用气流检测和控制降低氧化氮
Using Accurate Air Measurement and Control to reduce NOx

Air Monitor
Type K
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为什么要检测燃烧气流？

一次风气流检测

- 一次风气流的严密控制能够降低任何燃烧器的火炬温度以及将火炬移动到鍋爐的正中心，因此能提高燃烧效率和减少火火焰冲刷对水壁所造成的问题。

- 一次风气流的最基本作用是一种压缩空气传动方式，将煤粉从磨煤机运送到个部燃烧机。一次风气流对低氧化氮燃烧机的效率也非常重视。大部分低氧化氮燃烧机制造厂商坚持一定要准确初级气流检测才能达到低氧化氮的水平保证。

一次风气流检测

- 过剩的一次风气流在锅炉里会提高火焰温度並在燃烧机会产生氧高温所引起的大量氧化氮。

- 一次风气流也会影响燃煤传送的速度以及燃烧机喷嘴对火焰的位置。对大部分低氧化氮燃烧机火焰温度和位置对降低氧化氮有非常重要的作用。既然如此准确气流监测和控制现在对整个降低氧化氮策略很关键。

二次风气流检测

- 二次风的用途是将气流灌输到风管然后分配到各燃烧器?二次风是锅炉的最大气流来源。

- 全世界多数烧煤电厂用古老气流方式譬如说文邱里，机翼，孔板等 来检二次风? (也有比率很大的电厂根本没有在用任何气流检测设备?) 当安装调校文邱里，机翼时需要作气流割线测量。但大部分电厂没有设计条件使这个调校过程能成功。（缺足够直线管道的位置。）

二次风气流检测

- 另外要要注意这些气流检测方式占管道的很大空间，因此会浪费风机的力量。
- 新厂用AM的气流检测方式可以配小一点的风机
- 旧厂改用AM可以增加气流检测准确性。某些厂解决锅炉空气限制的问题可以多发电。（叫做送风机限制–FD Fan Limited) 这个现象尤其是夏天，天气热的时候空气密度低的时候特别严重。

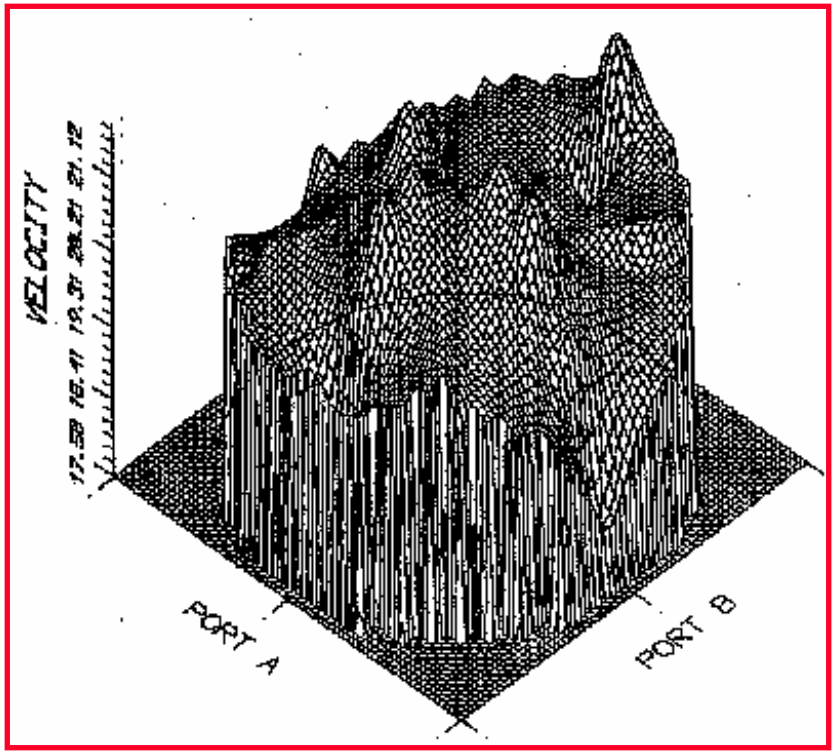
为什么选用美国气流侦测公司（AM公司）的总空气流量检测技术呢？

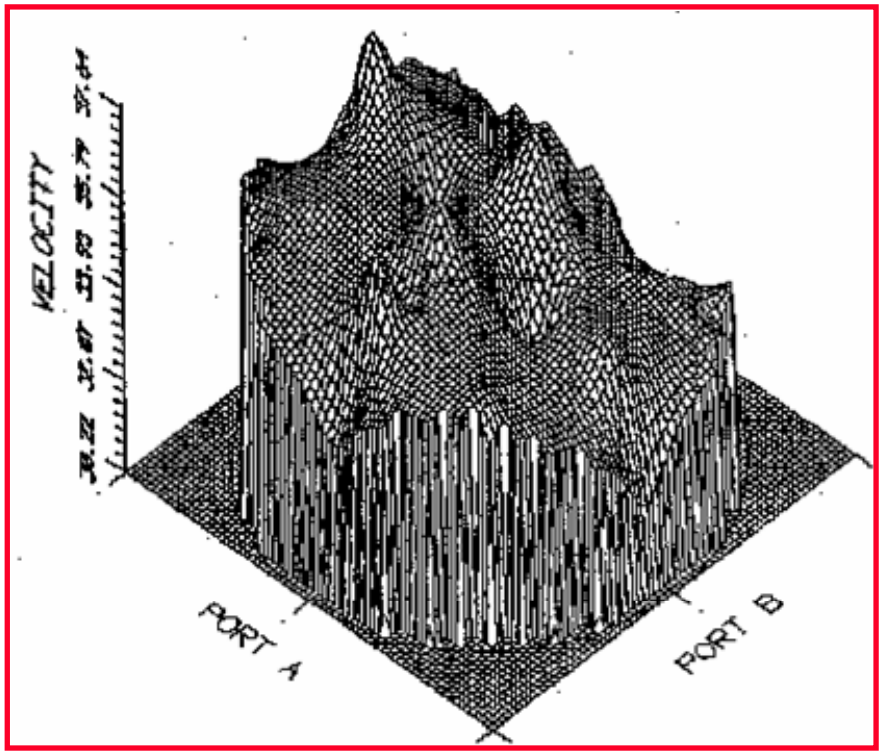
为什么电厂的空气流量检测会很困难呢？

- 空气流量在短短的几秒钟内会有很大的变化
- 管道里面不同的位置有很大的流速和气流角度的差异
- 管道直线部分很少，电厂总设计当中，准确气流检测被忽略
- 气流温度经常高，含灰量多，磨损性高，部分时候也有腐蚀性

