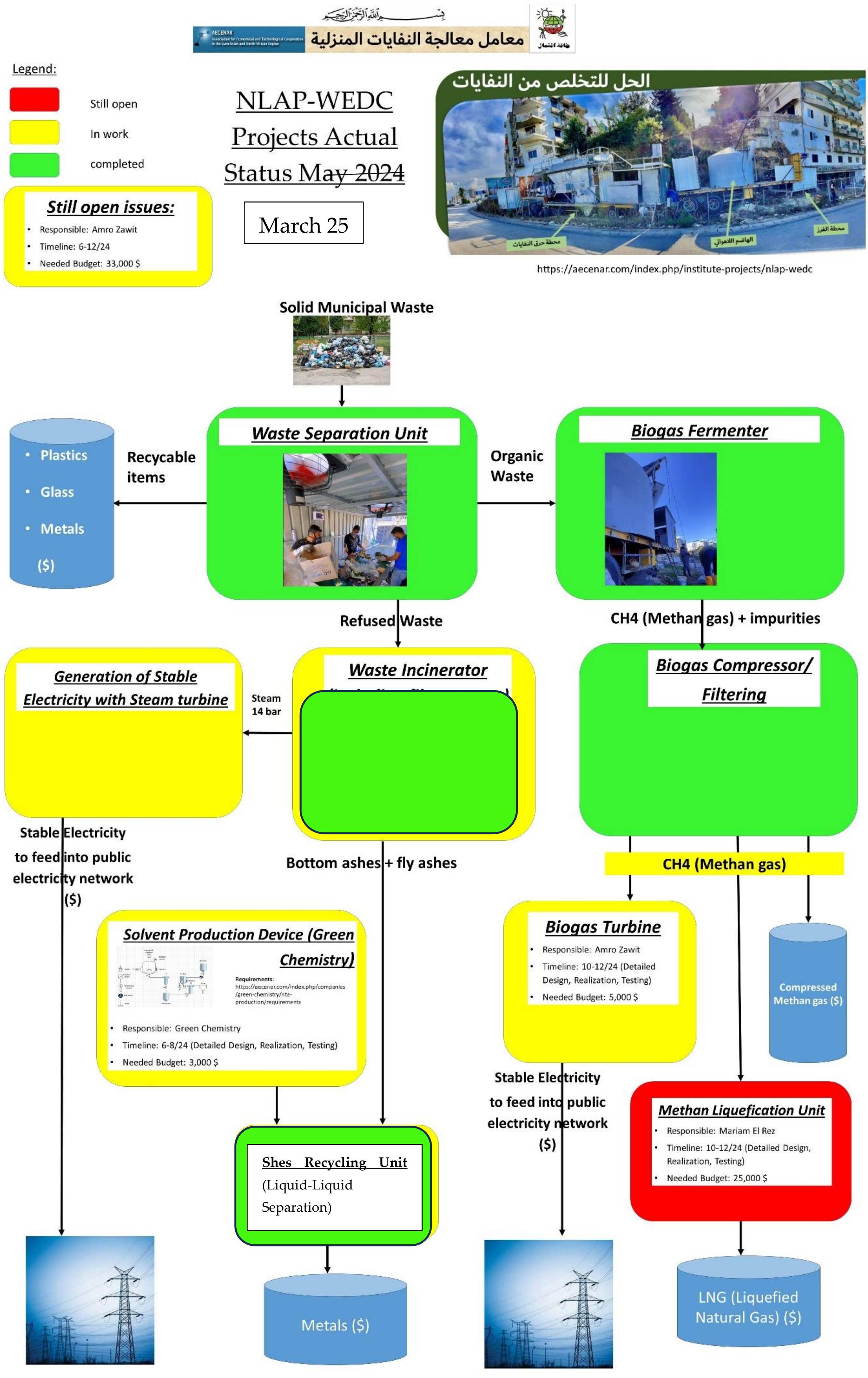
NLAP-WEDC Report 2024



بسم الله الرحمن الرحيم

NLAP-WEDC REPORT 2024 - Part I: Full waste management (Summary)

With contributions of:

Mariam EL REZ

Abdullah KASSEM

Ali DIB

Amro ZAWIT

Last Update: 11.03.2025 08:57

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Preface

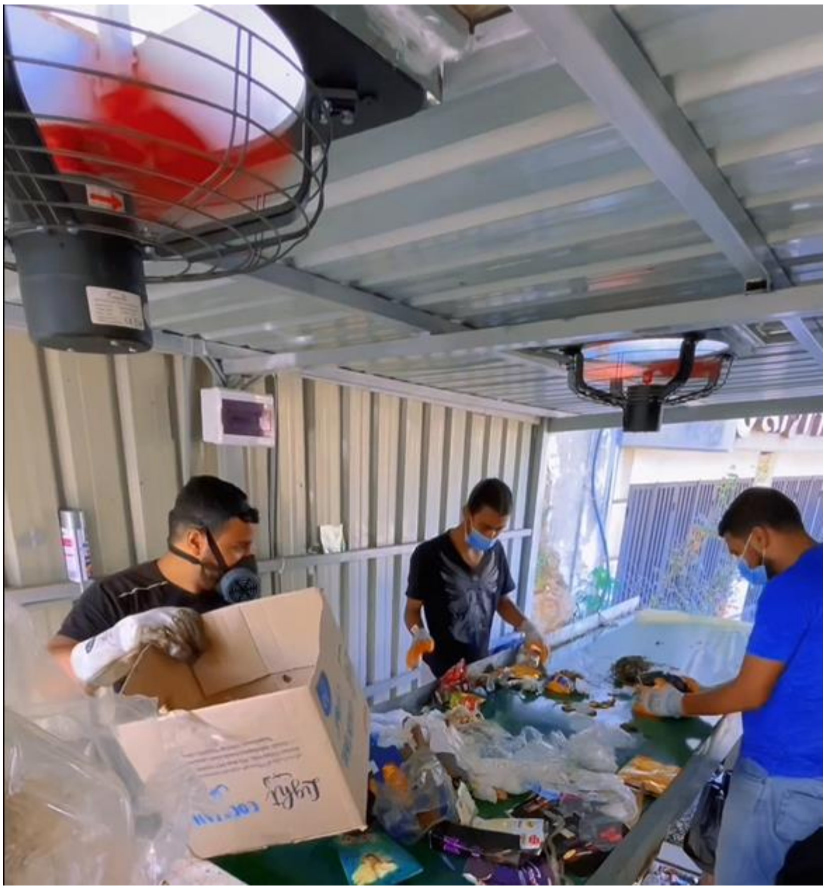
This report contains a short description of 3 parts (full) waste management pilot project.

1 Project 1: Full waste management pilot project (Summary)

1.1 Position Full waste management

The incineration results in Bkaa Sifrin showed the need to separate (and for efficiency also treatment) of organic waste to reduce the percentage of liquids in the waste. A household waste sorting project was proposed and designed in 2023, and the practical part was implemented in 2024.

1.2 Taking household waste from buildings and manual waste separation

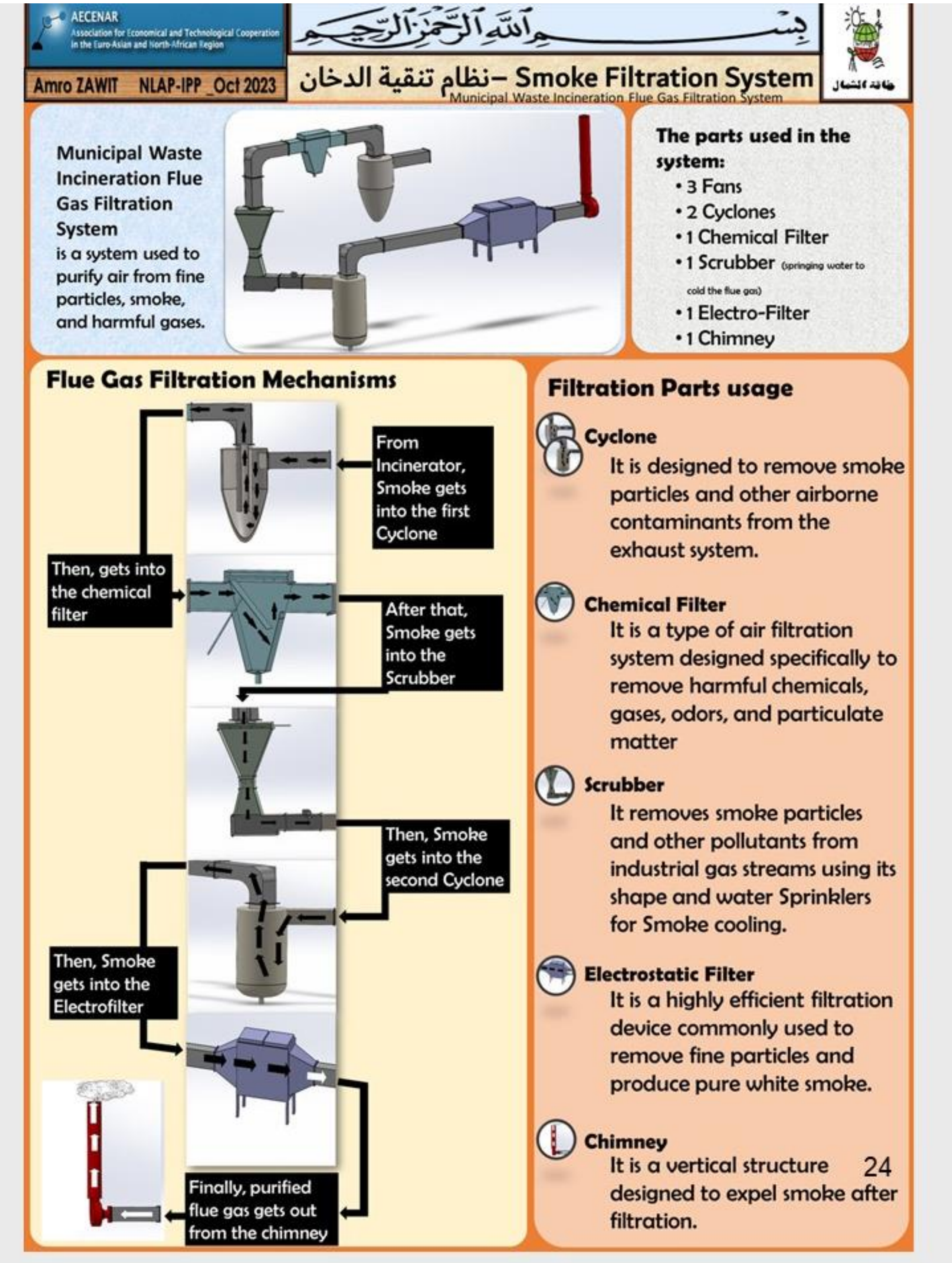


1.3 Organic waste treatment

Input of organic waste

Methan gas generation and filtering

1.4 Incineration of refused waste with improved filtering



<table>
<tr>
<td>



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Test from summer 2024
</td>
</tr>
<tr>
<td>Without efficient Electrofilter</td>
<td>With efficient Electrofilter</td>
</tr>
</table>

1.4.1 Geration of Electric Power from Waste Incinerator

1.5 Video of full (3 parts) waste management (with new Electrofilter) (in Arabic)

arab_3Steps_FullW
asteManagement_w

1.6 Video of full (3 parts) waste management (with new Electrofilter) (in English)

Flue Gas Cooling in front of the Electrofilter. Only 1% of smoke was visible: (integrated into 3steps waste management film from 2023 and improved with subtitles)

3Steps_FullWasteM
anagement_withSut

1.7 Petition to Municipality of Tripoli to operate the pilot system in Tripoli

بسم الله الرحمن الرحيم

طاقة الشمال
North Lebanon Alternative Power

AECENAR
TECDA
Association for Economical and Technological Cooperation in the Euro-Asian and North-African Region

جانب رئيس بلدية طرابلس الفيحاء الدكتور رياض يمق المحترم،

الموضوع: طلب تخصيص قطعة أرض مناسبة لعمل محطة معالجة النفايات.

المستدعي: جمعية AECENAR العلمية الألمانية ومؤسسة طاقة الشمال.

السلام عليكم ورحمة الله وبركاته وبعد،

1. تتقدم جمعية AECENAR العلمية الألمانية ومؤسسة طاقة الشمال ممثلتان برئيسيهما الدكتور سمير مراد من حضرتكم بطلب الحصول على ارض في منطقة بلدية طرابلس وذلك لمدة ستة أشهر قابلة للتجديد، بهدف استعمالها لتشغيل محطة معالجة النفايات لأغراض علمية.
2. يُفضَّل أن تكون مساحة الأرض تقريبا ألف متر مربع وتكون بعيدة نوعا ما عن الأماكن السكنية.
3. إن المحطة المذكورة ذات مواصفات مطابقة للبيئة حسب المعايير الأوروبية.
4. تتألف المحطة من ثلاثة أقسام: فرز ، تخمير ومعالجة حرارية.

نشكر لكم تعاونكم وتقبلوا منا فائق الاحترام.

طرابلس في 19 .11 .2024

د. سمير مراد

AECENAR
Harba Building, 1 st floor (near to Hospital Albert Haykal)
Tel.: 06409544 / 76341526
Email: info@aecenar.com

بسم الله الرحمن الرحيم

NLAP-WEDC REPORT 2024 – Part II: Project 2 (Improvement of Filter System in Incinerator Power Plant NLAP-IPP)

With contribution of:

Amro ZAWIT

Maryam EL REZ

Abdullah KASSEM

Ali DIB

Last Update: 11.03.2025 23:18

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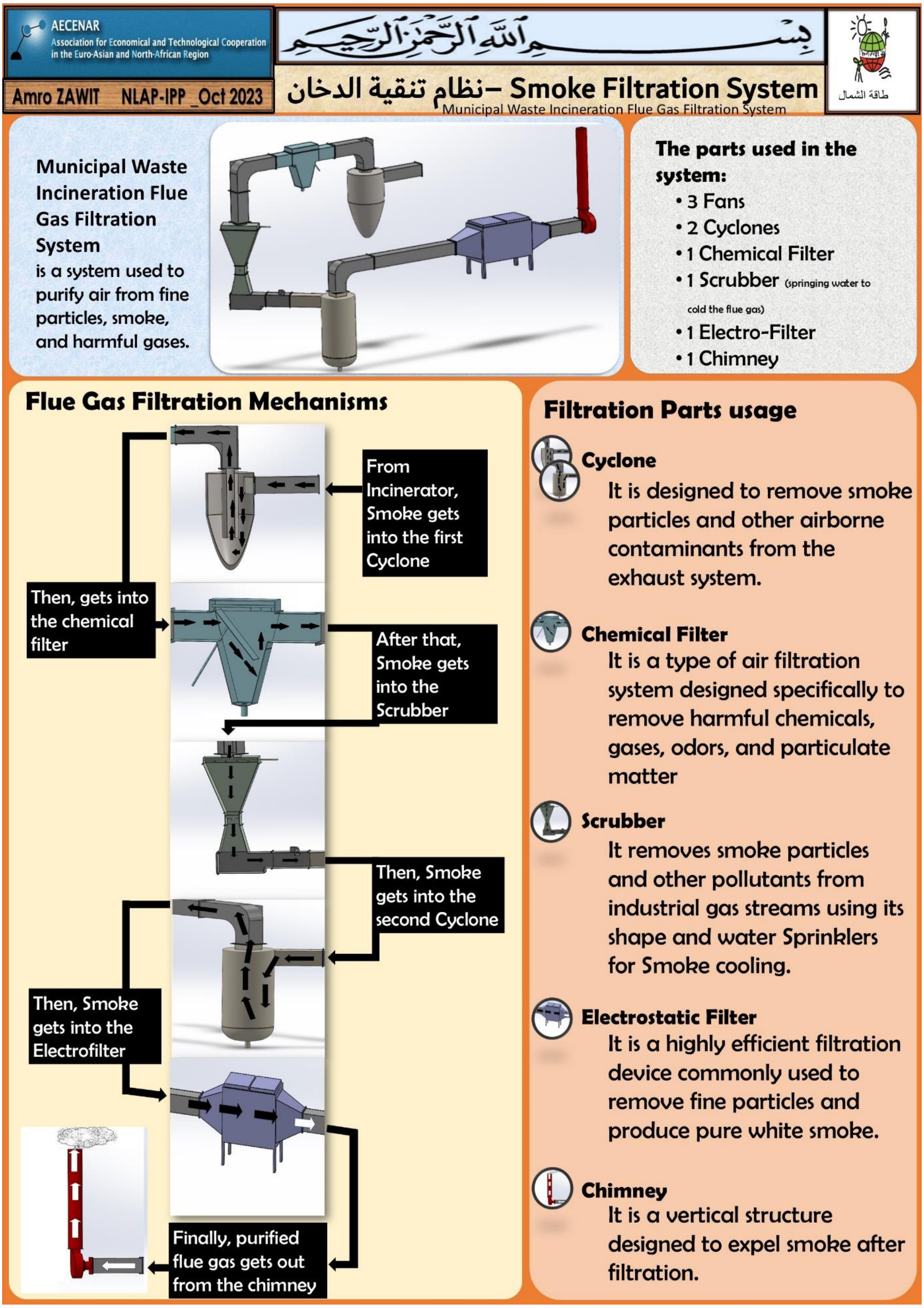
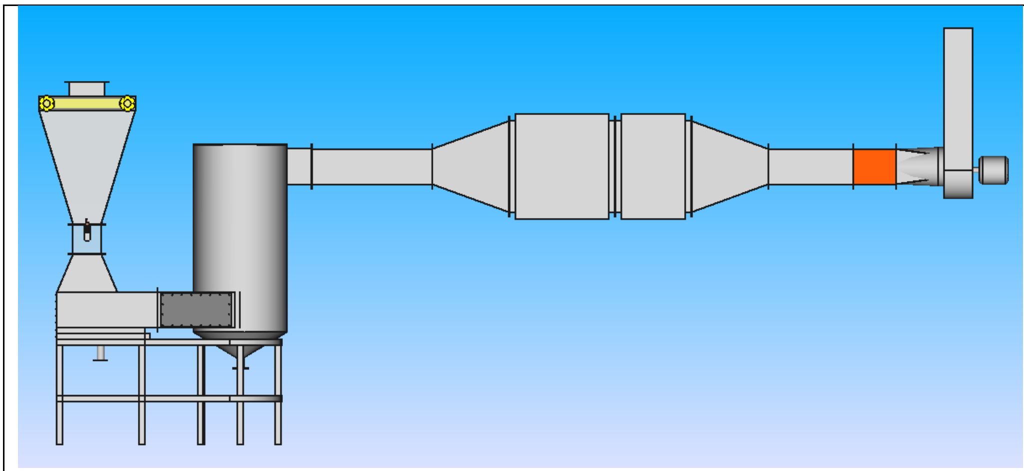
2 Project 2: Improvement of Filter System in Incinerator Power Plant 2023/24

2.1 Filter System Overview

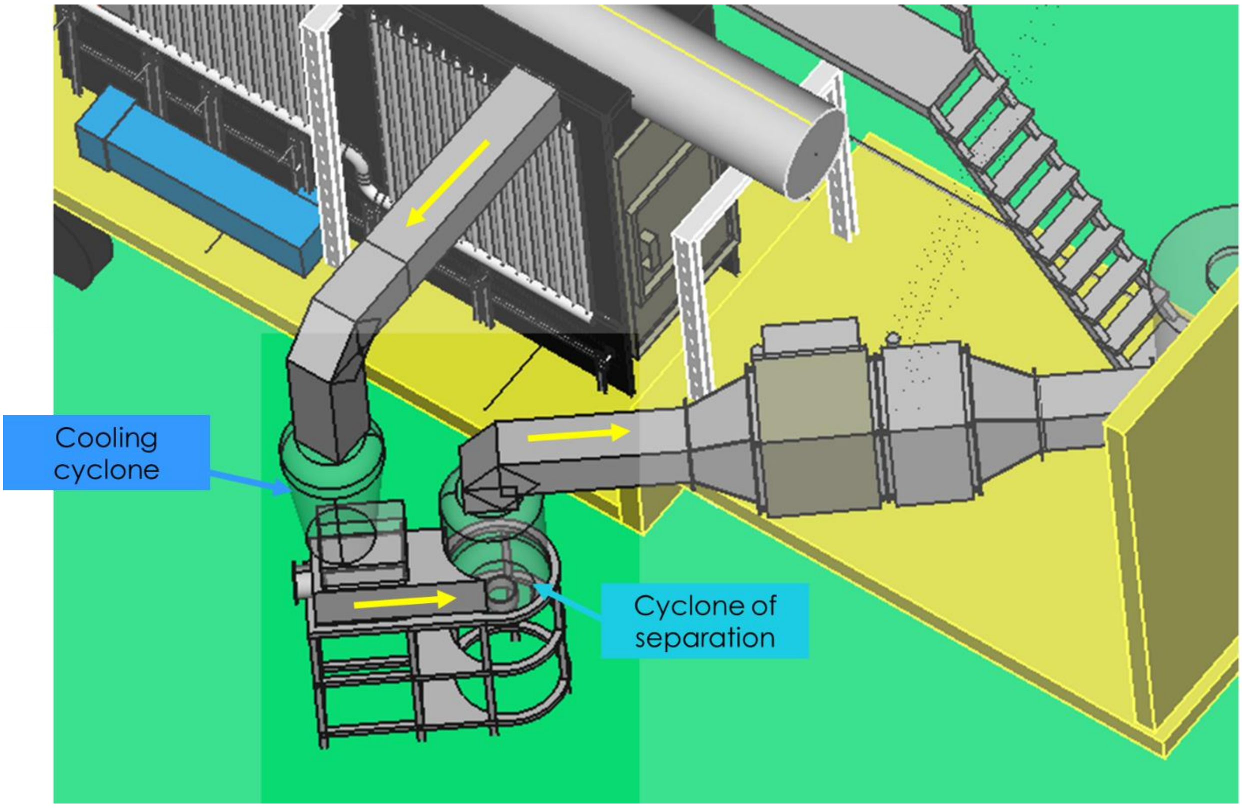


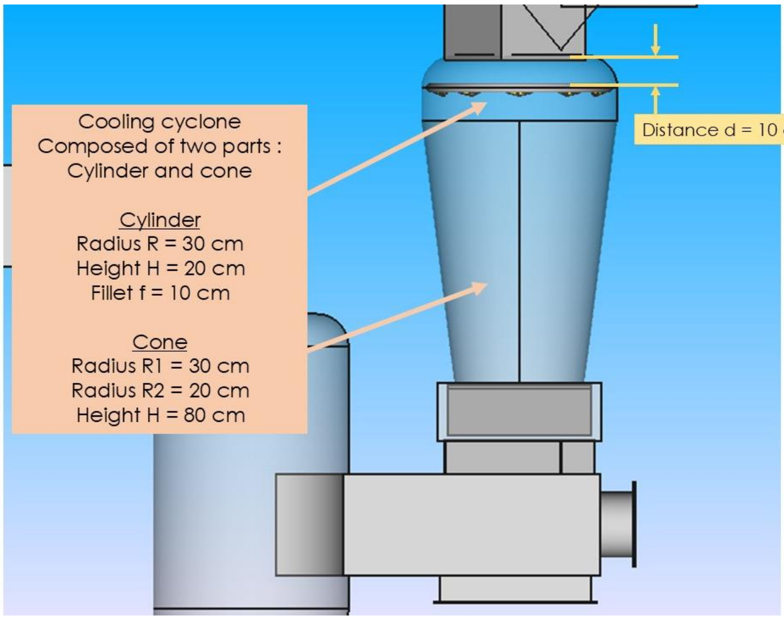
2.2 Assembly of Components

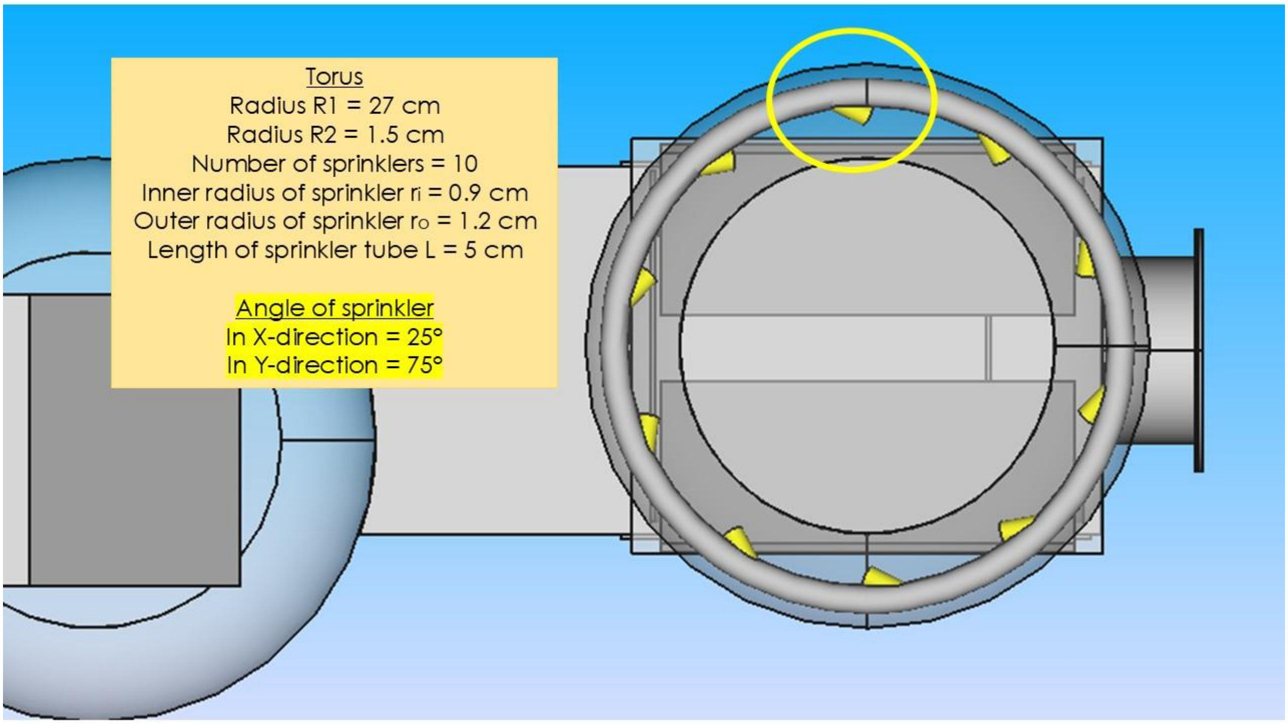
	26042023_cyclones, electrofilter,exhaust

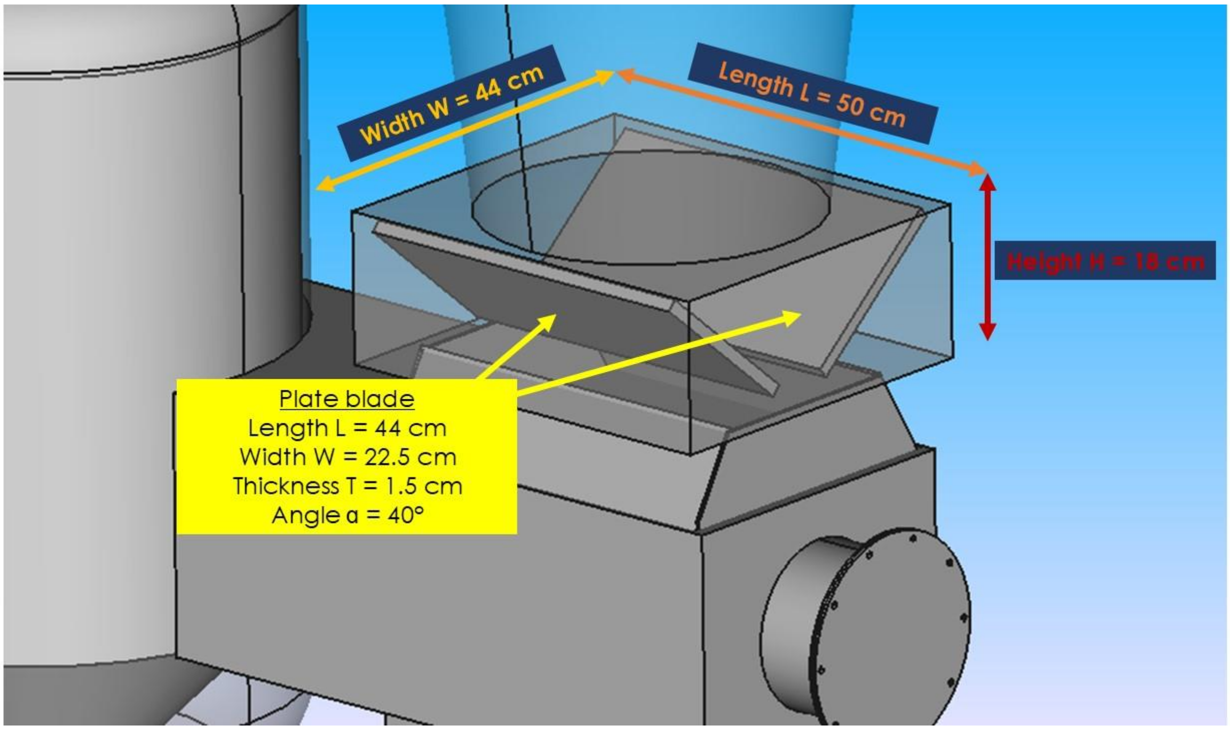
2.3 The 2 Cyclones

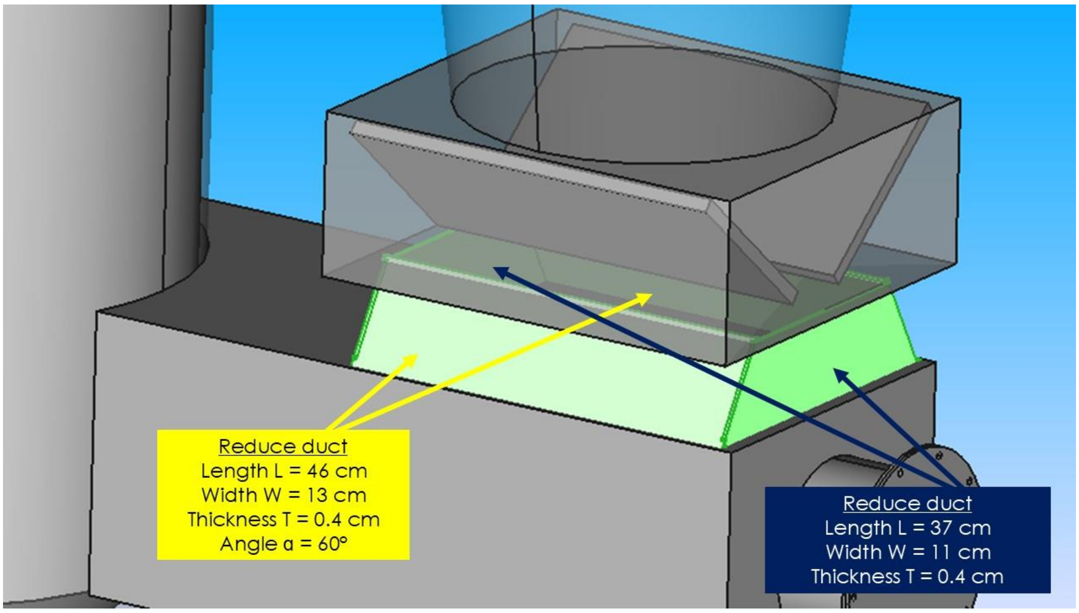
2.3.1 Cyclone Sizing

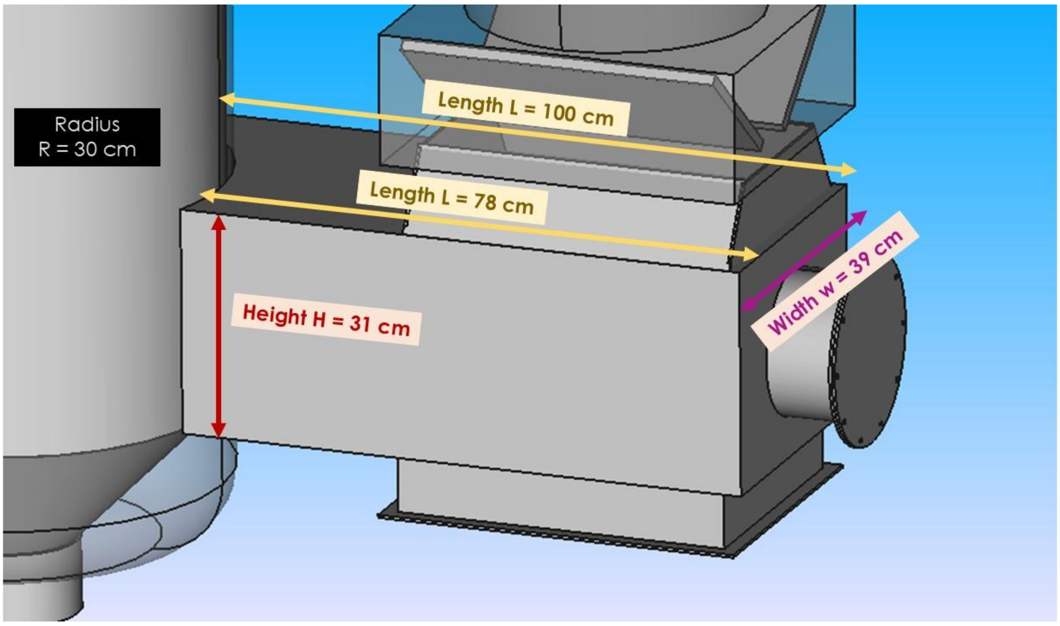


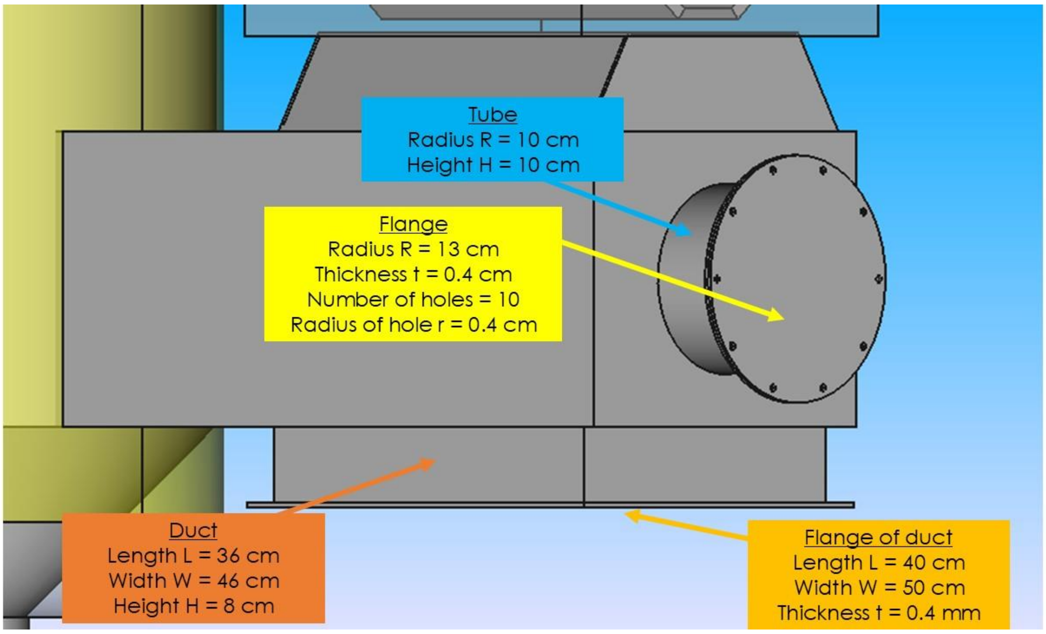

Cooling cyclone
Composed of two parts :
Cylinder and cone
Cylinder
Radius R = 30 cm
Height H = 20 cm
Fillet f = 10 cm
Cone
Radius R1 = 30 cm
Radius R2 = 20 cm
Height H = 80 cm
Distance d = 10 cm

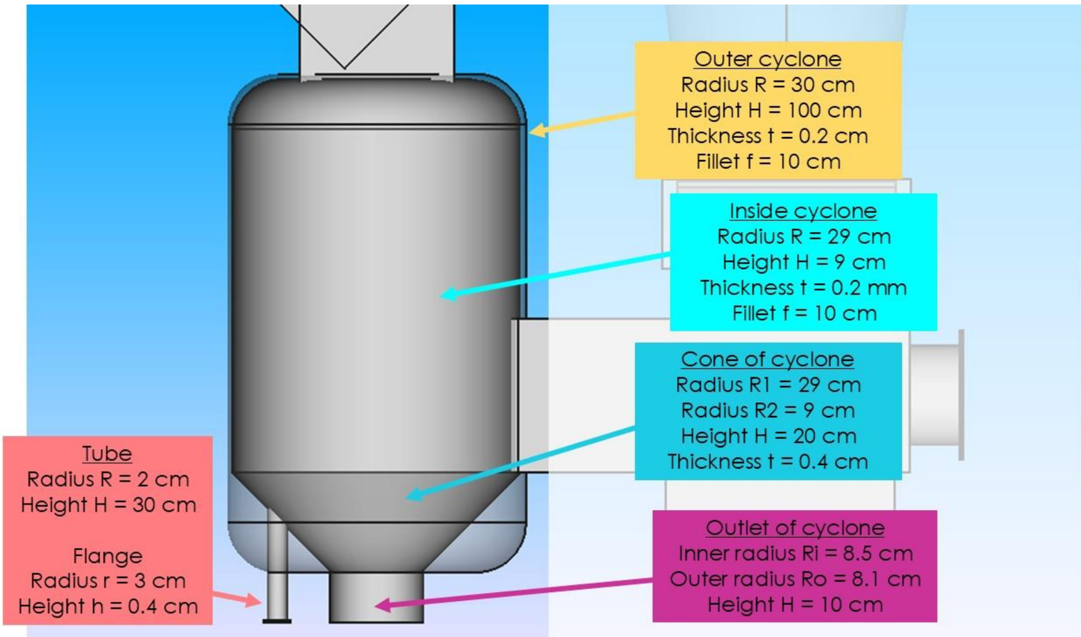

Torus
Radius R1 = 27 cm
Radius R2 = 1.5 cm
Number of sprinklers = 10
Inner radius of sprinkler ri = 0.9 cm
Outer radius of sprinkler ro = 1.2 cm
Length of sprinkler tube L = 5 cm
Angle of sprinkler
In X-direction = 25°
In Y-direction = 75°

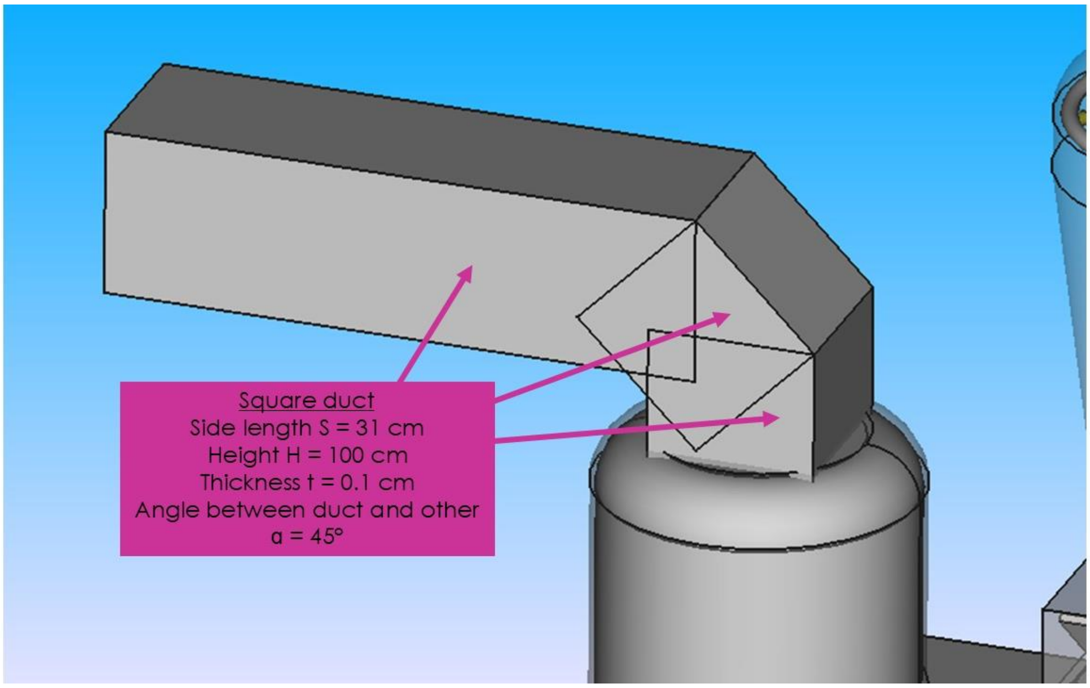

Width W = 44 cm
Length L = 50 cm
Height H = 18 cm
Plate blade
Length L = 44 cm
Width W = 22.5 cm
Thickness T = 1.5 cm
Angle α = 40°

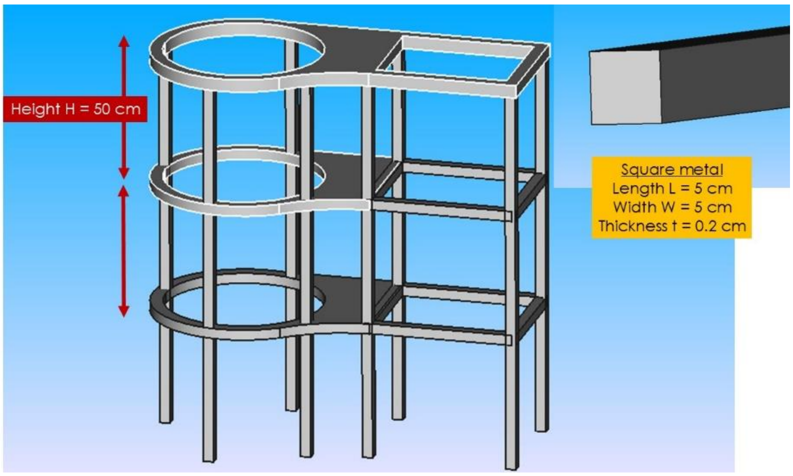

Reduce duct
Length L = 46 cm
Width W = 13 cm
Thickness T = 0.4 cm
Angle α = 60°
Reduce duct
Length L = 37 cm
Width W = 11 cm
Thickness T = 0.4 cm

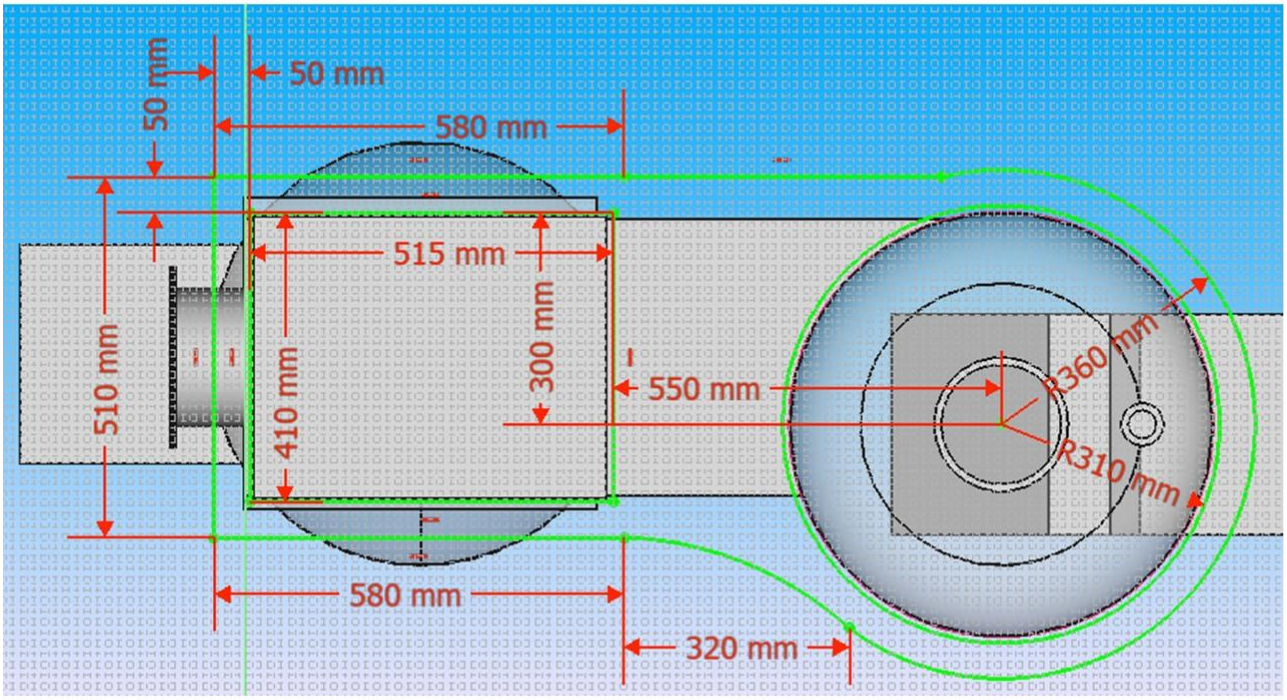

Radius
R = 30 cm
Length L = 100 cm
Length L = 78 cm
Height H = 31 cm
Width w = 39 cm

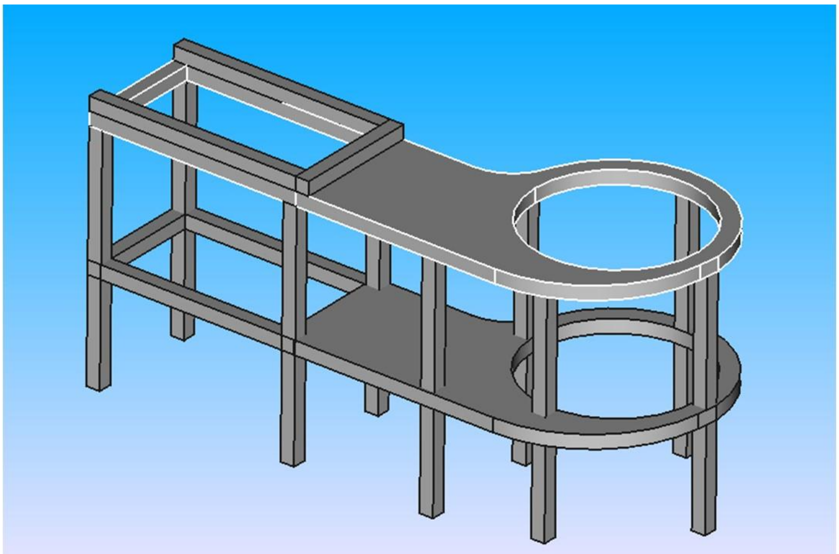

Tube
Radius R = 10 cm
Height H = 10 cm
Flange
Radius R = 13 cm
Thickness t = 0.4 cm
Number of holes = 10
Radius of hole r = 0.4 cm
Duct
Length L = 36 cm
Width W = 46 cm
Height H = 8 cm
Flange of duct
Length L = 40 cm
Width W = 50 cm
Thickness t = 0.4 mm

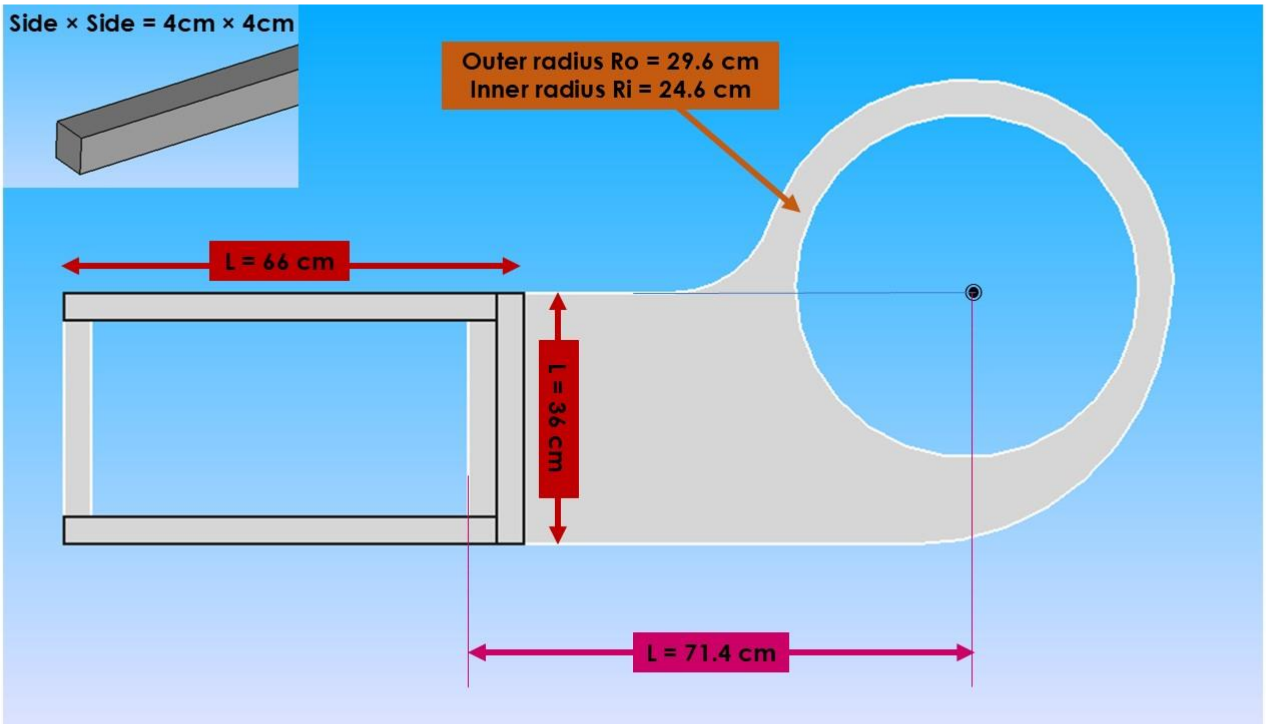

Outer cyclone
Radius R = 30 cm
Height H = 100 cm
Thickness t = 0.2 cm
Fillet f = 10 cm
Inside cyclone
Radius R = 29 cm
Height H = 9 cm
Thickness t = 0.2 mm
Fillet f = 10 cm
Cone of cyclone
Radius R1 = 29 cm
Radius R2 = 9 cm
Height H = 20 cm
Thickness t = 0.4 cm
Tube
Radius R = 2 cm
Height H = 30 cm
Flange
Radius r = 3 cm
Height h = 0.4 cm
Outlet of cyclone
Inner radius Ri = 8.5 cm
Outer radius Ro = 8.1 cm
Height H = 10 cm

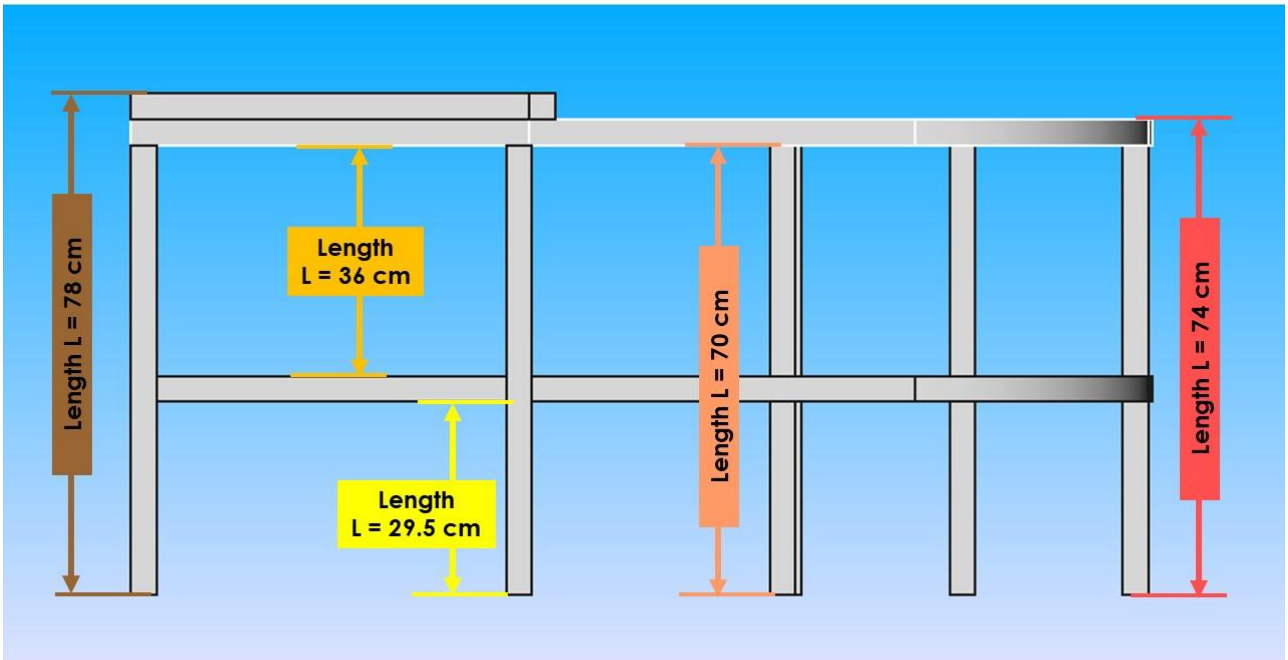

Square duct
Side length S = 31 cm
Height H = 100 cm
Thickness t = 0.1 cm
Angle between duct and other
α = 45°


Height H = 50 cm
Square metal
Length L = 5 cm
Width W = 5 cm
Thickness t = 0.2 cm


50 mm
50 mm
580 mm
515 mm
510 mm
410 mm
300 mm
550 mm
R360 mm
R310 mm
580 mm
320 mm



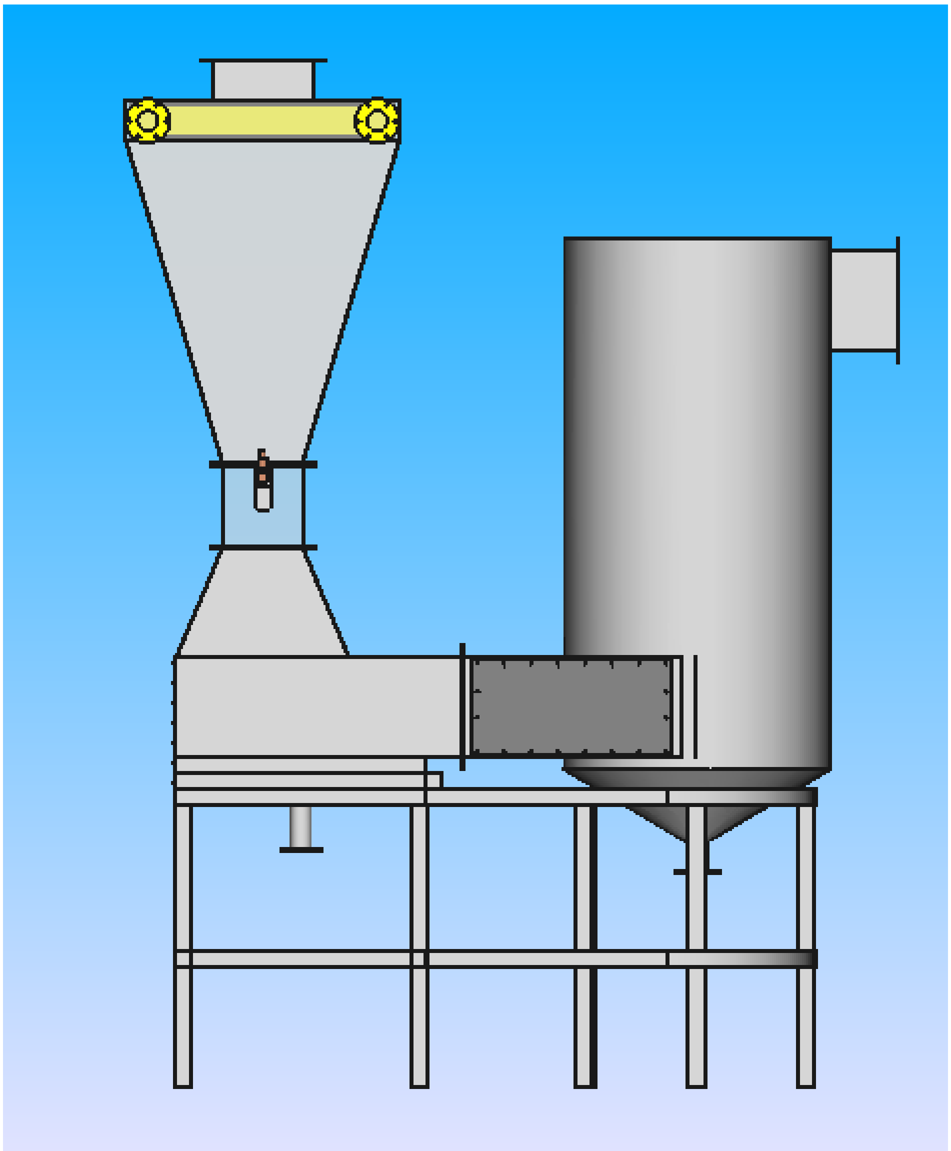




2.3.2 Design of cyclone

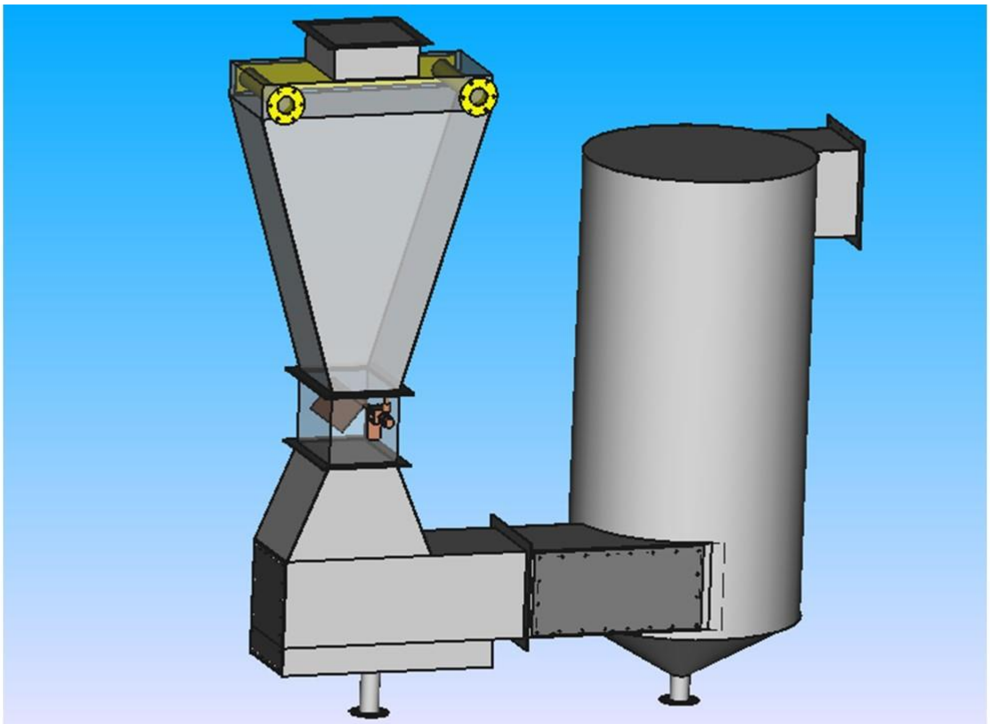
Separation cyclone with cooling venturi scrubber

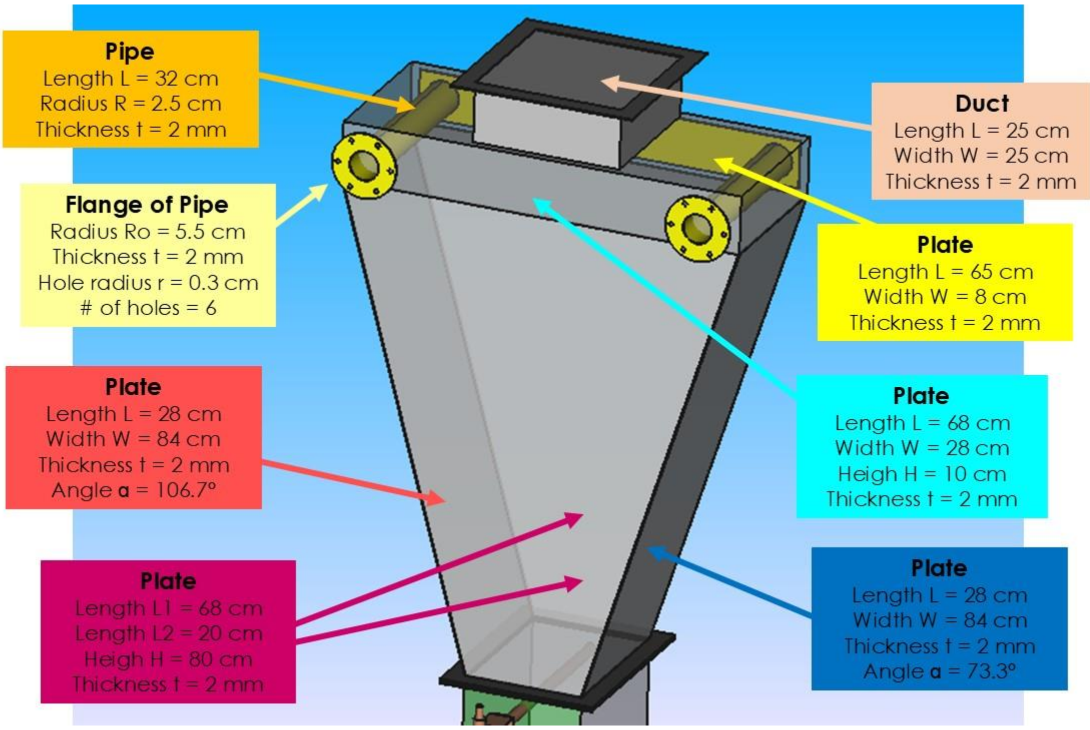
24042023_FINAL
CYCLONES DESIGN V



2.4 Venturi scrubber

2.4.1 Sizing of cooling with separation cyclone





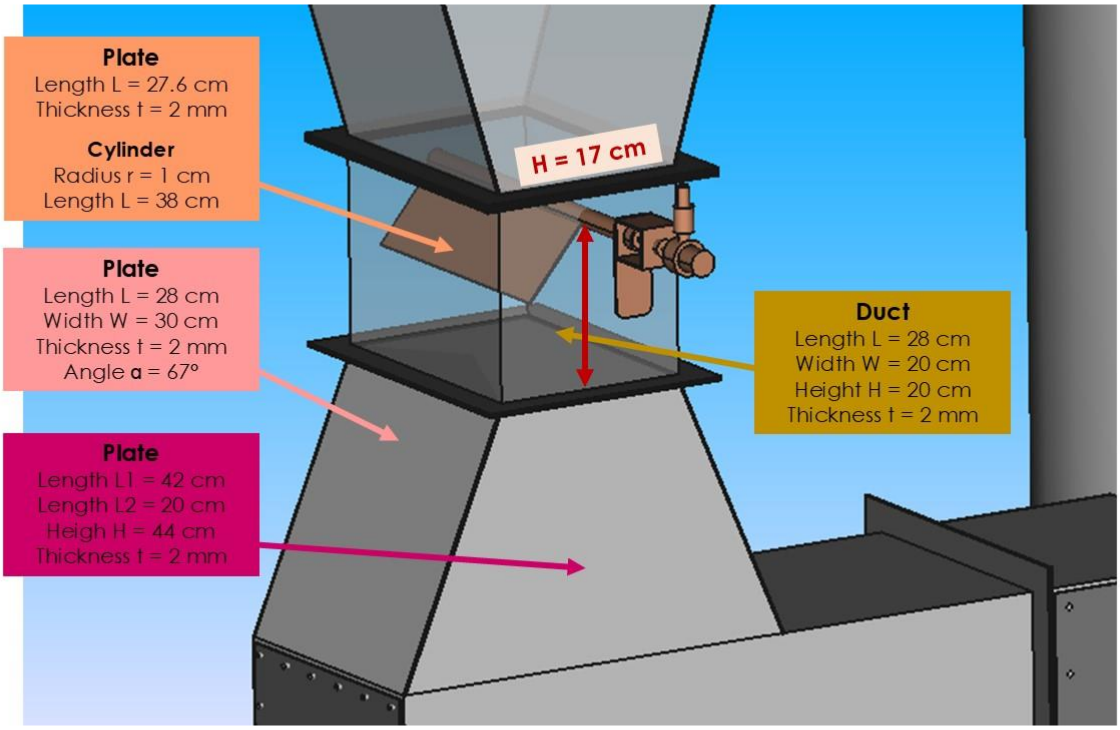
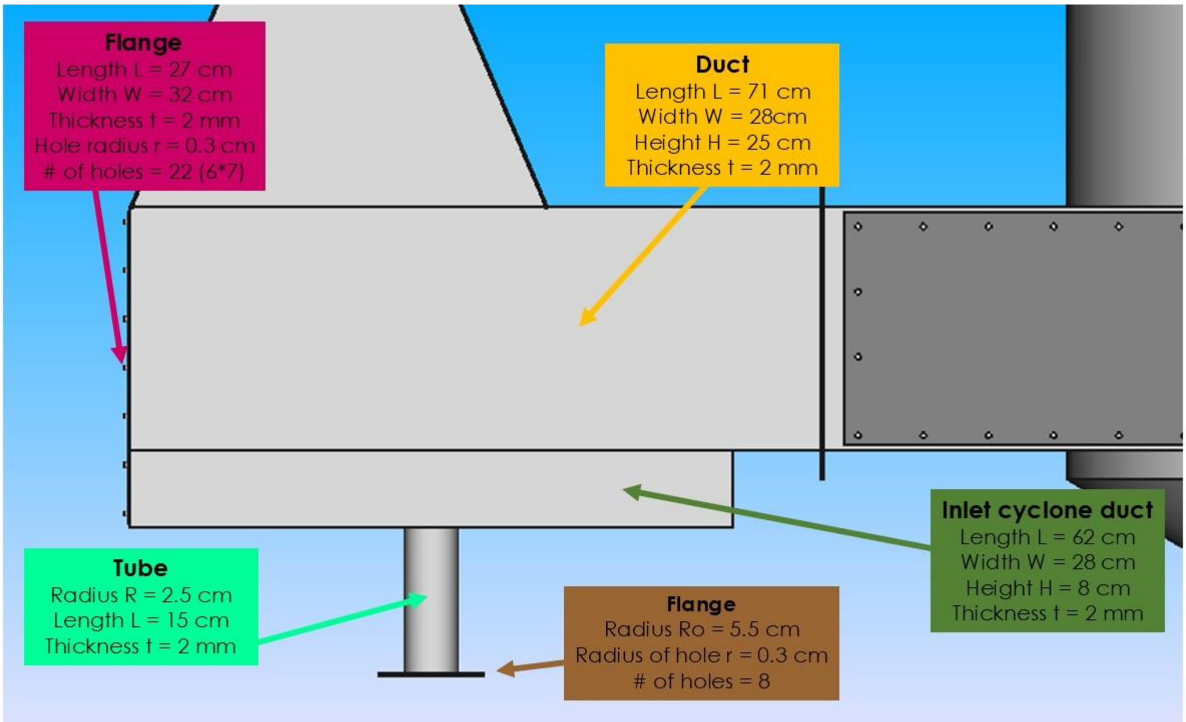
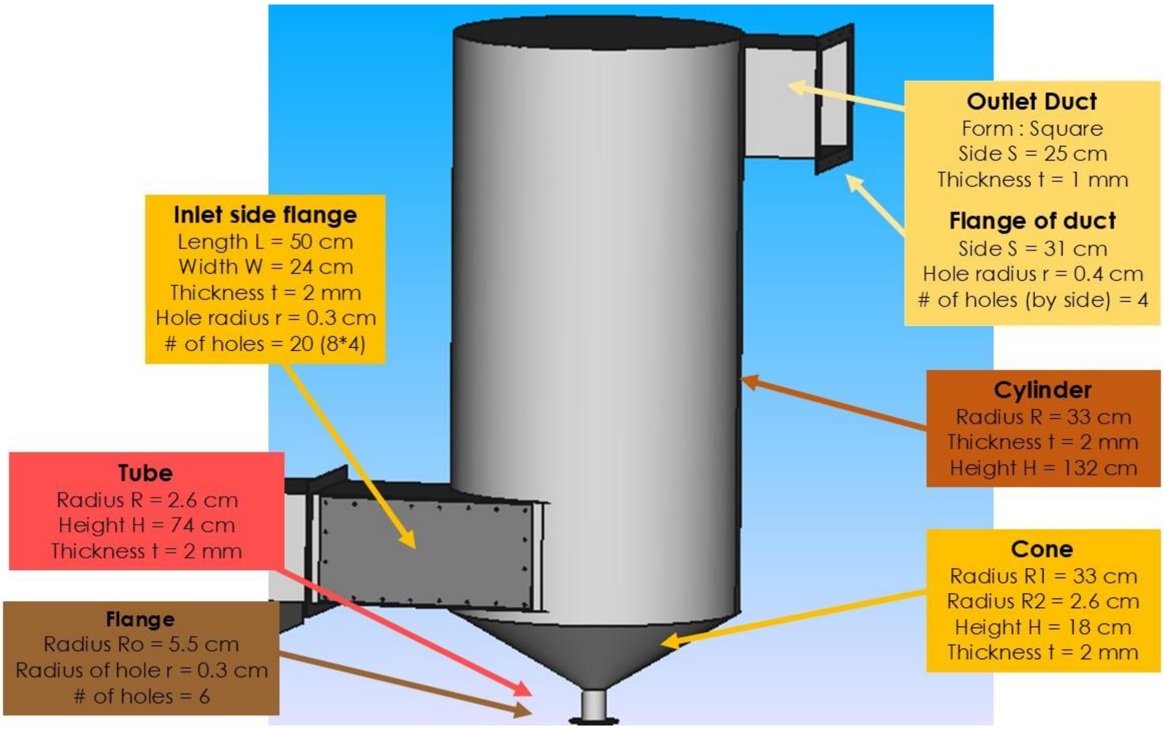
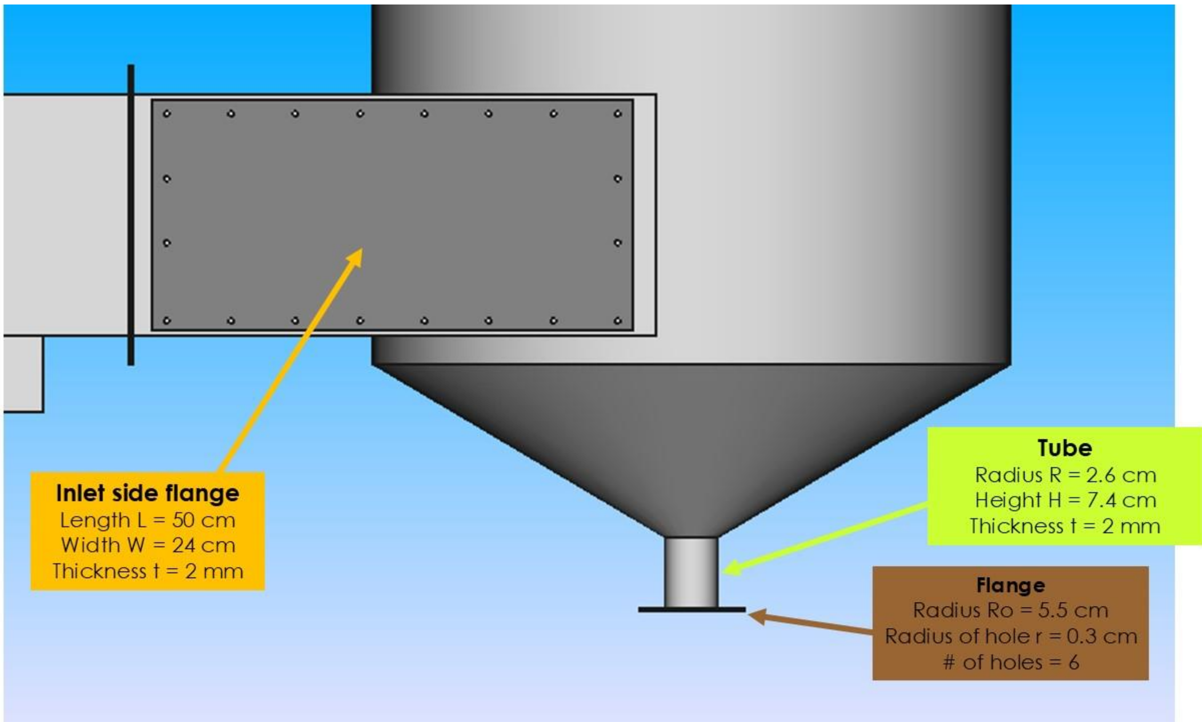
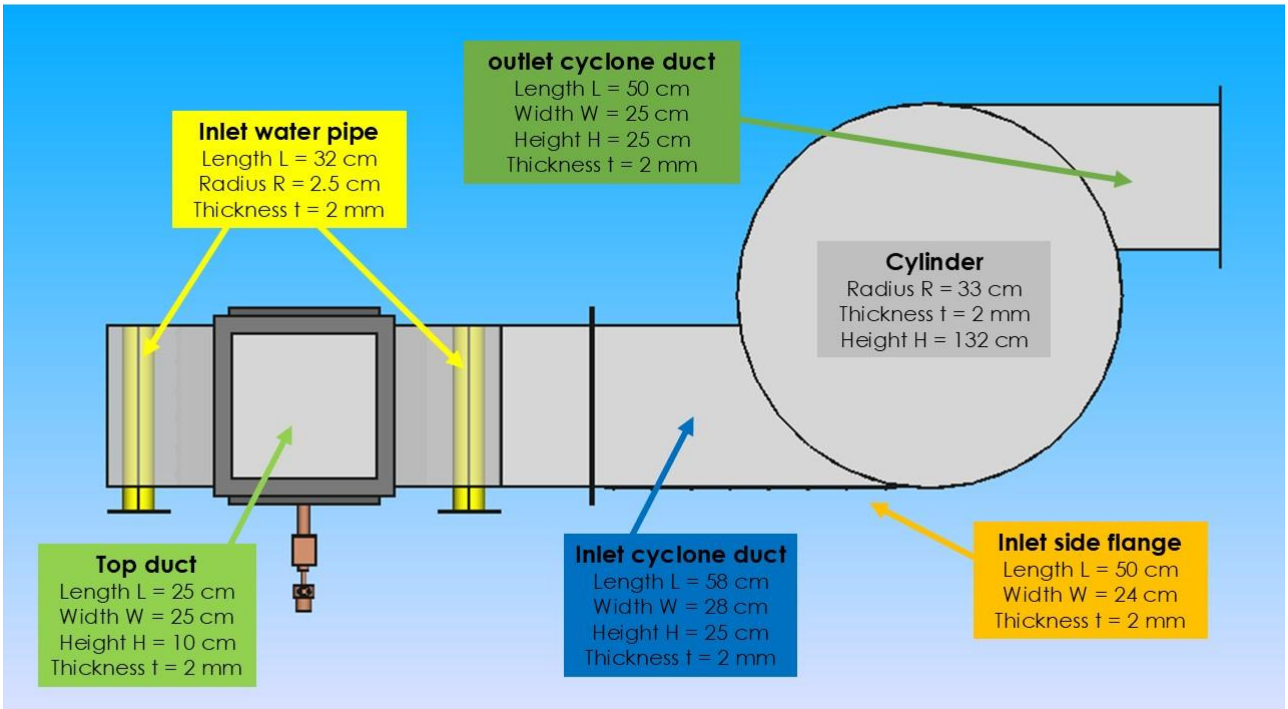


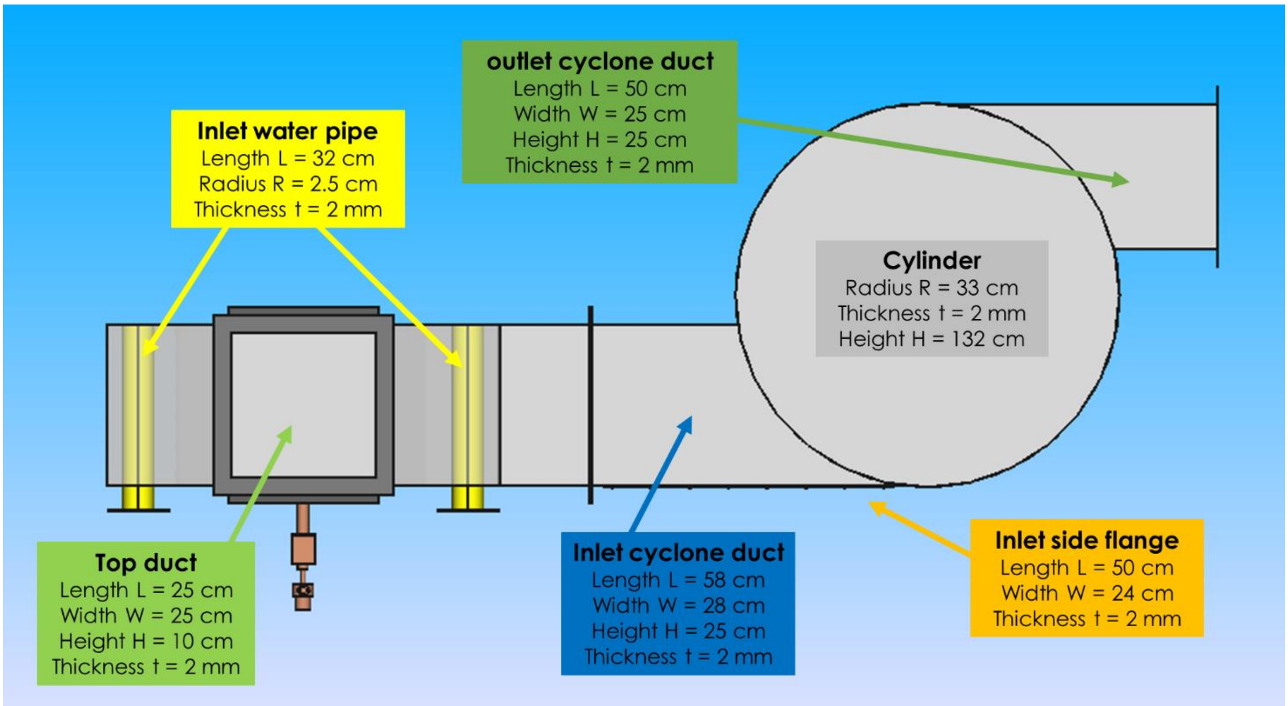
Plate
Length L = 27.6 cm
Thickness t = 2 mm
Cylinder
Radius r = 1 cm
Length L = 38 cm
H = 17 cm
Plate
Length L = 28 cm
Width W = 30 cm
Thickness t = 2 mm
Angle α = 67°
Duct
Length L = 28 cm
Width W = 20 cm
Height H = 20 cm
Thickness t = 2 mm
Plate
Length L1 = 42 cm
Length L2 = 20 cm
Heigh H = 44 cm
Thickness t = 2 mm


Flange
Length L = 27 cm
Width W = 32 cm
Thickness t = 2 mm
Hole radius r = 0.3 cm
# of holes = 22 (6*7)
Duct
Length L = 71 cm
Width W = 28cm
Height H = 25 cm
Thickness t = 2 mm
Inlet cyclone duct
Length L = 62 cm
Width W = 28 cm
Height H = 8 cm
Thickness t = 2 mm
Tube
Radius R = 2.5 cm
Length L = 15 cm
Thickness t = 2 mm
Flange
Radius Ro = 5.5 cm
Radius of hole r = 0.3 cm
# of holes = 8


Outlet Duct
Form : Square
Side S = 25 cm
Thickness t = 1 mm
Flange of duct
Side S = 31 cm
Hole radius r = 0.4 cm
# of holes (by side) = 4
Inlet side flange
Length L = 50 cm
Width W = 24 cm
Thickness t = 2 mm
Hole radius r = 0.3 cm
# of holes = 20 (8*4)
Cylinder
Radius R = 33 cm
Thickness t = 2 mm
Height H = 132 cm
Tube
Radius R = 2.6 cm
Height H = 74 cm
Thickness t = 2 mm
Cone
Radius R1 = 33 cm
Radius R2 = 2.6 cm
Height H = 18 cm
Thickness t = 2 mm
Flange
Radius Ro = 5.5 cm
Radius of hole r = 0.3 cm
# of holes = 6


Inlet side flange
Length L = 50 cm
Width W = 24 cm
Thickness t = 2 mm
Tube
Radius R = 2.6 cm
Height H = 7.4 cm
Thickness t = 2 mm
Flange
Radius Ro = 5.5 cm
Radius of hole r = 0.3 cm
# of holes = 6

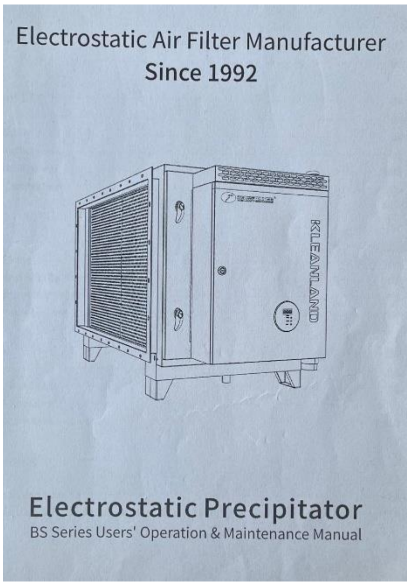




2.5 Atomizer nozzles for incinerator Exhaust gas cooling for Electro-Filter

In this section, we will talk about the atomizer nozzle with 6 holes and a wide-angle spray at 60 degrees with stainless steel materials.

