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FASTENER TRAINING WEEK

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Workbook Key

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Introductory Quiz

KEY

Test your Fastener IQ- answer these 20 questions with a True, False or Don't Know

1.	A 1"-8 x 6" Grade 8 (high strength bolt) should act like a rigid steel bar	T	F	DK
2.	An automotive OEM standard is a consensus standard	T	F	DK
3.	Most fasteners are produced by cutting them on screw machines	T	F	DK
4.	Torque Control provides the most accurate method of tightening	T	F	DK
5.	In a bolted joint, the nut should be stronger than the bolt	T	F	DK
6.	A M10 bolt is a good substitute for a ½"bolt and vice versa	T	F	DK
7.	There is a relationship between torque and tension	T	F	DK
8.	A Wedge Tensile Test can be conducted on any part	T	F	DK
9.	The default understanding is that threads are right-handed	T	F	DK
10.	A Charpy Impact Test is used to test Ductility	T	F	DK
11.	Stainless Steel is never magnetic	T	F	DK
12.	A metric bolt with 8.8 on the head is about as strong as an inch Grade 8	T	F	DK
13.	If a fastener's tensile strength is exceeded, it will fracture	T	F	DK
14.	A fine pitch fastener and coarse pitch fastener have equal strength	T	F	DK
15.	On an inch UNC thread, the pitch diameter grows by 4 times the plating thickness	T	F	DK
16.	Hardness testing is only done in test labs	T	F	DK
17.	A class 3 thread fit has no allowance for plating	T	F	DK
18.	Tempering makes quench and tempered fasteners harder and stronger	T	F	DK
19.	If parts are properly heat treated we don't need to worry about fatigue failure	T	F	DK
20.	ASTM, ASME, and ISO standards are exactly the same	T	F	DK

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Navigating Fastener Standards

Section 1-5

Workbook

Revised 10172024

KEY

Exercise Problem #1

Problem:

The foreman on a job site has two pails of hex bolts. One pail is comprised of bolts produced to SAE J429 Grade 8. The other pail is comprised of bolts produced to ASTM F3125/F3125M Grade A325. The foreman is curious to know if they have the same Tensile Strength or not. How would he go about finding out?

Helpful Hints:

Tensile Strength = The maximum load that the bolt can withstand before breaking.

List the key words/topics that will assist in finding the answer:

- _____**Hex Bolt, Tensile Strength**_____
- _____**SAE J429 Grade 8**_____
- _____**ASTM F3125/3125M Grade A325**_____

What type of standard would you expect to find the answer in?

Product **Material** Test

Considering the IFI Book of Fastener Standards:

Using Table of Contents (List Standards and Pages you might explore):

- _____**SAE J429 12th: pg 247 11th pg 238**_____
- _____**ASTM F3125/F3125M 12th pg 542 11th pg 531**_____

Using the Designation Index (List Standards and Pages you might explore):

- ___**Same as above**_____
- _____

Answer:

Tensile strength of SAE J429 Grade 8:_____**150,000 psi**_____

Where you found answer: _____**Table 1** _____

Tensile strength of ASTM F3125/F3125M Grade 325: ____**120,000 psi** _____

Where you found answer: ____**Table 1 and Table 2**_____

What do you tell the Foreman? _____**They are not equivalent strength**_____

Exercise Problem #2

Problem:

A customer brings a nut to your customer service counter and explains that they know it is an ASTM A194 Grade 8 nut but nothing more. They ask what material it is made of so that they can be sure to purchase the right replacement. What do you tell them?

Helpful Hints:

One of the confusing things about standards is the use of the same terms with different meaning or understanding. In this case, there is no similarity between the Grade 8 bolt of the previous problem and this Grade 8 nut. The term "grade" in these two standards generically refers to a particular strength of material or product and is not understood to be equivalent even though the term is the same.

List the key words/topics that will assist in finding the answer:

- _____**ASTM A194 Grade 8**_____
- _____
- _____

What type of standard would you expect to find the answer in?

Product **Material** Test

Considering the IFI Book of Fastener Standards:

Using Table of Contents (List Standards and Pages you might explore):

- _____**A194/A194M 12th: pg 646 11th: pg 635**_____
- _____

Using the Designation Index (List Standards and Pages you might explore):

- _____**Same as above**_____
- _____

Answer:

What Table do you use to find the answer? _____**Table 1, column 2**_____

What material is a Grade 8?___ _____**S30400 which is 304SS**_____

Exercise Problem #3

Problem:

A customer calls you on the phone and explains that they purchased a ½-13 x 4" Grade 5 hex cap screw from you. They want to know what the load in pounds-force this bolt can hold. What would you tell them?

Helpful Hints:

In this case, you have to be careful of the word "strength". Strength is defined as the material's ability to withstand an applied stress without breaking. This allows us to describe the capacity of different sized parts with the same term, although clearly a larger bolt will be able to hold a greater load than a smaller one with the same strength capacity. "Grade 5" gives us a clue, BUT be careful, the customer wants to know the strength of a ½-13 part and not ones that are bigger or smaller.

As asked there are two right answers to this question.

If you hit a road block looking for hex cap screws, be careful this is an example where the industry uses a term that might normally be associated with another type of product.

List the key words/topics that will assist in finding the answer:

- __**1/2-13 x 4", Hex Cap Screw, Grade 5, Strength**_____
- _____
- _____

What type of standard would you expect to find the answer in?

Product **Material** Test

Based on that, which CSO(s) standards will you be searching for? _____**SAE or ASTM**_____

Considering the IFI Book of Fastener Standards:

Using Table of Contents (List Standards and Pages you might explore):

- _____**Grade 5 = SAE J429 12th: pg 247 11th: pg 238** _____
- _____

Answer:

What Standard will you find this information in? ____**SAE J429**_____

Why is 120,000 psi NOT the right answer? ____**This is strength and not load**_____

What Table do you use to find the answer?_____ **Table 5**_____

What is the load can a ½-13 HCS carry? ___ _**12,100 lbf Proof Load and 17,000 lbf Tensile Load**

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Exercise Problem #4

Problem:

A customer calls you up and inquires about the following: he would like to know what the "head height, recess size, penetration depth, and maximum fall away" is for a #8 Type VI Pan Head Tapping Screw. Can you find the information for him?

Helpful Hints:

This standard is an example of a standard with many pages of diagrams and dimensions. You may have to spend a little time searching for the answer. Is the answer in the diagrams?

Remember to always pay attention to the Footnotes.

Penetration Depth (Also called "Recess Penetration Depth") is the distance from the top of the head to the "effective" bottom of the driving feature. This is a very important dimension because if it is either too shallow or too deep, it could result in problems with the part.

Recess Size determines how large the driver bit, i.e. what size, needs to be.

Fall-away refers to the amount of underfill at the interface of the top head surface and the vertical recess wall. Too much Fall-away results in a sloppy fit of the bit and recess.

This example illustrates the frustration many of you will find, i.e. that there are often multiple terms meaning the same thing and one customer may use a term that is different than the standard.

In CSO standards, they usually prefer NOT to use trademarked names. This is the case for the way this standard designates recess styles. For example, a Type 1 is what we would normally refer to as a "Phillips Drive". Flip through to see if you can figure out what a Type VI recess is.

List the key words/topics that will assist in finding the answer:

- ___**Head Height, Recess Size, Penetration Depth,** _____
- ___**Maximum Fall Away, Type VI,** _____
- ___**Pan Head Tapping Screw**_____

What type of standard would you expect to find the answer in?

Product Material Test

Based on that, which CSO(s) standards will you be searching for? ____**ASME**_____

Considering the IFI Book of Fastener Standards:

Using Table of Contents (List Standards and Pages you might explore):

- ____**Tapping Screws = ASME B18.6.3 12th: pg 734 11th: pg 723**
- _____

Answer:

What Standard will you find this information in? _____**ASME B18.6.3**_____

What is a Type VI recess? ____**Six Lobe or Torx®**_____

In what Table or Tables will you find these answers? ____**12th: 2.2.5-3 and 2.2.5-2 11th: Table 19 and Table 18**_____

Recess Size: _____ _**T20**_____

Penetration Depth:_____ _**.070/.055**_____

Max Fall-Away: _____**.031**___ _____

Head Height: _____.**115/.105**_____

How did you find the Head Height? _____**Use Footnote**_____

Exercise Problem #5

Problem:

A customer calls complaining about cracks in the heads of Alloy Steel Socket Head Cap Screws you supplied. Are they allowed?

Helpful Hints:

This is a rare example where the answer will be found in the relevant Socket Head Cap Screw standard rather than a more generic “Quality Standard”.

Pay attention to “alloy steel”

List the key words/topics that will assist in finding the answer:

- ___**Cracks, Alloy Steel, Socket Head Cap Screw**_____
- _____
- _____

What type of standard would you expect to find the answer in?

Product **Material** Test

Considering the IFI Book of Fastener Standards:

Using Table of Contents (List Standards and Pages you might explore):

- ____**Socket Product = ASTM A574 12th: pg 463 11th: pg 452**_____
- _____

Answer:

In what standard will you find the answer? _____**ASTM A574**_____

Are the cracks allowed or not?_____ **It depends- A574 does allow some cracks that are limited in size, depth, and/or location**_____

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How Fasteners are Made

Section 1-6

Workbook

KEY

1. In your own words, how would you describe cold heading to a colleague or interested family member?

"Cold heading is a manufacturing process where you manipulate the shape of the parts you are forming at room temperature by applying very large forming loads (smashing the heck out of them) in a series of dies and tools."

2. List three advantages to cold heading

a. _Productivity (Speed of process)_____
b. _Little or no waste_____
c. _Stronger than cut parts_____

(Also Net Shape or Near Net Shape, more cost effective, effective method of getting internal drive recesses)

3. What would be some limitations on cold headed parts?

- Tolerances may be looser than some methods such as machining
- Limited by how much material you can move (head to shank ratios are limited)
- Significant complexity may be difficult or impossible to get
- Surface finish less rough than forging but rougher than grinding and some machining
- May have some areas that are naturally underfilled
- Ends may be rough and irregular

4. Why are rolled threads preferred on external parts?

"Rolled threads are stronger than cut threads because the grain pattern is manipulated into a stronger configuration than prior to rolling."

5. Which process would you use to make the following parts? (Choose between Cold Heading, Screw Machining, and Hot/Warm Heading)

Source: 3VFasteners

Aerospace 12Pt Spline Head Bolt COLD HEADING w/secondary operations

Source: rays-tek surplus.co.uk

Typical Countersunk Head Aerospace Screw COLD HEADING w/secondary operations

Source:www.acrospec.com

Steel Part SCREW MACHINING

Source: www.grambo.com

Large 2 ½" to 3" diameter Socket Screw SCREW MACHINING or HOT HEADING

Source: Stanley Engineered Fasteners

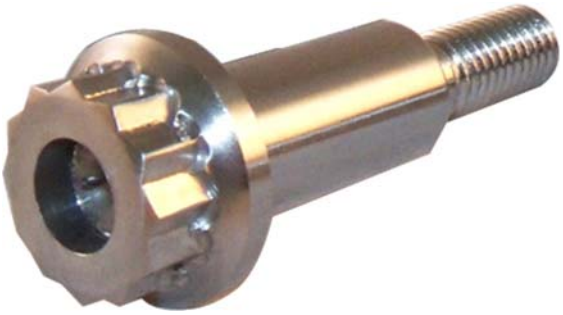
Special Hex Bolt COLD HEADING w. secondary operations

Source: Wei Shian Fasteners

Special Fastener SCREW MACHINING

Source: yuinsokotion.com

Fluid Line Adapter SCREW MACHINING



Source: fastenersolutions.com

Alloy 718 (Inconel) 12PT Spline Flange Bolt WARM or HOT HEADING

Source: altrod.com

1 ½ - 2” Hex Bolt HOT HEADING

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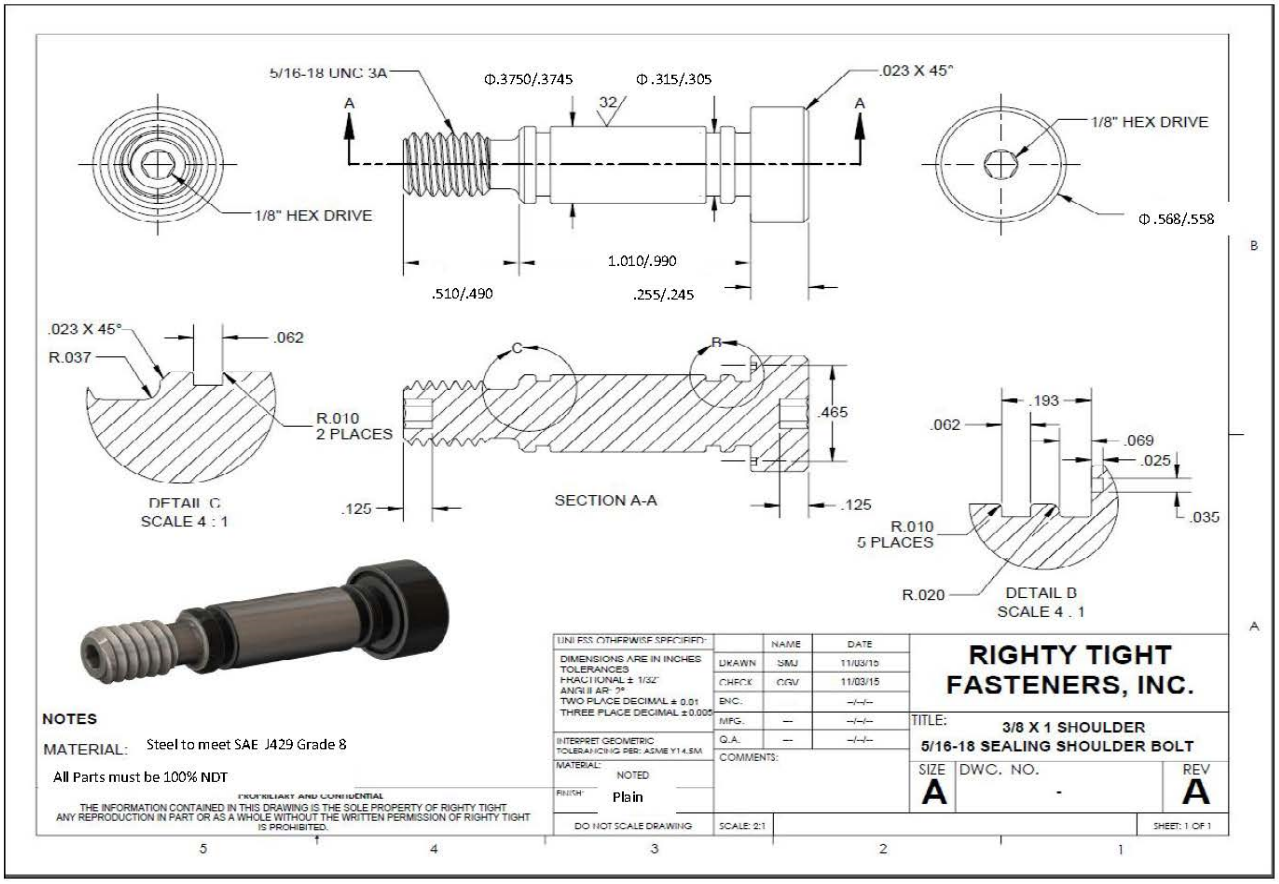
Section: 1-7 Feasibility Exercise

Revision: 04162020

Certified Fastener Specialist: Fastener Training Week
"Hands-On: Feasibility Exercise"

Feasibility Assignment



- Outline a “rough” manufacturing process
- Determine what can be done in-house and what needs to be outsourced
- Are there any parts of the operation you are not capable of meeting the quality requirements?
- Is there anything about the print that needs further clarification from the customer?
- Do you have the capacity to make the part?
- Does this part “fit” your operation?
- Is this an expensive or inexpensive part?
- What material would you quote for this job and why?
- Identify at least three cost drivers?
- Which requirements are going to require outsourcing?

