AMCA 210-99 系列
風洞簡介

瑞領科技股份有限公司

Long Win Science & Technology Corp.

+886-3-464-3221

Web Site: www.longwin.com

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Fundamental, Forward & First

瑞領科技公司 台灣楊梅幼獅廠

土地面積：4500 m^2

廠房面積：6600 m^2

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瑞領科技公司簡介

- 瑞領公司目前廠房約6600 m^2

- 研發能力：擁有2000 m^2實驗室

  熱傳實驗室，流力實驗室，光學實驗室，化學實驗室，相變化實驗室。

- 生產能力：自有各種生產工場2500 m^2

  各種CNC加工設備-車、銑、放電、雷射，板金工場，焊接結構工場，烤漆表面處理工場，電氣、裝配工場。

- 相關熱傳研究設備研發100種以上

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瑞領科技 – 儀器設備研發中心






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摘要

1. AMCA 210 標準簡介
2. 流量量測原理
3. 校正流程
4. 風洞特點
5. 風扇PQ比較
6. 應用案例

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AMCA 是什麼？

Air Movement and Control Association

Lab. Methods of Testing Fans for Aerodynamic Performance Rating

Published by

ANSI/AMCA 210-99
ANSI/ASHRAE 51-1999

American National Standard Institute
American Society of Heating, Refrigerating and Air Conditioning Engineers

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風扇性能測試標準

AMCA 210-99

Laboratory Methods of Testing Fans for Aerodynamic Performance Rating

ISO 5801- 1997

Industrial fans -- Performance testing using standardized airways

BS 848	UK
DIN 24163	Germany
GB/T1236-2000.	China
JIS B 8330-1981	Japan

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AMCA 210規範腔體配置
Outlet (Fig.12) & Inlet (Fig.15)

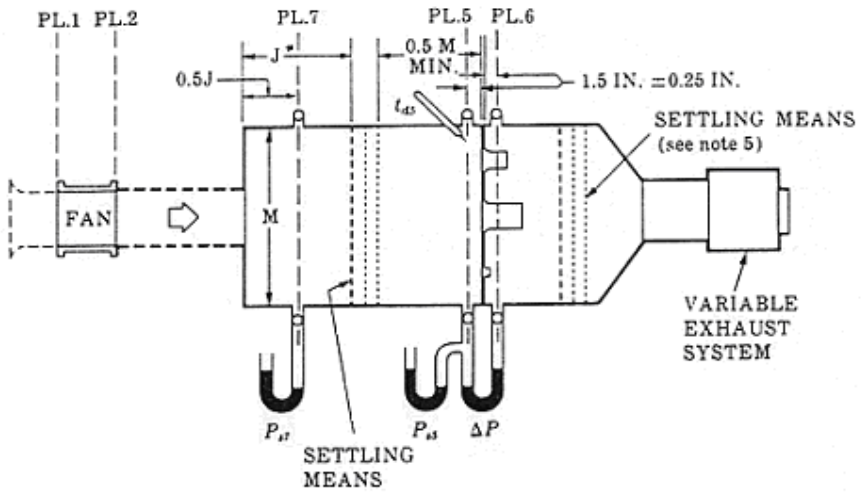

Figure 12 Outlet Chamber
ANSI/AMCA STANDARD 210-85

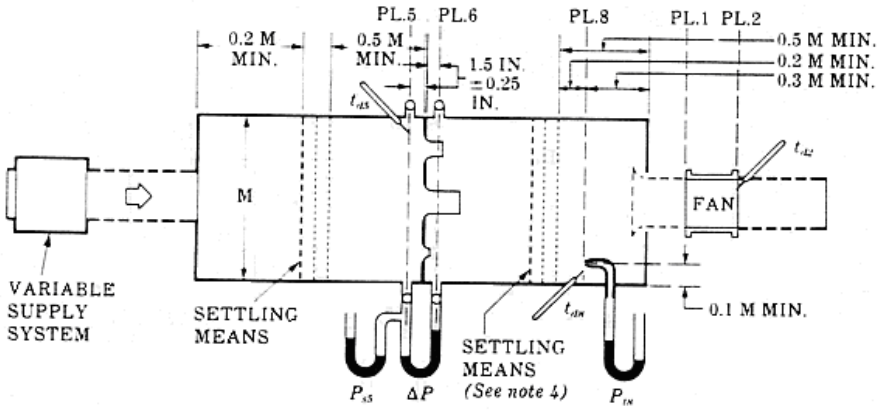

Figure 15 Inlet Chamber
ANSI/AMCA STANDARD 210

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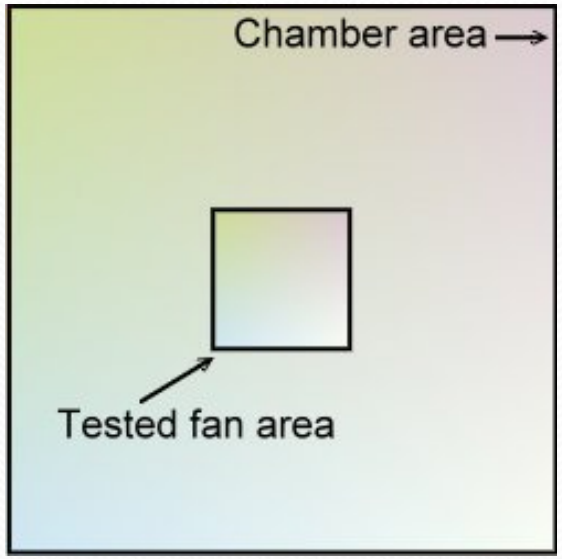
AMCA 210 風洞設計標準



Outlet Chambers

An outlet chamber (figure 12) shall have a cross-sectional area at least **nine times** the area of the fan outlet or outlet duct for fans with axis of rotation perpendicular to the discharge flow and a cross-sectional area at least **sixteen times** the area of the fan outlet or outlet duct for fans with axis of rotation parallel to the discharge flow.

Inlet Chambers

Inlet chambers (Figure 15) shall have a cross- sectional area at least **five times** the fan inlet area.

From AMCA 210-99 page10

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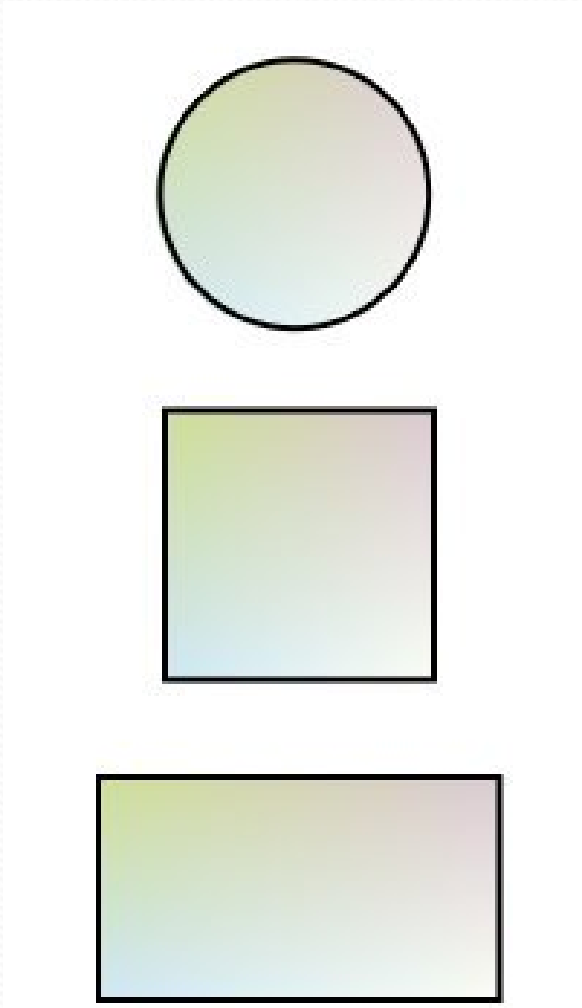
AMCA 210 風洞設計標準



different chamber shapes

A chamber may have a **circular** or **rectangular** cross-sectional shape.

The dimension M in the test setup diagram is the inside diameter of a circular chamber or the equivalent diameter of dimensions a and b where

$$M = \sqrt{\frac{4ab}{\pi}}$$

From AMCA 210-99 Page10

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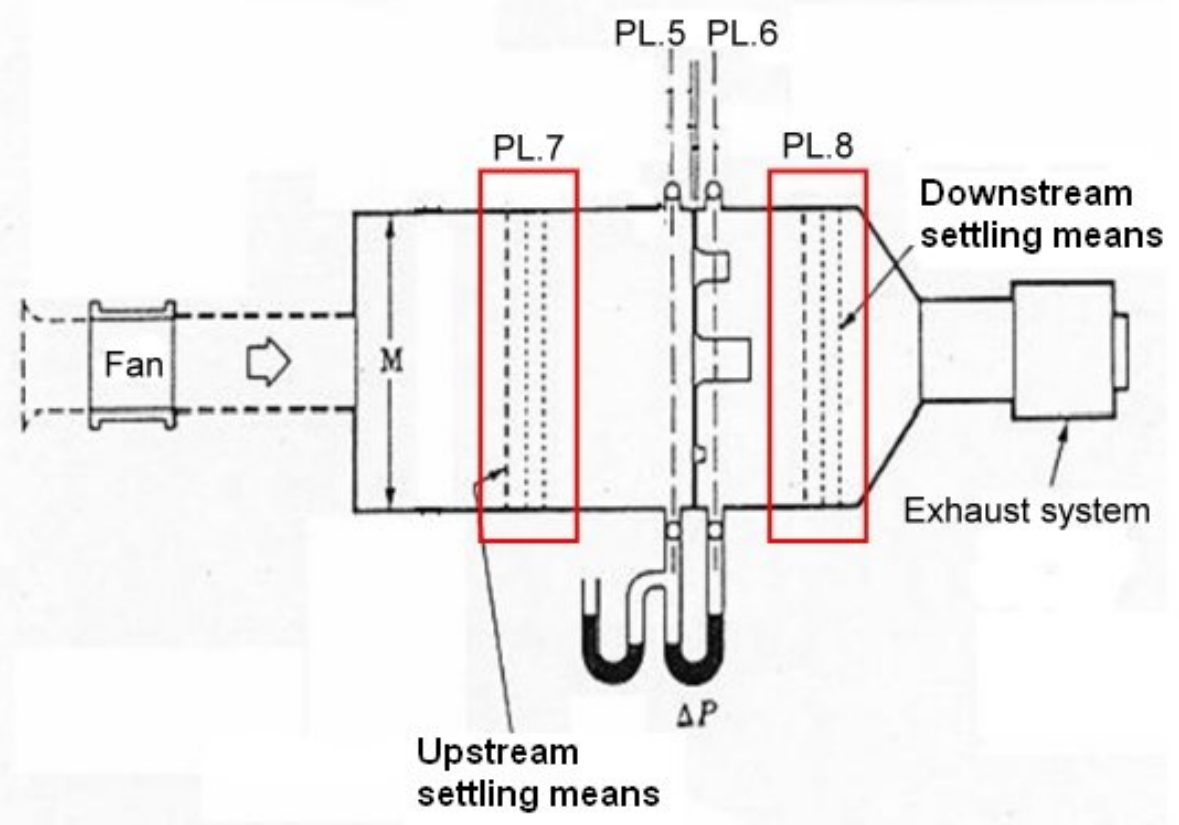
AMCA 210 風洞設計標準



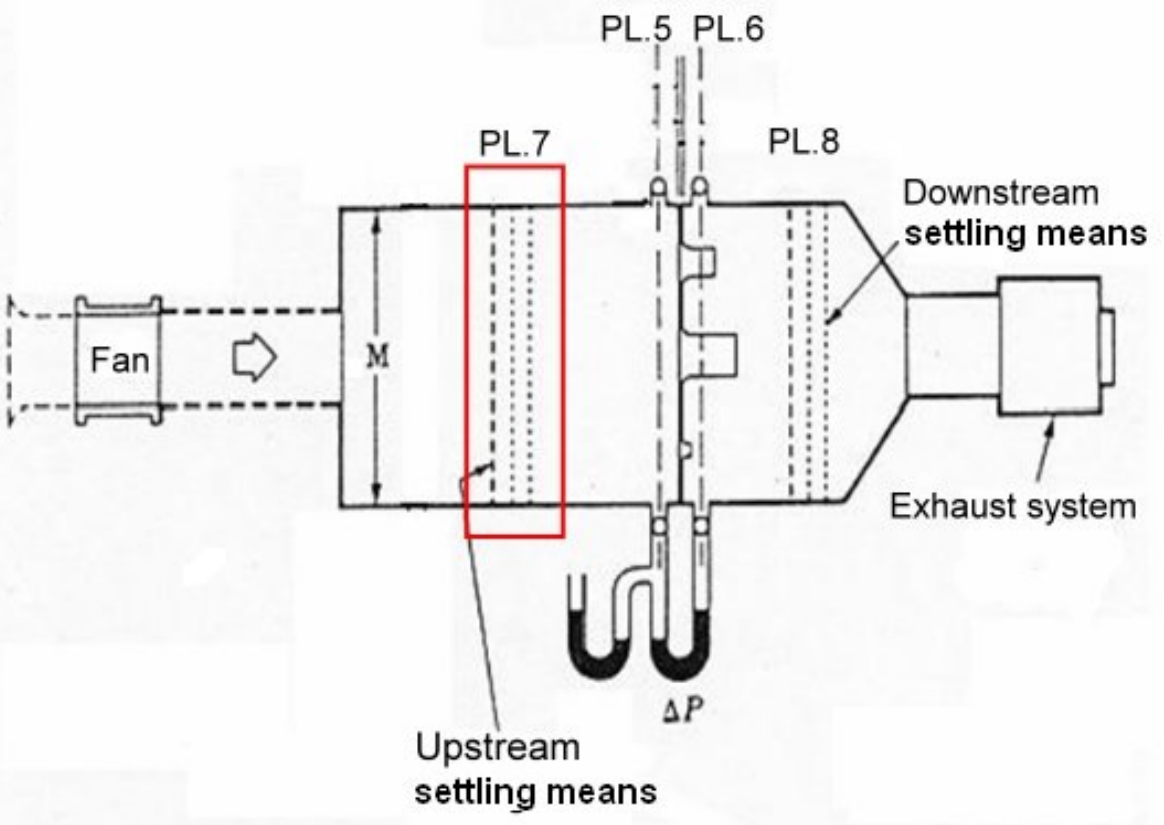
Any combinations of screens or perforated plates that will meet these requirements may be used, but in general a reasonable chamber length for the settling means is necessary to meet both requirements.

Screens of square mesh round wire with open areas of 50% to 60% are suggested and several will usually be needed to meet the above performance specifications.

A performance check will be necessary to verify the flow settling means are providing proper flow patterns.

From AMCA 210-99

AMCA 210 風洞設計標準



Upstream Settling Means

Where a measuring plane is located upstream of the settling means, the purpose of the settling screen is to absorb the kinetic energy of the upstream jet. and allow its normal expansion as if in an unconfined space.

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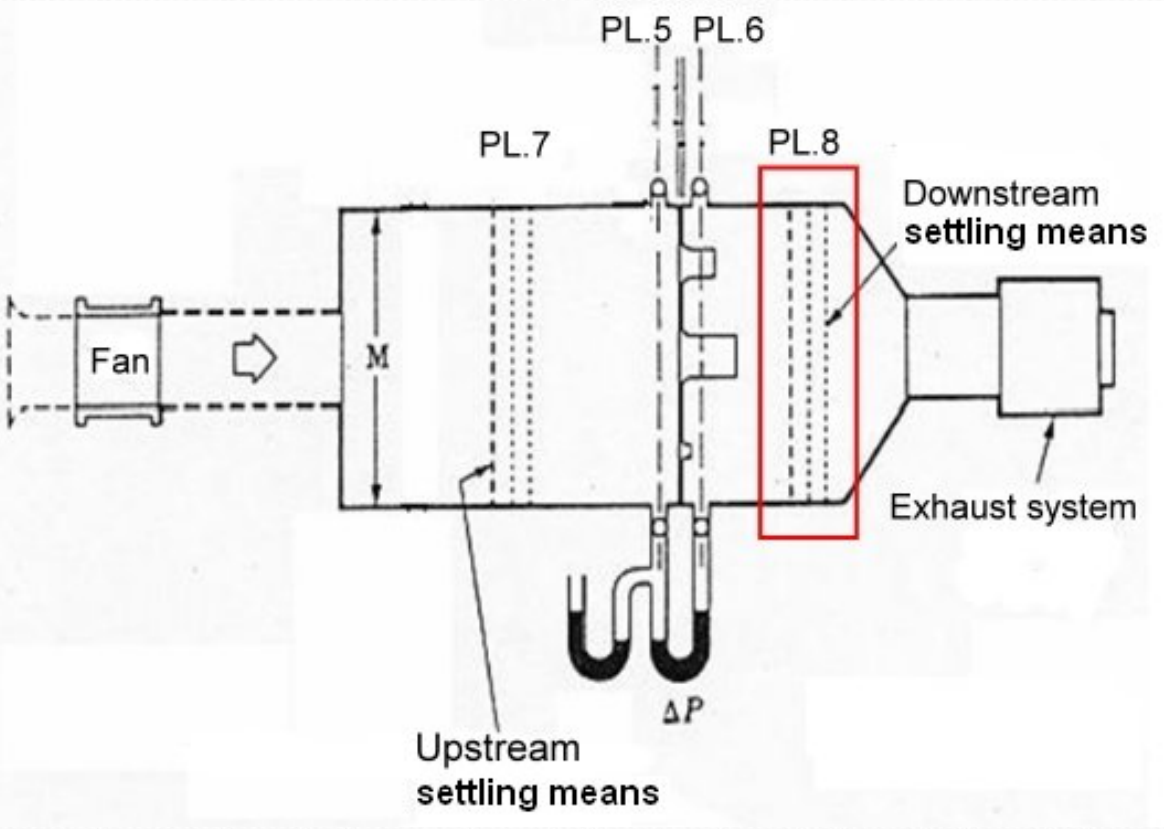

Downstream Settling Means

Flow settling means shall be installed in chambers where indicated on the test setup figures to provide proper airflow patterns.

Where a measuring plane is located downstream of the settling means, the settling means is provided to ensure a substantially uniform airflow ahead of the measuring plane.

In this case, the maximum local velocity at a distance 0.1 M downstream of the screen shall not exceed the average velocity by more than 25% unless the maximum local velocity is less than 2 m/s (400 fpm).