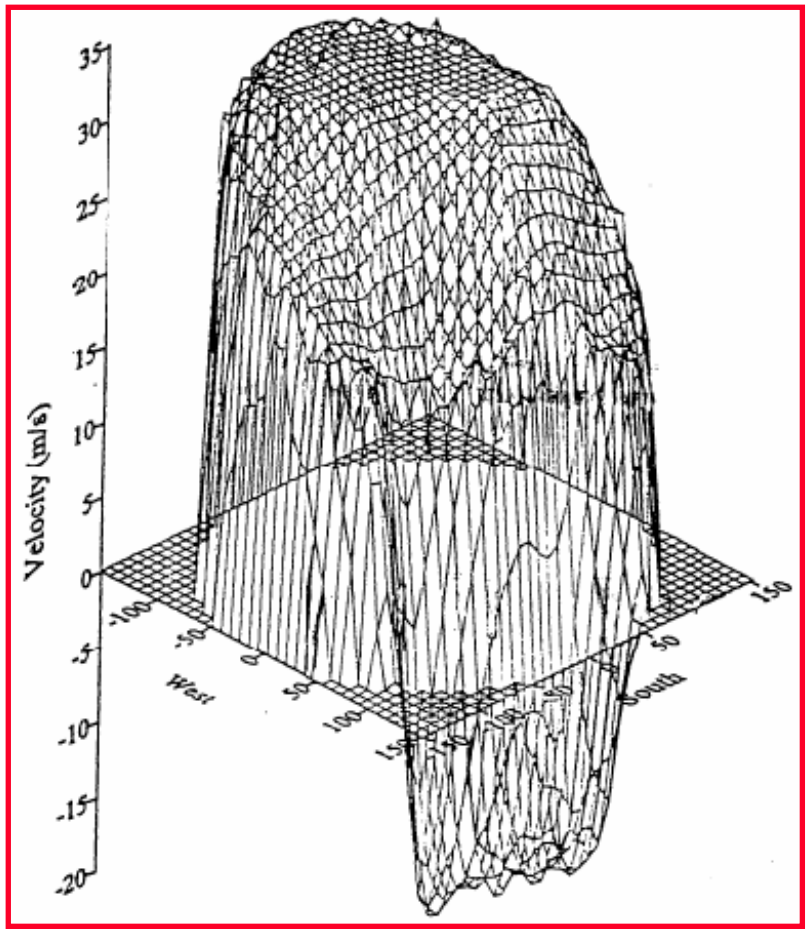
多点检测的必须性

- 很少电厂有足够的直线管道直径来准确检测气流
- 同一个管道的位置在不同的气流量有不同流速状况



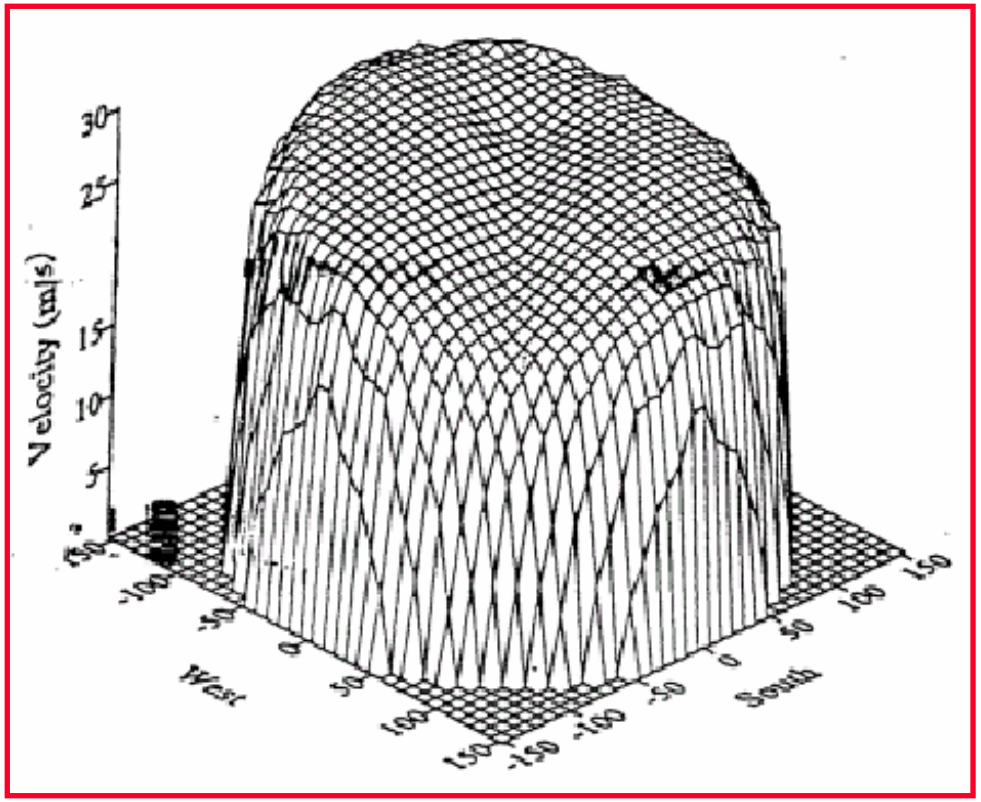


证明多点空气流量检测的必要性



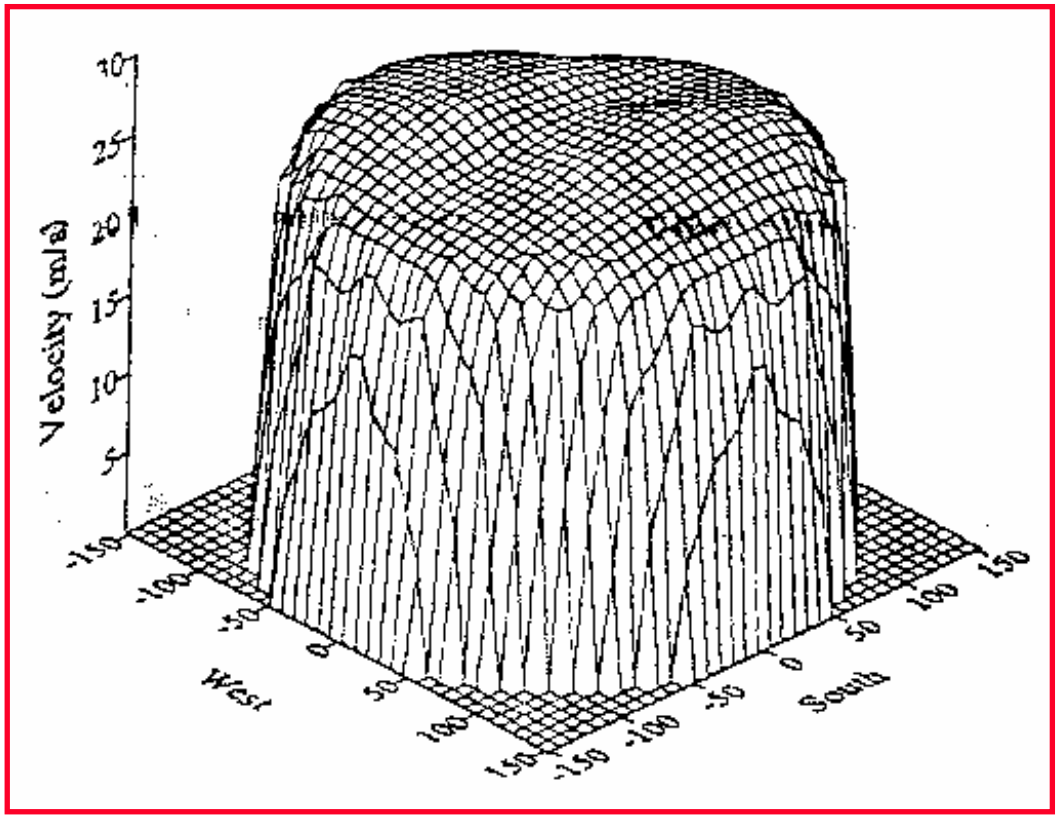
空气流速数据图表在直径为1.5，流速平均 26 m/s

证明多点空气流量检测的必要性



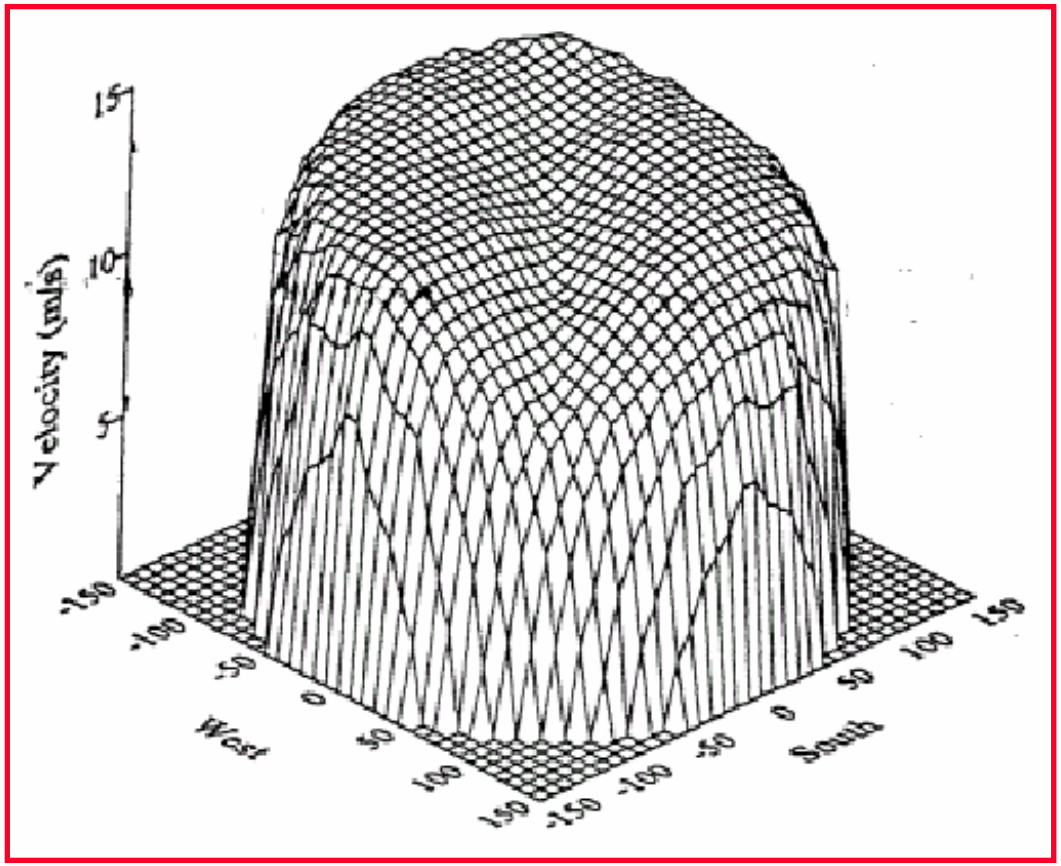
空气流速数据图表在直径为9，流速平均 26 m/s

证明多点空气流量检测的必要性



空气流速数据图表在14 直径，流速平均 26 m/s

证明多点空气流量检测的必要性

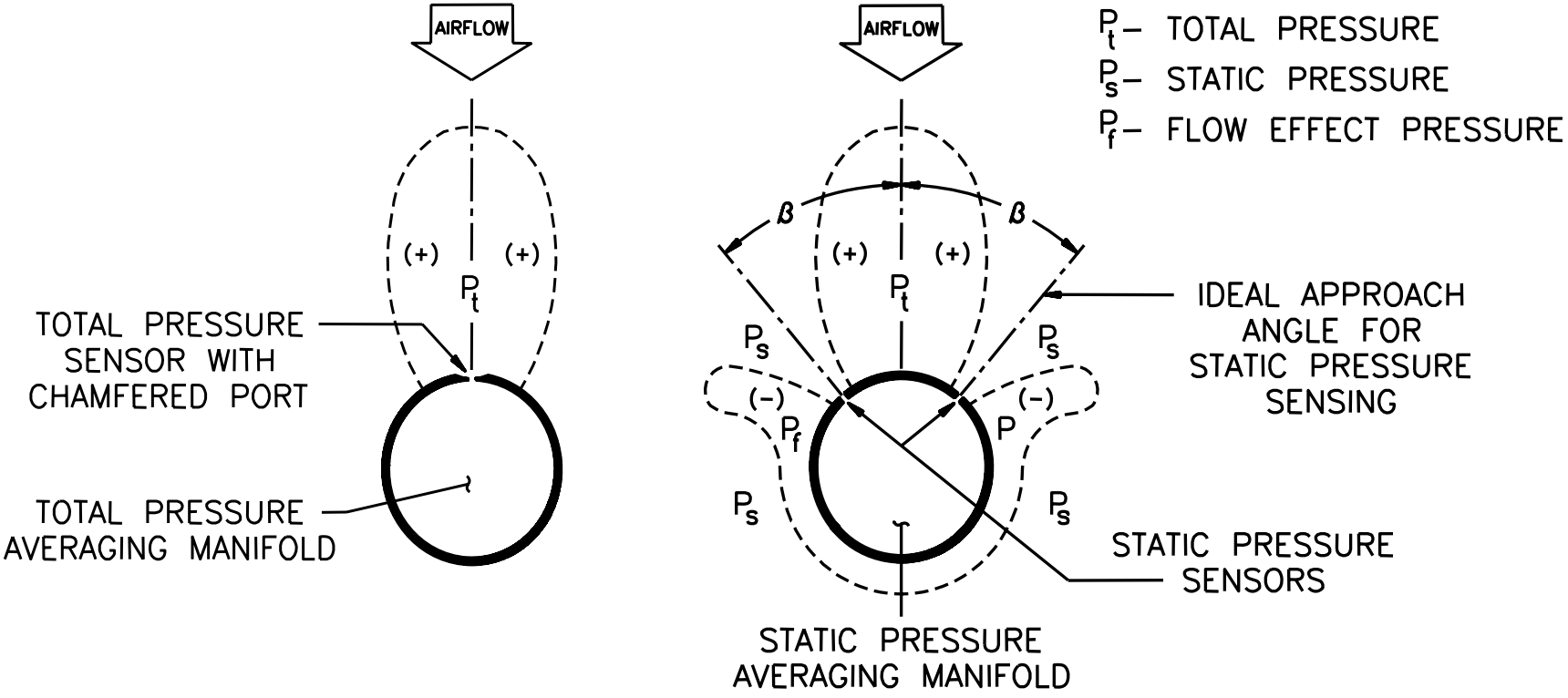


空气流速数据图表在 直径为9，流速平均 11 m/s

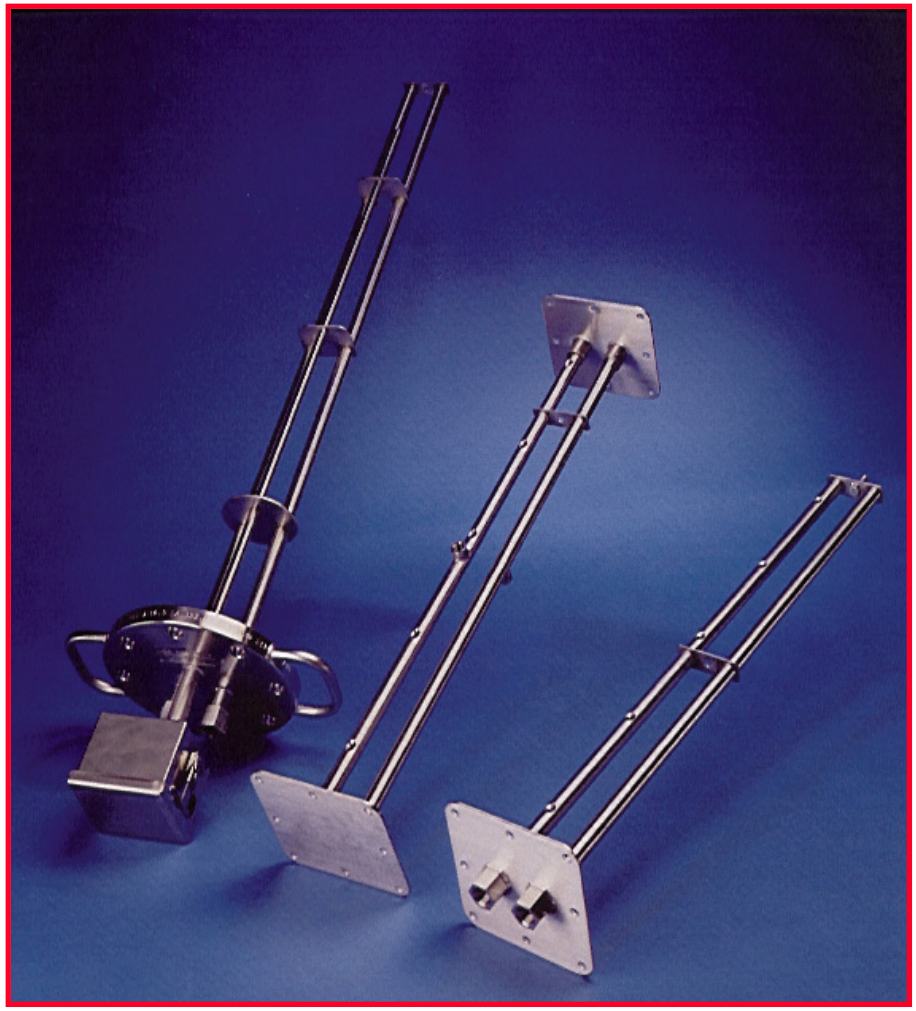
空气流量技术标准

- U.S. Code of Federal Regulations 40CFR60, Appendix A美国法规
- ANSI/ASME PTC 11 机械工程
- AMCA Publication 203 – Field Performance Measurements 野外机械工程标准
- 2001 ASHRAE Handbook – Fundamentals, Section 14
- 2002 Industrial Ventilation – Testing of Ventilation Systems 工业流通空气系统检测标准