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Outline a “Rough” manufacturing Process

- **Option 1:**
  - **Raw material**
  - **Head w/o end recess (2d3b Header)**
  - **Re-Head end recess**
  - **Shave upper grooves**
  - **Shave lower groove**
  - **Heat Treat**
  - **Centerless Grind**
  - **100%NDT**
  - **Final Inspection**
  - **Sort**
  - **Package**

- **Option 2:**
  - **Raw material**
  - **Head w end recess (4d4b Header)**
  - **Shave upper grooves**
  - **Shave lower groove**
  - **Heat Treat**
  - **Centerless Grind**
  - **100%NDT**
  - **Final Inspection**
  - **Sort**
  - **Package**

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Determine What you Can do In-house

- **Option 1:**
  - Raw material (Purchase)
  - Head w/o end recess (2d3b Header) (In-house)
  - Re-Head end recess (In-house)
  - Shave upper grooves (In-house TBD)
  - Shave lower groove (In-House TBD)
  - Heat Treat (Outsource)
  - Centerless Grind (Outsource)
  - 100%NDT (Outsource)
  - Final Inspection (In-house)
  - Sort (In-house)
  - Package (In-house)

- **Option 2:**
  - Raw material (Purchase)
  - Head w end recess (4d4b Header) (In-house)
  - Shave upper grooves (In-house TBD)
  - Shave lower groove (In-house TBD)
  - Heat Treat (Outsource)
  - Centerless Grind (Outsource)
  - 100%NDT (Outsource)
  - Final Inspection (In-house)
  - Sort (In-house)
  - Package (In-house)

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Feasibility Review- Meeting Quality Requirements

Are there any parts of the operation you are not capable of meeting the quality requirements?

- The .3750/.3745 Body Diameter has a tolerance of .0005”- Cold Heading would not be capable of holding this tight tolerance. Therefore, a grinding operation would be required to meet this tolerance. Additionally there is a surface finish requirement that may or may not be feasible for cold heading alone- this is another reason why grinding is necessary.

- The thread fit requirement is Class 3A, which requires tighter quality control than the standard 2A

- There is a requirement for 100% NDT- this is a non-destructive test for workmanship and surface quality. It is an extremely expensive and time consuming test, however.

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Feasibility Review- Missing Information

Is there anything about the print that needs further clarification from the customer

- There is no locating dimension for the lower groove- this would need to be resolved with customer before this part could be made
- Undercut geometry needs further clarification- as shown it is impossible to make- no radiuses at corners. The ideal solution would be to get enough radius and tolerance to put into the cold heading sequence. The alternative is another, added shaving operation.
- Clarify whether chamfers are needed or just a corner break?

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Feasibility Review- Capacity

Do you have the capacity to make the part?

Option A:

2d3b header: 120ppm x 224 min/day x 280 days/year = Annual Capacity 7,526,400
Reheader: 40ppm x 224 x 280 = Annual Capacity 2,508,800
Shave: 6ppm x 3 x 224 x 280 = Annual Capacity 1,128,960

Conclusion: Annual part volume is 1,375,000- Depending on the existing utilization of the equipment, you would be able to add this part to the header and reheader but do NOT have enough shaving capacity. In fact, because there are (2) shaving passes, the three shavers would only provide about ½ of the required capacity. Either new shavers would need to be invested in or one or both shaves would need to be outsourced.

Option B:
4d4b header: 80ppm x 224 x 280 = Annual Capacity 5,017,600

Conclusion: Once again, depending on utilization, addition of this part should be no problem BUT same restraint with the shaving operations.

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Feasibility Review- Other Questions

Is this an expensive or inexpensive part?
A: Yes, very expensive. Even at this volume this part is either pushing or exceeds $1 each

What material would you quote for this job and why?
A: Alloy Steel (4037, 4140, or 8740) SAEJ429 Grade 8 gives several options, the most expensive but safest choice, especially as you get larger in diameter, is Alloy Steel

Identify at least three cost drivers?
A:
1. Grade 8
2. Upper shaved grooves
3. Lower shaved groove and maybe chamfer
4. Class 3A threads
5. Centerless Ground Shank
6. Lower hex recess
7. 100% NDT
8. Possibly undercut depending on what customer needs

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Questions…

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Dimensional Standards Exercise

Section 2-3

Rev 11222024

Workbook

KEY

Purpose:

The purpose of this exercise is to further acquaint you with navigating and understanding standards, in this case Product (or Dimensional) Standards. This exercise will have you comparing and answering some questions regarding (5) broad fastener categories:

1. Bolts
2. Socket Products
3. Screws
4. Nuts
5. Washers

Unlike yesterday's *Navigating Standards* exercise where "getting the right answer was less important than gaining a feel for how standards are set-up and work, this exercise is all about practicing getting the right answer and gaining a deeper understanding of a small selection of the fastener standards that are out there.

Duration:

1 hour and 15-20 minute wrap-up discussion at the end of the day to go over your answers

Instructions:

Use the IFI Book of Standards to work through the Workbook Exercises

Exercise #1 – Bolts (Hex Head Products)

In your IFI Book of Standards- Locate:

- **ASME B18.2.1**
- **ASME B18.2.6**

1. What is the Title of ASME B18.2.1? ___Square , hex, heavy hex, and askew head bolts and hex, heavy hex, hex flange, lobed head, and lag screws (Inch Series)_____
2. What is the most current revision level? _ 2012_____
3. What is the Title of ASME B18.2.6? ___Fasteners for Use in Structural Applications
4. What is the most current revision level? __2019_____

- **Review the Scope of ASME B18.2.1**

1. How many different product types are included in this standard? ____9_____
2. What measurement system is used by this standard? _____Inch_____
3. What relationship do these products have to ISO standard products? ____None__
4. Explain the difference between a "Short Bolt/Screw" and a "Long Bolt/Screw"? _Short Bolt = Threaded the full length and Long Bolt = Not threaded the full length so a combination of threads and shoulder_____

- **Quickly Review the Text in sections 2,3,4, and 5**

1. What main theme does each section cover?
   2: ____General Data for Both Bolts and Screws_
   3: ____Bolts_____
   4: ____Screws_____
   5: ____Lag Screws_____

2. From Section 2: What is the thread inspection requirement for these products? ____System 21_____
3. From Section 2: What Thread Class are these products (except Lag Screws)? _____2A_____

4. From Section 2: What finish do these products receive? _____
_____It is the decision of the purchaser- default is plain or light oil_____

- **Review the Scope of ASME B18.2.6**

1. How many different product types are included in this standard? ___5_____
2. What measurement system is used by this standard? _____Inch_____

- **Quickly Review the Text in sections 2,3,4, 5, and 6**

1. What main theme does each section cover?

   2: _____Heavy Hex Structural Bolts_____

   3: _____Heavy Hex Nuts_____

   4: _____Hardened Steel Washers_____

   5: _____Compressible Washer-Type Direct Tension Indicators

   6: _____Twist-off Type Structural Bolts, Heavy Hex and Round

- **Referring to both standards, fill in the following Table for a ½" Diameter Example**

Product/Table	Full Body/Body Diameter	Basic Width Across Flats	Max Width Across Flats	Min Width Across Flats	Max Width Across Corners	Min Width Across Corners	Basic Head Height	Max Head Height	Min Head Height
Hex Bolts (Table 2)	.515/.482	3/4	.750	.725	.866	.826	11/32	.364	.302
Heavy Hex Bolts (Table 3)	.515/.482	7/8	.875	.850	1.010	.969	11/32	.364	.302
Hex Cap Screw (Table 6)	.500/.493	3/4	.750	.736	.866	.840	5/16	.323	.302
Heavy Hex Screws (Table 7)	.500/.482	7/8	.875	.850	1.010	.969	5/16	.323	.302
Heavy Hex Structural Bolts (Table 1)	.515/.482	7/8	.875	.850	1.010	.969	5/16	.323	.302

1. How is a Heavy Hex Bolt different than a Hex Bolt? ____Larger size hex, both Width Across Flats and Width Across Corners_____
2. How is a Hex Cap Screw different than a Hex Bolt? ____Smaller Body diameter and tighter tolerance, Same size but tighter WAF and WAC dimensions, and Thinner head_____
3. How is a Heavy Hex Structural Bolt different than a Heavy Hex Bolt? ____Structural bolt has a thinner head 5/16 versus heavy hex having 11/32_____

Bonus Question:

You may have noticed that the Basic Head Height of the Structural Bolts are less than that for a Heavy Hex and if you dug deeper into the standards you would see that the length tolerance for Structural Bolts (generally speaking) is unilateral and less than that for Heavy Hex Bolts. (For example, the tolerance for a ½" x 6" long heavy hex bolt is +0.12/-0.18 and for the same size structural bolt +0/-0.19. Why do you think these differences exist?

_____Most structural bolts are loaded in shear and not tension so that Grip Length control is important and material in head a little less important than for a tension application_____

Exercise #2 – Socket Products

In your IFI Book of Standards- Locate:

- **ASME B18.3**

1. What is the Title of ASME B18.3? __Socket Cap, Shoulder, Set Screws, and Hex Keys (Inch Series)_____
2. What is the most current revision level? _____2012_____

- **Review the Scope of ASME B18.3**

1. How many different product types are included in this standard? __4_____
2. How many different head styles are included in this standard? ____7_____
3. In addition to the product types, what else does the scope say is included in the standard? ____Gages, Keys and Bits, and Drill and Counterbore Sizes_____
4. What measurement system are these products in? _____Inch_____

- **Quickly Review the Text in sections 1 and 2**

1. What main theme does each section cover?
   1: ___Scope_____
   2: ___General Data_____

2. From Section 2: What is the thread inspection requirement for these products? ____System 22_____
3. From Table 1: What Thread Class is a Socket Head Cap Screw? _____3A_____
4. From Table 1: What thread series are Socket Head Cap Screws?_UNRC and UNRF__
5. From Section 2: What finish do these products receive? ___Per material standard but generally plain or black oxide- they should not be electroplated_____

- **Referring to the standard, fill in the following Table:**
  [Use a ½" diameter to answer columns 3-8]

(1)Product/Table	(2)Range of Product Size	(3)Max Body Diameter	(4)Min Body Diameter	(5)Min Head Diameter	(6)Max Head Diameter	(7)Min Head Height	(8)Max Head Height
Socket Head Cap Screw (Table 12)	#0-4"	0.500	0.4919	0.750	0.725	0.500	0.492
Socket Flat Countersunk Head Cap Screw (Table 8)	#0-1 ½"	X	X	X	X	X	X
Socket Button Head Cap Screw (Table 11)	#0-3/4	X	X	X	X	X	X
Low Head Socket Head Cap Screws (Table 12)	#4- 5/8	0.500	0.4919	0.750	0.743	0.254	0.244
Socket Head Shoulder Screws (Table 13)	1/8"-2"	0.4980	0.4960	0.750	0.729	0.312	0.302
Socket Set Screws (Table 14)	#0-2"	X	X	X	X	X	X

1. How do the head dimensions on a ½ Socket Cap Screw compare to a ½ Hex Cap Screw?
   _____Socket Head Cap diameter is nearly equal to the Across flats (so smaller overall bearing area) and significantly taller head_____

Exercise #3 – Nuts

In your IFI Book of Standards- Locate:

- **ASME B18.2.2**
- **ASME B18.16.4**
- **ASME B18.16.6**

1. What is the Title of ASME B18.2.2? ___Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)_____
2. What is the most current revision level? _____2022_____
3. What is the Title of ASME B18.16.4? ____Serrated Hex Flange Locknuts 90000 PSI (Inch Series)_____
4. What is the most current revision level? _____2008 (Reaffirmed 2013)_____
5. What is the Title of ASME B18.16.6? ____Prevailing Torque Locknuts (Inch Series)____
6. What is the most current revision level? _____2017_(Reaffirmed 2022)_____

- **Review the Scope of ASME B18.2.2**

1. What product does the standard cover? _____
   _____Machine, Square, and Hex Nuts _____
2. What relationship is this standard to ISO products? _____None_____

- **Quickly Review the Text in section 3**

1. What main theme of this section?
   3: ___General Data_____

2. What is the thread class?
   _____2B_____
3. What does it say about Grade and ID Marking?_____ _____
   _____Follow the instructions of the material standard_____
4. What does it say about corner fill? _____
   _____Basically that it must fall within the WAC specification_____

Bonus Question:

Why is Corner Fill important? ____Rounded corners strip easily when torque is applied to the wrench___

- **Referring to the standard, fill in the following Tables:**

Product (Table)	Size Range
Square + Hex Machine Screw Nuts (Table 1.1.1-1)	#0-3/8"
Small pattern Hex Machine Screw Nuts (Table 1.1.1-2)	#0-#10
Square Nuts (Table 1.1.1-3)	¼"-1 ½"
Hex Flat +Hex Flat Jam Nuts (Table 1.1.1-4)	1 1/8"- 1 ½"
Hex Nuts + Hex Jam Nuts (Table 1.1.1-5)	¼" -4"
Hex Slotted Nuts (Table 1.1.1-6)	¼" -1 ½"
Hex Thick Nuts (Table 1.1.1-7)	¼" – 1 ½"
Hex Thick Slotted Nuts (Table 1.1.1-8)	¼" – 1 ½"
Heavy Square Nuts (Table 1.1.1-9)	¼" – 1 ½"
Heavy Hex Flat + Heavy Flat Jam Nuts (Table 1.1.1-10)	1 1/8" – 4"
Heavy Hex + Heavy Jam Nuts (Table 1.1.1-11)	¼" – 4"
Heavy Hex Slotted (Table 1.1.1-12)	¼" – 4"
Hex Flange + Large Hex Flange Nuts (Table 1.1.1-13)	#6 -3/4" and ¼"- 5/8"
Coupling Nuts Table 1.1.1-14)	#6 – 6"

- **Refer to Tables 1.1.1-5 (Table 4 in 11th) and 1.1.1-11 (Table 10 in 11th), Fill out for a ½" size Nut:**

Product/Table	Min Width Across Flats	Max Width Across Flats	Min Width Across Corners	Max Width Across Corners	Min Hex Thickness	Max Hex Thickness
Hex + Hex Jam Nuts (Table 1.1.1-5)	0.736	0.750	0.840	0.866	0.427	0.448
Heavy Hex + Heavy Jam Nuts (Table 1.1.1-11)	0.850	0.875	0.969	1.010	0.464	0.504

1. How are Heavy Hex Nuts different than Hex Nuts? _____Larger WAF, WAC, and Thicker_____

Exercise #4 – Machine and Tapping Screws

In your IFI Book of Standards- Locate:

- **ASME B18.6.3**

1. What is the Title of ASME B18.6.3? ___Machine Screws, Tapping Screws, and Metallic Drive Screws (Inch Series)_____
2. What is the most current revision level? _____2024_____

- **Review the Scope of ASME B18.3**

1. How many different product types are included in this standard? ____3_____
2. What relationship do these products have with ISO Products?_____None_____

- **Quickly Review the Text in sections 2,3,4, and 5**

1. What main theme does each section cover?
   2: _____General Data for Machine Screws and Tapping Screws
   3: _____General Data for Machine Screws_____
   4: _____General Data for Tapping Screws_____
   5: _____General Data for Metallic Drive Screws

2. How many head types are included in this standard for Machine and Tapping Screws? _____12_____
3. What inspection system is used for Machine Screws? __System 21_____
4. What are the material options for Machine Screws?
   - __Carbon Steel Unhardened_____
   - __Carbon Steel Hardened_____
   - __Other materials such as Stainless Steel
   - __and nonferrous_____
5. Name the (7) different Tapping screw types that form their own thread in this standard?
   1. ____AB_____
   2. ____ABR_____
   3. ____B_____
   4. ____BP_____

5. _____A_____
6. _____C_____
7. _____TRS_____

6. List at least (2) (of the 5) Performance Tests that might be conducted on Tapping Screws?

1. ____Drive Test_____
2. ____Drive Torque Test_____
3. ____Torsional Strength_____
4. ____Ductility Test_____
5. ____Hydrogen Embrittlement Test_____

Exercise #5 – Washer Products

In your IFI Book of Standards- Locate:

- **ASME B18.21.1**
- **ASTM F2437/F2437M**

1. What is the Title of ASME B18.21.1? ____Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)_____
   _____
2. What is the most current revision level? _____2009 (Reaffirmed 2016)_____
3. What is the Title of ASTM F2437/F2437M ____Carbon and Alloy Steel Compressible-Washer-Type Direct Tension Indicators for Use With Cap Screws, Bolts, Anchors, and Studs_____
4. What is the current revision level? _____2019_____

- **Review the Scope of ASME B18.21.1**

1. How many different product types are included in this standard? ___3_____
2. How does this standard relate to ISO Products? _____No Relation_____
3. What size range is included for Plain Washers? _____ #0-3”_____

- **Quickly Review the Text in sections 2,3, and 4**

1. What main theme does each section cover?
   2: ____General Data for Helical Spring Lock Washers
   3: ____General Data for Tooth-Lock Washers___
   4: ____General Data for Plain Washers (Flat and Fender)

2. What are the three types of Plain Washers?
   1. ____Type A_____
   2. ____Type B_____
   3. ____Fender_____

3. What is each Plain Washer Type intended to do?

1._____Type A - Minimize embedment_____

2._____Type B - Distribute Load_____

3._____Fender - Cover oversize holes or slots and distribute load over large areas

- **Review the Scope of ASTM F2437/F2437M**

1. What Product does this standard cover? _____
__Carbon and Allow Steel Compressible-Type Direct Tension Indicators (DTIs)___

2. How many different types are included in this standard? _____
___2 Styles, 4 Grades, and 2 Property Classes _____

3. What size range is included for these washers? _____1/4”-2 ½” and M6-M72____

4. What measurement system does this standard use? ___Inch and Metric_____

5. What are these products used with and/or for? ____Under a Bolt or Cap Screw head, under a hex nut, or against a hardened washer or other flat hardened surface – usually used in structural bolting _____

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Section: 2-9 Review of Certification Case Study

Revision: 04102024

Certified Fastener Specialist: Fastener Training Week
"Review of Certification Case Study"

STARTING QUESTIONS

What did the customer want?

