. Set the jet pressure to 40 psi (.28 MPa) and the OPEN the jet.
3. After the jet is open, the diaphragm can be inserted into the heater block.
   - First, align the diaphragm to the heater block using the rectangular grooves as shown in Figure 3-7.
   - Once aligned, gently press the diaphragm into the rectangular grooves until it is firmly in place.

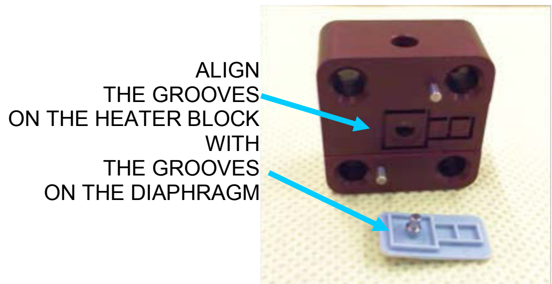


Figure 3-7:
Align the Grooves

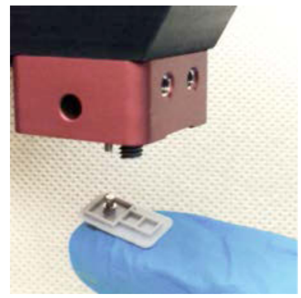


Figure 3-6:
Press Diaphragm into Place

4. After the diaphragm is inserted, the nozzle plate can be attached to the heater.
   - The nozzle plate has two pins for aligning the nozzle plate with the heater block.
   - Use the pins to align the nozzle plate on the heater block. The fluid barb faces the fluid syringe.

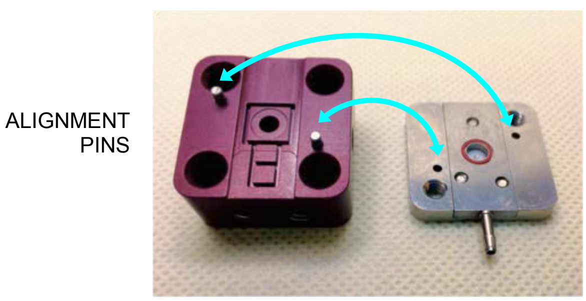


Figure 3-9:
Alignment Pins on Heater Block

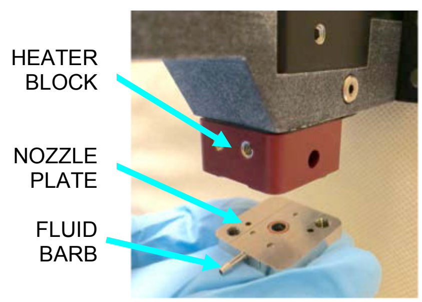


Figure 3-9:
Fluid Barb Faces Syringe

5. Once the nozzle plate has been positioned on the heater block, tighten the two embedded screws with a 3-mm Hex Driver. Do not over-tighten; it is possible to strip the screws.
6. Before installing the fluid syringe, CLOSE the jet.

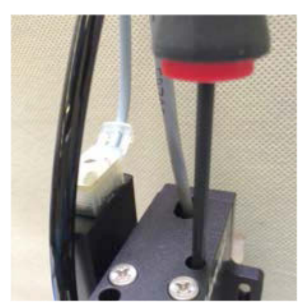


Figure 3-10:
Secure the Nozzle Plate

3.6 Install the Fluid Syringe

1. If the syringe is smaller than 30 cc, insert a syringe spacer ring; 3-cc, 5-cc, and 10-cc adapters are available.

Figure 3-11: Insert Spacer Ring

2. Attach the feed tube to the syringe and place the syringe in the Jet.

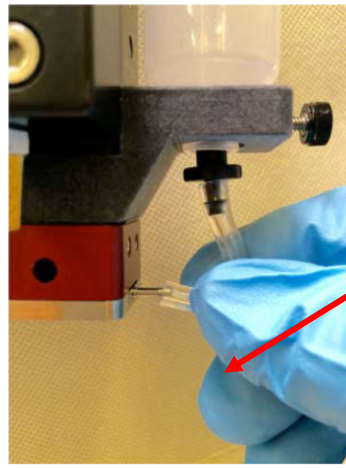


Figure 3-12: Attach Feed Tube and Insert Syringe

3. Slip the feed tube onto the barb end of the nozzle plate.

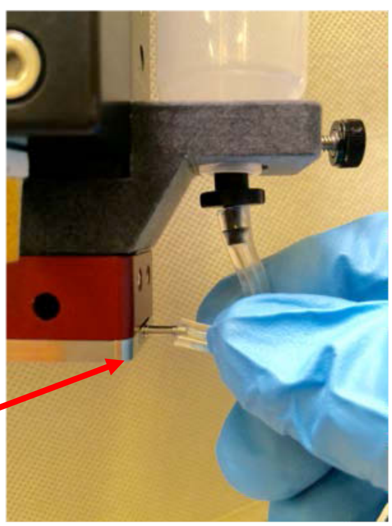


Figure 3-13: Attach Feed Tube to Nozzle Plate

4. Install the receiver head.

Figure 3-14: Install Receiver Head

3.7 Prime the Jet

1. Prior to dispensing, it is necessary to prime the jet in order to purge residual air from the system.

   In order to do this, the fluid must be brought to dispensing temperature.

