

APPENDIX A
STATEMENT OF WORK
"Custom Glove Box System"

July 6, 2023

1.0 BACKGROUND

The National Renewable Energy Laboratory (NREL) is a national laboratory owned by the U.S. Department of Energy (DOE). NREL is the only federal laboratory dedicated to research, development, commercialization, and deployment of renewable energy and energy efficiency technologies. NREL is managed and operated for DOE's Office of Energy Efficiency and Renewable Energy by The Alliance for Sustainable Energy (Alliance), the "M&O Contractor".

NREL is engaged in a design/build project for a pilot-scale, plasma-enhanced chemical vapor deposition (PECVD) system for producing high surface area silicon nanoparticles (Si NPs) funded by NREL General Purpose Investment and DOE in both applied (EERE-VTO) and fundamental science (SC/BES-CSGB) offices. These Si NPs are useful as active materials in anodes for lithium-ion batteries and in photochemical conversion of light energy to fuels and chemicals. NREL has a decade of experience in growing, handling and manipulating these Si NPs at small scale (<10 g), and the new pilot production PECVD system is capable of synthesizing 1 kilogram (kg) per day. Given their small size (3–30 nm in diameter) and hydrogen surface termination, the Si NPs spontaneously react with oxygen in air. This pilot-scale system will also support and supply several other National Laboratories and researchers, demanding an inventory and supply of pyrophoric Si NPs. A custom, air-free glove box system is required for dry handling and storage as well as wet chemical processing of kg of Si NP material.

2.0 OBJECTIVE

The objective of this work effort is to provide a custom glove box system that provides ample space for the handling, storage and processing of kg's of Si NPs in support of mission goals.

3.0 SCOPE OF WORK

To meet the objective, the Subcontractor shall provide innovative solutions within the following general work scope:

- 3.1. The Subcontractor shall be responsible for the design of a custom glove box system with specifications meeting the general concept requirements shown in Attachment 1, Drawing #001. The system shall be comprised of a single-sided glove box for the handling of dry powder (Dry Box), a dual sided glove box for wet chemical processing (Wet Box), a co-joined antechamber connecting the Wet and Dry Boxes, a custom enclosure mounted on the Wet Box to house a distillation column, and an air conditioning unit for the Wet Box. Both the Dry Box and Wet Box shall have internal, cartridge-based gas purification systems. The glove box system must be Nationally Recognized Testing Laboratory (NRTL) listed or field evaluated by a NRTL.

Go/No Go decision by NREL

- 3.2. The Subcontractor shall manufacture the glove box system after final design approval by NREL.
- 3.3. The Subcontractor shall deliver the complete glove box system to NREL, assist with installation and train NREL staff.

4.0 TASKS

- 4.1 The Subcontractor shall design the Dry Box based on the specifications and drawings provided by NREL (Attachment 1, Drawing #002). The Dry Box shall be single sided with a minimum of 6 gloves. Half the Dry Box (Dry Box A) shall include a 4" tri-clamp feedthrough that can support an approximate 100 Lb load for air-free powder transfer. The other half (Dry Box B) shall be designed with a double height and shelving for storage. Details of the glove box dimensions and layout are provided in Attachment 1, Drawing #002. Required specifications, such as power and facility requirements, are provided in the Addendum. The final design will be approved by mutual agreement between the Subcontractor and NREL.
- 4.2 The Subcontractor shall design the Wet Box based on the specifications and drawings provided by NREL. The Wet Box shall be double sided with a minimum of 16 gloves. Half of the box, Wet Box A, shall be double height with a minimum of 12 glove ports and the other half (Wet Box B) shall be single height with 4 glove access as shown in Attachment 1, Drawing #003. Wet Box A shall be double height for additional storage on shelves on the side panels and include a top-mounted, water-cooled air conditioning unit as well as various feed throughs. Wet Box B shall include a recessed equipment well, a 3"x3" pass through panel (see details in Attachment 1, Drawing #006), as well as support for a separate ventilated enclosure above the Glove Box (see details in Attachment 1, Drawing #004). Required specifications, such as power and facility requirements, are provided in the Addendum. The final design will be approved by mutual agreement between the Subcontractor and NREL.
- 4.3 The Subcontractor shall design an antechamber system that co-joins and services both glove boxes. The antechamber shall have a sliding tray with a capacity of 60 Lb that can pass a 20 L round bottom flask between both glove boxes and external to the glove box as shown in Attachment 1, Drawing #005. Each glove box shall also include a small antechamber for the transfer of the smaller equipment or samples. All antechambers shall be plumbed with NREL-supplied inert gas, not refilled directly from the glove box. The final design will be approved by mutual agreement between the Subcontractor and NREL.
- 4.4 The Subcontractor shall provide an internal, cartridge-based gas purification system for each glove box. The system must be rated to keep each box below 1 part per million (ppm) oxygen and water. The glove box operator must be able to remotely control the integrated blowers circulating glove box atmosphere through the cartridges. The Subcontractor must provide a cartridge exchange program for the replacement of used cartridges. The final design will be approved by mutual agreement between the Subcontractor and NREL.

- 4.5 The Subcontractor shall provide an air conditioning unit to cool the Wet Box atmosphere during high temperature reaction chemistry. This unit shall be water cooled and provide at least 10,000 BTUs of cooling capacity. Full specifications are provided in the Addendum under Wet Box Specifications. The final design will be approved by mutual agreement between the Subcontractor and NREL.
- 4.6 The Subcontractor shall design an enclosure that houses NREL-provided equipment (large-scale condenser columns) that attaches to other equipment (reaction and distillation components) within the Wet Box via the panel feedthrough. The enclosure shall be separately ventilated and purged with inert nitrogen (i.e., not connected to the glove box atmosphere). It shall also have two sealable access doors, exhaust ports, purge ports. Details and dimensions are provided in Attachment 1, Drawing #004). The final design will be approved by mutual agreement between the Subcontractor and NREL.

GO/NO Go Decision By NREL

- 4.7 The Subcontractor shall manufacture and deliver the final glove box system to NREL central Shipping and Receiving. NREL shall deliver shipping boxes from NREL central Shipping and Receiving into the laboratory. Components must be shipped such that the packages (including pallet and pallet jack) fit through a 93" H x 66" W doorway.
- 4.8 The Subcontractor shall conduct system installation (including any required assembly), startup, and provide a 2-hour training session to NREL staff on the operation and maintenance of the glove box system. NREL shall provide all gas piping/tubing to point of use locations specified by the Subcontractor and shall make final utilities connections to the glove boxes. The Subcontractor shall also inspect final installation and sign off on use.

5.0 REVIEW MEETINGS AND TRAVEL REQUIREMENTS

There shall be a project kickoff meeting between technical leads of the Subcontractor and NREL. There shall also be a review meeting of each deliverable from 6.1-6.5 to ensure that design requirements and projects goals will be met. These design meetings shall be held virtually.