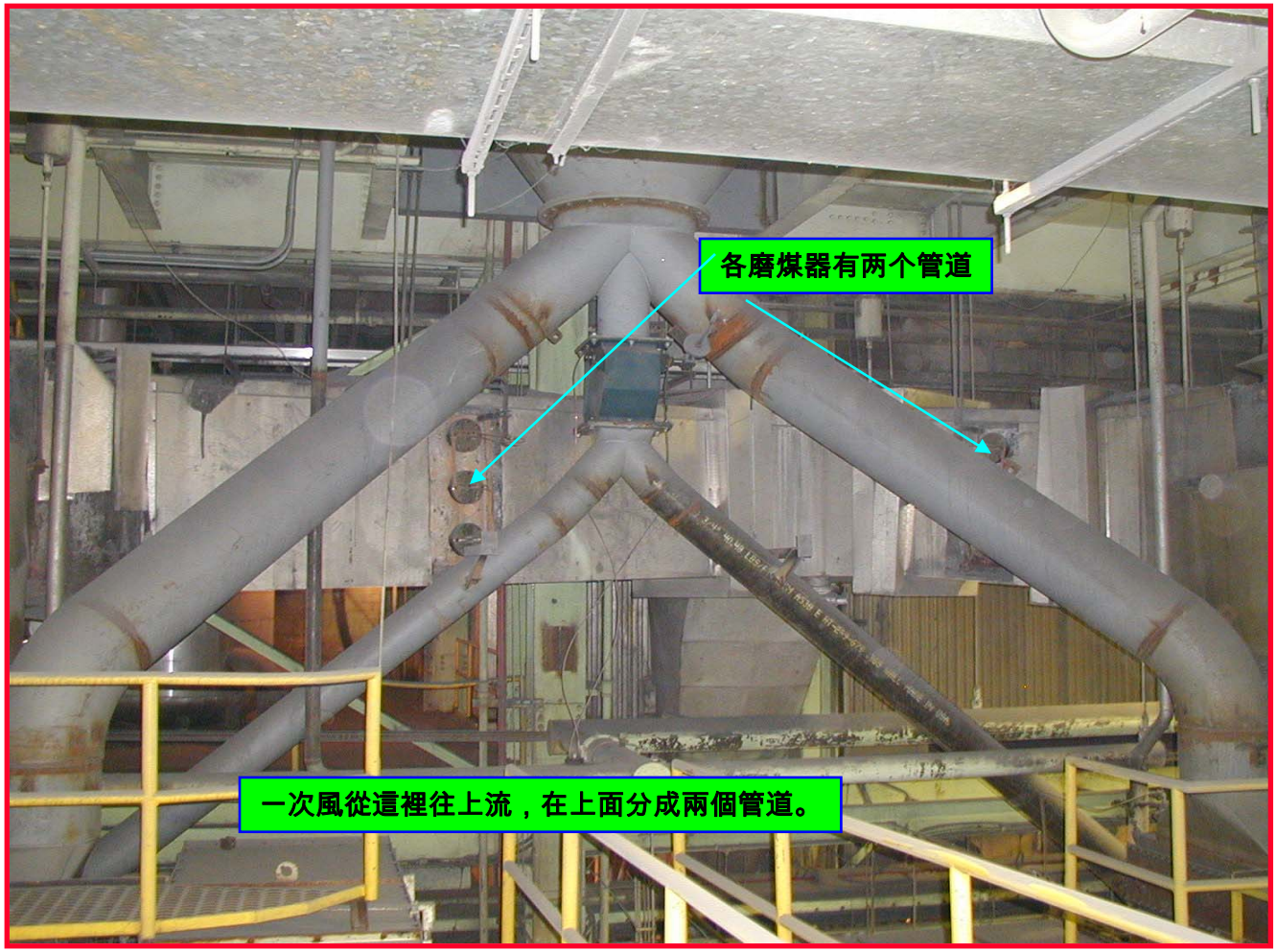
皮拖–菲克亥尔麻Pitot-Fechheimer 原理 – 如何准确检测气流



AM公司之VOLU-probe/SS不锈钢探头



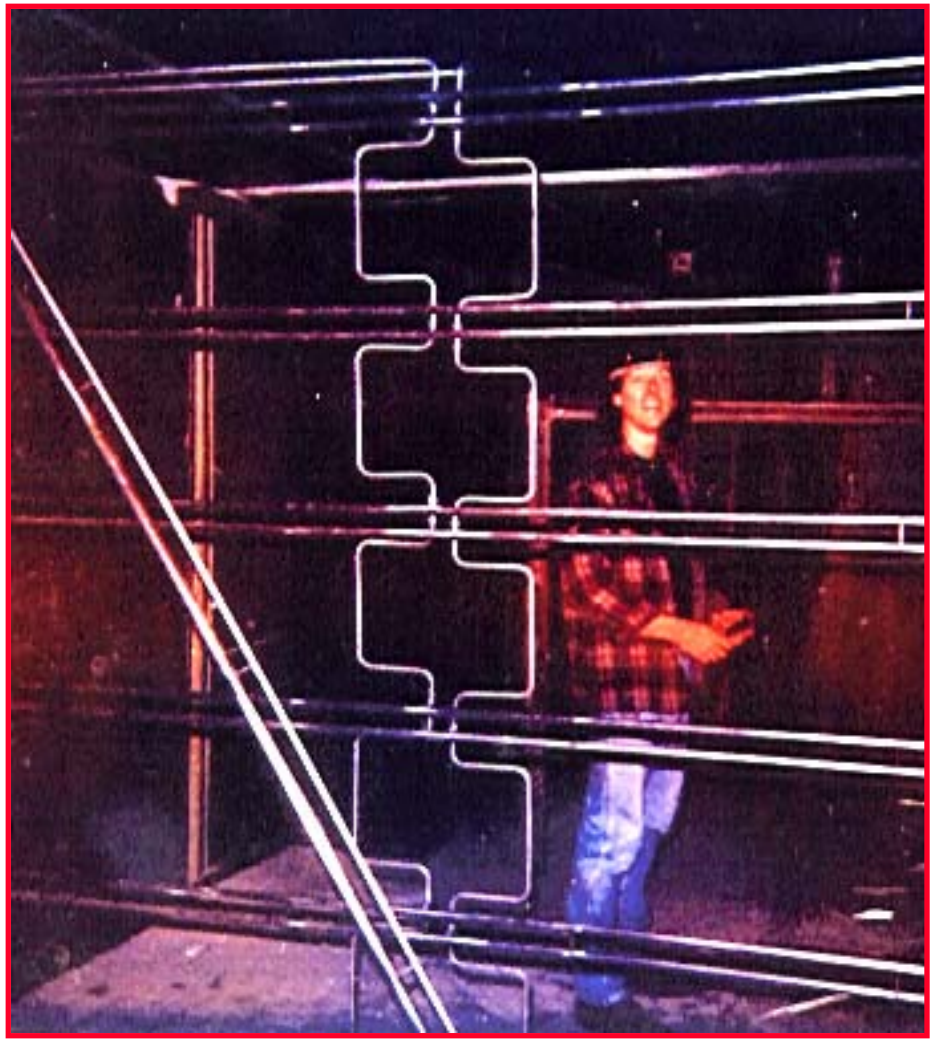
一次风双道球型磨煤器
PA – Double Ended Ball Mill



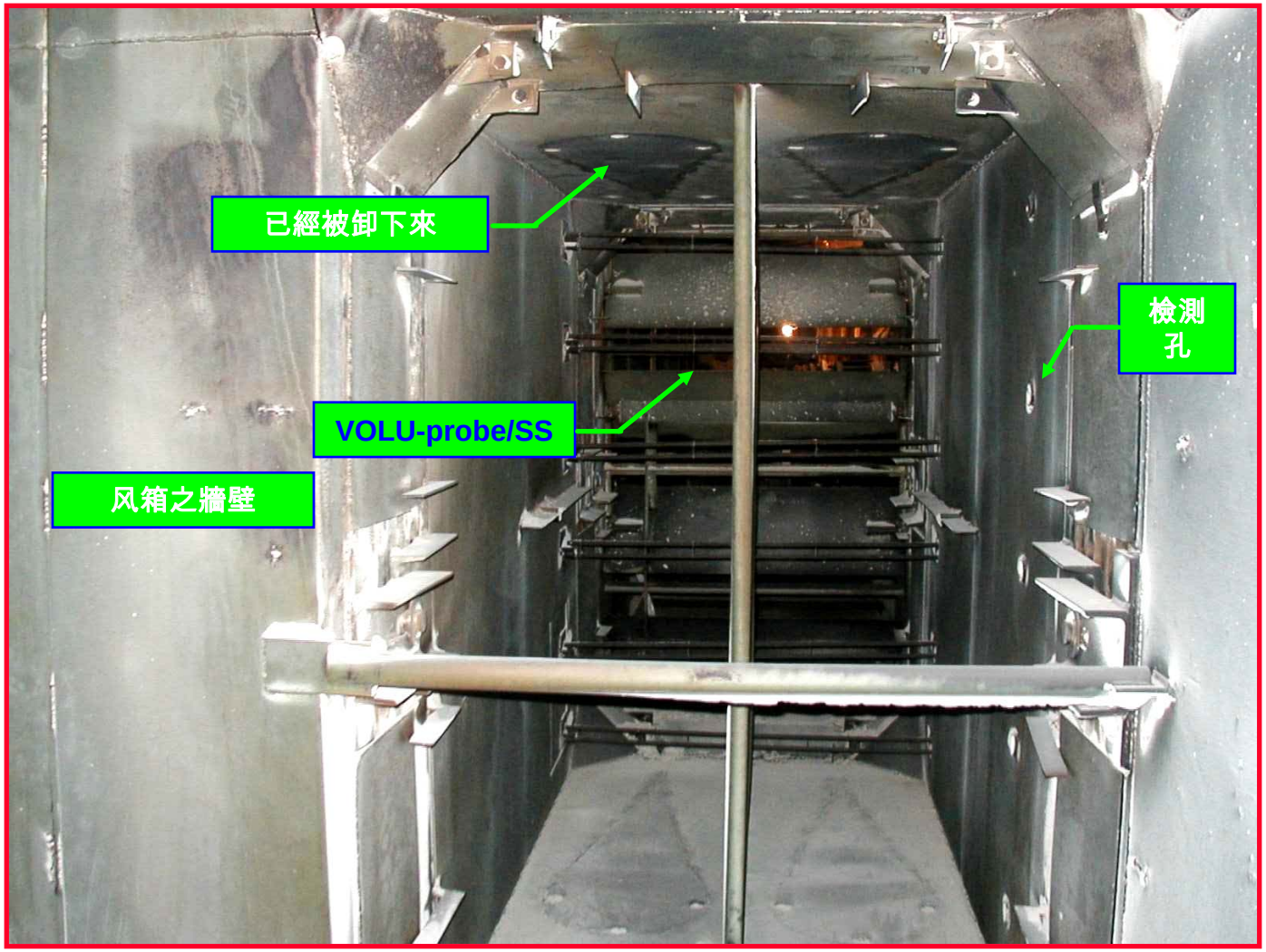
内装气流量监测探头排列

内装气流量监测探头排列

二次风气流监测
Secondary Airflow Measurement



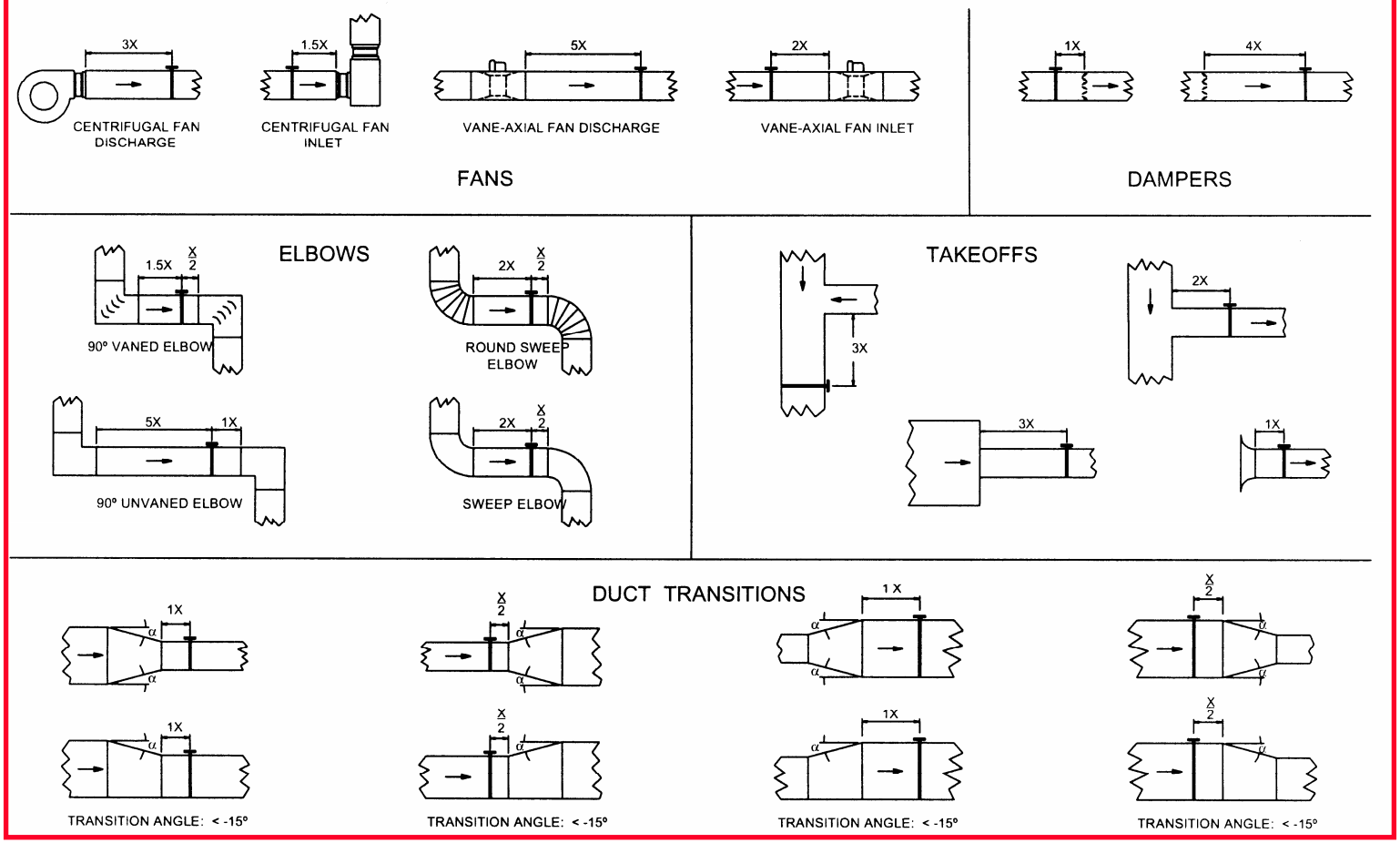
隔断式风箱。原使用螺旋式气流量检测器以ＡＭ的VOLU-probe/SS更换



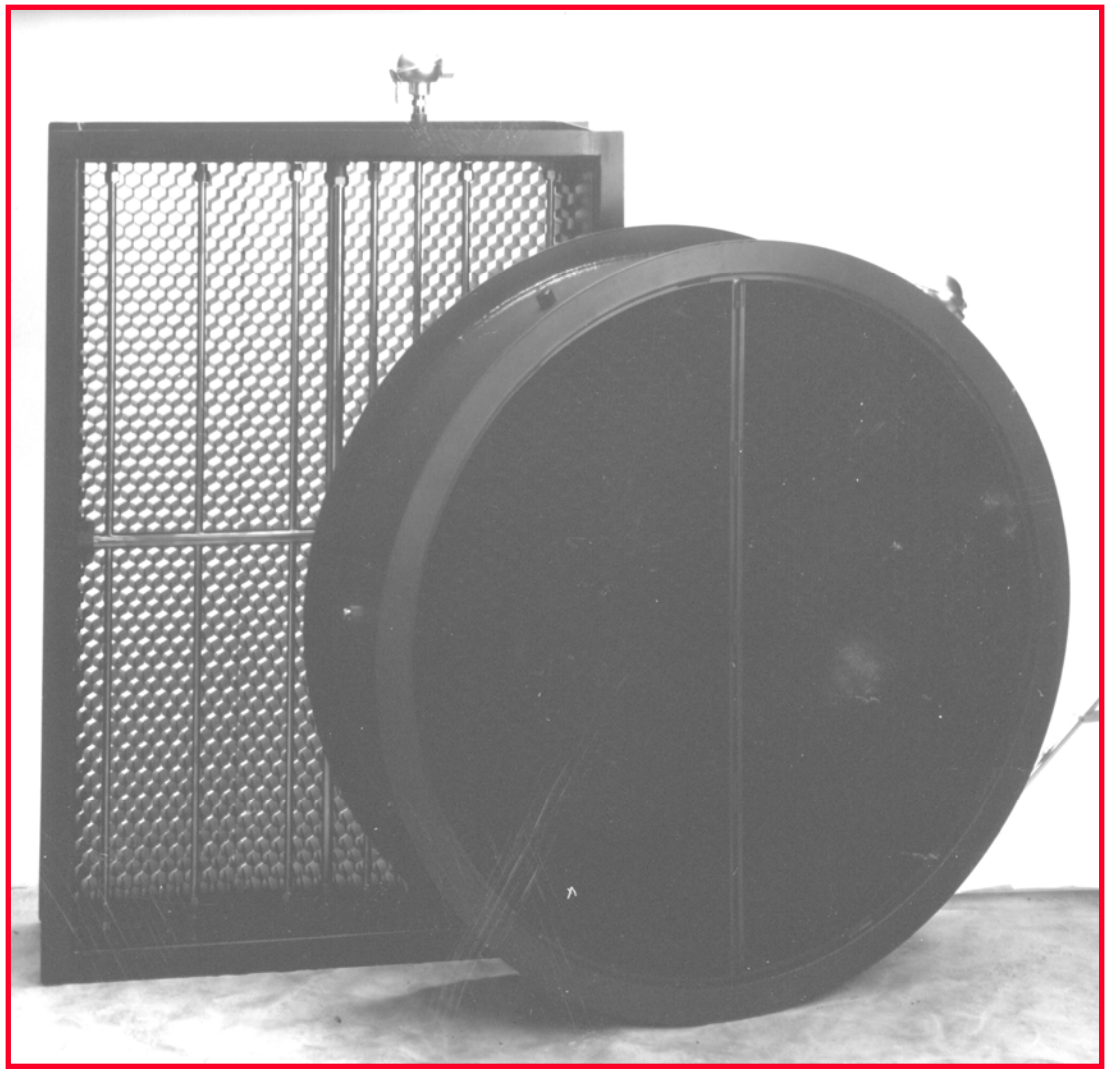
上二次风从二次风管道”舀”出空气

VOLU-probe
最低安装要求

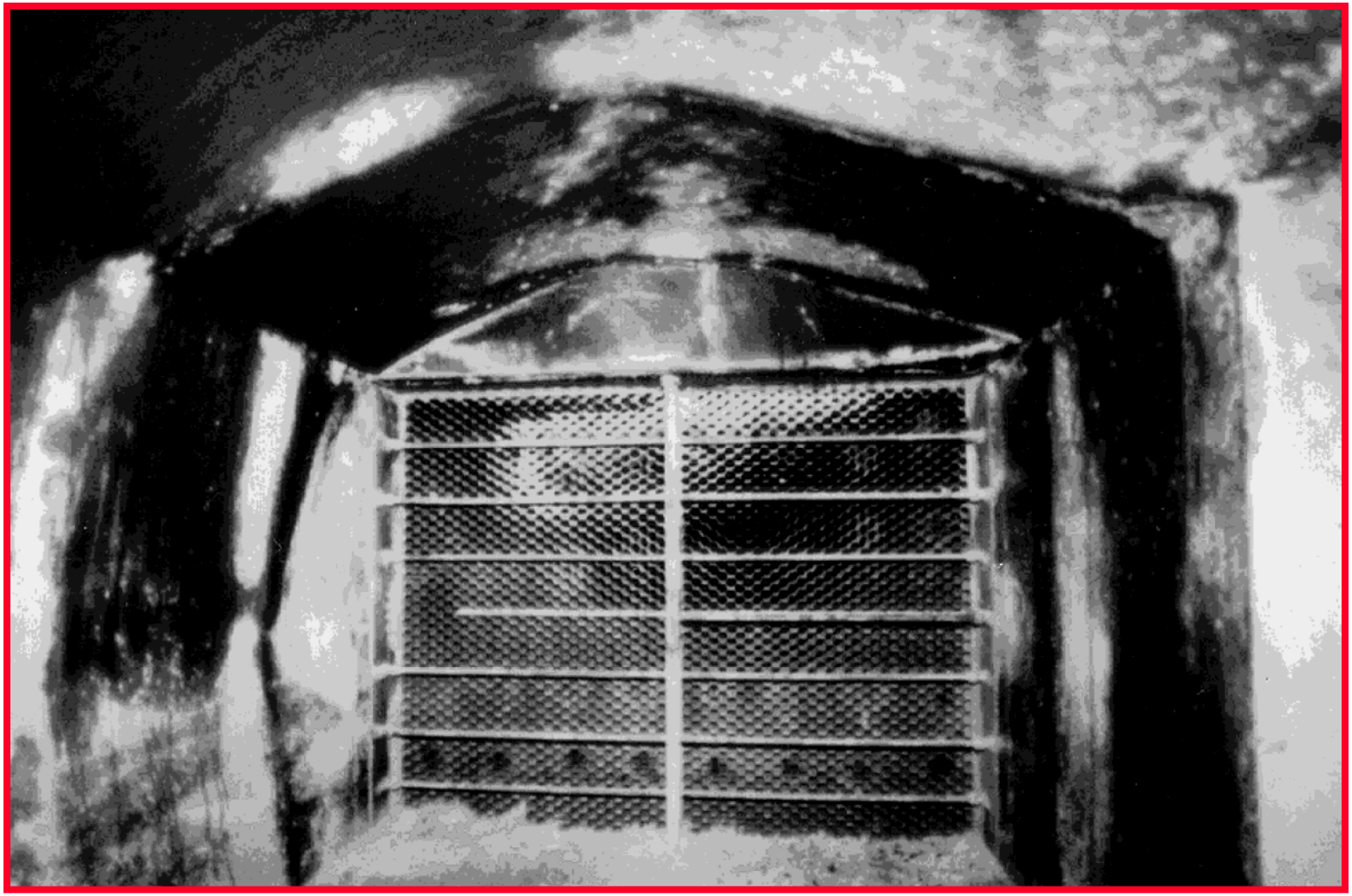
MINIMUM REQUIREMENTS FOR INSTALLATION. Note: VOLU-probe locations shown are NOT ideal. They indicate the minimum clearance required from air turbulence producing sources. Wherever possible, the VOLU-probe should be installed where greater runs of straight duct (or clearances) than shown exist.



