UNIVERSIDAD NACIONAL DE INGENIERÍA

FACULTAD DE INGENIERÍA MECÁNICA

DISEÑO DE UN SISTEMA DE DISTRIBUCIÓN DE VAPOR

PARA UNA PLANTA DE LA INDUSTRIA

FARMACÉUTICA

INFORME DE SUFICIENCIA
PARA OPTAR EL TÍTULO PROFESIONAL DE:
INGENIERO MECÁNICO

GIOVANNA LLANOS CABRERA

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DEDICATORIA

Un agradecimiento muy especial a mis padres por el apoyo que siempre me han brindado, a mis hijos Carlita y Fernando, quienes con su amor y cariño son la principal motivación para seguir superándome y finalmente a mi Alma Mater la UNI, de la cual me siento muy orgullosa.

ÍNDICE

PROLOGO

El presente informe tiene por finalidad dimensionar un sistema de tuberías de vapor según normas y códigos establecidos, a fin de obtener una instalación confiable y segura; así como prevenir y/o anular los riesgos asociados a dichos sistemas.

El contenido de este informe se ha divido en cinco capítulos:

En el primer capítulo se explica en forma detallada los antecedentes, los objetivos, los alcances y las limitaciones del presente trabajo, orientándolo a una descripción bastante simple.

En el segundo capítulo se muestra una breve presentación de la empresa, indicando los servicios y productos que fabrica.

En el Tercer capítulo se tocan temas conceptuales acerca del vapor y tuberías,

Así como normas y códigos usados en dimensionamiento de dichos sistemas.

En el cuarto capítulo se desarrolla el dimensionamiento del sistema de tuberías (cálculos), así como la selección de válvulas, trampas y accesorios necesarios para el adecuado funcionamiento del mismo.

En el quinto capítulo se desarrolla el presupuesto del proyecto.

El trabajo contiene en la parte final las conclusiones y recomendaciones así como los planos del sistema de tuberías además de una lista bibliográfica de los libros y normas utilizadas para el desarrollo de la misma.

Cabe resaltar que el presente informe está basado en el proyecto:

"SUMINISTRO, INSTALACION Y MONTAJE DE UN SISTEMA DE TUBERIAS"

Desarrollado para una planta farmacéutica ubicada en Lurín, siendo el suscrito parte de la ejecución del proyecto, el cual incluía la instalación de línea de vapor, líneas de retorno de condensado, línea de agua helada, líneas de purga, líneas de aire, línea de gas, y se desarrollo durante los meses de Enero a Diciembre del 2010.

Actualmente dichas líneas están funcionando y totalmente operativas.

CAPÍTULO I

INTRODUCCIÓN

1.1 ANTECEDENTES

La primera máquina a vapor ha sido el motor de la Revolución Industrial que desde fines del siglo XVIII en Inglaterra y casi mediados del siglo IX, aceleró portentosamente el desarrollo económico de muchos de los principales estados de Europa Occidental y de los Estados Unidos.

El empleo de la energía producida por las calderas de vapor para mover las máquinas tejedoras y de hilar marcó el comienzo del extraordinario incremento de la producción y, al mismo tiempo, de la Revolución Industrial. Al principio esta máquina se utilizó en la industria textil y en las minas; más tarde se aprovechó también para el desplazamiento de algunos medios de transporte, como las locomotoras y las embarcaciones.

Actualmente el vapor es uno de los fluidos más utilizados para calentar equipos o instalaciones en cualquier tipo de industria: química, petroquímica, alimentación, farmacéutica, o en procesos de como el de producción de papel, lavandería, humidificación y muchos más, debido a su bajo costo y fácil manipulación.

1.2 OBJETIVO

Diseñar el Sistema de distribución de Vapor para una planta de la industria farmacéutica cuya capacidad es 12937.5 lb/hr de vapor, el diseño abarca el dimensionamiento de las tuberías, así como la información técnicas para la selección de válvulas, filtros, trampas de vapor y los accesorios necesarios para el adecuado funcionamiento de la nueva planta.

1.3 ALCANCE

El presente informe abarca:

- Establecimiento de las condiciones de diseño incluyendo presión, temperatura y consumo de vapor a cada uno de los equipos, cabe resaltar que estos datos son conocidos y nos limitamos a seleccionar y dimensionar los componentes para estas condiciones.
- Determinación del diámetro de la tubería, el cual depende fundamentalmente de las condiciones del proceso, es decir, del caudal, la velocidad y la presión del fluido.
- Selección de los materiales y espesor de la tubería, para las temperaturas y presiones de diseño, de manera que la tubería sea capaz de soportar los esfuerzos producidos por la presión del fluido.
- Especificaciones Técnicas de bridas y conexiones
- Especificaciones Técnicas de válvulas (de control, reductoras, de seguridad)
- Análisis de flexibilidad mediante el cual se verifica los esfuerzos en la tubería, los esfuerzos en componentes locales del sistema.

1.4 JUSTIFICACIÓN:

La operación de un sistema de energía térmica y, específicamente la distribución de vapor requieren de un tratamiento y conocimientos específicos para su producción eficiente y uso racional.

En este informe, se darán a conocer los códigos y normas para un adecuado diseño de un sistema de distribución de vapor, con el fin de mejorar la confiabilidad y prevenir riesgos asociados con dichos sistemas.

1.5 LIMITACIONES

El presente trabajo se limita al dimensionamiento de un sistema de distribución de vapor típico.

No incluye:

a. Cálculos de consumo de vapor, esta información es tomada de las placas y/o ficha técnica cada equipo.
b. Cálculo estructural (para soportes).
c. No profundiza en la selección de aislamiento, sistemas de reducción y control de vapor.
d. No profundiza en la selección de válvulas y conexiones.
e. Dimensionamiento de la línea de purga y retorno de condensado.
f. Dimensionamiento de equipos (calderas, marmitas, tanques reactores, Tanques de condensado, tanques rompe purga etc.).
g. Sistemas de limpieza superficial y acabados.
h. No profundiza en los ensayos No destructivos a usar.

i. Procedimientos de soldadura y calificación de soldadores (WPS, WPQ, PQR).

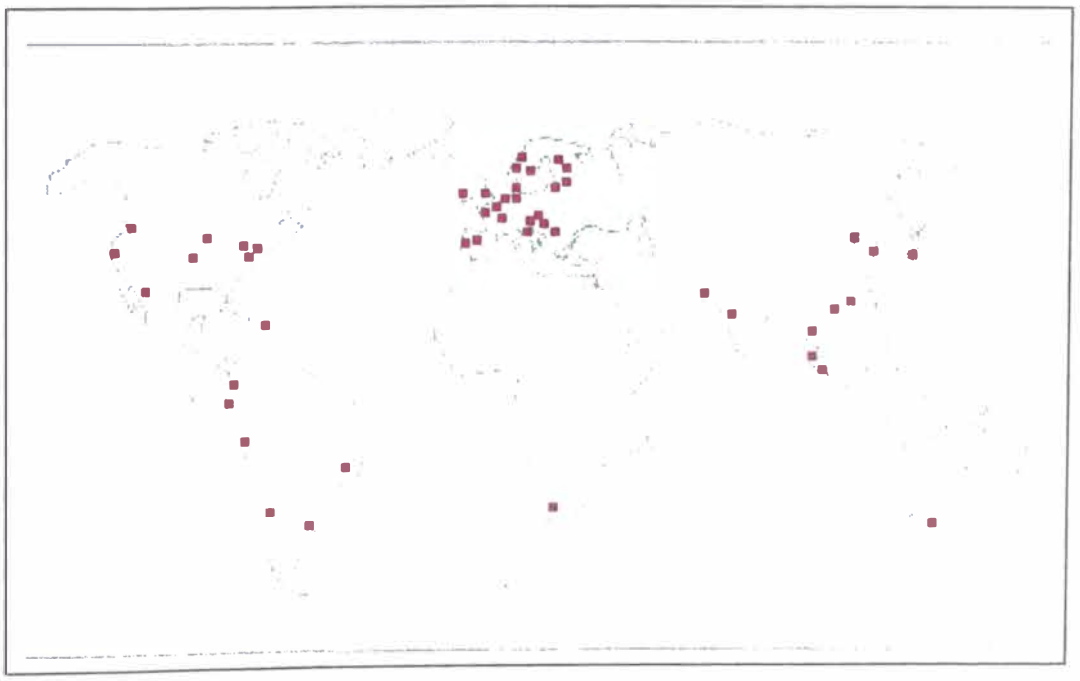
Cabe resaltar que los puntos expuestos son demasiado amplios para analizarlos en el presente informe.

CAPÍTULO II

DESCRIPCION DE LA EMPRESA

2.1 PRESENTACIÓN:

Esta empresa Farmacéutica es uno de los proveedores más reconocidos por los profesionales de la salud. Con 41.666 colaboradores, además investiga, desarrolla, produce y distribuye productos y servicios sanitarios en todo el mundo.



En España durante el 2010, alcanzó un volumen de negocio de 4.422,8 millones de euros, suministrando a múltiples áreas de la medicina.

Hoy en día esta empresa es uno de los proveedores mundiales más reconocidos por los profesionales de la salud, con una amplia gama de suministros para hospitales: productos farmacéuticos, aparatos quirúrgicos, equipamientos médicos y servicios diversos.

En el Perú está presente desde hace 20 años y actualmente produce en su planta Farma un promedio de un millón de soluciones parenterales al mes, así como cerca de 140,000 galones de soluciones para hemodiálisis y soluciones orales".

Actualmente este laboratorio exporta soluciones parenterales a países como Chile y Ecuador. En este último es uno de los principales proveedores del Seguro Social Ecuatoriano así como la Junta de Beneficencia de Guayaquil.

También, con estos productos de alta calidad se ha convertido en un proveedor estratégico del estado peruano al vender sus productos tanto en Seguridad Social, como en hospitales del Ministerio de Salud, Fuerzas Armas y clínicas. B. Braun es el líder indiscutido del mercado sueros y soluciones médicas.

2.2. SERVICIOS

Su principal objetivo es brindar el máximo apoyo al sector sanitario .

Los cambios en las regulaciones legales y la presión económica están obligando a cambiar modelos y formas de actuar en el sector sanitario: se impone una mayor eficiencia, un análisis detallado de todos los procesos y el coraje de asumir cambios.

Esta empresa ofrece una amplia gama de servicios para ayudar en esta reorientación, tanto en el campo de la **formación y capacitación** adicional para profesionales sanitarios como en la **optimización de procesos** o en la **externalización de servicios hospitalarios**.

2.3 DIVISIONES

Cuenta con cuatro divisiones comerciales: Hospital Care ó División de Cuidados Hospitalarios, línea que incluye productos como soluciones parenterales, cáteres, anestesia regional, nutrición parenteral entre otros; División OPM-Out Patient Market, con productos para desarrollar terapias en casa; División Avitum con soluciones médicas para el tratamiento de diálisis crónicas y División Aesculap que comercializa productos y equipos para las diferentes especialidades quirúrgicas.

CAPÍTULO III

GENERALIDADES DE TUBERIAS Y VAPOR

3.1 EL VAPOR

El vapor se produce con unas condiciones termodinámicas constantes, las cuales son temperatura y presión constante. Esto se da en un dispositivo llamado caldera la cual pueden ser acuotubulares o pirotubulares lo cual dice por donde va a pasar los gases calientes de la combustión. Esta máquina térmica solo genera vapor saturado seco ya que de lo contrario el vapor generado tendría una presión superior al de la entrada de la caldera y se devolvería.

A la presión atmosférica la temperatura de saturación es de 100 ° C. Sin embargo, si la presión se incrementa, lo que permitirá la adición de más calor y un aumento de la temperatura sin un cambio de fase.

La relación entre la temperatura de saturación y la presión que se conoce como la curva de saturación de vapor (Ver Figura 3.1).

El agua y el vapor pueden coexistir en cualquier presión sobre esta curva, ambos en la temperatura de saturación.

Vapor a una condición por encima de la curva de saturación se conoce como vapor sobrecalentado:

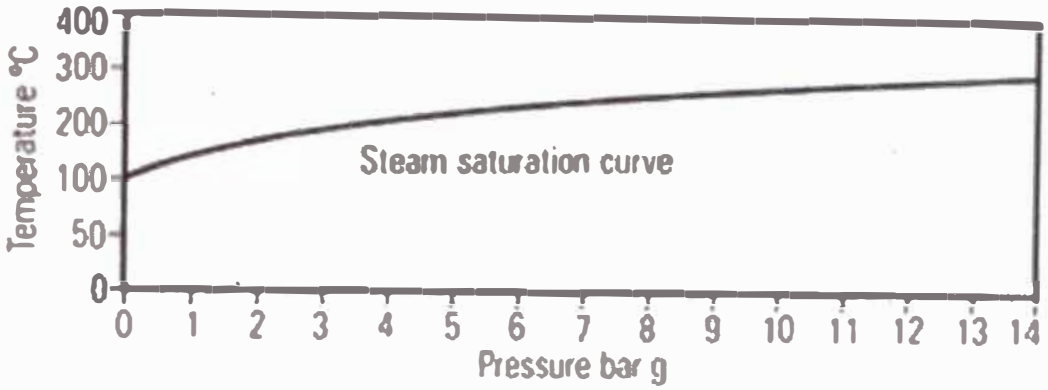


Figura 3.1 Curva de Saturación de Vapor

La temperatura por encima de la temperatura de saturación se denomina el grado de recalentamiento del vapor.

El agua en una condición bajo la curva se llama sub-saturada de agua. Si el vapor es capaz de fluir de la caldera a la misma velocidad que se produce, la adición de calor más simplemente aumenta la tasa de producción. Si el vapor se le impide salir de la caldera, y la tasa de entrada de calor se mantiene, la energía que fluye en la caldera será mayor que la energía que fluye. Este exceso de energía aumenta la presión, permitiendo a su vez la temperatura de saturación en aumento, como la temperatura del vapor saturado se correlaciona con la presión.

3.1.1. Características del Vapor

El vapor de agua es el fluido térmico más ampliamente utilizado. La generalización del uso está basada en un conjunto de características singulares que le convierten en prácticamente insustituible. Son destacables:

- Materia prima barata y asequible.
- Amplio rango de temperatura.
- Inflamable y no tóxico.

- Fácilmente transportable por tubería.
- Elevado calor de condensación.
- Elevado calor específico.
- Temperatura de condensación fácilmente regulable.

3.1.2. Ventajas del uso del vapor

- El uso de tuberías de vapor es relativamente seguro en comparación con el uso de tuberías de gas o petróleo altamente inflamable.
- Es fácil de controlar las temperaturas de proceso con la multitud de válvulas y accesorios para equipos en el mercado para el uso con vapor de agua.
- Es bien sabido, ha ganado el respeto entre los operadores de la planta en todo el mundo, y es muy predecible y estable.
- El agua es uno de los más baratos y abundantes materiales en la faz de la tierra, y para las presiones encontradas en el sector de calderas industriales.
- No necesita bombas para ser transportado de un lugar a otro (se realiza desde la misma caldera), que es el corazón de la red).
- El vapor tiene un elevado poder calorífico por unidad de masa. Eso significa que nos permite transportar una buena cantidad de energía de un lugar a otro por cada unidad de masa.
- Tiene un excelente coeficiente de transferencia térmica (2,3 a 2,9 kW/m² °C). O sea, resulta fácil que el vapor "suelte" el calor que transporta en un punto más frío.

- Ese potencial energético puede ser utilizado para producir trabajo en turbinas (producir energía eléctrica) o bombas (producir energía mecánica).

3.2 TUBERIAS

Las principales normas que rigen todo lo concerniente a los sistemas de tuberías y su instalación constituyen las bases de muchas leyes relativas a la seguridad. La norma de mayor envergadura en esta aplicación es el Código ASME para calderas y recipientes a presión, el cual en sus secciones I, II, III, VIII, IX y XI define claramente los requerimientos mínimos que consolidan la óptima instalación de un sistema.

Enfatizando en el planteamiento de tuberías a presión, se encuentran diferentes secciones separadas para este código que enmarcan la implantación de estos sistemas:

- Tuberías para Sistemas de Potencia B31.1
- Tuberías para Gases Combustibles B31.2
- Tuberías Plantas Químicas y Refinerías de Petróleo B31.3
- Tuberías para transporte de petróleo líquido B31.4
- Tuberías para Refrigeración B31.5
- Tuberías para transmisión y distribución de Gas B31.8
- Tuberías para Servicios en Edificios B31.9

Indudablemente existen muchas otras organizaciones que se han dedicado a resaltar los requerimientos en las instalaciones de tuberías como tal. Entre ellas podemos mencionar El Instituto Americano de Petróleo (API), La

Sociedad Americana para Pruebas y Materiales (ASTM), La Asociación Nacional de Protección Contra Incendios (NFPA), El Instituto Nacional Americano de Normas (ANSI), etc.

3.2.1 Especificaciones técnicas para tuberías:

Las tuberías con destinación industrial tienen una muy amplia aplicación, pues es por medio de ellas que se transportan todos los fluidos (gases, mezclas, líquidos, etc.) para optimizar y no limitar los procesos industriales.

Existen tubos con costura y sin costura, la diferencia entre ellos radica en el modo de fabricación. Los primeros basan su manufactura en la soldadura, mientras los segundos no.

Modo de Especificación:

Denominación: Diámetro, Costura, SCH, Material, Longitud, Tolerancia.

- **Diámetro:** Diámetro nominal de la tubería en pulgadas.
- **Costura:** SMLS (Tubería sin costura), Welded (Tubería con costura.
- **SCH:** Schedule de la tubería.
- **Material:** Material de la tubería. Ej. ASTM A 53 gr. B –Api 5L
- **Longitud:** Longitud por pieza. Ej. Piezas de 6m de largo.
- **Tolerancia:** Tolerancia de longitud de la tubería.

3.2.2 Tablas Normalizadas de dimensiones y pesos de tuberías:

Tabla 3. 1 Tabla de dimensiones y propiedades mecánicas.

X2. TABLES FOR DIMENSIONAL AND CERTAIN MECHANICAL REQUIREMENTS

X2.1 Tables X2.1-X2.4 address dimensional and certain mechanical requirements.

TABLE X2.1 Calculated *H* Values for Seamless Pipe

NPS Designator	DN Designator	Outside Diameter, in. [mm]	Nominal Wall Thickness, in. [mm]	Distance, in. [mm], Between Plates "H" by Formula: $H = (1 + e)/(e + 0.08)$	
				Grade A	Grade B
2½	65	2.875 [73.0]	0.203 [5.16]	1.378 [35.0]	1.545 [39.2]
			0.276 [7.01]	1.618 [41.1]	1.775 [45.2]
3	80	3.500 [88.9]	0.216 [5.49]	1.552 [39.4]	1.755 [44.6]
			0.300 [7.62]	1.861 [47.3]	2.052 [52.4]
3½	90	4.000 [101.6]	0.225 [5.74]	1.682 [42.7]	1.912 [48.6]
			0.318 [8.08]	2.045 [51.9]	2.276 [57.8]
4	100	4.500 [114.3]	0.237 [6.02]	1.811 [46.0]	2.067 [52.5]
			0.337 [8.56]	2.228 [56.6]	2.485 [63.2]
5	125	5.563 [141.3]	0.258 [6.55]	2.062 [52.4]	2.372 [60.2]
			0.375 [9.52]	2.597 [66.0]	2.920 [74.2]
6	150	6.625 [168.3]	0.280 [7.11]	2.308 [58.6]	2.665 [67.8]
			0.432 [10.97]	3.034 [77.1]	3.419 [86.8]
8	200	8.625 [219.1]	0.277 [7.04]	2.473 [62.8]	2.902 [73.7]
			0.322 [8.18]	2.757 [70.0]	3.210 [81.5]
			0.500 [12.70]	3.683 [93.5]	4.181 [106.2]
10	250	10.750 [273.0]	0.279 [7.09]*	2.523 [66.6]	3.111 [79.0]
			0.307 [7.80]	2.823 [71.7]	3.333 [84.7]
			0.365 [9.27]	3.210 [81.5]	3.757 [95.4]
			0.500 [12.70]	3.953 [101.4]	4.592 [116.6]
12	300	12.750 [323.8]	0.300 [7.62]	3.105 [78.9]	3.683 [93.5]
			0.375 [9.52]	3.423 [86.9]	4.037 [102.5]
			0.500 [12.70]	4.218 [107.1]	4.699 [124.4]
14	350	14.000 [355.6]	0.375 [9.52]	3.500 [88.9]	4.146 [105.3]
			0.500 [12.70]	4.336 [110.1]	5.061 [128.5]
16	400	16.000 [406.4]	0.375 [9.52]	3.603 [91.5]	4.294 [109.1]
			0.500 [12.70]	4.454 [113.1]	5.284 [134.2]
18	450	18.000 [457]	0.375 [9.52]	3.669 [93.7]	4.417 [112.2]
			0.500 [12.70]	4.628 [117.6]	5.472 [139.0]
20	500	20.000 [508]	0.375 [9.52]	3.758 [95.5]	4.521 [114.8]
			0.500 [12.70]	4.740 [120.4]	5.632 [143.1]
24	600	24.000 [610]	0.375 [9.52]	3.869 [98.3]	4.686 [119.0]
			0.500 [12.70]	4.918 [124.9]	5.890 [149.5]

* Special order only.

Tabla 3. 2. Tabla de dimensiones, pesos y presiones en las tuberías.

TABLE X2.2 Dimensions, Weights, and Test Pressures for Plain End Pipe

NPS Designator	DN Designator	Outside Diameter, in. [mm]	Nominal Wall Thickness, in. [mm]	Nominal Weight (Mass) per Unit Length, Plain End, lbft [kg/m]	Weight Class	Schedule No.	Test Pressure,[4] psi [kPa]	
							Grade A	Grade B
⅛	6	0.405 [10.3]	0.068 [1.73]	0.24 [0.37]	STD	40	700 [4800]	700 [4800]
			0.095 [2.41]	0.31 [0.47]	XS	80	850 [5900]	850 [5900]
¼	8	0.540 [13.7]	0.088 [2.24]	0.43 [0.63]	STD	40	700 [4800]	700 [4800]
			0.119 [3.02]	0.54 [0.80]	XS	80	850 [5900]	850 [5900]
⅜	10	0.675 [17.1]	0.091 [2.31]	0.57 [0.84]	STD	40	700 [4800]	700 [4800]
			0.126 [3.20]	0.74 [1.10]	XS	80	950 [5900]	850 [5900]
½	15	0.840 [21.3]	0.109 [2.77]	0.85 [1.27]	STD	40	700 [4800]	700 [4800]
			0.147 [3.73]	1.09 [1.62]	XS	80	850 [5900]	850 [5900]
			0.188 [4.78]	1.31 [1.95]	—	160	900 [6200]	900 [6200]
			0.294 [7.47]	1.72 [2.55]	XXS	—	1000 [6900]	1000 [6900]
¾	20	1.050 [26.7]	0.113 [2.87]	1.13 [1.69]	STD	40	700 [4800]	700 [4800]
			0.154 [3.91]	1.48 [2.20]	XS	80	850 [5900]	850 [5900]
			0.219 [5.56]	1.95 [2.90]	—	160	950 [6500]	950 [6500]
			0.308 [7.82]	2.44 [3.64]	XXS	—	1000 [6900]	1000 [6900]
1	25	1.315 [33.4]	0.133 [3.38]	1.68 [2.50]	STD	40	700 [4800]	700 [4800]
			0.179 [4.55]	2.17 [3.24]	XS	80	850 [5900]	850 [5900]
			0.250 [6.35]	2.85 [4.24]	—	160	950 [6500]	950 [6500]
			0.358 [9.09]	3.66 [5.45]	XXS	—	1000 [6900]	1000 [6900]
1¼	32	1.660 [42.2]	0.140 [3.56]	2.27 [3.39]	STD	40	1200 [8300]	1300 [9000]
			0.191 [4.85]	3.00 [4.47]	XS	80	1800 [12 400]	1900 [13 100]
			0.250 [6.35]	3.77 [5.61]	—	160	1900 [13 100]	2000 [13 800]
			0.382 [9.70]	5.22 [7.77]	XXS	—	2200 [15 200]	2300 [15 900]
1½	40	1.900 [48.3]	0.145 [3.68]	2.72 [4.05]	STD	40	1200 [8300]	1300 [9000]
			0.200 [5.08]	3.63 [5.41]	XS	80	1800 [12 400]	1900 [13 100]
			0.281 [7.14]	4.86 [7.25]	—	160	1950 [13 400]	2050 [14 100]
			0.400 [10.16]	6.41 [9.56]	XXS	—	2200 [15 200]	2300 [15 900]
2	50	2.375 [60.3]	0.154 [3.91]	3.66 [5.44]	STD	40	2300 [15 900]	2500 [17 200]
			0.218 [5.54]	5.03 [7.48]	XS	80	2500 [17 200]	2500 [17 200]
			0.344 [8.74]	7.47 [11.11]	—	160	2500 [17 200]	2500 [17 200]
			0.436 [11.07]	9.04 [13.44]	XXS	—	2500 [17 200]	2500 [17 200]
2½	65	2.875 [73.0]	0.203 [5.16]	5.80 [8.63]	STD	40	2500 [17 200]	2500 [17 200]
			0.276 [7.01]	7.67 [11.41]	XS	80	2500 [17 200]	2500 [17 200]
			0.375 [9.52]	10.02 [14.90]	—	160	2500 [17 200]	2500 [17 200]
			0.552 [14.02]	13.71 [20.39]	XXS	—	2500 [17 200]	2500 [17 200]
3	80	3.500 [88.9]	0.125 [3.18]	4.51 [6.72]	—	—	1290 [8900]	1500 [10 000]
			0.156 [3.96]	5.58 [8.29]	—	—	1600 [11 000]	1870 [12 900]
			0.188 [4.78]	6.66 [9.92]	—	—	1930 [13 330]	2250 [15 500]
			0.216 [5.49]	7.58 [11.29]	STD	40	2220 [15 300]	2500 [17 200]
			0.250 [6.35]	8.69 [12.93]	—	—	2500 [17 200]	2500 [17 200]
			0.281 [7.14]	9.67 [14.40]	—	—	2500 [17 200]	2500 [17 200]
			0.300 [7.62]	10.26 [15.27]	XS	80	2500 [17 200]	2500 [17 200]
			0.438 [11.13]	14.34 [21.35]	—	160	2500 [17 200]	2500 [17 200]
			0.600 [15.24]	18.60 [27.68]	XXS	—	2500 [17 200]	2500 [17 200]
3½	90	4.000 [101.6]	0.125 [3.18]	5.18 [7.72]	—	—	1120 [7700]	1310 [9 000]
			0.156 [3.96]	6.41 [9.53]	—	—	1400 [9700]	1640 [11 300]
			0.188 [4.78]	7.66 [11.41]	—	—	1690 [11 700]	1970 [13 500]
			0.226 [5.74]	9.12 [13.57]	STD	40	2030 [14 000]	2370 [16 300]
			0.250 [6.35]	10.02 [14.92]	—	—	2250 [15 500]	2500 [17 200]
			0.281 [7.14]	11.17 [16.63]	—	—	2500 [17 200]	2500 [17 200]
			0.318 [8.05]	12.52 [18.63]	XS	80	2800 [19 300]	2800 [19 300]
4	100	4.500 [114.3]	0.125 [3.18]	5.85 [8.71]	—	—	1000 [6900]	1170 [8100]
			0.156 [3.96]	7.24 [10.73]	—	—	1250 [8600]	1460 [10 100]
			0.188 [4.78]	8.67 [12.91]	—	—	1500 [10 300]	1750 [12 100]
			0.219 [5.56]	10.02 [14.91]	—	—	1750 [12 100]	2040 [14 100]
			0.237 [6.02]	10.80 [16.07]	STD	40	1900 [13 100]	2210 [15 200]
			0.250 [6.35]	11.36 [16.90]	—	—	2036 [13 800]	2370 [16 100]
			0.281 [7.14]	12.67 [18.87]	—	—	2250 [15 100]	2622 [18 100]
			0.312 [7.92]	13.97 [20.78]	—	—	2500 [17 200]	2800 [19 300]

Tabla 3. 3 Tabla de dimensiones, pesos y presiones en las tuberías.

TABLE X2.2 *Continued*

NPS Designator	DN Designator	Outside Diameter, in. [mm]	Nominal Wall Thickness, in. [mm]	Nominal Weight [Mass] per Unit Length, Plain End, lb/ft [kg/m]	Weight Class	Schedule No.	Test Pressure,[A] psi [kPa]	
							Grade A	Grade B
			0.337 [8.56]	15.90 [22.32]	XS	80	2790 [18 600]	2800 [19 300]
			0.438 [11.13]	19.02 [28.32]	...	120	2800 [19 300]	2800 [19 300]
			0.531 [13.49]	22.53 [33.54]	...	160	2800 [19 300]	2800 [19 300]
			0.674 [17.12]	27.57 [41.03]	XXS	...	2800 [19 300]	2800 [19 300]
5	125	5.563 [141.3]	0.156 [3.96]	9.02 [13.41]	...	...	1010 [7000]	1160 [8100]
			0.188 [4.78]	10.80 [16.09]	...	...	1220 [8400]	1420 [9800]
			0.219 [5.56]	12.51 [18.61]	...	...	1420 [9800]	1650 [11 400]
			0.258 [6.55]	14.63 [21.77]	STD	40	1670 [11 500]	1950 [13 400]
			0.281 [7.14]	15.87 [23.62]	...	...	1820 [12 500]	2120 [14 600]
			0.312 [7.92]	17.51 [26.05]	...	...	2020 [13 900]	2360 [16 300]
			0.344 [8.74]	19.19 [28.57]	...	...	2230 [15 400]	2600 [17 900]
			0.375 [9.52]	20.80 [30.94]	XS	80	2430 [16 800]	2800 [19 300]
			0.500 [12.70]	27.06 [40.28]	...	120	2800 [19 300]	2800 [19 300]
			0.625 [15.88]	32.99 [49.11]	...	160	2800 [19 300]	2800 [19 300]
			0.750 [19.05]	38.59 [57.43]	XXS	...	2800 [19 300]	2800 [19 300]
6	150	6.625 [168.3]	0.188 [4.78]	12.94 [19.27]	...	...	1020 [7000]	1190 [8200]
			0.219 [5.56]	15.00 [22.31]	...	...	1190 [8200]	1390 [9600]
			0.250 [6.35]	17.04 [25.36]	...	...	1360 [9400]	1590 [10 900]
			0.280 [7.11]	18.99 [28.26]	STD	40	1520 [10 500]	1780 [12 300]
			0.312 [7.92]	21.06 [31.32]	...	...	1700 [11 700]	1980 [13 700]
			0.344 [8.74]	23.10 [34.39]	...	...	1870 [12 900]	2180 [15 000]
			0.375 [9.52]	25.05 [37.29]	...	...	2040 [14 100]	2380 [16 400]
			0.432 [10.97]	28.50 [42.56]	XS	80	2350 [16 200]	2740 [18 900]
			0.562 [14.27]	36.43 [54.20]	...	120	2800 [19 300]	2800 [19 300]
			0.719 [18.26]	45.39 [67.56]	...	160	2800 [19 300]	2800 [19 300]
			0.864 [21.95]	53.21 [79.22]	XXS	...	2800 [19 300]	2800 [19 300]
8	200	8.625 [219.1]	0.188 [4.78]	16.96 [25.26]	...	...	780 [5400]	920 [6300]
			0.203 [5.16]	18.28 [27.22]	...	...	850 [5900]	1000 [6900]
			0.219 [5.56]	19.68 [29.29]	...	...	910 [6300]	1070 [7400]
			0.250 [6.35]	22.36 [33.31]	...	20	1040 [7200]	1220 [8400]
			0.277 [7.04]	24.72 [36.81]	...	30	1160 [7800]	1350 [9300]
			0.312 [7.92]	27.73 [41.24]	...	...	1300 [9000]	1520 [10 500]
			0.322 [8.18]	28.58 [42.55]	STD	40	1340 [9200]	1570 [10 800]
			0.344 [8.74]	30.45 [45.34]	...	...	1440 [9900]	1680 [11 600]
			0.375 [9.52]	33.07 [49.20]	...	...	1570 [10 800]	1830 [12 600]
			0.406 [10.31]	35.67 [53.08]	...	60	1700 [11 700]	2000 [13 800]
			0.438 [11.13]	38.33 [57.08]	...	...	1830 [12 600]	2130 [14 700]
			0.500 [12.70]	43.43 [64.64]	XS	80	2090 [14 400]	2430 [16 800]
			0.594 [15.09]	51.00 [75.92]	...	100	2500 [17 200]	2800 [19 300]
			0.719 [18.26]	60.77 [90.44]	...	120	2800 [19 300]	2800 [19 300]
			0.812 [20.62]	67.82 [100.92]	...	140	2800 [19 300]	2800 [19 300]
			0.875 [22.22]	72.49 [107.88]	XXS	...	2800 [19 300]	2800 [19 300]
			0.906 [23.01]	74.76 [111.27]	...	160	2800 [19 300]	2800 [19 300]
10	250	10.750 [273.0]	0.188 [4.78]	21.23 [31.62]	...	...	630 [4300]	730 [5000]
			0.203 [5.16]	22.89 [34.08]	...	...	680 [4700]	800 [5500]
			0.219 [5.56]	24.65 [36.67]	...	...	730 [5000]	860 [5900]
			0.250 [6.35]	28.06 [41.75]	...	20	840 [5800]	980 [6800]
			0.279 [7.09]	31.23 [46.49]	...	...	930 [6400]	1090 [7500]
			0.307 [7.80]	34.27 [51.01]	...	30	1030 [7100]	1200 [8300]
			0.344 [8.74]	38.27 [56.96]	...	...	1150 [7900]	1340 [9200]
			0.365 [9.27]	40.52 [60.29]	STD	40	1220 [8400]	1430 [9900]
			0.438 [11.13]	48.28 [71.87]	...	...	1470 [10 100]	1710 [11 800]
			0.500 [12.70]	54.79 [81.52]	XS	60	1670 [11 500]	1950 [13 400]
			0.594 [15.09]	64.49 [95.97]	...	80	1990 [13 700]	2325 [16 000]
			0.719 [18.26]	77.10 [114.70]	...	100	2410 [16 600]	2800 [19 300]
			0.844 [21.44]	89.38 [133.00]	...	120	2800 [19 300]	2800 [19 300]
			1.000 [25.40]	104.23 [155.09]	XXS	140	2800 [19 300]	2800 [19 300]
			1.125 [28.57]	115.75 [172.21]	...	160	2800 [19 300]	2800 [19 300]
12	300	12.750 [323.8]	0.203 [5.16]	27.23 [40.55]	...	...	570 [3900]	670 [4500]
			0.219 [5.56]	29.34 [43.63]	...	...	620 [4300]	720 [5000]
			0.250 [6.35]	33.41 [49.71]	...	20	710 [4900]	820 [5700]
			0.281 [7.14]	37.46 [55.75]	...	...	790 [5400]	930 [6400]
			0.312 [7.92]	41.48 [61.69]	...	...	860 [6100]	1030 [7100]
			0.330 [8.38]	43.81 [65.18]	...	30	930 [6400]	1090 [7500]
			0.344 [8.74]	45.62 [67.90]	...	...	970 [6700]	1130 [7800]
			0.375 [9.52]	49.61 [73.78]	STD	...	1060 [7300]	1240 [8500]

Tabla 3. 4 Tabla de dimensiones, pesos y presiones en las tuberías.

TABLE X2.2 *Continued*

NPS Designator	DN Designator	Outside Diameter, in. [mm]	Nominal Wall Thickness, in. [mm]	Nominal Weight [Mass] per Unit Length, Plain End, lbm [kg/m]	Weight Class	Schedule No.	Test Pressure,[A] psi [kPa]	
							Grade A	Grade B
			0.406 [10.31]	53.57 [79.70]	...	40	1150 [7900]	1340 [9200]
			0.438 [11.13]	57.65 [85.82]	...	...	1240 [8500]	1440 [9900]
			0.500 [12.70]	65.48 [97.43]	XS	...	1410 [9700]	1650 [11 400]
			0.562 [14.27]	73.22 [108.92]	...	60	1590 [11 000]	1850 [12 800]
			0.688 [17.46]	88.71 [132.04]	...	80	1940 [13 400]	2270 [15 700]
			0.844 [21.44]	107.42 [159.86]	...	100	2390 [16 500]	2780 [19 200]
			1.000 [25.40]	125.61 [186.91]	XXS	120	2800 [19 300]	2800 [19 300]
			1.125 [28.57]	139.81 [208.00]	...	140	2800 [19 300]	2800 [19 300]
			1.312 [33.32]	160.42 [238.68]	...	160	2800 [19 300]	2800 [19 300]
14	350	14.000 [355.6]	0.210 [5.33]	30.96 [46.04]	...	...	540 [3700]	630 [4300]
			0.219 [5.56]	32.26 [47.99]	...	...	560 [3900]	660 [4500]
			0.250 [6.35]	36.75 [54.69]	...	10	640 [4400]	750 [5200]
			0.281 [7.14]	41.21 [61.35]	...	...	720 [5000]	840 [5800]
			0.312 [7.92]	45.65 [67.90]	...	20	800 [5500]	940 [6500]
			0.344 [8.74]	50.22 [74.76]	...	...	880 [6100]	1030 [7100]
			0.375 [9.52]	54.62 [81.25]	STD	30	960 [6600]	1120 [7700]
			0.438 [11.13]	63.50 [94.55]	...	40	1130 [7800]	1310 [9000]
			0.469 [11.91]	67.84 [100.94]	...	...	1210 [8300]	1410 [9700]
			0.500 [12.70]	72.16 [107.39]	XS	...	1290 [8900]	1500 [10 300]
			0.594 [15.09]	85.13 [126.71]	...	60	1530 [10 500]	1790 [12 300]
			0.750 [19.05]	106.23 [158.10]	...	80	1930 [13 300]	2250 [15 500]
			0.938 [23.83]	130.98 [194.96]	...	100	2410 [16 600]	2800 [19 300]
			1.094 [27.75]	150.93 [224.65]	...	120	2800 [19 300]	2800 [19 300]
			1.250 [31.75]	170.37 [253.56]	...	140	2800 [19 300]	2800 [19 300]
			1.406 [35.71]	189.29 [281.70]	...	160	2800 [19 300]	2800 [19 300]
			2.000 [50.80]	256.56 [381.83]	...	...	2800 [19 300]	2800 [19 300]
			2.125 [53.97]	259.76 [401.44]	...	...	2800 [19 300]	2800 [19 300]
			2.200 [55.88]	277.51 [413.01]	...	...	2800 [19 300]	2800 [19 300]
			2.500 [63.50]	307.34 [457.40]	...	...	2800 [19 300]	2800 [19 300]
16	400	16.000 [406.4]	0.219 [5.56]	36.95 [54.95]	...	...	490 [3400]	570 [3900]
			0.250 [6.35]	42.09 [62.64]	...	10	560 [3900]	660 [4500]
			0.281 [7.14]	47.22 [70.30]	...	...	630 [4350]	740 [5100]
			0.312 [7.92]	52.32 [77.83]	...	20	700 [4800]	820 [5700]
			0.344 [8.74]	57.57 [85.71]	...	...	770 [5300]	900 [6200]
			0.375 [9.52]	62.64 [93.17]	STD	30	840 [5900]	980 [6800]
			0.438 [11.13]	72.86 [108.49]	...	...	950 [6600]	1150 [7900]
			0.469 [11.91]	77.87 [115.86]	...	...	1060 [7300]	1230 [8500]
			0.500 [12.70]	82.85 [123.30]	XS	40	1120 [7700]	1310 [9000]
			0.656 [16.66]	107.50 [160.12]	...	60	1480 [10 200]	1720 [11 900]
			0.844 [21.44]	136.74 [203.53]	...	80	1900 [13 100]	2220 [15 300]
			1.031 [26.19]	164.98 [245.56]	...	100	2320 [16 000]	2710 [18 700]
			1.219 [30.96]	192.61 [286.64]	...	120	2740 [18 900]	2800 [19 300]
			1.438 [36.53]	223.85 [333.19]	...	140	2800 [19 300]	2800 [19 300]
			1.594 [40.49]	245.48 [365.35]	...	160	2800 [19 300]	2800 [19 300]
18	450	18.000 [457]	0.250 [6.35]	47.44 [70.60]	...	10	500 [3400]	580 [4000]
			0.281 [7.14]	53.23 [79.24]	...	...	560 [3900]	660 [4500]
			0.312 [7.92]	58.99 [87.75]	...	20	620 [4300]	730 [5000]
			0.344 [8.74]	64.93 [96.66]	...	...	690 [4800]	800 [5500]
			0.375 [9.52]	70.65 [105.10]	STD	...	750 [5200]	860 [6100]
			0.406 [10.31]	76.36 [113.62]	...	...	810 [5600]	950 [6500]
			0.438 [11.13]	82.23 [122.43]	...	30	860 [6100]	1020 [7000]
			0.469 [11.91]	87.89 [130.78]	...	...	940 [6500]	1090 [7500]
			0.500 [12.70]	93.54 [139.20]	XS	...	1000 [6900]	1170 [8100]
			0.562 [14.27]	104.76 [155.87]	...	40	1120 [7700]	1310 [9000]
			0.750 [19.05]	138.30 [205.83]	...	60	1500 [10 300]	1750 [12 100]
			0.938 [23.83]	171.08 [254.67]	...	80	1880 [13 000]	2190 [15 100]
			1.156 [29.36]	208.15 [309.76]	...	100	2310 [15 900]	2700 [18 600]
			1.375 [34.92]	244.37 [363.64]	...	120	2750 [19 000]	2800 [19 300]
			1.562 [39.67]	274.48 [408.45]	...	140	2800 [19 300]	2800 [19 300]
			1.781 [45.24]	308.79 [459.59]	...	160	2800 [19 300]	2800 [19 300]
20	500	20.000 [508]	0.250 [6.35]	52.78 [73.55]	...	10	450 [3100]	520 [3600]
			0.281 [7.14]	59.23 [88.19]	...	...	510 [3500]	590 [4100]
			0.312 [7.92]	65.66 [97.67]	...	...	560 [3900]	660 [4500]
			0.344 [8.74]	72.28 [107.60]	...	...	620 [4300]	720 [5000]
			0.375 [9.52]	78.67 [117.02]	STD	20	680 [4700]	790 [5400]
			0.406 [10.31]	84.04 [126.53]	...	...	730 [5000]	850 [5900]
			0.438 [11.13]	91.59 [136.37]	...	...	790 [5400]	920 [6300]

Tabla 3. 5 Tabla de dimensiones, pesos y presiones en las tuberías.

TABLE X2.2 *Continued*

NPS Designator	DN Designator	Outside Diameter, in. [mm]	Nominal Wall Thickness, in. [mm]	Nominal Weight [Mass] per Unit Length, Plain End, lb/ft [kg/m]	Weight Class	Schedule No.	Test Pressure,[A] psi [kPa]	
							Grade A	Grade B
			0.469 [11.91]	97.92 [145.70]	...	...	850 [5900]	950 [6500]
			0.500 [12.70]	104.23 [155.12]	XS	30	900 [6200]	1050 [7200]
			0.594 [15.09]	123.23 [183.42]	...	40	1170 [8100]	1250 [8600]
			0.812 [20.62]	166.56 [247.83]	...	60	1460 [10 100]	1710 [11 800]
			1.031 [26.19]	209.06 [311.17]	...	80	1850 [12 800]	2170 [15 000]
			1.281 [32.54]	256.34 [381.53]	...	100	2310 [15 900]	2690 [18 500]
			1.500 [38.10]	296.65 [441.49]	...	120	2700 [18 600]	2800 [19 300]
			1.750 [44.45]	341.41 [508.11]	...	140	2800 [19 300]	2800 [19 300]
			1.969 [50.01]	379.53 [564.81]	...	160	2800 [19 300]	2800 [19 300]
24	600	24.000 [610]	0.250 [6.35]	63.47 [94.46]	...	10	380 [2600]	440 [3000]
			0.281 [7.14]	71.25 [106.06]	...	...	420 [2900]	490 [3400]
			0.312 [7.92]	79.01 [117.61]	...	...	470 [3200]	550 [3800]
			0.344 [8.74]	86.99 [129.50]	...	...	520 [3600]	600 [4100]
			0.375 [9.52]	94.71 [140.96]	STD	20	560 [3900]	660 [4500]
			0.406 [10.31]	102.40 [152.37]	...	...	610 [4200]	710 [4900]
			0.438 [11.13]	110.32 [164.26]	...	...	660 [4500]	770 [5300]
			0.469 [11.91]	117.98 [175.54]	...	...	700 [4800]	820 [5700]
			0.500 [12.70]	125.61 [186.94]	XS	...	750 [5200]	880 [6100]
			0.562 [14.27]	140.81 [209.50]	...	30	840 [5800]	980 [6800]
			0.688 [17.48]	171.45 [255.24]	...	40	1030 [7100]	1200 [8300]
			0.938 [23.83]	231.25 [344.23]	...	...	1410 [9700]	1640 [11 300]
			0.969 [24.61]	238.57 [355.02]	...	60	1450 [10 000]	1700 [11 700]
			1.219 [30.96]	296.86 [441.76]	...	80	1830 [12 600]	2130 [14 700]
			1.531 [38.89]	367.74 [547.33]	...	100	2300 [15 900]	2680 [18 500]
			1.812 [46.02]	429.79 [639.58]	...	120	2720 [18 800]	2800 [19 300]
			2.062 [52.37]	483.57 [719.63]	...	140	2800 [19 300]	2800 [19 300]
			2.344 [59.54]	542.64 [807.63]	...	160	2800 [19 300]	2800 [19 300]
26	650	26.000 [660]	0.250 [6.35]	68.82 [102.42]	...	...	350 [2400]	400 [2800]
			0.281 [7.14]	77.26 [115.02]	...	...	350 [2700]	450 [3100]
			0.312 [7.92]	85.68 [127.43]	...	10	430 [3000]	500 [3400]
			0.344 [8.74]	94.35 [140.45]	...	...	480 [3300]	560 [3900]
			0.375 [9.52]	102.72 [152.80]	STD	...	520 [3600]	610 [4200]
			0.406 [10.31]	111.08 [165.26]	...	...	560 [3900]	660 [4500]
			0.438 [11.13]	119.69 [178.20]	...	...	610 [4200]	710 [4900]
			0.469 [11.91]	128.00 [190.46]	...	...	650 [4500]	760 [5200]
			0.500 [12.70]	136.30 [202.85]	XS	20	690 [4800]	810 [5600]
			0.562 [14.27]	152.83 [227.37]	...	...	780 [5400]	910 [6300]

[A] The minimum test pressure for outside diameters and wall thicknesses not listed shall be computed by the formula given below. The computed test pressure shall be used in all cases with the following exceptions:

(1) When the wall thickness is greater than the heaviest wall thickness shown for a given diameter, the test pressure for the heaviest wall listed shall be the required test pressure.

(2) For Grades A and B in sizes under NPS 2 [DN 50] when the wall thickness is lighter than the lightest shown for a given diameter, use the test pressure given for the lightest wall thickness of the table for the diameter involved.

(3) For all sizes of Grade A and B pipe smaller than NPS 2 [DN 50], the test pressure has been arbitrarily assigned. Test pressures for intermediate outside diameters need not exceed those for the next larger listed size.

$$P = \frac{2St}{D}$$

where:

P = minimum hydrostatic test pressure, psi [kPa],
S = 0.60 times the specified minimum yield strength, psi [kPa],
t = nominal wall thickness, in. [mm], and
D = specified outside diameter, in. [mm].

3.2.3 Flexibilidad en Tuberías:

La flexibilidad es una parte importante del diseño de sistemas de tuberías. El concepto es relativamente simple, cuando los tubos se calientan, se expanden y están limitados al libre desplazamiento, se desarrollan tensiones.

Ningún sistema de tuberías real se calienta una sola vez y se mantiene a una temperatura constante, esto se traduce en el cambio de tensiones, ya que se calienta y se enfría, lo cual produce fatiga. La fatiga es el fenómeno por el que una estructura, la tubería en este caso, se producirá una falla a pesar de que no existir una tensión que está por encima de su valor estático del esfuerzo soportado por el material.

La cuestión de la flexibilidad es fácil de explicar en un sistema simple, que se llama un sistema de anclaje de dos, por ejemplo entre una bomba y un tanque de almacenamiento que tiene que ir en torno a un rincón, por razones de diseño. La Figura 3.2 muestra el sencillo ejemplo de lo que sucede a la tubería ya que se expande si sube la temperatura.

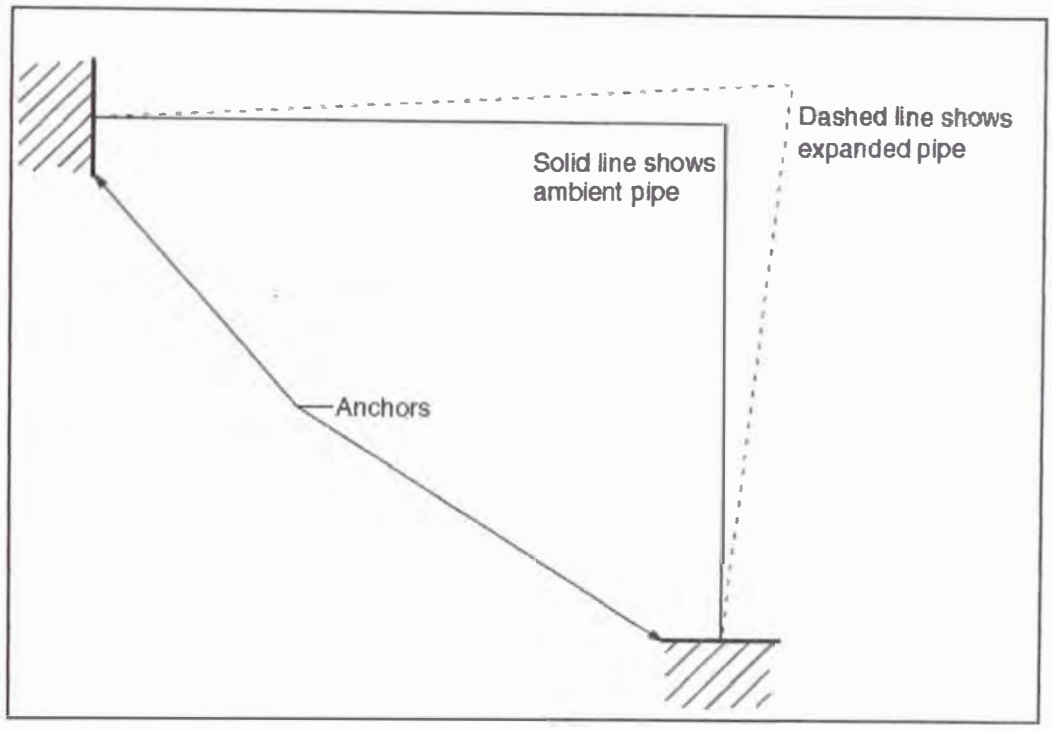


Figura 3.2 Sistema de Anclaje

El análisis de flexibilidad consiste en calcular las tensiones permisibles en un sistema, existen varios métodos que han utilizado: gráficos, análisis gráfico y análisis simplificado, análisis general, algunos de estos otros se siguen utilizando.

Para utilizar muchos de estos sistemas requiere una gran habilidad y la comprensión de todas las cuestiones planteadas. Los esfuerzos calculados no son los igual para todos los sistemas.

En muchas de las plantas hay varios ciclos diferentes, varios estados de temperatura, así como los estados de presión, puede cambiar con frecuencia.

En cualquier caso, si la tubería está enterrada o sobre tierra, el ingeniero debe tener ciertos elementos básicos para trabajar. Una de las diferencias significativas entre el análisis de la flexibilidad y la presión diseño es que el

análisis de la flexibilidad trabaja en un rango de tensiones en lugar de en un esfuerzo específico. Como se señaló anteriormente, estas tensiones son del tipo secundario del tipo que se auto limitan. Es decir, el cambio de temperatura y la expansión crea las tensiones. La tensión admisible en una temperatura más alta no suele ser el mismo que a menor temperatura.

En este Caso analizaremos el sistema por dos métodos:

- Método Antiguo (ASA)
- Método Actual (ASME)

A continuación detallamos cada uno de ellos:

a. *Método Antiguo*

Aplicando el análisis de esfuerzos y flexibilidad, según el "Código ASA

B – 31 - 1 para Tuberías a Presión" (*), se obtiene:

L= Longitud total de tubería

U = Distancia neta entre apoyos

D= Diámetro nominal de la tubería

Calcular:

$$\frac{U}{D} \text{ y } \frac{L}{U}$$

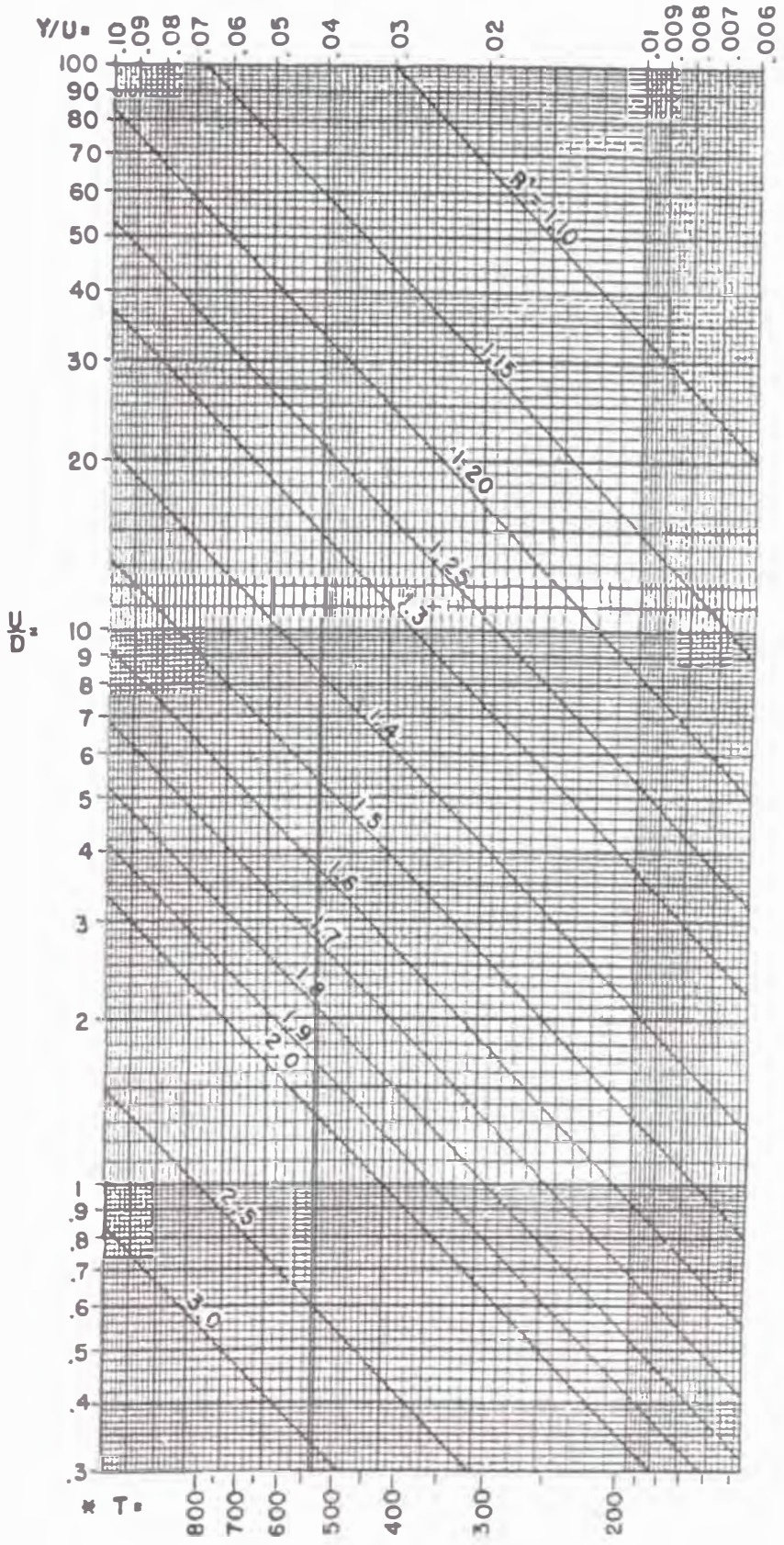
Para un material ASTM A – 106 / A – 53 a una temperatura de TF y un valor de U/D ingresar a la figura 2.3:

Se debe cumplir el siguiente criterio

➔ R < L/U

Por lo tanto, el sistema es flexible y no requiere juntas de expansión.

Figura 3.3. Regla para determinar la necesidad de un cálculo exacto (Diseño de tuberías para Plantas de proceso, Howard F. Rase,b Editorial Blume , primera edición española 1973)



b. Método actual :

ASME CODE FOR PRESSURE PIPING, B31" ASME B31.3-2002.

