API 570 Certification Contents and Guidelines

- ✓Part 1: Piping Components
- ✓Part 2: B31.3 – Pipe Design
- ✓Part 3: B31.3 – Pipe Fabrication
- ✓Part 4: Read API 570
- ✓Part 5: Read ASME Section V – NDT Procedure
- ✓Part 6: Understand ASME Section IX – Welding Procedure
- ✓Part 7: Do the homework! Practice makes perfect

API 570 Piping Inspection Code

Part 1: Pipe Components

Objectives

- ✓Know the types of pipe and piping components
- ✓Have an understanding of piping specs
- ✓Understand the pro's and con's of pipe joining methods
- ✓Successfully use the B16.5 Flange Standard
- ✓Solve flange rating problems
- ✓Determine the maximum hydrotest pressure for a flange

**** API 574 Sections 4.1.1 & 4.1.2 provide a great summary about pipe. These sections discuss pipe schedules, sizes, forming methods, tolerance, etc.***

Pipe Specifications

✓**Pipe and piping components are built in the pipe mill to a spec, like ASTM A106 (CS pipe)**

✓**These manufacturing specs cover items like**

- **Materials**
- **Inspection requirements**
- **Minimum tensile strength**
- **Fabrication process**

✓**Note! For most Spec #'s like A-106, the actual number does not have special significance. It just refers to a section in a code.**

All pipe over 6" dia must have the words "large pipe" painted on it. We don't want contractor to mistake it for a small pipe.

Manufacturing of Pipe

- ✓Seamless (drawn through dies)
  - Used the most in our petrochemical plants
  - Tolerance: -12.5%

- ✓Welded (plate that is rolled and welded)
  - Most piping greater than 16 NPS (Nominal Pipe Size) is rolled & welded
  - Tolerance: -0.010”

- ✓Cast (and machined)
  - Not used often
  - Tolerance: -0.00 + 1/16”

Info

Seamless Pipe: The Advantage

✓Fewer welds! Welds are generally places for potential leaks and failures

✓No longitudinal welds! In all cylinders, the stresses on longitudinal welds are twice that of circumferential welds

API 574 Table 3 Pipe Tolerances (Partial List)

ASTM Material	NPS	Dia. Tolerances	Thick. Tolerances
A53	≤1-1/2	-1/32" + 1/64"	-12.5%
A53	>1-1/2	±1%	-12.5%
A106	1/8 to 1-1/2	-1/32" + 1/64"	-12.5%
A106	>1-1/2 to 4	±1/32"	-12.5%
A134	All	Circumference ± 0.5% of diameter	Tolerance of plate standard
A135	All	+ 1% of nominal	-12.5%
A358	All	±0.5%	-0.01"

Pipe Sizes

- ✓**Diameters – standardized through 48”**
  - **Up to 12 NPS, size refers to pipe ID**
  - **Above 12 NPS, size refers to pipe OD**
- ✓**Thickness standardized through 36”**
  - **Thicker pipe has smaller ID, OD stays the same**
  - **Traditional: Std. weight, extra strong, double extra strong**
  - **Schedules: 10, 40 80, etc.**
    - ***B16.5 Annex C or API 574 Table 1***

Pipe Schedules ending in “S” (ie 10S) refers Stainless Steel (SS) pipe schedule chart. The SS charts are not shown in B16.5 or API 574.

Other Piping

- ✓Tubing
  - Stated size is the actual OD
  - Not generally used for piping
  - Applications: furnace & heat exchanger tubes
- ✓Cast Iron Piping
  - Sizes are different than the sizes for steel piping
  - Susceptible to brittle failures
  - Not used for hydrocarbon services

Exercise 1

During projects & repairs, new pipe is ordered. Inspectors should measure the wall thickness of new pipe to determine if the thickness meets minimum code requirements.

<u>Minumum Thickness for New Seamless Pipe</u>

The tolerance for seamless is -12.5%. This means it can be 12.5% thinner than what is listed in the pipe schedule or the pipe has to be at least 87.5% as thick as the nominal thickness. Since our UT instruments measure wall thickness, we need to know the minimum allowed thickness.

