NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

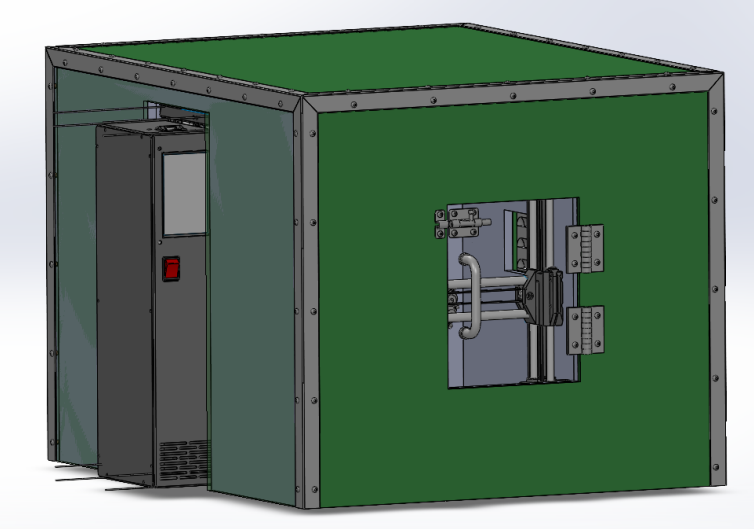
INTELLIGENT SYSTEMS DIVISION, ENGINEERING LAB

DEVELOPMENT OF A SOFT MATERIAL 3D PRINTER FOR ADVANCING CAPABILITIES IN SOFT ROBOTICS AT NIST

Heated Chamber Assembly Instructions

Jennifer Case, Jeremy Marvel

27 September 2022



Audience: Users who are required to assemble the heating chamber for the soft material printer.

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Disclaimer

Certain trade names and company products are mentioned in the text or identified in certain illustrations. In no case does such an identification imply recommendation or endorsement by the NIST, nor does it imply that the products are necessarily the best available for the purpose.

Change Log

1. Introduction

This document contains instructions for the assembly of a heated chamber that is designed to cover the print area for a Lulzbot TAZ Pro printer. The heated chamber is an insulated box heated by off-the-shelf incubator heaters that are self-contained for monitoring and controlling temperature.

2. List of Parts and Tools

The heated chamber is intended to be constructed from materials that are readily available through online vendors. The vendors listed in these instructions are not affiliated with NIST nor does NIST benefit from purchases made through the vendor. NIST does not endorse these vendors or products, nor does their inclusion here imply they are the best for the application. These specific product links are provided merely as a convenience, and the prices listed are for reference purposes only to estimate costs for construction.

2.1. Manufactured Parts

To assemble the syringe pump, it is necessary to cut or customize parts from stock materials: aluminum trim, acrylic, insulation, and plastic hinges. While these instructions specify acrylic as the outer material of the heated chamber, users are welcome to change that for alternative materials. Any alternative materials selected should be evaluated for fire safety and replacement insets will need to be sourced if the selected material is not a plastic. Table 1 contains a list of materials used to manufacture parts for the heated chamber.

Table 1. Materials for manufactured parts.

	Description	# Required	Vendor Link	Cost
1	Aluminum Corner Trim, 1"x1", 1/16" thick, 3' long	8	mcmaster.com	$143.04
2	Cast Acrylic Sheet 24" x 36" x 1/4"	5	mcmaster.com	$332.10
3	Clear Cast Acrylic Sheet 12" x 12" x 1/4"	1	mcmaster.com	$18.38
4	Melamine Insulation Sheet 48" x 8' x 1/2"	1	mcmaster.com	$194.12
5	Plastic Hinges without Holes	2	mcmaster.com	$11.00
6	????			

2.2. Required Hardware

In addition to manufactured parts, the heated chamber also uses various hardware in the construction. Table 2 contains a list of the hardware used. Note that the number required that is listed in the hardware is per component not per ordering unit from suppliers.

Table 2. Hardware needed for heated chamber.

	Description	# Required	Vendor Link	Cost
1	Insulation Tape 3" wide, 30' long	1	mcmaster.com	$12.04
2	Heat-Set Inserts for Plastic, 8-32, 1/4" long	110	mcmaster.com	$41.67
3	Slide-Bolt Latch	1	mcmaster.com	$3.30
4	Threaded-Hole Pull Handle	1	mcmaster.com	$6.83
5	IncuKit MINI	1	incubatorwarehouse.com	$66.49
6	Surface Mount Enclosure Louver	2	mcmaster.com	$97.56
7	8-32 Screw, 1/4" long	112	mcmaster.com	$13.76
8	8-32 Screw, 3/8" long	8	mcmaster.com	$7.58
9	M5 Screw, 12mm long	2	mcmaster.com	$12.05
10	????			

2.3. Tools

To complete the assembly of the heated chamber, the following tools are required:

- [Optional] drill,
- soldering iron,
- M3 allen wrench,
- 3/32" allen wrench,
- ????.

3. Preparation of Parts for Assembly

The preparation of parts can be divided into (1) manufacturing parts using the materials provided in Table 1 and preparing the acrylic shell for assembly.

3.1. Manufacturing Parts

The parts requiring manufacturing are:

- aluminum trim that is used to hold the heated chamber together,
  - 4x side aluminum trim,
  - 2x top wide aluminum trim,
  - 2x top length aluminum trim,
- acrylic sheets that serve as the shell for the heated chamber,
  - 1x front acrylic,
  - 1x back acrylic,
  - 1x left acrylic,
  - 1x right acrylic,
  - 1x top acrylic,
  - 1x acrylic door,
- insulation sheets that insulate the heated chamber,
  - 1x front insulation,
  - 1x back insulation,
  - 1x left insulation,
  - 1x right insulation,
  - 1x top insulation,
- plastic hinges to attach the door to the heated chamber,
- ????.

The aluminum trim can be manufactured using a CNC, drill press, drill, band saw, hacksaw, etc.

The acrylic sheets and insulation can be manufactured with a laser cutter, water jet, CNC, etc.

The plastic hinges can be manufactured with a CNC, drill press, drill, etc.

STEP files are provided in the exploratory-soft-printer\equipment\heated-chamber\STEP_files folder. Drawings for the parts are provided in Appendix A.

3.2. Preparing Acrylic Parts

To assemble the heated chamber, screws are used to hold everything together. In order to enable that, heat-set inserts are placed in the acrylic parts that serve as the shell for the heated chamber. Here, we show where the inserts should be placed. The inserts can be added to the acrylic by simply using a soldering iron to drive them into the acrylic. As the insert heats up, it will melt the surrounding acrylic and lock in place when the parts cool.

3.2.1. Front Acrylic

Heat-set inserts should be added to the 21 locations highlighted in red in Fig. 1.

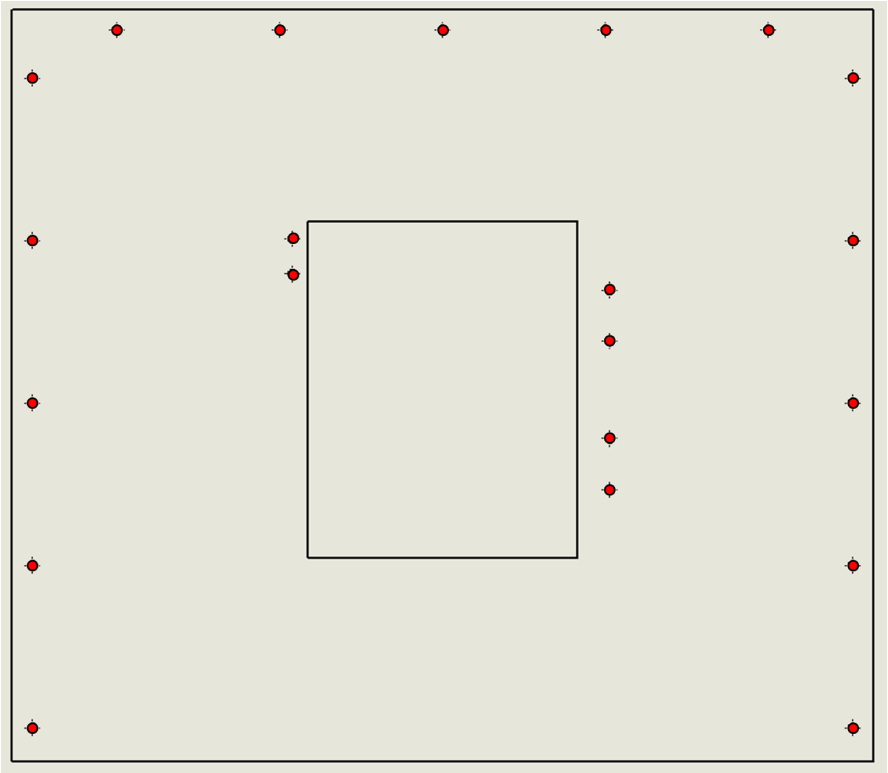


Fig. 1. Red dots show the locations of heat-set inserts for the front acrylic.

3.2.2. Back Acrylic

Heat-set inserts should be added to the 15 locations highlighted in red in Fig. 2.

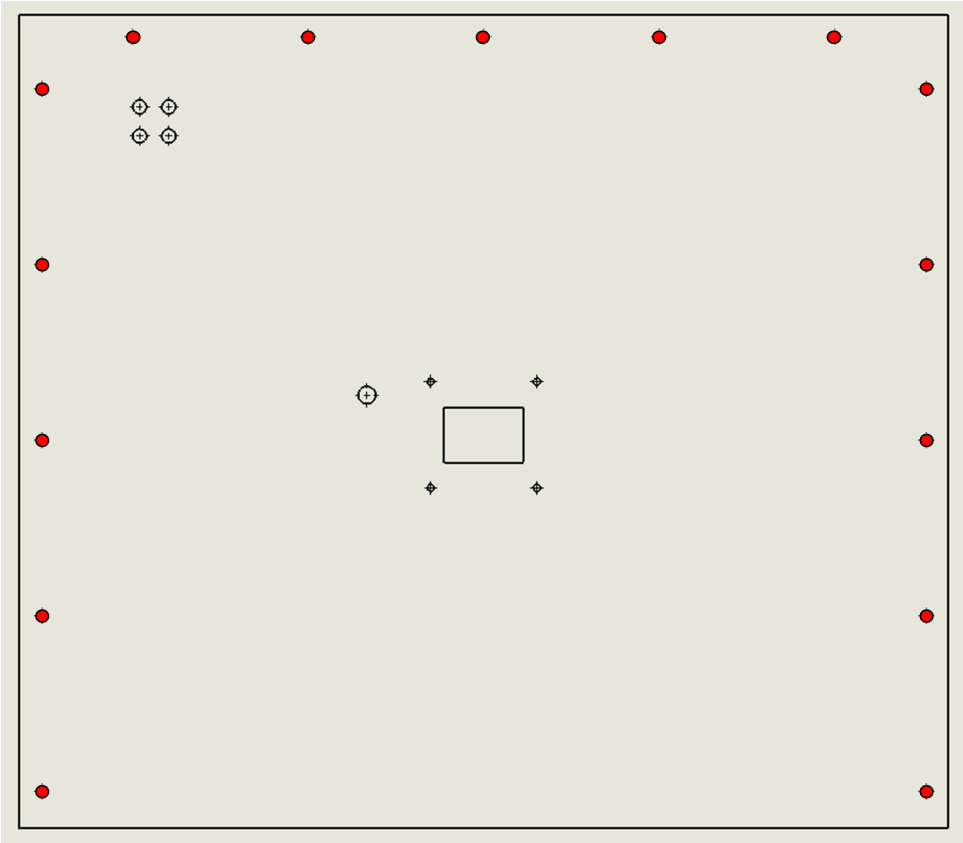


Fig. 2. Red dots show the locations of heat-set inserts for the back acrylic.

3.2.3. Left Acrylic

Heat-set inserts should be added to the 25 locations highlighted in red in Fig. 3.

