真空系統的設計、腔體設計及控制與操作及軟體撰寫

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真空系統建置 須考量如下

主要區別

- 壓力範圍
- 製程方式
- 抽氣方式

以上 主要項目 次要項目 互相影響 互相牽制 才有結論

次要項目

- 真空計選用
- 真空幫浦選用
- 閥門選用
- 材料選用
- 腔體大小形狀
- 溫度
- 氣 電 引入
- 安全設計
- 容易安裝 日後容易維修
- 容易操作
- 操控系統
- 紀錄

設計Chamber 需考量事項

- 大小
- 形體
- 強度
- 使用的真空度
- **Flange**
- 溫度
- 腐蝕性**?**
- 引入
- 機械傳輸 轉動
- 未來 保養**&**破大氣的頻率
- **………….. (略)**

- 適度大小
- 圓柱, 方形, 圓形,…….
- 壓力產生的形變**(1kg/cm2) &** 腔們強度 , 載重**(Valve, Pump…)**
- **304, 316, 304ESR,** 鋁合金,
- **ISO ,ASA, Conflat Flange…..**
- **ORING**材質**, All Metal(** 硬鋼咬軟銅,硬鋁壓軟鋁**)**
- 各式引入
- 冷卻水,**(**超低溫**)Helium Cryogenic,** 液態氮, 氣, 電 ,**ROBOT,,,,,,,,**
- **N/A**
- **…………..(略)**

設計Chamber 需考量事項-本公司圖例

- Flanges 多寡, Size, Oring or All metal (CFF, ISO, KF, ANSI?)
- 是否需要視窗
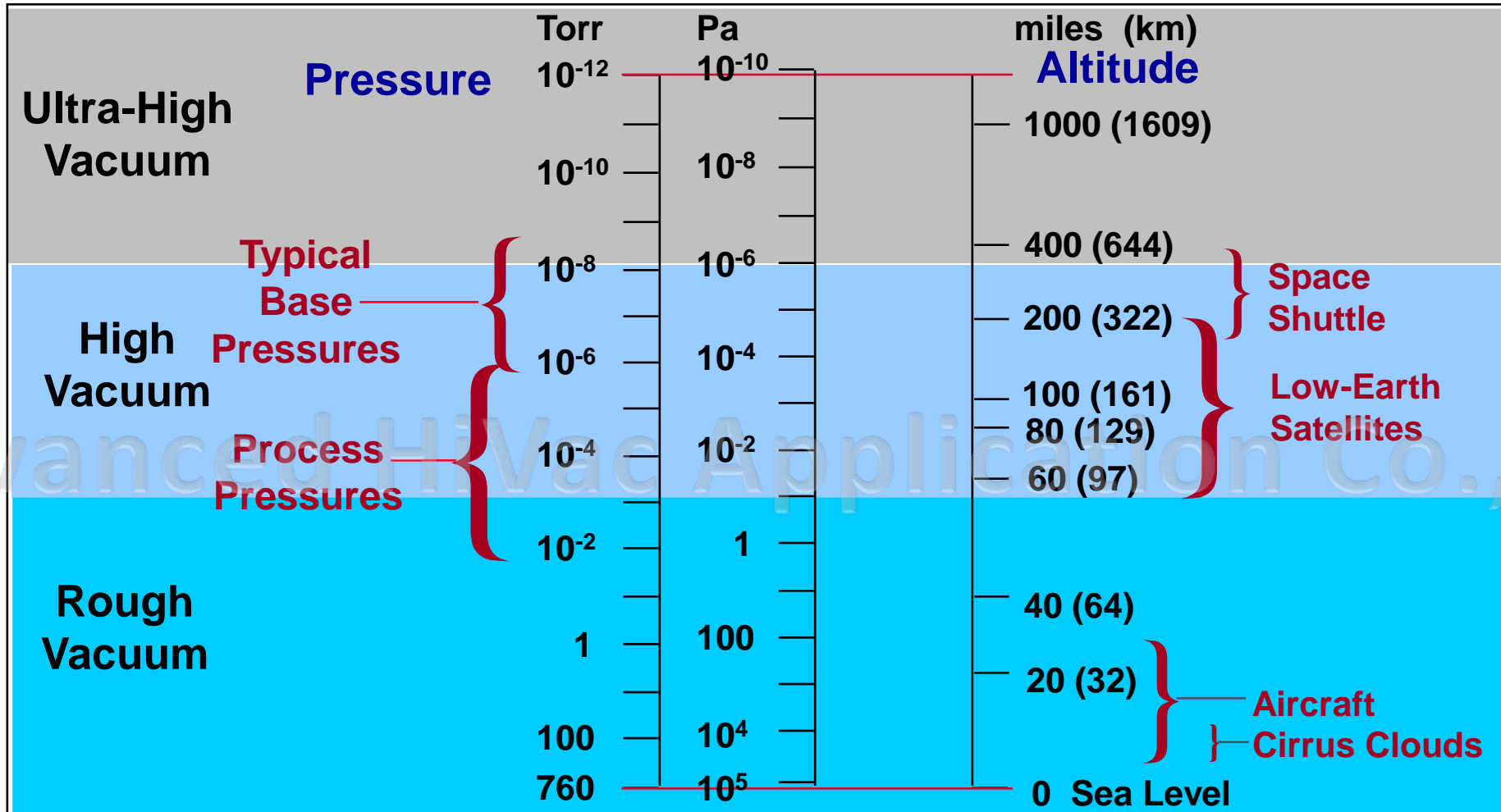- Turbo pump/Cryo pump 採 橫掛 或垂直
- 震動考量
- Feedthrough
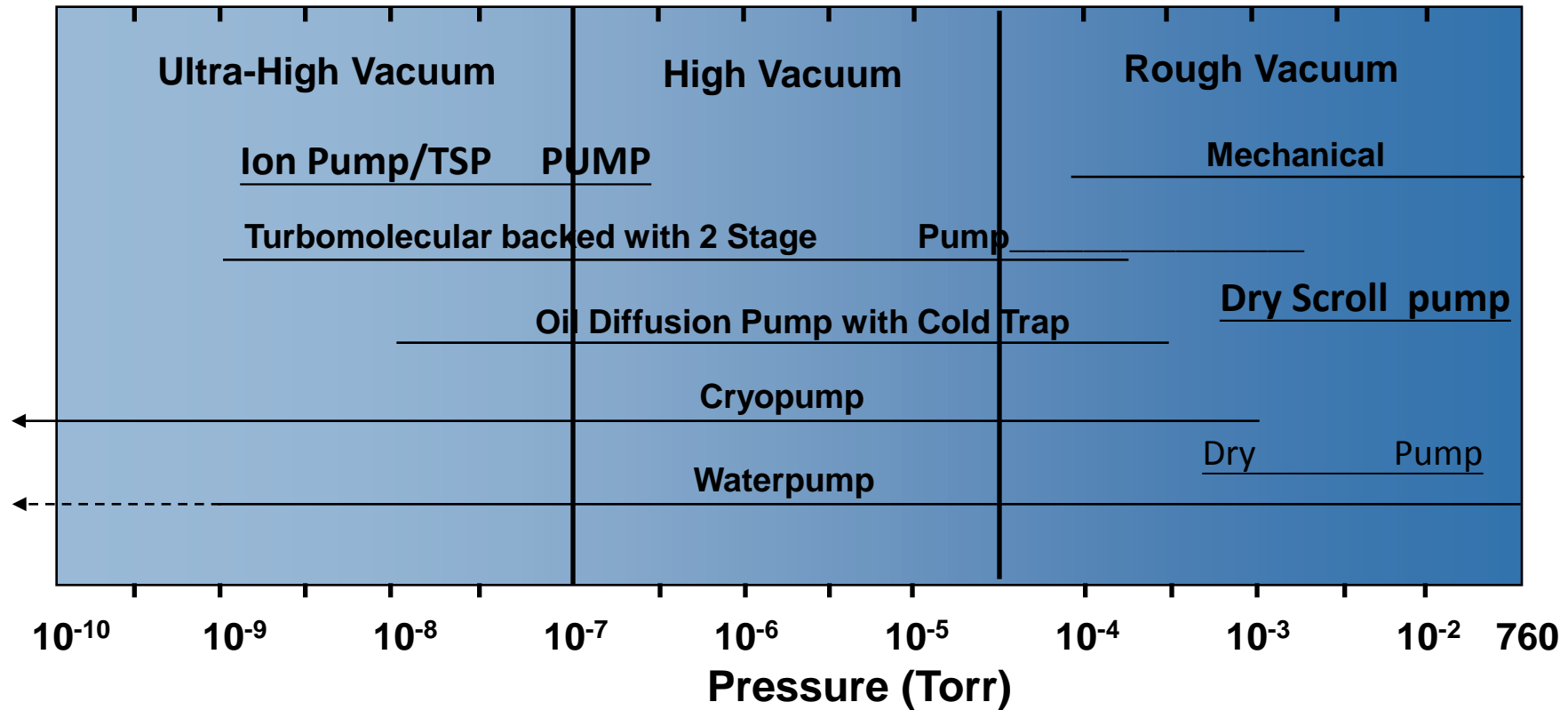- ....略

