陸.鋼瓶厚度計算式
JIS無縫鋼瓶之厚度

CALCULATION FOR MIN. WALL THICKNESS OF CYLINDRICAL SHELL	CLASSIFICATION CDS 2141

DESIGN BASIS

DESIGN PRESSURE	19.6	MPa
MAX. FILLING PRESSURE AT 35℃	19.6	MPa
HYDROSTATIC TEST PRESSURE	32.7	MPa
KIND OF GAS	COMPRESSED GAS	
OUTSIDE DIAMETER	232	mm
INSIDE DIAMETER	———	mm
KIND OF STEEL	Cr – Mo STEEL Y.S. ≧ 720 N/mm², T.S. = 850 ~ 950 N/mm²	

SPECIFICATION	FORMULA FOR MIN. WALL THICKNESS
THE HIGH PRESSURE GAS SAFETY LAW, JAPAN. AND APPENDIX I. INTERPRETATION OF THE TECHNICAL STANDARDS OF SEAMLESS GAS CYLINDER	$t = \frac{D}{2}\left(1-\sqrt{\frac{S-1.3P}{S+0.4P}}\right)$ OR $t = \frac{d}{2}\left(\sqrt{\frac{S+0.4P}{S-1.3P}}-1\right)$

SYMBOL	ITEMS	VALUES
t	MIN. WALL THICKNESS	mm
P	HYDROSTATIC TEST PRESSURE	32.7 MPa
D	OUTSIDE DIAMETER	232 mm
d	INSIDE DIAMETER	——— mm
S	MAX. ALLOWABLE STRESS 720 ×5/6	600.0 N/mm²

CALCULATION FOR MIN. WALL THICKNESS

$$t = \frac{232}{2}\left(1-\sqrt{\frac{600.0 - 1.3 \times 32.7}{600.0 + 0.4 \times 32.7}}\right) = 5.38$$

MINIMUM WALL THICKNESS OF THIS CYLINDER IS STATED AS 5.5 mm, THEREFORE, IT IS GREATER THAN THE ABOVE CALCULATED VALUE.

CHIEF	CHK'D BY	DESIGN	DATE	CHANGE RECORD
			NOV.7.'03	

陸.鋼瓶厚度計算式
DOT 3AA Cylinder之厚度-1/4

聯華林德 Linde LienHwa

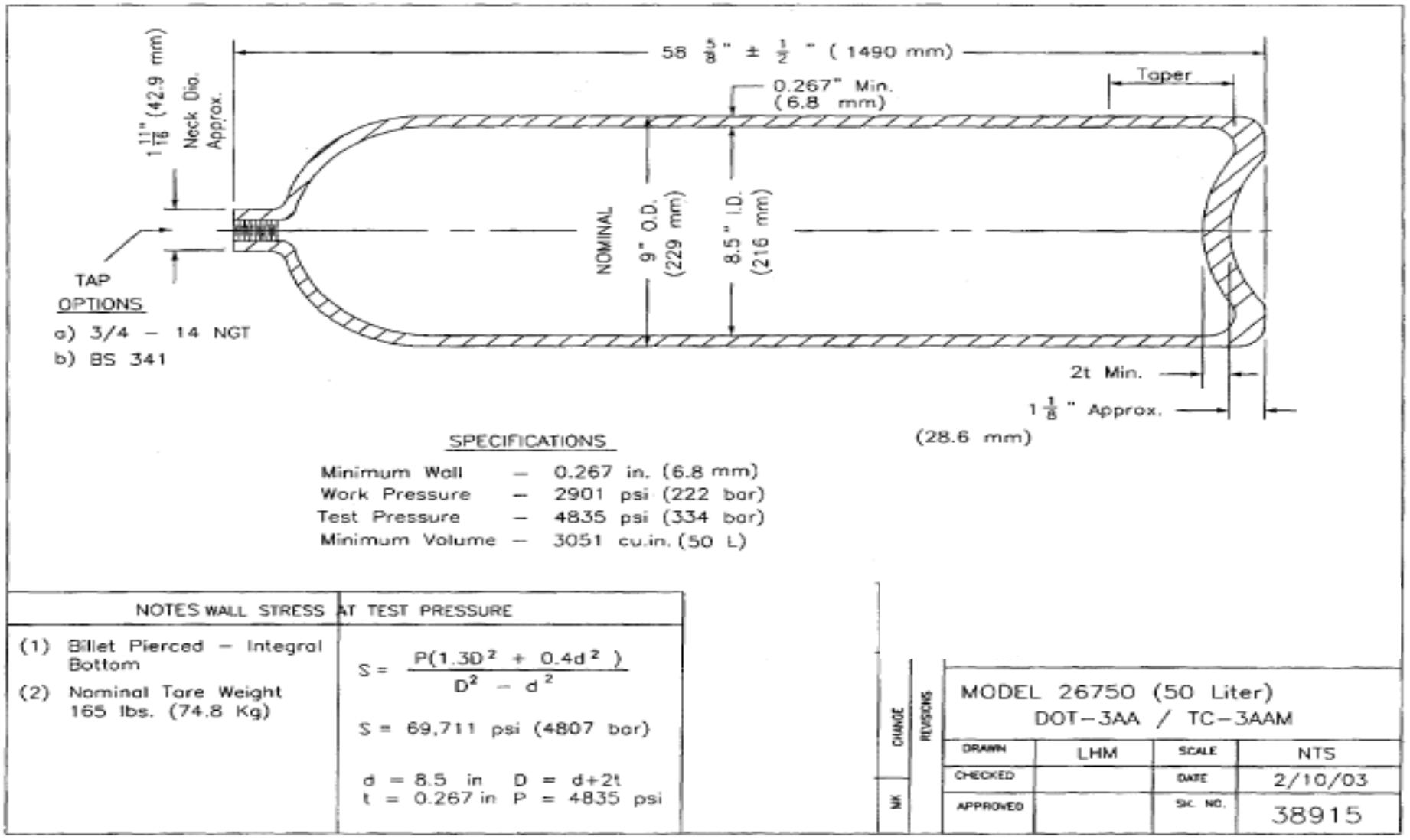
(f) *Wall thickness.* The wall stress may not exceed 24,000 psi. The minimum wall thickness is 0.090 inch for any cylinder with an outside diameter of 6 inches. Calculation must be made by the following formula:

$$S = [P(1.3D^2+0.4d^2)]/(D^2-d^2)$$

Where:

S = wall stress in psi;
P = at least two times service pressure or 450 psig, whichever is the greater;
D = outside diameter in inches;
d = inside diameter in inches.