   Turn on the heater and wait 10 minutes for the temperature of the nozzle to be stable.
2. Turn the fluid air pressure OFF.
3. OPEN the jet.
4. Set fluid air pressure to 0.
5. Turn fluid air pressure ON.
6. Place a substrate under the nozzle. While watching for fluid flow from the nozzle, slowly increase the fluid air pressure.

   Once fluid begins to slowly flow, continue at that pressure until there are no bubbles in the fluid.
7. CLOSE the jet.
8. Select a dispensing recipe for testing. The following parameters are useful:
   - Refill = 10.0 ms
   - Dwell = 10.0 ms
   - Refill+ = 0.3 ms
   - Drops = 250

   This recipe may not yield the best looking dispense, but it allows most fluids to flow through the jet easily.

9. Place a substrate under the nozzle and run the recipe once.

   Observe the quality of the drops.

   Repeat this 4 to 5 times to ensure the jet is properly primed.
10. Wipe the nozzle tip of any accumulation. The jet is ready to operate.

3.8 Check for Fluid Leaks

Important: *If fluid leaks between the diaphragm and the nozzle plate, the jet will not function correctly. Dispensing should be discontinued, and the components should be cleaned or replaced as required.*

Before running a program, it is important to check for fluid leaks.

- Assemble the diaphragm and attach the nozzle plate to the jet (see Section 3.5).
- Fill a syringe with fluid and attach to the feed tube.
- CLOSE the jet valve, connect the receiver head to the syringe, and turn the fluid air pressure ON.
- Set the fluid pressure to 10 psi (.070 Mpa).
- Set the jet pressure to 45 psi (.320 Mpa).

Fluid should not drip through the orifice. If fluid is leaking through the nozzle tip when the jet valve is closed, check to see if the jet pressure is set to at least 35 psi. Increase the pressure to 60 psi and check to see it the leak stops.

There are several areas to check for fluid leaks:

- Check to see if fluid leaks out of the weep hole in the heater block shown in Figure 3-15. If fluid is leaking, the diaphragm is either missing or damaged and should be replaced. The heater block will need to be removed and the leaking fluid should be cleaned.

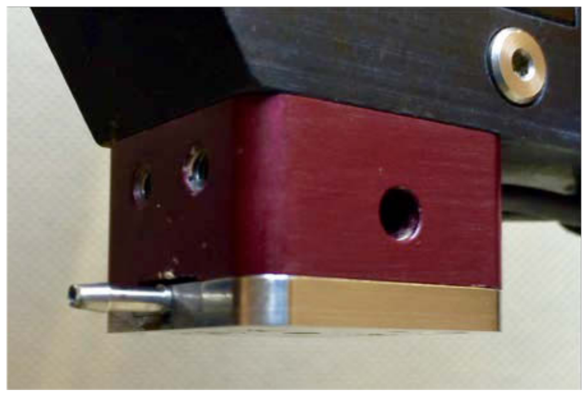


Figure 3-15: Check For Leaks at Weep Hole

- Fluid can leak out of the luer fitting that attaches the syringe to the feed tube. Sometimes the luer fitting is a little snug and hard to twist in completely. If fluid is leaking, give the fitting an extra turn to seat it completely. If this does not solve the leaking, change the feed tube and/or the syringe and check again.
- Fluid can leak at the junction between the feed tube and the nozzle plate inlet fitting. The feed tube is connected using a standard barb to the inlet fitting. If fluid is leaking at the barb end of the fitting, replace the feed tube.
- Check for leaks between the diaphragm and the nozzle plate. The nozzle plate must be attached correctly with screws well tightened. Make sure the jet valve is closed. If you observe fluid leaking under the diaphragm, then the jet has not been assembled correctly. Disassemble the dispensing components and inspect, clean, and/or replace the diaphragm as required.

If the leak continues, the diaphragm or nozzle plate is likely damaged or dirty, and it should be cleaned or replaced.

4. Cleaning the Jet

CAUTION!	*AVERTISSEMENT!*
WARNING: *Make sure you have proper ventilation. Wear appropriate eye and skin protection as instructed by the solvent manufacturer. Move the nozzle in a position so there is minimal misting of the solvent during flushing.*	*AVERTISSEMENT: Assurez-vous d'avoir une ventilation adéquate. Porter des lunettes de protection appropriées selon les instructions du fabricant. Déplacer la buse dans une position de manière à minimiser le spray du solvant lors du rinçage.*
WARNING: *Do not use a dripping wet cloth and do not pour solvents, alcohol, water or other liquids directly on the jet. Also, do not submerge the jet in the cleaning agent. Otherwise the jet can be damaged.*	*AVERTISSEMENT: Ne pas utiliser un chiffon mouillé et ne pas versez de solvants, d'alcool, d'eau ou d'autres liquides directement sur le jet. En outre, ne pas immerger le jet dans l'agent de nettoyage. Cela pourrait causer le jet d'être endommagé.*

4.1 Cleaning the Exterior of the Jet

To clean the exterior of the jet, use a soft cotton or cellulose cloth. If the jet exterior is extremely dirty, a small amount of alcohol can be used.

