MECHANICAL ENGINEERING PROJECT I

ÇUKUROVA UNIVERSITY
DEPARTMENT OF MECHANICAL ENGINEERING

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PROJECT TITLE: Pneumatic Tube Transfer System Automation

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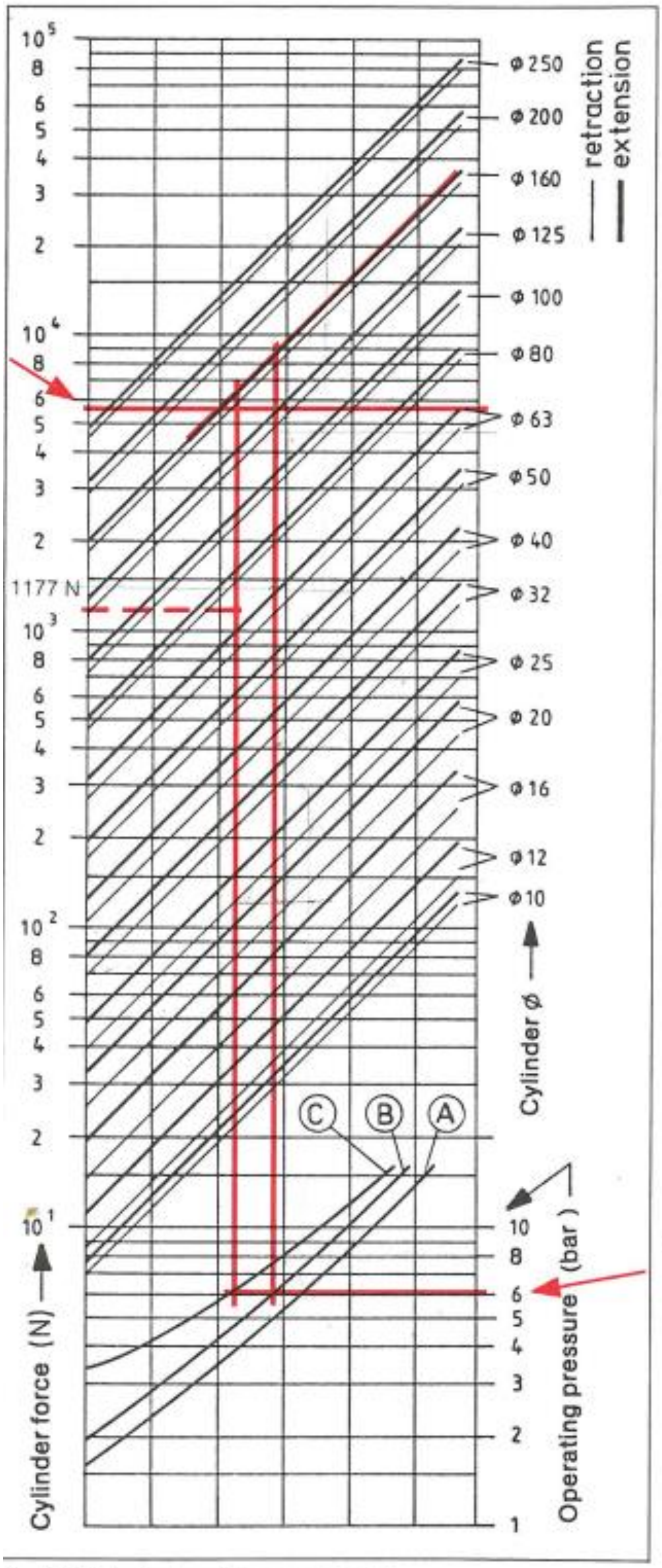


Fig. 3-26 Actuator sizing nomogram.

fig 3-26.

Aim of the Project

Pneumatic tube systems are a type of material handling system that uses compressed air to transport carriers through a network of tubes. These systems are commonly used in hospitals, banks, and other facilities where there is a need for rapid and efficient transport of small items. A significant limitation of pneumatic tube systems is that they are not fully automatic. However, my project aims to be the solution for this issue.The main aim of this project is remove the need for human intervention in pneumatic tube systems as a conclusion of this elimination pneumatic tube systems will work much more efficient and achieve greater stability.

Deisgn Considerations

This project proposes a novel design for pneumatic tube systems specifically tailored for transporting medical samples. With the primary objective of aiding medical staff, the design prioritizes:

Enhanced Efficiency: Compared to manual transport, the system boasts significantly faster delivery times, minimizing sample exposure and expediting critical medical processes.

Minimized Risk of Damage: The design ensures safe and secure transport, eliminating potential harm to sensitive samples caused by human error or environmental factors.

Reduced Error Potential: Automated operation eliminates the risk of confusion among samples, guaranteeing accurate delivery to the designated destination.

Beyond these core objectives, the design excels in its user-friendliness and safety:

Intuitive Usability: Designed for near-complete automation, the system requires minimal user interaction and can be operated safely and effectively even under pressure.

Emergency Stopping Mechanism: Equipped with an easily accessible stop button, the system can be safely halted in case of unforeseen circumstances, ensuring sample integrity remains uncompromised.

Material selection focuses on optimal performance and sample protection:

Carrier: Borosilicate glass, chosen for its exceptional thermal shock resistance and low coefficient of thermal expansion, safeguards samples against temperature fluctuations. Additionally, the outer shell utilizes high-strength polyurethane, offering excellent impact resistance and low density for efficient transport.

Tube System: Cost-effective and readily available, PVC serves as the perfect material for the tubing network, ensuring leak-proof operation and ease of installation.

Safety remains paramount throughout the design, employing minimal forces that pose no risk to users or samples. While aesthetics are considered less significant given the typically concealed nature of tube systems within walls, the overall design prioritizes functionality and reliability.

