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Design and construction of a Flow Bench

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AUTHOR: de Coen, Maxime

Tutor: Payri Marín, Raúl

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Design and construction of a flow bench

AUTHOR: Maxime De Coen

SUPERVISOR UPV: Raúl Payri

SUPERVISOR KUL: Sanjay Gothivarekar

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After four years I am able to finish my degree of industrial electromechanical engineering in Valencia, one of the most beautiful cities I have ever seen. I applied all the knowledge I gained in these years to successfully complete the thesis and obtain my degree. Therefore, I would love to express my gratitude to the people that helped me to achieve this goal.

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Thank you all.

Maxime.

Keywords: flow bench, urea injection, PVC, PID control, PVC valves, LabVIEW-program

Summary

The aim of this thesis is to build a flow bench. The idea of the flow bench is based upon the work of a UPV student a couple of years ago. He made a device that served as a tool to carry out tests of urea injection on exhaust gases.

Apart from urea injection, there is a general global urge to improve the efficiency of internal combustion engines as well as the aerodynamics of transportation applications. In this regard a more versatile flow bench can play a vital role. The thesis presents the optimisation of an existing flow bench to enhance the overall power and accessibility.

The flow bench was equipped with more advanced parts to fulfil this demand. The blower was replaced with a more powerful model, an inverter with integrated PID control was implemented and self-designed heaters were installed, with thyristors managing their power control. Then to enable incredibly high precision control of the airflow, the manual PVC valves were swapped out for stainless steel control valves with positioners and three velocity sensors with six thermocouples were placed. All these parts will work together to create a machine that can be automatically controlled by a LabVIEW-program, where the operator will be able to adjust the temperatures and flow rates of three different exhausts that can run at the same time, all monitored by live data visualisation in graphs and Excel sheets.

The accessibility is enhanced by flexible hoses and flanges specified at the outlet of the flow bench that provide easy connection to any given application. Supported by six swivel castors and suitably dimensioned, the flow bench can be transported through the door of any industrial building. In a nutshell, the flow bench can be seen as the ultimate air manipulation unit.

Palabras clave: banco de flujo, inyección de urea, PVC, control PID, válvulas de PVC, programa LabVIEW

Resumen

El objetivo de esta tesis es construir un banco de flujo. La idea del banco de flujo se basa en el trabajo de un estudiante de la UPV hace un par de años. Fabricó un dispositivo que servía como herramienta para realizar pruebas de inyección de urea en gases de escape.

Aparte de la inyección de urea, existe una urgencia global general por mejorar la eficiencia de los motores de combustión interna, así como la aerodinámica de las aplicaciones de transporte. En este sentido, un banco de flujo más versátil puede desempeñar un papel vital. La tesis presenta la optimización de un banco de flujo existente para mejorar la potencia global y la accesibilidad.

El banco de flujo se equipó con piezas más avanzadas para satisfacer esta demanda. El soplador se sustituyó por un modelo más potente, se implementó un inversor con control PID integrado y se instalaron calentadores de diseño propio, con tiristores que gestionan su control de potencia. A continuación, para permitir un control increíblemente preciso del caudal de aire, se cambiaron las válvulas manuales de PVC por válvulas de control de acero inoxidable con posicionadores y se colocaron tres sensores de velocidad con seis termopares. Todas estas piezas trabajarán juntas para crear una máquina que pueda controlarse automáticamente mediante un programa LabVIEW, en el que el operario podrá ajustar las temperaturas y caudales de tres escapes distintos que pueden funcionar al mismo tiempo, todo ello supervisado mediante la visualización de datos en directo en gráficos y hojas de Excel.

La accesibilidad se ve reforzada por las mangueras flexibles y las bridas especificadas en la salida del banco de flujo, que facilitan la conexión a cualquier aplicación. Soportado por seis ruedas giratorias y adecuadamente dimensionado, el banco de flujo puede transportarse a través de la puerta de cualquier nave industrial. En pocas palabras, el banco de flujo puede considerarse la unidad de manipulación de aire definitiva.

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List of abbreviations

3D	Three-dimensional
AC	Alternating current
atm	Atmospheric pressure
CMT	Instituto Universitario de Motores Térmicos
CAD	Computer aided design
Cos	Cosinus
D	Derivative value of PID control
DC	Direct current
EU	European Union
eq	Equivalent value
FPZ	Company that manufactures blowers
f	Frequency
GND	Ground
HVAC	Heating, ventilation and air cooling
I	Integration value of PID control
I/O	Input/output
IP	Internet protocol
M	Metric
max	Maximum
PLC	Programmable logic controller
P	Proportional value of PID control
Pn	Nominal power
PID	Proportional, integration, derivative

PVC	Polyvinyl chloride
rpm	Rotations per minute
Td	Derivative time constant
Ti	Integration time constant
v	Velocity

List of Units

Percentage	%
Ampere	A
Decibel	dB
Temperature degrees	°C
Hertz	Hz
Kilogram	kg
Kilowatt	kW
Millimetre	mm
Milliampere	mA
Millibar	mbar
Meters per second	m/s
Cubic meters per hour	m^3/h
Square meters	m^2
Square millimetres	mm^2
Volt	V
seconds	s

List of symbols

Delta connection of a motor	Δ
Pi	π
Phi	ϕ
Length of the blower in millimetre	H^2
Proportional factor	K_v
Noise level	L
Potential difference	U
Flow rate in cubic meters per second	Q

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1 INTRODUCTION

1.1 Context

As we live in a world where technology is evolving exponentially, pollution as a result of this automation can no longer be ignored. In 2019 fossil fuels, which play a significant role in European industry, made up 71 % of the gross available energy in the EU [1]. Fossil fuels are used in transportation, industrial processes, agriculture, and electricity generation. Almost every single industrial application has the side effect of pollution by emission gases. One of the main examples is the emission of carbon dioxide while driving a car. It is this gas that creates the so-called greenhouse effect. This greenhouse effect occurs when gases like carbon dioxide, methane, ozone and nitrous oxide allow the sun's radiation to shine onto the surface of the Earth, but capture the reflected radiation inside the Earth's atmosphere, causing the Earth to get warmer. In fact, these greenhouse gases act like the glass walls of a greenhouse, hence the name greenhouse gases [2]. To avoid this effect it is vital to neutralize the emission of carbon dioxide. This idea formed the base of a thesis made by a former UPV student. His goal was to investigate the effect of the injection of a urea solution. Urea is a chemical element that neutralizes the pollutant effect of carbon dioxide and transforms it into an inert gas. The last thesis described a research tool for the optical study of urea injection, where the installation was able to deliver a certain airflow at a given temperature and pressure to simulate different operating points of the engine [3].

The design of this thesis is inspired by the project a couple of years ago (see Figure 1-1). My master's thesis will improve this model and broaden the number of applicable applications by designing a versatile flow bench. Similar to the well-known wind tunnel, an airflow bench is a tool to test the internal aerodynamic properties of an engine part. It is mostly used to test the inlet and outlet ports from the internal cylinder heads of a combustion engine. Additionally, it is used to test components on the ability of their gas flow, including filters or carburettors for example. A flow bench is vital for engine developers. It consists of a type of blower, temperature, pressure and flow meters and numerous controls. The air is blown through the whole installation, while the test piece, blower and measuring instruments are connected in series. As a result, the entire flow rate goes through the test part and the measuring devices. Since the volumetric flow rate that goes through the measuring instrument and the test piece is equal, together with the pressure and temperature values the air density can be calculated. By multiplying this result with the volumetric flow rate the mass flow rate is obtained [4]. Besides engine components, a flow bench can be used to evaluate HVAC. Heating, ventilation, and cooling are referred to as HVAC. The installation can provide valves and air filters with specific working conditions, which can be used to develop heat generators for domestic use for example [5].

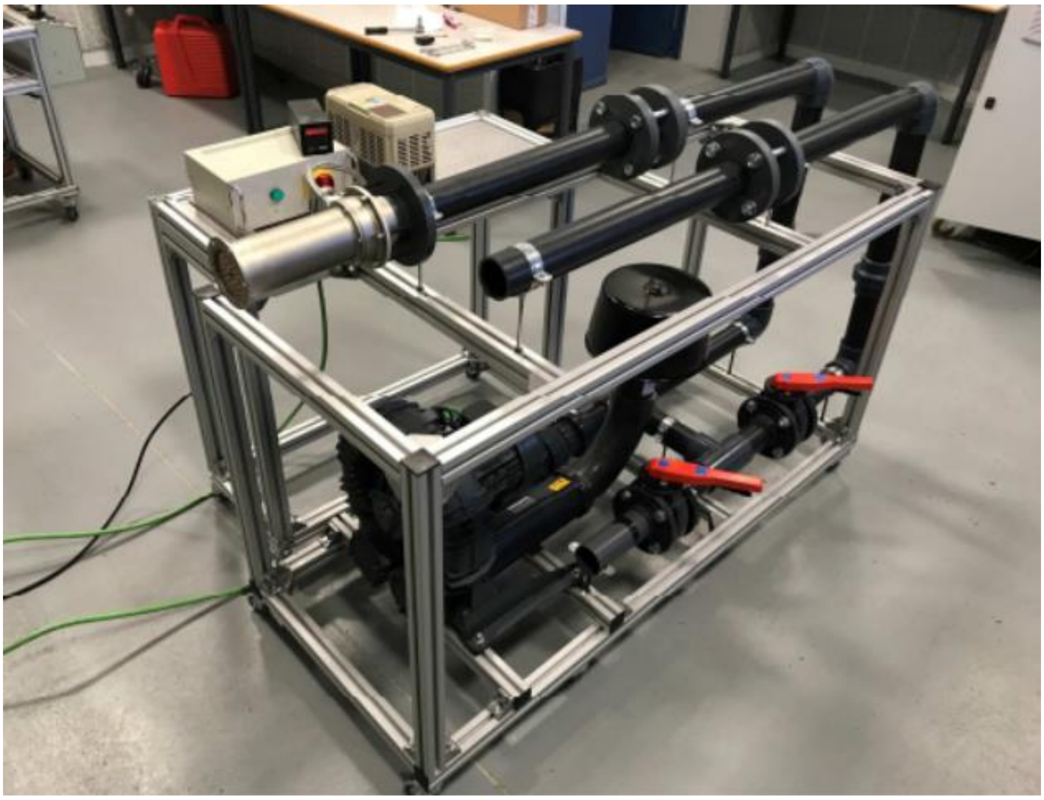


Figure 1-1: Previous installation [3]

1.2 Goals

This master's thesis aims to make a construction that can deliver a certain airflow at a given temperature and pressure, while continuously measuring those values and controlling the installation via a program called 'LabVIEW'.

To improve the previous installation, the focus relies mainly on expanding the range of the different variable parameters linked to the flow bench. The second wish is to get rid of the urea injector and make it usable for a diversity of applications.

The first adjustment is increasing the power of the blower (and so the airflow). The second improvement will be applying new valves that can be directed automatically instead of manually, which increases the accuracy and opportunities of the installation. Extra pipelines could provide more possibilities and several heating options. Then the temperature range should broaden by choosing different heaters and materials. Sensors will be needed to measure the flow and temperature of the airflow to maintain a continuous measurement of the important variables and quality control of the installation. Finally, the whole flow bench needs to be transportable and fit through doors to ensure its use for other applications. By removing the injector and installing flanges at the end of the air pipes the usage for other applications is enhanced.

The whole installation will first be designed in 'SolidWorks', a 3D program to make a small version of the flow bench, providing drawings of self-designed parts and room for try-outs of different versions before ordering all the materials. Then a financial analysis will be put together to compare the cost of different parts and give a good overview of where to order each component.

In the end, LabVIEW-software and an electrical schematic will be created as the basis for operating the flow bench and displaying the measured values.

1.2.1 The following objectives are presented as research topics:

- Dimensioning all the components related to the flow bench, which will improve the previous model. This includes looking at prices, materials and the applicability between each component to make a solid installation. Even the production of self-designed parts should be taken into account.

- Designing the 3D model of the installation and finding a way to attach each part to the framework and deciding what kind of framework suits best to do this.

- A financial analysis will give an overview of the prices of the different parts of the model and where they got ordered.

- Drawing the electrical scheme in 'Fluid Draw' and making sure every part of the flow bench is correctly connected and provided with power while making sure all safety prescriptions are followed correctly.

- Writing a LabVIEW-program to control important variables such as, airflow and temperature. Making sure the program is well integrated with the design and tested on given changes in the software.

- Control of the working of the flow bench. Evaluation of the flow bench and it's functionalities

1.3 Required functionality of the model

The initiative is that the model will deliver airflow with a certain temperature and pressure that the operator has to set in the program. The flow bench will be able to deliver three separate airflows at the same time, each individually controlled in speed, temperature, and pressure. Three control valves interact with each other to make this happen.

Every variable will be shown on the display of the program in graphs and data tables to make a quality analysis of the airflow for every application. Because the model consists of six castor wheels it will be movable in any direction. The width of the model is defined so it can pass through a normal door. The flexible hoses at the end of the three pipes will give the option to easily connect the system to any given application.

1.4 Methodology

1. Preliminary study of the assignment.
2. Discuss with my mentor what the different steps of the process are and what they entail to design the flow bench.
3. Breaking down these different steps into sub-steps and deciding what to do and when.
4. Theoretical study of the previous design to understand its limitations and the improvements that could be made.
5. Finding all the components needed for the project and asking prices for each part.
6. Designing a 3D model of the flow bench on SolidWorks with the assembled parts.
7. If necessary, design parts to make the model fit together properly.
8. Making drawings of the 3D-model and self-designed parts.
9. For the parts that are self-designed, look for possible manufacturers and ask for the price.
10. Putting the prices of all the parts (bought and self-designed), suppliers, and quantity on a report.
11. After a thorough overview of the report, order every part.
12. Make an electrical scheme via FluidDraw that presents the electrical connections between each component.
13. Study the working of LabVIEW.
14. Putting a program together on LabVIEW that complies with all the variables and controllable components.
15. After all the parts got delivered put everything mechanically together.
16. Connect the components electrically following the scheme.
17. Insert the program in the flow bench.
18. Perform several tests to make sure the installation works satisfactorily.

1.5 Framework

The structure of this final work consists of six parts:

Introduction

The reader gets an idea of what the thesis entails. It gives a summary of the upgrades that can be made based on the previous design and which steps will be taken to reach the goal of a successful flow bench.

Theoretical study and dimensioning

Each components that plays a role in the project will be explained theoretically to clarify its operation and will be compared in each of its features to find the best suiting type for the flow bench.

3D model

In the 3D model, all the parts will be individually discussed on how they are implemented in the design and why this type of implementation was chosen above others.

Electrical scheme

The paragraph of the electrical scheme provides meaning to each electrical component displayed on the electrical scheme added to this thesis. This implies a detailed explanation of the electrical connections and cooperation between these parts.

LabVIEW

LabVIEW is the control panel of the flow bench, the program is written with this software and described in depth. This ranges from starting the flow bench, to automatically generating PID values for blower speed control.

Conclusion

A conclusion is formed to give a brief idea of what this design has improved on, where the difficulties were hidden in the project, and how this design meets the predefined requirements.

2 THEORETICAL STUDY AND DIMENSIONING

2.1 The Blower

2.1.1 Theoretical study

A blower is a device which main function is to deliver a strong airflow or gas to different parts of a building or other structures. This is done by rotating several blades, linked to a hub and a shaft, and powered by a motor or turbine. There is an offer of various blower types on the market. The blower used in the prior thesis was a regenerative blower [3,6].

A regenerative blower or side channel blower, is a machine used to displace air and raise pressure by rotating an impeller within a toroidal channel (see Figure 2-1), so there is a gradual increase of energy. The term "side channel" comes from the lateral position of the toroidal channel compared to the impeller shaft. A side channel blower exists of an impeller with blades and a housing with a peripheral toroidal channel. When running, the impeller rotates without touching the enclosed parts, so durability increases and the need for maintenance is reduced. Custom-made silencers are designed to decrease the blower’s noise, while the airflow is sent from the inlet to the outlet (Figure 2-2). These blowers provide large amounts of air through a pipe or hose delivering it to a specific application. They are incorporated into devices that supply pressure and vacuum for pneumatic conveying and aeration in wastewater and fish farm facilities, as well as for installations involving air quality monitoring. Since this thesis is about building a flow bench a precise control of airflow is necessary which is what a regenerative blower stands for [7,8].

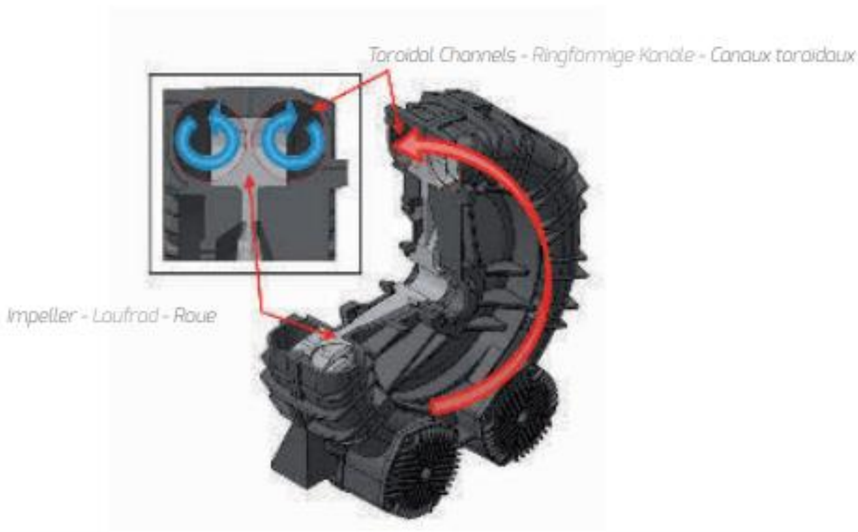


Figure 2-1: FPZ blower [8]

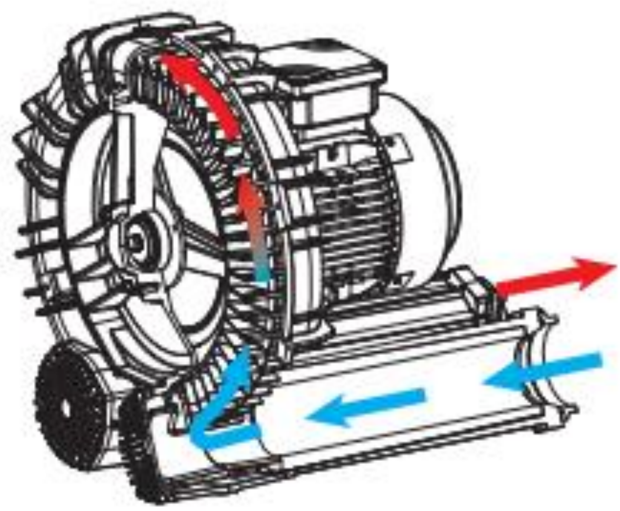


Figure 2-2: FPZ blower air direction [8]

2.1.2 Dimensioning

The blower used in the last thesis is a blower from FPZ a company that produces blowers since 1975. The version in the previous installation was: FPZ K07 MS. A regenerative blower for pressure applications. All the details of this blower can be found in the table below [9].

FPZ K07 MS					
Pn (kW)	**Frequency (Hz)**	**Δp (mbar) Suction**	**Δp (mbar) Compression**	**Qmax (m^3/h)**	**Leq [dB(A)]**
2,2	50	100	100	414	75,4
Weight (kg)	H^3	**Current consumption (Y/Δ) (A)** $IE2^2$	**Current consumption (Y/Δ) (A) Range**	**Cos ϕ**	**Speed (rpm)**
52,5	400	5,00/8,66	5,10-5,20/8,83-9,00	0,75	2945

Table 2-1: Blower K07 MS [10]

My supervisor advised me to upgrade the blower to the following model according to the purpose of this thesis, which is to improve the existing design and broaden the range of applications that are applicable (or increase the airflow range). A bigger airflow means more power. That’s exactly what the next version of regenerative blowers provides. The FPZ K08 MS model is superior to the FPZ K07 MS model (Table 2-1) in the key aspects as displayed in the corresponding tables [11].

FPZ K08 MS					
Pn (kW)	**Frequency (Hz)**	**Δp (mbar) Suction**	**Δp (mbar) Compression**	**Qmax (m^3/h)**	**Leq [dB(A)]**
3	50	100	100	536	76,5
Weight (kg)	H^3	**Current consumption (Y/Δ) (A)** $IE2^2$	**Current consumption (Y/Δ) (A) Range**	**Cos ϕ**	**Speed (rpm)**
55,3	400	6,27/10,8	6,88-6,36/11,9-11,0	0,82	2920

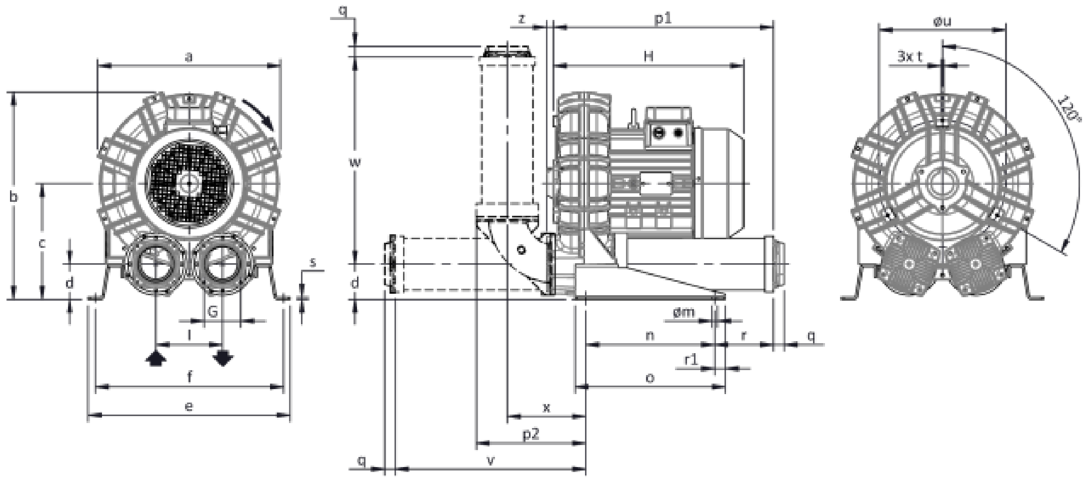
Table 2-2: Blower K08 MS [10]

The new blower has 3 kW of power in comparison with the 2,2 kW power of the last model. This causes the maximum flow to increase from 122 m^3/h up to 536 m^3/h. The K08 MS version is a bit more noisy and heavier but it is more efficient. The cos ϕ factor is 0,82 instead of 0,75 which means that the efficiency of the used power has gone up by 7%. For this project, the airflow is more important than the pressure since the pressure is proportional to the temperature which can be adjusted by the heaters. So following the catalogue from FPZ, the K08 MS version is preferred. The pressure difference delivered by the blower between the new and the old model stays the same. However, since the airflow is more important, a motor of 3 kW will suffice instead of a motor of 4 kW which can deliver the same airflow, but with a higher pressure difference [9,11].

Following the guide on the electrical motors on the website of FPZ, the TDS0108 AC motor is the best option. It can provide a maximum power of 4 kW, so 3 kW will be easily obtained. The extra kW in power ensures a longer lifetime compared to a motor continuously working on its maximum power [8].

According to the website, the air filter and the tubing, which need to connect to the blower's input, are included with the blower. Flanges are present on the inlet and exit to enable a secure connection (see Figure 2-4) [8].

Figure 2-3: FPZ K08 [10]



Configuration with a vertical silencer is only available with the CK accessory kit; for all assembly options refer to FPZ.
NOT Binding
Dimensions in mm

a	b	c	d	d1	e	f	G	l	l1	l2	m	n	o	p1	p2	q	r	r1	s	t	u	v	w	x	y	z
457	498	269	82	-	480	448	G 3"	155	-	-	13	300	350	512	255	25	137	25	5	M8	310	443	481	183	-	16

Figure 2-4: FPZ K08 dimensions [10]

2.2 Velocity Sensor

2.2.1 Theoretical study

To measure the airflow in the installation an air velocity sensor is needed. This velocity sensor has a probe, calibration, data acquisition and processing systems. Tiny metallic components, such as wires or films, whose electrical resistance changes with the variation in temperature, form the probe. The sensor is based on the principle of hot-wire anemometry also referred as the constant temperature method. This method emerged as the most reliable and efficient way for determining the air speed from the sensor data. Its main feature consists of an electric circuit with a feedback loop that compensates thermic losses of the resistor caused by a cooling effect of the airflow. By adding a compensatory voltage, the resistor heats up to obtain a constant temperature. This voltage is transformed in a specific airspeed value. In comparison to other measurement methods, the hot-wire anemometer despite being very brittle, has an uncommon high-frequency reaction and precise special resolution coupled with high accuracy and stable measurements [12].

2.2.2 Dimensioning

Seikom Electronics, a business founded in 1994 with an emphasis on the production of sensors, is the source of the suitable air velocity transmitter for this project. The project calls for a pencil-style type air velocity sensor, working on hot-wire anemometry for HVAC applications. This sensor, which was also employed in the prior thesis, continues to be the least expensive and most accurate to measure airspeed. But this thesis offers a superior sensor, which should now be able to measure velocities up to 30 m/s. Thanks to the pencil type, there's no more need to foresee flanges in the air pipes which simplifies the system. A hole can simply be drilled in the pipe to implement the sensor without further modifying the pipelines. How this is done exactly, is explained in the 3D model section [13].

This sensor is a viable option because of its extensive choice of immersion depths. The sensor's output voltage ranges between 0-10 V and the supply voltage amounts to 24 V AC/DC. This output voltage corresponds with the I/O-module that will read those signals. How the I/O-module works is clarified in Section 2.8. Another crucial factor is airspeed [13]. The flow of 536 m^3/h is divided between three pipes. In consultation with my promotor, it has been decided that the airflow in one of the pipes will never reach a value above 300 m^3/h.

From this value, the following necessary air speed was derived:

$Inner\ diameter\ of\ the\ pipes$: $63{,}5mm$ (see dimensioning of PVC)

$$Velocity\ v = \frac{Flow\ Q}{Cross\ section\ A} \tag{2.1}$$

$$Cross\ section\ A = 0{,}003175\ mm^2 *\ \pi \tag{2.2}$$

$$v = \frac{\frac{300\ m^3/h}{3600\ s}}{0{,}003166922\ m^2} \tag{2.3}$$

$$v = 26{,}31\ m/s \tag{2.4}$$

The maximum air speed through the pipe will be 26,31 m/s. The air velocity sensor from Seikom Electronics has a range of up to 30 m/s, so it meets the requirement. Lastly, the temperature range of the sensors medium lies within 0-70 °C. Because the air passing the sensor won't have warmed up yet, this range is safe. The model that fully satisfies every requirement is the RLSW4A M8 24 V AC/DC model (see Figure 2-5 and Figure 2-6) [13].

Figure 2-5: RLSW4A M8 24 V AC/DC

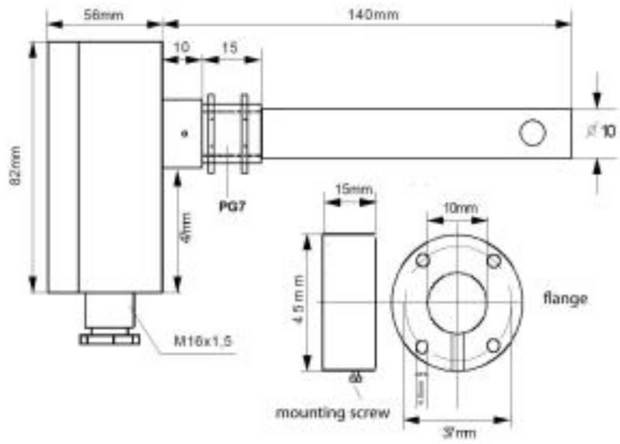


Figure 2-6: RLSW4A M8 24 V AC/DC dimensions [13]

2.3 Temperature Sensor

2.3.1 Theoretical study

The most straightforward method to measure the temperature of the airflow is to use a thermocouple. The principle to measure the temperature difference between a reference junction and a measuring point relies on the thermoelectric effect [14].

When a metal is heated at one end of the two-wire junction, the kinetic energy of the electrons at this end increases. A kind of net diffusion occurs between the two ends of the two-wire junction in which positive ions accumulate at one end and electrons at the other. This phenomenon causes an electric field and when reached equilibrium this field causes a voltage across the material. This method can be used to measure the temperature as the voltage depends on the temperature difference between the reference junction and the measurement junction [15,16].

Thermocouples, in contrast to resistance thermometers, have a broad measuring range, a quick response time, and have no influence on the measuring medium. Type T thermocouples are used to measure temperatures between -185 °C and 300 °C, whereas type S thermocouples measure temperatures up to 1600 °C. For industrial applications, the most used one is a K-type thermocouple, which can continuously measure temperatures between 0 and 1100 °C [14].

2.3.2 Dimensioning

The company providing this thermocouple is called 'RS', one of the biggest suppliers of industrial and electrical components. The specific model chosen is the RS PRO type K thermocouple with a length of 150 mm and a 3 mm diameter, but most importantly a temperature range of up to 1100°C (see Figure 2-7). The probe length of 150 mm gives the possibility to use the thermocouple in a wide range of pipe diameters. Additionally, the temperature range won't ever go above 1100 °C, because of the restriction of power from the heaters, which are designed to heat the air temperature to 800 °C. The 1 m cable length is also perfect for an easy connection to one of the I/O-modules [17].

A thermocouple was also used in the prior design a couple of years ago and is still the cheapest and best method to measure the temperature. There were no direct improvements possible in this area.

Figure 2-7: Thermocouple type K from RS [17]

2.4 Frequency Variator

2.4.1 Theoretical study

A variable frequency drive, commonly referred to as an AC drive or inverter, is abbreviated as VFD. These tools are made to control the speed of AC motors. It is the invention that has resurrected the use of AC motors. Since the speed of an AC motor depends on the rotary field, the speed of the AC motor can be adjusted by changing the speed of this rotary field or vary the frequency of its supply voltage. Because lowering the frequency increases the motor current, the amplitude of the supply voltage should decrease as well since the ratio of supply voltage to frequency must remain constant. This constant ratio ensures that engine torque remains constant [18,19].

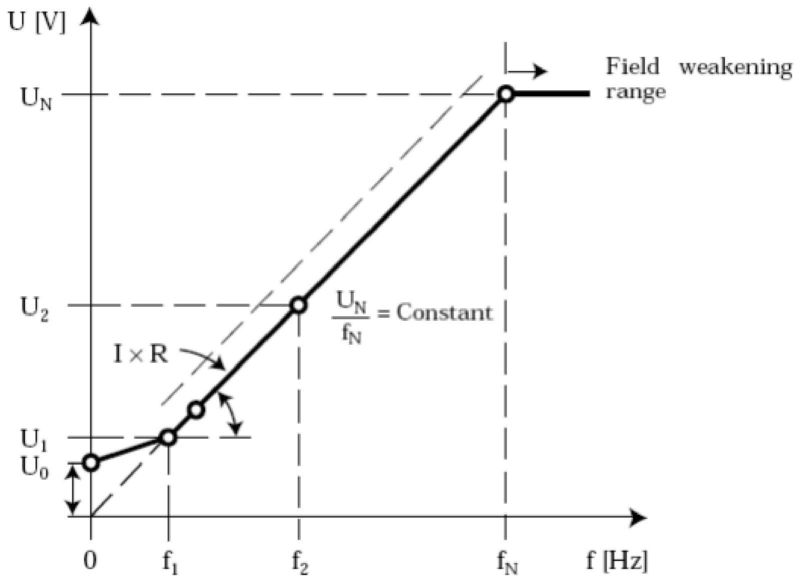


Figure 2-8: 2.1 U/f control [18]

At low frequencies, the ratio of supply voltage over frequency gets increased to compensate for the stator losses and produce a higher actuating torque. The ratio has a limit, known as the field weakening range. This limit occurs when the voltage continues to increase and so the frequency increases with it (see Figure 2-8). At some point the frequency reaches a value at which the electric field starts to weaken, this results in a negative effect on the motor control. The frequency drive consists mainly of four parts. First, the rectifier expanded with a load circuit and a circuit to protect the input from excessive voltage. Second, a capacitor-based intermediate DC voltage circuit. Third a 3-phase transistor inverter. A control circuit comes last. All these components make up the variable speed drive as represented in Figure 2-9 [18].

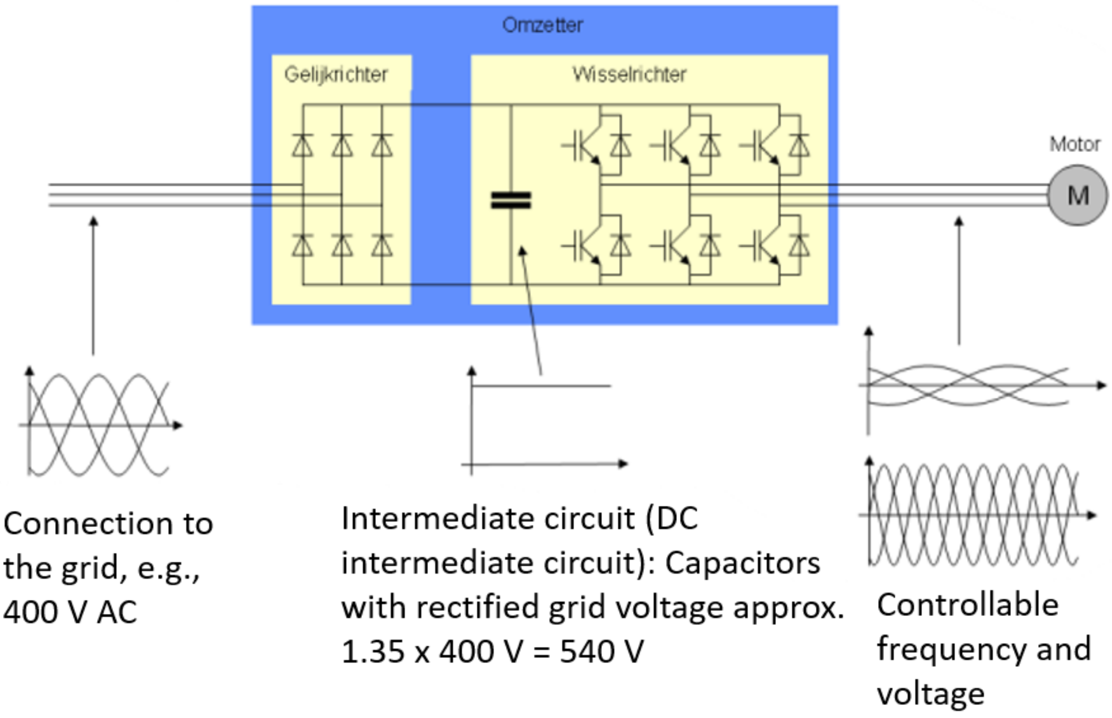


Figure 2-9: Components of a frequency drive [18]

So briefly, this all means that the motor will turn at its nominal speed at 50 Hz. If the frequency is increased to for example 60 Hz the motor will run faster than its rated nominal. By decreasing the frequency to for example 40 Hz, the motor will run slower than its nominal speed. So by using this theory of controlling the frequency and supply voltage to change the motor speed, the airflow will be regulated [18,19].

2.4.2 Dimensioning

To drive the 3-phase electrical AC motor of the blower a frequency variator/drive is necessary to variate the frequency at which the voltage is supplied. The motor has a nominal voltage of 400 V and a power needed of 3 kW. Additionally, the torque of the motor is variable. This is always the case with a blower. Considering all these features the 3G3HV-A4037-E model from Omron fits best (see Figure 2-10). It is a 400 V class frequency variator, which means that it works on 400 V and delivers a maximum applied power of 3,7 kW to the blower. This type of frequency variator is special because it is integrated with a PID controller, which is needed for a very accurate setting of the blower's speed.

Since the power of the blower in this design is still within the range of the frequency drive of the previous model, the same could be used, which avoids buying a new model. This type of frequency drive was eventually selected because of its high reliability and capability of using the PID control [20].

