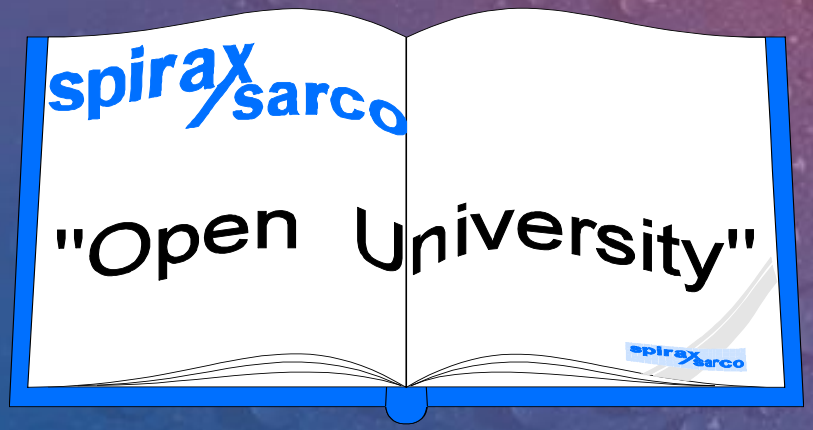
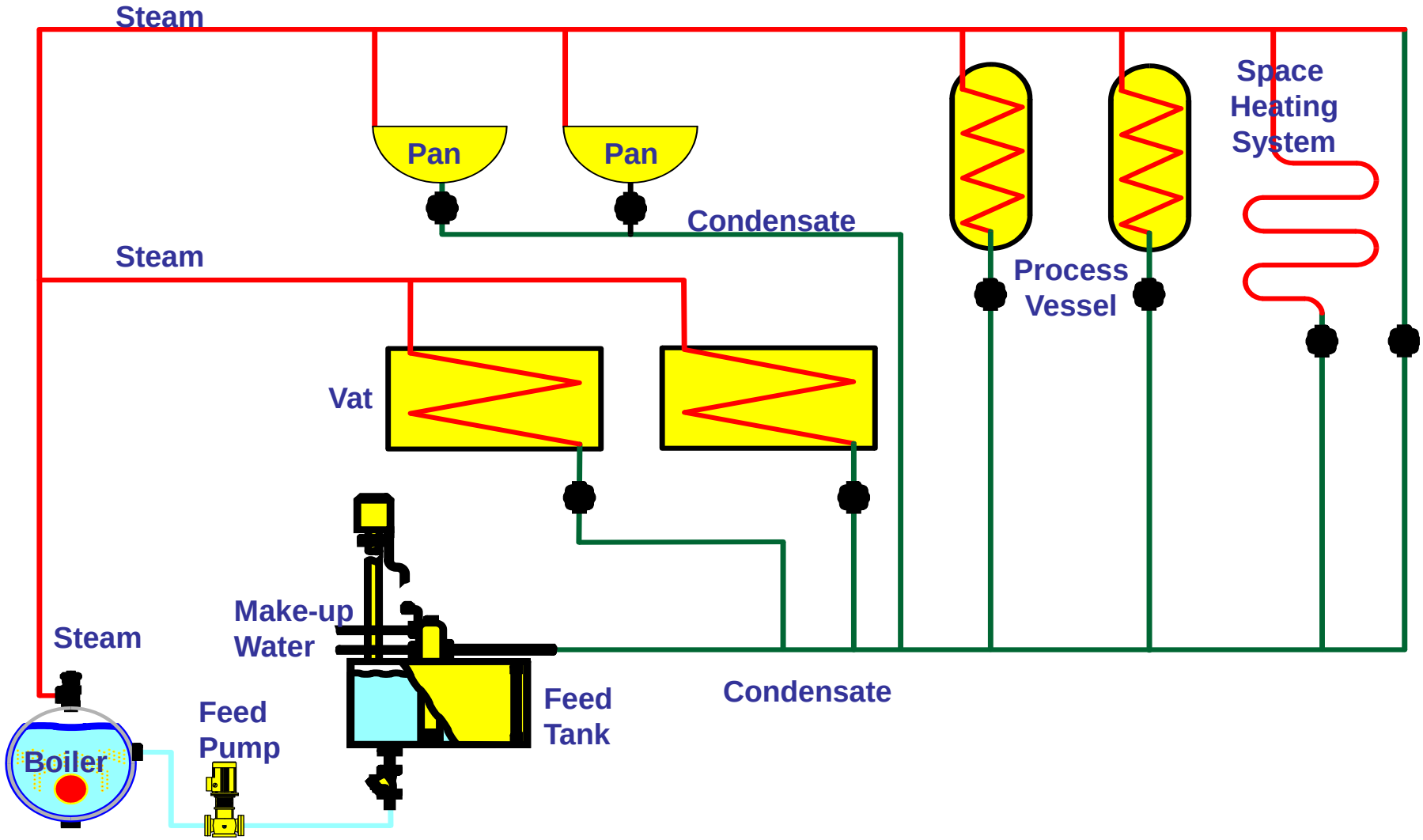
蒸汽課程

蒸汽管路的選擇



斯派瑞莎克(股)公司 朱應欽

典型之蒸汽系統圖


Steam
Pan
Pan
Condensate
Steam
Space
Heating
System
Process
Vessel
Vat
Steam
Make-up
Water
Feed
Tank
Condensate
Boiler
Feed
Pump

無縫鋼管- ASTM A106

Designation: A 106/A 106M – 04b

Used in USDOE-NE standards

Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service[1]

This standard is issued under the fixed designation A 106/A 106M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

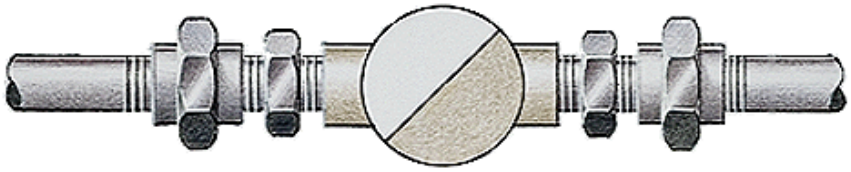
This standard has been approved for use by agencies of the Department of Defense.

鋼管對照表	JIS 日本		ASTM 美國	BS 英國	DIN 德國
Carbon Steel Pipe for High Temperature Service	G3456	STPT 370	A106 GR. A	3602 P1--360	17175(1)(2)ST35.8
		STPT 410	A106 GR. B	3602 P1--410	17175(1)(2)ST45.8
				3602 P1--460	
		STPT 480	A106 GR. C	3602 P1--490Nb	

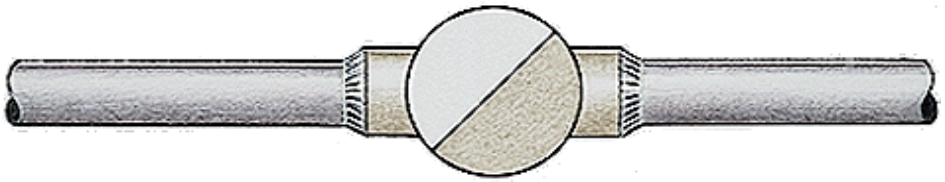
無縫鋼管- ASME B36.1 SCH40 , 80

ASTM 標準規格		OD mm	10	20	30	STD	40	60	XS	80	100	120	140	160	XXS
6	1/8	10.3				1.73 0.37	1.73 0.37		2.41 0.47	2.41 0.47					
8	1/4	13.7				2.24 0.63	2.24 0.63		3.02 0.80	3.02 0.80					
10	3/8	17.1				2.31 0.84	2.31 0.84		3.20 1.10	3.20 1.10					
15	1/2	21.3				2.77 1.27	2.77 1.27		3.73 1.62	3.73 1.62				4.78 1.95	7.47 2.55
20	3/4	26.7				2.87 1.69	2.87 1.69		3.91 2.20	3.91 2.20				5.56 2.90	7.82 3.64
25	1	33.4				3.38 2.50	3.38 2.50		4.55 3.24	4.55 3.24				6.35 4.24	9.09 5.45
32	1-1/4	42.2				3.56 3.39	3.56 3.39		4.85 4.47	4.85 4.47				6.35 5.61	9.70 7.77
40	1-1/2	48.3				3.68 4.05	3.68 4.05		5.08 5.41	5.08 5.41				7.14 7.25	10.15 9.55
50	2	60.3				3.91 5.44	3.91 5.44		5.54 7.48	5.54 7.48				8.74 11.11	11.07 13.44
65	2-1/2	73.0				5.16 8.63	5.16 8.63		7.01 11.41	7.01 11.41				9.53 14.92	14.02 20.39
80	3	88.9				5.49 11.29	5.49 11.29		7.62 15.27	7.62 15.27				11.13 21.35	15.24 27.68

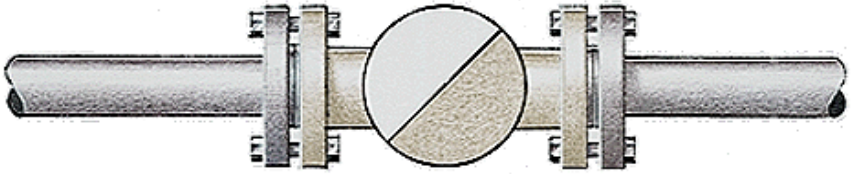
Connection Types



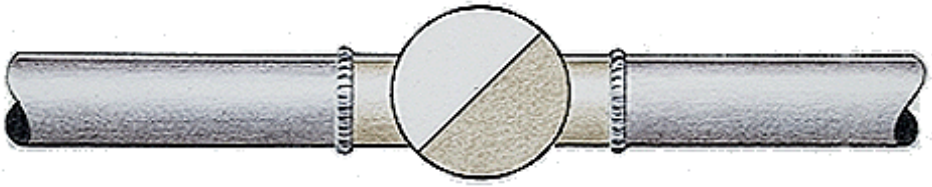
SCREWED
Remakeable, using nipples and unions with thread sealant. Low level of skill for assembly.
Cannot be guaranteed against leaks



SOCKET WELD
A permanent leak free joint. Easily aligned. Low level of skill for welding.
Pipework must be cut to remove trap



FLANGED
Remakeable joint. Greater skill to ensure torquing and optimum compression.
Cannot be guaranteed against leaks



BUTT WELD
Permanent leak free joint. Careful alignment and skilled labour for welding
Pipework must be cut to remove trap

管道篩選 –流速法

$$W \text{ kg/h} = \frac{0.002827 \ D^2 V}{\upsilon}$$

$$V = \frac{W \ \upsilon}{0.002827 \ D^2}$$

D = Pipe bore mm　　V = Steam Velocity m/s　　υ = specific volume m^3/kg

DN		15	20	25	32	40	50	65	80	100	125	150
Bore (mm)	Sch 40	15.8	21.0	26.6	35.1	40.9	52.5	62.7	77.9	102.3	128.2	154.1
	Sch 80	13.8	18.9	24.3	32.5	38.1	49.2	59.0	73.7	97.2	122.3	146.4
	Sch 160	11.7	15.6	20.7	29.5	34.0	42.8	53.9	66.6	87.3	109.5	131.8

蒸汽管道篩選表 (kg/h) SCH40

Pressure bar g	Velocity m/s	Pipe Size Nominal / Actual Inside Diameter										
		15 15.8	20 20.93	25 26.64	32 35.04	40 40.9	50 52.5	65 62.7	80 77.92	100 102.26	125 128.2	150 154.05
0.4	15	9	15	25	43	58	95	136	210	362	569	822
	25	14	25	41	71	97	159	227	350	603	948	1369
	40	23	40	66	113	154	254	363	561	965	1517	2191
0.7	15	10	18	29	51	69	114	163	251	433	681	983
	25	17	30	49	85	115	190	271	419	722	1135	1638
	40	28	48	78	136	185	304	434	671	1155	1815	2621
1	15	12	21	34	59	81	133	189	292	503	791	1142
	25	20	35	57	99	134	221	315	487	839	1319	1904
	40	32	56	91	158	215	354	505	779	1342	2110	3046
2	15	18	31	50	86	118	194	277	427	735	1156	1669
	25	29	51	83	144	196	323	461	712	1226	1927	2782
	40	47	82	133	230	314	517	737	1139	1961	3083	4451
3	15	23	40	65	113	154	254	362	559	962	1512	2183
	25	38	67	109	188	256	423	603	931	1603	2520	3639
	40	61	107	174	301	410	676	964	1490	2565	4032	5822
4	15	28	50	80	139	190	313	446	689	1186	1864	2691
	25	47	83	134	232	316	521	743	1148	1976	3106	4485
	40	75	132	215	371	506	833	1189	1836	3162	4970	7176
5	15	34	59	96	165	225	371	529	817	1408	2213	3195
	25	56	98	159	276	375	619	882	1362	2347	3688	5325
	40	90	157	255	441	601	990	1411	2180	3755	5901	8521
6	15	39	68	111	191	261	430	613	947	1631	2563	3700
	25	65	114	184	319	435	716	1022	1578	2718	4271	6167
	40	104	182	295	511	696	1146	1635	2525	4348	6834	9867
7	15	44	77	125	217	296	487	695	1073	1848	2904	4194
	25	74	129	209	362	493	812	1158	1788	3080	4841	6989
	40	118	206	334	579	788	1299	1853	2861	4928	7745	11183