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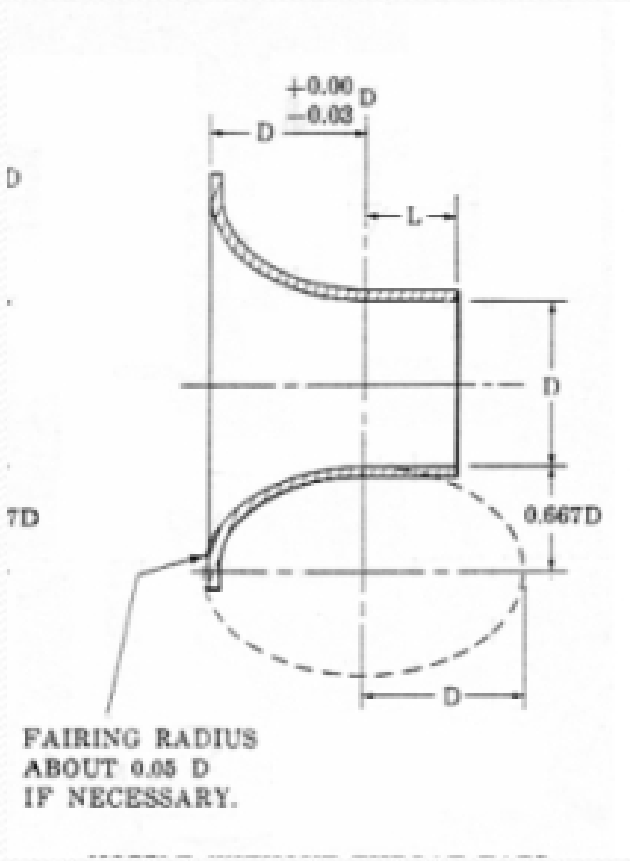
AMCA 210 風洞設計標準



Notes

1. Nozzle throat dimension L shall be either 0.6D±0.005D (recommended) or 0.5D±0.005D.
2. Nozzle shall have elliptical section as shown. Two and three radii approximations to the elliptical form that do not differ at any point in the normal direction more than 1.5% D from the elliptical form may be used. The outlet edge of the nozzle shall be square, sharp, and free from burrs, nicks or roundings.
3. The nozzle throat shall be measured (to an accuracy of 0.001 D) at the minor axis of the ellipse and the nozzle exit. At each place, four diameters—approximately 45° apart must be within ±0.002 D of the mean. At the entrance to the throat the mean may be 0.002 D greater, but no less than the mean at the nozzle exit.

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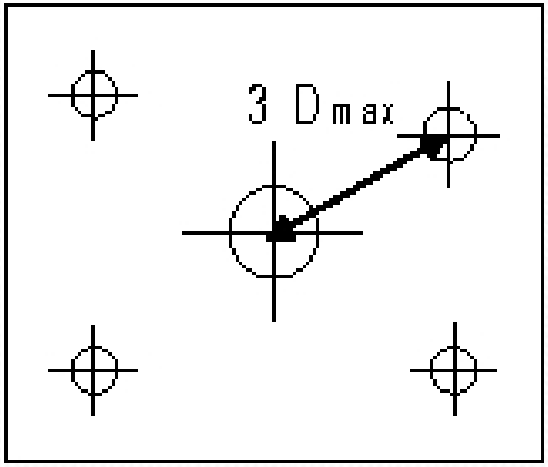
AMCA 210 風洞設計標準



6.3.4 Multiple Nozzles.

Multiple nozzles shall be located as symmetrically as possible.The centerline of each nozzle shall be at least 1.5 nozzle throat diameters from the chamber wall.

The minimum distance between centers of any two nozzles in simultaneous use shall be three times the throat diameter of the larger nozzle.

The uncertainty of the airflow rate measurement can be reduced by changing to a smaller nozzle or combination of nozzles for the lower airflow rate range of the fan.

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AMCA 210 風洞設計標準

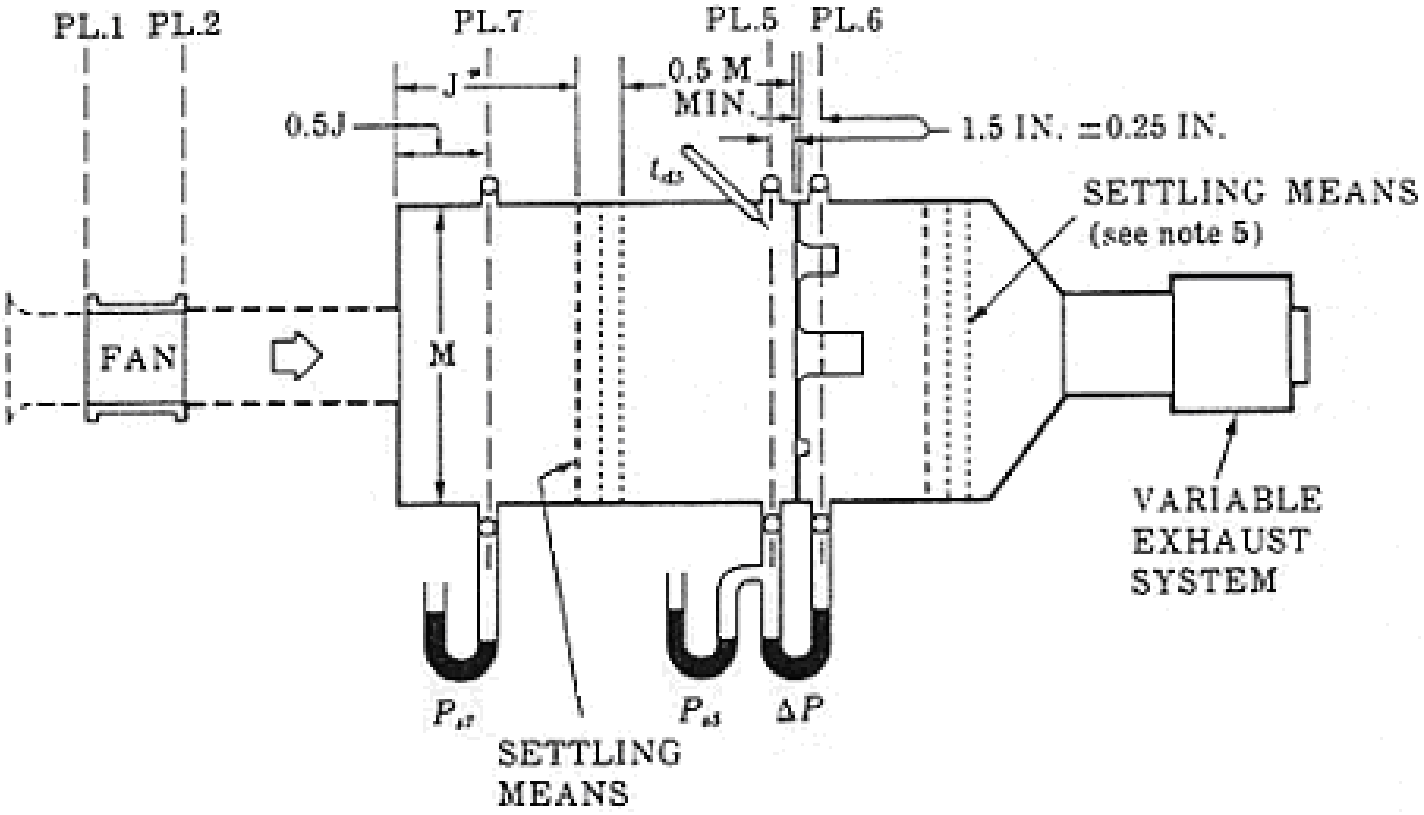

Figure 12 Outlet Chamber
ANSI/AMCA STANDARD 210-85

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流量量測原理

Bernoulli's equation

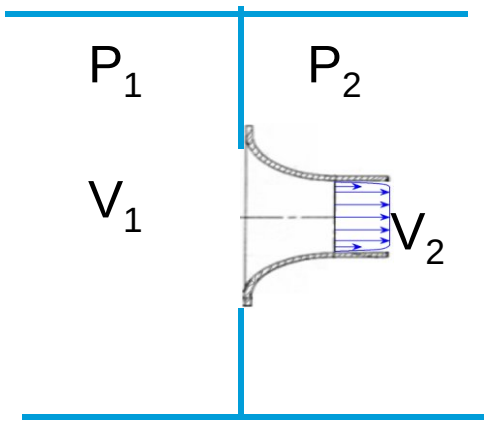
$$P_1 + \frac{1}{2} \cdot \rho \cdot V_1^2 = P_2 + \frac{1}{2} \cdot \rho \cdot V_2^2$$

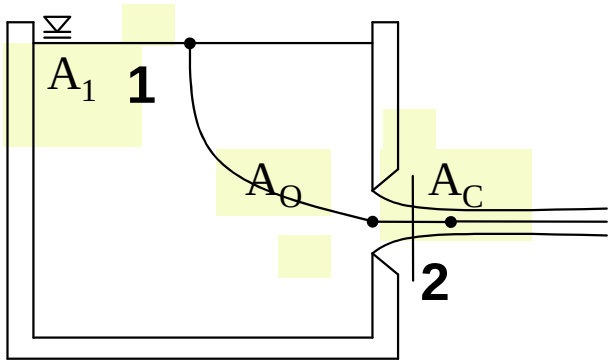
$$Q_{real} = Cd \times V_2 \times A$$

$V_2 >> V_1$

$$V_2 = \sqrt{\frac{2 \times (P_1 - P_2)}{\rho}}$$

Cd:discharge coefficient
A: nozzle throttle area





流量量測原理

How to get the Cd ?

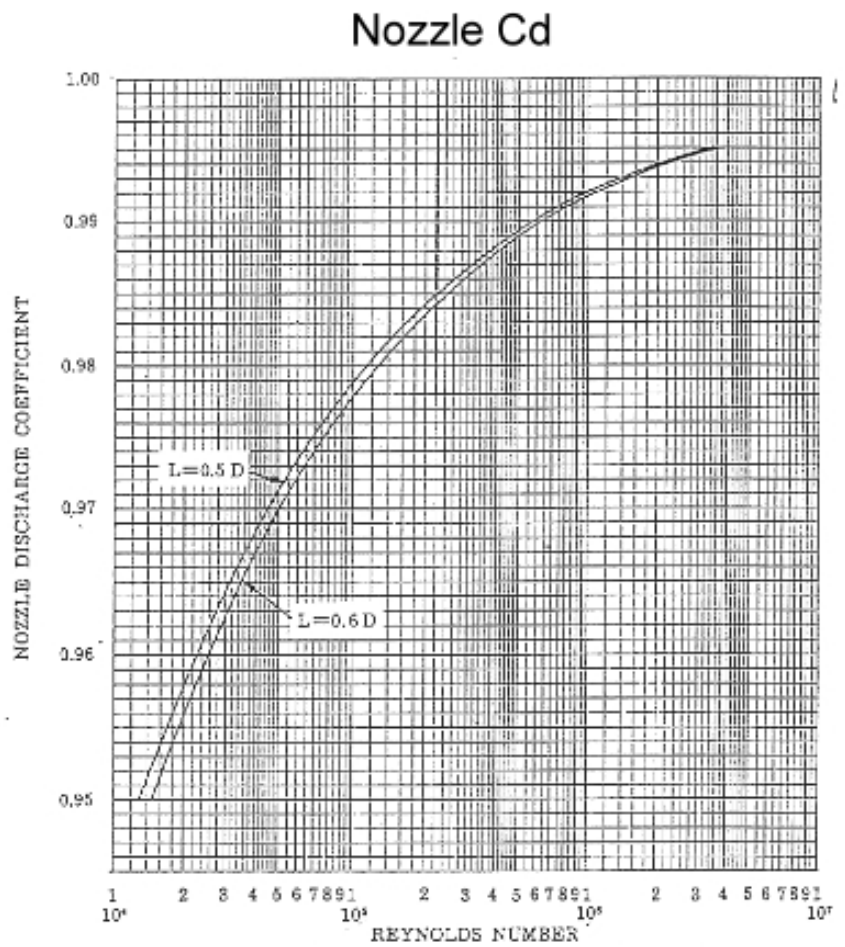


Figure 18 Coefficients of Discharge For Flow Nozzles

From AMCA 210-85 Page 38

$$C_d = 0.9986 - \frac{7.006}{\sqrt{Re}} + \frac{134.6}{Re}$$

$$Re = \frac{D_n \cdot U_n}{\nu}$$

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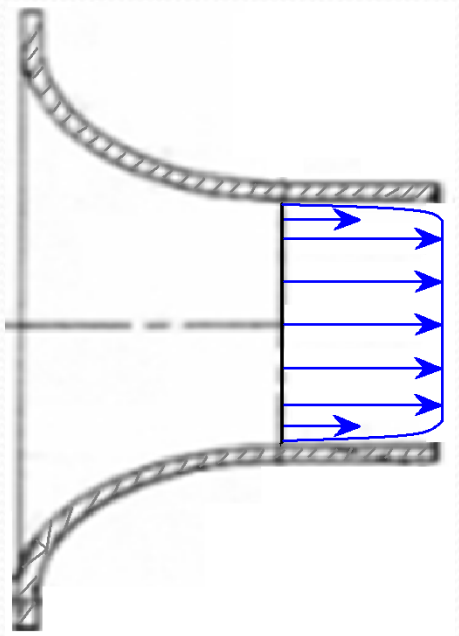
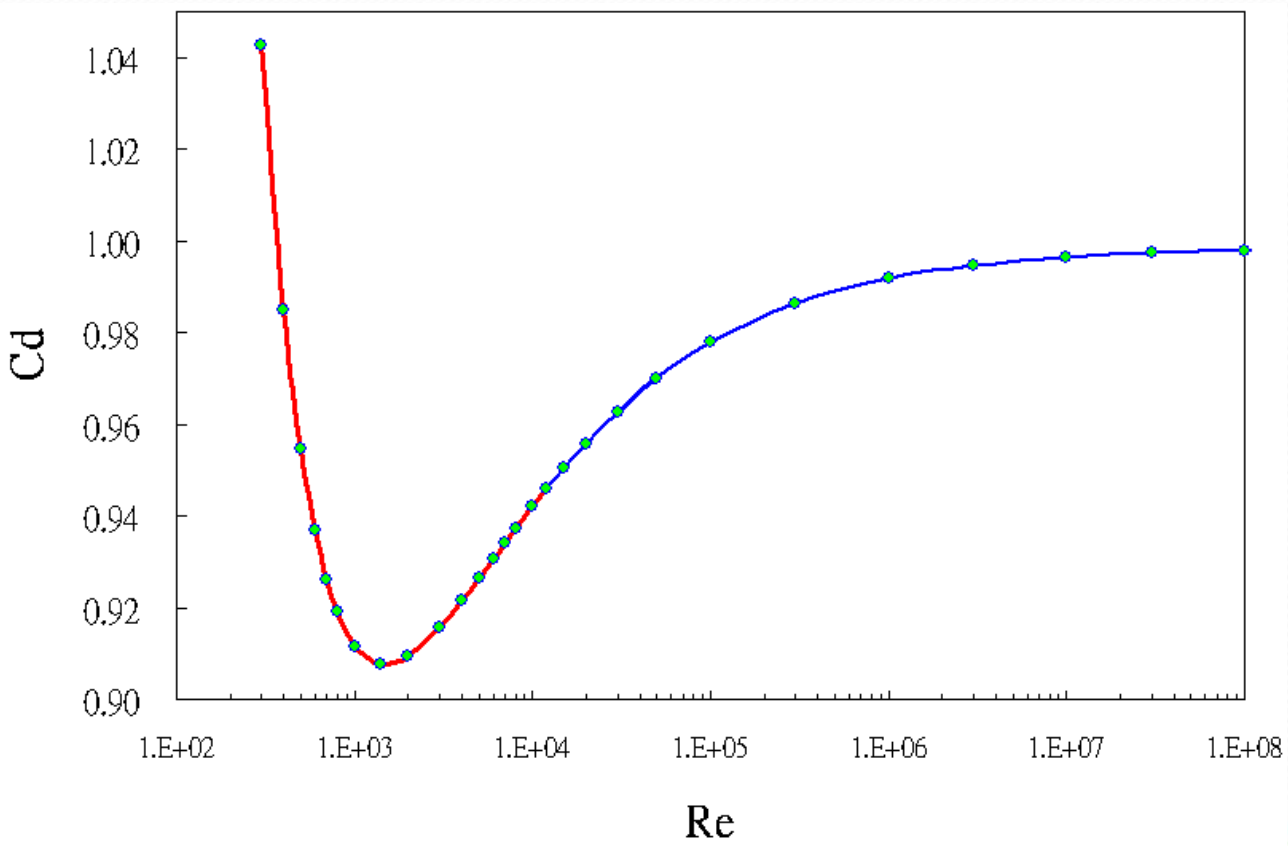
流量量測原理

From AMCA 210 Standard

$$Cd_{\mathrm{Re}>12000} = 0.9986 - \frac{7.006}{\sqrt{\mathrm{Re}}} + \frac{134.6}{\mathrm{Re}} \quad for\ \frac{L}{D} = 0.6$$





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流量量測原理

Cd calculation formula

$$\mathbf{Cd}_{\text{Re>12000}} = 0.9986 - \frac{7.006}{\sqrt{\mathrm{Re}}} + \frac{134.6}{\mathrm{Re}} \qquad for\ \frac{L}{D} = 0.6$$

Cd modify equation :

$$\mathbf{Cd}_{\text{Re<12000}} = 0.999976 - \frac{5.922888}{\sqrt{\mathrm{Re}}} \qquad for\ \frac{L}{D} = 0.6$$

Ref.

Journal: Flow Measurement and Instrument

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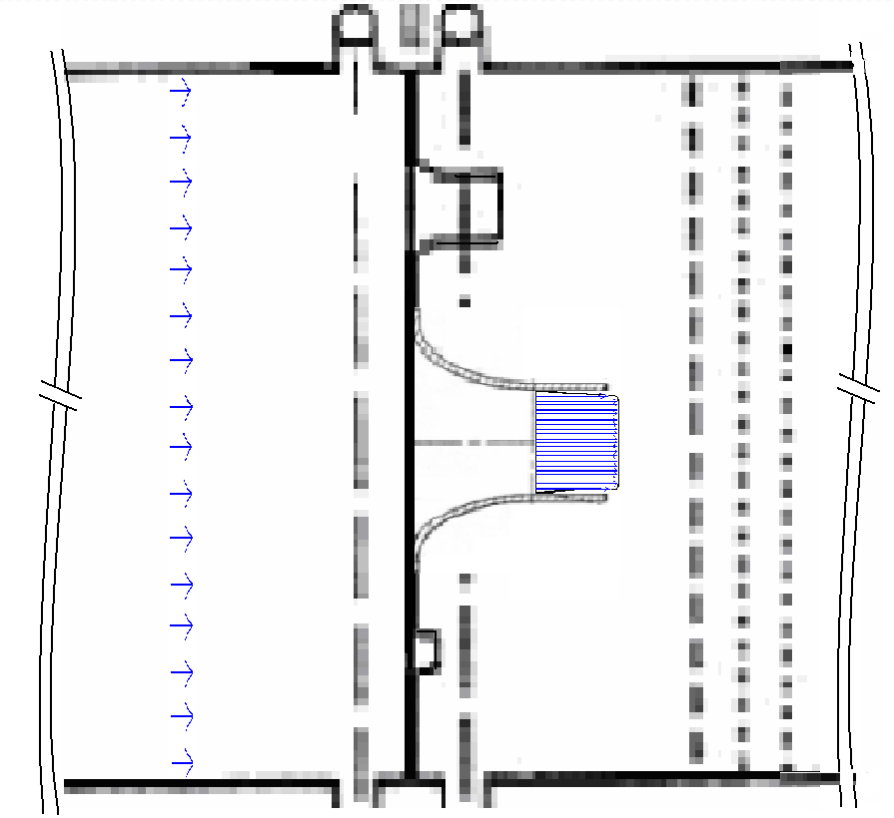
多噴嘴 流量量測

Measuring the Pressure Difference
Across the Nozzle(ΔP56) to Calculate the Air Flow Rate.
Fig.8～12，14，15 Structure.

QN = Cd x Un x An single nozzle
QT = Σ QN multi-nozzle

Cd : Discharge Coefficient.
Un : Velocity at Nozzle Throttle.
An : Nozzle Throttle Cross-section.
QN : Single Nozzle Air Flow Rate
QT : Multi Nozzle Air Flow Rate.