Formula: $t_{min\ new} = 0.875 \times t_{nom}$

Question: Determine minimum wall thickness of a new 6 NPS seamless pipe.

<u>Minumum Thickness for New Welded Pipe</u>

Since the mill tolerance for rolled and welded pipe is – 0.010”, this is much easier to calculate.

Formula: $t_{min\ new} = t_{nom} – 0.010”$

Question: Determine minimum wall thickness of a new 6 NPS welded pipe.

Answers 1

Minumum Thickness for New Seamless Pipe

Question: Determine minimum wall thickness of a new 6 NPS seamless pipe.

From pipe schedule chart: t_{nom} = 0.280”
$t_{min\ new}$ = 0.875 x 0.280” = 0.245”
New pipe below 0.245” is rejectable

Minumum Thickness for New Welded Pipe

Question: Determine minimum wall thickness of a new 6 NPS welded pipe.

From pipe schedule chart: t_{nom} = 0.280”
$t_{min\ new}$ = 0.280” – 0.010” = 0.270”
New pipe below 0.270” is rejectable

Exercise 2

Pipe Dimensions:

1) **What is the nominal wall thickness of a 6 NPS, Sch 80 pipe?**

2) **What is the nominal wall thickness of a 2 NPS, Sch 40 pipe?**

3) **What is the OD of a 4 NPS furnace tube? (tube is made to a pipe spec)**

4) **What is the OD of a 4” furnace tube? (tube is made to a tube spec)**

5) **What is the minimum allowed thickness of a new 8 NPS Sch 80 seamless pipe?**

6) **What is the minimum allowed thickness of a new 8 NPS Sch 80 welded pipe?**

Answers 2

Pipe Dimensions:

1) What is the nominal wall thickness of a 6 NPS, Sch 80 pipe? 0.432”

2) What is the nominal wall thickness of a 2 NPS, Sch 40 pipe? 0.154”

3) What is the OD of a 4 NPS furnace tube? (tube is made to a pipe spec) 4.5”

4) What is the OD of a 4” furnace tube? (tube is made to a tube spec) 4”

5) What is the minimum allowed thickness of a new 8 NPS Sch 80 seamless pipe?

$t_{min\ new} = 0.875 \times t_{nom}$
$t_{nom} = 0.5”$
$t_{min\ new} = 0.875 \times 0.5” = 0.4375”$
New pipe below 0.4375” is rejectable

6) What is the minimum allowed thickness of a new 8 NPS Sch 80 welded pipe?

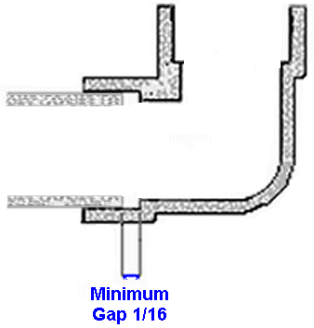
$t_{min\ new} = t_{nom} – 0.01”$
$t_{nom} = 0.5”$
$t_{min\ new} = 0.5” – 0.01” = 0.49”$
New pipe below 0.49” is rejectable

Joining Method - Welding

Primary joining method – fewer leaks & repairs.

✓**Socket-weld**

- **Generally limited to pipe ≤ 2 NPS**
- **Watch out for "the gap"**
- **Advantages: Quick, less skill required**
- **Potential crevice corrosion**



✓**Butt-welded**

- **Used on all line sizes**
- **High Strength**
- **Inspect with RT**

Joining Method - Welding

Primary joining method – fewer leaks & repairs.

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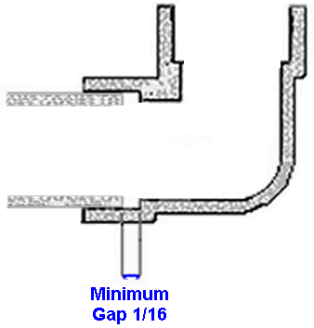


"The gap" is needed for thermal expansion! If there is no gap and it pipe grows more than socket weld fitting, then the fillet weld may crack. How this could occur?