陸.鋼瓶厚度計算式
DOT 3AA Cylinder之厚度-2/4



SPECIFICATIONS

Minimum Wall	–	0.267 in. (6.8 mm)
Work Pressure	–	2901 psi (222 bar)
Test Pressure	–	4835 psi (334 bar)
Minimum Volume	–	3051 cu.in. (50 L)

NOTES

(1) Billet Pierced – Integral Bottom

(2) Nominal Tare Weight 165 lbs. (74.8 Kg)

WALL STRESS AT TEST PRESSURE

$$S = \frac{P(1.3D^2 + 0.4d^2)}{D^2 - d^2}$$

S = 69,711 psi (4807 bar)

d = 8.5 in D = d+2t
t = 0.267 in P = 4835 psi

REVISIONS

CHANGE	NK

MODEL 26750 (50 Liter)
DOT–3AA / TC–3AAM

DRAWN	LHM	SCALE	NTS
CHECKED		DATE	2/10/03
APPROVED		SK. NO.	38915

陸.鋼瓶厚度計算式
DOT 3AA Cylinder之厚度(材料-4130X)-3/4

聯華林德 Linde LienHwa

1. MATERIAL : **Cr—Mo steel / 4130X**
2. MECHANICAL PROPERTIES
   - Tensile strength, psi/MPa : min. **104,500 / 720**
   - Yield strength, psi/MPa : min. **70,053 / 483**

3. CALCULATION FOR Max. WALL STRESS

3.1 Calculation formula

$$t = \frac{D}{2}\left(1-\sqrt{\frac{S-1.3P}{S+0.4P}}\right)$$

$$S = \frac{P(1.3D^2+0.4d^2)}{D^2-d^2}, \text{ or } S = \frac{1.7\,P\,D^2}{4t(D-t)} - 0.4P$$

t	: Wall thickness, inch/mm	;	**0.650 / 16.5**
D	: Outer diameter inch/mm	;	**22 / 558.8**
d	: Inner diameter, inch/mm	;	**20.70 / 525.8**
S	: Wall stress at Test pressure, psi	;	**70,000**
P	: Min. test pressure, psig/bar	;	**4,830/333**

3.2 Calculation for Min. Wall thickness of Tube

$$t = \frac{22}{2}\left(1-\sqrt{\frac{70{,}000 - 1.3 \times 4{,}830}{70{,}000 + 0.4 \times 4{,}830}}\right) = 0.64684" = 16.4287 \text{ mm}$$

Therefore, Use **0.650"/ 16.5** mm Minimum Wall Pipe.

3.3 Calculation for Max. Wall stress,

$$S = \frac{4{,}830 \times (1.3 \times 22^2 + 0.4 \times 20.70^2)}{22^2 - 20.70^2}$$

$$= 69660.938 < 70{,}000 \text{ psi, or}$$

$$S = \frac{1.7 \times 4{,}830 \times 22^2}{4 \times 0.650\,(22 - 0.650)} - 0.4 \times 4{,}830$$

$$= 71{,}592.938 - 0.4*4{,}830$$

$$= 69660.938 < 70{,}000 \text{ psi}$$

陸.鋼瓶厚度計算式
DOT 3AA Cylinder之厚度(材料-4130X)-4/4

聯華林德 Linde LienHwa

4. Additional Requirements for Tubes from Clause 4.2.2

4.1 $S = \frac{M\ C}{I}$ ---------- (3)

$= \frac{394{,}890.445 \times 11}{2{,}486.5}$

$= 1{,}746.951$ psi

4.2 $M = \frac{w\ L^2}{8}$ ---------- (4)

$= \frac{26.05189 \times 348.228^2}{8}$

$= 394{,}890.445$ in.lb

4.3 $I = 0.04909(D^4 - d^4)$ -- (5)

$= 0.04909(22^4 - 20.70^4)$

$= 2{,}486.52238$ inch^4

4.4 $S = \frac{A1\ P}{A2} = \frac{d^2}{D^2 - d^2} P$ -- (6)

$= \frac{20.70^2}{22^2 - 20.70^2} \times 4{,}830 = 37{,}283.5$ psi

- S : Tensile stress(max.),
- P : Hyd. test pressure,
- D : Outside diameter,
- d : Inside diameter,
- M : Bending moment,
- I : Moment of inertia,
- C : Radius(D/2 of tube),
- w : Weight per inch of cylinder filled with water,
- L : Length of tube, (including neck)
- A1 : Internal area in cross section of tube,
- A2 : Area of metal in cross section of tube,

4.5 The sum of two times the above each max. tensile stress shall not exceed 80 % of the min. yield strength of the steel.

Therefore, 4.1 + 4.4 = (1,747 x 2) + 37,283.5 = 40,777.5 psi

= 40,777.5 psi < 56,000 (Y.S x 80%)

and met the requirements of regulation.

