# Cartridge Concepts 2

## Nemo

September 24, 2019

# Cartridge Concepts 2

## Summary

- MBARI Updates
- CAD layouts
  - Lyse-n-Go 4
  - Archive 0
- Next Steps/Questions

# Lyse-n-Go 4

# Cartridge Concepts 2

## Lyse-n-Go 4: Bi-Directional 3-State Valve, No Manifold Check Valves

| | action | valve | syringe 4 | | | syringe 3 | syringe 2 | syringe 1 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | air | | | diluent | lysis buffer | diluent 2 | | | |
| | | | ▼ | | | manifold | | | | | |
| | | | puck top | | puck side | | | | puck bottom | | |
| 1 | sample | sample | | | | | | | | | Water in first to puck side, then water out for free flow. Syringe 4 check valve sees full sea pressure |
| 2-4 | pressurize | bottom | ↓ | | | | X | | | | Pump syringe 4 air to exceed filter bubble point pressure |
| 5 | drain | bottom | | | | | ↓waste | ↑ | | | Open waste to drain water, water remains between puck side and upper valve, air between upper valve and manifold |
| 6 | vent top | bottom | ↑ | | | | ↓waste | | | | Vent syringe 4 to relieve puck top pressure |
| 7 | fill line | bottom | | | | | ↓waste | | | | Push syringe 2 to displace Bukert line air with lysis buffer (0.3 ml) |
| 8 | fill puck | side | ↑ | | ↑ | | X | | | | Vent syringe 4, push syringe 2 to fill puck with puck side water, manifold air, and lysis buffer. Air remains between puck bottom and checkvalve |
| 9 | pressurize | side | ↑ | | ↑ | | X | | | | Empty syringe 2, actuate syringe 4 checkvalve to set pressure. Heat to 85°C, 14 minutes |
| 10a | pull bubble | bottom | | | | | | ↑ | | | Pull syringe 2 0.2ml to extract puck bottom air and unreacted lysis buffer |
| 10b | push bubble | side | | | | ↓ | | | | | Push syringe 2 0.2ml to shunt air and lysis buffer to puck side |
| 10c | extract | bottom | ↓ | | | | X | ↑ | | | Pump syringe 4 to add pressure, retract syringe 2 to extract 0.9 ml lysate from puck bottom |
| 11 | vent | bottom | ↑ | | | | ↓waste | ↑ | | | Relieve pressure from puck top and bottom |
| 12a | dump | sample | | | | | ↓waste | | | | Push syringes 2 & 3 (lysate & diluent), dump initial mixture to waste, valve prevents leakage into puck |
| 12b | analysis | sample | | | | | ↓analysis | | | | Continue to push syringes 2 & 3 (lysate & diluent) to analysis, valve prevents leakage into puck |
| | | | | water in | | | Burkert | | | water out | |

| | | sample | bottom | side | |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| 1 | | | | | water in |
| 2 | puck side | | | | |
| 3 | manifold | | | | |
| 4 | puck bottom | | | | |
| 5 | | | | | water out |
| | | | | | |
| | | | | | |

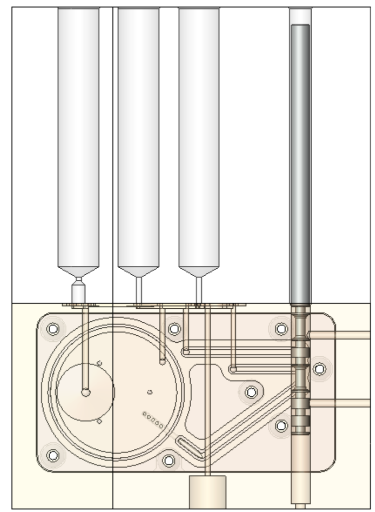
- Spring (plus magnet, if needed) returns the valve back up to the side state

# Cartridge Concepts 2

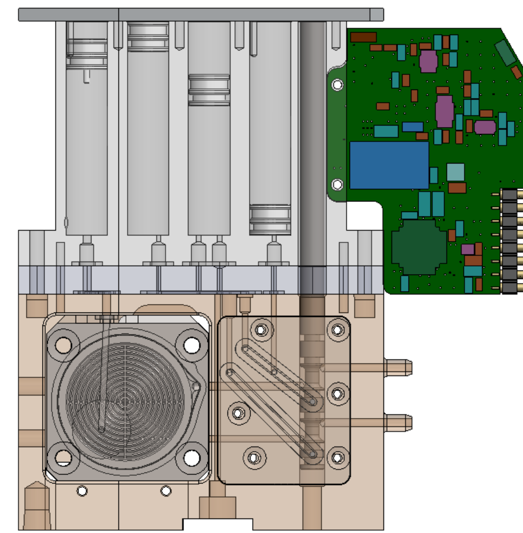
## Lyse-n-Go 4: Comparison

Lyse-n-Go 4 Main Differences:

- Syringe 1 removed
- Longer Syringe – +9mm (optional)
- Water in location moved up – 2.7mm, water out same as current
- Bi-directional 3-state valve eliminates two check valves
- Return spring needed for valve – actuator must overcome spring + valve friction
  - Smaller valve diameter for reduced friction
- Puck top and cover integrated into housing
- Channels moved to the back side
- Center manifold part removed



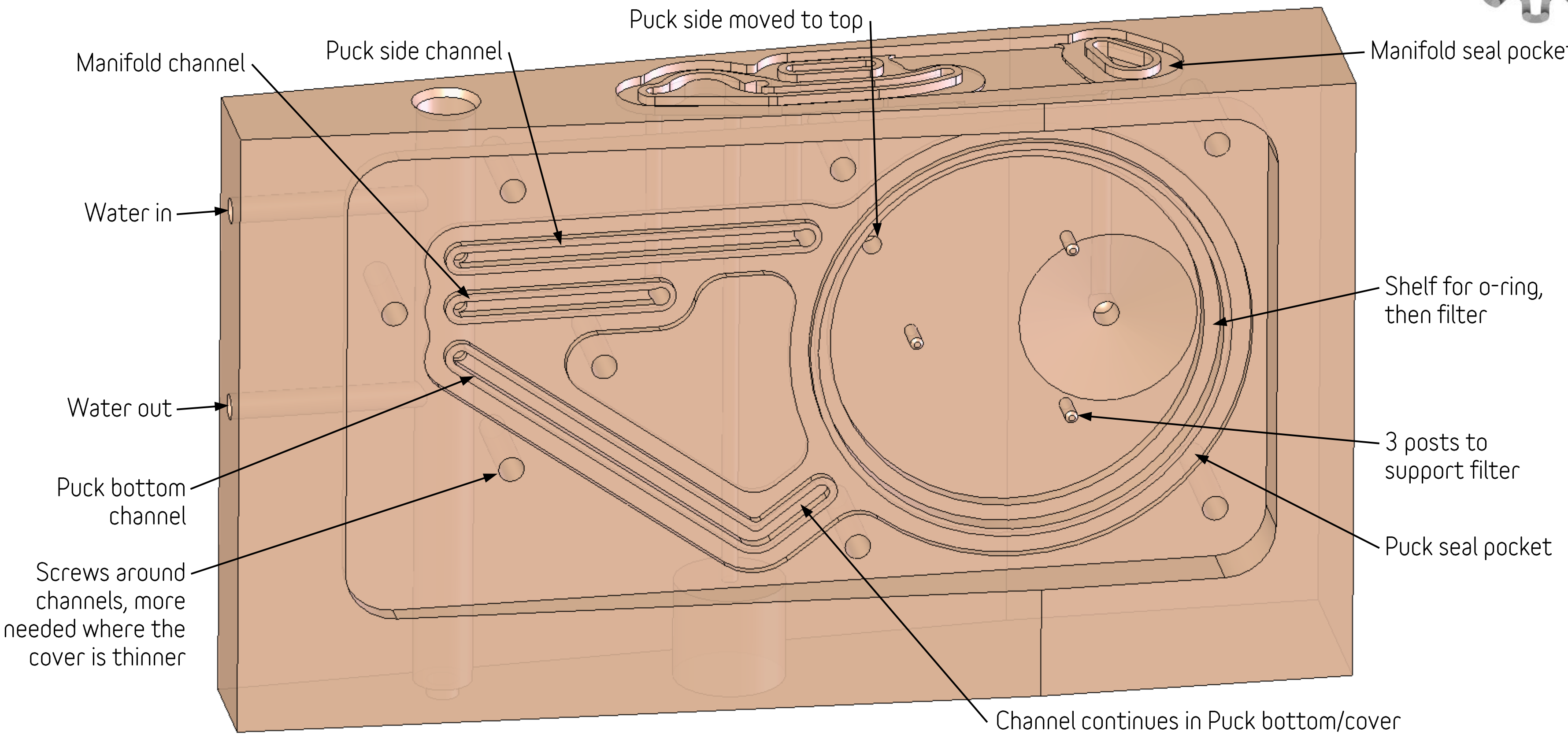
LnG 4 (layout only)