- Round headed bolt
- Hot hip galvanized
- Per ASTM A449

- **Did the supplier provide bolts that satisfy the customer's request?**
  - ✓Round head
  - ✓Hot dip galvanized

- **Do the parts that were supplied meet ASTM A449?**

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Items in Question- Material Cert

In ASTM A449 the Carbon Range for Alloy Boron Steel is .28-.55. This is out-of-range. (Note: Boron is in range but just barely- it is near the max of .003)

Material Cert

Date: 14-Apr-14
Customer Name :
Customer Address :
P/O No. : 420924 & 421067
Part No. : 708042536
Description : A449 ROUND HEAD TC Bolt, Without nut & Washer, Steel, Per A449 Spec
Size : 7/8-9 X 7"
Finish : Hot Dip Galvanized
Specification : Head Marking: A449 + Mfg's ID

Brand: 20MnTiB

Chemical Analysis(%)

Heat No.	Dia (mm)	C	Si	Mn	P	S
3105764	29	0.2200	0.2300	1.5200	0.0130	0.0050
		Cr	Ni	Mo	Cu	W
		0.0400	0.0200	0.0010	0.0300	0.0030
		V	Ti	B	Al	Als
		0.0030	0.0600	0.0027	0.0240	0.0220

Heat Treatment			Technical & Mechanical Performance						
˚C	Time	Medium	Re Mpa	Rm Mpa	Z %	A %	AK Single Value	AK T ˚C	Hot Forge
960	50	Oil	1071	1388	62	15	127		OK
200	60	Water	1063	1358	62	14	132		OK

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WHAT ABOUT THE “QUALITY” OF THE CERTS?

- Bad
- Bad
- **Worse!**

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Items in Question- Test Report

Test Report

Report No. : R20140415060 | **Application No. : A20140414-061**

Description	: A449 Round Head TC Bolt without Nut & Washer	Applicant	:
		Applicant Address	: Dist, Kaohsiung City 829, Taiwan. R.O.C.
Size	: 7/8-9x7		
Finish	: HDG	Receipt Date	: 2014/4/14
Sampler	:	Inspection Date	: 2014/4/15
Sample Size	: 4 Pcs		
Lot No.	: 20140409	Reference PO No.	: 420924&421067
Lot Quantity	: Pcs	Reference Line Item No.	:
Heat No.	: 3105764	Reference Part No.	: 708042536
Material Type	: Steel	Reference Print No.:	Revision:

Dimensional Inspection

Item	Characteristics	Sample (pcs)	Specification	Test Method	Requirement	Unit	Actual Result	Acc.	Rej.	Gage No.
1	Appearance	4	ASTM F788	Visual			OK	4	0	Visual
2	Head Diameter	4	IFI 7th	JIS B1071-1985	1.880 - Max	Inch	1.574 - 1.588	4	0	V-001
3	Head Height	4	IFI 7th	JIS B1071-1985	0.531 - 0.563	Inch	0.562 - 0.563	4	0	Z-005
4	Body Diameter	4	IFI 7th	JIS B1071-1985	0.852 - 0.895	Inch	0.863 - 0.864	4	0	V-001
5	Bearling Diameter	4	IFI 7th	JIS B1071-1985	1.535 - Min	Inch	***1.496 - 1.498***	***0***	***4***	Z-005
6	Thread Length	4	IFI 7th	JIS B1071-1985	1.500 - Ref	Inch	1.562 - 1.564	4	0	Z-005
7	Spline Length	4	IFI 7th	JIS B1071-1985	0.720 - Ref	Inch	0.825 - 0.854	4	0	Z-005
8	Spline A/F	4	IFI 7th	JIS B1071-1985	0.610 - Ref	Inch	0.609 - 0.310	4	0	Z-005
9	Spline	4	IFI 7th	JIS B1071-1985	12	Teeth	OK	4	0	Visual
10	Grip Gaging Length	4	IFI 7th	JIS B1071-1985	0.280 - Ref	Inch	0.208 - 0.212	4	0	Z-005
11	Center of Groove to 1st Fully Form Thread	4	IFI 7th	JIS B1071-1985	0.278 - Max	Inch	0.276 - 0.278	4	0	Z-005
12	Groove Angle	4	IFI 7th	JIS B1071-1985	55° - 65°	Degree	Undefined test Position			
13	Head Marking	4	IFI 7th	JIS B1071-1985	A449+CHLI		OK	4	0	Visual
14	Go Gauge	4	IFI 7th	JIS B1071-1985	Nut		OK	4	0	
15	Length	4	IFI 7th	JIS B1071-1985	6.75 - 7.00	Inch	6.872 - 6.873	4	0	Z-005
16	Finish	4			HDG		OK	4	0	Visual

Physical Properties

Item	Characteristics	Sample (pcs)	Specification	Test Method	Requirement	Unit	Actual Result	Acc.	Rej.	Gage No.
17	Core Hardness	1	Per IFI 7th	ASTM E18-11	25 - 34	HRC	32 - 32	1	0	Z-001
18	Tensile Strength	1	Per IFI 7th	ASTM F606-11a	120000 - Min	Psi	142815 - 142815	1	0	

1. A449 and TC Bolt (ASTM F3125/F3125M Grade A325TC) are not equivalent
2. Twist-Off (TC) Bolts are not to be separated, i.e. they must be sold as an assembly

3. We don't know what lot size or sampling plan standard is being utilized so we can't be sure if the Sample Size is adequate or not.

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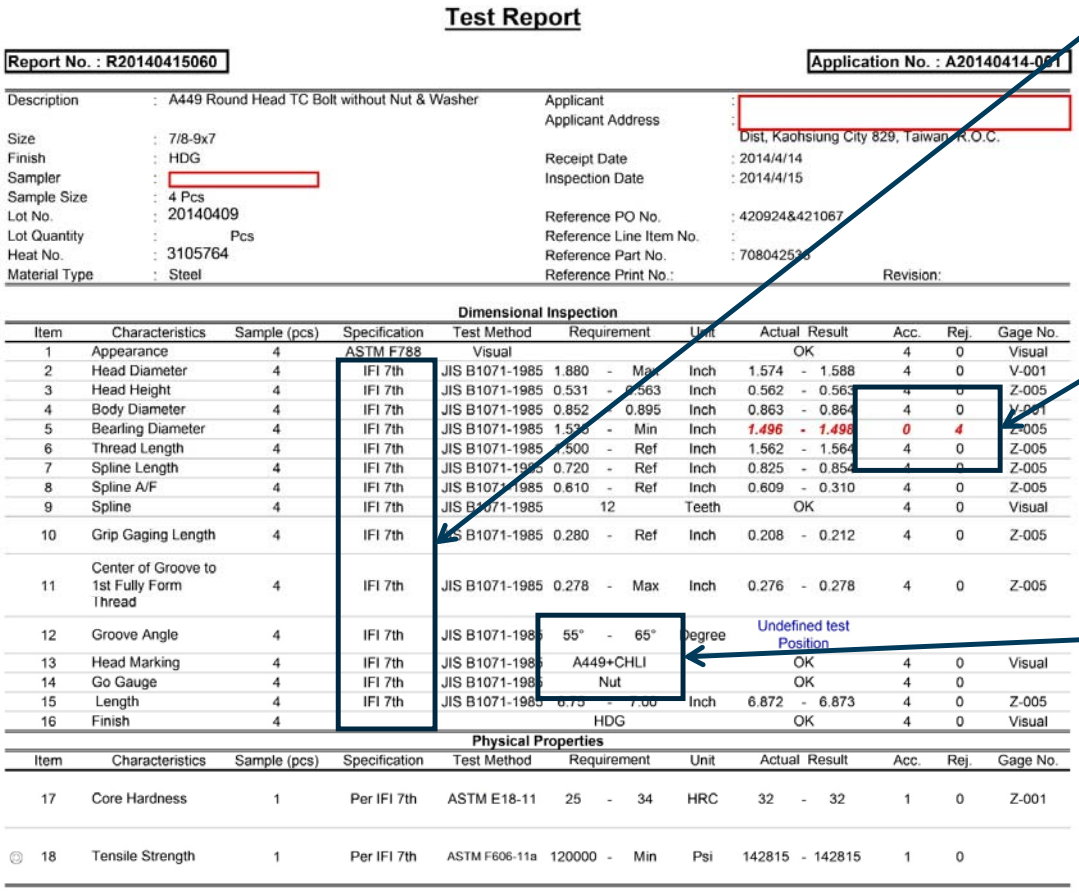
Items in Question- Test Report



Test Report

Report No. : R20140415060 **Application No. : A20140414-001**

Description	: A449 Round Head TC Bolt without Nut & Washer		Applicant	:	
			Applicant Address	:	Dist, Kaohsiung City 829, Taiwan, R.O.C.
Size	: 7/8-9x7				
Finish	: HDG		Receipt Date	: 2014/4/14	
Sampler	:		Inspection Date	: 2014/4/15	
Sample Size	: 4 Pcs				
Lot No.	: 20140409		Reference PO No.	: 420924&421067	
Lot Quantity	: Pcs		Reference Line Item No.	:	
Heat No.	: 3105764		Reference Part No.	: 70804253	
Material Type	: Steel		Reference Print No.:		Revision:

Dimensional Inspection

Item	Characteristics	Sample (pcs)	Specification	Test Method	Requirement	Unit	Actual Result	Acc.	Rej.	Gage No.
1	Appearance	4	ASTM F788	Visual			OK	4	0	Visual
2	Head Diameter	4	IFI 7th	JIS B1071-1985	1.880 - Ma	Inch	1.574 - 1.588	4	0	V-001
3	Head Height	4	IFI 7th	JIS B1071-1985	0.531 - 0.563	Inch	0.562 - 0.563	4	0	Z-005
4	Body Diameter	4	IFI 7th	JIS B1071-1985	0.852 - 0.895	Inch	0.863 - 0.864	4	0	V-001
5	Bearing Diameter	4	IFI 7th	JIS B1071-1985	1.5[illegible] - Min	Inch	*1.496 - 1.498*	*0*	*4*	Z-005
6	Thread Length	4	IFI 7th	JIS B1071-1985	1.500 - Ref	Inch	1.562 - 1.564	4	0	Z-005
7	Spline Length	4	IFI 7th	JIS B1071-1985	0.720 - Ref	Inch	0.825 - 0.854	4	0	Z-005
8	Spline A/F	4	IFI 7th	JIS B1071-1985	0.610 - Ref	Inch	0.609 - 0.310	4	0	Z-005
9	Spline	4	IFI 7th	JIS B1071-1985	12	Teeth	OK	4	0	Visual
10	Grip Gaging Length	4	IFI 7th	JIS B1071-1985	0.280 - Ref	Inch	0.208 - 0.212	4	0	Z-005
11	Center of Groove to 1st Fully Form Thread	4	IFI 7th	JIS B1071-1985	0.278 - Max	Inch	0.276 - 0.278	4	0	Z-005
12	Groove Angle	4	IFI 7th	JIS B1071-1985	55° - 65°	Degree	Undefined test Position			
13	Head Marking	4	IFI 7th	JIS B1071-1985	A449+CHLI		OK	4	0	Visual
14	Go Gauge	4	IFI 7th	JIS B1071-1985	Nut		OK	4	0	
15	Length	4	IFI 7th	JIS B1071-1985	6.75 - 7.00	Inch	6.872 - 6.873	4	0	Z-005
16	Finish	4			HDG		OK	4	0	Visual

Physical Properties

Item	Characteristics	Sample (pcs)	Specification	Test Method	Requirement	Unit	Actual Result	Acc.	Rej.	Gage No.
17	Core Hardness	1	Per IFI 7th	ASTM E18-11	25 - 34	HRC	32 - 32	1	0	Z-001
18	Tensile Strength	1	Per IFI 7th	ASTM F606-11a	120000 - Min	Psi	142815 - 142815	1	0	

4. IFI 7th is not a valid specification to reference
5. JIS B1071-1985 does not appear in the IFI 7th edition. There is also a newer 2010 revision. (Note: This may not be considered wrong, only inconsistent)

6. They report all four samples failing this requirement but certify that the parts conform. There is no explanation or documentation that a deviation was requested and accepted for this out-of-specification condition

7. Is this an A449 or a TC Bolt? If it is considered a TC Bolt as the description implies, this head marking is incorrect

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Items in Question-Material Cert

Material Cert

Date: 14-Apr-14
Customer Name :
Customer Address :
P/O No. : 420924 & 421067
Part No. : 708042536
Description : A449 ROUND HEAD TC Bolt, Without nut & Washer, Steel, Per A449 Spec
Size : 7/8-9 X 7"
Finish : Hot Dip Galvanized
Specification : Head Marking: A449 + Mfg's ID
Brand: 20MnTiB

Chemical Analysis(%)

Heat No.	Dia (mm)	C	Si	Mn	P	S
3105764	29	0.2200	0.2300	1.5200	0.0130	0.0050
		Cr	Ni	Mo	Cu	W
		0.0400	0.0200	0.0010	0.0300	0.0030
		V	Ti	B	Al	Als
		0.0030	0.0600	0.0027	0.0240	0.0220

Heat Treatment			Technical & Mechanical Performance						
˚C	Time	Medium	Re Mpa	Rm Mpa	Z %	A %	AK Single Value	AK T ˚C	Hot Forge
960	50	Oil	1071	1388	62	15	127		OK
200	60	Water	1063	1358	62	14	132		OK

1. A449 and TC Bolt (ASTM F3125/F3125M Grade A325TC) are not equivalent
2. Twist-Off (TC) Bolts are not to be separated, i.e. they must be sold as an assembly

7. Is this an A449 or a TC Bolt? If it is considered a TC Bolt as the description implies, this head marking is incorrect

FASTENER TRAINING INSTITUTE

Items in Question- Material Cert

Material Cert

Date:	14-Apr-14
Customer Name	:
Customer Address	:
P/O No.	: 420924 & 421067
Part No.	: 708042536
Description	: A449 ROUND HEAD TC Bolt, Without nut & Washer, Steel, Per A449 Spec
Size	: 7/8-9 X 7"
Finish	: Hot Dip Galvanized
Specification	: Head Marking: A449 + Mfg's ID

Brand: 20MnTiB

Chemical Analysis(%)

Heat No.	Dia (mm)	C	Si	Mn	P	S
3105764	29	0.2200	0.2300	1.5200	0.0130	0.0050
		Cr	Ni	Mo	Cu	W
		0.0400	0.0200	0.0010	0.0300	0.0030
		V	Ti	B	Al	Als
		0.0030	0.0600	0.0027	0.0240	0.0220

Heat Treatment			Technical & Mechanical Performance						
˚C	Time	Medium	Re Mpa	Rm Mpa	Z %	A %	AK Single Value	AK T ˚C	Hot Forge
960	50	Oil	1071	1388	62	15	127		OK
200	60	Water	1063	1358	62	14	132		OK

9. This information is, at best confusing, and potentially flags something very dangerous. Line one seems to show a Q&T operation at 960 C and oil quench. The result is an UTS of about 1000MPa, roughly equivalent to the reported value of 143ksi in the Test Report. The second line suggests a 60 minute temper at 200C. This is way too low to accomplish anything and half the minimum value of about 430C required by the A449 Specification. The resulting change to UTS is negligible. These bolts are very likely brittle.

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What would you do?

- This is a special order ➔ look at the certs before buying
- Proper sales practice
  - Contract review
  - APQP

BUYER BEWARE!

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Questions…

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Using a Caliper Exercise- KEY

Required:

- Dimensional Worksheet
- Calipers
- Bolt
- Nut
- Pen/Pencil
- IFI Book of Fastener Standards

Exercise Instructions:

Using the supplied calipers measure and record the characteristics of the Hex Cap Screw(s) and Nut in the Table below. Using the IFI Book of Standards, locate the standard that provides dimensional information for this product and locate the actual size part you measured. Provide a thorough description of the Product tested.