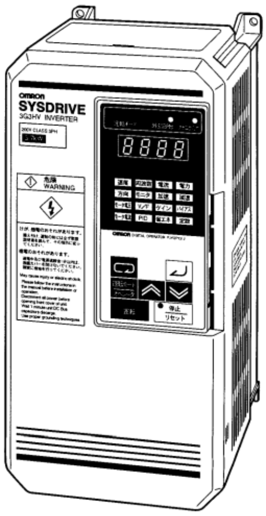


Figure 2-10: VFD Omron [21]

2.5 Heater

2.5.1 Theoretical study

The heaters used in the flow bench are designed by the UPV. My supervisor has decided to implement these types of heaters in my design. They consist of ceramic discs with a couple of holes in them. Each hole will be wired and at the end connected to the thyristor. By sending an electric current through the wires, the wires (red lines in Figure 2-11) get heated causing the airflow to get warmer. By coupling a number of several discs together the power of the heaters can be increased. The heaters in my thesis will be respectively 15 kW and 30 kW for the small and larger heater as recommended by my promotor. To insert the discs into the flow bench, some extra components will be necessary. These components will be fully discussed in the paragraph of the 3D model.

2.5.2 Dimensioning

The discs are made out of a ceramic material to be able to resist very high temperatures. The dimensions of the discs are fixed and represented in Figure 2-11. By coupling a certain number of discs the specific power of 15 kW or 30 kW can be reached. The positive side of this type of heater is that they are adjustable in contrast to the heaters with a fixed power in the prior thesis. If along the way, the power of the heaters needs to be increased or sized down, a ceramic disc can be added or removed.

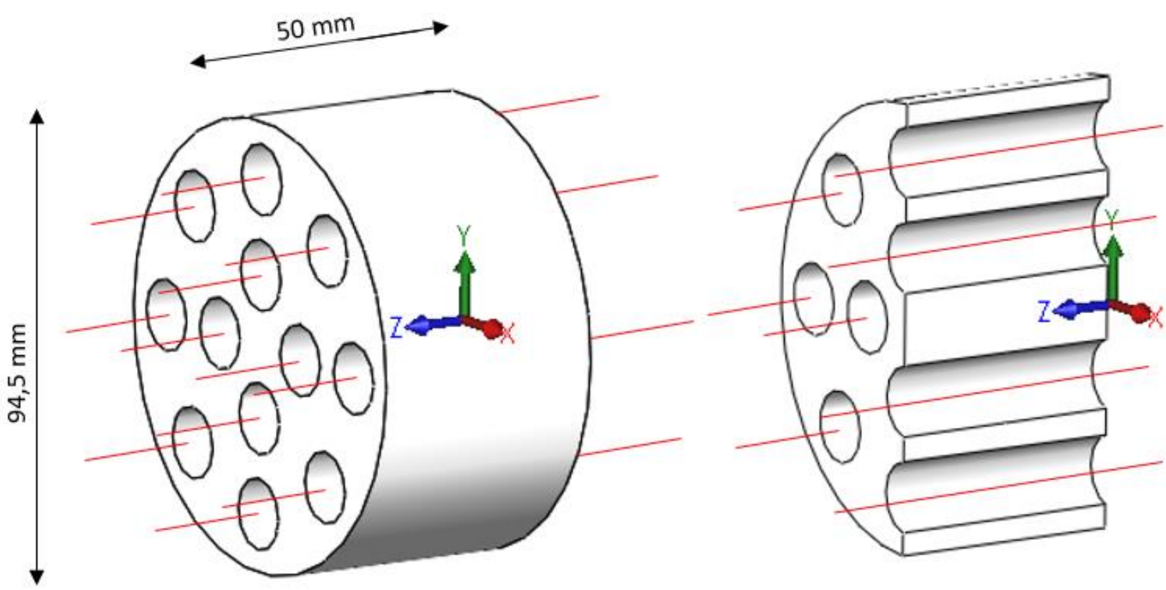


Figure 2-11: Ceramic disc SolidWorks

2.6 Thyristors

2.6.1 Theoretical study

Thyristors (see Figure 2-12) operate similarly to switchable diodes. They consist of several PN junctions and three terminals: the anode, the cathode and the gate. A thyristor is bistable in contrast to a transistor, where the relationship between load and current is linear. In a circuit, this device is used to create closed-loop or open-loop ideal switches. When a positive load is applied to the anode, a current can flow through the thyristor, only if the gate terminal is triggered by a pulse. Regardless of the size of this pulse at the gate, the current will keep flowing through the thyristor. However if the voltage at the gate is too large, the dissipation of heat increases. This can be prevented by using a pulse train (small pulses instead of a constant voltage) at the gate. Only when the gate voltage falls below a certain minimum value, the current will be blocked. The minimal current a thyristor can pass through is called the holding current. If the voltage applied to the anode is negative the thyristor turns into an isolator. In this thesis, the purpose is to control the power of the heaters. For every thyristor, the load to which power must be managed has to be connected in series with the anode and cathode terminals [22].

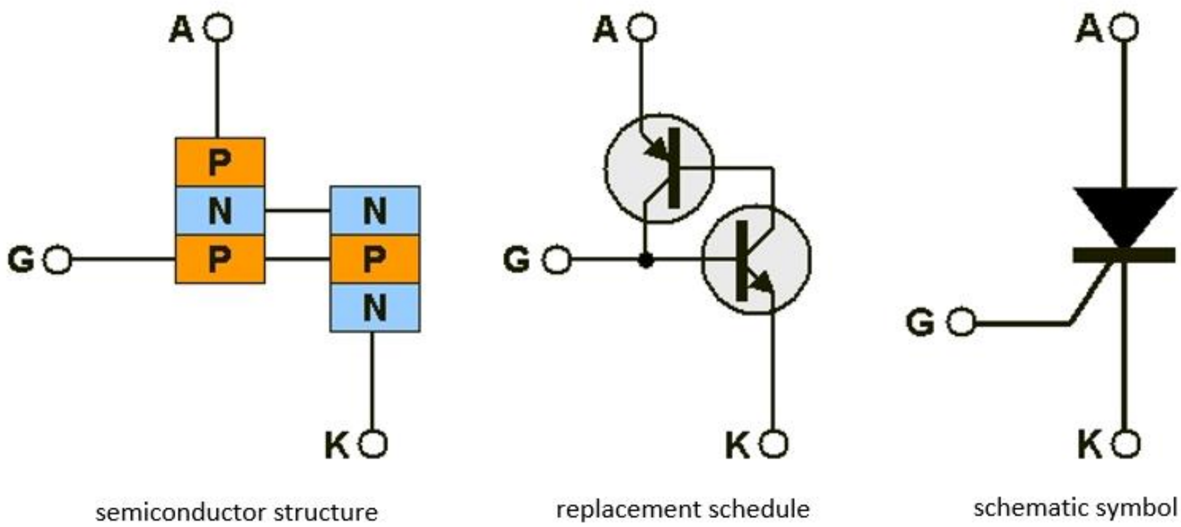


Figure 2-12: Thyristor structure [22]

2.6.2 Dimensioning

The thyristors are from Watlow (see Figure 2-13), a company that offers global electric and thermal solutions. This company provided thyristors a couple of years ago in the previous design. Each thyristor is specified by the electric current they can control. The power of the heaters are 15 kW and 30 kW. Each thyristor will be driven on 400 V. To find the electric current, the power is divided by the voltage and a factor of 1,73 (the conversion from line voltage to phase voltage). The result of this equation gives the current in amperes. Following the selection guide from Watlow the next heaters were selected: DB20-60F0-0000 up to 15 kW and DC20-60F0-0000 up to 30 kW. There is no improvement that could be made relative to the prior thesis, except the fact that this design contains two thyristors for two different heating options [23].

Figure 2-13: Thyristor from Watlow [23]

2.7 Control valves

2.7.1 Theoretical study

A control loop is needed for precise airflow conditions. It consists of a sensor that measures the real-time position of the valve. This signal will be transmitted to the controller by the transmitter and compared with the setpoint position given by the operator through LabVIEW. The controller reacts to this error (the difference between the setpoint position and the real-time position) by generating an output signal. Then, the control valve will receive a corrective signal from the controller and be able to vary its position to bring the airflow to the desired value [24].

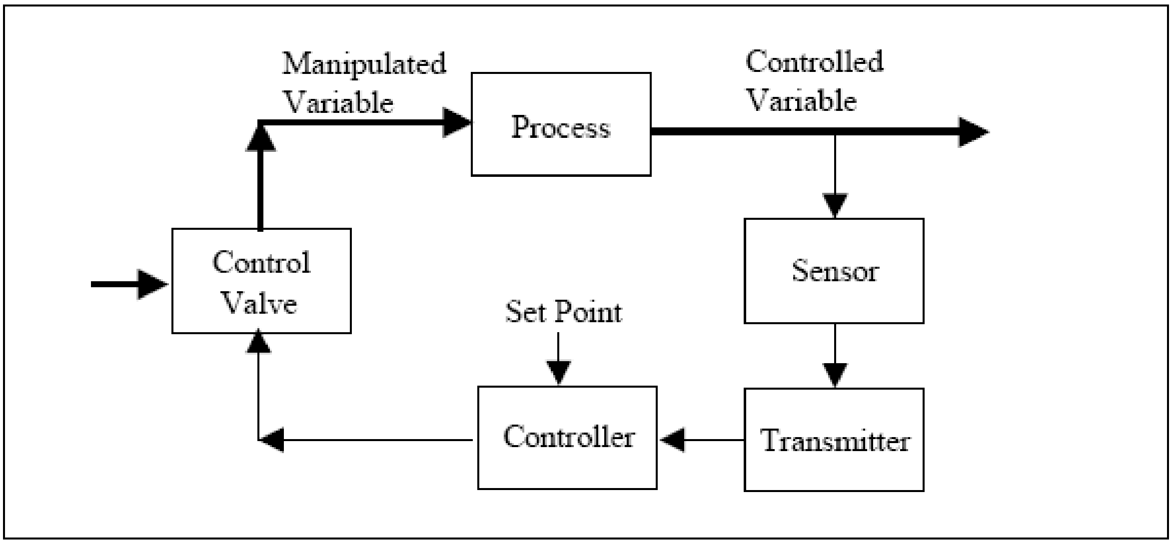


Figure 2-14: Control loop [24]

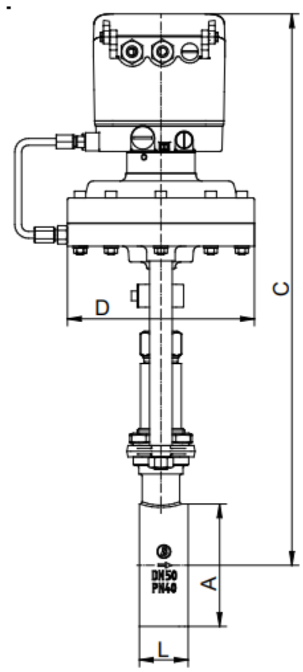
A control valve is the most common type of control element. Other types include, for example variable speed motors or pumps. In contrast to valves that operate in ON- and OFF-mode referred to as automated valve, the peculiarity of a control valve lies in the ability to modulate. It is the way this valve is able to position itself freely through a large number of throttling positions during regular control duty, to induce a very accurate flow control. A control valve is composed mostly out of three main parts: the valve body, or the actual pressure vessel, the actuator that controls the throttling positions, and other electric components like limit switches.

There are three primary parameters that play a significant role in the controller of the valves positioning system (see Figure 2-14), which is referred to as the PID parameters. The P-action (proportional action) amplifies the difference between the measured position value and the setpoint value by the factor K_v. This action only operates if the difference between the measured value and the setpoint exists. This difference is called an error. So if the P-action only functions if an error is present, the actual setpoint will never be reached and a static error persists. The I-action integrates the previous values of the error signal, thereby considering both the magnitude and duration of the error. The I-action will increase the longer the error signal persists. T_i is the integration time constant or follow-up time. It is the amount of time required to obtain a value that is as large as the P action. A small T_i results in a powerful I-action. The D-action reacts to the error's derivative or the error's rate of change. Further, the D-action slows the feedback down if the measured value starts changing in the direction of the setpoint value and will most likely overshoot this value. The feedback is accelerated with the D-action if the measured value deviates from the setpoint. If the derivative of the error is not equal to zero, the D-action becomes relevant when the error signal changes. The higher T_d, the stronger the response to changes in the measured value. The differentiating term works less naturally than the I and P-action and is therefore less common. There are also control algorithms where the D-action is determined by changes in the measured value rather than by the error signal. In this way, the control responds more smoothly [25,26].

2.7.2 Dimensioning

To dimension a control valve it is important to examine all environmental and operational conditions. First of all the medium going through the valve is air. The temperature of the air plays a role in the material selection of the control valve. The blower will be placed in a building where the experiments will be carried out. In this case, it will be the CMT building on the UPV. The air inside the building will be drawn in by the blower and blown out at a certain flow rate. The air drawn in, will therefore never exceed 60 °C, as these temperatures are not realistic inside a building. Since the blown-out air passes through PVC pipes to the valves, which are located before the heaters, the temperature of the blown-out air will not increase significantly. Another crucial factor is the valve's diameter. Since the PVC pipes in the flow bench have a nominal diameter of 75 mm, the closest corresponding diameter of the valve was 80 mm. This small difference causes a smooth transition and easy connection between the PVC pipes and the valve which minimises the pressure difference. The valve that suited these conditions, and was the cheapest, was the control valve model 8021-GS1 from Schubert and Salzer (see Figure 2-15). Implementing this type of valve offered a major improvement compared to using the previous valves. The old valves consist of a PVC housing and a handle to manually set the valve opening, whereas the new valves are way more sophisticated and versatile. They allow digital control through LabVIEW and really accurate positioning, thanks to a positioner with integrated PID control, which is essential in the monitoring of airflow [27].

Figure 2-15: Control valve 8049 from Schubert and Salzer [27]



digital positioner ,Type 8049

DN	ØA	C	D Actuator		L	Stroke	Weight kg	
			125	250			D 125	D 250
15	53	460	165	222	33	6	6,9	9,1
20	62	465	165	222	33	6	7	9,2
25	72	470	165	222	33	6	7,2	9,4
32	82	475	165	222	33	6	7,5	9,7
40	92	480	165	222	33	6	7,7	9,9
50	108	490	165	222	43	8	8,9	11,1
65	127	500	165	222	46	8	9,7	11,9
80	142	510	165	222	46	8	10,3	12,5
100	164	520	165	222	52	8,5	11,8	14
125	194	535	165	222	56	8,5	15,5	17,7
150	219	550	165	222	56	8,5	17,4	19,6

Dimensions in mm

Figure 2-16: Dimensions control valve 8049 from Schubert and Salzer [27]

2.8 I/O-modules

2.8.1 Theoretical study

To control the variables of the flow bench, a variety of measuring instruments are implemented in the model. These measuring instruments, such as temperature sensors or velocity sensors, transfer data that is needed to precisely drive the flow bench. To read this data, these sensors need to be connected to I/O-modules (input/output modules). These modules form the connection between the measuring instruments and a programmable logic controller (PLC), that processes this data and sends it to an interface (for example, a computer with ‘LabVIEW’). An I/O-module consists of several input and output connections. The type of connection can be different depending on the measuring device. A distinction can be made between analogue and digital I/O-modules. An analogue signal is a continuous signal both in time and in value, like a radio wave for example. Another illustration is the use of an analogue output to control the speed of a motor. Unlike analogue signals, digital signals are binary. This means they represent a value like ‘on’ or ‘off’ or ‘1’ or ‘0’. Digital I/O-modules prevail over analogue signals because of the numerous use of digital technologies. An example of a digital I/O-module is a digital output to light up a specific indicator lamp [28].

The I/O-modules used in every part of the dimensioning paragraph originate from Promux (see Figure 2-17 and Figure 2-18), a supplier of relatively cheap and effective modules. This company was recommended to me, because of its former cooperation with the UPV in other projects. The working principle of this specific type of module will be explained in this part, while the dimensioning paragraph deals with the aspect of input or output types.

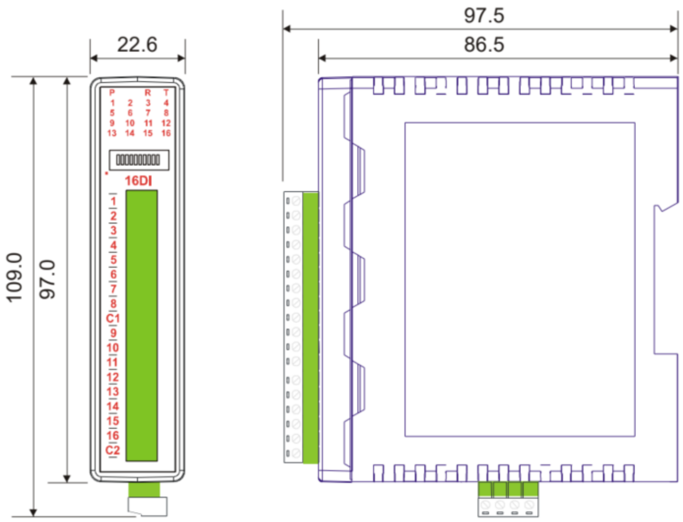


Figure 2-17: Promux module example [29]

The modules from Promux will be connected to an RS485 network. Through this network, the I/O-modules transfer information to the PC with LabVIEW. To communicate with the PC, some type of converter is needed. This converter is also supplied by Promux and transfers the communication on RS485 level to ethernet level to which the PC is connected. The PC is now capable of 'asking' values to the I/O-modules, which respond back to the PC. In the digital world, this type of interaction is seen as master/slave communication. The PC gives commands and is thus the master of the I/O-modules, which serve a response and so are the slaves. The detailed connection of this module with the associated communication devices is explained during the discussion of the electrical diagram [29].

2.8.2 Dimensioning

To dimension the right I/O-modules, it is important to know how a certain measurement instrument indicates a measurement value.

2.8.2.1 Thermocouples

The temperature sensors are thermocouples type K. The Promux catalogue includes a separate module described for thermocouples. The name of this module is PM8TC(ISO). The PM stands for Promux module, which is the name of the brand. TC stands for thermocouple. The temperature is an analogue measurement that needs to be displayed on an interface and changed equally with the temperature measured inside the tube. Therefore an analogue input module is needed, that reads the temperature value, which is an input for the module. The eight in the name stands for eight inputs. Following the design of the flow bench, only six thermocouples should be enough. Because the lowest input model is eight, there is room for extra thermocouples if needed along the way. ISO stands for isolated and is preferred over the normal version because problems could arise if the thermocouples are attached to conductive materials [29].

2.8.2.2 Control valves

The control valves come together with a positioner. The manual of the positioner states that the input signal should be a current between 0-20 mA or a voltage between 0-10 V. The PM16DO is the module that stands out. It consists of 16 digital outputs (16DO). The positioner that controls the valves is an output from the module going to the valves and consists of PID control [27,29].

2.8.2.3 Flow sensor

The velocity sensor from Seikom displays its flow by using an analogue signal between 0-10 V proportional to the velocity rate. To collect this information, an analogue input module for voltages is selected. Because only three flow sensors will be implemented in the installation, eight inputs are sufficient. This results in the following model: PM8AI/V.

2.8.2.4 Frequency drive

The frequency drive from Omron has according to its catalogue an analogue input to control the frequency of the drive and an analogue output for the velocity of the variator. Both signals are between 4-20 mA. The analogue output of the frequency drive will be connected to an analogue input module, namely the PM8AI/I model. The analogue input of the frequency drive will be connected to an analogue output module, the PM8AO.

2.8.2.5 Thyristors

The thyristors from Watlow will control the electric current running to the ceramic heaters. On the other hand, are the thyristors connected to a Promux module to monitor the electric current flowing to the heaters. The thyristors or power controllers can be controlled by a 4-20 mA current. They need to be controlled, which means that the power controllers receive data from an external analogue output module, the 8PMAO.

2.8.2.6 Relays and contacts

To be able to have a smooth electrical interaction between the written program and every component in the flow bench, some relays and contacts are needed. These components prevent the thyristors from continuing to operate when the blower is switched off, for example. By connecting these in a certain way, a logical and safe machine can be created. To monitor these relays with the program on the computer, a digital I/O-module of Promux is required. It is necessary to read and write binary signals to these relays to control the flow bench easily. The chosen module is the 8PMDIO [29].

Figure 2-18: Example of three Promux modules [29]

2.9 Pipes

2.9.1 Theoretical study

To find the right type of material that will guide the air through the flow bench, several restrictions need to be taken into account. First of all the material needs to be lightweight and affordable. Since the pipes will be mounted in a displaceable frame, a very heavy material is not suitable. The price needs to be considered as cheap as possible since the whole project is going to be expensive and the money can better be spent on the more sophisticated electronic parts like control valves for instance.

To compare different materials based on these two design parameters (price and density), the program 'Granta' was used. This program compares every material in user-defined features. Doing so, the following chart was formed:

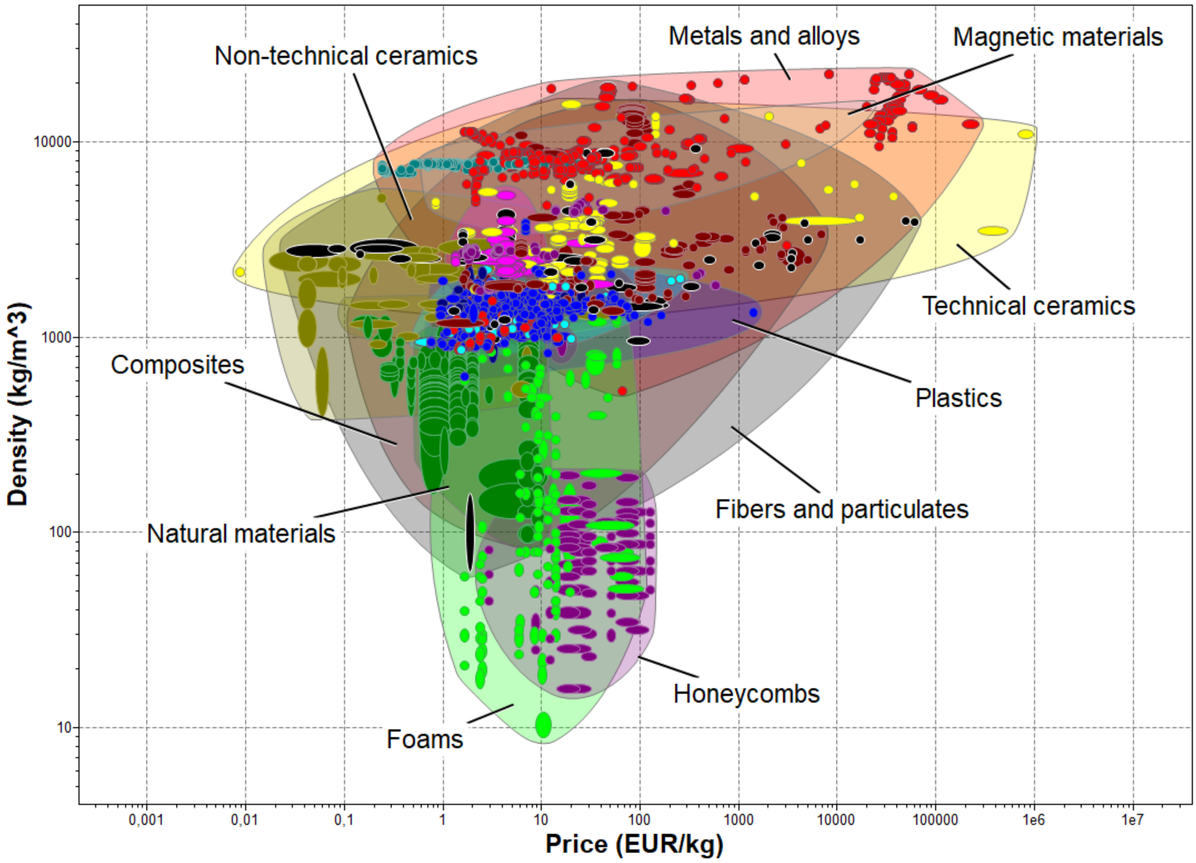


Figure 2-19: Granta graph 1

On the vertical axis, the density in kilogram per cubic meter is displayed on a rising logarithmical scale, while the horizontal axis indicates the price in euro per kilogram on a rising logarithmical scale. On reflection, this chart still contains too much material types to make a proper selection. Therefore extra limits should be considered.

The first one was the working temperature. Since the air is going through the pipes and valves before the heater, only friction from air moving through these elements, could cause heating. To be safe the material should be able to endure a working temperature of around 60 °C, as discussed in the previous section. By inserting this limit in Granta and after verifying that the material is accessible in pipe form the next chart was displayed:

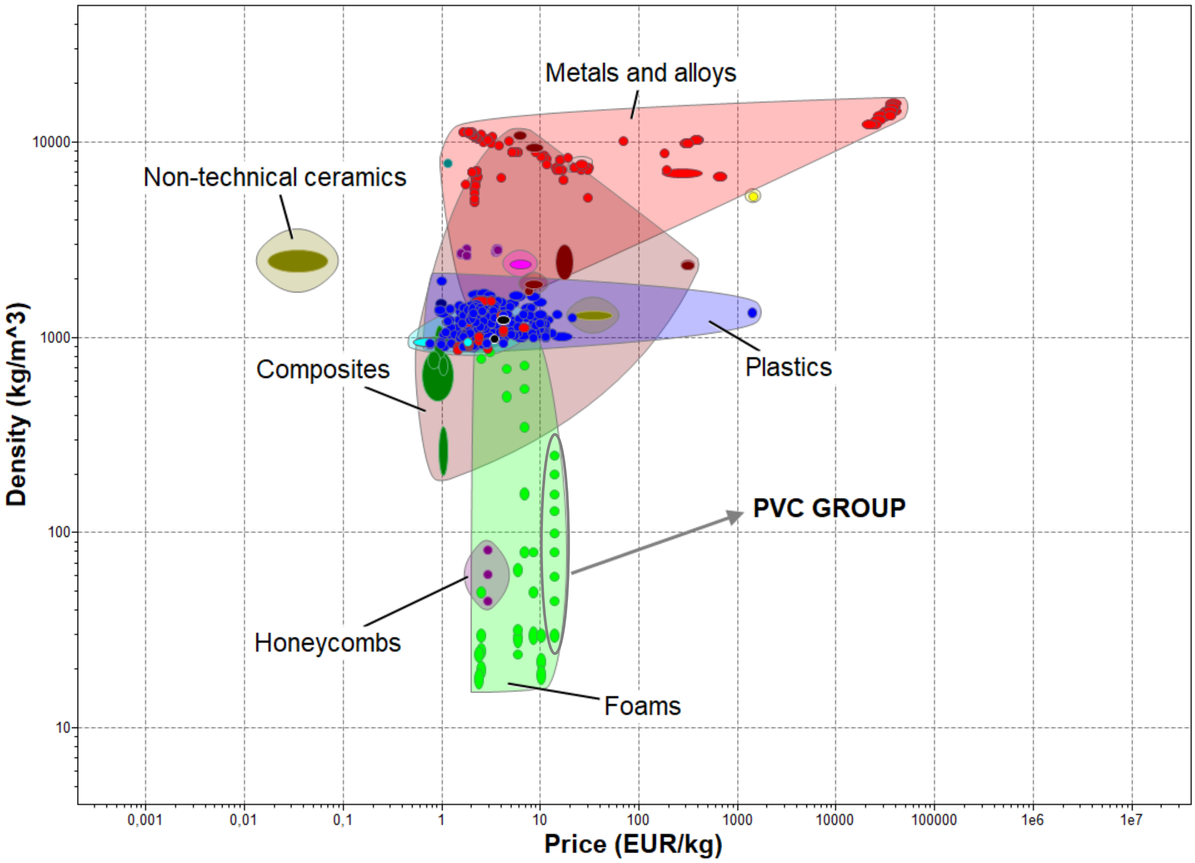


Figure 2-20: Granta graph 2

From this graph, the material group that quite clearly stands out in weight, are the foams. Since the price difference of the foams in comparison with the other material groups is really small relative to the density difference, the pipe material will be chosen out of this selection. To find the right foam material, a comparison was made in durability. Since the PVC group is resistant to corrosion, chemical reactions and complies with all the other requirements, it is preferred above any other material.

2.9.2 Dimensioning

PVC pipes were also utilized in the earlier thesis. It appears that this material continues to stand out for this kind of project. The dimensions of these pipes are restricted to the diameter of the blower's outlet. To ensure a stable airflow and smooth connection the difference in diameter between these two components should be as small as possible. The diameter of the blowers exit is three inches which is equal to 76,2 mm. The PVC pipes' closest-fitting standard diameter is 75 mm. The supplier of the pipes (see Figure 2-21) is called 'Tuberplas', a company that delivers quality PVC parts for sanitary applications, which the UPV has worked with in the past. They deliver 75 mm PVC pipes with an inner diameter of 63,5 mm, which was also taken into account when studying the connection to the blower, as it must also fit properly on the inside and not impede airflow. Tuberplas offers pipes in a variety of sizes as well as internal pressure resistances. The safest choice, and hence the highest internal pressure of 16 atm, was chosen because the cost difference between pipes with different internal pressures is quite limited. It is worth mentioning that this flow bench should be capable of regulating large airflow rates through a combination of valve setting, thereby inducing significant peak pressures in the pipe structure [30].

Figure 2-21: PVC pipe [31]

2.10 Frame

2.10.1 Theoretical study

In consultation with my supervisor, I was told to use item profiles of the company ‘Fasten’, while building the frame. This is because these profiles were used a couple of years ago in the previous project and are easy to assemble. The fact that they are lightweight and capable of supporting a considerable mass is another quality of this sort of profile. Additionally, it is favoured because the relative dimensions of one profile to another are easy to adjust since the profiles are fixed with bolts and nuts in contrast to a welded frame that cannot be modified [32].

2.10.2 Dimensioning

The dimensioning of the profile type results from the profiles used in the previous thesis, where they used the 45 x 45 Item profile (see Figure 2-22) [3].

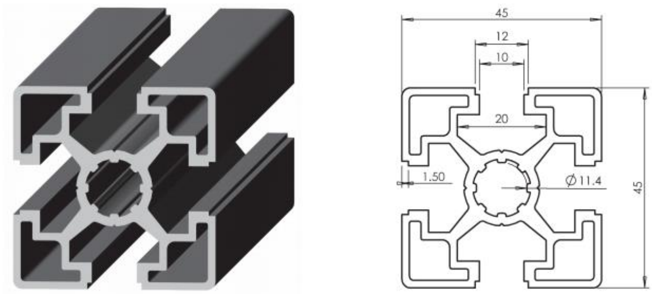


Figure 2-22: Fasten 45 x 45 Item profile [32]

3 3D MODEL

3.1 Introduction

In this paragraph, the 3D design (see Figure 3-1) will be reviewed in depth. This means that every part will be individually discussed on how its placed in the framework and why. Consulting the accompanying SolidWorks drawings, where each component is depicted in detail with the corresponding dimensions, can be done if not every connection in the images is obvious. Since the electrical components, like thyristors for example, are not placed directly into the frame, they will not be included in this part.

The 3D design is made in SolidWorks. It is a computer-aided design (CAD) software for Windows. The program is developed by Dassault Systems SolidWorks Corp., a part of Dassault Systems. Dassault Systems is a software supplier, founded in 1981. They originally started with the automation of plane designs.

Now, with their program SolidWorks, the user can design 3D parts and make the drawings needed for production. Even parts that already exist can be downloaded and implemented in the program to assemble it with new parts [33].

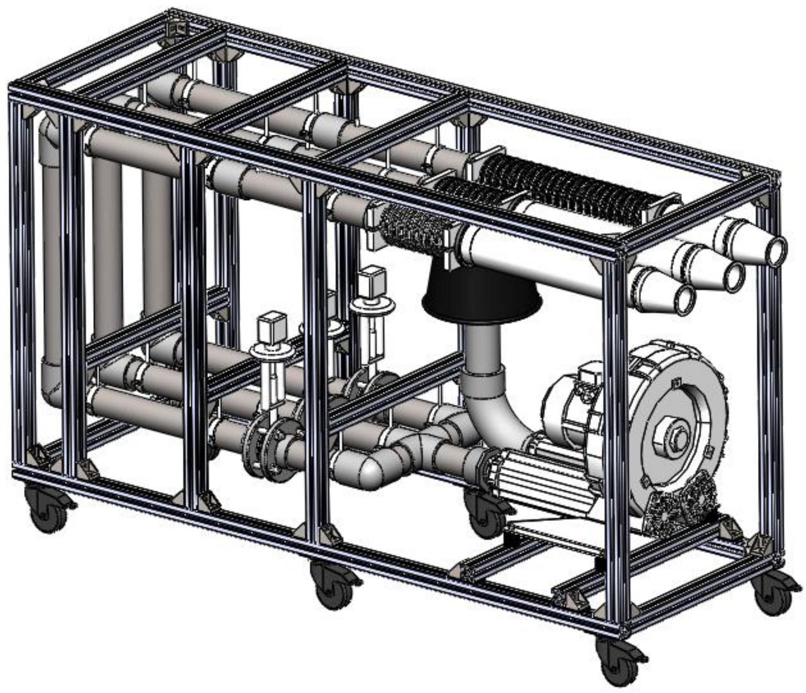


Figure 3-1: Flow bench design in SolidWorks

3.2 The Blower

The blower consists of an inlet and an outlet. The inlet is provided with a filter (the black part in Figure 3-2) and a pipe leading the filtered air to the inlet. The air gets sucked into the blower, which blows the air back out on the other end. The blower has two flanges included which allow for easy connection with the PVC parts. The connection with the filter tube is made with a sealing ring and screws. The sealing ring assures no air will leak through. This connection is visible in the drawings attached to this thesis. The link between the outlet and the PVC is formed by a screw connection, where the PVC is screwed into the flange of the blower.

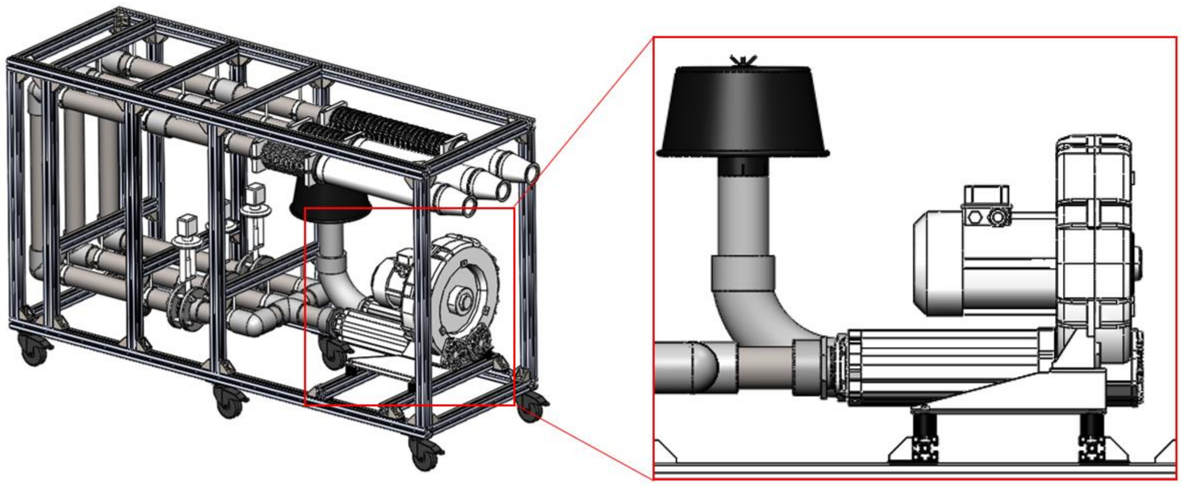


Figure 3-2: Blower in SolidWorks

The blower is placed on two perpendicular item profiles to the frame, which ensures that the blower can be aligned in two dimensions. Together with their slot and through the use of bolts and nuts, the profiles can be fixed in every position relative to each other. This type of connection is displayed in Figure 3-4. According to the catalogue of the blower, the nominal speed amounts to 3515 rpm. With a mass of 55,3 kg, this can cause numerous vibrations. To reduce these vibrations four dampers were placed underneath the blower (black cylindrical part in Figure 3-3). Since the profiles resting on the frame also pass vibrations from the blower to the frame, four damping plates (black rectangular part in Figure 3.3) were provided to ensure the frame was subjected to as little vibration as possible caused by the blower [10].