No requiere ningún análisis formal de flexibilidad un sistema de tuberías que:

- Reemplazan sin cambios significativos del sistema operativo con un servicio exitoso.
- Por comparación de sistemas previamente analizados.
- Si es de tamaño uniforme, no tiene más de dos puntos fijos, no tiene restricciones intermedias, y cumple con las limitaciones de la ecuaciones :

$$DY/ (L-U)^2 \leq K_1 \quad \text{.....(3.1)}$$

$$K_1 = 30\, S_A/E_a \quad (\text{in/ft})^2 \quad \text{.....(3.2)}$$

$$S_A = f\,(1.25\, S_c + 0.25\, S_h) \quad \text{..... (3.3)}$$

Donde tendremos:

L = Longitud total de tubería .

U = Distancia neta entre apoyos

D= Diámetro exterior de la tubería

Y = Resultante total del desplazamiento en pulgadas.

E_a = Módulo de Elasticidad a la temperatura de operación (Anexo 10)

S_A = Desplazamiento Permisible para un rango de esfuerzos.

S_c = Esfuerzo básico permisible a la mínima temperatura del metal durante el ciclo de desplazamiento en el análisis (Anexo 11 y Anexo 12)

S_h = Esfuerzo básico permisible a la máxima temperatura del metal durante el ciclo de desplazamiento en el análisis (Anexo 11 y Anexo 12)

f = Factor de Reducción para un Rango de esfuerzos (Tabla 3.6)

N = Número equivalente de ciclos desplazamiento total durante la vida de servicio del sistema de tuberías.

Tabla 3. 6 Factor de Reducción para un Rango de esfuerzos

STRESS-RANGE REDUCTION FACTORS, *f*

Cycles, *N*	Factor, *f*
7,000 and less	1.0
Over 7,000 to 14,000	0.9
Over 14,000 to 22,000	0.8
Over 22,000 to 45,000	0.7
Over 45,000 to 100,000	0.6
Over 100,000 to 200,000	0.5
Over 200,000 to 700,000	0.4
Over 700,000 to 2,000,000	0.3

Método de Cálculo:

- Hallar S_A con la ecuación (3.3)

$$S_A = f\,(1.25\,S_c + 0.25\,S_h)$$

- Hallar K_1 con la ecuación (3.2)

$$K_1 = 30\,S_A/E_a \quad (\text{in/ft})^2$$

- Hallar el valor de la ecuación (3.1)

$$DY/\,(L\text{-}U)^2 \leq K_1$$

- Si el Valor de K_1 hallado con la ecuación (3.2) es menor que el valor hallado por la ecuación (3.1), el sistema es flexible no requiere cálculos detallados ni juntas de expansión.

3.2.4 Aislamiento Térmico:

Las razones para la utilización del aislamiento térmico son fundamentalmente:

- Necesidades de proceso, ya que deben evitarse transferencias térmicas que disfuncionen el proceso por diferencia de temperatura no admisibles.
- Seguridad de las personas y bienes, no existe aislamiento térmico suficiente, las temperaturas superficiales externas pueden ser elevadas y provocar lesiones en las personal.
- El aislamiento térmico reduce pérdidas energéticas, de tal modo que éstas pueden llegar a ser el 2- 3% de las perdidas energéticas sin aislamiento.

Es el mejor método de ahorro de energía conocido, permitiendo la amortización de material aislante, en un período de tiempo muy bajo.

a) Lana de Vidrio:

Es un material aislante se caracteriza por su conductividad térmica, su poder aislante es tanto más elevado cuando más pequeña es su conductividad.

La lana de vidrio, es un material compuesto. El fieltro que se forma en la cadena, está constituido por fibras entrelazadas desordenadamente, que impiden las corrientes de convección de aire . El valor de la conductividad varía entre 0.032 y 0.045 W /(m.K) (a 10°C).

Los productos fabricados son ligeros y varían entre 10 y 110 kg/m3. Y fáciles de cortar y manejar.

La lana de vidrio es incombustible, inatacable por agentes externos: agua, vapor, aceite, ácidos (Excepto el fluorhídrico).

Tabla 3.8 . Tabla de espesores de aislamiento – Lana de vidrio

TEMPERATURA °C	100	150	200	250	300
DIÁMETRO TUBERÍA	ESPESORES DE AISLAMIENTO (mm)				
1"	30	30	40	40	50
1 1/2"	30	30	40	50	60
2"	30	40	40	50	60
2 1/2"	40	40	50	60	70
3"	40	50	50	60	70
4"	40	50	60	70	80
6"	50	60	70	80	90
8"	50	60	70	80	90
10"	60	70	80	90	90
12"	60	70	80	90	110
14"	60	70	80	100	110
16"	60	70	90	100	120
18"	60	80	90	100	120
20"	70	80	90	110	120
22"	70	80	100	110	130
24"	70	80	100	110	130

b) Lana de Roca:

Otro tipo de lana mineral es la llamada "Lana de Roca", que elaborada a partir de rocas basálticas, obteniéndose un producto de propiedades complementarias a la lana de vidrio.

Es un producto es especialmente indicado para aislamientos térmicos en la industria (elevadas temperaturas).

La lana de roca se obtiene fibrando por centrifugación del material, controlando en el proceso los contenidos de sílice y de óxido metálicos.

La composición química final debe asegurar una gran estabilidad mecánica hasta los 750°C.

Tabla 3.9 . Materias primas de la lana de roca

Materias primas	Materias primas encolado
Roca basáltica Grava Fosfato Mineral de hierro	Aceite de linaza Resina escórez Naftenato de manganeso Baquelita Aceite mineral

Tabla 3.10 . Tabla de espesores de aislamiento – Lana de Roca

TEMPERATURA °C	100	150	200	250	300	350	400	450	500	550
DIÁMETRO TUBERÍA	ESPESORES DE AISLAMIENTO (mm)									
1"	30	30	40	40	50	60	60	70	80	90
1 1/2"	30	30	40	50	60	60	70	70	80	90
2"	30	40	40	50	60	70	80	80	90	100
2 1/2"	40	40	50	60	70	70	80	90	100	110
3"	40	50	50	60	70	70	80	90	110	120
4"	40	50	60	70	80	80	90	100	120	130
6"	50	60	70	80	90	100	110	120	130	140
8"	50	60	70	80	90	110	120	130	140	160
10"	60	70	80	90	90	110	120	130	150	170
12"	60	70	80	90	110	120	130	140	160	180
14"	60	70	80	100	110	120	140	130	170	180
16"	60	70	90	100	120	120	140	150	170	190
18"	60	80	90	100	120	130	140	160	170	190
20"	70	80	90	110	120	130	150	160	180	200
22"	70	80	100	110	130	140	150	170	180	200
24"	70	80	100	110	130	140	150	180	190	210
Producto	Coquilla ROCLAINE®1 Manta SP 322-G-70				Coquilla ROCLAINE®1 Manta SP 342-G-100			Coquilla ROCLAINE®1 Manta SP 342-G-125		

3.2.5 Soportes :

La ubicación apropiada de soportes colgantes o soportes fijos involucra consideraciones de la propia tubería, de la estructura a la cual se transmite la carga y de las limitaciones de espacio. Los puntos preferidos de fijación de la tubería son:

a) Sobre tubería propiamente y no sobre componentes tales como: válvulas, accesorios o juntas de expansión. Bajo cargas concentradas (puntuales), las bridas y juntas roscadas pueden gotear y los cuerpos de válvulas pueden deformarse produciendo goteo, trabazón del vástago o goteo a través del asiento.

b) Sobre tramos rectos de tuberías en lugar de sobre codos de radios agudos, juntas angulares o conexiones de ramales prefabricados, puesto que en estos sitios se encuentra la tubería ya sometida a esfuerzos altamente localizados, a los cuales se agregarían los efectos locales de la fijación. Sobre tramos de tuberías que no requieran remoción frecuenta para limpieza o mantenimiento.

c) Tan cerca como sea posible de concentraciones grandes de carga, tales como: tramos verticales, ramales de tubería, válvulas motorizadas o bien válvulas pesadas y recipientes menores, tales como separadores, colabores.

La localización de los soportes depende del tamaño de la tubería, configuración de la misma, localización de las válvulas y accesorios y de la estructura disponible para el soporte de tuberías.

En un tendido de tubería horizontal, sencillo, en campo abierto, el espaciamiento de soportes depende únicamente de la resistencia del tubo. Dentro de los límites de una unidad de proceso, por otra parte, el espaciamiento de soportes está determinado mayormente por el espaciamiento de columnas convenientemente ubicadas.

Comúnmente el espaciamiento o tramo entre pórticos de un puente de tubería se determinará con base en la tubería más débil. Las líneas de diámetro pequeños pueden apuntalarse a lo largo de extensas luces proveyéndolas de soportes intermedios, sujetos a las tuberías adyacentes más grandes; un grupo de tales líneas pueden también atarse juntas, de manera tal que aumente la inercia combinada. Algunas veces, sin embargo, la solución más práctica es, simplemente, incrementar el diámetro del tubo hasta el punto que sea auto soportante a lo largo de la luz requerida.

Las luces permisibles para líneas horizontales están principalmente limitadas por los esfuerzos longitudinales que deben mantenerse dentro de los límites o, en algunos casos, por la máxima deflexión. El máximo espacio sugerido entre soportes, se encuentra listado en la tabla 3.9.

En caso que se presenten cargas concentradas, los soportes deberían estar puestos tan cerca como sea posible a la carga, con la intención de mantener el esfuerzo flexionarte al mínimo.

En la práctica, un soporte debería ser colocado inmediatamente después de cualquier cambio de dirección en la tubería.

Por economía de los soportes de sistemas de baja presión y temperatura y largas líneas externas de transmisión, la distancia entre soportes se puede basar sobre el esfuerzo total permisible de la tubería y la cantidad de deflexión permisible entre soportes.

Tabla 3.11 : Según ASME B31.1 – 1995

SUGGESTED PIPE SUPPORT SPACING

Nominal Pipe Size, NPS	Suggested Maximum Span			
	Water Service		Steam, Gas, or Air Service	
	ft	m	ft	m
1	7	2.1	9	2.7
2	10	3.0	13	4.0
3	12	3.7	15	4.6
4	14	4.3	17	5.2
6	17	5.2	21	6.4
8	19	5.8	24	7.3
12	23	7.0	30	9.1
16	27	8.2	35	10.7
20	30	9.1	39	11.9
24	32	9.8	42	12.8

3.3 ESPECIFICACIONES TÉCNICAS DE VÁLVULAS Y CONEXIONES

Una válvula se puede definir como un aparato mecánico con el cual se puede iniciar, detener o regular la circulación (paso) de líquidos o gases mediante una pieza movible que abre, cierra u obstruye en forma parcial uno o más orificios o conductos.

Las válvulas son unos de los instrumentos de control más esenciales en la industria. Debido a su diseño y materiales, las válvulas pueden abrir y cerrar, conectar y desconectar, regular, modular o aislar una enorme serie de líquidos y gases. En un sistema de vapor, la presión mínima y rango de temperatura para todas las válvulas y conexiones será igual a la presión y temperatura especificada en el lado de mayor presión, la cual no será menor a 100 psig.

Y para sistemas donde la presión no excede a 100 psig las válvulas y conexiones deben cumplir como mínimo los requerimientos de ASME para Clase 125 en fierro fundido o Clase 150 en acero al carbono.

3.3.1 Especificaciones Técnicas de Válvulas:

Denominación: Tipo de válvula, Diámetro, Material, Clase, Extremos.

Tipo de Válvula : Ej. Válvula Globo

Diámetro: Diámetro nominal de la válvula . Ej. 2"

Material del Cuerpo : Acero al carbono, Acero forjado, Acero Inoxidable

Clase: Ej. 150 Lbs. Vapor

Vástago: vástago ascendente

Bonete: Roscado, empernado

Norma: API 600, API 602

Ejemplo de especificación de una válvula:

Válvula Globo 4" de acero al carbono, 150 lbs. vapor, vástago ascendente, bonete empernado , API 600

Tipos de Válvulas más usadas:

- *Válvula Globo bridada :*

  Las válvulas globo son unidireccionales, comúnmente son utilizadas como válvulas de regulación. Su robustez y cierre hermético Metal-Metal hacen que éstas válvulas sean adaptables a las más altas exigencias de servicio. La junta cuerpo-bonete, puede ser plana, macho-hembra ó tipo ring-joint, dependiendo de la serie y servicio. El obturador está guiado para evitar su desalineación.

  Los detalles constructivos pueden variar en función de las dimensiones y series.

  A continuación se muestra las partes de una válvula globo.

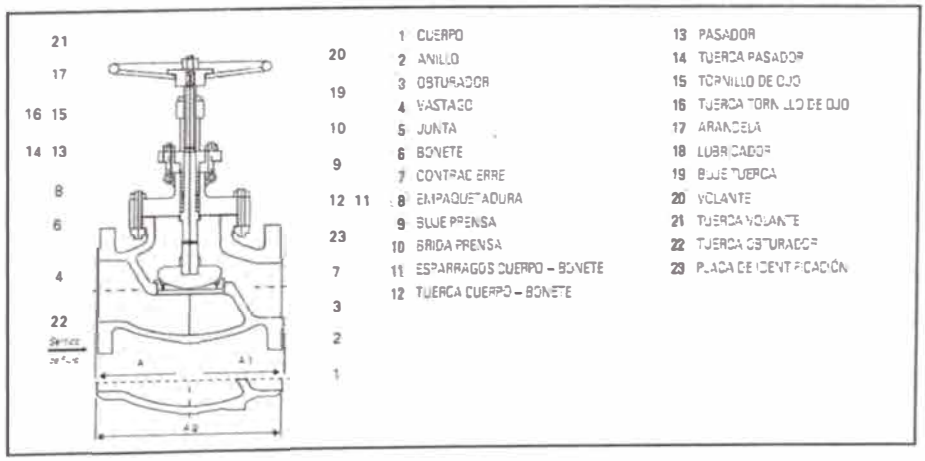


Figura 3.10 Válvula Globo

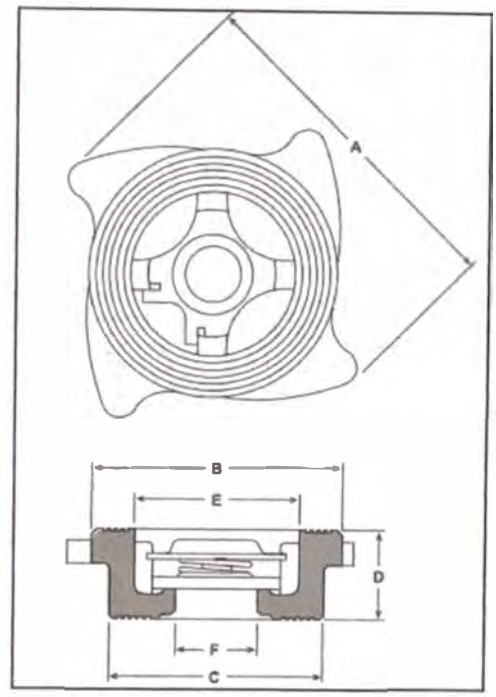


Figura 3.12 Check Disco

Tabla 3.14 Tabla de Dimensiones

Dimensiones/pesos (aproximados) en mm y kg

Tamaño	A	B	C	D	E	F	Peso
DN15	60,0	43	38	16,0	29,0	15	0,13
DN20	69,5	53	45	19,0	35,7	20	0,19
DN25	80,5	63	55	22,0	44,0	25	0,32
DN32	90,5	75	68	28,0	54,5	32	0,55
DN40	101,0	85	79	31,5	65,5	40	0,74
DN50	115,0	95	93	40,0	77,0	50	1,25
DN65	142,0	115	113	46,0	97,5	65	1,87
DN80	154,0	133	128	50,0	111,5	80	2,42
DN100	184,0	154	148	60,0	130,0	100	3,81

- Válvula reguladora de Presión:

Para obtener una ejecución de control efectivo el reductor de presión siempre diseñado con un diámetro menor que aquel de la línea de presión de entrada. La línea de control debe ser conectada a un punto de la línea de presión de salida donde el flujo esté quieto, es decir no

debe haber válvulas o codos dentro de una distancia mínima de 10x DN o al menos 1 m. desde el punto de toma.

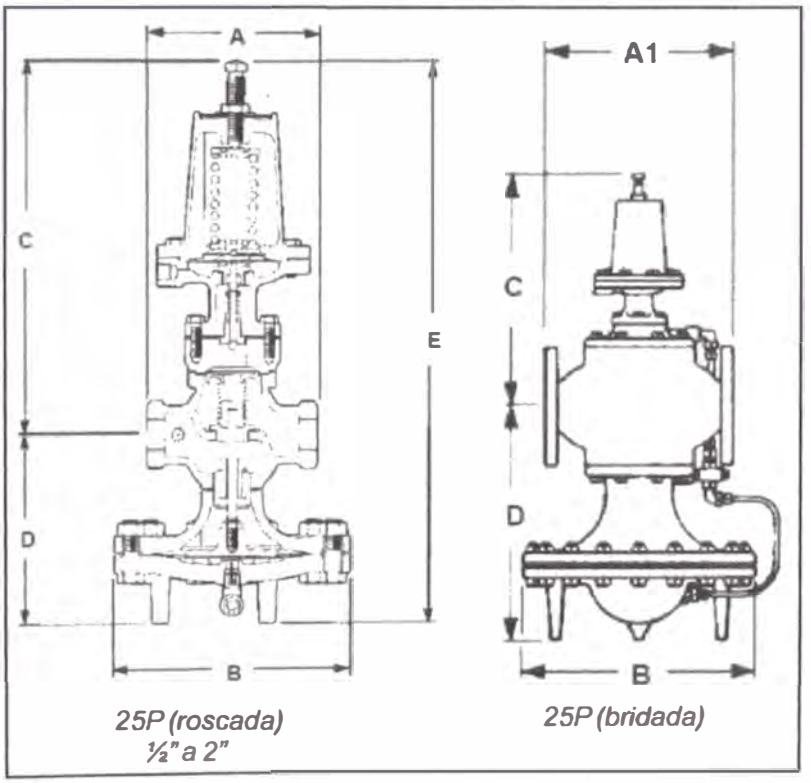


Figura 3.13 Válvula Reguladora de Presión

Tabla 3.15 Tabla de Dimensiones

Tamaño	A	A1	B	C	D	E	Peso
1/2"	140	161	193	309	157	466	14
3/4"	.140	160	193	309	157	466	14
1"	152	168	219	308	171	479	17
1.1/4"	184	206	219	322	179	501	20
1.1/2"	184	218	219	322	179	501	20
2"	216	242	269	338	208	546	31
2.1/2"		292	346	297	354	651	71
3"		318	346	294	367	660	85
4"		368	397	325	410	735	129

- Válvula de Seguridad:

Este tipo de válvula protege el sistema de una sobre presurización eliminando el exceso de presión por encima de la presión de calibración. Es importante el mantenimiento y acción preventiva en el lágrimeo de una válvula de seguridad, así como la ausencia de revisiones periódicas, favorecen a la acumulación excesiva de materias extrañas que se pegan en los asientos de la válvulas.

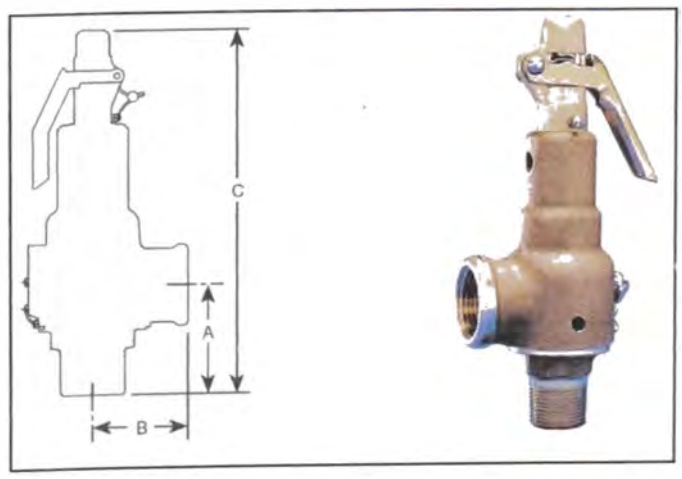


Figura 3.14 Válvula De seguridad

Tabla 3.16 Tabla de Dimensiones

Número de Modelo	Orificio	Conexiones ANSI estándar				Dimensiones de la válvula						Peso Aproximado	
		Entrada		Salida		A		B		C			
		in	mm	in	mm	in	mm	in	mm	in	mm	lb	kg
60**DC	D	1/2	12,7	3/4	19,0	2,1/8	54	1,5/8	41	6,1/2	165	1,1/2	0,7
60**DD	D	3/4	19,0	3/4	19,0	2,1/8	54	1,5/8	41	6,/12	165	1,3/4	0,8
60**ED	E	3/4	19,0	1	25,4	2,3/8	60	1,3/4	44	7,/12	191	2,1/2	1,1
60**EE	E	1	25,4	1	25,4	2,1/2	64	1,3/4	44	7,5/8	194	2,3/4	1,2
60**FE	F	1	25,4	1,1/4	31,8	2,5/8	67	2	51	8,1/2	216	3,1/2	1,6
60**FF	F	1,1/4	31,8	1,1/4	31,8	2,7/8	73	2	51	8,3/4	222	3,3/4	1,7
60**GF	G	1,1/4	31,8	1,1/2	38,0	3,1/8	79	2,3/8	60	9,5/8	244	5,1/2	2,5
60**GG	G	1,1/2	38,0	1,1/2	38,0	3,3/8	86	2,3/8	60	10	254	5,3/4	2,6
60**HG	H	1,1/2	38,0	2	51,0	3,5/8	92	2,3/4	70	10,5/8	270	7,3/4	3,5
60**HH	H	2	51,0	2	51,0	4,1/8	105	2,3/4	70	11,1/8	283	8	3,6
60**JH	J	2	51,0	2,1/2	64,0	4,1/4	108	3,3/8	86	13,5/8	346	15,1/2	7,0
60**JJ	J	2,1/2	64	2,1/2	64,0	4,1/2	114	3,3/8	86	14	356	15,3/4	7,2

3.3.2 Especificaciones Técnicas de Conexiones :

Los accesorios de Tuberías son todos aquellos elementos que instalados en conjunto con el tubo, conforman el sistema de tuberías.

En todo sistema de tuberías se hacen presente los siguientes elementos:

- Codos de 90º (radio corta o radio largo)
- Codos de 45º (radio corto o radio largo)
- Tee
- Reducciones
- Bridas
- Empaquetaduras
- Pernos

Es importante saber que cuando se va a realizar la adquisición de los materiales involucrados en el desarrollo de un Proyecto, se cuenta con una amplia gama especificaciones que definen las características del accesorio.

- Codos:

Denominación: Angulo, Diámetro, Tipo de Radio. (SCH o Rating), Extremos, Material.

Angulo: Angulo de giro para el Fluido. Ej. 90º.

Diámetro: Diámetro nominal del codo. Ej. 2"

Tipo de Radio: Radio Largo o Radio Corto

Sch o Rating : Schedule del codo (. Ej. Sch40)

Extremos: Extremos para encastrar (SW), Biselados (BW), Roscados (THHD).

Material: Material de codo. Ej. ASTM A105.

Ejemplo de especificación de un Codo:

Codo 90º ¾", Radio largo, SCH40, extremos para encastrar (SW), según ASTM A105.

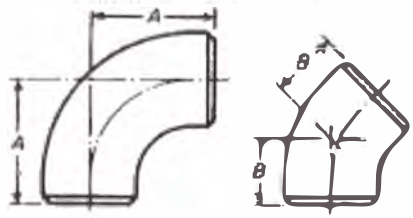


TABLE 2 DIMENSIONS OF LONG RADIUS ELBOWS

Nominal Pipe Size (NPS)	Outside Diameter at Bevel *D*	Center-to-End	
		90 deg. Elbows *A*	45 deg. Elbows *B*
½	0.84	1.50	0.62
¾ (1)	1.05	1.50	0.75
1	1.32	1.50	0.88
1¼	1.66	1.88	1.00
1½	1.90	2.25	1.12
2	2.38	3.00	1.38
2½	2.88	3.75	1.75
3	3.50	4.50	2.00
3½	4.00	5.25	2.25
4	4.50	6.00	2.50
5	5.56	7.50	3.12
6	6.62	9.00	3.75
8	8.62	12.00	5.00
10	10.75	15.00	6.25
12	12.75	18.00	7.50
14	14.00	21.00	8.75
16	16.00	24.00	10.00
18	18.00	27.00	11.25
20	20.00	30.00	12.50
22	22.00	33.00	13.50
24	24.00	36.00	15.00
26	26.00	39.00	16.00
28	28.00	42.00	17.25
30	30.00	45.00	18.50
32	32.00	48.00	19.75
34	34.00	51.00	21.00
36	36.00	54.00	22.25
38	38.00	57.00	23.62
40	40.00	60.00	24.88
42	42.00	63.00	26.00
44	44.00	66.00	27.38
46	46.00	69.00	28.62
48	48.00	72.00	29.88

Fig. 3.15

Dimensiones de Codos SCH40

- Tee:

Denominación: Diámetro, (SCH o Rating), Extremos, Material.

Diámetro: Diámetro nominal de la Tee. Ej. 2"

Sch o Rating : Schedule de la Tee

Extremos: Extremos para encastrar (SW), Biselados (BW), Roscados (THHD).

Material: Material de codo. Ej. ASTM A105.

Ejemplo de especificación de una Tee recta:

Tee recta 4", SCH 40, extremos biselados (BW), según ASTM A234 gr. WPB.

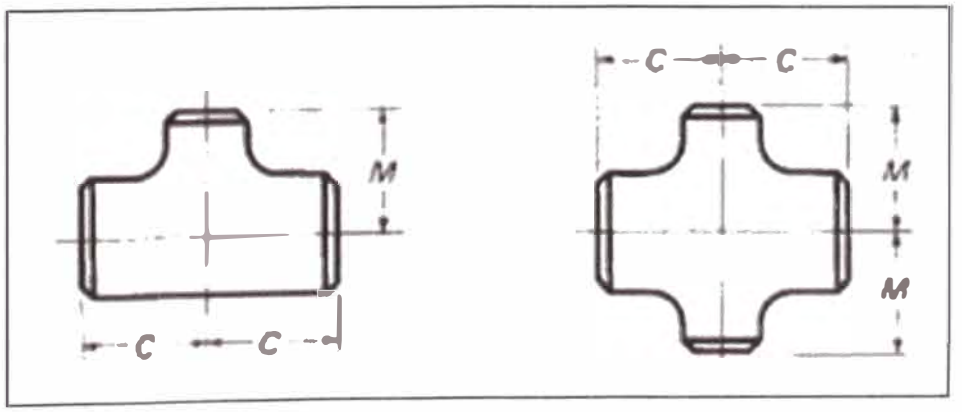


Figura 3.16

Tabla 3.17. Dimensiones de Tee Sch40

DIMENSIONS OF STRAIGHT TEES AND CROSSES

Nominal Pipe Size (NPS)	Outside Diameter at Bevel D	Center-to-End	
		Run C	Outlet (1),(2) M
½	0.84	1.00	1.00
¾	1.05	1.12	1.12
1	1.32	1.50	1.50
1¼	1.66	1.88	1.88
1½	1.90	2.25	2.25
2	2.38	2.50	2.50
2½	2.88	3.00	3.00
3	3.50	3.38	3.38
3½	4.00	3.75	3.75
4	4.50	4.12	4.12
5	5.56	4.88	4.88
6	6.62	5.62	5.62
8	8.62	7.00	7.00
10	10.75	8.50	8.50
12	12.75	10.00	10.00
14	14.00	11.00	11.00
16	16.00	12.00	12.00
18	18.00	13.50	13.50
20	20.00	15.00	15.00
22	22.00	16.50	16.50
24	24.00	17.00	17.00
26	26.00	19.50	19.50
28	28.00	20.50	20.50
30	30.00	22.00	22.00
32	32.00	23.50	23.50
34	34.00	25.00	25.00
36	36.00	26.50	26.50
38	38.00	28.00	28.00
40	40.00	29.50	29.50
42	42.00	30.00	28.00
44	44.00	32.00	30.00
46	46.00	33.50	31.50
48	48.00	35.00	33.00

- Reducción Campana Excéntrica/ Concéntrica:

Denominación: Diámetro, (SCH o Rating), Extremos, Material.

Diámetro: Diámetro nominal de la Reducción

SCH o Rating : Schedule de la Reducción

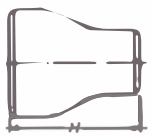
Extremos: Extremos para encastrar (SW), Biselados (BW), Roscados (THHD).

Material: Material de la Reducción. Ej. ASTM A105.

Ejemplo de especificación de una Campana reductora:

Reducción Campana excéntrica 2"x1", extremos para encastrar (SW), 3000 lbs., según ASTM A105.

Tabla 3.16. Dimensiones de Reducción CampanaSCH40



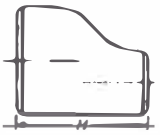


TABLE 9 DIMENSIONS OF REDUCERS

Nominal Pipe Size (NPS)	Outside Diameter at Bevel D		End-to-End H	Nominal Pipe Size (NPS)	Outside Diameter at Bevel D		End-to-End H
	Large End	Small End			Large End	Small End	
¾ x ½	1.05	0.84	1.50	6 x 5	6.62	5.56	5.50
¾ x ⅜	1.05	0.68	1.50	6 x 4	6.62	4.50	5.50
1 x ¾	1.32	1.05	2.00	6 x 3½	6.62	4.00	5.50
1 x ½	1.32	0.84	2.00	6 x 3	6.62	3.60	5.50
				6 x 2½	6.62	2.88	5.50
1¼ x 1	1.66	1.32	2.00				
1¼ x ¾	1.66	1.05	2.00	8 x 6	8.62	6.62	6.00
1¼ x ½	1.66	0.84	2.00	8 x 5	8.62	5.56	6.00
				8 x 4	8.62	4.50	6.00
1½ x 1¼	1.90	1.66	2.50	8 x 3½	8.62	4.00	6.00
1½ x 1	1.90	1.32	2.50				
1½ x ¾	1.90	1.05	2.50	10 x 8	10.75	8.62	7.00
1½ x ½	1.90	0.84	2.50	10 x 6	10.75	6.62	7.00
				10 x 5	10.75	5.56	7.00
2 x 1½	2.38	1.90	3.00	10 x 4	10.75	4.50	7.00
2 x 1¼	2.38	1.66	3.00				
2 x 1	2.38	1.32	3.00	12 x 10	12.75	10.75	8.00
2 x ¾	2.38	1.05	3.00	12 x 8	12.75	8.62	8.00
				12 x 6	12.75	6.62	8.00
2½ x 2	2.88	2.38	3.50	12 x 5	12.75	5.56	8.00
2½ x 1½	2.88	1.90	3.50				
2½ x 1¼	2.88	1.66	3.50	14 x 12	14.00	12.75	13.00
2½ x 1	2.88	1.32	3.50	14 x 10	14.00	10.75	13.00
				14 x 8	14.00	8.62	13.00
3 x 2½	3.50	2.88	3.50	14 x 6	14.00	6.62	13.00
3 x 2	3.50	2.38	3.50				
3 x 1½	3.50	1.90	3.50	16 x 14	16.00	14.00	14.00
3 x 1¼	3.50	1.66	3.50	16 x 12	16.00	12.75	14.00
				16 x 10	16.00	10.75	14.00
3½ x 3	4.00	3.50	4.00	16 x 8	16.00	8.62	14.00
3½ x 2½	4.00	2.88	4.00				
3½ x 2	4.00	2.38	4.00	18 x 16	18.00	16.00	15.00
3½ x 1½	4.00	1.90	4.00	18 x 14	18.00	14.00	15.00
3½ x 1¼	4.00	1.66	4.00	18 x 12	18.00	12.75	15.00
				18 x 10	18.00	10.75	15.00
4 x 3½	4.50	4.00	4.00				
4 x 3	4.50	3.50	4.00	20 x 18	20.00	18.00	20.00
4 x 2½	4.50	2.88	4.00	20 x 16	20.00	16.00	20.00
4 x 2	4.50	2.38	4.00	20 x 14	20.00	14.00	20.00
4 x 1½	4.50	1.90	4.00	20 x 12	20.00	12.75	20.00
5 x 4	5.56	4.50	5.00				
5 x 3½	5.56	4.00	5.00	22 x 20	22.00	20.00	20.00
5 x 3	5.56	3.50	5.00	22 x 18	22.00	18.00	20.00
5 x 2½	5.56	2.88	5.00	22 x 16	22.00	16.00	20.00
5 x 2	5.56	2.38	5.00	22 x 14	22.00	14.00	20.00

- Bridas:

Son accesorios para conectar tuberías con equipos (Bombas, intercambiadores de calor, calderas, tanques, etc.) o accesorios (codos, válvulas, etc.). La unión se hace por medio de dos bridas, en la cual una de ellas pertenece a la tubería y la otra al equipo o accesorio a ser conectado. La ventaja de las uniones bridadas radica en el hecho de que por estar unidas por espárragos, permite el rápido montaje y desmontaje a objeto de realizar reparaciones o mantenimiento.

Estas se clasifican en:

- Brida con cuello para soldar.
- Brida Slip On
- Brida roscada.
- Brida Socket Welding
- Bridas locas
- Brida ciega.

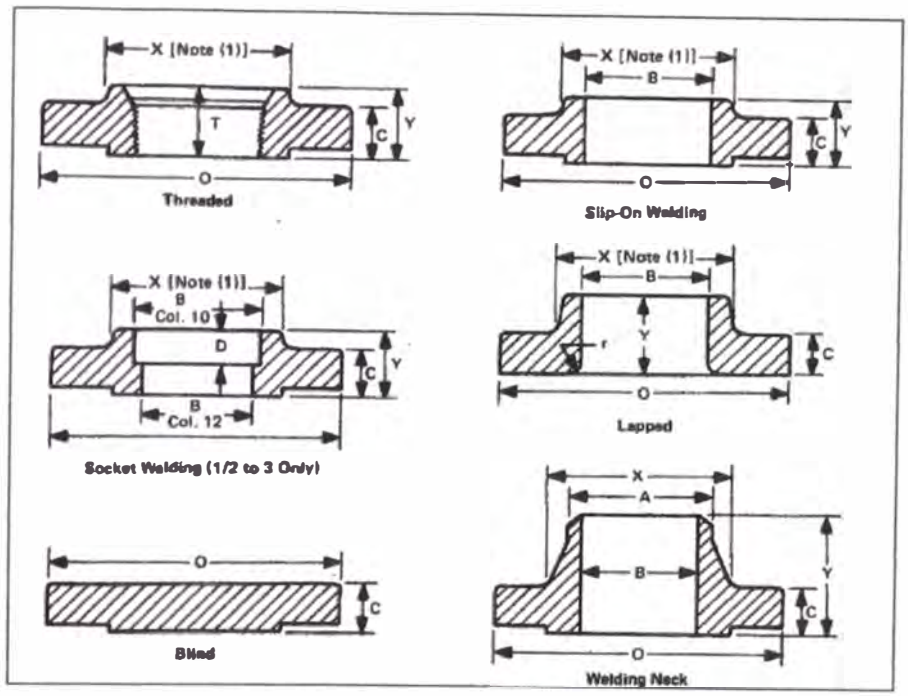


Figura 3.17

Tabla 3.17 Dimensiones de Bridas

DIMENSIONS OF CLASS 150 FLANGES[2-8]

1	2	3	4	5	6	7	8	9	10	11	12	13	14
					Length Through Hub				Bore				
Nominal Pipe Size	Outside Diameter of Flange O	Thickness of Flange [(9)–(11)], Min. C	Diameter of Hub X	Hub Diameter Beginning of Chamfer Welding Neck (12) A	Threaded Slip-On Socket Welding Y	Lapped Y	Welding Neck Y	Thread Length Threaded Flange (13), Min. T	Slip-On Socket Welding, Min. B	Lapped, Min. B	Welding Neck Socket Welding (14) B	Corner Radius of Bore of Lapped Flange and Pipe r	Depth of Socket D
½	3.50	0.44	1.19	0.84	0.62	0.62	1.00	0.62	0.88	0.90	0.62	0.12	0.38
¾	3.88	0.50	1.50	1.05	0.62	0.62	2.06	0.62	1.09	1.11	0.82	0.12	0.44
1	4.25	0.56	1.94	1.32	0.69	0.69	2.19	0.69	1.36	1.38	1.06	0.12	0.50
1¼	4.62	0.62	2.31	1.66	0.81	0.81	2.25	0.81	1.70	1.72	1.38	0.19	0.56
1½	5.00	0.69	2.56	1.90	0.88	0.88	2.44	0.88	1.95	1.97	1.61	0.25	0.62
2	6.00	0.75	3.06	2.38	1.00	1.00	2.50	1.00	2.44	2.46	2.07	0.31	0.69
2½	7.00	0.88	3.56	2.88	1.12	1.12	2.75	1.12	2.94	2.97	2.47	0.31	0.75
3	7.50	0.94	4.25	3.50	1.19	1.19	2.75	1.19	3.57	3.60	3.07	0.38	0.81
3½	8.50	0.94	4.81	4.00	1.25	1.25	2.81	1.25	4.07	4.10	3.55	0.38	...
4	9.00	0.94	5.31	4.50	1.31	1.31	3.00	1.31	4.60	4.60	4.03	0.44	...
5	10.00	0.94	6.44	5.56	1.44	1.44	3.50	1.44	5.69	5.69	5.05	0.44	...
6	11.00	1.00	7.56	6.63	1.56	1.56	3.50	1.56	6.72	6.76	6.07	0.50	...
8	13.50	1.12	9.69	8.63	1.75	1.75	4.00	1.75	8.72	8.75	7.98	0.50	...
10	16.00	1.19	12.00	10.75	1.94	1.94	4.00	1.94	10.88	10.92	10.02	0.50	...
12	19.00	1.25	14.38	12.75	2.19	2.19	4.50	2.19	12.88	12.92	12.00	0.50	...
14	21.00	1.38	15.75	14.00	2.25	3.12	5.00	2.25	14.14	14.18	To be specified by purchaser	0.50	...
16	23.50	1.44	18.00	16.00	2.50	3.44	5.00	2.50	16.16	16.19		0.50	...
18	25.00	1.56	19.88	18.00	2.69	3.81	5.50	2.69	18.18	18.20		0.50	...
20	27.50	1.69	22.00	20.00	2.88	4.06	5.88	2.88	20.20	20.25		0.50	...
24	32.00	1.88	26.12	24.00	3.25	4.38	6.00	3.25	24.25	24.26		0.50	...

3.4 EQUIPOS DE COMBUSTION CONSIDERADOS EN ESTE PROYECTO

Tabla 3.18 Equipos Instalados

EQUIPO	POTENCIA (BHP)	CAUDAL (lb/hr)	OBS
CALDERA 1	125	4312.5	EN FUNCIONAMIENTO
CALDERA 2	250	8625	EN FUNCIONAMIENTO
CALDERA 3	250	8625	CONSUMO FUTURO

3.5 DESCRIPCION DE LA LINEA DE VAPOR Y EQUIPOS

El sistema de tuberías de vapor consta de líneas principales de suministro y distribución de vapor así como líneas de distribución secundarias las cuales llegan a cada consumidor.

La instalación también se cuenta con estaciones de reguladoras de vapor y 02 manifolds de vapor .

A continuación detallamos cada línea :

3.5.1 Línea de Suministro de Vapor a la planta : Calderas- Manifold Principal

En la sala de calderas actualmente se encuentran instaladas 01 caldera de 125 BHP y otra 250 BHP, las cuales suministran el vapor necesario para los procesos mediante 02 líneas de alimentación de vapor de 3" de diámetro van desde la calderas dichas calderas hasta el manifold principal ; tienen una longitud aprox. de 10 metros y 16 metros respectivamente .

La Línea de vapor existente está totalmente aislada con Medias cañas de lana mineral y acabado metálico en Aluminio.

Tabla 3.19

Ítem	Descripción	Cantidad	Marca
1	Válvula globo bridada de 3 " x 150 lbs. (Caldera)	2	Crean

Figura 3.18 Sala de Calderas

3.5.2 Línea de Distribución principal de Vapor: Manifold Principal - Consumidores

Está línea es la que suministra vapor al manifold secundario desde donde se distribuye a todos los consumidores, la línea tiene una longitud aprox de 100 mts.

Su recorrido comienza en el Manifold Principal ubicado en la sala de Calderas pasa por el Puente Técnico, cruza El techo Técnico de Farma hasta llegar al Manifold Secundario Ubicado en esta Zona.

Esta totalmente aislada con Medias cañas de lana mineral y acabado metálico en Aluminio.

Trayectoria de La tubería

La tubería de Vapor de 6" en su trayectoria pasa por las siguientes aéreas:

a) *Sala de calderas*

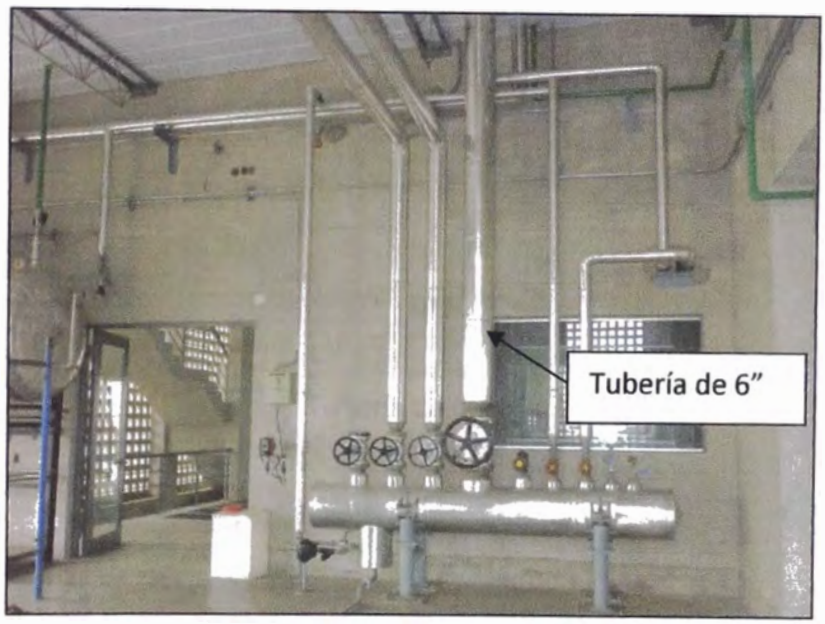


Figura 3.19

b) *Puente Técnico*

Figura 3.20

c) *Techo Técnico de Farma (Manifold secundario)*

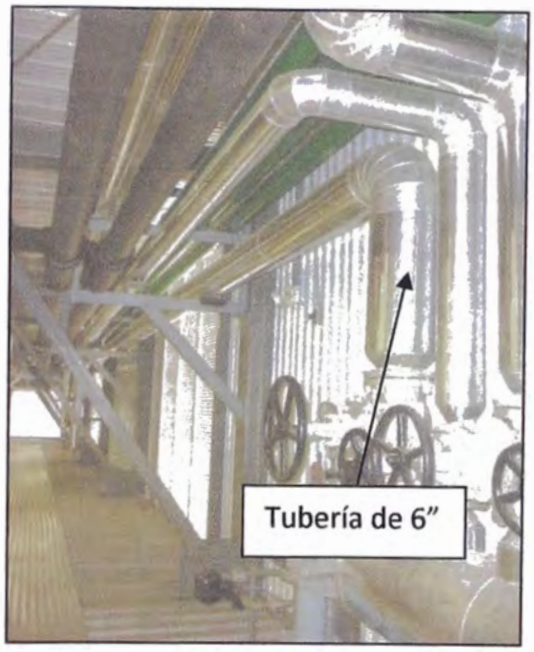


Figura 3.21

3.5.3 Línea de Vapor hacia Autoclaves

Son tres líneas de vapor de 4" que van desde el manifold secundario ubicado en el techo técnico de Farma hasta las autoclaves A3500 , A4000 y un consumo futuro.

Esta totalmente aislada con Medias cañas de lana mineral y acabado metálico en Aluminio.

Trayectoria de La tubería

Las 03 tuberías de Vapor de 4" está Instalada en el en Techo Técnico de Farma:

a) *Techo Técnico de Farma : Manifold Secundario*

Figura 3.22
Manifold Secundario

b) *Techo Técnico de Farma - Consumo futuro*

Figura 3.23
Pto de llegada – Consumo Futuro

c) *Techo Técnico de Farma : Autoclave A 3500 y A4000*

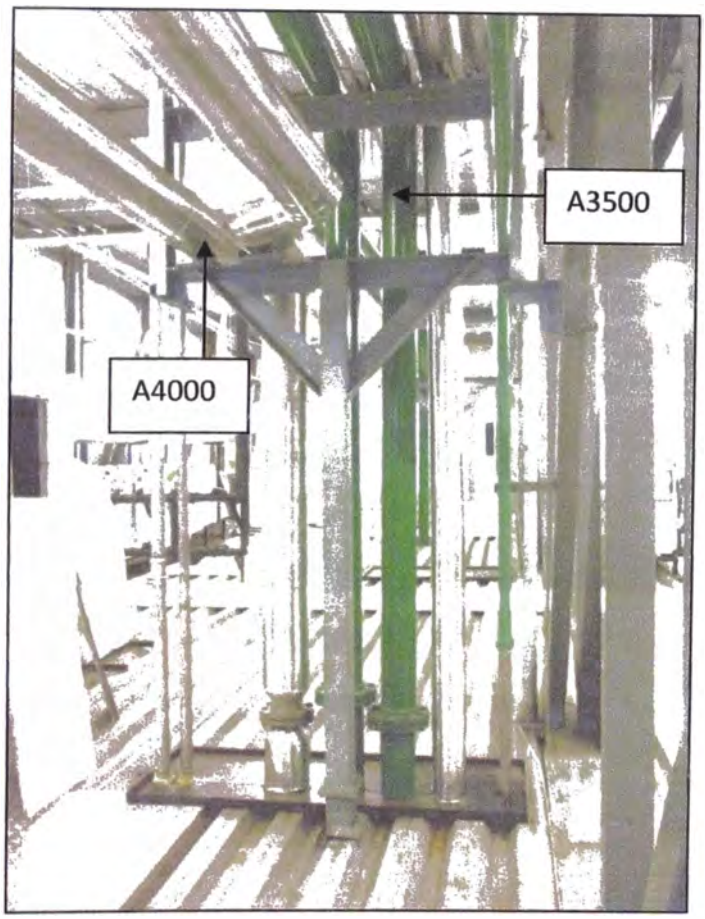


Figura 3.24

3.5.4 Línea de Distribución de Vapor hacia tanques de Preparación

Esta línea va desde la estación Reductora N°1 ubicado en el techo técnico de Farma hasta los 11 tanques de preparación, la cual a su vez tiene acometidas hasta cada tanque con diámetro de 1 ½" .

Esta totalmente aislada con Medias cañas de lana mineral y acabado metálico en Aluminio.

Trayectoria de La tubería :

La tubería de Vapor de 4" está Instalada en el en Techo Técnico de Farma y llega hasta los tanques en el nivel inferior.

a) Techo Técnico de Farma :

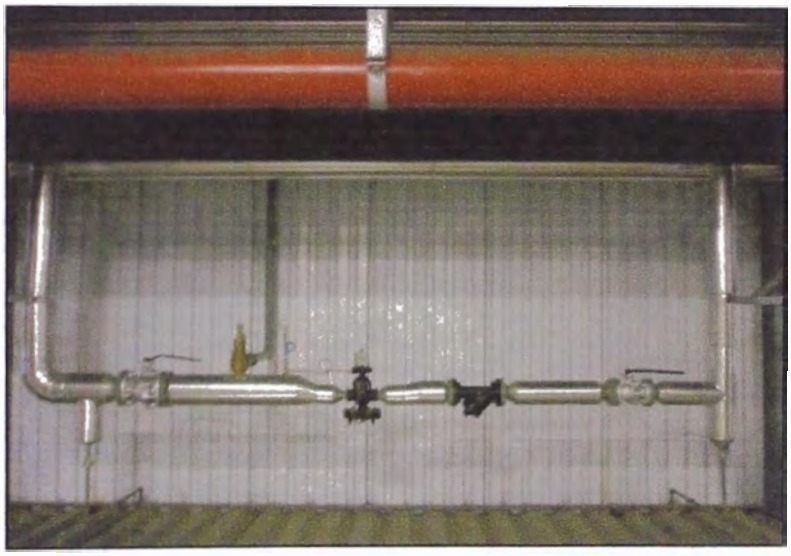


Figura 3.25

Estación Reductora de Vapor Nº 1

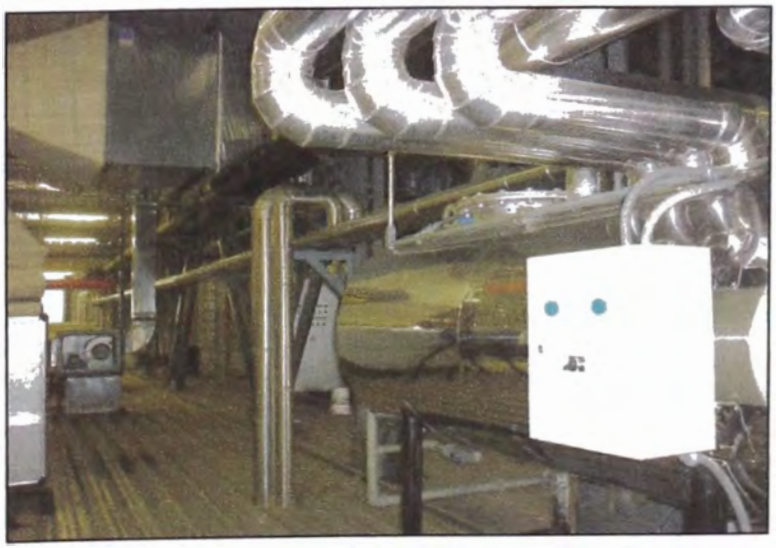


Figura 3.26

Tubería de 4" bajando hacia tanques preparación

b) Línea de Vapor de 1 ½" (tanques de Preparación)

Figura 3.27

Línea de Vapor 1 ½" – Ingreso a tks de preparación

Tabla 3.20 Válvulas y accesorios Instalados

Ítem	Descripción	Cant	Marca
1	Válvula bola de 1 1/2 " x 150 lbs.	11	Spirax Sarco
2	Válvula de Seguridad de 1/2 " x 3/4" x 150 lbs. Regulada a 40 Psi	11	Kunkle
3	Válvula Solenoide de diafragma 1 1/2"	11	SMC
4	Válvula de 1/4" x 1000 wog	11	Sun
5	Manómetro 0- 150 psi Dial de 2 1/2" conex. Inf 1/4"	11	Wika

3.5.5 Línea de Distribución a Estación Reguladora N°1

Esta línea va desde el manifold secundario hasta la Estación Reductora N°1 ambos ubicados en el techo técnico de Farma , está totalmente aislada con Medias cañas de lana mineral y acabado metálico en Aluminio.

Trayectoria de La tubería

a) *Techo Técnico de Farma :*

Figura 3.28

En el Manifold Secundario

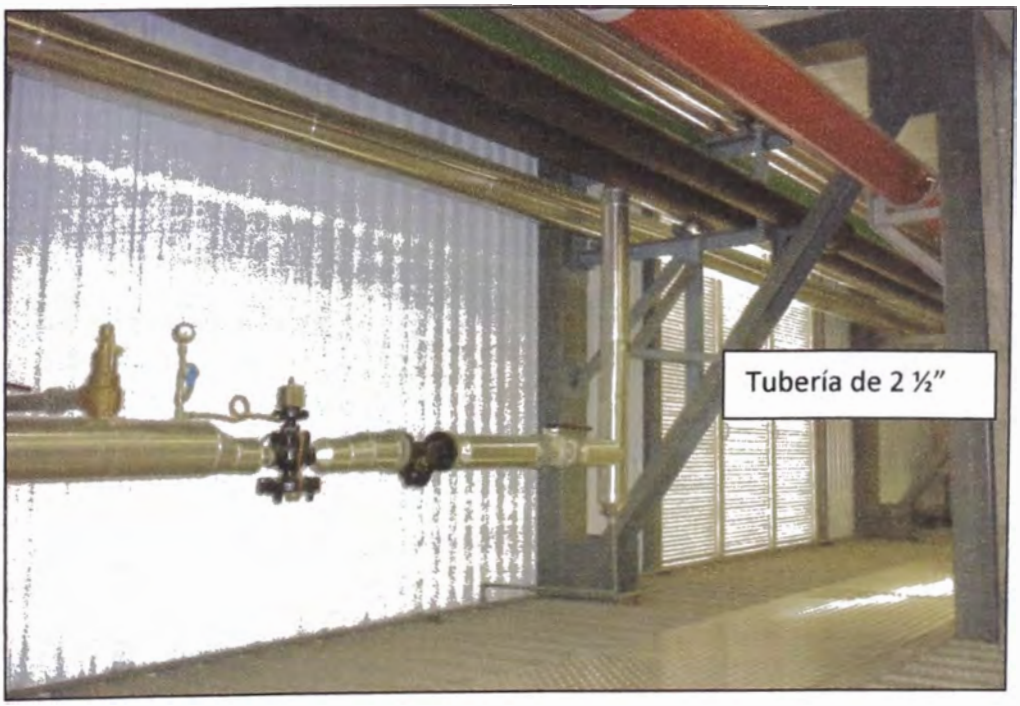


Figura 3.29

Linea de 2 ½" - Estacion de Regulación Nº 1

3.5.6 Línea de Distribución de Vapor a Sala de de Tratamiento de agua.

Esta línea suministra vapor a dos equipos dentro de la Sala tratamiento de agua, al Skid de Distribución WFI y al Skid WFI, llega a cada uno de ellos con una presión de 3 bar y 2 bar respectivamente.

Su trayectoria comienza en el Manifold principal con un diámetro de 1 ½" y llega a las Estaciones Reductoras 2 y 3 ; de donde se distribuye a cada consumidor.

Trayectoria de La tubería

a) *Línea de Vapor Hacia Skid de Distribución WFI* :

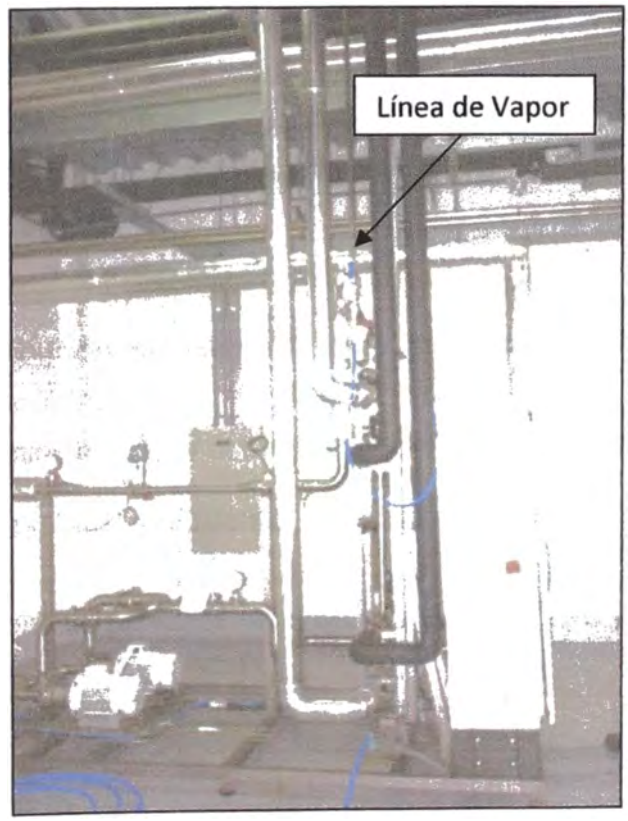


Figura 3.30

b) *Línea de Vapor Hacia Skid WFI :*

Figura 3.31

3.5.7 Línea de Distribución de vapor a Tanque de Condensado

Esta Línea suministra vapor al tanque de condensado principal ubicado en la sala de calderas , para precalentar el agua que ingresa al caldero .

Sale desde Manifold principal ; con un diámetro de 1 ½" y llega al tanque de condensado con un diámetro de ½".