Current

# Cartridge Concepts 2

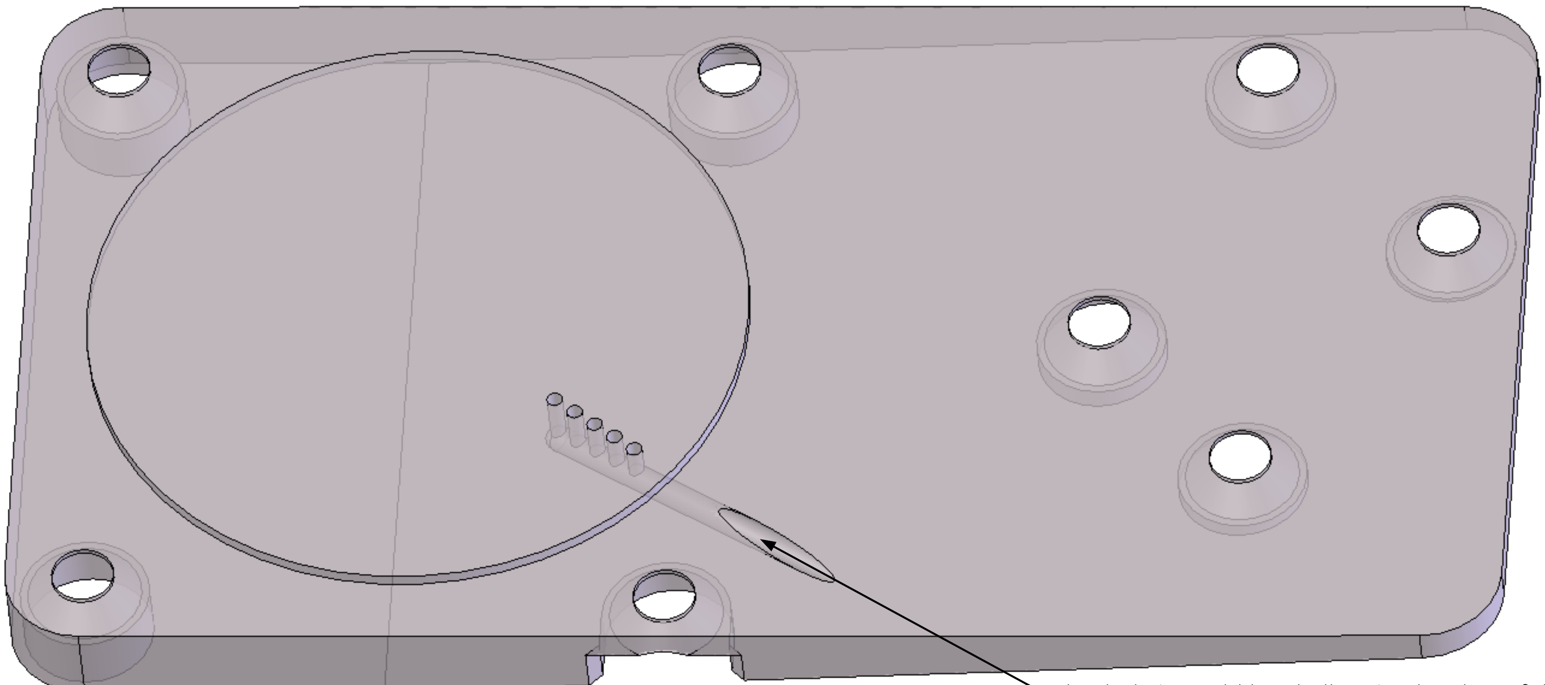
## Lyse-n-Go 4 Cartridge




- Internal vias and surface channels are both on the cartridge part where possible for alignment/tolerance
- Moving puck side port to the top allows 360° o-ring seal over the filter