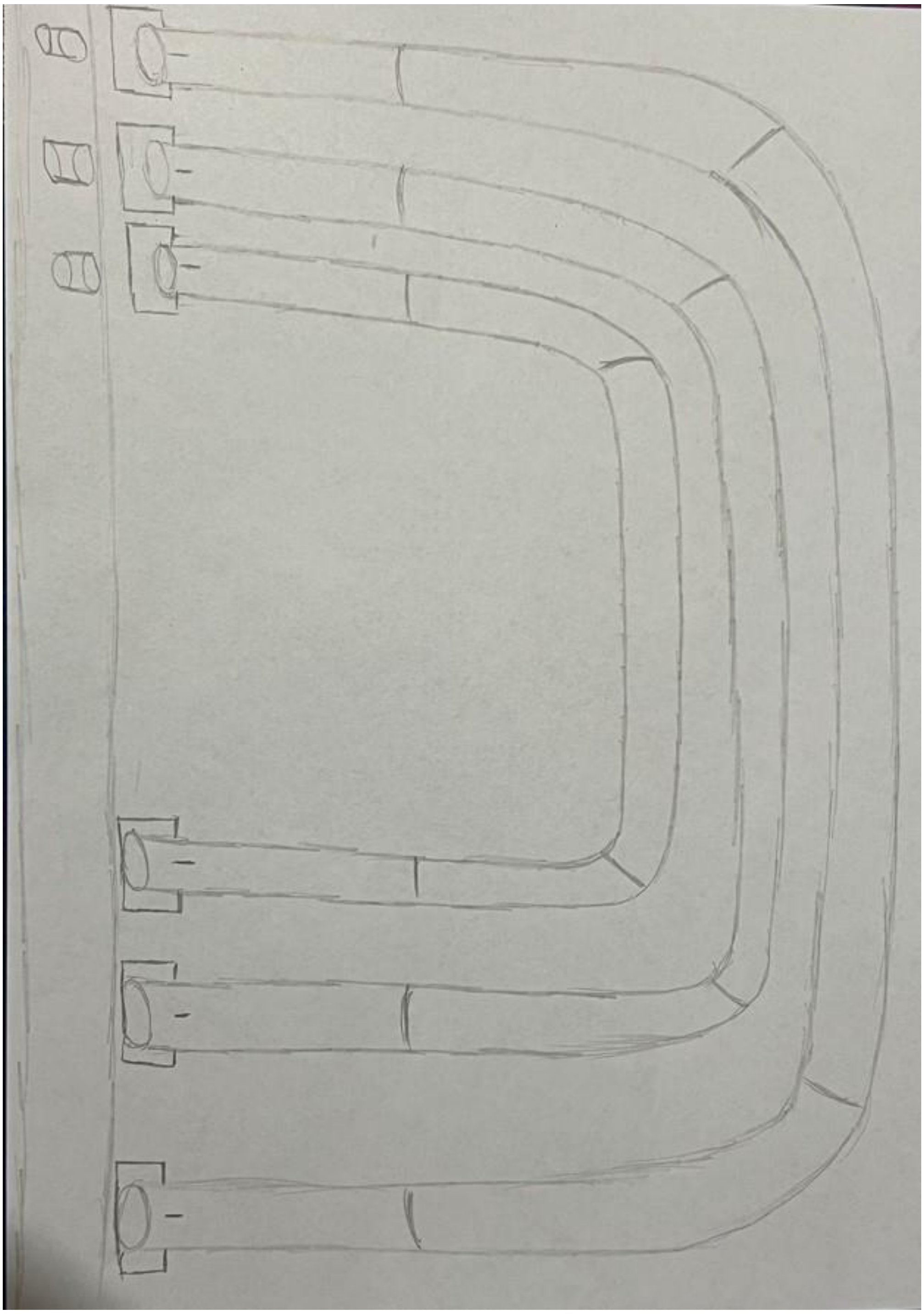
In conclusion, this project presents a well-considered pneumatic tube system design optimized for medical sample transport. By prioritizing efficiency, safety, and user-friendliness, the proposed system holds significant potential to streamline medical operations and ensure the integrity of critical samples.

Project Planning

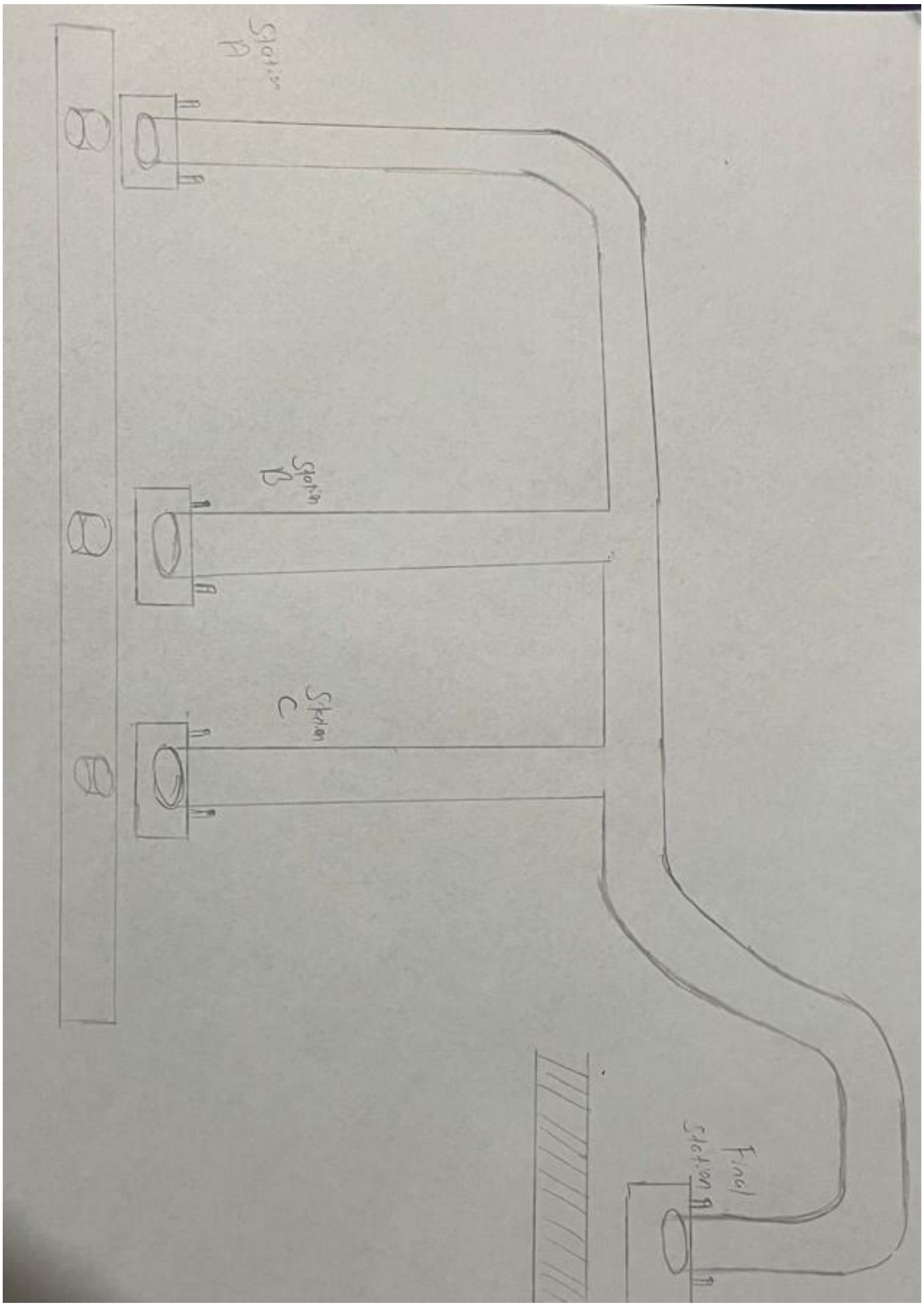
Tasks	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14	WEEK 15
Defination of Problem													
Concept Generation													
1.Concept A													
2.Concept B													
3.Concept C													
Development of The Design													
1.Schematic Layout													
2.Program Flow Chart													
3.Step-counter Chart													
Designing of Actuators													
1.Sizing of the Actuators													
2.Air Consumption for Actuators													
Technical Drawing													