4.2 Cleaning the Interior of the Jet

The GPD Global NCM7500 is a high precision jet for dispensing minute amounts of fluid. Dispensing nozzles can become blocked or clogged by the smallest contaminates, which will adversely affect dispensing results.

These are symptoms of a contaminated jet:

- Unclean or uneven dispensing
- Drops become irregular or vary in size
- Residual flow or drooling out of the tip when the jet is in the closed position
- Interrupted dispensing (places where fluid no longer is dispensed)
- Splatter or satellites

The importance of clean jetting is a key design element of the NCM7500, resulting in a jet that is quick and easy to clean. Following these simple cleaning steps will optimize jetting quality and maximize productivity.

4.2 Cleaning the Interior of the Jet, cont'd.

1. Turn the fluid air OFF.

CAUTION!	***AVERTISSEMENT!***
*It is important to first **turn off the air**. If not, the fluid from the syringe will make a mess if the feed tube is dismounted under pressure.*	*Il est important d'éteindre l'interrupteur de l'air en premier. Sinon, le liquide de la seringue pourrat se déverser si vous démontez le tube d'alimentation sous pression.*

2. Remove the receiver head.
3. Remove the feed tube from the nozzle plate.
4. Remove the syringe from the jet.
5. Install an empty syringe with a feed tube onto the fluid barb of the nozzle plate.

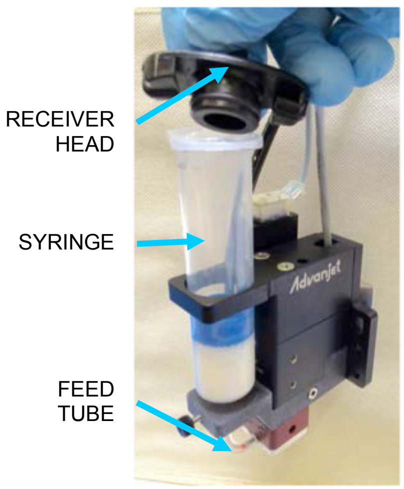


Figure 4-2:
Disassemble and Remove Syringe

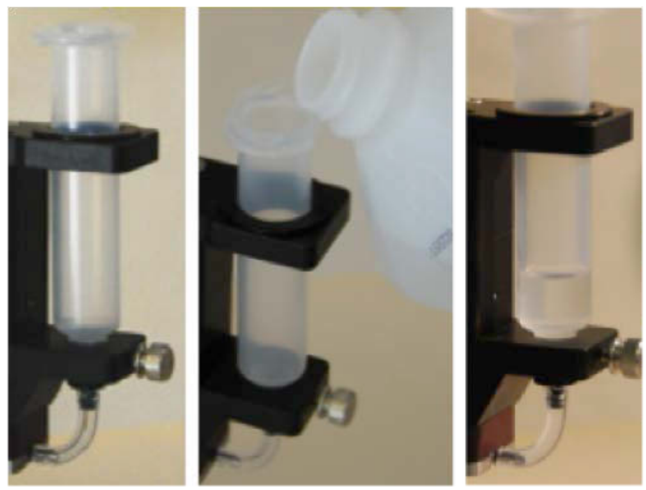


Figure 4-2: Install an Empty Syringe and Fill With Solvent

6. Fill the syringe with about 3 cc of mild solvent compatible with your fluid material.
7. Replace the receiver head onto the syringe.
8. Set up a test recipe using the following parameters:
   - 10.0 msec Refill
   - 10.0 msec Dwell
   - 0.3 msec Refill+
   - 250 Drops.
9. Run the test recipe, which will flush the Jet.
   - Continue to run the recipe until the liquid coming out of the nozzle is clear and clean, or all 3 cc of the solvent is flushed. It normally requires about 5 or 6 flushes of 250 drops.
   - If there is too much solvent in the syringe, you can open the jet to let out the remaining solvent.

Figure 4-3:
Replace Receiver Head

***Note**: It is easier to work with an empty syringe –*
let the remaining solvent drain completely to manage the solvent in the cleanest way.

4.2 Cleaning the Interior of the Jet, cont'd.

10. Turn the fluid air OFF.
11. Remove the flushing syringe.
12. Use the 3 mm Hex driver to remove the nozzle plate.
13. Remove the diaphragm from the heater block.
14. Inspect if the diaphragm or nozzle plate requires further cleaning. Normally, the flushing process achieves 90% clean.
15. Hand-clean the diaphragm with mild solvent and a brush.
16. The nozzle plate can be cleaned with a stronger solvent than the one used for the diaphragm. If necessary, thoroughly clean the nozzle plate by submerging into an ultrasonic cleaner for 10 minutes. If necessary, repeat a second time. Do not submerge the nozzle plate for extended periods of time.

IMPORTANT!

Never submerge the diaphragm in solvents as they might be damaged.

Diaphragms can be cleaned successfully with a small amount of solvent and a soft brush and cotton swab.

Do not submerge the diaphragm into the ultrasonic cleaner because it will deteriorate the diaphragm and shorten its life.