柒.瓶頸螺牙解說
JIS無縫鋼瓶之瓶頸環螺牙

聯華林德 Linde LienHwa

圖 2　頸環之形狀

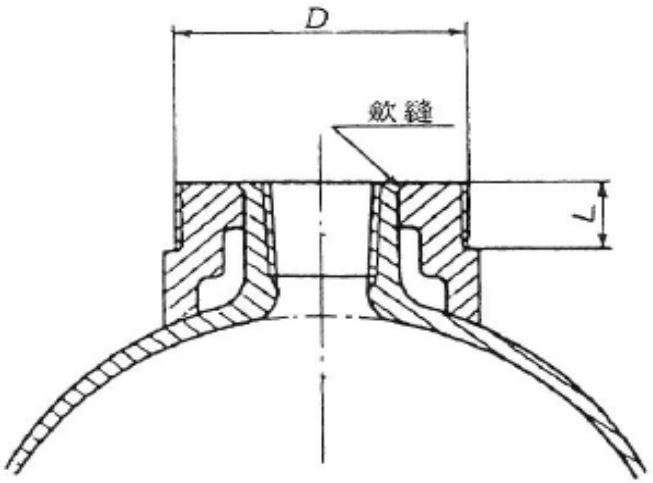


表 10 項環螺紋之尺寸

單位：mm

外徑 D	螺紋牙數 (每 25.4mm)n	螺紋部長度(約) L
80	11	20

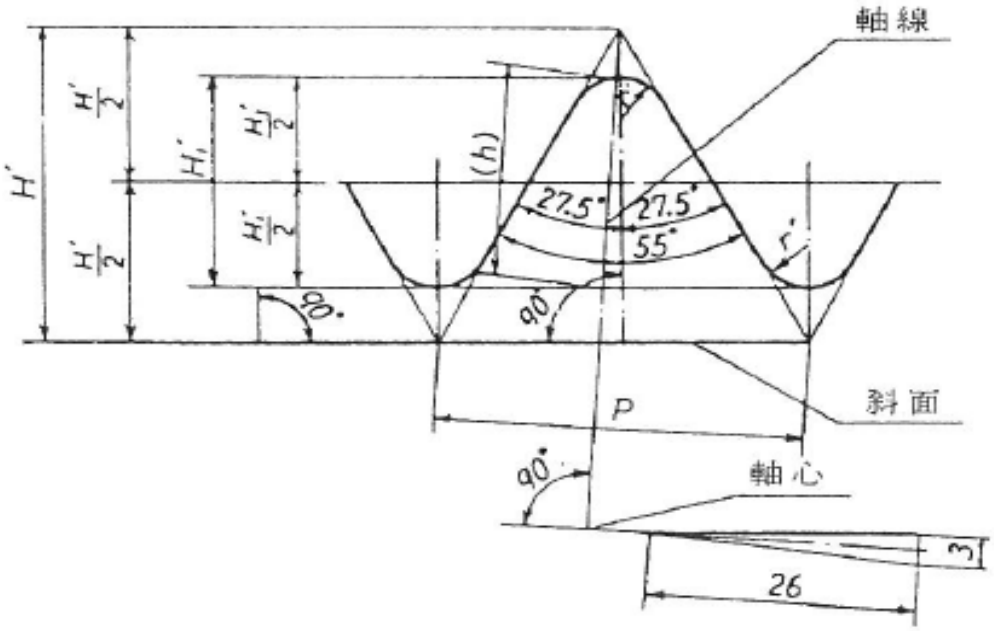
備考 1. 螺釘之標準形狀及標準尺寸，依照附屬書 2 之規定。

2. 內容積 5 公升以下，或閥帽安裝困難之特殊用途之內容積在 500 公升以下之容器，閥帽安裝部之螺紋不切除亦可，另不安裝頸環也可。

柒.瓶頸螺牙解說
JIS無縫鋼瓶之瓶頸螺牙

1. 適用範圍：本附屬書，就無縫高壓氣體容器閥安裝部之螺紋規定之。
2. 螺紋之基準形狀及尺寸：螺紋之標準形狀爲附屬書 1 表 1 所示，標準尺寸如附屬書 1 表 2 。

附屬書 1 表 1　標準形狀



$$P = \frac{25.4}{n}$$

$H' = 0.962088\ P$

$H_1' = 0.639264\ P$

$h = 0.640327\ P$

$r' = 0.138470\ P$

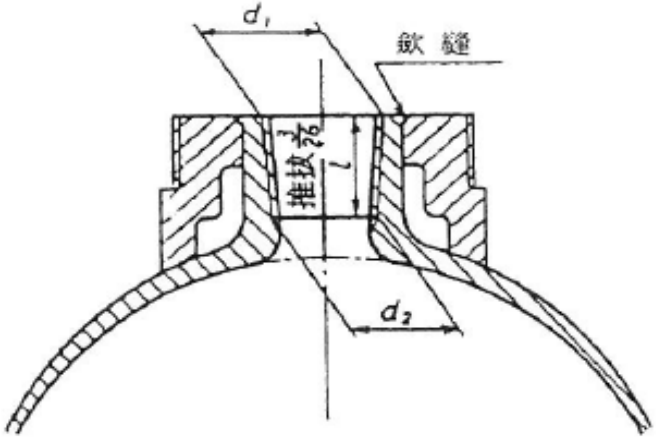
備考 1. 與斜面或直角之螺牙之高度 H′1係包含軸線之斷面形，牙頂之連接線與谷底之連接線間之距離，由與斜面成直角之垂直線測得之。

2. 螺紋爲直角面，節距沿軸心測之。

柒.瓶頸螺牙解說
JIS無縫鋼瓶之瓶頸螺牙

聯華林德 Linde LienHwa

附屬書 1 表 2 基準尺寸



單位：mm

適用閥記號	螺牙數(每25.4mm) n	節距 P	螺牙之高度 H′1	谷底之修整 r	標準徑			參考	螺紋部之長度(約) l
					谷徑 d_1	有效徑	內徑	d_2	
V_1	14	1.8143	1.160	0.25	20.000	18.838	17.676	17.7	20
V_2	14	1.8143	1.160	0.25	28.000	26.838	25.676	24.8	28
V_3	14	1.8143	1.160	0.25	28.000	26.838	25.676	25.2	24

備考 1. 螺紋爲右旋螺紋

2. 螺紋用螺紋規配合其配合之容許差爲對規定牙數±1牙。

3. 適用閥 V_1, V_2 及 V_3，按照 CNS 10848〔高壓鋼瓶用閥〕之規定。

柒.瓶頸螺牙解說
Straight or Parallel Threads

聯華林德 Linde LienHwa

Straight or Parallel Threads

- Usually identified by no threads being visible.
- Seal is made between the O- Ring on the valve inlet
- sealing against a ledge in the cylinder.
- Tape on the valve threads is not needed!
- Generally used for non- corrosive and non-toxic gases.
- Torques required specified by manufacturer.
- Lower for aluminium cylinders than steel cylinders.

柒.瓶頸螺牙解說
Tapered Valve Inlets

聯華林德 Linde LienHwa

Usually identified by valve threads being visible.

Seal is made at the flank of the valve and cylinder thread, rather than at the root and crest.

A form of lubrication is used such as PTFE tape.

Care must be taken for oxidizers if a secondary lubricant is used.

Tapered threads are used for toxic, corrosive, flammable, oxidizers, & non-corrosives.

柒.瓶頸螺牙解說
DOT Cylinder Neck Thread-1/3

聯華林德 Linde LienHwa

The Whitworth System dating back to 1841 forms the basis for the 25E and 8246V2 thread used in Asia and Europe.

In 1917, the Compressed Gas Manufacturer’ s Association improved the NPT thread and developed what we know today as the NGT (National Gas Taper).

The NGT was an enhancement over the NPT thread in that it not only had two additional threads, but gave attention to the roots and crests of the threads which impact the sealing.

Gauging was developed for the NGT threads.

Designs were based on brass valves and steel cylinders commonly used before 1920.

柒.瓶頸螺牙解說
DOT Cylinder Neck Thread-2/3

聯華林德 Linde LienHwa

NGT

ANSI Approved CGA V-1

Taper is 1 in 16, Marking is “12N”

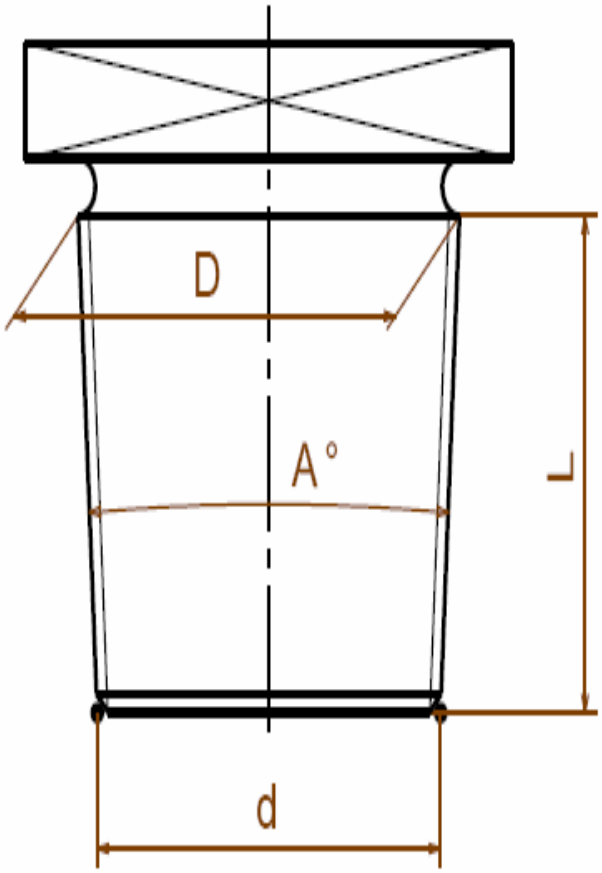
ISO10920

Taper is 3 in 25, Marking is “25E”

The 25E tapered inlet reflects identical thread types approved by DIN, BS, and AFNOR.