# Cartridge Concepts 2

## Lyse-n-Go 4 Puck Bottom/Cover

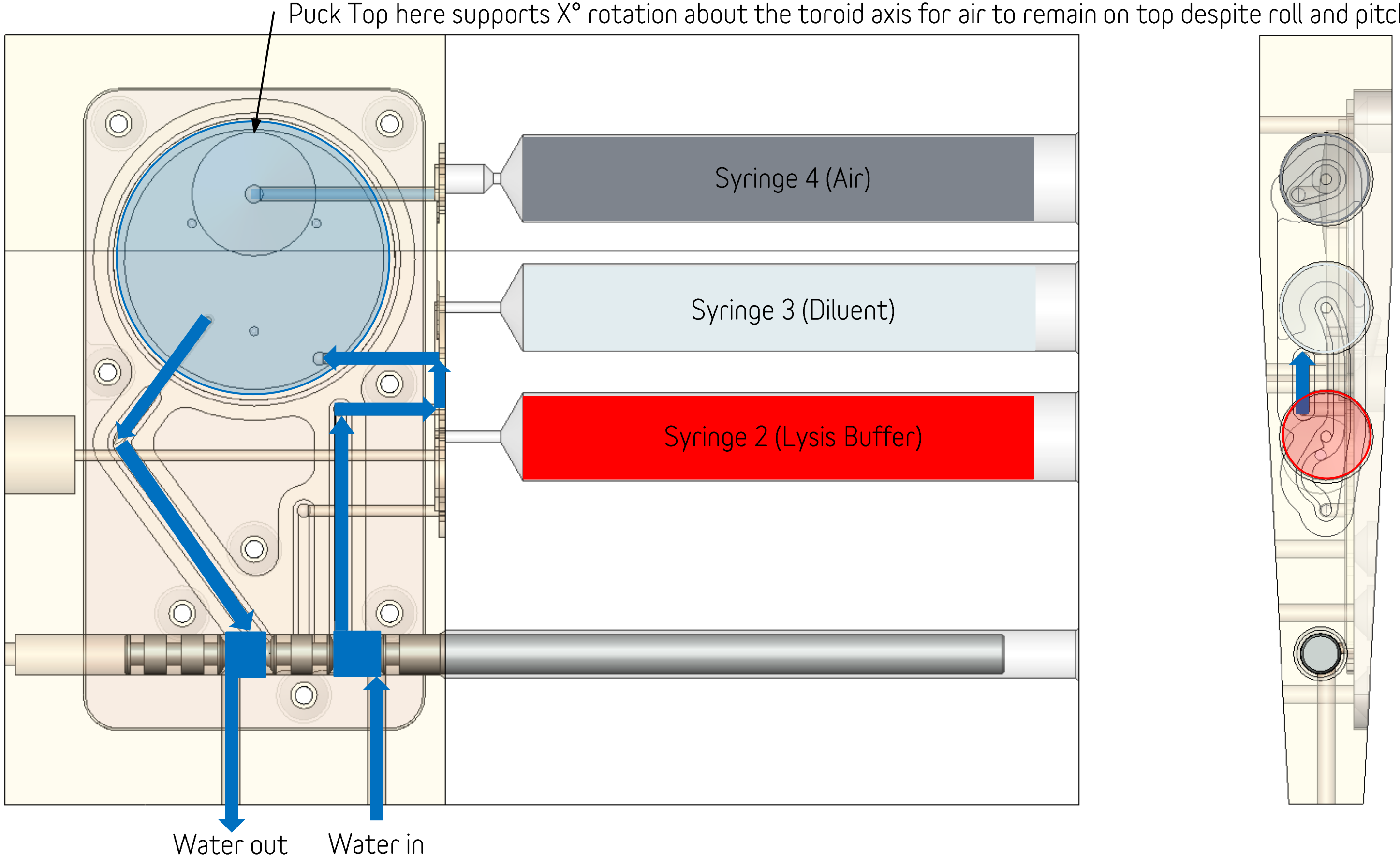


Angled via could be challenging but hopefully feasible for machining and injection molding

- Maximize thickness for stiffness to seal vs. pressure
- Puck Bottom rib pattern and heater cutout not yet modeled
- Machined part should be metal to conduct heat, maybe insert molded plastic over metal disc for production

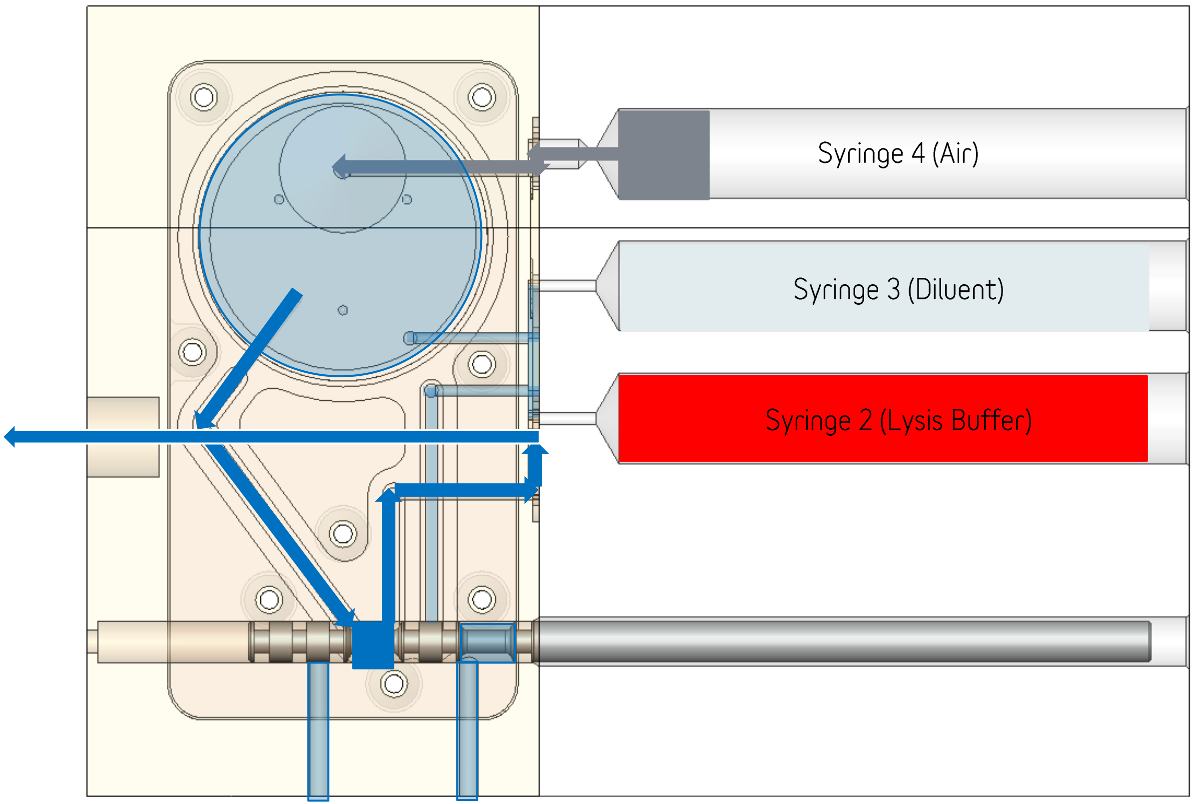
# Cartridge Concepts 2

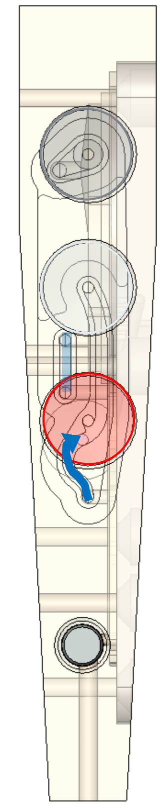
## Lyse-n-Go 4: Sample - Sampling



# Cartridge Concepts 2

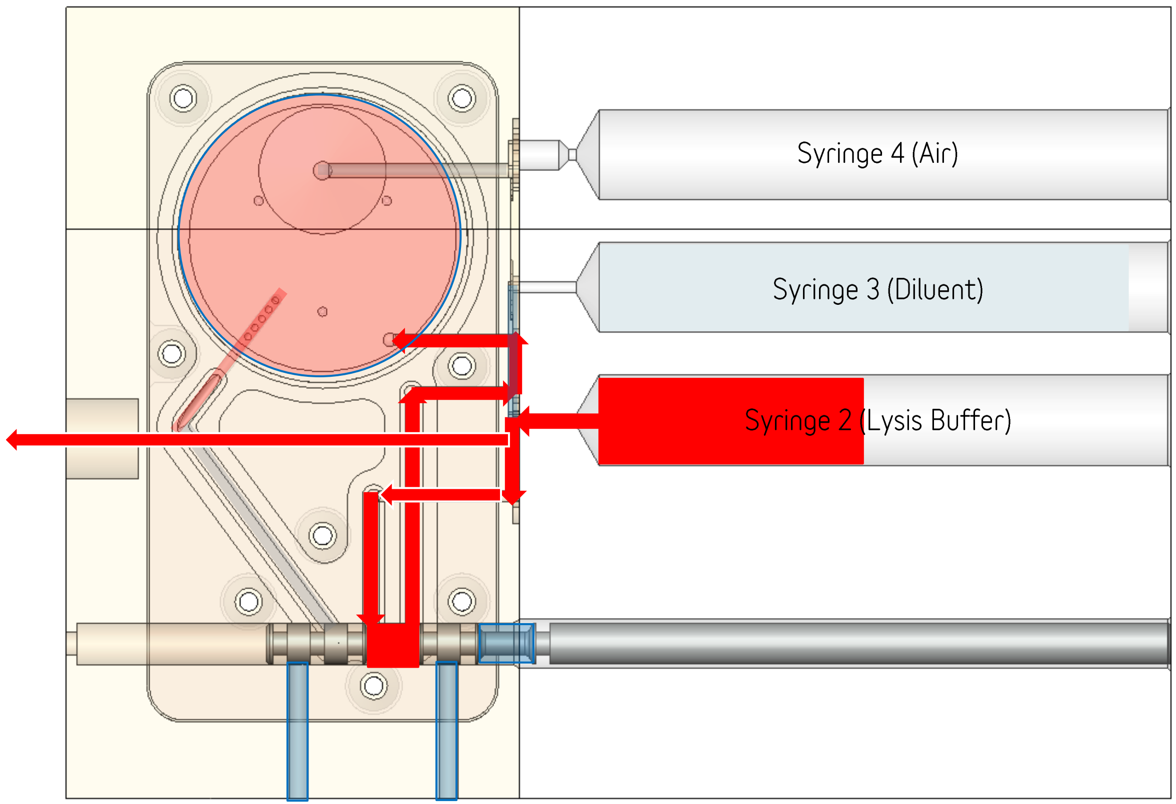
## Lyse-n-Go 4: Puck Bottom – Evacuate Water

