Precision Reimagined: The Evolution of the TseNC to the TzeNC-Pro

An Applied Research Project

Submitted to the

Technology and Bionics Faculty of

Hochschule Rhein-Waal

by Aaron Hinkle

22113

In partial fulfillment of the

requirements for the degree of

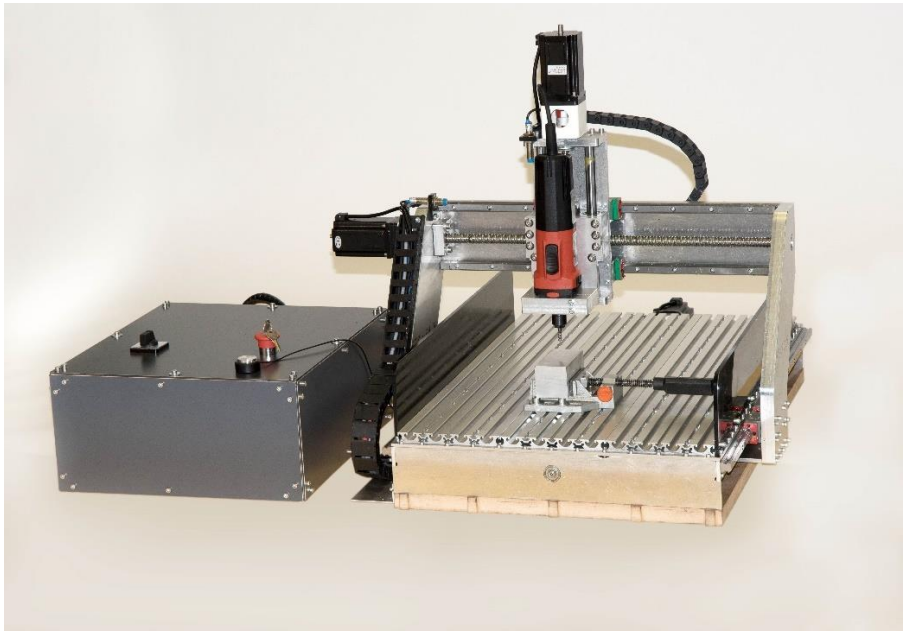
Master of Science in Bionics

December 21st, 2023

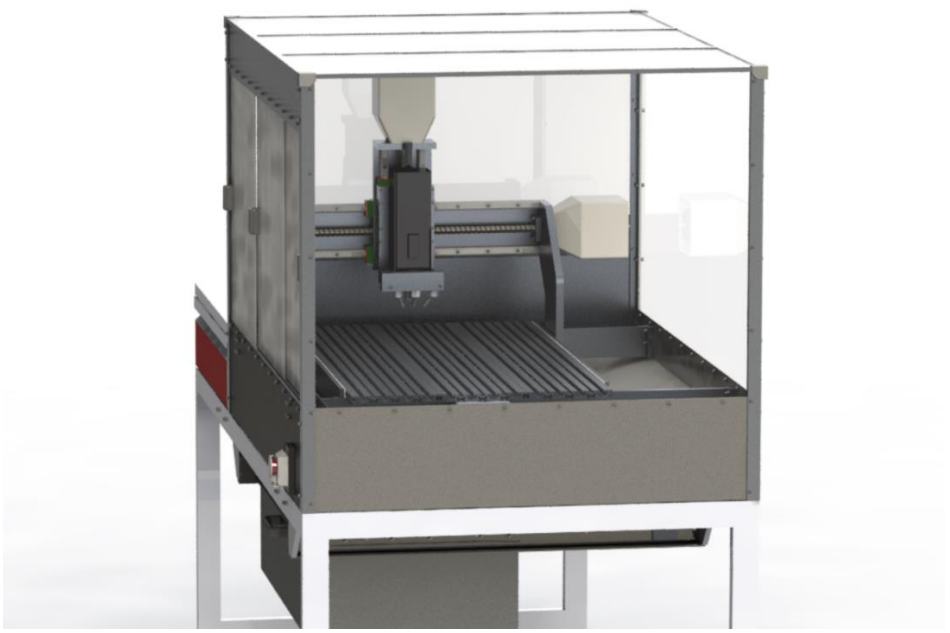
Hochschule Rhein-Waal

Kleve, Nordrhein-Westfalen

Table of Contents



Original TseNC by Daniele Ingrassia



New Redesigned TzeNC-Pro

Introduction

In the evolving landscape of computer numerical control (CNC) machinery, the pursuit of greater precision, versatility, and reliability remains paramount. The original TseNC, designed by Daniele Ingrassia, stood as a testament to innovation in hobbyist CNC design. However, despite its forward-thinking approach, the TseNC presented several areas for improvement, particularly in rigidity, durability, and its capability to work with more robust materials. Commissioned to undertake a comprehensive redesign, this project aimed to transform the TseNC from a machine suited for cutting plastics and woods into a robust, industrial-grade apparatus capable of precisely cutting aluminum or steel for extended periods without interruption or constant supervision. This report introduces the TzeNC-Pro, a machine that not only honors its predecessor through its name and shared hardware but also markedly transcends it in performance and functionality. With a background firmly rooted in mechanical engineering and manufacturing, this redesign was approached with a critical eye towards enhancing structural integrity, operational efficiency, and user-friendliness. The TzeNC-Pro emerges not

as a mere iteration of its former self but as a reinvented entity, equipped to meet industrial demands.
The most significant functional enhancement in the TseNC-Pro is the incorporation of a sophisticated flood coolant system, a feature absent in the original design. This advancement necessitated the full enclosure of the machine, dramatically altering its aesthetics and improving its operational longevity by mitigating the impact of debris and heat.

Mechanically, the TseNC-Pro has been refined to achieve a delicate balance between weight and strength, resulting in a machine that is both lighter and more rigid. This was accomplished through a series of targeted modifications aimed at improving the gantry's rigidity and streamlining both the fabrication and assembly processes. Notable among these is the innovative reconfiguration of the gantry, which is now suspended from the Y-axis rails, enhancing movement freedom while protecting the critical linear guides from dust and debris.

Technical specifications of the TseNC-Pro underscore its industrial capabilities and include an expanded working area of 600x370x145mm (Y-X-Z), a robust enclosure comprised of aluminum, extruded steel, and acrylic, and a bolted aluminum plate frame and gantry. It boasts advanced actuators, high-quality Hiwin HGR15 linear guides, and a maximum speed of 4000mm/min. The machine's precision is highlighted by its mechanical resolution of 0.003125mm. The heart of the TseNC-Pro lies in its Mafell FM1000 1Kw spindle, controlled by the GRBL-LPC firmware and an LPC1768 32bit controller, and driven by powerful NEMA 24 4MN motors and DM556 motor controllers. Additional features such as quick spindle release, a Z-axis zero sensor, inductive endstops with soft limits, and an emergency button with fuse protection have all been integrated to enhance the machine's performance, safety, and ease of use.
Accompanying this report is a comprehensive fabrication plan for each component, an assembly manual detailing the construction of the TseNC-Pro, and in-depth discussions on the electronics and software that bring this machine to life. This document not only serves as a testament to the TseNC-Pro's innovative design but also as a guide for replication and further innovation in the field of CNC machinery.
As we delve into the details of the TseNC-Pro's design, enhancements, and capabilities, it is clear that this project was not merely a revision but a reinvention, setting a new standard for what can be expected from high-performance, industrial-grade CNC machines.

Bill of Materials

Item Name	Description	QTY	Link	Unit Price	Total Price
COTS Ready to Install					
5mm T-Nut M4	K20.N5 T-slot nut 5 mm - M4	16	Link	0.71	11.36
6000-2RS Sealed Ball Bearing	SKF 6000-2RSH deep groove ball bearing 1 row, 10x26x8 mm	3	Link	6.62	19.86
16101 2RS Sealed Ball Bearing	Deep Groove Ball Bearing 16101-2RS1, 12x30x8 mm	2	Link	19.14	38.28
688-2RS Sealed Ball Bearing	Stainless Steel Miniature Deep Groove Ball Bearing SS 688 2RS 8x16x5 mm	1	Link	3.20	3.20
HGR15 780mm	Guide Rails cut to 751mm	2		38.48	76.96
HGR15 X	Guide Rails cut to 505mm	2	Link	25.88	51.75
HGR15 Z	Guide Rails cut to 243mm	2		12.45	24.90
HGH15 C	Profile rail guide carriage	12	Link	33.00	396.00
SFU1204 250mm Z	SFU 1204-3 Ball spindle with nut 1204, 250mm	1	Link	36.61	36.61
SFU1610 800mm Y	1610-3 Ball spindle with nut 1610, 800mm	1	Link	75.90	75.90
SFU1610 550mm X	1610-3 Ball spindle with nut 1610, 550m	1	Link	79.96	79.96
Nema 24 Motor	Dual Shaft Nema 24 Stepper Motor 4.2A 4Nm 60x60x100mm 4 Wires	3	Link	40.41	121.23
Stepper Driver	Stepper Motor Driver TB6600 4A 9-42V Controller Control CNC Stepper Motor		Link	11.15	11.15
Mafell FM 1000	CNC milling spindle	1	Link	236.81	236.81
Shaft Coupler	DIN912 D25L30 8mm to 10mm	1	Link	6.66	13.32
Shaft Coupler	DIN912 D25L30 10mm to 10mm	2	Link	6.66	13.32
Dibond for Electric Box	3mm 2050 x 1000mm Slate Gray	1	Link	54.70	54.70
Power Plug with Fuse and Switch	IEC C14 built-in plug 250 V 10 A switch fuse holder module 14554	1	Link	3.19	3.19
Shielded Cable	Shielded control line Data line LIYCY 4 x 0.5 mm² (10m total)	10	Link	1.49	14.90
Shielded Cable	Shielded control line Data line LIYCY 3 x 0.25 mm² (10m total)	10	Link	1.20	12.00

Low Voltage Cable	low voltage line, max 24 V, 2 x 1.5 mm² (10m total)	10	Link	1.29	12.90
Power Switch	Cam rotary reversing switch 20A, 2 pole, 1 phase	1	Link	7.99	7.99
PC AC Power Cable	Power cable Europe - CEE 7/17 E + F to C17, black, 2m	1	Link	3.59	3.59
List Connecting Terminals	12-pole List connecting terminals 1.5-2.5mm² (12 slots, 1.5-2.5 mm², lot: 5 pieces)	1	Link	6.99	6.99
Magnetic Switch	Normally open Magnetic Switch PS-3150	10	Link	1.99	19.90
Emergency Button with key	Emergency stop pressure switch (not sure what type I need right now. I need to talk to Daniele.)		Link		
Cable Chain	Closed 25 x 57/77		Link		
Cable Wrap	10/20mm		Link		
Drawer Hardware	Heavy duty drawer runners, fully extendable, 80 kg load capacity, 1 pair, 400mm	1	Link	48.82	48.82
Kedu KJD18	3-Phase 7-Pin Start/Stop switch	1	Link	14.99	14.99
Centrifugal Pump - Yu Hseng TC-6180	1/6 HP Coolant circulation pump, immersion 130mm (5"), NPT 1/2"	1	Link	27.56	27.56
Nozzles	JETON 1/4" NPT Angled Injection High-Pressure Coolant Ball Nozzle, with 30 mm Nozzle (Size name: 1/4"NPT-Φ4*30L)	3	Link	23.88	71.64
1/2” Braided Steel Hose	1500mm Verbindungsschlauch *available at Hagebaumarkt	2	xxx	10.99	21.98
1/2” Braided Steel Hose	1000mm *available at Hagebaumarkt	1	xxx	10.99	10.99
1/2” Pipe thread stopper	*available at Hagebaumarkt	1	xxx	2.79	2.79
1/2” Pipe thread connector	Doppelnippel *available at Hagebaumarkt	2	xxx	1.99	3.98
Coolant flow switch	*Couldn’t find a simple mechanical one online, but I guess we can get this at Hagebaumarkt too	1	xxx		
Tools					
1/4" NPT thread Tap	Machine Tap JIS B-4430 Form C HSS-G - NPT 1/4 x 18	1	Link	14.99	14.99
1/2" NPT thread Tap	Machine Tap JIS B-4430 Form C HSS-G - NPT 1/2 x 14	1	Link	27.97	27.97
4mm Punch for Rubber	Handheld Precision Hollow Hole Punch for Leather Crafting	1	Link	3.29	3.29
Utility Knife	Construction duty utility knife with retractable blade	1	Link	7.65	7.65

Replacement Blades	Heavy duty utility blades pack of 100	1	Link	34.95	34.95
Plumbers Tape	PTFE Teflon Thread Seal Tape, 12 mm x 12 m		Link	5.20	5.20
Gorilla Tape	Rubberized waterproof patch and seal tape (4” x 10’)	1	Link	27.58	27.58
Double-Sided Tape					
Clamps	Probably going to need a few assorted clamps to accomplish some of these parts, but we can burn that bridge when we come to it.				
Paint	Going to need something to protect the steel parts. We can either go for metal primer and paint or have it done professionally again like with the casting machine.				
Aluminum Extrusion					
T-Nut Plate	160 x 16 x 1000	3	Link	35.99	107.97
U - Profile for 4mm Panels	8 x 14 x 3000	1	Link	13.50	13.50
H - Profile for 4mm Panels	8 x 25 x 3000	1	Link	16.50	16.50
25 x 2mm L-Angle Bar	25 x 25 x 2 1000mm	4	Link	3.00	12.00
15 x 2mm L-Angle Bar	15 x 15 x 2 1000mm	2	Link	2.10	4.20
3mm Acrylic					
PG Front Panel	3mm acrylic cut to 630 x 822mm with all edges polished	1		54.86	54.86
PG Back Panel	3mm acrylic cut to 825 x 480mm with all edges polished	1	Link	47.40	47.40
PG Side Panel	3mm acrylic cut to 630 x 1092mm with all edges polished	1		66.44	66.44
X Axis Shield	3mm acrylic cut to 50 x 139mm with all edges polished				
4mm Acrylic					
PG Door Panels	4mm acrylic cut to 372 x 494mm with all edges polished	3	Link	34.00	102.00
PG Top Panels	4mm acrylic cut to 363 x 835mm with rough cut edges	3		25.11	75.33
Misc.					
Table					

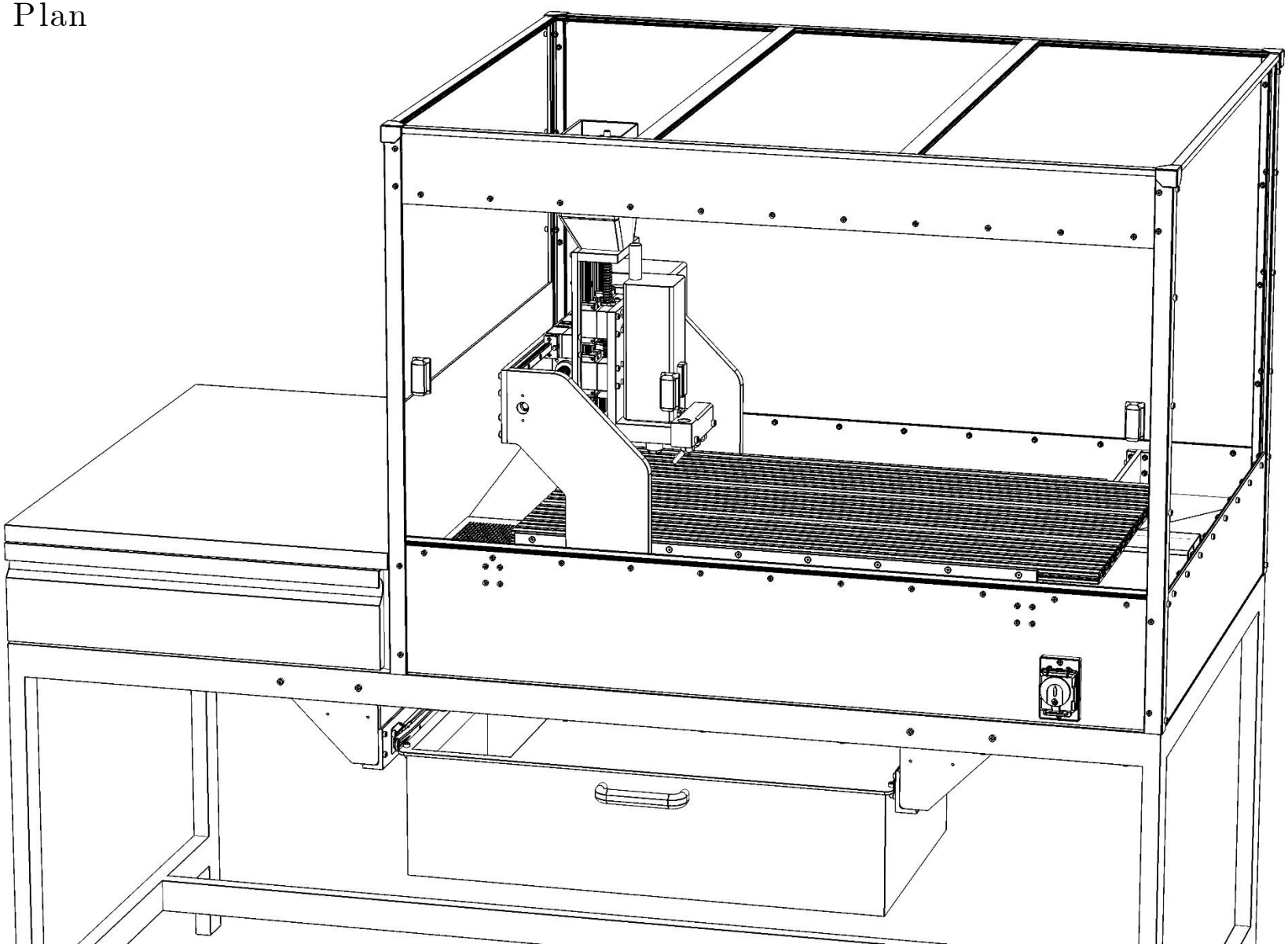
Plastic Sheet 1.5mm	1.5 x 200 x 300 ABS plastic sheets (4 pack – need 7 total)	2	Link	11.49	23.98
3mm rubber gasket for base	Nitrile butadiene rubber strips SBR 50x3mm, 10m	1	Link	19.23	19.23
Aluminum Plate AlMg3					
1.5mm					
Y Axis Rail Guard	1.5 x 85 x 751	2	Link	10.00	20.00
Y Axis Guard	1.5 x 151 x 751	1	“ “	10.00	10.00
Door Bracket Inserts	1.5 x 15 x 1079	2	“ “	10.00	19.99
Top Door Bracket Inserts	1.5 x 19 x 1079	2	“ “	10.00	19.99
3mm 83.35 for everything in one plate so individual cuts are cheaper					
Drain for Chip Tray	3 x 145 x 175	1	“ “	10.00	10.00
Stopper Bracket for Doors	3 x 15 x 1079	2	“ “	10.00	20.00
Al Back Panel	3 x 265 x 825	1	“ “	33.42	33.42
Front Plate for Doors	3 x 100 x 1086	1	“ “	16.60	16.60
4mm					
Reinforcements for Base	4 x 95 x 751	2	“ “	12.40	24.80
5mm 39.98 for individual cuts so everything in one plate is cheaper					
Spacer for Spindle Plate / Bottom Bracket for Doors	5 x 110 x 1140	1	“ “	33.05	33.05
6mm					
Y Bottom Plate for Screw	6 x 100 x 496	1	“ “	12.98	12.98
8mm 116.01 to have them cut it vs 109.37 for me to do it. I choose them 😊					
Y Back Plate / Y Front Plate	8 x 60 x 825	2	“ “	15.09	30.18
Side Supports for Base	8 x 47.5 x 751	2	“ “	10.98	21.97
26mm OD Bearing Block	8 x 36 x 46	1	“ “	10.00	10.00
30mm OD Bearing Block	8 x 40 x 46	1	“ “	10.00	10.00

X Back Plate	8 x 105 x 535	1	“ “	17.12	17.12
Z Back plate	8 x 115 x 255	1	“ “	10.00	10.00
Motor Mount for X Axis	8 x 60 x 60	1	“ “	10.00	10.00
8.5mm					
Y Spacer Block (4)	15 x 34 x 39.4 x8				
10mm 109.96 for individual cuts so everything in one plate is way cheaper					
X 26mm OD Bearing Block / X 30mm OD Bearing Block/ Corner Block for Base (4) / Z Ball Screw Lower Support	10 x 140 x 70	1	“ “	10.00	10.00
Corner Braces for Drawer Hardware	10 x 340 x 300 (for all 4)	1	“ “	38.96	38.96
Tray Support Back / Tray Support Front / Reinforcement for Small Drain	10 x 142 x 319 + 170 + 153				
12mm 39.98 for individual cuts so everything in one plate is cheaper					
Y Bottom Plate for Rails (2) / Z Top Plate / Z Front Plate	12 x 210 x 235	2	“ “	12.80	25.60
15mm					
Left Shoulder / Right Shoulder / Brackets for Weight Support (8)	15 x 320 x 340	1	“ “	75.26	75.26
Z Spacer Block (4)/ X Spacer Block (2) / X Spacer Block for shield (2)	15 x 33 x 39.4 x8				
25mm					

Spindle Plate	25 x 85 x 108	1	“ “	10.00	10.00
30mm					
Coolant Distributor	30 x 35 x 120	1	“ “	10.00	10.00
40mm 29.98 for individual cuts so everything in one plate is cheaper					
Nut Block (2) / Nut Block Z	40 x 56 x 130	1	“ “	12.09	12.09
Steel					
Chip Tray	1.5mm x 210 x 645	1**		12.15	12.15
Bottom Tray	1.5mm x 1115 x 1525	1**		108.52	108.52
Coolant Tank	2mm x 700 x 1000 We could also have this built by professionals for 233.18 (Link). May not be the worst idea…	1**	Link		61.29
Left Side Skirt/ Right Side Skirt	3 x 215 x 1101	2		32.79	65.58
Front Skirt	3 x 215 x 828	1		25.74	25.74
Angle Iron for Drawers	60x30x6, 1000mm	2	Link	29.89	59.78
**Featuring processes that are entirely new to me so no guarantees that it will work on the first try. Backups might be a good idea.					
3D Printed					
Y-Axis Motor Adaptor		1			
X-Axis Motor Adaptor		1			
Z-Axis Motor Adaptor		1			
Cover for Y-Motor		1			
Cover for X-Motor		1			
Cover for Z-Motor		1			
Corner Pieces for Lid		4			
Door Handles		3			
Handle for Drawer		1			
Hardware					

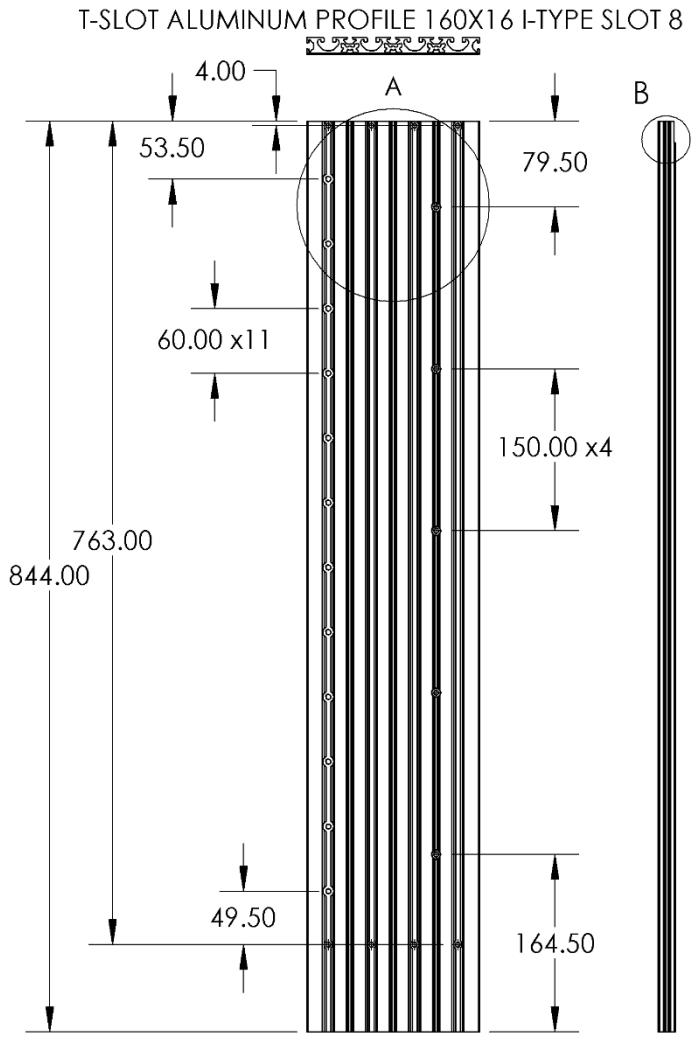
DIN 471 10 mm External Circlip		2			
DIN 471 8 mm External Circlip		1			
ISO - 10511 - M4 - D - N	M4 Lock Nut (100 pieces per lot, need 211 total)	3	Link	0.83	2.49
ISO 4762 M4 x 10 - 10N	M4 x 10 Hex Socket Head Bolt (100 pieces per lot, need 16 total)	1	Link	2.12	2.12
ISO 4762 M4 x 12 - 12N	M4 x 12 Hex Socket Head Bolt (100 pieces per lot, need 22 total)	1	Link	2.35	2.35
ISO 10642 - M4 x 12 - 12N	M4 x 12 Hex Socket Countersunk Head Bolt (100 pieces per lot, need 16 total)	1	Link	1.84	1.84
ISO 4762 M4 x 16 - 16N	M4 x 16 Hex Socket Head Bolt (100 pieces per lot, need 87 total)	1	Link	2.45	2.45
ISO 4762 M4 x 20 - 20N	M4 x 20 Hex Socket Head Bolt (100 pieces per lot, need 43 total)	1	Link	2.38	2.38
ISO 4762 M4 x 25 - 25N	M4 x 25 Hex Socket Head Bolt (100 pieces per lot, need 52 total)	1	Link	1.97	1.97
ISO 4762 M4 x 30 - 30N	M4 x 30 Hex Socket Head Bolt (100 pieces per lot, need 99 total)	1	Link	3.23	3.23
ISO 4762 M4 x 40 - 20N	M4 x 40 Hex Socket Head Bolt (100 pieces per lot, need 8 total)	1	Link	3.28	3.28
ISO - 10511 - M5 - D - N	M5 Lock Nut (100 pieces per lot, need 36 total)	1	Link	1.04	1.04
ISO 4762 M5 x 16 - 16N	M5 x 16 Hex Socket Head Bolt (100 pieces per lot, need 20 total)	1	Link	2.52	2.52
ISO 4762 M5 x 20 - 20N	M5 x 20 Hex Socket Head Bolt (100 pieces per lot, need 7 total)	1	Link	2.45	2.45
ISO 4762 M5 x 25 - 25N	M5 x 25 Hex Socket Head Bolt (100 pieces per lot, need 14 total)	1	Link	2.85	2.85
ISO 4762 M5 x 30 - 30N	M5 x 30 Hex Socket Head Bolt (100 pieces per lot, need 20 total)	1	Link	3.70	3.70
ISO 4762 M5 x 40 - 22N	M5 x 40 Hex Socket Head Bolt (100 pieces per lot, need 10 total)	1	Link	5.46	5.46
ISO 4762 M5 x 50 - 22N	M5 x 50 Hex Socket Head Bolt (50 pieces per lot, need 30 total)	1	Link	2.77	2.77
ISO 4762 M5 x 70 - 22N	M5 x 70 Hex Socket Head Bolt (50 pieces per lot, need 2 total)	1	Link	4.02	4.02
ISO - 10511 - M6 - D - N	M6 Lock Nut (100 pieces per lot, need 4 total)				
ISO 4762 M6 x 20 - 20N	M5 x 20 Hex Socket Head Bolt (100 pieces per lot, need 4 total)				
		Total ink. 19% VAT			3099.89

Fabrication Plan

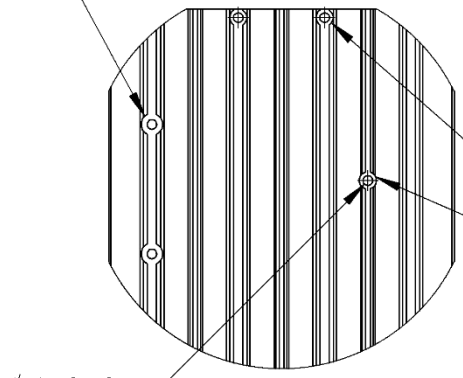


Aluminum Extrusion

T-Nut Plate Left



WAIT TO DRILL THESE 12 UNTIL AFTER MEASURING THE HOLE PLACEMENT IN THE HGR15 780mm. THEY ALSO HAVE TO BE COUNTERBORED AT 10 mm DOWN TO THE FLAT TO MAKE ROOM FOR THE NUT

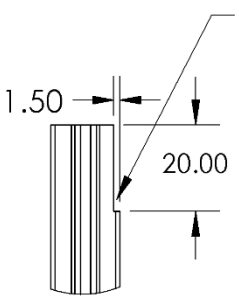


DETAIL A
SCALE 2 : 7

THESE 13 HAVE TO BE COUNTERBORED AT 8 mm DOWN TO THE FLAT TO MAKE ROOM FOR THE BOLT HEADS

NOTES:

- START WITH ALUMINUM EXTRUSION
- ALL HOLES ARE IN THE CENTERS OF THEIR RESPECTIVE GROOVES
- CUT THE COUNTERBORES IN THE SAME SETUP AS DRILLING THE HOLES
- THE GROOVE FOR THE CHIP TRAY SHOULD BE CUT CAREFULLY SO AS TO NOT CUT ALL THE WAY THROUGH THE EXTRUSION



DETAIL B
SCALE 4 : 7

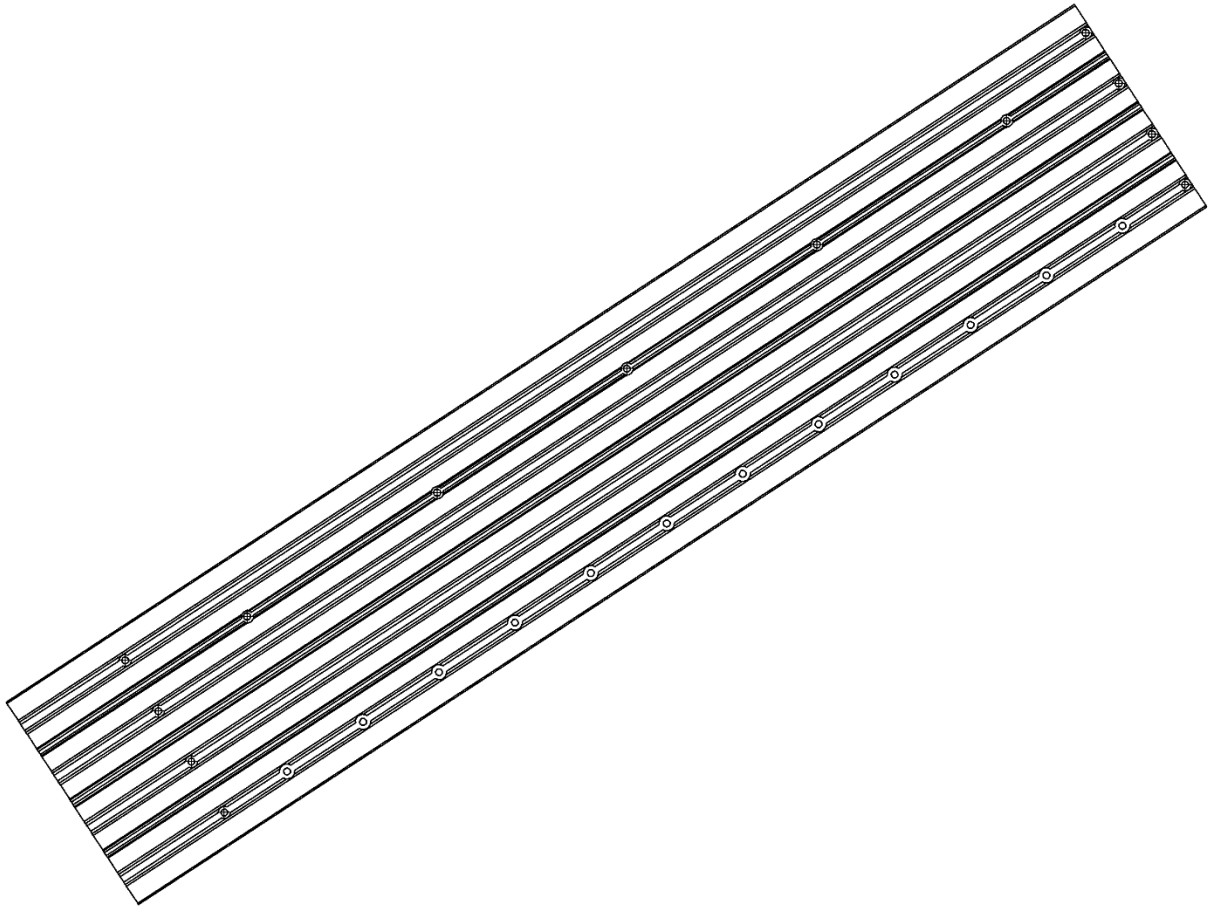
TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	T-NUT PLATE 160X16 LEFT
MATERIAL	EXTRUDED ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	3.13 kg
THIRD ANGLE PROJECTION	
SCALE	1 : 7
QUANTITY	1

T-Nut Plate Right



NOTES:
- CHIRAL-LY SYMMETRIC TO T-NUT PLATE 160 X 16 LEFT
- DON'T FORGET THE GROOVE FOR THE CHIP TRAY

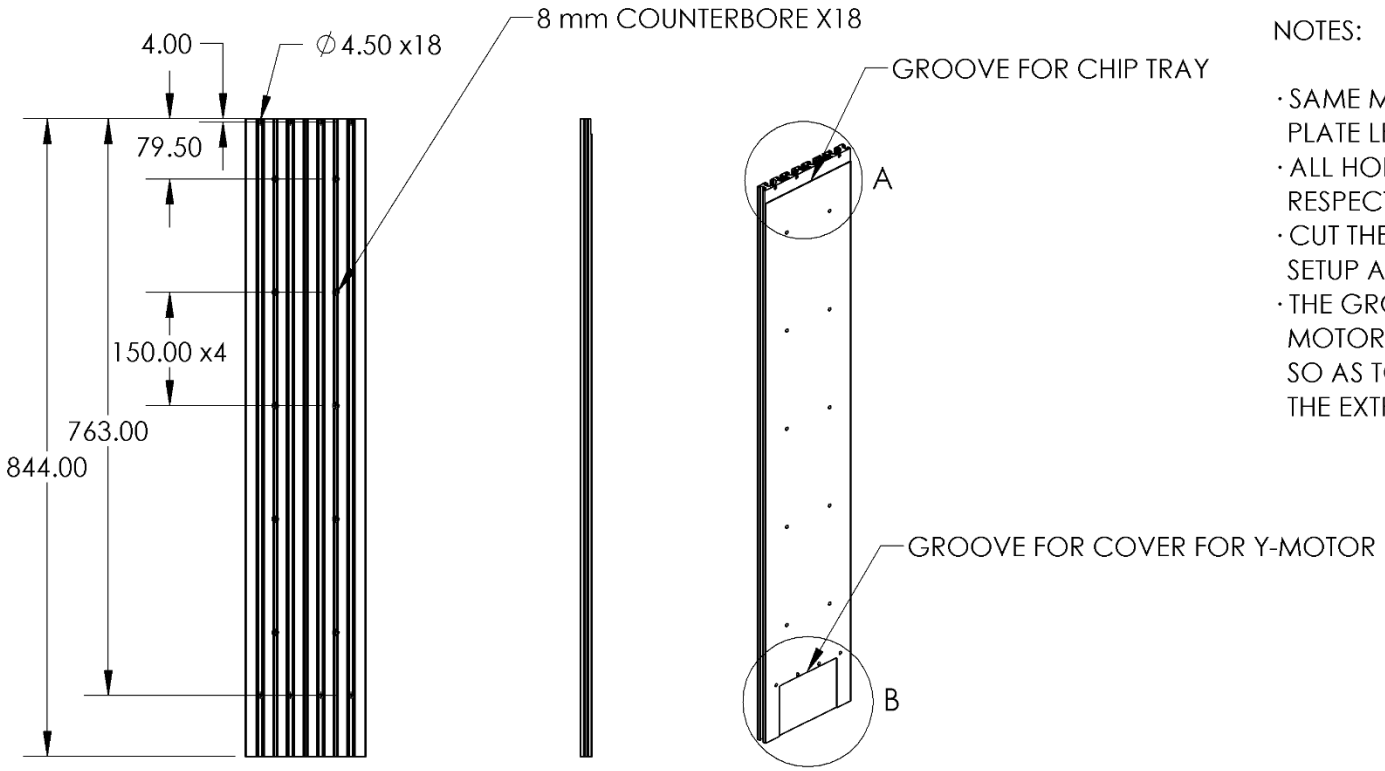
TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

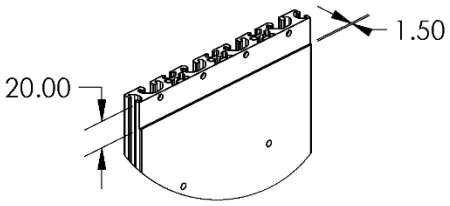
TITLE	T-NUT PLATE 160X16 RIGHT
MATERIAL	EXTRUDED ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	3.13 kg
THIRD ANGLE PROJECTION	
SCALE	1: 5
QUANTITY	1

T-Nut Plate Center

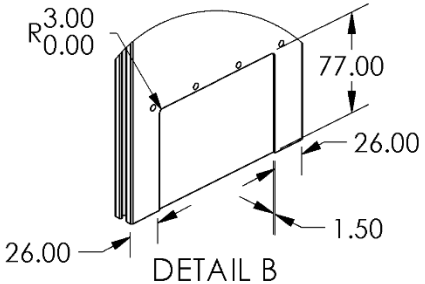


NOTES:

- SAME MATERIAL AND PROCESS AS T-NUT PLATE LEFT AND RIGHT
- ALL HOLES ARE IN THE CENTERS OF THEIR RESPECTIVE GROOVES
- CUT THE COUNTERBORES IN THE SAME SETUP AS DRILLING THE HOLES
- THE GROOVES FOR THE CHIP TRAY AND MOTOR COVER SHOULD BE CUT CAREFULLY SO AS TO NOT CUT ALL THE WAY THROUGH THE EXTRUSION



DETAIL A
SCALE 1 : 5



DETAIL B
SCALE 1 : 5

TzeNC-PRO

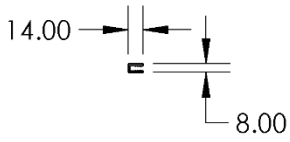
TITLE	T-NUT PLATE 160X16 CENTER
MATERIAL	EXTRUDED ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	3.10 kg
SCALE	1: 10
QUANTITY	1

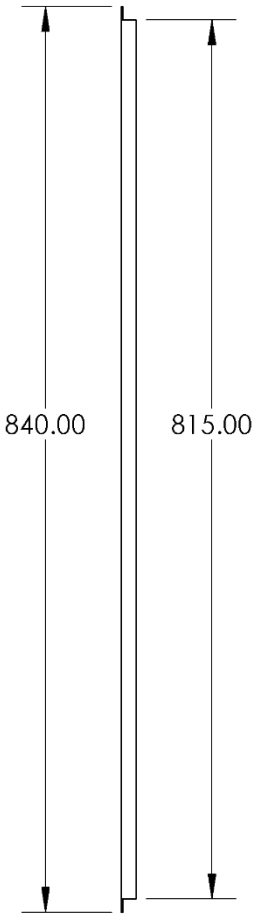
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

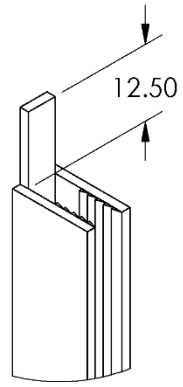
TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

THIRD ANGLE PROJECTION

U - Profile for Front and Back







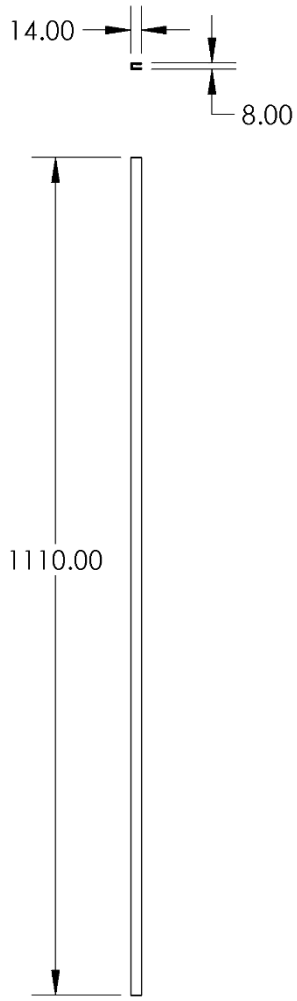
DETAIL A
SCALE 1 : 1

NOTES:

- START WITH 14 X 8 mm EXTRUDED ALUMINUM U-PROFILE MADE TO TAKE A 4 mm PANEL
- CUT THE OVERALL LENGTH AND THEN REMOVE THE MATERIAL AT THE ENDS SO THEY CAN SLIDE INTO THE EXTRUDED U-PROFILE ON THE SIDES OF THE LID

TzeNC-PRO	TITLE: U - PROFILE FOR FRONT AND BACK	
	MATERIAL: EXTRUDED ALUMINUM	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: NA	WEIGHT: 117.68 g
	THIRD ANGLE PROJECTION	SCALE: 1:7
		QUANTITY: 2

U - Profile for Left and Right

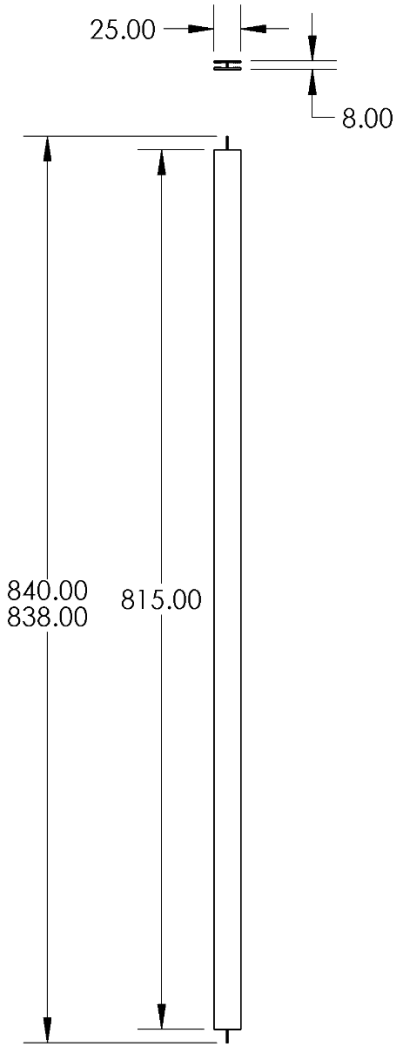


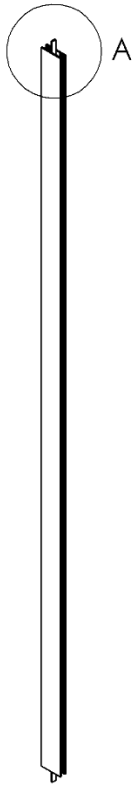
NOTES:

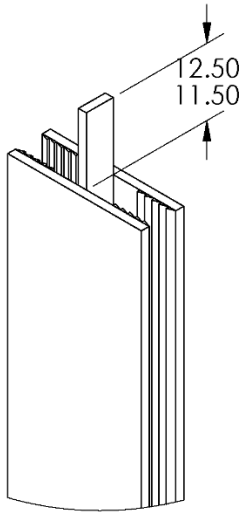
· MAKE FROM 14 X 8 mm EXTRUDED ALUMINUM U-PROFILE MADE TO TAKE A 4 mm PANEL

TzeNC-PRO	TITLE: U - PROFILE FOR LEFT AND RIGHT	
	MATERIAL: EXTRUDED ALUMINUM	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: NA	WEIGHT: 159.59 g
	THIRD ANGLE PROJECTION	SCALE: 1: 10
		QUANTITY: 2

H – Profile for Lid







DETAIL A
SCALE 1 : 1

NOTES:

- START WITH 25 X 8 mm EXTRUDED ALUMINUM H-PROFILE MADE TO TAKE A 4 mm PANEL
- CUT THE OVERALL LENGTH AND THEN REMOVE THE MATERIAL AT BOTH ENDS SO THEY CAN SLIDE INTO THE EXTRUDED U-PROFILE ON THE SIDES OF THE LID

TzeNC-PRO

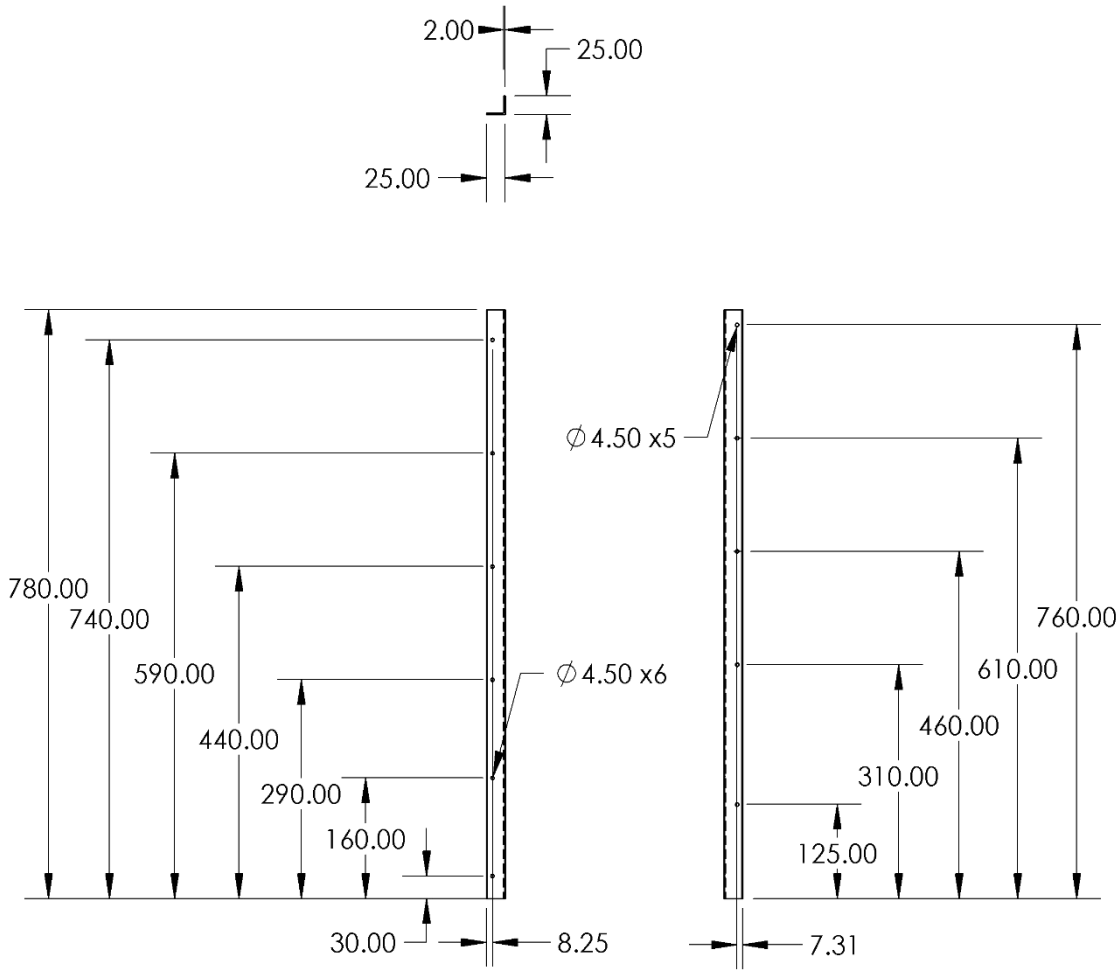
TITLE	H - PROFILE FOR LID
MATERIAL	EXTRUDED ALUMINUM
FINISH	NA
WEIGHT	196.90 g
SCALE	1: 7
QUANTITY	2

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

THIRD ANGLE PROJECTION

Back Right Outer Corner

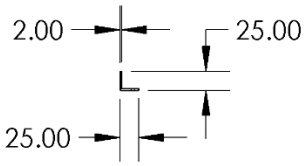


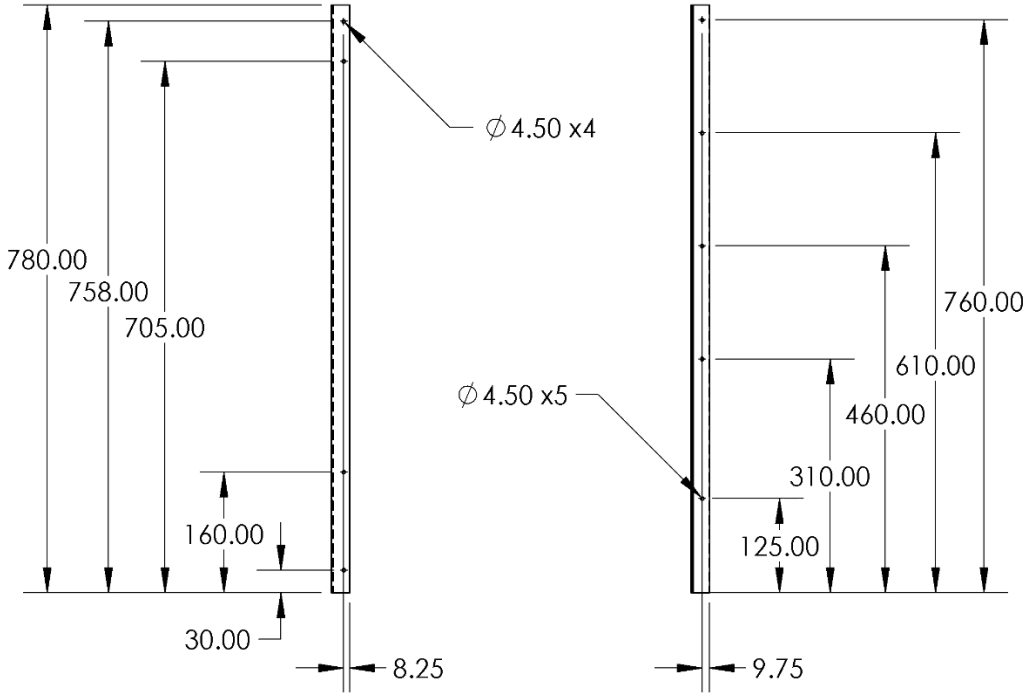
NOTES:

· START WITH 25 X 25 X 2 mm ALUMINUM L-BRACKET

TzeNC-PRO	TITLE: BACK RIGHT OUTER CORNER	
	MATERIAL: ALUMINUM L-PROFILE	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: AS MACHINED	WEIGHT: 200.33 g
	THIRD ANGLE PROJECTION	SCALE: 1: 10
		QUANTITY: 1

Back Left Outer Corner



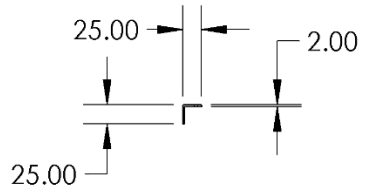


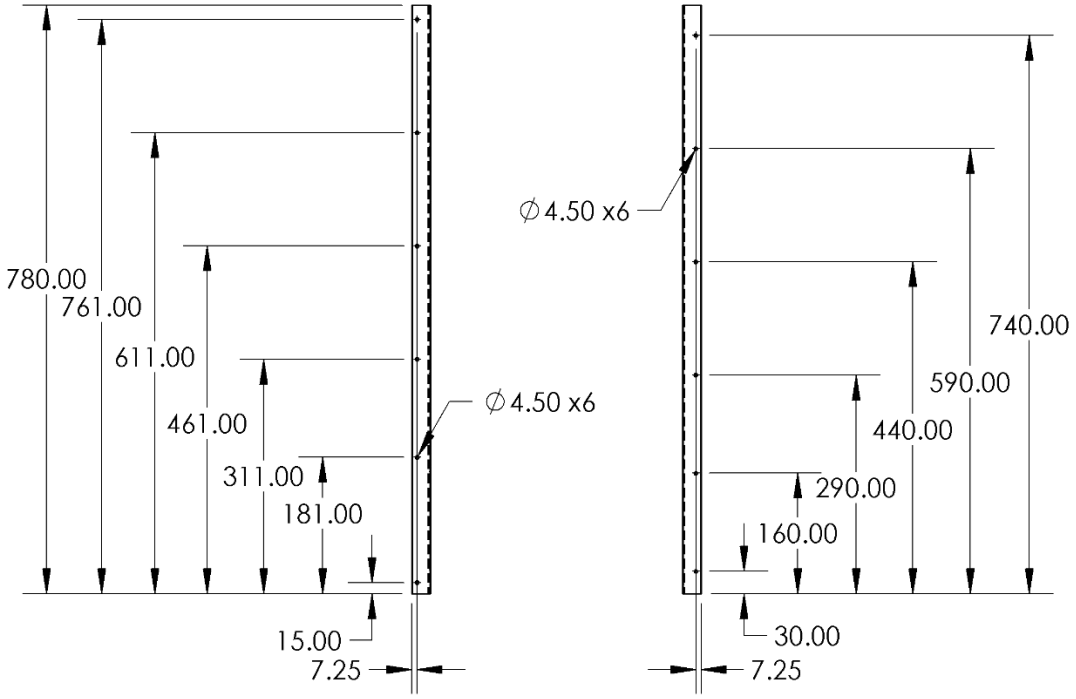
NOTES:

· START WITH 25 X 25 X 2 mm ALUMINUM L-BRACKET

TzeNC-PRO	TITLE: BACK LEFT OUTER CORNER
	MATERIAL: ALUMINUM L-PROFILE
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: AS MACHINED WEIGHT: 200.50 g THIRD ANGLE PROJECTION SCALE: 1: 10 QUANTITY: 1

Front Right Outer Corner





NOTES:

· START WITH 25 X 25 X 2 mm ALUMINUM L-BRACKET

TzeNC-PRO

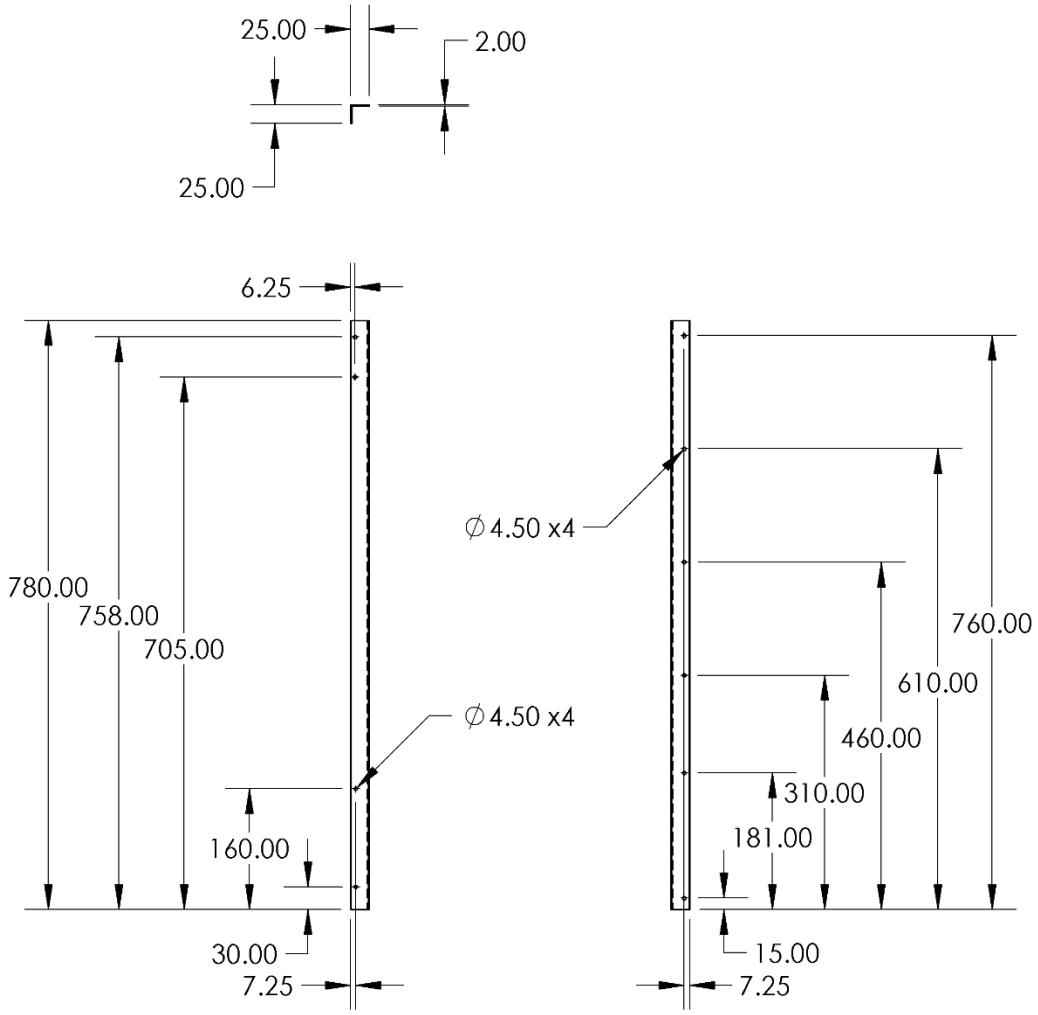
TITLE	FRONT RIGHT OUTER CORNER
MATERIAL	ALUMINUM L-PROFILE
FINISH	AS MACHINED
WEIGHT	200.24 g
SCALE	1: 10
QUANTITY	1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

THIRD ANGLE PROJECTION

Front Left Outer Corner

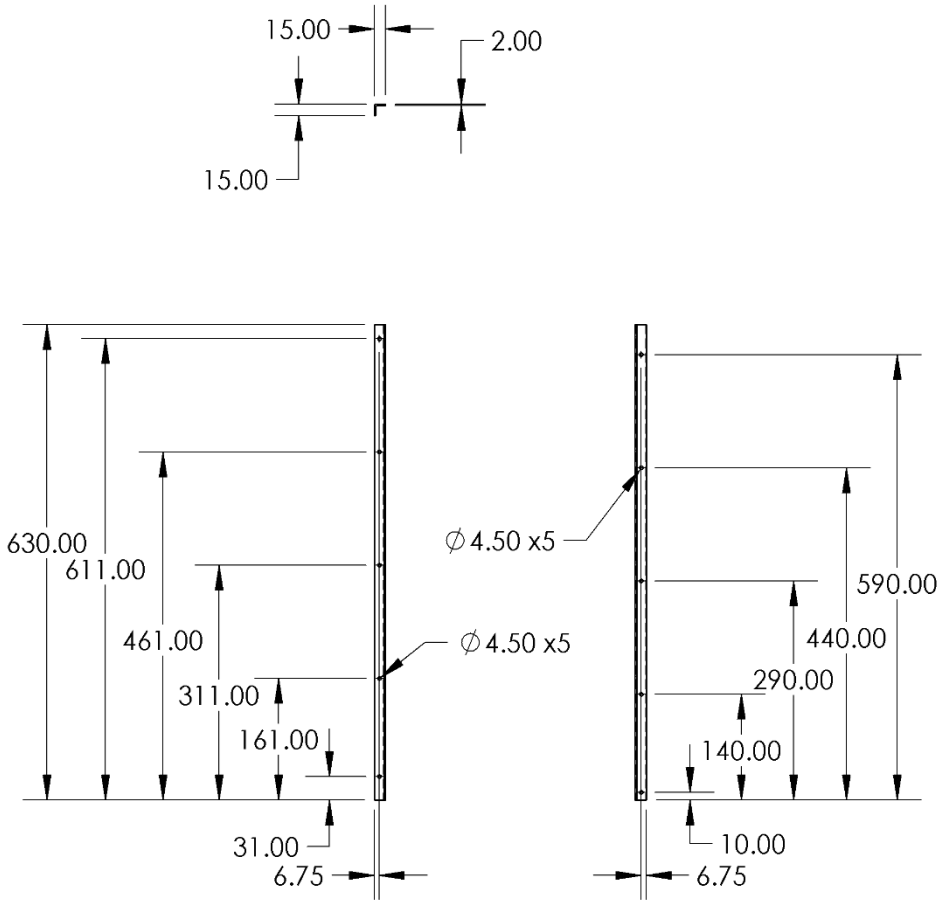


NOTES:

· START WITH 25 X 25 X 2 mm ALUMINUM L-BRACKET

TzeNC-PRO	TITLE: FRONT LEFT OUTER CORNER	
	MATERIAL: ALUMINUM L-PROFILE	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: AS MACHINED	WEIGHT: 200.41 g
	THIRD ANGLE PROJECTION	SCALE: 1: 10
		QUANTITY: 1

Front Inner Corner

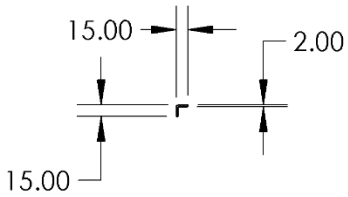


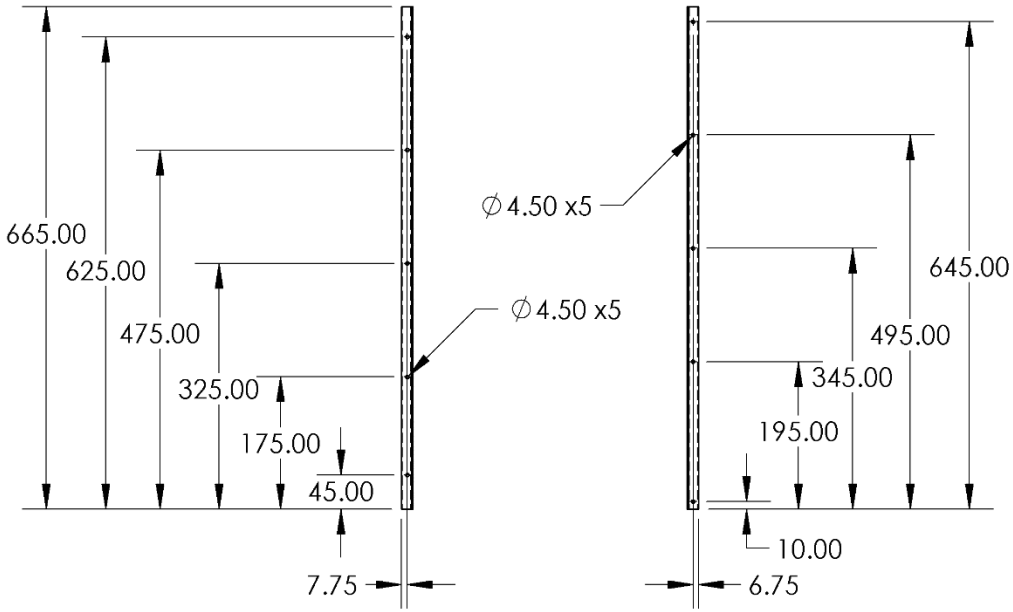
NOTES:

· START WITH 15 X 15 X 2 mm ALUMINUM L-BRACKET

TzeNC-PRO	TITLE: FRONT INNER CORNER	
	MATERIAL: ALUMINUM L-PROFILE	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: AS MACHINED	WEIGHT: 92.57 g
	THIRD ANGLE PROJECTION	SCALE: 1: 10
		QUANTITY: 1

Back Inner Corner





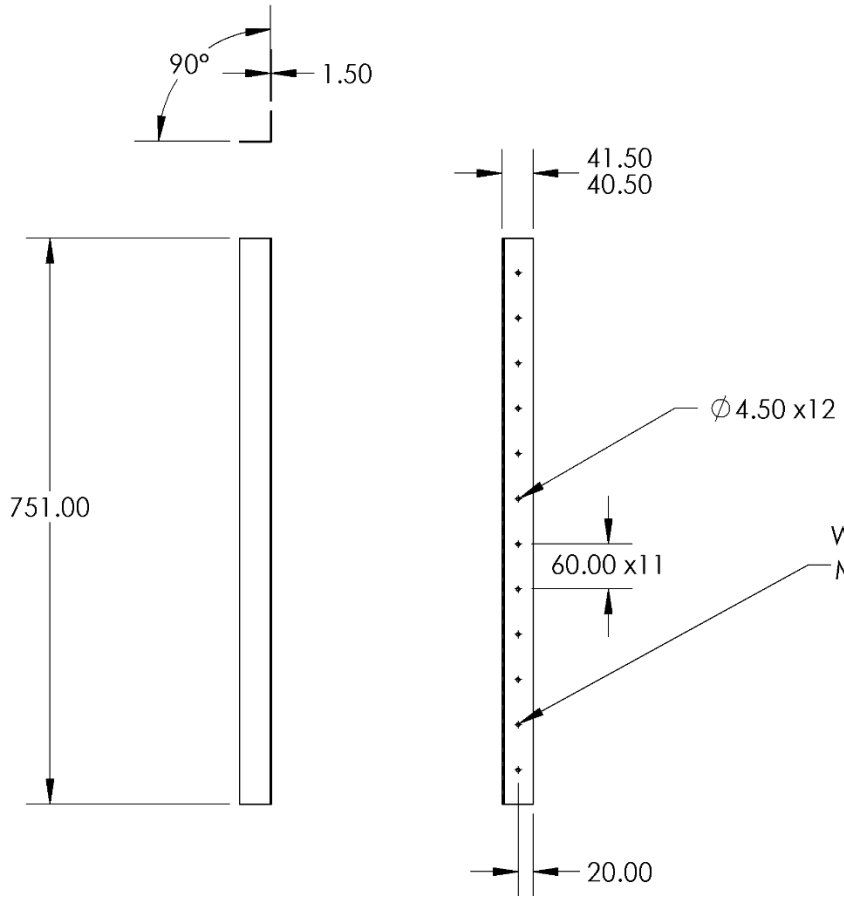
NOTES:

· START WITH 15 X 15 X 2 mm ALUMINUM L-BRACKET

TzeNC-PRO	TITLE: BACK INNER CORNER	
	MATERIAL: ALUMINUM L-PROFILE	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: AS MACHINED	WEIGHT: 97.76 g
	THIRD ANGLE PROJECTION	SCALE: 1: 10
		QUANTITY: 1

1.5mm Aluminum Plate

Y Axis Rail Guard



NOTES:

- START WITH 1.5 X 85 X 751 mm ALUMINUM SHEET
- BEND THE 90° ANGLE USING THE METAL BRAKE IN BUILDING 07.
- ONCE THE HOLE LOCATIONS ARE KNOWN, IT SHOULD BE EASY ENOUGH TO MARK AND DRILL THEM BY HAND
- ANY DEVIATION FROM 41.50 mm IN THE OVERALL WIDTH OF THE SIDE WITH THE HOLES SHOULD BE SUBTRACTED FROM THE 20.00 mm DISTANCE FROM THE EDGE

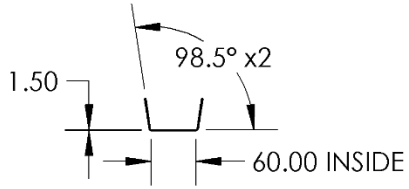
TzeNC-PRO

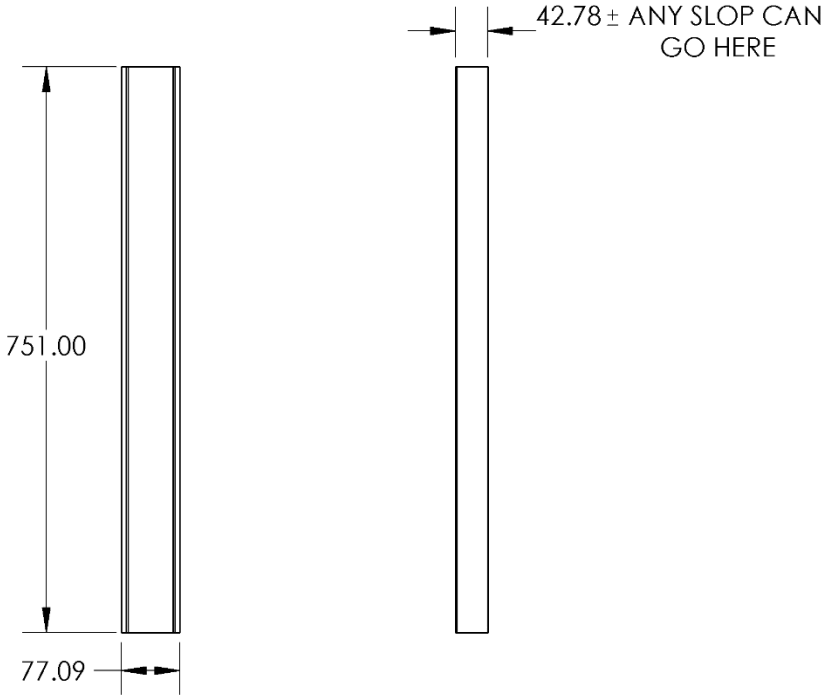
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	Y-AXIS RAIL GUARD
MATERIAL	ALUMINUM SHEET
FINISH	AS MACHINED
WEIGHT	249.39 g
THIRD ANGLE PROJECTION	
SCALE	1: 10
QUANTITY	2

Y Axis Guard





NOTES:

- START WITH 1.5 X 151 X 171 mm ALUMINUM SHEET.
- BEND THE 98.5° ANGLES USING THE METAL BRAKE IN BUILDING 07.

TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

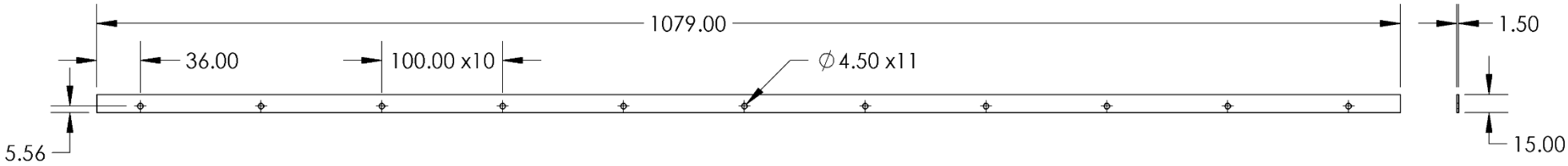
TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	Y-AXIS GUARD
MATERIAL	ALUMINUM SHEET
FINISH	AS MACHINED
WEIGHT	447.65 g
THIRD ANGLE PROJECTION	
SCALE	1: 10
QUANTITY	1

Door Bracket Inserts

NOTES:

- START WITH 1.5 mm ALUMINUM SHEET STOCK
- MAKE SURE THE HOLES STAY ALIGNED WITH THE OTHER DOOR PARTS



TzeNC-PRO

TITLE	DOOR BRACKET INSERTS
MATERIAL	ALUMINUM SHEET
FINISH	AS MACHINED
WEIGHT	64.84 g
SCALE	1: 5
QUANTITY	2

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

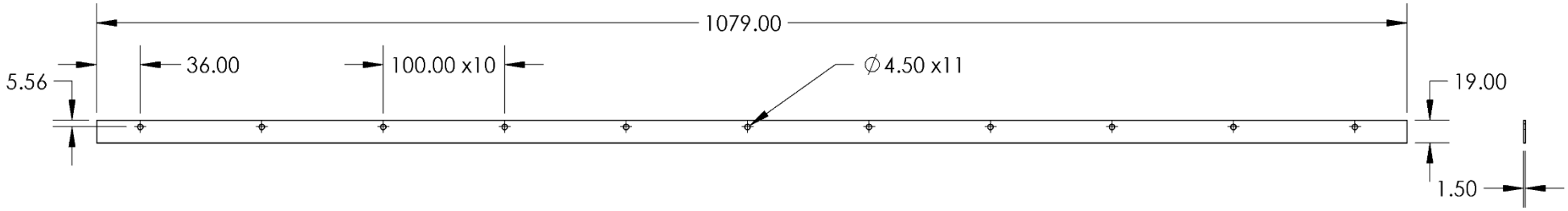
TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

THIRD ANGLE PROJECTION

Top Door Bracket Inserts

NOTES:

- START WITH 1.5 mm ALUMINUM SHEET STOCK
- MAKE SURE THE HOLES STAY ALIGNED WITH THE OTHER DOOR PARTS



TzeNC-PRO

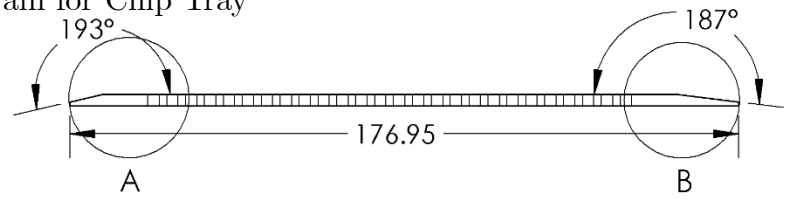
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	TOP DOOR BRACKET INSERTS
MATERIAL	ALUMINUM SHEET
FINISH	AS MACHINED
WEIGHT	82.32 g
THIRD ANGLE PROJECTION	
SCALE	1: 5
QUANTITY	2

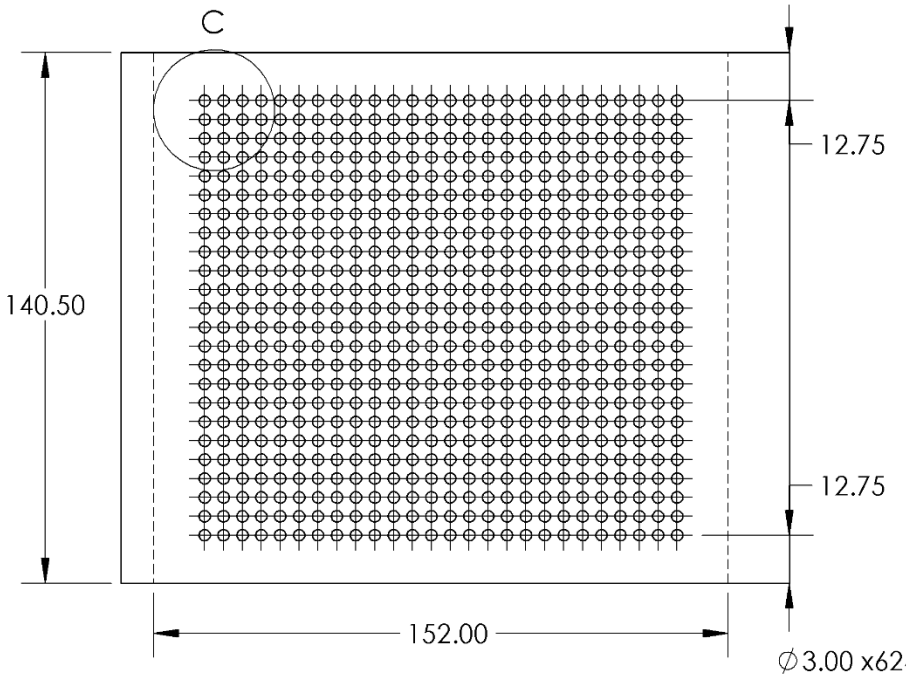
3mm Aluminum Plate

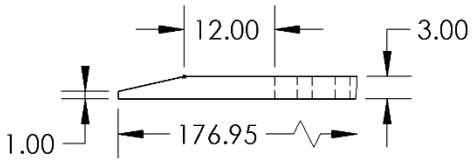
Drain for Chip Tray



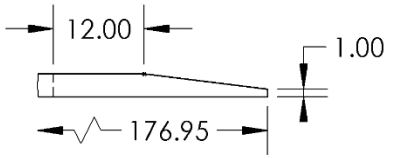
NOTES:

- START WITH 3 X 145 X 175 mm ALUMINUM PLATE
- THE 152 X 140.5 mm DIMENSIONS ARE THE ONLY CRITICAL DIMENSIONS. ALL OTHERS CAN BE PLAYED BY EAR DURING FABRICATION

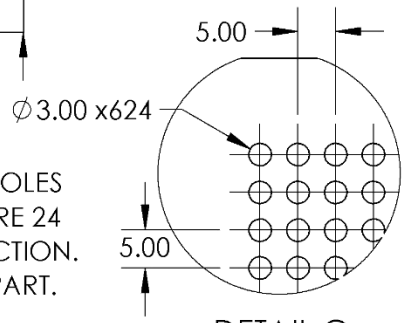




DETAIL A
SCALE 1 : 1



DETAIL B
SCALE 1 : 1



DETAIL C
SCALE 1 : 1

THE NUMBER AND LOCATION OF THESE HOLES IS NONCRITICAL. IN THE DESIGN, THERE ARE 24 IN THE Y-DIRECTION AND 26 IN THE X DIRECTION. THEY ARE 3 mm HOLES SPREAD 5 mm APART.

TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

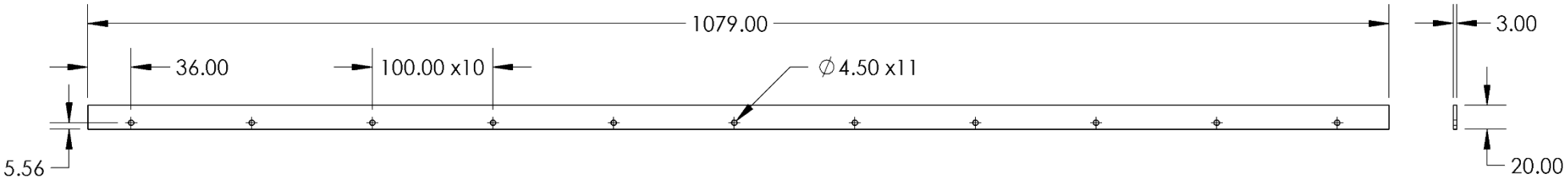
TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	DRAIN FOR CHIP TRAY
MATERIAL	ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	156.19 g
THIRD ANGLE PROJECTION	
SCALE	1: 2
QUANTITY	1

Stopper Bracket for Doors

NOTES:

- START WITH 3.0 mm ALUMINUM SHEET STOCK
- MAKE SURE THE HOLES STAY ALIGNED WITH THE OTHER DOOR PARTS



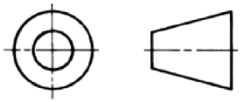
TzeNC-PRO

TITLE	STOPPER BRACKET FOR DOORS
MATERIAL	ALUMINUM SHEET
FINISH	AS MACHINED
WEIGHT	173.38 g
SCALE	1: 5
QUANTITY	2

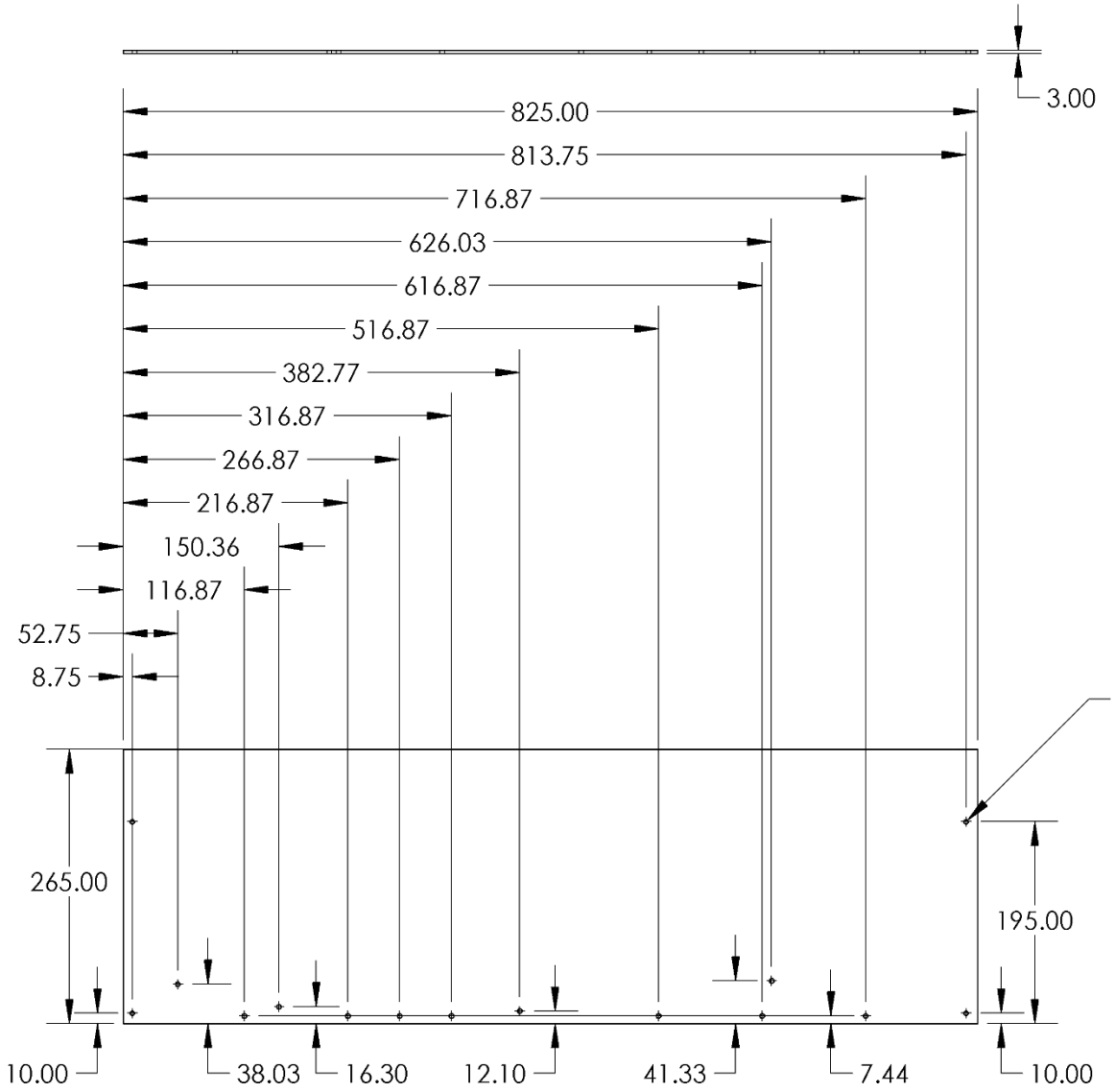
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

THIRD ANGLE PROJECTION

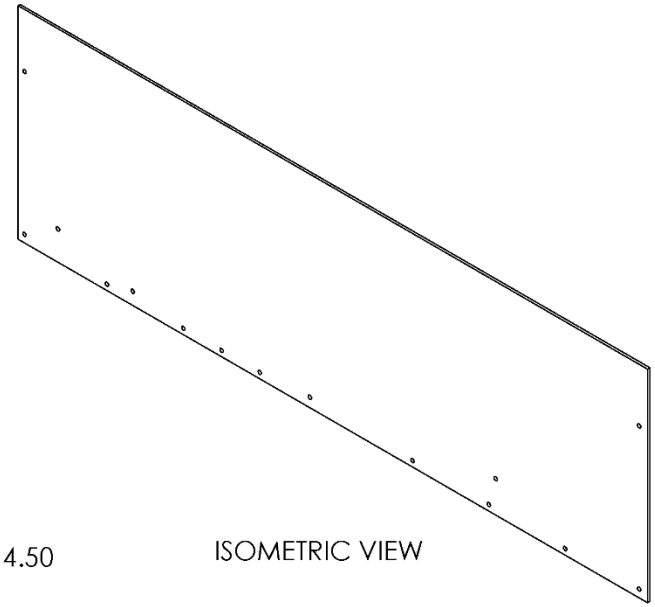


Al Back Panel



NOTES:

· MILL FROM 3.0 mm ALUMINUM SHEET STOCK



ISOMETRIC VIEW

TzeNC-PRO

TITLE	AL BACK PANEL
MATERIAL	ALUMINUM SHEET
FINISH	AS MACHINED
WEIGHT	1.77 kg
SCALE	1: 7
QUANTITY	1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

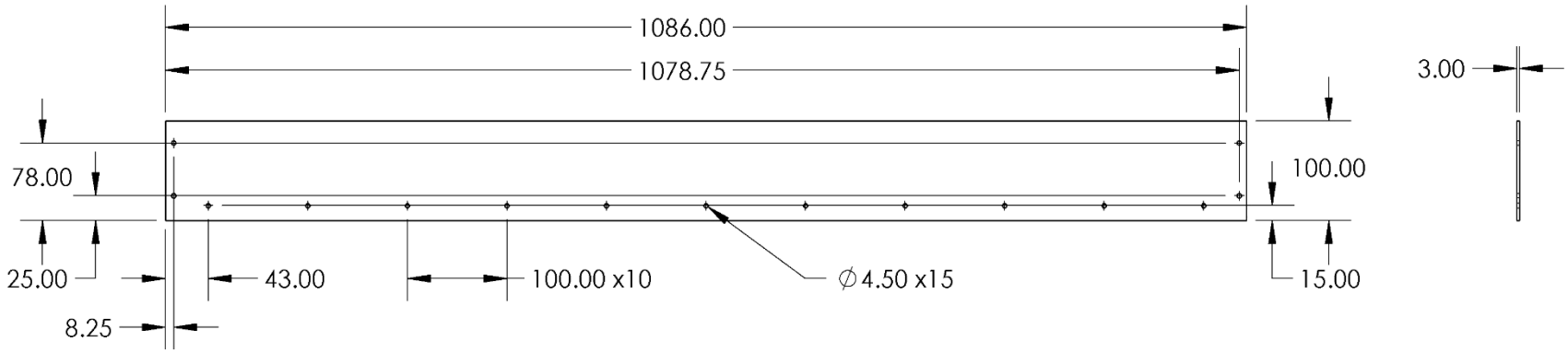
TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

THIRD ANGLE PROJECTION

Front Plate for Doors

NOTES:

- START WITH 3.0 mm ALUMINUM SHEET STOCK
- MAKE SURE THE HOLES STAY ALIGNED WITH THE OTHER DOOR PARTS



TzeNC-PRO

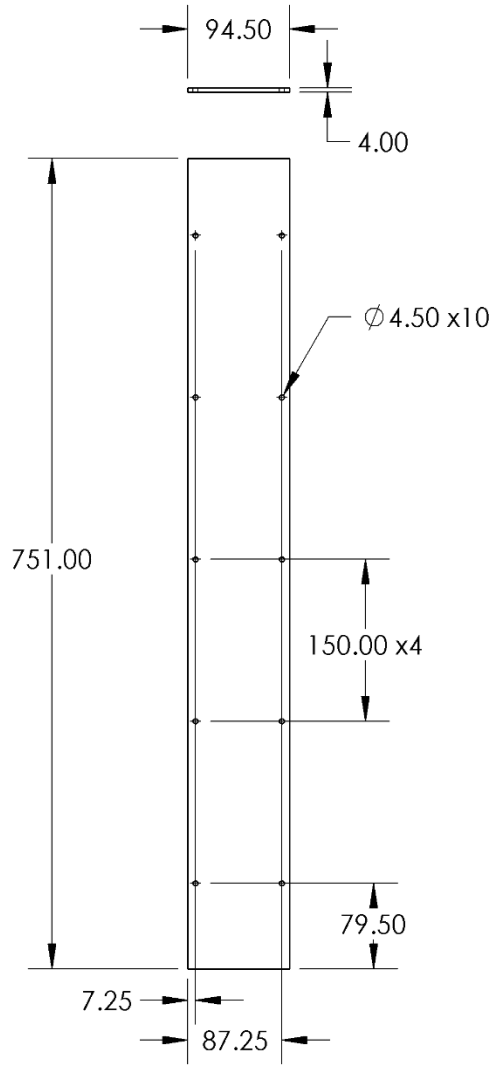
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	FRONT PLATE FOR DOORS
MATERIAL	ALUMINUM SHEET
FINISH	AS MACHINED
WEIGHT	877.73 g
THIRD ANGLE PROJECTION	
SCALE	1: 7
QUANTITY	1

4mm Aluminum Plate

Reinforcements for Base



NOTES:

- START WITH 4 X 95 X 751 mm ALUMINUM PLATE
- DRILL THE FIRST HOLE BY HAND AND THEN USE THE T-NUT PLATE AS A TEMPLATE FOR THE REST

TzeNC-PRO

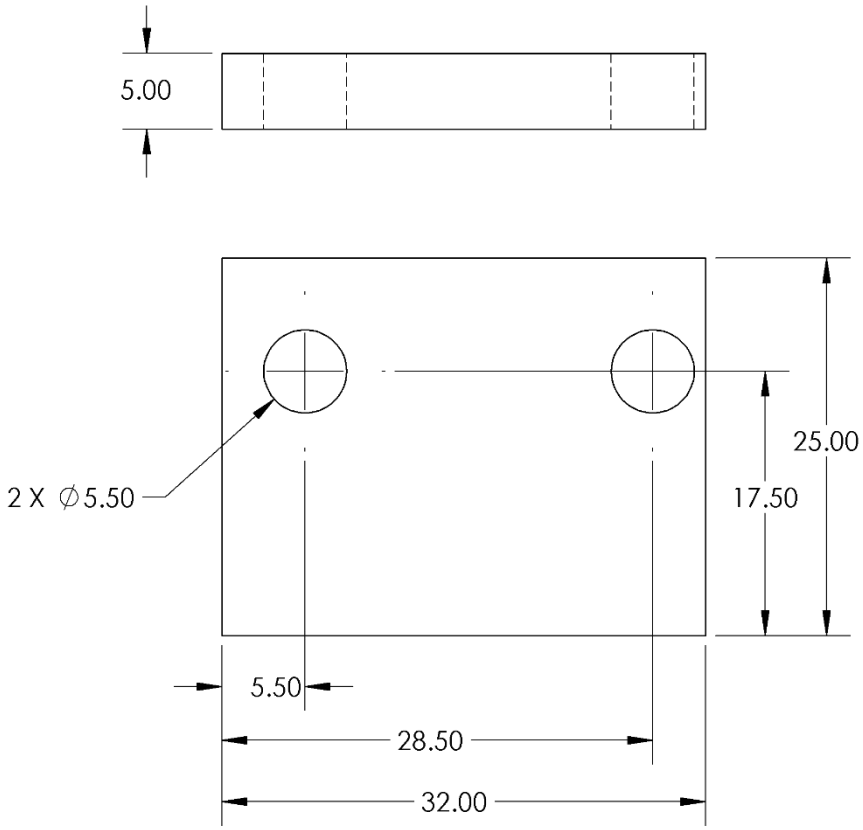
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	REINFORCEMENTS FOR BASE
MATERIAL	ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	764.75 g
THIRD ANGLE PROJECTION	
SCALE	1: 7
QUANTITY	2

5mm Aluminum Plate

Spacer for Spindle Plate



NOTES:

- START WITH 30 X 40 mm ALUMINUM BAR STOCK
- MAKE THE PIECE THICKER TO START (~6 mm). USE THE SPINDLE PLATE AND THE MAFELL 1000 TO SLOWLY APPROACH THE FINAL WIDTH FOR THIS PART (~5 mm).

TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE: SPACER FOR SPINDLE PLATE

MATERIAL: ALUMINUM PLATE

FINISH: AS MACHINED

WEIGHT: 10.16 g

THIRD ANGLE PROJECTION

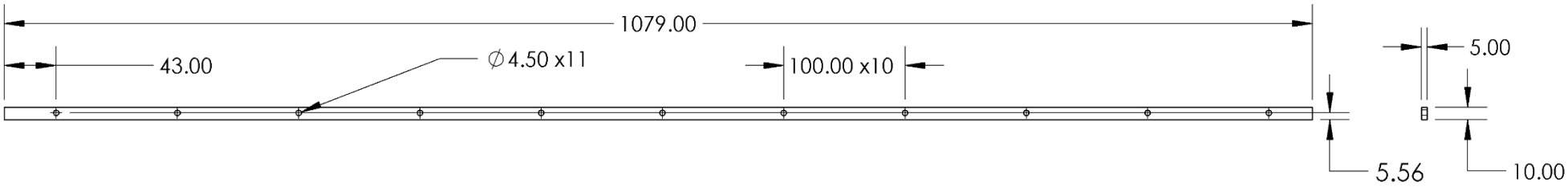
SCALE: 2: 1

QUANTITY: 1

Bottom Bracket for Doors

NOTES:

- START WITH 5mm ALUMINUM SHEET STOCK
- MAKE SURE THE HOLES STAY ALIGNED WITH THE OTHER DOOR PARTS AND WITH THE LEFT SIDE SKIRT.



TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE
BOTTOM BRACKET FOR DOORS

MATERIAL
ALUMINUM PLATE

FINISH
AS MACHINED

WEIGHT
143.30 g

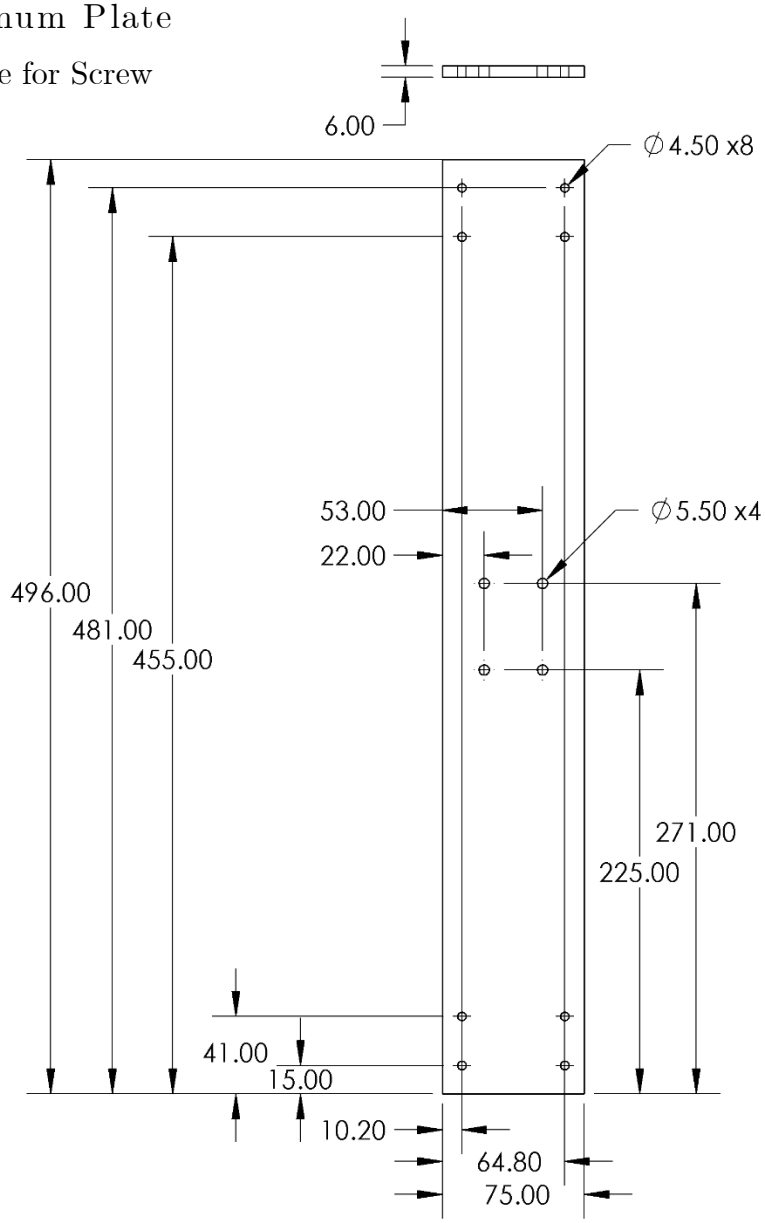
THIRD ANGLE PROJECTION

SCALE
1: 5

QUANTITY
6

6mm Aluminum Plate

Y Bottom Plate for Screw



NOTES:

· START WITH 6 X 100 X 496 mm ALUMINUM PLATE

TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE: Y BOTTOM PLATE FOR SCREW

MATERIAL: ALUMINUM PLATE

FINISH: AS MACHINED

WEIGHT: 599.04 g

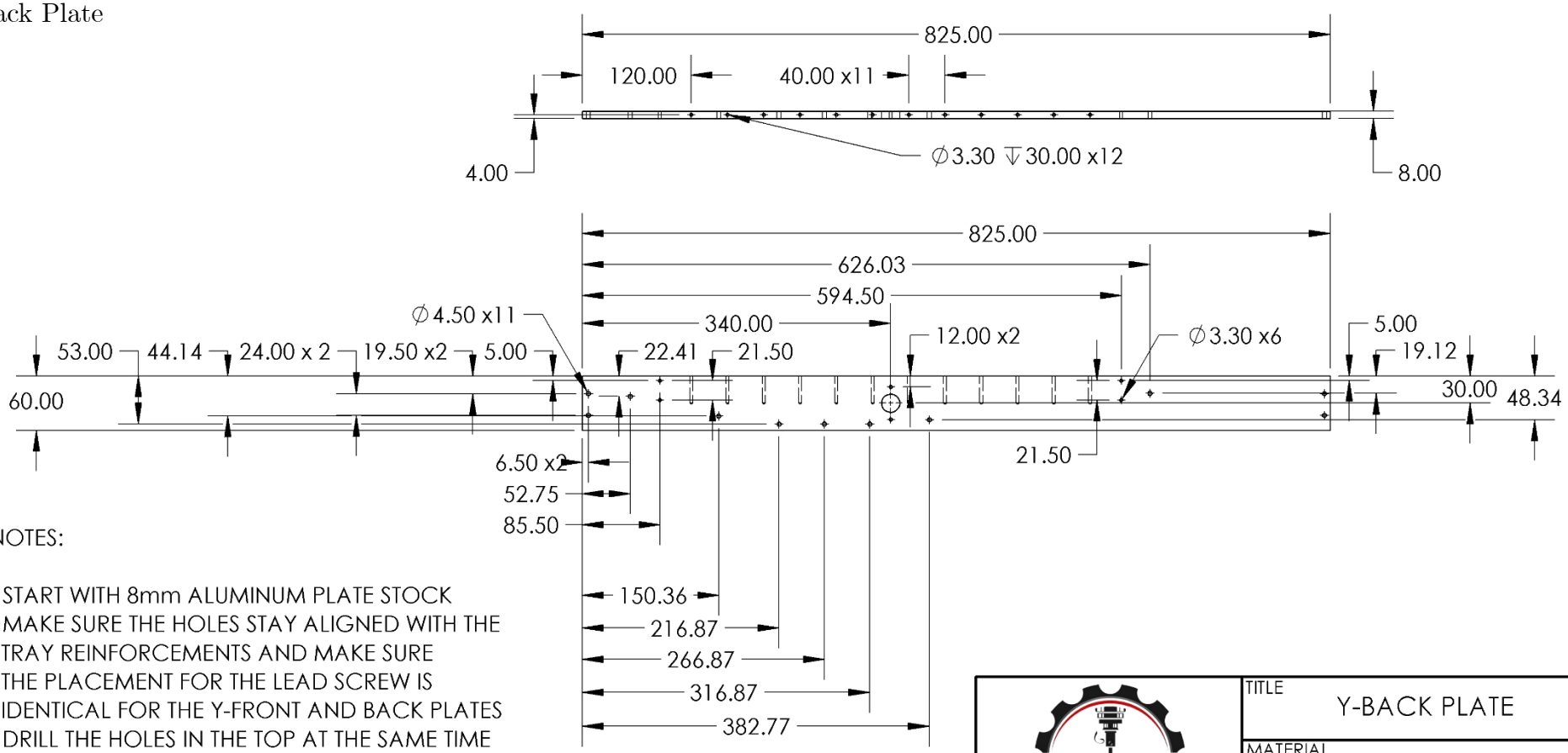
THIRD ANGLE PROJECTION

SCALE: 1: 4

QUANTITY: 1

8mm Aluminum Plate

Y Back Plate



NOTES:

- START WITH 8mm ALUMINUM PLATE STOCK
- MAKE SURE THE HOLES STAY ALIGNED WITH THE TRAY REINFORCEMENTS AND MAKE SURE THE PLACEMENT FOR THE LEAD SCREW IS IDENTICAL FOR THE Y-FRONT AND BACK PLATES
- DRILL THE HOLES IN THE TOP AT THE SAME TIME AS THE CHIP TRAY, USING THE THREE T-NUT PLATESFOR THE BASE
- THE 3.30 mm HOLES ARE PREDRILLS FOR AN M4 TAP. DRILL THEM AT THE SAME TIME AS THE CHIP TRAY, USING THE THREE T-NUT PLATES AS A TEMPLATE

TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

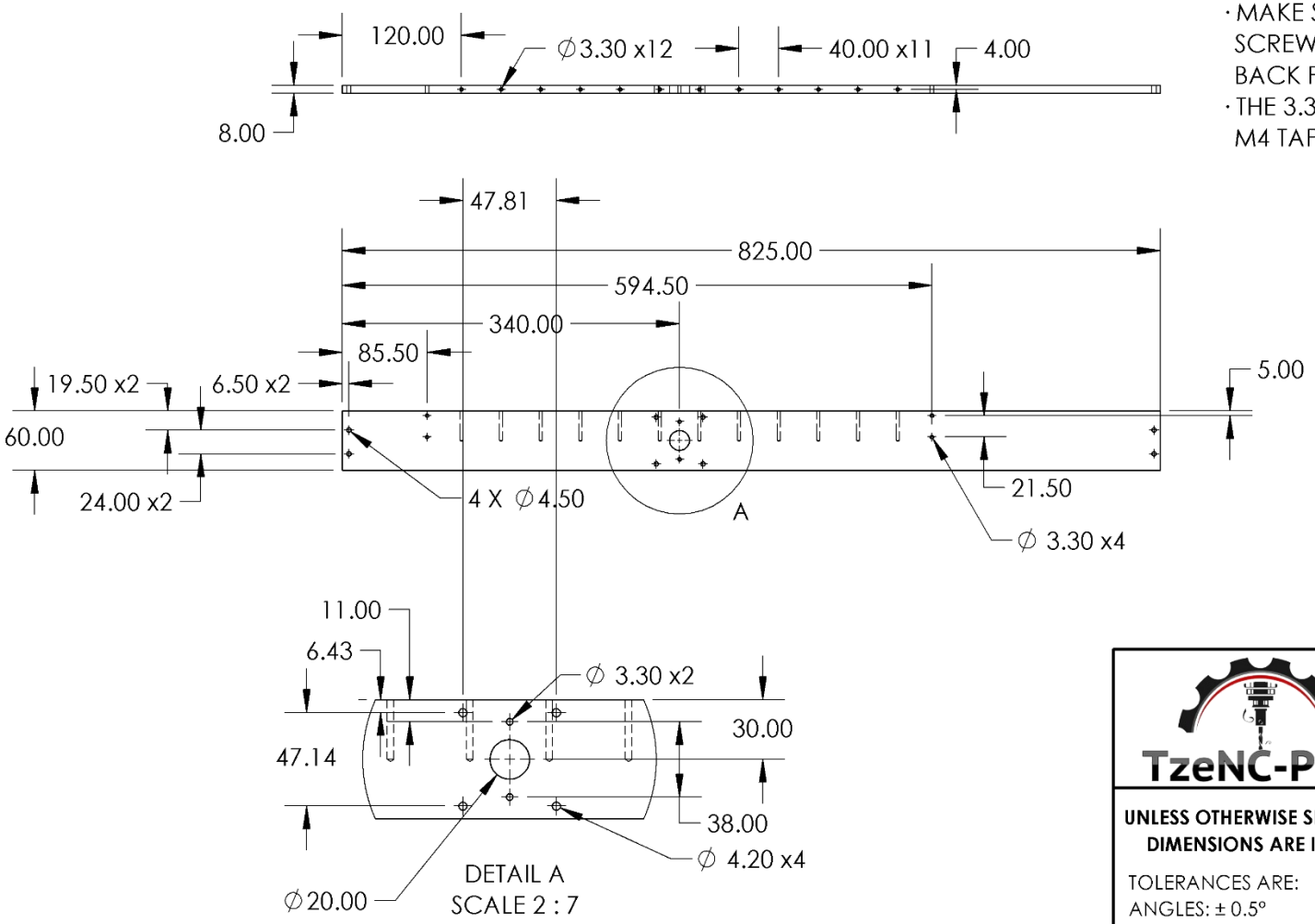
TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	Y-BACK PLATE
MATERIAL	ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	1.05 kg
THIRD ANGLE PROJECTION	
SCALE	1 : 7
QUANTITY	1

Y Front Plate

NOTES:

- START WITH 8mm ALUMINUM SHEET STOCK
- MAKE SURE THE PLACEMENT FOR THE LEAD SCREW IS IDENTICAL FOR THE Y-FRONT AND BACK PLATES
- THE 3.30 mm HOLES ARE PREDRILLS FOR AN M4 TAP

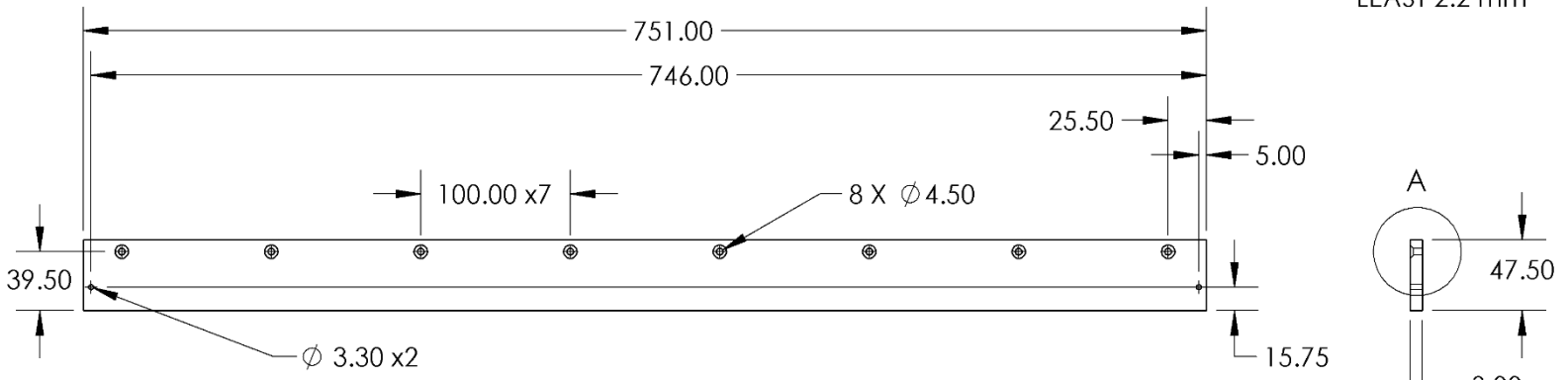


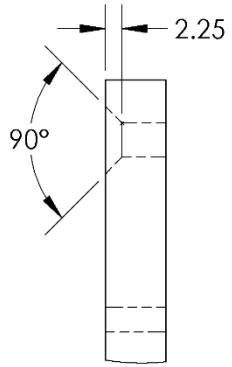
TzeNC-PRO	TITLE: Y-FRONT PLATE	
	MATERIAL: ALUMINUM PLATE	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: AS MACHINED	WEIGHT: 1.05 kg
	THIRD ANGLE PROJECTION	SCALE: 1 : 7
		QUANTITY: 1

Side Supports for Base

NOTES:

- MILL FROM 8.0 mm ALUMINUM PLATE
- THE 3.30 mm HOLES ARE PREDRILLS FOR AN M4 TAP
- THE 4.50 mm HOLES NEED TO BE COUNTERSUNK AT 90° TO A DEPTH OF AT LEAST 2.2 mm

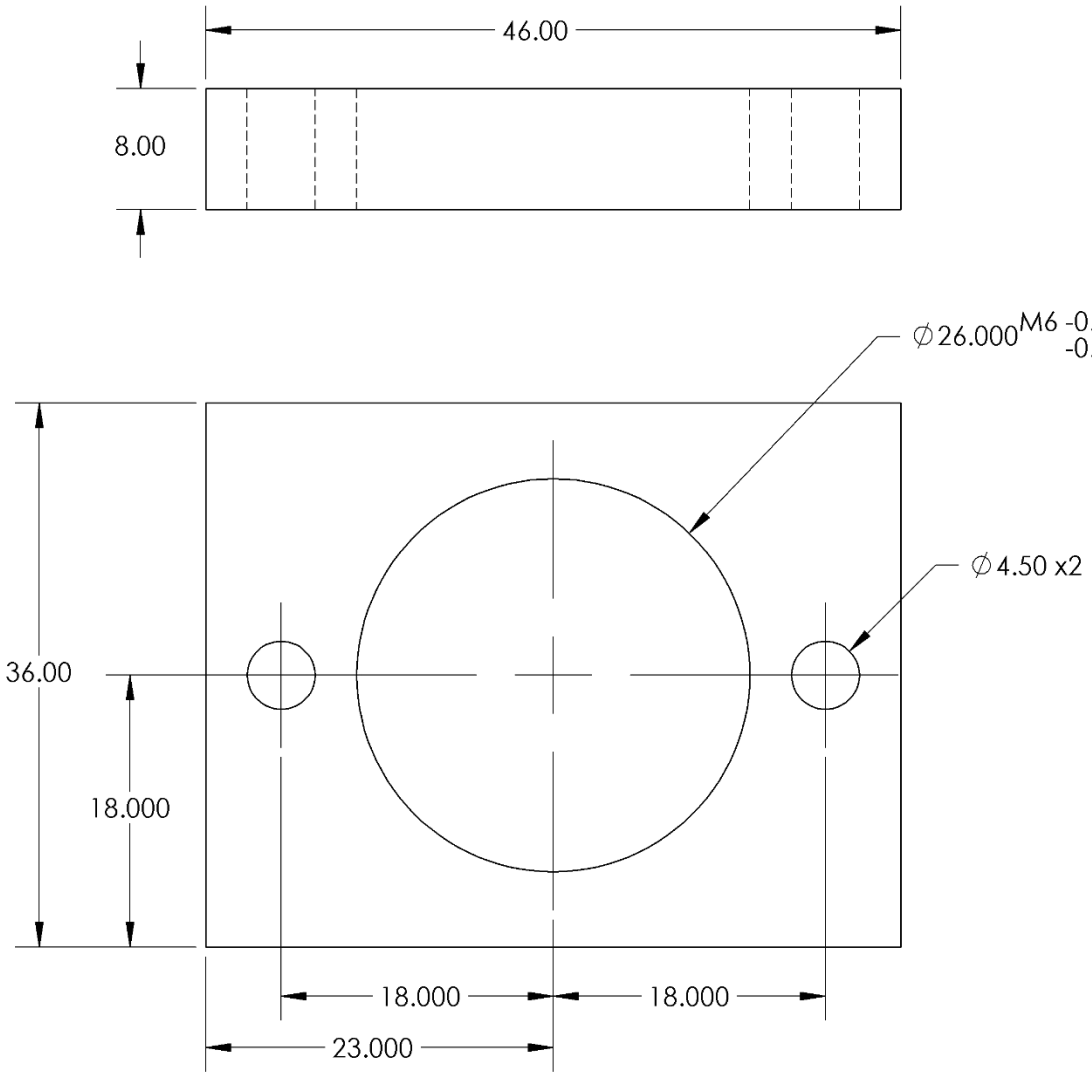




DETAIL A
SCALE 1 : 1

TzeNC-PRO	TITLE: SIDE SUPPORTS FOR BASE		
	MATERIAL: ALUMINUM PLATE		
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: AS MACHINED	WEIGHT: 766.38 g	
	THIRD ANGLE PROJECTION	SCALE: 1: 5	
		QUANTITY: 2	

26mm OD Bearing Block



NOTES:

- START WITH 8 X 36 X 46 mm ALUMINUM PLATE
- DRILL THE CENTER HOLE OUT TO 25 mm AND THEN USE A BORING BAR TO APPROACH THE IDEAL 25.990 mm SLOWLY