Travel is required for Task 4.8 and all costs shall be included within the subcontract. The Subcontractor shall plan for 3 days at NREL including Environment, Health, Safety, and Quality (ESH&Q) training/orientation, glove box system unpacking and assembly, coordination with NREL staff on utilities hookups, system startup, and NREL staff training.

6.0 DELIVERABLES

Deliverable No.	Associated Task(s) No.	Deliverable Description	Due Date and Payment
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6.1 Dry Box Drawing and Specifications	4.1, 4.3	Drawings and schematics that detail the Dry Box design.	2 weeks after award
6.2 Enclosure Drawing and Specifications	4.6	Drawings and schematics that detail the separate enclosure design.	3 weeks after award
6.3 Wet Box Drawing and Specifications	4.2, 4.3, 4.4, 4.6	Drawings and schematics that detail the Wet Box design.	6 weeks after award
6.4 Draft of Complete Glove Box System Drawing and Specifications	4.1, 4.2, 4.3, 4.4, 4.5, 4.6	Drawings and schematics that detail the full glove box system design for NREL review and approval	7 weeks after award
6.5 Final Design Drawing and Specifications	4.1, 4.2, 4.3, 4.4, 4.5, 4.6	Drawings and schematics that detail the full glove box system design implementing feedback and modifications provided by NREL under review of Deliverable 6.4.	10 weeks after award,
GO/NO GO DECISION BY NREL			
6.6 Delivery of system to NREL	4.7	The manufactured system shall be delivered to NREL	24 weeks after award,
6.7 Installation, Startup, and Training	4.8	The system shall be installed, started up, and NREL staff shall be trained on maintenance and operation.	26 weeks after delivery,

DELIVERY OF COMPUTER SOFTWARE CODE (AS APPLICABLE)

All object, source, or other code (including all applicable data sets) developed under this subcontract effort shall be provided to the technical monitor as a condition of final payment, in accordance with the subcontract. It is expected that all delivered source code shall be original and the subcontractor shall provide a written certification to the Technical Monitor that all source, or other code developed and delivered under this subcontract does not contain any open source code - as a condition of final payment in accordance with the subcontract. The subcontractor's (including all lower tier subcontractors, as applicable) certification shall specify that "All source, or other software code developed and/or delivered under this Subcontract No. _____ is original and does not contain any 3rd party or other open source software."

7.0 ELECTRONIC REPORTING REQUIREMENTS FOR SUBCONTRACT REPORT DELIVERABLES

It is NREL's intention to publish subcontract report deliverables containing publicly available information (e.g. non-confidential, non-protected, non-proprietary information) for distribution on the internet.

The subcontractor shall provide the final approved version of report deliverables in accordance with the electronic reporting requirements described below.

The technical monitor may specifically direct the subcontractor to provide reports in one or more of the file format standards provided below:

- 7.1. The subcontractor shall submit all report deliverables (including status, annual, or final reports) as electronic files in Adobe .pdf format, preferably with all graphics and images embedded within the document.
- 7.2. All final approved version submissions shall be delivered to NREL via e-mail to the NREL Technical Monitor.
- 7.3. If it is not possible to include all of the graphics and images (figures, illustrations, and photographs) in the same file as the text, NREL will accept the text in Adobe .pdf formats and the graphics and images as separate electronic graphic or image files*.

The accepted standard for page layout and graphics is the Adobe Creative Suite of programs.

*The acceptable graphic or image file formats are: .eps, .tif, .gif, .jpg, .wmf, .emf, .pct, .png, .bmp, .psd, .ai, .fh, .qif, .fpx, cdr. The preferred resolution for graphics or images is 300 dpi. Include all fonts used in creating the file.

- 7.4. For animation, video, or multi-media elements, CD-ROM, DVR and thumb drive are acceptable technical deliverable media.
- 7.5. For all calculations in support of subcontract reports that are conducted in ASPEN+, an electronic copy of INPUT, REPORT and BACKUP (if Model Manager is used) must be submitted with all reports. Additionally, if costing or sizing calculations are conducted in a spreadsheet [no process calculations (heat and material balances) in spreadsheet format are permitted], a copy of the fully documented MS Excel file shall be supplied.
- 7.6. A fully executed model release shall be supplied to NREL with all photographs and images, regardless of whether such photographs or images are delivered to NREL electronically or in hard copy. Such model release shall certify that the Alliance for Sustainable Energy, LLC, Management and Operating Contractor for the National Renewable Energy Laboratory for the U.S. Department of Energy is granted a non-exclusive, paid-up, irrevocable, worldwide license to publish such photographs in any medium or reproduce such photographs or allow others to do so for United States Government purposes. Model releases are required in all situations in which a reasonable person would respond in the affirmative to the question – could someone, other than the model himself/herself, recognize the person in this photograph or image? All model releases shall be provided to the subcontract associate as a condition of final payment, in accordance with the subcontract. To obtain a Subcontractor Model Release form, please contact images@nrel.gov.

8.0 ACKNOWLEDGEMENTS IN SUBCONTRACTOR PUBLICATIONS

In any scientific or technical report or article, conference paper, journal article, etc. based on or containing data first produced in the performance of this subcontract and published in academic, technical or professional journals, symposia proceedings or similar works, the subcontractor shall use this acknowledgement stating, "This [article, conference paper, journal article, etc.] was developed based upon funding from the Alliance for Sustainable Energy, LLC, Managing and Operating Contractor for the National Renewable Energy Laboratory for the U.S. Department of Energy."

9.0 COPYRIGHT PERMISSION/AUTHORIZATIONS

The subcontractor is responsible for obtaining copyright permissions and/or authorizations for all information and/or data, as applicable that is incorporated into all final technical reports. Electronic copies of these copyright permissions and/or authorizations shall be provided to the at the email address provided below. The subcontractor shall also provide a written certification to the Technical Monitor as to such permissions and/or authorizations as a condition of final payment. The subcontractor's (including all lower tier subcontractors, as applicable) certification shall specify that "I have obtained all necessary and legally required copyright permissions and/or authorizations for any and all information, data, graphs, images, etc., as applicable, that is incorporated into the final Technical Report titled _____, delivered under this Subcontract No. _____. Copies of these permissions and/or authorizations are attached."

10.0 DELIVERABLE ADDRESS:

The subcontractor shall clearly label all deliverables to include:

- The subcontractor's name
- NREL's subcontract number
- NREL Technical Monitor's name
- Deliverable date, and
- Deliverable description.