CA 燃烧气流调直站



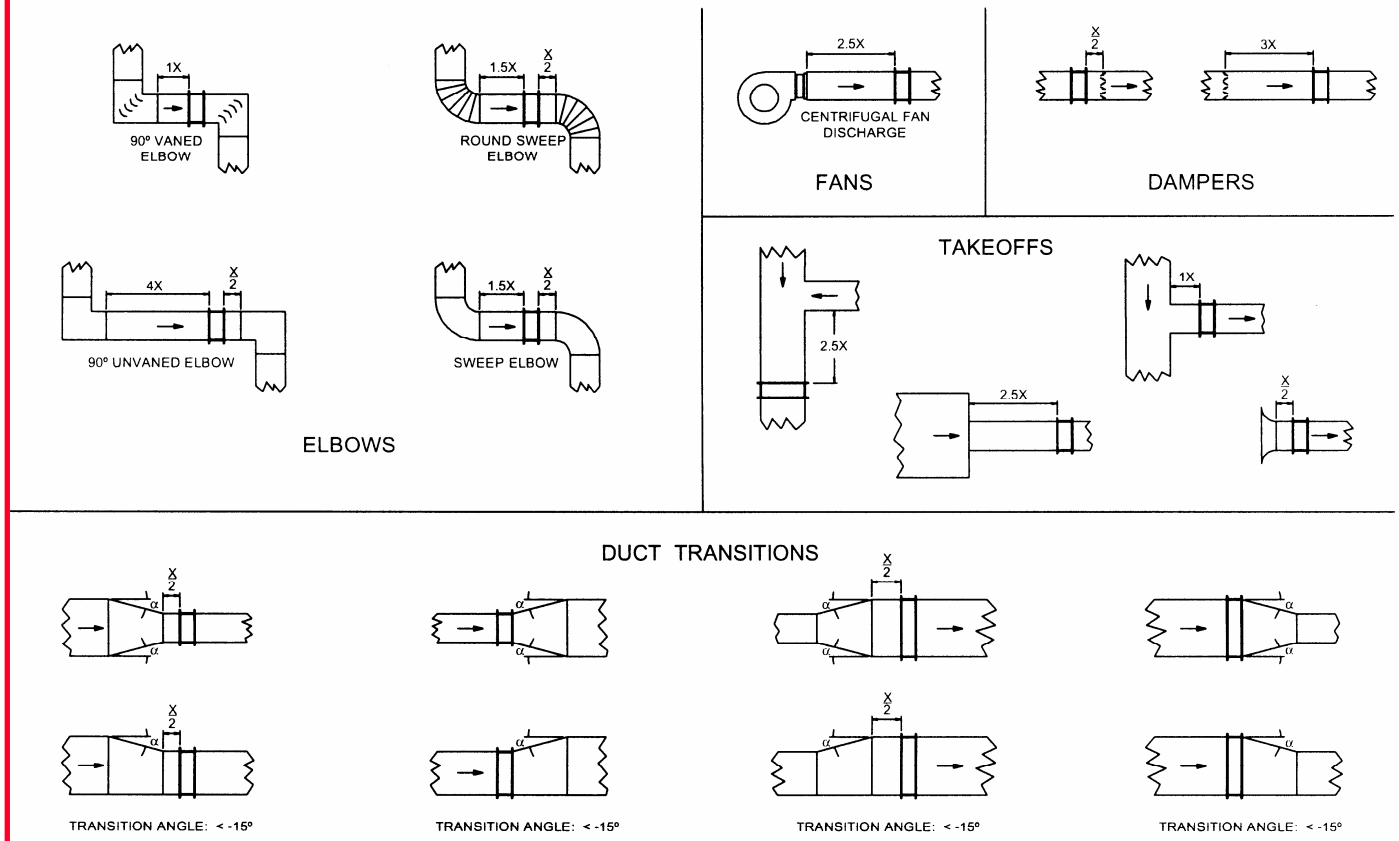
Combustion Airflow Station
燃烧空气调直并检测站



雷门氏碗型磨煤器–调温度外面空气口
Raymond Bowl Mill – Tempering Air Inlet

CA 气流调直站最少直径要求

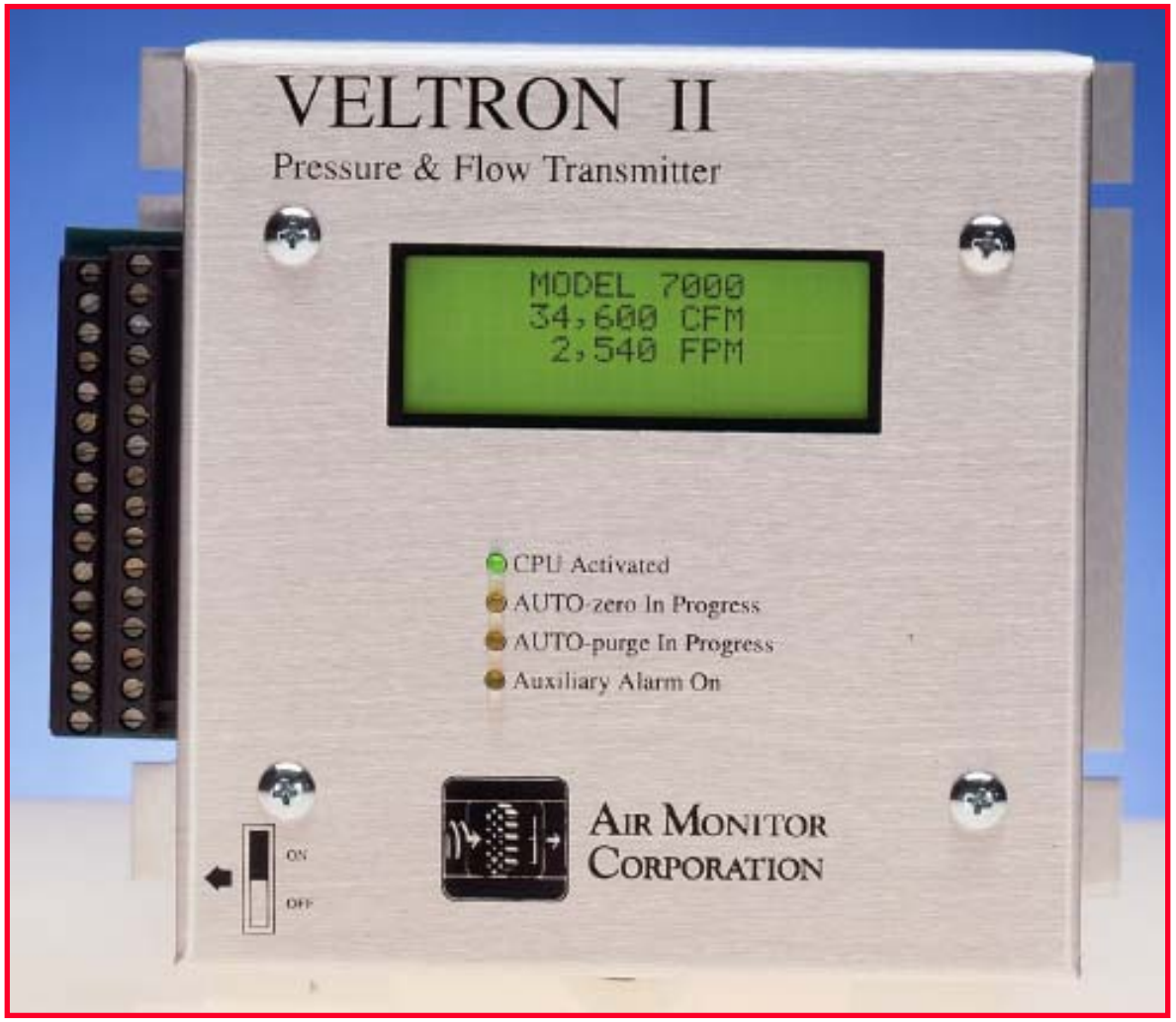
MINIMUM REQUIREMENTS FOR INSTALLATION. **Note: Combustion Air Station locations shown are NOT ideal**. They indicate the minimum clearance required from air turbulence producing sources. Wherever possible, the Combustion Air Station should be installed where greater runs of straight duct (or clearances) than shown exist.



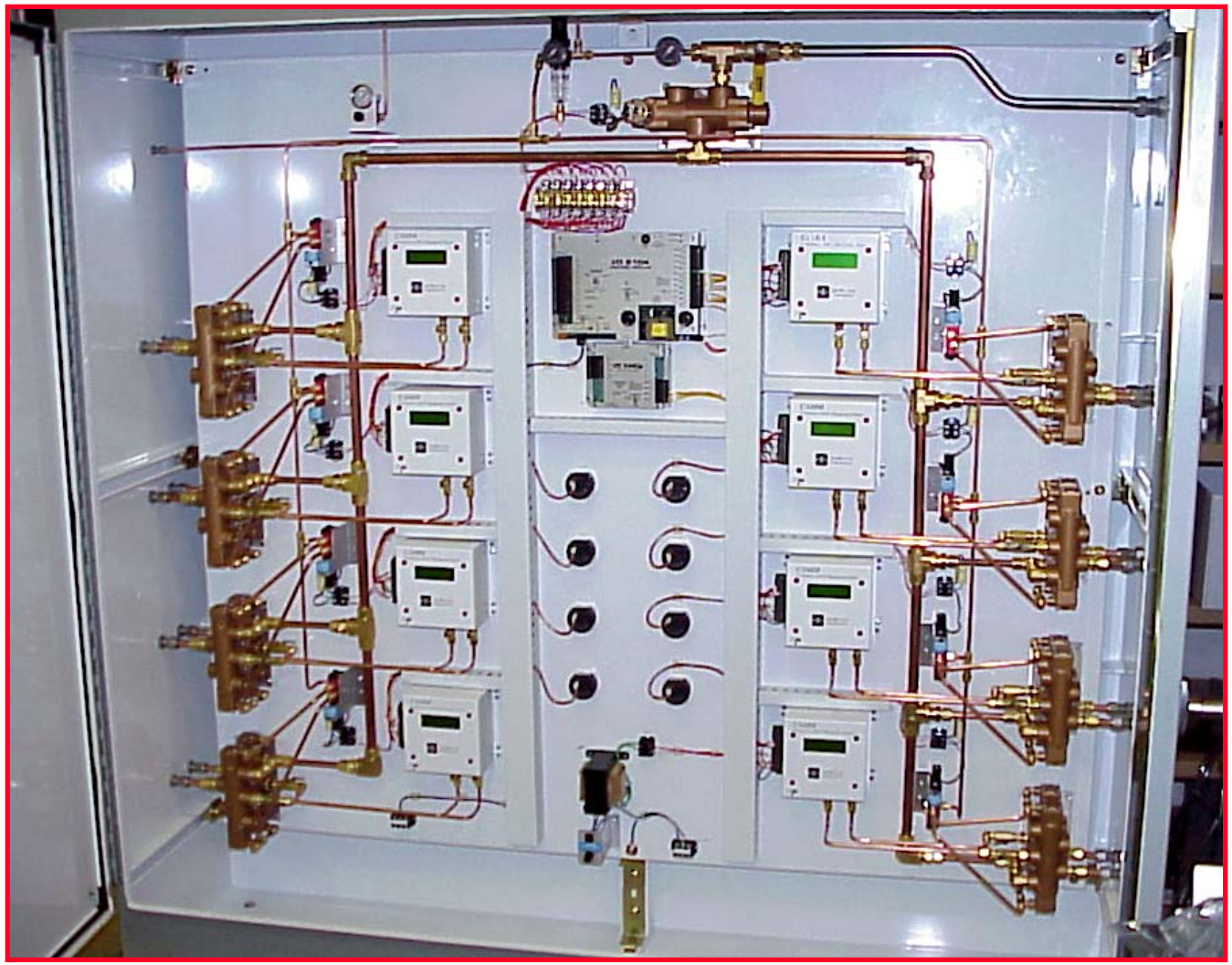
VOLU-probe/SS 和 CA 调直检测站对比

- VOLU-probe/SS 的优势
  - 仪器价格低
  - 安装费用低
  - 不可恢复气压损失小
  - 检查和清洗仪器拆卸费用低
- CA 调直检测站之优势
  - 在短直径距离的情况下，任能达到 97 - 98% 的空气流准确度