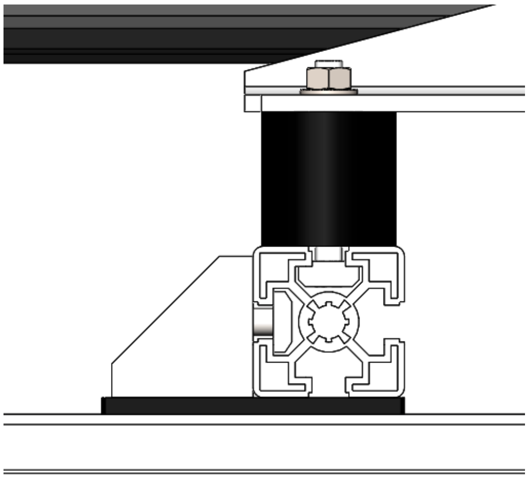


Figure 3-3: Damper in SolidWorks

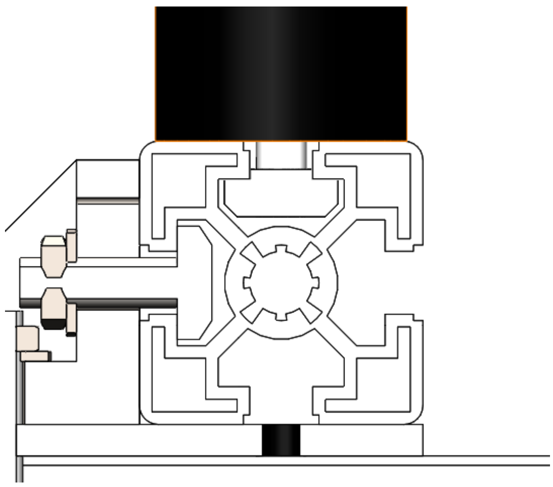


Figure 3-4: Item connection in SolidWorks

3.3 PVC-parts

All PVC parts are connected via a kind of PVC glue. Every part that holds the pipes together, such as corner pieces, for example, contains a notch. Because of this notch (red circle in Figure 3.5), the pipe can never be pushed too far and is always fixed in a specific position. This ensures a very strong connection, that is also completely sealed so that no air can escape.

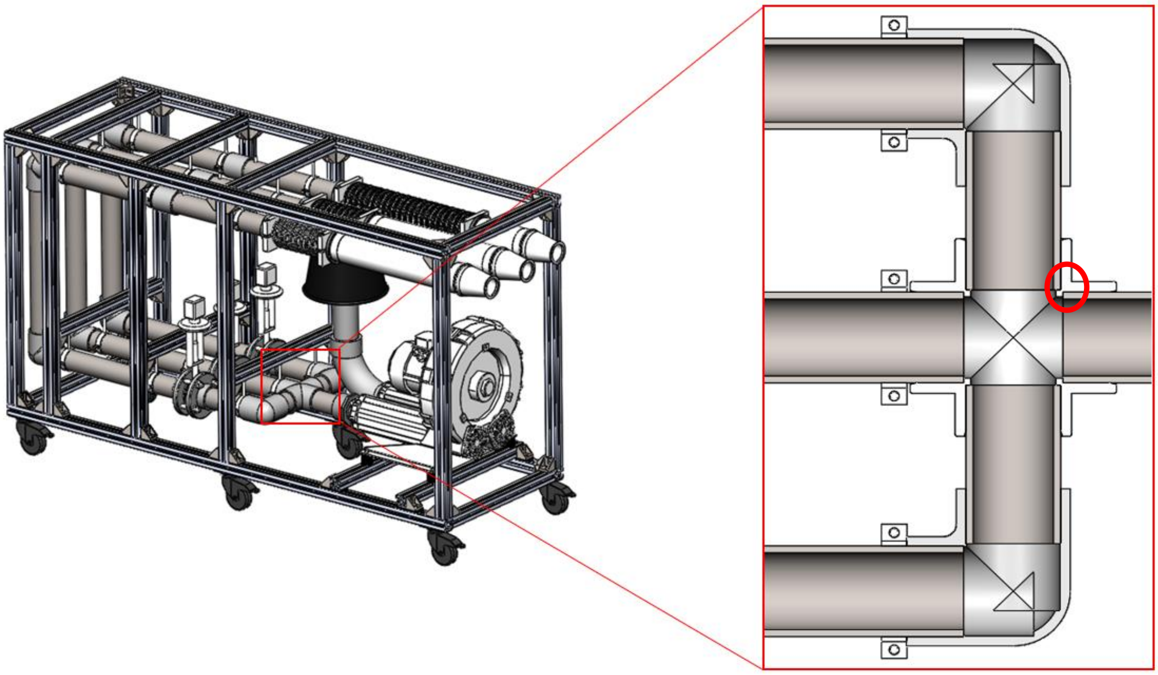


Figure 3-5: PVC section SolidWorks

To hang the PVC pipes from the frame, clamp rings are used. These parts are bought from the same supplier that delivers the PVC pipes. The clamp rings can clamp the pipe using a bolt-nut combination on each side (green circle in Figure 3.6). A threaded rod, with T-slot, provides the connection between this ring and the frame (red circle in Figure 3.6). The T-slot just simply glides in the groove of the item profile to the desired position and is then fixed with a nut and a washer.

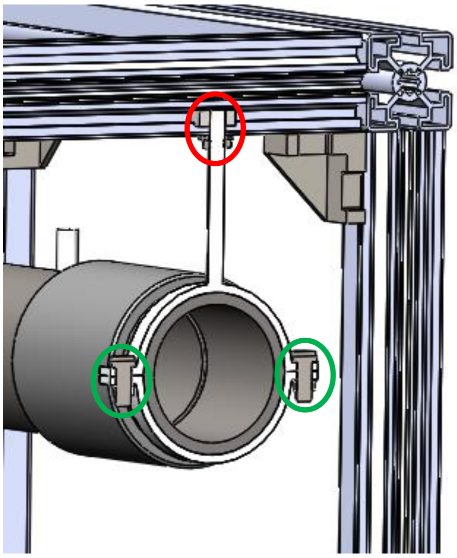


Figure 3-6: Clamp ring SolidWorks

3.4 Control Valves

The control valves by Schubert & Salzer have a diameter of 80 mm. To implement the valves in the flow bench, PVC flanges are used. The flanges exist of a small flange directly glued onto the PVC pipe and a bigger flange to lock the valve in place (see Figure 3.7).

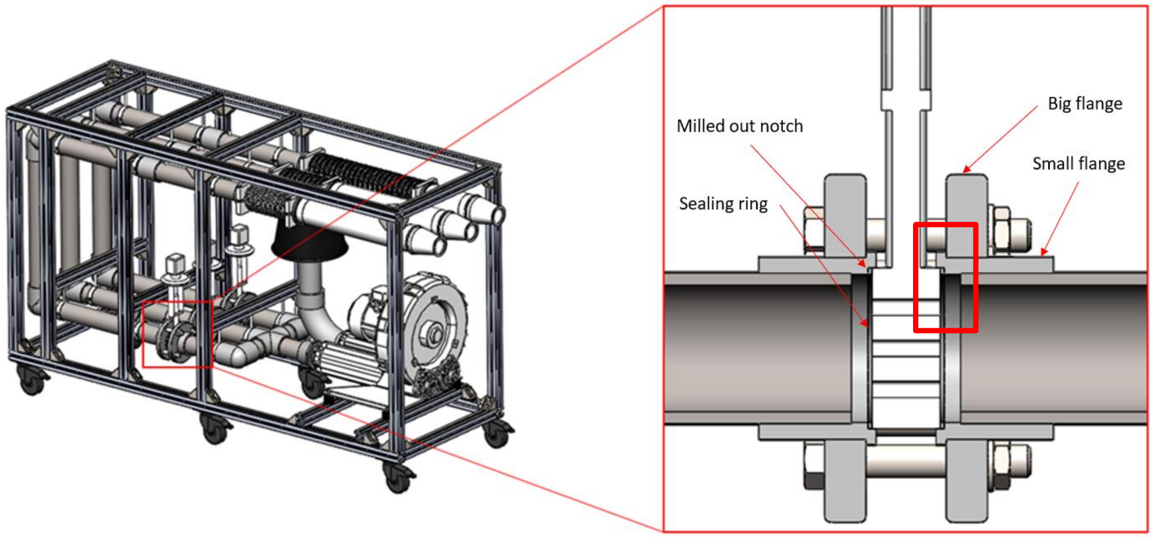


Figure 3-7: Valve section SolidWorks

The small flanges are glued onto the PVC pipes, with their notch ensuring that they cannot be pushed too far onto the pipe (red box in Figure 3-7 and in detail in Figure 3-8). Another notch is milled out in the front flange, into which a rubber sealing ring is inserted. This ensures a leak-free connection between the valve and the PVC parts. Next, the large flange is placed over the small flange where it is clamped by the protruding part of the small flange. Together with four bolts, nuts and washers, the valve and the two PVC pipes are clamped for a good connection.

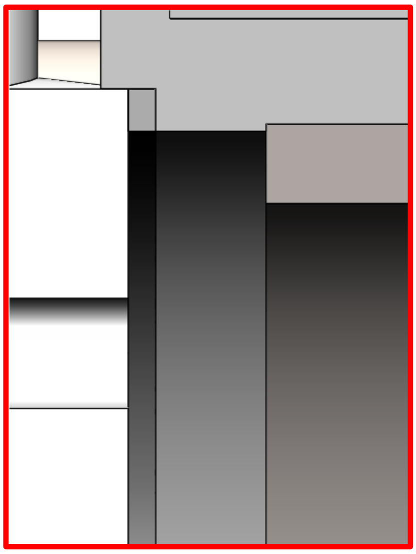


Figure 3-8: Zoomed in valve section SolidWorks

3.5 Frame

The frame, build from item profiles, is held together by the corner parts (see Figure 3-9). These pieces are placed at the point where two profiles need to be attached.

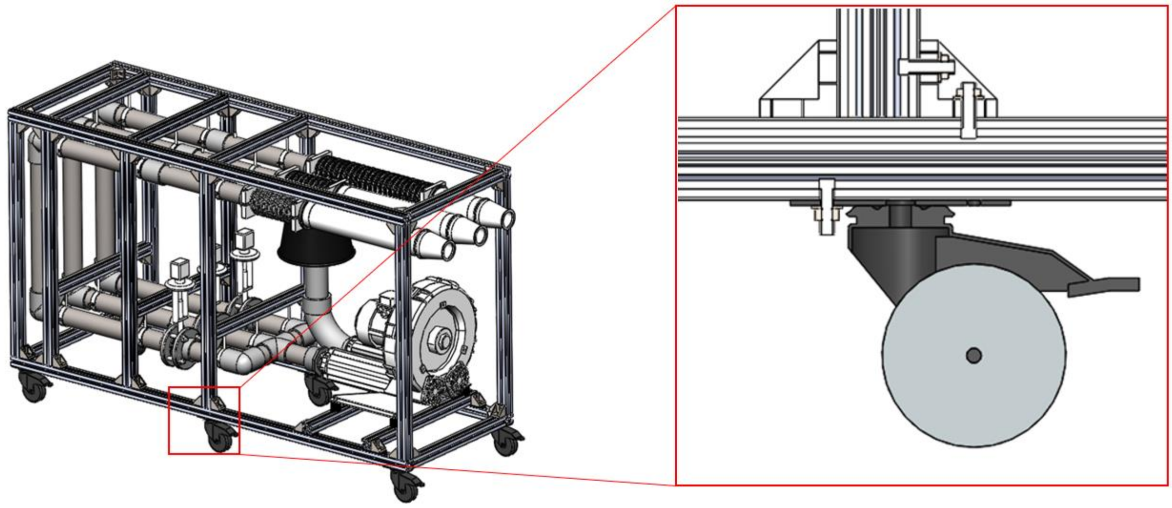


Figure 3-9: Frame section SolidWorks

Since these have two bores perpendicular to each other, a profile can be fixed at each corner. A T-slot bolt is inserted into the item profile (see Figure 3-9) and placed through the bore of the corner piece. The profile can first be positioned and then secured by tightening the nut. This principle is used over the entire frame. In this way, a profile can easily be added, repositioned or removed. When deciding the dimensions of the frame (or the length of the profiles), the ability to relocate the flow bench was considered. The flow bench is put together in the CMT building at the UPV site and must be movable outside the building if a different working place is required. For this, the width of the frame is limited to the width of the doors in the building. The dimensions of the flow bench are restricted to 690 mm for width and 2000 mm for height. Furthermore, six castor wheels are added with brakes to ensure a stable and smooth displacement.

3.6 Velocity Sensor

The implementation of the velocity sensors is composed of the velocity sensor itself (see Figure 3-10), the PVC pipe with a drilled hole, a small PVC tube with inner thread, a rivet nut, an M8 nut and a compression fitting (see Figure 3-11). The small PVC tube is glued into the hole drilled in the PVC pipe. This tube contains metric threads on the inside. As the stainless steel flow sensor must be removable and reinserted for cleaning or inspection, it is not screwed directly into the PVC. Since stainless steel and PVC are two different materials, wear would quickly occur on the PVC part. Therefore, a stainless steel tube (rivet nut) was provided with thread on the inside and outside. This tube is screwed into the small PVC tube and stays in place. It is only the remaining flow meter that is then screwed in. The flow meter consists of electronics in a cubic housing and a measuring probe. Using a compression fitting, this flat measuring rod is screwed into the PVC pipe. A tiny tube with threads on the outside makes up the compression fitting's underside. This tube will be used to attach the velocity sensor by screwing it into the rivet nut. The velocity sensor is intended to be clamped on the upper surface of the compression fitting. It comprises of a tube with threads on the outside that is somewhat conical. By compressing the conical section against the velocity sensor by tightening a nut over it, it gets clamped in place.

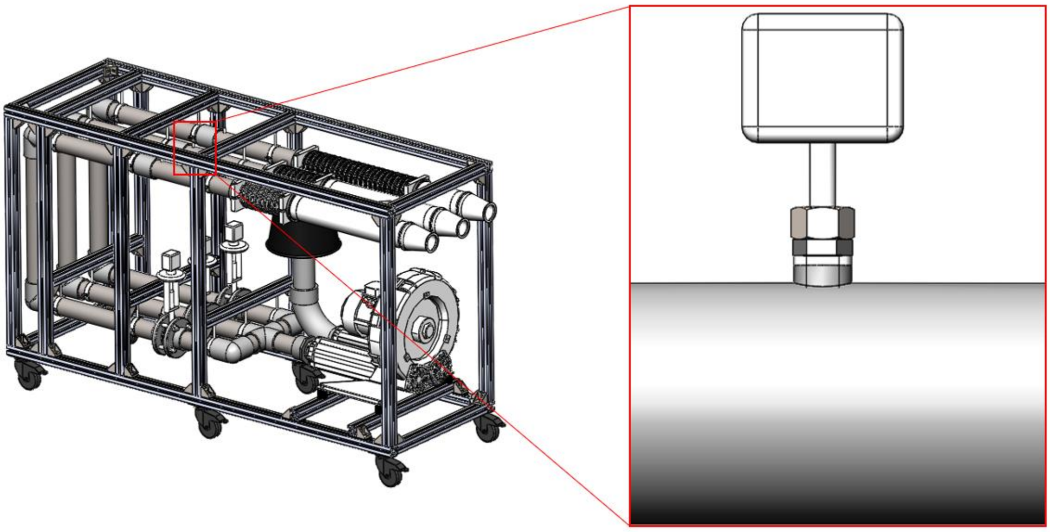


Figure 3-10: Velocity sensor SolidWorks

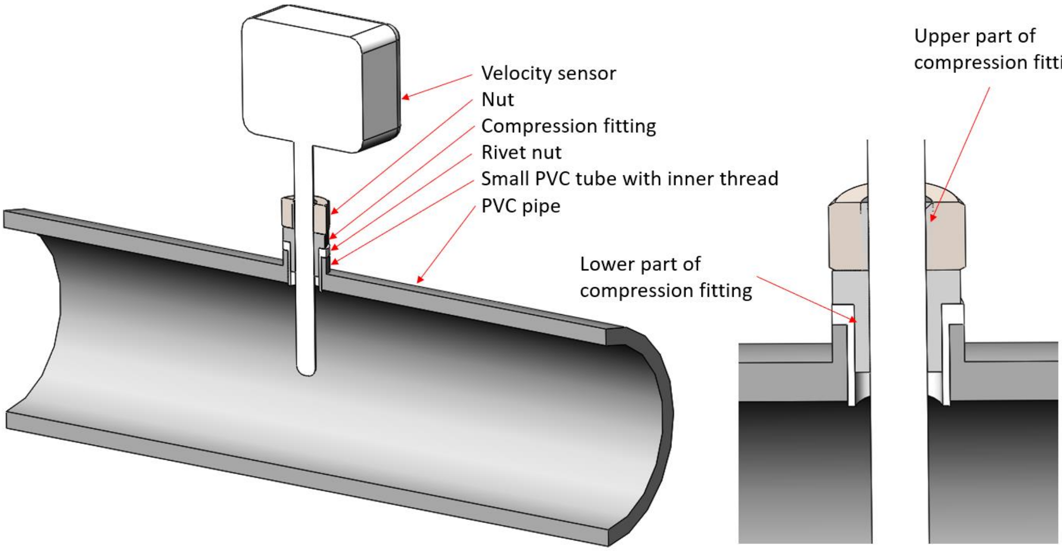


Figure 3-11: Velocity sensor SolidWorks

3.7 Thermocouples

The thermocouples are placed in each pipe before and after the heaters. This means that in total, six thermocouples will be implemented. This is done in the same way as the velocity sensor (see Figure 3-11). The only difference is the fact that the thermocouple's probe is thinner, so the rivet nut, compression fitting, the hole, the PVC tube and the normal nut will all be scaled down.

3.8 Heater

3.8.1 Introduction

The purpose of the heater (Figure 3-12) is to heat the air to temperatures of 800 °C, which was given to me as a requirement by my supervisor. To achieve this, ceramic discs with holes are connected by wires. These wires are put under intense currents, generating heat. The air flowing through these holes absorbs this heat and thus rises in temperature. To insulate these ceramic discs from the outside air, a stainless steel tube is provided, which only melts at temperatures of 1500 °C. To minimize convection between the heater and the stainless steel tube an insulator gets wrapped around the heater before placing it into the tube. However, since the flow bench will have to be usable for several applications, a flexible end is required. This allows the three end pipes to connect easily with a certain application. Everything discussed in the introduction is broken down into different sections below to explain each part in detail.

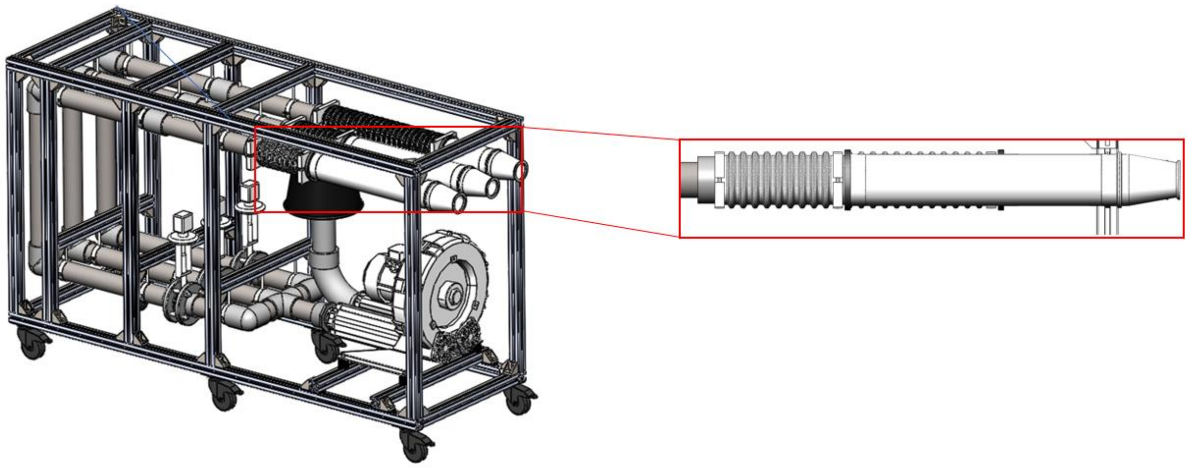


Figure 3-12: Heater SolidWorks

3.8.2 Flexible tube

Flexible tubes are used to make the installation connectable to various applications. The company providing this type of flexible tube is VENA HTD, a company specialised in producing silicon ducting for air conduction at high temperatures. These tubes should be placed in front of the heater as they melt at temperatures above 300 °C. They form the connection between the PVC section and the stainless steel tube containing the heaters.

First, the PVC tube is increased to a diameter of 100 mm since the flexible tube has a diameter of 102 mm. In this way, the flexible tube will be easily attached to the PVC part. The diameter of 102 mm is fixed because of the diameter of the stainless steel tube. This will be further explained. So to make the connection between the PVC pipe and the VENA HTD tube as simple as possible, the diameter of the PVC pipe is increased by a standard piece from Tuberplas, which is glued on the pipe. Over this piece, the VENA HTD tube is slid and then fastened with a clamp ring. This forms the first part of the heater (see Figure 3-13) [34].

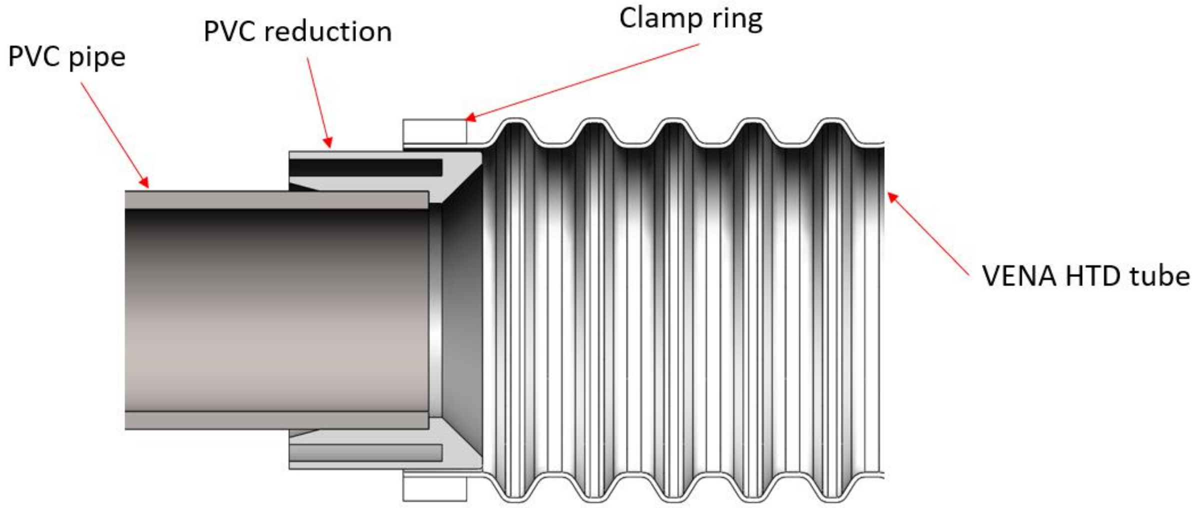


Figure 3-13: Heater section 1 SolidWorks

3.8.3 Heating tube

The design of this tube (see Figure 3-14) exists of a tube with an inner diameter of 100 mm, a ceramic cylinder consisting of one or more discs, flanges and insulation paper. Beforehand, the value of the heater's capacity was determined by my supervisor. The capacity was respectively 15 kW and 30 kW for the smaller and bigger heater. Based on this value, the number of ceramic discs was calculated. I had no influence on this. These discs were wired together to form one big cylinder. Thanks to its diameter of 94.5 mm, the ceramic cylinder can easily be inserted into the pipe and can be wrapped in insulating paper beforehand to minimise heat loss through convection. The disc is placed in the middle of the tube. The front space before the ceramic cylinder plays an important role. Tests of other heating designs in the UPV have shown that this space heats up but will not exceed 90°C at the end due to convection if the minimal distance before the ceramic cylinder is respected. The tube is designed in SolidWorks and produced by a company that has worked with UPV in the past.

To keep these ceramic discs in place, small stainless steel pins are welded to the inside of the tube, which axially secures the ceramic discs on both sides. The wiring through these discs (that will heat up the airflow) leaves the heating tube along the side where the air exits. The way the electric wires are leaving the heating tube is corresponding to the way the thermocouples were implemented in the PVC pipe. To connect the heating tube to the flexible tube on one hand and the air exit on the other hand, flanges are needed. The flanges are standard pieces bought from a company called Clamp. This company also provides clamp rings and lip gaskets. On the left side of the connection between the flexible tube and the heating tube, a flange is welded to a stainless steel tube to provide enough space for the VENA HTD tube slid over the flange. A clamp ring holds the flexible tube in place. On the side of the heating tube, the other flange from Clamp is welded to the heating tube. By using flanges and connecting them with a lip gasket, the parts can be easily detached for cleaning or inspection and reconnected afterwards [35].

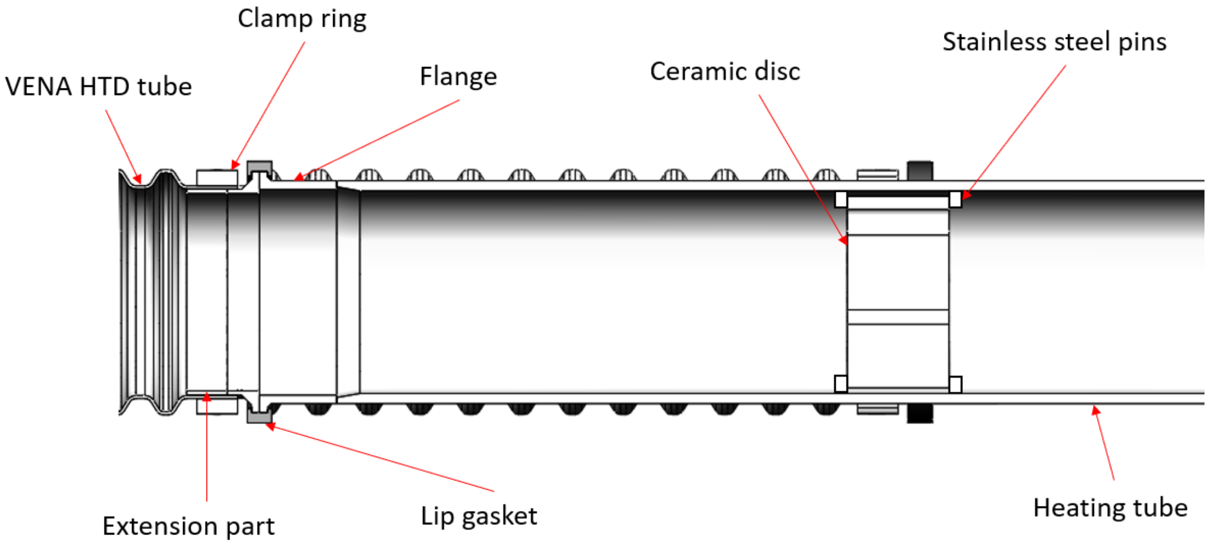


Figure 3-14: Heater section 2 SolidWorks

3.8.4 End flange

The flange at the end of the heating tube (Figure 3-15) provides an easy connection to a particular application and is welded to the heating tube using an additional flange that equalises the corresponding diameters.

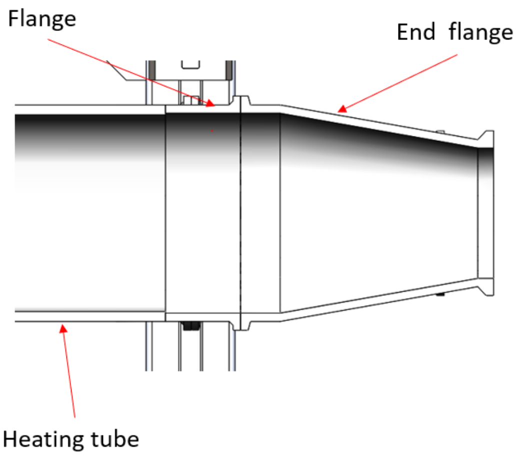


Figure 3-15: Heater section 3 SolidWorks

4 ELECTRICAL SCHEME

4.1 Introduction

As already explained, the LabVIEW-program will allow the user to run the installation. This is only possible if there is an electrical connection between each component, supplied with power, and the right modules to communicate with the program. It is the electrical scheme that displays all the connections made between the different electrical components, to ensure a safe and well-controllable flow bench. In this paragraph, the main principles of the electrical diagram are explained, each time referring to the page of the electrical diagram, in the appendix, under discussion.

When an element from the electrical diagram is discussed in detail, it will always be referred to in the same way. For example, according to the figure, the element QF1 is referred to via position D2 (Figure 4.1). These are the coordinates of the element on the page currently being discussed.

If on a page, a reference is found, similar to 1-D14, it means the following: the point at which this reference is placed is connected to the point at coordinates D14 on page 1. In this way, the different pages of the diagram are connected to form one large diagram.

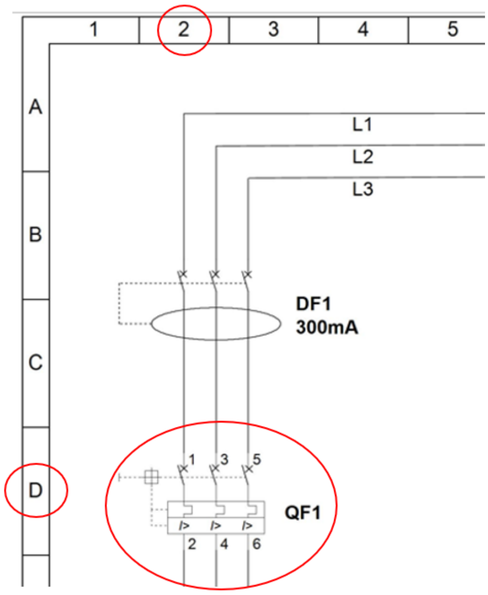


Figure 4-1: Section of page 1 of the electrical scheme

4.1.1 Electrical scheme: Page 1

The installation is protected by the fuse Q1 against short-circuit current. A fuse is a type of current limiting component. It is characterised by the maximum current it lets through. When this current is exceeded, the fuse will melt, isolating the system from the grid. In this installation, the fuse will be responsible for protecting against short-circuit current. Short-circuit current is caused when current, instead of flowing back to the grid, finds a shortcut along a different path, with all the following consequences [36].

When the blower motor is running, its windings become hotter, caused by electric current. For this, the motor is thermally and overcurrent protected by QF1. If the switch opens due to too much current consumption by the motor, the motor can be restarted by manually closing the switch, after the necessary checks were done.

The third protection component is the differential switch DF1, which disconnects the installation from the grid in the event of a difference in current between one of the three lines due to, for example, human contact with the system or electrical loss of a component.

Using the transformer T1 and the rectifier R, the 3-phase line voltage is converted to 24 V DC with additional protection against overcurrent using a fuse F. The 24 V is needed to supply certain electrical components in the flow bench.

4.1.2 Electrical scheme: Page 2

This section explains the principle of the safety relay. This is a compact relay that offers a wide range of safety inputs and outputs. Via various switching options between certain inputs and outputs, the desired safety features of the installation can be built up.

A1 and A2 are the connections for the power supply circuit. Safety input one and safety input two are internal contacts that are combined and switched according to an emergency stop. When the emergency stop is pressed, the blower and heaters will be switched off. This is due to safety outputs k1 and k2. These outputs respond to changes in the safety inputs. If the value of safety input 1 changes (the emergency stop is pressed), k1 opens and the relay K1 is de-energised (see page 9 B11). Since K2 and K3 are connected to K1 (shown by the references of K1 on page 1) and K1 is de-energised, K2 and K3 also become de-energised, causing both heaters to switch off. The other safety output k2 depends on the reset. k2 closes only when the reset was pressed. If the reset is not operated, k2 will not close, preventing the system from starting. So, a reset has to be made before starting. If the installation is running (i.e. K1, K2 and K3 are active), k1 and k2 are closed, making K5 active. K5 is a contact that operates a light. H1 is a red lamp. If K1 and K2 are not active, the contact of K5 is connected to H1, which causes the red lamp to light up. The installation is therefore switched off. If K5 is active due to the closed state of k1 and k2, then the green lamp H2 is on, indicating that the installation is running. The reset is operated by relay K4. If the flow bench is not running, the normally closed contacts K1, K2 and K3 under the reset connection are closed. If the reset is pressed (K4 becomes active), the reset can proceed. However, if the flow bench is running, the normally closed contacts K1, K2 and K3 under the reset terminal are open. If the reset is now pressed, the circuit cannot close making a reset impossible. Thus, a stop must first be made via K1, causing K1, K2 and K3 to close first.

4.1.3 Electrical scheme: Page 3

The thyristors, frequency drive, heaters and blower are the components powered on the 3-phase grid. As discussed earlier, it was made clear that the thyristors are activated by contacts K2 and K3. These contacts are normally-open and -closed when the relays K2 and K3 are activated. This supplies the thyristors with voltage and in turn, allows them to control the heaters R1 and R2. Each thyristor has an input on the right-hand side. This input is connected to an I/O-module that will pass signals from the PC with the LabVIEW-program to the thyristors. Both thyristors are protected by a QF-switch, whose function has already been described. If the motor is switched on via K1, the frequency variator will drive the motor. The frequency drive contains a built-in PID control to best approximate the set flow rate. This PID controller is automatically activated via the status relay K6 when K1 is energised. When the frequency variator drives the motor, K6 closes. The MC terminal will then nearby supply the PID controller with 24 V DC and the MA terminal will now be actively controllable from the corresponding I/O-module. The terminals AM and AC are the analogue outputs from the frequency drive to the I/O-module, while FI and FC are the analogue inputs from the I/O-module to the frequency drive.

4.1.4 Electrical scheme: Page 4

On page four of the electrical diagram, the I/O-modules are connected. They are responsible for communication between a measuring instrument, or control element, and the PC running the LabVIEW-program. Each module is connected to a different type of measuring element or control element. The control valves must be controlled and thus receive signals from the PC with the LabVIEW-program. Because the control valve receives signals, the module that transmits these signals will be an output module. Each instrument in the installation is thus connected to a specific module. An RS485 communication protocol is used to connect all modules and offer them to the PC. The principle of this protocol relies on differential data transmission. A signal is sent via two wires, where one wire sends the original signal and the other wire the inverted signal. This creates a potential difference between the two wires that offers high resistance to interference.

All I/O-modules are connected to the RS485 bus, the communication medium. In this installation, it is the user who, using a PC and LabVIEW, decides which signals he/she wants to see on the program's interface. This principle, that initiates the communication, is called 'MODBUS'. This principle consists of a master and a slave. The master gives a particular slave the operation to write or read the information via binary registries (coils) and 16-bit words. These slave devices reply to the master only when prompted to do so. To address this slave, a slave ID is used, which is a type of binary code that identifies the slave.

In the story of the flow bench, the PC with LabVIEW behaves as the master with all the I/O-modules serving as slaves. The PC decides when an I/O-module will read or write info to a measuring instrument or control valve.

The converter on the left side of the modules enables communication between the RS485 bus and the PC. It converts the RS485 bus to an Ethernet signal that can be read by the PC. Therefore the IP address of the converter must be programmed into the PC.

The combination of all these elements makes it possible to control the flow bench with a LabVIEW-program and display the measurements of the implemented sensors on the programs interface.

4.1.5 Electrical scheme: Page 5

On page 5, the thermocouple module is presented. Seven thermocouples are connected to this module. The first three are thermocouples that will be placed in front of the heater to measure the temperature before heating. The next three are thermocouples that will be placed after the heaters to graphically represent the difference in temperature through the heater and give a correct idea of the outgoing air’s temperature.

4.1.6 Electrical scheme: Page 6

The analogue outputs coming from the PID control of the frequency drive are connected to this module.

4.1.7 Electrical scheme: Page 7

The analogue outputs coming from the PID control of the frequency variator are connected to this module.

4.1.8 Electrical scheme: Page 8

The analogue inputs from the thyristors are connected to this module. The module transmits signals from the PC to the thyristors.