The purpose of using this nozzle is that the Electrostatic filter that is being used in the filtration system needs a temperature of less than 60 degrees Celsius to perform at its best conditions

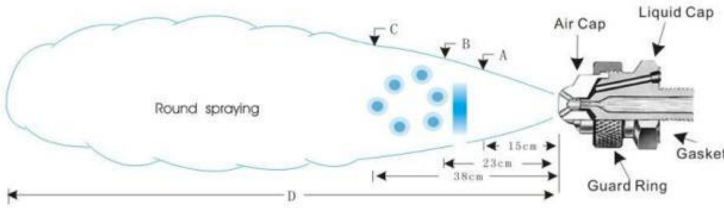


This is the Requirements for the installation site

A. Temperature: +5~+50°C
B. Humidity: 20~90%
C. Altitude: <1000M
D. Nature of smoke: <60°C, non-flammable, non-explosive, non-volatile and
E. non- corrosive.

The Atomizing Nozzle uses pressured air and liquid to give the best performance, and this nozzle got the following table to get air-to-fluid ratio:

For round spray, the spray angle "A" is maintained within the distance of" B", the spraying will turn into torrent if the distance has reached "D". as the right chart



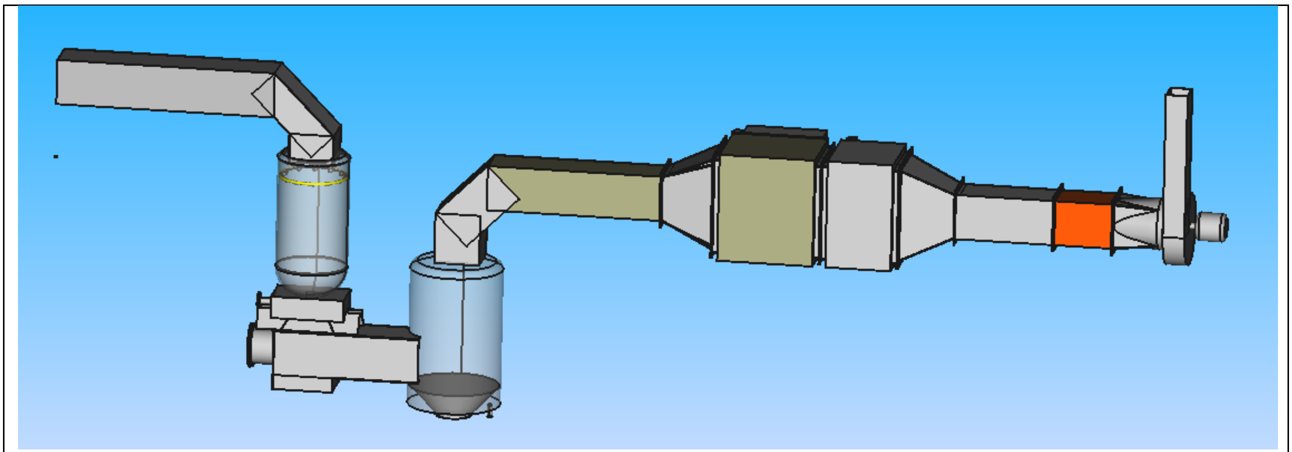
Wide-angle round spray

Performance date

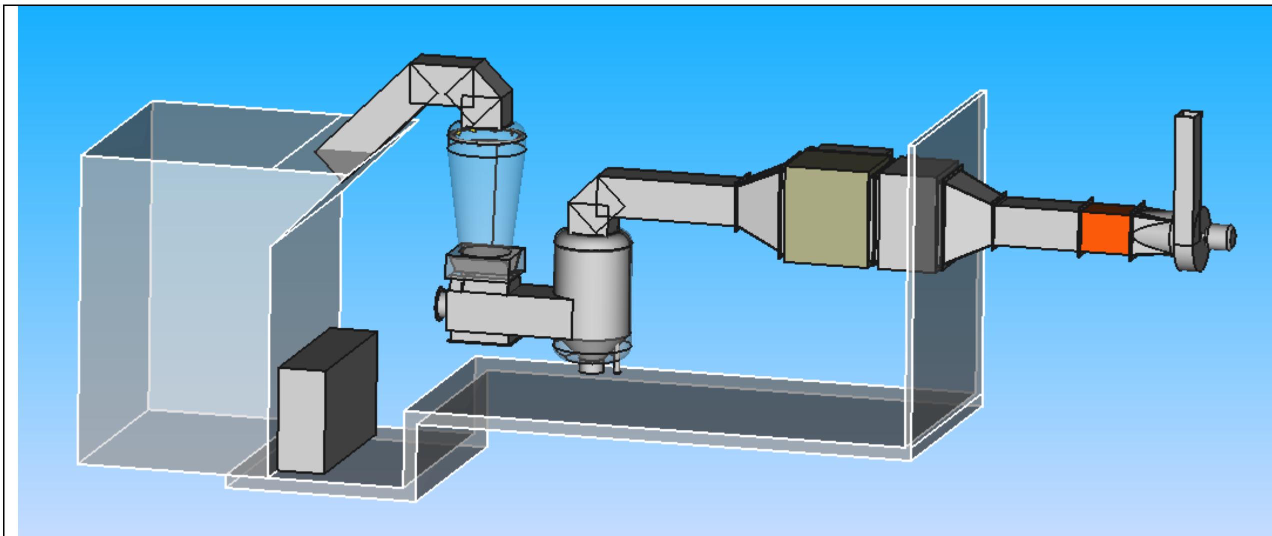
spray device model	spray device consists of air cap and fluid cap	liquid flow (L/min)and flow (L/min)															Size					
		Water pressure (bar)																				
		0.7bar			1.5bar			2bar			3bar			4bar								
		Air pressure (bar)	Water (L/h)	Air (L/min)	Air pressure (bar)	Water (L/h)	Air (L/min)	Air pressure (bar)	Water (L/h)	Air (L/min)	Air pressure (bar)	Water (L/h)	Air (L/min)	Air pressure (bar)	Water (L/h)	Air (L/min)	Air (bar)	Liquid (bar)	A (cm)	B (cm)	C (cm)	D (cm)
SUK16	Liquid C 2050 and Air Ca 67-6-20-7	0.6	5.3	10.2	1.1	6.1	13.3	1.5	8.1	16.4	2.4	8.9	22	3.1	10.5	24	0.7	0.7	14	18	23	1.5
		0.7	4.3	12.2	1.3	7.0	15.0	1.8	6.6	21	2.7	8.1	26	3.4	9.7	28	1.4	1.5	15	19	24	1.8
		.85	3.0	14.2	1.4	6.4	17.0	2.1	4.9	25	3.0	6.4	30	3.9	7.8	36	1.8	2.0	16	20	25	2.1
		.0	1.7	17.0	1.5	5.5	19.0	2.4	3.2	29	3.2	4.9	34	4.2	6.1	42	3.0	3.0	16	20	26	2.7
					1.7	4.5	22				3.4	4.2	37	4.6	4.4	47	3.9	4.0	19	23	30	4.0
					1.8	3.5	24				3.5	3.4	40	4.9	2.8	54						
SUK26B	Liquid Cap 60100 and Air Cap 140-6-37-70°	0.85	7.0	5.0	1.7	13.2	68	2.0	18.5	68	2.8	25	84	3.7	31	96						
		1.0	2.1	62	1.8	9.8	79	2.1	15.1	76	3.0	22	92	3.8	28	105	0.85	0.7	18	24	31	1.8
								2.2	11.7	85	3.1	18.5	101	3.9	26	113	1.7	1.5	19	25	33	2.4
											3.2	15.1	119	4.1	23	122	2.1	2.0	19	25	33	3.2
											3.4	12.1	130	4.2	20	130	3.2	3.0	20	26	26	4.1
											3.5	9.1	142	4.6	13.6	153	4.1	4.0	21	28	28	5.9
											3.7	6.1	65	4.9	6.8	183						
SUK26	Liquid Cap 60100 and Air Cap 140-6-37-70°	0.7	24	32	1.4	43	37	2.1	33	66	2.8	52	76	3.7	63	68					36	
		0.85	13.6	44	1.5	35	49	2.2	26	78	3.0	46	87	3.8	68	79	1.85	0.7	19	25	37	2.1
		1.0	7.6	57	1.7	28	61	2.4	18.9	89	3.1	39		3.9	52	101	1.5	1.5	20	27	37	3.2
					1.8	21	71	2.5	11.7	100	3.2	33	99	4.2	41	111	2.4	2.0	20	27	38	4.1
											3.4	26	110	4.6	27	138	3.2	3.0	20	28	38	5.0
											3.5	19.5	122	4.9	15.9	166	3.9	4.0	20	28	39	6.8
											3.7	13.2	133									
SUK29	Liquid Cap 60100 and Air Cap 140-6-52-70°	1.3	36	85	2.1	57	116	3.1	53	156	4.2	64	197	5.6	74	245						
		1.5	29	102	2.4	51	130	3.2	50	163	4.9	51	230	6.0	68	260	2.0	0.7	20	25	33	5.5
		1.8	23	117	2.7	45	143	3.4	47	170	5.6	40	265	6.3	62	280	3.0	1.5	20	27	34	6.4
		2.0	19.7	125	3.0	39	157	3.5	45	177	6.0	34	285	6.7	56	295	3.9	2.0	22	28	37	8.2
		2.1	16.7	133	3.2	33	170	3.9	38	194	6.3	28	300	7.0	51	315	6.0	3.0	23	29	38	9.1
		2.3	14.0	142	3.5	28	185	4.6	25	230	6.7	22	320				6.3	4.0	24	32	41	10.4
		2.4	11.4	149	4.2	13.6	220	4.9	18.5	245	7.0	17.8	335									
SUK30	Liquid Cap 40100 and Air Cap 120-6-35-60°	1.1	12.3	40	2.2	16.3	62	2.7	21	69	4.2	19.3	100	5.6	22	130						
		1.3	9.9	45	2.5	12.1	71	3.0	16.3	78	4.6	14.6	113	6.0	17.6	142	1.5	0.7	15	19	23	2.7
		1.4	7.9	50	2.8	8.9	79	3.2	12.3	86	4.9	10.8	124	6.3	14.0	152	3.0	1.5	16	20	24	4.6
		1.5	6.1	54	3.0	7.6	83	3.4	10.7	91	5.3	8.1	135	6.7	11.4	163	3.4	2.0	16	20	24	5.5
		1.7	4.9	58	3.1	6.4	87	3.5	9.3	94	5.6	6.2	146	7.0	9.1	174	5.3	3.0	18	22	25	7.3
		1.8	3.9	62	3.2	5.5	91	3.9	6.4	105	6.0	4.9	157				6.3	4.0	19	24	30	9.4
		2.0	3.1	67	3.4	4.7	95	4.2	4.7	115	6.3	4.0	167									
SUK46	Liquid Cap 100150 and Air Cap 189-6-62-70°	1.7	25	156	3.0	39	230	3.4	50	250	4.6	62	320	6.0	93	395	2.0	0.7	24	33	46	5.5
		1.8	19.7	167	3.1	33	240	3.5	43	260	4.9	47	345	6.3	77	425	3.2	1.5	25	34	47	6.4
		2.0	15.1	178	3.2	27	255	3.7	41	275	5.3	36	375	6.7	62	460	3.9	2.0	28	37	51	7.3
		2.1	11.4	193	3.4	23	265	3.9	27	300	5.6	26	405	7.0	52	495	5.3	3.0	29	38	53	7.9
		2.3	7.6	205	3.5	18.5	280	4.1	23	310	6.0	18.9	435				6.3	4.0	33	42	58	9.8
					3.7	14.8	290	4.2	18.9	320	6.3	13.6	460									
								4.4	15.9	335												

This atomizing nozzle will be installed in the scrubber section for cooling, and it might use the same air compressor and water pump for each of the four nozzles.

2.6 Electrofilter



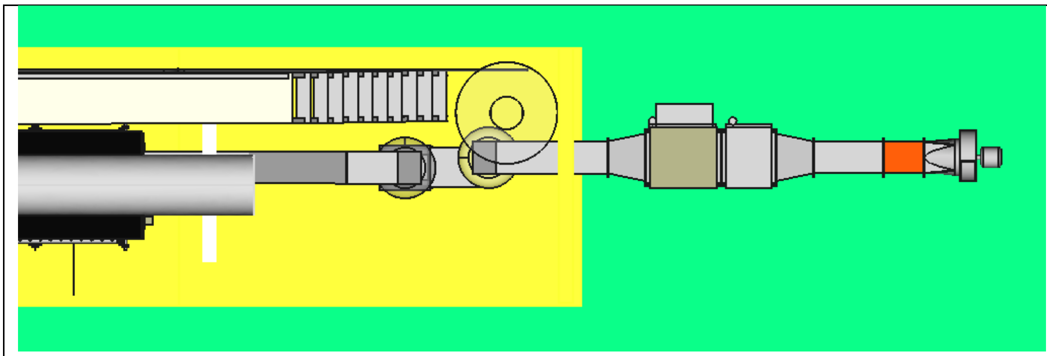
22032023_
electro-filter linear c



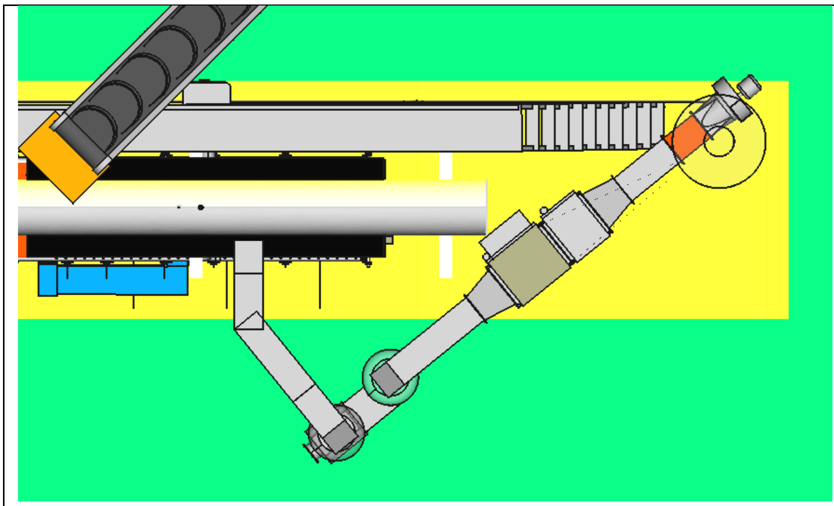
Electrofilter design -with stand_FreeCAD file: 24032023_ELECTRO FILTER - FINAL DESIC

2.6.1 Options of electro filter installation

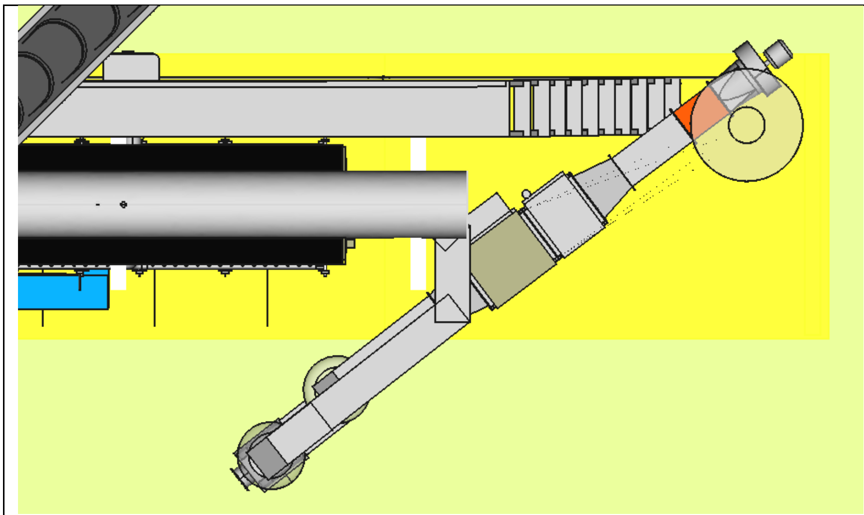
2.6.1.1 Electrofilter Option 1

	31032023_NLAP electrofilter -option

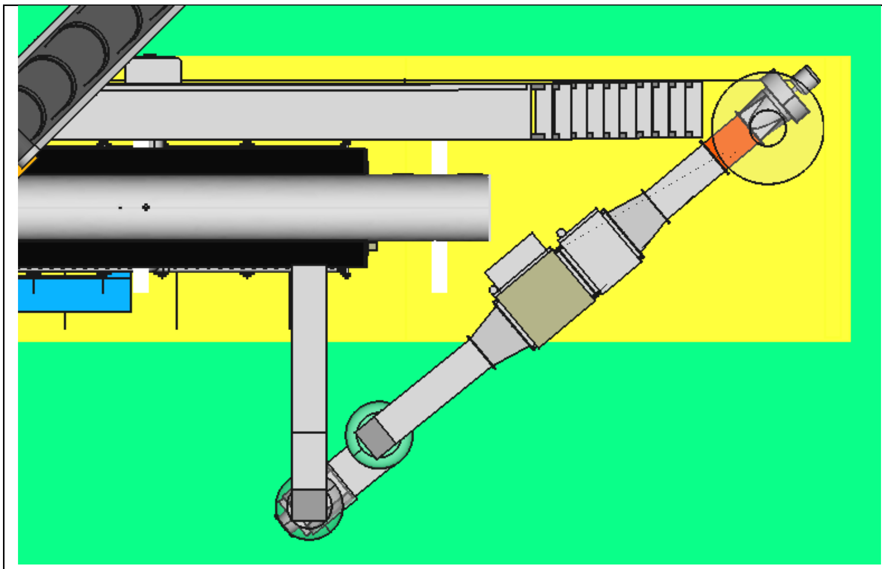
2.6.1.2 Electrofilter Option 2

	30032023_NLAP electrofilter -option

2.6.1.3 Electrofilter Option 3

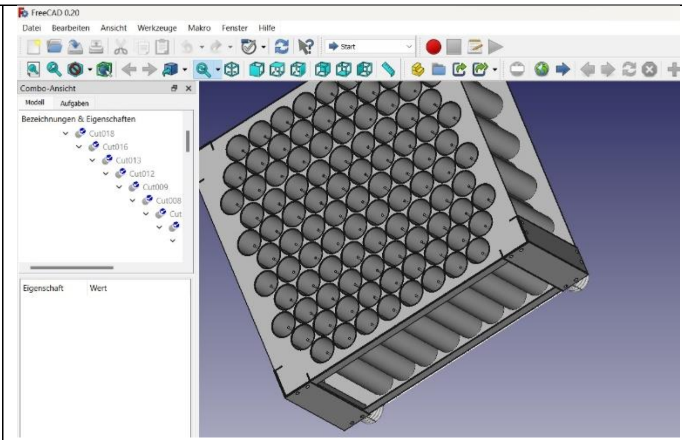
	03042023_NLAP electrofilter -option

2.6.1.4 Electrofilter Option 4

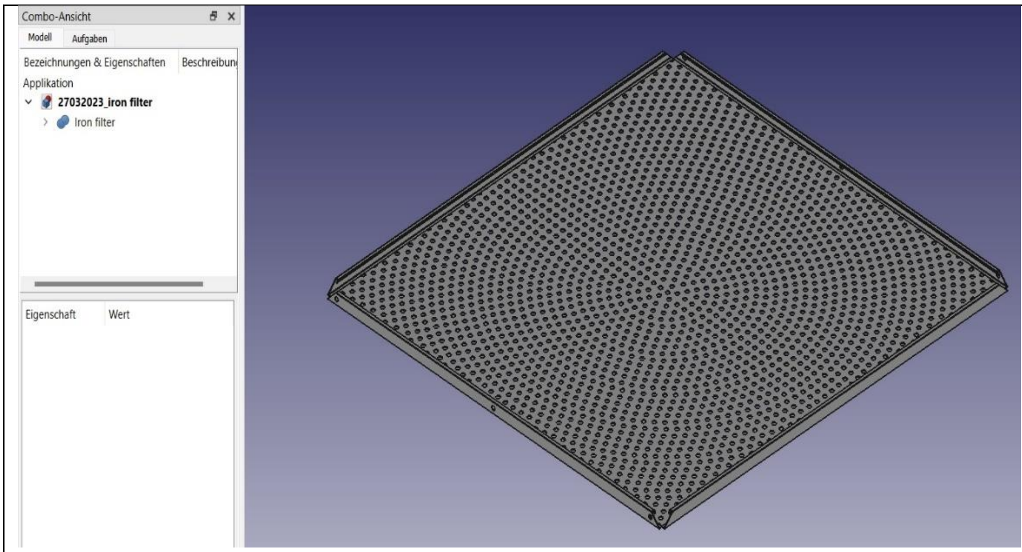
	03042023_NLAP electrofilter -option

2.7 Electrofilter Internal details

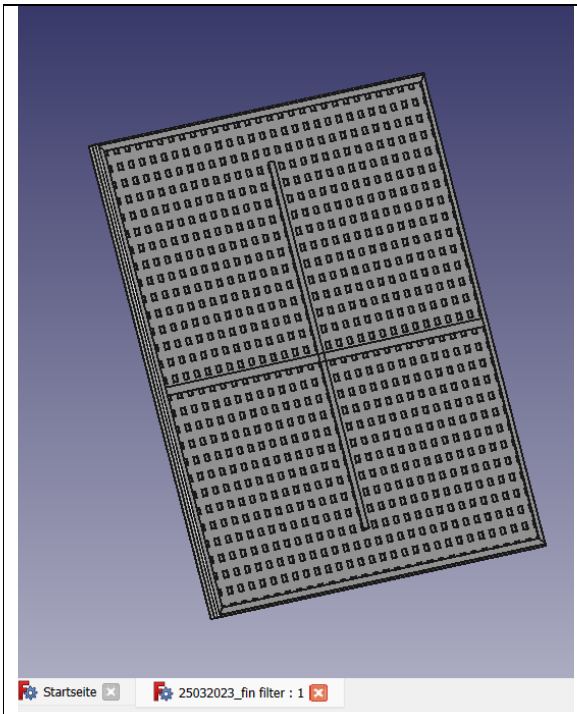
2.7.1 Electro design (tubes with central electrode)

		05042023_electro.FCStd

2.7.2 Iron filter design

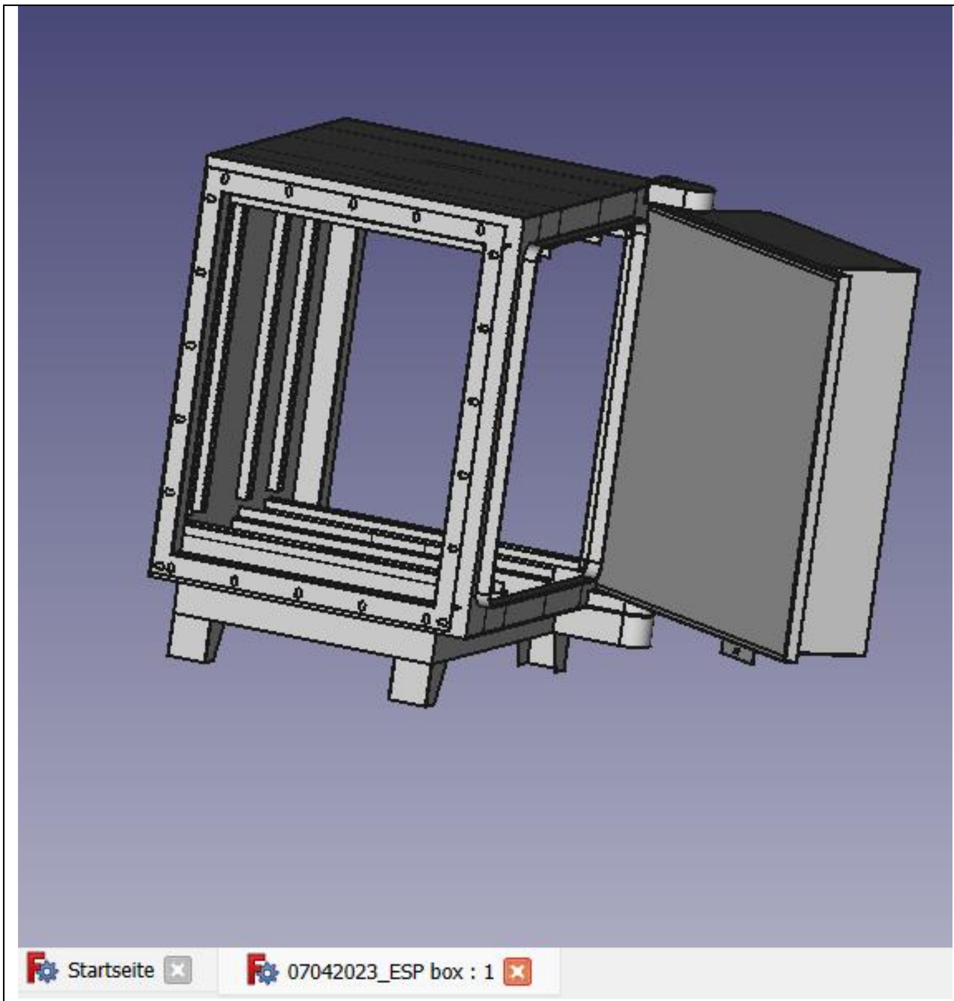
	27032023_iron filter.FCStd

2.7.3 Fin filter design

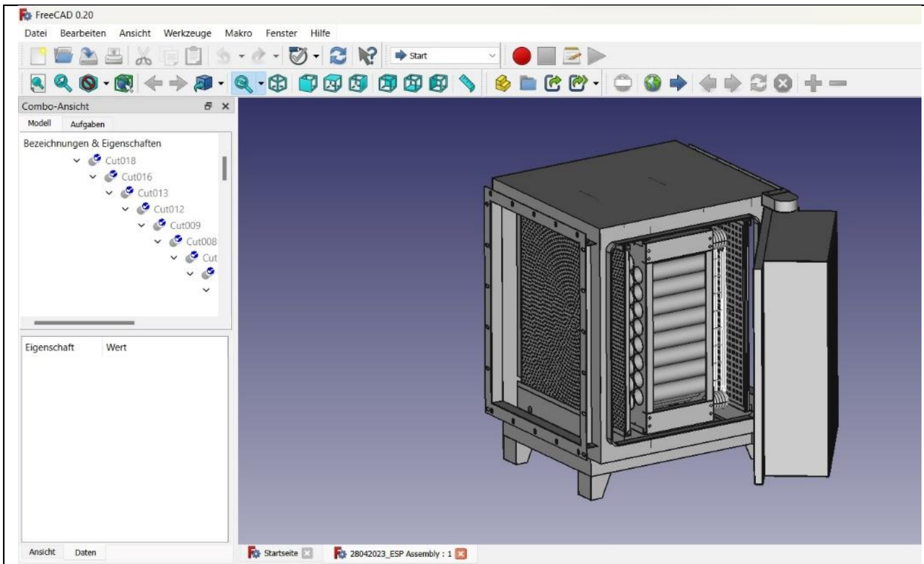


25032023_fin filter.FCStd

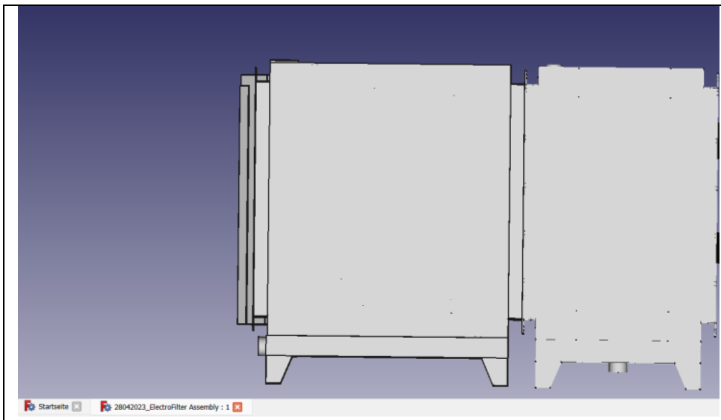
2.7.4 ESP box design

	07042023_ESP box.FCStd

2.7.5 ESP assembly design

	28042023_ESP Assembly.FCStd

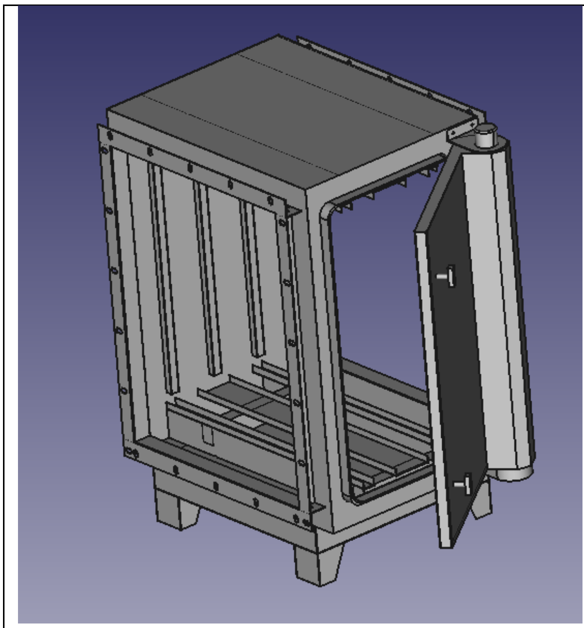
2.7.6 Electro-Filter Assembly design



28042023_ElectroFilter Assembly.FCStd

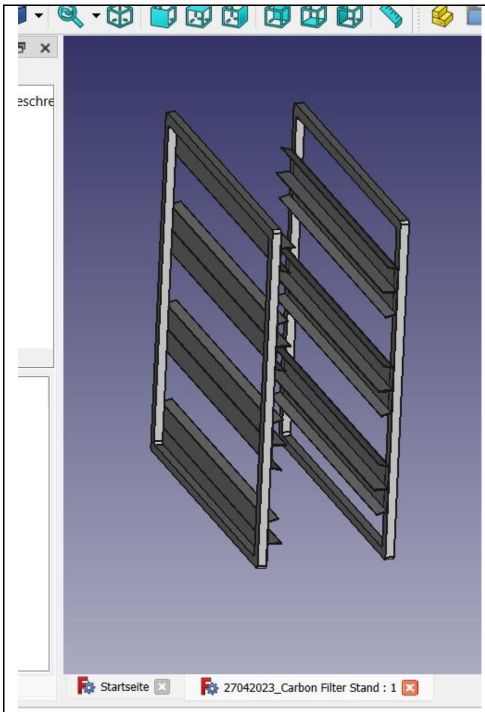
2.8 Carbon Filter

2.8.1 Carbon filter box design



10042023_Carbon Box.FCStd

2.8.2 Carbon filter stand design

	27042023_Carbon Filter Stand.FCStd

2.8.3 Carbon filter design

11042023_Carbon filter.FCStd

2.8.4 Carbon assembly design

2.9 NLAP-IPP Chemical Filter (Realization)

Chemical filter Testing the new Sprinklers and the pumps Video:

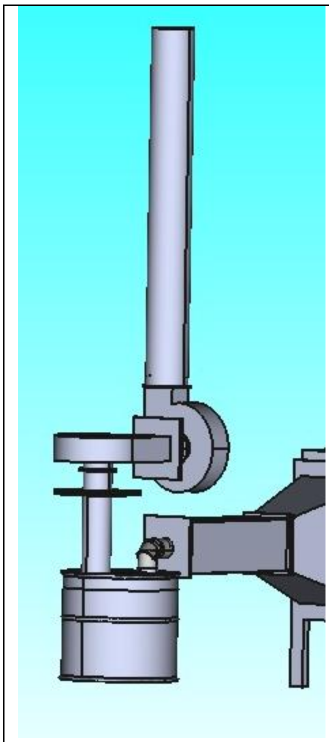
water pumps and
sprinklers.mp4

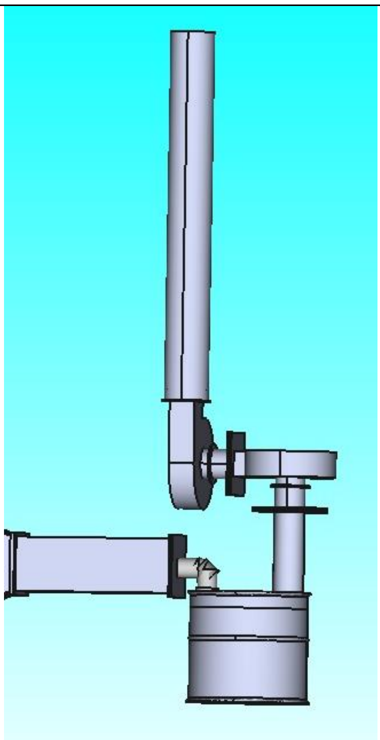
Chemical tanks filling and PH scale computing Video:

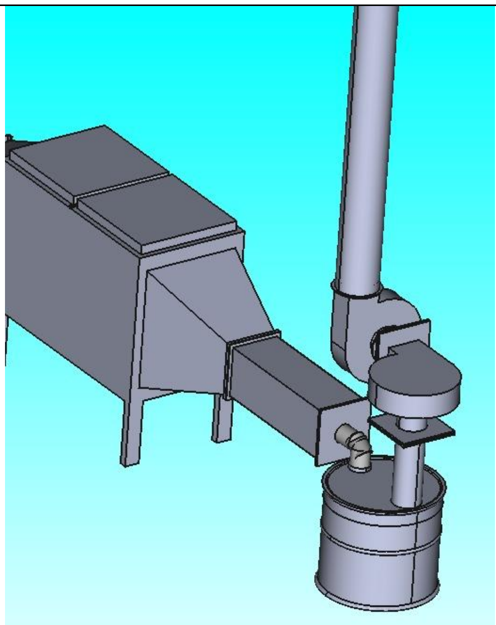
 pH = 12.24	chemical tank.mp4

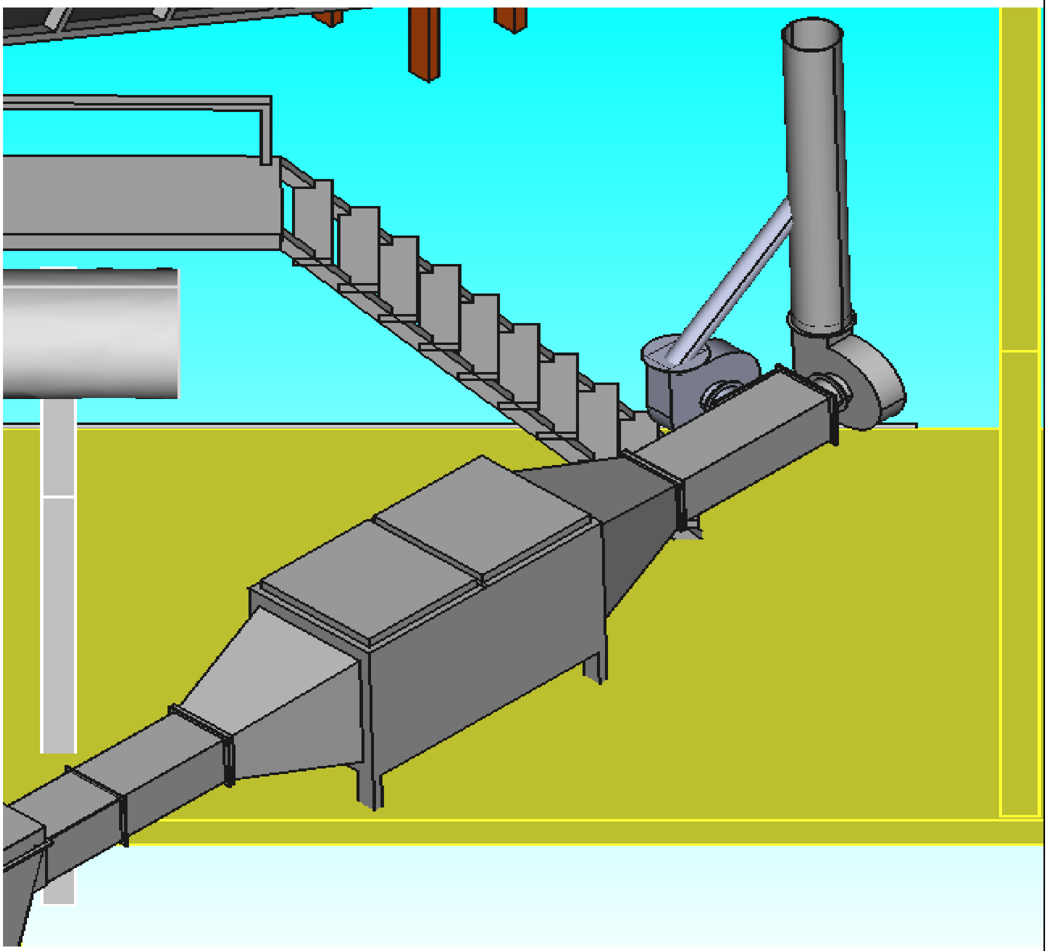
2.10 Barrel Water Filter

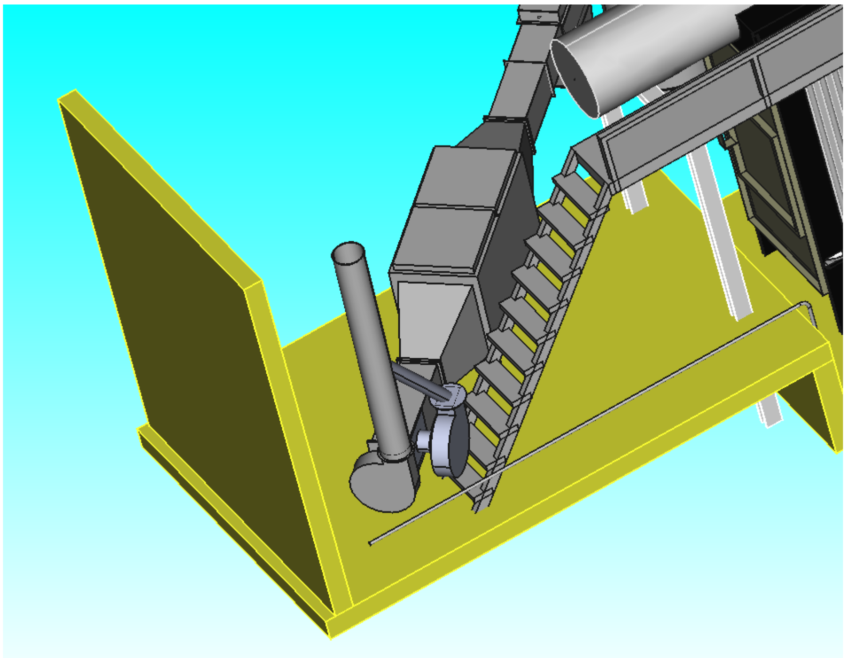
in front of flue gas outlet: flue gas flows through water (like argile) - 14.06.24











LAST UPDATE
01072024.FCStd

To address the challenge of filtering smoke particles from the air, we designed and implemented an innovative solution using a water-based filtration tank. The initial setup involved chaining the smoke through a tank filled with water, where the particles were effectively trapped and removed, resulting in cleaner, purified air.

This method leverages the principle of wet scrubbing, where contaminants are absorbed and neutralized by the liquid medium. Encouraged by the success of our initial prototype, which significantly reduced airborne particulates, we expanded our system by constructing an additional filtration tank.

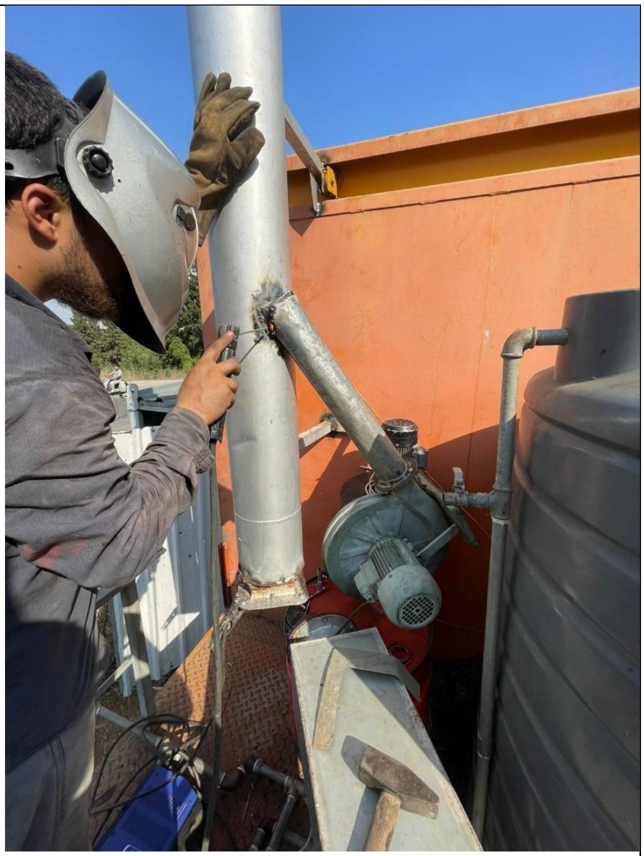
This second tank was crafted using a repurposed oil barrel, demonstrating both cost-efficiency and resourcefulness. By integrating this new unit into the existing setup, we enhanced the overall capacity and efficiency of the filtration process. The combined system now offers a robust solution for smoke particle filtration, with each stage contributing to improved air quality through successive layers of water-based particle trapping. Below are some pictures that illustrate our filtration system and its components

we found that it should be smaller to fit in our system

To further optimize the performance of our smoke filtration system, we installed two additional exhaust fans downstream of the oil barrel-based filtration tank.

These fans were strategically positioned to enhance the airflow through the entire system, ensuring a steady and robust flue. By increasing the air movement, the exhaust fans aid in pulling smoke more effectively through the water in the oil barrel filtration unit, thus maximizing the contact between smoke particles and the water.

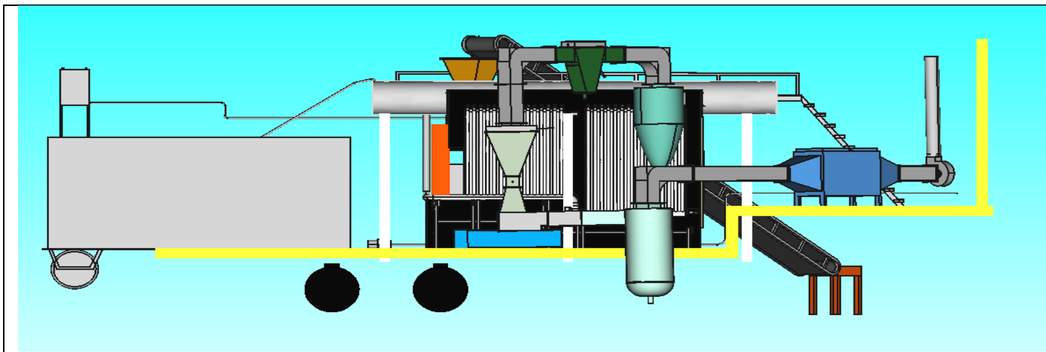
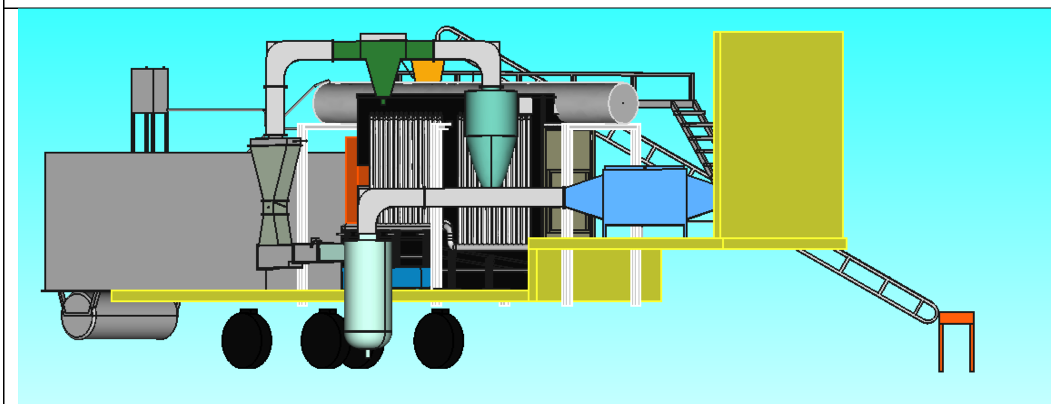
This enhanced airflow accelerates the rate at which particles are trapped and removed from the air, boosting the system's overall efficiency.



2.11 Realization of filter system on Ras Maska site 2024

2.12 NLAP-IPP Mobile Plant at Ras Maska

2.12.1 NLAP-IPP Ras Maska 19.10.2023

<table>
<tr><td></td><td rowspan="2">
full filtration system on 18102023.FCStd</td></tr>
<tr><td></td></tr>
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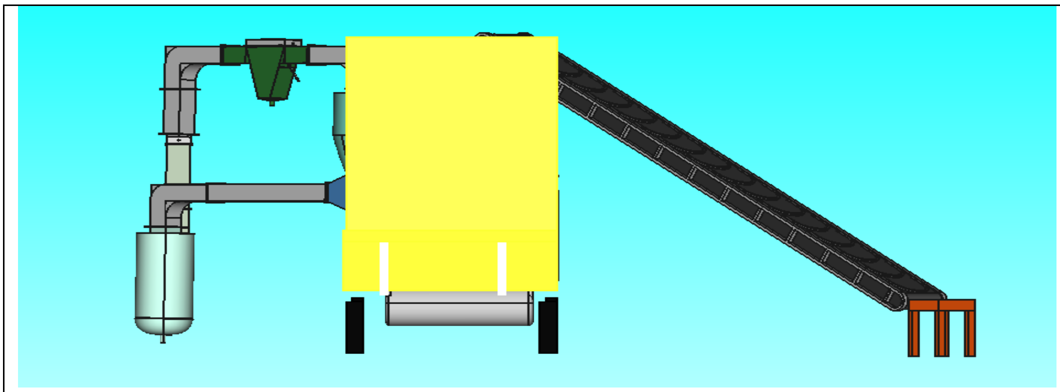
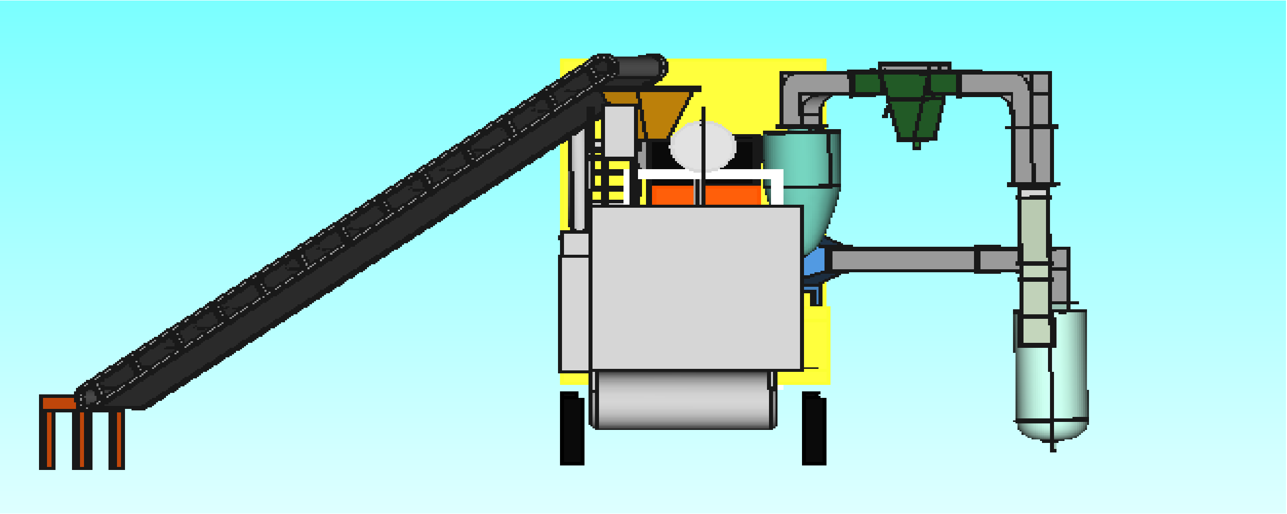
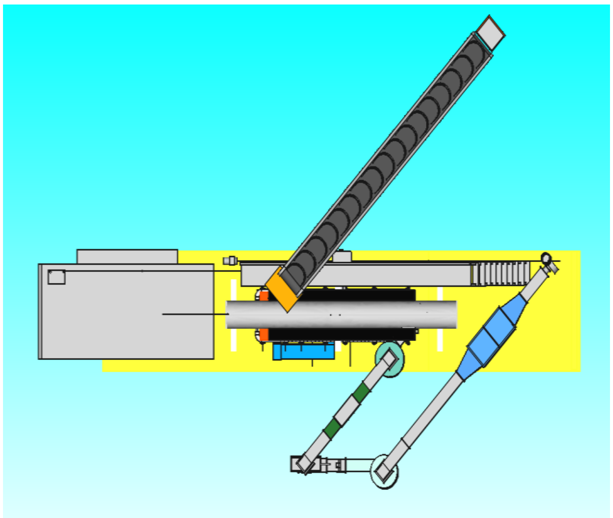
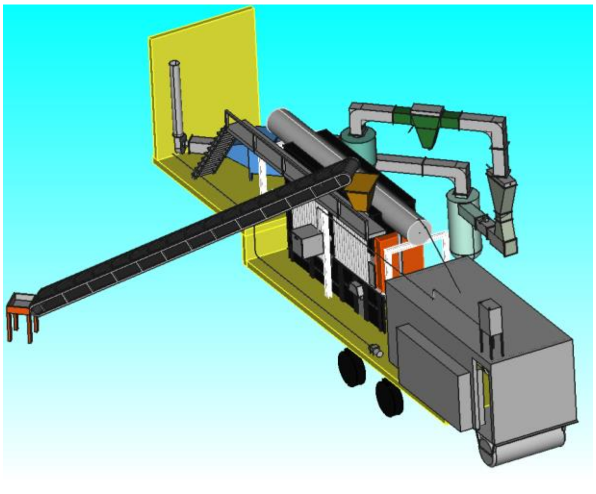
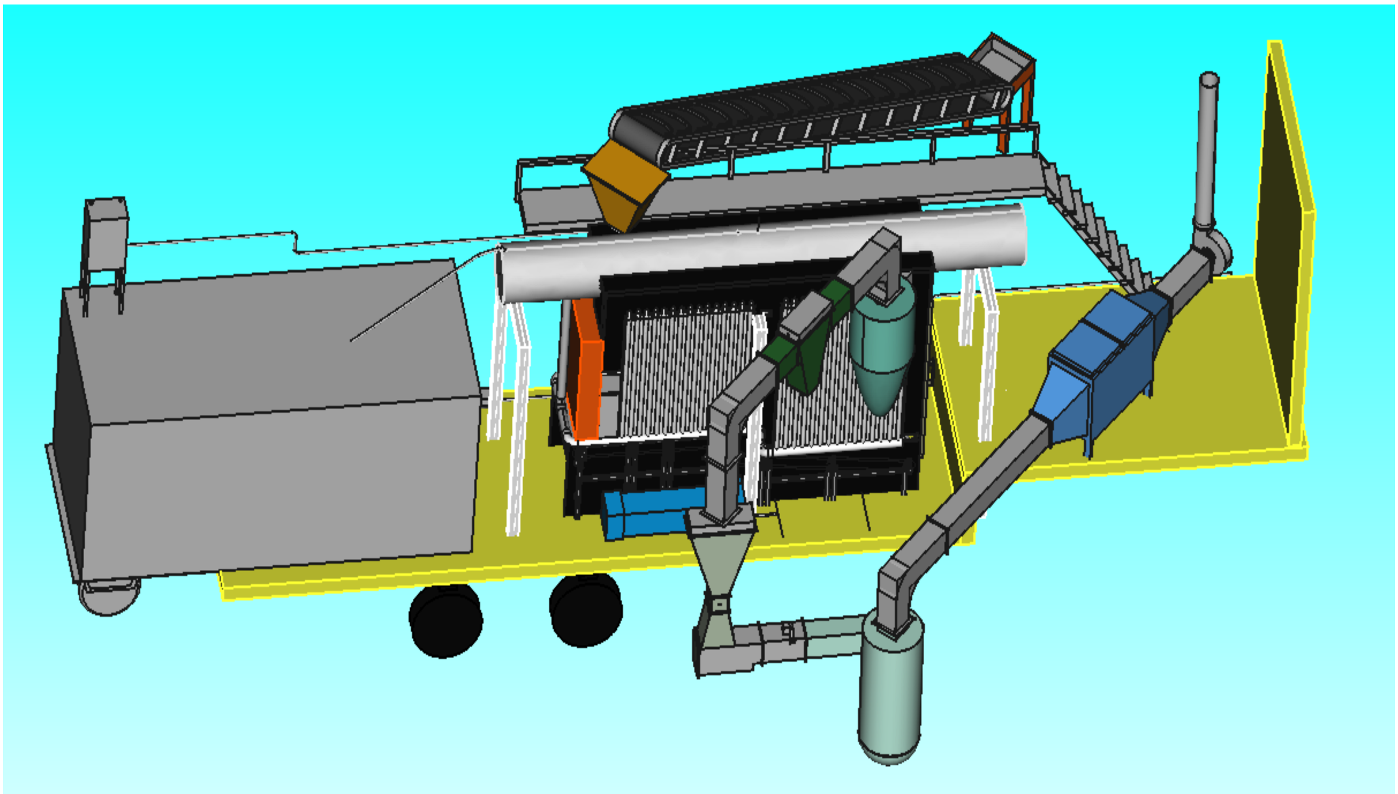


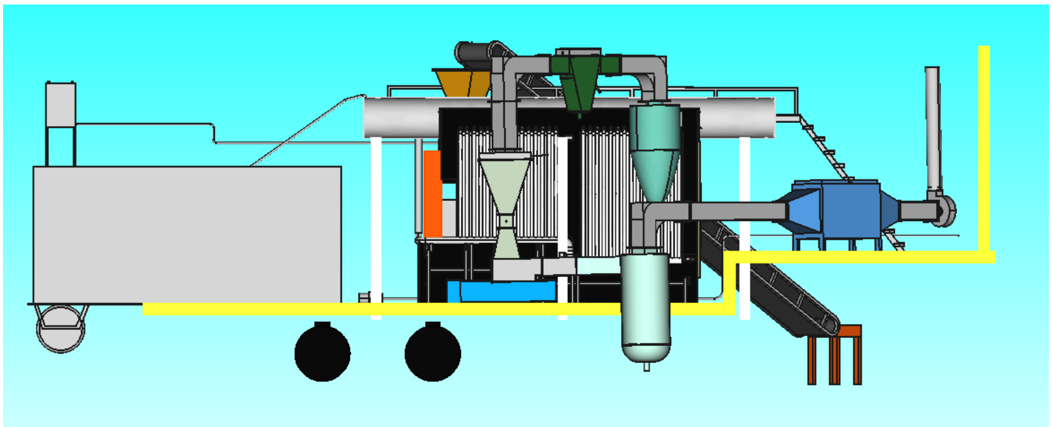


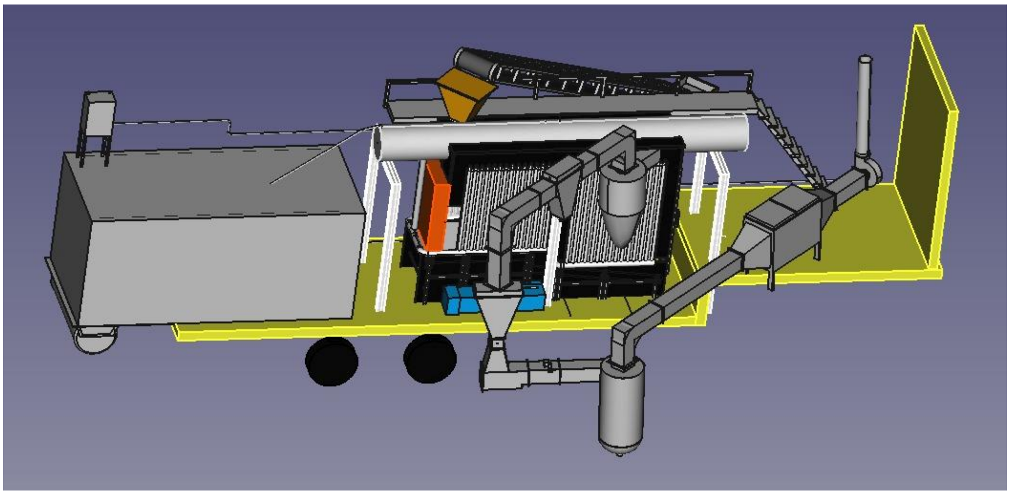




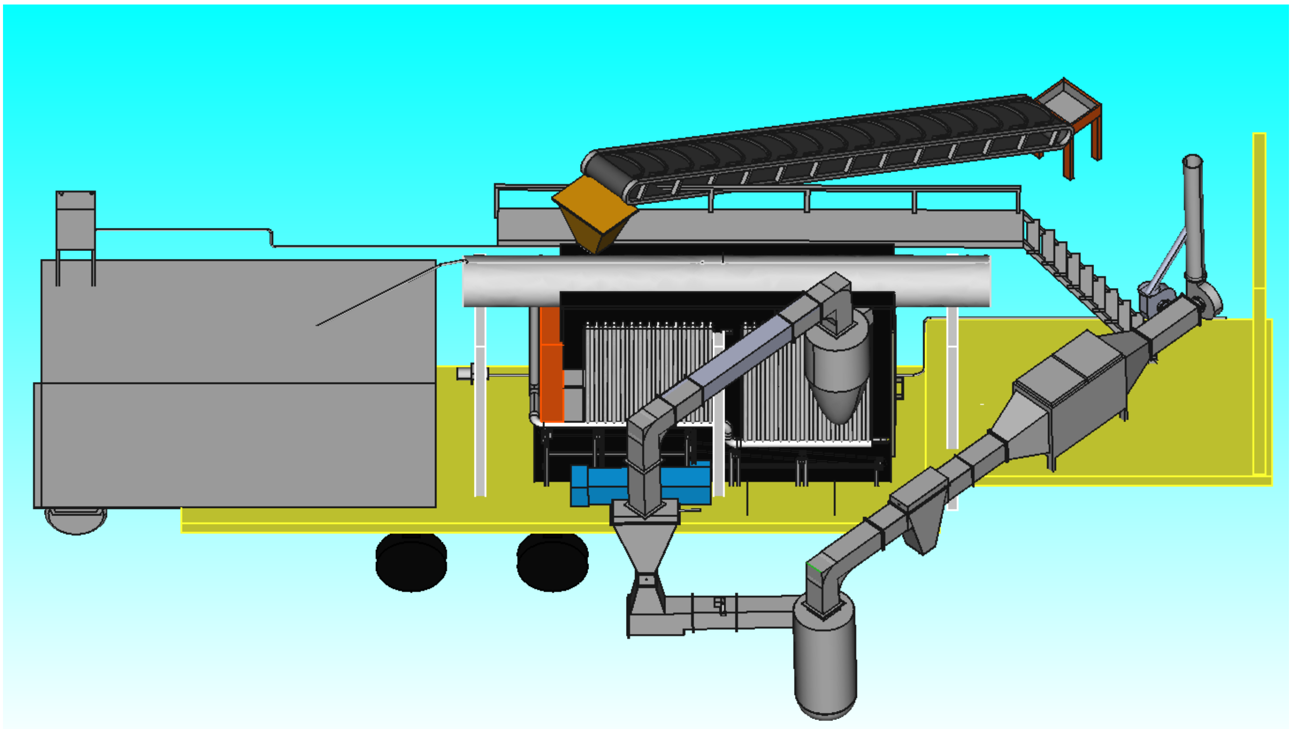


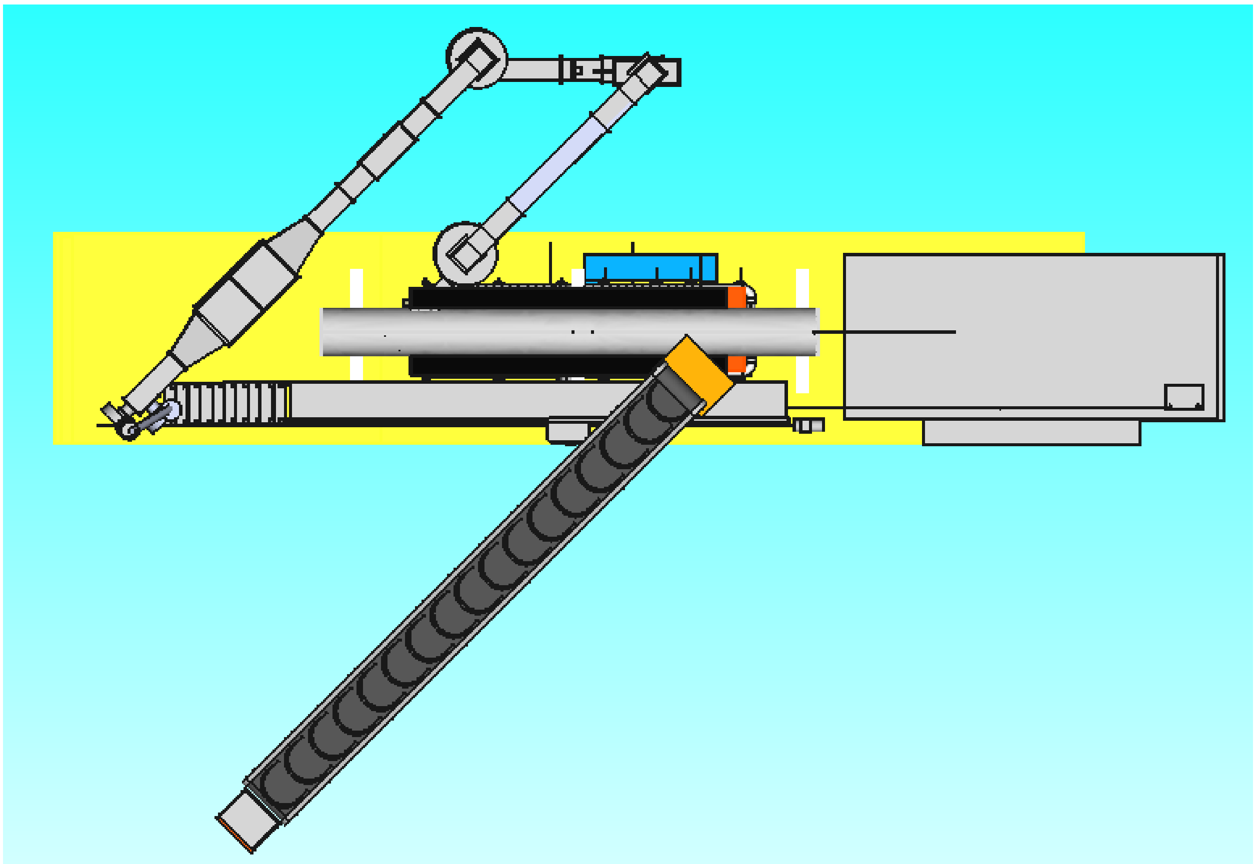
2.12.2 NLAP-IPP, Ver. 21.10.23





2.12.3 NLAP-IPP (last Ver. on 02.07.24)





2.13 NLAP-IPP Process Control System (Automation)

2.13.1 NLAP-IPP_PCS(Modbus address on the PLC) [xlsx file]

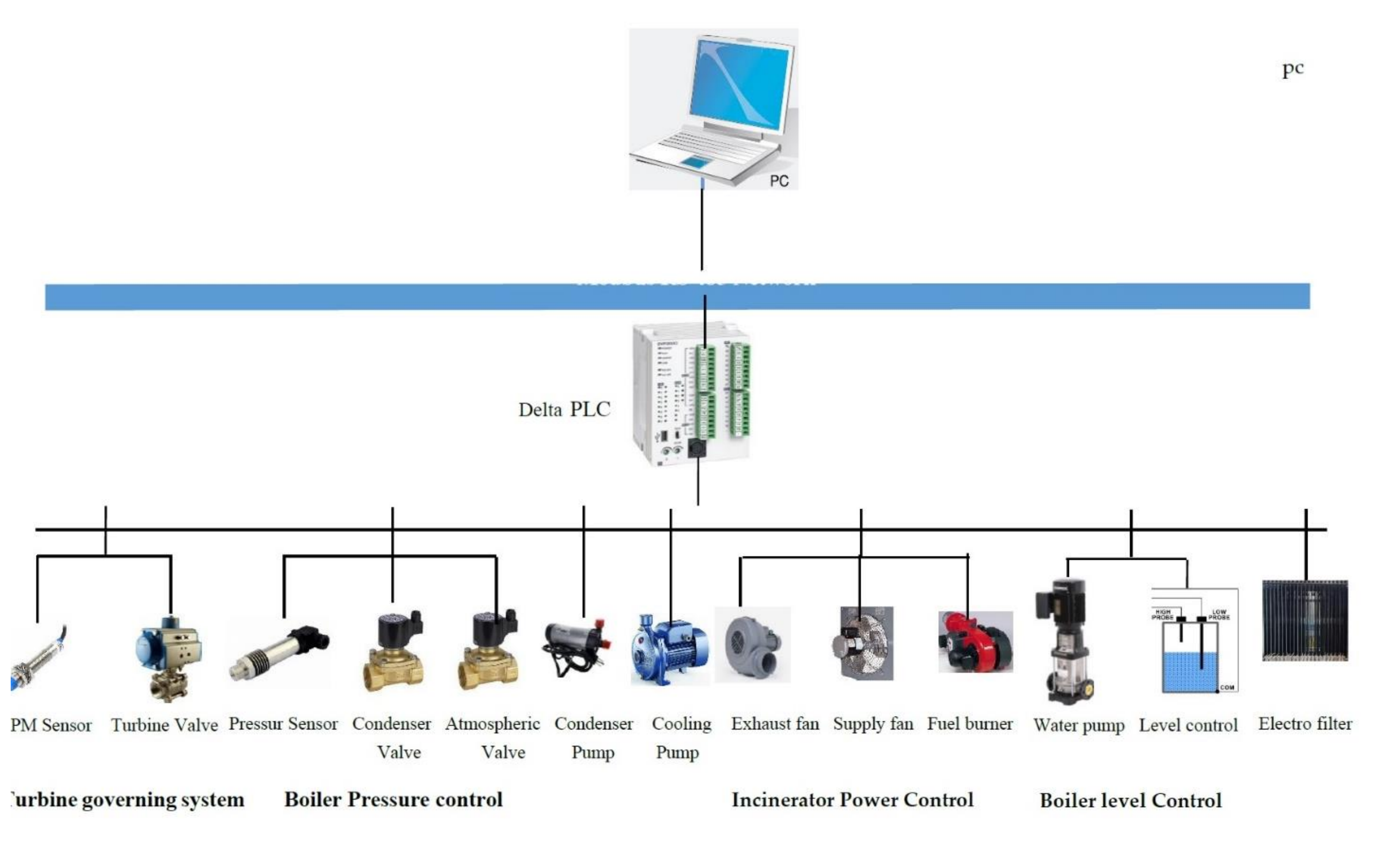
NLAP-WEDC PCS _PLC Modbus addre

Point	Addresses inside GUI	Modbus-addresses	Physical Address (PLC)	Remarque
//boilerPressureControl				
BPC_BOILER_CURR_PRESSURE	4101	44102	D5	
BPC_CONDENSER_CURR_PRESSURE	4171	44172	D75	
BPC_SET_ATMOSPHERIC_VALVE_OPENING	1284	1285	Y4	
BPC_OPEN_OR_AUTOMATIC_ATMOSPHERIC_VALVE	2059	2060	M11	
BPC_AUTOMAN_SETPOINT_PRESSURE	2060	2061	M12	
BPC_SETPOINT_ATMOSPHERIC_PRESSURE	4105	44106	D9	
//turbineGoveringSystem				
TGS_CURR_TURBINE_SPEED	4107	44108	D11	
TGS_CURR_VALVE_OPENING	4128	44129	D32	
TGS_SET_VALVE_OPENING	4109	44110	D13	
TGS_AUTOMAN_VALVE	2068	2069	M20	
TGS_AUTOMAN_SETPOINT_RPM	2069	2070	M21	
TGS_SETPOINT_RPM	4106	44107	D10	
//inceneratorPowerControl				
IPC_SET_SUPPLYFAN	1300	1301	Y4, Ext	
IPC_CURR_SUPPLYFAN_STATUS	1044	11045	X4, Ext	
IPC_SET_FUELBURNER1	1302	1303	Y6,EXT	
IPC_CURR_FUELBURNER1_STATUS	1046	11047	X6,EXT	
IPC_SET_EXHAUSTFAN1	1296	1297	Y0, Ext	

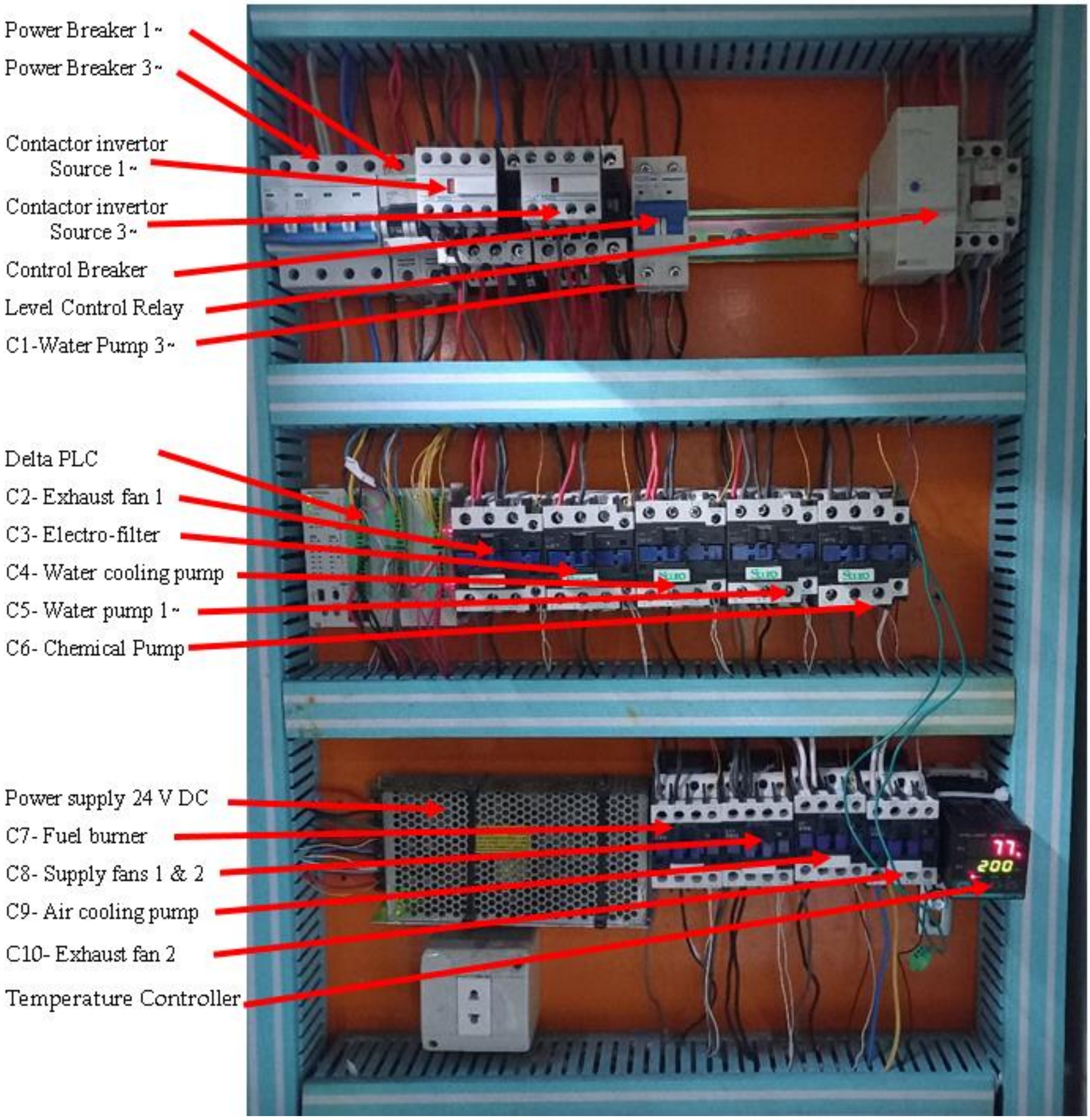
IPC_CURR_EXHAUSTFAN1_STATUS	1040	11041	X0, Ext	
IPC_SET_EXHAUSTFAN2	1281	1282	Y1	
IPC_CURR_EXHAUSTFAN2_STATUS	1025	11026	X1	
IPC_SET_Water_COOLINGPUMP	1298	1299	Y2, Ext	
IPC_CURR_Water_COOLINGPUMP_STATUS	1042	11043	X2, Ext	
//FilteringSystem				
FS_SET_ELECTROFILTER	1297	1298	Y1, Ext	
FS_CURR_ELECTROFILTER_STATUS	1041	11042	X1,EXT	
FS_CURR_TEMPERATURE1_incinerator	4146	44147	D50	
FS_CURR_TEMPERATURE_After_Chemical_FILTER	8208	8209	Temperature Controller	
FS_CURR_TEMPERATURE_After_Cooling	5208	45209	D1112	
FS_SET_Chemical_PUMP	1282	1283	Y2	
FS_CURR_Chemical_PUMP_STATUS	1026	11027	X2	
FS_SET_Air_COOLINGPUMP	1303	1304	Y7, Ext	
FS_CURR_Air_COOLINGPUMP_STATUS	1047	11048	X7, Ext	
//Boiler Level Control				
LC_CURR_LEVELCONTROL_STATUS	1030	11031	X6	
LC_SET_WATER STEAM CYCLE MAIN PUMP 3PHASE	1301	1302	Y5, Ext	
LC_CURR_WATER STEAM CYCLE MAIN PUMP 3PHASEE_STATUS	1045	11046	X5, Ext	
LC_SET_WATER PUMP 1PHASE	1299	1300	Y3, Ext	
LC_CURR_WATER PUMP 1PHASE	1043	11044	X3, Ext	

Coil/Register Numbers	Data Addresses	Type	Table Name
1 to 9999		Read-Write	Discrete Output Coils
10001-19999	0000 to 270E	Read-Only	Discrete Input Contacts
30001-39999	0000 to 270E	Read-Only	Analog Input Registers
40001-49999	0000 to 270E	Read-Write	Analog Output Holding Registers

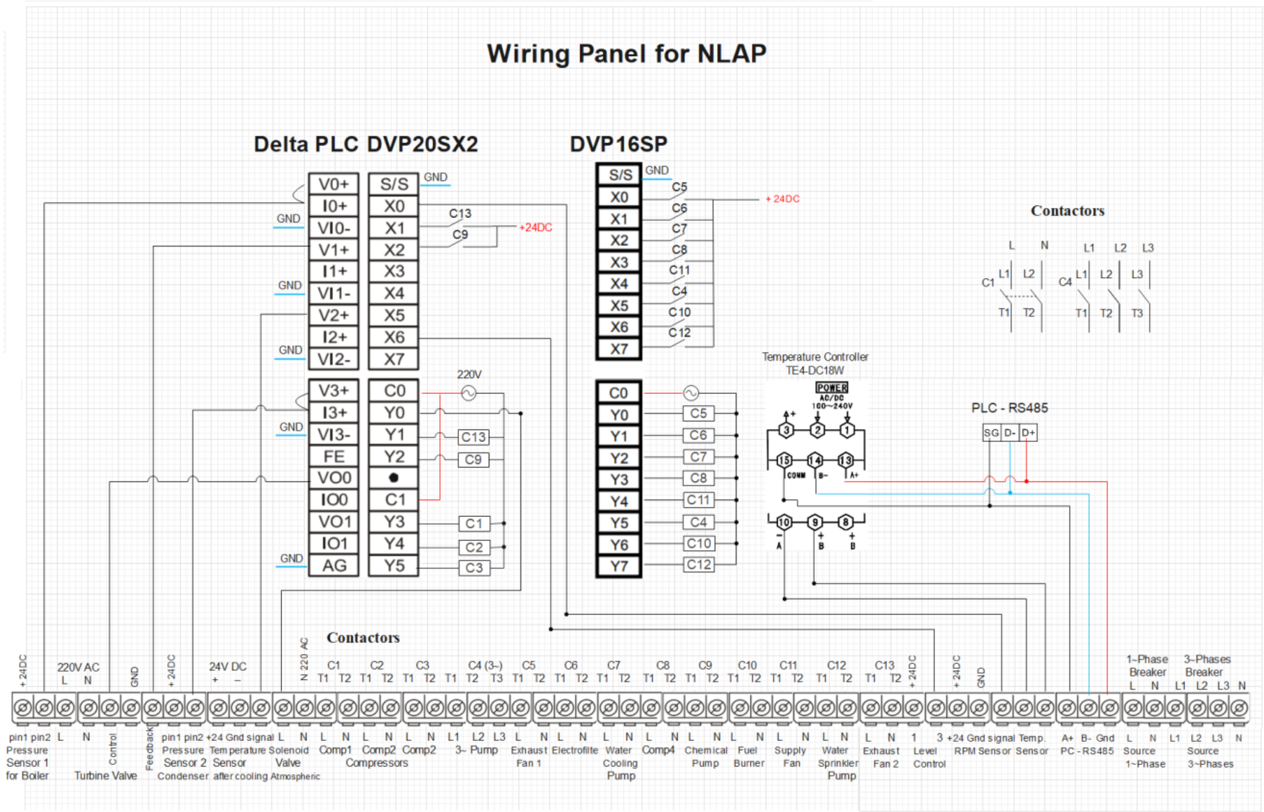
2.13.2 Process Control system Topology



2.13.3 Control Panel, Version 06.09.2023



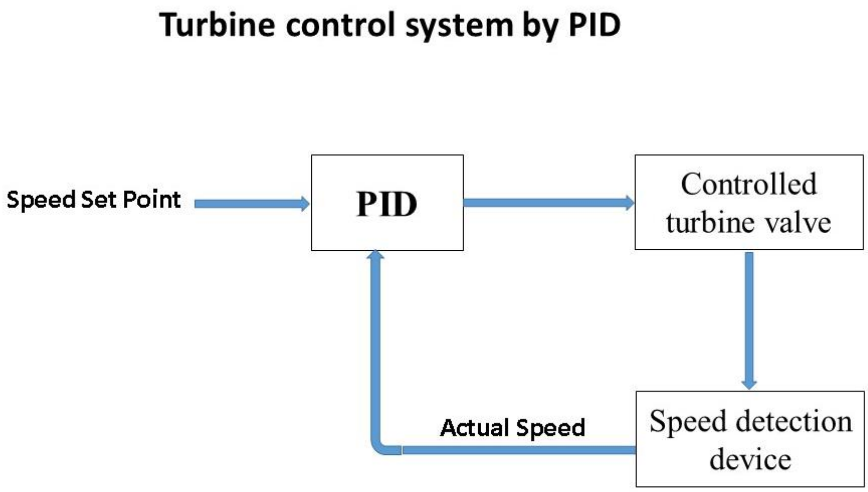
2.13.4 Wiring Panel



Wiring Panel file:

230724-NLAP_WED
C PCS - Control Pane

2.13.5 Turbine Governing System (TGS)



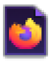
PID Parameter Adjustment by GUI

Code repository :

- GUI (C#) Source Code:

NLAP-IPP_PCS_GUI_
070824.rar

- PLC Ladder Code:



161223 NLAP IPP
PCS.dvp

2.14 Testing without Electro-filter for temperature Calculation

First of all, the powerplant checked for the electric parts

4 water sprinklers added to the scrubber

13-waste bags installed in the furnace for the test

fire started in the furnace

The powerplant started working and data collected of the temperature

The fire started choking due to water overflow in the scrubber

The ball valve of the cyclone opened to release the excess amount of water

chocking the flow of t

2.15 Test 01.09.2023 - Ras Maska

2.15.1 Goal

The goal of the experiment is to calculate the temperature of the outlet of the cyclone's flow gases that should be less than 60 Degrees Celsius and to test the sprinklers of the scrubber to see if they are good to use in the smoke filtering process.