本公司過去圖例

本公司圖例

Vacuum Levels

	Torr	Pa	miles (km)
	Pressure		**Altitude**
Ultra-High Vacuum	10^{-12}	10^{-10}	
			1000 (1609)
	10^{-10}	10^{-8}	
			400 (644)
	10^{-8}	10^{-6}	Space Shuttle
Typical Base Pressures			200 (322)
High Vacuum	10^{-6}	10^{-4}	100 (161)
			80 (129)
Process Pressures	10^{-4}	10^{-2}	60 (97)
			Low-Earth Satellites
	10^{-2}	1	
Rough Vacuum			40 (64)
	1	100	20 (32)
	100	10^{4}	Aircraft
			Cirrus Clouds
	760	10^{5}	0 Sea Level

Vacuum Pumps-真空幫浦選擇

Pumping System Ranges

Ultra-High Vacuum	High Vacuum	Rough Vacuum

Ion Pump/TSP   PUMP

Mechanical

Turbomolecular backed with 2 Stage   Pump

Oil Diffusion Pump with Cold Trap

Dry Scroll pump

Cryopump

Dry   Pump

Waterpump

10^{-10} 10^{-9} 10^{-8} 10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 760

Pressure (Torr)

如何選擇低真空幫浦

考慮項目

- 終極壓力
- Pumping Speed (必須考量在不同壓力下的抽氣速度)
- Cost
- 乾式或油式,水冷或氣冷
- 腐蝕程度 粉塵程度
- 耗電及變頻節能
- Dimension
- Noise & Vibration...
- MTTF
- 日後保養價格

各種形式的低真空幫浦
- 薄膜幫浦
- Oil Rotary Vane pump
- Dry Scroll Pump
- 多級魯式幫浦
- ....