Electronic deliverables shall be sent via email to the Technical Monitor as follows:

Nathan Neale, Technical Monitor

e-mail: Nathan.Neale@nrel.gov

- One (1) master electronic version, including graphics

Deliverable(s) No. 6.6 shall be shipped to:

National Renewable Energy Laboratory
Attn: Recipients' Name Nathan Neale, Building SERF / Room W132
16253 Denver West Parkway
Golden, CO 80401

Addendum to:
STATEMENT OF WORK
"Custom Glove Box System"
12-June-2023

This document provides detailed technical specifications for the glove box system to be built by the subcontractor for NREL. This document is not intended to be comprehensive of all features for the glove box, but a guiding document that outlines necessary features and design constraints. The subcontractor and NREL shall determine final specifications by mutual agreement as specified in the Statement of Work. The glove box system must be Nationally Recognized Testing Laboratory (NRTL) listed or field evaluated by a NRTL.

Dry Box Requirements	
Atmosphere	Nitrogen
Performance	<1 ppm oxygen and water
Leak Rate	Helium < 1×10^{-6} std cc/sec
Dimensions	See Attachment 1, Drawings #001 and #002.
Sides	Single Sided
Glove Ports and Gloves	Six (6) total. Four (4) on base level and two (2) on raised section. All gloves shall be butyl rubber, 30 mil, ambidextrous. An internal, evacuable glove port cover shall be provided.
Control System	Integrated programmable logic controller (PLC) with touch screen interface. User settable pressure and purge control. Automated monitoring of moisture and oxygen levels. Automatic control of large antechamber. Automated purifier blower fan controls.
Antechambers	One (1) large antechamber shared with Wet Box (Attachment 1, Drawing #005), one (1) dedicated smaller antechamber (see Attachment 1, Drawing #002). All antechambers shall be plumbed with NREL-supplied inert gas, not refilled directly from the glove box.
Feedthroughs	Four (4) KF40 feedthroughs, 4" tri-clamp Sanitary feedthrough on ceiling of glove box (see Attachment 1, Drawing #002).

	Sanitary feedthrough must be capable of supporting a 100 Lb load.
Power	Quadplex junction box, 120 V 20A
Shelving	Telescoping shelves located in Dry Box B (Attachment 1, Drawing #002)
Vacuum Pump	~7 CFM, oil free, 5 mTorr base pressure, scroll pump, 120V

Wet Box Requirements	
Atmosphere	Nitrogen
Performance	<1 ppm oxygen and water vapor
Leak Rate	Helium < 1x10 ⁻⁶ std cc/sec
Dimensions	See Attachment 1, Drawings #001 and #003.
Sides	Double Sided
Load Requirements	Wet Box A must support load Air Conditioning unit and recirculating water. Wet Box B must support load of Ventilated Enclosure, Feedthrough, and 37 L water.
Air Conditioning (AC)	Water cooled AC unit, 10,000 BTU cooling, mounted to top of Wet Box A (Attachment 1, Drawing #003). Unit must achieve the specified cooling capacity using a water inlet temp = 75 °F; water flow = 1.7 GPM maximum; and water pressure = 1.4 PSI maximum.
Equipment Well	Wet Box B shall include a welded, ~35" L x ~23" W x ~12" D equipment well. Well must be capable of supporting a total load of 100 Lbs.
Glove Ports and Gloves	Sixteen (16) total. Five (5) per side on base level and three (3) per side on raised section. All gloves shall be butyl rubber, 30 mil, ambidextrous. An internal, evacuable glove port cover shall be provided.
Control System	Integrated programmable logic controller (PLC) with touch screen interface. User settable pressure and purge control. Automated monitoring of moisture and oxygen levels. Automatic control of large

	antechamber. Automated purifier blower fan controls.
Antechambers	One (1) large antechamber shared with Dry Box (Attachment 1, Drawing #005), one (1) dedicated smaller antechamber (Attachment 1, Drawing #003). All antechambers shall be plumbed with NREL-supplied inert gas, not refilled directly from the glove box.
Feedthroughs	Four (4) KF40 feedthroughs, four (4) 3/8" tube bulkhead fitting for liquid connections, custom removable feedthrough for enclosure (Attachment 1, Drawing #006). Feedthrough must accommodate a load of 50 Lbs.
Power	120 V 20A Quadplex junction box and a separate dedicated 120V/20A junction box
Shelving	Telescoping shelves located in Wet Box A (see Attachment 1, Drawing #003)
Vacuum Pump	~7 CFM, oil free, 5 mTorr base pressure, scroll pump, 120V

Ventilated Enclosure Requirements	
Location	Mounted flush on top of and fully supported by Wet Box B.
Dimensions	A minimum of 28" L x ~14" W x ~46" H with a maximum no greater than 3" more than these values in any direction. See Attachment 1, Drawing #004.
Ventilation	2.25" diameter ventilation stub. See Attachment 1, Drawing #004.
Gas and Liquid Feedthroughs	Four (4) water input/output valves and two (2) gas input valves shall be provided. All valves shall be 1/2" NPT with quarter-turn shutoffs located outside the enclosure.
Doors	The enclosure shall include two (2) hinged doors with latches. The door material construction shall be optically transparent and offer the same chemical robustness as the glove box windows.

	The doors shall be gasketed such that the enclosure withstands 1.5" WC pressure.
Enclosure Sealing	The enclosure shall have be of welded construction and be leak-tight such that it may serve as secondary containment for liquid spills up to 37 L in volume. Thus, the welded section below the Doors shall be at least 9.5" H using the minimum dimensions listed in the Dimensions. See Attachment 1, Drawing #004.

Attachment 1

1. Two sided 4" Sanitary feed through
2. 100 lb load

- Large antechamber (See drawing 005):
- accommodate a ~60Lb, 20L spherical glass flask!
 - Sliding tray in/out of glove box
 - Minimize door swing area

10,000BTU Box cooler
Water inlettemp:75F
Water flow: 1.7GPM max
Water pressure: 1.4PSI max

Four $\frac{3}{8}$ in. SS tubes for solvents delivery (see drawing 003)

- Enclosure (See drawing 004):
1. Two hinged Doors with latches
 2. Secondary containment for 37L
 3. Window/door material same as glove box windows
 4. Withstand 1.5" WC pressure

$\frac{1}{2}$ in NPT On/OFF valve
Two $\frac{1}{2}$ in NPT water input/output
One $\frac{1}{2}$ in NPT N2 input

- See drawing 006 to accomidate feed through
- Two sided flat glass feed through
 - 50lb load