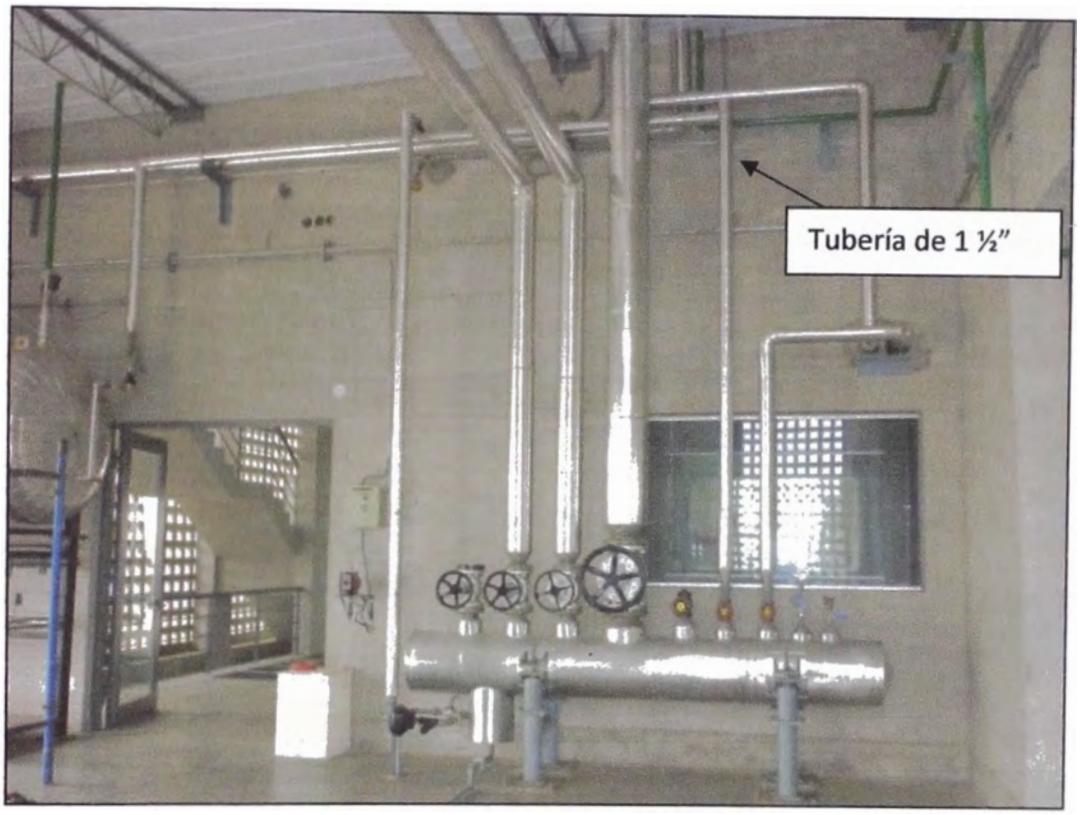


Figura 3.32

Sala de calderas

3.5.8 Línea de Distribución de vapor a calentador de agua.

Es línea secundaria que sale de la tubería de vapor de 6", en la zona del puente técnico y llega hasta el calentador de agua ubicado en el 1er. Nivel, tiene un longitud de 12 mts aprox.

Esta totalmente aislada con Medias cañas de lana mineral y acabado metálico en Aluminio.

Trayectoria de La tubería

a) *En el Puente Técnico:*

Figura 3.33

b) En la plataforma sobre la zona de Compresores

Figura 3.34

3.5.9 Manifold Principal

El manifold principal ha sido fabricado en Tubo de 12" sch40 A53-A106 , aislado térmicamente con lana mineral y acabado metálico en aluminio.

Cuenta con:

- 03 Ingresos de Vapor de ϕ 3".
- 01 salida de ϕ 6" Hacia manifold secundario Techo Farma
- 01 salida de ϕ 2" Consumo futuro
- 01 salida de ϕ 1 1/2" Hacia sala de tratamiento de agua
- 01 salida de ϕ 1 1/2" Hacia sala de tanque de Condensado principal
- 02 Copla ½" Manómetro y eliminador de aire
- 01 Colector de Condensado (ubicado en la parte Inferior)
- 01 Sistema de trampeo de Condensado.

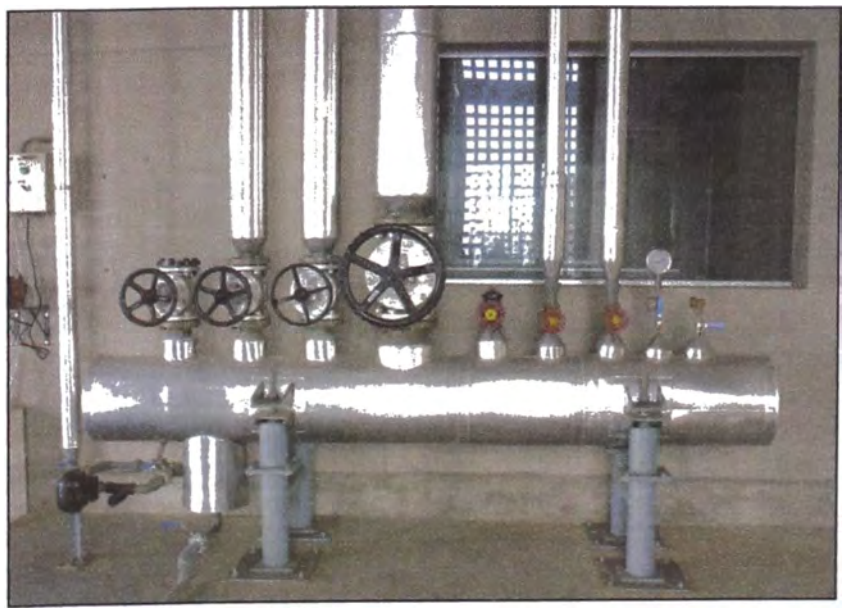


Figura 3.35

Manifold Principal

Tabla 3.21 Válvulas y accesorios Instalados

Ítem	Descripción	Cantidad	Marca
1	Válvula globo Bridada de 3" x 150 lbs.	1	Leon
2	Válvula globo Bridada de 3" x 150 lbs.	2	Crane
2	Válvula globo Bridada de 6" x 150 lbs.	1	Crane
3	Válvula globo de 2" x 150 lbs.	1	Crane
4	Válvula globo de 1 1/2" x 150 lbs.	1	Crane
7	Válvula de 1/2" x 1000 wog	2	Sun
8	Manómetro 0- 200 psi Dial de 4" conex. Inf 1/2"	1	
9	Eliminador de aire de 3/4"	1	Spirax Sarco
10	Válvula bola de 1" x 1000 wog (purga)	1	Spirax Sarco

SISTEMA DE TRAMPEO DE CONDENSADO

Figura 2.36

Tabla 3.22 Válvulas y accesorios Instalados

Ítem	Descripción	Cantidad	Marca
1	Válvulas bola de 1" x 150 lbs.	03	Spirax Sarco
2	Filtro tipo Y 1" para vapor	01	Spirax Sarco
3	Trampa de Tipo Flotador FT14 de 1"	01	Spirax Sarco
4	Valvulas check Swing 1" x 150 lbs	01	Crane

3.5.10 Manifold Secundario

El manifold secundario ha sido fabricado en Tubo de 12" sch40, aislado térmicamente con lana mineral y acabado metálico en aluminio.

Cuenta con:

- 03 copla ½" — Manómetro, eliminador de aire y consumo futuro
- 01Salida de 1 ½" — Consumo futuro
- 01 Ingreso de ϕ 6" — De Manifold Principal
- 01 salida de ϕ 21/2 " — Hacia Estación de Regulación Secundaria

- 03 salidas de ϕ 4" — Hacia Autoclaves
- 01 salida de ϕ 2 " — Consumo futuro
- 01 Colector de Condensado (ubicado en la parte Inferior)
- 01 Sistema de trampeo de Condensado.

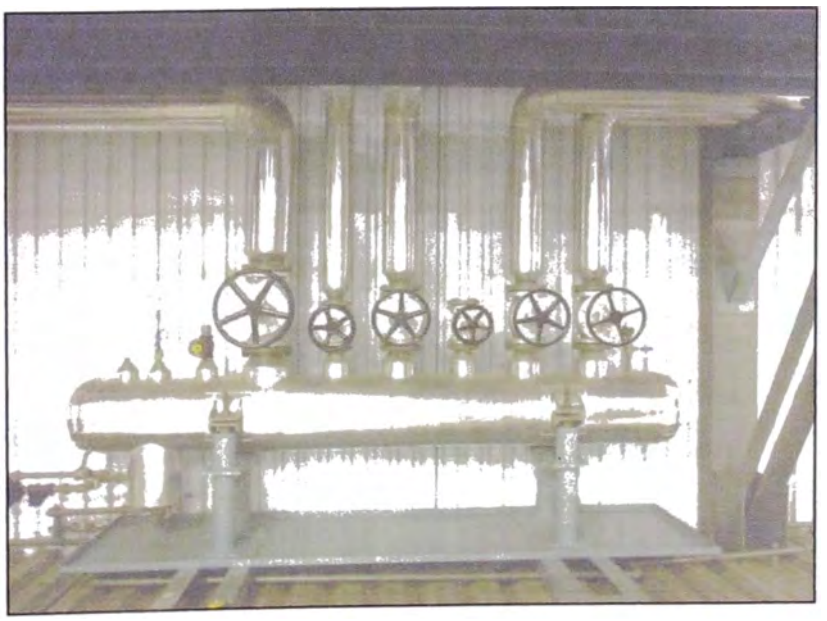


Figura 3.37
Manifold secundario

Tabla 3.23. Válvulas y accesorios Instalados

Ítem	Descripción	Cantidad	Marca
1	Válvula globo Bridada de 6" x 150 lbs.	01	Powell
2	Válvula globo Bridada de 4" x 150 lbs.	03	Crane
2	Válvula globo Bridada de 2 ½ " x 150 lbs.	01	Leon
3	Válvula globo Bridada de 21/2 " x 150 lbs.	01	Rex
4	Válvula globo de 1 1/2" x 150 lbs.	01	Crane
7	Válvula bola de 1/2" x 1000 wog	02	Spirax Sarco
8	Manómetro 0- 200 psi Dial de 4" conex. Inf 1/2"	01	
9	Eliminador de aire de 3/4"	01	Spirax Sarco
10	Válvula bola de 1" x 1000 wog (purga)	01	Spirax Sarco

SISTEMA DE TRAMPEO DE CONDENSADO

Figura 3.38

Tabla 3.24. Válvulas y accesorios Instalados

Ítem	Descripción	Cant.	Marca
1	Válvulas bola de 1" x 150 lbs.	03	Spirax Sarco
2	Filtro tipo Y 1" para vapor	01	Spirax Sarco
3	Trampa Tipo Flotador FT14 de 1" x 150 lbs.	01	Spirax Sarco
4	Valvulas check Swing 1" x 150 lbs	01	Crane

3.5.11 Estación de Regulación de vapor N°1

A continuación detallamos los componentes del sistema de reducción de presión N°1 . El control de presión se realiza a través de una válvula de control especial, conocida como reductor de presión. Para operar un reductor de presión en una instalación de vapor es necesario una cantidad **de válvulas auxiliares y accesorios.**

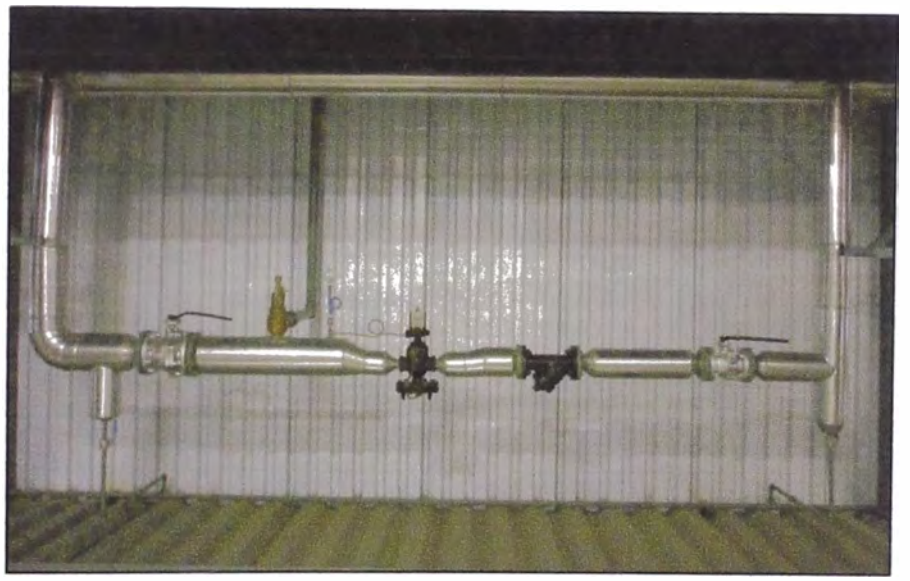


Figura 3.39

Estación Reductora de Vapor N°1.

ESTACIÓN REDUCTORA DE VAPOR Nº 1:

Tabla 3.25. Válvulas y accesorios Instalados

Ítem	Descripción	Cant	Marca
1	Válvula bola Bridada de 2 1/2" x 150 lbs.	01	Kitz
2	Válvula bola Bridada de 4" x 150 lbs.	01	Crane
3	Filtro tipo Y 2 1/2" bridado para vapor x 200 lbs.	01	Spirax Sarco
4	Válvula de Seguridad de 2 " x 2 1/2" x 150 lbs. Regulada a 38 Psi	01	Kunkle
5	Válvula Reductora de Presión 25P De 1 1/2" Caudal : 1200 kg/hr Rango de Regulación : 20 -100 psi (Resorte azul)	01	Spirax Sarco
6	Manómetro 0-60 PSI Dial 2 1/2"	01	
7	Válvula de ¼" x 1000 wog	01	Sun
8	Válvula de 1/2" x 1000 wog	02	Spirax Sarco

3.5.12 Estación de Regulación de vapor N°2 y N°3

El control de presión se realiza a través de una válvula de control especial, conocida como reductor de presión. Para operar un reductor de presión en una instalación de vapor es necesario una cantidad de válvulas auxiliares y accesorios.

Figura 3.40

En la foto adjunta podemos apreciar dos estaciones reductoras ; Estación Reductora N°2 (Superior) y Estación Reductora N°3 (inferior).

a) Estación Reductora de Presión N°2 : Skid de distribución WFI

Diseñada para un caudal de 350 Kg/ hr y una presión de trabajo de 3 bar .

Ubicada al costado de la sala de Calderas.

Tabla 3.26. Válvulas y accesorios Instalados

Ítem	Descripción	Cant	Marca
1	Válvulas Globo de 1 ½" x 800 lbs.	2	Neway
2	Filtro tipo Y 1 ½" para vapor	1	Spirax Sarco
3	Válvula de Seguridad de ¾" x ¾" Regulada a 50 Psi	1	Helbert
4	Válvula Reductora de Presión 25P De 3/4" Caudal : 350 kg/hr Rango de Regulación: 20 -100 psi (Resorte azul) Presión de Seteo : 3 bar (45 psi)	1	Spirax Sarco
5	Manómetro 0-60 PSI Dial 2 1/2"	1	
6	Válvula de ¼" x 1000 wog	1	Genebre

b) Estación Reductora de Presión N°3 : Skid WFI

Diseñada para un caudal de 160 Kg/ hr y una presión de trabajo de 2 bar .

Tabla 3.27. Válvulas y accesorios Instalados

Ítem	Descripción	Cant	Marca
1	Válvulas Globo de 1 ½" x 800 lbs.	2	Neway
2	Filtro tipo Y 1 ½" para vapor	1	Spirax Sarco
3	Válvula de Seguridad de 1/2" x ¾" Regulada a 35 Psi	1	Helbert
4	Válvula Reductora de Presión 25P De 1/2" Caudal : 160 kg/hr Rango de Regulación: 20 -100 psi (Resorte azul) Presión de Seteo : 2 bar (30 psi)	1	Spirax Sarco
5	Manómetro 0-60 PSI Dial 2 1/2"	1	
6	Válvula de ¼" x 1000 wog	1	Genebre

3.6 PLANTEAMIENTO DEL PROBLEMA

Debido a que la planta farmaceútica es nueva, no cuenta con las instalaciones mecánicas necesarias para el funcionamiento de los equipos usados en el proceso de fabricación de sus productos.

Cabe resaltar que la mayoría de estos equipos funcionan con vapor entre ellos tenemos autoclaves, reactores, calentadores de agua etc.

Por tal motivo se realizó diseño del sistema de distribución de Vapor .

CAPÍTULO IV

DISEÑO DEL SISTEMA DE TUBERIAS

4.1 DIMENSIONAMIENTO DEL SISTEMA DE TUBERIAS DE VAPOR:

El problema básico es determinar un diámetro adecuado de tubería para manejar un cierto flujo de vapor a una velocidad razonable con pérdidas de presión por fricción aceptables. La velocidad de vapor es limitada por la erosión que esta causa sobre las paredes del tubo y la pérdida de presión correspondiente.

Desde el punto de vista económico, la velocidad se debe de mantener lo más alta posible, sin exceder los límites establecidos o la caída máxima permisible entre le punto de suministro y el punto de alimentación de vapor.

Si se dimensiona la tubería en función de la velocidad, entonces los cálculos se basan en el volumen de vapor que se transporta con relación a la sección de la tubería.

Para tuberías de distribución de vapor saturado seco , por experiencia se demuestra que son razonables las velocidades entre 25-40 m/s (4900 – 8000 ppm) , pero deben considerarse como el máximo sobre la cual aparecen el ruido y la erosión.

a) Cálculo del Diámetro de Tuberías:

Para calcular el tamaño de la tubería existen diversos métodos, a continuación detallaremos dos métodos de cálculo:

El primero siguiendo el proceso matemático y el segundo utilizando monogramas.

Método 1 :

Consideraciones Iniciales:

V= La velocidad del Vapor (m/s)

Ve = Volumen específico del vapor (m^3/hg) (Ver anexo 10)

W = Flujo de masa del vapor (kg/s)

$\dot{V}$ = Caudal volumétrico (m^3/ s)

$$\dot{V} = W * Ve$$

A partir de esta información, se puede calcular la Sección A de la tubería:

$$Sección\ (A) = \frac{Caudal\ Volumétrico\ (\dot{V})}{Velocidad\ de\ Flujo\ (V)}$$

$$\frac{\pi x d^2}{4} = \frac{Caudal\ Volumétrico\ (\dot{V})}{Velocidad\ de\ Flujo\ (V)}$$

d = Diámetro interior de la tubería

Esta fórmula puede arreglarse para despejar el diámetro de la tubería:

$$d = \sqrt{\frac{(4 * \dot{V})}{\pi * C}}$$

.....(4.1)

Esto nos dará el diámetro de la tubería en m

Método 2:

El siguiente procedimiento asume el uso de gráficas anexas aunque también pueden utilizarse la fórmula 4.1 para mayor exactitud ó si las condiciones del sistema quedan fuera del rango de las gráficas.

Consideraciones Iniciales:

- Hacer un esquema de la instalación, de preferencia isométrico, mostrando cambios de dirección, bajadas, subidas, ramales etc.
- Hallar la longitud equivalente de cada tramo
- Las condiciones de vapor se deberán definir:

  V= La velocidad del Vapor (ppm)

  W = Flujo de masa del vapor (lb/hr))

  P1 = Presión (psi)
- Cuantificar la longitud equivalente de conexiones y válvulas
- Utilizando la figura 4.1 y obtener un diámetro de tubería tentativo.
- Con el diámetro seleccionado hallar la caída de Presión total P de toda la longitud equivalente (L) utilizando las figuras 4.2 y 4.3.

- Esta selección se deberá efectuar para cada tramo de tubería que maneje flujos diferentes y para cada ramal

Procedimiento de Cálculo:

1. Utilizando la figura 4.1 obtener el diámetro de tubería tentativo, ingresando a dicha gráfica con el caudal y Presión, trazar una línea horizontal del Pto A (caudal) hasta el pto B (presión). Luego seguir verticalmente Hasta C , donde la intersección con una diagonal caiga dentro de la banda de Velocidades comprendidas entre 4900 y 8000 pies por minuto.

2. Con el diámetro seleccionados en el punto 2 determinar la caída de presión unitaria (por cada 100 pies) utilizando las figuras 4.2 ó 4.3.

3. Calcular la caída de presión total P de toda longitud equivalente (L)

4. Hacer la selección del diámetro que cumpla mejor con los requerimientos técnicos y económicos.

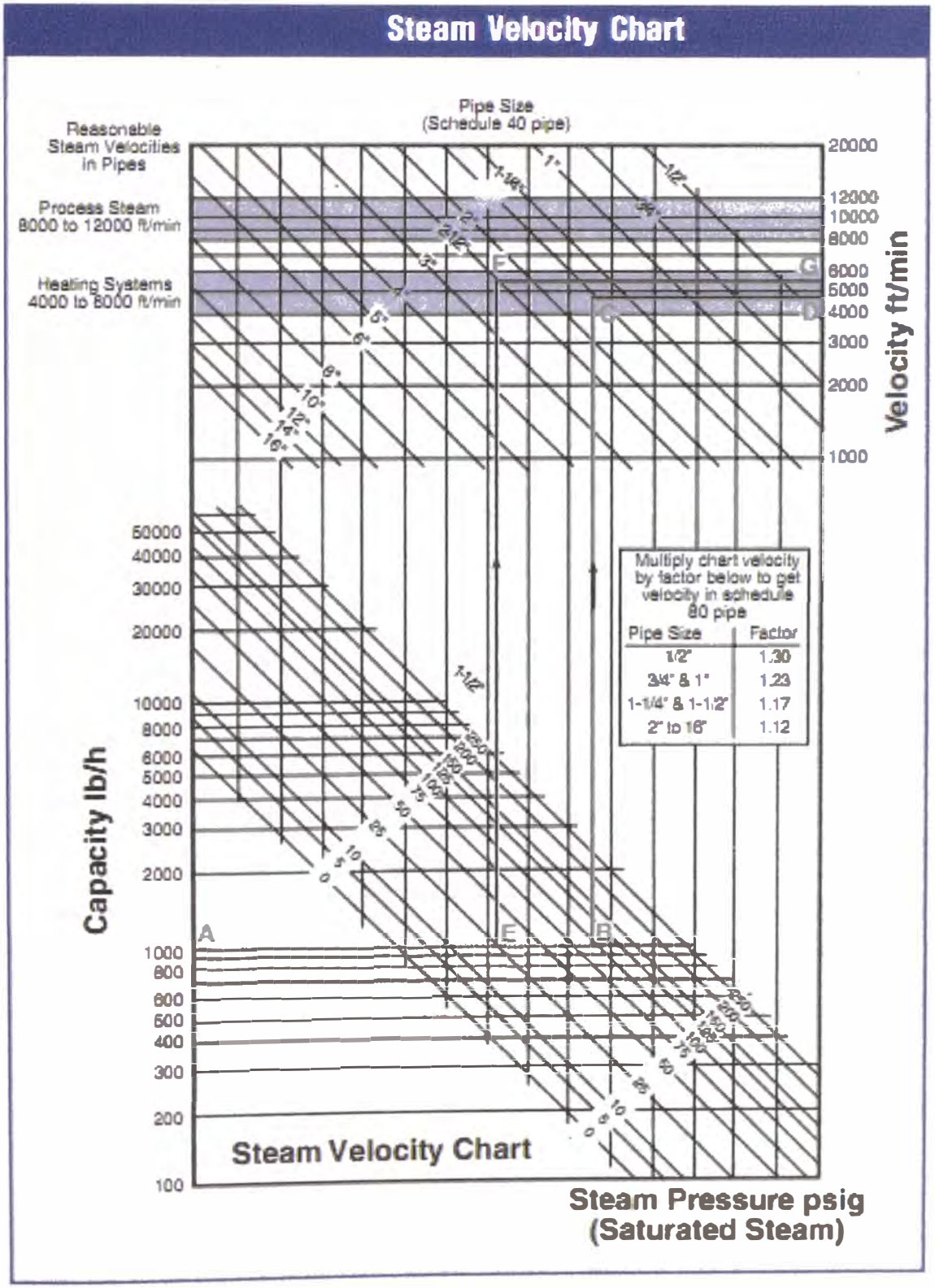

Steam Velocity Chart
Pipe Size
(Schedule 40 pipe)
Reasonable
Steam Velocities
in Pipes
Process Steam
8000 to 12000 ft/min
Heating Systems
4000 to 8000 ft/min
Velocity ft/min
20000
12000
10000
8000
6000
5000
4000
3000
2000
1000
Capacity lb/h
50000
40000
30000
20000
10000
8000
6000
5000
4000
3000
2000
1000
800
600
500
400
300
200
100
Multiply chart velocity by factor below to get velocity in schedule 80 pipe
Pipe Size | Factor
1/2" | 1.30
3/4" & 1" | 1.23
1-1/4" & 1-1/2" | 1.17
2" to 16" | 1.12
Steam Velocity Chart
Steam Pressure psig
(Saturated Steam)

Figura 4.1

b) Cálculo de la caída de Presión en tuberías:

El siguiente procedimiento asume el uso de gráficas, los cuales dan caídas de presión en tuberías SCh40 y Sch80.

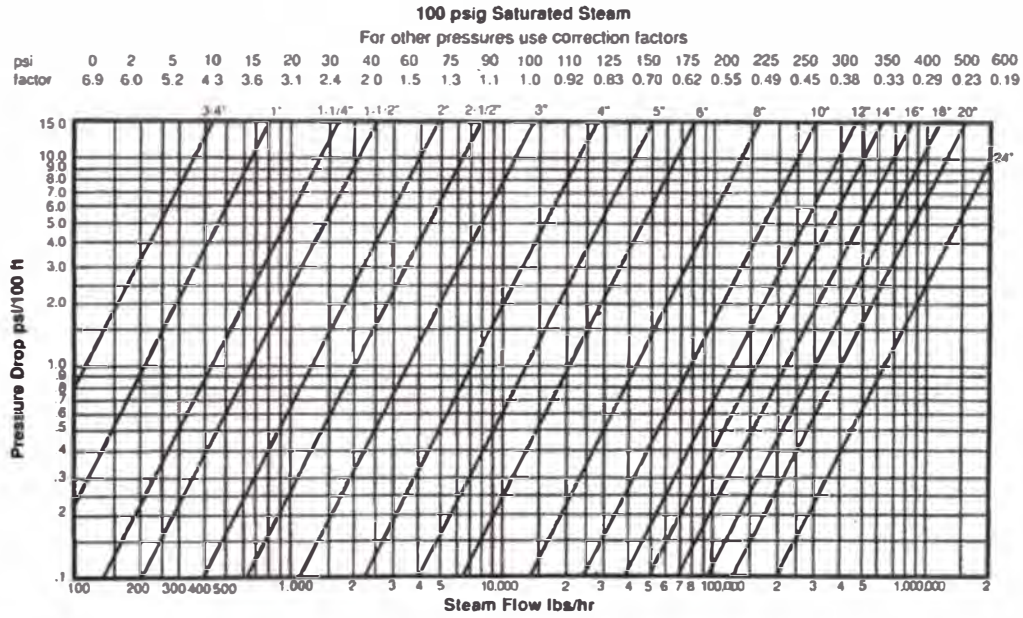


Figura 4.2

Caída de Presión en Tuberías SCh- 40 (0- 15 PSI)

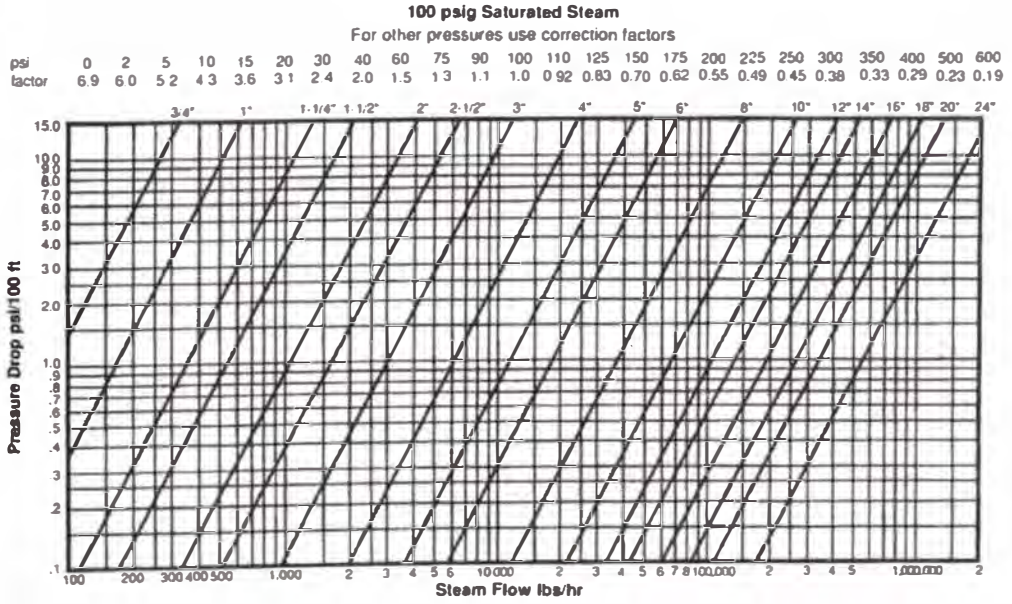


Figura 4.3

Caída de Presión en Tuberías SCh- 80 (0- 15 PSI)

Tabla : 4.1 Cantidad de vapor por equipo

ITEM	EQUIPOS	VAPOR		PRESION DE TRABAJO		OBS
1	SALA DE TRATAMIENTO DE AGUA					Los equipos no operan todos a la vez
1.1	Skid de Distribución WFI	250	Lb/hr	43.5	psi	
1.2	Skid WFI	160	Lb/hr	29	psi	
	Consumo de Vapor item 1	410	Lb/hr			
2	CALENTADOR DE AGUA					
2.1	Calentador de agua	385	Lb/hr	80-90	psi	
	Consumo de Vapor item 2	385	Lb/hr			
3	ZONA DE TANQUES PARENTERALES Y FRUTIFLEX					
3.1	Tanque Parenteral N°1	880	Lb/hr	20- 30	psi	
3.2	Tanque Parenteral N°2	880	Lb/hr	20- 30	psi	
3.3	Tanque Parenteral N°3	880	Lb/hr	20- 30	psi	
3.4	Tanque Parenteral N°4	880	Lb/hr	20- 30	psi	
3.5	Tanque Parenteral N°5	880	Lb/hr	20- 30	psi	
3.6	Tanque Parenteral N°6	880	Lb/hr	20- 30	psi	
3.7	Tanque Parenteral N°7	880	Lb/hr	20- 30	psi	
3.8	Tanque Frutiflex N°8	880	Lb/hr	20- 30	psi	
3.9	Tanque Frutiflex N°9	880	Lb/hr	20- 30	psi	
3.1	Tanque Dialisis N°10	880	Lb/hr	20- 30	psi	
3.11	Tanque Dialisis N°11	880	Lb/hr	20- 30	psi	
	Consumo de Vapor item 3	3520	Lb/hr			(solo operan 4 tks a la vez)
4	ZONA DE ESTERILIZADO					
4.1	Autoclave A4000	8800	Lb/hr	80-90	psi	
4.2	Autoclave A3500	8800	Lb/hr	80-90	psi	
	Consumo de Vapor item 4	8800	Lb/hr			
5	TANQUE DE CONDENSADO PRINCIPAL					
5.1	Tanque de condensado Principal	400	Lb/hr	80-90	psi	
	Consumo de Vapor item 5	400	Lb/hr			

4.1.1. Línea de Alimentación de Vapor a Manifold Principal :

a) Caldera 1: Caldera pirotubular de 125 BHP

Condiciones solicitadas:

Caudal : 4313 (lb/hr) ..... (4.1)

Presión Inicial del vapor saturado : 100 psig .....(4.2)

Solución:

Para el dimensionamiento de la tubería debemos considerar los Datos iniciales de Caudal ecuación (4.1) y Presión ecuación (4.2) Ingresamos a la gráfica de velocidades (figura 4.1).

Para una velocidad de 5500 pies por minuto , la tubería seleccionada es:

Diametro : ϕ 3" .

De la figura 4.2 calculamos la caída de Presión (ΔP) , ingresando con la presión y el caudal indicados en las condiciones Iniciales.

Siendo:

P_2 : Presión Final del tramo de tubería.

L: Longitud equivalente del tramo de Tubería.

$P_2 = P1 - \Delta P * (L /100)$

$P_2 = 100 \text{ Psi} - 2.2 \times (42.5 \text{ pies}/100 \text{ pies})$

$P_2 = 99.06 \text{ Psi}$

b)Caldera 2: Caldera pirotubular de 250 BHP

Condiciones solicitadas:

Caudal : 8625 (lb/hr) ..... (4.3)

Presión del vapor saturado: 100 psig .....(4.4)

Solución:

Para el dimensionamiento de la tubería debemos considerar los Datos iniciales de Caudal ecuación (4.3) y Presión ecuación (4.4) Ingresamos a la gráfica de velocidades (Figura 4.1).

Para una velocidad de 5500 pies por minuto , la tubería seleccionada es:

Diametro : ϕ 4" .

De la figura 4.2 calculamos la caída de Presión (ΔP) , ingresando con la presión y el caudal indicados en las condiciones Iniciales.

Siendo:

P_2 : Presión Final del tramo de tubería.

L: Longitud equivalente del tramo de Tubería.

$P_2 = P1 - \Delta P * (L /100)$

P_2 = 100 Psi – 1.4 x (25 pies/100 pies)

P_2 = 99.65 Psi

4.1.2. Línea de Distribución principal de Vapor de ϕ 6

Condiciones solicitadas:

Caudal : 21563 (lb/hr) ..... (4.5)

Presión Inicial del vapor saturado: 100 psig .....(4.6)

Solución:

Con los Datos iniciales de Caudal ecuación (4.5) y Presión ecuación (4.6) Ingresamos a la gráfica de velocidades (Figura 4.1).

Para una velocidad de 6000 pies por minuto , la tubería seleccionada es:

Diámetro : ϕ 6"

De la figura 3.2 cálculamos la caída de Presión (ΔP) , ingresando con la presión y el caudal indicadas en las condiciones Iniciales.

P_2 : Presión Final del tramo de tubería.

L: Longitud equivalente del tramo de Tubería.

$P_2 = P1 - \Delta P * (L /100)$

P_2 = 100 Psi – 0.35 x (339 pies/100 pies)

P_2 = 98.81Psi

4.1.3 Línea de Distribución de Vapor ϕ 4" – Autoclaves

Condiciones solicitadas:

Caudal : 4000 (kg/hr) = 8800 (lb/hr) ..... (4.7)

Presión Inicial del vapor saturado: 100 psig .....(4.8)

Solución:

Con los Datos iniciales de Caudal ecuación (4.7) y Presión ecuación (4.8) Ingresamos a la gráfica de velocidades (Tabla 4.1).

Para una velocidad de 6000 pies por minuto , la tubería seleccionada es:

Diámetro : ϕ 4"

De la figura 4.2 calculamos la caída de Presión (ΔP) , ingresando con la presión y el caudal indicados en las condiciones Iniciales.

P_2 : Presión Final del tramo de tubería.

L: Longitud equivalente del tramo de Tubería.

P_2= P1- ΔP *(L /100)

P_2 = 100 Psi – 1.5 x (84.29 pies/100 pies)

P_2 = 98.81Psi

4.1.4 Línea de Distribución de Vapor de ϕ4" - Tanques de Preparación

Condiciones solicitadas:

Caudal : 1600 (kg/hr) =3520 (lb/hr) ..... (4.9)

Presión Inicial del vapor saturado: 25 psig .....(4.10)

Solución:

Con los Datos iniciales de Caudal ecuación (4.9) y Presión ecuación (4.10) Ingresamos a la gráfica de velocidades (Tabla 4.1).

Para una velocidad de 6500 pies por minuto , la tubería seleccionada es:

Diámetro : ϕ 4"

De la figura 4.2 calculamos la caída de Presión (ΔP) , ingresando con la presión y el caudal indicadas en las condiciones Iniciales.

P_2 : Presión Final del tramo de tubería.

L: Longitud equivalente del tramo de Tubería.

$P_2 = P1 - \Delta P * (L / 100)$

P_2 = 25 Psi – 0.25 x (185 pies/100 pies) *f (factor de corrección a 25 psi)

P_2 = 25 Psi – 0.25 x (185 pies/100 pies) *3.3

P_2 = 24.75Psi

4.1.5 Línea de Distribución de Vapor de ϕ2 1/2" a Estación Reductora N° 1

Condiciones solicitadas:

Caudal : 1600 (kg/hr) =3520 (lb/hr) ..... (4.11)

Presión del vapor saturado: 100 psig .....(4.12)

Solución:

Con los Datos iniciales de Caudal ecuación (4.11) y Presión ecuación (4.12) Ingresamos a la gráfica de velocidades (Tabla 4.1).

Para una velocidad de 6000 pies por minuto , la tubería seleccionada es:

Diametro : ϕ 2 1/2"

4.1.6 Línea de Distribución de Vapor ϕ 1 1/2" a Sala de tratamiento de agua

a) Equipo SKID WFI:

Condiciones solicitadas:

Caudal : 350 (lb/hr) ..... (4.13)

Presión del vapor saturado: 43.5 psig .....(4.14)

Solución:

Con los Datos iniciales de Caudal ecuación (4.13) y Presión ecuación (4.14) Ingresamos a la gráfica de velocidades (Tabla 4.1).

Para una velocidad de 4000 pies por minuto , la tubería seleccionada es:

Diametro : ϕ 1 1/4"

c) Equipo SKID DE DISTRIBUCION WFI:

Condiciones solicitadas:

Caudal : 160 (lb/hr) ..... (4.15)

Presión del vapor saturado: 29 psig .....(4.16)

Solución:

Con los Datos iniciales de Caudal ecuación (4.15) y Presión ecuación (4.16) Ingresamos a la gráfica de velocidades (Tabla 4.1).

Para una velocidad de 4000 pies por minuto , la tubería seleccionada es:

Diámetro : ϕ1 "

4.1.7 Línea de Distribución de Vapor ϕ1" a Tanque de condensado principal

Condiciones solicitadas:

Caudal : 400 (lb/hr) ..... (4.17)

Presión del vapor saturado: 100 psig .....(4.18)

Solución:

Con los Datos iniciales de Caudal ecuación (4.17) y Presión ecuación (4.18) Ingresamos a la gráfica de velocidades (Tabla 4.1).

Para una velocidad de 4000 pies por minuto , la tubería seleccionada es:

Diametro : ϕ 1"

4.1.8 Línea de Distribución de Vapor ϕ 1 " a Calentador de agua

Condiciones solicitadas:

Caudal : 385 (lb/hr) ..... (4.19)

Presión del vapor saturado: 100 psig .....(4.20)

Solución:

Con los Datos iniciales de Caudal ecuación (4.19) y Presión ecuación (4.20) Ingresamos a la gráfica de velocidades (Tabla 4.1).

Para una velocidad de 4000 pies por minuto , la tubería seleccionada es:

Diametro : ϕ 1"

4.2 ANÁLISIS DE FLEXIBILIDAD.

Se tiene el siguiente sistema real de tuberías:

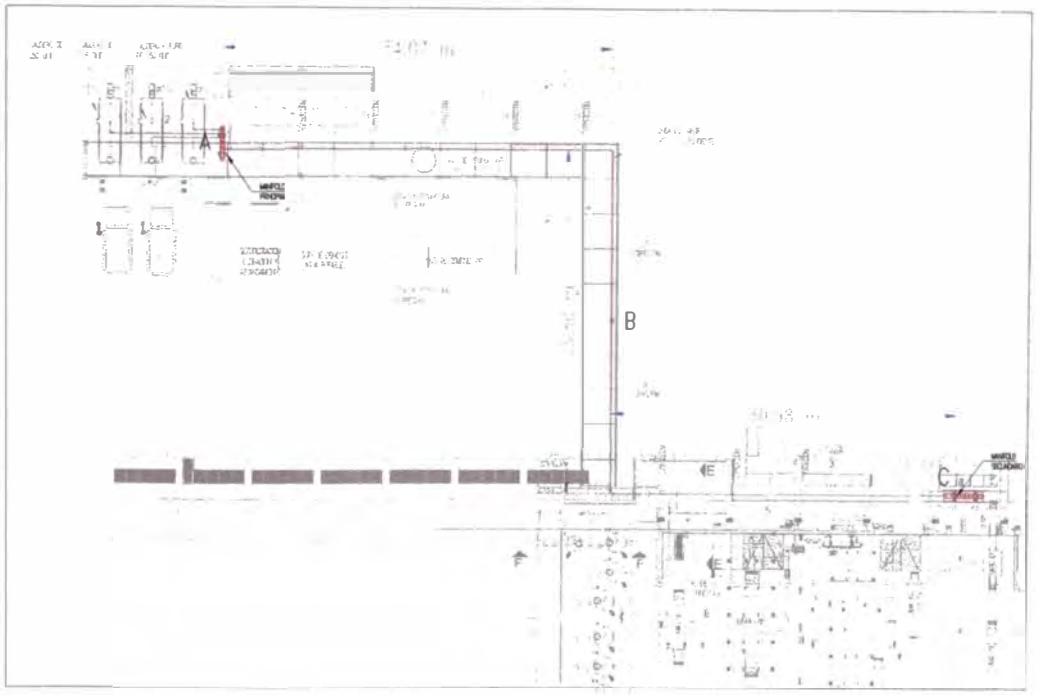


Figura 4.4

El sistema de tuberías para el análisis se separará en dos tramos.

Tabla 4.2- Tramo 1 (A-B)

ITEM	PRIMER TRAMO	LONGITUD (m)	DEFORMACION (mm)	
			150 ºC	171 ºC
1	L1	6.32	7.96	8.22
2	L2	3	4.64	4.90
3	L3	1.59	3.23	3.49
4	L4	31.07	32.71	32.97
5	L5	14.4	16.04	16.30

Tabla 4.3- Tramo 2 (B-C)

ITEM	SEGUNDO TRAMO	LONGITUD (m)	DEFORMACION (mm)	
			150 ºC	171 ºC
1	L1	14.4	16.04	16.30
2	L2	30.98	32.62	32.88
3	L3	1.445	3.08	3.35

El sistema de tuberías se puede representar en dos tramos como sigue:

Con dos apoyos fijos y resto de apoyos sin restricción al movimiento.

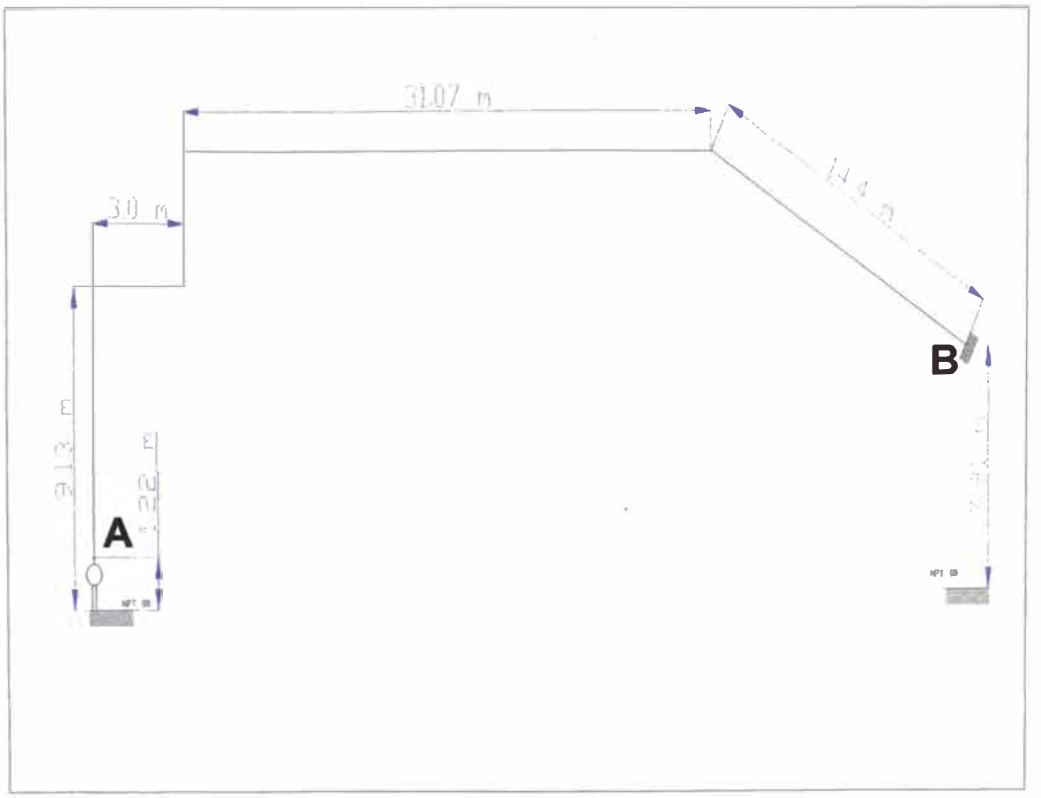


Figura 4.4- Tramo 1

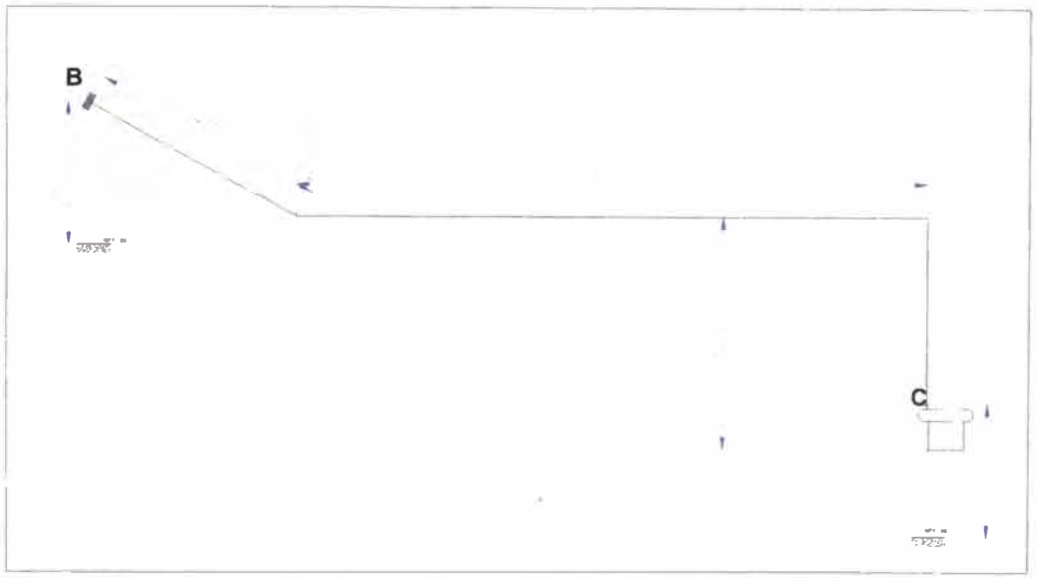


Figura 4.5 -Tramo 2

4.2.1 Método Antiguo :

Tramo 1:

Aplicando el análisis de esfuerzos y flexibilidad, según el "Código ASA B – 31 - 1 para Tuberías a Presión" , se obtiene:

L= Longitud total de tubería (Ver Figura 4.4)

L = L1 + L2 + L3 + L4 + L5 =6.32 + 3.00 + 1.59 + 31.07 + 14.4 =56.38 m ≈184.9 pies

U = Distancia neta entre apoyos

U = 36.92 m ≈ 121.12 pies

D= Diámetro nominal de la tubería

D = 6"

$$\frac{U}{D} = \frac{121.12}{6} = 20.18$$

$$\frac{L}{U} = \frac{184.9}{121.12} = 1.52$$

De la figura 4.3 (Ver capítulo 4), para una temperatura de operación de 365.9 °F y un valor de U/D de 20.18, se tiene:

➔ El valor R = 1.20

Se debe cumplir el siguiente criterio

➔ R < L/U

Vemos que R= 1.2 < L/U = 1.52

Por lo tanto:

El tramo 1 es flexible y no requiere juntas de expansión.

Tramo 2:

Aplicando el análisis de esfuerzos y flexibilidad, según el "Código ASA B – 31 - 1 para Tuberías a Presión" , se obtiene:

L= Longitud total de tubería (Ver Figura 4.5)

L = L1 + L2 + L3 =46.825 m ≈153.6 pies

U = Distancia neta entre apoyos

U = 34.19 m ≈ 112.18 pies

D= Diámetro nominal de la tubería

D = 6"

$$\frac{U}{D} = \frac{112.18}{6} = 18.69$$

$$\frac{L}{U} = \frac{153.6}{112.18} = 1.37$$

De la figura 4.3 (Ver capítulo 4), para una temperatura de operación de 365.9 ºF y un valor de U/D de 18.69, se tiene:

➔ El valor R = 1.21

Se debe cumplir el siguiente criterio

➔ R < L/U

Vemos que R= 1.21 < L/U = 1.52

Por lo tanto:

El tramo 2 es flexible y no requiere juntas de expansión.

4.2.2 Método Nuevo :

Tramo 1:

L= Longitud total de tubería (Ver Figura 4.5)

L = L1 + L2 + L3 + L4 + L5 =6.32 + 3.00 + 1.59 + 31.07 + 14.4 =56.38 m ≈184.9 pies

U = Distancia neta entre apoyos

U = 36.92 m ≈ 121.12 pies

D= Diámetro exterior de la tubería

D = 6.625"

Y = Resultante total del desplazamiento en pulgadas.

Y = 65.88 mm =2.56" para estar en el lado conservativo tomaremos como 3"

De la ecuación (3.2)

$$K_1 = 30\, S_A/E_a \ (in/ft)^2$$

Donde:

E_a = 29500000 Psi

De la ecuación (2.3)

$$S_A = f\,(1.25\, S_c + 0.25\, S_h)$$

De forma conservativa podremos tomar f = 0.9 ver tabla 3.6

S_c = 23300 psi para 25 ºC

S_h = 20300 psi para 180 ºC

Luego reemplazando valores :

S_A = 0.9 (1.25 *23300 + 0.25 *20300) = 30780 psi

Reemplazando valores :

K_1 = 30* 30780/29500000 = 0.03130

Luego :

$DY/ (L-U)^2 \leq K_1$

$DY/ (L-U)^2$ = 6.625 *3/(184.9 - 121.12)^2 = 0.004885 ≤ 0.030798

Por lo tanto, el sistema es flexible no requiere cálculos detallados ni juntas de expansión.

Tramo 2:

L= Longitud total de tubería (Ver Figura 4.5)

L = L1 + L2 + L3 =46.825 m ≈153.6 pies

U = Distancia neta entre apoyos

U = 34.19 m ≈ 112.18 pies

D= Diámetro exterior de la tubería

D = 6.625"

Y = Resultante total del desplazamiento en pulgadas.

Y = 52.53 mm =2.068" para estar en el lado conservativo tomaremos como 2 1/2".

De la ecuación (3.2)

$$K_1 = 30\ S_A/E_a\ (in/ft)^2$$

Donde:

E_a = 29500000 Psi

De la ecuación (3.3)

$$S_A = f\ (1.25\ S_c + 0.25\ S_h)$$

De forma conservativa podremos tomar f = 0.9 ver tabla 3.6

S_c = 23300 psi para 25 ºC

S_h = 20300 psi para 180 ºC

Luego reemplazando valores :

S_A = 0.9 (1.25 *23300 + 0.25 *20300) = 30780 psi

Reemplazando valores :

K_1 = 30* 30780/29500000 = 0.03130

Luego :

$DY/(L-U)^2 \leq K_1$

$$DY/(L-U)^2 = 6.625 * 2.5 /(153.6 - 112.182)^2 = 0.00965 \leq 0.030798$$

Por lo tanto, el sistema es flexible no requiere cálculos detallados ni juntas de expansión

CAPITULO V

PRESUPUESTO DEL PROYECTO

A continuación mostraremos el presupuesto presentada al cliente:

5.1 COSTO DE MATERIALES:

La oferta presentada fue a suma alzada (tablas del presupuesto 5.1 al 5.4)

5.2 COSTO DE EQUIPOS:

La oferta presentada fue a suma alzada (tablas del presupuesto 5.1 al 5.4)

5.3 RESUMEN DE COSTOS.

5.3.1 DESCRIPCIÓN DE LOS TRABAJOS

5.3.2 ALCANCE DE LOS TRABAJOS

5.3.3 SUMINISTROS

5.3.4 SUMINISTRO DEL CLIENTE

5.3.5 ACLARACIONES TÉCNICAS

5.3.6 ACLARACIONES COMERCIALES

5.3.7 IMPUESTO GENERAL A LAS VENTAS

5.3.8 VALOR DE LA OFERTA

5.3.9 PLAZO PARA LA EJECUCION DE LOS TRABAJOS

5.3.10 FORMA DE PAGO

5.3.11 VALIDEZ DE LA OFERTA

5.3.1 DESCRIPCIÓN DE LOS TRABAJOS

El presente proyecto consiste en el dimensionamiento de una red de tuberías y accesorios para vapor, para una planta farmacéutica totalmente nueva y moderna, la cual utiliza vapor en sus diversos procesos de fabricación.

5.3.2 ALCANDE DE LOS TRABAJOS

OBRA MECÁNICA:

MONTAJE MECÁNICO:

- Sistemas de vapor

  Montaje de tuberías y equipos auxiliaraes, válvulas manuales y de control, forrado del sistema.

El presupuesto está de acuerdo con la descripción proporcionada en los documentos por el cliente.

5.3.3 SUMINISTROS:

En la propuesta ha considerado:

- El personal calificado, directo e indirecto necesario para la ejecución de las actividades a ejecutar.
- La dotación del personal y elementos de protección personal (EPP).
- Se ha considerado la implementación de una oficina en campo.
- Los materiales consumibles y fungibles (electrodos de soldadura, discos de pulir brocas, gases industriales, gratas, polines de madera,

cinta de seguridad,) requeridos para eventuales trabajos menores de instalación de elementos objeto de este proyecto.

- Equipos mayores (grúas, camiones, manlift, montacargas), equipos menores y herramientas necesarios en calidad y cantidad suficiente, para la ejecución de los trabajos.

- Dossier del proyecto que incluye registros de calidad, procedimientos calificados, registro fotográfico, plan de calidad, cronograma de actividades, panorama de riesgos, etc., en copia dura.

5.3.4 SUMINISTRO DEL CLIENTE:

- Acompañamiento para la realización del plan de desarrollo de actividades necesario.
- Dos (2) copias impresas de planos de detalle, manuales y documentos técnicos de montaje, debidamente aprobados para construcción, que se requiera para desarrollar los trabajos objeto de esta propuesta, por lo menos dos (2) semanas antes de iniciar los trabajos, para realizar el plan de desarrollo de actividades necesario, el cliente será responsable de la calidad de dicha información.
- Todas las obras civiles, que se requieran previas a la realización de nuestro alcance, que no se encuentren descritas en el presente documento, de tal manera que se garantice la continuidad en la ejecución del plan de trabajo establecido, una vez se formalice el contrato.
- Suministros de todos los materiales permanentes, estructuras y equipos a ser instalados, los cuales hemos considerado serán entregados en el sitio de la obra a realizar.

- Acompañamiento técnico de los proveedores principales de los equipos suministrados por el cliente.
- Suministro de todos los equipos para el montaje del sistema.
- Los permisos necesarios para acceder a los sitios donde se realizarán los trabajos de la presente oferta y otros si son requeridos.
- Suministro de agua industrial en cantidad y calidad suficiente, en el sitio de las obras. Para las pruebas hidrostáticas, el punto de toma para esta actividad a una distancia no mayor de 50 metros de la obra.
- Suministro de energía eléctrica

5.3.5 ACLARACIONES TÉCNICAS

- Las cantidades de obra, se pagarán de acuerdo a los precios pactados y a las cantidades reales ejecutadas, acordando un nuevo plazo en caso que las estas aumenten por motivos ajenos.
- Los ítems nuevos que resultaren y por tanto no tengan cantidades ni precio serán negociados como obra extra.
- Nuestra oferta no incluye las siguientes actividades ya que asumimos hacen parte del alcance del cliente: Suministro de agua para pruebas hidrostáticas y control de polvos.
- El cliente deberá entregar todas las áreas a ser intervenidas libres de materiales y escombros. Igualmente todas las facilidades en condiciones seguras para realizar los trabajos dentro del plazo establecido.
- Hemos considerado una jornada de trabajo normal diurna de 48 horas a la semana, sin trabajos en domingos o festivos y bajo el sistema de contratación de régimen común. En caso de requerirse horarios

adicionales, por razones no imputables a la empresa, el recargo por horas extras que se ocasionen, será reconocido por el cliente.

- Nuestros precios se basan en las condiciones técnicas entregadas y cantidades indicadas por el cliente . Si las cantidades varían en un más o menos 3%, respecto a las condiciones iniciales presentadas, deberán ser revisados los precios y plazos indicados en nuestra oferta.
- Dentro de nuestro alcance no hemos considerado trabajos de adecuación de zonas de ensamble, mantenimiento de las vías de acceso a las zonas de trabajo e instalaciones provisionales, los cuales consideramos responsabilidad del cliente.
- Toda actividad que se encuentre fuera del alcance de los trabajos descritos anteriormente, será cobrado como obra adicional.
- Todos nuestros precios son ajustados al año 2010 la fecha de entrega de esta oferta, por lo cual no hemos considerado incremento por cambio de años ni fórmulas de reajuste.

5.3.6 ACLARACIONES COMERCIALES

a. Dentro de nuestra oferta hemos considerado:

- Salario del personal con todos los porcentajes de Ley.
- Prestaciones sociales.
- Dotación y elementos de seguridad.
- Costos de contratación de personal.
- Suministro de equipos propios y alquilados para las labores objeto de esta propuesta.
- Utilidad
- Herramientas y consumibles.