管道篩選 –流速法

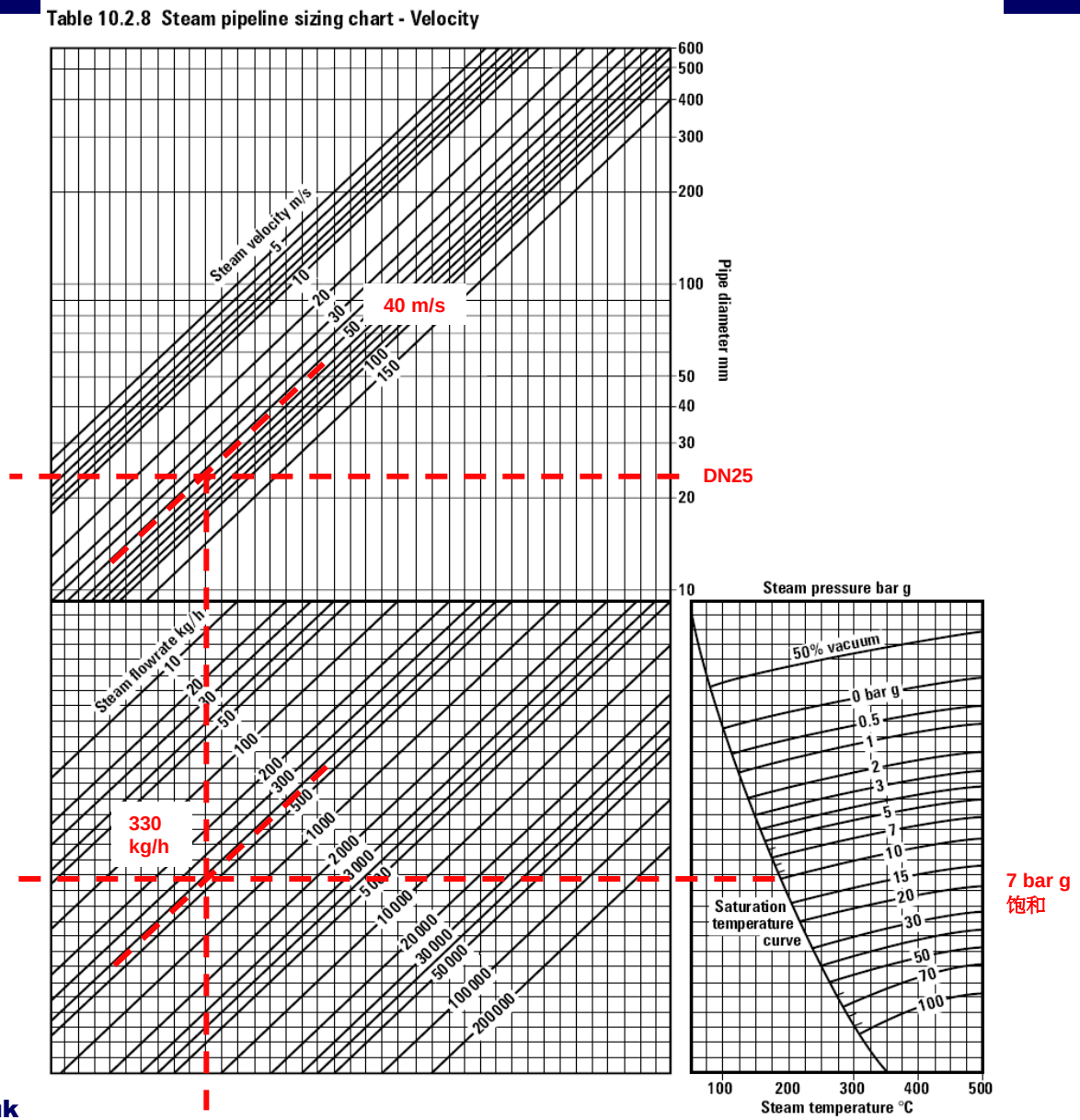


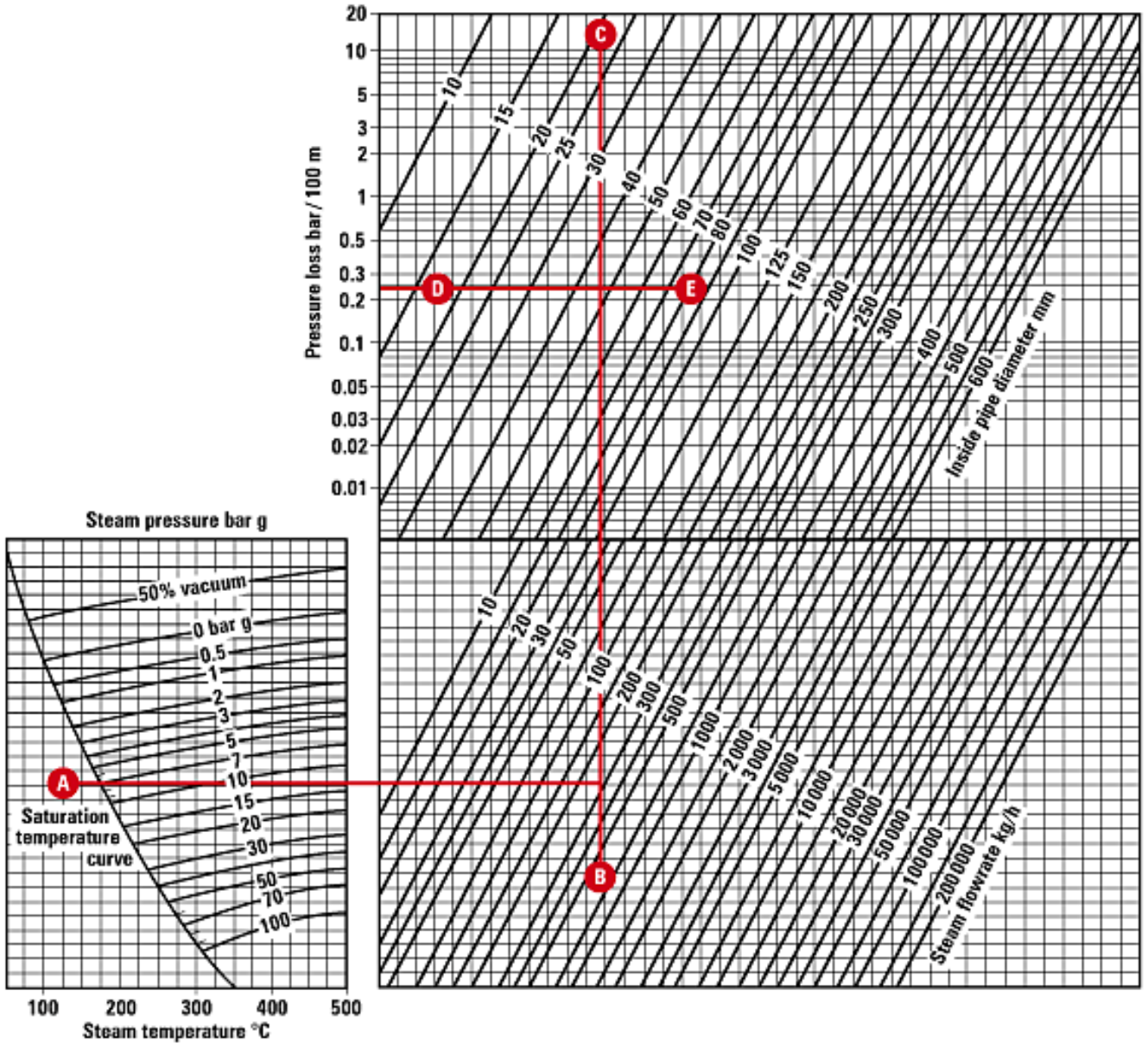
Table 10.2.8 Steam pipeline sizing chart - Velocity
Steam velocity m/s
5
10
20
30
50
100
150
40 m/s
Pipe diameter mm
600
500
400
300
200
100
50
40
30
20
10
DN25
Steam flowrate kg/h
10
20
30
50
100
200
300
500
1000
2000
3000
5000
10000
20000
30000
50000
100000
200000
330
kg/h
Steam pressure bar g
50% vacuum
0 bar g
0.5
1
2
3
5
7
10
15
20
30
50
70
100
7 bar g
饱和
Saturation temperature curve
100
200
300
400
500
Steam temperature °C

管道篩選 – 壓損法

$$\Delta P = \frac{L \; v_g \; \dot{m}^2}{0.08 \; D^5}$$

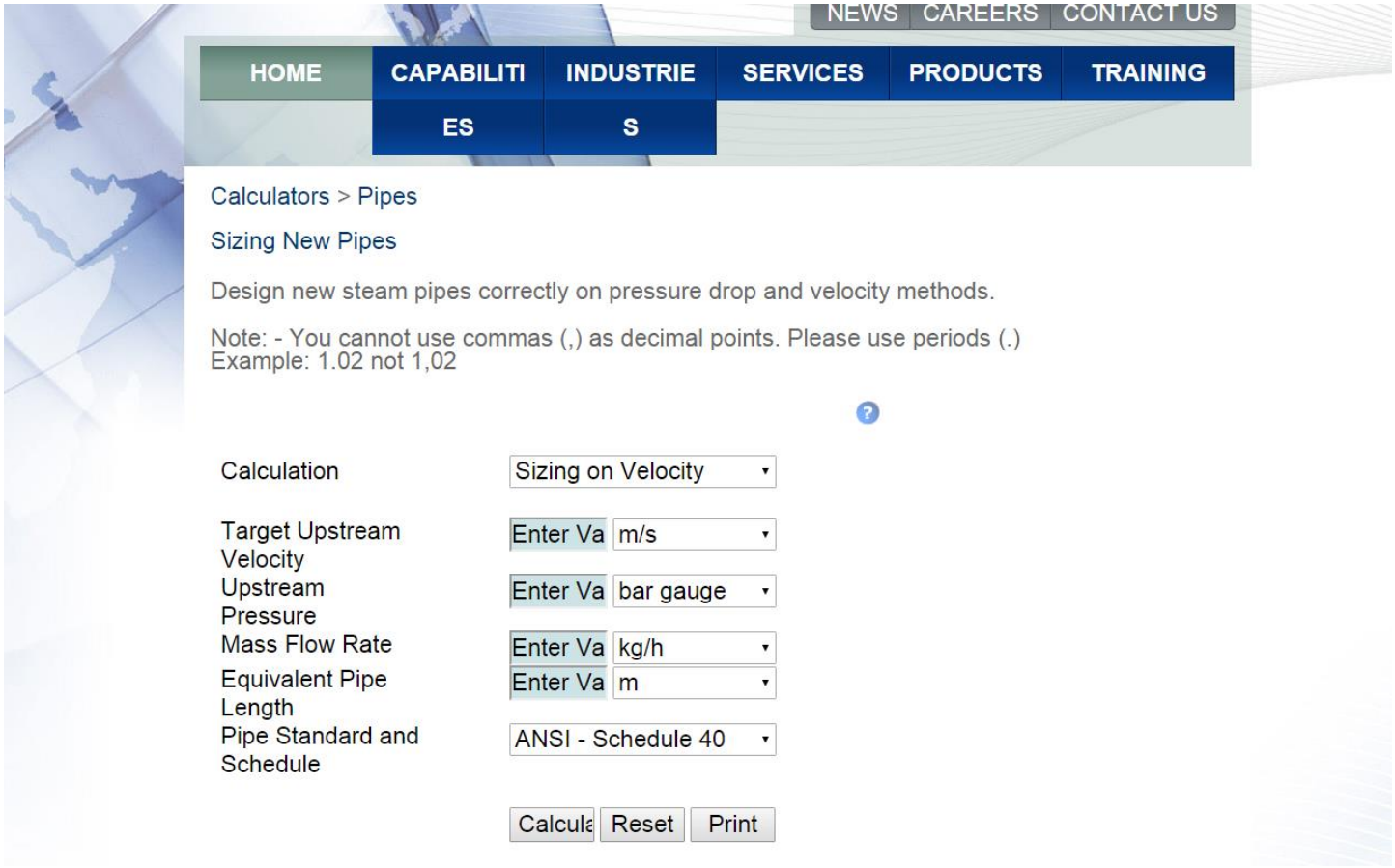
ΔP = Pressure drop (bar)
L = Length of pipe (m)
v_g = Specific volume of steam (m^3 / kg)
$\dot{m}$ = Mass flowrate (kg/h)
D = Pipe diameter (mm)

管道篩選 – 壓損法


Pressure loss bar / 100 m
20
10
5
3
2
1
0.5
0.3
0.2
0.1
0.05
0.03
0.02
0.01
10
15
20
25
30
40
50
60
70
80
100
125
150
200
250
300
400
500
600
Inside pipe diameter mm
C
D
E
B
10
20
30
50
100
200
300
500
1000
2000
3000
5000
10000
20000
30000
50000
100000
200000
Steam flowrate kg/h
Steam pressure bar g
50% vacuum
0 bar g
0.5
1
2
3
5
7
10
15
20
30
50
70
100
A
Saturation temperature curve
100
200
300
400
500
Steam temperature °C

管道篩選 – 線上軟體

http://www.spiraxsarco.com/Resources/Pages/Calculators/pipes/sizing-new-pipes.aspx



管道篩選

流速選擇(飽和蒸汽)

主管線: 15m/s~25m/s
設備端: 25m/s~40m/s
* 15m/s 以下 , 40m/s 以上 ----------不建議

壓損選擇(飽和蒸汽)

考慮使用端壓力要求
建議值: 小於0.1bar/50m

管路尺寸

OVERSIZING

- 配管成本較高
- 較大之熱損失
- 冷凝水形成時體積較大

UNDERSIZING

- 壓損較大
- 噪音
- 蒸汽量不夠
- 因流速較快易造成水錘及切割

高壓輸送蒸汽

優點:

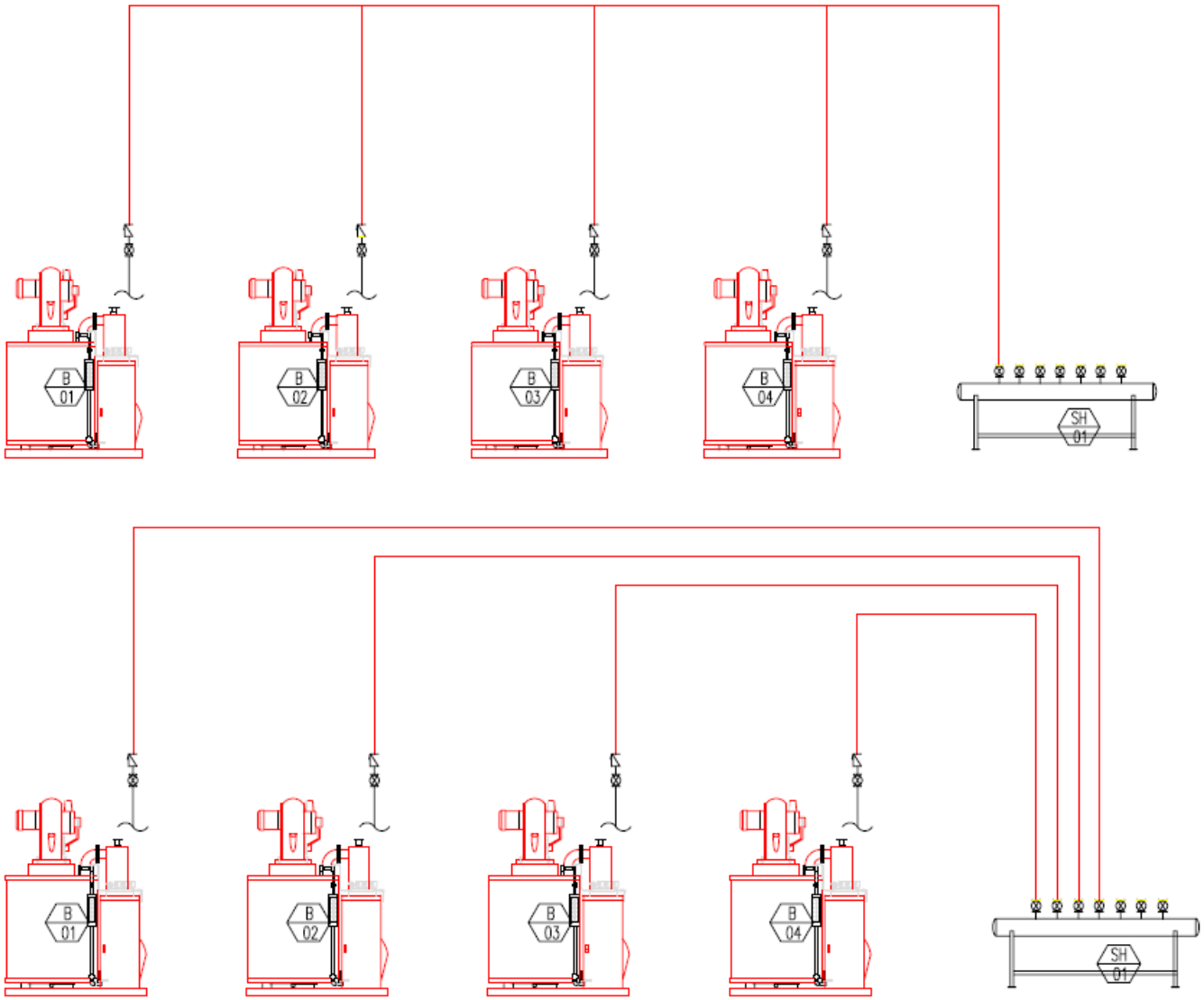
- 蒸汽管道的口徑更小，管道表面的熱損失減少。
- 更低的管道费用，例如管道、法蘭、支撐另件和安裝费用。
- 保溫費用減少。
- 減壓後可提高蒸汽乾燥度。
- 鍋爐於高壓下運行更容易達到最佳狀態，運轉效率高。
- 蒸汽體積小，可達到最大儲氣量，有利於反應負載的變化，減少汽水共騰發生機率。