Concept Generation

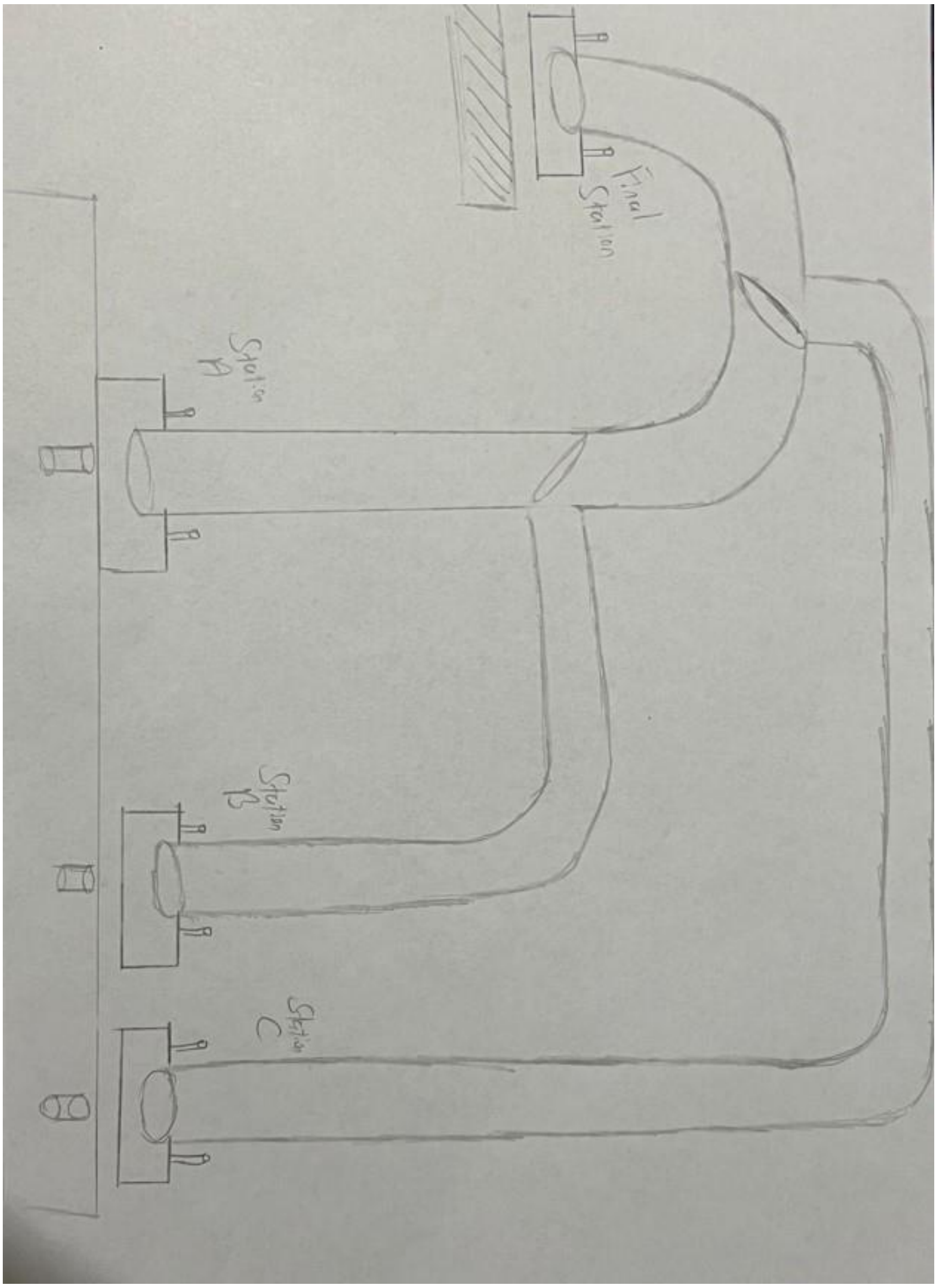
Concept A



Concept B



Concept C



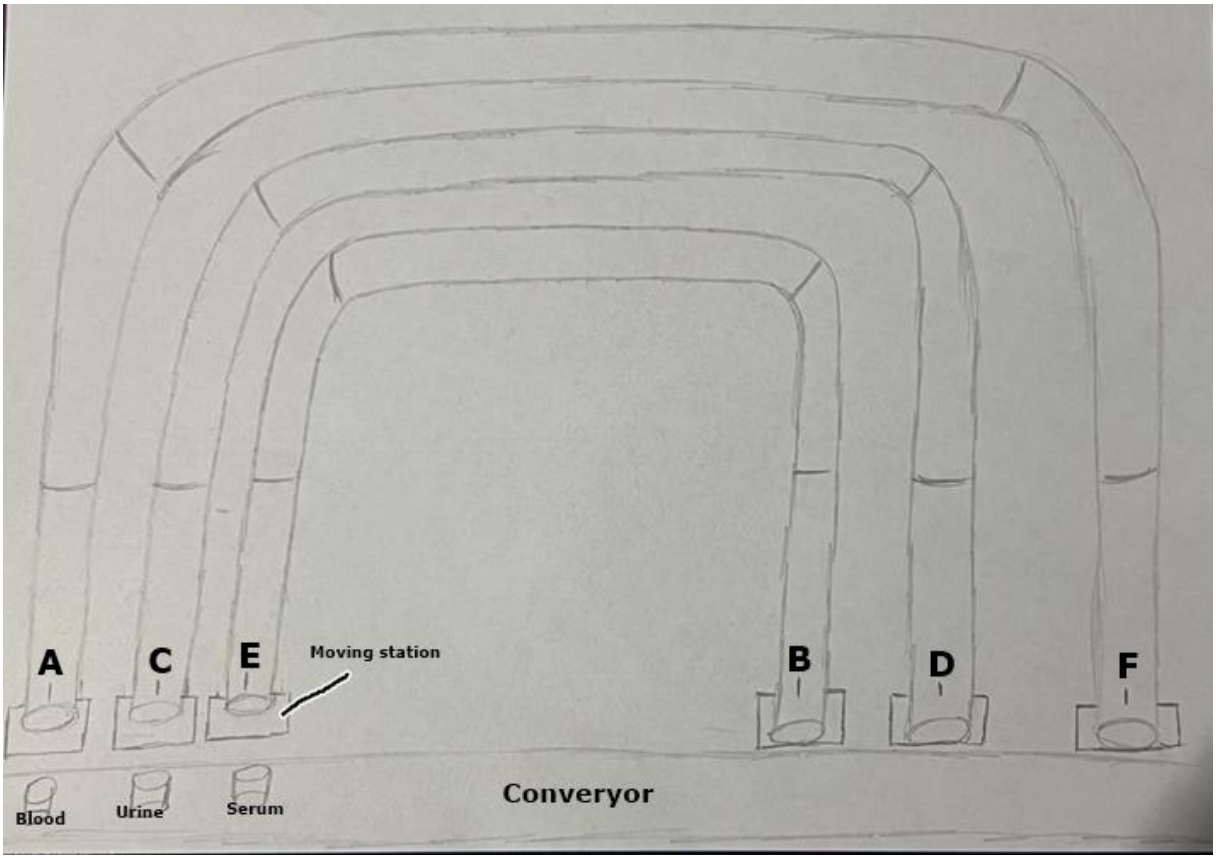
Weighted Decision Matrix

WEIGHTED DECISION MATRIX TEMPLATE

Prioratization Criteria	Value	Concept A	Score	Concept B	Score	Concept C	Score
Number of Parts	0.2	6	1.2	8	1.6	7	1.4
Ease of Manufacture	0.2	10	2	6	1.2	7	1.4
Cost	0.3	10	3	8	2.4	9	2.7
Applicability	0.2	7	1.4	3	0.6	5	1
Weight	0.1	5	0.5	8	0.8	7	0.7
Total	1	38	8.1	33	6.6	35	7.2

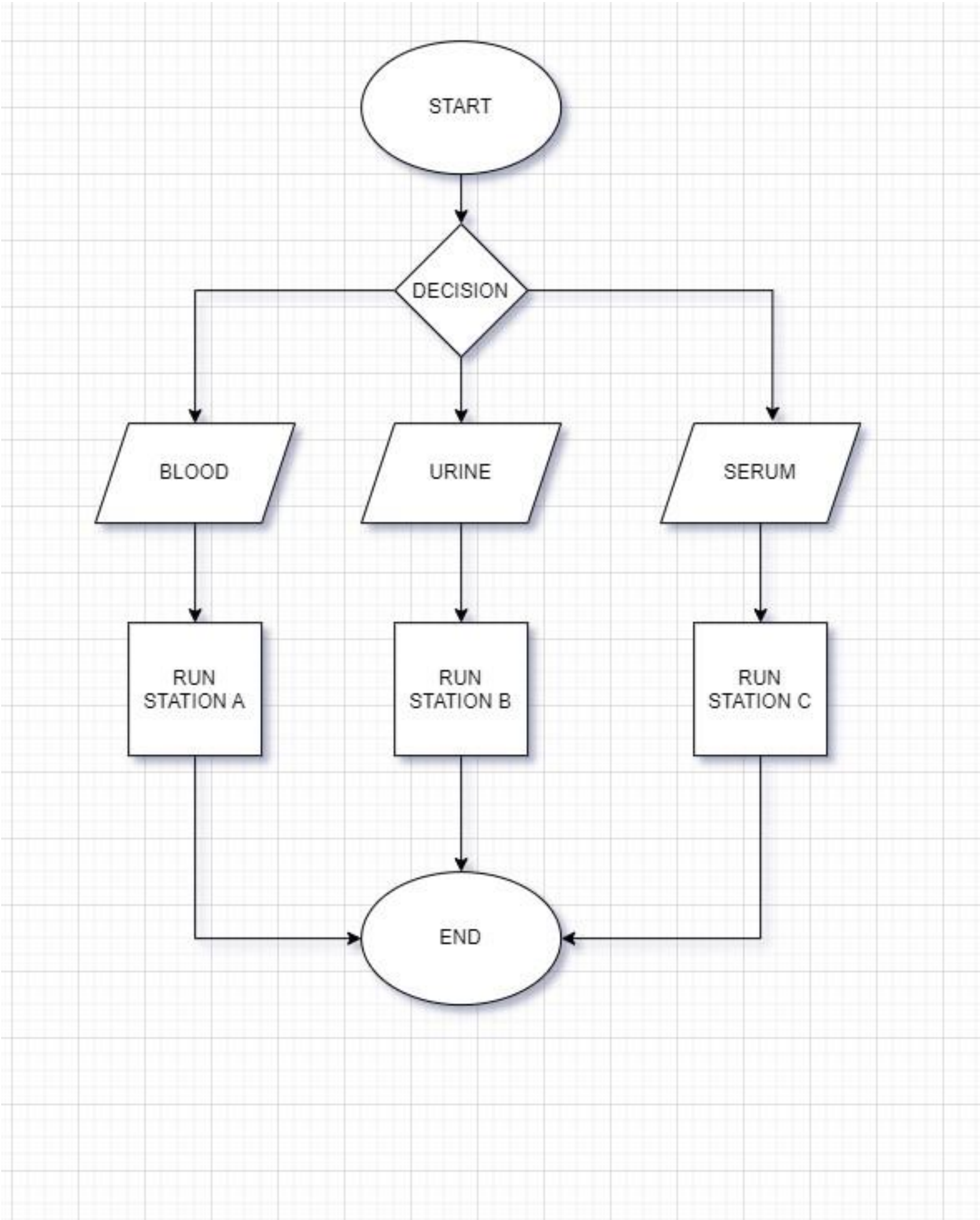
Development of Design

Schematic Layout



Description	Function
Actuator A	Slowly pushing down the moving station to conveyor and gripping the conveyor
Actuator B	Slowly pushing down the moving station to conveyor and gripping the conveyor but working contrary with actuator A
Actuator C	Slowly pushing down the moving station to conveyor and gripping the conveyor
Actuator D	Slowly pushing down the moving station to conveyor and gripping the conveyor but working contrary with actuator C
Actuator E	Slowly pushing down the moving station to conveyor and gripping the conveyor
Actuator F	Slowly pushing down the moving station to conveyor and gripping the conveyor but working contrary with actuator E