- Gastos generales de dirección y administración.

b. La empresa ha considerado dentro del valor de la oferta los costos de las primas de las siguientes cartas fianzas y seguros emitidas por una compañía de seguros legalmente constituida en Perú, o por un banco local:

- Carta Fianza por buen manejo de anticipo por el 100% del valor recibido en anticipo y vigente por la duración de los trabajos y dos (2) meses más.
- Carta Fianza por Cumplimiento del contrato por el 10% del valor del contrato, vigente por la duración de los trabajos y dos (2) meses más.
- Seguro de responsabilidad civil extracontractual por el 20% del valor total del contrato y con una vigencia igual a la duración del mismo y un (1) mes más.
- Seguro de Todo Riesgo por el 100% del valor total del contrato y con una vigencia igual a la duración del mismo y un (1) mes más.

c. En caso de terminación anticipada de los trabajos por causas no imputables a nuestra empresa, se dará aviso por escrito con ocho (8) días de anticipación. En este caso nuestra empresa, recibirá el pago íntegro de la parte ejecutada del CONTRATO, incluyendo los valores correspondientes a los trabajos ejecutados hasta la fecha de terminación, los pendientes laborales del personal contratado para ejecutar la obra, así como los materiales e insumos comprados para la ejecución del proyecto, y aquellos a los cuales se les haya colocado

orden de compra y se encuentren en proceso, previo a su entrega y el reintegro de los documentos de garantía en poder del cliente, una vez saldado íntegramente el CONTRATO.

d. En caso que se presenten mayores permanencias de equipos o mano de obra que afecten nuestra estructura de costos, por causas no imputables a nuestra empresa, estos deberán ser reconocidos por el cliente.

e. En caso de que nuestra empresa, deba efectuar compras que estén por fuera del alcance de la propuesta, éstas se realizarán con el visto bueno del cliente se cobrará el valor de la compra más los costos de entrega en sitio, más un porcentaje por gestión de compra del 15%..

f. En caso que se presenten nuevos impuestos después de aceptada la oferta, decretados por el gobierno de Perú que afecten la estabilidad económica del proyecto, estos nuevos impuestos deberán ser reconocidos por el cliente.

g. Nuestros precios no contemplan sobrecostos por concepto de cambio de año para el 2011. En caso de realizar trabajos durante el año 2011, se realizarán los ajustes correspondientes a los precios de mano de obra, insumos, subcontratos, etc., de acuerdo con los índices que más se ajusten a cada variable los cuales serán previamente acordados entre las partes.

h. Si llegase a existir la necesidad de usar algún suministro que contenga acero debido a los cambios constantes en su precio a nivel mundial, en caso de haber variación entre la fecha de presentación de la propuesta, la fecha de negociación del contrato u orden de compra y la fecha de compra de este material, se harán los ajustes económicos

correspondientes y las diferencias por incrementos en el precio serán reconocidos por el cliente.

i. Las partes de común acuerdo se comprometen y asumen la obligación ineludible, de no contratar ni de ofrecer contrato a los empleados directos o indirectos que las partes utilicen en la ejecución de la obra Esta obligación tendrá una duración equivalente al plazo de ejecución de los trabajos y un año más a partir de su terminación. En caso de incumplimiento las partes acuerdan que se podrán hacer efectivas las multas y cláusula penal que establece el contrato con el propósito de resarcir los daños y perjuicios que se llegaren a ocasionar.

j. Nuestra oferta aplica siempre y cuando sea adjudicada por el total de los trabajos presupuestados. Adjudicaciones parciales conllevan ajustes de precios.

k. Los términos y condiciones así como el clausulado del futuro contrato a firmar serán revisados en caso que la oferta presentada por nuestra empresa resultare elegida, será acordado previamente entre las partes antes del inicio de los trabajos.

5.3.7 IMPUESTO GENERAL A LAS VENTAS

Nuestra oferta NO incluye el impuesto general a las ventas (IGV).

5.3.8 VALOR DE LA OFERTA.

El valor total de nuestra es a suma alzada por un monto de **($./ 446,300.39) CUATROCIENTOS CUARENTA Y SEIS MIL TRECIENTOS NUEVOS SOLES CON TREINTA Y NUEVE CENTAVOS, ANTES DE IGV.**

5.3.9 PLAZO ESTIMADO PARA LA EJECUCIÓN DE LOS TRABAJOS

El plazo estimado para la ejecución de los trabajos en obra es de once (11) meses calendario, incluyendo dos meses de labores de movilización, desmovilización y planificación detallada de la obra.

El plazo cuenta a partir de la firma del contrato, pago del anticipo, entrega de ingeniería de detalle, materiales y equipos.

5.3.10 FORMA DE PAGO

Nuestra empresa propone el siguiente esquema de pagos:

El 20% como anticipo, sobre el valor total del contrato pagadero al momento de la firma del contrato y previa entrega de la carta fianza de buen manejo del anticipo.

El monto restante del valor del contrato se pagará mediante actas de avance quincenales con pago a (30) días después de radicada la factura.

5.3.11 VALIDEZ DE LA OFERTA

La presente oferta es válida por ciento veinte (30) días a partir de la fecha de entrega.

5.1 Tabla de presupuesto

HOMOLOGACION			PRESUPUESTO	Aprobado:		JGP
SGS				Por:		
nivel B+				Fecha:		27-May-10
PROYECTO		TUBERIAS	AUXILIARES PARA NUEVA PLANTA - LURIN			
Item	Cant.	Unid.	DETALLE		P.unit	P. Total
1			Línea de vapor			
			Plano: TE09-PL-BBM-NPBL-ME-IS001-A			
			Suministro de Materiales:			
1.1	18	Pza	Tubo de 6", acero al carbono ASTM A53, Sch40			
1.2	28	Pza	Tubo de 4", acero al carbono ASTM A53, Sch40			
1.3	7	Pza	Tubo de 3", acero al carbono ASTM A53, Sch40			
1.4	10	Pza	Tubo de 2 1/2", acero al carbono ASTM A53, Sch40			
1.5	10	Pza	Tubo de 1 1/2", acero al carbono ASTM A53, Sch40			
1.6	6	Pza	Tubo de 1", acero al carbono ASTM A53, Sch40			
1.7	7	Pza	Tubo de 1/2", acero al carbono ASTM A53, Sch40			
1.8	8	UND	Codo 90° de 6", acero al carbono, Sch40			
1.9	18	UND	Codo 90° de 4", acero al carbono , Sch40			
1.2	8	UND	Codo 90° de 3", acero al carbono , Sch40			
1.21	10	UND	Codo 90° de 2 1/2", acero al carbono , Sch40			
1.22	38	UND	Codo 90° de 1 1/2", fierro negro 150 lbs, roscado			
1.23	8	UND	Codo 90° de 1", fierro negro 150 lbs, roscado			
1.24	10	UND	Codo 90° de 1/2", fierro negro 150 lbs, roscado			
1.25	3	UND	Tee de 4", clase 150 , acero al carbono			
1.26	3	UND	Tee de 2 1/2", clase 150 , caeo al carbono			
1.27	28	UND	Union universal fierro negro 150 lbs, roscado de 1 1/2"			
1.28	8	UND	Union universal fierro negro 150 lbs, roscado de 1"			
1.29	9	UND	Union universal fierro negro 150 lbs, roscado de 1/2"			
1.3	1	UND	Reduccion excentrica Ac soldable sch40 de 2 1/2"x4"			
1.31	4	UND	Brida tipo anillo acero soldable ANSI 150, de 6"			
1.32	22	UND	Brida tipo anillo acero soldable ANSI 150, de 4"			
1.33	4	UND	Brida tipo anillo acero soldable ANSI 150, de 3"			
1.34	18	UND	Brida tipo anillo acero soldable ANSI 150 de 2 1/2"			
1.35	1	UND	Brida tipo anillo acero soldable ANSI 150 de 2"			
1.36	16	UND	Empaque espirometalico c-304 relleno de grafito de 6"x150			
1.37	13	UND	Empaque espirometalico c-304 relleno de grafito de 4"x150			
1.38	14	UND	Empaque espirometalico c-304 relleno de grafito de 3"x150			
1.39	8	UND	Empaque espirometalico c-304 relleno de grafito de 2 1/2"x150			
1.4	200	UND	Perno acero forjado grado 5 de 5/8"x3"			
1.41	100	UND	Perno acero forjado grado 5 de3/4"x3 1/2"			
1.42	2	UND	Valvula de Globo de 6",143xU ANSI 150, Crane			
1.43	2	UND	Valvula de Globo de 4",143xU ANSI 150, Crane			
1.44	3	UND	Valvula de Globo de 3",143xU ANSI 150, Crane			
1.45	1	UND	Valvula de Globo de 2 1/2",143xU ANSI 150, Crane			
1.46	1	UND	Valvula de Globo de 2", 143xU ANSI 150, Crane			
1.47	1	UND	Valvula de Globo de 1 1/2", 143xU ANSI 150, Crane			
1.48	1	UND	Valvula de Globo de 1", 143xU ANSI 150, Crane			
1.49	2	UND	Valvula de esfera M10S2 de 1 1/2", sarco			
			SISTEMA DE VAPOR A TANQUE DE CONDENSADO			
1.50	1	UND	Valvula de globo de 1"			
1.51	1	UND	Filtro de 1"			
1.52	1	UND	Valvula de espera M10S2 DE 1", SARCO			
1.53	1	UND	Actuador neumatico			
1.54	1	UND	Electrovalvula 5/2			
1.55	1	UND	Filtro Regulador			
1.56	1	UND	Control de temperatura			
1.57	11	Unid	Valvula Bola para vapor de 1.1/2"			
1.58	2	Und	Valvula de globo para vapor de 1.1/2"			
1.59	11	Unid	Niple de 1.1/2" x 3" fe ne.			
1.60	1	Unid	Reduc. excentrica de 4 x 2 1/2" Ac.Sold.sch40			
			SUB TOTAL			172,473

5.2. Tabla de presupuesto

2			Estación Reductora de Presión			
			Plano: TE09-PL-BBM-NPBL-ME-EQ009-A			
			Suministro de Materiales:			
2.1	1.00	pza	Valvula reductora de presion 25P de 1 1/2"			
2.2	1.00	pza	reduccion excentrica de 4"x 1 1/2", acero al carbono Sch40			
2.3	1.00	pza	reduccion excentrica de 2 1/2x 1 1/2", acero al carbono Sch40			
2.4	2.00	pza	Empaque espirometalico c-304 relleno de grafito de 4"x150			
2.5	2.00	pza	Empaque espirometalico c-304 relleno de grafito de 2 1/2"x150			
2.6	12.00	pza	Perno acero foriado grado 5 de 5/8"x3"			
2.7	1.00	pza	valvulas esferica de 4" bridada			
2.8	2.00	pza	valvulas esferica de 2 1/2" bridada			
2.9	1.00	pza	valvulas de Seguridad de 2"x2 1/2"			
2.3	1.00	pza	filtro tipo Y de 2 1/2"			
2.31	1.00	pza	Manometro 2 1/2", Conx inf de 1/4", O-50 psi, tubo sifon y valvula			
2.32	2.00	pza	Bridas Slip-on de 4" clase 150			
2.33	2.00	pza	Bridas Slip-on de 2 1/2" clase 150			
			SUB TOTAL			10,834.00
3			Manifold de Vapor Principal			
			Plano: TE09-PL-BBM-NPBL-ME-EQ001-A			
			Suministro de Materiales:			
3.1	2.19	m	Tubo de 10", acero al carbono ASTM A53, Sch40			
3.2	0.30	m	Tubo de 8", acero al carbono ASTM A53, Sch40			
3.3	0.15	m	Tubo de 6", acero al carbono ASTM A53, Sch40			
3.4	2.00	pza	Cap acero soldable Sch40 de 10"			
3.5	1.00	pza	Cap acero soldable Sch40 de 8"			
3.6	1.00	pza	Brida tipo anillo acero soldable ANSI 150, de 6"			
3.7	3.00	pza	Brida tipo anillo acero soldable ANSI 150, de 3"			
3.8	4.00	pza	Brida ciega acero soldable ANSI 150, de 3"			
3.9	2.00	pza	Copla acero soldable clase 3000 con rosca interna, de 1"			
3.4	2.00	pza	Copla acero soldable clase 3000 con rosca interna, de 1/2"			
3.41	2.00	pza	Tapon macho, fierro negro 150 lbs roscado de 2"			
3.42	1.00	pza	Manometro de 4" de 0-200 psi, conx inf de 1/2", con tubo sifon y			
3.43	1.00	pza	Eliminador de aire AV13 de 1/2", Sarco			
3.44	1.00	pza	Valvula de esfera de 1/2", crane			
3.45	3.00	pza	Valvula esférica M10 S2 Ø1", SARCO			
3.46	1.00	pza	Filtro tipo y de Ø1, SARCO			
3.47	1.00	pza	Trampa flotador de Ø1" Spirax Sarco			
3.48	2.55	m	Tubo de 12", acero al carbono ASTM A53, Sch40			
3.49	2	pza	Niples Ø 1/2" x 4" sch 40			
3.5	2	pza	Niples Ø 1" x 4" sch 40			
3.51	2	pza	Niples Ø 1-1/2" x 4" sch 40			
3.52	1	pza	Niples Ø 2" x 4" sch 40			
			SUB TOTAL			15,600.00
4			Manifold de Vapor Secundario			
			Plano: TE09-PL-BBM-NPBL-ME-EQ002-A			
			Suministro de Materiales:			
4.1	3.00	m	Tubo de 10", acero al carbono ASTM A53, Sch40			
4.2	1.00	m	Tubo de 8", acero al carbono ASTM A53, Sch40			
4.3	1.00	m	Tubo de 6", acero al carbono ASTM A53, Sch40			
4.4	2.00	pza	Cap acero soldable Sch40 de 10"			
4.5	1.00	pza	Cap acero soldable Sch40 de 8"			
4.6	1.00	pza	Brida tipo anillo acero soldable ANSI 150, de 6"			
4.7	3.00	pza	Brida tipo anillo acero soldable ANSI 150, de 4"			
4.8	3.00	pza	Brida tipo anillo acero soldable ANSI 150, de 2 1/2"			
4.9	2.00	pza	Copla acero soldable clase 3000 con rosca interna, de 1 1/2"			
4.5	3.00	pza	Copla acero soldable clase 3000 con rosca interna, de 1/2"			
4.51	2.00	pza	Tapon macho, fierro negro 150 lbs roscado de 2"			
4.52	1.00	pza	Manometro de 4" de 0-200 psi, conx inf de 1/2", con tubo sifon y			
4.53	1.00	pza	Eliminador de aire AV13 de 1/2", Sarco			
4.54	1.00	pza	Valvula de esfera de 1/2", crane			
4.55	3.00	pza	Válvula esférica M10 S2 Ø1", SARCO			
4.56	1.00	pza	Filtro tipo y de Ø1, SARCO			
4.57	1.00	pza	Trampa flotador de Ø1" Spirax Sarco			
4.58	3	m	Tubo de 12", acero al carbono ASTM A53, Sch40			
4.59	3	pza	Niples Ø 1/2" x 4" sch 40			
4.6	2	pza	Niples Ø 1" x 4" sch 40			
4.61	1	pza	Niples Ø 1-1/2" x 4" sch 40			
			SUB TOTAL			18,096.00

5.3 Tabla de presupuesto

5			LINEA DE VAPOR DESDE MANIFOLD SEC. HASTA AUTOCLAVE A4000			
			Suministro de Materiales:			
5.1	7	PZ	Tubo 4" x 6.0 mts SCH40			
5.2	5	pz	Codo 4" x 90° sch40			
5.3	2	pz	Codo 4" x 45° sch40			
5.4	4	pz	Brida t/anillo 4" x 150 lbs			
5.5	16	pz	Pernos			
5.6	1	pz	Valvula Globo 4 x 150 lbs			
5.7	2	pz	Empaquetadura 4"			
			SUB TOTAL			10074.99
6			SALA DE TRATAMIENTO DE AGUA			
			ESTACION REDUCTORA 2 (EQUIPO 1)			
			Suministro de Materiales:			
6.1	1	pz	FILTRO TIPO Y 1/2 PARA VAPOR SPIRAX SARCO			
6.2	1	pz	VALVULA REDUCTORA 25 P DE 1/2"			
6.3	1	pz	MANOMETRO DIAL 2 1/2"			
6.4	3	pz	VALVULA GLOBO PARA VAPOR 1/2"			
6.5	6	pz	CODO 1/2 X 90° FN			
6.6	2	pz	UNION SIMPLE 1/2" X 150 LBS			
6.7	1	pz	UNION UNIVERSAL 1/2" X 150 LBS			
6.8	1	pz	VALVULA DE SEGURIDAD			
6.9	2	pz	TUBO 1/2" X 6.0 MTS SCH40			
6.10			OTROS			
6.11	5	pz	SOPORTES			
			SUB TOTAL			6111
			ESTACION REDUCTORA 3 (EQUIPO 2)			
			Suministro de Materiales:			
6.12	1	pz	FILTRO TIPO Y 3/4" PARA VAPOR SPIRAX SARCO			
6.13	1	pz	VALVULA REDUCTORA 25 P DE 3/4"			
6.14	1	pz	MANOMETRO DIAL 2 1/2"			
6.15	3	pz	VALVULA GLOBO PARA VAPOR 3/4"			
6.16	6	pz	CODO 3/4"X 90° FN			
6.17	2	pz	UNION SIMPLE 3/4" X 150 LBS			
6.18	1	pz	UNION UNIVERSAL 3/4" X 150 LBS			
6.19	1	pz	VALVULA DE SEGURIDAD			
6.20	2	pz	TUBO 3/4" X 6.0 MTS SCH40			
6.21			OTROS			
6.22	5	pz	SOPORTES			
			SUB TOTAL			6786
7			Aislamiento Térmico			
			Suministro de Materiales:			
			Aislamiento termico con lana mineral, sujecion aislante con			
			Lineas de Vapor			
7.1	104	m	Cañuela de fibra mineral de 6"x2"			
7.2	81.4	m	Cañuela de fibra mineral de 1 1/2"x1 1/2"			
7.3	1	pza	Tee de 4", clase 150 , acero al carbono			
7.4	1	pza	Tee de 2 1/2", clase 150 , caeo al carbono			
7.5	24	pza	Union universal fierro negro 150 lbs, roscado de 1 1/2"			
7.6	6	pza	Union universal fierro negro 150 lbs, roscado de 1"			
7.7	7	pza	Union universal fierro negro 150 lbs, roscado de 1/2"			
7.8	1	pza	Reduccion excentrica Ac soldable sch40 de 2 1/2"x4"			
7.9	2	pza	Brida tipo anillo acero soldable ANSI 150, de 6"			
7.1	18	pza	Brida tipo anillo acero soldable ANSI 150, de 4"			
7.11	2	pza	Brida tipo anillo acero soldable ANSI 150, de 3"			
7.12	11	pza	Brida tipo anillo acero soldable ANSI 150 de 2 1/2"			
7.13	116	pza	Cañuela de fibra mineral de 4"x2"			
7.14	26.9	pza	Cañuela de fibra mineral de 3"x2"			
7.15	87.41	pza	Cañuela de fibra mineral de 2 1/2"x2"			
7.16	11	pza	Cañuela de fibra mineral de 1"x1 1/2"			
7.17	27.77	pza	Cañuela de fibra mineral de 1/2"x1"			
7.16	6.00	pza	Cañuela de fibra mineral Codo, 6"x2"			
7.19	16.00	pza	Cañuela de fibra mineral Codo, 4"x2"			
7.20	6.00	pza	Cañuela de fibra mineral Codo, 3"x2"			
7.21	9.00	pza	Cañuela de fibra mineral Codo, 2 1/2"x2"			
7.22	34.00	pza	Cañuela de fibra mineral Codo, 1 1/2"x1 1/2"			
7.23	6.00	pza	Cañuela de fibra mineral Codo, 1x1 1/2"			
7.24	7.00	pza	Cañuela de fibra mineral Codo, 1/2"x1"			
7.25	1.00	pza	Cañuela de fibra mineral Tee, 2 1/2"x2"			
7.26	1.00	pza	Cañuela de fibra mineral Codo, 4"x2"			
			SUB TOTAL			52500

5.4 Tabla de Presupuesto

			ADICIONAL DE AISLAMIENTO LINEA DE CONDENSO			
			Cañuelas aislantes en lana de vidrio en diferentes espesores			
			acabado: en planchas de aluminio liso de 0.5 mm rolados y			
			sujecion de acabado: autorroscantes galavanizados de 10 x 12			
7.27			**Salida de tanque de condensado**			
	106.00	m	de 2"Ø x 2"espesor			
	12.00	pza	codos 2"Ø x 2"espesor			
7.28			**Planta de tratamiento de agua**			
	53.00	m	1"Ø x 11/2"espesor			
	14.00	pza	1"Ø x 11/2"espesor			
7.29			**Linea de condensadoa autoclave (primer piso)**			
	183.00	m	2"Ø x 11/2"espesor			
	20.00	pza	codos 2"Ø x 11/2"espesor			
7.3			**Linea de condensado a tanques**			
	40.00	m	11/2"Ø x 11/2"espesor			
	6.00	pza	codos 11/2"Ø x 11/2"espesor			
7.31			**Zona Tanques**			
	12.00	m	de 1"Ø x 11/2"espesor			
	9.00	pza	codos 1"Ø x 11/2"espesor			
	30.00	m	de 11/2"Ø x 11/2"espesor			
	30.00	m	de 11/2"Ø x 11/2"espesor			
			SUB TOTAL			**36000**
8			**Instalacion de accesorios de vapor a Tks de Preparacion**			
			Suministro de Materiales:			
8.1	11.00	pzas	Brida tipo anillo 1"x 150 lbs inox			
8.2	33.00	pzas	Brida tipo anillo 1"x 150 lbs acero			
8.3	6.00	pzas	Niple 1" x 8" inox 304			
8.4	11.00	pzas	Niple 1" x 3" sch40			
8.5	11.00	pzas	Niple 1" x 3 1/2" sch40			
8.6	11.00	pzas	Niple 1" x 8" sch40			
8.7	11.00	pzas	Niple 1" x 4" sch40			
8.8	11.00	pzas	Valvula bola 1 1/2" clase 150 para vapor			
8.9	11.00	pzas	Red. Campana 1 1/2 x 1" x 150 lb roscada			
8.10	11	pzas	Sifon 1/4"			
8.11	11	pzas	Union simple 1/4" x 150 lb			
8.12	11	pzas	Valvula bola 1/4" x 1000 wog			
8.13	22	pzas	Junta espirometalica 1" x 150 lb			
8.14	44	pzas	Pernos 1/2" x 2 / 1/2 inox completo (tuercas, arandelas)			
8.15	44	pzas	Pernos 1/2" x 2 / 1/2 Gr.5 completo (tuercas, arandelas)			
			Incluye suministro, fabricación, traslado, montaje			
			SUB TOTAL			**10054**
9			**Soporteria**			
			Plano: TE09-PL-BBM-NPBL-ME-SP001-A			
			Suministro de Materiales:			
9.10	35.00	m	Perfil C 2"x4 Lb/Pie			
9.20	215.00	m	Perfil C 3"x6 Lb/Pie			
9.30	126.00	m	Perfil C 4"x7.25 Lb/Pie			
9.40	80.00	m	Angulo 2x3/16			
9.50	344.00	pza	pernos de expansión de 1/2"x3" + tuercas + arandelas			
9.60	11.00	pza	Plancha 3/8"x 132x175			
9.70	10.00	pza	Plancha de 1/4" x200x200			
9.80	10.00	pza	plancha de 3/8" x 135x175			
9.90	115.00	m	Tubo cuadrado de 2" x3mm			
9.10	18.00	m	Tubo cuadrado de 4" x3mm			
9.11	550.00	pza	Pernos U Bolt			
			SUB TOTAL			**24334**

5.5 Tabla de Presupuesto

10			Instalacion de accesorios de vapor a Tks de Preparacion			
			Suministro de Materiales:			
10.1	11	pzas	Brida tipo anillo 1"x 150 lbs inox			
10.2	33	pzas	Brida tipo anillo 1"x 150 lbs acero			
10.3	6	pzas	Niple 1" x 8" inox 304			
10.4	11	pzas	Niple 1" x 3" sch40			
10.5	11	pzas	Niple 1" x 3 1/2" sch40			
10.6	11	pzas	Niple 1" x 8" sch40			
10.7	11	pzas	Niple 1" x 4" sch40			
10.8	11	pzas	Valvula bola 1 1/2" clase 150 para vapor			
10.9	11	pzas	Red. Campana 1 1/2 x 1" x 150 lb roscada			
10.11	11	pzas	Sifon 1/4"			
10.12	11	pzas	Union simple 1/4" x 150 lb			
10.13	11	pzas	Valvula bola 1/4" x 1000 wog			
10.14	22	pzas	Junta espirometalica 1" x 150 lb			
10.15	44	pzas	Pernos 1/2" x 2 / 1/2 inox completo (tuercas, arandelas)			
10.16	44	pzas	Pernos 1/2" x 2 / 1/2 Gr.5 completo (tuercas, arandelas)			
			SUB TOTAL			10054
			SUB TOTAL S/.			371,916.99
			GASTOS GENERALES 7%			26,034.19
			UTILIDAD 13%			48,349.21
			TOTAL S/.			446,300.39

CONDICIONES DE VENTA	
Tiempo de Entrega	10 Semanas
Forma de Pago	50 % con su orden . saldo contra entrega
Tiempo Validez de la Oferta	15 dias.
Garantia	24 Meses en condiciones normales de funcionamiento.
Lugar de Entrega	Instalado en su planta Lurin
ACTIVIADES PRINCIPALES Y COMPLEMENTARIAS INCLUIDAS EN NUESTRA PROPUESTA	
Materiales	Suministro de todos los materiales señalados en el metrado de la ingenieria alcanzada y señaladas en nuestra propuesta
Servicio	Fabricación
Transporte	Transporte de nuestra planta Greco - Callao cliente
Montaje	Grua e equipos de maniobra necesarias pare el montaje
	Servicio de montaje
Acabado Final.	Tuberias pintadas de acuerdo a codigo internacional de identificación
Servicio post Venta	Presencia fisica durante la puesta en marcha
SEGUROS	
Responsabilidad Civil	Por US $ 5000,000.00 a favor de B.Braum
Transporte	No Aplica
Seguro para personal	Seguro complementario de trabajo de riesgo Salud- Pensi
DOCUMENTOS	
Homologación de Soldadores	Calificación 6G, 3G
PQR	Registro de Calificación de procedimiento de soldadura
WPS	Especificación de procedimiento de soldadura
Certificado de Materiales (Tubos)	Aplica
Certificado de Pruebas y ensayos no destructivos.	Liquido Penetrante (Limpieza, base y revelador)

CONCLUSIONES

1. Para el diseño de una instalación adecuada de distribución de vapor debe partir de conocer exactamente las necesidades de cantidad de vapor y presión necesarios en cada punto de consumo.
2. Para el diseño de un sistemas de tuberías a vapor, se debe poner énfasis en la selección de la trayectoria más adecuada, tratando que el sistema de tuberías sea lo suficientemente flexible, minimizando de esta forma el uso de juntas de dilatación.
3. El diseño de los puntos deslizantes solo debe permitir el movimiento longitudinal del tubo, evitando todo movimiento transversal.
4. Un sistema de tuberías será considerado seguro para la operación si la máxima presión y temperatura sostenida, puede actuar en cualquier parte o componente del sistema sin superar la presión y temperatura máxima permitida para cada componente en particular.
5. Utilizar tuberías de grande tamaño (velocidad de vapor baja) reduce sensiblemente la pérdida de carga pero incrementa el costo de la instalación así como la cantidad de vapor condensado.
6. La máxima pérdida de carga permisible dependerá de la presión de vapor en la válvula de salida de vapor en la caldera y la presión de vapor necesaria en el punto de consumo.

RECOMENDACIONES

Se recomienda para el adecuado funcionamiento del sistema de tuberías:

1. La tubería deberá tener siempre pendiente negativa en la dirección de avance del vapor.
2. Instalar venteos de aire en la tubería , en los puntos más altos.
3. Las tomas de vapor, desde la línea principal hasta los puntos consumidores se realizará siempre por la generatriz superior de la conducción principal y con el tubo de conexión en forma de "báculo de obispo".
4. Todo sistema de tuberías a vapor debe contar con el forrado correspondiente, reduciendo de esta forma las pérdidas de calor por convección, así como quemaduras por contacto.
5. Los venteos (válvulas de alivio y seguridad) deben estar instaladas de tal forma que pueda desalojar libremente la sobrepresión al medio ambiente.
6. Incluir en el diseño de este sistema, equipos de medición de flujo de vapor.
7. En el diseño del sistema de vapor, se debe evitar el uso de conexiones roscadas. Se recomienda consultar el código ANSI para el uso de conexiones para diferentes presiones de vapor.
8. Instalar puntos para la purga de condesado cada 50 metros de Tubería.
9. Las uniones de los tubos (bridas), deben estar instaladas de tal forma que sea fácil el acceso.
10. Limpiar los soportes, verificar que el tubo pueda dilatarse libremente antes de ponerla el sistema en operación.

11. La tubería debe estar completamente pintada antes de iniciar el forrado de la misma.
12. Reparar cualquier fuga que se presente durante las pruebas de arranque y puesta en marcha.
13. Revisar periódicamente los sistemas de vapor para detectar líneas de vapor usadas con muy poca frecuencia y que puedan ser eliminadas o sacadas de servicio.
14. Mantener los sistemas de trazado con el mínimo flujo requerido, ya que pueden ocasionar desperdicios de vapor.
15. Elaborar un plan de mantenimiento a fin de verificar una operación adecuada. La frecuencia de revisión dependerá de las condiciones particulares de cada área; sin embargo, debe revisarse, como mínimo, mensualmente.
16. Capacitar al personal operativo y de mantenimiento sobre las técnicas de pruebas de operación de trampas.
17. Inspeccionar periódicamente el aislamiento a fin de reemplazar o reparar los tramos dañados o deteriorados.
18. Todas las fugas de vapor deben repararse tan pronto como sea posible.
19. En los procedimientos de mantenimiento, especifique el tipo de juntas y empaques para las bridas de las válvulas.
20. Recurra a un especialista en reparación de fugas, si el sistema de vapor no puede ser sacado de operación.

BIBLIOGRAFIA

- American Society of Mechanical Engineer - ASME

  ASME B31.1 Tuberías para Sistemas de Potencia

  ASME B16.5 Bridas y Conexiones Bridadas

- American National Standars Institut - ANSI

- American Society for testing and Materials -ASTM

  ASTM 105 Forgings, Carbon Steel, for piping component

  ASTM B16.9 Factory made wrought steel buttweld fittings

- Reglamento Nacional de Edificaciones Ministerio de Vivienda

- Industrial Boiler Management - Kenneth G. Oliver

- Techcnical book- Garioni Aval

- Manual de Recipientes a Presión - Eugene F. Megyesy

- Formulario de elementos de máquinas- Ceac

- Catálogo: Desing of Fluid Systems- Spirax Sarco

PLANOS

- Esquema de Línea de vapor y condensado

  N° de plano : 071010205M

- Vista de Planta General

  N° de plano : 071030208M

- Línea de Ingreso de Vapor - tanques de Preparación

  N° de plano : 071030201M

- Recorrido en sala de calderos

  N° de plano : 0700930220-1M

- Estaciones Reductoras de Presión N°2 y N°3

  N° de plano : 071030203M

PUENTE TECNICO

CONDENSADO BOMBEADO ø 2"

ø6" sch40 f/n–110psi; 173°C–ΔP 0.31psi/100m

ø2 ½" – Tks

ø4" – A–4000

ø2½" Reserva

ø4" – A–3500

ø4" A–4000 Futuro

ø1" Calentador

ø1/2" Calentador Retorno

ESTACION REDUCTORA DE PRESION

VRP 25P 1½"

V.S. 2"

1200 Kg/h
PRESION : 20– 30 PSI

Reserva (Destilador)

ø4" Reserva

MANIFOLD SECUND. ø12"

FT14–10–ø1"

ø3"–110psi; 173°C

ø3"–110psi 173°C

ø3"–110psi 173°C Futuro

ø1" Tk. Condensado

ø2" Futura

ø1¼" Sala de Tratamiento de Agua

250 BHP

125 BHP

BHP

CALDERA APIN

CALDERA ETPSA

CALDERA FUTURO

MANIFOLD PRINCIP. ø12"

FT14–10–ø1"

Vapor ø4"

ø2" – sch40 f/n

ø1½" sch40 f/n – CONDENSADO

ø4" sch40 f/n – LINEA DE VAPOR

TK 3000 L

200 Kg/h

TK 1 6000 L

TK 2 6000 L

TK 3 6000 L

TK 4 6000 L

TK 5 6000 L

TK 6 6000 L

400 Kg/h

ø1 1/2"

ø1"

SALA DE PREPARACION PARENTERAL

Linea de Retorno de Condensado ø1"

Agua de Reposicion

Vapor 1/2" de Manifold

TK DE CONDENS.

A CALDEROS

ø1 1/2" – sch40 f/n

A–4000

4000 Kg/h

A–3500

ø1" – sch40 f/n

ø2" – sch40 f/n

ø2" A–3500

ø2" A–4000

ø2" A–4000 Futuro

Venteo ø2" – sch40 f/n

TANQUE DE CONDENSADO SECUNDARIO

SALA DE TRATAMIENTO DE AGUA

SKID WF1

1 1/4"

11/4"

SKID DE DISTRIBUCION WF1

ø1 1/2"

CAUDAL : 350 Lb/hr
PRESION : 3 BAR

CAUDAL : 160 Lb/hr
PRESION : 2 BAR

ESTACION REDUCTORA DE PRESION

VRP 25P 1"

V.S. 1" x 3/4"

VRP 25P 3/4"

V.S. 1" x 3/4"

TK 6000

SALA DE PREPARACION FRUTIFLEX

SALA DE PREPARACION DIALISIS

SIMBOLOGIA:

- VALVULA SOLENOIDE
- VALVULA DE BOLA
- ELIMINADOR DE AIRE
- VALVULA GLOBO BRIDADA
- TRAMPA DE VAPOR
- VALVULA CHECK
- FILTRO
- MANOMETRO
- VALVULA DE SEGURIDAD
- VALVULA REDUCTORA DE PRECION 25P
- VALVULA (ROMPER VACIO)

OBS:
Linea de vapor: Acero ASTM A53 sch40

Linea condensado: Acero ASTM A53 sch40

REV	FECHA	DESCRIPCIÓN	DIB	REV	APR
F	16-09-2010	SE MODIFICO DE ACUERDO A INDICACIONES DEL CLIENTE	GLL	GLL	JG
E	16-09-2010	REVISION INTERNA	GLL	GLL	JG

CLIENTE: LABORATORIOS B. BRAUN MEDICAL PERU S.A.

PROYECTO: NUEVA PLANTA LURIN

SECCION:

PLANO: ESQUEMA DE LINEA DE VAPOR Y CONDENSADO

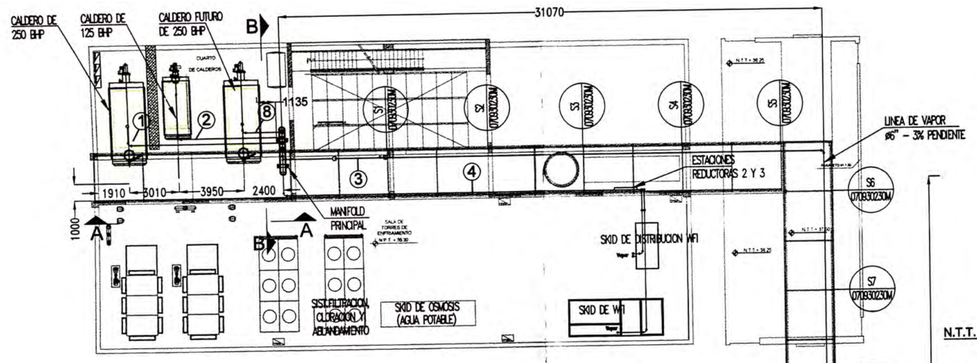
RUTA: Z:\\CLIENTES2010\0710_B.BRAUN\PLANOS2010\0710_SISTEMA_HIDRONEUMATICO_DAG

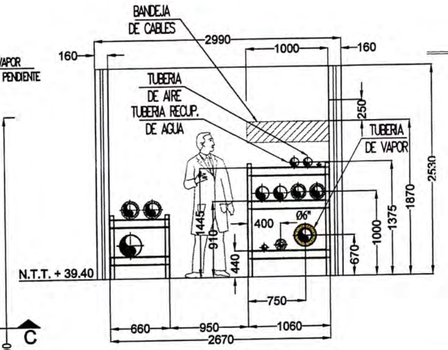
GRACO Contratistas Generales S.A.

N° DE PLANO 071010205M

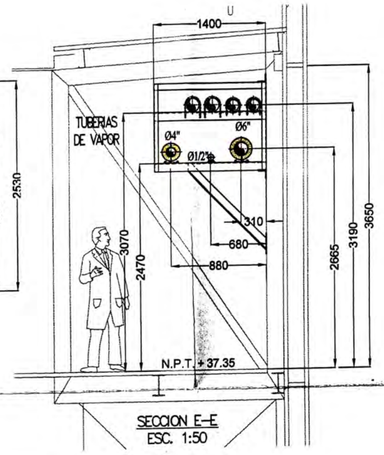
ESCALA: S/E

REV. F

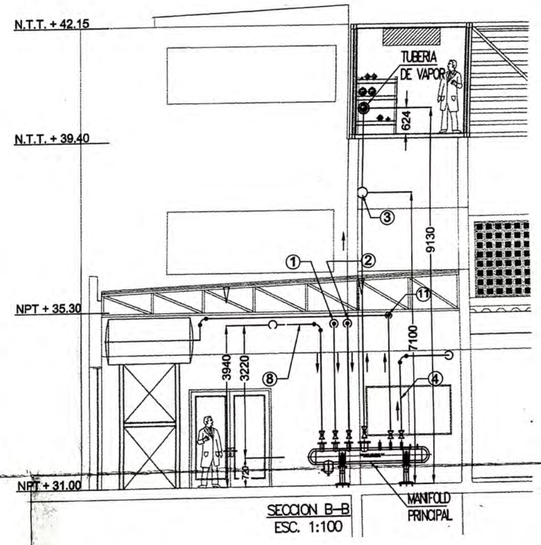




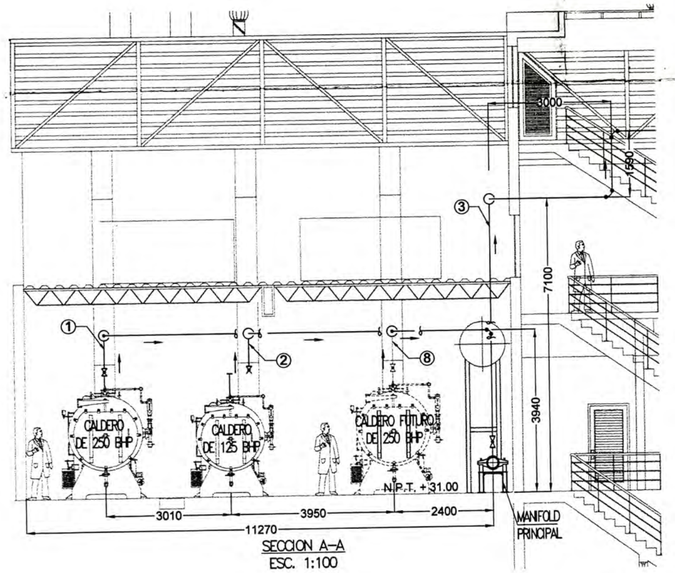
SECCION C-C
ESC. 1:50



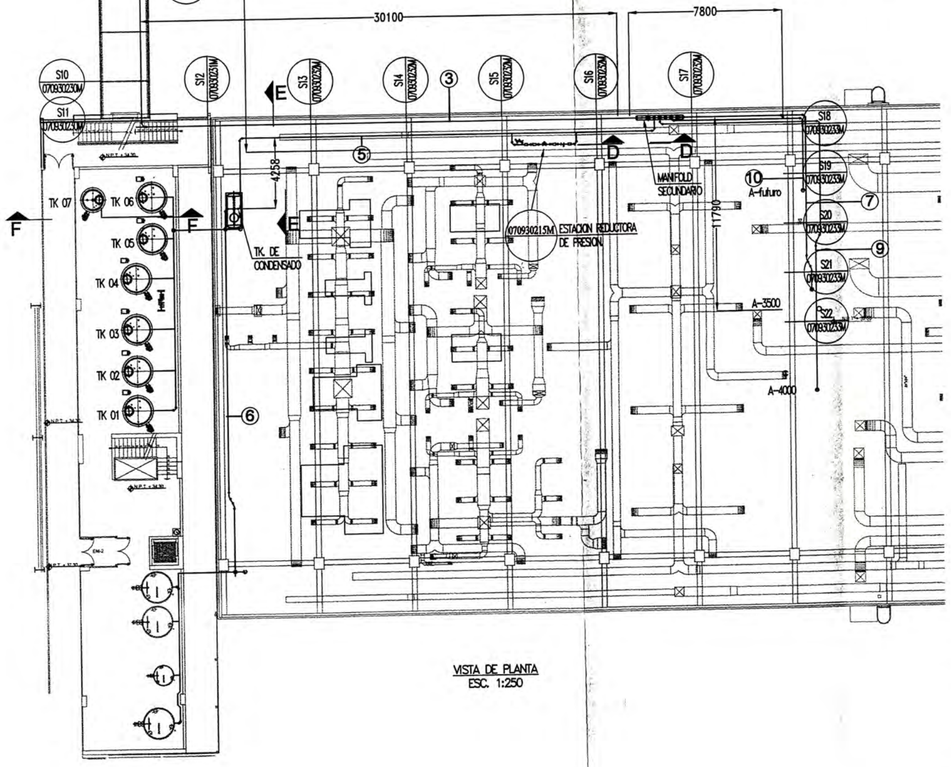
SECCION E-E
ESC. 1:50



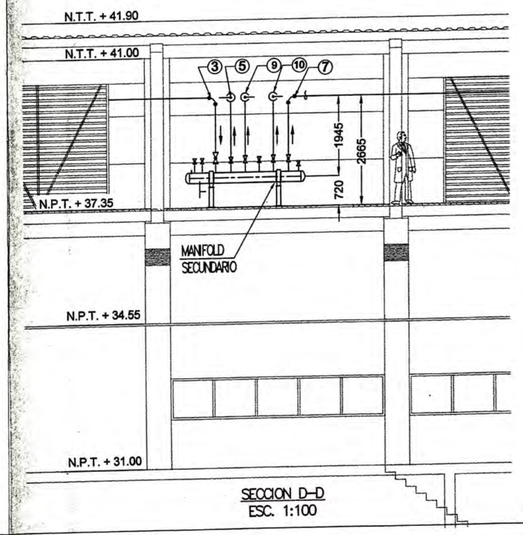
SECCION B-B
ESC. 1:100



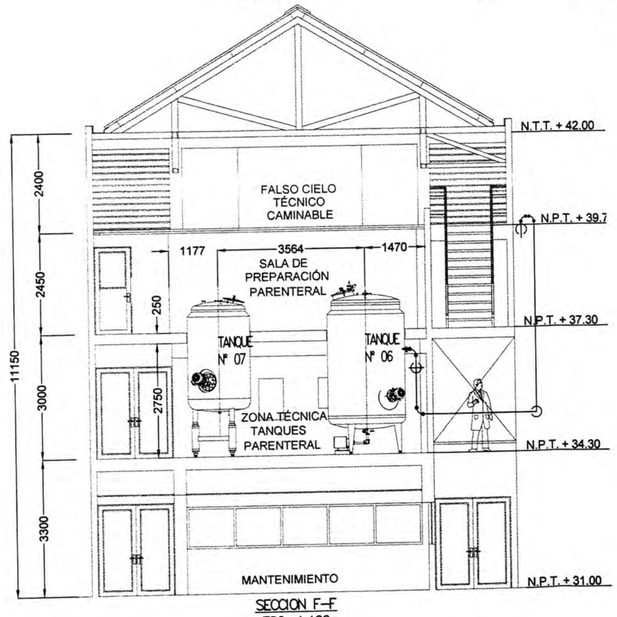
SECCION A-A
ESC. 1:100



VISTA DE PLANTA
ESC. 1:250



SECCION D-D
ESC. 1:100



SECCION F-F
ESC. 1:100

Item	Descripción
11	Linea de Vapor a Tanque de condensado (ASTM A-53 ø 1 1/2 ")
10	Linea de Vapor a Autoclave CONSUMOP FUTURO (ASTM A-53 ø4")
9	Linea de Vapor a Autoclave A-4000 (ASTM A-53 ø4")
8	Linea de Futuro caldero 250 BHP (ASTM A-53 ø3")
7	Linea de Vapor Autoclave A-3500 (ASTM A-53 ø4")
6	Linea de Vapor Tanque de Preparación (ASTM A-53 ø4")
5	Linea de Vapor a Tanques (ASTM A-53 ø2.1/2")
4	Linea de Vapor a Sala de Trat. de agua (ASTM A-53 ø 11/2")
3	Linea Principal de Vapor (ASTM A-53 ø6")
2	Linea de caldero 250 BHP (ASTM A-53 ø3")
1	Linea de caldero 125 BHP (ASTM A-53 ø3")

D	01/12/09	SE MODIFICO DE ACUERDO A INDICACIONES DEL CLIENTE.	IM	NO	JG
C	10/11/09	EMITIDO PARA APROBACION.	IM	NO	JG
B	04/11/09	REVISION GERENCIA DE GRACO.	IM	MV	JG
A	28/10/09	REVISION INTERNA.	IM	MV	JG
		DESCRIPCION	DIB.	REV.	APR.

CLIENTE: LABORATORIOS B.BRAUN MEDICAL PERU S.A.

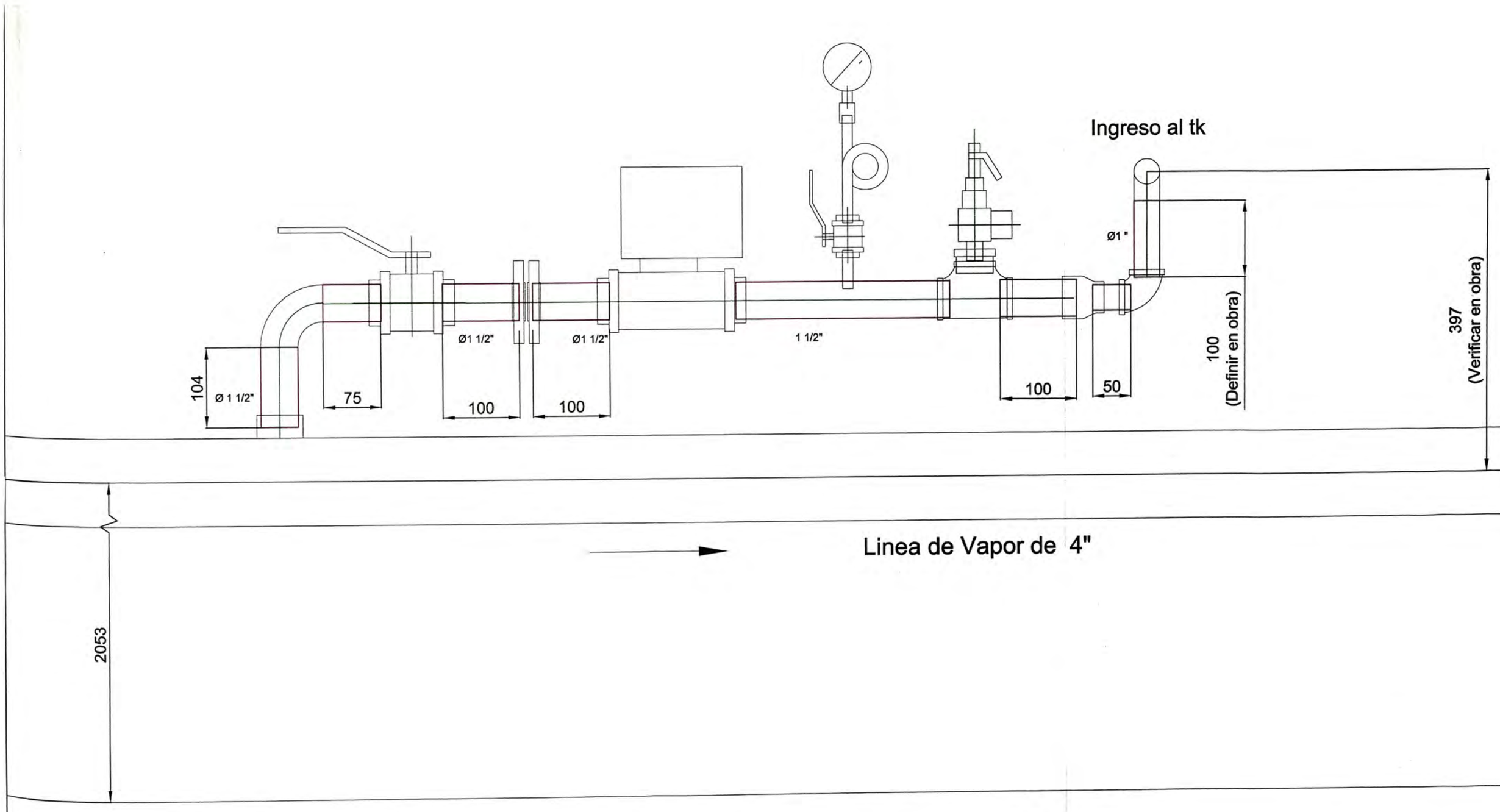
PROYECTO: NUEVA PLANTA LURIN
SECCION : LINEA DE VAPOR
PLANO: VISTA DE PLANTA GENERAL

GRACO Contratistas Generales S.A.

Nº DE PLANO 071030208M

RUTA: Z:\LABORATORIOS B.BRAUN MEDICAL PERU S.A.\TUBERIAS NUEVA PLANTA LURIN\PLANOS\PLANOS GRACO

ESCALA: INDICADA | REV. D



Item	Descripción	Cant	Marca
1	Valvula bola de 1 1/2 " x 150 lbs	11	Sarco Spirax
2	Válvula de Seguridad de 1/2 " x 3/4" x 150 lbs	11	Kunkle
3	Regulada a 40 Psi		
3	Valvula Solenoide de diafragma 1 1 /2	11	SMC
4	Válvula de 1/4" x 1000 wog	11	Sun
5	Manometro de 0- 150 psi Dial de 2 1/2" conex. Inf 1/4"	11	Wika

REV	FECHA	DESCRIPCIÓN	DIB	REV	APR
B	16-06-2010	SE MODIFICO DE ACUERDO A INDICACIONES DEL CLIENTE	GLL	GLL	JG
A	16-06-2010	REVISION INTERNA	GLL	GLL	JG

CLIENTE: LABORATORIOS B. BRAUN MEDICAL PERU S.A.

PROYECTO: NUEVA PLANTA LURIN

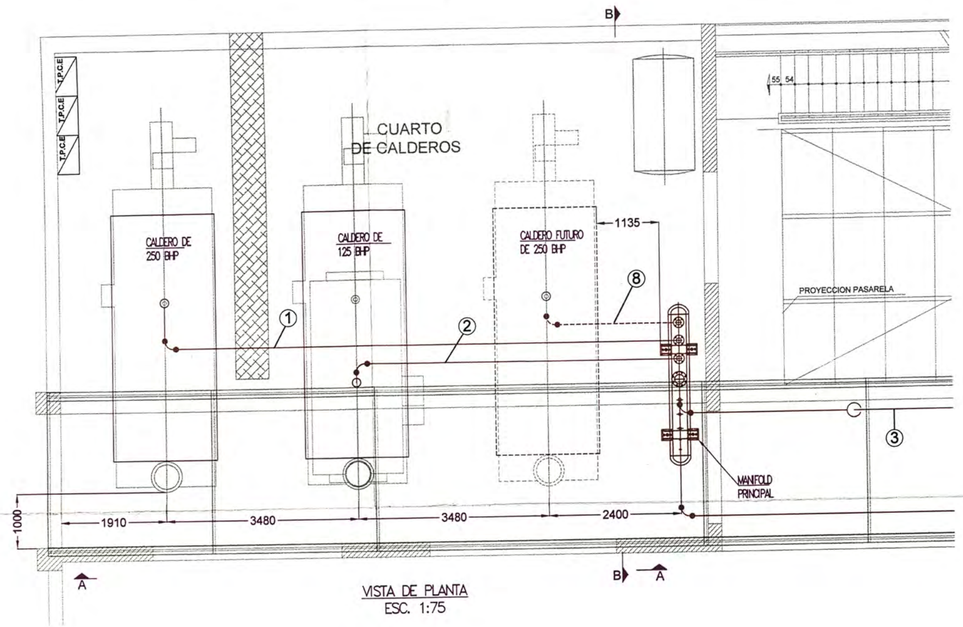
SECCION:

PLANO: LINEA DE INGRESO DE VAPOR (TANQUES DE PREPARACION)

N° DE P 071030.