低壓使用蒸汽

優點：

- 較多潛熱焓
- 減少閃發蒸汽產生量

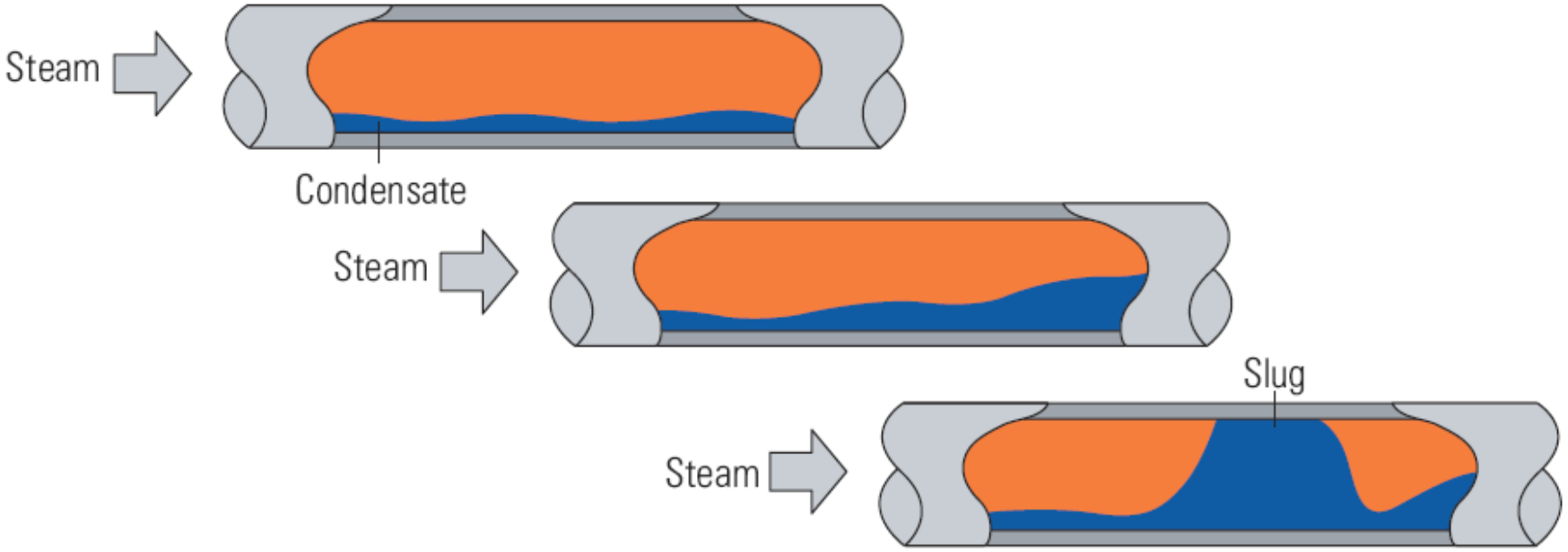
管路分配决定



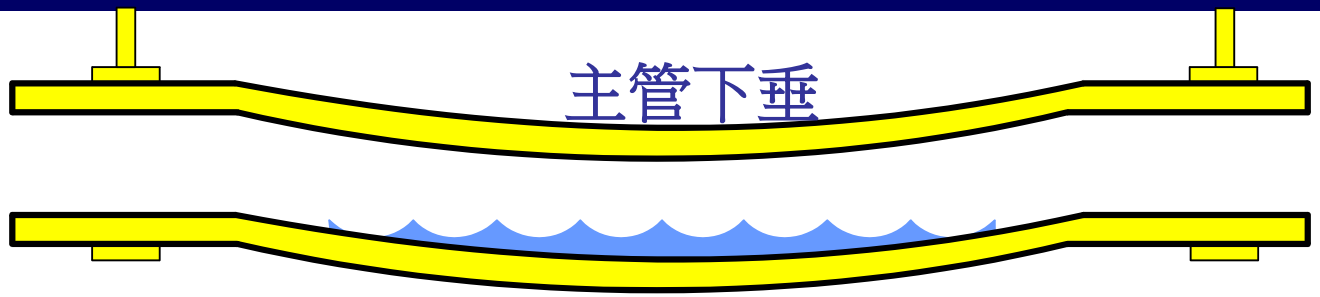
蒸汽主管的水錘

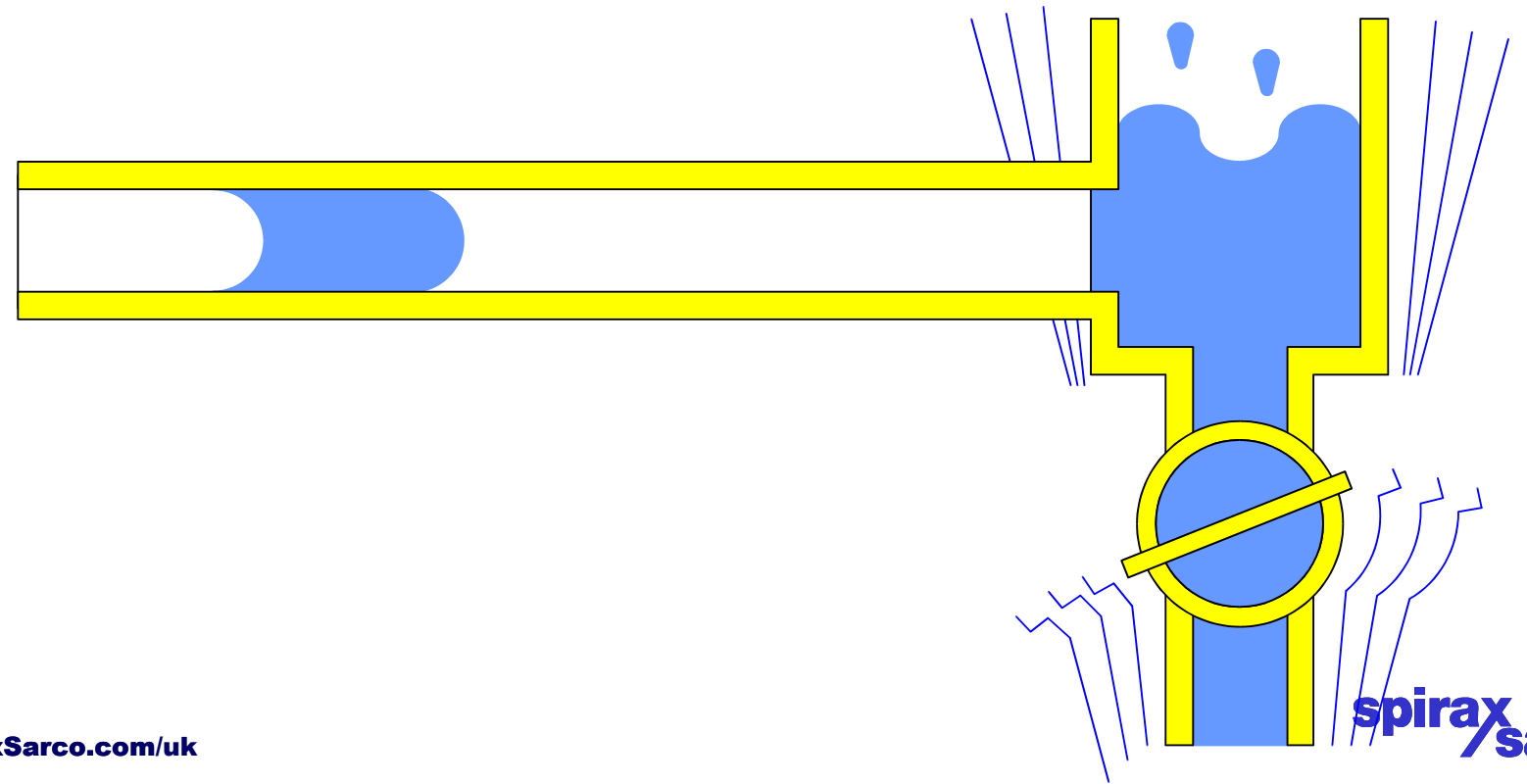
蒸汽管道中冷凝水的流動

‘solid’ slug of water will produce waterhammer

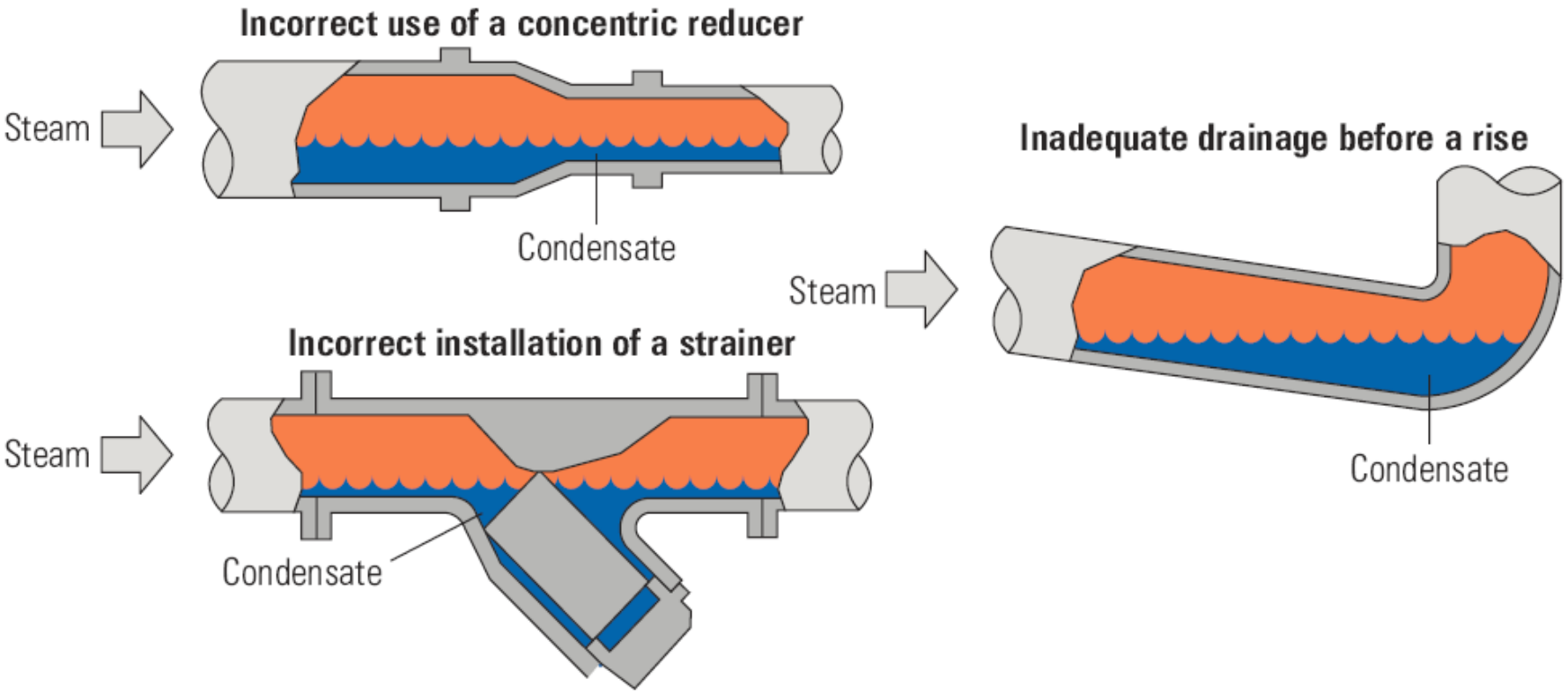


水錘

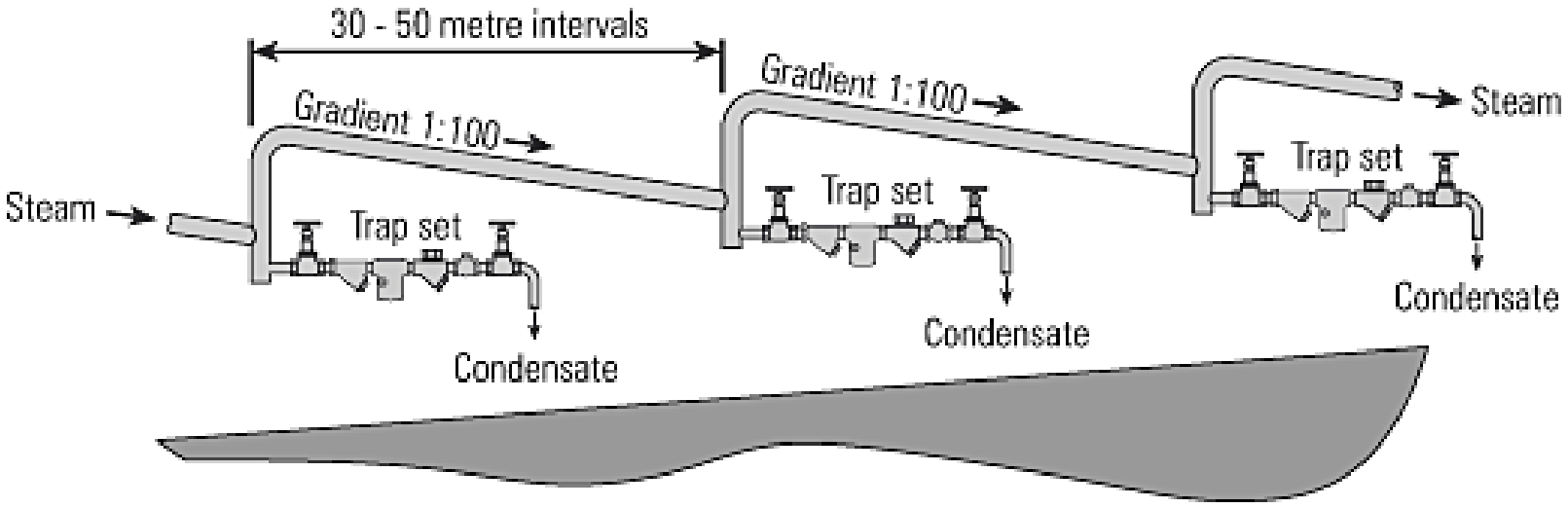




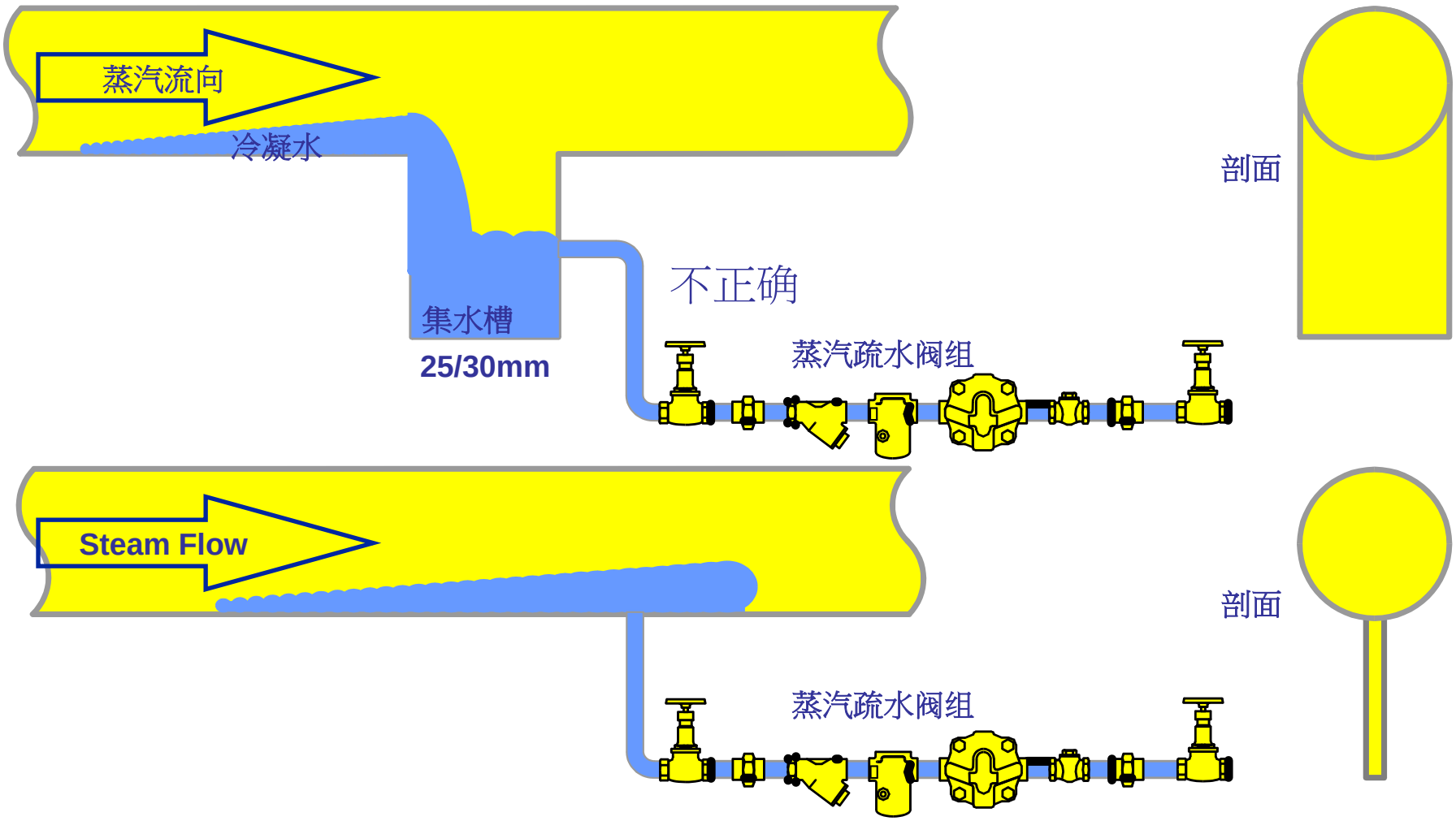
潛在的水錘根源


Incorrect use of a concentric reducer
Steam
Condensate
Inadequate drainage before a rise
Steam
Condensate
Incorrect installation of a strainer
Steam
Condensate

典型的蒸汽主管安装


30 - 50 metre intervals
Gradient 1:100
Gradient 1:100
Steam
Steam
Trap set
Trap set
Trap set
Condensate
Condensate
Condensate

正確的冷凝水排放點



集水袋尺寸建議

Mains diameter - D	Pocket diameter - d_1	Pocket depth - d_2
Up to 100 mm nb	$d_1 = D$	Minimum d_2 = 100 mm
125 - 200 mm nb	d_1 = 100 mm	Minimum d_2 = 150 mm
250 mm and above	$d_1 \geq D/2$	Minimum $d_2 = D$

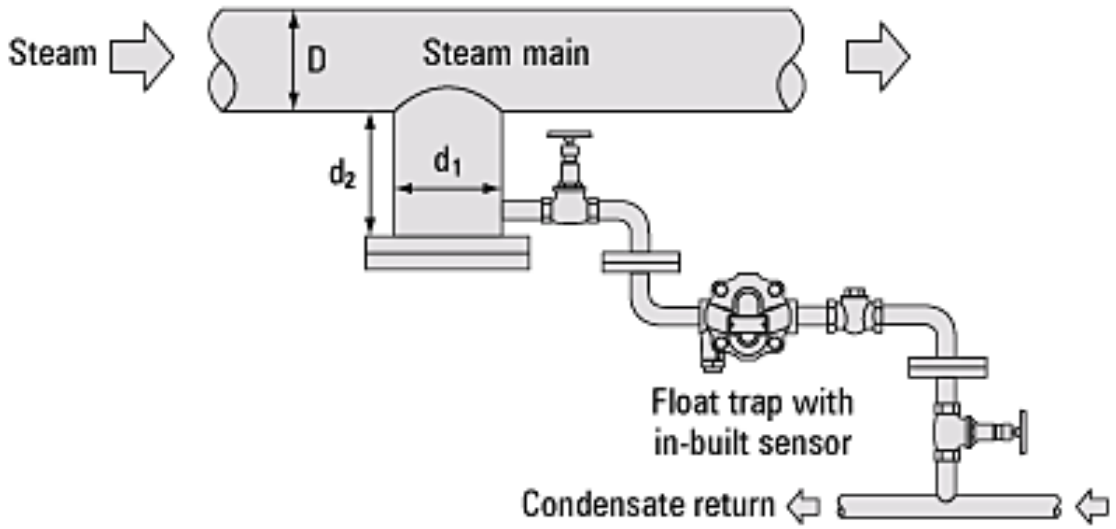
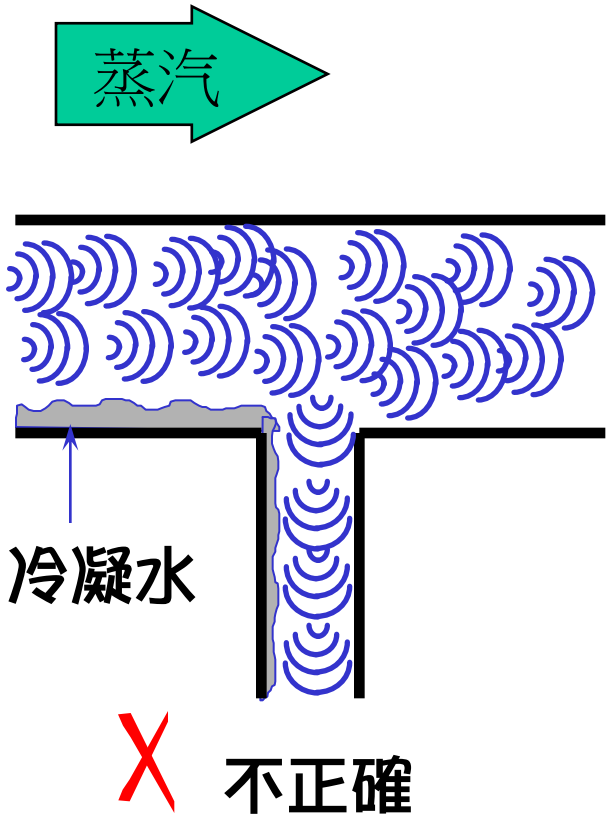
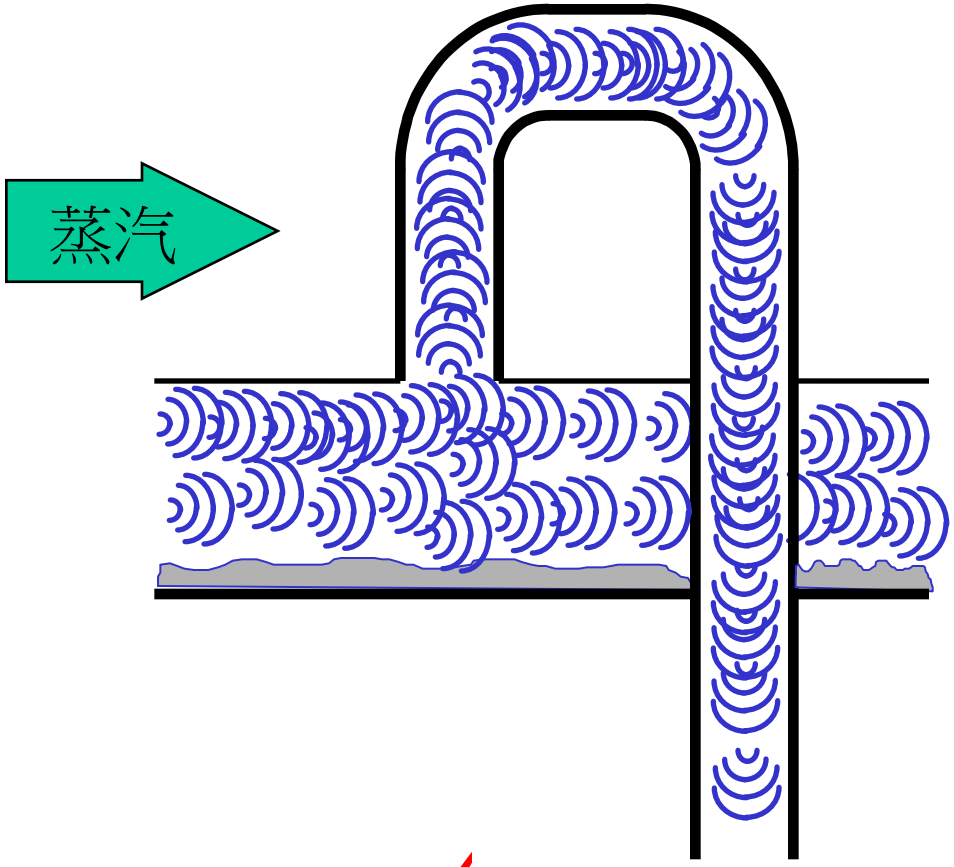