The JIS Equivalent is the 8246B2 thread

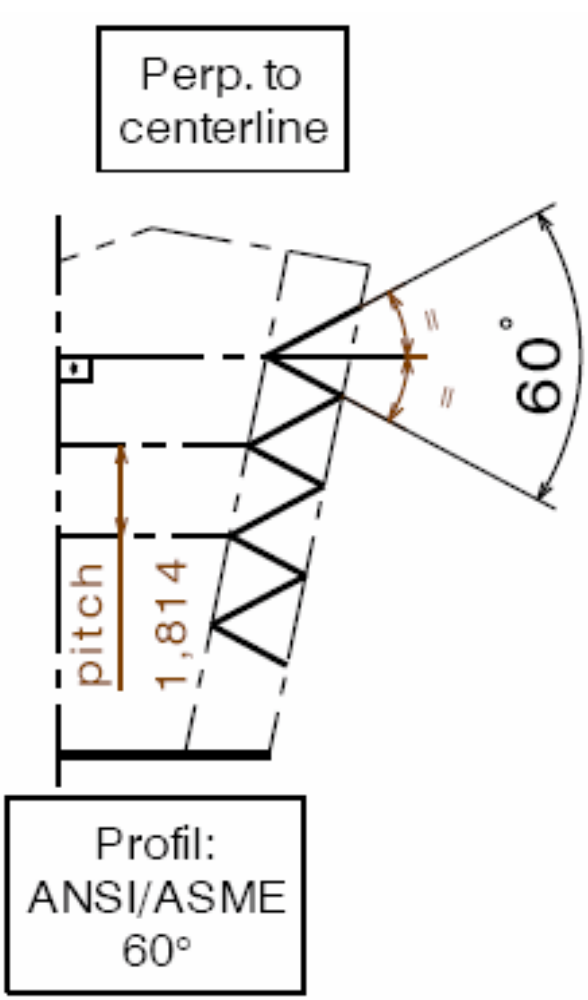
which is similar but not identical to the 25E.

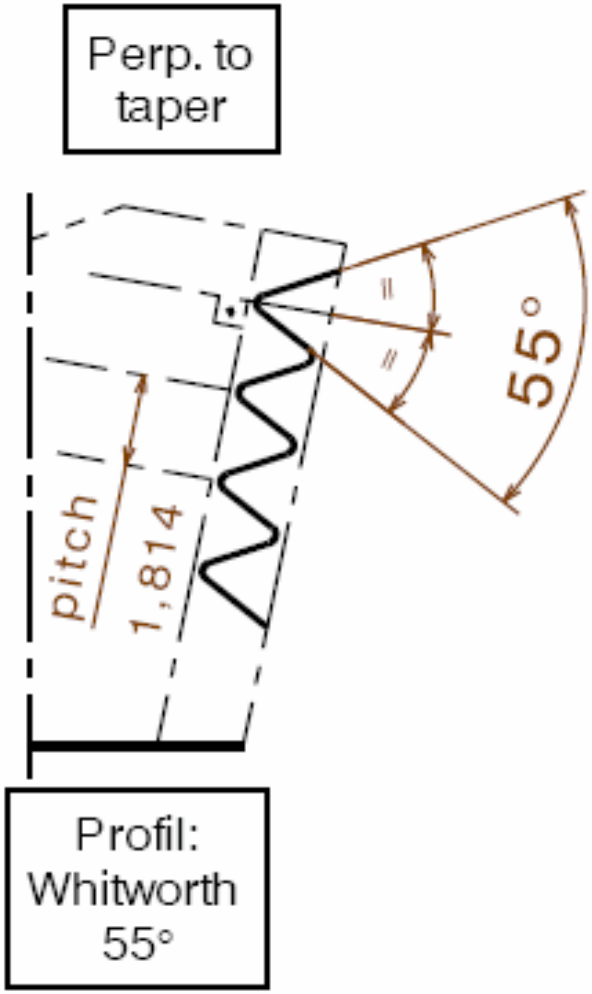


柒.瓶頸螺牙解說
DOT Cylinder Neck Thread-3/3

聯華林德 Linde LienHwa

Comparison of NGT & 25E Tapered Threads





柒.瓶頸螺牙解說
The Unique Requirements for Oxygen Packaged in Aluminium Cylinders (氧氣鋁瓶之瓶頸牙)

聯華林德 Linde LienHwa

In the United States, aluminium cylinders packaged with oxygen must have straight threads.

In Europe, the use of tapered threads for aluminium cylinders in oxygen service has been allowed.

With the advent of the new UN cylinders, the US DOT has approved the use of tapered threaded aluminium cylinders.

Valves for straight threaded and tapered threaded cylinders should be coded to be sure that the correct valve thread type is matched to the aluminium cylinder.

It is important to follow the manufacturers' recommendations for torques.

Generally, aluminium cylinders use lower torques than tapered threads.

柒.瓶頸螺牙解說
Valving a Tapered Cylinder(斜形瓶頸牙之瓶閥安裝)

聯華林德 Linde LienHwa

Handtight engagement occurs when the pitch diameters are equal and sealing takes place on the flanks.

New valve and cylinder should be gauged first to be sure they are in spec.