	Hex Across Flats	Hex Across Corners	Major Diameter	Shoulder Diameter	Hex Height	Grade	Overall Length
Hex Cap Screw 1	.812/798	.938/.910	.5609/.5495	.5625/.5545	.371/.348	Grade 8	3

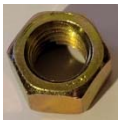
Hex Cap Screw Description:

9/16-12 x 3” Grade 8 Hex Cap Screw

	Hex Across Flats	Hex Across Corners	Major Diameter	Shoulder Diameter	Hex Height	Grade	Overall Length
Hex Cap Screw 2	.938/.922	1.083/1.051	.6233/.6112	.6250/.6170	.403/.378	Grade 5	2 1/2

Hex Cap Screw Description:

5/8-11 x2 ½" Grade5 Hex Cap Screw



	Hex Across Flats	Hex Across Corners	Minor Diameter	Hex Height	Grade
Nut 1	.938/.922	1.083/1.051	.5460/.5270	.559/.535	Grade 8

Nut Description:

5/8 -11 -2B Grade 8 Hex Nut

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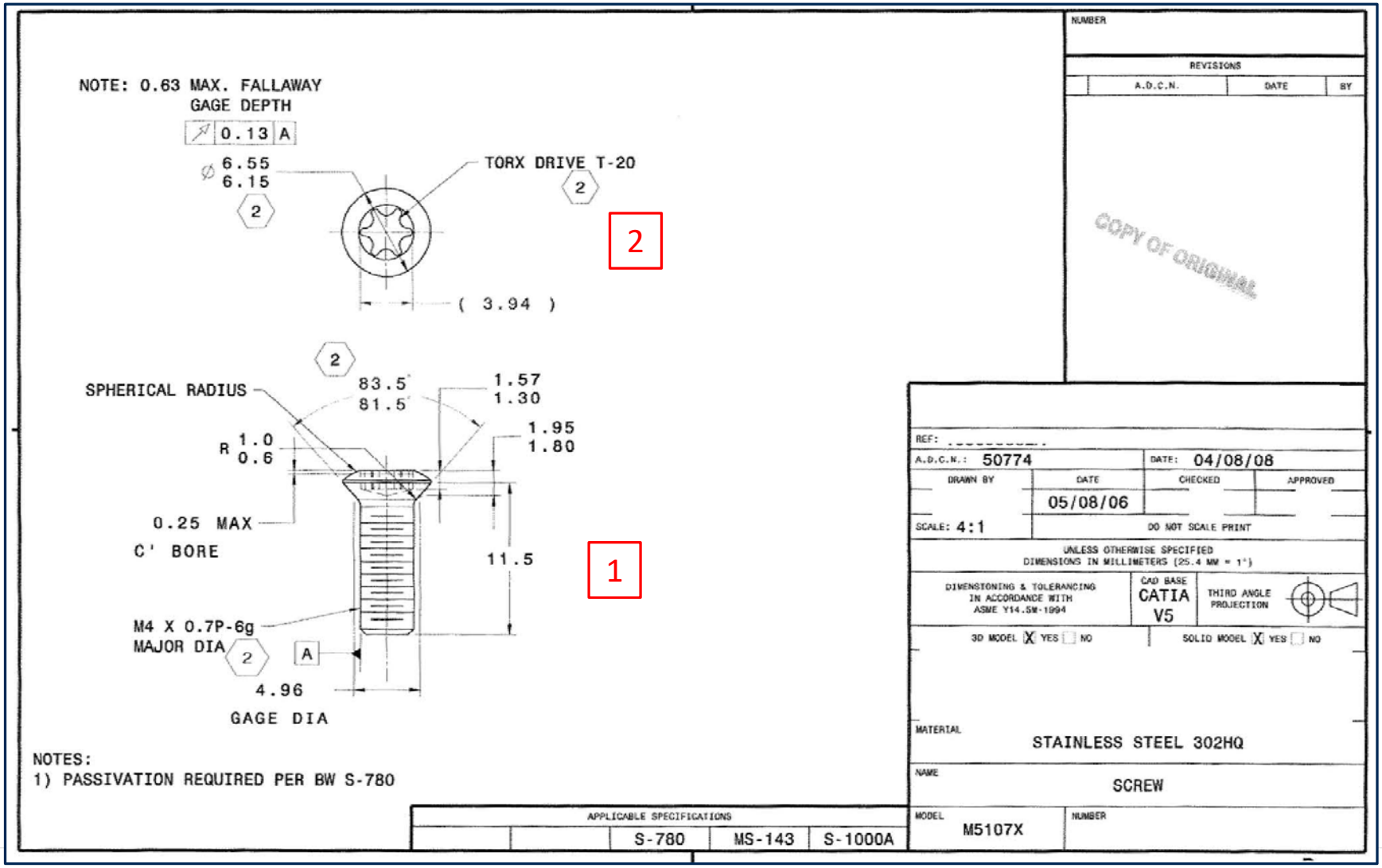
Section: 4-2 Print Comprehension Exercise Review

Revision: 04272020

Certified Fastener Specialist: Fastener Training Week
"Print Comprehension- Exercise Review"



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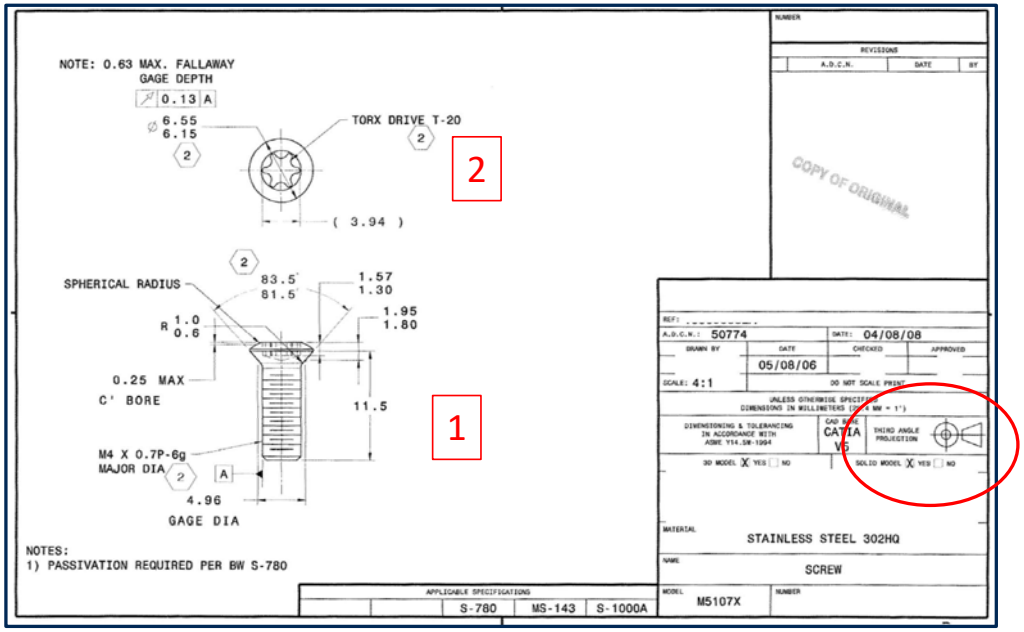
Print #1

1. **What Projection Convention is this print drawn to? Which part view is View 1? Which part view is View 2?**

   - **Third Angle Projection**
   - **View 1 = Front View**
   - **View 2 = Top View**



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Print #1

2. What is the part material?

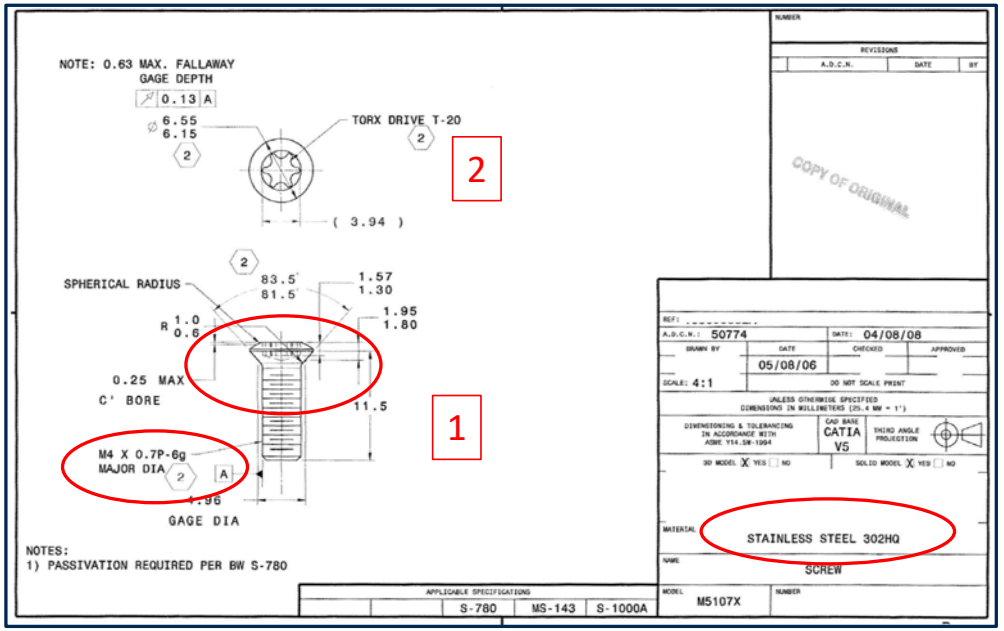
- **302HQ Stainless Steel**

3. What do the Hidden Lines in View 1 tell you?

- **The shape of the recess and defines the depth of the recess**

4. What is the Thread Class?

- **6g**



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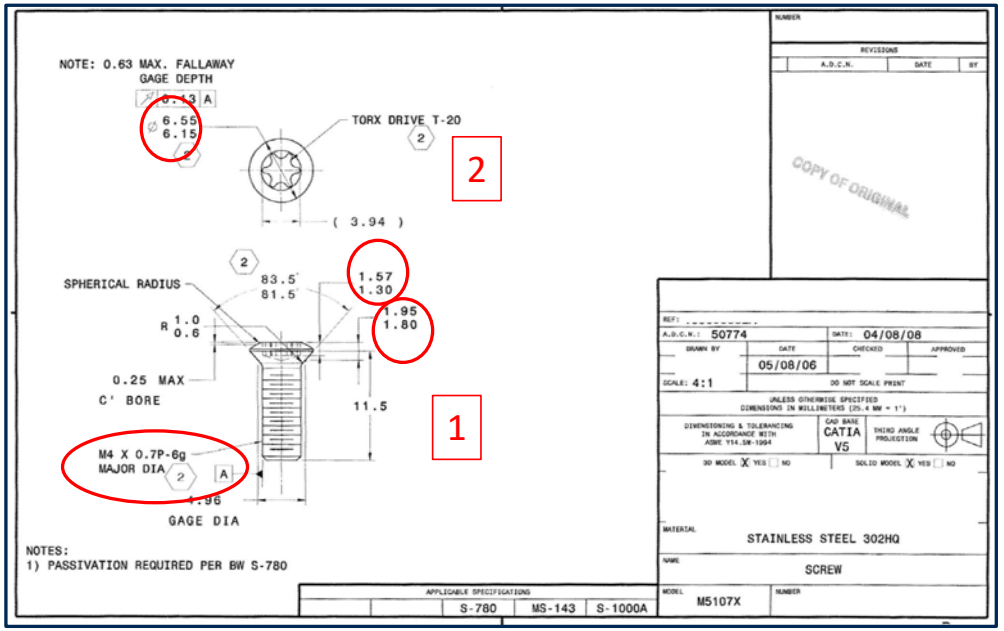
Print #1

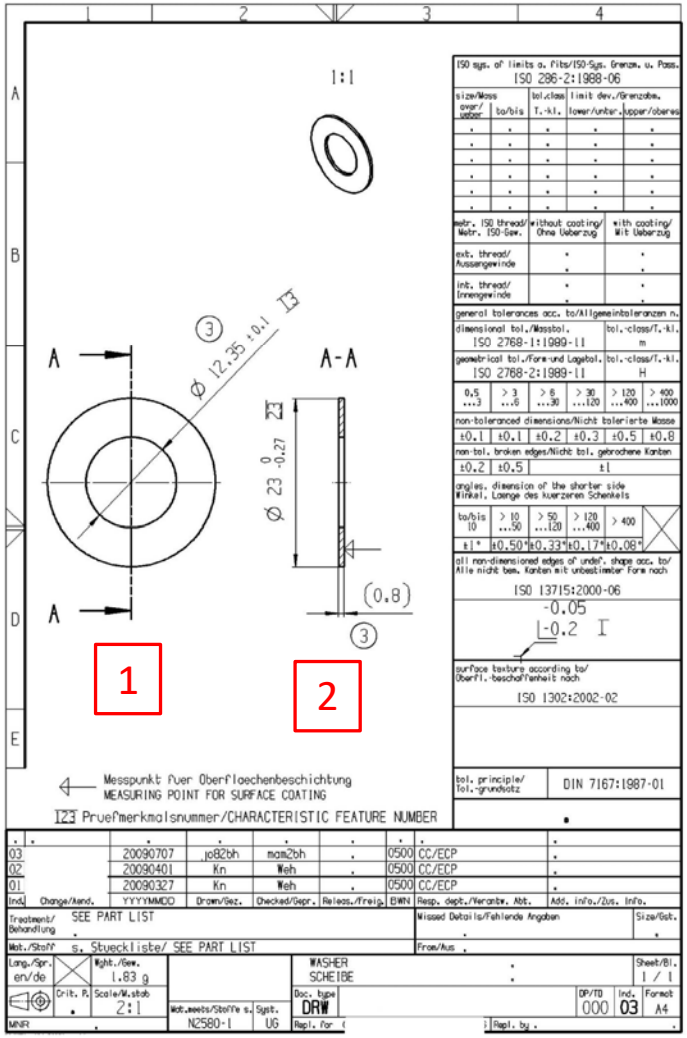
5. What is the recess penetration depth, head height, and head diameter?

- **1.57/1.30 = Recess Penetration Depth**
- **1.95/1.80 = Head Height**
- **6.55/6.15 = Head Diameter**

6. Bonus Question: What is Datum A?

- **Datum A is the M4 Threads. Normally the default when a thread is chosen is the Pitch Diameter. In this case, however, the "Major Diameter" is specified, so it is the datum.**

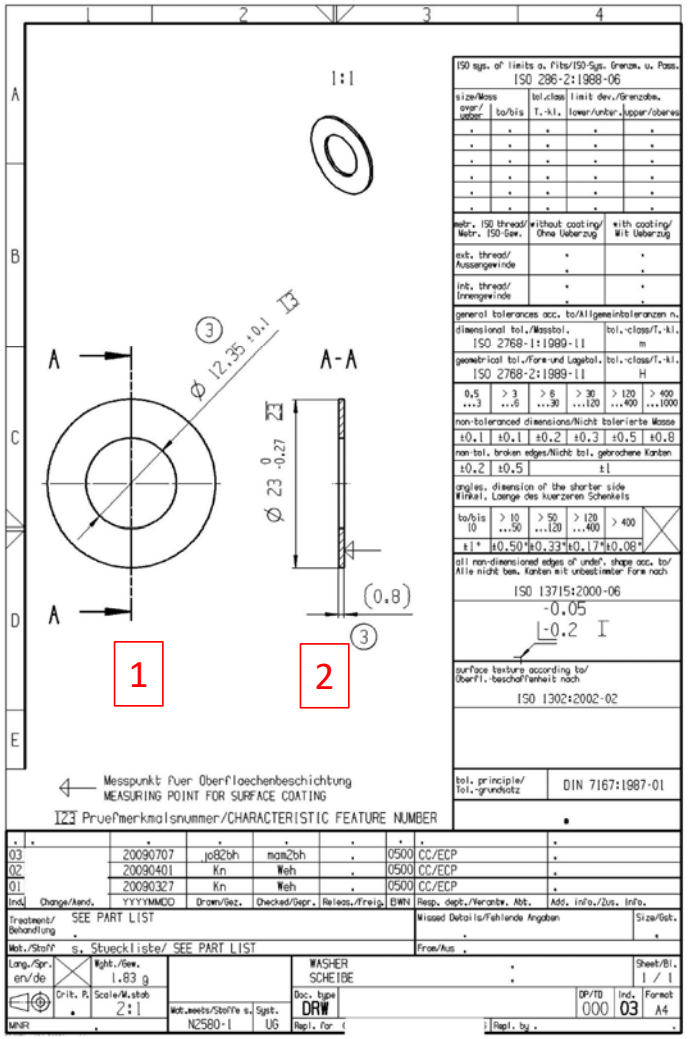




Print #2

1. **What projection convention is the print drawn in? Which part is View 1? Which part is View 2?**