如何選擇高真空幫浦

(超)高真空幫浦
- Turbo Pump
- Cryo pump
- Diffusion Pump
- Ion Pump/TSP/NEG
- 複合式幫浦

選擇高真空幫浦的重點
- 期待的真空度/時間
- Cost & Reliability
- MTTF & 日後維護成本
- 供應商

Turbo 跟 Cryo pump 的主要差異及選擇

Turbo pump
1. Turbo Pump 的價錢隨著抽氣速度成正比
2. 高壓(10Torr) 就能有抽氣能力
3. 抽氣能力弱(Gas Independent)
4. 連續性不用再生
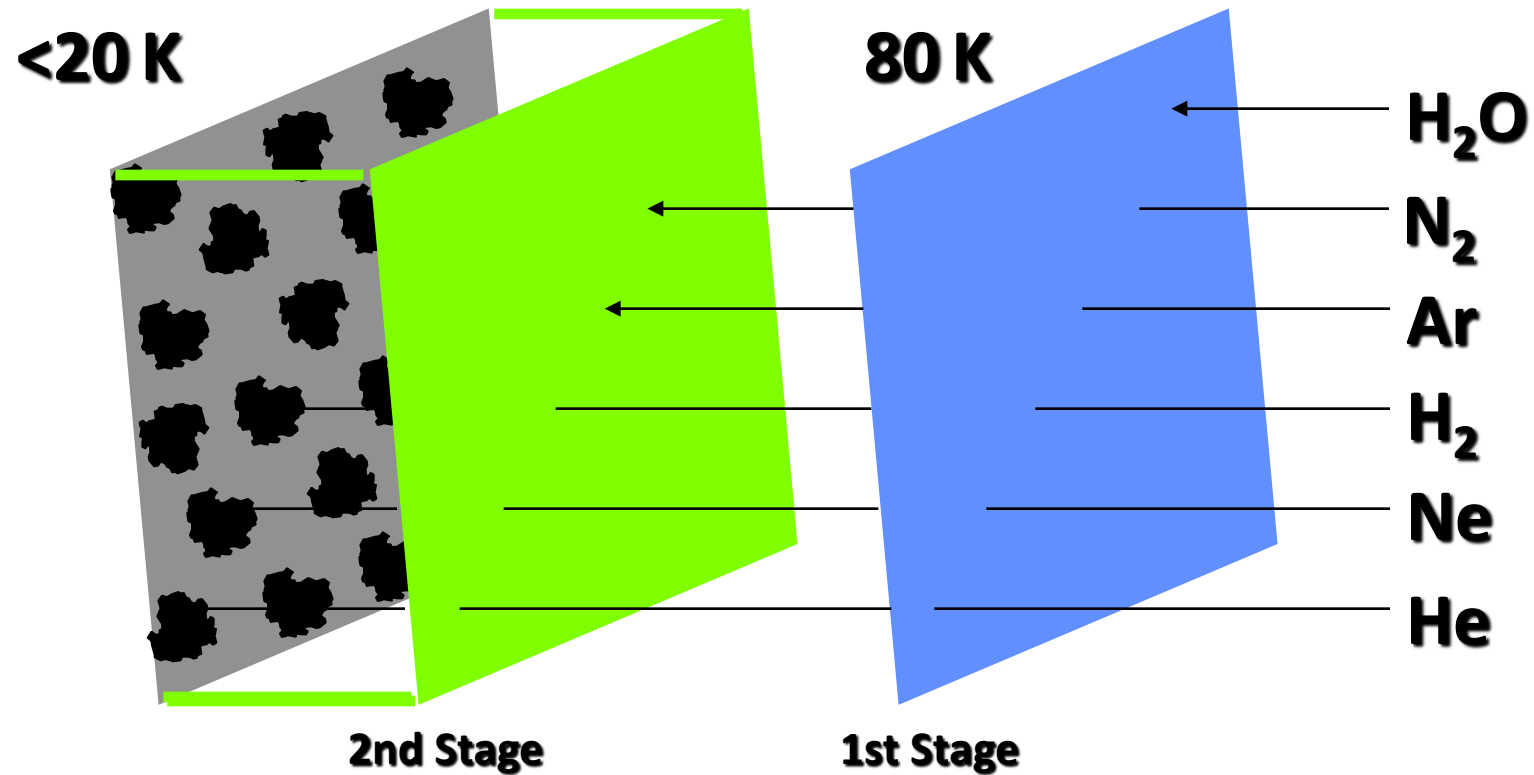5. 50/50 使用 Gate Valve
6. 省電(<50 watt)
7. 體積小
8. 其他

Cryo pump
1. Cryo pump 的價錢, 只有2個等級
2. 5.0E-2 Torr 才能開始抽氣
3. 抽氣能力強(Gas Independent)
4. 需要再生 , 再生耗時 4小時
5. 99%需要 Gate Valve
6. 耗電 (>2000 watt)
7. 體積大
8. 其他

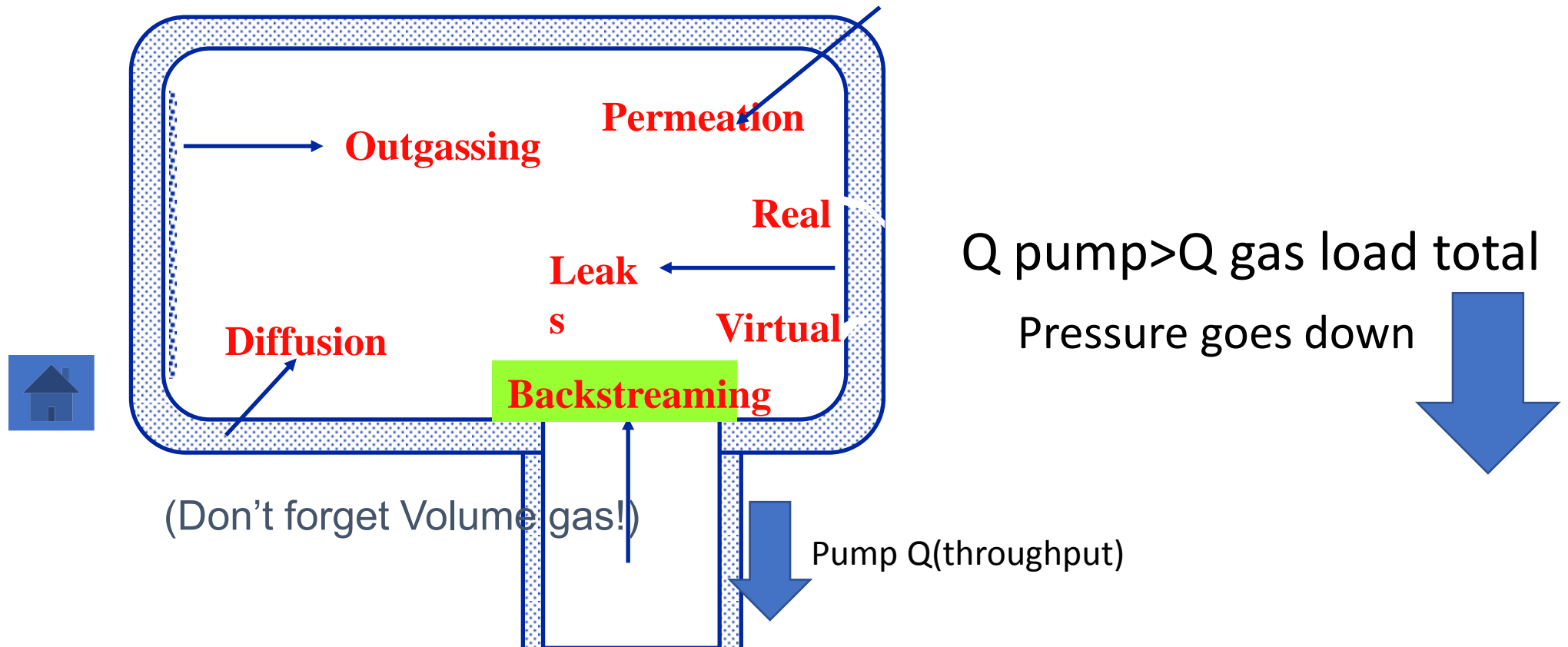# CRYOPUMPING BASICS:
Operation - Cryoadsorption