ΔP Across the Nozzle

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AMCA 標準噴嘴

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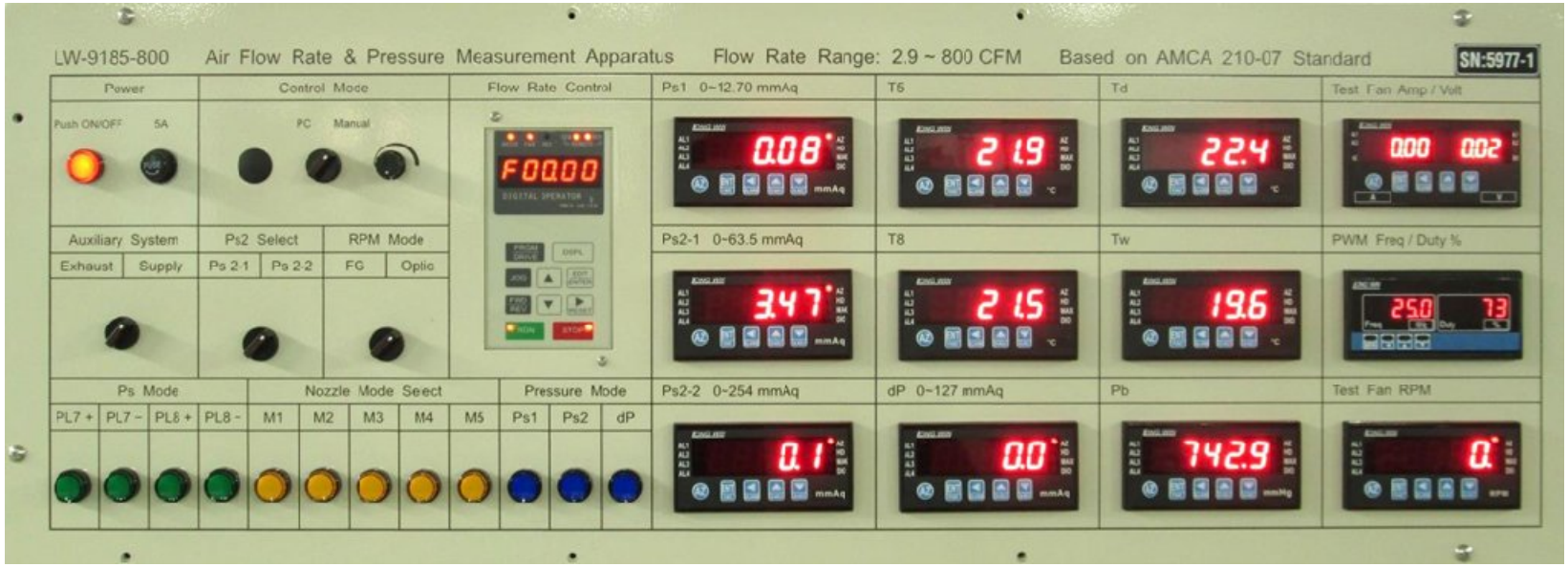
儀表校正



The quality of our thermometer, pressure, electrical meter (voltage, current, fan speed) will be approved by a third party (SGS).

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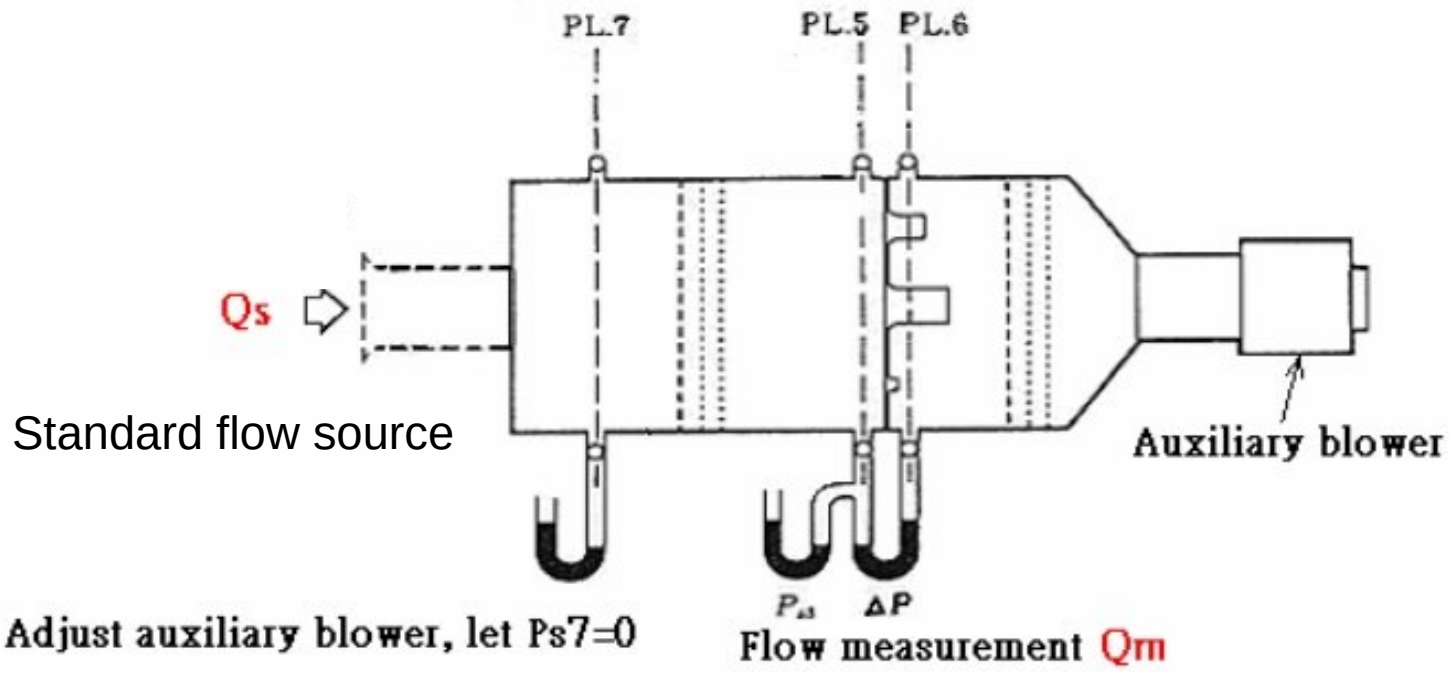
風洞校正流程



$$\text{Relative error} = \frac{Qs - Qm}{Qm}$$

Wind tunnel calibration Scheme

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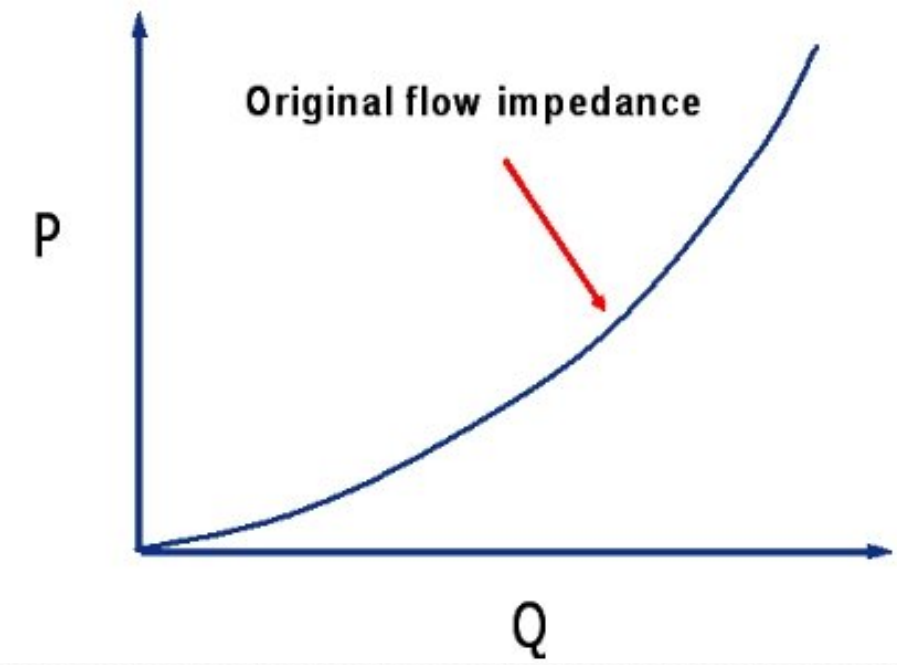
風洞校正流程



Long Win provides the orifice plate to create original flow impedance curve.

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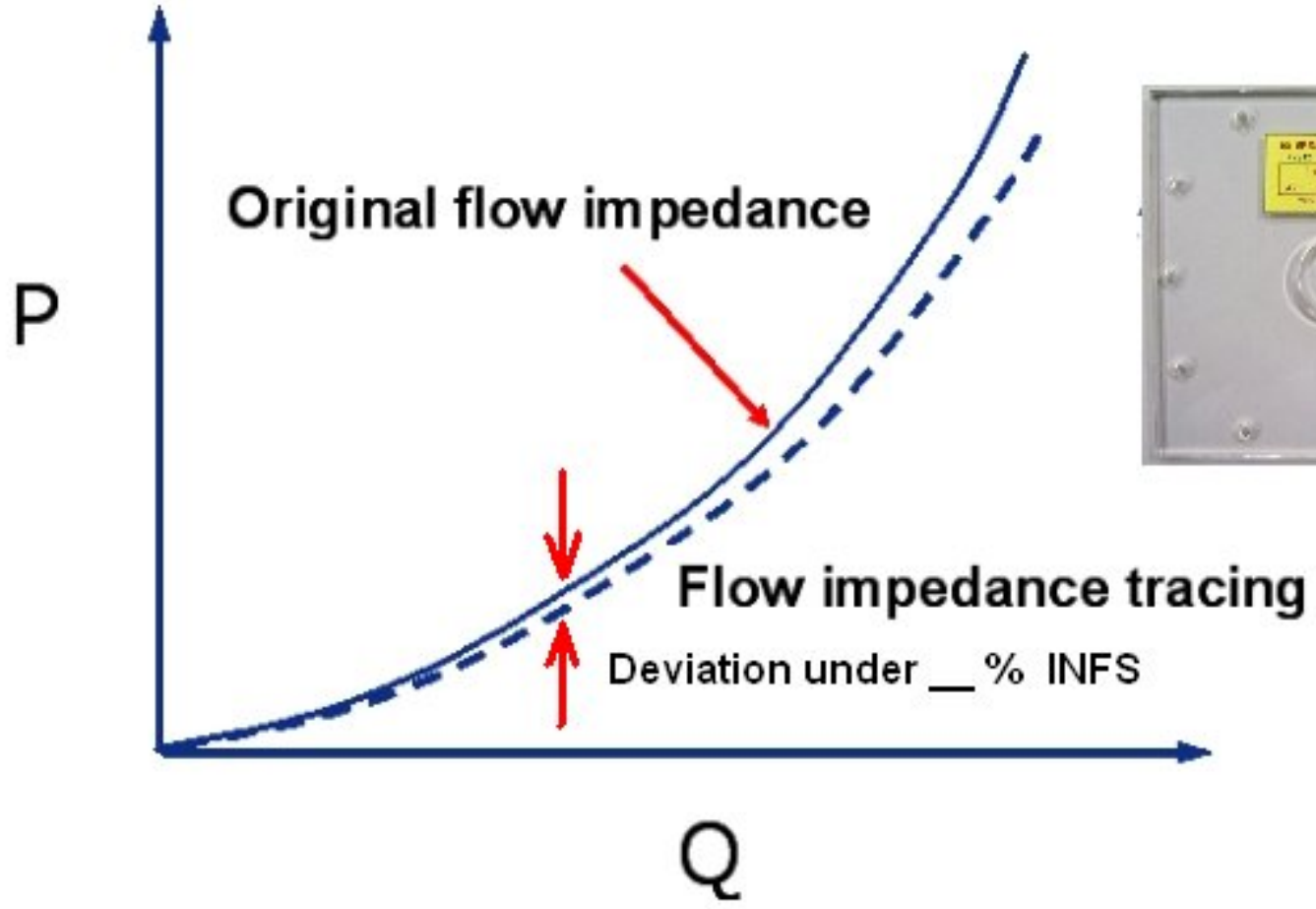
風洞校正流程

Traceability

Long Win provides the orifice plate to measure flow impedance curve for tracing.



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風洞特點

☆ AMCA 210規範 Fig.12 & Fig.15二合一結構

☆ 全系統自動化控制

☆ 設備流量精度

☆ 風扇PQ五種測試模式

☆ 標準狀態STP轉換

☆ 高靜壓風扇測試

☆ 系統流阻曲線(SRC)測試

☆ 散熱模組自動熱阻-流量(R-Q)測試

☆ 品管 - Cpk測試

☆ 品管 - 控制點(Operation Point)檢查

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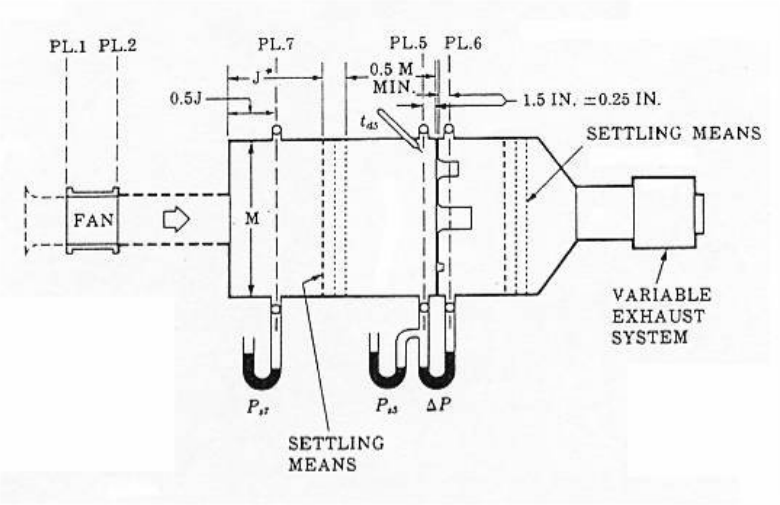
☆ AMCA 210規範 Fig.12 & Fig.15二合一結構

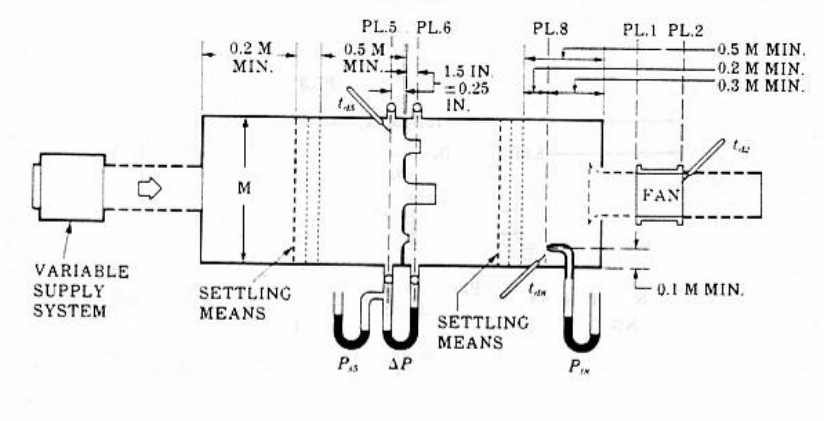
2 in 1

Combine AMCA 210-99

Fig.12 & Fig.15 Two Structures



AMCA 210 Fig.12 Outlet Chamber Setup Multiple Nozzles in Chamber



AMCA 210 Figure 15 Inlet Chamber Setup Multiple Nozzle in Chamber

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☆ 全系統自動化控制

＊ Auto Change Nozzles

＊ Auto Switching Ps

(Ps1,Ps2,Ps3 auto switching)

＊ Smart fan PQ measurment

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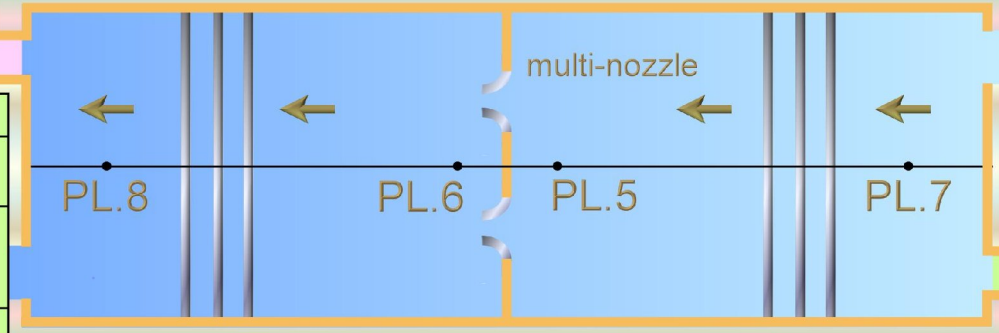
LW-Series Air Flow Rate & Pressure Measurement Apparatus

Meeting AMCA 210-99 Standard
Including Fig.12 & Fig.15 Structure
design & manufacturer : Long Win Science & Technology Corporation
Web site : http://www.longwin.com
Tel : 886-3-464-3221
Fax : 886-3-496-1307

Fig.12 Structure

Auxiliary Blower Suction Flow

Specimen
fan & fan tray performance test
system or module impedance, operation air flow rate
standard air flow rate for system testing



Specimen
fan & fan tray performance test
system or module impedance, operation air flow rate
standard air flow rate for system testing

Auxiliary Blower Blow Down Flow

Fig.15 Structure

Features

- fan performance, PQ curve,blade design, electric function
- system & module impedance
- offer operation air flow rate set up T-Q / R-Q chart

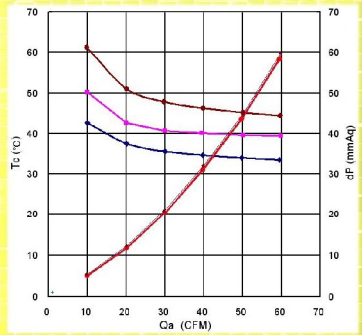
Measurement Item

- air flow rate : series 2.4 ~ 3000 CFM
- accuracy : 1 ~ 3.5% INFS full scale of indicated nozzle
- I , V , rpm of Fan

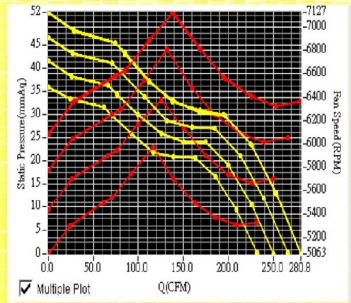
Air Flow Rate Calculation

$Q = Cd \cdot \Sigma A \cdot U$
Q : air flow rate
ΣA : nozzle area
Cd : discharge coefficient
$1/2\rho U^2 = \Delta P = P_{56}$
$\rho_{air} = f(Td, Tw, Tc, P_{PL.5})$
$Cd = f(Re)$
$Re = f(D, U, \mu, \rho)$