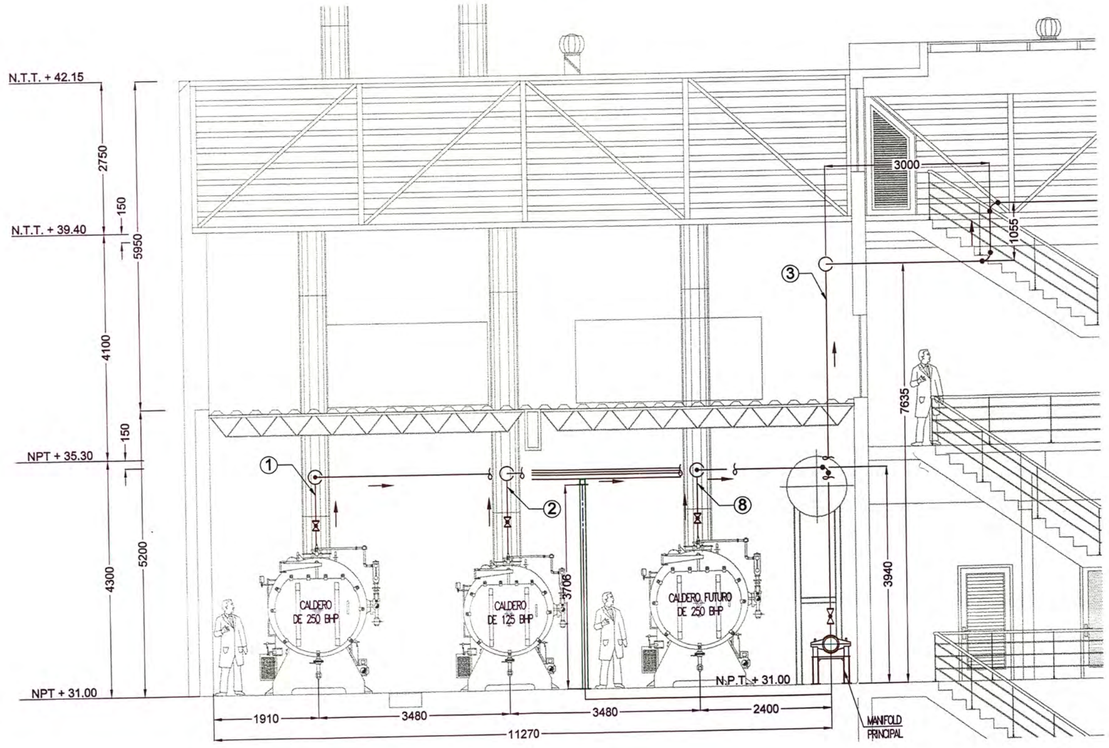
RUTA: Z:\\CLIENTES2010\0710_B.BRAUN\PLANOS2010\0710_SISTEMA_HIDRONEUMATICO_DAG

ESCALA: S/E

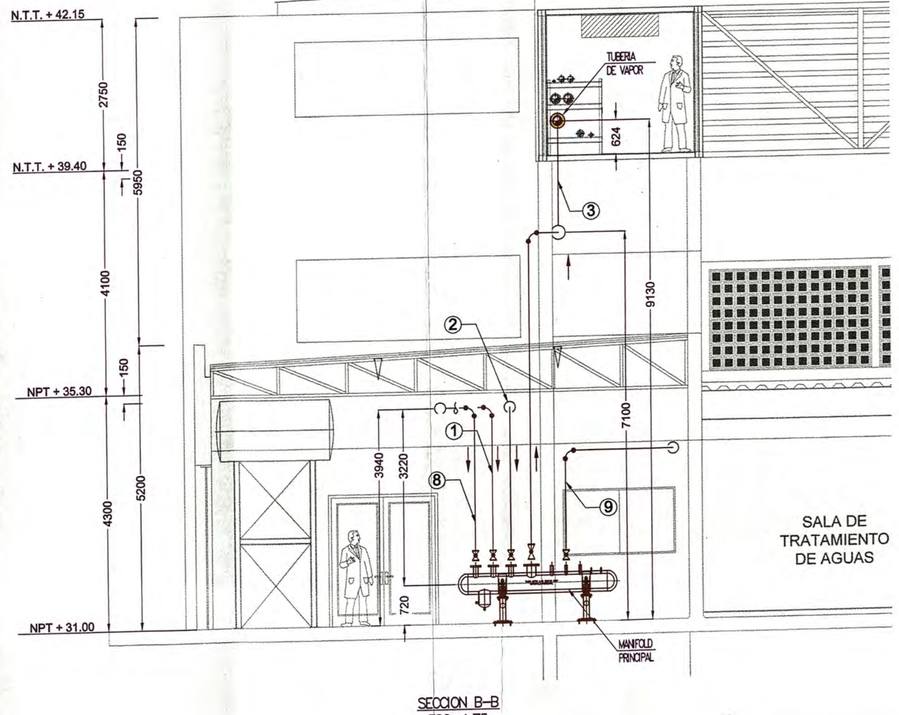


VISTA DE PLANTA
ESC. 1:75

Item	Descripción
9	Linea de Vapor a WFI (ASTM A-53 ø1.1/2")
8	Linea de Futuro caldero 250 BHP (ASTM A-53 ø3")
7	Linea de Vapor Autoclave A-3500 (ASTM A-53 ø4")
6	Linea de Vapor Autoclave A-4000 (ASTM A-53 ø4")
5	Linea de Vapor a Tanques (ASTM A-53 ø2.1/2")
4	Linea de Vapor a TK Condensado (ASTM A-53 ø1/2")
3	Linea Principal de Vapor (ASTM A-53 ø6")
2	Linea de caldero 125 BHP (ASTM A-53 ø3")
1	Linea de caldero 250 BHP (ASTM A-53 ø3")



SECCION A-A
ESC. 1:75



SECCION B-B
ESC. 1:75

REV.	FECHA	DESCRIPCION	DIB.	REV.	APR.
C	10/11/09	EMITIDO PARA APROBACION.	IM	NO	JG
B	04/11/09	REVISION GERENCIA DE GRACO.	IM	MV	JG
A	28/10/09	REVISION INTERNA.	IM	MV	JG

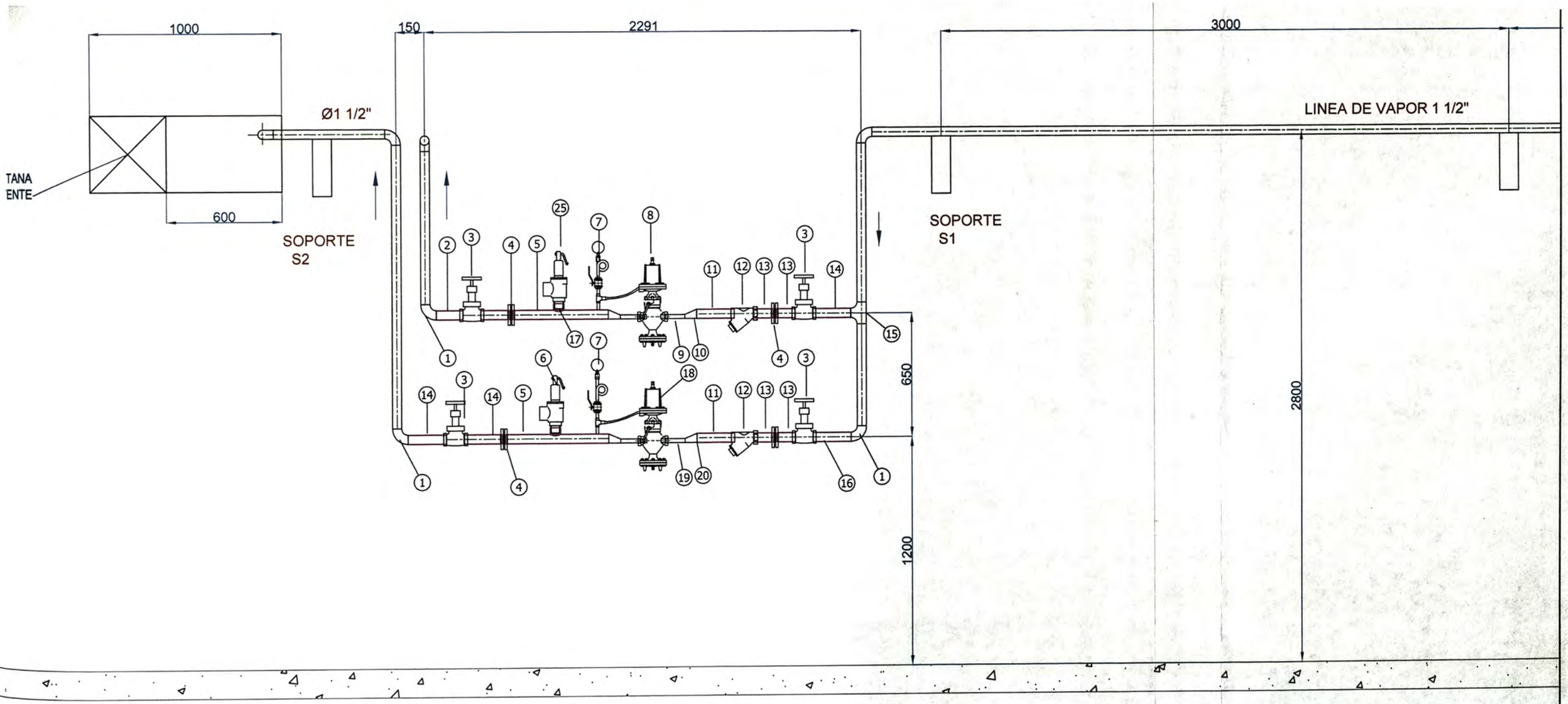
CLIENTE: LABORATORIOS B.BRAUN MEDICAL PERU S.A.

PROYECTO: NUEVA PLANTA LURIN
SECCION : LINEA DE VAPOR
PLANO: RECORRIDO EN SALA DE CALDEROS
PLANTA Y ELEVACIONES

RUTA: Z:\LABORATORIOS B.BRAUN MEDICAL PERU S.A.\TUBERIAS NUEVA PLANTA LURIN\PLANOS\PLANOS GRACO

N° DE PLANO
070930220-1 M

ESCALA: INDICADA | REV. C



Item	Descripcion	Cantidad	Unidad
1	Codo 1 1/2" x 90° sch40	3	pzas
2	Punta Roscada 1 1/2" x 6" Sch40	2	pzas
3	Valvula Globo 1 1/2" x 150 lbs	4	pzas
4	Brida t/anillo 1 1/2" x 150 lbs	8	pzas
5	Tubo 1 1/2" x 500 mm sch40	2	pzas
6	Valvula de seguridad 1/2"	1	pzas
	Presion de Seteo : 2 bar		
	Capacidad : 160 kg/hr		
7	Equipo de medición		
	Sifon 1/4" sch40	2	pzas
	Manometro 0-60Psi Dial 2 1/2" conx. Inferior inox- bronce	2	pzas
	Valvula bola 1/4" x 1000 wog p/vapor	2	pzas
	Niple 1/4" x 4" sch40	2	pzas
	Tee 1/4" x 150 lbs roscada	2	pzas
	Union Simple 1/4" x150 lbs	2	pzas
	Copla 1/4" x 3000 lbs roscada	2	pzas
8	Valvula Red. De Presion 25 P Spirax Sarco- 3/4"	1	pzas
9	Punta Roscada 3/4" x 4" Sch40	2	pzas
10	Red. Campana 1 1/2" x 3/4" Sch40	2	pzas

11	Punta Roscada 1 1/2" x 8" Sch40	2	pzas
12	Filtro 1 1/2" para vapor	2	pzas
13	Punta Roscada 1 1/2" x 4" Sch40	4	pzas
14	Punta Roscada 1 1/2" x 8" Sch40	4	pzas
15	Tee 1 1/2" Sch40	1	pzas
16	Punta Roscada 1 1/2" x L (verificar en obra)	1	pzas
17	Copla 1" x 3000 lbs Roscada	2	pzas
18	Valvula Red. De Presion 25 P Spirax Sarco- 1/2"	1	pzas
19	Punta Roscada 1/2" x 4" Sch40	2	pzas
20	Red. Campana 1 1/2" x 1/2" Sch40	2	pzas
21	Pernos 1/2" x 2 1/2" completo GR.5	16	pzas
22	Empaquetadura espirometalica 1 1/2" x 150 lbs	4	pzas
23	Red. Bushing 1" x 3/4" roscada	1	pzas
24	Red. Bushing 1" x 1/2" roscada	1	pzas
25	Valvula de seguridad 3/4"	1	pzas
	Presion de Seteo : 3 bar		
	Capacidad : 350 kg/hr		

REV.	FECHA	DESCRIPCION	DIB.	REV.	APR.
E	03/08/10	SE MODIFICO DE ACUERDO A INDICACIONES DEL CLIENTE.	G.LL	G.LL	JG
D	01/12/09	SE MODIFICO DE ACUERDO A INDICACIONES DEL CLIENTE.	IM	NO	JG
C	10/11/09	EMITIDO PARA APROBACION.	IM	NO	JG
B	04/11/09	REVISION GERENCIA DE GRACO.	JV	MV	JG
A	19/06/09	REVISION INTERNA.	JV	MV	JG

CLIENTE: LABORATORIOS B. BRAUN MEDICAL PERU S.A.

PROYECTO: NUEVA PLANTA LURIN

SECCION:

PLANO: ESTACIONES REDUCTORAS DE PRESION 2 Y 3

GRACO Contratistas Generales S.A.

N° DE PLANO 071030203M

RUTA: Z:\\CLIENTES2010.\0710_B.BRAUN.\PLANOS2010.

ESCALA: S/E

REV. E

APENDICES

- Anexo 1: Certificado de Prueba Hidráulica- Línea de Vapor 1 1/2"
- Anexo 2: Certificado de Prueba Hidráulica- Línea de Vapor de 4"
- Anexo 3: Reporte de Líquidos penetrantes
- Anexo 4: Foto de Prueba hidráulica de línea de vapor de 4"
- Anexo 5: Foto de Prueba hidráulica de línea de vapor de 6"
- Anexo 6: Certificado de calibración de Válvula reguladora
- Anexo 7: Certificado de calibración de Válvula reguladora
- Anexo 8: Certificado de calibración de Válvula reguladora
- Anexo 9: Extracto de Norma ASME 31.3 - 2002
- Anexo 10: ASME 31.3 – Tablas de Módulo de Elasticidad
- Anexo 11: ASME 31.3 – Tablas de Módulo de Elasticidad
- Anexo 12: ASME 31.3 – Tablas de Módulo de Elasticidad
- Anexo 13 : ANSI – 105
- Anexo 14 : ASTM 1-53 / A-106

ANEXO 1

GRACO

N°	11
FECHA	21/09/2010

CERTIFICADO DE PRUEBA HIDRAULICA

Cliente	B. BRAUN MEDICAL DEL PERU S.A.		
Proyecto	TUBERIAS AUXILIARES PARA NUEVA PLANTA B BRAUN - LURIN		
Equipo Probado	Linea de Vapor de 1 1/2" (Sala de tratamiento de agua)		
Lugar de Prueba	Planta de B. Braun (Lurin)	Tipo de Prueba	Hidráulica
Presión de Trabajo	30-50 psi	Presión de Prueba	80 PSI
Manómetros Escala	0-150psi	Fecha de la Prueba	02/08/2010
Tiempo de Prueba	12 Horas	Resultado	ACEPTADO

Prueba efectuada según Codigo ASME año 2004 Seccion I Addenda

Observaciones

Se realizó la prueba hidraulicaa una presión de 80 Psi
observandose que la presión permaneció constante durante el el tiempo de
duración de la prueba, no presentando fugas

B. Braun Medical del Perú S.A

Supervisor
Graco Contratistas Generales S.A.

ANEXO 2

GRACO

N° 10
FECHA 21/09/2010

CERTIFICADO DE PRUEBA HIDRAULICA

Cliente	B. BRAUN MEDICAL DEL PERU S.A.		
Proyecto	TUBERIAS AUXILIARES PARA NUEVA PLANTA B.BRAUN - LURIN		
Equipo Probado	Linea de Vapor de 4" (Estación de Regulación de Vapor N°1 hasta Tanques de Preparación)		
Lugar de Prueba	Planta de B. Braun (Lurin)	Tipo de Prueba	Hidráulica
Presión de Trabajo	100 psi	Presión de Prueba	60 PSI
Manómetros Escala	0-200psi	Fecha de la Prueba	18/08/2010
Tiempo de Prueba	12 Horas	Resultado	ACEPTADO

Prueba efectuada según Codigo ASME año 2004 Seccion I Adderda

Observaciones:

Se realizó la prueba hidraulicaa una presión de 60 Psi observandose que la presión permaneció constante durante el el tiempo de duración de la prueba, no presentando fugas .

B. Braun Medical del Perú S.A.

Supervisor
Graco Contratistas Generales S.A.

ANEXO 3

GRACO

REPORTE DE LIQUIDOS PENETRANTES

Nº 5

FECHA DICIEMBRE

Cliente: B BRAUN MEDICAL DEL PERU S.A

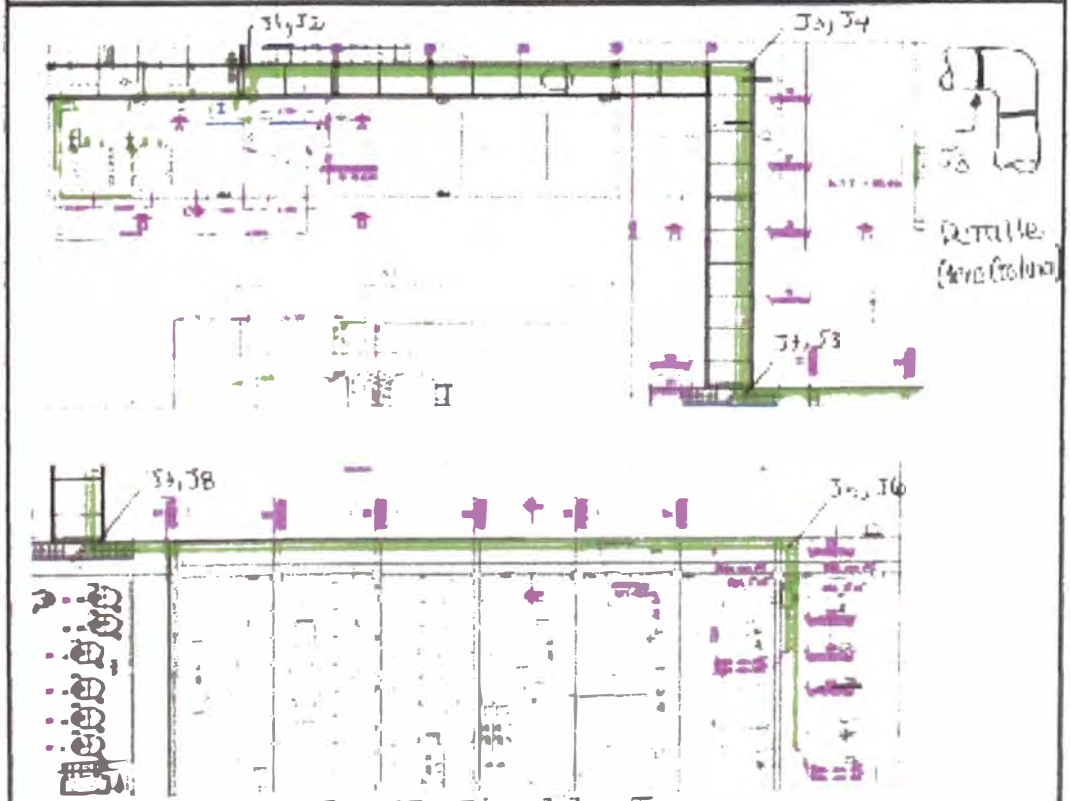
Proyecto: TUBERIAS AUXILIARES PARA NUEVA PLANTA B BRAUN - LURIN

Equipo Probado: tubería Ø6"

INFORMACION TECNICA

PROCEDIMIENTO: END Nº1-01	TECNICA -PROCEDIMEINTO Penetrante y Revelador aplicado por rocio (spray) limpieza y remocion manualmente con trapo y solvente
TIPO Y METODO DE EXAMEN TIPO II (Penetrante Visible) Metodo : B (Removible y solvente)	TIEMPO DE PENETRACION 15 min
INSUMOS PARA EL EXAME Revelador Penetrante y solvente	TEMP. DURANTE EL ENSAYO :
CONDICION DE SUPERFICI Escobillado	
FUENTE DE ILUMINACION Luz Natural	

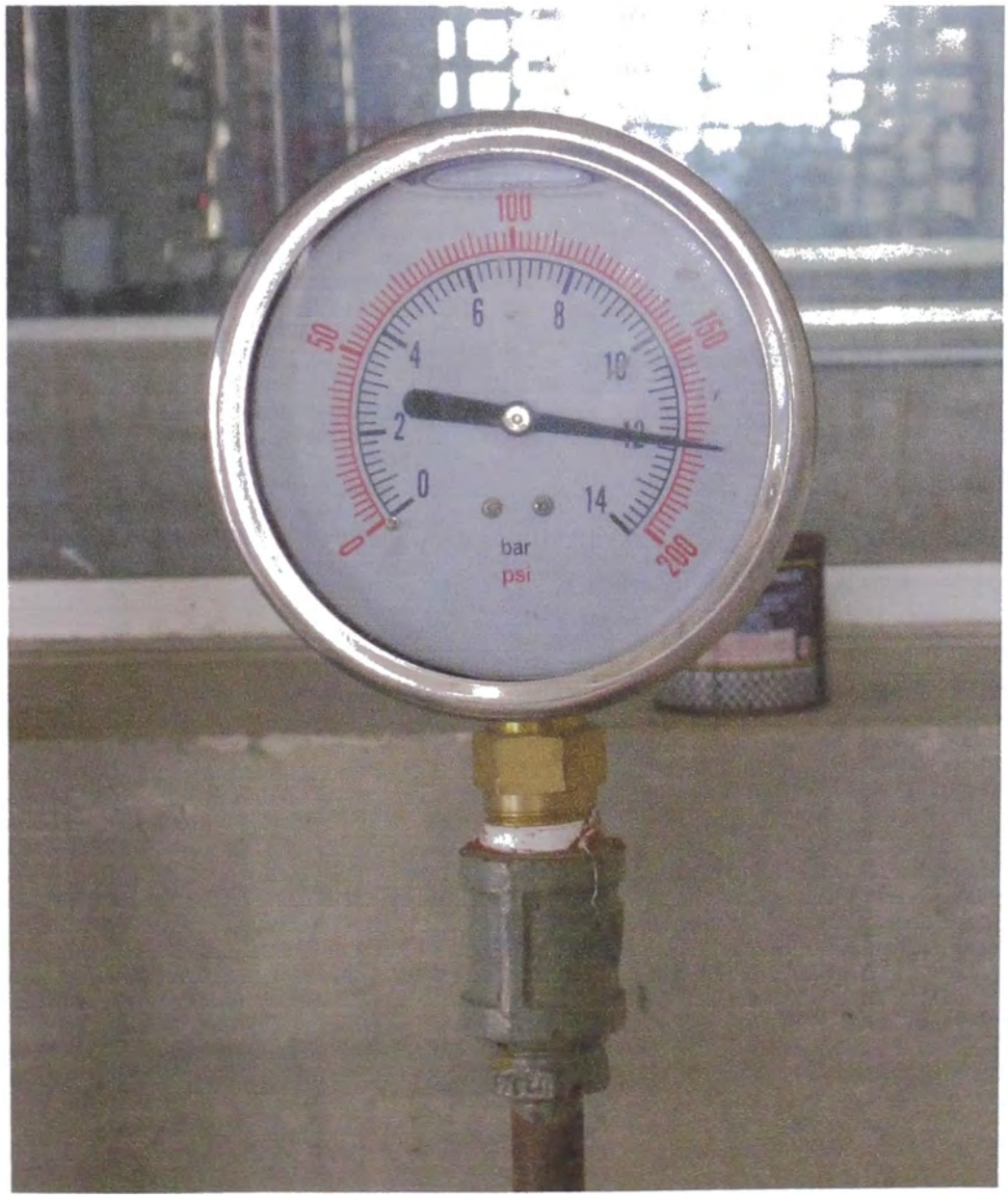
ESQUEMA



ANEXO 4

PRUEBA HIDRAULICA

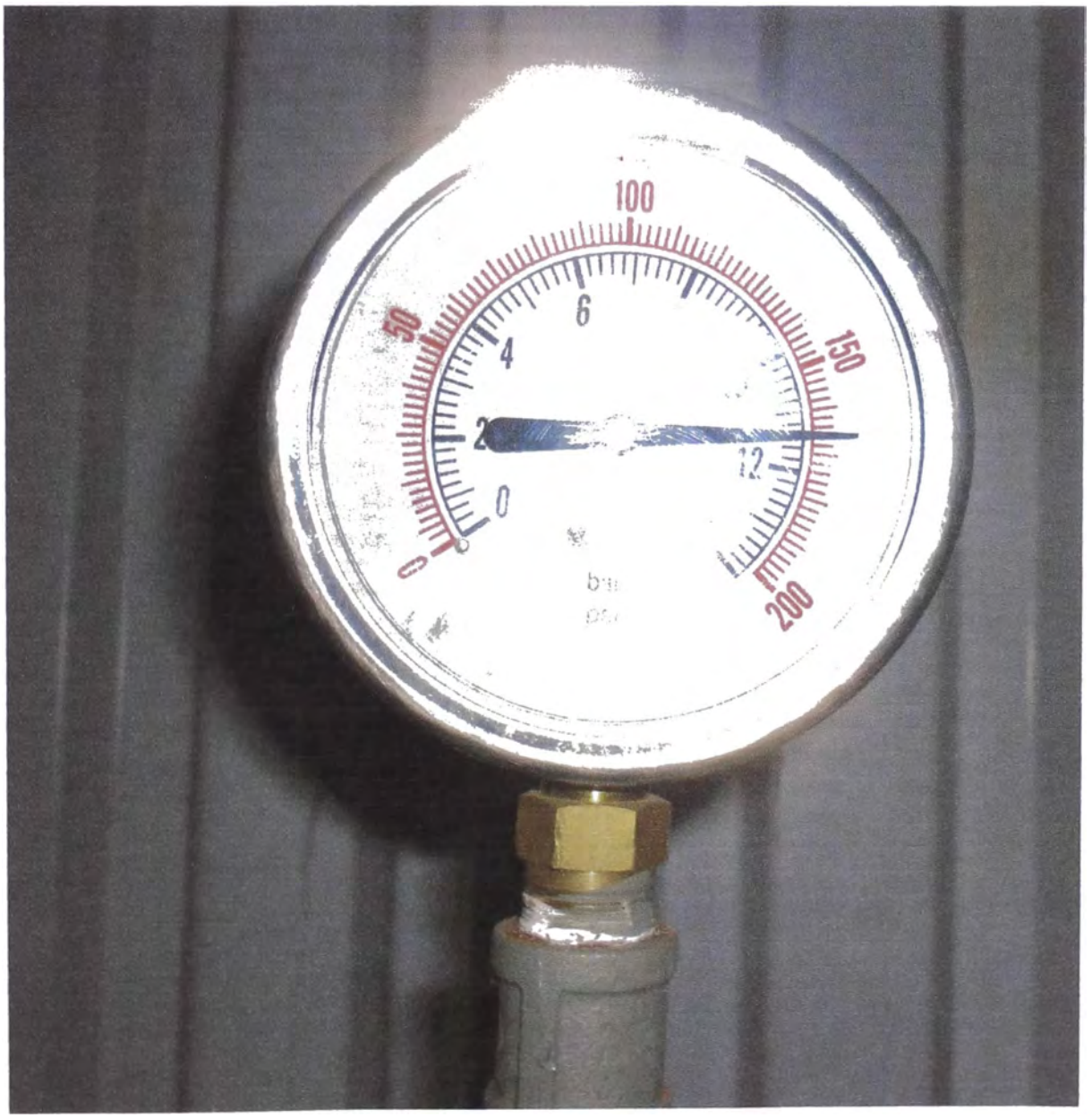
LINEA DE VAPOR DE 4" DESDE MANIFOLD PRINCIPAL HASTA AUTOCLAVES



ANEXO 5

PRUEBA HIDRAULICA

LINEA DE VAPOR DE 6" DESDE MANIFOLD PRINCIPAL HASTA MANIFOLD SECUNDARIO



ANEXO 6

TERMODINAMICA S.A.

INGENIERIA - PROYECTOS - SERVICIOS

CONSTANCIA DE CALIBRACION DE VALVULA DE SEGURIDAD / ALIVIO

Codigo TE-FA-027

EMPRESA: GRACO CONTRATISTAS GENERALES S.A.

DIRECCION: AV. JORGE CHAVEZ MZA. F LOTE. 35 URB. AEROPUERTO

EQUIPO: VALVULA DE SEGURIDAD	**MARCA:** HELBERT	**MODELO:** VR
UBICACIÓN:	**TAG:** VSHIBR-35-1187	**NOTAS:**

FLUIDO DE TRABAJO		MATERIAL		TIPO DE UNION	
Vapor/Condensado	X	Ac. Carbono (cuerpo)		Roscable	X
Aire		Ac. Inox. (internos)		Soldable	
Agua		Bronce	X	Bridado	
Gas		Fierro Fund.			
Otro _____		Otro _____			

PRESION DE OPERACION: 35 PSI

DIAMETRO: 1/2 x 3/4

PRESION DE CALIBRACION: P1 _____ PSI P2 _____ PSI P3 _____ PSI

 # DE DISPAROS DE PRUEBA: 3 Disparos

TIEMPO DE PRUEBA: 2 Horas

FLUIDO DE PRUEBA

Vapor	
Aire	
Agua	
Nitrogeno	X
Otro	

EQUIPO DE PRUEBA

BANCO DE PRUEBA NEUMATICO	X
BOTELLA DE NITROGENO	X

CHECK LIST

FUGAS EXTERNAS	NO
ESTADO DE PERNOS	Ok
ESTADO DE ROSCAS	Ok
FUGAS INTERNAS	NO
ESTADO DE SELLOS	Ok

CONFORMIDAD

Habiendose realizado la prueba de presion y observado los resultados se da por efectuada la misma. Asi mismo se aprueba el funcionamiento de este sistema con el fluido de trabajo bajo los parametros mencionados. La prueba se realizo con nuestro manometro patron de deformacion elastica Marca ASHCROFT de rango 0 - 300 psi con certificado de INDECOPI LFP - 740 - 2009

Fecha: 21/05/2010

Jefe División Servicios

Ing. Sandra Huamaní Pérez

Responsable del Grupo y Unidad de Valvulas

Ing. Rafael C.

CIP 534

Calle Victor Reynel N° 1035
Lot. Industrial Conde - Lima 61
Telf.: 336 6850 - Fax: 336 6801
www.termodinamica.com.pe

ANEXO 7

TERMODINAMICA S.A.

INGENIERIA - PROYECTOS - SERVICIOS

CONSTANCIA DE CALIBRACION DE VALVULA DE SEGURIDAD / ALIVIO

Codigo: TE-R-027

EMPRESA: GRACO CONTRATISTAS GENERALES S A

DIRECCION: AV JORGE CHAVEZ MZA F LOTE 35 URB AEROPUERTO

EQUIPO: VALVULA DE SEGURIDAD	**MARCA:** KUNKLE	**MODELO:** 6010HW61
UBICACIÓN:	**TAG:** VSHIDR-35-1186	**NOTAS:**

FLUIDO DE TRABAJO		MATERIAL		TIPO DE UNION	
Vapor/Condensado	X	Ac Carbono (cuerpo)		Roscable	X
Aire		Ac Inox (internos)		Soldable	
Agua		Bronce	X	Bridado	
Gas		Fierro Fund.			
Otro		Otro			

PRESION DE OPERACION: 30 PSI

DIAMETRO: 2" a 2 1/2

PRESION DE CALIBRACION: P1: ____ PSI P2: ____ PSI P3: ____ PSI

N° DE DISPAROS DE PRUEBA: 3 Disparos

TIEMPO DE PRUEBA: 2 Horas

FLUIDO DE PRUEBA

Vapor	
Aire	
Agua	
Nitrogeno	X
Otro	

EQUIPO DE PRUEBA

BANCO DE PRUEBA NEUMATICO X

BOTELLA DE NITROGENO X

CHECK LIST

FUGAS EXTERNAS	NO
ESTADO DE PERNOS	Ok
ESTADO DE ROSCAS	Ok
FUGAS INTERNAS	NO
ESTADO DE SELLOS	Ok

CONFORMIDAD

Habiendose realizado la prueba de presion y observado los resultados se da por efectuada la misma. Asi mismo se aprueba el funcionamiento de este accesorio con el fluido de trabajo bajo los parametros mencionados. La prueba se realizo con nuestro manometro patron de deformacion elastica Marca ASHCROFT de rango 0 - 300 psi con certificado de INDECOPI LFP - 740 - 2009

Fecha: 21/05/2010

Jefe Division Servicios

Ing. Sandro Hinostroza

Responsable del Dpto. Odyssey de Vapor

Ing. Rafael Calle

CIP 53419

Calle Victor Raynel N° 1045
Urb. Industrial Conde - Lima 01
Telf.: 336 6850 - Fax: 336 6801
www.termodinamica.com.pe

ANEXO 8

TERMODINAMICA S.A.

INGENIERÍA - PROYECTOS - SERVICIOS

CONSTANCIA DE CALIBRACION DE VALVULA DE SEGURIDAD / ALIVIO

Codigo: TE-R-027 | VER: 1 | PAG: 1 DE 1

EMPRESA:	GRACO CONTRATISTAS GENERALES S A		
DIRECCION:	AV JORGE CHAVEZ MZA F LOTE 35 URB AEROPUERTO		
EQUIPO:	VALVULA DE SEGURIDAD	MARCA: HELBERT	MODELO: VR
UBICACIÓN:		TAG:	NOTAS:

FLUIDO DE TRABAJO		MATERIAL		TIPO DE UNION	
Vapor/Condensado	☐	Ac. Carbono (cuerpo)	☐	Roscable	☒
Aire	☐	Ac. Inox. (internos)	☐	Soldable	☐
Agua	☐	Bronce	☒	Bridada	☐
Gas	☐	Fierro Fund.	☐		
Otro _____	☐	Otro _____	☐		

PRESION DE OPERACION: 60 PSI

DIAMETRO: 3/4 x 3/4

PRESION DE CALIBRACION: P1 ____ PSI P2 ____ PSI P3 ____ PSI

# DE DISPAROS DE PRUEBA:	3 Disparos	EQUIPO DE PRUEBA	
TIEMPO DE PRUEBA:	2 Horas	BANCO DE PRUEBA NEUMATICO	☒
FLUIDO DE PRUEBA		BOTELLA DE NITROGENO	☒
Vapor	☐	CHECK LIST	
Aire	☐	FUGAS EXTERNAS	NO
Agua	☐	ESTADO DE PERNOS	Ok
Nitrogeno	☒	ESTADO DE ROSCAS	Ok
Otro	☐ _____	FUGAS INTERNAS	NO
		ESTADO DE SELLOS	Ok

CONFORMIDAD

Habiendose realizado la prueba de presion, y observado los resultados se da por efectuada la misma. Asi mismo se aprueba el funcionamiento de este sistema con el fluido de trabajo bajo los parametros mencionados. La prueba se realizo con medidor manometro patron de deformación elastica Marca ASHCROFT de rango 0 - 300 psi con certificado de INDECOPI LFP - 740 - 2009

Fecha	Jefe Division Servicios	Responsable del Dpto. o Area de Valvulas
21/05/2010	Ing. Sandra [illegible]	Ing Rafael Calle CIP 52416

Calle Victor Reynel N° 1045
Urb. Industrial Conde - Lima 01
Telf.: 336 6850 - Fax: 336 6801
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ANEXO 9

TABLE 302.3.3D[1]
ACCEPTANCE LEVELS FOR CASTINGS

Material Examined Thickness, T	Applicable Standard	Acceptance Level (or Class)	Acceptable Discontinuities
Steel $T \le 25$ mm (1 in.)	ASTM E 446	1	Types A, B, C
Steel $T > 25$ mm, ≤ 51 mm (2 in.)	ASTM E 446	2	Types A, B, C
Steel $T > 51$ mm, ≤ 114 mm ($4\frac{1}{2}$ in.)	ASTM E 186	2	Categories A, B, C
Steel $T > 114$ mm, ≤ 305 mm (12 in.)	ASTM E 280	2	Categories A, B, C
Aluminum & magnesium	ASTM E 155	...	Shown in reference radiographs
Copper, Ni-Cu	ASTM E 272	2	Codes A, Ba, Bb
Bronze	ASTM E 310	2	Codes A and B

NOTE:
(1) Titles of standards referenced in this Table are as follows:
ASTM
E 155 Reference Radiographs for Inspection of Aluminum and Magnesium Castings
E 186 Reference Radiographs for Heavy-Walled [2 to 4-½-in. (51 to 114-mm)] Steel Castings
E 272 Reference Radiographs for High-Strength Copper-Base and Nickel-Copper Castings
E 280 Reference Radiographs for Heavy-Walled [4-½ to 12-in. (114 to 305-mm)] Steel Castings
E 310 Reference Radiographs for Tin Bronze Castings
E 446 Reference Radiographs for Steel Castings Up to 2 in. (51 mm) in Thickness

ness of the piping component, including any reinforcement, meets the requirements of para. 304.

(b) External Pressure Stresses. Stresses due to external pressure shall be considered safe when the wall thickness of the piping component, and its means of stiffening, meet the requirements of para. 304.

(c) Longitudinal Stresses S_L. The sum of longitudinal stresses in any component in a piping system, due to pressure, weight, and other sustained loadings S_L shall not exceed S_h in (d) below. The thickness of pipe used in calculating S_L shall be the nominal thickness $\overline{T}$ minus mechanical, corrosion, and erosion allowance c, for the location under consideration. The loads due to weight should be based on the nominal thickness of all system components unless otherwise justified in a more rigorous analysis.

(d) Allowable Displacement Stress Range S_A. The computed displacement stress range S_E in a piping system (see para. 319.4.4) shall not exceed the allowable displacement stress range S_A (see paras. 319.2.3 and 319.3.4) calculated by Eq. (1a):

$$S_A = f(1.25S_c + 0.25S_h) \quad (1a)$$

When S_h is greater than S_L, the difference between them may be added to the term $0.25S_h$ in Eq. (1a). In that case, the allowable stress range is calculated by Eq. (1b):

$$S_A = f[1.25(S_c + S_h) - S_L] \quad (1b)$$

In Eqs. (1a) and (1b):

S_c = basic allowable stress[3] at minimum metal temperature expected during the displacement cycle under analysis

S_h = basic allowable stress[3] at maximum metal temperature expected during the displacement cycle under analysis

f = stress range reduction factor,[4] from Table 302.3.5 or calculated by Eq. (1c):[5]

$$f = 6.0(N)^{-0.2} \le 1.0 \quad (1c)$$

where

N = equivalent number of full displacement cycles during the expected service life of the piping system[6]

When the computed stress range varies, whether from thermal expansion or other conditions, S_E is defined as the greatest computed displacement stress range. The value of N in such cases can be calculated by Eq. (1d):

[3] For castings, the basic allowable stress shall be multiplied by the applicable casting quality factor E_c. For longitudinal welds, the basic allowable stress need not be multiplied by the weld quality factor E_j.

[4] Applies to essentially noncorroded piping. Corrosion can sharply decrease cyclic life; therefore, corrosion resistant materials should be considered where a large number of major stress cycles is anticipated.

[5] Equation (1c) does not apply beyond approximately 2×10^6 cycles. Selection of f factors beyond 2×10^6 cycles is the designer's responsibility.

[6] The designer is cautioned that the fatigue life of materials operated at elevated temperature may be reduced.

TABLE 302.3.5
STRESS-RANGE REDUCTION FACTORS, f

Cycles, N	Factor, f
7,000 and less	1.0
Over 7,000 to 14,000	0.9
Over 14,000 to 22,000	0.8
Over 22,000 to 45,000	0.7
Over 45,000 to 100,000	0.6
Over 100,000 to 200,000	0.5
Over 200,000 to 700,000	0.4
Over 700,000 to 2,000,000	0.3

$$N = N_E + \sum(r_i^5 N_i) \text{ for } i = 1, 2, \ldots, n \qquad (1d)$$

where

N_E = number of cycles of maximum computed displacement stress range, S_E

r_i = S_i/S_E

S_i = any computed displacement stress range smaller than S_E

N_i = number of cycles associated with displacement stress range S_i

302.3.6 Limits of Calculated Stresses due to Occasional Loads

(a) Operation. The sum of the longitudinal stresses due to pressure, weight, and other sustained loadings S_L and of the stresses produced by occasional loads, such as wind or earthquake, may be as much as 1.33 times the basic allowable stress given in Appendix A. For castings, the basic allowable stress shall be multiplied by the casting quality factor E_c. Where the allowable stress value exceeds two-thirds of yield strength at temperature, the allowable stress value must be reduced as specified in para. 302.3.2(c). Wind and earthquake forces need not be considered as acting concurrently.

(b) Test. Stresses due to test conditions are not subject to the limitations in para. 302.3. It is not necessary to consider other occasional loads, such as wind and earthquake, as occurring concurrently with test loads.

302.4 Allowances

In determining the minimum required thickness of a piping component, allowances shall be included for corrosion, erosion, and thread depth or groove depth. See definition for c in para. 304.1.1(b).

302.4.1 Mechanical Strength. When necessary, the wall thickness shall be increased to prevent overstress, damage, collapse, or buckling due to superimposed loads from supports, ice formation, backfill, transportation, handling, or other causes. Where increasing the thickness would excessively increase local stresses or the risk of brittle fracture, or is otherwise impracticable, the required strength may be obtained through additional supports, braces, or other means without an increased wall thickness. Particular consideration should be given to the mechanical strength of small pipe connections to piping or equipment.

PART 2
PRESSURE DESIGN OF PIPING COMPONENTS

303 GENERAL

Components manufactured in accordance with standards listed in Table 326.1 shall be considered suitable for use at pressure-temperature ratings in accordance with para. 302.2.1. The rules in para. 304 are intended for pressure design of components not covered in Table 326.1, but may be used for a special or more rigorous design of such components. Designs shall be checked for adequacy of mechanical strength under applicable loadings enumerated in para. 301.

304 PRESSURE DESIGN OF COMPONENTS

304.1 Straight Pipe

304.1.1 General

(a) The required thickness of straight sections of pipe shall be determined in accordance with Eq. (2):

$$t_m = t + c \qquad (2)$$

The minimum thickness T for the pipe selected, considering manufacturer's minus tolerance, shall be not less than t_m.

(b) The following nomenclature is used in the equations for pressure design of straight pipe.

t_m = minimum required thickness, including mechanical, corrosion, and erosion allowances

t = pressure design thickness, as calculated in accordance with para. 304.1.2 for internal pressure or as determined in accordance with para. 304.1.3 for external pressure

c = the sum of the mechanical allowances (thread or groove depth) plus corrosion and erosion allowances. For threaded components, the

U = anchor distance, straight line between anchors, m (ft)
K_1 = 208,000 S_A/E_a, (mm/m)^2
= 30 S_A/E_a, (in./ft)^2

$$\frac{Dy}{(L-U)^2} \le K_1 \quad (16)$$

where
S_A = allowable displacement stress range per Eq. (1a), MPa (ksi)
E_a = reference modulus of elasticity at 21°C (70°F), MPa (ksi)

319.4.2 Formal Analysis Requirements

(a) Any piping system which does not meet the criteria in para. 319.4.1 shall be analyzed by a simplified, approximate, or comprehensive method of analysis, as appropriate.

(b) A simplified or approximate method may be applied only if used within the range of configurations for which its adequacy has been demonstrated.

(c) Acceptable comprehensive methods of analysis include analytical and chart methods which provide an evaluation of the forces, moments, and stresses caused by displacement strains (see para. 319.2.1).

(d) Comprehensive analysis shall take into account stress intensification factors for any component other than straight pipe. Credit may be taken for the extra flexibility of such a component.

319.4.3 Basic Assumptions and Requirements. Standard assumptions specified in para. 319.3 shall be followed in all cases. In calculating the flexibility of a piping system between anchor points, the system shall be treated as a whole. The significance of all parts of the line and of all restraints introduced for the purpose of reducing moments and forces on equipment or small branch lines, and also the restraint introduced by support friction, shall be recognized. Consider all displacements, as outlined in para. 319.2.1, over the temperature range defined by para. 319.3.1.

319.4.4 Flexibility Stresses

(a) The range of bending and torsional stresses shall be computed using the reference modulus of elasticity at 21°C (70°F), E_a, except as provided in para. 319.2.2(b)(4), and then combined in accordance with Eq. (17) to determine the computed displacement stress range S_E, which shall not exceed the allowable stress range S_A in para. 302.3.5(d).

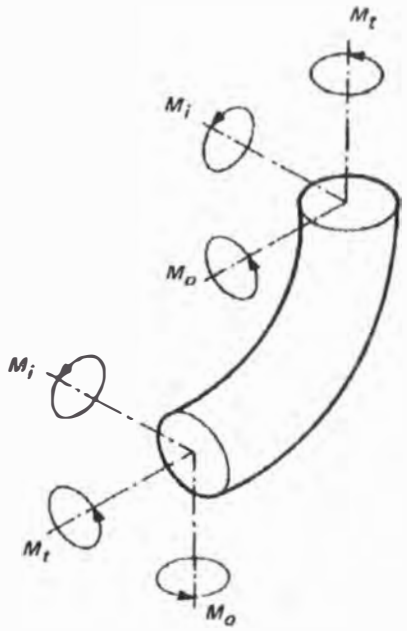

FIG. 319.4.4A MOMENTS IN BENDS

$$S_E = \sqrt{S_b^2 + 4S_t^2} \quad (17)$$

where
S_b = resultant bending stress
S_t = torsional stress
= $M_t/2Z$
M_t = torsional moment
Z = section modulus of pipe

(b) The resultant bending stresses S_b to be used in Eq. (17) for elbows, miter bends, and full size outlet branch connections (Legs 1, 2, and 3) shall be calculated in accordance with Eq. (18), with moments as shown in Figs. 319.4.4A and 319.4.4B.

$$S_b = \frac{\sqrt{(i_i M_i)^2 + (i_o M_o)^2}}{Z} \quad (18)$$

where
S_b = resultant bending stress
i_i = in-plane stress intensification factor from Appendix D
i_o = out-plane stress intensification factor from Appendix D
M_i = in-plane bending moment
M_o = out-plane bending moment
Z = section modulus of pipe

(c) The resultant bending stress S_b to be used in

TABLE K302.3.3D
ACCEPTABLE SEVERITY LEVELS FOR STEEL CASTINGS

Thickness Examined, mm (in.)	Applicable Standards	Acceptable Severity Level	Acceptable Discontinuity Categories
$\overline{T} \le 51$ (2)	ASTM E 446	1	A, B, C
$51 < \overline{T} \le 114$ (4.5)	ASTM E 186	1	A, B, C
$114 < \overline{T} \le 305$ (12)	ASTM E 280	1	A, B, C

K302.3.4 Weld Joint Quality Factor. Piping components containing welds shall have a weld joint quality factor $E_j = 1.00$ (see Table 302.3.4 for requirements) except that the acceptance criteria for these welds shall be in accordance with para. K341.3.2. Spiral welds are not permitted.

K302.3.5 Limits of Calculated Stresses Due to Sustained Loads and Displacement Strains

(a) Internal Pressure Stresses. Stresses due to internal pressure shall be considered safe when the wall thickness of the piping component, and its means of stiffening, meet the requirements of para. K304.

(b) External Pressure Stresses. Stresses due to external pressure shall be considered safe when the wall thickness of the piping component, and its means of stiffening, meet the requirements of para. K304.

(c) Longitudinal Stresses S_L. The sum of longitudinal stresses in any component in a piping system, due to pressure, weight, and other sustained loadings S_L shall not exceed S_h in (d) below. The thickness of pipe used in calculating S_L shall be the nominal thickness minus mechanical, corrosion, and erosion allowance c.

(d) Allowable Displacement Stress Range S_A. The computed displacement stress range S_E in a piping system (see para. 319.4.4) shall not exceed the allowable displacement stress range S_A (see para. 319.2.3) calculated by

$$S_A = 1.25S_c + 0.25S_h \quad (32)$$

In the above equation,

S_c = allowable stress from Table K-1 at minimum metal temperature expected during the displacement cycle under analysis

S_h = allowable stress from Table K-1 at maximum metal temperature expected during the displacement cycle under analysis

K302.3.6 Limits of Calculated Stresses Due to Occasional Loads

(a) Operation. The sum of the longitudinal stresses due to pressure, weight, and other sustained loadings S_L, and of the stresses produced by occasional loads such as wind or earthquake, may be as much as 1.2 times the allowable stress given in Table K-1. Wind and earthquake forces need not be considered as acting concurrently.

(b) Test. Stresses due to test conditions are not subject to the limitations in para. K302.3. It is not necessary to consider other occasional loads, such as wind and earthquake, as occurring concurrently with test loads.

K302.4 Allowances

In determining the minimum required thickness of a piping component, allowances shall be included for corrosion, erosion, and thread or groove depth. See the definition of c in para. K304.1.1(b).

K302.4.1 Mechanical Strength. Paragraph 302.4.1 applies. In addition, a fatigue analysis in accordance with para. K304.8 shall be performed for any means used to increase the strength of a piping component.

PART 2
PRESSURE DESIGN OF PIPING COMPONENTS

K303 GENERAL

Components manufactured in accordance with standards listed in Table K326.1 shall be considered suitable for use at pressure-temperature ratings in accordance with para. K302.2.

ANEXO 10

TABLE C-6
MODULUS OF ELASTICITY, U.S. UNITS, FOR METALS

Material	E = Modulus of Elasticity, Msi (Millions of psi), at Temperature, °F									
	−425	−400	−350	−325	−200	−100	70	200	300	400
Ferrous Metals										
Gray cast iron	...	...	...	...	...	...	13.4	13.2	12.9	12.6
Carbon steels, C ≤ 0.3%	31.9	...	...	31.4	30.8	30.2	29.5	28.8	28.3	27.7
Carbon steels, C > 0.3%	31.7	...	...	31.2	30.6	30.0	29.3	28.6	28.1	27.5
Carbon-moly steels	31.7	...	...	31.1	30.5	29.9	29.2	28.5	28.0	27.4
Nickel steels, Ni 2%–9%	30.1	...	...	29.6	29.1	28.5	27.8	27.1	26.7	26.1
Cr-Mo steels, Cr ½%–2%	32.1	...	...	31.6	31.0	30.4	29.7	29.0	28.5	27.9
Cr-Mo steels, Cr 2¼%–3%	33.1	...	...	32.6	32.0	31.4	30.6	29.8	29.4	28.8
Cr-Mo steels, Cr 5%–9%	33.4	...	...	32.9	32.3	31.7	30.9	30.1	29.7	29.0
Chromium steels, Cr 12%, 17%, 27%	31.8	...	...	31.2	30.7	30.1	29.2	28.5	27.9	27.3
Austenitic steels (TP304, 310, 316, 321, 347)	30.8	...	...	30.3	29.7	29.0	28.3	27.6	27.0	26.5
Copper and Copper Alloys (UNS Nos.)										
Comp. and leaded Sn-bronze (C83600, C92200)	...	...	...	14.8	14.6	14.4	14.0	13.7	13.4	13.2
Naval brass, Si- & Al-bronze (C46400, C65500, C95200, C95400)	...	...	...	15.9	15.6	15.4	15.0	14.6	14.4	14.1
Copper (C11000)	...	...	...	16.9	16.6	16.5	16.0	15.6	15.4	15.0
Copper, red brass, Al-bronze (C10200, C12000, C12200, C12500, C14200, C23000, C61400)	...	...	...	18.0	17.7	17.5	17.0	16.6	16.3	16.0
90Cu-10Ni (C70600)	...	...	...	19.0	18.7	18.5	18.0	17.6	17.3	16.9
Leaded Ni-bronze	...	...	...	20.1	19.8	19.6	19.0	18.5	18.2	17.9
80Cu-20Ni (C71000)	...	...	...	21.2	20.8	20.6	20.0	19.5	19.2	18.8
70Cu-30Ni (C71500)	...	...	...	23.3	22.9	22.7	22.0	21.5	21.1	20.7
Nickel and Nickel Alloys (UNS Nos.)										
Monel 400 N04400	28.3	...	...	27.8	27.3	26.8	26.0	25.4	25.0	24.7
Alloys N06007, N08320	30.3	...	...	29.5	29.2	28.6	27.8	27.1	26.7	26.4
Alloys N08800, N08810, N06002	31.1	...	...	30.5	29.9	29.4	28.5	27.8	27.4	27.1
Alloys N06455, N10276	32.5	...	...	31.6	31.3	30.6	29.8	29.1	28.6	28.3
Alloys N02200, N02201, N06625	32.7	...	...	32.1	31.5	30.9	30.0	29.3	28.8	28.5
Alloy N06600	33.8	...	...	33.2	32.6	31.9	31.0	30.2	29.9	29.5
Alloy N10001	33.9	...	...	33.3	32.7	32.0	31.1	30.3	29.9	29.5
Alloy N10665	34.2	...	...	33.3	33.0	32.3	31.4	30.6	30.1	29.8
Unalloyed Titanium										
Grades 1, 2, 3, and 7	...	...	...	...	...	...	15.5	15.0	14.6	14.0

(continued)

ANEXO 11

TABLE K-1
ALLOWABLE STRESSES IN TENSION FOR METALS FOR CHAPTER IX[1-6, 18]

Numbers in Parentheses Refer to Notes for Appendix K Tables; Specifications are ASTM Unless Otherwise Indicated

Material	Spec. No.	P-No. or S-No. (7)	Type or Grade	Notes	Specified Min. Strength, ksi	
					Tensile	Yield
Carbon Steel						
Pipes and Tubes (17)						
...	A 53	1	B	(8)(16)		
...	A 106	1	B	...		
...	A 333	1	6	(8)	60	35
...	A 334	1	6	(8)		
...	API 5L	S-1	B	(8)(9)		
...	A 210	1	A-1	...	60	37
...	A 106					
...	A 210	1	C	...	70	40
...	API 5L	S-1	X42	(8)(9)	60	42
...	API 5L	S-1	X46	(8)(9)	63	46
...	API 5L	S-1	X52	(8)(9)	66	52
...	API 5L	S-1	X56	(8)(9)(10)	71	56
...	API 5L	S-1	X60	(8)(9)(10)	75	60
...	API 5L	S-1	X65	(8)(9)(10)	77	65
...	API 5L	S-1	X70	(8)(9)(10)	82	70
...	API 5L	S-1	X80	(8)(9)(10)	90	80
Forgings and Fittings						
...	A 234	1	WPB			
...	A 420	1	WPL6	(8)	60	35
...	A 350	1	LF2			
...	A 105	1	...	...	70	36
...	A 234	1	WPC	(8)	70	40
Low and Intermediate Alloy Steel						
Pipes and Tubes (17)						
C-½Mo	A 335	3	P1	...	55	30
1Cr-½Mo	A 335	4	P12	...	60	32
1¼Cr-½Mo	A 335	4	P11	...	60	30
5Cr-½Mo	A 335	5A	P5	...	60	30
2¼Cr-1Mo	A 335	5A	P22	...	60	30

(continued)

ANEXO 12

TABLE K-1
ALLOWABLE STRESSES IN TENSION FOR METALS FOR CHAPTER IX[1-6, 18]
Numbers in Parentheses Refer to Notes for Appendix K Tables; Specifications are ASTM Unless Otherwise Indicated

Allowable Stress, ksi (Multiply by 1000 to Obtain psi), for Metal Temperature, °F, Not Exceeding								Type or Grade	Spec. No.
100	200	300	400	500	600	650	700		
									Carbon Steel Pipes and Tubes (17)
23.3	21.3	20.7	20.0	18.9	17.3	16.9	16.8	B	A 53
								B	A 106
								6	A 333
								6	A 334
								B	API 5L
24.7	22.5	21.9	21.1	20.0	18.3	17.9	17.8	A-1	A 210
26.7	24.3	22.9	23.7	21.6	19.7	19.4	19.2	C	A 106, A 210
28.0	20.0	20.0	20.0	...	...	...	...	X42	API 5L
30.7	21.0	21.0	21.0	...	...	...	...	X46	API 5L
34.7	22.0	22.0	22.0	...	...	...	...	X52	API 5L
37.3	23.7	23.7	23.7	...	...	...	...	X56	API 5L
40.0	25.0	25.0	25.0	...	...	...	...	X60	API 5L
43.3	...	...	...	...	...	...	...	X65	API 5L
46.7	...	...	...	...	...	...	...	X70	API 5L
53.3	...	...	...	...	...	...	...	X80	API 5L
									Forgings and Fittings
23.3	21.3	20.7	20.0	18.9	17.3	16.9	16.8	WPB	A 234
								WPL6	A 420
24.0	21.9	21.3	20.6	19.5	17.7	17.5	17.3	LF2	A 350
								...	A 105
26.7	24.3	23.7	22.9	21.6	19.7	19.4	19.2	WPC	A 234
									Low and Intermediate Alloy Steel Pipes and Tubes (17)
20.0	18.5	17.5	16.9	16.3	15.7	15.4	15.1	P1	A 335
21.3	19.3	18.1	17.3	16.7	16.3	16.1	15.8	P12	A 335
20.0	18.7	17.9	17.5	17.2	16.7	16.2	15.7	P11	A 335
20.0	18.1	17.4	17.2	17.1	16.8	16.6	16.3	P5	A 335
20.0	18.5	18.1	17.9	17.9	17.9	17.9	17.9	P22	A 335

(continued)

ANEXO 13

Designation: A 105/A 105M – 01

An American National Standard

Endorsed by
Manufacturers Standardization Society
of the Valve and Fittings Industry
Used in USI/DOE-NE Standards

Standard Specification for Carbon Steel Forgings for Piping Applications[1]

This standard is issued under the fixed designation A 105/A 105M; 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.

1. Scope

1.1 This specification[2] covers forged carbon steel piping components for ambient- and higher-temperature service in pressure systems. Included are flanges, fittings, valves, and similar parts ordered either to dimensions specified by the purchaser or to dimensional standards such as the ASME and API specifications referenced in Section 2. Forgings made to this specification are limited to a maximum weight of 10 000 lb [4540 kg]. Larger forgings may be ordered to Specification A 266/A 266M. Tubesheets and hollow cylindrical forgings for pressure vessel shells are not included within the scope of this specification. Although this specification covers some piping components machined from rolled bar and seamless tubular products (see 4.2), it does not cover raw material produced in these product forms.

1.2 Supplementary requirements are provided for use when additional testing or inspection is desired. These shall apply only when specified individually by the purchaser in the order.

1.3 Specification A 266/A 266M covers other steel forgings and Specifications A 675, A 695, and A 696 cover other steel bars.

1.4 This specification is expressed in both inch-pound units and SI units. However, unless the order specifies the applicable "M" specification designation (SI units), the material shall be furnished to inch-pound units.

1.5 The values stated in either inch-pound units or SI are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

NOTE 1—The dimensionless designator NPS (nominal pipe size) has been substituted in this standard for such traditional terms as "nominal diameter," "size," and "nominal size."

2. Referenced Documents

2.1 In addition to those reference documents listed in Specification A 961, the following list of standards apply to this specification:

2.2 *ASTM Standards:*

A 266/A 266M Specification for Carbon Steel Forgings for Pressure Vessel Components[3]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[3,4,5]

A 675/A 675M Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties[3]

A 695 Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, for Fluid Power Applications[3]

A 696 Specification for Steel Bars, Carbon, Hot-Wrought or Cold-Finished, Special Quality, for Pressure Piping Components[3]

A 788 Specification for Steel Forgings, General Requirements[3]

A 961 Specification for Common Requirements for Steel Flanges, Forged Fittings, Valves, and Parts for Piping Applications[4]

2.3 *MSS Standards:*

SP 44 Standard for Steel Pipe Line Flanges[6]

2.4 *ASME Standards:*

B16.5 Dimensional Standards for Steel Pipe Flanges and Flanged Fittings[7]

B16.9 Wrought Steel Buttwelding Fittings[7]

B16.10 Face-to-Face and End-to-End Dimensions of Ferrous Valves[7]

B16.11 Forged Steel Fittings, Socket Weld, and Threaded[7]

B16.34 Valves-Flanged, Threaded and Welding End[7]

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[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.22 on Steel Forgings and Wrought Fittings for Piping Applications and Bolting Materials for Piping and Special Purpose Applications.

Current edition approved May 10, 2001. Published May 2001. Originally published as A 105 – 36 T. Last previous edition A 105/A 105M – 00.

[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SA-105 in Section II of that Code.

[3] *Annual Book of ASTM Standards*, Vol 01.05.

[4] *Annual Book of ASTM Standards*, Vol 01.01.

[5] *Annual Book of ASTM Standards*, Vol 01.03.

[6] Available from Manufacturers' Standardization Society of the Valve and Fittings Industry, 127 Park Street, NE, Vienna, VA 22180-4602.

[7] Available from ASME International, Three Park Avenue, New York, NY 10016-5990.