Air gases and water vapor still condensed - noncondensible gases captured.

<20 K   **80 K**

H$_2$O

N$_2$

Ar

H$_2$

Ne

He

2nd Stage   **1st Stage**

GAS LOAD and Pump througtput

• Another name for Q, the throughput, is gas load. Where does gas load, "Q" come from?

$$Q_{TOTAL} = Q_{VOLUME} + Q_{LEAK} + Q_{OUTGAS} + Q_{DIFFUSION} + Q_{PERMEATION}$$

Permeation

Outgassing

Real

Leaks

Virtual

Diffusion

Backstreaming

Q pump>Q gas load total

Pressure goes down

(Don't forget Volume gas!)

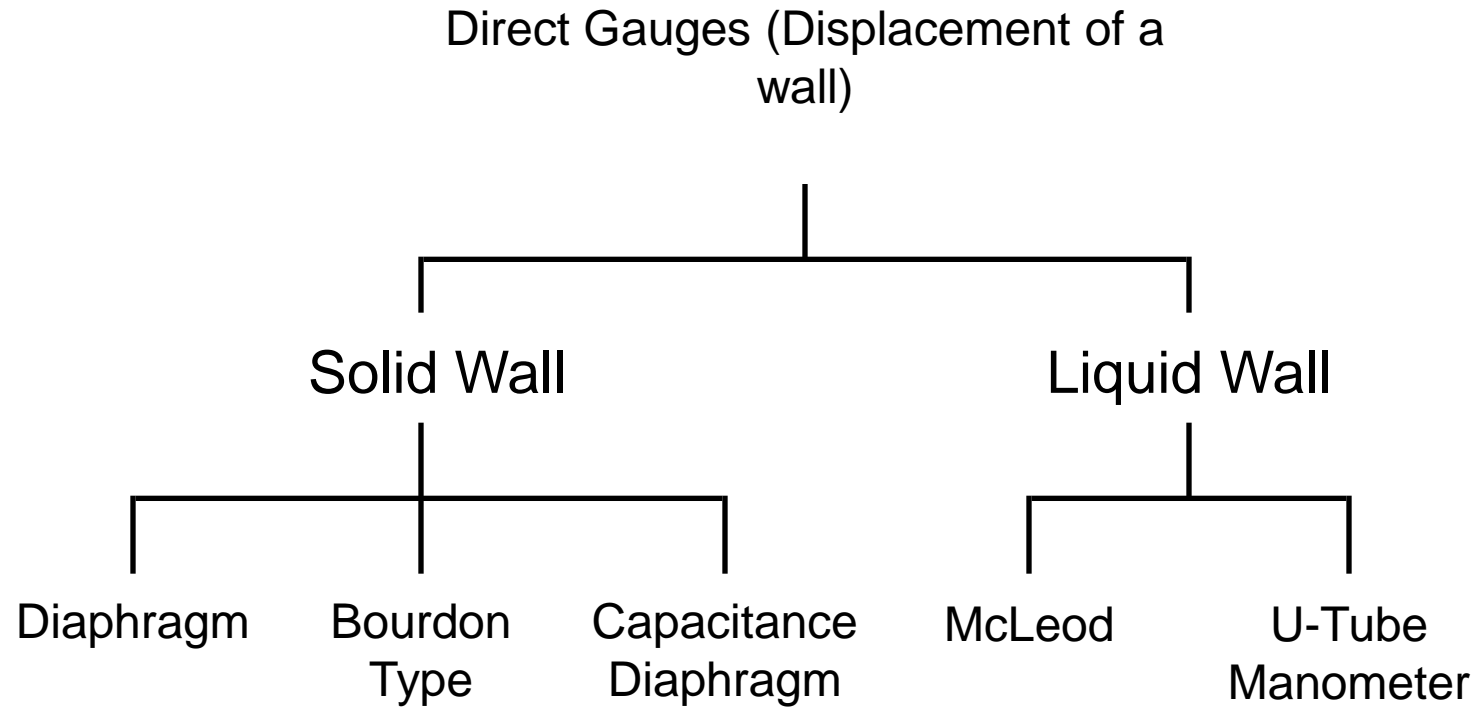Pump Q(throughput)

選擇Valves

- Gate Valve
- Butterfly Valve
- Roughing Valves(inline/right angle)
- Needle valve
- Ball valve
- 進氣閥
- 微漏閥
- ....