4.1.9 Electrical scheme: Page 9

This page consists of the relays and contacts that will control the flow bench. Through the LabVIEW-program, this I/O-module can be used to activate relays, which in turn affects a component of the installation. For example, activation of relay K1 can switch on the blower. By activating relay K4, a reset can be performed. K6 activates the PID control of the frequency variator and K2 and K3 control the operation of the heaters. When the safety relay is active, the module receives a signal at its inputs via 2-F7. The same applies when the blower is activated. In this case, K1 is closed and the module receives a high input via 3-F12.

4.1.10 Electrical scheme: Page 10

The flow sensors are connected by a single wire going to the input of the module. On the other hand, they are provided by 24 V DC. Since the module is already grounded, an extra connection between the flow sensors and GND is unnecessary.

4.1.11 Electrical scheme: Page 11

The control valves also run on 24 V DC but have a two-wired connection with the module.

5 LabVIEW

5.1 Introduction

The LabVIEW program is designed to control the flow bench. It consists of an interface and a code. In LabVIEW, it refers to a front panel and a block diagram, respectively. While using the program, the code remains unchanged for the operator. It is only the interface that can be accessed to perform various actions. Figure 5-1 shows the interface explained in this section.

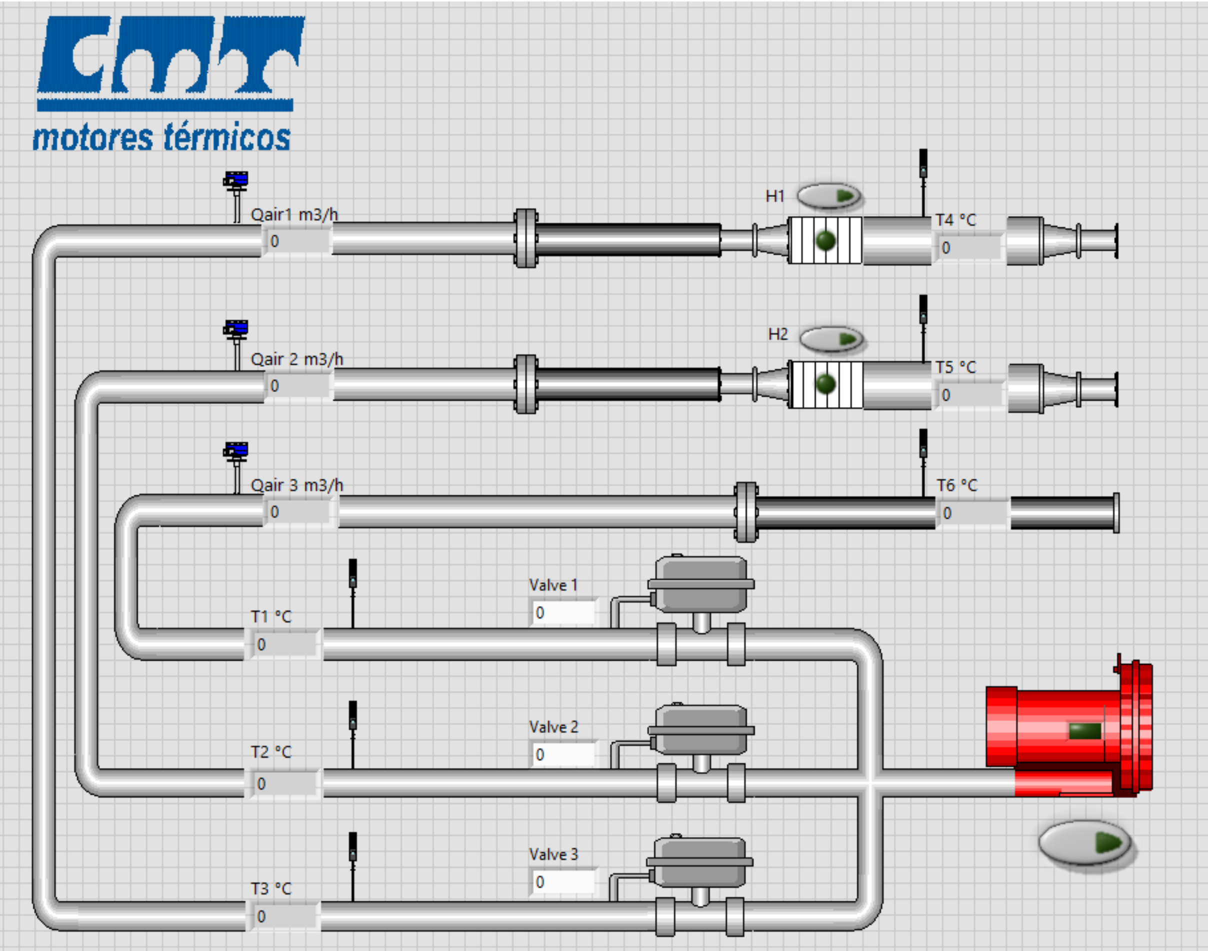


Figure 5-1: LabVIEW interface 1

The interface consists of the blower (in red) followed by the output line. The blower contains a green lamp, indicating its status. The lamp will light green when the blower is on and dark green when it is off. To switch the blower on or off, the button below the blower can be pressed. The outgoing air is split into three lines, each with its flow rate determined by its corresponding control valve. Next to each valve in the program is a control. This is a box where the operator can enter in percentage to what extent that valve should be closed. Following this, three thermocouples are visible on the diagram, each with its indicator. This indicator shows the temperature before heating while the flow bench is running. After measuring the temperature, the tubes are tilted 90° upwards, after which they are turned back horizontally. This makes for a more compact installation. However, after an angle of 90° the airflow can be affected by turbulence, flow rate losses and heat generation. Only after sufficient distance, the air velocity meter can be placed to provide an accurate measurement. From the air velocity, the flow rate can be calculated and displayed on the indicators. The next component in the installation is the heater. Only two of the three lines have a heater, one large, one smaller and the third has none. The heaters can be switched on by pressing their button, after which the green round lamp lights up to represent their active state. Finally, the installation consists of three thermocouples, each displaying the temperature after heating on their corresponding indicators.

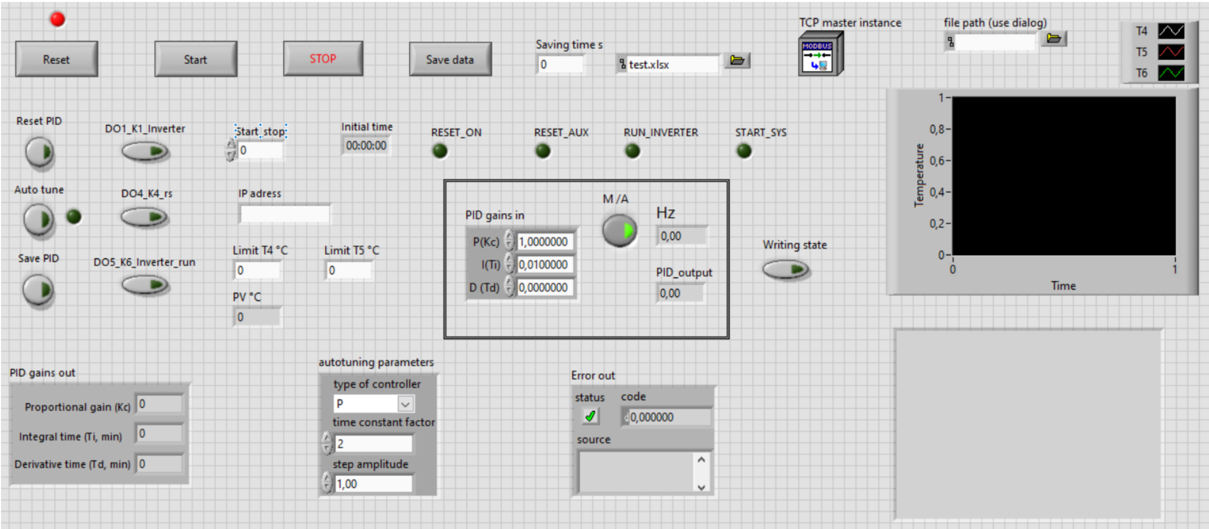


Figure 5-2: LabVIEW interface 2

This section explains the figure that contains the control panel of the flow bench (see Figure 5-2). On the top left side the reset button can be found, this button has the same function as activating relay K4 and must be selected to reset the system. The red light at the top will illuminate green after the reset has occurred. Next, the start button is used to control the blower and has the same function as K1. The stop button serves as an emergency stop and will switch everything off. This is because the start button is bistable and will therefore also be used as a stop button.

When the start button is pressed, an I/O-module will activate relay K1. It is the button with the light ‘DO1_K1_Inverter’ that will display the status of that relay. There is an additional indicator provided that will respond to pressing the start button and that is the START_SYS lamp. As long as the system is running, that light will be on. The same principle applies to the reset button. If the reset button is pressed, the DO4_K4_rs indicator will light up because relay K4 is currently energised. After this, indicator RESET_ON will show that the reset is in progress. RESET_AUX will signal when the complete reset cycle is completed. When the button under the blower is pressed on the front panel, the frequency drive is activated. Relay K6 is activated on which DO5_K6_Inverter_run indicates it. Again, this time the RUN_Inverter lamp will light.

When the system is running, temperatures T4, T5 and T6 are measured continuously. If the writing state button is pressed, the temperatures will be plotted in the top right graph with its respective colour code. Not only these temperatures will be displayed on the screen, but all variables such as flow rates and other temperatures will appear on their corresponding indicator. The frequency drive has, like mentioned before, an integrated PID control to assure an accurate airflow setting. This PID control with its values can be configured manually or automatically. When pressing the auto-tune button, the PID values will be automatically tuned to approach its optimal setpoint as accurately as possible and displayed in the box PID gains out. When the save PID button is pressed these PID values are saved in a text file. If any error would occur while running the LabVIEW-program it will be presented on the error out display. The box of autotuning parameters is a tool to manually decide if the user only wants to apply P, PI or PID control to the frequency variator. This will only work when the button M/A is on manual use. Then the corresponding PID values can be given in the PID gains in box. Next to this box refers indicator Hz to the frequency the motor is running on and SP mass to the mass flow of air blown out by the blower. These PID values together with the IP address can also be taken from a text file where the file path box indicates the file path to that text file. When reading the text file, LabVIEW will present these values in the box below the graph and insert them in the PID control. Additionally, the save data button will start saving the data like airflows and temperatures in an excel file given by the user in the box text.xlsx until the button is pressed for a second time. The initial time indicator will indicate for how long the data has already been saved, while the write state will show the operator if the data is still going to the Excel file. The controls limits T4 °C and T5 °C are boxes where the desired temperatures at the outlet of the flow bench needs to be filled in. The heater will be regulated by these temperatures so the limit will never be violated.

6 CONCLUSION

6.1 Summary

The objectives to be achieved are the following:

1. Dimensioning all the components related to the flow bench, which will improve the previous model. This includes looking at prices, materials and the applicability between each component to make a solid installation. Even the production of self-designed parts should be taken into account.

2. Designing the 3D model of the installation and finding a way to attach each part to the framework and deciding what kind of framework suits best to do this.

3. A financial analysis will give an overview of the prices of the different parts of the model and where they got ordered.

4. Drawing the electrical scheme in ‘Fluid Draw’ and making sure every part of the flow bench is correctly connected and provided with power while making sure all safety prescriptions are followed correctly.

5. Writing a LabVIEW-program to control important variables such as, airflow and temperature. Making sure the program is well integrated with the design and tested on given changes in the software.

6. Control of the working of the flow bench. Evaluation of the flow bench and it’s functionalities

In terms of dimensioning, the entire flow bench was provided with new and improved components, while trying to minimise the cost. The connection between these components was taken into account to form a strong control system that works smoothly. Therefore, the first objective can be considered as achieved.

The second objective was achieved using SolidWorks. The frame profiles (item profiles) were chosen for its versatile positioning capabilities and easy connections to the measuring instruments and air pipes. It also allows easy addition or removal of profiles if technical modifications are desired in the future. From the choice of frame profile, the frame was designed that protects and fixes all components. In addition, it is movable due to its castor wheels and thanks to its dimensions, it can be taken to different test sites.

The third target describes the financial analysis of the flow bench. This involved successfully requesting quotes for each component to arrive at a total cost of components of 16,975.15 euros. Together with the cost of working hours, VAT and indirect costs, a total amount for the flow bench was obtained of 30.789,22 euros. From a quote for a similar flow bench, provided by SuperFlow, it could be concluded that the self-designed model of this thesis proved to be more financially advantageous and, in addition, more versatile. The flow bench from SuperFlow costs 36.565 euros, which is 5.775,78 euros more than the self-designed model.

The fourth objective was achieved with the use of FluidDraw. Each component in the system to be electrically connected was connected in the electrical diagram to the power supply, ground and possibly to each other to allow certain control between the components. For instance, the thyristors control the current to the heaters. When drawing the diagram, the electrical protection the flow bench was taken into consideration to avoid damage to the components and to operator.

For the fifth and sixth objective, it was only possible to write the LabVIEW-program. Tests could not be carried out, as not all components of the flow bench had been delivered yet and therefore the construction of the flow bench could not be finished.

The flow bench was successfully created so that it could test HVAC applications like filters and carburettors. In the field of engine development, where it can enhance the performance of combustion engines, it can also have a significant impact. In comparison to a regular model bought from a provider, it is the ideal test bench for people and organizations with limited resources. It also has a certain degree of adaptability and the capacity to test several components at once. The range of controllable variables such as air flow rate and temperature is extremely wide and can be displayed on graphs and Excel sheets. It is the ultimate mobile air flow manipulator with three independent controllable exhaust pipes.

6.2 Future work

There are several tasks that arise after creating the thesis. First of all, the remaining components that have not yet been ordered, must be ordered in accordance with their individual quotations in order to construct the flow bench by using the 3D-drawings.

After assembling the flow bench, using the electrical diagram, each component has to be electrically connected, with appropriate safety measures.

To ensure a smooth and reliable operation, tests utilizing the LabVIEW-program must be performed.

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8 ANNEXES

8.1 Financial Analysis

Index

8.1.1 Introduction

8.1.2 Financial Analysis

8.1.2.1 Price per component

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8.1.2.4 Cost of work hours

8.1.2.5 Budget summary

8.1.2.6 Conclusion

8.1.1 Introduction

This budget analysis will shed light on the cost breakdown of the flow bench. The price of the parts are derived from the respective catalogues, each time showing the number and unit price of a particular part in the budget analysis. Each part belongs to a supply group. For instance, the blower is ordered at FPZ, but in order to operate properly, the filter and filter tube are included as a standard extra parts. These three costs form the total FPZ cost of the flow bench and are represented in the overview of the price per component group. To visually represent this, an extra graph was created. Because the number of work hours of these types of projects can vary significantly, the accumulated cost is estimated and included in the analysis, as shown in Section 8.1.2.4, where the cost per working hour was provided by my supervisor. In order to arrive at the final cost for the flow bench, an overview of the various costs is provided along with the breakdown into indirect costs and VAT costs. The cost for each component in the flow bench was derived from the quotes requested for it, which can be found in section 8.4.

8.1.2 Financial Analysis

8.1.2.1 Price per component

Blower parts - FPZ	Number	Price (inc. VAT)	Total
Blower FPZ	1	€ 1.750,00	€ 1.750,00
Filter Collector	1	€ 80,00	€ 80,00
Filter	1	€ 70,00	€ 70,00
Transport	1	€ 70,00	€ 70,00
TOTAL	**4**	**€ 1.970,00**	**€ 1.970,00**

Frequency variator - Omron	Number	Price (inc. VAT)	Total
Omron Sysdrive 3G3HV-A4037-E	1	€ 1.183,83	€ 1.183,83
Transport		included	
TOTAL	**1**	**€ 1.183,83**	**€ 1.183,83**

Valves - Bvalve	Number	Price (inc. VAT)	Total
Control Valve GS8021 GS1	3	€ 2.763,50	€ 8.290,50
Transport		included	
TOTAL	**3**	**€ 2.763,50**	**€ 8.290,50**

Flow sensor - Seikom	Number	Price (inc. VAT)	Total
RLSW4A 24V AC/DC	3	€ 194,20	€ 582,60
Transport		included	
TOTAL	**3**	**€ 194,20**	**€ 582,60**

Temperature sensor - RS	Number	Price (inc. VAT)	Total
RS thermocouple type K	6	€ 30,20	€ 181,20
Transport	1	€ 9,75	€ 9,75
TOTAL	**7**	**€ 39,95**	**€ 190,95**

Thyristors - Watlow	Number	Price (inc. VAT)	Total
DB20 60F0 0000	1	€ 470,00	€ 470,00

DC20 60F0 0000	1	€ 700,00	€ 700,00
Transport		included	
TOTAL	**2**		**€ 1.170,00**

I/O-modules - Promux	Number	Price (inc. VAT)	Total
PM8TC(ISO) thermocouple module	1	€ 162,00	€ 162,00
PM8AI/V flow sensor module	1	€ 110,00	€ 110,00
PM16DO valves module	1	€ 82,00	€ 82,00
PM8AO thyristor module + frequency drive	2	€ 122,00	€ 244,00
PM8AI/I frequency drive module	1	€ 110,00	€ 110,00
PM8DIO	1	€ 82,00	€ 82,00
PT8TCS	1	€ 173,00	€ 173,00
MMTCPBCONV-VDC	1	€ 120,00	€ 120,00
Transport	1	€ 90,00	€ 90,00
TOTAL	**9**		**€ 1.173,00**

Pipes - Tuberplas - Plastic pipe shop	Number	Measure [mm]	Price (inc. VAT) [euro/mm]	Total
Tuberplas				
PVC Pipe 75 mm diameter 16 atm:				
	2	130,00		
	1	190,00		
	3	250,00		
	3	500,00		
	3	550,00		
	6	640,00		

Total:		8.190,00	€ 0,01	€ 108,76

Pipes - Tuberplas - Plastic pipe shop	Number	Price (inc. VAT)	Total
Tuberplas			
Corner - 622	8	€ 8,27	€ 66,16
Little flange - 716	6	€ 6,47	€ 38,82
Large flange - 606	6	€ 11,54	€ 69,24
Attatchment PVC - 1812	18	€ 2,74	€ 49,32
Transition - 697	1	€ 16,30	€ 16,30
Connection - 706	3	€ 7,09	€ 21,27
Varilla roscada - 1821	4	€ 1,89	€ 7,56
Reduction - 747	1	€ 7,99	€ 7,99
Reduction - 750	3	€ 14,64	€ 43,92
Plastic pipe shop			
Cross 75 mm	1	€ 32,00	€ 32,00
Transport		included	
TOTAL	**67**		**€ 461,34**

Frame parts - Fasten	Number	Measure [mm]	Price (excl. VAT) [euro/mm]	Total
Fasten				
Item profiles 45x45 mm:				
	4	2000		
	6	150		
	10	1000		
	10	600		
	2	690		
Total:		27600	€ 0,0184	€ 507,54

Frame parts - Fasten	Number	Measure [mm]	Price (excl. VAT)	Total
Fasten				
Item bolt, nut and washer - 525025	145		€ 0,35	€ 50,75
Item corner attachment part - 53302	80		€ 2,36	€ 188,80
T-slot nut M8 - 52058	30		€ 0,62	€ 18,60
Castor wheels - 5421125127	6		€ 23,72	€ 142,32
-15%				€ 136,20
Transport				€ 39,40
Work hours				€ 32,00
Neto				**€ 843,21**
21% tax				€ 177,07
TOTAL	**293**			**€ 1.020,28**

Accesories - Chassisparts - RS	Number	Price (exc. VAT)	Total
Chassisparts			
Dampers	4	€ 4,09	€ 16,36
RS Online (stainless steel version)			
Hexagon socket cylindrical screw M5x22	50	€ 0,63	€ 31,34
Hexagon socket cylindrical screw M5x30	50	€ 0,63	€ 31,46
Hex bolt M16x100	20	€ 6,87	€ 137,48
Low hex nut M16	25	€ 1,39	€ 34,80
Flat washer M16	25	€ 0,77	€ 19,23
Flat washer M8	100	€ 0,09	€ 9,13

Low hex nut M8	50	€ 0,28	€ 14,10
Machine head screw M8	50	€ 1,22	€ 60,78
Transport		included	
Netto			**€ 354,68**
21 % tax			€ 74,48
TOTAL	**374**		**€ 429,16**

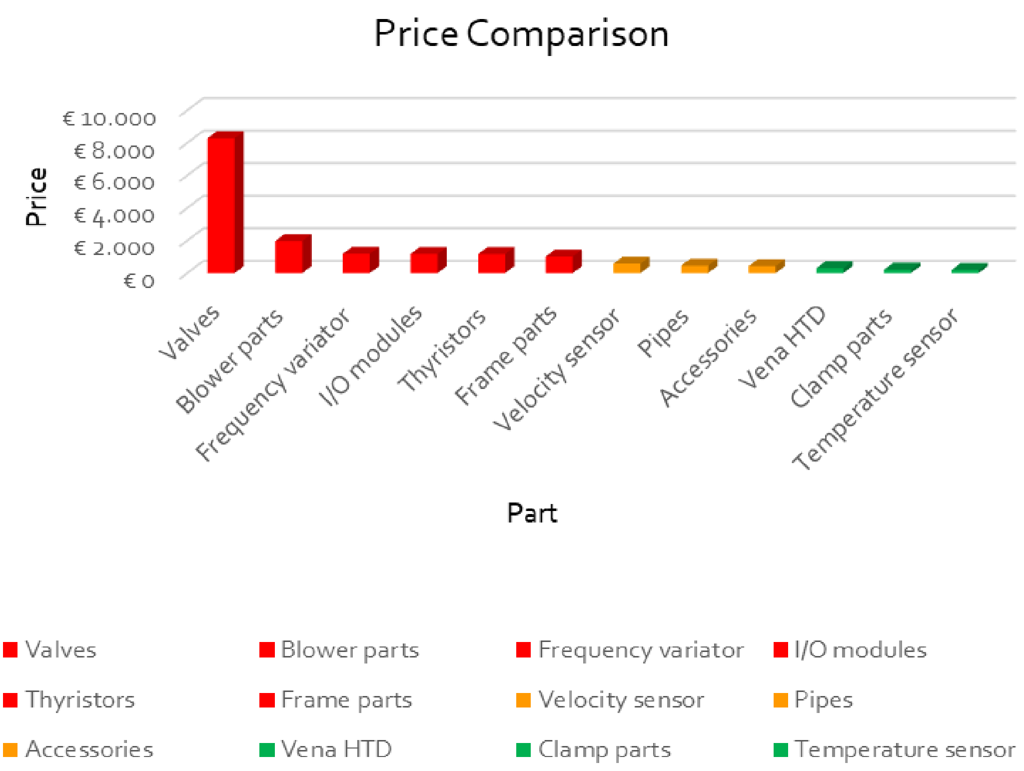
Clamp parts	Number	Price (exc. VAT)	Total
Roll-on ferrule K14 R 4”	6	€ 14,94	€ 89,66
Short Wg. Ferrule K14 S 4”	3	€ 8,86	€ 26,58
Lip gasket K39 4”	6	€ 4,29	€ 20,59
Heavy duty clamp 4”	6	€ 4,29	€ 20,59
Transport	1	€ 12,00	€ 12,00
Netto			**€ 169,42**
21% VAT			€ 35,58
TOTAL	**22**		**€ 205,00**

VENA HTD	Number	Price (inc. VAT)	Total
AI348102	1	€ 302,27	€ 302,27
Transport		included	
TOTAL	**1**		**€ 302,27**

8.1.2.2 Overview price per component group

Product	Price (inc. VAT)
Blower parts	€ 1.970,00
Frequency variator	€ 1.183,83
Valves	€ 8.290,50
Flow sensor	€ 582,60
Temperature senor	€ 190,95
Thyristors	€ 1.170,00
I/O-modules	€ 1.173,00
Pipes	€ 457,56
Frame parts	€ 1.020,28
Accessories	€ 429,16
Clamp parts	€ 205,00
Vena HTD	€ 302,27
TOTAL	**€ 16.975,15**

8.1.2.3 Graphical overview



8.1.2.4 Cost of work hours

Cost of work hours	Hours	Price/hour	Total
Work hours			
Student (20 ECTS x 25 h/ECTS)	500 h	20 euro/h	€ 10.000,00
Expert engineer	15 h	40 euro/h	€ 600,00
TOTAL	**500 h**		**€ 10.600,00**

8.1.2.5 Budget summary

Master thesis budget summary			
Cost of the flow bench parts			**€ 16.975,15**
Cost of the working hours			**€ 10.600,00**
Subtotal			**€ 27.575,15**
		Base	**Amount**
Indirect costs	6 %	€ 16.467,88	**€ 1.018,51**
VAT	21 %	€ 10.600,00	**€ 2.226,00**
TOTAL			**€ 30.789,22**

8.1.2.6 Conclusion

The full cost price of the flow bench is 30.789,22 euros. In order to draw a conclusion, a comparison was made between the self-designed model and a flow bench with similar features bought from a supplier. One of the largest distributors of industrial test benches including flow benches is SuperFlow a company founded in 1972 with the aim of improving the performance of engines. A quotation was requested from this company for the SF 1020 model, a similar installation to the flow bench developed in this thesis. Within the framework of cost-effectiveness, I assessed the cost of the both benches and made a comparison. The basic version of this model costs 26.565 euros excluded transportation. In order to compete with the self-designed flow bench, the costs of transport, packaging, along with the costs of a monitoring system, still need to be included in the cost of the SuperFlow bench. It is estimated that this amounts to a 5.000 euros. Extra equipment costs are also necessary to ensure an easy applicability with different parts that need to be tested. Taking this into account, an estimation was made, in consultation with the salesman, of the total cost which would be 36.565 euros. This is 5.775,78 euros more than the flow bench displayed in this thesis. Another difference is that this flow bench is capable of controlling three airflows simultaneously, unlike the SF 1020 model which can only manipulate one airflow. Given the versatility of three independent controllable airflow pipelines and a saving of 5.775,78 euros on estimate, this flow bench stands out in comparison with the model bought from SuperFlow. It can tests different components at once and is an attractive option for budget-conscious organizations or individuals [37].

8.2 Electrical Scheme

Master Thesis: Flow Bench

Electrical Scheme

Maxime De Coen

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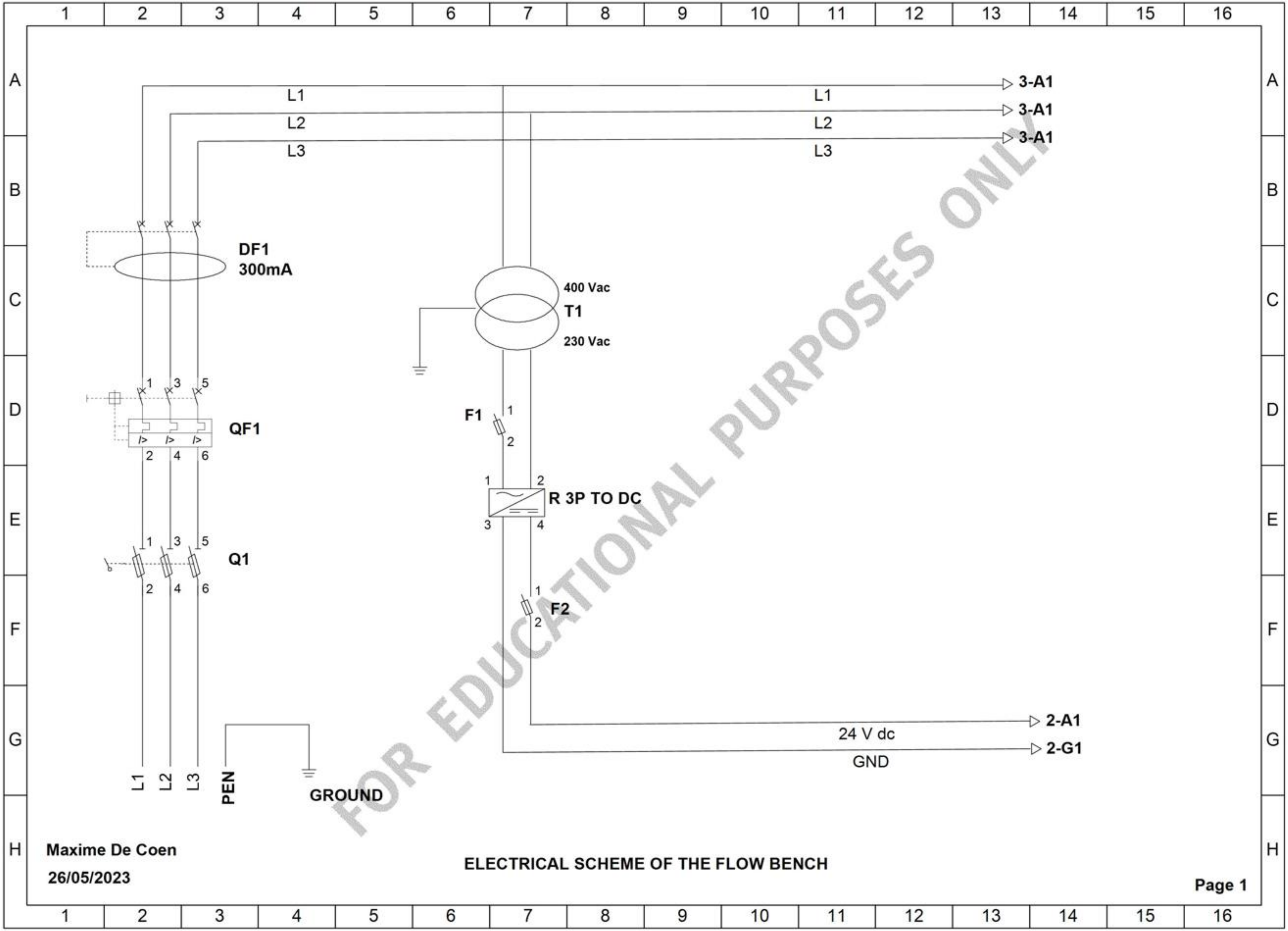

L1
L2
L3
3-A1
3-A1
3-A1
DF1
300mA
400 Vac
T1
230 Vac
QF1
F1
R 3P TO DC
Q1
F2
24 V dc
GND
2-A1
2-G1
L1
L2
L3
PEN
GROUND
FOR EDUCATIONAL PURPOSES ONLY
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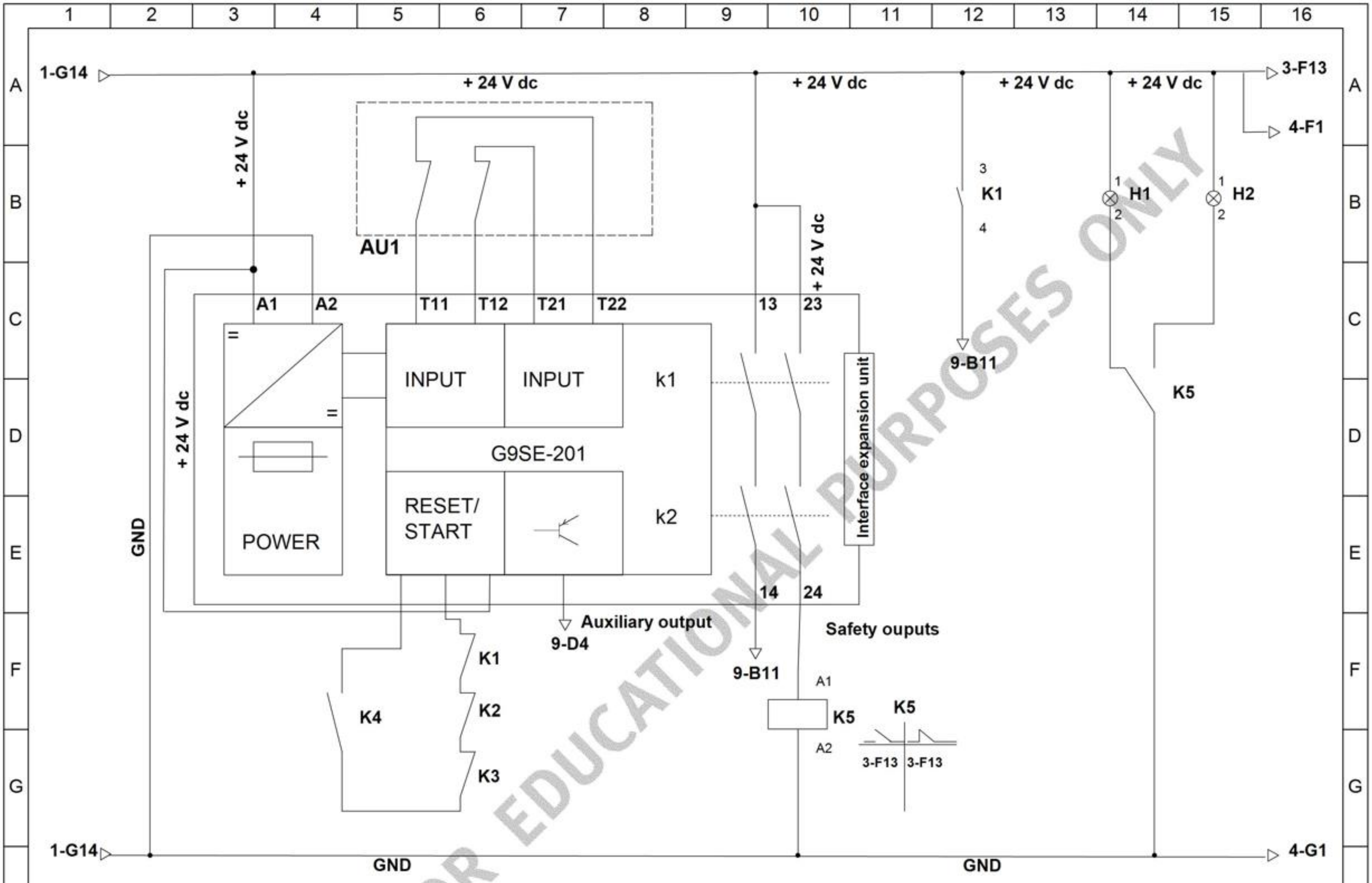
ELECTRICAL SCHEME OF THE FLOW BENCH
Page 1



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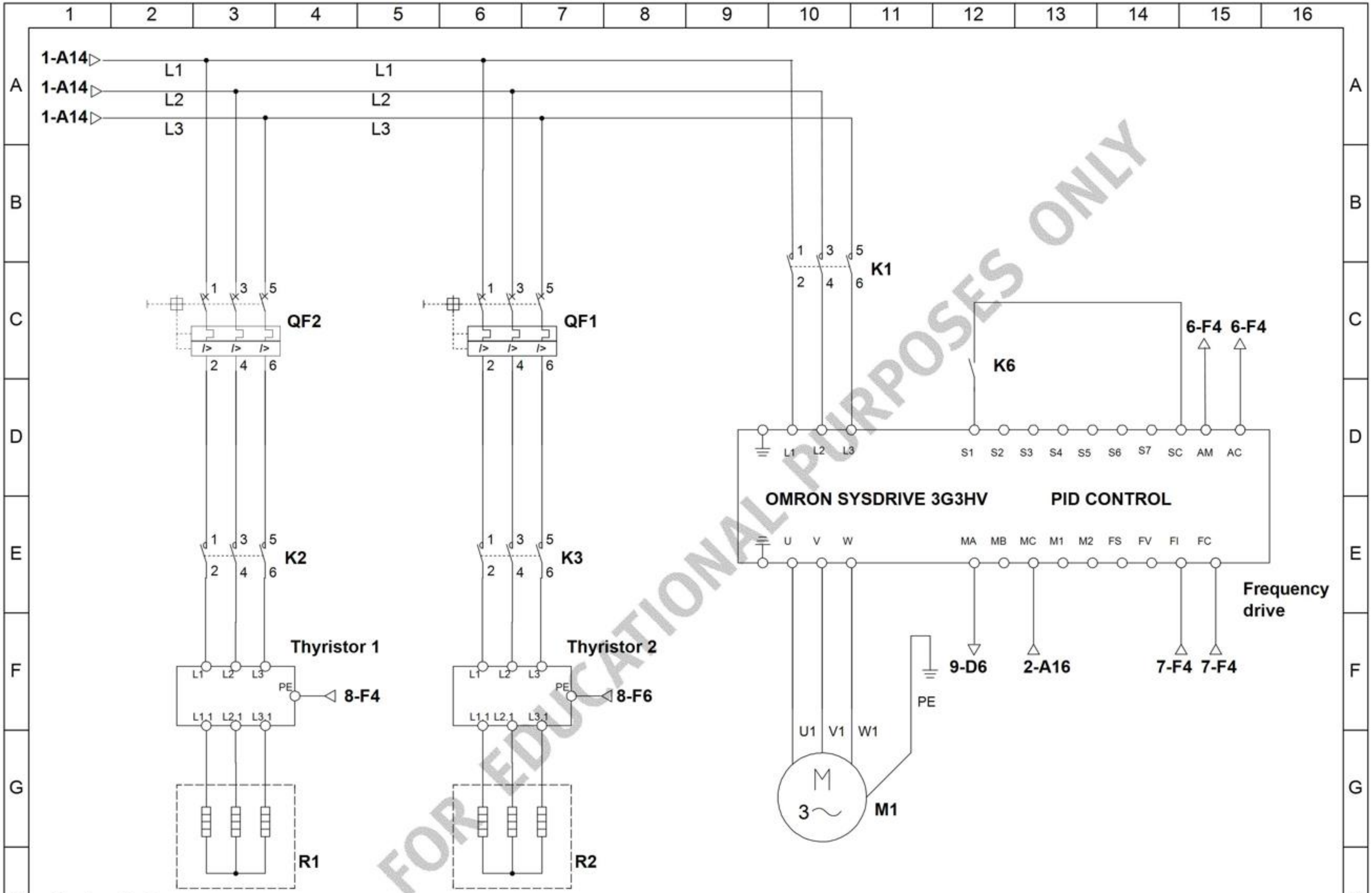
ELECTRICAL SCHEME OF THE FLOW BENCH