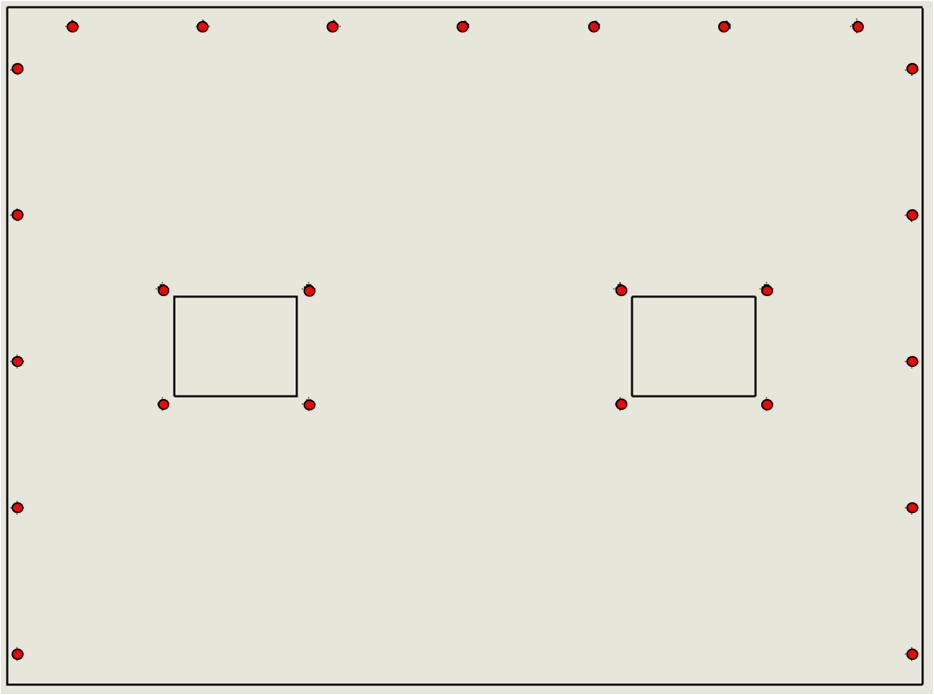


Fig. 3. Red dots show the locations of heat-set inserts for the left acrylic.

3.2.4. Right Acrylic

Heat-set inserts should be added to the 17 locations highlighted in red in Fig. 4.

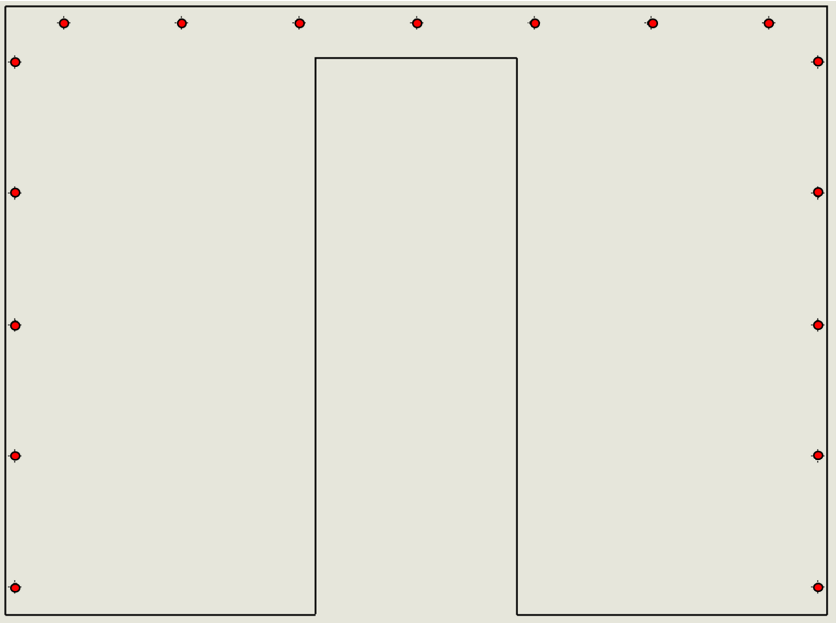


Fig. 4. Red dots show the locations of heat-set inserts for the right acrylic.

3.2.5. Top Acrylic

Heat-set inserts should be added to the 24 locations highlighted in red in Fig. 5.

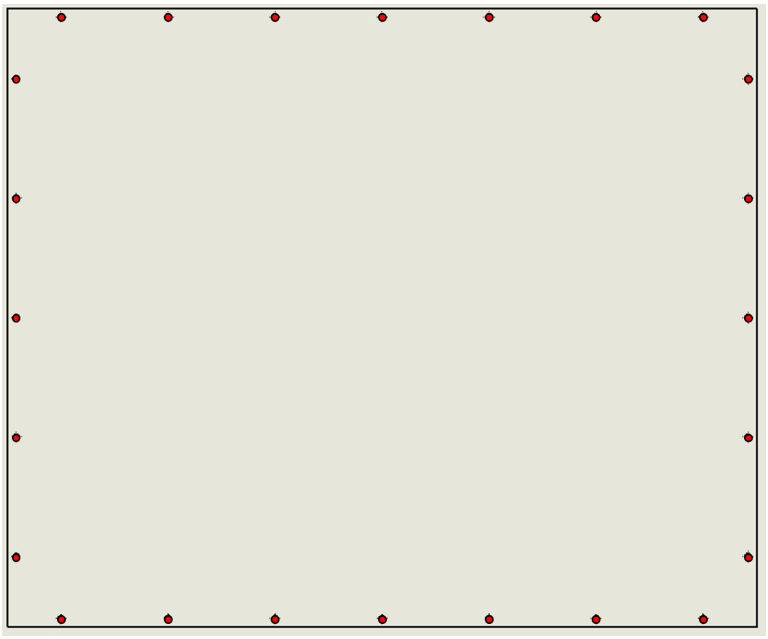


Fig. 5. Red dots show the locations of heat-set inserts for the top acrylic.

3.2.6. Acrylic Door

Heat-set inserts should be added to the 8 locations highlighted in red in Fig. 6.

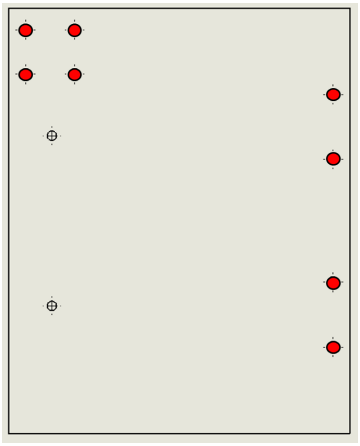


Fig. 6. Red dots show the locations of heat-set inserts for the acrylic door.

4. Assembly Instructions

The assembly of the heated chamber is divided into four parts: (1) assembling the chamber, (2) attaching the louvers, (3) attaching the door, and (4) attaching the IncuKit MINI.

4.1. Assembling the Chamber

The parts needed for this sub-assembly are:

- front acrylic,
- back acrylic,
- left acrylic,
- right acrylic,
- top acrylic,
- front insulation,
- back insulation,
- left insulation,
- right insulation,
- top insulation,
- side aluminum trim,
- top wide aluminum trim,
- top length aluminum trim,
- 1/4" long 8-32 screws,
- insulation tape.

1. Screw two side aluminum trims and one top wide aluminum trim onto the front acrylic, see Fig. 7.

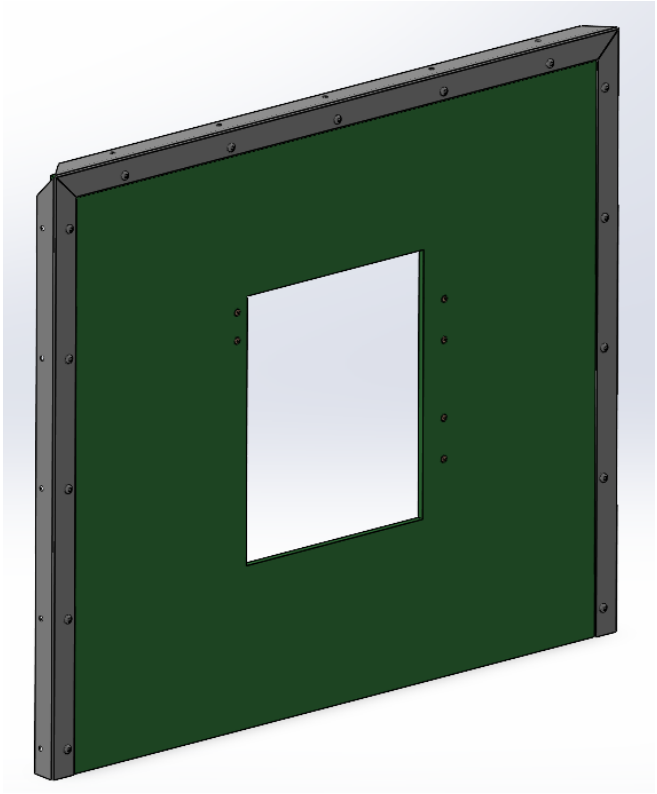


Fig. 7. Aluminum side trim and top wide trim installed on the front acrylic.

2. Screw the left and right acrylic on their corresponding sides to the aluminum trim, see Fig. 8.

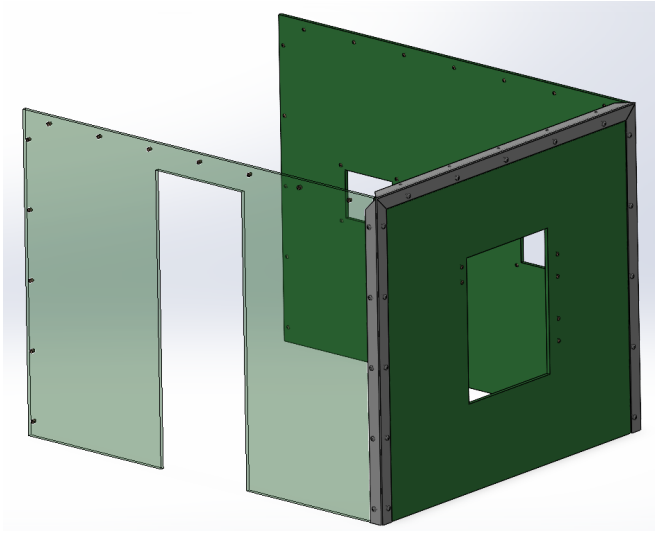


Fig. 8. Left and right acrylic installed onto the chamber assembly.

3. Screw the top length aluminum trims onto the right and left acrylics, see Fig. 9.

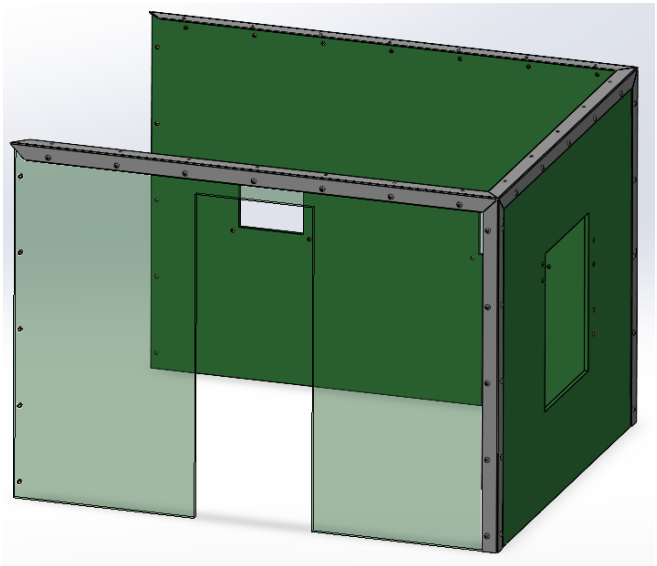


Fig. 9. Top length trim installed on the left and right acrylics.

4. Screw the top acrylic to the chamber assembly, see Fig. 10.

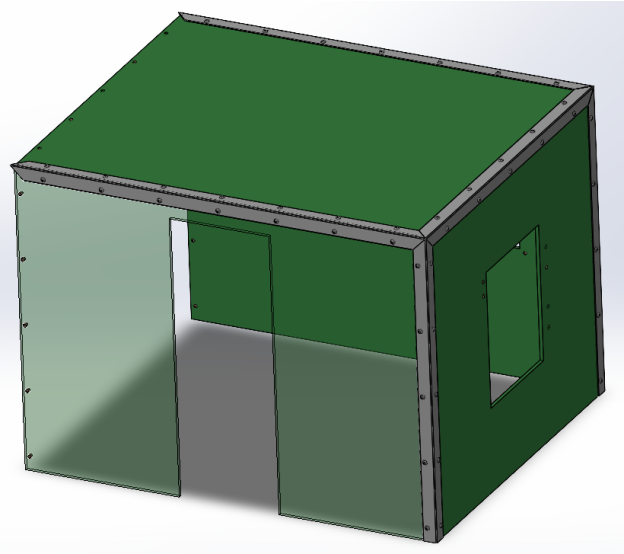


Fig. 10. Top acrylic installed onto the chamber assembly.