RQ Chart



PQ Chart



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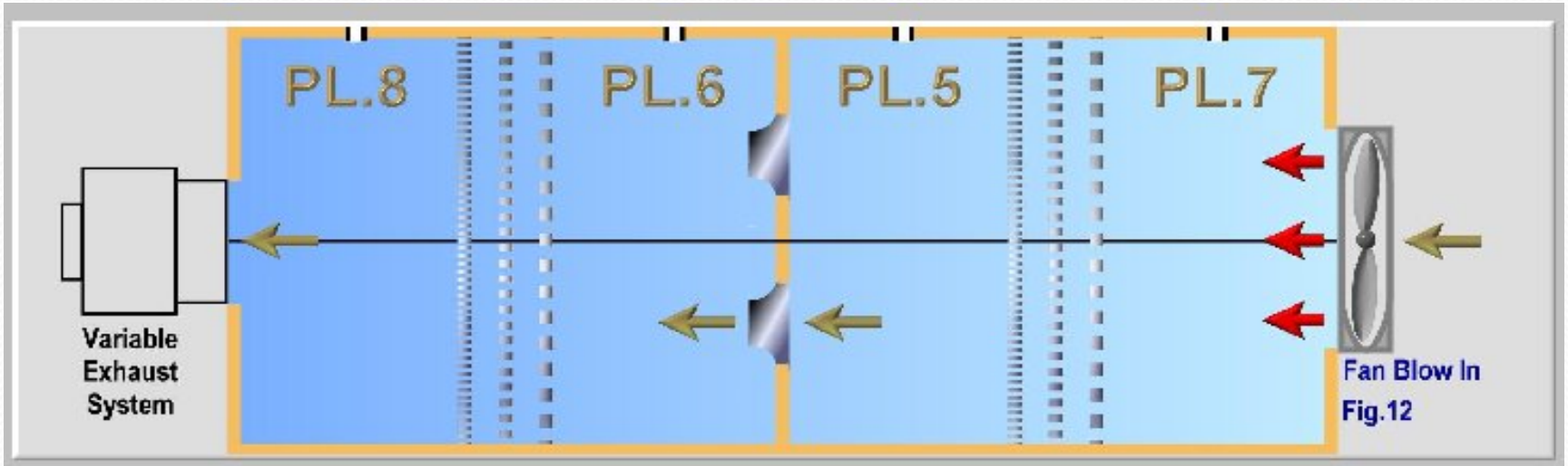

Fig.15 Inlet Chamber

- D. Fan Performance Curve - FPC
- E. System Resistance Curve - SRC
- F. Airflow / Thermal Resistance - TRC

Fig.12 Outlet Chamber

- A. Fan Performance Curve - FPC
- B. System Resistance Curve - SRC
- C. Airflow / Thermal Resistance - TRC

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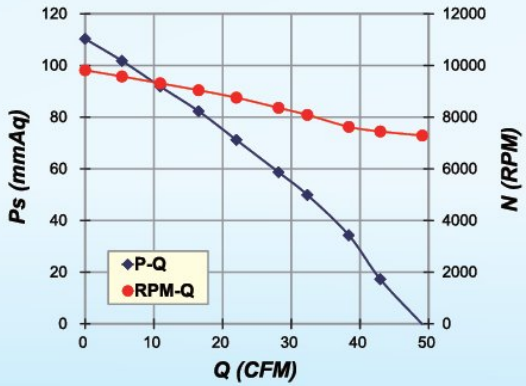
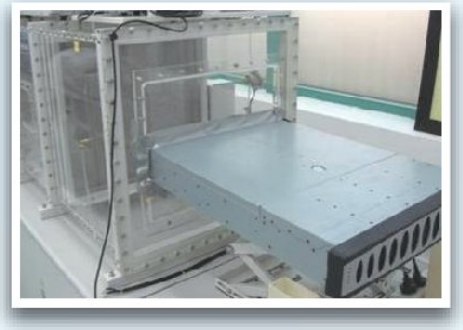
PQ curve

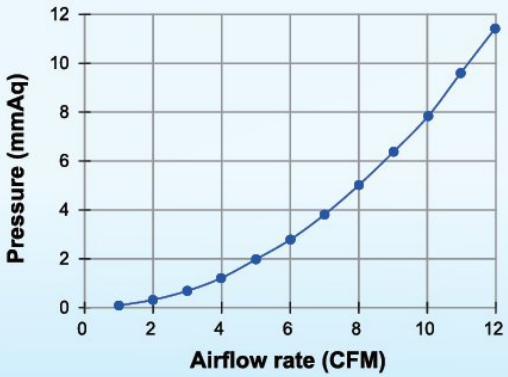
- The fan performance curve with pressure (P) and airflow rate (Q).



SRC curve

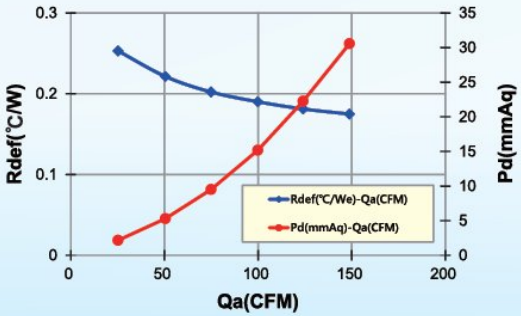
- Applicable to system resistance measurement for PC, Notebook, and server.





RQ curve

- To analyze thermal resistance (R) and the correlation of P and Q. A thermal wind tunnel or standard TTP can be cooperated.



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測試數據範例

Test Condition @ 1760 RPM								
Ps	Q	P_{STP}	Q_{STP}	Rotary Speed	Torque	Shaft Power	Ps Efficiency	Pt Efficiency
Pa	CMH	Pa	CMH	RPM	N-m	Watt	%	%
1144.3	0	1238.8	0	1762	32.4	5978.3	0.0	0.0
1029.4	2344	1112.5	2344	1763	29.9	5520.2	12.1	12.2
926.4	4715	995.5	4715	1760	27.9	5142.2	23.6	23.7
844.0	6718	904.8	6718	1760	26.5	4884.1	32.2	32.6
667.3	9322	713.1	9322	1762	23.5	4336.1	39.9	41.1
522.1	11357	556.8	11357	1761	20.5	3780.4	43.6	46.1
410.2	13591	437.0	13591	1760	20.4	3759.9	41.2	45.6
320.9	15847	341.8	15847	1761	19.7	3632.9	38.9	46.1
175.7	18215	186.8	18215	1762	18.0	3321.3	26.8	38.9
-2.0	20609	-2.1	20609	1760	15.8	2912.0	-0.4	19.5

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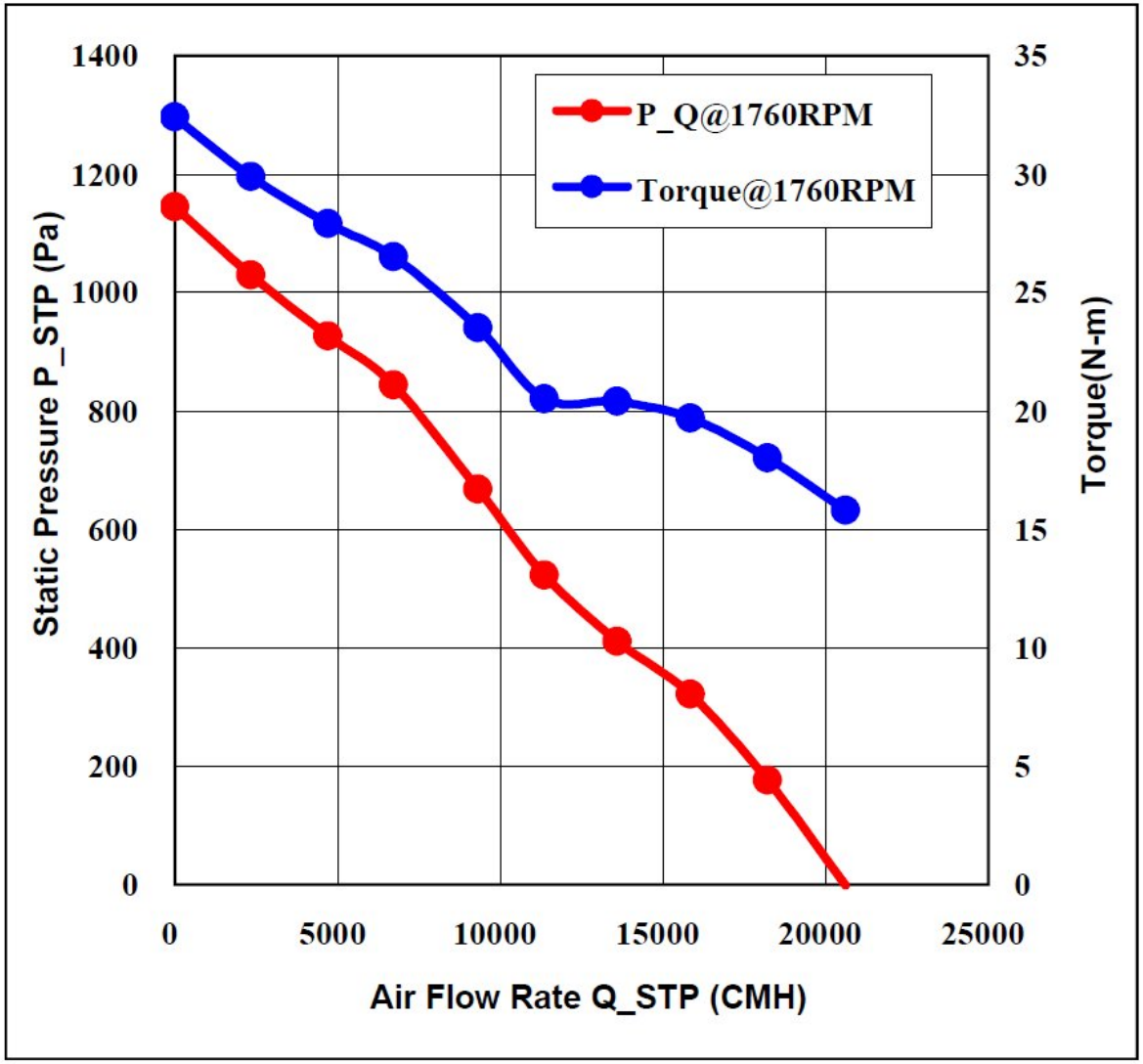
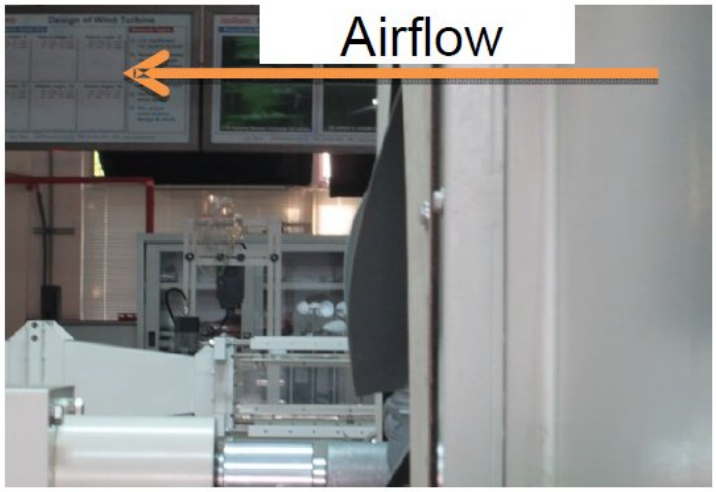
測試數據範例 – PQ & TQ



Installation



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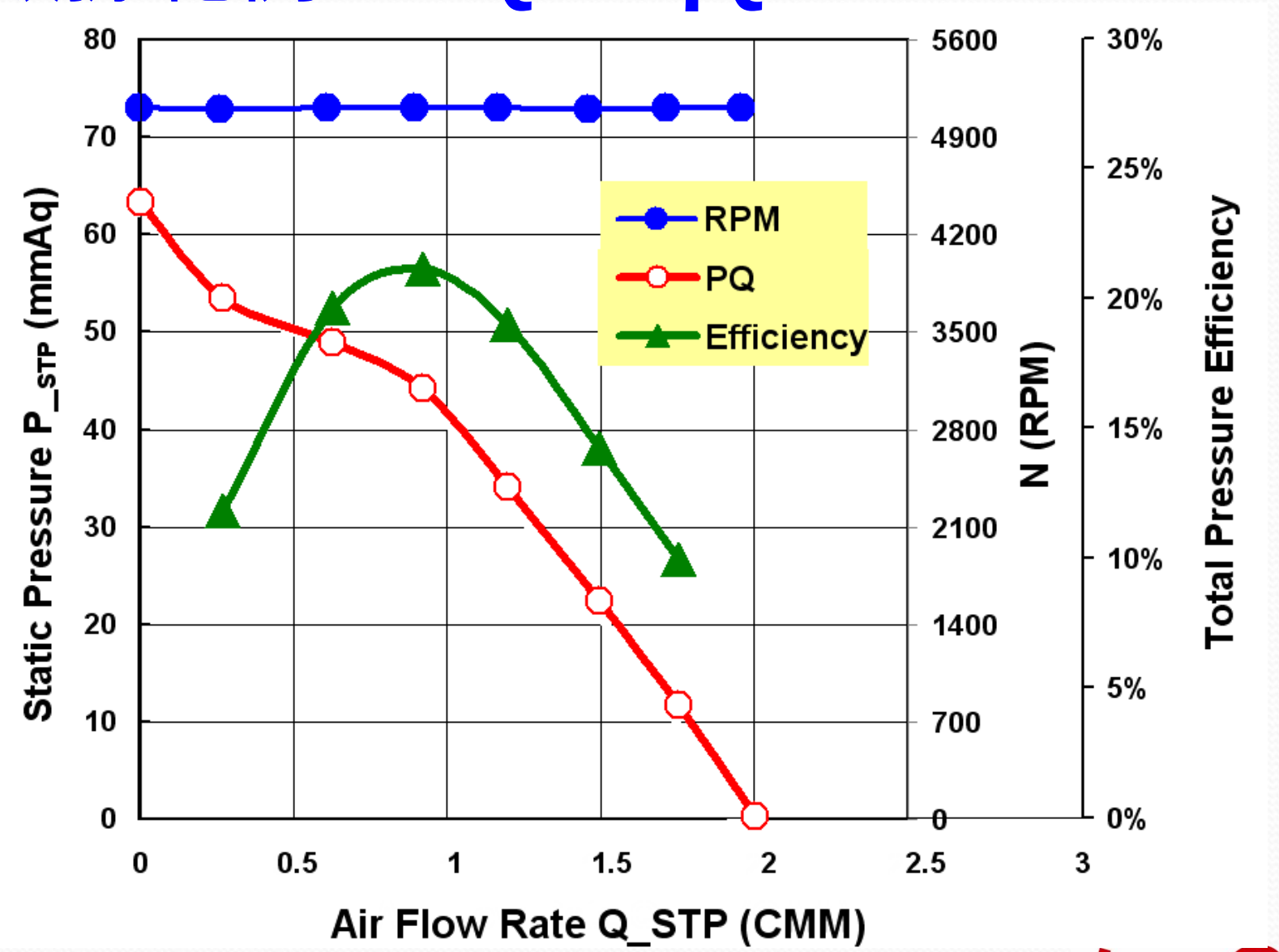
測試數據範例 – PQ & ηQ



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☆ 風扇PQ五種測試模式

- Constant Volt
- PWM
- Constant RPM
- Cpk
- Operation Point Check

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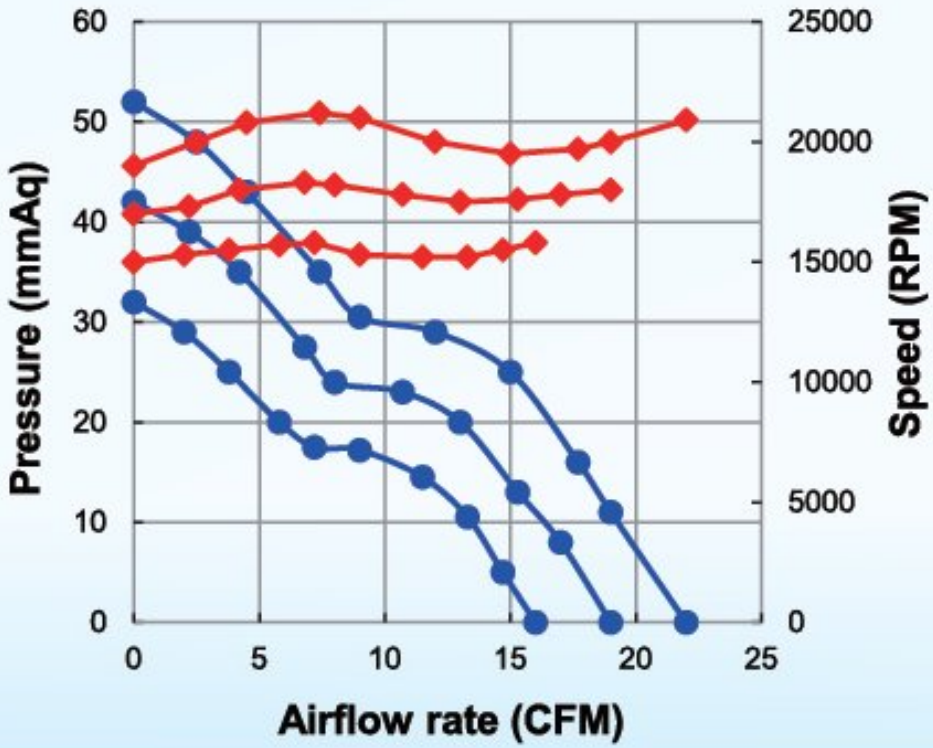
Constant voltage

- Apply certain DC or AC power to specimen.



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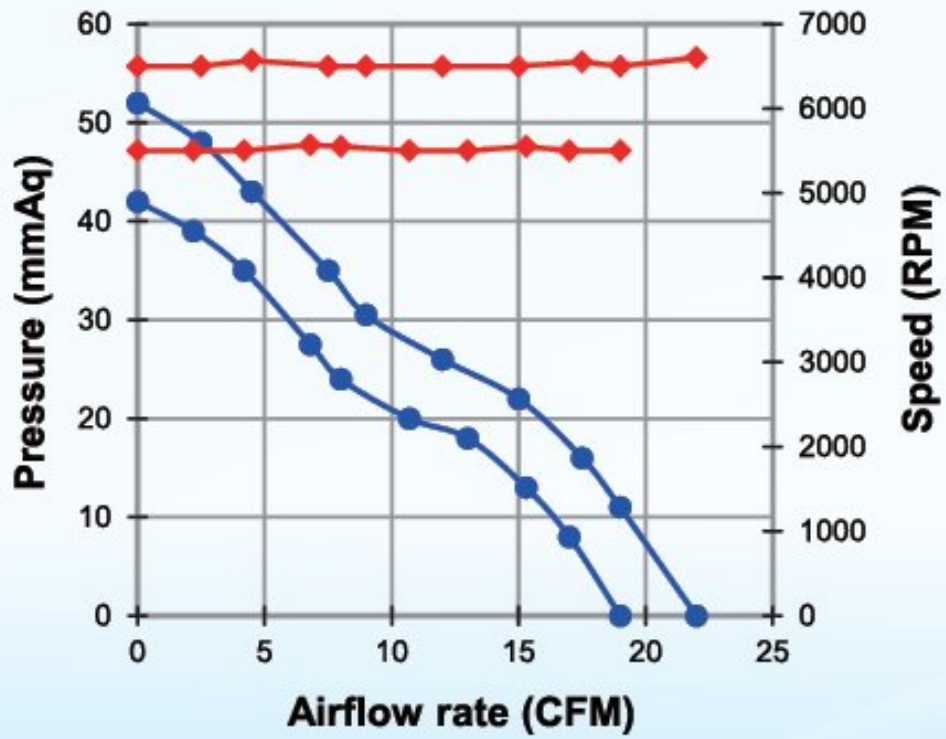
Constant RPM

- RPM can be controlled by DC voltage or PWM.