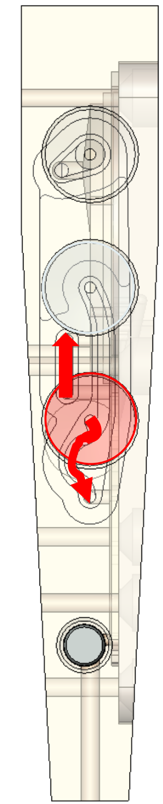


# Cartridge Concepts 2

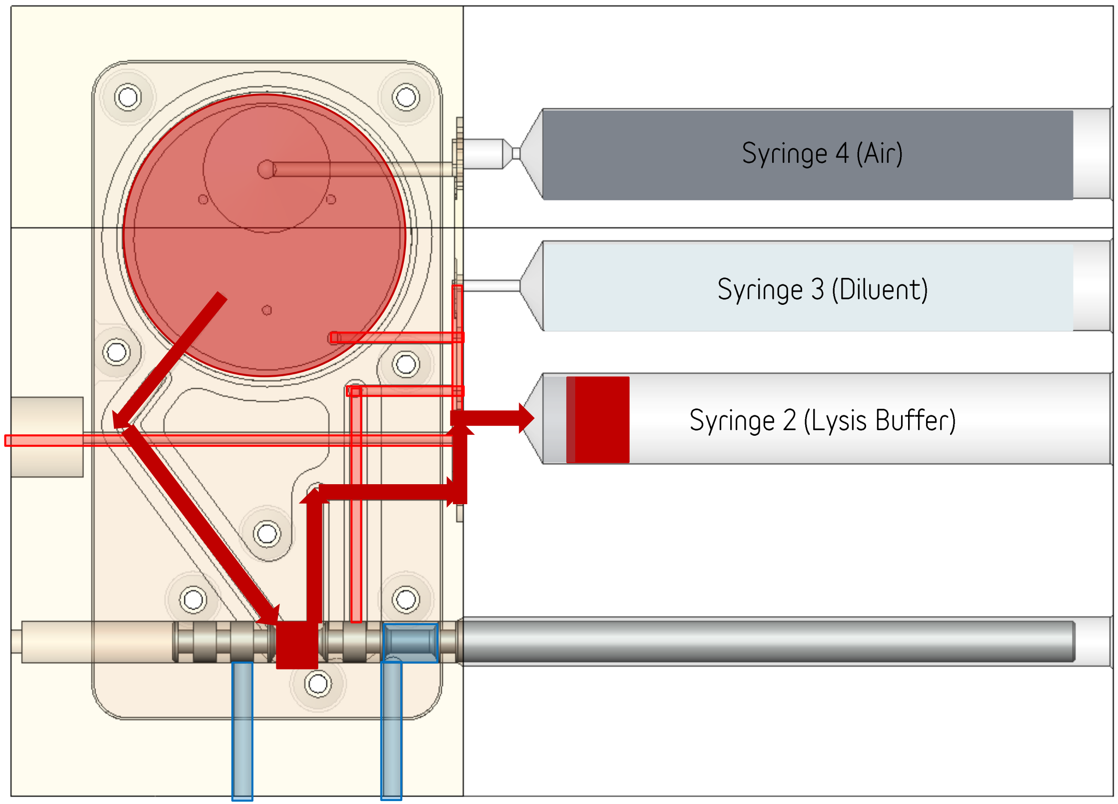
## Lyse-n-Go 4: Puck Side – Add Lysis Buffer & Heat

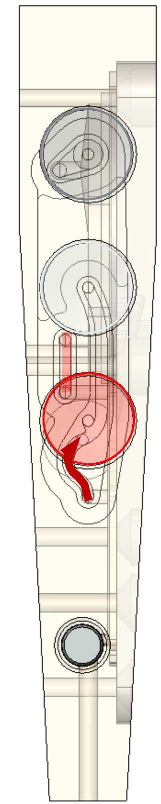


# Cartridge Concepts 2

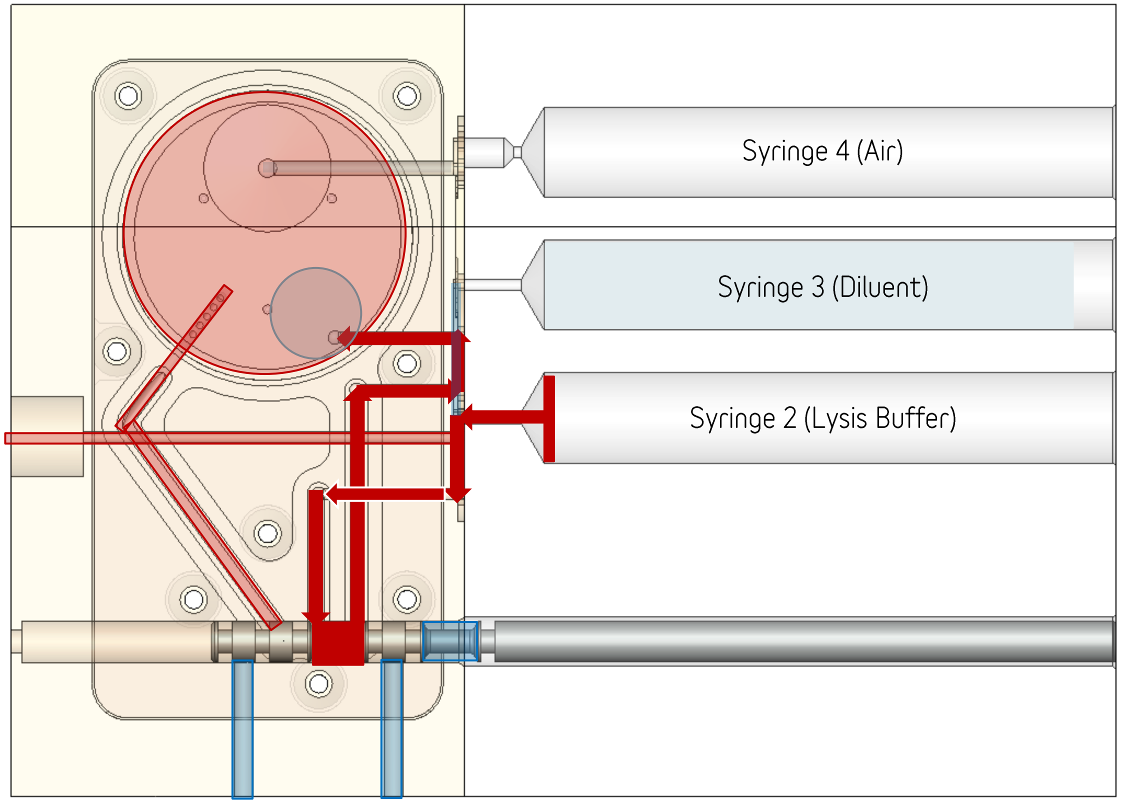
## Lyse-n-Go 4: Puck Bottom – Pull Bubble