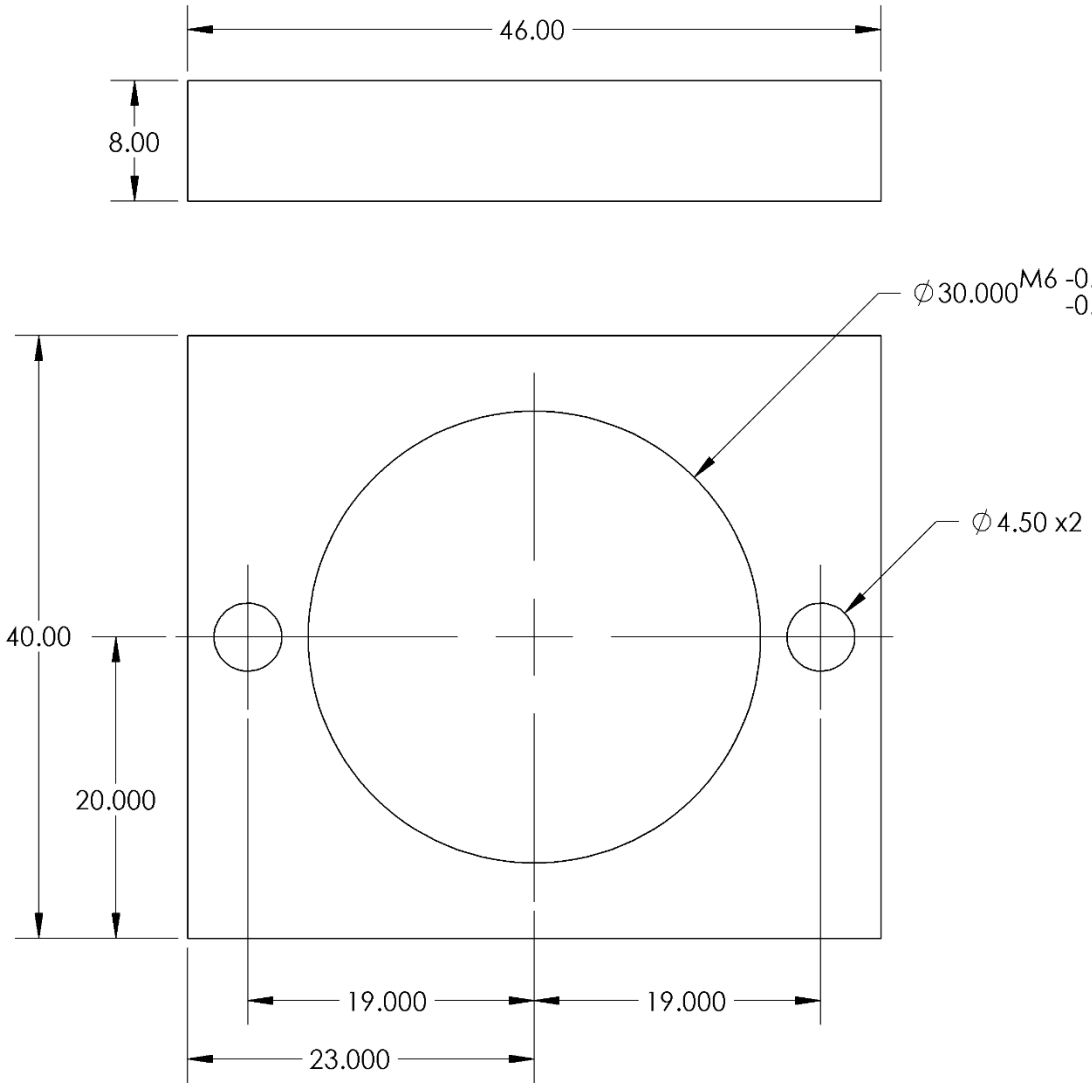
TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	26 mm OD BEARING BLOCK
MATERIAL	ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	23.61 g
THIRD ANGLE PROJECTION	
SCALE	2: 1
QUANTITY	1

30mm OD Bearing Block



NOTES:

- START WITH 8 X 40 X 46 mm ALUMINUM PLATE
- DRILL THE CENTER HOLE OUT TO 25 mm AND THEN USE A BORING BAR TO APPROACH THE IDEAL 29.990 mm SLOWLY

TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

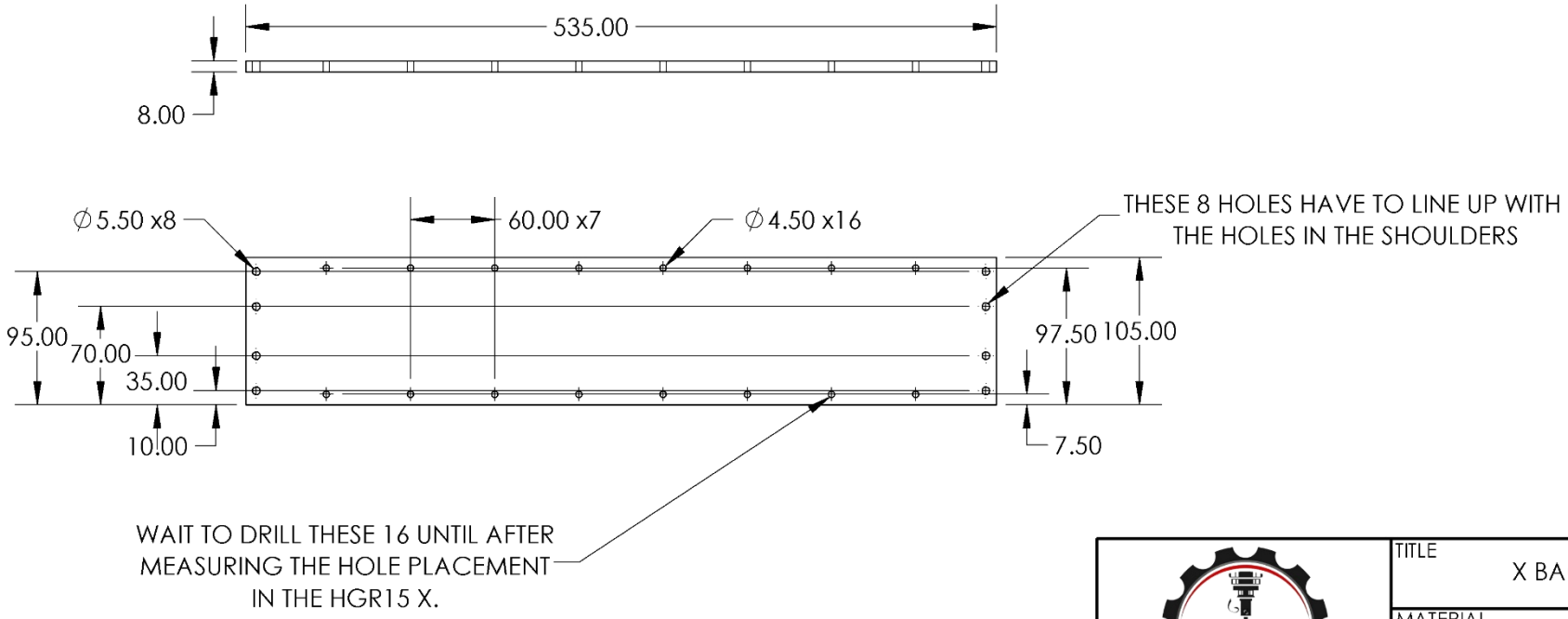
TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE: 30 mm OD BEARING BLOCK		
MATERIAL: ALUMINUM PLATE		
FINISH: AS MACHINED	WEIGHT: 23.79 g	
THIRD ANGLE PROJECTION	SCALE: 2: 1	
	QUANTITY: 1	

X Back Plate

NOTES:

· START WITH 8 X 105 X 535 mm ALUMINUM PLATE



TzeNC-PRO

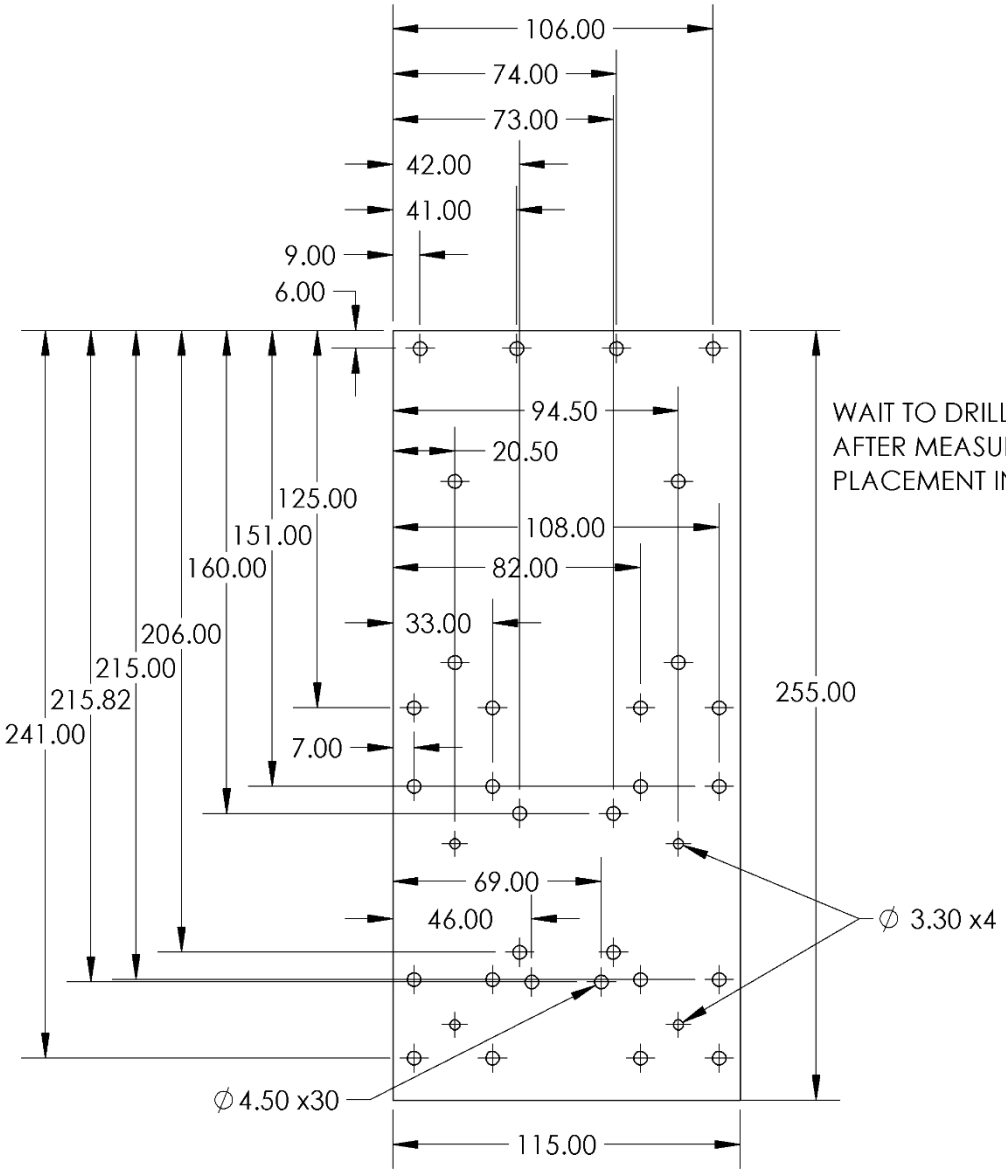
TITLE	X BACK PLATE
MATERIAL	ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	1.20 kg
SCALE	1: 5
QUANTITY	1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

THIRD ANGLE PROJECTION

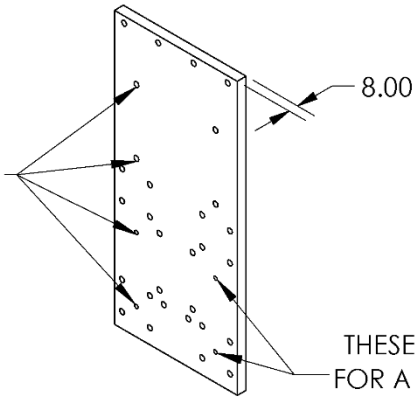
Z Back Plate



NOTES:

- START WITH 8mm ALUMINUM PLATE STOCK
- THE 3.30 mm HOLES ARE PREDRILLS FOR AN M4 TAP

WAIT TO DRILL THESE 8 UNTIL AFTER MEASURING THE HOLE PLACEMENT IN THE HGR15 Z



ISOMETRIC VIEW
SCALE 1:5

TzeNC-PRO

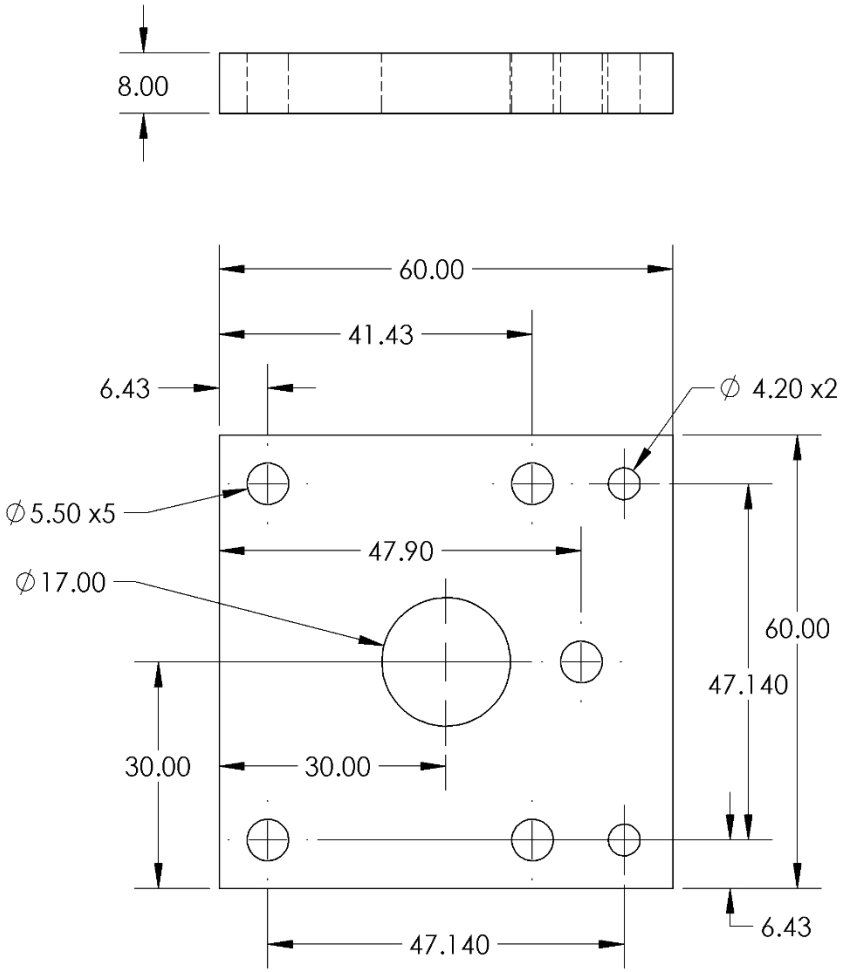
TITLE	Z-BACK PLATE
MATERIAL	ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	622.38 g
SCALE	1: 2.5
QUANTITY	1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

THIRD ANGLE PROJECTION

Motor Mount for X Axis



NOTES:

- START WITH 8 mm ALUMINUM PLATE STOCK
- DOUBLE CHECK THE HOLE SIZES AND PLACEMENT WITH THE NEMA 24 MOTOR
- THE 4.20 mm HOLES ARE PREDRILLS FOR AN M5 TAP

TzeNC-PRO

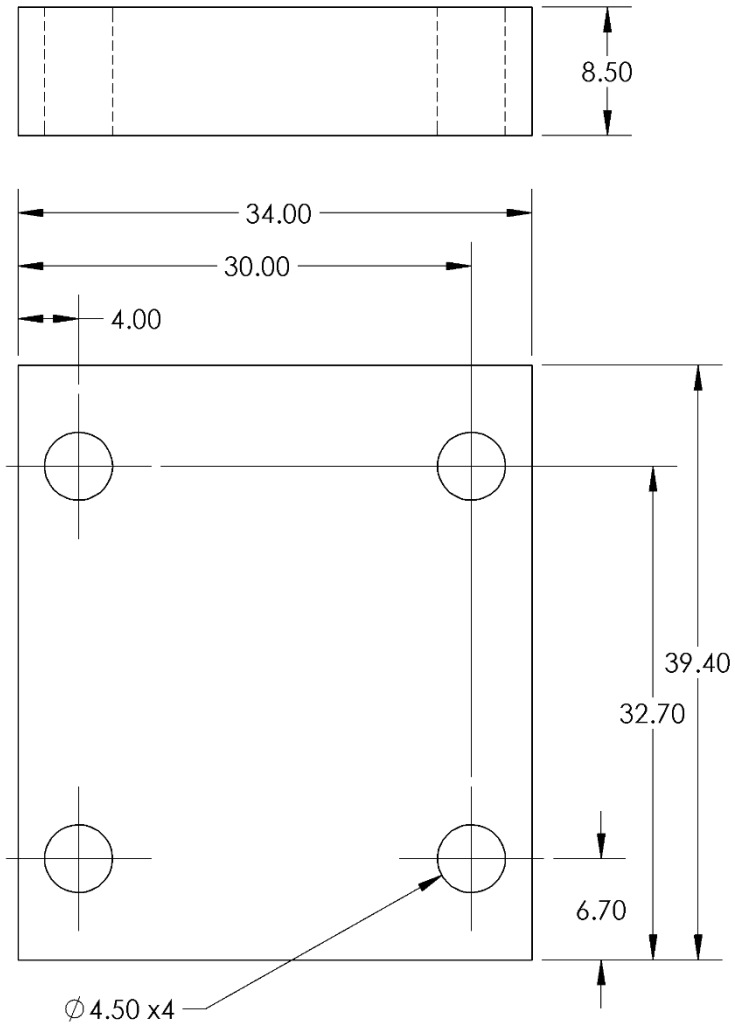
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	MOTOR MOUNT FOR X-AXIS
MATERIAL	ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	69.69 g
THIRD ANGLE PROJECTION	
SCALE	1:1
QUANTITY	1

8.5mm Aluminum Plate

Y Spacer Block



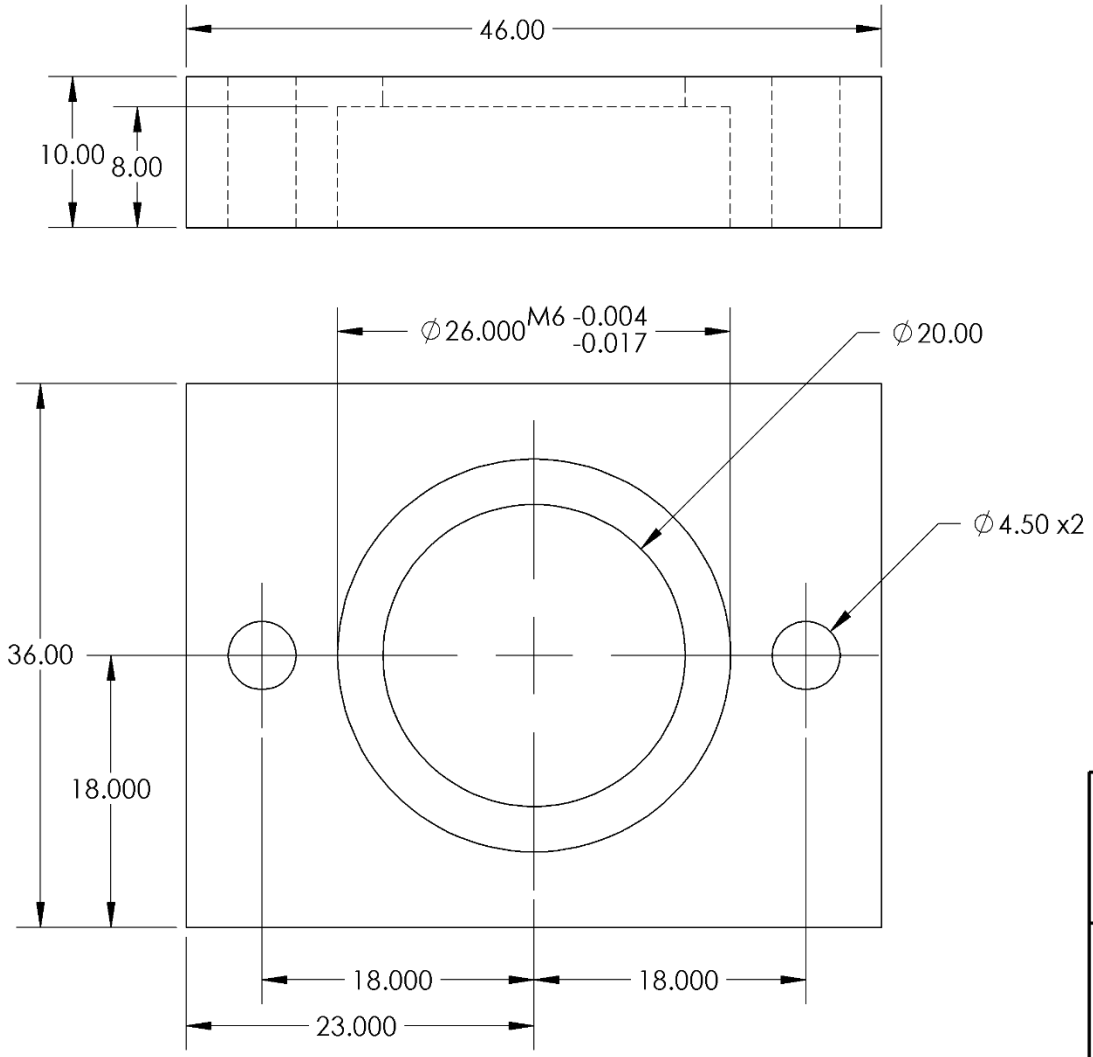
NOTES:

· CUT THESE ON THE MILL USING POM OR SOME SIMILAR VIBRATION DAMPENING PLASTIC

TzeNC-PRO	TITLE: Y-SPACER BLOCK	
	MATERIAL: POM ACETAL	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: AS MACHINED	WEIGHT: 15.08 g
	THIRD ANGLE PROJECTION	SCALE: 2: 1
		QUANTITY: 4

10mm Aluminum Plate

X 26mm OD Bearing Block



NOTES:

- START WITH 10 mm ALUMINUM PLATE
- DRILL THE CENTER HOLE OUT TO 20.00 mm AND THEN USE A BORING BAR TO APPROACH THE IDEAL 25.990 mm SLOWLY FOR THE 8 mm DEEP POCKET

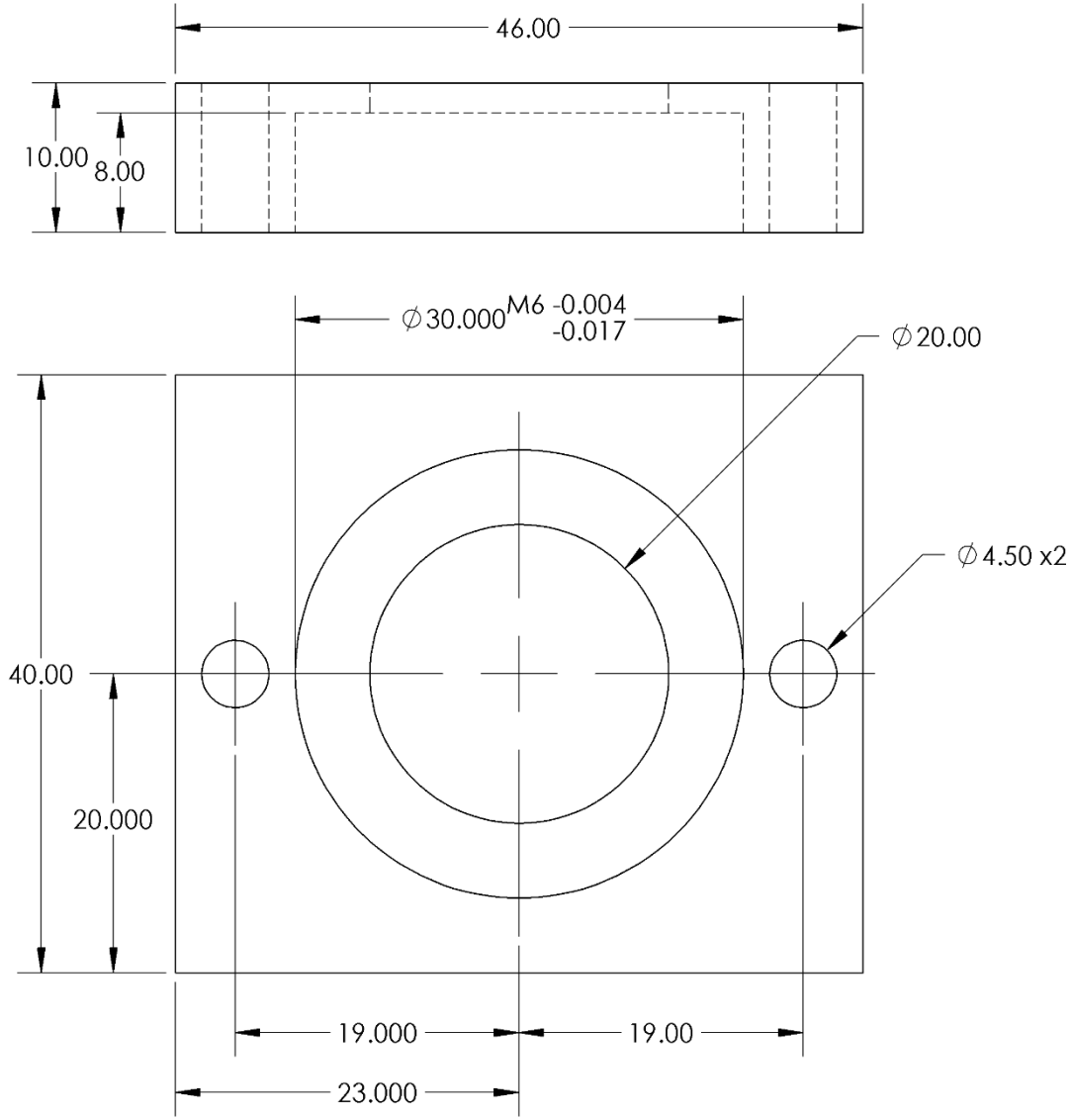
TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	X 26 mm OD BEARING BLOCK
MATERIAL	ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	30.69 g
THIRD ANGLE PROJECTION	
SCALE	2: 1
QUANTITY	1

X 30mm OD Bearing Block



NOTES:

- START WITH 10 mm ALUMINUM PLATE
- DRILL THE CENTER HOLE OUT TO 20.00 mm AND THEN USE A BORING BAR TO APPROACH THE IDEAL 29.990 mm SLOWLY FOR THE 8 mm DEEP POCKET

TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

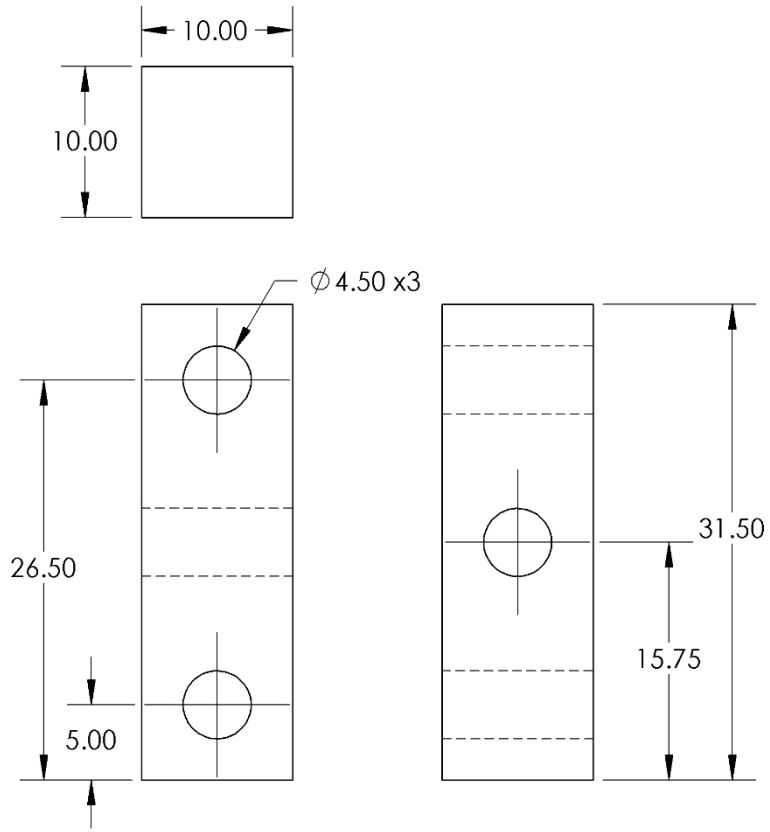
TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	X 30 mm OD BEARING BLOCK
MATERIAL	ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	31.86 g
THIRD ANGLE PROJECTION	
SCALE	2: 1
QUANTITY	1

Corner Block for Base

NOTES:

· START WITH 10 mm ALUMINUM PLATE



TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE: CORNER BLOCKS FOR BASE

MATERIAL: ALUMINUM PLATE

FINISH: AS MACHINED

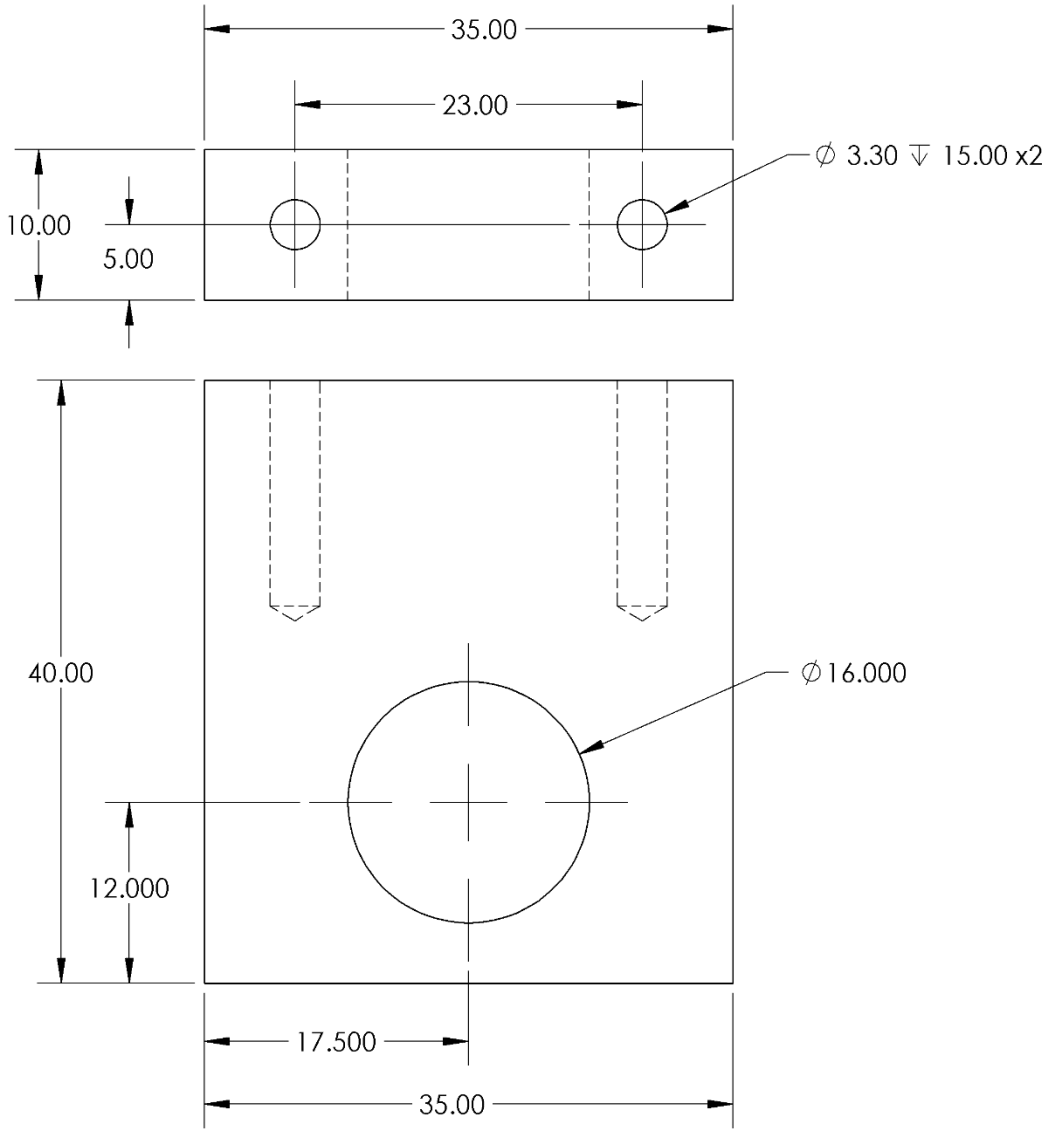
WEIGHT: 7.22 g

THIRD ANGLE PROJECTION

SCALE: 2: 1

QUANTITY: 4

Z Ball Screw Lower Support

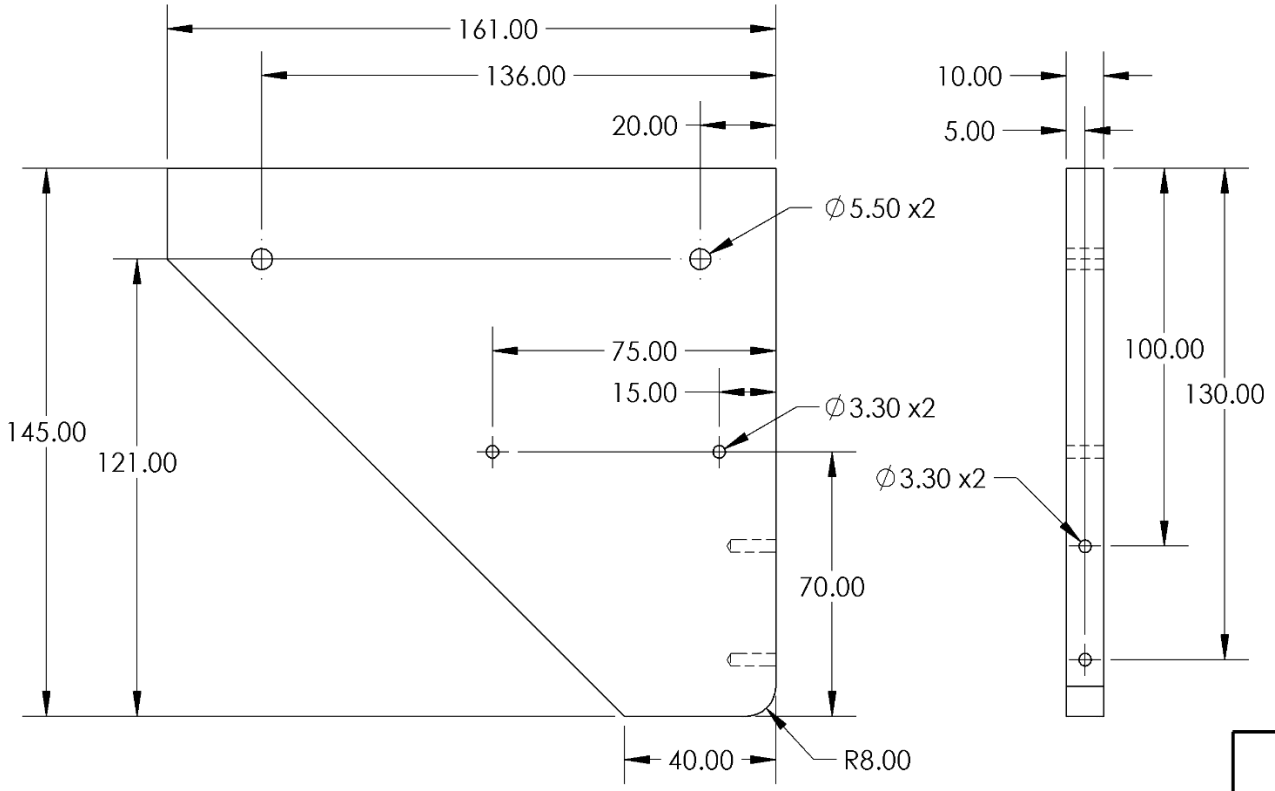


NOTES:

- START WITH 10mm ALUMINUM PLATE STOCK
- THE 3.30 mm HOLES ARE PREDRILLS FOR AN M4 TAP

TzeNC-PRO	TITLE: Z-BALL SCREW LOWER SUPPORT	
	MATERIAL: ALUMINUM PLATE	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: AS MACHINED	WEIGHT: 31.66 g
	THIRD ANGLE PROJECTION	SCALE: 2: 1
		QUANTITY: 1

Corner Braces for Drawer Hardware



NOTES:

- START WITH 12 X 300 X 240 mm ALUMINUM PLATE TO MAKE ALL FOUR OF THESE
- THE FOUR 3.3 mm HOLES ARE PREDRILLS FOR AN M4 TAP

TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE
CORNER BRACES FOR DRAWER HARDWARE

MATERIAL
ALUMINUM PLATE

FINISH
AS MACHINED

WEIGHT
429.98 g

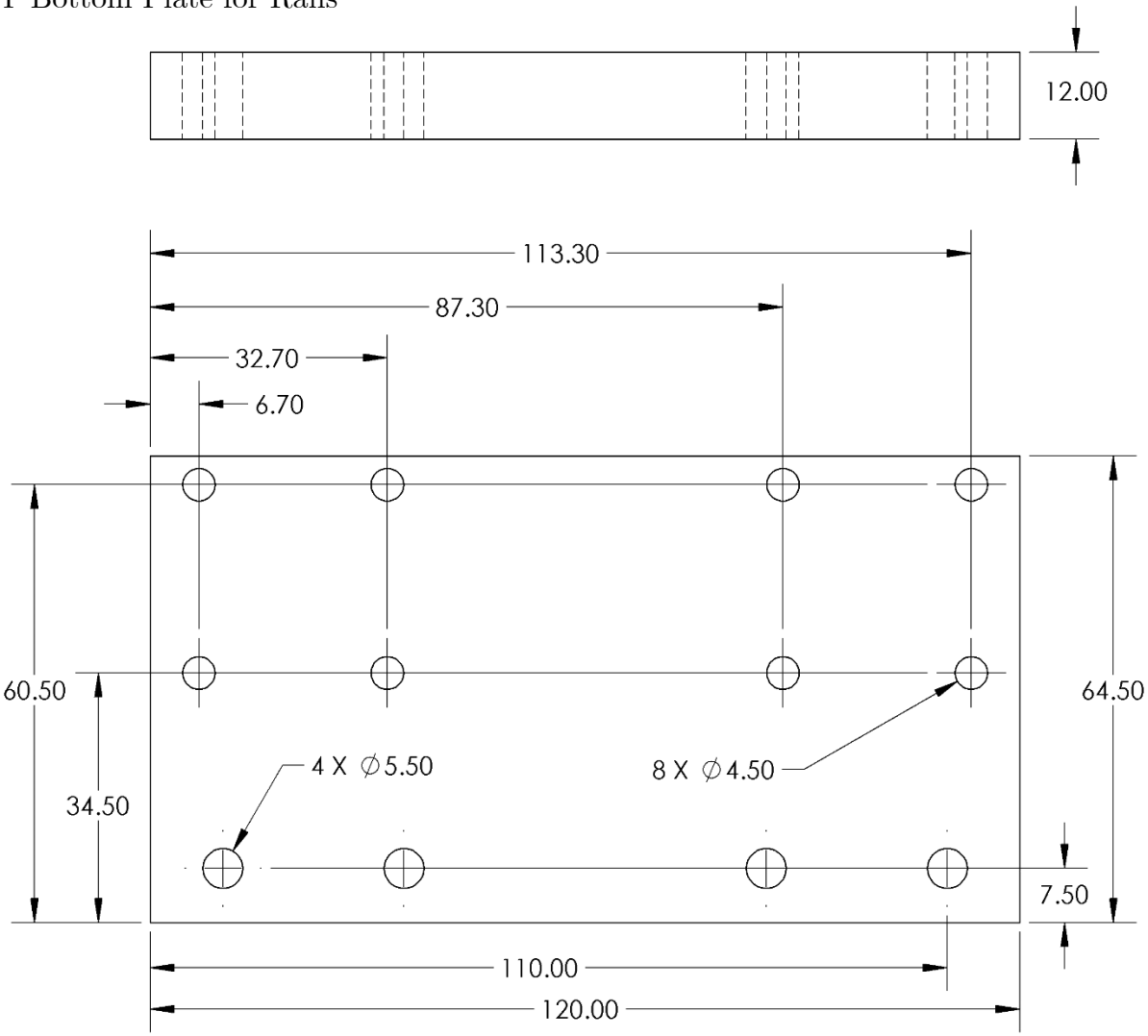
THIRD ANGLE PROJECTION

SCALE
1: 2

QUANTITY
4

12mm Aluminum Plate

Y Bottom Plate for Rails



NOTES:

· START WITH 12 mm ALUMINUM PLATE

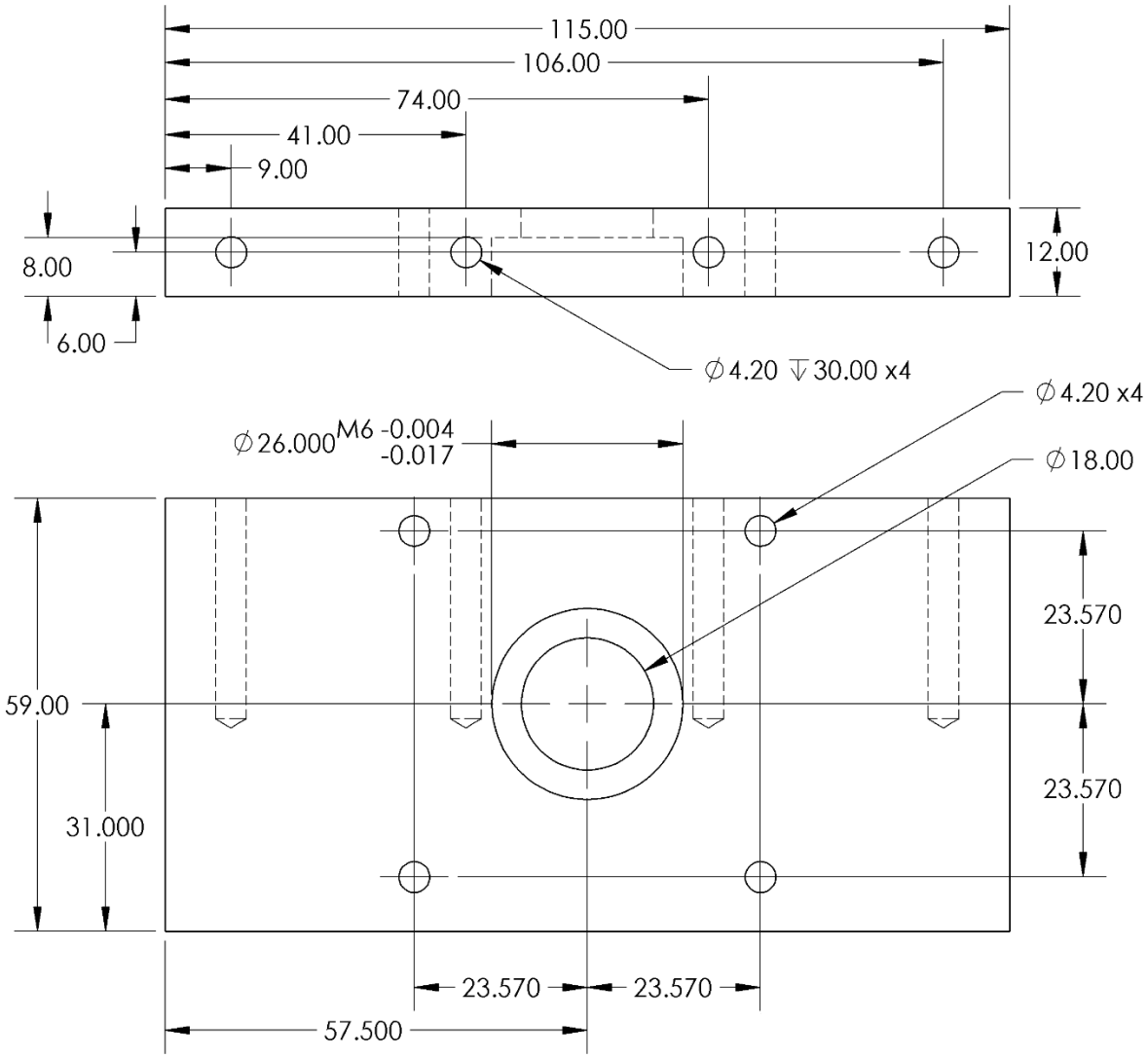
TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	Y BOTTOM PLATE FOR RAILS
MATERIAL	ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	249.39 g
THIRD ANGLE PROJECTION	
SCALE	1: 1
QUANTITY	2

Z Top Plate



NOTES:

- START WITH 12 mm ALUMINUM PLATE
- DRILL THE CENTER HOLE OUT TO 18.00 mm AND THEN USE A BORING BAR TO APPROACH THE IDEAL 25.990 mm SLOWLY FOR THE 8 mm DEEP HOLE
- THE 4.2 mm HOLES ARE PREDRILLS FOR AN M5 TAP

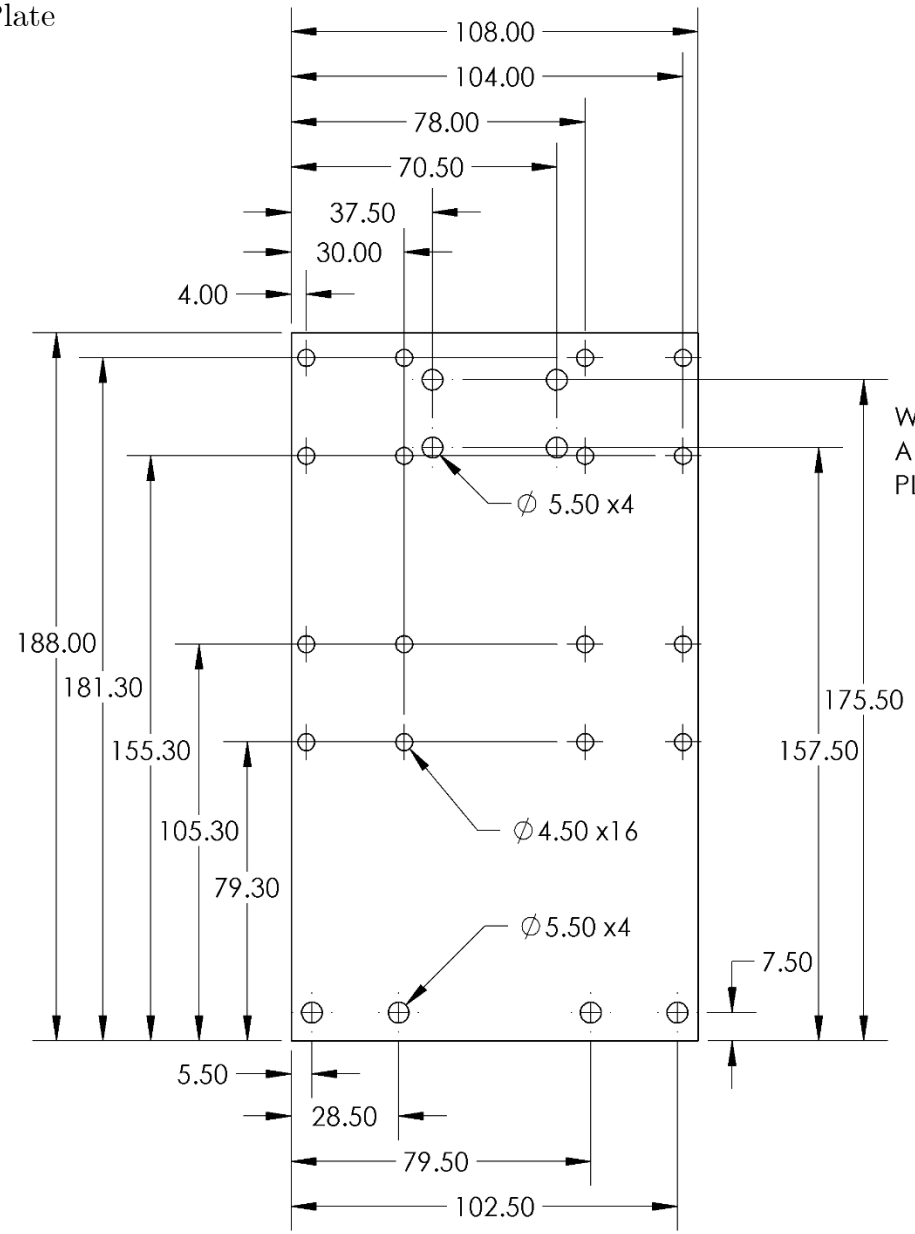
TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	Z TOP PLATE
MATERIAL	ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	199.27 g
THIRD ANGLE PROJECTION	
SCALE	1: 1
QUANTITY	1

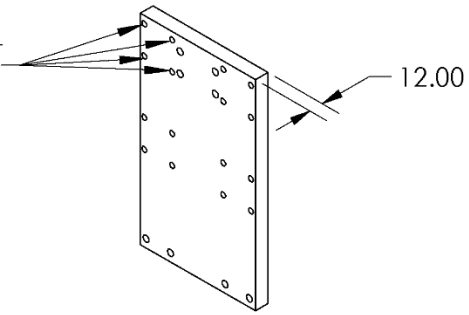
Z Front Plate



NOTES:

- START WITH 12 mm ALUMINUM PLATE STOCK
- WAIT TO DRILL THE 16 M4 HOLES UNTIL MEASURING THE HOLE PLACEMENT ON THE LINEAR RAIL CARRIAGES

WAIT TO DRILL THESE 16 UNTIL AFTER MEASURING THE HOLE PLACEMENT IN THE HGH15 Z



ISOMETRIC VIEW
SCALE 1:5

TzeNC-PRO

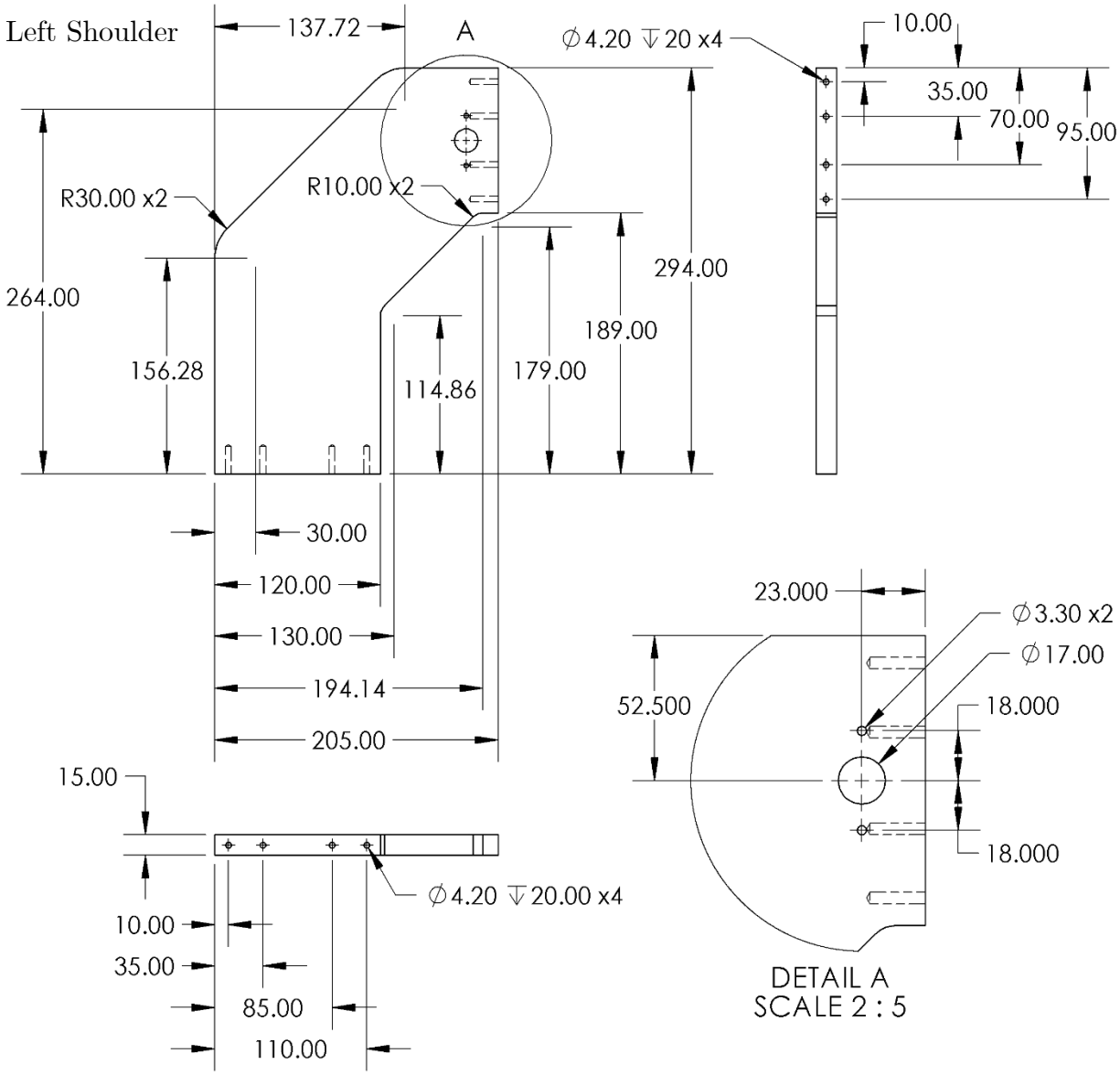
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	Z-FRONT PLATE
MATERIAL	ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	643.45 g
THIRD ANGLE PROJECTION	
SCALE	1: 2
QUANTITY	1

15mm Aluminum Plate AlMg3

Left Shoulder



NOTES:

- CNC THE PROFILES OF BOTH OF THE SHOULDERS FROM ONE 15 X 320 X 340 mm ALUMINUM PLATE
- DRILL THE HOLES IN THE SIDE AND BOTTOM ON THE MILL
- THE TWO 3.3 mm HOLES ARE PREDRILLS FOR AN M4 TAP AND THE EIGHT 4.2 X 20 mm HOLES ARE FOR AN M5 TAP

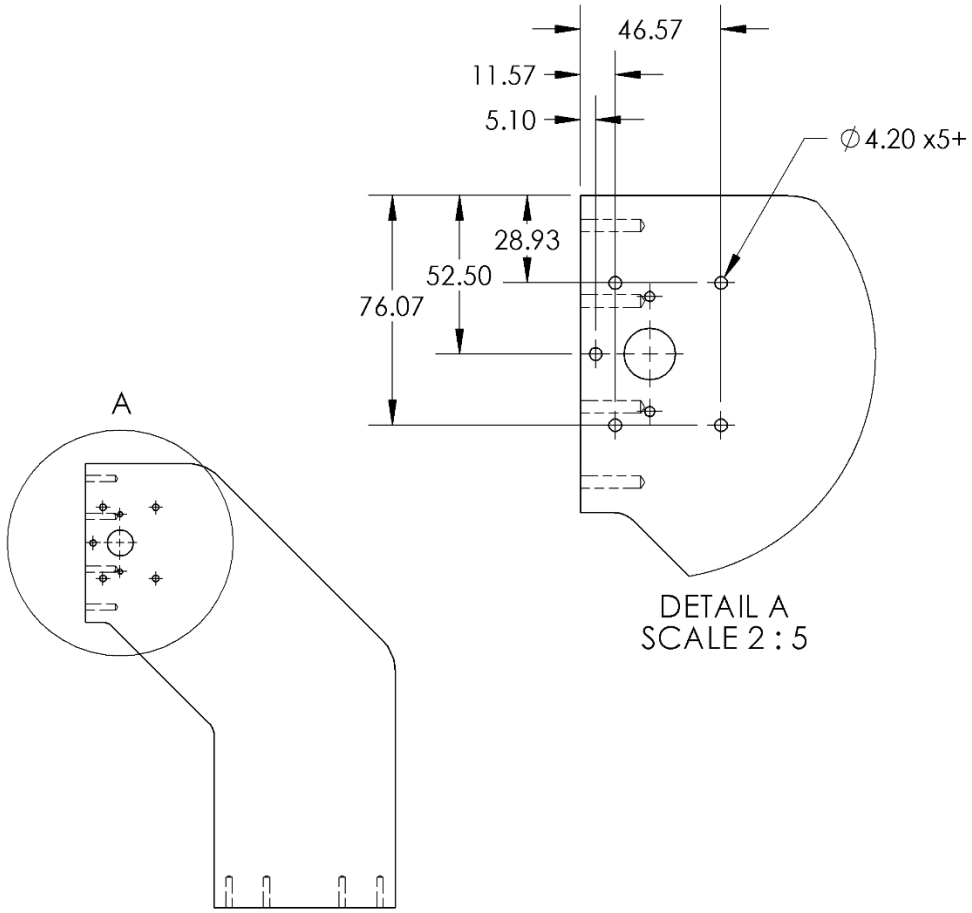
TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	LEFT SHOULDER
MATERIAL	ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	1.55 kg
THIRD ANGLE PROJECTION	
SCALE	1: 5
QUANTITY	1

Right Shoulder



NOTES:

- THIS PART IS CHIRAL-LY SEMMETRIC TO THE LEFT SHOULDER FOR ALL DIMENSIONS NOT SHOWN HERE
- CNC THE PROFILES OF BOTH OF THE SHOULDERS FROM ONE 15 X 320 X 340 mm ALUMINUM PLATE
- DRILL THE HOLES IN THE SIDE AND BOTTOM ON THE MILL
- THE RIGHT SHOULDER HAS FIVE ADDITIONAL 4.2 mm HOLES. ALL 13 ARE PREDRILLS FOR AN M5 TAP

TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

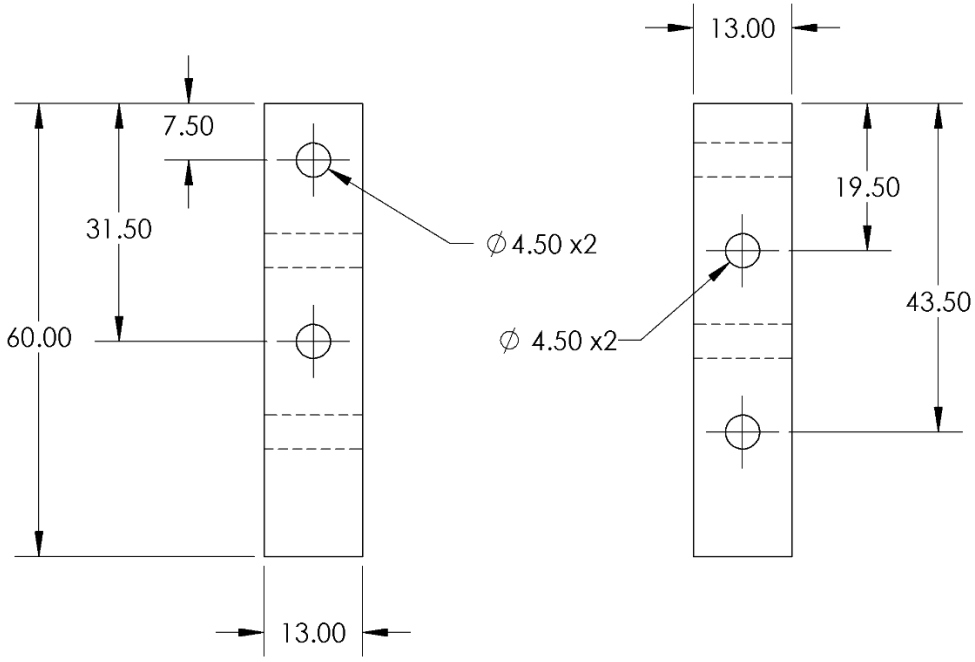
TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	RIGHT SHOULDER
MATERIAL	ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	1.55 kg
THIRD ANGLE PROJECTION	
SCALE	1: 5
QUANTITY	1

Brackets for Weight Support

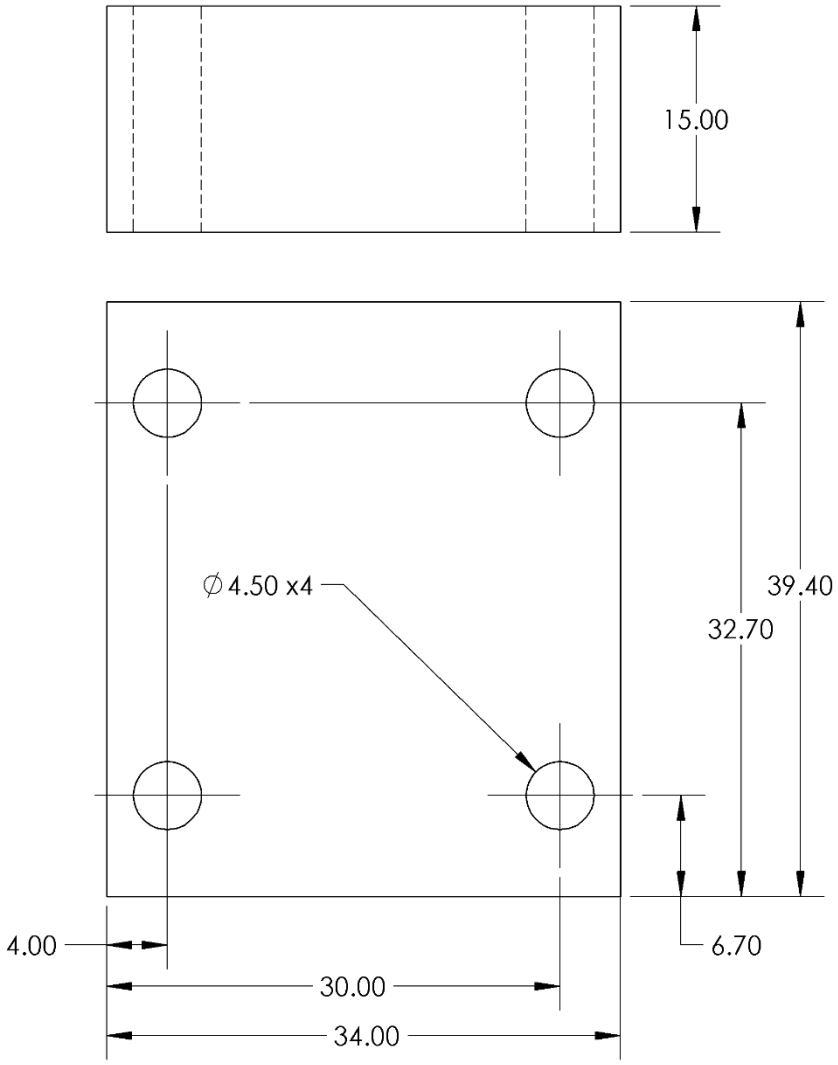
NOTES:

· START WITH 15 mm ALUMINUM SHEET STOCK



TzeNC-PRO	TITLE: BRACKETS FOR WEIGHT SUPPORT	
	MATERIAL: ALUMINUM PLATE	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: AS MACHINED	WEIGHT: 25.15 g
	THIRD ANGLE PROJECTION	SCALE: 1: 1
		QUANTITY: 8

Z Spacer Block

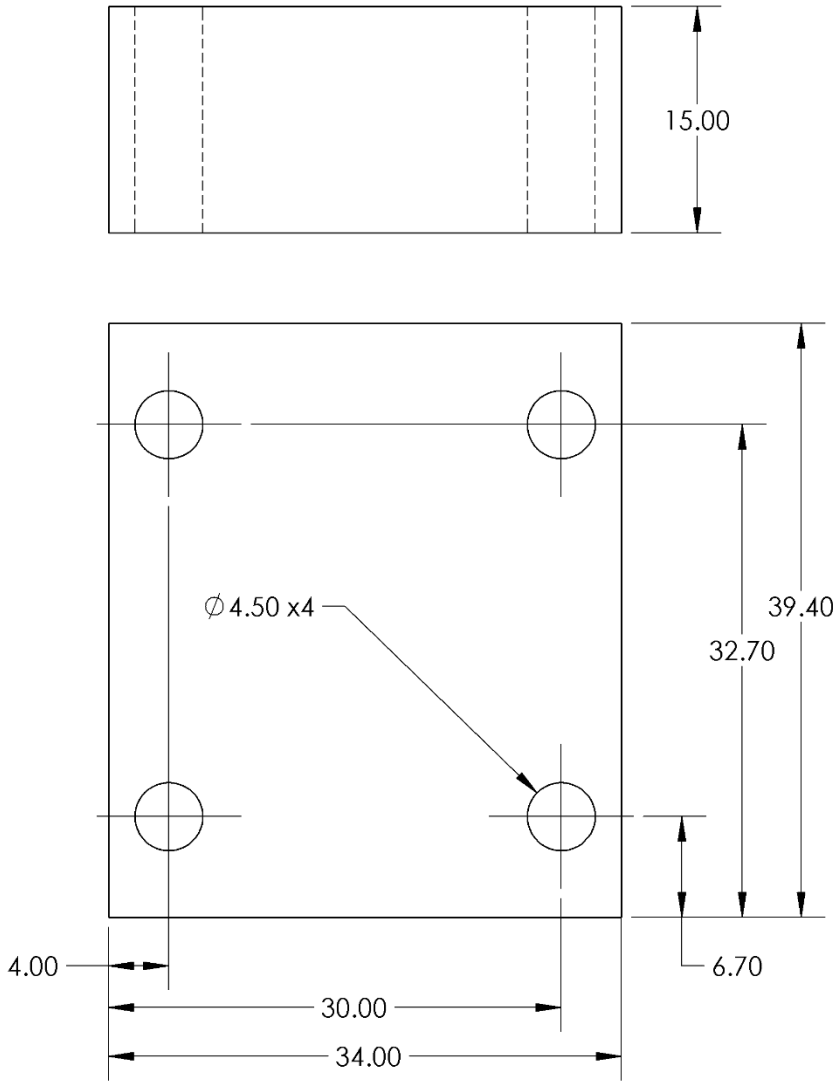


NOTES:

· CUT THESE ON THE MILL USING POM OR SOME SIMILAR VIBRATION DAMPENING PLASTIC

TzeNC-PRO	TITLE: Z-SPACER BLOCK	
	MATERIAL: POM ACETAL	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: AS MACHINED	WEIGHT: 26.60 g
	THIRD ANGLE PROJECTION	SCALE: 2: 1
		QUANTITY: 4

X Spacer Block

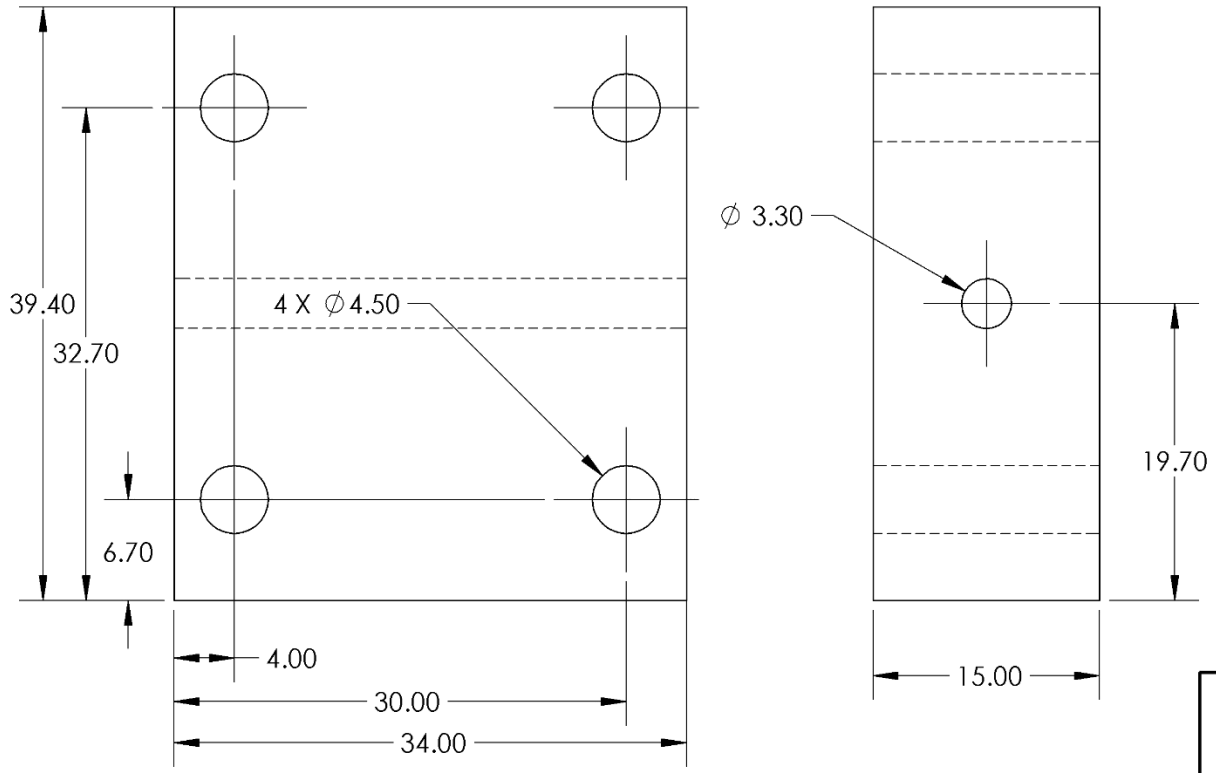


NOTES:

· CUT THESE ON THE MILL USING POM OR SOME SIMILAR VIBRATION DAMPENING PLASTIC

TzeNC-PRO	TITLE: X-SPACER BLOCK	
	MATERIAL: POM ACETAL	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: AS MACHINED	WEIGHT: 26.60 g
	THIRD ANGLE PROJECTION	SCALE: 2: 1
		QUANTITY: 2

X Spacer Block for shield



NOTES:

- CUT THESE ON THE MILL USING POM OR SOME SIMILAR VIBRATION DAMPENING PLASTIC
- THE HOLE THROUGH THE SIDE IS FOR INSTALLING THE PROTECTIVE SHIELD. LEAVE THE POM UNTAPPED UNTIL THE ASSEMBLY AND CUT THE THREADS WITH THE BOLT WHEN YOU INSTALL THE SHIELD (IT MIGHT EVEN BE A GOOD IDEA TO USE A WOOD SCREW WITH A LARGER PITCH)

TzeNC-PRO

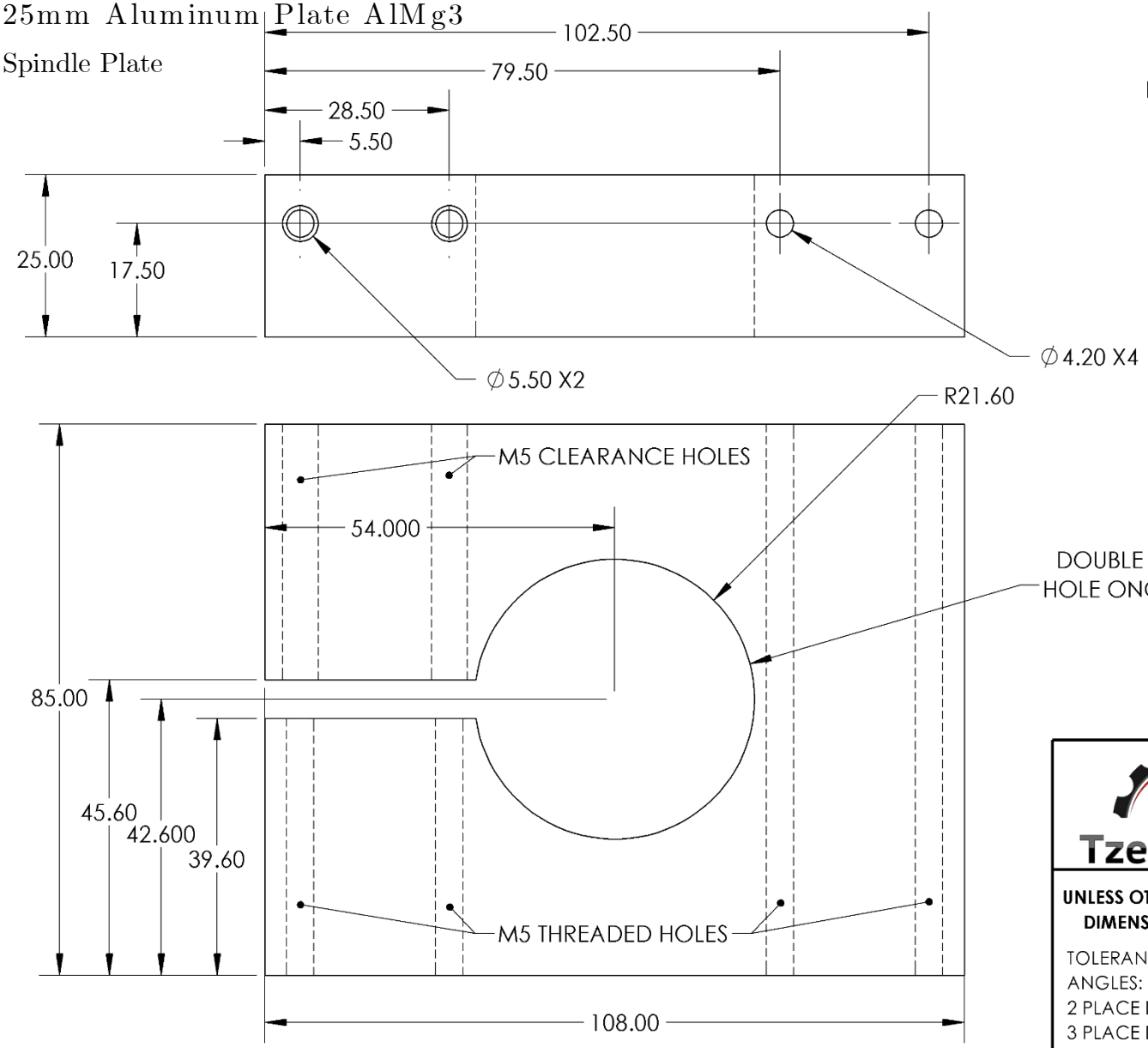
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE: X-SPACER BLOCK FOR SHIELD
MATERIAL: POM ACETAL
FINISH: AS MACHINED
WEIGHT: 26.20 g
THIRD ANGLE PROJECTION
SCALE: 2: 1
QUANTITY: 2

25mm Aluminum Plate AlMg3

Spindle Plate



NOTES:

- START WITH 25 X 85 X 108 mm ALUMINUM PLATE
- DRILL THE CENTER HOLE OUT TO 25.00 mm AND THEN USE A BORING BAR TO APPROACH THE TARGET DIAMETER OF 43.20 MM

TzeNC-PRO

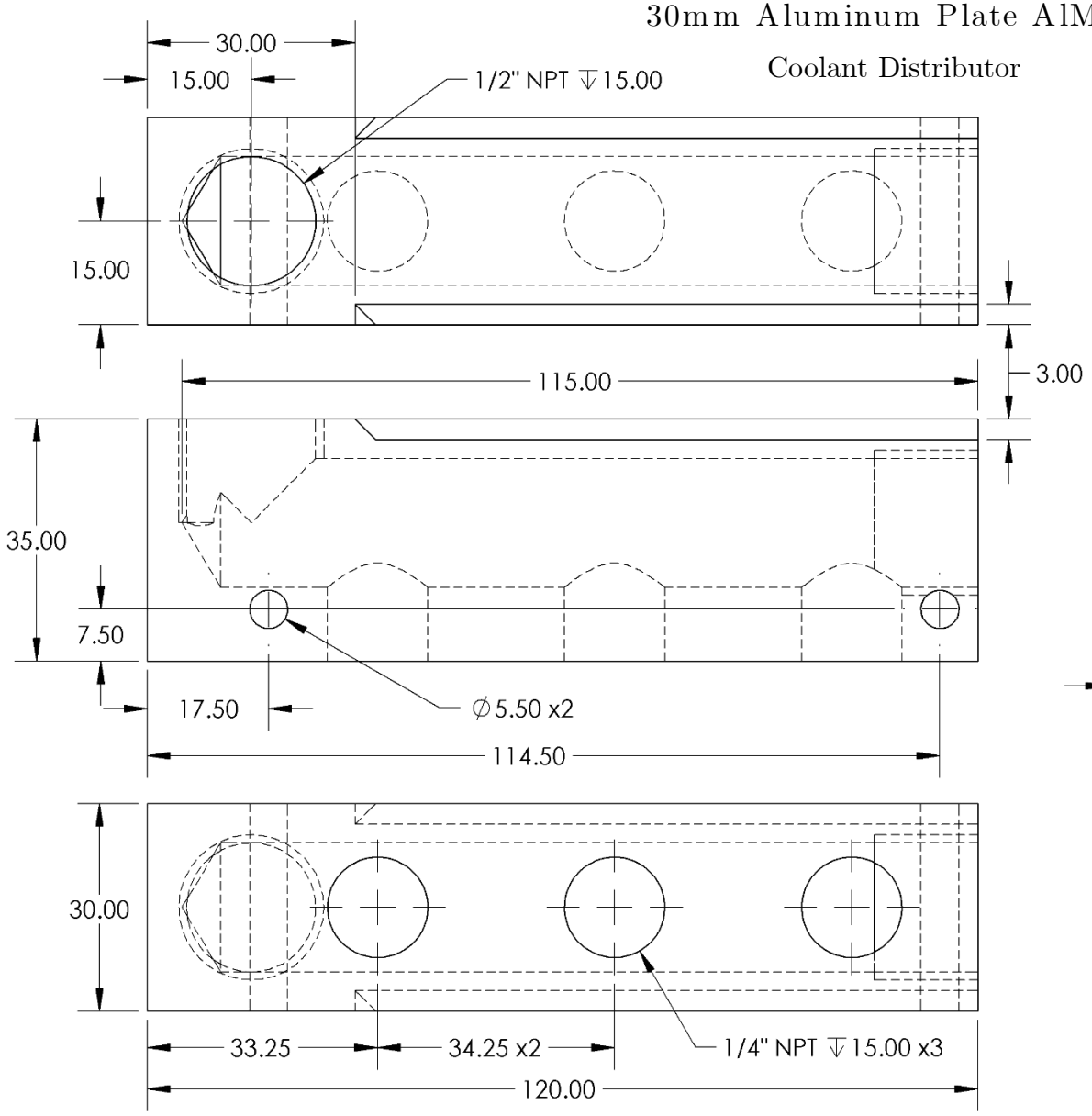
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

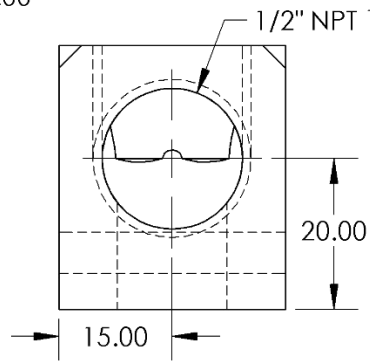
TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	SPINDLE PLATE
MATERIAL	ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	493.19 g
THIRD ANGLE PROJECTION	
SCALE	1: 1
QUANTITY	1

30mm Aluminum Plate AlMg3

Coolant Distributor





NOTES:

- START WITH 30 X 35 X 120 mm ALUMINUM BAR
- THE 1/4" NPT THREADS SHOULD BE PREDRILLED WITH A 7/16" DRILL BIT
- THE 1/2" NPT THREADS SHOULD BE PREDRILLED WITH A 45/64" OR 23/32" DRILL BIT
- CAREFUL NOT TO TAP TOO DEEP WITH THE NPT THREADS (THEY ARE TAPERED)

TzeNC-PRO

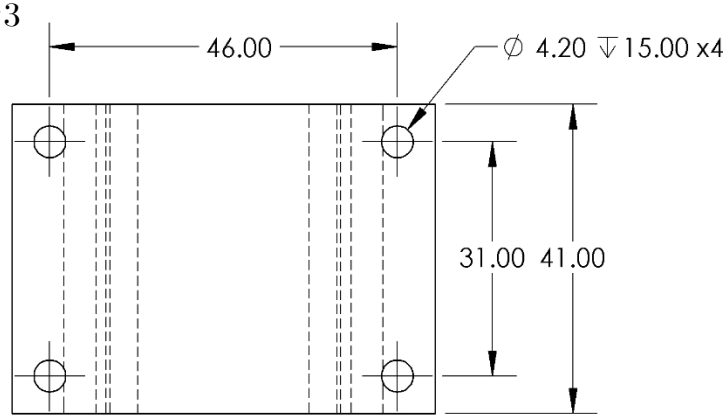
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	COOLANT DISTRIBUTOR
MATERIAL	ALUMINUM BAR
FINISH	AS MACHINED
WEIGHT	231.11 g
THIRD ANGLE PROJECTION	
SCALE	1: 1
QUANTITY	1

40mm Aluminum Plate AlMg3

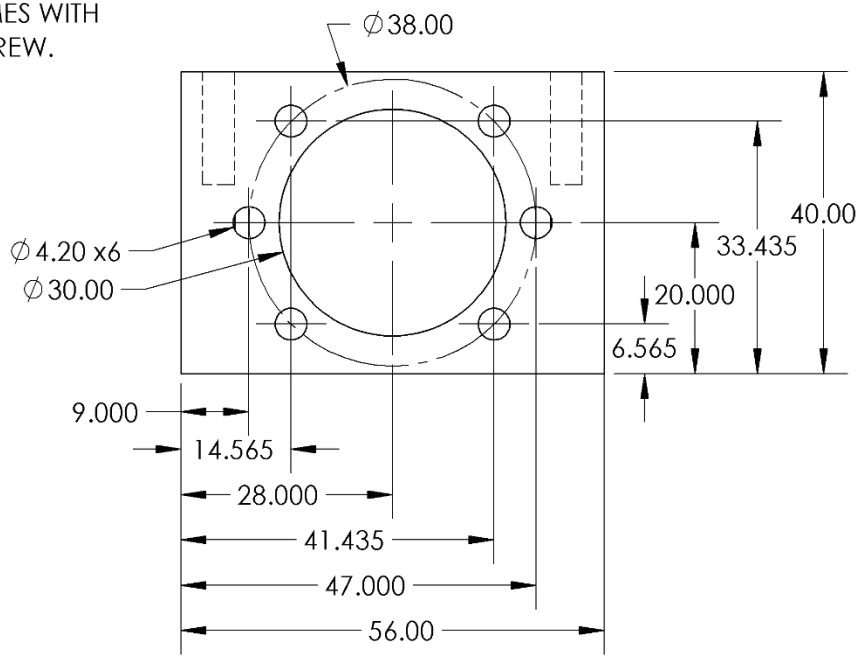
Nut Block



NOTES:

- START WITH 30 X 40 mm ALUMINUM BAR STOCK
- THE 4.20 mm HOLES ARE PREDRILLS FOR AN M5 TAP

BEFORE DRILLING, DOUBLE CHECK THE PLACEMENT OF THESE HOLES WITH THE NUT THAT COMES WITH THE Y-AXIS LEAD SCREW.



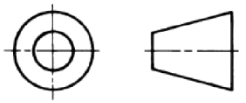
TzeNC-PRO

TITLE	NUT BLOCK
MATERIAL	aluminum PLATE
FINISH	AS MACHINED
WEIGHT	158.27 g
SCALE	1:1
QUANTITY	2

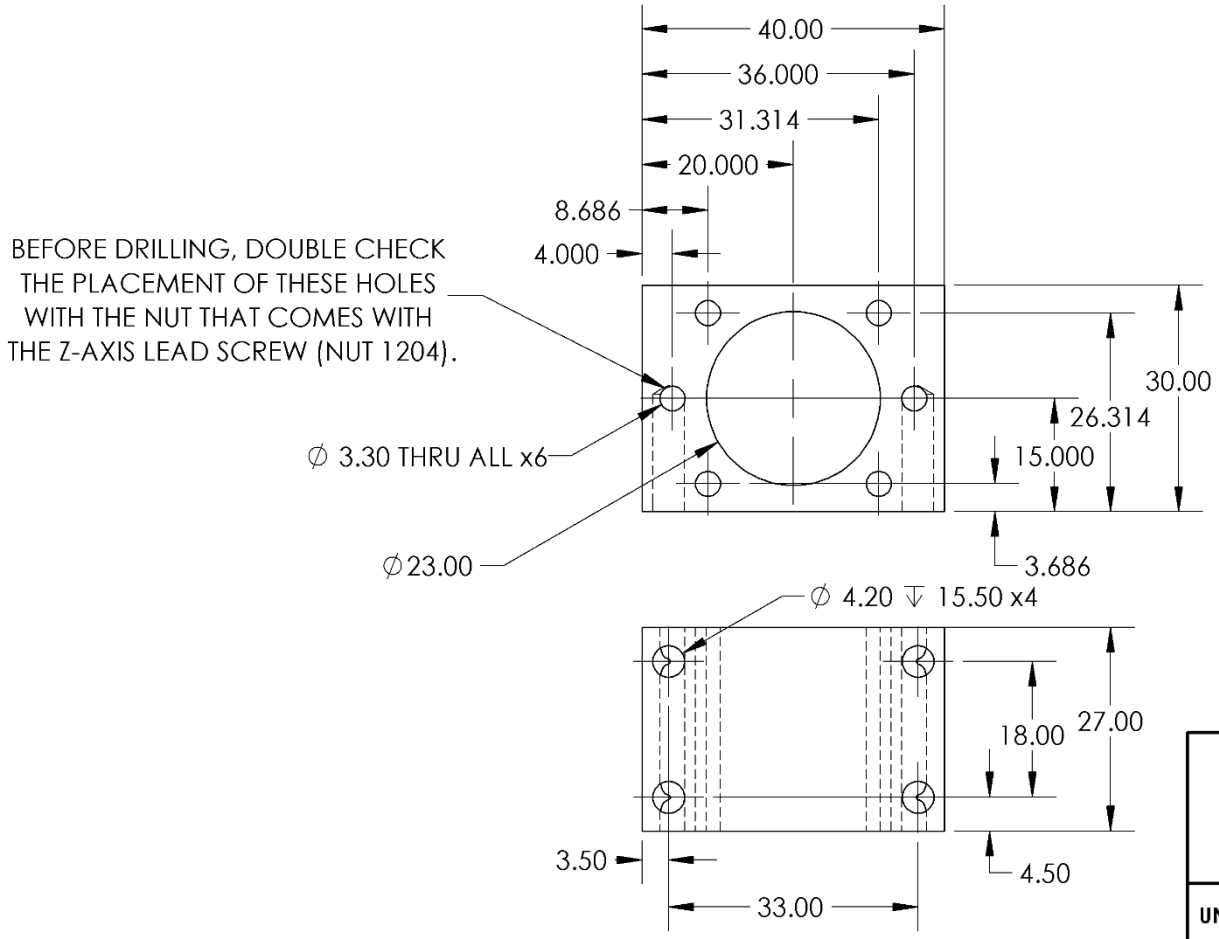
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

THIRD ANGLE PROJECTION



Nut Block Z



NOTES:

- START WITH 30 X 40 mm ALUMINUM BAR STOCK
- THE 3.30 mm HOLES ARE PREDRILLS FOR AN M4 TAP
- THE 4.20 mm HOLES ARE PREDRILLS FOR AN M5 TAP

TzeNC-PRO

TITLE	NUT BLOCK Z
MATERIAL	ALUMINUM PLATE
FINISH	AS MACHINED
WEIGHT	51.35 g
SCALE	1: 1
QUANTITY	1

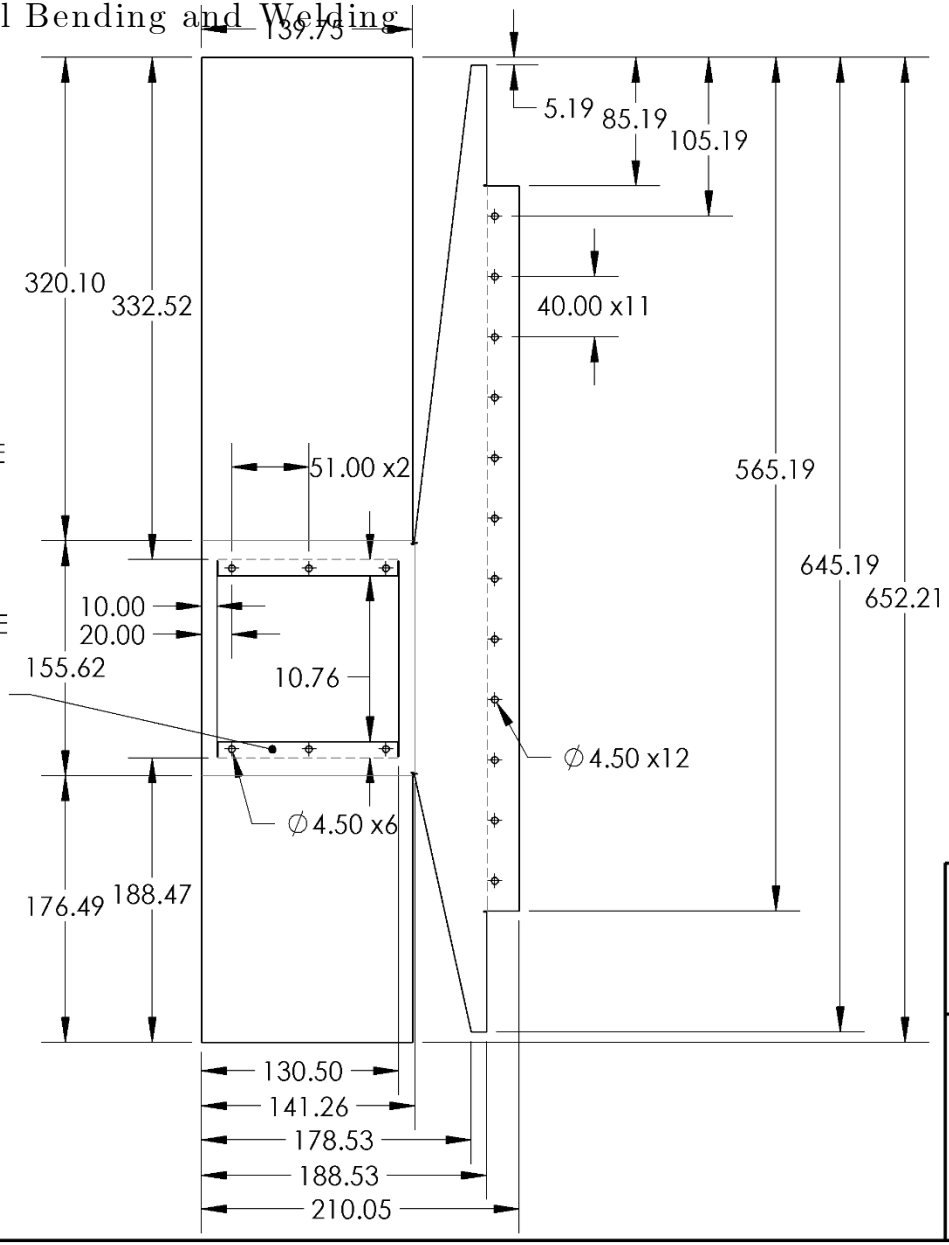
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

THIRD ANGLE PROJECTION

Steel Sheetmetal Bending and Welding

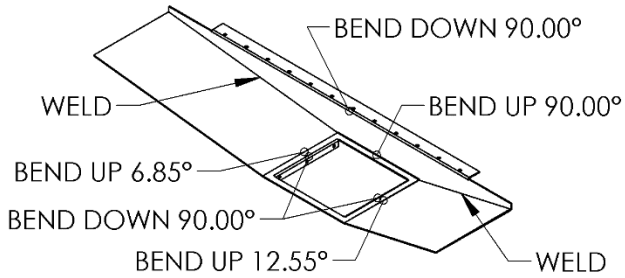
Chip Tray



AFTER BENDING, THESE TWO TABS FIT INSIDE THE REINFORCEMENT FOR SMALL DRAIN WITH AN INTERNAL WIDTH OF 133 mm. THE HOLES ALSO NEED TO ALIGN

NOTES:

- START WITH 1.5 mm STEEL SHEET
- THIS PART WOULD BE BEST CUT ON A FULL FORMAT WATER JET CUTTER
- THE TWO WELDS ARE OPTIONAL SINCE THIS PART GETS ITS RIGIDITY FROM THE REINFORCEMENTS
- DRILL THE HOLES IN THE TOP WITH THE Y-BACK PLATE USING THE T-NUT PLATES AS A TEMPLATE
- ALL BENDS HAVE A BENDING RADIUS R = 0.74 mm



ISOMETRIC VIEW OF FOLDED PART
SCALE: 1:10

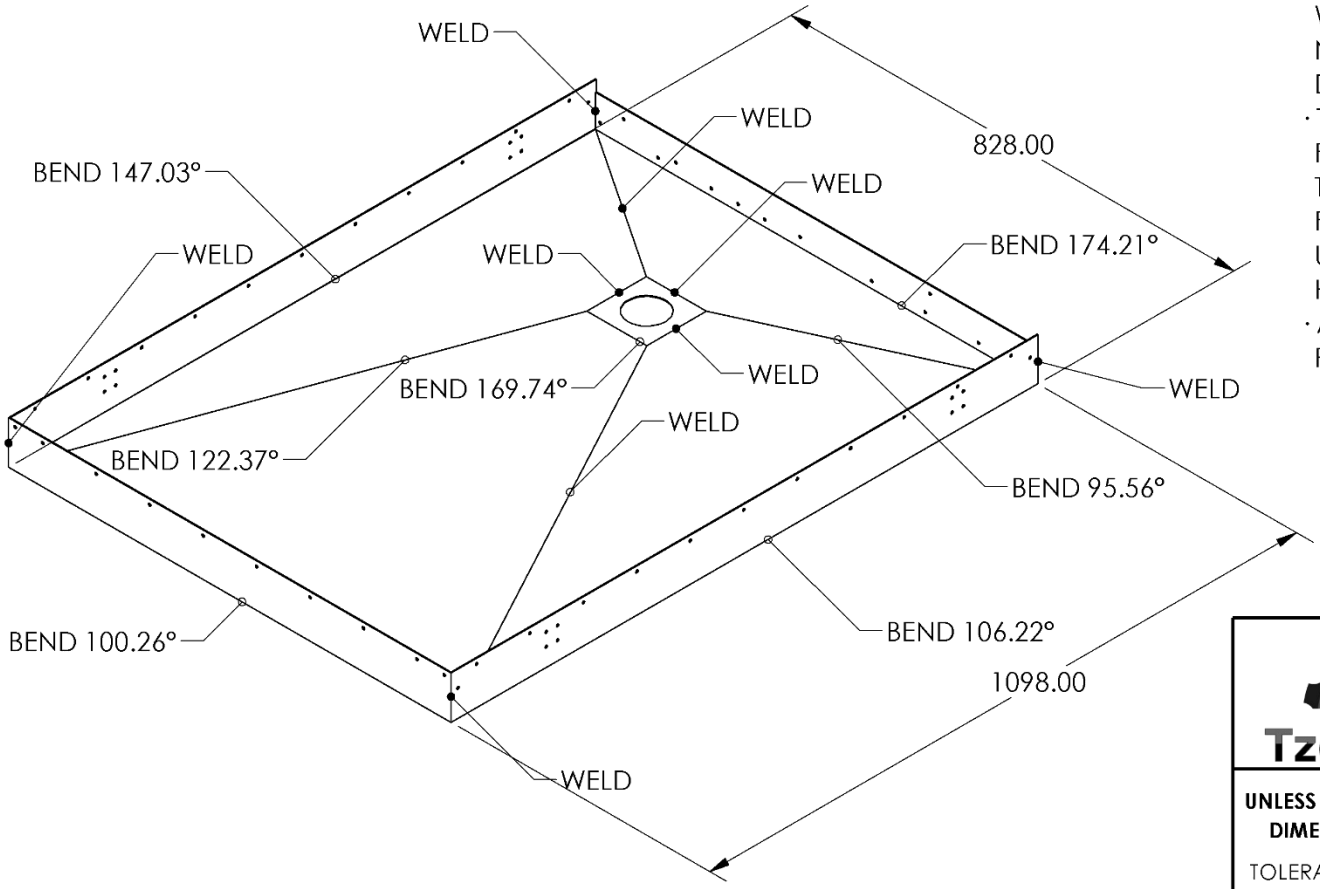
TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	CHIP TRAY
MATERIAL	STEEL SHEET
FINISH	AS MACHINED
WEIGHT	1.28 kg
THIRD ANGLE PROJECTION	
SCALE	1: 5
QUANTITY	1

Bottom Tray



NOTES: **DRAWING 1 OF 4 FOR THIS PART**

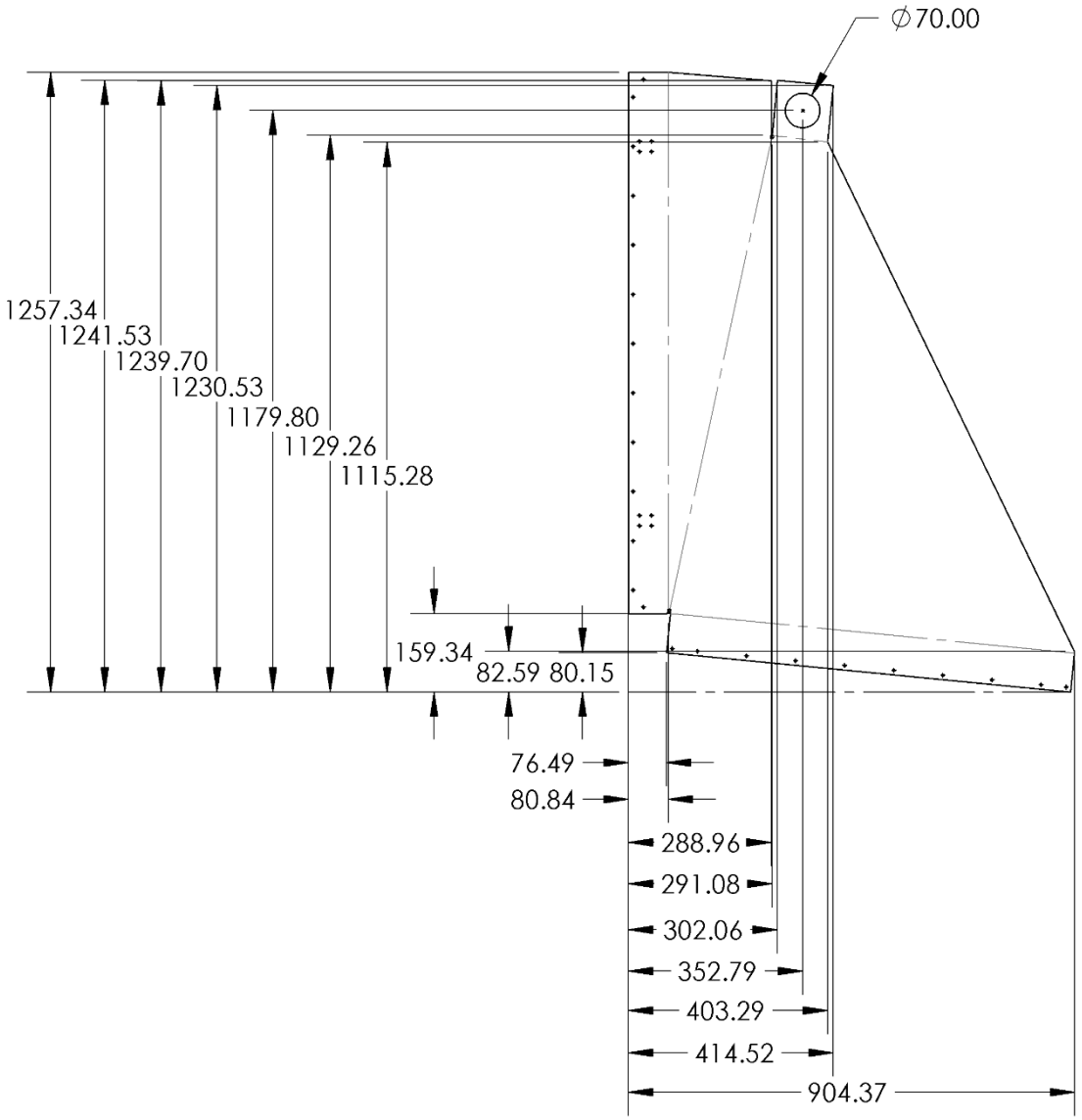
- START WITH 1.5 mm STEEL SHEET
- THE UNFOLDED PART IS TOO LARGE TO BE CUT FROM A SINGLE SHEET OF STEEL SO THE PART WILL BE FABRICATED IN TWO HALVES THAT WILL NEED TO BE WELDED TOGETHER. THE OUTSIDE DIMENSIONS OF THE FINISHED PART ARE GIVEN
- THESE PARTS WOULD BE BEST CUT ON A FULL FORMAT WATER JET CUTTER. IF YOU DO THAT, THEN USE THIS FINISHED PART AS A TEMPLATE FOR THE HOLES IN THE SIDE SKIRTS. OTHERWISE, USE THE SIDE SKIRTS AS A TEMPLATE FOR THE HOLES IN THIS PART
- ALL BENDS ARE UPWAWRD WITH A BENDING RADIUS R = 0.74 mm

TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	BOTTOM TRAY
MATERIAL	STEEL SHEET
FINISH	AS MACHINED
WEIGHT	15.85 kg
THIRD ANGLE PROJECTION	
SCALE	1: 10
QUANTITY	1



NOTES: **DRAWING 2 OF 4 FOR THIS PART**

· HERE IS THE POINT CLOUD FOR THE CUTS

TzeNC-PRO

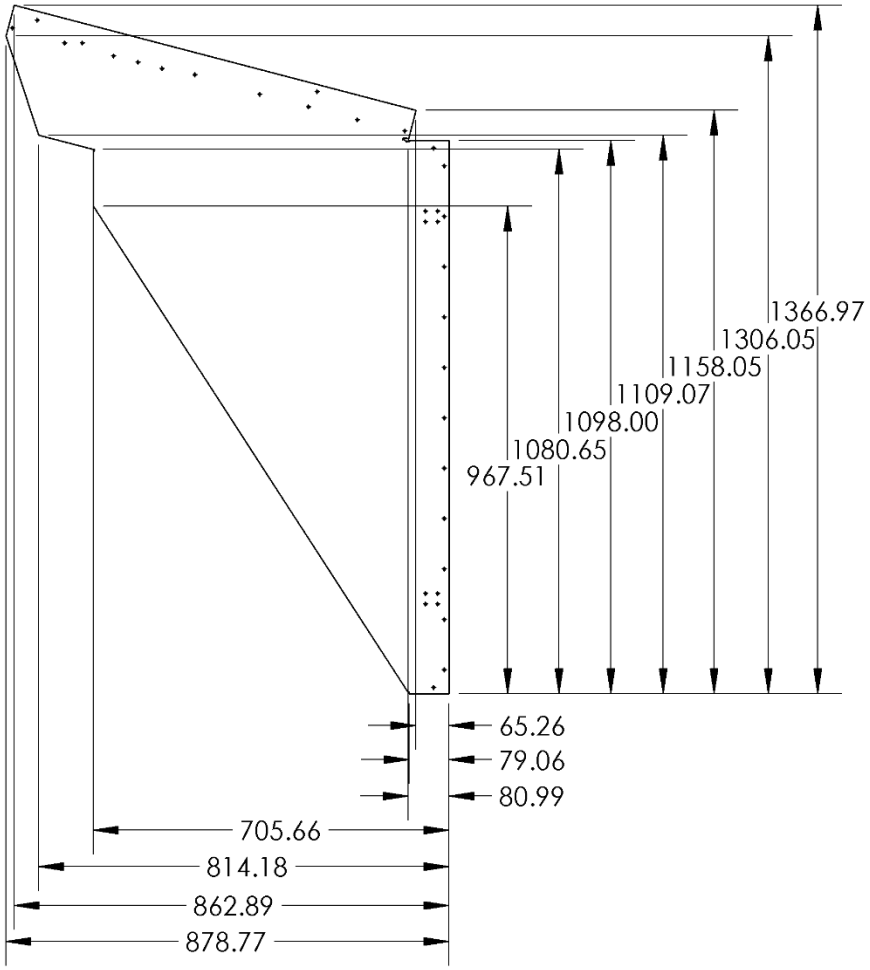
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	BOTTOM TRAY (LEFT HALF)
MATERIAL	STEEL SHEET
FINISH	AS MACHINED
WEIGHT	8.87 kg
THIRD ANGLE PROJECTION	
SCALE	1: 15
QUANTITY	1

NOTES: **DRAWING 3 OF 4 FOR THIS PART**

· HERE IS THE POINT CLOUD FOR THE CUTS

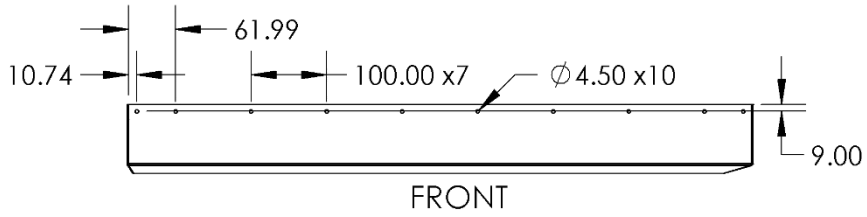


TzeNC-PRO

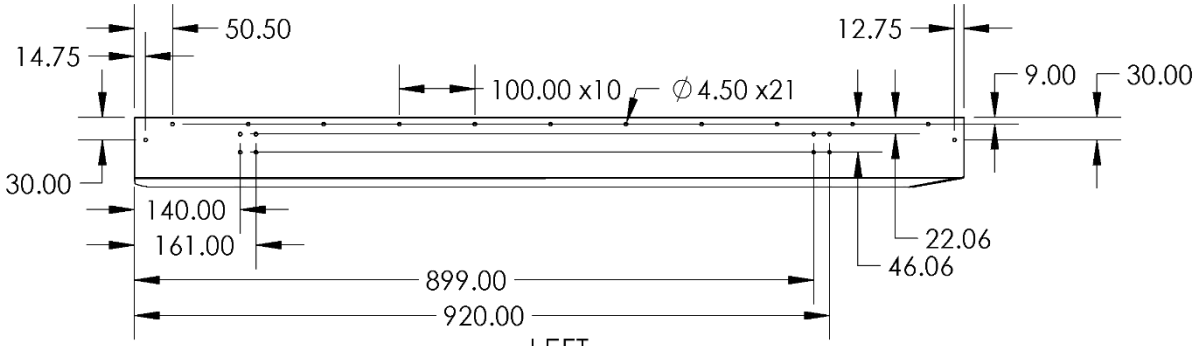
TITLE	BOTTOM TRAY (RIGHT HALF)
MATERIAL	STEEL SHEET
FINISH	AS MACHINED
WEIGHT	7.06 kg
THIRD ANGLE PROJECTION	
SCALE	1: 15
QUANTITY	1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

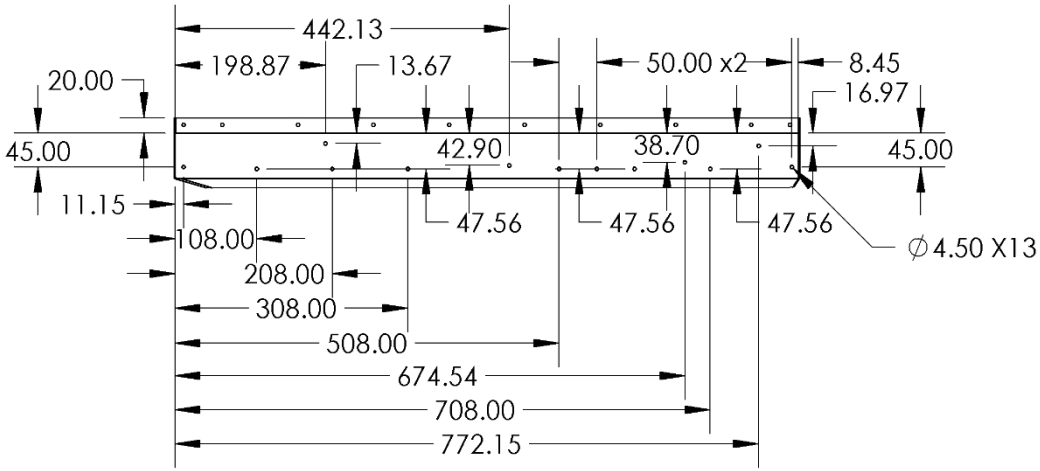
TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05



FRONT



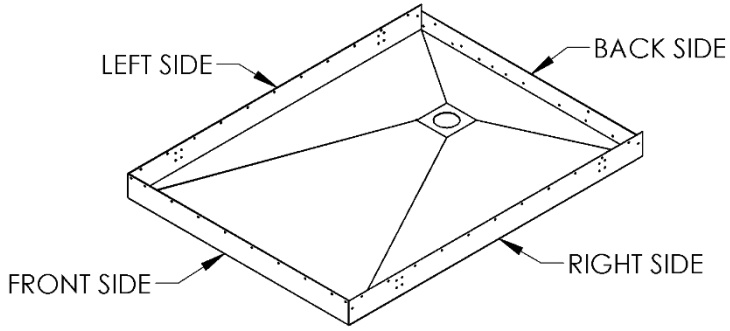
LEFT



BACK

NOTES: **DRAWING 4 OF 4 FOR THIS PART**

- THESE ARE THE HOLE PATTERNS FOR THE BOTTOM TRAY
- THE SIDES ARE LABELLED AS SHOWN IN THE ISOMETRIC DRAWING
- THE RIGHT SIDE IS CHIRAL-LY SYMMETRIC TO THE LEFT
- USE THIS FINISHED PART AS A TEMPLATE FOR THE HOLES IN THE SIDE SKIRTS OR USE THE SIDE SKIRTS AS A TEMPLATE FOR THE HOLES IN THIS PART



TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE: BOTTOM TRAY (HOLE PATTERNS)

MATERIAL: STEEL SHEET

FINISH: AS MACHINED

WEIGHT: NA

THIRD ANGLE PROJECTION

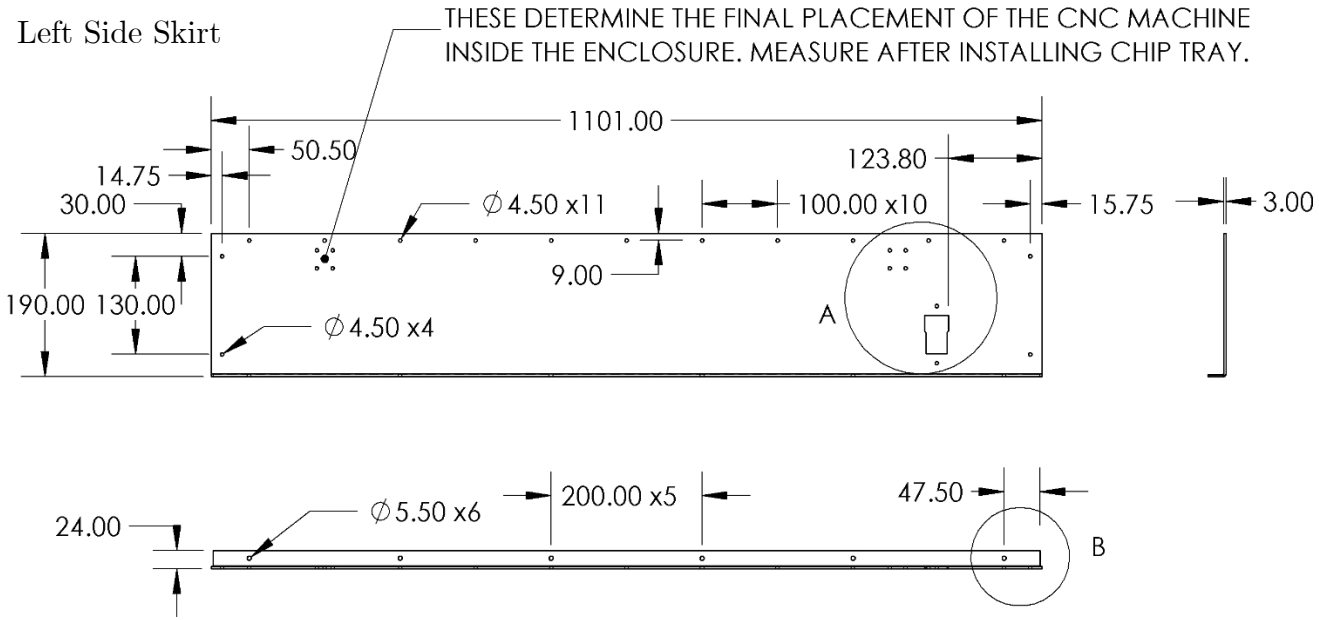
SCALE: 1: 10

QUANTITY: 1

Coolant Tank

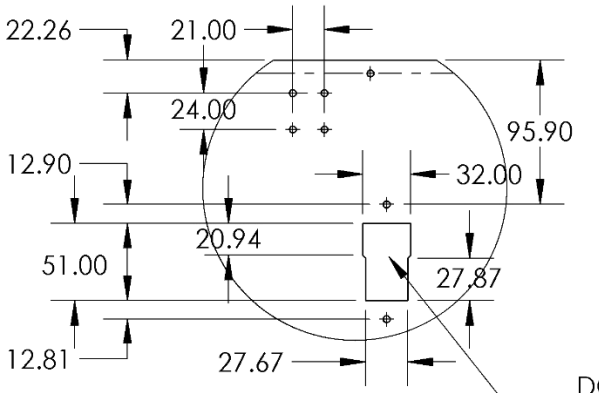
Extruded Steel

Left Side Skirt

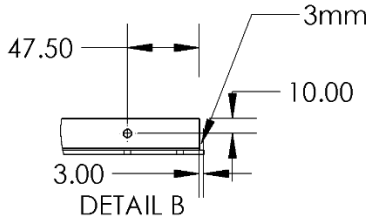


NOTES:

- START WITH 3mm STEEL SHEET.
- BEND THE 90° ANGLE USING THE METAL BRAKE IN BUILDING 07.
- IT'S TOO BIG TO FIT INTO THE MILL VISE SO FIGURE OUT A WAY TO CLAMP IT TO THE BED. REMOVE THE FENCE FROM THE MILL IF NECESSARY. POSSIBLY DRILL BY HAND IF IT SOUNDS EASIER THAN SETTING UP ON THE MILL.
- USE THIS TO TEMPLATE THE HOLES IN THE TABLE SO THEY STAY ALIGNED.
- DOUBLE CHECK THE HOLE PLACEMENT FOR THE WEIGHT SUPPORT BRACKETS AFTER WELDING THE CHIP TRAY. THIS IS WHERE YOU CAN ACCOUNT FOR ANY WELDING ERROR IN THE Y-DIMENSION.