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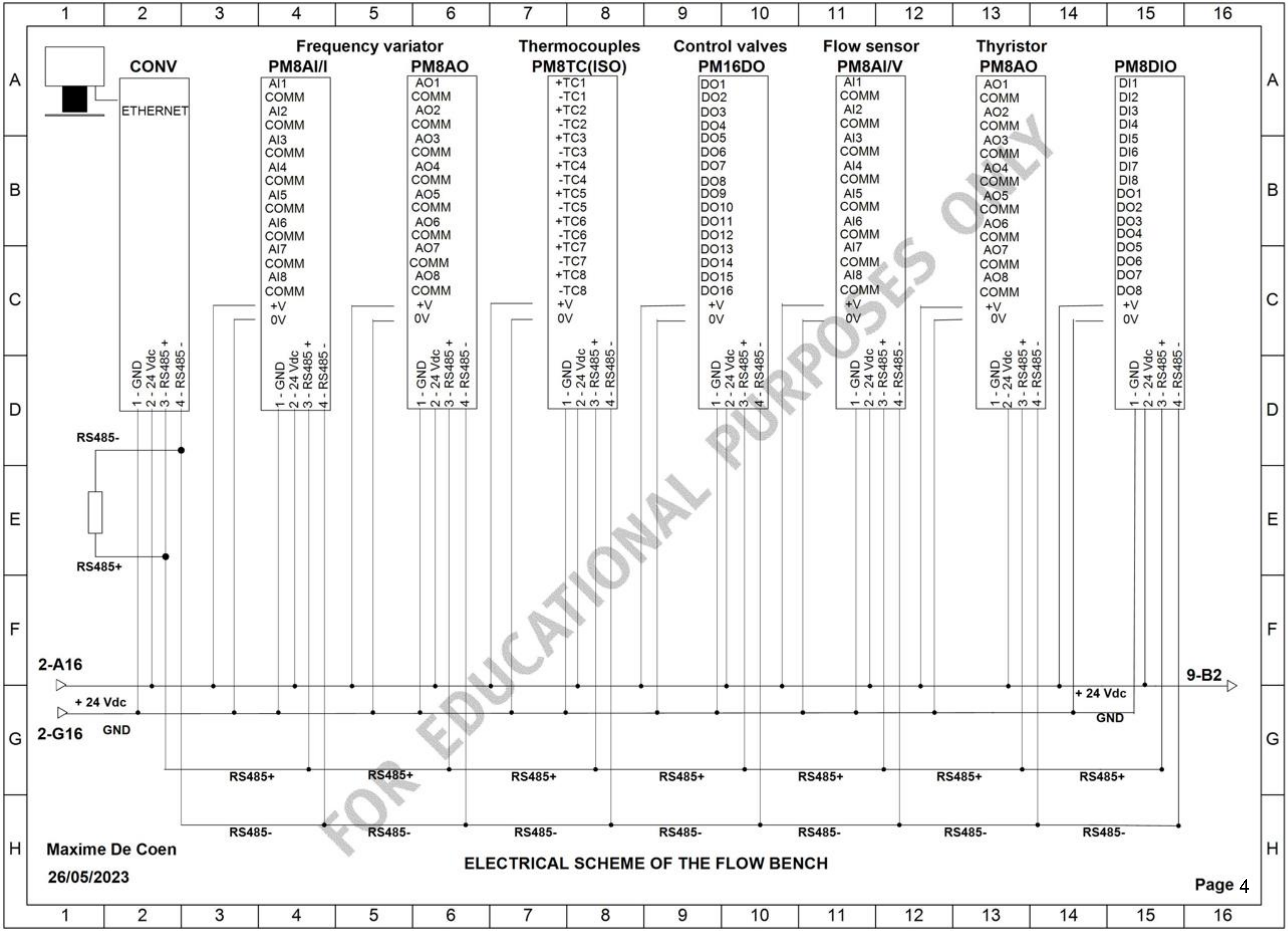
ELECTRICAL SCHEME OF THE FLOW BENCH


CONV
ETHERNET
1 - GND
2 - 24 Vdc
3 - RS485 +
4 - RS485 -
Frequency variator
PM8AI/I
AI1
COMM
AI2
COMM
AI3
COMM
AI4
COMM
AI5
COMM
AI6
COMM
AI7
COMM
AI8
COMM
+V
0V
PM8AO
AO1
COMM
AO2
COMM
AO3
COMM
AO4
COMM
AO5
COMM
AO6
COMM
AO7
COMM
AO8
COMM
+V
0V
Thermocouples
PM8TC(ISO)
+TC1
-TC1
+TC2
-TC2
+TC3
-TC3
+TC4
-TC4
+TC5
-TC5
+TC6
-TC6
+TC7
-TC7
+TC8
-TC8
+V
0V
Control valves
PM16DO
DO1
DO2
DO3
DO4
DO5
DO6
DO7
DO8
DO9
DO10
DO11
DO12
DO13
DO14
DO15
DO16
+V
0V
Flow sensor
PM8AI/V
Thyristor
PM8AO
PM8DIO
DI1
DI2
DI3
DI4
DI5
DI6
DI7
DI8
DO1
DO2
DO3
DO4
DO5
DO6
DO7
DO8
+V
0V
RS485-
RS485+
2-A16
+ 24 Vdc
2-G16
GND
9-B2
+ 24 Vdc
GND
RS485+
RS485-
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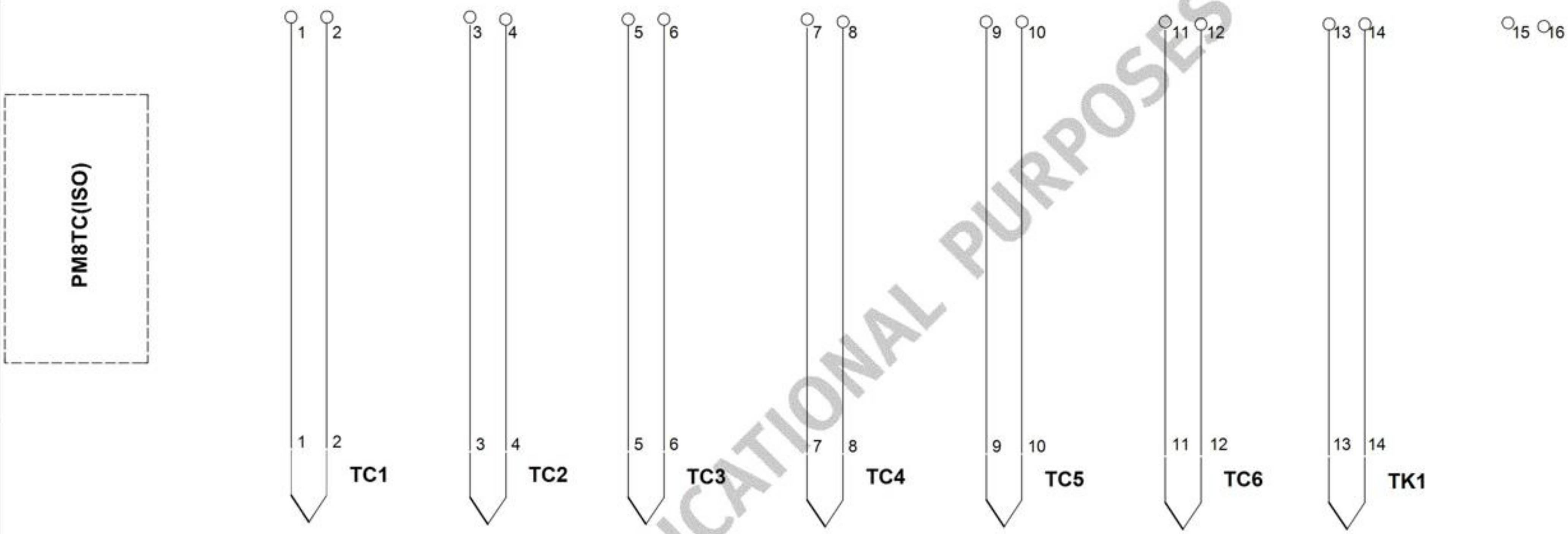
ELECTRICAL SCHEME OF THE FLOW BENCH
Page 4

Inputs thermocouples



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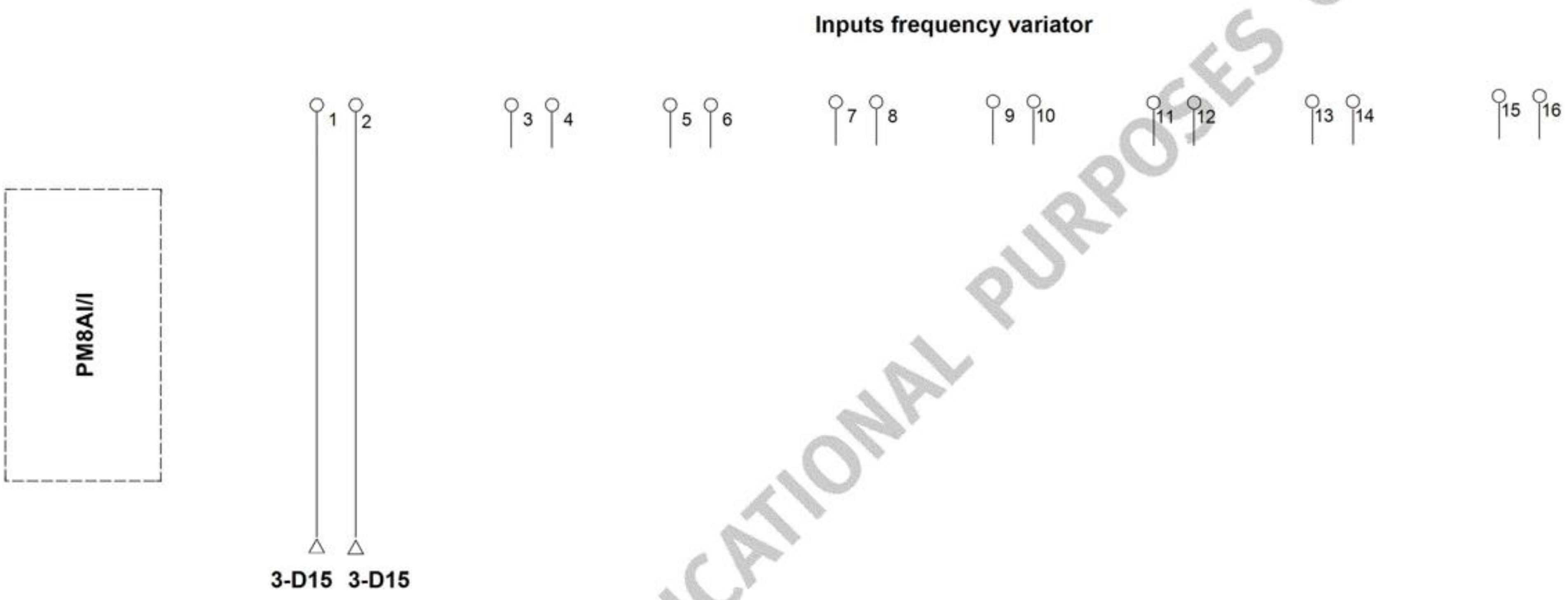

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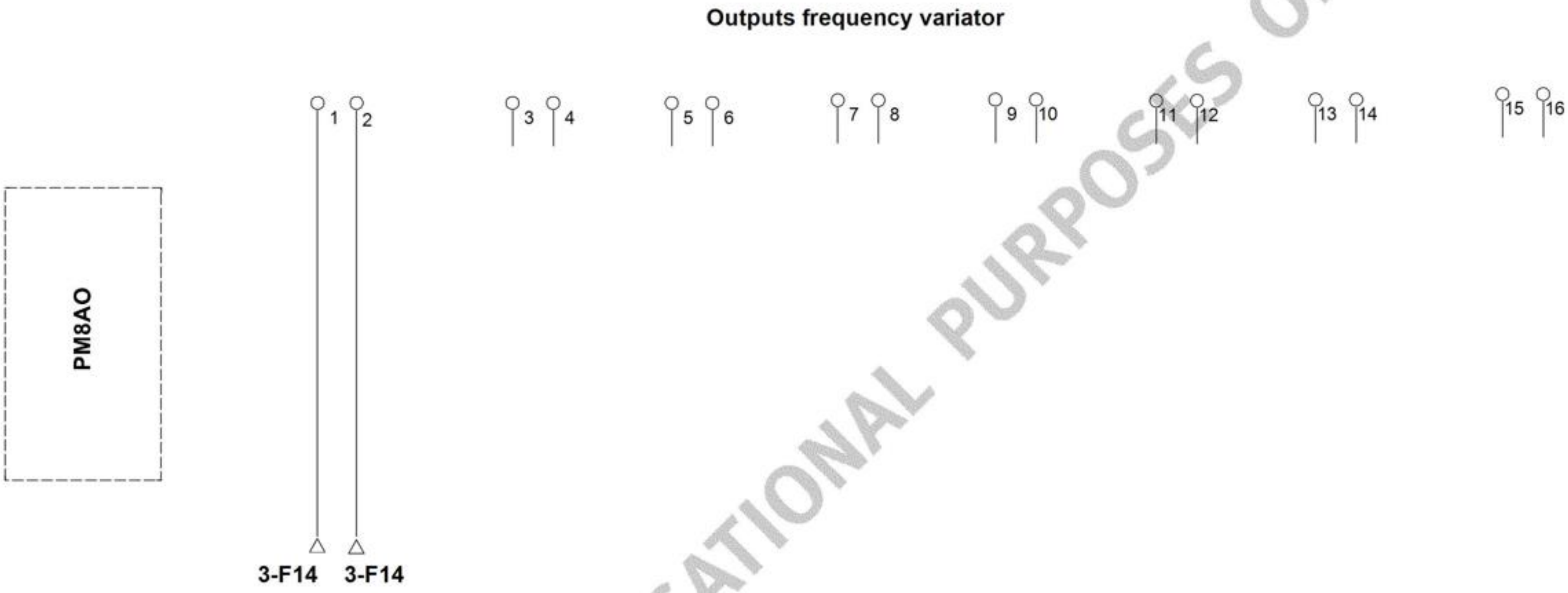
ELECTRICAL SCHEME OF THE FLOW BENCH



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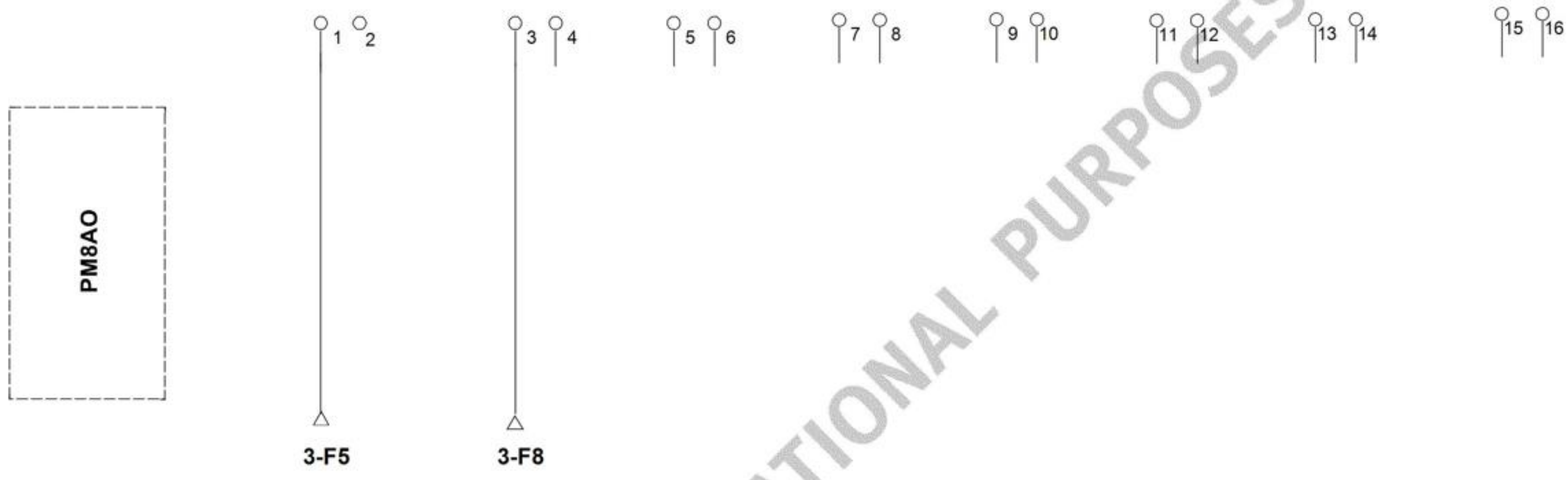
ELECTRICAL SCHEME OF THE FLOW BENCH

Inputs thyristors



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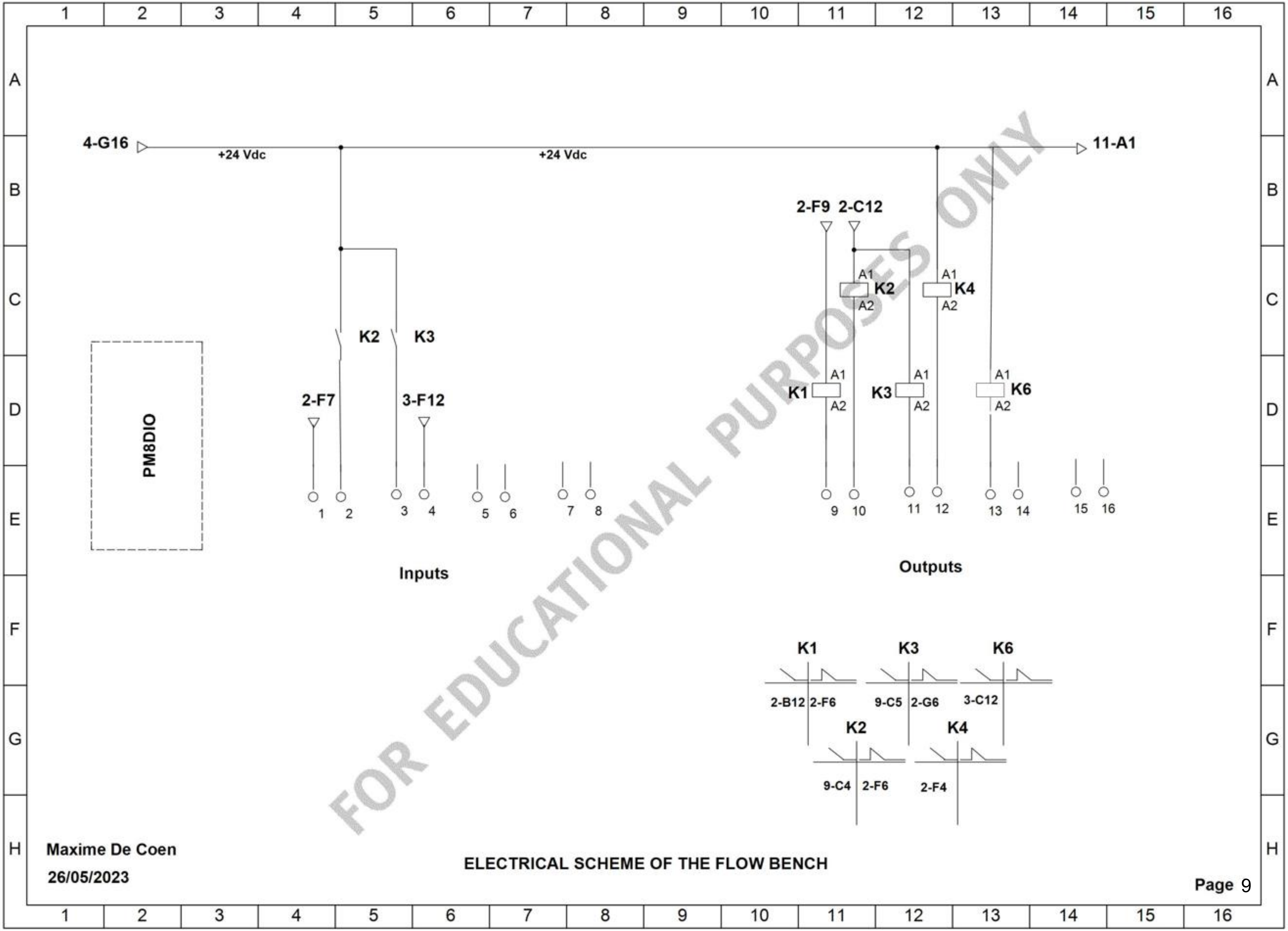
ELECTRICAL SCHEME OF THE FLOW BENCH



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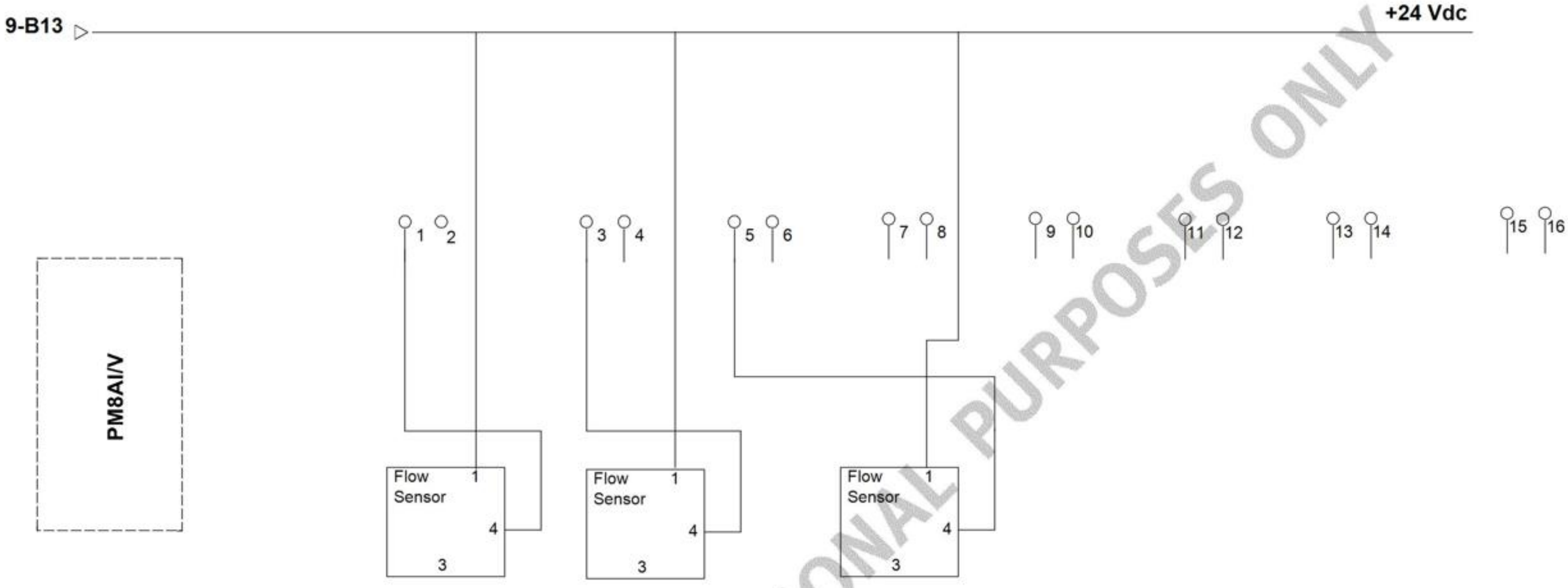
ELECTRICAL SCHEME OF THE FLOW BENCH

Inputs flow sensor



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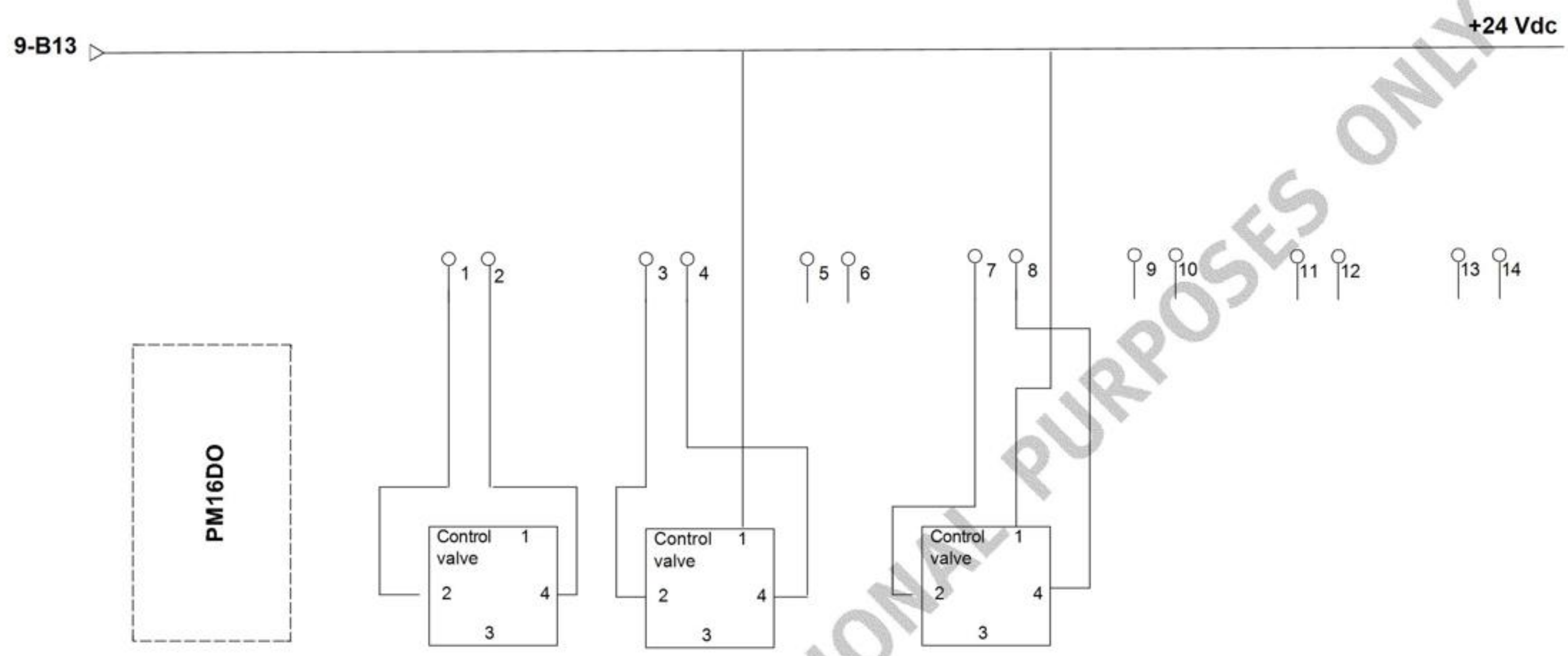
ELECTRICAL SCHEME OF THE FLOW BENCH

Ouputs control valves



8.3 3D Drawing

Master Thesis: Flow Bench

3D Drawings

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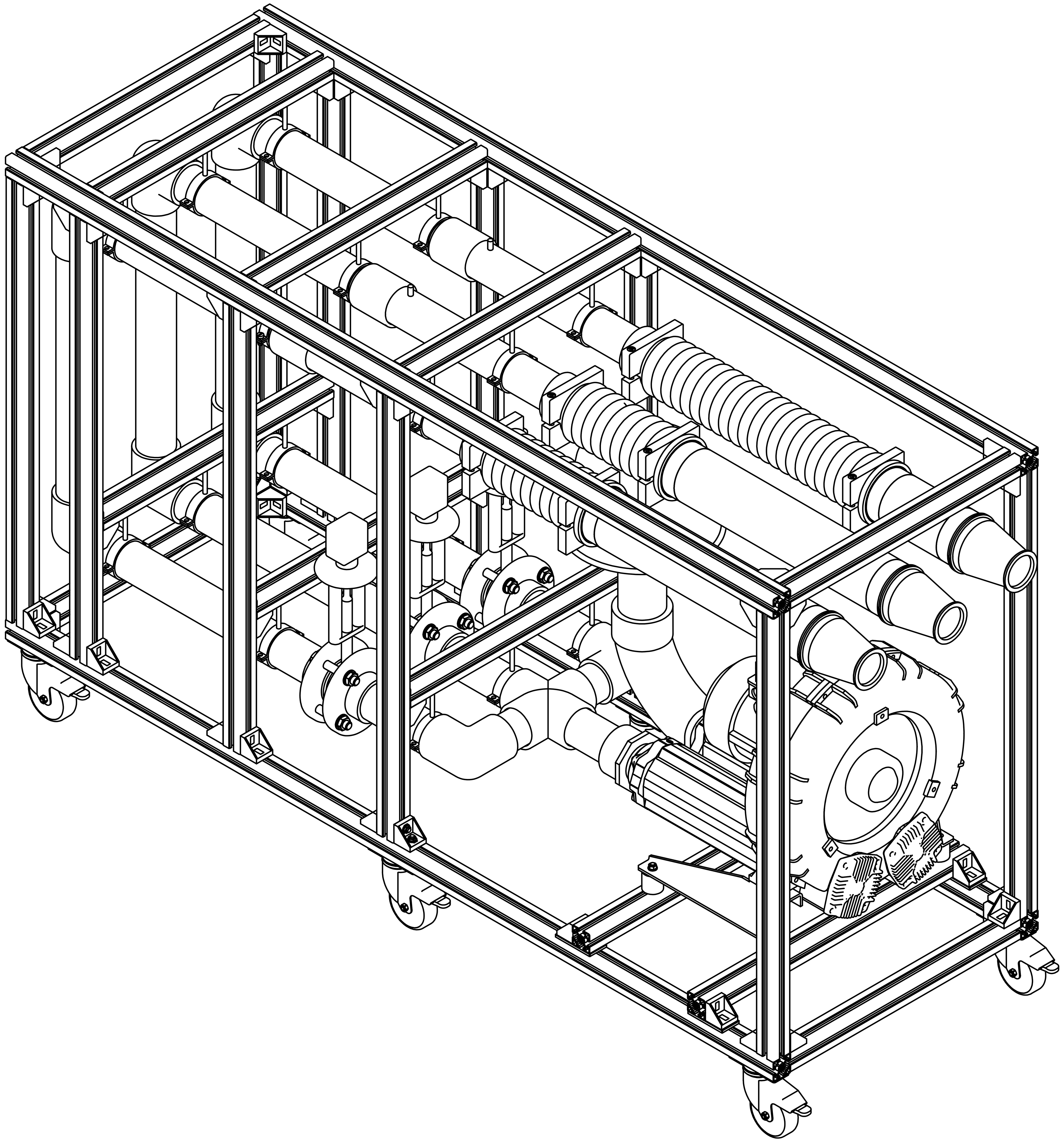
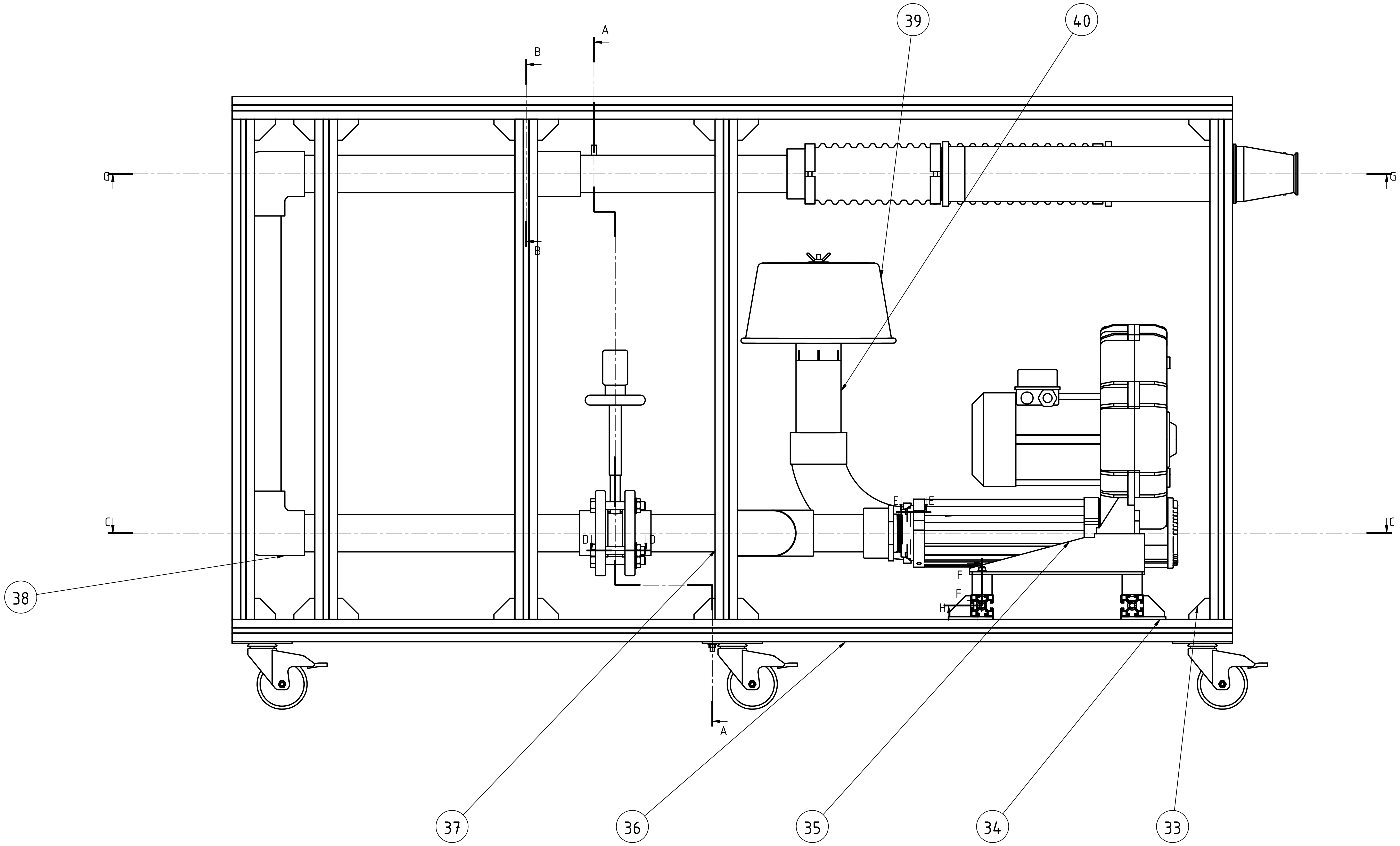
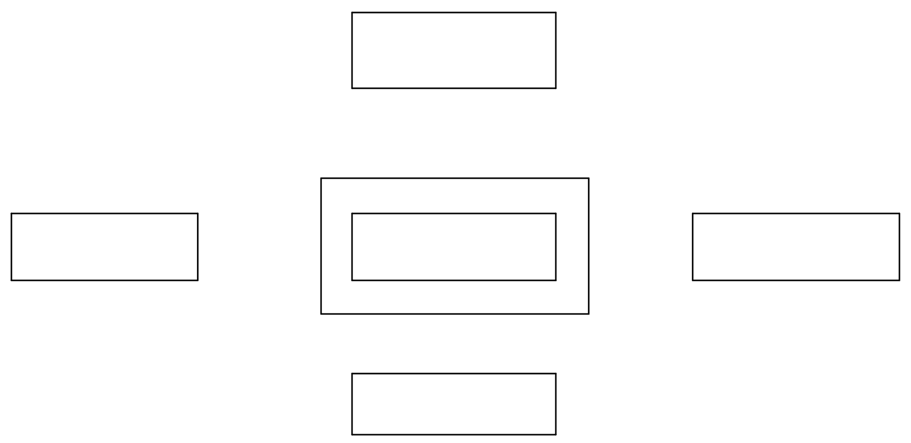