- During fabrication: If the pipe wall is thinner than the SW fitting, then the pipe will become hotter than the fitting during welding.
- Hot services: If the line is uninsulated, the socket will not heat up as much as the pipe.
- Hot cyclic conditions

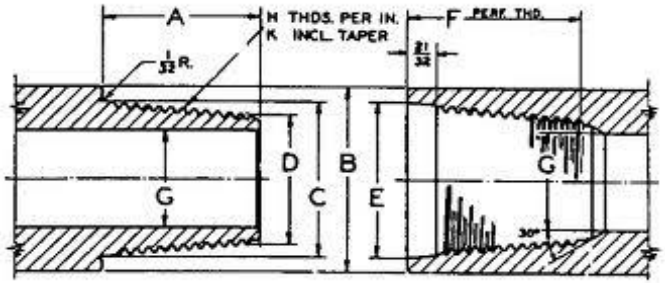
During in-service inspections using profile RT, occasionally a SW fitting is found without a gap. If this pipe has withstood the "test of time", usually there is no reason to repair and add "the gap". However, if operating temperature or cyclic conditions increase, then this need to discuss further.

Joining Method - Welding

- ✓Butt-welded
  - Used on all line sizes
  - High Strength
  - Inspect with RT

Joining Method - Threaded

✓**Limitations**
- **Non-critical service**
- **2 NPS or smaller**



✓**Advantages**
- **Quick installation**
- **No “hot work” required**
- **Lower manpower skill required**

✓**Disadvantages**
- **A significant portion of the pipe has been removed in the threading process.**
- **Susceptible to fatigue cracks**

Joining Method – Flanged

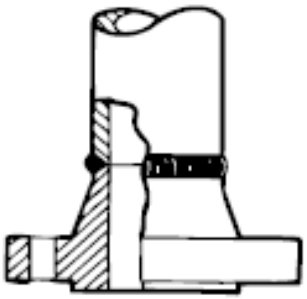
- ✓Purpose for flanges
  - Disconnect or isolate piping & equipment
  - Connect to other equipment, eg pumps, HEX
  - Install piping in areas where welding is not permitted

- ✓Codes
  - B16.5: ½ thru 24 NPS
  - B16.47: 26-60 NPS
  - API Std 605

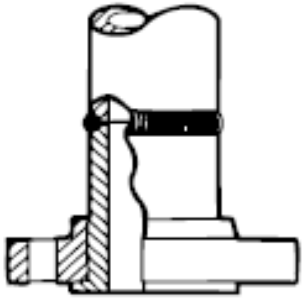
- ✓Classes: 150, 300, 400, ….
- ✓Types: Weldneck, Slip-On, etc.

Joining Method – Flanged

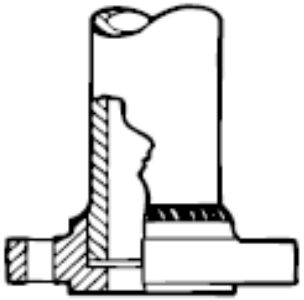
Every flange is a potential leak. During design, the number of flanges are usually minimized. In high pressure units, there are very few flanges. This reduces cost and minimizes the potential for serious leaks. Often, even welded valves are used.