5. Screw the top wide and side aluminum trims onto the back acrylic, see Fig. 11.

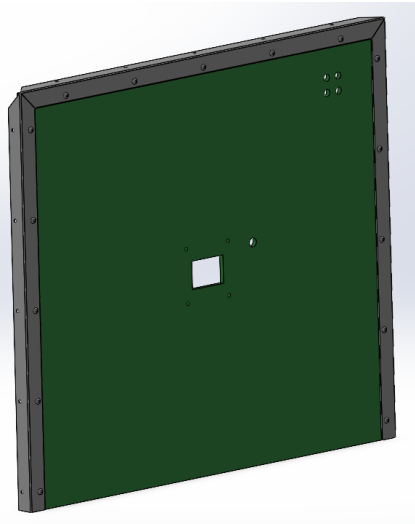


Fig. 11. Aluminum side trim and top wide trim installed on the back acrylic.

6. Screw the back acrylic to the chamber assembly, see Fig. 12.

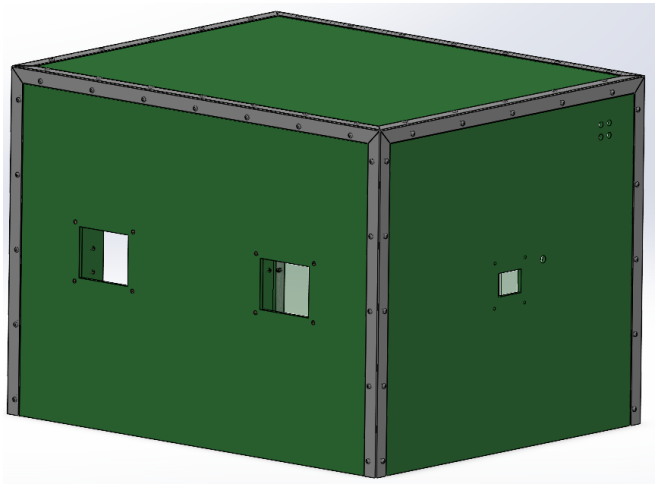


Fig. 12. Back acrylic installed onto the chamber assembly.

7. Add the front and back insulation to the front and back acrylic, see Fig. 13.

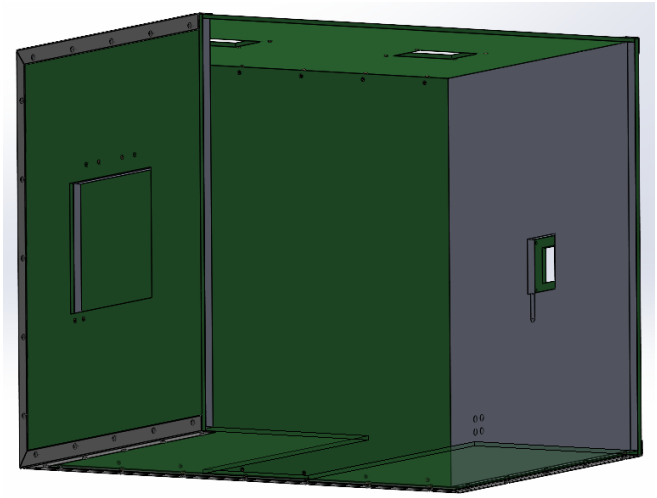


Fig. 13. Front and back insulation installed in the chamber assembly.

8. Add the left and right insulation to the left and right acrylic.

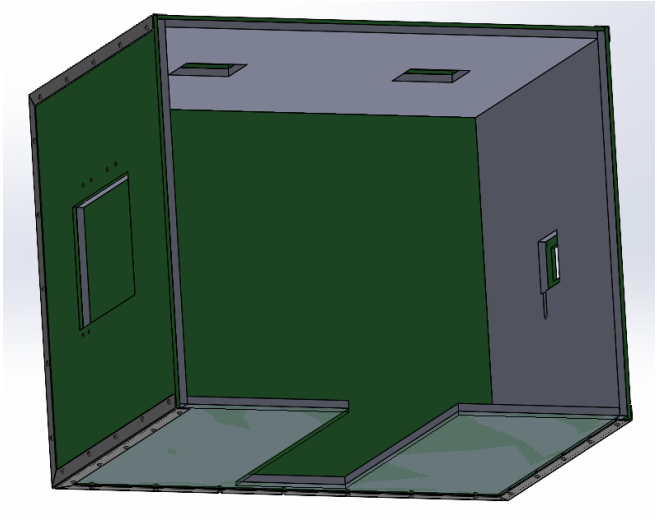


Fig. 14. Left and right insulation installed in the chamber assembly.

9. Add the top insulation to the top acrylic.

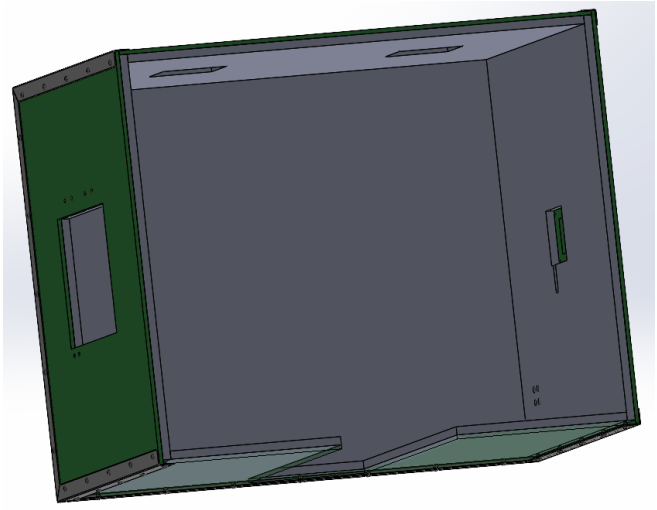


Fig. 15. Top insulation installed in the chamber assembly.

10. Seal the corners of the insulation with the insulation tape to help contain the heat.

4.2. Attaching the Louvers

The parts needed for this sub-assembly are:

- chamber assembly,
- louvers,
- 1/4" long 8-32 screws.

1. Screw the louvers onto the left acrylic, see Fig. 16.

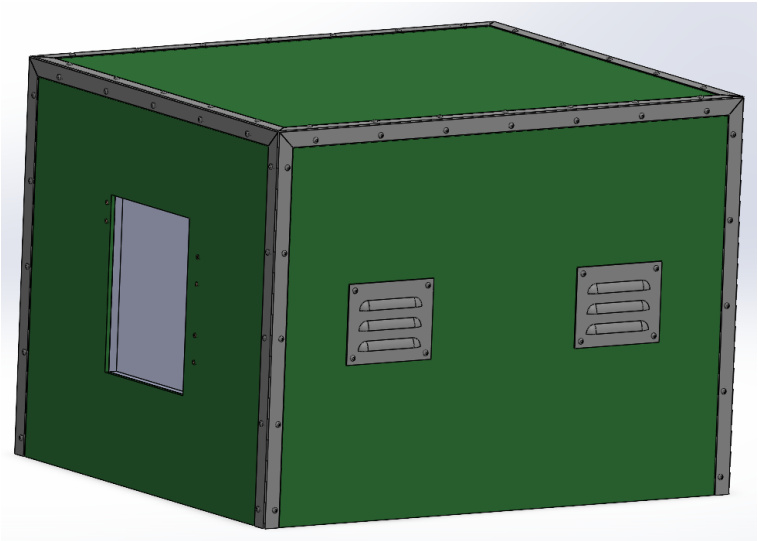


Fig. 16. Louvers installed on the left acrylic.

4.3. Attaching the Door

The parts needed for this sub-assembly are:

- chamber assembly,
- acrylic door,
- plastic hinges,
- slide-bolt latch,
- pull handle,
- 1/4" long 8-32 screws,
- 3/8" long 8-32 screws,
- 12mm long M5 screws.

1. Screw the pull handle onto the outer side of the door using the M5 screws, see Fig. 17.

Fig. 17. Pull handle installed on the acrylic door.

2. Screw the plastic hinges onto the outer side of the door using the 3/8" 8-32 screws, see Fig. 18.

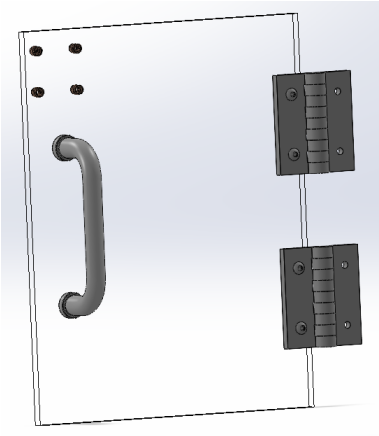


Fig. 18. Hinges installed on the acrylic door.

3. Screw the plastic hinges onto the front acrylic using the 3/8" 8-32 screws, see Fig. 19.

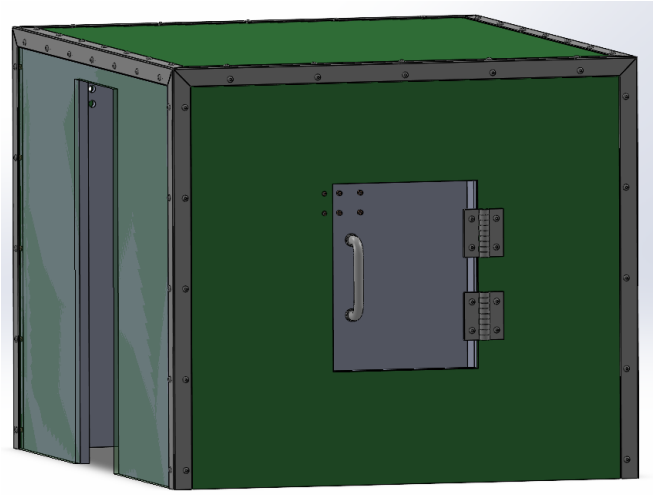


Fig. 19. Acrylic door installed onto the chamber assembly.

