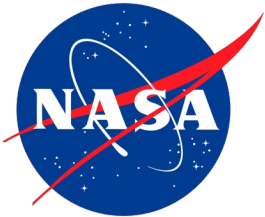


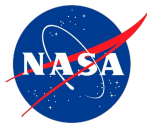
CDC Bioreactor Configuration Method for Volume Level Control with Controlled Inlet and Outlet Flow

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7.16.23

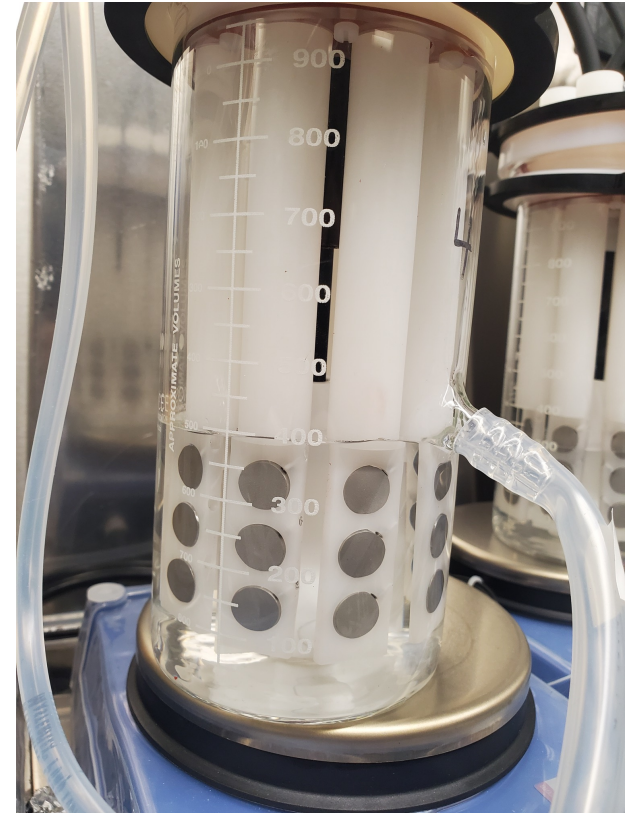


Introduction

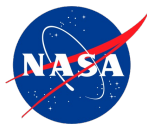


Environmental Control Life Support Systems and other groups that perform microbiological biofilm studies often utilize small scale bioreactors. One of the popular choices for a small scale bioreactor is the BioSurface CDC bioreactors. These bioreactors have an ASTM standard, ASTM E3161-21, that describes how to operate them, in which the reactors are gravity drained through the outlet port located around the 350 - 400 mL volume line.

Marshall Space Flight Center's test stand required a larger fluid volume and thus designed a mechanism to restrict the flow out of the reactor until a desired volume was reached.

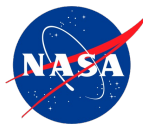


CDC BioSurface Bioreactor



- 8 polypropylene sample coupon rods, with three sample coupons per rod
- Baffle stir bar for continuous stirring
- Thermowell to pair with a stir plate for heating
- Anaerobic variation of the CBR 90 bioreactor
- 1L capacity

Standard Operation of the CDC Bioreactors



- Each bioreactor has an inlet connection that is in-line with a peristaltic pump to control flow rate
- The inlet line has a flow break to prevent contamination with the bulk fluid
- The bioreactor is stirred and heated by a stir plate and the inlet line is connected to the top of the bioreactor
- The outlet is connected to a waste tank and is gravity drained