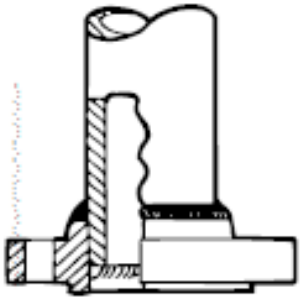
WELDING-NECK FLANGE



LAP-JOINT FLANGE

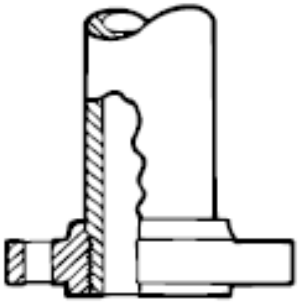


SOCKET-WELDED FLANGE



SLIP-ON WELDED FLANGE

BLIND FLANGE



THREADED FLANGE

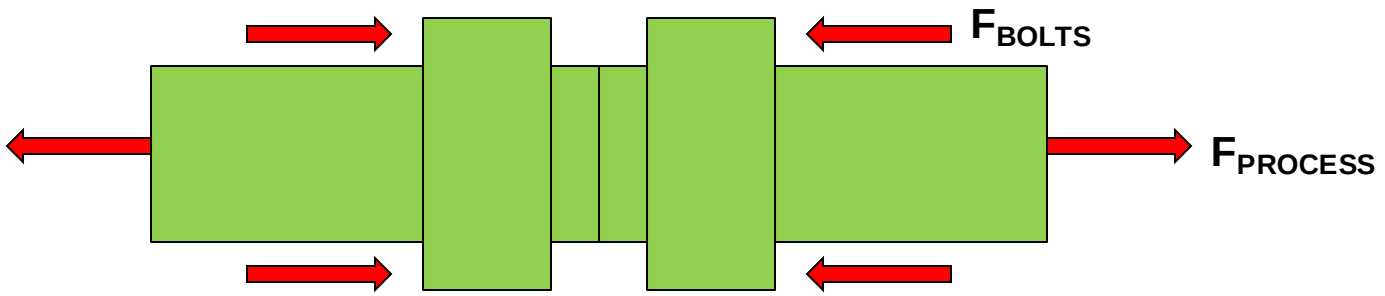
Successful Flanging

- ✓**Flange Selection – Appropriate Strength**
  - **Must know material temp and pressure ratings**
- ✓**Gasket**
  - **Appropriately compressed, no blowouts**
- ✓**Bolting – Provides the "Squeeze"**
  - **Bolting Strength**
  - **Bolting Stretch**
- ✓**The Assembler**
  - **Correct torqueing procedure – ASME PCC-1**
  - **Larger flanges are more difficult to assemble**

Flange – The Weak Link

The weak link is the bolts! The bolts are like monster springs. As the nuts are tightened, the bolts stretch. This creates a squeeze on the gasket. If there is not enough "stretch", then there is not enough "squeeze" and the gasket will leak.

Also, the pressure from the process creates a force trying to pull apart the flanges. If the force from the process exceeds the bolt force (squeeze), the flange will leak.



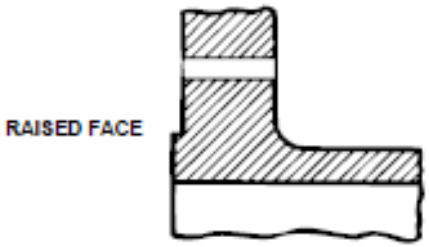
A leak occurs when $F_{PROCESS} > F_{BOLTS}$

B16.5 – The Flange Standard

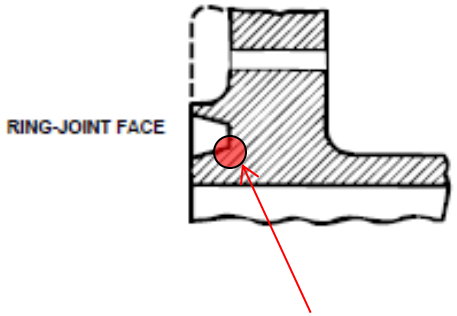
- ✓Scope of B16.5
  - Flange & Flange fittings
- ✓Types of Material
  - Steels and alloys
- ✓Fabrication Methods
  - Casting
  - Forging
  - Plate (only blind flange)
- ✓Raised Face vs Flat Face
- ✓Flange Markings
- ✓Flange Dimensions
  - Do not change with different flange metallurgies. Eg, all 6 NPS, Class 300 flanges have exactly the same dimensions.
- ✓Flange Facing
  - Visual comparator
  - Normal finish
    - 125-250 micro-inch
    - 45-55 grooves/inch

Note: B16.5 is over 200 pages long but only 9 pages are “real” text. The rest is charts and sketches!