变送器產品系列（最低0.127MM水柱）



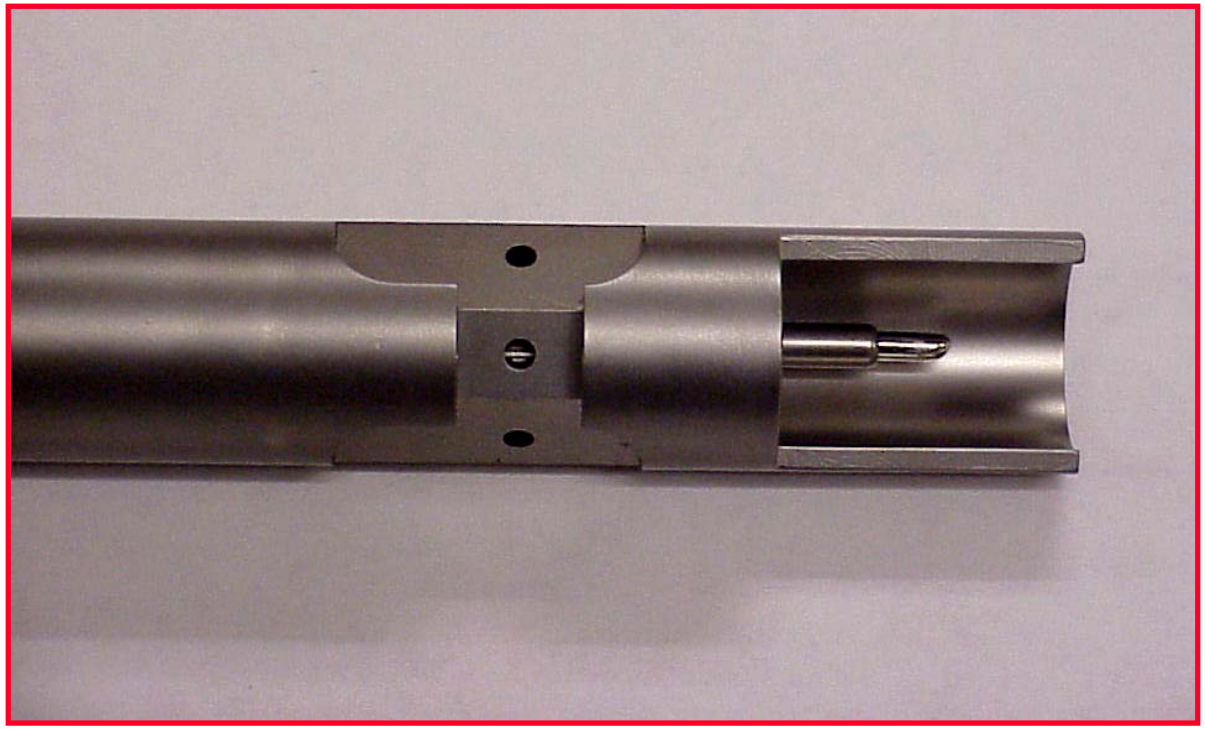
多部-CAMS 系统



VELTRON DPT-plus变送器

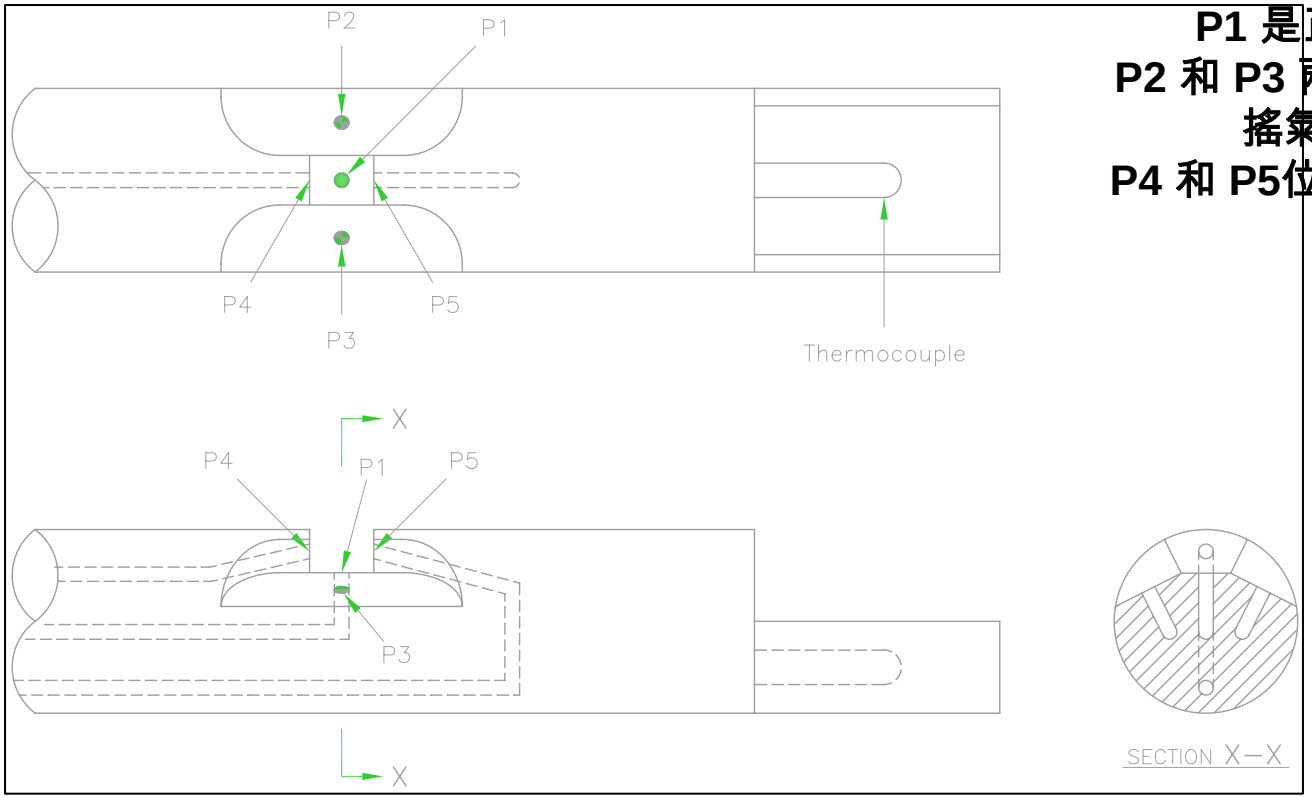
CAMS – Combustion Airflow Management System
燃烧气流管理系统

三维探头
3-D Probe



三維方向探頭 3-D Directional Probe

- 能准确检测受偏摇和螺距影响的非直线流体及总压和静压和总温度。各探头有五个检测孔。P1 是位于正中间。P2和P3是在两个侧面，用来检测偏摇气流。P4和P5是在P1的上下面。这两个孔检测螺距气流。



P1 是正中心的壓力孔
P2 和 P3 兩個側面的孔檢測偏搖氣流（YAW）
P4 和 P5位於 P1用來檢測螺距氣.

AM公司画线测试仪器箱

Intermountain（地名）电厂画線測試記錄圖表

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/ P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/ P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees	Traverse Point Velocity	Probes Point Velocity
1	1	2.376	-3.00	402	2.451	0.072	39.09	36.62	-0.006	-0.015	39.11	36.19	0.029	2.118	0.973	2.385	3.67	136.65	136.68
	2	2.373	-5.00	400	2.600	0.313	39.02	36.44	-0.010	-0.026	39.05	35.99	0.120	10.203	0.979	2.546	11.35	138.61	136.47
	3	2.376	-5.00	400	2.177	0.320	38.44	36.22	-0.010	-0.022	38.46	35.83	0.147	12.380	0.984	2.143	13.34	126.22	136.59
	4	2.423	-5.00	394	1.719	0.318	38.06	36.33	-0.011	-0.018	38.08	36.03	0.185	15.136	0.993	1.707	15.92	110.91	137.41
2	1	2.390	-6.00	400	2.567	0.010	38.73	36.17	-0.005	-0.012	38.74	35.72	0.004	-0.094	0.974	2.500	6.00	139.37	137.01
	2	2.397	5.00	396	2.534	0.060	38.57	36.05	-0.006	-0.015	38.58	35.61	0.024	1.616	0.973	2.466	5.25	138.28	136.91
	3	2.423	13.00	394	2.535	0.086	38.74	36.19	-0.007	-0.016	38.76	35.75	0.034	2.520	0.973	2.466	13.24	135.00	137.47
	4	2.453	11.00	393	2.291	0.219	38.59	36.28	-0.009	-0.021	38.61	35.88	0.096	8.050	0.976	2.236	13.60	128.25	138.21
3	1	2.397	-7.00	399	2.506	-0.122	38.88	36.39	-0.002	-0.006	38.89	35.96	-0.049	-4.308	0.979	2.453	8.21	137.26	137.09
	2	2.419	-3.00	397	2.524	-0.193	38.70	36.19	-0.001	-0.004	38.70	35.76	-0.076	-6.302	0.982	2.479	6.98	138.26	137.59
	3	2.421	6.00	393	2.489	-0.111	38.83	36.33	-0.003	-0.006	38.84	35.90	-0.045	-4.000	0.978	2.435	7.21	136.62	137.30
	4	2.378	12.00	390	2.017	0.280	38.39	36.38	-0.010	-0.021	38.41	36.03	0.139	11.730	0.983	1.982	16.72	118.75	135.81
4	1	2.342	-7.00	396	2.453	-0.098	38.98	36.51	-0.003	-0.007	38.99	36.08	-0.040	-3.647	0.978	2.399	7.89	135.58	135.25
	2	2.361	6.00	395	2.457	-0.129	38.78	36.34	-0.002	-0.006	38.79	35.92	-0.053	-4.592	0.979	2.406	7.55	135.85	135.74
	3	2.368	5.00	392	2.416	-0.136	38.80	36.36	-0.002	-0.005	38.81	35.94	-0.056	-4.870	0.980	2.367	6.98	134.67	135.70
	4	2.380	8.00	389	1.840	0.175	38.25	36.40	-0.009	-0.017	38.27	36.08	0.095	8.007	0.976	1.796	11.30	115.65	135.78
5	1	2.391	10.00	392	2.543	-0.069	39.09	36.54	-0.003	-0.008	39.10	36.10	-0.027	-2.647	0.977	2.484	10.34	136.69	136.33
	2	2.442	6.00	389	2.580	-0.151	38.91	36.34	-0.002	-0.005	38.92	35.89	-0.059	-5.033	0.980	2.529	7.83	138.68	137.57
	3	2.431	0.00	388	2.439	-0.186	38.81	36.38	-0.001	-0.003	38.81	35.96	-0.076	-6.288	0.982	2.396	6.29	135.35	137.17
	4	2.414	-2.00	386	1.938	0.143	38.32	36.39	-0.008	-0.016	38.34	36.05	0.074	6.100	0.974	1.887	6.42	119.95	136.51
6	1	2.421	5.00	392	2.586	-0.055	39.10	36.50	-0.004	-0.009	39.11	36.05	-0.021	-2.178	0.976	2.524	5.45	139.45	137.19
	2	2.413	12.00	387	2.510	-0.070	38.89	36.37	-0.003	-0.008	38.90	35.93	-0.028	-2.707	0.977	2.451	12.30	134.51	136.59
	3	2.408	7.00	385	2.420	-0.053	38.60	36.19	-0.004	-0.009	38.61	35.77	-0.022	-2.229	0.976	2.362	7.34	133.90	136.31
	4	2.462	-7.00	381	2.238	0.163	38.46	36.21	-0.008	-0.018	38.48	35.82	0.073	6.014	0.974	2.179	9.22	127.70	137.50
7	1	2.413	6.00	389	2.680	-0.022	39.04	36.39	-0.004	-0.011	39.05	35.93	-0.008	-1.111	0.975	2.613	6.10	141.49	136.75
	2	2.431	9.00	387	2.622	0.017	38.96	36.33	-0.005	-0.013	38.97	35.87	0.006	0.127	0.974	2.554	9.00	138.79	137.10
	3	2.418	-2.00	383	2.578	0.057	38.76	36.17	-0.006	-0.015	38.77	35.72	0.022	1.479	0.973	2.509	2.49	138.85	136.44
	4	2.420	-18.00	382	2.285	0.282	38.52	36.23	-0.010	-0.023	38.54	35.83	0.123	10.459	0.980	2.239	20.73	122.70	136.40
8	1	2.441	11.00	386	2.678	-0.013	39.12	36.43	-0.004	-0.012	39.13	35.96	-0.005	-0.831	0.975	2.610	11.03	139.34	137.29
	2	2.402	5.00	384	2.630	0.102	39.04	36.40	-0.007	-0.017	39.06	35.94	0.039	2.953	0.973	2.559	5.80	139.67	136.03
	3	2.400	-2.00	384	2.707	0.142	38.98	36.29	-0.007	-0.020	39.00	35.82	0.052	4.178	0.973	2.634	4.63	142.00	136.00
	4	2.392	-8.00	380	2.482	0.269	38.93	36.43	-0.010	-0.024	38.95	35.99	0.108	9.172	0.978	2.426	12.15	133.33	135.42
9	1	2.455	11.00	385	2.718	0.034	39.29	36.57	-0.005	-0.014	39.30	36.10	0.013	0.644	0.974	2.646	11.02	140.20	137.58
	2	2.380	7.00	382	2.732	0.195	39.12	36.40	-0.008	-0.022	39.14	35.93	0.071	5.883	0.974	2.660	9.13	141.18	135.25
	3	2.398	10.00	380	2.653	0.202	38.97	36.30	-0.009	-0.022	38.99	35.83	0.076	6.312	0.974	2.584	11.81	137.80	135.61
	4	2.409	10.00	377	2.186	0.325	38.58	36.40	-0.010	-0.023	38.60	36.02	0.149	12.512	0.985	2.153	15.97	123.28	135.65
										Avg. Duct Static =		35.92							