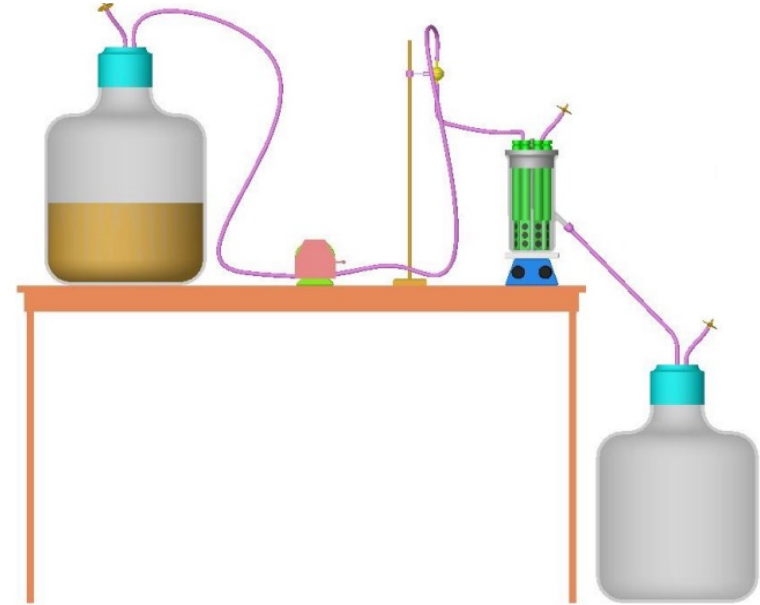
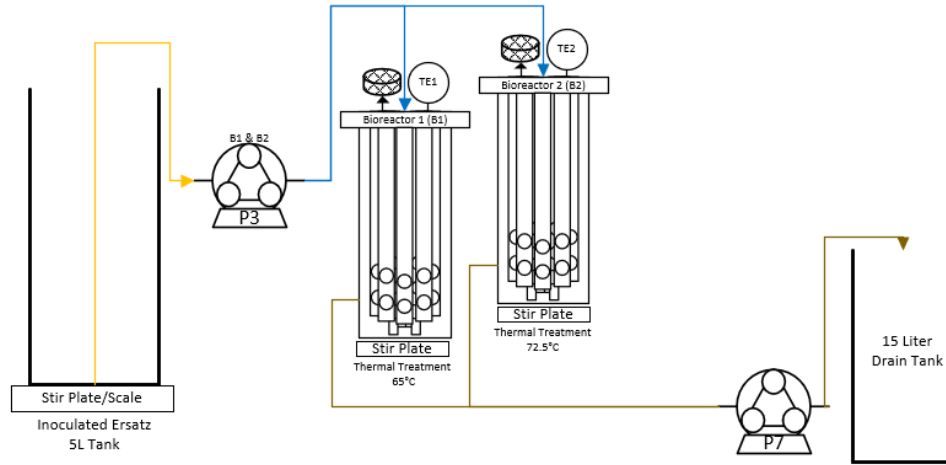
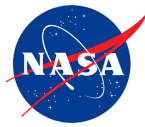


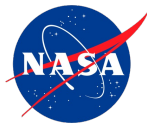
Image credits: P. Norris and BioSurface Technologies

MSFC Operation of the CDC Bioreactor



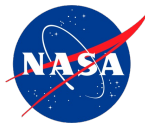
- A single peristaltic pump fed two bioreactors (Due to lack of space and pumps)
- A peristaltic pump downstream of the outlet port
- The downstream pump allowed for stopping the draining of the bioreactors to achieve a higher volume within the bioreactors
- A total of 10 bioreactors were initially used, downsized to 8 for later tests

Initial Volume Control Method



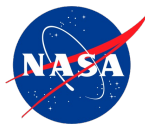
- The downstream pump was initially controlled by using the weight readout from the stir plates
- Used simple conversion of 1 gram to 1 mL, since the working fluid was mostly water
- A DAQ (Data acquisition) device was already in use to continuously record the readouts of the stir plates
- Lightweight and simple addition to the existing test stand