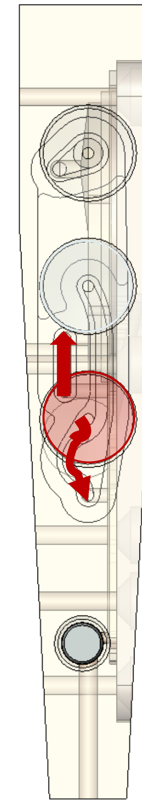


# Cartridge Concepts 2

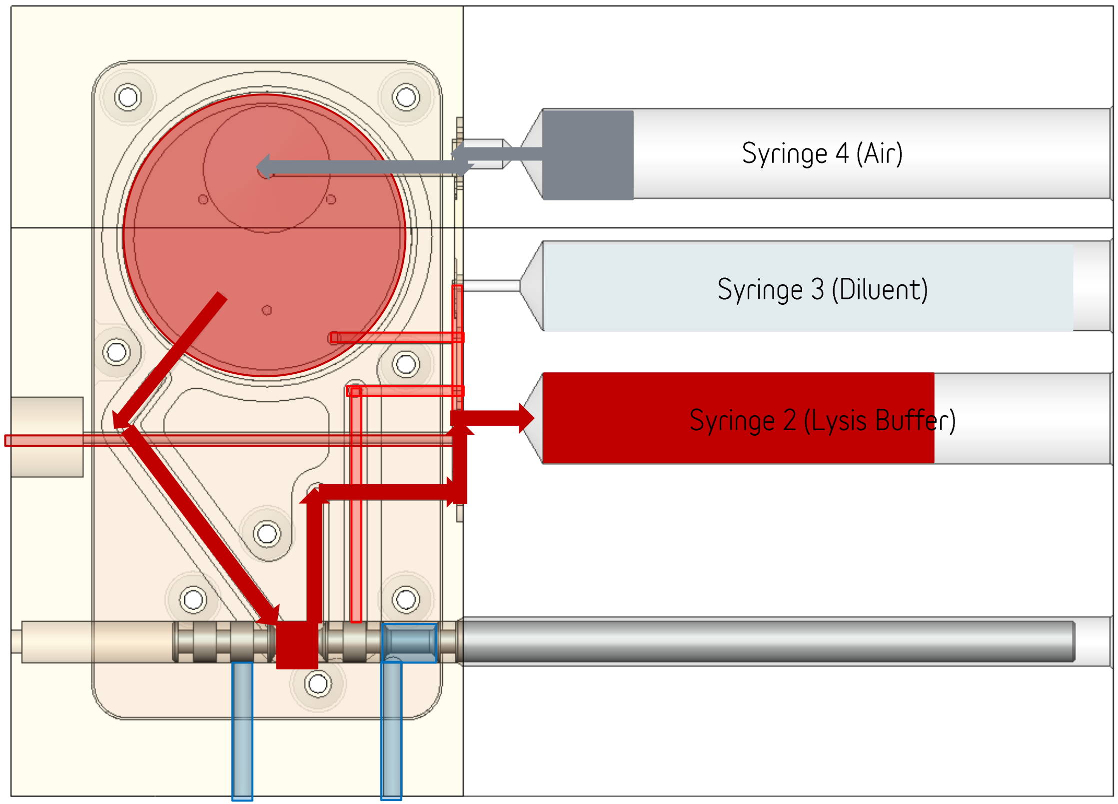
## Lyse-n-Go 4: Puck Side – Push Bubble

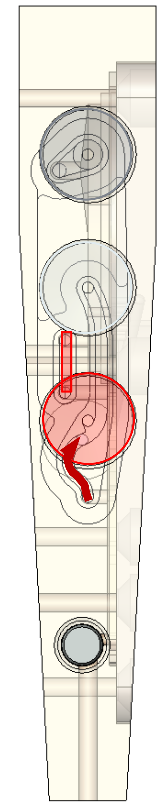


# Cartridge Concepts 2

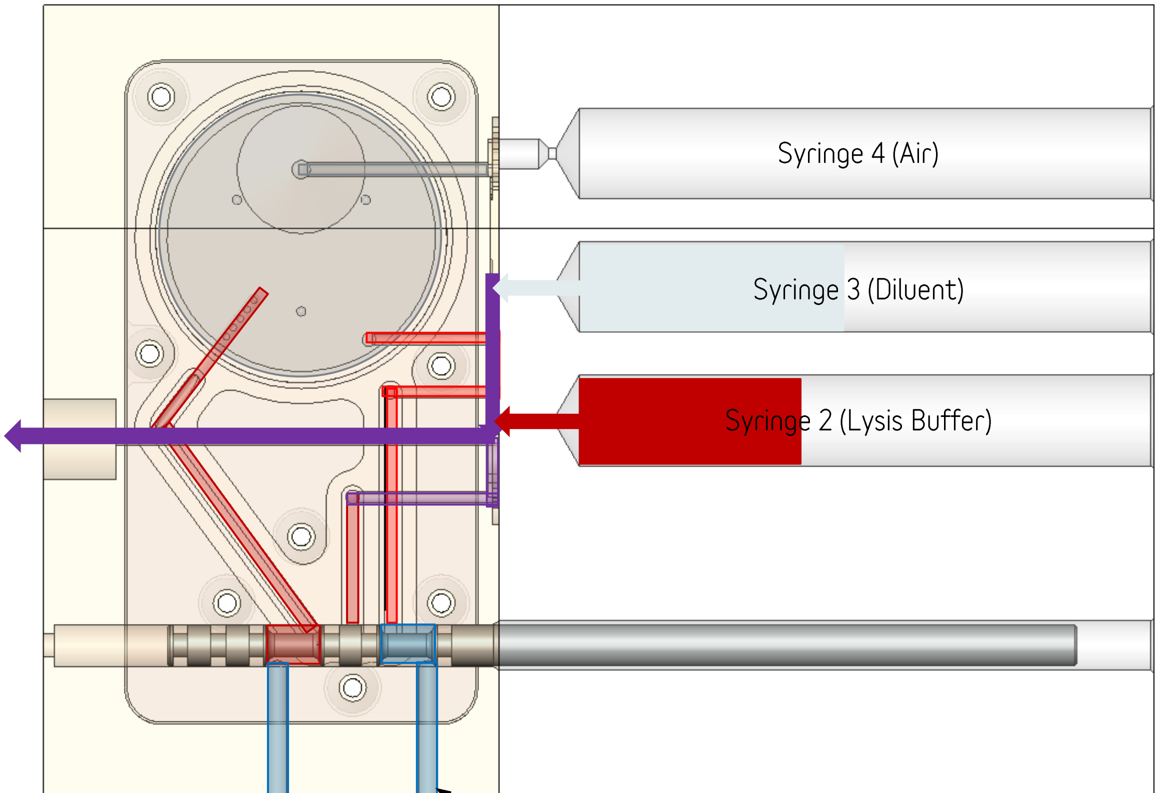
## Lyse-n-Go 4: Puck Bottom – Recover Lysate