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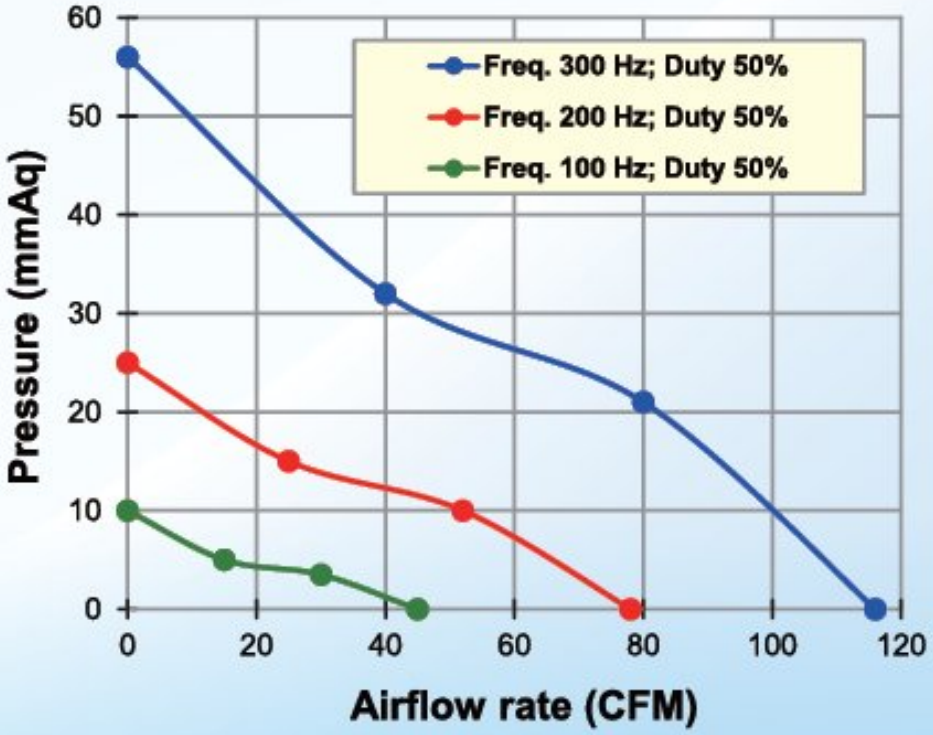
PWM mode

- Adjusting frequency and duty cycle under a constant DC voltage.



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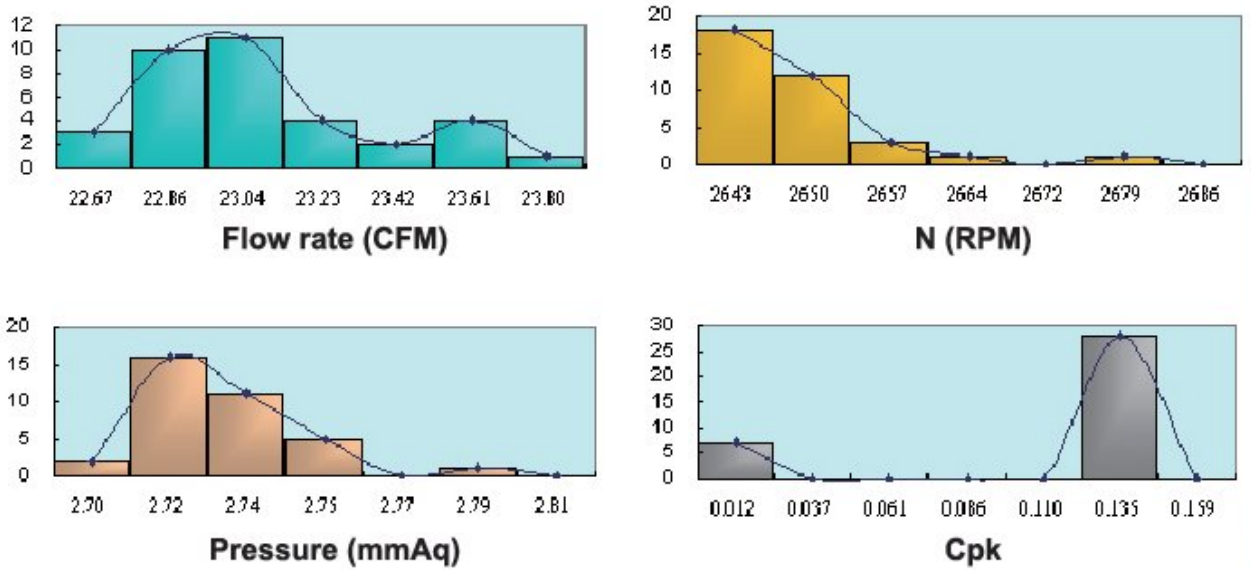
Cpk mode

- A statistical method to analyze the mass production performance while doing quality assurance.

Engineering Specification					
		A	B	C	D
	product spe	23.3896	2.72743	2648.09	0.114
	+ Tolerence	0.92445	0.06015	23.6424	0.17102
	- Tolerence	0.92445	0.06015	23.6424	0.17102
	USL	24.014	2.78758	2671.73	0.23902
	LSL	22.1651	2.66728	2624.44	-0.057
Actual Data					
		A	B	C	D
	X bar	23.3896	2.72743	2647.07	0.114
	Sigma	0.31365	0.02034	7.96565	0.05784
	Median	23.099	2.72	2646	0.142
	Mode	#N/A	2.72	2645	0.142
	Max	23.7065	2.8	2682.5	0.147
	Min	22.5752	2.69	2639	0
UCL 3 Sigma	1 Sigma	23.4022	2.74777	2655.07	0.17104
	2 Sigma	23.7140	2.76811	2663.07	0.22068
	3 Sigma	24.0259	2.78845	2671.06	0.23752
LCL 3 Sigma	1 Sigma	22.7769	2.70709	2639.08	0.05616
	2 Sigma	22.4643	2.68675	2631.08	-0.00017
	3 Sigma	22.1516	2.6664	2623.09	-0.0595
SPC	CP	0.93561	0.98561	0.98561	0.93561
	CPL	0.93561	0.98561	0.94341	0.93561
	CPU	0.93561	0.98561	1.02781	0.93561
	S. CP	0.93561	0.98561	0.94341	0.93561
	Ca	3.8E-15	0	0.1428	2E-16
	Cpk	0.93561	0.98561	0.94341	0.93561



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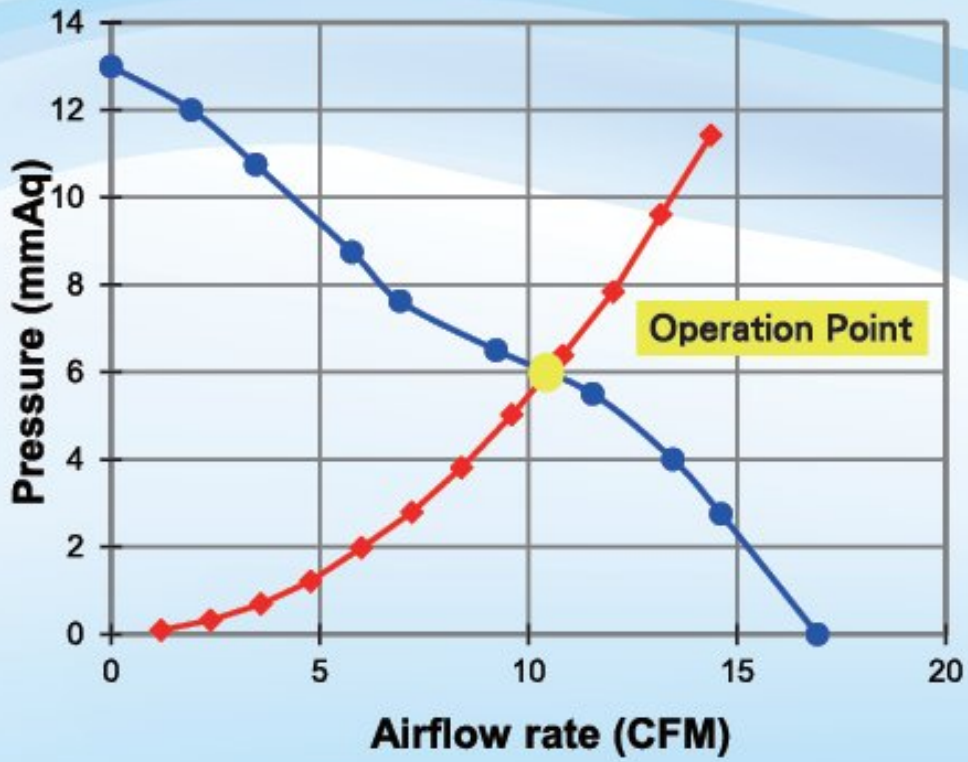
Operation Point (OP) check

- Providing a required flow rate (Q) :
  Static pressure (Ps) > OP : The fan is OK.
  (OP-Uncertainty) < Ps : The fan is NG.



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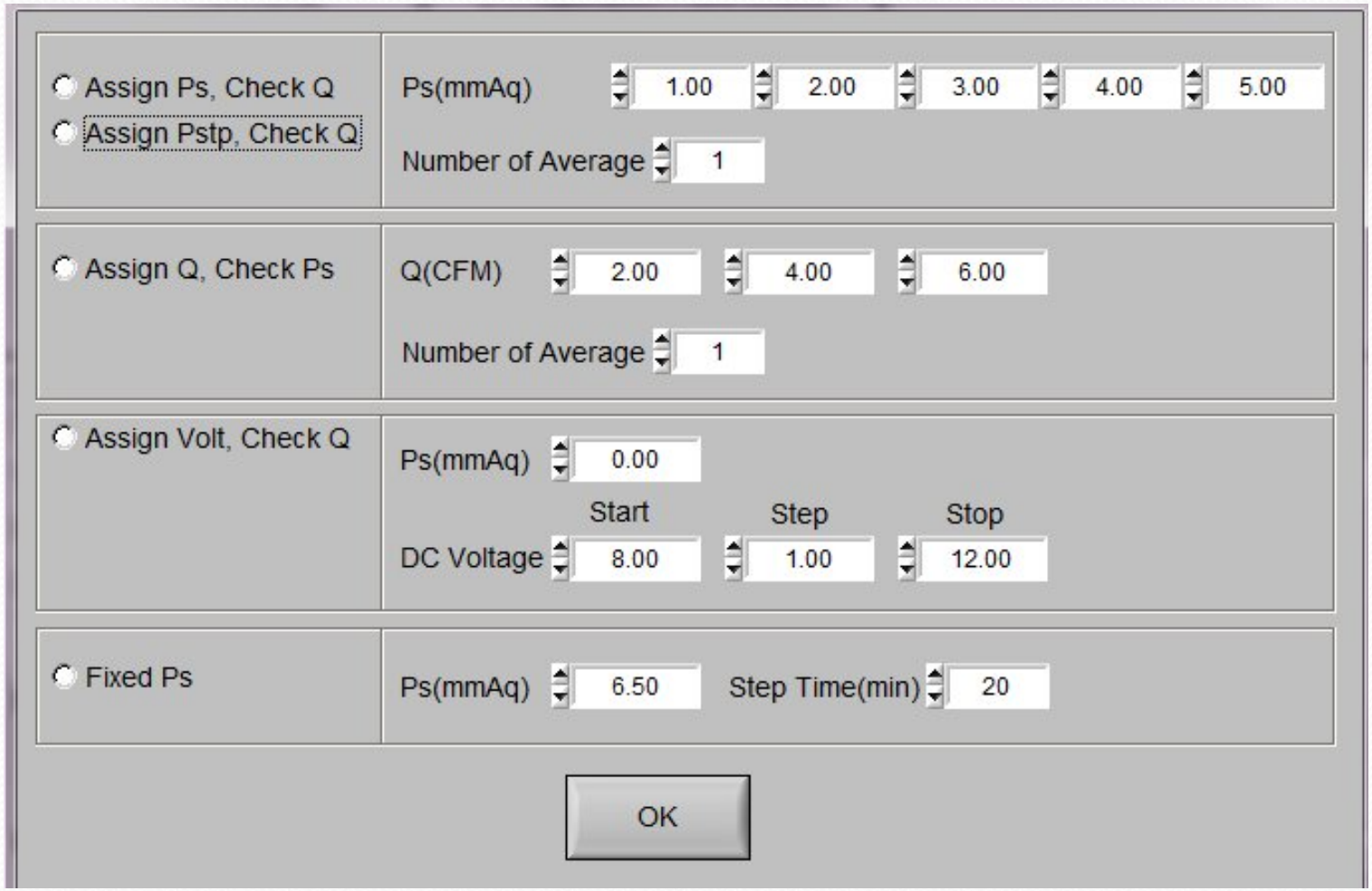
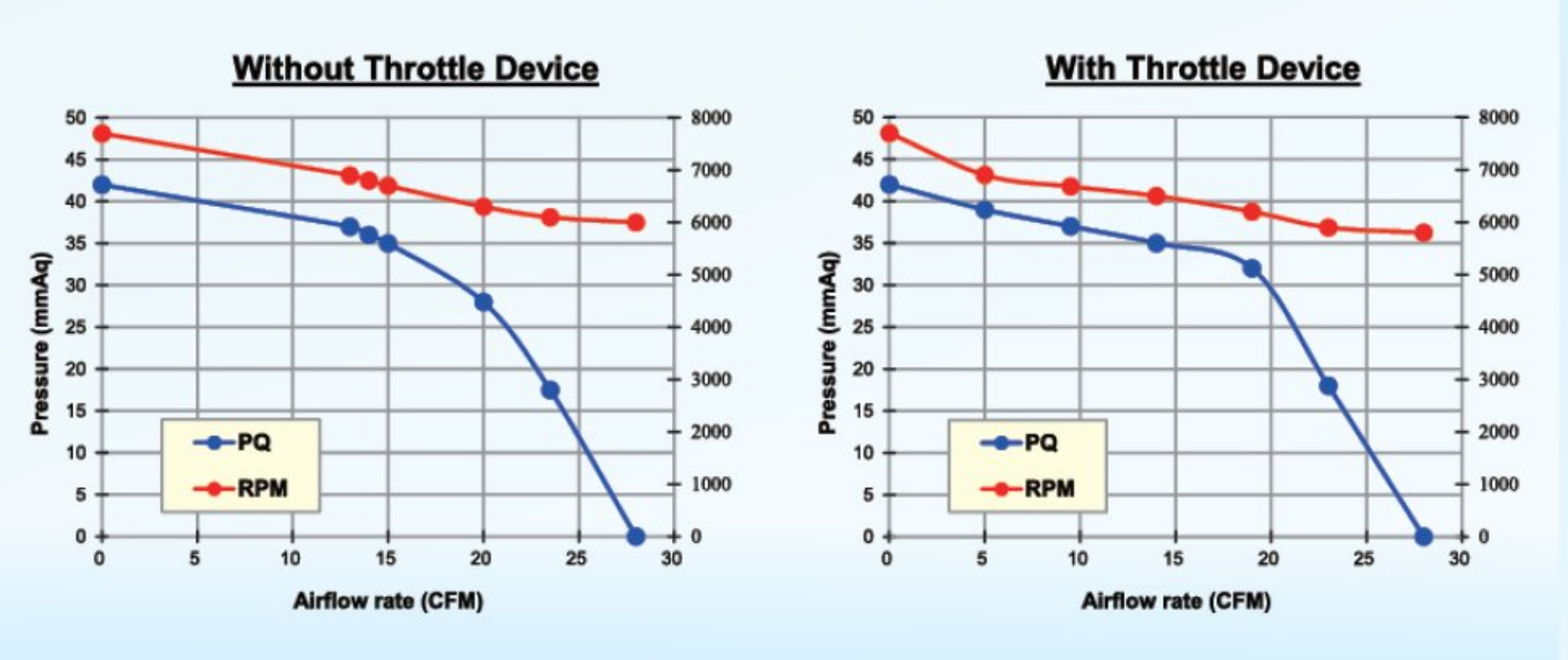
控制點測試應用