Initial Volume Control Method Results

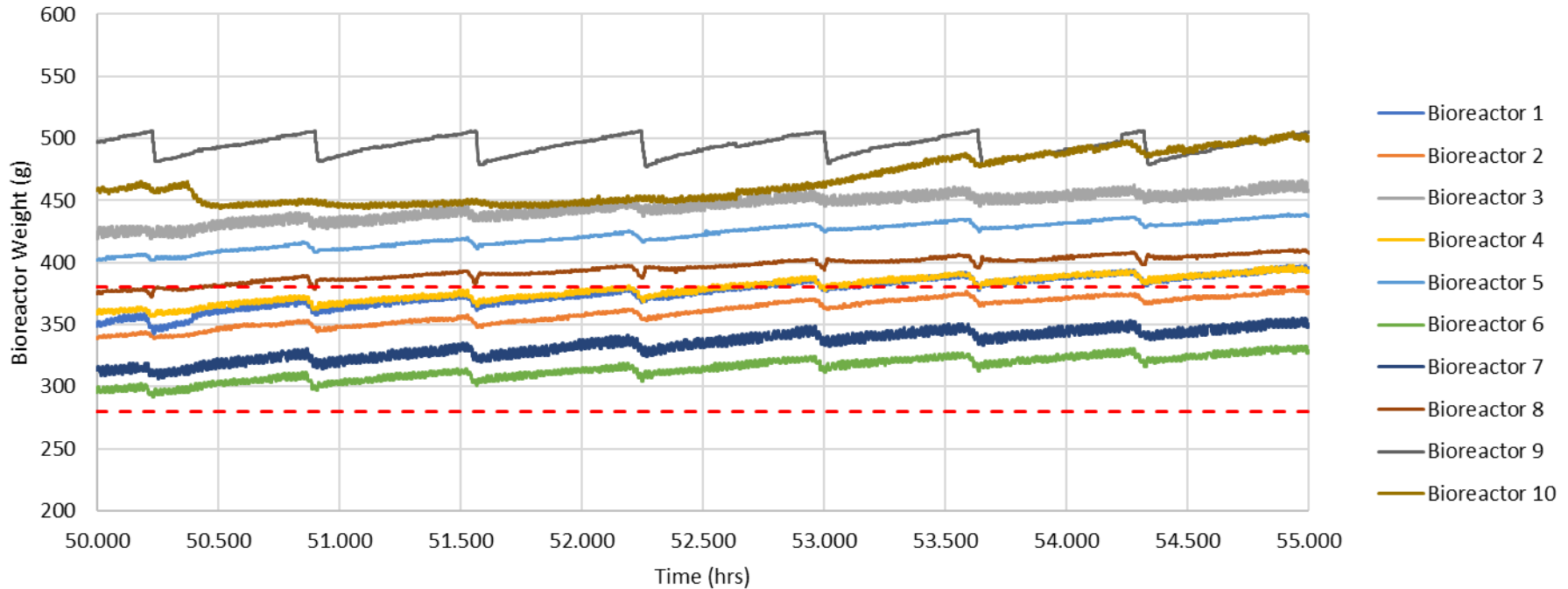


- This method proved to be highly ineffective
- The stir plate weight readouts would drift downwards, such that the actual weight of the bioreactors would exceed the reported weight
- This was determined to be caused in part by both the continuous heating and stirring during weight measurement
- The drifting measurements continued to compound over the test run
- This resulted in several bioreactors continuously draining, yielding the same conditions that would be present if using a gravity drain

Initial Volume Control Method Results

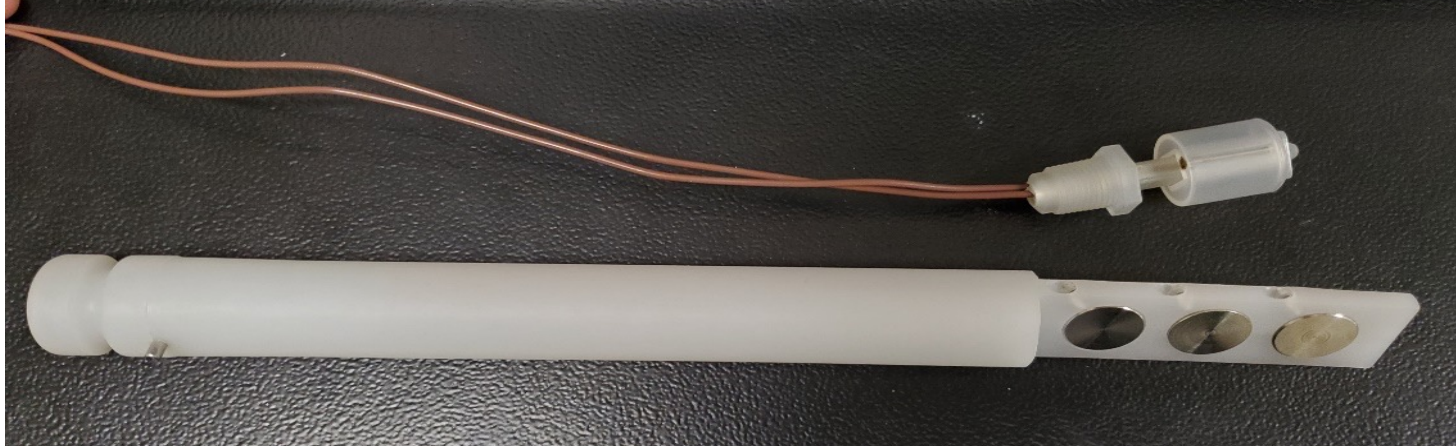


Sample of Level Control Data Collected During First Iteration

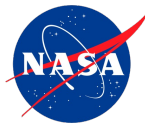


Alternative Method of Level Control

- Several alternative methods of maintaining control over the volume within the bioreactors were investigated
- The control needed to be made of inert material or be noninvasive
- The method chosen was to utilize a small polypropylene float switch
- This float switch directly connected to the DAQ, similarly to the stir plates, and when the switch was floated, the pump would allow the bioreactor to drain