Appendix 1: Jet Dispensing Parameters

Appendix 1-1: Effects of Material on Jetting Quality

The NCM7500 Jet accomplishes fluid dispensing by rapidly changing the momentum of a minute volume of fluid to eject a drop of material. Like all jetting systems, the state of the material is extremely important for high-quality dispensing. While not all fluids can be successfully dispensed using a jetting system, the NCM7500 Jet is designed to dispense a wide variety of fluids. There are several general areas to consider when choosing a material to jet dispense.

Very compliant fluids or fluids with large amounts of dissolved gas are problematic and care should be taken to prepare the material for dispensing. If the fluid contains a large amount of dissolved gas, it is likely that the gas will come out of the solution and form bubbles. Bubbles in the fluid path will cause erratic dispensing and missed drops. Make sure all material is carefully degassed. If a batch reservoir is used, make sure the fluid is not open to air after degassing, or else the air will quickly be reabsorbed into the fluid. Alternatively, for low viscosity fluids, an inline degasser can be supplied that degasses the material just prior to entering the nozzle plate. When using fluids with entrapped air or gas, frequent purging is highly recommended to expel any air collecting in the fluid path. However, it is best to never introduce bubbles into the fluid path by carefully degassing the material.

Fluids with very high surface tension can also be problematic, as they tend to form “satellites.” Satellites are very small droplets that are sometimes formed during the jetting process. These satellites can fly off in many directions, even backwards toward the dispensing tip. If the satellites stick to the dispensing tip, they can build up and attract more satellites. Eventually, the tip has a glob of fluid on the tip that can interfere with the quality of the dispensing. It is recommended to set the jet air pressure as low as possible. Limiting the jet air pressure has the effect of reducing the energy imparted to the fluid, which can reduce the production of satellites. Also, it is highly recommended that the tip be located over a “service station” when not actually dispensing. A well-designed service station should have a slight vacuum, which can clean material off the tip as well as provide a cup for purging fluid as described above.

High viscosity fluids often require the addition of heat to facilitate jetting. If a drop of material does not eject, heat may be needed. The NCM7500 Jet has an internal heater and integrated heater controller which can elevate the fluid temperature. Only the fluid inside the nozzle plate is heated. Heating the fluid reservoir is rarely required. The addition of heat is often the solution for difficult dispensing materials. When using heat, be sure not to heat the material so high that it cures inside the nozzle plate.

For help with settings for a variety of fluids, please refer to the table at the end of this appendix.

Appendix 1-1: Effects of Material on Jetting Quality, cont'd.

The NCM7500 jet default setting is generally sufficient to provide enough energy for most materials. However, the amount of energy imparted during jetting varies with the material. For reliable jetting, some materials will need more energy and some will need less. A Tool Kit is available from GPD Global to make the energy adjustments to the jet hammer gap (Jet Maintenance Tool Kit P/N 2650-0241). The procedure to adjust the energy is provided in the NCM5000 Pump Maintenance Guide P/N 22200601.

Appendix 1-2: Nozzle Size

The first step in the process is to pick a nozzle size that will yield approximately the desired drop volume or drop diameter. Some customer applications will specify a drop diameter and others will specify a drop weight.

- Drop diameter is highly dependent on the surface tension of the material and the wetting characteristic of the substrate and is therefore not always a straightforward determination. For example, epoxy such as SMA is designed to stand up and has a "tall" drop profile resulting in a small diameter-to-weight ratio.
- Underfill material is designed to wick into small gaps and tends to spread out and form a larger "flat" drop profile, resulting in a large diameter-to-weight ratio.

When qualifying the dispense characteristics of a new material, it is always recommended to use drop weight. Weighing 100 or 200 drops on a scale is the most reliable method to determine drop weight. Alternatively, weighing drops dispensed on pre-weighed slides also works well.

The following can be used as guide for initial selection of nozzle size.

Nozzle Size	Drop Weight (Specific Gravity = 1)	Drop Diameter (Contact Angle = 90°)
75 µm	5 – 25 µg	270– 460 µm
100 µm	15 – 50 µg	390 – 580 µm
125 µm	25 – 80 µg	460 – 675 µm
200 µm	80 – 200 µg	675 – 910 µm
400 um	200 – 500 µg	910 – 1250 µm

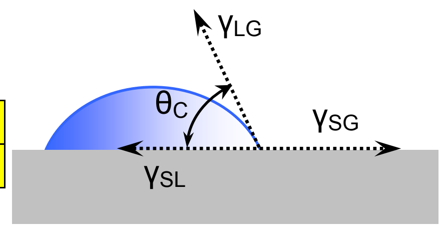
Figure A1 - 1: Guide to Selecting Nozzle Size

Appendix 1-2: Nozzle Size, cont'd.

The drop weights listed in the table below are typical, but can vary widely with material properties and jet setting.

- The table uses a material specific gravity of one. For a different specific gravity, multiply the dot weights by the specific gravity to get the estimated dot weights.
- The dot diameter (µm) in the table is calculated based on a 90° contact angle.
- The contact angle (θ_C) is dependent on both the fluid and the substrate, and must be determined experimentally. Most fluids used for semiconductors have around 60° contact angles.