Fig. 10.3.4

分支管路



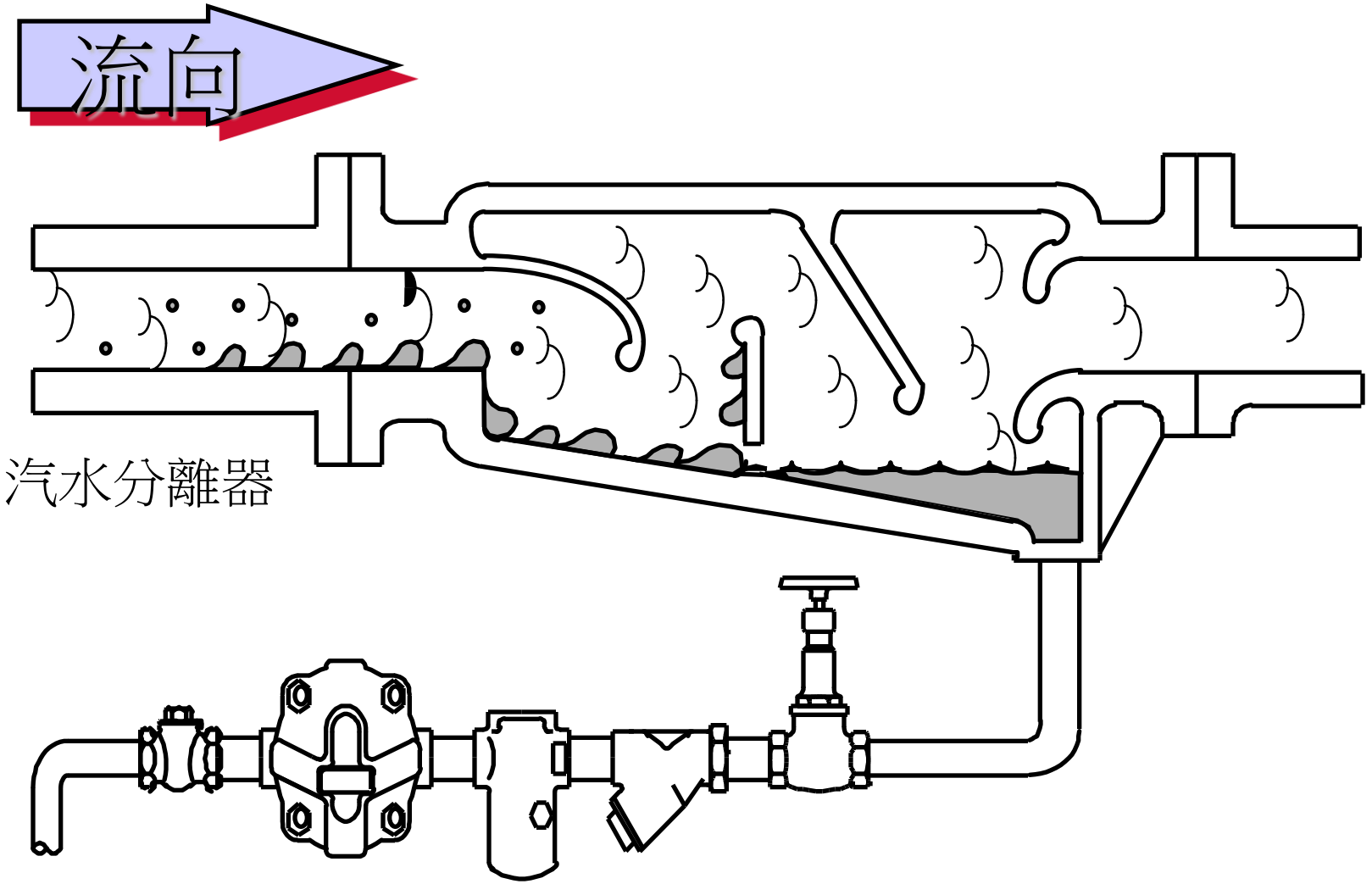
✗ 不正確



✓ 正確

spirax sarco

蒸氣乾燥器



熱膨脹 –熱位移

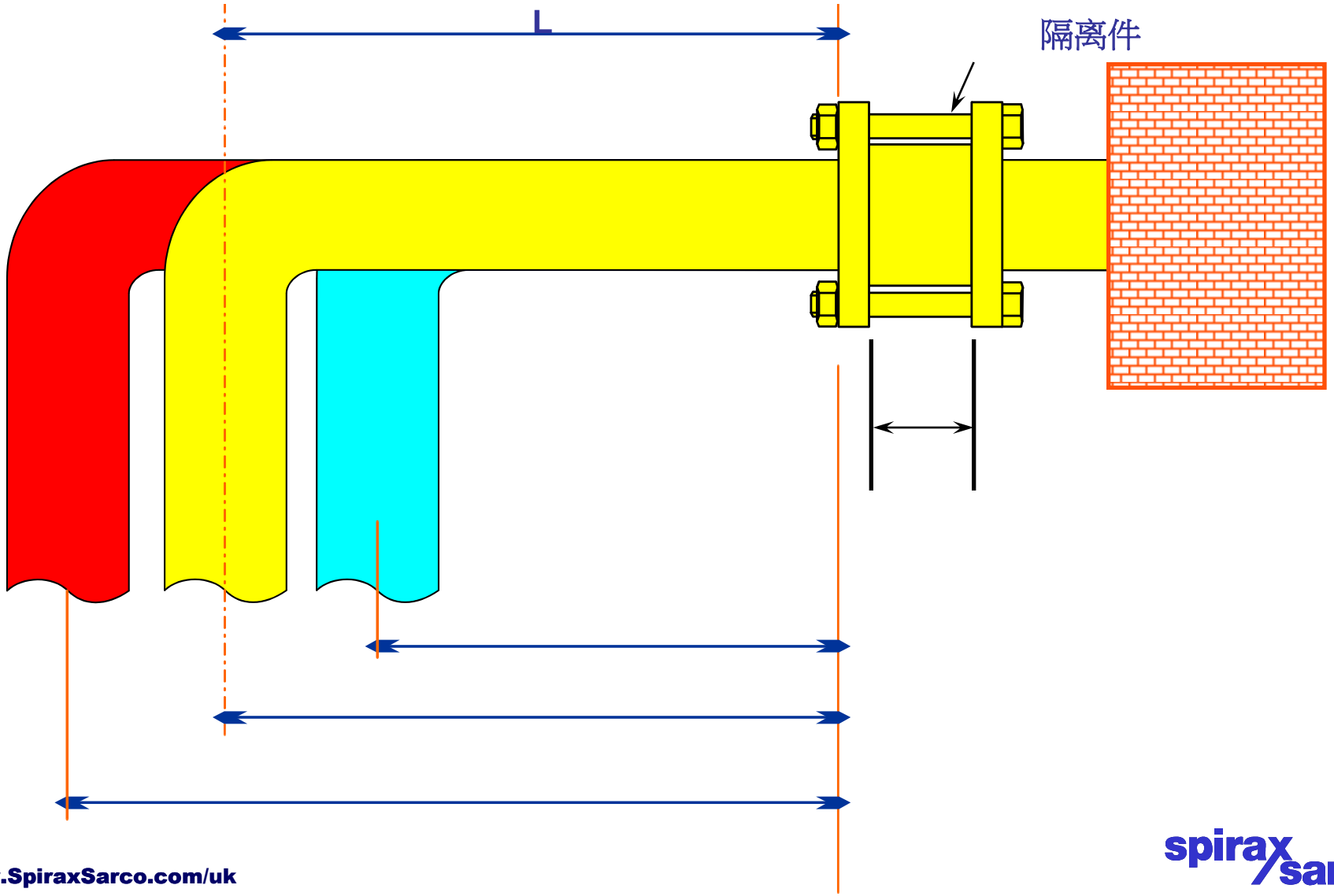
管道的膨脹量

$$膨脹量\ (\Delta) = L \times \Delta t \times \alpha\ (mm)$$

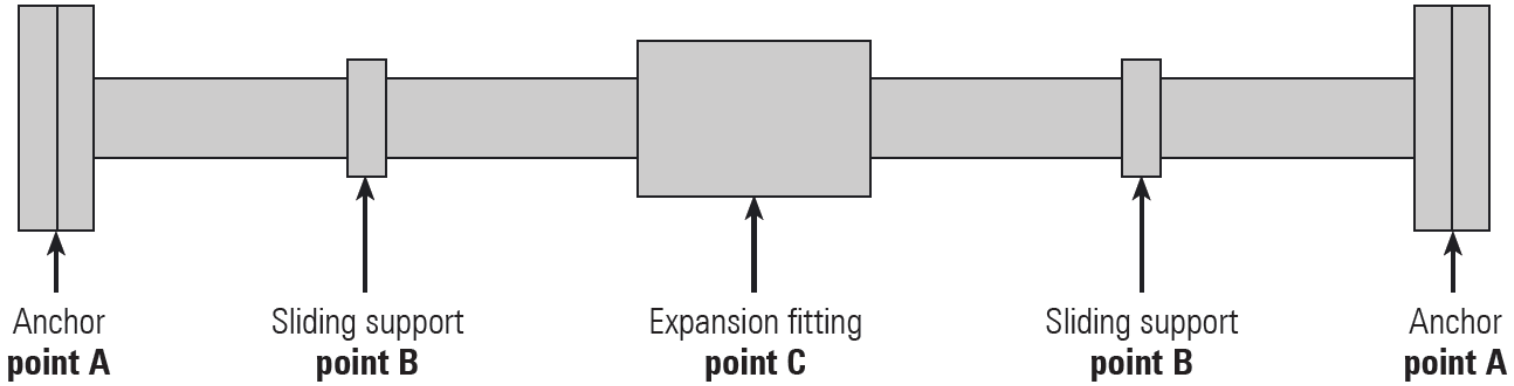
L	=	管線長度	(m)
Δt	=	温差	(°C)
α	=	膨脹系数	

Material	Temperature range (°C)							
	< 0	0 - 100	0 - 200	0 - 300	0 - 400	0 - 500	0 - 600	0 - 700
Carbon steel 0.1% - 0.2% C	12.8	13.9	14.9	15.8	16.6	17.3	17.9	-
Alloy steel 1% Cr 0.5% Mo	13.7	14.5	15.2	15.8	16.4	17.0	17.6	-
Stainless steel 18% Cr 8% Ni	9.4	20.0	20.9	21.2	21.8	22.3	22.7	23.0