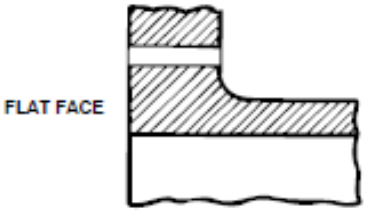
Flange Faces



-Commonly used



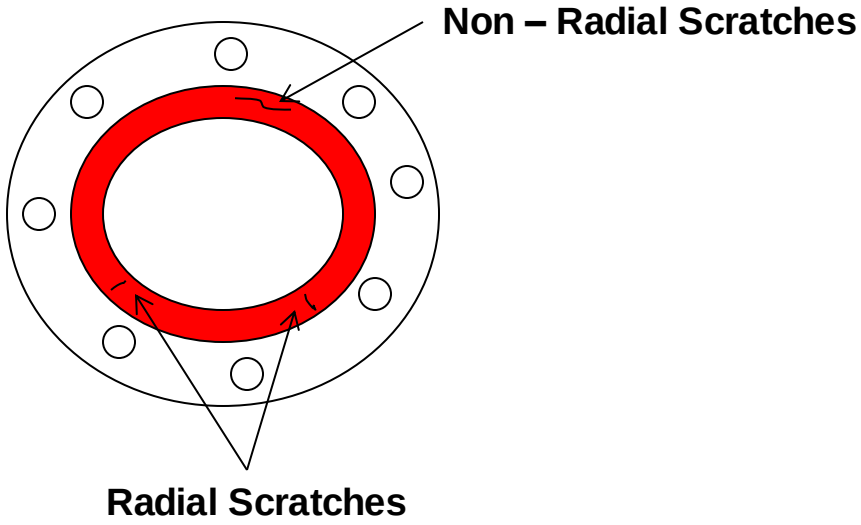
Area to focus during inspection



-Need to use soft gasket eg teflon
-Common in big equipment eg compressor

Scratches on Flange Face

Definition Radial – Direction that is moving away from a center point



NPS	Imperfections ≤ Bottom of Serrations	Imperfections ≥ Bottom of Serrations
½ - 2-1/2	0.12	0.06
3	0.18	0.06
3-1/2 – 6	0.25	0.12
8-14	0.31	0.18

B16.5 Table 3: Max. Radial Imperfections (in)

Flange Flaws

When new flanges are installed, some or all of the flanges should be inspected for:

- ✓**Correct Stamping**
  - **Class, metallurgy, bore, etc.**
- ✓**Flange face finish**
- ✓**Scratches on flange face – B16.5 Table 3**

Note: For limits of thin areas on flanged fittings see 6.1.1

Exercise 3

Flanges:

1) **Flange material made of plate is only allowed for what type of flanges?**

2) **B16.5 covers flanges for what pipe sizes?**

3) **What is normal flange finish on a weld neck flange?**

4) **What is the required stud length for 6 NPS Class 600 weld neck flange?**

5) **What is the height (length) of a 4 NPS Class 300 weld neck flange?**

6) **What is the max. allowed radial length of a scratch on a 8 NPS flange face?**
   a) **Scratch is not deeper than the grooves**
   b) **Scratch is deeper than the grooves**

Answers 3

Flanges:

1) **Flange material made of plate is only allowed for what type of flanges?** Blind

2) **B16.5 covers flanges for what pipe sizes?** NPS ½ - NPS 24

3) **What is normal flange finish on a weld neck flange?** 6.4.5.3: 125µ" - 250µ"

4) **What is the required stud length for 6 NPS Class 600 weld neck flange?** Table 11-15: 8.75"

5) **What is the height (length) of a 4 NPS Class 300 weld neck flange?** Table 11-11: 3.32"

6) **What is the max. allowed radial length of a scratch on a 8 NPS flange face?**
   a) **Scratch is not deeper than the grooves** Table 11-3: 0.31"
   b) **Scratch is deeper than the grooves** Table 11-3: 0.18"

Flange Calculations

Types of Flange Calculations:

- ✓**Maximum Flange Pressure**
- ✓**Maximum Flange Temp**
- ✓**Select most cost effective Flange Class**
- ✓**Maximum HT Pressure**
  - **This is normally higher than B31.3 system HT pressure**

Factor for Calculations:

- ✓**Maximum Pressure**
- ✓**Maximum Temp**
- ✓**Flange Class**
- ✓**Flange Metallurgy**
  - **Metallurgy is always provided in the API exam questions**

When to Calculate?