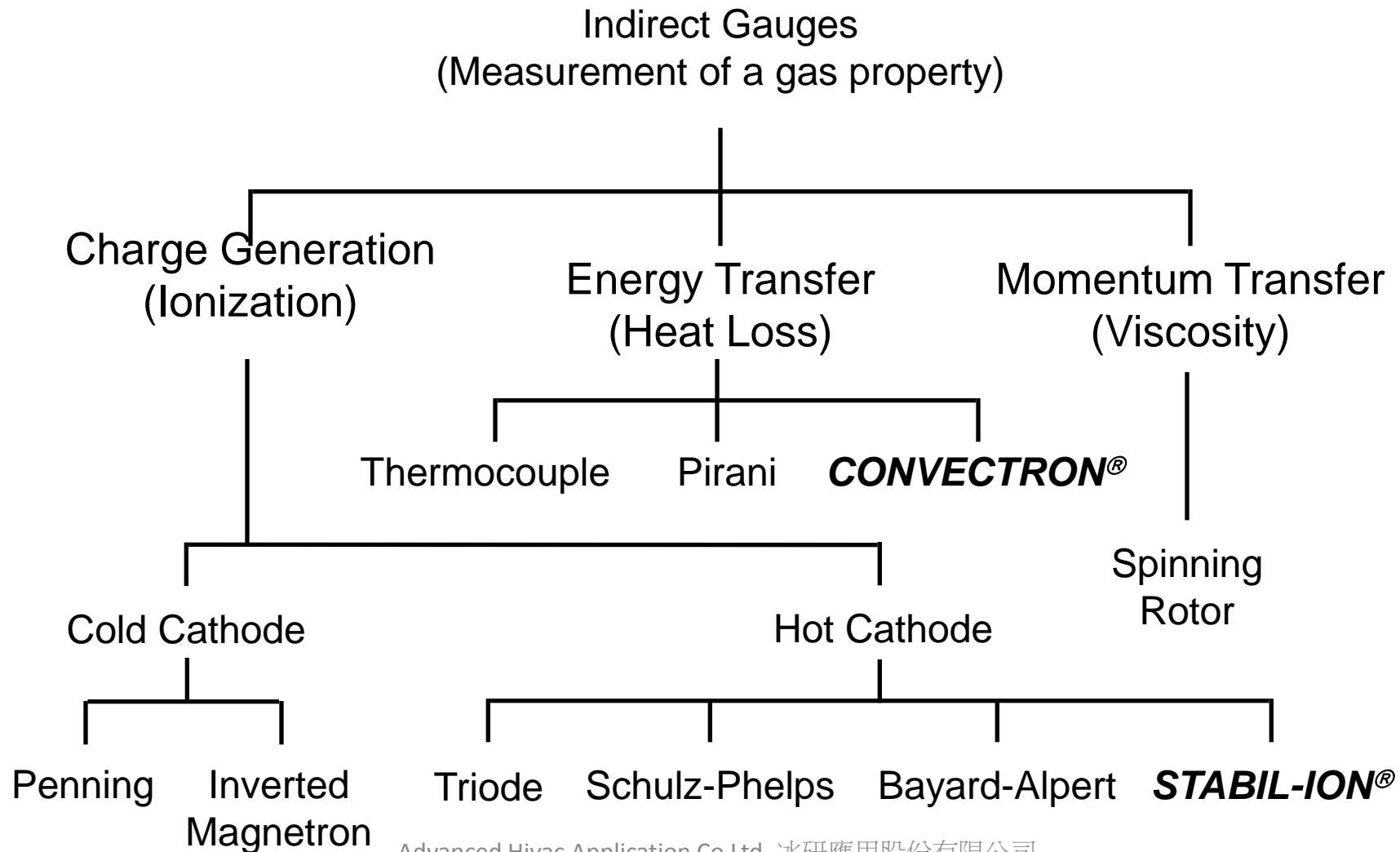- 不同的閥門有其功能性，其中需考量 真空度 氣導 逸氣 開關次數 洩漏率 價錢 ....
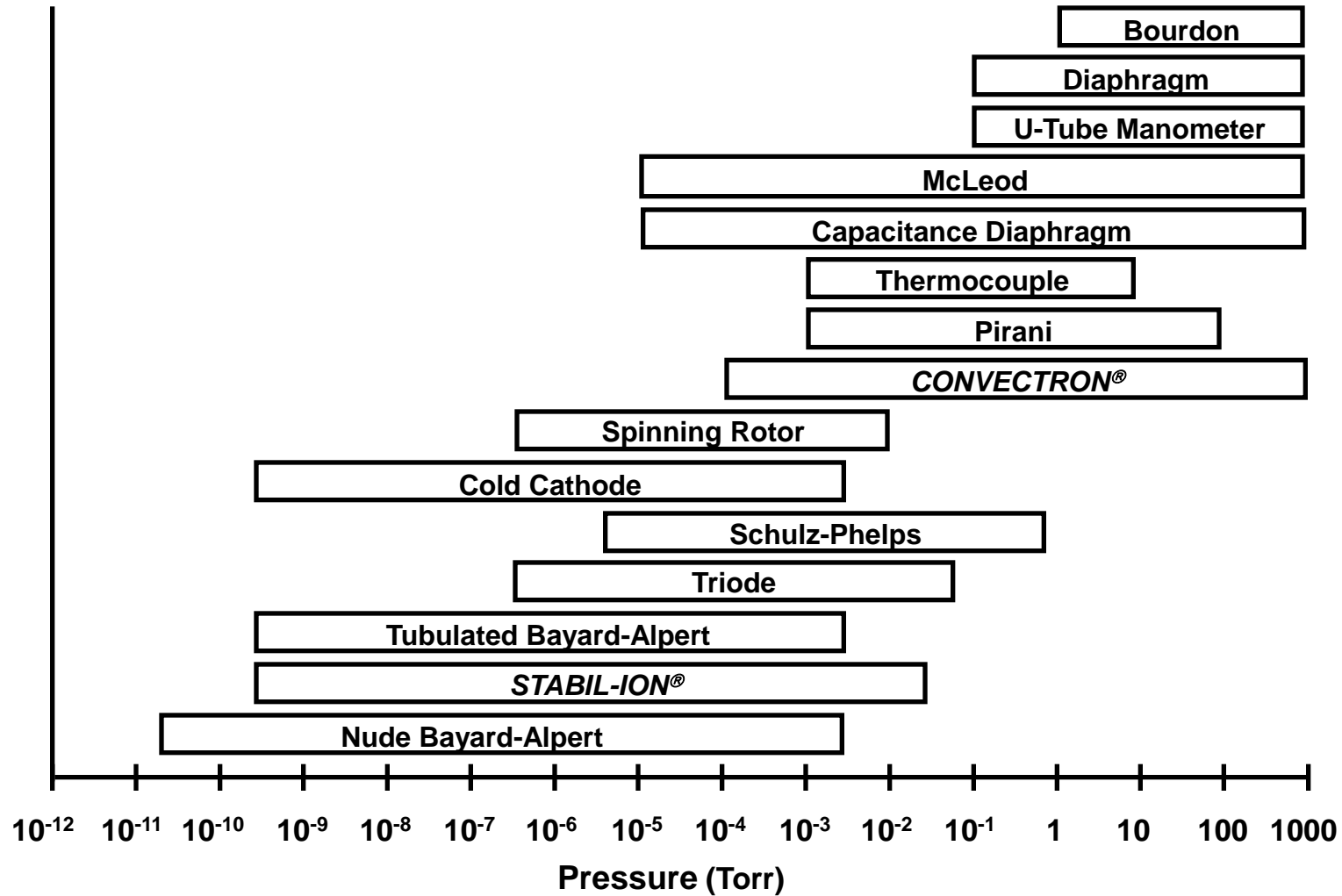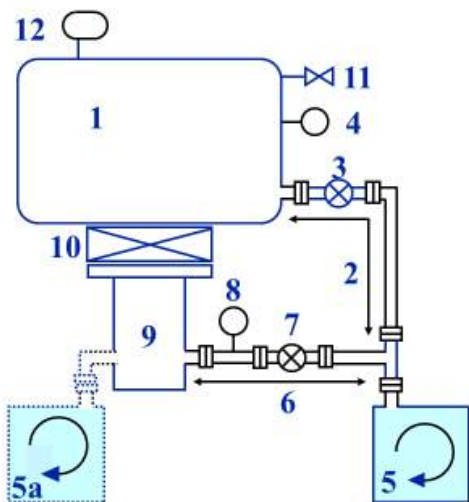
選擇真空計