4. Screw the slide-bolt latch onto the door and front acrylic using the 1/4" 8-32 screws, see Fig. 20.

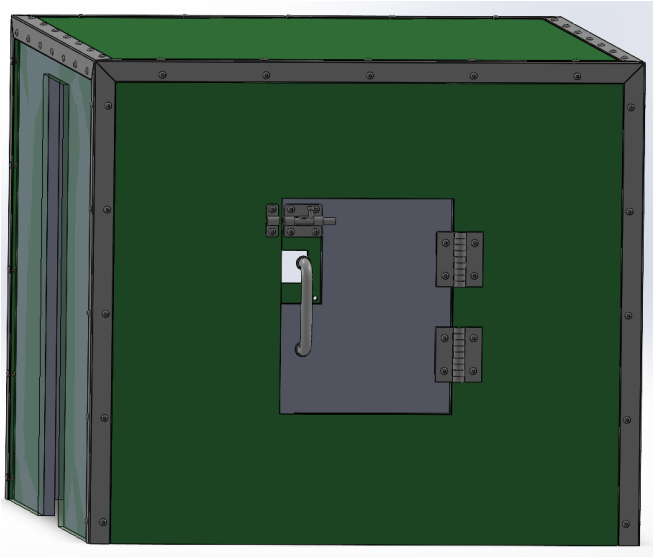
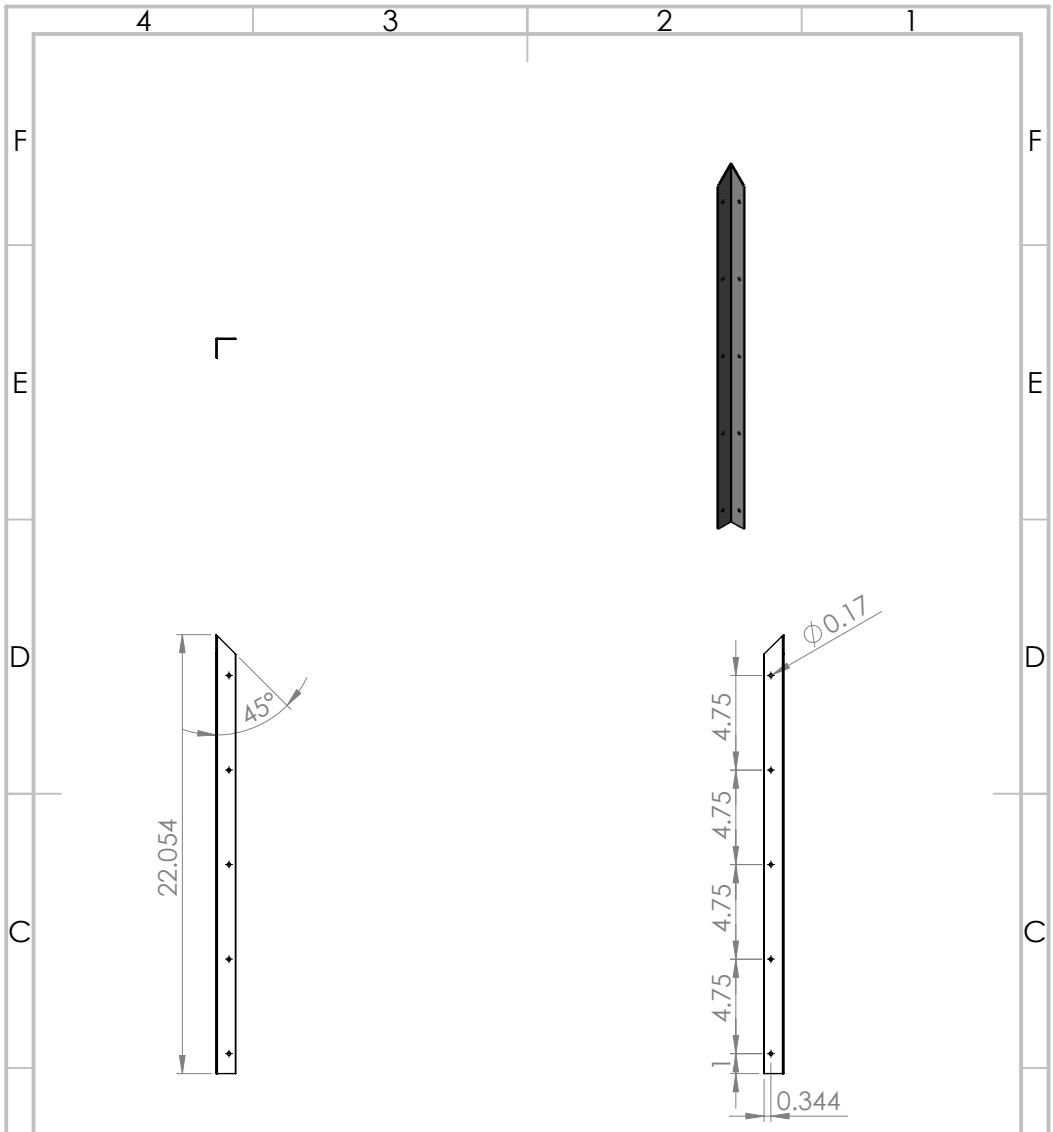


Fig. 20. Slide-bolt latch installed on the door and front acrylic.

4.4. Attaching the IncuKit MINI

A. Machined Part Drawings

The following pages include engineering drawings for the manufactured parts of the heated chamber.



Stock Aluminum Trim (8122A58, McMaster-Carr)
Needs to be cut to length and holes drilled in
All dimensions are in inches
Tolerance: +/- 0.003"

