Multi-Chamber BioGator 8000

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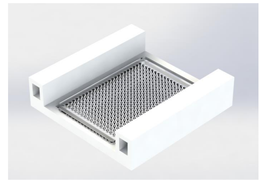
ABSTRACT: Group 7's goal was to design a system that maximizes the number of compartments, each capable of independent temperature control and gas composition regulation, that can be easily added if the budget were expanded. The vertical and modular design utilizes space on the bench top efficiently. A custom pipette with a linear actuator controls the flow of liquid into and out of the pipette for disbursement. Replaceable tips are pressed on and off from a foam block as needed to eliminate cross-contamination. The linear rail system combines a claw for movement of samples and the pipetting system in three-dimensional motion. Two linear rail systems supporting the shaking table are capable of linear, orbital, and double orbital shaking patterns. A custom holder for the well plates and conical tubes allows for the claw to pick up the samples to perform shaking, liquid disbursement, and OD/FI measurements outside of the compartment. A central chiller presents additional cooling capacity that can be used for multiple compartments. Within each enclosure, evaporative cooling comes from a heat exchanger while a cartridge heater supplies heat necessary to maintain the desired temperature. A fan beneath these elements disburses the heating and cooling evenly. The optical density and fluorescent intensity measurements are taken at the stationary laser beam and Photomultiplier tube (PMT) sensor combination. The movement mechanism maneuvers each sample between the two and the measurements are completed.

PRODUCT FUNCTIONALITY: This robot eliminates human intervention from cell culturing and OD/FI measurements. It is a fully autonomous device capable of various functions based on the customer needs. The user inserts the well plate, or the tray of conical tubes, into the compartment and places them into the custom holder that is designed to be able to connect with the robot arm inside the main compartment. Temperature can be adjusted inside the compartment within a range of 4 and 70 degrees Celsius through evaporative cooling and a heating element. A composition of gas can be added to the environment of the compartment to allow cell culturing. After having the cells live in this desired environment, the custom well plate is picked up by the robot arm and goes through different processes such as liquid control where liquid could be added using a pipette system. In addition, the cells needs to go through a shaking process where a designated area inside the main compartment is capable of various types of shaking. Finally, there is a stationary OD/FI measurement device that has full access to the well plate and allows for measurements that backs out the changed properties of the cells after going through the desired environment. This OD/FI system utilizes a laser beam, a filter, and a Photomultiplier tube. The device is capable of collecting measurements and keeping the well plates inside for up to two weeks.

CUSTOM SAMPLE HOLDER

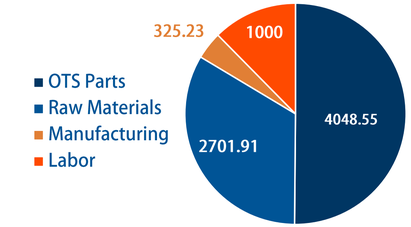
Custom holder for the well plates and conical tubes allow for our custom claw to pickup and transport samples

Clear bottom to aid in OD/FI measurements

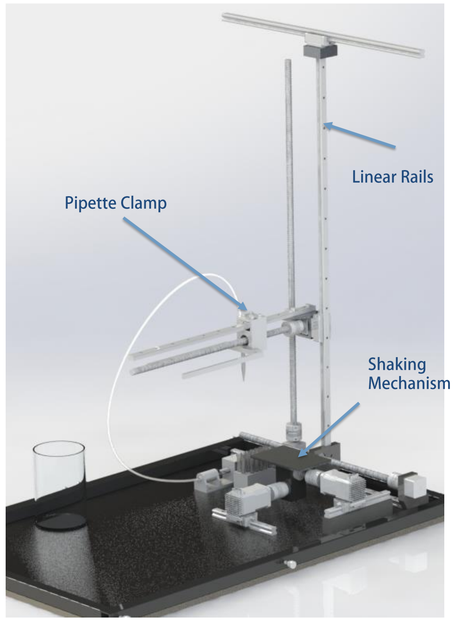


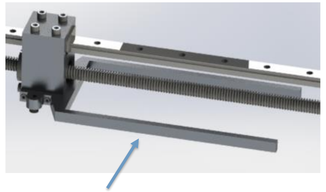
COST OVERVIEW:

Total Cost of $8075.69



MOVEMENT FOR LIQUID DISBURSEMENT





Three Nema-14 stepper motors, each with a lead screw, and linear rails allow for three-dimensional motion

Custom claw picks up samples by utilizing custom made holders

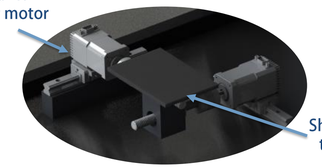
Supplies movement for liquid disbursement, OD/FI measuring, and traveling to the shaking table

SHAKING MECHANISM

Two linear rail system capable of two-dimensional motion

Controlled by 2 Nema-17 stepper motors

Capable of linear, orbital, and double orbital shaking patterns



DISPLAY & USER INTERFACE

Safety button shuts down all activity in the case of emergency.