Types of Vacuum Gauges

Direct Gauges (Displacement of a wall)

Solid Wall

Liquid Wall

Diaphragm

Bourdon Type

Capacitance Diaphragm

McLeod

U-Tube Manometer

Types of Vacuum Gauges (cont.)

Indirect Gauges
(Measurement of a gas property)

Charge Generation
(Ionization)

Energy Transfer
(Heat Loss)

Momentum Transfer
(Viscosity)

Thermocouple   Pirani   **CONVECTRON®**

Cold Cathode   Hot Cathode   Spinning Rotor

Penning   Inverted Magnetron   Triode   Schulz-Phelps   Bayard-Alpert   **STABIL-ION®**

Ranges of Vacuum Gauges

Chart of vacuum gauge pressure ranges versus Pressure (Torr):

- Bourdon
- Diaphragm
- U-Tube Manometer
- McLeod
- Capacitance Diaphragm
- Thermocouple
- Pirani
- CONVECTRON®
- Spinning Rotor
- Cold Cathode
- Schulz-Phelps
- Triode
- Tubulated Bayard-Alpert
- STABIL-ION®
- Nude Bayard-Alpert

X-axis: Pressure (Torr): 10^{-12}, 10^{-11}, 10^{-10}, 10^{-9}, 10^{-8}, 10^{-7}, 10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}, 10^{-2}, 10^{-1}, 1, 10, 100, 1000

決定真空行程

1. Chamber
2. Roughing Line
3. Roughing Valve
4. Roughing Gauge
5. **Roughing Pump**
5a. **Forepump**
6. Foreline
7. Foreline Valve
8. Foreline Gauge
9. High Vacuum Pump
10. High Vacuum Valve
11. Vent Valve
12. High Vacuum Gauge