DETAIL A
SCALE 1 : 5



DETAIL B
SCALE 1 : 5

DOUBLE CHECK THESE DIMENSIONS WITH THE KEDU SWITCH AND DOUBLE CHECK CLEARANCE FROM BOTTOM TRAY

TzeNC-PRO

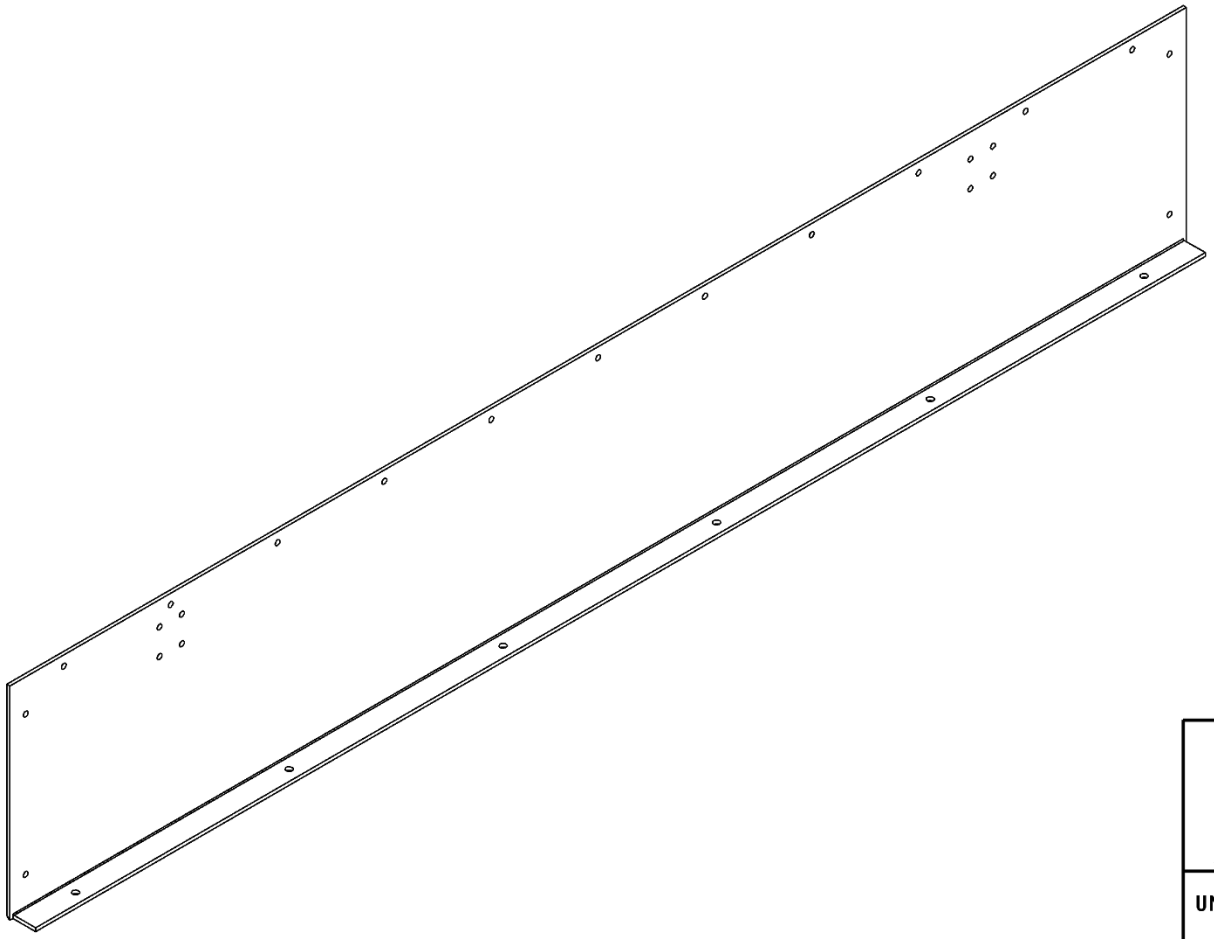
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	LEFT SIDE SKIRT
MATERIAL	CARBON STEEL SHEET
FINISH	AS MACHINED
WEIGHT	5.40 kg
FIRST ANGLE PROJECTION	
SCALE	1: 10
QUANTITY	1

Right Side Skirt

NOTES:
· CHIRAL-LY SYMMETRIC TO LEFT SIDE SKIRT, BUT WITHOUT THE SLOT FOR THE SWITCH.



TzeNC-PRO

TITLE	RIGHT SIDE SKIRT
MATERIAL	CARBON STEEL SHEET
FINISH	AS MACHINED
WEIGHT	5.43 kg
FIRST ANGLE PROJECTION	
SCALE	1 : 5
QUANTITY	1

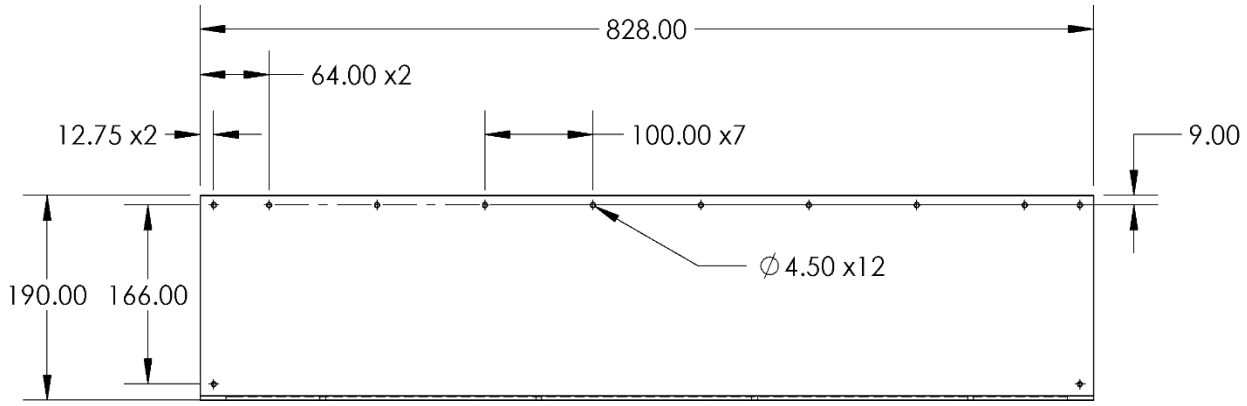
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

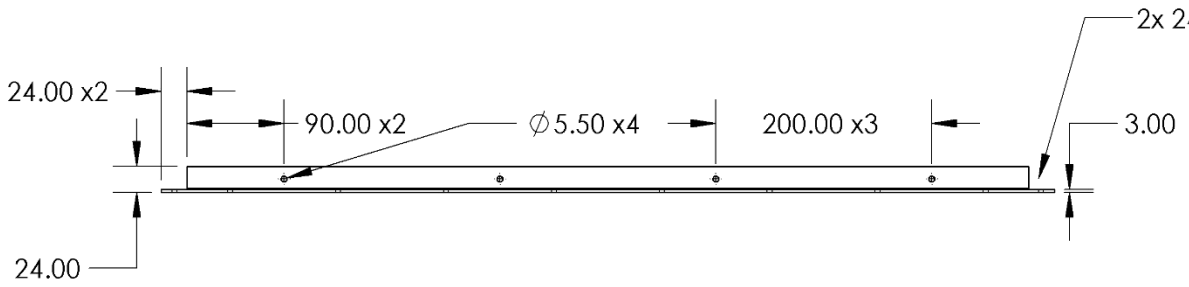
TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

Front Skirt

NOTES:

- SAME STOCK AND PROCESSING AS OTHER SKIRTS.
- USE THIS TO TEMPLATE THE HOLES IN THE TABLE SO THEY STAY ALIGNED.
- M4 CLEARANCE HOLES ON TOP ARE MOSTLY FOR AESTHETICS SO ONLY DRILL THEM IF IT'S CONVENIENT TO DO SO ON THE MILL.





TzeNC-PRO

TITLE	FRONT SKIRT
MATERIAL	CARBON STEEL SHEET
FINISH	AS MACHINED
WEIGHT	4.07 kg
FIRST ANGLE PROJECTION	
SCALE	1: 7
QUANTITY	1

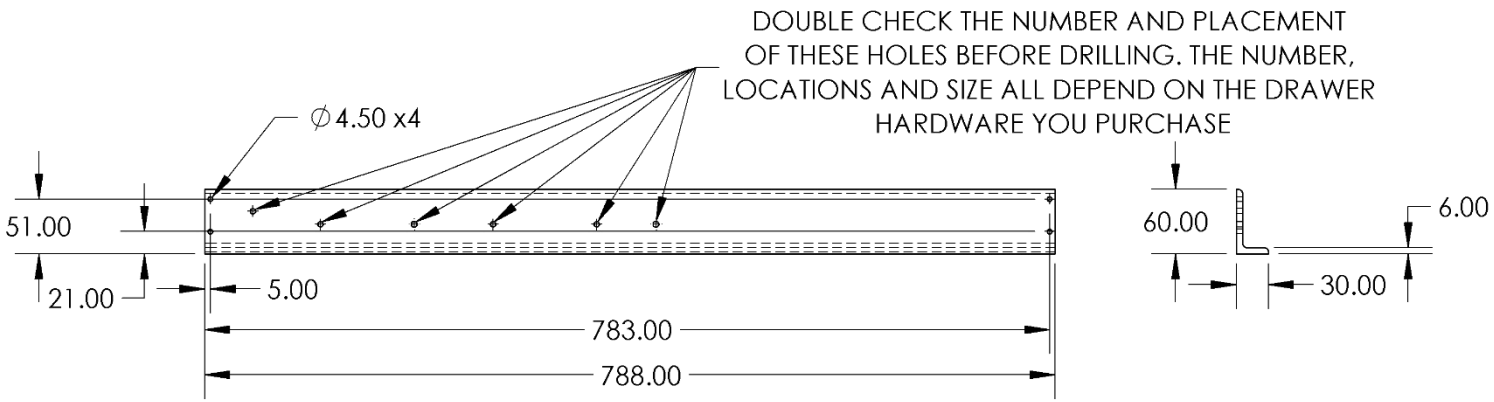
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

Angle Iron for Drawer Left

NOTES:

- START WITH 60 X 30 X 6 X 1000 mm ANGLE IRON
- LOCATE THE HOLES FOR THE DRAWER HARDWARE USING THE HARDWARE ITSELF AS A TEMPLATE
- DRILL THE HOLES ON THE MILL OR USING A MAG DRILL



TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE: ANGLE IRON FOR DRAWER LEFT

MATERIAL: S275 MILD STRUCTURAL STEEL

FINISH: AS MACHINED

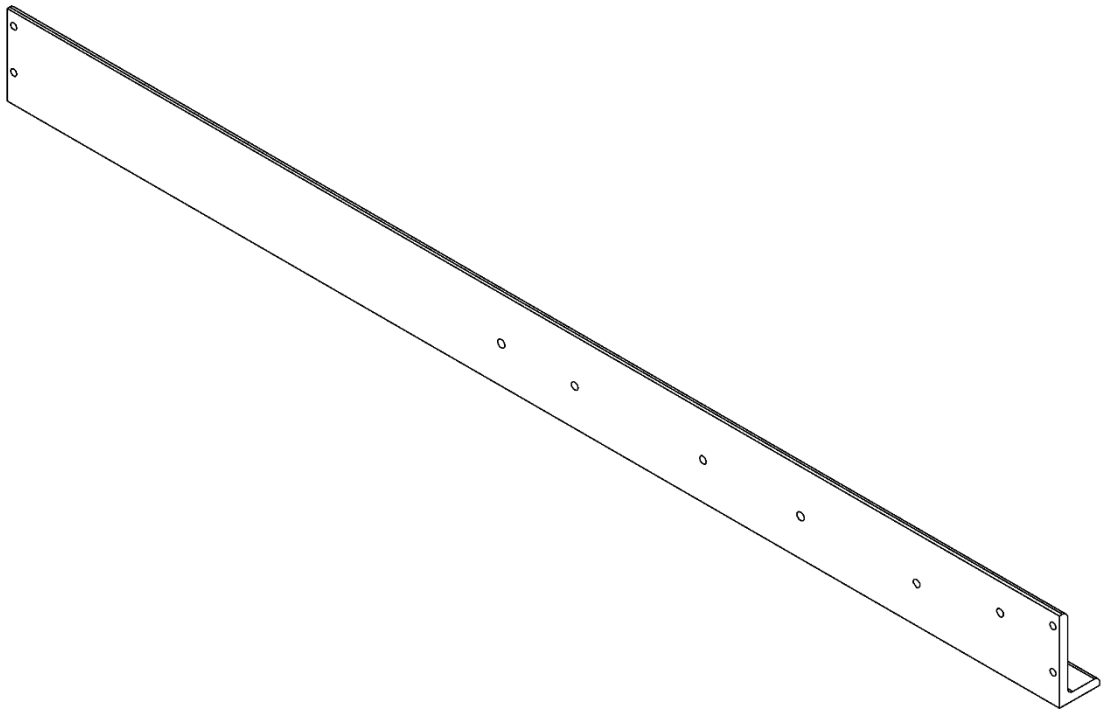
WEIGHT: 3.07 kg

THIRD ANGLE PROJECTION

SCALE: 1: 7

QUANTITY: 1

Angle Iron for Drawer Right



NOTES:

· THIS PART IS CHIRAL-LY SYMMETRIC TO THE ANGLE IRON FOR DRAWER LEFT

TzeNC-PRO

TITLE	ANGLE IRON FOR DRAWER RIGHT
MATERIAL	S275 MILD STRUCTURAL STEEL
FINISH	AS MACHINED
WEIGHT	3.07 kg
THIRD ANGLE PROJECTION	
SCALE	1: 5
QUANTITY	1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

3D Printed

Y-Axis Motor Adaptor

X-Axis Motor Adaptor

Z-Axis Motor Adaptor

Cover for Y-Motor

Cover for X-Motor

Cover for Z-Motor

Corner Pieces for Lid

Door Handles

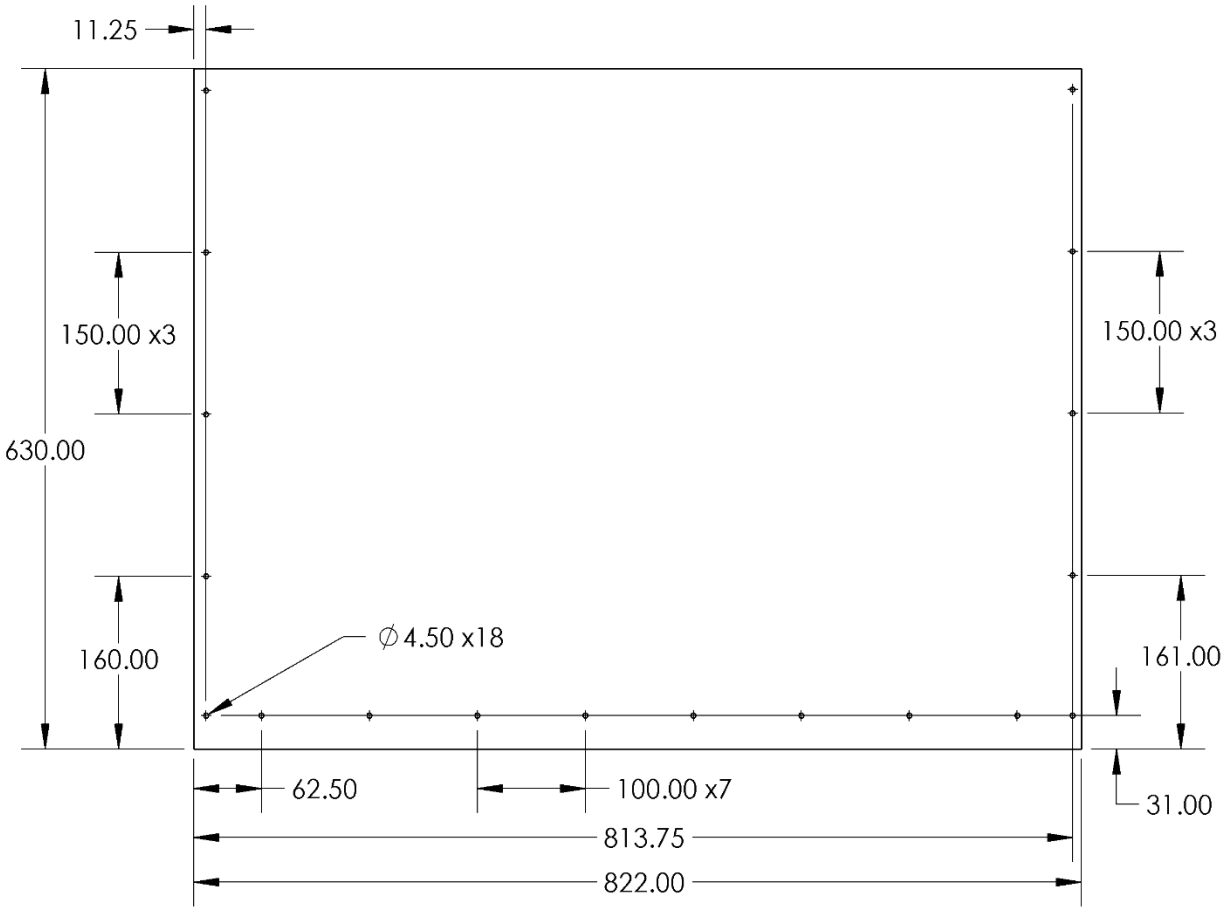
Drawer Endcap Left

Drawer Endcap Right

Handle for Drawer

3mm Acrylic

PG Front Panel



NOTES:

- MAKE FROM 3.0 mm CAST ACRYLIC SHEETS
- IDEALLY, LASER CUT EDGES AND HOLES

TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

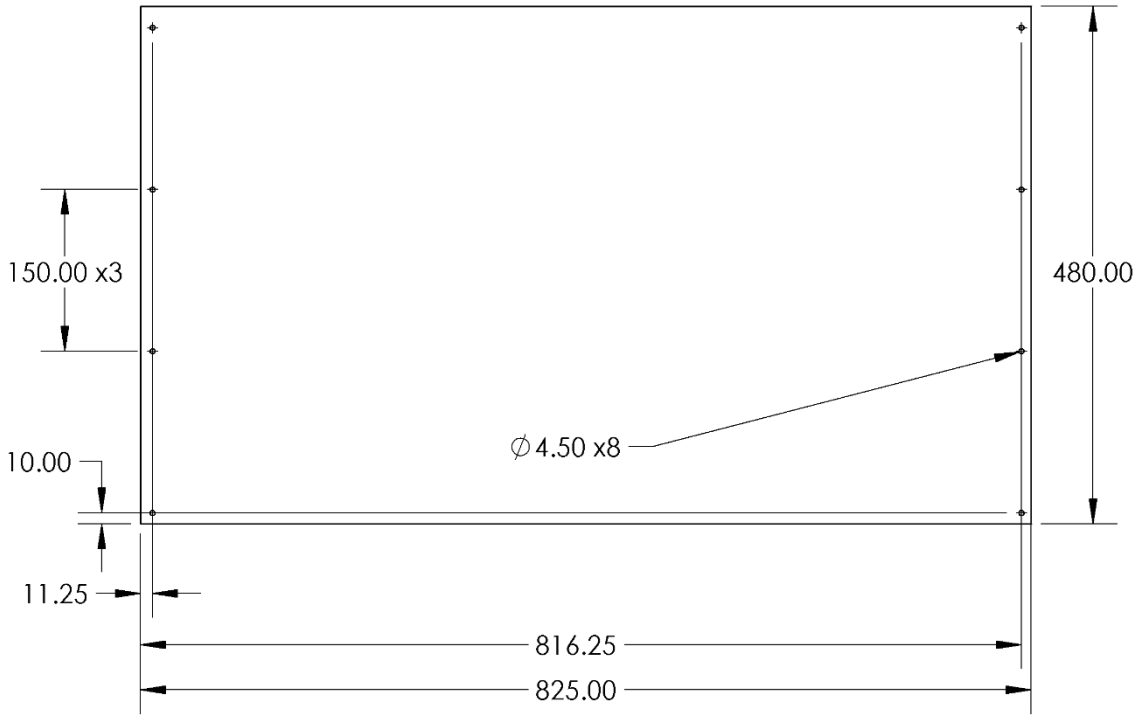
TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	PG FRONT PANEL
MATERIAL	CAST ACRYLIC SHEET
FINISH	POLISHED EDGES
WEIGHT	1.85 kg
THIRD ANGLE PROJECTION	
SCALE	1: 7
QUANTITY	1

PG Back Panel

NOTES:

- MAKE FROM 3.0 mm CAST ACRYLIC SHEETS
- IDEALLY, LASER CUT EDGES AND HOLES



TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE: PG BACK PANEL

MATERIAL: CAST ACRYLIC SHEET

FINISH: POLISHED EDGES

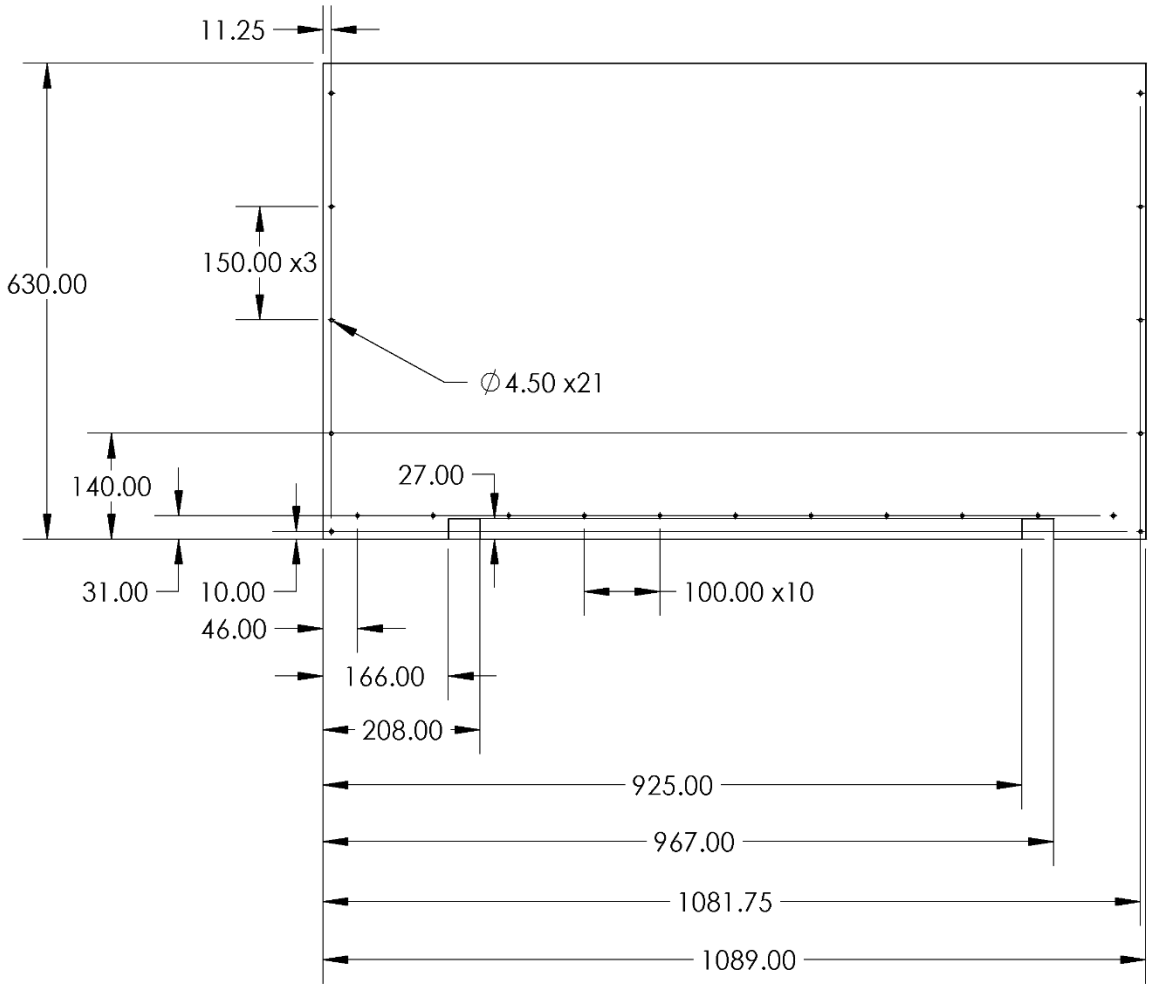
WEIGHT: 1.41 kg

THIRD ANGLE PROJECTION

SCALE: 1: 7

QUANTITY: 1

PG Side Panel



NOTES:

- MAKE FROM 3.0 mm CAST ACRYLIC SHEETS
- IDEALLY, LASER CUT EDGES AND HOLES

TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

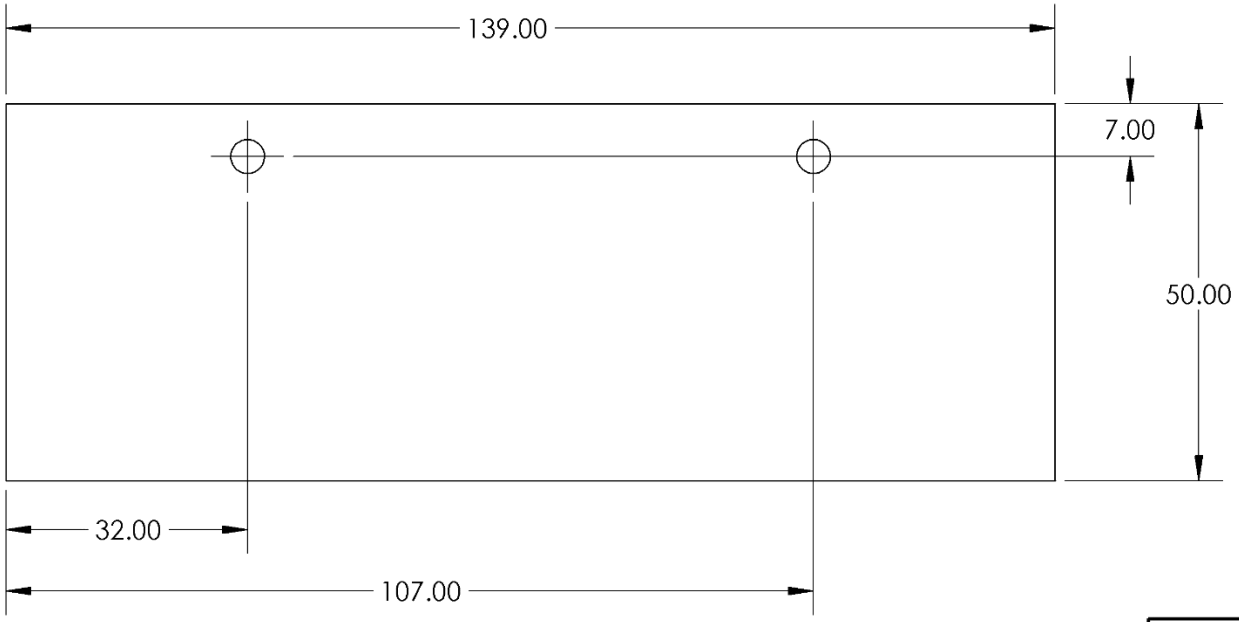
TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	PG SIDE PANEL
MATERIAL	CAST ACRYLIC SHEET
FINISH	POLISHED EDGES
WEIGHT	2.44 kg
THIRD ANGLE PROJECTION	
SCALE	1: 10
QUANTITY	1

X Axis Shield

NOTES:

- MAKE FROM 3.0 mm CAST ACRYLIC SHEETS
- IDEALLY, LASER CUT EDGES AND HOLES



TzeNC-PRO

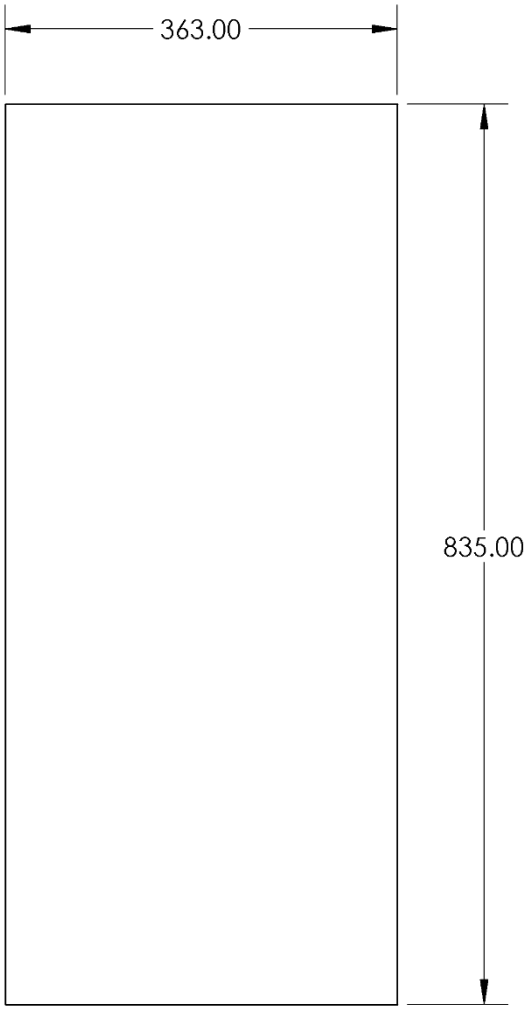
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	X AXIS SHIELD
MATERIAL	CAST ACRYLIC SHEET
FINISH	POLISHED EDGES
WEIGHT	24.70 g
THIRD ANGLE PROJECTION	
SCALE	1: 1
QUANTITY	1

4mm Acrylic

PG Top Panels

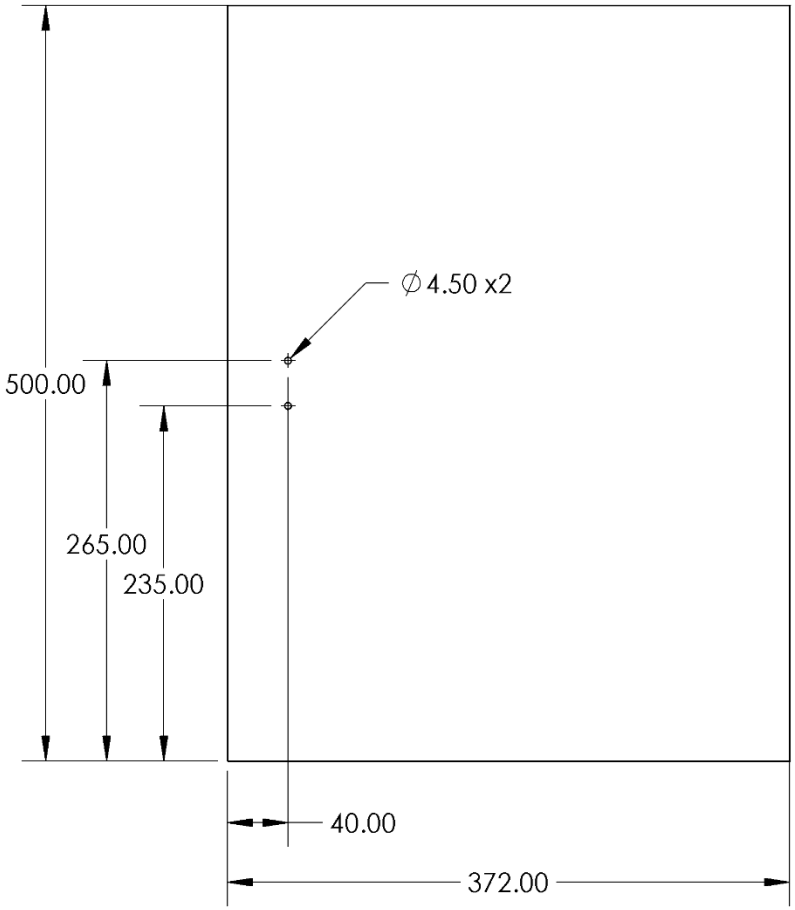


NOTES:

- MAKE FROM 4.0 mm CAST ACRYLIC SHEETS
- IDEALLY, LASER CUT EDGES AND HOLES

TzeNC-PRO	TITLE: PG TOP PANELS	
	MATERIAL: CAST ACRYLIC SHEET	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: POLISHED EDGES	WEIGHT: 1.44 kg
	THIRD ANGLE PROJECTION	SCALE: 1: 7
		QUANTITY: 3

Doors Side



NOTES:

- MAKE FROM 4.0 mm CAST ACRYLIC SHEETS
- IDEALLY, LASER CUT EDGES AND HOLES

TzeNC-PRO

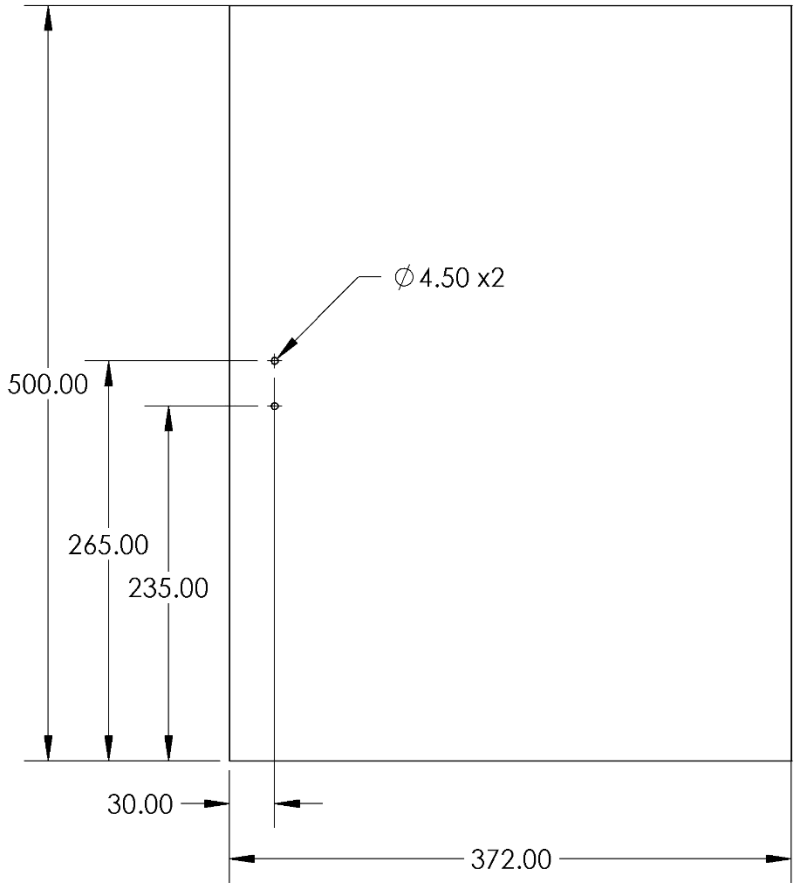
TITLE	DOORS SIDE
MATERIAL	CAST ACRYLIC SHEET
FINISH	POLISHED EDGES
WEIGHT	885.21 g
SCALE	1: 7
QUANTITY	2

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

THIRD ANGLE PROJECTION

Doors Center



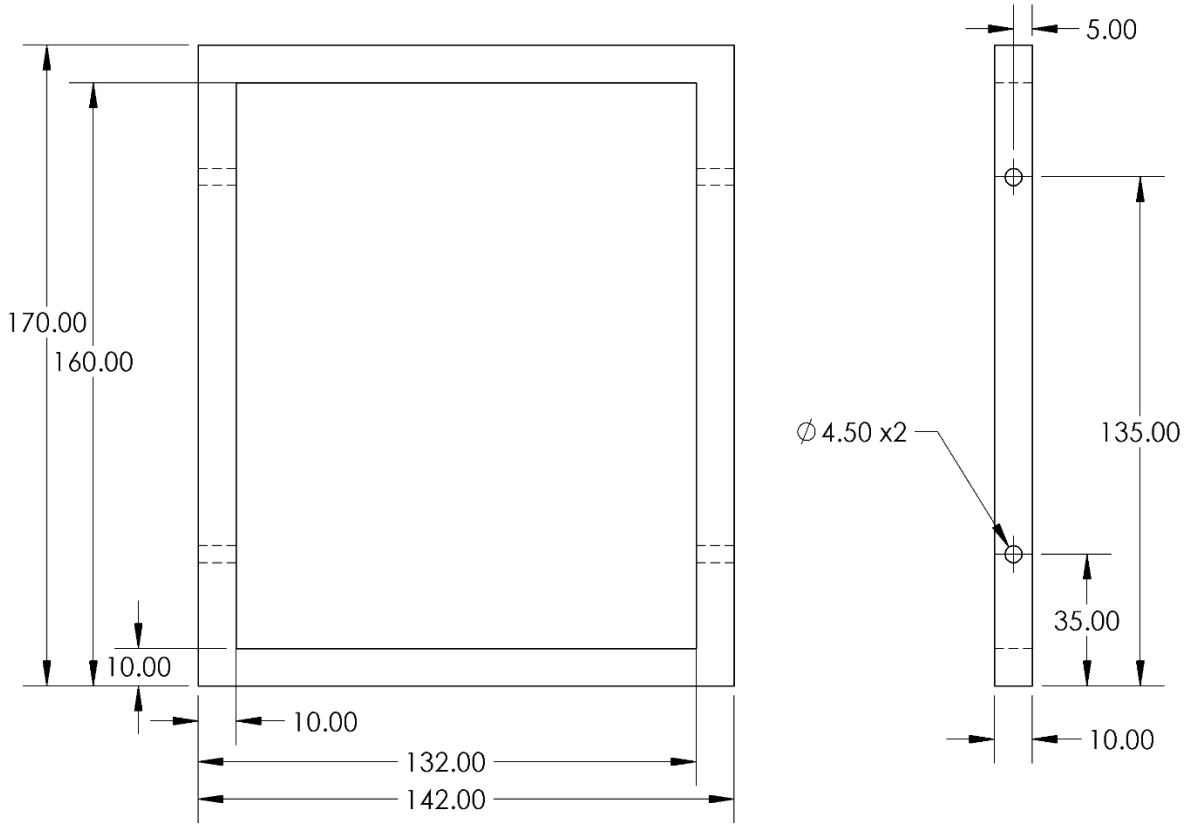
NOTES:

- MAKE FROM 4.0 mm CAST ACRYLIC SHEETS
- IDEALLY, LASER CUT EDGES AND HOLES

TzeNC-PRO	TITLE: DOORS CENTER	
	MATERIAL: CAST ACRYLIC SHEET	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: POLISHED EDGES	WEIGHT: 885.21 g
	THIRD ANGLE PROJECTION	SCALE: 1: 5
		QUANTITY: 1

POM

Tray Support Front

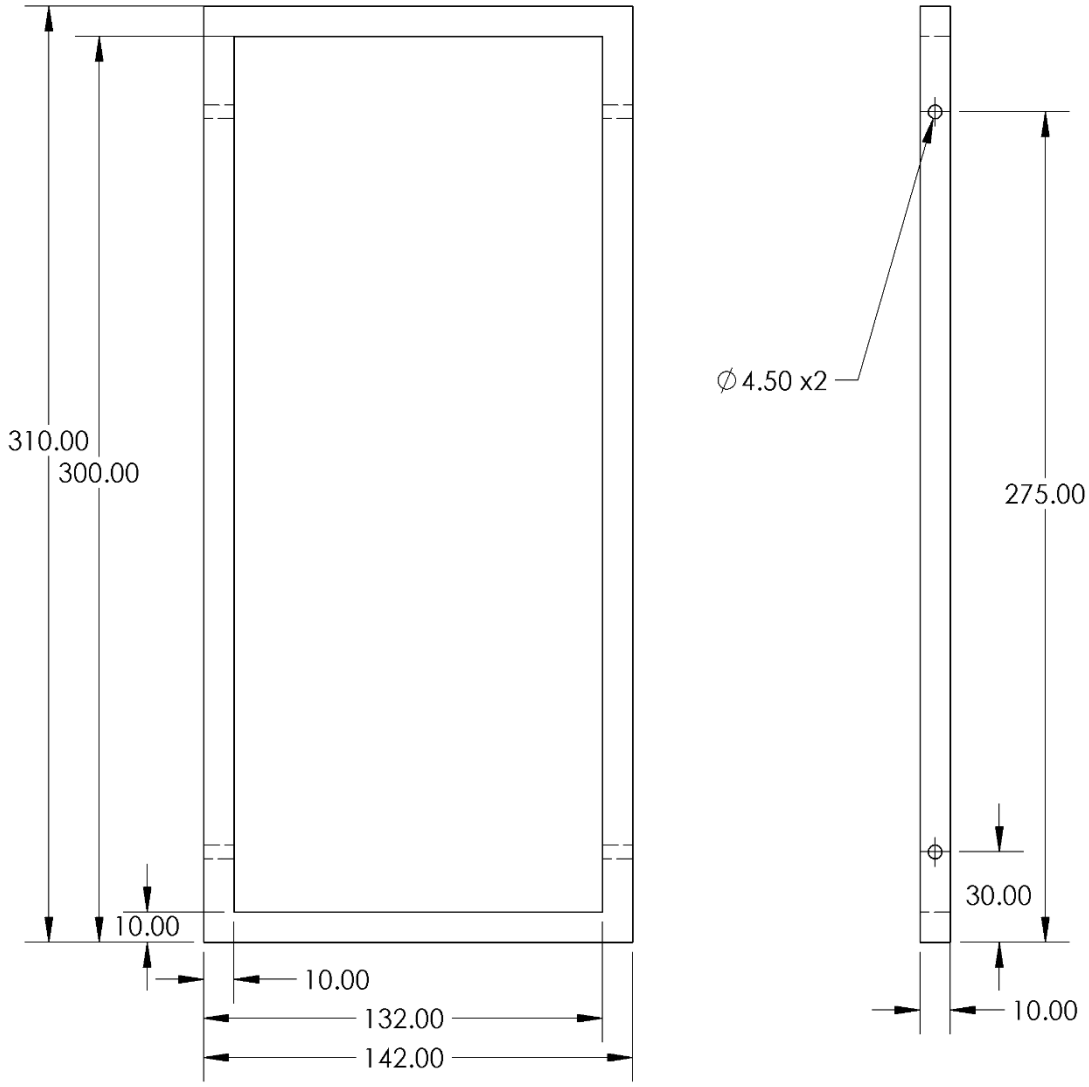


NOTES:

· MAKE THIS ON THE MILL FROM POM

TzeNC-PRO	TITLE: TRAY SUPPORT FRONT	
	MATERIAL: POM ACETAL	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: AS MACHINED	WEIGHT: 80.29 g
	THIRD ANGLE PROJECTION	SCALE: 1: 2
		QUANTITY: 1

Tray Support Back

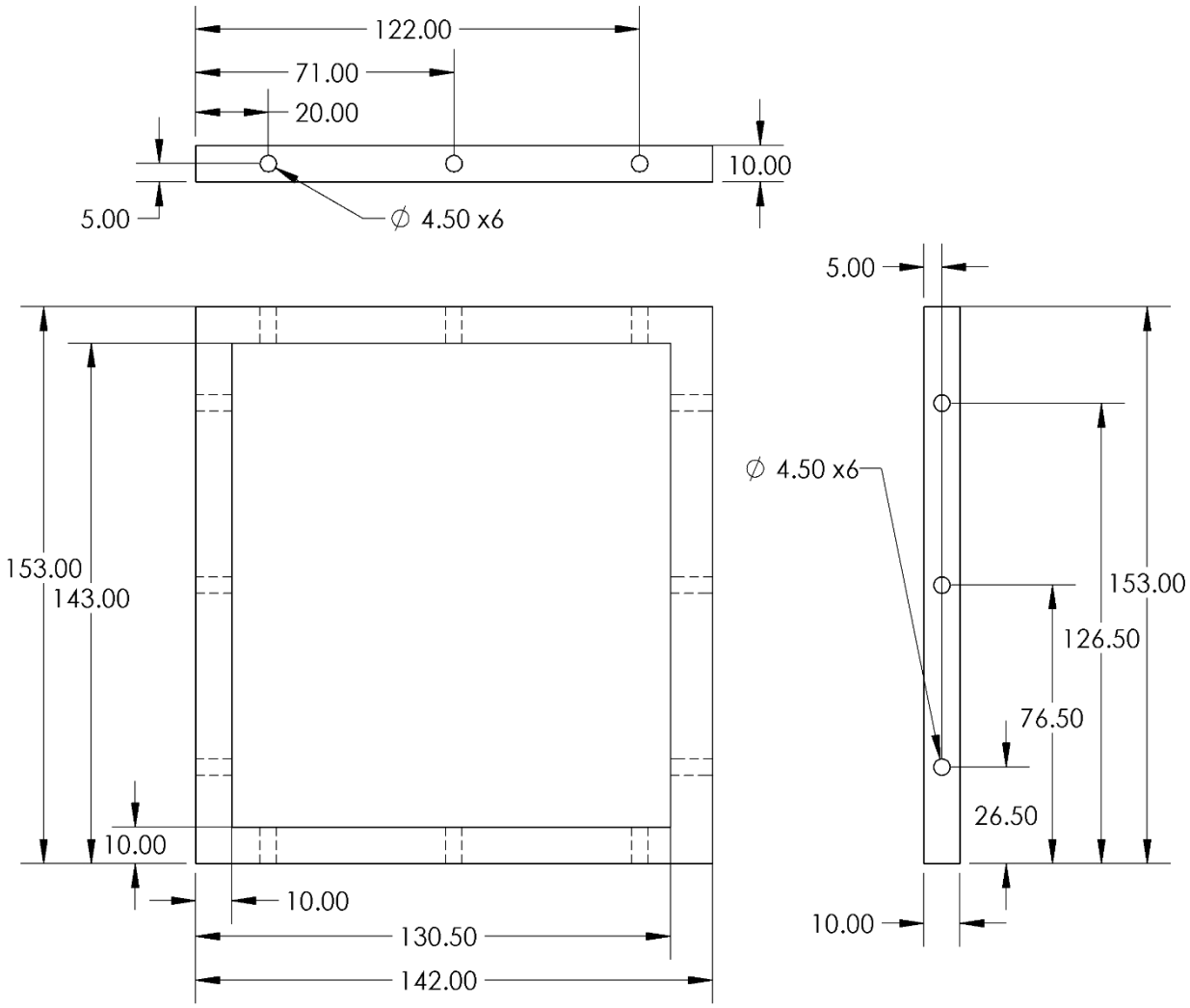


NOTES:

· MAKE THIS ON THE MILL FROM POM

TzeNC-PRO	TITLE: TRAY SUPPORT BACK	
	MATERIAL: POM ACETAL	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: AS MACHINED	WEIGHT: 119.21 g
	THIRD ANGLE PROJECTION	SCALE: 1: 2.5
		QUANTITY: 1

Reinforcement for Small Drain



NOTES:

· THIS ONE WILL TAKE MORE WEAR AND TEAR THAN THE OTHER TWO SO IT MAY NEED TO BE REPLACED AT SOME POINT WITH ONE MADE FROM ALUMINUM. FOR NOW, I WILL TRY IT IN POM SINCE I HAVE A LOT OF SCRAP

TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE: REINFORCEMENT FOR SMALL DRAIN

MATERIAL: POM ACETAL

FINISH: AS MACHINED

WEIGHT: 76.47 g

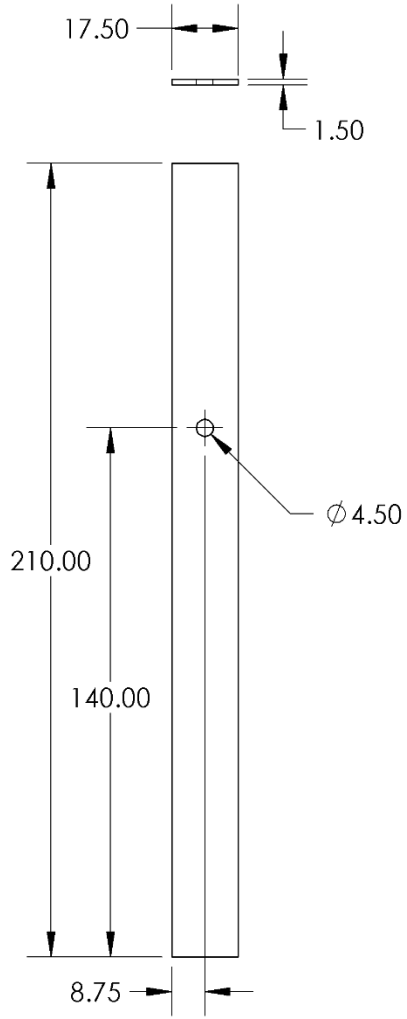
THIRD ANGLE PROJECTION

SCALE: 1: 2

QUANTITY: 1

ABS Sheet

Back Left Corner Inserts 1.5mm

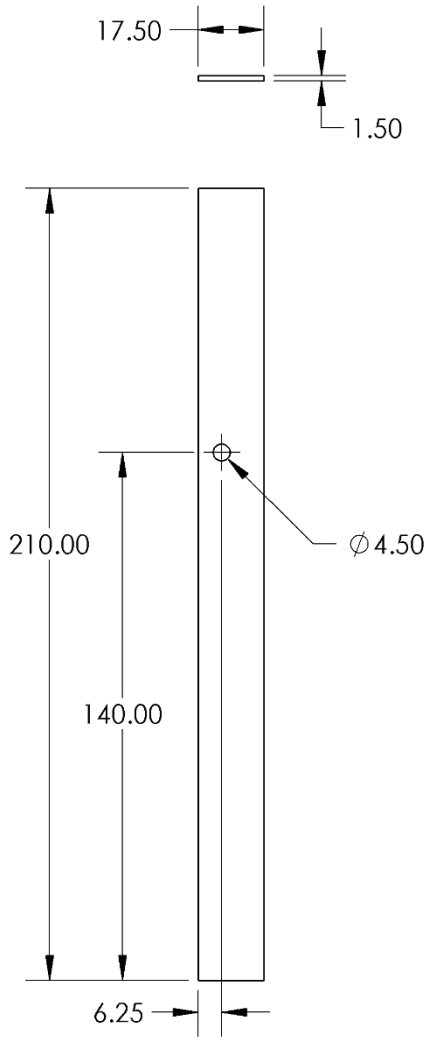


NOTES:

- MAKE ALL OF THE INSERTS FROM 1.5 X 200 X 300 mm ABS SHEETS
- OVERLAPPING WHERE NECESSARY TO MAINTAIN STRUCTURE, SUPERGLUE STRIPS TOGETHER TO MAKE THE OUTER DIMENSIONS
- USE A HOLE PUNCH TO MAKE THE M4 CLEARANCE HOLES

TzeNC-PRO	TITLE: BACK LEFT CORNER INSERTS 1.5 mm		
	MATERIAL: ABS SHEET		
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: NA	WEIGHT: 5.60 g	
	THIRD ANGLE PROJECTION	SCALE: 1: 2	
		QUANTITY: 1	

Back Right Corner Inserts 1.5mm

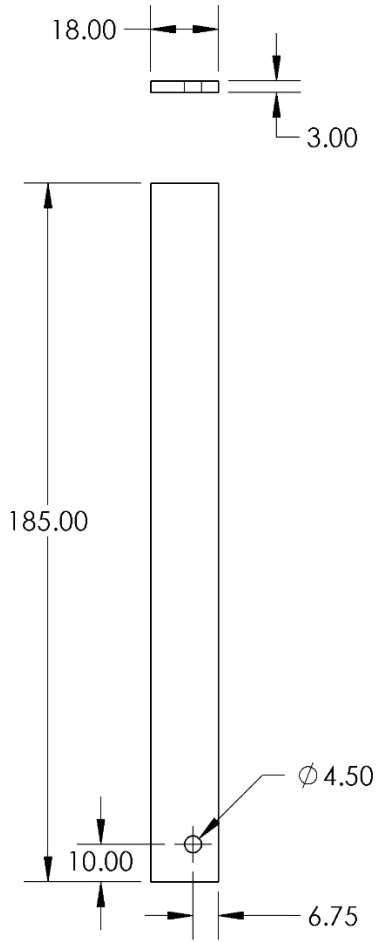


NOTES:

- MAKE ALL OF THE INSERTS FROM 1.5 X 200 X 300 mm ABS SHEETS
- OVERLAPPING WHERE NECESSARY TO MAINTAIN STRUCTURE, SUPERGLUE STRIPS TOGETHER TO MAKE THE OUTER DIMENSIONS
- USE A HOLE PUNCH TO MAKE THE M4 CLEARANCE HOLES

TzeNC-PRO	TITLE: BACK RIGHT CORNER INSERTS 1.5 mm	
	MATERIAL: ABS SHEET	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: NA	WEIGHT: 5.60 g
	THIRD ANGLE PROJECTION	SCALE: 1: 2
		QUANTITY: 1

Back Right Inside Corner Inserts 3mm

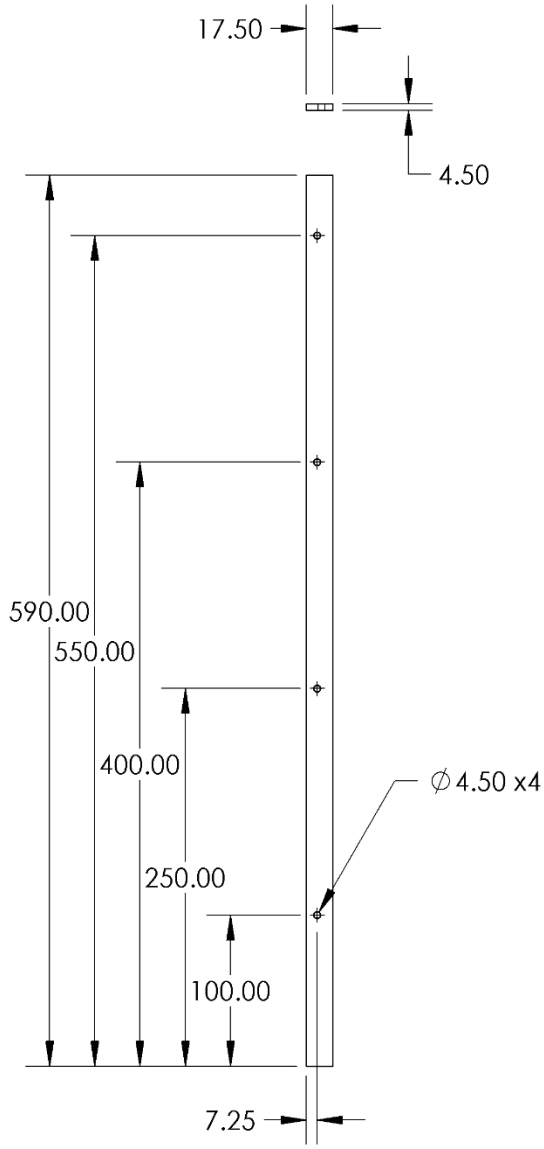


NOTES:

- MAKE ALL OF THE INSERTS FROM 1.5 X 200 X 300 mm ABS SHEETS
- OVERLAPPING WHERE NECESSARY TO MAINTAIN STRUCTURE, SUPERGLUE STRIPS TOGETHER TO MAKE THE OUTER DIMENSIONS
- USE A HOLE PUNCH TO MAKE THE M4 CLEARANCE HOLES

TzeNC-PRO	TITLE: BACK RIGHT INSIDE CORNER INSERTS 3mm	
	MATERIAL: ABS SHEET	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: NA	WEIGHT: 10.14 g
	THIRD ANGLE PROJECTION	SCALE: 1: 2
		QUANTITY: 1

Right Back Corner Insert 4.5mm

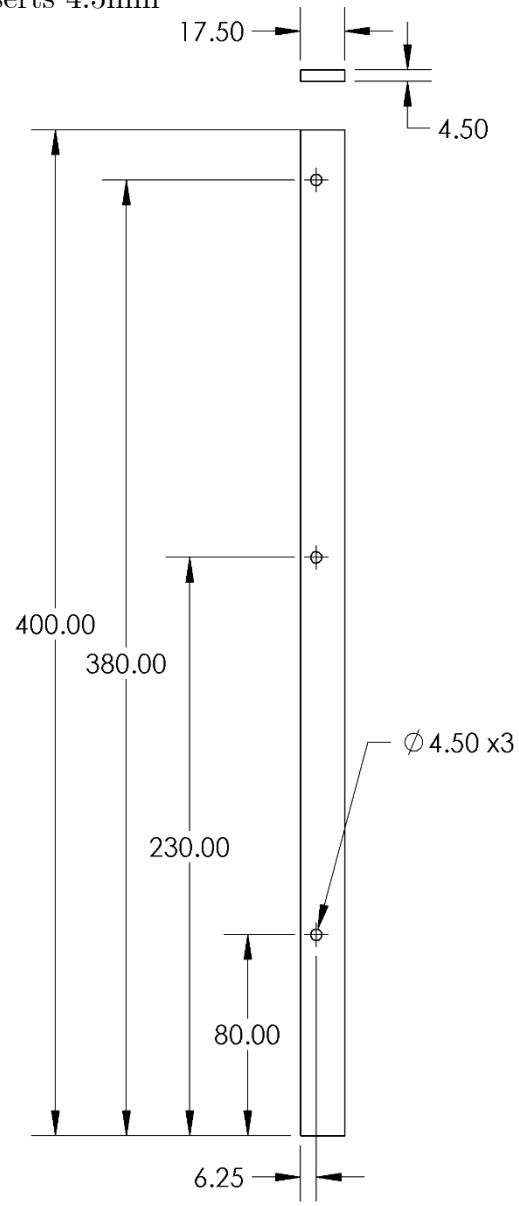


NOTES:

- MAKE ALL OF THE INSERTS FROM 1.5 X 200 X 300 mm ABS SHEETS
- OVERLAPPING WHERE NECESSARY TO MAINTAIN STRUCTURE, SUPERGLUE STRIPS TOGETHER TO MAKE THE OUTER DIMENSIONS
- USE A HOLE PUNCH TO MAKE THE M4 CLEARANCE HOLES

TzeNC-PRO	TITLE: RIGHT BACK CORNER INSERTS 4.5 mm	
	MATERIAL: ABS SHEET	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: NA	WEIGHT: 47.10 g
	THIRD ANGLE PROJECTION	SCALE: 1: 5
		QUANTITY: 1

Back Right Corner Inserts 4.5mm

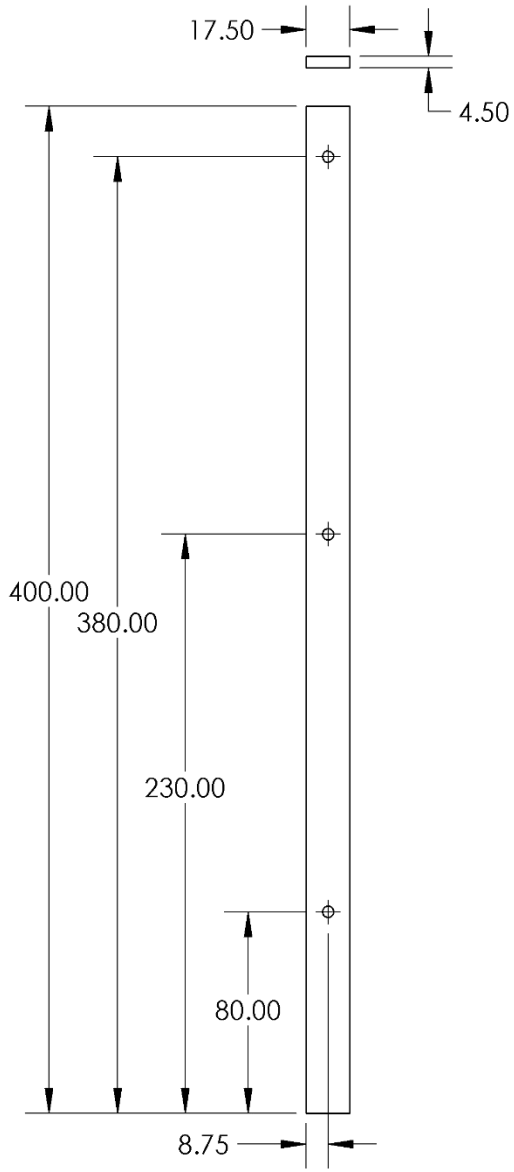


NOTES:

- MAKE ALL OF THE INSERTS FROM 1.5 X 200 X 300 mm ABS SHEETS
- OVERLAPPING WHERE NECESSARY TO MAINTAIN STRUCTURE, SUPERGLUE STRIPS TOGETHER TO MAKE THE OUTER DIMENSIONS
- USE A HOLE PUNCH TO MAKE THE M4 CLEARANCE HOLES

TzeNC-PRO	TITLE: BACK RIGHT CORNER INSERTS 4.5 mm	
	MATERIAL: ABS SHEET	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: NA	WEIGHT: 31.91 g
	THIRD ANGLE PROJECTION	SCALE: 1: 3
		QUANTITY: 1

Back Left Corner Inserts 4.5mm



NOTES:

- MAKE ALL OF THE INSERTS FROM 1.5 X 200 X 300 mm ABS SHEETS
- OVERLAPPING WHERE NECESSARY TO MAINTAIN STRUCTURE, SUPERGLUE STRIPS TOGETHER TO MAKE THE OUTER DIMENSIONS
- USE A HOLE PUNCH TO MAKE THE M4 CLEARANCE HOLES

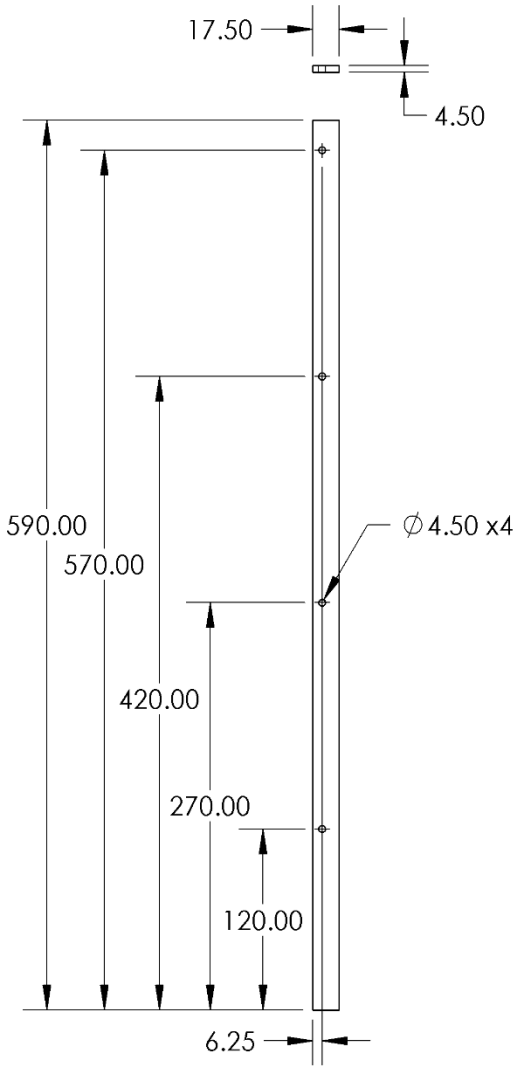
TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE	BACK LEFT CORNER INSERTS 4.5 mm
MATERIAL	ABS SHEET
FINISH	NA
WEIGHT	31.91 g
THIRD ANGLE PROJECTION	
SCALE	1: 3
QUANTITY	1

Front Left Corner Insert 4.5mm

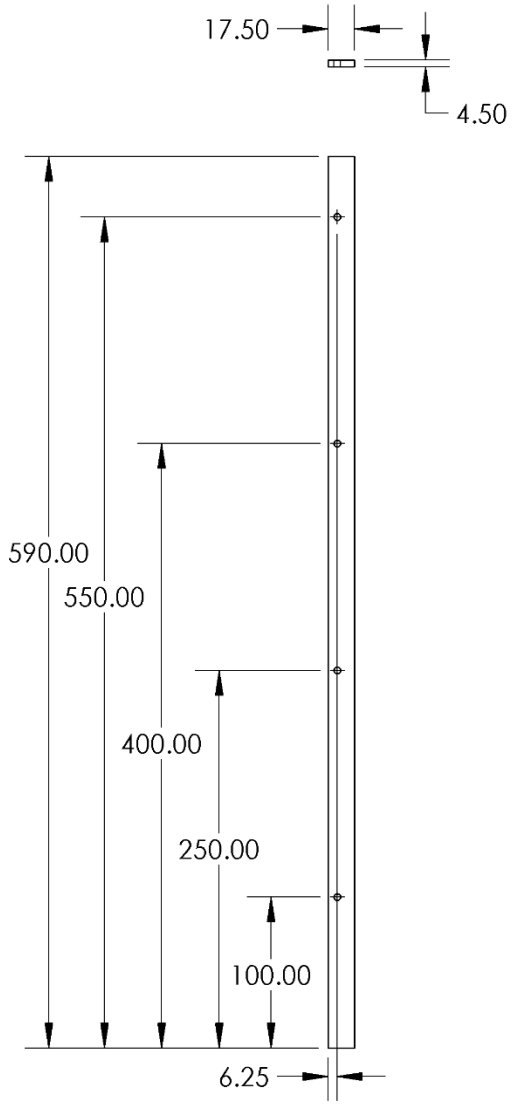


NOTES:

- MAKE ALL OF THE INSERTS FROM 1.5 X 200 X 300 mm ABS SHEETS
- OVERLAPPING WHERE NECESSARY TO MAINTAIN STRUCTURE, SUPERGLUE STRIPS TOGETHER TO MAKE THE OUTER DIMENSIONS
- USE A HOLE PUNCH TO MAKE THE M4 CLEARANCE HOLES

TzeNC-PRO	TITLE: FRONT LEFT CORNER INSERTS 4.5 mm	
	MATERIAL: ABS SHEET	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: NA	WEIGHT: 47.10 g
	THIRD ANGLE PROJECTION	SCALE: 1: 5
		QUANTITY: 1

Right Front Corner Inserts 4.5mm



NOTES:

- MAKE ALL OF THE INSERTS FROM 1.5 X 200 X 300 mm ABS SHEETS
- OVERLAPPING WHERE NECESSARY TO MAINTAIN STRUCTURE, SUPERGLUE STRIPS TOGETHER TO MAKE THE OUTER DIMENSIONS
- USE A HOLE PUNCH TO MAKE THE M4 CLEARANCE HOLES

TzeNC-PRO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

TITLE: RIGHT FRONT CORNER INSERTS 4.5 mm

MATERIAL: ABS SHEET

FINISH: NA

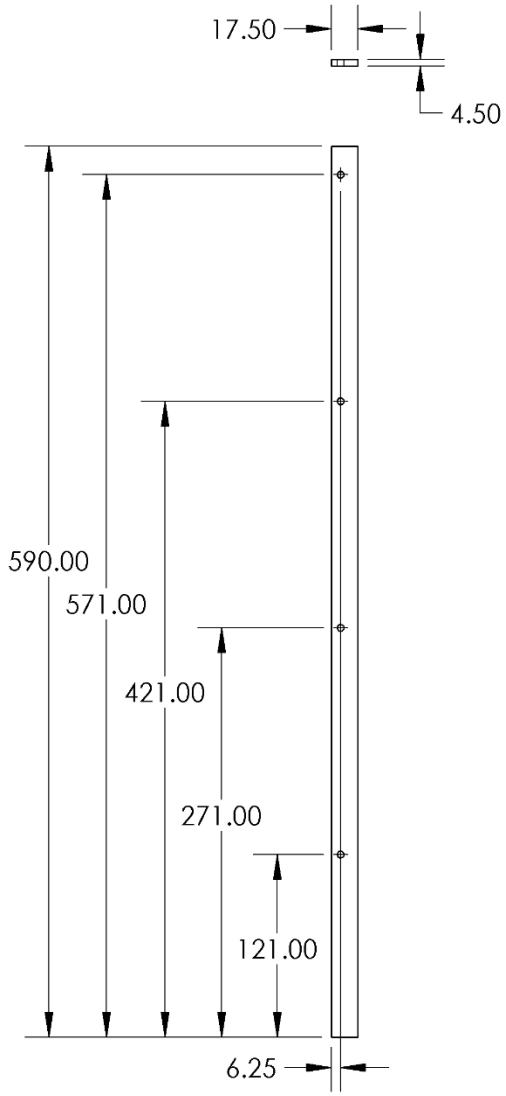
WEIGHT: 47.10 g

THIRD ANGLE PROJECTION

SCALE: 1: 5

QUANTITY: 1

Front Right Corner Insert 4.5mm

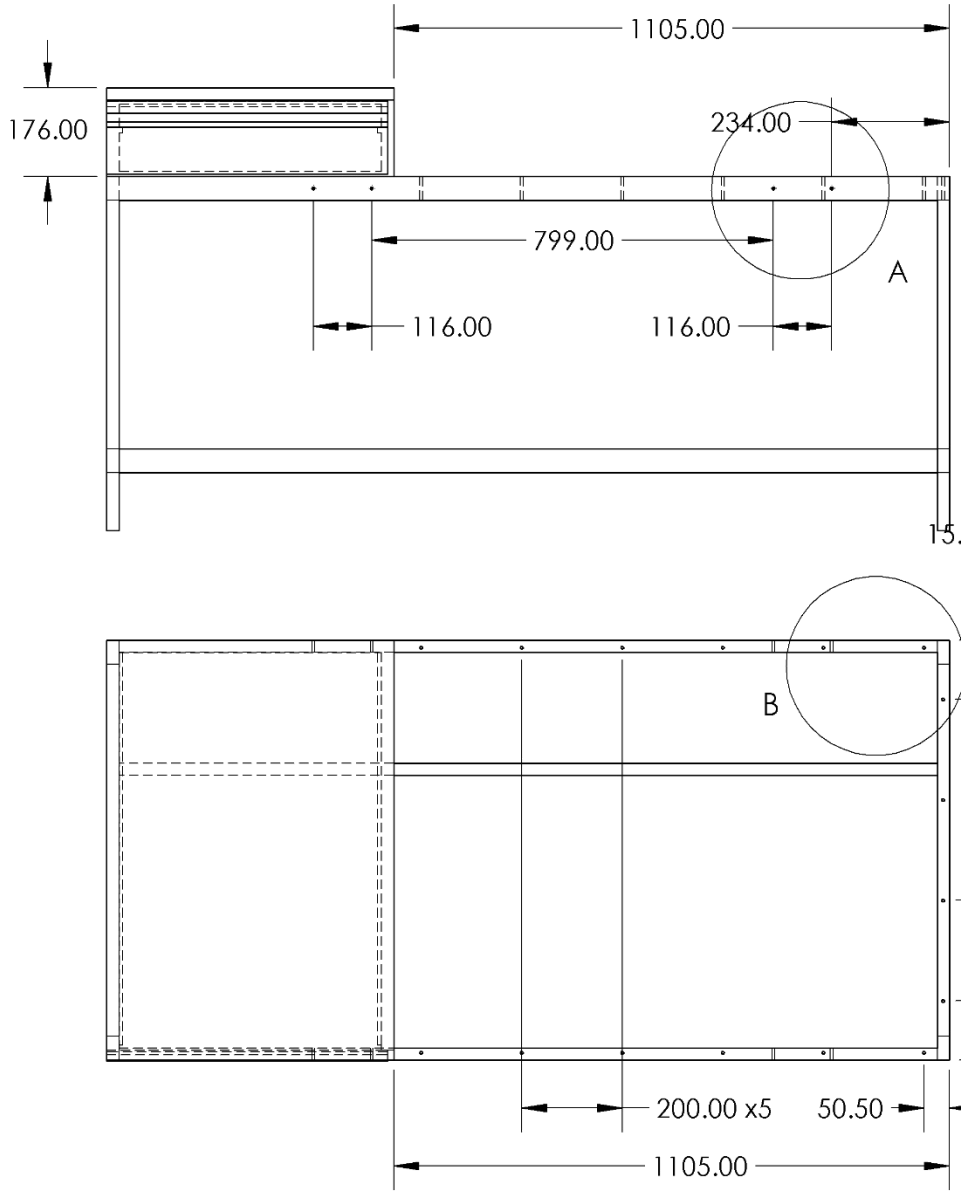


NOTES:

- MAKE ALL OF THE INSERTS FROM 1.5 X 200 X 300 mm ABS SHEETS
- OVERLAPPING WHERE NECESSARY TO MAINTAIN STRUCTURE, SUPERGLUE STRIPS TOGETHER TO MAKE THE OUTER DIMENSIONS
- USE A HOLE PUNCH TO MAKE THE M4 CLEARANCE HOLES

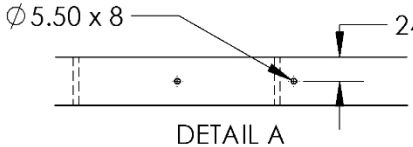
TzeNC-PRO	TITLE: FRONT RIGHT CORNER INSERTS 4.5 mm	
	MATERIAL: ABS SHEET	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: NA	WEIGHT: 47.10 g
	THIRD ANGLE PROJECTION	SCALE: 1: 5
		QUANTITY: 1

Table

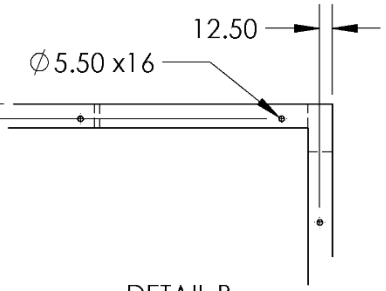


NOTES:

- AFTER REMOVING THE DRAWERS AND ANY STAPLES, NAILS, SCREWS, OR BOLTS, USE A ROUTER TO CUT THE TOP OF THE TABLE TO MAKE ROOM FOR THE CNC MACHINE.
- UNFORTUNATELY, THE M5 THRu HOLES WILL HAVE TO BE DRILLED BY HAND. DO SO CAREFULLY WHILE USING PLENTY OF CUTTING OIL. GET A MAG-DRILL IF POSSIBLE.
- USE THE SIDE AND FRONT SKIRTS AS A TEMPLATE TO KEEP THE HOLES ALIGNED.



DETAIL A
SCALE 2 : 15



DETAIL B
SCALE 2 : 15

TzeNC-PRO

TITLE	TABLE
MATERIAL	N/A
FINISH	N/A
WEIGHT	N/A
SCALE	1:20
QUANTITY	1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM

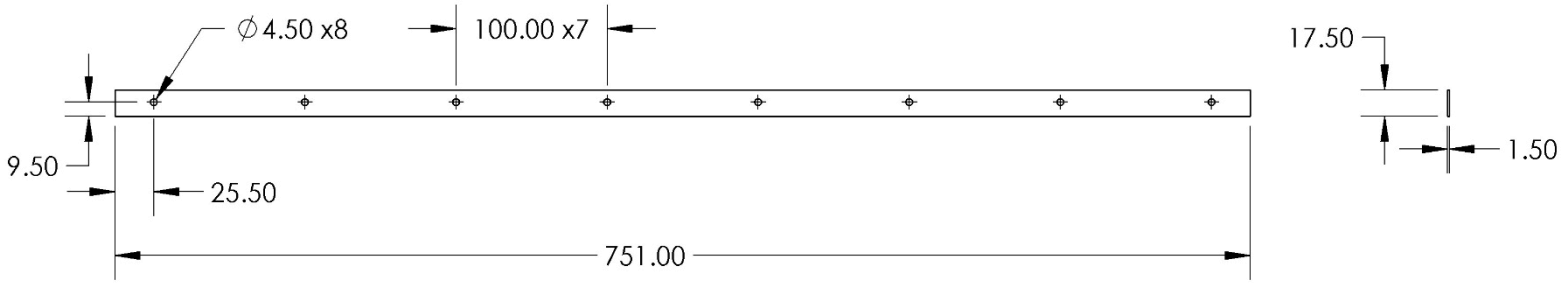
TOLERANCES ARE:
ANGLES: ± 0.5°
2 PLACE DECIMAL: ± 0.1
3 PLACE DECIMAL: ± 0.05

FIRST ANGLE PROJECTION

Rubber gaskets for Base

NOTES:

- CUT THESE WITH A UTILITY KNIFE FROM A 10 m ROLL
- MAKE THE HOLES WITH A LEATHER PUNCH



TzeNC-PRO	TITLE: RUBBER GASKETS FOR BASE	
	MATERIAL: NITRILE BUTADIENE RUBBER (SBR)	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM TOLERANCES ARE: ANGLES: ± 0.5° 2 PLACE DECIMAL: ± 0.1 3 PLACE DECIMAL: ± 0.05	FINISH: NA	WEIGHT: 18.35 g
	THIRD ANGLE PROJECTION	SCALE: 1: 5
		QUANTITY: 2

Assembly Instructions

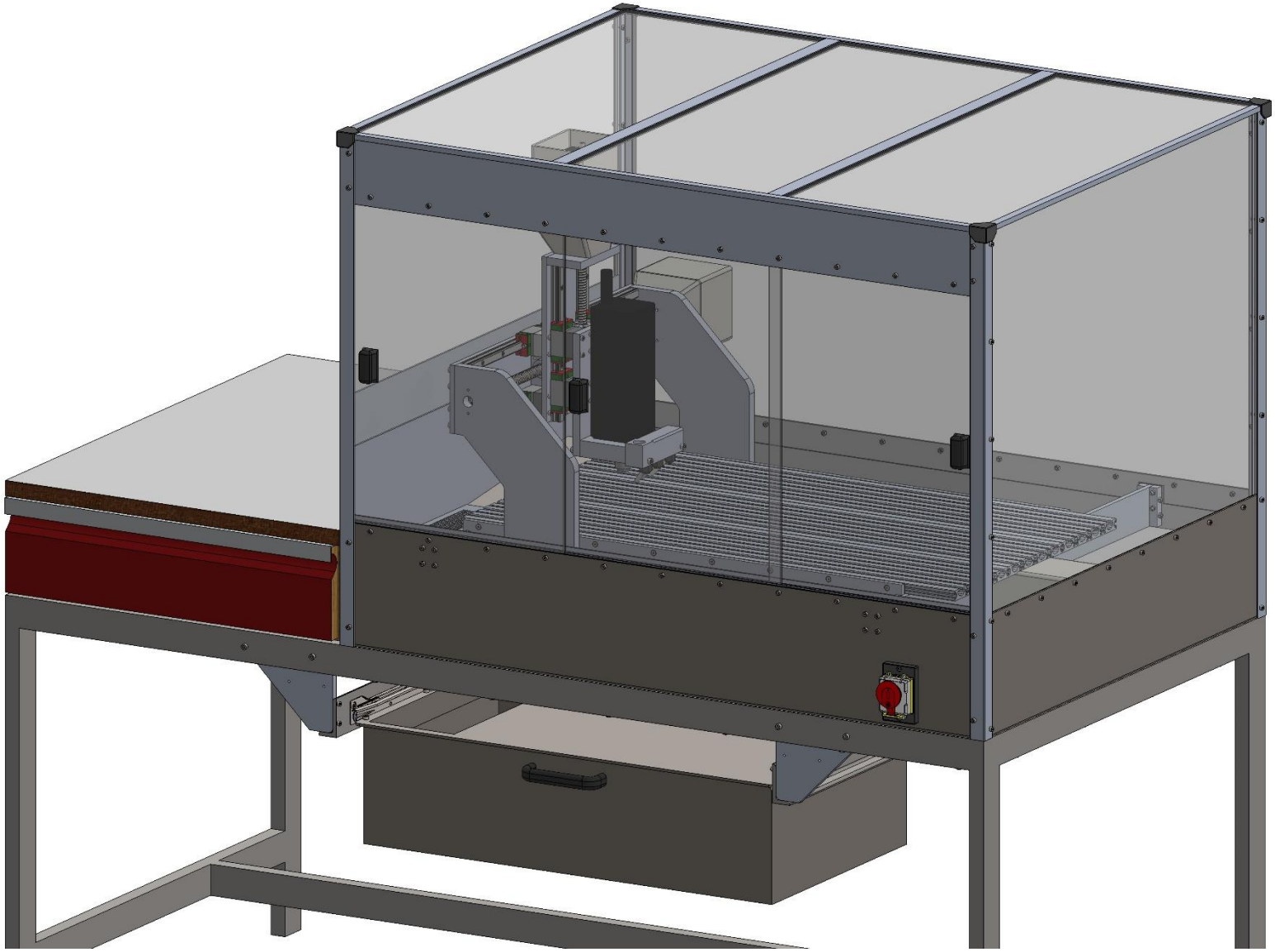


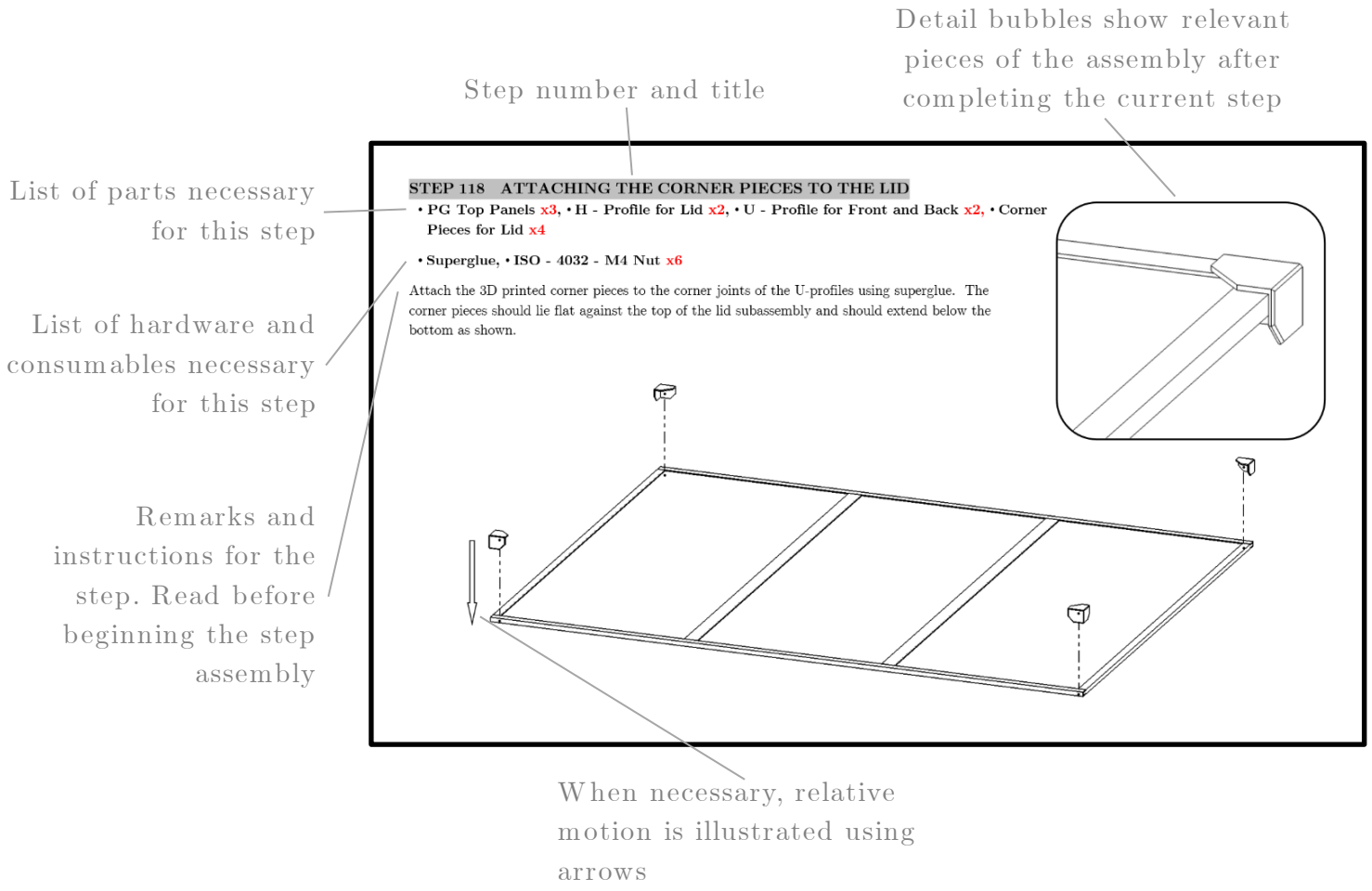
Table of Contents

HOW TO USE THIS MANUAL

This manual provides a step-by-step guide for assembling the TzeNC-Pro CNC machine. It was designed to be visually instructive, with only the necessary text support.

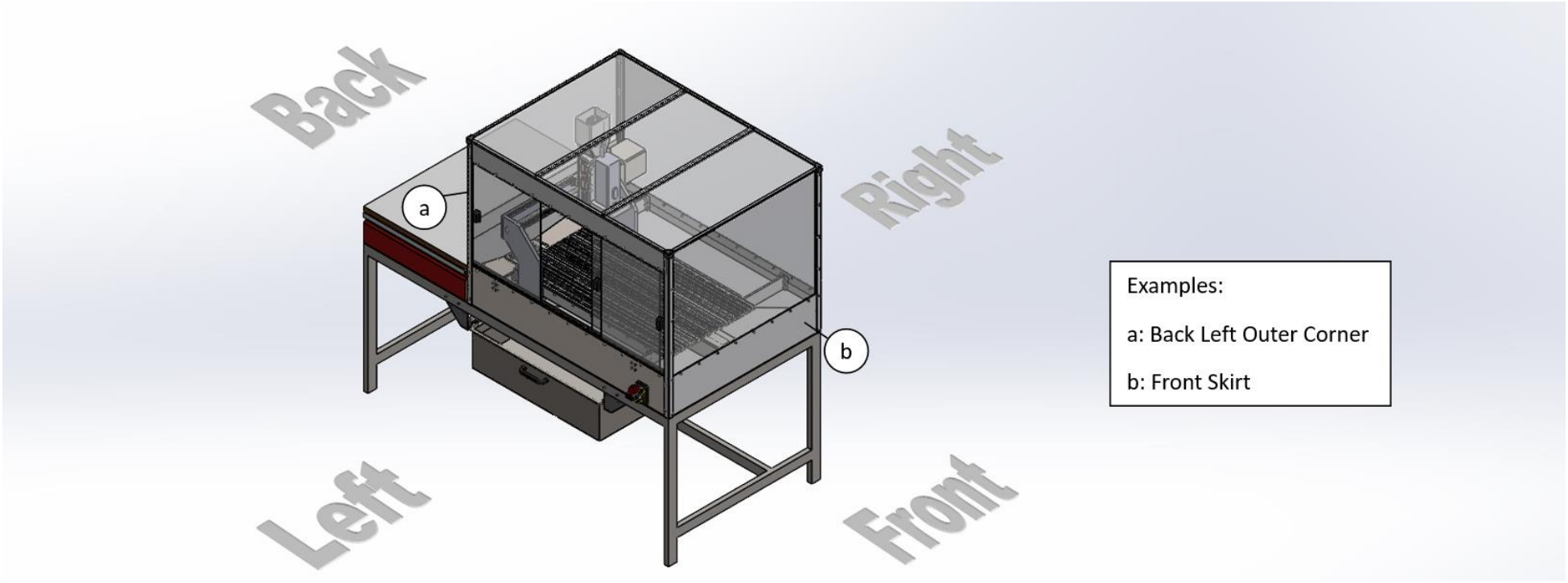
Please read the safety instructions before starting the assembly.

Begin each step by collecting the necessary parts, tools and assistance if necessary. Then, read the remarks and how-to's related to the step.



NAMING CONVENTION

In the interest of simplifying the assembly instructions, a naming convention was chosen. All part names also conform to this naming convention.



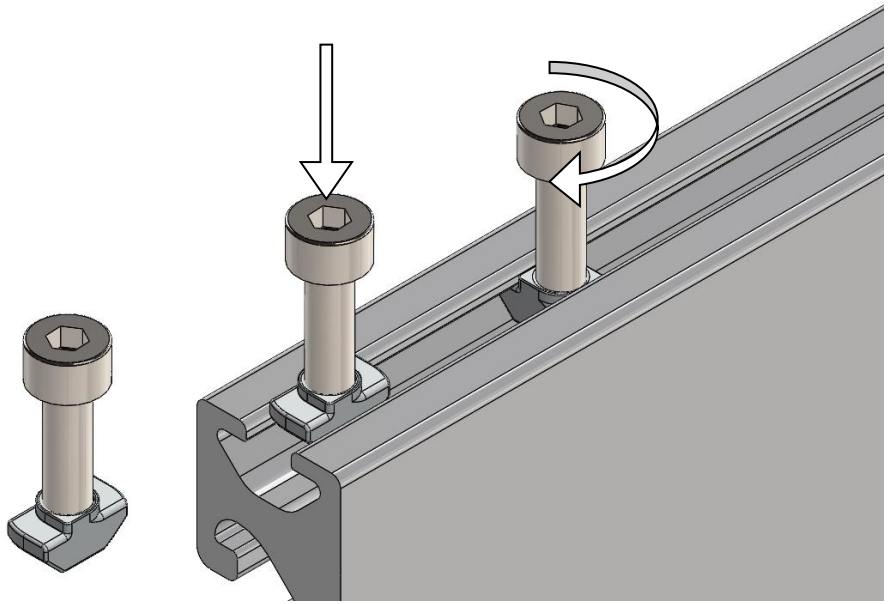
T-NUTS AND T-SLOT SYSTEM FOR EXTRUDED PARTS

T-nuts need to be inserted in the profiles to enable the screws to be fixed. The correct position of the T-nut is with the ball bearing pointing towards the inside of the profile.

There are two different ways of inserting a T-nut into a profile:

Option 1:
If the profile is not yet blocked at the ends, the T-nut can be inserted from the side of the profile by sliding it already in the correct orientation (perpendicular to the slit) into the slit from the end.

Option 2:
Insert the T-nut sideways in the profile slit. Using a small screwdriver or an allen key, turn the T-nut to the correct orientation.



SAFETY INSTRUCTIONS

Read these safety instructions carefully
before beginning assembly of the machine.

The majority of the assembly for the TzeNC-Pro is interfacing small mechanical parts. However, some steps require potentially dangerous situations when positioning heavy or awkward subassemblies, or due to the involvement of electricity. Thus, it is imperative to follow the safety rules and to have assistance for some steps.

Mechanical Safety

- Get assistance when needed. Most steps only require lifting low weight components, but some of the components are large and unwieldy. Some steps require connecting heavy subassemblies to the main assembly. These can be potentially dangerous or impossible for a single person.
- Make sure that all mechanical parts have been correctly installed and that the moving parts can move freely.

Fluids Safety

- Be sure the coolant connections have been firmly tightened, but do NOT overtighten any aluminum threads. This is especially important when connecting the Coolant Distributor.
- Make sure the coolant tank has at least 20 liters of coolant at all times during operation
- Verify that no water is leaking from any point, junction, or connection.
- Make sure the coolant pipes are not kinked or blocked anywhere and that the coolant is flowing in the proper direction.
- Running the pump when dry can damage it. Make sure that the bottom of the pump is submerged in the coolant before operation.

Electrical Safety

For steps involving wiring and electricity, it is highly recommended to read the following instructions carefully before connecting the machine to an electrical power socket (220V):

- Verify if the cables are not damaged from the packaging, shipping or being damaged during/after the assembly.
- Make sure the cables are firmly connected after soldering or tightening (check by pulling it lightly).
- Make sure cables are correctly connected by double checking the connections with the wiring diagrams and instructions.
- Make sure there are no short-circuits in the wiring. It is recommended to use a multimeter with the “beep” diode

function. Be sure to check that there is not a short-circuit between: Line and Neutral; 24V+ and 24V-.

- Verify if the axis limit switches, door limit switches and the emergency button are functional; it is possible to check them with a multimeter with the “beep” diode function.
- Make sure that all the wiring has been correctly connected and that it has been tested beforehand.

Operating Safety

- The SOP should be read and followed at all times during operation.
- Make sure your computer is running only the UGS software and nothing else; if the UGS is running too slow, try it with another computer.
- When starting a new operation, be ready to push the emergency button in case any part of the machine does not behave as expected.
- Only operate the machine with the doors closed. Do not disable the limit switches.

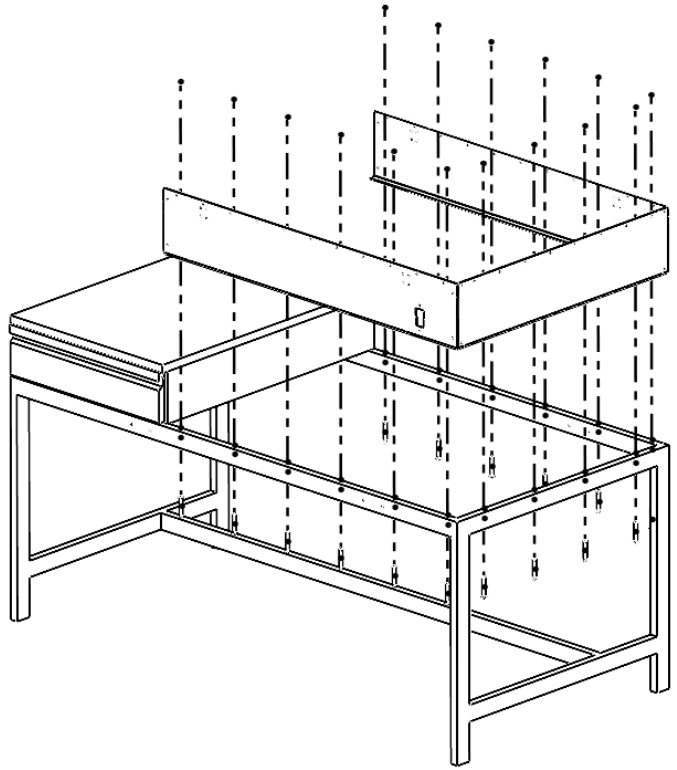
ASSEMBLY INSTRUCTIONS

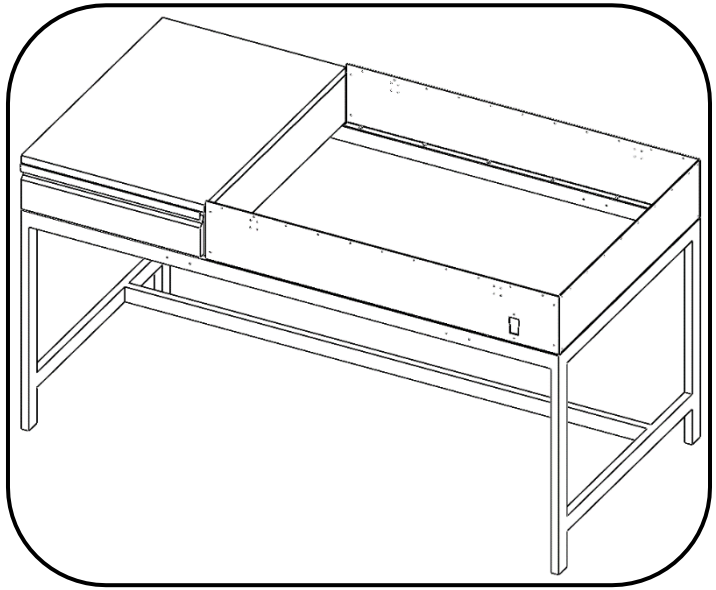
SECTION 1: BASE AND TABLE

STEP 1 ATTACH THE SIDE SKIRTS TO THE TABLE

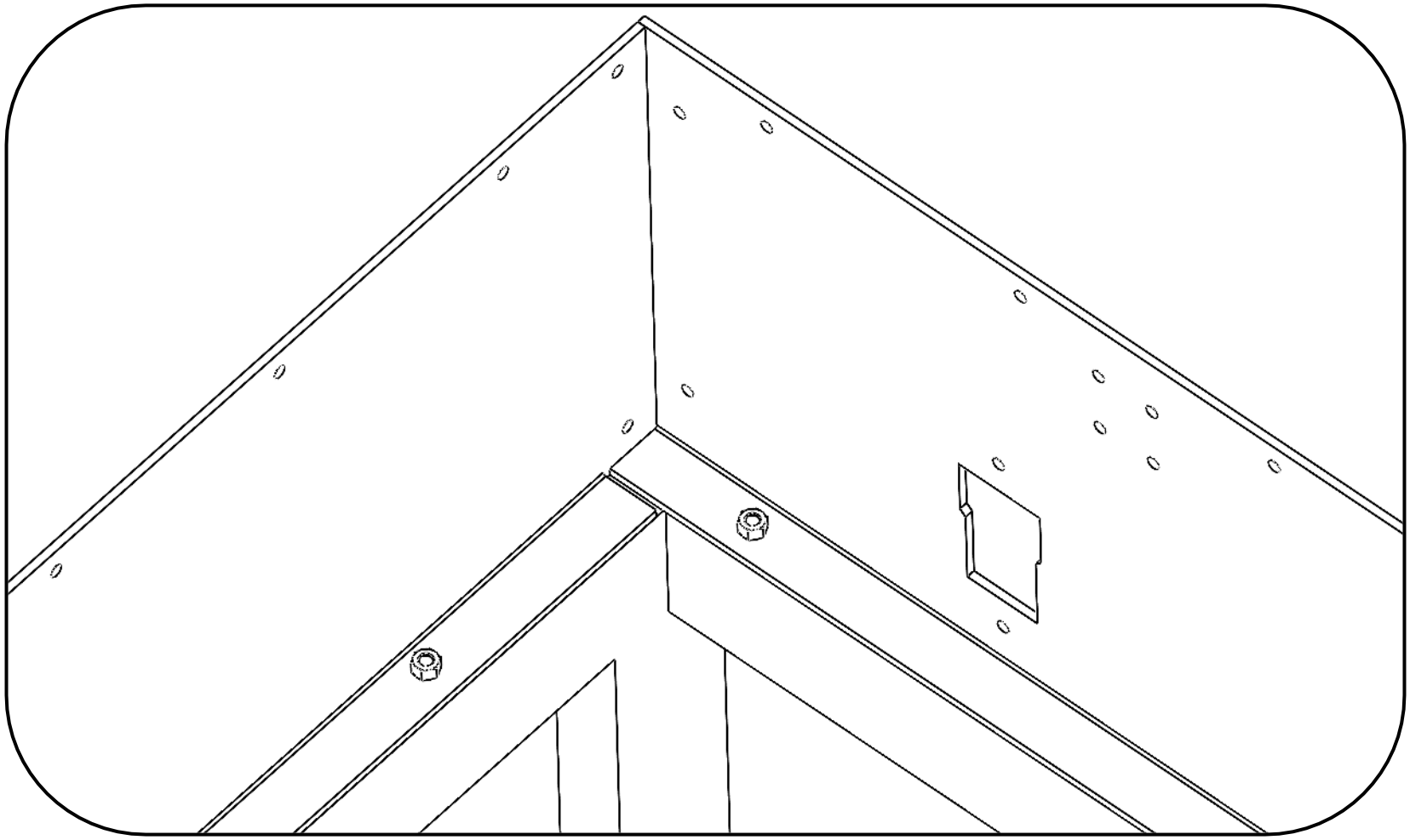
- Table, Left Side Skirt, • Right Side Skirt, Front Skirt
- ISO 4762 M5 x 55 - 22N x16, • ISO - 4032 - M5 Nut x16

Begin the assembly by attaching the side skirts to the table using 16 M5 bolts and locking nuts





Note: Orient bolts and nuts as shown in figures 1 and 2, so in the case of excessively long bolts, the excess will be hidden inside the casing of the machine instead of sticking out the bottom where they could cause injury or damage. If the skirts are installed correctly, the side skirts should overlap the front skirts on the corners as seen in figure 2.

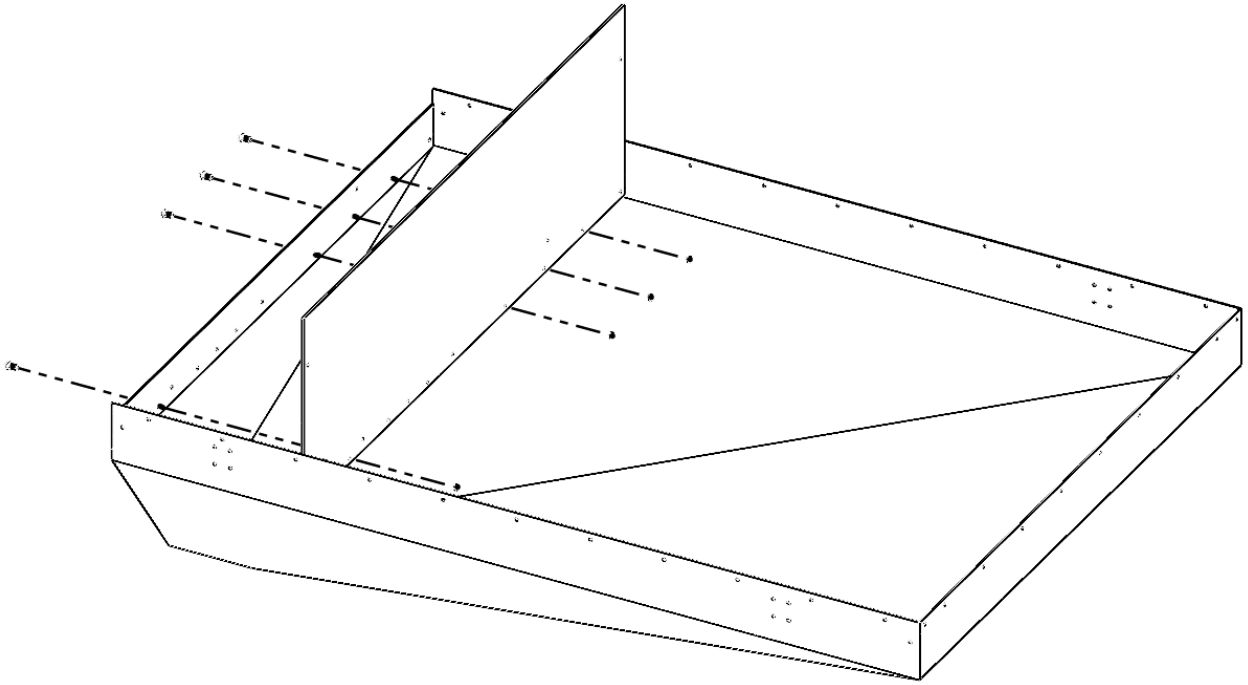


A few things have to be attached to the Bottom Tray next, since the bolts will be inaccessible once the tray is installed into the Table.

STEP 2 CONNECT THE AL BACK PANEL TO THE BOTTOM TRAY

- Bottom Tray, • Al Back Panel
- ISO 4762 M4 x 10 - 10N x4, • ISO - 4032 - M4 Nut x4

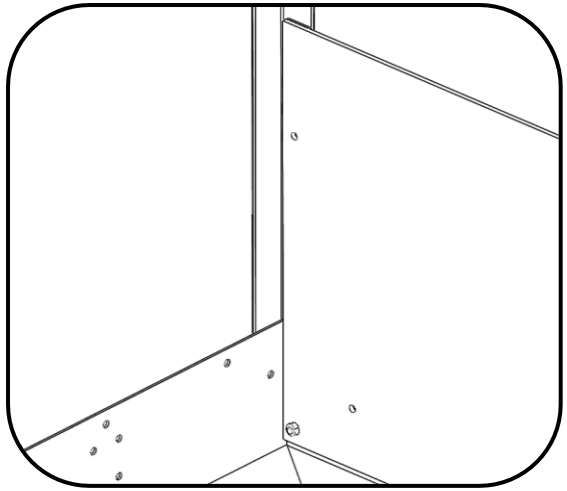
Connect the Al Back Panel to the Bottom Tray using four M4 x 10 bolts and locking nuts

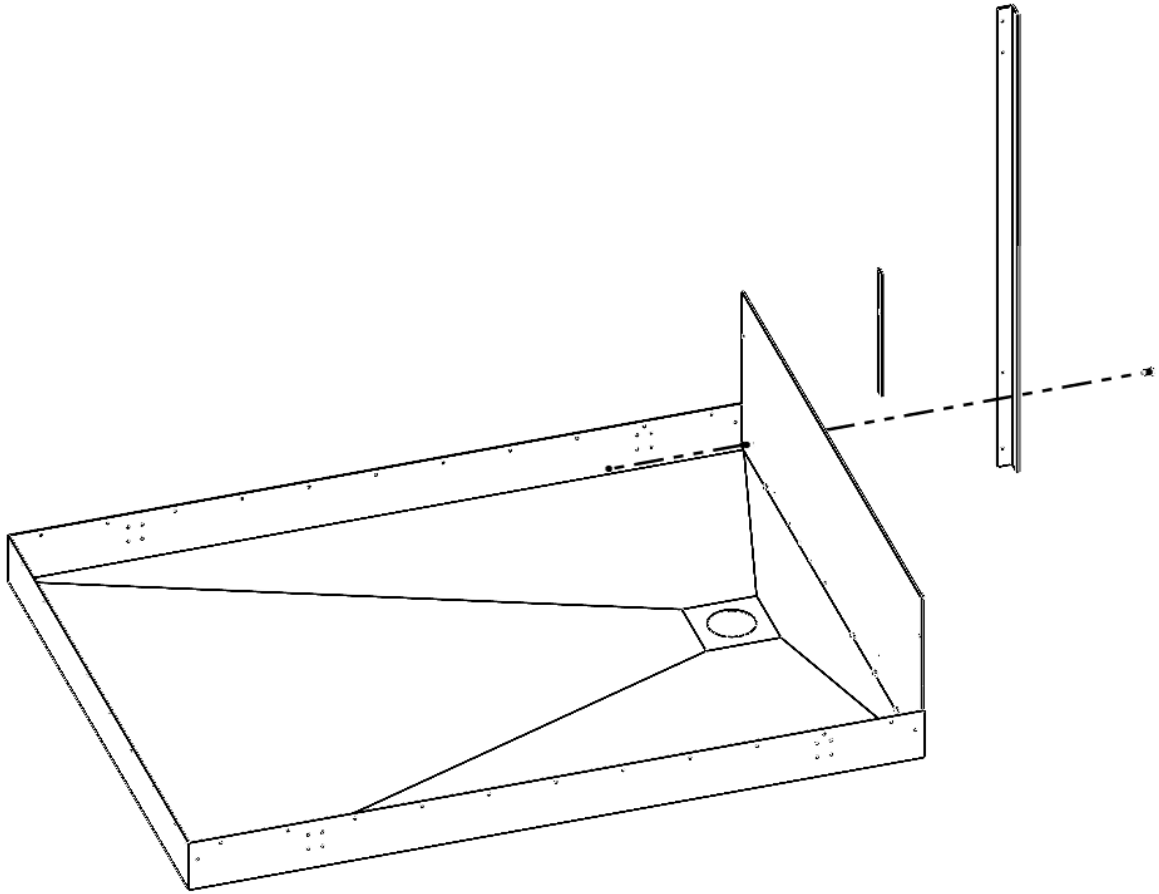


STEP 3 CONNECT THE LEFT CORNER TO THE BOTTOM TRAY SUBASSEMBLY

- Back Left Outer Corner, • Back Left Corner Insert 1.5mm
- ISO 4762 M4 x 12 - 12N, • ISO - 4032 - M4 Nut

Use a single M4 x 12 bolt to attach the Back Left Outer Corner and the Back Left Corner Insert to the Bottom Tray



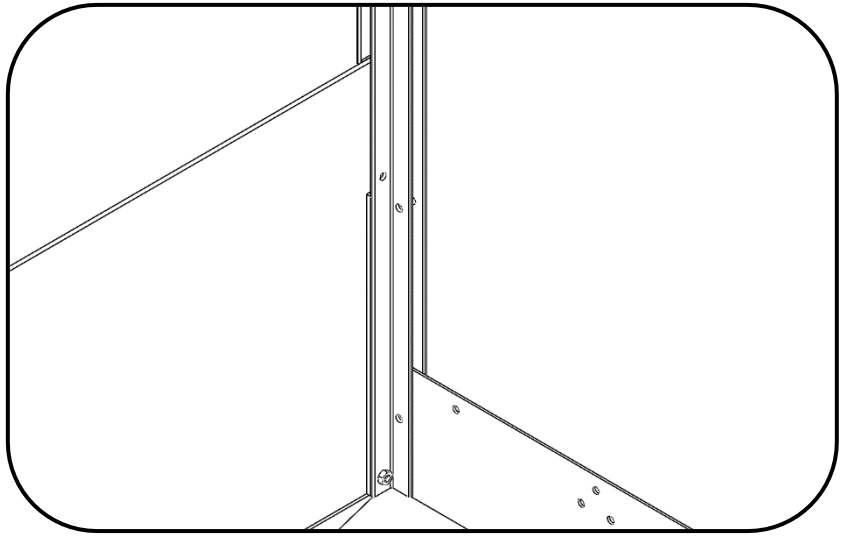


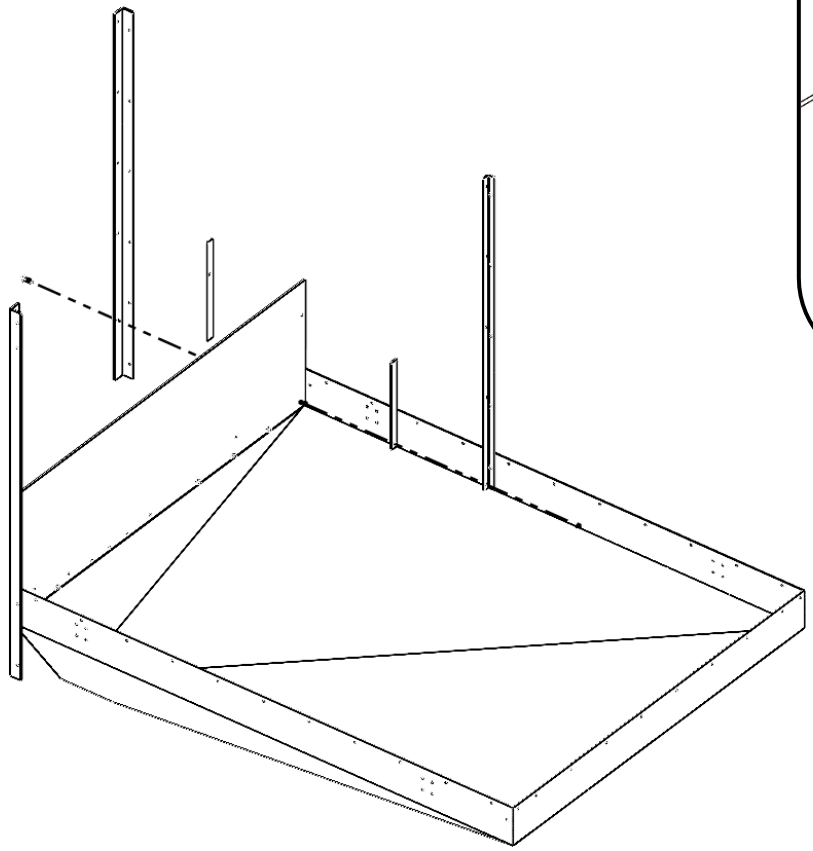
STEP 4 CONNECT THE RIGHT CORNER TO THE BOTTOM TRAY SUBASSEMBLY

• Back Right Outer Corner, • Back Right Corner Inserts 1.5mm, • Back Right Inside Corner Inserts 3mm, • Back Inner Corner

• ISO 4762 M4 x 16 - 16N, • ISO - 4032 - M4 Nut

Now assemble the back right corner using another single M4 x 16 bolt and a locking nut.