Gen. tolerance		Drawing by : Maxime De Coen
Flow Bench		Date : 27/05/2023
Unit : mm	UPV Universitat Politècnica de València Faculty Of Industrial Engineering	Scale : 1:5 — Format : A1

Tekeningnaam : Flow bench drawing.slddrw



Positioning papers



Nr.	QTY	Name	Quality standard	Delivery standard	Rough measure	Supplier
40	1	Filter pipe			Ø88	FPZ
39	1	Filter			Ø88	FPZ
38	8	Corner 90° PVC			Ø75	Tuberplas
37	10	Item 45x45-1000			45x45-1000	Fasten
36	4	Item 45x45-2000			45x45-2000	Fasten
35	1	Blower with one flange			550x500x480	FPZ
34	4	Rubber damper			45x90x2	RS
33	64	Corner attatchment			42x42x42	Fasten

Gen. tolerance :

Drawing by:
Maxime De Coen

Flow Bench

Date : 27/05/2023

Unit : mm

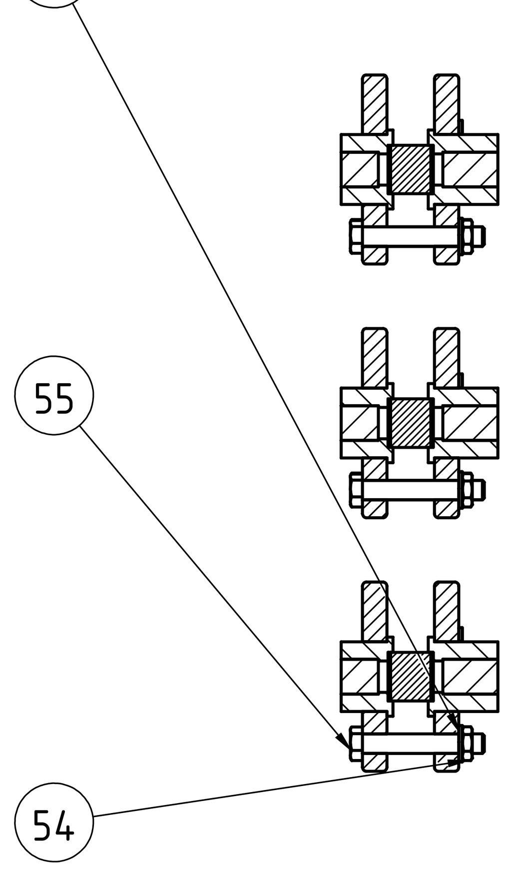
UPV
Universitat Politècnica de València
Faculty Of Industrial Engineering

Scale : 1:5

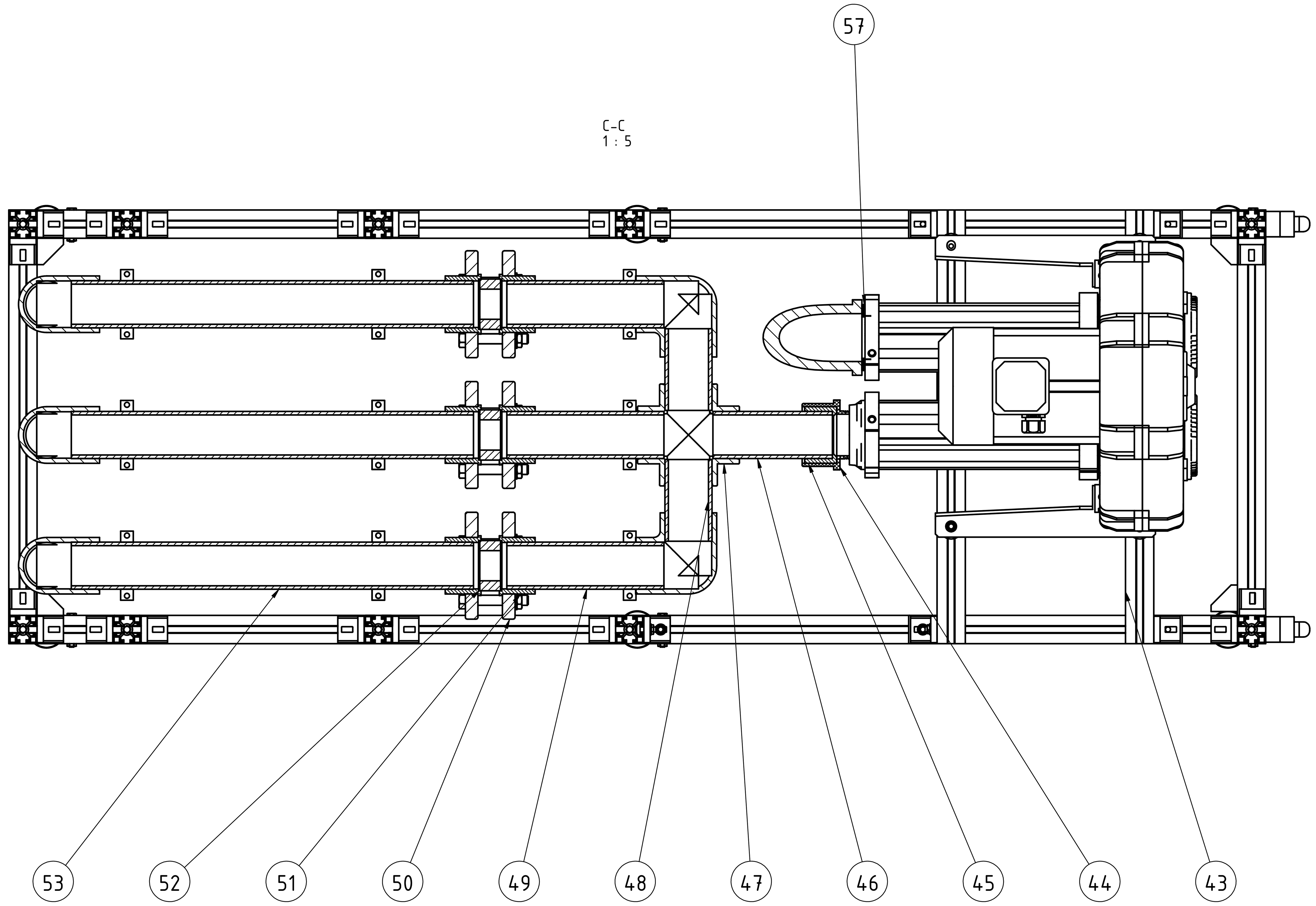
Format : A1

Tekeningnaam : Flow bench drawing.slddrw

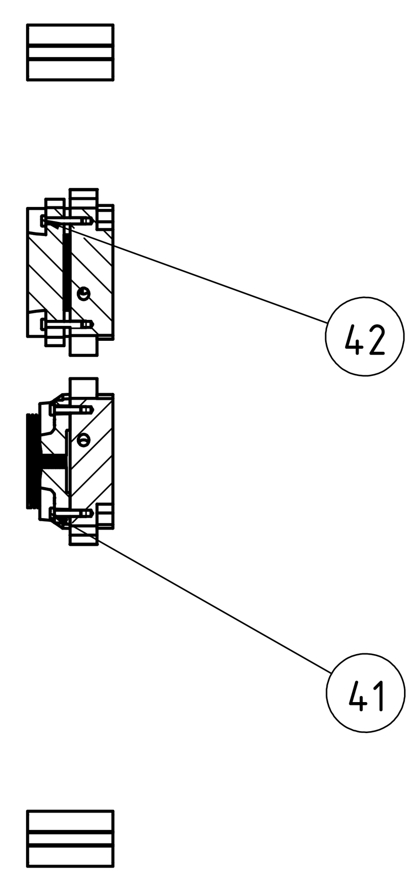
D-D
1 : 5



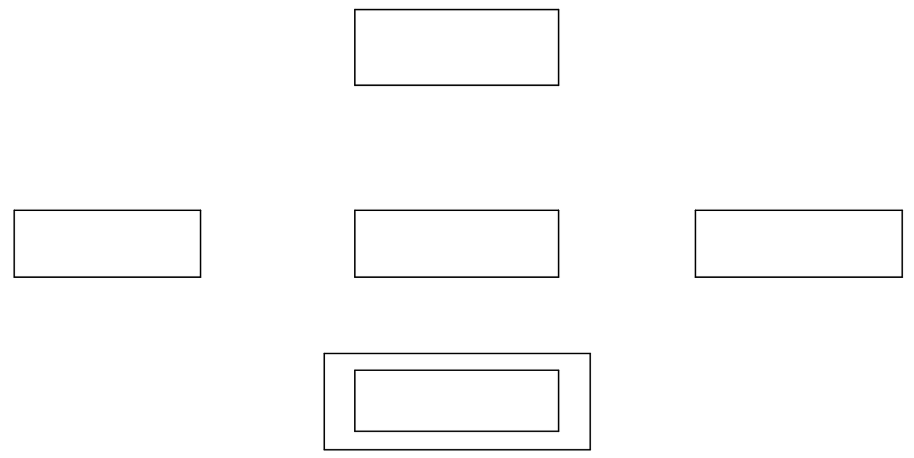
C-C
1 : 5



E-E
1 : 5



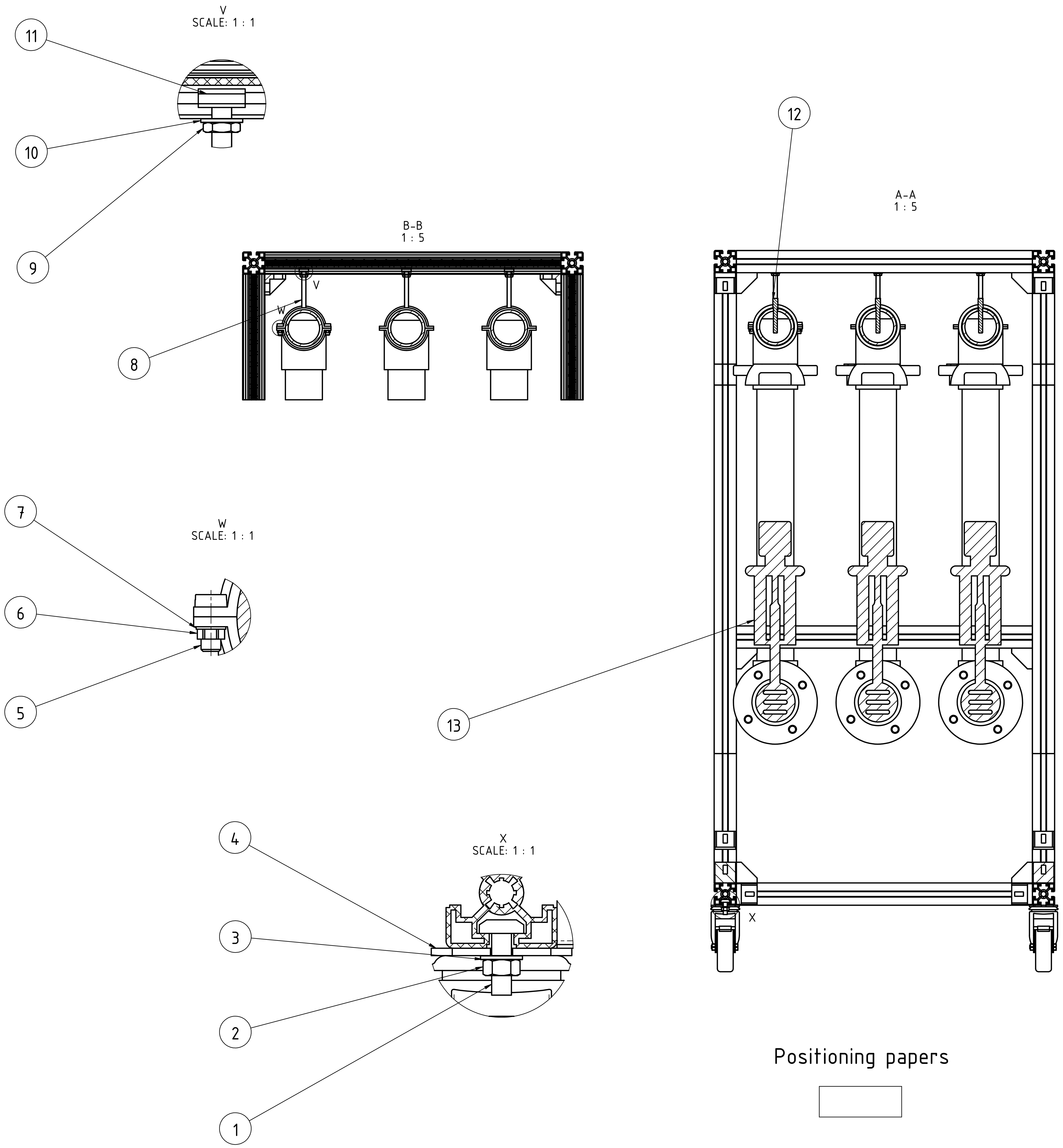
Positioning papers



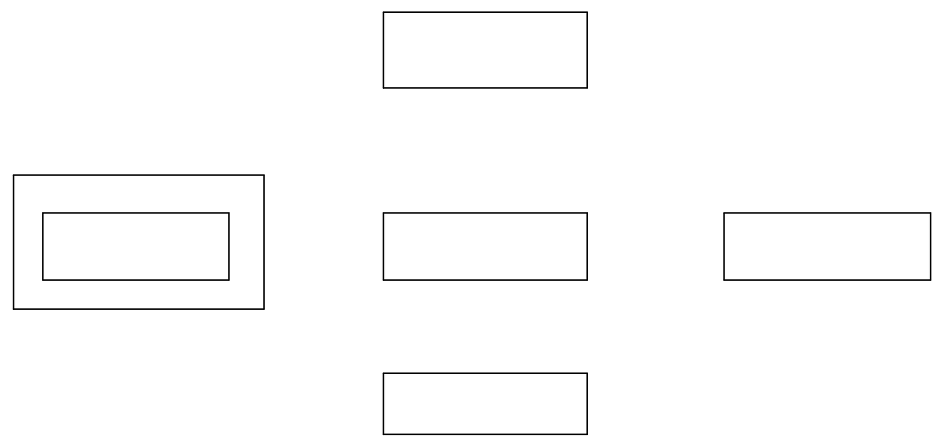
Nr.	QTY	Name	Quality standard	Delivery standard	Rough measure	Supplier
57	1	Sealing ring			Ø105-5	RS
56	12	Vlakke sluitring	St Elvz	DIN 126	M16	Fabory
55	12	Zeskantbout	St8.8 Elvz	DIN 931	M16x100	Fabory
54	12	Lage zeskantmoer	St04 Elvz	DIN 439 B	M16	Fabory
53	6	PVC pipe			Ø75x640	Tuberplas
52	6	Sealing ring flange			Ø80x2	RS
51	6	PVC flange for sealing			Ø75x57	Tuberplas
50	6	PVC flange			Ø90x20	Tuberplas
49	3	PVC pipe			Ø75x250	Tuberplas
48	2	PVC pipe			Ø75x130	Tuberplas
47	1	PVC cross			4xØ75	Plastic pipe shop
46	1	PVC pipe			Ø75x190	Tuberplas
45	1	Reduction 90-75			Ø90-Ø75	Tuberplas
44	1	Transition blower-PVC			G3	FPZ
43	2	Item 45x45-690			45x45-690	Fasten
42	4	Cylindrical screw with hexagonal_low	St8.8	DIN 6912	M5x30	Fabory
41	4	Cylindrical screw with hexagonal_low	St8.8	DIN 6912	M5x22	Fabory

Gen. tolerance :		Drawing by : Maxime De Coen
	Flow Bench	Date : 27/05/2023
Unit : mm	UPV Universitat Politècnica de València Faculty Of Industrial Engineering	Scale : 1:5 / Format : A1

Tekeningnaam : Flow bench drawing.slddrw



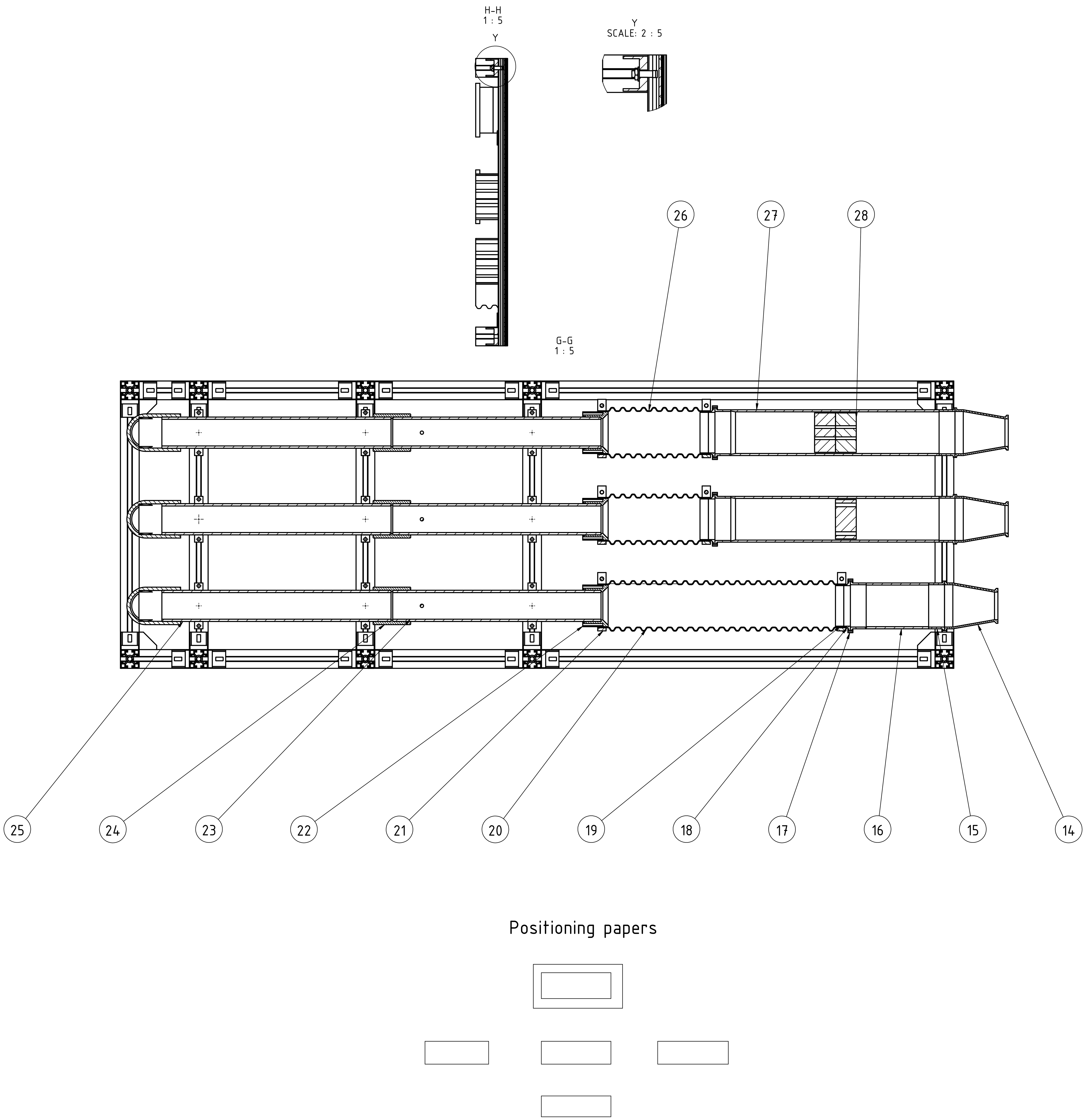
Positioning papers



Nr.	QTY	Name	Quality standard	Delivery standard	Rough measure	Supplier
13	3	Controlvalve			Ø80	Bvalve
12	3	Pen Style velocity sensor			M8	Seikom
11	26	T nut	St 8.8 Elvz	DIN 934	M8	Fasten
10	26	Flat washer	St 140 HV Elvz	DIN 125-1A	M8	Fabory
9	26	Low hex nut	St04 Elvz	DIN 439 B	M8	Fabory
8	18	Attatchment ring PVC-Item			Ø75	Tuberplas
7	36	Flat washer	St 140 HV Elvz	DIN 125-1A	M8	Fabory
6	36	Hex nut	St 8.8 Elvz	DIN 934	M8	Fabory
5	36	Cilindrical screw	St4.8 Elvz	DIN 84A	M8x20	Fabory
4	6	Castor wheel			Ø100-120x40	Item 24
3	128	Flat washer	St 8.8 Elvz	DIN 126	M8	Fabory
2	128	Hex nut	St 8.8 Elvz	DIN 934	M8	Fabory
1	128	T bolt	St 8.8 Elvz	DIN 186	M8x25	Fasten

Gen. tolerance :	Drawing by : Maxime De Coen
Flow Bench	Date : 27/05/2023
Unit : mm	Scale : 1:5
UPV Universitat Politècnica de València Faculty Of Industrial Engineering	Format : A1

Tekeningnaam : Flow bench drawing.slddrw



Nr.	QTY	Name	Quality standard	Delivery standard	Rough measure	Supplier
28	3	Ceramic air heater			Ø94x50	UPV
27	2	Heating tube	S355J2	EN 10060	Ø110x700	UPV
26	2	Flexible hose			Ø102x500	VENA HTD
25	3	PVC pipe			Ø75x550	Tuberplas
24	3	Socket			42x42x42	Fasten
23	3	PVC pipe			Ø75x500	Tuberplas
22	3	Reduction 100-75			Ø110-Ø75	Tuberplas
21	6	Clamp ring K12			Ø4"	Clamp
20	1	Flexible hose long			Ø102x1000	VENA HTD
19	3	Extension part flange	S355J2	EN 10060	Ø101,6x20	UPV
18	3	Flange on hose K14 S			Ø4"	Clamp
17	3	Lip gasket K39			Ø4"	Clamp
16	1	Heating tube small	S355J2	EN 10060	Ø110x150	UPV
15	6	Flange on heater K14 R			Ø4"	Clamp
14	3	End flange K32			Ø4"	Clamp

Gen. tolerance :

Drawing by :
Maxime De Coen

Flow Bench

Date :
27/05/2023

Unit : mm

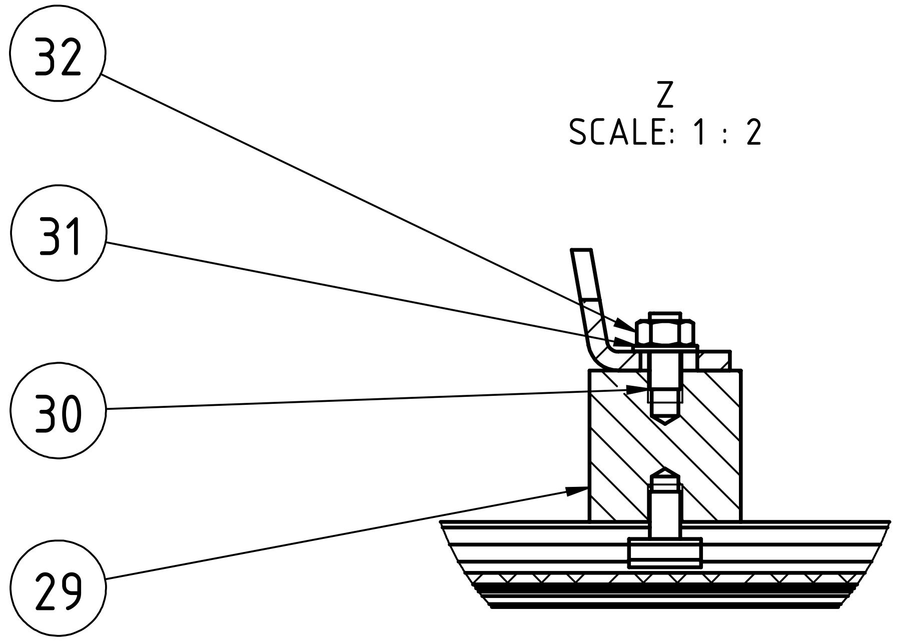
UPV
Universitat Politècnica de València
Faculty Of Industrial Engineering

Scale :
1:5

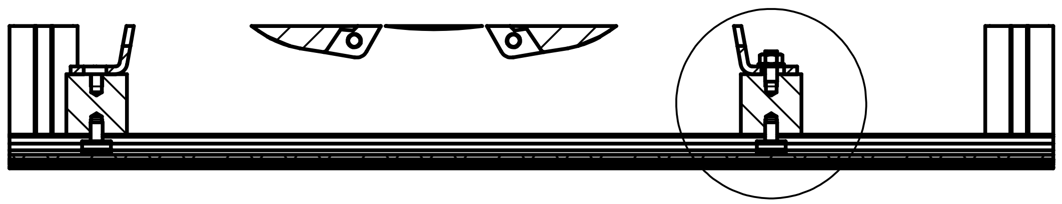
Format :
A1

Tekeningnaam : Flow bench drawing.slddrw

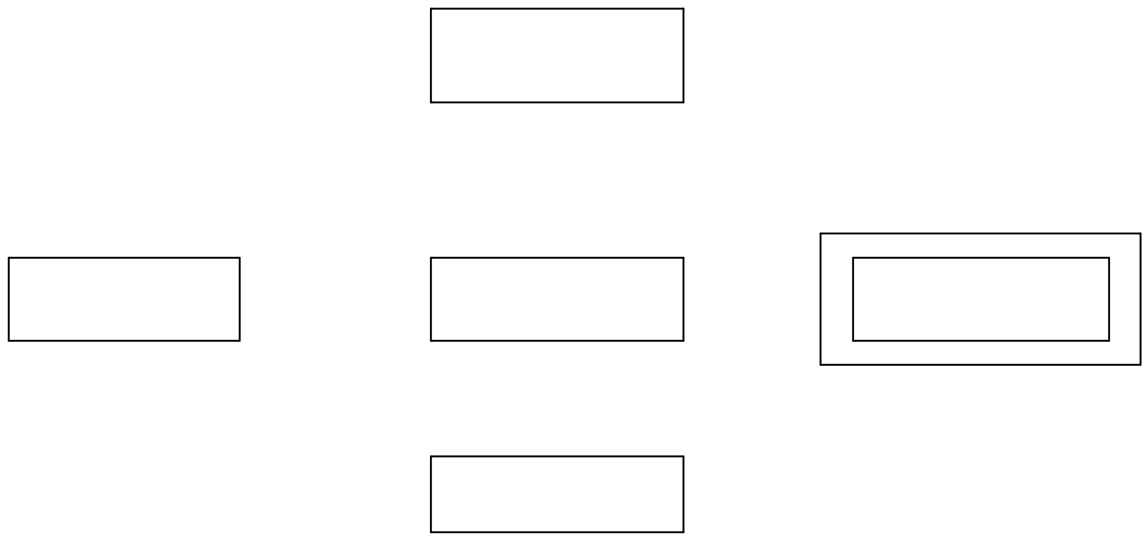
Z
SCALE: 1 : 2



F-F
1 : 5



Positioning papers



Nr.	QTY	Name	Quality standard	Delivery standard	Rough measure	Supplier
32	4	Hex nut	St 8.8 Elvz	DIN 934	M8	Fabory
31	4	Flat washer	St 8.8 Elvz	DIN 126	M8	Fabory
30	8	Threaded rod			M8x20	RS
29	4	Damper			Ø40-M8	Chassisparts

Gen. tolerance :

Drawing by :
Maxime De Coen

PC-nr.

Flow Bench

Date :
27/05/2023

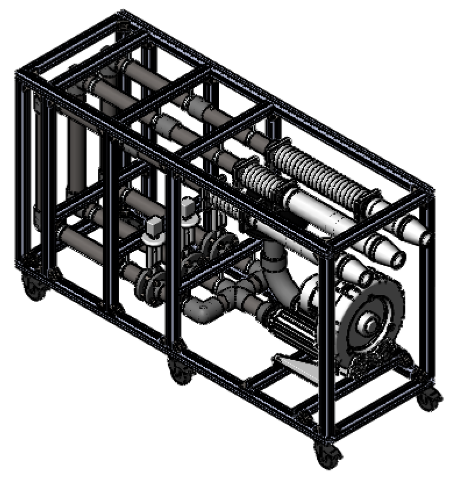
Unit : mm

UPV
Universitat Politècnica de València
Faculty Of Industrial Engineering

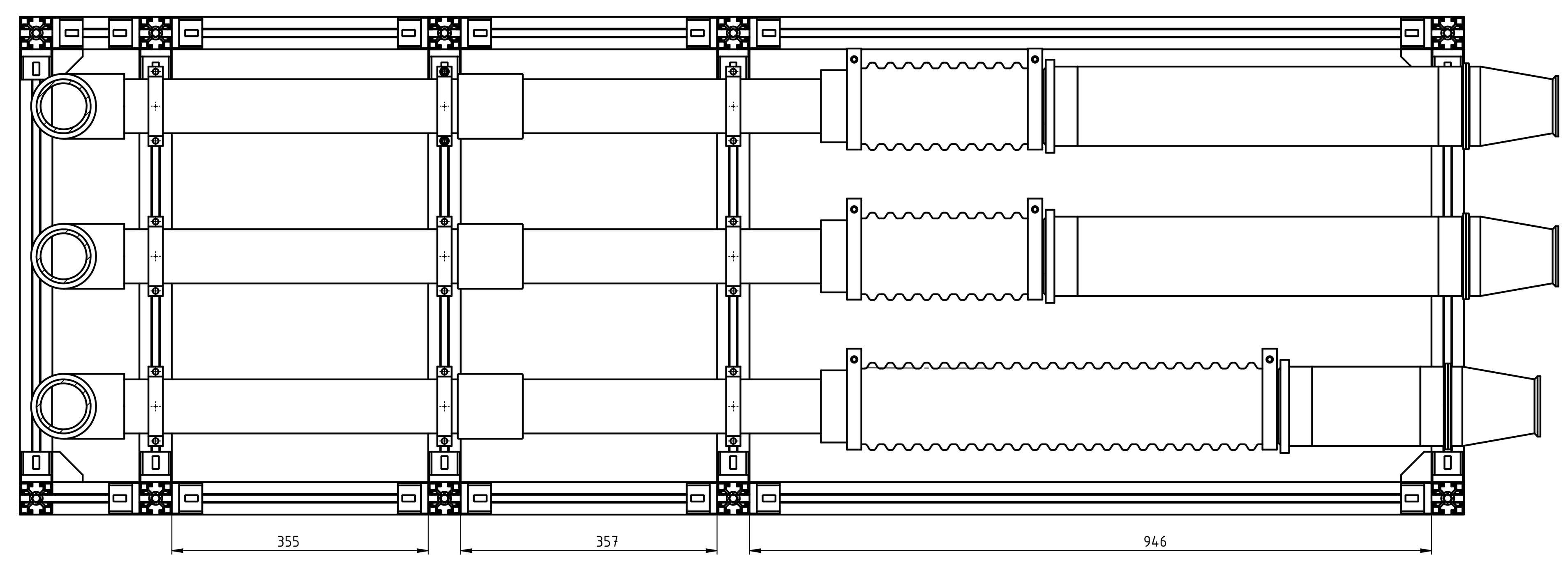
Scale :
1:5

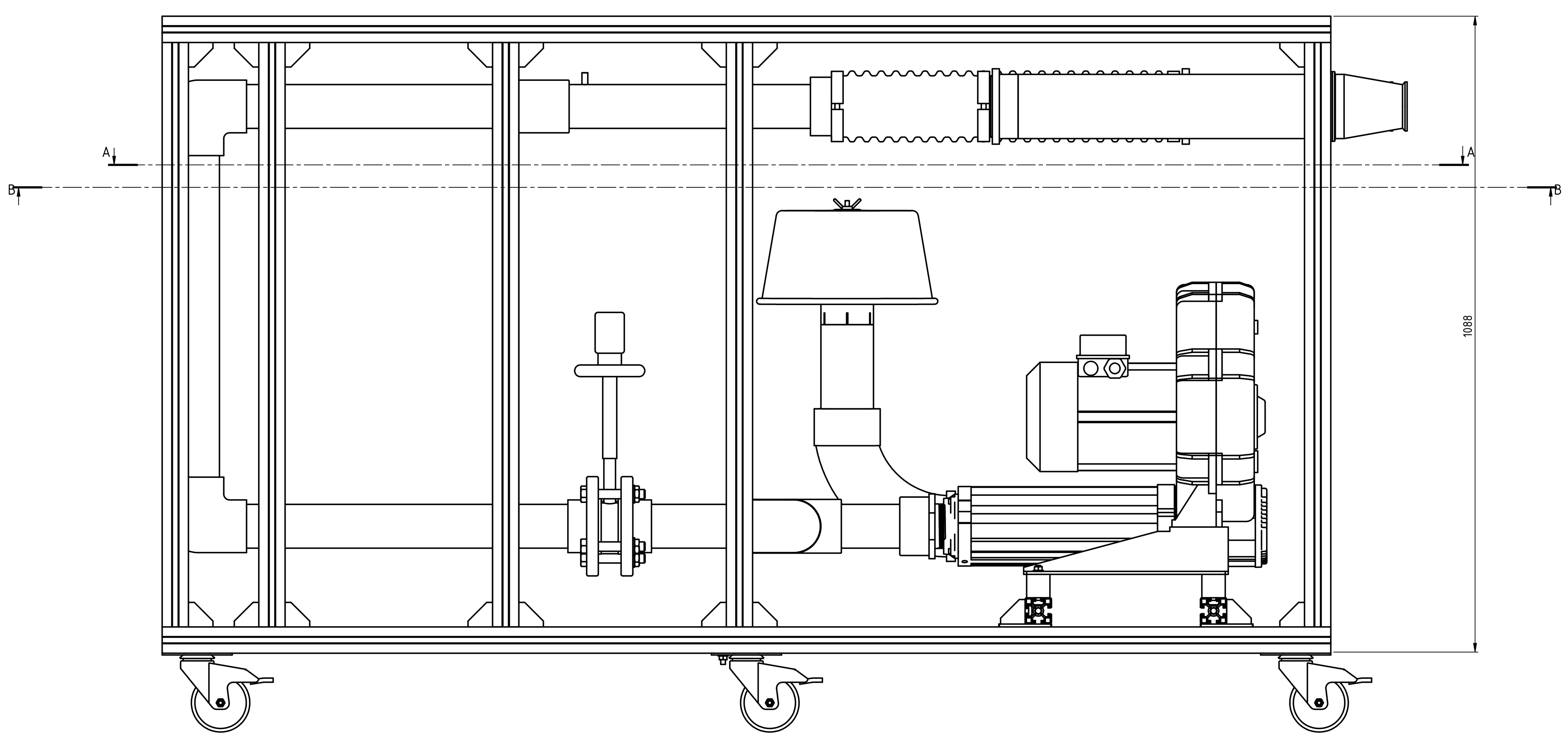
Format :
A3

Tekeningnaam : Flow bench drawing.slddrw

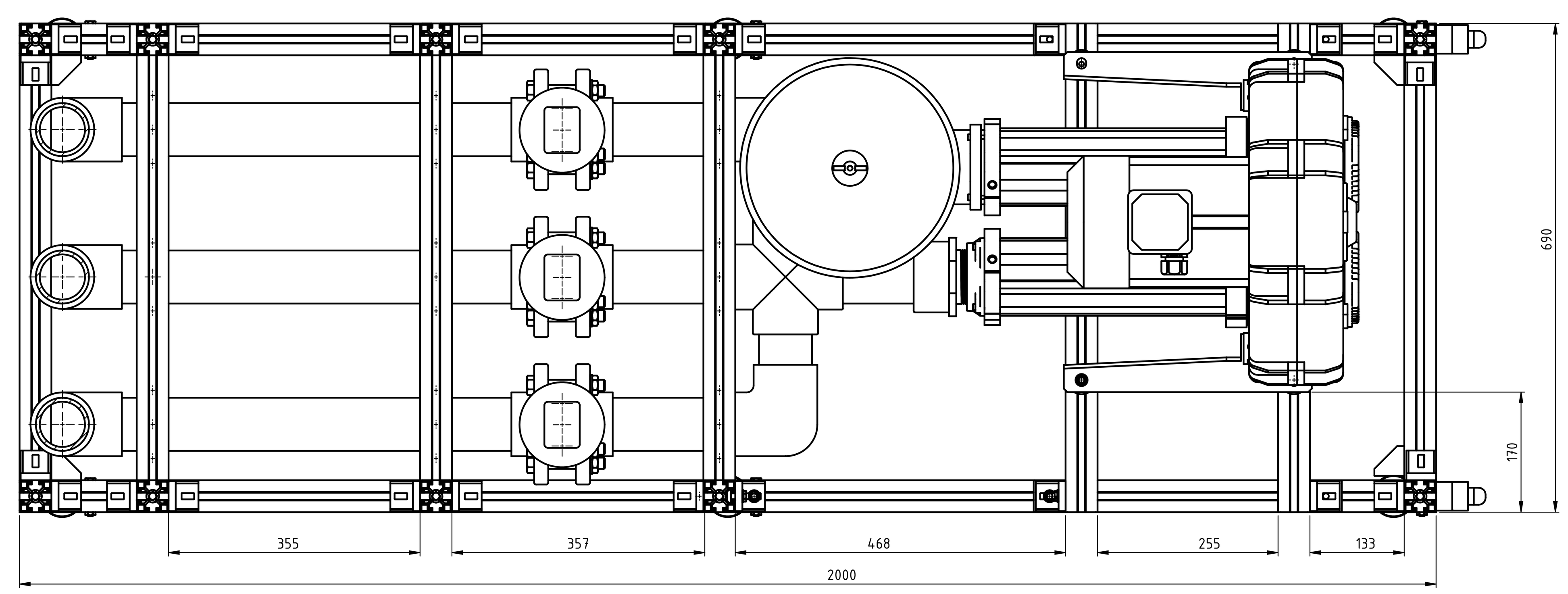


B-B
1 : 5





A-A
1 : 5



Gen. tolerance :		Drawing by: Maxime De Coen
	Flow Bench	Date: 27/05/2023
Unit : mm	UPV Universitat Politècnica de València Faculty Of Industrial Engineering	Schale : 1:5 | Format : A0

Tekeningnaam : Flow bench positioning.slddrw

8.4 Quotations

OFERTA: DV2302655-2-DD
Proyecto: 2302655
Fecha: 14/06/2023

BVALVE Flow, Systems & Controls S.L

Since/Desde 1996

www.bvalve.es - www.thebellowssealedvalve.com
Address:Pol.Ind.I.1, C/Travessa de Peralta, SA
46540 El Puig (Valencia) España
Tel. /Phone. + 34 961 473 161 - Fax + 34 961 473 170
administracion@bvalve.es - ventas@bvalve.es

Empresa: UNIVERSIDAD POLITECNICA DE VALENCIA
Nº de Cliente: C00179
A/A: MAXIME DE COEN
De: Helga Delgado
Referencia: RE. OFERTA
E-mail: maxime.decoen@student.kuleuven.be

Adjunto le remitimos nuestro mejor precio y plazo de entrega para los materiales detallados en las siguientes hojas. A la espera de que esta oferta sea de su conformidad, aprovechamos la ocasión para saludarle. Rogamos citen nuestra referencia de oferta en caso de eventual pedido o futuras consultas.