Table 2-4 Dual Mechanical Pump System Valve Sequence

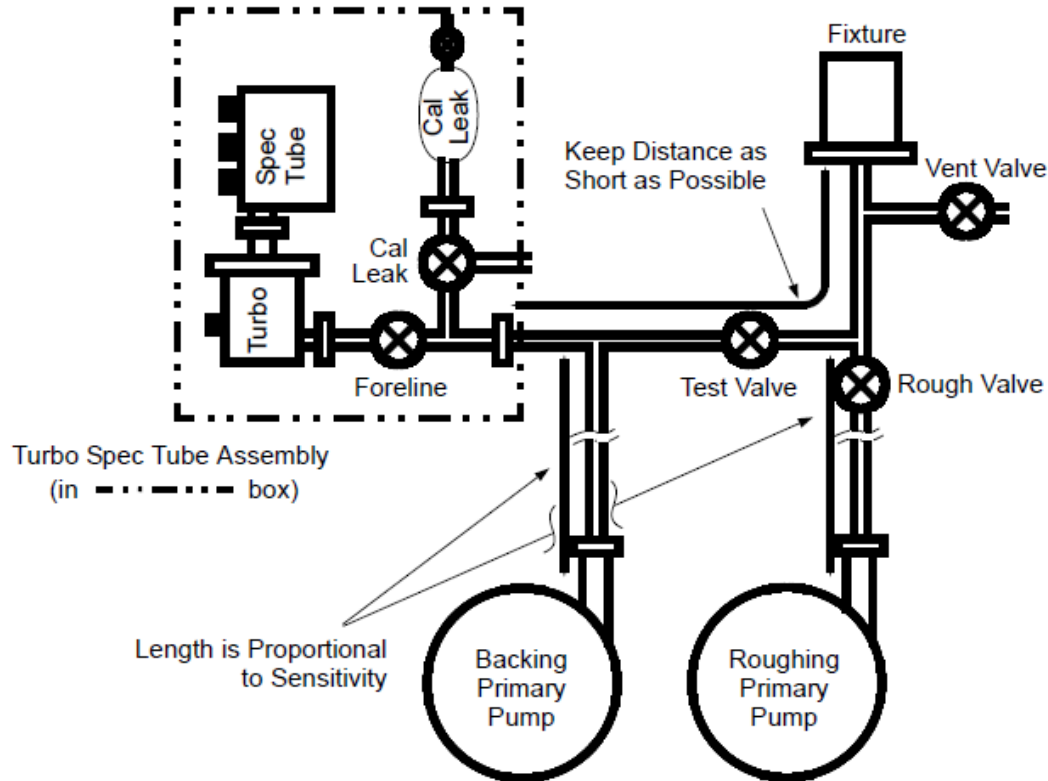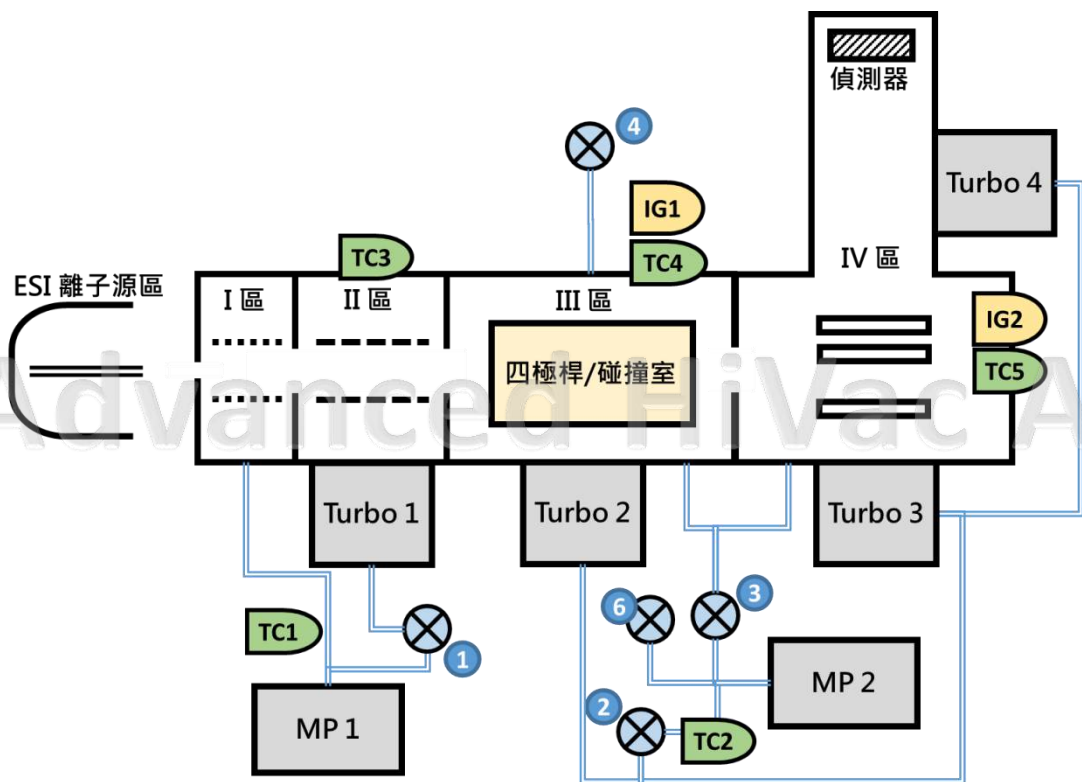| State	Vent Valve	Rough Valve	Test Valve	Remarks
Pre-Vented	Closed	Closed	Closed	The Pre-Vented state allows time to ensure that all valves are closed before any open. The time spent in the pre-vented state depends on valve actuation time.
Vented	Opened	Closed	Closed	The Vented state places the fixture at atmosphere. The backing primary pump keeps the turbo backed.
Pre-Roughing	Closed	Closed	Closed	The Pre-Roughing state allows time to ensure that all valves are closed before any open. The time spent in the pre-roughing state depends on valve actuation time.
Roughing	Closed	Opened	Closed	The Roughing state brings the fixture to vacuum.
Test	Closed	Closed	Opened	The Test Valve re-opens at the appropriate foreline pressure, exposing the fixture to the foreline.

範例一簡單版 :Leak Detectors Valves Logistics

Turbo Spec Tube Assembly (in — ·· — ·· — box)

Length is Proportional to Sensitivity

Figure 2-2   Dual Mechanical Pump Configuration

Table 2-4   Dual Mechanical Pump System Valve Sequence

State	Vent Valve	Rough Valve	Test Valve	Remarks
Pre-Vented	Closed	Closed	Closed	The Pre-Vented state allows time to ensure that all valves are closed before any open. The time spent in the pre-vented state depends on valve actuation time.
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Roughing	Closed	Opened	Closed	The Roughing state brings the fixture to vacuum.
Test	Closed	Closed	Opened	The Test Valve re-opens at the appropriate foreline pressure, exposing the fixture to the foreline.