105.2in

Dry Box A

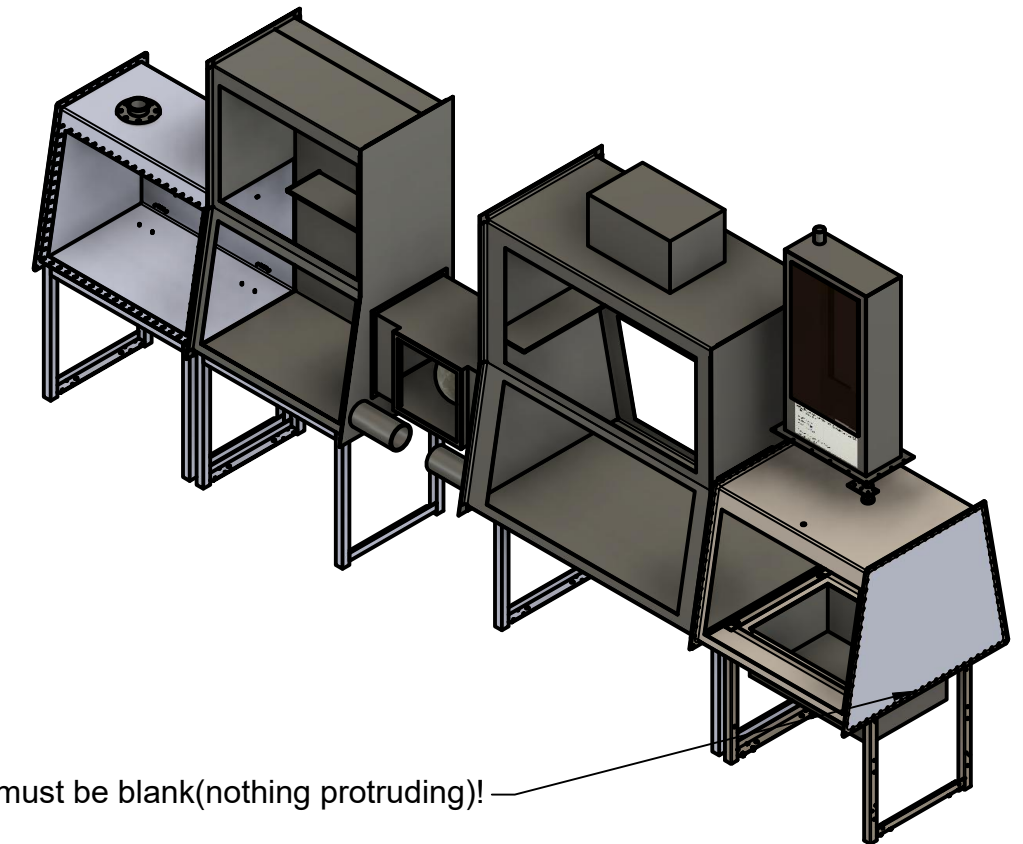
Dry Box B

Wet Box A

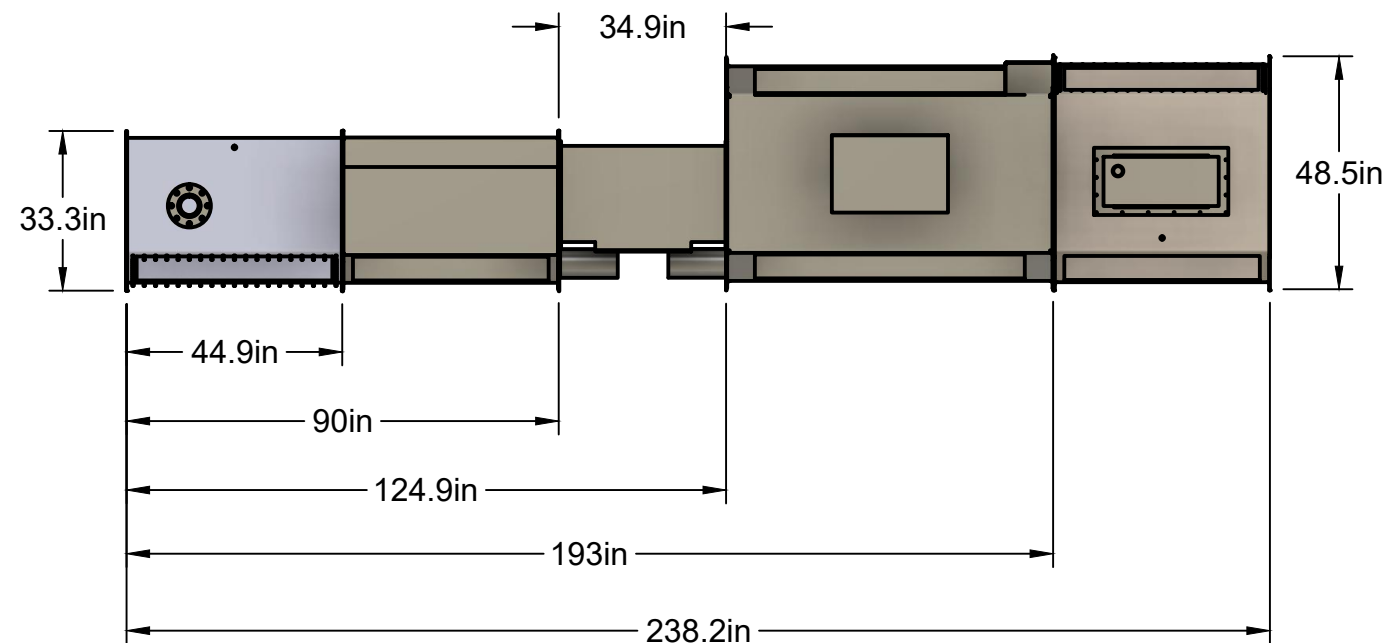
Wet Box B

Two Small antechambers

35"x23"x12" open bottom box



Side of box must be blank(nothing protruding)!



**Glove Box System Overview.
Drawing #: 001**

Two sided 4" Sanitary feed through

Large antechamber (See drawing 005):

10,000BTU Box cooler

SS tubes for solvents delivery (see drawing 003)

Ventilated enclosure (See drawing 004):