Pos	Cant.	Descripción	Precio Neto Unit	Neto pos.	Plazo
1	3	Articulo 0SCSX0000 **Válvula de control S&S tipo GS8021 diseño GS1** - Material cuerpo: Acero carbono 1.0570/1.0619 - Material disco fijo: Acero inoxidable 1.4571 - Material disco deslizante: Grafito puro - Equipada con actuador neumático de simple efecto de 125 cm2 a fallo de aire cierra - Equipada con posicionador electroneumático digital Eckardt mod. SRD998, HART, señal de control 4-20 mA, retroalimentación 4-20 mA, clasificación eléctrica ATEX/IEC Ex:II 2G Ex ia IIC T4/T6 Gb, II 1D Ex ia IIIB T100°C - Equipada con filtro manorreductor con manómetro (0-10) bar - Valor Kvs: 92 m3/h - Característica de paso: Modificada lineal - Estanqueidad mayor del 0,0001% del valor Kvs (Clase VI) - Conexión a proceso: Wafer (entre bridas DIN EN1092 forma B PN10-40) - Presión nonimal: PN40 - Diámetro nominal: DN80	2.763,50 EUR	8.290,50 EUR	2 Semanas s/v
2	3	Articulo 0SCSX0000 **Válvula de control S&S tipo GS8021 diseño GS1**	2.525,00 EUR	7.575,00 EUR	2 Semanas s/v

Pos	Cant.	Descripción	Precio Neto Unit	Neto pos.	Plazo
		- Material cuerpo: Acero carbono 1.0570/1.0619 - Material disco fijo: Acero inoxidable 1.4571 - Material disco deslizante: Grafito puro - Equipada con actuador neumático de simple efecto de 125 cm2 a fallo de aire cierra - Equipada con posicionador electroneumático digital Eckardt mod. SRD998, HART, señal de control 4-20 mA, retroalimentación 4-20 mA, clasificación eléctrica ATEX/IEC Ex:II 2G Ex ia IIC T4/T6 Gb, II 1D Ex ia IIIB T100°C - Equipada con filtro manorreductor con manómetro (0-10) bar - Valor Kvs: 52 m3/h - Característica de paso: Modificada lineal - Estanqueidad mayor del 0,0001% del valor Kvs (Clase VI) - Conexión a proceso: Wafer (entre bridas DIN EN1092 forma B PN10-40) - Presión nonimal: PN40 - Diámetro nominal: DN65			

IMPORTE.	%DTO.PP		TOTAL DOCUMENTO
15.865,50	0,00	0,00	15.865,50 EUR

CONDICIONES DE VENTA:

1. PRECIOS Y PLAZOS:
Los precios cotizados se entienden netos en euros. El plazo de entrega se entiende ESTIMADO en el momento de la cotización y como fecha disponible en nuestras instalaciones sin tener en cuenta el plazo de transporte. Los plazos de stock se entienden salvo venta.

2. CONDICIONES DE ENTREGA:
DDP – En sus instalaciones según Incoterms 2010

3. ENVIOS A CANARIAS:
El pedido y factura se emitirán sin IVA condicionado a la obtención del DUA donde conste explícitamente FCA Valencia y prueba de transporte de entrada en Canarias, de no recibir dichos documentos, nos reservamos el derecho de emitir la factura con IVA.

4. IMPUESTOS
IVA aplicable no incluido en los precios cotizados.

5. CERTIFICADOS, DOCUMENTACIÓN, PRUEBAS E INSPECCIONES:
La necesidad de certificados tipo EAN1024-3.1, pruebas, documentación especial (planos, 3D, ...) o inspecciones debe ser indicada en sus pedidos y se facturaría por separado. Si en la presente oferta no están indicados significa que no están incluidos. Para ello, soliciten presupuesto de nuevo al Dpto. Comercial.

6. GARANTÍA:
El material queda garantizado 1 año, contado desde la fecha de entrega contra todo defecto de fabricación. Se hace constar que BVALVE únicamente suministra los equipos solicitados por el cliente, no haciéndose responsable de la adecuación de los mismos a las características de la instalación ni de si dicho equipo es adecuado al uso que pueda dársele por el comprador. Cualquier término de GARANTÍA ESPECIAL debe ser presupuestado y acordado con nuestro Dpto. Comercial

7. RECLAMACIONES:
El plazo máximo para reclamaciones será de 2 años desde la fecha en que se manifieste o el comprador conozca los defectos de fabricación.

8. FORMA DE PAGO:
La habitual condicionada a la cobertura del crédito por parte de nuestra empresa aseguradora. Para clientes nuevos la primera operación será al contado mediante transferencia bancaria, excepto acuerdos comerciales específicos. En estos casos el plazo de entrega empezara a contar una vez recibida la transferencia.

9. CUMPLIMENTO CON LA DIRECTIVA DE EQUIPOS A PRESIÓN PED:
Los productos destinados a países de la Unión Europea han de cumplir con las Directivas Europeas aplicables y entre ellas la de Equipos a Presión PED 2014/68/UE. Rogamos nos faciliten los datos de proceso para verificar que la aplicación está dentro de los límites de uso de acuerdo con la categorización del producto. De lo contrario entenderemos que el cliente lo verifica antes de su instalación de acuerdo con nuestras fichas técnicas.
Nuestra compañía no asumirá ningún tipo de responsabilidad por un uso indebido de los productos suministrados.

10. VALIDEZ
La presente oferta tiene una validez de 30 días. Nos reservamos el derecho de efectuar modificaciones transcurrida la validez de la presente oferta. Cualquier otro plazo debe de ser acordado con nuestro Dpto. Comercial.

11. DEVOLUCIONES Y CANCELACIONES:
Nuestra Compañía se reserva el derecho a no aceptar la devolución de pedidos de materiales que no formen parte de nuestro programa de almacén estándar y no se admitirán las devoluciones sin autorización previa de la empresa. Es necesario acompañar dicho material con su anexo correspondiente facilitado por el personal de BVALVE. Sin este anexo y sin autorización previa por parte del personal de BVALVE el bulto será rechazado.
En el caso de cancelación de pedido, pasada 1 semana, nos reservamos el derecho a no aceptar dicha cancelación o de lo contrario a aplicar un recargo (demérito) mínimo del 25% con carácter irrevocable, pudiendo ser superior en función de la mercancía.

12. OTROS:
BVALVE Flow, Systems & Controls, le informa que los datos personales que nos facilite serán tratados de acuerdo con lo dispuesto en la Legislación vigente referente a datos de carácter personal. En este sentido, podrán ser incorporados a un fichero automatizado de datos cuya finalidad es realizar la gestión administrativa y con el objeto de mejorar la calidad de nuestro servicio. Garantizamos el derecho de acceder, modificar, oponerse o cancelar los datos personales contenidos en nuestros ficheros, para lo cual deberá hacernos llegar su consulta a la dirección de nuestras Oficinas Centrales indicada en el encabezado.
Las partes con renuncia a su fuero propio se someten a los Juzgados y Tribunales de Valencia y a la ley española. La disminución de la solvencia del adquiriente, la presentación y/o declaración de concurso de acreedores por la compradora, la presentación de la comunicación prevista en el artículo 5.bis de la Ley Concursal o precepto que lo sustituía o cualquier otra situación que pueda suponer un riesgo en el cobro del producto vendido, facultará a la vendedora para suspender el suministro pendiente e, incluso, en su caso, resolver el contrato de compraventa, sin que por ello haya lugar al pago de indemnización y/o penalización alguna, salvo que por la parte compradora se de garantía suficiente (a juicio de la vendedora) del pago de los suministros efectuados o pendientes de realizar.

FASTEN SISTEMAS

C./ Fedra, 12
Arroyo de la Encomienda
47195 - VALLADOLID
C.I.F. B47514930
Tel.:+34 983 54 70 17
Fax:+34 983 54 70 96
comercial@fasten.es

O F E R T A

UNIVERSIDAD POLITECNICA DE VALENCI
Cno. De Vera S/N
Valencia
46022 Valencia
Tel.: 963.877.650
Fax: 963.877.659
CIF : Q4618002B

Cliente:460018

OFERTA Nº: OF23/2640	**FECHA :**25/05/2023	**SU REF.:**

Código	Artículo	Cantidad	Precio €	TOTAL
	Solicitud de cotización Maxime De Coen Dpto Motores Térmicos Profesor Raul Payri	1,00		
5021	Perfil básico 45x45 aluminio anodizado natural 4x 2000mm 10x 1000mm 10x 600mm 2x 690mm 6x 150mm	27,60	18,389	507,540
525025	Conjunto tornillo cabeza martillo 8.8 M8x25 + tuerca M8	145,00	0,350	50,750
53302	Escuadra aluminio fundido 42x42x42 con tapeta	80,00	2,360	188,800
52058	Tuerca en T cuello alto M8, canal 10 mm	30,00	0,620	18,600
5421125127	Rueda Ø125 Goma, con freno, espárrago M12x70	6,00	23,720	142,320
		1,00		
	Material en stock			

IMPORTE TOTAL , €	908,010
- 15,00%	136,200
Transporte	39,40 €
Mano de obra	32,00 €
N E T O,	**843,210**
I.V.A.% 21,00	177,0700
TOTAL FACTURA , EUROS......	1.020,28

Peso (Kgs.): 61,37

Forma de Pago: TRANSFERENCIA 30d.f.

Vto.: Importe:

Nº cuenta: 0049 1866 24 2510452192

Carlos Rafales Paz

Agente exclusivo España & Portugal FPZ SpA

NIF : ES75816475B

Sucursal Responsable Espana & Portugal
Agente Carlos Rafales
Tel. +34 607623203
E-mail carlos.rafales@fpz.com

UNIVERSITAT POLITECNICA DE VALENCIA
Camino de Vera s / n.
00000 Valencia 46022
ES

Tel. +34 963 87 70 00
Fax
E-mail informacion@upv.es

Asunto: OFERTA nr. 23VQ-001917 del 23/03/2023

Su Referencia

Moneda
EUR

Conforme a su solicitud, adjunto le remitimos oferta del material que se describe a continuación:

Còd.de Articulo	Descripcion	Cantidad	U.M.	Precio Unitario	% Descuento	Entrega	Importe
SK08MS00+0205	SCL K08-MS MOR IE3 - M.E. 3.0 - 3.5 kW - 2 POLI - 345-415/200-240V 50Hz - 380-480/220-280V 60Hz WR - cURus - IE3 - CL. F TROP. - PTO - IP55 - PAINTED	1	Nr.	1,750.00			1,750.00
25CA8	Colector Filtro 3"	1	Nr.	80.00			80.00
25FL8	Filtro FL8	1	Nr.	70.00			70.00
0510203004	RIMBORSO SPESE TRASP. SPAGNA	1	Nr.	70.00			70.00
						Total EUR	**1,970.00**

Condiciones comerciales

Forma de pago	Transferencia	Embalaje	Incluido
Condiciones de pago	30 Dias	Portes	DAP - Delivered at place / unfree (incoterms 2010)
Validez de la Oferta	15 D	Còdigo transportista	SCHENKER ITALIANA SPA

Condiciones generales de venta

Prot. Nr 304 serie 3 del 11/02/2015 Agenzia dell'Entrate Uff. di Vimercate. Disponible en www.fpz.com

Los pedidos irán dirigidos a FPZ S.p.A. - Via F. lli Cervi, 16 - 20863 Concorezzo (MB) ITP. IVA/VAT Nr. IT05933070962 y enviados via email a carlos.rafales@gmail.com

Con la esperanza de que nuestra propuesta sea de su interés, no dude en ponerse en concacto con nosotros para cualquier consulta.
Saludos

Carlos Rafales

PO BOX 164
Seven Hills, 1730
NSW, Australia
Tel: +61 2 9624 8376
web: www.proconel.com
email: proconel@proconel.com
ABN: 19 141 007 810

UNIT 22
195 Prospect Highway
Seven Hills, 2147
Fax: +61 2 9620 8709

Proforma Invoice

Shipper PROCON ELECTRONICS PTY LTD UNIT 22, 195 PROSPECT HIGHWAY SEVEN HILLS, 2147 NSW, AUSTRALIA	Date: 23-May 2023 Document No: QU102332C Buyers Reference: Prof. Raul Payri Exporters Reference UPV001
Consignee Universitat Politècnica de València Cami de Vera s/n València 46022 SPAIN	Notify Party / Delivery Address Universitat Politècnica de València Cami de Vera s/n València 46022 SPAIN Phone : +34-963879658

Delivery Method: AIR FREIGHT -DHL	Port of Loading: Sydney	Country of Origin: Australia
Delivery and Payment Terms: FCA / Advance TT	Port of Discharge: València	Country of Final Destination: Spain

Customs	Order Code	Description	Quantity	Unit Price	Amount
8543.70.00	PM8AI/I	8 ANALOG INPUT 0-20mA / 4-20mA	1	€ 101.76	€ 101.76
8543.70.00	PM8AO	8 ANALOG OUTPUT 0-20mA	2	€ 112.87	€ 225.74
8543.70.00	PM8TCISO	8 TC INPUT MODULE INCL. +/-100mV I/P FULLY ISOLATED	1	€ 149.87	€ 149.87
8543.70.00	PM16DO	16 DIGITAL OUTPUT MODULE	1	€ 75.86	€ 75.86
8543.70.00	PM8AI/V	8 ANALOG INPUT 0-5V / 1-5V / 0-10V / 2-10V	1	€ 101.76	€ 101.76
8543.70.00	PM8DIO	8 DIGITAL INPUT / 8 DIGITAL OUTPUT	1	€ 75.86	€ 75.86
8543.70.00	PT8TCS	8 TC INPUT MODULE INCL. +/-100mV I/P FULLY ISOLATED	1	€ 160.05	€ 160.05
8543.70.00	MMTCPBCONV-VDC	TCP / RS232(RS485) Serial boxed converter VDC	1	€ 111.02	€ 111.02
	Shipping Costs	COURIER CHARGES			€ 83.26

NOTES:

In accordance with EU Directive 98/8/EC, we declare that our products do not contain Dimethyl Fumarate (DMF), neither in the dessicant, nor in the packaging.

Quantity Ordered: 9	Total quantity to be supplied: 9	Total of Invoice: **All figures shown in EURO** € 1,085.18
Quantity of Repairs: 0	Total number of packages: 1	Name of Authorized Signatory: Glen Easton-Berry
Quantity of Samples: 0	Packing Method: EXPORT CARTON	Place and Date of Issue: Seven Hills 23-May 2023
Gr. Weight (Kg's): ±2		Signature:

SEIKOM-Electronic GmbH & Co. KG | Fortunastraße 20 | 42489 Wülfrath

Universitat Politècnica de València
Prof. Raul Payri
Mr. Maxime De Coen
Cami de Vera s/n
46022 València
Spain

Quote 1000557

Date:	24.05.2023
Valid until:	15.06.2023
Your quote from:	25.05.2023
Customer No.:	10593
Agent:	Ulrike Batz
E-mail:	batz@seikom-electronic.com

Dear Mr. De Coen,

Thank you for your interest in products by SEIKOM Electronic. Please find our quotation below.

Pos.	Art. No.	Description	Quantity	Unit	Price/unit €	Total €
1	74825A/50	Air flow monitor RLSW4A 24 V AC/DC 50 mm Compact unit including sensor (fixed mounted) Operating voltage: 24 V AC/DC Immersion depth of sensor: 50 mm, alternatively available with 130 mm, 165 mm, 300 mm (special lengths on request) Probe material: nickel-plated brass, alternatively available in stainless steel Process connection: PG7 Measuring range: 0.1 m/s ... 30 m/s Media temperature range: 0°C ... 70°C Output signal for flow: analogue output (0 ... 10 V) Customs tariff number: 90 26 80 20	3.00	pc.	194.20	582.60

Items net	582.60 €
Shipping cost net	28.00 €
Items VAT 0.00% on 582.60 €	0.00 €
Shipping VAT 0.00% on 28.00 €	0.00 €
Total sum	**610.60 €**

Term of payment: Payable within 14 days without deduction

Tax-exempt delivery EU

The delivery time is about 1 - 2 weeks.

VAT-Id. ES Q4618002B

In case you have any questions or remarks, please do not hesitate to contact our team.

Kind regards

Ulrike Batz

Product Inquiry Details

Watlow Code Number	: DC20-60F0-0000
Mfg Plant	: WIN

Part Information

Description 1	: DIN-A-MITE DC
Description 2	: DC1 POWER CONTROL
Configuration Details	: Phase 2 = 3-phase, 2 controlled legs Cooling & Current Rating per leg 0 = Natural convection stanc Line & Load Voltage 60 = 277 to 600VA (ac) Control F0 = 4 to 20mA (dc) proportional Alarm 0 = No Alarm Model Number DC20-60F0-0000
Product Class	: PW
Product Sub Class	: D1
Unit of Measure	: EA

Estimated price: 700€ + Transport (from US)

Product Inquiry Details

Watlow Code Number	: DB20-60F0-0000
Mfg Plant	: WIN

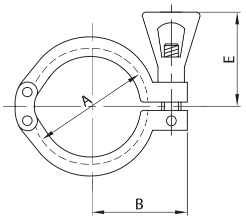
Part Information

Description 1	: DIN-A-MITE DB
Description 2	: DB POWER CONTROL
Configuration Details	: Package Style DB = Style B, DIN-A-MITE power control Phase 2 = 3-phase, 2 controlled legs Line & Load Voltage 60 = 277 to 600VA (ac) Input Control Signal F0 = 4 to 20mA (dc) proportional Alarm 0 = No Alarm CD With All Languages 0 = English Custom 00 = Standard Model Number DB20-60F0-0000
Product Class	: PW
Product Sub Class	: D1
Unit of Measure	: EA

Estimated price: 470€ + Transport (from US)

MORSETTO DOPPIO
HEAVY DUTY CLAMP
COLLIER CLAMP
ABRAZADERA

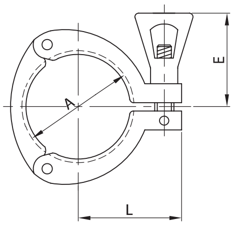
K12



DN	A	E	L	gr
1/2″ 12	27,0	35,0	27,0	120
3/4″ 19	27,0	35,0	27,0	120
1″ 25	53,4	53,0	43,0	220
1 1/2″ 38	53,4	53,0	43,0	220
2″ 51	67,0	53,0	50,0	260
2 1/2″ 63	80,4	53,0	56,5	330
3″ 76	94,0	53,0	65,0	400
4″ 101	122,0	53,0	85,0	500

MORSETTO 3 GANASCE
HEAVY DUTY CLAMP 3 PCS.
COLLIER CLAMP 3 PIECES
ABRAZADERA

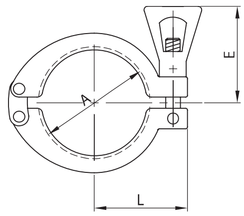
K13



DN	A	E	L	gr
1″ 25	53,4	53,0	45,0	270
1 1/2″ 38	53,4	53,0	45,0	270
2″ 51	67,0	53,0	51,5	330
2 1/2″ 63	80,4	53,0	58,2	395
3″ 76	94,0	53,0	65,0	425
4″ 101	122,0	53,0	81,0	540

MORSETTO DOPPIO
HEAVY DUTY CLAMP
COLLIER CLAMP
ABRAZADERA

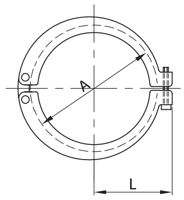
K15



DN	A	E	L	gr
1/2″ 25	54,5	53,0	43,7	220
1 1/2″ 38	54,5	53,0	43,7	220
2″ 51	68,0	53,0	50,5	260
2 1/2″ 63	81,5	53,0	57,2	330
3″ 76	95,0	53,0	64,0	400
4″ 101	123,0	53,0	78,0	500

MORSETTO DOPPIO
HEAVY DUTY CLAMP
COLLIER CLAMP
ABRAZADERA

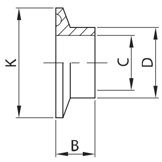
K12 HP



DN	A	L	gr
5″ 127	148,0	95,0	750
6″ 152	170,0	111,0	1.450
8″ 203	222,0	137,0	1.750

SEMIRACCORDO CORTO SR.
SHORT WG. FERRULE
FERRULE SR. COURTE
ENLACE CORTO SR.

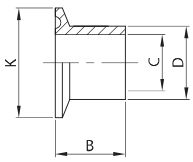
K14 S



DN	B	C	D	K	gr
1/2″ 12	12,7	9,4	12,7	25,0	16
3/4″ 19	12,7	15,7	19,0	25,0	14
1″ 25	12,7	22,1	25,4	50,5	60
1 1/2″ 38	12,7	34,8	38,1	50,5	40
2″ 51	12,7	47,5	50,8	64,0	60
2 1/2″ 63	12,7	60,2	63,5	77,5	75
3″ 76	12,7	72,9	76,2	91,0	95
4″ 101	15,8	97,4	101,6	119,0	180
4″ 104	15,8	100,0	104,0	119,0	180

SEMIRACCORDO SR.
WG. FERRULE
FERRULE SR.
ENLACE SR.

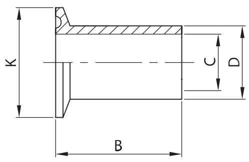
K14 W



DN	B	C	D	K	gr
1/2″ 12	21,0	9,4	12,7	25,0	19
3/4″ 19	21,0	15,7	19,0	25,0	20
1″ 25	28,6	22,1	25,4	50,5	80
1 1/2″ 38	28,6	34,8	38,1	50,5	60
2″ 51	28,6	47,5	50,8	64,0	95
2 1/2″ 63	28,6	60,2	63,5	77,5	115
3″ 76	28,6	72,9	76,2	91,0	150
4″ 101	28,6	97,4	101,6	119,0	250
4″ 104	28,6	100,0	104,0	119,0	250
5″ 127	28,6	122,0	127,0	144,4	320
6″ 152	28,6	147,4	152,4	166,0	400
8″ 203	28,6	198,2	203,2	217,0	500

SEMIRACCORDO LUNGO SR.
LONG WG. FERRULE
FERRULE SR. LONGUE
ENLACE SR.

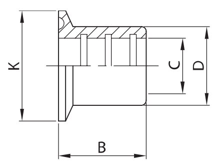
K14 WL



DN	B	C	D	K	gr
1″ 25	76,2	22,1	25,4	50,5	120
1 1/2″ 38	76,2	34,8	38,1	50,5	130
2″ 51	76,2	47,5	50,8	64,0	180
2 1/2″ 63	76,2	60,2	63,5	77,5	280
3″ 76	101,6	72,9	76,2	91,0	380
4″ 101	101,6	97,4	101,6	119,0	560
4″ 104	101,6	100,0	104,0	119,0	560

SEMIRACCORDO MR.
ROLL-ON FERRULE
FERRULE DR.
ENLACE MR.

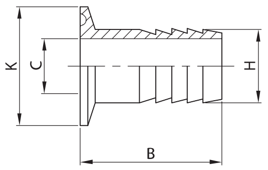
K14 R



DN	B	C	D	K	gr
1″ 25	19,0	25,4	29,6	50,5	60
1 1/2″ 38	28,6	38,1	42,6	50,5	65
2″ 51	33,4	50,8	55,8	64,0	105
2 1/2″ 63	35,0	63,5	68,8	77,5	145
3″ 76	36,5	76,2	82,0	91,0	190
4″ 101	38,0	101,6	110,0	119,0	300

PORTAGOMMA E. SM.
HOSE ADAPTOR E. FR.
PORTE CAOUTCH. B. FR.
M. MANGUERA E. SM.

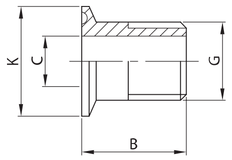
K14 RHA



DN	B	C	H	K	gr
1/2" 12	38,1	9,5	13,7	25,0	26
3/4" 19	38,1	15,7	21,3	25,0	40
1" 25	42,9	20,6	25,4	50,5	70
1 1/2" 38	42,9	33,3	38,1	50,5	140
2" 51	58,7	46,0	50,8	64,0	250
2 1/2" 63	59,5	58,7	63,5	77,5	370
3" 76	78,6	72,0	76,2	91,0	505
4" 101	86,5	97,4	101,6	119,0	685

SEMIRACCORDO EF. GAS
BSP ADAPTOR
FERRULE BF. GAZ
ENLACE ROSCA GAS

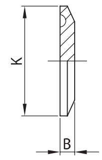
K14 BSPM



DN	B	C	G	K	gr
1" 25	30,0	21,7	1"	50,5	70
1 1/2" 38	32,0	34,4	1 1/2"	50,5	140
2" 51	36,0	47,1	2"	64,0	250
2 1/2" 63	39,0	59,8	2 1/2"	77,5	370
3" 76	46,0	72,5	3"	91,0	505
4" 101	56,0	96,7	4"	119,0	685

TAPPO
SOLID END CAP
BOUCHON
TAPÓN

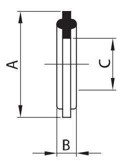
K16



DN	B	K	gr
1/2" 12	4,7	25,0	16
3/4" 19	4,7	25,0	16
1" 25	6,4	50,5	70
1 1/2" 38	6,4	50,5	70
2" 51	6,4	64,0	140
2 1/2" 63	6,4	77,5	200
3" 76	6,4	91,0	410
4" 101	7,9	119,0	570
5" 127	11,0	144,4	1.400
6" 152	13,0	166,0	2.200
8" 203	13,0	217,0	3.700

GUARNIZIONE
GASKET
JOINT
JUNTA

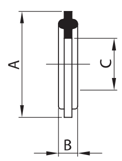
K40



DN	A	B	C
1/2" 12	21,8	4,5	10,0
3/4" 19	21,8	4,5	16,5
1" 25	49,5	5,3	23,2
1 1/2" 38	49,5	5,3	36,2
2" 51	63,0	5,3	49,2
2 1/2" 63	76,5	5,3	60,5
3" 76	90,0	5,3	73,1
4" 101	118,0	5,3	97,6
4" 104	118,0	5,3	100,0
5" 127	143,4	5,3	121,0
6" 152	165,0	5,3	146,4
8" 203	216,0	5,3	194,2

GUARNIZIONE A BUSTA
ENVELOPE GASKET
JOINT À ENVELOPPE
JUNTA DE SOBRE

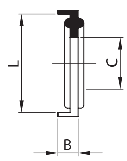
K40 TE



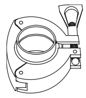
DN	A	B	C
1/2" 12	21,8	4,5	10,0
3/4" 19	21,8	4,5	16,5
1" 25	49,5	5,3	23,2
1 1/2" 38	49,5	5,3	36,2
2" 51	63,0	5,3	49,2
2 1/2" 63	76,5	5,3	60,5
3" 76	90,0	5,3	73,1
4" 101	118,0	5,3	97,6
4" 104	118,0	5,3	100,0

GUARNIZIONE A LABBRO
LIP GASKET
JOINT À LÈVRE
JUNTA DE REBORDE

K39

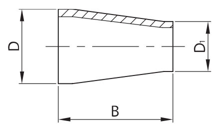


DN	B	C	L
1/2" 12	4,5	10,0	25,0
3/4" 19	4,5	16,5	25,0
1" 25	4,5	23,2	50,5
1 1/2" 38	4,5	36,2	50,5
2" 51	4,5	49,2	64,0
2 1/2" 63	4,5	60,5	77,5
3" 76	4,5	73,1	91,0
4" 101	4,5	97,6	119,0
4" 104	4,5	100,0	119,0
5" 127	4,5	143,4	144,4
6" 152	4,5	165,0	166,0
8" 203	4,5	216,0	217,0



RIDUZIONE CONC. EL.
CONC. REDUCER PE.
RÉDUCTION CONC. BL.
REDUCCIÓN CONC. EL.

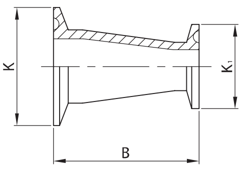
W31



DN		B	D	D_1	gr
3/4"-1/2"	19/12	25,4	19,0	12,7	50
1"-1/2"	25/12	25,4	25,4	12,7	70
1"-3/4"	25/19	25,4	25,4	19,0	80
1 1/2"-1/2"	38/12	50,8	38,1	12,7	90
1 1/2"-3/4"	38/19	50,8	38,1	19,0	90
1 1/2"-1"	38/25	67,0	38,1	25,4	100
2"-1 1/2"	51/38	67,0	50,8	38,1	140
2 1/2"-2"	63/51	67,0	63,5	50,8	160
3"-2"	76/51	67,0	76,2	50,8	180
3"-2 1/2"	76/63	67,0	76,2	63,5	220
4"-3"	101/76	67,0	101,6	76,2	280

RIDUZIONE CONC. E. SM.
CONC. REDUCER E. FR.
RÉDUCTION CONC. B. FR.
REDUCCIÓN CONC. E. SM.

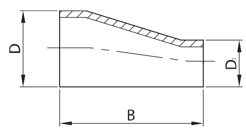
K31



DN		B	K	K_1	gr
3/4"-1/2"	19/12	50,8	25,0	25,0	80
1-1/2"	25/12	50,8	50,5	25,0	140
1"-3/4"	25/19	50,8	50,5	25,0	160
1 1/2"-1/2"	38/12	76,2	50,5	25,0	200
1 1/2"-3/4"	38/19	76,2	50,5	25,0	200
1 1/2"-1"	38/25	92,4	50,5	50,5	240
2"-1 1/2"	51/38	92,4	64,0	50,5	250
2 1/2"-2"	63/51	92,4	77,5	64,0	300
3"-2"	76/51	92,4	91,0	64,0	400
3"-2 1/2"	76/63	92,4	91,0	77,5	390
4"-3"	101/76	92,4	119,0	91,0	775

RIDUZIONE ECC. EL.
ECC. REDUCER PE.
RÉDUCTION EXC. BL.
REDUCCIÓN EXC. EL.

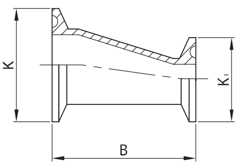
W32



DN		B	D	D_1	gr
3/4"-1/2"	19/12	25,4	19,0	12,7	50
1"-1/2"	25/12	25,4	25,4	12,7	80
1"-3/4"	25/19	25,4	25,4	19,0	80
1 1/2"-1"	38/25	67,0	38,1	25,4	110
2"-1 1/2"	51/38	67,0	50,8	38,1	150
2 1/2"-2"	63/51	67,0	63,5	50,8	170
3"-2"	76/51	67,0	76,2	50,8	250
3"-2 1/2"	76/63	67,0	76,2	63,5	230
4"-3"	101/76	67,0	101,6	76,2	510

RIDUZIONE ECC. E. SM.
ECC. REDUCER E. FR.
RÉDUCTION EXC. B. FR.
REDUCCIÓN EXC. E. SM.

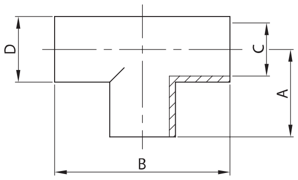
K32



DN		B	K	K_1	gr
3/4"-1/2"	19/12	50,8	25,0	25,0	80
1"-1/2"	25/12	50,8	50,5	25,0	160
1"-3/4"	25/19	50,8	50,5	25,0	160
1 1/2"-1"	38/25	92,4	50,5	50,5	250
2"-1 1/2"	51/38	92,4	64,0	50,5	260
2 1/2"-2"	63/51	92,4	77,5	64,0	300
3"-2"	76/51	92,4	91,0	64,0	400
3"-2 1/2"	76/63	92,4	91,0	77,5	400
4"-3"	101/76	92,4	119,0	91,0	790

TEE EL.
TEE PE.
TE BL.
TE EL.

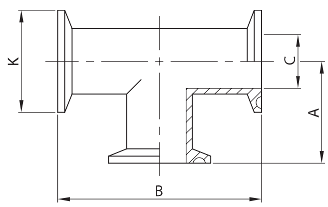
W7



DN		A	B	C	D	gr
1/2"	12	53,9	107,8	9,4	12,7	56
3/4"	19	53,9	107,8	15,7	19,0	98
1"	25	28,6	57,2	22,1	25,4	80
1 1/2"	38	42,1	84,2	34,8	38,1	160
2"	51	52,4	104,8	47,5	50,8	235
2 1/2"	63	59,5	119,0	60,2	63,5	340
3"	76	65,9	131,8	72,9	76,2	500
4"	101	87,3	174,6	97,4	101,6	900

TEE E. SM.
TEE E. FR.
TE B. FR.
TE E. SM.