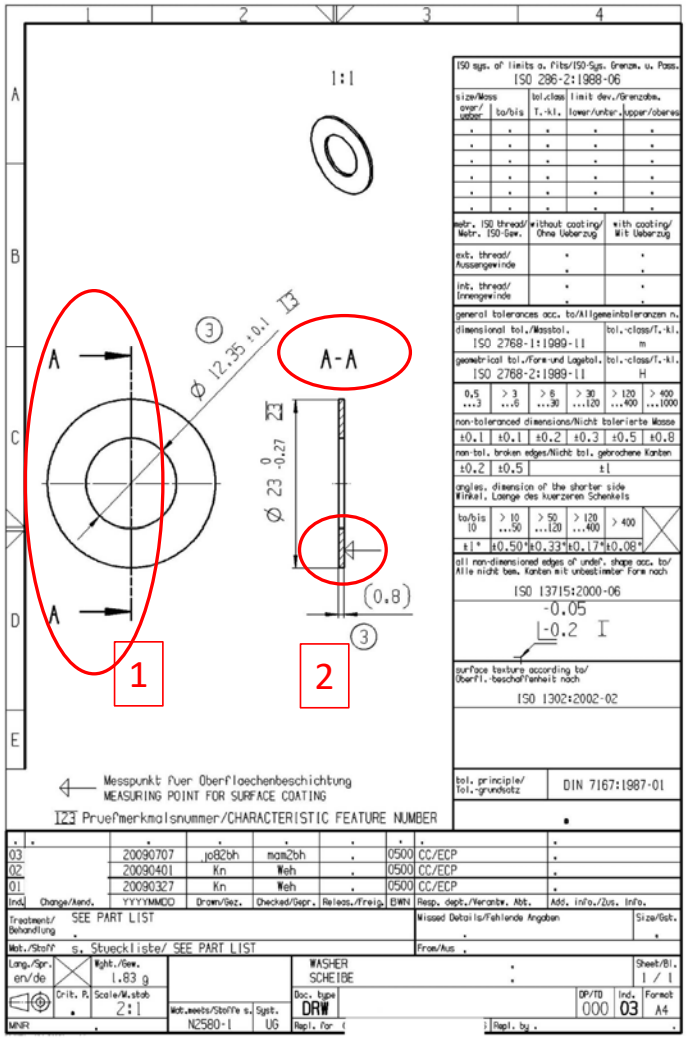
- **First Angle Projection**
- **Front View**
- **Section A-A (If this was not a Section View, this is the position for the Left Side View)**



Print #2

2. What type of view is View 2? How do you know this?

- **Section View**
- **Presence of Cutting Plane Line A-A**
- **Title “A-A”, Often this will have the title “Section” in front of “A-A”**
- **Diagonal Section Lines**



Print #2

3. What kind of tolerance is the Washer ID? Washer OD?

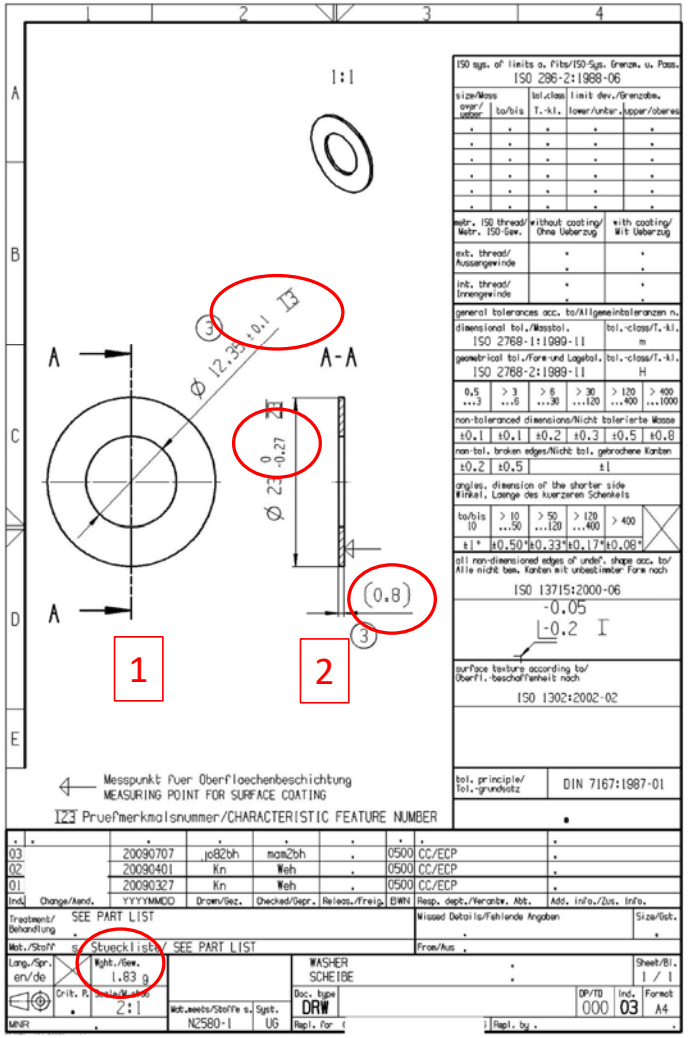
- **Washer ID = Bi-Lateral Tolerance**
- **Washer OD = Uni-Lateral Tolerance**

4. How much does the part weigh?

- **1.83g**

5. What do the brackets on the thickness dimension mean?

- **That it is an uncontrolled reference dimension**



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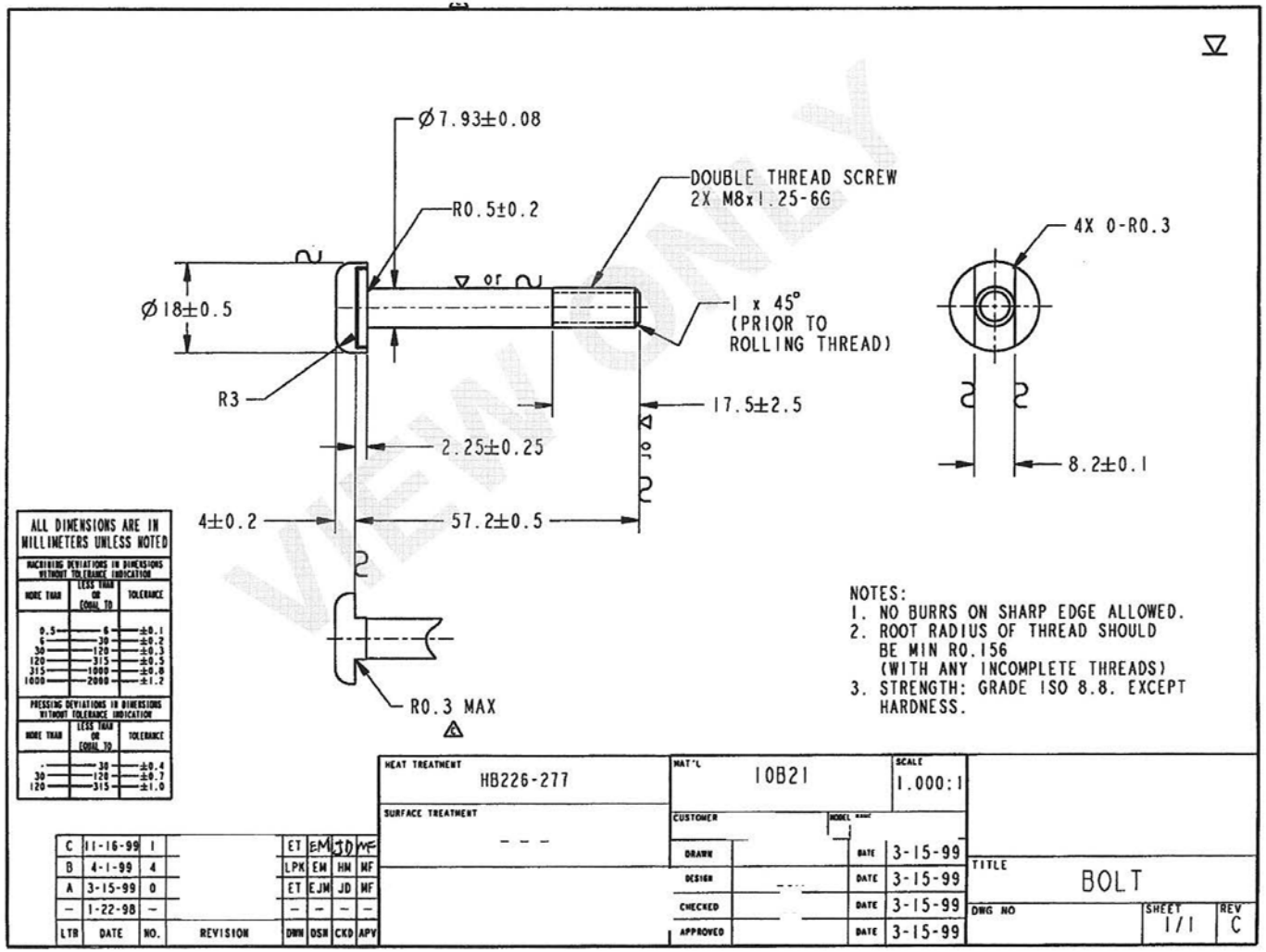
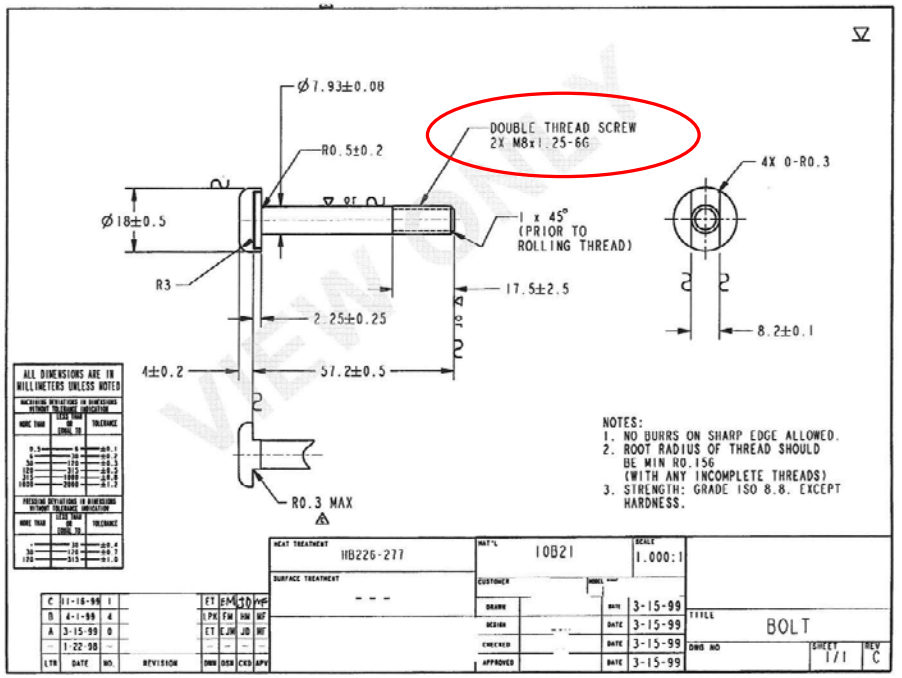


Print #3

1. **What does the thread designation "2x M8 x 1.25-6G" tell us? Is there anything wrong with this designation?**

   - **The intention of the "2x" is that it is a double lead thread**
   - **There is one thing definitely wrong and one that might be better- the "2x" would probably be better after the rest of the thread designation . The item that is definitely wrong is the "G". This is an external thread so that the Tolerance Position designation should be a small "g".**



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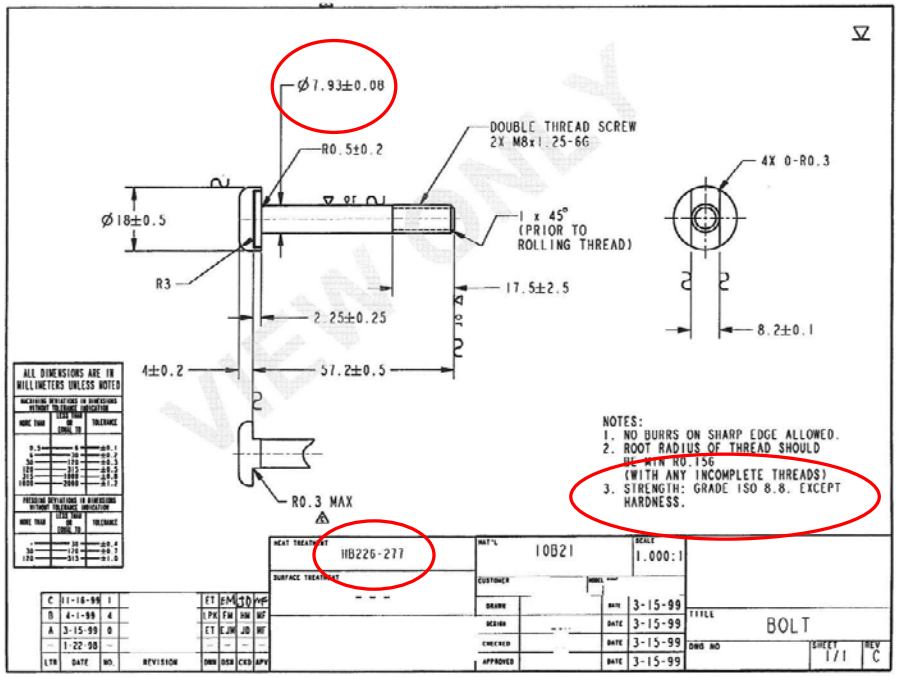
Print #3

2. What is the unthreaded shank diameter?

- **7.93 +/- 0.08**

3. What is the heat treatment?

- **Heat treat to ISO 8.8, which is a quench and temper process, but there is a hardness exception to HB226-277, which is HRC 20-29. The standard for 16mm or less is HRC 22-32. Therefore, it is not really an 8.8 and can't be promoted as such.**



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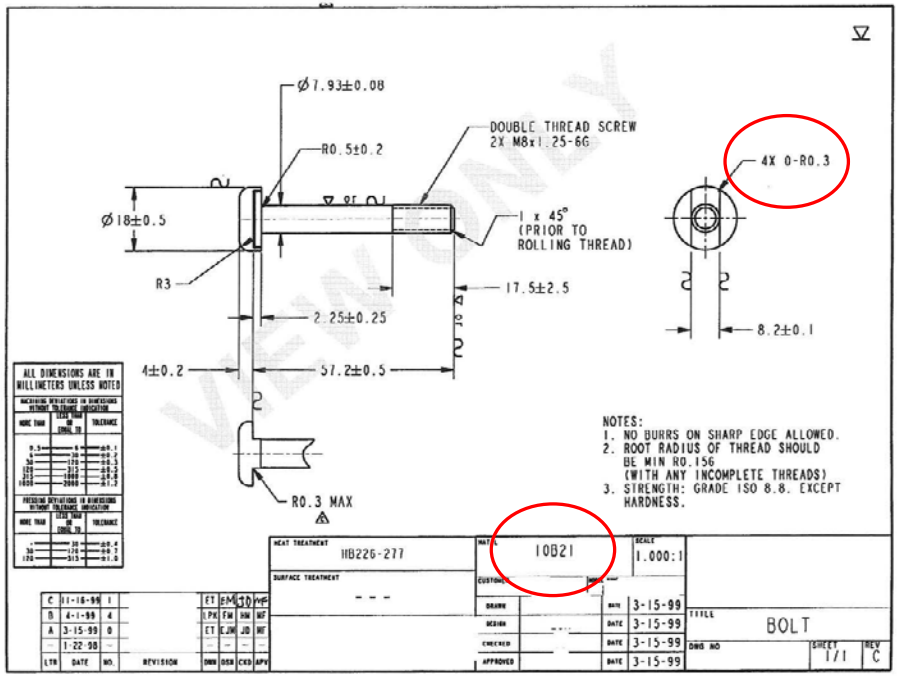
Print #3

4. What does “4x” in “4x 0-R0.3” mean?

- **“4x” means that feature is repeated 4 times. Instead of dimensioning it four times on the print, it can be shown in one place and noted that it repeats in four places.**