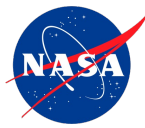
Alternative Method of Level Control



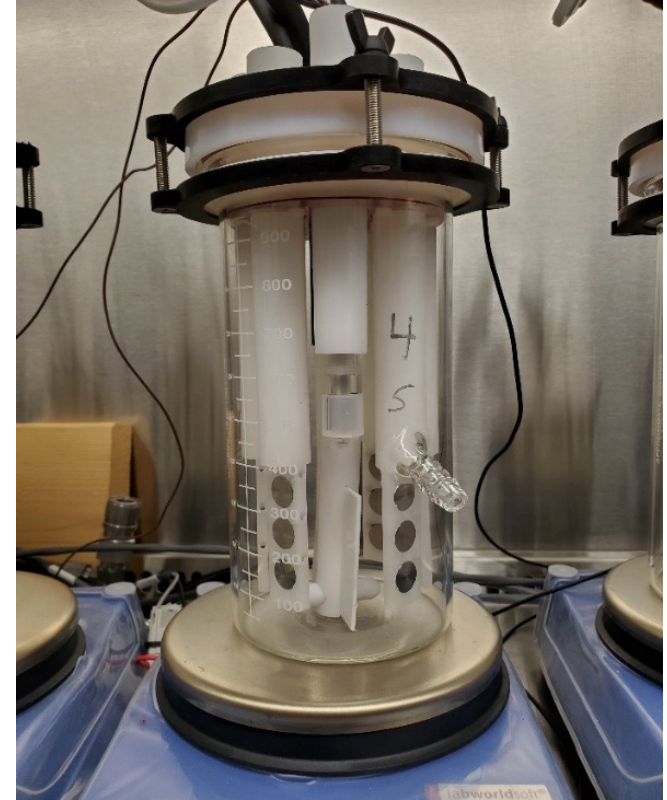
- Several polypropylene rods were machined to create a housing for the float switches
- This allows for the float switch and housing to replace one of the coupon holder rods and to maintain a consistent set point
- The desired liquid volume could then be set by adjusting the height of the float switch and inserting a notch into the housing, so that it does not slide into the reactor



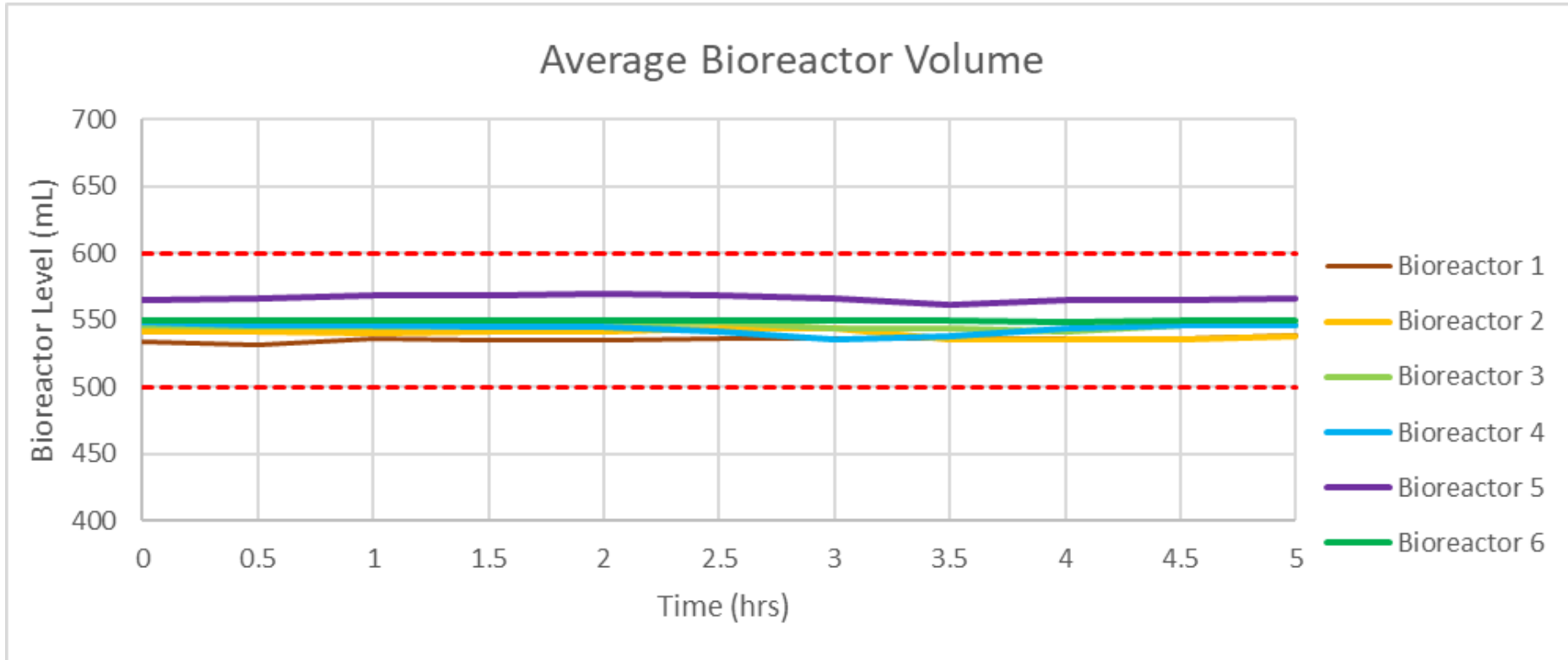
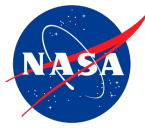
Assembled Float Switch and Bioreactor