Program Flow Chart



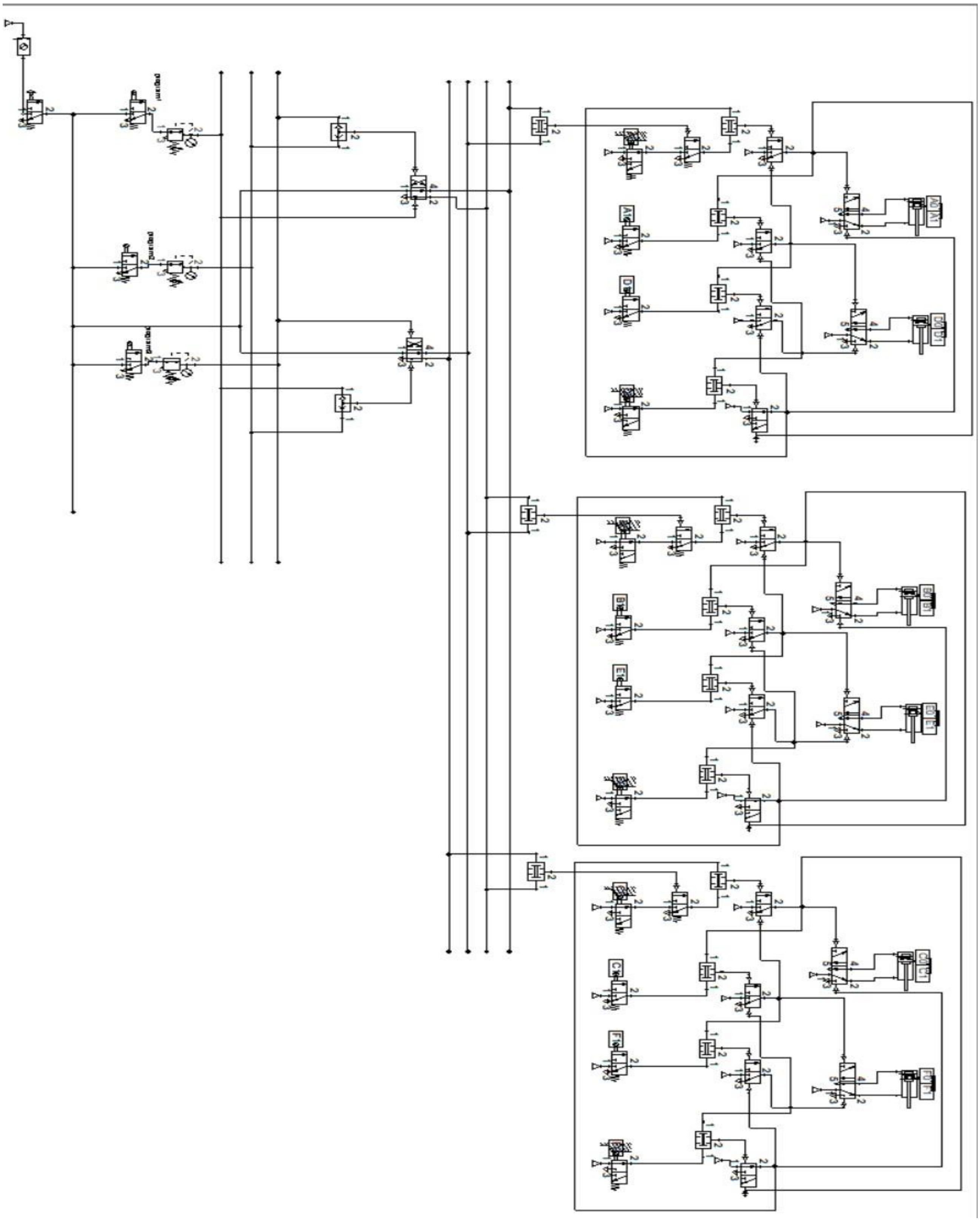
Series Function Chart

b0	x1	
b1	x1	
e0	x1	
e1	x1	
ST.	x1	Program2.b0.Start

a0	x1	
a1	x1	
d1	x1	
d0	x1	
ST.	x1	Program1.a0.Start

c0	x1	
c1	x1	
f0	x1	
f1	x1	
ST.	x1	Program3.c0.Start

Step-Counter Chart



Direct Control Valve Inputs

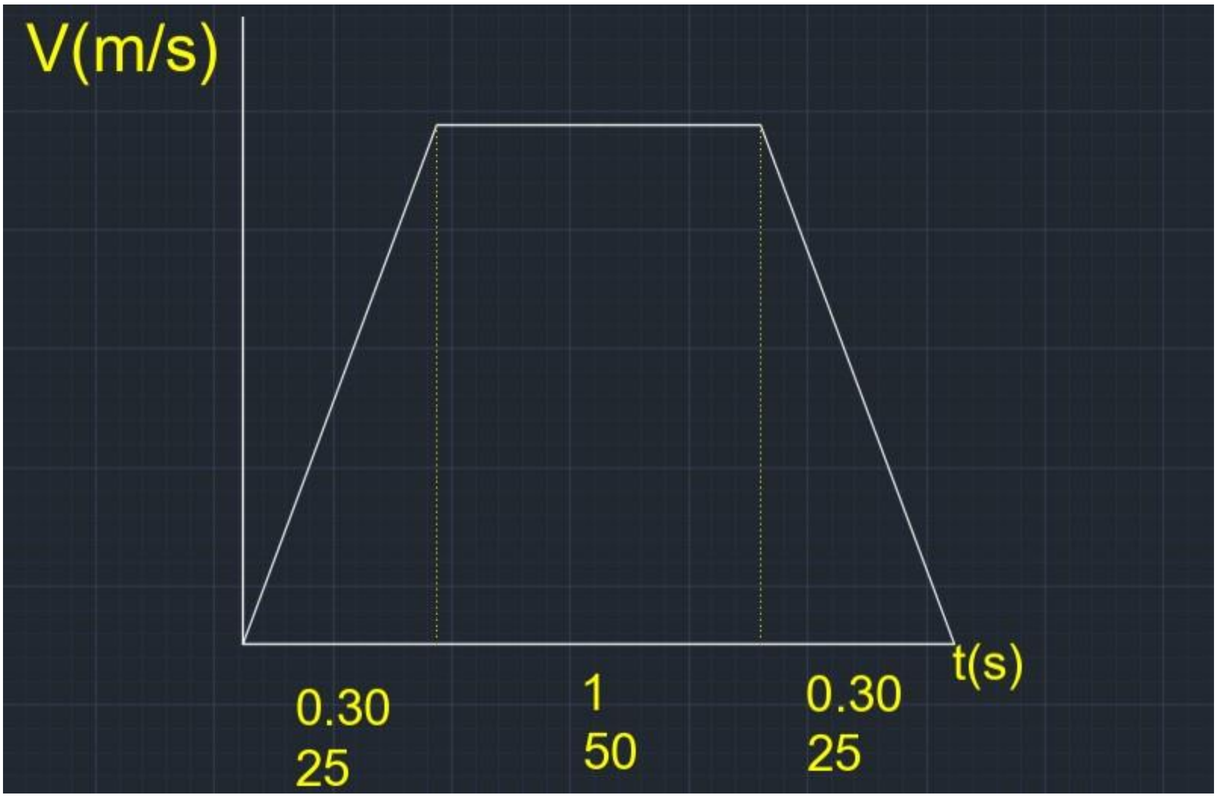
DCV(power valve) Inputs		
A1	Step1	
A0	Step4	
D1	Step2	Program1
D0	Step3	
B1	Step1	
B0	Step4	
E1	Step2	Program2
E0	Step3	
C1	Step1	
C0	Step4	Program3
F1	Step2	
F0	Step3	