LCD screen displays visual indicators necessary to program the experiments.

Temperature controllers for each enclosure are displayed.

HOUSING MECHANISM

2 compartments (With the ability to add more)

Easy user access to each compartment to place samples inside

Easy access to waste compartment for disposal

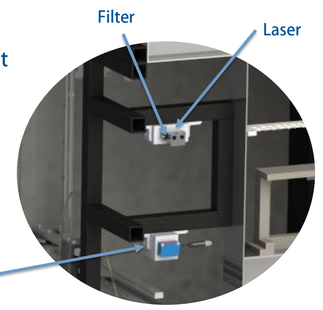
Thumbscrews on removal panels to reduce reach length

OD/FI MEASUREMENTS

Movement mechanism equipped with claw maneuvers samples between the stationary laser and Photomultiplier (PMT) tube combination.

Laser beam equipped with filter sends light through the samples

PMT tube measures light absorption



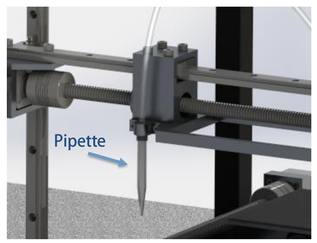
LIQUID CONTROL

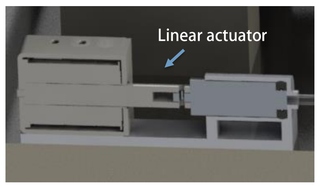
Custom pipette connected to a linear actuator controls flow of liquid in and out of the pipette

Replaceable tips are pressed on and off of the foam block to eliminate cross-contamination

Indentations on the tips compress rubber cylinder to lock on

Reservoir tank holds 1.18 L of required medium





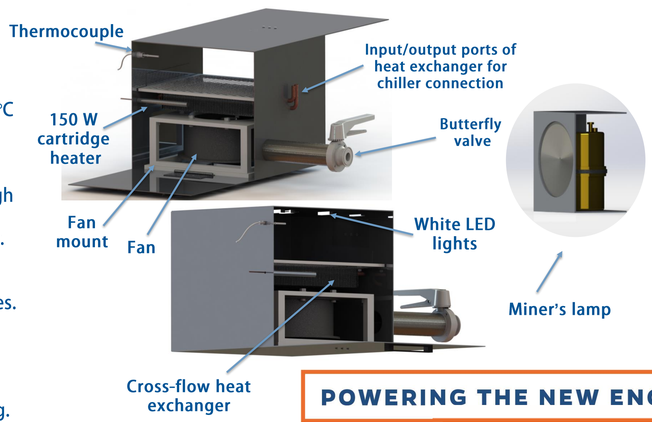
TEMPERATURE CONTROL

Heat transfer from the 150 W cartridge heater to the environment achieves the 70°C requirement.

The central chiller provides cooled fluid that is run through the heat exchanger and achieves the 4°C requirement.

This design reaches the set temperature in just 11 minutes.

The fan, located beneath the heat exchanger, introduces forced convection to evenly distribute the heating/cooling.



GAS COMPOSITION

Butterfly valves equipped with sensors control injecting, measuring, and regulating the composition of gases:
N_2, O_2, CO_2, CH_4, H_2

5 input ports, one for each gas

Miner's lamp used to burn combustible exhaust gas

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POWERING THE NEW ENGINEER

TO TRANSFORM THE FUTURE

- LCD Screen
- Safety Shut Off
- Temperature Controllers
- Electrical Box

Display & User Interface

1	10 year lifetime
2	Cost ≤ $10,000
3	Individual parts ≤ 51 lbs
5	Voltage required ≤ 120 V
8	Programmed with ≤ 20 clicks
9	Visual indicators ≥ 1
10	Has 1 USB port, 8 GB memory, 64 GB storage

- Linear Rails
- Shaking Table
- Stepper Motors
- Lead Screws
- Linear, Orbital, Double Orbital Patterns

Shaking Mechanism

1	10 year lifetime
2	Cost ≤ $10,000
3	Individual parts ≤ 51 lbs
5	Voltage required ≤ 120 V
25	Must fit largest well plate of 127.76 mm x 85.47 mm x 10.40 mm
26	Must fit twenty conical tubes of 15 mL & 50 mL
28	Shakes samples in listed patterns in a time ≤ 30 secs
29	Performs more than 1 independent shaking pattern