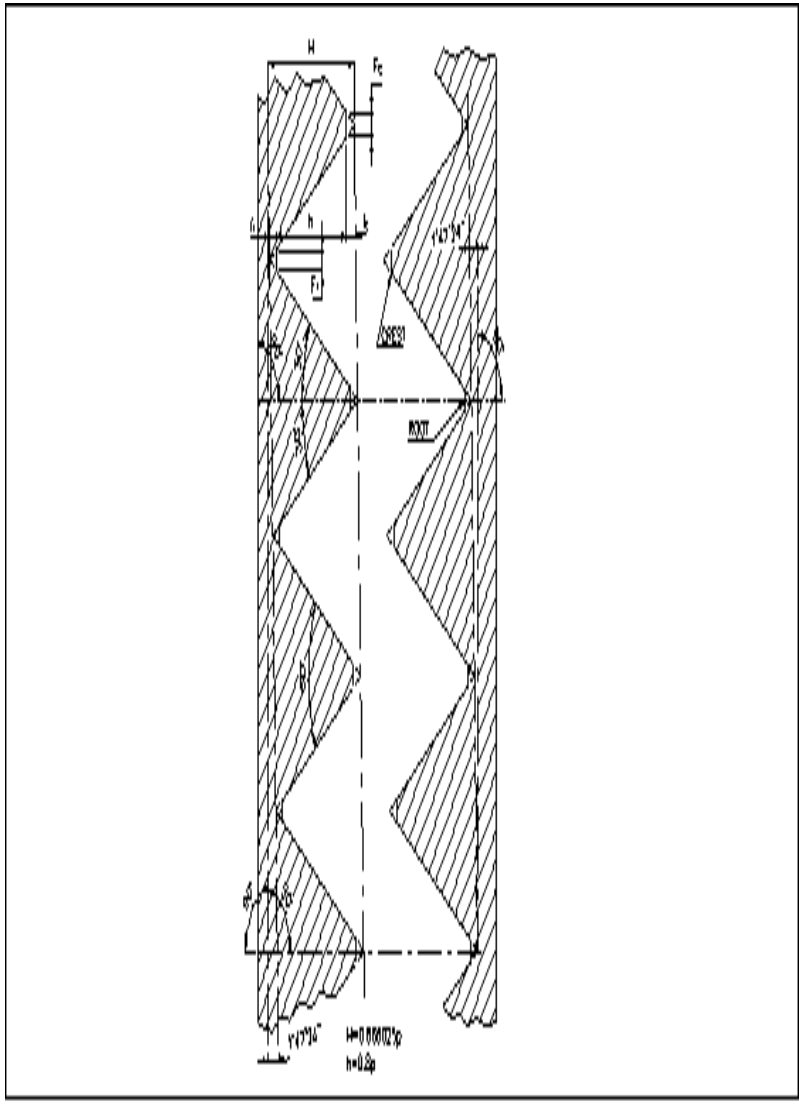
Gauging older valves can damage gauges.

Apply tape and torque to manufacturer’ s specs.

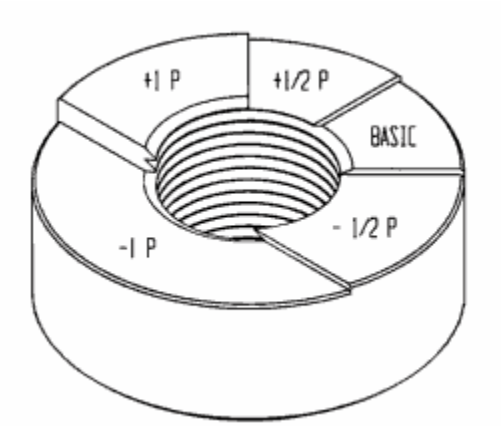
For brass, handtight + 3

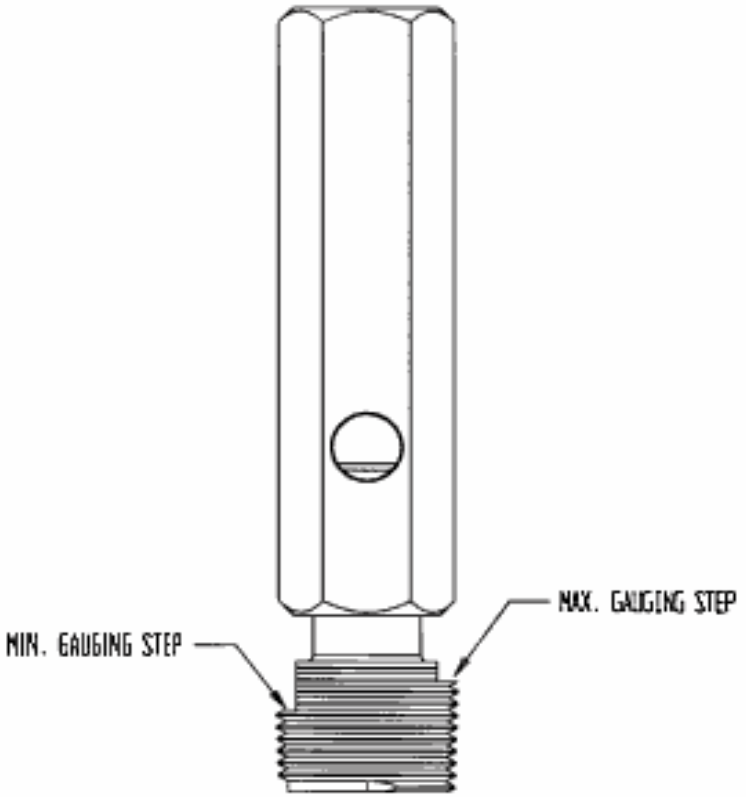
For S.S., special care is needed.

Important that a minimum number of threads are engaged and a minimum torque is achieved.



柒.瓶頸螺牙解說
Typical Gauges





柒.瓶頸螺牙解說
Why Some Installed Valves Show More Threads Than Others

聯華林德 Linde LienHwa

A ¾” -14NGT thread has 14 threads per inch.

The L 1 hand tight engagement is 0.3390 inch.

0.3390 x 14 = ~4.750 threads engaged

Both the cylinder and valve have a tolerance of + or − 1 thread

Therefore between 2.75 and 6.75 threads are engaged hand-tight.