2.15.2 Description

The previous smoke filtering system in the power plant was replaced with a new scrubber, cyclone, and the connections between them. The system received new sprinklers to improve smoke filtration and cooling.

The powerplant's electric components were successfully maintained. and a temperature sensor was connected to the electro-filter intake before doing this test since the electro-filter requires a temperature of less than 60 degrees Celsius to remain safe and not malfunction.(we removed the Electro-Filter parts in this test)

2.15.3 Test Specification

1. Connect the incinerator to the venturi scrubber, the cyclone, and the chimney.
2. Checking all ducts and pipes.
3. Removing the electro-filter from the system.
4. Connecting the temperature sensor to the outlet of the cyclone.
5. Putting 13 bags of wood in the combustion chamber of the incinerator.
6. Setting fire to the combustion chamber of the incinerator.
7. Turning on the 2 fans placed in the combustion chamber.
8. Turning on the pump (P). the water started to run in the system and we opened the scrubber ball valve to let the water coming out of the sprinklers, filtering the smoke and cooling it to get out of the system.
9. Running the incinerator with a scrubber, measuring smoke temperature after cyclone by sensor related to the GUI., it was found that it is 150 degrees without water and 106 degrees with sprinklers turned on
10. with the sprinklers turned on the smoke starts choking due to the water overflow in the scrubber and that closes the cyclone gasses inlet, we open the main door of the combustion chamber manually to let the smoke return to its full combustion process.
11. We opened the ball valve of the cyclone manually to let the smoke receive to the chimney.
12. We closed the main door of the combustion chamber manually when the gases flowed back to normal.
13. We Turned off the 2 fans placed in the combustion chamber. when the process was done.
14. We turned off the incinerator.
15. We waited until the smoke stopped emitting.
16. We Turned off the pump (P), Closed the ball valve of the cyclone manually, disconnected the electrical connections, and opened the boiler head gate valve to let the pressurized water vapor get out of the system then we closed it again.

2.15.4 Steps

Steps	Steps description	Excepted result	Result
Precondition	The incinerator is connected to the venturi scrubber, then the cyclone, then the chimney		✓

	All electrical parts of the power plant are connected (without electro-filter)		
	All ducts are checked		✔
	All pipes are checked		✔
	4 sprinklers are connected to the pipe in the venturi scrubber		✔
	The electro-filter removed from the system		✔
	The temperature sensor is connected to the outlet of the cyclone		✔
Run the incinerator with measuring smoke temperature after cyclone	Put 13 bags of wood in the combustion chamber of the incinerator	13 bags of wood are put in the incineration	✔
	Set fire to the combustion chamber of the incinerator	The wood started to burn	✔
		Smoke started to appear	✔
	Turn on the 2 fans placed in the combustion chamber	The 2 fans are turned on	✔
		The wood combustion is more efficient	✘
	Turn on the pump (P)	The pump (P) is turned on	✔
		The sprinklers start working	✔
		The water flow out of the sprinklers working properly	✘

		The water doesn´t enter the cyclone	✘
	Open the ball valve of the scrubber manually	Water starts to exit from the outlet of the scrubber	✔
		The flow of the smoke doesn´t choke in the combustion chamber	✘
		The smoke passing out of the chimney	✘
	The smoke is choking, open the main door of the combustion chamber manually	The smoke getting out of the combustion chamber door	✔
		The fire back to normal combustion	✔
	Open the ball valve of the cyclone manually	The water flow can be extracted from the bottom of the cyclone	✔
		The water has a little black color in the smoke due to the cyclone	✔
		The smoke can enter the cyclone normally	✔
	Read the temperature value in the outlet of the cyclone by sensor related to the GUI	The temperature is read by the GUI	✔
Turn Off the incinerator	Close the main door of the combustion chamber manually	The main door of the combustion chamber is closed	✔

	Turn Off the 2 fans placed in the combustion chamber	The 2 fans are turned off	✓
	Wait until the smoke stops emitted	The smoke emission stops	✓
	Turn Off the pump (P)	The pump (P) is turned off	✓
	Close the ball valve of the cyclone manually	The ball valve of the cyclone is closed	✓
	Disconnect the electrical connections	All electrical connections are disconnected	✓
	Open the boiler gate valve manually	the superheated vapor gets out from the valve	✓
	Close the boiler gat manually after the pressurized vapor gets out	It is closed successfully	✓

2.15.5 Pictures related to the test




2.15.6 Data Collected

- The temperature of the smoke at the outlet of the cyclone without water was 150 degrees Celsius.
- The temperature of the smoke at the outlet of the cyclone with sprinklers turned on was 106 degrees Celsius.
- The water flow from the sprinklers was not sufficient to cool the smoke.
- The smoke was able to enter the cyclone normally, but the water flow from the sprinklers caused the water to back up into the cyclone and choke the smoke.

2.15.7 Data Analysis

- The sprinkler holes are large.
- The fans are not enough to push the smoke out of the incinerator.
- The used water is hot to cool the smoke

2.15.8 Future Work

- New sprinklers will be used in the system.
- 2 fans will be connected to the incinerator.
- Another water tank will be used
- Water should be cooled with the cooling process that will be installed in the tank.

2.16 Filtration test (18.12.2023)

2.16.1 Goal

In this test, we adhere to the test specification (01 Test Specification of the filtration System) by inspecting each component of the filter system to ensure its functionality.

First, we double-checked the mechanical components, such as the ball valves, ducts, and piping system from the chemical filter and scrubber to the chemical and water supply tanks, to ensure that everything was properly linked.

Second, we used the GUI software to inspect the electrical connections for each item, such as pumps, air supply fans, and exhaust fans. Each device was checked for functionality for 10 seconds

Third, we discovered that the garbage bags had become wet as a result of the rain; therefore, instead of the waste bags, we used bags filled with wood.

Fourth, we examined the manual flame igniter and discovered that it was not working properly due to a malfunction in its electric parts, and the trailer of the powerplant was also not steady and was inclined, preventing the tank from pushing the Diesel to the flame igniter.

Fifth, we used the GUI software to open the exhaust fans and the air supply fans, then we manually started the fire through the main gate, and when the fire started, we closed the main gate.

Sixth, we begin collecting data for the temperature at the incinerator outlet, the temperature between the chemical filter and the scrubber, and finally the temperature in the electro-filter inlet.

Seventh, we collected data on T1, T2, and T3 sensors when P1 and P2 were closed when P1 and P2 were opened when P2 was closed, and finally when both P1 and P2 were opened together again.

Eighth, we used the GUI software to close the pumps P1 and P2, the exhaust fans E1 and E2, and the air supply fans AF1 and AF2, while manually closing the ball valves BV1, BV2, BV3, BV4, and BV5. to put out the fire, and we double-checked that all systems were turned off.

2.16.2 Table of System Test

Step	Step description	Expected result	result		result description											
Precondition			✗	✓	Why?											
check out the system	System is off	All system is off		✓												
Initial Condition																
check out steps	check the mechanical filtration connections: Ducts, BV1, BV2, BV3, BV4, BV5, P1, P2, E1 and E2.	All Mechanical connections are good		✓												
	Check the electrical filtration connections: wires. T1, T2, T3, P1, P2, E1, and E2 (By the GUI Software) for 10 seconds each.	All Electrical connections are good and the temperature between 20 and 30℃		✓												
	Check the Air Supply fans AF1 and AF2 for 10 seconds (By the GUI Software).	The air fan Supply working well		✓												

	check the flame igniter manually for the incinerator	The flame igniter working well	✗		the flame igniter didn't work											
putting waste bags	put the waste bags inside the incinerator	no obstacle	✗		we use wood instead of the wet waste bags											
add Diesel	add Diesel inside the diesel-tank presented above the turbine room	no obstacle	✗		the power plant trailer is inclined and the diesel not moving in the pipes											
Turn on E1 and E2	for 10 Seconds Turn on the Exhaust fans presented above Cyclone #1 and below the chimney (By the GUI Software).	The exhaust fan working		✓												
Turn on P1 and P2	for 10 Seconds Turn on the liquid pumps for the chemical filter and the Scrubber (By the GUI Software).	The liquid pumps working		✓												
open BV1, BV2, BV3, BV4 and BV5	open the ball valves for the chemical filter, scrubber, cyclone #2, the Water tank, and the chemical tank. Manually	no obstacle		✓												

Starting Test																
check out T1, T2 and T3	Check the temperature at its initial condition before starting (by the GUI Software).	The temperature must be between 20 and 30℃		✓		T_1	16	T_2	25	T_3	17					
Turn on E1, E2, AF1 and AF2	Turn on the exhaust fans (E1, E2) and the air supply fan (AF1, AF2) of the incinerator (By the GUI Software).	air starts flowing out of the chimney		✓												
	Start the fire using the Flame igniter to the waste bags (manually).	Igniter starts fire	✗		the fire started manually and igniter doesn't work											
	Close the main incinerator gate	It close well		✓												
check out T1, T2 and T3	Check out the T1 Sensor to get the maximum Temperature	The max. temperature above 400℃		✓		T_1	125	140	200	226						
	Check out T2 Sensor to see the Effectiveness of the Chemical filter chamber and the Cyclone #1	no obstacle		✓		T_2	60	70	95	120						

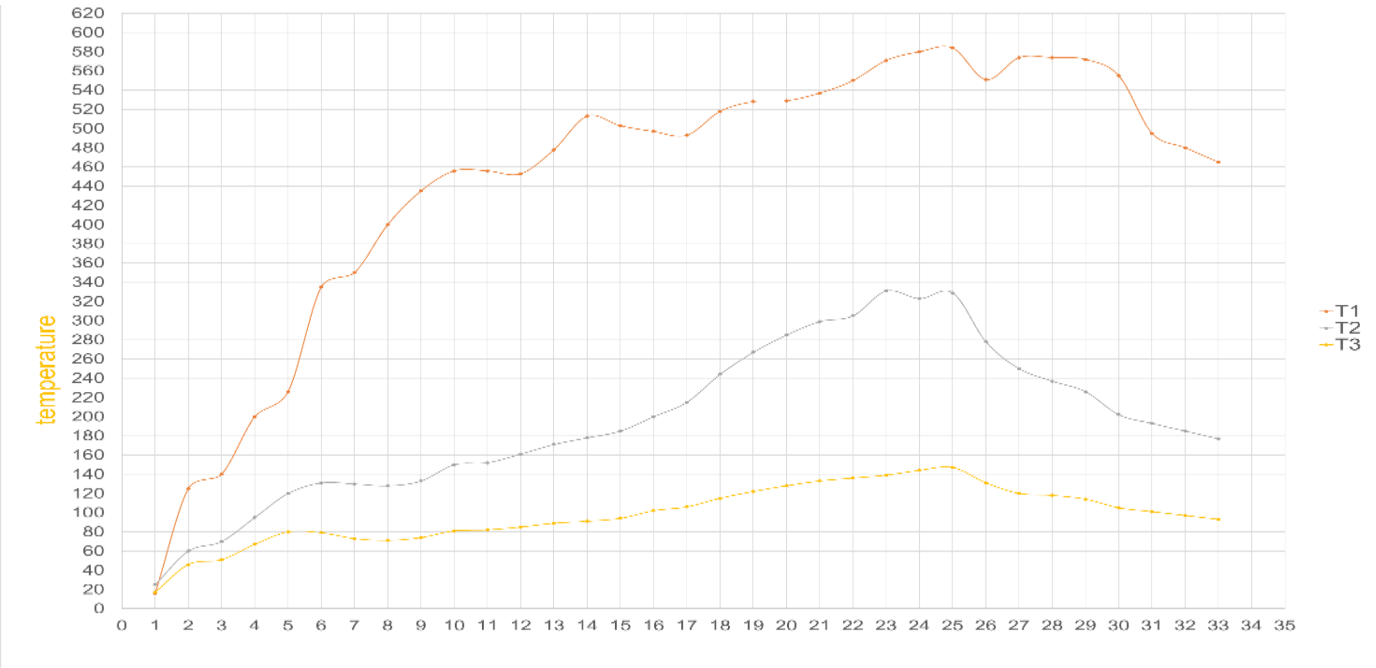
	Check out T3 Sensor to see the effectiveness of the Cyclone #2	no obstacle		✔		T_3	46	51	67	80						
open P1 and P2	Turn on the liquid pump for the chemical filter to start filtration and the scrubber to start cooling	the pumps start working well		✔												
check out T1, T2 and T3	Check out T1 Sensor to get the max temperature	temperature increasing or stay steady		✔		T_1	335	350	400	435	456	456	453	478	513	503
	Check out the T2 Sensor to see the Effectiveness of the Chemical Filter and Cyclone #1 cooling	temperature decrease		✔		T_2	131	130	128	133	150	152	161	171	178	185
	Check out the T3 Sensor to see the effectiveness of the system, especially the scrubber cooling	temperature decrease below 60℃	✗		the temperature is between 74℃ and 94℃	T_3	79	73	71	74	81	82	85	89	91	94
open the Chemical tanks	check out the filtration Cycle	the color of the water starts to change		✔												
close P2 pump	close the chemical liquid pump to check the effectiveness of the	the pump P2 close normally		✔												

	cooling process by the scrubber															
check out T1, T2 and T3	Check out the T1 Sensor to get the max Temperature	temperature increasing or staying steady		✓		T_1	497	493	518	528	529	537	550	571	580	584
	Check out T2 Sensor	the temperature starts to rise up		✓		T_2	200	215	244	267	285	299	305	331	323	329
	Check out the T3 Sensor to see the effectiveness of the scrubber cooling compared to the initial process without both Pumps	difference in the temperature compared to the initial data	✗		the temperature is increasing	T_3	102	106	115	122	128	133	136	139	144	147
open P2 pump	open the chemical liquid pump	the pump P2 open normally		✓												
check out T1, T2 and T3	Check out the T1 Sensor to get the max Temperature	temperature increasing or staying steady	✗		the temperature started to decrease because the wood bags are mostly finished	T_1	551	574	574	572	555	495	480	465		

	Check out T2 Sensor	the temperature starts to decrease		✓		T_2	278	250	237	226	202	193	185	177		
	Check out the T3 Sensor to see the effectiveness of the filters cooling compared to the condition when P2 was closed	difference in the temperature compared to the above condition		✓		T_3	131	120	118	114	105	101	97	93		
close P1 and P2	disconnect the water and chemical from the filters	the system kills the fire		✓												
close BV1, BV2, BV3, BV4 and BV5	close the ball valves to close the filtration system			✓												
close E1 and E2	close the exhaust fan (E1, E2)			✓												
Close AF1 and AF2	close the Air supply fan (AF1, AF2)			✓												

Postcondition																
check out the system	System is off	all system is off		✔												

2.16.3 Graph of the Temperature Sensors [Temperature in degree Celsius]



Guide:

From 0 to 1, the Table system was in rest.

From 1 to 5, Pumps P1 and P2 were closed.

From 5 to 15, Pumps P1 and P2 were opened.

From 15 to 25, pump P2 was closed and P1 was opened.

From 25 to 33, P2 was opened again when P1 was already opened.

2.16.4 Test Analysis

- The flame igniter had difficulty since the trailer became inclined due to rain and sank backward to the ground, preventing the fuel from feeding the flame igniter.
- Both pumps P1 and P2 assisted the flue gas in lowering the temperature when it reached values between 74 and 94 degrees Celsius; it was not enough, but it did a nice job in comparison to the previous test results.
- The chemical filter performed well in the filtration process and in cooling the flue gases, but this was not permanent because the drainage of the chemical filter was connected to the main hole of the chemical, so it was fed again, causing its temperature to rise to 60 degrees Celsius, reducing the cooling process of the flue gases.
- The new sprinklers did a better job of chilling the flue gas with less water and chemical supplies than the old standard method.
- The cleaning procedure was improved by the addition of cyclone number one.
- Adding an extra temperature sensor to the filtering cycle improves data collection accuracy.
- Connecting the GUI software in the room close to the engine trailer rather than the far-distant center improves data transmission speed.

2.16.5 What should we do next?

- Repairing the flame igniter and connecting it to the graphical user interface software.
- Maintain the trailer's stability on the ground.
- Increase the cooling process with the chemical filter and get a bigger water tank.
- Re-cool the flue gas with the scrubber drainage water.
- Including additional methods to get the flue gas to the required temperature.
- Using fewer trash bags instead of 12 bags to avoid a dramatic spike in temperature.

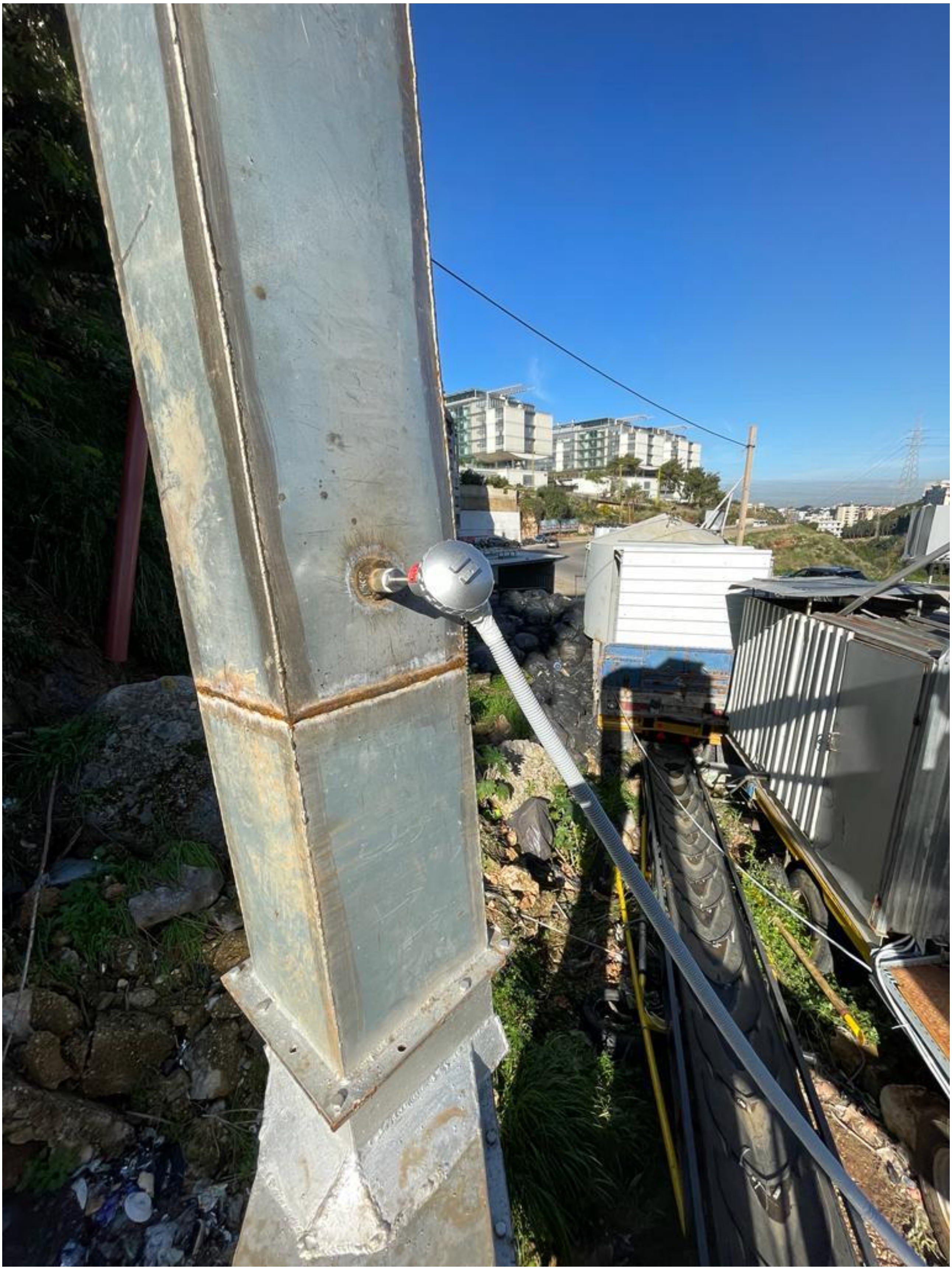
2.16.6 Pictures related to test on 18.12.23

Filter System pic

Project 2: Improvement of Filter System in Incinerator Power Plant 2023/24

Filter System Pic

Temperature Sensor T1 Pic



Temperature Sensor T2 Pic

Filtration test (18.12.2023)

Filter System pic

Exhaust fan E1 pic

Filtration test (18.12.2023)

Exhaust fan E2 pic

Water pump P1 pic

Filtration test (18.12.2023)

Chemical pump P2 pic

Air supply fan AF1 pic

Filtration test (18.12.2023)

Flame igniter chamber pic

Incinerator chamber pic

Filtration test (18.12.2023)

Incinerator chamber main gate pic

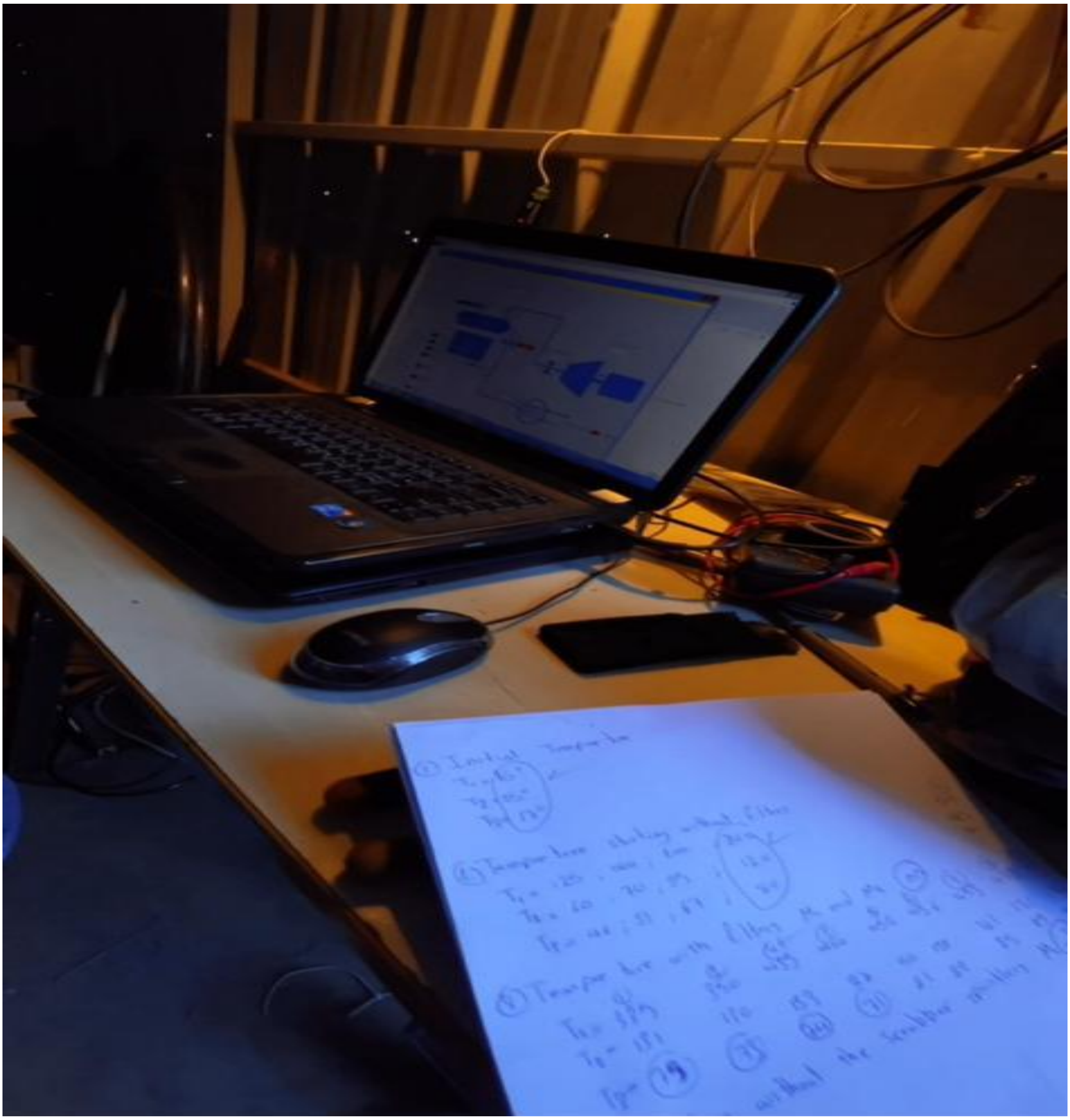
chemical filter tank process pic

Filtration test (18.12.2023)

The drainage of the water by the scrubber cooler pic

Filtration test (18.12.2023)

Flue gas getting out through the chimney pic



GUI software control and the data collected by it pic

The filtration system of flue gas of the powerplant [mp4 file]:

WhatsApp Video
2023-12-21 at 10.01.

2.17 Test.Atomizing Nozzle Air to Fluid ratio (27.04.2024)

In this testing, we tried 4 nozzles (Type: Round 60-degree angle with 6 holes). this test used a 1/2-HP pump and 1.5-HP air compressor in a 40-liter tank.

when the test started, we found that the four nozzles needed more Air-compressor power to maintain constant air pressure. when the 1.5 HP tank couldn't give us the best performance and the pressure started to decrease when the wanted air pressure was up to 4.2 bar and it should stay constant.

The water pump gave us good pressure for all four nozzles, as shown in the following picture:

about 3.5 bar water pressure, so the air pressure should be about 3.5 bar too.

These are pictures of the video experiment:

Test.Atomizing Nozzle Air to Fluid ratio (08.05.2024)

This is the video that shows what happened in the experiment:

27042024.AtomizingNozzle.Test.mp4

2.18 Test.Atomizing Nozzle Air to Fluid ratio (08.05.2024)

- Compression Time Test with 1.5HP-40L-Compressor

  T average = 3 minutes and 22seconds

- (1.5 HP-40L compressor) + (Pressure Regulator at 3.45 bar)

  Compressor Pressure at ball valve = 6 bar

  Compressor Pressure at ball valve = 1 bar

  The regulator gives 0 pressure because it is open to space

- (1.5 HP-40L-Compressor) + (Pressure Regulator at 3.45 bar) + (4-Nozzle)

  Compressor Pressure at ball valve = 3 bar

  Compressor Pressure at ball valve = 1 bar

  The regulator gives 0 pressure because it is connected to 4 nozzles

- (1.5 HP-40L-Compressor) + (Pressure Regulator at 3.45 bar) + (4-Nozzle) + (water Pump ½ HP)

  Compressor Pressure at ball valve = 2.5 bar

  Compressor Pressure at ball valve = 1 bar

  The regulator gives 0 pressure because it is connected to 4 nozzles

- (1.5 HP-40L-Compressor) + (Pressure Regulator at 3.45 bar) + (1-Nozzle)

  Compressor Pressure at ball valve = 4.1 bar / Regulator = 3.45 bar

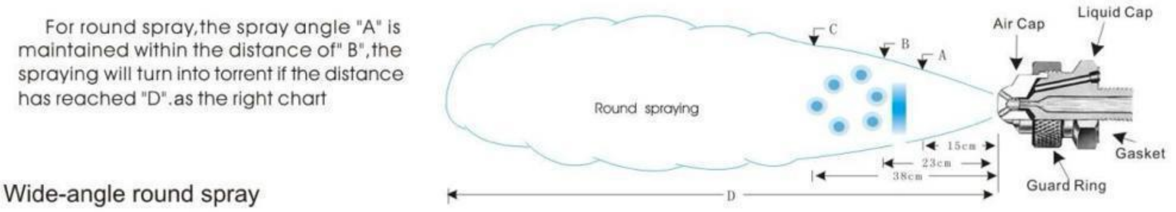
  Compressor Pressure at ball valve = 1 bar / Regulator = 3.45 bar

- (1.5 HP-40L-Compressor) + (Pressure Regulator at 3.45 bar) + (1-Nozzle) + (water Pump ½ HP)

  Compressor Pressure at ball valve = 3.5 bar / Regulator = 3.45 bar

  Compressor Pressure at ball valve = 3.25 bar / Regulator = 3.25 bar

Note: By using interpolation, we could find the air pressure for each nozzle at a value of 3.45 for a water pump of ½ HP of 3.5 bar pressure. The following diagram shows the values taken:



Performance date

spray device model	spray device consists of air cap and fluid cap	liquid flow (L/min)and flow (L/min)															Size					
		Water pressure (bar)																				
		0.7bar			1.5bar			2bar			3bar			4bar								
		Air pressure (bar)	Water (L/h)	Air (L/min)	Air pressure (bar)	Water (L/h)	Air (L/min)	Air pressure (bar)	Water (L/h)	Air (L/min)	Air pressure (bar)	Water (L/h)	Air (L/min)	Air pressure (bar)	Water (L/h)	Air (L/min)	Air (bar)	Liquid (bar)	A (cm)	B (cm)	C (cm)	D (cm)
SUK16	Liquid C 2050 and Air Ca 67-6-20-7	0.6	5.3	10.2	1.1	6.1	13.3	1.5	8.1	16.4	2.4	8.9	22	3.1	10.5	24	0.7	0.7	14	18	23	1.5
		0.7	4.3	12.2	1.3	7.0	15.0	1.8	6.6	21	2.7	8.1	26	3.4	9.7	28	1.4	1.5	15	19	24	1.8
		.85	3.0	14.2	1.4	6.4	17.0	2.1	4.9	25	3.0	6.4	30	3.9	7.8	36	1.8	2.0	16	20	25	2.1
		.0	1.7	17.0	1.5	5.5	19.0	2.4	3.2	29	3.2	4.9	34	4.2	6.1	42	3.0	3.0	16	20	26	2.7
					1.7	4.5	22				3.4	4.2	37	4.6	4.4	47	3.9	4.0	19	23	30	4.0
					1.8	3.5	24				3.5	3.4	40	4.9	2.8	54						
		0.85	7.0	5.0	1.7	13.2	68	2.0	18.5	68	2.8	25	84	3.7	31	96						

- Conclusion

We found that every single Nozzle needs a compressor of 1.5 HP to function at best performance with a 45-degree open valve.

2.19 Flue Gas into Water test (12.06.2024)

Smoke Filtration using a water Tank

The test was done and it gave us great results for filtering the smoke, especially the big particles. The test keeps going for 2 minutes, and then the flexible duct melts.

2.20 Flow gas into Barrel water Filter Test (24.6.2024)

The water Barrel test showed minimal filtration of the smoke in the exhaust gases.

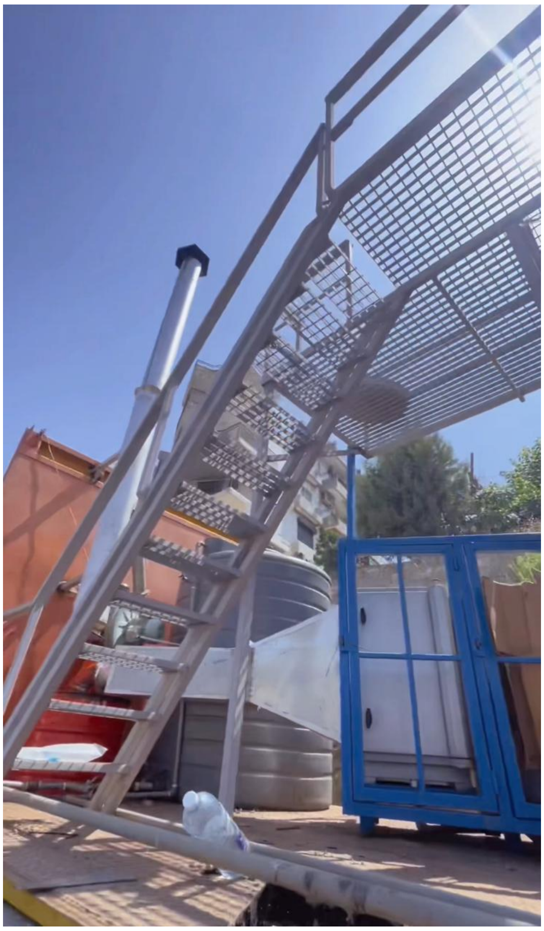
However, the flow rate of the smoke decreased. Due to the small amount of water in the barrel, the smoke passed through with little to no change after a few minutes of the test.

- Video of the test:

WhatsApp Video
2024-06-25 at 10.51.

- Picture of the test:

Flow gas into Barrel water Filter Test (24.6.2024)

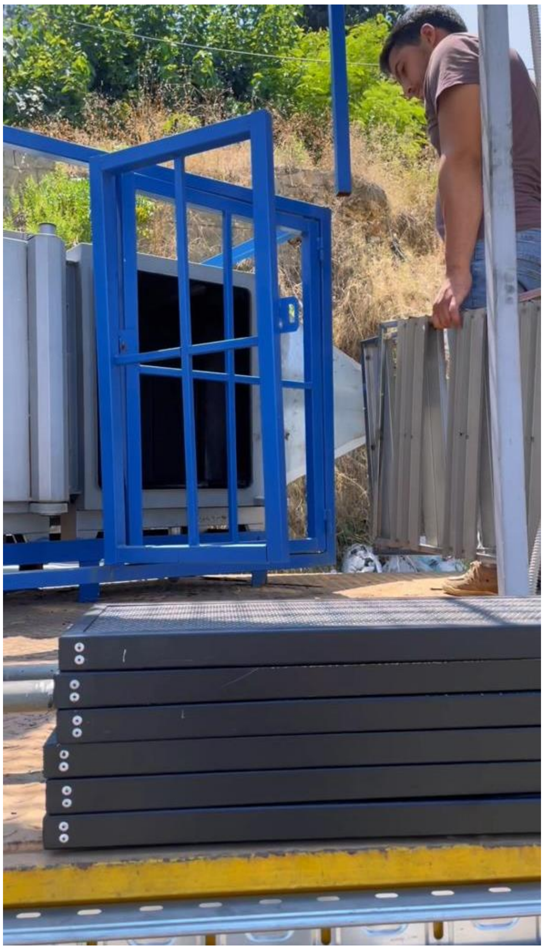


2.21 Filtration test on 27.06.2024

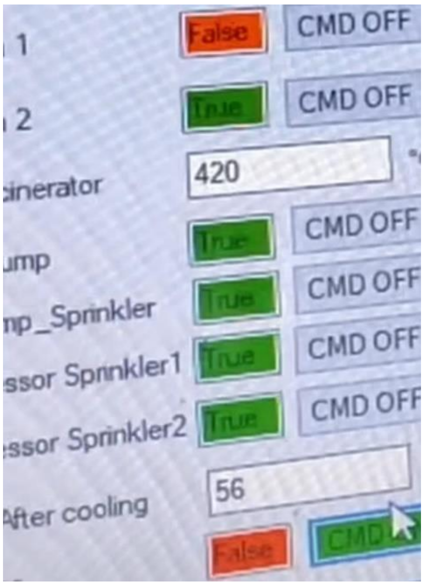
On this date, we conducted a filtration test, marking the first installation of the electro filter. This installation was necessitated by the recent integration of a cooling system into the scrubber. Additionally, we retained the sprinklers of the chemical filter.

To enhance the cooling process, we implemented an extra step of cooling the water tanks using ice molds. This measure was taken to achieve optimal temperatures during the cooling process managed by the pressurized sprinklers in both the scrubber and the chemical filter.

Filtration test on 27.06.2024

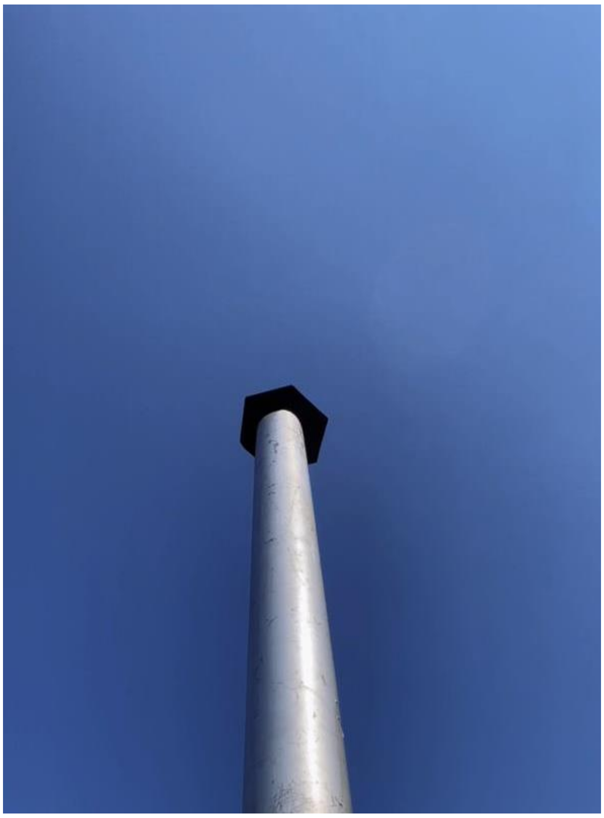


The cooling system effectively reduces the temperature from 42 to 56°C.



At this reduced temperature, the electro filter operated flawlessly, achieving a filtration efficiency of approximately 98%, effectively purifying the smoke.

Before turning on the electro filter



After turning on the electro filter

Here is a video that shows the full process:

27062024
electrofilter test.mp

2.22 Filtration test (02.07.2024)

Here is the Video explaining everything during this test:

WhatsApp Video
2024-07-03 at 12.14.

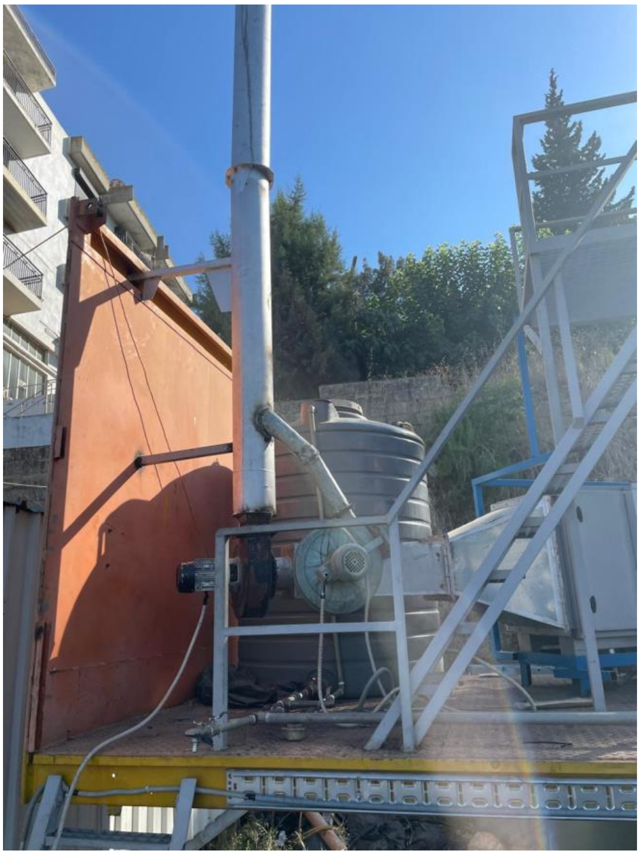
We are pleased with the positive results we have achieved in this experiment. However, we face challenges regarding the amount of waste and high temperatures, which negatively affect the electrostatic filter, reducing its filtration efficiency from 100% to 70%.

Additionally, the cooling system using sprinklers works excellently for a limited period. However, after this period, the cooling process stops due to the compressor's high temperature, caused by the weather conditions and environmental factors that increase the compressor's temperature.

The plant can operate in smaller quantities continuously with this system. However, if we aim to incinerate larger amounts of waste, we must improve the heat reduction techniques or replace the electrostatic filter with a larger system capable of withstanding high temperatures and operating efficiently under these conditions.

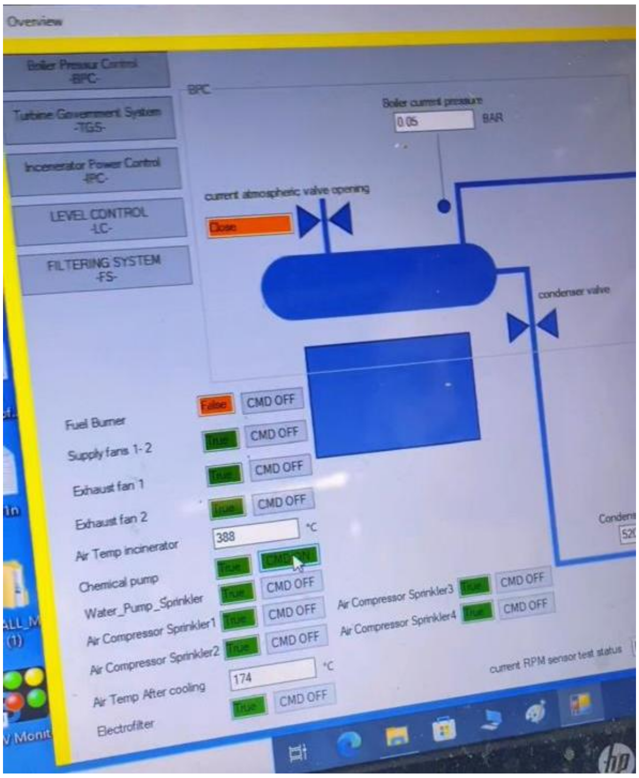
By taking these steps, we can achieve better efficiency and ensure the plant's continuous operation in handling larger quantities of waste effectively.

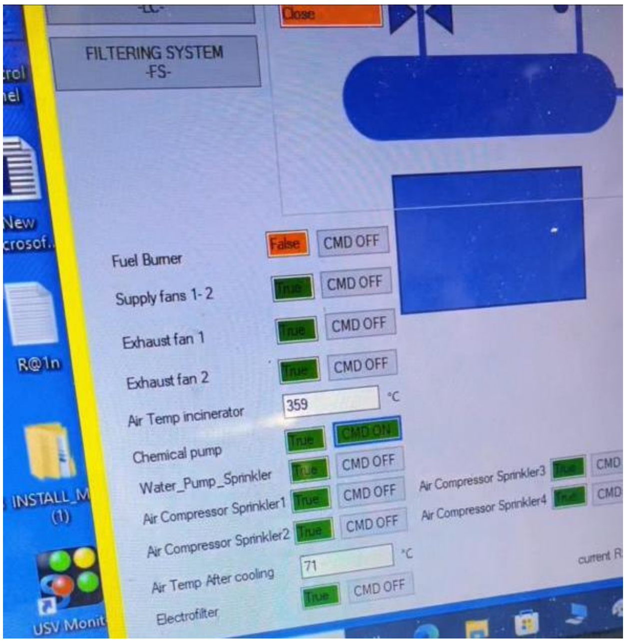
Here are pictures related:



Filtration test (02.07.2024)

With Electrofilter





With cooling system on

Without electro-filter

2.23 Cleaning Electro-Filter (8.7.24)

Today (8.7.24), we cleaned the electric filter using its dedicated tools and followed the instructions.

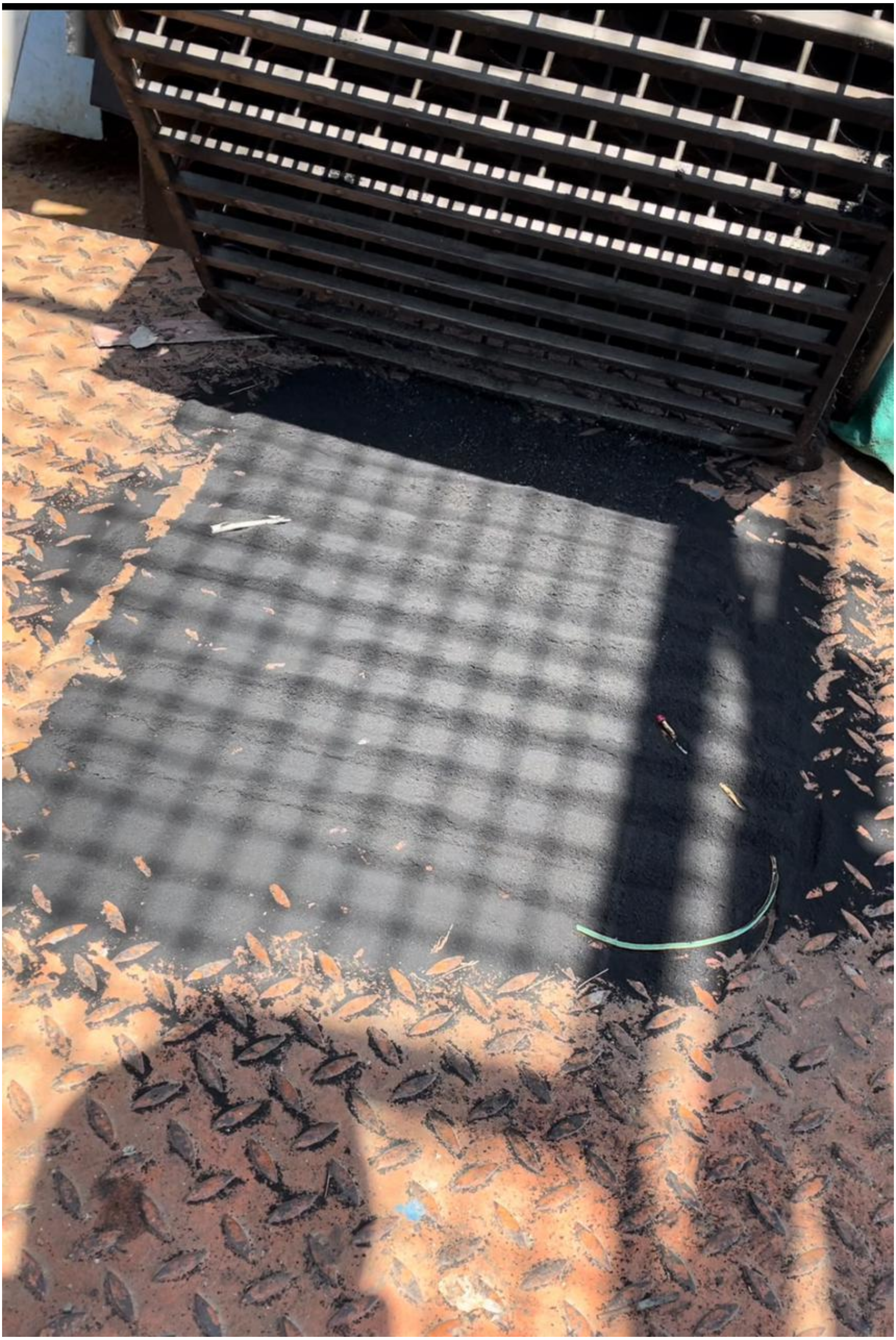
Here are some pictures of the cleaning process:

To download the Video:

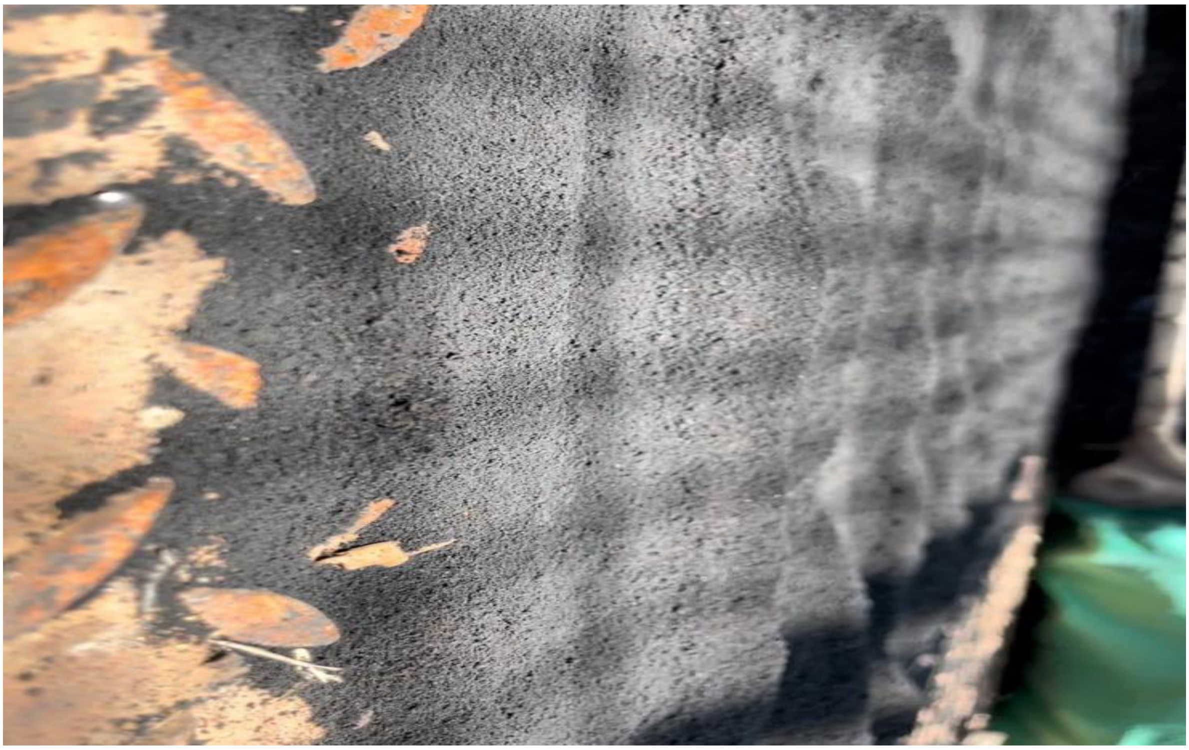
WhatsApp Video
2024-07-08 at 9.46.3

Cleaning Electro-Filter (8.7.24)

Project 2: Improvement of Filter System in Incinerator Power Plant 2023/24



Filtration test



2.24 Filtration test

In this test, we added 45 kg of waste inside the incinerator and made the test,

Unfortunately, the Electro-Filter didn't work due to the Troubleshooting Diagnostic code C03 (Short Fault) and C08 (Sparking) caused by our cleaning the filters and we didn't follow the instructions in the data sheets, which caused the Electro-Filter to stop working

Here is the Video of the test:

WhatsApp Video
2024-07-08 at 9.46.3

Here are some pictures related to:

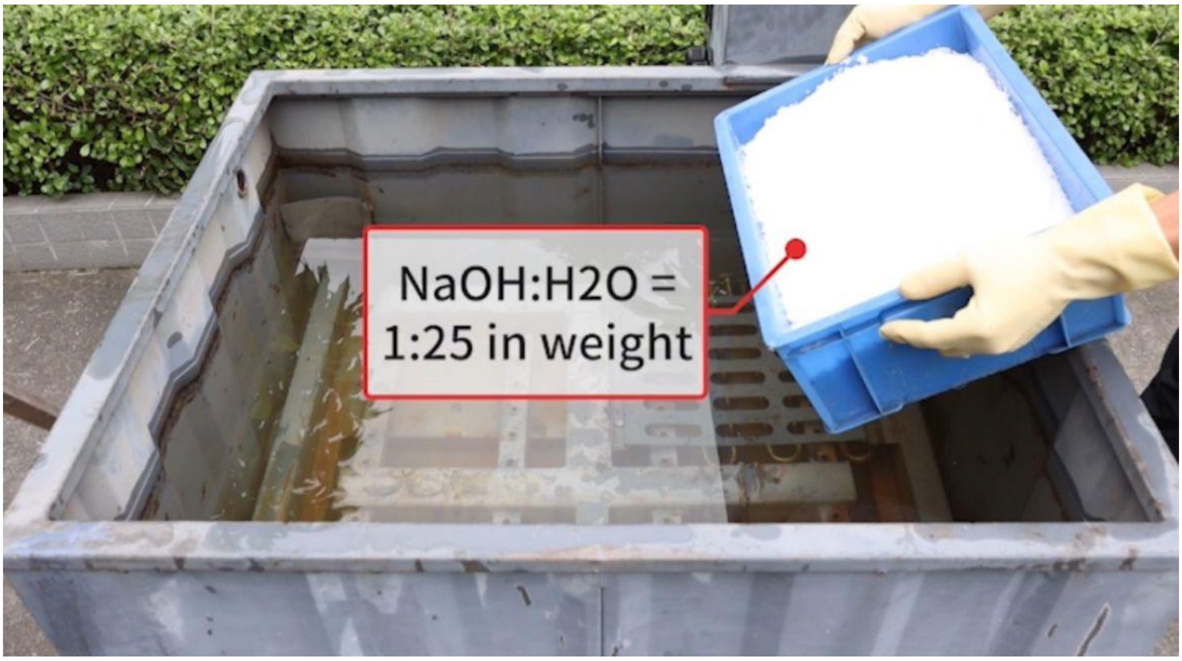
Filtration test

C03 (Short Fault)

C08 (Sparking)

2.25 The right way to clean the Filters

First of all, add NaOH: H2O in ratio of 1:25 in weight to a water container of 75℃ water or above

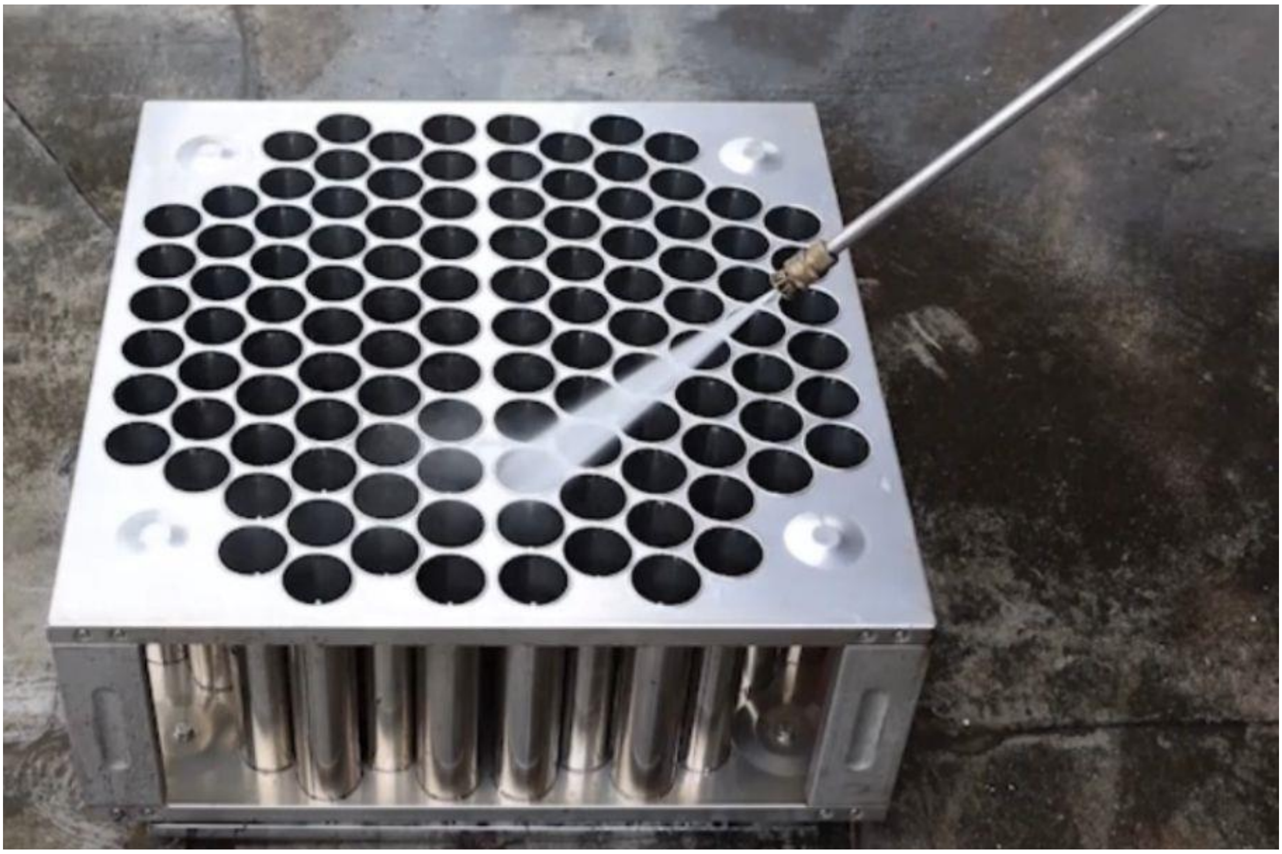


Mix the Mixture Well

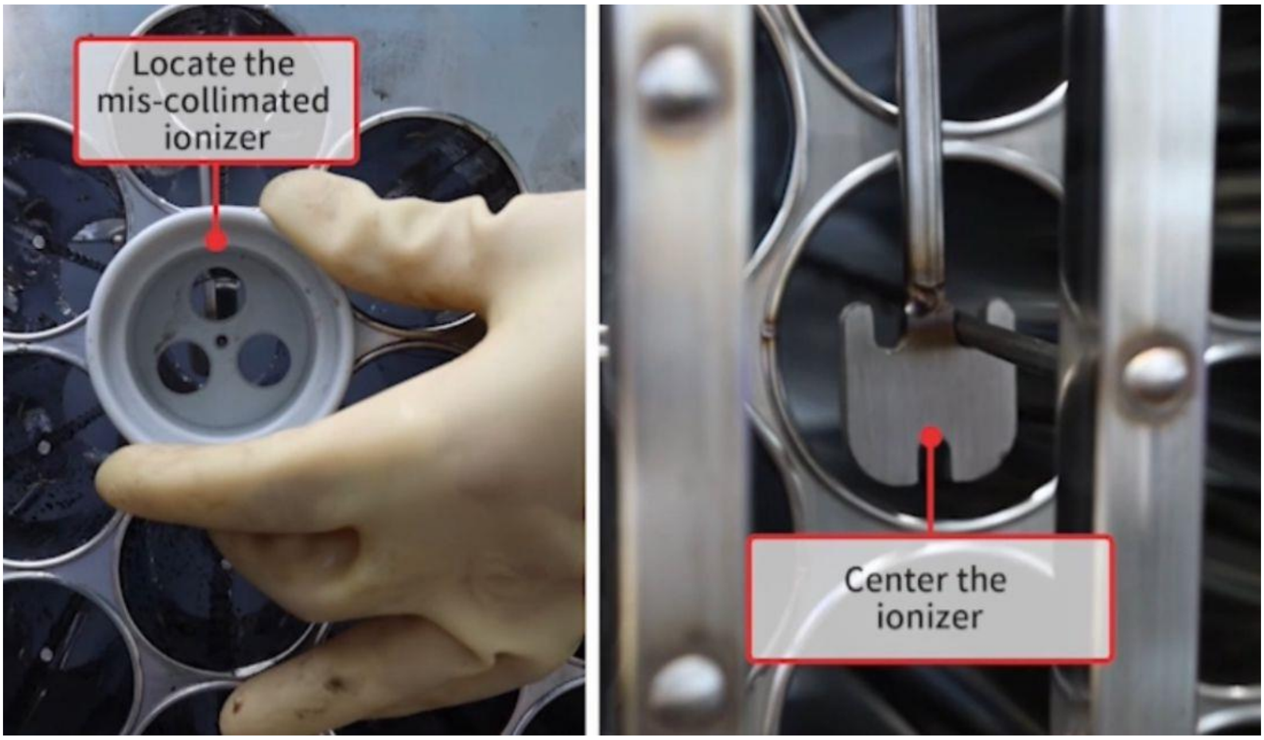
Put the filter inside the container for 20 minutes to let the caustic soda do its job

Use the wash brush to clean the filters tubes if too much oil

Wash filter cells with a pressure water gun



Adjust the cathode needle to the central position by needle adjuster



2.26 Cleaning Electro-Filter using KLEAN LAND Technique (11.07.2024)

2.26.1.1 Materials Needed

- NaOH (Sodium Hydroxide)
- Water
- Container capable of holding hot water (preferably a repurposed diesel tank)
- Heating resistor to maintain water temperature
- Wash brush
- Pressure water gun
- Needle adjuster

2.26.1.2 Preparation

- **Prepare the cleaning solution**
  - Mix NaOH and water in a ratio of 1:25 by weight. For example, if you use 1 kg of NaOH, you will need 25 kg (or liters) of water.
  - Ensure the water temperature is 75°C or higher for optimal effectiveness. Ideally, the temperature should be around 80°C.

- **Prepare the cleaning container:**
  - Use a diesel tank for this purpose. First, cut off the top of the tank to create an open container.
  - Clean the tank thoroughly to remove any residual diesel or contaminants.
  - Install a heating resistor in the tank to maintain the water temperature at 80 °C.

2.26.1.3 Cleaning Process (Leaching)

- **Soaking the filter:**
  - Place the electro-filter inside the container.
  - Let the filter soak in the solution for 20 minutes. This allows the caustic soda (NaOH) to break down and loosen any accumulated dirt and oil.

- **Brushing the filter:**
  - Use a wash brush to clean the filter tubes, especially if there is excessive oil build-up.

- **Rinsing the Filter:**
  - After soaking and brushing, rinse the filter cells using a pressure water gun. This will remove any remaining cleaning solution and dislodged debris.

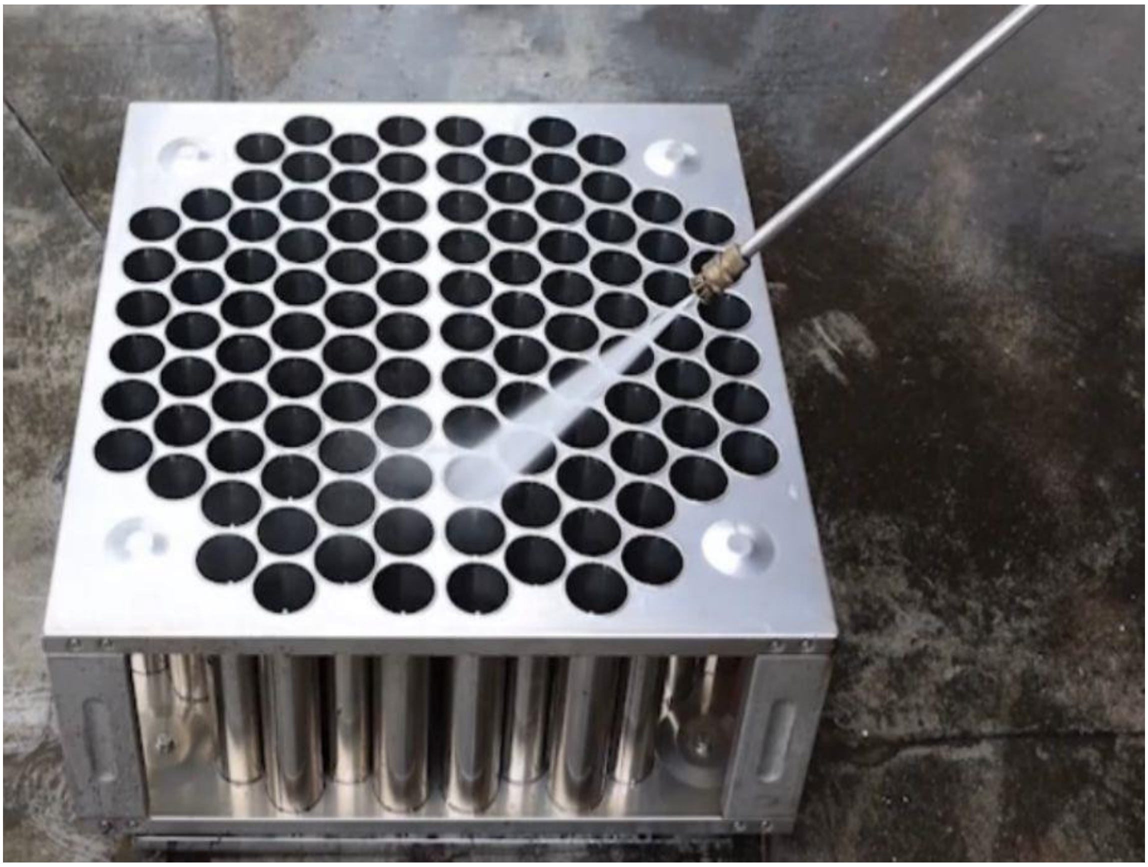
- **Adjusting the Cathode Needle:**
  - Use a needle adjuster to position the cathode needle centrally. Proper adjustment is crucial for the optimal performance of the electro-filter.

Following these steps, the electro-filter will be thoroughly cleaned and maintained using the KLEAN LAND technique. This ensures its efficiency and longevity in capturing pollutants and maintaining air quality.

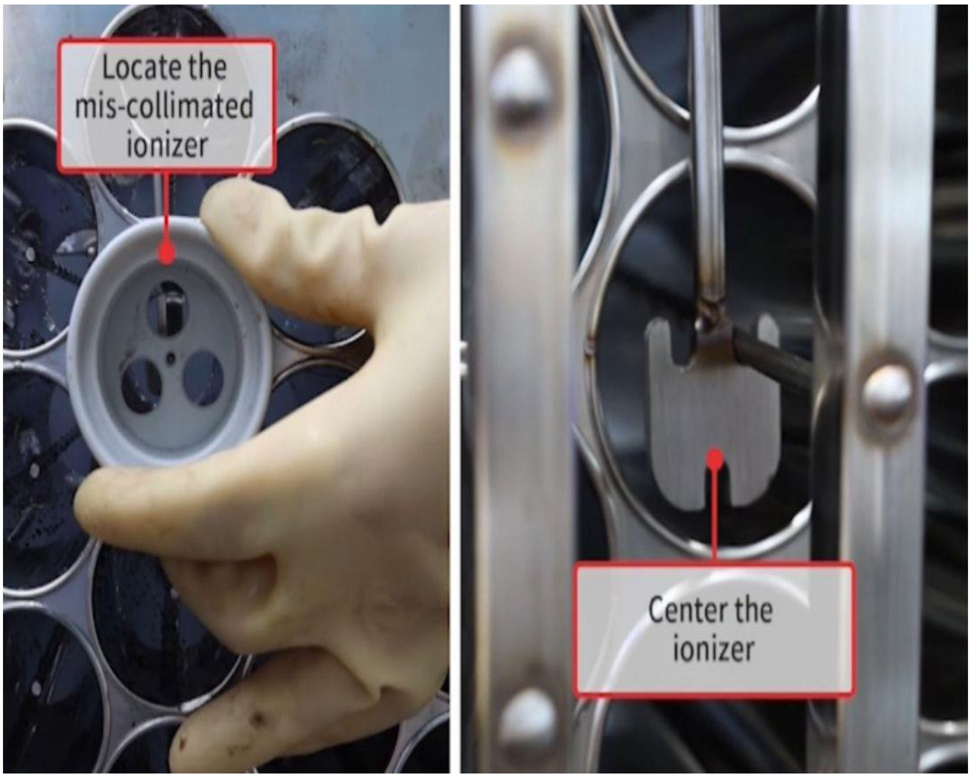
- **Mixing the Solution:**

  - Pour the NaOH and water mixture into the prepared container.
  - Stir the mixture well to ensure an even distribution of the NaOH.

Cleaning Electro-Filter using KLEAN LAND Technique (11.07.2024)



Here is how our cleaning of the Electro-Filter was done



2.27 Here is how our cleaning of the Electro-Filter was done

2.27.1 First, we brought a Plastic tank

2.27.2 Second, we cut its top

2.27.3 Third, we clean it

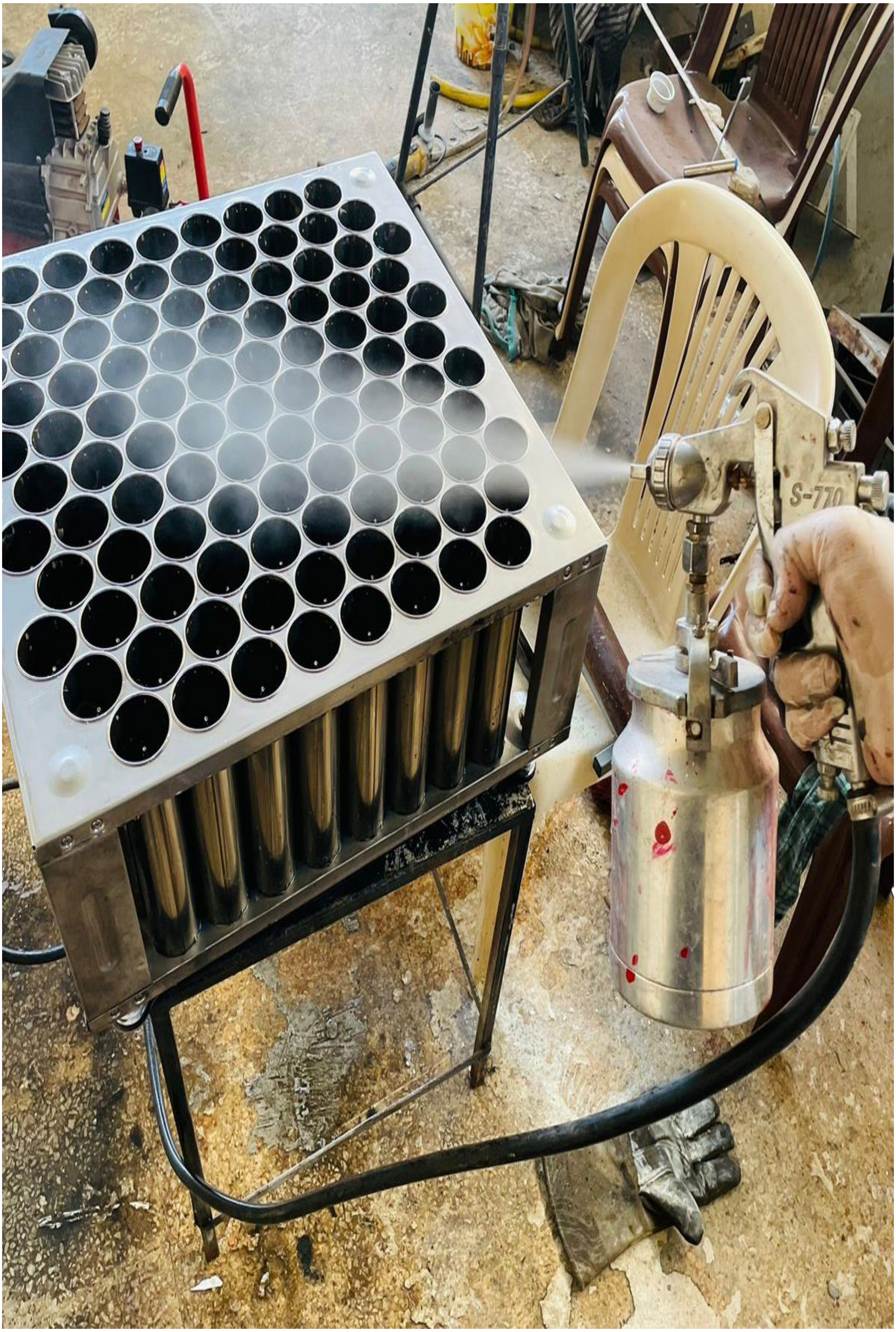
2.27.4 Fourth, we bought a resistor to get the water to 80 degrees, which is best for NaOH solution

2.27.5 Fifth, we filled the tank with water

Here is how our cleaning of the Electro-Filter was done

Here is how our cleaning of the Electro-Filter was done

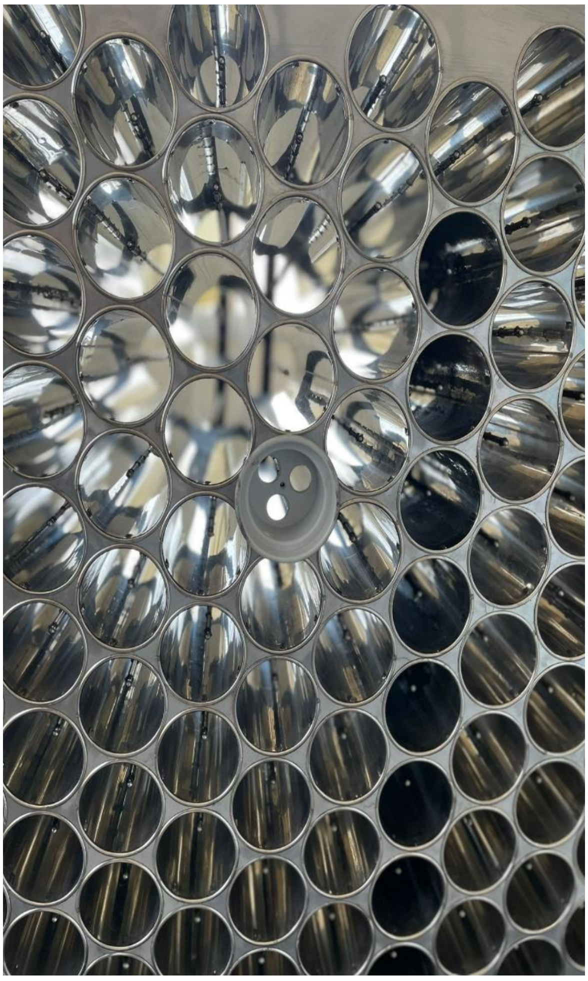
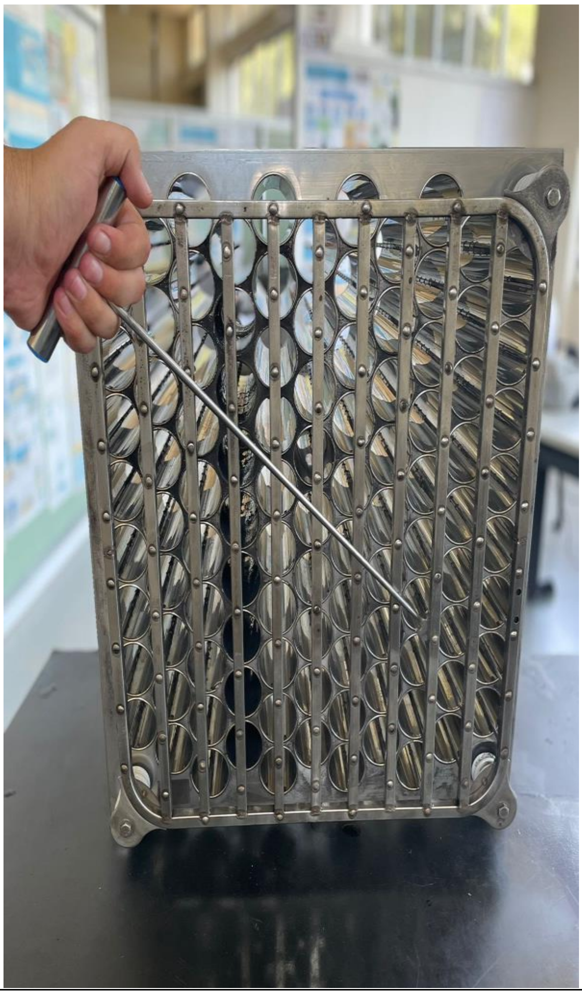
Here is how our cleaning of the Electro-Filter was done




S-770

Here is how our cleaning of the Electro-Filter was done



بسم الله الرحمن الرحيم

AECENAR
Association for Economical and Technological Cooperation in the Euro-Asian and North-African Region
www.aecenar.com

NLAP
North Lebanon Alternative Power

NLAP-WEDC REPORT 2024 – Part 3 (Reengineering and Manufactoring of Electrofilter)

With contribution of:

Amro ZAWIT

Ali DIB

Maryam EL REZ

Last Update: 11.03.2025 23:55

Table of Contents

3 Project 3: Electrofilter

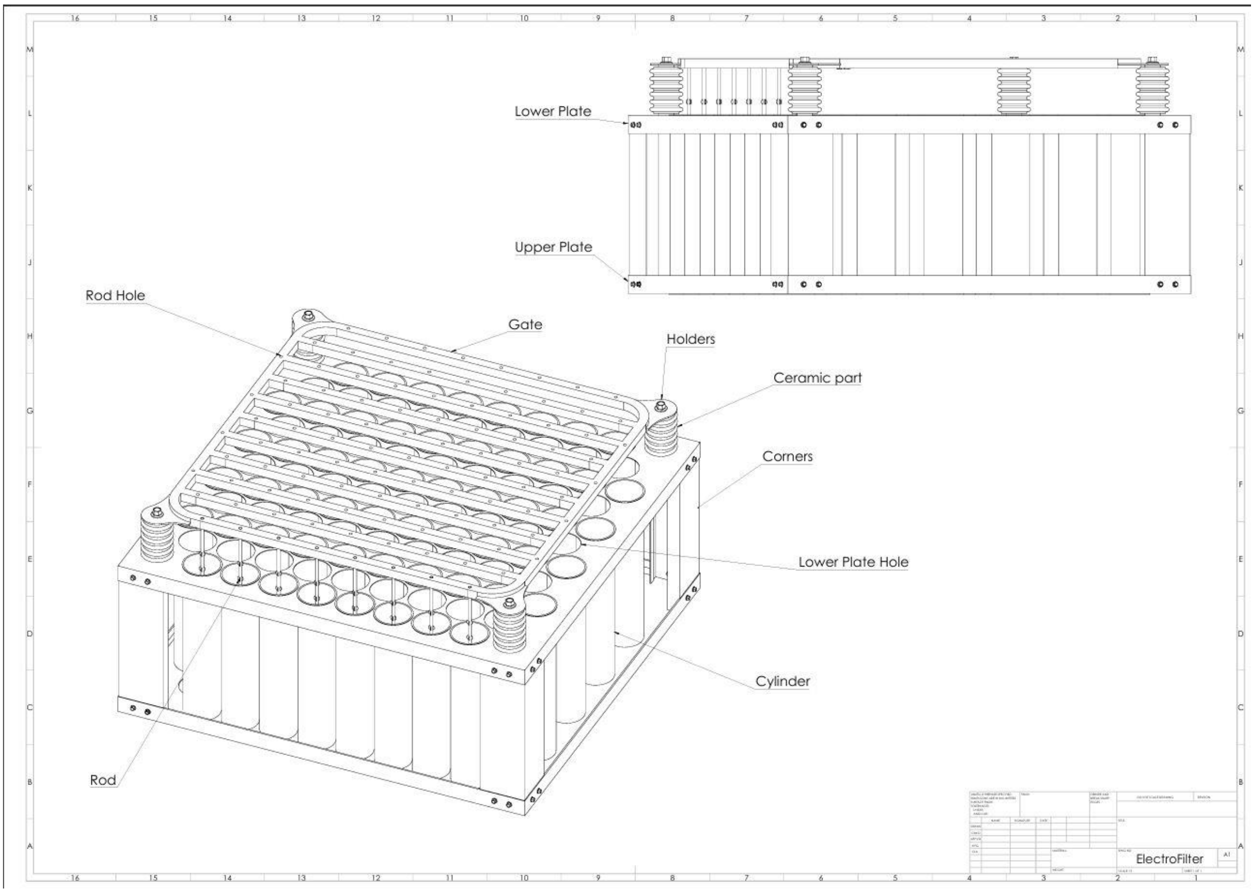
3.1 Position of Electrofilter

This project aims to locally remanufacture the electro-filter and test its efficiency.