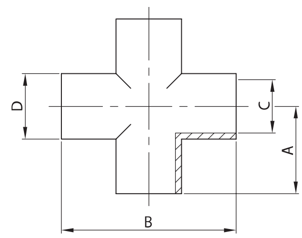
K7



DN		A	B	C	K	gr
1/2"	12	66,6	133,2	9,4	25,0	104
3/4"	19	66,6	133,2	15,7	25,0	150
1"	25	60,3	120,6	22,1	50,5	175
1 1/2"	38	69,9	139,8	34,8	50,5	315
2"	51	88,9	177,8	47,5	64,0	628
2 1/2"	63	88,9	177,8	60,2	77,5	780
3"	76	95,3	190,6	72,9	91,0	1.135
4"	101	114,3	228,6	97,4	119,0	1.760

CROCE EL.
CROSS PE.
CROIX BL.
CRUZ EL.

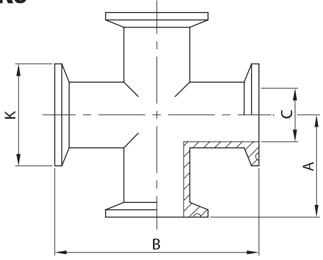
W9



DN		A	B	C	D	gr
1/2"	12	53,9	107,8	9,4	12,7	75
3/4"	19	53,9	107,8	15,7	19,0	130
1"	25	28,6	57,2	22,1	25,4	108
1 1/2"	38	42,1	84,2	34,8	38,1	220
2"	51	52,4	104,8	47,5	50,8	320
2 1/2"	63	59,5	119,0	60,2	63,5	460
3"	76	65,9	131,8	72,9	76,2	668
4"	101	87,3	174,6	97,4	101,6	1.200

CROCE E. SM.
CROSS E. FR.
CROIX B. FR.
CRUZ E. SM.

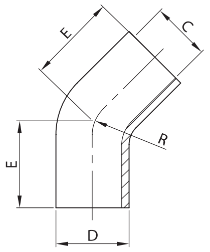
K9



DN		A	B	C	K	gr
1/2"	12	66,6	133,2	9,4	25,0	138
3/4"	19	66,6	133,2	15,7	25,0	200
1"	25	60,3	120,6	22,1	50,5	260
1 1/2"	38	69,9	139,8	34,8	50,5	400
2"	51	88,9	177,8	47,5	64,0	715
2 1/2"	63	88,9	177,8	60,2	77,5	810
3"	76	95,3	190,6	72,9	91,0	1.265
4"	101	114,3	228,6	97,4	119,0	1.880

CURVA 45° EL.
BEND 45° PE.
COUDE 45° BL.
CODO 45° EL.

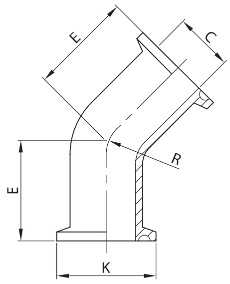
W2K



DN		C	D	E	R	gr
1/2″	12	9,4	12,7	57,1	44,4	40
3/4″	19	15,7	19,0	57,1	66,5	75
1″	25	22,1	25,4	30,2	38,1	50
1 1/2″	38	34,8	38,1	41,3	57,2	100
2″	51	47,5	50,8	58,7	76,2	180
2 1/2″	63	60,2	63,5	76,2	95,3	200
3″	76	72,9	76,2	93,7	114,3	500
4″	101	97,4	101,6	122,3	152,4	800

CURVA 45° E. SM.
BEND 45° E. FR.
COUDE 45° B. FR.
CODO 45° E. SM.

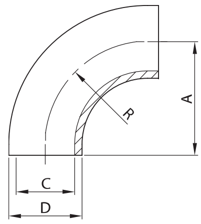
K2K



DN		C	E	K	R	gr
1/2″	12	9,4	69,8	25,0	44,4	70
3/4″	19	15,7	69,8	25,0	66,5	100
1″	25	22,1	28,6	50,5	38,1	120
1 1/2″	38	34,8	36,5	50,5	57,2	141
2″	51	47,5	44,5	64,0	76,2	227
2 1/2″	63	60,2	52,4	77,5	95,3	259
3″	76	72,9	60,3	91,0	114,3	540
4″	101	97,4	79,4	119,0	152,4	1.020

CURVA 90° ES.
BEND 90° WE.
COUDE 90° BS.
CODO 90° ES.

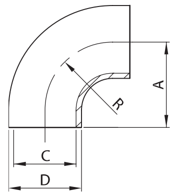
310 LA



DN		A	C	D	R	gr
1″	25	38,0	22,1	25,4	38,0	50
1 1/2″	38	57,0	34,8	38,1	57,0	120
2″	51	76,0	47,5	50,8	76,0	205
2 1/2″	63	95,0	60,2	63,5	95,0	325
3″	76	114,0	72,9	76,2	114,0	515
4″	101	152,0	97,4	101,6	152,0	815

CURVA 90° ES.
BEND 90° WE.
COUDE 90° BS.
CODO 90° ES.

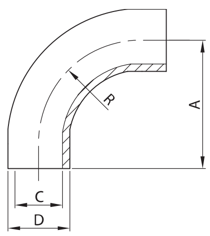
320 LA



DN		A	C	D	R	gr
1″	25	25,0	22,1	25,4	25,0	40
1 1/2″	38	38,0	34,8	38,1	38,0	100
2″	51	51,0	47,5	50,8	51,0	180
2 1/2″	63	64,0	60,2	63,5	64,0	295
3″	76	76,0	72,9	76,2	76,0	480
4″	101	101,0	97,4	101,6	101,0	770

CURVA 90° ES.
BEND 90° WE.
COUDE 90° BS.
CODO 90° ES.

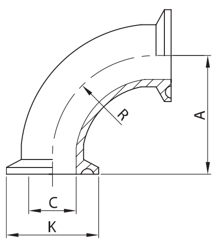
W2C



DN		A	C	D	R	gr
1/2″	12	76,2	9,4	12,7	44,4	56
3/4″	19	76,2	15,7	19,0	66,5	95
1″	25	52,4	22,1	25,4	38,1	160
1 1/2″	38	74,6	34,8	38,1	57,2	180
2″	51	103,2	47,5	50,8	76,2	340
2 1/2″	63	131,8	60,2	63,5	95,3	460
3″	76	160,3	72,9	76,2	114,3	700
4″	101	211,1	97,4	101,6	152,4	1.300

CURVA 90° E. SM.
BEND 90° E. FR.
COUDE 90° B. FR.
CODO 90° E. SM.

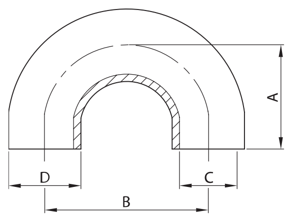
K2C



DN		A	C	K	R	gr
1/2″	12	88,8	9,4	25,0	44,4	90
3/4″	19	88,8	15,7	25,0	66,5	120
1″	25	50,8	22,1	50,5	38,1	170
1 1/2″	38	69,9	34,8	50,5	57,2	200
2″	51	88,9	47,5	64,0	76,2	370
2 1/2″	63	108,0	60,2	77,5	95,3	500
3″	76	127,0	72,9	91,0	114,3	910
4″	101	168,3	97,4	119,0	152,4	1.660

CURVA 180° EL.
BEND 180° PE.
COUDE 180° BL.
CODO 180° EL.

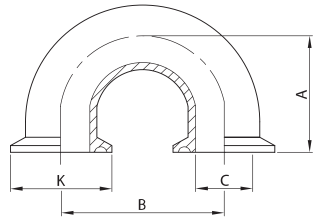
W3C



DN		A	B	C	D	gr
1″	25	86,5	73,0	22,1	25,4	170
1 1/2″	38	102,0	104,0	34,8	38,1	320
2″	51	125,5	151,0	47,5	50,8	500
2 1/2″	63	140,0	180,0	60,2	63,5	740
3″	76	147,0	194,0	72,9	76,2	1.180
4″	101	150,0	220,0	97,4	101,6	1.980

CURVA 180° E. SM.
BEND 180° E. FR.
COUDE 180° B. FR.
CODO 180° E. SM.

K3C



DN		A	B	C	K	gr
1″	25	99,2	73,0	22,1	50,5	340
1 1/2″	38	114,7	104,0	34,8	50,5	400
2″	51	138,2	151,0	47,5	64,0	740
2 1/2″	63	152,7	180,0	60,2	77,5	1.000
3″	76	159,7	194,0	72,9	91,0	1.820
4″	101	165,8	220,0	97,4	119,0	3.320

TUBERÍA P.V.C.- PRESIÓN

Tuberplas

NORMA UNE - EN - 1452

DIÁMETRO EXTERIOR mm		6 ATMÓSFERAS			10 ATMÓFERAS			16 ATMÓFERAS			20 ATMÓFERAS		
		e mm	Código	€/metro	e mm	Código	€/metro	e mm	Código	€/metro	e mm	Código	€/metro
ENCOLAR	16	-	-	-	-	-	-	-	-	-	1'5	499	1,15
	20	-	-	-	-	-	-	-	-	-	1'9	970	2,18
	25	-	-	-	-	-	-	1'9	563	2,10	2'3	971	2,69
	32	-	-	-	-	-	-	2'4	564	3,45	-	-	-
	40	-	-	-	1'9	546	2,79	3'0	565	4,61	-	-	-
	50	-	-	-	2'4	547	4,06	3'7	566	6,36	-	-	-
	63	2'0	530	4,19	3'0	548	6,15	4'7	567	9,58	-	-	-
	75	2'3	531	5,70	3'6	549	8,43	5'6	568	13,28	-	-	-
	90	2'8	532	8,07	4'3	550	12,08	6'7	569	19,04	-	-	-
	110	2'7	533	8,99	4'2	551	13,67	6'6	570	21,89	-	-	-
	125	3'1	534	11,75	4'8	552	17,62	-	-	-	-	-	-
	140	3'5	535	15,00	5'4	553	22,59	-	-	-	-	-	-
	160	4'0	536	19,09	6'2	554	29,07	-	-	-	-	-	-
	180	4'4	537	24,20	6'9	555	36,88	-	-	-	-	-	-
	200	4'9	538	29,16	7'7	556	44,86	-	-	-	-	-	-
	250	6'2	539	46,15	9'6	557	69,83	-	-	-	-	-	-
	315	7'7	540	71,85	12'1	558	110,85	-	-	-	-	-	-

DIÁMETRO EXTERIOR mm		6 ATMÓSFERAS			10 ATMÓSFERAS			16 ATMÓSFERAS		
		e mm	Código	€/metro	e mm	Código	€/metro	e mm	Código	€/metro
J. ELÁSTICA	63	2'0	406	4,25	3'0	418	6,33	4'7	429	9,88
	75	2'3	407	5,78	3'6	419	8,81	5'6	430	13,75
	90	2'8	408	8,15	4'3	420	12,37	6'7	431	19,64
	110	2'7	409	9,00	4'2	421	14,01	6'6	432	22,64
	125	3'1	410	11,83	4'8	422	18,02	7'4	433	28,83
	140	3'5	411	15,11	5'4	423	23,15	8'3	434	36,86
	160	4'0	412	17,90	6'2	424	29,77	9'5	435	47,21
	200	4'9	413	29,27	7'7	425	45,92	11'9	436	75,02
	250	6'2	414	46,80	9'6	426	71,46	14'8	437	114,45
	315	7'7	415	72,82	12'1	427	113,45	18'7	979	182,10
	400	9'8	416	117,27	15'3	428	181,70	23'7	980	271,07
	500	12'3	417	183,97	19'1	977	283,27	29'7	981	426,58
	630	15'4	975	289,57	24'1	978	449,69	-	-	-

TUBERÍA P.V.C. ALBAÑAL (SIN NORMA)

ENCOLAR	DIÁMETRO	160	200	250	315
	espesor	2 mm	2'5 mm	3'1 mm	3'9 mm
	Código	500	501	502	503
	€/metro	15,70	24,41	36,67	55,18

ACCESORIOS P.V.C.- PRESIÓN

Tuberplas

DIÁMETRO mm	BRIDA Código	BRIDA €/Ud	JUNTA POLIETILENO Código	JUNTA POLIETILENO €/Ud	PORTABRIDAS Código	PORTABRIDAS €/Ud	MANGUITO UNIÓN Código	MANGUITO UNIÓN €/Ud	TE Código	TE €/Ud	TAPÓN Código	TAPÓN €/Ud	DIÁMETRO mm
16	-	-	-	-	-	-	699	1,02	776	1,05	765	0,70	**16**
20	-	-	-	-	-	-	700	0,99	777	0,98	766	0,78	**20**
25	601	5,59	-	-	711	2,20	701	1,18	778	1,38	767	0,91	**25**
32	602	6,18	-	-	712	2,40	702	1,38	779	1,85	768	1,22	**32**
40	603	7,19	2590	1,38	713	3,08	703	2,06	780	3,27	769	1,92	**40**
50	604	8,08	2591	1,69	714	3,83	704	2,31	781	4,03	770	2,77	**50**
63	605	8,89	1712	1,80	715	4,74	705	3,42	782	5,75	771	3,83	**63**
75	606	11,54	1701	2,40	716	6,47	706	7,09	783	12,07	772	7,28	**75**
90	607	12,31	1702	2,65	717	9,73	707	9,15	784	22,18	773	11,86	**90**
110	608	16,71	1703	3,33	718	11,34	708	15,06	785	32,42	774	23,99	**110**
125	-	-	1704	3,98	719	16,05	709	26,67	786	53,15	775	33,61	**125**
125-140	609	29,76	-	-	-	-	-	-	-	-	-	-	**125-140**
140	610	27,27	-	-	720	21,44	901	39,45	787	80,75	893	43,93	**140**
160	611	32,98	1705	4,96	721	27,59	710	46,27	788	95,72	916	50,78	**160**
200	-	-	1706	6,28	722	50,48	909	79,87	790	153,14	917	63,15	**200**
200-225	612	50,59	-	-	-	-	-	-	-	-	-	-	**200-225**
250	613	112,26	1607	21,04	723	125,57	889	231,01	792	472,08	993	229,06	**250**
315	614	170,83	1608	33,84	724	195,48	890	326,08	793	848,44	994	353,65	**315**
400	997	330,62	-	-	998	465,59	-	-	-	-	-	-	**400**

CODO

ÁNGULO	45º		90º	
DIÁMETRO mm	Código	€/Ud	Código	€/Ud
16	629	1,18	615	0,85
20	630	1,18	616	0,81
25	631	1,54	617	0,99
32	632	2,06	618	1,52
40	633	2,56	619	2,11
50	634	3,21	620	2,93
63	635	4,66	621	4,48
75	636	9,33	622	8,27
90	637	13,80	623	13,99
110	638	23,11	624	26,07
125	639	33,61	625	37,47
140	640	62,47	626	64,13
160	641	66,17	627	74,83
200	642	98,15	628	117,45
250	883	336,30	881	412,05
315	884	955,51	882	830,59

CURVA

45º		90º		ÁNGULO
Código	€/Ud	Código	€/Ud	DIÁMETRO mm
672 *	28,17	-	-	**90**
674 *	58,21	665	229,23	**125**
675 *	80,27	666	241,72	**140**
676 *	123,14	-	-	**160**

CODO TRANSICIÓN

DIÁMETRO (mm x ")	Código	€/Ud
20 x ½"	643	1,78
25 x ¾"	644	2,06
32 x 1"	645	2,76
40 x 1 ¼"	646	3,65
50 x 1 ½"	647	5,40
63 x 2"	648	7,58

*HASTA AGOTAR EXISTENCIAS

ACCESORIO P.V.C.-PRESIÓN

Tuberplas

MEDIDA	MANGUITO TRANSICIÓN ROSCA MACHO Código	MANGUITO TRANSICIÓN ROSCA MACHO €/Ud	MANGUITO TRANSICIÓN ROSCA HEMBRA Código	MANGUITO TRANSICIÓN ROSCA HEMBRA €/Ud	TE TRANSICIÓN Código	TE TRANSICIÓN €/Ud	MEDIDA
16 x 3/8"	689	1,33	681	1,80	-	-	16 x 3/8"
20 x 1/2"	690	1,33	682	1,80	828	2,26	20 x 1/2"
25 x 3/4"	691	1,49	683	2,06	829	2,56	25 x 3/4"
32 x 1"	692	1,75	684	2,29	830	3,22	32 x 1"
40 x 11/4"	693	2,32	685	3,02	831	5,27	40 x 11/4"
50 x 11/2"	694	2,35	686	3,89	832	7,25	50 x 11/2"
63 x 2"	695	3,69	687	5,53	833	11,76	63 x 2"
75 x 21/2"	696	8,06	688	12,07	-	-	75 x 21/2"
90 x 3"	697	16,30	902	18,26	-	-	90 x 3"
110 x 4"	698	24,61	885	29,04	-	-	110 x 4"

MACHÓN DOBLE ROSCA

DIÁMETRO (")	Código	€/Ud
3/8"	886	1,38
1/2"	854	1,47
3/4"	855	1,74
1"	856	2,06
11/4"	857	2,56
11/2"	858	3,36
2"	859	4,28
21/2"	887	7,58
3"	888	11,85

DIÁMETRO(mm)	UNIÓN GIBAULT CUELLO LARGO PARA P.V.C. Código	UNIÓN GIBAULT CUELLO LARGO PARA P.V.C. €/Ud	TUERCA UNIÓN Código	TUERCA UNIÓN €/Ud
16	-	-	834	3,31
20	-	-	835	3,27
25	-	-	836	3,76
32	-	-	837	5,28
40	-	-	838	6,41
50	-	-	839	6,80
63	844	21,55	840	9,99
75	845	26,62	841	33,19
90	846	30,90	891	43,93
110	847	39,93	892	64,24
125	848	45,41	-	-
140	849	49,31	-	-
160	850	60,90	-	-
180	913	77,09	-	-
200	851	98,67	-	-
250	852	145,37	-	-
315	853	184,24	-	-
50 x 1½" RM	-	-	842	9,76
63 X 2" RM	-	-	843	15,05

COLLARÍN DE TOMA

	ROSCA	DIÁMETRO (mm)	Código	€/Ud
POLIETILENO	½"	25	903	3,99
		32	904	5,46
		40	3764	5,97
		50	3765	6,23
	¾"	25	877	3,99
		32	878	5,46
		40	905	5,97
		50	3766	6,23
		63	3767	6,43
		75	3768	6,93
		90	3769	8,01
	1"	40	649	5,97
		50	650	6,23
		63	906	6,43
		75	3780	6,93
		90	3781	8,01
		110	3783	10,24
	1 1/4"	90	3782	8,01
		110	3784	10,24
	1 1/2"	75	3785	7,24
		90	3786	9,16
		110	3788	10,81
FUNDICIÓN	1"	50	651	13,08
		63	652	14,57
		75	653	15,32
		90	654	18,64
	1 ¼"	110	655	26,40
		125	656	35,77
		160	657	31,43
		200	658	58,33

ACCESORIO PVC-PRESIÓN

REDUCCCIÓN CASQUILLO

DIÁMETROS (mm)		Código	€/Ud
D	d		
20	16	725	0,65
25	20	726	0,73
32	20	727	1,05
32	25	728	0,73
40	20	729	1,61
40	25	730	1,61
40	32	731	1,18
50	20	732	2,11
50	25	733	2,11
50	32	734	2,11
50	40	735	1,50
63	32	737	2,82
63	40	738	2,82
63	50	739	2,00
75	40	741	4,18
75	50	742	4,18
75	63	743	3,57
90	40	744	7,99
90	50	745	7,99
90	63	746	7,99
90	75	747	7,99
110	50	748	14,64
110	63	749	12,98
110	75	750	14,64
110	90	751	14,64
125	75	915	17,32
125	90	825	17,02
125	110	752	13,68
140	110	753	22,37
140	125	754	19,94
160	125	755	29,49
160	140	756	26,07
200	160	758	46,98
250	200	759	101,39
315	250	760	400,70
400	315	999	418,54

REDUCCIÓN CÓNICA

50	25	491	2,40
63	25	736	3,83
75	32	740	6,13
140	110	492	24,63

TE REDUCIDA

DIÁMETROS (mm)			Código	€/Ud
D_1	D_2	D_3		
25	20	25	794	1,74
32	25	32	796	2,37
40	20	40	797	4,12
40	25	40	798	4,12
40	32	40	799	4,12
50	32	50	802	5,28
50	40	50	803	5,28
63	32	63	806	8,86
63	40	63	807	8,86
63	50	63	808	8,86
75	50	75	811	15,01
90	75	90	816	26,63
110	63	110	818	38,09
110	75	110	819	38,09
125	63	125	864	63,25
125	75	125	865	63,25
125	90	125	821	63,25
125	110	125	822	63,25
160	110	160	823	112,42

ADAPTADOR TRANSICIÓN

DIÁMETROS (mm x ")	Código	€/Ud
25-20 x ½"	761	2,77
32-25 x ¾"	762	3,46
40-32 x 1"	763	3,89
50-40 x 1 ¼"	764	5,53

ABRAZADERA PLÁSTICO

DIÁMETRO (mm)	Código	€/Ud
20	591	1,11
25	592	1,16
32	593	1,47
40	594	1,76
50	595	2,16
63	596	2,53
75	597	3,35
90	598	3,90
110	599	7,58
125	600	8,55

ELEMENTOS DE SUJECIÓN

ABRAZADERA

DIÁMETRO 8 a 63 - MÉTRICA 6

DIÁMETRO 75 a 315 - MÉTRICA 8

DIÁMETRO mm	Código	€/Ud
8	1716	0,26
10	1800	0,26
12	1801	0,26
14	1717	0,26
15	1802	0,27
16	1718	0,28
18	1803	0,29
20	1804	0,30
22	1805	0,31
25	2514	0,32
26	1806	0,33
28	1807	0,34
32	1808	0,38
35	1719	0,44
37	1720	0,34
40	2057	0,47
42	1809	0,48
47	1721	0,57
50	1810	0,59
54	1722	0,71
60	1723	0,77
63	1811	0,80
75	1812	2,21
90	1813	2,20
110	1814	2,18
125	1815	2,30
160	1816	3,38
200	1817	4,21
250	1714	7,51
315	1774	10,30

ABRAZADERA CIERRE

DIÁMETRO mm	Código	€/Ud
15	1732	0,42
16	1733	0,46
18	1734	0,49
20	1735	0,50
22	1736	0,51
25	3057	0,56
28	1737	0,56
32	1738	0,70
35	1739	0,58 **
40	1740	0,79
50	1741	0,98
TOPE GUÍA	1742	0,56
GUÍA 1 mt METÁLICA	3058	6,34

ABRAZADERA ISOFÓNICA M-6

DIÁMETRO mm	Código	€/Ud
12	2219	0,40
15	2220	0,46
18	2221	0,48
22	2222	0,52
25/26	2397	0,58
28	2223	0,60
35	2224	0,76
42	2225	1,00
54	2226	1,34

ABRAZ. PLASTIFICADA CON TIRAFONDO M-6

DIÁMETRO mm	Código	€/Ud
12	1724	0,53
15	1725	0,55
18	1726	0,57
22	1727	0,61
28	1728	0,65
32	1729	0,64 **
35	1730	0,80
42	1731	0,88

GRAPA PUENTE

DIÁMETRO mm	Código	€/Ud
20	2737	0,25
32	2315	0,36
37	2316	0,34
42	2317	0,40
47	2318	0,43
52	2319	0,37 **
62	2320	0,45 **

ABRAZADERA CLAC M-6

DIÁMETRO mm	Código	€/Ud
12	4612	0,42 **
22	4615	0,55 **

CLIP DOBLE M-6

CLIP M-6

DIÁMETRO mm	Clip doble M-6 Código	Clip doble M-6 €/Ud	Clip M-6 Código	Clip M-6 €/Ud
12	1790	0,60	1794	0,34
15	1791	0,64	1795	0,37
18	1792	0,83	1796	0,46
22	1793	0,70	1797	0,48
-	-	-	-	-

ABRAZADERA DOBLE M-6

MEDIDA	Código	€/Ud
12	4618	0,43
15	4619	0,47
18	4620	0,52
22	4621	0,59
28	4622	0,68

ESPÁRRAGO CON SEPARADOR

MEDIDA	Código	€/Ud
M-6 x 20	4609	0,28
M-8 x 20	4610	0,38
M-6 x 30	1798	0,53
M-8 x 30	1799	0,69
-	-	-

** Hasta Fin de Existencias.

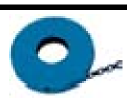
Los datos, fotos y esquemas de la tarifa no son vinculantes y están sujetos a modificación sin previo aviso.

ELEMENTOS DE SUJECIÓN

Tuberplas

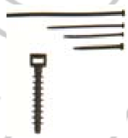



DIÁMETRO	ABRAZADERA REFORZADA Código	ABRAZADERA REFORZADA €/Ud.	ABRAZADERA PERA Código	ABRAZADERA PERA €/Ud.	ABARCÓN Código	ABARCÓN €/Ud.	ABRAZADERA ISOFÓNICA DIÁMETRO mm	DIÁMETRO "	ROSCA FIJACIÓN (MÉTRICA)	Código	€/Ud.
1/4"	-	-	-	-	-	-	15	1/4"	M8+M10	1764	1,29
3/8"	-	-	-	-	-	-	18	3/8"	M8+M10	1765	1,31
1/2"	1789	1,02	-	-	4600	0,53	22	1/2"	M8+M10	1766	1,35
3/4"	1743	1,05	-	-	4601	0,69	26-28	3/4"	M8+M10	1767	1,48
1"	1744	1,11	1751	1,05	4602	0,70	35	1"	M8+M10	1768	1,61
1 1/4"	1745	1,19	1752	1,10	4603	0,70	40-42	1 1/4"	M8+M10	1769	1,78
1 1/2"	1746	1,21	1753	1,18	4604	1,31	48-50	1 1/2"	M8+M10	1770	1,95
2"	1747	1,34	1754	1,43	4605	1,43	60	2"	M8+M10	1771	2,11
2 1/2"	1748	1,57	1755	2,06	4606	1,95	75	2 1/2"	M8+M10	1772	2,74
3"	1749	1,75	1756	2,21	4607	2,10	90	3"	M8+M10	1773	3,42
110	2505	2,66	-	-	-	-	110	-	M8+M10	2502	4,05
4"	1750	2,59	1758	2,78	4608	2,75	115	4"	M8+M10	1775	4,82
125	2506	3,37	-	-	-	-	125	-	M8+M10	2503	4,62
5"(140)	2508	4,04	1759	5,11	4616	4,71	140	5"	M8+M10	1776	7,41
6"(160)	2510	4,17	1760	6,75	4617	5,34	160	6"	M8+M10	2504	6,03



CINTA PERFORADA

MEDIDA	Cód.	€/Ud.
ROLLO 10 mts.	1836	10,76



BRIDA NYLON

MEDIDA	Cód.	€/Ud.
2'5 x 160	1874	0,04
3'6 x 290	1871	0,11
4'8 x 360	1872	0,18
TACO BRIDA	1873	0,20

TACO NYLON

TIPO	Cód.	€/Ud.
N 6	1861	0,06
N 8	1862	0,14
N 10	1863	0,19
N 12	1864	0,33

ABRAZ. HIERRO (GALVANIZADA)

Ø	50	75	90	110	125	160	200	250	315
Cód.	55	56	57	58	59	60	61	62	63
€/Ud.	1,42 **	1,91	1,99	2,21	2,44	3,03	3,36	6,34	7,98

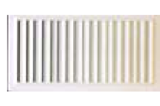
** HASTA AGOTAR EXISTENCIAS

ANCLAJE METÁLICO STANDARD (FISCHER)



	CON GANCHO	C/ HEMBRILLA CERRADA	CON TORNILLO EXAGONAL
TIPO	FMS-G 8	FMS-H 8	FMS-T 8-L
Cód.	1867	1866	1865
€/Ud.	1,80	1,80	0,99

REJILLA P.V.C. VERTICAL CON MARCO




	Cód.	€/Ud.
S/CIERRE	1827	4,48
C/CIERRE	1839	5,52

TORNILLO DOBLE ROSCA (DOWELL)

MEDIDA	Cód.	€/Ud.
M-8 x 80	1940	0,27
M-8 x 90	1941	0,30
M-8 x 100	1942	0,33
M-8 x 120	1943	0,59

ELEMENTOS DE SUJECIÓN

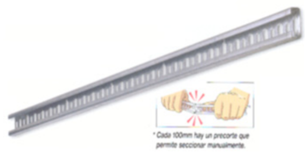
Tuberplas

MEDIDA	VARILLA ROSCADA (1 metro)		TACO METÁLICO		TUERCA HEXAGONAL		ARANDELA METÁLICA		TIRAFONDOS		MEDIDA
											
	Código	€/Ud.	Código	€/Ud.	Código	€/Ud.	Código	€/Ud.	Código	€/Ud.	
M-6	1820	**1,21**	1833	**0,25**	1824	**0,06**	1828	**0,06**	1818	**0,10**	**M-6**
M-8	1821	**1,89**	1834	**0,34**	1825	**0,07**	1829	**0,09**	1819	**0,28**	**M-8**
M-10	1822	**3,36**	1835	**0,48**	1826	**0,21**	1830	**0,12**	1786	**0,74**	**M-10**
M-12	1778	**4,90**	1780	**1,15**	1782	**0,30**	1784	**0,20**	-	-	**M-12**
M-16	1779	**10,85**	1781	**2,53**	1783	**0,47**	1785	**0,33**	-	-	**M-16**
M-20	-	-	-	-	2586	**1,17**	2587	**0,41**	-	-	**M-20**

TACO PLÁSTICO			BROCA DE WIDIA			MANGUITO		
								
MEDIDA	Código	€/Ud.	MEDIDA	Código	€/Ud.	MEDIDA	Código	€/Ud.
M-6	1831	**0,03**	**6 mm**	2996	**2,34**	**M-6 x 20**	2994	**0,31**
M-8	1832	**0,05**	**8 mm**	2997	**3,31**	**M-8 x 20**	2995	**0,50**
M-10	1787	**0,09**	**10 mm**	2998	**6,27**	**M-10 x 30**	2999	**0,82**

ABRAZADERA ABRANYL		
MEDIDA	Código	€/Ud.
14-18	4690	**0,37**
20-25	4691	**0,41**
26-32	4692	**0,49**

Tuerca M-6 de fácil inserción para fijar todo tipo de elementos roscados.



INSERMAX		TACOMAX		PERFIL PVC	
Código	€/Ud.	Código	€/Ud.	Código	€/Ud.
4693	**0,12**	4694	**0,10**	4696	**3,05**

JGO.TORNILLO INOD./BIDÉ LATERAL		JGO.TORNILLO LAVABO		JGO.TORNILLO INOD./BIDÉ	
Código	€/Ud.	Código	€/Ud.	Código	€/Ud.
4623	**2,06**	6692	**3,23**	6693	**2,36**

TORNILLO		
MEDIDA	Cód.	€/Ud.
M-16 X 60	2077	**1,33**
M-16 X 80	2078	**1,65**
M-16 X 100	2079	**1,98**
M-16 X 120	2089	**2,12**

Quotation VENAIR

De: Allan Franco <afranco@venair.com>
Enviado el: lunes, 26 de junio de 2023 8:55
Para: Raul Payri <rpayri@mot.upv.es>
CC: Yolanda Ruiz <yruiz@venair.com>
Asunto: RE: Solicitud oferta tubo flexible

Hola Prof. **Raul,**

Gracias por contactarnos.
Soy **Allan Franco**, comercial de **VENAIR** para la zona de Levante.
Somos los fabricantes de este tubo.
Este tipo de material solamente vendemos en tramos de 4m

VENA HTD Ø102mm
REF: **510210000102**
Precio: **302,27€** tramo de 4m.
Material en stock.
Portes debidos en factura.
Primera operación al contado (transferencia bancaria).

Por favor, enviadnos los datos fiscales para abrir ficha de cliente y posterior realización de factura proforma.

Saludos
Meus melhores cumprimentos

Allan Franco Da Silva
Sales Executive
venair
c/ Cerdanya, 26 08826 Terrassa (Barcelona) - Spain
(+34) 93 736 48 61 / (+34) 650 334 874

TÉCNICA Y MANTENIMIENTO, S.A.
Camino del Fus, 59 · 46470 Massanassa (Valencia)
Tel. 96 125 30 55 • tecniman@tecniman.es
www.tecniman.es

Dirección de facturación:
UNIVERSIDAD POLITEC. VALENCIA
UNIVERSIDAD POLITECNICA VALENCIA
CAMINO DE VERA, S/N
46022 VALENCIA
València (Valencia) España

NIF: ESQ4618002B

Dirección de envío:
UNIVERSIDAD POLITEC. VALENCIA
Dirección fiscal
Tlf: 963879245
CAMINO DE VERA, S/N
46022
València (Valencia) España

Presupuesto # P/2023/01/10233

Fecha de presupuesto:	**Comercial:**	**Att por:**
29/06/2023 13:48:22	CASA,	Luis Rodriguez

Línea	Código	Descripción	Cantidad	Precio unitario	Desc. (%)	Desc. 2(%)	Desc. 3(%)	Precio
1	FIC190119001016	CASQ. CLAMP SOLDAR PLATO D.119'0 TUBO 101'6 MM. 4"	3,00	11,07000	20,00	0,00	0,00	26,57 €
2	FIC191001190	ABRAZ. CLAMP PLATO D.119'0 MM. 4" DIN-100	6,00	18,68000	20,00	0,00	0,00	89,66 €
3	FIC192001190	JUNTA CLAMP EPDM PLATO D.119'0 MM. DN100 4"	6,00	4,29000	20,00	0,00	0,00	20,59 €
4	2	CARGO PORTES VENTAS	1,00	12,00000	0,00	0,00	0,00	12,00 €

Total base	148,82 €
I.V.A. 21%	31,25 €
Total	180,07 €
Descuento Financiero :	0,00 %
Total con descuento :	180,07 €

Quotation SuperFlow

Miguel Prieto Baumann <miguelp@powertestdyno.com>
Aan: Maxime De Coen
Zo 25-6-2023 17:34

SF1600v001-Flowbenches-Se...
695 kB

Hello Maxime,

I'm responsable for Europe .
I'm located in Austria but I'm Spanish. If you want, I can contact directly with the responsible in Valencia.
In order to offer complete Equipment I would like to know what equipment do you want to test and what kind of test you want to perform.
We have PortFlow software, Valve opener, adapters for cylinder heats etc...

The basic price for the 1020 Pro Bench is 26.565 USD EXW Wisconsin. This price do not include handling , Packing and Shipping.
For Testing equipment imported form USA to the EU there is no Import tax (0%)

The Flow Bench
- Designed for high pressure or high air flow testing
- Intake and Exhaust flow capability: 1000 cfm ± 10% @ 25" test pressure
- Maximum test pressure of 65" of water
- Includes FlowCom digital airflow measurement system and motor controller for automated flow or pressure control, repeatable tests and external inputs for velocity probes.
- Stand alone cabinet well suited to test cylinder heads, intake manifolds, air intakes, throttle bodies and carburetors, catalytic converters, particulate filters and other exhaust system components.
- Cabinet includes storage area for test fixtures
- Flat surface with no obstructions for easy fixture mounting and a work space next to the test plate.
- System includes bench flowcheck test plate, operators manual and one year warranty.
- 240 VAC, 75 Amp 50-60 Hz, single phase power
- Weighs 563 lbs

Best regards,

Miguel Prieto Baumann
phone: (+43) 664 191 8472
miguelp@powertestdyno.com
www.powertestdyno.com

ESCOLA TECNICA SUPERIOR ENGINYERIA INDUSTRIAL VALENCIA
UNIVERSITAT POLITECNICA DE VALENCIA
Camí de Vera s/n – Edificio 5F
46022 VALÈNCIA, España
tel. + 34 963 87 71 70
informatica@etsii.upv.es
https://www.etsii.upv.es/