105.2in

See drawing 006 to accomidate feed through

Dry Box A

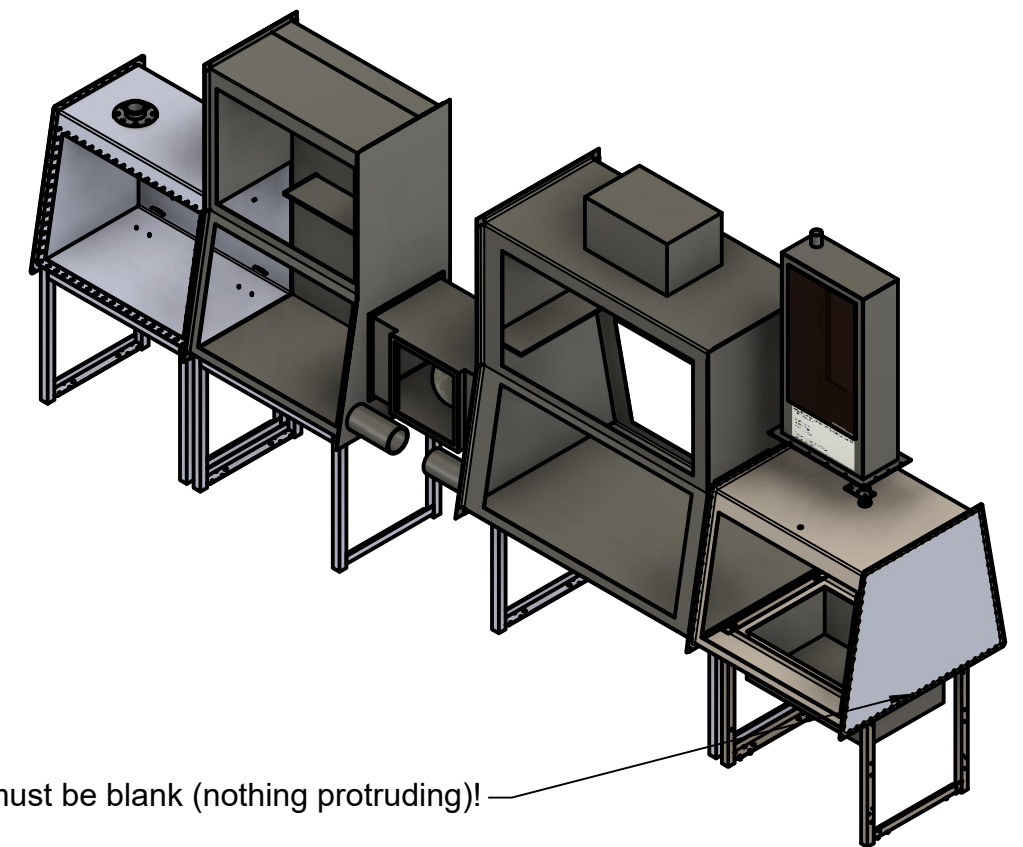
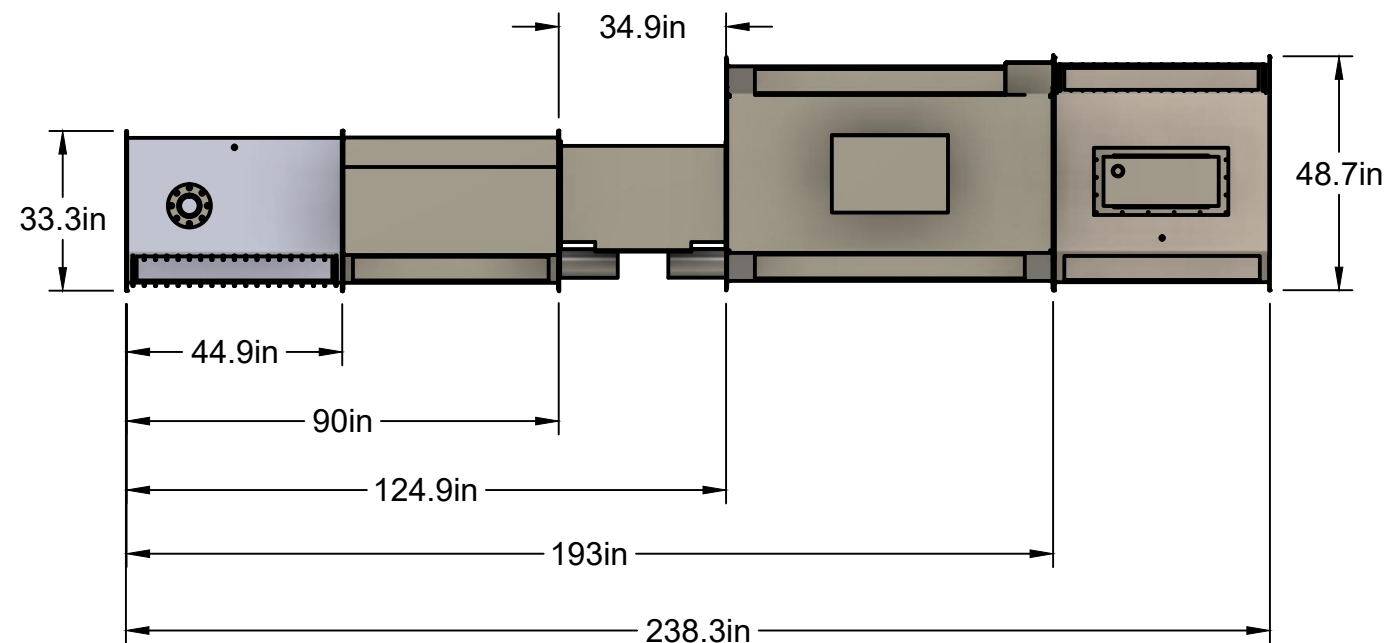
Dry Box B