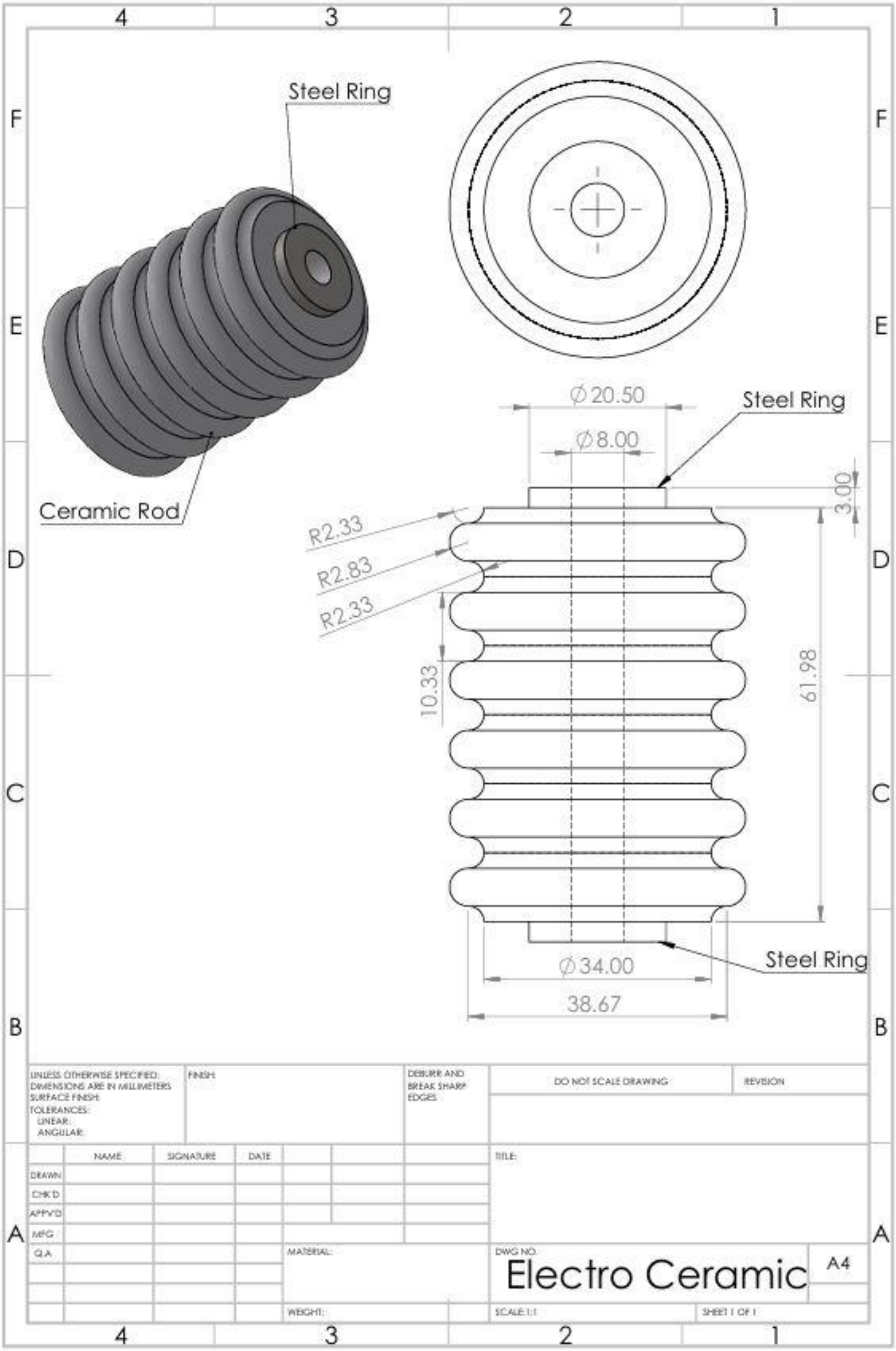
3.2 Detailing and Pricing of Each Part of the Electro Filter

The Electro Filter comprises Different Parts: Electro-Filter, Pre-Filters, Activated Carbon Filters, the outside body for all components, and finally the Control Panel.

3.2.1 The Electro Filter

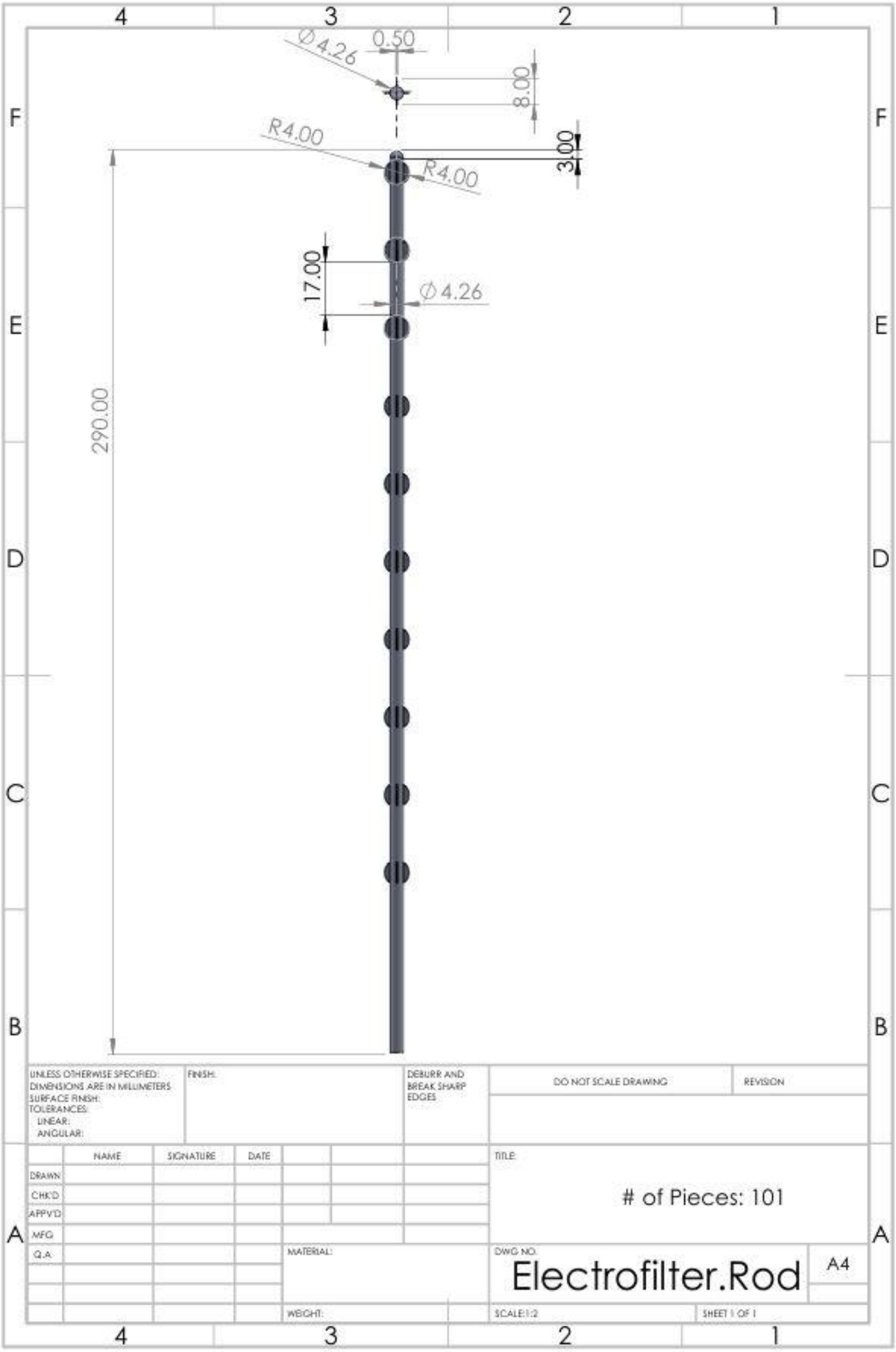


3.2.2 Ceramics



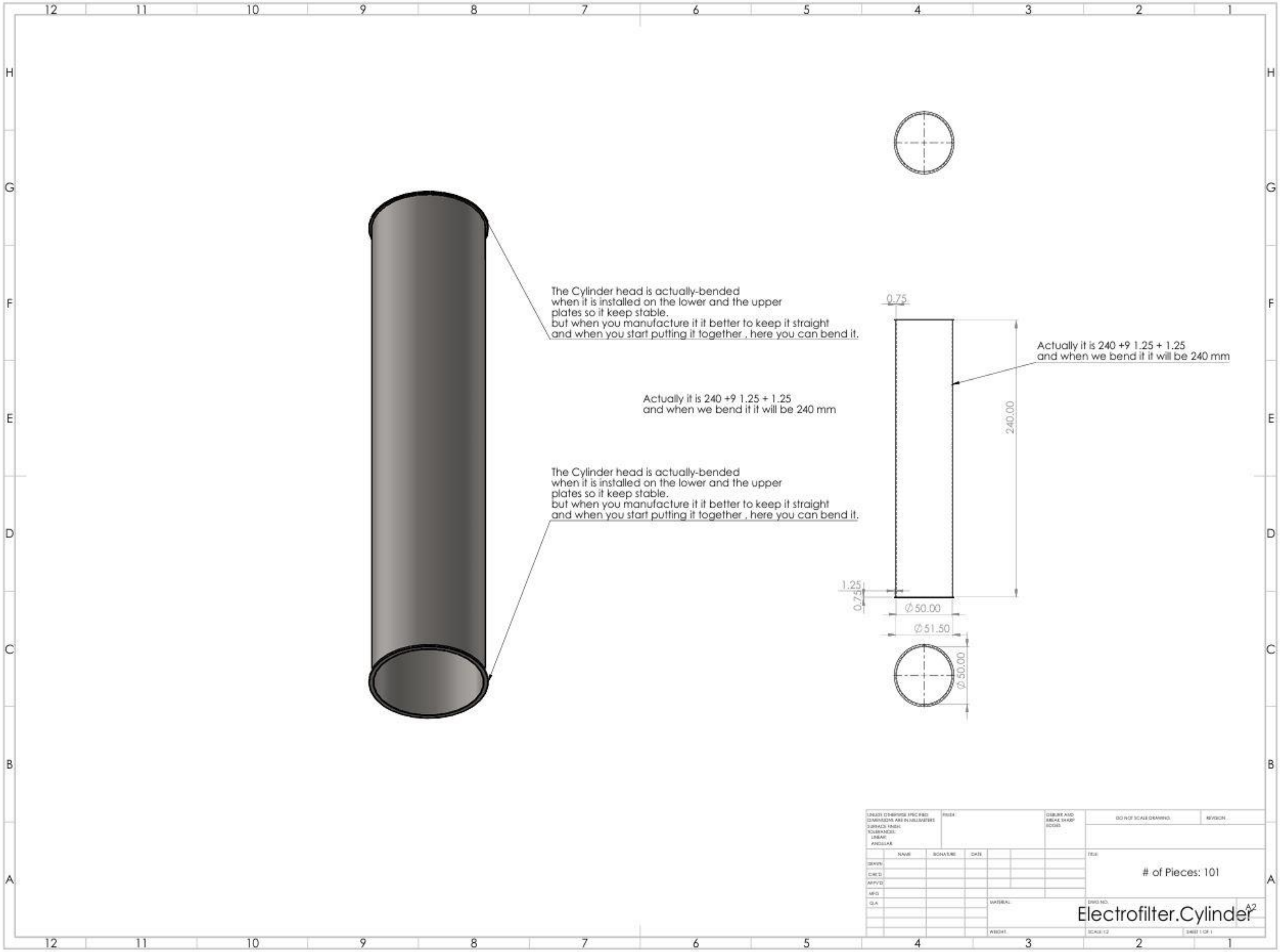
We Got 4 Ceramics

3.2.3 Rods



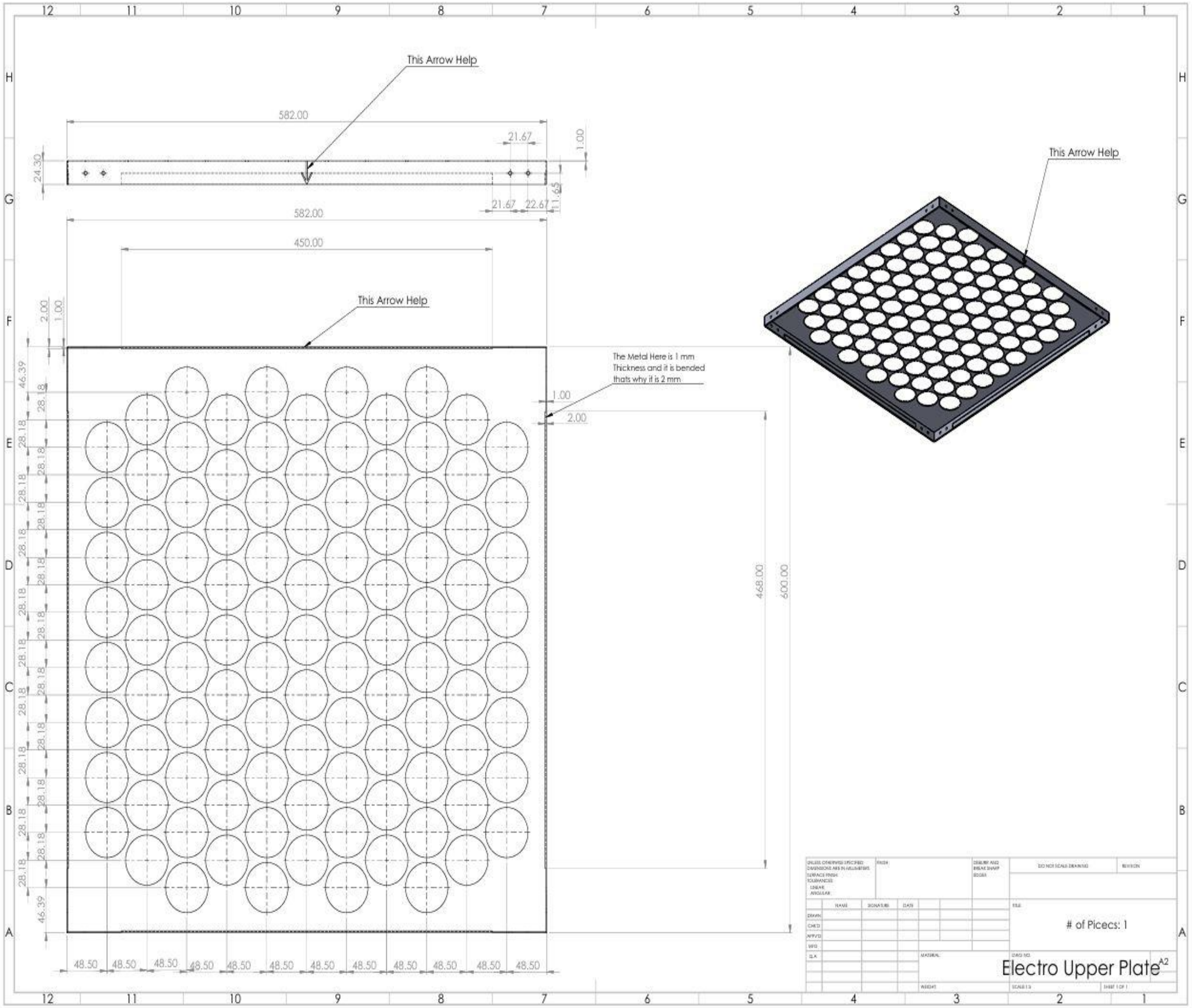
We got 101 Rods

3.2.4 Cylinders



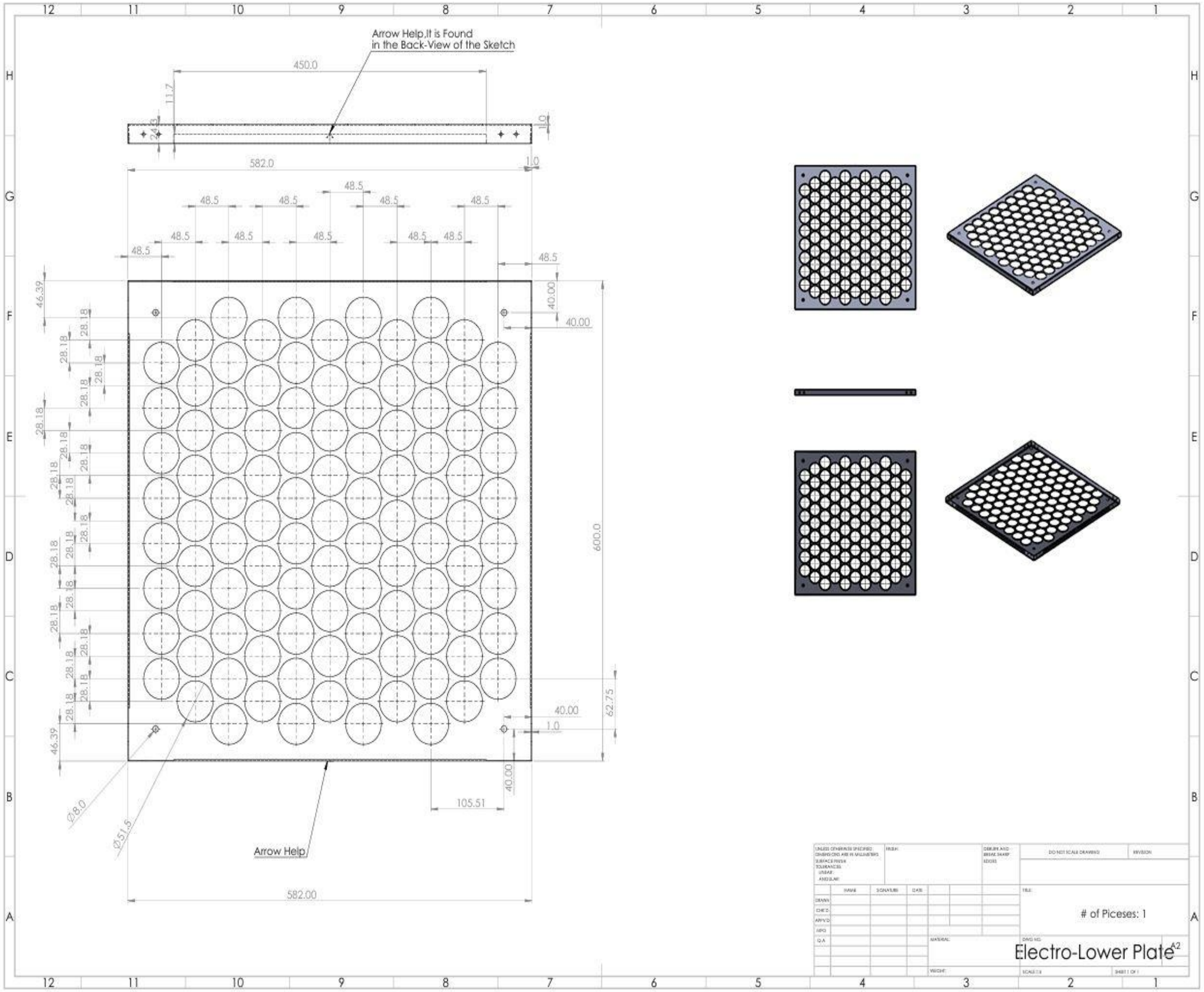
We got 101 Cylinders

3.2.5 Upper Plate



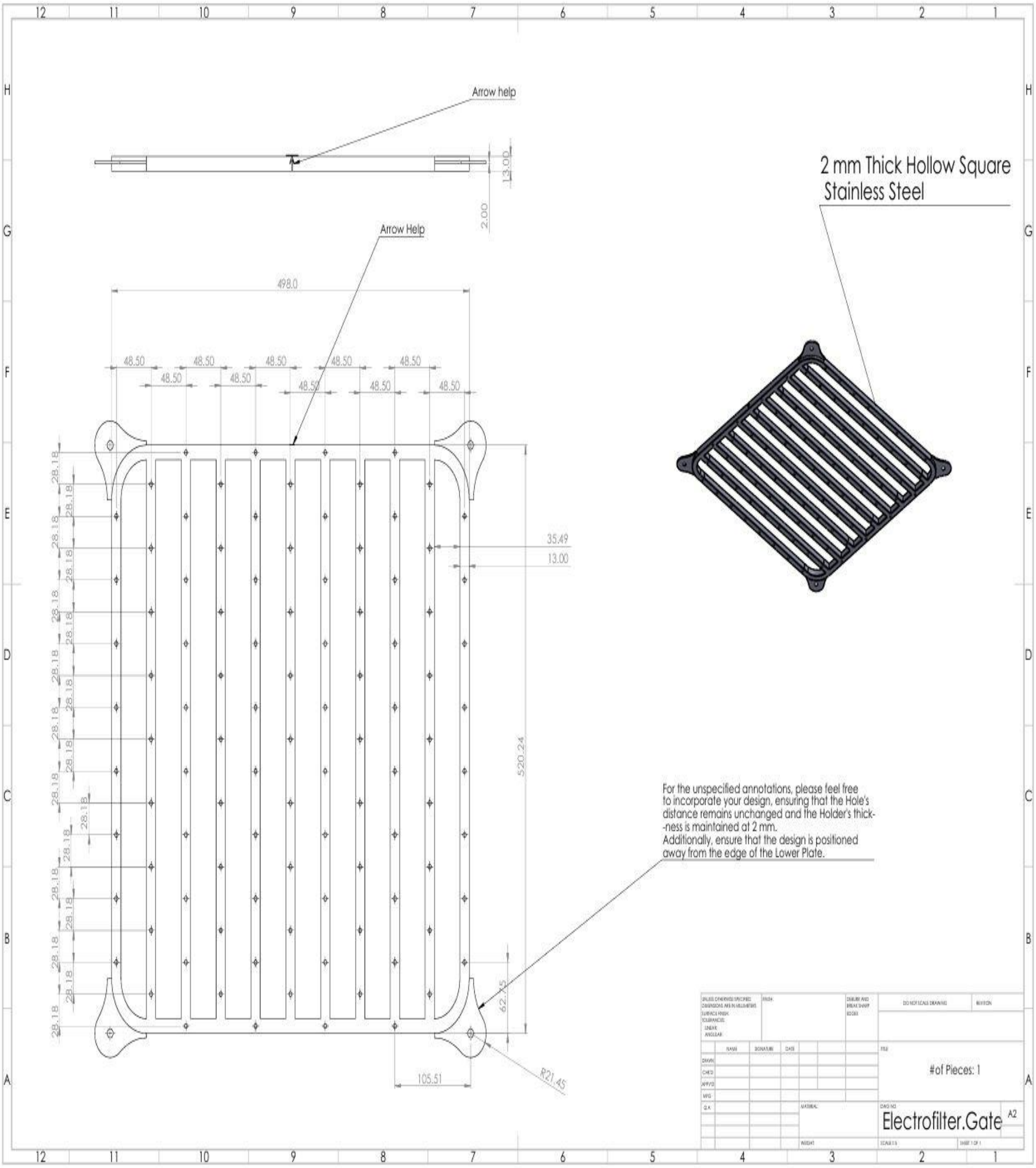
We have 1 Upper Plate

3.2.6 Lower Plate



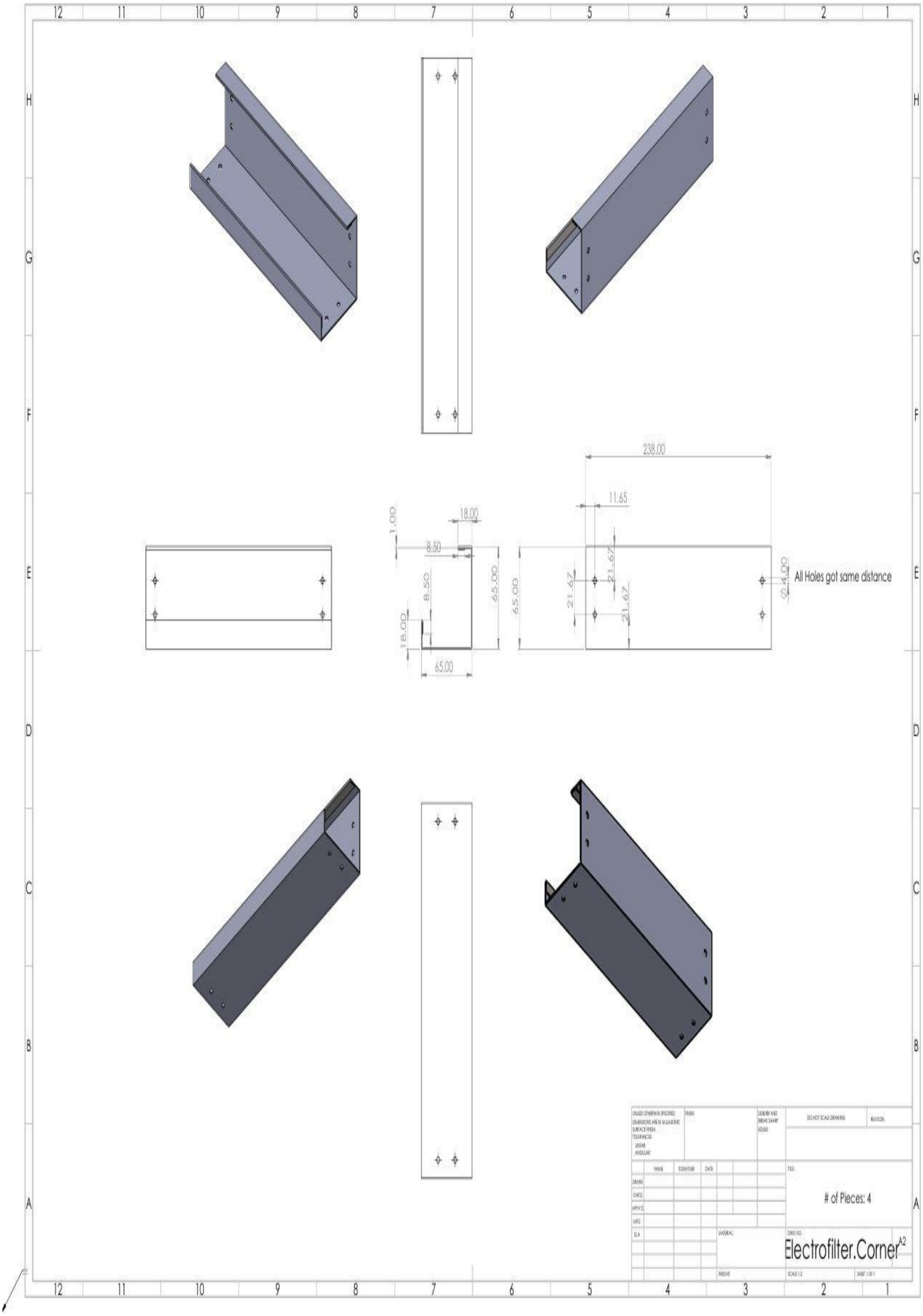
We got 1 Lower Plate

3.2.7 Gate



We got 1 Gate

3.2.8 Corners



We Got 4 Corners

3.2.9 CAD Files

- **FreeCad.Files.26092024**

Free Cad.rar

- **Step.Files.26092024**

Step Files.rar

3.3 Realization of Electrofilter (2024) - Film

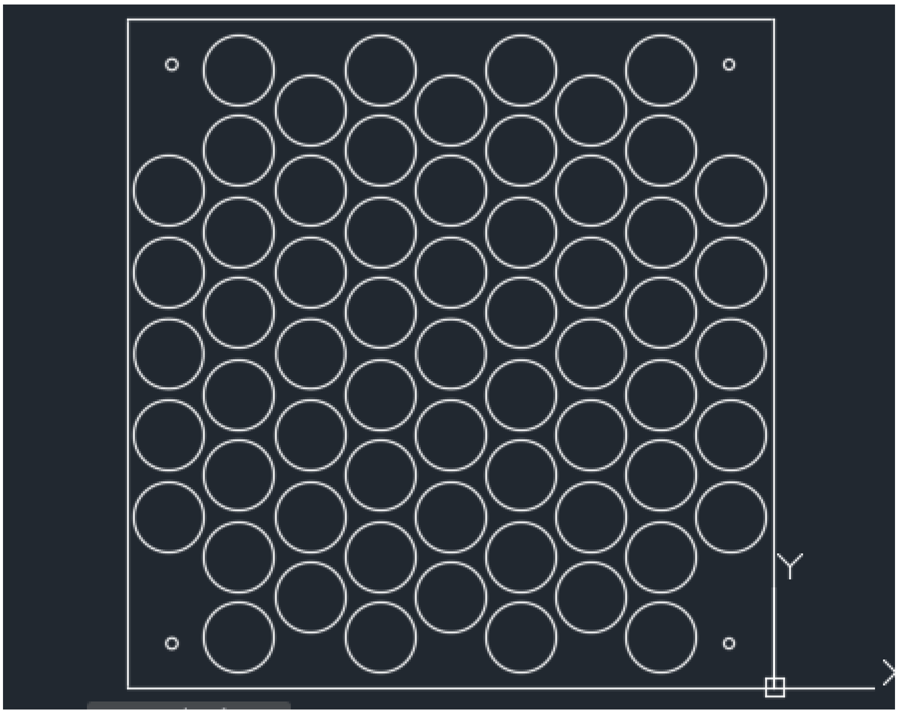
ElectrofilterProductionVideo 2025-01-17

3.4 Electrofilter design

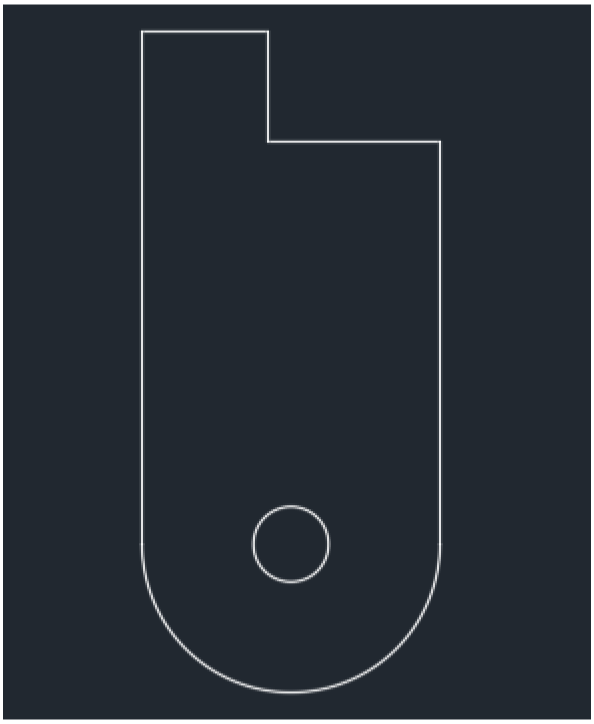
3.4.1 Autocad 2D

1) Lower plate

Lower plate.DWG

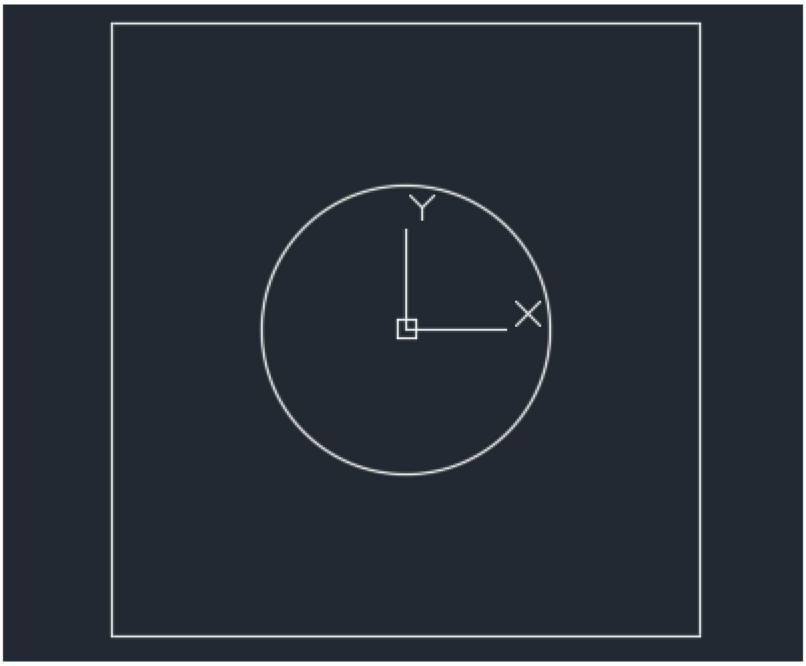


2) Gate holder



Gate Holder.DWG

3) Nuts for electrode

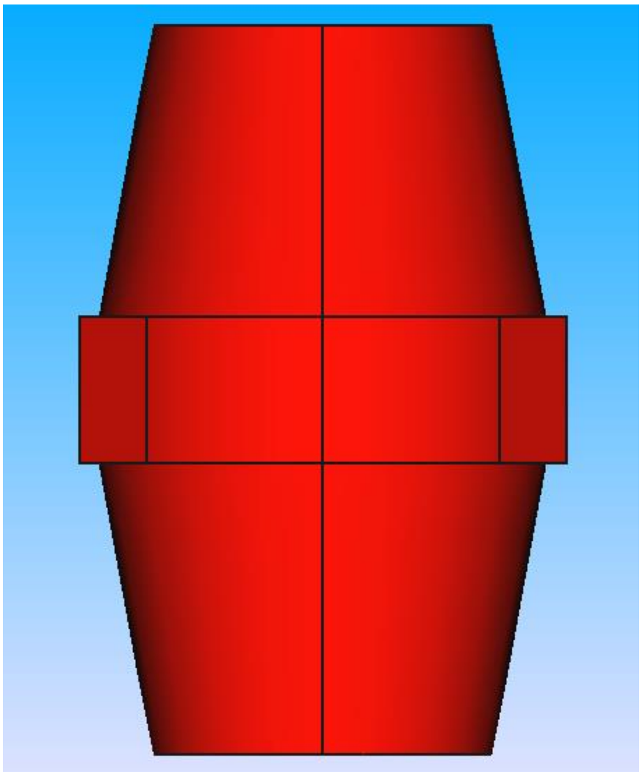


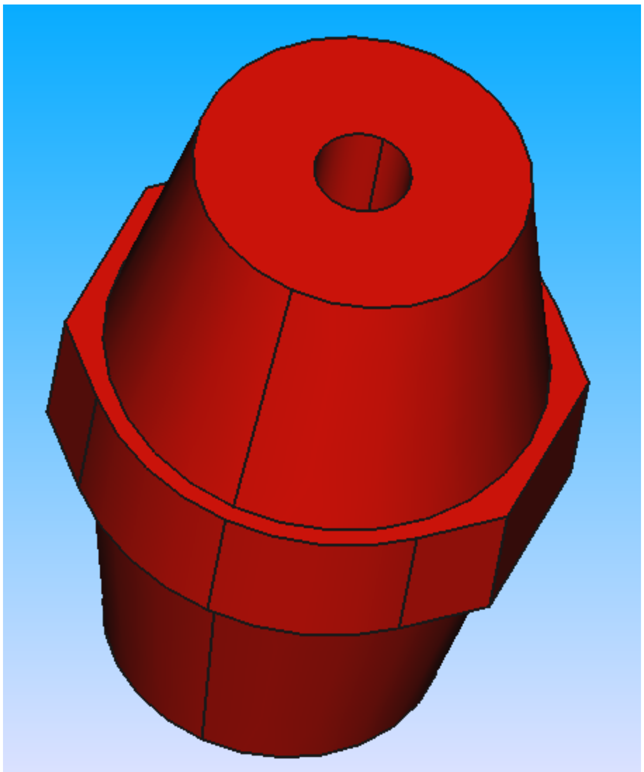
nuts for electrode.DWG

3.4.2 FreeCAD

1) ElectroFilter. BUS-BAR insulators code.SM-76

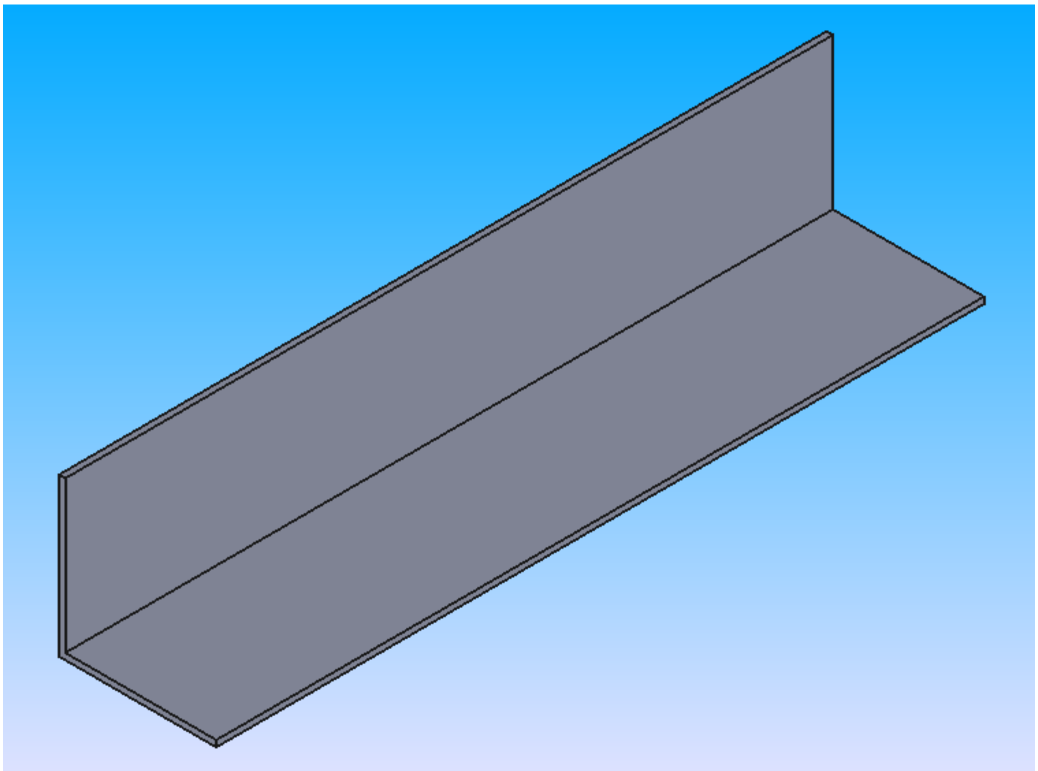
ElectroFilter.
BUS-BAR insulators (





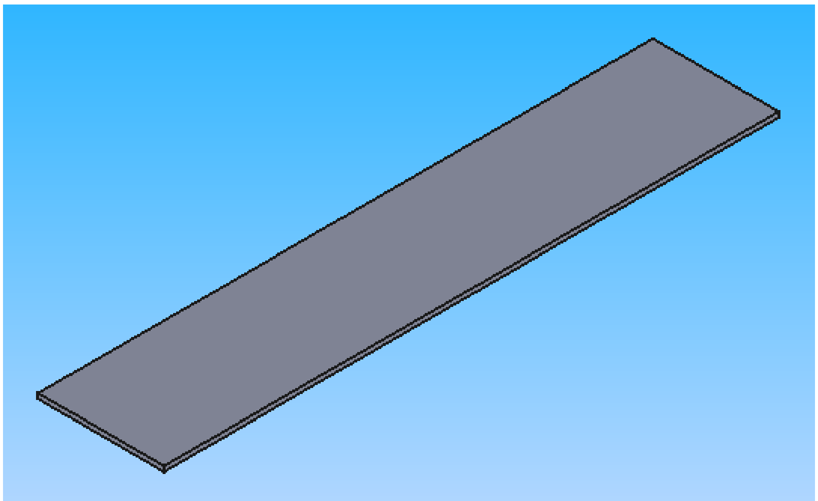
2) ElectroFilter. Corener fore cylinder holder plate

ElectroFilter.
Corener fore cylinde



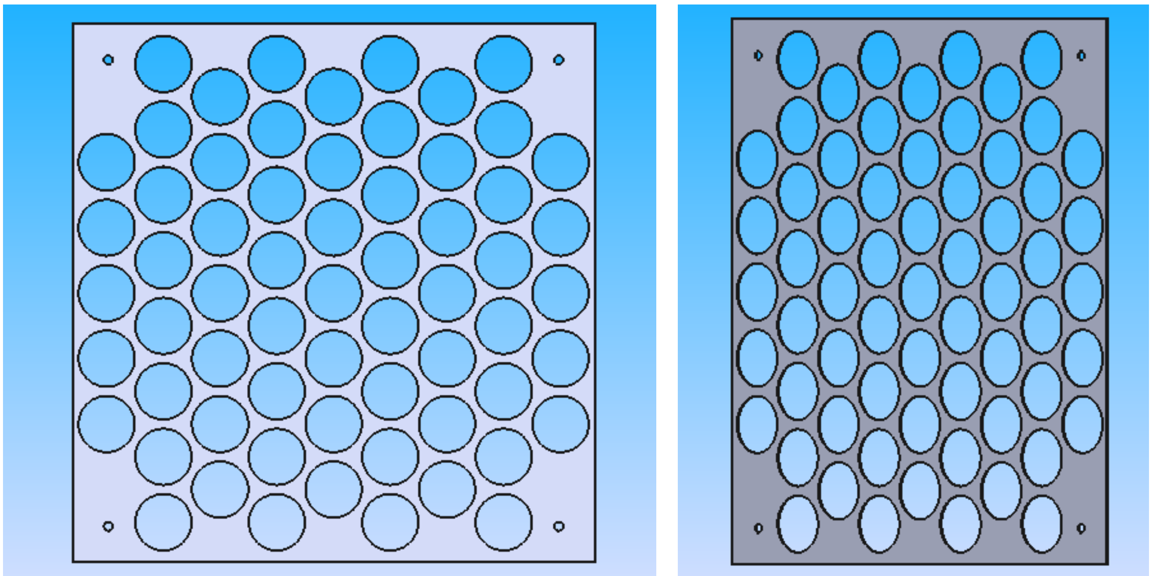
3) ElectroFilter. Corner one side for the cylider holder plate

ElectroFilter. Corner
one side for the cyli



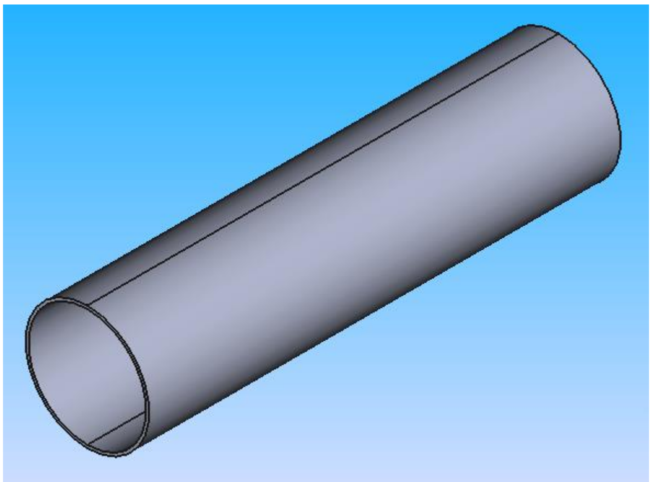
4) ElectroFilter. cylinder Holder plate

ElectroFilter.
cylinder Holder plat



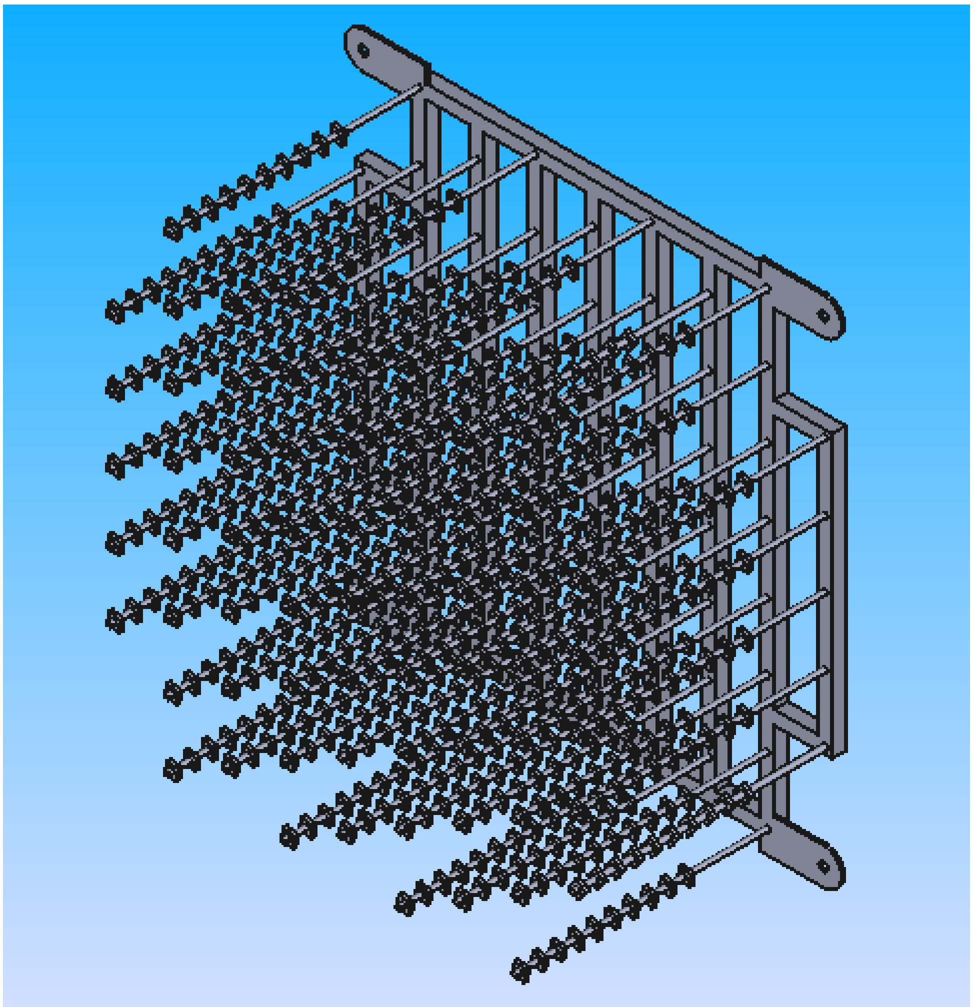
5) ElectroFilter. Cylinder

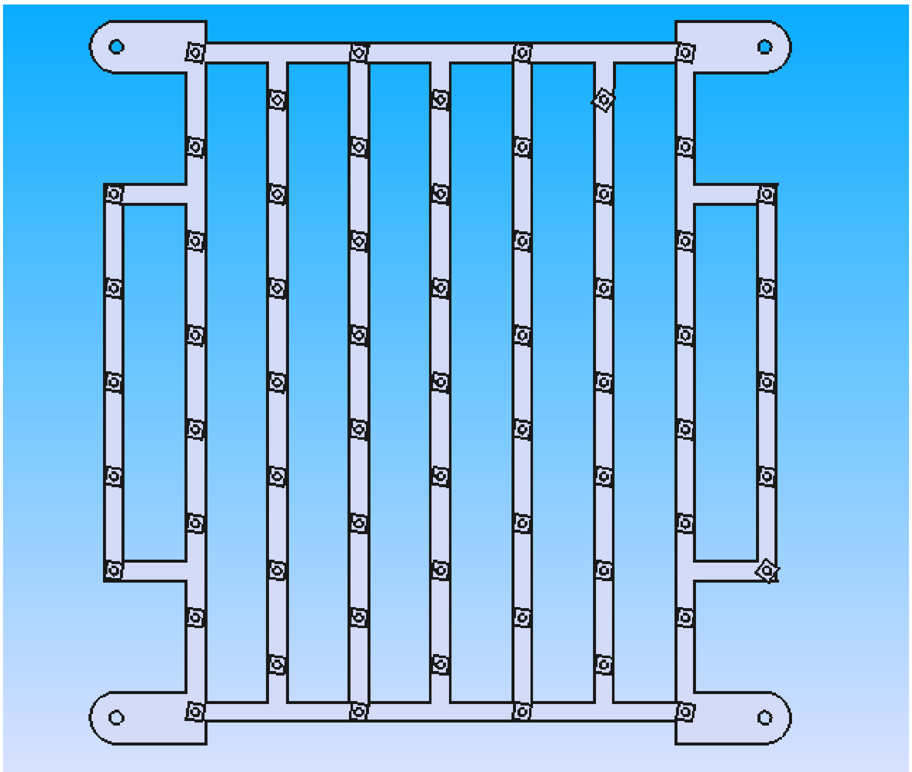
ElectroFilter.
Cylinder.FCStd

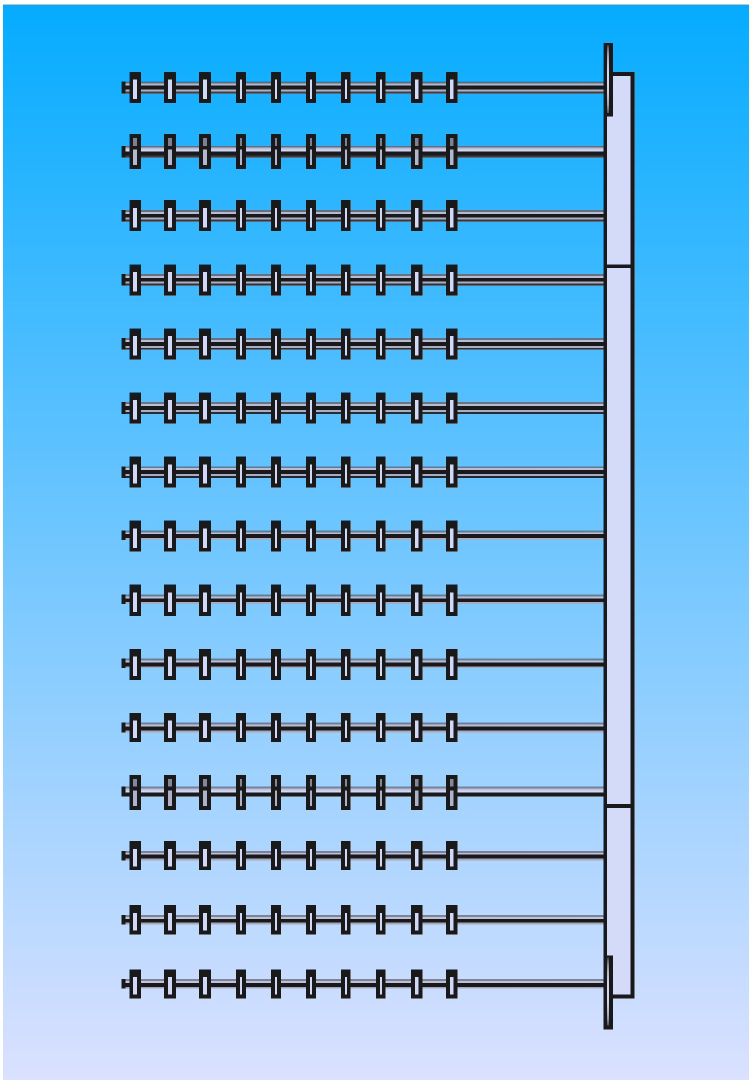


6) ElectroFilter. first part

ElectroFilter. first part.FCStd

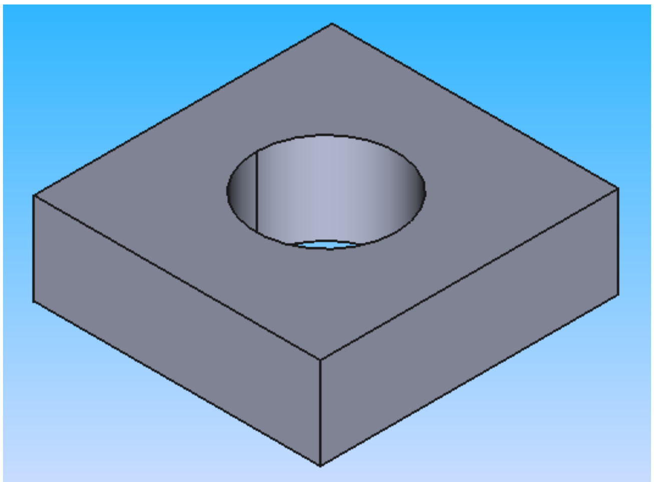






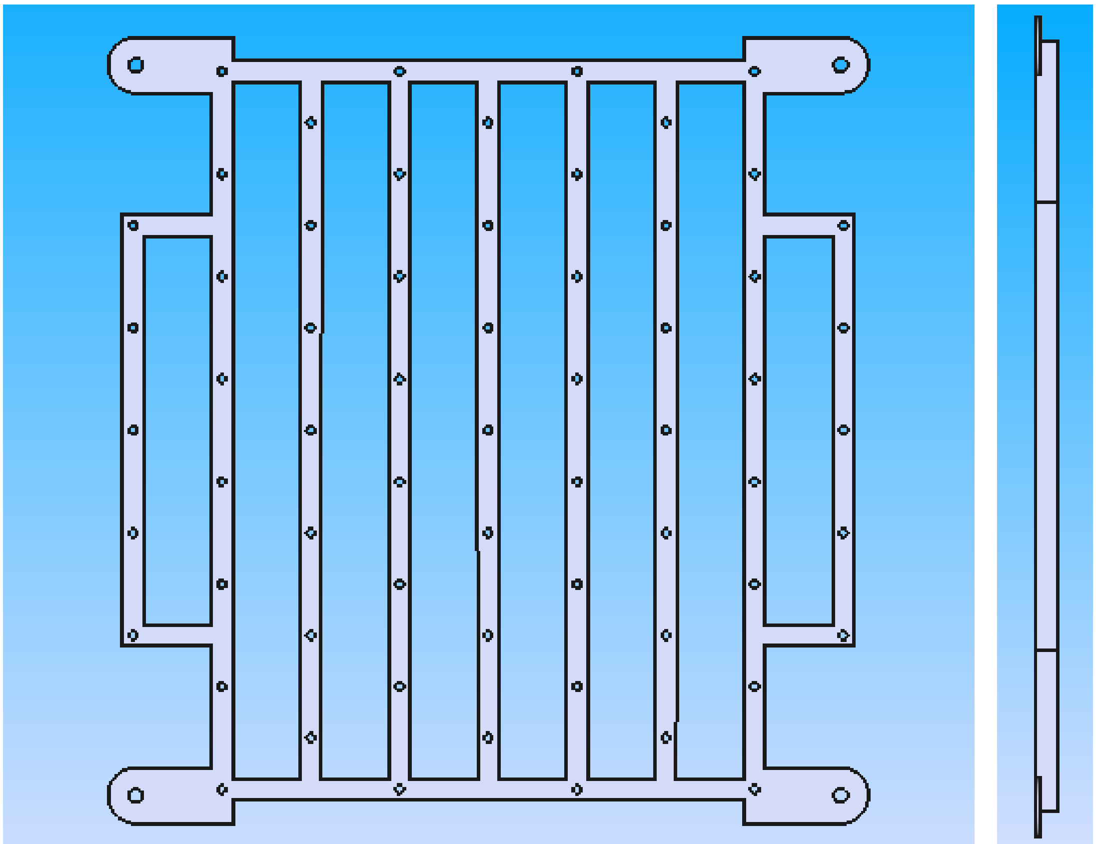
7) ElectroFilter. Nuts

ElectroFilter.
Nuts.FCStd



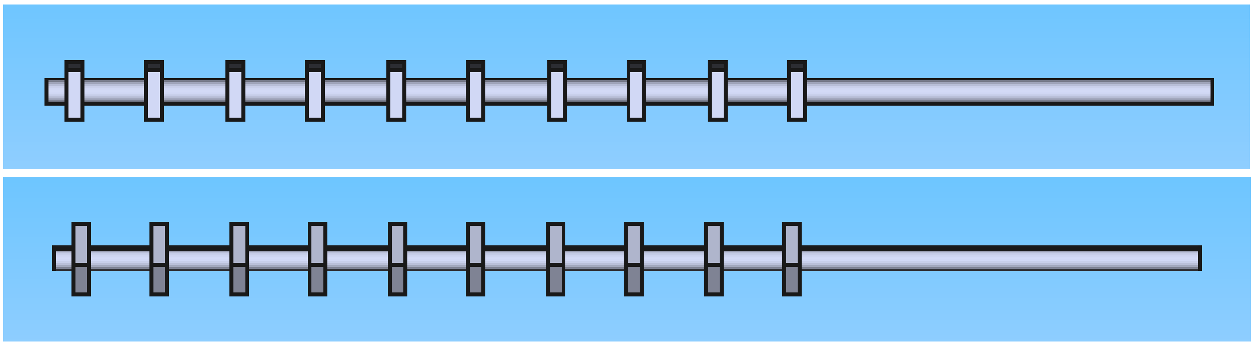
8) ElectroFilter. Rode Holder Gate

ElectroFilter. Rode
Holder Gate.FCStd



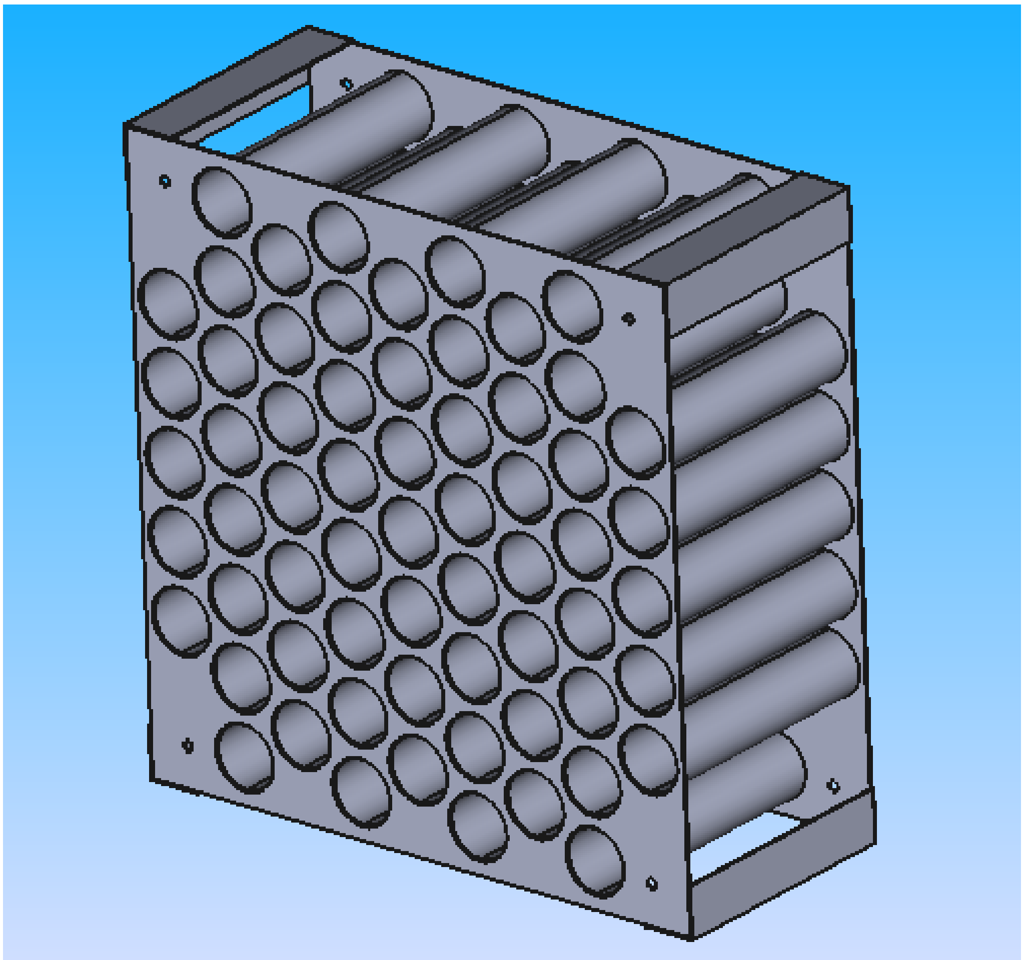
9) ElectroFilter. Rods with nuts

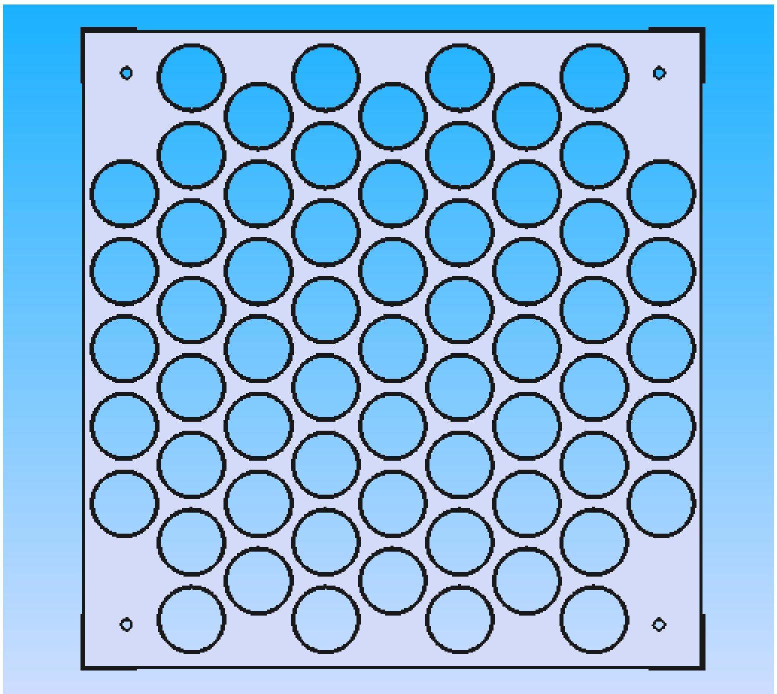
ElectroFilter. Rods with nuts.FCStd

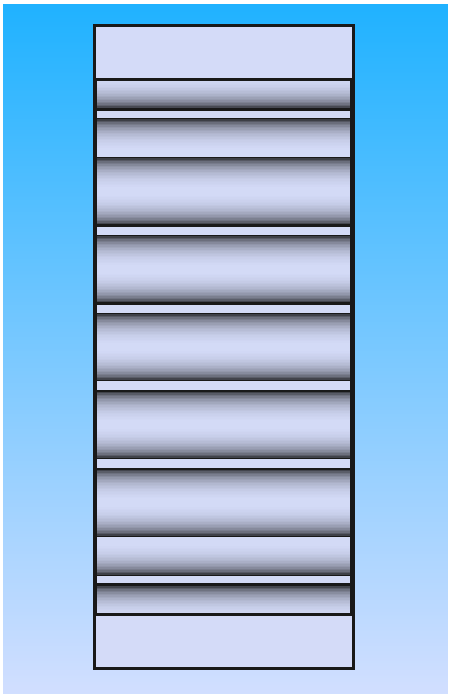


10) ElectroFilter. Second part

ElectroFilter. Secand part.FCStd

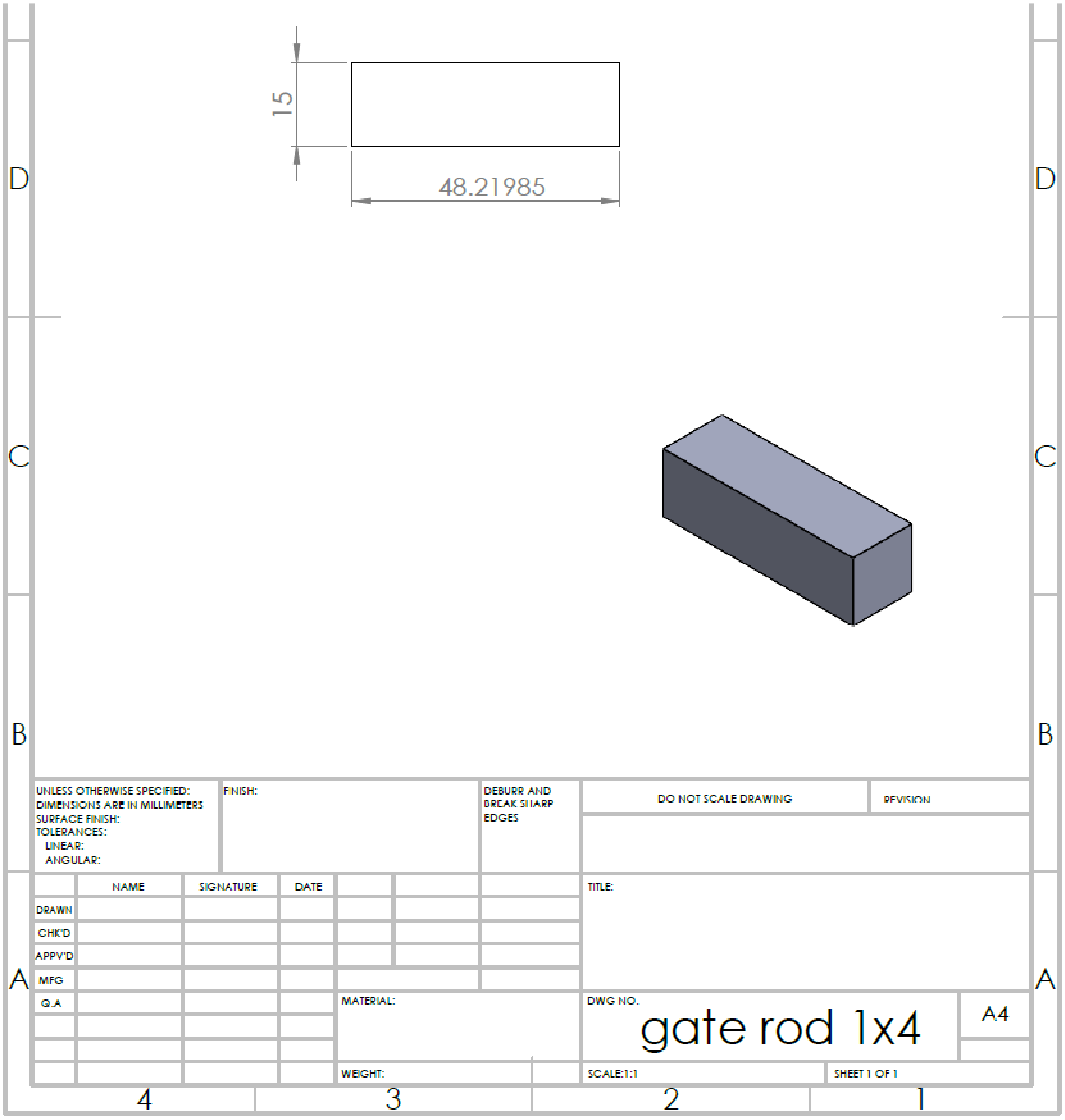






3.4.3 Pdf drawing files

A.gate rod 1x4.pdf	B.gate rod 1x4 middle rod.pdf	C.gate rod 1x3 middle rod.pdf	corner metal sheet.pdf	cylinder.pdf
D.gate rod 1x2.pdf	E.Gate Holder.pdf	electrode with nuts.pdf	F.gate rod sides 1x2.pdf	final plate parts name.pdf
final plate.pdf	nuts for electrode.pdf	plate holder.pdf	rode Electrode.pdf	SM-76 BUS-BAR INSULATORS.pdf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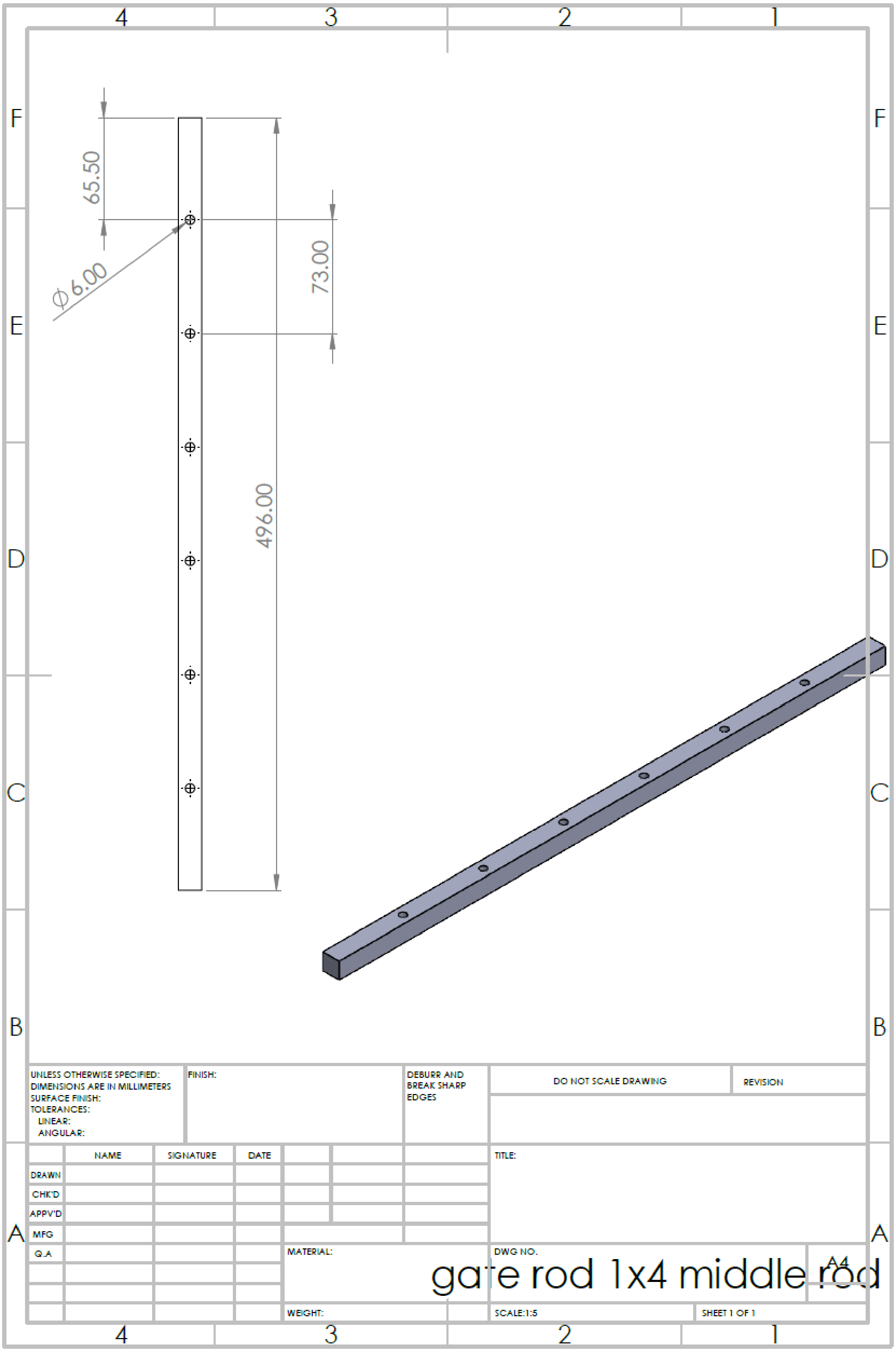

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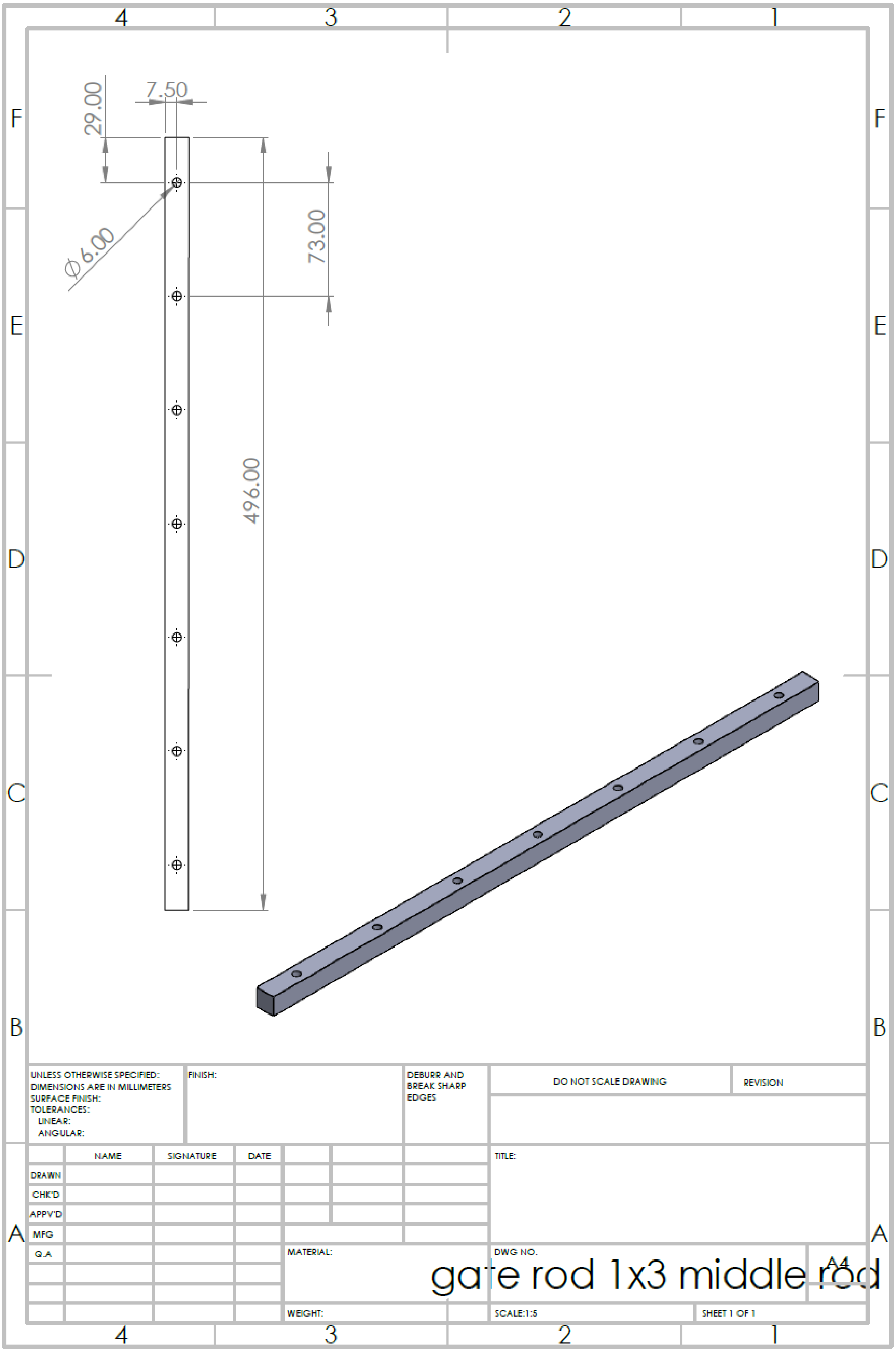
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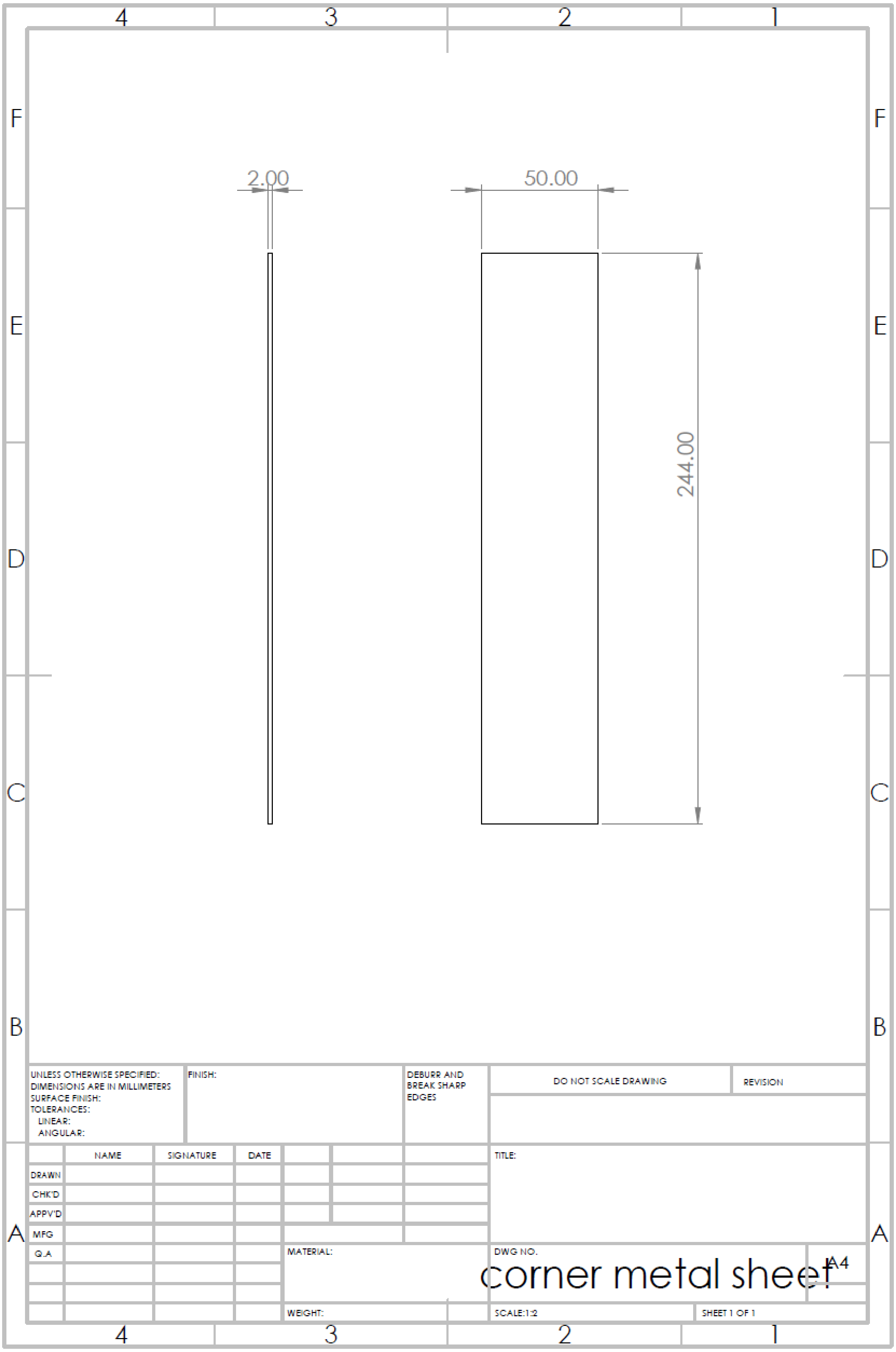
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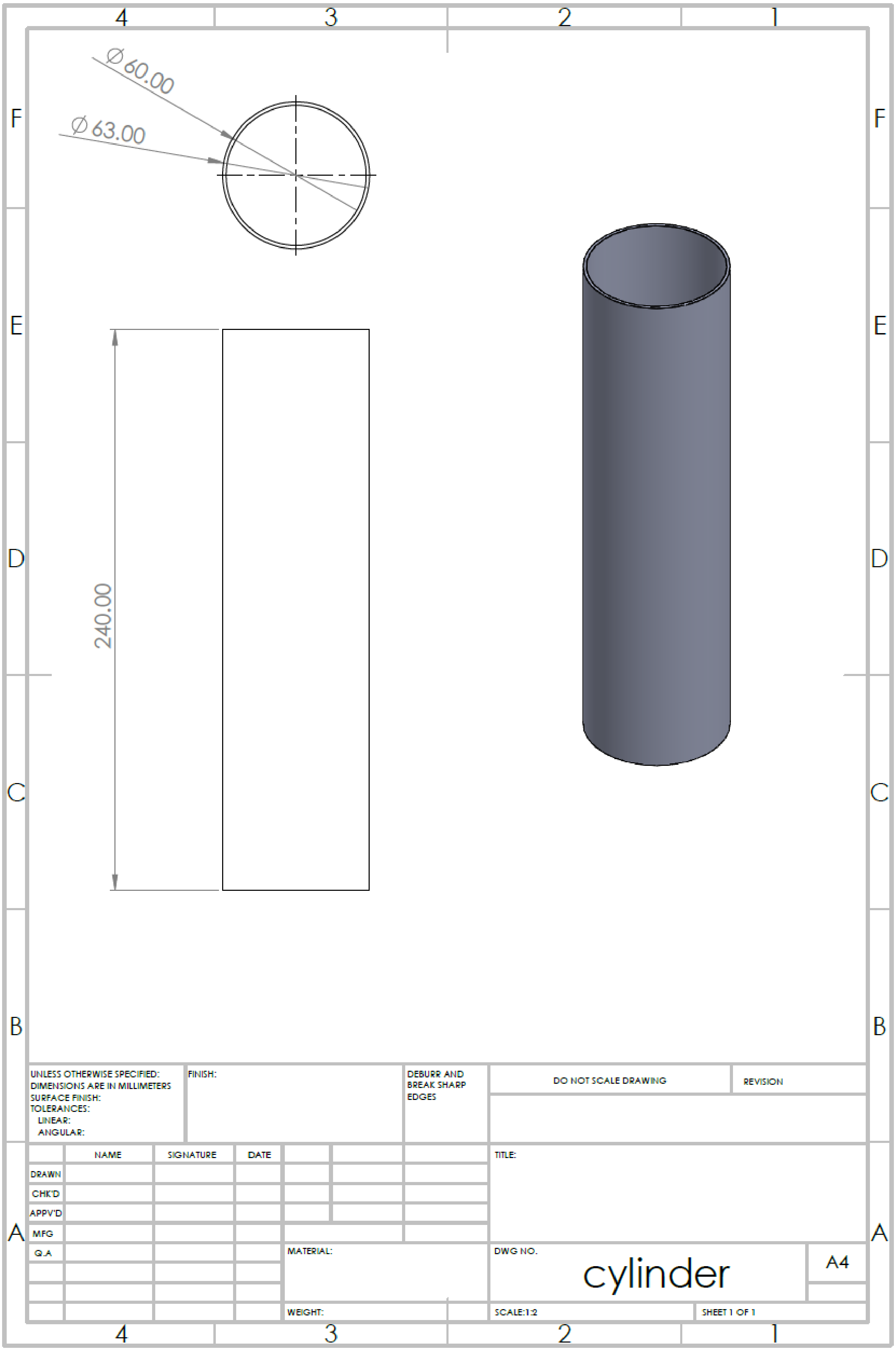
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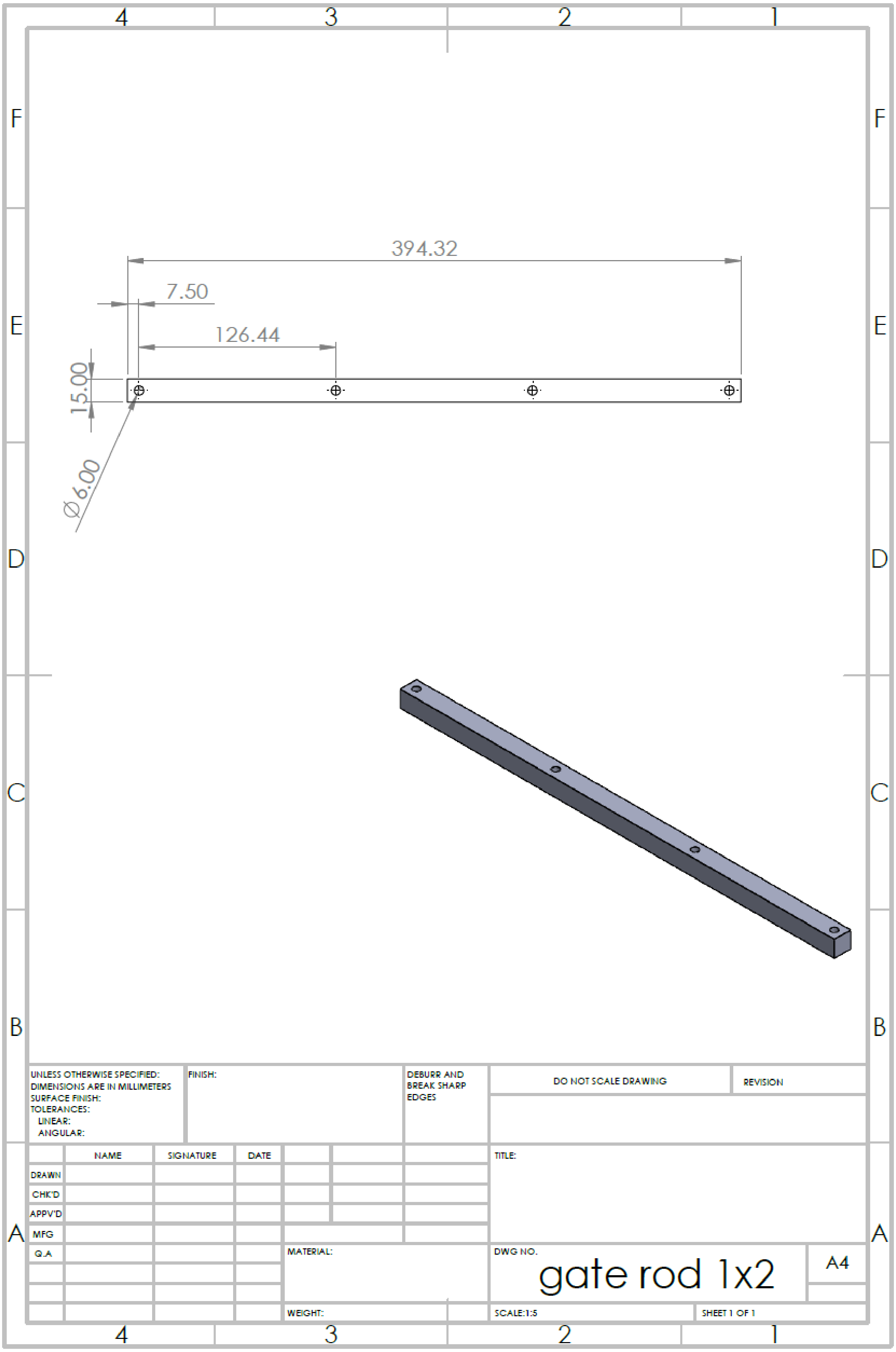