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MATERIAL: Aluminum

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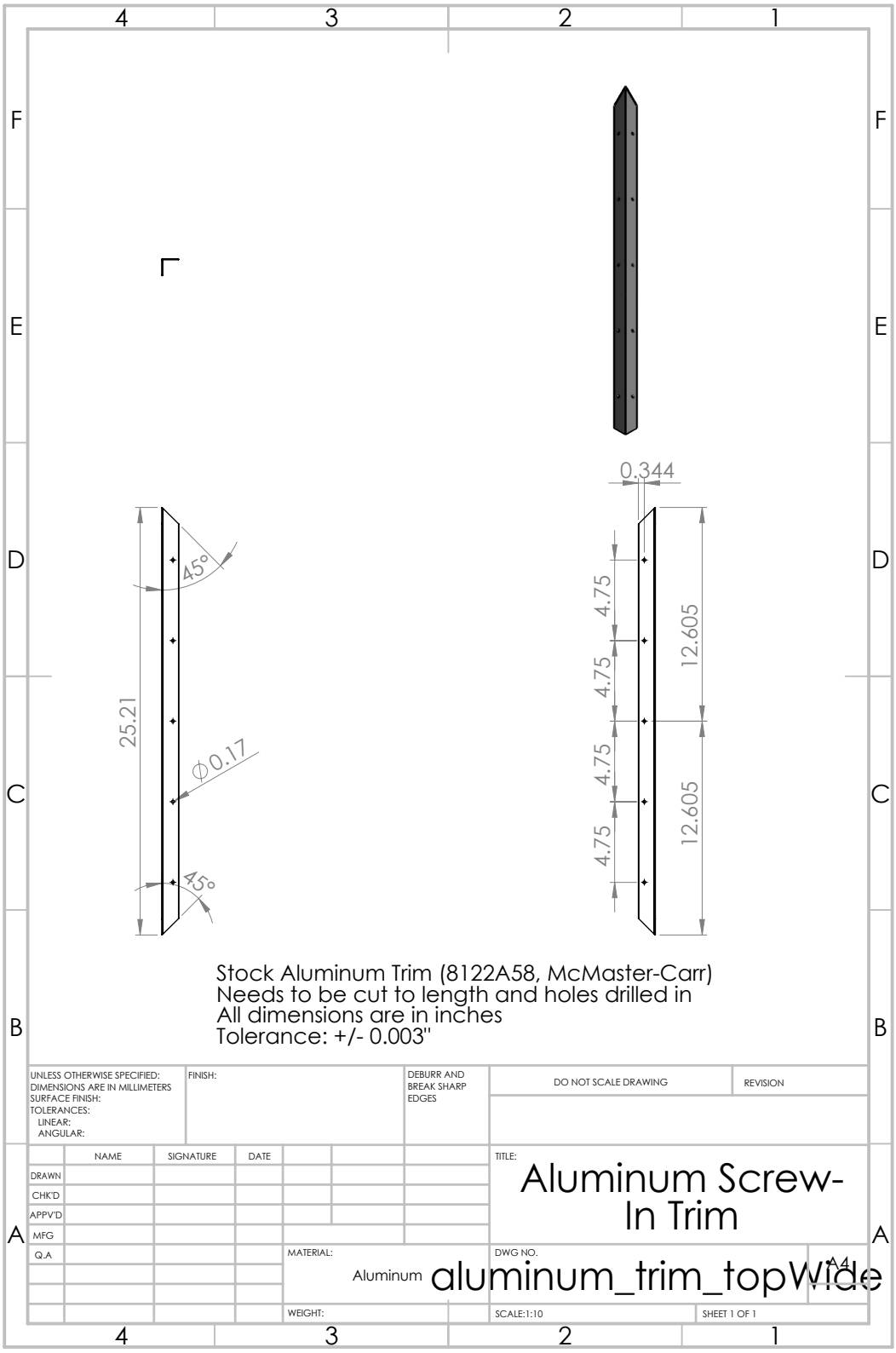
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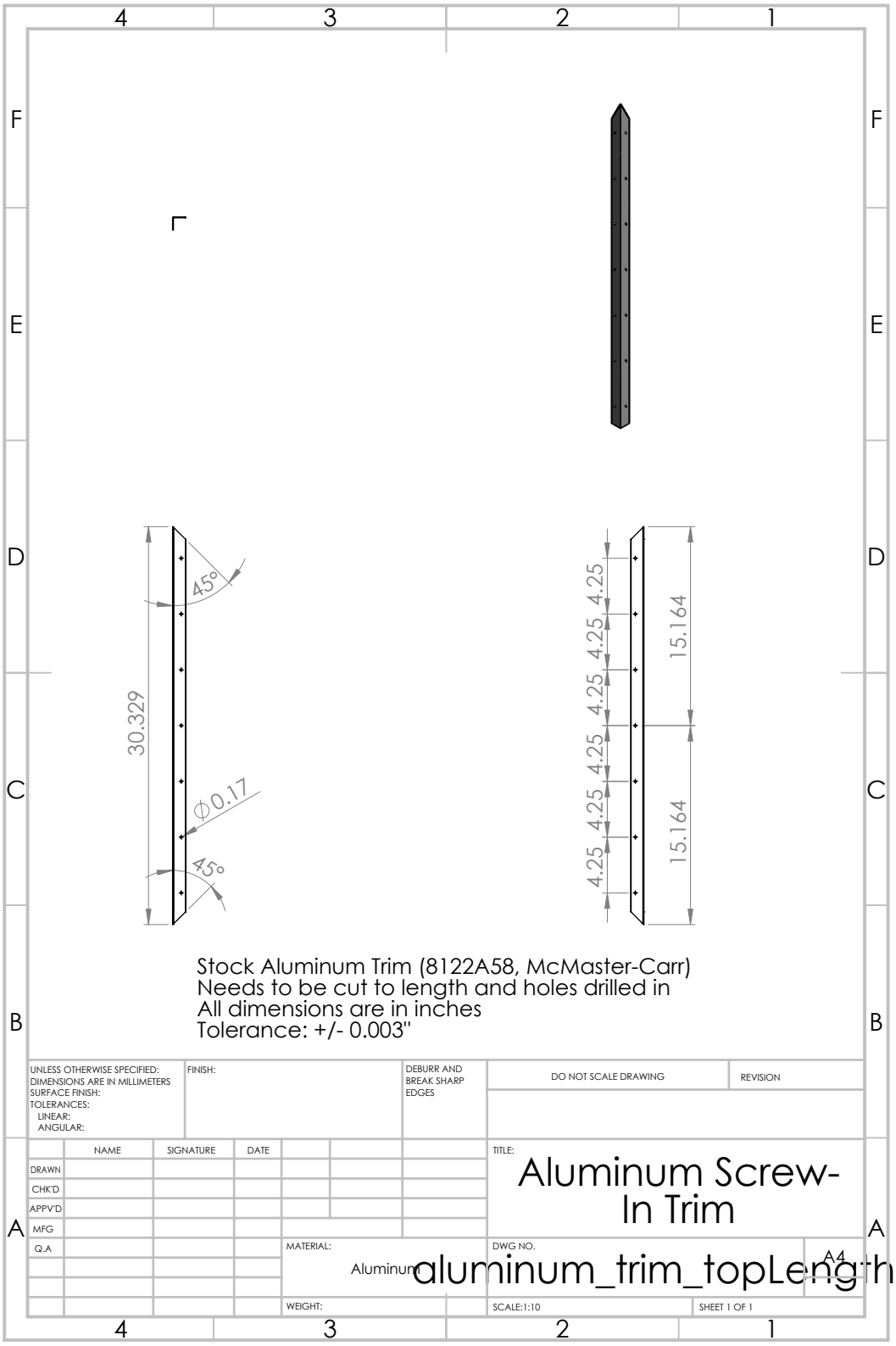
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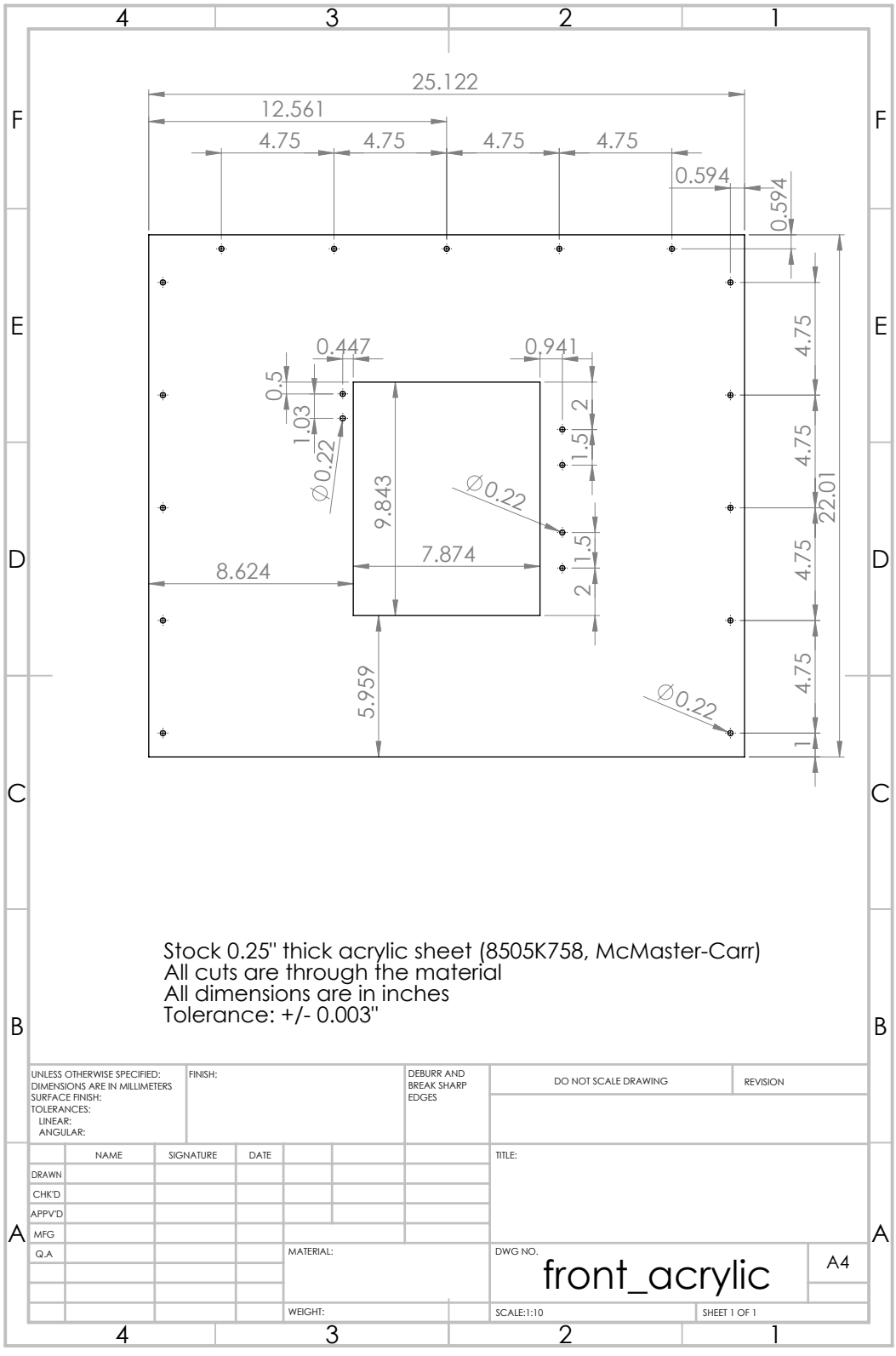
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Stock 0.25" thick acrylic sheet (8505K758, McMaster-Carr)
All cuts are through the material
All dimensions are in inches
Tolerance: +/- 0.003"
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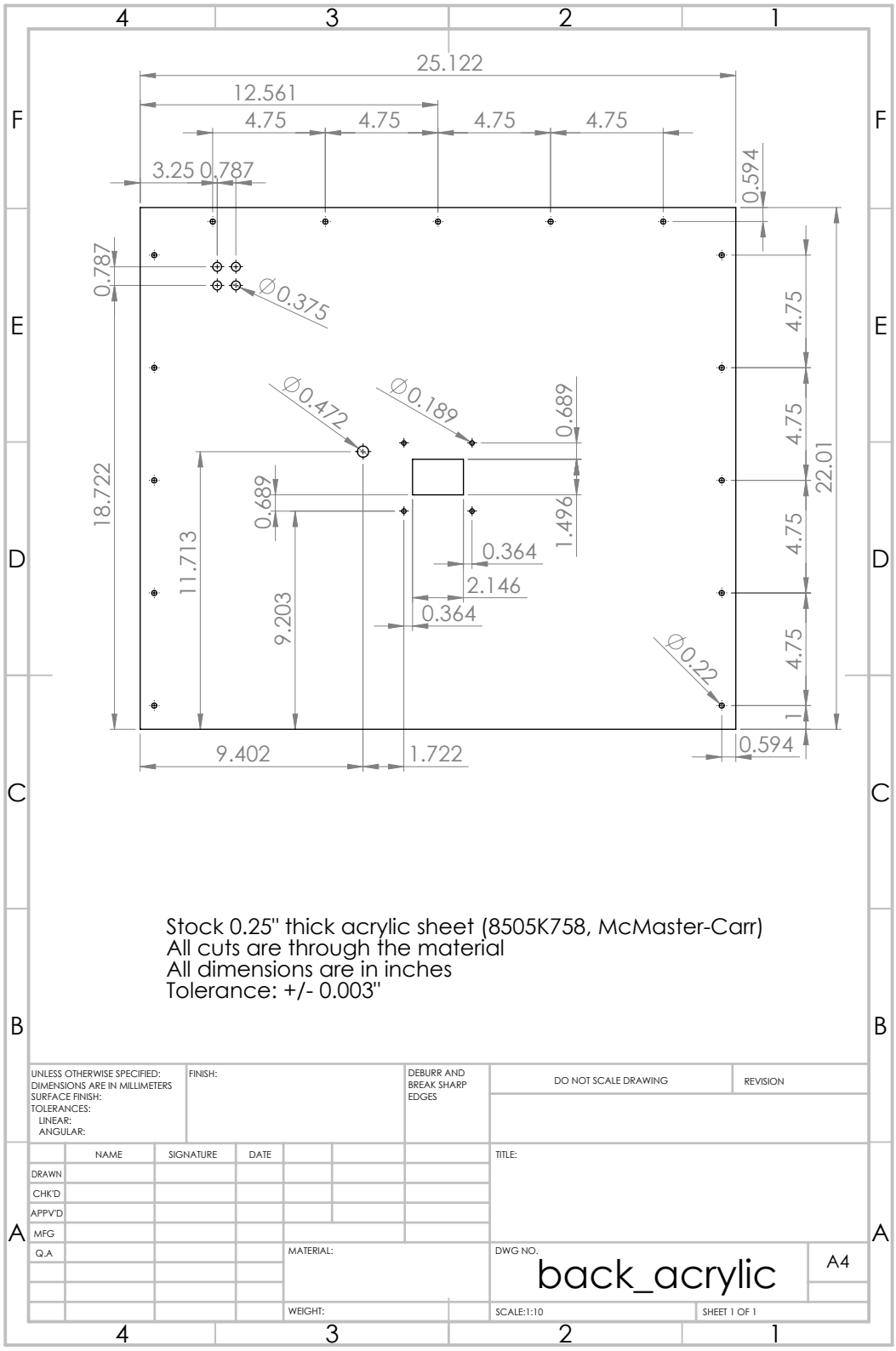