Wet Box A

Wet Box B

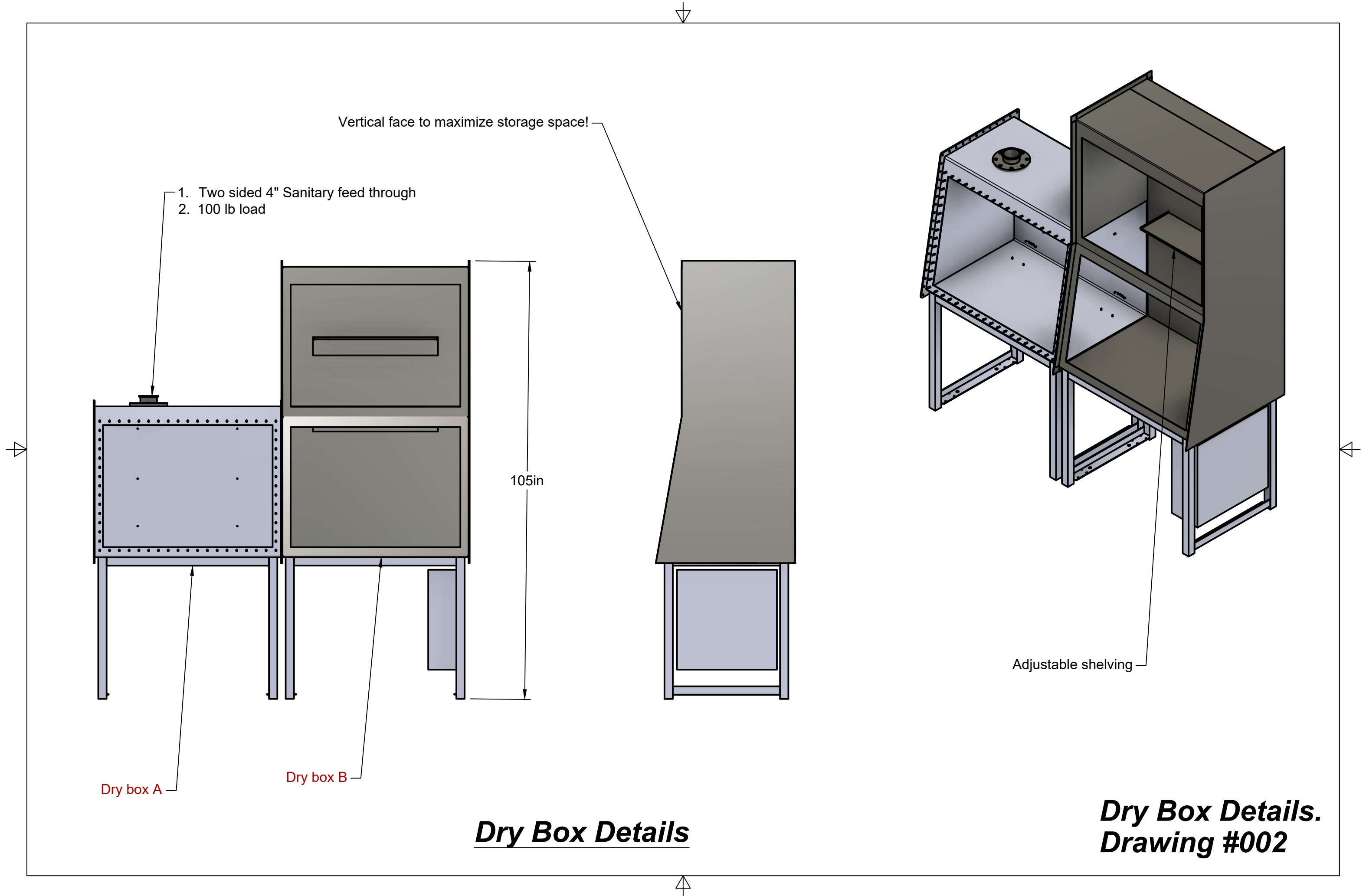
Two Small antechambers

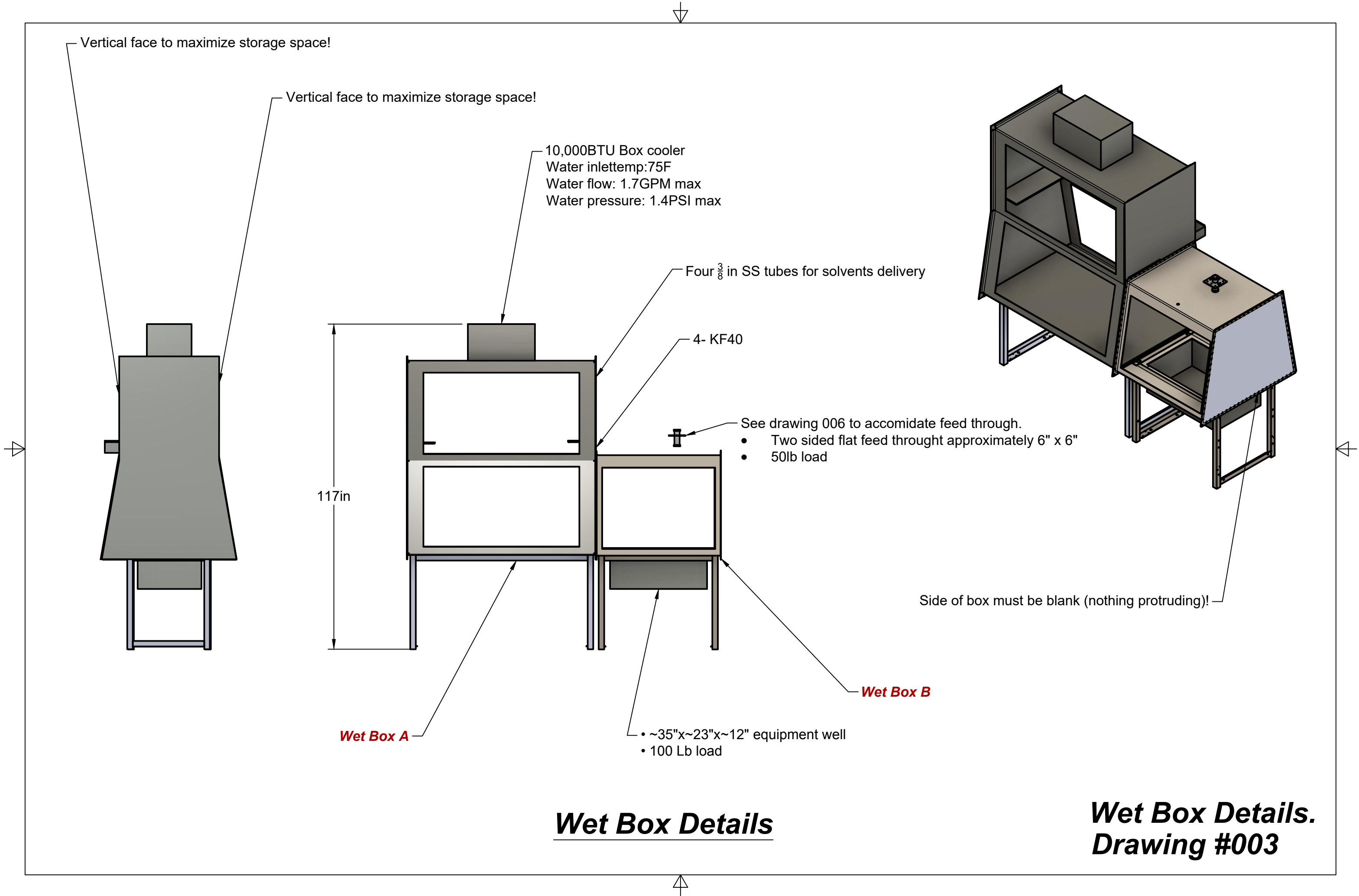
35"x23"x12" open bottom box

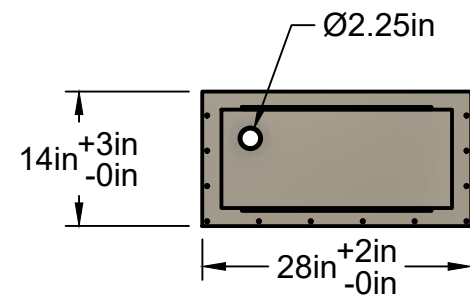


Side of box must be blank (nothing protruding)!