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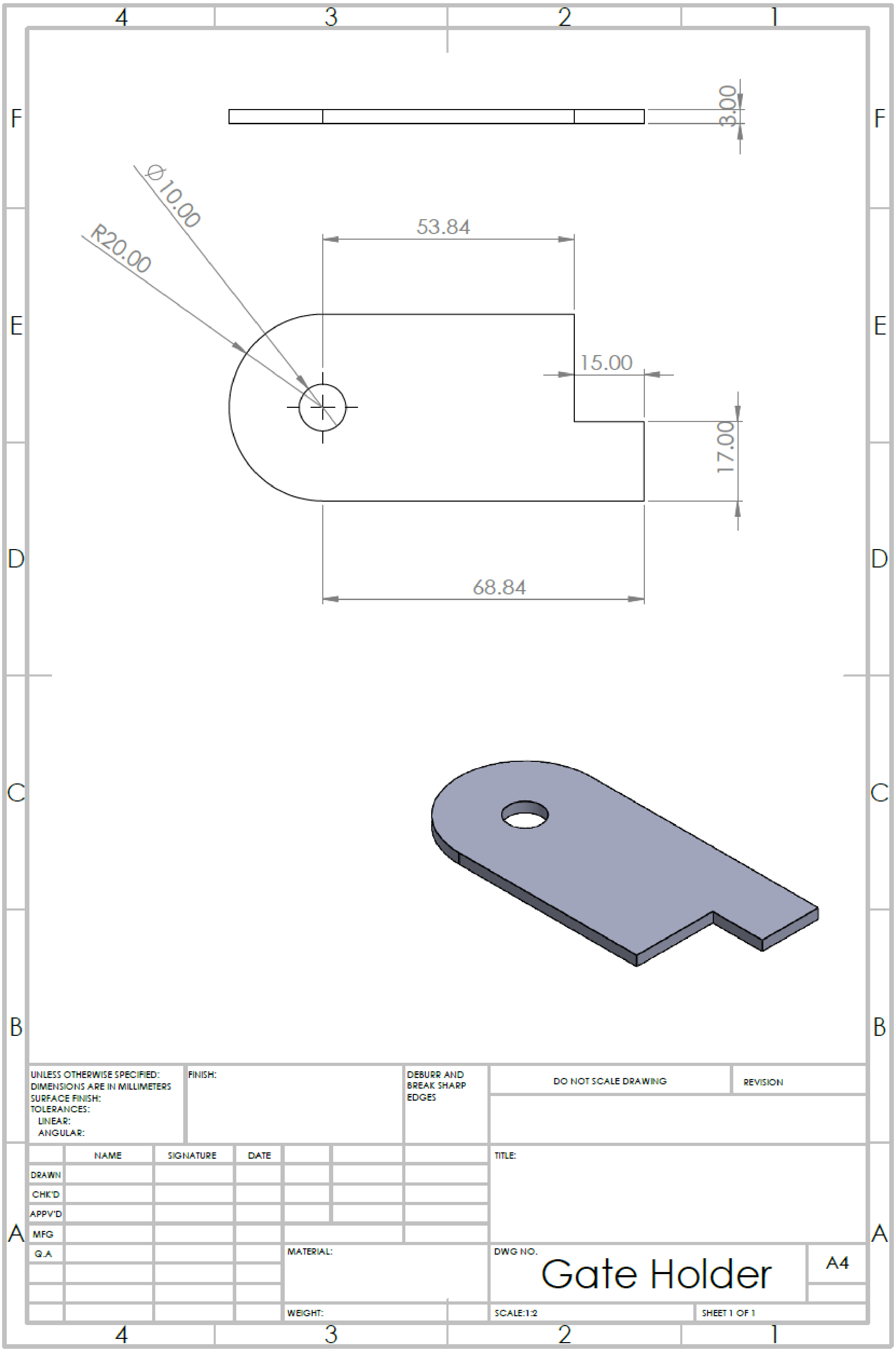
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DWG NO.
Gate Holder
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WEIGHT:
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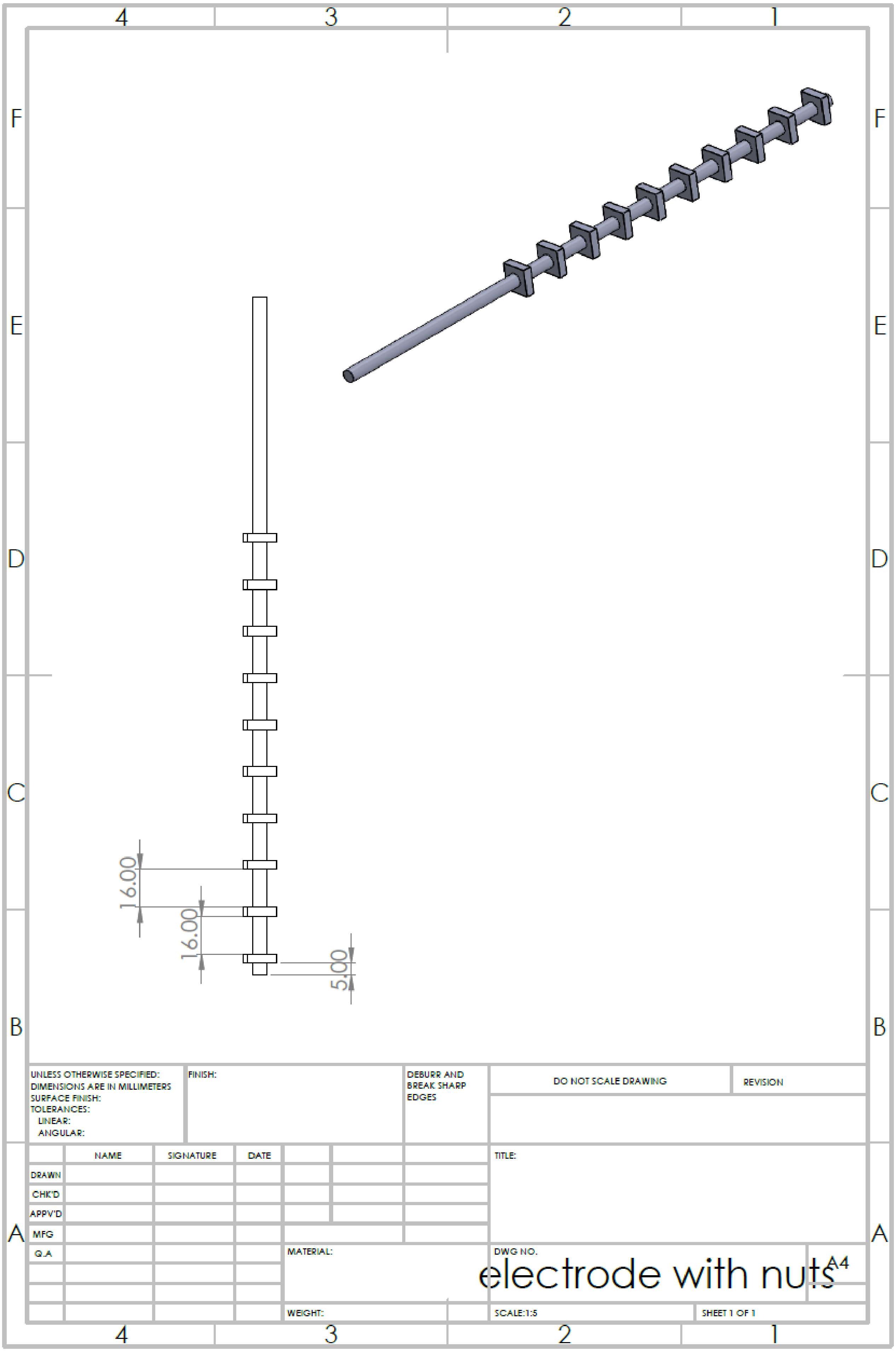
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DWG NO.
electrode with nuts
A4
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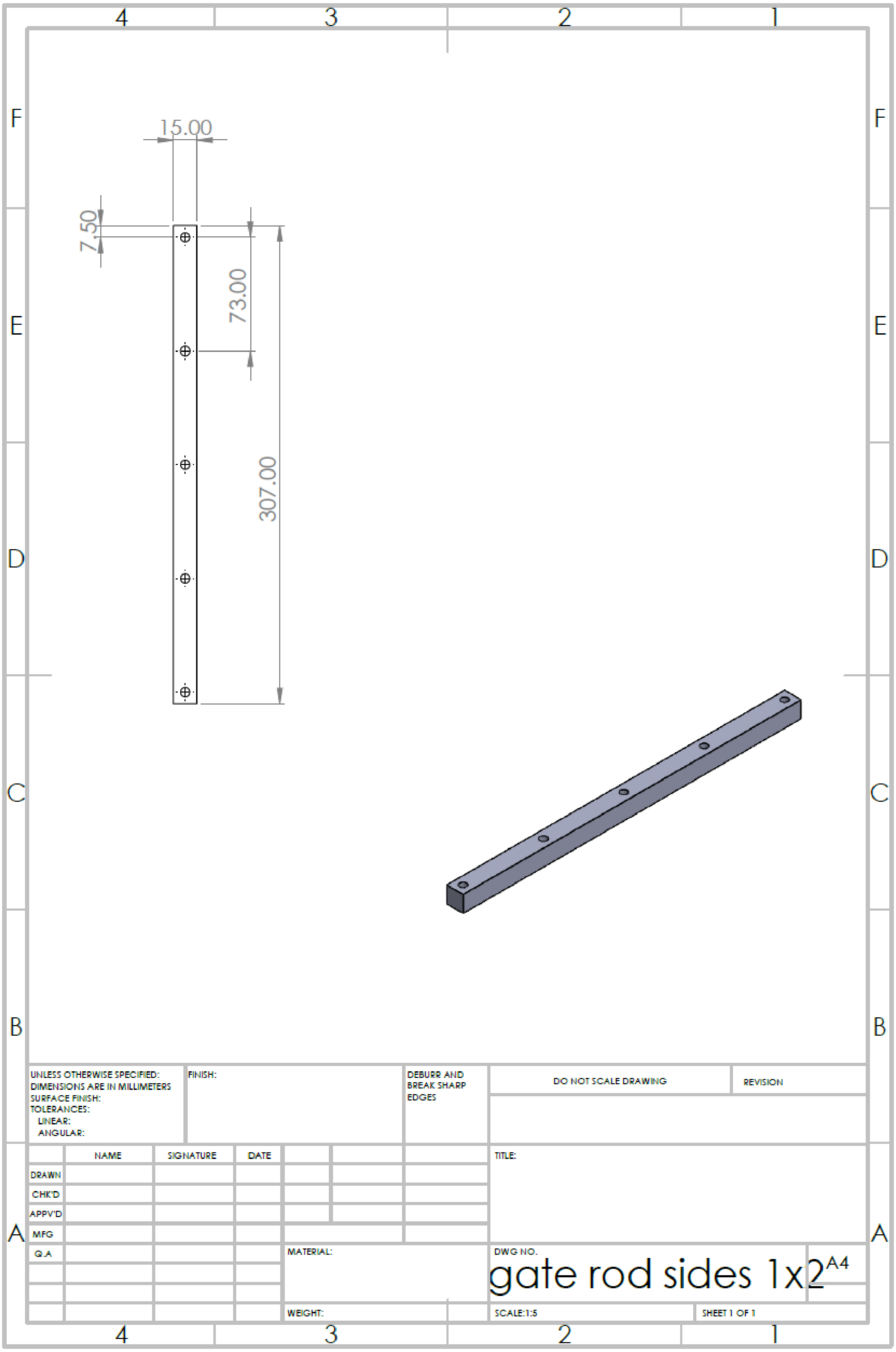
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A4
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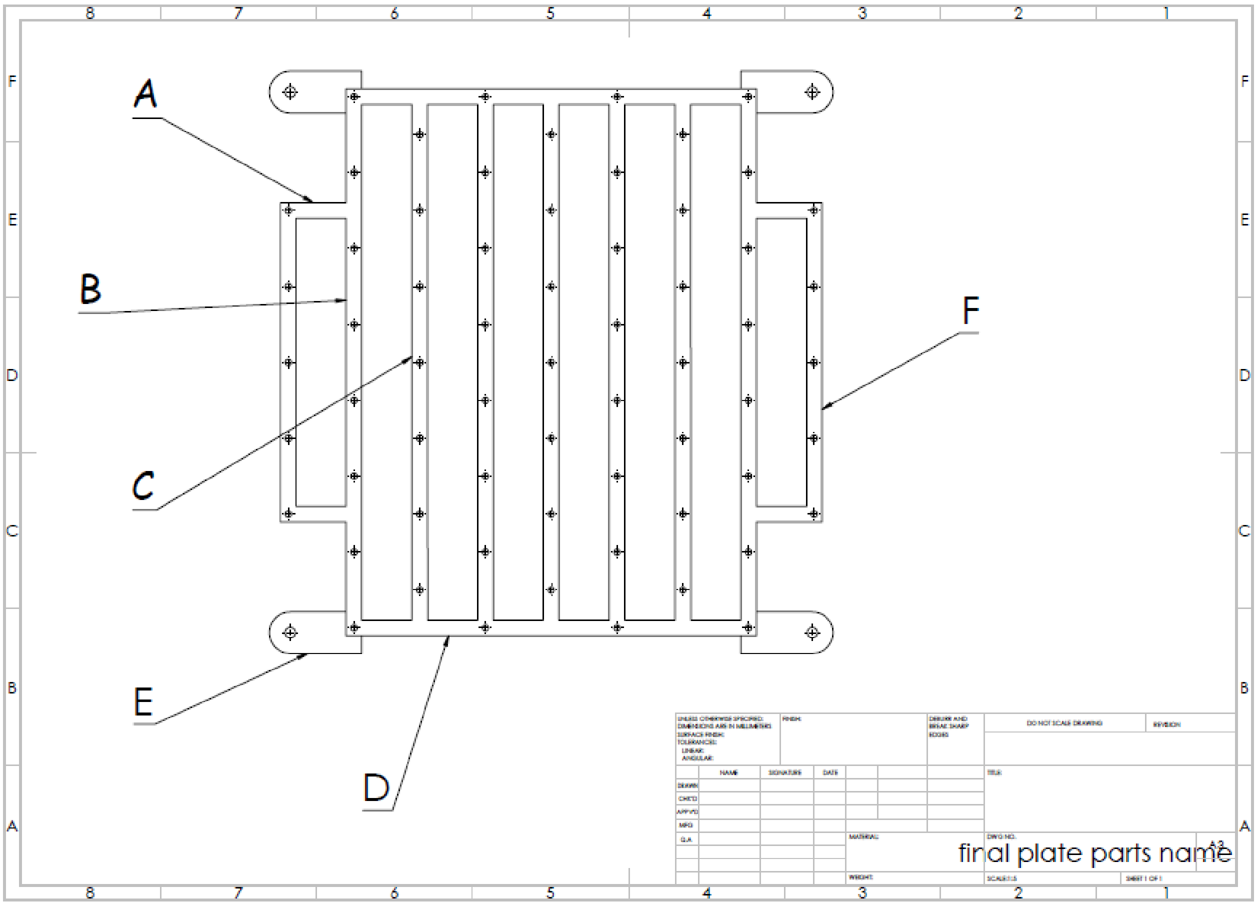
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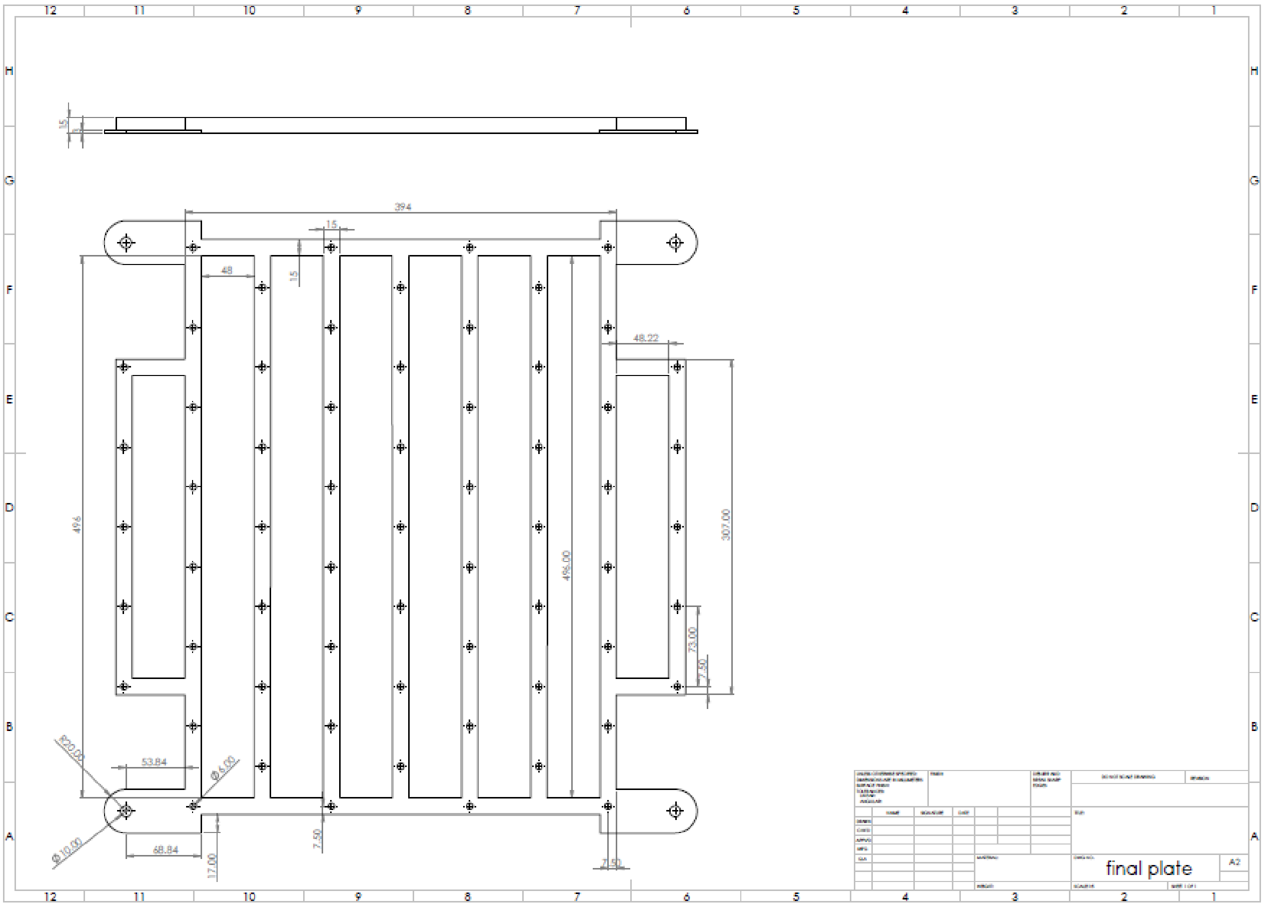
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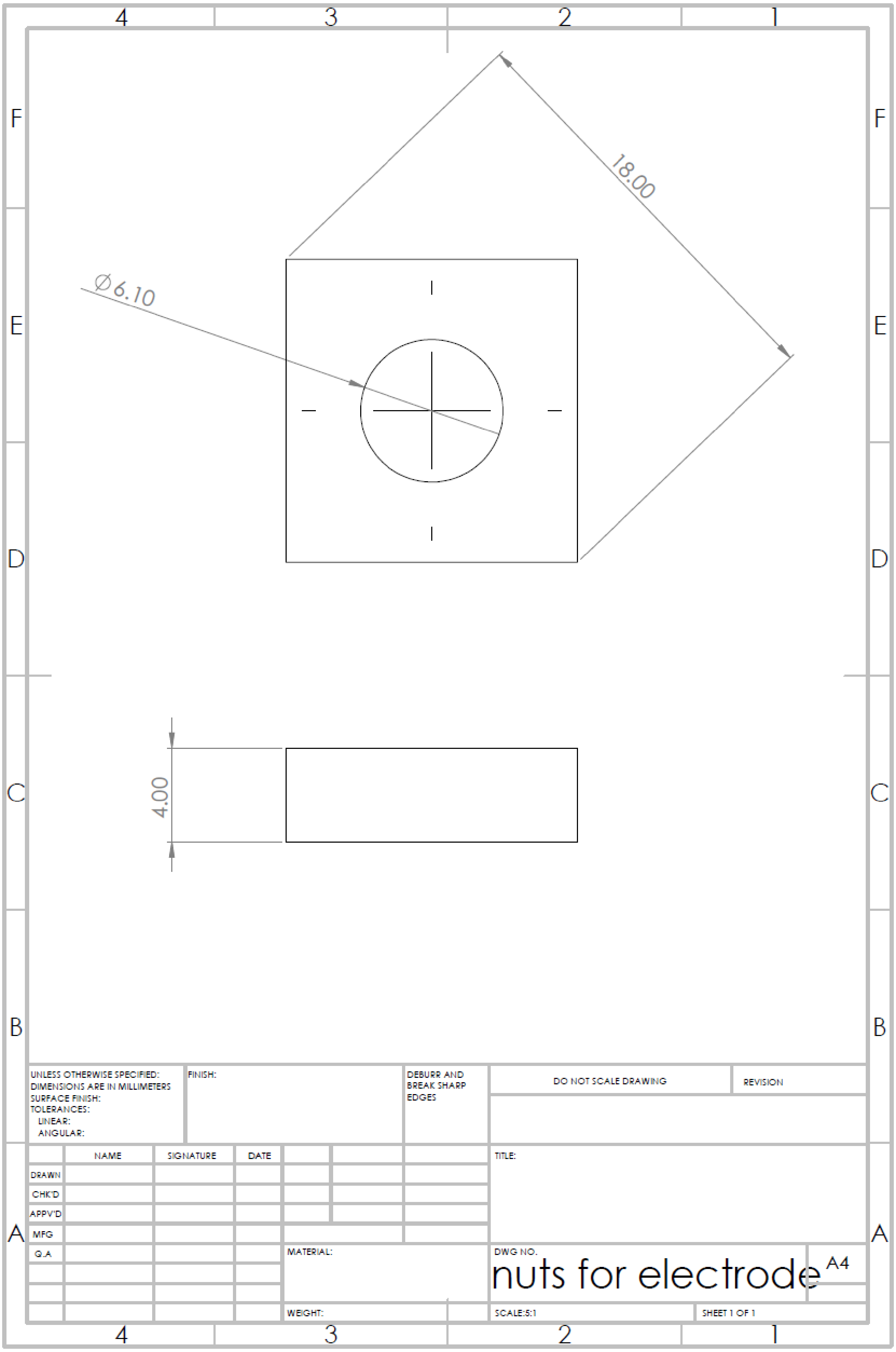
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NAME
SIGNATURE
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CHK'D
APPV'D
MFG
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DWG NO.
nuts for electrode
A4
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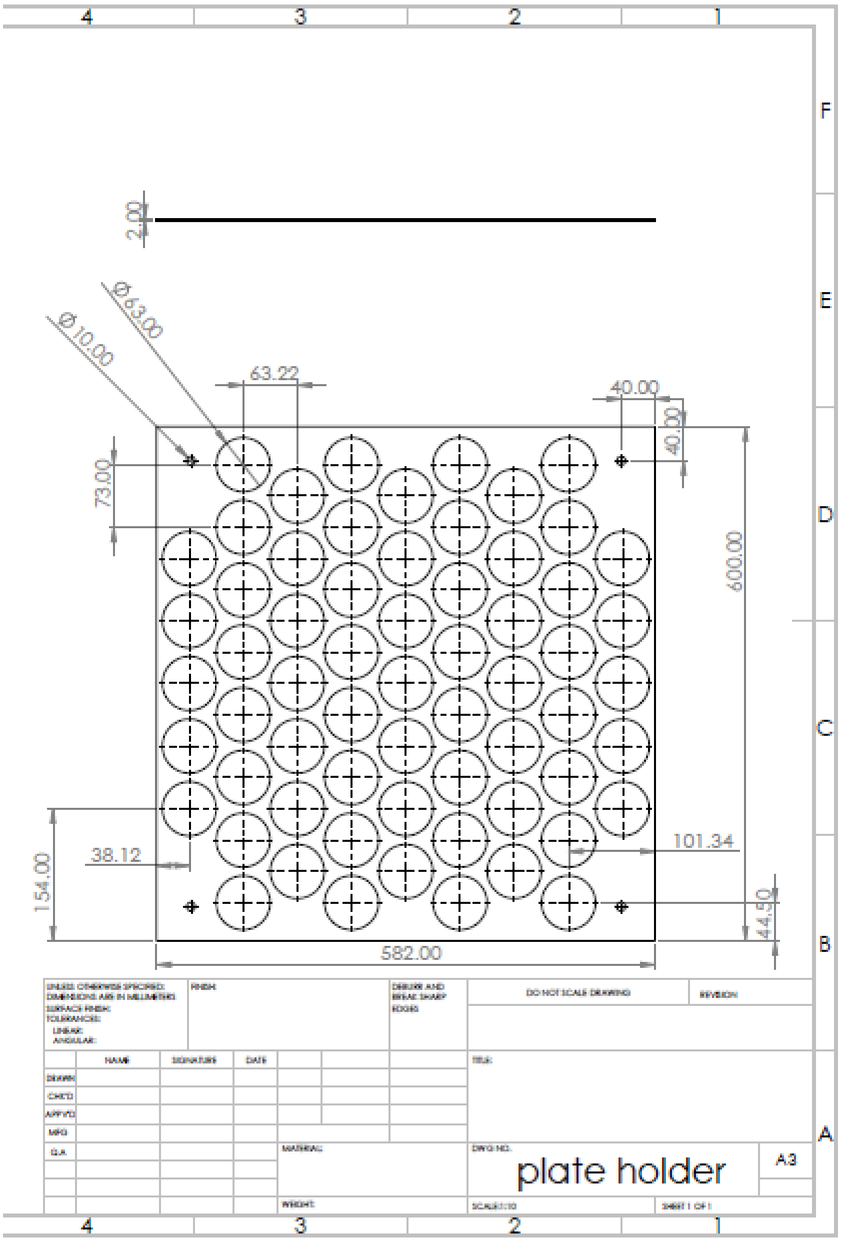

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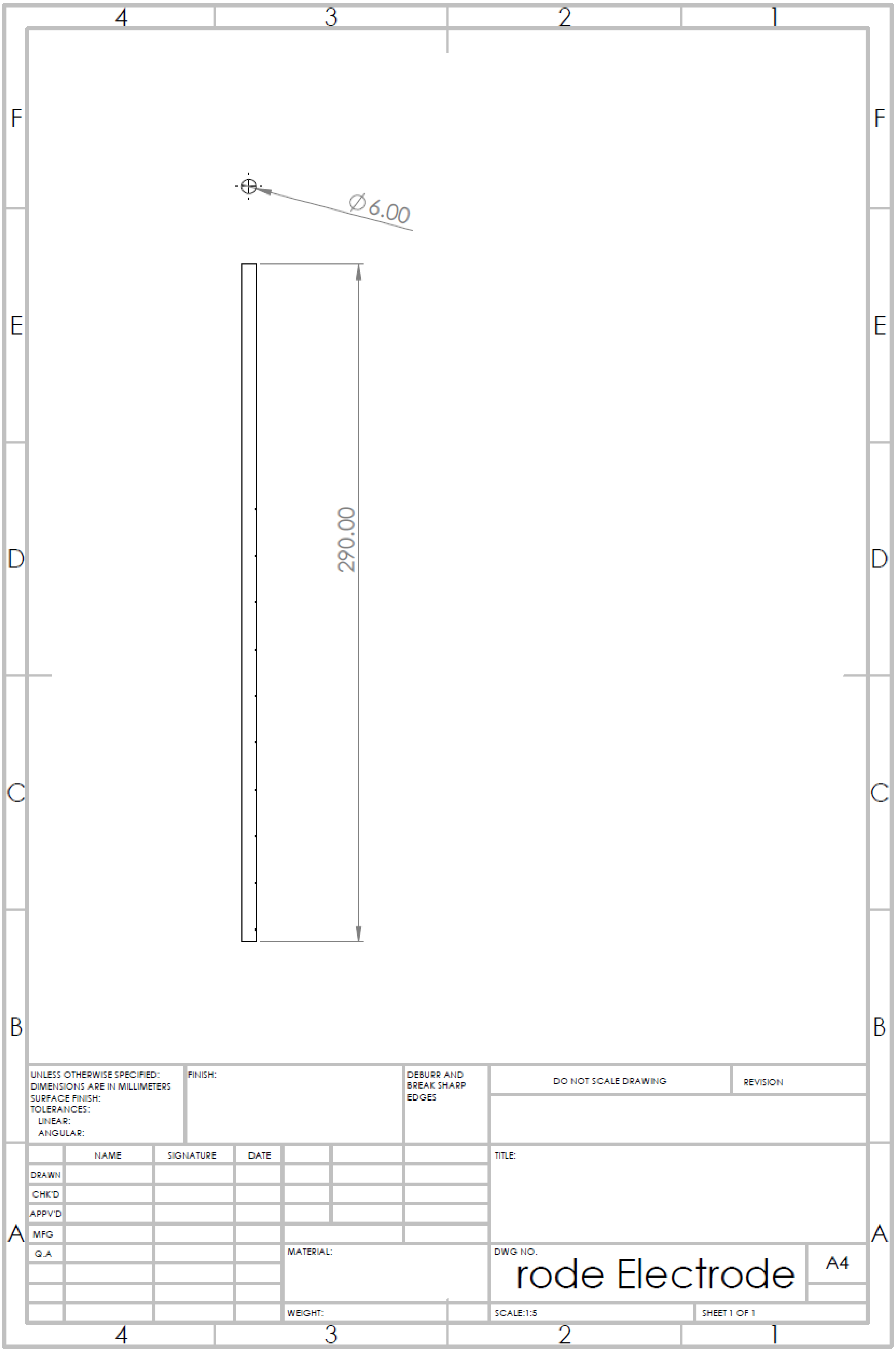

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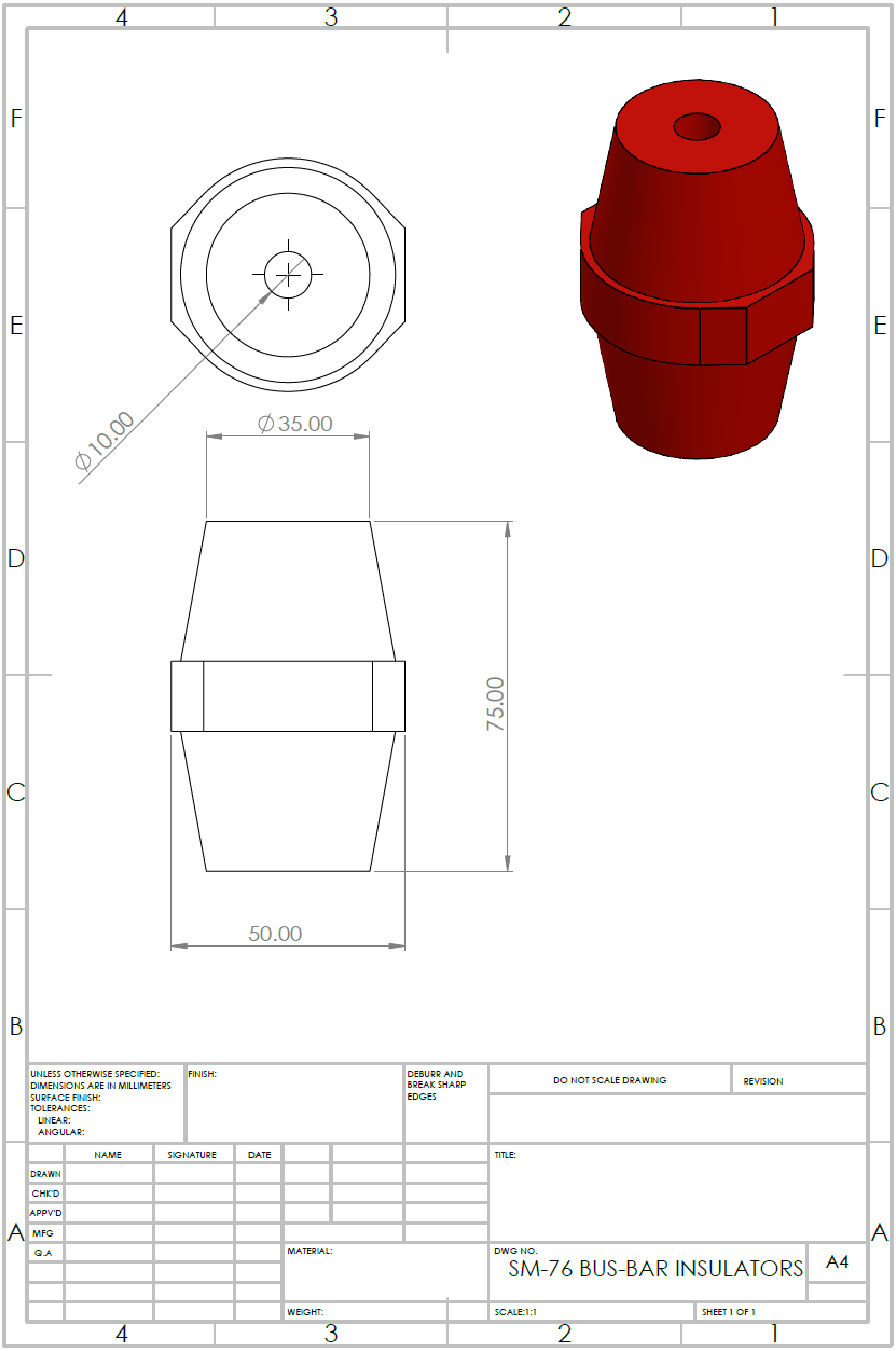
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
TITLE:
MATERIAL:
DWG NO.
rode Electrode
A4
WEIGHT:
SCALE:1:5
SHEET 1 OF 1



4
3
2
1
F
E
D
C
B
A
∅10.00
∅35.00
75.00
50.00
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
TITLE:
DRAWN
CHK'D
APPV'D
MFG
Q.A
MATERIAL:
DWG NO.
SM-76 BUS-BAR INSULATORS
A4
WEIGHT:
SCALE:1:1
SHEET 1 OF 1

3.4.4 Sketch SW

corner metal sheet.SLDDRW	cylinder.SLDDRW	electrode with nuts.SLDDRW	final plate parts name.SLDDRW	final plate.SLDDRW
Gate Holder.SLDDRW	gate rod 1x2.SLDDRW	gate rod 1x3 middle rod.SLDDRW	gate rod 1x4 middle rod.SLDDRW	gate rod 1x4.SLDDRW
gate rod sides 1x2.SLDDRW	nuts for electrode.SLDDRW	plate holder.SLDDRW	rode Electrode.SLDDRW	SM-76 BUS-BAR INSULATORS.SLDDR

3.4.5 Step files

corner metal sheet.STEP	corner.STEP	cylinder.STEP	Electro filter first part.STEP	electrode with base.STEP
electrode with nuts.STEP	final plate.STEP	new02 Lower plate.STEP	nuts for electrode.STEP	SM-76 BUS-BAR INSULATORS.STEP

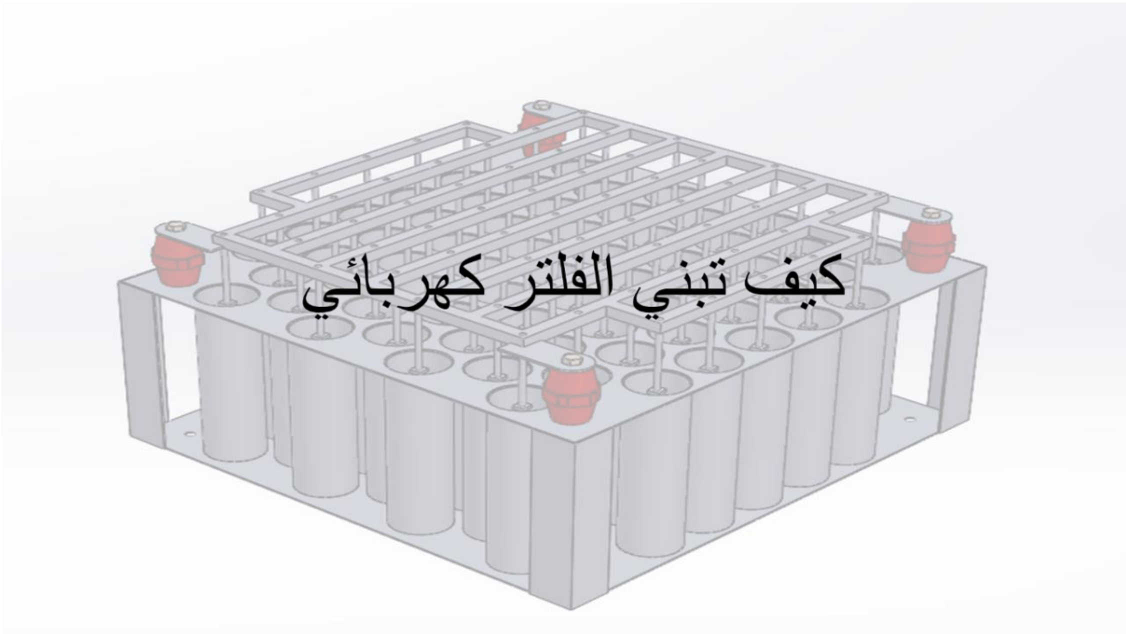
3.4.6 SW files

copy.SLDPRT	corner metal sheet.SLDPRT	corner.SLDPRT	cylinder.SLDPRT
Electro filter first part.SLDASM	Electro filter first part.SLDPRT	electro filter.SLDASM	electrode with base.SLDASM
electrode with base.SLDPRT	electrode with nuts.SLDASM	electrode with nuts.SLDPRT	final plate.SLDPRT
Gate Holder.SLDPRT	gate rod 1x2.SLDPRT	gate rod 1x3 middle rod.SLDPRT	gate rod 1x4 middle rod.SLDPRT
gate rod 1x4.SLDPRT	gate rod sides 1x2.SLDPRT	new02 Lower plate.SLDPRT	nuts for electrode.SLDPRT

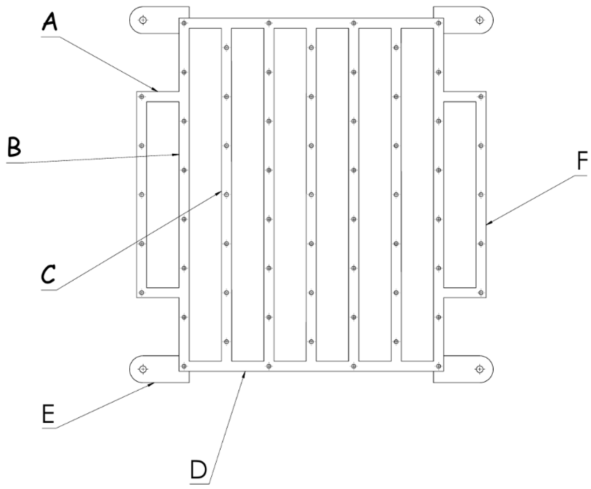
rode Electrode.SLDPRT	SM-76 BUS-BAR INSULATORS.SLDPR¯

3.4.7 How to build the electro filter

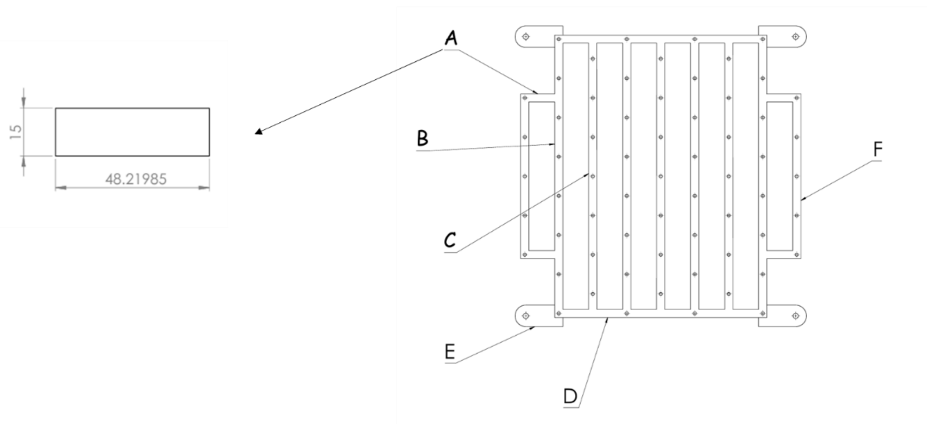
how to build electro filter.pptx



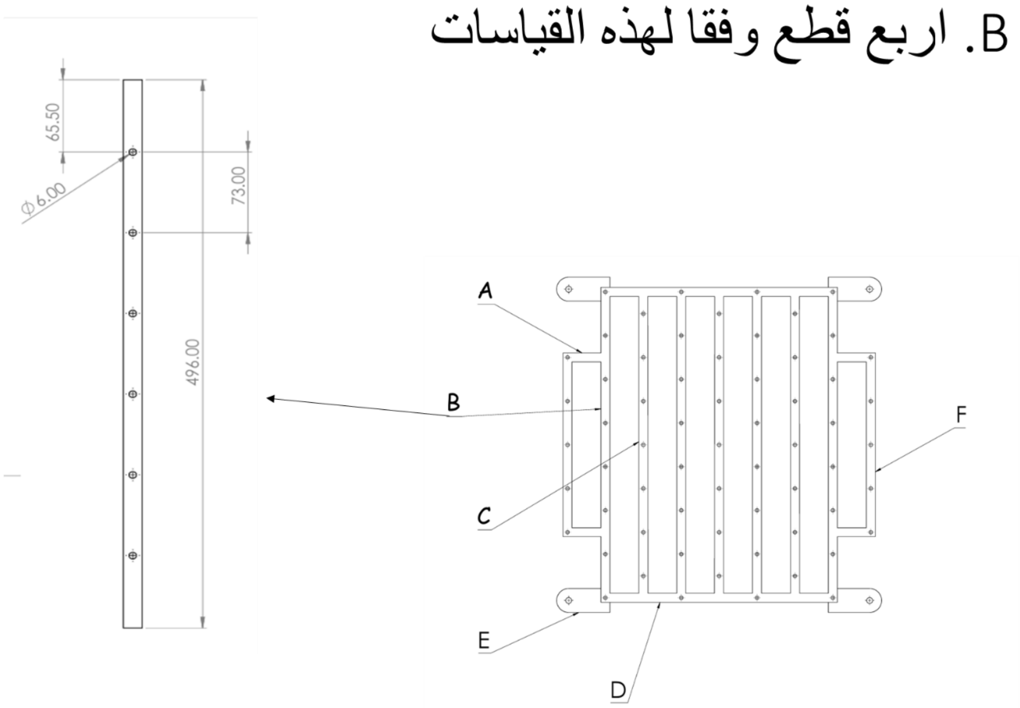
أولا لبناء القاعدة التي تحمل السياخ مع الصواميل تحتاج للقطع التالية:



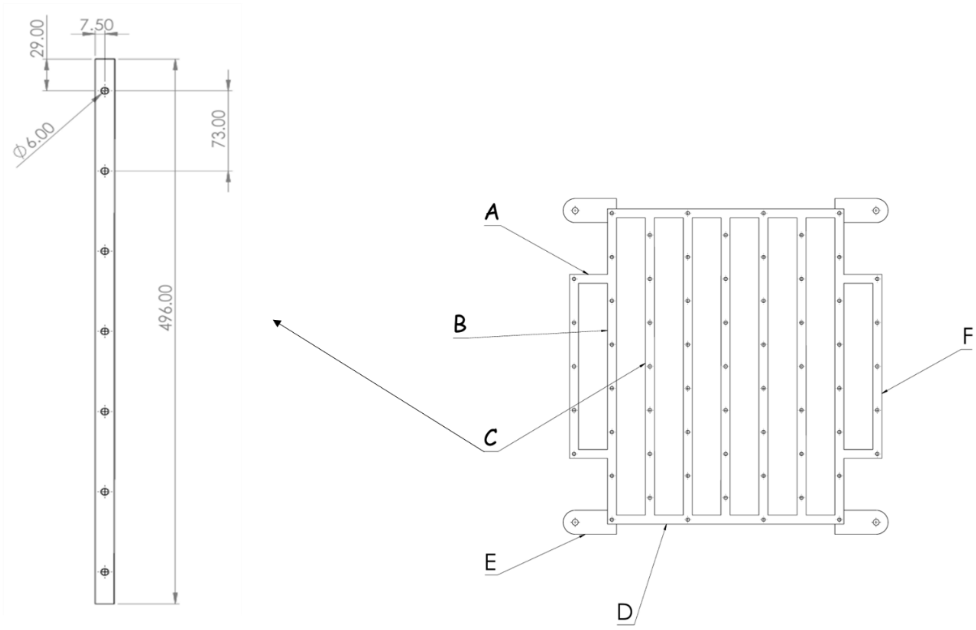
A. اربع قطع وفقا لهذه القياسات لذلك تحتاج الى قضيب مفرغ
Stainless steel 304 بقياس 15x15 mm بطول 6 m



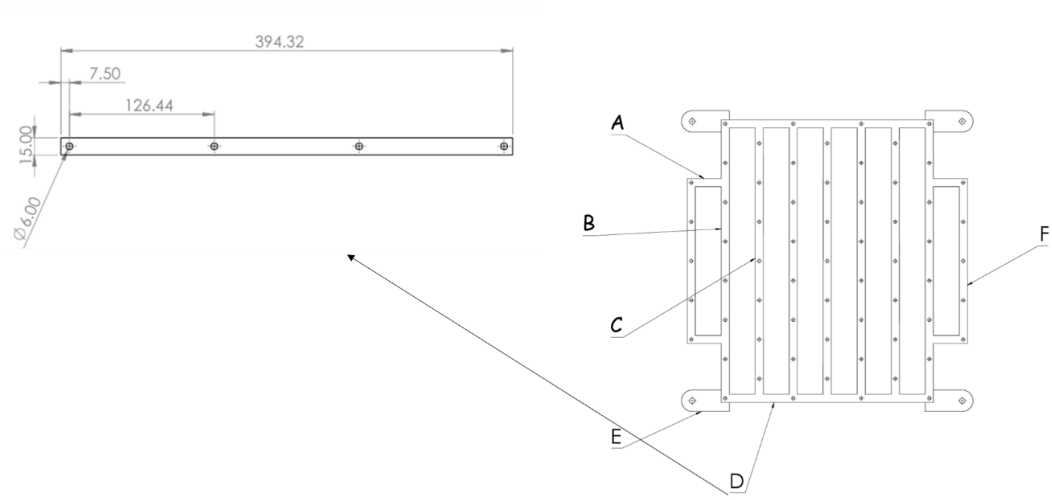
B. اربع قطع وفقا لهذه القياسات



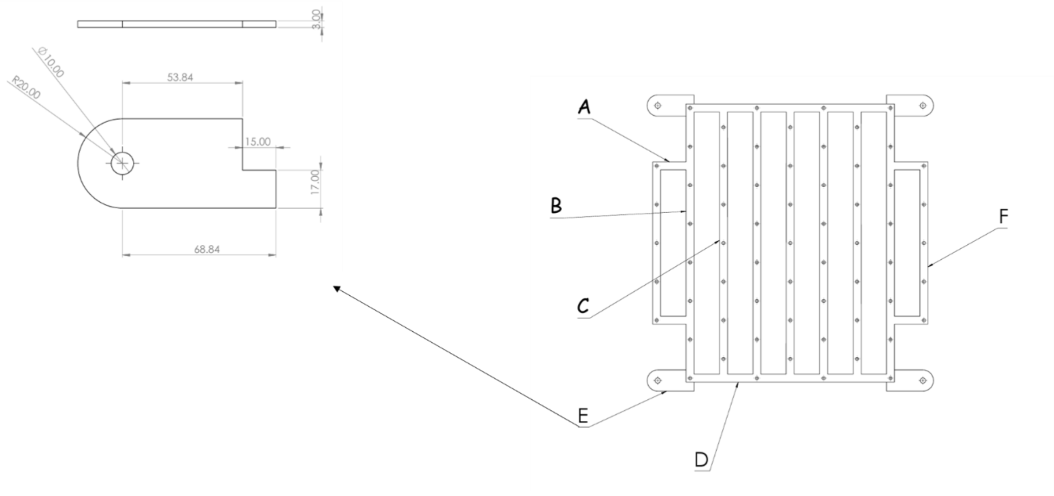
C. ثلاث قطع وفقا لهذه القياسات



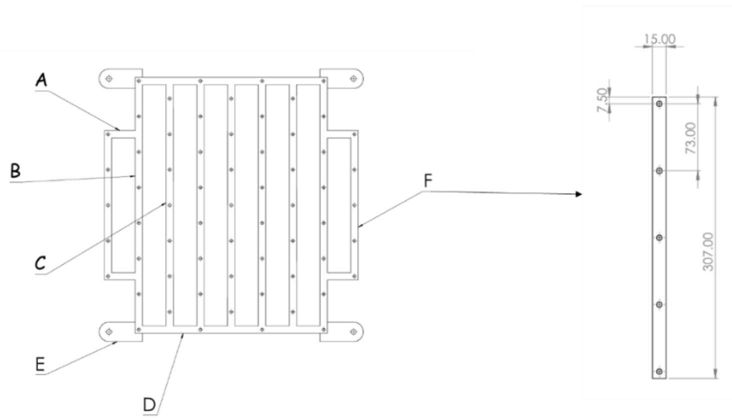
D. قطعتان وفقا لهذه القياسات



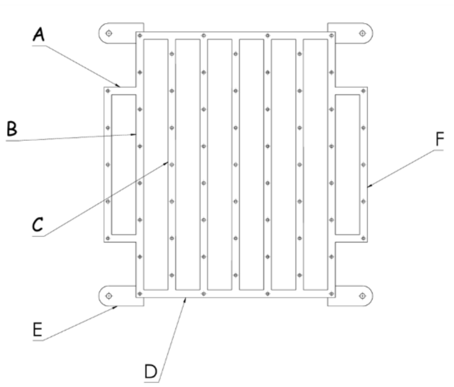
E. اربع قطع وفقا لهذه القياسات عن طريق قصها باللليزر بسماكة 3 mm



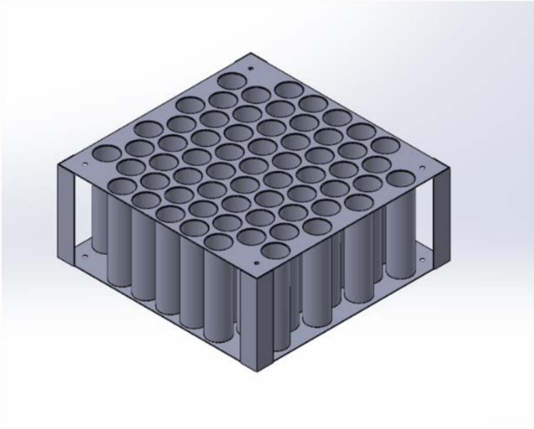
E. قطعتان وفقا لهذه القياسات



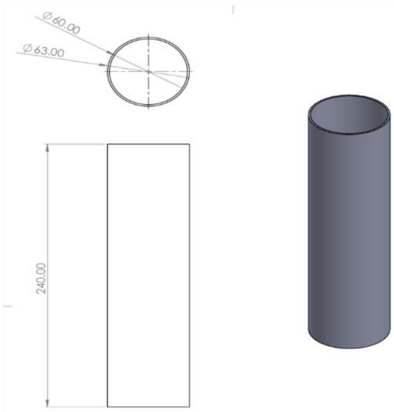
و اخيرا يتم جمعها و تلحيمها باستخدام ال Argon



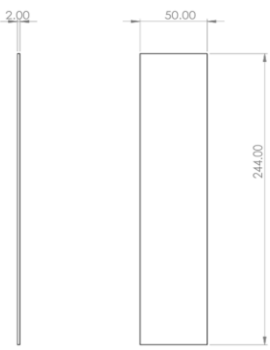
ثانيا لبناء الشكل الثاني مع الأسطوانات هناك 3 قطع نحتاجها
و يتم تلحيمها باستخدام ال Argon



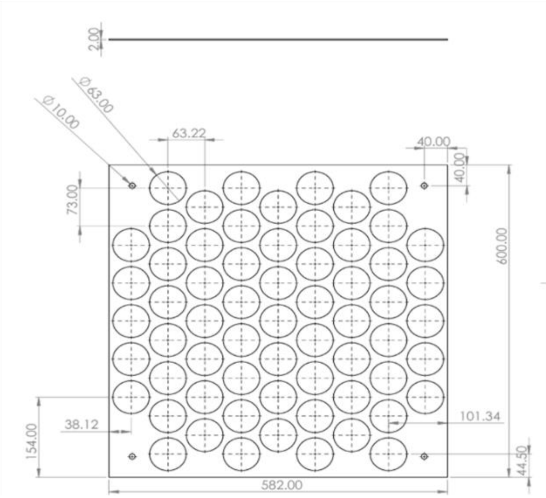
الأسطوانات بالقياسات التالية و بعدد 63 أسطوانة
304 Stainless steel



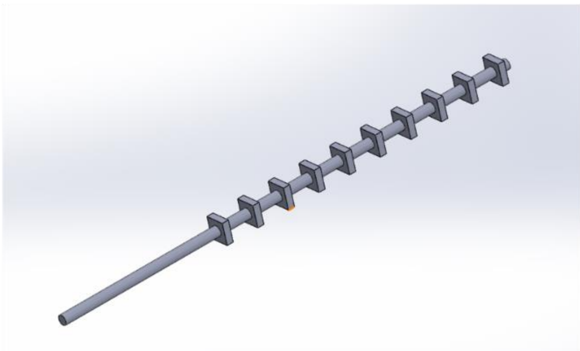
زوايا بعدد 4 زوايا او 8 حبات مستطيلة كالتالي بسماكة 2 mm و يتم قصها
بالليزر



لوحان مستطيلان بالشكل التالي و بسماكة 2 mm و يتم قصها بالليزر

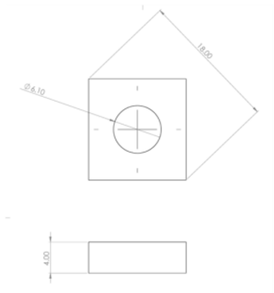


ثالثا لبناء 63 سيخ مع الصواميل نحتاج الاتي :

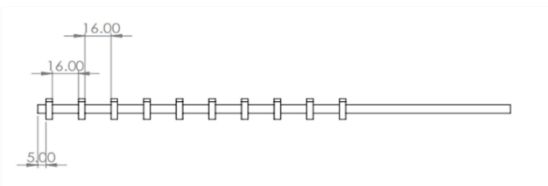


نحتاج الى 63 قضيب بسماكة 6 mm بالقياس التالي

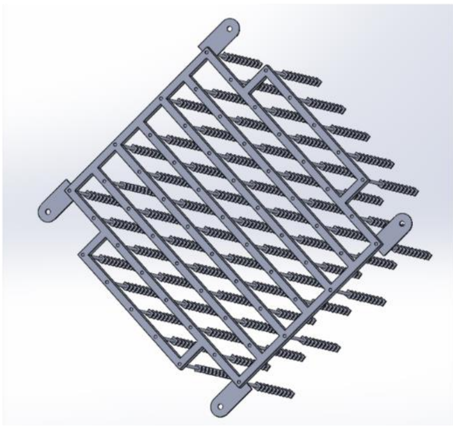
نحتاج الى 630 صامولة بسماكة 4 mm بالقياسات التالي لكل قضيب 10 حبات



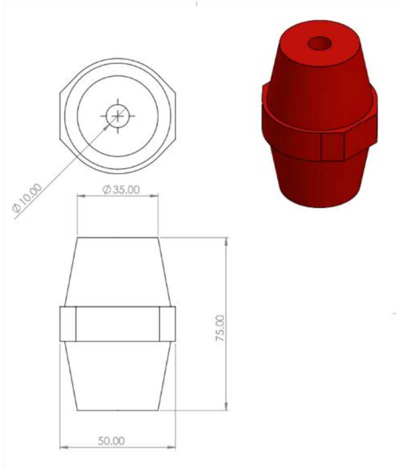
نقوم بتلحيم الصواميل على القضيب بالمسافات التالية باستخدام ال Argon



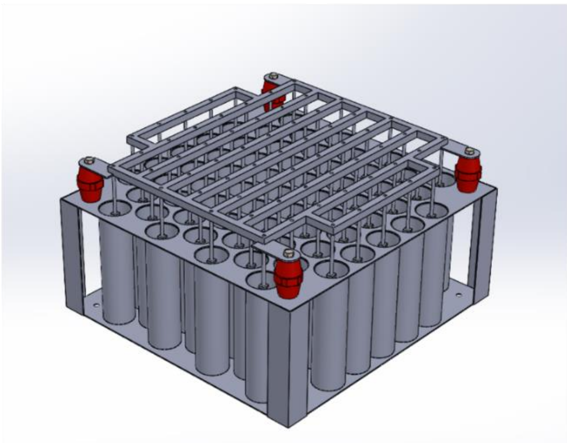
نقوم بتلحيم السياخ على القاعدة باستخدام ال Argon



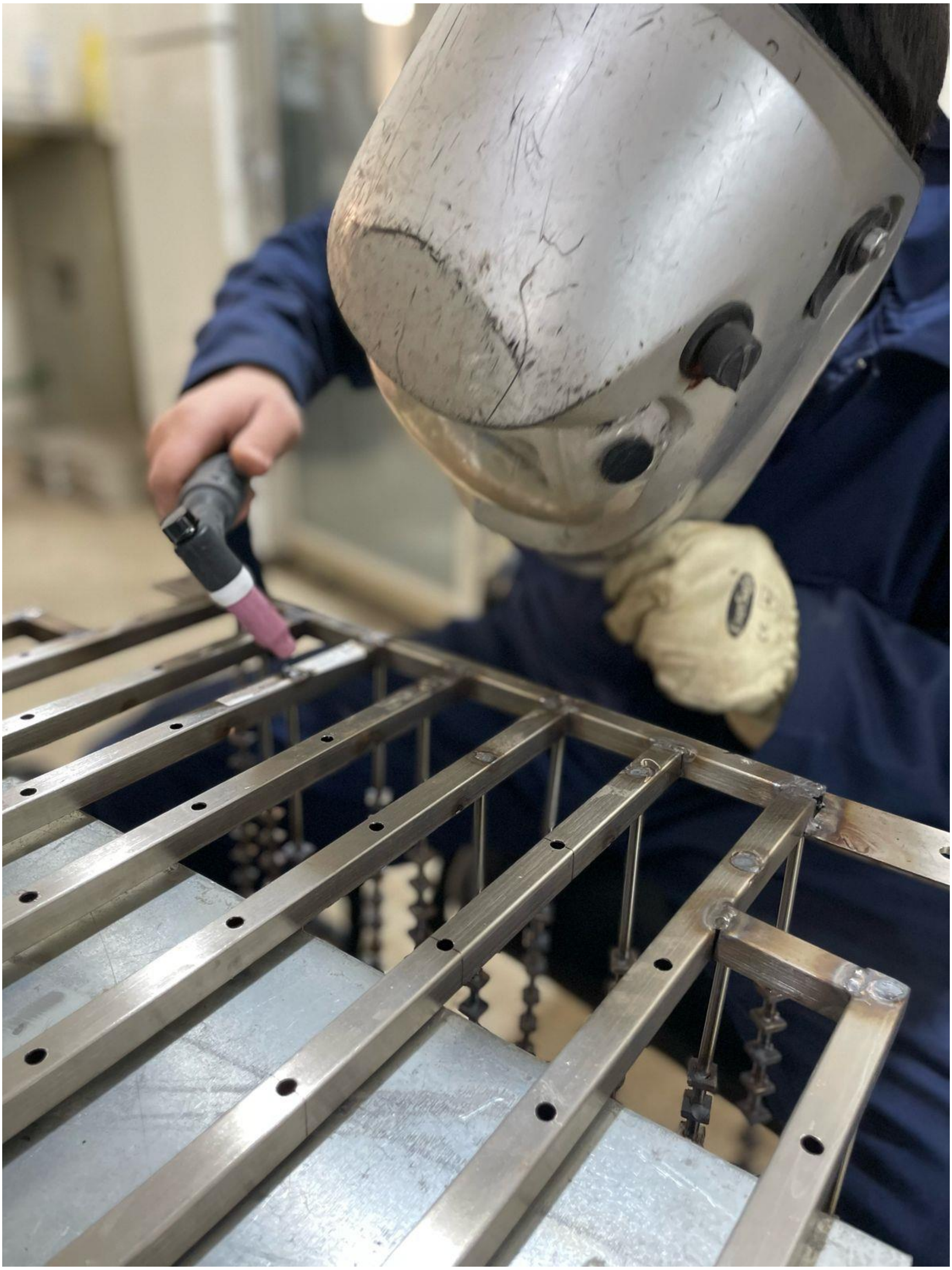
نحتاج ال شراء اربع قطع من عازل البس بار او BUS-BAR Insulator نوعيته SM-76 و بالقياسات التالية

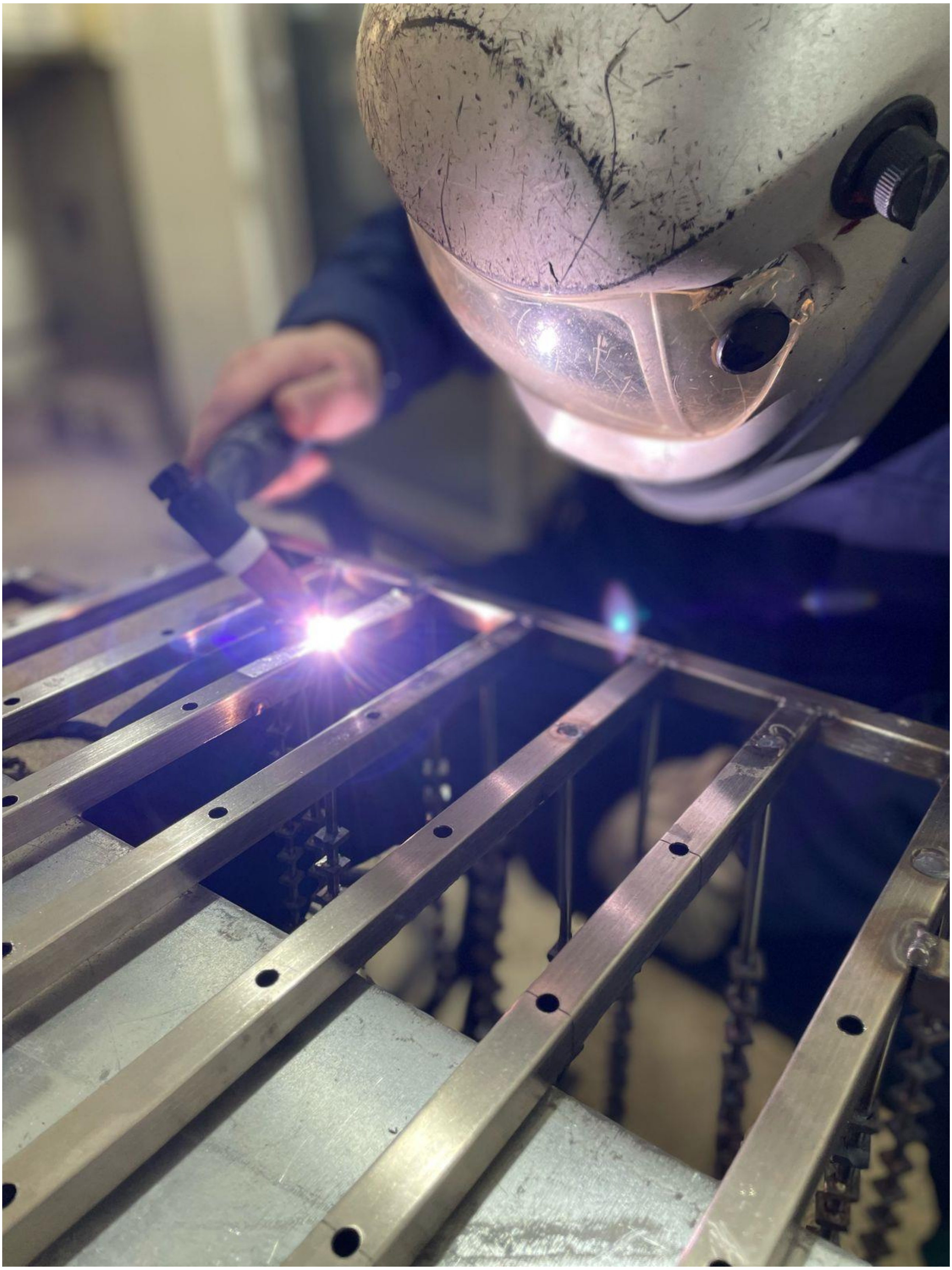


أخيرا نقوم بجمع الأجواء ببعضها و يكون ال الفلتر جاهز للتشغيل و لكن يجب تثبيت ال سياخ في منتصف الأسطوانة لنتائج افضل

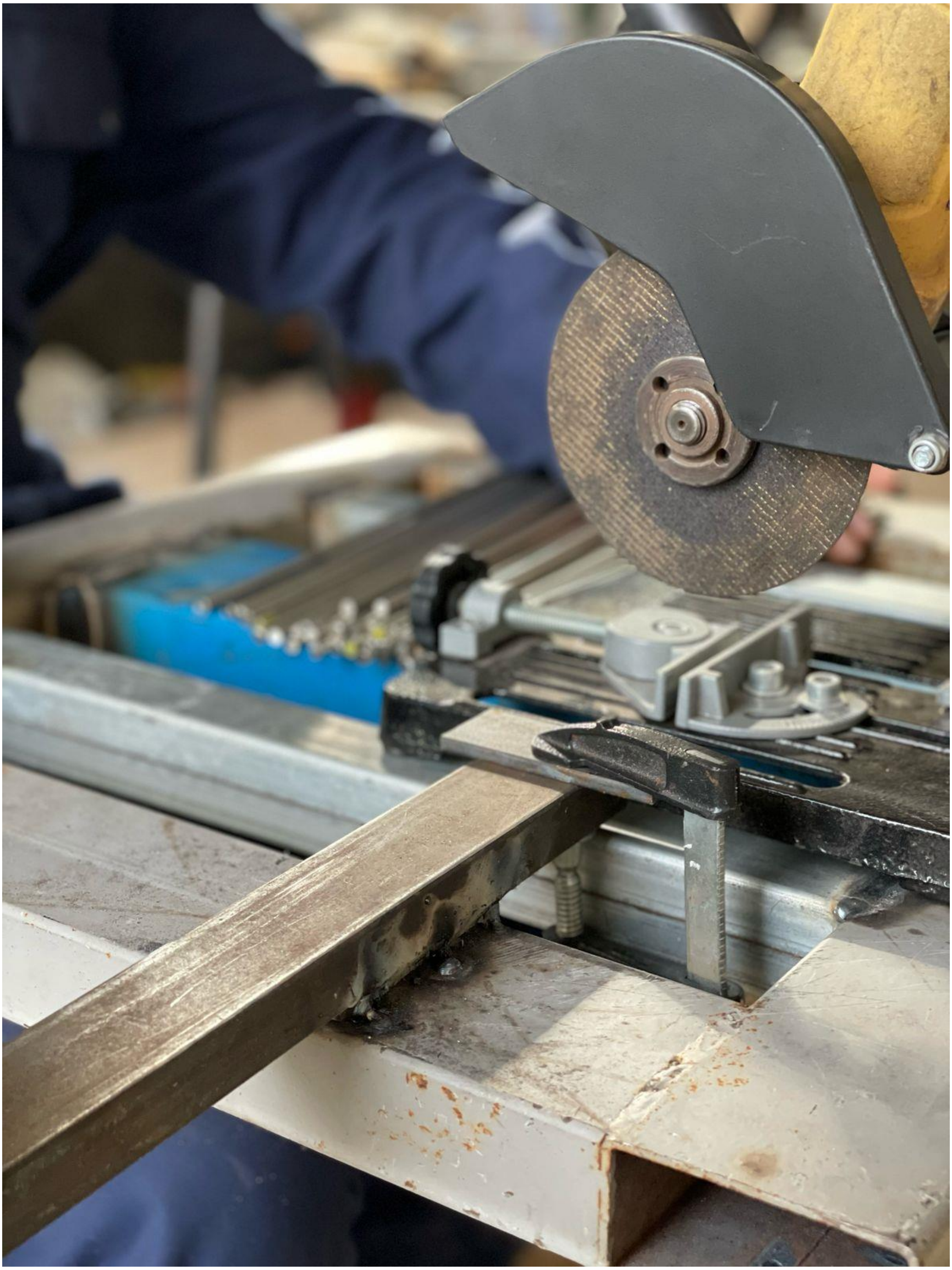


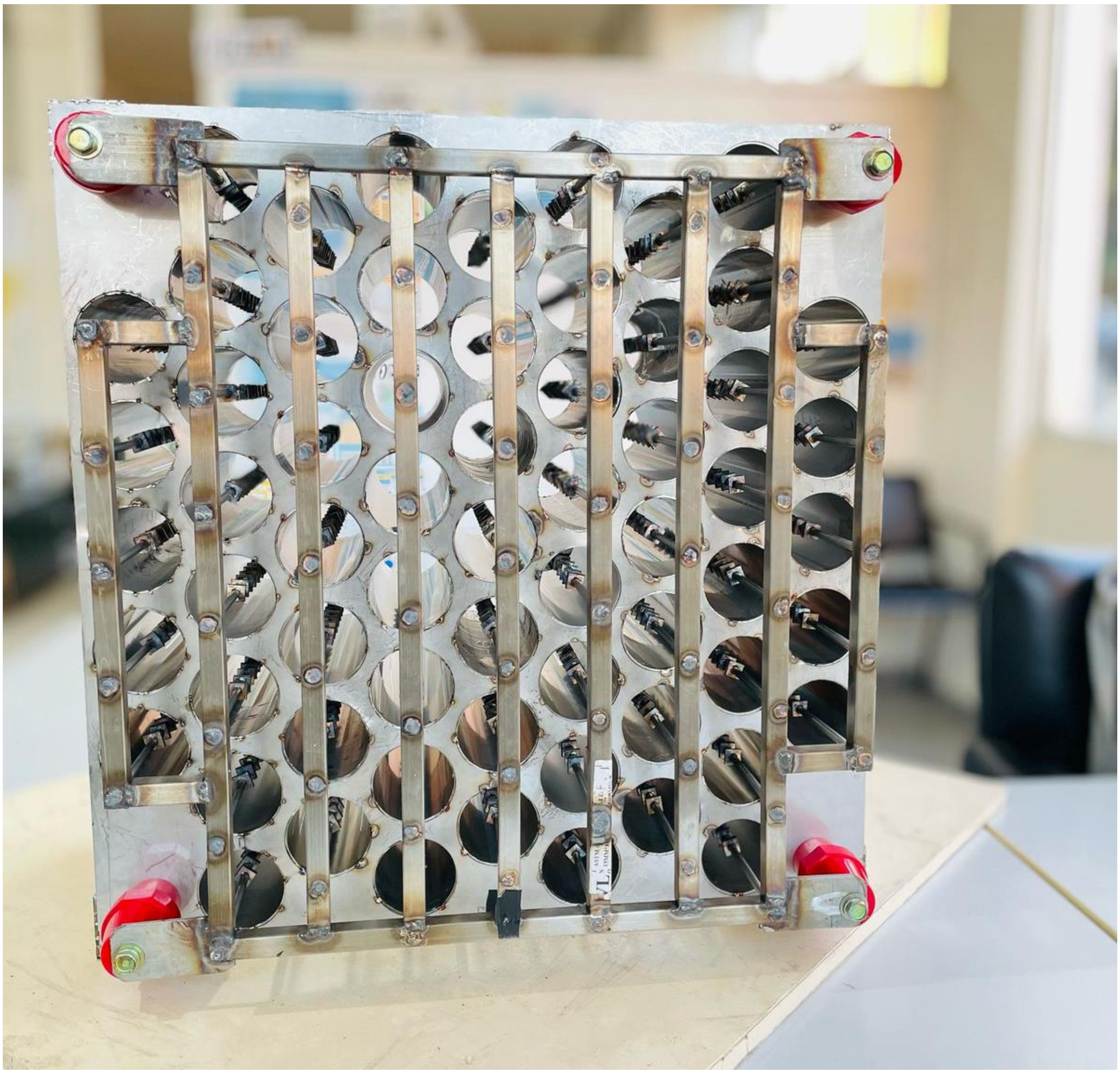
3.5 Manufacturing of the Electro-filter

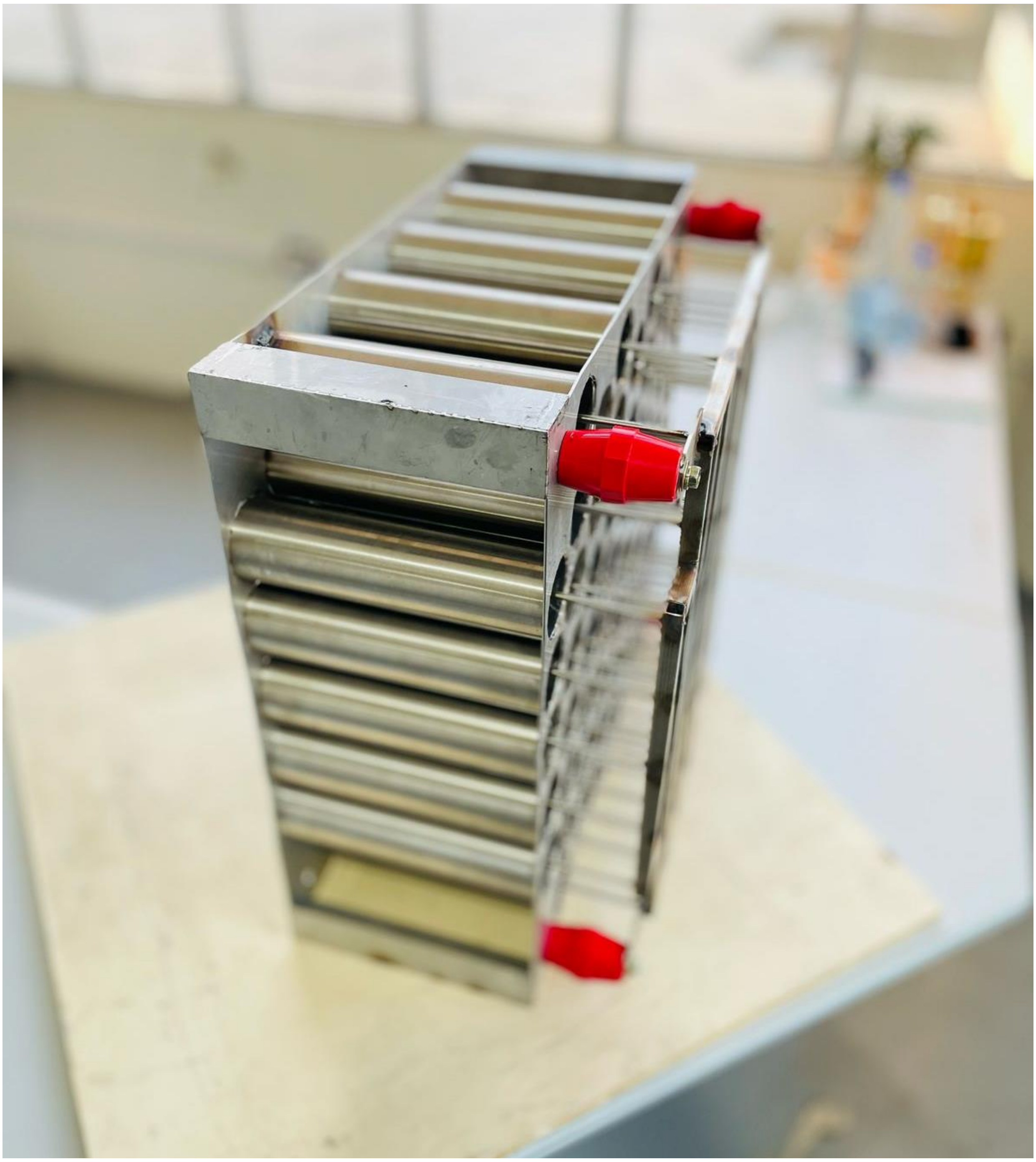





EverSafe







Videos concerning the electro-filter manufacturing process:

WhatsApp Video 2025-02-18 at 13.25.	WhatsApp Video 2025-02-18 at 14.11.	WhatsApp Video 2025-02-18 at 14.12.
WhatsApp Video 2025-02-18 at 14.12.	WhatsApp Video 2025-02-18 at 14.49.	WhatsApp Video 2025-02-18 at 14.49.