	Average Temp.
Yaw Avg. = 2.64	390
Std. Dev. = 7.62	

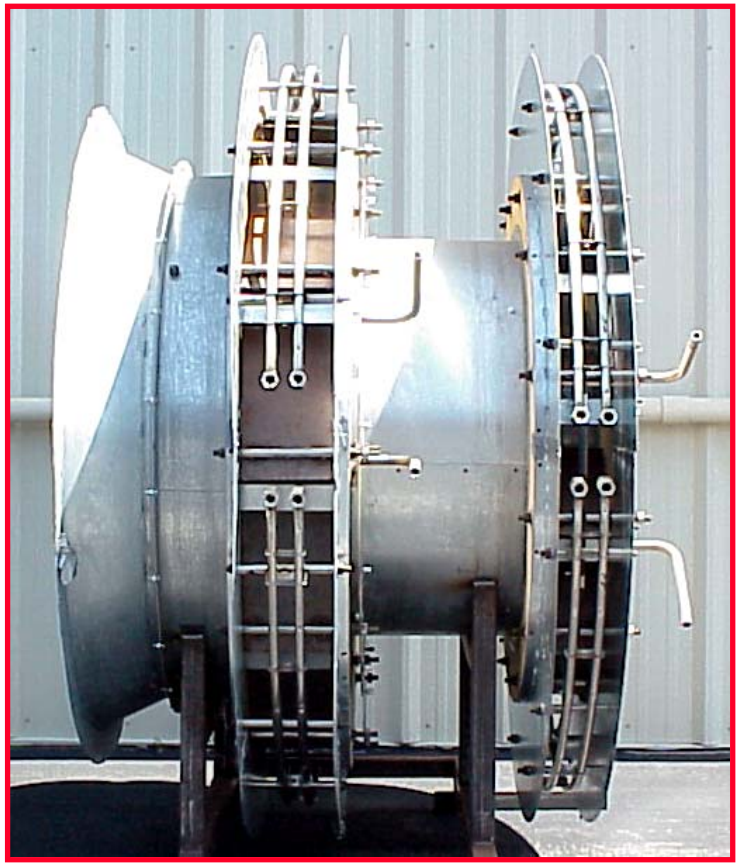
		Traverse	Probes
Pitch Avg. = 2.41	Result Angle Avg. = 9.45	Avg. Velocity in ft/s	
Std. Dev. = 6.11	Std. Dev. = 4.04	133.63	136.60

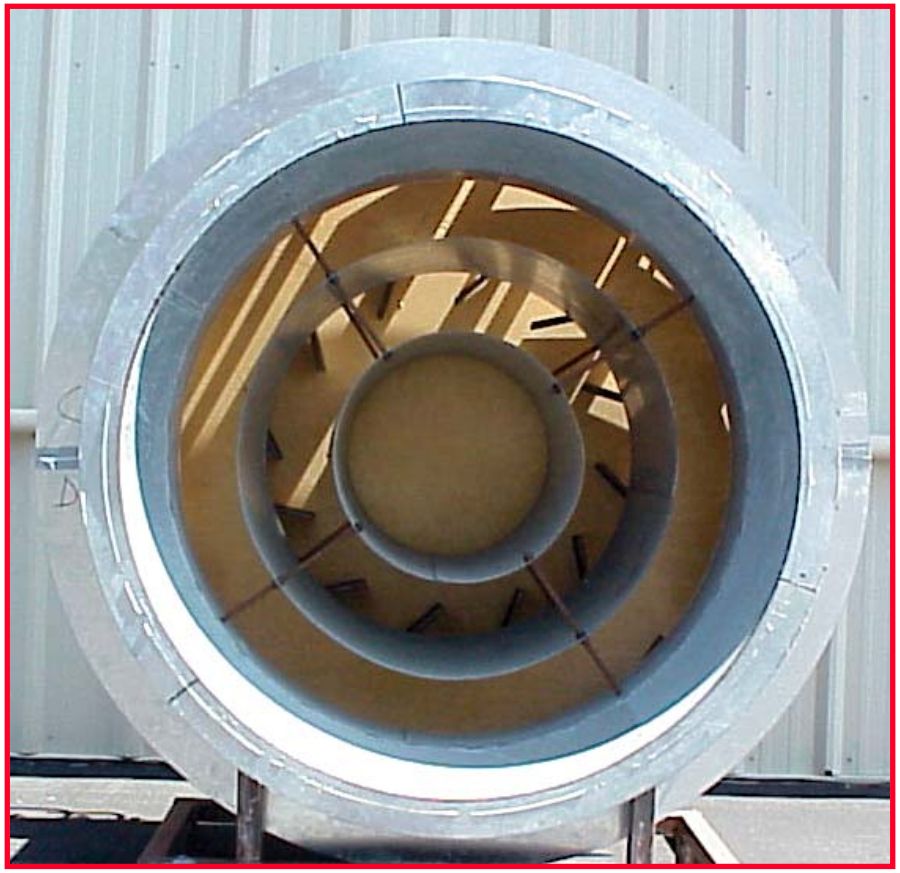
NOTE: Temp taken off of CAMM therocouple on 3-D probe bad.

漩涡器测试–在AM測試中心進行檢測
Cyclone Test – Outlet View

旋转锅炉测试 – 进气口

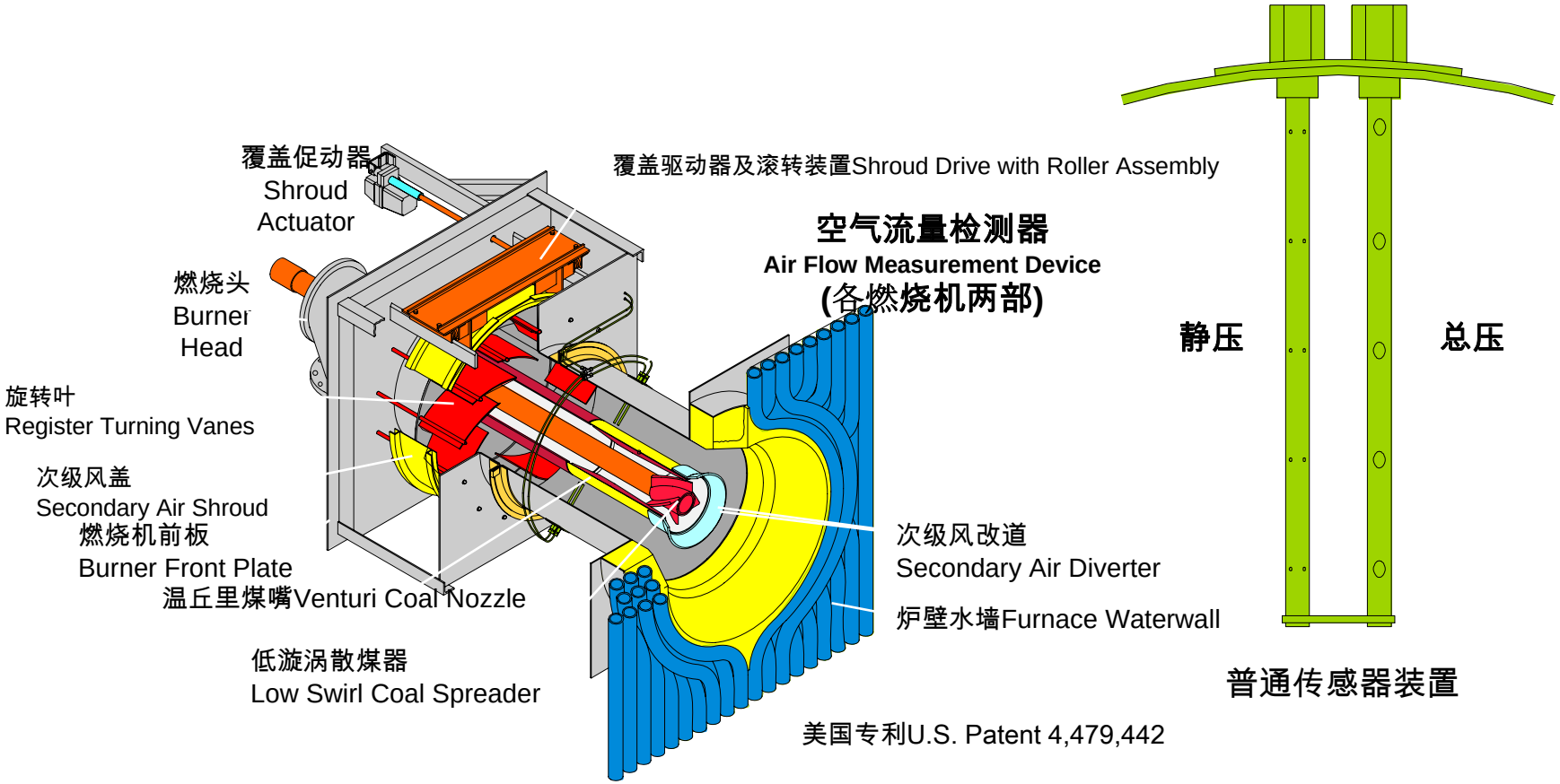
B&W 锅炉厂早期双区气流通道燃烧机测试用样机





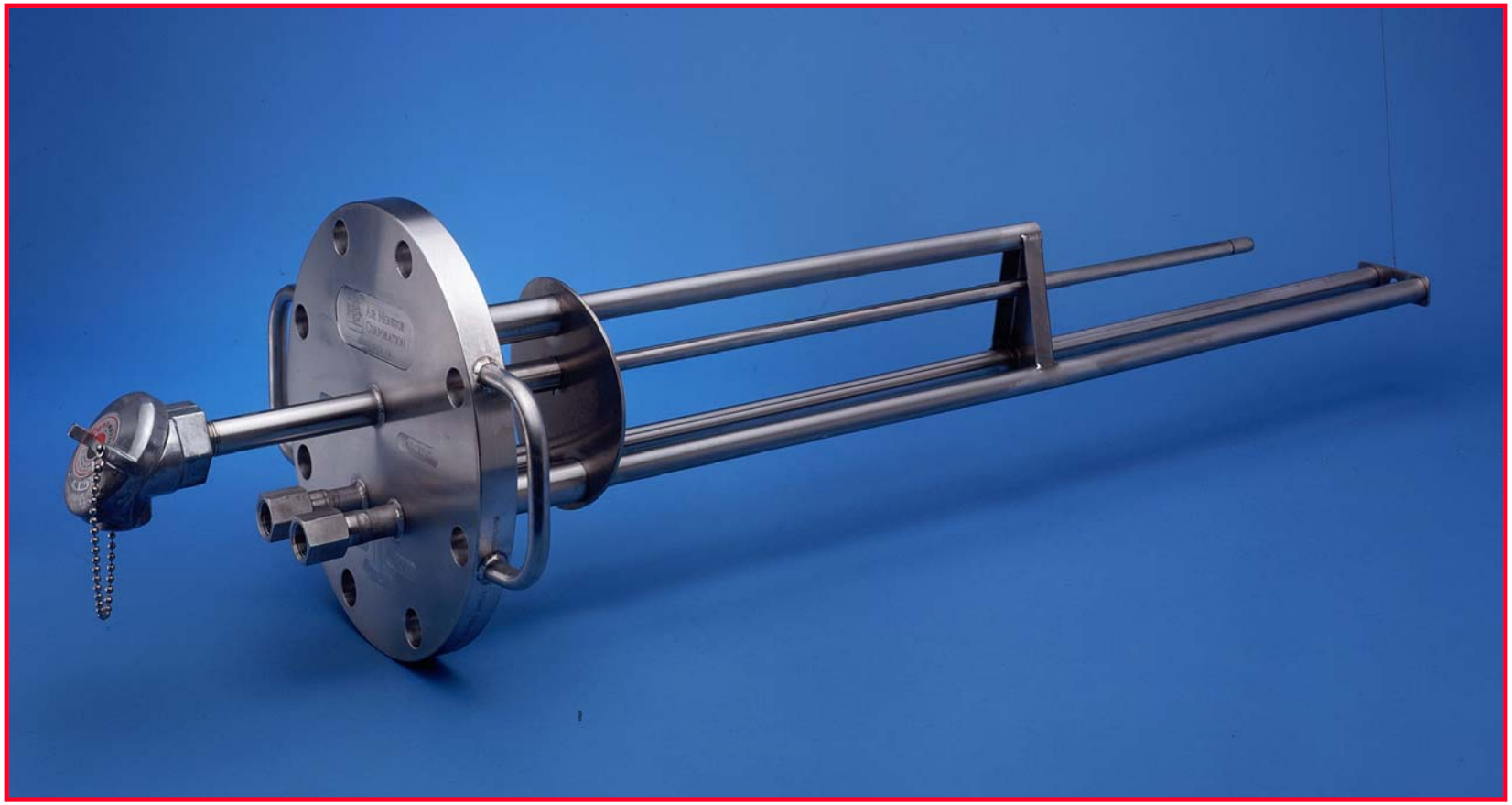
IBAM-O
個別燃燒機氣流檢測
Individual Burner Airflow Measurement