Contact Angle	90°
Specific Gravity	1



Dot Dia (µm)	Dot Height (µm)	Dot Volume (nl)	Dot Mass (µg)
100	50.0	0.262	0.262
110	55.0	0.348	0.348
120	60.0	0.452	0.452
130	65.0	0.575	0.575
140	70.0	0.718	0.718
150	75.0	0.884	0.884
160	80.0	1.072	1.072
170	85.0	1.286	1.286
180	90.0	1.527	1.527
190	95.0	1.796	1.796
200	100.0	2.094	2.094

Figure A1 - 2: Guide to Selecting Nozzle Size

Appendix 1-3: Diaphragm Material

The NCM7500 jet uses four different diaphragm materials: FKM (fluoropolymer elastomer), Silicone, FFKM (perfluoroelastomer), and EPDM (ethylene propylene diene terpolymer. In most cases, the type of solvent in the dispensed fluid determines its chemical compatibility with the diaphragm. The chemicals in the material can be found in the Material Data Safety Sheet (MSDS). The table below shows typical chemical compatibilities. In some cases, even if there is an incompatible solvent in the fluid, it might not affect the diaphragm. The best way to determine compatibility is to soak a diaphragm in the fluid for 24 hours and inspect the diaphragm for swelling. If there is any permanent swelling, then the diaphragm material is incompatible with the fluid.

	FKM	Silicone	FFKM	EPDM
Chemical				
Acetone	✗	✗	✔	✔
Acetic Acid	✗	✔	✔	✗
Ammonia	✗	✔	✔	✗
Benzene	✔	✗	✔	✗
Cyclohexane	✔	✗	✔	✗
Cyclohexanol	✔	✗	✔	✗
Dimethyl Formaide	✗	✔	✔	✔
Ethanol	✗	✔	✔	✔
Hexane	✔	✗	✔	✗
Isopropanol	✔	✔	✔	✔
Methyl Ethyl Ketone	✗	✗	✔	✔
Silicone Oil	✔	✔	✔	✔
Toluene	✔	✗	✔	✔
Xylene	✔	✗	✔	✔

Figure A1 - 3: Diaphragm and Chemical Compatibilities

☐ = Compatible; ☐ = DO NOT USE

⚠ ***Important:*** *If unsure of the proper choice of diaphragm materials, please contact the factory for recommendations. In general, if the diaphragm material is incompatible with the fluid, the diaphragm will exhibit slight swelling around the metal insert. If swelling occurs, the performance of the jet will be adversely affected. In general, all of the diaphragms are compatible with most epoxies and UV fluids. The most chemically inert diaphragm is the FFKM perfluoroelastomer. The longest cycle life diaphragm is silicone.*

Appendix 1-3: Diaphragm Material, cont'd.

Along with chemical compatibility, the cycle life of each diaphragm is determined by the flexibility of the material. The most flexible materials are silicone and EPDM, so they have the longest cycle life. FKM is also reasonably flexible and its life is good. FFKM is the least flexible of the diaphragm materials and therefore has the shortest cycle life.

There are two series of diaphragms: flat diaphragms and contoured diaphragms. The two series are shown below. The flat diaphragms make larger drops than contoured diaphragms for the same recipe settings. The difference in drop size is dependent on the dispensed fluid and the diaphragm material. In general, the flat diaphragm will make a 10-25% larger drop than the contoured diaphragm. The advantage of the contoured diaphragm is the cycle life can be longer. In general the cycle life of a contoured diaphragm can be increased up to 25%. The life is especially improved with the contoured FFKM diaphragm. The GPD Global part number for each diaphragm is listed in the table below.

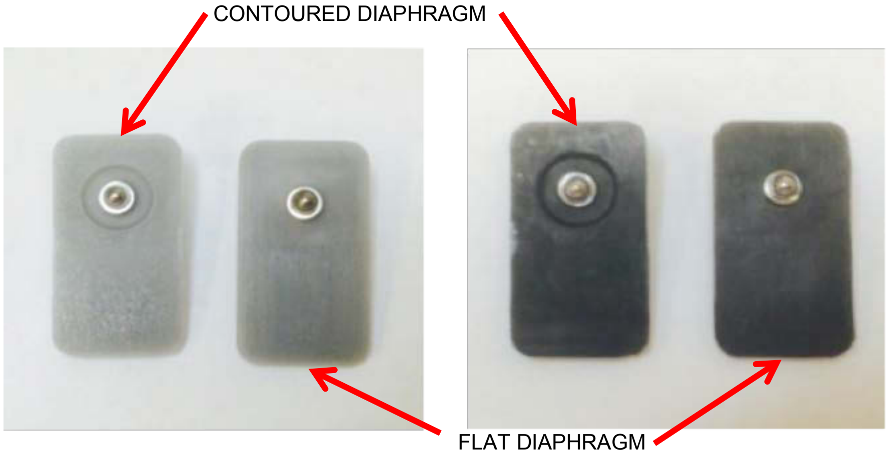


Figure A1 - 4: Contoured and Flat Diaphragms

GPD Global Diaphragm Part Numbers		
Material	**Flat P/N**	**Contoured P/N**
FKM	-------	2650-0307
Silicone	2650-0150	2650-0308
FFKM	2650-0225	2650-0309
EPDM	2650-0147	-------

Appendix 1-4: Feed Tube Material

The NCM7500 currently uses two different Feed Tube materials. The clear Tygon Feed Tube is recommended for most fluids except UV cure materials. For dispensing UV material, a black silicone Feed Tube is recommended.