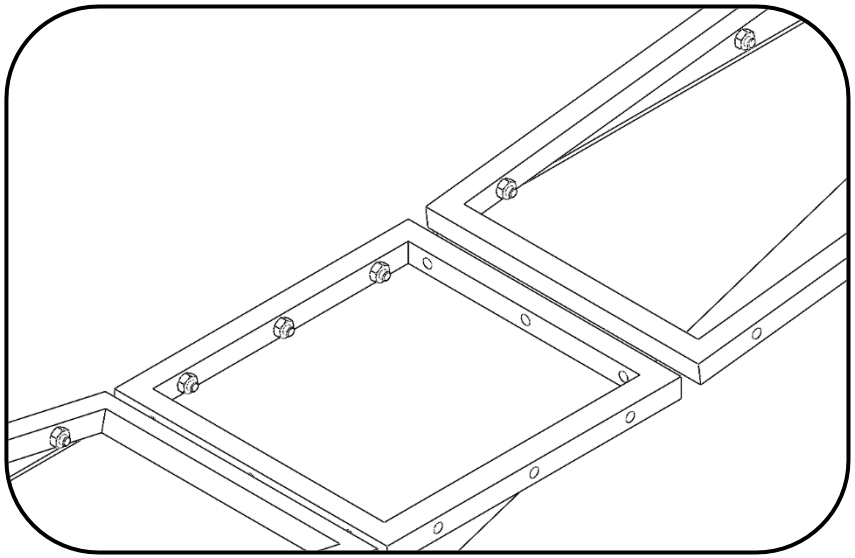


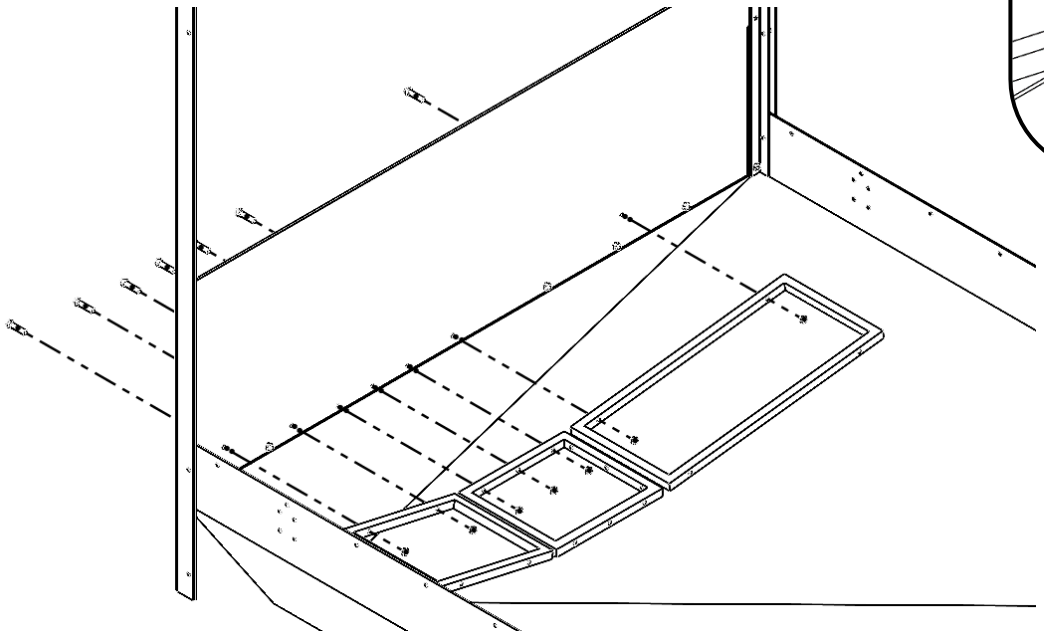
STEP 5 ATTACH TRAY REINFORCEMENTS TO BOTTOM TRAY SUBASSEMBLY

• Tray Support Front, • Reinforcement for Small Drain, • Tray Support Back

• ISO 4762 M4 x 20 - 20N x7, • ISO - 4032 - M4 Nut x7

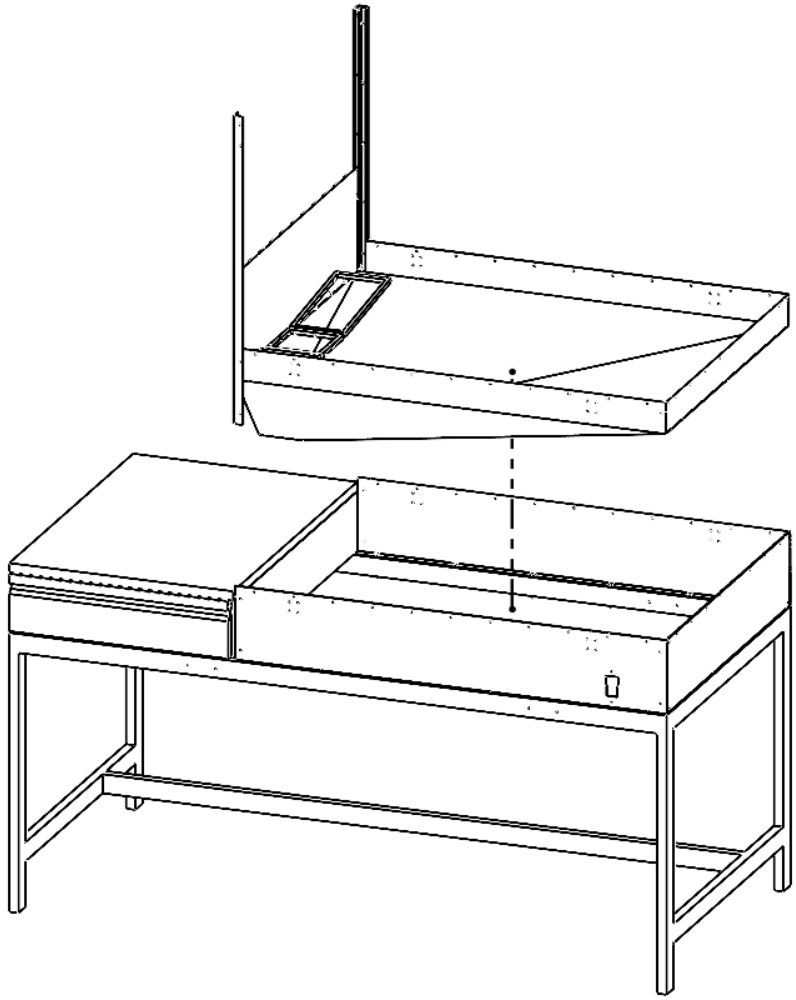
Attach the reinforcements for the chip tray to the bottom tray using seven M4 x 20 mm bolts and locking nuts.

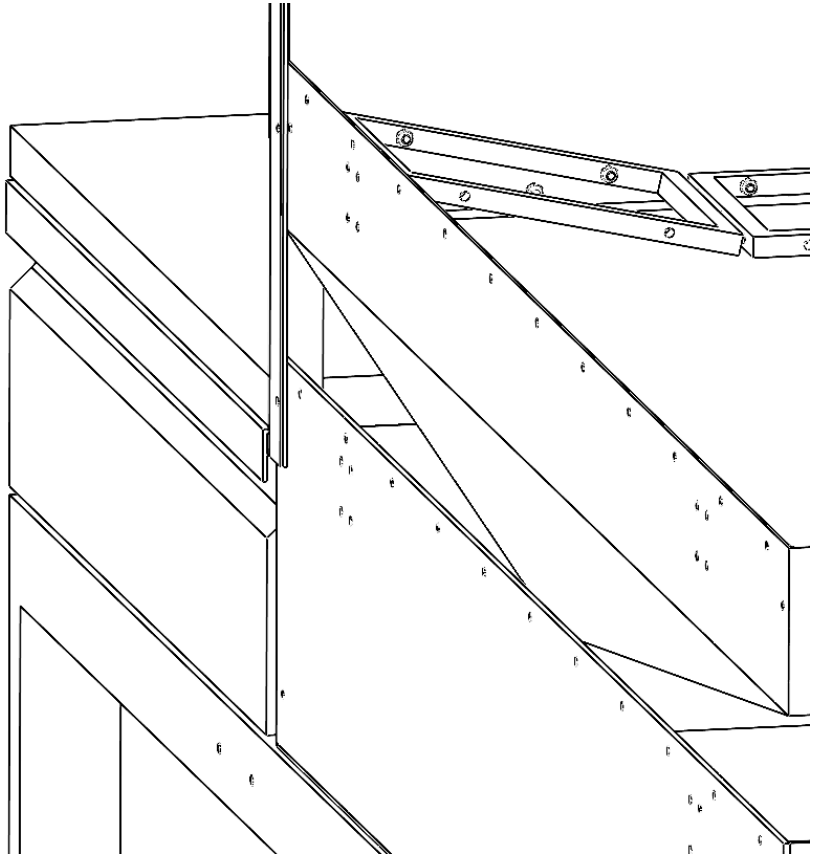




STEP 6 ATTACH THE BOTTOM TRAY SUBASSEMBLY TO THE MAIN ASSEMBLY

The subassembly from Steps 2 – 5 can now be added to the main assembly. Lower the Bottom Tray carefully so the side skirts slide between the outer corners as shown.

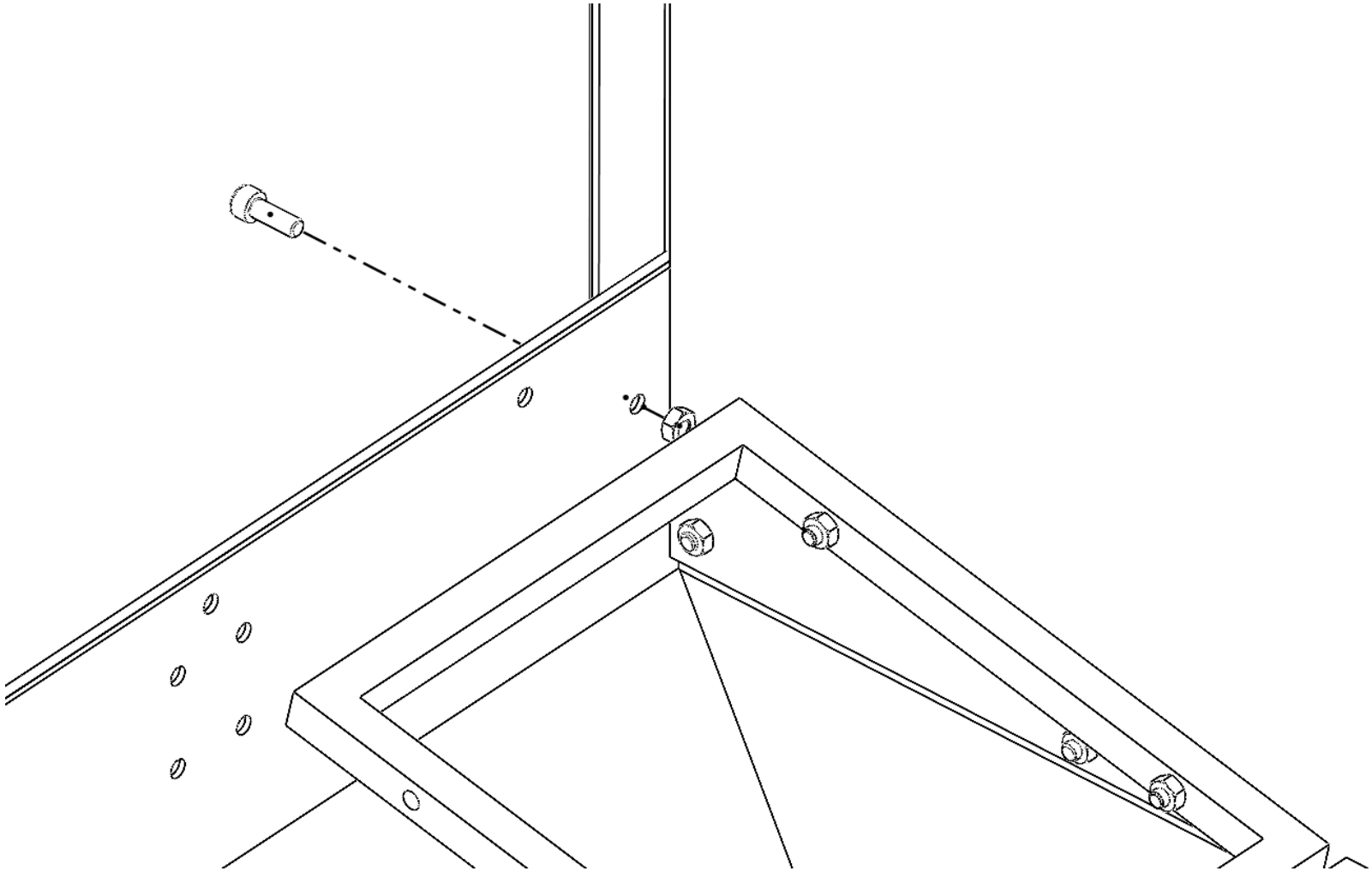




STEP 7 CONNECT THE SUBASSEMBLIES

• ISO 4762 M4 x 12 - 12N, • ISO - 4032 - M4 Nut

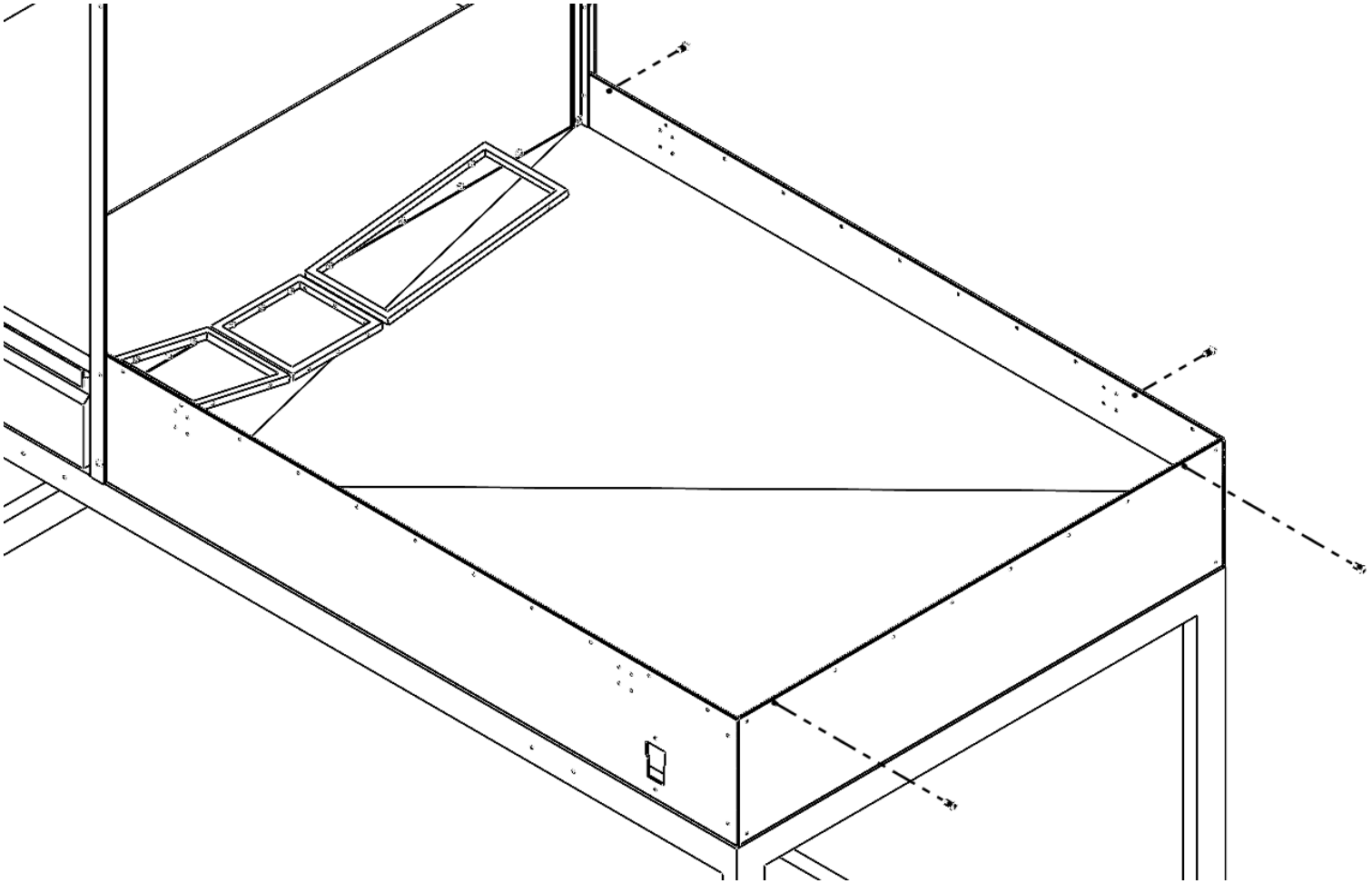
Attach the two assemblies using a M4 x 12 mm bolt and a locking nut in the back left corner.



STEP 8 TEMPORARY SUPPORT FOR THE BOTTOM TRAY

- ISO 4762 M4 x 12 - 12N x4

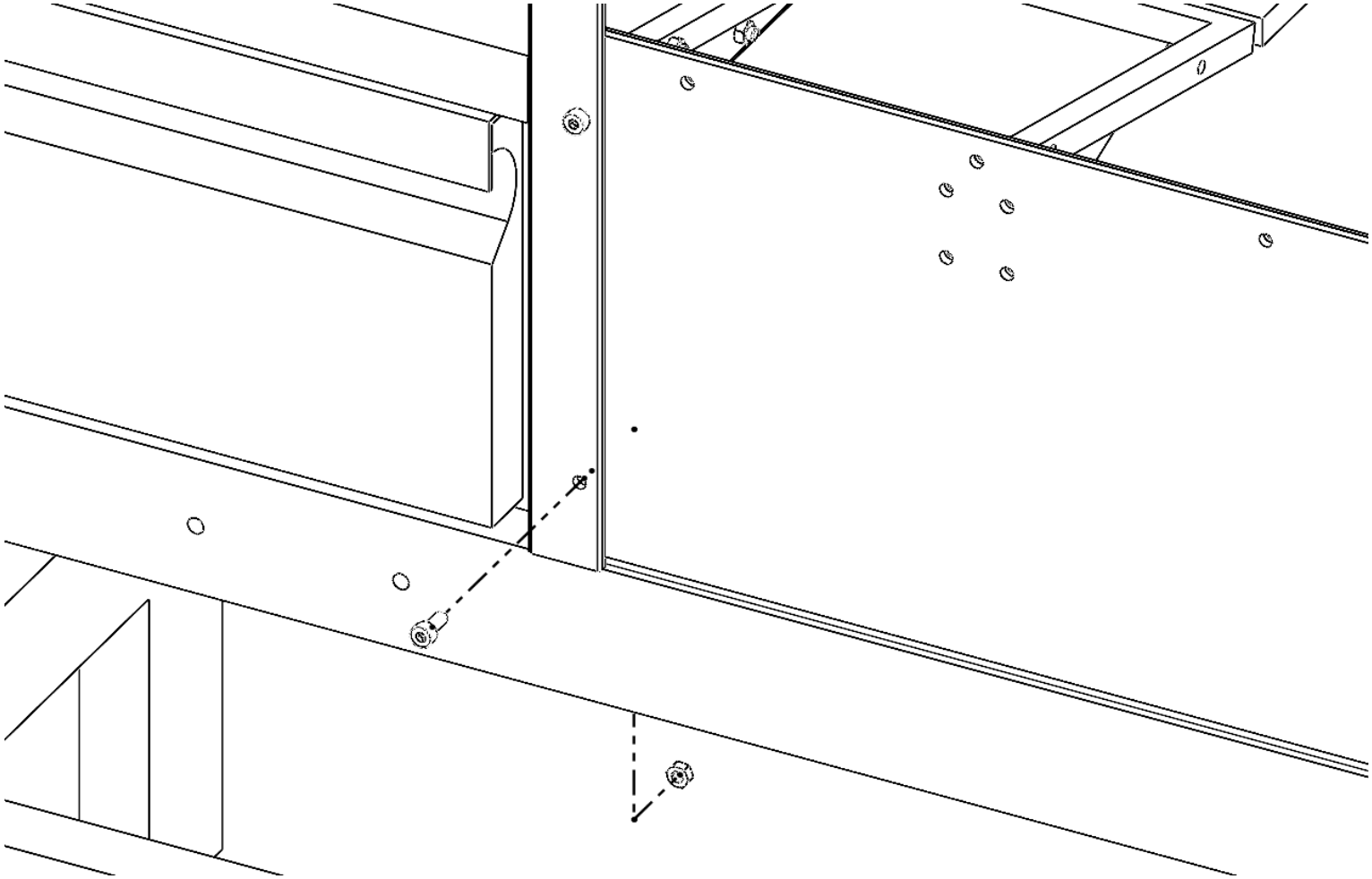
Insert four more M4 x 12 bolts into the aligned holes in the Bottom Tray and the Front Skirts and Right Side Skirt. These will only be for support at the moment so they will not yet be secured with nuts. Note: these can go anywhere, but it is recommended to avoid the corner holes for now.



STEP 9 ATTACH THE BACK LEFT OUTER CORNER

• ISO 4762 M4 x 10 - 10N, • ISO - 4032 - M4 Nut

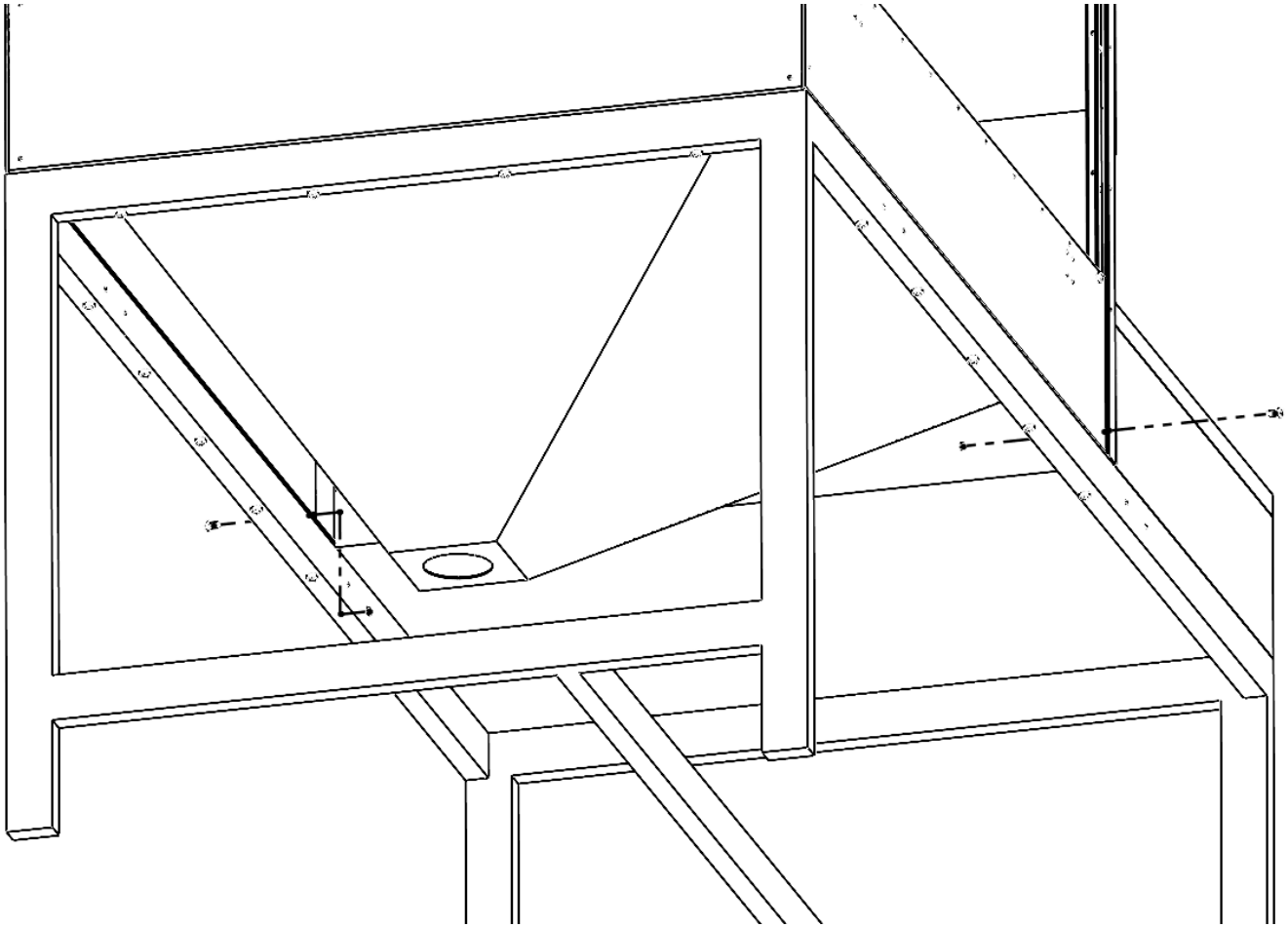
In the back left corner, insert an M4 x 10 bolt through the Back Left Outer Corner and the Left Side Skirt. Secure it from behind using an M4 locking nut.



STEP 10 ATTACH THE BACK RIGHT OUTER CORNER

• ISO 4762 M4 x 10 - 10N, • ISO - 4032 - M4 Nut

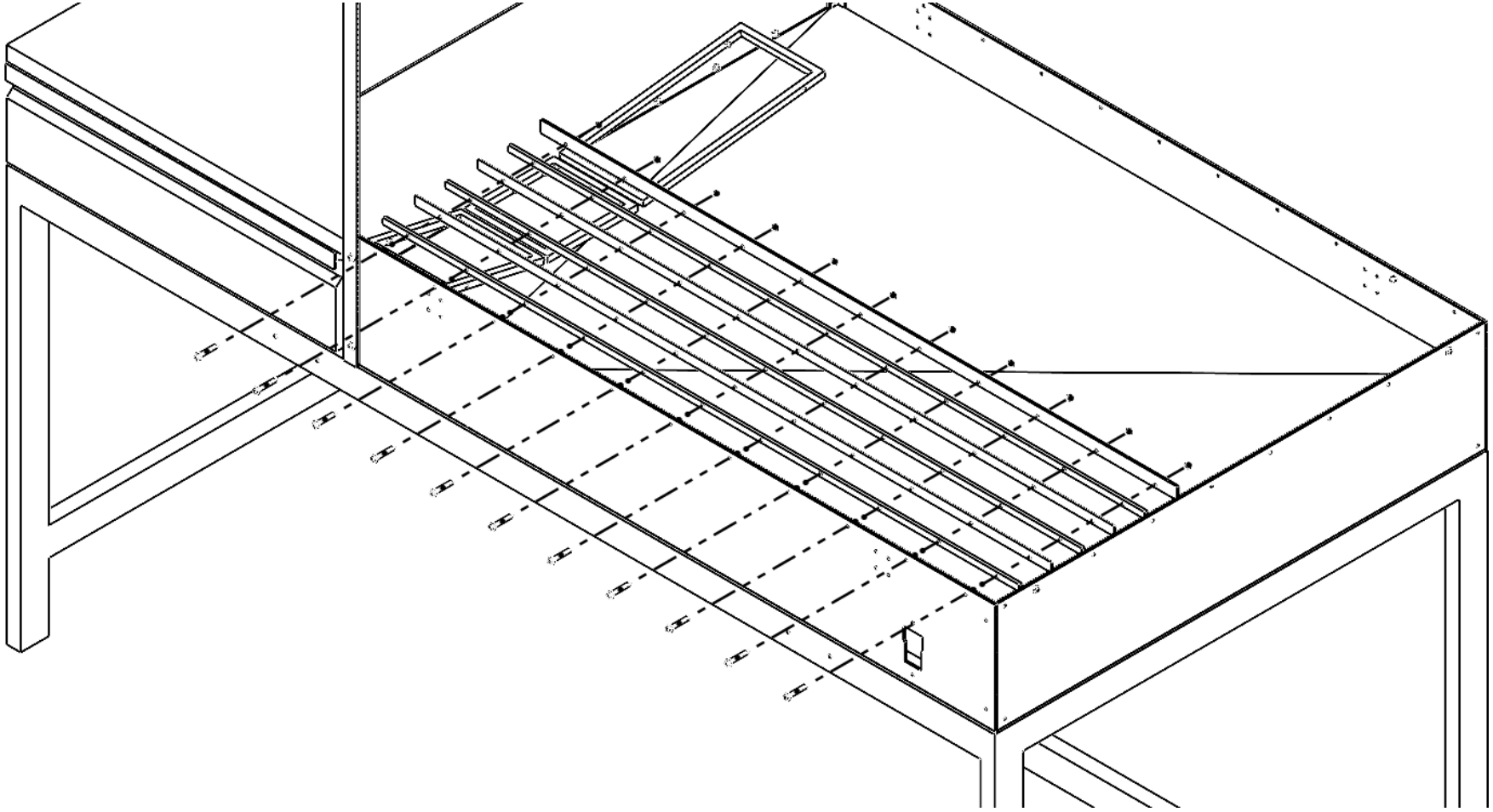
Repeat this process for the back right side.

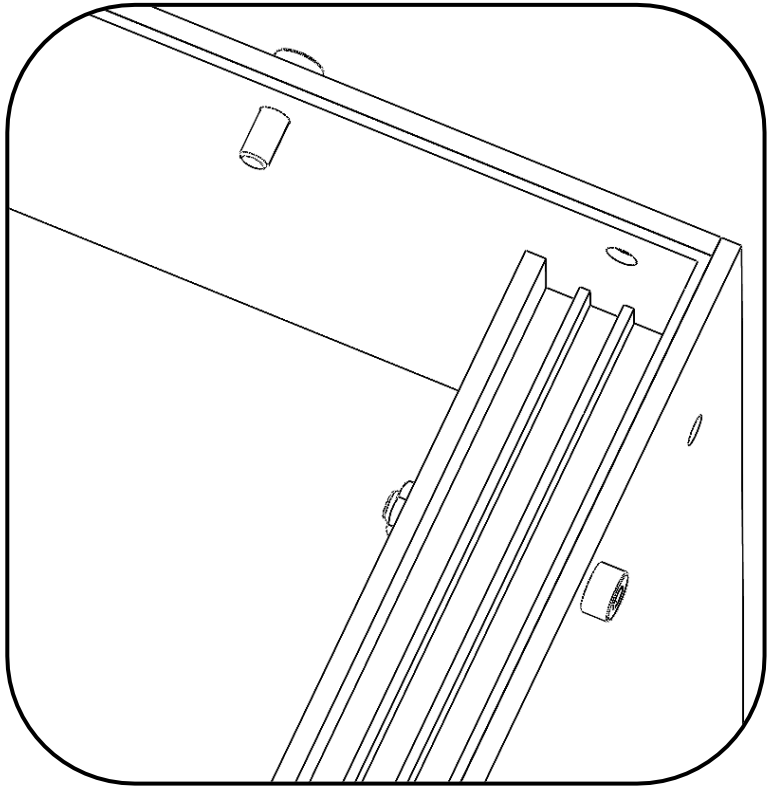


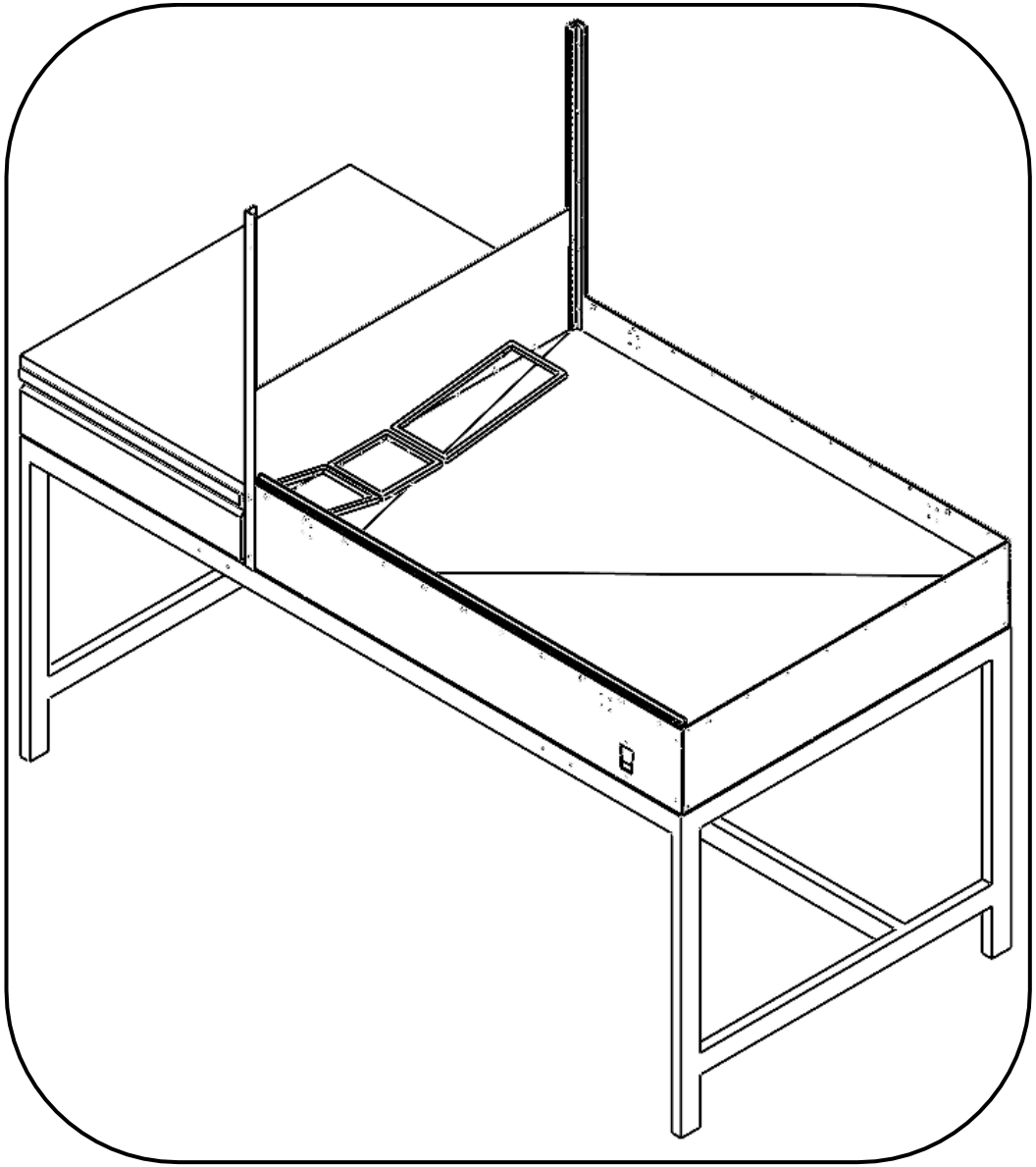
STEP 11 ASSEMBLE THE DOOR SUPPORT BOTTOM

- Bottom Bracket for Doors x3, • Door Bracket Inserts x2, • Stopper Bracket for Doors
- ISO 4762 M4 x 30 - 30N x11, • ISO - 4032 - M4 Nut x11

Connect the components that will eventually make the bottom tracks for the doors to the left side of the assembly.





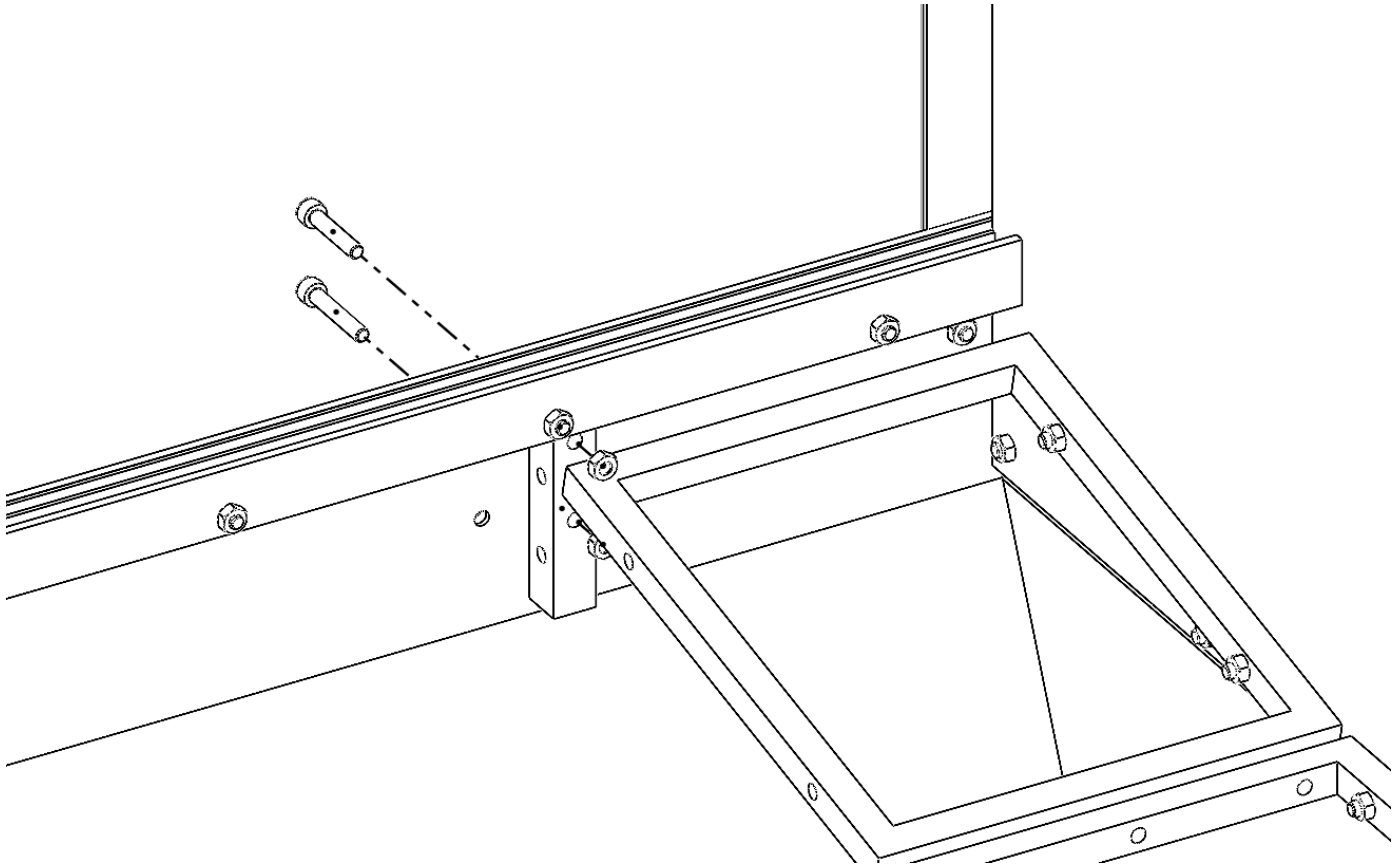


SECTION 2: CNC MACHINE PLATFORM AND Y-AXIS

STEP 12 INSTALL THE BACK LEFT BRACKET FOR WEIGHT SUPPORT

- Brackets for Weight Support
- ISO 4762 M4 x 25 - 25N, • ISO 4762 M4 x 22 Modified, • ISO - 4032 - M4 Nut x2

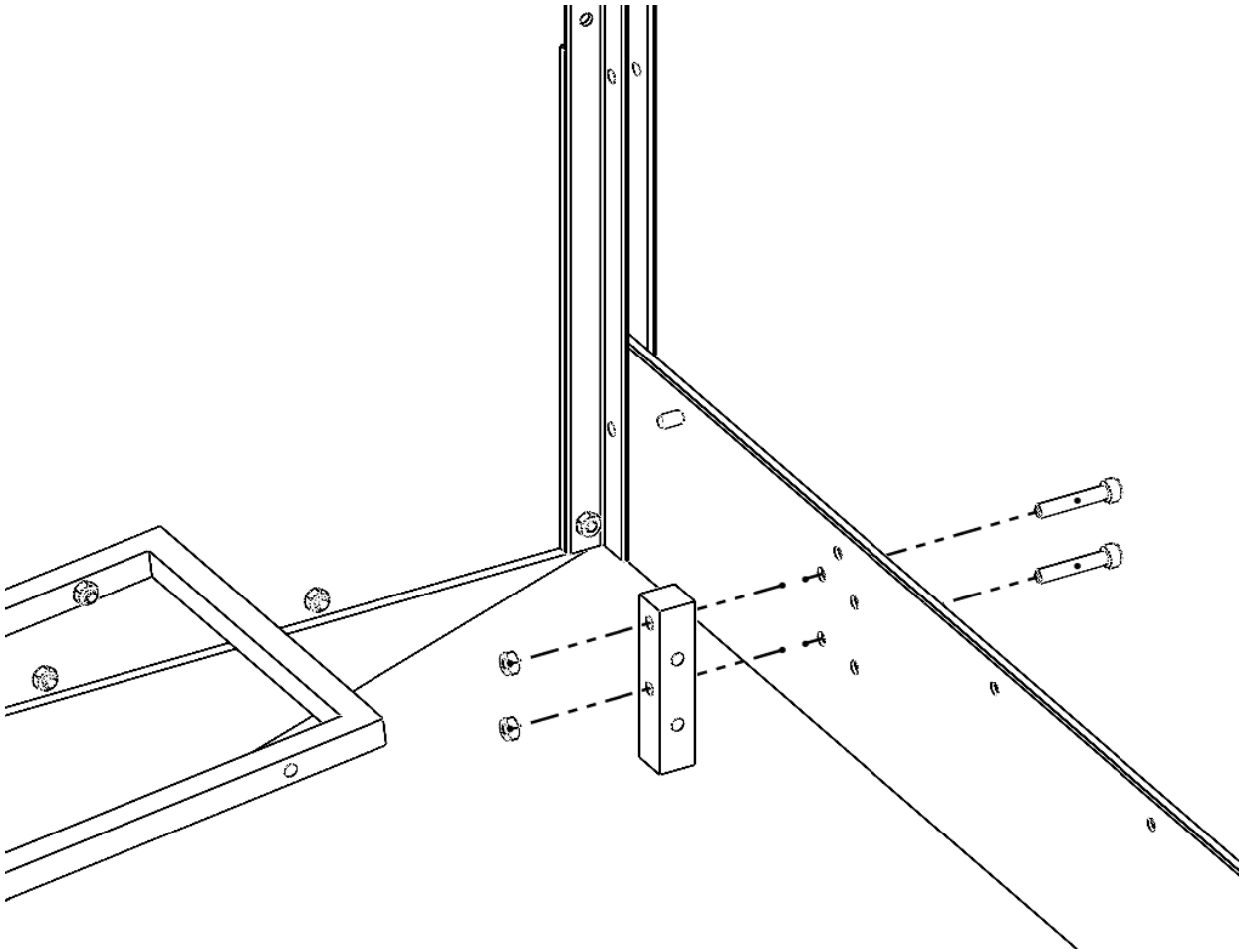
Install the first of the Brackets for Weight Support in the back left corner using an M4 x 25 for the bottom hole and a modified M4 x 22 for the top hole (the shortened bolt allows it to fit behind the Tray Support Front).



STEP 13 INSTALL THE BACK RIGHT BRACKET FOR WEIGHT SUPPORT

- Brackets for Weight Support
- ISO 4762 M4 x 25 - 25N x2, • ISO - 4032 - M4 Nut x2

Repeat for the second of the Brackets for Weight Support in the back right corner, this time using two M4 x 25 bolts.

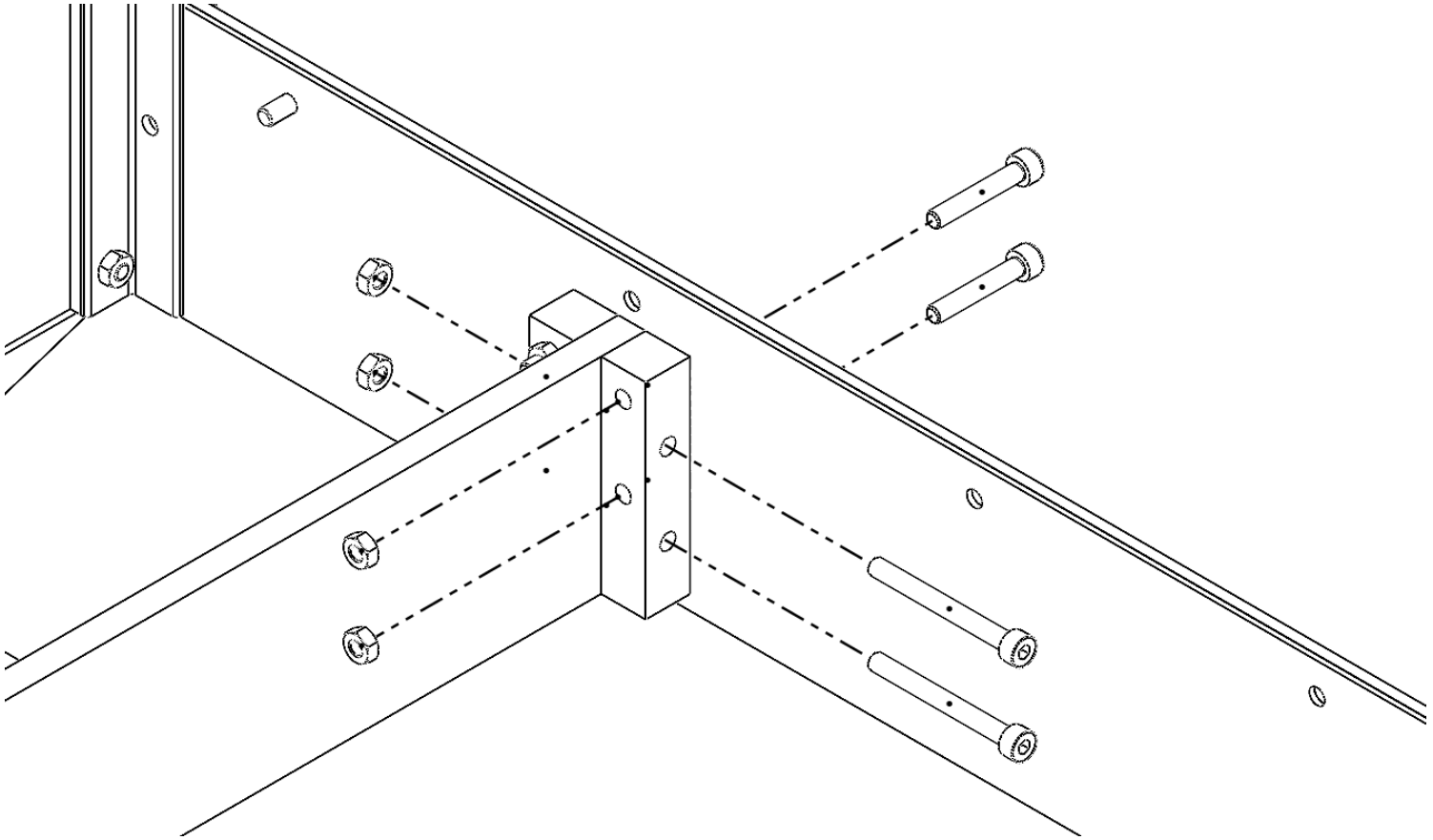


STEP 14 INSTALL THE SECOND BACK RIGHT BRACKET FOR WEIGHT SUPPORT

• Y-Back Plate, • Brackets for Weight Support

• ISO 4762 M4 x 25 - 25N x2, • ISO 4762 M4 x 40 - 20N x2, • ISO - 4032 - M4 Nut x4

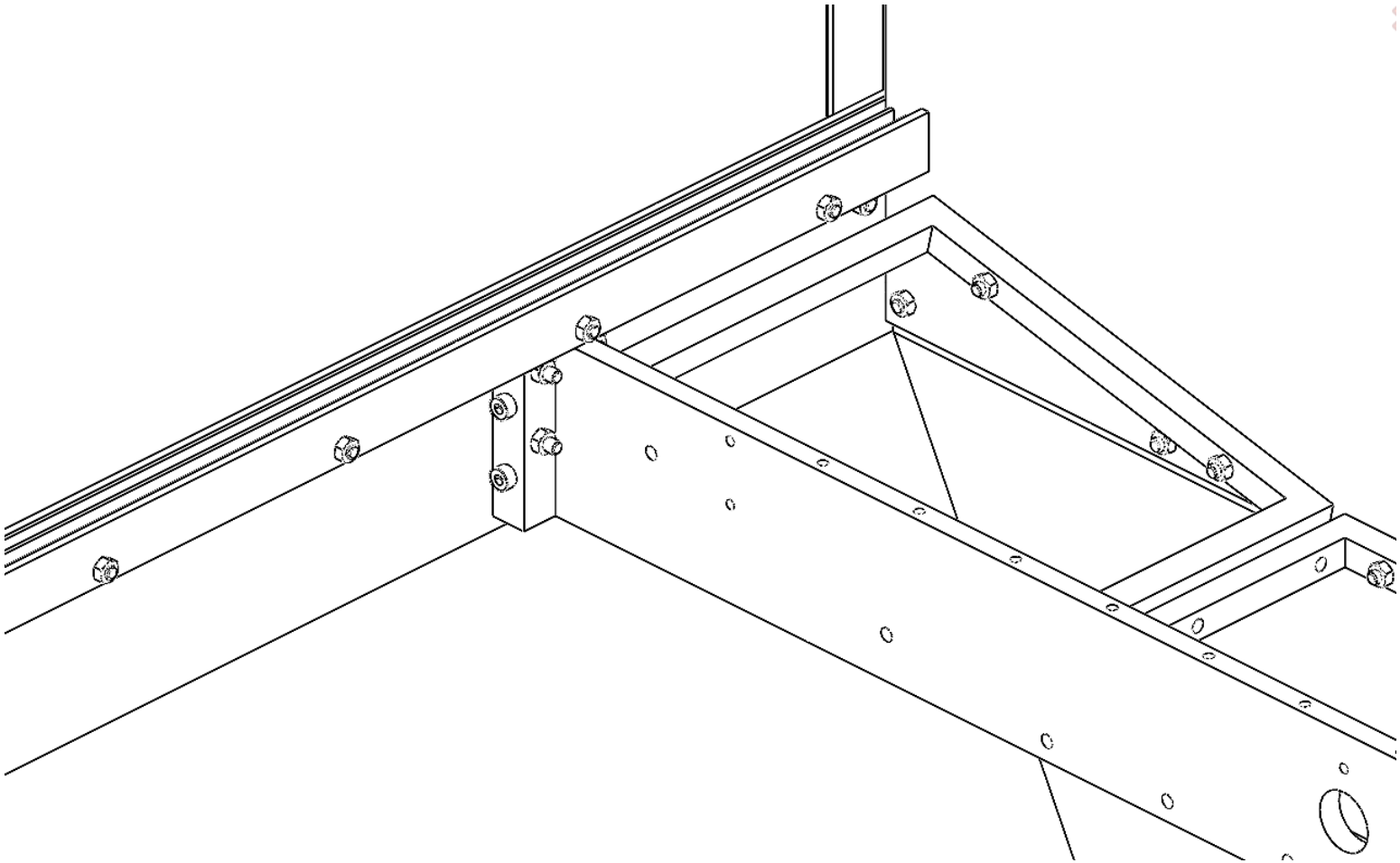
Holding the Y-Back Plate in place against the Brackets for Weight Support from Steps 12 and 13, add another of the Brackets for Weight Support and secure everything in place using two more M4 x 25 bolts, two M4 x 40 bolts, and four M4 locking nuts. Note: Be sure to orient the Y-Back Plate so that the holes in it align with the holes in the chip tray supports with the vertical holes on top.



STEP 15 INSTALL THE SECOND BACK LEFT BRACKET FOR WEIGHT SUPPORT

- Brackets for Weight Support
- ISO 4762 M4 x 25 - 25N x2, • ISO 4762 M4 x 40 - 20N x2, • ISO - 4032 - M4 Nut x4

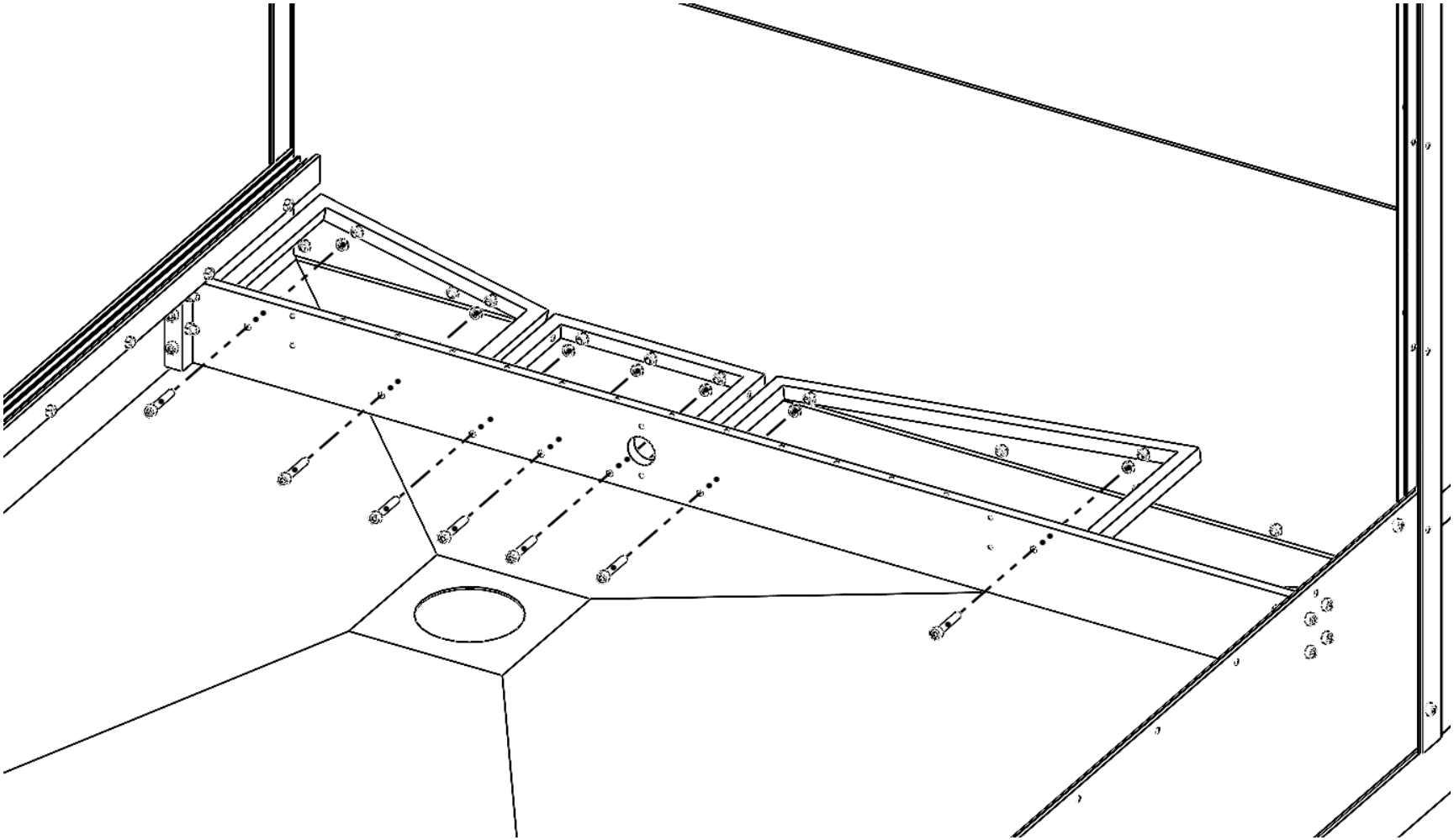
Repeat the process for the other back corner.



STEP 16 BOLT THE Y-BACK PLATE

• ISO 4762 M4 x 25 - 25N x7, • ISO - 4032 - M4 Nut x7

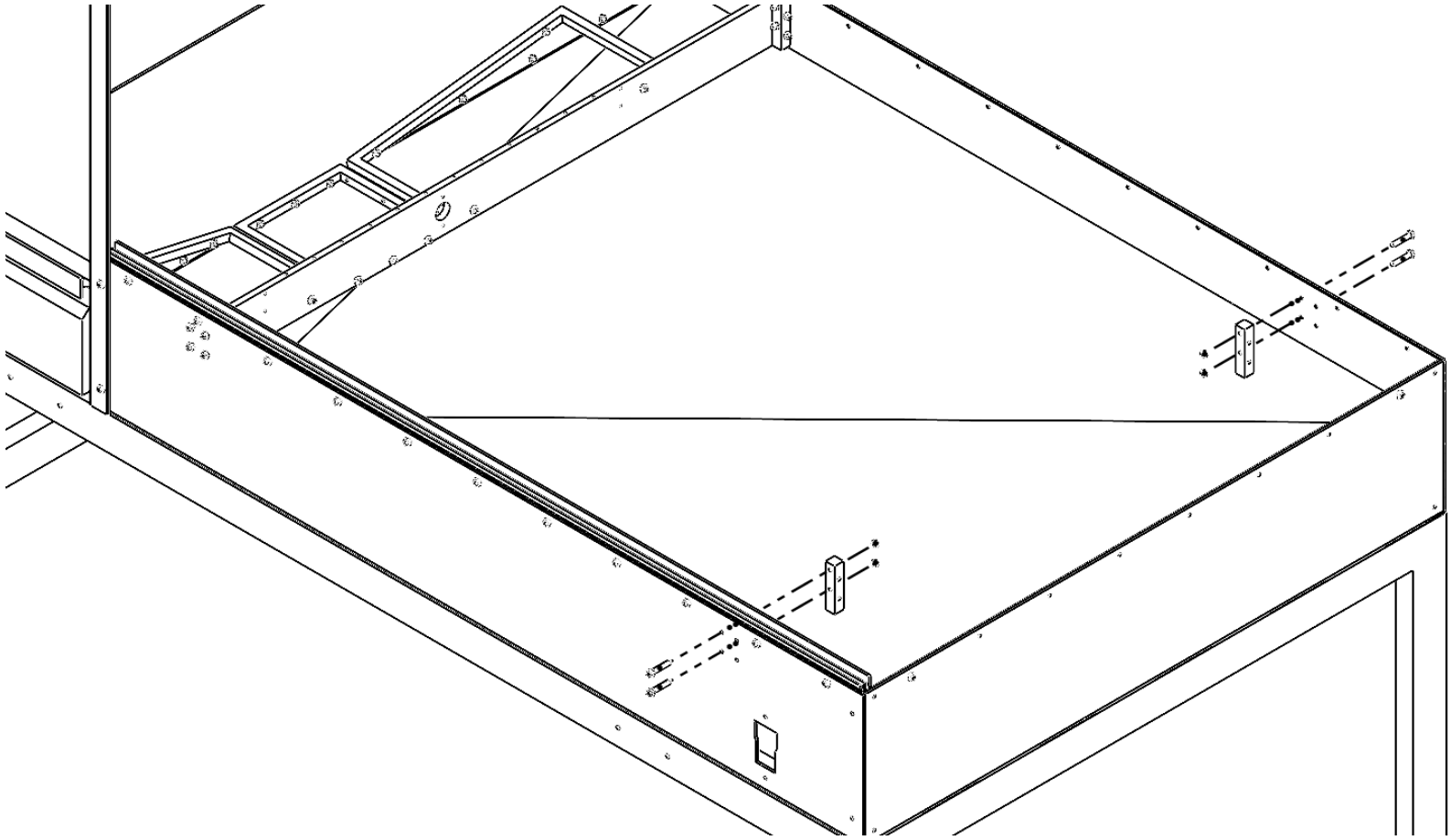
Connect the Y Back Plate to the tray supports using M4 x 25 bolts and locking nuts.



STEP 17 INSTALL THE FIRST TWO FRONT BRACKETS FOR WEIGHT SUPPORT

- Brackets for Weight Support x2
- ISO 4762 M4 x 25 - 25N x4, • ISO - 4032 - M4 Nut x4

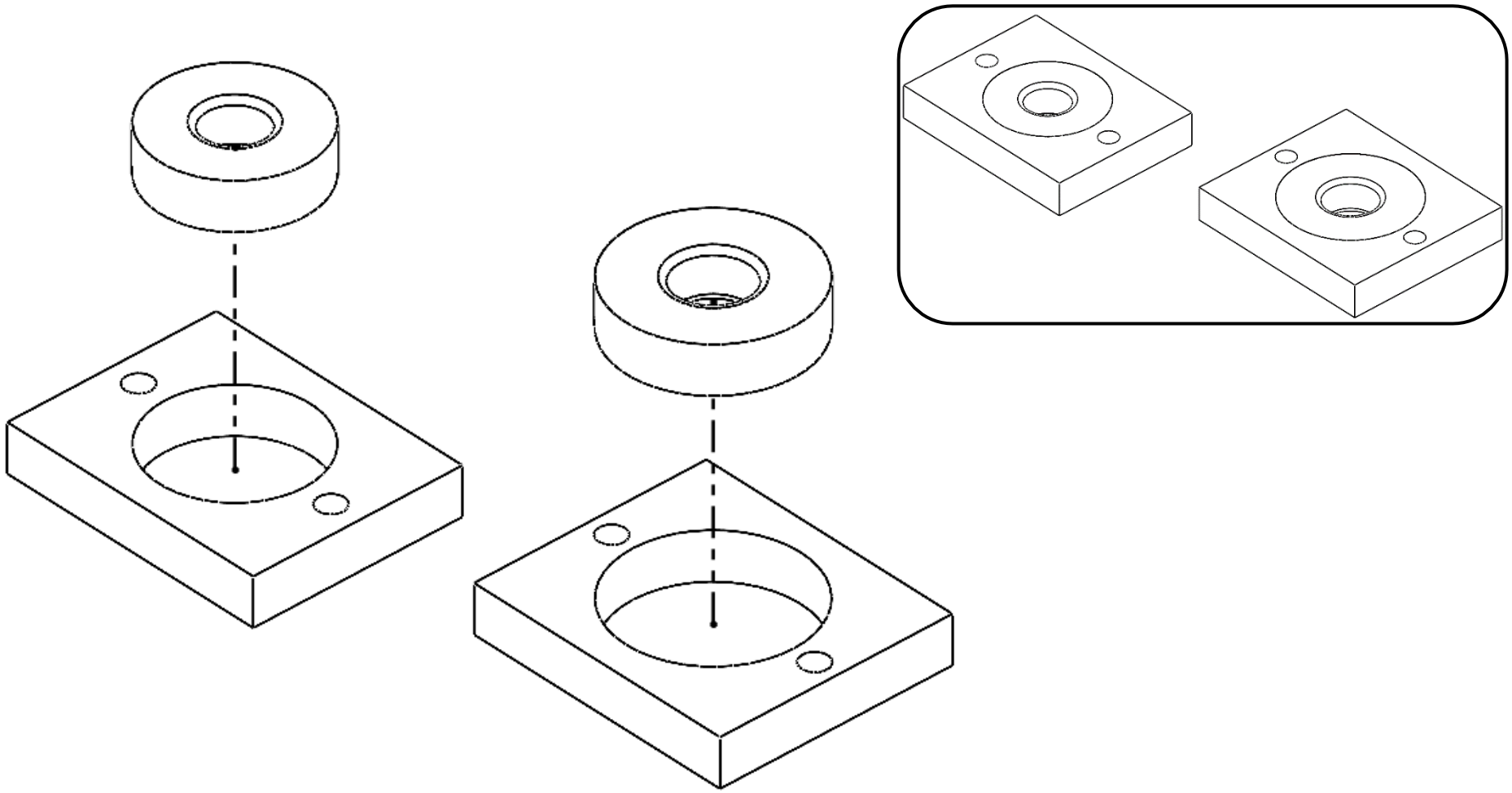
Using two more M4 x 25 bolts and locking nuts on each side, now add two more brackets to the front half of the machine. Note: only add these two; the final two weight support brackets will be added in Steps 13.3 and 13.4.



STEP 18 Y-AXIS BEARING BLOCK SUBASSEMBLIES

• 6000-2RS Sealed Ball Bearing, • 26mm OD Bearing Block, • 16101 2RS Sealed Ball Bearing, • 30mm OD Bearing Block

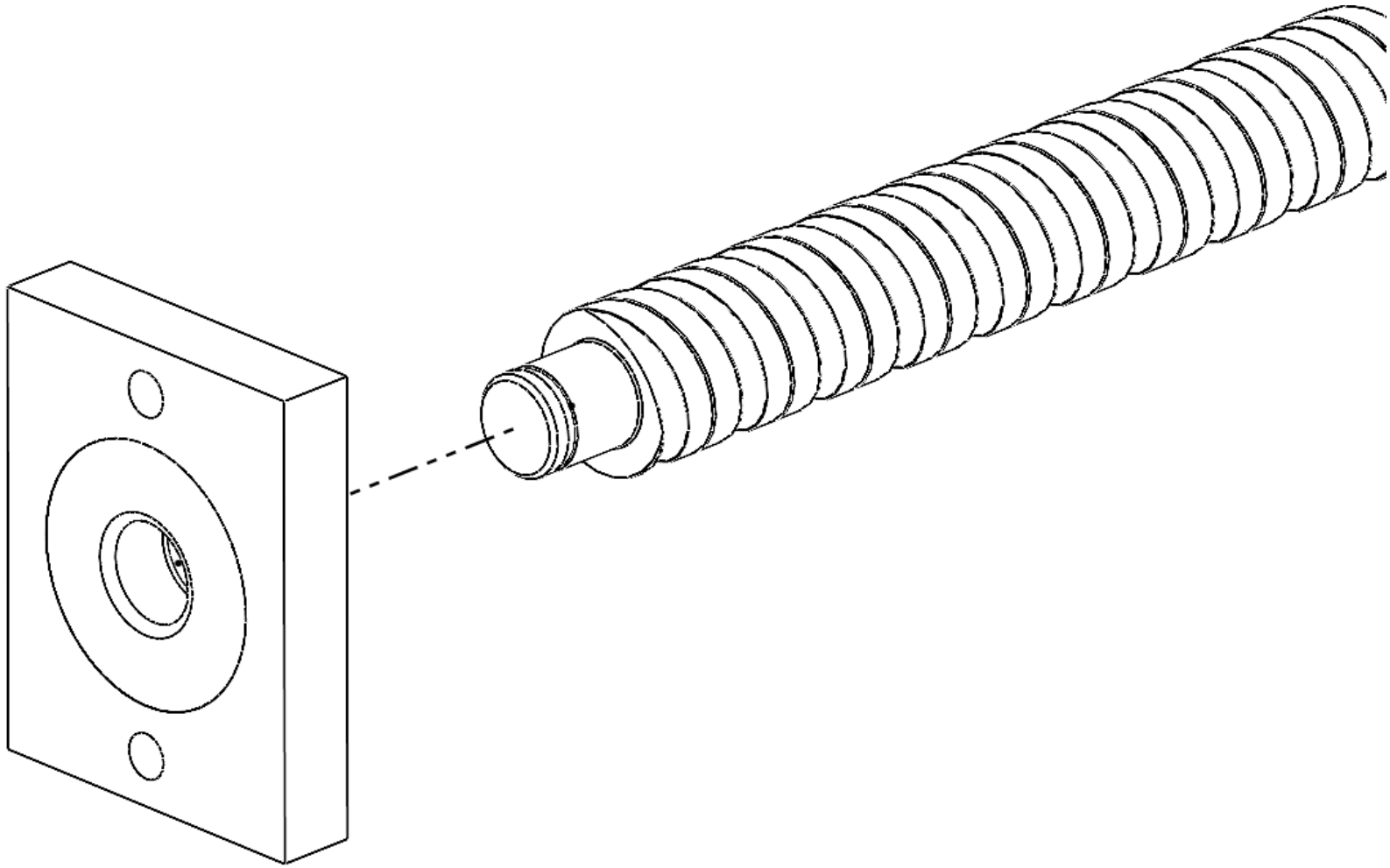
The Y-axis lead screw will require a 26 mm ball bearing on the back side and a 30 mm ball bearing on the front. Begin the Y-axis subassembly by seating both bearings into their respective bearing blocks using an arbor press (J6 transition fit).



STEP 19 PRESS FIT THE Y-AXIS LEAD SCREW

- SFU1610 800mm Y

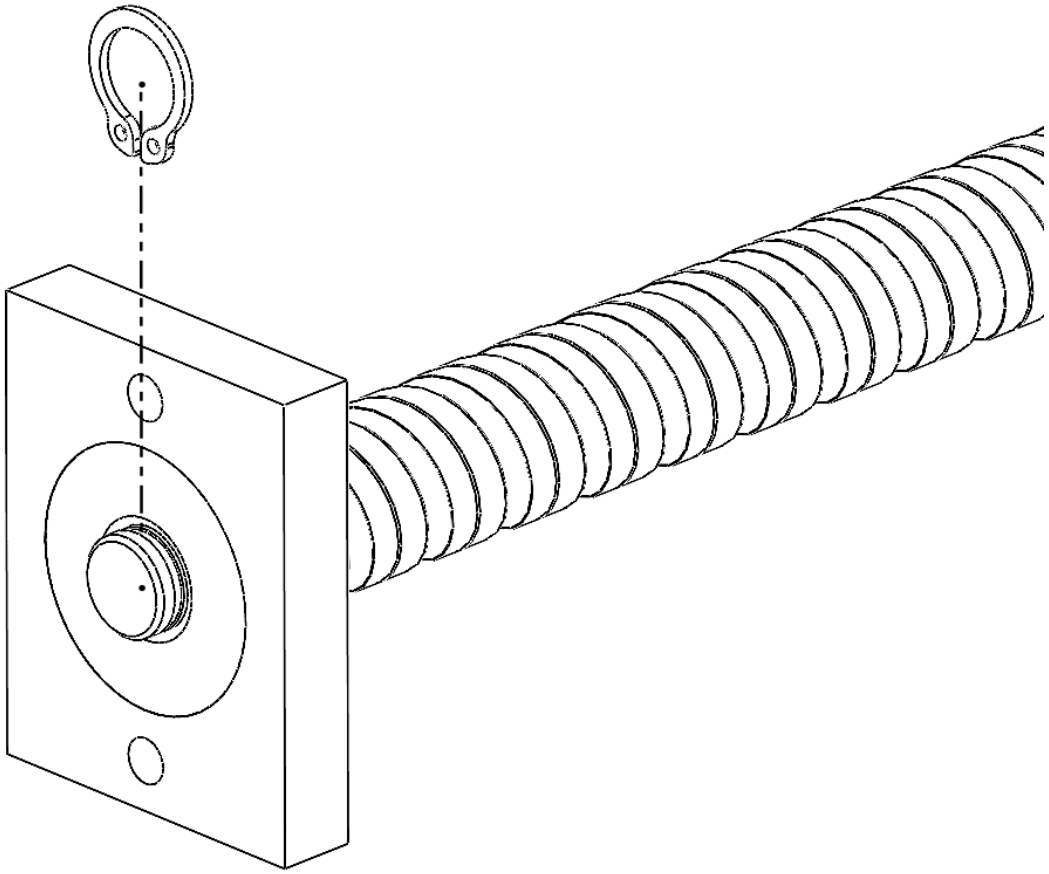
Press the back side of the Y-axis lead screw into the inner trace of the 26 mm bearing from Step 18 (j6 transition fit).

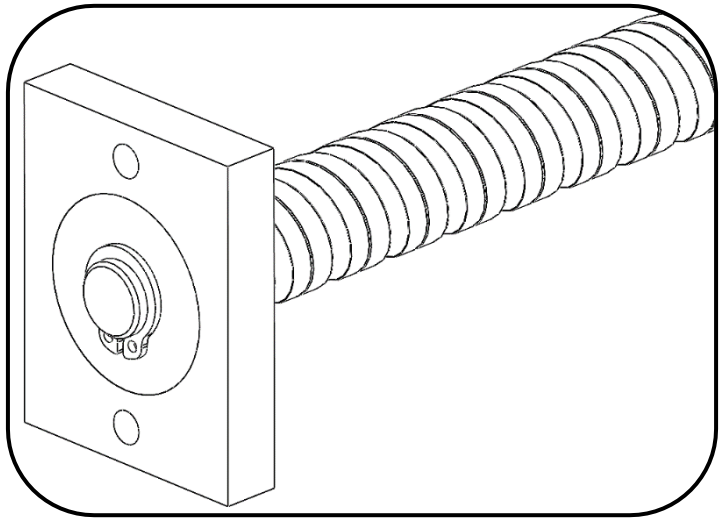


STEP 20 SECURE THE Y-AXIS LEAD SCREW TO THE BEARING BLOCKS

- DIN 471 10 mm External Circlip

Secure the components in place using a 10 mm circlip

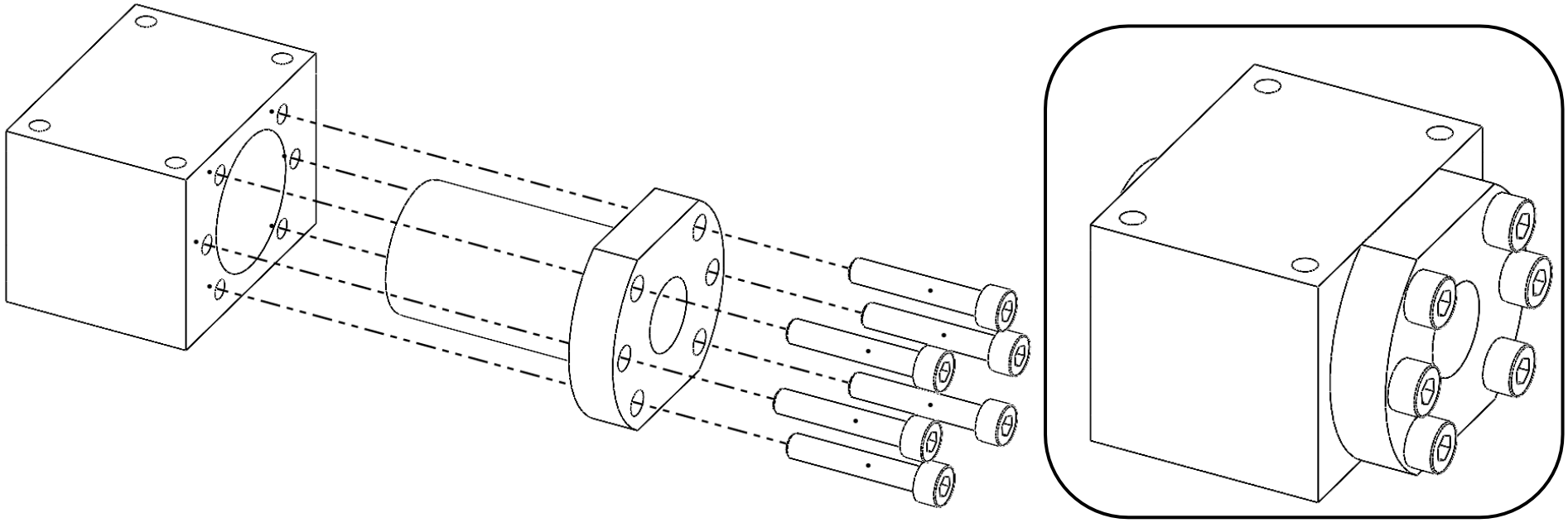




STEP 21 NUT BLOCK FOR THE Y-AXIS LEAD SCREW

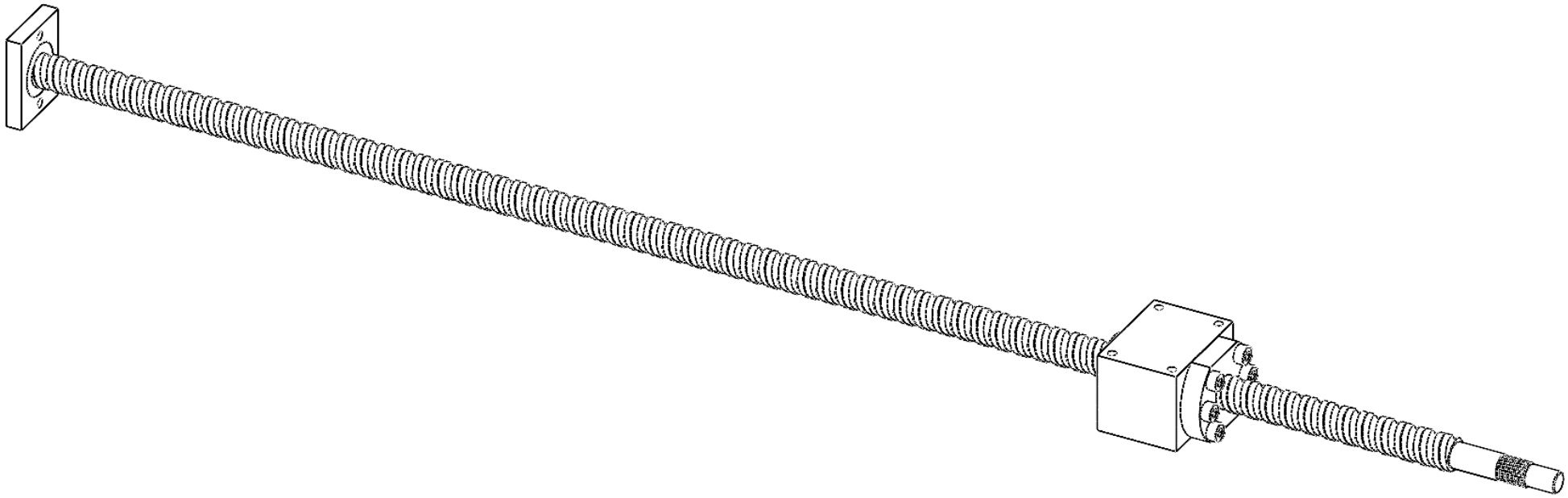
- Nut Block, • Nut 1610
- ISO 4762 M5 x 30 - 30N x6

Attach the Y-axis nut block to the lead screw nut using six M5 x 30 bolts.



STEP 22 COMBINE THE NUT BLOCK AND LEAD SCREW SUBASSEMBLIES FOR THE Y-AXIS

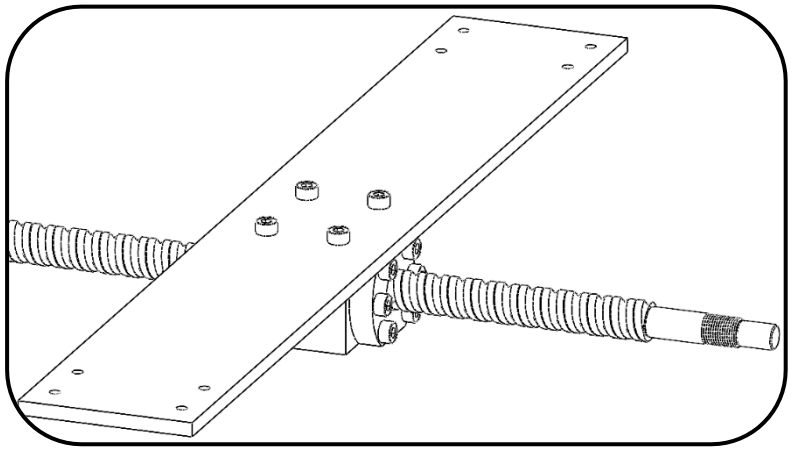
Combine the subassemblies from Step 6 by threading the nut onto the lead screw. Note: make sure the flange of the lead screw nut and the heads of the bolts are oriented toward the open end of the lead screw.

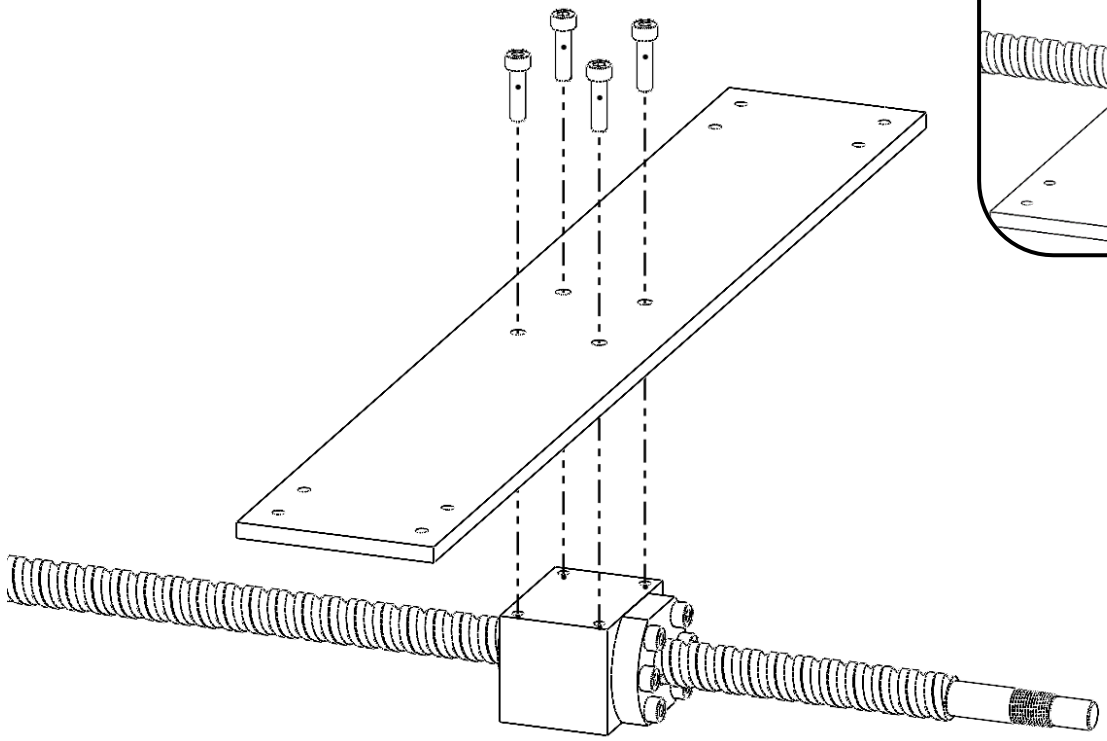


STEP 23 ADD THE Y-BOTTOM PLATE TO THE Y-AXIS SUBASSEMBLY

- Y Bottom Plate for Screw
- ISO 4762 M5 x 20 - 20N x4

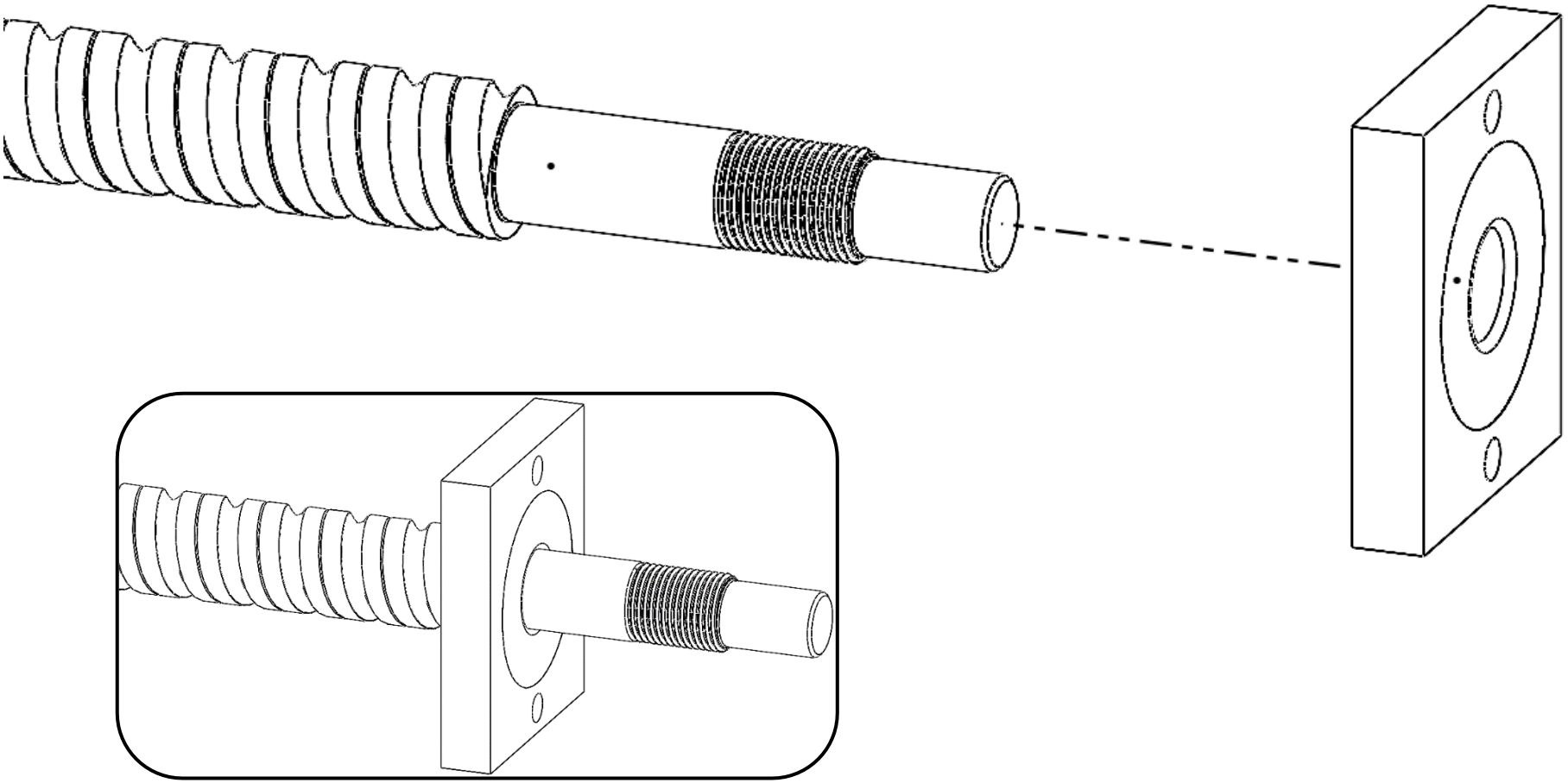
Attach the Y-Bottom Plate to the Y-axis subassembly using four M5 x 20 bolts.





STEP 24 OTHER BEARING BLOCK FOR THE Y-AXIS SUBASSEMBLY

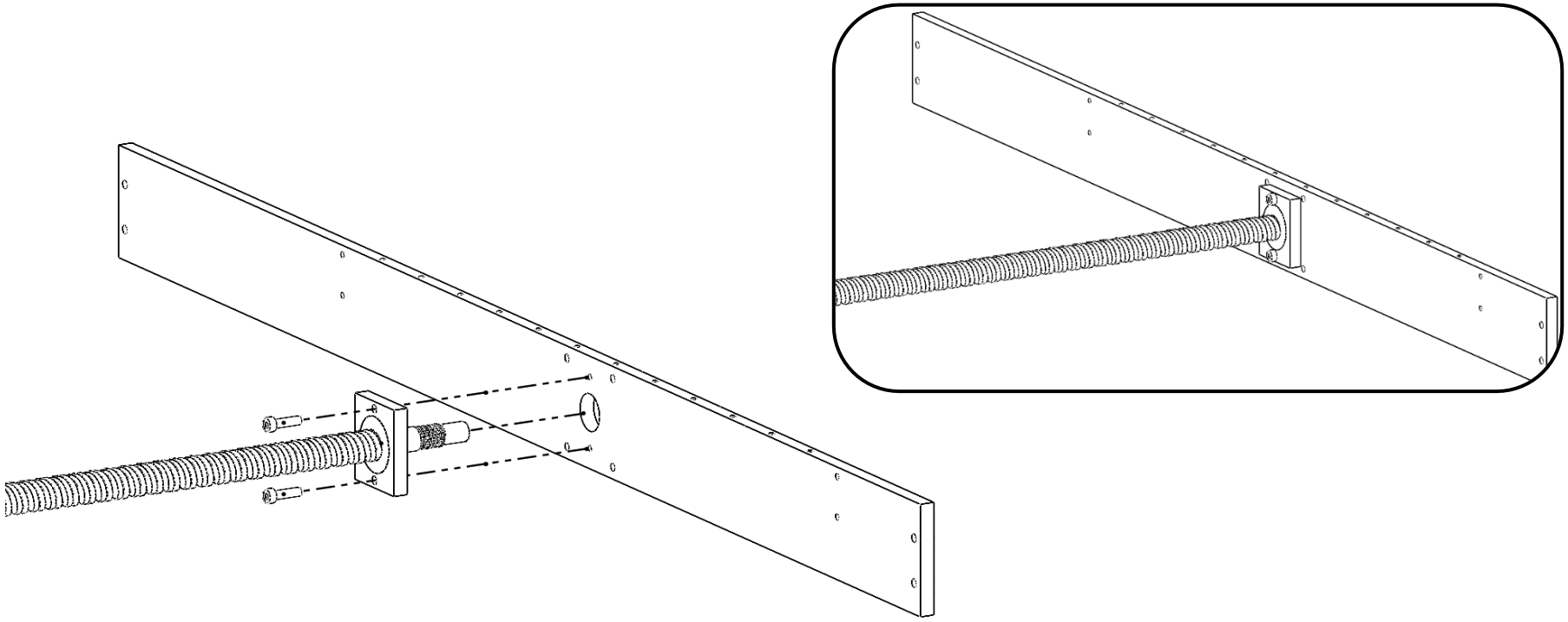
Now press the 30 mm bearing subassembly from Step 18 onto the open end of the Y-axis lead screw (j6 transition fit).



STEP 25 ATTACH THE Y-FRONT PLATE TO THE Y-AXIS SUBASSEMBLY

- Y Front Plate
- ISO 4762 M4 x 16 - 16N x2

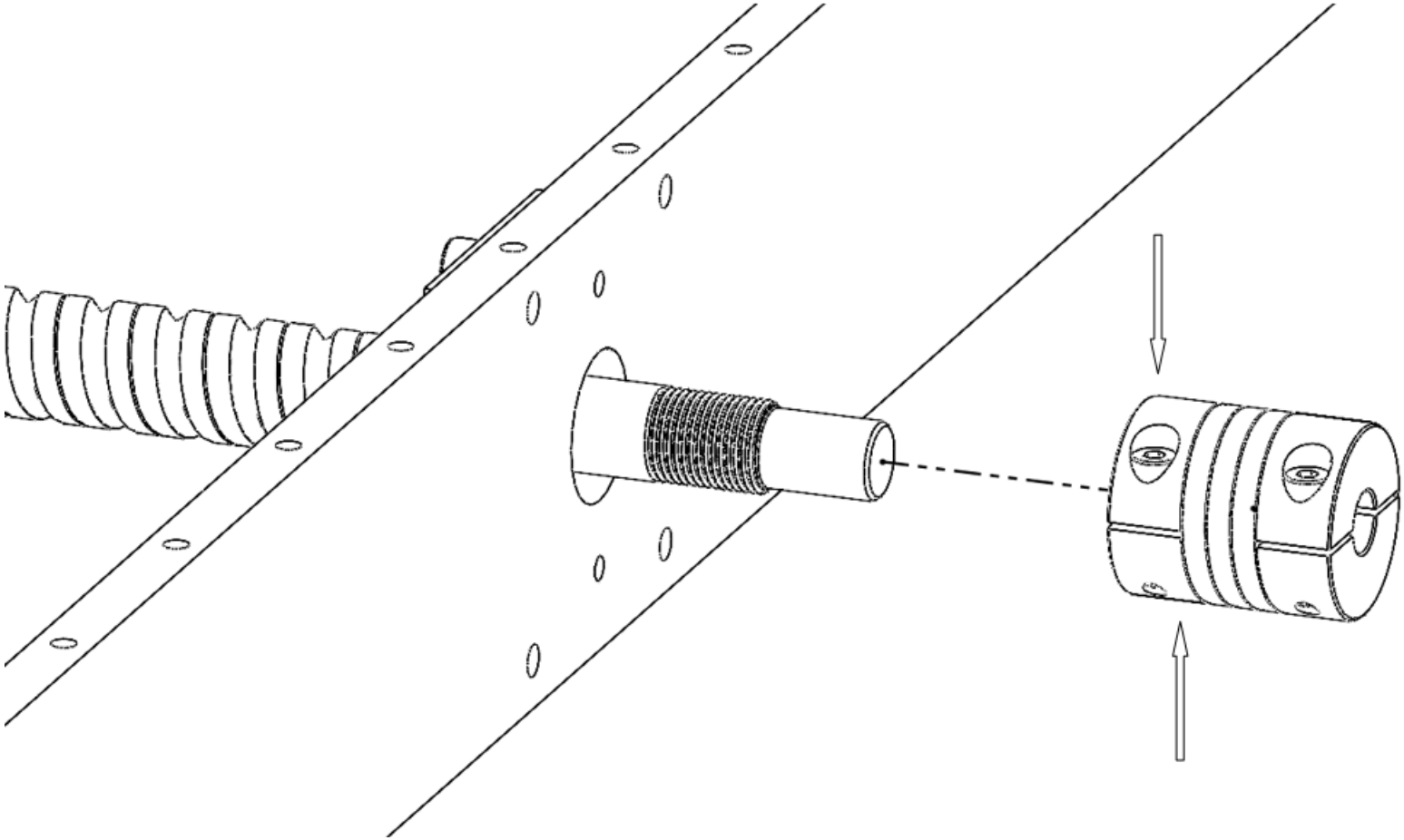
Attach the front plate to the Y-axis subassembly using two M4 x 16 bolts through the 30 mm bearing block. Note: be sure to orient it so that the holes in the thin edge are facing upward.



STEP 26 CONNECT THE SHAFT COUPLER FOR THE Y-AXIS MOTOR TO THE LEAD SCREW

- Shaft Coupler 8x10mm

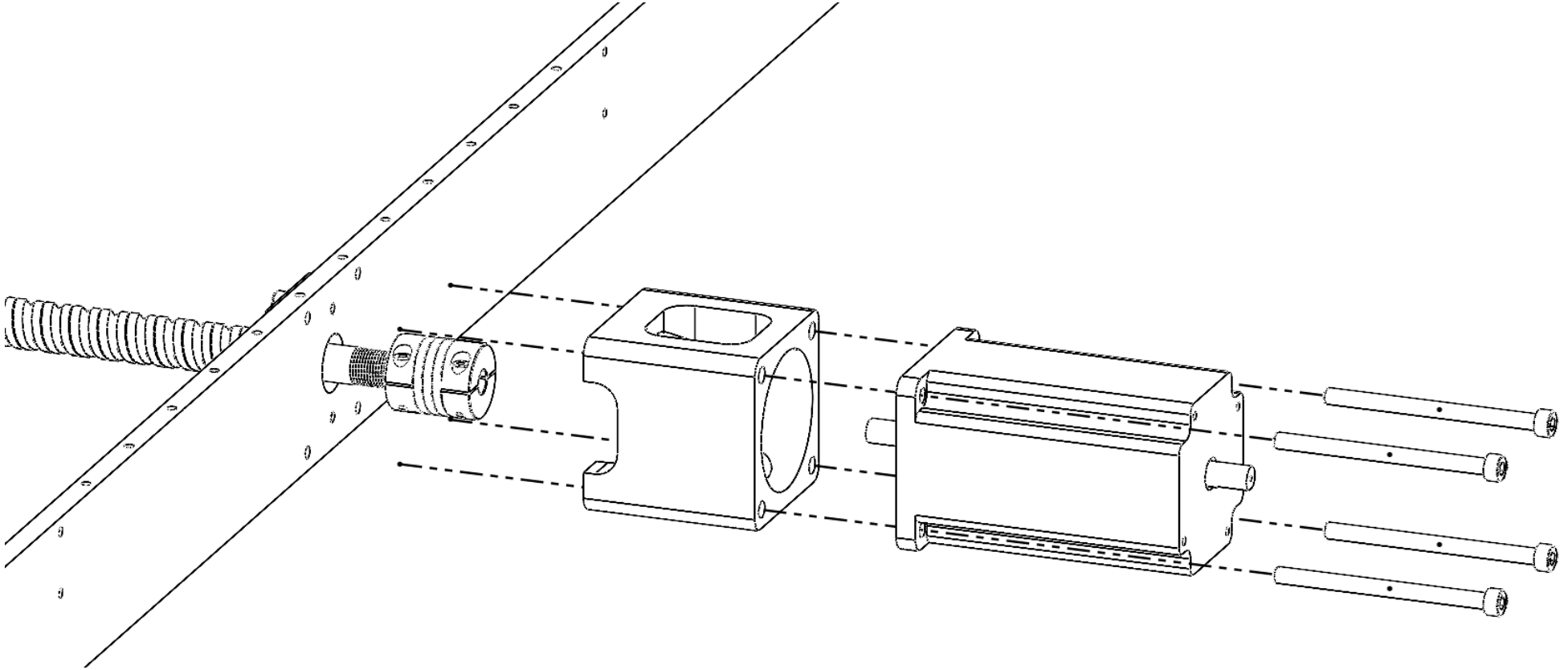
There will not be a better opportunity to attach the Y-axis motor, so let's do that now. Begin by attaching the shaft coupler to the lead screw using the provided set screw and clamping bolt.



STEP 27 ATTACH THE Y-AXIS MOTOR

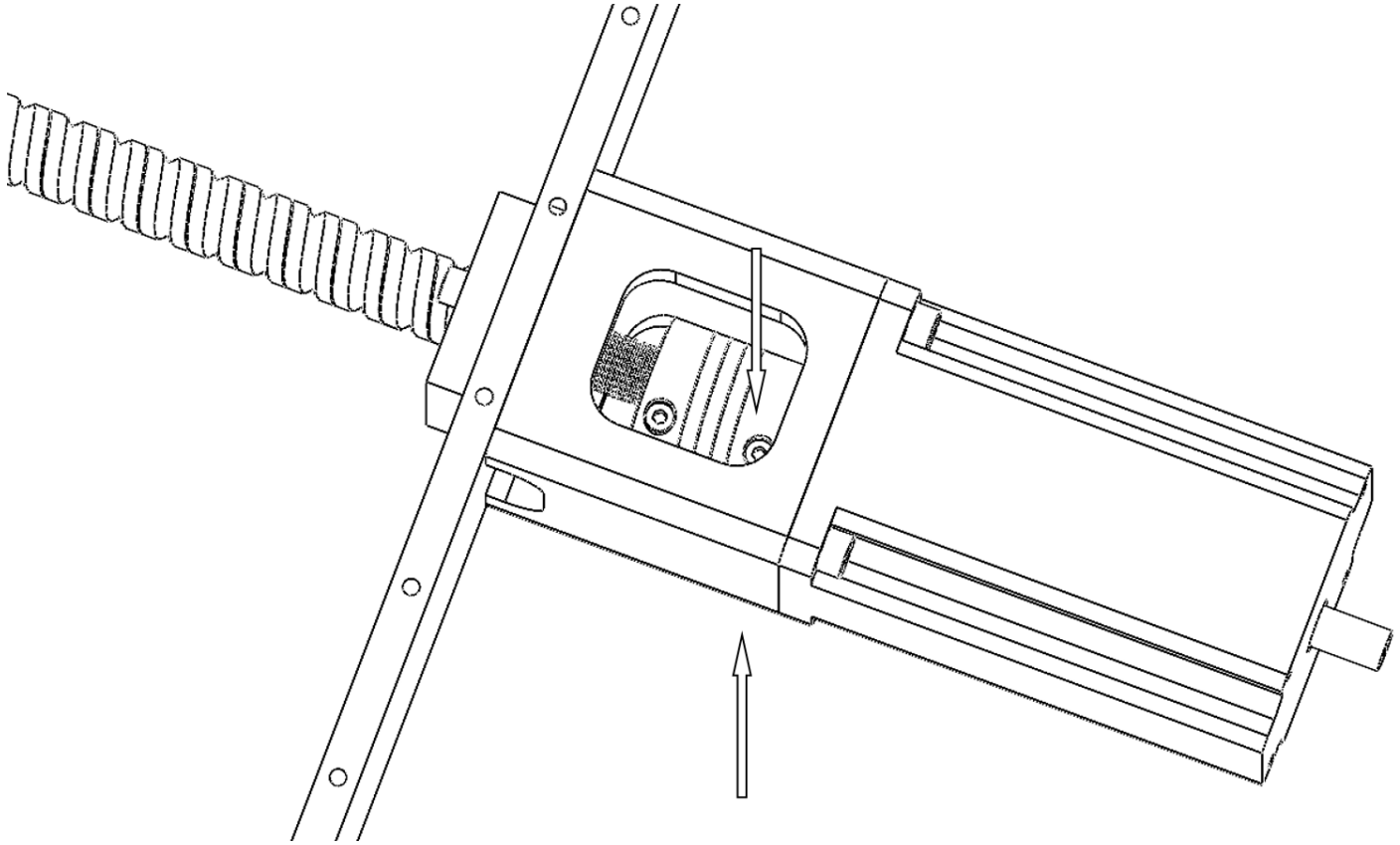
- Y-Axis Motor Adaptor, • Nema 24 Motor
- ISO 4762 M5 x 75 - 22N Modified x4

Then use four M5 x 75 bolts to connect the motor to the subassembly via the motor adaptor. Note: pay attention to the orientation of the cables for the motor.



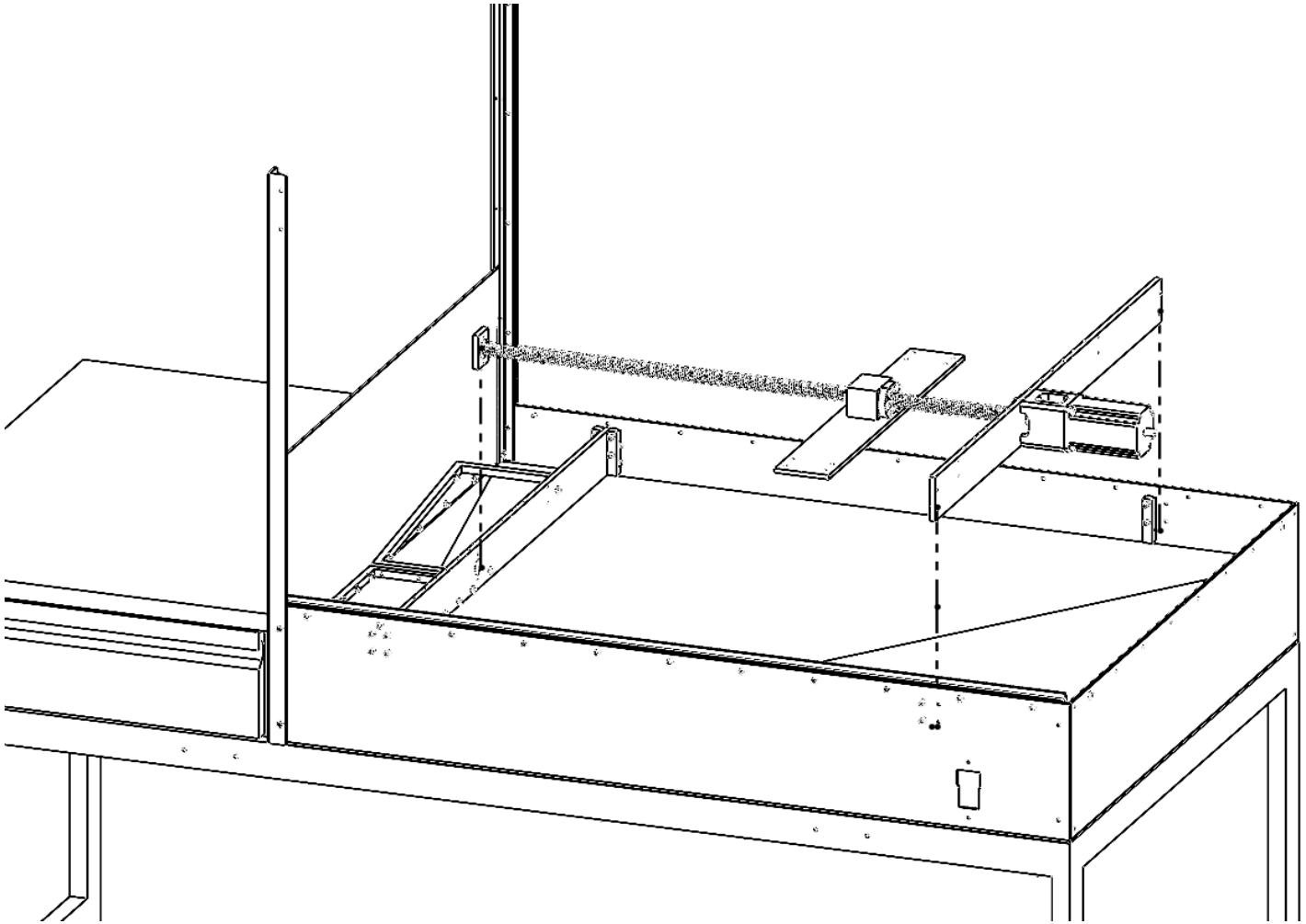
STEP 28 CONNECT THE SHAFT COUPLER TO THE Y-AXIS MOTOR

Finally attach the shaft coupler to the motor shaft through the cavities in the motor mount using the provided set screw and clamping bolt.



STEP 29 ADD THE Y-AXIS SUBASSEMBLY TO THE MAIN ASSEMBLY

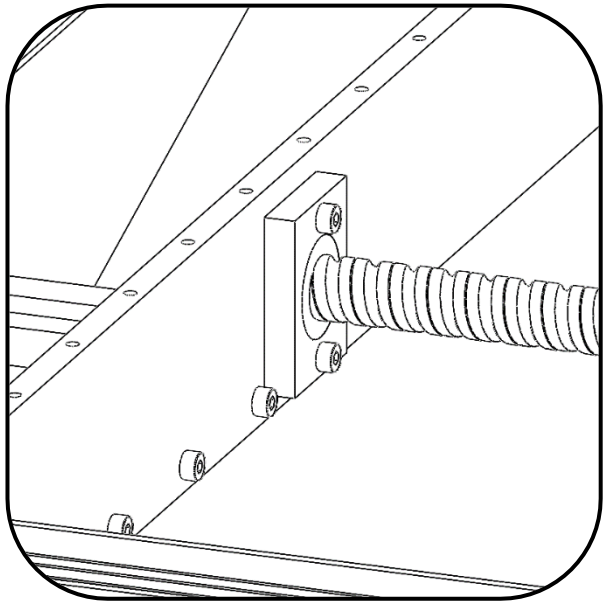
Carefully lower the Y-axis subassembly into the machine so that the bolt holes are aligned at the correct locations

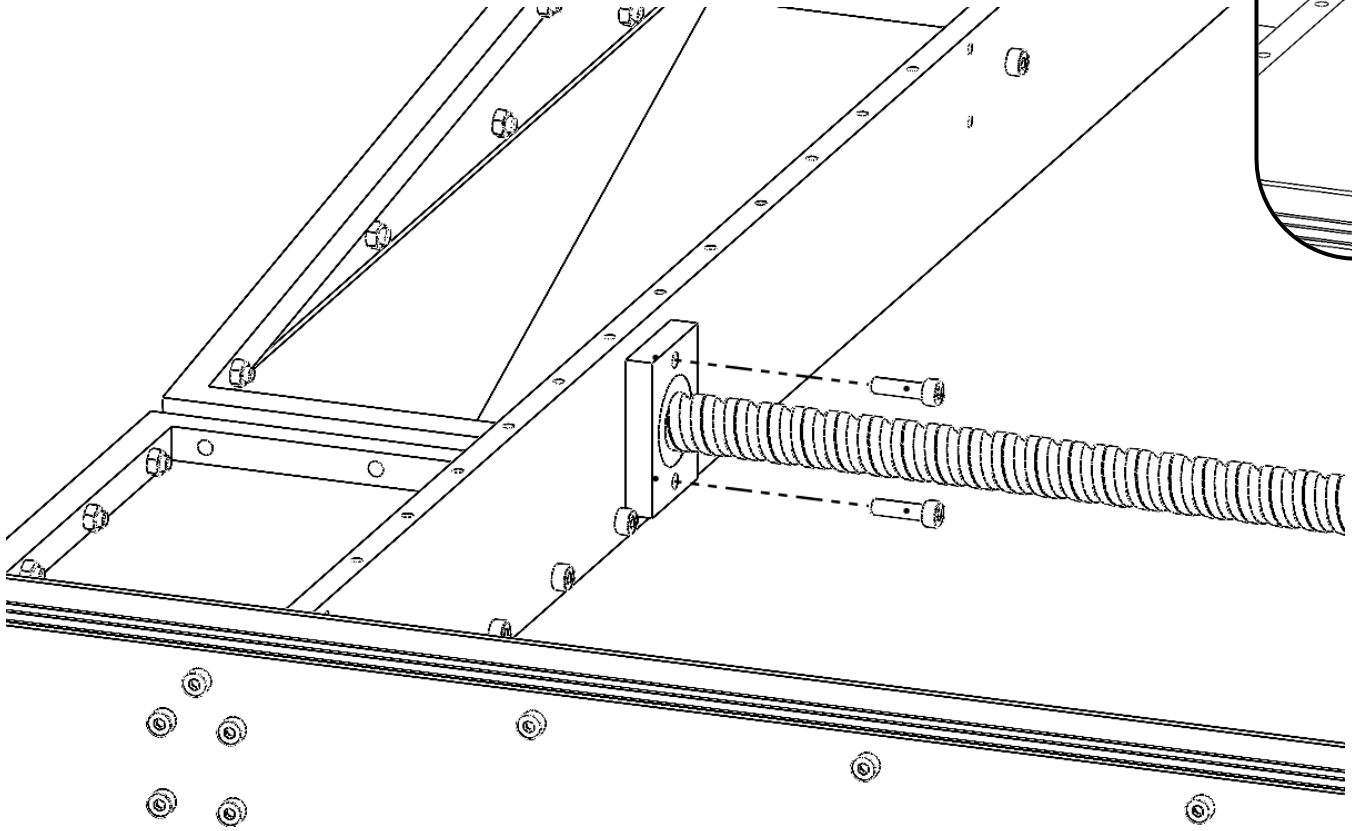


STEP 30 BOLT THE BACK BEARING BLOCK

- ISO 4762 M4 x 16 - 16N x2

Attach the 26 mm bearing block to the Y-axis back plate using two M4 x 16 bolts.



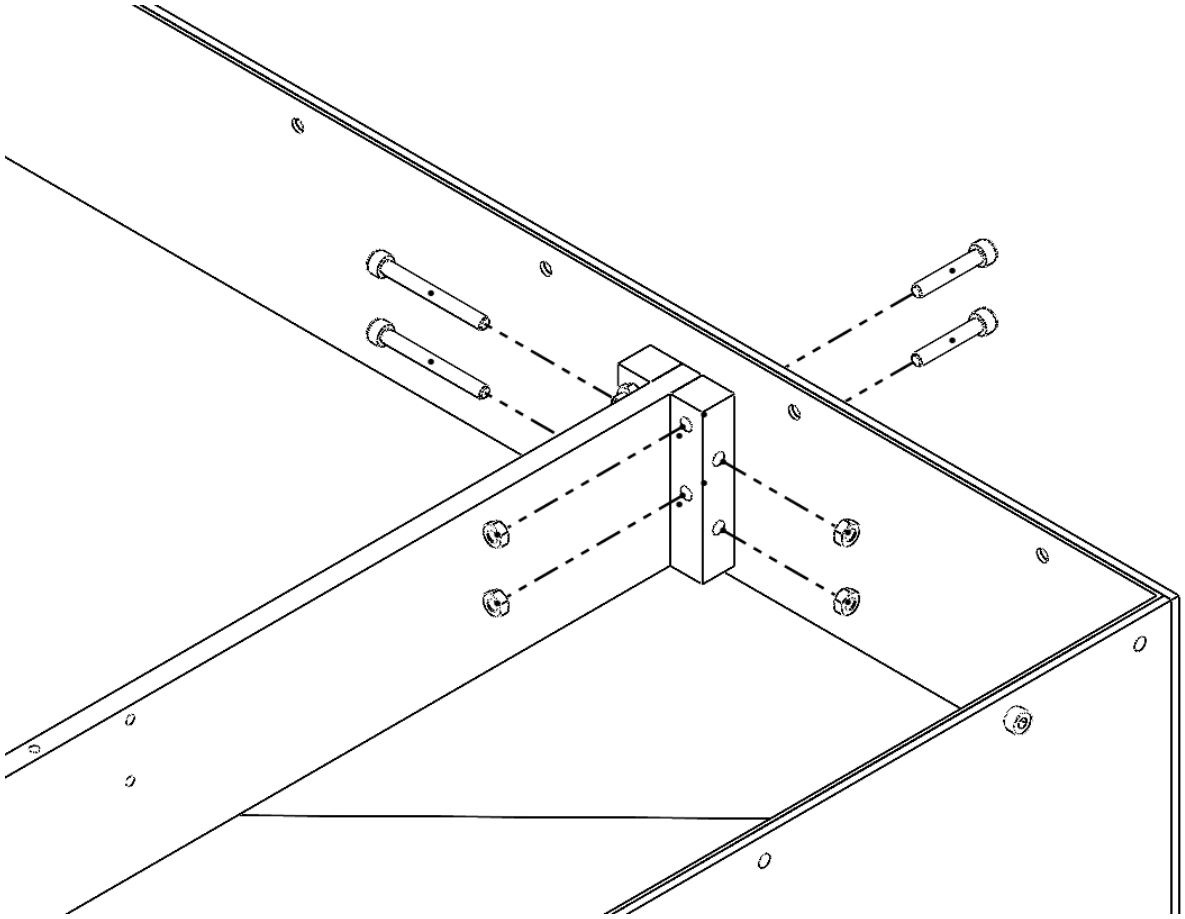


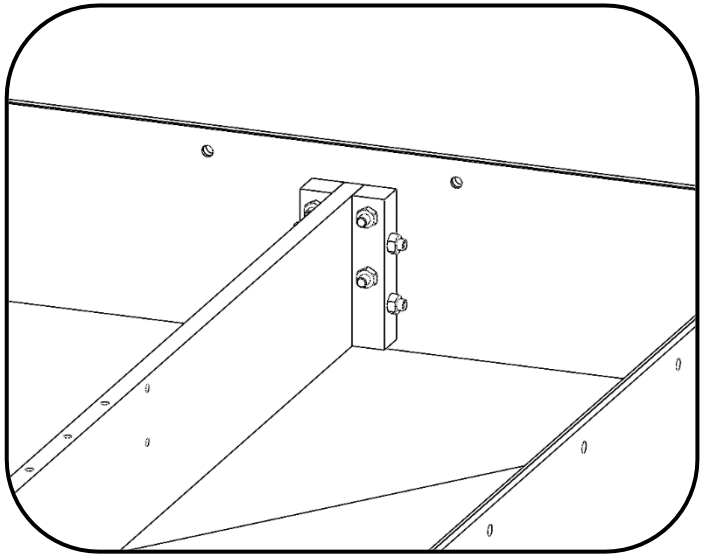
STEP 31 SECURE THE Y-FRONT PLATE WITH THE FRONT LEFT BRACKETS FOR WEIGHT SUPPORT

- Brackets for Weight Support

- ISO 4762 M4 x 25 - 25N x2, • ISO 4762 M4 x 40 - 20N x2, • ISO - 4032 - M4 Nut x4

Holding the Y Front Plate in place against the Brackets for Weight Support from Step 17, add another of the Brackets for Weight Support and secure everything in place using two more M4 x 25 bolts, two M4 x 40 bolts, and four M4 locking nuts.