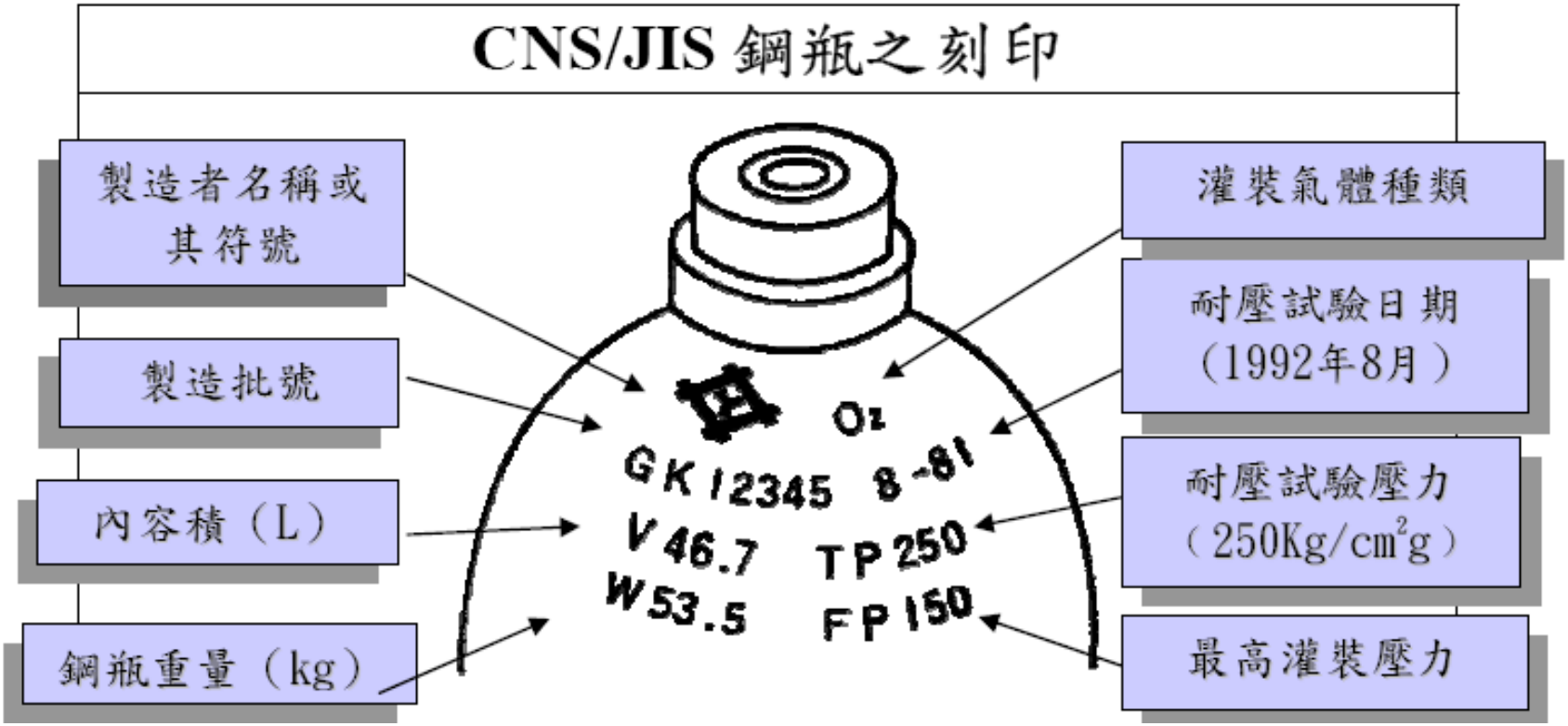
Add three threads for wrenching and as few as 5.75 threads or as many as 9.75 threads are engaged.

There are only 10.75 threads available.

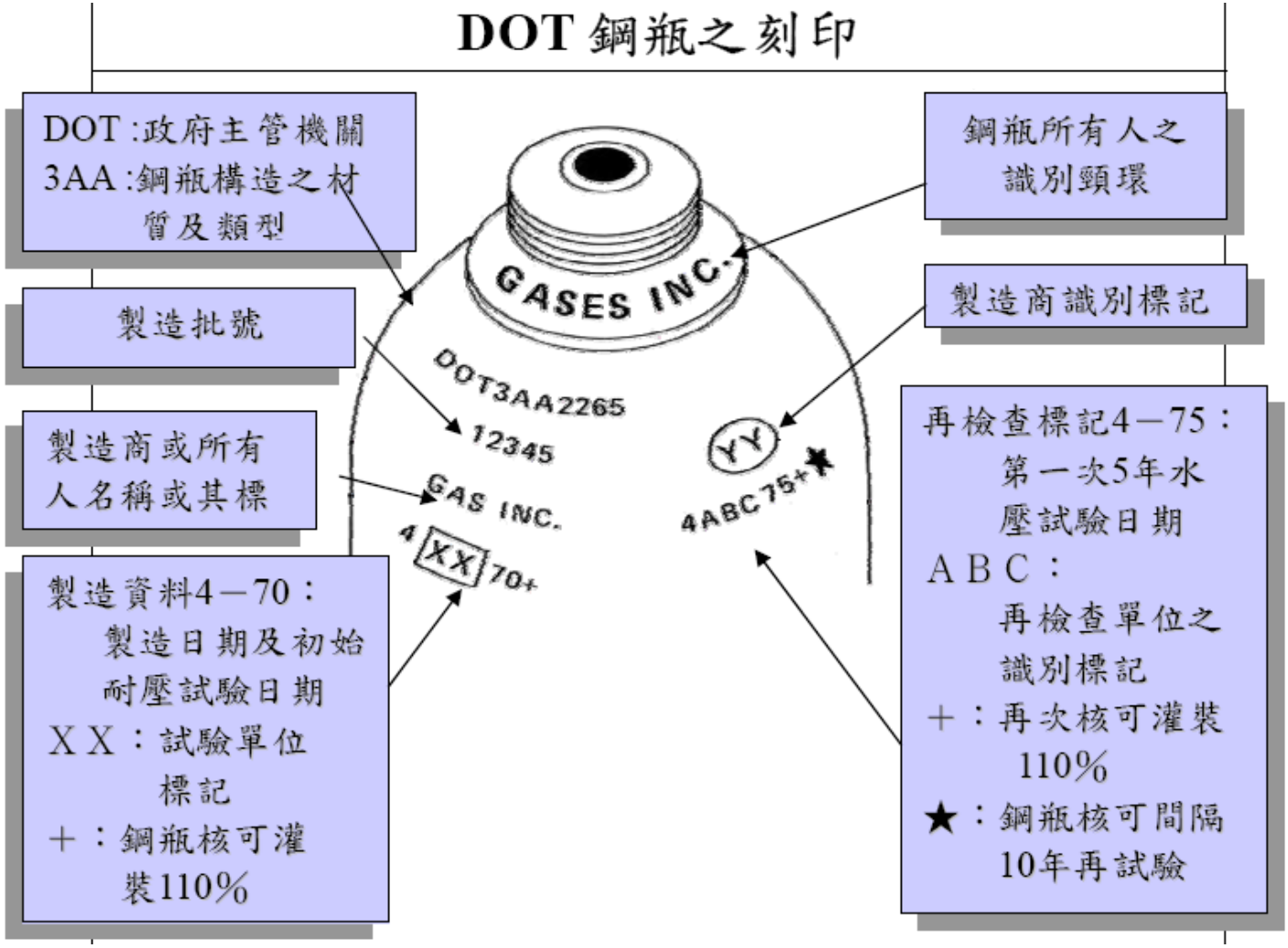
In this case between 1 and 5 threads may be visible when the valving is completed