IBAM装在 BPI (Riley) 燃烧机里面



个别燃烧机气流检测

STACK-probe烟囱流量探头



MASS-tron/CEM烟囱流量变送器

AM气流检测技术和降氮的作用

2002 年12月美国火力电厂安装好或有计划安装的空气污染控制技术

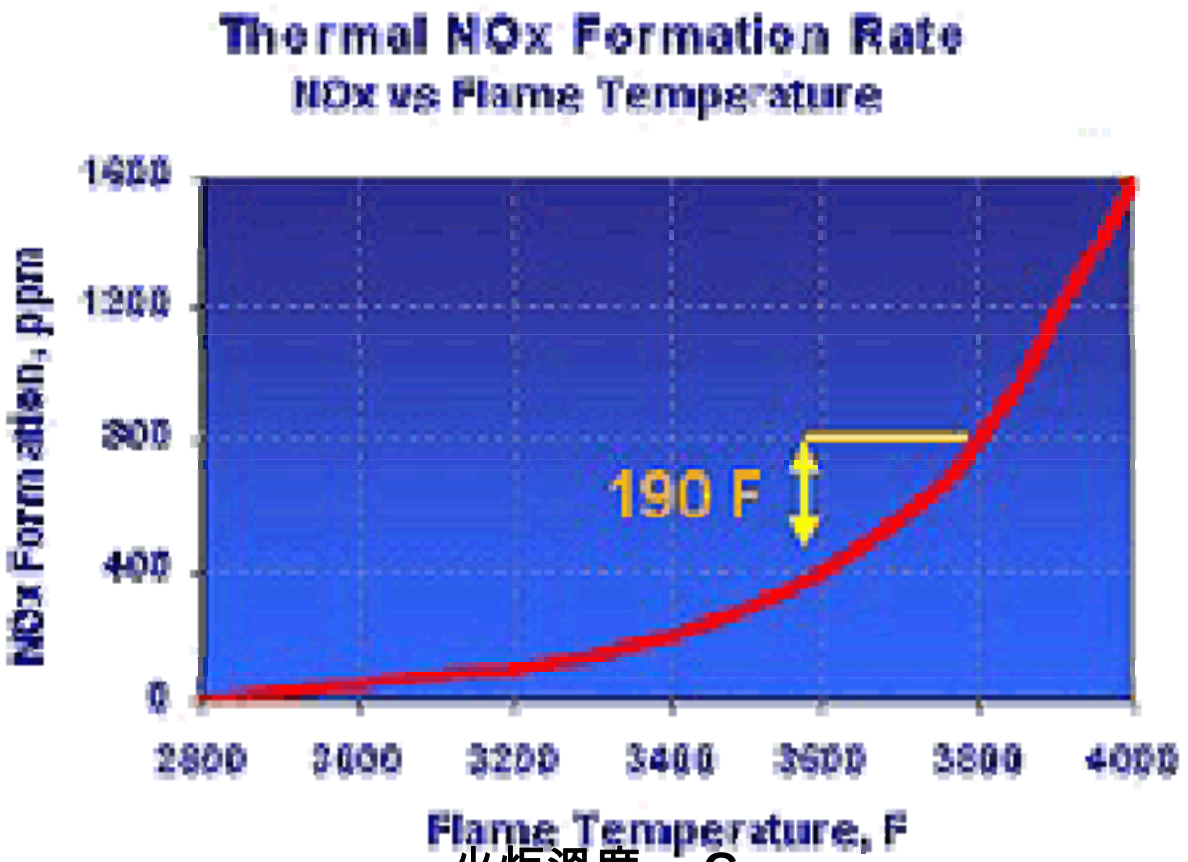
NOx

催化器	14％ (SNCR1%,SCR13%)
燃烧控制	57％
没有控制	29％

SO2

脱硫设备	31％
没有控制	69％（包括使用低硫煤）

燃燒溫度和產生氧化氮(NOx)的影響
氧化氮和火炬對比



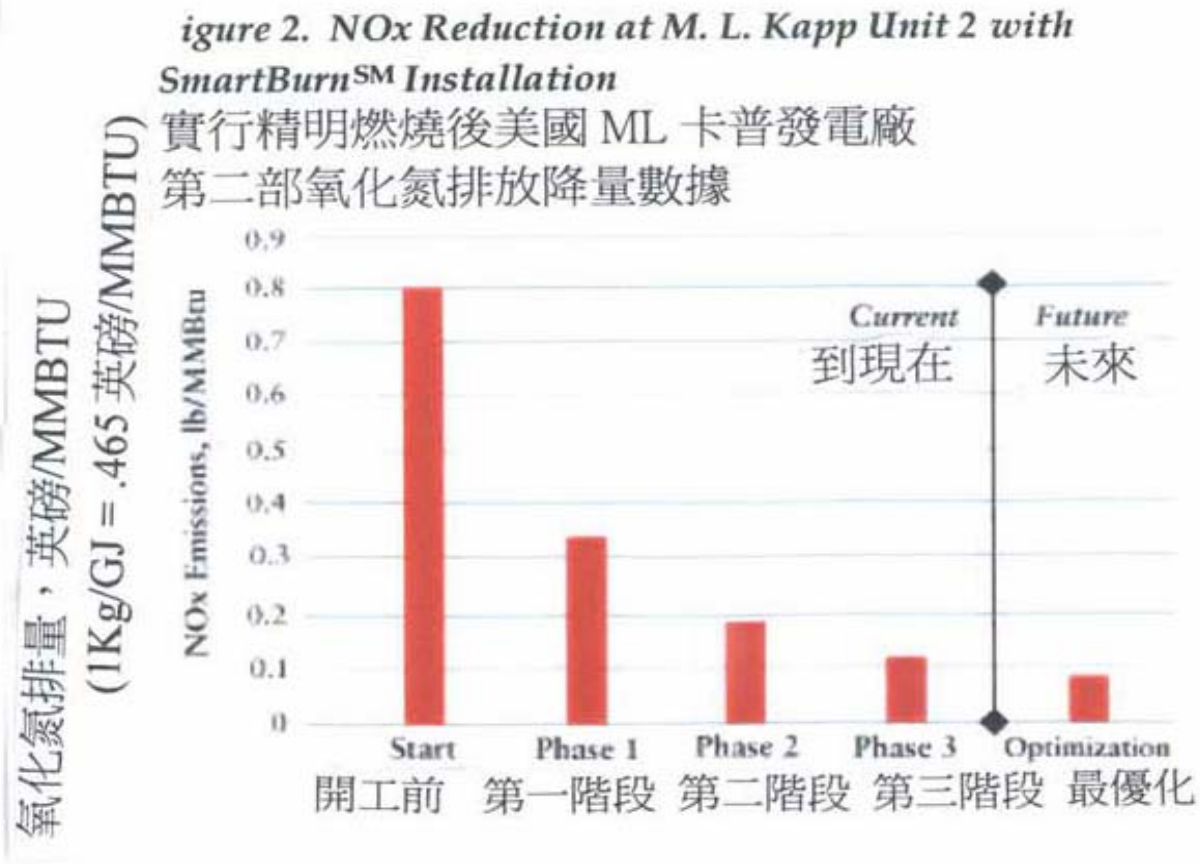
火炬溫度，C

1540 1650 1760 1870 1980 2100 2210

美国Alliant电力公司精明燃烧作法

- 确定磨煤气得有效工作
- 上低氮燃烧机
- 顶棚二次风
- 上一次风，二次风，顶棚二次风，个别燃烧机气流检测I
- 确定风门执行器准确运行
- 风箱改造

精明燃燒效率


igure 2. NOx Reduction at M. L. Kapp Unit 2 with SmartBurnSM Installation
實行精明燃燒後美國 ML 卡普發電廠
第二部氧化氮排放降量數據
氧化氮排量，英磅/MMBTU
(1Kg/GJ = .465 英磅/MMBTU)
NOx Emissions, lb/MMBtu
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Current
到現在
Future
未來
Start
開工前
Phase 1
第一階段
Phase 2
第二階段
Phase 3
第三階段
Optimization
最優化

精明燃烧适合各种锅炉

- 切向锅炉（四角对吹）
- 对立锅炉
- 旋流锅炉
- 三种锅炉都上AM气流量检测产品

AM和其他流量公司美國市場佔有率

电厂燃烧空气流量检测

AM	90-95%
阿牛巴，微力巴等等	5-10%

蒸汽，液体，其它流量

其它牌子	100%
AM	0%

AM和阿尔斯通 的关系

- 根据两个公司的1994年协议所有一次风气流检测项目有AM供应

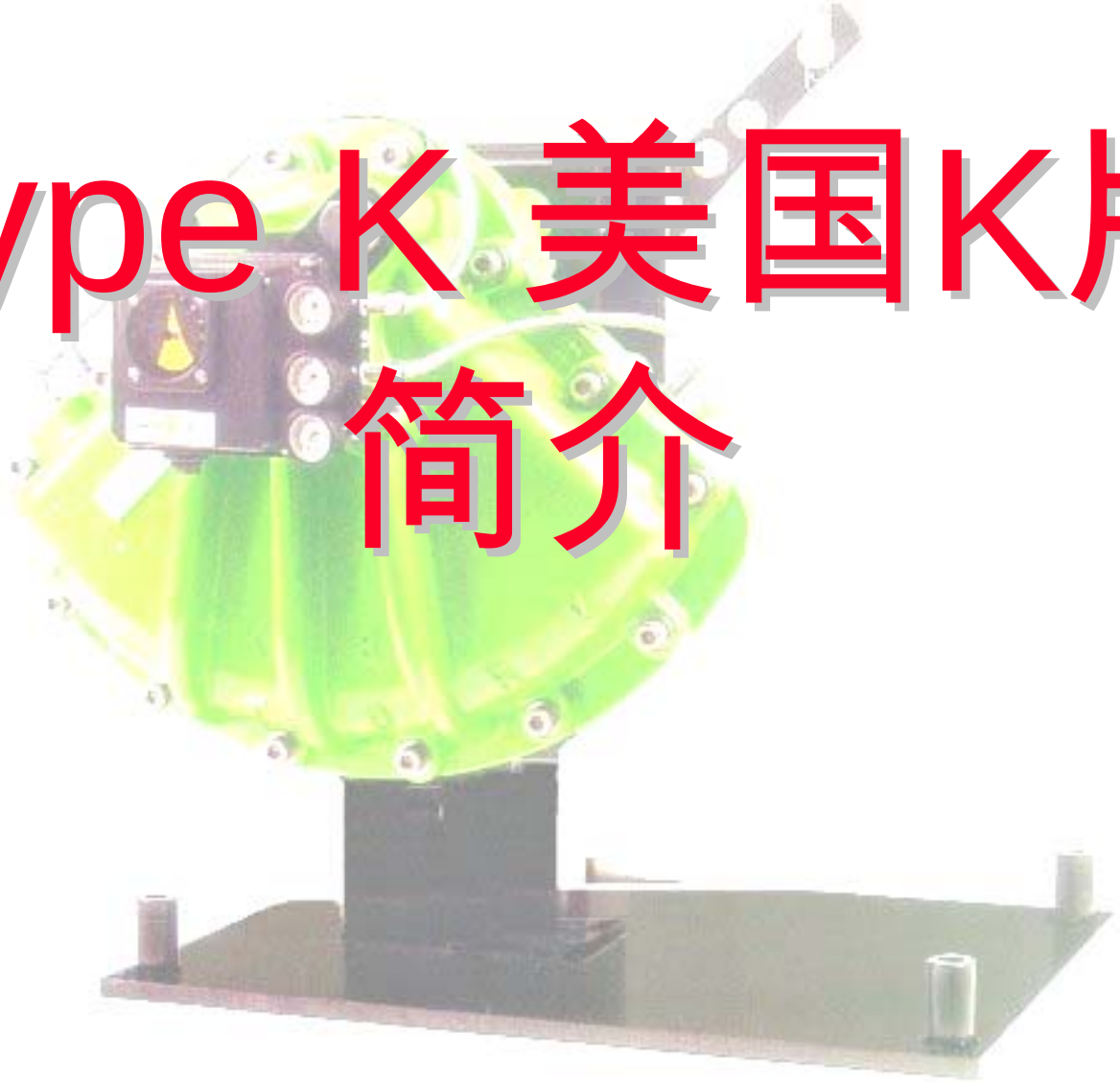
- 二次风等气流检测工作阿尔私通有权力选其它流量供应 商但是根据我们的了解阿尔私通也都是选AM的产品

摩托羅拉，天津開發區手機場

默沙東製藥，杭州廠

江西南昌賽特利化纖廠
毒氣流量檢測

Type K 美国K牌简介



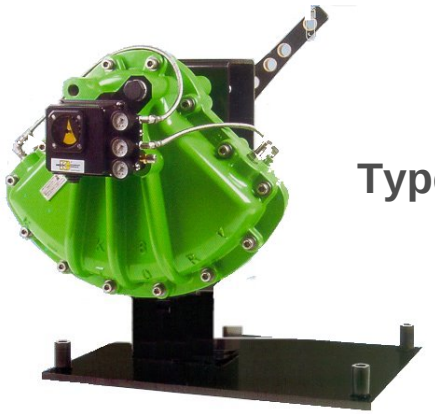
风门执行器有什么作用呢?

氣流

P

过程便送器
(一般传送气流数据)

风门执行器
（阻尼器）



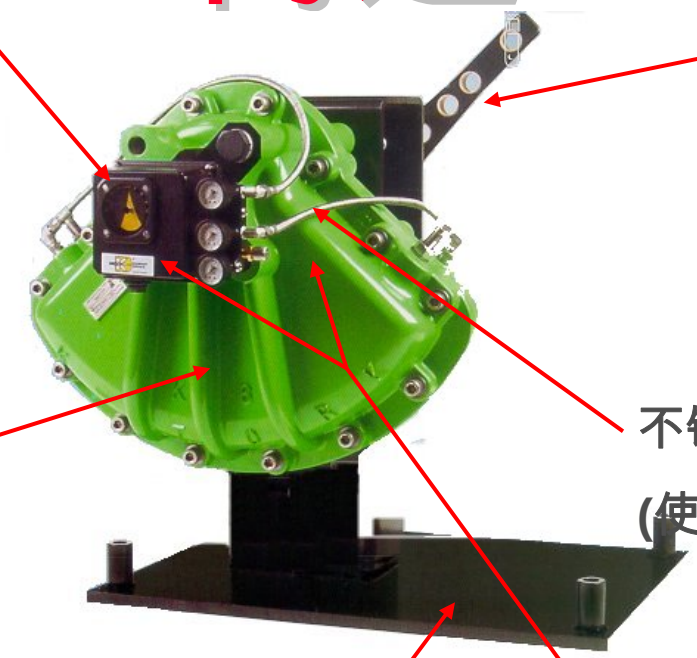
Type K风门执行器

控制系统

Type K 风门执行器构造

C-400 位置调整器

安照客户要求订作执行器之控制杆



K-TORK執行器

不锈钢筒和和连接配件

(使用寿命长, 保养少)

安照客户需要专门制造特殊相配仪器柱脚和底座) (能配上原有连接底座)

NEMA 4X 安全生产

(污物和液体不会透入)

K牌风门执行器有哪些优势？

- 可以更准确控制。根据操作员的要求 <0.5% 信号范围
- 在150° C气温环境照样使用良好(特殊材料可高達300 ° C)
- 运转稳定。风门连杆不会左右摇。
- 三年4,000,000使用次全面保证
- 能上百万使用周期正常使用并不须要操作员之监督。

Type R风门执行器—应用在送风机以及抽风机（F.D.）—

- 转矩高达 >14,124 N-m
- 快速反应, 1.1 (米/秒)
- 根据不同进气需要快速调整阻尼器之位置反应 <0.5% 信号范围
- 改善锅炉压力控制
- 数子或模拟控制
- 降低保养费

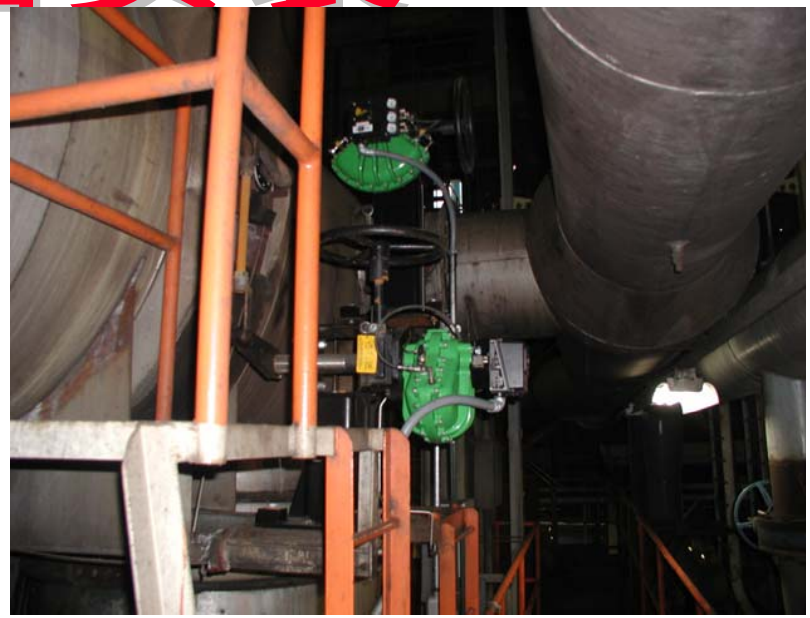
一般风机设置

改进前—旧行圆筒式执行器

改进后—Type K 安装在原底座接原有的连接装置

一般磨煤器用的风门执行器安装

改良过前—就型缸式执行器.