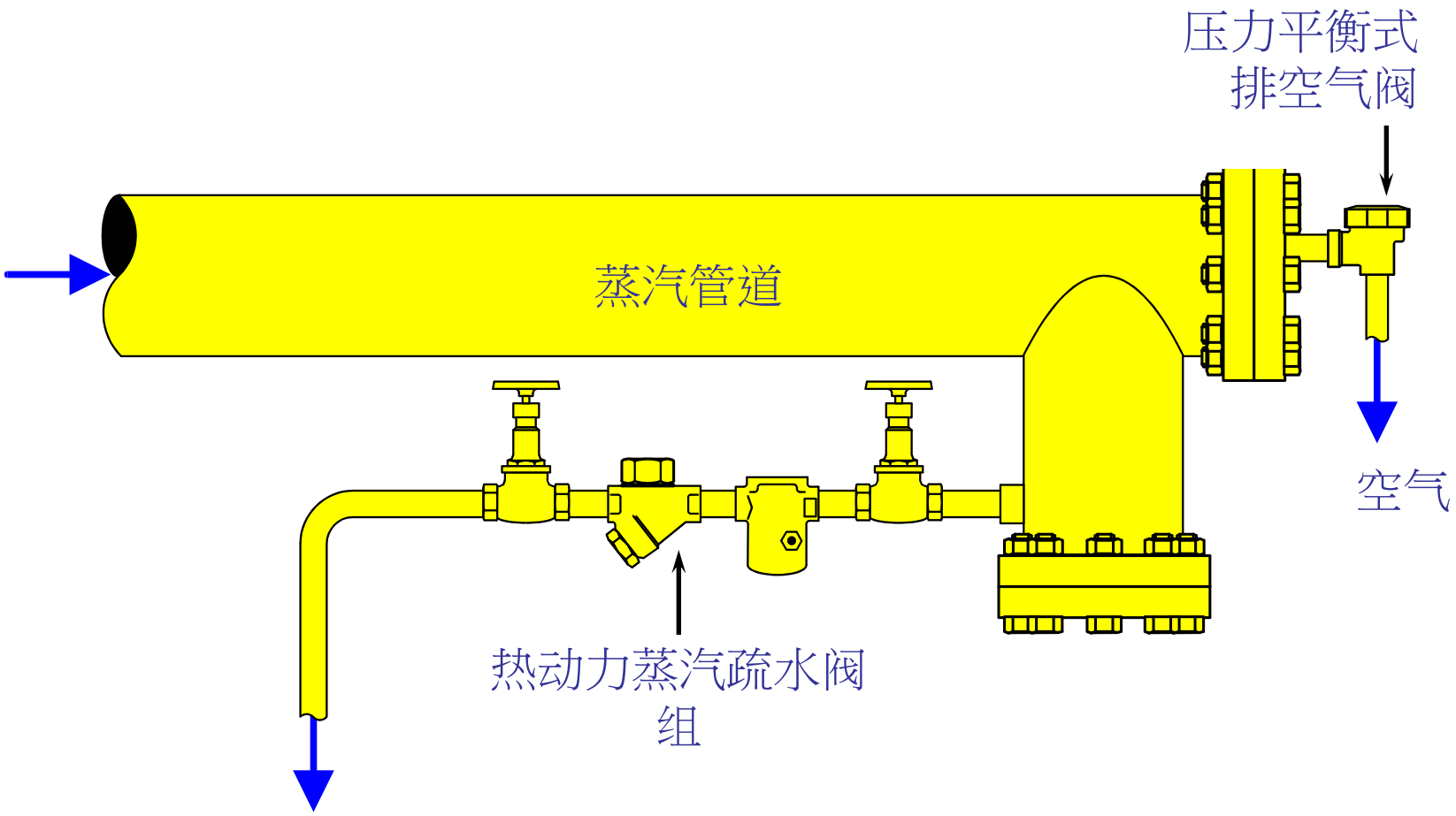
管道的膨脹



管道的膨脹量


Anchor
point A
Sliding support
point B
Expansion fitting
point C
Sliding support
point B
Anchor
point A

空气的排除



管路保溫

AMO ENERGY TIPS FOR STEAM

Applications

Reusable insulating pads are commonly used in industrial facilities for insulating flanges, valves, expansion joints, heat exchangers, pumps, turbines, tanks, and other irregular surfaces. The pads are flexible and vibration-resistant and can be used with equipment that is horizontally or vertically mounted or that is difficult to access. Any high-temperature piping or equipment should be insulated to reduce heat loss, reduce emissions, and improve safety. As a general rule, any surface that reaches temperatures greater than 120°F should be insulated to protect personnel. Insulating pads can be easily removed for periodic inspection or maintenance, and replaced as needed. Insulating pads can also contain built-in acoustical barriers to help control noise.

48℃

保溫效能量測工具-熱顯像儀

Photo 2a. Visual of panel system.

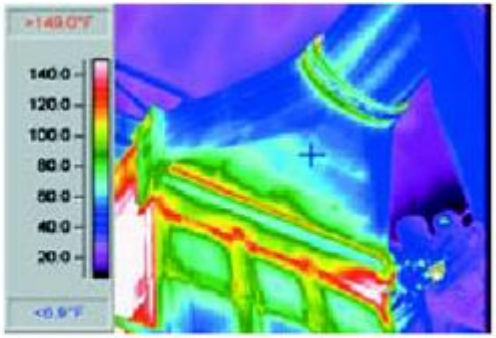


Photo 2b. Infrared photo of the same panel system showing high surface below the connecting horizontal duct.

LandGuide M4手持型

參考價 $51萬

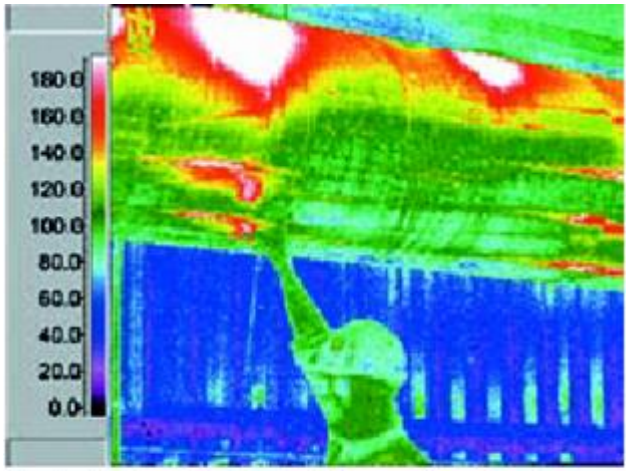


Photo 4. An insulated horizontal seam shows two large areas on the top surface with surface temperatures in excess of 180˚F, as well as some smaller areas on the lower half of the pipe. Note that the well-insulated areas have surface temperatures in the 80˚F to 100˚F range.

檢測工程師需具保溫概念與熱像照片分析能力,並依檢測目標類型調整取景方向或影像解析以找出環狀保溫,濕保溫,保溫不當等問題點

管路保溫效益計算-裸管

Heat emission from single horizontal steel pipes freely exposed in surroundings at 20 °C

Temperature difference between pipe surface and ambient-°C	Heat Emission W/m										
	Nominal Pipe Size mm										
	15	20	25	32	40	50	65	80	100	125	150
40	42	51	62	75	84	102	125	143	179	214	248
50	55	67	81	99	111	135	165	189	236	281	327
60	69	84	102	125	140	169	207	238	297	354	411
70	84	103	125	152	170	206	253	290	362	432	502
80	100	122	149	181	203	246	301	345	431	515	598
100	135	164	200	244	273	331	406	466	582	695	808
120	173	211	257	314	352	427	523	600	750	897	1040
140	215	262	320	391	438	532	653	750	937	1120	1310
160	261	318	389	476	534	648	796	915	1140	1370	1600
180	311	380	465	569	638	776	954	1100	1370	1650	1920
200	366	447	547	670	753	916	1130	1300	1620	1950	2270
220	425	520	637	781	878	1070	1320	1510	1900	2280	2660
240	490	600	735	902	1010	1240	1520	1750	2200	2650	3090

以4”(DN100)的10barg蒸汽管為例. 溫差160C時,每m的熱散失為1140 W/m. 現場若有截3m管未保溫, 全年8400小時x1140W/m x 3m = 28728 kWh的熱散失, 約等於2.5公秉的燃油熱值

閥件保溫利益計算

Energy Savings[a] from Installing Removable Insulated Valve Covers (Btu/hour)						
Operating Temperature, °F	Valve Size (inches)					
	3	4	6	8	10	12
200	800	1,090	1,560	2,200	2,900	3,300
300	1,710	2,300	3,300	4,800	6,200	7,200
400	2,900	3,400	5,800	8,300	10,800	12,500
500	4,500	6,200	9,000	13,000	16,900	19,700
600	6,700	9,100	13,300	19,200	25,200	29,300

[a] Based on installation of a 1-inch thick insulating pad on an ANSI 150-pound class flanged valve with an ambient temperature of 65°F and zero wind speed.

回收計算:
將1個250psig,406F的6”未保溫閘閥保溫後, 可節省的熱能約5800BTU/h相當6120kJ/h.
全年8400小時約1.2公秉 或$9600燃油費

蒸汽設備不使用時,將蒸汽源關閉

- 將停機中或已不再使用的蒸汽關閉可以減少經由管線的熱散失.

未保溫的蒸汽管閥件

是許多廠房員工心中理想的烘衣設備

但源源不斷散失到大氣的熱源卻是燃燒昂貴的燃油與排放溫室氣體所造成

管路保温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25 P
CAST IRON


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25 P
CAST IRON
1260 ACE BLANKET

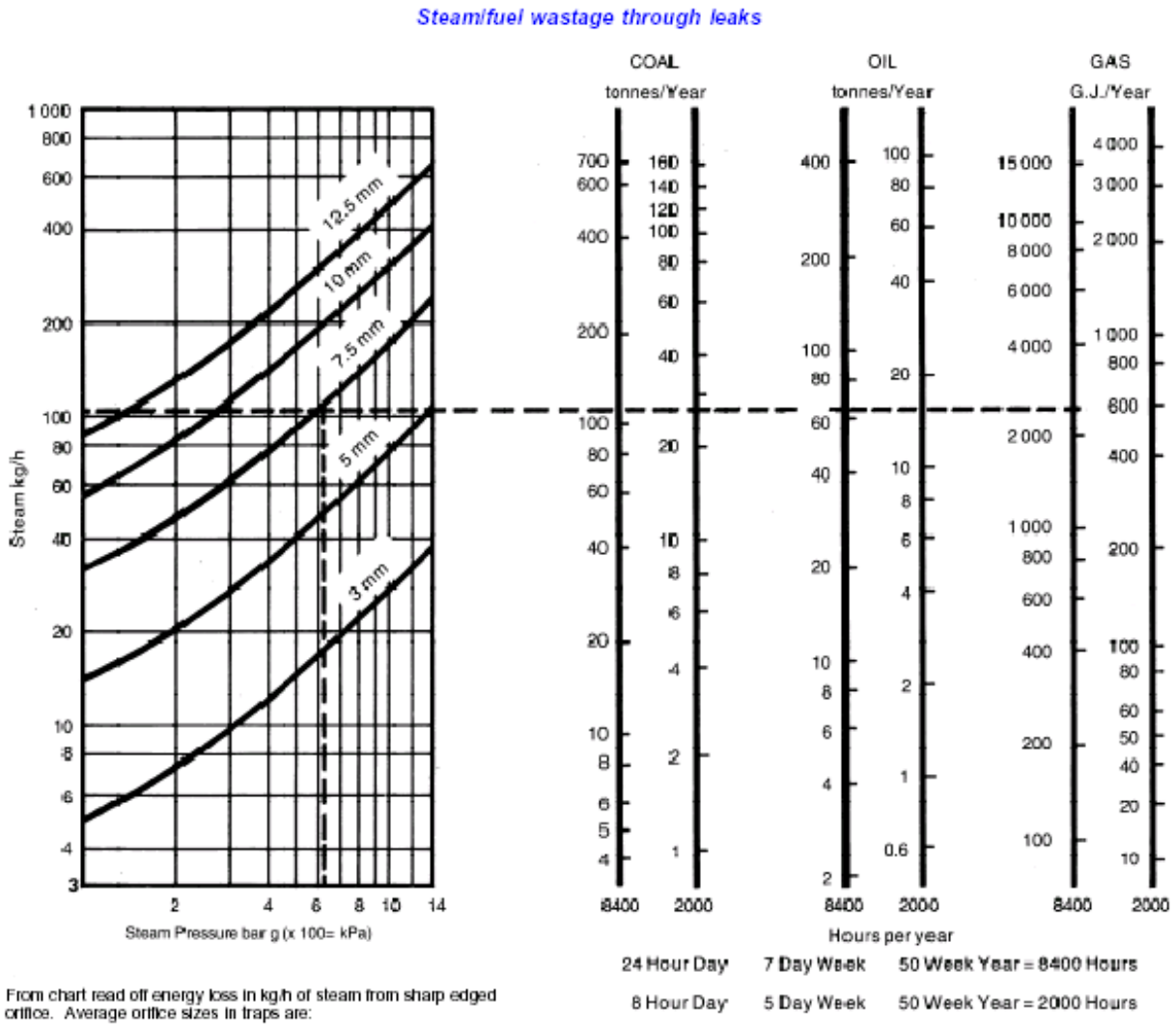
阻止蒸汽外洩

蒸汽外洩-最直接的能源損失

管破洩漏

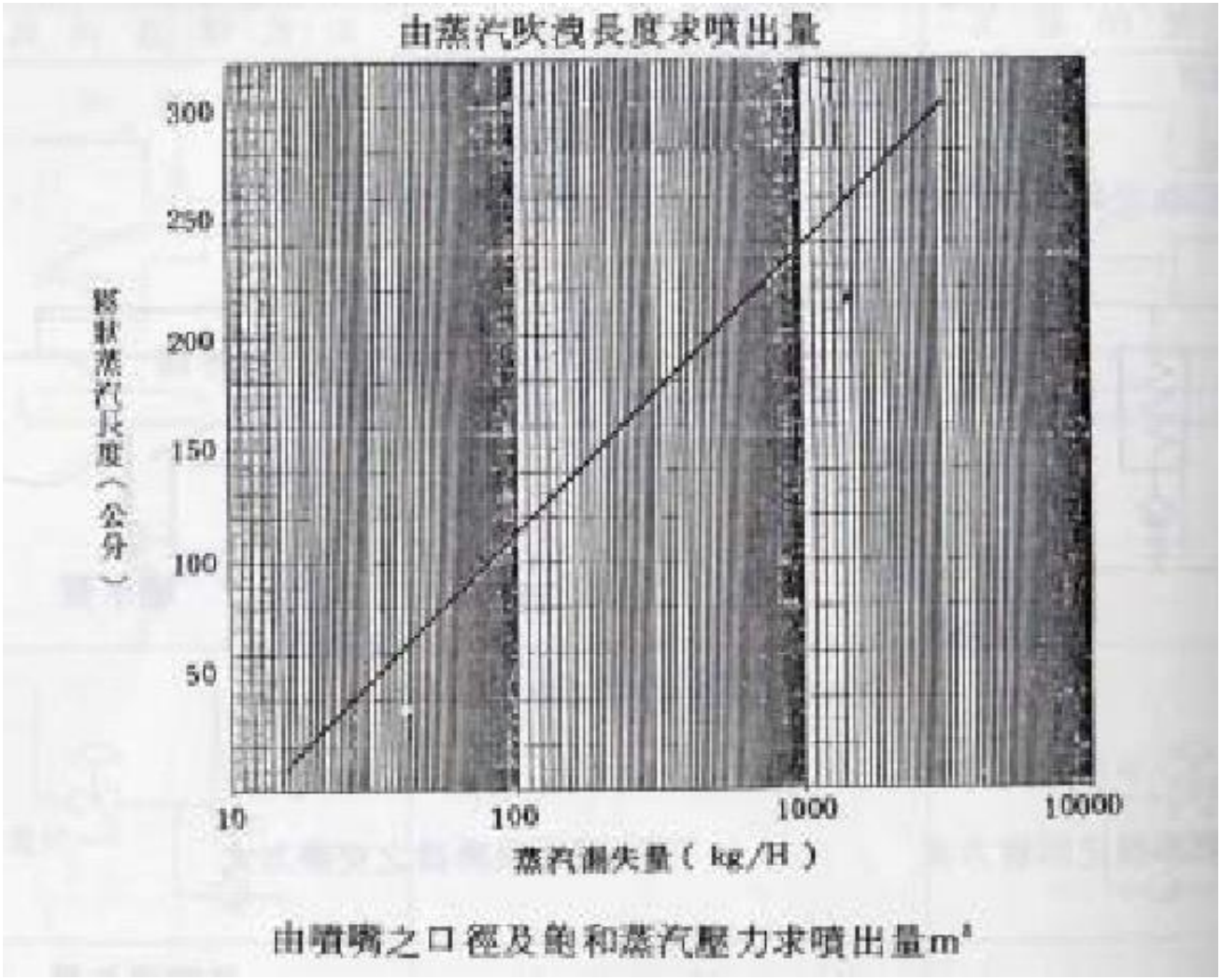
閥件外殼穿孔洩漏

蒸汽外洩損失計算 – 孔徑法



蒸汽洩漏是最直接的能源損失。以一個7.5mm的小孔而言，每小時可洩漏100kg/h的蒸汽量. 若久未察覺或視而不管，全年8400小時會造成約60公秉的額外燃油消耗，