بسم الله الرحمن الرحيم

AECENAR
Association for Economical and Technological Cooperation in the Euro-Asian and North-African Region
www.aecenar.com

NLAP
North Lebanon Alternative Power

NLAP-WEDC REPORT 2024 – Part 4: Biogas, Gas Turbine, Liquid-Liquid Separation Solvent Production, Ashes Recycling

With contribution of:

Maryam EL REZ

Abdullah KASSEM

Ali DIB

Amro ZAWIT

Last Update: 12.03.2025 16:23

Table of Contents

4 Project 4: Biogas project

4.1 Position of biogas project

This project was proposed to produce methane gas for later use in the burner. In 2023 - 2024, the focus was on implementing and operating the project.

4.2 Placement of digester on mobile platform

4.2.1 Place in Ras Maska for Mobile Biogas Generation and Gas Turbine Testrig

4.2.2 Moving of Biogas Generation Device on Mobile Plant 30.05.23

4.2.3 Situation on 31.5.23

4.2.4 Shredder

4.3 Test specifications/Operational Steps of Biogas Generation

4.3.1 Operation steps of Digester

- مرحلة جمع النفايات
- مرحلة الفرز والفرم
- مرحلة التخمير

4.3.2 Gas extraction

Steps	Steps description	Excepted result
Precondition	The pump is turned off	
	By the GUI the "Pressure Sensor" read 1 atm	
	The water was under level	
	Both digester inlet and outlet were opened (atmospheric pressure)	

Gas extraction process 1	Connect the balloon beside the pressure gauge	Balloon is connected
	Open the ball valve of the pressure gauge	Gas is captured
		Inflation of balloon
Creation a storage tank through the vacuum	18.5-liter galloon bought	
	Connect a pipe internally to the main inlet of the galloon	The pipe is connected
	Attach the balloon to the inner entrance of the tube	The balloon is attached
	Connect a ball valve to the outer end of the pipe	The ball valve is connected
	Create a hole in the bottom of the galloon	The galloon is perforated at the bottom
	Connect the gas inlet connexion to the bottom hole of the galloon	The inlet gas connexion is connected
	Connect a vacuum pump to the gas inlet connexion	The vacuum pump is connected
Gas extraction process 2 _ By vacuum tank	Connect the galloon to the pressure gauge inlet using Tee valve	The galloon is connected
	Open both ball valves of the pressure gauge and galloon	The ball valves are opened
	Turn on the vacuum pump	The vacuum pump is turned on
		Gas was captured
	Close both ball valves of the pressure gauge and galloon	The ball valves are closed
	Disconnect the galloon from the digester	The galloon is disconnected
Combustion process	Open the vacuum connection at the bottom of the galloon	The vacuum connection is opened
	Open the ball valve of the galloon	The ball valve is opened

	Ignite a fire (spark) near the ball valve	A flame appears at the ball valve outlet and continues until the balloon is deflated
		Methane gas existed

4.3.3 Digester leakage's test

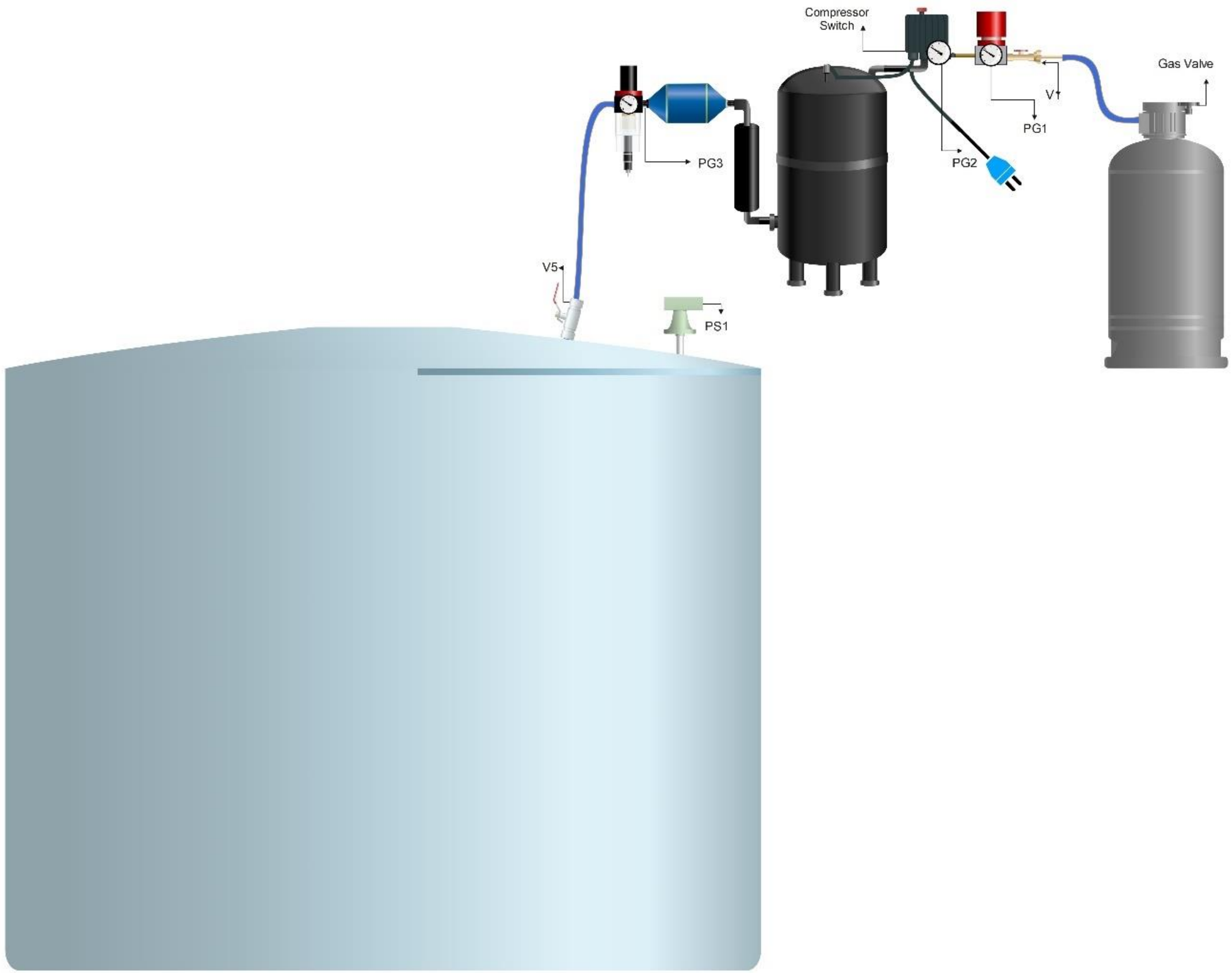
Steps	Steps description	Excepted result
Precondition	Pump is turned off	
	The pressure of digester is 1 atm (digital pressure gauge reading)	
	The water was under level	
	Both digester inlet and outlet was opened (atmospheric pressure)	
Digester leakage test	Connect the air compressor to the pressure gauge, from the top of the digester, through a tee connection	The air compressor is connected
	Open the ball valve at the top of the digester	The ball valve is opened
	Turn on the air compressor	The air compressor is turned on
		Water comes out of the outlet of the digestive mixture
		Air bubbles appear on the inlet and outlet surfaces of the digester
	Turn off the air compressor	The air compressor is turned off
	Close the ball valve at the top of digester	The ball valve is closed
	Separate the air compressor from the digester	The air compressor is separated from the digester

4.3.4 Enhancing Methane Storage Through Gas Compression

Step	Step description	Expected Result
Precondition		
System is off	all Valves are closed	System is off
Connection		
Connecting gas entrance	Connect the PEX tube to the compression machine inlet (manually)	Connected
connecting check valve	Connect the check valve to the machine outlet (manually)	connected
Connecting the system to the gas storage tank	Connect the pipe in the machine outlet to the methane gas storage (manually)	connected
Leakage check	start the compressor and open Valves V1 and V5 and Gas Tank main Valve to check the leakage in the system (with Soap)	no leak
	close the compressor and close the Valves V1 and V5 and Gas Tank main Valve	no obstacles

4.3.4.1 Operational Steps

Test Starts		
0pen gas tank	open the gas tank main valve (manually)	opened
open V1	open the Valve (V1) (manually)	no obstacles
open V5	Open Valve V5 of the Biogas (manually)	no obstacles
start the Switch of the compressor	start the switch of the compressor (by GUI)	compression started (and compression ended by the Compressor switch when it reaches 8 bar (on PG2) or when the pressure at the biogas reaches atmospheric pressure (by PG4))
Close the red emergency switch of the compressor	Close the red switch of the compressor (manually) in case of emergency when neither the switch turned off automatically nor the GUI gives the order to close the system cycle	Compressor turned off
close V5	close the Valve V5 of the Biogas (manually)	no obstacles
close V1	close the Valve (V1) (manually)	no obstacles
Post condition		
System is off	all Valves are closed	System is off



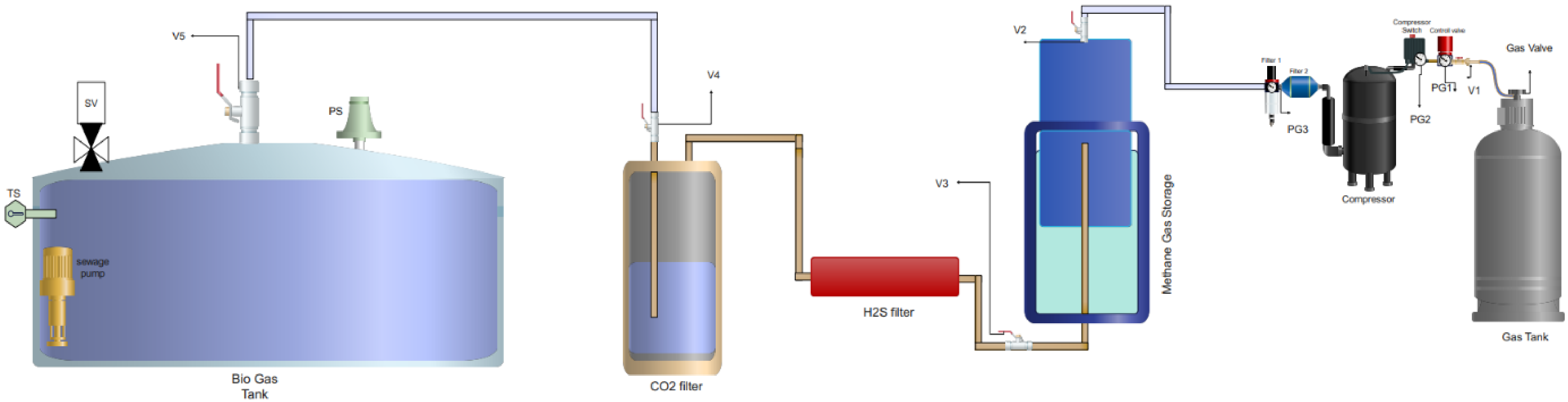
Compressor Switch
Gas Valve
V1
PG1
PG2
PG3
V5
PS1

4.3.5 Enhancing Methane Storage Through Gas Compression With Filtration System

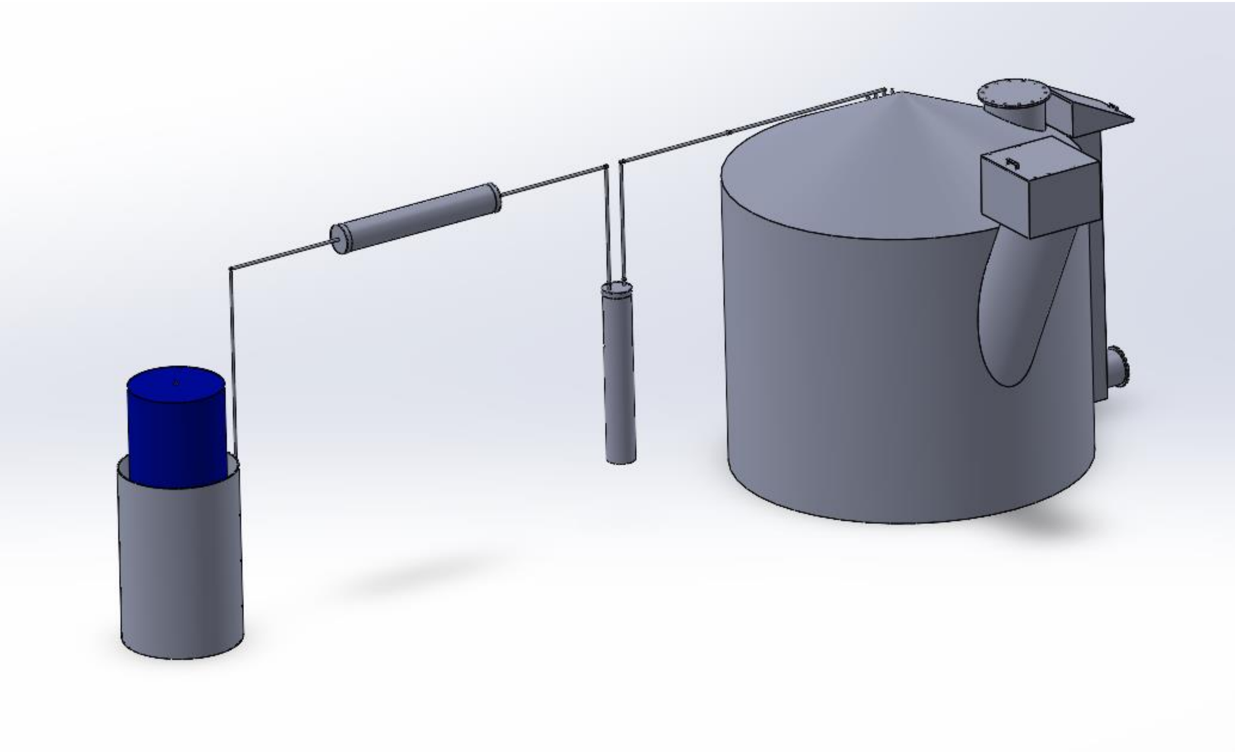
Step	Step description	Expected Result
Precondition		
System is off	all Valves are closed	System is off
Connection		
Connecting gas entrance	Connect the PEX tube to the compression machine inlet (manually)	Connected
connecting check valve	Connect the check valve to the machine outlet (manually)	connected
Connecting the system to the gas storage tank	Connect the pipe in the machine outlet to the methane gas storage (manually)	connected
Leakage check	start the compressor and open Valves V1 and V2 and Gas Tank main Valve to check the leakage in the system (with Soap)	no leak
	close the compressor and close the Valves V1 and V2 and Gas Tank main Valve	no obstacles

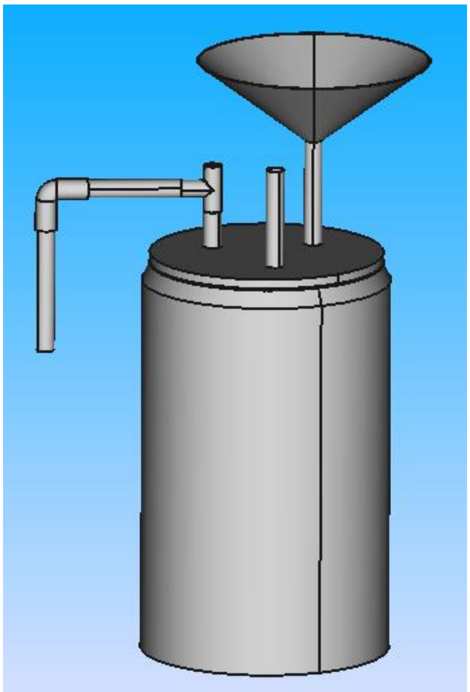
Test Starts		
Open gas tank	open the gas tank main valve (manually)	opened
open V1	open the Valve (V1) (manually)	no obstacles
open V2 , V3, V4, V5	Open Valve V2 , V3, V4, V5 of the Biogas (manually)	gas inlet should be equal gas outlet
start the Switch of the compressor	start the switch of the compressor (by GUI)	compression started (and compression ended by the Compressor switch when it reaches 8 bar (on PG2) or when the pressure at the biogas reaches atmospheric pressure (by PS))

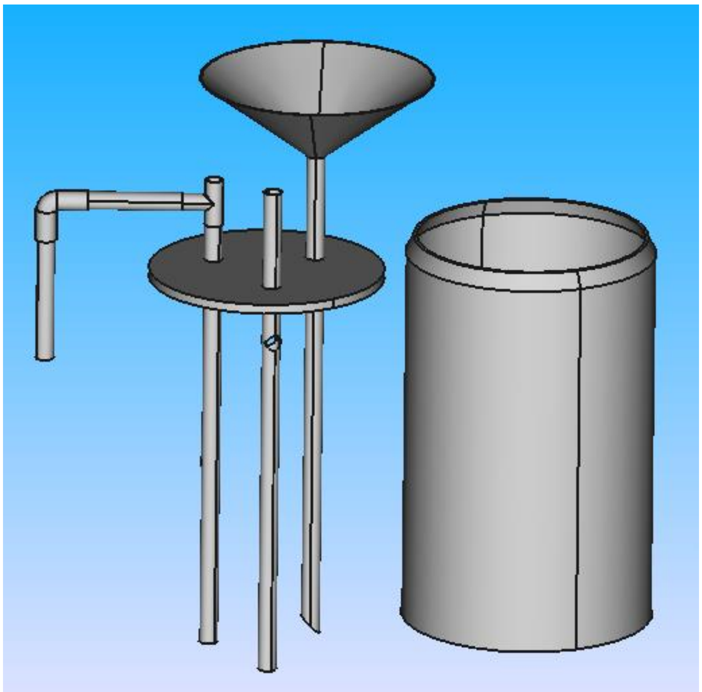
Close the red emergency switch of the compressor	Close the red switch of the compressor (manually) in case of emergency when neither the switch turned off automatically nor the GUI gives the order to close the system cycle	Compressor turned off
close V2 , V3, V4, V5	close the Valve V2 , V3, V4, V5 of the Biogas (manually)	no obstacles
close V1	close the Valve (V1) (manually)	no obstacles
Post condition		
System is off	all Valves are closed	System is off


V5
SV
PS
TS
sewage pump
Bio Gas Tank
V4
CO2 filter
H2S filter
V3
V2
Methane Gas Storage
Filter 1
Filter 2
PG3
Compressor
Compressor Switch
Control valve
PG2
PG1
V1
Gas Valve
Gas Tank

4.4 Ras Maska Biogas Prototype Reactor - Mechanical Realization







Biogas SolidWorks file :

Assem1.STEP

4.5 Realization of biogas storage parts

4.5.1 The H_2S filter tank

It is made of pipe that contains iron wool and 240 activated charcoal pills

4.5.2 The CO_2 filter storage

It is made of water and one pipe immersed in water and another pipe connected to the surface for pure methane gas with the H_2S

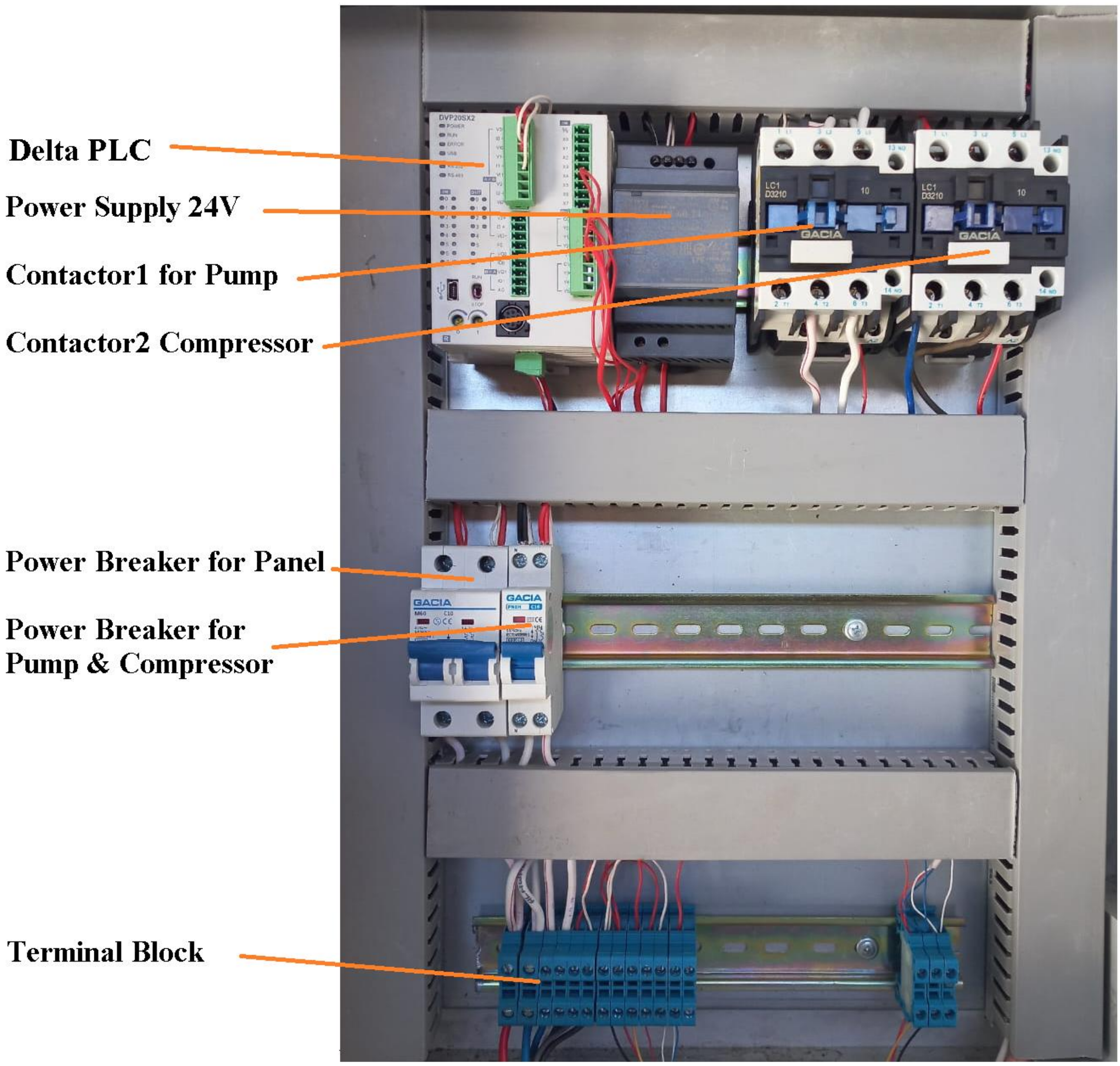
Carbon Dioxide (CO_2) Filter Storage Liquid Preparation Video:

WhatsApp Video
2023-12-13 at 11.49.

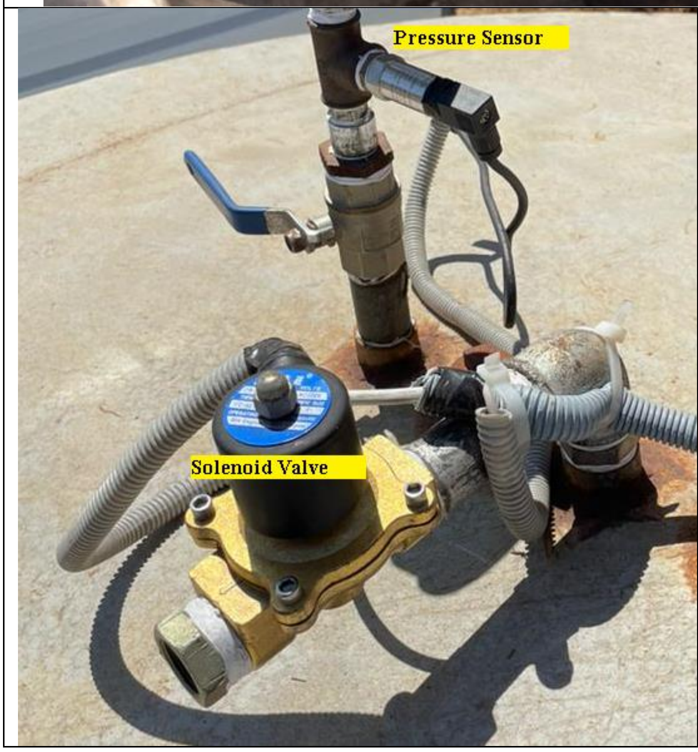
Filling of tank to clean from CO_2	Filling of calc with water		Opening Valve
	 	 	 

4.6 Biogas PCS implementation

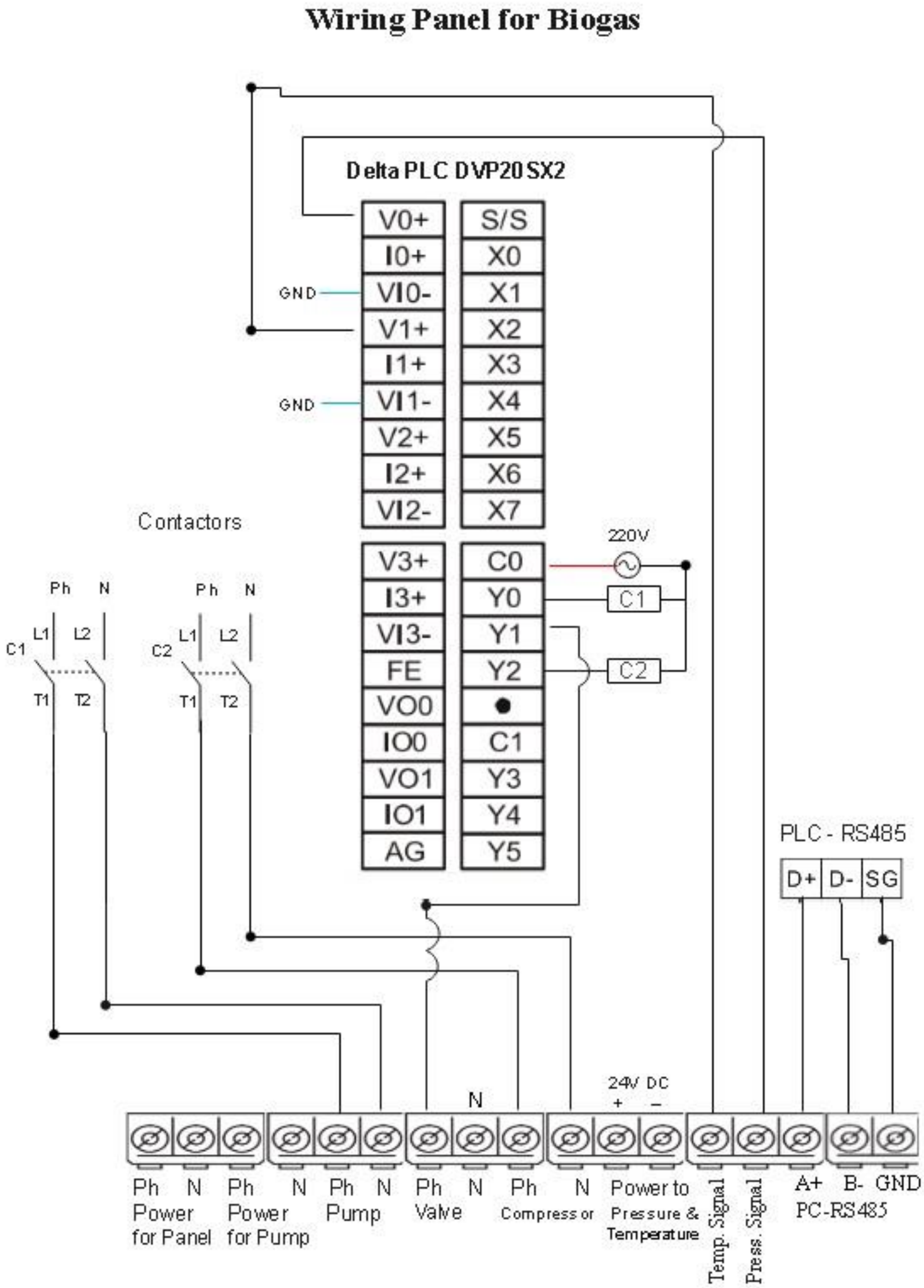
4.6.1.1 Control Panel



4.6.1.2 Instruments



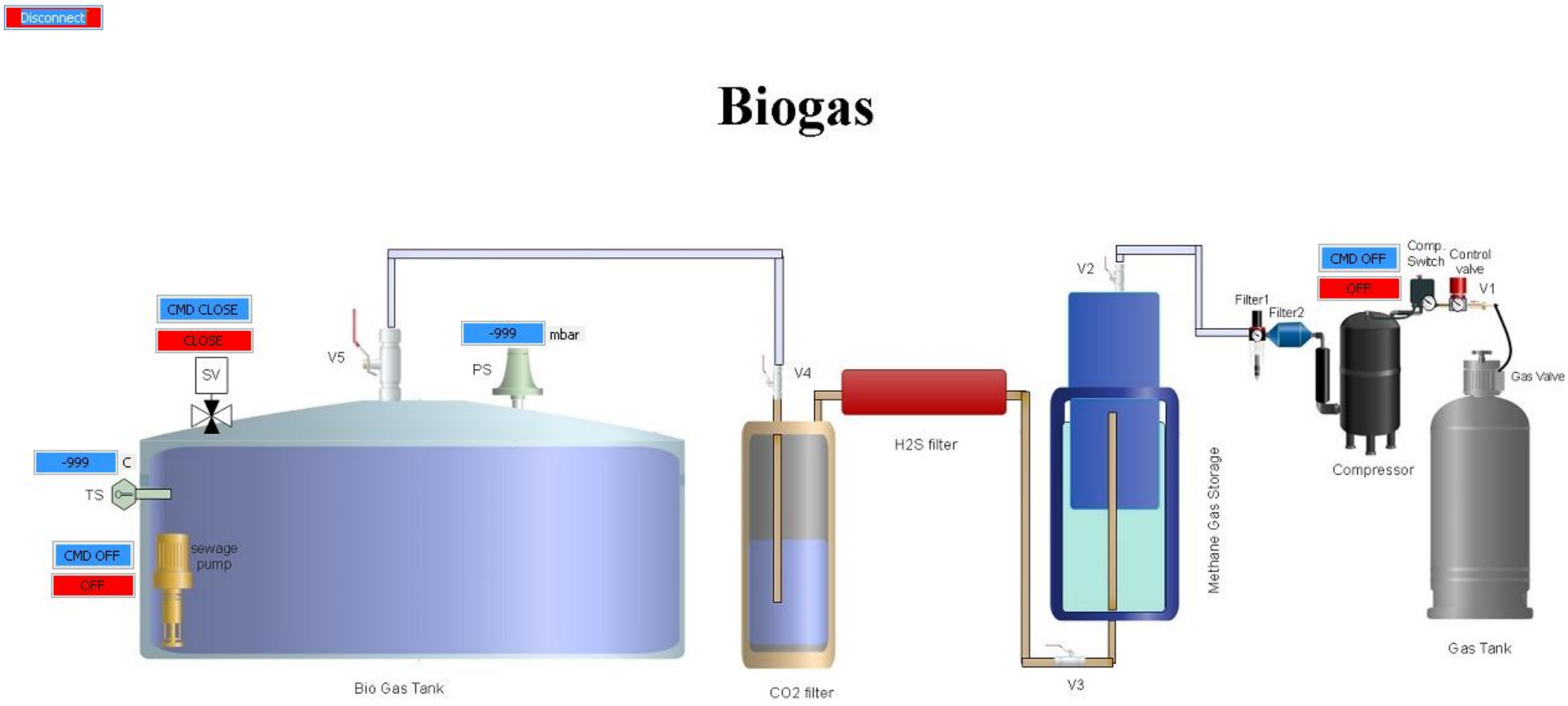
4.6.1.3 Wiring Control Panel



4.6.1.4 Graphical User Interface code (C#) and PLC Code

NLAP-Biogas_Fuel-Burner_PCS_GUI_010	NLAP_Biogas_Fuel-Burner_PCS_PLC-code

4.6.1.5 Graphical User Interface (GUI)


Disconnect
Biogas
CMD CLOSE
CLOSE
SV
V5
-999
mbar
PS
V4
-999
C
TS
CMD OFF
OFF
sewage pump
Bio Gas Tank
CO2 filter
H2S filter
V2
V3
Methane Gas Storage
Filter1
Filter2
CMD OFF
OFF
Comp. Switch
Control valve
V1
Gas Valve
Compressor
Gas Tank

4.6.1.6 PLC_Modbus_addresses

	Addresses inside (GUI)	Modbus addresses (PLC)	Physical Address (PLC)	Remarque
Biogas				
BG_Presure Sensore	4097	4098	D1	
BG_Temperature_Sensor	4098	4099	D2	
BG_Pump_Status	1280	1281	Y0	
BG_ON/OFF_Pump	1280	1281	Y0	
BG_Valve_Status	1281	1282	Y1	
BG_ON/OFF_Valve	1281	1282	Y1	
BG_Compressor_Status	1282	1283	Y2	
BG_ON/OFF_Compressor	2048	2049	M0	
Fuel Burner				
FB_Temperature_Sensor	4106	4107	D10	
FB_Valve1_Status	1283	1284	Y3	Valve 1 for gas (Butane/Methane)
FB_ON/OFF_Valve1	2069	2070	M21	
FB_Valve2_Status	1284	1285	Y4	Valve 2 for Oxygen/Air
FB_ON/OFF_Valve2	2070	2071	M22	
FB_Valve3_Status	1282	1283	Y5	Valve 3 _ gas for lighter
FB_ON/OFF_Valve3	2048	2049	Y2	
FB_Valve4_Status	1285	1286	M0	Valve 4 _ gas for Burner
FB_ON/OFF_Valve4	1285	1286	Y5	
FB_Lighter_Status	1285	1286	Y5	
FB_ON/OFF_Lighter	1285	1286	Y5	
FB_ON/OFF_Valves 1_2	2068	2069	M20	

Coil/Register Numbers	Data Addresses	Type	Table Name
1 to 9999		Read-Write	Discrete Output Coils
10001-19999	0000 to 270E	Read-Only	Discrete Input Contacts
30001-39999	0000 to 270E	Read-Only	Analog Input Registers
40001-49999	0000 to 270E	Read-Write	Analog Output Holding Registers

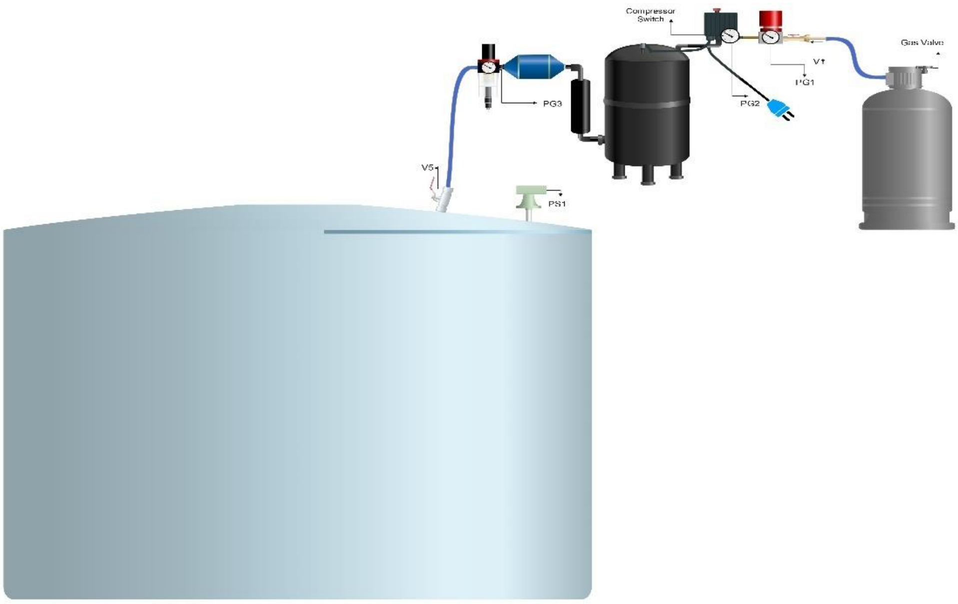
4.7 Biogas tests

4.7.1 Test 4 -16012024: Enhancing Methane Storage through Gas Compression

Step	Step description	Expected Result	Result		Result Discription
	Precondition		❌	✓	
System is off	all Valves are closed	System is off		✓	
		Connection			
Connecting gas entrance	Connect the PEX tube to the compression machine inlet (manually)	Connected		✓	
connecting check valve	Connect the check valve to the machine outlet (manually)	connected		✓	
Connecting the system to the gas storage tank	Connect the pipe in the machine outlet to the methane gas storage (manually)	connected		✓	
Leakage check	start the compressor and open Valves V1 and V5 and Gas Tank main Valve to check the leakage in the system (with Soap)	no leak	❌		there was leakage in the pipe ,and was fixed immediatlly.

	close the compressor and close the Valves V1 and V5 and Gas Tank main Valve	no obstacles	✓
Test Starts			
Open gas tank	open the gas tank main valve (manually)	opened	✓
open V1	open the Valve (V1) (manually)	no obstacles	✓
open V5	Open Valve V5 of the Biogas (manually)	no obstacles	✓
start the Switch of the compressor	start the switch of the compressor (by GUI)	compression started (and compression ended by the Compressor switch when it reaches 8 bar (on PG2) or when the pressure at the biogas reaches atmospheric pressure (by PG4))	✓

Close the red emergency switch of the compressor	Close the red switch of the compressor (manually) in case of emergency when neither the switch turned off automatically nor the GUI gives the order to close the system cycle	Compressor turned off	✓
close V5	close the Valve V5 of the Biogas (manually)	no obstacles	✓
close V1	close the Valve (V1) (manually)	no obstacles	✓
	Post condition		
System is off	all Valves are closed	System is off	✓



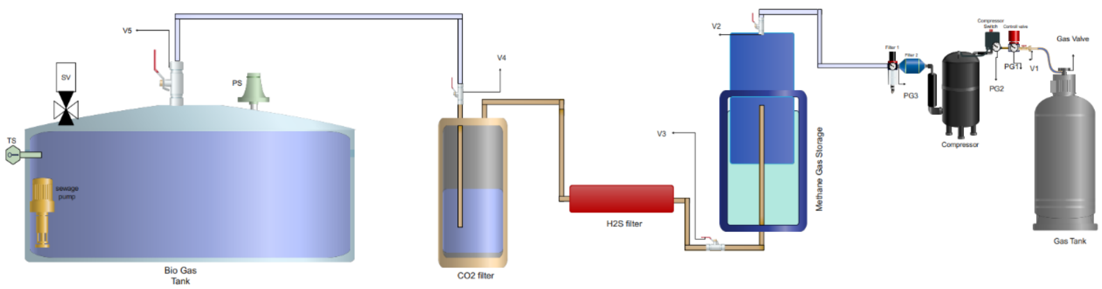
4.7.2 Test 5 -18012024: Enhancing Methane Storage through Gas Compression with Filtration System Part 2

Step	Step description	Expected Result	Result		Result Description
	Precondition		❌	✓	
System is off	all Valves are closed	System is off		✓	
		Connection			
Connecting gas entrance	Connect the PEX tube to the compression machine inlet (manually)	Connected		✓	
connecting check valve	Connect the check valve to the machine outlet (manually)	connected		✓	
Connecting the system to the gas storage tank	Connect the pipe in the machine outlet to the methane gas storage (manually)	connected		✓	

Leakage check	start the compressor and open Valves V1 and V2 and Gas Tank main Valve to check the leakage in the system (with Soap)	no leak	✓
	close the compressor and close the Valves V1 and V2 and Gas Tank main Valve	no obstacles	✓
Test Starts			
Open gas tank	open the gas tank main valve (manually)	opened	✓
open V1	open the Valve (V1) (manually)	no obstacles	✓
open V2 , V3, V4, V5	Open Valve V2 , V3, V4, V5 of the Biogas (manually)	gas inlet should be equal gas outlet	✓

start the Switch of the compressor	start the switch of the compressor (by GUI)	compression started (and compression ended by the Compressor switch when it reaches 8 bar (on PG2) or when the pressure at the biogas reaches atmospheric pressure (by PS))	✓	switch reached 8 bar pressure and system turned off
Close the red emergency switch of the compressor	Close the red switch of the compressor (manually) in case of emergency when neither the switch turned off automatically nor the GUI gives the order to close the system cycle	Compressor turned off	✗	we didn't use it

close V2 , V3, V4, V5	close the Valve V2 , V3, V4, V5 of the Biogas (manually)	no obstacles	✓
close V1	close the Valve (V1) (manually)	no obstacles	✓
Post condition			
System is off	all Valves are closed	System is off	✓



Full video of the biogas Process:

WhatsApp Video 2024-01-20 at 9.13.4

4.8 What’s next

The first objective of the project has been achieved, after that the focus should be on the efficiency of the project to obtain accurate scientific data.

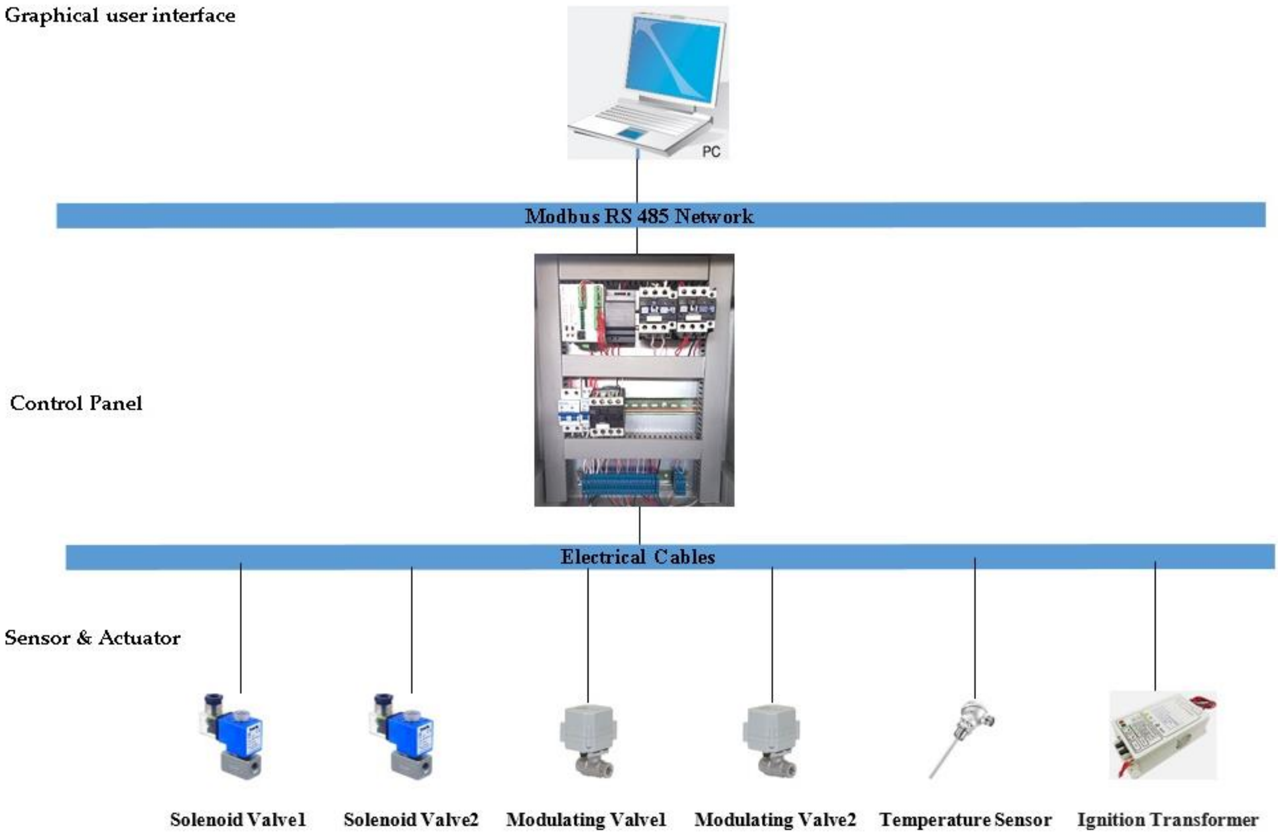
5 Project 5: Gas Turbine for Methane gas

5.1 Position of Gas turbine project

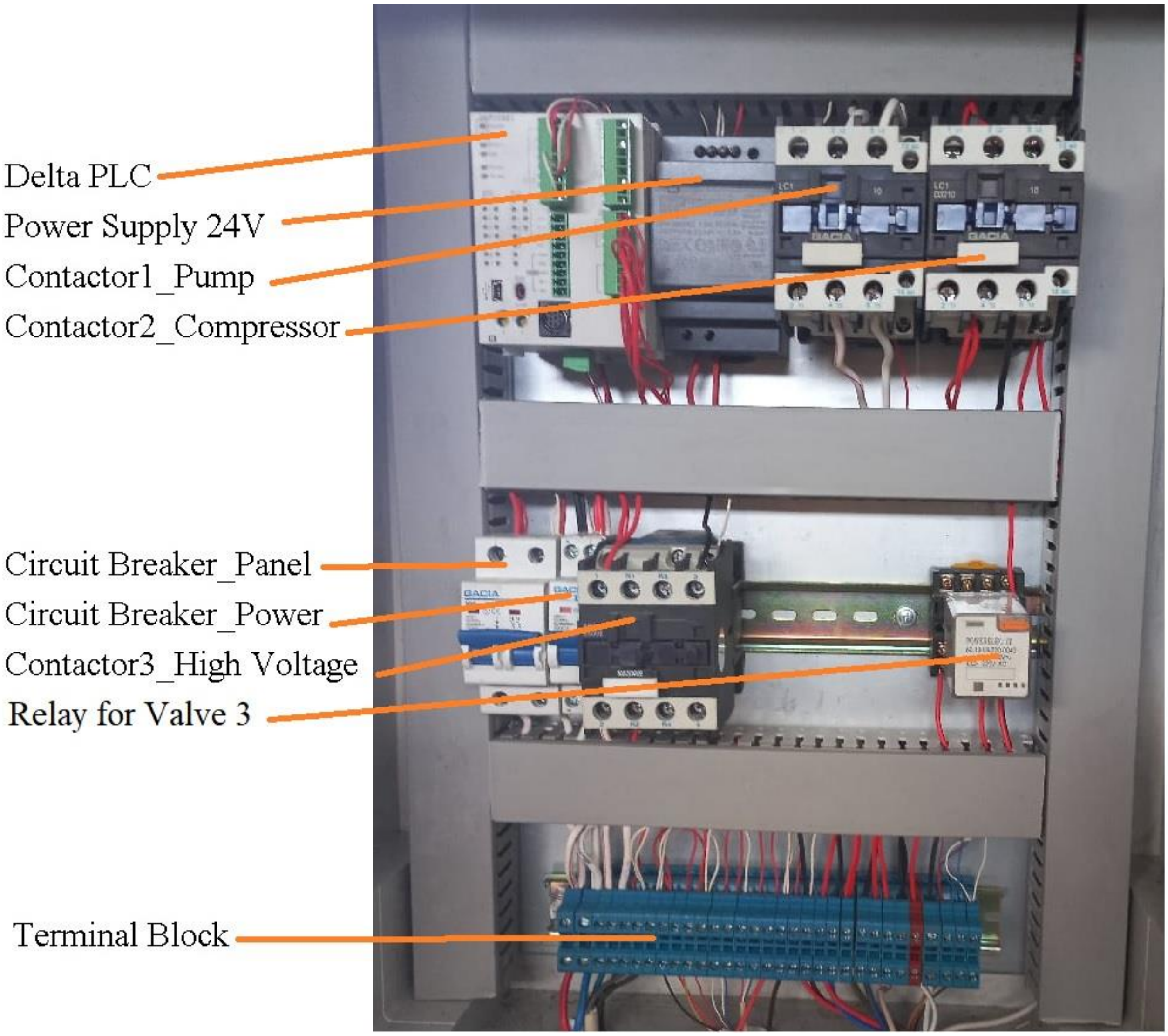
This project is divided into two parts: the fuel burner and the gas turbine. Work has been done on the fuel burner section in the past years, this year the stand was manufactured for the burner only. While the focus was on the gas turbine, the project was studied theoretically, and a preliminary design of the gas turbine was developed.

5.2 Fuel burner PCS realization

5.2.1 The process control system for the Fuel Burner

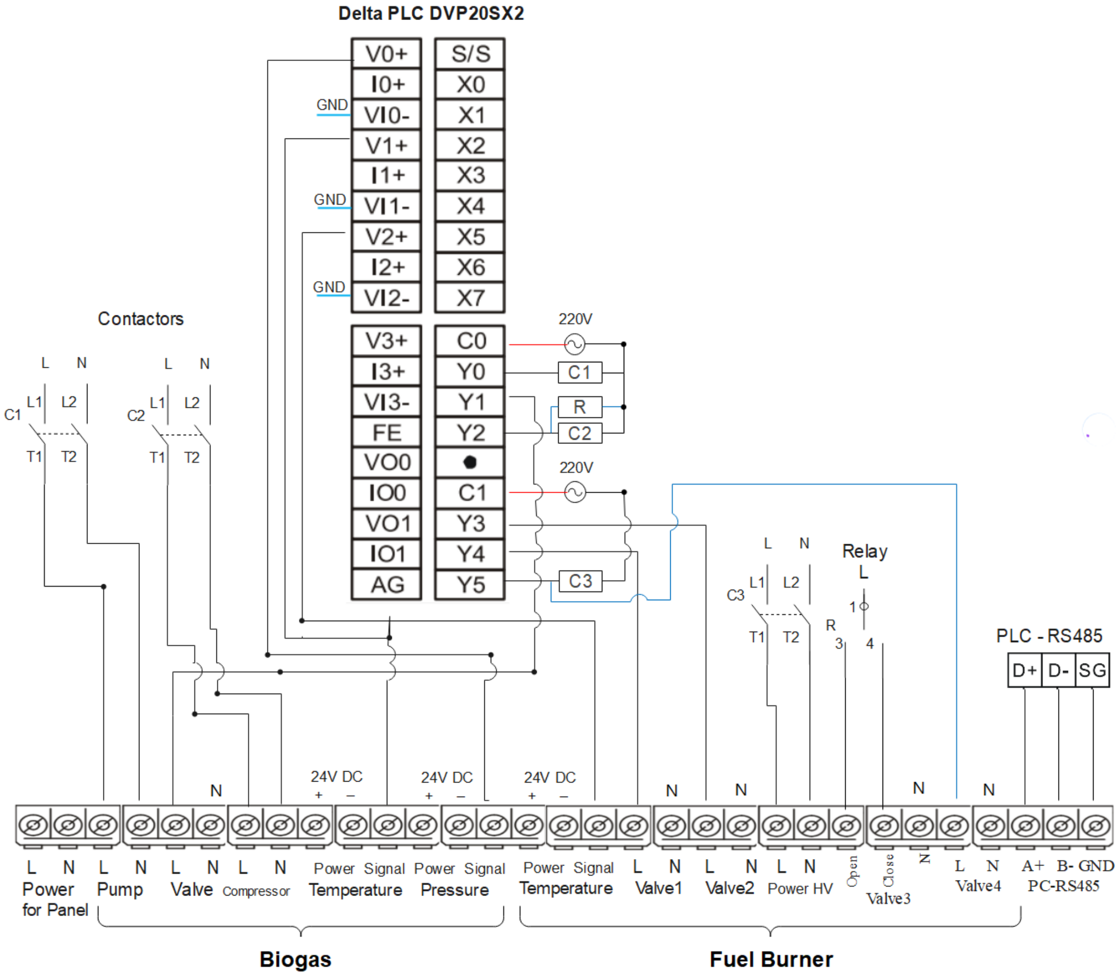


5.2.2 Control Panel



5.2.3 Control Panel Wiring Diagram

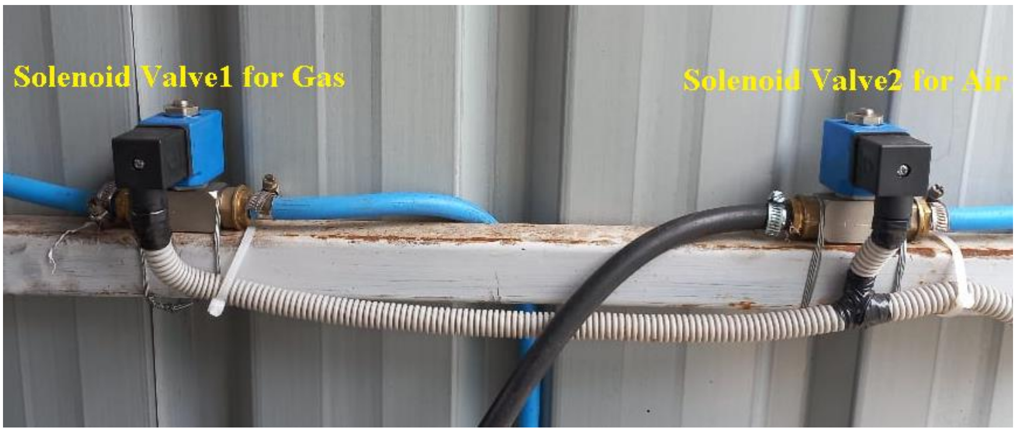
Wiring Panel for Biogas & Fuel Burner



Panel Wiring Diagram:

NLAP- Biogas_Fuel burner_Panel Wiring

5.2.4 Instruments




Valve 3
Gas for Burner


Solenoid valve 4
Gas for ignition


Temperature Sensor

5.2.5 PLC Modbus addresses - Communication points

	addresses inside (GUI)	Modbus-addresses (PLC)	Physical Address (PLC)
Fuel Burner			
FB_Temperature_Sensor	4106	4107	D10
FB_Valve1_Status	1283	1284	Y3
FB_ON/OFF_Valve1	2069	2070	M21
FB_Valve1_Status	1284	1285	Y4
FB_ON/OFF_Valve1	2070	2071	M22
FB_Lighter_Status	1285	1286	Y5
FB_ON/OFF_Lighter	1285	1286	Y5
FB_ON/OFF_Valves 1_2	2068	2069	M20

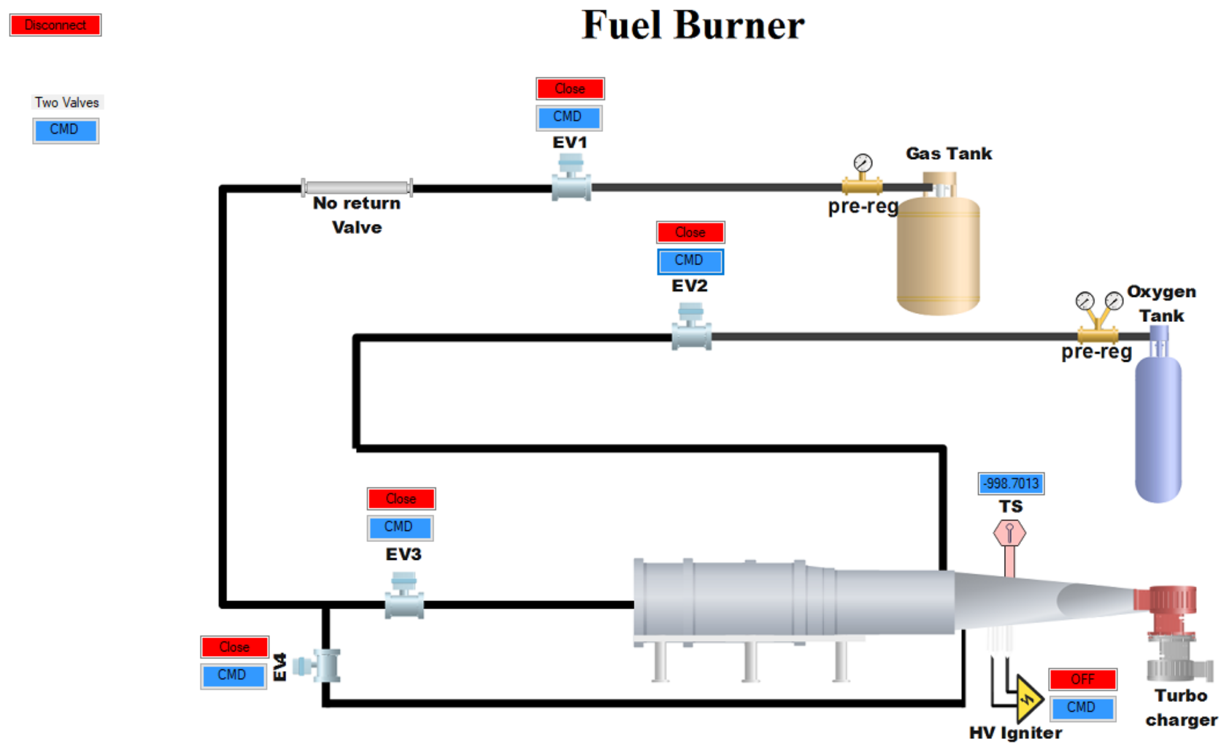
5.2.6 PLC Modbus addresses:

	Addresses inside (GUI)	Modbus addresses (PLC)	Physical Address (PLC)	Remark	
Biogas					
BG_Presure Sensore	4097	4098	D1		
BG_Temperature_Sensor	4098	4099	D2		
BG_Pump_Status	1280	1281	Y0		
BG_ON/OFF_Pump	1280	1281	Y0		
BG_Valve_Status	1281	1282	Y1		
BG_ON/OFF_Valve	1281	1282	Y1		
BG_Compressor_Status	1282	1283	Y2		
BG_ON/OFF_Compressor	2048	2049	M0		
Fuel Burner					
FB_Temperature_Sensor	4106	4107	D10		
FB_Valve1_Status	1283	1284	Y3	Valve 1 for gas (Butane/Methane)	
FB_ON/OFF_Valve1	2069	2070	M21		
FB_Valve2_Status	1284	1285	Y4	Valve 2 for Oxygen/Air	
FB_ON/OFF_Valve2	2070	2071	M22		
FB_Valve3_Status	1282	1283	Y5	Valve 3_ gas for lighter	
FB_ON/OFF_Valve3	2048	2049	Y2		
FB_Valve4_Status	1285	1286	M0	Valve 4 _ gas for Burner	
FB_ON/OFF_Valve4	1285	1286	Y5		
FB_Lighter_Status	1285	1286	Y5		
FB_ON/OFF_Lighter	1285	1286	Y5		
FB_ON/OFF_Valves 1_2	2068	2069	M20		

Coil/Register Numbers	Data Addresses	Type	Table Name
1 to 9999		Read-Write	Discrete Output Coils
10001-19999	0000 to 270E	Read-Only	Discrete Input Contacts
30001-39999	0000 to 270E	Read-Only	Analog Input Registers
40001-49999	0000 to 270E	Read-Write	Analog Output Holding Registers

290324_NLAP-Bioga
s_Fuel-Burner_PCS_F

5.2.7 Graphical User Interface



5.2.8 Graphical User Interface code (C#) and PLC Code

NLAP-Biogas_Fuel-Burner_PCS_GUI_010	NLAP_Biogas_Fuel-Burner_PCS_PLC-code

5.3 Fuel Burner System test specification

Test 00001: Test of Ethanol liquid combustion with liquid Hydrogen peroxide using the Fuel burner

Step	Step description	Expected result
Precondition	The system is Off	All valves are closed
		All pumps are turned Off
Turn On the transformer (T)	Connect electricity to the transformer (T)	Spark is On
Open the Automatic controller valve of Ethanol (BV_1)	Click "Turn On" on BV_1 button from the GUI	BV_1 is open
Turn On the ethanol pump (P_1)	Click "Turn On" on P_1 button from the GUI	P_1 is turned On
		The spark is appeared, and will turns into a flame

Control the flame without oxidant	Adjust the orifice degree to control the ethanol flow rate from the GUI	The flame will be more stable
Open the Automatic controller valve of Hydrogen peroxide (BV_2)	Click "Turn On" on BV_2 button from the GUI	BV_2 is open
Turn On the Hydrogen peroxide pump (P_2)	Click "Turn On" on P_2 button from the GUI	P_2 is turned On
		The flame will be more strong
Control the flame with oxidant	Adjust the orifice degree to control the hydrogen peroxide flow rate from the GUI	The flame will become stronger and more stable
Turn Off the system	Turn Off the Hydrogen peroxide pump (P_2)	P_2 is turned Off
	Close the Automatic controller valve of Hydrogen peroxide (BV_2)	BV_2 is closed
	Turn Off the ethanol pump (P_1)	P_1 is turned Off
	Close the Automatic controller valve of Ethanol (BV_1)	BV_1 is closed
		The flame disappears with time
	Turn Off the transformer (T)	The transformer (T) is turned Off
		The spark is disappeared

5.4 Fuel Burner system test

5.4.1 Fuel Burner on Test Rig with Nozzle 23.03.23

5.4.2 Gas Turbine at the side of the Nozzle (29.03.23)

5.5 Biogas Turbine System Stochiometric Calculation and System Test

Balanced equation for complete combustion of butane:

$2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$

- The mole ratio of butane to oxygen = 2:13
- The density of butane = 0.579 g/mL

- Mass of 5 mL of butane = Volume x density = 5 mL x 0.579 g/mL = 2.895 g
- Molar mass of butane = 12*4 + 1*10 = 58 g/mol
- Moles in 2.895 g of butane, C_4H_{10} = 2.895 g/(58 g/mol) = 0.05 mol

1. As per the reaction equation, the mole ratio of butane to oxygen is 2: 13.

- Moles of oxygen that react with 0.05 mol of butane =
  = 0.05 mol x 13/2 = 0.325 mol
- Molar mass of oxygen, O_2 = 16*2 = 32 g/mol
- Mass of 0.325 mol of oxygen = (32 g/mol) x 0.325 g = <u>10. 4 g for 2.895 g of Butane to make complete Combustion in atmospheric pressure</u>

2. Mole ratio of butane used to water (H_2O) formed = 2:10 = 1:5

- Moles of water formed =
- Moles of butane used x 5 = 0.05 mol x 5 = 0.25 mol
- of molecules in 0.25 mol of water = Avogadro number x 0.25 = 6.022 x 10^23 x 0.25 = 1.506 x 10^23
- Percentage of oxygen in air = 23%
- Mass of air needed for 23 g of oxygen = 100 g
- Mass of air needed for 10.4 g of oxygen = 10.4 g x (100 g/23 g) = 49.2 g ………….. (answer 3)

ANSWERS:

(1) Mass of oxygen needed for combustion = 10.4 g
(2) Number of molecules of water produced = 1.506 x 10^23
(3) Mass or air needed = 49.2 g

PV=
P1 = for Butane
P2 = For Oxygen

Therefore,
If P1 is 3 bar, then
<u>But the butane gas is not ideal. So non-ideal gases are often modeled by the Van der Waals equation:</u>
p1 = 3 bar
a = 13.36
b = 0.1168
n1 = 0.05 mole
n2 = 0.325 mole
R = 8.125 J/mole.k
T = 298 k

$$① \rightarrow \left(P_1 + \frac{a n_1^2}{V_2^2}\right)\left(V - n_1 b\right) = n_1 R T$$

$$② \rightarrow P_2 V_2 = n_2 R T$$

$$② \rightarrow V = \frac{n_2 R T}{P_2}$$

$$\Rightarrow ① \Rightarrow \left(P_1 + \frac{a n_1^2}{\left(\frac{n_2 R T}{P_2}\right)^2}\right)\left(\frac{n_2 R T}{P_2} - n_1 b\right) = n_1 R T$$

$$\Rightarrow \left[3\times10^5 + \frac{13{,}36 \times (0{,}05)^2}{\left(\frac{0{,}325\times 8{,}314 \times 298}{P_2}\right)^2}\right]\left[\frac{0{,}325 \times 8{,}314 \times 298}{P_2} - 0{,}05 \times 0{,}1168\right] = 0{,}05 \times 8{,}314 \times 298$$

$$\Rightarrow \left[3\times10^5 + \frac{0{,}0334 \times P_2^2}{648364{,}593}\right]\left[\frac{805{,}2109}{P_2} - 0{,}00584\right] = 123{,}8786$$

$$\Rightarrow \left[3\times10^5 + 5{,}1514\times10^{-8} P_2^2\right]\left[\frac{805{,}2109}{P_2} - 0{,}00584\right] = 123{,}8786$$

$$\Rightarrow \frac{241563270}{P_2} - 1752 + 4{,}147963\times10^{-5} P_2 - 3\times10^{-10} P_2^2 = 123{,}8736$$

$$\Rightarrow 241563270 - 1752 \times P_2 + 4{,}147963\times10^{-5} P_2^2 - 3\times10^{-10} \times P_2^3 = 0$$

$$-1875{,}8736 P_2 \qquad = 123{,}8736 P_2$$

$$\Rightarrow -3\times10^{-10} P_2^3 + 4{,}147963\times10^{-5} P_2^2 - 1875{,}8736 P_2 + 241563270 = 0$$

$$P_2 = 128798{,}8608 \Rightarrow P_2 = 1{,}287988$$

Then =128798.8608 Pa, or 1.29 bar of oxygen for 3 bar of butane.

Mass Flow Rate = Mass/Δ*t*

Where:

- Mass is the mass of the gas (in kg),
- Δt is the time interval (in seconds).

Since we're assuming a time interval of 1 second, the mass flow rate will be equal to the mass of the gas.

For butane (C4H10), the mass flow rate is 2.906 g per second, which needs to be converted to kilograms (since 1 g = 0.001 kg): Mass Flow Rate of Butane=2.906 g/1 s×0.001 kg/g
Mass Flow Rate of Butane = 2.906×10^{-3} kg/s

For oxygen (O2), the mass flow rate is 10.4 g per second, which also needs to be converted to kilograms: Mass Flow Rate of Oxygen = 10.4 g/s x 0.001 kg/g Mass Flow Rate of Oxygen =10.4×10^{-3}kg/s

So, the mass flow rate of butane is 2.906×10^{-3} kg/s.

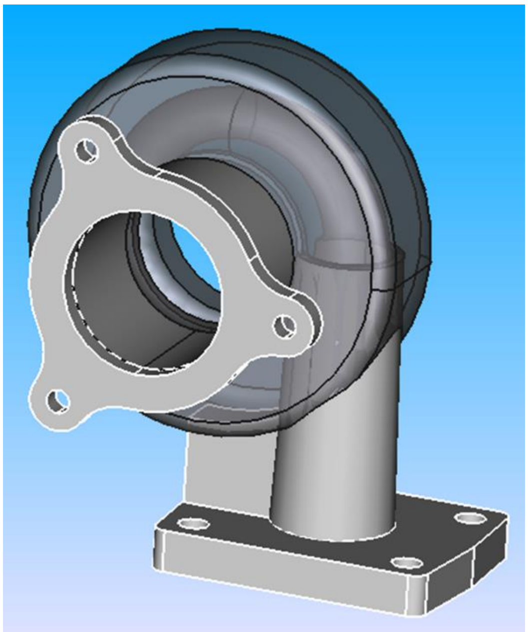
and the mass flow rate of oxygen is 10.4×10^{-3} kg/s.

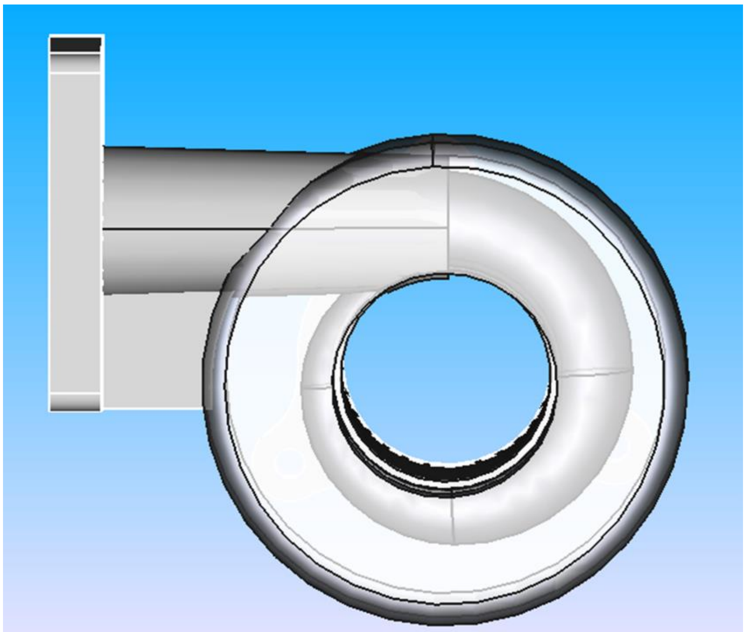
These values represent the mass flow rate at which each gas enters the combustion chamber at a volume of 0.025 m^3 and at T=25^{o} C and the pressure of the Combustion Chamber is equal to the atmospheric pressure

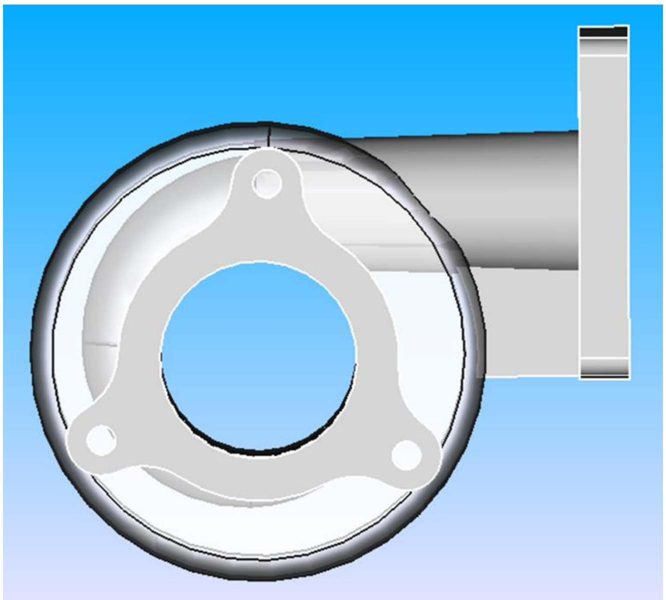
5.6 Gas turbine, Version 2

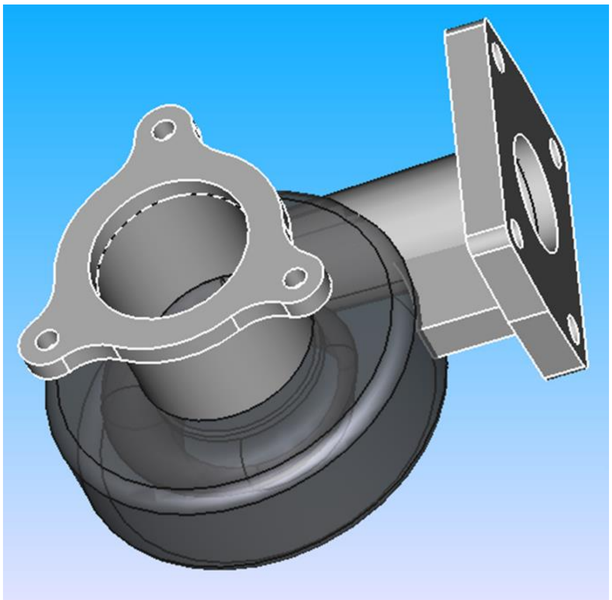
5.6.1 Housing_turbine

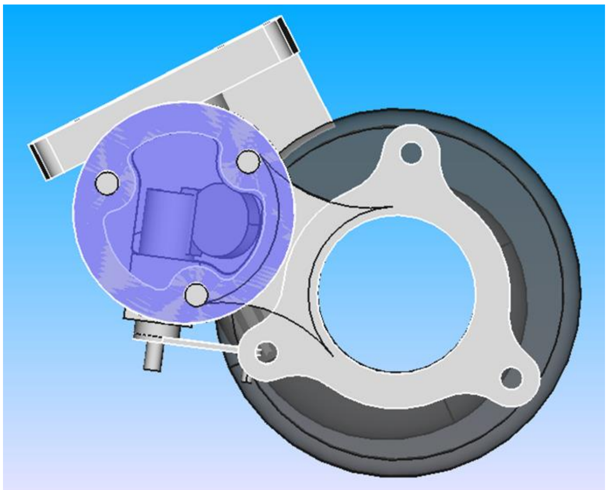
Housing turbo turbine_ FreeCAD file (v0.20):	13022023_ housing turbo turbine.FCStd

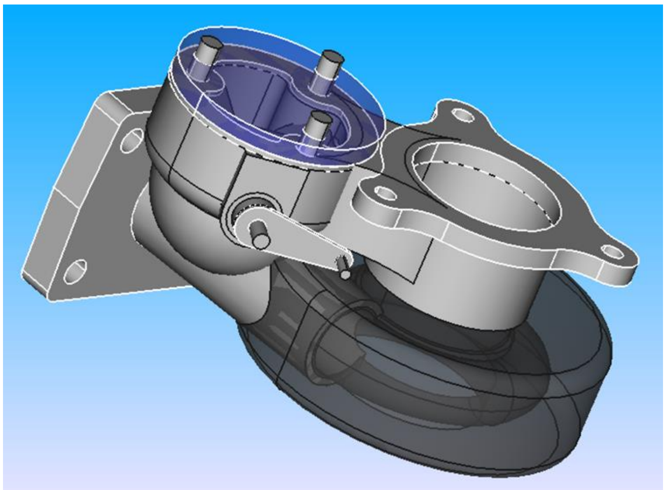






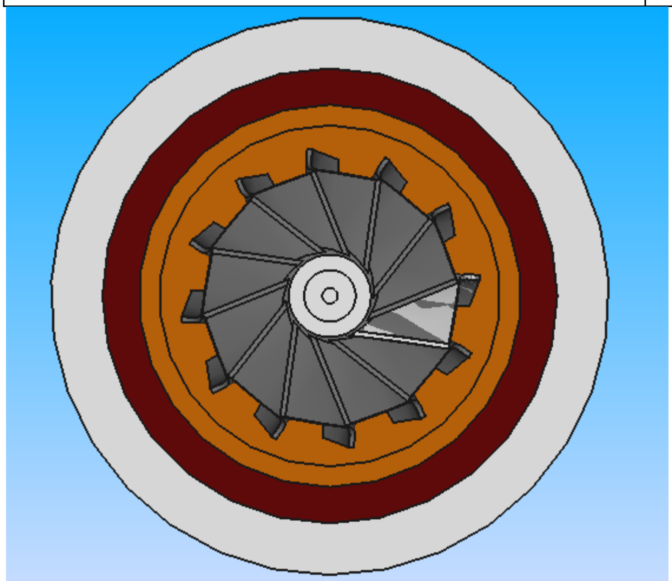


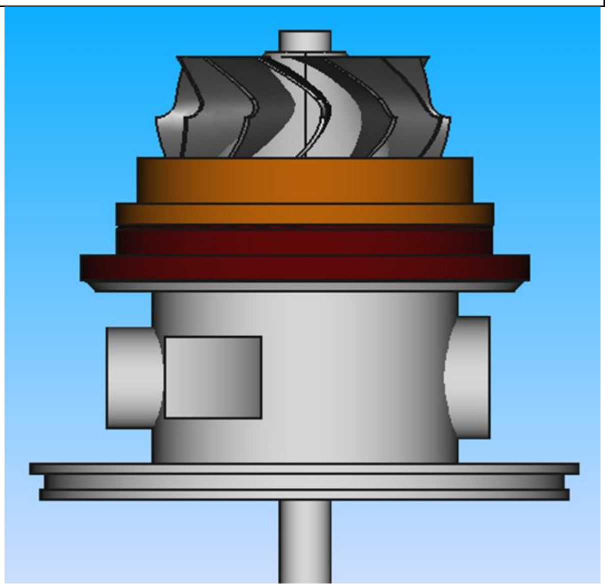


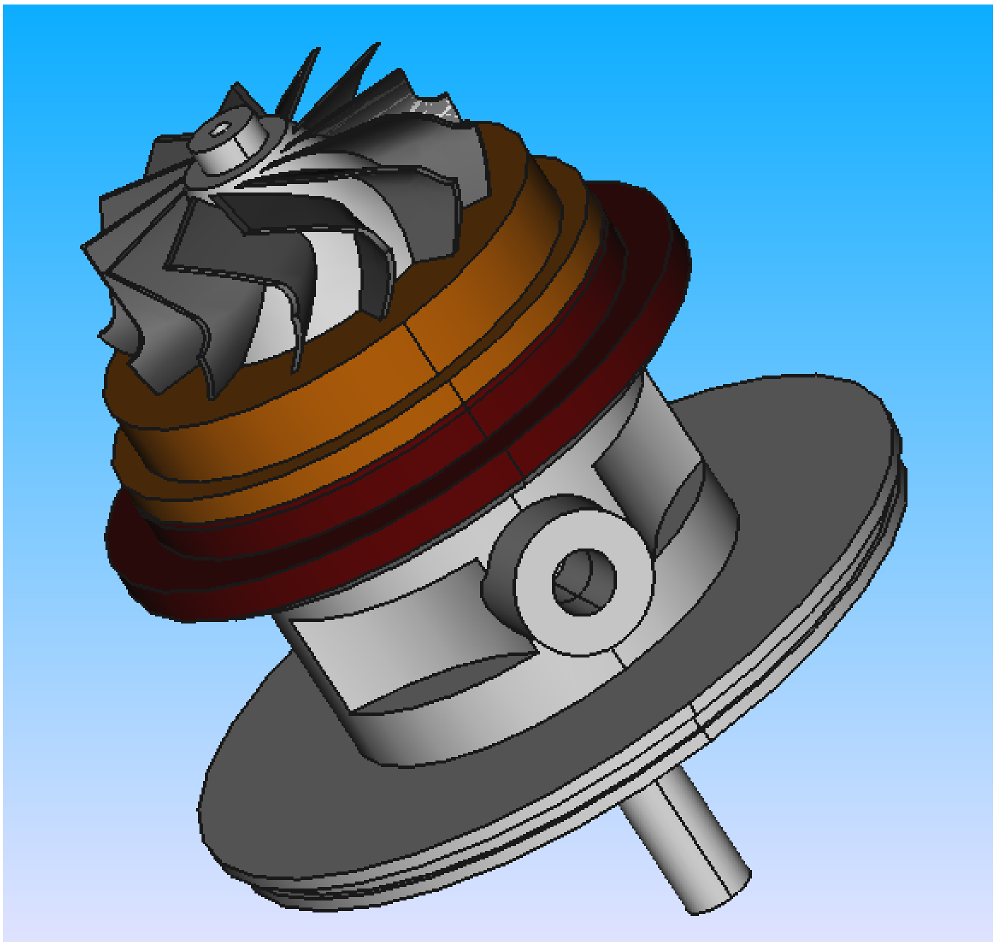


5.6.2 Blade_turbo

Blade turbo_ FreeCAD file (v0.20):	15022023_ Blade turbo turbine - Cop

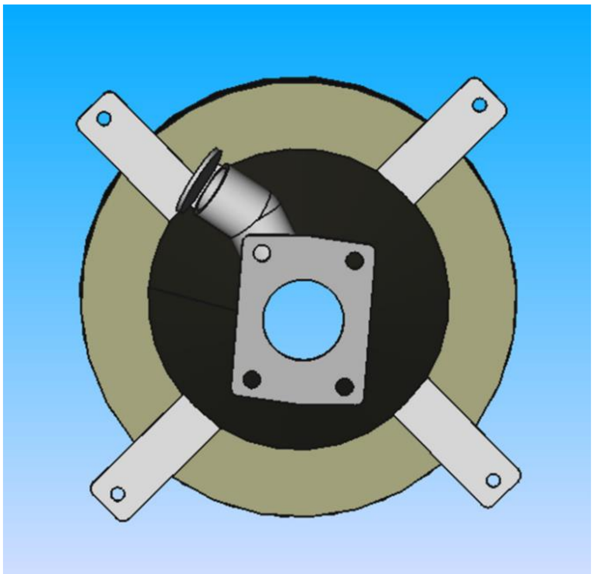
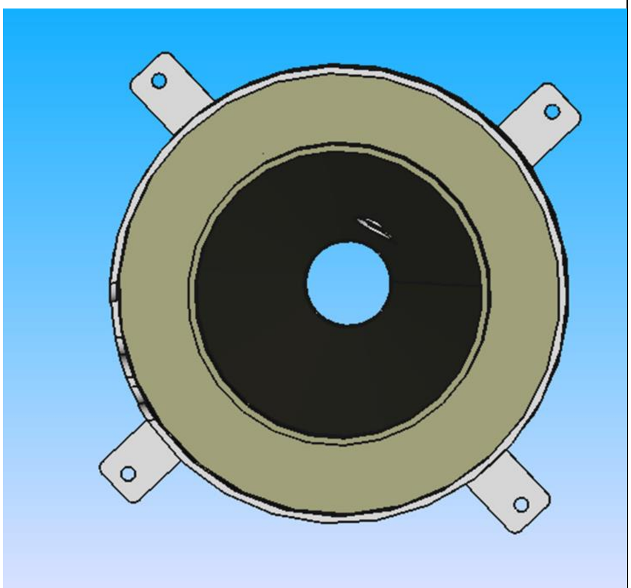