B16.47 Large Diameter Steel Flanges[7]

2.5 *ASME Boiler and Pressure Vessel Code:*

Section IX Welding Qualifications[7]

2.6 *API Standards:*

API-600 Flanged and Butt-Welding-End Steel Gate Valves[8]

API-602 Compact Design Carbon Steel Gate Valves for Refinery Use[8]

3. Ordering Information

3.1 See Specification A 961.

3.1.1 Additional requirements (see 12.2).

4. General Requirements

4.1 Product furnished to this specification shall conform to the requirements of Specification A 961, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the requirements of Specification A 961 constitutes nonconformance with this specification. In case of a conflict between the requirements of this specification and Specification A 961, this specification shall prevail.

4.2 Except as permitted by Section 6 in Specification A 961, the finished product shall be a forging as defined in the Terminology Section of Specification A 788.

5. Heat Treatment

5.1 Heat treatment is not a mandatory requirement of this specification except for the following piping components:

5.1.1 Flanges above Class 300.[9]

5.1.2 Flanges of special design where the design pressure at the design temperature exceeds the pressure-temperature ratings of Class 300, Group 1.1.

5.1.3 Flanges of special design where the design pressure or design temperature are not known.

5.1.4 Piping components other than flanges which meet both of the following criteria: (*1*) over NPS 4 and (*2*) above Class 300, and

5.1.5 Piping components of Special Class[10] other than flanges which meet both of the following criteria: (*1*) over NPS 4 and (*2*) when the working pressure at the operating temperature exceeds the tabulated values for Special Class 300, Group 1.1.

5.2 Heat treatment, when required by 5.1 shall be annealing, normalizing, or normalizing and tempering or quenching and tempering in accordance with Specification A 961.

6. Chemical Composition

6.1 The steel shall conform to the chemical requirements specified in Table 1.

6.2 Steels to which lead has been added shall not be used.

7. Mechanical Properties

7.1 The material shall conform to the mechanical property requirements prescribed in Table 2 and Table 3.

TABLE 1 Chemical Requirements

Note—For each reduction of 0.01 % below the specified carbon maximum (0.35 %), an increase of 0.06 % manganese above the specified maximum (1.05 %) will be permitted up to a maximum of 1.35 %.

Element	Composition, %
Carbon	0.35 max
Manganese	0.60–1.05
Phosphorus	0.035 max
Sulfur	0.040 max
Silicon	0.10–0.35
Copper	0.40 max[A]
Nickel	0.40 max[A]
Chromium	0.30 max[A,B]
Molybdenum	0.12 max[A,B]
Vanadium	0.08 max
Columbium	0.02 max

[A] The sum of copper, nickel, chromium, molybdenum and vanadium shall not exceed 1.00 %.

[B] The sum of chromium and molybdenum shall not exceed 0.32 %.

TABLE 2 Mechanical Requirements[A]

Tensile strength, min, psi [MPa]	70 000 [485]
Yield strength, min, psi [MPa][B]	36 000 [250]
Elongation in 2 in. or 50 mm, min, %	
Basic minimum elongation for walls $^{5}/_{16}$ in. [7.9 mm] and over in thickness, strip tests	30
When standard round 2-in. or 50-mm gage length or smaller proportionally sized specimen with the gage length equal to 4D is used	22
For strip tests, a deduction for each $^{1}/_{32}$-in. [0.8-mm] decrease in wall thickness below $^{5}/_{16}$ in. [7.9 mm] from the basic minimum elongation of the percentage points of Table 3	1.50[C]
Reduction of area, min, %[D]	30
Hardness, HB, max	187

[A] For small forgings, see 7.3.4.

[B] Determined by either the 0.2 % offset method or the 0.5 % extension-under-load method.

[C] See Table 3 for computed minimum values.

[D] For round specimens only.

TABLE 3 Computed Minimum Values

Wall Thickness, in.	Wall Thickness, mm	Elongation in 2 in. or 50 mm, min, %
$^{5}/_{16}$ (0.312)	7.9	30.00
$^{9}/_{32}$ (0.281)	7.1	28.50
$^{1}/_{4}$ (0.250)	6.4	27.00
$^{7}/_{32}$ (0.219)	5.6	25.50
$^{3}/_{16}$ (0.188)	4.8	24.00
$^{5}/_{32}$ (0.156)	4.0	22.50
$^{1}/_{8}$ (0.125)	3.2	21.00
$^{3}/_{32}$ (0.094)	2.4	19.50
$^{1}/_{16}$ (0.062)	1.6	18.00

Note—The above table gives the computed minimum elongation values for each $^{1}/_{32}$-in. [0.8-mm] decrease in wall thickness. Where the wall thickness lies between two values shown above, the minimum elongation value is determined by the following equation.

$$E = 48T - 15.00$$

where:

E = elongation in 2 in. or 50 mm, %, and

T = actual thickness of specimen, in. [mm].

7.2 For normalized, normalized and tempered, or quenched and tempered forgings, the central axis of the test specimen shall correspond to the 1/4 T plane or deeper position, where T is the maximum heat-treated thickness of the represented

[8] Available from American Petroleum Institute, 2101 L St. N.W., Washington, DC 20037.

[9] For definition of Class 300, see ASME B16.5.

[10] For definition of special class, see ASME B16.34.

forging. In addition, for quenched and tempered forgings, the midlength of the test specimen shall be at least T from any second heat-treated surface. When section thickness does not permit this positioning, the test specimen shall be positioned as near as possible to the prescribed location.

7.3 *Tension Tests*:

7.3.1 One tension test shall be made for each heat of as-forged components.

7.3.2 One tension test shall be made from each heat-treating charge. If more than one heat is included in such a charge, each heat shall be tested.

7.3.2.1 When the heat-treating temperatures are the same and the furnaces (either batch or continuous type), are controlled within ±25°F [±14°C] and equipped with recording pyrometers so that complete records of heat treatment are available, then one tension test from each heat is required instead of one test from each heat in each heat-treatment charge. The test specimen material shall be included with a furnace charge.

7.3.3 Testing shall be performed in accordance with Test Methods and Definitions A 370. The largest feasible round specimen as described in Test Methods and Definitions A 370 shall be used except when hollow cylindrically shaped parts are machined from seamless tubulars. The gage length for measuring elongation shall be four times the diameter of the test section. When hollow cylindrically shaped parts are machined from seamless tubular materials, strip tests may be used.

7.3.4 Forgings too small to permit obtaining a subsize specimen of 0.250 in. [6.35 mm] diameter or larger (see Test Methods and Definitions A 370) parallel to the direction of maximum working, and produced in equipment unsuitable for the production of a separately forged test bar such as an automatic or semi-automatic press, may be accepted on the basis of hardness only. One percent of the forgings per lot (see Note 2), or ten forgings, whichever is the lesser number, shall be selected at random, prepared, and tested using the standard Brinell test in Test Methods and Definitions A 370. The locations of the indentations shall be at the option of the manufacturer but shall be selected to be representative of the forging as a whole. One indentation per forging shall be required but additional indentations may be made to establish the representative hardness. The hardness of all forgings so tested shall be 137 to 187 HB inclusive.

NOTE 2—A lot is defined as the product from a mill heat or if heat treated, the product of a mill heat per furnace charge.

7.4 *Hardness Tests*—Except when only one forging is produced, a minimum of two forgings shall be hardness tested per batch or continuous run as defined in 7.3.2.1 to ensure that forgings are within the hardness limits given in Table 2. When only one forging is produced, it shall be hardness tested as defined in 7.3.2.1 to ensure it is within the hardness limits given in Table 2. Testing shall be in accordance with Test Methods and Definitions A 370. The purchaser may verify that the requirement has been met by testing at any location on the forging, provided such testing does not render the forging useless.

8. Hydrostatic Tests

8.1 Such tests shall be conducted by the forging manufacturer only when Supplementary Requirement S8 in Specification A 961 is specified.

9. Retreatment

9.1 If the results of the mechanical tests do not conform to the requirement specified, the manufacturer may heat treat or reheat treat the forgings as applicable and repeat the test specified in Section 7.

10. Repair by Welding

10.1 Repair of defects by the manufacturer is permissible for forgings made to dimensional standards such as those of ASME or for other parts made for stock by the manufacturer. Prior approval of the purchaser is required to repair-weld special forgings made to the purchaser's requirements.

10.2 Weld repairs shall be made by a process that does not produce undesirably high levels of hydrogen in the welded areas.

10.3 All forgings repaired by welding shall be post-weld heat treated between 1100°F [593°C] and the lower transformation temperature for a minimum of ½ h/in. [½ h/25.4 mm] of maximum section thickness, or alternatively annealed, normalized and tempered, or quenched and tempered. If the forging was not previously heat treated, the original tempering temperature was exceeded, or the forging was fully heat treated in the post weld cycle, then the forging shall be tested in accordance with Section 7 on completion of the cycle.

10.4 The mechanical properties of the procedure-qualification weldment shall, when tested in accordance with Section IX of the ASME Boiler and Pressure Vessel Code, conform with the requirements listed in Table 2 for the thermal condition of repair-welded forgings.

11. Rejection and Rehearing

11.1 Each forging that develops injurious defects during shop working or application shall be rejected and the manufacturer notified.

12. Certification

12.1 *Identification Marking*—For forgings made to specified dimensions, when agreed upon by the purchaser, and for forgings made to dimensional standards, application of identification marks as required in Specification A 961 shall be the certification that the forgings have been furnished in accordance with the requirements of this specification. The specification designation included on test reports shall include year of issue and revision letter, if any.

12.2 *Test Reports*—When test reports are required, the manufacturer shall also provide the following, where applicable:

12.2.1 Type heat treatment, Section 5,

12.2.2 Tensile property results, Section 7 (Table 2), report the yield strength and ultimate strength, in ksi [MPa], elongation and reduction in area, in percent,

12.2.3 Chemical analysis results, Section 6 (Table 1). When the amount of an unspecified element is less than 0.02 %, then the analysis for that element may be reported as "< 0.02 %,"

12.2.4 Hardness results, Section 7 (Table 2), and

12.2.5 Any supplementary testing required by the purchase order.

13. Product Marking

13.1 If the forgings have been quenched and tempered, the letters "QT" shall be stamped on the forgings following this specification number.

13.2 Forgings repaired by welding shall be marked with the letter "W" following this specification number.

13.3 When test reports are required for larger products, the markings shall consist of the manufacturer's symbol or name, this specification number, and such other markings as necessary to identify the part with the test report (13.1 and 13.2 shall apply). The specification number marked on the forgings need not include specification year of issue and revision letter.

13.4 *Bar Coding*—In addition to the requirements in Specification A 961 and 13.3, bar coding is acceptable as a supplemental identification method. The purchaser may specify in the order a specific bar coding system to be used. The bar coding system, if applied at the discretion of the supplier, should be consistent with one of the published industry standards for bar coding. If used on small parts, the bar code may be applied to the box or a substantially applied tag.

14. Keywords

14.1 pipe fittings, steel; piping applications; pressure containing parts; steel flanges; steel forgings, carbon; steel valves; temperature service applications, elevated; temperature service applications, high

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract, and order.

S1. Hardness

S1.1 The purchaser may check the hardness of any or all forgings supplied at any location on the forging and the hardness shall be 137 to 187 HB. All forgings not within the specified hardness range shall be rejected.

S2. Heat Treatment

S2.1 All forgings shall be heat treated as specified by the purchaser.

S2.2 When forgings not requiring heat treatment by 5.1 are supplied heat treated by purchaser request, the basis for determining conformance with Table 2 and Table 3 shall be hardness testing per 7.4 and either (*1*) tensile testing of heat treated forgings per 7.2, or (*3*) tensile tests from as-forged forgings or separately forged test blanks, as agreed upon between the supplier and purchaser.

S2.3 When test reports are required, and tensile test results were obtained from as-forged forgings or as-forged test blanks, it shall be so indicated on the test report.

S2.4 In addition to the marking required by Section 13, this specification shall be followed by the letter: A for annealed, N for normalized, NT for normalized and tempered, or QT for quenched and tempered, as appropriate.

S3. Marking Small Forgings

S3.1 For small products where the space for marking is less than 1 in. [25 mm] in any direction, test reports are mandatory and marking may be restricted to only such symbols or codes as are necessary to identify the parts with test reports.

S3.2 When the configuration or size does not permit marking directly on the forging, the marking method shall be a matter of agreement between the manufacturer and the purchaser.

S4. Carbon Equivalent

S4.1 The maximum carbon equivalent, based on heat analysis, shall be 0.47 for forgings with a maximum section thickness of 2 in. or less, and 0.48 for forgings with a maximum section thickness of greater than 2 in.

S4.2 Determine the carbon equivalent (CE) as follows:

$$CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$$

S4.3 A lower maximum carbon equivalent may be agreed upon between the supplier and the purchaser.

ANEXO 14

Designation: A 53/A 53M – 01

An American National Standard

Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless[1]

This standard is issued under the fixed designation A 53/A 53M, 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.

1. Scope

1.1 This specification[2] covers seamless and welded black and hot-dipped galvanized steel pipe in NPS ⅛ to NPS 26 [DN 6 to DN 650] (Note 1), inclusive, with nominal wall thickness (Note 2) as given in Table X2.2 and Table X2.3. It shall be permissible to furnish pipe having other dimensions (Note 2) provided such pipe complies with all other requirements of this specification.

NOTE 1—The dimensionless designators NPS (nominal pipe size) [DN (diameter nominal)] have been substituted in this specification for such traditional terms as "nominal diameter," "size," and "nominal size."

NOTE 2—The term nominal wall thickness has been assigned for the purpose of convenient designation, existing in name only, and is used to distinguish it from the actual wall thickness, which may vary over or under the nominal wall thickness.

1.2 This specification covers the following types and grades:

1.2.1 *Type F*—Furnace-butt welded, continuous welded Grade A,

1.2.2 *Type E*—Electric-resistance welded, Grades A and B, and

1.2.3 *Type S*—Seamless, Grades A and B.

NOTE 3—See Appendix X1 for definitions of types of pipe.

1.3 Pipe ordered under this specification is intended for mechanical and pressure applications and is also acceptable for ordinary uses in steam, water, gas, and air lines. It is suitable for welding, and suitable for forming operations involving coiling, bending, and flanging, subject to the following qualifications:

1.3.1 Type F is not intended for flanging.

1.3.2 When Types S and E are required for close coiling or cold bending, Grade A is the preferred grade. This provision is not intended to prohibit the cold bending of Grade B pipe.

1.3.3 Type E is furnished either nonexpanded or cold expanded at the option of the manufacturer.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 The following precautionary caveat pertains only to the test method portion, Sections 9, 10, 11, 15, 16, and 17 of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.6 The text of this specification contains notes or footnotes, or both, that provide explanatory material. Such notes and footnotes, excluding those in tables and figures, do not contain any mandatory requirements.

2. Referenced Documents

2.1 *ASTM Standards:*

A 90/A 90M Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings[3]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[4]

A 530/A 530M Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe[5]

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment[6]

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products[4]

A 865 Specification for Threaded Couplings, Steel, Black or Zinc-Coated (Galvanized) Welded or Seamless, for Use in Steel Pipe Joints[5]

B 6 Specification for Zinc[7]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[8]

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[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.09 on Carbon Steel Tubular Products.

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[2] For ASME Boiler and Pressure Vessel Code applications, see related Specification SA-53 in Section II of that code.

[3] *Annual Book of ASTM Standards*, Vol 01.06.

[4] *Annual Book of ASTM Standards*, Vol 01.03.

[5] *Annual Book of ASTM Standards*, Vol 01.01.

[6] *Annual Book of ASTM Standards*, Vol 01.05.

[7] *Annual Book of ASTM Standards*, Vol 02.04.

[8] *Annual Book of ASTM Standards*, Vol 14.02.

E 213 Practice for Ultrasonic Examination of Metal Pipe and Tubing[9]
E 309 Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation[9]
E 570 Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products[9]
E 1806 Practice for Sampling Steel and Iron for Determination of Chemical Composition[10]
2.2 *ANSI Standards:*
ASC X12[11]
B1.20.1 Pipe Threads, General Purpose[11]
2.3 *ASME Standard:*
B36.10 Welded and Seamless Wrought Steel Pipe[12]
2.4 *Military Standards:*
MIL-STD-129 Marking for Shipment and Storage[13]
MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage[13]
2.5 *Federal Standards:*
Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[14]
Fed. Std. No 183 Continuous Identification Marking of Iron and Steel Products[14]
2.6 *API Standard:*
5L Specification for Line Pipe[15]

3. Ordering Information

3.1 Information items to be considered, if appropriate, for inclusion in the purchase order are as follows:
3.1.1 Specification designation (A 53 or A 53M, including year of issue),
3.1.2 Quantity (feet, metres, or number of lengths),
3.1.3 Grade (see Table 1),
3.1.4 Type (see 1.2 and Table 2),
3.1.5 Finish (black or galvanized),
3.1.6 Size (either nominal (NPS) [DN] and weight class or schedule number, or both; or outside diameter and nominal wall thickness, Table X2.2 and Table X2.3),
3.1.7 Length (specific or random, Section 18),
3.1.8 End finish (plain end or threaded, Section 13),
3.1.8.1 Threaded and coupled, if desired,
3.1.8.2 Threads only (no couplings), if desired,
3.1.8.3 Plain end, if desired,
3.1.8.4 Couplings power tight, if desired,
3.1.8.5 Taper tapped couplings for NPS 2 [DN 50] and smaller, if desired,
3.1.9 Close coiling, if required (see 8.2),
3.1.10 Skelp for tension tests, if permitted (see 17.2),
3.1.11 Certification (see Section 22),
3.1.12 End use of material,
3.1.13 Special requirements, and
3.1.14 Selection of applicable level of preservation and packaging and level of packing required, if other than as specified or if MIL-STD-163 applies (see 21.2).

4. Materials and Manufacture

4.1 The steel for both seamless and welded pipe shall be made by one or more of the following processes: open-hearth, electric-furnace, or basic-oxygen.
4.2 When steels of different grades are sequentially strand cast, identification of the resultant transition material is required. The producer shall remove the transition material by any established procedure that positively separates the grades.
4.3 The weld seam of electric-resistance welded pipe in Grade B shall be heat treated after welding to a minimum of 1000°F [540°C] so that no untempered martensite remains, or otherwise processed in such a manner that no untempered martensite remains.
4.4 When pipe is cold expanded, the amount of expansion shall not exceed 1½ % of the outside diameter pipe size.

5. Chemical Composition

5.1 The steel shall conform to the requirements as to chemical composition in Table 1 and the chemical analysis

[9] *Annual Book of ASTM Standards*, Vol 03.03.
[10] *Annual Book of ASTM Standards*, Vol 03.06.
[11] Available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.
[12] Available from ASME International, Three Park Avenue, New York, NY 10016–5990.
[13] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.
[14] Available from General Services Administration, Washington, DC 20405.
[15] Available from American Petroleum Institute, 1220 L Street, Northwest, Washington, DC 20005–4070.

TABLE 1 Chemical Requirements

	Composition, max, %								
	Carbon	Manganese	Phosphorus	Sulfur	Copper[A]	Nickel[A]	Chromium[A]	Molybdenum[A]	Vanadium[A]
Type S (seamless pipe)									
Open-hearth, electric-furnace or basic-oxygen:									
Grade A	0.25	0.95	0.05	0.045	0.40	0.40	0.40	0.15	0.08
Grade B	0.30	1.20	0.05	0.045	0.40	0.40	0.40	0.15	0.08
Type E (electric-resistance-welded)									
Open-hearth, electric-furnace or basic-oxygen:									
Grade A	0.25	0.95	0.05	0.045	0.40	0.40	0.40	0.15	0.08
Grade B	0.30	1.20	0.05	0.045	0.40	0.40	0.40	0.15	0.08
Type F (furnace-welded pipe)									
Open-hearth, electric-furnace, or basic oxygen									
Grade A	0.30	1.20	0.05	0.045	0.40	0.40	0.40	0.15	0.08

[A] The combination of these five elements shall not exceed 1.00 %.

TABLE 2 Tensile Requirements

	Type F	Types E and S	
	Open-Hearth, Basic Oxygen, or Electric-Furnace, Grade A	Grade A	Grade B
Tensile strength, min, psi [MPa]	48 000 [330]	48 000 [330]	60 000 [415]
Yield strength, min, psi, [MPa]	30 000 [205]	30 000 [205]	35 000 [240]
Elongation in 2 in. [50 mm]	A,B	A,B	A,B

[A] The minimum elongation in 2 in. [50 mm] shall be that determined by the following equation:

$$e = 625\ 000\ [1940]\ A^{0.2}/U^{0.9}$$

where:

e = minimum elongation in 2 in. [50 mm] in percent rounded to the nearest percent,

A = cross-sectional area of the tension specimen, rounded to the nearest 0.01 in.^{2} [1 mm^2], based on the specified outside diameter or the nominal specimen width and specified wall thickness. If the area calculated is equal to or greater than 0.75 in.^{2} [500 mm^2], then the value 0.75 in.^{2} [500 mm^2] shall be used, and

U = specified tensile strength, psi [MPa].

[B] See Table X4.1 or Table X4.2, whichever is applicable, for minimum elongation values for various size tension specimens and grades.

shall be in accordance with Test Methods, Practices, and Terminology A 751.

6. Product Analysis

6.1 The purchaser is permitted to perform an analysis of two pipes from each lot of 500 lengths, or fraction thereof. Samples for chemical analysis, except for spectrographic analysis, shall be taken in accordance with Practice E 1806. The chemical composition thus determined shall conform to the requirements specified in Table 1.

6.2 If the analysis of either pipe does not conform to the requirements specified in Table 1, analyses shall be made on additional pipes of double the original number from the same lot, each of which shall conform to the requirements specified.

7. Tensile Requirements

7.1 The material shall conform to the requirements as to tensile properties prescribed in Table 2.

7.2 The yield strength corresponding to a permanent offset of 0.2 % of the gage length of the specimen or to a total extension of 0.5 % of the gage length under load shall be determined.

7.3 The test specimen taken across the weld shall show a tensile strength not less than the minimum tensile strength specified for the grade of pipe ordered. This test will not be required for pipe under NPS 8 [DN 200].

7.4 Transverse tension test specimens for electric-welded pipe NPS 8 [DN 200] and larger shall be taken opposite the weld. All transverse test specimens shall be approximately 1½ in. [40 mm] wide in the gage length, and shall represent the full wall thickness of the pipe from which the specimen was cut. This test is required for NPS 8 [DN 200] and larger.

8. Bending Requirements

8.1 For pipe NPS 2 [DN 50] and under, a sufficient length of pipe shall be capable of being bent cold through 90° around a cylindrical mandrel, the diameter of which is twelve times the outside diameter of the pipe, without developing cracks at any portion and without opening the weld.

8.2 When ordered for close coiling, the pipe shall stand being bent cold through 180° around a cylindrical mandrel, the diameter of which is eight times the outside diameter of the pipe, without failure.

8.3 Double-extra-strong pipe over NPS 1¼ [DN 32] need not be subjected to the bend test.

9. Flattening Test

9.1 The flattening test shall be made on pipe over NPS 2 [DN 50] with all thicknesses extra strong and lighter.

9.2 *Seamless Pipe*:

9.2.1 For seamless pipe, a test specimen at least 2 ½ in. [60 mm] in length shall be flattened cold between parallel plates in two steps. During the first step, which is a test for ductility, no cracks or breaks on the inside, outside, or end surfaces, except as provided for in 9.7, shall occur until the distance between the plates is less than the value of H calculated as follows:

$$H = (1 + e)t/(e + t/D)$$

where:

H = distance between flattening plates, in. [mm] (Note 4),

e = deformation per unit length (constant for a given grade of steel, 0.09 for Grade A, and 0.07 for Grade B),

t = nominal wall thickness, in. [mm], and

D = specified outside diameter, in. [mm]

9.2.2 During the second step, which is a test for soundness, the flattening shall be continued until the test specimen breaks or the opposite sides of the pipe meet. Evidence of laminated or unsound material that is revealed during the entire flattening test shall be cause for rejection.

NOTE 4—The H values have been calculated for standard and extra-heavy weight sizes from NPS 2½ to NPS 24 [DN 65 to DN 600], inclusive, and are shown in Table X2.1.

9.3 *Electric-Resistance-Welded Pipe*— A test specimen at least 4 in. [100 mm] in length shall be flattened cold between parallel plates in three steps, with the weld located either 0° or 90° from the line of direction of force as required in 9.3.1 or 9.3.2, whichever is applicable. During the first step, which is a test for ductility of the weld, no cracks or breaks on the inside or outside surfaces at the weld shall occur until the distance between the plates is less than two thirds of the specified diameter of the pipe. As a second step, the flattening shall be continued as a test for ductility away from the weld. During the second step, no cracks or breaks on the inside or outside surfaces away from the weld, except as provided for in 9.7, shall occur until the distance between the plates is less than one third of the specified outside diameter of the pipe but is not less than five times the wall thickness of the pipe. During the third step, which is a test for soundness, the flattening shall be continued until the test specimen breaks or the opposite walls of the pipe meet. Evidence of laminated or unsound material or of incomplete weld that is revealed by the flattening test shall be cause for rejection.

9.3.1 For pipe produced in single lengths, the flattening test

specified in 9.3 shall be made using a test specimen taken from each end of each length of pipe. The tests from each end shall be made alternately with the weld at 0° and at 90° from the line of direction of force.

9.3.2 For pipe produced in multiple lengths, the flattening test specified in 9.3 shall be made as follows:

9.3.2.1 Test specimens taken from, and representative of, the front end of the first pipe intended to be supplied from each coil, the back end of the last pipe intended to be supplied from each coil, and each side of any intermediate weld stop location shall be flattened with the weld located at 90° from the line of direction of force.

9.3.2.2 Test specimens taken from pipe at any two locations intermediate to the front end of the first pipe and the back end of the last pipe intended to be supplied from each coil shall be flattened with the weld located at 0° from the line of direction of force.

9.3.3 For pipe that is to be subsequently reheated throughout its cross section and hot formed by a reducing process, the manufacturer shall have the option of obtaining the flattening test specimens required by 9.3.1 or 9.3.2, whichever is applicable, either prior to or after such hot reducing.

9.4 *Continuous-Welded Pipe*—A test specimen at least 4 in. [100 mm] in length shall be flattened cold between parallel plates in three steps. The weld shall be located at 90° from the line of direction of force. During the first step, which is a test for ductility of the weld, no cracks or breaks on the inside, outside, or end surfaces at the weld shall occur until the distance between the plates is less than three fourths of the specified diameter of the pipe. As a second step, the flattening shall be continued as a test for ductility away from the weld. During the second step, no cracks or breaks on the inside, outside, or end surfaces away from the weld, except as provided for in 9.7, shall occur until the distance between the plates is less than 60 % of the specified outside diameter of the pipe. During the third step, which is a test for soundness, the flattening shall be continued until the test specimen breaks or the opposite walls of the pipe meet. Evidence of laminated or unsound material or of incomplete weld that is revealed by the flattening test shall be cause for rejection.

9.5 Surface imperfections in the test specimen before flattening, but revealed during the first step of the flattening test, shall be judged in accordance with the finish requirements in Section 14.

9.6 Superficial ruptures as a result of surface imperfections shall not be cause for rejection.

9.7 When low D-to-t ratio tubulars are tested, because the strain imposed due to geometry is unreasonably high on the inside surface at the 6 and 12 o'clock locations, cracks at these locations shall not be cause for rejection if the D-to-t ratio is less than 10.

10. Hydrostatic Test

10.1 The hydrostatic test shall be applied, without leakage through the pipe wall, to each length of pipe except as provided in 11.2 for seamless pipe.

10.2 Each length of plain-end pipe shall be hydrostatically tested to the pressures prescribed in Table X2.2, and each threaded-and-coupled length shall be hydrostatically tested to the pressures prescribed in Table X2.3. It shall be permissible, at the discretion of the manufacturer, to perform the hydrostatic test on pipe with plain ends, with threads only, or with threads and couplings and also shall be permissible to test pipe in either single lengths or multiple lengths.

NOTE 5—The hydrostatic test pressures given herein are inspection test pressures, are not intended as a basis for design, and do not have any direct relationship to working pressures.

10.3 The minimum hydrostatic test pressure required to satisfy these requirements need not exceed 2500 psi [17 200 kPa] for NPS 3 [DN 80] and under, nor 2800 psi [19 300 kPa] for all sized over NPS 3 [DN 80]. This does not prohibit testing at a higher pressure at the manufacturer's option. The hydrostatic pressure shall be maintained for not less than 5 s for all sizes of seamless and electric-welded pipe.

11. Nondestructive Electric Test

11.1 *Type E Pipe*:

11.1.1 The weld seam of each length of ERW pipe NPS 2 [DN 50] and larger shall be tested with a nondestructive electric test as follows:

11.1.2 *Ultrasonic and Electromagnetic Inspection*—Any equipment utilizing the ultrasonic or electromagnetic principles and capable of continuous and uninterrupted inspection of the weld seam shall be used. The equipment shall be checked with an applicable reference standard as described in 11.1.3 at least once every working turn or not more than 8 h to demonstrate its effectiveness and the inspection procedures. The equipment shall be adjusted to produce well-defined indications when the reference standard is scanned by the inspection unit in a manner simulating the inspection of the product.

11.1.3 *Reference Standards*—The length of the reference standards shall be determined by the pipe manufacturer, and they shall have the same specified diameter and thickness as the product being inspected. Reference standards shall contain machined notches, one on the inside surface and one on the outside surface, or a drilled hole, as shown in Fig. 1, at the option of the pipe manufacturer. The notches shall be parallel to the weld seam, and shall be separated by a distance sufficient to produce two separate and distinguishable signals. The ⅛-in. [3.2-mm] hole shall be drilled through the wall and perpendicular to the surface of the reference standard as shown in Fig. 1. Care shall be taken in the preparation of the reference standard to ensure freedom from fins or other edge roughness, or distortion of the pipe.

NOTE 6—The calibration standards defined in 11.1.3 are convenient standards for calibration of nondestructive testing equipment. The dimensions of such standards are not to be construed as the minimum sizes of imperfections detectable by such equipment.

11.1.4 *Acceptance Limits*—Table 3 gives the height of acceptance limit signals in percent of the height of signals produced by reference standards. Imperfections in the weld seam that produce a signal greater than the acceptance limit signal given in Table 3 shall be considered a defect unless the pipe manufacturer can demonstrate that the imperfection does not reduce the effective wall thickness beyond 12½ % of the specified wall thickness.

11.2 *Seamless Pipe*—As an alternative to the hydrostatic

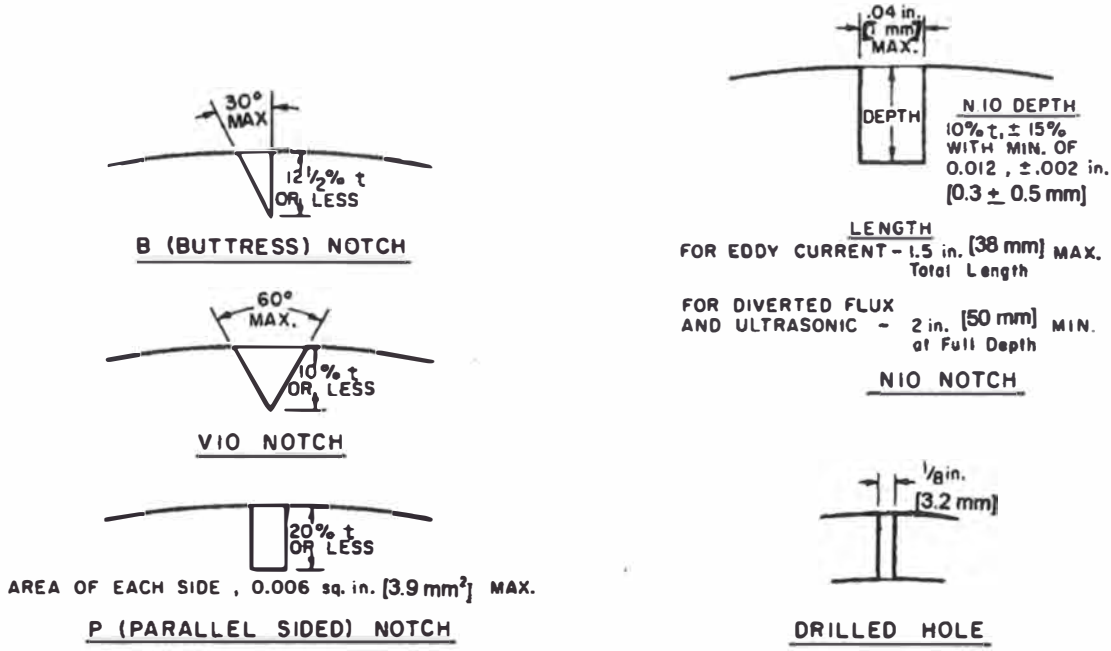

FIG. 1 Calibration Standards

TABLE 3 Acceptance Limits

Type Notch	Size of Hole		Acceptance Limit Signal, %
	in.	mm	
N10, V10	⅛	3.2	100
B.P.	...	...	80

test, and when specified by the purchaser, the full body of each seamless pipe shall be tested with a nondestructive electric test in accordance with Practices E 213, E 309, or E 570. In this case each length so furnished shall include the mandatory marking of the letters "NDE." Except as provided in 11.2.6.2 it is the intent of this test to reject pipe with imperfections which produce test signals equal to or greater than that of the calibration standard.

11.2.1 When the nondestructive electric test is performed, the lengths shall be marked with the letters "NDE." The certification, when required, shall state Nondestructive Electric Tested and shall indicate which of the tests was applied. Also, the letters NDE shall be appended to the product specification number and material grade shown on the certification.

11.2.2 The following information is intended to facilitate the use of this specification.

11.2.2.1 The calibration standards defined in 11.2.3 through 11.2.5 are convenient standards for calibration of nondestructive testing equipment. The dimensions of such standards are not to be construed as the minimum sizes of imperfections detectable by such equipment.

11.2.2.2 The ultrasonic testing referred to in this specification is capable of detecting the presence and location of significant longitudinally or circumferentially oriented imperfections; however, different techniques need to be employed for the detection of differently oriented imperfections. Ultrasonic testing is not necessarily capable of detecting short, deep imperfections.

11.2.2.3 The eddy current examination referenced in this specification has the capability of detecting significant discontinuities, especially of the short abrupt type.

11.2.2.4 The flux leakage examination referred to in this specification is capable of detecting the presence and location of significant longitudinally or transversely oriented discontinuities. The provisions of this specification only require longitudinal calibration for flux leakage. Different techniques need to be employed for the detection of differently oriented imperfections.

11.2.2.5 The hydrostatic test referred to in 10.2 has the capability of finding imperfections of a size permitting the test fluid to leak through the tube wall and may be either visually seen or detected by a loss of pressure. Hydrostatic testing is not necessarily capable of detecting very tight through-the-wall imperfections or imperfections that extend an appreciable distance into the wall without complete penetration.

11.2.2.6 A purchaser interested in ascertaining the nature (type, size, location, and orientation) of imperfections that are capable of being detected in the specific application of these examinations is directed to discuss this with the manufacturer of the tubular product.

11.2.3 For ultrasonic testing, the calibration reference notches shall be at the option of the producer, and shall be any one of the three common notch shapes shown in Practice E 213. The depth of notch shall not exceed 12.5 % of the specified wall thickness of the pipe or 0.004 in. [0.1 mm], whichever is greater.

11.2.4 For eddy current testing, the calibration pipe shall contain, at the option of the producer, any one of the following calibration standards to establish a minimum sensitivity level for rejection.

11.2.4.1 *Drilled Hole*—Depending upon the pipe diameter the calibration pipe shall contain three holes spaced 120° apart or four holes spaced 90° apart and sufficiently separated

longitudinally to ensure separately distinguishable responses. The holes shall be drilled radially and completely through the pipe wall, care being taken to avoid distortion of the pipe while drilling. Depending upon the pipe diameter the calibration pipe shall contain the following hole:

NPS	DN	Diameter of Drilled Hole
≤ ½	≤ 15	0.039 in. [1 mm]
> ½ ≤ 1¼	> 15 ≤ 32	0.055 in. [1.4 mm]
> 1¼ ≤ 2	> 32 ≤ 50	0.071 in. [1.8 mm]
> 2 ≤ 5	> 50 ≤ 125	0.087 in. [2.2 mm]
> 5	> 125	0.106 in. [2.7 mm]

11.2.4.2 *Transverse Tangential Notch*—Using a round tool or file with a ¼ in. [6 mm] diameter, a notch shall be filed or milled tangential to the surface and transverse to the longitudinal axis of the pipe. The notch shall have a depth not exceeding 12.5 % of the specified wall thickness of the pipe or 0.012 in. [0.3 mm], whichever is greater.

11.2.4.3 *Longitudinal Notch*—A notch 0.031 in. [0.8 mm] or less in width shall be machined in a radial plane parallel to the tube axis on the outside surface of the pipe, to have a depth not exceeding 12.5 % of the specified wall thickness of the tube or 0.012 in. [0.3 mm], whichever is greater. The length of the notch shall be compatible with the testing method.

11.2.4.4 *Compatibility*—The discontinuity in the calibration pipe shall be compatible with the testing equipment and the method being used.

11.2.5 For flux leakage testing, the longitudinal calibration reference notches shall be straight sided notches machined in a radial plane parallel to the pipe axis. For wall thickness under 0.500 in. [12.7 mm], outside and inside notches shall be used. For wall thickness equal and above 0.500 in. [12.7 mm], only an outside notch shall be used. Notch depth shall not exceed 12.5 % of the specified wall thickness, or 0.012 in. [0.3 mm], whichever is greater. Notch length shall not exceed 1 in. [25 mm], and the width shall not exceed the depth. Outside diameter and inside diameter notches shall be located sufficiently apart to allow separation and identification of the signals.

11.2.6 Pipe containing one or more imperfections that produce a signal equal to or greater than the signal produced by the calibration standard shall be rejected or the area producing the signal shall be rejected.

11.2.6.1 Test signals produced by imperfections that cannot be identified, or produced by cracks or crack-like imperfections, shall result in rejection of the pipe, unless it is repaired and retested. To be accepted, the pipe must pass the same specification test to which it was originally subjected, provided that the remaining wall thickness is not decreased below that permitted by the specification. It shall be permissible to reduce the outside diameter at the point of grinding by the amount so removed.

11.2.6.2 It shall be permissible to evaluate test signals produced by visual imperfections in accordance with provisions of Section 14. A few examples of these imperfections would be straightener marks, cutting chips, scratches, steel die stamps, stop marks, or pipe reducer ripple.

11.2.7 The test methods described in this section are not necessarily capable of inspecting the end portion of pipes. This condition is referred to as end effect. The length of the end effect shall be determined by the manufacturer and, when specified in the purchase order, reported to the purchaser.

12. Permissible Variations in Weight and Dimensions

12.1 *Weight*—The weight of the pipe as specified in Table X2.2 and Table X2.3 or as calculated from the relevant equation in ASME B36.10M shall not vary by more than ±10 %.

NOTE 7—The weight tolerance is determined from the weights of the customary lifts of pipe as produced for shipment by the mill, divided by the number of feet of pipe in the lift. On pipe sizes over NPS 4 [DN 100], where individual lengths are weighed, the weight tolerance is applicable to the individual length.

12.2 *Diameter*—For pipe NPS 1½ [DN 40] and under, the outside diameter at any point shall not vary more than ± 1/64 in. [0.4 mm] from the standard specified. For pipe NPS 2 [DN 50] and over, the outside diameter shall not vary more than ±1 % from the standard specified.

12.3 *Thickness*—The minimum wall thickness at any point shall be not more than 12.5 % under the nominal wall thickness specified. The minimum wall thickness on inspection shall conform to the requirements in Table X2.4.

13. End Finish

13.1 When ordered with plain ends, the pipe shall be furnished to the following practice, unless otherwise specified.

13.1.1 NPS 1½ [DN 40] and Smaller—Unless otherwise specified on the purchase order, end finish shall be at the option of the manufacturer.

13.1.2 NPS 2 [DN 50] and Larger:

13.1.2.1 Pipe of standard or extra strong weights, or in wall thickness less than 0.500 in. [12.7 mm], other than double extra strong pipe, shall be plain-end beveled with ends beveled to an angle of 30°, +5°, −0°, measured from a line drawn perpendicular to the axis of the pipe, and with a root face of 1/16 in. ± 1/32 in. [1.6 mm ± 0.8 mm].

13.1.2.2 Pipe with wall thicknesses over 0.500 in. [12.7 mm], and all double extra strong, shall be plain-end square cut.

13.2 When ordered with threaded ends, the pipe ends shall be provided with a thread in accordance with the gaging practice and tolerances of ANSI B1.20.1. For standard-weight pipe NPS 6 [DN 150] and smaller, refer to Table X3.1 for threading data. For standard-weight pipe NPS 8 [DN 200] and larger and all sizes of extra-strong weight and double extra-strong weight, refer to Table X3.2 for threading data. Threaded pipe NPS 4 [DN 100] and larger shall have thread protectors on the ends not protected by a coupling.

13.3 When ordered with couplings, one end of each length of pipe shall be provided with a coupling manufactured in accordance with Specification A 865. The coupling threads shall be in accordance with the gaging practice of ANSI B1.20.1. The coupling shall be applied handling-tight, unless power-tight is specified on the order. Couplings are to be made of steel. Taper-tapped couplings shall be furnished on all weights of threaded pipe sizes NPS 2½ [DN 65] and larger. For pipe NPS 2 [DN 50] and smaller, it is regular practice to furnish straight-tapped couplings for standard-weight pipe and taper-tapped couplings for extra-strong and double extra-strong pipe. If taper-tapped couplings are required for pipe NPS 2

[DN 50] and smaller on standard-weight pipe, it is recommended that line pipe threads in accordance with API Specification 5L be ordered. The taper-tapped couplings provided on line pipe in these sizes may be used on mill-threaded standard-weight pipe of the same size.

14. Workmanship, Finish and Appearance

14.1 The pipe manufacturer shall explore a sufficient number of visual surface imperfections to provide reasonable assurance that they have been properly evaluated with respect to depth.

14.2 Surface imperfections that penetrate more than 12½ % of the nominal wall thickness or encroach on the minimum wall thickness shall be considered defects. Pipe with defects shall be given one of the following dispositions:

14.2.1 The defect shall be removed by grinding, provided that the remaining wall thickness is within specified limits,

14.2.2 Type S pipe and the parent metal of Type E pipe, except within ½ in. [13 mm] of the fusion line of the electric resistance seam, are permitted to be repaired in accordance with the welding provisions of 14.5. Repair welding of Type F pipe and the weld seam of Type E is prohibited.

14.2.3 The section of pipe containing the defect may be cut off within the limits of requirement on length, or

14.2.4 Rejected.

14.3 At the purchaser's discretion, pipe shall be subjected to rejection if surface defects repaired in accordance with 14.2 are not scattered, but appear over a large area in excess of what is considered a workmanlike finish. Disposition of such pipe shall be a matter of agreement between the manufacturer and the purchaser.

14.4 When imperfections or defects are removed by grinding, a smooth curved surface shall be maintained, and the wall thickness shall not be decreased below that permitted by this specification. It shall be permissible to reduce the outside diameter at the point of grinding by the amount so removed.

14.4.1 Wall thickness measurements shall be made with a mechanical caliper or with a properly calibrated nondestructive testing device of appropriate accuracy. In the case of a dispute, the measurement determined by use of the mechanical caliper shall govern.

14.5 Weld repair shall be permitted only subject to approval of the purchaser and in accordance with Specification A 530/A 530M.

14.6 The finished pipe shall be reasonably straight.

14.7 The pipe shall contain no dents greater than 10 % of the pipe diameter or ¼ in. [6 mm], whichever is smaller, measured as a gap between the lowest point of the dent and a prolongation of the original contour of the pipe. Cold-formed dents deeper than ⅛ in. [3 mm] shall be free of sharp bottom gouges; it shall be permissible to remove the gouges by grinding, provided that the remaining wall thickness is within specified limits. The length of the dent in any direction shall not exceed one half the pipe diameter.

15. Number of Tests

15.1 Except as required by 15.2, one of each of the tests specified in Section 7, 8.2, and Section 9 shall be made on test specimens taken from one length of pipe from each lot of each pipe size. For continuous-welded pipe, a lot shall contain no more than 25 tons [23 Mg] of pipe for pipe sizes NPS 1½ [DN 40] and smaller, and no more than 50 tons [45 Mg] of pipe for pipe sizes NPS 2 [DN 50] and larger. For seamless and electric-resistance-welded pipe, a lot shall contain no more than one heat, and at the option of the manufacturer shall contain no more than 500 lengths of pipe (as initially cut after the final pipe-forming operation, prior to any further cutting to the required ordered lengths) or 50 tons [45 Mg] of pipe.

15.2 The number of flattening tests for electric-resistance-welded pipe shall be in accordance with 9.3.1 or 9.3.2, whichever is applicable.

15.3 Except as allowed by 11.2, each length of pipe shall be subjected to the hydrostatic test specified in Section 10.

16. Retests

16.1 If the results of the mechanical tests of any lot do not conform to the requirements specified in Sections 7, 8, and 9, retests are permitted to be made on additional pipe of double the original number from the same lot, each of which shall conform to the requirements specified.

16.2 For pipe produced in single lengths, if any section of the pipe fails to comply with the requirements of 9.3, it shall be permissible to cut other sections from the same end of the same length until satisfactory tests are obtained, except that the finished pipe shall not be shorter than 80 % of its length after the original cropping; otherwise the length shall be rejected. For pipe produced in multiple lengths, it shall be permissible to cut retests from each end of each individual length in the multiple. Such tests shall be made with the weld alternately 0° and 90° from the line of direction of force.

17. Test Methods

17.1 The test specimens and the tests required by this specification shall conform to those described in the latest issue of Test Methods and Definitions A 370.

17.2 The longitudinal tension test specimen shall be taken from the end of the pipe or, for continuous-welded pipe, it shall be permissible to be taken from the skelp, at a point approximately 90° from the weld, and shall not be flattened between gage marks. The sides of each specimen shall be parallel between gage marks. If desired, the tension tests are permitted to be made on the full section of pipe. When impracticable to pull a test specimen in full section, the standard 2-in. [50-mm] gage length tension test specimen shown in Fig. A2.3 of Test Methods and Definitions A 370 is acceptable.

17.3 Transverse weld test specimens from electric-resistance-welded pipe shall be taken with the weld at the center of the specimen. All transverse test specimens shall be approximately 1½ in. [40 mm] wide in the gage length and shall represent the full wall thickness of the pipe from which the specimen was cut.

17.4 Test specimens for the bend and flattening tests shall be taken from pipe. Test specimens for the flattening test shall be smooth on the ends and free from burrs.

17.5 All specimens shall be tested at room temperature.

18. Lengths

18.1 Unless otherwise specified, pipe lengths shall be in

accordance with the following regular practice.

18.1.1 Pipe of weights lighter than extra strong shall be in single-random lengths of 16 to 22 ft [4.88 to 6.71 m], but not more than 5 % of the total number of threaded lengths are permitted to be jointers (two pieces coupled together). When ordered with plain ends, 5 % are permitted to be in lengths of 12 to 16 ft [3.66 to 4.88 m].

18.1.2 Pipe of extra-strong and heavier weights shall be in random lengths of 12 to 22 ft [3.66 to 6.71 m]. Five percent are permitted to be in lengths of 6 to 12 ft [1.83 to 3.66 m].

18.1.3 When extra-strong or lighter pipe is ordered in double-random lengths, the minimum lengths shall be not less than 22 ft [6.71 m], with a minimum average for the order of 35 ft [10.67 m].

18.1.4 When lengths longer than single random are required for wall thicknesses heavier than extra-strong, the length shall be subject to negotiation.

18.1.5 When pipe is furnished with threads and couplings, the length shall be measured to the outer face of the coupling.

19. Galvanized Pipe

19.1 Galvanized pipe ordered under this specification shall be coated with zinc inside and outside by the hot-dip process. The zinc used for the coating shall be any grade of zinc conforming to Specification B 6.

19.2 *Weight of Coating*—The weight of zinc coating shall be not less than 1.8 oz/ft^2 [0.55 kg/m^2] as determined from the average results of the two specimens taken for test in the manner prescribed in 19.5 and not less than 1.6 oz/ft^2 [0.49 kg/m^2] for either of these specimens. The weight of coating expressed in ounces per square foot shall be calculated by dividing the total weight of zinc, inside plus outside, by the total area, inside plus outside, of the surface coated. Each specimen shall have not less than 1.3 oz/ft^2 [0.40 kg/m^2] of zinc coating on each surface, calculated by dividing the total weight of zinc on the given surface (outside or inside) by the area of the surface coated (outside or inside).

19.3 *Weight of Coating Test*—The weight of zinc coating shall be determined by a stripping test in accordance with Test Method A 90/A 90M. The total zinc on each specimen shall be determined in a single stripping operation.

19.4 *Test Specimens*—Test specimens for determination of weight of coating shall be cut approximately 4 in. [100 mm] in length.

19.5 *Number of Tests*—Two test specimens for the determination of weight of coating shall be taken, one from each end of one length of galvanized pipe selected at random from each lot of 500 lengths or fraction thereof, of each size.

19.6 *Retests*—If the weight of coating of any lot does not conform to the requirements specified in 19.2, retests of two additional pipes from the same lot shall be made, each of which shall conform to the requirements specified.

19.7 When pipe ordered under this specification is to be galvanized, the tension, flattening, and bend tests shall be made on the base material before galvanizing. When specified, results of the mechanical tests on the base material shall be reported to the purchaser. If it is impracticable to make the mechanical tests on the base material before galvanizing, it shall be permissible to make such tests on galvanized samples, and any flaking or cracking of the zinc coating shall not be considered cause for rejection. When galvanized pipe is bent or otherwise fabricated to a degree that causes the zinc coating to stretch or compress beyond the limit of elasticity, some flaking of the coating is acceptable.

20. Inspection

20.1 The inspector representing the purchaser shall have entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. All tests (except product analysis) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

21. Rejection

21.1 The purchaser is permitted to inspect each length of pipe received from the manufacturer and, if it does not meet the requirements of this specification based on the inspection and test method as outlined in the specification, the length shall be rejected and the manufacturer shall be notified. Disposition of rejected pipe shall be a matter of agreement between the manufacturer and the purchaser.

21.2 Pipe found in fabrication or in installation to be unsuitable for the intended use, under the scope and requirements of this specification, shall be set aside and the manufacturer notified. Such pipe shall be subject to mutual investigation as to the nature and severity of the deficiency and the forming or installation, or both, conditions involved. Disposition shall be a matter for agreement.

22. Certification

22.1 The producer or supplier shall, upon request, furnish to the purchaser a certificate of inspection stating that the material has been manufactured, sampled, tested, and inspected in accordance with this specification (including year of issue), and has been found to meet the requirements.

22.2 *Report*—For Types E and S, the producer or supplier shall furnish to the purchaser a chemical analysis report for the elements specified in Table 1.

22.3 *EDI*—A certificate of inspection or chemical analysis report printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier's facility. The use and format of the EDI document are subject to agreement between the purchaser and the supplier.

NOTE 8—EDI is the computer to computer exchange of business information in a standard format such as ANSI ASC X12.

22.4 Notwithstanding the absence of a signature, the organization submitting the certificate of inspection or chemical analysis report is responsible for its content.

23. Product Marking

23.1 Except as allowed by 23.5 and 23.6, each length of

pipe shall be legibly marked in the following sequence by rolling, stamping, or stenciling to show:

23.1.1 Manufacturer's name or mark,

23.1.2 Specification number (year of issue not required),

NOTE 9—Pipe that complies with multiple compatible specifications may be marked with the appropriate designation for each specification.

23.1.3 Size (NPS and weight class, schedule number, or nominal wall thickness; or specified outside diameter and nominal wall thickness),

23.1.4 Grade (A or B),

23.1.5 Type of pipe (F, E, or S),

23.1.6 Test pressure, seamless pipe only (if applicable, in accordance with Table 4),

23.1.7 Nondestructive electric test, seamless pipe only (if applicable, in accordance with Table 4),

23.2 Unless another marking format is specified in the purchase order, length shall be marked in feet and tenths of a foot, or metres to two decimal places, dependent upon the units to which the pipe was ordered. The location of such marking shall be at the option of the manufacturer.

23.3 Heat number, lot number, run number, or a combination thereof shall be marked at the option of the manufacturer, unless specific marking is specified in the purchase order. The location of such marking shall be at the option of the manufacturer.

23.4 Any additional information desired by the manufacturer or specified in the purchase order.

23.5 For pipe NPS 1½ [DN 40] and smaller that is bundled, it shall be permissible to mark this information on a tag securely attached to each bundle.

23.6 When pipe sections are cut into shorter lengths by a subsequent producer for resale as material, the processor shall transfer complete identification including the name or brand of the manufacturer, to each unmarked cut length, or to metal tags securely attached to unmarked pipe bundled in accordance with the requirements of 23.5. The same material designation shall be included with the information transferred, and the processor's name, trademark, or brand shall be added.

23.7 *Bar Coding*—In addition to the requirements in 23.1, 23.5, and 23.6, bar coding is acceptable as a supplementary identification method. It is recommended that bar coding be consistent with the Automotive Industry Action Group (AIAG) standard prepared by the Primary Metals Subcommittee of the AIAG Bar Code Project Team.

TABLE 4 Marking of Seamless Pipe

Hydro	NDE	Marking
Yes	No	Test pressure
No	Yes	NDE
Yes	Yes	Test Pressure/NDE

24. Government Procurement

24.1 When specified in the contract, material shall be preserved, packaged, and packed in accordance with the requirements of MIL-STD-163. The applicable levels shall be as specified in the contract. Marking for shipment of such material shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 or Federal Std. No. 183 if continuous marking is required, for military agencies.

24.2 *Inspection*—Unless otherwise specified in the contract, the producer is responsible for the performance of all inspection and test requirements specified herein. Except as otherwise specified in the contract, the manufacturer shall use its own or any other suitable facilities for performing the inspection and test requirements specified herein, unless otherwise disapproved by the purchaser in the contract or purchase order. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where deemed necessary to ensure that the material conforms to prescribed requirements.

25. Packaging and Package Marking

25.1 When specified on the purchase order, packaging, marking, and loading or shipment shall be in accordance with those procedures recommended by Practices A 700.

26. Keywords

26.1 black steel pipe; seamless steel pipe; steel pipe; welded steel pipe; zinc coated steel pipe

APPENDIXES

(Nonmandatory Information)

X1. DEFINITIONS OF TYPES OF PIPE

X1.1 *Type F, Furnace-Butt-Welded Pipe, Continuous-Welded*—Pipe produced in continuous lengths from coiled skelp and subsequently cut into individual lengths, having its longitudinal butt joint forge welded by the mechanical pressure developed in rolling the hot-formed skelp through a set of round pass welding rolls.

X1.2 *Type E, Electric-Resistance-Welded Pipe*—Pipe produced in individual lengths or in continuous lengths from coiled skelp and subsequently cut into individual lengths, having a longitudinal butt joint wherein coalescence is produced by the heat obtained from resistance of the pipe to the flow of electric current in a circuit of which the pipe is a part, and by the application of pressure.

X1.3 *Type S, Wrought Steel Seamless Pipe*—Wrought steel seamless pipe is a tubular product made without a welded seam. It is manufactured by hot working steel and, if necessary, by subsequently cold finishing the hot-worked tubular product to produce the desired shape, dimensions, and properties.

X2. TABLES FOR DIMENSIONAL AND CERTAIN MECHANICAL REQUIREMENTS

X2.1 Tables X2.1-X2.4 address dimensional and certain requirements.

TABLE X2.1 Calculated *H* Values for Seamless Pipe

NPS Designator	DN Designator	Outside Diameter, in. [mm]	Nominal Wall Thickness, in. [mm]	Distance, in. [mm], Between Plates "*H*" by Formula: $H = (1 + e)t/(e + t/D)$	
				Grade A	Grade B
2½	65	2.875 [73.0]	0.203 [5.16]	1.378 [35.0]	1.545 [39.2]
			0.276 [7.01]	1.618 [41.1]	1.779 [45.2]
3	80	3.500 [88.9]	0.216 [5.49]	1.552 [39.4]	1.755 [44.6]
			0.300 [7.62]	1.861 [47.3]	2.062 [52.4]
3½	90	4.000 [101.6]	0.226 [5.74]	1.682 [42.7]	1.912 [48.6]
			0.318 [8.08]	2.045 [51.9]	2.276 [57.8]
4	100	4.500 [114.3]	0.237 [6.02]	1.811 [46.0]	2.067 [52.5]
			0.337 [8.56]	2.228 [56.6]	2.489 [63.2]
5	125	5.563 [141.3]	0.258 [6.55]	2.062 [52.4]	2.372 [60.2]
			0.375 [9.52]	2.597 [66.0]	2.920 [74.2]
6	150	6.625 [168.3]	0.280 [7.11]	2.308 [58.6]	2.669 [67.8]
			0.432 [10.97]	3.034 [77.1]	3.419 [86.8]
8	200	8.625 [219.1]	0.277 [7.04]	2.473 [62.8]	2.902 [73.7]
			0.322 [8.18]	2.757 [70.0]	3.210 [81.5]
			0.500 [12.70]	3.683 [93.5]	4.181 [106.2]
10	250	10.750 [273.0]	0.279 [7.09][A]	2.623 [66.6]	3.111 [79.0]
			0.307 [7.80]	2.823 [71.7]	3.333 [84.7]
			0.365 [9.27]	3.210 [81.5]	3.757 [95.4]
			0.500 [12.70]	3.993 [101.4]	4.592 [116.6]
12	300	12.750 [323.8]	0.300 [7.62]	3.105 [78.9]	3.683 [93.5]
			0.375 [9.52]	3.423 [86.9]	4.037 [102.5]
			0.500 [12.70]	4.218 [107.1]	4.899 [124.4]
14	350	14.000 [355.6]	0.375 [9.52]	3.500 [88.9]	4.146 [105.3]
			0.500 [12.70]	4.336 [110.1]	5.061 [128.5]
16	400	16.000 [406.4]	0.375 [9.52]	3.603 [91.5]	4.294 [109.1]
			0.500 [12.70]	4.494 [114.1]	5.284 [134.2]
18	450	18.000 [457]	0.375 [9.52]	3.688 [93.7]	4.417 [112.2]
			0.500 [12.70]	4.628 [117.6]	5.472 [139.0]
20	500	20.000 [508]	0.375 [9.52]	3.758 [95.5]	4.521 [114.8]
			0.500 [12.70]	4.740 [120.4]	5.632 [143.1]
24	600	24.000 [610]	0.375 [9.52]	3.869 [98.3]	4.686 [119.0]
			0.500 [12.70]	4.918 [124.9]	5.890 [149.6]

[A] Special order only.