1. **Rerates: If either the pressure or temperature is being raised the flange rating must be checked.**

2. **New Construction or Alterations: The appropriate flange class must be selected based on the design conditions.**

3. **New Construction, Alterations or Repairs: If hydrotesting is performed on the equipment or pipe, the maximum allowed flange HT pressure must not be exceeded.**

Note: On most piping systems the flange are usually the limiting component. This may not be the case on large pipe diameter.

Flange Design Charts

- ✓**Pressure-Temperature Charts needed because:**
  - **Flange dimensions are based on class not metallurgy**
  - **Some materials are stronger than others**
  - **As operating temperature increases, material strength decreases**

- ✓**Key Flange Charts**
  - **Material Group: Table 1A**
  - **Pressure-Temperature Ratings: Table 2.x.x**
    - **“x.x” = Material Group Number**

Flange – Max Pressure

Step 1: At Table 1A determine Material Group #

- **Based on flange metallurgy**

Step 2: Go to correct P-T Rating chart

- **“x-x” represents material group number**
- **Validate material is listed on top of chart**
- **Check appropriate footnotes**

Step 3: Find intersection of Design Temp row and Designated Flange Class column

Exercise 4

Determining Maximum Flange Pressure:

1) **A rerate is being performed on a piping system. Determine the maximum pressure rating for the existing Class 300 flanges. The flanges have a maximum operating temperature of 500°F. The flange material is ASTM A182 Gr F316.**

2) **Determine the maximum pressure of a Class 600 flange that has a maximum design temperature of 750°F. Flange material is A105.**

Answers 4

Determining Maximum Flange Pressure:

1) **A rerate is being performed on a piping system. Determine the maximum pressure rating for the existing Class 300 flanges. The flanges have a maximum operating temperature of 500°F. The flange material is ASTM A182 Gr F316.**

   Step 1: At Table 1A determine Material Group #
   - **Material Group # for A182 Gr F316 is 2.2 (Stainless Steel forging)**

   Step 2: Go to Table 2-2.2. Validate material is listed on top of chart. Check footnotes

   Step 3: Find intersection of temperature (500°F) in Temperature Column and Designated Flange Class (Class 300)
   - **Maximum Pressure is 480 psig.**

2) **Determine the maximum pressure of a Class 600 flange that has a maximum design temperature of 750°F. Flange material is A105.**

   1015 psig

Flange – Max Temperature

Step 1: At Table 1A determine Material Group #

Step 2: Go to correct P-T Rating chart

- **“x-x” represents material group number**
- **Validate material is listed on top of chart**
- **Check appropriate footnotes**

Step 3: At designated flange class column, drop down until finding design pressure. If exact pressure is not listed, stop at the closest higher pressure

Step 4: At this pressure, run left along same row to the Temp column. This is your max temperature

Exercise 5

Determining Maximum Temperature Rating:

1) **A piping system with A105 flanges is being rerated for the Class 600 flanges. The piping system has a new design pressure of 1000 psig. Determine maximum temperature.**

2) **Determine the maximum allowed temperature of a Class 300 flange that has a maximum design pressure of 400 psig. Flange material is A182 Gr. 304.**

Answers 5

Determining Maximum Temperature Rating:

1) **A piping system with A105 flanges is being rerated for the Class 600 flanges. The piping system has a new design pressure of 1000 psig. Determine maximum temperature.**

   Step 1: At Table 1A determine Material Group #
   - **Material Group Number for A105 is 1.1 (Carbon Steel forging)**

   Step 2: Go to Table 2-1.1. Validate material is listed on top of chart. Check footnotes

   Step 3: At Class 600 column, drop down until finding design pressure. If exact pressure is not listed, stop at the closest higher pressure
   - **Design Pressure is 1000 psig. Select the listed value of 1015 psig.**

   Step 4: At this pressure, run left along same row to the Temp column. This is your max temperature
   - **Temperature rating is 750°F.**