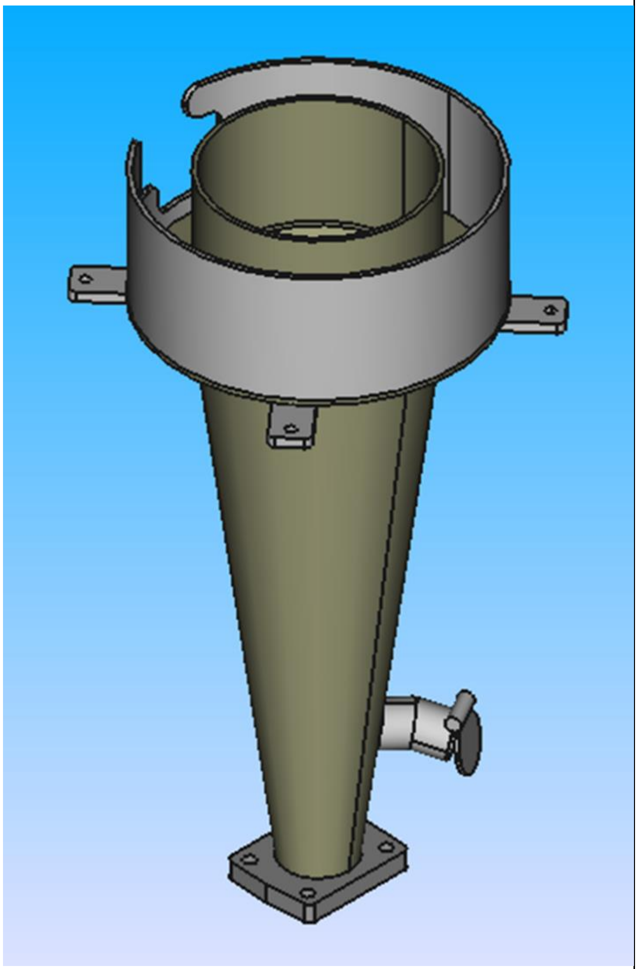


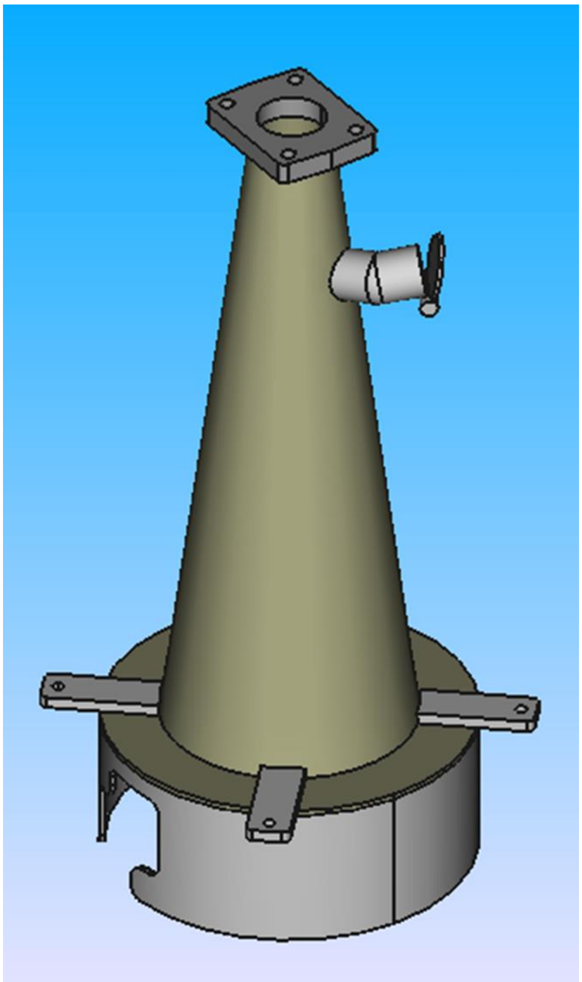


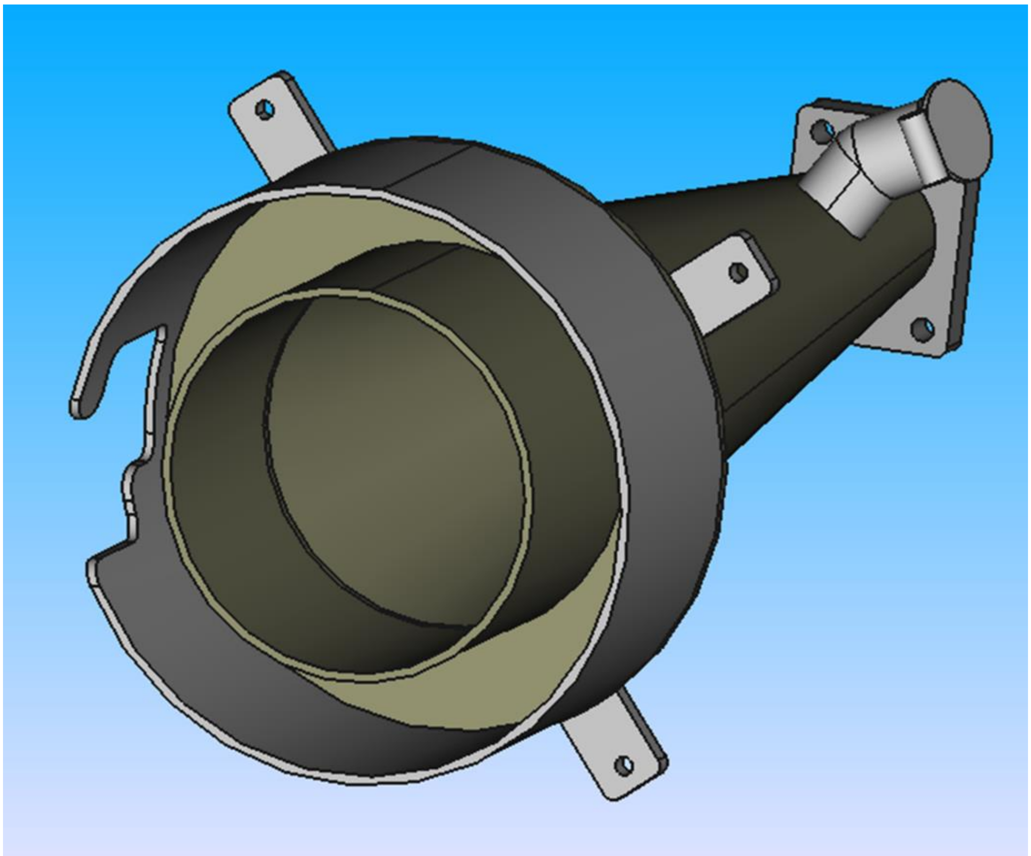
5.6.3 Nozzle design - premium design

Nozzle premium design_ FreeCAD file (v0.20):	17022023_Nozzle Final design.FCStd

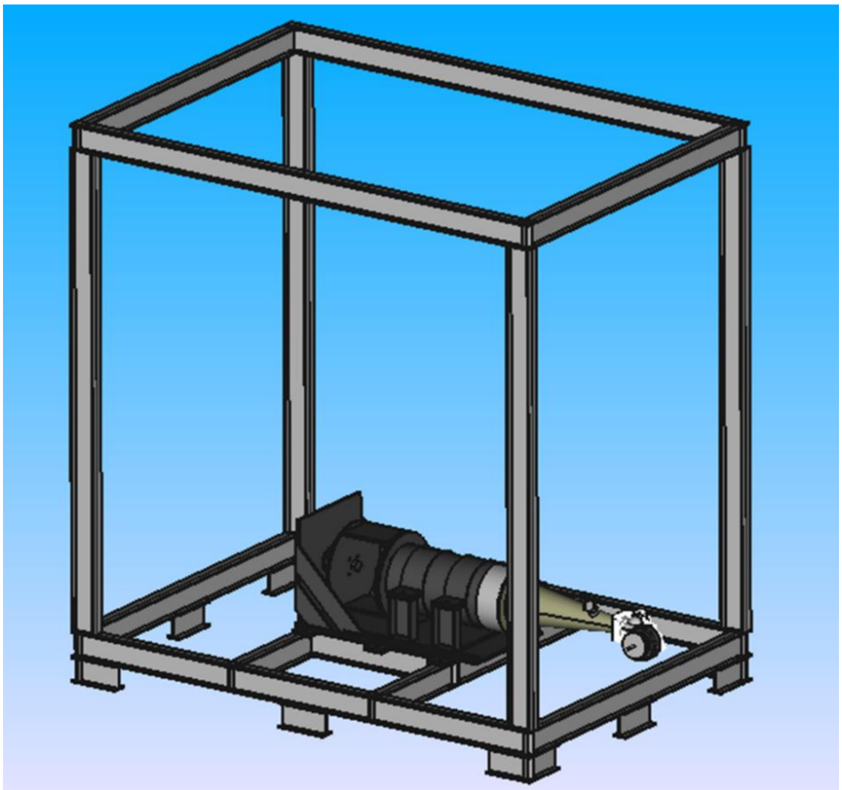


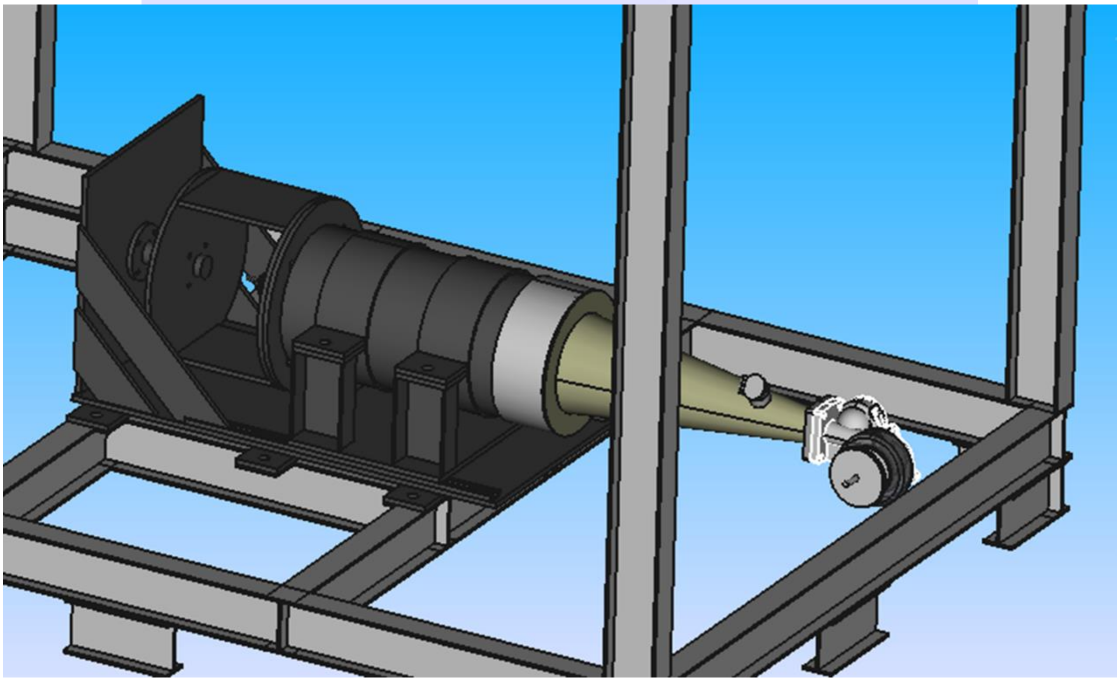


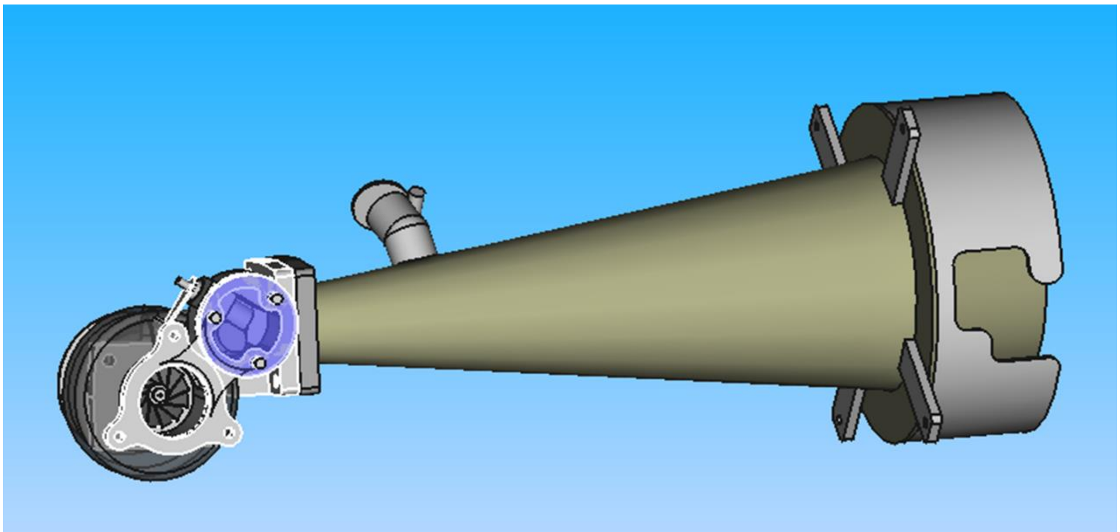


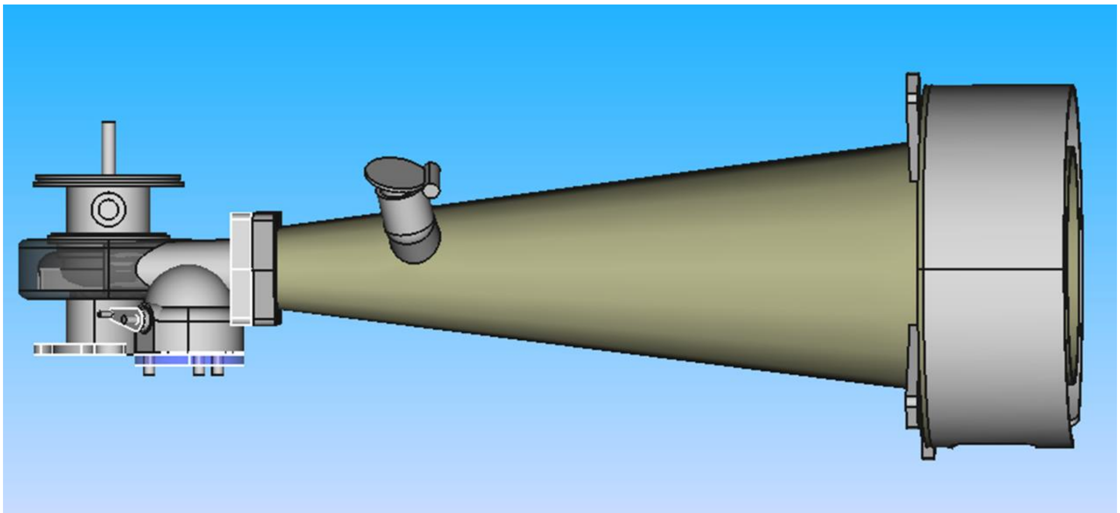
5.6.4 GTM Assembly - premium design

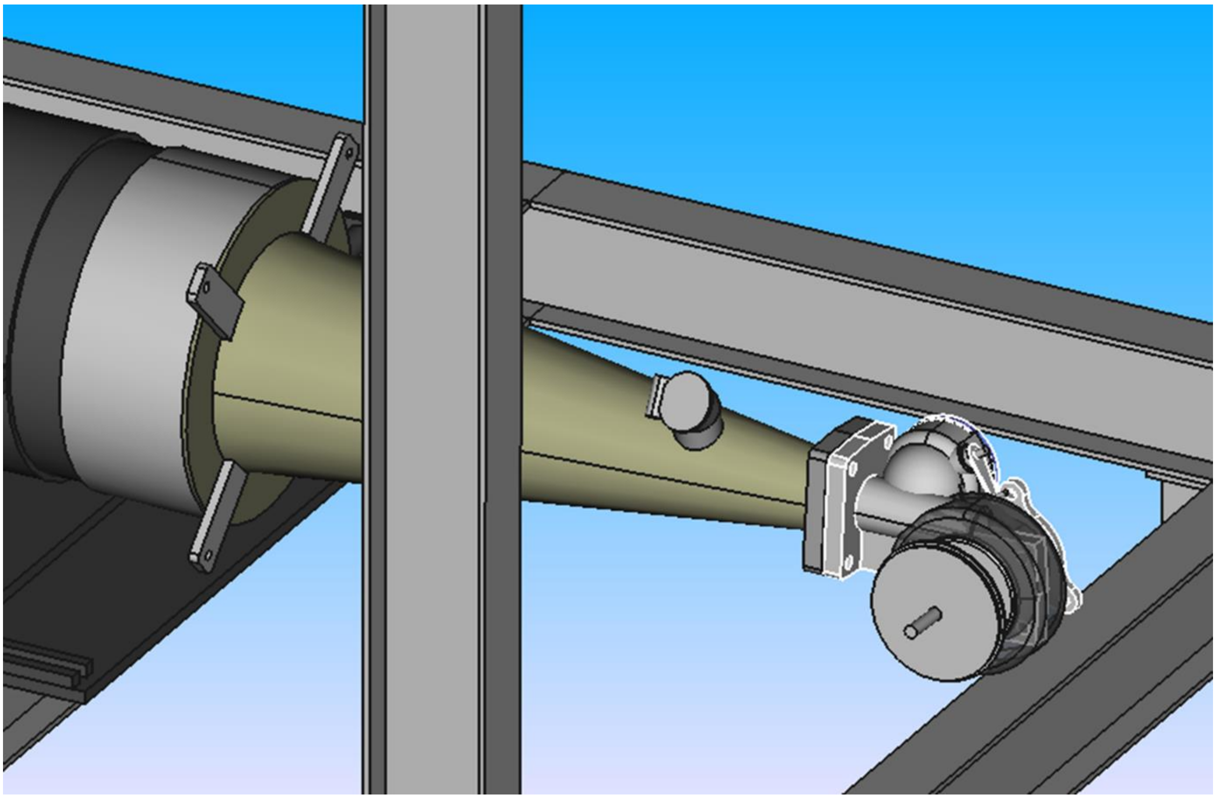
GTM Assembly - premium design_ FreeCAD file (v0.20)	17022023_GTM Assembly.FCStd

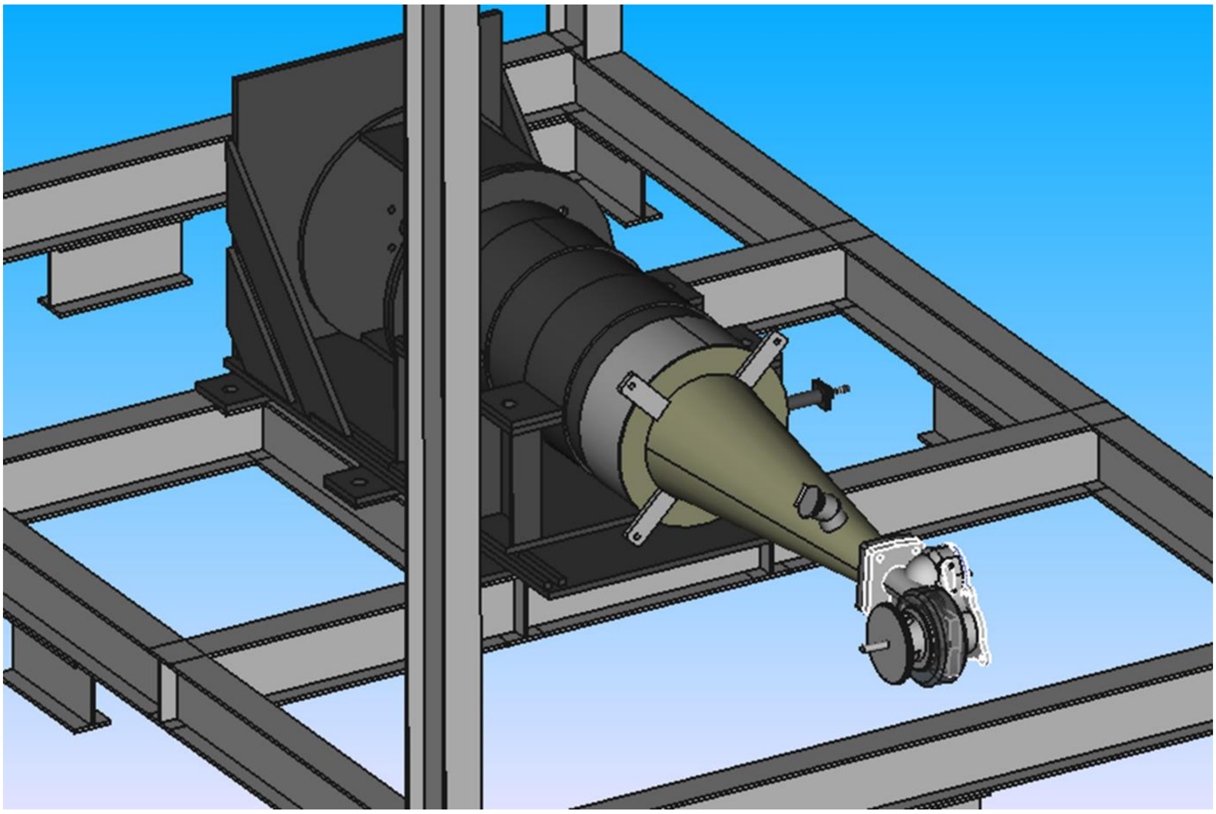


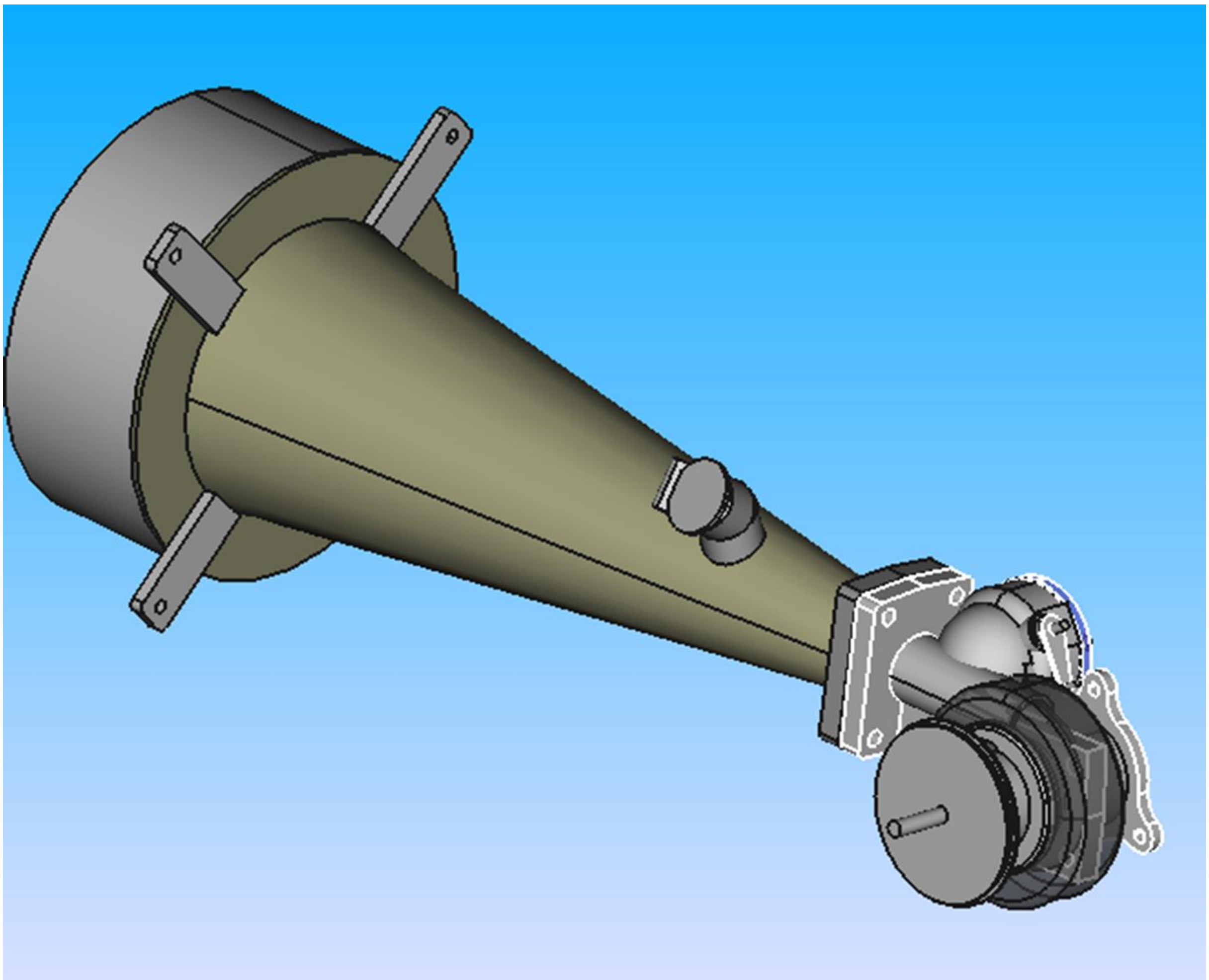






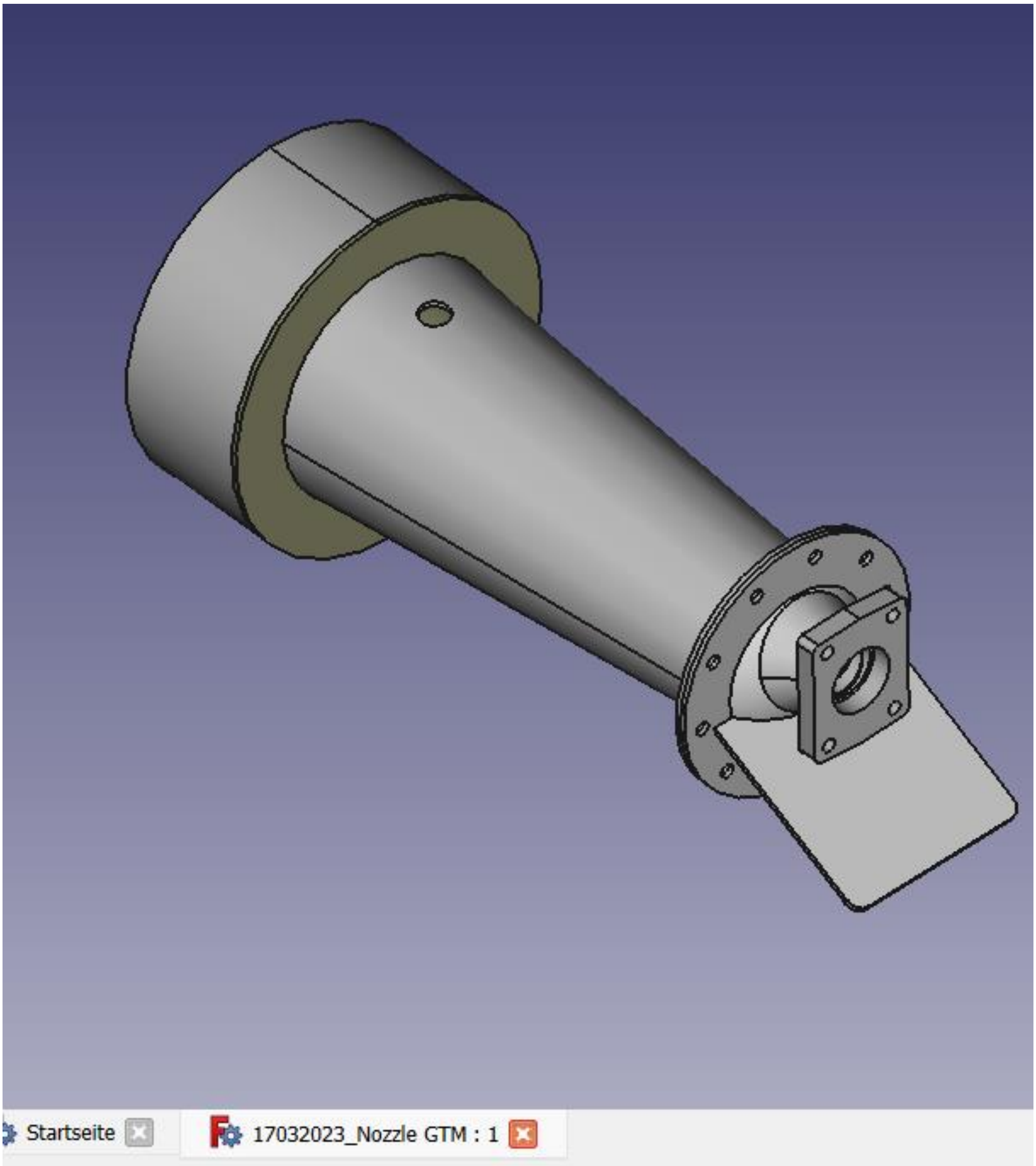






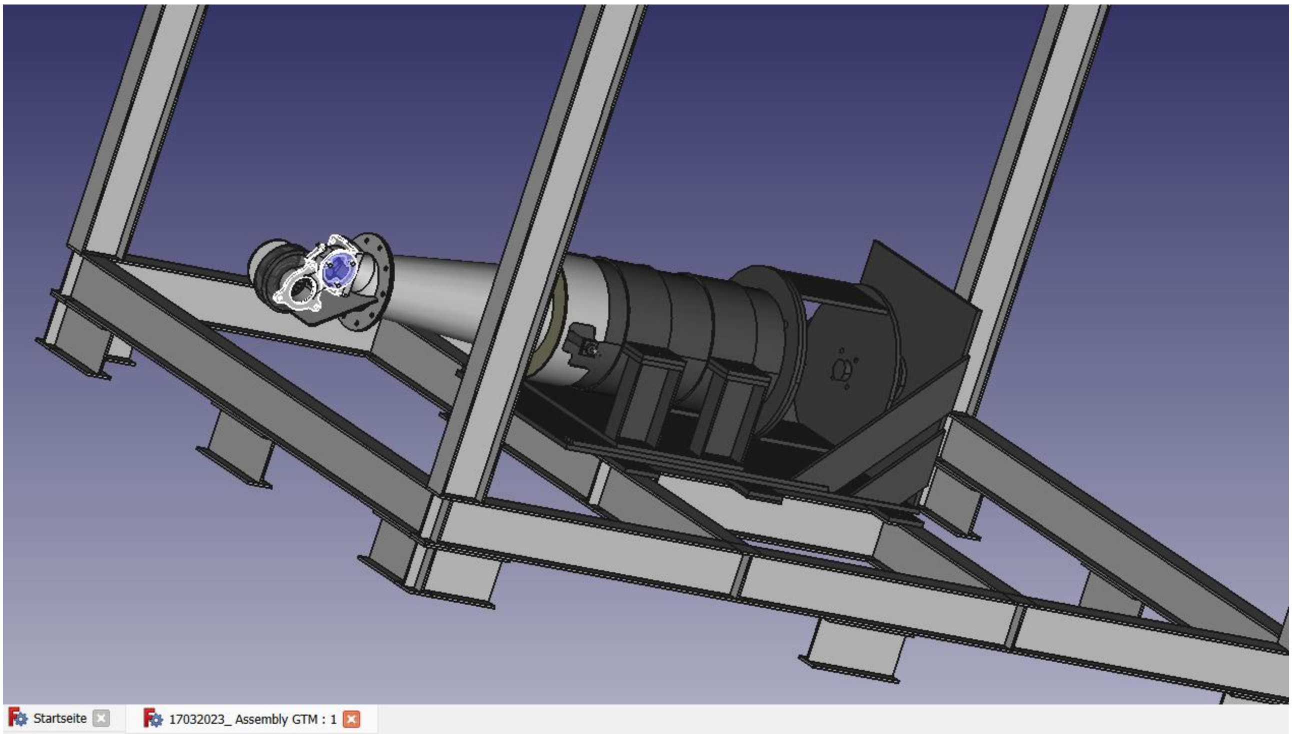
5.6.5 Nozzle design - Final design

5.6.5.1 Nozzle final design



Nozzle final design_FreeCAD file (v0.20):

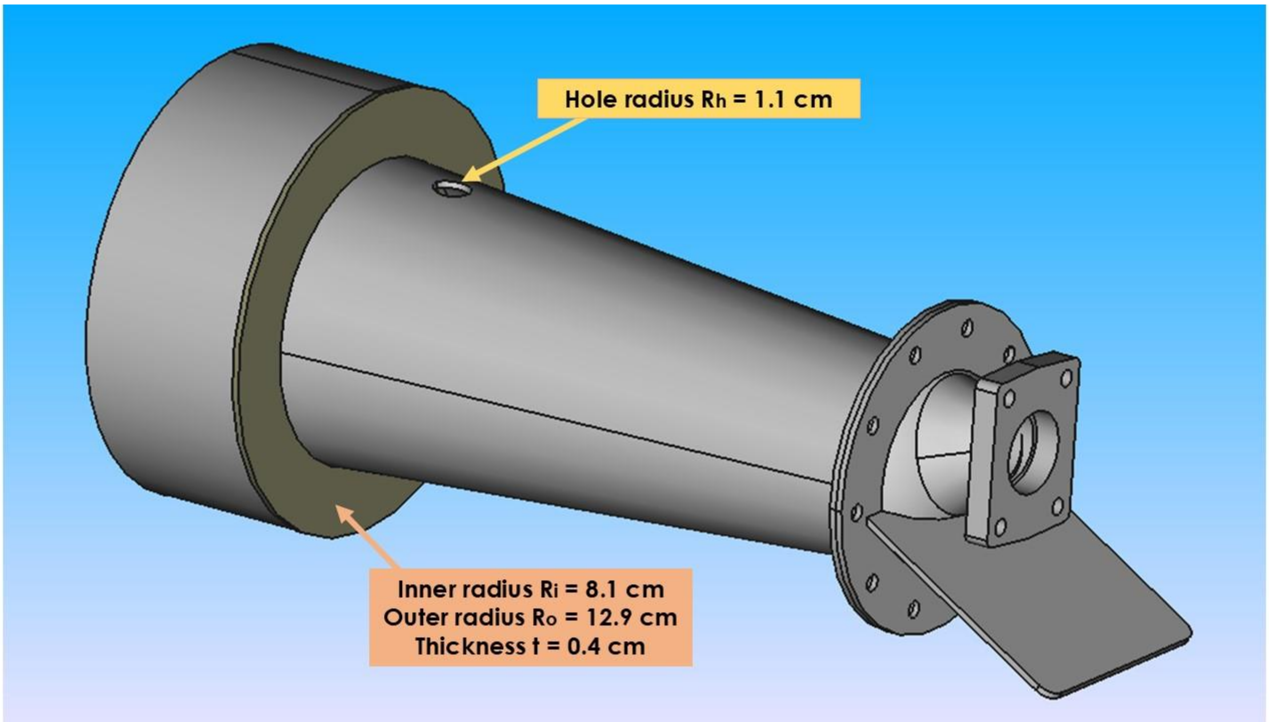
5.6.5.2 GTM assembly for the final design

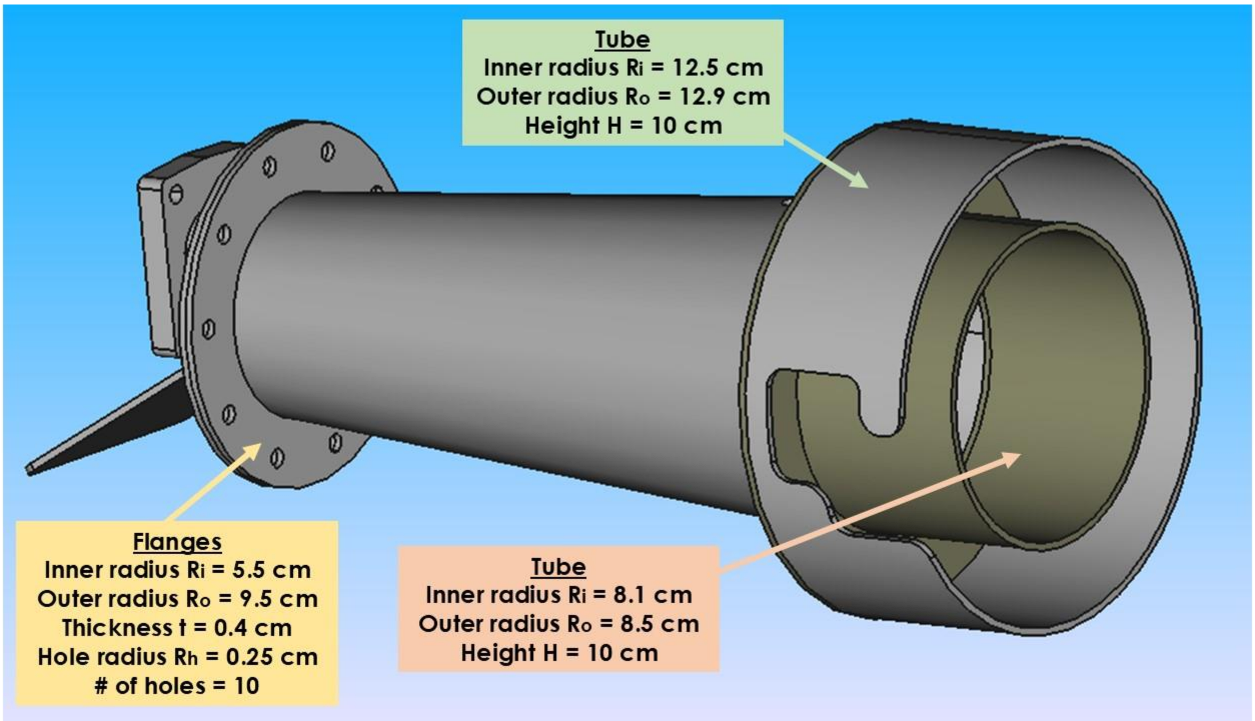


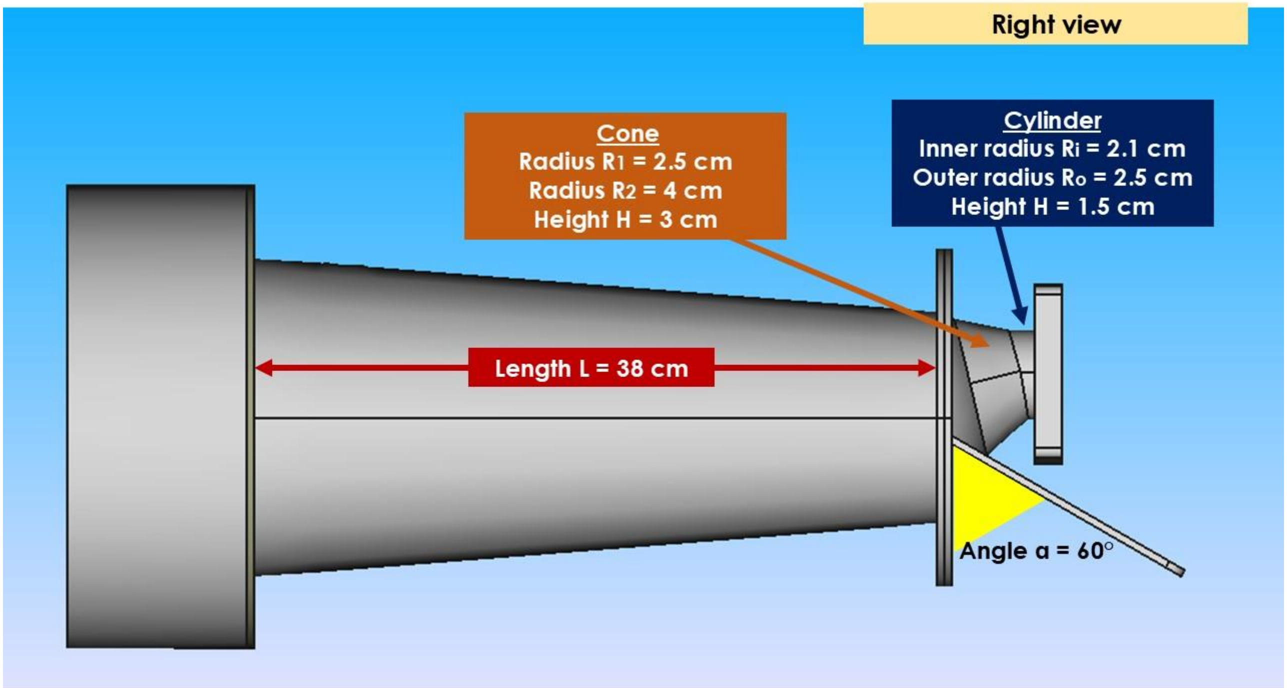
Final GTM assembly_FreeCAD file (v0.20)

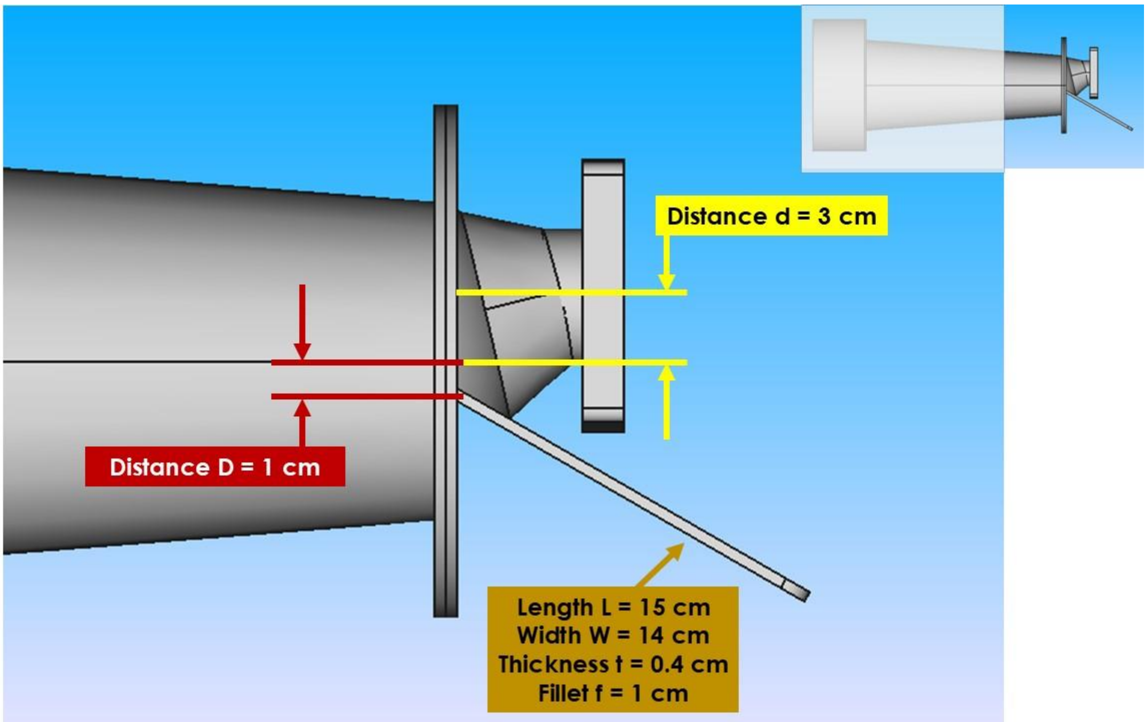
17032023_
Assembly GTM.FCSt

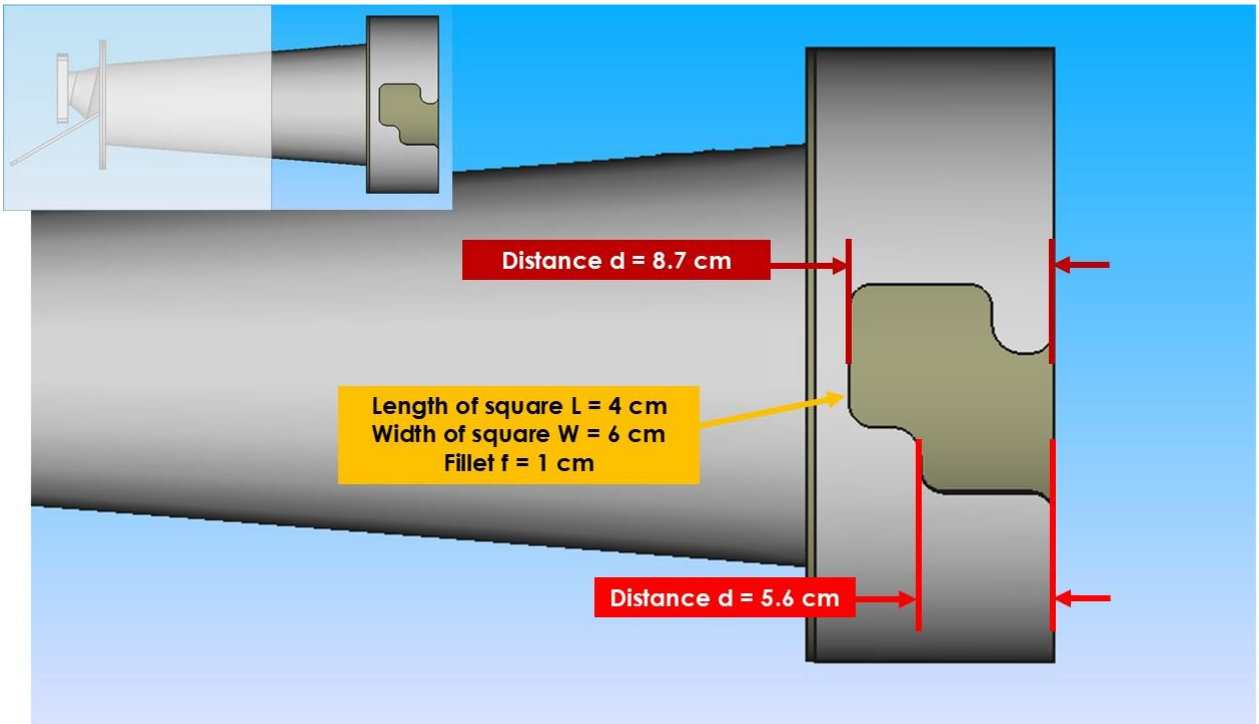
5.6.5.3 Nozzle sizing for the final design

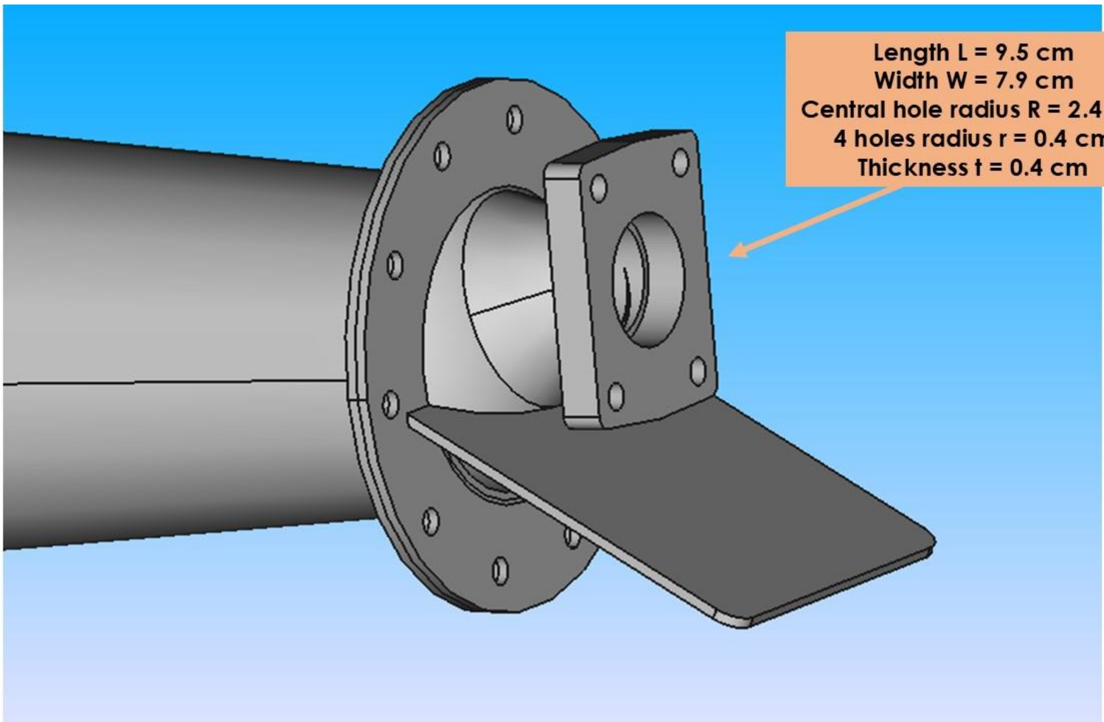


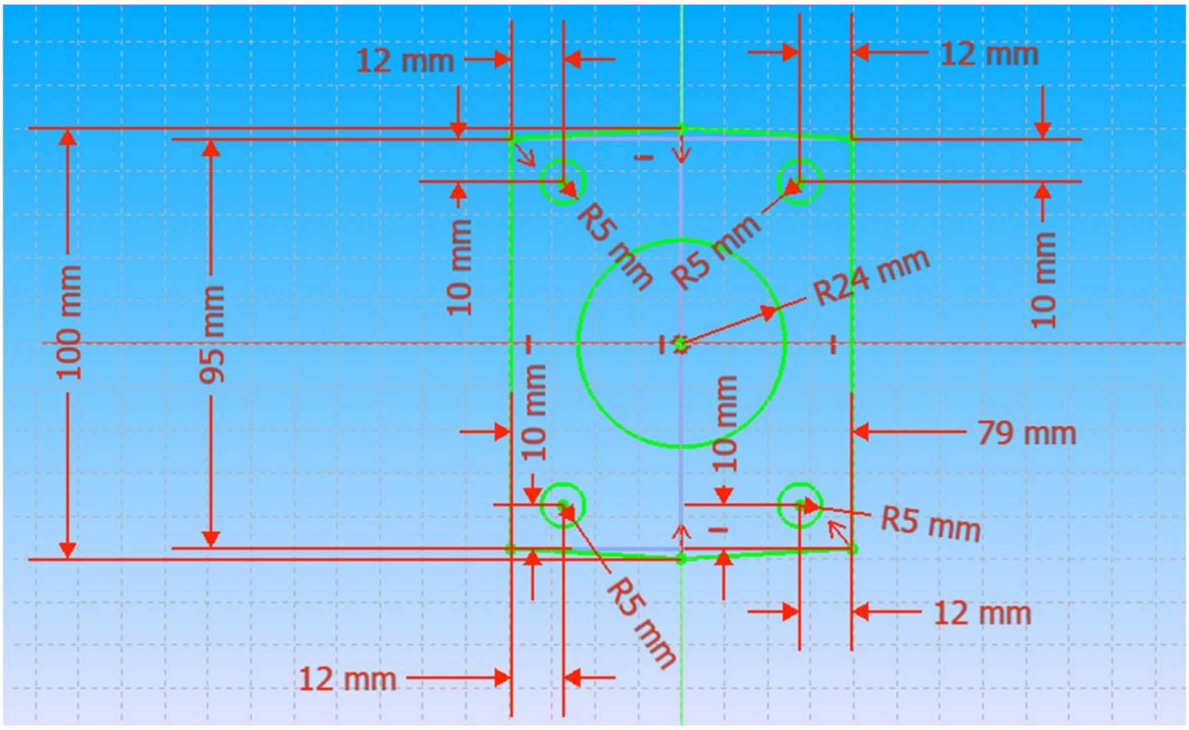


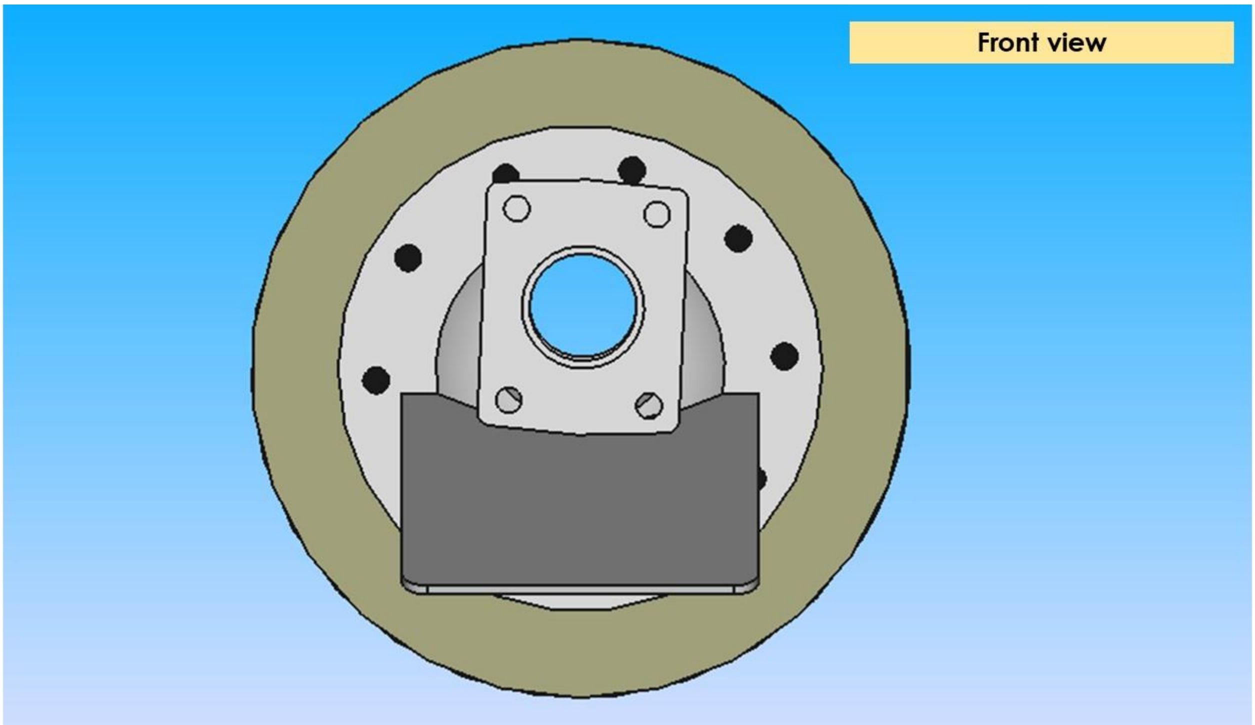

Right view
Cone
Radius R1 = 2.5 cm
Radius R2 = 4 cm
Height H = 3 cm
Cylinder
Inner radius Ri = 2.1 cm
Outer radius Ro = 2.5 cm
Height H = 1.5 cm
Length L = 38 cm
Angle α = 60°

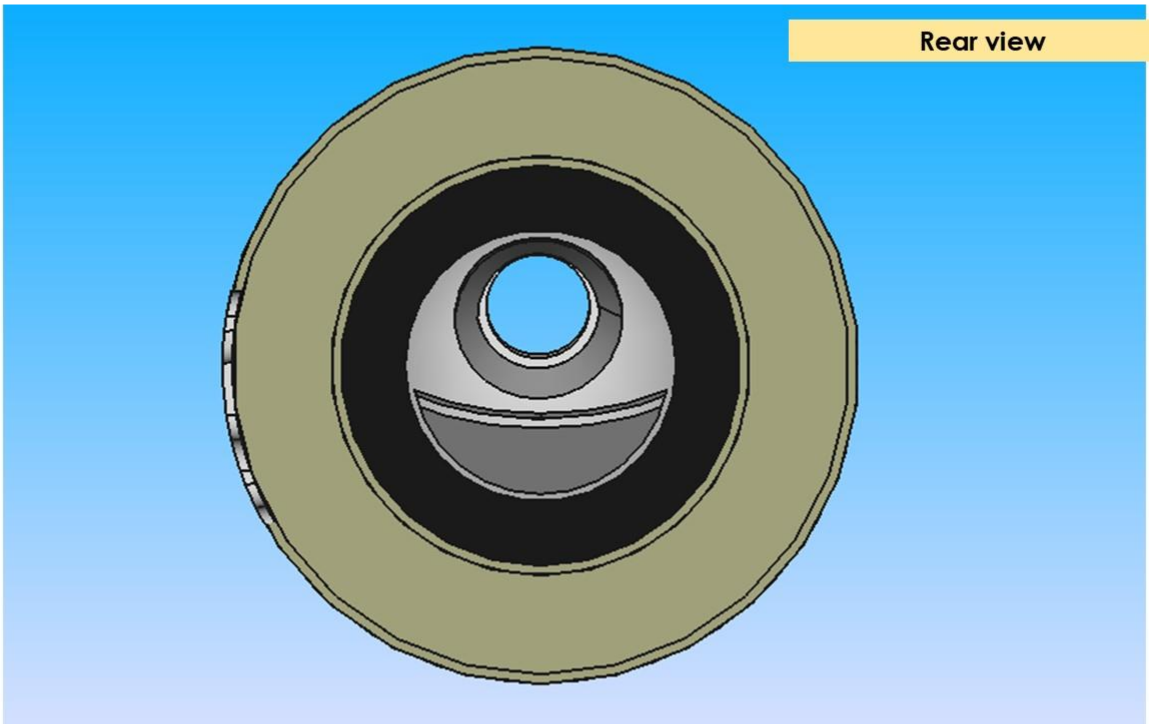

Distance d = 3 cm
Distance D = 1 cm
Length L = 15 cm
Width W = 14 cm
Thickness t = 0.4 cm
Fillet f = 1 cm

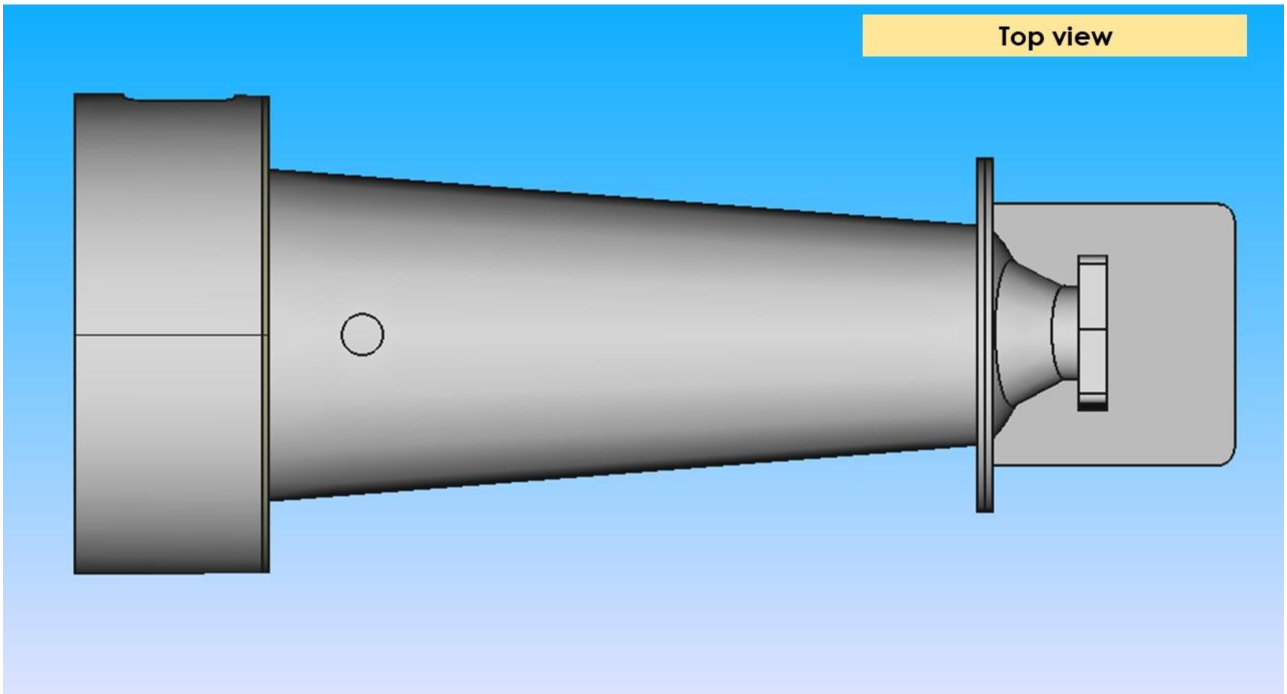

Distance d = 8.7 cm
Length of square L = 4 cm
Width of square W = 6 cm
Fillet f = 1 cm
Distance d = 5.6 cm


Length L = 9.5 cm
Width W = 7.9 cm
Central hole radius R = 2.4 cm
4 holes radius r = 0.4 cm
Thickness t = 0.4 cm


12 mm
12 mm
R5 mm
R5 mm
R24 mm
100 mm
95 mm
10 mm
10 mm
10 mm
10 mm
79 mm
R5 mm
R5 mm
12 mm
12 mm


Front view

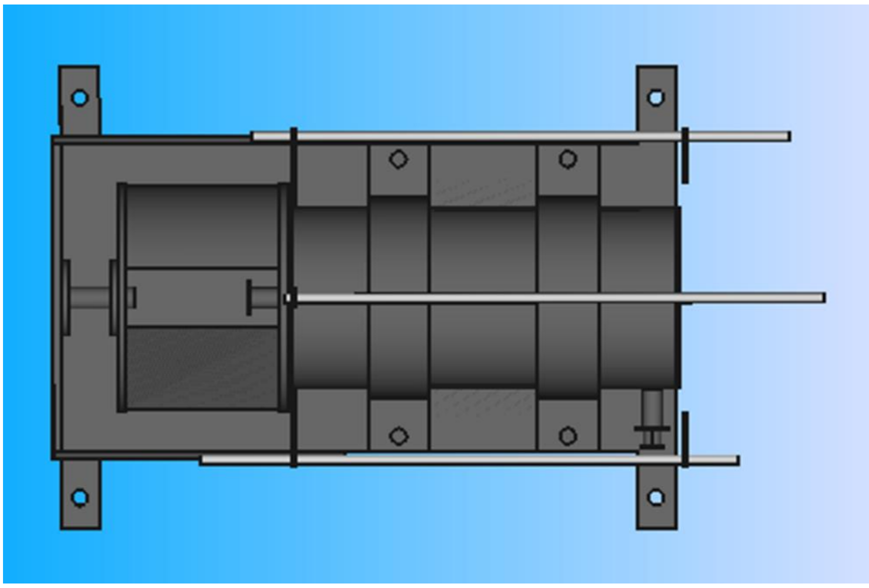


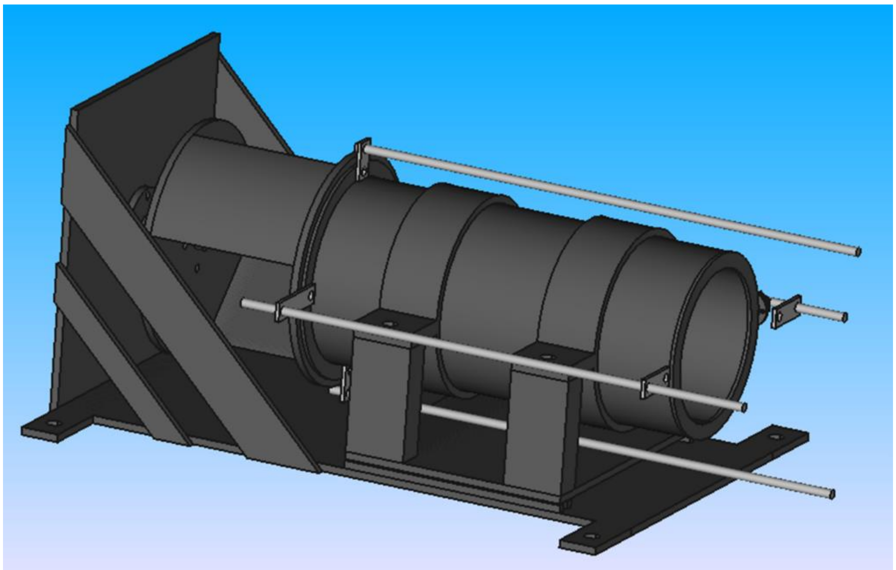


<u>Nozzle sizing - Final design _ pptx file</u>:

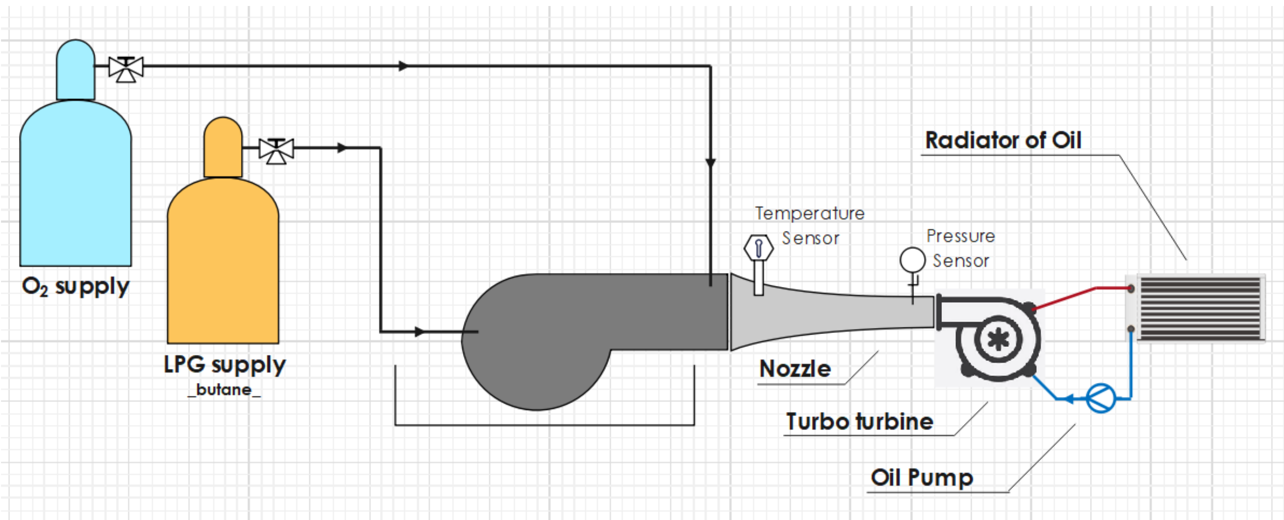
20032023_Nozzle
final design.pptx

5.6.6 Fuel Burner connections



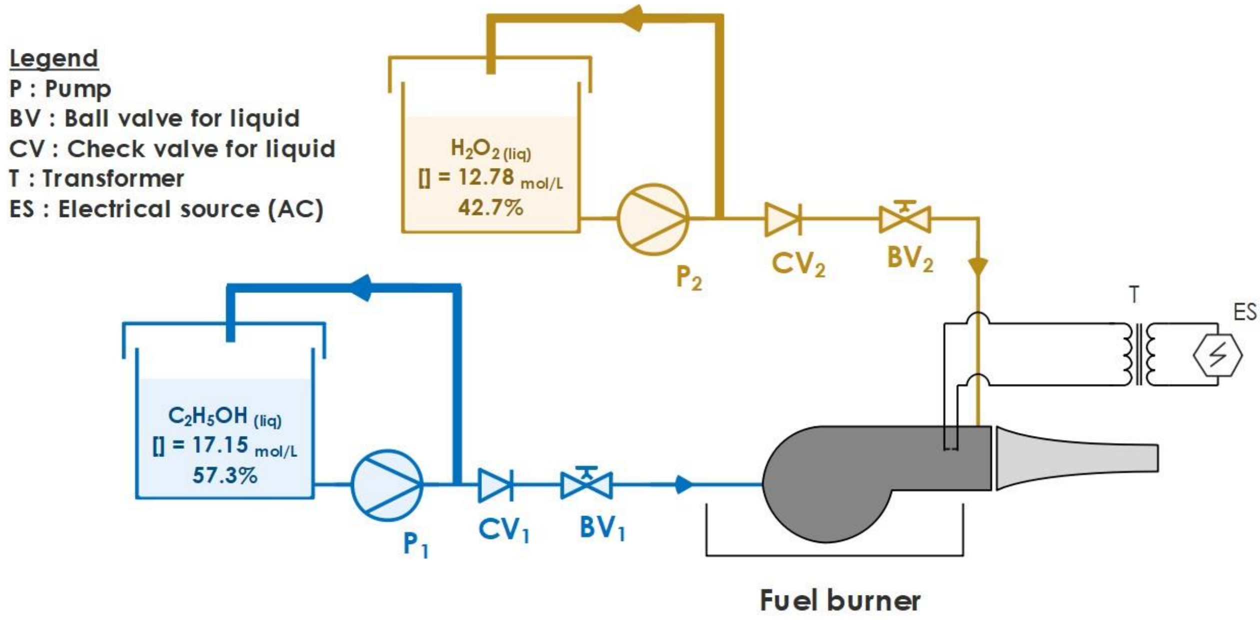


5.7 Fuel burner flow chart



5.8 Combustion of Ethanol with H2O2

5.8.1 Design of Liquid Ethanol Combustion with Liquid Hydrogen peroxide unit using the FuelBurner



FB - Combustion of Ethanol Eddx file:

29072023_FB
-Ethanol Combustio

5.8.2 FuelBurner Requirements

- The concentration of Hydrogen peroxide (H_2O_2) should be about 12.8 mol/L.
- The concentration of Ethanol (C_2H_5OH) should be about 17.2 mol/L.
- The pumps should be able to pump the liquids (ethanol and hydrogen peroxide) from tank to the fuel burner.
- The PLC should be able to control the pumps and the Automatic controller valves.
- The fuel burner should be able to burn the liquid ethanol with oxidant (H_2O_2).
- The check valve must be able to pass fluids in one direction only.
- The Automatic controller valve should be able to open and close through the GUI.
- The tanks must be semi-closed to prevent the evaporation of the solutions (C_2H_5OH & H_2O_2) and to avoid explosion due to expansion.

5.8.3 FuelBurner Test specifications

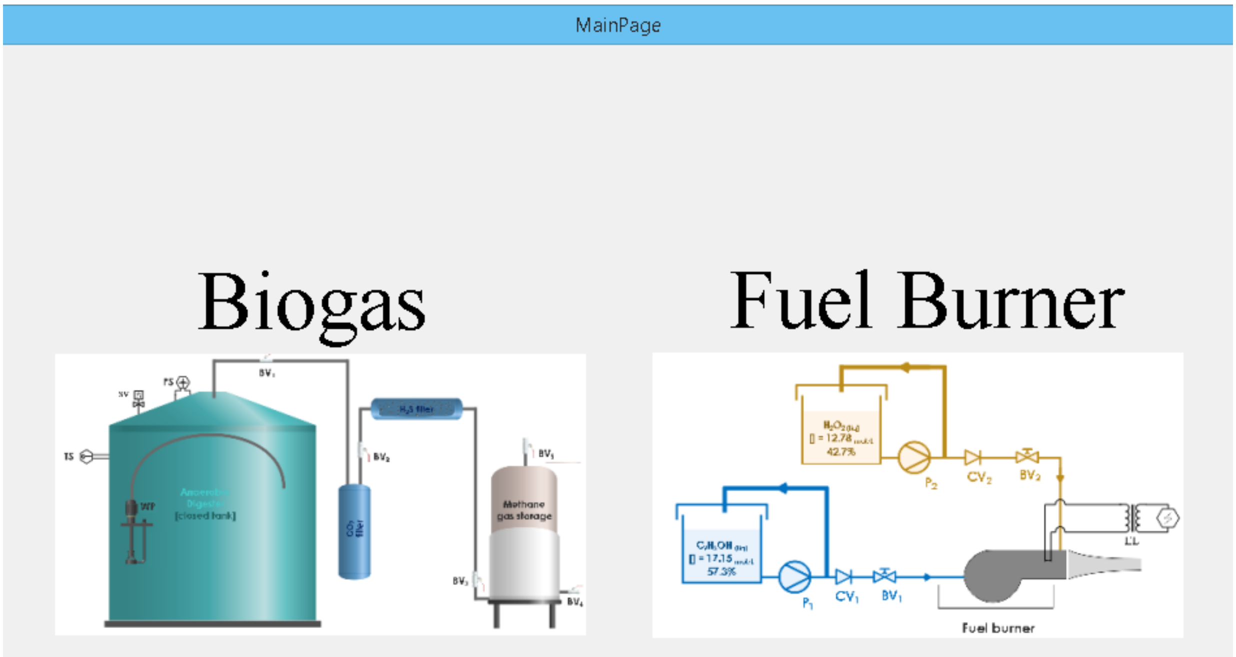
Step	Step description	Expected result	Result
Precondition	The system is Off	All valves are closed	

		All pumps are turned Off	
Turn On the transformer (T)	Connect electricity to the transformer (T)	Spark is On	
Open the Automatic controller valve of Ethanol (BV_1)	Click "Turn On" on BV_1 button from the GUI	BV_1 is open	
Turn On the ethanol pump (P_1)	Click "Turn On" on P_1 button from the GUI	P_1 is turned On	
		The spark is appeared, and will turns into a flame	
Control the flame without oxidant	Adjust the orifice degree to control the ethanol flow rate from the GUI	The flame will be more stable	
Open the Automatic controller valve of Hydrogen peroxide (BV_2)	Click "Turn On" on BV_2 button from the GUI	BV_2 is open	
Turn On the Hydrogen peroxide pump (P_2)	Click "Turn On" on P_2 button from the GUI	P_2 is turned On	
		The flame will be more strong	
Control the flame with oxidant	Adjust the orifice degree to control the hydrogen peroxide flow rate from the GUI	The flame will become stronger and more stable	
Turn Off the system	Turn Off the Hydrogen peroxide pump (P_2)	P_2 is turned Off	

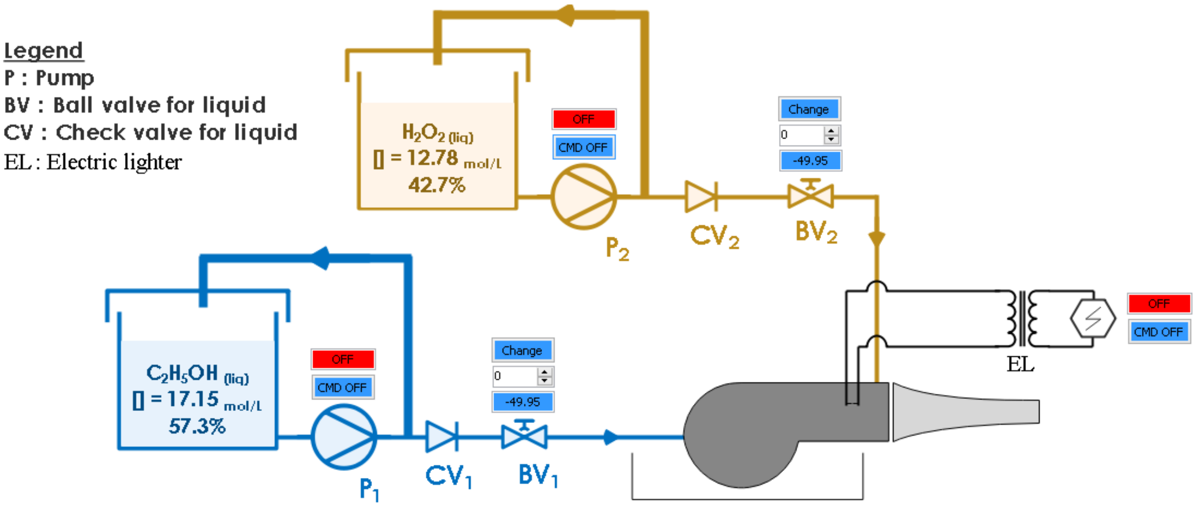
	Close the Automatic controller valve of Hydrogen peroxide (BV_2)	BV_2 is closed	
	Turn Off the ethanol pump (P_1)	P_1 is turned Off	
	Close the Automatic controller valve of Ethanol (BV_1)	BV_1 is closed	
		The flame disappears with time	
	Turn Off the transformer (T)	The transformer (T) is turned Off	
		The spark is disappeared	

5.8.4 PCS Ethanol combustion

5.8.4.1 GUI



Fuel Burner



5.8.5 Graphical User Interface code (C#) and PLC Code

PLC Code	Graphical User Interface code (C#)
NLAP_Biogas_Fuel-Burner_PCS_PLC-code_2!	NLAP-Biogas_Fuel-Burner_PCS_GUI_0104

5.9 Fuel Burner Test using Air-compressor on 12.2.2024

5.9.1 What is the goal of this test?

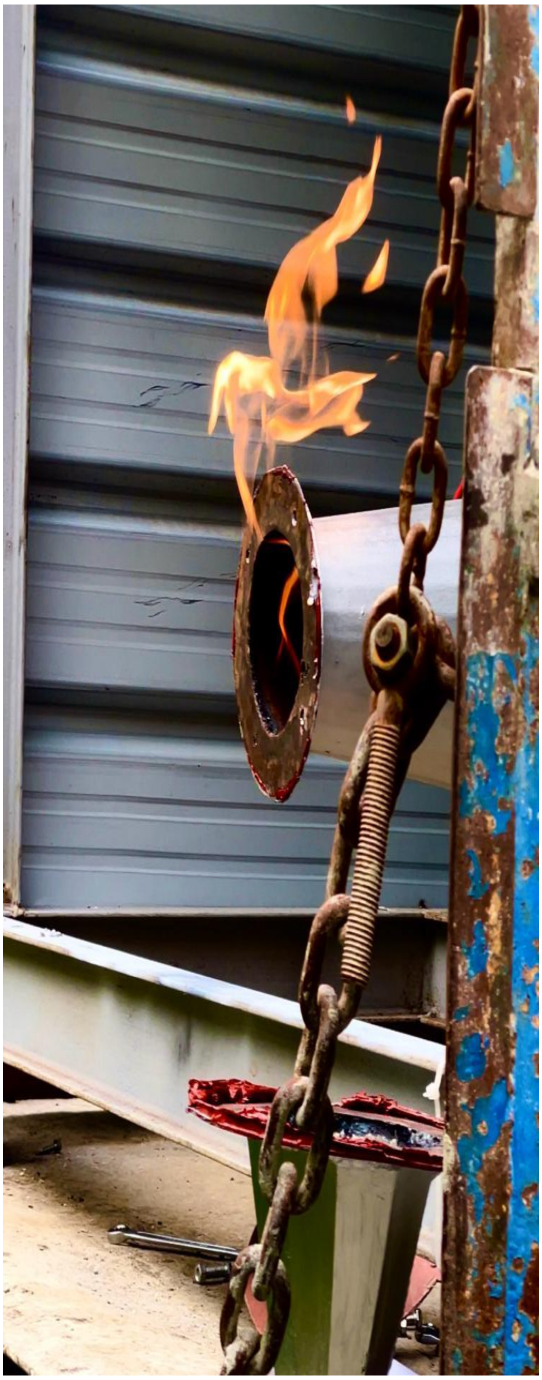
This project aims to study and test the fuel burner's effectiveness using butane gas with compressed air. When the main goal of the test is to make the turbocharger rotate.

5.9.2 What has been changed compared to the previous test?

Compared to the previous tests, the turbocharger was installed in the outlet hole of the fuel burner, whereas in the previous test, it was installed in the side of the conic shape of the fuel burner.