- Butterfly Valves
- Pilot Flame
- Sensors
- Tubing

Gas Composition

1	10 year lifetime
2	Cost ≤ $10,000
3	Individual parts ≤ 51 lbs
5	Voltage required ≤ 120 V
16	Supports 2 or more independent enclosures
17	Exhausts gases independently
18	Equipped with 5 sensors, 5 input ports, & 5 output ports
19	Incubation period ≥ 2 weeks
23	ΔT between surfaces & environment ≤ 5°C

- Steel Square Extrusion Frame
- Ambient Light Blocking
- Removable Panels
- Waste Tank
- Electrical Box

Housing Mechanism

1	10 year lifetime
2	Cost ≤ $10,000
3	Individual parts ≤ 51 lbs
4	Shortest side ≤ 24“, longest side ≤ 40" , weight ≤ 5000 lbs, fits through door (36” wide)
5	Voltage required ≤ 120 V
6	Reach length ≤ 2ft, entry points no smaller than 1’x1’
7	Has 1 emergency shut off
13	Splashes and aerosols under 1000 ppm
14	Surface temperature ≤ 30°C
15	Has ≥ ½ gallon waste tank
16	Supports 2 or more independent enclosures
17	Minimizes heat loss
18	Equipped with 5 sensors, 5 input ports, & 5 output ports
25	Must fit largest well plate of 127.76 mm x 85.47 mm x 10.40 mm
26	Must fit twenty conical tubes of 15 mL & 50 mL
27	Has 1 white light

- Claw
- Lead Screws
- Stepper Motors
- Linear rails
- Custom Holder for Samples

Movement for Liquid Disbursement

1	10 year lifetime
2	Cost ≤ $10,000
3	Individual parts ≤ 51 lbs
5	Voltage required ≤ 120 V
11	Materials in contact have pore size ≤ 0.5μm
12	0 reactive materials
15	Has ≥ ½ gallon waste tank
25	Must fit largest well plate of 127.76 mm x 85.47 mm x 10.40 mm
26	Must fit twenty conical tubes of 15 mL & 50 mL
34	Minimum reservoir of 1L
35	Aerosols spreading range < 1000 parts per million
36	225 $\mu L/s$ ≤ fluid dispense rate ≤ 300 $\mu L/s$
37	5 μL ≤ deposited fluid volume ≤ 20,000 μL
38	Dispensing volume accuracy of $\pm 0.1 \mu L$
39	Dispensing volume precision of $\pm 0.01 \mu L$
40	0 cross contamination

- Fan
- Temperature Controller
- Central Chiller
- Heat Exchanger
- Cartridge Heater
- Thermocouple
- Insulation

Temperature Control

1	10 year lifetime
2	Cost ≤ $10,000
3	Individual parts ≤ 51 lbs
5	Voltage required ≤ 120 V
14	Surface temperature ≤ 30°C
16	Supports 2 or more independent enclosures
17	Minimizes heat loss
19	Incubation period ≥ 2 weeks
20	4°C ≤ achievable temperature ≤ 70°C
21	Temperature maintained within ±2.5°C
22	Temperature spatial variation ≤ 2.5 °C
23	ΔT between surfaces & environment ≤ 5°C
24	Time it takes to reach set temperature ≤ 15 minutes

- Pipette
- Linear Actuator
- Solenoid Valve
- Disposable Tips
- Reservoir Tank

Liquid Control

1	10 year lifetime
2	Cost ≤ $10,000
3	Individual parts ≤ 51 lbs
5	Voltage required ≤ 120 V
11	Materials in contact have pore size ≤ 0.5μm
12	0 reactive materials
15	Has ≥ ½ gallon waste tank
34	Minimum reservoir of 1L
35	Aerosols spreading range < 1000 parts per million
36	225 $\mu L/s$ ≤ fluid dispense rate ≤ 300 $\mu L/s$
37	5 μL ≤ deposited fluid volume ≤ 20,000 μL
40	0 cross contamination

- Laser
- PMT
- Filter
- White LED lights

OD/FI Measurements

1	10 year lifetime
2	Cost ≤ $10,000
3	Individual parts ≤ 51 lbs
5	Voltage required ≤ 120 V
27	Has 1 white light
30	Measures OD in more than one sample at a time
31	Measures FI in more than one sample at a time
32	Light intensity ≤ 1 kW/cm3
33	Measurement time ≤ 6.5 minutes

Subsystem
Feature
Customer Need #
Quantified Metric

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