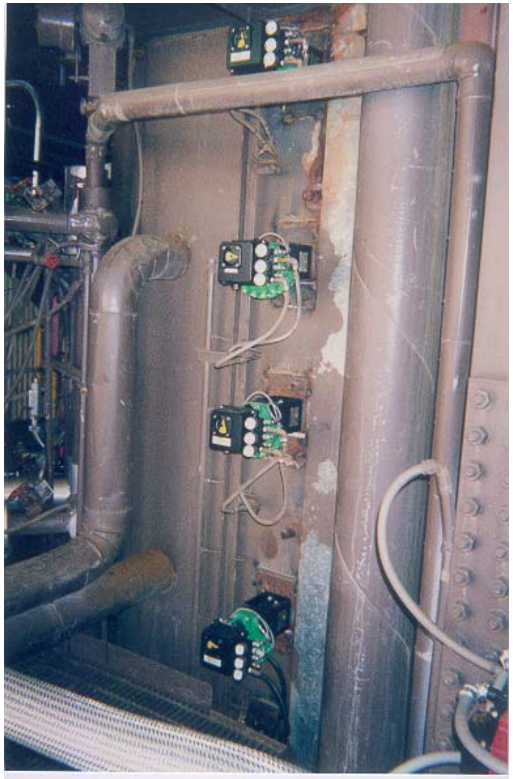
改良过后—带电子输入和位置反馈

Type K 风门执行器—燃烧机高低位置调整器

- 几种安装方式.
- 耐高温机械.
- 压缩空气或电子输入.
- 带位置反馈和极限开关.
- 简便安装.

Type K风门 执行器
—风箱应用—

- 改进风箱操作
- 适合高温环境实用
- 可以实用气压或电子输入
- 内装位置反馈, 和极限开关.
- 减少废气量



一般风箱安装情况

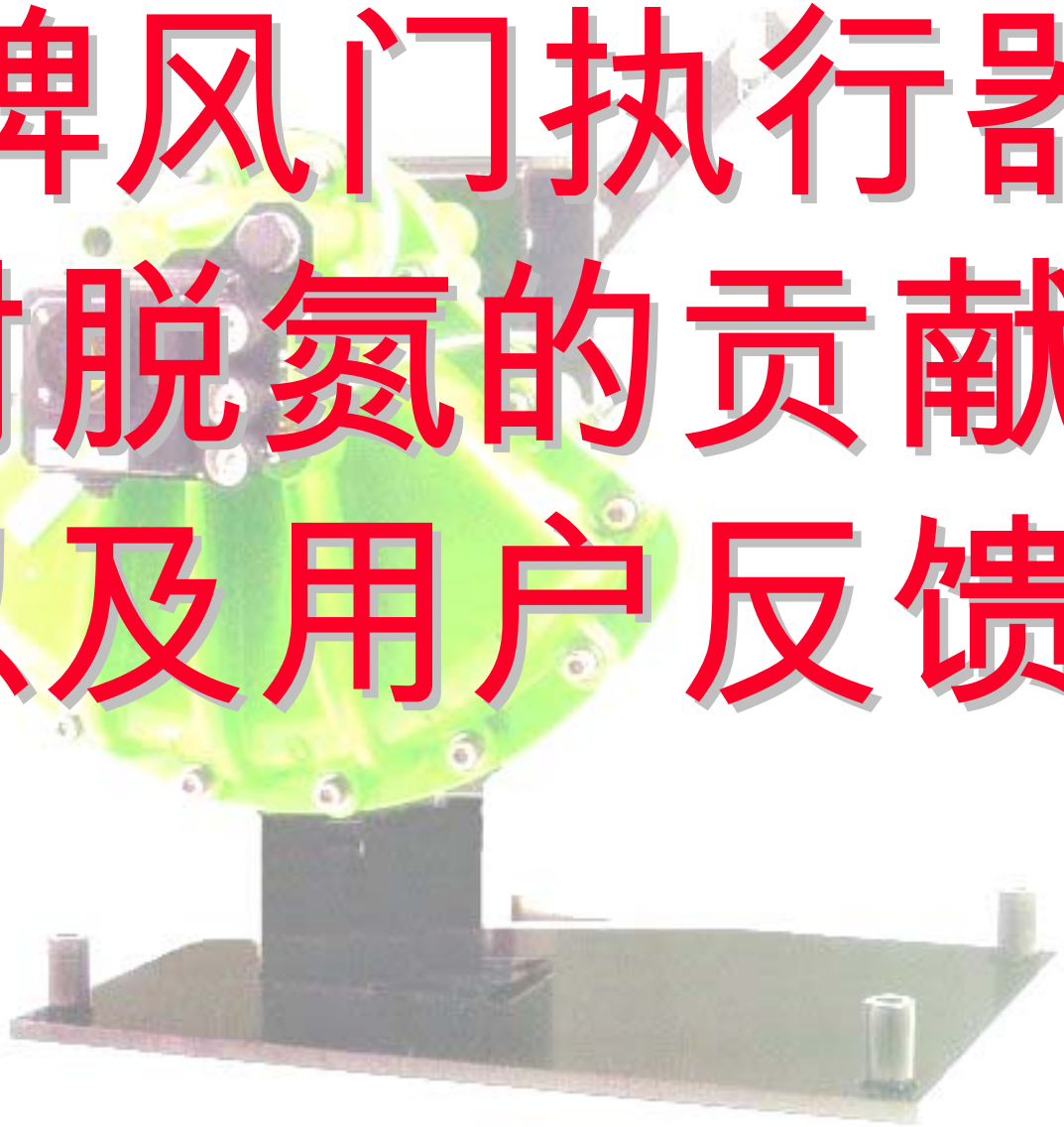
安装前—有压缩空气输入没有输出原廠汽缸式風門執行器

安装后—有电子输入输出Type K风门执行器

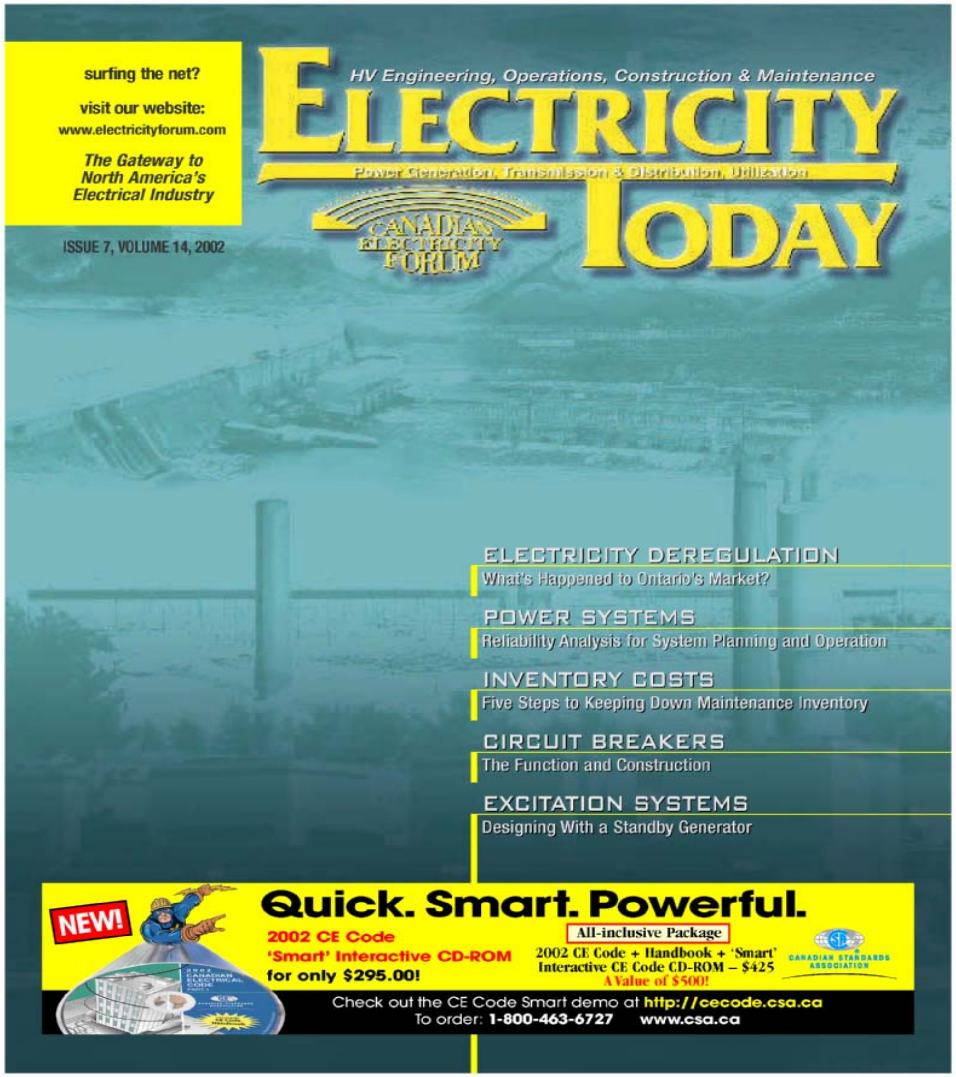
切向锅炉（四角对吹）应用
风箱经验

- 曾经装过几千个该锅炉之传动机.
- 占本公司传动机之 50% 销售额.
- 为了应付切向锅炉厂之需要K牌免费提供周全安装设计服务。
- 耐高温制造保证长年良好操作.
- 电子输入和位置反馈给予良好个别角落控制。

K牌风门执行器对脱氮的贡献以及用户反馈



加拿大 2年）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Power Generation, Transmission & Distribution, Utilization
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ELECTRICITY DEREGULATION
What's Happened to Ontario's Market?
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PETROLEUM INDUSTRY REPORT

The Importance of Damper Drive Performance For Clean Air

By: Kevin Wistrom

Because of the 1990 Amendments to the Federal Clean Air Act, petroleum refineries and other industries throughout the country are now forced to examine every aspect of their process-heating operations in order to reduce cumulative nitrogen oxides (NOx) emissions from their plants. While aging furnace burners are already rapidly being replaced with newer low NOx burners, attention is now being directed toward the furnace and heater stack damper drives.

Changing the final damper control elements to more reliable and accurate damper drives greatly improves the combustion of air and flue gases and reduces tramp air from entering furnaces. The resulting efficiency (depending on the type of low NOx burner selected and on how "tight" the furnace is for leaks can lower emissions as much as 55 to 80 per cent, when used in combination with other low NOx strategies while potentially increasing profit margins from two to eight per cent per furnace from fuel savings alone.

An Industry-Wide Issue With Inescapable Deadlines

In 1998, the US Environmental Protection Agency (EPA) refined the Act's amendments into the National Emission Standards for Hazardous Air Pollutants from Petroleum Refinery Vents (referred to as Refinery MACT II), which cover emissions from catalytic cracker, catalytic reformer and sulfur plants.

These rules were promulgated in late 2000 and have now officially impacted the majority of refineries throughout the country. Some areas of the country have until 2008 to fully meet emissions targets, but the EPA has already teamed up with the US Department of Justice to force multi-million dollar emission-reduction deals with major oil producers throughout the country.

At the state and local level, deadlines loom even closer. California's Rule 1109 dictates that refinery-wide emissions not exceed 0.3 pounds (0.14 kilograms) of NOx per million BTUs of heat input when operated on liquid fuel. In the San Francisco area of the state, this target was to be met by July 1.

"The consequences of these deadlines are severe," says Don Nelson, a NOx Project Engineer for ConneXsys Engineering with 30 years experience in the petroleum refining and production industry. "You either comply or you shut the high NOx producing furnaces down. You cannot count on deviations or variances." Nelson is currently doing contract work for a major refinery near San Francisco Bay.

Reheat Before Reheat After

Strategies For Reducing Emissions

Thermal NOx is a result of the thermal fixation of molecular nitrogen and oxygen present in the combustion air. NOx emissions increase rapidly at peak flame temperatures exceeding 1540°C (2800°F) and with the increasing duration of time that the reactants remain within the area of peak flame.

"The more oxygen in the eye of the flame, the more NOx you make," observes Nelson. "The industry norm is to burn with a residual three per cent oxygen going out the stack. More than that and you increase emissions. Plus, your burn becomes less efficient."

One of the more common methods to lower NOx emissions is a combination of low NOx burners (LNB) and flue gas recirculation (FGR). According to EPA technical document number 453/R-93-034 (which identifies alternative controls for NOx emitters) FGR combined with LNBs can lead to total NOx reductions of 55 per cent over uncontrolled emissions.

State of the art burners spin the flame and induce recirculation of nearby flue gases inside the firebox thereby cooling the peak flame temperature. Nelson has worked closely with burner vendors to perfect this technique, while still allowing the burner parts to be manufactured economically.

FGR operates to reduce O2 usage by forcing the return of flue gas to the burners. By recycling 15 to 30 per cent of the inert products of combustion to the primary combustion zone, the reactants are diluted. This reduces the peak flame temperature, reduces local oxygen concentrations to levels below three per cent and inhibits thermal NOx formation.

"For this technique to work optimally, you need precise damper control to maintain a slight negative draft inside the firebox," says Nelson. "For this reason, every time you put in a new burner, you should consider installation of precision damper drives, linkages, damper blades, bearings, etc. to effect smooth control of the draft. Even with selective

风门执行器对改善工业炉子，锅炉的作用

風門執行器對改善工業爐子，鍋爐的作用

風門執行器和燃氣再迴圈技術(FGD)

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-

風門執行器和燃氣再迴圈技術(FGD)

加拿大今日電力雜誌（2002年）

风门执行器和燃气再循环技术(FGD)

风门执行器和燃气再循环技术(FGD)

炉子气流供应和执行器

炉子气流供应和执行器

爐子氣流供應和執行器

炉子气流供应和执行器

燃料成分不稳定的时候

-
-
-

燃料成分不稳定的时候

氧化氮排量和K牌风门执行气的影响

氧化氮排量和K牌风门执行气的影响

氧化氮排量和K牌风门执行气的影响

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氧化氮排量和K牌风门执行气的影响

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-

氧化氮排量和K牌风门执行气的影响

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与中国电厂相关 的业绩分析Case Studies Relevant to the Chinese Power Industry

美国电力（AEP） 珀肯（Pirkey）一号机组

- 高水分和灰份的德克萨斯褐煤High Moisture and Ash Content Texas Lignite
- 低发热量Low Heating Value of 6500 Btu/lb (13,700 kJ/kg)
- ABT第二代弯管式燃烧器，极低的氮氧化物水平 0.15 lb/MMBtu (220 mg NOx/Nm3)
- 与中国的劣质煤相似，磨损问题得以解决 Erosion
- 火焰很稳定，明亮 Improved Flame Conditions and Excellent Turndown Capability
- 改造前喉部附近燃烧不稳定，在煤粉着火之前有1.8 – 2.4米的煤粉带 There was generally a 6 – 8 ft (1.8 – 2.4 m) coal skirt developed prior to initiation of combustion.
- 美国第一例成功改造燃用低劣褐煤的低NOx 燃烧器的案例 Highly Successful Retrofit by ABT at Pirkey is the First of Its Kind in the U.S.

燃烬风喷口关闭OFA Ports Closed

燃烬风喷口打开OFA Ports Open

美国电力公司—珀肯厂

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美国电力公司一珀肯厂

4043
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