The pictures show the changes made:

The flame igniter installed in the left side of the Fuel Burner



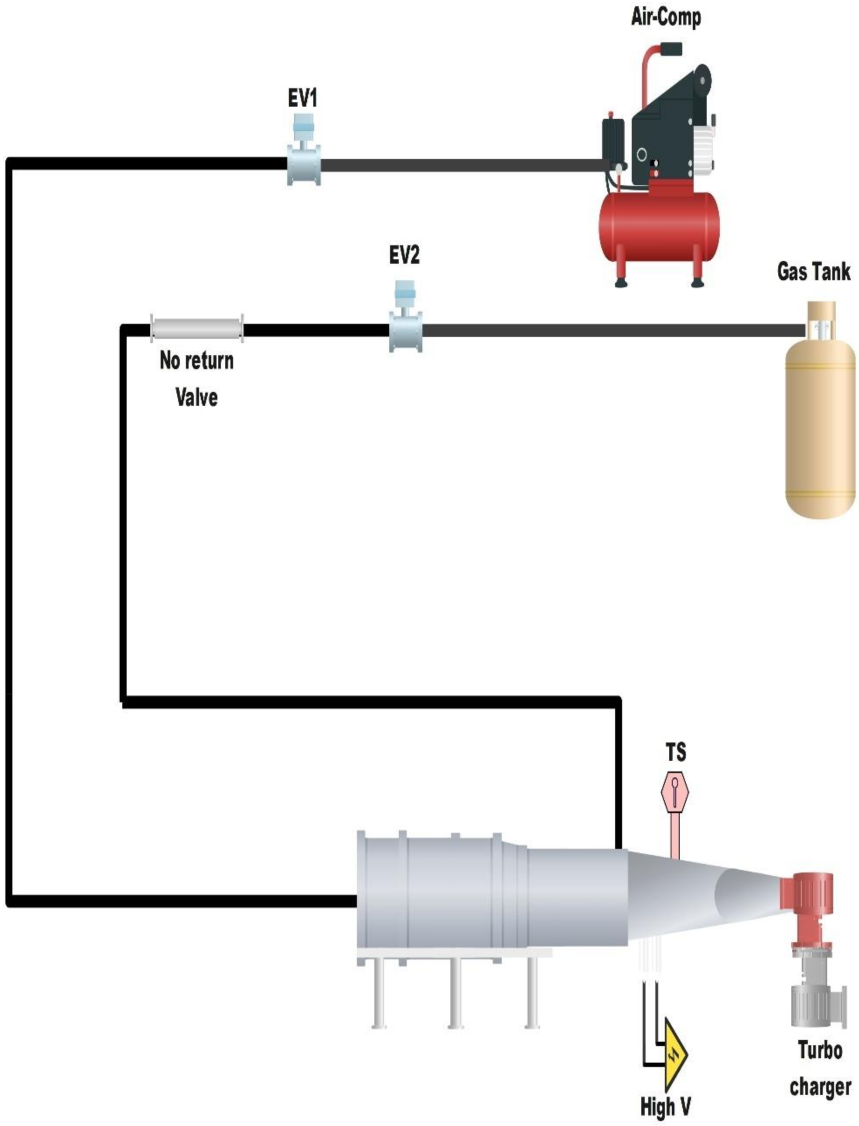
5.9.3 What are the results?

Steps	Step Description	Expected Result	Result
Precondition			
System is off	All valves and systems are closed	System is off	System is off
Check out			
Check out EV1	Check out by GUI EV1 valve (open it/close it)	Working good	Working good

Check out EV2	Check out by GUI EV2 valve (open it/close it)	Working good	Working good
Check out high V	Check out by GUI the high Voltage or flame igniter (open it/close it)	Working good	we make some changes
Check out Ts	Check out the temperature sensor By Gui	Reading ambient Temperature	Reading ambient Temperature
Check out Ps	Check out the pressure sensor By Gui	Reading the Atmospheric pressure	no pressure sensor
Check out TU	Check out theTurbocharger (manually)	Blades rotating normally	Blades rotating normally
Check out A-COM	Check out the air compressor main valve and its connection (manually)	Working good	Working good
Check out C1	Check out the camera 1 filming	The system visible	no camera
Check out C2	Check out the camera 2 filming	The turbocharger blades are visible	The system visible
Test Start			
Open Gas Tank	Open the gas tank main Valve (manually)	Working good	Working good
Open A-COM	Open the Air compressor main Valve (manually)	Working good	Working good
Open High V	Open the High V or the flame igniter by GUI	Start Working	Start Working
Open EV1	Open EV1 valve by GUI	Fire Start	Fire Start
Close High V	Close the High V or the flame igniter by GUI after fire start	Closes	Closes
Read Ts	Read the temperature sensor by GUI	Temperature rise	Temperature rise
Read Ps	Read the Pressure sensor by GUI	Pressure normal	no pressure sensor

See C1	Using camera 1 watch the System	No abnormal activity	no camera
See C2	Using camera 2 watch the Turbocharger blades rotation	Blade starts to rotate	Blade start to rotate for 0.5 seconds only
Open Ev2	Open the EV2 valve by the GUI	The fire starts to rise	Fire starts to rise slightly
See C1	Using camera 1 watch the System	No abnormal activity	no camera
See C2	Using camera 2 watch the Turbocharger blades' rotational speed	Blade rotational speed increases	no rotation as expected
Read Ts	Read the temperature sensor by GUI	Temperature rise	Temperature rise
Read Ps	Read the Pressure sensor by GUI	Pressure normal	no pressure sensor
Close EV2	Close the EV2 valve by the GUI	Fire gets back to normal	not the expected result
Close EV1	Close EV1 valve by GUI	Fire is off	Fire is off
Close Gas Tank	Close the gas tank main Valve (manually)	No abnormal activity	No abnormal activity
Close A-COM	Close the Air compressor main Valve (manually)	No abnormal activity	No abnormal activity
Postcondition			
System is off	All valves and systems are closed	System is off	System is off

Here is a diagram of the system:



The problems we faced during the test were:

- **leakage in the pipes**
- **A high-voltage igniter is not enough to fire the system**
- fire doesn't reach out its full combustion
- the turbocharger didn't rotate
- the system needs a regulating valve to control the flow of gases

Video concerning the Test connections:

WhatsApp Video
2024-02-18 at 8.25.0

5.9.4 What is the next test about?

In the next tests, we will use oxygen gas instead of compressed air, we will fix the leakage in the system, and we will install regulating valves to control the flow of the gases.

5.10 Fuel Burner test using Butane/Oxygen on 20.02.2024

5.10.1 Test conditions

Butane pressure: 12 bar

Oxygen pressure: 12 bar

Result: Unexpected high-pressure explosion

5.10.2 Analysis

The test resulted in a high-pressure explosion due to an improper fuel-to-oxidant ratio. The supplied amount of oxygen exceeded the amount of butane that could be completely combusted by the igniter. This led to unburned butane gas accumulating within the chamber, which ignited explosively upon reaching a critical concentration.

5.10.3 System Test

Steps	Step Description	Expected Result	Result
Precondition			Failure in the system When we open the system the conic shape gets out from the system due to high pressure from the ignition process.
System is off	All valves and systems are closed	System is off	
Check out			
Check out EV1 ,RV1	Check out by GUI EV1 and RV1 valve (open it/close it)	Working good	
Check out EV2, RV2	Check out by GUI EV2 and RV2 valve (open it/close it)	Working good	
Check out high V	Check out by GUI the high Voltage or flame igniter (open it/close it)	Working good	
Check out Ts	Check out the temperature sensor By Gui	Reading ambient Temperature	
Check out Ps	Check out the pressure sensor By Gui	Reading the Atmospheric pressure	
Check out TU	Check out theTurbocharger (manually)	Blades rotating normally	
Check Oxygen tank	Check out the oxygen tank main valve and its connection (manually)	Working good	
Check out C1	Check out the camera 1 filming	The system visible	

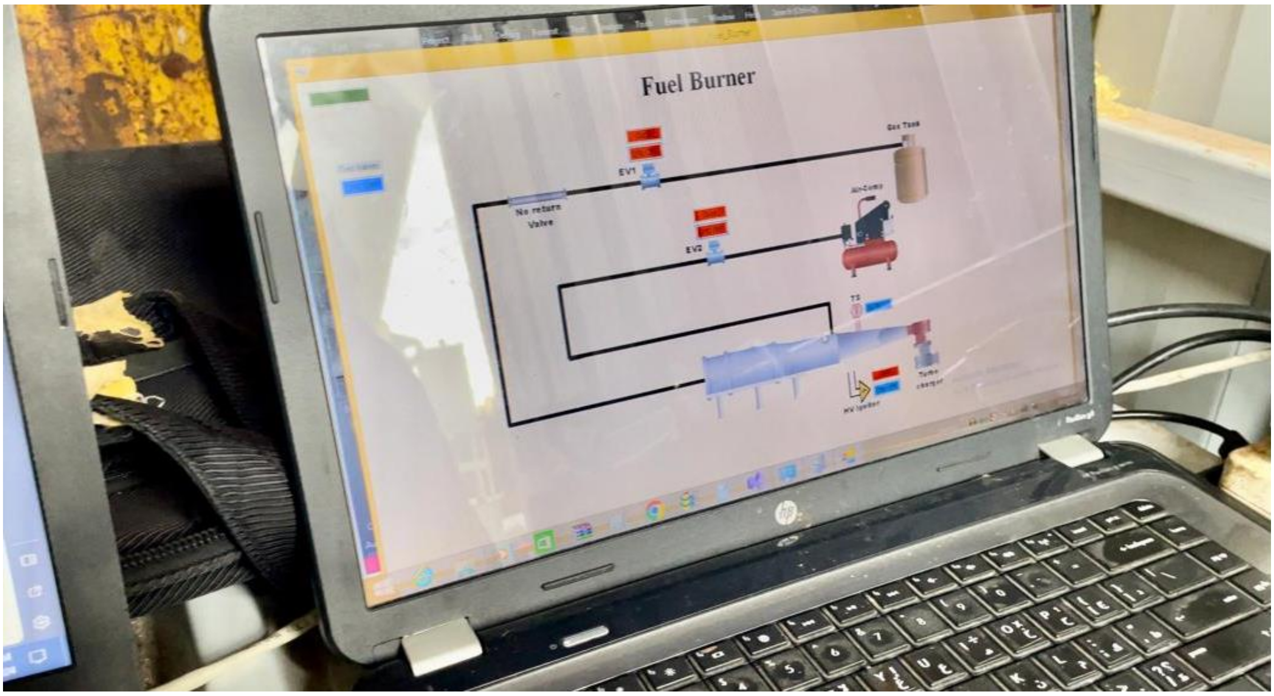
Check out C2	Check out the camera 2 filming	The turbocharger blades are visible	
Test Start			
Open Gas Tank	Open gas tank main Valve (manually)	Working good	
Open oxygen gas	Open the oxygen tank main Valve (manually)	Working good	
Open High V	Open the High V or the flame igniter by GUI	Start Working	
Open EV1 and RV1	Open EV1 and RV1 valve by GUI	Fire Start	
Close High V	Close the High V or the flame igniter by GUI after fire start	Closes	
Read Ts	Read the temperature sensor by GUI	Temperature rise	
Read Ps	Read the Pressure sensor by GUI	Pressure normal	
See C1	Using camera 1 watch the System	No abnormal activity	
See C2	Using camera 2 watch the Turbocharger blades rotation	Blade start to rotate	
Open Ev2 and RV2	Open EV2 valve by the GUI	Fire starts to rise	
See C1	Using camera 1 watch the System	No abnormal activity	
See C2	Using camera 2 watch the Turbocharger blades' rotational speed	Blade rotational speed increases	
Read Ts	Read the temperature sensor by GUI	Temperature rise	
Read Ps	Read the Pressure sensor by GUI	Pressure normal	
Close EV2 and RV2	Close EV2 and RV2 valve by the GUI	Fire gets back to normal	
Close EV1 and RV1	Close EV1 and RV1 valve by GUI	Fire is off	

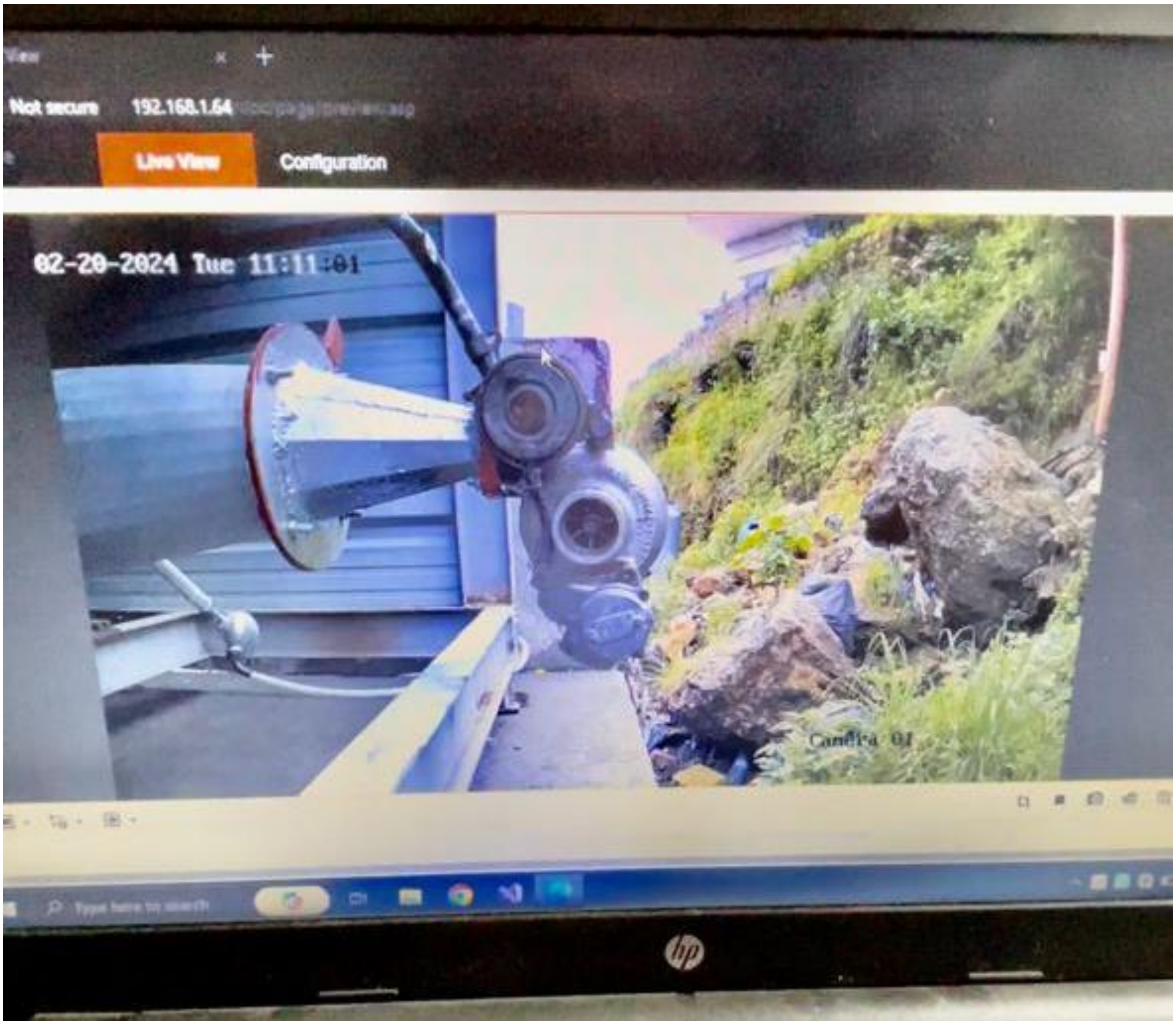
Close Gas Tank	Close the gas tank main Valve (manually)	No abnormal activity	
Close oxygen tank	Close the oxygen tank main Valve (manually)	No abnormal activity	
Postcondition			
System is off	All valves and systems are closed	System is off	

Video related:

WhatsApp Video
2024-04-01 at 1.01.1

5.10.4 Pictures Related:


Fuel Burner
EV1
No return
Valve
EV2
Gas Tank
HV Igniter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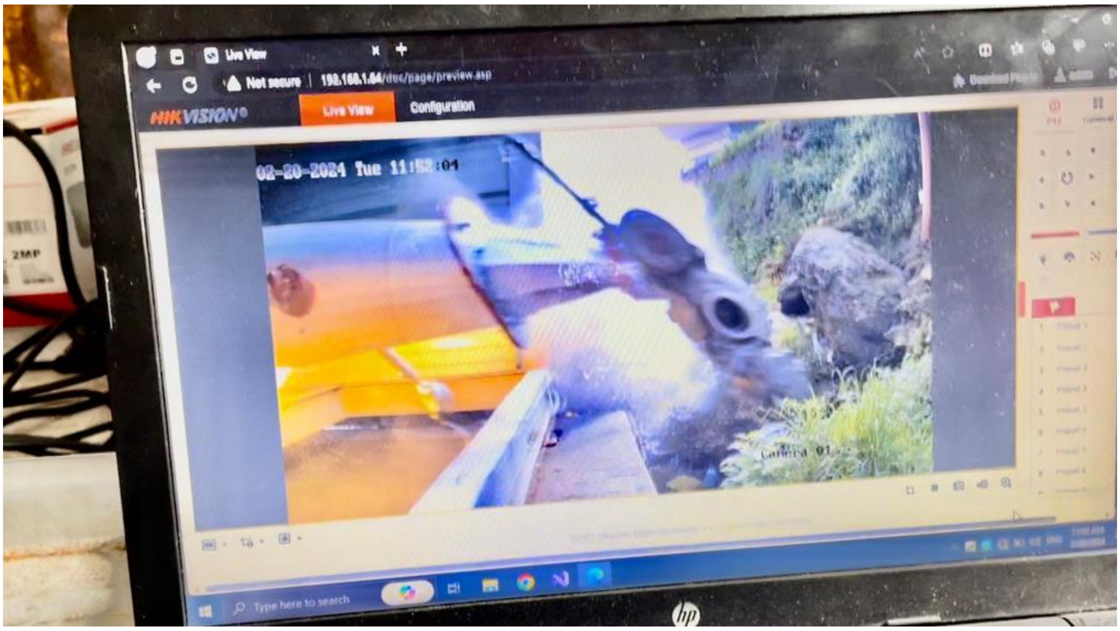
192.168.1.64
Live View
Configuration
02-20-2024 Tue 11:11:01
Camera 01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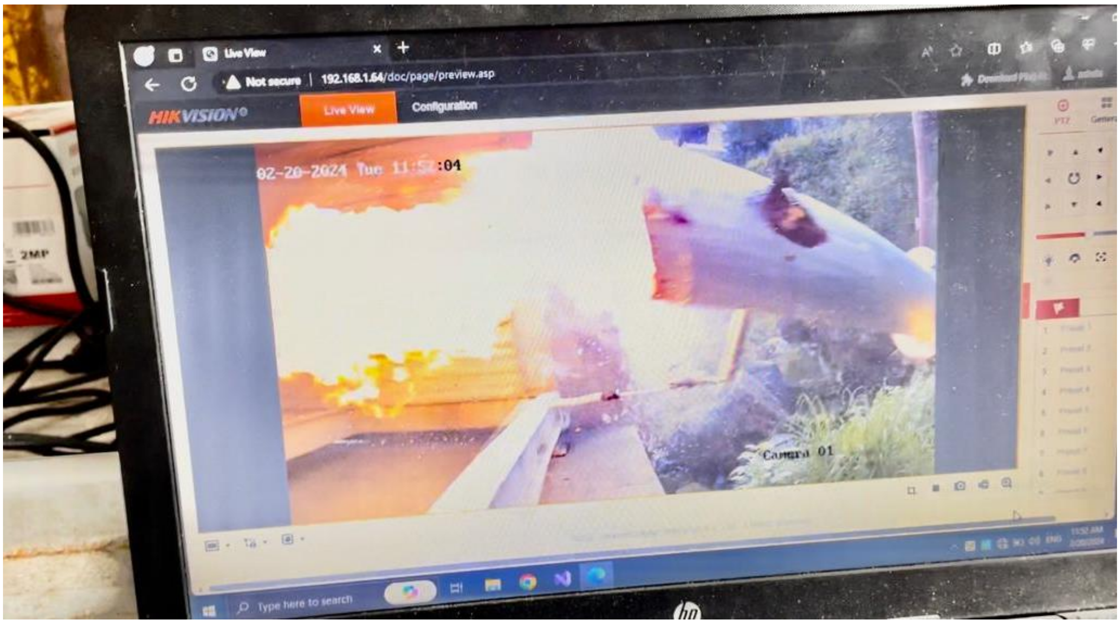
HIKVISION
Live View
Configuration
02-20-2024 Tue 11:
:04
Camera 01
2MP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HIKVISION
Live View
Configuration
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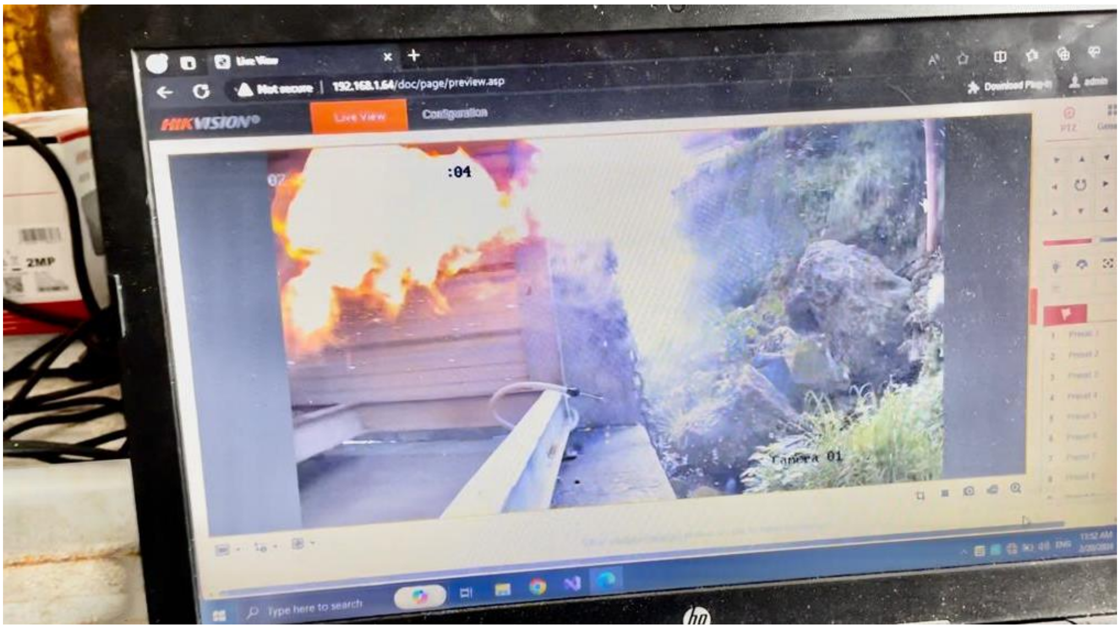
:04
Camera 01
Type here to search
2MP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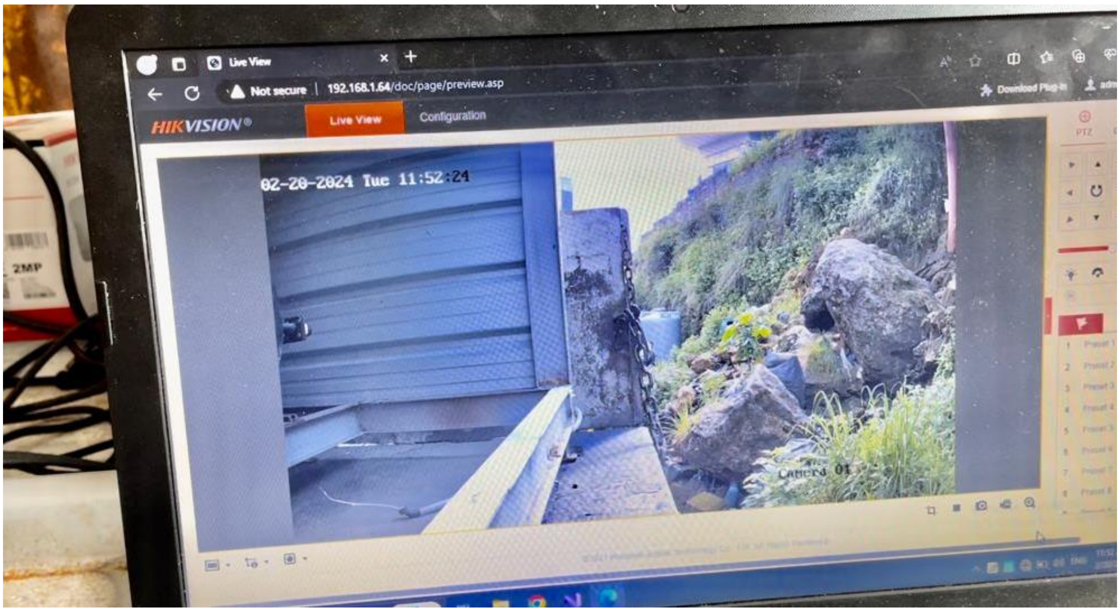
192.168.1.64/doc/page/preview.asp
HIKVISION
Live View
Configuration
:04
Camera 01
Type here to search
2MP



5.11 Biogas Turbine test using Butane/Oxygen on 29.03.2024

5.11.1 Test Description

On **March 29, 2024**, a test was conducted on the Biogas Turbine using **butane gas** and **oxygen gas** in a 3:1.29 ratio. By introducing oxygen, we achieved complete combustion of the butane gas. A video demonstrating the difference between combustion with and without oxygen is available." Click the icon below" to get the video demonstrating the difference between each case.

WhatsApp Video
2024-04-02 at 11.16.

The test showed us a good result compared to the previous test with controlled pressure, but due to the low pressure of 2.5 bar butane, we didn't get the combustion force we expected to add the turbocharger to the system, we will connect it to see the result of the biogas turbine in its complete form with the turbocharger before we make any changes or decisions to the system.

5.11.2 System Test

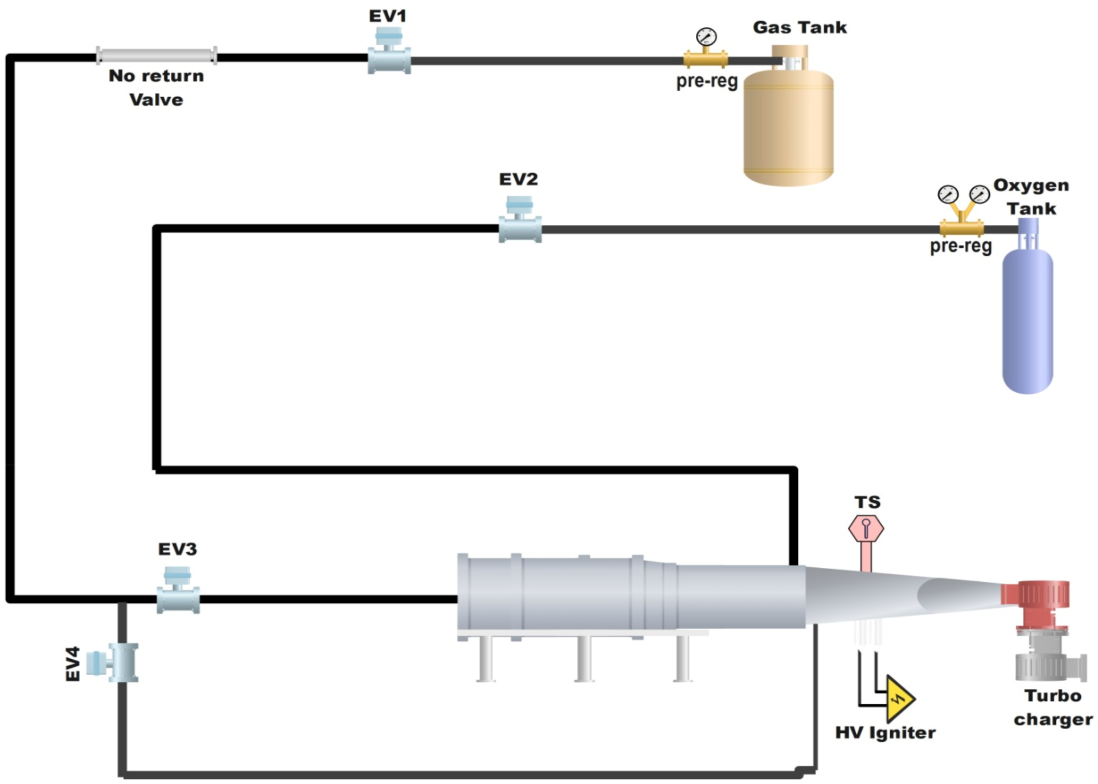
Steps	Step Description	Expected Result	Result
Precondition			
System is off	All valves and systems are closed	system is off	System is off
Check out			

Check out EV1	Check out by GUI EV1 (open it/close it)	Working good	Working good
Check out EV2	Check out by GUI EV2 (open it/close it)	Working good	Working good
Check out EV3	Check out by GUI EV3 (open it/close it)	Working good	Working good
Check out EV4	Check out by GUI EV4 (open it/close it)	Working good	Working good
Check out HV igniter	Check out by GUI the high Voltage or flame igniter (open it/close it)	Working good	Working good
Check out Ts	Check out the temperature sensor By Gui	Reading ambient Temperature	Reading ambient Temperature
Check out Ps	Check out the pressure sensor By Gui	Reading the Atmospheric pressure	not connected
Check out TU	Check out theTurbocharger (manually)	Blades rotating normally	not connected
Check Oxygen tank	Check out the oxygen tank main valve and its regulator (manually)	Working good	Working good
Check Butane tank	Check out the Butane tank main valve and its regulator (manually)	Working good	Working good

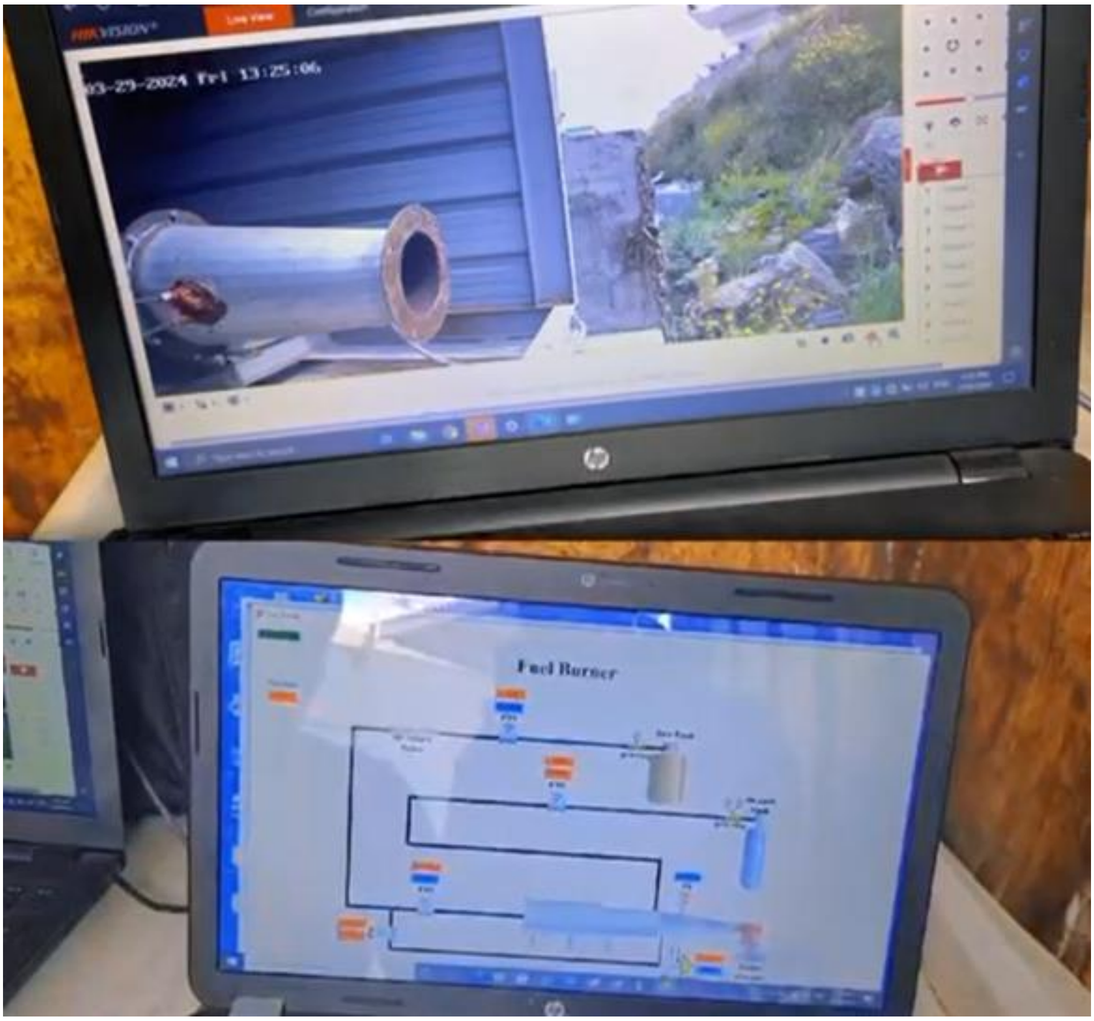
Check out C1	Check out the camera 1 filming	The system visible	The system is visible
Check out C2	Check out the camera 2 filming	The turbocharger blades are visible	not connected
Test Start			
Open Gas Tank	Open gas tank main Valve (manually)	Working good	Working good
Open oxygen gas	Open the oxygen tank main Valve (manually)	Working good	Working good
Open HV igniter with EV4	Open the High Voltage with EV4 By Gui	Start Working	Start Working
Open EV1	Open EV1 By Gui	Fire Start	Fire Start
Close HV Igniter with EV4	Close the high-voltage Voltage Igniter and the EV4 by GUI after the fire starts	Closes	Closes
Read Ts	Read the temperature sensor using the GUI	Temperature rise	Temperature rise
Read Ps	Read the Pressure sensor by GUI	Pressure normal	Pressure normal
See C1	Using camera 1, watch the System	No abnormal activity	the system visible
See C2	Using camera 2, watch the Turbocharger blade's rotation	Blade starts to rotate	Blade starts to rotate

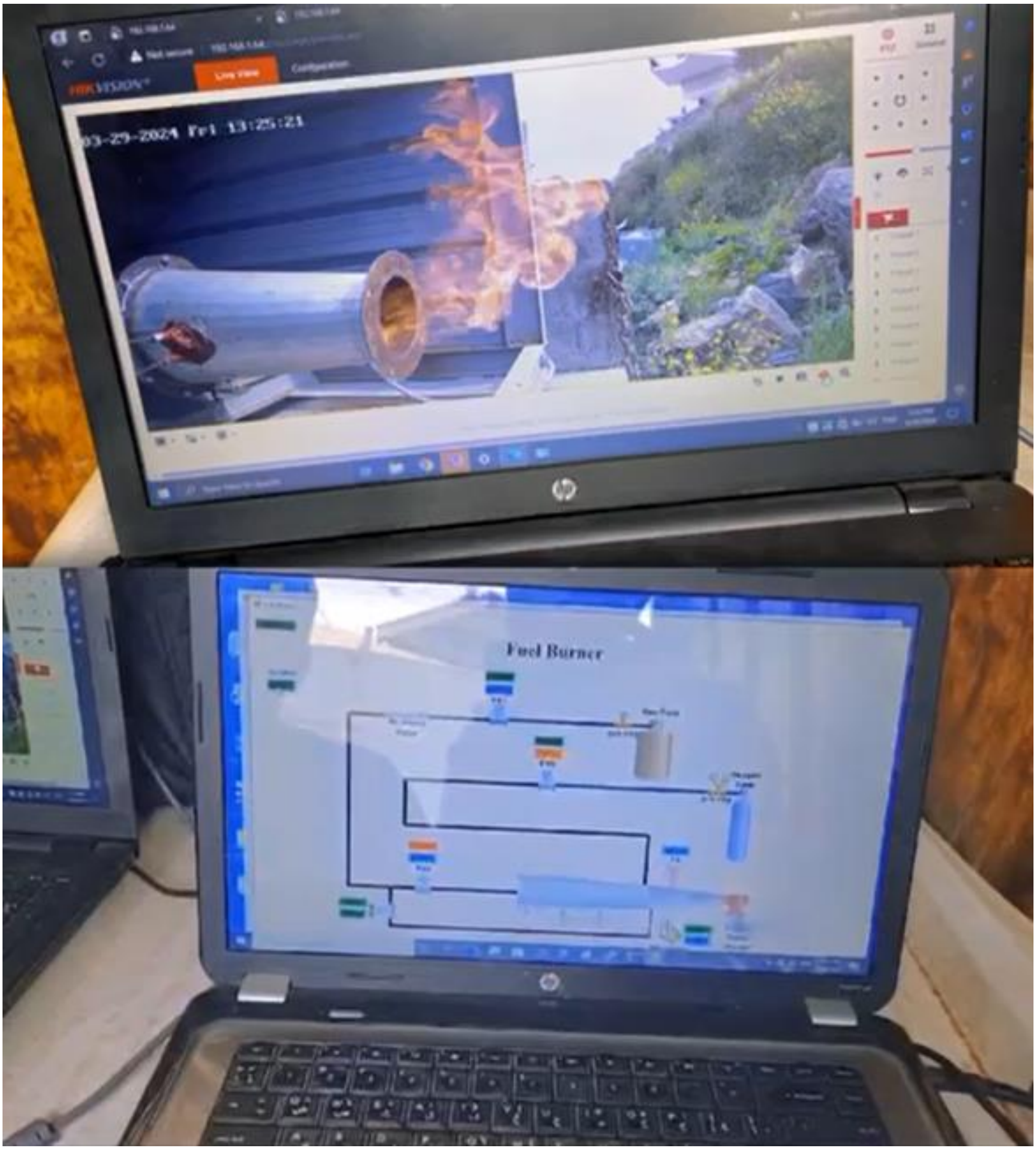
Open Ev2 and EV3	Open EV2 and EV3 valves using the GUI	Fire starts to rise	fire starts to rise
See C1	Using camera 1, watch the System	No abnormal activity	No abnormal activity
See C2	Using camera 2, watch the Turbocharger blades' rotational speed	Blade rotational speed increases	Blade rotational speed increases
Read Ts	Read the temperature sensor using the GUI	Temperature rise	Temperature rise
Read Ps	Read the Pressure sensor by GUI	Pressure normal	Pressure normal
Close EV2 and EV3	Close EV2 and EV3 valves by the GUI	Fire gets back to normal	fire gets back to normal
Close EV1 and EV4	Close EV1 and EV4 valves by GUI	Fire is off	fire is off
Close the gas tank.	Close the gas tank main Valve (manually)	No abnormal activity	No abnormal activity
Close oxygen tank	Close the oxygen tank main Valve (manually)	No abnormal activity	No abnormal activity
Postcondition			
system is off	All valves and systems are closed	System is off	system is off

5.11.3 Scheme of the System by GUI



5.11.4 Pictures Related


HIKVISION
03-29-2024 Fri 13:25:06
Fuel Burner


Live View
Fuel Burner

This is a gas explosion that happened for 1 second,

5.12 Biogas Turbine test using Butane/Oxygen with Turbocharger on 02.04.2024

5.12.1 Test Description

On April 2, 2024, the Biogas Turbine was tested using butane gas and oxygen gas at a 3:1.29 ratio. By adding oxygen, we were able to complete the burning of butane gas. A video that shows the difference between combustion with and without oxygen is available: "Click the icon below to view a video illustrating the differences between each situation.

WhatsApp Video
2024-04-07 at 10.37.

The test revealed findings compared to the prior test with regulated pressure.

First, we set the Butane pressure to 2 bar and the oxygen pressure to 0.86 bar. The fire in the Biogas turbine chamber began, and we noticed it after the blades began to rotate. After a while, we didn't notice anything because the blades began to rotate when there was an excess of butane and oxygen, or, in other words, when the pressure in the chamber increased.

We noticed that the temperature began to drop, so we closed the system. We then changed the butane pressure to 3 bar and the oxygen pressure to 1.29 bar, and we started the HV igniter. We encountered the same issue, and the fire began after high pressure. We noticed it with blade rotation, and fire emitted from the turbocharger.

Finally, we increased the oxygen pressure to 3 bar while keeping the butane constant at 3 bar. After a few seconds, the pressure exited the Biogas turbine with a pop sound, and the turbocharger was damaged as a result of the high pressure caused by oxygen and butane gases, the combustion process power, and the gases produced by the combustion itself.

This test concludes that the system requires breathing and that the system failed due to the turbocharger's limited exit diameter. In the following stage, we will need a better design of rotatable blades than the turbocharger, as well as a new approach, to complete the power-generating process.

5.12.2 System Test

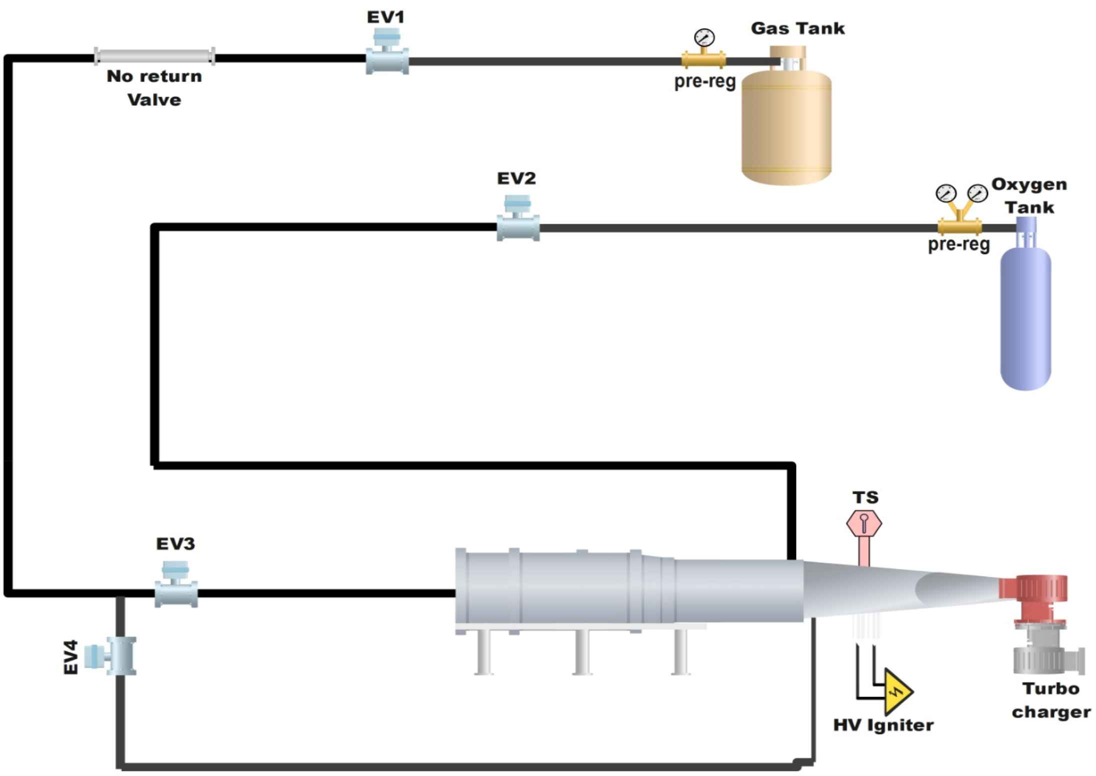
Steps	Step Description	Expected Result	Result
Precondition			
System is off	All valves and systems are closed	System is off	System is off
Check out			
Check out EV1	Check out by GUI EV1 (open it/close it)	Working good	Working good

Check out EV2	Check out by GUI EV2 (open it/close it)	Working good	Working good
Check out EV3	Check out by GUI EV3 (open it/close it)	Working good	Working good
Check out EV4	Check out by GUI EV4 (open it/close it)	Working good	Working good
Check out HV igniter	Check out by GUI the high Voltage or flame igniter (open it/close it)	Working good	Working
Check out Ts	Check out the temperature sensor By Gui	Reading ambient Temperature	Reading ambient Temperature 40
Check out TU	Check out theTurbocharger (manually)	Blades rotating normally	Blades rotating
Check Oxygen tank	Check out the oxygen tank main valve and its regulator (manually)	Working good	we put it on 0.86 bar
Check Butane tank	Check out the Butane tank main valve and its regulator (manually)	Working good	we put it on 2 bar
Check out C1	Check out the camera 1 filming	The system visible	The blades are Visible
Test Start			
Open Gas Tank	Open gas tank main Valve (manually)	Working good	Working good
Open oxygen gas	Open the oxygen tank main Valve (manually)	Working good	Working good

Open HV igniter with EV4	Open the High Voltage with EV4 By Gui	Start Working	Start Working
Open EV1	Open EV1 By Gui	Fire Start	we are checking Ts and it started to rise
Close HV Igniter with EV4	Close the High Voltage Igniter and the EV4 by GUI after the fire start	Closes	we didn't close it
Read Ts	Read the temperature sensor by GUI	Temperature rise	Temperature rise
See C1	Using camera 1 watch the Turbocharger blades rotation	Blade start to rotate	Blade starts to rotate after we get excess quantity of oxygen.
Open Ev2 and EV3	Open EV2 and EV3 valves by the GUI	Fire starts to rise	
See C1	Using camera 1 watch the Turbocharger blades' rotational speed	Blade rotational speed increases	Blade rotational speed increases due to high pressure
Read Ts	Read the temperature sensor by GUI	Temperature rise	Temperature rise in abnormal way
Close EV2 and EV3	Close EV2 and EV3 valve by the GUI	Fire gets back to normal	abnormal activity
Close EV1 and EV4	Close EV1 and EV4 valves by GUI	Fire is off	
Close Gas Tank	Close gas tank main Valve (manually)	No abnormal activity	

Close oxygen tank	Close the oxygen tank main Valve (manually)	No abnormal activity	
Postcondition			
System is off	All valves and systems are closed	System is off	System is off

5.12.3 Scheme of the System by GUI



5.12.4 Pictures Related

5.13 What's next

To complete this project, we must select the type of metals and sensors suitable for the model. Then, we can start manufacturing the turbine.

6 Project 6: NTA Production

6.1 NTA production poster

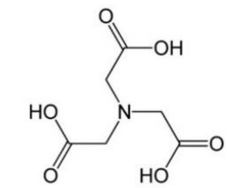
AECENAR TECDA
Association for Economical and Technological Cooperation in the Euro-Asian and North-African Region

بسم الله الرحمن الرحيم

MEGBI - Middle East Genetics and Biotechnology Institute
مركز أبحاث للجينات والتقنية البيولوجية
http://aecenar.com/institutes/megbi

Introduction

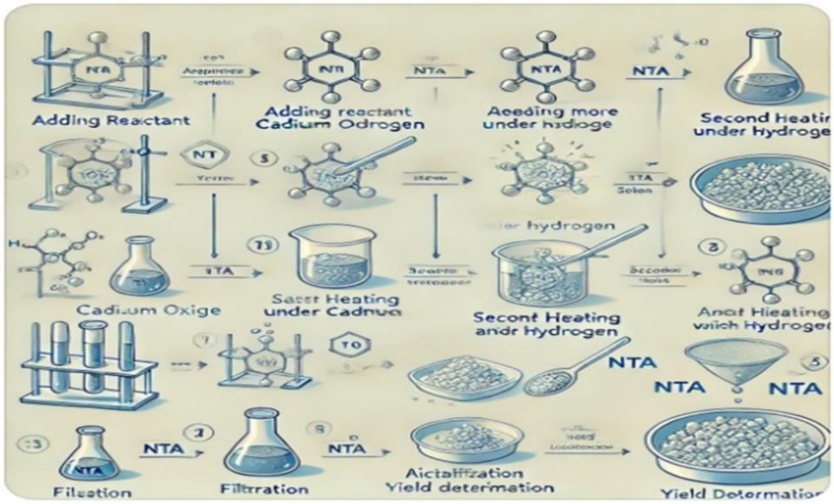
NTA is a molecule which used as an extractant in liquid-liquid extraction from Cu, Zn, and Pb. It is used for the extraction of toxic metals in municipal waste incineration ashe, so that the toxic metals can be removed before putting the ashes in the lanyard. In this way, the environment is protected.



Nitrilotriacetic acid (NTA) production

Material:

- Hydrogen gas (H2) (controlled pressure)
- Triethanol amine
- Sodium hydroxide (NaOH)
- Cadmium Oxide (CdO) (Catalyst)



To be done:
FreeCAD of plant

Requirements:

1. Physical: Pipes, tanks, and autoclave must withstand high temperatures (T = 300°C) and pressures (P = 260 bar).

2. Chemical: - Tanks, autoclaves, pipes, valves, and sensors must resist corrosion from Triethanol amine, sodium hydroxide, and hydrochloric acid

3. Mechanical: 1-Autoclave and tank systems, pipes, valves, and sensors must be made of stainless steel 316

2-complete system closure, resisting high-pressure

4. Electronic: Sensors must accurately read system data

Prepare the Autoclave hastelloy B:

1. Make sure all valves are closed
2. Make sure the power is turned off

Connect the reagent valve to the reactor

3. Put the amount of the reagent needed in the reactor
4. Close the valve for reagent filling

Safety precautions:

1. **Electrical Heating:**
2. **Triethanolamine**: Irritates eyes, skin, and respiratory tract
3. **Sodium Hydroxide**: Dangerous substance
4. **Cadmium Oxide (CdO)**: Highly corrosive

Noor.Koulayb **@AECENAR/July2024**

6.2 Protocol NTA production

6.2.1 Introduction

Nitrilotriacetic acid, or NTA, is a molecule that acts like a metal magnet. It grabs onto minerals in water, like calcium and magnesium, which can make soap less effective. This grabbing power makes NTA useful in detergents and water treatment to soften hard water and remove unwanted metals.

6.2.2 Materials and Equipment

- Hastelloy B autoclave (**use only under supervision!**)
- Safety goggles
- Gloves
- Lab coat
- Temperature sensor x2 (T1 and T2)
- Pressure sensor (S1)
- Flow sensor (F1)
- Heater x2 (Heater 1 and Heater 2)
- Mixers 2
- Filter x2 (F1 and F2)
- Stainless steel tanks x2 (waste tank and HCl Tank)
- Hydrogen gas (controlled pressure)
- Triethanol amine (0.8 mol)
- Sodium hydroxide (3 mol)
- Cadmium Oxide (Catalyst)

6.2.3 Procedure

The passage you provided can be summarized into the following steps:

1. **Adding reactants to the autoclave:**
    - 119g of triethanolamine (0.8 mol)
    - 148.5g of water
    - 120g sodium hydroxide (3.0 mol)
    - 6g of cadmium oxide CdO
    - All these were added to a Hastelloy B autoclave.

2. **Heating under hydrogen:**
    - The mixture in the autoclave was stirred and heated for 3 minutes at 260°C under a hydrogen atmosphere.
    - The pressure during this heating reached 3,600 PSIg
3. **Adding more cadmium oxide:**
    - The autoclave was cooled down, and the pressure was vented.
    - Another 6.0 g of cadmium oxide were added to the mixture.
4. **Second heating under hydrogen:**

  - The mixture with the additional cadmium oxide was reheated under hydrogen at 260°C for another 3 minutes.
  - The pressure during this heating reached 460 p.s.i.g. (lower than the first heating).

5. **Workup and Filtration:**
   - Water was added to the reaction product.
   - The resulting turbid solution (800 grams) was filtered.

6. **Acidification and Crystallization:**
   - The filtrate was acidified as in Example I (add 350ml HCl to reach pH = 0.35).
   - The solution was then heated to 100°C and cooled.

7. **NTA Isolation:**

- The precipitated NTA was filtered, separating the solid NTA from the liquid.
- The filtered NTA was washed with ice water until the washings were free of chloride ions (test for chloride using a standard silver nitrate test).
- The washed NTA was further washed with methanol to remove any remaining water.
- Finally, the purified NTA was dried at 120℃.

8. **Yield Determination:**

- Although not explicitly mentioned in the provided steps, the yield of the recovered NTA can be determined at this point using appropriate analytical techniques (refer to the original protocol for yield calculation).

6.3 Requirements NTA pilot plant

6.3.1 System requirements

- NTA (nitrilotriacetic acid) Pilot Plant shall be able to produce the nitrilotriacetic acid.
- The control panel shall be able to control all valves, mixers, and Heaters and read the sensor data (Temperature, Pressure, and Flow).

6.3.2 Physical requirements

- The pipes shall be able to withstand the temperatures and pressures that exist at the points.

  - Temperature that shall be withstood: 100℃ plus.

  - Pressure that shall be withstood: 2 bars.

- The **tanks** and **autoclave** shall be able to withstand the Temperature exchanges, pressures, and mechanical forces that exist at the points.
  - Temperature in **tanks** that shall be withstood:100℃ plus.
  - -Temperature in **Autoclave** that shall be withstood: 200-300℃.
  - Pressure in **tanks** that shall be withstood: 2 bars.
  - Pressure an **autoclave** that shall be withstood: 200-260 bars.
  - -mechanical forces: shall be withstood: mixer movements and rotation.
- The sensors (Temperature, Pressure, and Flow) shall be able to withstand the temperatures and pressures that exist at the points.
  - Temperature that shall be withstood:100℃ plus. In **tanks** and 200-300℃ in **autoclave.**
  - Pressure that shall be withstood: 2 bars in **tanks** and 200-260 bars in **autoclave.**

6.3.3 Chemical Requirements

- The **Tanks** and **autoclave** system shall be able to withstand the corrosion with organic and inorganic reagents: Tri-ethanol amine, sodium hydroxide, and chloridric acid.
- The **pipe system** used shall be able to withstand the corrosion with Tri-ethanol amine, sodium hydroxide, and chloridric acid.
- The **valves** shall be able to withstand the corrosion with Tri-ethanol amine, sodium hydroxide, and chloridric acid.
- The **sensors** (Temperature, Pressure, and flow) shall be able to withstand corrosion with Tri-ethanol amine, sodium hydroxide, and chloridric acid.

6.3.4 Mechanical Requirements

- The **Autoclave** Hastelloy B shall be made of stainless steel 316.
- The **Autoclave** shall be able to close the system completely.
- The **Autoclave** shall be able to resist the pressure (+240 bars) without letting gas or vapor exit through.
- The **Tank system** shall be made of Stainless Steel 316.
- The **Tank system** shall be able to close the system completely.

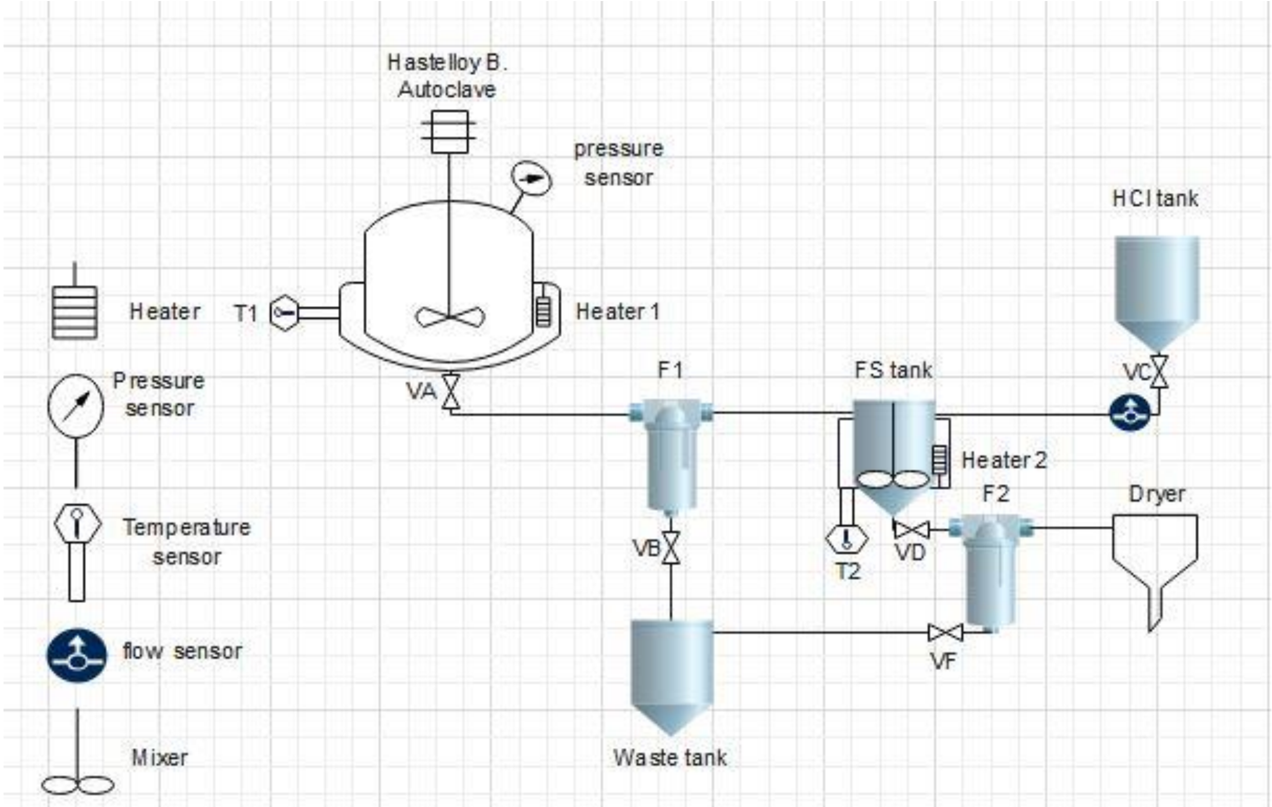
- The **pipes** shall be made of stainless steel 316.
- The **pipes** shall be able to resist the pressure without letting gas or vapor exit through.
- The **valves** shall be made of stainless steel 316.
- The **valves** shall be able to close completely.
- The **valves** shall be able to open or close independently of the pressure.
- The **sensors** shall be made of stainless steel 316.
- The **sensors** shall be able to close the system completely.
- The **NTA** pilot plant shall be designed according to the mechanical design

6.3.5 Electrical requirements:

- The **sensors** shall be able to read the data from the system.
- The control panel connected to the GUI shall be able to control the whole system:
  - Open/close valves
  - Turn ON/OFF Moto mixer
  - Turn ON/OFF heater

6.4 NTA Pilot Plant

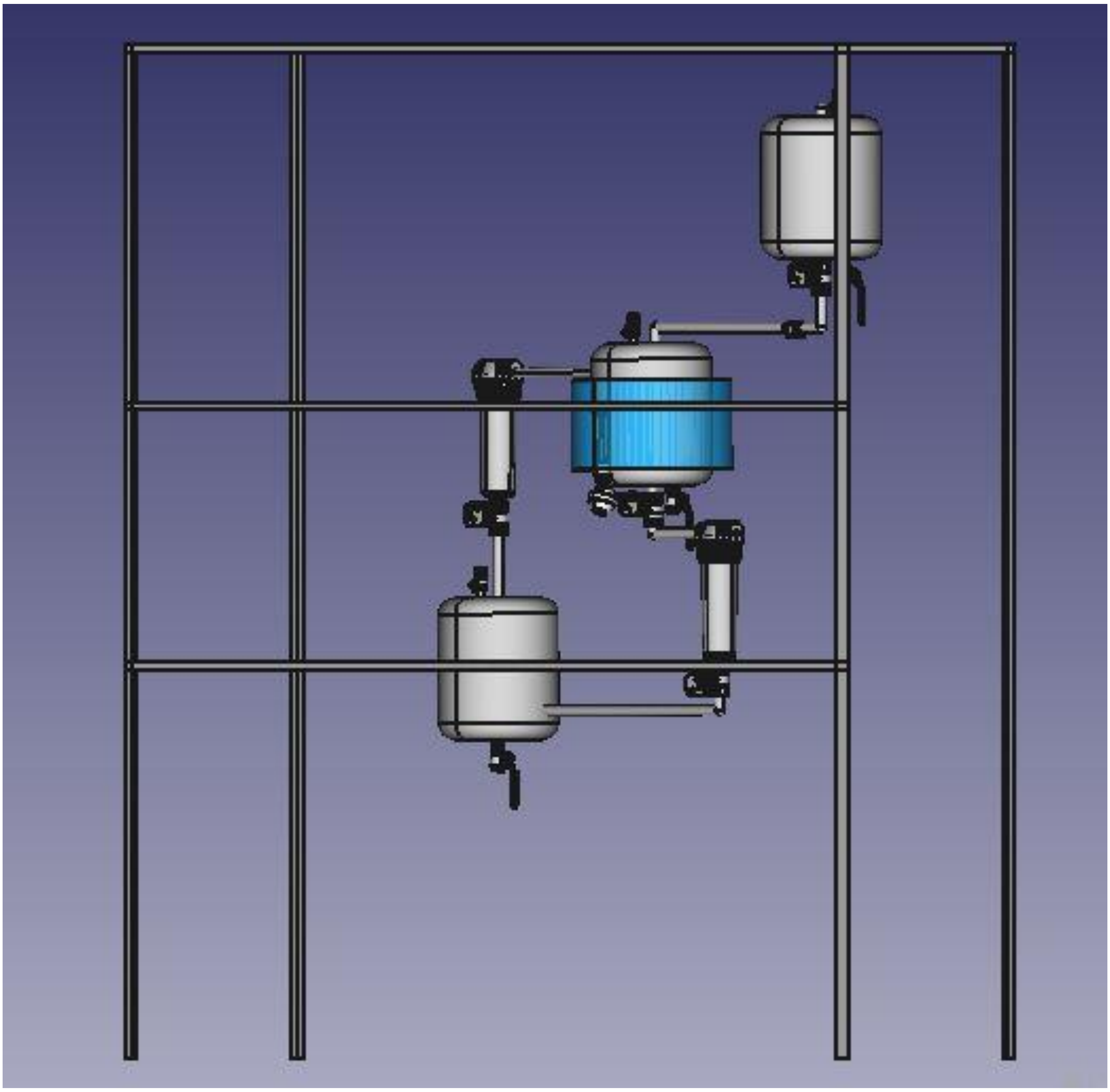
6.4.1 System design / System concept (NTA Pilot Plant)

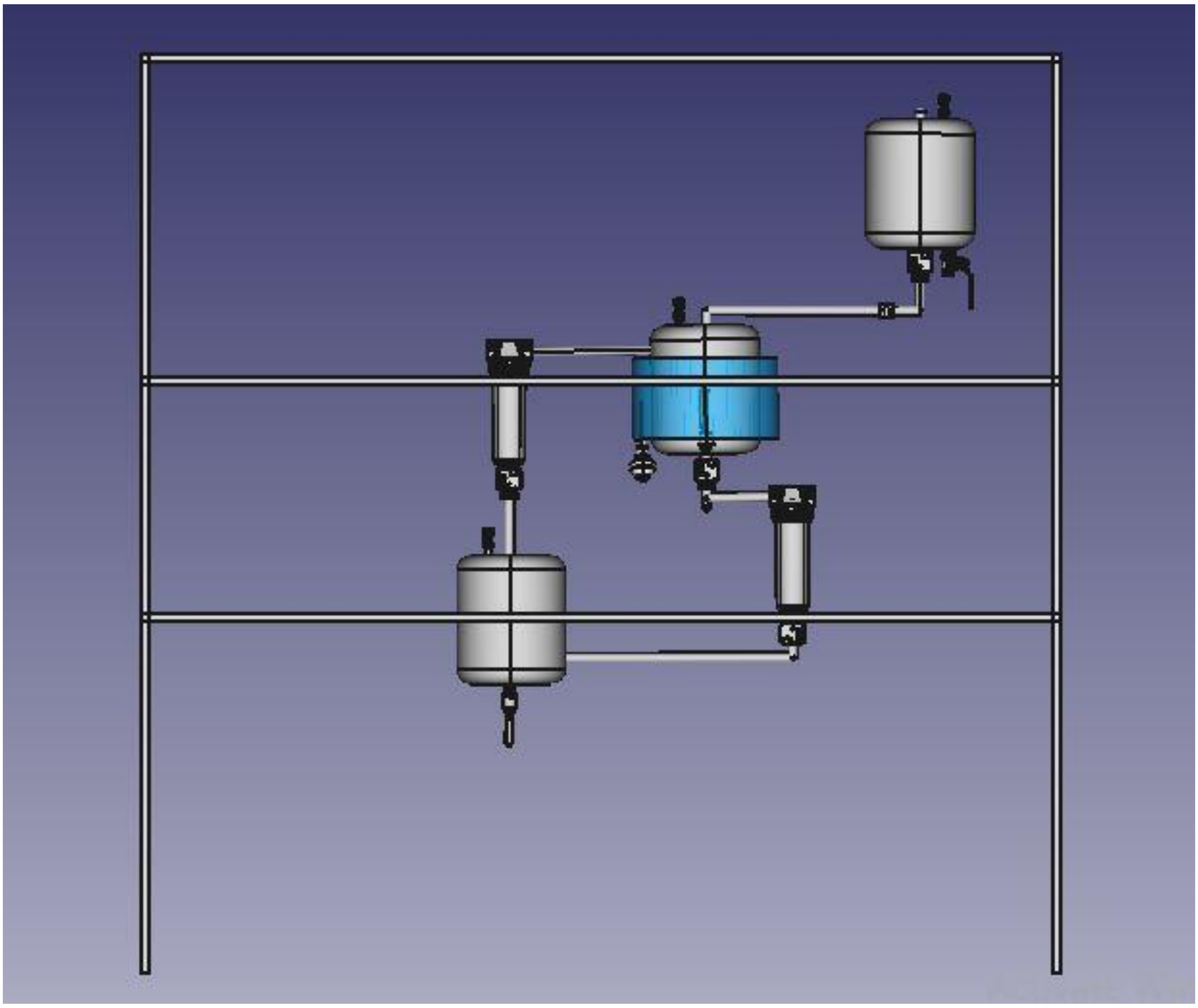


NTA pilot plan _24052024 [Edraw file]:

Edraw file NTA production MAP for

6.4.2 Mechanical design (NTA pilot plant)





Pilot Plant production design _25.07.24_ (NOT COMPLETED YET) [FreeCAD file]:

NTA free-cad file
10.6.24.FCStd

6.5 Test specification NTA pilot plant

6.5.1 Prepare the Autoclave hastelloy B

1. Make sure all valves are closed
2. Make sure the power is turned off
3. Connect the reagent valve to the reactor
4. Put the amount of the reagents needed in the reactor (amount of reagents: **119g** tri-ethanol amine (0.8mol), **120 g** sodium hydroxide (3mol), **12g divided** CdO (cadmium oxide) and **148 ml** water)
5. Close the valve for reagent filling.

6.5.2 Safety precaution

- Electrical heating (+260 °c) could suffer fourth degree burns (Autoclave = tank 1)

- Tri-ethanol amine: Irritating to the eyes, skin, and respiratory tract.

- Sodium hydroxide: Dangerous substance. It can hurt you if it touches your skin and if you breathe it. Eating or drinking sodium hydroxide can cause severe burns and vomiting, nausea, diarrhea, burns eyes, or chest and stomach pain.

- Cadmium oxide (CdO): highly corrosive, burns eyes and skin, inhaling damages lungs, a potential carcinogen, flammable, and reacts violently with many substances.

⚠ **N.B.: Wear protective gloves/protective clothing/eye protection/face protection.**

6.5.3 NTA Production Operation Method

1) Ensure all sanitary connections
2) Put the reagents in "Autoclave B" (tri ethanol amine, sodium hydroxide, and CdO)
3) Reaction: (TEA + 3 NaOH + CdO (catalyst) --> NTA + 3 H2O + Na-byproducts)
4) Plug the control system
5) Check the control system if it's working properly
6) Operate the "mixer" to mix the reagents in the "Autoclave B"
7) Operate the "heater 1" to heat = (260°c) in the "Autoclave B", 3600 PSI (248 bars) for 3 min
8) After 3 min: Operate the control system to Cooling and pressure venting
9) Put the catalyst in "Autoclave B" for the second time (CdO only and the same amount as the first one)
10) Re-heat by "Heater 1" to reach 260°C, 460 PSI (32 bars) and for 3 min
11) Operate "Filter F1" to filtrate the turbid solution obtained
12) Operate "Heater 2" to heat the water (100°C) in the "Filtered solution tank"
13) Operate the control system to add HCl in "Filtered solution tank"
14) Operate "Filter F2" to filtrate the acidic solution obtained
15) Operate the dryer to dry the solution obtained in the "Dryer"
16) After finishing, Operate the valves, heaters and mixers to close.

6.6 001: NITRILOTRIACETIC ACID PRODUCTION SYSTEM TEST

Step	Step Description	Expected Result
Precondition	System is **OFF**	
TURNING ON the system	Turn ON the **GUI**	The system is **ON**

6.6.1 Reaction phase 1

Reagents adding*

Switch ON the "heater 1" (Autoclave Hastelloy B)	Turn ON the "Heater 1" from the **GUI**	"THE HEATER 1" is heating till reaches 260°C indicated on the "T1" (autoclave's temperature sensor) and 3600 PSI (248 bar) indicated on the "Pressure Sensor"
i-Switch **ON the "mixer" (Autoclave B)** ii-Switch **ON the "timer" (autoclave B)**	i-Turn ON the mixer from the **GUI** ii-Turn ON the timer from the **GUI**	i-Mixing the reagents (manually added) to obtain the mixture in the "autoclave B" ii-Reaction timer's set at 3 min to be completed
iii- Switch **OFF the "mixer" (Autoclave B)** iv- Switch **OFF the "Heater 1" (Autoclave B)** v- Switch **OFF the "Timer" (Autoclave B)**	i-Turn OFF the "mixer" from the **GUI** ii-Turn OFF the "heater 1" from the **GUI** iii-Turn OFF the "timer" from the **GUI**	i- The "mixer" is OFF ii- The "Autoclave B" and the mixture in the "Autoclave" is cooled till reaches room temperature indicated on the "T1" (temperature sensor of the Autoclave) iii- Reaction "Timer" is OFF
- **Open the "venting valve" (Autoclave B)**	- Open the venting valve from the **GUI**	- The venting valve is open for cooling and pressure realizing from the system

6.6.2 Reaction phase 2

Switch ON the "heater 1" (Autoclave B)	Turn ON the "Heater 1" from the **GUI**	The "Heater 1" is heating till reaches 260°C indicated on the "T1" (autoclave's temperature sensor) and 460 PSI indicated on the "Pressure Sensor"
-Switch ON the "mixer" (Autoclave B) **-Switch ON the "timer" (autoclave B)**	-Turn ON the "mixer" from the **GUI** -Turn ON the "timer" from the **GUI**	-Mixing the reagents = catalyst in reaction 2 (manually added) -Reaction timer's set at 3 min to be completed
- Switch OFF the "mixer" (Autoclave B) **- Switch OFF the "heater 1" (Autoclave B)** **- Switch OFF the "timer" (autoclave B)**	-Turn OFF the "mixer" from the **GUI** -Turn OFF the "heater 1" from the **GUI** -Turn OFF the "timer" from the **GUI**	-The "mixer" is OFF -The "Autoclave jacket" and the mixture in the "Autoclave" are cooled till reach room temperature indicated on the "T1" (temperature sensor of the Autoclave) -Reaction "timer" is OFF

6.6.3 Filtration

-Open the "valve A" (Autoclave B: filter F1)	-Open the valve "VA" to transfer the turbid solution (after adding 400ml Distilled Water) from the Autoclave to filter "F1"	-Turbid solution is filtered and the filtrate is transferred to "FS tank"
-Open the "Valve B" (Filter F1: waste tank)	-Open the valve "VB" to transfer the solid residue to the waste tank	-Turbid solution is filtered and the solid residue is transferred to the "Waste tank"

6.6.4 Acidification

-Open the valve C (HCl tank: FS tank)	-Open the valve VC to transfer the HCl solution from the "HCl tank" to the "FS tank"	- (350 ml indicated in the flow sensor) Hydrochloric acid is transferred to "FS tank": pH= 0.35

-Switch ON the mixer (FS Tank)	-Turn ON the mixer from the GUI	- Mixing the filtrate and Hydrochloric acid in "FS tank"
-Switch ON the heater 2 (FS tank)	-Turn ON the heater 2 from the GUI	- Heater 2 is heating the water in the jacket till reaches 260°C indicated on the T1 (autoclave's temperature sensor) and 460 PSI indicated on the Pressure Sensor
-Switch OFF the "mixer" (FS tank)	-Turn OFF the "mixer" from the GUI	-The "mixer" is OFF
-Switch OFF the "heater 2" (Autoclave B)	-Turn OFF the "heater 2" from the GUI	The "Heater 2" is OFF

6.6.5 NTA Isolation

Open the "valve D" (FS tank: filter 2)	- Open the valve "VD" to transfer the acidic filtrate from the "FS tank" to the "Filter F2"	-"The acidic filtrate" is filtrated and the filtrate is transferred to the "Dryer"
Switching off the system	Switch off the system	The system is OFF
Postcondition	system is OFF	

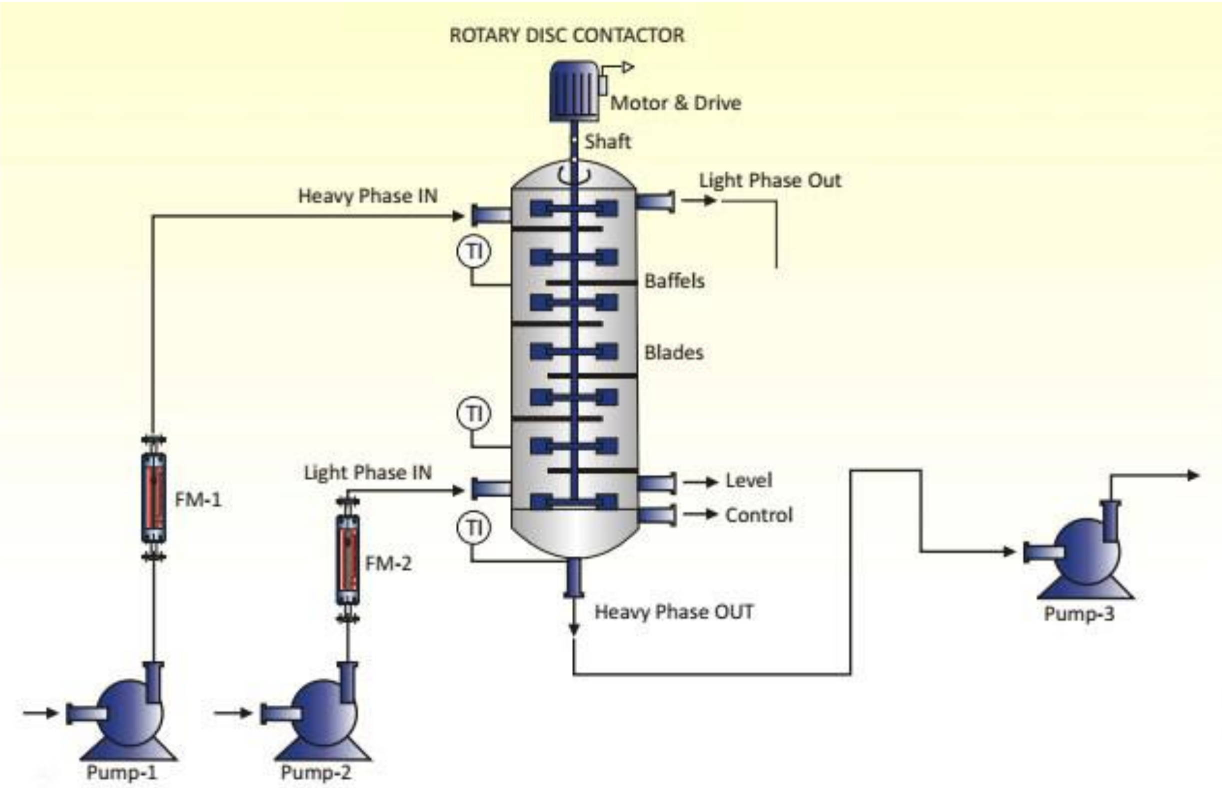
6.7 What's next

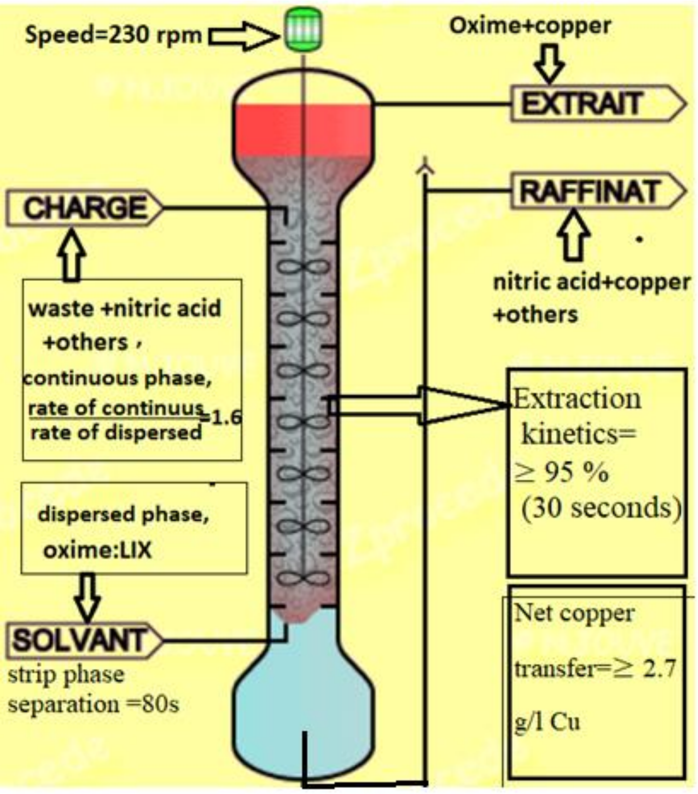
Procurement/producing of solubles.

7 Project 7: Ashes Recycling Project

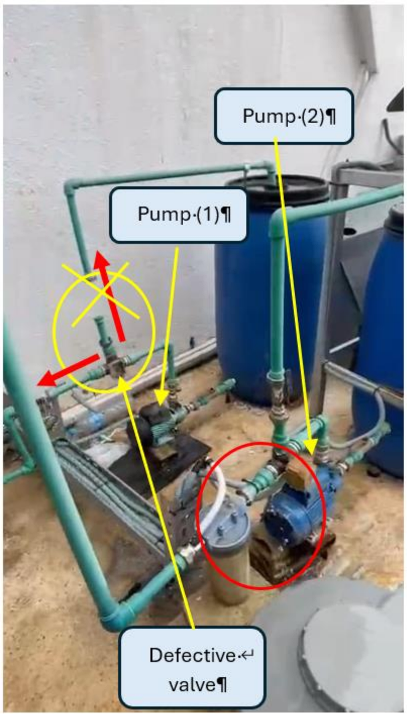
7.1 System Test only with water in February 2025

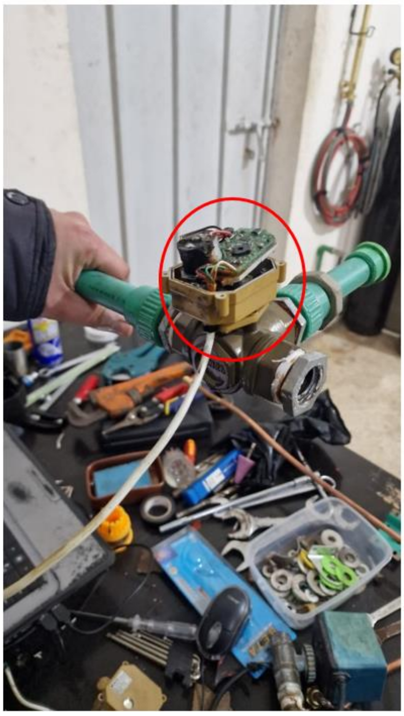
7.1.1 Ashes recycling - test specification





7.1.2 Ashes recycling - test documentation (test date: 12.02.2025)





This experiment was carried out exclusively with water for demonstration purposes. First, pump (1) and pump (2) were turned on to transport the water to the separation tower. Due to a defective valve (right picture, red circle), the backflow-path (left picture, yellow circle) to the tank was closed so that the test could be carried out. The water now flows in the direction of the red arrow. The defective valve was not removed from the system because no valve of the same model was available. Only the flow direction was manually adjusted so that the water can only flow in one direction, as previously described. During the test it was also discovered that there was a leak next to the filter (left picture, red circle).

	Motor (1) was turned on.

Now the water was pumped via pump (1) to the tank on the left side.

The water was also pumped into the upper part of the tower via pump (2). As soon as the tower is filled to the top, the water should flow through the path (red arrow) into the bottle. This test was only carried out for a short time to test the system, so the tower was not filled. During the test it was also discovered that the upper valve after the tower (red circle) was defective. The valve was replaced by a different model. The old model runs with 24V and needs a relay. The new valve runs with 220V and doesn't need a relay. The PLC can access it immediately.

7.2 Whats next?

Procurement of solvents for extraction of specific metals