蒸汽外洩計算 – 吹洩距離法



由蒸汽噴出的煙霧長度換算出蒸汽的洩漏量

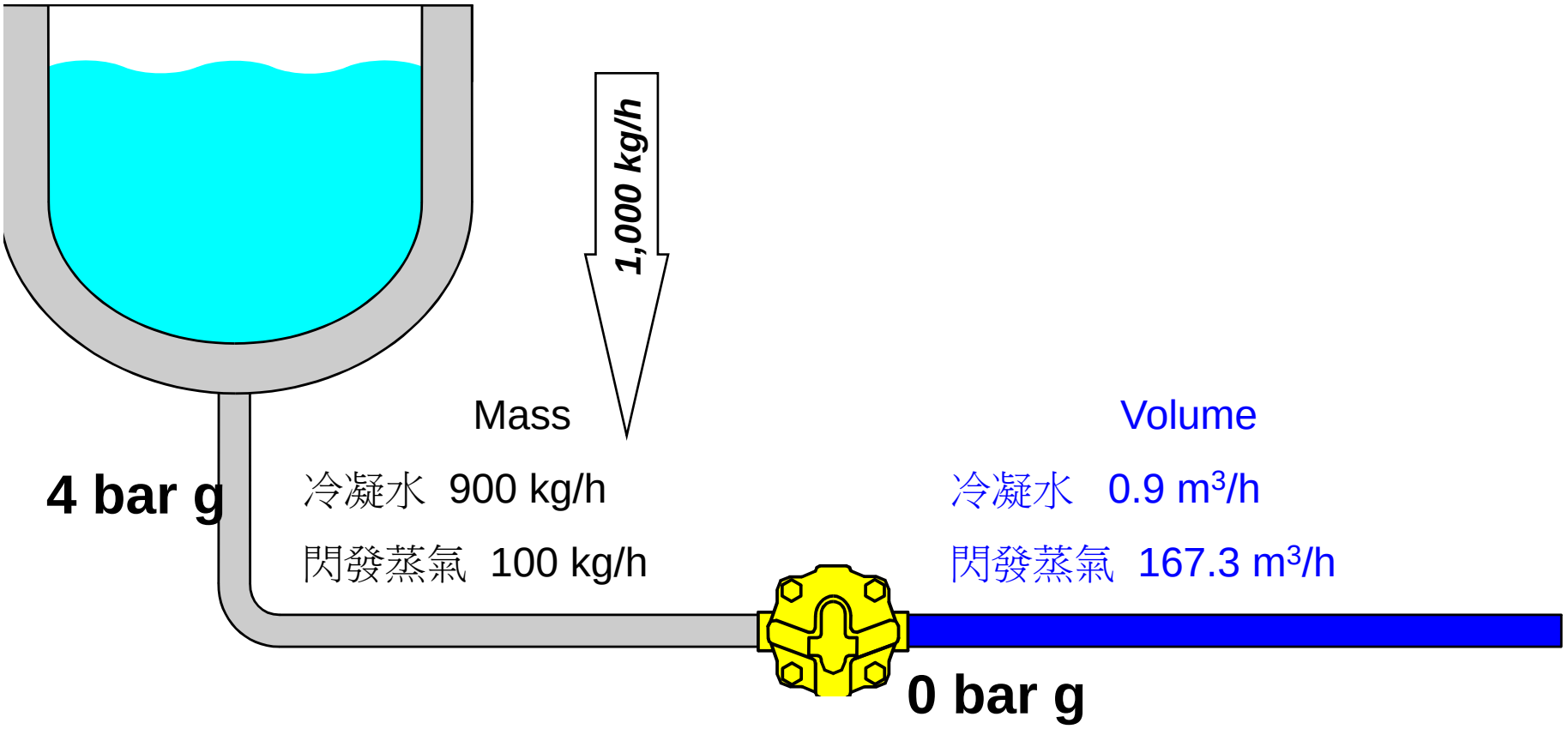
蒸汽消耗減量 – 避免開啟設備旁通閥

Table 6.1.1

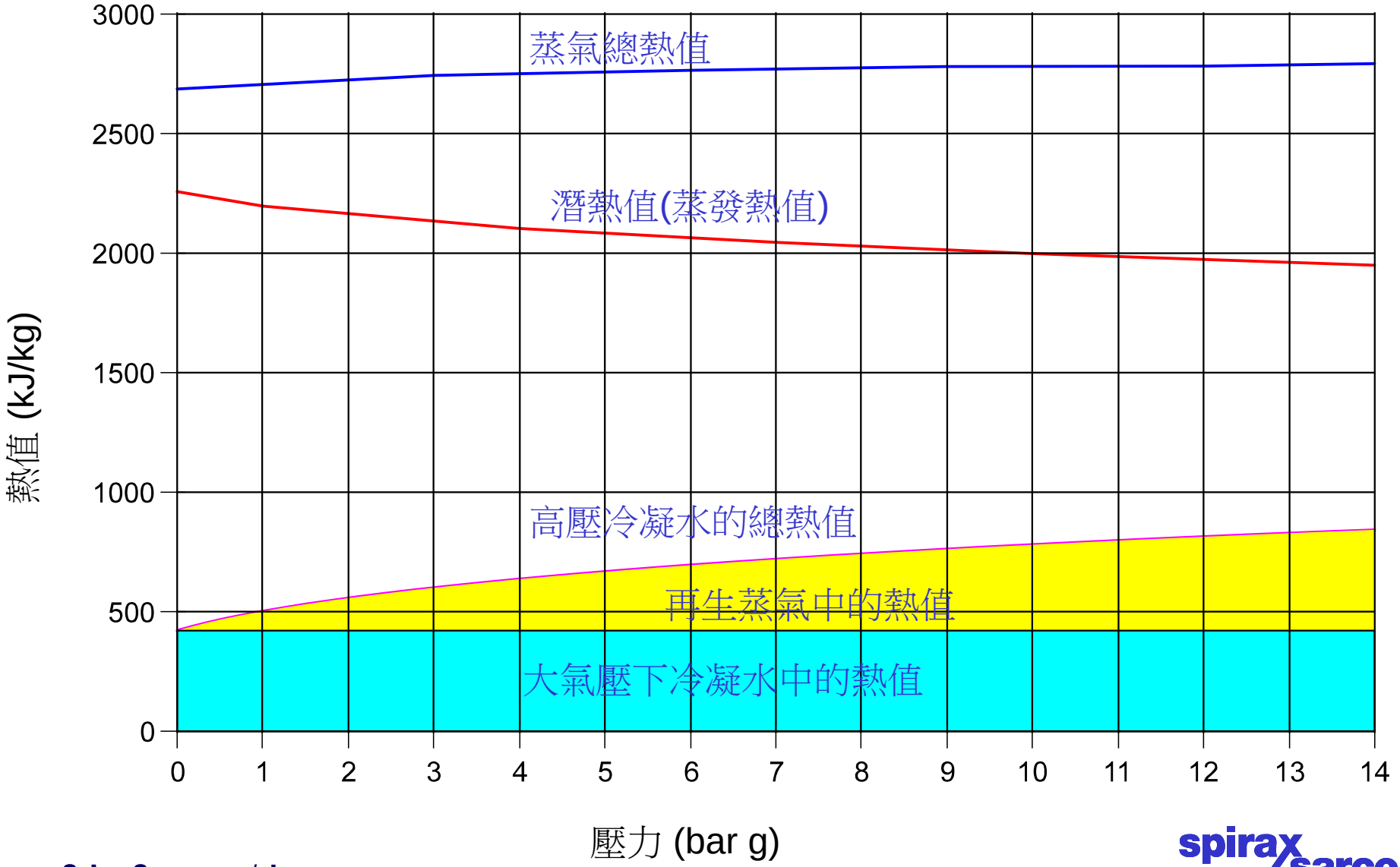
The main categories of heat treatment in the dairy industry

Process	Temperature	Time
Thermisation	63 – 65°C	15 s
LTLT pasteurisation of milk	63°C	30 min
HTST pasteurisation of milk	72 – 75°C	15 – 20 s
HTST pasteurisation of cream etc.	>80°C	1 – 5 s
Ultra pasteurisation	125 – 138°C	2 – 4 s
UHT (flow sterilisation) normally	135 – 140°C	a few seconds
Sterilisation in container	115 – 120°C	20 – 30 min

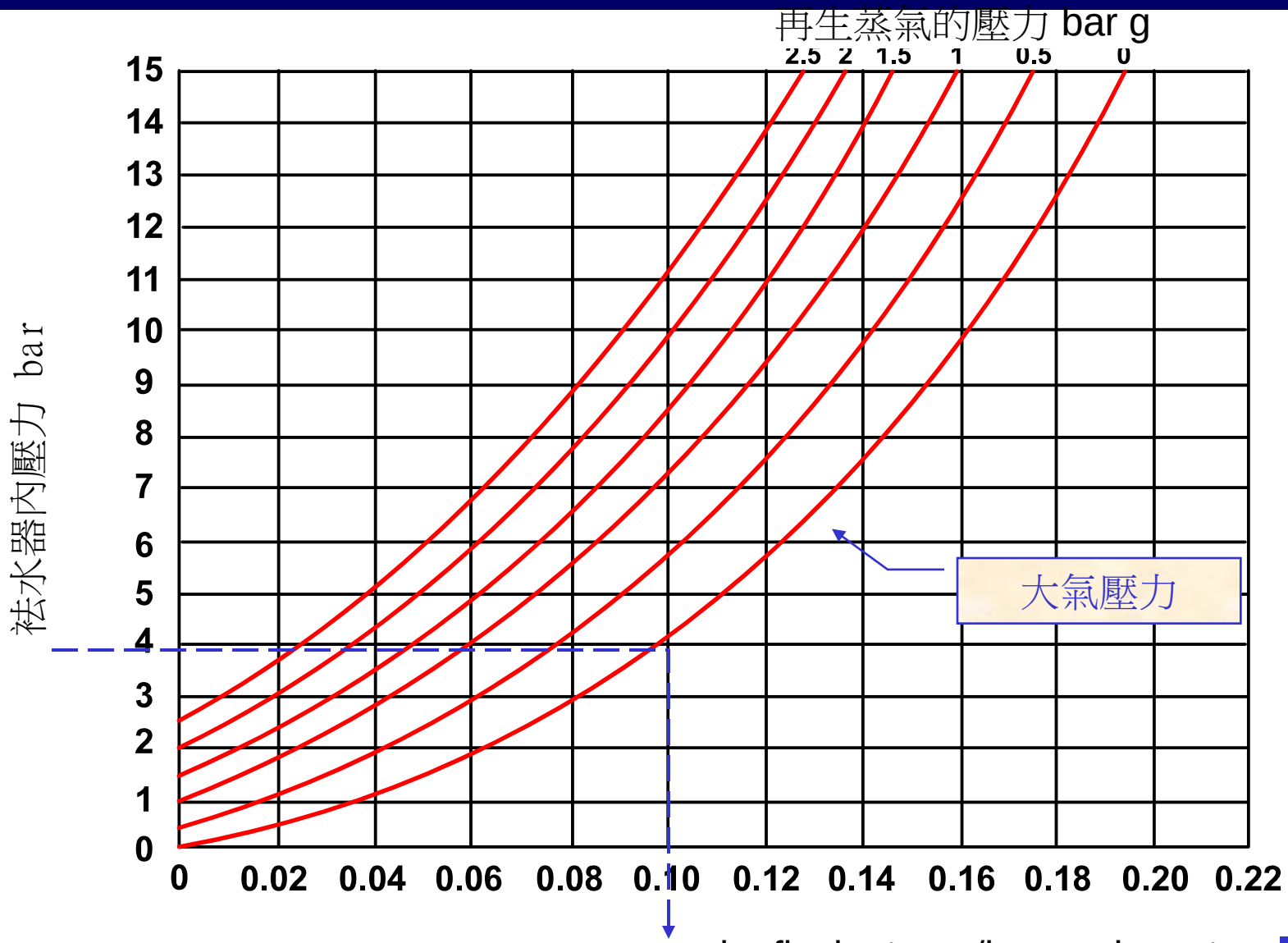
冷凝水能產生的再生蒸氣量



蒸氣與冷凝水的熱值


3000
2500
2000
1500
1000
500
0
熱值 (kJ/kg)
蒸氣總熱值
潛熱值(蒸發熱值)
高壓冷凝水的總熱值
再生蒸氣中的熱值
大氣壓下冷凝水中的熱值
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
壓力 (bar g)