Removing and revalving consumes one additional thread

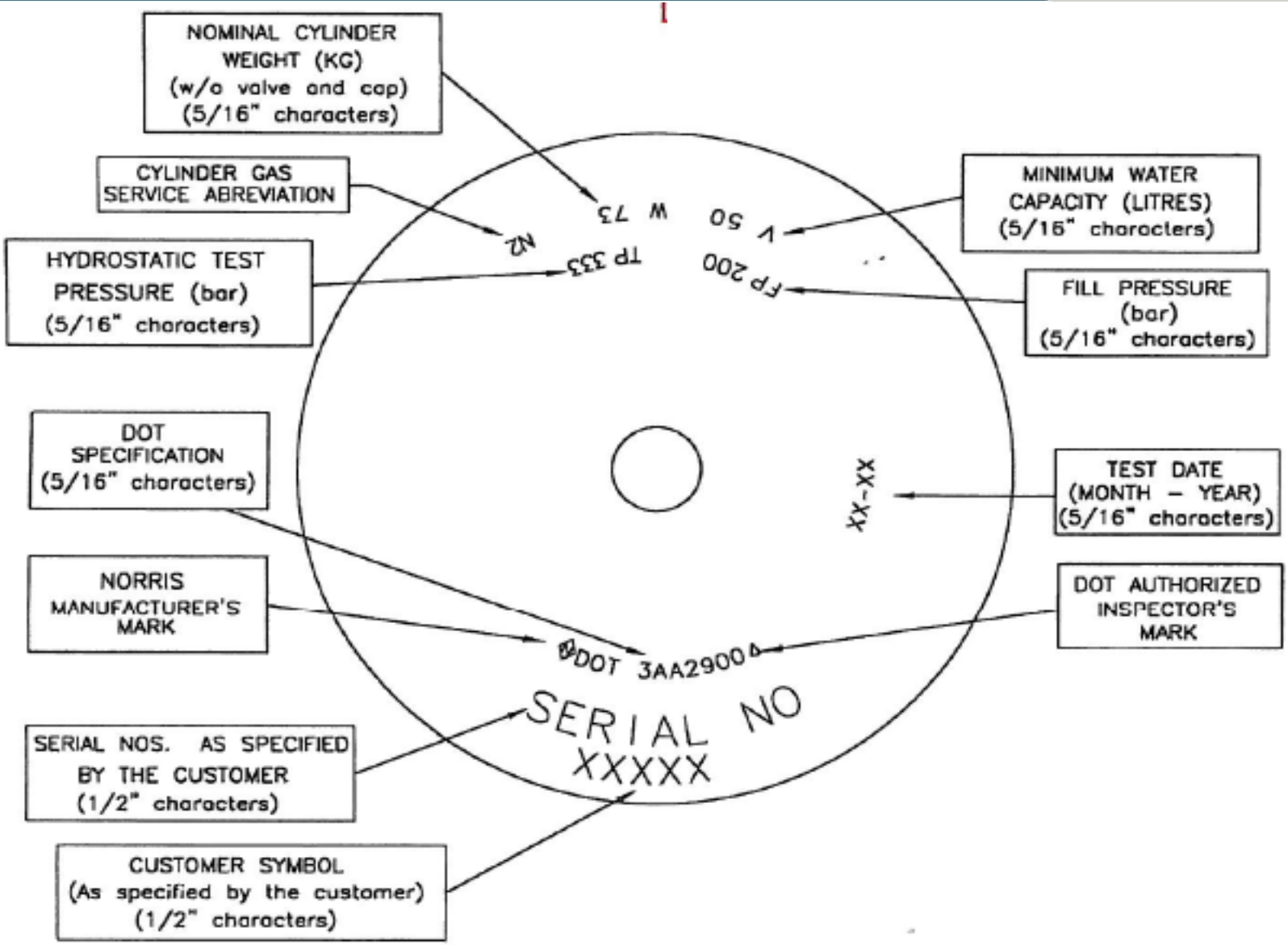
捌.鋼瓶鋼印解說-Cylinder stamp



捌.鋼瓶鋼印解說-Cylinder stamp



捌.鋼瓶鋼印解說-DOT Cylinder stamp



玖.DOT 3AA與 JIS無縫鋼瓶法規比較說明
-日本及美國有關 3AAX 無縫容器法規條文對照表

聯華林德 Linde LienHwa

日本「一般無縫容器技術性標準	美國聯邦法規 49 CFR	說明
第一章 總則	178.37 規格 3AA 及 3AAX 無縫鋼瓶	
第一條 適用範圍	(a)型式、大小及使用壓力	
第二條 用辭定義	171.8 定義及縮寫 180.203 定義	
第二章 製造方法之基準 第三條 材料	178.37 (b) 經核准的鋼	
第四條 厚度	178.37(f) 壁厚 178.37 (a)(2)DOT-3AAX 無縫鋼瓶應符合的要求	
第五條 構造及規格		名詞說明
第六條加工、熔接及熱處理之方法	178.37 (g)熱處理	
第七條 尺度精度	178.37 (d)製造	
第三章設計確認試驗及組試驗 第八條 容器檢查		與容器規則條文對照
第九條 設計確認試驗時之壓力循環試驗		僅適用於高強度鋼
第十條 組試驗時之外觀檢查	178.35 規格容器的一般規定 (c)檢查員的職責 173.302a 裝載永久壓縮氣體的規格容器之額外運送要求	
第十一條 組試驗時之超音波探傷試驗等	178.37 (g)熱處理	
第十二條 組試驗時之材料試驗	178.37(j)壓扁試驗 (k)物理性試驗 (l)可接受的物理性和壓扁試驗結果	
第十三條 組試驗時之破裂試驗		僅適用於小型容器
第十四條 組試驗時之耐壓試驗	178.37 (i)靜水壓試驗	
第十五條 組試驗時之氣密試驗	178.37 (m)洩漏試驗	
第四章 型式試驗 第十六條 型式試驗	178.37 (c)材料鑑定 178.37 (e)銲接或以銅鋅合金焊接(硬焊) 178.37 (h)容器的開口與開口的連接物(閥、熔融塞等) 178.37 (n)退回的容器	型式試驗之內容

玖.DOT 3AA與 JIS無縫鋼瓶法規比較說明
-日本與美國對於 3AAX 無縫容器之檢查規定比較

聯華林德 Linde LienHwa

項目	日本	美國	說明
容 器 之 厚 度 計算	1. 容器的厚度計算在第 4 條中規定，該條文中有 兩個計算厚度，取其中 比較大的計算值。厚度 值與容器內徑、外徑、 耐壓試驗之壓力、容許應力有關。 2. 鉻鉬鋼及其他合金鋼若 實施淬火與回火者，其 容許應力應取降伏點之5/6 數值。	178.37(f)壁厚 容器厚度計算公式，與容 器內徑、外徑、耐壓試驗之壓力、內壁壓力有關。	厚度計算公式 相同，只是公 式呈現形式不 同，且日本使 用容許應力， 而美國採用內 壁壓力來計算。
容器材 料 強度	容器材料的「保證降伏強 度」應在該材料『保證抗 拉強度』之 85%以下，換 言之，施加在容器之負載 應不可超過『保證降伏強 度』。	容器是由水平支撐的兩端 來承受壓力，容器內加壓 後，因彎曲所造成的底部 壓力應爲最大抗拉強度的2 倍，所以對容器的縱向 施加的應力總合應該不可 以超過材料最小降伏強度 的 80%。	日本規定負載 不可超過材料『保證抗拉強 度』之 85%， 美國規定應力 總合不可超過 材料最小降伏強度的 80%。
容器之外觀 檢查	日本對於外觀檢查之厚度 量測方式爲在同一圈周向 量測 4 點厚度。（第 10 條）	依據 CGA C-6 壓縮氣體鋼 瓶目視標準。(包含內部與 外部檢查)	
熱處理	容器保安規則第 6條規定，對於鉻鉬鋼及低合金 鋼或同等材料，應實施淬火與回火。	178.37(g)熱處理 (5)規定了 4130X 鋼可以在1650°F 溫度下實施正常化 處理，而不需要實施淬火，正常化處理之容器不 需要回火。	日本規定鉻鉬 鋼及低合金鋼 需要淬火與回 火。美國亦規 定淬火與回火 程 序 ， 但4130X 型鋼可 在1650°F 溫 度正常化，則 不需做淬火及回火