TABLE X2.2 Dimensions, Weights, and Test Pressures for Plain End Pipe

NPS	DN Designator	Outside Diameter, in. [mm]	Nominal Wall Thickness, in. [mm]	Nominal Weight [Mass] per Unit Length, Plain End, lb/ft [kg/m]	Weight Class	Schedule No.	Test Pressure,[A] psi [kPa]	
							Grade A	Grade B
⅛	6	0.405 [10.3]	0.068 [1.73]	0.24 [0.37]	STD	40	700 [4800]	700 [4800]
			0.095 [2.41]	0.31 [0.47]	XS	80	850 [5900]	850 [5900]
¼	8	0.540 [13.7]	0.088 [2.24]	0.43 [0.63]	STD	40	700 [4800]	700 [4800]
			0.119 [3.02]	0.54 [0.80]	XS	80	850 [5900]	850 [5900]
⅜	10	0.675 [17.1]	0.091 [2.31]	0.57 [0.84]	STD	40	700 [4800]	700 [4800]
			0.126 [3.20]	0.74 [1.10]	XS	80	850 [5900]	850 [5900]
½	15	0.840 [21.3]	0.109 [2.77]	0.85 [1.27]	STD	40	700 [4800]	700 [4800]
			0.147 [3.73]	1.09 [1.62]	XS	80	850 [5900]	850 [5900]
			0.188 [4.78]	1.31 [1.95]	...	160	900 [6200]	900 [6200]
			0.294 [7.47]	1.72 [2.55]	XXS	...	1000 [6900]	1000 [6900]
¾	20	1.050 [26.7]	0.113 [2.87]	1.13 [1.69]	STD	40	700 [4800]	700 [4800]
			0.154 [3.91]	1.48 [2.20]	XS	80	850 [5900]	850 [5900]
			0.219 [5.56]	1.95 [2.90]	...	160	950 [6500]	950 [6500]
			0.308 [7.82]	2.44 [3.64]	XXS	...	1000 [6900]	1000 [6900]
1	25	1.315 [33.4]	0.133 [3.38]	1.68 [2.50]	STD	40	700 [4800]	700 [4800]
			0.179 [4.55]	2.17 [3.24]	XS	80	850 [5900]	850 [5900]
			0.250 [6.35]	2.85 [4.24]	...	160	950 [6500]	950 [6500]
			0.358 [9.09]	3.66 [5.45]	XXS	...	1000 [6900]	1000 [6900]
1¼	32	1.660 [42.2]	0.140 [3.56]	2.27 [3.39]	STD	40	1200 [8300]	1300 [9000]
			0.191 [4.85]	3.00 [4.47]	XS	80	1800 [12 400]	1900 [13 100]
			0.250 [6.35]	3.77 [5.61]	...	160	1900 [13 100]	2000 [13 800]
			0.382 [9.70]	5.22 [7.77]	XXS	...	2200 [15 200]	2300 [15 900]
1½	40	1.900 [48.3]	0.145 [3.68]	2.72 [4.05]	STD	40	1200 [8300]	1300 [9000]
			0.200 [5.08]	3.63 [5.41]	XS	80	1800 [12 400]	1900 [13 100]
			0.281 [7.14]	4.86 [7.25]	...	160	1950 [13 400]	2050 [14 100]
			0.400 [10.16]	6.41 [9.56]	XXS	...	2200 [15 200]	2300 [15 900]
2	50	2.375 [60.3]	0.154 [3.91]	3.66 [5.44]	STD	40	2300 [15 900]	2500 [17 200]
			0.218 [5.54]	5.03 [7.48]	XS	80	2500 [17 200]	2500 [17 200]
			0.344 [8.74]	7.47 [11.11]	...	160	2500 [17 200]	2500 [17 200]
			0.436 [11.07]	9.04 [13.44]	XXS	...	2500 [17 200]	2500 [17 200]
2½	65	2.875 [73.0]	0.203 [5.16]	5.80 [8.63]	STD	40	2500 [17 200]	2500 [17 200]
			0.276 [7.01]	7.67 [11.41]	XS	80	2500 [17 200]	2500 [17 200]
			0.375 [9.52]	10.02 [14.90]	...	160	2500 [17 200]	2500 [17 200]
			0.552 [14.02]	13.71 [20.39]	XXS	...	2500 [17 200]	2500 [17 200]
3	80	3.500 [88.9]	0.125 [3.18]	4.51 [6.72]	...	...	1290 [8900]	1500 [1000]
			0.156 [3.96]	5.58 [8.29]	...	...	1600 [11 000]	1870 [12 900]
			0.188 [4.78]	6.66 [9.92]	...	...	1930 [13 330]	2260 [15 600]
			0.216 [5.49]	7.58 [11.29]	STD	40	2220 [15 300]	2500 [17 200]
			0.250 [6.35]	8.69 [12.93]	...	...	2500 [17 200]	2500 [17 200]
			0.281 [7.14]	9.67 [14.40]	...	...	2500 [17 200]	2500 [17 200]
			0.300 [7.62]	10.26 [15.27]	XS	80	2500 [17 200]	2500 [17 200]
			0.438 [11.13]	14.34 [21.35]	...	160	2500 [17 200]	2500 [17 200]
			0.600 [15.24]	18.60 [27.68]	XXS	...	2500 [17 200]	2500 [17 200]
3½	90	4.000 [101.6]	0.125 [3.18]	5.18 [7.72]	...	...	1120 [7700]	1310 [19 000]
			0.156 [3.96]	6.41 [9.53]	...	...	1400 [6700]	1640 [11 300]
			0.188 [4.78]	7.66 [11.41]	...	...	1690 [11 700]	1970 [13 600]
			0.226 [5.74]	9.12 [13.57]	STD	40	2030 [14 000]	2370 [16 300]
			0.250 [6.35]	10.02 [14.92]	...	...	2250 [15 500]	2500 [17 200]
			0.281 [7.14]	11.17 [16.63]	...	...	2500 [17 200]	2500 [17 200]
			0.318 [8.08]	12.52 [18.63]	XS	80	2800 [19 300]	2800 [19 300]
4	100	4.500 [114.3]	0.125 [3.18]	5.85 [8.71]	...	...	1000 [6900]	1170 [8100]
			0.156 [3.96]	7.24 [10.78]	...	...	1250 [8600]	1460 [10 100]
			0.188 [4.78]	8.67 [12.91]	...	...	1500 [10 300]	1750 [12 100]
			0.219 [5.56]	10.02 [14.91]	...	...	1750 [12 100]	2040 [14 100]
			0.237 [6.02]	10.80 [16.07]	STD	40	1900 [13 100]	2210 [15 200]
			0.250 [6.35]	11.36 [16.90]	...	...	2000 [13 800]	2330 [16 100]
			0.281 [7.14]	12.67 [18.87]	...	...	2250 [15 100]	2620 [18 100]
			0.312 [7.92]	13.97 [20.78]	...	...	2500 [17 200]	2800 [19 300]

TABLE X2.2 *Continued*

NPS	DN Designator	Outside Diameter, in. [mm]	Nominal Wall Thickness, in. [mm]	Nominal Weight [Mass] per Unit Length, Plain End, lb/ft [kg/m]	Weight Class	Schedule No.	Test Pressure,[A] psi [kPa]	
							Grade A	Grade B
			0.337 [8.56]	15.00 [22.32]	XS	80	2700 [18 600]	2800 [19 300]
			0.438 [11.13]	19.02 [28.32]	...	120	2800 [19 300]	2800 [19 300]
			0.531 [13.49]	22.53 [33.54]	...	160	2800 [19 300]	2800 [19 300]
			0.674.[17.12]	27.57 [41.03]	XXS	...	2800 [19 300]	2800 [19 300]
5	125	5.563 [141.3]	0.156 [3.96]	9.02 [13.41]	...	...	1010 [7000]	1180 [8100]
			0.188 [4.78]	10.80 [16.09]	...	...	1220 [8400]	1420 [9800]
			0.219 [5.56]	12.51 [18.61]	...	...	1420 [9800]	1650 [11 400]
			0.258 [6.55]	14.63 [21.77]	STD	40	1670 [11 500]	1950 [13 400]
			0.281 [7.14]	15.87 [23.62]	...	...	1820 [12 500]	2120 [14 600]
			0.312 [7.92]	17.51 [26.05]	...	...	2020 [13 900]	2360 [16 300]
			0.344 [8.74]	19.19 [28.57]	...	...	2230 [15 400]	2600 [17 900]
			0.375 [9.52]	20.80 [30.94]	XS	80	2430 [16 800]	2800 [19 300]
			0.500 [12.70]	27.06 [40.28]	...	120	2800 [19 300]	2800 [19 300]
			0.625 [15.88]	32.99 [49.11]	...	160	2800 [19 300]	2800 [19 300]
			0.750 [19.05]	38.59 [57.43]	XXS	...	2800 [19 300]	2800 [19 300]
6	150	6.625 [168.3]	0.188 [4.78]	12.94 [19.27]	...	...	1020 [7000]	1190 [8200]
			0.219 [5.56]	15.00 [22.31]	...	...	1190 [8200]	1390 [9600]
			0.250 [6.35]	17.04 [25.36]	...	...	1360 [9400]	1580 [10 900]
			0.280 [7.11]	18.99 [28.26]	STD	40	1520 [10 500]	1780 [12 300]
			0.312 [7.92]	21.06 [31.32]	...	...	1700 [11 700]	1980 [13 700]
			0.344 [8.74]	23.10 [34.39]	...	...	1870 [12 900]	2180 [15 000]
			0.375 [9.52]	25.05 [37.28]	...	...	2040 [14 100]	2380 [16 400]
			0.432 [10.97]	28.60 [42.56]	XS	80	2350 [16 200]	2740 [18 900]
			0.562 [14.27]	36.43 [54.20]	...	120	2800 [19 300]	2800 [19 300]
			0.719 [18.26]	45.39 [67.56]	...	160	2800 [19 300]	2800 [19 300]
			0.864 [21.95]	53.21 [79.22]	XXS	...	2800 [19 300]	2800 [19 300]
8	200	8.625 [219.1]	0.188 [4.78]	16.96 [25.26]	...	...	780 [5400]	920 [6300]
			0.203 [5.16]	18.28 [27.22]	...	...	850 [5900]	1000 [6900]
			0.219 [5.56]	19.68 [29.28]	...	...	910 [6300]	1070 [7400]
			0.250 [6.35]	22.38 [33.31]	...	20	1040 [7200]	1220 [8400]
			0.277 [7.04]	24.72 [36.31]	...	30	1160 [7800]	1350 [9300]
			0.312 [7.92]	27.73 [41.24]	...	...	1300 [9000]	1520 [10 500]
			0.322 [8.18]	28.58 [42.55]	STD	40	1340 [9200]	1570 [10 800]
			0.344 [8.74]	30.45 [45.34]	...	...	1440 [9900]	1680 [11 600]
			0.375 [9.52]	33.07 [49.20]	...	...	1570 [10 800]	1830 [12 600]
			0.406 [10.31]	35.67 [53.08]	...	60	1700 [11 700]	2000 [13 800]
			0.438 [11.13]	38.33 [57.08]	...	...	1830 [12 600]	2130 [14 700]
			0.500 [12.70]	43.43 [64.64]	XS	80	2090 [14 400]	2430 [16 800]
			0.594 [15.09]	51.00 [75.92]	...	100	2500 [17 200]	2800 [19 300]
			0.719 [18.26]	60.77 [90.44]	...	120	2800 [19 300]	2800 [19 300]
			0.812 [20.62]	67.82 [100.92]	...	140	2800 [19 300]	2800 [19 300]
			0.875 [22.22]	72.49 [107.88]	XXS	...	2800 [19 300]	2800 [19 300]
			0.906 [23.01]	74.76 [111.27]	...	160	2800 [19 300]	2800 [19 300]
10	250	10.750 [273.0]	0.188 [4.78]	21.23 [31.62]	...	...	630 [4300]	730 [5000]
			0.203 [5.16]	22.89 [34.08]	...	...	680 [4700]	800 [5500]
			0.219 [5.56]	24.65 [36.67]	...	...	730 [5000]	860 [5900]
			0.250 [6.35]	28.06 [41.75]	...	20	840 [5800]	980 [6800]
			0.279 [7.09]	31.23 [46.49]	...	...	930 [6400]	1090 [7500]
			0.307 [7.80]	34.27 [51.01]	...	30	1030 [7100]	1200 [8300]
			0.344 [8.74]	38.27 [56.96]	...	...	1150 [7900]	1340 [9200]
			0.365 [9.27]	40.52 [60.29]	STD	40	1220 [8400]	1430 [9900]
			0.438 [11.13]	48.28 [71.87]	...	...	1470 [10 100]	1710 [11 800]
			0.500 [12.70]	54.79 [81.52]	XS	60	1670 [11 500]	1950 [13 400]
			0.594 [15.09]	64.49 [95.97]	...	80	1990 [13 700]	2320 [16 000]
			0.719 [18.26]	77.10 [114.70]	...	100	2410 [16 600]	2800 [19 300]
			0.844 [21.44]	89.38 [133.00]	...	120	2800 [19 300]	2800 [19 300]
			1.000 [25.40]	104.23 [155.09]	XXS	140	2800 [19 300]	2800 [19 300]
			1.125 [28.57]	115.75 [172.21]	...	160	2800 [19 300]	2800 [19 300]
12	300	12.750 [323.8]	0.203 [5.16]	27.23 [40.55]	...	...	570 [3900]	670 [4600]
			0.219 [5.56]	29.34 [43.63]	...	...	620 [4300]	720 [5000]
			0.250 [6.35]	33.41 [49.71]	...	20	710 [4900]	820 [5700]
			0.281 [7.14]	37.46 [55.75]	...	...	790 [5400]	930 [6400]
			0.312 [7.92]	41.48 [61.69]	...	...	880 [6100]	1030 [7100]
			0.330 [8.38]	43.81 [65.18]	...	30	930 [6400]	1090 [7500]
			0.344 [8.74]	45.62 [67.90]	...	...	970 [6700]	1130 [7800]
			0.375 [9.52]	49.61 [73.78]	STD	...	1060 [7300]	1240 [8500]

TABLE X2.2 *Continued*

NPS	DN Designator	Outside Diameter, in. [mm]	Nominal Wall Thickness, in. [mm]	Nominal Weight [Mass] per Unit Length, Plain End, lb/ft [kg/m]	Weight Class	Schedule No.	Test Pressure,[A] psi [kPa]	
							Grade A	Grade B
			0.406 [10.31]	53.57 [79.70]	...	40	1150 [7900]	1340 [9200]
			0.438 [11.13]	57.65 [85.82]	...	...	1240 [8500]	1440 [9900]
			0.500 [12.70]	65.48 [97.43]	XS	...	1410 [9700]	1650 [11 400]
			0.562 [14.27]	73.22 [108.92]	...	60	1590 [11 000]	1850 [12 800]
			0.688 [17.48]	88.71 [132.04]	...	80	1940 [13 400]	2270 [15 700]
			0.844 [21.44]	107.42 [159.86]	...	100	2390 [16 500]	2780 [19 200]
			1.000 [25.40]	125.61 [186.91]	XXS	120	2800 [19 300]	2800 [19 300]
			1.125 [28.57]	139.81 [208.00]	...	140	2800 [19 300]	2800 [19 300]
			1.312 [33.32]	160.42 [238.68]	...	160	2800 [19 300]	2800 [19 300]
14	350	14.000 [355.6]	0.210 [5.33]	30.96 [46.04]	...	...	540 [3700]	630 [4300]
			0.219 [5.56]	32.26 [47.99]	...	...	560 [3900]	660 [4500]
			0.250 [6.35]	36.75 [54.69]	...	10	640 [4400]	750 [5200]
			0.281 [7.14]	41.21 [61.35]	...	...	720 [5000]	840 [5800]
			0.312 [7.92]	45.65 [67.90]	...	20	800 [5500]	940 [6500]
			0.344 [8.74]	50.22 [74.76]	...	...	880 [6100]	1030 [7100]
			0.375 [9.52]	54.62 [81.25]	STD	30	960 [6600]	1120 [7700]
			0.438 [11.13]	63.50 [94.55]	...	40	1130 [7800]	1310 [9000]
			0.469 [11.91]	67.84 [100.94]	...	...	1210 [8300]	1410 [9700]
			0.500 [12.70]	72.16 [107.39]	XS	...	1290 [8900]	1500 [10 300]
			0.594 [15.09]	85.13 [126.71]	...	60	1530 [10 500]	1790 [12 300]
			0.750 [19.05]	106.23 [158.10]	...	80	1930 [13 300]	2250 [15 500]
			0.938 [23.83]	130.98 [194.96]	...	100	2410 [16 600]	2800 [19 300]
			1.094 [27.79]	150.93 [224.65]	...	120	2800 [19 300]	2800 [19 300]
			1.250 [31.75]	170.37 [253.56]	...	140	2800 [19 300]	2800 [19 300]
			1.406 [35.71]	189.29 [281.70]	...	160	2800 [19 300]	2800 [19 300]
			2.000 [50.80]	256.56 [381.83]	...	...	2800 [19 300]	2800 [19 300]
			2.125 [53.97]	269.76 [401.44]	...	...	2800 [19 300]	2800 [19 300]
			2.200 [55.88]	277.51 [413.01]	...	...	2800 [19 300]	2800 [19 300]
			2.500 [63.50]	307.34 [457.40]	...	...	2800 [19 300]	2800 [19 300]
16	400	16.000 [406.4]	0.219 [5.56]	36.95 [54.96]	...	...	490 [3400]	570 [3900]
			0.250 [6.35]	42.09 [62.64]	...	10	560 [3900]	660 [4500]
			0.281 [7.14]	47.22 [70.30]	...	...	630 [4300]	740 [5100]
			0.312 [7.92]	52.32 [77.83]	...	20	700 [4800]	820 [5700]
			0.344 [8.74]	57.57 [85.71]	...	...	770 [5300]	900 [6200]
			0.375 [9.52]	62.64 [93.17]	STD	30	840 [5800]	980 [6800]
			0.438 [11.13]	72.86 [108.49]	...	...	990 [6800]	1150 [7900]
			0.469 [11.91]	77.87 [115.86]	...	...	1060 [7300]	1230 [8500]
			0.500 [12.70]	82.85 [123.30]	XS	40	1120 [7700]	1310 [9000]
			0.656 [16.66]	107.60 [160.12]	...	60	1480 [10 200]	1720 [11 900]
			0.844 [21.44]	136.74 [203.53]	...	80	1900 [13 100]	2220 [15 300]
			1.031 [26.19]	164.98 [245.56]	...	100	2320 [16 000]	2710 [18 700]
			1.219 [30.96]	192.61 [286.64]	...	120	2740 [18 900]	2800 [19 300]
			1.438 [36.53]	223.85 [333.19]	...	140	2800 [19 300]	2800 [19 300]
			1.594 [40.49]	245.48 [365.35]	...	160	2800 [19 300]	2800 [19 300]
18	450	18.000 [457]	0.250 [6.35]	47.44 [70.60]	...	10	500 [3400]	580 [4000]
			0.281 [7.14]	53.23 [79.24]	...	...	560 [3900]	660 [4500]
			0.312 [7.92]	58.99 [87.75]	...	20	620 [4300]	730 [5000]
			0.344 [8.74]	64.93 [96.66]	...	...	690 [4800]	800 [5500]
			0.375 [9.52]	70.65 [105.10]	STD	...	750 [5200]	880 [6100]
			0.406 [10.31]	76.36 [113.62]	...	...	810 [5600]	950 [6500]
			0.438 [11.13]	82.23 [122.43]	...	30	880 [6100]	1020 [7000]
			0.469 [11.91]	87.89 [130.78]	...	...	940 [6500]	1090 [7500]
			0.500 [12.70]	93.54 [139.20]	XS	...	1000 [6900]	1170 [8100]
			0.562 [14.27]	104.76 [155.87]	...	40	1120 [7700]	1310 [9000]
			0.750 [19.05]	138.30 [205.83]	...	60	1500 [10 300]	1750 [12 100]
			0.938 [23.83]	171.08 [254.67]	...	80	1880 [13 000]	2190 [15 100]
			1.156 [29.36]	208.15 [309.76]	...	100	2310 [15 900]	2700 [18 600]
			1.375 [34.92]	244.37 [363.64]	...	120	2750 [19 000]	2800 [19 300]
			1.562 [39.67]	274.48 [408.45]	...	140	2800 [19 300]	2800 [19 300]
			1.781 [45.24]	308.79 [459.59]	...	160	2800 [19 300]	2800 [19 300]
20	500	20.000 [508]	0.250 [6.35]	52.78 [78.55]	...	10	450 [3100]	520 [3600]
			0.281 [7.14]	59.23 [88.19]	...	...	510 [3500]	590 [4100]
			0.312 [7.92]	65.66 [97.67]	...	...	560 [3900]	660 [4500]
			0.344 [8.74]	72.28 [107.60]	...	...	620 [4300]	720 [5000]
			0.375 [9.52]	78.67 [117.02]	STD	20	680 [4700]	790 [5400]
			0.406 [10.31]	84.04 [126.53]	...	...	730 [5000]	850 [5900]
			0.438 [11.13]	91.59 [136.37]	...	...	790 [5400]	920 [6300]

TABLE X2.2 *Continued*

NPS	DN Designator	Outside Diameter, in. [mm]	Nominal Wall Thickness, in. [mm]	Nominal Weight [Mass] per Unit Length, Plain End, lb/ft [kg/m]	Weight Class	Schedule No.	Test Pressure,[A] psi [kPa]	
							Grade A	Grade B
			0.469 [11.91]	97.92 [145.70]	...	...	850 [5900]	950 [6500]
			0.500 [12.70]	104.23 [155.12]	XS	30	900 [6200]	1050 [7200]
			0.594 [15.09]	123.23 [183.42]	...	40	1170 [8100]	1250 [8600]
			0.812 [20.62]	166.56 [247.83]	...	60	1460 [10 100]	1710 [11 800]
			1.031 [26.19]	209.06 [311.17]	...	80	1860 [12 800]	2170 [15 000]
			1.281 [32.54]	256.34 [381.53]	...	100	2310 [15 900]	2690 [18 500]
			1.500 [38.10]	296.65 [441.49]	...	120	2700 [18 600]	2800 [19 300]
			1.750 [44.45]	341.41 [508.11]	...	140	2800 [19 300]	2800 [19 300]
			1.969 [50.01]	379.53 [564.81]	...	160	2800 [19 300]	2800 [19 300]
24	600	24.000 [610]	0.250 [6.35]	63.47 [94.46]	...	10	380 [2600]	440 [3000]
			0.281 [7.14]	71.25 [106.08]	...	...	420 [2900]	490 [3400]
			0.312 [7.92]	79.01 [117.51]	...	...	470 [3200]	550 [3800]
			0.344 [8.74]	86.99 [129.50]	...	...	520 [3600]	600 [4100]
			0.375 [9.52]	94.71 [140.88]	STD	20	560 [3900]	660 [4500]
			0.406 [10.31]	102.40 [152.37]	...	...	610 [4200]	710 [4900]
			0.438 [11.13]	110.32 [164.26]	...	...	660 [4500]	770 [5300]
			0.469 [11.91]	117.98 [175.54]	...	...	700 [4800]	820 [5700]
			0.500 [12.70]	125.61 [186.94]	XS	...	750 [5200]	880 [6100]
			0.562 [14.27]	140.81 [209.50]	...	30	840 [5800]	980 [6800]
			0.688 [17.48]	171.45 [255.24]	...	40	1030 [7100]	1200 [8300]
			0.938 [23.83]	231.25 [344.23]	...	...	1410 [9700]	1640 [11 300]
			0.969 [24.61]	238.57 [355.02]	...	60	1450 [10 000]	1700 [11 700]
			1.219 [30.96]	296.86 [441.78]	...	80	1830 [12 600]	2130 [14 700]
			1.531 [38.89]	367.74 [547.33]	...	100	2300 [15 900]	2680 [18 500]
			1.812 [46.02]	429.79 [639.58]	...	120	2720 [18 800]	2800 [19 300]
			2.062 [52.37]	483.57 [719.63]	...	140	2800 [19 300]	2800 [19 300]
			2.344 [59.54]	542.64 [807.63]	...	160	2800 [19 300]	2800 [19 300]
26	650	26.000 [660]	0.250 [6.35]	68.82 [102.42]	...	...	350 [2400]	400 [2800]
			0.281 [7.14]	77.26 [115.02]	...	...	390 [2700]	450 [3100]
			0.312 [7.92]	85.68 [127.43]	...	10	430 [3000]	500 [3400]
			0.344 [8.74]	94.35 [140.45]	...	...	480 [3300]	560 [3900]
			0.375 [9.52]	102.72 [152.80]	STD	...	520 [3600]	610 [4200]
			0.406 [10.31]	111.08 [165.28]	...	...	560 [3900]	660 [4500]
			0.438 [11.13]	119.69 [178.20]	...	...	610 [4200]	710 [4900]
			0.469 [11.91]	128.00 [190.46]	...	...	650 [4500]	760 [5200]
			0.500 [12.70]	136.30 [202.85]	XS	20	690 [4800]	810 [5600]
			0.562 [14.27]	152.83 [227.37]	...	...	780 [5400]	910 [6300]

[A] The minimum test pressure for outside diameters and wall thicknesses not listed shall be computed by the formula given below. The computed test pressure shall be in all cases with the following exceptions:

(*1*) When the wall thickness is greater than the heaviest wall thickness shown for a given diameter, the test pressure for the heaviest wall listed shall be the required pressure.

(*2*) For Grades A and B in sizes under NPS 2 [DN 50] when the wall thickness is lighter than the lightest shown for a given diameter, use the test pressure given for lightest wall thickness of the table for the diameter involved.

(*3*) For all sizes of Grade A and B pipe smaller than NPS 2 [DN 50], the test pressure has been arbitrarily assigned. Test pressures for intermediate outside diameters not exceed those for the next larger listed size.

$$P = 2St/D$$

where:

P = minimum hydrostatic test pressure, psi [kPa],
S = 0.60 times the specified minimum yield strength, psi [kPa],
t = nominal wall thickness, in. [mm], and
D = specified ouside diameter, in. [mm].

TABLE X2.3 Dimensions, Weights, and Test Pressures for Threaded and Coupled Pipe

NPS Designator	DN Designator	Outside Diameter, in. [mm]	Nominal Wall Thickness, in. [mm]	Nominal Weight [Mass] per Unit Length, Threaded and Coupled, lb/ft [kg/m]	Weight Class	Schedule No.	Test Pressure, psi [kPa]	
							Grade A	Grade B
⅛	6	0.405 [10.3]	0.068 [1.73]	0.25 [0.37]	STD	40	700 [4800]	700 [4800]
			0.095 [2.41]	0.32 [0.46]	XS	80	850 [5900]	850 [5900]
¼	8	0.540 [13.7]	0.088 [2.24]	0.43 [0.63]	STD	40	700 [4800]	700 [4800]
			0.119 [3.02]	0.54 [0.80]	XS	80	850 [5900]	850 [5900]
⅜	10	0.675 [17.1]	0.091 [2.31]	0.57 [0.84]	STD	40	700 [4800]	700 [4800]
			0.126 [3.20]	0.74 [1.10]	XS	80	850 [5900]	850 [5900]
½	15	0.840 [21.3]	0.109 [2.77]	0.86 [1.27]	STD	40	700 [4800]	700 [4800]
			0.147 [3.73]	1.09 [1.62]	XS	80	850 [5900]	850 [5900]
			0.294 [7.47]	1.72 [2.54]	XXS	...	1000 [6900]	1000 [6900]
¾	20	1.050 [26.7]	0.113 [2.87]	1.14 [1.69]	STD	40	700 [4800]	700 [4800]
			0.154 [3.91]	1.48 [2.21]	XS	80	850 [5900]	850 [5900]
			0.308 [7.82]	2.45 [3.64]	XXS	...	1000 [6900]	1000 [6900]
1	25	1.315 [33.4]	0.133 [3.38]	1.69 [2.50]	STD	40	700 [4800]	700 [4800]
			0.179 [4.55]	2.19 [3.25]	XS	80	850 [5900]	850 [5900]
			0.358 [9.09]	3.66 [5.45]	XXS	...	1000 [6900]	1000 [6900]
1¼	32	1.660 [42.2]	0.140 [3.56]	2.28 [3.40]	STD	40	1000 [6900]	1100 [7600]
			0.191 [4.85]	3.03 [4.49]	XS	80	1500 [10 300]	1600 [11 000]
			0.382 [9.70]	5.23 [7.76]	XXS	...	1800 [12 400]	1900 [13 100]
1½	40	1.900 [48.3]	0.145 [3.68]	2.74 [4.04]	STD	40	1000 [6900]	1100 [7600]
			0.200 [5.08]	3.65 [5.39]	XS	80	1500 [10 300]	1600 [11 000]
			0.400 [10.16]	6.41 [9.56]	XXS	...	1800 [12 400]	1900 [13 100]
2	50	2.375 [60.3]	0.154 [3.91]	3.68 [5.46]	STD	40	2300 [15 900]	2500 [17 200]
			0.218 [5.54]	5.08 [7.55]	XS	80	2500 [17 200]	2500 [17 200]
			0.436 [11.07]	9.06 [13.44]	XXS	...	2500 [17 200]	2500 [17 200]
2½	65	2.875 [73.0]	0.203 [5.16]	5.85 [8.67]	STD	40	2500 [17 200]	2500 [17 200]
			0.276 [7.01]	7.75 [11.52]	XS	80	2500 [17 200]	2500 [17 200]
			0.552 [14.02]	13.72 [20.39]	XXS	...	2500 [17 200]	2500 [17 200]
3	80	3.500 [88.9]	0.216 [5.49]	7.68 [11.35]	STD	40	2200 [15 200]	2500 [17 200]
			0.300 [7.62]	10.35 [15.39]	XS	80	2500 [17 200]	2500 [17 200]
			0.600 [15.24]	18.60 [27.66]	XXS	...	2500 [17 200]	2500 [17 200]
3½	90	4.000 [101.6]	0.226 [5.74]	9.27 [13.71]	STD	40	2000 [13 800]	2400 [16 500]
			0.318 [8.08]	12.67 [18.82]	XS	80	2800 [19 300]	2800 [19 300]
4	100	4.500 [114.3]	0.237 [6.02]	10.92 [16.23]	STD	40	1900 [13 100]	2200 [15 200]
			0.337 [8.56]	15.20 [22.60]	XS	80	2700 [18 600]	2800 [19 300]
			0.674 [17.12]	27.62 [41.09]	XXS	...	2800 [19 300]	2800 [19 300]
5	125	5.563 [141.3]	0.258 [6.55]	14.90 [22.07]	STD	40	1700 [11 700]	1900 [13 100]
			0.375 [9.52]	21.04 [31.42]	XS	80	2400 [16 500]	2800 [19 300]
			0.750 [19.05]	38.63 [57.53]	XXS	...	2800 [19 300]	2800 [19 300]
6	150	6.625 [168.3]	0.280 [7.11]	19.34 [28.58]	STD	40	1500 [10 300]	1800 [12 400]
			0.432 [10.97]	28.88 [43.05]	XS	80	2300 [15 900]	2700 [18 600]
			0.864 [21.95]	53.19 [79.18]	XXS	...	2800 [19 300]	2800 [19 300]
8	200	8.625 [219.1]	0.277 [7.04]	25.53 [38.07]	...	30	1200 [8300]	1300 [9000]
			0.322 [8.18]	29.35 [43.73]	STD	40	1300 [9000]	1600 [11 000]
			0.500 [12.70]	44.00 [65.41]	XS	80	2100 [14 500]	2400 [16 500]
			0.875 [22.22]	72.69 [107.94]	XXS	...	2800 [19 300]	2800 [19 300]
10	250	10.750 [273.0]	0.279 [7.09]	32.33 [48.80]	...	...	950 [6500]	1100 [7600]
			0.307 [7.80]	35.33 [53.27]	...	30	1000 [6900]	1200 [8300]
			0.365 [9.27]	41.49 [63.36]	STD	40	1200 [8300]	1400 [9700]
			0.500 [12.70]	55.55 [83.17]	XS	60	1700 [11 700]	2000 [13 800]
12	300	12.750 [323.8]	0.330 [8.38]	45.47 [67.72]	...	30	950 [6500]	1100 [7600]
			0.375 [9.52]	51.28 [76.21]	STD	...	1100 [7600]	1200 [8300]
			0.500 [12.70]	66.91 [99.4]	XS	...	1400 [9700]	1600 [11 000]

TABLE X2.4 Table of Minimum Wall Thicknesses on Inspection for Nominal Pipe Wall Thicknesses

NOTE 1—The following equation, upon which this table is based, shall be applied to calculate minimum wall thickness from nominal wall thickness:

$$t_n \times 0.875 = t_m$$

where:

t_n = nominal wall thickness, in. [mm], and

t_m = minimum wall thickness, in. [mm].

The wall thickness is expressed to three decimal places the fourth decimal place being carried forward or dropped in accordance with Practice E 29.

NOTE 2—This table is a master table covering wall thicknesses available in the purchase of different classifications of pipe, but it is not meant to imply that all of the walls listed therein are obtainable under this specification.

Nominal Wall Thickness (t_n), in. [mm]	Minimum Wall Thickness on Inspection (t_m), in. [mm]	Nominal Wall Thickness (t_n), in. [mm]	Minimum Wall Thickness on Inspection (t_m), in. [mm]	Nominal Wall Thickness (t_n), in. [mm]	Minimum Wall Thickness on Inspection (t_m), in. [mm]
0.068 [1.73]	0.060 [1.52]	0.294 [7.47]	0.257 [6.53]	0.750 [19.05]	0.656 [16.66]
0.088 [2.24]	0.077 [1.96]	0.300 [7.62]	0.262 [6.65]	0.812 [20.62]	0.710 [18.03]
0.091 [2.31]	0.080 [2.03]	0.307 [7.80]	0.269 [6.83]	0.844 [21.44]	0.739 [18.77]
0.095 [2.41]	0.083 [2.11]	0.308 [7.82]	0.270 [6.86]	0.864 [21.94]	0.756 [19.20]
0.109 [2.77]	0.095 [2.41]	0.312 [7.92]	0.273 [6.93]	0.875 [22.22]	0.766 [19.46]
0.113 [2.87]	0.099 [2.51]	0.318 [8.08]	0.278 [7.06]	0.906 [23.01]	0.793 [20.14]
0.119 [3.02]	0.104 [2.64]	0.322 [8.18]	0.282 [7.16]	0.938 [23.82]	0.821 [20.85]
0.125 [3.18]	0.109 [2.77]	0.330 [8.38]	0.289 [7.34]	0.968 [24.59]	0.847 [21.51]
0.126 [3.20]	0.110 [2.79]	0.337 [8.56]	0.295 [7.49]	1.000 [25.40]	0.875 [22.22]
0.133 [3.38]	0.116 [2.95]	0.343 [8.71]	0.300 [7.62]	1.031 [26.19]	0.902 [22.91]
0.140 [3.56]	0.122 [3.10]	0.344 [8.74]	0.301 [7.65]	1.062 [26.97]	0.929 [26.30]
0.145 [3.68]	0.127 [3.23]	0.358 [9.09]	0.313 [7.95]	1.094 [27.79]	0.957 [24.31]
0.147 [3.73]	0.129 [3.28]	0.365 [9.27]	0.319 [8.10]	1.125 [28.58]	0.984 [24.99]
0.154 [3.91]	0.135 [3.43]	0.375 [9.52]	0.328 [8.33]	1.156 [29.36]	1.012 [25.70]
0.156 [3.96]	0.136 [3.45]	0.382 [9.70]	0.334 [8.48]	1.219 [30.96]	1.067 [27.08]
0.179 [4.55]	0.157 [3.99]	0.400 [10.16]	0.350 [8.89]	1.250 [31.75]	1.094 [27.79]
0.187 [4.75]	0.164 [4.17]	0.406 [10.31]	0.355 [9.02]	1.281 [32.54]	1.121 [28.47]
0.188 [4.78]	0.164 [4.17]	0.432 [10.97]	0.378 [9.60]	1.312 [33.32]	1.148 [29.16]
0.191 [4.85]	0.167 [4.24]	0.436 [11.07]	0.382 [9.70]	1.343 [34.11]	1.175 [29.85]
0.200 [5.08]	0.175 [4.44]	0.437 [11.10]	0.382 [9.70]	1.375 [34.92]	1.203 [30.56]
0.203 [5.16]	0.178 [4.52]	0.438 [11.13]	0.383 [9.73]	1.406 [35.71]	1.230 [31.24]
0.216 [5.49]	0.189 [4.80]	0.500 [12.70]	0.438 [11.13]	1.438 [36.53]	1.258 [31.95]
0.218 [5.54]	0.191 [4.85]	0.531 [13.49]	0.465 [11.81]	1.500 [38.10]	1.312 [33.32]
0.219 [5.56]	0.192 [4.88]	0.552 [14.02]	0.483 [12.27]	1.531 [38.89]	1.340 [34.04]
0.226 [5.74]	0.198 [5.03]	0.562 [14.27]	0.492 [12.50]	1.562 [39.67]	1.367 [34.72]
0.237 [6.02]	0.207 [5.26]	0.594 [15.09]	0.520 [13.21]	1.594 [40.49]	1.395 [35.43]
0.250 [6.35]	0.219 [5.56]	0.600 [15.24]	0.525 [13.34]	1.750 [44.45]	1.531 [38.89]
0.258 [6.55]	0.226 [5.74]	0.625 [15.88]	0.547 [13.89]	1.781 [45.24]	1.558 [39.57]
0.276 [7.01]	0.242 [6.15]	0.656 [16.66]	0.574 [14.58]	1.812 [46.02]	1.586 [40.28]
0.277 [7.04]	0.242 [6.15]	0.674 [17.12]	0.590 [14.99]	1.968 [49.99]	1.722 [43.74]
0.279 [7.09]	0.244 [6.20]	0.688 [17.48]	0.602 [15.29]	2.062 [52.37]	1.804 [45.82]
0.280 [7.11]	0.245 [6.22]	0.719 [18.26]	0.629 [15.98]	2.344 [59.54]	2.051 [52.10]
0.281 [7.14]	0.246 [6.25]				

X3. BASIC THREADING DATA

X3.1 Figure X3.1 is to be used with Table X3.1. Figure X3.2 is to be used with Table X3.2.

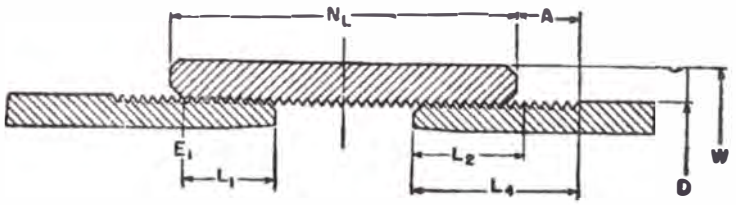

FIG. X3.1 Dimensions of Hand Tight Assembly for Use with Table X3.1

TABLE X3.1 Basic Threading Data for Standard-Weight NPS 6 [DN 50] and Under

NOTE 1—All dimensions in this table are nominal and subject to mill tolerances.
NOTE 2—The taper of threads is ¾ in./ft [62.5 mm/m] on the diameter.

Pipe				Threads				Coupling		
NPS Designator	DN Designator	Outside Diameter, in. [mm]	Number per inch	End of Pipe to Hand Tight Plane, in. [mm]	Effective Length, in. [mm]	Total Length, in. [mm]	Pitch Diameter at Hand Tight Plane, in. [mm]	Outside Diameter, in. [mm]	Length, min., in. [mm]	Hand Tight Stand-Off (Number of Threads)
		D		L_1	L_2	L_4	E_1	*W*	N_L	*A*
⅛	6	0.405 [10.3]	27	0.1615 [4.1021]	0.2638 [6.7005]	0.3924 [9.9670]	0.37360 [9.48944]	0.563 [14.3]	¾ [19]	4
¼	8	0.540 [13.7]	18	0.2278 [5.7861]	0.4018 [10.2057]	0.5946 [15.1028]	0.49163 [12.48740]	0.719 [18.3]	1⅛ [29]	5½
⅜	10	0.675 [17.1]	18	0.240 [6.096]	0.4078 [10.3581]	0.6006 [15.2552]	0.62701 [15.92605]	0.875 [22.2]	1⅛ [29]	5
½	15	0.840 [21.3]	14	0.320 [8.128]	0.5337 [13.5560]	0.7815 [19.8501]	0.77843 [19.77212]	1.063 [27.0]	1½ [38]	5
¾	20	1.050 [26.7]	14	0.339 [8.611]	0.5457 [13.8608]	0.7935 [20.1549]	0.98887 [25.11730]	1.313 [33.4]	1 [40]	5
1	25	1.315 [33.4]	11½	0.400 [10.160]	0.6828 [17.3431]	0.9845 [25.0063]	1.23863 [31.46120]	1.576 [40.0]	1 15/16 [49]	5
1¼	32	1.660 [42.2]	11½	0.420 [10.668]	0.7068 [17.9527]	1.0085 [25.6159]	1.58338 [40.21785]	1.900 [48.3]	2 [50]	5
1½	40	1.900 [48.3]	11½	0.420 [10.668]	0.7235 [18.3769]	1.0252 [26.0401]	1.82234 [46.28744]	2.200 [55.9]	2 [50]	5½
2	50	2.375 [60.3]	11½	0.436 [11.074]	0.7565 [19.2151]	1.0582 [26.8783]	2.29627 [58.32526]	2.750 [69.8]	2 1/16 [52]	5½
2½	65	2.875 [73.0]	8	0.682 [17.323]	1.1376 [28.8950]	1.5712 [39.9085]	2.76216 [70.15886]	3.250 [82.5]	3 1/16 [78]	5½
3	80	3.500 [88.9]	8	0.766 [19.456]	1.2000 [30.4800]	1.6337 [41.4960]	3.38850 [86.06790]	4.000 [101.6]	3 3/16 [81]	5½
3½	90	4.000 [101.6]	8	0.821 [20.853]	1.2500 [31.7500]	1.6837 [42.7660]	3.88881 [98.77577]	4.625 [117.5]	3 5/16 [84]	5½
4	100	4.500 [114.3]	8	0.844 [21.438]	1.3000 [33.0200]	1.7337 [44.0360]	4.38713 [111.43310]	5.000 [127.0]	3 7/16 [87]	5
5	125	5.563 [141.3]	8	0.937 [23.800]	1.4063 [35.7200]	1.8400 [46.7360]	5.44929 [138.41200]	6.296 [159.9]	3 11/16 [94]	5
6	150	6.625 [168.3]	8	0.958 [24.333]	1.5125 [38.4175]	1.9462 [49.4335]	6.50597 [165.25164]	7.390 [187.7]	4 15/16 [125]	6

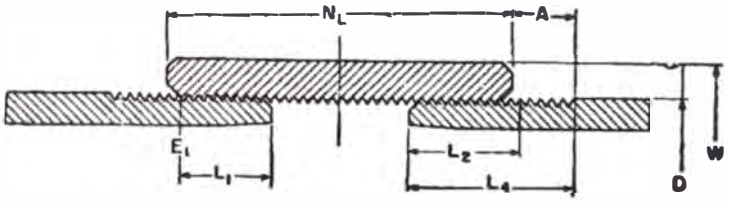

FIG. X3.2 Dimensions of Hand Tight Assembly for Use with Table X3.2

TABLE X3.2 Basic Threading Data for Standard-Weight Pipe in NPS 8 [DN 200] and Larger, and all Sizes of Extra-Strong and Double-Extra-Strong Weight

NOTE 1—The taper of threads is ¾ in./ft [62.5 mm/m] on the diameter.

Pipe				Threads								Coupling				
NPS Designator	DN Designator	Outside Diameter, in.	[mm]	Number per Inch	End of Pipe to Hand Tight Plane, in.	[mm]	Effective Length, in.	[mm]	Total Length, in.	[mm]	Pitch Diameter at Hand Tight Plane, in.	[mm]	Outside Diameter, in.	[mm]	Length, min, in.	[mm]	Hand Tight Stand-Off (Number of Threads)
		D			L_1		L_2		L_4		E_1		*W*		N_L		
⅛	6	0.405	[10.3]	27	0.1615	[4.1021]	0.2638	[6.7005]	0.3924	[9.9670]	0.37360	[9.48944]	0.563	[14.3]	1 1/16	[27]	3
¼	8	0.540	[13.7]	18	0.2278	[5.7861]	0.4018	[10.2057]	0.5946	[15.1028]	0.49163	[12.48740]	0.719	[18.3]	1 5/8	[41]	3
⅜	10	0.675	[17.1]	18	0.240	[6.096]	0.4078	[10.3581]	0.6006	[15.2552]	0.62701	[15.92605]	0.875	[22.2]	1 5/8	[41]	3
½	15	0.840	[21.3]	14	0.320	[8.128]	0.5337	[13.5560]	0.7815	[19.8501]	0.77843	[19.77212]	1.063	[27.0]	2 1/8	[54]	3
¾	20	1.050	[26.7]	14½	0.339	[8.611]	0.5457	[13.8608]	0.7935	[20.1549]	0.98887	[25.11730]	1.313	[33.4]	2 1/8	[54]	3
1	25	1.315	[33.4]	11	0.400	[10.160]	0.6828	[17.3431]	0.9845	[25.0063]	1.23863	[31.46120]	1.576	[40.0]	2 5/8	[67]	3
1¼	32	1.660	[42.2]	11½	0.420	[10.668]	0.7068	[17.9527]	1.0085	[25.6159]	1.58338	[40.21785]	2.054	[52.2]	2¾	[70]	3
1½	40	1.900	[48.3]	11½	0.420	[10.668]	0.7235	[18.3769]	1.0252	[26.0401]	1.82234	[46.28744]	2.200	[55.9]	2¾	[70]	3
2	50	2.375	[60.3]	11½	0.436	[11.074]	0.7565	[19.2151]	1.0582	[26.8783]	2.29627	[58.32526]	2.875	[73.0]	2⅞	[73]	3
2½	65	2.875	[73.0]	8	0.682	[17.323]	1.1375	[28.8950]	1.5712	[39.9085]	2.76216	[70.15886]	3.375	[85.7]	4⅛	[105]	2
3	80	3.500	[88.9]	8	0.766	[19.456]	1.2000	[30.4800]	1.6337	[41.4960]	3.38850	[86.06790]	4.000	[101.6]	4¼	[108]	2
3½	90	4.000	[101.6]	8	0.821	[20.853]	1.2500	[31.7500]	1.6837	[42.7660]	3.88881	[98.77577]	4.625	[117.5]	4⅜	[111]	2
4	100	4.500	[114.3]	8	0.844	[21.438]	1.3000	[33.0200]	1.7337	[44.0360]	4.38713	[111.43310]	5.200	[132.1]	4½	[114]	2
5	125	5.563	[141.3]	8	0.937	[23.800]	1.4063	[35.7200]	1.8400	[46.7360]	5.44929	[138.41200]	6.296	[159.9]	4⅝	[117]	2
6	150	6.625	[168.3]	8	0.958	[24.333]	1.5125	[38.4175]	1.9462	[49.4335]	6.50597	[165.25164]	7.390	[187.7]	4⅞	[124]	2
8	200	8.625	[219.1]	8	1.063	[27.000]	1.7125	[43.4975]	2.1462	[54.5135]	8.50003	[215.90076]	9.625	[244.5]	5¼	[133]	2
10	250	10.750	[273.0]	8	1.210	[30.734]	1.9250	[48.8950]	2.3587	[59.9110]	10.62094	[269.77188]	11.750	[298.4]	5¾	[146]	2
12	300	12.750	[323.8]	8	1.360	[34.544]	2.1250	[53.9750]	2.5587	[64.9910]	12.61781	[320.49237]	14.000	[355.6]	6⅛	[156]	2
14	350	14.000	[355.6]	8	1.562	[39.675]	2.2500	[57.1500]	2.6837	[68.1660]	13.87263	[352.36480]	15.000	[381.0]	6⅜	[162]	2
16	400	16.000	[406.4]	8	1.812	[46.025]	2.4500	[62.2300]	2.8837	[73.2460]	15.87575	[403.24405]	17.000	[432]	6¾	[171]	2
18	450	18.000	[457]	8	2.000	[50.800]	2.6500	[67.3100]	3.0837	[78.3260]	17.87500	[454.02500]	19.000	[483]	7⅛	[181]	2
20	500	20.000	[508]	8	2.125	[53.975]	2.8500	[72.3900]	3.2837	[83.4060]	19.87031	[504.70587]	21.000	[533]	7⅝	[194]	2

X4. ELONGATION VALUES

X4.1 Tabulated in Table X4.1 are the minimum elongation values calculated by the equation given in Table 2.

TABLE X4.1 Elongation Values

Area, *A*, in.²	Tension Test Specimen			Elongation in 2 in., min, %	
	Nominal Wall Thickness, in.			Specified Tensile Strength, psi	
	¾-in. Specimen	1-in. Specimen	1½-in. Specimen	48 000	60 000
0.75 and greater	0.994 and greater	0.746 and greater	0.497 and greater	36	30
0.74	0.980–0.993	0.735–0.745	0.490–0.496	36	29
0.73	0.967–0.979	0.726–0.734	0.484–0.489	36	29
0.72	0.954–0.966	0.715–0.725	0.477–0.483	36	29
0.71	0.941–0.953	0.706–0.714	0.471–0.476	36	29
0.70	0.927–0.940	0.695–0.705	0.464–0.470	36	29
0.69	0.914–0.926	0.686–0.694	0.457–0.463	36	29
0.68	0.900–0.913	0.675–0.685	0.450–0.456	35	29
0.67	0.887–0.899	0.666–0.674	0.444–0.449	35	29
0.66	0.874–0.886	0.655–0.665	0.437–0.443	35	29

TABLE X4.1 *Continued*

Area, A, in.^{2}	Tension Test Specimen			Elongation in 2 in., min, %	
	Nominal Wall Thickness, in.			Specified Tensile Strength, psi	
	¾-in. Specimen	1-in. Specimen	1½-in. Specimen	48 000	60 000
0.65	0.861–0.873	0.646–0.654	0.431–0.436	35	29
0.64	0.847–0.860	0.635–0.645	0.424–0.430	35	29
0.63	0.834–0.846	0.626–0.634	0.417–0.423	35	29
0.62	0.820–0.833	0.615–0.625	0.410–0.416	35	28
0.61	0.807–0.819	0.606–0.614	0.404–0.409	35	28
0.60	0.794–0.806	0.595–0.605	0.397–0.403	35	28
0.59	0.781–0.793	0.586–0.594	0.391–0.396	34	28
0.58	0.767–0.780	0.575–0.585	0.384–0.390	34	28
0.57	0.754–0.766	0.566–0.574	0.377–0.383	34	28
0.56	0.740–0.753	0.555–0.565	0.370–0.376	34	28
0.55	0.727–0.739	0.546–0.554	0.364–0.369	34	28
0.54	0.714–0.726	0.535–0.545	0.357–0.363	34	28
0.53	0.701–0.713	0.526–0.534	0.351–0.356	34	28
0.52	0.687–0.700	0.515–0.525	0.344–0.350	34	27
0.51	0.674–0.686	0.506–0.514	0.337–0.343	33	27
0.50	0.660–0.673	0.495–0.505	0.330–0.336	33	27
0.49	0.647–0.659	0.486–0.494	0.324–0.329	33	27
0.48	0.634–0.646	0.475–0.485	0.317–0.323	33	27
0.47	0.621–0.633	0.466–0.474	0.311–0.316	33	27
0.46	0.607–0.620	0.455–0.465	0.304–0.310	33	27
0.45	0.594–0.606	0.446–0.454	0.297–0.303	33	27
0.44	0.580–0.593	0.435–0.445	0.290–0.296	32	27
0.43	0.567–0.579	0.426–0.434	0.284–0.289	32	26
0.42	0.554–0.566	0.415–0.425	0.277–0.283	32	26
0.41	0.541–0.553	0.406–0.414	0.271–0.276	32	26
0.40	0.527–0.540	0.395–0.405	0.264–0.270	32	26
0.39	0.514–0.526	0.386–0.394	0.257–0.263	32	26
0.38	0.500–0.513	0.375–0.385	0.250–0.256	32	26
0.37	0.487–0.499	0.366–0.374	0.244–0.249	31	26
0.36	0.474–0.486	0.355–0.365	0.237–0.243	31	26
0.35	0.461–0.473	0.346–0.354	0.231–0.236	31	25
0.34	0.447–0.460	0.335–0.345	0.224–0.230	31	25
0.33	0.434–0.446	0.326–0.334	0.217–0.223	31	25
0.32	0.420–0.433	0.315–0.325	0.210–0.216	30	25
0.31	0.407–0.419	0.306–0.314	0.204–0.209	30	25
0.30	0.394–0.406	0.295–0.305	0.197–0.203	30	25
0.29	0.381–0.393	0.286–0.294	0.191–0.196	30	24
0.28	0.367–0.380	0.275–0.285	0.184–0.190	30	24
0.27	0.354–0.366	0.266–0.274	0.177–0.183	29	24
0.26	0.340–0.353	0.255–0.265	0.170–0.176	29	24
0.25	0.327–0.339	0.246–0.254	0.164–0.169	29	24
0.24	0.314–0.326	0.235–0.245	0.157–0.163	29	24
0.23	0.301–0.313	0.226–0.234	0.151–0.156	29	23
0.22	0.287–0.300	0.215–0.225	0.144–0.150	28	23
0.21	0.274–0.286	0.260–0.214	0.137–0.143	28	23
0.20	0.260–0.273	0.195–0.205	0.130–0.136	28	23
0.19	0.247–0.259	0.186–0.194	0.124–0.129	27	22
0.18	0.234–0.246	0.175–0.185	0.117–0.123	27	22
0.17	0.221–0.233	0.166–0.174	0.111–0.116	27	22
0.16	0.207–0.220	0.155–0.165	0.104–0.110	27	22
0.15	0.194–0.206	0.146–0.154	0.097–0.103	26	21
0.14	0.180–0.193	0.135–0.145	0.091–0.096	26	21
0.13	0.167–0.179	0.126–0.134	0.084–0.090	25	21
0.12	0.154–0.166	0.115–0.125	0.077–0.083	25	20
0.11	0.141–0.153	0.106–0.114	0.071–0.076	25	20
0.10	0.127–0.140	0.095–0.105	0.064–0.070	24	20
0.09	0.114–0.126	0.086–0.094	0.057–0.063	24	19
0.08	0.100–0.113	0.075–0.085	0.050–0.056	23	19
0.07	0.087–0.099	0.066–0.074	0.044–0.049	22	18
0.06	0.074–0.086	0.055–0.065	0.037–0.043	22	18
0.05	0.061–0.073	0.046–0.054	0.031–0.036	21	17
0.04	0.047–0.060	0.035–0.045	0.024–0.030	20	16
0.03	0.034–0.046	0.026–0.034	0.017–0.023	19	16
0.02	0.020–0.033	0.015–0.025	0.010–0.016	17	14
0.01 and less	0.019 and less	0.014 and less	0.009 and less	15	12

X4.2 Tabulated in Table X4.2 are the minimum elongation values calculated by the equation given in Table 2.