Step-counter Inputs

Step-counter inputs	
Stepping Module 1	a0.Start.Program1
Stepping Module 2	a1
Stepping Module 3	d1
Stepping Module 4	d0
Stepping Module 1	b0.Start.Program2
Stepping Module 2	b1
Stepping Module 3	e1
Stepping Module 4	e0
Stepping Module 1	c0.Start.Program3
Stepping Module 2	c1
Stepping Module 3	f1
Stepping Module 4	f0

Sizing of the Actuators

For all actuators my calculation is same because all actuators carry the same weight and repeating same motions. For actuator A=B=C=D E=F.



$$V = \frac{S}{t} = \frac{0.05}{1} = \frac{0.05m}{s}$$

$$S = \frac{V^2}{2a} = a = \frac{(0.05)^2}{2x(0.025)} = \frac{0.05m}{s^2}$$

My station weight is 7.76 kilogram but for safety purposes i choose my weight as 8 kilogram

$$Fl = mxg = 8x9.81 = 78.48N$$

$Fm = mxa = 8x0.05 = 0.4N$

$Ft = Fl + Fm = 78.88N$

$nd = 3$

$Fd = 3x78.88 = 236.64N$

Using curve C from fig 3-26.

Diameter is 25mm.

Air Consumption for Actuators

$$Q = (101{,}3 + \frac{P}{101{,}3})xd^2x0{,}7854xS$$

$$Qv = (101{,}3 + \frac{600}{101{,}3})x0.08^2x0{,}7854x0{,}1x30$$

$$Qv = \frac{0{,}1043966m^3}{minute}$$

$$Qtotal = 0.1043966x6 = \frac{0.62637986m^3}{minute}$$

Selecting of Actuators

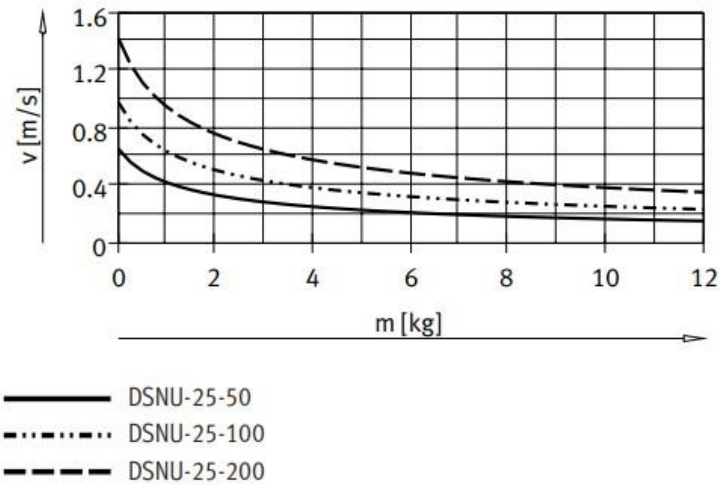
According to our calculations I selected DSNU piston with 25mm diameter because relatively cheaper than the other DSNU pistons and enough to for our application. My all actuators will be same because all of them carrying same weight and same direction with constant speed.

Datasheet

Speed [mm/s][1] Piston ø	16	20	25	32	40	50	63
Speed with stick-slip-free operation, horizontal, without load, at 0.6 MPa (6 bar) S10	10 ... 100			8 ... 100			5 ... 100

Forces [N] and impact energy [J] Piston ø	8	10	12	16	20	25	32	40	50	63
Theoretical force at 0.6 MPa (6 bar), advancing	30	47	68	121	189	295	483	753	1178	1870
Theoretical force at 0.6 MPa (6 bar), retracting	23	40	51	104	158	247	415	633	990	1682
Impact energy in the end positions for P cushioning[1]	0.03	0.05	0.07	0.15	0.20	0.30	0.40	0.70	1.00	1.30

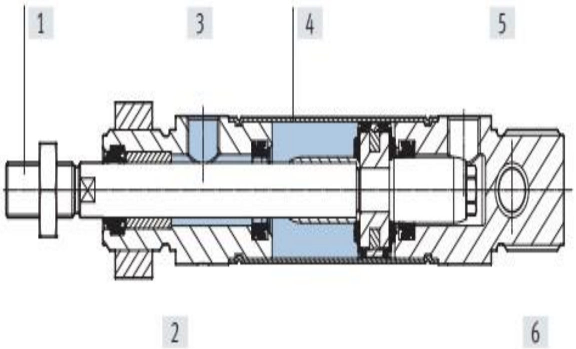
Piston ø 25



Datasheet

Materials

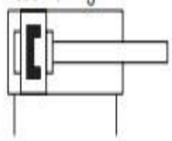
Sectional view



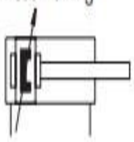
Round cylinder		8 ... 25	32 ... 63
[1]	Piston rod		
	DSNU-...	High-alloy steel	
	DSNU-...-R3	High-alloy stainless steel	
	DSNU-...-A6	–	Hard-chrome-plated tempered steel
[2]	Piston rod bearing	Sintered bronze	
[3]	Bearing cap	Colourless anodised wrought aluminium alloy	
[4]	Cylinder barrel	High-alloy stainless steel	
[5]	End cap	Colourless anodised wrought aluminium alloy	
[6]	Swivel bearing	Polymer	
–	Seals		
	DSNU ...	TPE U(PU), NBR	
	DSNU-...-S6	FPM	
	DSNU-...-S10/-L	FPM	FPM, TPE-U(PU)
	DSNU-...-R3	TPE-U (PUR) media seal (modified for resistance to hydrolysis and cleaning)	
	Piston rod scraper		
	DSNU-...-A6	–	CuZn
	PWIS conformity	VDMA24364-B1/B2-L[1]	
	Cleanroom class	Class 6 according to ISO 14644-1	
	Note on materials		
	DSNU-...	RoHS-compliant	
	DSNU-...-S10	Contains paint-wetting impairment substances	
	DSNU-...-F1A	Metals with more than 1% copper, zinc or nickel by mass are excluded from use. Exceptions are nickel in steel, chemically nickel-plated surfaces, printed circuit boards, cables, electrical plug connectors and coils	