2) **Determine the maximum allowed temperature of a Class 300 flange that has a maximum design pressure of 400 psig. Flange material is A182 Gr. 304.**

   800°F

Flange – Flange Class

Step 1: At Table 1A determine Material Group #

Step 2: Go to correct P-T Rating chart

- **“x-x” represents material group number**
- **Validate material is listed on top of chart**
- **Check appropriate footnotes**

Step 3: In the temp column find the design temp

Step 4: At this row move right to find the first pressure that exceeds the design pressure

Step 5: At this pressure move straight up to flange class

Exercise 6

Determining Most Cost Effective Flange Class:

1) **A new piping system is being installed. Determine the most cost effective flange class for this system. The pipe has a design pressure of 700 psig and a design temperature of 650^{o}F. The flange material is ASTM A182 Gr. F5a.**

2) **A new piping system is being installed. Determine the most cost effective flange class. Flange material is A105. Design temperature is 600^{o}F and design pressure is 950 psig.**

Answers 6

Determining Most Cost Effective Flange Class:

1) **A new piping system is being installed. Determine the most cost effective flange class for this system. The pipe has a design pressure of 700 psig and a design temperature of 650°F. The flange material is ASTM A182 Gr. F5a.**

   Step 1: At Table 1A determine Material Group #
   - **Material Group is 1.13 (5% Chrome forging)**

   Step 2: Go to Table 2-1.13. Validate material is listed on top of chart. Check footnotes

   Step 3: In the temp column find the design temp
   - **Design Temperature is 650°F.**

   Step 4: At this row move right to find the first Maximum Pressure that exceeds the design pressure of 700 psig.
   - **1st Column – 125 psig, 2nd Column – 590 psig, 3rd Column – 785 psig**

   Step 5: At this pressure move straight up to flange class
   - **Flange Class is Class 400**

2) **A new piping system is being installed. Determine the most cost effective flange class. Flange material is A105. Design temperature is 600°F and design pressure is 950 psig.**

   Class 600

Flange – Maximum Hydrotest Pressure

Maximum allowed flange hydrotest pressure (P_{TEST})

$$P_{TEST} = 1.5P_{@100^oF} \uparrow$$ Round up to next 25 psig

$P_{@100^oF}$ = The pressure rating of the flange at 100°F. (found on P-T Rating charts)

$\uparrow$ next 25 psig = All answers need to end in: "00, 25, 50, 75"

Hold at least 10 min.

All flange fittings must be hydrotested at the mill. Flanges are not hydrotested at the mill.

Note: Usually the flanges are the limiting component. Often the fabrication hydrotest is based on this flange hydro calculation instead of the B31.3 piping system hydro calculation. (eg All A105 CS Class 150 flanges are tested at 450 psig regardless of the design pressure)

Exercise 7

Determining Maximum Hydrotest Pressure:

1) **Determine the maximum hydrotest pressure for a Class 300 flange that has a maximum operating temperature of 500°F. The flange material is ASTM A182 Gr. F316.**

2) **Determine the maximum hydrotest pressure for a Class 600 flange made of A105.**

Answers 7

Determining Maximum Hydrotest Pressure:

1) **Determine the maximum hydrotest pressure for a Class 300 flange that has a maximum operating temperature of 500°F. The flange material is ASTM A182 Gr. F316.**

   Step 1: Determine Material Group #.
   - **Group 2.2 (316 SS forging)**

   Step 2: At Table 2-2.2, validate material is listed in the top chart.

   Step 3: In the Temperature Column, find the Hydrotest Temperature.
   - **Hydrotest Temperature is 100°F**

   Step 4: At this row, move directly to the right to find Class 300 column. Read the maximum pressure.
   - **Maximum Pressure is 720 psig**

   Step 5: Calculate the HT pressure per formula given in paragraph 2.5 System Hydrotest.
   - **P_{TEST} = 1.5 x 720 = 1080, round up: 1100 psig.**

2) **Determine the maximum hydrotest pressure for a Class 600 flange made of A105.**

   = 1480 x 1.5 = 2220, round up: 2225 psig