TABLE X4.2 Elongation Values

Area, *A*, mm²	Tension Test Specimen			Elongation in 50 mm, min, %	
	Nominal Wall Thickness, mm			Specified Tensile Strength, MPa	
	19-mm Specimen	25-mm Specimen	38-mm Specimen	330	415
500 and greater	26.3 and greater	20.0 and greater	13.2 and greater	36	30
480-499	25.3-26.2	19.2-19.9	12.7-13.1	36	30
460-479	24.2-25.2	18.4-19.1	12.1-12.6	36	29
440-459	23.2-24.1	17.6-18.3	11.6-12.0	36	29
420-439	22.1-23.1	16.8-17.5	11.1-11.5	35	29
400-419	21.1-22.0	16.0-16.7	10.6-11.0	35	29
380-399	20.0-21.0	15.2-15.9	10.0-10.5	35	28
360-379	19.0-19.9	14.4-15.0	9.5-9.9	34	28
340-359	17.9-18.9	13.6-14.3	9.0-9.4	34	28
320-339	16.9-17.8	12.8-13.5	8.5-8.9	34	27
300-319	15.8-16.8	12.0-12.7	7.9-8.4	33	27
280-299	14.8-15.7	11.2-11.9	7.4-7.8	33	27
260-279	13.7-14.7	10.4-11.1	6.9-7.3	32	26
240-259	12.7-13.6	9.6-10.3	6.4-6.8	32	26
220-239	11.6-12.6	8.8-9.5	5.8-6.3	31	26
200-219	10.5-11.5	8.0-8.7	5.3-5.7	31	25
190-199	10.0-10.4	7.6-7.9	5.0-5.2	30	25
180-189	9.5-9.9	7.2-7.5	4.8-4.9	30	24
170-179	9.0-9.4	6.8-7.1	4.5-4.7	30	24
160-169	8.4-8.9	6.4-6.7	4.2-4.4	29	24
150-159	7.9-8.3	6.0-6.3	4.0-4.1	29	24
140-149	7.4-7.8	5.6-5.9	3.7-3.9	29	23
130-139	6.9-7.3	5.2-5.5	3.5-3.6	28	23
120-129	6.3-6.8	4.8-5.1	3.2-3.4	28	23
110-119	5.8-6.2	4.4-4.7	2.9-3.1	27	22
100-109	5.3-5.7	4.0-4.3	2.7-2.8	27	22
90-99	4.8-5.2	3.6-3.9	2.4-2.6	26	21
80-89	4.2-4.7	3.2-3.5	2.1-2.3	26	21
70-79	3.7-4.1	2.8-3.1	1.9-2.0	25	21
60-69	3.2-3.6	2.4-2.7	1.6-1.8	24	20
50-59	2.7-3.1	2.0-2.3	...	24	19
40-49	2.1-2.6	1.6-1.9	...	23	19
30-39	1.6-2.0	...	...	22	18

Designation: A 106 – 99ε1

An American National Standard
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; 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.

ε[1] NOTE—Values in 14.5.1were editorially corrected August 1999.

1. Scope

1.1 This specification[2] covers seamless carbon steel pipe for high-temperature service (Note 1) in NPS ⅛ to NPS 48 inclusive, with nominal (average) wall thickness as given in ANSI B 36.10. It shall be permissible to furnish pipe having other dimensions provided such pipe complies with all other requirements of this specification. Pipe ordered under this specification shall be suitable for bending, flanging, and similar forming operations, and for welding. When the steel is to be welded, it is presupposed that a welding procedure suitable to the grade of steel and intended use or service will be utilized (Note 2).

NOTE 1—It is suggested, consideration be given to possible graphitization.

NOTE 2—The purpose for which the pipe is to be used should be stated in the order. Grade A rather than Grade B or Grade C is the preferred grade for close coiling or cold bending. This note is not intended to prohibit the cold bending of Grade B seamless pipe.

1.2 Supplementary requirements (S1 to S7) of an optional nature are provided for seamless pipe intended for use in applications where a superior grade of pipe is required. These supplementary requirements call for additional tests to be made and when desired shall be so stated in the order.

1.3 When these products are to be used in applications conforming to ISO Recommendations for Boiler Construction, the requirements of Specification A 520 (Mechanical Property Requirements Section) shall supplement and supersede the requirements of this specification.

1.4 The values stated in inch-pound units are to be regarded as the standard.

NOTE 3—The dimensionless designator NPS (nominal pipe size) has been substituted in this standard for such traditional terms as "nominal diameter," "size," and "nominal size."

1.5 The following precautionary caveat pertains only to the test method portion, Sections 11, 12, 13, 14, and 15, of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

A 520 Specification for Supplementary Requirements for Seamless and Electric-Resistance-Welded Carbon Steel Tubular Products for High-Temperature Service Conforming to ISO Recommendations for Boiler Construction[3]

A 530/A 530M Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe[3]

E 213 Practice for Ultrasonic Examination of Metal Pipe and Tubing[4]

E 309 Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation[4]

E 381 Method of Macroetch Testing, Inspection, and Rating Steel Products, Comprising Bars, Billets, Blooms, and Forgings[5]

E 570 Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products[4]

2.2 *ANSI Standard:*

ANSI B 36.10 Welded and Seamless Wrought Steel Pipe[6]

2.3 *Military Standards:*

MIL-STD-129 Marking for Shipment and Storage[7]

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage[7]

2.4 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)[7]

Fed. Std. No. 183 Continuous Identification Marking of Iron and Steel Products[7]

2.5 *Other Standards:*

[1] This specification is under the jurisdiction of Committee A01 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.09 on Carbon Steel Tubular Products.

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[2] For ASME Boiler and Pressure Vessel Code applications see related Specifications SA-106 in Section II of that Code.

[3] *Annual Book of ASTM Standards*, Vol 01.01.

[4] *Annual Book of ASTM Standards*, Vol 03.03.

[5] *Annual Book of ASTM Standards*, Vol 03.01.

[6] Available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.

[7] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

SSPC-SP 6 Surface Preparation Specification No. 6[8]

3. Ordering Information

3.1 The inclusion of the following, as required will describe the desired material adequately, when ordered under this specification:

3.1.1 Quantity (feet or number of lengths),

3.1.2 Name of material (seamless carbon steel pipe),

3.1.3 Grade (Table 1),

3.1.4 Manufacture (hot-finished or cold-drawn),

3.1.5 Size (NPS and weight class or schedule number, or both; outside diameter and nominal wall thickness; or inside diameter and nominal wall thickness),

3.1.6 Special outside diameter tolerance pipe (16.2.2),

3.1.7 Inside diameter tolerance pipe, over 10 in. (254 mm) ID (16.2.3),

3.1.8 Length (specific or random, Section 20),

3.1.9 Optional requirements (Section 9 and S1 to S7),

3.1.10 Test report required (Section on Certification of Specification A 530/A 530M),

3.1.11 Specification designation,

3.1.12 End use of material,

3.1.13 Hydrostatic test in accordance with Specification A 530/A 530M or 13.3 of this specification, or NDE in accordance with Section 14 of this specification.

3.1.14 Special requirements.

4. Process

4.1 The steel shall be killed steel, with the primary melting process being open-hearth, basic-oxygen, or electric-furnace, possibly combined with separate degassing or refining. If secondary melting, using electroslag remelting or vacuum-arc remelting is subsequently employed, the heat shall be defined as all of the ingots remelted from a single primary heat.

4.2 Steel cast in ingots or strand cast is permissible. When steels of different grades are sequentially strand cast, identification of the resultant transition material is required. The producer shall remove the transition material by any established procedure that positively separates the grades.

4.3 For pipe NPS 1½ and under, it shall be permissible to furnish hot finished or cold drawn.

4.4 Unless otherwise specified, pipe NPS 2 and over shall be furnished hot finished. When agreed upon between the manufacturer and the purchaser, it is permissible to furnish cold-drawn pipe.

5. Heat Treatment

5.1 Hot-finished pipe need not be heat treated. Cold-drawn pipe shall be heat treated after the final cold draw pass at a temperature of 1200°F (650°C) or higher.

6. General Requirements

6.1 Material furnished to this specification shall conform to the applicable requirements of the current edition of Specification A 530/A 530M unless otherwise provided herein.

7. Chemical Composition

7.1 The steel shall conform to the requirements as to chemical composition prescribed in Table 1.

8. Heat Analysis

8.1 An analysis of each heat of steel shall be made by the steel manufacturer to determine the percentages of the elements specified in Section 7. If the secondary melting processes of 5.1 are employed, the heat analysis shall be obtained from one remelted ingot or the product of one remelted ingot of each primary melt. The chemical composition thus determined, or that determined from a product analysis made by the manufacturer, if the latter has not manufactured the steel, shall be reported to the purchaser or the purchaser's representative, and shall conform to the requirements specified in Section 7.

9. Product Analysis

9.1 At the request of the purchaser, analyses of two pipes from each lot (Note 4) of 400 lengths or fraction thereof, of each size up to, but not including, NPS 6, and from each lot of 200 lengths or fraction thereof of each size NPS 6 and over, shall be made by the manufacturer from the finished pipe. The results of these analyses shall be reported to the purchaser or the purchaser's representative and shall conform to the requirements specified in Section 7.

9.2 If the analysis of one of the tests specified in 9.1 does not conform to the requirements specified in Section 7, analyses shall be made on additional pipes of double the original number from the same lot, each of which shall conform to requirements specified.

NOTE 4—A lot shall consist of the number of lengths specified in Sections 9 and 21 of the same size and wall thickness from any one heat of steel.

10. Tensile Requirements

10.1 The material shall conform to the requirements as to tensile properties prescribed in Table 2. Computed elongation values are contained in Table 3 and Table 4.

[8] Available from Steel Structures Painting Council, 4400 5th Ave., Pittsburgh, PA 15213-2683.

TABLE 1 Chemical Requirements

	Composition, %		
	Grade A	Grade B	Grade C
Carbon, max[A]	0.25	0.30	0.35
Manganese	0.27–0.93	0.29–1.06	0.29–1.06
Phosphorus, max	0.035	0.035	0.035
Sulfur, max	0.035	0.035	0.035
Silicon, min	0.10	0.10	0.10
Chrome, max[B]	0.40	0.40	0.40
Copper, max[B]	0.40	0.40	0.40
Molybdenum, max[B]	0.15	0.15	0.15
Nickel, max[B]	0.40	0.40	0.40
Vanadium, max[B]	0.08	0.08	0.08

[A] For each reduction of 0.01 % below the specified carbon maximum, an increase of 0.06 % manganese above the specified maximum will be permitted up to a maximum of 1.35 %.

[B] These five elements combined shall not exceed 1 %.

TABLE 2 Tensile Requirements

	Grade A (Explanatory Note 2)		Grade B		Grade C	
Tensile strength, min, psi (MPa)	48 000 (330)		60 000 (415)		70 000 (485)	
Yield strength, min, psi (MPa)	30 000 (205)		35 000 (240)		40 000 (275)	
	Longitudinal	Transverse	Longitudinal	Transverse	Longitudinal	Transverse
Elongation in 2 in. or 50 mm, min, %:						
Basic minimum elongation transverse strip tests, and for all small sizes tested in full section	35	25	30	16.5	30	16.5
When standard round 2-in. or 50-mm gage length test specimen is used	28	20	22	12	20	12
For longitudinal strip tests	[A,B]		[A,B]		[A,B]	
For transverse strip tests, a deduction for each 1/32-in. (0.8-mm) decrease in wall thickness below 5/16 in. (7.9 mm) from the basic minimum elongation of the following percentage shall be made		1.25[C]		1.00[C]		1.00[C]

[A] The minimum elogation in 2 in. (50.8 mm) shall be determined by the following equation:

$$e = 625\,000A^{0.2} / U^{0.9}$$

where:

e = minimum elongation in 2 in. (50.8 mm), %, rounded to the nearest 0.5%

A = cross-sectional area of the tension test specimen, in.^{2}, based on specified outside diameter or nominal specimen width and specified wall thickness rounded to the nearest 0.01 in.^{2} (if the area thus caluclated is greater than the value 0.75 in.^{2} shall be used), and

U = specified tensile strength, psi.

[B] See Table number 4 for minimum elongation values for various size tension specimens and grades.

[C] Table number 3 gives the computed minimum values:

TABLE 3 Computed Transverse Elongation[A]

Wall Thickness		Elongation in 2 in. or 50 mm, min, %	
in.	mm	Grade A, Transverse	Grades B and C, Transverse
5/16 (0.312)	7.9	25.00	16.50
9/32 (0.281)	7.1	23.75	15.50
1/4 (0.250)	6.4	22.50	14.50

[A] This table gives the computed minimum elongation values for each 1/32-in. (0.8-mm) decrease in wall thickness. Where the wall thickness lies between two values shown above, the minimum elongation value is determined by the following equation:

Grade	Direction of Test	Equation
A	Transverse	$E = 40t + 12.50$
B and C	Transverse	$E = 32t + 6.50$

where:

E = elongation in 2 in. or 50 mm, %, and

t = actual thickness of specimen, in.

TABLE 4 Elongation Values

					Elongation in 2 in. min., Specified Tensile Strength, psi		
	Tension Test Specimen Wall Thickness, in.[B]				*Grade A*	*Grade B*	*Grade C*
Area, in.^{2}[A]	1/2 in. Specimen	3/4 in. Specimen	1 in. Specimen	1 1/2 in. Specimen	48 000	60 000	70 000
≥ 0.75	≥ 1.491	≥ 0.994	≥ 0.746	≥ 0.497	36.0	29.5	25.5
0.74	1.470–1.490	0.980–0.993	0.735–0.745	0.490–0.496	36.0	29.5	25.5
0.73	1.451–1.469	0.967–0.979	0.726–0.734	0.484–0.489	36.0	29.5	25.5
0.72	1.430–1.450	0.954–0.966	0.715–0.725	0.477–0.483	36.0	29.5	25.5
0.71	1.411–1.429	0.941–0.953	0.706–0.714	0.471–0.476	35.5	29.0	25.5
0.70	1.390–1.410	0.927–0.940	0.695–0.705	0.464–0.470	35.5	29.0	25.5
0.69	1.371–1.389	0.914–0.926	0.686–0.694	0.457–0.463	35.5	29.0	25.5
0.68	1.350–1.370	0.900–0.913	0.675–0.685	0.450–0.456	35.5	29.0	25.0
0.67	1.331–1.349	0.887–0.899	0.666–0.674	0.444–0.449	35.5	29.0	25.0
0.66	1.310–1.330	0.874–0.886	0.655–0.665	0.437–0.443	35.0	29.0	25.0
0.65	1.291–1.309	0.861–0.873	0.646–0.654	0.431–0.436	35.0	28.5	25.0
0.64	1.270–1.290	0.847–0.860	0.635–0.645	0.424–0.430	35.0	28.5	25.0
0.63	1.251–1.269	0.834–0.846	0.626–0.634	0.417–0.423	35.0	28.5	25.0
0.62	1.230–1.250	0.820–0.833	0.615–0.625	0.410–0.416	35.0	28.5	25.0
0.61	1.211–1.229	0.807–0.819	0.606–0.614	0.404–0.409	34.5	28.5	24.5

TABLE 4 *Continued*

Area, in.²[A]	Tension Test Specimen Wall Thickness, in.[B]				Elongation in 2 in. min., Specified Tensile Strength, psi		
					Grade A	*Grade B*	*Grade C*
	½ in. Specimen	¾ in. Specimen	1 in. Specimen	1 ½ in. Specimen	48 000	60 000	70 000
0.60	1.190–1.210	0.794–0.806	0.595–0.605	0.397–0.403	34.5	28.5	24.5
0.59	1.171–1.189	0.781–0.793	0.586–0.594	0.391–0.396	34.5	28.0	24.5
0.58	1.150–1.170	0.767–0.780	0.575–0.585	0.384–0.390	34.5	28.0	24.5
0.57	1.131–1.149	0.754–0.766	0.566–0.574	0.377–0.383	34.0	28.0	24.5
0.56	1.110–1.130	0.740–0.753	0.555–0.565	0.370–0.376	34.0	28.0	24.5
0.55	1.091–1.109	0.727–0.739	0.546–0.554	0.364–0.369	34.0	28.0	24.9
0.54	1.070–1.090	0.714–0.726	0.535–0.545	0.357–0.363	34.0	27.5	24.0
0.53	1.051–1.069	0.701–0.713	0.526–0.534	0.351–0.356	33.5	27.5	24.0
0.52	1.030–1.050	0.687–0.700	0.515–0.525	0.344–0.350	33.5	27.5	24.0
0.51	1.011–1.029	0.674–0.686	0.506–0.514	0.337–0.343	33.5	27.5	24.0
0.50	0.990–1.010	0.660–0.673	0.495–0.505	0.330–0.336	33.5	27.0	23.5
0.49	0.971–0.989	0.647–0.659	0.486–0.494	0.324–0.329	33.0	27.0	23.5
0.48	0.950–0.970	0.634–0.646	0.475–0.485	0.317–0.323	33.0	27.0	23.5
0.47	0.931–0.949	0.621–0.633	0.466–0.474	0.311–0.316	33.0	27.0	23.5
0.46	0.910–0.930	0.607–0.620	0.455–0.465	0.304–0.310	33.0	27.0	23.5
0.45	0.891–0.909	0.594–0.606	0.446–0.454	0.297–0.303	32.5	26.5	23.0
0.44	0.870–0.890	0.580–0.593	0.435–0.445	0.290–0.296	32.5	26.5	23.0
0.43	0.851–0.869	0.567–0.579	0.426–0.434	0.284–0.289	32.5	26.5	23.0
0.42	0.830–0.850	0.554–0.566	0.415–0.425	0.277–0.283	32.0	26.5	23.0
0.41	0.811–0.829	0.541–0.553	0.406–0.414	0.271–0.276	32.0	26.0	23.0
0.40	0.790–0.810	0.527–0.540	0.395–0.405	0.264–0.270	32.0	26.0	22.5
0.39	0.771–0.789	0.514–0.526	0.386–0.394	0.257–0.263	31.5	26.0	22.5
0.38	0.750–0.770	0.500–0.513	0.375–0.385	0.250–0.256	31.5	26.0	22.5
0.37	0.731–0.749	0.487–0.499	0.366–0.374	0.244–0.249	31.5	25.5	22.5
0.36	0.710–0.730	0.474–0.486	0.355–0.365	0.237–0.243	31.0	25.5	22.0
0.35	0.691–0.709	0.461–0.473	0.346–0.354	0.231–0.236	31.0	25.5	22.0
0.34	0.670–0.690	0.447–0.460	0.335–0.345	0.224–0.230	31.0	25.0	22.0
0.33	0.651–0.669	0.434–0.446	0.326–0.334	0.217–0.223	30.5	25.0	22.0
0.32	0.630–0.650	0.420–0.433	0.315–0.325	0.210–0.216	30.5	25.0	21.5
0.31	0.611–0.629	0.407–0.419	0.306–0.314	0.204–0.209	30.5	25.0	21.5
0.30	0.590–0.610	0.394–0.406	0.295–0.305	0.197–0.203	30.0	24.5	21.5
0.29	0.571–0.589	0.381–0.393	0.286–0.294	0.191–0.196	30.0	24.5	21.5
0.28	0.550–0.570	0.367–0.380	0.275–0.285	0.184–0.190	29.5	24.5	21.0
0.27	0.531–0.549	0.354–0.366	0.266–0.274	0.177–0.183	29.5	24.0	21.0
0.26	0.510–0.530	0.340–0.353	0.255–0.265	0.170–0.176	29.0	24.0	21.0
0.25	0.491–0.509	0.327–0.339	0.246–0.254	0.164–0.169	29.0	23.5	20.5
0.24	0.470–0.490	0.314–0.326	0.235–0.245	0.157–0.163	29.0	23.5	20.5
0.23	0.451–0.469	0.301–0.313	0.226–0.234	0.151–0.156	28.5	23.5	20.5
0.22	0.430–0.450	0.287–0.300	0.215–0.225	0.144–0.150	28.5	23.0	20.0
0.21	0.411–0.429	0.274–0.286	0.206–0.214	0.137–0.143	28.0	23.0	20.0
0.20	0.390–0.410	0.260–0.273	0.195–0.205	0.130–0.136	27.5	22.5	19.5
0.19	0.371–0.389	0.247–0.259	0.186–0.194	0.124–0.129	27.5	22.5	19.5
0.18	0.350–0.370	0.234–0.246	0.175–0.185	0.117–0.123	27.0	22.0	19.5
0.17	0.331–0.349	0.221–0.233	0.166–0.174	0.111–0.116	27.0	22.0	19.0
0.16	0.310–0.330	0.207–0.220	0.155–0.165	0.104–0.110	26.5	21.5	19.0
0.15	0.291–0.309	0.194–0.206	0.146–0.154	0.097–0.103	26.0	21.5	18.5
0.14	0.270–0.290	0.180–0.193	0.135–0.145	0.091–0.096	26.0	21.0	18.5
0.13	0.251–0.269	0.167–0.179	0.126–0.134	0.084–0.090	25.5	21.0	18.0
0.12	0.230–0.250	0.154–0.166	0.115–0.125	0.077–0.083	25.0	20.5	18.0
0.11	0.211–0.229	0.141–0.153	0.106–0.114	0.071–0.076	24.5	20.0	17.5
0.10	0.190–0.210	0.127–0.140	0.095–0.105	0.064–0.070	24.0	19.5	17.0
0.09	0.171–0.189	0.114–0.126	0.086–0.094	0.057–0.063	23.5	19.5	17.0
0.08	0.150–0.170	0.100–0.113	0.075–0.085	0.050–0.056	23.0	19.0	16.5
0.07	0.131–0.149	0.087–0.099	0.066–0.074	0.044–0.049	22.5	18.5	16.0
0.06	0.110–0.130	0.074–0.086	0.055–0.065	0.037–0.043	22.0	18.0	15.5
0.05	0.091–0.109	0.061–0.073	0.046–0.054	0.031–0.036	21.0	17.0	15.0
0.04	0.070–0.090	0.047–0.060	0.035–0.045	0.024–0.030	20.0	16.5	14.5
0.03	0.051–0.069	0.034–0.046	0.026–0.034	0.017–0.023	19.0	15.5	13.5
0.02	0.030–0.050	0.020–0.033	0.015–0.025	0.010–0.016	17.5	14.5	12.5
≤0.01	≤ 0.029	≤ 0.019	≤ 0.014	≤ 0.009	15.0	12.5	11.0

[A] 1 in.² = 645.16 mm².

[B] 1 in. = 25.4 mm.

11. Bending Requirements

11.1 For pipe NPS 2 and under a sufficient length of pipe shall stand being bent cold through 90° around a cylindrical mandrel, the diameter of which is twelve times the outside diameter (as shown in ANSI B 36.10) of the pipe, without developing cracks. When ordered for close coiling (Note 2), the pipe shall stand being bent cold through 180° around a cylindrical mandrel, the diameter of which is eight times the

outside diameter (as shown in ANSI B 36.10) of the pipe, without failure.

11.2 Subject to the approval of the purchaser, for pipe whose diameter exceeds 10 in. (254 mm), it shall be permissible for the bend test to be substituted for the flattening test described in Section 12. The bend test specimens shall be bent at room temperature through 180° with the inside diameter of the bend being 1 in. (25.4 mm), without cracking on the outside portion of the bent portion.

11.3 For pipe whose diameter exceeds 25 in. (635 mm) and whose diameter to wall thickness ratio is 7.0 or less, the bend test described in 11.2 shall be conducted instead of the flattening test.

NOTE 5—Diameter to wall thickness ratio = specified outside diameter/nominal wall thickness.

Example: For 28 in. diameter 5.000 in. thick pipe the diameter to wall thickness ratio = 28/5 = 5.6.

12. Flattening Tests

12.1 Except as allowed by 11.2, for pipe over NPS 2, a section of pipe not less than 2½ in. (63.5 mm) in length shall be flattened cold between parallel plates until the opposite walls of the pipe meet. Flattening tests shall be in accordance with Specification A 530/A 530M, except that in the formula used to calculate the "*H*" value, the following "*e*" constants shall be used:

0.08 for Grade A
0.07 for Grades B and C

12.2 When low *D*-to-*t* ratio tubulars are tested, because the strain imposed due to geometry is unreasonably high on the inside surface at the six and twelve o'clock locations, cracks at these locations shall not be cause for rejection if the *D*-to-*t* ratio is less than ten.

NOTE 6—The *H* values have been calculated for sizes from NPS 2½ to 24, inclusive, and are shown in Table X1.1 of this specification.

13. Hydrostatic Test

13.1 Each length of pipe shall withstand without leakage through the pipe wall, a hydrostatic test, except as provided for in 13.2, 13.3, and 13.4.

13.2 When specified by the purchaser, it shall be permissible for pipe to be tested by the nondestructive electric test described in Section 14 in lieu of the hydrostatic test.

13.3 When specified in the order, pipe shall be furnished without hydrostatic test and without the NDE in Section 14. In this case, each length so furnished shall include the mandatory marking of the letters "NH."

13.4 When the hydrostatic test and the NDE test are omitted and the lengths marked with the letters "NH," the certification, when required, shall clearly state "Not Hydro Statically Tested," the specification number and material grade, as shown on the certification, shall be followed by the letters "NH."

14. Nondestructive Electric Test

14.1 When allowed by 13.2, each pipe shall be tested with a nondestructive electric test in accordance with Practice E 213, Practice E 309, or Practice E 570. In such cases, the marking of each length of pipe so furnished shall include the letters "NDE." It is the intent of this test to reject pipe with imperfections that produce test signals equal or greater than that of the calibration standard.

14.2 When the nondestructive electric test is performed, the lengths shall be marked with the letters "NDE." The certification, when required, shall state "Nondestructive Electric Tested" and shall indicate which of the tests was applied. Also the letters "NDE" shall be appended to the product specification number and material grade shown on the certification.

14.3 The following information is for the benefit of the user of this specification:

14.3.1 The reference standards defined in 14.4 through 14.6 are convenient standards for calibration of nondestructive testing equipment. The dimensions of such standards are not to be construed as the minimum sizes of imperfections detectable by such equipment.

14.3.2 The ultrasonic testing referred to in this specification is capable of detecting the presence and location of significant longitudinally or circumferentially oriented imperfections: however, different techniques need to be employed for the detection of such differently oriented imperfections. Ultrasonic testing is not necessarily capable of detecting short, deep imperfections.

14.3.3 The eddy current examination referenced in this specification has the capability of detecting significant imperfections, especially of the short abrupt type.

14.3.4 The flux leakage examination referred to in this specification is capable of detecting the presence and location of significant longitudinally or transversely oriented imperfections: however, different techniques need to be employed for the detection of such differently oriented imperfections.

14.3.5 The hydrostatic test referred to in Section 13 has the capability of finding defects of a size permitting the test fluid to leak through the tube wall and may be either visually seen or detected by a loss of pressure. Hydrostatic testing is not necessarily capable of detecting very tight, through-the-wall imperfections or imperfections that extend an appreciable distance into the wall without complete penetration.

14.3.6 A purchaser interested in ascertaining the nature (type, size, location, and orientation) of discontinuities that can be detected in the specific applications of these examinations is directed to discuss this with the manufacturer of the tubular product.

14.4 For ultrasonic testing, the calibration reference notches shall be, at the option of the producer, any one of the three common notch shapes shown in Practice E 213. The depth of notch shall not exceed 12½ % of the specified wall thickness of the pipe or 0.004 in. (0.102 mm), whichever is greater.

14.5 For eddy current testing, the calibration pipe shall contain, at the option of the producer, any one of the following discontinuities to establish a minimum sensitivity level for rejection:

14.5.1 *Drilled Hole*—The calibration pipe shall contain depending upon the pipe diameter three holes spaced 120° apart or four holes spaced 90° apart and sufficiently separated longitudinally to ensure separately distinguishable responses. The holes shall be drilled radially and completely through the pipe wall, care being taken to avoid distortion of the pipe while drilling. Depending upon the pipe diameter the calibration pipe

shall contain the following hole:

≤½ in.	0.039 in. (1 mm)
>½ ≤ 1¼ in.	0.055 in. (1.4 mm)
>1¼ ≤ 2 in.	0.071 in. (1.8 mm)
>2 ≤ 5 in.	0.087 in. (2.2 mm)
>5 in.	0.106 in. (2.7 mm)

14.5.2 *Transverse Tangential Notch*—Using a round tool or file with a ¼in. (6.4-mm) diameter, a notch shall be filed or milled tangential to the surface and transverse to the longitudinal axis of the pipe. Said notch shall have a depth not exceeding 12½ % of the specified wall thickness of the pipe or 0.004 in. (0.102 mm), whichever is greater.

14.5.3 *Longitudinal Notch*—A notch 0.031 in. (0.787 mm) or less in width shall be machined in a radial plane parallel to the tube axis on the outside surface of the pipe, to have a depth not exceeding 12½ % of the specified wall thickness of the tube or 0.004 in. (0.102 mm), whichever is greater. The length of the notch shall be compatible with the testing method.

14.5.4 *Compatibility*—The discontinuity in the calibration pipe shall be compatible with the testing equipment and the method being used.

14.6 For flux leakage testing, the longitudinal calibration reference notches shall be straight-sided notches machined in a radial plane parallel to the pipe axis. For wall thickness under ½ in. (12.7 mm), outside and inside notches shall be used; for wall thickness equal and above ½ in. (12.7 mm), only an outside notch shall be used. Notch depth shall not exceed 12½ % of the specified wall thickness, or 0.004 in. (0.102 mm), whichever is greater. Notch length shall not exceed 1 in. (25.4 mm), and the width shall not exceed the depth. Outside diameter and inside diameter notches shall be located sufficiently apart to allow separation and identification of the signals.

14.7 Pipe containing one or more imperfections that produce a signal equal to or greater than the signal produced by the calibration standard shall be rejected or the area producing the signal shall be reexamined.

14.7.1 Test signals produced by imperfections which cannot be identified, or produced by cracks or crack-like imperfections shall result in rejection of the pipe, unless it is repaired and retested. To be accepted, the pipe must pass the same specification test to which it was originally subjected, provided that the remaining wall thickness is not decreased below that permitted by this specification. The OD at the point of grinding may be reduced by the amount so reduced.

14.7.2 Test signals produced by visual imperfections such as those listed below may be evaluated in accordance with the provisions of Section 18:

14.7.2.1 Dinges,

14.7.2.2 Straightener marks,

14.7.2.3 Cutting chips,

14.7.2.4 Scratches,

14.7.2.5 Steel die stamps,

14.7.2.6 Stop marks, or

14.7.2.7 Pipe reducer ripple.

14.8 The test methods described in this section are not necessarily capable of inspecting the end portion of pipes, a condition referred to as "end effect." The length of such end effect shall be determined by the manufacturer and, when specified in the purchase order, reported to the purchaser.

15. Nipples

15.1 Nipples shall be cut from pipe of the same dimensions and quality described in this specification.

16. Dimensions, Weight, and Permissible Variations

16.1 *Weight*—The weight of any length of pipe shall not vary more than 10 % over and 3.5 % under that specified. Unless otherwise agreed upon between the manufacturer and the purchaser, pipe in NPS 4 and smaller may be weighed in convenient lots; pipe larger than NPS 4 shall be weighed separately.

16.2 *Diameter*—The tolerances for diameter shall be in accordance with the following:

16.2.1 Except for pipe ordered as special outside diameter tolerance pipe or as inside diameter tolerance pipe, variations in outside diameter shall not exceed those precribed in Table 5.

16.2.2 For pipe over 10 in. (254 mm) OD ordered as special outside diameter tolerance pipe, the outside diameter shall not vary more than 1 % over or 1 % under the specified outside diameter.

16.2.3 For pipe over 10 in. (254 mm) ID ordered as inside diameter tolerance pipe, the inside diameter shall not vary more than 1 % over or 1 % under the specified inside diameter.

16.3 *Thickness*—The minimum wall thickness at any point shall not be more than 12.5 % under the nominal wall thickness specified.

NOTE 7—The minimum wall thicknesses on inspection of some of the available sizes are shown in Table X2.1.

17. Lengths

17.1 Pipe lengths shall be in accordance with the following regular practice:

17.1.1 The lengths required shall be specified in the order, and

17.1.2 No jointers are permitted unless otherwise specified.

17.1.3 If definite lengths are not required, pipe may be ordered in single random lengths of 16 to 22 ft (4.8 to 6.7 m) with 5 % 12 to 16 ft (3.7 to 4.8 m), or in double random lengths with a minimum average of 35 ft (10.7 m) and a minimum length of 22 ft with 5 % 16 to 22 ft.

18. Workmanship, Finish and Appearance

18.1 The pipe manufacturer shall explore a sufficient number of visual surface imperfections to provide reasonable

TABLE 5 Variations in Outside Diameter

NPS Designator	Permissible Variations in Outside Diameter			
	Over		Under	
	in.	mm	in.	mm
⅛ to 1½, incl	1/64 (0.015)	0.40	1/64 (0.015)	0.40
Over 1½ to 4, incl	1/32 (0.031)	0.79	1/32 (0.031)	0.79
Over 4 to 8, incl	1/16 (0.062)	1.59	1/32 (0.031)	0.79
Over 8 to 18, incl	3/32 (0.093)	2.38	1/32 (0.031)	0.79
Over 18 to 26, incl	1/8 (0.125)	3.18	1/32 (0.031)	0.79
Over 26 to 34, incl	5/32 (0.156)	3.97	1/32 (0.031)	0.79
Over 34 to 48, incl	3/16 (0.187)	4.76	1/32 (0.031)	0.79

assurance that they have been properly evaluated with respect to depth. Exploration of all surface imperfections is not required but consideration should be given to the necessity of exploring all surface imperfections to assure compliance with 18.2.

18.2 Surface imperfections that penetrate more than 12½ % of the nominal wall thickness or encroach on the minimum wall thickness shall be considered defects. Pipe with such defects shall be given one of the following dispositions:

18.2.1 The defect shall be removed by grinding, provided that the remaining wall thickness is within the limits specified in 16.3.

18.2.2 Repaired in accordance with the repair welding provisions of 18.6.

18.2.3 The section of pipe containing the defect may be cut off within the limits of requirements on length.

18.2.4 Rejected.

18.3 To provide a workmanlike finish and basis for evaluating conformance with 18.2 the pipe manufacturer shall remove by grinding the following noninjurious imperfections:

18.3.1 Mechanical marks, abrasions (Note 8) and pits, any of which imperfections are deeper than 1/16 in. (1.58 mm).

18.3.2 Visual imperfections commonly referred to as scabs, seams, laps, tears, or slivers found by exploration in accordance with 18.1 to be deeper than 5 % of the nominal wall thickness.

18.4 At the purchaser's discretion, pipe shall be subjected to rejection if surface imperfections acceptable under 18.2 are not scattered, but appear over a large area in excess of what is considered a workmanlike finish. Disposition of such pipe shall be a matter of agreement between the manufacturer and the purchaser.

18.5 When imperfections or defects are removed by grinding, a smooth curved surface shall be maintained, and the wall thickness shall not be decreased below that permitted by this specification. The outside diameter at the point of grinding is permitted to be reduced by the amount so removed.

18.5.1 Wall thickness measurements shall be made with a mechanical caliper or with a properly calibrated nondestructive testing device of appropriate accuracy. In case of dispute, the measurement determined by use of the mechanical caliper shall govern.

18.6 Weld repair shall be permitted only subject to the approval of the purchaser and in accordance with Specification A 530/A 530M.

18.7 The finished pipe shall be reasonably straight.

NOTE 8—Marks and abrasions are defined as cable marks, dinges, guide marks, roll marks, ball scratches, scores, die marks, etc.

19. End Finish

19.1 The Pipe shall be furnished to the following practice, unless otherwise specified.

19.1.1 *NPS 1-1/2 and Smaller*—All walls shall be either plain-end square cut, or plain-end beveled at the option of the manufacturer.

19.1.2 *NPS 2 and Larger*—Walls through extra strong weights, shall be plain end-beveled.

19.1.3 *NPS 2 and Larger*—Walls over extra strong weights, shall be plain-end square cut.

NOTE 9—Plain-end beveled is defined as plain-end pipe having a bevel angle of 30°, +5° or -0°, as measured from a line drawn perpendicular to the axis of the pipe with a root face of 1/16 ± 1/32in. (1.5875 ± 0.7938 mm). Other bevel angles may be specified by agreement between the purchaser and the manufacturer.

20. Number of Tests

20.1 The tensile requirements specified in Section 7 shall be determined on one length of pipe from each lot (Note 4) of 400 lengths or fraction thereof of each size under NPS 6, and from each lot of 200 lengths or fraction thereof of each size NPS 6 and over.

20.2 For pipe NPS 2 and under, the bend test specified in 11.1 shall be made on one pipe from each lot of 400 lengths or fraction thereof of each size. The bend test, where used as permitted by 11.2 or required by 11.3, shall be made on one end of 5 % of the pipe from each lot. For small lots, at least one pipe shall be tested.

20.3 The flattening test specified in Section 12 shall be made on one length of pipe from each lot of 400 lengths or fraction thereof of each size over NPS 2, up to but not including NPS 6, and from each lot of 200 lengths or fraction thereof, of each size NPS 6 and over.

20.4 Each length of pipe shall be subjected to the hydrostatic test specified in Section 13.

20.5 If any test specimen shows defective machining or develops flaws, it is permissible to discard the flawed specimen and substitute another specimen.

21. Retests

21.1 If the percentage of elongation of any tension test specimen is less than that prescribed in Table 1 and any part of the fracture is more than ¾in. (19.0 mm) from the center of the gage length of a 2-in. (50-mm) specimen as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed. If a specimen breaks in an inside or outside surface flaw, a retest shall be allowed.

21.2 Should a crop end of a finished pipe fail in the flattening test, one retest is permitted to be made from the failed end. Pipe shall be normalized either before or after the first test, but pipe shall be subjected to only two normalizing treatments.

22. Test Specimens and Test Methods

22.1 On NPS 8 and larger, specimens cut either longitudinally or transversely shall be acceptable for the tension test. On sizes smaller than NPS 8, the longitudinal test only shall be used.

22.2 When round tension test specimens are used for pipe wall thicknesses over 1.0 in. (25.40 mm), the mid–length of the longitudinal axis of such test specimens shall be from a location midway between the inside and outside surfaces of the pipe.

22.3 Test specimens for the bend test specified in Section 11 and for the flattening tests shall consist of sections cut from a pipe. Specimens for flattening tests shall be smooth on the ends and free from burrs, except when made on crop ends.

22.4 Test specimens for the bend test specified in 11.2 and 11.3 shall be cut from one end of the pipe and, unless otherwise

specified, shall be taken in a transverse direction. One test specimen shall be taken as close to the outer surface as possible and another from as close to the inner surface as possible. The specimens shall be either ½ by ½ in. (12.7 by 12.7 mm) in section or 1 by ½ in. (25.4 by 12.7 mm) in section with the corners rounded to a radius not over 1/16 in. (1.6 mm) and need not exceed 6 in. (152 mm) in length. The side of the samples placed in tension during the bend shall be the side closest to the inner and outer surface of the pipe respectively.

22.5 All routine check tests shall be made at room temperature.

23. Certification

23.1 When test reports are requested, in addition to the requirements of Specification A 530/A 530M, the producer or supplier shall furnish to the purchaser a chemical analysis report for the elements specified in Table 1.

24. Product Marking

24.1 In addition to the marking prescribed in Specification A 530/A 530M, the marking shall include heat number, the information as per Table 6, an additional symbol" S" if one or more of the supplementary requirements apply; the length, OD 1 %, if ordered as special outside diameter tolerance pipe; ID 1 %, if ordered as special inside diameter tolerance pipe; the schedule number, weight class, or nominal wall thickness; and, for sizes larger than NPS 4, the weight. Length shall be marked in feet and tenths of a foot, or metres to two decimal places, depending on the units to which the material was ordered, or other marking subject to agreement. For sizes NPS 1½, 1¼, 1, and ¾, each length shall be marked as prescribed in Specification A 530/A 530M. These sizes shall be bundled in accordance with standard mill practice and the total bundle footage marked on the bundle tag; individual lengths of pipe need not be marked with footage. For sizes less than NPS ¾, all the required markings shall be on the bundle tag or on each length of pipe and shall include the total footage; individual lengths of pipe need not be marked with footage. If not marked on the bundle tag, all required marking shall be on each length.

TABLE 6 Marking

Hydro	NDE	Marking
Yes	No	Test Pressure
No	Yes	NDE
No	No	NH
Yes	Yes	Test Pressure/NDE

24.2 When pipe sections are cut into shorter lengths by a subsequent processor for resale as material, the processor shall transfer complete identifying information, including the name or brand of the manufacturer to each unmarked cut length, or to metal tags securely attached to bundles of unmarked small diameter pipe. The same material designation shall be included with the information transferred, and the processor's name, trademark, or brand shall be added.

24.3 *Bar Coding*—In addition to the requirements in 24.1 and 24.2, bar coding is acceptable as a supplementary identification method. The purchaser may specify in the order a specific bar coding system to be used.

25. Government Procurement

25.1 When specified in the contract, material shall be preserved, packaged, and packed in accordance with the requirements of MIL-STD-163. The applicable levels shall be as specified in the contract. Marking for the shipment of such material shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 or Fed. Std. No. 183 if continuous marking is required for military agencies.

25.2 *Inspection*—Unless otherwise specified in the contract, the producer is responsible for the performance of all inspection and test requirements specified herein. Except as otherwise specified in the contract, the producer shall use his own, or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to ensure that the material conforms to the prescribed requirements.

26. Keywords

26.1 carbon steel pipe; seamless steel pipe; steel pipe

SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements shall apply only when specified in the purchase order. The purchaser may specify a different frequency of test or analysis than is provided in the supplementary requirement. Subject to agreement between the purchaser and manufacturer, retest and retreatment provisions of these supplementary requirements may also be modified.

S1. Product Analysis

S1.1 Product analysis shall be made on each length of pipe. Individual lengths failing to conform to the chemical composition requirements shall be rejected.

S2. Transverse Tension Test

S2.1 A transverse tension test shall be made on a specimen from one end or both ends of each pipe NPS 8 and over. If this supplementary requirement is specified, the number of tests per pipe shall also be specified. If a specimen from any length fails to meet the required tensile properties (tensile, yield, and elongation), that length shall be rejected subject to retreatment in accordance with Specification A 530/A 530M and satisfactory retest.

S3. Flattening Test

S3.1 The flattening test of Specification A 530/A 530M shall be made on a specimen from one end or both ends of each pipe. Crop ends may be used. If this supplementary requirement is specified, the number of tests per pipe shall also be specified. If a specimen from any length fails because of lack of ductility prior to satisfactory completion of the first step of the flattening test requirement, that pipe shall be rejected subject to retreatment in accordance with Specification A 530/A 530M and satisfactory retest. If a specimen from any length of pipe fails because of a lack of soundness, that length shall be rejected, unless subsequent retesting indicates that the remaining length is sound.

S4. Metal Structure and Etching Test

S4.1 The steel shall be homogeneous as shown by etching tests conducted in accordance with the appropriate sections of Method E 381. Etching tests shall be made on a cross section from one end or both ends of each pipe and shall show sound and reasonably uniform material free from injurious laminations, cracks, and similar objectionable defects. If this supplementary requirement is specified, the number of tests per pipe required shall also be specified. If a specimen from any length shows objectionable defects, the length shall be rejected, subject to removal of the defective end and subsequent retests indicating the remainder of the length to be sound and reasonably uniform material.

S5. Carbon Equivalent

S5.1 The steel shall conform to a carbon equivalent (CE) of 0.50 maximum as determined by the following formula:

$$CE = \%C + \frac{\%Mn}{6} + \frac{\%Cr + \%Mo + \%V}{5} + \frac{\%Ni + \%Cu}{15}$$

S5.2 A lower CE maximum may be agreed upon between the purchaser and the producer.

S5.3 The CE shall be reported on the test report.

S6. Heat Treated Test Specimens

S6.1 At the request of the purchaser, one tensile test shall be performed by the manufacturer on a test specimen from each heat of steel furnished which has been either stress relieved at 1250°F or normalized at 1650°F, as specified by the purchaser. Other stress relief or annealing temperatures, as appropriate to the analysis, may be specified by agreement between the purchaser and the manufacturer. The results of this test shall meet the requirements of Table 1.

S7. Internal Cleanliness–Government Orders

S7.1 The internal surface of hot finished ferritic steel pipe and tube shall be manufactured to a free of scale condition equivalent to the visual standard listed in SSPC-SP6. Cleaning shall be performed in accordance with a written procedure that has been shown to be effective. This procedure shall be available for audit.

APPENDIXES

(Nonmandatory Information)

X1. CALCULATED H VALUES FOR SEAMLESS PIPE

X1.1 Tables X1.1 and X1.2 list values for *H* to be used for the test of Section 12.

TABLE X1.1 Calculated "H" Values for Seamless Pipe

Inch-Pound Units

NPS Designator	Outside Diameter, in.	Wall Thickness, in.	Schedule Number	Distance, in inches, Between Plates "H" by Equation: $H = -\frac{(1 + e)t}{e + t/D}$	
				Grade A	Grades B & C
2½	2.875	0.203	40	1.456	1.545
		0.276	80	1.694	1.779
		0.375	160	1.925	2.002
3	3.500	0.216	40	1.646	1.755
		0.300	80	1.955	2.062
		0.438	160	2.306	2.398
3½	4.000	0.226	40	1.788	1.912
		0.318	80	2.153	2.276
4	4.500	0.237	40	1.929	2.067
		0.337	80	2.350	2.489
		0.438	120	2.687	2.818
		0.531	160	2.896	3.022
5	5.563	0.258	40	2.205	2.372
		0.375	80	2.747	2.920
		0.500	120	3.179	3.346
		0.625	160	3.509	3.667
6	6.625	0.280	40	2.473	2.669
		0.432	80	3.213	3.419
		0.562	120	3.682	3.884
		0.719	160	4.116	4.307
8	8.625	0.250	20	2.477	2.702
		0.277	30	2.668	2.902
		0.322	40	2.964	3.210
		0.406	60	3.451	3.711
		0.500	80	3.914	4.181
		0.593	100	4.305	4.573
		0.719	120	4.750	5.013
		0.812	140	5.036	5.293
		0.906	160	5.288	5.538
10	10.750	0.250	20	2.615	2.868
		0.307	30	3.054	3.333
		0.365	40	3.459	3.757
		0.500	60	4.268	4.592
		0.593	80	4.738	5.070
		0.719	100	5.320	5.621
		0.843	120	5.747	6.077
		1.000	140	6.242	6.564
		1.125	160	6.580	6.892
12	12.750	0.250	20	2.711	2.985
		0.330	30	3.366	3.683
		0.406	40	3.921	4.266
		0.562	60	4.892	5.271
		0.687	80	5.542	5.934
		0.843	100	6.231	6.627
		1.000	120	6.817	7.209
		1.125	140	7.222	7.607
		1.312	160	7.747	8.119
14	14.000	0.250	10	2.759	3.045
		0.312	20	3.294	3.617
		0.375	30	3.792	4.146
		0.438	40	4.669	5.125
		0.593	60	5.234	5.647
		0.750	80	6.064	6.494
		0.937	100	6.887	7.322
		1.093	120	7.479	7.902
		1.250	140	7.974	8.397
		1.406	160	8.416	8.827
16	16.000	0.250	10	2.284	3.124
		0.312	20	3.387	3.730
		0.375	30	3.915	4.294
		0.500	40	4.854	5.284
		0.656	60	5.855	6.324
		0.843	80	6.861	7.352
		1.031	100	7.709	8.206
		1.218	120	8.426	8.919
		1.438	140	9.141	9.625
		1.593	160	9.579	10.050
18	18.000	0.250	10	2.876	3.189
		0.312	20	3.462	3.823
		0.438	30	4.535	4.963
		0.562	40	5.457	5.941
		0.750	60	6.656	7.185
		0.937	80	7.663	8.214
		1.156	100	8.657	9.216
		1.375	120	9.495	10.043
		1.562	140	10.115	10.660
		1.781	160	10.665	11.198
20	20.000	0.250	10	2.919	3.242
		0.375	20	4.101	4.521
		0.500	30	5.143	5.632
		0.593	40	5.841	6.367
		0.812	60	7.272	7.856
		1.031	80	8.464	9.072
		1.281	100	9.601	10.221
		1.500	120	10.452	11.069
		1.750	140	11.284	11.889
		1.968	160	11.913	12.504
24	24.000	0.250	10	2.986	3.326
		0.375	20	4.236	4.686
		0.562	30	5.869	6.437
		0.687	40	6.831	7.454
		0.968	60	8.690	9.390
		1.218	80	10.061	10.793
		1.531	100	11.449	12.244
		1.812	120	12.585	13.32
		2.062	140	13.424	14.150
		2.343	160	14.248	14.958

TABLE X1.2 Calculated "H" Values for Seamless Pipe Continued

SI Units

NPS Designator	Outside Diameter, mm	Wall Thickness, mm	Schedule Number	Distance, in mm, Between Plates "H" by Equation: $H = \frac{(1 + e)t}{e + t/D}$	
				Grade A	Grades B & C
2 ½	73.0	5.16	40	37.0	39.2
		7.01	80	43.0	45.2
		9.52	160	48.9	50.8
3	88.9	5.49	40	41.8	44.6
		7.62	80	49.6	52.4
		11.13	160	58.6	60.9
3½	101.6	5.74	40	45.4	48.6
		8.08	80	54.7	57.8
4	114.3	6.02	40	49.0	52.5
		8.56	80	59.7	63.2
		11.13	120	67.0	71.6
		13.49	160	73.6	76.8
5	141.3	6.55	40	56.0	60.2
		9.52	80	69.8	74.2
		12.70	120	80.8	85.0
		15.88	160	89.1	93.1
6	168.3	7.11	40	62.8	67.8
		10.97	80	81.6	86.8
		14.27	120	93.5	98.6
		18.24	160	104.6	109.4
8	219.1	6.35	20	63.0	68.6
		7.04	30	67.8	73.7
		8.18	40	75.3	81.5
		10.31	60	87.7	94.3
		12.70	80	99.4	106.2
		15.06	100	109.4	116.2
		18.24	120	120.6	127.3
		20.62	140	127.9	134.4
		23.01	160	134.3	140.7
10	273.0	6.35	20	66.4	72.8
		7.80	30	77.6	84.7
		9.27	40	87.9	95.4
		12.70	60	108.4	116.6
		15.06	80	120.4	128.8
		18.24	100	135.1	142.8
		21.41	120	146.0	154.4
		25.40	140	158.6	166.7
		28.58	160	167.1	175.1
12	323.8	6.35	20	68.9	75.8
		8.38	30	85.5	93.6
		10.31	40	99.6	108.4
		14.27	60	124.3	133.9
		17.35	80	140.8	150.7
		21.41	100	158.3	168.3
		25.40	120	173.2	183.1
		28.58	140	183.4	193.2
		33.32	160	196.8	206.2
14	355.6	6.35	10	70.1	77.3
		7.92	20	83.7	91.8
		9.52	30	96.3	105.3
		11.13	40	118.6	130.2
		15.06	60	132.9	143.4
		19.05	80	154.0	165.0
		23.80	100	174.9	186.0
		27.76	120	190.0	200.7
		31.75	140	202.5	213.3
		35.71	160	213.8	224.2
16	406.4	6.35	10	71.7	79.4
		7.92	20	89.0	94.7
		9.52	30	99.4	109.1
		12.70	40	123.3	143.2
		16.66	60	148.7	160.6
		21.41	80	174.3	186.7
		26.19	100	195.8	208.4
		30.94	120	214.0	226.6
		36.53	140	232.2	244.5
		40.46	160	243.3	255.3
18	457.2	6.35	10	73.0	81.0
		7.92	20	87.9	97.1
		11.13	30	115.2	126.1
		14.27	40	139.5	150.9
		19.05	60	169.1	182.5
		23.80	80	194.6	208.6
		29.36	100	219.9	234.1
		34.92	120	241.2	255.1
		39.67	140	256.9	270.7
		45.24	160	270.9	284.4
20	508.0	6.35	10	74.1	82.4
		9.52	20	104.2	114.8
		12.70	30	130.6	143.0
		15.06	40	148.4	161.7
		20.62	60	184.7	199.5
		26.19	80	215.0	230.4
		32.54	100	243.9	259.6
		38.10	120	265.5	281.2
		44.45	140	286.6	302.0
		49.99	160	302.6	317.6
24	609.6	6.35	10	75.8	84.5
		9.52	20	107.6	119.0
		14.27	30	149.1	163.5
		17.35	40	173.5	189.3
		24.59	60	220.7	238.5
		30.94	80	255.6	274.1
		38.89	100	290.8	311.0
		46.02	120	319.7	338.6
		52.37	140	341.0	359.4
		59.51	160	361.9	379.9

X2. MINIMUM WALL THICKNESS

X2.1 Table X2.1 lists minimum wall thicknesses for nominal pipe wall thickness.

TABLE X2.1 Mimimum Wall Thicknesses on Inspection for Nominal (Average) Pipe Wall Thicknesses

NOTE 1—The following equation, upon which this table is based, may be applied to calculate minimum wall thickness from nominal (average) wall thickness:

$$t_n \times 0.875 = t_m$$

where:
t_n = nominal (average) wall thickness, in. and
t_m = minimum wall thickness, in.
The wall thickness is expressed to three decimal places, the fourth decimal place being carried forward or dropped, in accordance with Practice E 29.

NOTE 2—This table covers some wall thicknesses associated with standard pipe sizes but is not meant to imply that these are the only thicknesses obtainable under this specification.

Nominal (Average) Thickness (t_n)		Minimum Thickness on Inspection (t_m)		Nominal (Average) Thickness (t_n)		Minimum Thickness on Inspection (t_m)		Nominal (Average) Thickness (t_n)		Minimum Thickness on Inspection (t_m)	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
0.068	1.73	0.060	1.52	0.281	7.14	0.246	6.25	0.864	21.94	0.756	19.20
0.083	2.11	0.073	1.85	0.294	7.47	0.257	6.53	0.875	22.22	0.766	19.46
0.088	2.24	0.077	1.96	0.300	7.62	0.262	6.65	0.906	23.01	0.793	20.14
0.091	2.31	0.080	2.03	0.307	7.80	0.269	6.83	0.938	23.82	0.821	20.85
0.095	2.41	0.083	2.11	0.308	7.82	0.270	6.86	0.968	24.59	0.847	21.51
0.109	2.77	0.095	2.41	0.312	7.92	0.273	6.93	1.000	25.40	0.875	22.22
0.113	2.87	0.099	2.51	0.318	8.07	0.278	7.06	1.031	26.19	0.902	22.91
0.119	3.02	0.104	2.64	0.322	8.18	0.282	7.16	1.062	26.97	0.929	23.60
0.125	3.18	0.109	2.77	0.330	8.38	0.289	7.34	1.094	27.79	0.957	24.31
0.126	3.20	0.110	2.79	0.337	8.56	0.295	7.49	1.125	28.58	0.984	24.99
0.133	3.38	0.116	2.95	0.344	8.74	0.301	7.64	1.156	29.36	1.012	25.70
0.140	3.56	0.122	3.10	0.358	9.09	0.313	7.95	1.219	30.96	1.066	27.08
0.141	3.58	0.123	3.12	0.365	9.27	0.319	8.10	1.250	31.75	1.094	27.79
0.145	3.68	0.127	3.23	0.375	9.52	0.328	8.33	1.281	32.54	1.121	28.47
0.147	3.73	0.129	3.28	0.382	9.70	0.334	8.48	1.312	33.32	1.148	29.16
0.154	3.91	0.135	3.43	0.400	10.16	0.350	8.89	1.375	34.92	1.203	30.56
0.156	3.96	0.136	3.45	0.406	10.31	0.355	9.02	1.406	35.71	1.230	31.24
0.172	4.37	0.150	3.81	0.432	10.97	0.378	9.60	1.438	36.53	1.258	31.95
0.179	4.55	0.157	3.99	0.436	11.07	0.382	9.70	1.500	38.10	1.312	33.32
0.188	4.78	0.164	4.17	0.438	11.12	0.383	9.73	1.531	38.89	1.340	34.04
0.191	4.85	0.167	4.24	0.469	11.91	0.410	10.41	1.562	39.67	1.367	34.72
0.200	5.08	0.175	4.44	0.500	12.70	0.438	11.13	1.594	40.49	1.395	35.43
0.203	5.16	0.178	4.52	0.531	13.49	0.465	11.81	1.635	41.53	1.431	36.35
0.210	5.33	0.184	4.67	0.552	14.02	0.483	12.27	1.750	44.45	1.531	38.89
0.216	5.49	0.189	4.80	0.562	14.27	0.492	12.50	1.781	45.24	1.558	39.57
0.218	5.54	0.191	4.85	0.594	15.09	0.520	13.21	1.812	46.02	1.586	40.28
0.219	5.56	0.192	4.88	0.600	15.24	0.525	13.34	1.875	47.62	1.641	41.68
0.226	5.74	0.198	5.03	0.625	15.88	0.547	13.89	1.969	50.01	1.723	43.76
0.237	6.02	0.207	5.26	0.656	16.66	0.574	14.58	2.000	50.80	1.750	44.45
0.250	6.35	0.219	5.56	0.674	17.12	0.590	14.99	2.062	52.37	1.804	45.82
0.258	6.55	0.226	5.74	0.688	17.48	0.602	15.29	2.125	53.98	1.859	47.22
0.276	7.01	0.242	6.15	0.719	18.26	0.629	15.98	2.200	55.88	1.925	48.90
0.277	7.04	0.242	6.15	0.750	19.05	0.656	16.66	2.344	59.54	2.051	52.10
0.279	7.09	0.244	6.19	0.812	20.62	0.710	18.03	2.500	63.50	2.188	55.58
0.280	7.11	0.245	6.22	0.844	21.44	0.739	18.77				