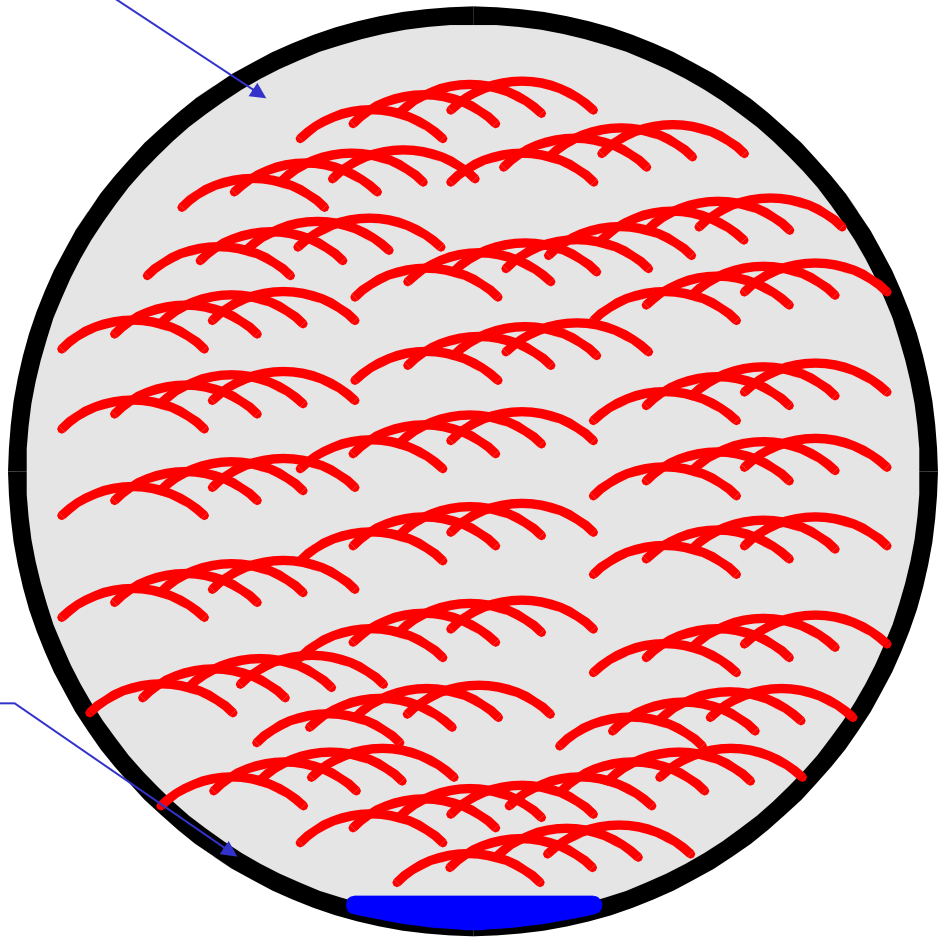
再生蒸氣表


再生蒸氣的壓力 bar g
2.5
2
1.5
1
0.5
0
祛水器內壓力 bar
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
0.22
大氣壓力
kg flash steam/kg condensate

管內的再生蒸氣量

100 kg 的再生蒸氣

99.44% 的空間都是蒸氣



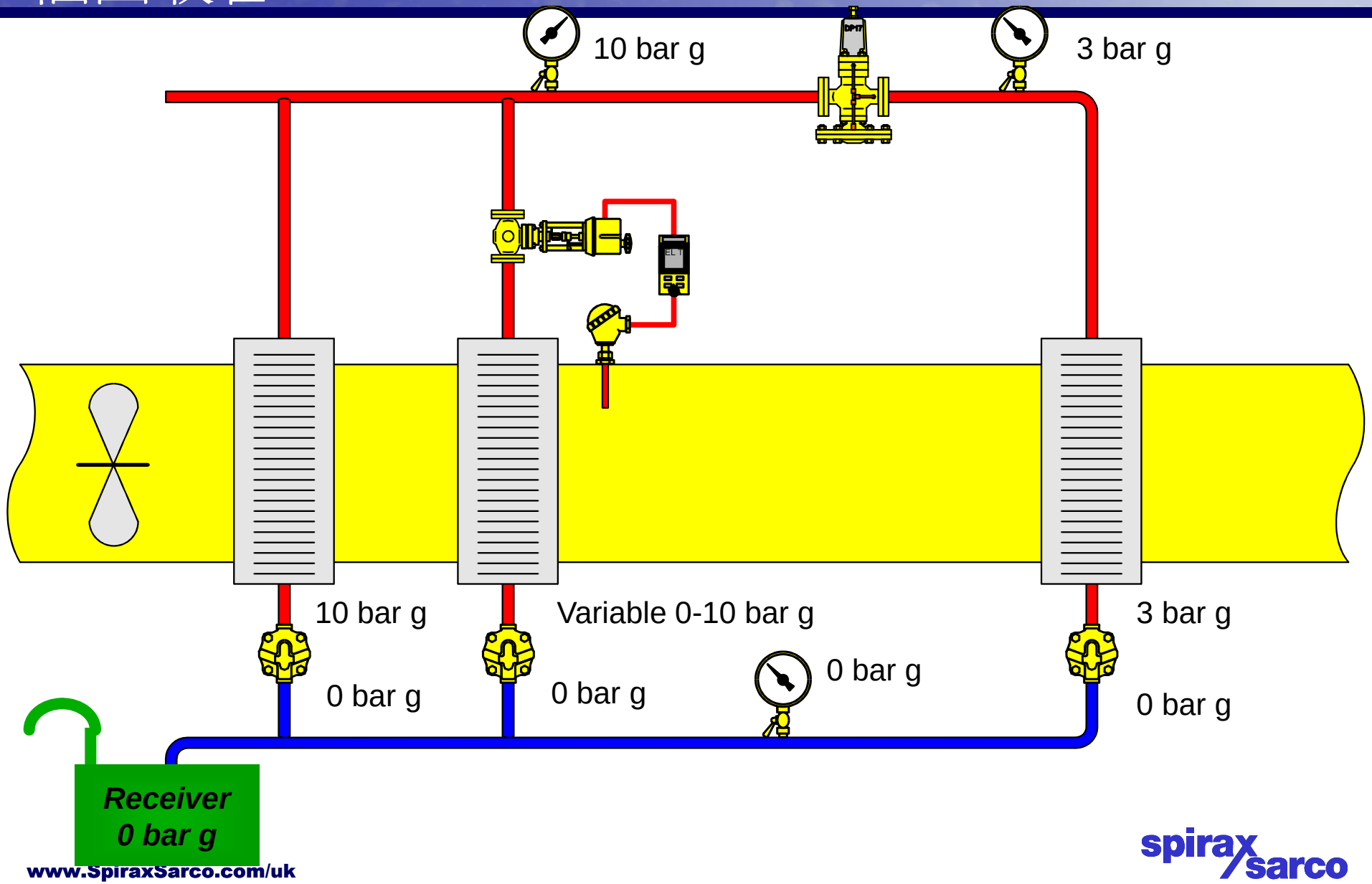
900 kg 的冷凝水

0.56 % 的總容積

冷凝水管徑的篩選 (kg/h)

Press. Down Stream of Trap	Pipe Size (mm)										
bar g	15	20	25	32	40	50	65	80	100	125	150
0	6	11	18	30	42	69	98	152	262	411	594
0.1	7	12	19	33	46	76	108	166	286	450	650
0.2	7	13	21	36	50	82	117	180	310	488	705
0.3	8	14	23	39	54	88	126	194	335	526	760

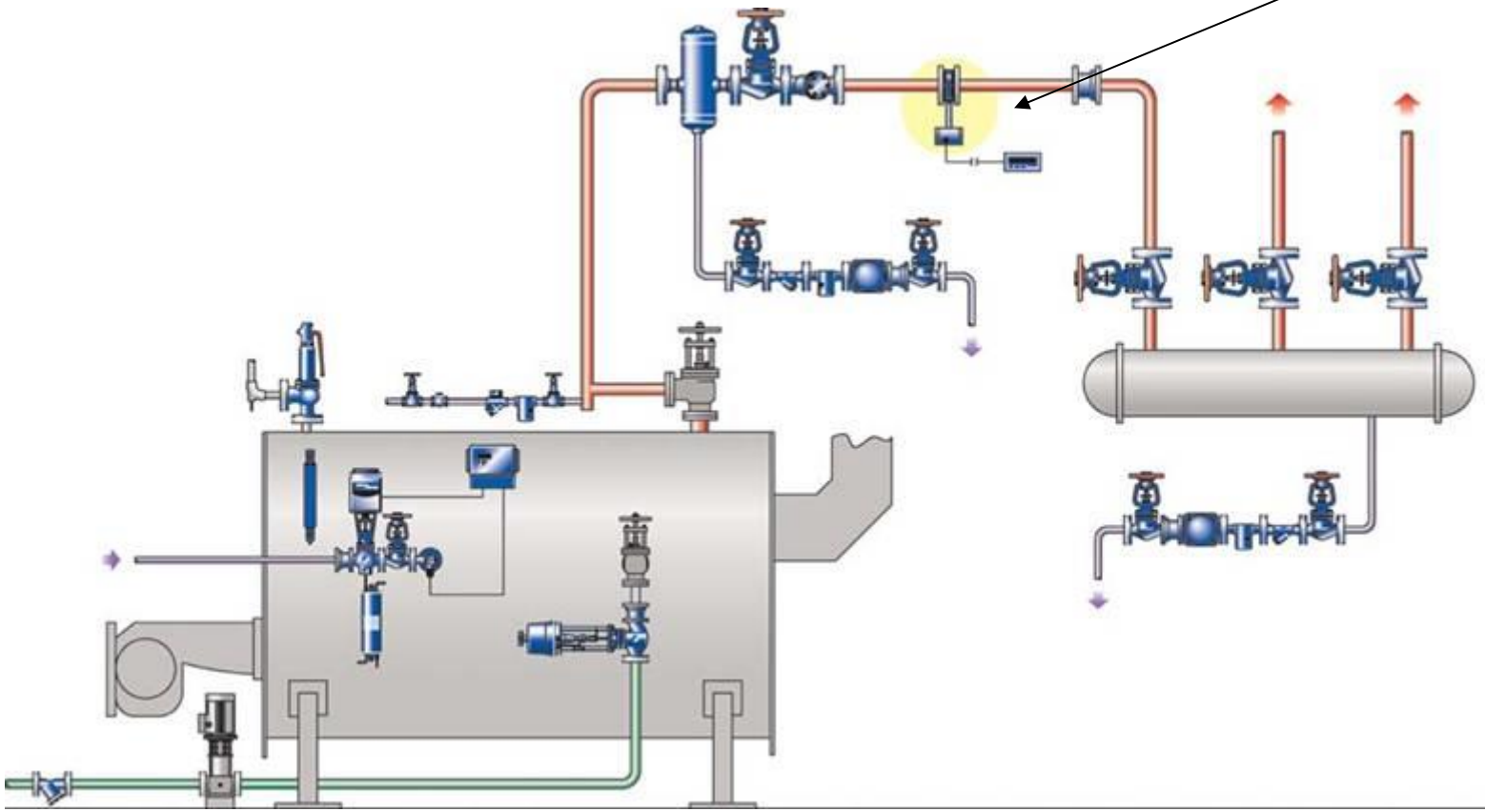
不同壓力的卻水器是否能用一個回收管?



蒸汽耗能參數的建立-蒸汽流量計

"You can't manage what you can't measure"

- Lord Kelvin



spirax sarco

安裝流量計之重要性

- 瞭解蒸汽實際總使用量及成本計算管理。
- 計量各使用點之蒸汽用量及成本計算管理。
- 建立利潤管理制度，檢討比較各部門成本支出。
- 建立基準線與同業之間合理成本比較。
- 分析鍋爐效率是否合理?是否需要保養或汰換?
- 分析節能設備是否有效節能。
- 確認蒸汽使用量是否有異常變化，進而檢視是否有蒸汽設備損壞或洩漏情形

安裝流量計之目的

- 建立管理單位使用”數字管理”之觀念，而非流於”感覺管理”。
- 並且便於分析評 比各用單位之績效，同時在訂定節能管理時才有可靠客觀之數據作為節能減碳之目標。
- 集團節能小組執行節能評比時，有流量計所提出之數據，才能有令人信服的報告。

流量計準確之重要因素

•(1)峰值比：即鍋爐可偵測之最大流量與最小流量之比值

$$\text{峰值比} = \frac{\text{最大流量}}{\text{最低流量}}$$

•(2)安裝距離：不同型式之流量計皆有安裝距離之要求，若未依照要求方式安裝，則偵測之數據，**將會是『無意義』，而非所謂失準如此簡單**。

•(3)密度補償: 蒸汽壓力會變化的管路

•(4)準確度及重複性: 製造工廠校正方式與設備之認證 ISO17025

•(5)安裝注意事項：

•一體成型 震動 ， 方向 ,配線，