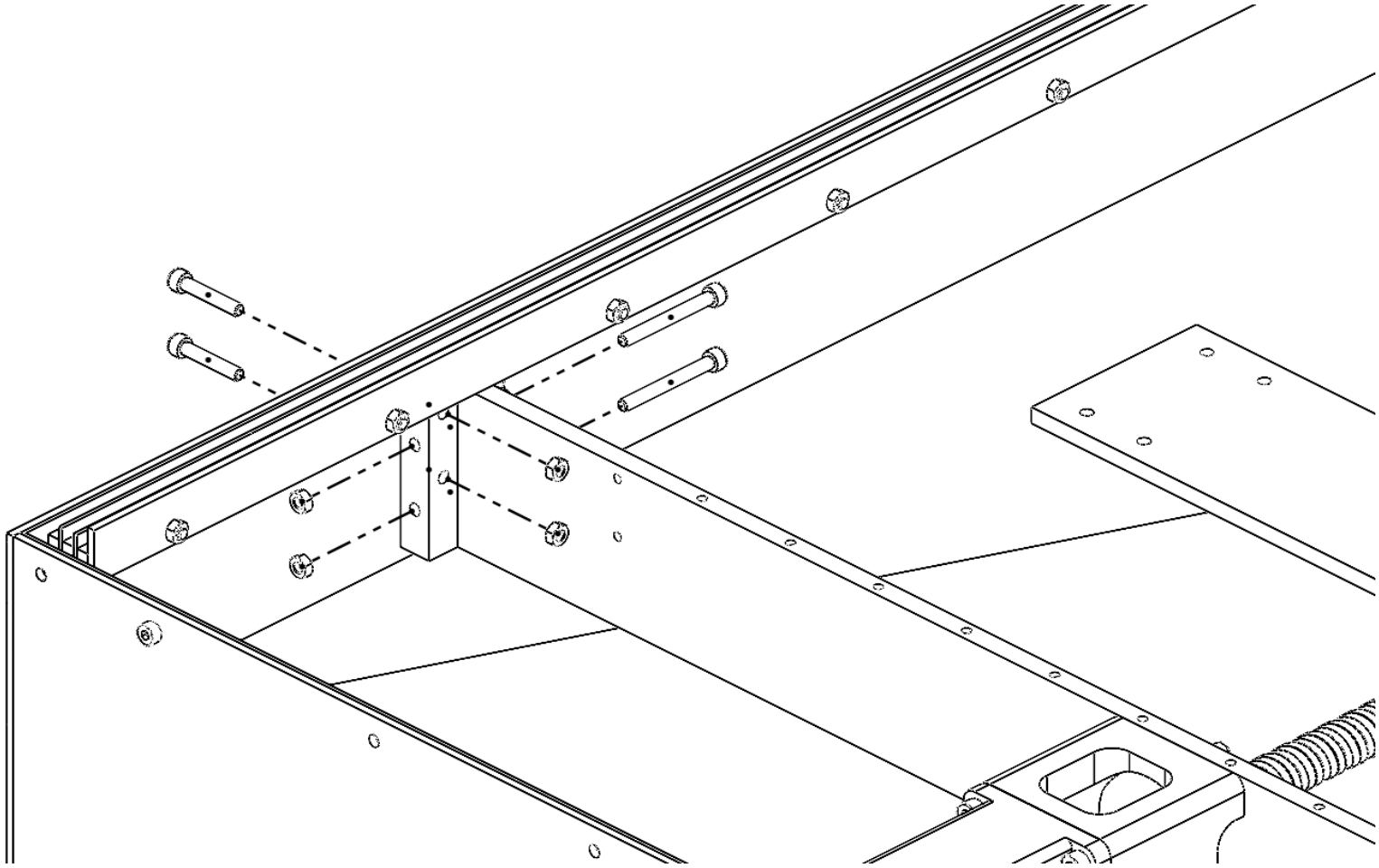




STEP 32 SECURE THE Y-FRONT PLATE WITH THE FRONT RIGHT BRACKETS FOR WEIGHT SUPPORT

- Brackets for Weight Support
- ISO 4762 M4 x 25 - 25N x2, • ISO 4762 M4 x 40 - 20N x2, • ISO - 4032 - M4 Nut x4

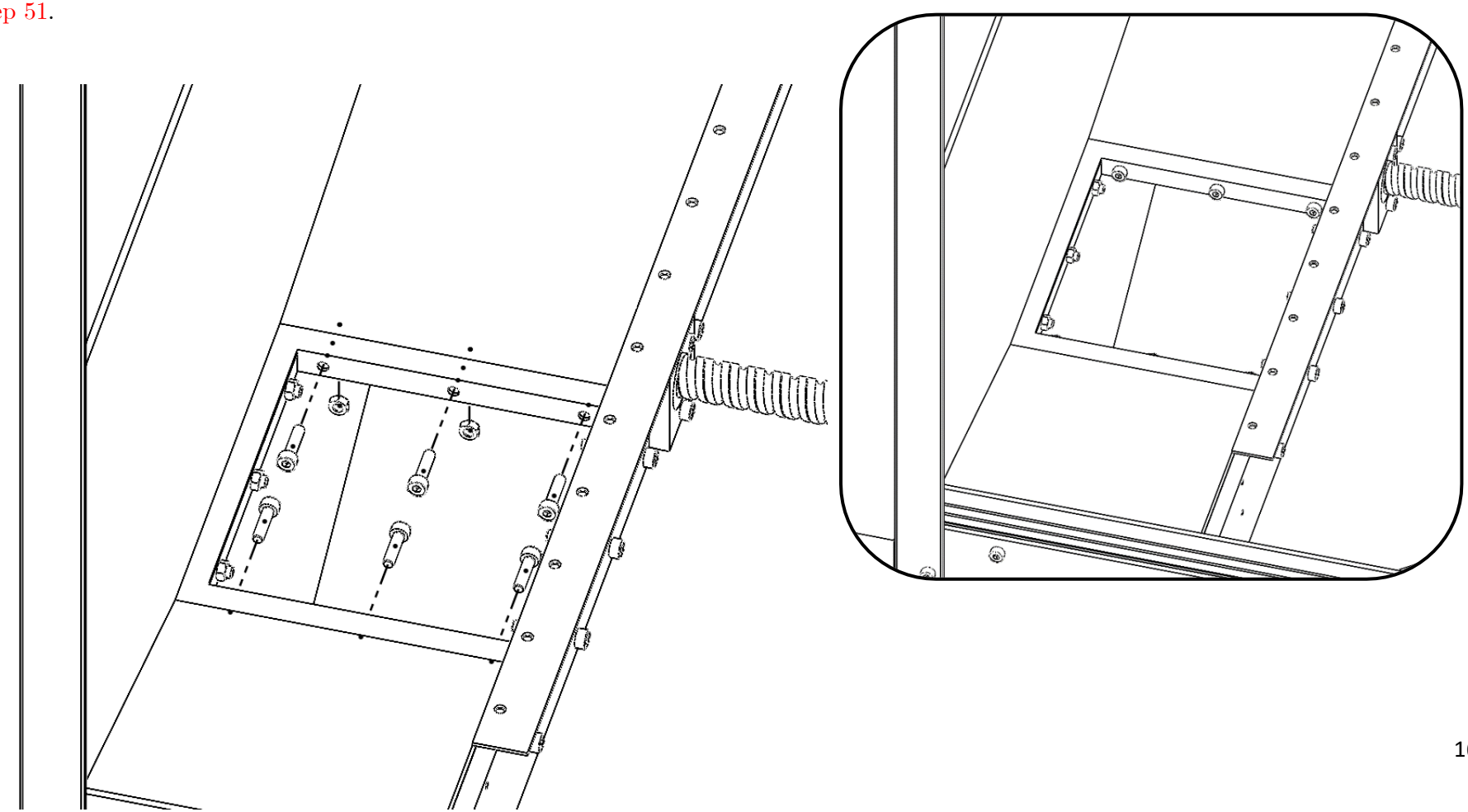
Repeat the process for the other front corner.



STEP 33 ADD THE CHIP TRAY

- Chip Tray
- ISO 4762 M4 x 16 - 16N x6, • ISO - 4032 - M4 Nut x6

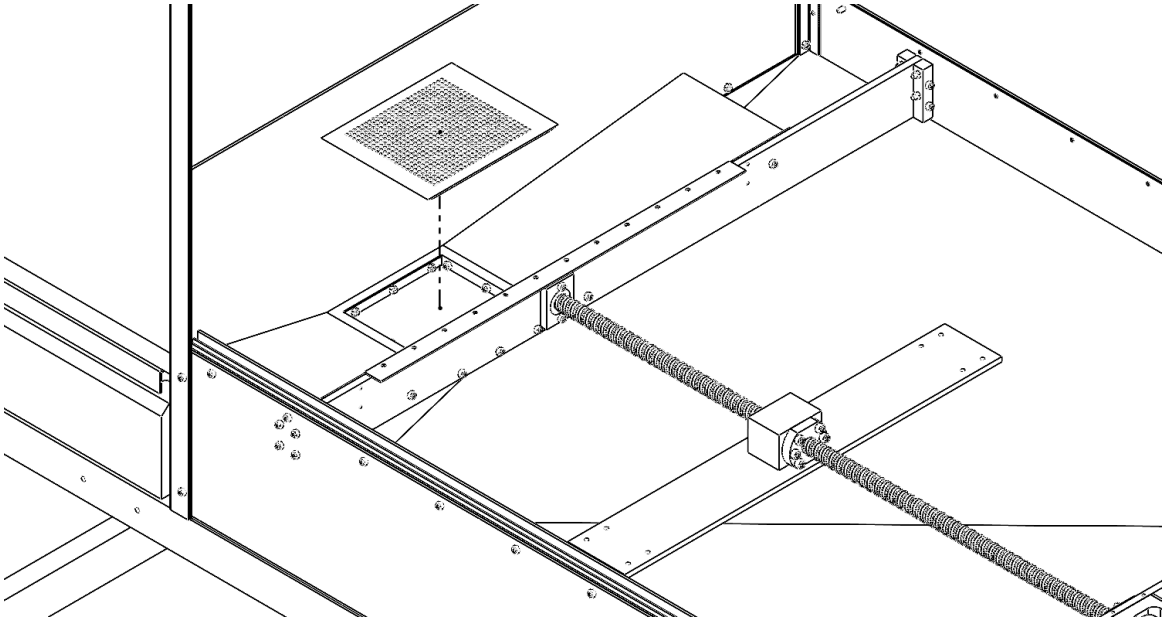
Attach the Chip Tray to the assembly using six M4 x 16 bolts and locking nuts (only two shown) through the left and right sides of the Reinforcement for Small Drain. Note: It may be a better order of operations to do Step 49 and 50 before adding the Chip Tray to the assembly. It won't interfere with anything while sitting in place, and it will be less convenient to add it later. If you choose to add it now, then leave the second backing on the tape until Step 51.

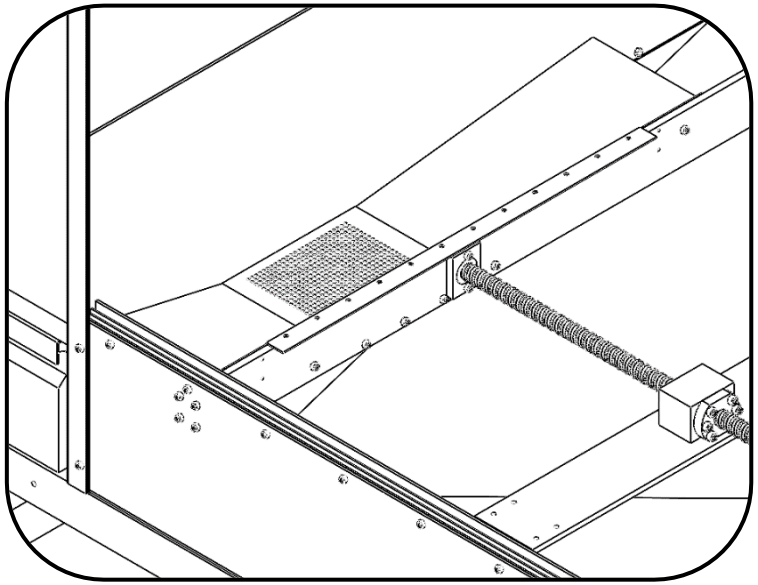


STEP 34 ADD THE DRAIN FOR THE CHIP TRAY

- Drain for Chip Tray

The Drain for Chip Tray sits inside the Chip Tray and covers the hardware.

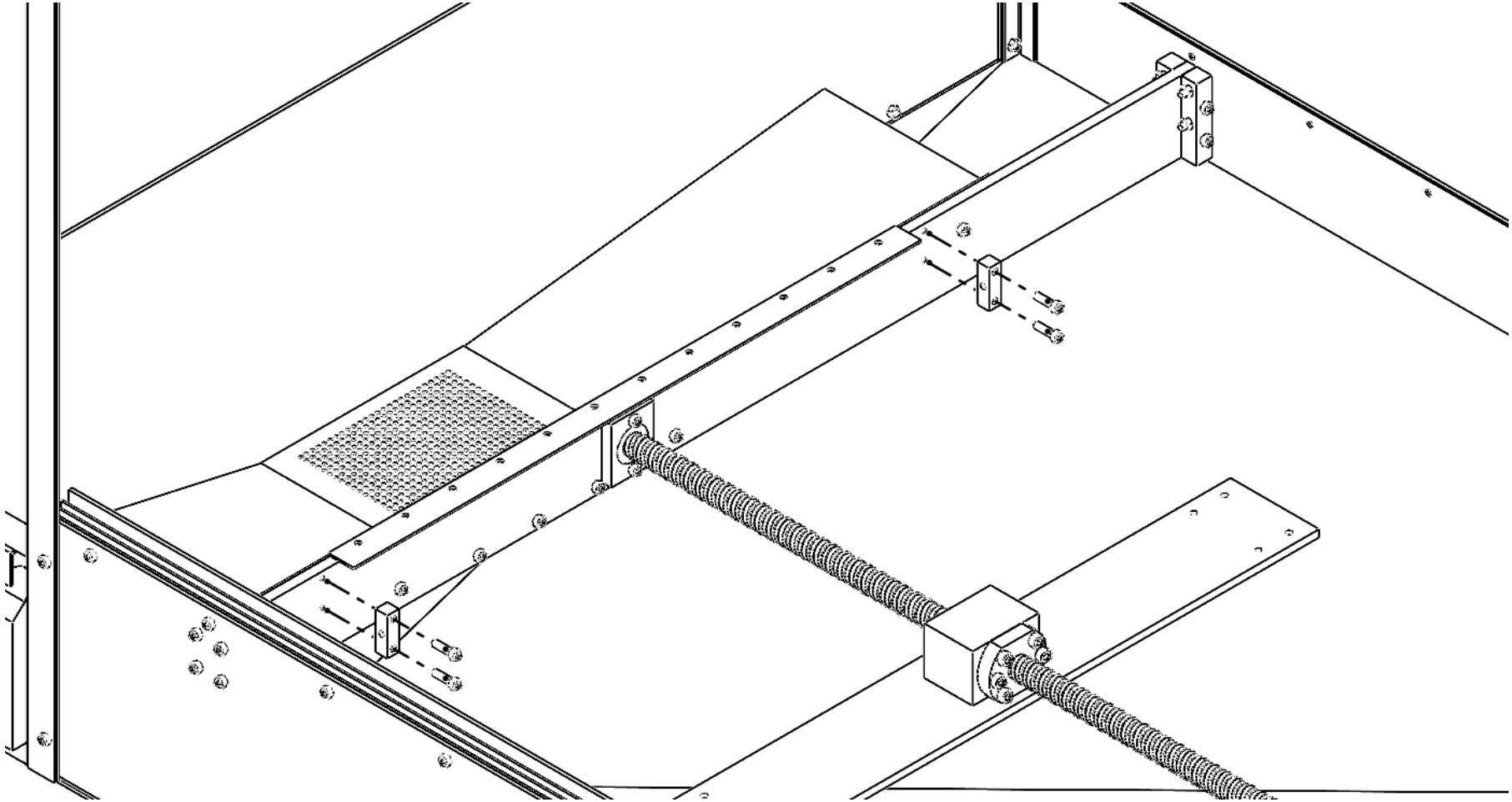




STEP 35 ADD THE BACK CORNER BLOCKS FOR THE BASE

- Corner Block for Base x2
- ISO 4762 M4 x 16 - 16N x4

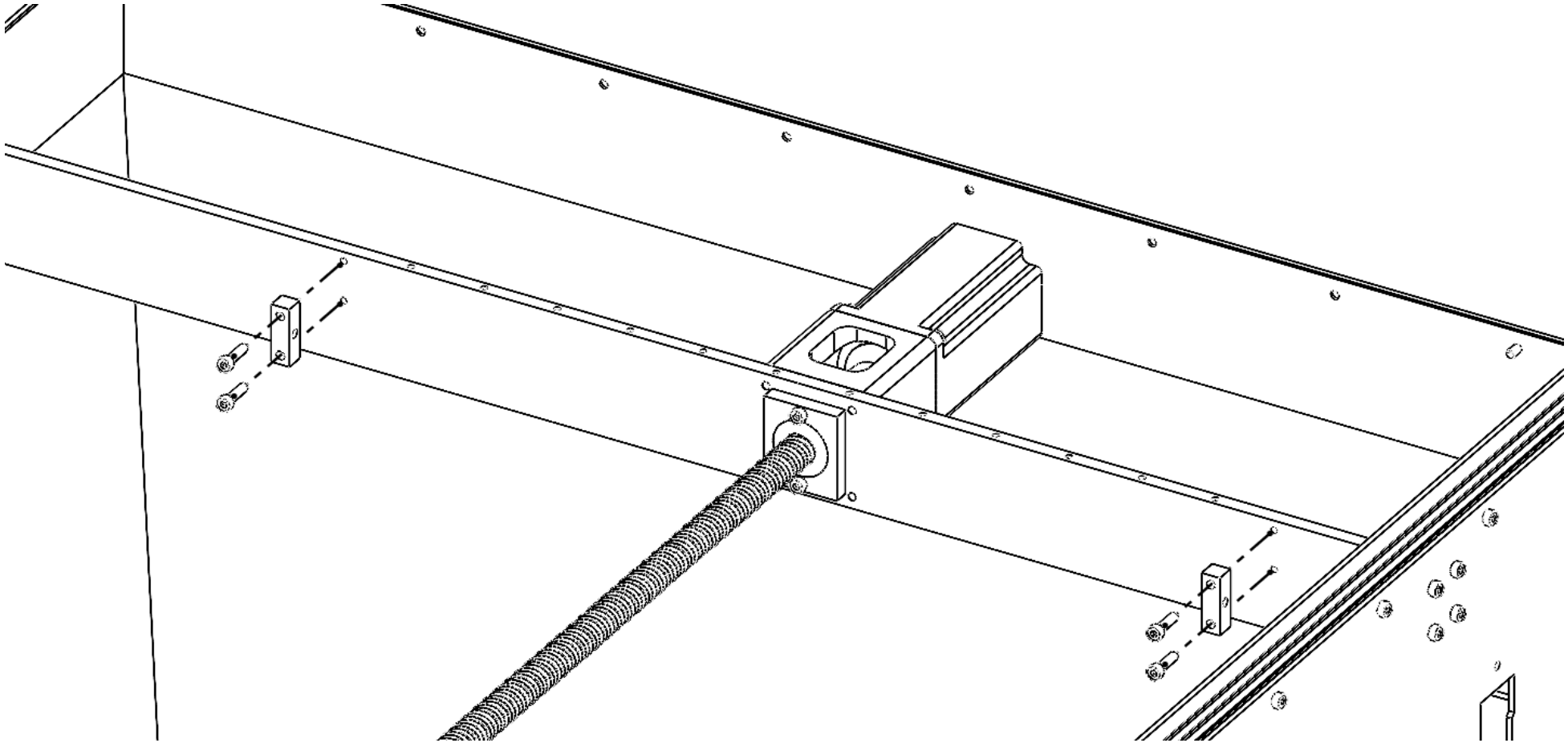
Add the corner blocks to the last remaining holes in the Y Back Plate using four M4 x 16 bolts



STEP 36 ADD THE FRONT CORNER BLOCKS FOR THE BASE

- Corner Block for Base x2
- ISO 4762 M4 x 16 - 16N x4

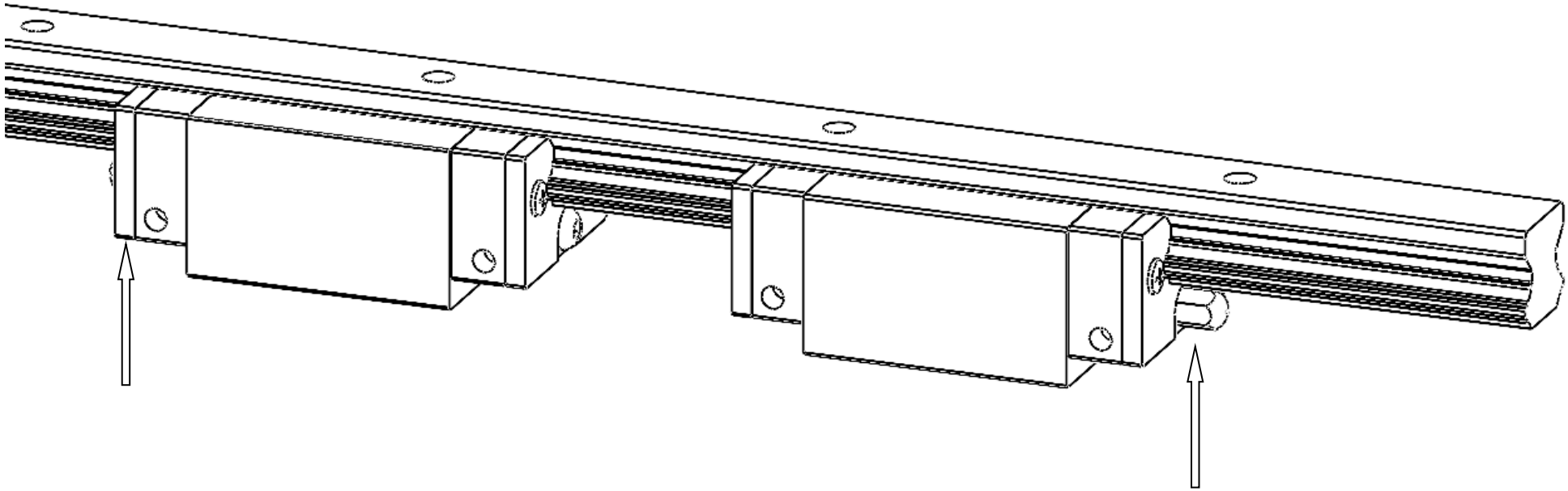
Repeat for the front side of the machine by adding the corner blocks to the last remaining holes in the Y Front Plate using four more M4 x 16 bolts



STEP 37 BEGIN THE LINEAR RAIL SUBASSEMBLY

• HGR15 780mm, • HGH15C x2

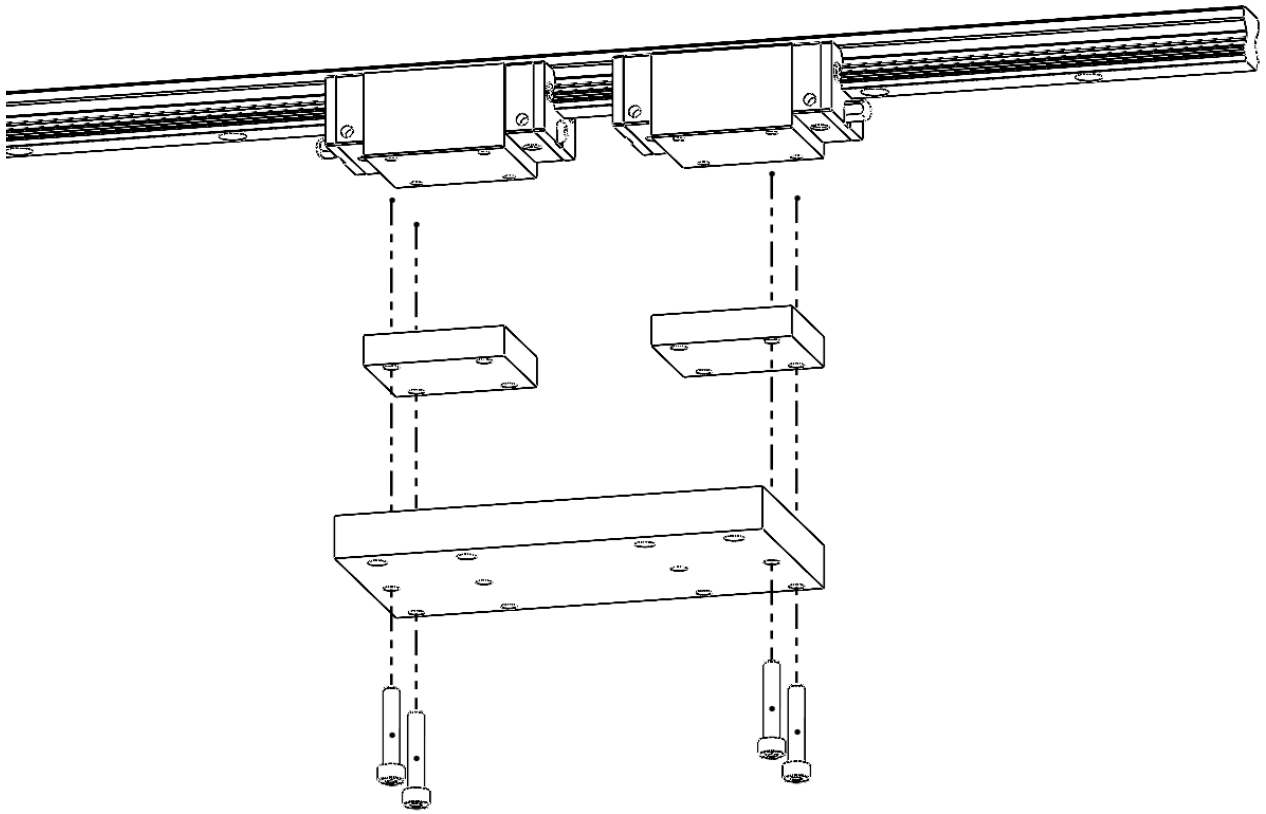
Slide two of the linear guides onto one of the 780mm linear rails. Make sure the grease nipples (see arrows below) are oriented away from each other.



STEP 38 ATTACH THE SPACER BLOCKS AND BOTTOM PLATE TO THE LINEAR RAIL SUBASSEMBLY

- Y Bottom Plate for Rails, • Y Spacer Block x2
- ISO 4762 M4 x 22 Modified x4

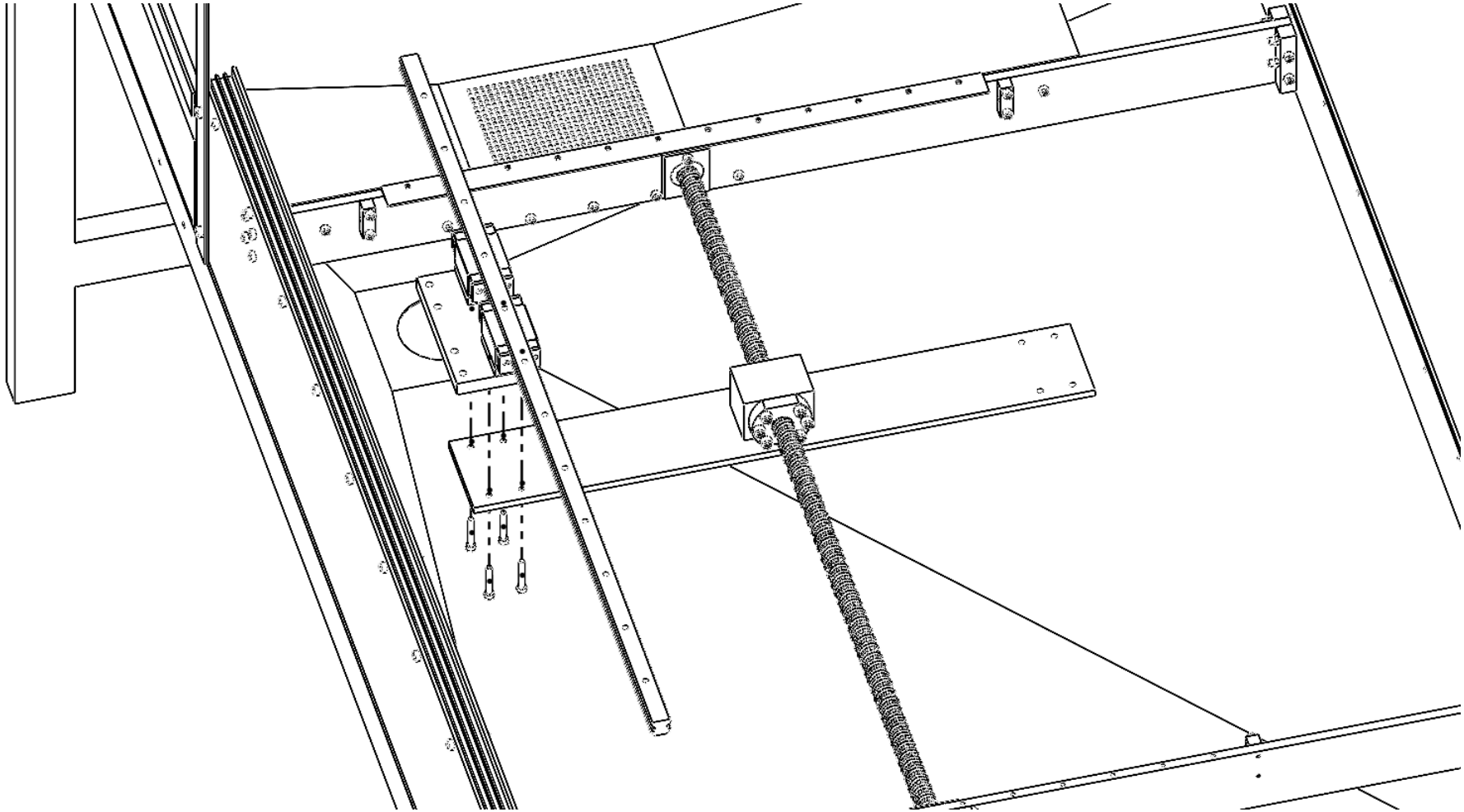
Connect the bottom plate and two of the spacer blocks to the subassembly using four M4 x 22 bolts. Only the outside holes are used for this step, so to prevent deformation, do not tighten the bolts completely. They will be fully tightened in the next step after the other four holes are filled. Note: M4 x 22mm bolts are necessary for this step since 25mm bolts are too long for the tapped holes in the linear guides, and 20mm bolts do not meet the minimum thread engagement.



STEP 39 CONNECT THE LINEAR RAIL SUBASSEMBLY TO THE MAIN ASSEMBLY

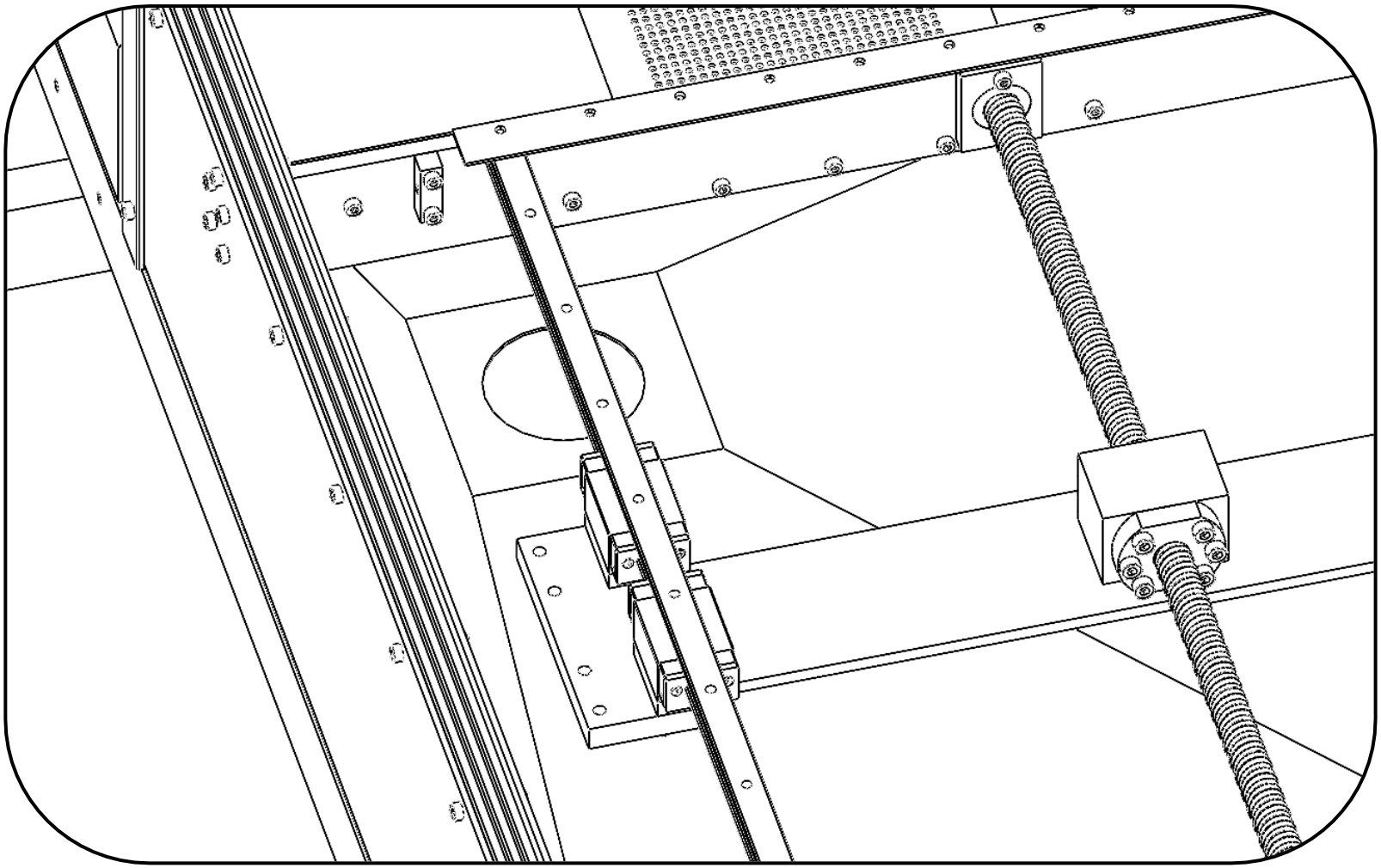
- ISO 4762 M4 x 28 - Modified x4

Attach the subassembly from Step 16 to the Y Bottom Plate for Screw using four M4 x 28 bolts. Note: Once again, M4 x 28mm bolts are necessary for this step since 30mm bolts are too long for the tapped holes in the linear guides, and 25mm bolts do not meet the minimum thread engagement.



STEP 40 TIGHTEN BOLTS TO SECURE THE LINEAR GUIDES TO THE LINEAR RAIL

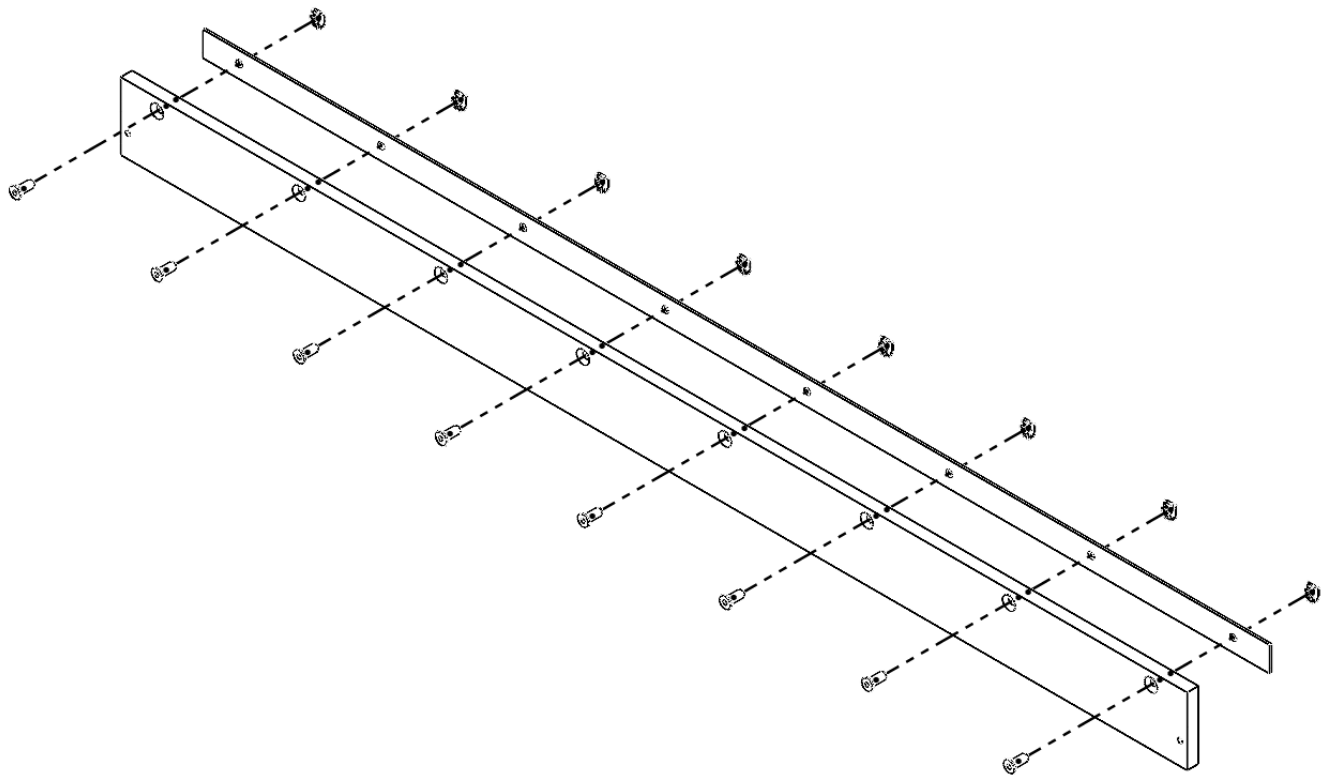
Now all eight bolts connecting the linear guides to the assembly (including the four M4 x 22 bolts that were not fully tightened during Step 38) can be fully tightened.



STEP 41 BEGIN THE SIDE SUPPORT SUBASSEMBLY FOR THE LEFT SIDE

- Side Supports for Base, • Rubber Gaskets for Base
- ISO 10642 - M4 x 15 - 15N x8, • 5mm T-Nut M4 x8

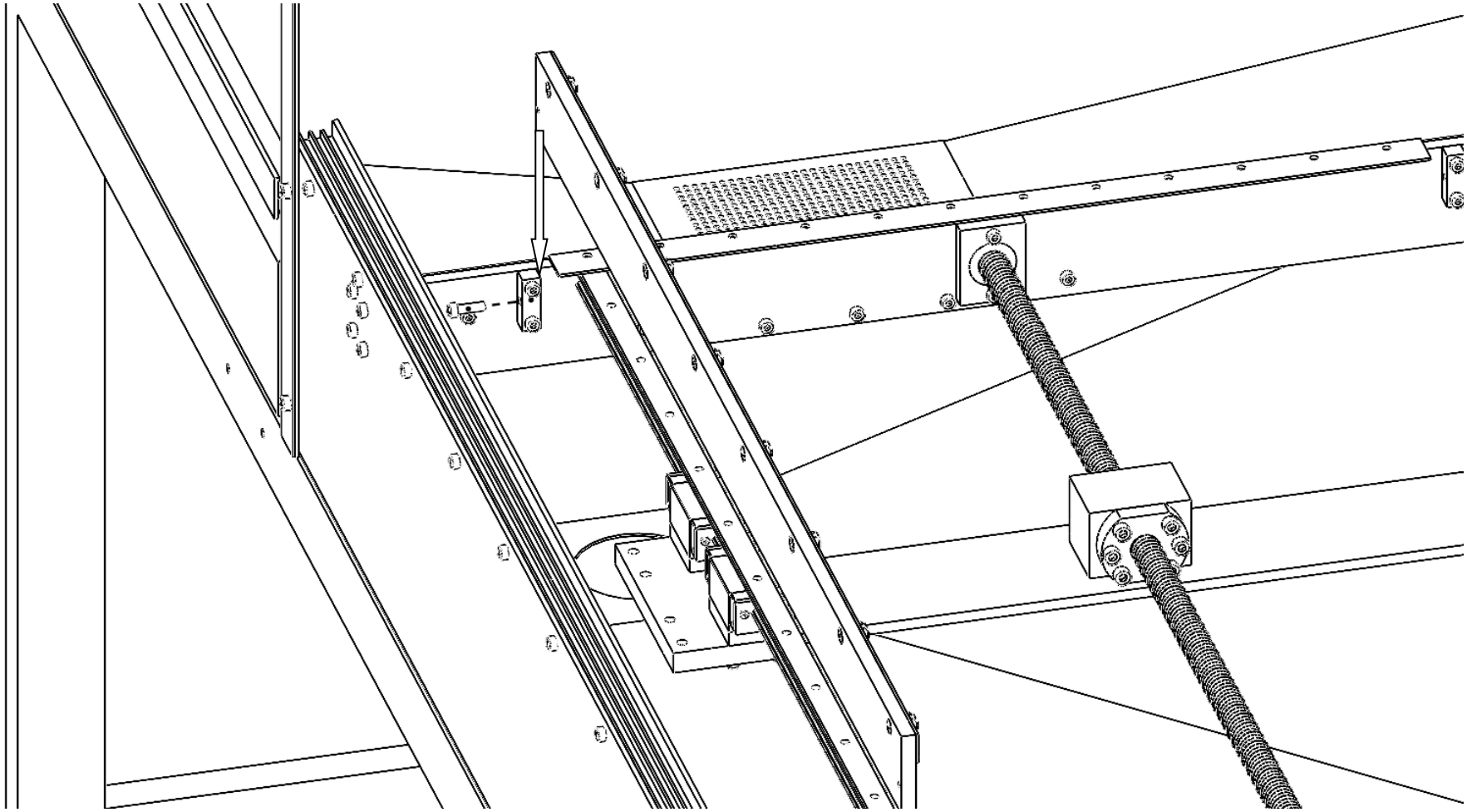
Connect the left side support and the rubber gasket by loosely threading eight of the M4 T-nuts onto eight of the countersunk M4 x 12 bolts. Note: these will be tightened later once they are in place.



STEP 42 CONNECT THE BACK OF THE SIDE SUPPORT SUBASSEMBLY TO THE MAIN ASSEMBLY

- ISO 4762 M4 x 16 - 16N

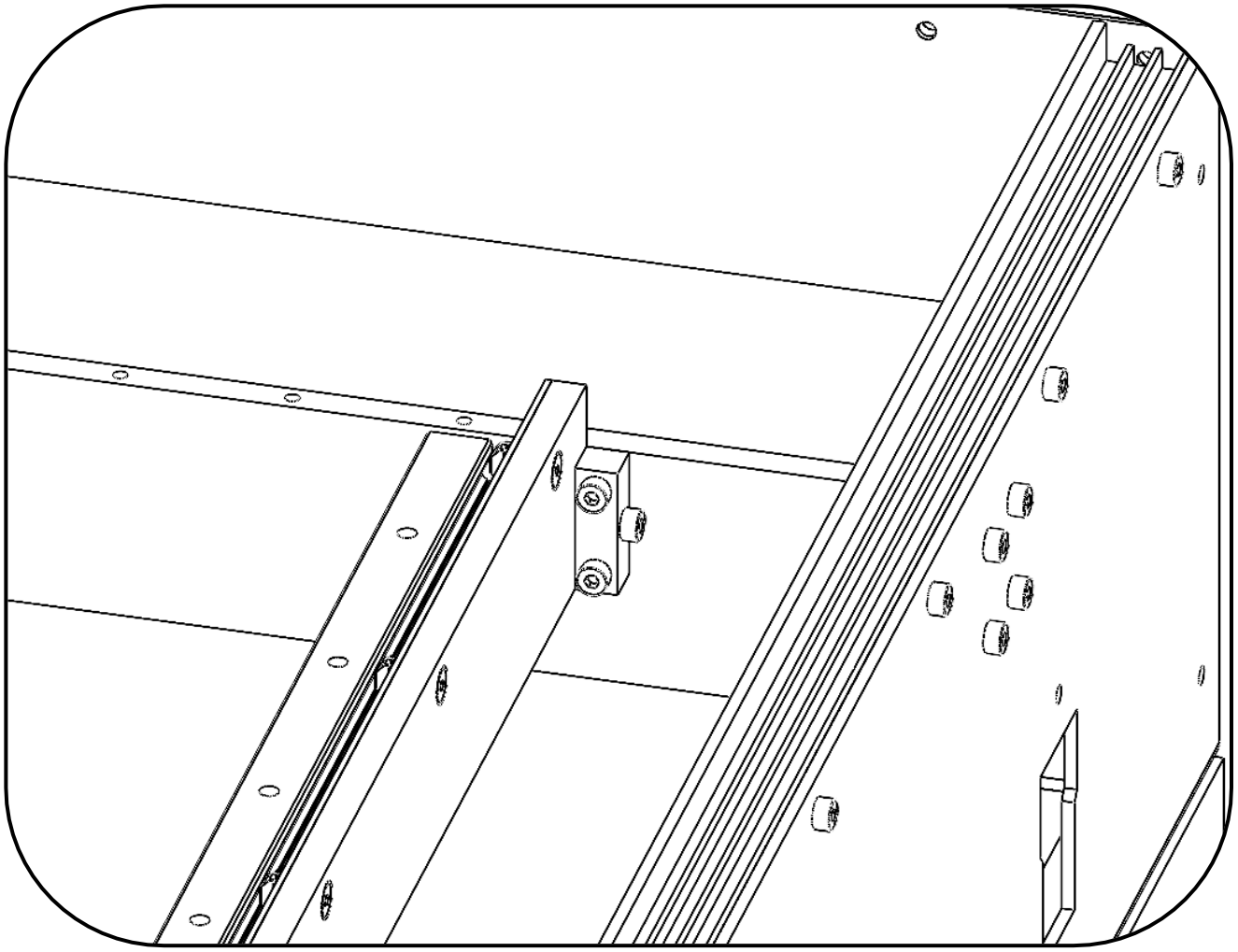
Lower the side support subassembly into the machine between the Y-front and back plates and secure it in place using an M4 x 16 bolt through the corner block from Step 34.



STEP 43 CONNECT THE FRONT OF THE SIDE SUPPORT SUBASSEMBLY TO THE MAIN ASSEMBLY

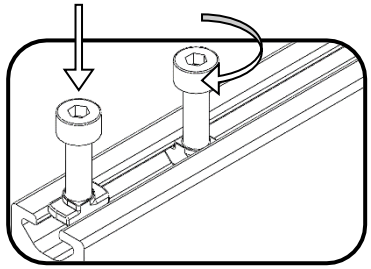
- ISO 4762 M4 x 16 - 16N

Repeat the same for the front side using another M4 x 16 bolt through the corner block from Step 36.

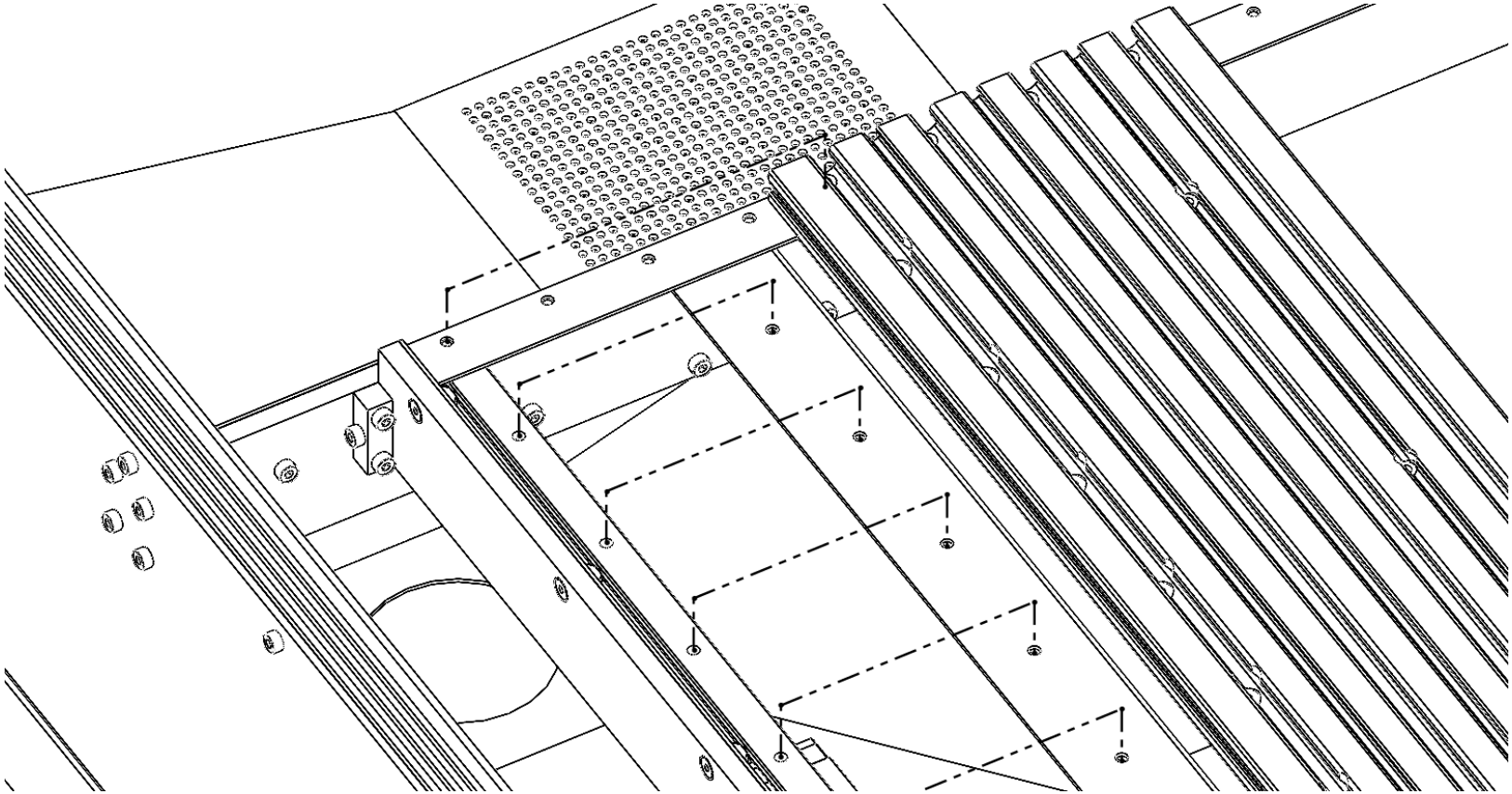


STEP 44 ATTACH THE LEFT T-NUT PLATE

• Y Axis Rail Guard, • T-Nut Plate 160x16 Left



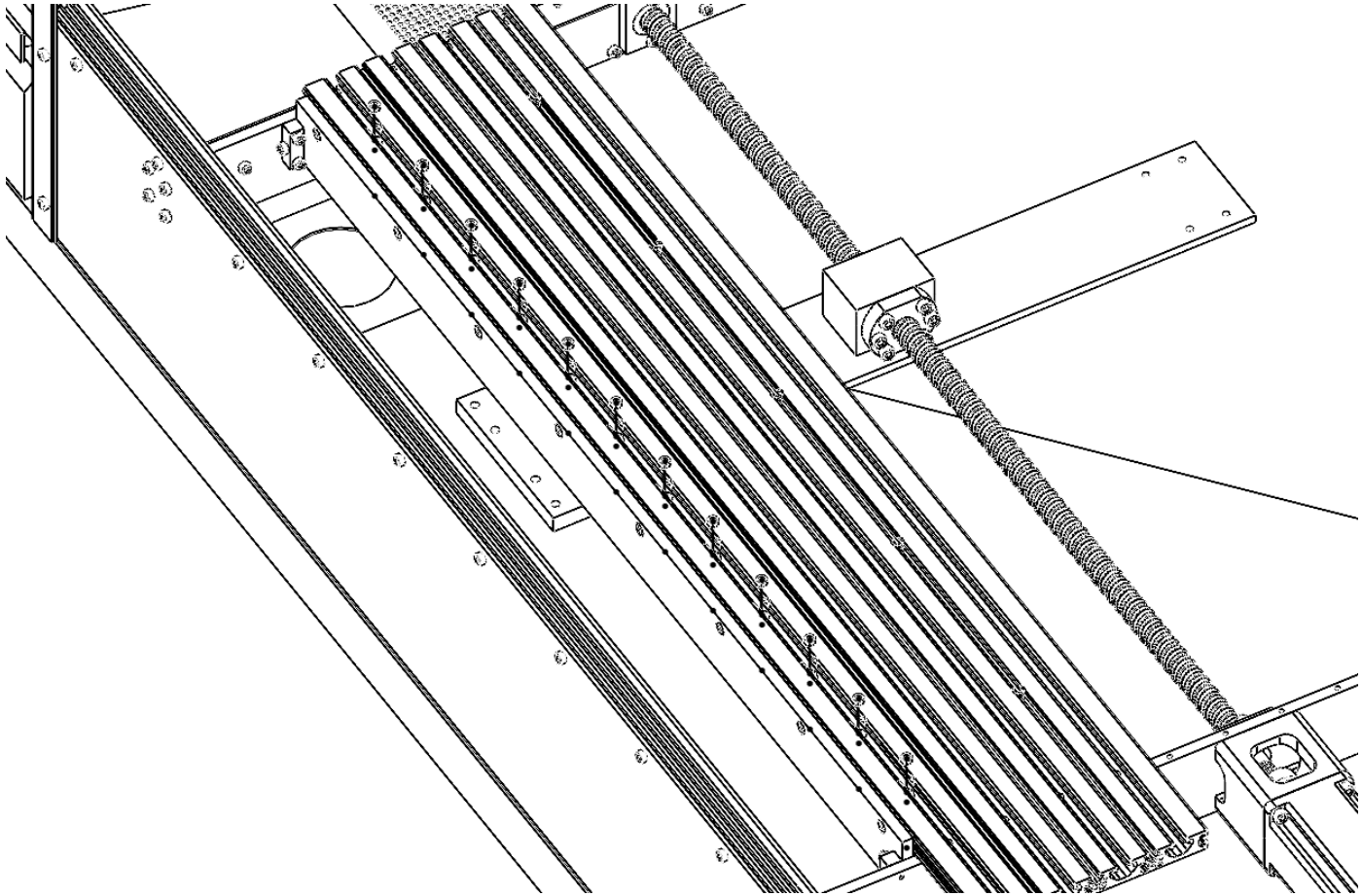
Slide the rail guard and the T-slot plate into place with the Chip Tray sandwiched between them. Slide them until the holes are aligned with the front and back plates at the front and back, and with the linear rail down the length of the machine. Note: The T-nuts will have to be loose and oriented horizontally. Also, the T-nut plate may have to be clamped to the side support to compress the rubber gasket enough to allow for hole alignment in the following steps.

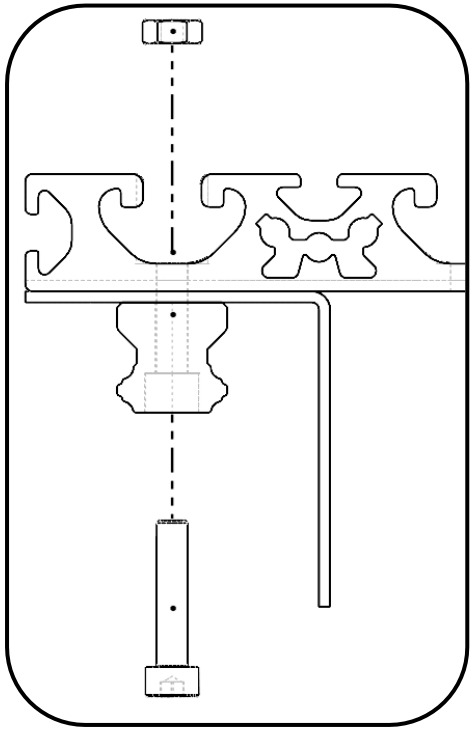


STEP 45 CONNECT THE LEFT T-NUT PLATE TO THE LEFT LINEAR RAIL

• ISO 4762 M4 x 20 - 20N x12, • ISO - 4032 - M4 Nut x12

Use 12 M4 x 20 bolts and locking nuts to connect the linear rail, axis guard and T-nut plate. Use the counter-bored holes in the linear rails from below as shown.

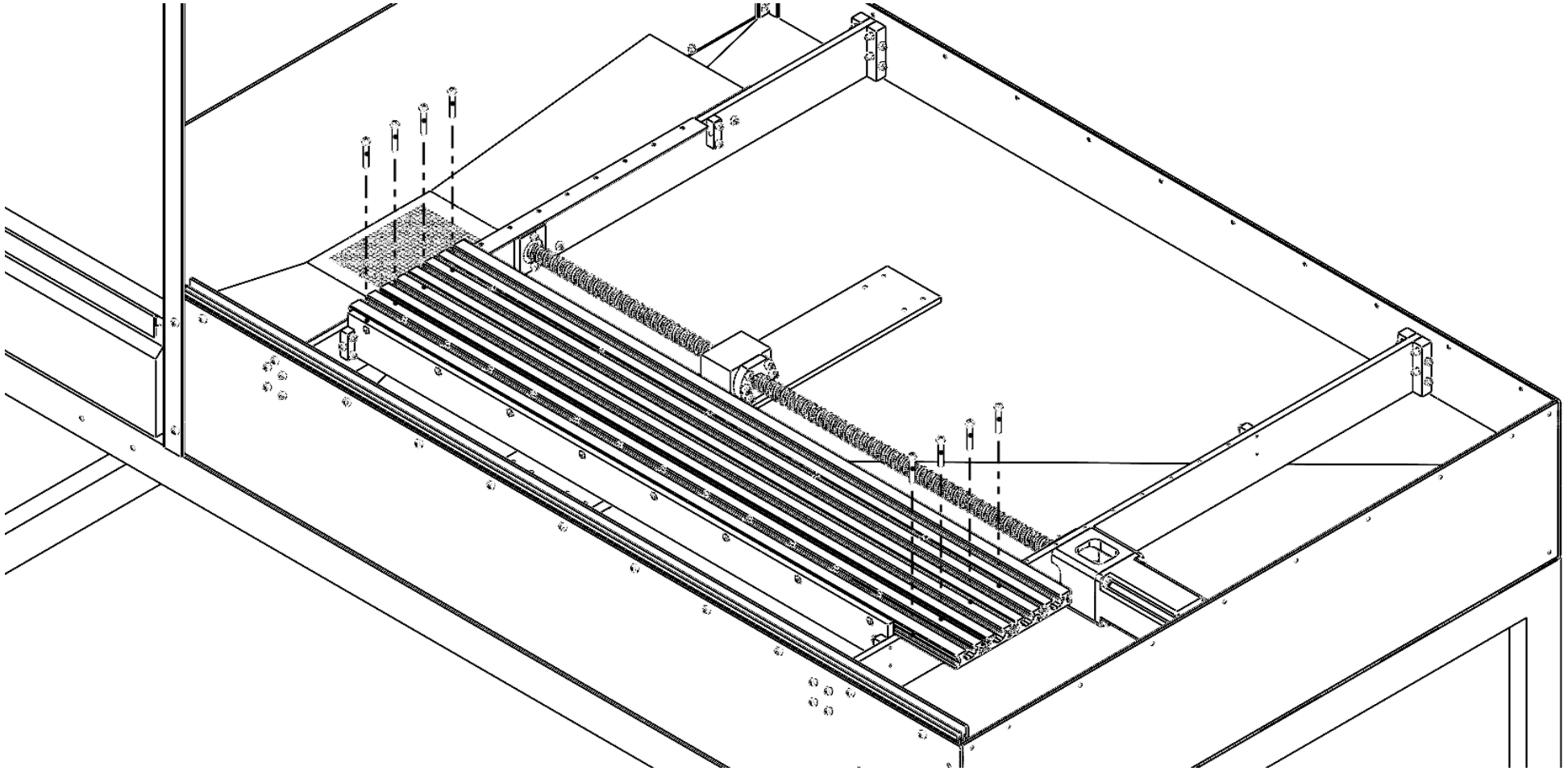




STEP 46 CONNECT THE LEFT T-NUT PLATE TO THE FRONT AND BACK PLATES

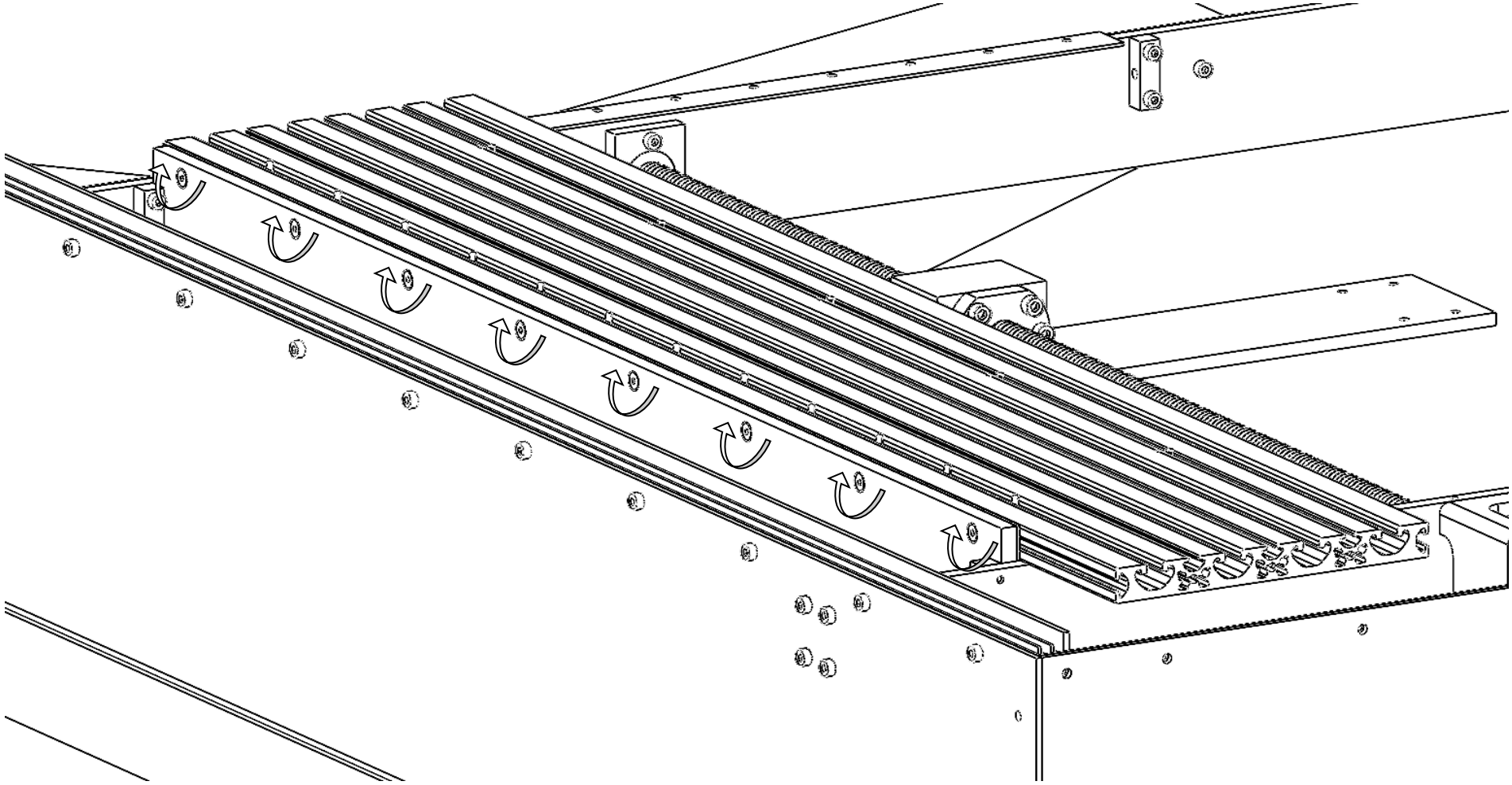
- ISO 4762 M4 x 30 - 30N x8

Secure the left T-slot plate to the front and back plates using four M4 x 30 bolts each



STEP 47 TIGHTEN T-NUTS TO SEAT THE RUBBER GASKET

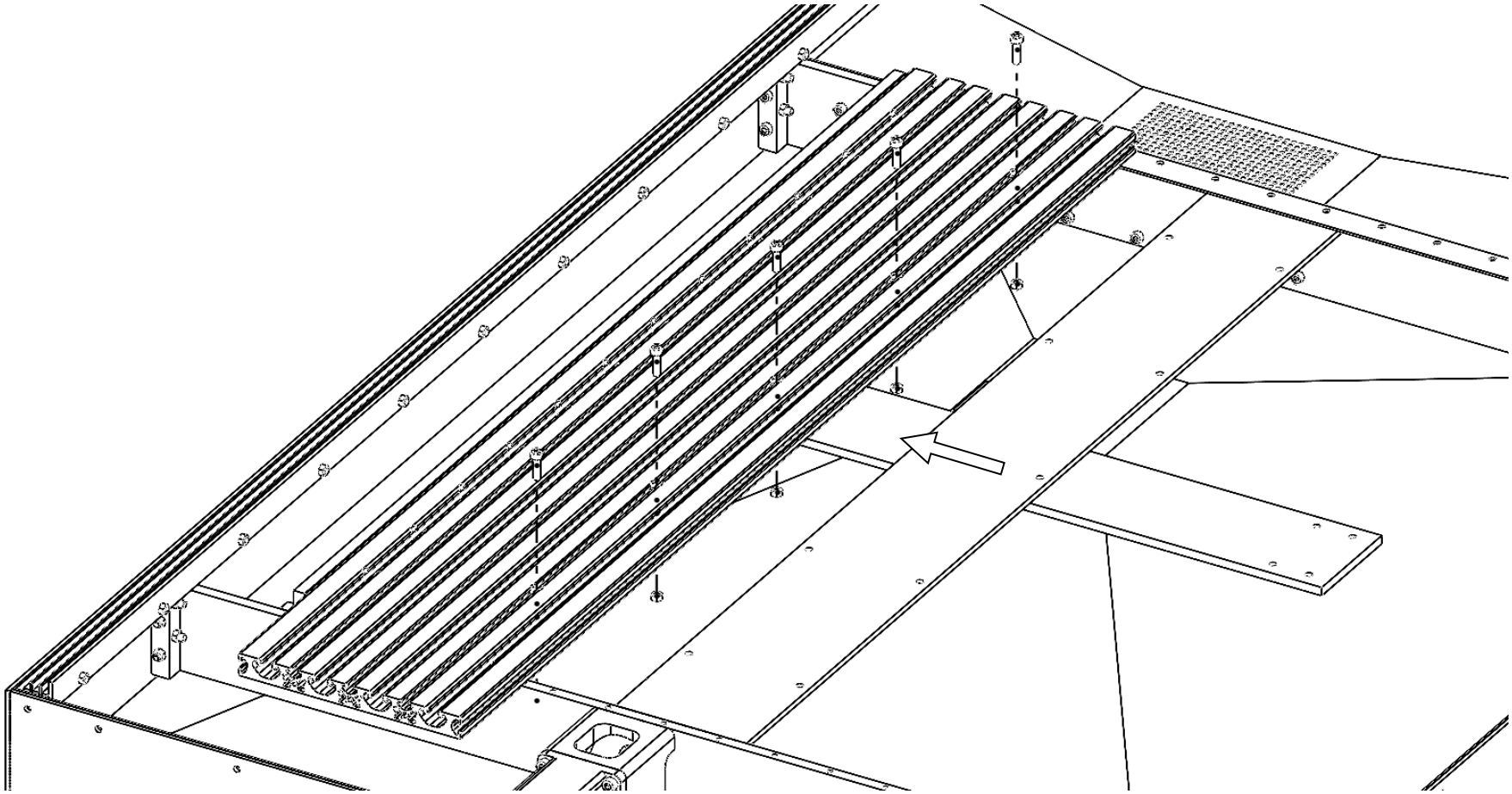
Finally, tighten the T-nuts from Step 41.to firmly seal the rubber gasket between the side support and the left T-nut plate.



STEP 48 CONNECT THE REINFORCEMENT TO THE LEFT T-NUT PLATE

- Reinforcements for Base
- ISO 4762 M4 x 16 - 16N x5, • ISO - 4032 - M4 Nut x5

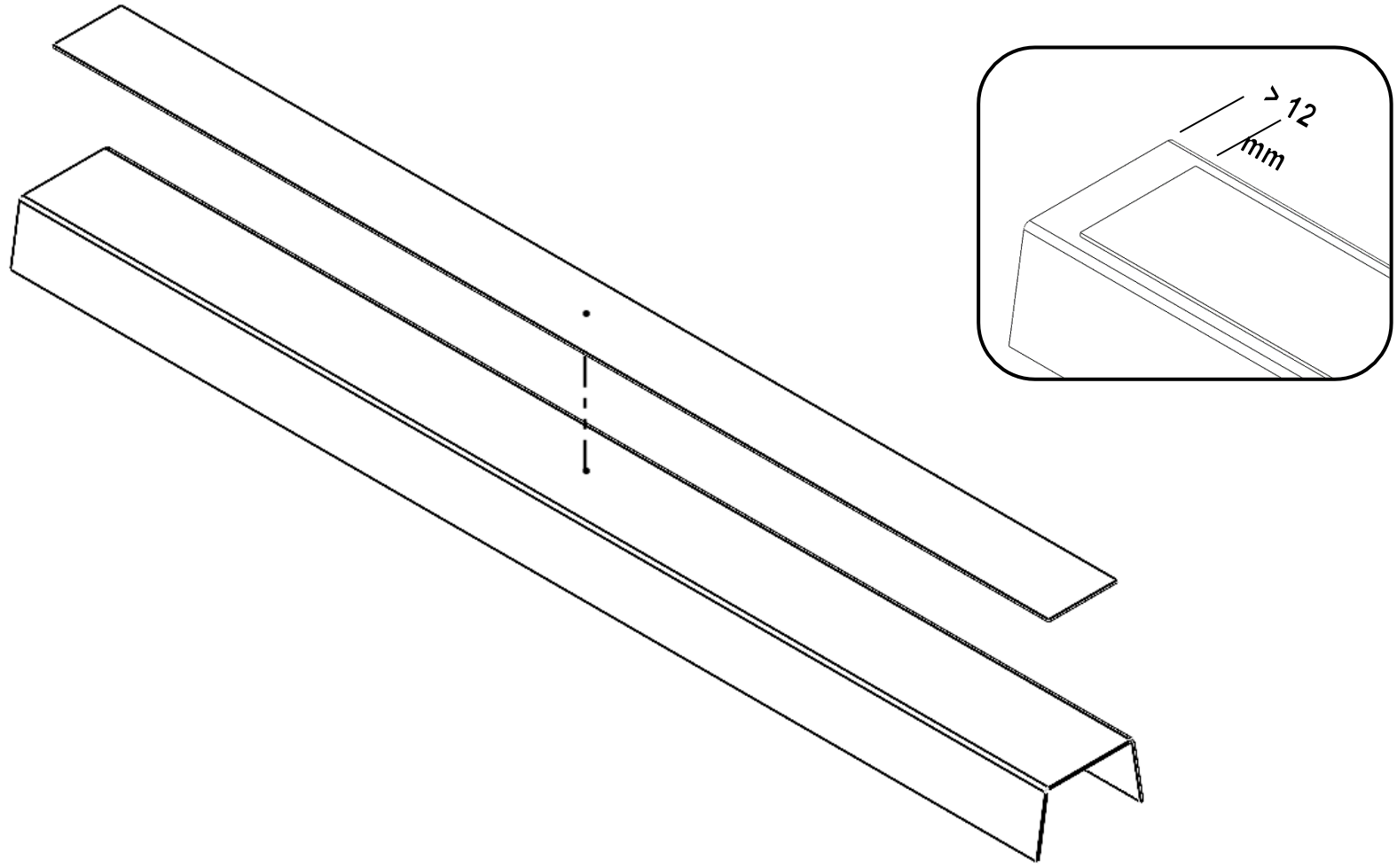
Slide the first of the reinforcements for the base into place beneath the left T-slot plate. Attach it to the assembly using five M4 x 16 bolts and locking nuts.



STEP 49 PREPARE THE Y-AXIS GUARD

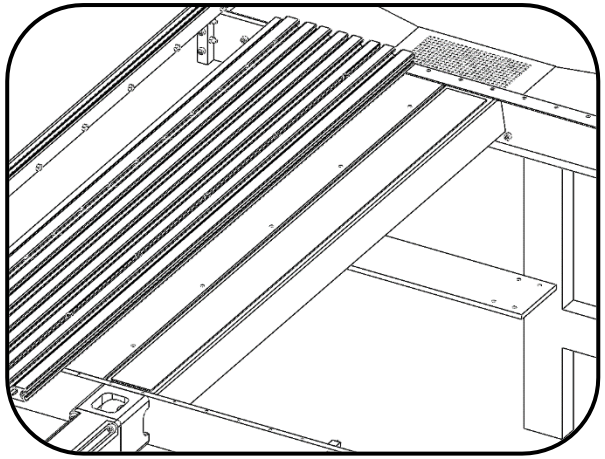
• Y Axis Guard, • Double Sided Tape

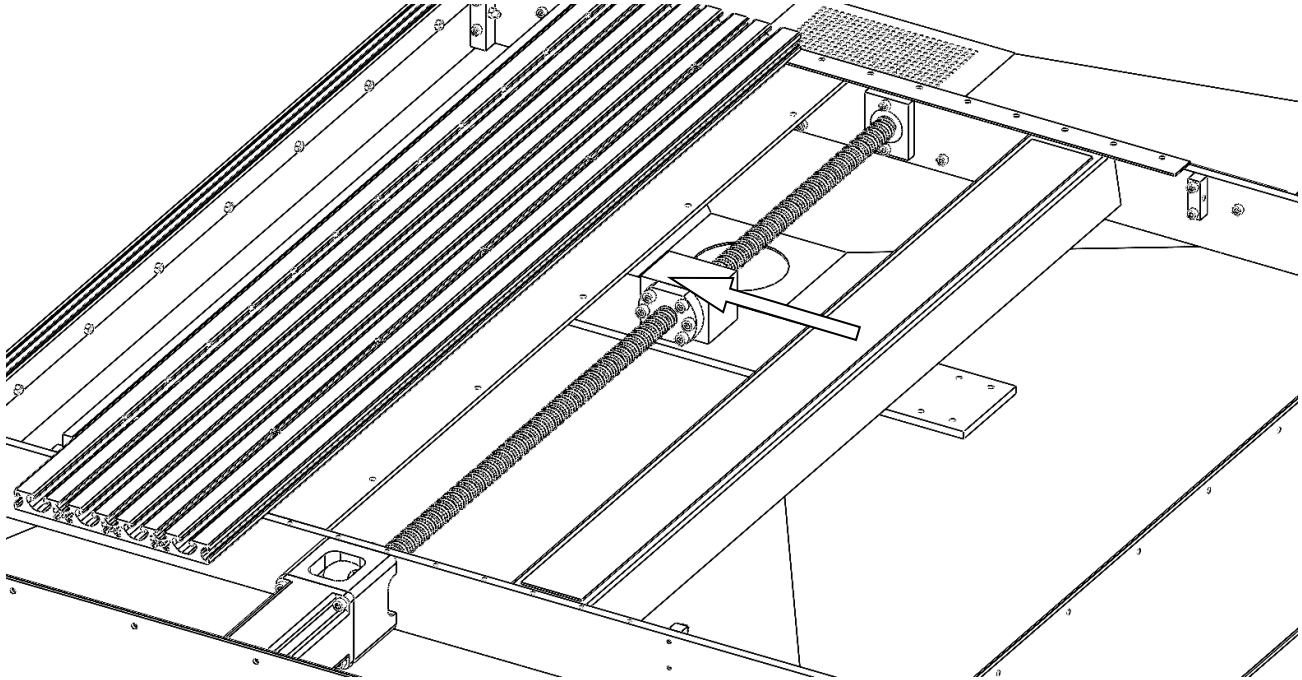
Attach the double-sided tape to the Y-axis guard leaving at least a 12 mm gap from the end on one side to leave room for the chip tray. Note: leave the second backing on the double-sided tape until you are ready to install the center T-slot plate in the next step.



STEP 50 PUT THE Y-AXIS GUARD INTO POSITION

Slide the taped Y-axis guard into place over the lead screw for the Y-axis and the nut block. This is a bit tricky since it needs to go between the front and back plates and under the exposed lip of the chip tray. For now, it will sit on top of the bearing blocks, about 7 mm below its final location (taped to the center T-slot plate) and will not be attached to anything until Step 54.

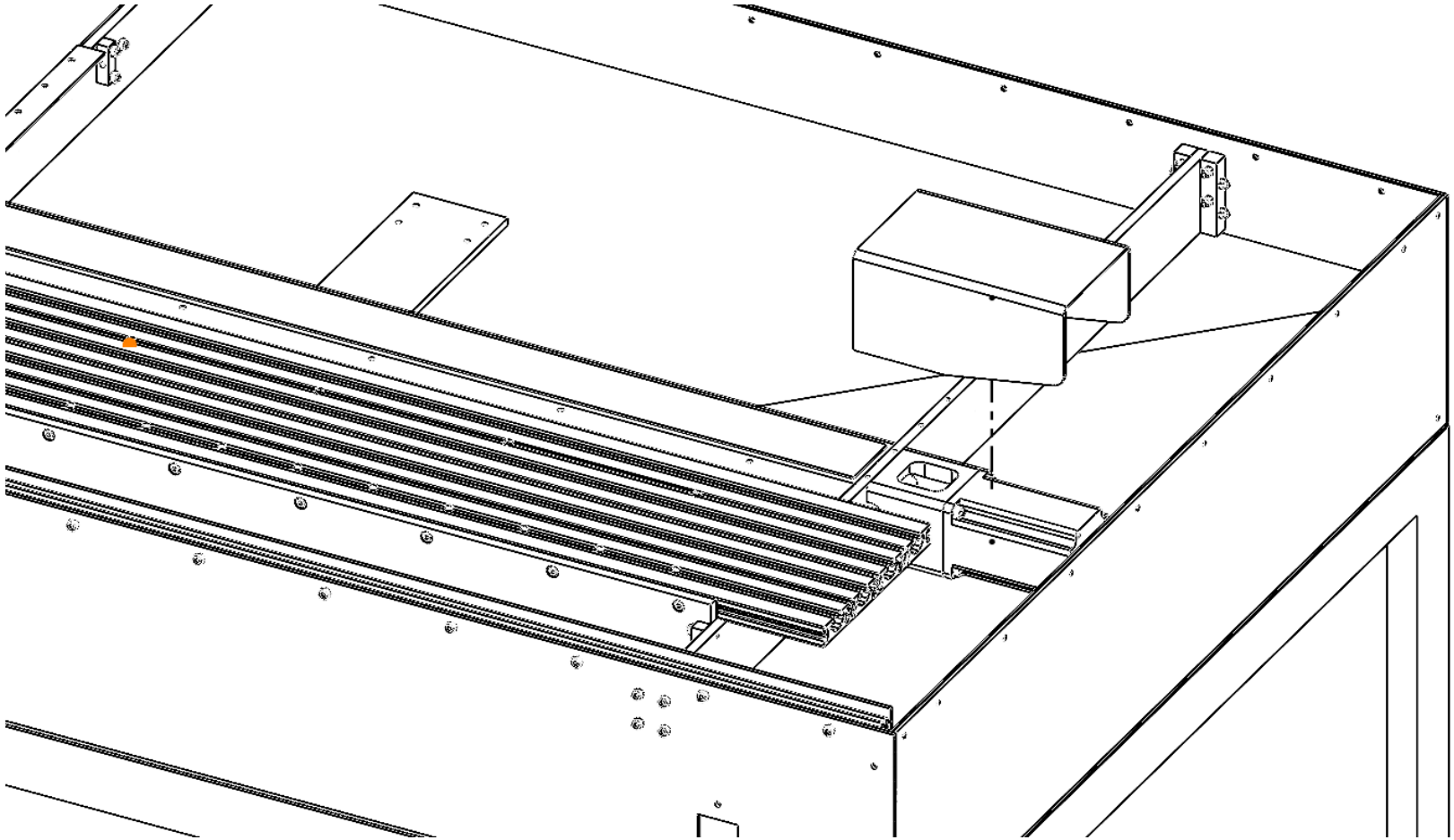




STEP 51 PUT THE COVER FOR THE Y-AXIS MOTOR INTO POSITION

- Cover for Y-Motor

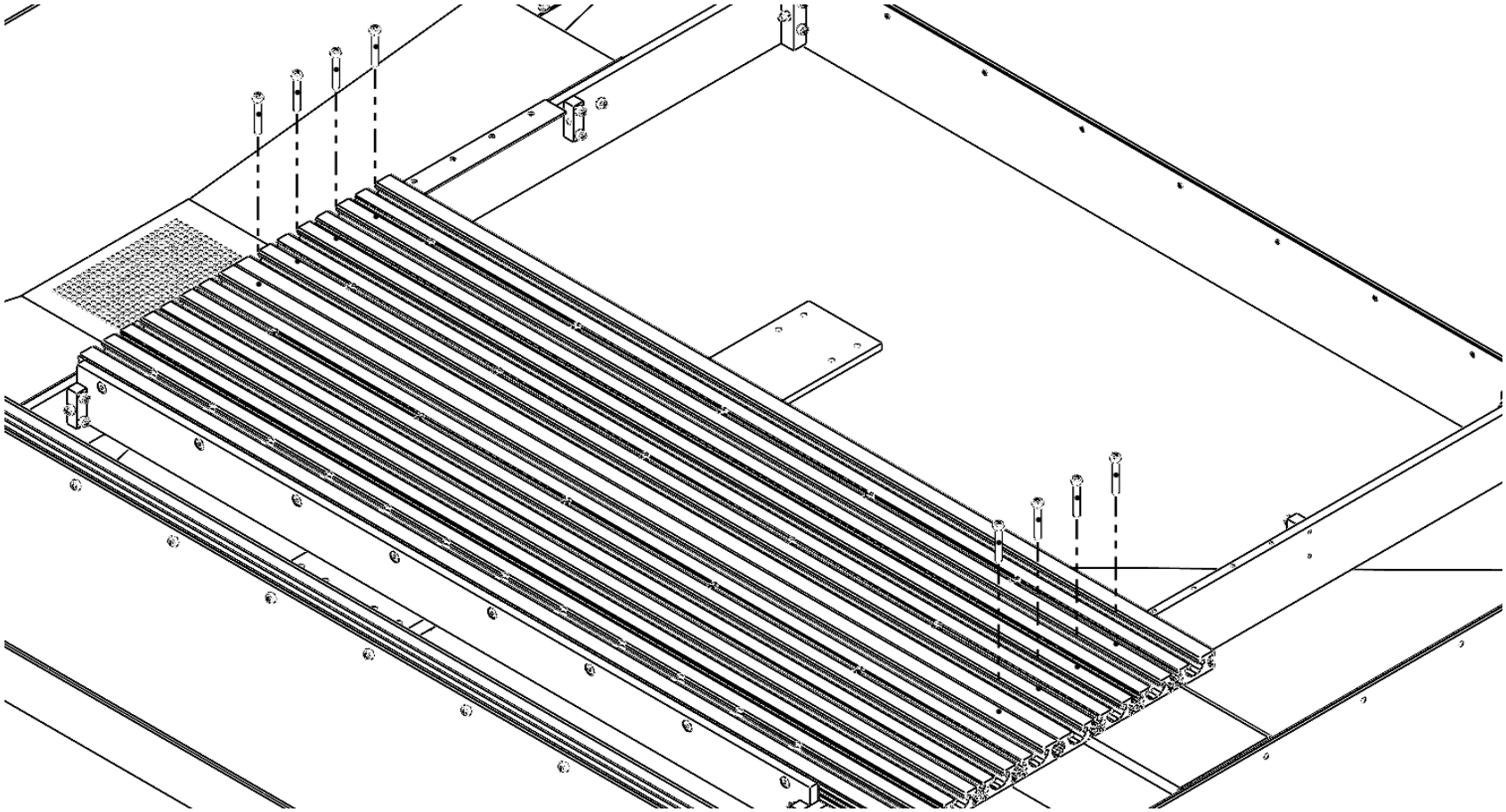
Install the cover for the Y-motor by simply setting it on top of the motor and adaptor. It will be somewhat loose at first, but it will be secured in the next step. Now is also the time to remove the second backing from the double-sided tape on the Y-axis guard in preparation for installing the central T-slot plate in the next step.



STEP 52 ATTACH THE CENTER T-NUT PLATE TO THE FRONT AND BACK PLATES

- T-Nut Plate 160x16 Left
- ISO 4762 M4 x 30 - 30N x8

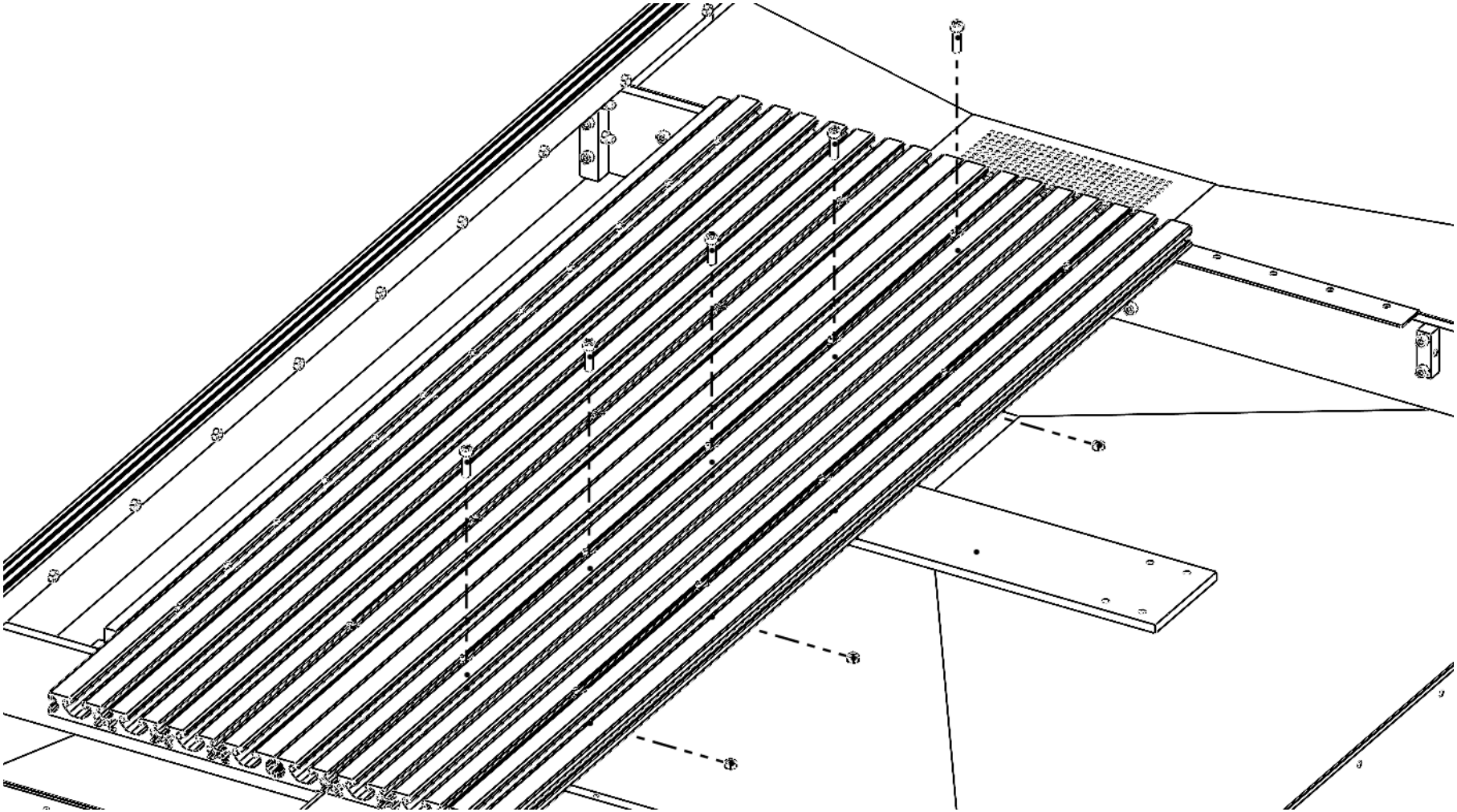
Now install the central T-slot plate and secure it to the front and back plates using another eight M4 x 30 bolts. This should secure the Cover for Y-Motor into place as well.



STEP 53 CONNECT THE REINFORCEMENT TO THE CENTER T-NUT PLATE

• ISO 4762 M4 x 16 - 16N x5, • ISO - 4032 - M4 Nut x5

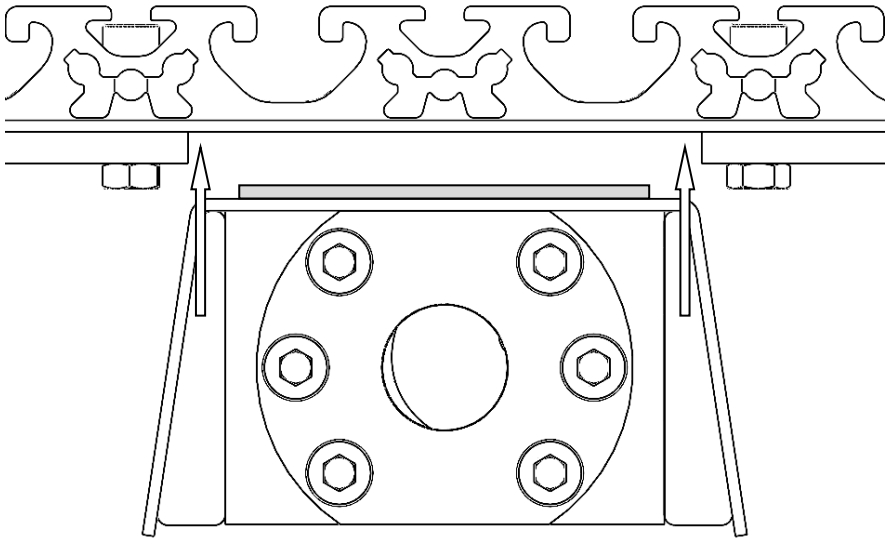
Attach the central T-slot plate to the Reinforcement for Base using another five M4 x 16 bolts and locking nuts.

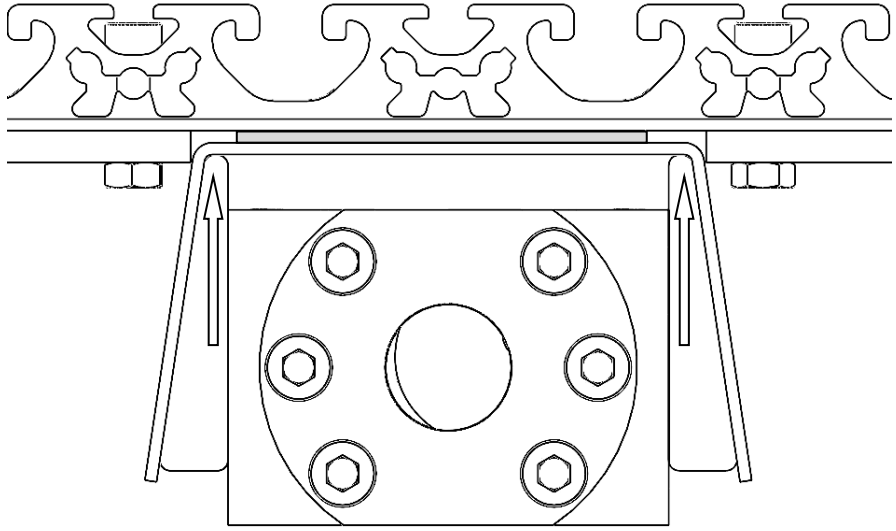


STEP 54 SECURE THE Y-AXIS GUARD TO THE CENTER T-NUT PLATE

- 3D Printed Spacers x2 (Shown with arrows below)

Using the sacrificial spacers to assist in proper placement, lift the Y-axis guard until the double-sided tape sticks securely to the central T-slot plate down the full length of the machine.

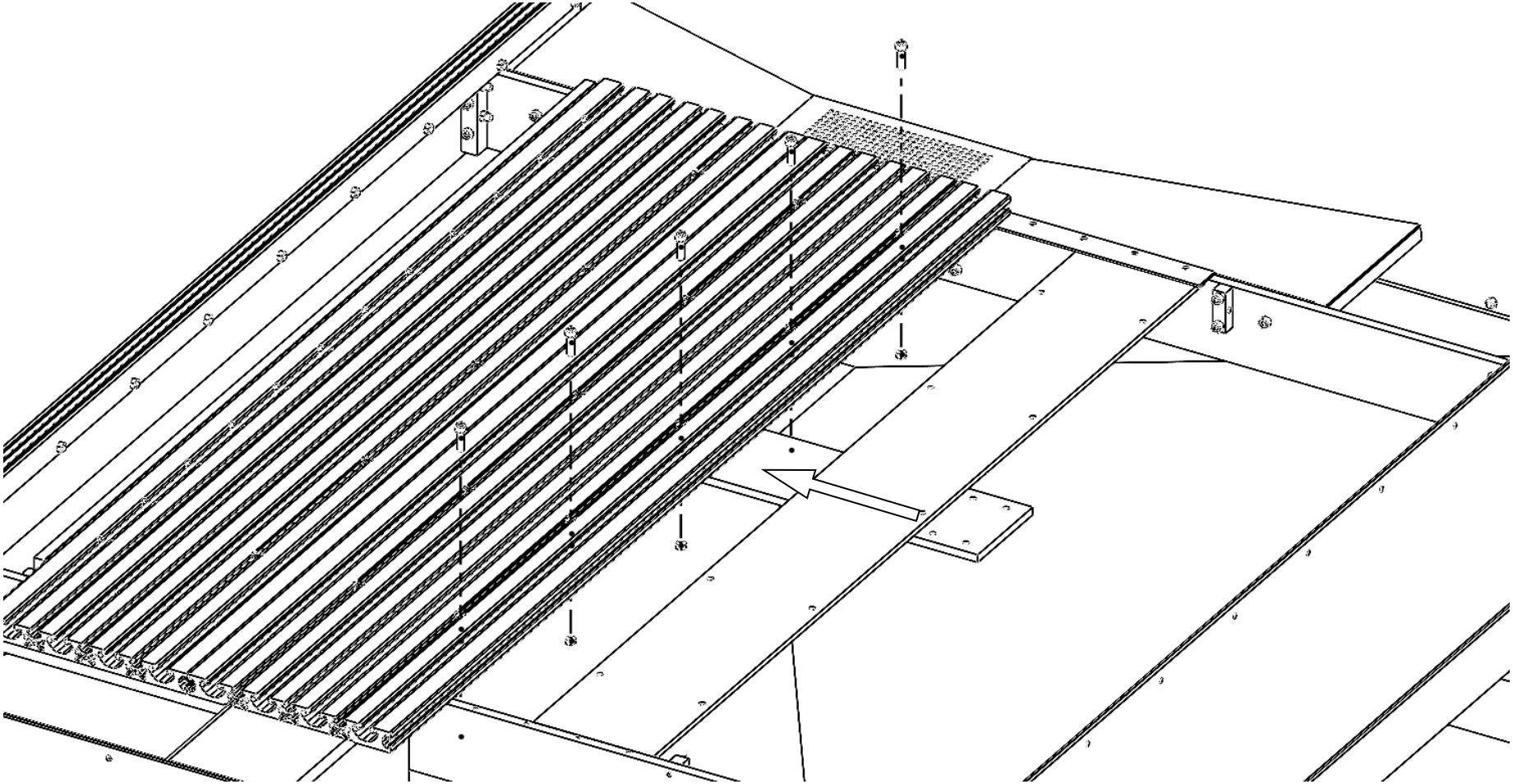




STEP 55 CONNECT THE OTHER REINFORCEMENT TO THE CENTER T-NUT PLATE

- Reinforcements for Base
- ISO 4762 M4 x 16 - 16N x5, • ISO - 4032 - M4 Nut x5

Attach the other of the Reinforcements for Base to the right side of the central T-slot plate using another five M4 x 16 bolts and locking nuts.

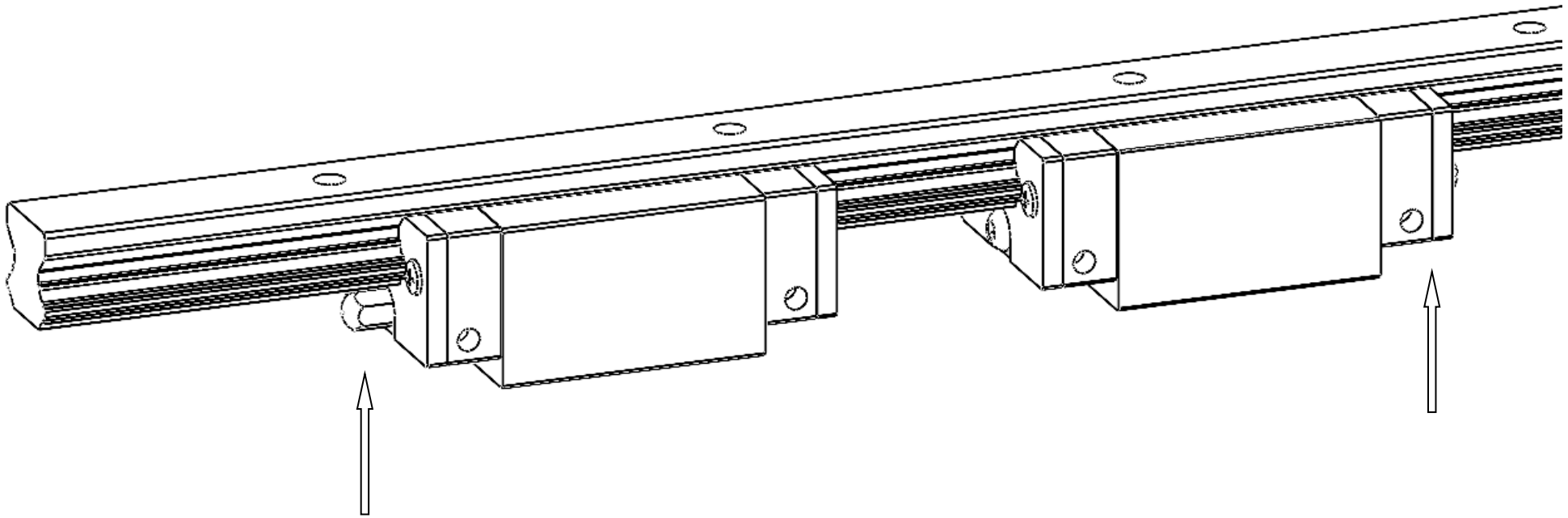


That takes care of the left and center plates. Now we will be more or less repeating Steps 37 - 47 for the right side this time.

STEP 56 BEGIN THE LINEAR RAIL SUBASSEMBLY

- HGR15 780mm, • HGH15C x2

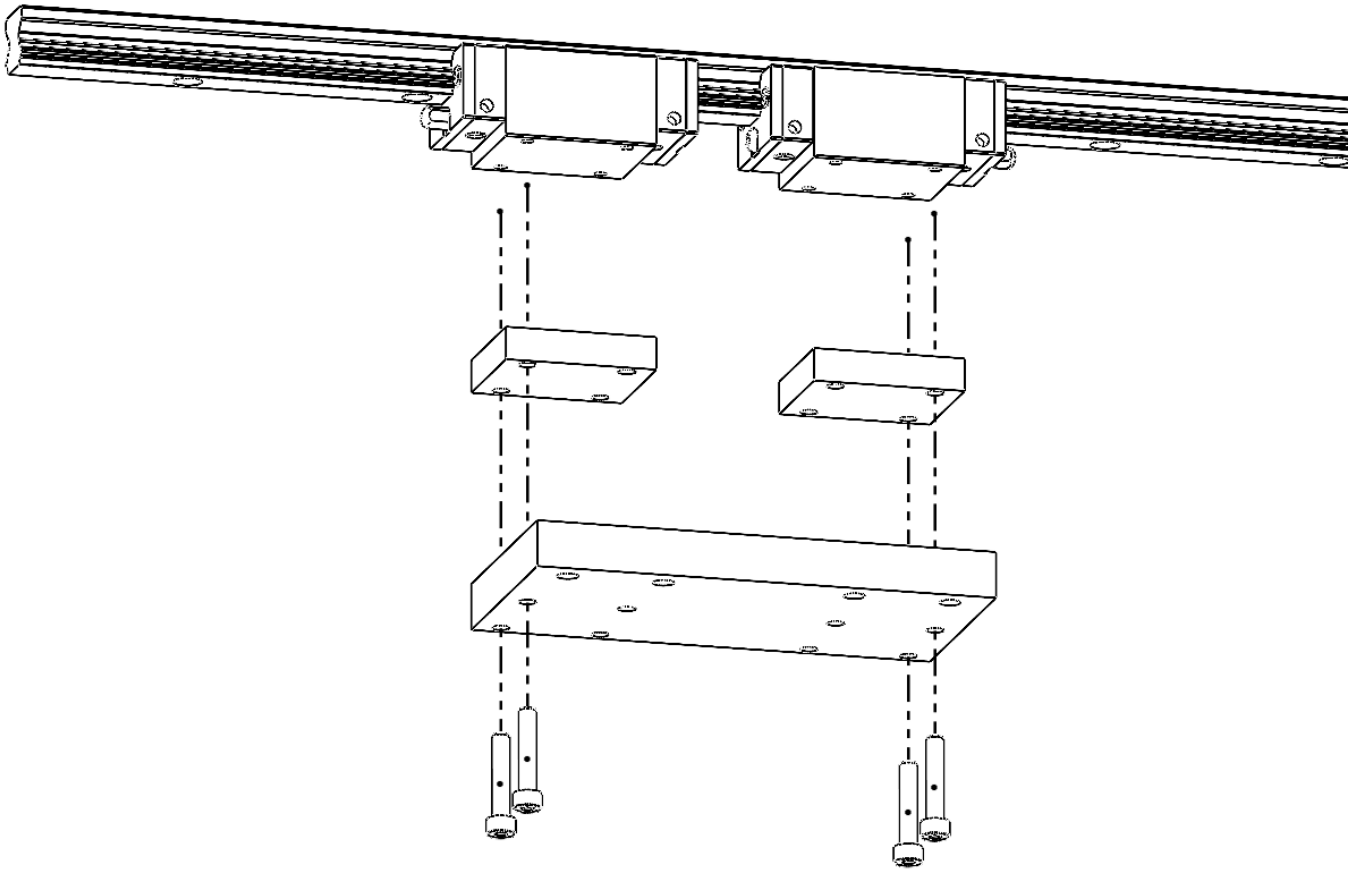
Slide two more of the linear guides onto the other of the 780mm linear rails. Once again, make sure the grease nipples (see arrows below) are oriented away from each other.



STEP 57 ATTACH THE SPACER BLOCKS AND BOTTOM PLATE TO THE LINEAR RAIL SUBASSEMBLY

- Y Bottom Plate for Rails, • Y Spacer Block x2
- ISO 4762 M4 x 22 Modified x4

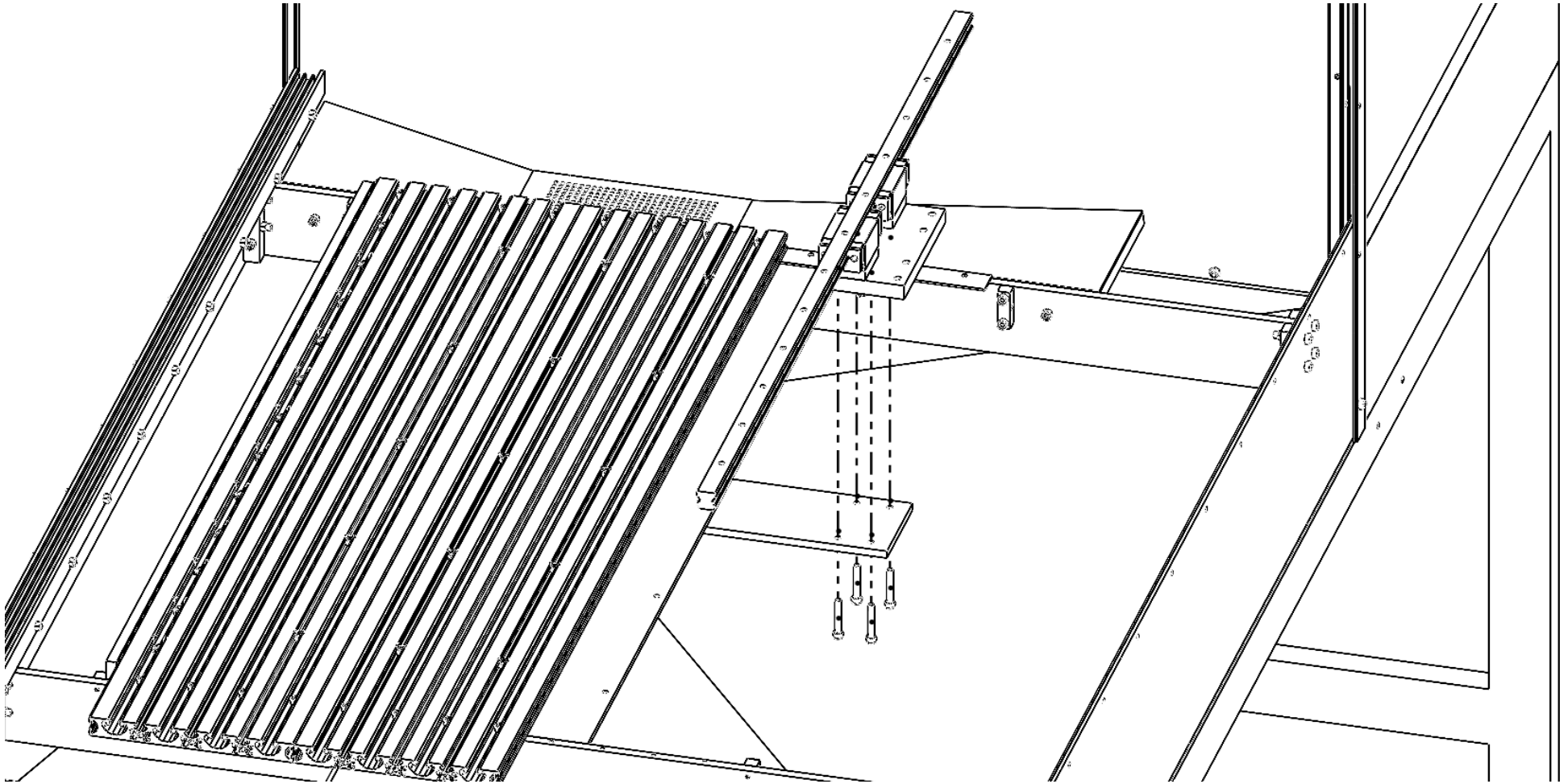
Connect the other bottom plate and the other two spacer blocks to the subassembly using four M4 x 22 bolts. Once again, only the outside holes are used for this step, so to prevent deformation, do not tighten the bolts completely. They will be fully tightened in the next step after the other four holes are filled.



STEP 58 CONNECT THE LINEAR RAIL SUBASSEMBLY TO THE MAIN ASSEMBLY

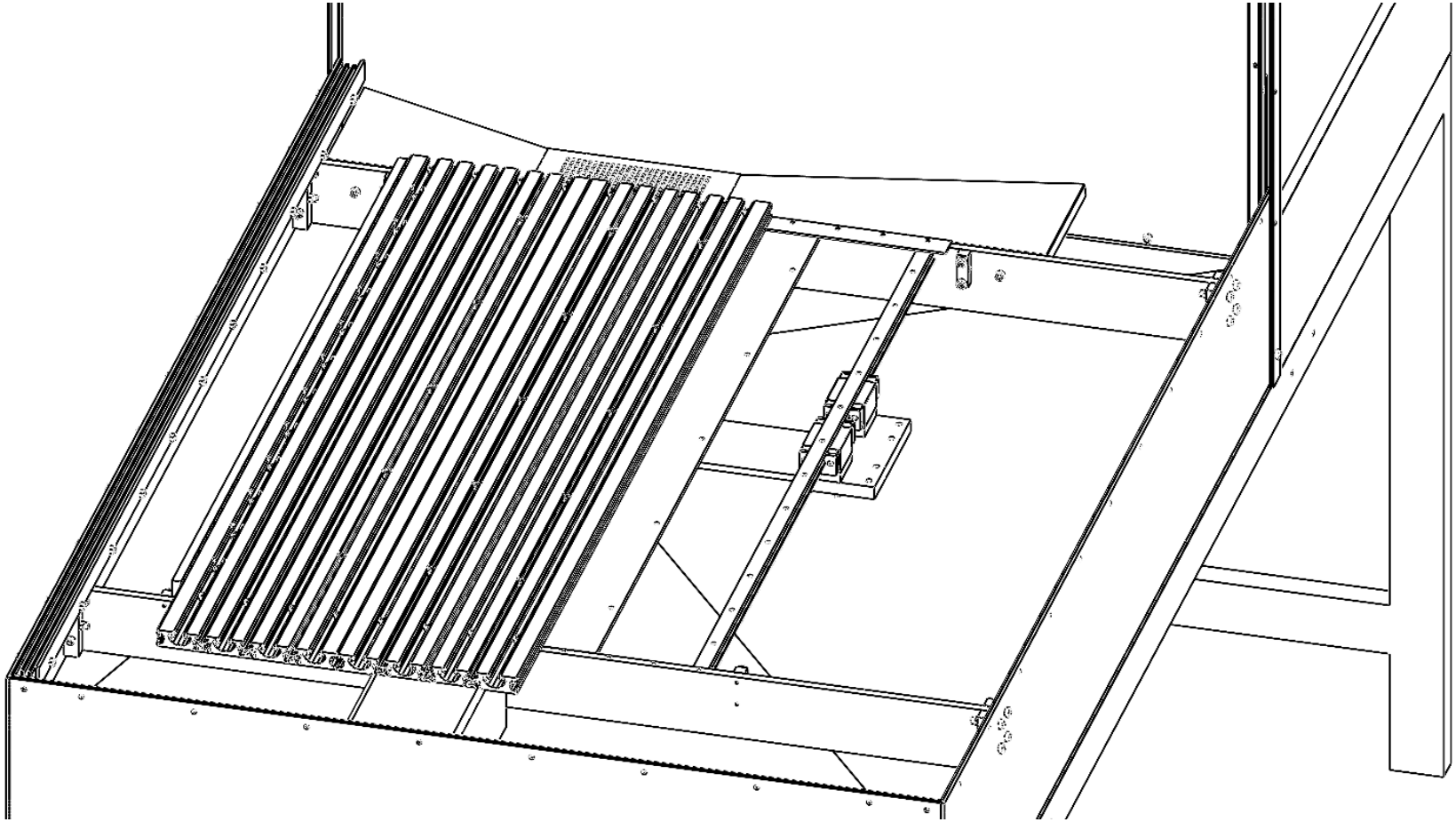
- ISO 4762 M4 x 28 - Modified x4

Attach the subassembly from Step 25 to the Y Bottom Plate for Screw using four M4 x 28 bolts just like in Step 40.