範例二複雜版-受客戶委託開發的高階質譜儀範例

部分邏輯行程

| ESI-Q-TOF 質譜儀	Power on (no vacuum)	Pump down	Ready	Data acquisition	Venting	Service	Shut down
Main board	On	On	On	On	On	On	Off
Mechanical pump 1	Off	Wait 5s and turn on (monitor I1)	On (monitor I1)	On (monitor I)	Off	Can turn on manually	Off
Mechanical pump 2	Off	Wait 5s and turn on (monitor I2)	On (monitor I2)	On (monitor I)	Wait 5s and turn off	Can turn on manually	Off
Turbo pump 1	Off	When Valve 1 on and P1 < 300 mtorr, turn on (monitor speed, power)	On (monitor speed, power)	On (monitor speed, power)	Off (monitor speed, power)	Can turn on manually (with certain conditions)	Off
Turbo pump 2	Off	When Valve 2 on and P2 < 100 mtorr, turn on (monitor speed, power)*	On (monitor speed, power)	On (monitor speed, power)	Off (monitor speed, power)	Can turn on manually (with certain conditions)	Off
Turbo pump 3	Off	When Valve 2 on and P2/P4 < 100 mtorr, turn on (monitor speed, power)*	On (monitor speed, power)	On (monitor speed, power)	Off (monitor speed, power)	Can turn on manually (with certain conditions)	Off

紀錄

日期	時間	毫秒	Eq ID	S/N	Op ID	Test Result	Leak Rate	Leak Trend
2018/6/13	9:22:22	240	0	0	0	2	0.7E-09	-8.93
2018/6/13	9:22:23	540	0	0	0	2	0.7E-09	-8.929
2018/6/13	9:22:24	210	0	0	0	2	0.7E-09	-8.928
2018/6/13	9:22:25	310	0	0	0	2	0.7E-09	-8.926
2018/6/13	9:22:26	280	0	0	0	2	0.8E-09	-8.92
2018/6/13	9:22:27	270	0	0	0	2	0.1E-09	-8.99
2018/6/13	9:22:28	230	0	0	0	2	0.0E-09	-8.999
2018/6/13	9:22:29	220	0	0	0	2	0.0E-09	-8.999
2018/6/13	9:22:30	320	0	0	0	2	0.0E-09	-8.999
2018/6/13	9:22:31	300	0	0	0	2	0.0E-09	-8.999
2018/6/13	9:22:32	270	0	0	0	2	0.0E-09	-8.999
2018/6/13	9:22:33	250	0	0	0	2	0.0E-09	-8.999
2018/6/13	9:22:34	220	0	0	0	2	0.0E-09	-8.999
2018/6/13	9:22:35	320	0	0	0	2	0.0E-09	-8.999
2018/6/13	9:22:36	300	0	0	0	2	0.0E-09	-8.999
2018/6/13	9:22:37	290	0	0	0	2	0.0E-09	-8.999
2018/6/13	9:22:38	270	0	0	0	2	0.0E-09	-8.999
2018/6/13	9:22:39	240	0	0	0	2	0.0E-09	-8.999

Endura® SL System Layout
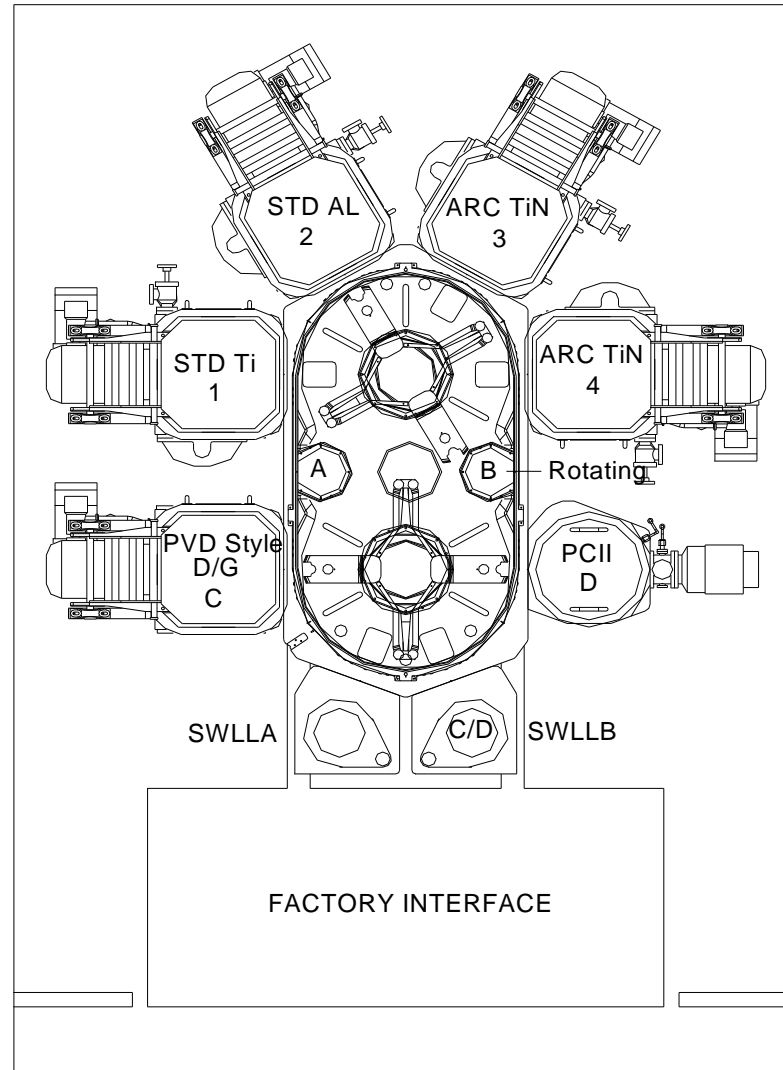
控制系統需要控制讀取的元件

- Turbo Pump

- Ion Pump/TSP

- Primary Pump

- Hi /Low Vacuum Gauges

- Sensors (Position, Temperature….)

- ……..

-

軟體

- Window,UNIX,DOS, LABVIEW…
- AHA 採 PLC +HMI
- ……….

- AMAT/ Varian Implanter/ R&D
- 小型系統/遠端監控/Cost Saving
- …………..

冰研標準版的五合一真空系統控制器

- Ion pump
- Turbo Pump
- Roughing Pump
- Vacuum Gauges
- Valve Control
- Other Control(Heater on/off, Power on/off)

冰研標準版的五合一真空系統控制器

Advanced Hivac Application Co Ltd, 冰研應用股份有限公司