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Stock 0.25" thick acrylic sheet (8505K758, McMaster-Carr)
All cuts are through the material
All dimensions are in inches
Tolerance: +/- 0.003"
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
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TOLERANCES:
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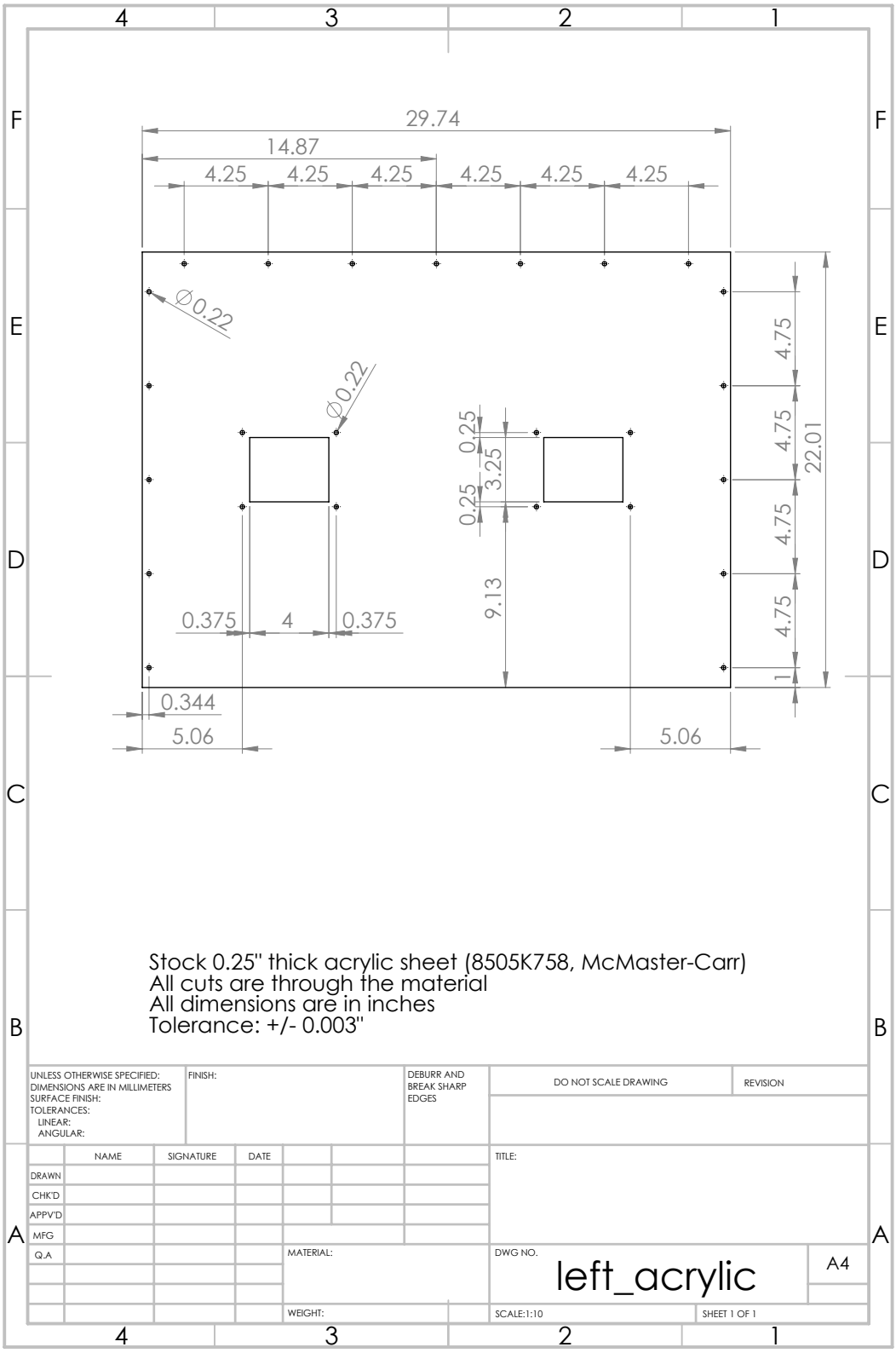
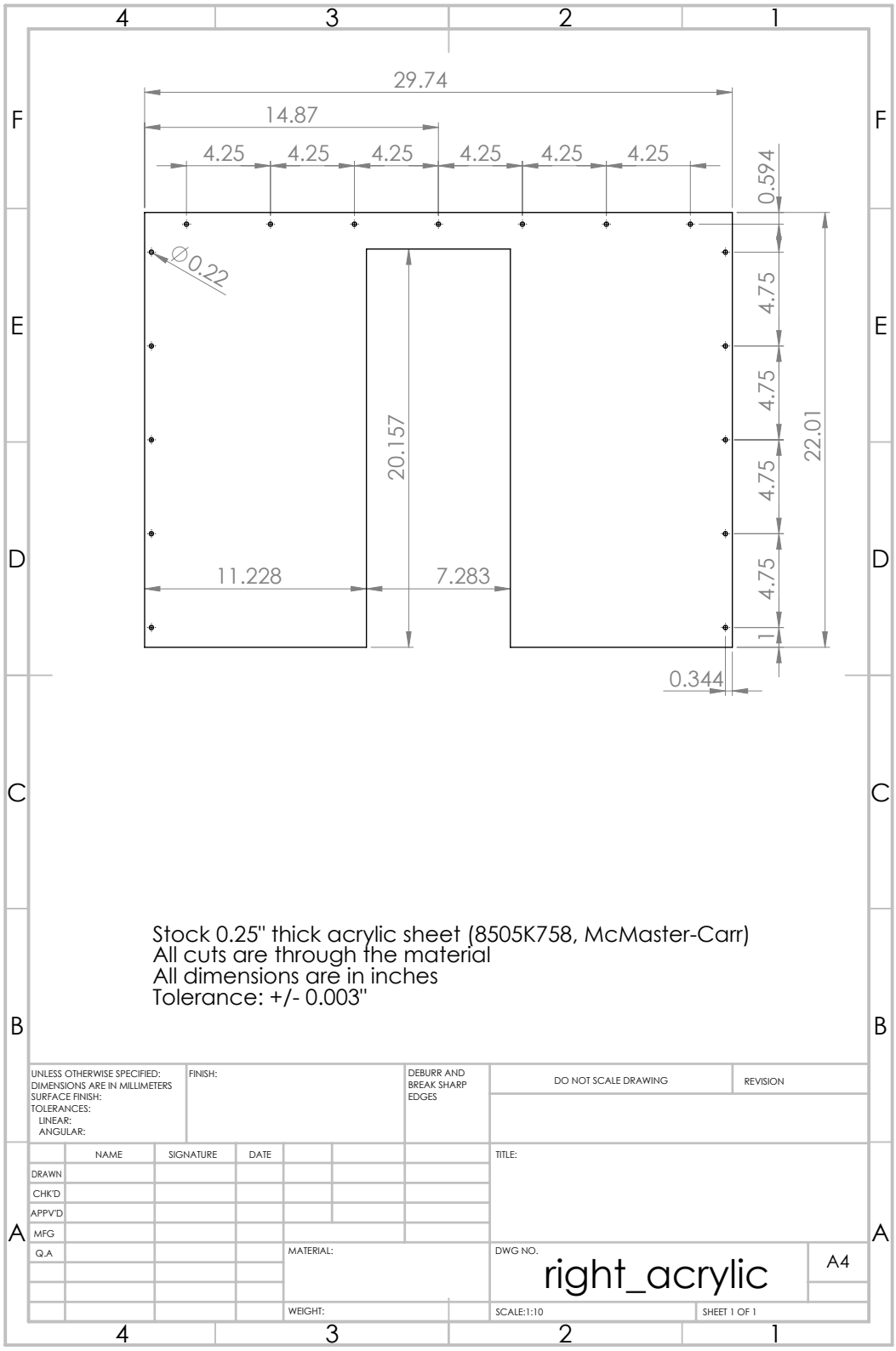
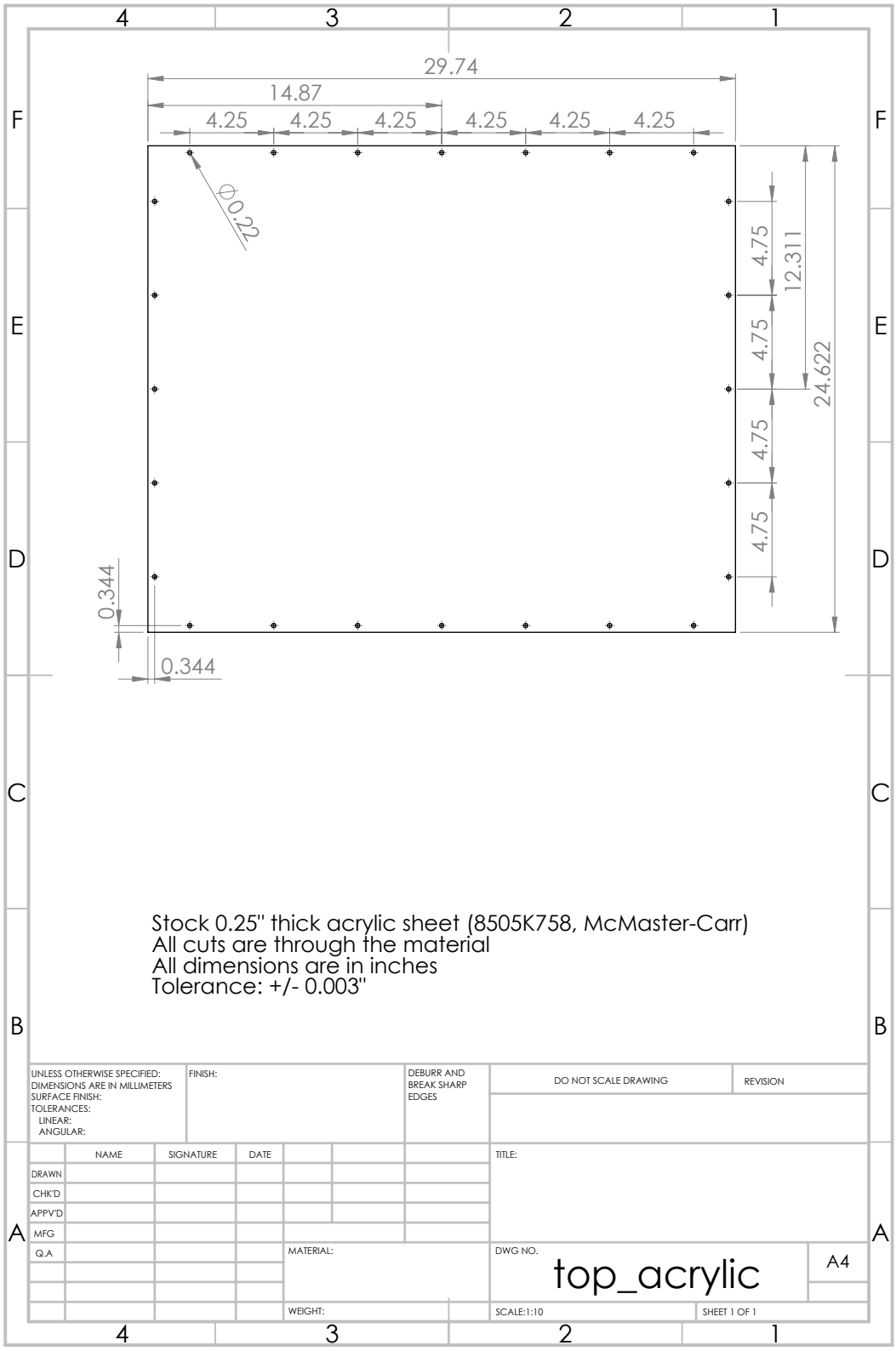
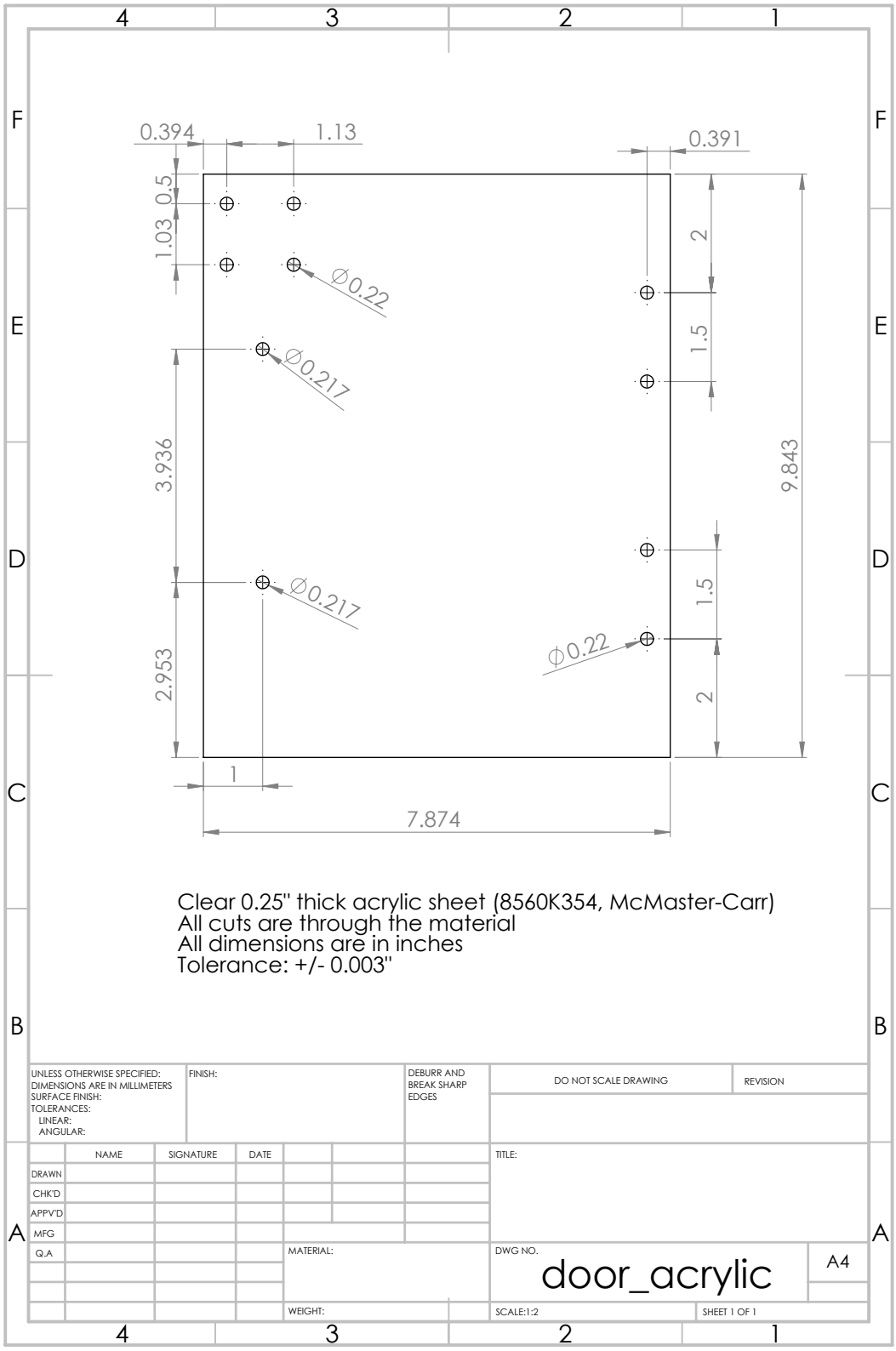
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
TITLE:
MATERIAL:
DWG NO.
back_acrylic
A4
WEIGHT:
SCALE:1:10
SHEET 1 OF 1