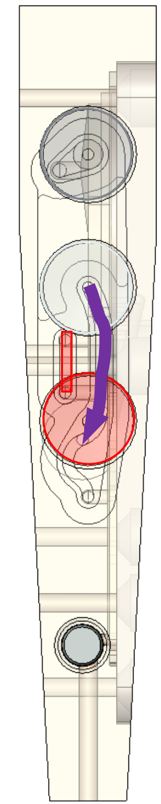


# Cartridge Concepts 2

## Lyse-n-Go 4: Sample – Off Cartridge Analysis



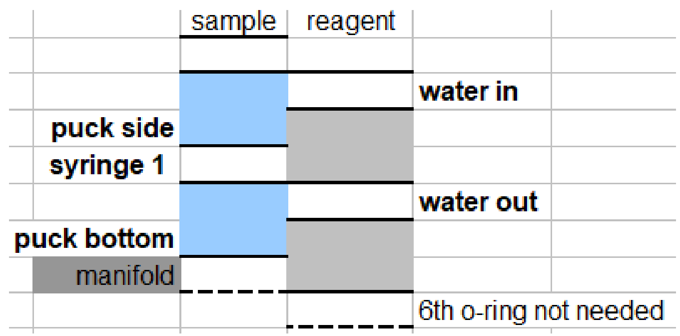



Possibility of lysate diffusing into water in line in toroid

# Archive 0

## Archive 0 (current)

| | action | valve | | | syringe 1 | | | syringe 2 | syringe 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | preservative | | | waste | waste | | |
| | | | | | | | | manifold | | | |
| | | | | puck side | ▼ | | puck bottom | ▲ | | | |
| 1 | sample | sample | → | | | ← | | | | | Water in first to puck side, then water out for free flow |
| 2 | preserve | reagent | | ← | | | → | | | | Empty preservative from syringe 1. Incubate. Pump syringe 1 to push air and displace preservative, plungers not backed up |
| | | | water in | | | water out | | | | | |



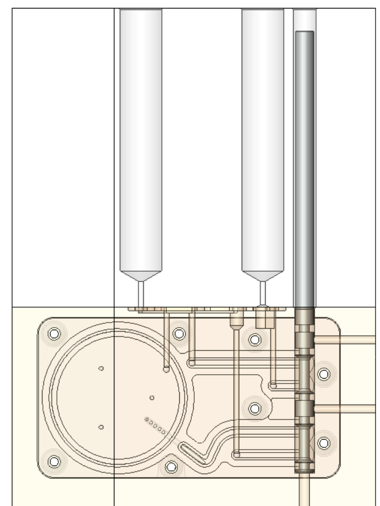

- Syringe 2 & 3 can be combined into a larger syringe 3

# Cartridge Concepts 2

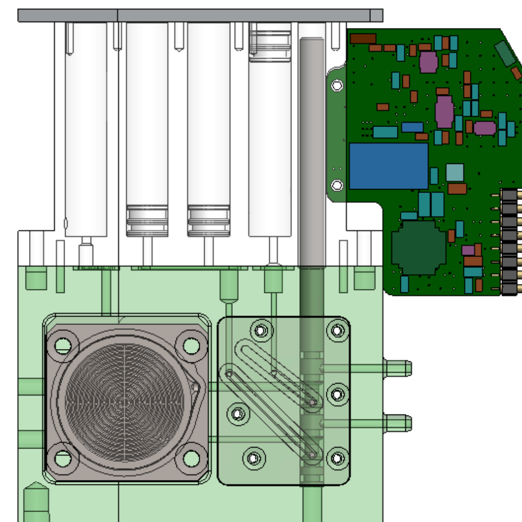
## Archive 0: comparison

Archive 0 Main Differences:

- Syringe 4 removed
- Single waste container (still needs to be enlarged)
- Longer Syringe – +9mm (optional)
- Water in location moved up – 2.7mm, water out same as current
- Bi-directional 3-state valve eliminates two check valves
- Puck top and cover integrated into housing
- Channels moved to the back side



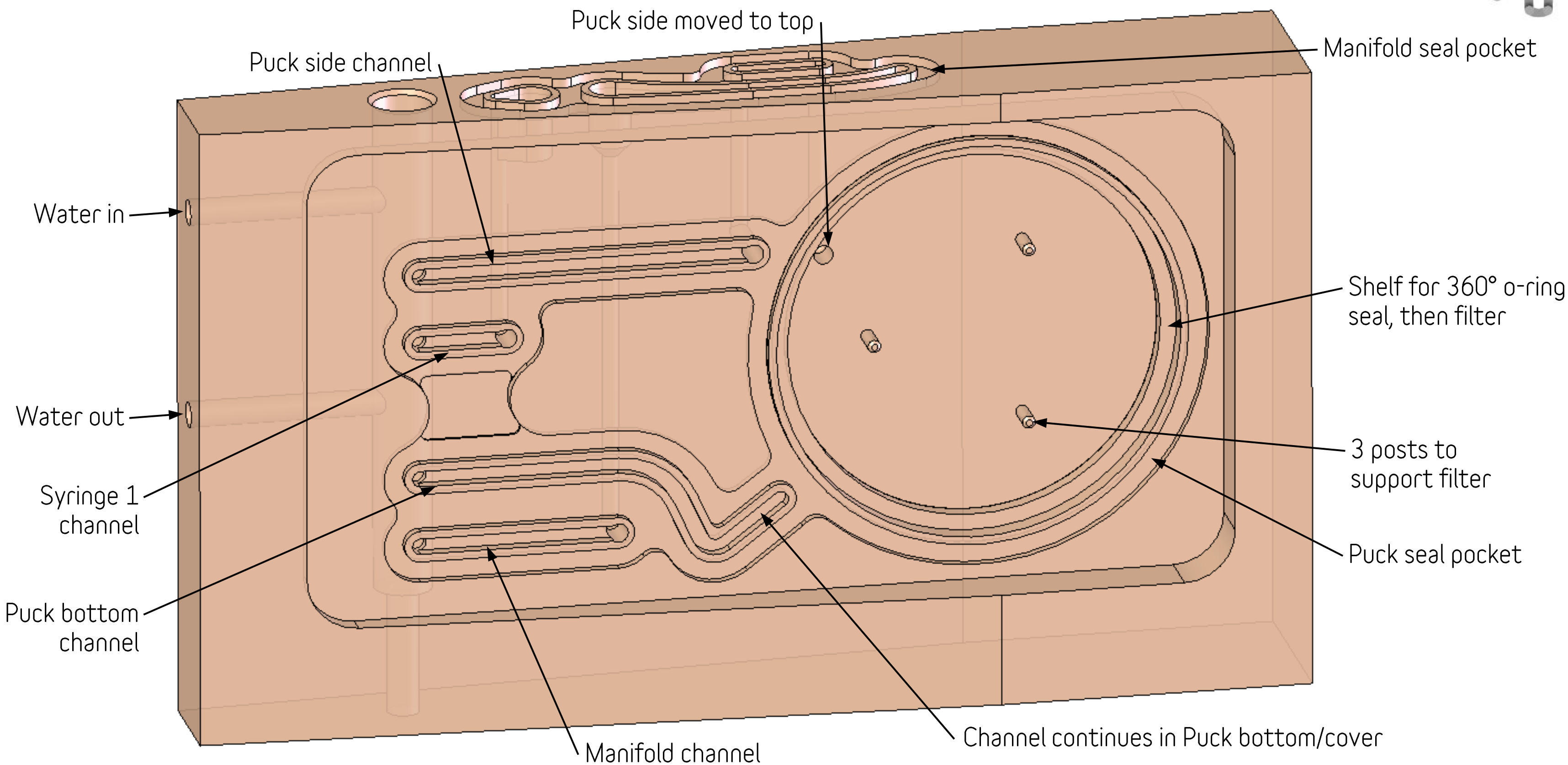
Archive 0: layout only)