STEP 59 TIGHTEN BOLTS TO SECURE THE LINEAR GUIDES TO THE LINEAR RAIL

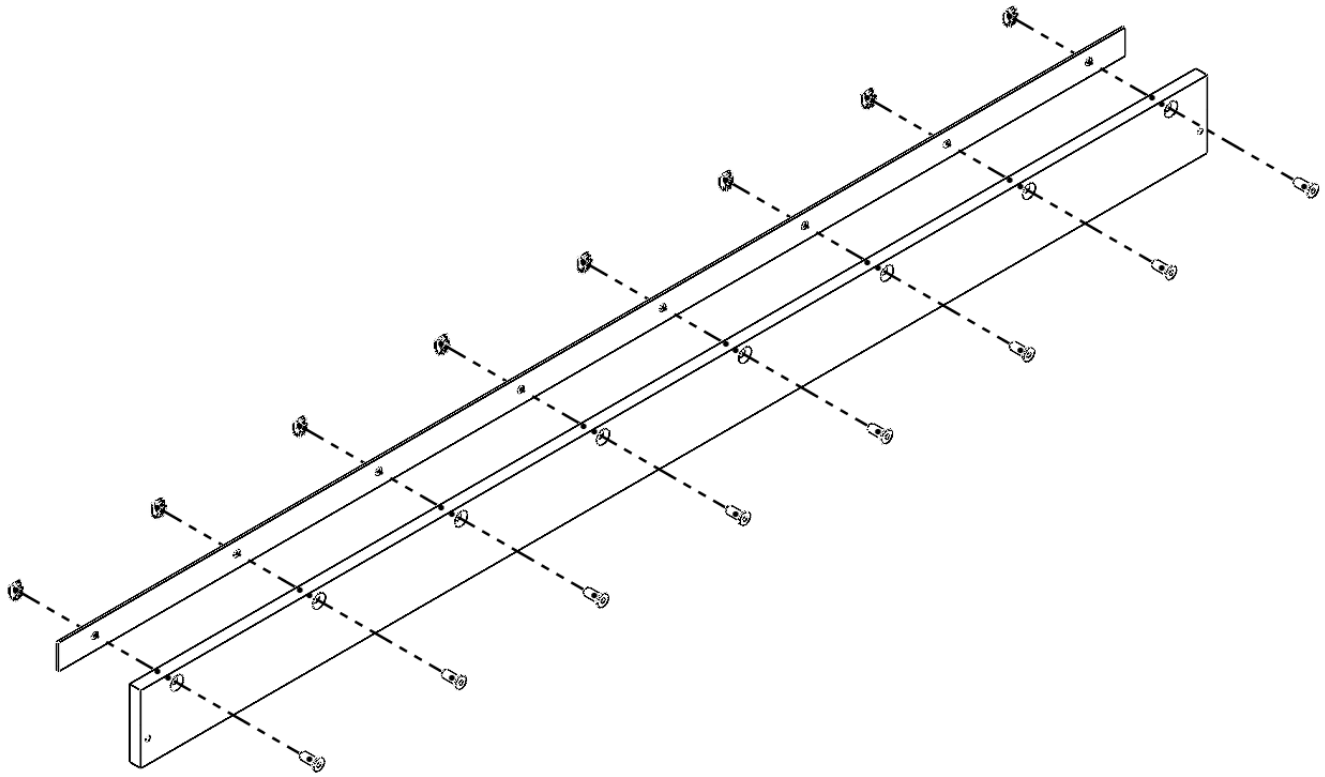
Now all eight bolts connecting the linear guides to the right side of the assembly (including the four M4 x 22 bolts that were not fully tightened during Step 57) can be fully tightened.



STEP 60 BEGIN THE SIDE SUPPORT SUBASSEMBLY FOR THE RIGHT SIDE

- Side Supports for Base, • Rubber Gaskets for Base
- ISO 10642 - M4 x 15 - 15N x8, • 5mm T-Nut M4 x8

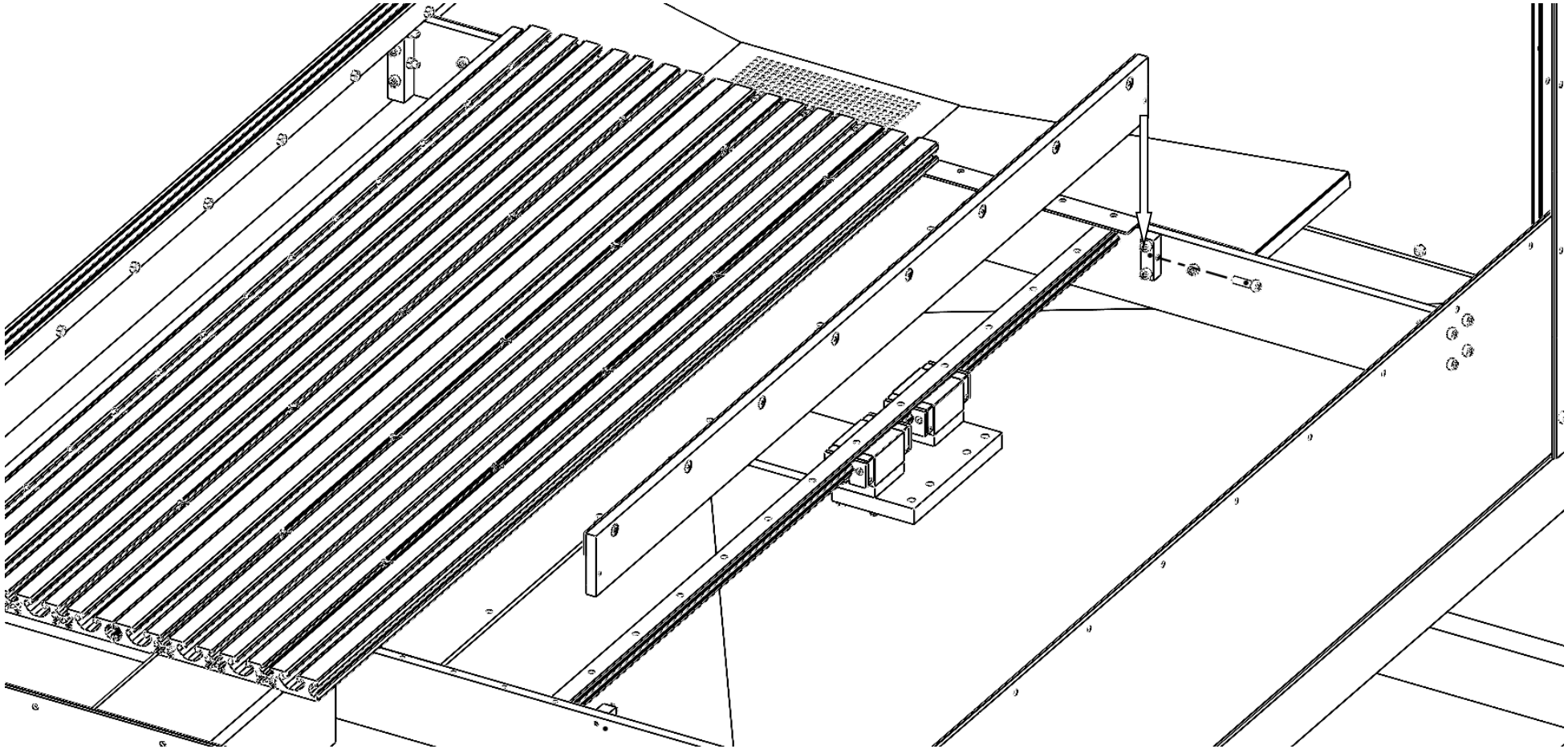
Connect the left side support and the rubber gasket by loosely threading eight of the M4 T-nuts onto eight of the countersunk M4 x 12 bolts. Note: once again, these will be tightened later once they are in place.



STEP 61 CONNECT THE BACK OF THE SIDE SUPPORT SUBASSEMBLY TO THE MAIN ASSEMBLY

- ISO 4762 M4 x 16 - 16N

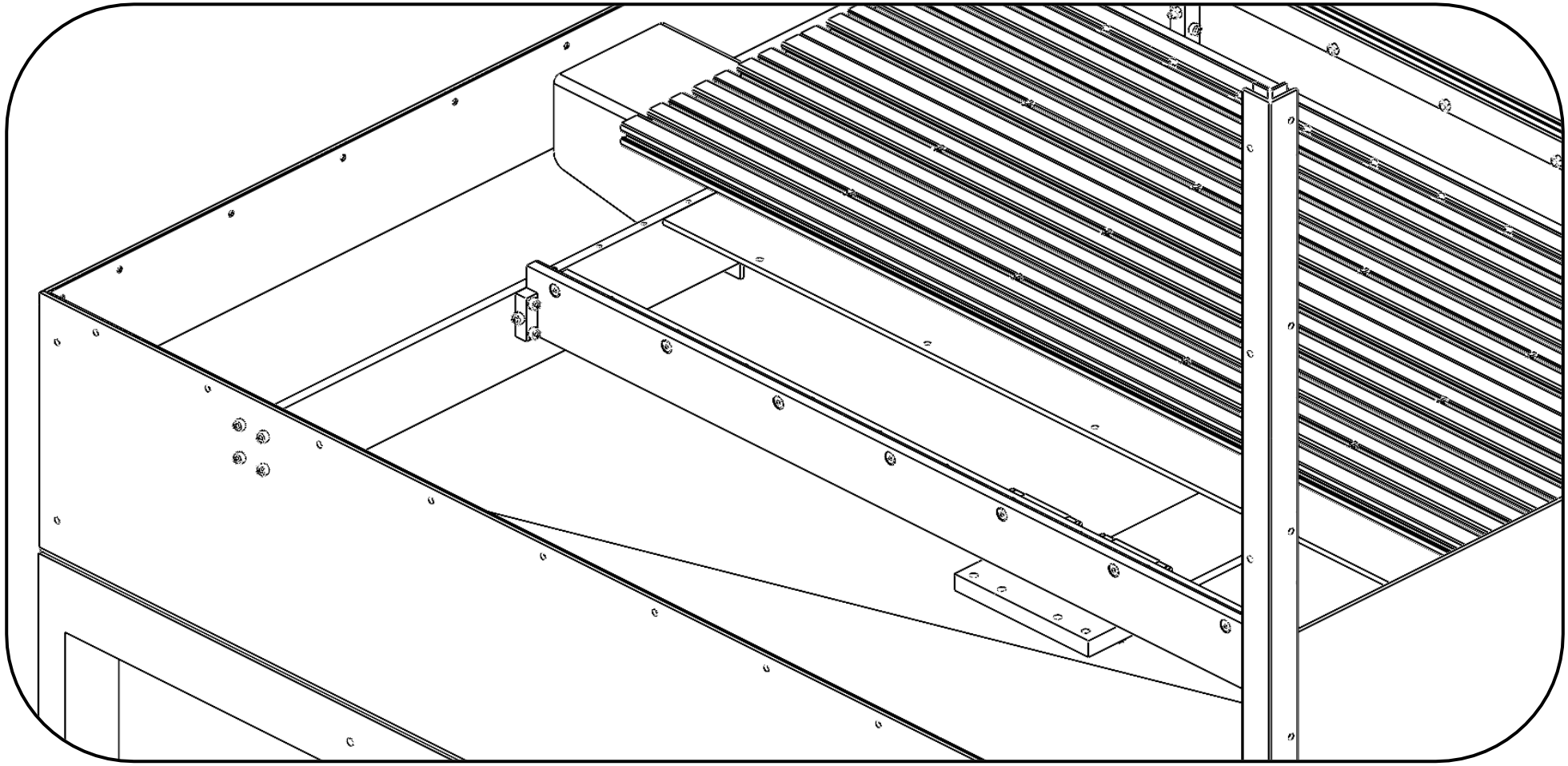
Lower the right side support subassembly into the machine between the Y-front and back plates and secure it in place using an M4 x 16 bolt through the corner block from Step 35.



STEP 62 CONNECT THE FRONT OF THE SIDE SUPPORT SUBASSEMBLY TO THE MAIN ASSEMBLY

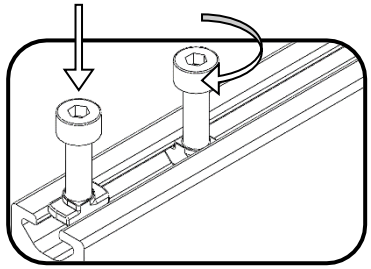
- ISO 4762 M4 x 16 - 16N

Repeat for the front right side using another M4 x 16 bolt through the corner block from Step 36.

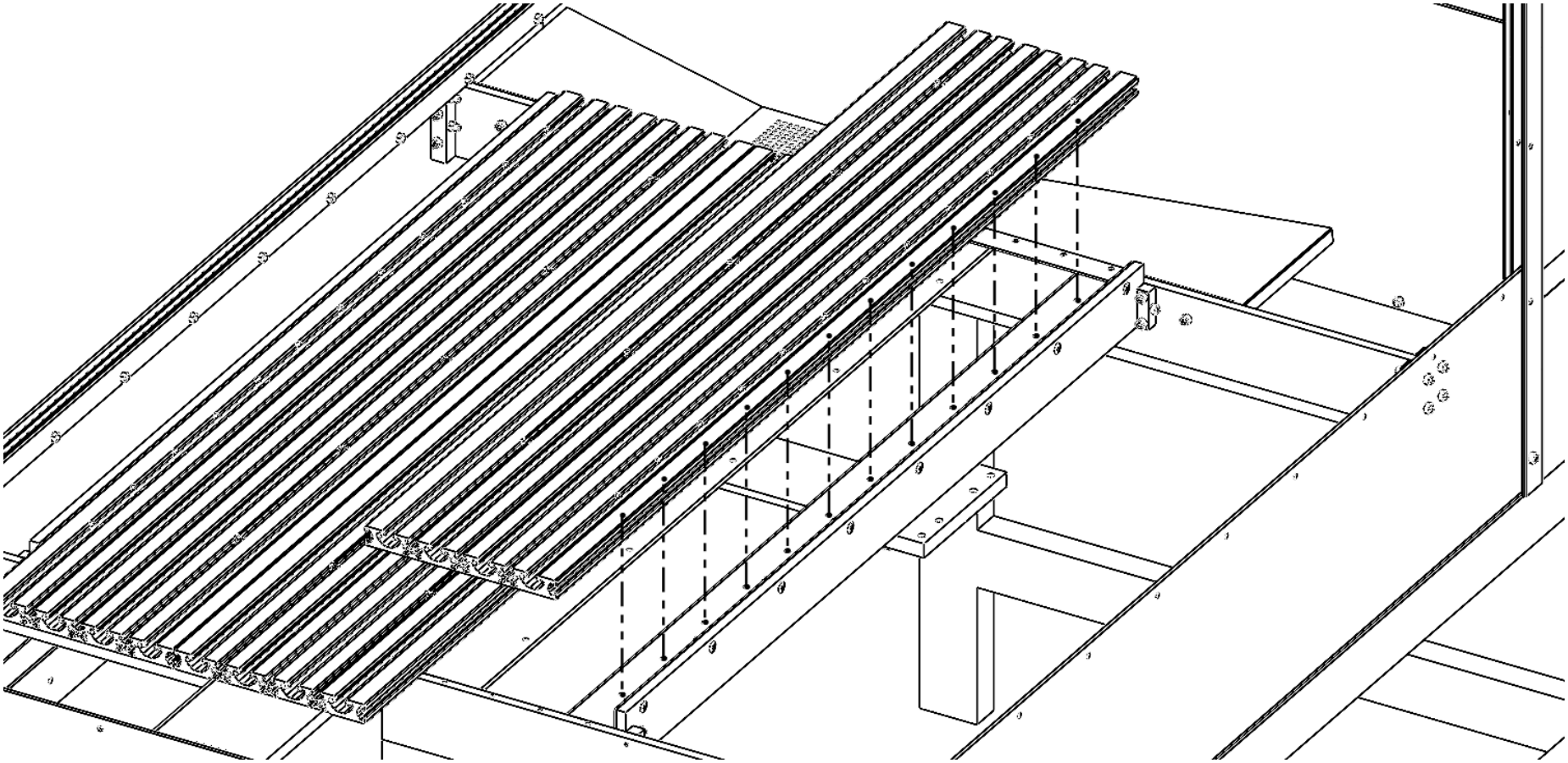


STEP 63 ATTACH THE RIGHT T-NUT PLATE

• Y Axis Rail Guard, • T-Nut Plate 160x16 Left



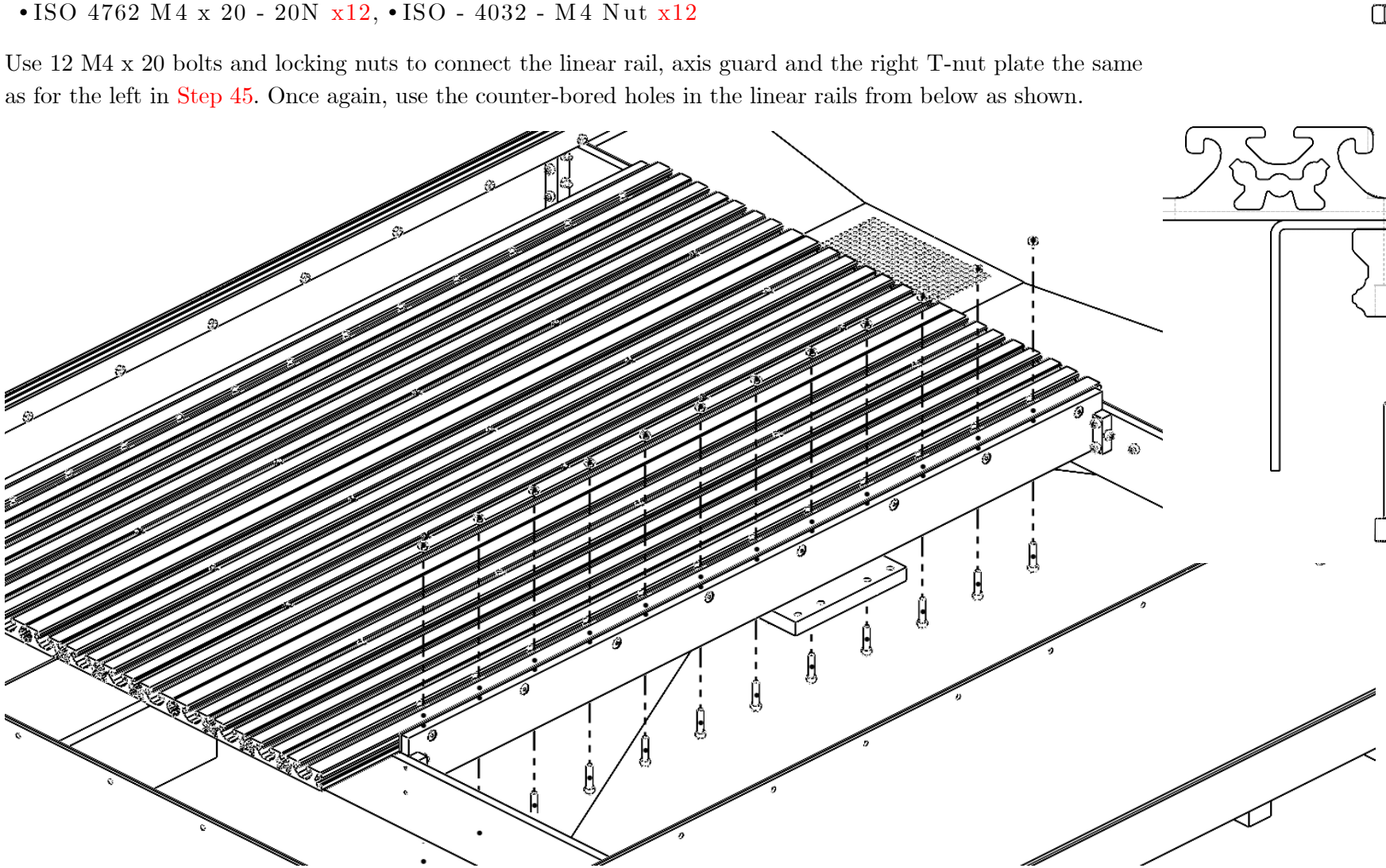
Once again, slide the rail guard and the T-slot plate into place with the Chip Tray sandwiched between them. Slide them until the holes are aligned with the rest of the assembly. Note: As in Step 44, the T-nuts will have to be loose and oriented horizontally, and the T-nut plate may have to be clamped to the side support to compress the rubber gasket enough to allow for hole alignment in the following steps.



STEP 64 CONNECT THE RIGHT T-NUT PLATE TO THE RIGHT LINEAR RAIL

• ISO 4762 M4 x 20 - 20N x12, • ISO - 4032 - M4 Nut x12

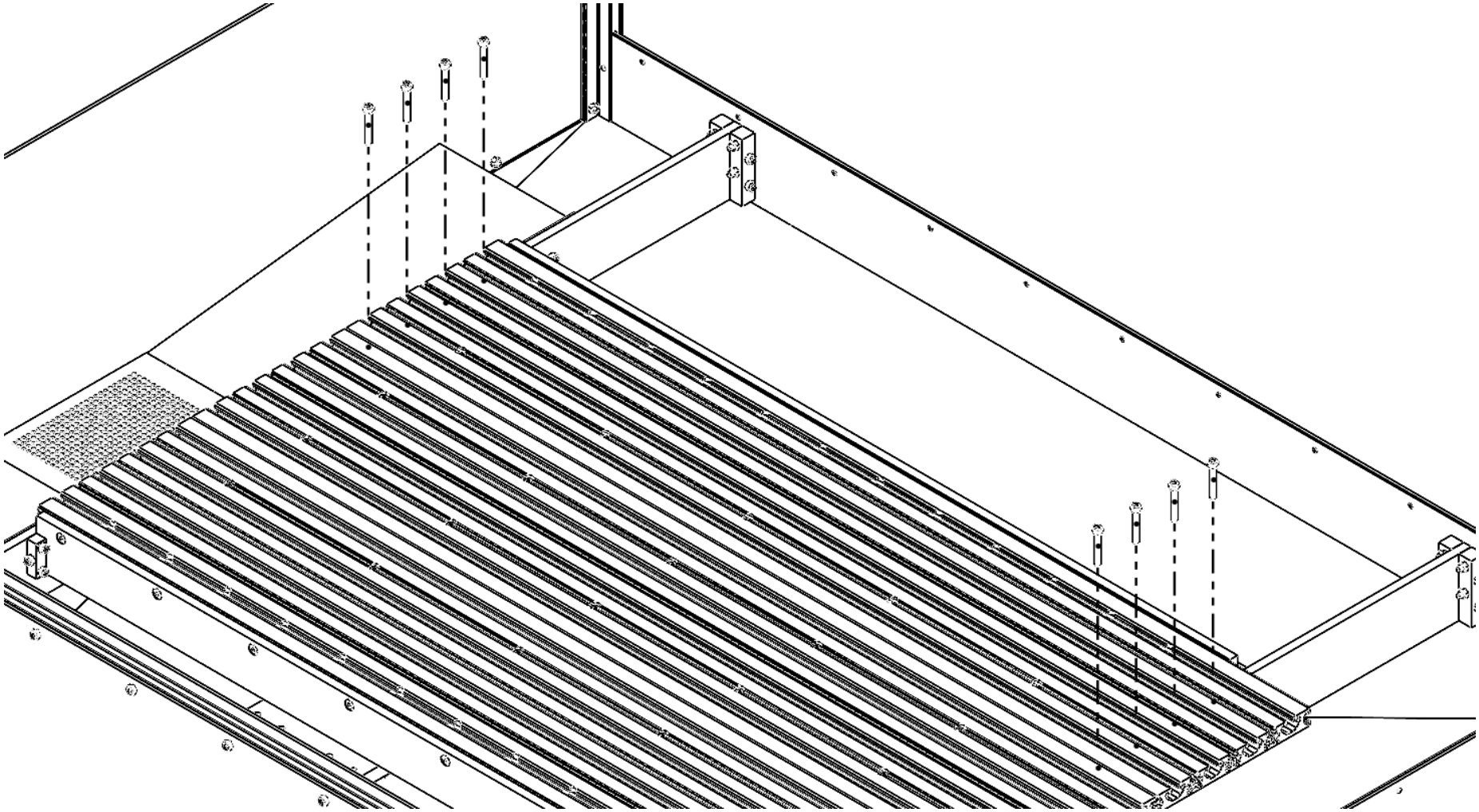
Use 12 M4 x 20 bolts and locking nuts to connect the linear rail, axis guard and the right T-nut plate the same as for the left in Step 45. Once again, use the counter-bored holes in the linear rails from below as shown.



STEP 65 CONNECT THE RIGHT T-NUT PLATE TO THE FRONT AND BACK PLATES

- ISO 4762 M4 x 30 - 30N x8

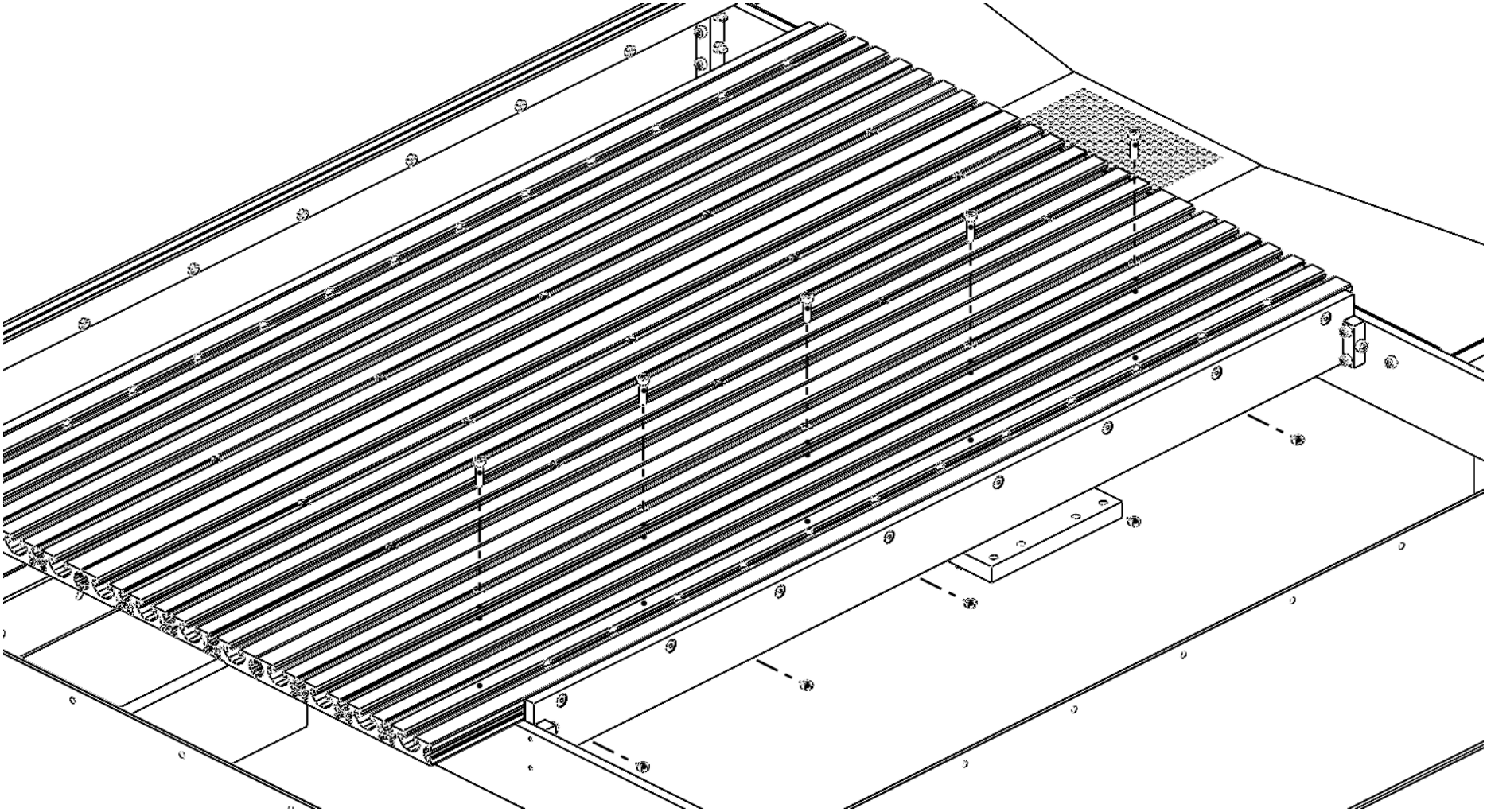
As done for the left in Step 46, attach the right T-slot plate to the front and back plates using four M4 x 30 bolts each



STEP 66 CONNECT THE REINFORCEMENT TO THE RIGHT T-NUT PLATE

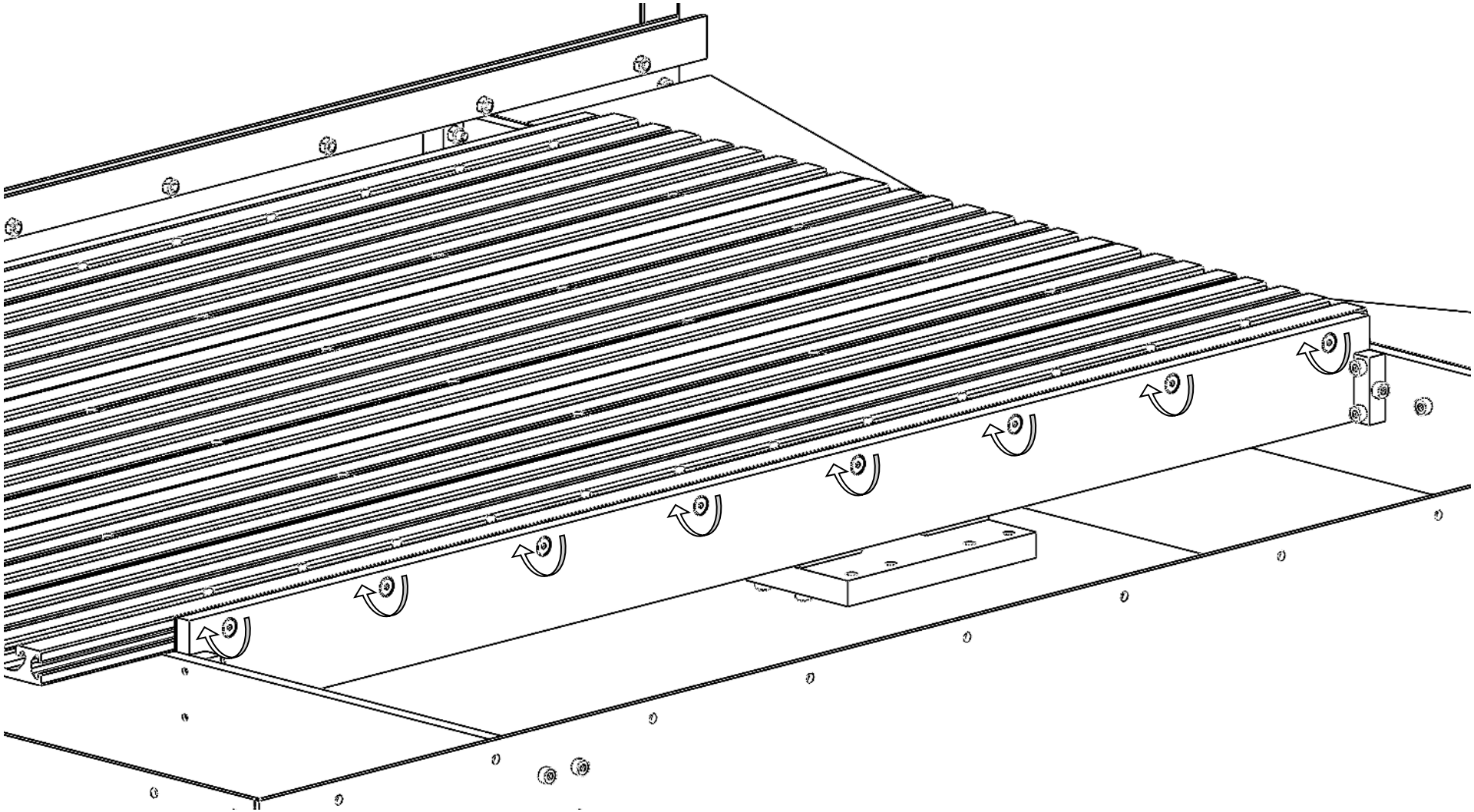
• ISO 4762 M4 x 16 - 16N x5, • ISO - 4032 - M4 Nut x5

Attach the second of the Reinforcements for Base to the right T-slot plate using another five M4 x 16 bolts and locking nuts.



STEP 67 TIGHTEN T-NUTS TO SEAT THE RUBBER GASKET

Finally, tighten the T-nuts from Step 61 to complete the Y-axis and the base platform.

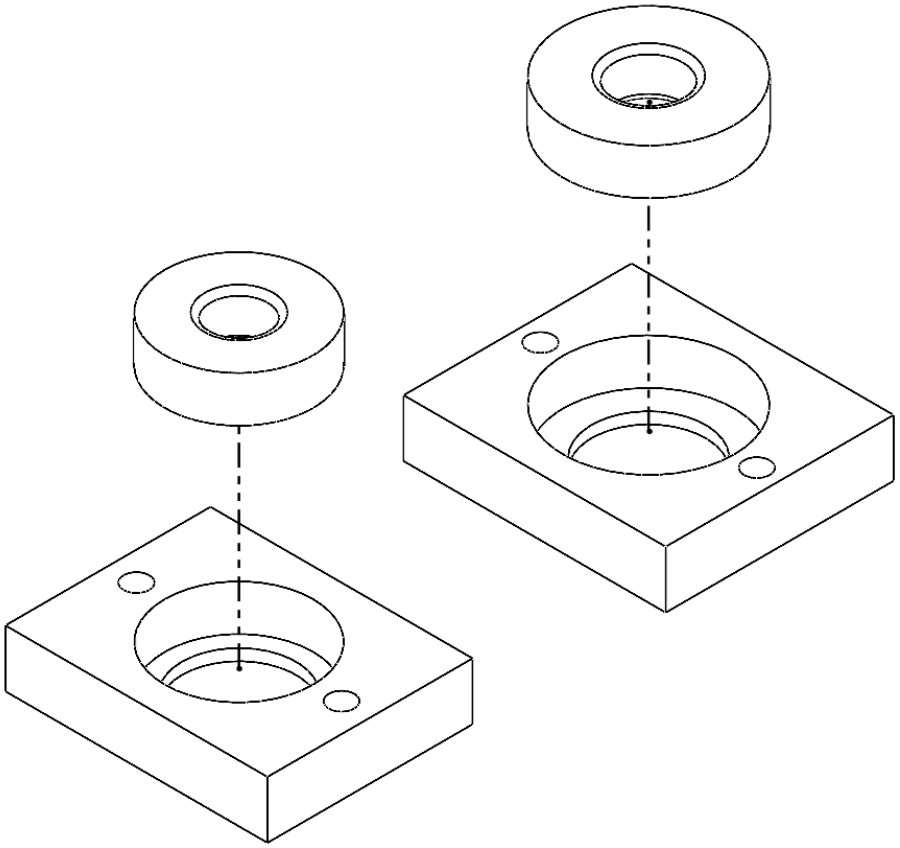


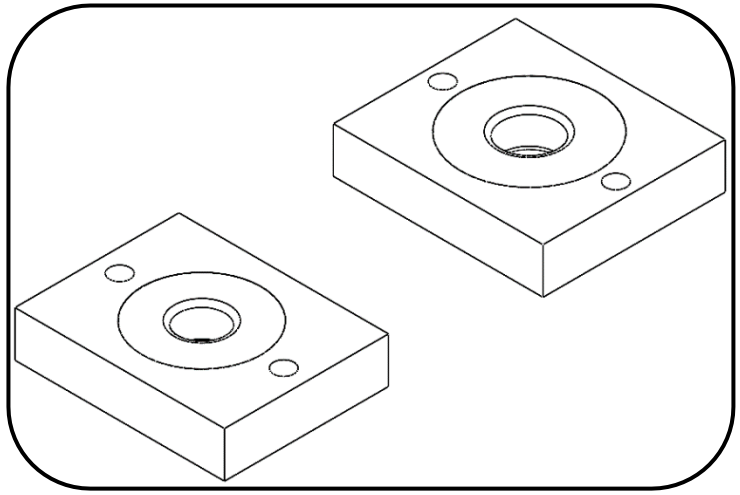
SECTION 2: CNC MACHINE - X-AXIS

STEP 68 X-AXIS BEARING BLOCK SUBASSEMBLIES

• 6000-2RS Sealed Ball Bearing, • X 26mm OD Bearing Block, • 16101 2RS Sealed Ball Bearing, • X 30mm OD Bearing Block

The X-axis lead screw will require a 26 mm ball bearing on the left side and a 30 mm ball bearing on the right. Begin the X-axis subassembly by seating both bearings into their respective bearing blocks using an arbor press (J6 transition fit).

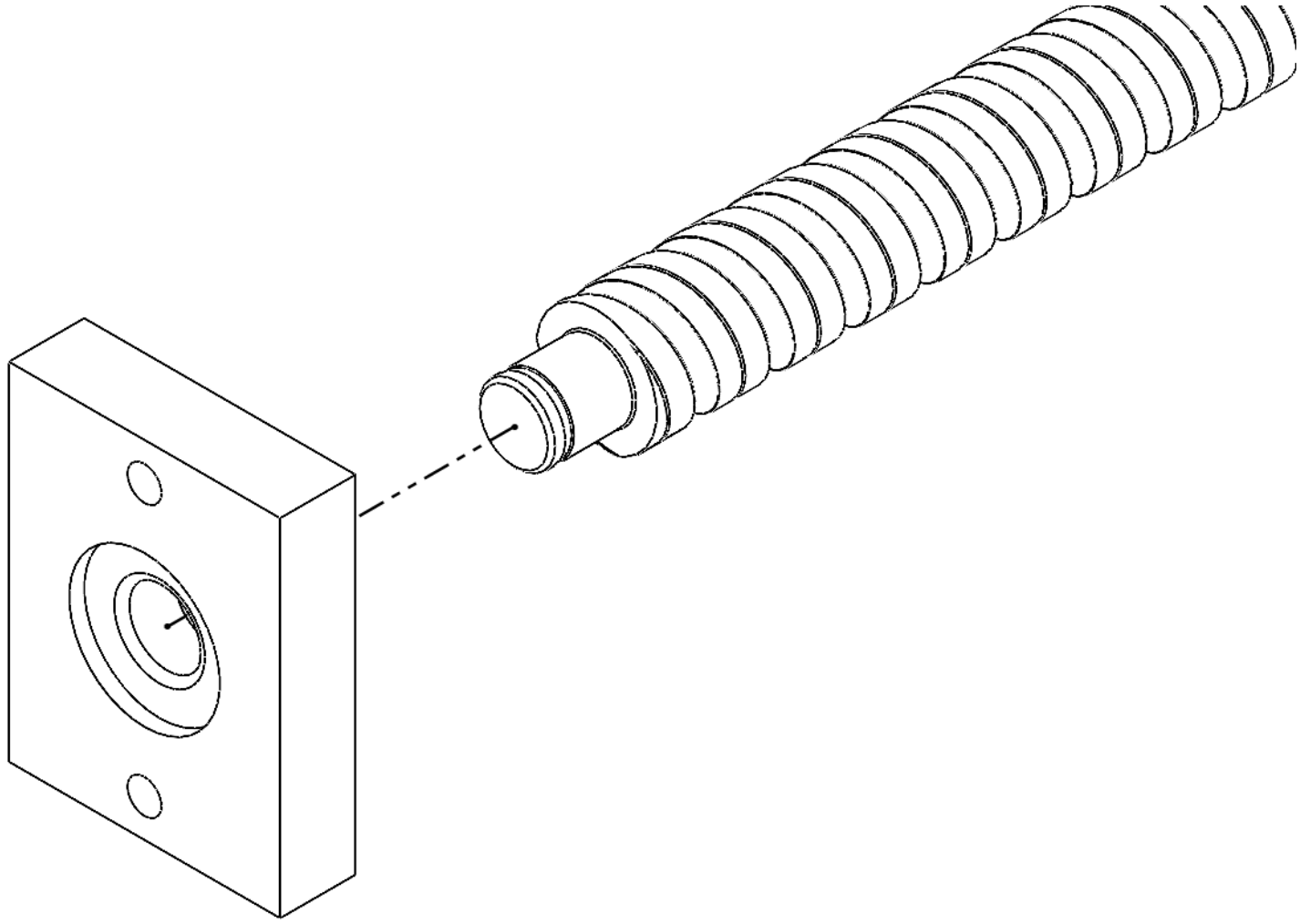




STEP 69 PRESS FIT THE X-AXIS LEAD SCREW

- SFU1610 550mm X

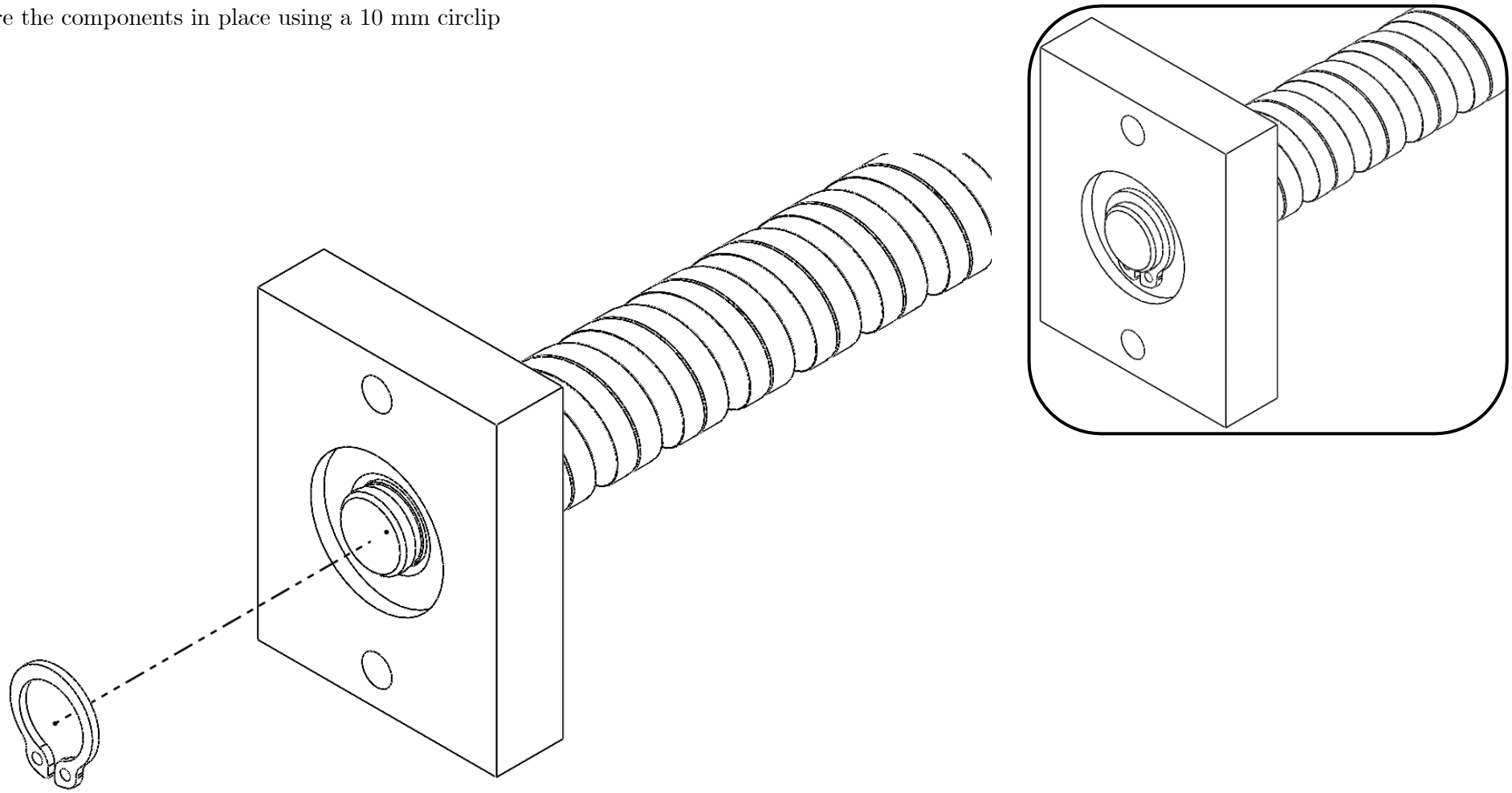
Press the back side of the X-axis lead screw into the inner trace of the 26 mm bearing from Step 69 (j6 transition fit).



STEP 70 SECURE THE X-AXIS LEAD SCREW TO THE BEARING BLOCKS

- DIN 471 10 mm External Circlip

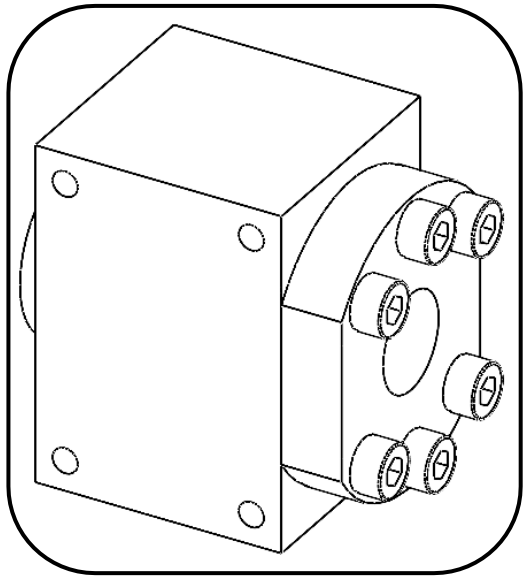
Secure the components in place using a 10 mm circlip

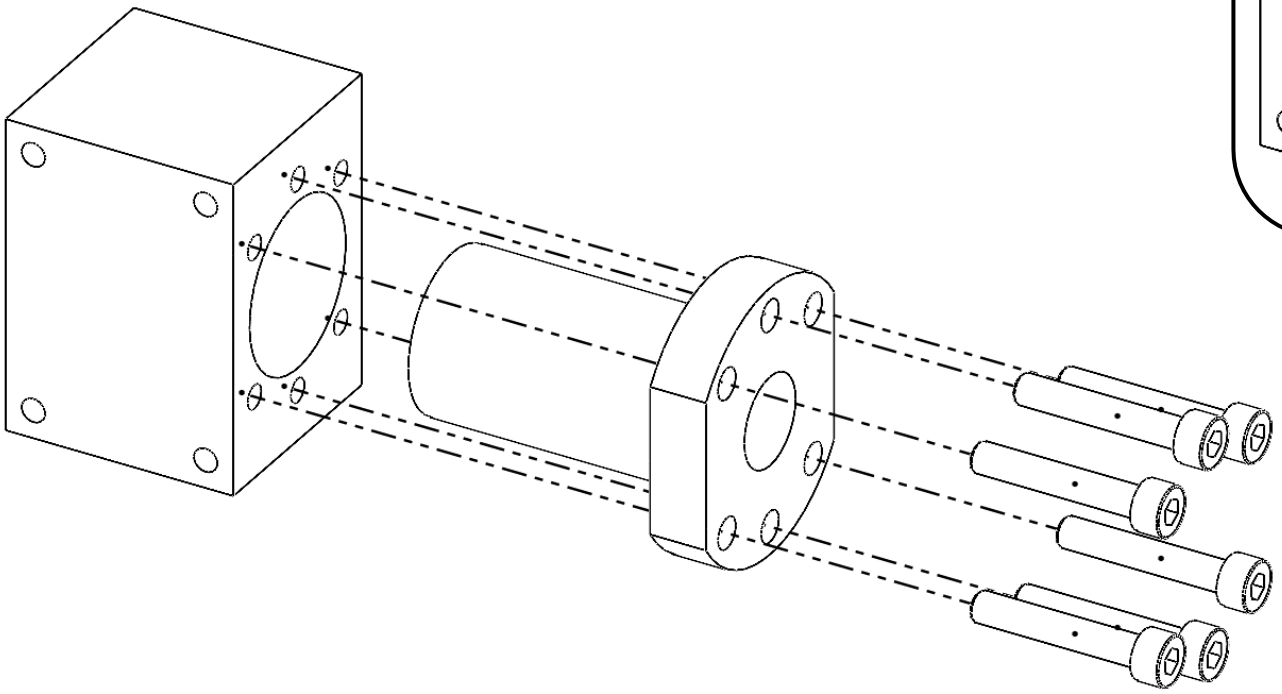


STEP 71 NUT BLOCK FOR THE X-AXIS LEAD SCREW

- Nut Block, • Nut 1610
- ISO 4762 M5 x 30 - 30N x6

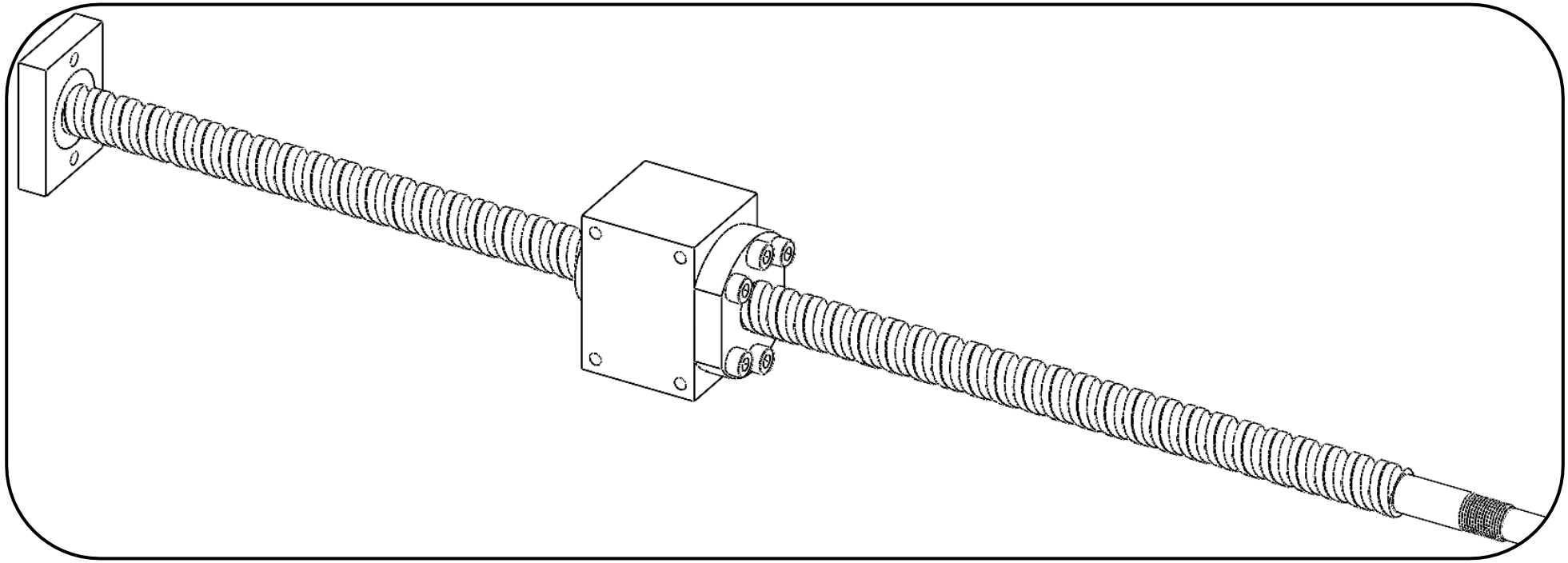
Attach the X-axis nut block to the lead screw nut using six M5 x 30 bolts.





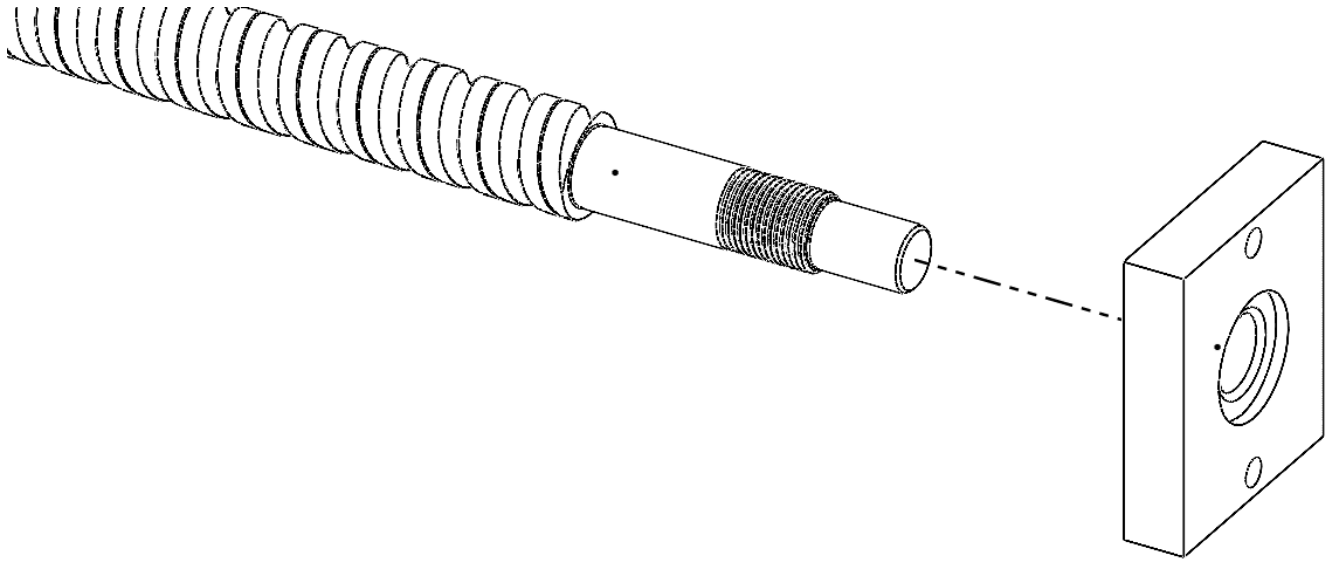
STEP 72 COMBINE THE NUT BLOCK AND LEAD SCREW SUBASSEMBLIES FOR THE X-AXIS

Combine the subassemblies from Steps 70 and 71 by threading the nut onto the lead screw. Note: make sure the flange of the lead screw nut and the heads of the bolts are oriented toward the open end of the lead screw.



STEP 73 OTHER BEARING BLOCK FOR THE X-AXIS SUBASSEMBLY

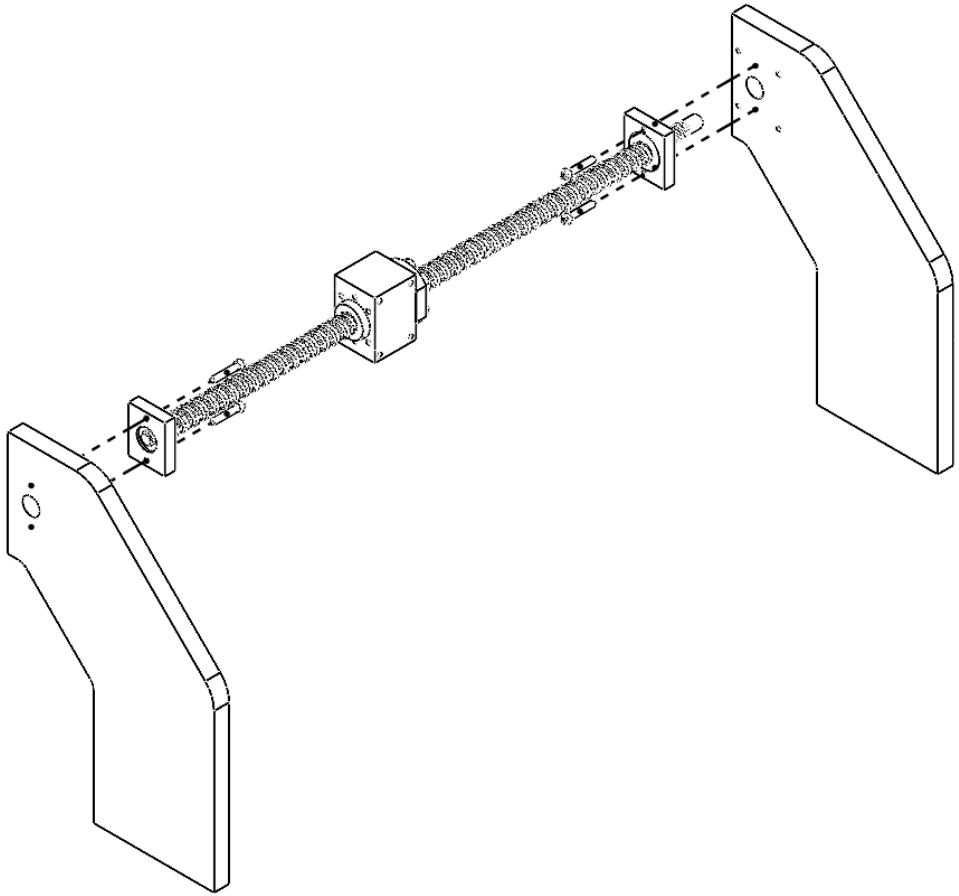
Now press the 30 mm bearing subassembly from Step 68 onto the open end of the X-axis lead screw (j6 transition fit).

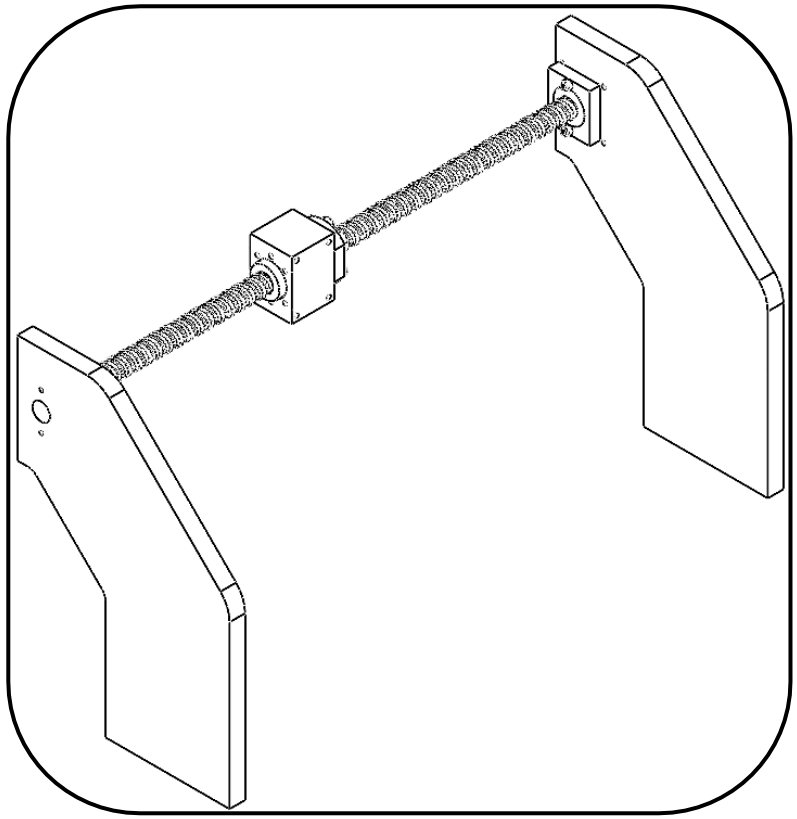


STEP 74 ATTACH THE SHOULDERS TO THE X-AXIS SUBASSEMBLY

- Left Shoulder, • Right Shoulder
- ISO 4762 M4 x 25 - 25N x4, • ISO - 4032 - M4 Nut x4

Attach the Left and Right Shoulders to the subassembly using two M4 x 25 molts on either side. The lead screw subassembly for the X-axis is now complete and can be set aside for a few steps.

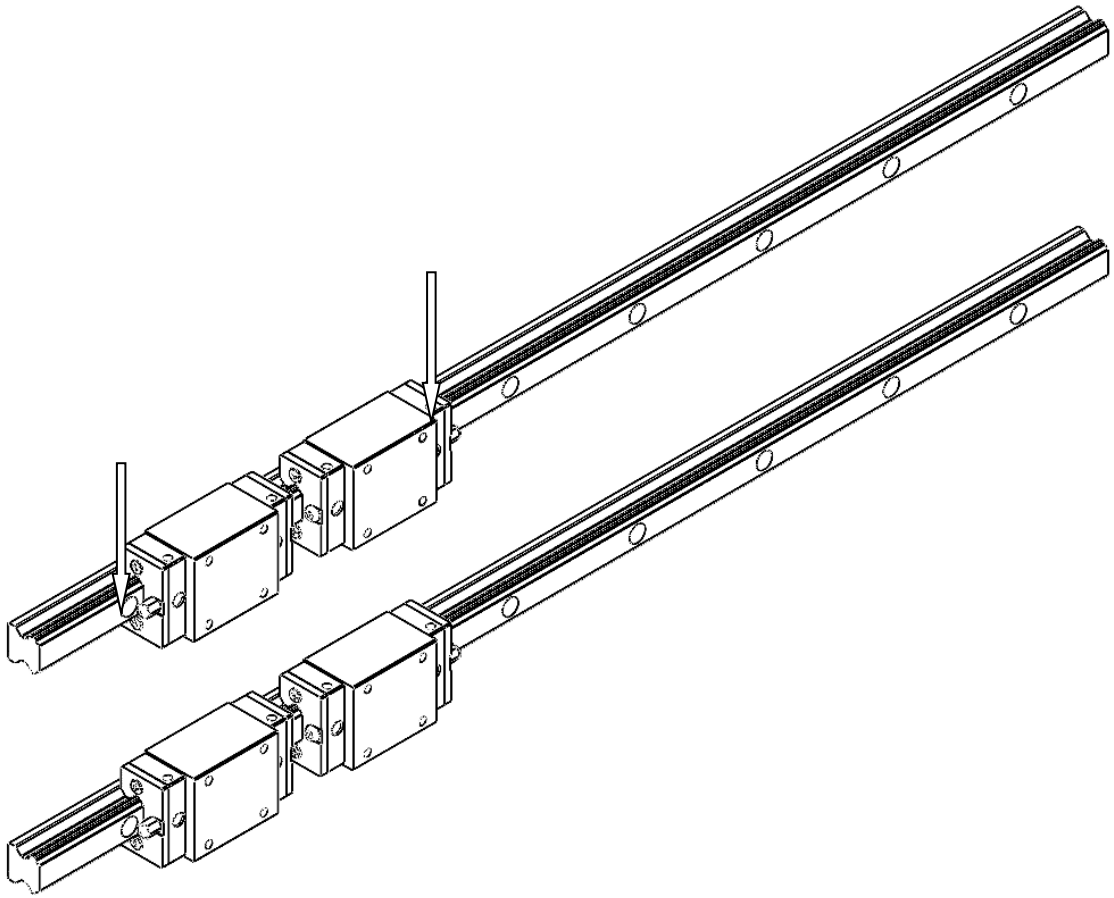




STEP 75 BEGIN THE LINEAR RAIL SUBASSEMBLY FOR THE X-AXIS

• HGR15 X x2, • HGH15C x4

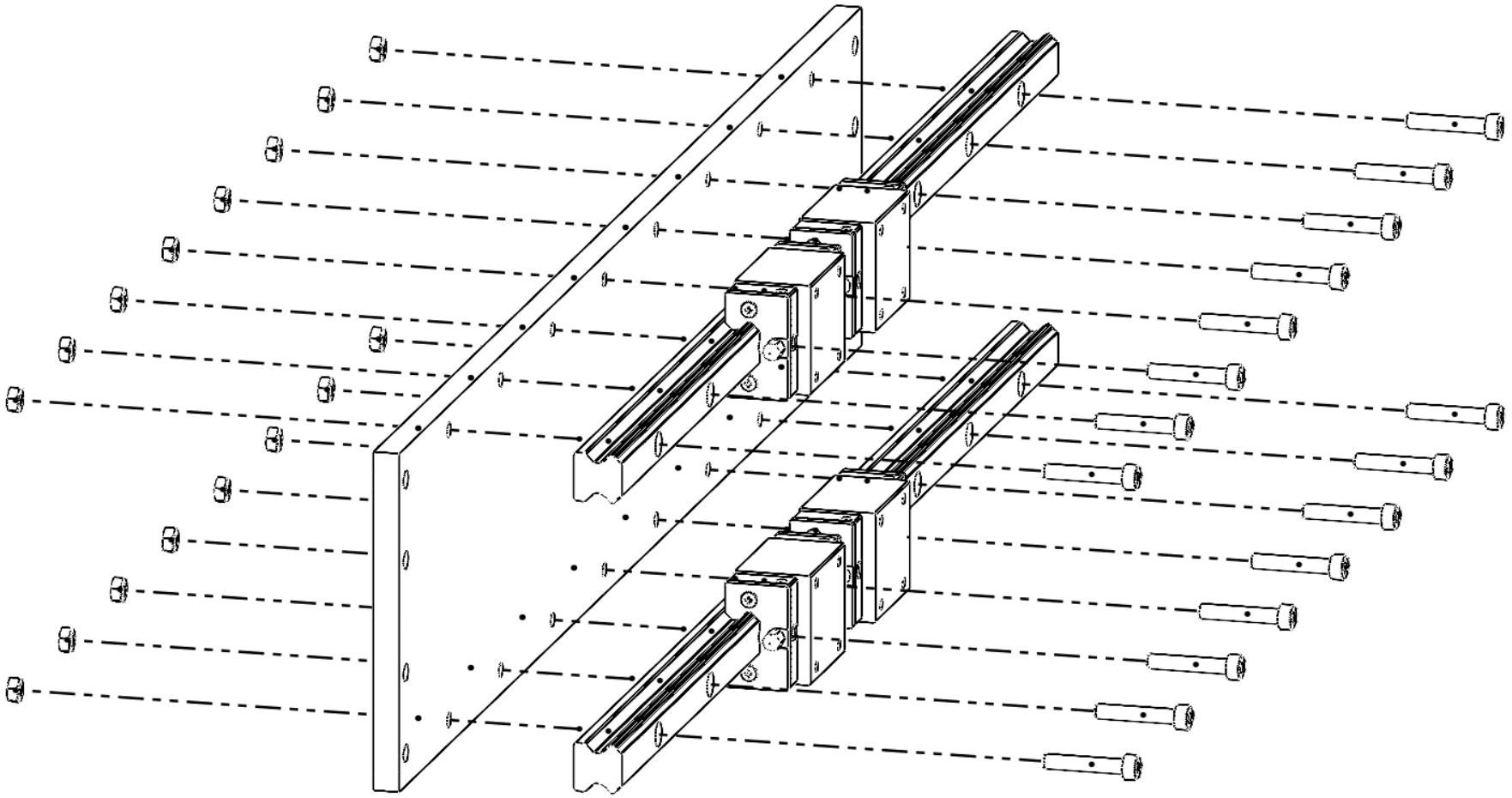
Slide two of the linear guides onto each of the 505 mm linear rails for the X-axis. As with the Y-axis, make sure the grease nipples (see arrows below) are oriented away from each other.



STEP 76 ATTACH THE BACK PLATE FOR THE X-AXIS TO THE LINEAR RAIL SUBASSEMBLY

- X Back Plate
- ISO 4762 M4 x 25 - 25N x16, • ISO - 4032 - M4 Nut x16

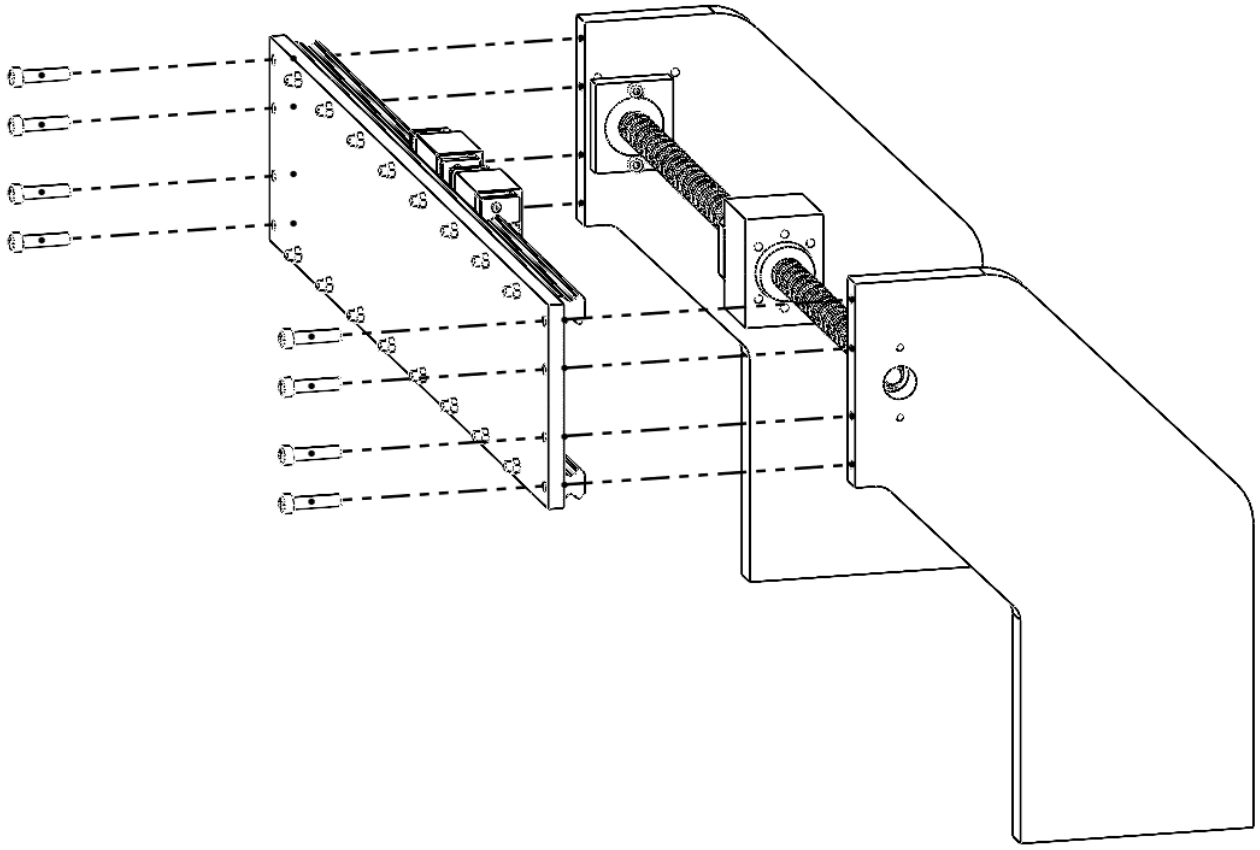
Attach the linear rails to the back plate using eight M4 x 25 bolts and locking nuts



STEP 77 CONNECT THE LINEAR RAIL AND X-AXIS SUBASSEMBLIES

- ISO 4762 M5 x 25 - 25N x8

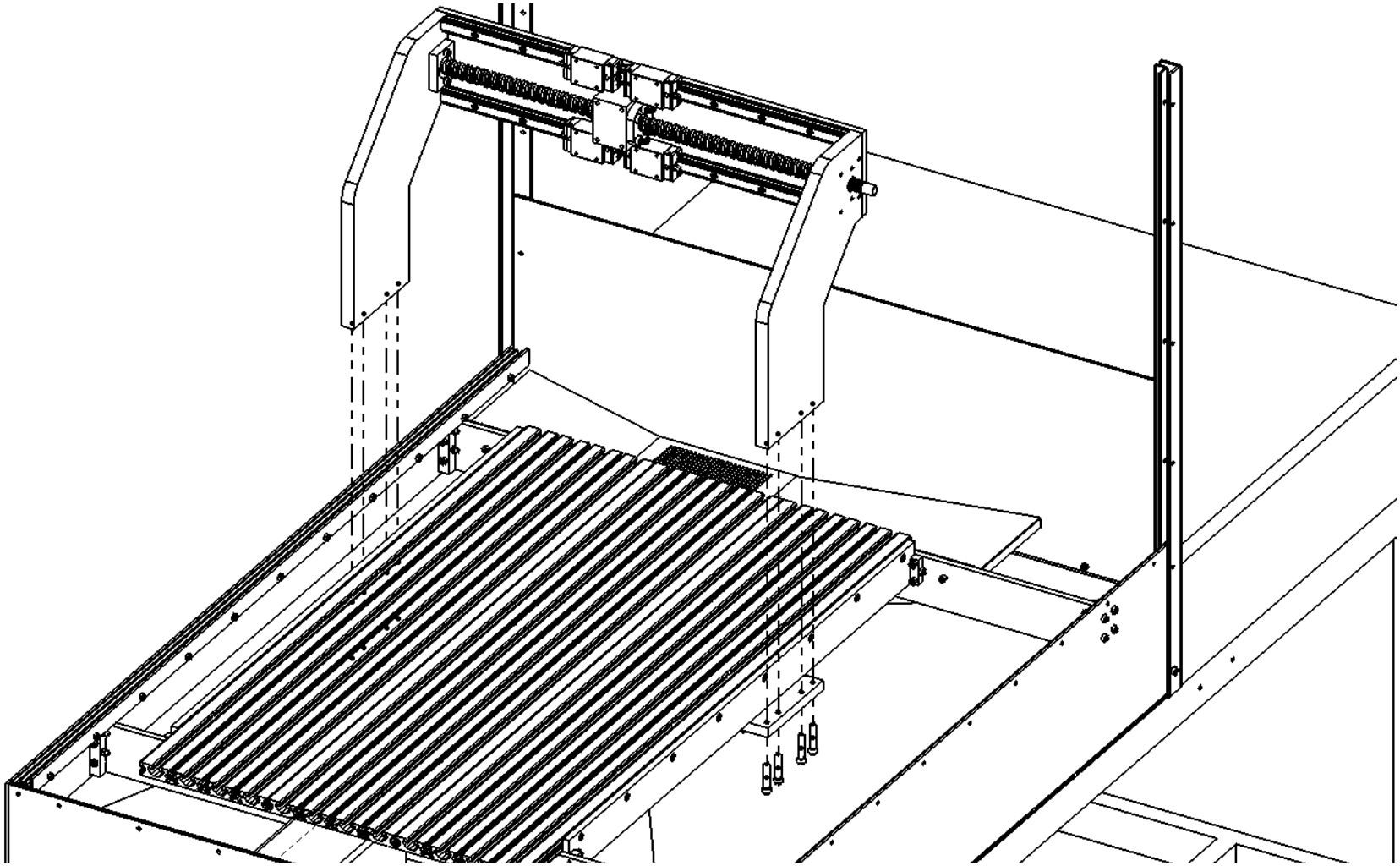
Connect the subassemblies using four M5 x 25 bolts on either side



STEP 78 ADD THE X-AXIS SUBASSEMBLY TO THE MAIN ASSEMBLY

- ISO 4762 M5 x 30 - 30N x8

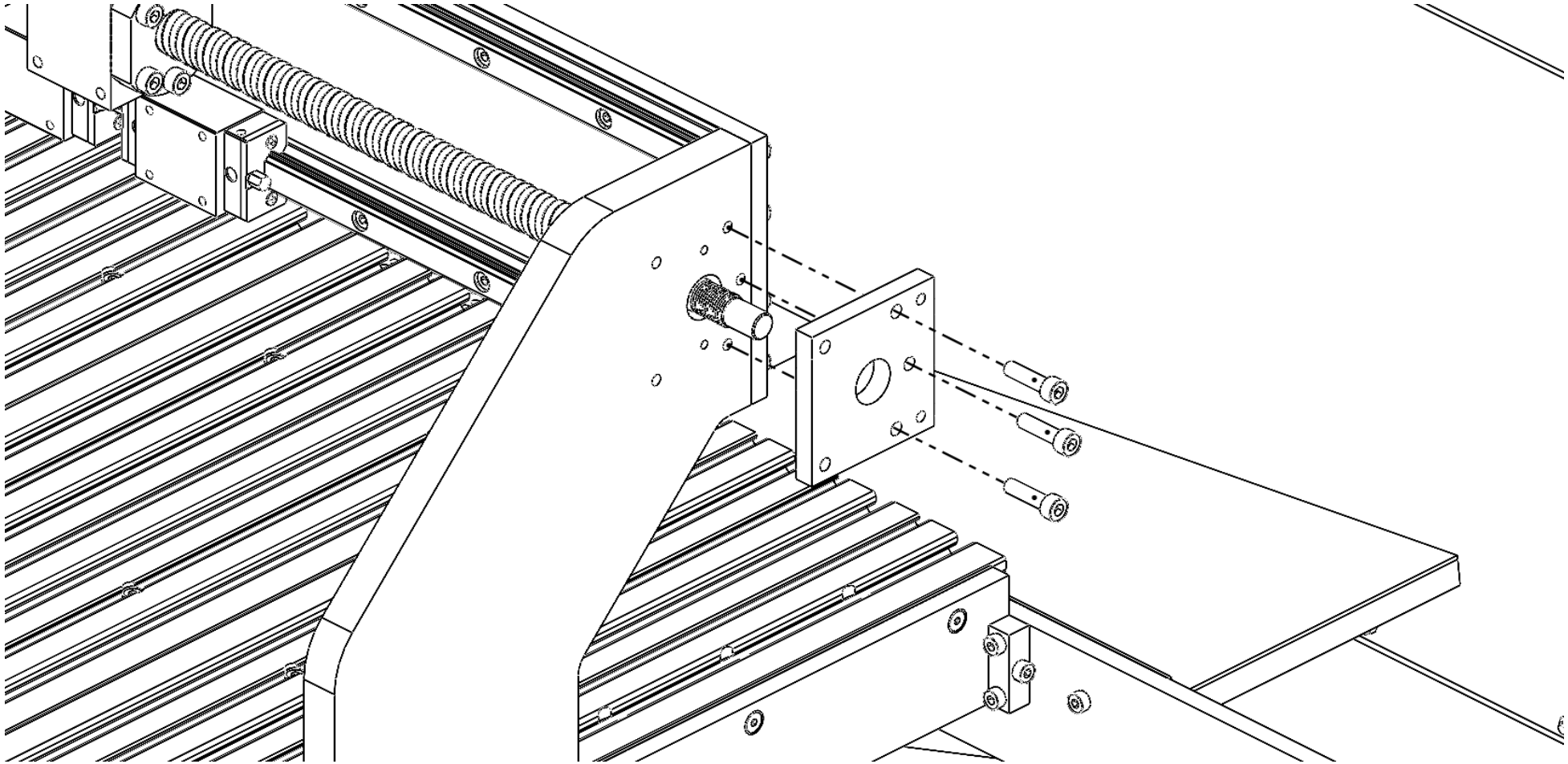
Attach the X-axis subassembly to the rest of the machine using eight M5 x 30 bolts through the Y-Bottom Plate for Rails.



STEP 79 CONNECT THE X-AXIS MOTOR MOUNT

- Motor Mount for X-Axis
- ISO 4762 M5 x 20 - 20N x3

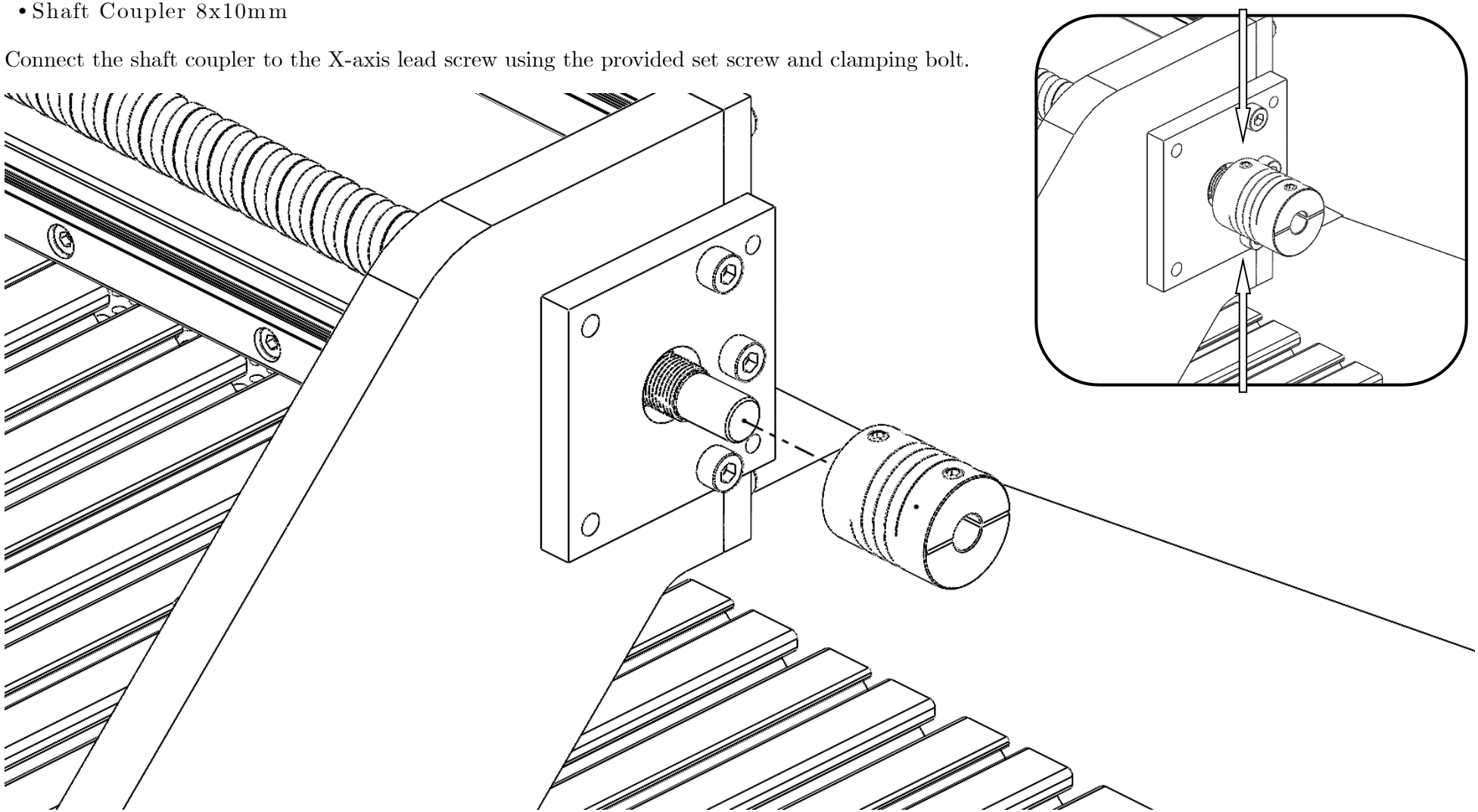
Attach the Motor Mount for X-Axis to the Right Shoulder using three M4 x 20 bolts



STEP 80 CONNECT THE SHAFT COUPLER FOR THE X-AXIS MOTOR TO THE LEAD SCREW

- Shaft Coupler 8x10mm

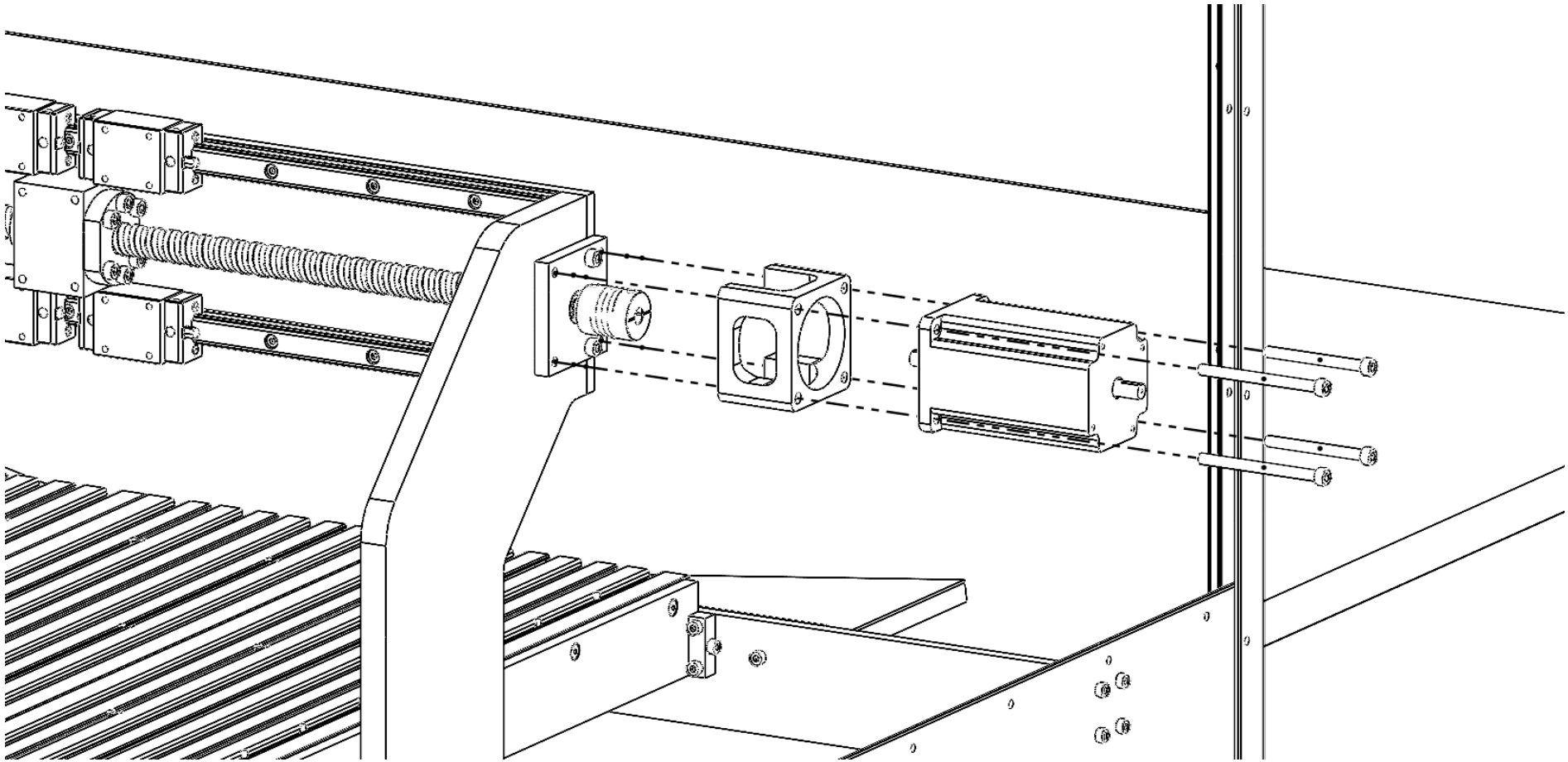
Connect the shaft coupler to the X-axis lead screw using the provided set screw and clamping bolt.



STEP 81 ATTACH THE X-AXIS MOTOR

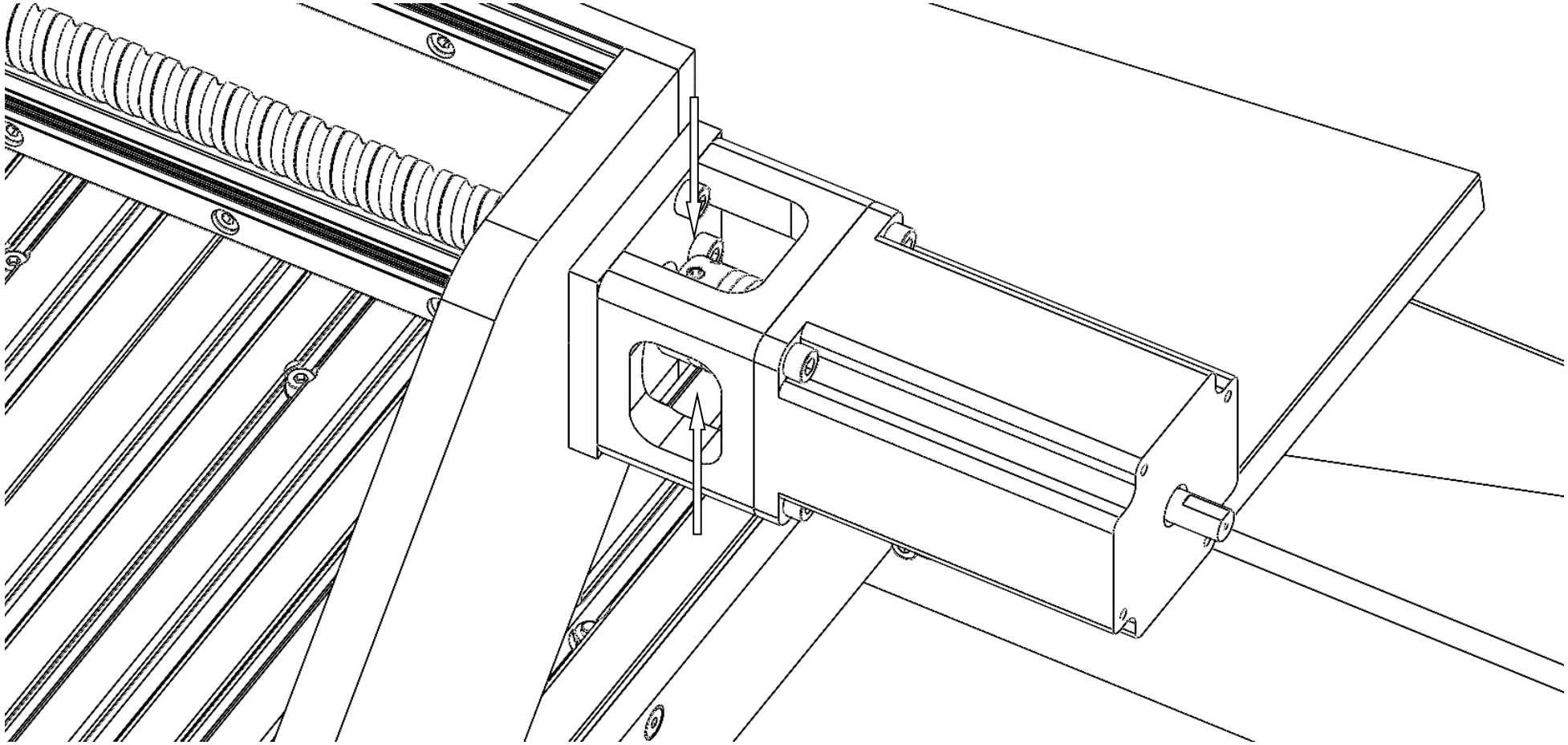
- X-Axis Motor Adaptor, • Nema 24 Motor
- ISO 4762 M5 x 70 - 22N x2, • ISO 4762 M5 x 58 - 22N Modified x2

Connect the X-axis motor using two M5 x 70 bolts on the front side and two M5 x 58 bolts on the back side. The 70 mm bolts thread into the Right Shoulder and the 58 mm bolts thread into the Motor Mount for X-Axis



STEP 82 CONNECT THE SHAFT COUPLER TO THE X-AXIS MOTOR

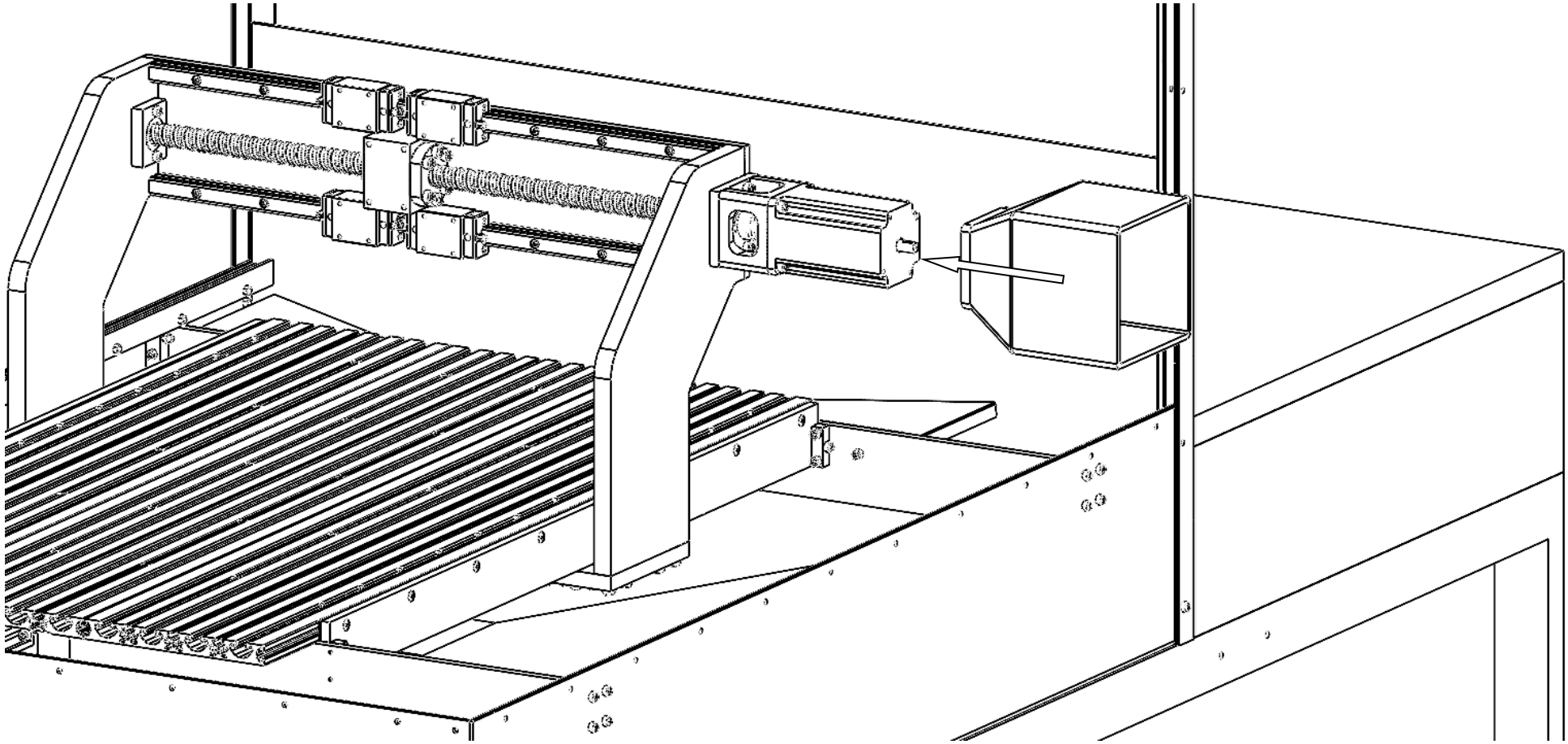
Connect the shaft coupler to the motor shaft through the cavities in the motor mount using the provided set screw and clamping bolt.



STEP 83 PUT THE COVER FOR THE X-MOTOR INTO POSITION

- Cover for X-Motor

Finally, slide the Cover for X-Motor over the motor, motor adaptor and motor mount. The fit should be snug enough that it does not need a mechanical connection.

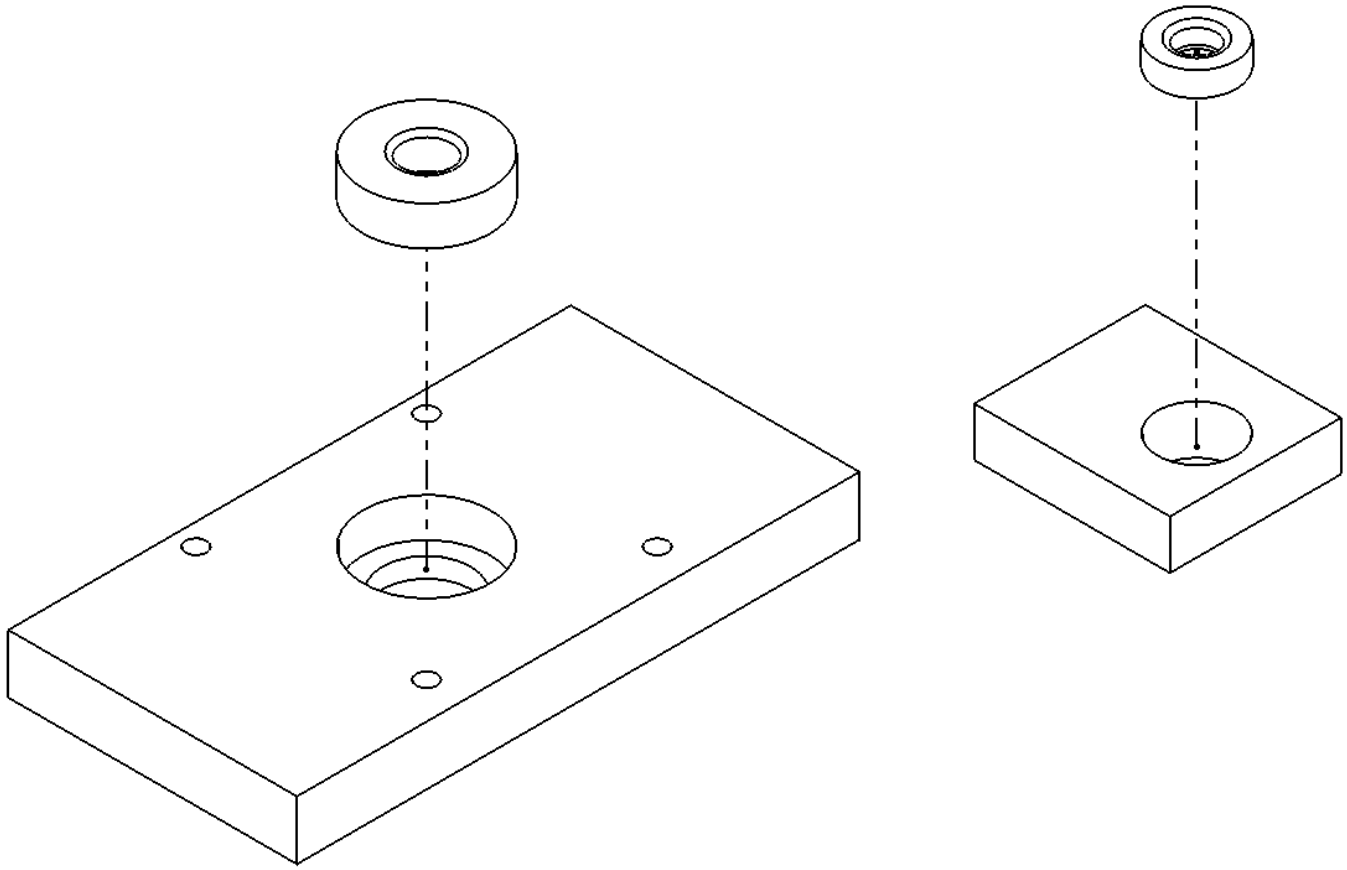


SECTION 2: CNC MACHINE - Z-AXIS

STEP 84 Z-AXIS BEARING BLOCK SUBASSEMBLIES

• 6000-2RS Sealed Ball Bearing, • Z-Top Plate, • 688-2RS Sealed Ball Bearing, • Z-BallScrew Lower Support

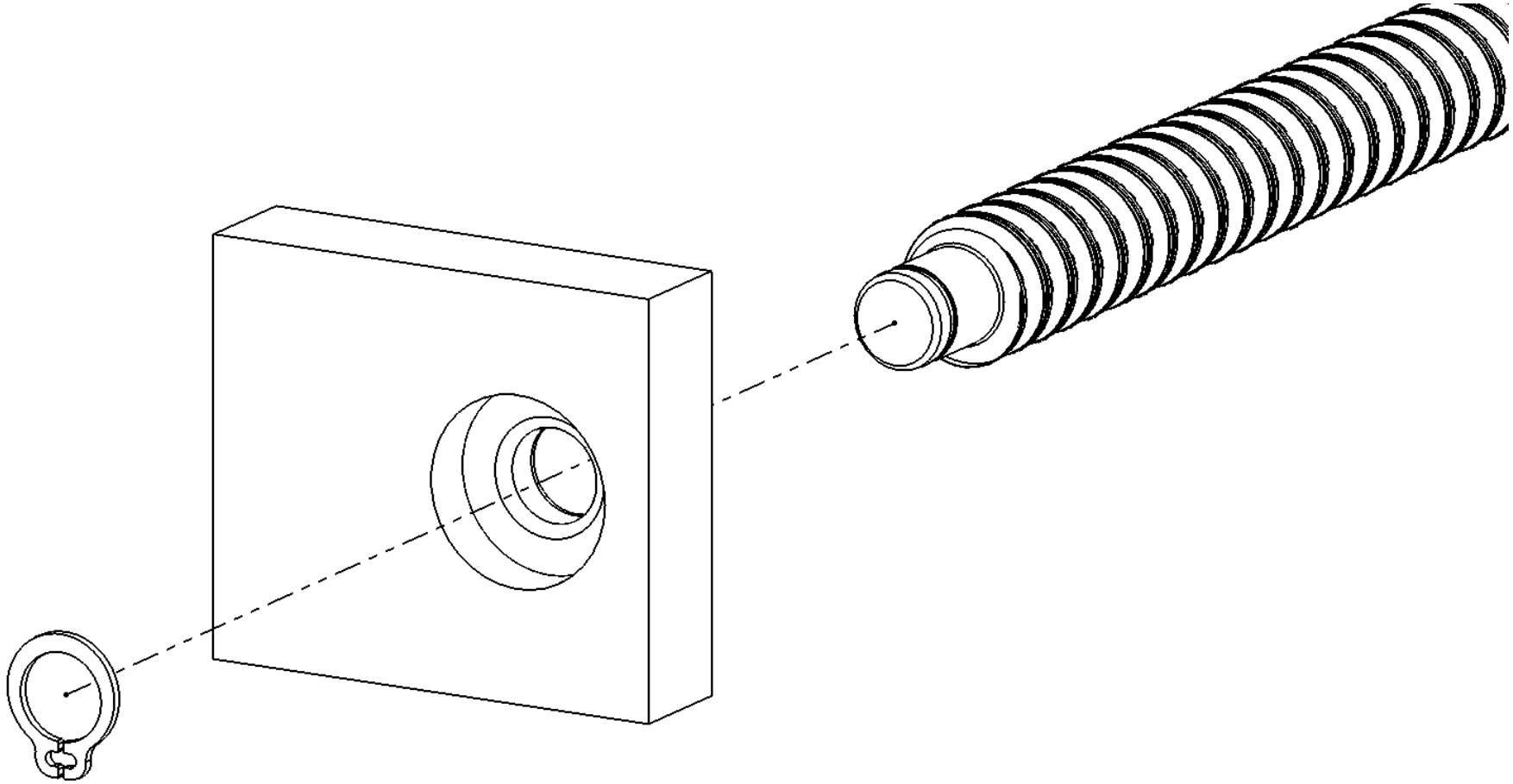
As with the previous two axes, begin the Z-axis subassembly by setting the bearings. The 26 mm bearing gets fully seated into the pocket in the Z-Top Plate. The 16 mm bearing gets seated into the Z-BallScrew Lower Support until it's flush with the top surface. (J6 transition-fit for both).



STEP 85 ATTACH THE Z-AXIS LEAD SCREW TO THE BEARING BLOCKS

• SFU1204 250mm Z, • DIN 471 8 mm External Circlip

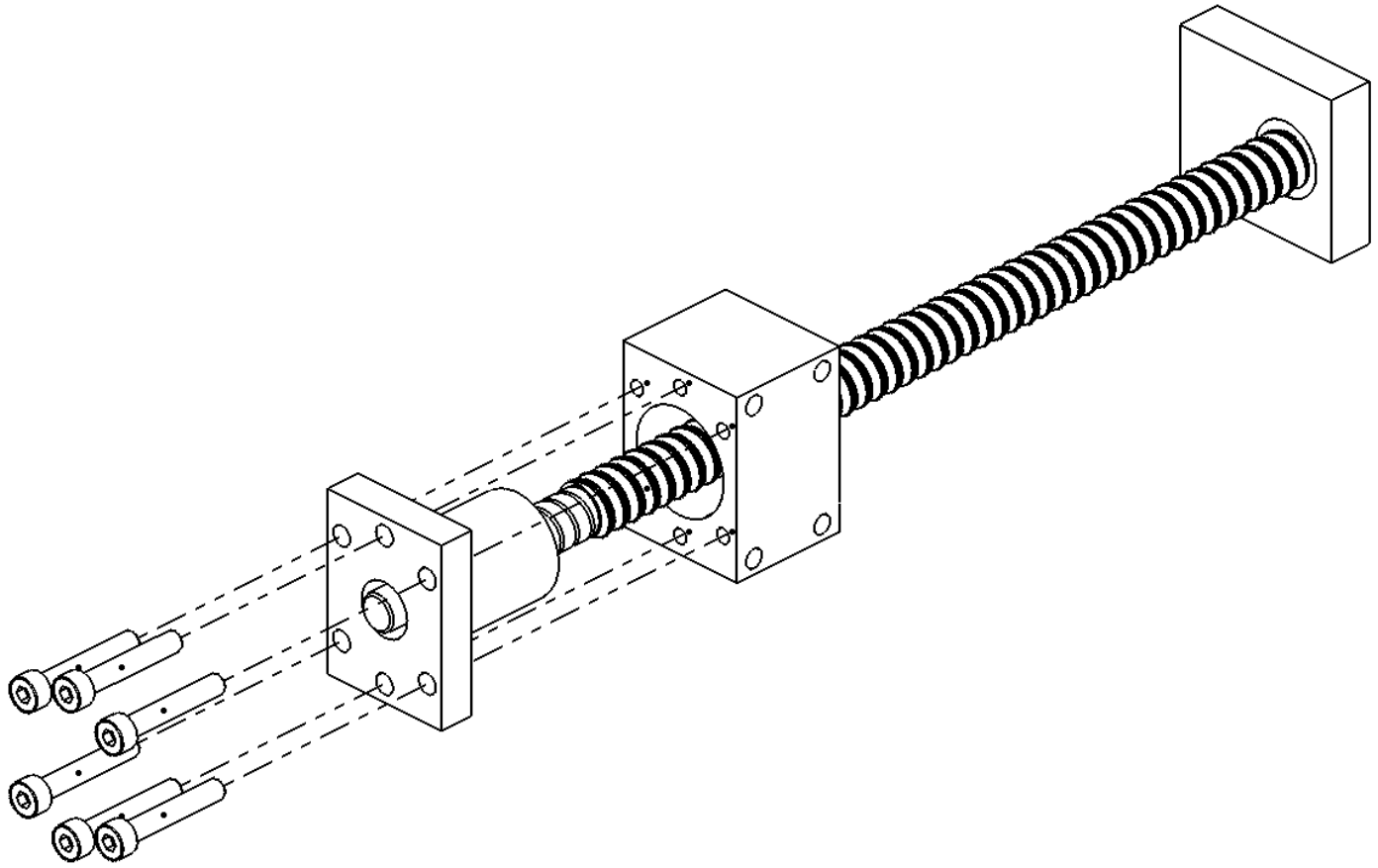
Press the back side of the Z-axis lead screw into the inner trace of the 16 mm bearing from Step 84 (j6 transition fit). Secure the components in place using an 8 mm circlip.



STEP 86 NUT BLOCK FOR THE Z-AXIS LEAD SCREW

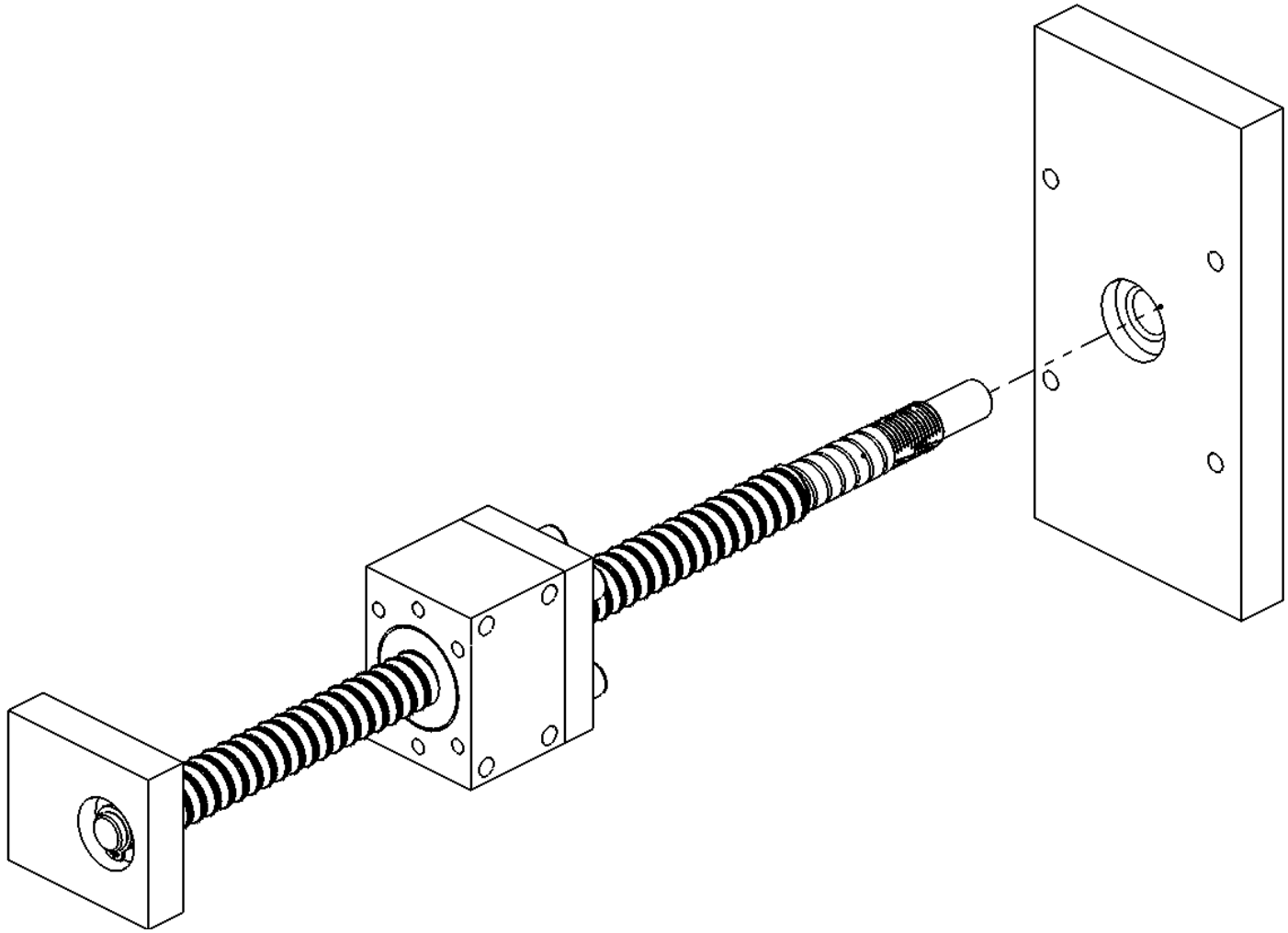
- SFU1204 Nut, • Nut Block Z
- ISO 4762 M4 x 25 - 25N x6

Attach the Z-axis nut block to the lead screw nut using six M5 x 25 bolts. Then thread the nut onto the lead screw. Note: make sure the flange of the lead screw nut and the heads of the bolts are oriented toward the open end of the lead screw.



STEP 87 TOP PLATE BEARING BLOCK FOR THE Z-AXIS SUBASSEMBLY

Complete the lead screw subassembly by pressing 26 mm bearing onto the open end of the lead screw (j6 transition fit).