29.74
14.87
4.25
4.25
4.25
4.25
4.25
4.25
∅0.22
∅0.22
0.25
3.25
0.25
4.75
4.75
4.75
4.75
1
22.01
9.13
0.375
4
0.375
0.344
5.06
5.06
Stock 0.25" thick acrylic sheet (8505K758, McMaster-Carr)
All cuts are through the material
All dimensions are in inches
Tolerance: +/- 0.003"
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
TITLE:
MATERIAL:
DWG NO.
left_acrylic
A4
WEIGHT:
SCALE:1:10
SHEET 1 OF 1

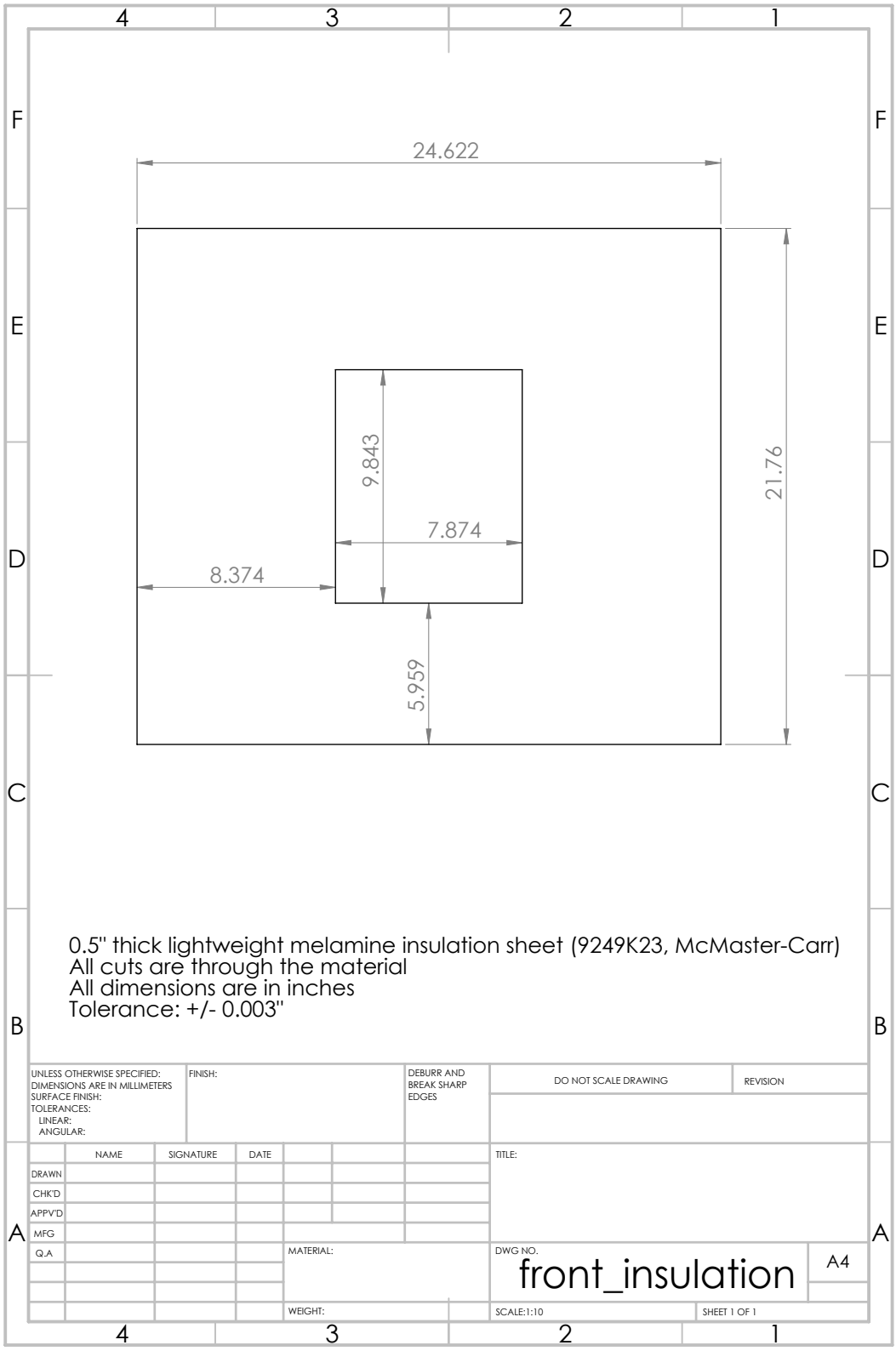

4
3
2
1
F
E
D
C
B
A
29.74
14.87
4.25
4.25
4.25
4.25
4.25
4.25
0.594
Ø0.22
4.75
4.75
4.75
4.75
22.01
20.157
11.228
7.283
1
0.344
Stock 0.25" thick acrylic sheet (8505K758, McMaster-Carr)
All cuts are through the material
All dimensions are in inches
Tolerance: +/- 0.003"
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
TITLE:
MATERIAL:
DWG NO.
right_acrylic
A4
WEIGHT:
SCALE:1:10
SHEET 1 OF 1

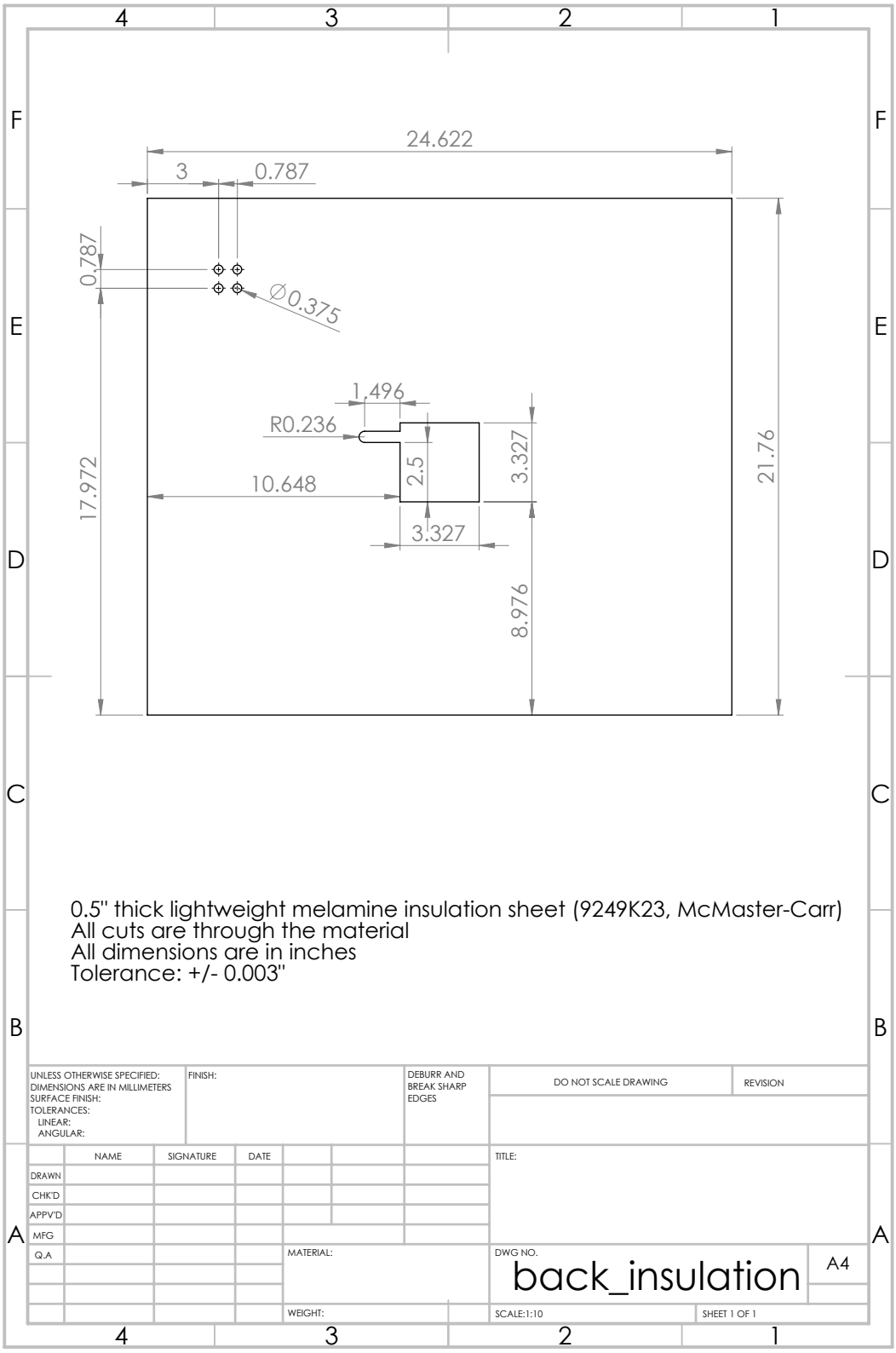

29.74
14.87
4.25
4.25
4.25
4.25
4.25
4.25
Φ0.22
4.75
4.75
4.75
4.75
12.311
24.622
0.344
0.344
Stock 0.25" thick acrylic sheet (8505K758, McMaster-Carr)
All cuts are through the material
All dimensions are in inches
Tolerance: +/- 0.003"
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
TITLE:
MATERIAL:
DWG NO.
top_acrylic
A4
WEIGHT:
SCALE:1:10
SHEET 1 OF 1



Clear 0.25" thick acrylic sheet (8560K354, McMaster-Carr)
All cuts are through the material
All dimensions are in inches
Tolerance: +/- 0.003"

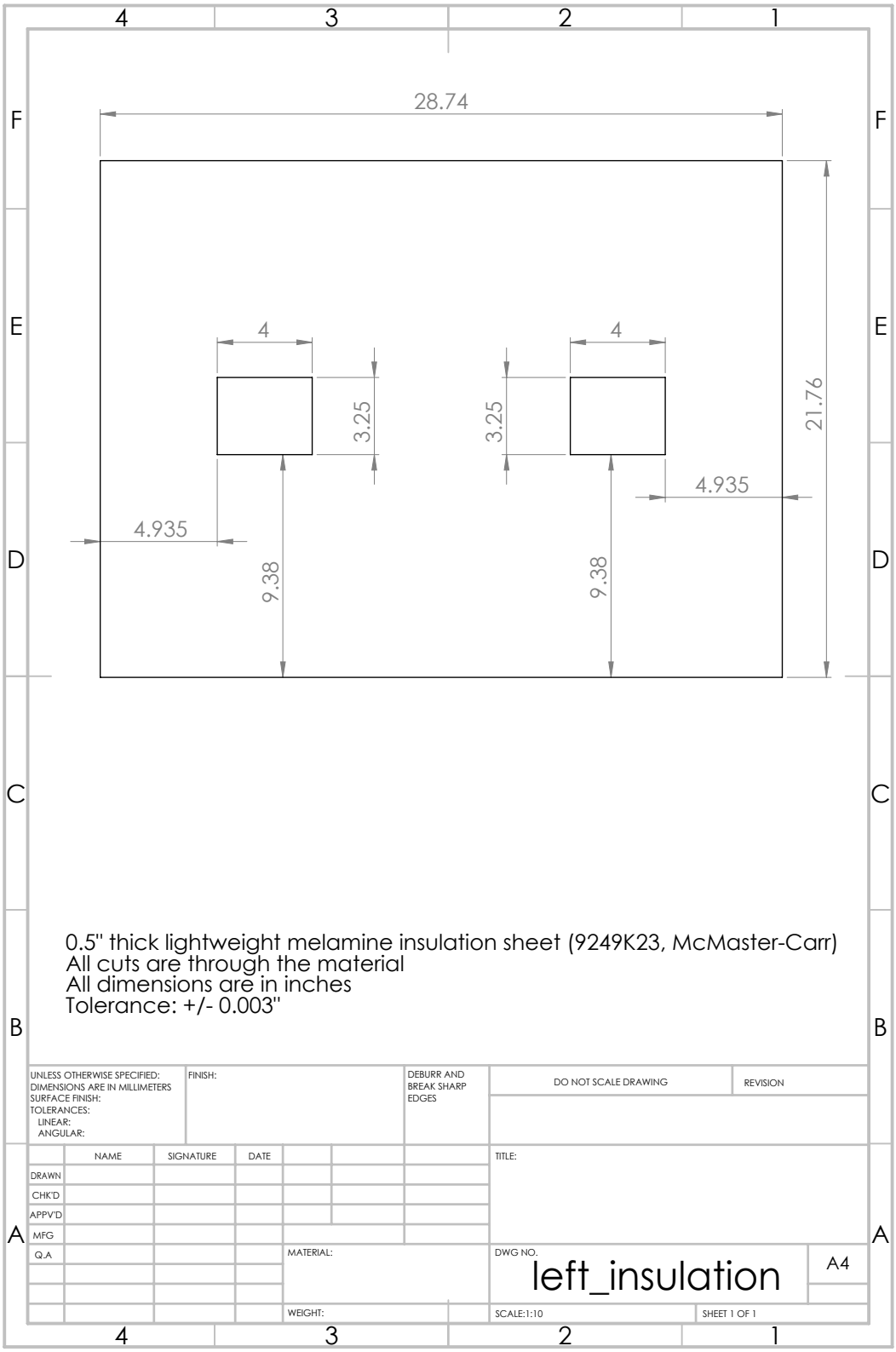
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:	FINISH:		DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION	
	NAME	SIGNATURE	DATE			TITLE:
DRAWN						
CHK'D						
APPV'D						
MFG						
Q.A				MATERIAL:	DWG NO. door_acrylic	A4
				WEIGHT:	SCALE:1:2	SHEET 1 OF 1


4
3
2
1
F
E
D
C
B
A
24.622
21.76
9.843
7.874
8.374
5.959
0.5" thick lightweight melamine insulation sheet (9249K23, McMaster-Carr)
All cuts are through the material
All dimensions are in inches
Tolerance: +/- 0.003"
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
TITLE:
MATERIAL:
DWG NO.
front_insulation
A4
WEIGHT:
SCALE:1:10
SHEET 1 OF 1