LongWin
Fundamental, Forward & First

☆ 高靜壓風扇測試 – 阻流裝置



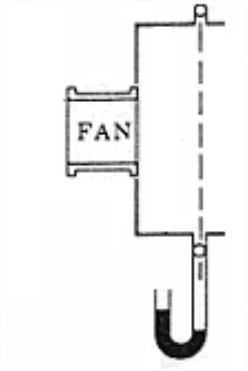
LonGwin
Fundamental, Forward & First

摘要

1. AMCA 210 標準簡介
2. 流量量測原理
3. 校正流程
4. 風洞特點
5. 風扇PQ比較
6. 應用案例

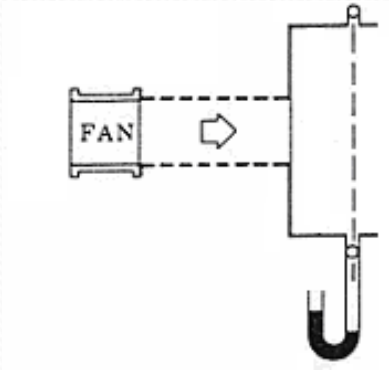
LongWin
Fundamental, Forward & First

風扇測試 – 安裝模式



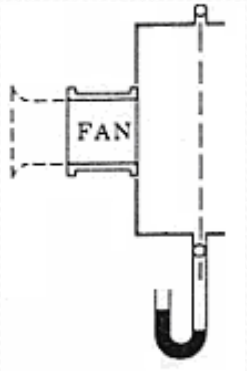
Type A

Free Inlet,
Free Outlet



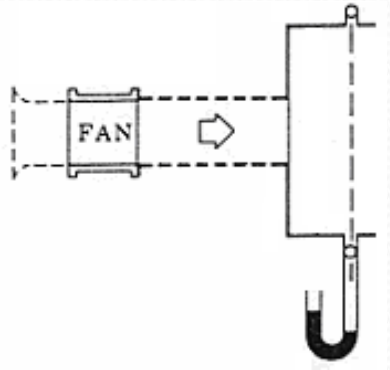
Type B

Free Inlet,
Ducted Outlet



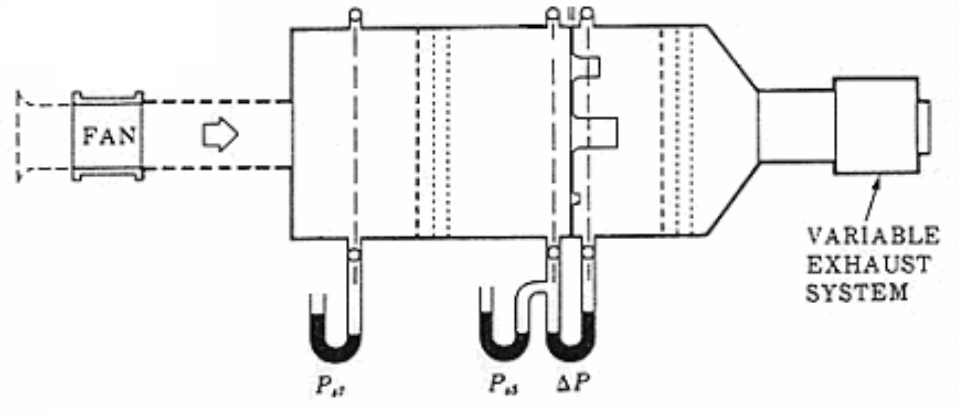
Type C

Ducted Inlet,
Free Outlet



Type D

Ducted Inlet,
Ducted Outlet



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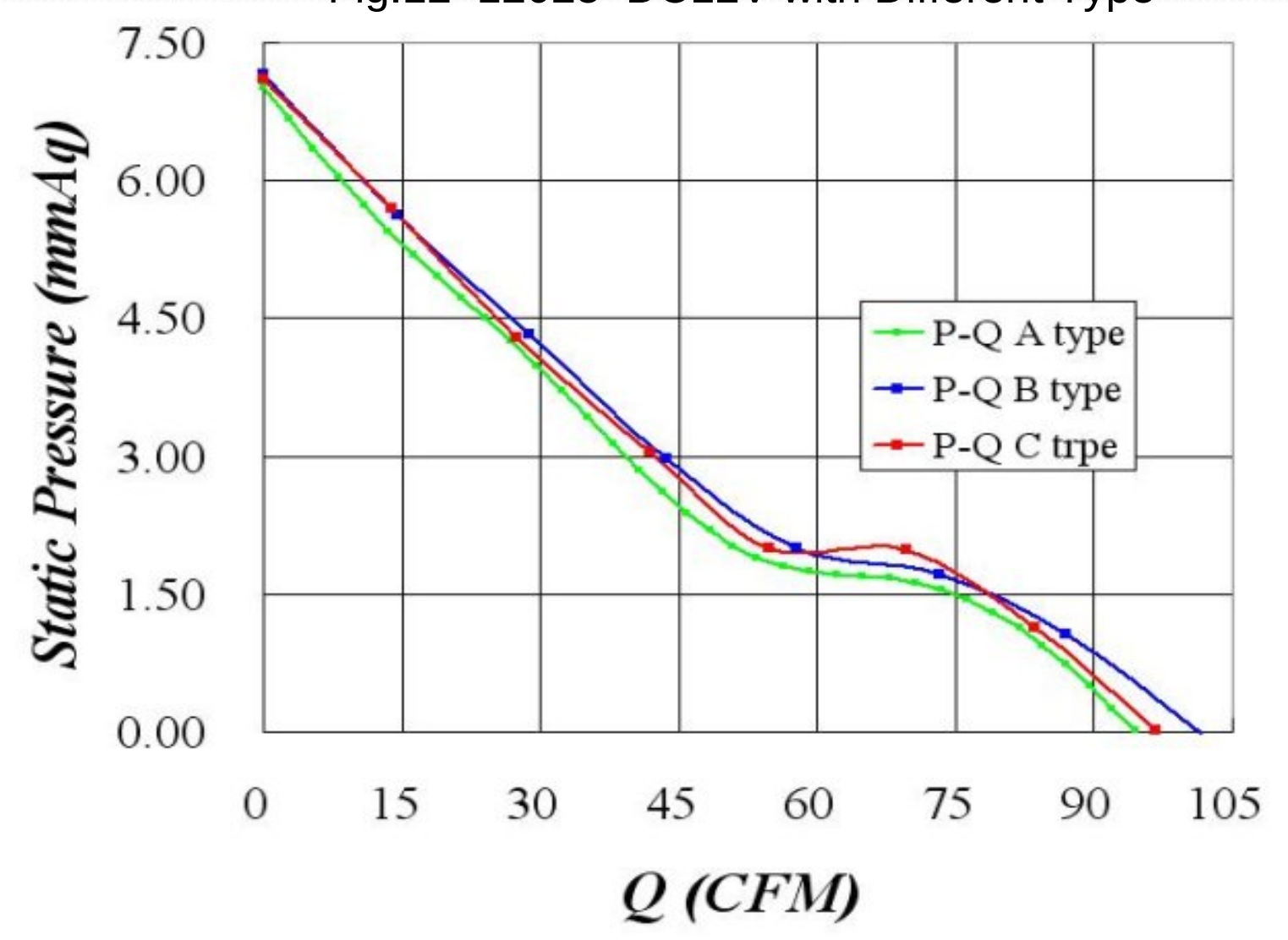
風扇測試 – 安裝模式

Fig.12 12025 DC12V with Different Type



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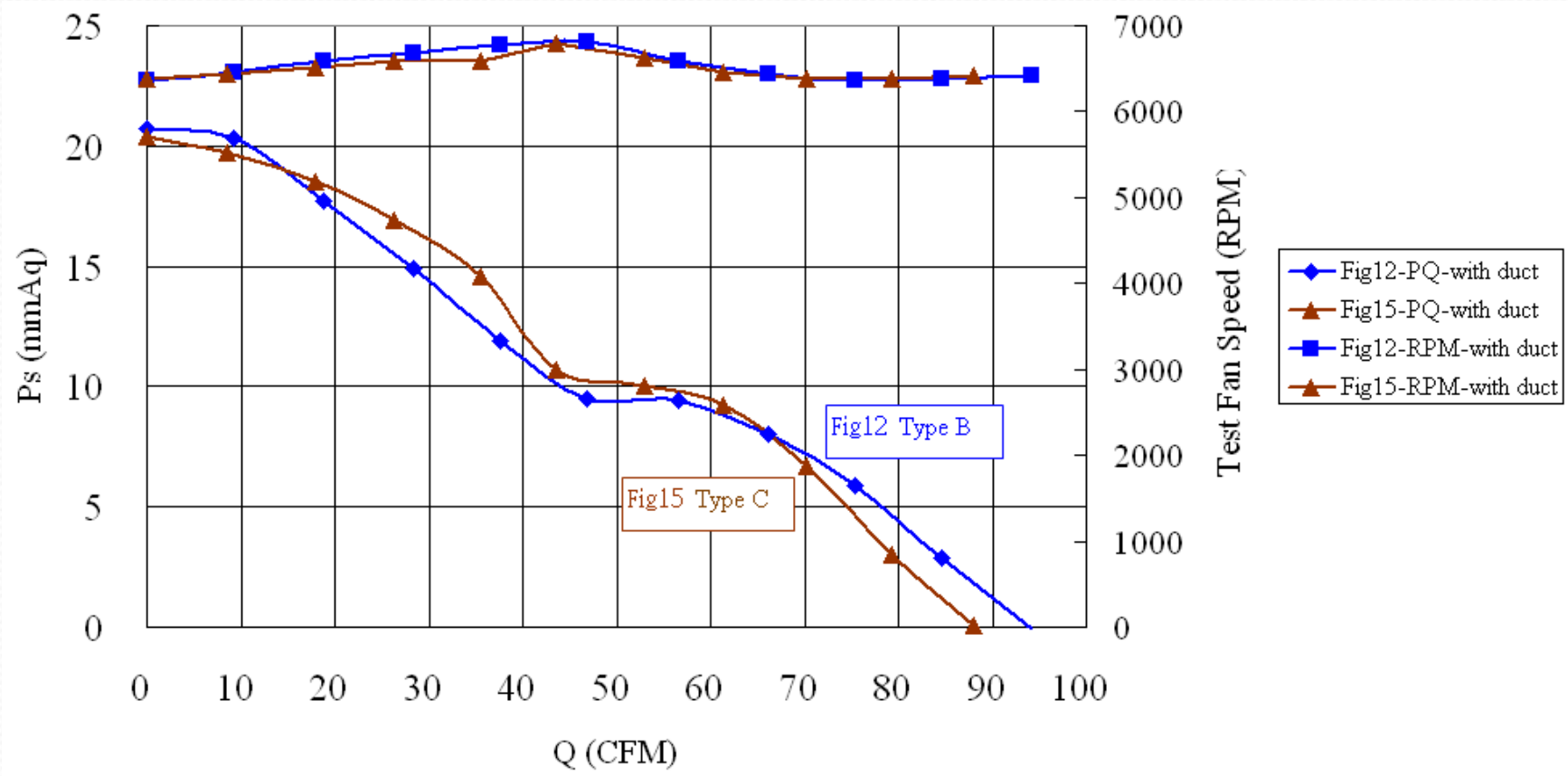
風扇測試 – 安裝模式

Fig.12/15 8038 DC12V with Different Type



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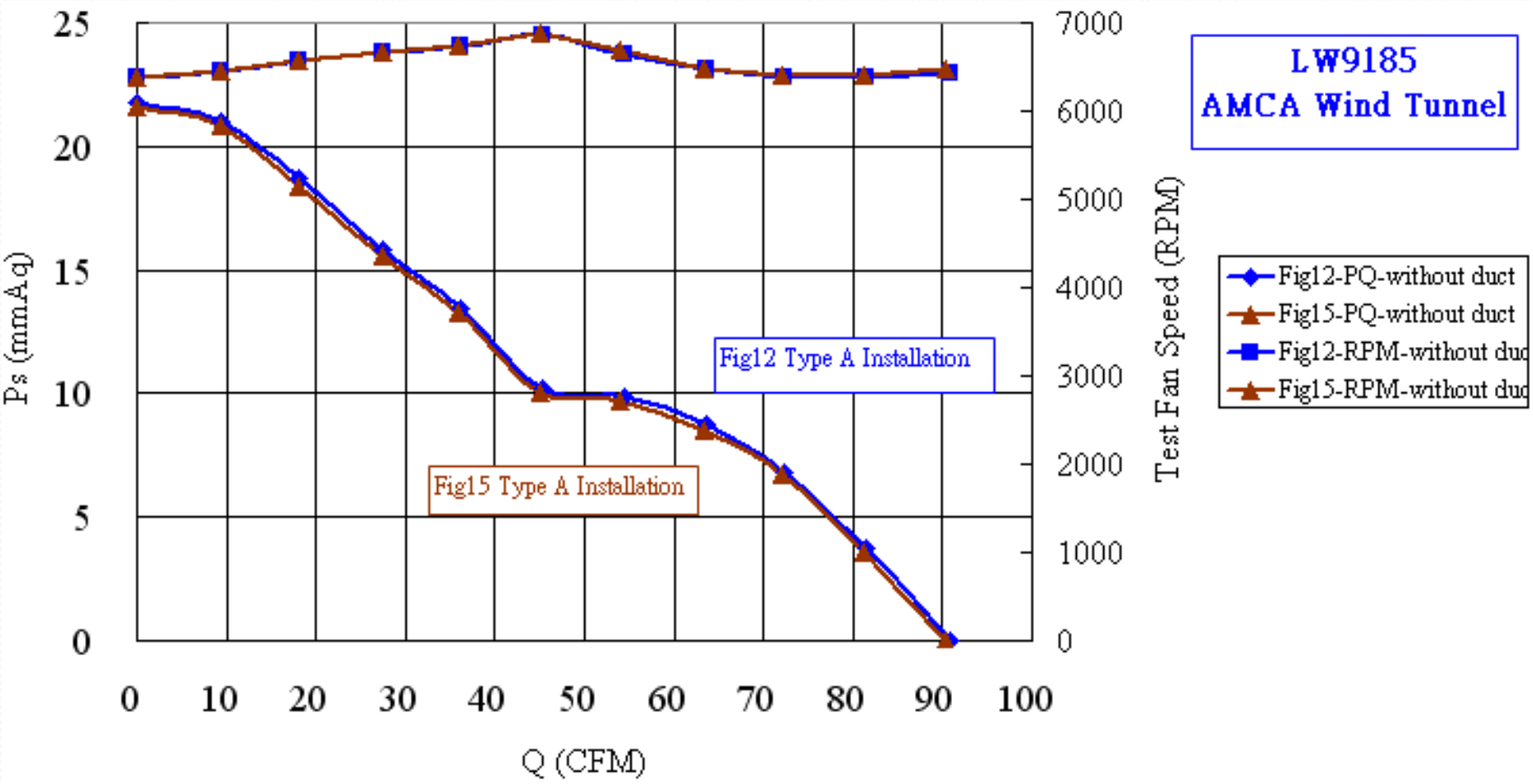
風扇測試 – 安裝模式

Fig.12/15 8038 DC12V with Type A



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風扇測試 – STP標準狀態轉換

Parameter 1 : Test Condition

Test Condition									
Td	Tw	RH	T5	T7	T8	Pb	Pmax	Qmax	Note
℃	℃	%	℃	℃	℃	mmHg	mmAq	CFM	
Dry-Bulb Temperature	Wet-Bulb Temperature	Relative Humidity	Plane 5 Temperature	Plane 7 Temperatur	Plane 8 Temperature	Barometric Pressure			
							21.5	90.00	?
20.3	18.3	82.5	20.1	20.2	20.1	745.5	20.7	94.11	Test Condition
20.0	14.0	50.0	20.0	20.0	20.0	760.0	21.2	91.99	STP

1. Temperature (Td) variation from 5 to 30 ℃	Deviation	9.2%
2. Barometric (Pb) variation from 0.95 to 1.05 atm	Deviation	10.0%
3. Both Temperature & Barometric variation	Deviation	20.1%

Axial FAN 8038 AMCA 210 Fig.12 Setup,
Installation Type B, Constant Voltage DC 12V

(**S**tandard **T**emperature and **P**ressure)

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風扇測試 – STP標準狀態轉換

Method of Test Condition to STP Condition.

Assume Fan constant RPM, *Nc* = *N* at Different Condition

$$Q_c = Q\left(\frac{N_c}{N}\right)\left(\frac{K_p}{K_{pc}}\right)$$

$$P_{sc} = P_{tc} - P_{vc}$$

$$= P_t\left(\frac{N_c}{N}\right)^2\left(\frac{\rho_c}{\rho}\right)\left(\frac{k_p}{k_{pc}}\right) - P_v\left(\frac{N_c}{N}\right)^2\left(\frac{\rho_c}{\rho}\right)$$

Q_c / P_{sc} : Nominal Values

$\left(\frac{K_p}{K_{pc}}\right) \propto 1$ Compressibility factor ratio

From AMCA 210-99 Eq. 8.59~8.62

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風扇測試 – STP標準狀態轉換

Ps		dP_{56}	Q		P_{STP}	Q_{STP}
mmAq	inAq	mmAq	CMM	CFM	mmAq	CFM
2.94	0.116	2.9	0.000	0.00	3.14	0.00
1.40	0.055	64.9	0.298	10.52	1.50	10.52
0.00	0.000	38.0	0.674	23.79	0.00	23.79

From Test Condition Convert to Nominal Values (STP).

STP: Standard Air Property is Air at
(Td) 20 ℃ Temperature,
(RH) 50 % Relative Humidity,
(Pb) 760 mmHg Barometric Pressure.

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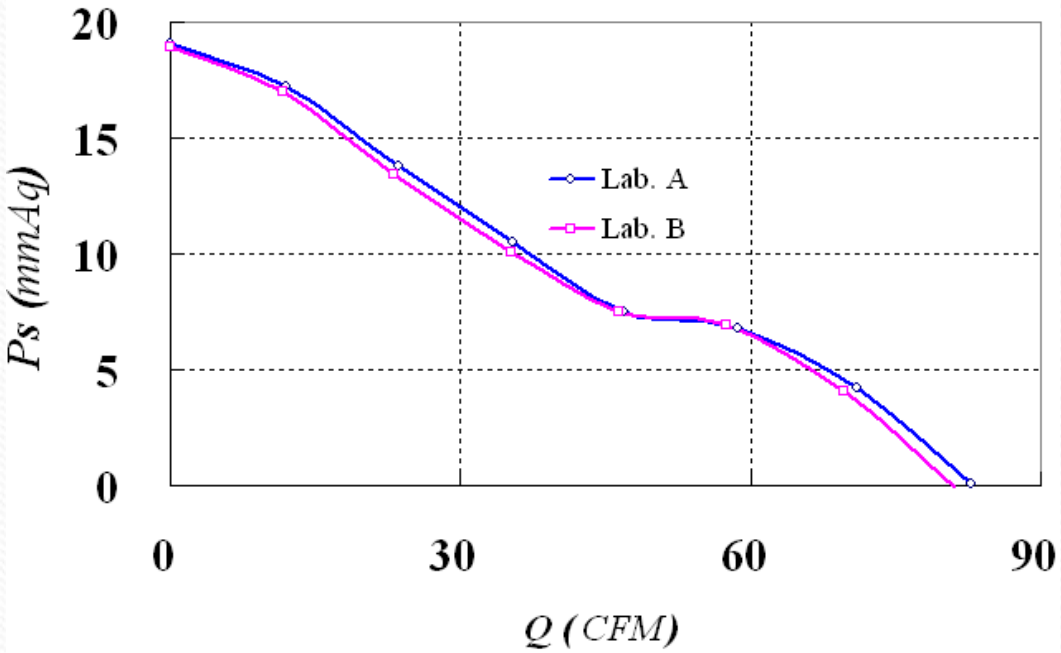
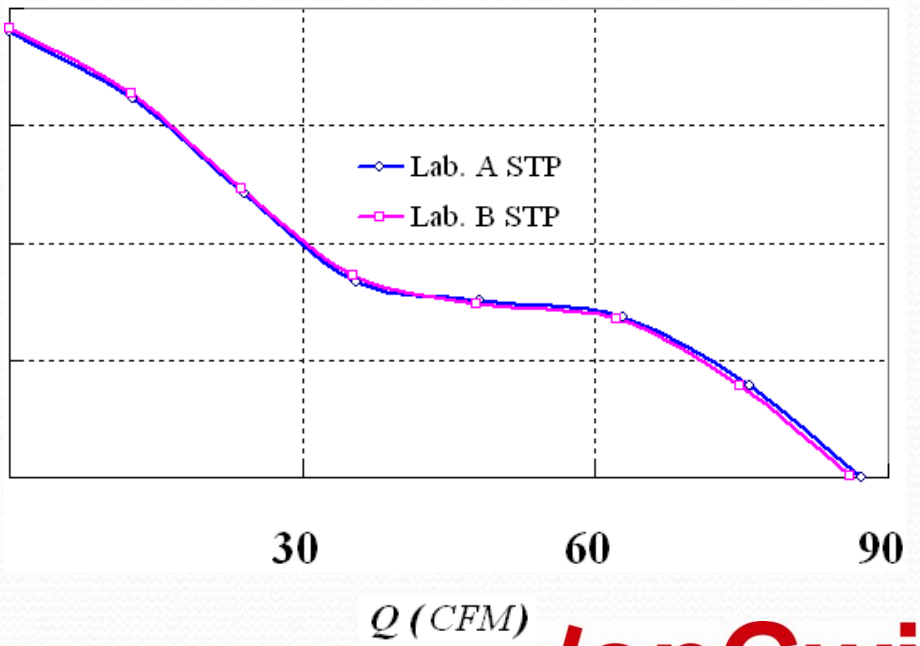
風扇測試 – STP標準狀態轉換

Td	Tw	RH	T5	T7	T8	Pb	
℃	℃	%	℃	℃	℃	mmHg	
23.8	20.4	73.7	23.9	24.2	23.8	760.5	F
19.7	16.5	72.1	19.3	19.2	19.5	742.6	LongWin

Date:	2008/3/13
Laboratory:	F. VS LongWin
Test Number:	SN9273
Curve by:	Ericfeng
Test Setup:	AMCA 210 Fig.12
Installation Type:	Type A





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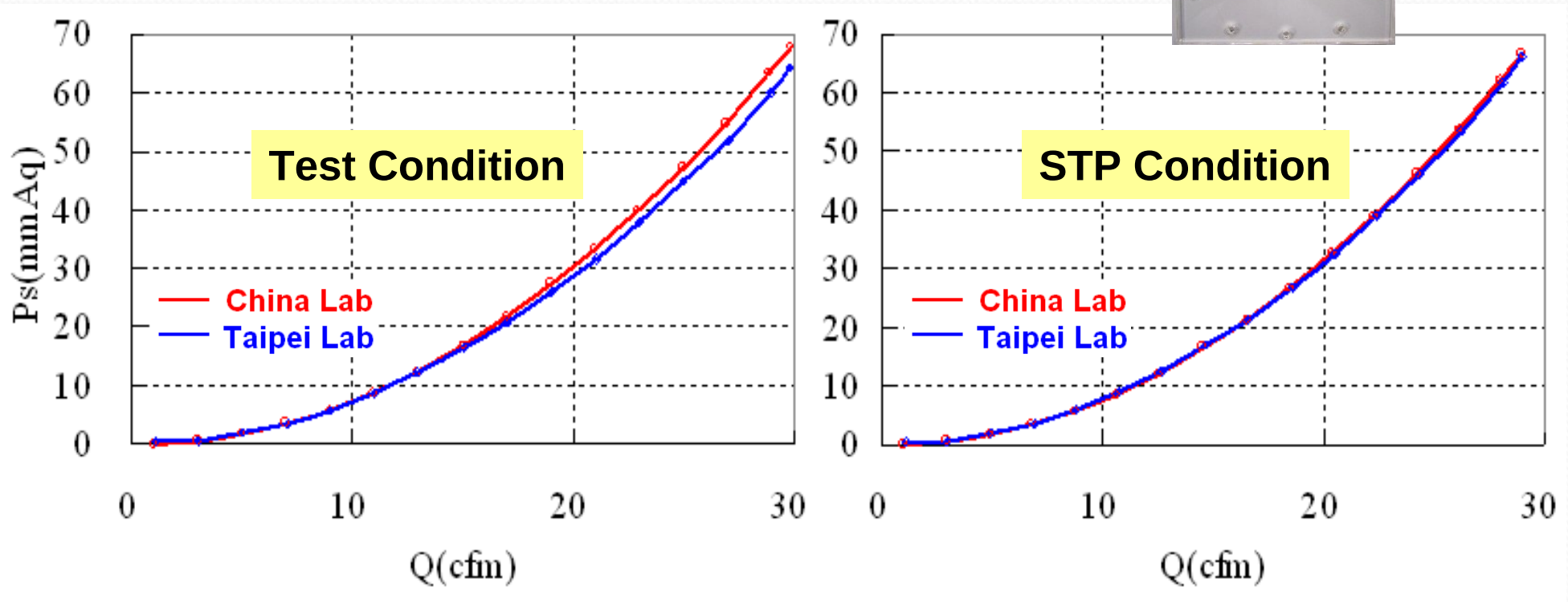
風扇測試 – STP標準狀態轉換