5. What is the material?

- **10B21**



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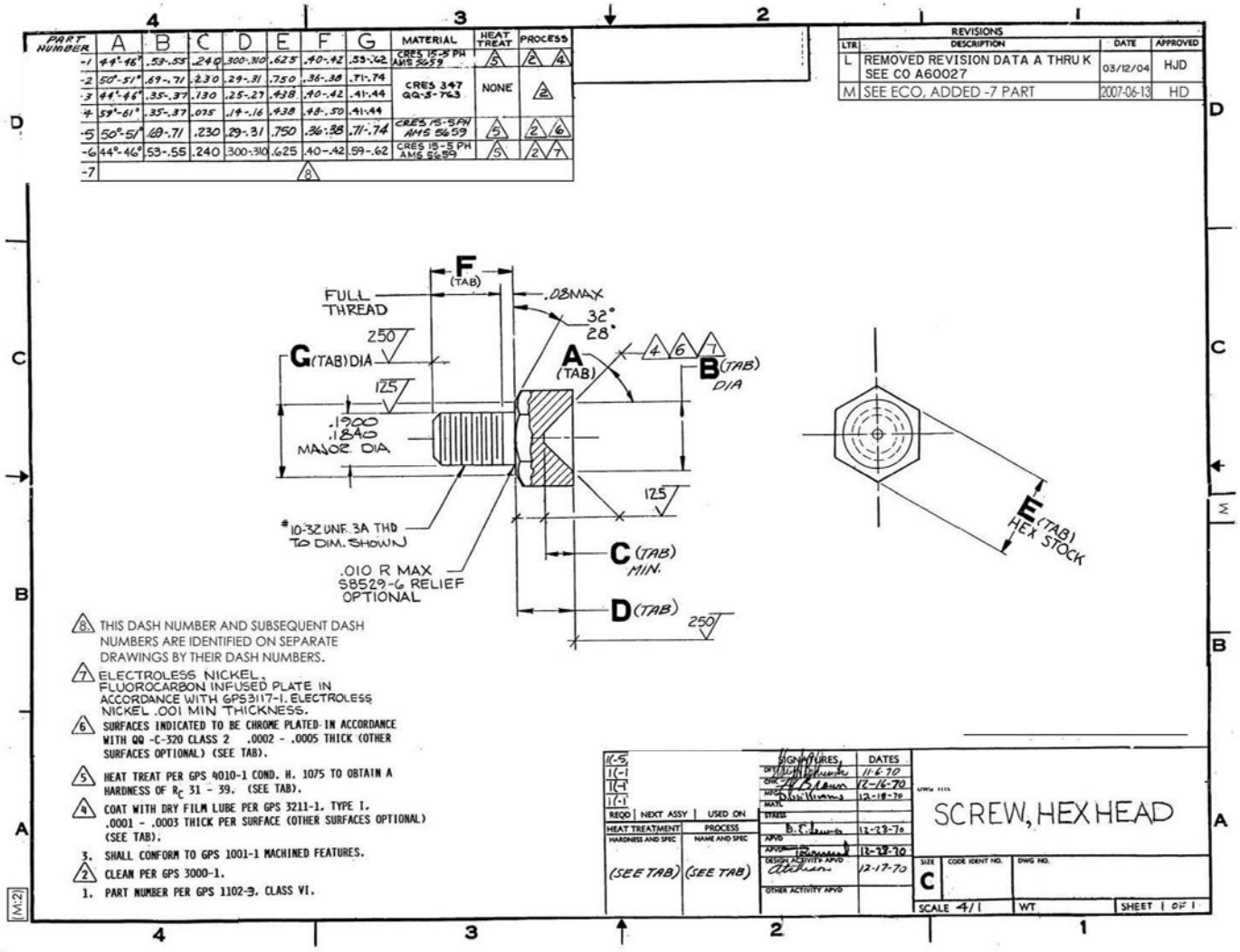


PART NUMBER	A	B	C	D	E	F	G	MATERIAL	HEAT TREAT	PROCESS
-1	44°-46°	.53-.55	.240	.300-.310	.625	.40-.42	.53-.62	CRES 15-5 PH AMS 5659	5	2 4
-2	50°-51°	.69-.71	.230	.29-.31	.750	.36-.38	.71-.74	CRES 347 QQ-S-763	NONE	2
-3	44°-46°	.35-.37	.130	.25-.27	.438	.40-.42	.41-.44			
-4	59°-61°	.35-.37	.075	.14-.16	.438	.48-.50	.41-.44			
-5	50°-51°	.69-.71	.230	.29-.31	.750	.36-.38	.71-.74	CRES 15-5 PH AMS 5659	5	2 6
-6	44°-46°	.53-.55	.240	.300-.310	.625	.40-.42	.59-.62	CRES 15-5 PH AMS 5659	5	2 7
-7										

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
L	REMOVED REVISION DATA A THRU K SEE CO A60027	03/12/04	HJD
M	SEE ECO, ADDED -7 PART	2007-06-13	HD

F (TAB)
FULL THREAD
.08 MAX
32° 28°
250
G (TAB) DIA
A (TAB)
4 6 7
B (TAB) DIA
125
.1900
.1840
MAJOR DIA
#10-32 UNF-3A THD TO DIM. SHOWN
.010 R MAX S8529-6 RELIEF OPTIONAL
C (TAB) MIN.
D (TAB)
250
E (TAB) HEX STOCK

8. THIS DASH NUMBER AND SUBSEQUENT DASH NUMBERS ARE IDENTIFIED ON SEPARATE DRAWINGS BY THEIR DASH NUMBERS.
7. ELECTROLESS NICKEL, FLUOROCARBON INFUSED PLATE IN ACCORDANCE WITH GPS3117-1. ELECTROLESS NICKEL .001 MIN THICKNESS.
6. SURFACES INDICATED TO BE CHROME PLATED IN ACCORDANCE WITH QQ-C-320 CLASS 2 .0002 - .0005 THICK (OTHER SURFACES OPTIONAL) (SEE TAB).
5. HEAT TREAT PER GPS 4010-1 COND. H, 1075 TO OBTAIN A HARDNESS OF R_C 31 - 39. (SEE TAB).
4. COAT WITH DRY FILM LUBE PER GPS 3211-1, TYPE I, .0001 - .0003 THICK PER SURFACE (OTHER SURFACES OPTIONAL) (SEE TAB).
3. SHALL CONFORM TO GPS 1001-1 MACHINED FEATURES.
2. CLEAN PER GPS 3000-1.
1. PART NUMBER PER GPS 1102-3, CLASS VI.

REQD	NEXT ASSY	USED ON
1(-5, -1, -4, -1)		

HEAT TREATMENT	PROCESS
HARDNESS AND SPEC	NAME AND SPEC
(SEE TAB)	(SEE TAB)

SIGNATURES	DATES
ORIG	11-6-70
CHK	12-16-70
MFG	12-18-70
MATL	
STRESS	
APVD	12-23-70
APVD	12-23-70
DESIGN ACTIVITY APVD	12-17-70
OTHER ACTIVITY APVD	

SCREW, HEX HEAD

SIZE	CODE IDENT NO.	DWG NO.
C		

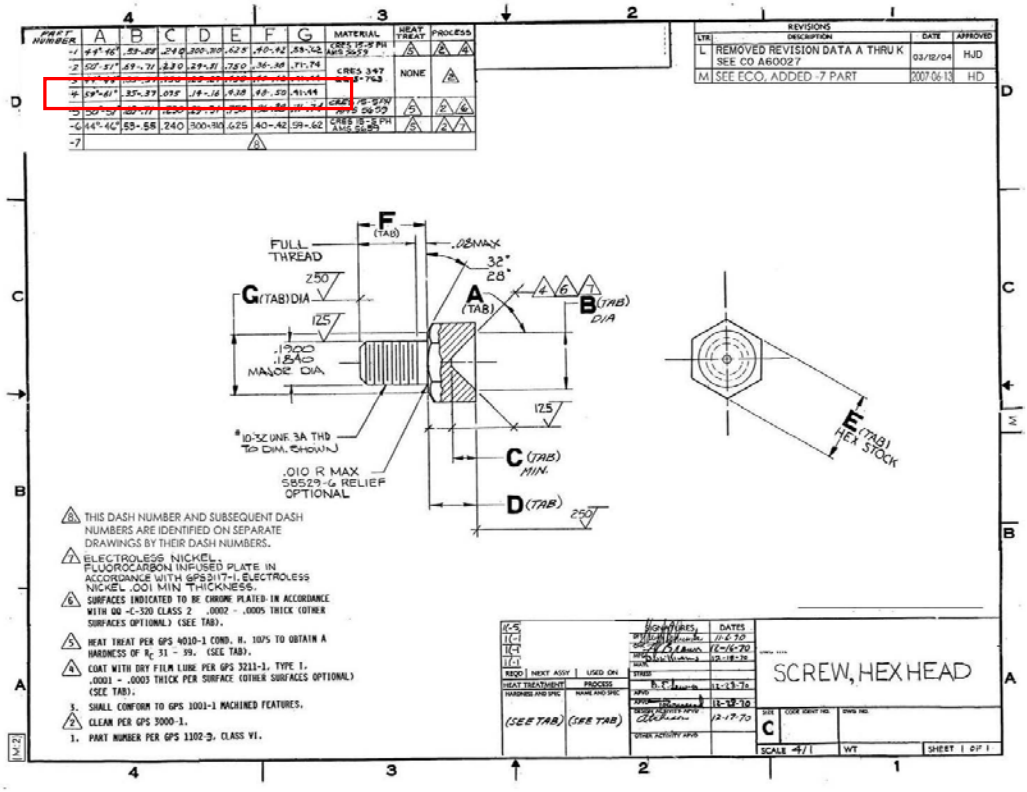
SCALE 4/1 | WT | SHEET 1 OF 1

FASTENER TRAINING INSTITUTE

Print #4

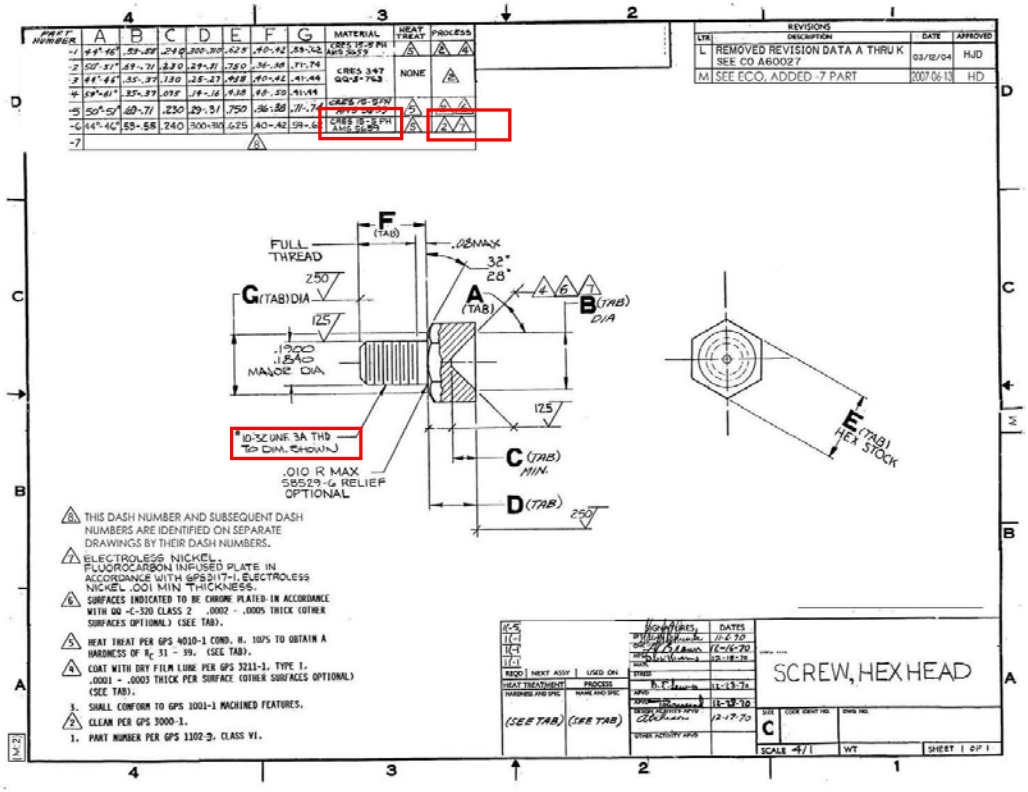
1. For Part #4, What are A, B,C,D,E,F,G dimensions?

- **A = 59°- 61°**
- **B = .35-.37**
- **C = .075**
- **D = .14-.16**
- **E = .438**
- **F = .48-.50**
- **G = .41-.44**



Print #4

2. **For Part #6, what is the material?**
   - **15-5 PH CRES (SS) per AMS 5659**
3. **What Part or Parts does Note 7 apply to?**
   - **Part #6**
4. **What is the Thread Class**
   - **3A**
5. **What is the Thread Series**
   - **UNF**



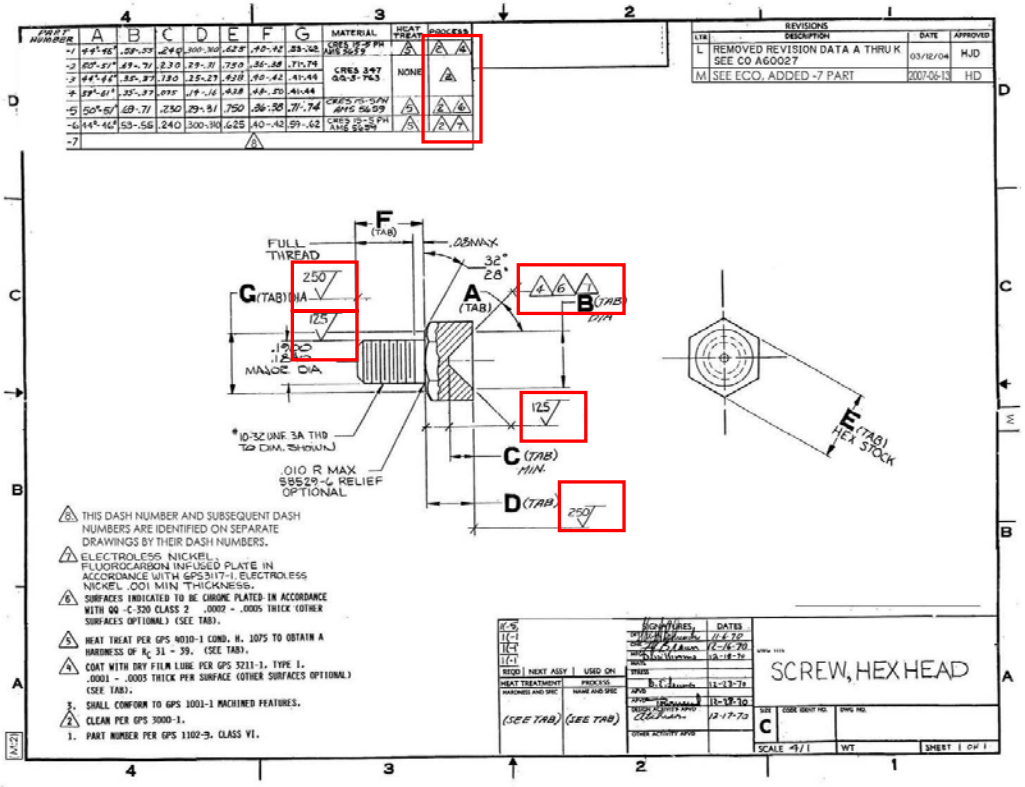
Print #4

6. Bonus Question 1: What do the 125V and 250V mean?

- **These are surface roughness requirements, which means the roughness on those surfaces needs to be controlled and may require a machining or grinding process.**

7. Bonus Question 2: What do the numbers 4, 6, and 7 in triangles located in the main view between the "A and B" dimensions tell us?

- **It tells us that part numbers which include the triangled number in the process column receive that process. For example, Part #1 shows the Triangle 4 in the "Process Column" meaning that Part 1 is to be coated in this area with Dry Film Lubricant.**



Questions…

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Key (1)

FASTENER TRAINING INSTITUTE

Certified Fastener Specialist-Fastener Training Week

Materials Case Study

Rev 08062023

Key

Section 4-6

Key (2)

Instructions:

When purchasing a Grade 8 Bolt at the local hardware store, most purchasers take for granted that everything was done properly and that they have a "strong" bolt in their possession. In most cases they would be right, but only because the manufacturer and sub-suppliers of that bolt knew what they were doing. As you have hopefully learned by this point in the Certified Fastener Specialist training, there is a lot to know about fasteners and even the smallest slip could have negative consequences.

This case will follow a fictional young engineer on his first project. Although this case never actually occurred, the scenario represented could easily fall on the desk of any "Fastener Specialist" and is intended to help you synthesize what you have learned today.

Your challenge will be to review this case and develop a plan of what you would do by answering the questions at the end. You should work with your group on this exercise. You will have about 45 minutes to work on it and then we will come together as a large group to discuss what you learned.

I. Introduction

Sean Mason is a beginning Mechanical Engineer about six months out of university. Since graduating he has been working for Acme Pipe and Flange Company. One of their new development products is a special heavy duty 8-bolt flange for pipelines carrying liquids at very high pressure. They are currently in the validation stages of design and hoping to release the product for full-scale production within several months. The bolts are tensioned using a torque-only method to a value just under their Proof Load. During life cycle testing they discovered that the 1"-8 x 4" Grade 5, 12-Point Flange Screw with zinc and clear chromate plating is occasionally failing by overload. Today the boss handed Sean this project and told him to propose a solution to the problem by the end of the week.

2. Problem

Sean recognizes that....

1. Either the bolts are not strong enough, or

2. The flange does not have enough bolts holding it together, or

3. The tightening strategy possesses too much variability and sometimes the installation exceeds the desired Proof Load goal.