Figure A1 - 5: (l - r)
Silicone and Tygon Feed Tubes

Appendix 1-5: Dispensing Temperature

In order to get reliable and repeatable dispensing, the drop must eject out of the nozzle forcefully and cleanly. If the jet does not have adequate energy to break off cleanly, it forms multiple small drops or “tails” that will cling to the nozzle tip and eventually completely block the orifice. This phenomenon is called “accumulation”.

Temperature is the most important parameter to get an excellent and reliable jetting condition. The goal is to heat the fluid and lower its viscosity so it flows through the nozzle, as well as enabling the jet to break off cleanly. Temperature can be selected based on the viscosity of the material—generally, the higher the viscosity, the higher the temperature required for high-quality jetting. However, viscosity is not always the only factor; the rheology of the material is also important. Some materials are “stringy” and need a higher temperature to jet cleanly.

Appendix 1-6: Fluid Pressure (FP)

Another important jet parameter is the Fluid Pressure. The fluid reservoir (the syringe) must supply enough fluid to the jet chamber to generate clean drop formation. The criterion is that the fluid must flow freely out of the nozzle when the jet is opened. As a general rule, a lower fluid pressure is more desirable than a higher pressure. However, the material rheology has a big effect on how the fluid flows out the nozzle.

Illustrated below are typical flow patterns when the jet is open and a given Fluid Pressure is applied.

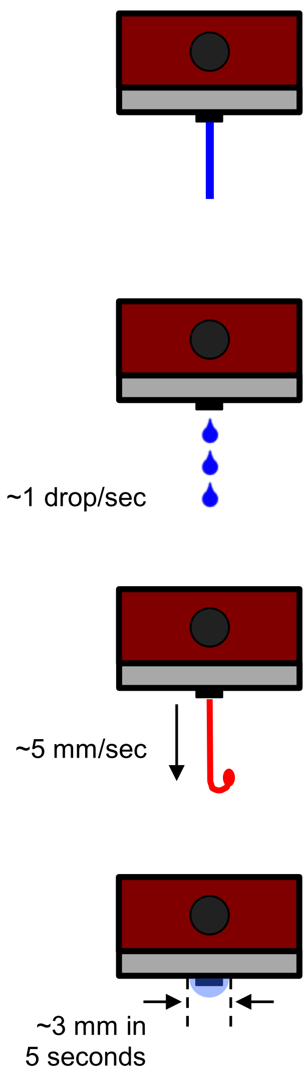


Figure A1 - 6:
Typical Flow Patterns

Stream: The first example is a material that flows freely and forms a stream. Some low viscosity epoxies will form a stream, and some will not. For example, low viscosity underfills will usually form a stream, while a low viscosity UV epoxy will not. Set Fluid Pressure to the minimum value that allows a clean stream to form.

Drop: Some materials form drops of fluid rather than a stream. These fluids tend to be higher viscosity and will not stream. A good rule of thumb is to set Fluid Pressure so you have about 1 drop/sec. Many highly filled underfill epoxies exhibit this flow pattern.

Curl: Other fluids will form a stream, but are “stringy” enough that they will curl at the end of the stream. A good example of this behavior is Loctite Chipbonder 3621. A good rule of thumb is to set Fluid Pressure so that the stream flows cleanly and not to worry about the curl at the end.

Pool: Another type of fluid will not form a drop or a stream. These fluids are very “stringy” and will form a “pool” of fluid around the nozzle tip very similar to accumulation that occurs when a jet is not performing correctly. A good rule of thumb is to set Fluid Pressure so that a 3mm pool forms in 5 seconds. UV epoxies can be examples of this type of flow.

Appendix 1-7: Jet Pressure (JP)

Jet Pressure is the key parameter for drop quality and is very important for accumulation-free jetting. Accumulation is a condition where the jet does not break off cleanly into a drop, leaving material to build up on the nozzle tip. The optimal minimum Jet Pressure setting is where the exit velocity of the jet allows for a clean break-off. After the minimum Jet Pressure is reached, increasing Jet Pressure can generate too forceful a jet and produce unwanted splashes. Also, with too high a Jet Pressure setting, smaller unwanted drops called "satellites" can form.

There is no magic number for Jet Pressure because it is dependent on the viscosity and surface tension of the material. The best technique is to start with a midpoint and adjust Jet Pressure for the best drop quality without accumulation, which is a symptom of poor breakoff. In general, a good starting point for Jet Pressure is 45 psi (0.310 Mpa). If the jet does not break off cleanly, increase Jet Pressure. Sometimes if the jet velocity is too high, many satellites are formed. In this case, decrease the Jet Pressure and see if the accumulation goes away. The jet requires a minimum of 35 psi (0.240 Mpa) to function correctly. Do not run below this value. If raising Jet Pressure as high as 65 psi (0.45 Mpa) still results in accumulation, try a higher Temperature. The table at the end of the appendix shows typical Air Pressure settings.