Current

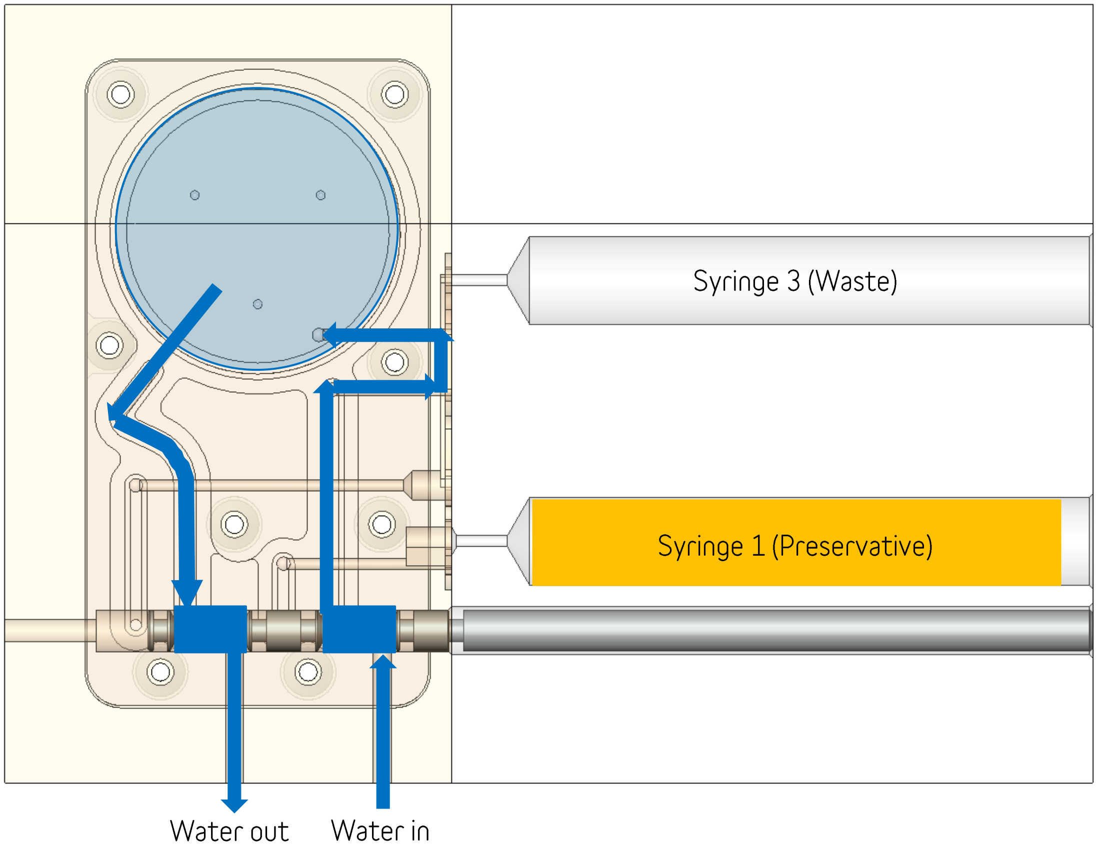
# Cartridge Concepts 2

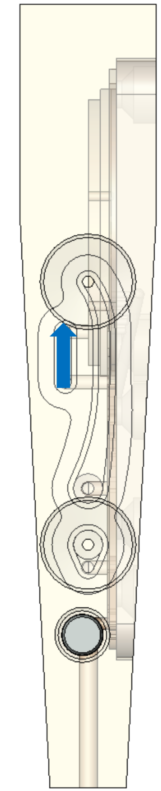
## Archive 0 Cartridge



# Cartridge Concepts 2

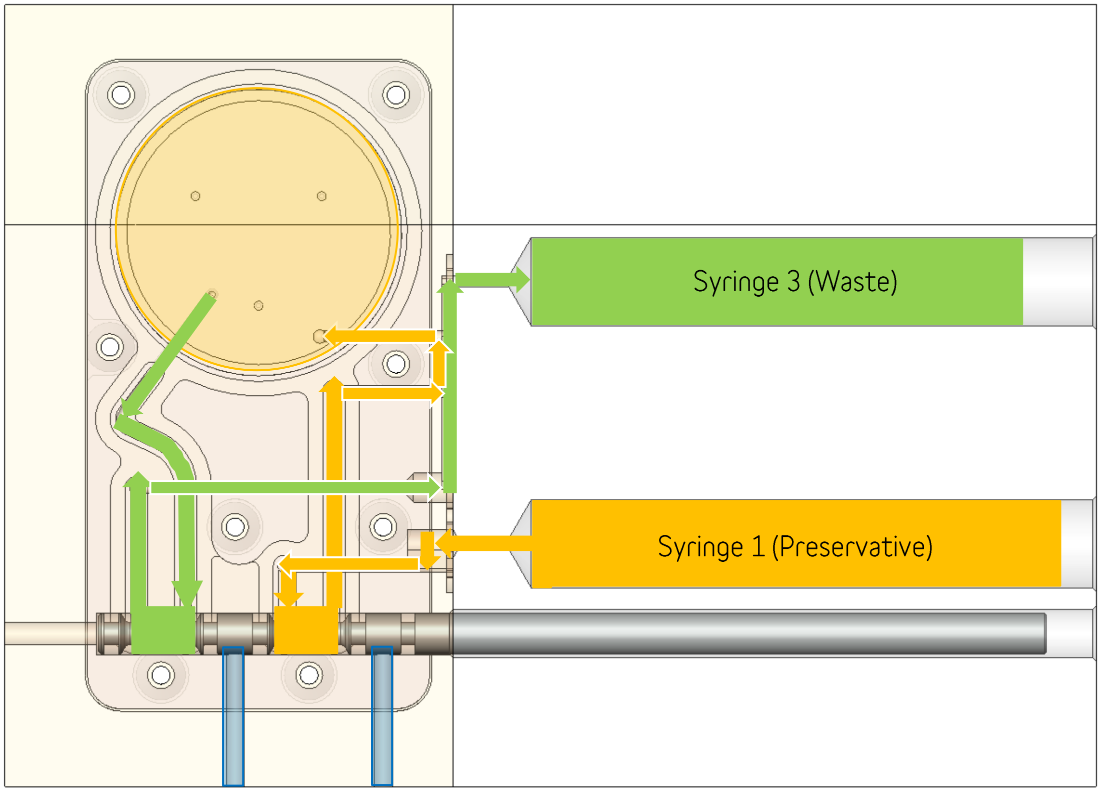
## Archive 0: Sample - Sampling

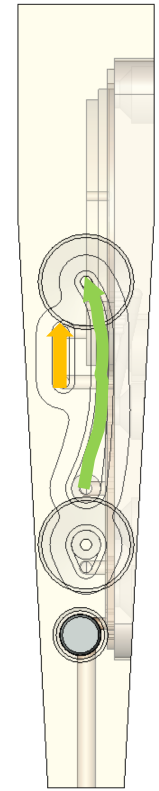


# Cartridge Concepts 2

## Archive 0: Reagent – Preserve Sample



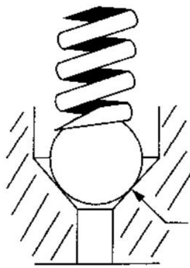
# Next Steps/Questions

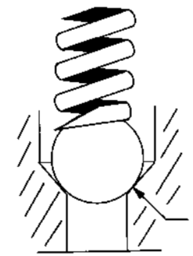
# Cartridge Concepts 2

## Questions

- If the bottom of the syringe can move down, how should we best take advantage?
  - Move Syringe vs. Actuator interface to increase plunger travel or reduce envelope?
  - Reduce syringe diameter and friction force while keeping the same volume?
  - Increase syringe length and total volume?
- Can the actuators move closer together?  Any future value in being able to fit 5 syringes?
  - Re-defining the interface to allow up to 5 syringes (if feasible), does not obligate current cartridges to have more syringes than needed
- Archival cartridge waste volume
- Re-evaluation of the ball valve is recommended in the next phase
  - What is the origin of the current ball seal geometry?
  - Chemical compatibility?