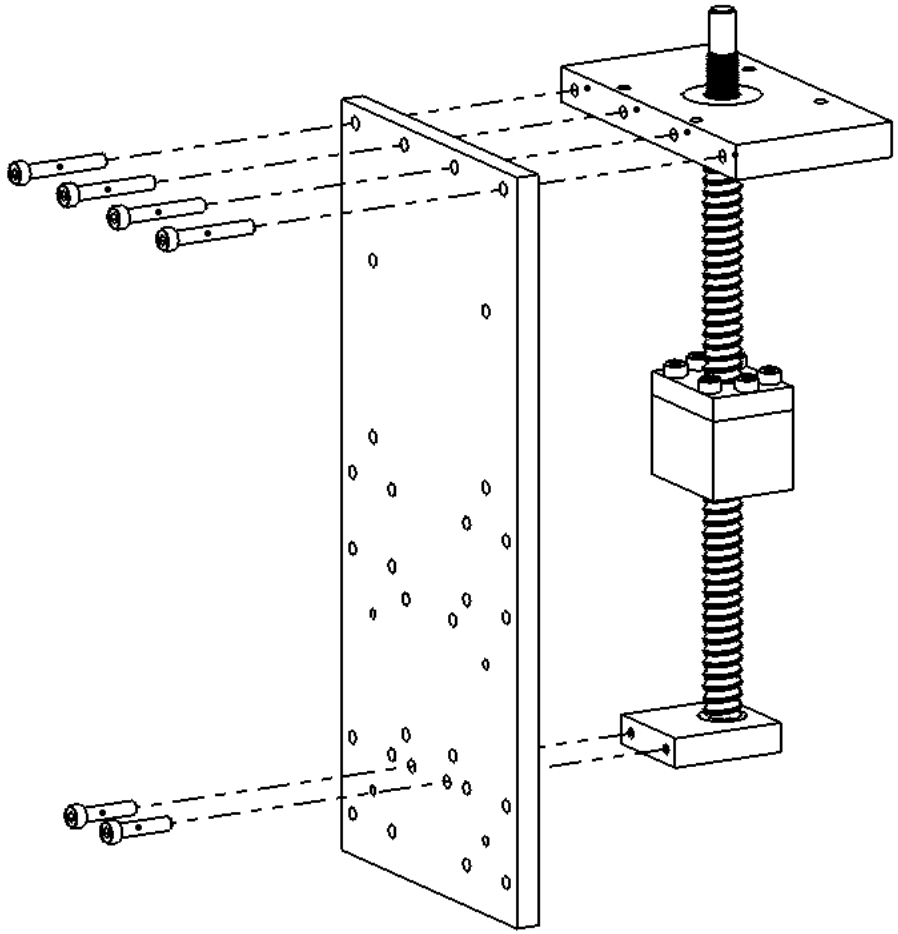


STEP 88 ATTACH THE BACK PLATE FOR THE Z-AXIS TO THE LEAD SCREW SUBASSEMBLY

- Z Back plate

- ISO 4762 M4 x 20 - 20N x2, • ISO 4762 M4 x 30 - 30N x4

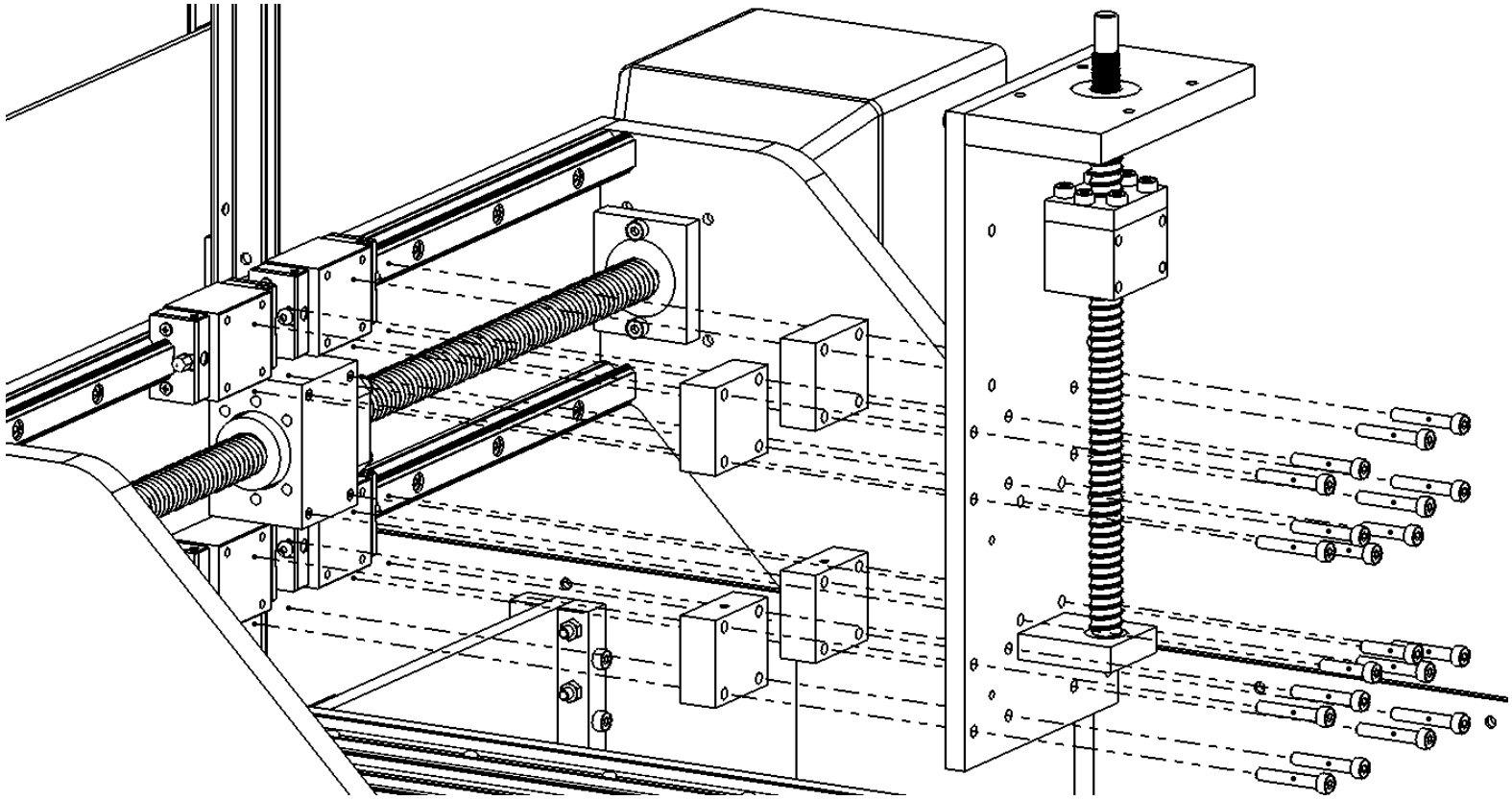
Attach the back plate to the top plate using four M4 x 30 bolts, and to the ballscrew lower support with two M4 x 20 bolts.



STEP 89 ADD THE Z-AXIS SUBASSEMBLY TO THE MAIN ASSEMBLY

- X Spacer Block x2, • X Spacer Block for shield x2
- ISO 4762 M4 x 27 Modified x16, • ISO 4762 M4 x 20 - 20N x4

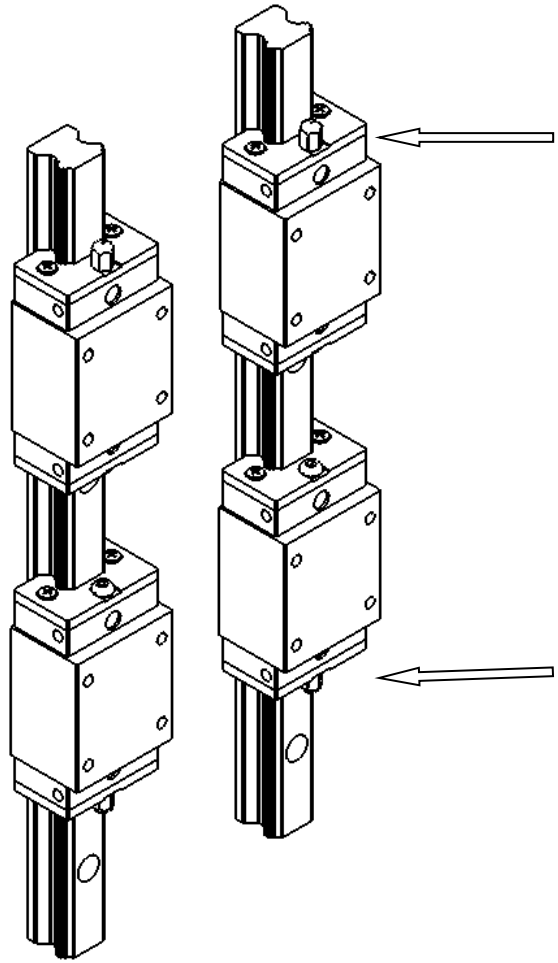
Now connect the Z-axis subassembly to the rest of the machine. The nut block attaches to the center using four M4 x 20 bolts. Then each of the linear guides gets a spacer block and is secured with four M4 x 27 bolts. The two linear guides on top get normal spacer blocks, and the two on the bottom get spacer blocks with an extra hole to attach the shield. Note: 27 mm bolts are necessary for this step since 30 mm bolts are too long for the tapped holes in the linear guides, and 25 mm bolts do not meet the minimum thread engagement.



STEP 90 BEGIN THE LINEAR RAIL SUBASSEMBLY FOR THE Z-AXIS

• HGR15 Z x2, • HGH15C x4

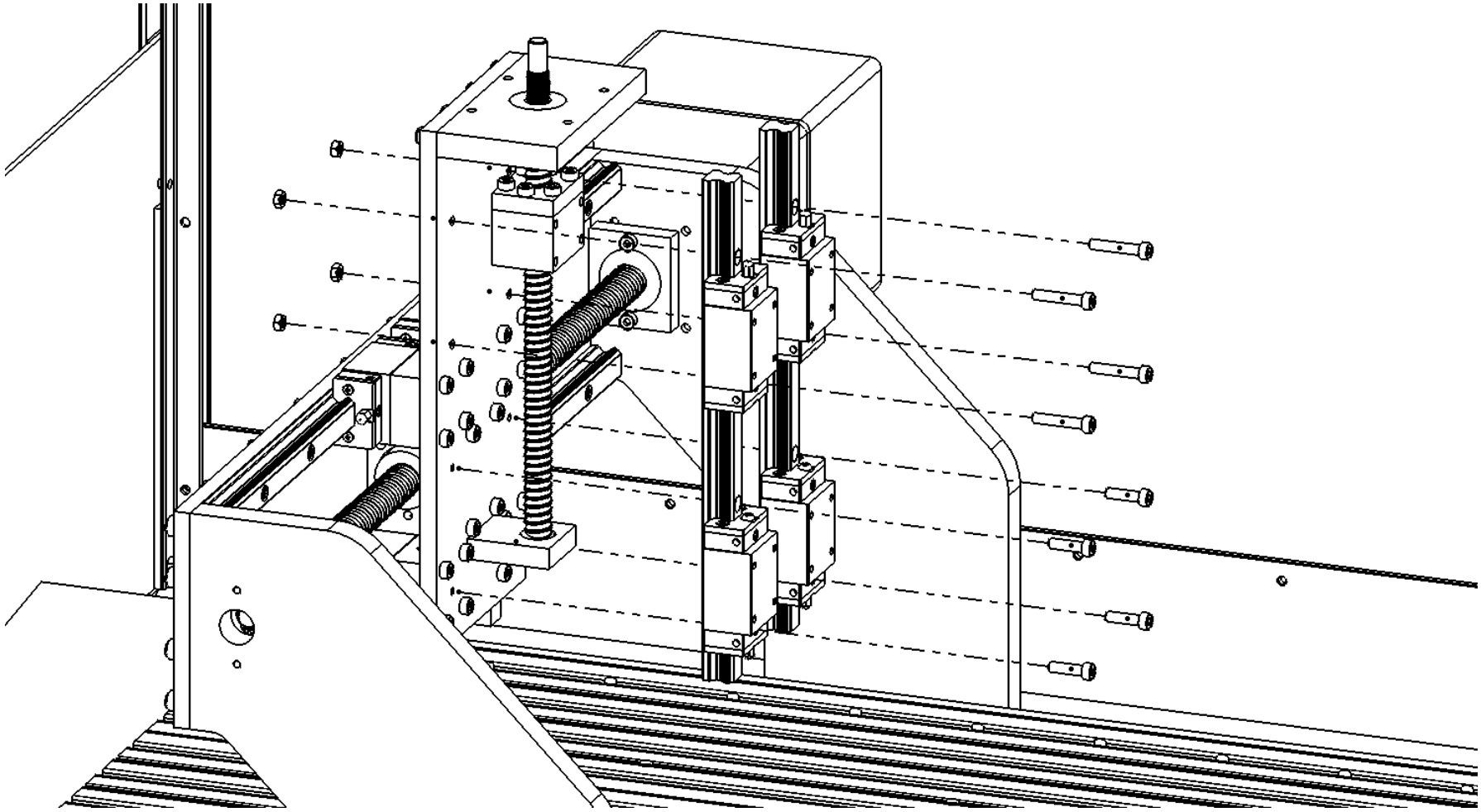
Slide the last four of the linear guides onto the two 243 mm linear rails for the Z-axis. Once again, make sure the grease nipples (see arrows below) are oriented away from each other.



STEP 91 CONNECT THE LINEAR RAIL SUBASSEMBLY TO THE MAIN ASSEMBLY

• ISO 4762 M4 x 25 - 25N x4, • ISO 4762 M4 x 17 - 17N x4, • ISO - 4032 - M4 Nut x4

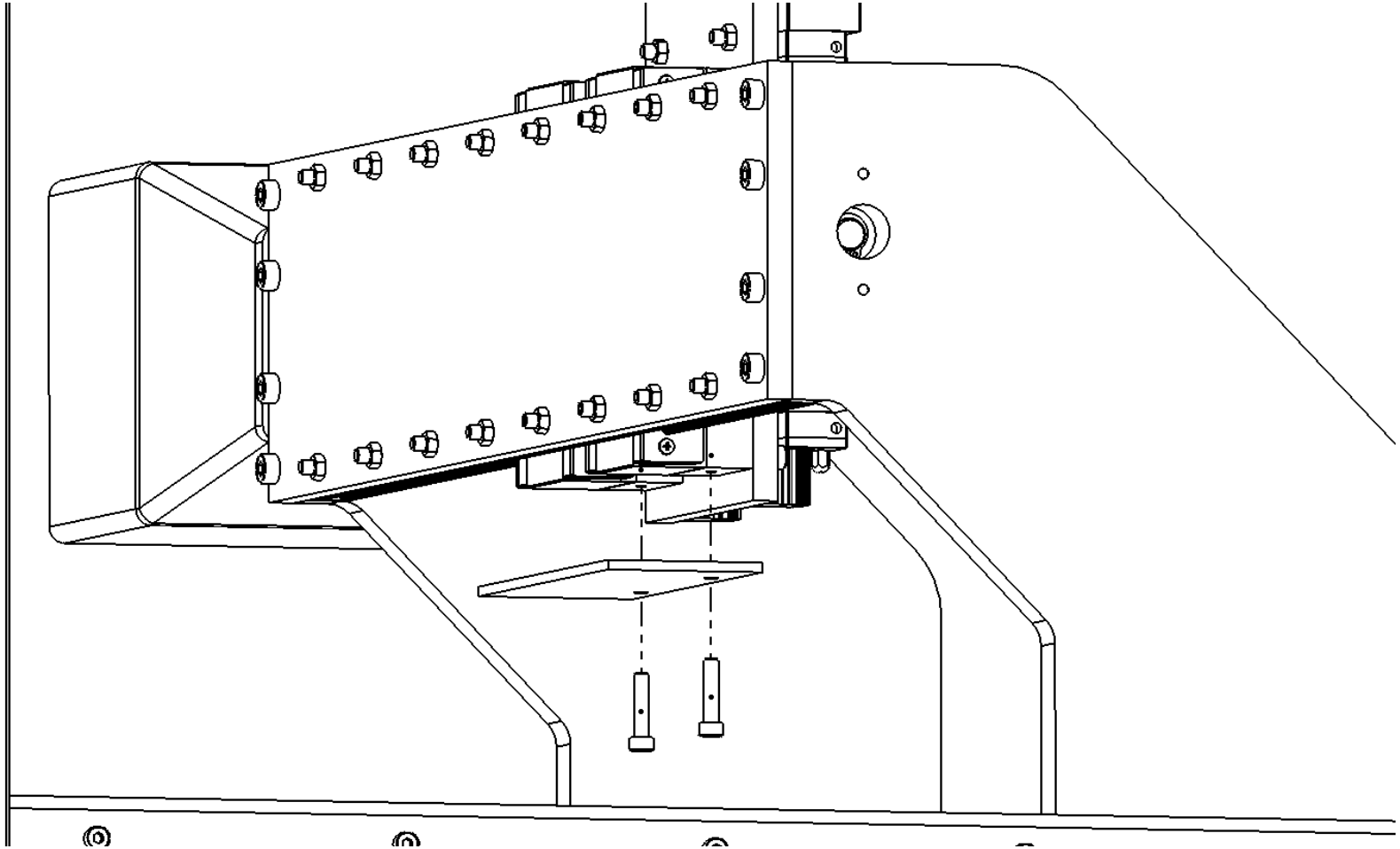
Attach the linear rails to the Z-Back Plate using four M4 x 17 bolts for the bottom holes where nuts would interfere with the X-axis. Use four M4 x 25 bolts for the top holes and secure them with four locking nuts.



STEP 92 INSTALL THE X-AXIS SHIELD

- X Axis Shield
- ISO 4762 M4 x 20 - 20N x2

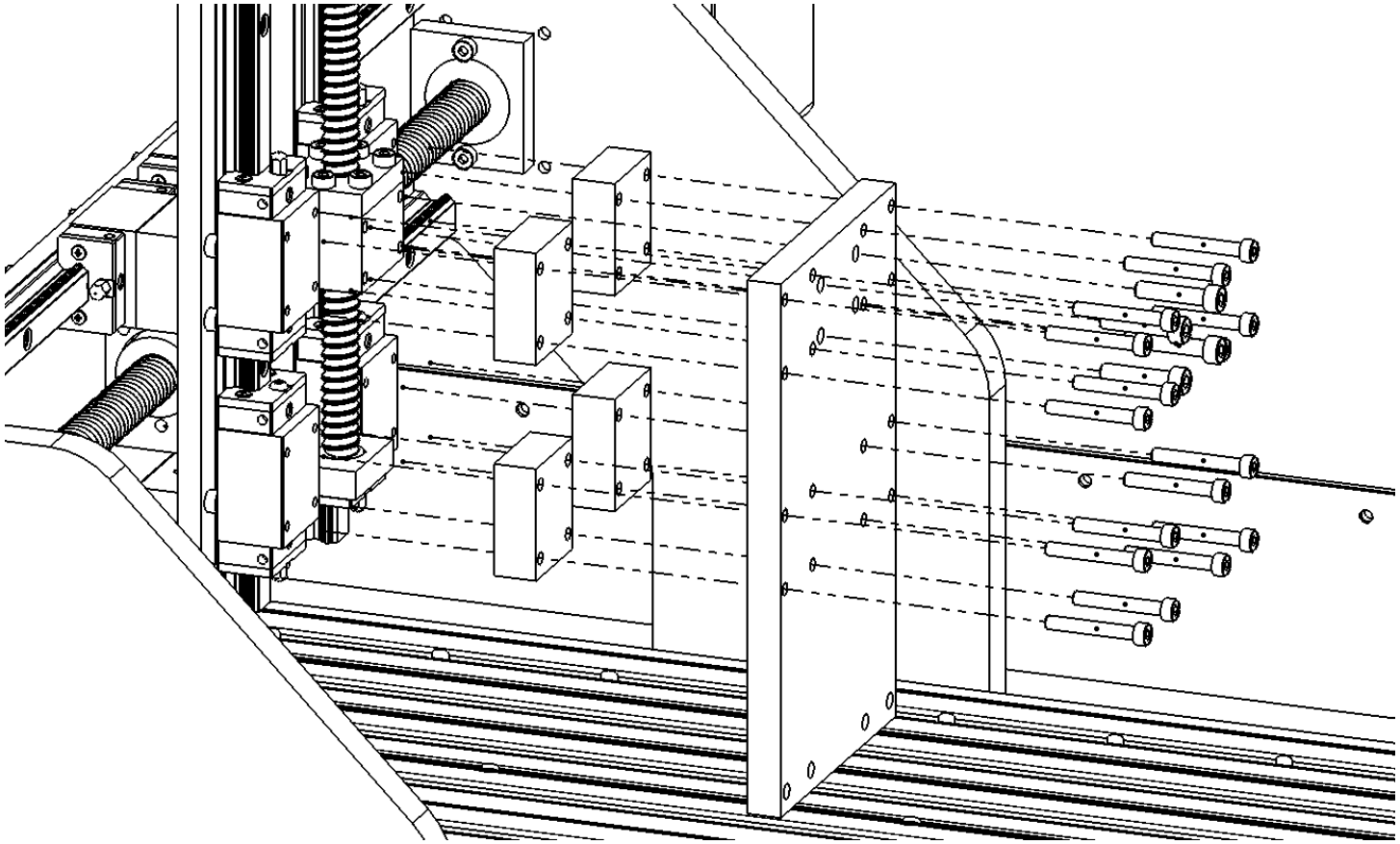
Attach the X-Axis Shield to the underside of the X-Spacer Blocks for Shield from Step 90 using two M4 x 20 bolts.



STEP 93 ATTACH THE FRONT PLATE AND SPACER BLOCKS FOR THE Z-AXIS

- Z-Spacer Block x4, • Z-Front Plate
- ISO 4762 M4 x 32 Modified x16, • ISO 4762 M5 x 25 - 25N x4

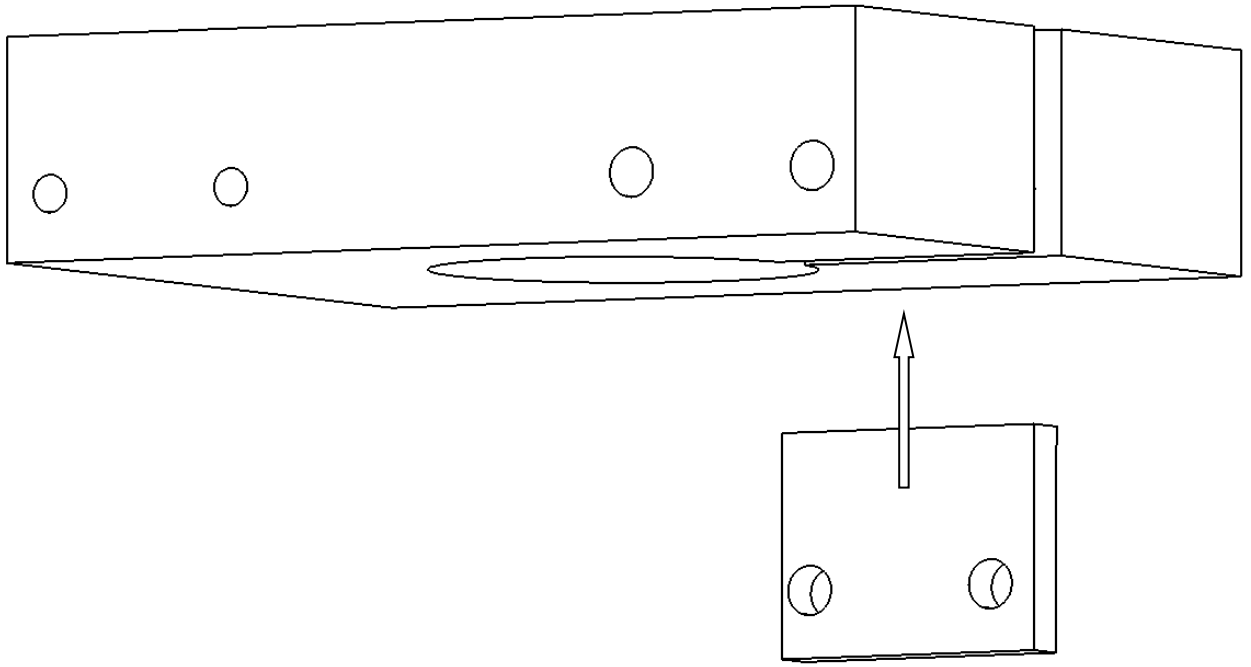
Connect the Z-Front Plate to the rest of the machine more or less the same way as the back plate in Step 89. The nut block attaches to the center using four M5 x 25 bolts. Then each of the linear guides gets a spacer block and is secured with four M4 x 25 bolts. Note: 32 mm bolts are necessary for this step since 35 mm bolts are too long for the tapped holes in the linear guides, and 30 mm bolts do not meet the minimum thread engagement.



STEP 94 INSERT THE SPACER FOR THE SPINDLE PLATE INTO THE SPINDLE PLATE

• Spindle Plate, • Spacer for Spindle Plate

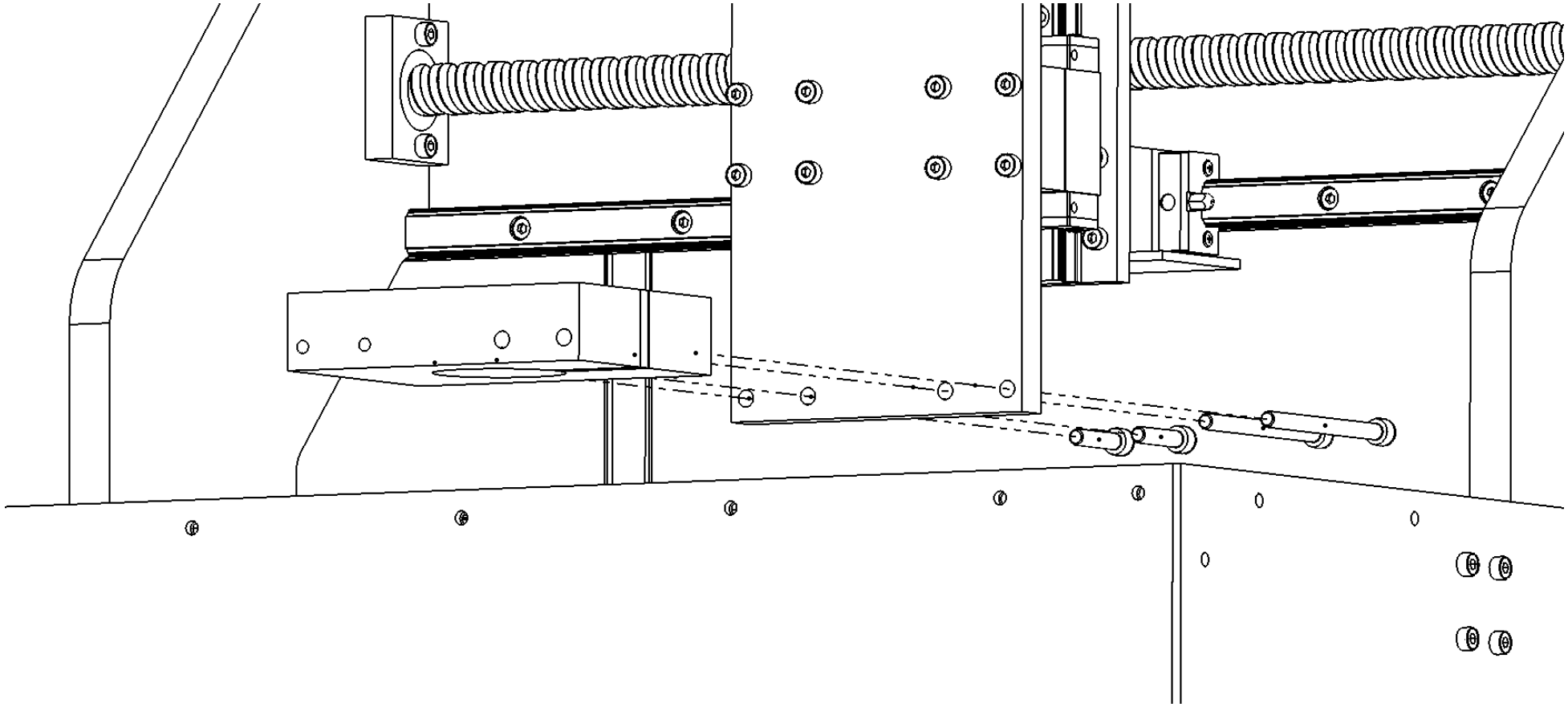
Insert the Spacer for Spindle Plate into the Spindle Plate.



STEP 95 CONNECT THE SPINDLE PLATE

• ISO 4762 M5 x 25 - 25N x2, • ISO 4762 M5 x 70 - 22N x2

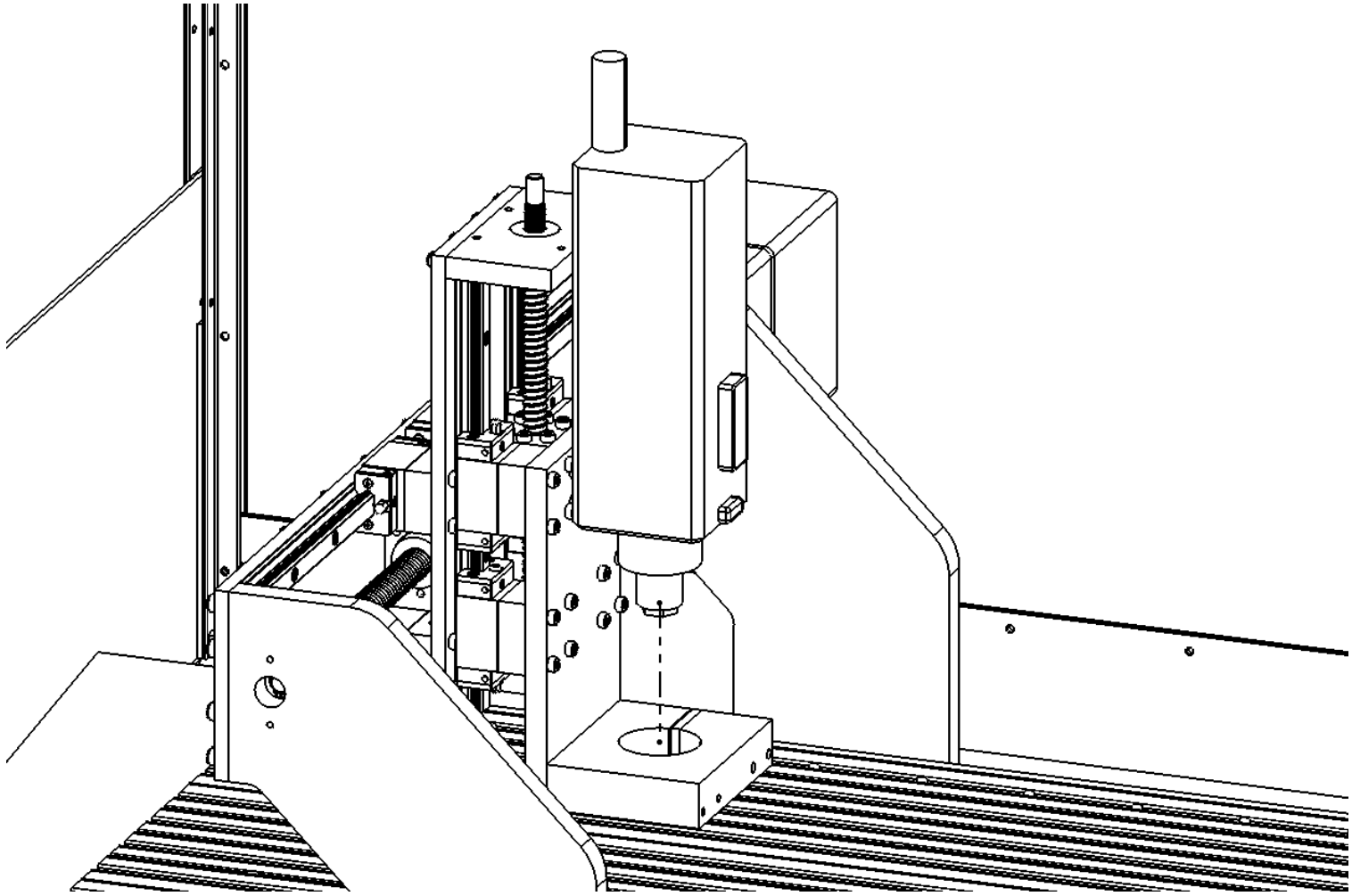
Connect the Spindle Plate to the Z-Front Plate using two M5 x 25 bolts on the solid side (LEFT) and two M5 x 70 bolts on the side with the spacer (RIGHT). Do not fully tighten the 70 mm bolts until after the router is installed in the next step.



STEP 96 INSTALL THE ROUTER

- Mafell FM 1000

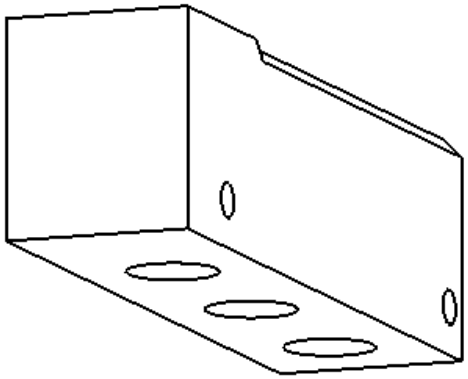
Attach the router to the machine by lowering it into place in the Spindle Plate and tightening the 70 mm bolts from the previous step.

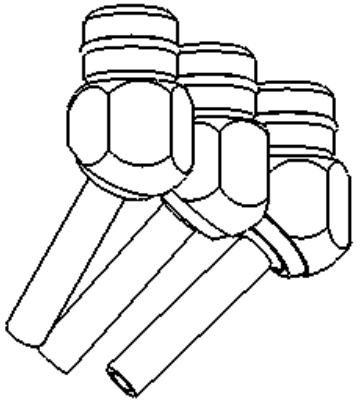


STEP 97 INSERT THE NOZZLES INTO THE COOLANT DISTRIBUTOR

• Coolant Distributor, • Adjustable Coolant Nozzle x3

Thread the adjustable nozzles into the Coolant Distributor. Note: Be careful not to overtighten them as this will damage the NPT threads and cause leaking.

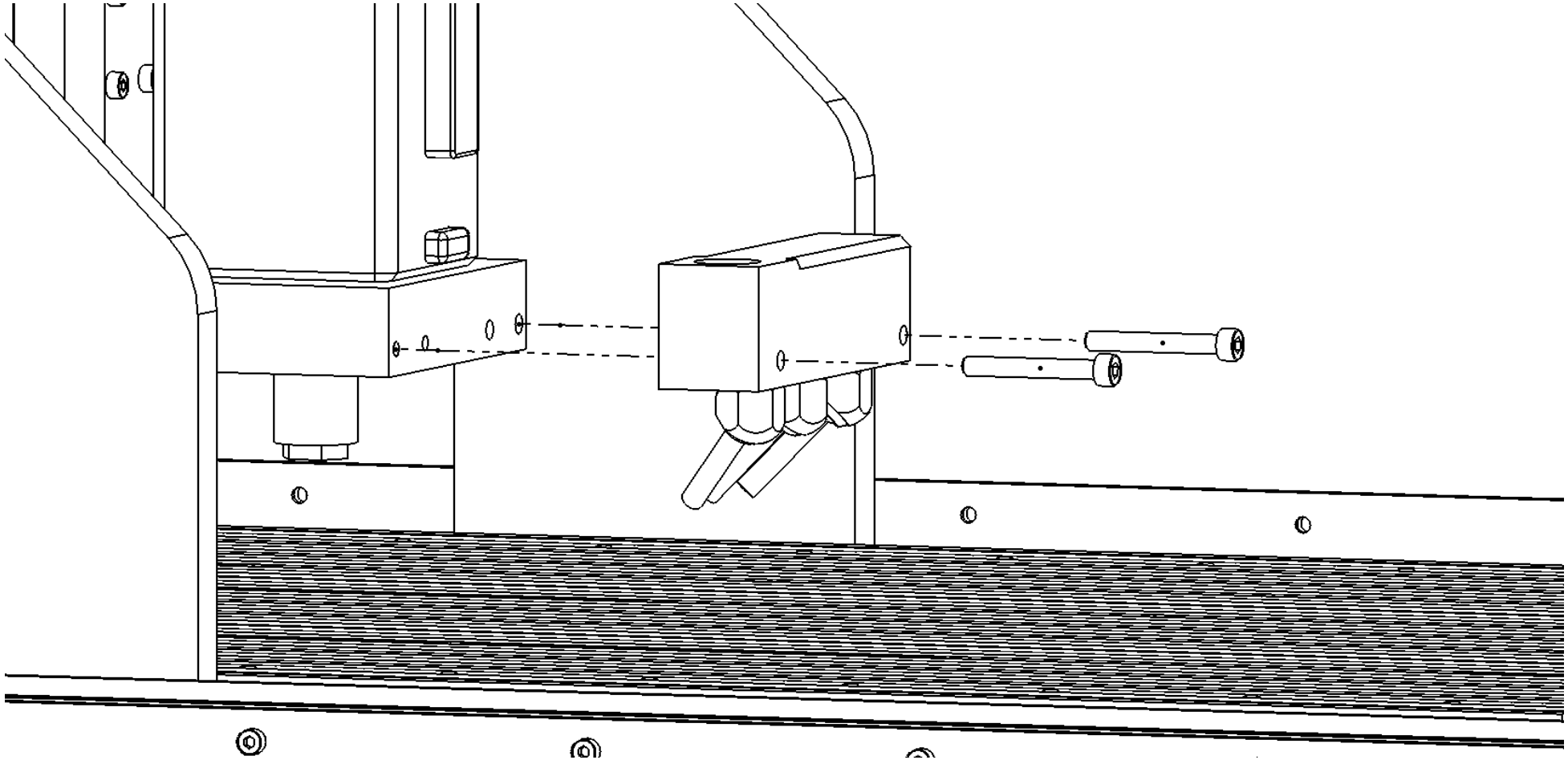




STEP 98 CONNECT THE COOLANT DISTRIBUTOR

- ISO 4762 M5 x 40 - 22N x2

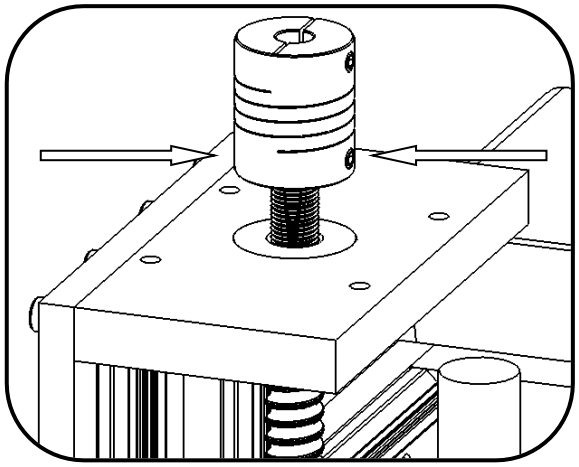
Attach the Coolant Distributor to the machine using two M5 x 40 bolts. Make sure the hole in the top is oriented toward the left side of the machine.

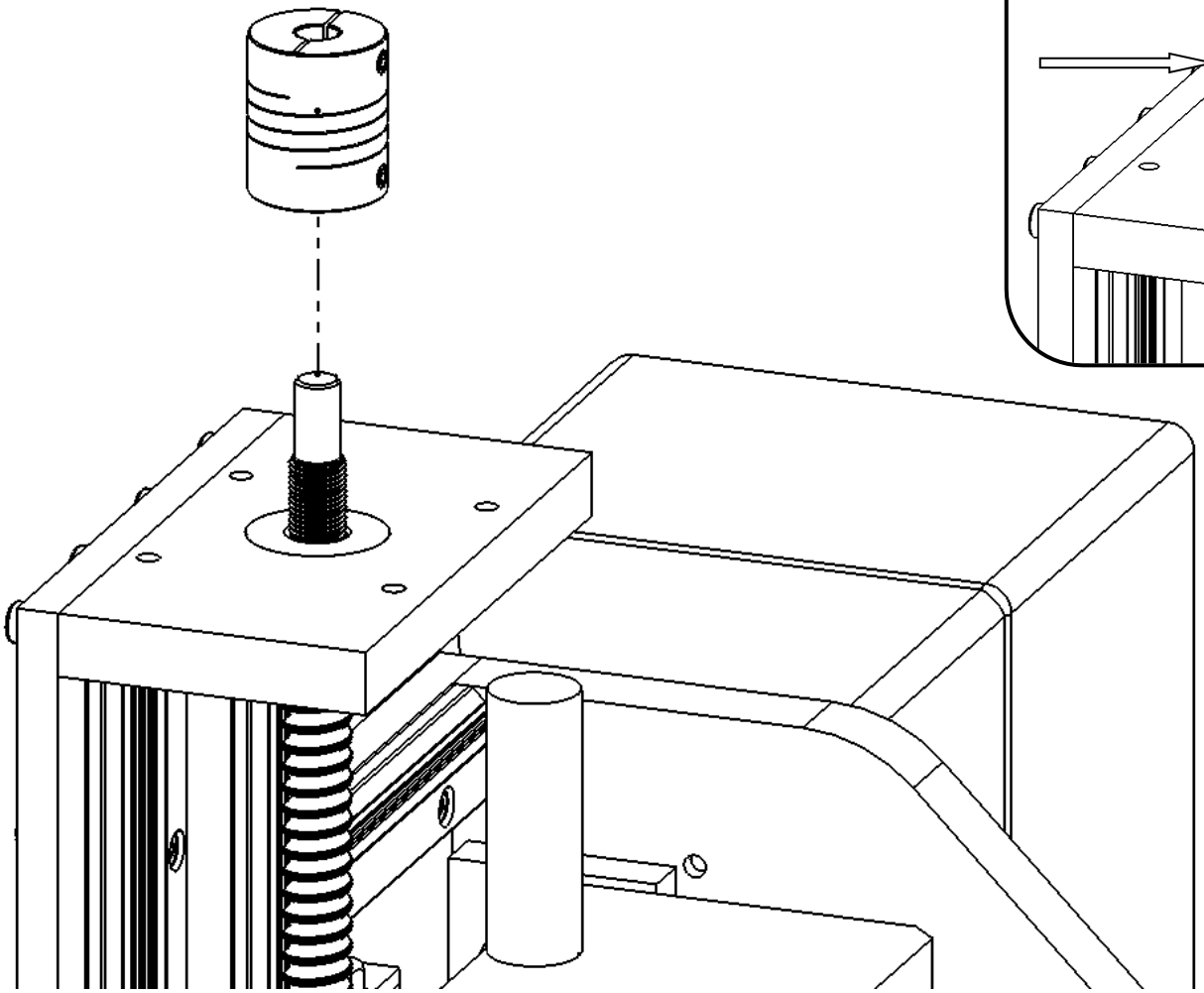


STEP 99 CONNECT THE SHAFT COUPLER FOR THE Z-AXIS MOTOR TO THE LEAD SCREW

- Shaft Coupler 8x8mm

Connect the shaft coupler to the Z-axis lead screw using the provided set screw and clamping bolt.

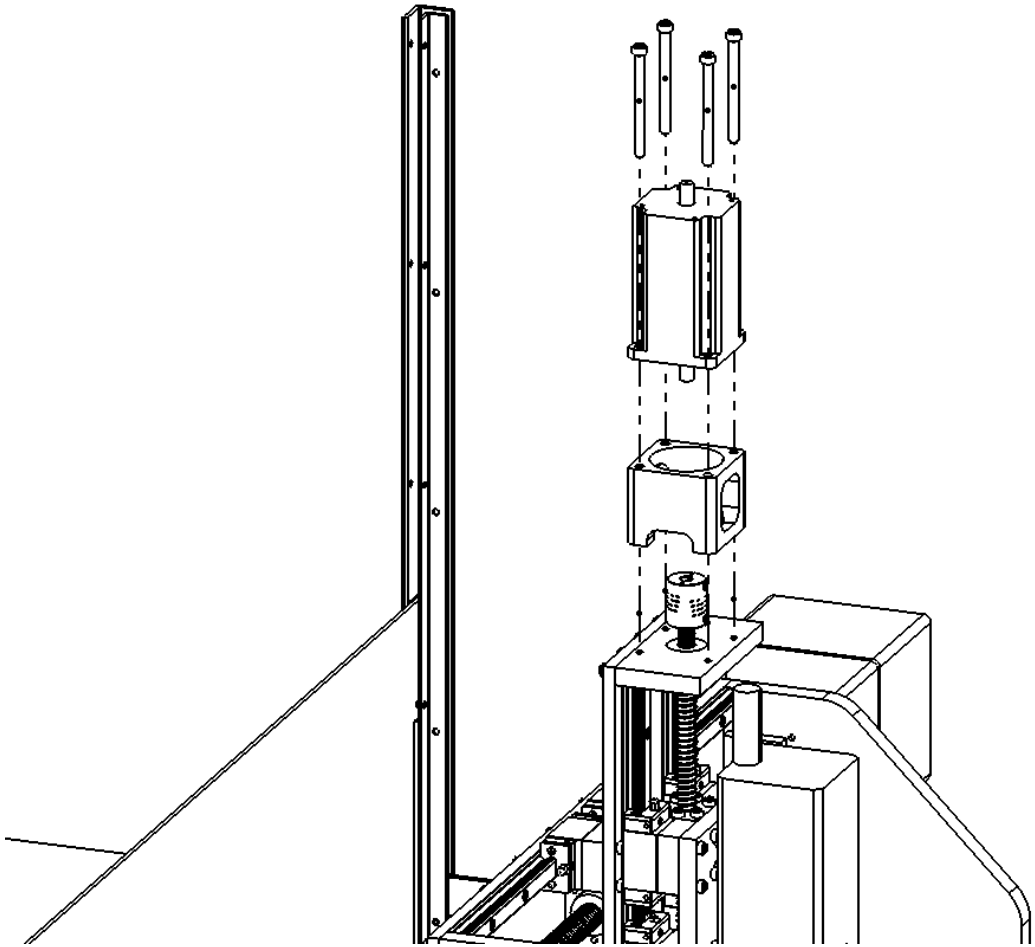




STEP 100 ATTACH THE Z-AXIS MOTOR

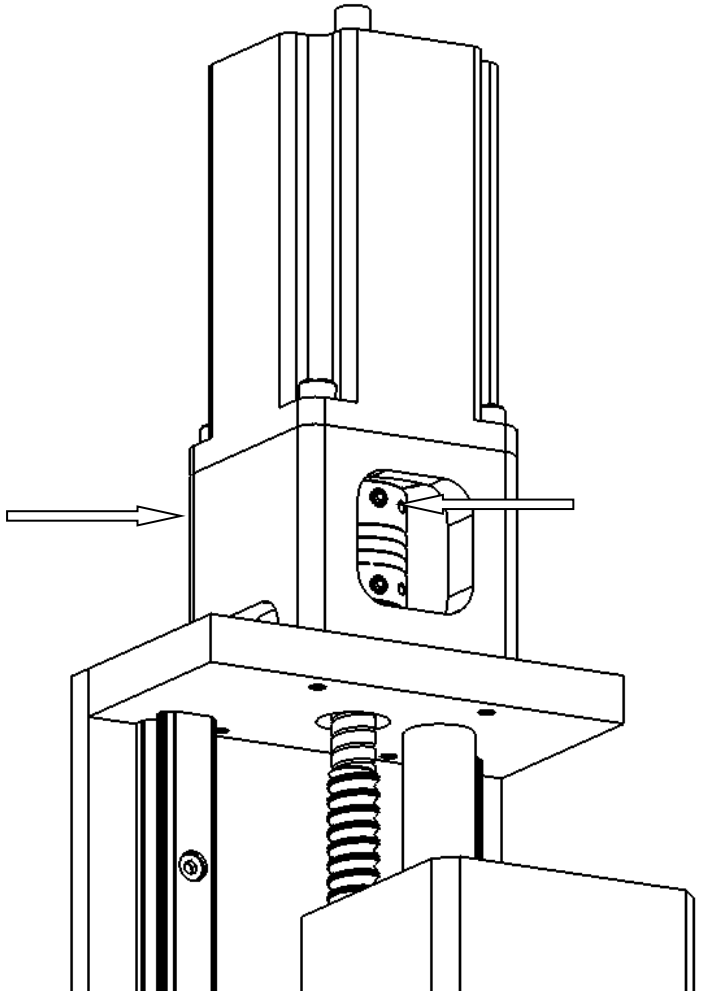
- Z-Axis Motor Adaptor, • Nema 24 Motor
- ISO 4762 M5 x 70 - 22N x4

Use four M5 x 70 bolts to connect the motor to the assembly via the motor adaptor.



STEP 101 CONNECT THE SHAFT COUPLER TO THE Z-AXIS MOTOR

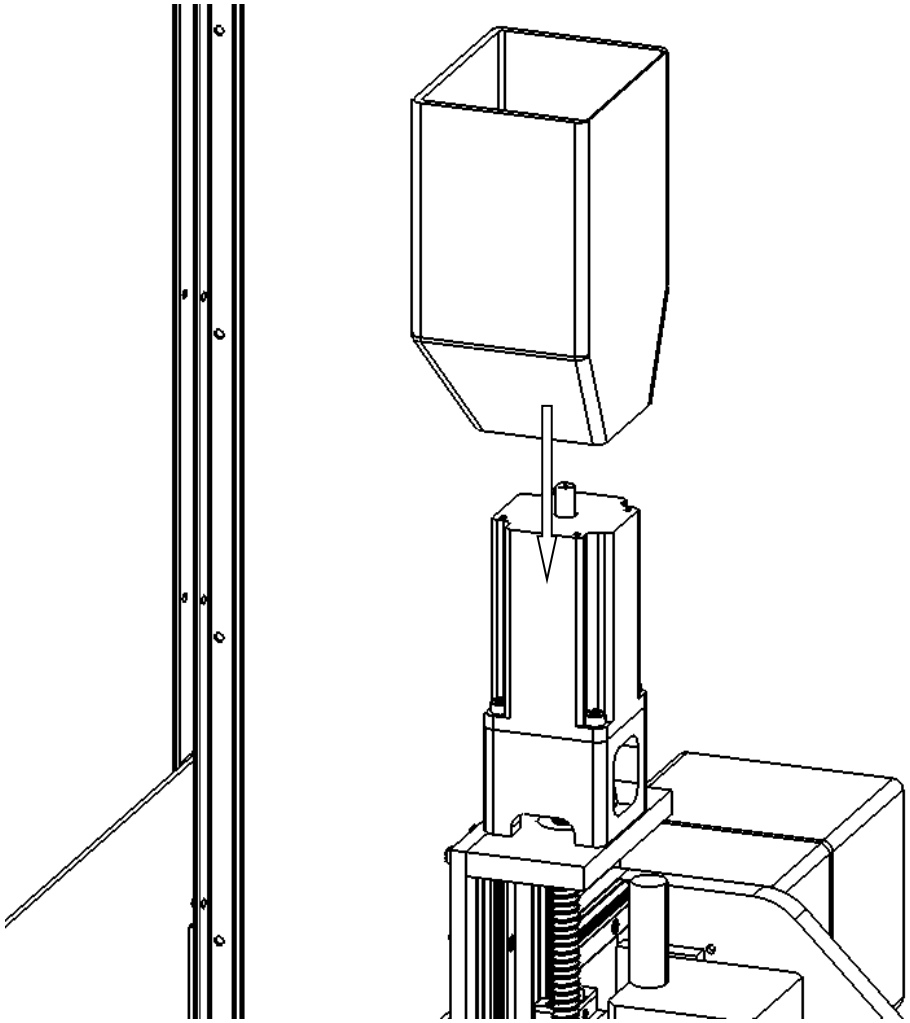
As done in Steps 28 and 82, connect the shaft coupler to the motor shaft through the cavities in the motor mount using the provided set screw and clamping bolt.



STEP 102 SLIDE THE Z-MOTOR COVER INTO POSITION

- Cover for Z-Motor

Finally, slide the Cover for Z-Motor over the motor and motor adaptor with the flat side facing the front of the machine.

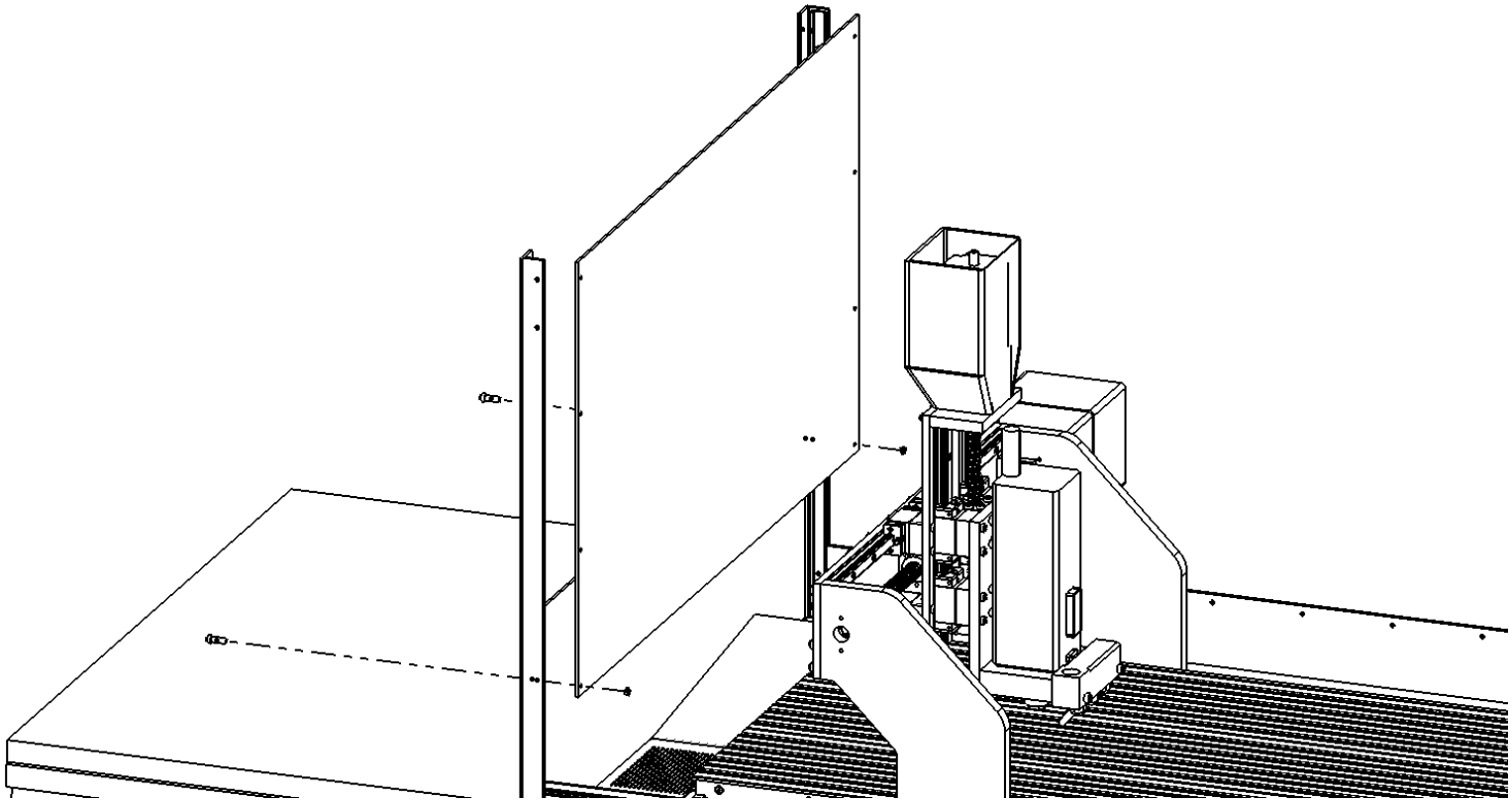


SECTION 3: ENCLOSURE

STEP 103 INSTALL THE BACK PLEXIGLASS PANEL

- PG Back Panel
- ISO 4762 M4 x 16 - 16N x2, • ISO - 4032 - M4 Nut x2

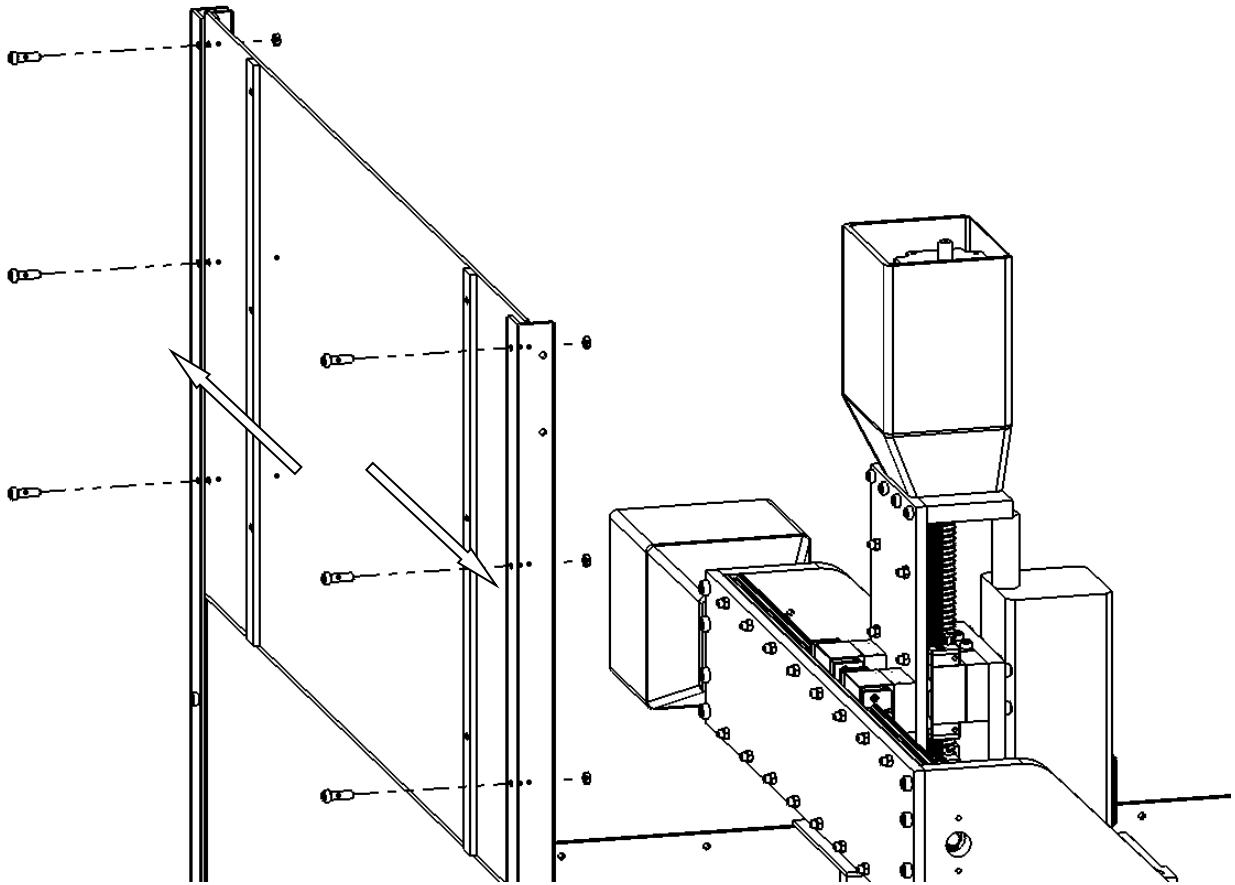
The plexiglass back panel should be attached to the front of the Al Back Panel using two M4 x 16 bolts and locking nuts in the bottom holes. Note: The back panel will need to slide between the Back Right Outer Corner and the Back Inner Corner, so this component will probably be easier to rotate into place instead of sliding.



STEP 104 ATTACH THE INSERTS FOR THE BACK SIDE

- Back Left Corner Inserts 4.5mm, • Back Right Corner Inserts 4.5mm
- ISO 4762 M4 x 16 - 16N x6, • ISO - 4032 - M4 Nut x6

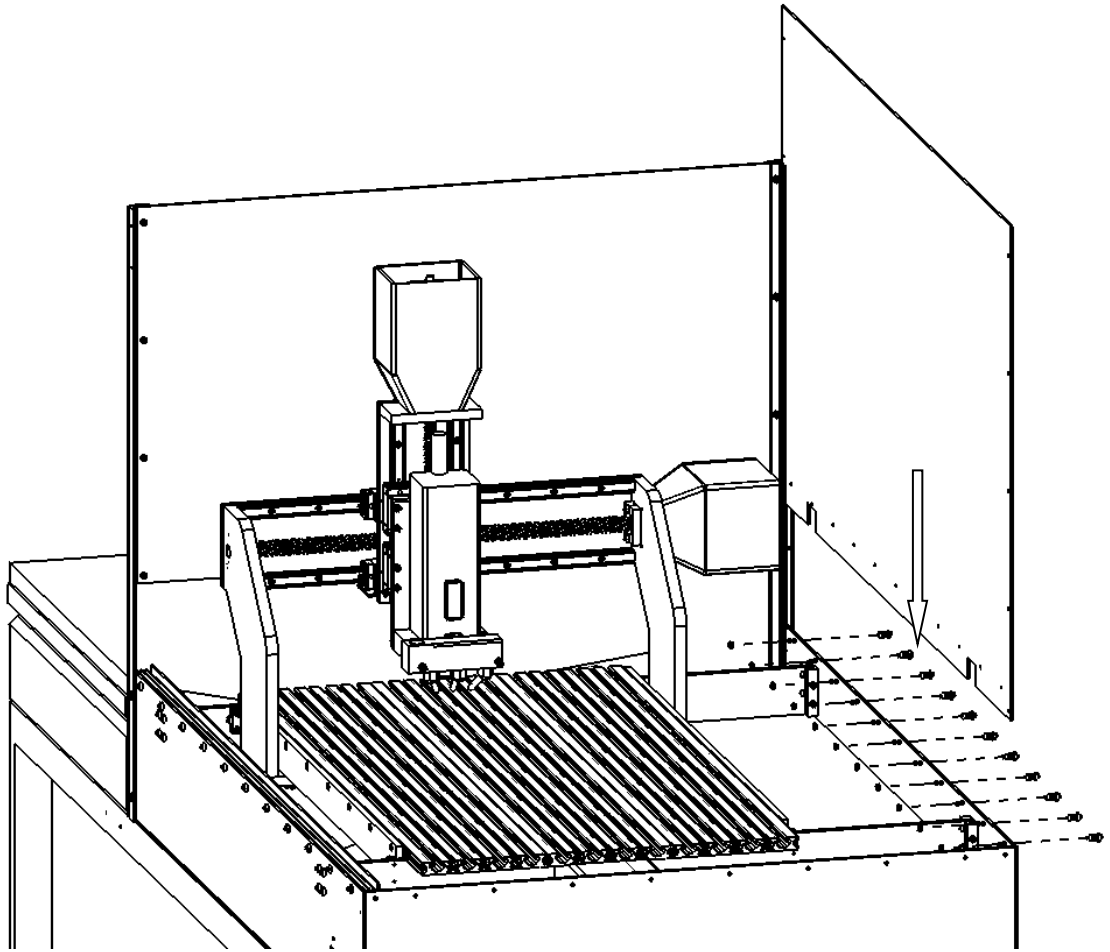
Insert the 4.5 mm inserts into the space between the plexilass and the outer corners and secure all of the components using three M4 x 16 bolts and locking nuts on either side.



STEP 105 ATTACH THE PLEXIGLASS PANEL FOR THE RIGHT SIDE

- PG Side Panel
- ISO 4762 M4 x 12 - 12N x11, • ISO - 4032 - M4 Nut x11

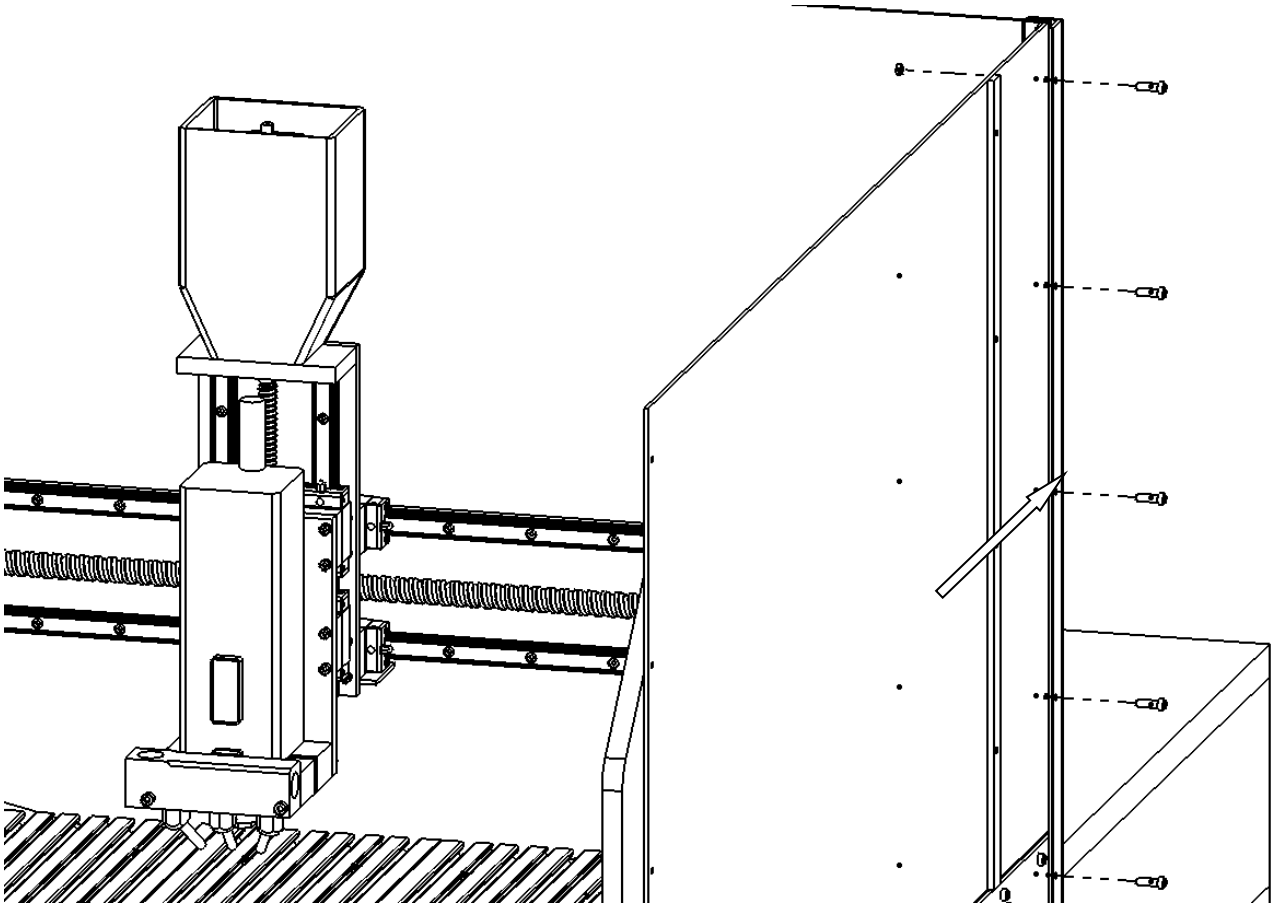
Slide the plexiglass panel for the right side into place and secure it along the bottom using 11 M4 x 12 bolts and locking nuts.



STEP 106 CONNECT THE INSERTS FOR THE BACK RIGHT CORNER

- Right Back Corner Inserts 4.5mm
- ISO 4762 M4 x 16 - 16N x5, • ISO - 4032 - M4 Nut x5

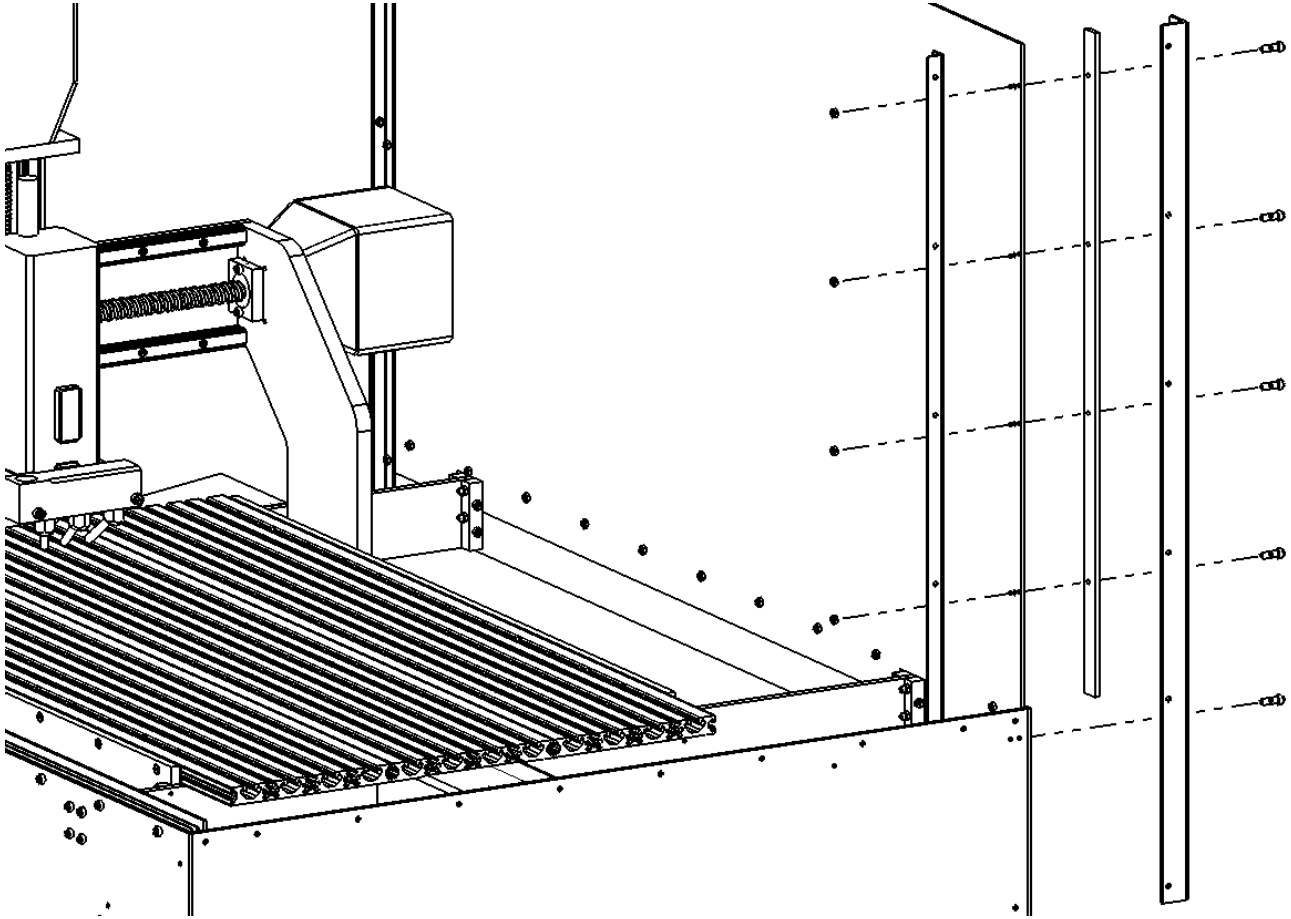
Slide the 4.5 mm insert for the right back corner into place so the holes line up with the corner pieces and the plexiglass on the right side. Secure the components in place using five M4 x 16 bolts and locking nuts.

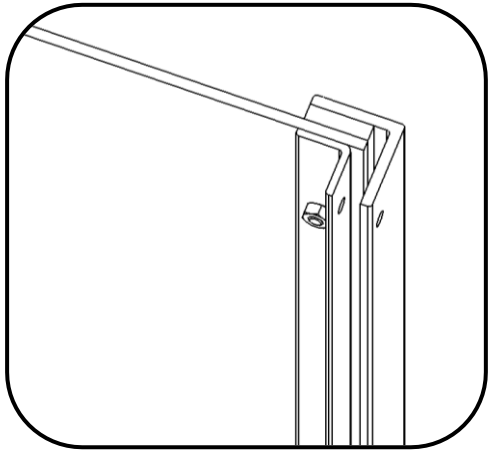


STEP 107 ASSEMBLE THE FRONT RIGHT CORNER

- Front Inner Corner, • Right Front Corner Inserts 4.5mm, • Front Right Outer Corner
- ISO 4762 M4 x 16 - 16N x5, • ISO - 4032 - M4 Nut x5

The front, right corner will be assembled in the same way, with the plexiglass and the insert sandwiched between the inner and outer corner components. Once again, all of the components will be secured using five M4 x 16 bolts on each side.

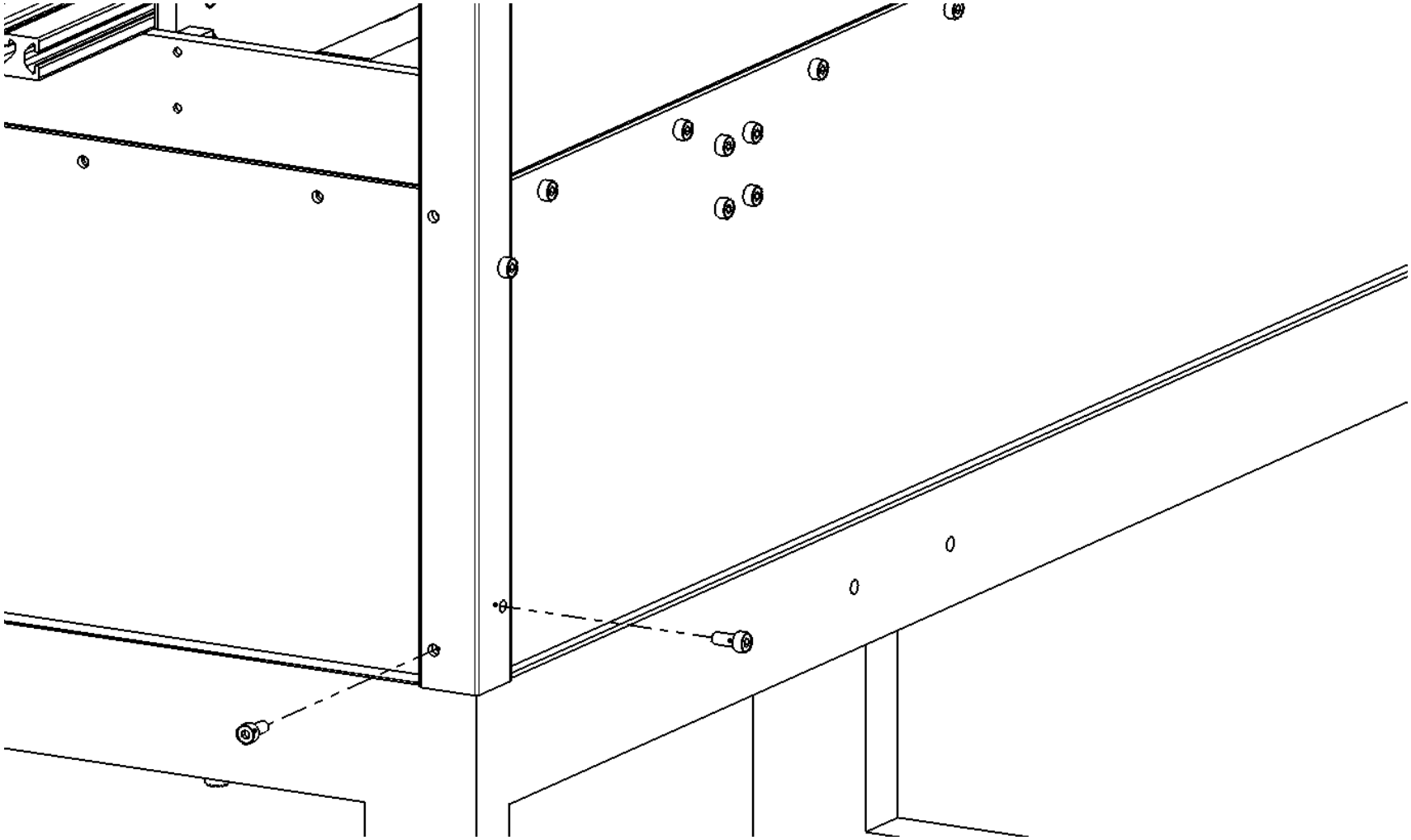




STEP 108 FINAL BOLTS FOR THE RIGHT SIDE SKIRT

• ISO 4762 M4 x 10 - 10N x2, • ISO - 4032 - M4 Nut x2

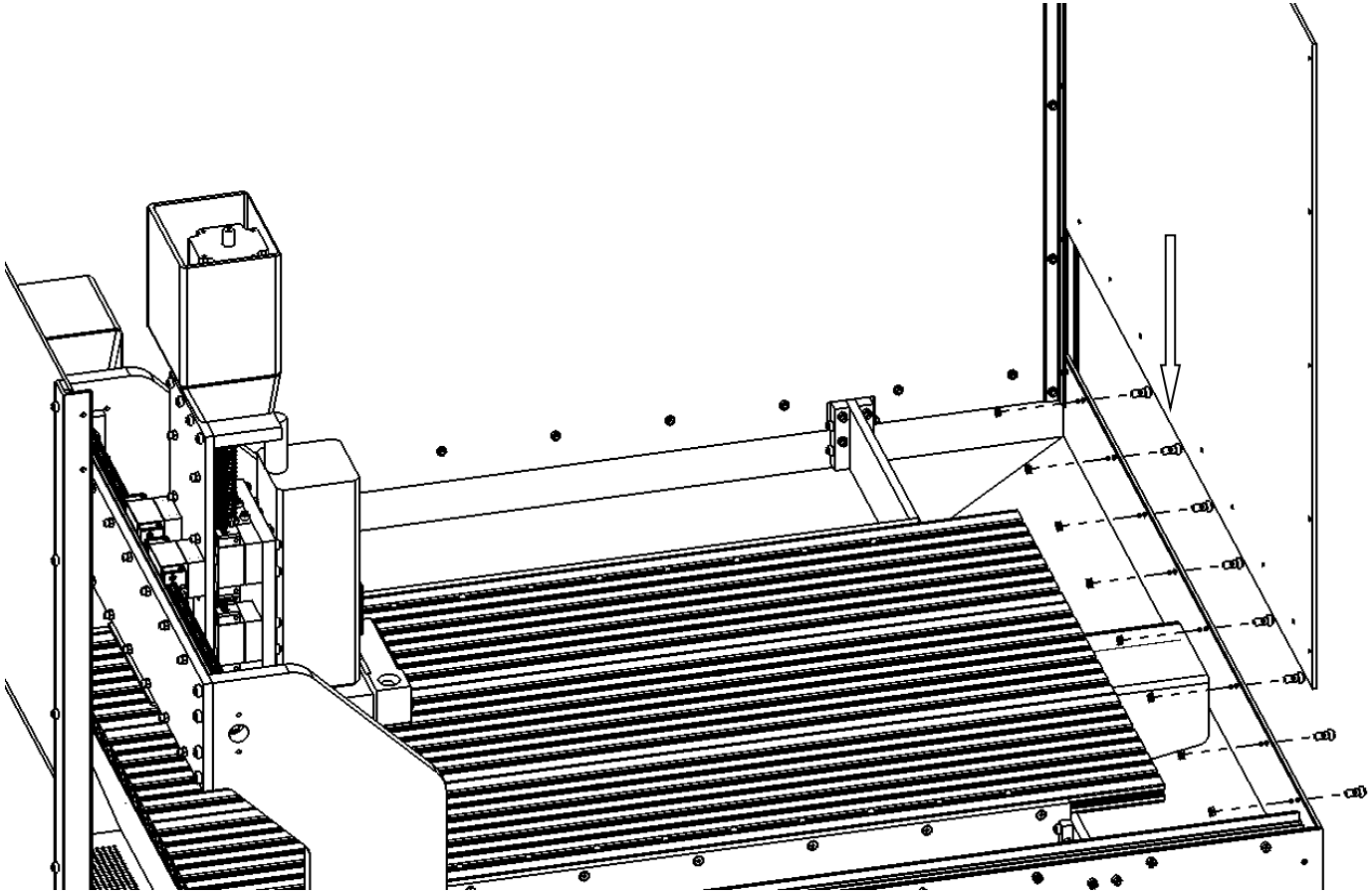
Add two M4 x 10 bolts to the bottom holes and secure them with locking nuts.



STEP 109 INSTALLING THE FRONT PLEXIGLASS PANEL

- PG Front Panel
- ISO 4762 M4 x 12 - 12N x8, • ISO - 4032 - M4 Nut x8

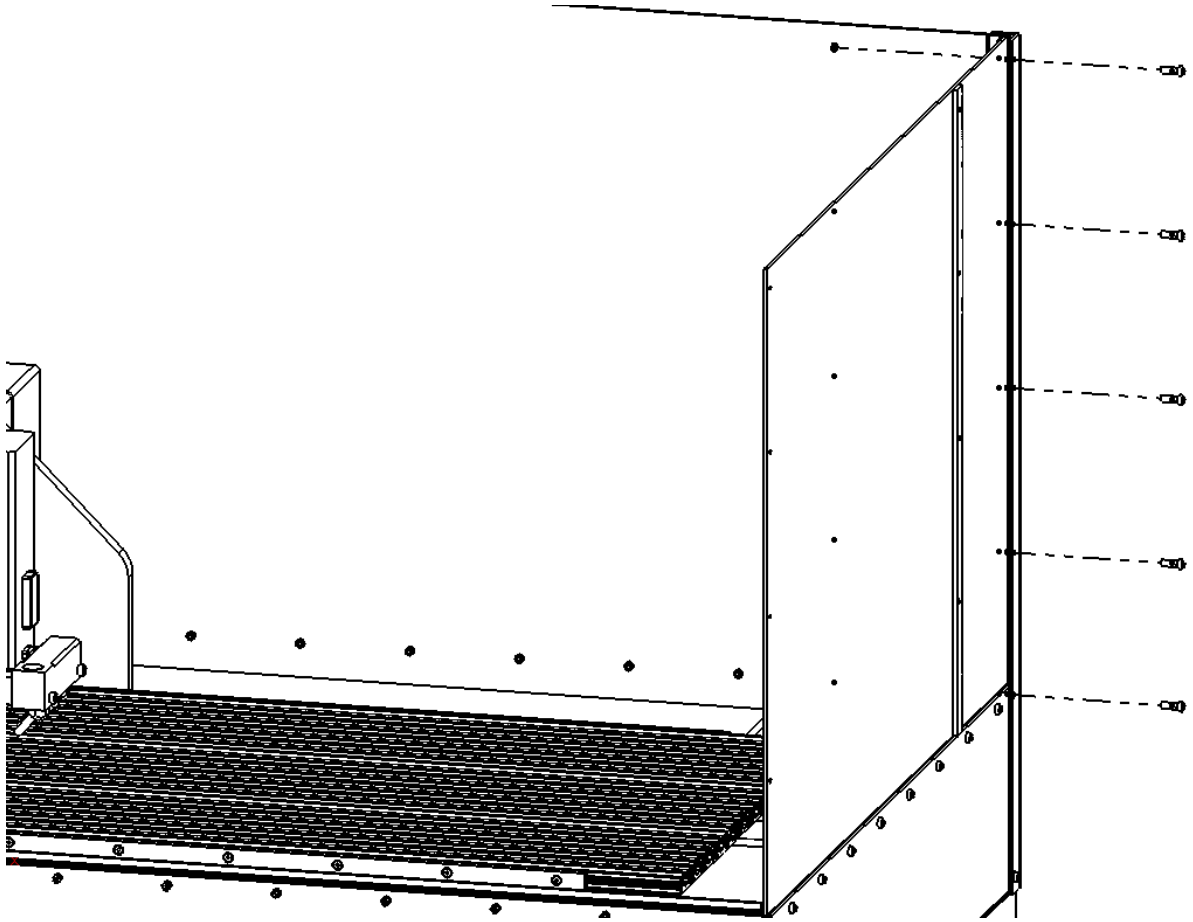
Add the front plexiglass panel to the machine in the same way as the Side Panel in Step 106 using eight M4 x 12 bolts and locking nuts along the bottom holes. Note: Once again, the panel needs to slide in between the inner and outer front, left corners so it might be easier to rotate it into place.



STEP 110 CONNECT THE INSERTS FOR THE FRONT RIGHT CORNER

- Front Right Corner Insert 4.5mm
- ISO 4762 M4 x 16 - 16N x5, • ISO - 4032 - M4 Nut x5

As in Step 107, slide the 4.5 mm insert for the front right corner into place so the holes line up with the corner pieces and the plexiglass. Secure the components in place using five M4 x 16 bolts and locking nuts.

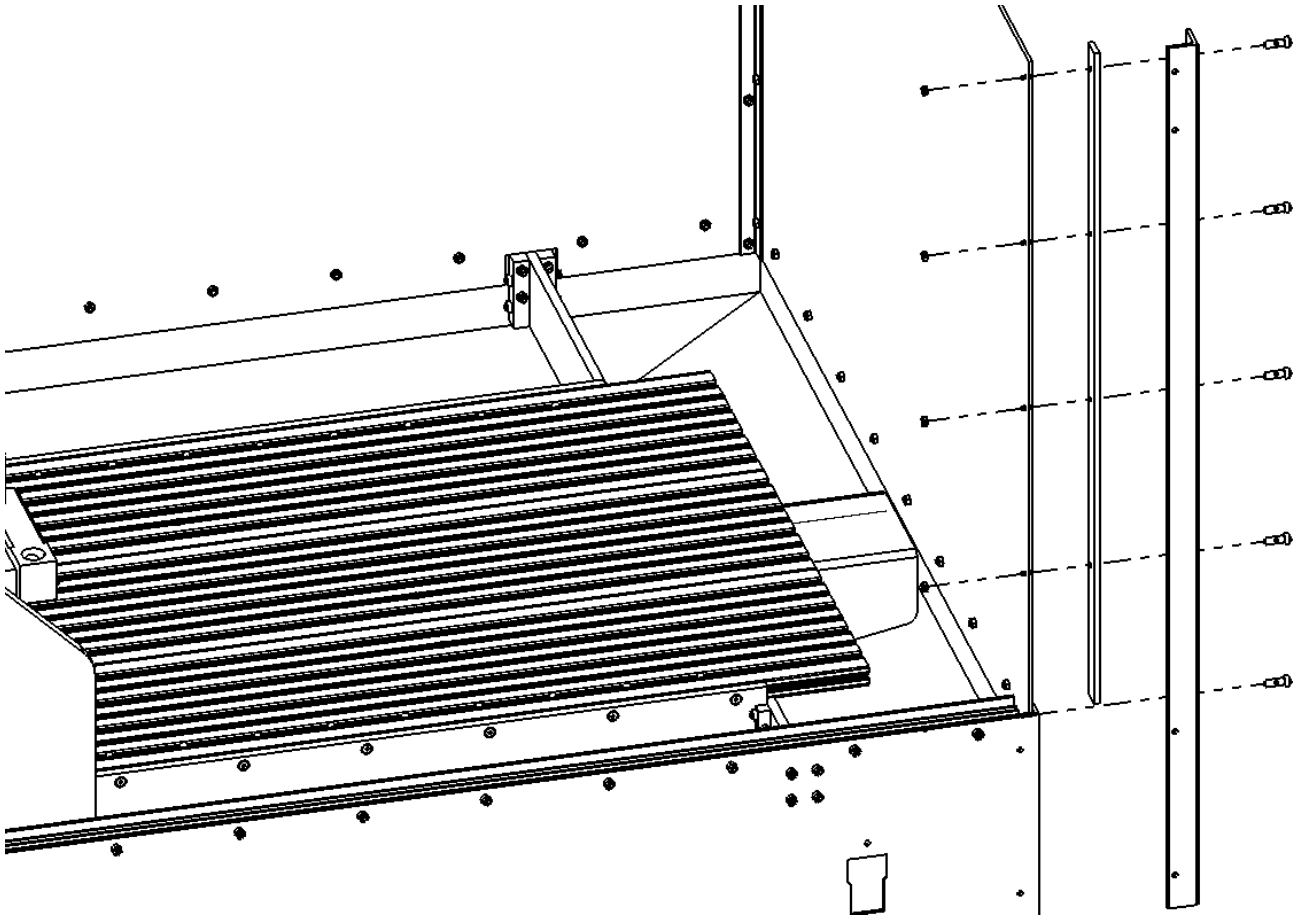


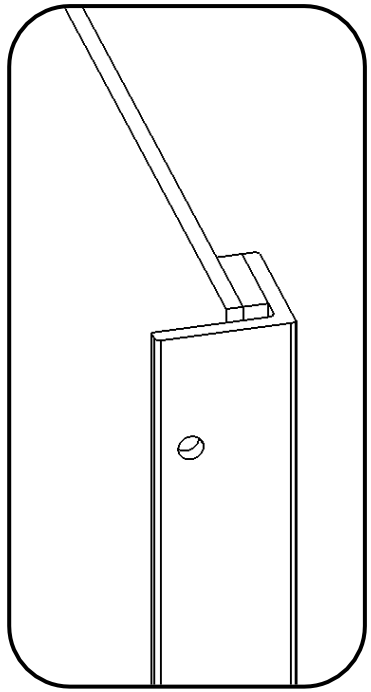
STEP 111 CONNECT THE INSERTS FOR THE FRONT LEFT CORNER

Front Left Corner Insert 4.5mm, Front Left Outer Corner

- ISO 4762 M4 x 16 - 16N x5, - ISO - 4032 - M4 Nut x5

The front left corner does not have an inner part like the front left side in Step 107, so the insert will be sandwiched between the outer corner and the plexiglass. Once again, all of the components will be secured using five M4 x 16 bolts on each side.

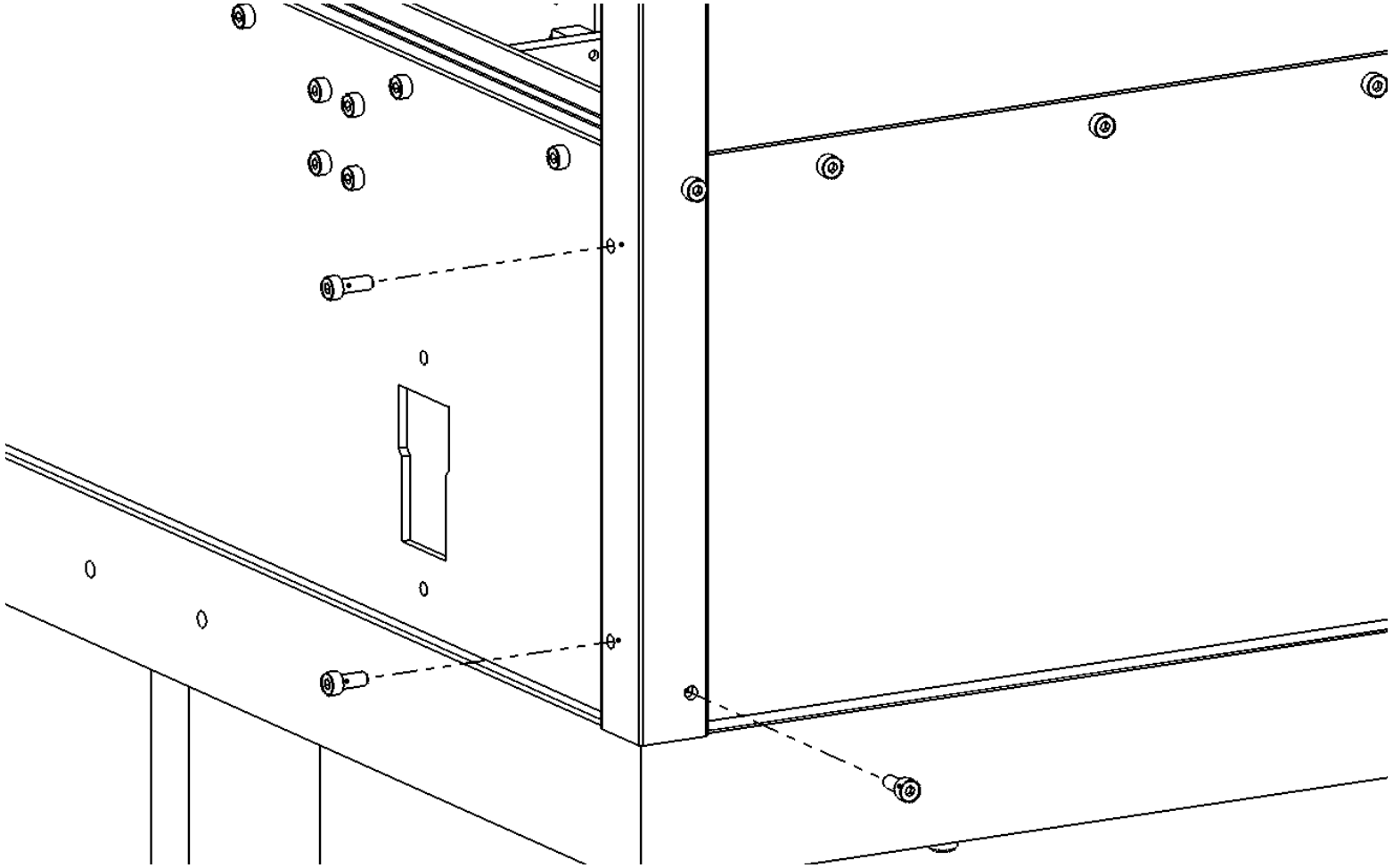




STEP 112 FINAL BOLTS FOR THE SIDE SKIRTS

•ISO 4762 M4 x 12 - 12N, •ISO 4762 M4 x 10 - 10N x2, •ISO - 4032 - M4 Nut x3

Finish off the bottom of the Front Left Outer Corner by adding one mor M4 x 12 bolt to the empty hole in the front and two M4 x 10 bolts to the bottom holes. Secure all three from behind with locking nuts.

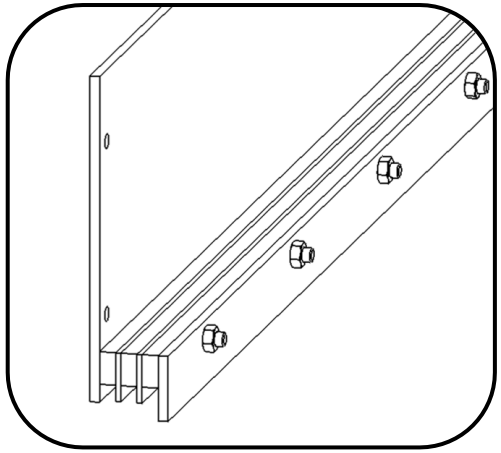


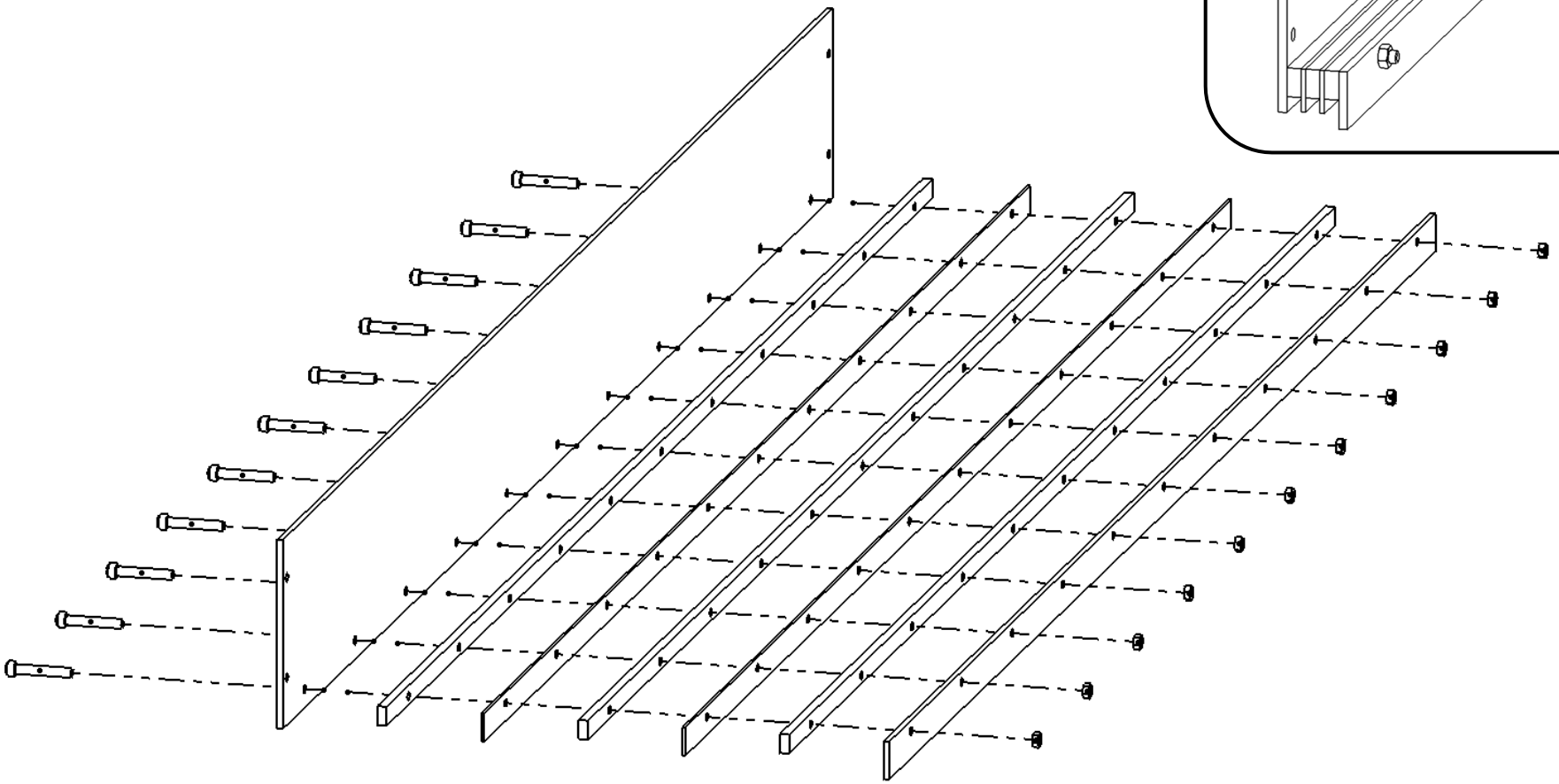
STEP 113 ASSEMBLE THE DOOR SUPPORT TOP

• Front Plate for Doors, • Bottom Bracket for Doors x3, • Door Bracket Inserts x2, • Stopper Bracket for Doors

• ISO 4762 M4 x 30 - 30N x11, • ISO - 4032 - M4 Nut x11

Now connect the components that will make the top tracks for the doors. This subassembly will be the inverse of that in Step 11.

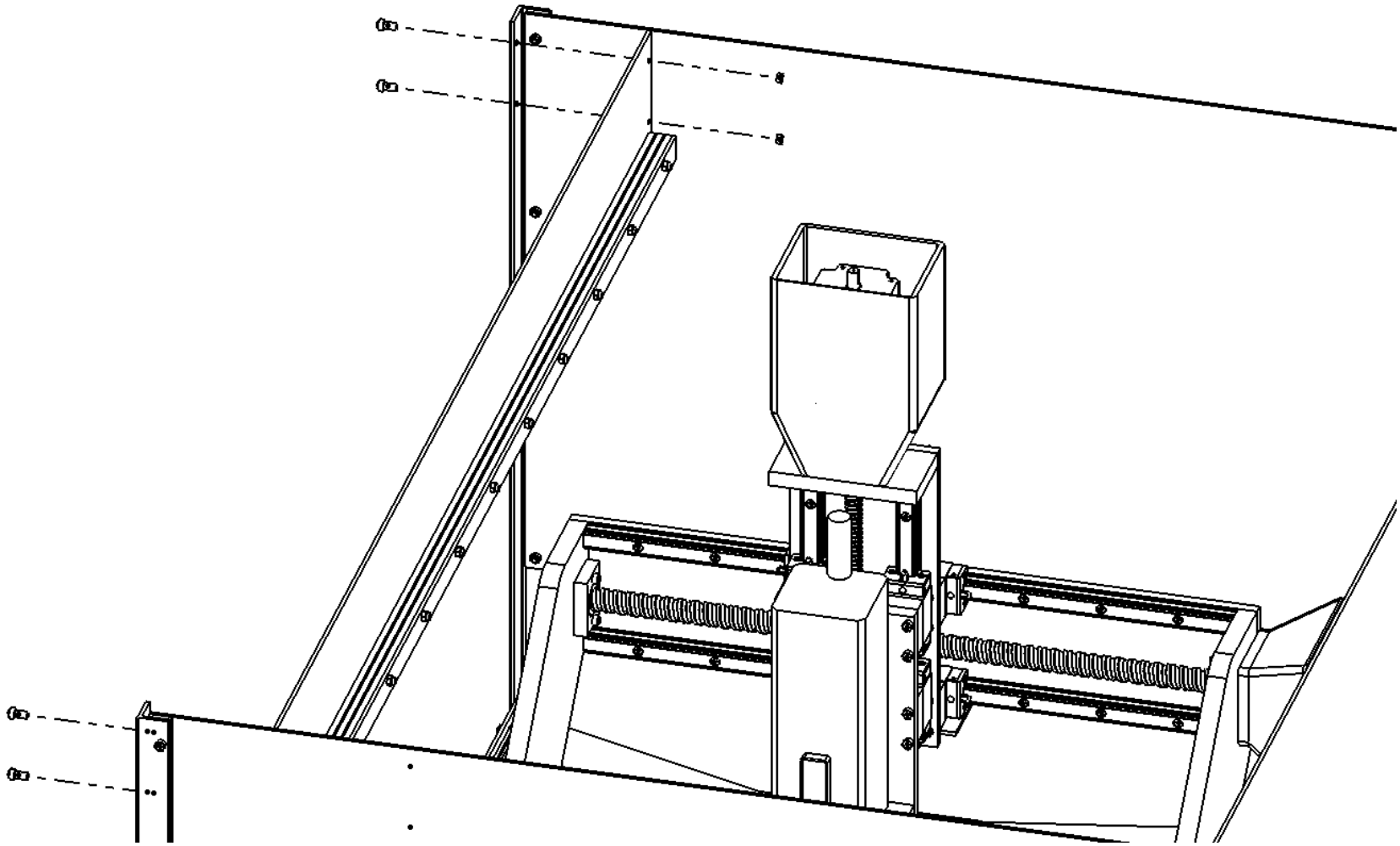




STEP 114 ATTACH THE DOOR SUPPORT SUBASSEMBLY TO THE MAIN ASSEMBLY

• ISO 4762 M4 x 10 - 10N x4, • ISO - 4032 - M4 Nut x4

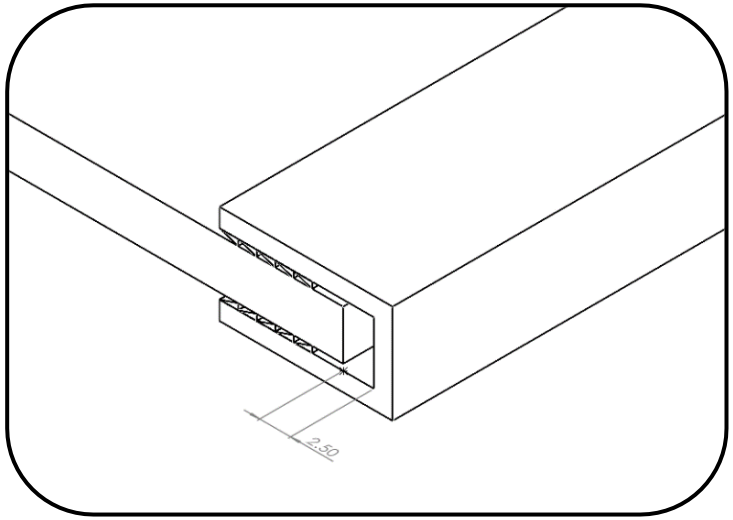
Attach the subassembly to the left side of the machine using two M4 x 10 bolts and locking nuts on either side.

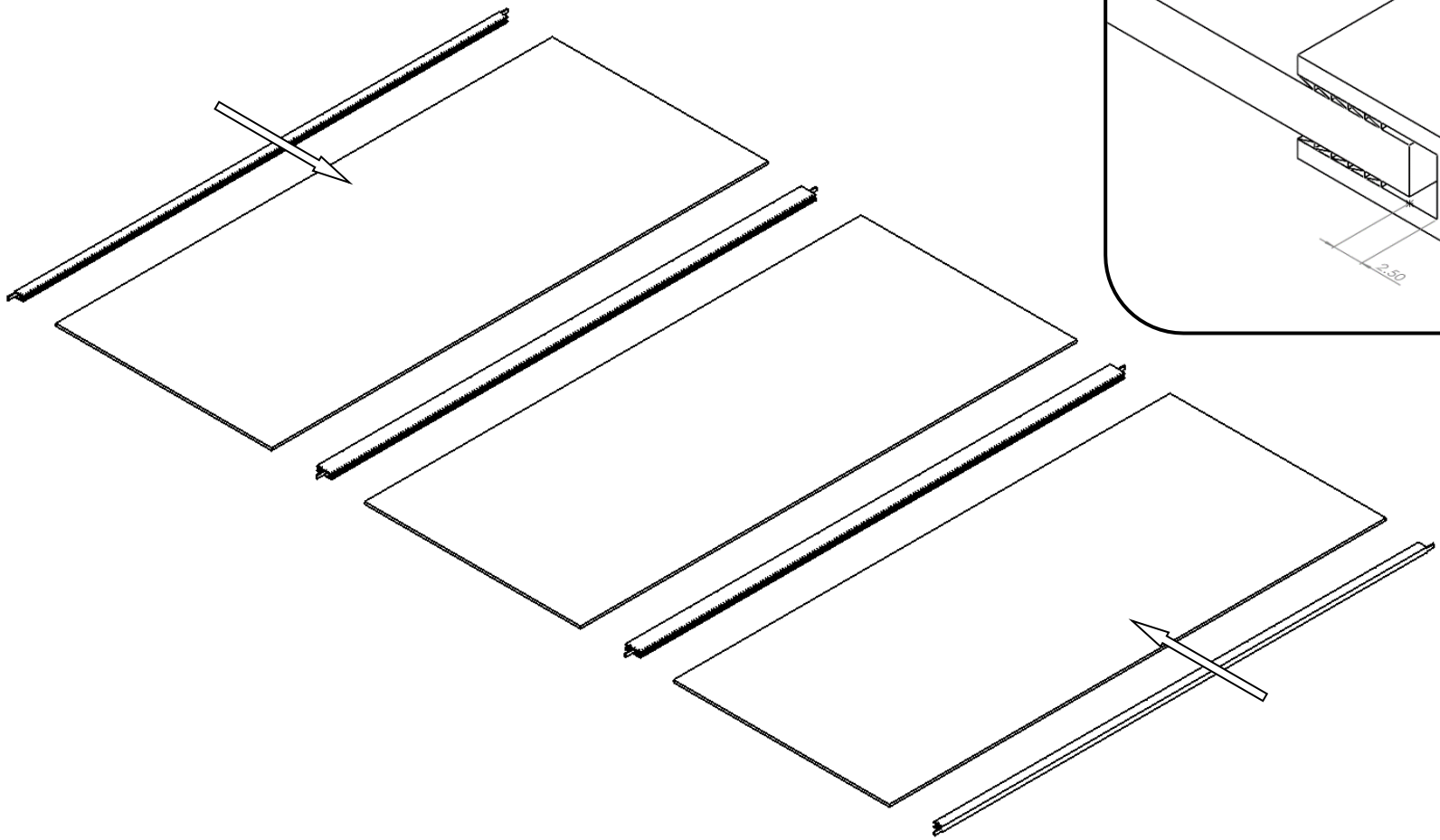


STEP 115 BEGIN THE LID SUBASSEMBLY

• PG Top Panels x3, • H - Pro%le for Lid x2, • U - Pro%le for Front and Back x2

Begin the subassembly for the lid by pressing the U- and H- profiles onto the plexiglass panels from front to back. Leave an approximately 2.5 mm gap between the profiles and the plexiglass.

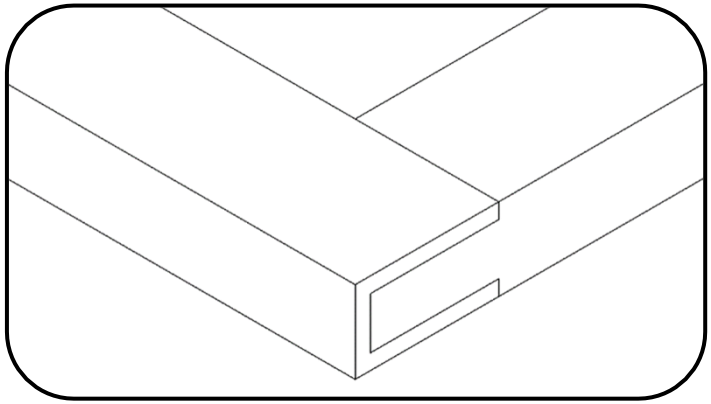


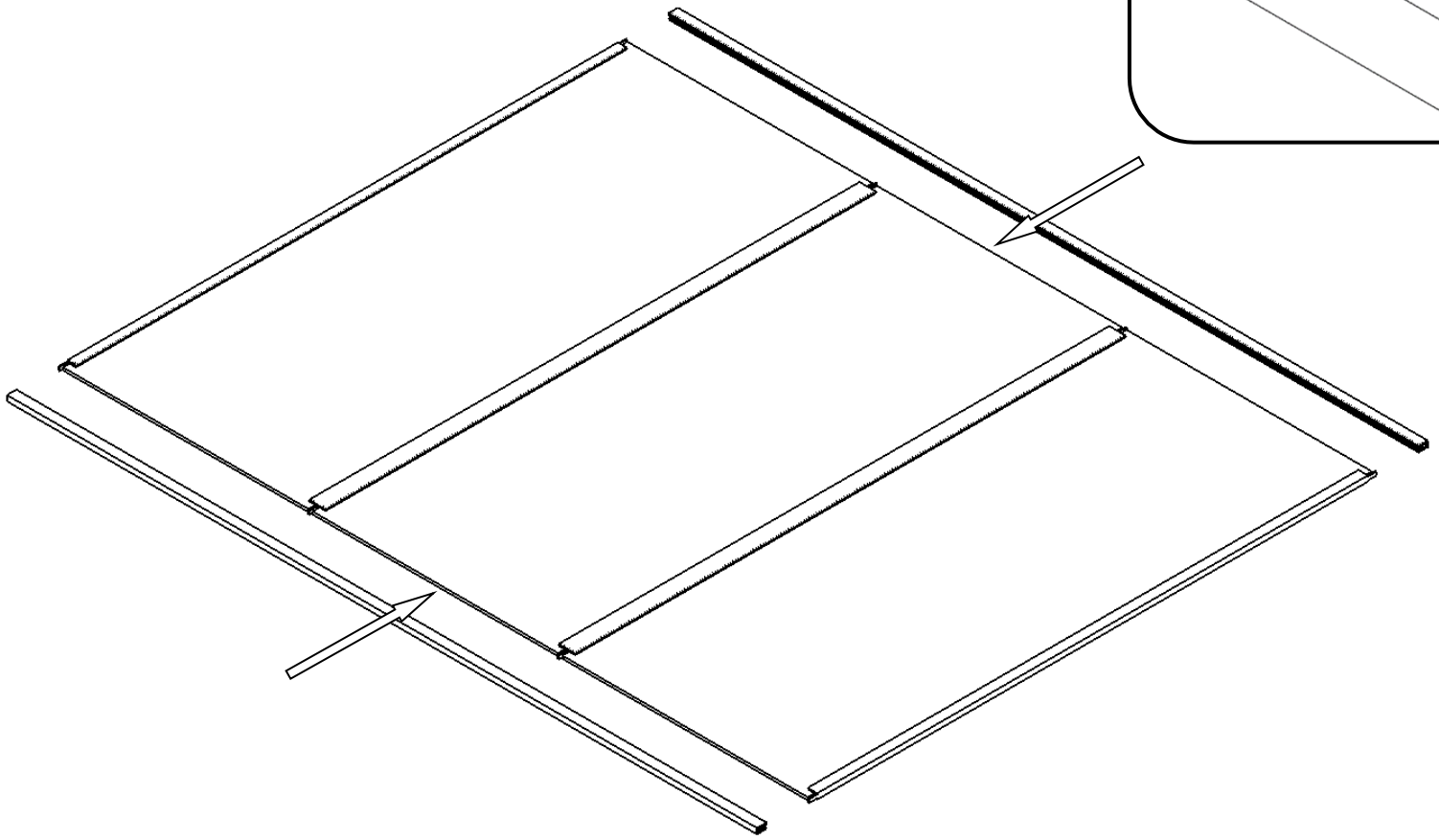


STEP 116 U-PROFILE FOR THE LID SUBASSEMBLY

- U - Pro%le for Left and Right x2

Add the U-profile pieces for the left and right sides next. All the pieces should fit together tightly at the corners.