Orifice Plate SRC Test



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風扇測試 – STP標準狀態轉換

風扇比較方法

1. 確認為相同安裝模式 **Installation Type.**

2. 轉換PQ測試結果：測試狀態→STP標準狀態
Test Condition to **STP Condition.**

3. 轉換PQ測試結果：根據Fan Law**轉換為指定RPM**

Fan law ：Q ~ RPM, P~$(RPM)^2$

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規格

型號	9014	9081	9015	9185	9120	9293	9545	9347	9266	9348
根據AMCA 210-07	圖 12 & 15 二合一結構							圖12結構		
流量 (CFM)	0.2~18	1.6~60	2.4~250	2.9~1000	100~5000	230~30100	9~2000	0.2~18	2.4~250	4~1000
壓力 (mmAq) * 含高靜壓阻流閥	0~30 0~200*	0~30 0~200*	0~30 0~200*	0~30 0~200*	0~150	0~150	0~800	0~20	0~20 0~100*	0~20 0~100*
最大測試物開口 (cm)	8 x 8	8 x 8	30 x 30	30 x 30	60 x 60	100 x 100	60 x 60	8 x 8	24 x 24	40 x 40
熱傳測試段RQ實驗	--	選配	選配	選配	–	--	--	–	--	–
高靜壓阻流閥	選配	選配	選配	選配	–	--	--	–	選配	選配
多風扇測試模組	選配	選配	選配	選配	–	--	--	選配	選配	選配
PWM 訊號產生器	內含	內含	內含	內含	內含	--	內含	選配	選配	選配
軸向力及扭矩量測	--	–	--	選配	選配	選配	選配	–	--	–
長 x 寬 x 高 (cm)	250 x 60 x 160	250 x 60 x 160	360 x 85 x 180	460 x 180 x 190	800 x 260 x 230	1200 x 350 x 260	450 x 180 x 200	160 x 60 x 140	220 x 70 x 160	260 x 80 x 190
淨重 (kg)	370	370	750	1500	2800	9000	2600	380	400	550
使用電力	AC 220V 5 Amp 單相	AC 220V 5 Amp 單相	AC 220V 5 Amp 單相	AC 220V 20 Amp 三相	AC 220V 40 Amp 三相	AC 380V 60 Amp 三相	AC 380V 50 Amp 三相	AC 220V 5 Amp 單相	AC 220V 5 Amp 單相	AC 220V 10 Amp 三相

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規格

型號	9015	9185	9120	9293	9545
根據AMCA 210-07	圖 12 & 15 二合一結構				
流量 (CFM)	2.4~250	2.9~1000	100~5000	230~30100	9~2000
壓力 (mmAq) * 含高靜壓阻流閥	0~30 0~200*	0~30 0~200*	0~150	0~150	0~800
最大測試物開口 (cm)	30 x 30	30 x 30	60 x 60	100 x 100	60 x 60
熱傳測試段RQ實驗	選配	選配	–	--	--
高靜壓阻流閥	選配	選配	–	--	--
多風扇測試模組	選配	選配	–	--	--
PWM 訊號產生器	內含	內含	內含	--	內含
軸向力及扭矩量測	--	選配	選配	選配	選配
長 x 寬 x 高 (cm)	360 x 85 x 180	460 x 180 x 190	800 x 260 x 230	1200 x 350 x 260	450 x 180 x 200
淨重 (kg)	750	1500	2800	9000	2600
使用電力	AC 220V 5 Amp 單相	AC 220V 20 Amp 三相	AC 220V 40 Amp 三相	AC 380V 60 Amp 三相	AC 380V 50 Amp 三相

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Fundamental, Forward & First

規格

型號	9347	9266	9348
根據AMCA 210-07	圖12結構		
流量 (CFM)	0.2~18	2.4~250	4~1000
壓力 (mmAq) * 含高靜壓阻流閥	0~20	0~20 0~100*	0~20 0~100*
最大測試物開口 (cm)	8 x 8	24 x 24	40 x 40
熱傳測試段RQ實驗	–	--	–
高靜壓阻流閥	–	選配	選配
多風扇測試模組	選配	選配	選配
PWM 訊號產生器	選配	選配	選配
軸向力及扭矩量測	–	--	–
長 x 寬 x 高 (cm)	160 x 60 x 140	220 x 70 x 160	260 x 80 x 190
淨重 (kg)	380	400	550
使用電力	AC 220V 5 Amp 單相	AC 220V 5 Amp 單相	AC 220V 10 Amp 三相

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LW-9014 (18CFM)& 9081 (60CFM)

LW-9015 (250 & 400CFM)

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LW-9185 (800&1000 CFM)

LW-9185 (1500 CFM)

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LW-9120 (2000~8000 CFM)

LW-9293 (20,000~30,000 CFM)

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LW-9545 (2100 CFM, Ps~800mmAq)

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LW-9266 (~250 CFM)

LW-9348 (~1000 CFM)

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Fundamental, Forward & First

摘要

1. AMCA 210 標準簡介
2. 流量量測原理
3. 校正流程
4. 風洞特點
5. 風扇PQ比較
6. 應用案例

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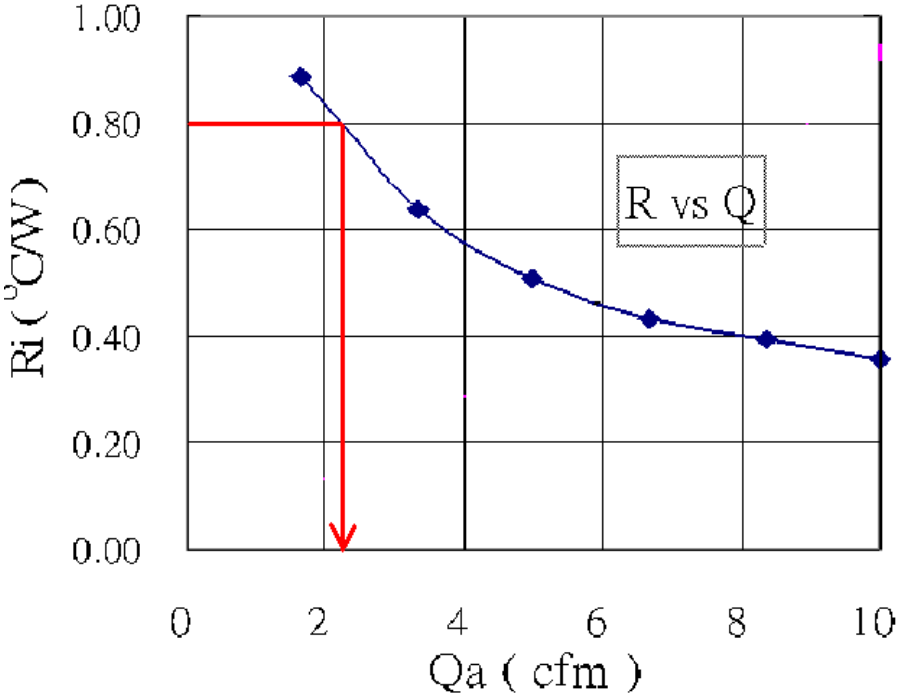
應用

☆ **NB** Thermal Design

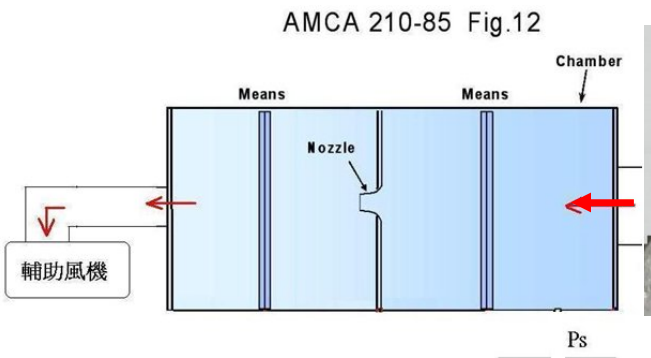
Step1 :

Worst case

Define mini air flow rate



NB
Power ON



Offer Air Flow $\mathbf{Q_{air}}$

Temperature
Data Log

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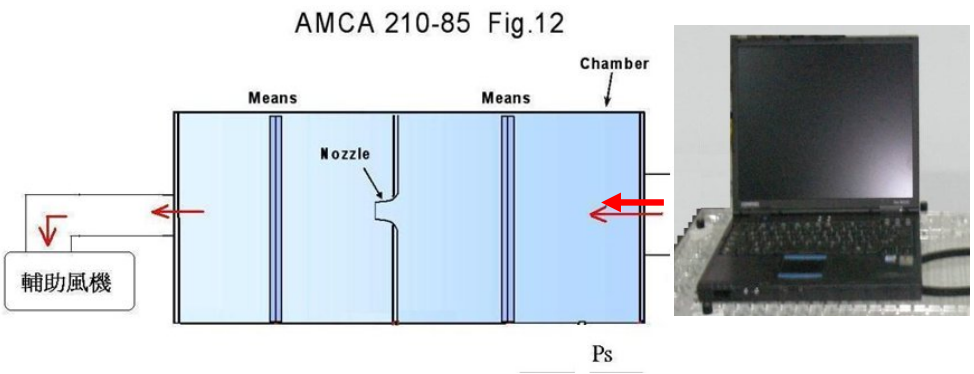
應用

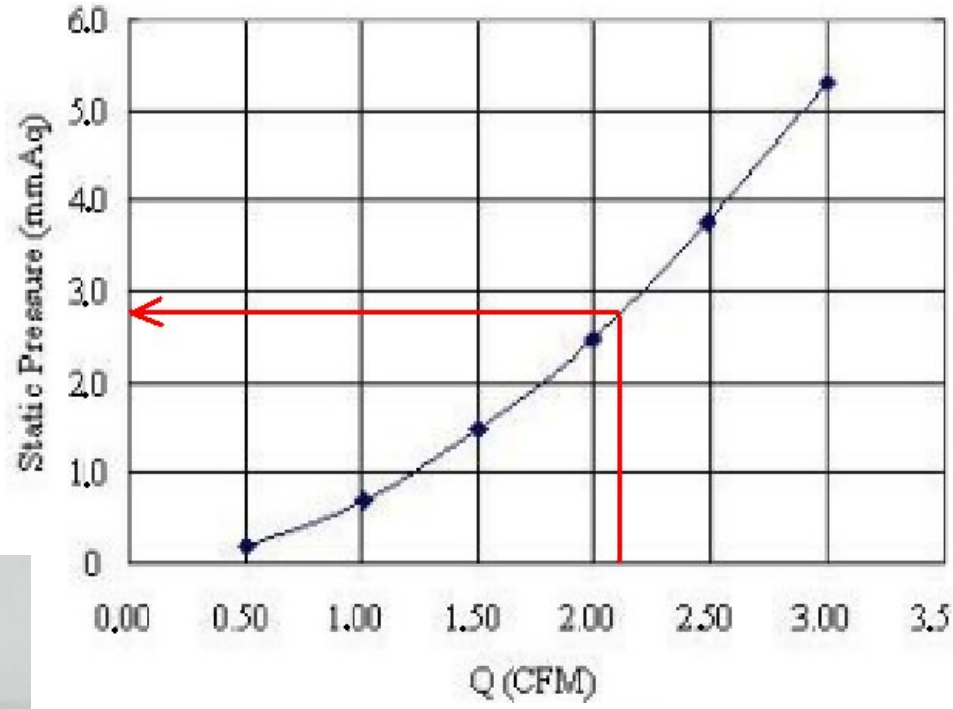
☆ NB Thermal Design

Step2 :

NB

Flow Impedance





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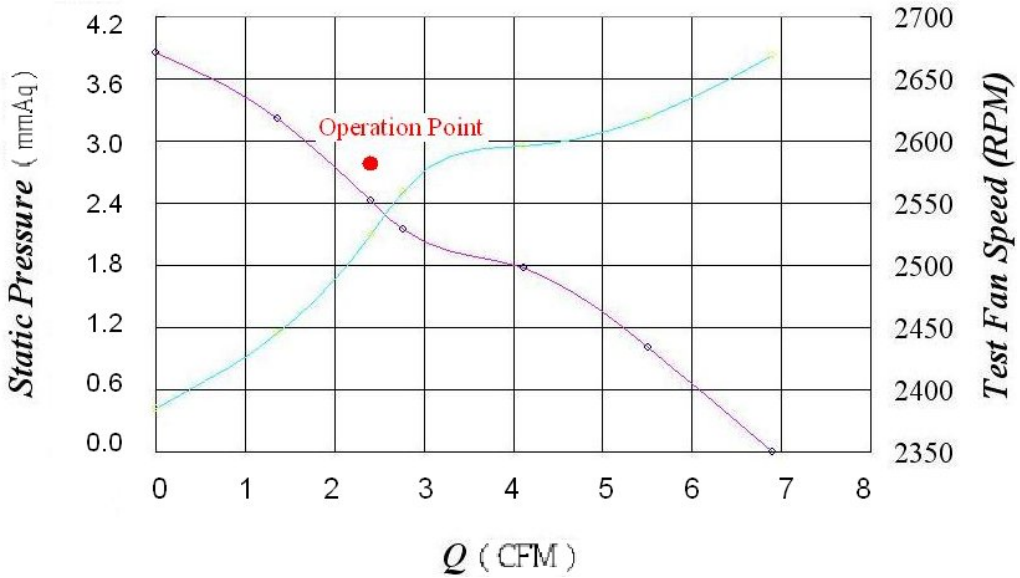
應用 ☆ NB Thermal Design

Step3 :

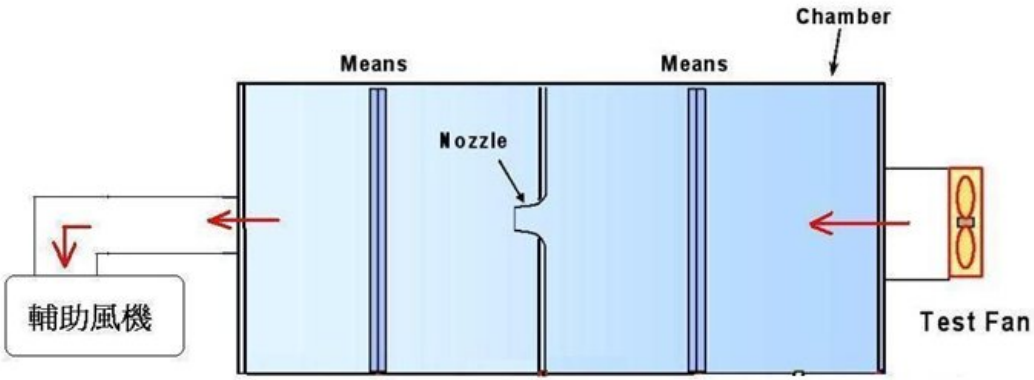
Step 3

NB

Blower



AMCA 210-85 Fig.12



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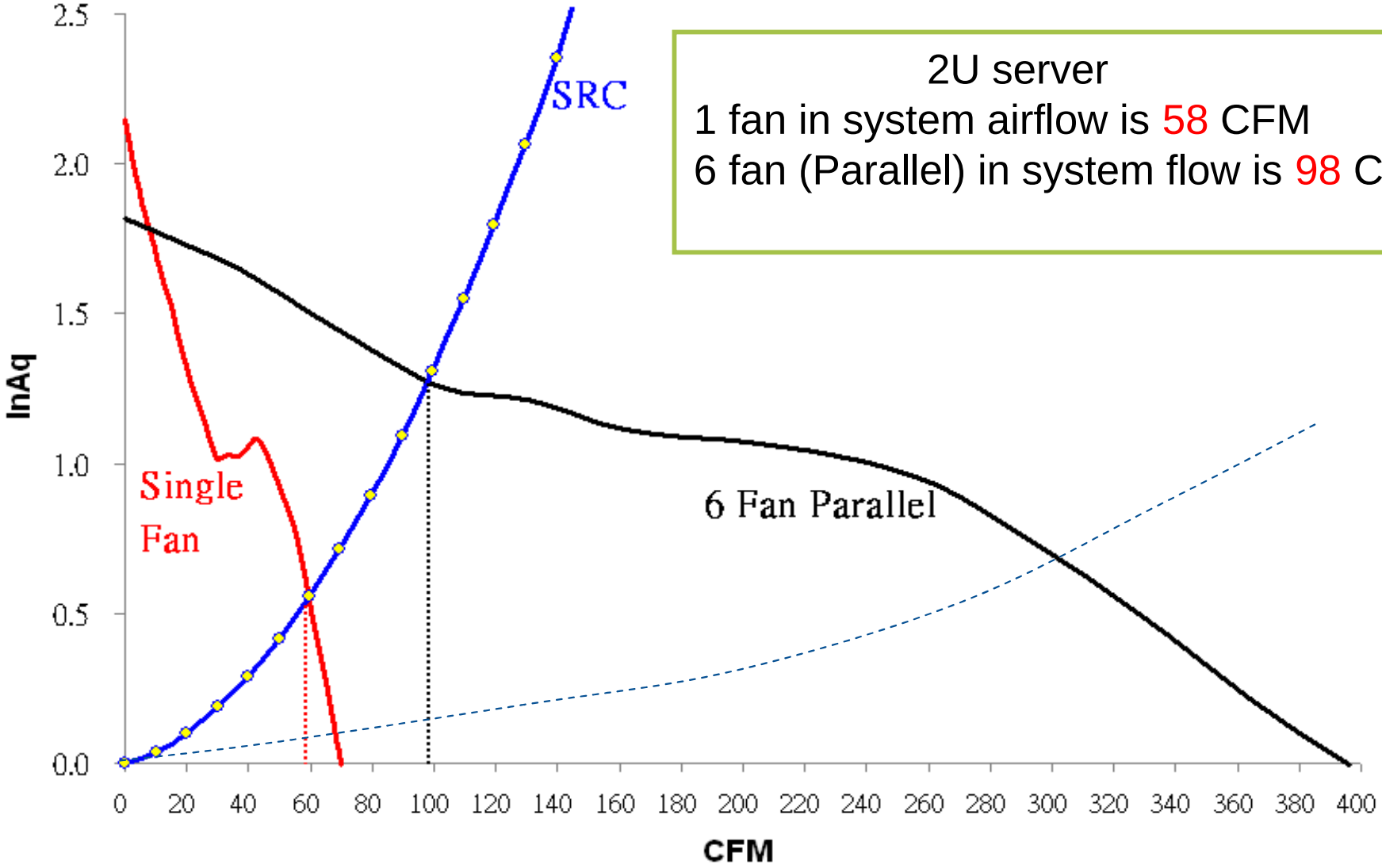
Server fan tray case study