## Ball Check Valve




A widely used ball seat design consists of an internal conical surface with a through hole. This design has the advantage that the ball will self center as it moves toward the seat. There are two functional variations of this design. In the first, the contact of the ball is tangent to the cone. Machining tolerances for this design can be liberal as the ball contact only needs to fall somewhere along the conical surface (see Figure #2.). For this design to work well, the cone must be machined very round.

The second version of the conical seat has the ball making contact right at the intersection of the cone and the through hole. Using the same conical angle this design yields much higher sealing forces. Therefore, a leak free valve is easier to produce, while still maintaining the good self-centering of the ball and the quick reaction of the valve. The machining tolerances for this design are quite tight, as the ball must end up exactly at the intersection of the cone and the through hole (see Figure #3). This design requires a very round cone and through hole and good concentricity between them.

A design question that must be answered is what should the angle of the conical seat be? There are several factors involved. The steeper the angle the better the balls self-aligning tendency will be. The steepness of the angle must be tempered by the fact that the ball must be released from the seat when the flow reverses. The flatter the seat angle the crisper the ball release will be, but as the included angle increases the sealing quality is reduced. The majority of ball seats have an included angle of 90 degrees, which is 45 degrees per side, or very near it.

- www.precisionballs.com/ball_valve.php

## Ball Check Valve

### *Plastic Balls*

In a closing note, we will look at using balls made of highly resilient materials such as rubbers and plastics. Rubber still finds some applications in low-pressure devices, but it has been replaced by much less expensive plastics in most applications.

### *Density of Plastic*

One common consideration is the specific gravity or mass of the plastic ball material. Polyethylene and polypropylene have specific masses of approximately .98 so they will just float in water. Polyethylene is slightly softer and more resilient, while polypropylene is harder and tougher. Both materials have good resistance to organic solvents as well as moderate acids and bases. Both are low cost materials that we stock in most sizes.

For heavy-duty applications, Nylon is the hands down favorite. It is fairly hard, very tough i.e. wear resistant and we stock finish ground balls in most sizes. Nylon is resistant to most organic solvents as well as mild acids and bases. Nylon does have a problem in aqueous solutions, as it is slightly hygroscopic and will swell about 1/4 of one percent ( 0.25% ).

### Teflon

For very high and very low temperatures → PTFE is the obvious choice. PTFE has a high density, i.e., it is heavy. We stock precision ground PTFE balls in most sizes. PTFE is not cheap, it is several times as expensive as most other plastics. There is another problem, PTFE can cold flow under heavy pressure and may not come out of the seat after a long exposure to a high-pressure condition. Care must be exercised in the seat design when using this material. A ball tangent to a rather large conical angle is the normal design.

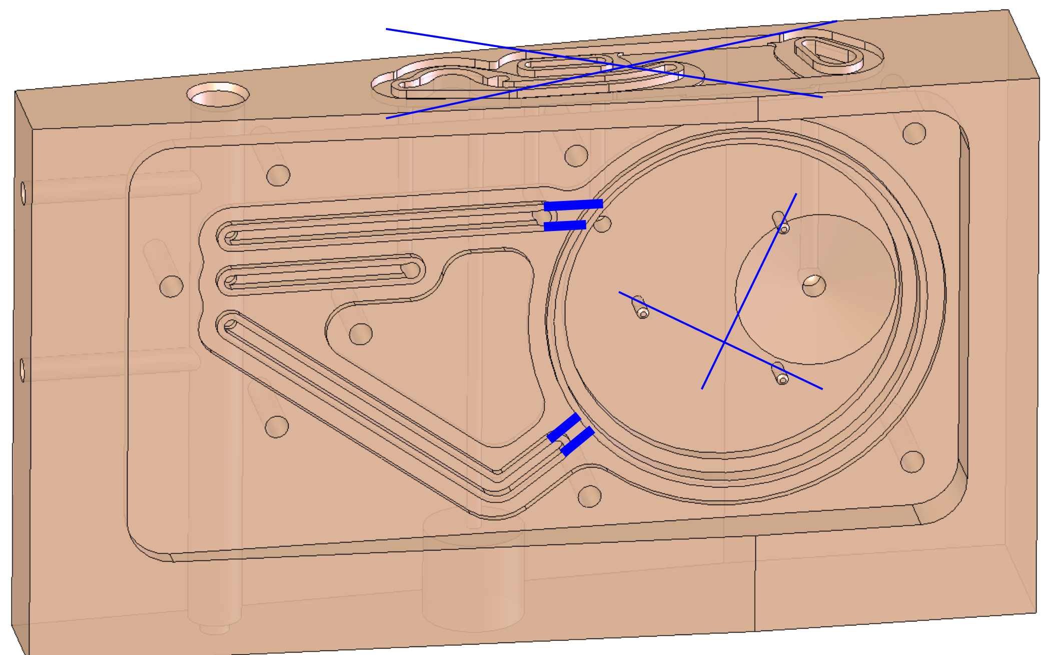
| | Minimum Temp., °F | Maximum Temp., °F | Acetic Acids | Animal/Veg-etable Oils | Detergents | Gasoline | Grease | Hydraulic Oils | Isopropyl Alcohol | Salt Water | Steam | Synthetic Lubricants | Water | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Multipurpose** | | | | | | | | | | | | | | |
| Neoprene | 0° | 200° | | | • | | | | • | • | | | • | |
| **High Temperature** | | | | | | | | | | | | | | |
| Silicone | –60° | 400° | • | | • | | | | • | • | | | • | |
| **Oil Resistant** | | | | | | | | | | | | | | |
| Buna-N | –20° | 170° | | • | • | • | • | • | • | • | | | • | |
| Buna-N/Vinyl | –20° | 200° | | • | • | • | • | • | • | • | | | • | |
| **Chemical Resistant** | | | | | | | | | | | | | | |
| Viton® Fluoroelastomer | 0° | 400° | | • | • | • | • | • | • | • | • | • | • | |
| Aflas | 40° | 400° | | | • | • | | • | • | • | • | • | • | |
| Fluorosilicone | –65° | 450° | | • | | • | • | • | • | • | | | • | |
| Kalrez | 0° | 525° | • | • | • | • | | • | • | • | • | | • | |
| **Abrasion Resistant** | | | | | | | | | | | | | | |
| Polyurethane | –10° | 200° | | • | | • | • | | | | | | • | |
| Natural Gum | –20° | 140° | | | • | | | | • | • | | | • | |
| SBR | –20° | 170° | | | | | | | | • | | | • | |
| **Weather-Resistant** | | | | | | | | | | | | | | |
| EPDM | –40° | 225° | • | | • | | | | • | • | • | | • | |
| Butyl | –40° | 225° | • | | • | | | | • | • | • | | • | |
| Santoprene | –50° | 250° | • | | | | • | | | • | | | • | |

- Ball valves typically use precision metal or ceramic balls in precisely lapped valve seats
- Softer ball/seat materials can seal with looser tolerances and easier manufacturing
  - Needs evaluation for chemical compatibility, performance, and manufacturability
- www.precisionballs.com/ball_valve.php, www.mcmaster.com/balls

# Cartridge Concepts 2

## Next Steps

- We suggest a breadboard prototype of a simplified LnG4 cartridge, cover, and valve to develop cut flat seals that hold seal pressure
- We would try different materials and seal compression



# Appendix

# Cartridge Concepts 2

## Appendix

Five state uni-directional valve