***Glove Box System Overview.
Drawing #001***

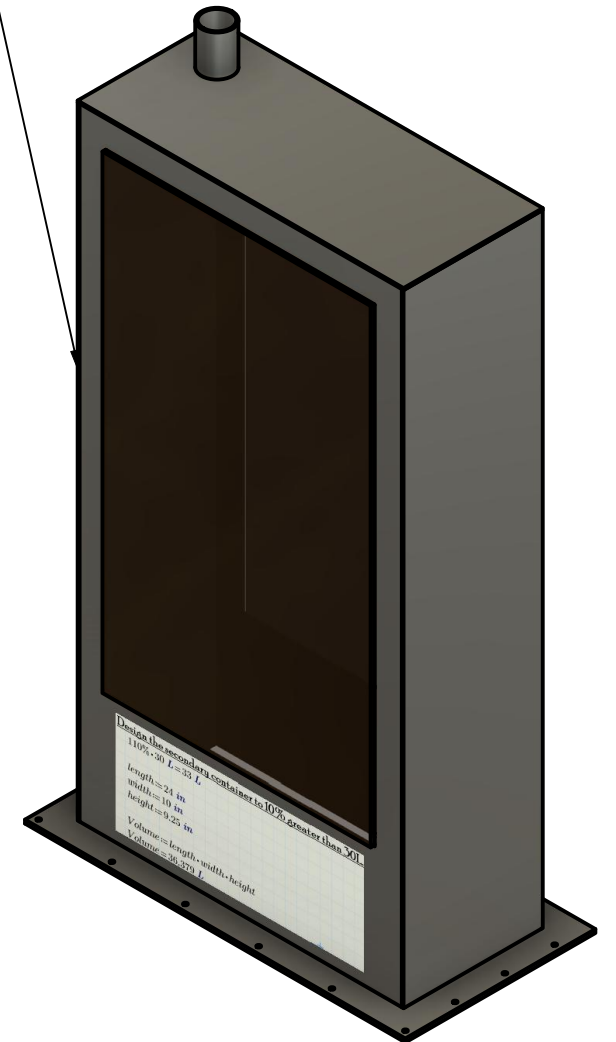
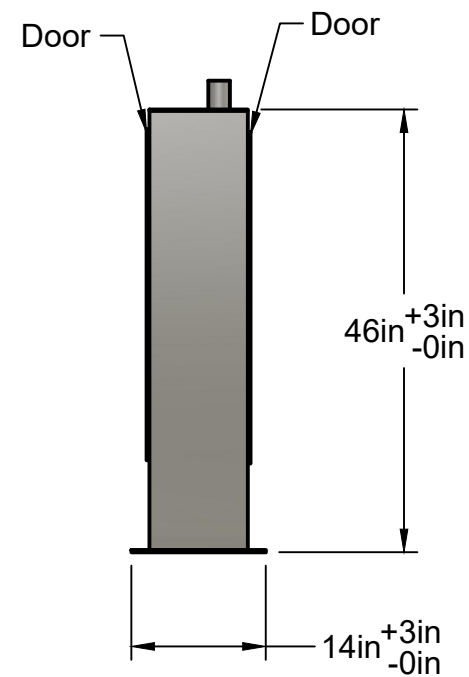
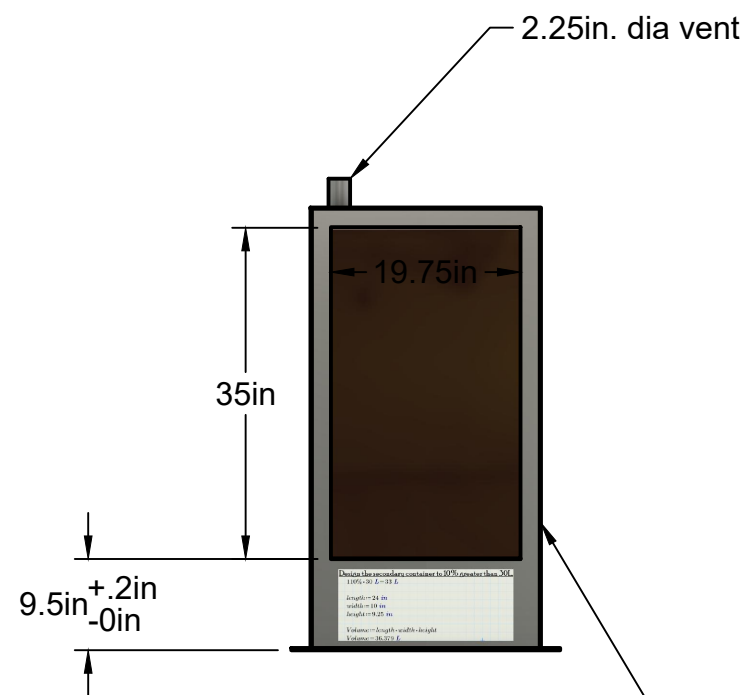






Ventilated enclosure:

1. Two hinged Doors with latches
2. Secondary containment for >37L
3. Window/door material same as glove box windows
4. Withstand 1.5" WC pressure



1/2in. NPT On/OFF GN2 valve
Four 1/2in. NPT water input/output
Two 1/2in. NPT N2 input

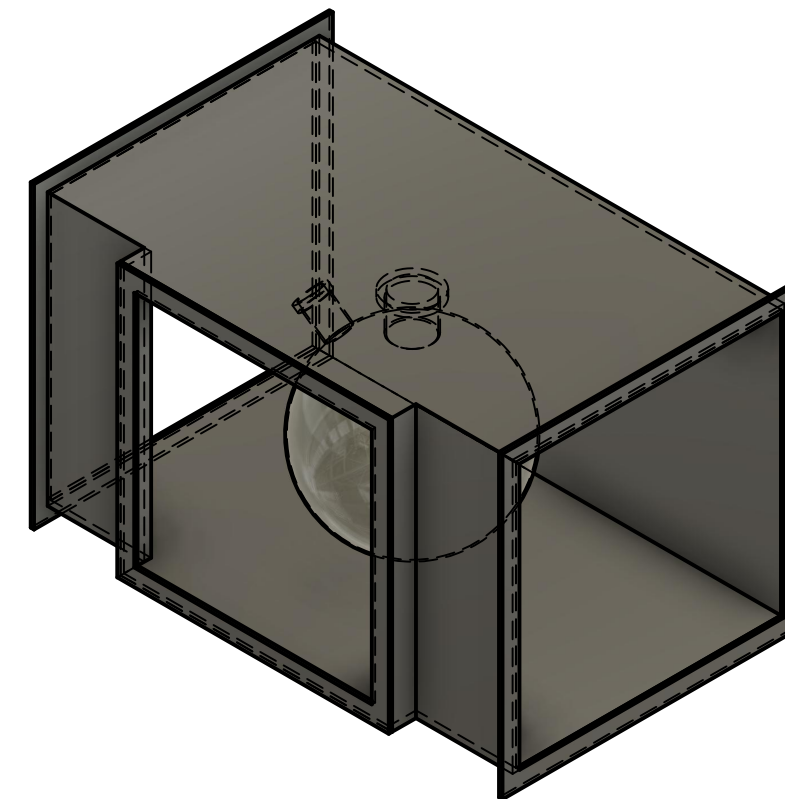
Enclosure Details

**Enclosure Details.
Drawing #004**

Large antechamber that can accommodate ~60Lb, 20L spherical glass flask!