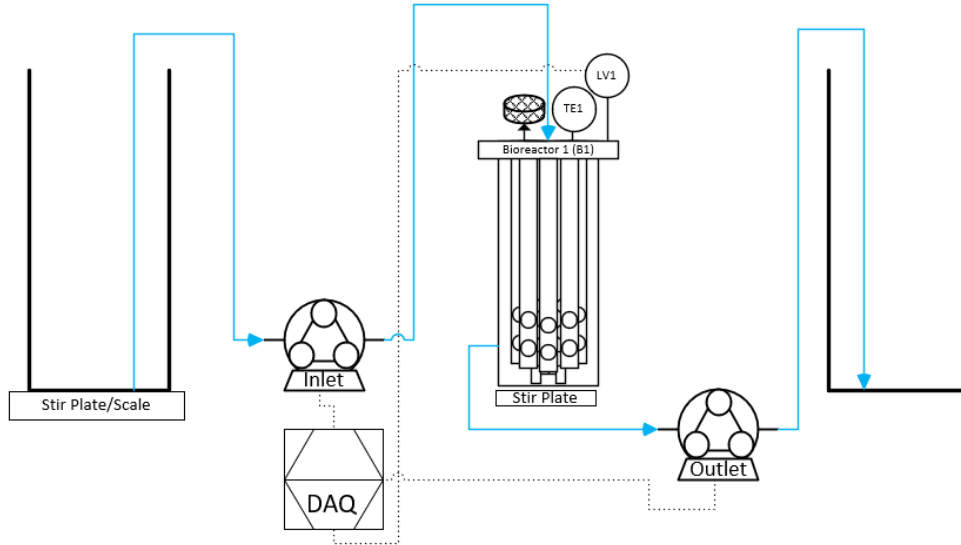
- To validate the stability of the float switches, three sets of data were visually determined and recorded
- Each test run was 5 hours, utilized 6 bioreactors, and used a continuous inlet flow of 10 mL/min
- The averaged results were very stable, with slight changes in volume occurring, but remained close to the desired 550 mL



Float Switch Volume Control Results

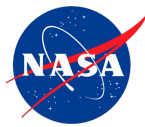


Downsides of the Float Switch Control



- The number of coupon sample rods is decreased to 7
- Introduces complexity to the bioreactor operation
- Requires the use of an additional pump downstream of the bioreactor

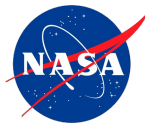
Conclusions of the Float Switch Volume Control Method



- The downsides presented by using the float switch for volume control were acceptable for the test stand that MSFC was operating
 - 6 coupon sample rods were required, so the reduction to 7 was acceptable
 - The test stand already utilized a pump downstream of the drains in order to increase the volume within the bioreactors
 - The test stand was also complex before the addition of float switches, so not much difficulty in operation was added



Future Applications



- Any test that requires an operating volume greater than 400 mL, which is dictated by the height of the outlet port, can benefit from the float switch volume control method
 - Any volume between 400 mL to 950 mL can be targeted by adjusting the height of the float switch within the bioreactor.
- Allow for creation of a flushing or alternating scenario
 - Drained position of 400 mL and a filled position of 700 mL
 - Both the drain and fill rates can be controlled separately, and the filled position volume can be adjusted
 - Recreate a condition of a tank that is continually filled and emptied throughout use

Questions?

Thank you for your time!