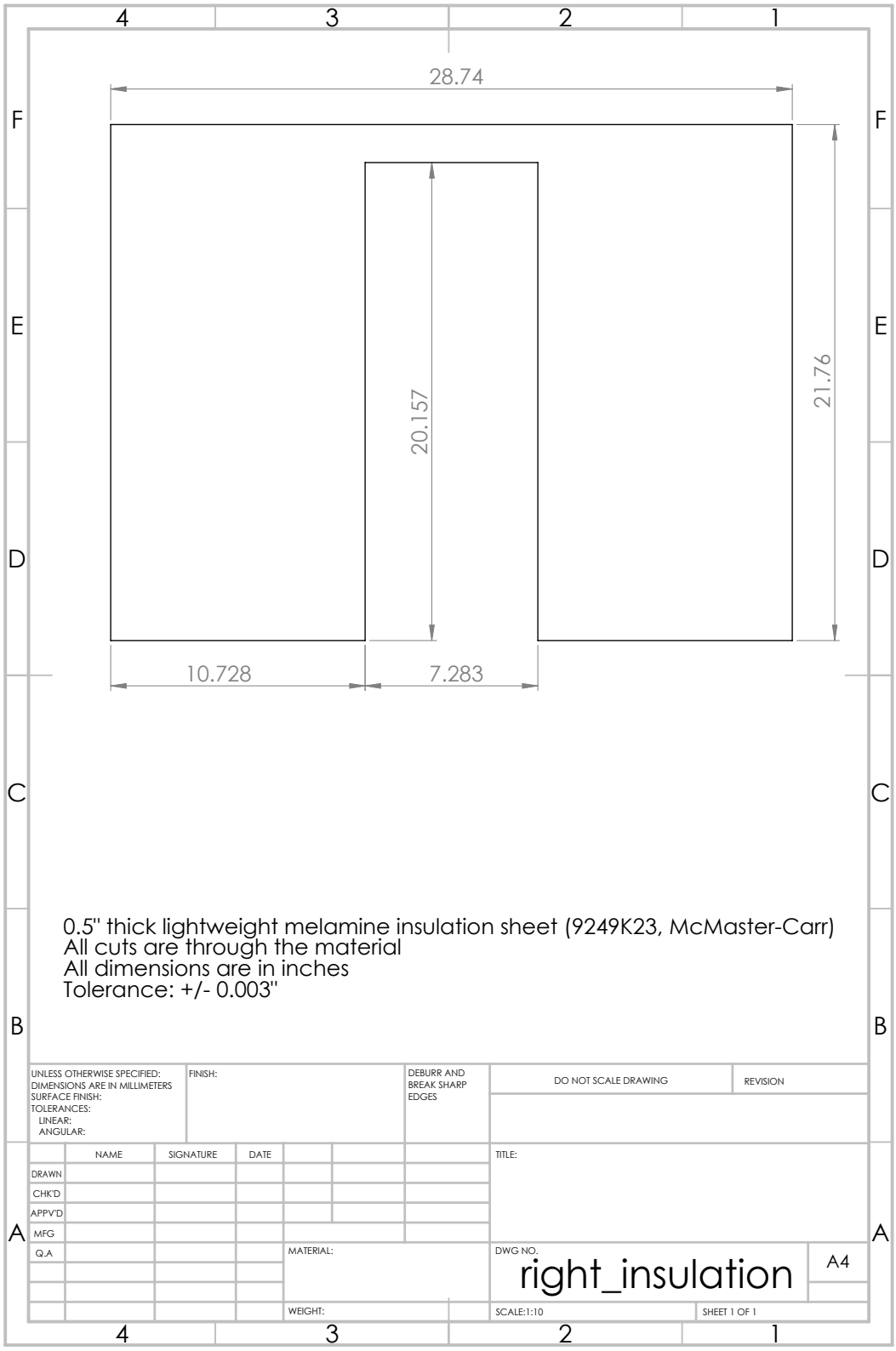
0.5" thick lightweight melamine insulation sheet (9249K23, McMaster-Carr)
All cuts are through the material
All dimensions are in inches
Tolerance: +/- 0.003"

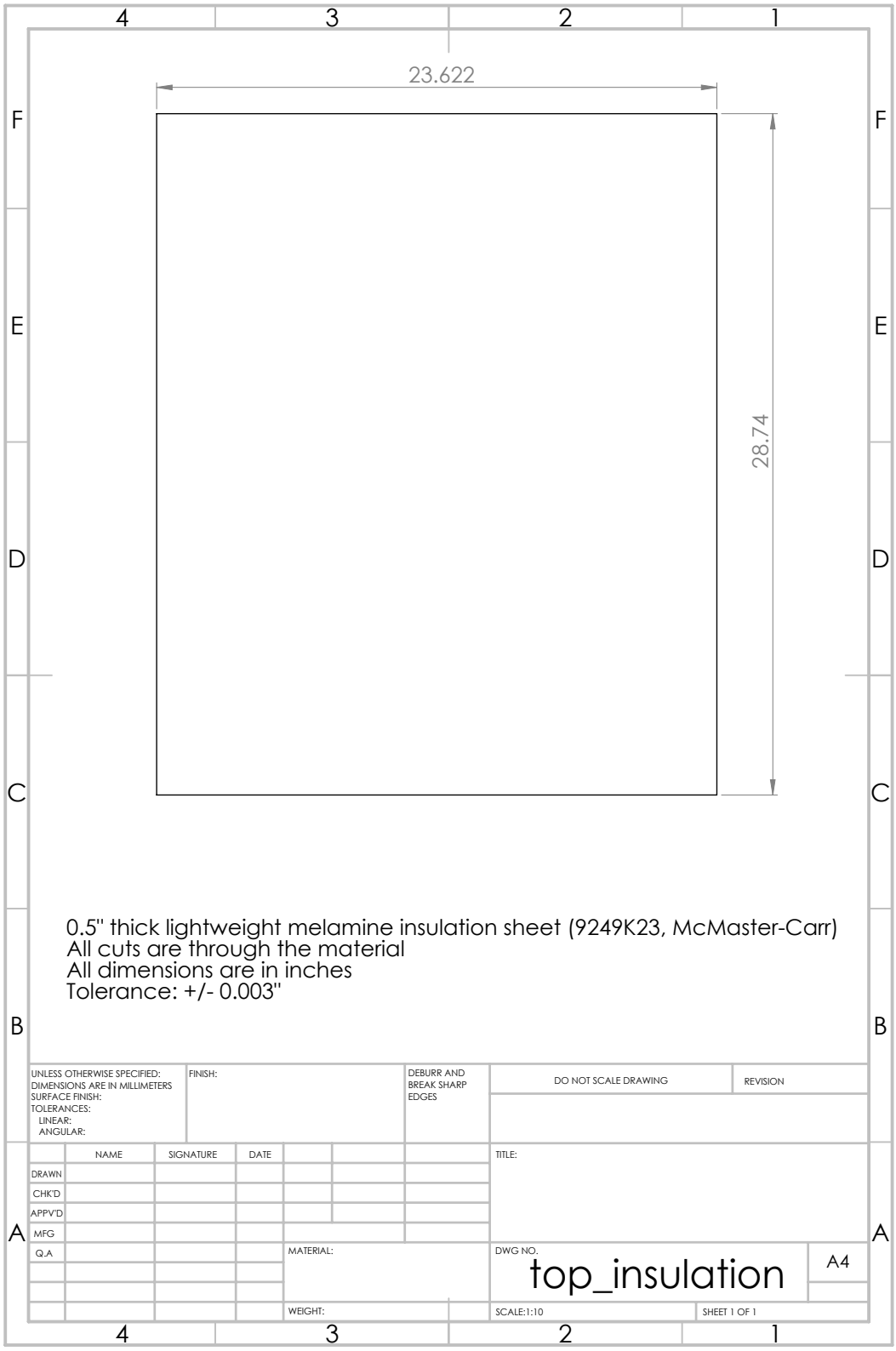
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:		FINISH:		DEBURR AND BREAK SHARP EDGES		DO NOT SCALE DRAWING	REVISION
	NAME	SIGNATURE	DATE			TITLE:	
DRAWN							
CHK'D							
APPV'D							
MFG							
Q.A				MATERIAL:		DWG NO. back_insulation	A4
				WEIGHT:		SCALE:1:10	SHEET 1 OF 1

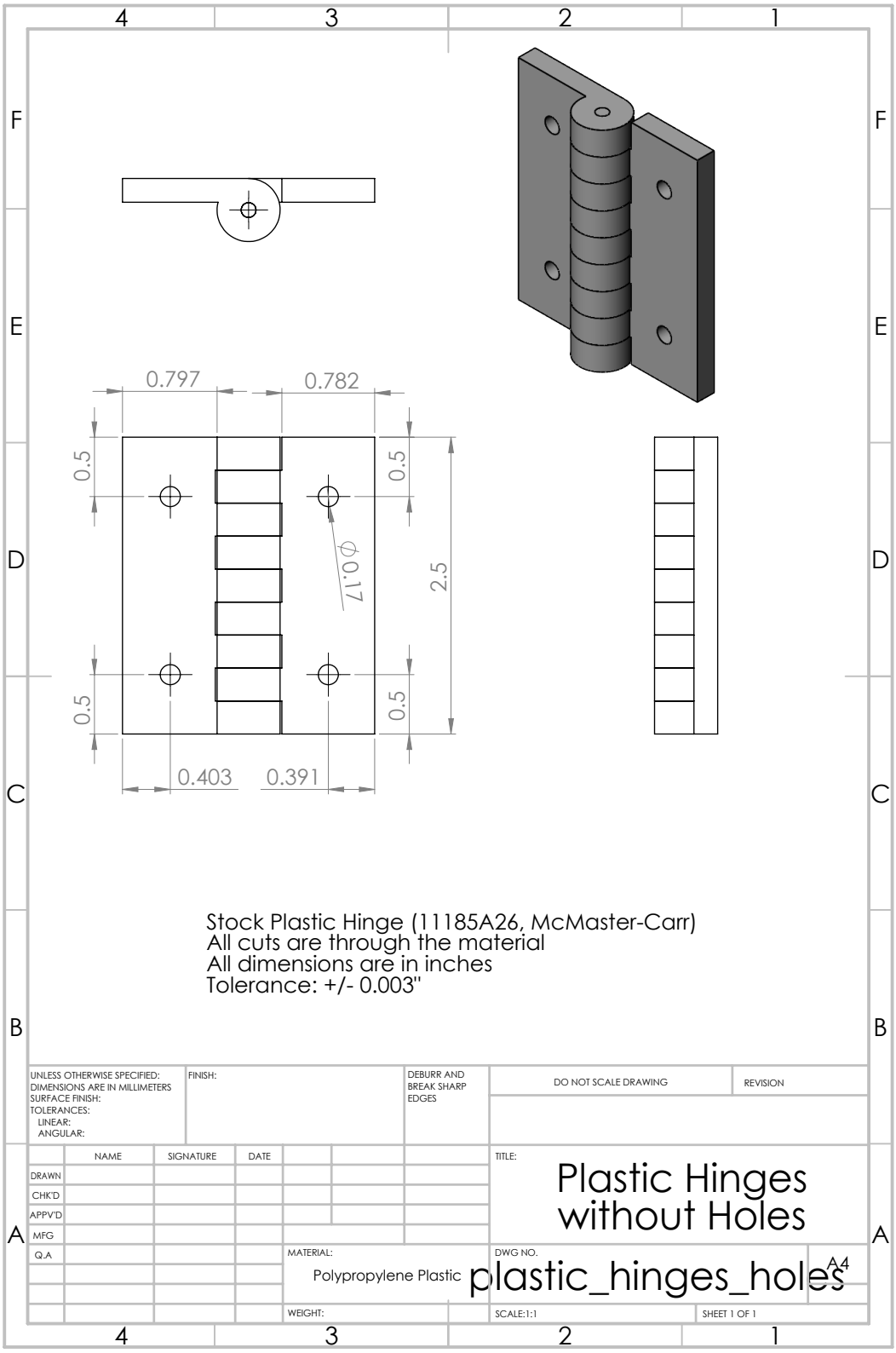


0.5" thick lightweight melamine insulation sheet (9249K23, McMaster-Carr)
All cuts are through the material
All dimensions are in inches
Tolerance: +/- 0.003"

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:	FINISH:		DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION	
	NAME	SIGNATURE	DATE			TITLE:
DRAWN						
CHK'D						
APPV'D						
MFG						
Q.A				MATERIAL:	DWG NO. left_insulation	A4
				WEIGHT:	SCALE:1:10	SHEET 1 OF 1


4
3
2
1
F
E
D
C
B
A
28.74
20.157
21.76
10.728
7.283
0.5" thick lightweight melamine insulation sheet (9249K23, McMaster-Carr)
All cuts are through the material
All dimensions are in inches
Tolerance: +/- 0.003"
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
TITLE:
DRAWN
CHK'D
APPV'D
MFG
Q.A
MATERIAL:
DWG NO.
right_insulation
A4
WEIGHT:
SCALE:1:10
SHEET 1 OF 1


4
3
2
1
F
E
D
C
B
A
23.622
28.74
0.5" thick lightweight melamine insulation sheet (9249K23, McMaster-Carr)
All cuts are through the material
All dimensions are in inches
Tolerance: +/- 0.003"
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
TITLE:
MATERIAL:
DWG NO.
top_insulation
A4
WEIGHT:
SCALE:1:10
SHEET 1 OF 1


4
3
2
1
F
E
D
C
B
A
0.797
0.782
0.5
0.5
0.5
0.5
2.5
ϕ0.17
0.403
0.391
Stock Plastic Hinge (11185A26, McMaster-Carr)
All cuts are through the material
All dimensions are in inches
Tolerance: +/- 0.003"
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
TITLE:
Plastic Hinges without Holes
MATERIAL:
Polypropylene Plastic
DWG NO.
plastic_hinges_holes
A4
WEIGHT:
SCALE:1:1
SHEET 1 OF 1