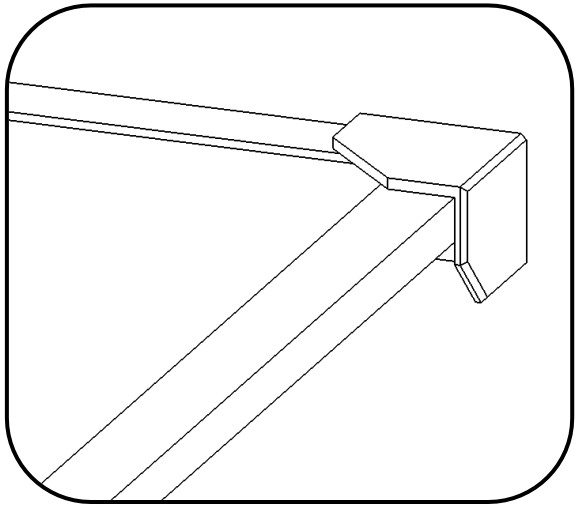


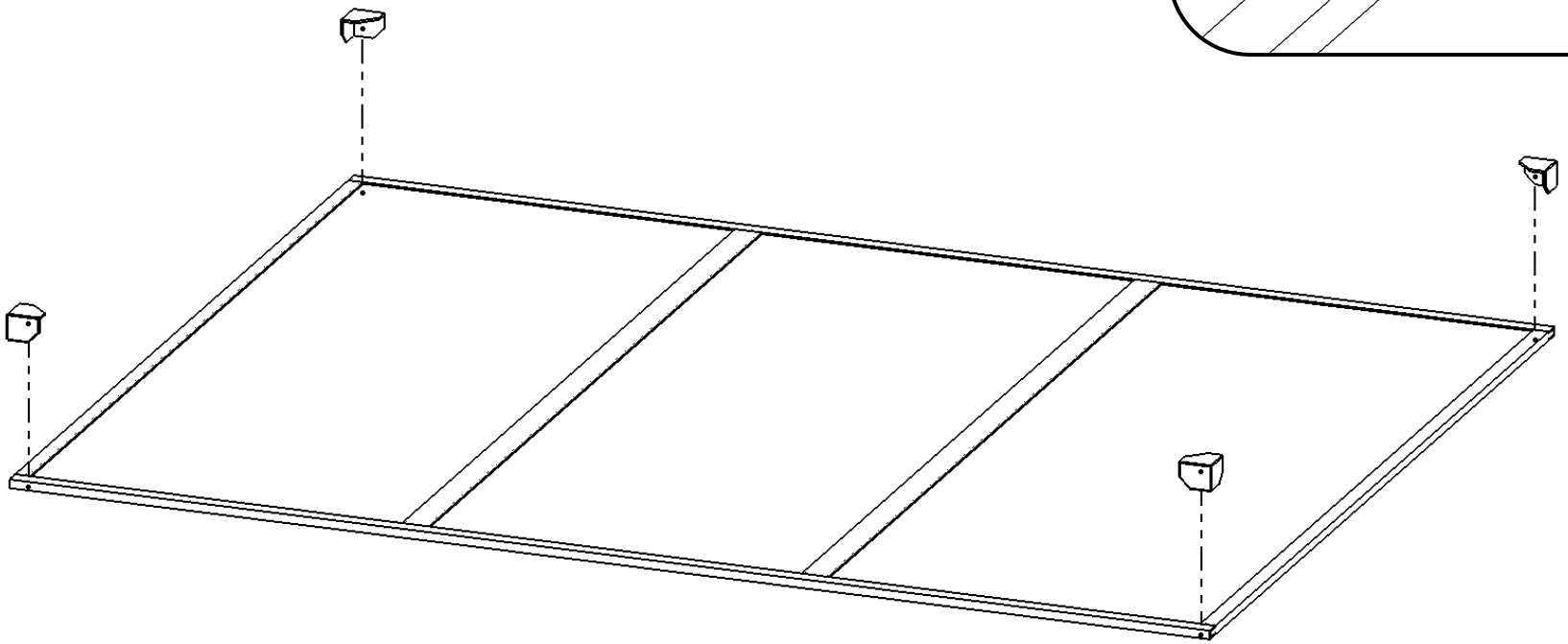


STEP 117 ATTACH THE CORNER PIECES TO THE LID

- Corner Pieces for Lid x4
- Superglue

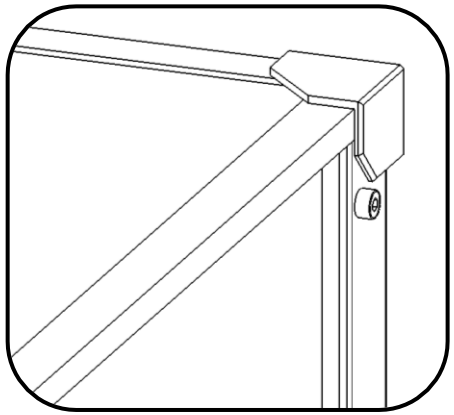
Attach the 3D printed corner pieces to the corner joints of the U-profiles using superglue. The corner pieces should lie flat against the top of the lid subassembly and should extend below the bottom as shown.

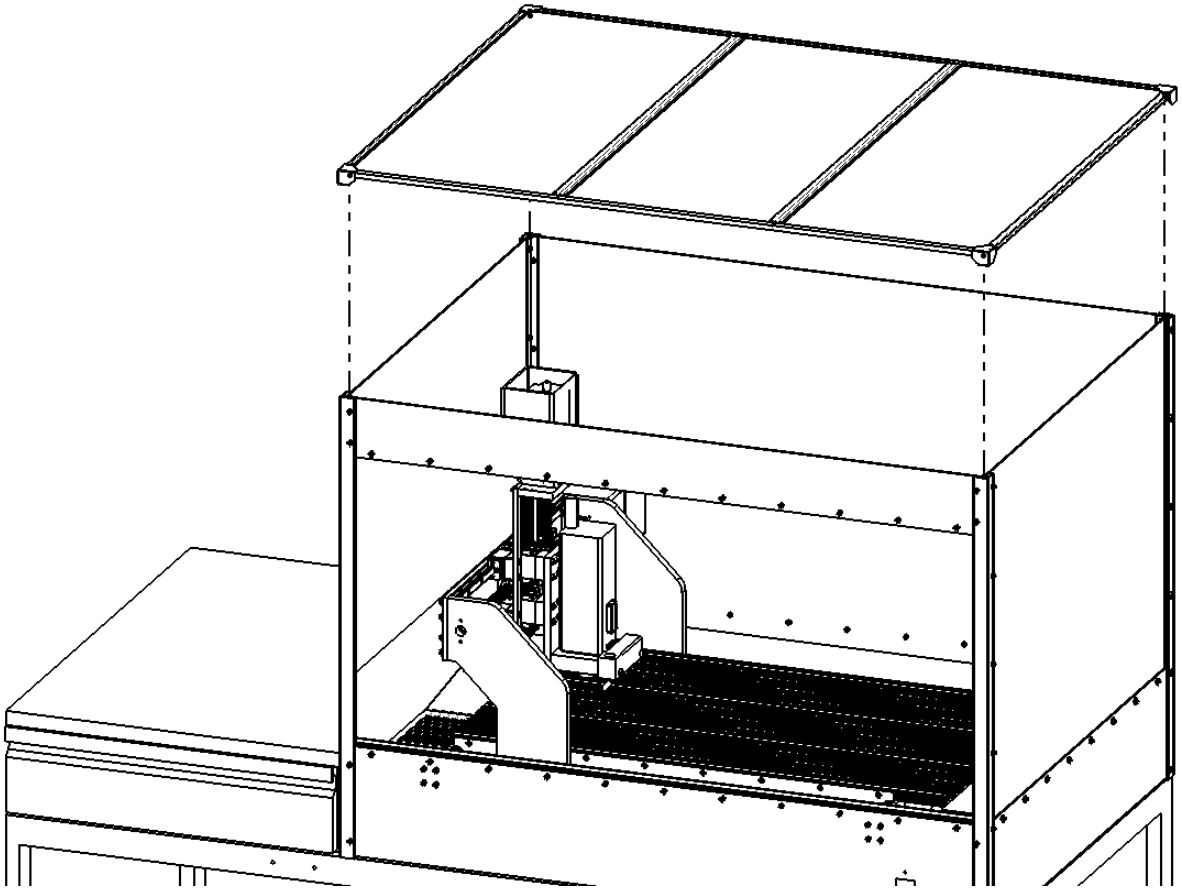




STEP 118 CONNECT THE LID SUBASSEMBLY TO THE MAIN ASSEMBLY

The corner pieces in the lid subassembly fit around the outer corner pieces of the enclosure. They, along with gravity, are what hold the lid in place on the machine and allow easy access through the top whenever necessary.

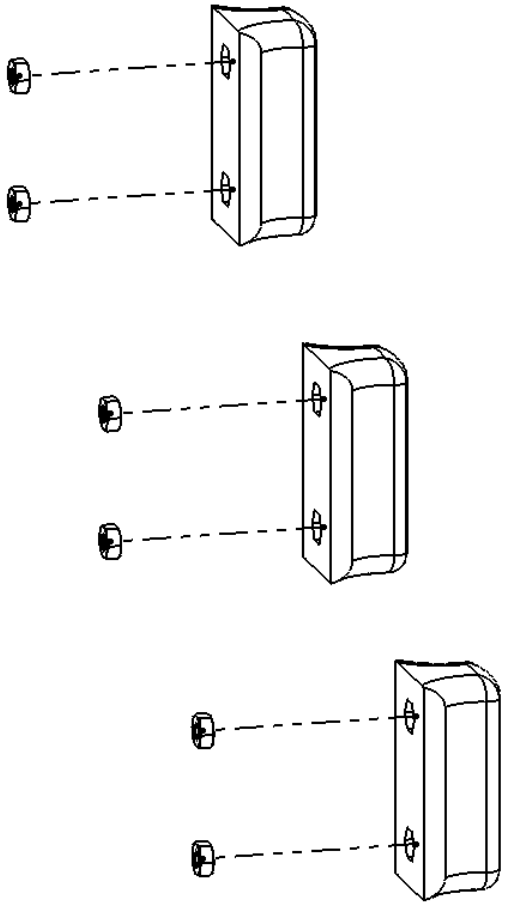




STEP 119 INSTALL THE CAPTIVE NUTS IN THE DOOR HANDLES

- Door Handles x3
- Superglue, • ISO - 4032 - M4 Nut x6

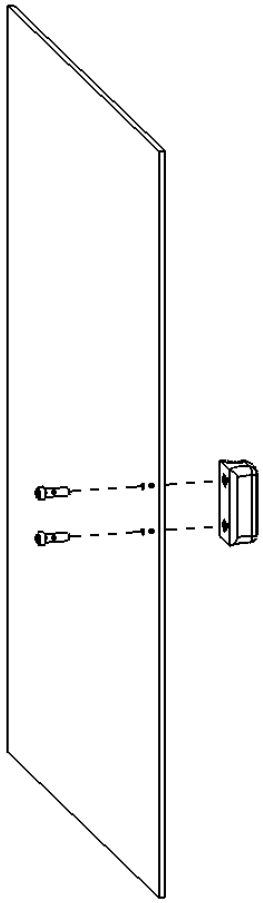
Begin the subassemblies for the doors by using superglue to set six captive M4 nuts into the 3D printed door handles.

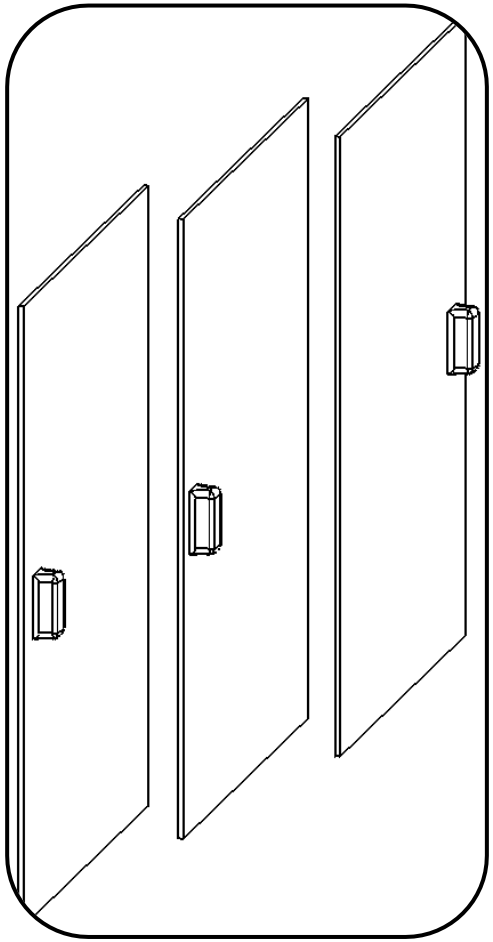


STEP 120 BOLT THE HANDLES TO THE DOORS

- Doors Side x2, • Doors Center
- ISO 4762 M4 x 16 - 16N x6

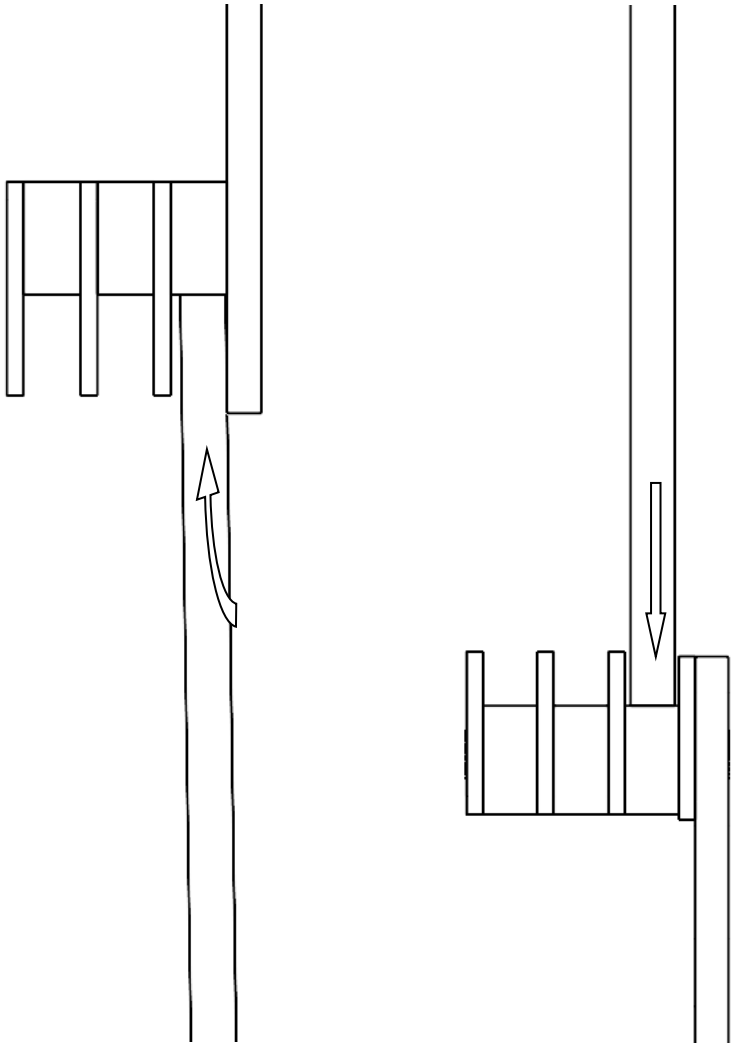
Secure the handles with the captive nuts to the plexiglass door panels using two M4 x 16 bolts for each.

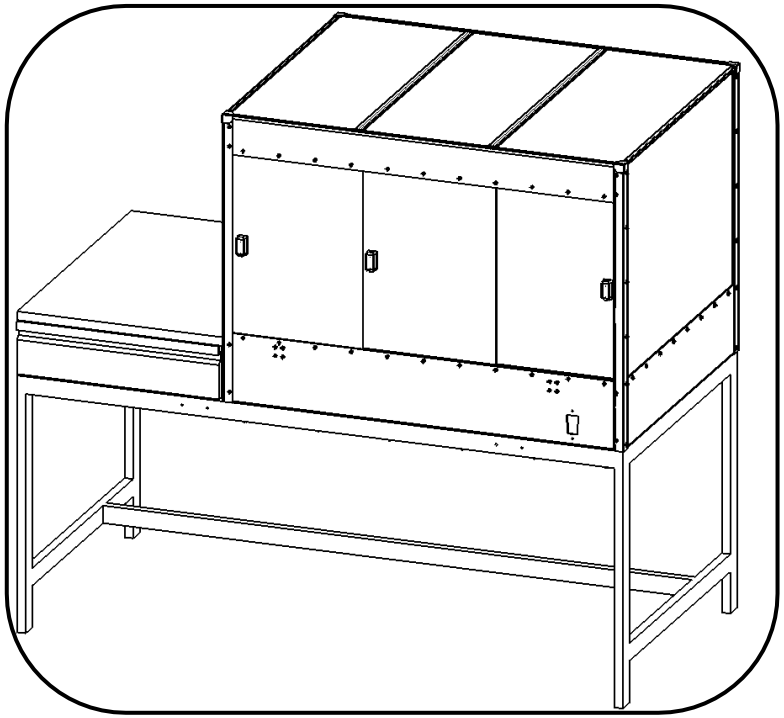




STEP 121 INSTALL THE DOORS

Connect the subassemblies by inserting the doors into the machine first at the top, then the bottom. Note: Make sure the center door goes in the center.

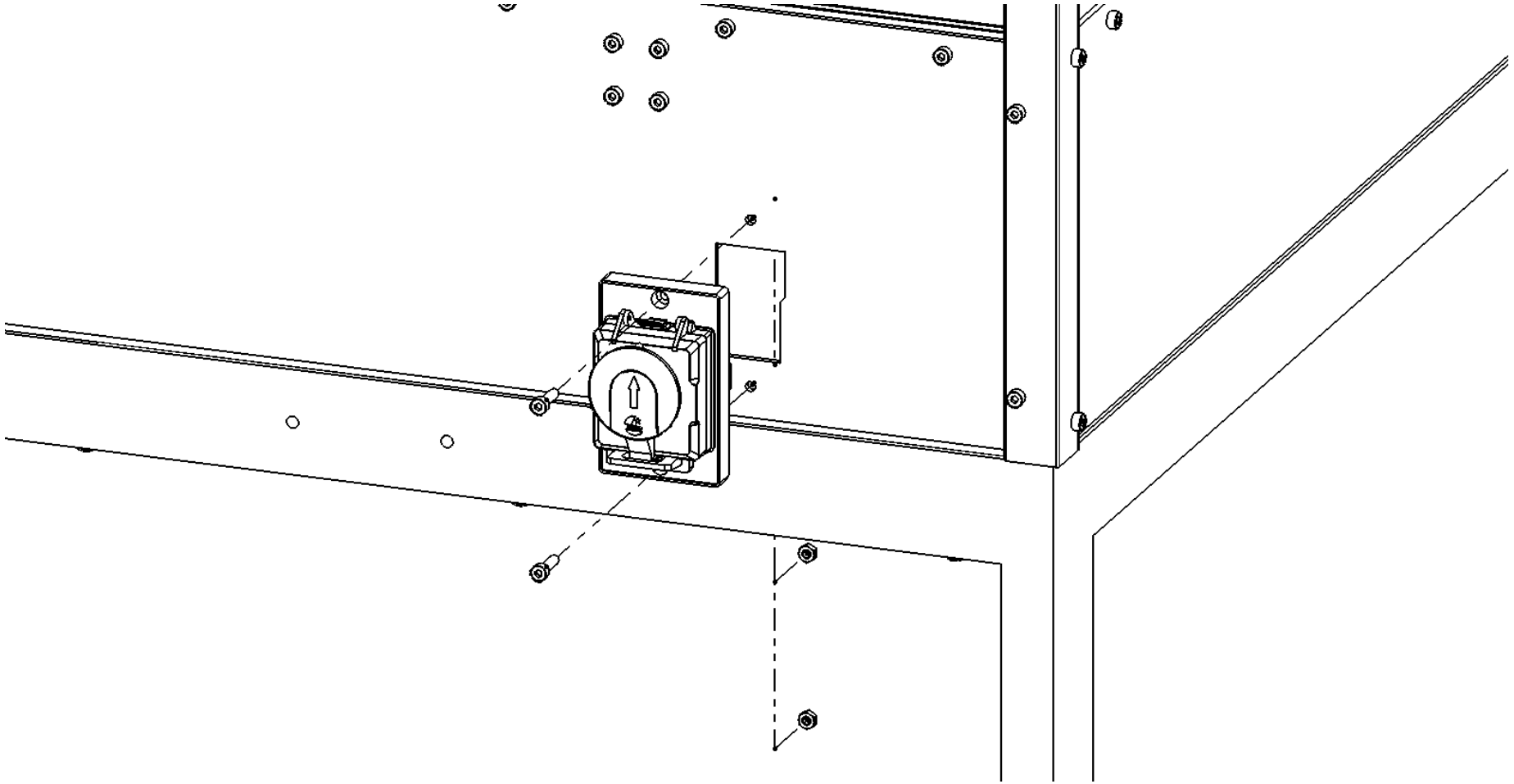




STEP 122 INSTALL THE SAFETY POWER SWITCH

- Kedu KJD18 3 phase Motor Starter
- ISO 4762 M4 x 16 - 16N x2, • ISO - 4032 - M4 Nut x2

Attach the stafety starter switch to the Left Side Skirt using two M4 x 16 bolts and two locking nuts.

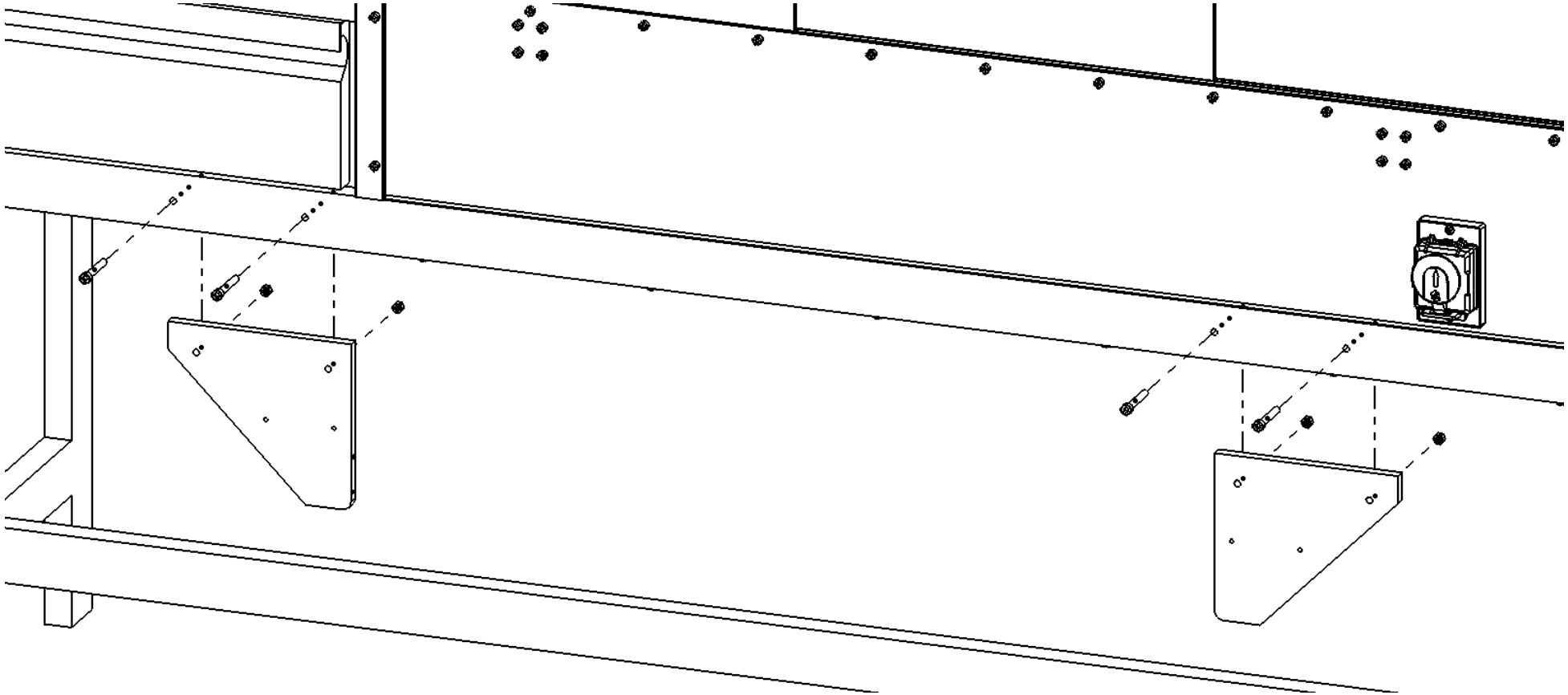


SECTION 4: COOLANT DRAWER

STEP 123 ATTACH THE LEFT CORNER BRACES FOR THE COOLANT DRAWER

- Corner Braces for Drawer Hardware x2
- ISO 4762 M5 x 40 - 22N x4, • ISO - 4032 M5 Nut x4

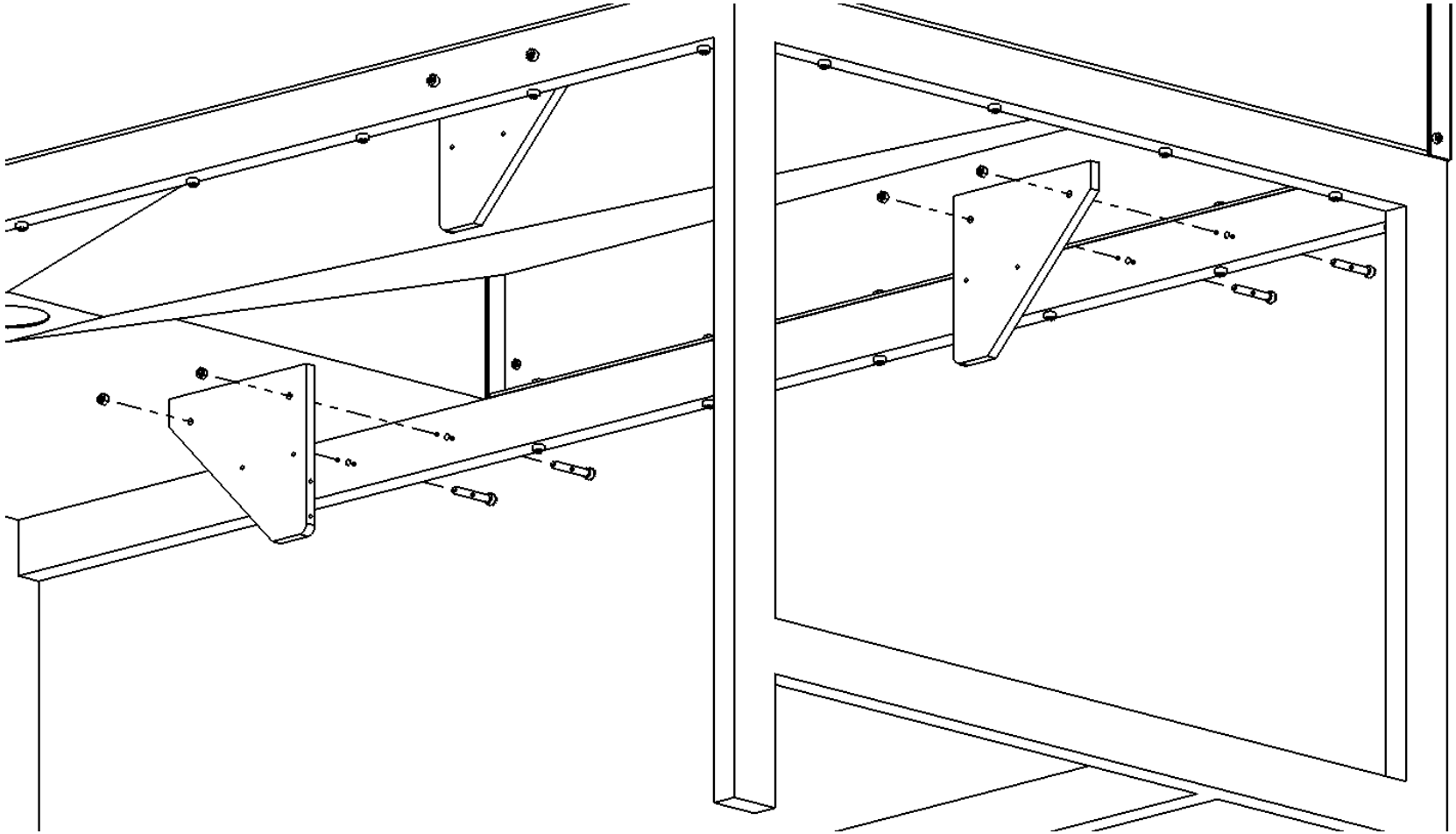
Attach two of the Corner Braces for Drawer Hardware to the left side of the table as shown using two M5 x 40 bolts and two locking nuts for each.



STEP 124 ATTACH THE RIGHT CORNER BRACES FOR THE COOLANT DRAWER

- Corner Braces for Drawer Hardware x2
- ISO 4762 M5 x 40 - 22N x4, • ISO - 4032 M5 Nut x4

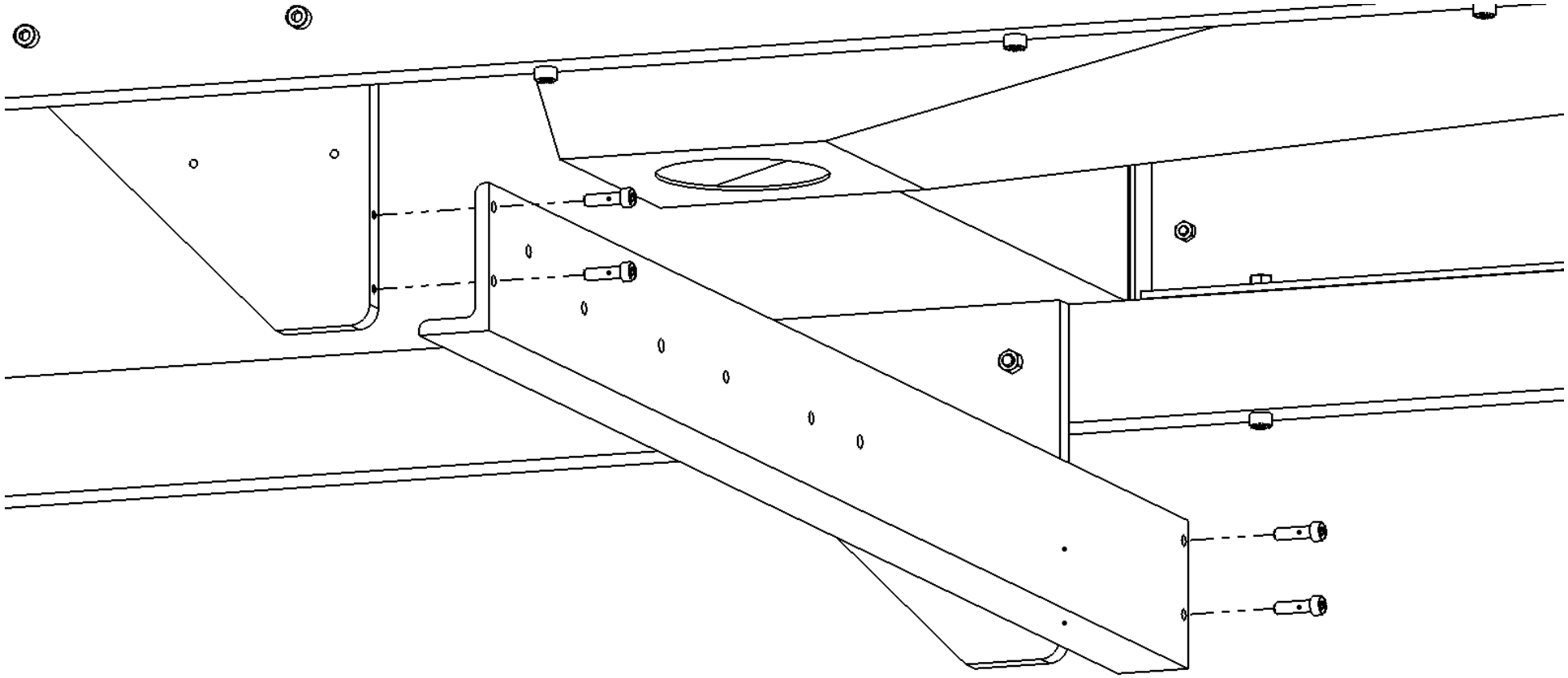
Repeat Step 124 now for the right side.



STEP 125 ATTACH THE ANGLE IRON FOR THE LEFT SIDE OF THE DRAWER

- 60x30x6 Angle Iron for Drawer Left
- ISO 4762 M4 x 16 - 16N x4

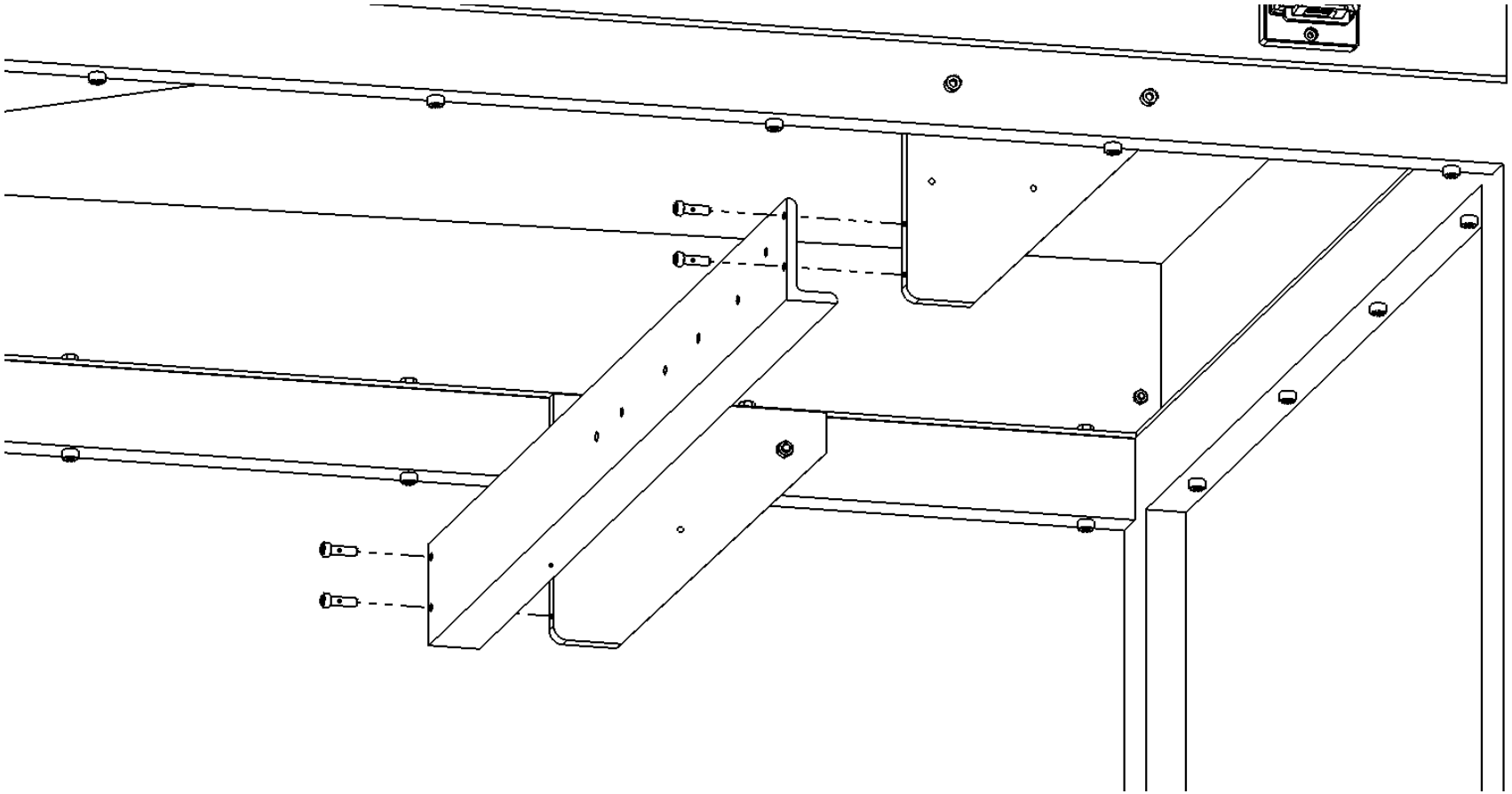
Connect the angle iron reinforcement for the left side of the drawer using two M4 x 16 bolts on either side.



STEP 126 ATTACH THE ANGLE IRON FOR THE RIGHT SIDE OF THE DRAWER

- 60x30x6 Angle Iron for Drawer Right
- ISO 4762 M4 x 16 - 16N x4

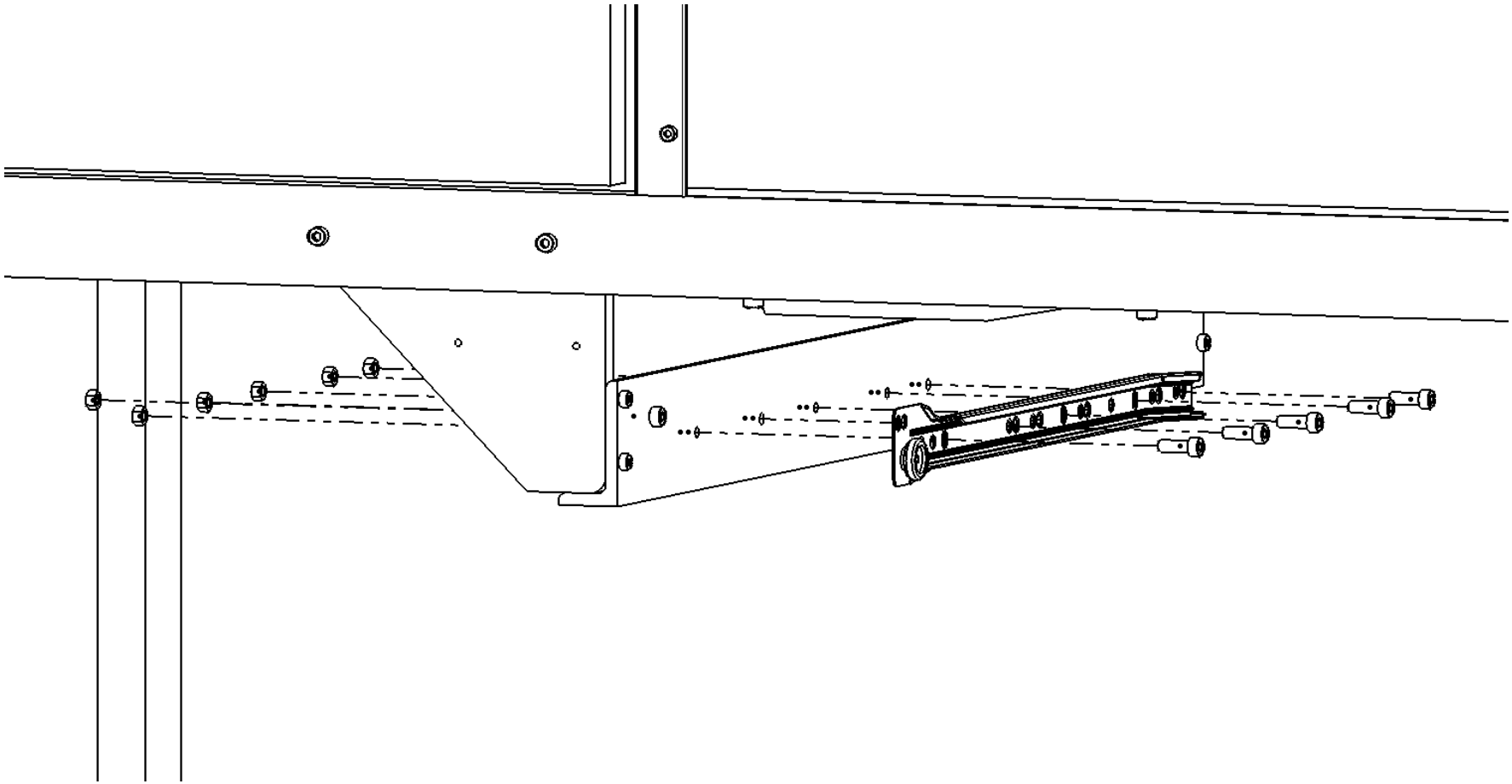
Repeat for the angle iron reinforcement on the right side of the drawer, once again using two M4 x 16 bolts for either side.



STEP 127 INSTALL THE OUTER HARDWARE FOR THE LEFT SIDE OF THE DRAWER

- Drawer Hardware Left Outer
- ISO 4762 M5 x 16 - 16N x6, • ISO - 4032 M5 Nut x6

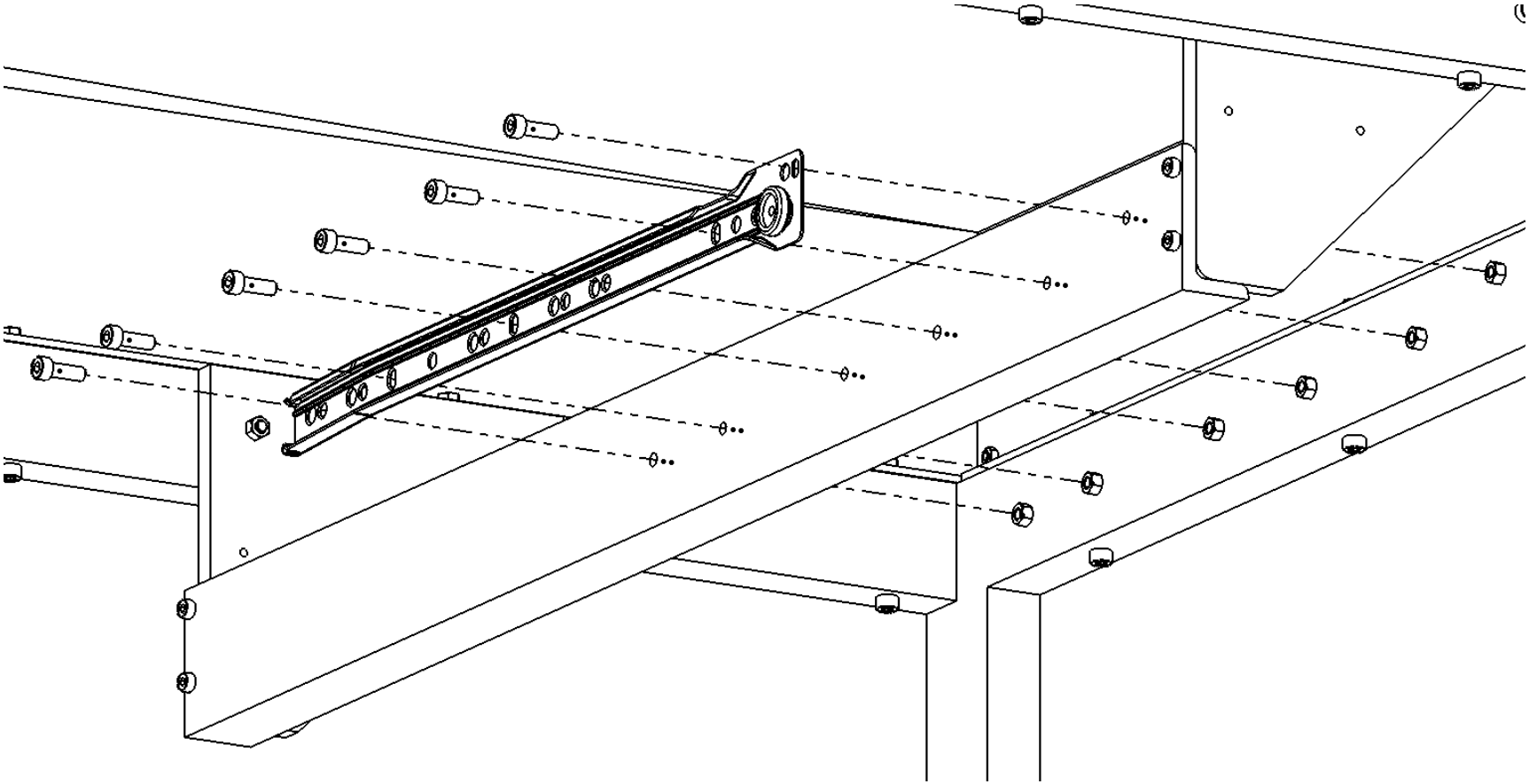
Attach the left outer piece of the drawer hardware to the angle iron reinforcement for the left side of the drawer using six M5 x 16 bolts with locking nuts.



STEP 128 INSTALL THE OUTER HARDWARE FOR THE LEFT SIDE OF THE DRAWER

- Drawer Hardware Right Outer
- ISO 4762 M5 x 16 - 16N x6, • ISO - 4032 M5 Nut x6

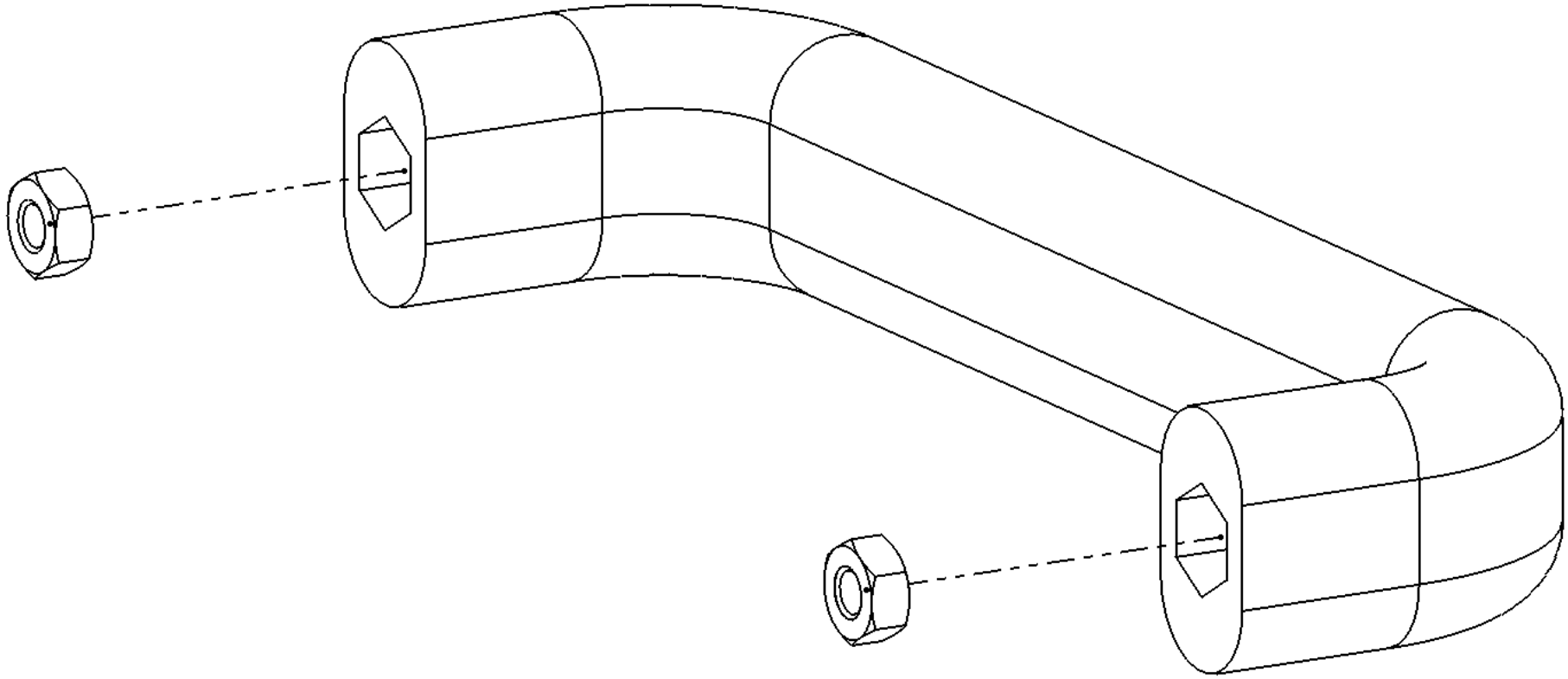
Repeat for the right outer piece of the drawer hardware for the right side of the drawer using six more M5 x 16 bolts with locking nuts.



STEP 129 INSTALL THE CAPTIVE NUTS IN THE DRAWER HANDLE

- Handle for Drawer
- Superglue, ISO - 4032 M5 Nut x2

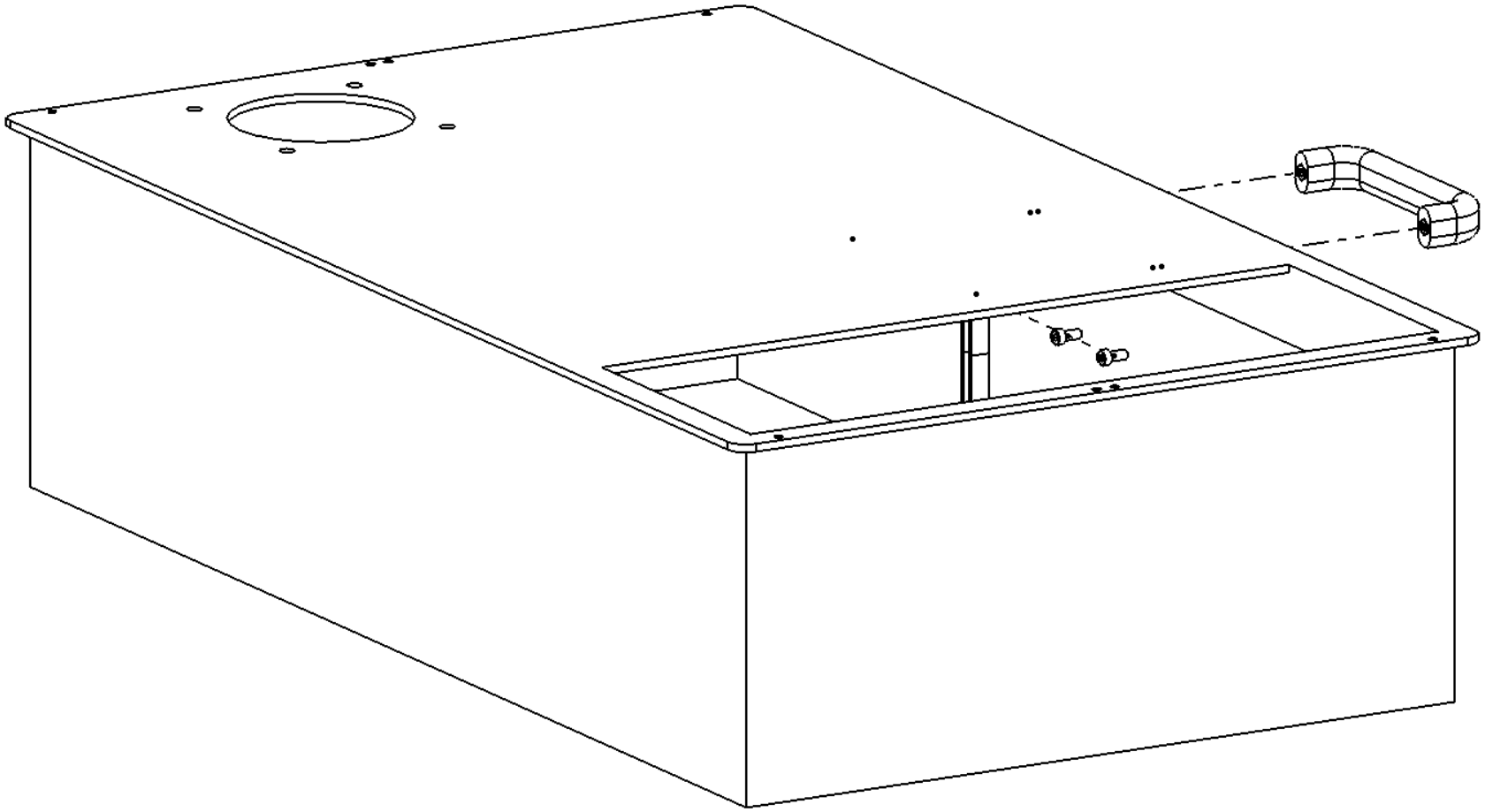
Begin the subassembly for the coolant tank by using superglue to set two captive M4 nuts into the 3D printed drawer handle.



STEP 130 ATTACH THE HANDLE TO THE COOLANT DRAWER

- Coolant Tank
- ISO 4762 M4 x 10 - 10N x2

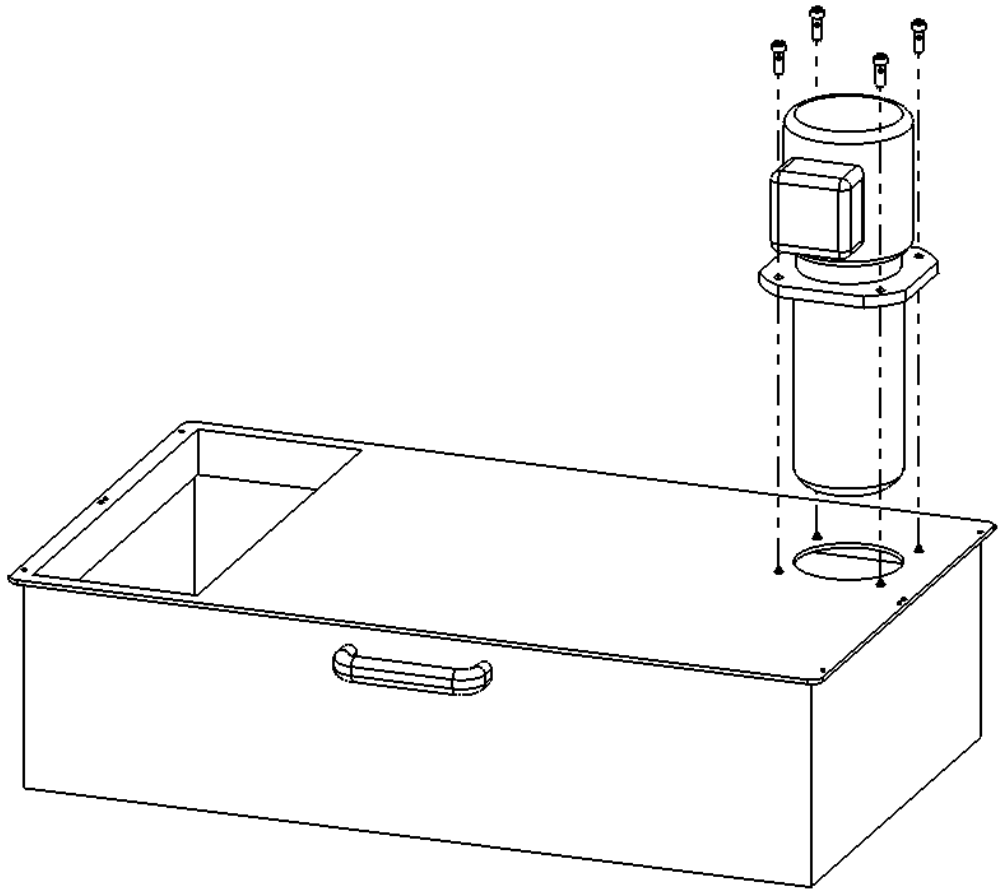
Install the handle into the Coolant Tank using two M4 x 10 bolts from inside the tank. Securely tighten them into the captive nuts from Step 129.



STEP 131 CONNECT THE COOLANT PUMP TO THE COOLANT TANK SUBASSEMBLY

- Centrifugal Pump - Yu Hseng TC-8180
- ISO 4762 M6 x 20 - 20N x4, • ISO - 4032 - M6 Nut x4

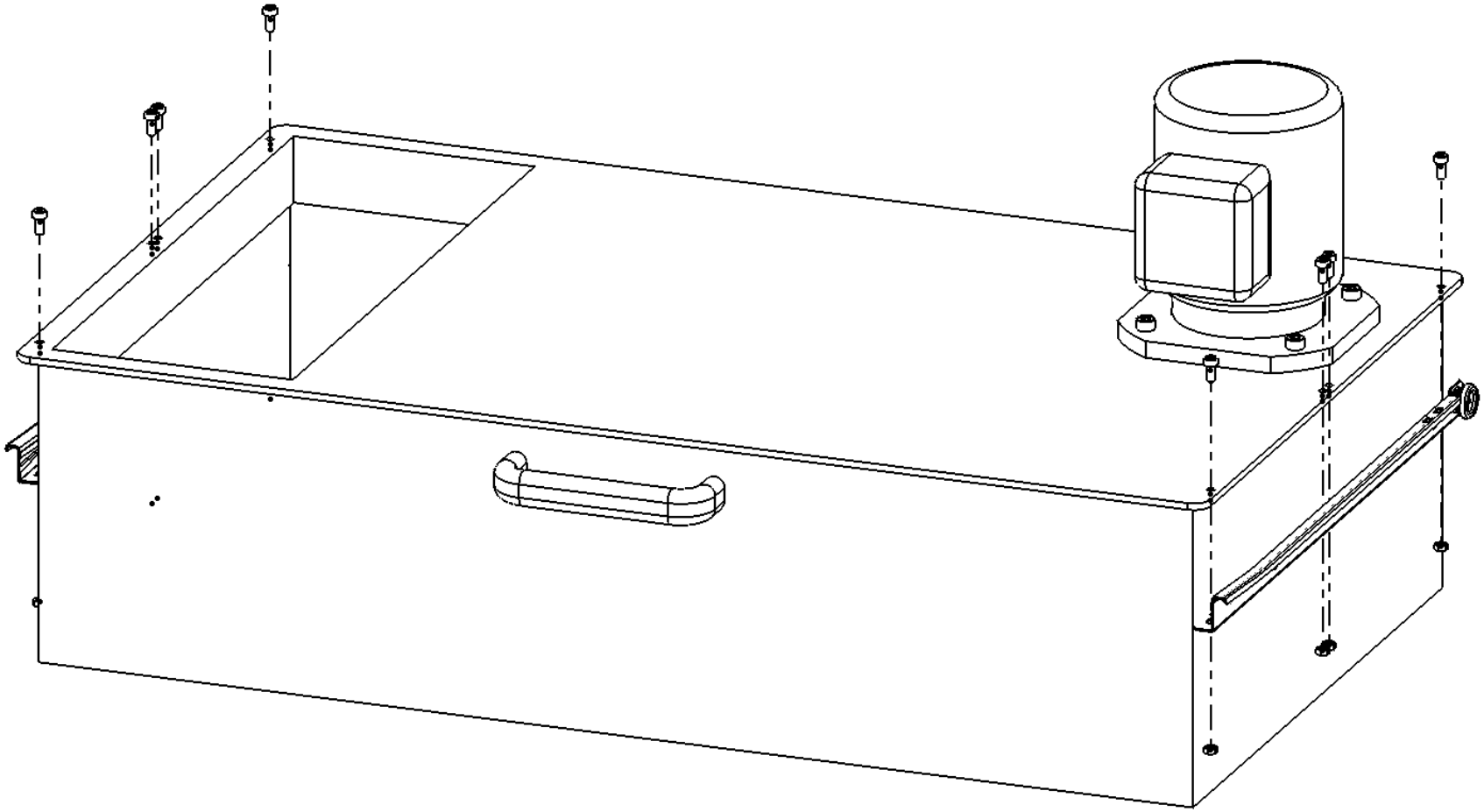
Connect the centrifugal pump to the coolant tank using four M6 x 20 bolts. Once again, securely tighten from inside the tank using four M6 locking nuts.



STEP 132 ATTACH THE INNER DRAWER HARDWARE TO THE COOLANT TANK SUBASSEMBLY

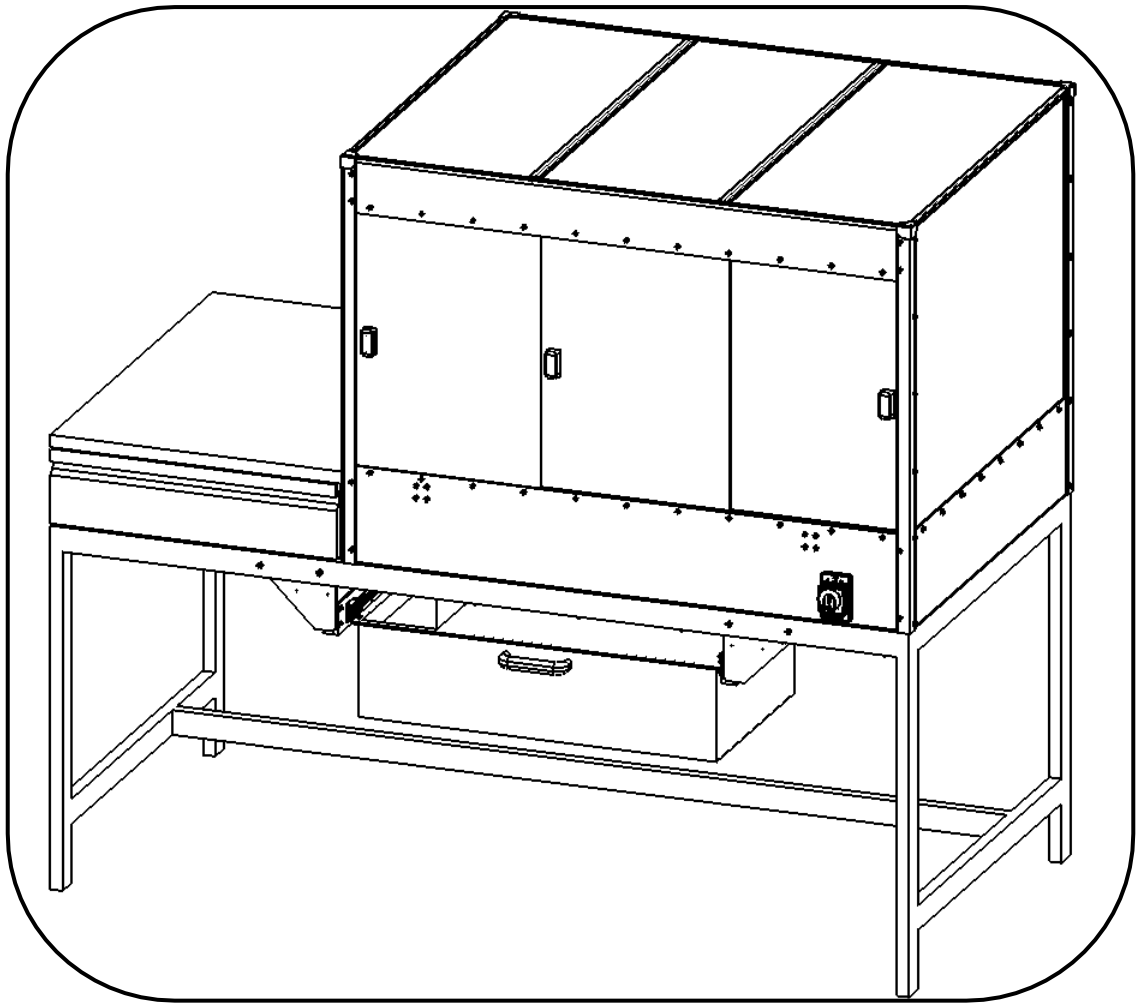
- Drawer Hardware Left Inner, • Drawer Hardware Right Inner
- ISO 4762 M5 x 16 - 16N x8, • ISO - 4032 M5 Nut x8

Attach the inner pieces of the drawer hardware to the coolant tank drawer using four M5 x 16 bolts with locking nuts on either side.



STEP 133 INSTAL THE COOLANT TANK SUBASSEMBLY INTO THE MAIN ASSEMBLY

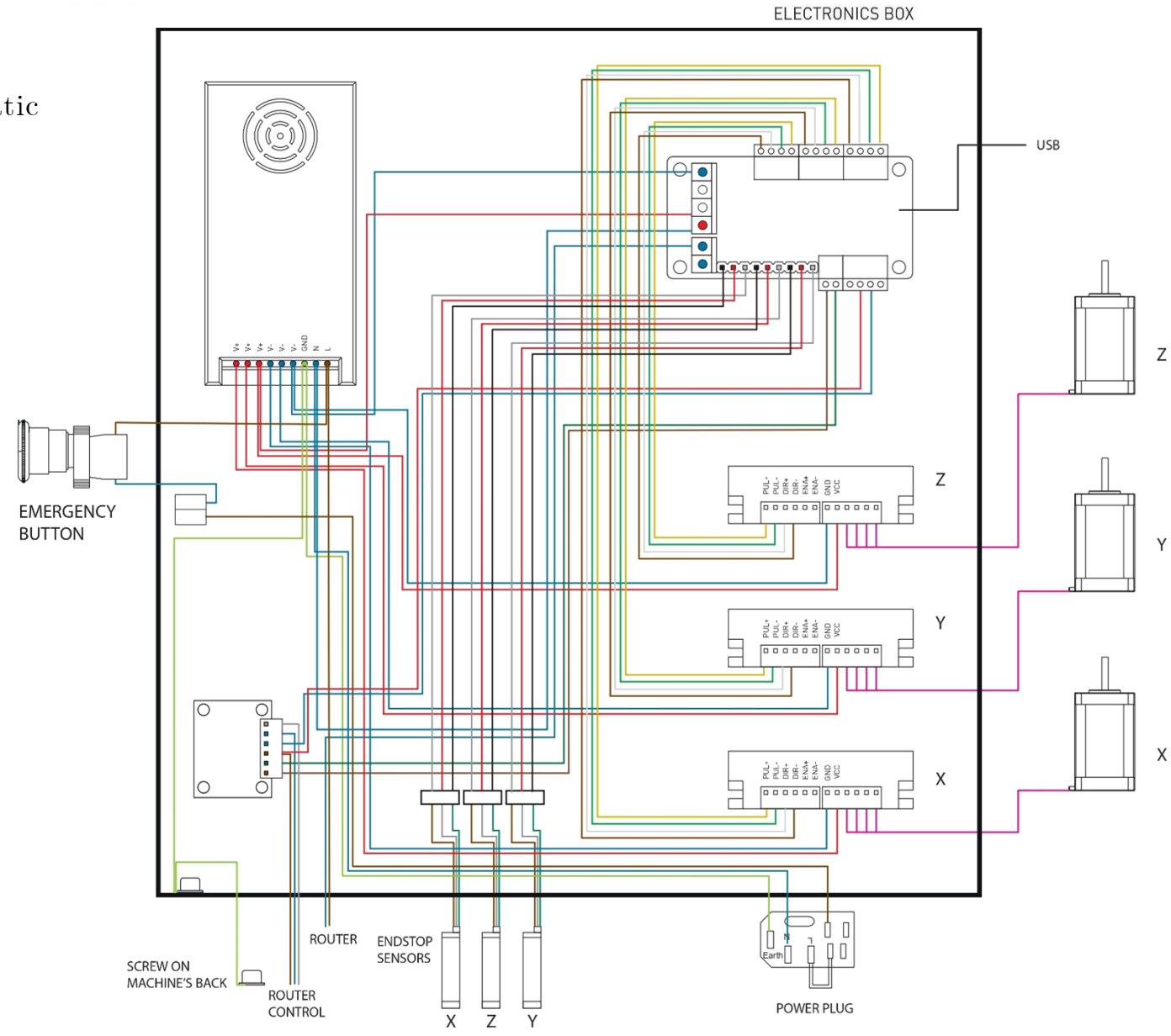
Attach the coolant drawer subassembly to the rest of the machine by interfacing the drawer hardware as instructed in its respective installation manual.



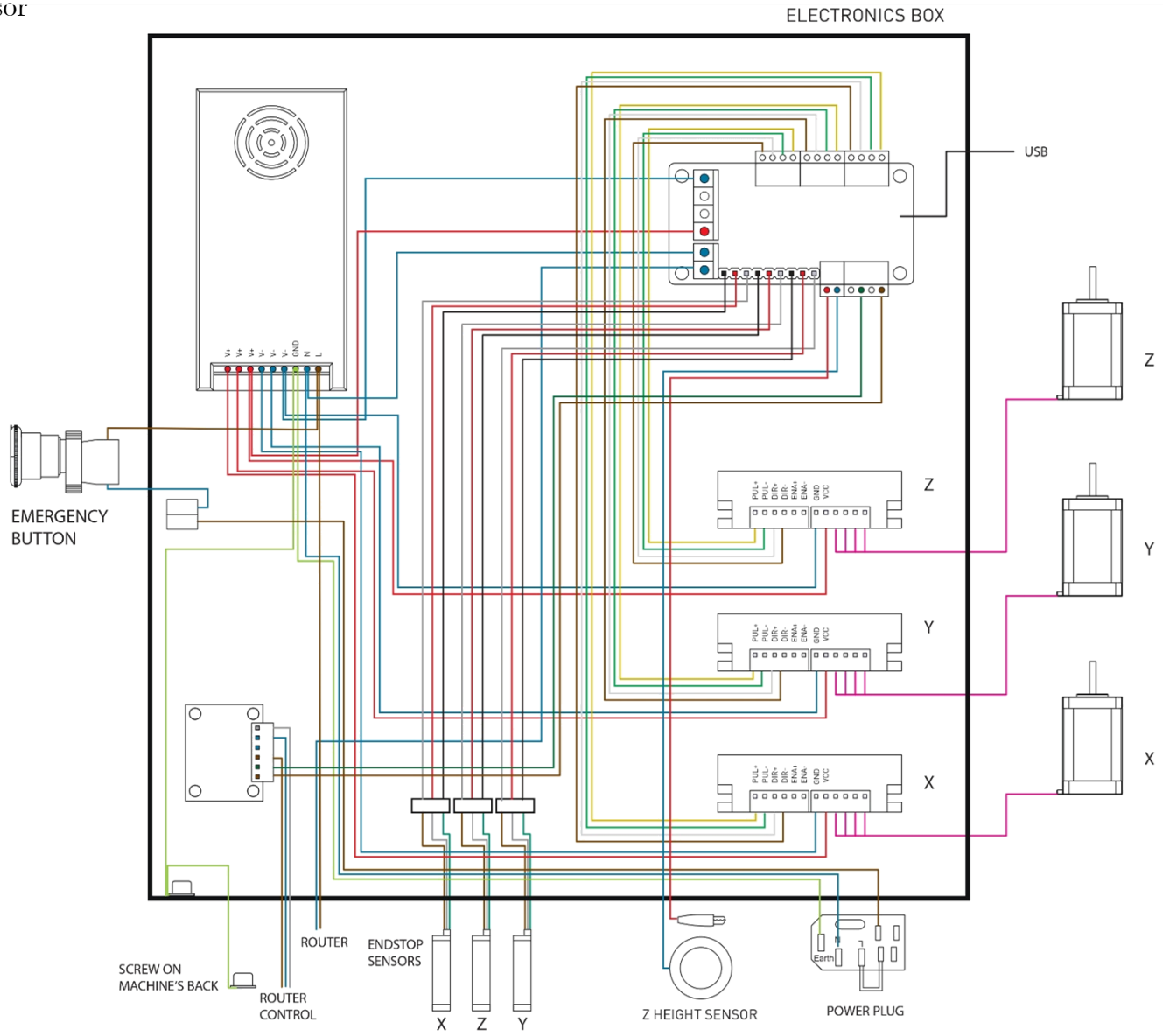
Electronics

Wiring Schematic

No Height Sensor



With Height Sensor



Software

GRBL is free, open-source software for controlling the motion of machines that move. It operates on an extensive range of microcontrollers and is used to power thousands of different CNC routers, lathes, mills, lasers and more. Since its release in 2009, it has essentially become the standard for open-source CNC machines (What is GRBL?, n.d.). As such, it was chosen as the controlling software for this machine as well. Following are detailed step-by-step instructions for installing the GRBL motion control software onto an EASON TB6600 4A DC9-42V 32 Division stepper motor controller for controlling three Nema 24 motors on a CNC machine:

Requirements

- EASON TB6600 Stepper Motor Controller
- Three Nema 24 Stepper Motors
- A computer with Arduino IDE installed
- An Arduino board (Uno is commonly used)
- Wiring cables
- Power supply suitable for your setup

Step-by-Step Instructions

Step 1: Install Arduino IDE

If you haven't already, download and install the Arduino IDE from Arduino's official website.

Step 2: Download GRBL

Download the latest version of GRBL from the GRBL GitHub repository and unzip the downloaded file.

Step 3: Upload GRBL to Arduino

Connect your Arduino to your computer.

Open Arduino IDE, go to File > Open, and select the GRBL code you've just unzipped.

Select the correct board and port under Tools in the Arduino IDE.

Click Upload to program your Arduino with GRBL.

Step 4: Wiring the Motors to TB6600 and Arduino

Connect each Nema 24 motor to a TB6600 driver. Ensure that the wiring is correct according to the motor and driver specifications.

Connect the TB6600 drivers to the Arduino:

Connect the PUL- and DIR- ports on the TB6600 to the GND pin on the Arduino.

Connect the PUL+ and DIR+ ports to the designated pin on the Arduino for each axis (e.g., pins 2, 3 for the X-axis, 4, 5 for the Y-axis, and 6, 7 for the Z-axis, or as per your GRBL configuration).

Step 5: Power Supply Connection

Connect the power supply to the TB6600 drivers. Make sure to use a power supply that matches the voltage and current requirements of your Nema 24 motors.

Step 6: Configuring GRBL

Once everything is connected and powered up, open the Arduino IDE.

Open the Serial Monitor and set the baud rate to 115200.

You can now enter GRBL commands to configure your setup. For example, $100=800 (steps/mm for X-axis), $101=800 (Y-axis), $102=800 (Z-axis). Adjust these values based on your machine's specifications.

Step 7: Testing

Send simple commands via the Serial Monitor to test each axis, such as G0 X10 to move the X-axis.

Step 8: Fine-Tuning

Fine-tune the settings in GRBL for things like step resolution, acceleration, and max speed to ensure smooth operation of your CNC machine.

Step 9: Safety Checks

Before operating the machine, ensure all connections are secure and perform safety checks.

Step 10: Software for Control

To control your CNC machine, you'll need software that can send G-code to GRBL, like Universal G-code Sender or GRBL Candle.

Additional Notes

Ensure your work area is safe and that you understand how to operate the CNC machine safely.

You might need to adjust settings or troubleshoot based on your specific hardware and requirements.

Remember, while GRBL is quite user-friendly, dealing with CNC machines and their setup can be complex. If you're not comfortable with the electrical or programming aspects, it's advisable to seek help from someone experienced in this area.

Post-Processor Con%guration

Here is the post-processor configuration for the TseNC. A new configuration for the TzeNC-Pro will follow once it has been built:

```
/**
  Copyright (C) 2012-2021 by Autodesk, Inc.
  All rights reserved.

  Grbl post processor configuration.

  $Revision: 43151 08c79bb5b30997ccb5fb33ab8e7c8c26981be334 $
  $Date: 2021-02-19 00:25:13 $

  FORKID {154F7C00-6549-4c77-ADE0-79375FE5F2AA}
*/

description = "Grbl";
vendor = "grbl";
vendorUrl = "https://github.com/gnea/grbl/wiki";
longDescription = "Generic milling post for Grbl. Use 'Split file' property to split files by tool for tool changes.";

// >>>>> INCLUDED FROM ../common/grbl.cps
legal = "Copyright (C) 2012-2021 by Autodesk, Inc.";
certificationLevel = 2;
minimumRevision = 45702;

```

```
extension = "nc";
setCodePage("ascii");

capabilities = CAPABILITY_MILLING;
tolerance = spatial(0.002, MM);

minimumChordLength = spatial(0.25, MM);
minimumCircularRadius = spatial(0.01, MM);
maximumCircularRadius = spatial(1000, MM);
minimumCircularSweep = toRad(0.01);
maximumCircularSweep = toRad(180);
allowHelicalMoves = true;
allowedCircularPlanes = undefined; // allow any circular motion

// user-defined properties
properties = {
  writeMachine: {
    title: "Write machine",
    description: "Output the machine settings in the header of the code.",
    group: 0,
    type: "boolean",
    value: false,
    scope: "post"
  },
  writeTools: {
    title: "Write tool list",
    description: "Output a tool list in the header of the code.",
    group: 0,
    type: "boolean",
    value: false,
    scope: "post"
  },
  safePositionMethod: {
    title: "Safe Retracts",
    description: "Select your desired retract option. 'Clearance Height' retracts to the operation clearance height.",
    type: "enum",
    values: [
      {title: "Clearance Height", id: "clearanceHeight"}
    ],
    value: "clearanceHeight",
    scope: "post"
  },
  showSequenceNumbers: {
    title: "Use sequence numbers",
```

```
    description: "Use sequence numbers for each block of outputted code.",
    group: 1,
    type: "boolean",
    value: false,
    scope: "post"
  },
  sequenceNumberStart: {
    title: "Start sequence number",
    description: "The number at which to start the sequence numbers.",
    group: 1,
    type: "integer",
    value: 10,
    scope: "post"
  },
  sequenceNumberIncrement: {
    title: "Sequence number increment",
    description: "The amount by which the sequence number is incremented by in each block.",
    group: 1,
    type: "integer",
    value: 1,
    scope: "post"
  },
  separateWordsWithSpace: {
    title: "Separate words with space",
    description: "Adds spaces between words if 'yes' is selected.",
    type: "boolean",
    value: true,
    scope: "post"
  },
  useToolChanger: {
    title: "Output tool number",
    description: "Disable to disallow the output of tool numbers (Txx).",
    type: "boolean",
    value: false,
    scope: "post"
  },
  useM06: {
    title: "Output M6",
    description: "Disable to disallow the output of M6 on tool changes.",
    type: "boolean",
    value: false,
    scope: "post"
  },
  splitFile: {
```

```
    title: "Split file",
    description: "Select your desired file splitting option.",
    type: "enum",
    values: [
      {title: "No splitting", id: "none"},
      {title: "Split by tool", id: "tool"},
      {title: "Split by toolpath", id: "toolpath"}
    ],
    value: "none",
    scope: "post"
  }
};

var numberOfToolSlots = 9999;
var subprograms = new Array();

var singleLineCoolant = false; // specifies to output multiple coolant codes in one line rather than in separate lines
// samples:
// {id: COOLANT_THROUGH_TOOL, on: 88, off: 89}
// {id: COOLANT_THROUGH_TOOL, on: [8, 88], off: [9, 89]}
var coolants = [
  {id: COOLANT_FLOOD, on: 8},
  {id: COOLANT_MIST},
  {id: COOLANT_THROUGH_TOOL},
  {id: COOLANT_AIR},
  {id: COOLANT_AIR_THROUGH_TOOL},
  {id: COOLANT_SUCTION},
  {id: COOLANT_FLOOD_MIST},
  {id: COOLANT_FLOOD_THROUGH_TOOL},
  {id: COOLANT_OFF, off: 9}
];

var gFormat = createFormat({prefix:"G", decimals:0});
var mFormat = createFormat({prefix:"M", decimals:0});

var xyzFormat = createFormat({decimals:(unit == MM ? 3 : 4)});
var feedFormat = createFormat({decimals:(unit == MM ? 1 : 2)});
var toolFormat = createFormat({decimals:0});
var rpmFormat = createFormat({decimals:0});
var secFormat = createFormat({decimals:3, forceDecimal:true}); // seconds - range 0.001-1000
var taperFormat = createFormat({decimals:1, scale:DEG});

var xOutput = createVariable({prefix:"X"}, xyzFormat);
var yOutput = createVariable({prefix:"Y"}, xyzFormat);
```

```
155. var zOutput = createVariable({onchange:function () {retracted = false;}, prefix:"Z"}, xyzFormat);
156. var feedOutput = createVariable({prefix:"F"}, feedFormat);
157. var sOutput = createVariable({prefix:"S", force:true}, rpmFormat);
158.
159. // circular output
160. var iOutput = createVariable({prefix:"I"}, xyzFormat);
161. var jOutput = createVariable({prefix:"J"}, xyzFormat);
162. var kOutput = createVariable({prefix:"K"}, xyzFormat);
163.
164. var gMotionModal = createModal({}, gFormat); // modal group 1 // G0-G3, ...
165. var gPlaneModal = createModal({onchange:function () {gMotionModal.reset();}}, gFormat); // modal group 2 // G17-19
166. var gAbsIncModal = createModal({}, gFormat); // modal group 3 // G90-91
167. var gFeedModeModal = createModal({}, gFormat); // modal group 5 // G93-94
168. var gUnitModal = createModal({}, gFormat); // modal group 6 // G20-21
169.
170. var WARNING_WORK_OFFSET = 0;
171.
172. // collected state
173. var sequenceNumber;
174. var currentWorkOffset;
175. var retracted = false; // specifies that the tool has been retracted to the safe plane
176.
177. /**
178.   Writes the specified block.
179. */
180. function writeBlock() {
181.   var text = formatWords(arguments);
182.   if (!text) {
183.     return;
184.   }
185.   if (getProperty("showSequenceNumbers")) {
186.     writeWords2("N" + sequenceNumber, arguments);
187.     sequenceNumber += getProperty("sequenceNumberIncrement");
188.   } else {
189.     writeWords(arguments);
190.   }
191. }
192.
193. function formatComment(text) {
194.   return "(" + String(text).replace(/[()]/g, "") + ")";
195. }
196.
197. /**
198.   Output a comment.
```

```
*/
function writeComment(text) {
  writeln(formatComment(text));
}

function onOpen() {
  if (!getProperty("separateWordsWithSpace")) {
    setWordSeparator("");
  }

  sequenceNumber = getProperty("sequenceNumberStart");

  if (programName) {
    writeComment(programName);
  }
  if (programComment) {
    writeComment(programComment);
  }

  // dump machine configuration
  var vendor = machineConfiguration.getVendor();
  var model = machineConfiguration.getModel();
  var description = machineConfiguration.getDescription();

  if (getProperty("writeMachine") && (vendor || model || description)) {
    writeComment(localize("Machine"));
    if (vendor) {
      writeComment("  " + localize("vendor") + ": " + vendor);
    }
    if (model) {
      writeComment("  " + localize("model") + ": " + model);
    }
    if (description) {
      writeComment("  " + localize("description") + ": "  + description);
    }
  }

  // dump tool information
  if (getProperty("writeTools")) {
    var zRanges = {};
    if (is3D()) {
      var numberOfSections = getNumberOfSections();
      for (var i = 0; i < numberOfSections; ++i) {
        var section = getSection(i);
```

```
243.         var zRange = section.getGlobalZRange();
244.         var tool = section.getTool();
245.         if (zRanges[tool.number]) {
246.           zRanges[tool.number].expandToRange(zRange);
247.         } else {
248.           zRanges[tool.number] = zRange;
249.         }
250.       }
251.     }
252.
253.     var tools = getToolTable();
254.     if (tools.getNumberOfTools() > 0) {
255.       for (var i = 0; i < tools.getNumberOfTools(); ++i) {
256.         var tool = tools.getTool(i);
257.         var comment = "T" + toolFormat.format(tool.number) + "  " +
258.           "D=" + xyzFormat.format(tool.diameter) + " " +
259.           localize("CR") + "=" + xyzFormat.format(tool.cornerRadius);
260.         if ((tool.taperAngle > 0) && (tool.taperAngle < Math.PI)) {
261.           comment += " " + localize("TAPER") + "=" + taperFormat.format(tool.taperAngle) + localize("deg");
262.         }
263.         if (zRanges[tool.number]) {
264.           comment += " - " + localize("ZMIN") + "=" + xyzFormat.format(zRanges[tool.number].getMinimum());
265.         }
266.         comment += " - " + getToolTypeName(tool.type);
267.         writeComment(comment);
268.       }
269.     }
270.   }
271.
272.   if ((getNumberOfSections() > 0) && (getSection(0).workOffset == 0)) {
273.     for (var i = 0; i < getNumberOfSections(); ++i) {
274.       if (getSection(i).workOffset > 0) {
275.         error(localize("Using multiple work offsets is not possible if the initial work offset is 0."));
276.         return;
277.       }
278.     }
279.   }
280.
281.   if (getProperty("splitFile") != "none") {
282.     writeComment(localize("***THIS FILE DOES NOT CONTAIN NC CODE***"));
283.     return;
284.   }
285.
286.   // absolute coordinates and feed per min
```

```
287.   writeBlock(gAbsIncModal.format(90), gFeedModeModal.format(94));
288.   writeBlock(gPlaneModal.format(17));
289.
290.   switch (unit) {
291.   case IN:
292.     writeBlock(gUnitModal.format(20));
293.     break;
294.   case MM:
295.     writeBlock(gUnitModal.format(21));
296.     break;
297.   }
298. }
299.
300. function onComment(message) {
301.   writeComment(message);
302. }
303.
304. /** Force output of X, Y, and Z. */
305. function forceXYZ() {
306.   xOutput.reset();
307.   yOutput.reset();
308.   zOutput.reset();
309. }
310.
311. /** Force output of X, Y, Z, and F on next output. */
312. function forceAny() {
313.   forceXYZ();
314.   feedOutput.reset();
315. }
316.
317. function isProbeOperation() {
318.   return hasParameter("operation-strategy") &&
319.     (getParameter("operation-strategy") == "probe");
320. }
321.
322. function onSection() {
323.   var insertToolCall = isFirstSection() ||
324.     currentSection.getForceToolChange && currentSection.getForceToolChange() ||
325.     (tool.number != getPreviousSection().getTool().number);
326.
327.   var splitHere = getProperty("splitFile") == "toolpath" || (getProperty("splitFile") == "tool" && insertToolCall);
328.
329.   retracted = false; // specifies that the tool has been retracted to the safe plane
330.   var newWorkOffset = isFirstSection() ||
```

```
    (getPreviousSection().workOffset != currentSection.workOffset) ||
    splitHere; // work offset changes
  var newWorkPlane = isFirstSection() ||
    !isSameDirection(getPreviousSection().getGlobalFinalToolAxis(), currentSection.getGlobalInitialToolAxis()) ||
    (currentSection.isOptimizedForMachine() && getPreviousSection().isOptimizedForMachine() &&
      Vector.diff(getPreviousSection().getFinalToolAxisABC(), currentSection.getInitialToolAxisABC()).length > 1e-4) ||
    (!machineConfiguration.isMultiAxisConfiguration() && currentSection.isMultiAxis()) ||
    (!getPreviousSection().isMultiAxis() && currentSection.isMultiAxis() ||
      getPreviousSection().isMultiAxis() && !currentSection.isMultiAxis()) ||
      splitHere; // force newWorkPlane between indexing and simultaneous operations
  if (insertToolCall || newWorkOffset || newWorkPlane) {
    // stop spindle before retract during tool change
    if (insertToolCall && !isFirstSection()) {
      onCommand(COMMAND_STOP_SPINDLE);
    }
    if (getProperty("splitFile") == "none" || isRedirecting()) {
      writeRetract(Z);
    }
  }

  writeln("");

  if (splitHere) {
    if (!isFirstSection()) {
      setCoolant(COOLANT_OFF);

      writeRetract(X, Y);

      onImpliedCommand(COMMAND_END);
      onCommand(COMMAND_STOP_SPINDLE);
      writeBlock(mFormat.format(30)); // stop program, spindle stop, coolant off
      if (isRedirecting()) {
        closeRedirection();
      }
    }

    var subprogram;
    if (getProperty("splitFile") == "toolpath") {
      var comment;
      if (hasParameter("operation-comment")) {
        comment = getParameter("operation-comment");

      } else {
        comment = getCurrentSectionId();
```

```
      }
      subprogram = programName + "_" + (subprograms.length + 1) + "_" + comment + "_" + "T" + tool.number;
    } else {
      subprogram = programName + "_" + (subprograms.length + 1) + "_" + "T" + tool.number;
    }

    // var index = 0;
    // var _subprogram = subprogram;
    // while (subprograms.indexOf(_subprogram) !== -1) {
    //   index++;
    //   _subprogram = subprogram + "_" + index;
    // }
    // subprogram = _subprogram;
    subprograms.push(subprogram);

    var path = FileSystem.getCombinedPath(FileSystem.getFolderPath(getOutputPath()), String(subprogram).replace(/[<>:"/\\|?*]/g, "") + "." +
extension);

    writeComment(localize("Load tool number " + tool.number + " and subprogram " + subprogram));

    redirectToFile(path);

    if (programName) {
      writeComment(programName);
    }
    if (programComment) {
      writeComment(programComment);
    }

    // absolute coordinates and feed per min
    writeBlock(gAbsIncModal.format(90), gFeedModeModal.format(94));
    writeBlock(gPlaneModal.format(17));

    switch (unit) {
    case IN:
      writeBlock(gUnitModal.format(20));
      break;
    case MM:
      writeBlock(gUnitModal.format(21));
      break;
    }

  }

```

```
418.   if (hasParameter("operation-comment")) {
419.     var comment = getParameter("operation-comment");
420.     if (comment) {
421.       writeComment(comment);
422.     }
423.   }
424.
425.   if (insertToolCall) {
426.     setCoolant(COOLANT_OFF);
427.
428.     if (tool.number > numberOfToolSlots) {
429.       warning(localize("Tool number exceeds maximum value."));
430.     }
431.
432.     if (getProperty("useToolChanger")) {
433.       writeBlock("T" + toolFormat.format(tool.number), conditional(getProperty("useM06"), mFormat.format(6)));
434.       if (!isFirstSection() && !getProperty("useM06")) {
435.         writeComment(localize("CHANGE TO T") + tool.number);
436.       }
437.     } else if (getProperty("useM06")) {
438.       writeBlock(mFormat.format(6));
439.     }
440.     if (tool.comment) {
441.       writeComment(tool.comment);
442.     }
443.     var showToolZMin = false;
444.     if (showToolZMin) {
445.       if (is3D()) {
446.         var numberOfSections = getNumberOfSections();
447.         var zRange = currentSection.getGlobalZRange();
448.         var number = tool.number;
449.         for (var i = currentSection.getId() + 1; i < numberOfSections; ++i) {
450.           var section = getSection(i);
451.           if (section.getTool().number != number) {
452.             break;
453.           }
454.           zRange.expandToRange(section.getGlobalZRange());
455.         }
456.         writeComment(localize("ZMIN") + "=" + zRange.getMinimum());
457.       }
458.     }
459.   }
460.
461.   if (insertToolCall ||
```

```
462.       isFirstSection() ||
463.       (rpmFormat.areDifferent(spindleSpeed, sOutput.getCurrent())) ||
464.       (tool.clockwise != getPreviousSection().getTool().clockwise)) {
465.     if (spindleSpeed < 1) {
466.       error(localize("Spindle speed out of range."));
467.     }
468.     if (spindleSpeed > 99999) {
469.       warning(localize("Spindle speed exceeds maximum value."));
470.     }
471.     writeBlock(
472.       sOutput.format(spindleSpeed), mFormat.format(tool.clockwise ? 3 : 4)
473.     );
474.   }
475.
476.   // wcs
477.   if (insertToolCall) { // force work offset when changing tool
478.     currentWorkOffset = undefined;
479.   }
480.   var workOffset = currentSection.workOffset;
481.   if (workOffset == 0) {
482.     //warningOnce(localize("Work offset has not been specified. Using G54 as WCS."), WARNING_WORK_OFFSET); //DANIELE
483.     workOffset = 1;
484.   }
485.   if (workOffset > 0) {
486.     if (workOffset > 6) {
487.       error(localize("Work offset out of range."));
488.       return;
489.     } else {
490.       if (workOffset != currentWorkOffset) {
491.         writeBlock(gFormat.format(53 + workOffset)); // G54->G59
492.         currentWorkOffset = workOffset;
493.       }
494.     }
495.   }
496.
497.   forceXYZ();
498.
499.   { // pure 3D
500.     var remaining = currentSection.workPlane;
501.     if (!isSameDirection(remaining.forward, new Vector(0, 0, 1))) {
502.       error(localize("Tool orientation is not supported."));
503.       return;
504.     }
505.     setRotation(remaining);
```

```
506.   }
507.
508.   // set coolant after we have positioned at Z
509.   setCoolant(tool.coolant);
510.
511.   forceAny();
512.
513.
514.   var initialPosition = getFramePosition(currentSection.getInitialPosition());
515.   if (!retracted) {
516.     if (getCurrentPosition().z < initialPosition.z) {
517.       writeBlock(gMotionModal.format(0), zOutput.format(initialPosition.z));
518.     }
519.   }
520.
521.   if (insertToolCall || retracted) {
522.     var lengthOffset = tool.lengthOffset;
523.     if (lengthOffset > numberOfToolSlots) {
524.       error(localize("Length offset out of range."));
525.       return;
526.     }
527.
528.     gMotionModal.reset();
529.     writeBlock(gPlaneModal.format(17));
530.
531.     if (!machineConfiguration.isHeadConfiguration()) {
532.         writeBlock(gMotionModal.format(0), zOutput.format(initialPosition.z)); //DANIELE
533.       writeBlock(
534.         gAbsIncModal.format(90),
535.         gMotionModal.format(0), xOutput.format(initialPosition.x), yOutput.format(initialPosition.y)
536.       );
537.       writeBlock(gMotionModal.format(0), zOutput.format(initialPosition.z));
538.     } else {
539.       writeBlock(
540.         gAbsIncModal.format(90),
541.         gMotionModal.format(0),
542.         xOutput.format(initialPosition.x),
543.         yOutput.format(initialPosition.y),
544.         zOutput.format(initialPosition.z)
545.       );
546.     }
547.   } else {
548.     writeBlock(
549.       gAbsIncModal.format(90),
```

```
      gMotionModal.format(0),
      xOutput.format(initialPosition.x),
      yOutput.format(initialPosition.y)
    );
  }
}

function onDwell(seconds) {
  if (seconds > 99999.999) {
    warning(localize("Dwelling time is out of range."));
  }
  seconds = clamp(0.001, seconds, 99999.999);
  writeBlock(gFormat.format(4), "P" + secFormat.format(seconds));
}

function onSpindleSpeed(spindleSpeed) {
  writeBlock(sOutput.format(spindleSpeed));
}

var pendingRadiusCompensation = -1;

function onRadiusCompensation() {
  pendingRadiusCompensation = radiusCompensation;
}

function onRapid(_x, _y, _z) {
  var x = xOutput.format(_x);
  var y = yOutput.format(_y);
  var z = zOutput.format(_z);
  if (x || y || z) {
    if (pendingRadiusCompensation >= 0) {
      error(localize("Radius compensation mode cannot be changed at rapid traversal."));
      return;
    }
    writeBlock(gMotionModal.format(0), x, y, z);
    feedOutput.reset();
  }
}

function onLinear(_x, _y, _z, feed) {
  // at least one axis is required
  if (pendingRadiusCompensation >= 0) {
    // ensure that we end at desired position when compensation is turned off
    xOutput.reset();
```

```
    yOutput.reset();
  }
  var x = xOutput.format(_x);
  var y = yOutput.format(_y);
  var z = zOutput.format(_z);
  var f = feedOutput.format(feed);
  if (x || y || z) {
    if (pendingRadiusCompensation >= 0) {
      error(localize("Radius compensation mode is not supported."));
      return;
    } else {
      writeBlock(gMotionModal.format(1), x, y, z, f);
    }
  } else if (f) {
    if (getNextRecord().isMotion()) { // try not to output feed without motion
      feedOutput.reset(); // force feed on next line
    } else {
      writeBlock(gMotionModal.format(1), f);
    }
  }
}

function onRapid5D(_x, _y, _z, _a, _b, _c) {
  error(localize("Multi-axis motion is not supported."));
}

function onLinear5D(_x, _y, _z, _a, _b, _c, feed) {
  error(localize("Multi-axis motion is not supported."));
}

function forceCircular(plane) {
  switch (plane) {
  case PLANE_XY:
    xOutput.reset();
    yOutput.reset();
    iOutput.reset();
    jOutput.reset();
    break;
  case PLANE_ZX:
    zOutput.reset();
    xOutput.reset();
    kOutput.reset();
    iOutput.reset();
    break;
```

```
638.   case PLANE_YZ:
639.     yOutput.reset();
640.     zOutput.reset();
641.     jOutput.reset();
642.     kOutput.reset();
643.     break;
644.   }
645. }
646.
647. function onCircular(clockwise, cx, cy, cz, x, y, z, feed) {
648.   // one of X/Y and I/J are required and likewise
649.
650.   if (pendingRadiusCompensation >= 0) {
651.     error(localize("Radius compensation cannot be activated/deactivated for a circular move."));
652.     return;
653.   }
654.
655.   var start = getCurrentPosition();
656.
657.   if (isFullCircle()) {
658.     if (isHelical()) {
659.       linearize(tolerance);
660.       return;
661.     }
662.     switch (getCircularPlane()) {
663.     case PLANE_XY:
664.       forceCircular(getCircularPlane());
665.       writeBlock(gPlaneModal.format(17), gMotionModal.format(clockwise ? 2 : 3), xOutput.format(x), iOutput.format(cx - start.x), jOutput.format(cy -
start.y), feedOutput.format(feed));
666.       break;
667.     case PLANE_ZX:
668.       forceCircular(getCircularPlane());
669.       writeBlock(gPlaneModal.format(18), gMotionModal.format(clockwise ? 2 : 3), zOutput.format(z), iOutput.format(cx - start.x), kOutput.format(cz -
start.z), feedOutput.format(feed));
670.       break;
671.     case PLANE_YZ:
672.       forceCircular(getCircularPlane());
673.       writeBlock(gPlaneModal.format(19), gMotionModal.format(clockwise ? 2 : 3), yOutput.format(y), jOutput.format(cy - start.y), kOutput.format(cz -
start.z), feedOutput.format(feed));
674.       break;
675.     default:
676.       linearize(tolerance);
677.     }
678.   } else {
```

```
679.     switch (getCircularPlane()) {
680.     case PLANE_XY:
681.       forceCircular(getCircularPlane());
682.       writeBlock(gPlaneModal.format(17), gMotionModal.format(clockwise ? 2 : 3), xOutput.format(x), yOutput.format(y), zOutput.format(z),
iOutput.format(cx - start.x), jOutput.format(cy - start.y), feedOutput.format(feed));
683.       break;
684.     case PLANE_ZX:
685.       forceCircular(getCircularPlane());
686.       writeBlock(gPlaneModal.format(18), gMotionModal.format(clockwise ? 2 : 3), xOutput.format(x), yOutput.format(y), zOutput.format(z),
iOutput.format(cx - start.x), kOutput.format(cz - start.z), feedOutput.format(feed));
687.       break;
688.     case PLANE_YZ:
689.       forceCircular(getCircularPlane());
690.       writeBlock(gPlaneModal.format(19), gMotionModal.format(clockwise ? 2 : 3), xOutput.format(x), yOutput.format(y), zOutput.format(z),
jOutput.format(cy - start.y), kOutput.format(cz - start.z), feedOutput.format(feed));
691.       break;
692.     default:
693.       linearize(tolerance);
694.     }
695.   }
696. }
697.
698. var mapCommand = {
699.   COMMAND_STOP:0,
700.   COMMAND_END:2,
701.   COMMAND_SPINDLE_CLOCKWISE:3,
702.   COMMAND_SPINDLE_COUNTERCLOCKWISE:4,
703.   COMMAND_STOP_SPINDLE:5
704. };
705.
706. function onCommand(command) {
707.   switch (command) {
708.   case COMMAND_START_SPINDLE:
709.     onCommand(tool.clockwise ? COMMAND_SPINDLE_CLOCKWISE : COMMAND_SPINDLE_COUNTERCLOCKWISE);
710.     return;
711.   case COMMAND_LOCK_MULTI_AXIS:
712.     return;
713.   case COMMAND_UNLOCK_MULTI_AXIS:
714.     return;
715.   case COMMAND_BREAK_CONTROL:
716.     return;
717.   case COMMAND_TOOL_MEASURE:
718.     return;
719.   }
```

```
720.
721.   var stringId = getCommandStringId(command);
722.   var mcode = mapCommand[stringId];
723.   if (mcode != undefined) {
724.     writeBlock(mFormat.format(mcode));
725.   } else {
726.     onUnsupportedCommand(command);
727.   }
728. }
729.
730. function onSectionEnd() {
731.   writeBlock(gPlaneModal.format(17));
732.   if (!isLastSection() && (getNextSection().getTool().coolant != tool.coolant)) {
733.     setCoolant(COOLANT_OFF);
734.   }
735.   forceAny();
736. }
737.
738. /** Output block to do safe retract and/or move to home position. */
739. function writeRetract() {
740.   var words = []; // store all retracted axes in an array
741.   var retractAxes = new Array(false, false, false);
742.   var method = getProperty("safePositionMethod");
743.   if (method == "clearanceHeight") {
744.     if (!is3D()) {
745.       error(localize("Retract option 'Clearance Height' is not supported for multi-axis machining."));
746.     }
747.     return;
748.   }
749.   validate(arguments.length != 0, "No axis specified for writeRetract().");
750.
751.   for (i in arguments) {
752.     retractAxes[arguments[i]] = true;
753.   }
754.   if ((retractAxes[0] || retractAxes[1]) && !retracted) { // retract Z first before moving to X/Y home
755.     error(localize("Retracting in X/Y is not possible without being retracted in Z."));
756.     return;
757.   }
758.   // special conditions
759.   if (retractAxes[2]) { // Z doesn't use G53
760.     method = "G28";
761.   }
762.
763.   // define home positions
```

```
764.   var _xHome;
765.   var _yHome;
766.   var _zHome;
767.   if (method == "G28") {
768.     _xHome = toPreciseUnit(0, MM);
769.     _yHome = toPreciseUnit(0, MM);
770.     _zHome = toPreciseUnit(0, MM);
771.   } else {
772.     _xHome = machineConfiguration.hasHomePositionX() ? machineConfiguration.getHomePositionX() : toPreciseUnit(0, MM);
773.     _yHome = machineConfiguration.hasHomePositionY() ? machineConfiguration.getHomePositionY() : toPreciseUnit(0, MM);
774.     _zHome = machineConfiguration.getRetractPlane() != 0 ? machineConfiguration.getRetractPlane() : toPreciseUnit(0, MM);
775.   }
776.   for (var i = 0; i < arguments.length; ++i) {
777.     switch (arguments[i]) {
778.     case X:
779.       words.push("X" + xyzFormat.format(_xHome));
780.       xOutput.reset();
781.       break;
782.     case Y:
783.       words.push("Y" + xyzFormat.format(_yHome));
784.       yOutput.reset();
785.       break;
786.     case Z:
787.       words.push("Z" + xyzFormat.format(_zHome));
788.       zOutput.reset();
789.       retracted = true;
790.       break;
791.     default:
792.       error(localize("Unsupported axis specified for writeRetract()."));
793.       return;
794.     }
795.   }
796.   if (words.length > 0) {
797.     switch (method) {
798.     case "G28":
799.       gMotionModal.reset();
800.       gAbsIncModal.reset();
801.       writeBlock(gFormat.format(28), gAbsIncModal.format(91), words);
802.       writeBlock(gAbsIncModal.format(90));
803.       break;
804.     case "G53":
805.       gMotionModal.reset();
806.       writeBlock(gAbsIncModal.format(90), gFormat.format(53), gMotionModal.format(0), words);
807.       break;
```

```
    default:
      error(localize("Unsupported safe position method."));
      return;
    }
  }
}

var currentCoolantMode = COOLANT_OFF;
var coolantOff = undefined;

function setCoolant(coolant) {
  var coolantCodes = getCoolantCodes(coolant);
  if (Array.isArray(coolantCodes)) {
    if (singleLineCoolant) {
      writeBlock(coolantCodes.join(getWordSeparator()));
    } else {
      for (var c in coolantCodes) {
        writeBlock(coolantCodes[c]);
      }
    }
    return undefined;
  }
  return coolantCodes;
}

function getCoolantCodes(coolant) {
  var multipleCoolantBlocks = new Array(); // create a formatted array to be passed into the outputted line
  if (!coolants) {
    error(localize("Coolants have not been defined."));
  }
  if (isProbeOperation()) { // avoid coolant output for probing
    coolant = COOLANT_OFF;
  }
  if (coolant == currentCoolantMode) {
    return undefined; // coolant is already active
  }
  if ((coolant != COOLANT_OFF) && (currentCoolantMode != COOLANT_OFF) && (coolantOff != undefined)) {
    if (Array.isArray(coolantOff)) {
      for (var i in coolantOff) {
        multipleCoolantBlocks.push(mFormat.format(coolantOff[i]));
      }
    } else {
      multipleCoolantBlocks.push(mFormat.format(coolantOff));
    }
```

```
852.   }
853.
854.   var m;
855.   var coolantCodes = {};
856.   for (var c in coolants) { // find required coolant codes into the coolants array
857.     if (coolants[c].id == coolant) {
858.       coolantCodes.on = coolants[c].on;
859.       if (coolants[c].off != undefined) {
860.         coolantCodes.off = coolants[c].off;
861.         break;
862.       } else {
863.         for (var i in coolants) {
864.           if (coolants[i].id == COOLANT_OFF) {
865.             coolantCodes.off = coolants[i].off;
866.             break;
867.           }
868.         }
869.       }
870.     }
871.   }
872.   if (coolant == COOLANT_OFF) {
873.     m = !coolantOff ? coolantCodes.off : coolantOff; // use the default coolant off command when an 'off' value is not specified
874.   } else {
875.     coolantOff = coolantCodes.off;
876.     m = coolantCodes.on;
877.   }
878.
879.   if (!m) {
880.     onUnsupportedCoolant(coolant);
881.     m = 9;
882.   } else {
883.     if (Array.isArray(m)) {
884.       for (var i in m) {
885.         multipleCoolantBlocks.push(mFormat.format(m[i]));
886.       }
887.     } else {
888.       multipleCoolantBlocks.push(mFormat.format(m));
889.     }
890.     currentCoolantMode = coolant;
891.     return multipleCoolantBlocks; // return the single formatted coolant value
892.   }
893.   return undefined;
894. }
895.
```

```
896. function onClose() {
897.   setCoolant(COOLANT_OFF);
898.
899.   writeRetract(Z);
900.
901.   writeRetract(X, Y);
902.
903.   onImpliedCommand(COMMAND_END);
904.   onCommand(COMMAND_STOP_SPINDLE);
905.   writeBlock(mFormat.format(30)); // stop program, spindle stop, coolant off
906.   if (isRedirecting()) {
907.     closeRedirection();
908.   }
909. }
910.
911. function setProperty(property, value) {
912.   properties[property].current = value;
913. }
914. // <<<<< INCLUDED FROM ../common/grbl.cps
915.
```

References

Literature References

- 3 Phase Coolant Pump. (n.d.). Mscdirect.com. Retrieved December 21, 2023, from https://www.mscdirect.com/product/details/55576466
- Bridgeport series II interact 2 CNC mill ==> enclosure. (n.d.). Chudov.com. Retrieved December 21, 2023, from http://igor.chudov.com/projects/Bridgeport-Series-II-Interact-2-CNC-Mill/23-Enclosure/
- CNC4XR [@CNC4XR7]. (2015, July 29). G0602 project DIY flood coolant pump and tank. Youtube. https://www.youtube.com/watch?v=lmskeUuxEeI
- Flood coolant pump specs. (2018, April 27). The Hobby-Machinist. https://www.hobby-machinist.com/threads/flood-coolant-pump-specs.69351/
- Flood Coolant Systems & Pumps. (n.d.). Mscdirect.com. Retrieved December 21, 2023, from https://www.mscdirect.com/browse/tn/Lubricants-Coolants-Fluids/Metalworking-Fluids-Coolants-Equipment/Coolant-Systems-Accessories/Flood-Coolant-Systems-Pumps?navid=2107423
- How does one size a coolant pump? (2017, March 9). Practical Machinist - Largest Manufacturing Technology Forum on the Web. https://www.practicalmachinist.com/forum/threads/how-does-one-size-a-coolant-pump.332316/
- IndustryArena - Business Netzwerk der Fertigungsindustrie. (n.d.). IndustryArena. Retrieved December 21, 2023, from https://en.industryarena.com/
- Mist vs. Flood coolant. (n.d.). Cnczone.com. Retrieved December 21, 2023, from https://www.cnczone.com/forums/bridgeport-hardinge-mills/109588-machinist.html
- O'Donnell, D. (2018, February 21). 3 types of cooling systems and how they work. Sensorex Liquid Analysis Technology; Sensorex. https://sensorex.com/how-cooling-towers-work/
- Small Cheap flood Coolant system. (n.d.). Cnczone.com. Retrieved December 21, 2023, from https://www.cnczone.com/forums/benchtop-machines/35408-small-cheap-flood-coolant-system.html
- Stuff Made Here [@StuffMadeHere]. (2020, March 29). Fixing a little mess with a big mess. Youtube. https://www.youtube.com/watch?v=1de6fO-9ZDU
- The Engineering Mindset [@EngineeringMindset]. (2017, July 8). Pump CALCULATIONS, flow rate, RPM, pressure, power, diameter. Youtube. https://www.youtube.com/watch?v=99vikjRrlgo
- What is GRBL? (n.d.). The Grbl Project. Retrieved December 21, 2023, from https://www.grbl.org/what-is-grbl

CAD References:

- https://grabcad.com/library/flexible-shaft-coupler-6-35-x-12mm-1
- https://grabcad.com/library/t-nut-m4-m5-1
- https://www.sorotec.de/shop/Mafell-FM1000-230V-50Hz-7924.html?language=en
- https://grabcad.com/library/nema-24
- https://grabcad.com/library/kjd18-motor-starter-1
- https://www.dold-mechatronik.de/CAD-Daten
- https://www.stlfinder.com/model/ball-screw-sfu1605-xJ4Oa0ww/2928864/

Online Tutorial References

- https://r1132100503382-eu1-3dswym.3dexperience.3ds.com/#community:yUw32GbYTEqKdgY7-jbZPg/iquestion:iC_XVM_4QxyKQOSwTQOTkA
- https://forum.solidworks.com/thread/243196
- https://forum.solidworks.com/thread/242578
- https://r1132100503382-eu1-3dswym.3dexperience.3ds.com/#community:yUw32GbYTEqKdgY7-jbZPg/iquestion:FBp01DXrSNirkZqYZ5e82Q
- https://help.solidworks.com/2021/english/SolidWorks/sldworks/t_combining_bodies_add.htm#:~:text=You%20cannot%20combine%20two%20separate,Combine%20on%20the%20multibody%20part.&text=(Features%20toolbar)%20or%20Insert%20%3E%20Features%20%3E%20Combine.
- https://help.solidworks.com/2020/english/DraftSight/html/object_selection_cycling.htm#:~:text=Hover%20the%20pointer%20over%20entities,the%20desired%20entity%20is%20highlighted.
- https://help.solidworks.com/2021/english/SolidWorks/sldworks/c_dimensions_in_drawings.htm#:~:text=You%20can%20specify%20that%20dimensions,Auto%20insert%20on%20view%20creation.
- https://www.youtube.com/watch?v=d5WarPraTgY&ab_channel=InfinityProjetosBrasil-SolidworksTutoriais
- https://www.reddit.com/r/SolidWorks/comments/b5vkg1/angular_alignment_of_leaders_in_drawings_i_made_a/
- https://tri-stateal.com/resources/extrusion-guide/#:~:text=Extruded%20Aluminum%20Alloy%20Selection,corrosion%20resistance%20and%20excellent%20workability.

- https://www.youtube.com/watch?v=i7cSkw2khhU&ab_channel=GoEngineer
- https://www.youtube.com/watch?v=xTJOKR-hPPM&ab_channel=TechnologyExplore%7CUsmanChaudhary
- https://www.youtube.com/watch?v=d9tu9JAoQ8c&ab_channel=GoEngineer
- https://www.youtube.com/watch?v=vMhMDdqLFMw&ab_channel=QuestIntegration
- https://www.youtube.com/watch?v=giXSQvOizAs&ab_channel=CADCAMTUTORIALBYMAHTABALAM
- https://www.youtube.com/watch?v=c4y3KcRu7nM&ab_channel=JoePhelan
- https://www.youtube.com/watch?v=TZIo2qowwgY&ab_channel=MLCCADSystems
- https://grabcad.com/questions/what-does-this-message-means-the-part-intersects-itself-after-bend-operation
- https://support.microsoft.com/en-us/office/insert-a-table-of-contents-882e8564-0edb-435e-84b5-1d8552ccf0c0#:~:text=Put%20your%20cursor%20where%20you,contents%20and%20choosing%20Update%20Field.
- https://www.youtube.com/watch?v=i55yXs4Qy18&ab_channel=LUCIDTUTORIALS
- https://www.youtube.com/watch?v=Xq8W_FEVQt8&ab_channel=VisiativUK
- https://help.solidworks.com/2021/english/solidworks/sldworks/t_solid_to_sheet_metal.htm

Technical Data References

- https://ntnamericas.com/wp-content/uploads/2020/03/brgfits.pdf
- https://baartgroup.com/how-to-determine-bearing-shaft-and-housing-fit/