Appendix 1-8: Refill Time

Refill Time is a major factor in determining drop volume. Refill Time is the "open" time of the jet when fluid flows into the orifice. It is important to allow enough time for the fluid to flow into the nozzle; otherwise the jet will be "starved." On the other hand, if there is too much fluid flowing into the nozzle, the drop will be too big to jet and accumulation will occur. If the drop volume is too high, decrease Refill Time; if volume is too low, increase Refill Time. If the proper drop volume cannot be achieved by adjusting Refill Time, change the Nozzle Size or the Fluid Pressure.

The Drop Speed of the jet in hertz (Hz) is defined as:

Drop Speed (hertz)	= 1 / (Refill + Dwell) seconds
50 Hz	= 1 / (0.005 + 0.015) sec
100 Hz	= 1 / (0.003 + 0.007) sec
200 Hz	= 1 / (0.002 + 0.003) sec
303 Hz	= 1 / (0.0016 + 0.0017) sec

At low speeds (under 50 Hz), Refill Time should be a minimum of 3 msec. As speed increases (over 100 Hz), Refill Time can be reduced to 2 msec. At high frequency (over 250 Hz), a refill of 1.7 msec can be used. The minimum refill time is 1.7 msec and is dependent on the fluid. A shorter refill time will probably fail to produce drops.

Many viscous fluids tend to "shear thin" when operating at high speed, and because of shear thinning, the drop volume sometimes increases with speed for a given refill time. The table at the end of the appendix shows typical Refill Times for different fluids.

Appendix 1-9: Dwell Time

The minimum Dwell Time is the time needed for a drop to be ejected from the nozzle tip once the diaphragm hits the nozzle seat. The Dwell Time is generally not important for Drop Mode dispensing. Drop Mode jets a single drop of fluid, moves to the next position and jets another drop. In Drop Mode, the motion of the robot from position to position always takes more time than the jet will need for the drop to eject.

However, in Line or Level Mode, Dwell Time is important. As shown above, the speed of the jet is determined by the sum of Refill Time and Dwell Time. A faster jet speed often produces less accumulation. In general, Dwell Time should be as low as possible, with the minimum of 1.5 msec. Of course, settings are dependent on material. For example, a very thick stringy material may not run faster than 50 Hz, while a thin material can run at 300 Hz. A good rule of thumb is to start with a Dwell Time of 3 to 8 msec.

In Line/Level Mode, the speed of the jet is used to calculate the velocity of the robot.

Robot Velocity V (mm/sec) = ΔX (mm) / ΔT (sec)

Where ΔX = the drop spacing and ΔT = (Refill Time + Dwell Time).

For example, in the figure below, drop spacing is 0.05 mm, Refill Time is .002 seconds and Dwell Time is .003 seconds. Robot Velocity is calculated to be 100 mm/sec.

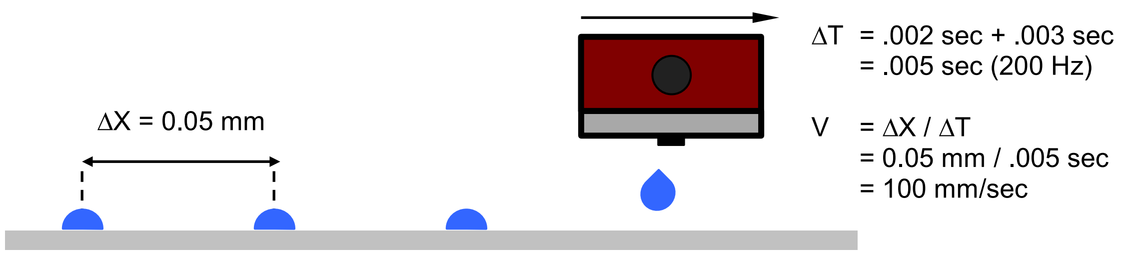


Figure A1 - 7: Calculating Robot Velocity for Drop Spacing = 0.05 mm, Refill Time = .002 Sec and Dwell Time = .003 sec

In this next example, drop spacing is 0.025 mm, Refill Time is .0017 seconds and Dwell Time is .0016 seconds. Robot Velocity is calculated to be 75.8 mm/sec.

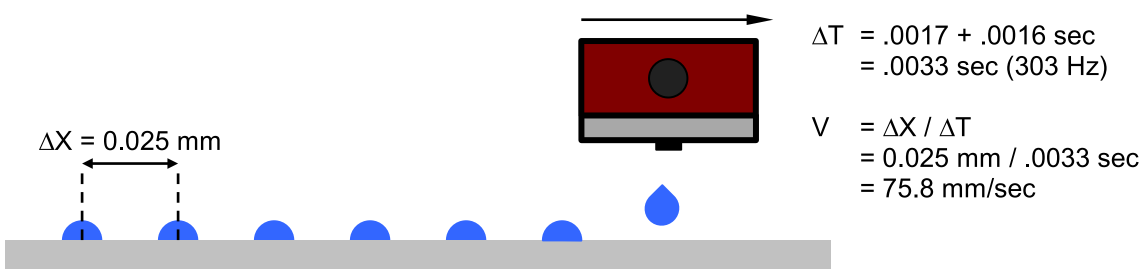


Figure A1 - 8: Calculating Robot Velocity for Drop Spacing = 0.025 mm, Refill Time = .0017 Sec and Dwell Time = .0016 sec