2U server
1 fan in system airflow is 58 CFM
6 fan (Parallel) in system flow is 98 CFM

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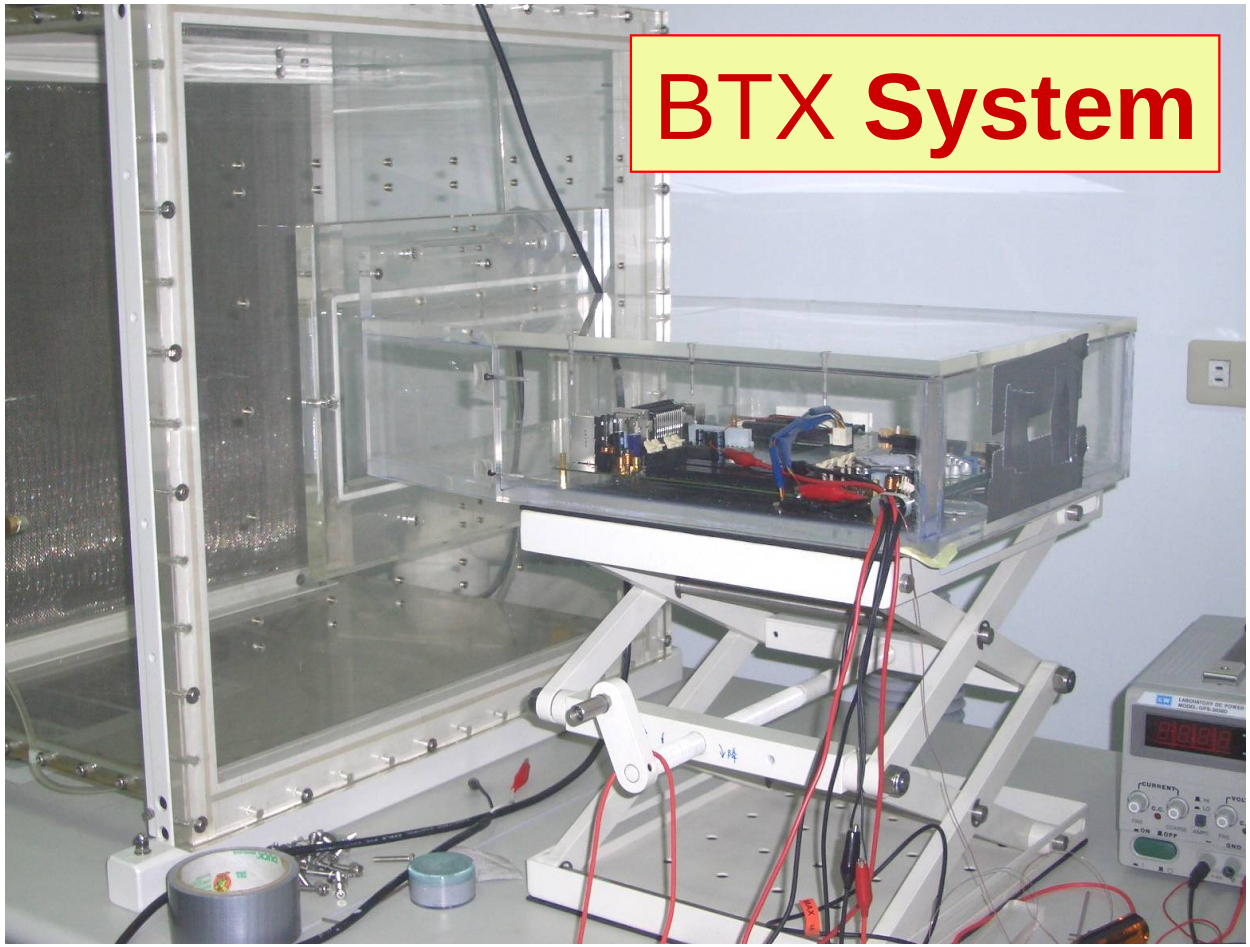
System Impedance Test



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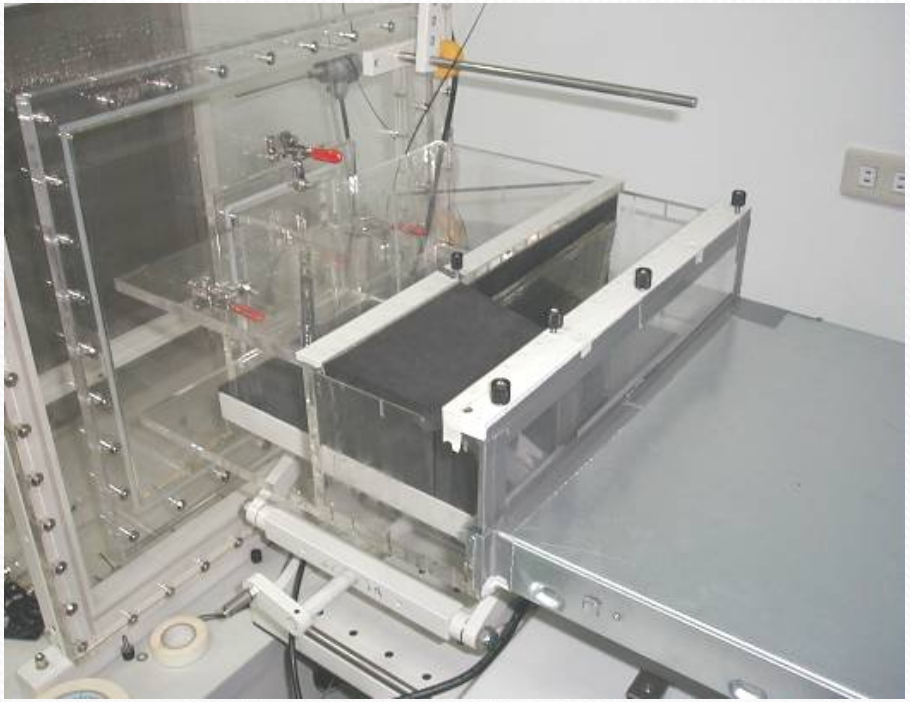
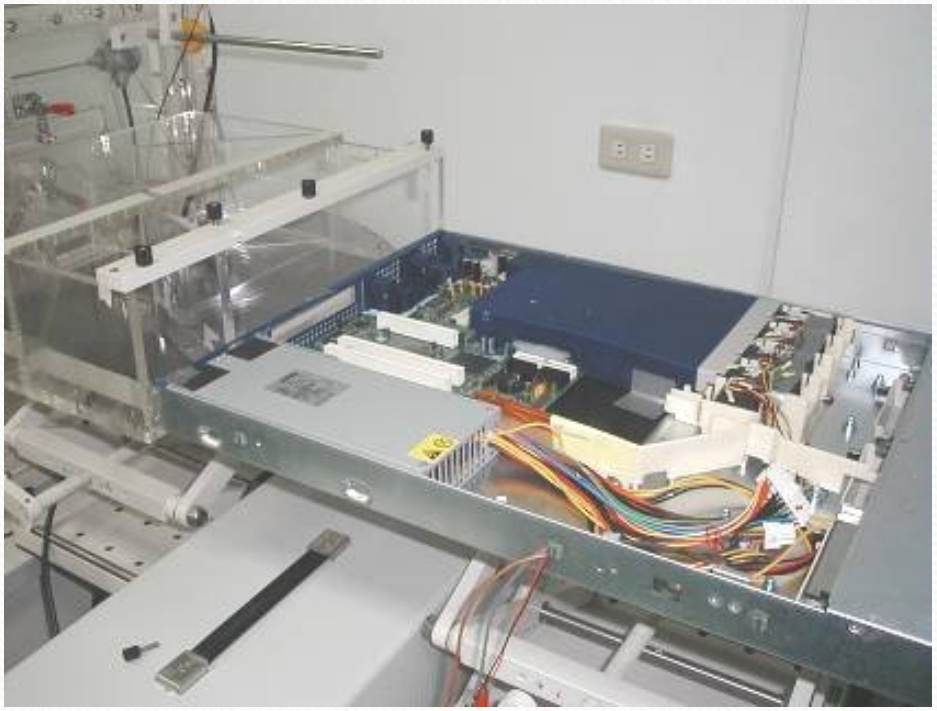
Server Thermal Test , Impedance Test, Airflow Test





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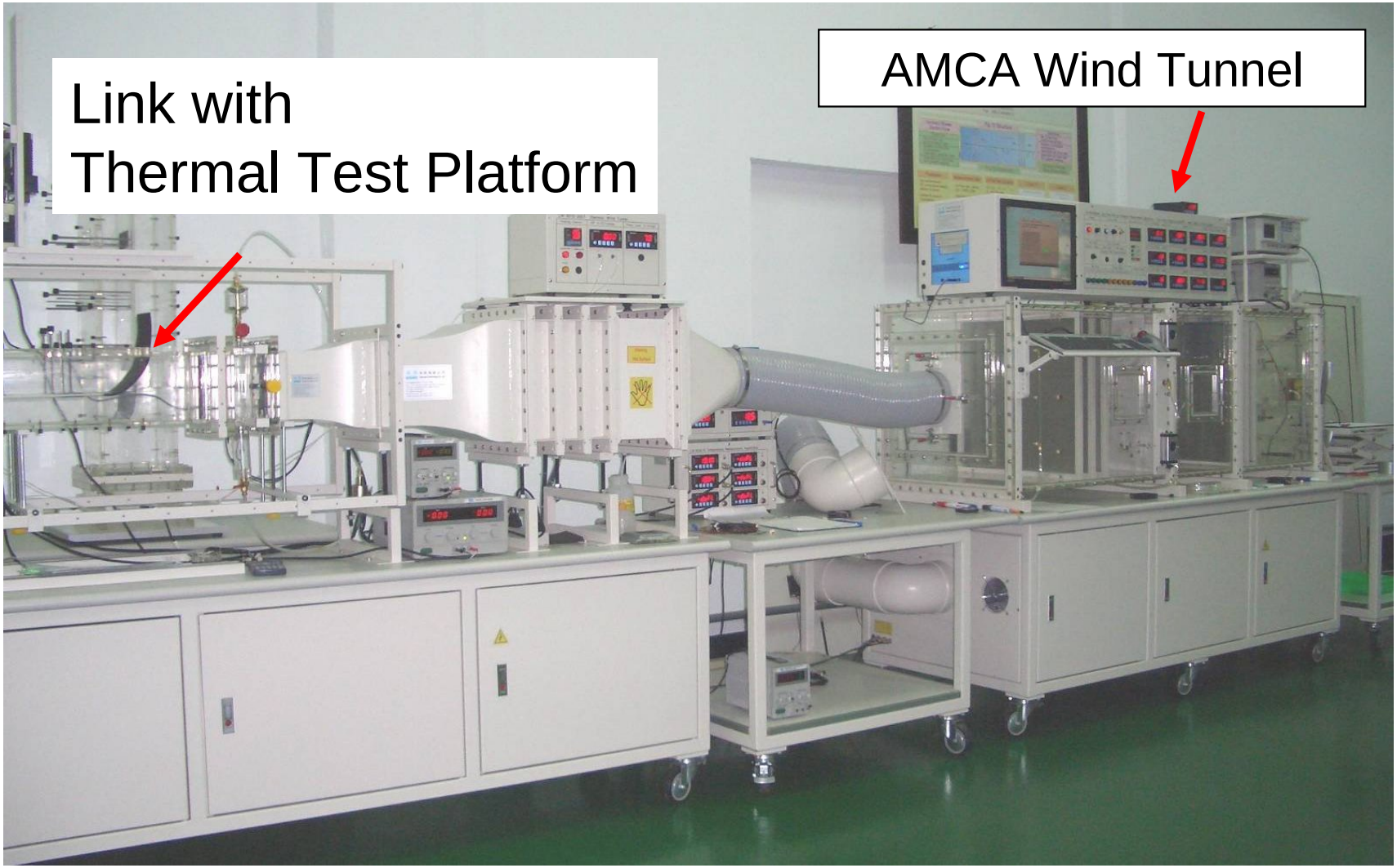

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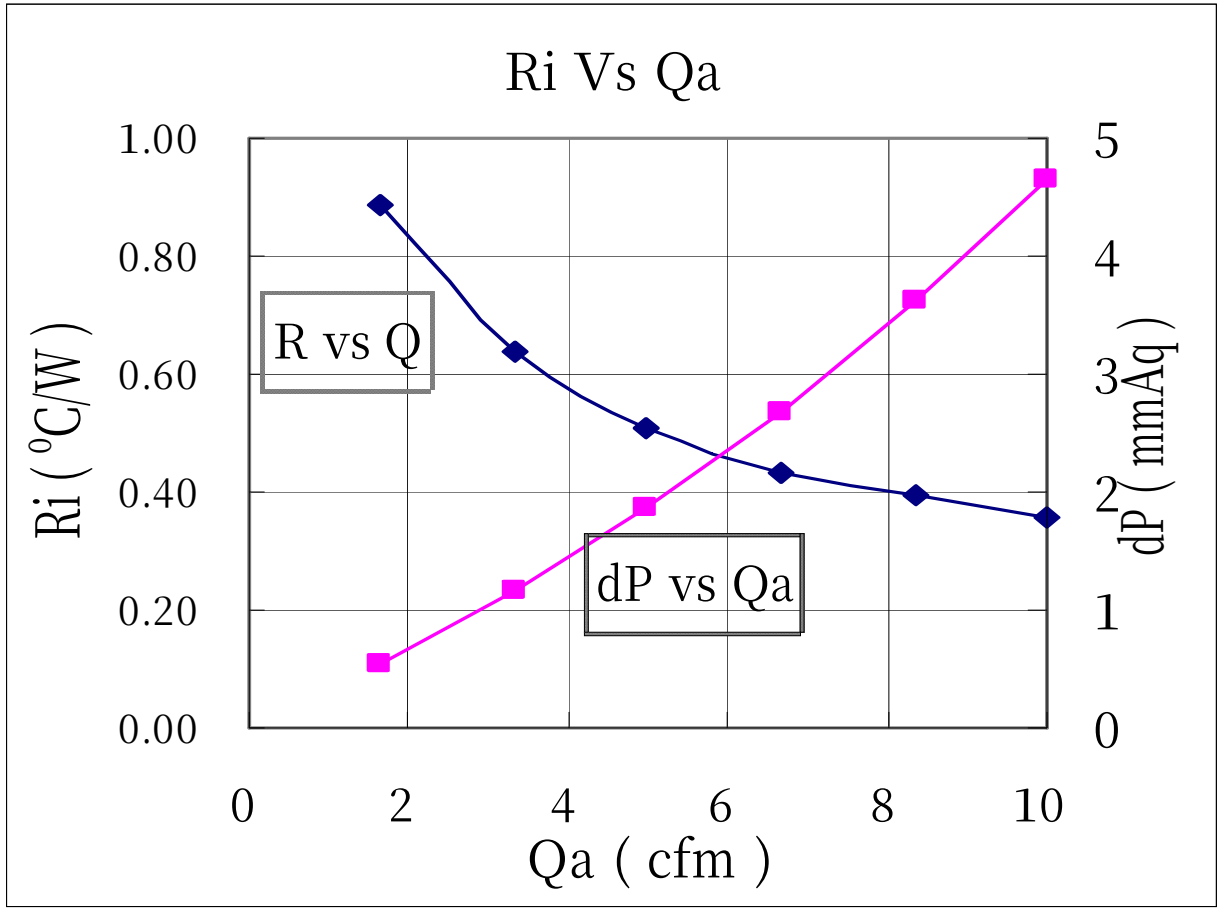
Thermal Module - Thermal Resistance Curve Test



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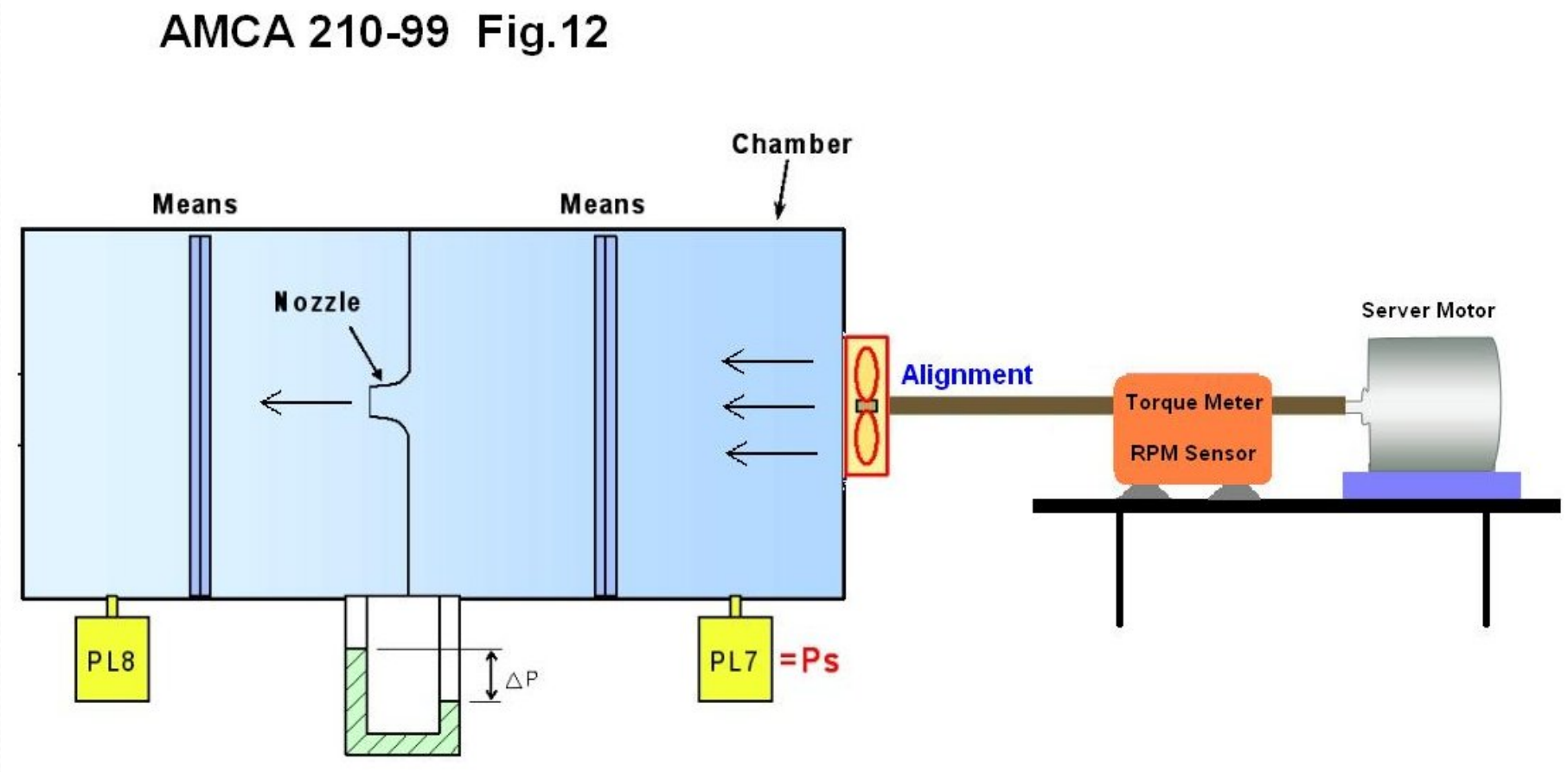

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Thank you !

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