Datasheet

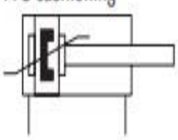
P cushioning



PPV cushioning



PPS cushioning



-Ø- Diameter
8 ... 25 mm
ISO 6432

-Ø- Diameter
32 ... 63 mm

-|- Stroke length
1 ... 500 mm,
longer strokes on request

General technical data

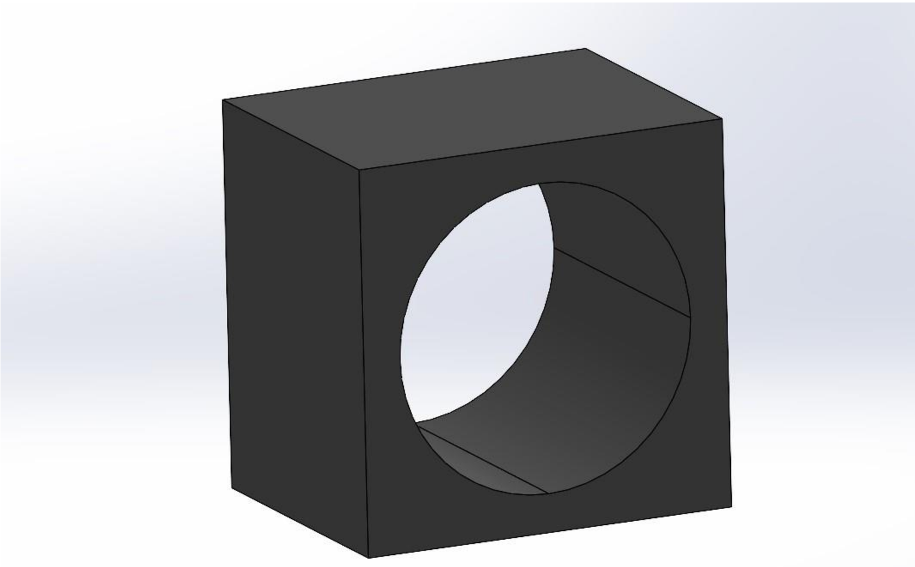
Piston ø		8	10	12	16	20	25	32	40	50	63
Conforms to standard		ISO 6432						–			
Pneumatic connection		M5	M5	M5	M5	G1/8	G1/8	G1/8	G1/4	G1/4	G3/8
Piston rod thread		M4	M4	M6	M6	M8	M10x1.25	M10x1.25	M12x1.25	M16x1.5	M16x1.5
Stroke[1]	[mm]	1 ... 100		1 ... 200		1 ... 320	1 ... 500				
Design		Piston/piston rod/cylinder barrel									
Cushioning											
DSNU-...-P		Elastic cushioning rings/pads at both ends									
DSNU-...-PPV		–		Cushioning, adjustable at both ends							
DSNU-...-PPS		–			Cushioning, self-adjusting at both ends						
Cushioning length											
DSNU-...-PPV	[mm]	–		9	12	15	17	14	18	20	21
DSNU-...-PPS	[mm]	–			12	15	17	14	18	20	21
Position sensing		Via proximity switch									
Type of mounting		Direct mounting (variant MH only)									
		With accessories									
Mounting position		Any									

1) Cylinders with position sensing require a minimum stroke of 10 mm to ensure reliable sensing.
Longer strokes on request

Sizing of the Station

$20x20x20 = 8000cm^3$

$$\frac{8000cm^3 x 0.97g}{cm^3} = 7760g = 7.76kg$$



Material of station is PE because PE is lightweight,flexible,durable and strong as well as friction resistance especially Ultra-high-molecular-weight polyethylene (UHMW-PE) is perfect our station thakns to excellent abrasion and wear resistance.

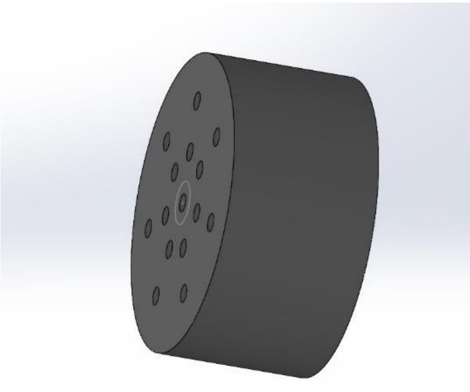
Sizing of the Carriers

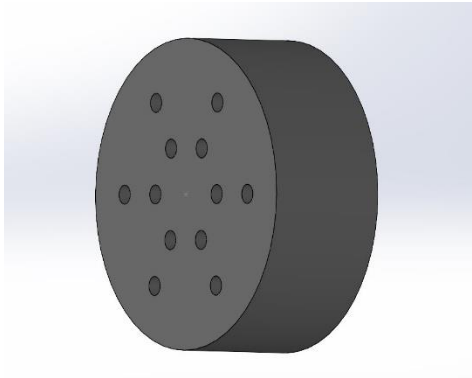
For blood carrier:

$15x3x1.5 = 67.5g$

For urine carrier:

$12x2x5 = 120g$





For main material of the carrier is polyurethane because polyurethane has good tensile strength,impact strength high melting point as well as low density compared to the other choices also polyurethane is very cheap so this is best material for our application.

Overall diameter for blood carrier:

$13x15 = 195mm$

Overall diameter for urine carrier:

$12x16 = 192mm$

Our carrier diameter has to be around 200mm.