Appendix 1-10: Summary of Typical Parameters and Their Effects

Parameter	Effect		
Nozzle Size	Nozzle Size	Drop Weight	Drop Diameter
	75 µm	5 – 25 µg	270 – 460 µm
	100 µm	15 – 50 µg	390 – 580 µm
	125 µm	25 – 80 µg	460 – 675 µm
	200 µm	80 – 200 µg	675 – 910 µm
	400 um	200 – 500 µg	910 – 1250 µm
Temperature	Adding heat lowers the viscosity of the fluid, and makes it easier to flow. Higher temperature allows a cleaner break off and less accumulation. “Stringy” materials require higher temperature. However, too high a temperature produces splashes and satellites.		
Fluid Pressure	Higher Fluid Pressure produces bigger dots. Thicker fluids need higher Fluid Pressure. Use a combination of Temperature and Fluid Pressure to control the Flow Rate. Good Flow Rate is important for reliable jetting.		
Jet Pressure	Jet Pressure (JP) is the key parameter to achieving good Jet Velocity. Good Jet Velocity produces clean jetting without accumulation. Minimum JP is 35 psi (0.24 Mpa). Maximum JP is 65 psi (0.45 Mpa). If the jet accumulates, increase JP. However, too high a JP can produce satellites. If JP is as high as 65 psi (0.45 Mpa) and there is still accumulation, increase the Temperature. If JP is as high as 65 psi (0.45 Mpa) and the jet won’t break off, the Jet Impact Gap might need to be increased (must use Gap Micrometer). Higher JP decreases dot weight, and lower JP increases dot weight. To maintain the same dot weight, change the Fluid Pressure accordingly.		
Refill Time	Longer Refill Time produces bigger dots. The combination of Fluid Pressure and Refill Time control the dot size. 2 msec is a good starting point. Increase or decrease as needed. Decrease Refill Time to go faster than 250 Hz. Minimum refill time is 1.7 msec.		
Dwell Time	Dwell Time has no effect in DOT mode. The Dwell time controls the jetting speed in LINE or LEVEL mode. Higher jetting speed produces higher Jet Velocity, and cleaner jetting. Jet Speed = 1 / (Refill time + Dwell time) For example: 100 Hz = 1 / (0.002 msec + 0.008 msec) = 1 / (0.003 msec + 0.007 msec) 200 Hz = 1 / (0.002 msec + 0.003 msec) = 1 / (0.003 msec + 0.002 msec) 303 Hz = 1 / (1.700 msec + 0.0016 msec)		

Warranty

General Warranty.
Subject to the remedy limitation and procedures set forth in the Section "Warranty Procedures and Remedy Limitations," GPD Global warrants that the system will conform to the written description and specifications furnished to Buyer in GPD Global's proposal and specified in the Buyer's purchase order, and that it will be free from defects in materials and workmanship for a period of one (1) year. GPD Global will repair, or, at its option, replace any part which proves defective in the sole judgment of GPD Global within one (1) year of date of shipment/invoice. Separate manufacturers' warranties may apply to components or subassemblies purchased from others and incorporated into the system. THIS WARRANTY IS EXPRESSLY IN LIEU OF ANY AND ALL OTHER WARRANTIES,EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

Limitations.
GPD Global reserves the right to refuse warranty replacement, where, in the sole opinion of GPD Global the defect is due to the use of incompatible materials or other damages from the result of improper use or neglect.

This warranty does not apply if the GPD Global product has been damaged by accident, abuse, or has been modified without the written permission of GPD Global.

Items considered replaceable or rendered unusable under normal wear and tear are not covered under the terms of this warranty. Such items include fuses, lights, filters, belts, etc.

Warranty Procedures and Remedy Limitations.
The sole and exclusive remedy of the buyer in the event that the system or any components of the system do not conform to the express warranties stated in the Section "Warranties" shall be the replacement of the component or part. If on-site labor of GPD Global personnel is required to replace the non-warranted defective component, GPD Global reserves the right to invoice the Buyer for component cost, personnel compensation, travel expenses and all subsistence costs. GPD Global's liability for a software error will be limited to the cost of correcting the software error and the replacement of any system components damaged as a result of the software error. In no event and under no circumstances shall GPD Global be liable for any incidental or consequential damages; its liability is limited to the cost of the defective part or parts, regardless of the legal theory of any such claim. As to any part claimed to be defective within one (1) year of date of shipment/invoice, Buyer will order a replacement part which will be invoiced in ordinary fashion. If the replaced part is returned to GPD Global by Buyer and found by GPD Global in its sole judgment to be defective, GPD Global will issue to Buyer a credit in the amount of the price of the replacement part. GPD Global's acceptance of any parts so shipped to it shall not be deemed an admission that such parts are defective.