玖.DOT 3AA與 JIS無縫鋼瓶法規比較說明
-日本與美國對於 3AAX 無縫容器之檢查規定比較

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日本	美國	說明
如果經過淬火之冷卻速度超過在溫度爲 20℃冷卻速度之 80%時，應實施超音波探傷、磁粉探傷、液滲探傷。（第 10 條）	178.37(g) 熱處理 (7)規定，除了本段(g)(6)規 定外，所有容器，如果使 用水來淬火或使用冷卻速 率超過水的冷卻速率之80%的液體來淬火，必須經 由磁性微粒、洗染滲透劑 或超音波方法來檢測淬火 裂縫的存在。設計成符合3AA規格要求的任一容器，被發現有淬火裂縫就必 須丟棄且不能重新檢查。	日本與美國之規定相同
鉻鉬鋼及其他低合金鋼之試驗片之形狀及尺度，爲 JIS Z2201(1980) 金屬材料 抗拉試驗片之形狀及尺度之 12 號試驗片，或在常溫 時不予搥擊之平片之 5 號試驗片；試驗片之厚度應 取試料之厚度。但試驗機之能力不足時，得使 5 號 試驗片之寬在 19mm。 拉伸試驗片在標點距離中至少有 20%的伸長率。	178.37(l) 可接受的物理性和壓扁試驗結果 可接受的物理性和壓扁試 驗結果爲在 2 英吋標點距離至少有 20%伸長率， 其他個案則至少 10%伸長 率。	日本與美國之拉伸試驗之伸長率要求是相同
容器長度 600mm 以上，胴體外徑 57mm 以上之容器應實施拉伸試驗、衝擊試 驗、壓壞試驗（壓扁試驗）或彎曲試驗。 壓壞試驗之２個楔子前端 間之距離，即加壓楔子壓 到容器胴部厚度之 9 倍時 沒有裂縫發生。	178.37(j)壓扁試驗(Flattening test) 此試驗要求從每一批含200 個或以下的容器中隨 機取一個容器進行壓扁試 驗。對於每一批含 30 個或 以下的容器，壓扁試驗實 施於每一個容器。 178.37(l) 可接受的物理性 和壓扁試驗結果可接受的物理性和壓扁試 驗結果，在 2"標點距離至少有 20%伸長率，其他個案則至少 10%伸長率。壓 扁試驗壓到容器厚度的6倍時沒有裂生。	美國 DOT對於容器壓扁試驗（或壓壞試驗）規定壓扁試驗壓到容器厚度的 6 倍時 沒有裂縫發 生。而日本規定壓扁試驗壓到容器厚度的 9 倍 時沒有裂縫發生。

玖.DOT 3AA與 JIS無縫鋼瓶法規比較說明
-日本與美國對於 3AAX 無縫容器之檢查規定比較

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項目	日本	美國	說明
衝擊試驗	與實施壓壞試驗條件相同	對 3AAX 規格容器未規定，僅對 3T 及 4L 規格容 器有此要求。	
彎曲試驗	試驗片彎曲部內面半徑對試驗片厚度之 3.5 倍時沒 有裂縫發生。	對無縫容器均無此要求，但對部分焊接容器有此要 求(詳見附表 5)。	日本要求壓壞試驗或彎曲試驗，擇一即可。

拾. 討　論

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鋼瓶規格表

Cylinder Data Sheet-1/2

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BOC Gases Group Cylinder Specification — Data Sheet No: 2010/2/6

Part C "High Pressure Seamless Steel Cylinder Data Sheet"

Checked: J.J.sang — Date: 2010.2.6

BOC GASES REGION :	BOCLH YRIG-LY

SERVICE

Gas:	Permanent	V	Liquefiable		Description: Medical O2
Working / Service Pressure:	150	kgf/cm2	35	°C	Reference Temperature
Nominated Countries of Use:	Taiwan				

SPECIFICATION

Standard:	JIS B8241				
Manufacturer:	KANTO KOATSU YOKI MFG.CO.,LTD.				
Manufacturing Route :					
Manufacturer's Drawing No:	SHM01-01039	Revision:		Date:	01-01-23
Stamping Drawing No:	CNS12242-B5107	Revision:		Date:	
Test Pressure:	250 kgf/cm2	Nominal Water Capacity:	3.4	Litre	
Nominal Outer Diameter:	101.6 mm	Nominal Empty Weight:	5	Kgf	
Overall Cylinder Length:	560 ± 5% mm (Measured from base to top of neck face)				
Neck Thread:	V1 JIS B8246	Neck Ring:	NO		

FITTINGS

Valve:	VALVE FOR OXYGEN SERVICE		
Thread Lubricant:	N/A		
Cap/Guard:	N/A		
Eductor/Dip Tube:	N/A	*Test Date Ring:*	No
Other:	NO		

PAINTING

Primer:	COAT WITH BLACK LACQUES
Other:	FOR MEDICAL O2 SERVICE

Cylinder Data Sheet-2/2

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A. Stamping as CNS 12242-B5107 as attached Drawing, including following items:

1. Name or trade mark of the cylinder manugacturer
2. Kind of gas to be filled in
3. Manufacturing and serial number of the cylinder
4. Internal capacity (measured value) in liters: symbol V
5. Tare mass of the cylinder excluding valve and cap in Kg: symbol W
6. Date of the pressure test in year and month
7. Pressure at the pressure test in mba Symbol TP
8. Maximum filling Pressure in mba Symbol FP
9. Owner Serial Number, eg. BOCLH-LC 241 for O2 Service
10. Certification Symbol
11. Size of stamped characters should be at least 6mm lengthwise

B. Document requirement:

1.material certification.
2.Hydrolic Test Report etc. for pressure Vessel.

C. Note:

1. Internally cylinder shall be dry, totally free of all rust, particulate, debris and hydrocarbon deposits per BOC UK specification 399856 & referred to Specifications.
2. Vendor to advise inlet seal / sealing details of their standard procedure for BOC approval & whether the cylinder is pressurised with dry nitrogen.
3. Supplier should verify correct thread engagement with cylinder valves nominated to be fitted in the BOC order.

Thank you for your attention.

JJ Sang 桑進家

聯華林德
Linde LienHwa