$V = \pi r^2 h = \pi x 10^2 x 10 = 3141.59cm^3$

$\frac{3141.59cm^3 x 1.2g}{cm^3} = 3769.91g$

$3769.91 + 67.5 = 3837.61g\ for\ blood\ carrier$

$3769.91 + 120 = 3889.91g\ for\ urine\ carrier$

List of Equipments

Designation	Description
	Double acting cy linder
	Double acting cy linder
	Distance rule
	Distance rule
	5/n Way Valv e
	5/n Way Valv e
	Compressed air supply
	Compressed air supply
	Two pressure v alv e
	3/n Way Valv e
	Compressed air supply
	Two pressure v alv e
	3/n Way Valv e
	Compressed air supply
	Two pressure v alv e
	3/n Way Valv e
	Compressed air supply
	Two pressure v alv e
	3/n Way Valv e
	Compressed air supply
	3/n Way Valv e
	3/n Way Valv e
	3/n Way Valv e
	3/n Way Valv e
	3/n Way Valv e
	Compressed air supply
	Compressed air supply
	Compressed air supply
	Compressed air supply
	Double acting cy linder
	Double acting cy linder
	Distance rule
	Distance rule
	5/n Way Valv e
	5/n Way Valv e
	Compressed air supply
	Compressed air supply
	Two pressure v alv e
	3/n Way Valv e
	Compressed air supply
	Two pressure v alv e
	3/n Way Valv e
	Compressed air supply
	Two pressure v alv e
	3/n Way Valv e
	Compressed air supply
	Two pressure v alv e
	3/n Way Valv e
	Compressed air supply
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	3/n Way Valv e
	Compressed air supply
	Compressed air supply
	Compressed air supply
	Compressed air supply
	Double acting cy linder
	Double acting cy linder
	Distance rule
	Distance rule
	5/n Way Valv e
	5/n Way Valv e
	Compressed air supply
	Compressed air supply
	Two pressure v alv e
	3/n Way Valv e
	Compressed air supply
	Two pressure v alv e
	3/n Way Valv e
	Compressed air supply
	Two pressure v alv e
	3/n Way Valv e
	Compressed air supply
	Two pressure v alv e
	3/n Way Valv e
	Compressed air supply
	3/n Way Valv e
	3/n Way Valv e
	3/n Way Valv e
	3/n Way Valv e
	3/n Way Valv e
	Compressed air supply
	Compressed air supply
	Compressed air supply
	Compressed air supply
	Shuttle v alv e
	4/n Way Valv e
	4/n Way Valv e
	Shuttle v alv e
	Two pressure v alv e
	Two pressure v alv e
	Two pressure v alv e
program1	3/2-way v alv e, pneumatically operated
program2	3/2-way v alv e, pneumatically operated
program3	3/2-way v alv e, pneumatically operated
	Pressure control v alv e with manometer
program2	Pressure control v alv e with manometer
program3	Pressure control v alv e with manometer
	Air serv ice unit, simplif ied representation
	3/n Way Valv e
	Compressed air supply

Selecting of the Conveyors

In this project we dont have to deal with high speed or high loads,weights so our conveyor it should be long enough to reach all stations as well as should be cheap to considered among other conveyors. D-Series Conveyors from Redline System Inc features perfect for our aim.

The D-Series line of material handling conveyor belts are second cousins to the SD-Series. The D-Series is used when you need to move your material along a horizontal plane or slight incline. If you need to get stuff from point A to point B, the D-Series may be just the ticket.

The bed of this industrial material handling conveyor belt is constructed with a 20 degree trough configuration. This is designed to prevent material from rolling off the belt during transit. The belt is supported by a center roller for additional strength. Bed widths are built in 16, 10, and 24 inch dimensions so that you can match the conveyor to your material throughput requirements. The bearings on the belt pulleys are sealed and pre-lubricated.

Specifications

D-Series Conveyor Features

- **Bed**– 16″ 20″, or 24″ wide troughed bed.
- **Frame:** Strong, Rugged Truss style welded frame.
- **Belt:** 2 ply 150 black Rubber.
- **Drive:** Electric, gas, or hydraulic motor available.
- **Bearings**– Sealed, pre-lubricated, self-aligning, ball bearings.
- **Drive pulley**– 7″ in diameter. Open caged for self-cleaning.
- **Tail Pulley**– 6″ in diameter. Open caged for self-cleaning.

Selecting of Blower

For this application we need at least 0.62 $\frac{m^3}{minute}$ blower and we should keep our blower around this number because if we exceed too much our blood samples will be exposed to shear stress due to shear stress blood sample results will not be true due to this issue I choose SANYO DENKI 109BF24HA2 Centrifugal blower.

High air flow and high static pressure

Low power consumption

PWM control function

40000 hours at 60°C expected life

Product Information

☐ **Blower Type:**	Centrifugal
☐ **Supply Voltage:**	24VDC
☐ **Voltage Type:**	DC
☐ **Fan Frame Size:**	120mm
☐ **External Depth:**	32mm
☐ **Flow Rate - Metric:**	0.78m³/min
☐ **Air Flow - CFM:**	27.5CFM
☐ **Air Flow - m3/min:**	0.78m³/min
☐ **Flow Rate - Imperial:**	27.5CFM
☐ **Noise Rating:**	52dBA
☐ **Bearing Type:**	Ball Bearing
☐ **Power Connection Type:**	2 Lead Wires
☐ **Power Rating:**	7.2W
☐ **Product Range:**	Scircoco Ace 120
☐ **IP Rating:**	-

Selecting of Pressure Control Valve

Proportional pressure control valve VPPM is perfect for our needs because of pilot actuated pressure regulating valve and also three default presets for fast commissioning features recover us select 3 different pressure control valve.

Innovative

Flexible

Operational Safety

Easy to Install

- Pilot actuated pressure regulating valve
- Multi-sensor control (cascade control)
- Three default presets for fast commissioning
- Integration in valve manifold MPA
- User interface with LED displays, LCD display, adjustment/selection buttons
- Integrated pressure sensor
- Electrical connection via plug, round design, 8-pin, M12 or manifold linking

Comments and Conclusion

In this project I aimed that eliminate the human factor in pneumatic tube systems. With elimination of the human factor, we can get our blood,urine tests feedback with little delay as well as carrying serum with this system with fully automatically reduces work load for nurses.

To make this project more efficient we can use CFD analysis to optimise pneumatic tube angles also we need a conveyor to achieve this project that mean is we need more available space to place conveyor and unfortunately this is not possible for many hospitals but in the future with some optimizations we can easily use this fuly automatic pneumatic tube system for any hospitals.

According to me, this project will be very useful for big hospitals. In Turkey we have lots of big hospitals and we are waiting for queue too long as well as to get our test results this project may be the solution for to reduce test result time also reduce nurses work load with this nurses can take care of more patient in hospitals.

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Appendix