Key (3)

3. Design Analysis

Sean performs the following:

- Sean conducts a dimensional analysis to see if the flange needs more bolts. For this size flange he determines that with a 1" diameter bolt the flange cannot accommodate more than 8 bolts.

- Based on the above analysis, Sean toys with the idea of reducing the bolt diameter so that the flange can accommodate more bolts. Although he concludes that this might have some merit, the company has invested a great deal of time and money in tooling for the 8-bolt flange, so that changing bolt size would add significant cost and time to the launch, which his superiors have made clear is not acceptable.

- Sean conducts a Finite Element Analysis of the current flange and bolts and one substituting higher strength Grade 8 bolts for the current Grade 5 bolts. Under the current conditions, the FEA predicts the very failures that they are occasionally experiencing, however, with the higher strength bolts, the FEA predicts no issues.

- With this promising note, Sean conducts a VDI 2230 bolted joint design analysis which confirms that the higher strength, Grade 8 bolts should solve the issue.

4. Sean's Solution

Sean proposes a relatively simple solution...

- Change the 1"-8 bolts from Grade 5 to Grade 8
- Change the finish on the parts from Zinc and Clear Chromate to Xylan (Teflon) Coating
- Include a written instruction encouraging installation using Torque-Angle or, better yet, Hydraulic Jacking instructions

5. Helpful Documents

- Exhibit 1: Print of 1"-8 x 4 12-Point Flange Head Screw Grade 5 With Zinc and Clear Chromate Finish
- Exhibit 2: Print of 1" -8 x 4 12-Point Flange Head Screw Grade 8 With Xylan Coating
- Exhibit 3: Table 1 SAE J429 (Mechanical Requirements and ID Markings)

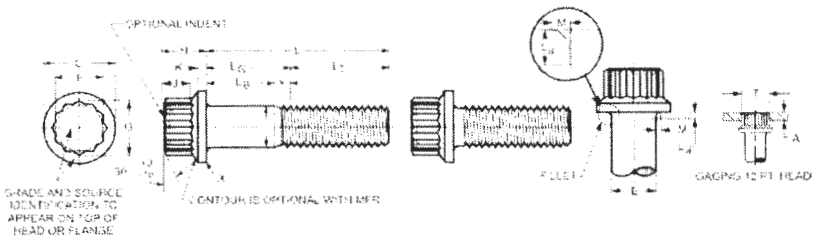
Key 4

- Exhibit 4: Table 2 SAE J429 (Chemical Composition and Tempering Temperature Page 1)
- Exhibit 5: Table 2 SAE J429 (Chemical Composition Tempering Temperature Page 2)
- Exhibit 6: Hardenability Curves for (5) steels with .4% C
- Exhibit 7: Tempering Curve for .4% Carbon Alloy Steels
- Exhibit 8: Hardness Conversion Table

Key 5

Exhibit 1: 1”-8 x 4 12-Point Flange Head Screw Grade 5 W/Zinc and Clear Chromate Finish

Flange 12-Point Screw



GRADE MARK

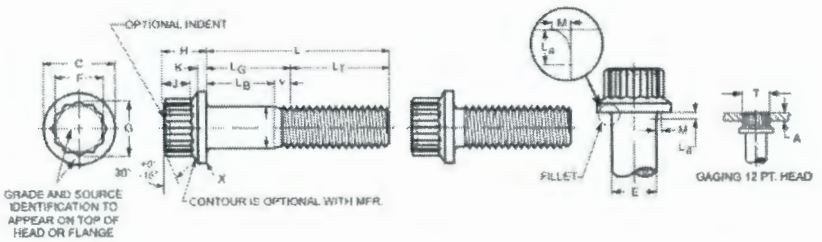
THREAD DATA		
Size: 1	**Threads per in.:** 8	**Series Designation:** UNC
Thread Class or Type: 2A	**Major Diameter:** 0.9980 - 0.9830	**Pitch and Functional Dia.:** 0.9168 - 0.9101
Tensile Stress Area: 0.6057	**Standard:** ASME B1.1 - 2019	**ITC Data Update:** 12/10/2021
DIMENSIONAL DATA		
Type: Flange 12-Point Screw	**Standard:** IFI - 115-2014	**Nominal Diameter:** 1
E - Body Diameter : 1.0000 - 0.9886	**F - Width Across Flats:** 1.003 - 0.991	**G - Width Across Corners:** 1.130 Min
H - Head Height: 1.000 Max	**J - Wrenching Height Min:** 0.600	**L_T - Thread Length for Screw Length 6 in. or less:** 2.250
Transition Thread Length - Ref.: 0.62	**Point Type:** Chamfered	**K - Flange Thickness:** 0.268 Min
A - Gaging Ring Thickness: 0.1893 - 0.1890	**T - Gaging Ring Dia:** 1.1303 - 1.1300	**FL - Fillet Length:** 0.332 Max
M - Fillet Extension: 0.050 - 0.040	**C - Flange Dia:** 1.500 - 1.479	**ITC Data Update:** 12/29/2021
LG max./LB min.: 1.000/0.380	**L - Length:** 4	**Length Tolerance:** -0.062
PHYSICAL REQUIREMENTS		
Nominal: 1	**Standard:** SAE J429-2014, Grade 5	**Typical Materials:** medium carbon steel, 1028 through 1055
Hardness: HRC 34 - 25	**Proof Load (lbf):** 51,500	**Tensile Load, Min. (lbf):** 72,700
Yield PSI, 2% Offset, Machined Specimen: 92,000	**Tensile Strength, Min. (psi):** 120,000	**Calculated Shear Load-BODY (ref.)(lbf):** 43,620
Calculated Shear Load-THREADS (ref.)(lbf): 36,350	**ITC Data Update:** 12/29/2021	**Straightness Factor:** 0.024
Calculated Pretension[2] (lbf) : 41,814	**Tightening Torque [1]:** 766 ft.lbf, 9,195 in.lbf, 1,038.8 Nm	
FINISH DATA		
Finish: Zinc & Clear, non-hexavalent/Cr(VI) free - .0001"/ 3µm	**K factor (ref. DIN 946):** 0.22	**Standard:** ASTM F1941/F1941M-2016, Fe/Zn 3AN
ITC Data Update: 3/20/2019		

[1] These torque values are based on K factors determined using DIN 946, tightening tension of 75% of the yield strength, and the calculation formula T=KDP. These values are advisory only. The torque for assembling critical joints should be determined and/or verified through actual experimentation by the user. The IFI is not responsible for any losses or claims resulting from the use of these values. [2] Calculated Pretension is equal to 75% of the bolt's yield strength achieved when using the indicated Tightening Torque.

Key 6

Exhibit 2: 1"-8 x 4 12-Point Flange Head Screw Grade 8 w/Xylan Coating

Flange 12-Point Screw



GRADE MARK

THREAD DATA		
Size: 1	**Threads per in.:** 8	**Series Designation:** UNC
Thread Class or Type: 2A	**Major Diameter:** 0.9980 - 0.9830	**Pitch and Functional Dia.:** 0.9168 - 0.9101
Tensile Stress Area: 0.6057	**Standard:** ASME B1.1 - 2019	**ITC Data Update:** 12/10/2021
DIMENSIONAL DATA		
Type: Flange 12-Point Screw	**Standard:** IFI - 115-2014	**Nominal Diameter:** 1
E - Body Diameter: 1.0000 - 0.9886	**F - Width Across Flats:** 1.003 - 0.991	**G - Width Across Corners:** 1.130 Min
H - Head Height: 1.000 Max	**J - Wrenching Height Min:** 0.600	**L_T - Thread Length for Screw Length 6 in. or less:** 2.250
Transition Thread Length - Ref.: 0.62	**Point Type:** Chamfered	**K - Flange Thickness:** 0.268 Min
A - Gaging Ring Thickness: 0.1893 - 0.1890	**T - Gaging Ring Dia:** 1.1303 - 1.1300	**FL - Fillet Length:** 0.332 Max
M - Fillet Extension: 0.050 - 0.040	**C - Flange Dia:** 1.500 - 1.479	**ITC Data Update:** 12/29/2021
LG max./LB min.: 1.000/0.380	**L - Length:** 4	**Length Tolerance:** -0.062
PHYSICAL REQUIREMENTS		
Nominal: 1	**Standard:** SAE J429-2014, Grade 8	**Typical Materials:** alloy steel, 4037, 4135, 4140, 5038, 5039
Hardness: HRC 38 - 33	**Proof Load (lbf):** 72,700	**Tensile Load, Min. (lbf):** 90,900
Yield PSI, 2% Offset, Machined Specimen: 130,000	**Tensile Strength, Min. (psi):** 150,000	**Calculated Shear Load-BODY (ref.)(lbf):** 54,540
Calculated Shear Load-THREADS (ref.)(lbf): 45,450	**ITC Data Update:** 12/29/2021	**Straightness Factor:** 0.024
Calculated Pretension[2] (lbf): 59,085	**Tightening Torque [1]:** 837 ft.lbf, 10,039 in.lbf, 1,134.3 Nm	
FINISH DATA		
Finish: Xylan 5230 (PTFE)	**K factor (ref. DIN 946):** 0.17	**ITC Data Update:** 3/20/2019

[1] These torque values are based on K factors determined using DIN 946, tightening tension of 75% of the yield strength, and the calculation formula T=KDP. These values are advisory only. The torque for assembling critical joints should be determined and/or verified through actual experimentation by the user. The IFI is not responsible for any losses or claims resulting from the use of these values. [2] Calculated Pretension is equal to 75% of the bolt's yield strength achieved when using the indicated Tightening Torque.

TABLE 1 - MECHANICAL REQUIREMENTS AND IDENTIFICATION MARKING FOR BOLTS, SCREWS, STUDS, SEMS, AND U-BOLTS[1,8]

Grade Designation	Products	Nominal Size Dia, in	Full Size[1,7] Bolts, Screws, Studs Sems, Stress under Proof Load, psi	Full Size[1] Bolts, Screws Studs, Sems, Tensile Strength Min, psi	Machine Test Specimens of Bolts, Screws, and Studs Yield[2] Strength Min, psi	Machine Test Specimens of Bolts, Screws, and Studs Tensile Strength Min, psi	Machine Test Specimens of Bolts, Screws, and Studs Elongation Min, %	Machine Test Specimens of Bolts Screws, and Studs Reduction of Area Min, %	Surface Hardness Rockwell 30N Max	Core Hardness Rockwell Min	Core Hardness Rockwell Max	Grade Identification Marking[3]
1	Bolts, Screws, Studs	1/4 thru 1-1/2	33 000[4]	60 000	36 000	60 000	18	35	—	B70	B100	None
2	Bolts, Screws, Studs	1/4 thru 3/4[5]	55 000[4]	74 000	57 000	74 000	18	35	—	B80	B100	None
		Over 3/4 thru 1-1/2	33 000	60 000	36 000	60 000	18	35	—	B70	B100	None
4	Studs	1/4 thru 1-1/2	65 000	115 000	100 000	115 000	10	35	—	C22	C32	None
5	Bolts, Screws, Studs (3)	1/4 thru 1	85 000	120 000	92 000	120 000	14	35	54	C25	C34	
		Over 1 thru 1-1/2	74 000	105 000	81 000	105 000	14	35	50	C19	C30	
5.1[6]	Sems	No. 4 thru 5/8	85 000	120 000	—	—	—	—	59.5	C25	C40	
5.2	Bolts, Screws	1/4 thru 1	85 000	120 000	92 000	120 000	14	35	56	C26	C36	
8	Bolts, Screws, Studs (3)	1/4 thru 1-1/2	120 000	150 000	130 000	150 000	12	35	58.6	C33	C39	
8.1	Studs	1/4 thru 1-1/2	120 000	150 000	130 000	150 000	10	35	58.6	C33	C39	None
8.2	Bolts, Screws	1/4 thru 1	120 000	150 000	130 000	150 000	10	35	58.6	C33	C39	

1. See footnote 2 of the scope.
2. Yield strength is stress at which a permanent set of 0.2% of gage length occurs.
3. Not applicable to studs or slotted and cross recess head products.
4. Proof load test. Requirements in these grades only apply to stress relieved products.
5. Grade 2 requirements for sizes 1/4 through 3/4 in apply only to bolts and screws 6 in. and shorter in length, and to studs of all lengths. For bolts and screws longer than 6 in., Grade 1 requirements shall apply.
6. Grade 5 material heat treated before assembly with a hardened washer is an acceptable substitute.
7. "Full Size" means a tension test specimen consisting of a completed fastener for testing in the ready to use condition without alteration.
8. To convert pounds per square inch to Mega-Pascals [MPa] multiply the values above by .00689.

TABLE 2 - CHEMICAL COMPOSITION TEMPERING TEMPERATURE AND IDENTIFICATION FOR BOLTS, SCREWS, AND STUDS

Grade Designation	Products	Nominal Size Dia, In	Material	Treatment	Product Chemical Analysis[1], (% by Weight) Carbon Min	Product Chemical Analysis[1], (% by Weight) Carbon Max	Product Chemical Analysis[1], (% by Weight) P Max	Product Chemical Analysis[1], (% by Weight) S Max	Product Chemical Analysis[1], (% by Weight) Boron Min	Product Chemical Analysis[1], (% by Weight) Boron Max	Tempering Temperature °F (Min)
1	Bolts, Screws, Studs	1/4 thru 1-1/2	Low or Medium Carbon Steel	See 4.4		0.55	0.025	0.025			See 4.4
2	Bolts, Screws, Studs	1/4 thru 1-1/2	Low or Medium Carbon Steel	See 4.4	0.15	0.55	0.025	0.025[2]			See 4.4
4	Studs	1/4 thru 1-1/2	Medium Carbon Steel	Cold Drawn	0.28	0.55	0.025	0.13			See 4.4
5	Bolts, Screws, Studs	1/4 thru 1-1/2	Medium Carbon Steel(3) Or	Quenched & Tempered	0.25	0.55	0.025	0.025[4]			425 °C (800 °F)
			Carbon Steel with additives (e.g. Boron (6, 9) or Cr, or Mn) Or	Quenched & Tempered	0.15	0.40	0.025	0.025[4]	0.0005	0.003	425 °C (800 °F)
5.1(5)	SEMS	No 4 thru 5/8	Low or Medium Carbon Steel(3, 6 9)	Quenched & Tempered	0.15	0.30	0.025	0.025		0.003	340 °C (650 °F)
5.2	Bolts, Screws	1/4 thru 1	Low Carbon Boron Steel (6)	Quenched & Tempered	0.15	0.25	0.025	0.025	0.0005	0.003	425 °C (800 °F)
8	Bolts, Screws, Studs	1/4 thru 1-1/2	Carbon (8) Steel with additives (e.g., Boron(9) or Cr, or Mn) Or	Quenched & Tempered	0.25	0.55	0.025	0.025[4]		0.003	425 °C (800 °F)
			Medium Carbon Steel Or	Quenched & Tempered	0.25	0.55	0.025	0.025[4]			425 °C (800 °F)
			Alloy Steel (7,8)	Quenched & Tempered	0.25	0.55	0.025 (10)	0.025 (10)			425 °C (800 °F)
8.1	Studs	1/4 thru 1-1/2	Medium Carbon Alloy (7, 8) or SAE 1541 Steel	Elevated Temperature Drawn	0.28	0.55	0.025	0.040			425 °C (800 °F)

Key 8

TABLE 2 - CHEMICAL COMPOSITION TEMPERING TEMPERATURE AND IDENTIFICATION FOR BOLTS, SCREWS, AND STUDS

Grade Designation	Products	Nominal Size Dia, In	Material	Treatment	Product Chemical Analysis[1], (% by Weight) Carbon Min	Product Chemical Analysis[1], (% by Weight) Carbon Max	Product Chemical Analysis[1], (% by Weight) P Max	Product Chemical Analysis[1], (% by Weight) S Max	Product Chemical Analysis[1], (% by Weight) Boron Min	Product Chemical Analysis[1], (% by Weight) Boron Max	Tempering Temperature °F (Min)
8.2	Bolts, Screws	1/4 thru 1	Low Carbon Boron Steel (6, 9)	Quenched & Tempered	0.15	0.25	0.025	0.025	0.0005	0.003	340°C (650°F)

1. All values are for product analysis (percent by weight). For cast or heat analysis, use standard permissible variations as shown in SAE J409.
2. For studs only, sulfur content may be 0.33% maximum.
3. For Grades 5 and 5.1, fasteners, alloy steels, as specified for Grades 8 fasteners, may also be used at the manufacturer's option.
4. For studs only, sulfur content may be 0.13% maximum.
5. Grade 5 material heat treated before assembly with a hardened washer is an acceptable substitute.
6. When the carbon content in boron steel is less than 0.25% the minimum manganese shall be 0.60%for Grades 5, 5.1, and 5.2 and 0.70% for Grades 8.2.
7. Alloy steel shall contain at least one of the following elements in the minimum quantity given: chromium 0.30 %, nickel 0.30 %, molybdenum 0.20 %, vanadium 0.10 %, manganese 1.65%. Where elements are specified in combinations of two, three, four, or five and have alloy contents less than those given above, the limit value to be applied for steel class determination is 70 % of the sum of the individual limit values shown above for the two, three, four or five elements concerned.
8. For steels of these types there shall be sufficient hardenability to ensure a microsructure consisting of approximately 90% martensite (refer Table 3) in the core of threaded sections of the fasteners after hardening and quenching and before tempering.
9. When boron is added the limits shall be 0.0005 % to 0.003 %.
10. Alloy steel used to make fasteners by hot forging or machining may have a maximum content by weight of 0.030% P (phosphorus) and 0.040% S (sulfur).