- Sliding tray in/out of glove box
- Minimize door swing area

Doors to accomidate 20L flask with clerince

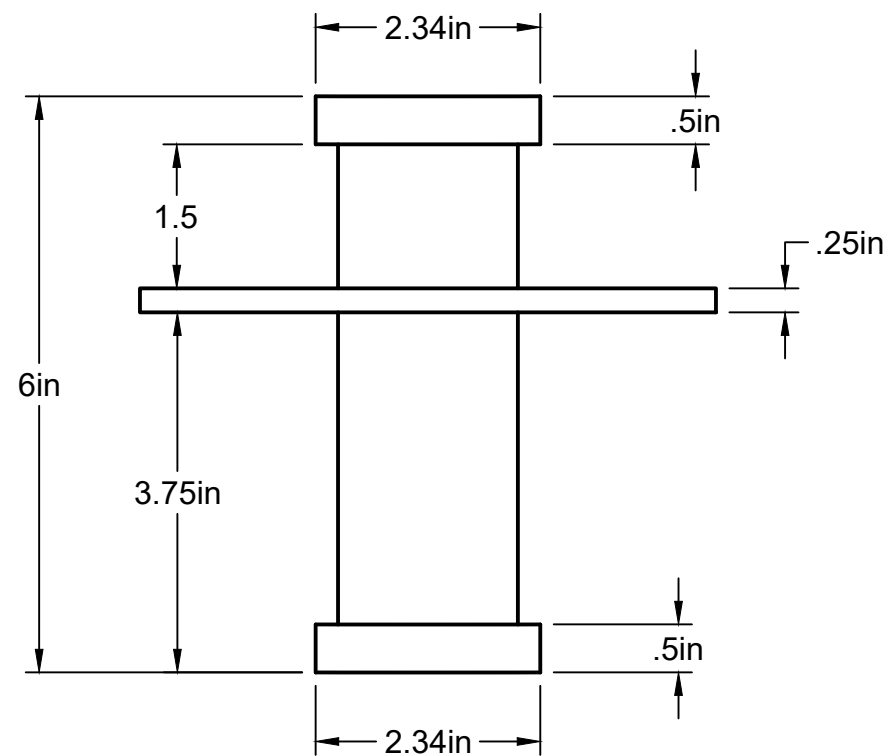
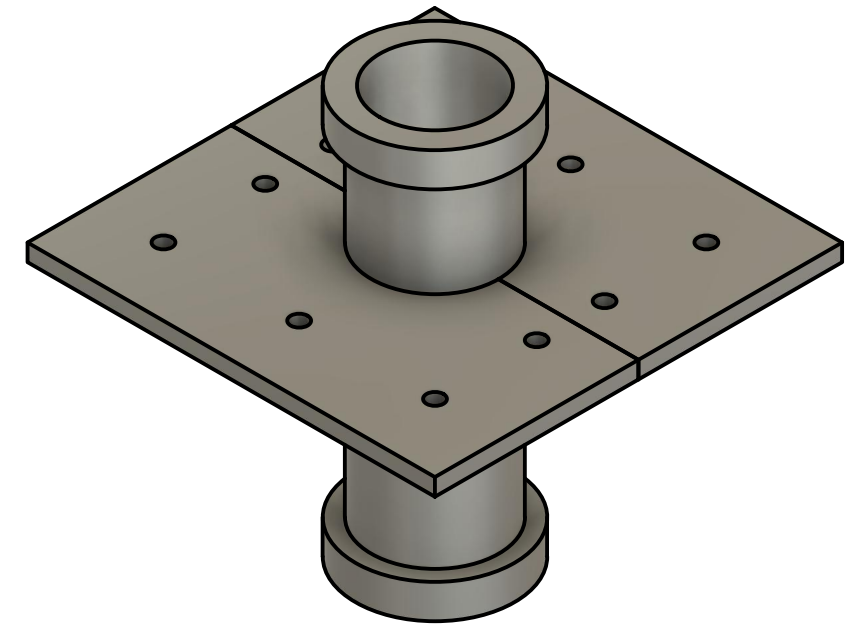
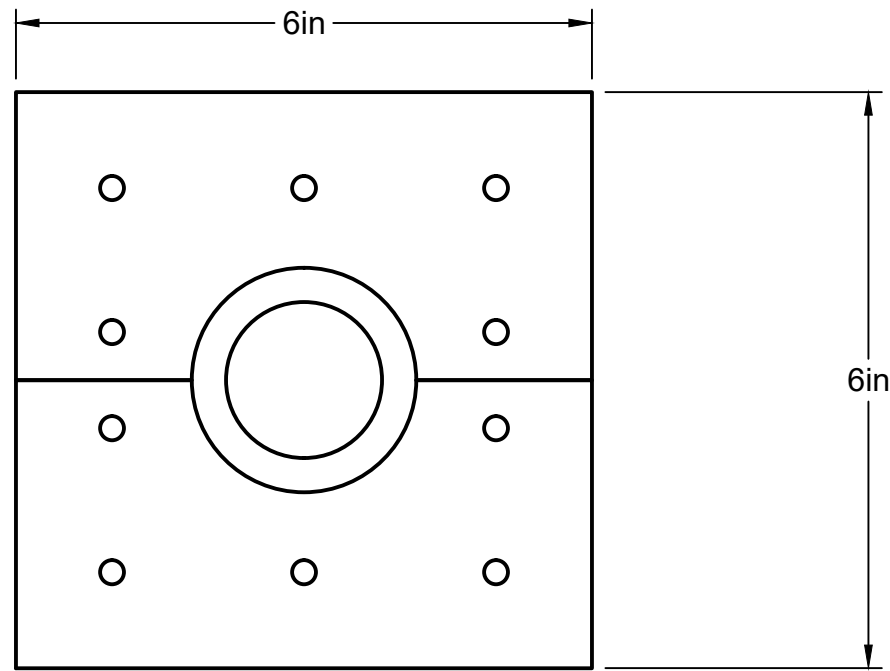


2.79in

Ø13.26in

20L glass flask needs to be transfered to/from glove box with >2" clearance!

***Antechamber Details.
Drawing #: 005***



- Two sided flat feed through approximately 6" x 6"
- 50lb load
- Removable/replaceable (i.e., gasketed and bolted not welded)

***Wet Box Panel Feedthrough Example.
Drawing #006***