Key (10)

Exhibit 6: Hardenability Curves for Selected 0.4% C Steels

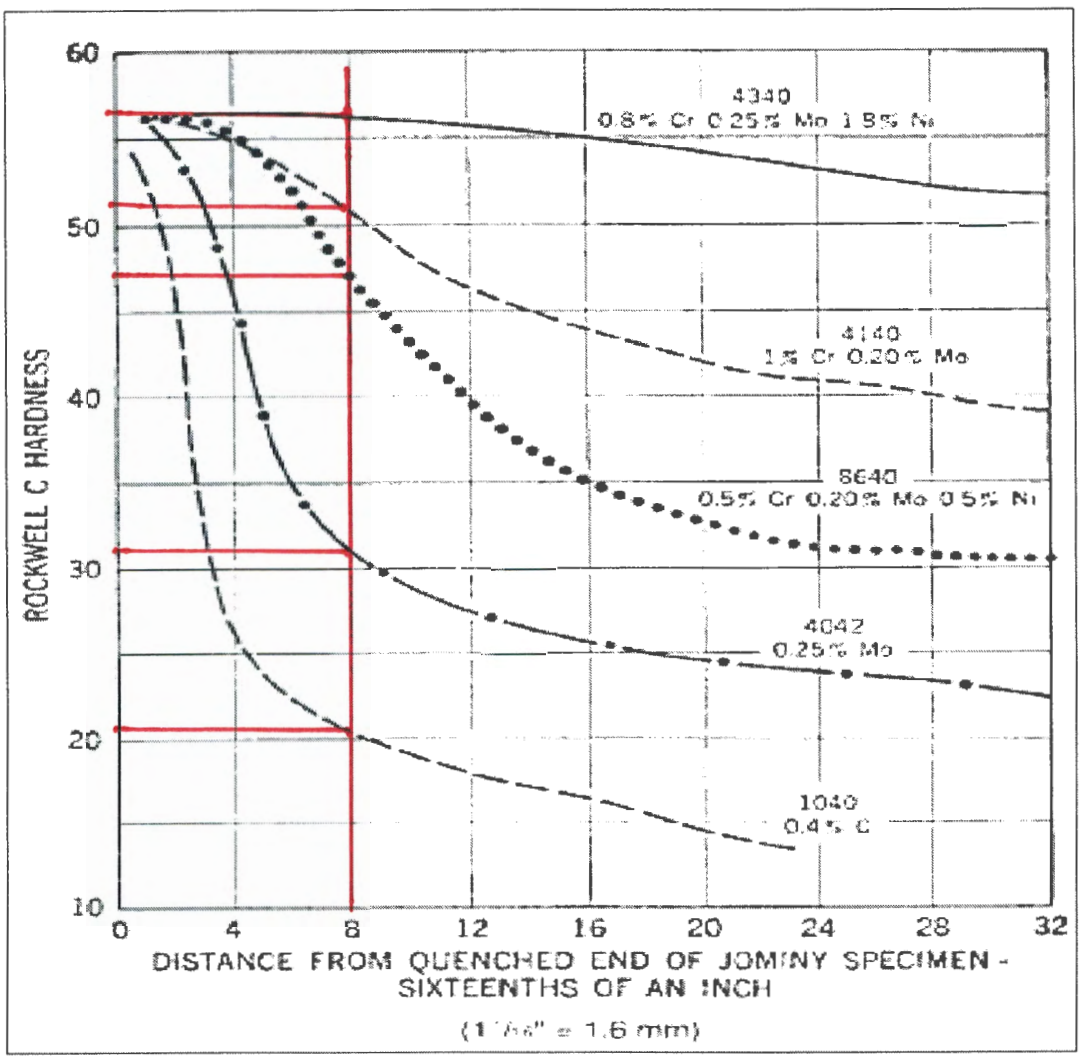
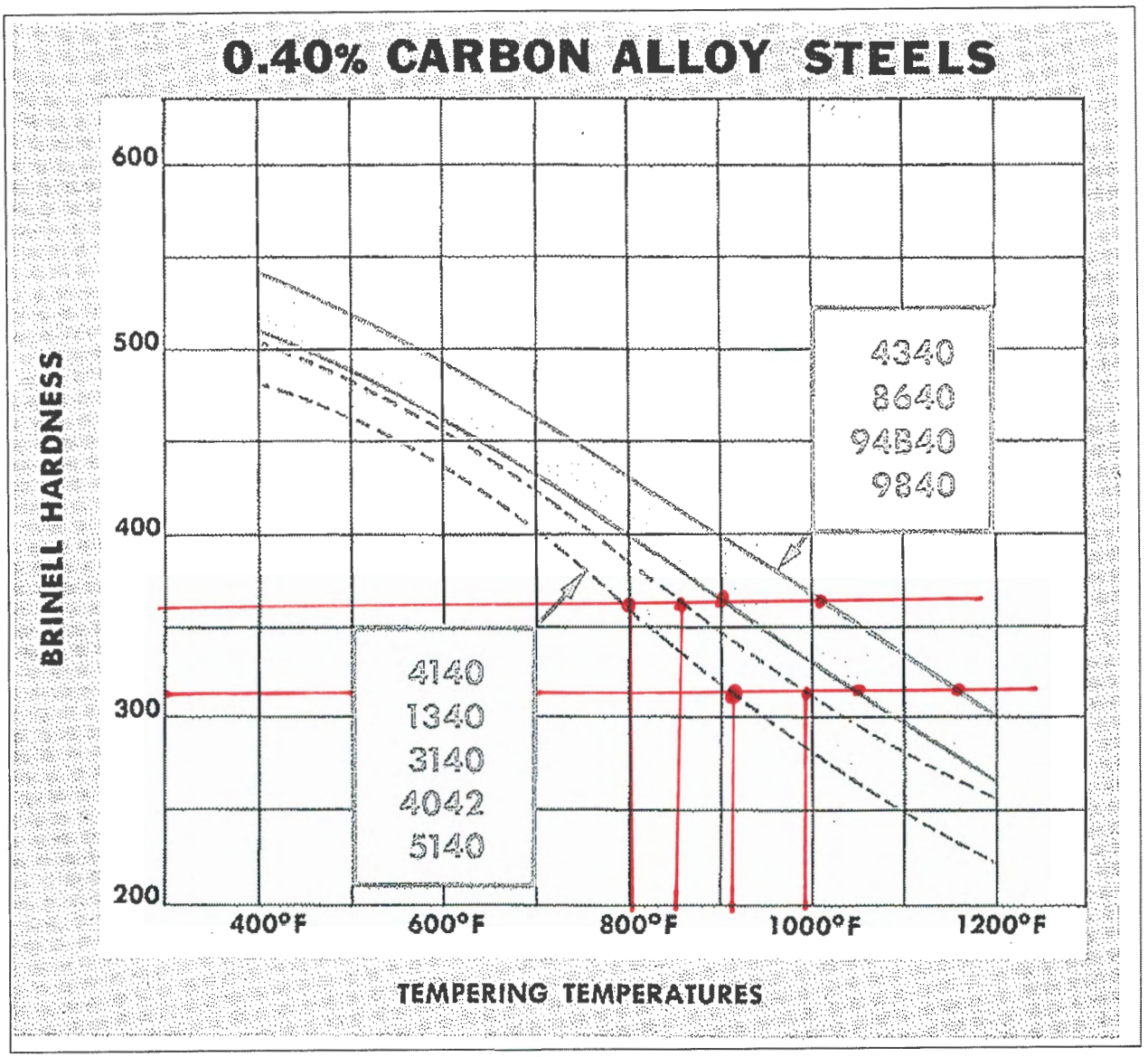


Exhibit 7: Tempering Curves for Several 0.4% C Steels



Key 12

Exhibit 8: Hardness Conversion Table

HARDENED STEEL AND HARD ALLOYS

Rockwell*				Superficial			Vickers	Knoop	Brinell	Tensile Strength	Micro-ficial
C	A	D	G	15-N	30-N	45-N	HV	HK	HB	KSI	WMN
150 kg Brale*	60 kg Brale	100 kg Brale	150 kg 1/16" ball	15 kg N Brale	30 kg N Brale	45 kg N Brale	10 kg	500 gm and over	3000 kg 10 mm ball	1000 lbs/ sq in	1000 gm
80	92.0	86.5	▲	96.5	92.0	87.0	1865	—	▲	▲	—
79	91.5	85.5	⋮	96.3	91.5	86.5	1787	—	⋮	⋮	—
78	91.0	84.5	⋮	96.0	91.0	85.5	1710	—	⋮	⋮	—
77	90.5	84.0	⋮	95.8	90.5	84.5	1633	—	⋮	⋮	—
76	90.0	83.0	⋮	95.5	90.0	83.5	1556	—	⋮	⋮	—
75	89.5	82.5	⋮	95.3	89.0	82.5	1478	—	⋮	⋮	—
74	89.0	81.5	⋮	95.0	88.5	81.5	1400	—	NOTE 1	NOTE 2	—
73	88.5	81.0	⋮	94.8	88.0	80.5	1323	—	⋮	⋮	—
72	88.0	80.0	⋮	94.5	87.0	79.5	1245	—	⋮	⋮	—
71	87.0	79.5	⋮	94.3	86.5	78.5	1160	—	⋮	⋮	—
70	86.5	78.5	⋮	94.0	86.0	77.5	1076	972	⋮	⋮	953
69	86.0	78.0	⋮	93.5	85.0	76.5	1004	946	⋮	⋮	949
68	85.6	76.9	⋮	93.2	84.4	75.4	940	920	⋮	⋮	945
67	85.0	76.1	⋮	92.9	83.6	74.2	900	895	⋮	⋮	942
66	84.5	75.4	⋮	92.5	82.8	73.3	865	870	NA	⋮	938
65	83.9	74.5	⋮	92.2	81.9	72.0	832	846	739	⋮	934
64	83.4	73.8	⋮	91.8	81.1	71.0	800	822	722	⋮	930
63	82.8	73.0	⋮	91.4	80.1	69.9	772	799	706	⋮	926
62	82.3	72.2	⋮	91.1	79.3	68.8	746	776	688	⋮	922
61	81.8	71.5	⋮	90.7	78.4	67.7	720	754	670	⋮	917
60	81.2	70.7	⋮	90.2	77.5	66.6	697	732	654	NA	913
59	80.7	69.9	⋮	89.8	76.6	65.5	674	710	634	351	909
58	80.1	69.2	⋮	89.3	75.7	64.3	653	690	615	338	904
57	79.6	68.5	⋮	88.9	74.8	63.2	633	670	595	325	900
56	79.0	67.7	⋮	88.3	73.9	62.0	613	650	577	313	896
55	78.5	66.9	⋮	87.9	73.0	60.9	595	630	560	301	891
54	78.0	66.1	⋮	87.4	72.0	59.8	577	612	543	292	887
53	77.4	65.4	⋮	86.9	71.2	58.6	560	594	525	283	883
52	76.8	64.6	⋮	86.4	70.2	57.4	544	576	512	273	879
51	76.3	63.8	⋮	85.9	69.4	56.1	528	558	496	264	874
50	75.9	63.1	⋮	85.5	68.5	55.0	513	542	481	255	870
49	75.2	62.1	⋮	85.0	67.6	53.8	498	526	469	246	865
48	74.7	61.4	⋮	84.5	66.7	52.5	484	510	455	238	861
47	74.1	60.8	⋮	83.9	65.8	51.4	471	495	443	229	856
46	73.6	60.0	⋮	83.5	64.8	50.3	458	480	432	221	851
45	73.1	59.2	⋮	83.0	64.0	49.0	446	466	421	215	847
44	72.5	58.5	⋮	82.5	63.1	47.8	434	452	409	208	842
43	72.0	57.7	⋮	82.0	62.2	46.7	423	438	400	201	837
42	71.5	56.9	⋮	81.5	61.3	45.5	412	426	390	194	832
41	70.9	56.2	⋮	80.9	60.4	44.3	402	414	381	188	827
40	70.4	55.4	⋮	80.4	59.5	43.1	392	402	371	182	822
39	69.9	54.6	⋮	79.9	58.6	41.9	382	391	362	177	817
38	69.4	53.8	⋮	79.4	57.7	40.8	372	380	353	171	812
37	68.9	53.1	⋮	78.8	56.8	39.6	363	370	344	166	807
36	68.4	52.3	⋮	78.3	55.9	38.4	354	360	336	161	802
35	67.9	51.5	⋮	77.7	55.0	37.2	345	351	327	156	798
34	67.4	50.8	⋮	77.2	54.2	36.1	336	342	319	152	793
33	66.8	50.0	⋮	76.6	53.3	34.9	327	334	311	149	788
32	66.3	49.2	⋮	76.1	52.1	33.7	318	326	301	146	783
31	65.8	48.4	NA	75.6	51.3	32.5	310	318	294	141	778
30	65.3	47.7	92.0	75.0	50.4	31.3	302	311	286	138	773
29	64.6	47.0	91.0	74.5	49.5	30.1	294	304	279	135	768
28	64.3	46.1	90.0	73.9	48.6	28.9	286	297	271	131	762
27	63.8	45.2	89.0	73.3	47.7	27.8	279	290	264	128	757
26	63.3	44.6	88.0	72.8	46.8	26.7	272	284	258	125	751
25	62.8	43.8	87.0	72.2	45.9	25.5	266	278	253	123	746
24	62.4	43.1	86.0	71.6	45.0	24.3	260	272	247	119	741
23	62.0	42.1	84.5	71.0	44.0	23.1	254	266	243	117	736
22	61.5	41.6	83.5	70.5	43.2	22.0	248	261	237	115	730
21	61.0	40.9	82.5	69.9	42.3	20.7	243	256	231	112	725
20	60.5	40.1	81.0	69.4	41.5	19.6	238	251	226	110	720

Note 1: A 10 mm steel ball was used for 450 BHN and below. A 10 mm carbide ball was used above 450 BHN.

2: The tensile strength relation to hardness is inexact, even for steel, unless it is determined for a specific material.

Key (13)

6: Questions

1. When Sean orders the new Grade 8 Fastener, it will require a different head marking. What head marking appears on the old, Grade 5 fastener and what head marking should appear on the new Grade 8 Fastener? Is this head marking optional?

No - Not optional.

2. Sean speaks with the Acme purchasing agent, who speaks with the screw supplier and learns that they have material options that include 10B21, 1540, 4037,4140, and 4340. Which are ok options? Explain.

   Hint: Review Exhibit 4, Table 2 for allowable materials for Grade 8. If any of the materials do not meet the required Chemical Constituency levels they must be discarded as options.

   Hint: 1540 Steel is considered a Plain Carbon Steel with added Manganese

   Hint: Consider data for 4042 and 4037 to be similar

   Hint: Review Exhibit 6, Hardenability Curves and determine the proper Jominy Number for the point furthest away from the quenched surface. Remember that a Jominy number of 1= 1'16" , so a Jominy # of 16 is 1" and a Jominy # of 8 is 8/16 or ½". When you have the right Jominy #, draw a line straight upward bisecting all of the hardness curves. From the bisected point draw a horizontal line to the left to find the hardness number. Remember, this is the AS-QUENCHED hardness expected at this depth in this steel type. Compare the value with the values required by a Grade 8 (See Exhibit 3).

   Hint: Remember the Hardness Charts show As-Quenched hardness. What does tempering do to the finish part hardness

   Hint: Discard any materials that clearly cannot meet the requirements of SAE J429 Table 1.

Per Table 2: 10B21 is not allowed, others are allowable materials

From Exhibit 6: 1540 ~ 21 HRC - Not an option
4037 ~ 31 HRC - Not an option
8640 ~ 47 HRC - Option
4140 ~ 52 HRC - Option
4340 ~ 57 HRC - Option

* Example: If a material has low hardenability and, say achieves only an as-quenched hardness in the low to middle Rockwell C 40's — when it is tempered at 800°F, it will fall below the required HRC 33-39 range and can be quickly excluded.

3. Consider the material options that are available- which one would you choose. Explain.

I would choose 4140, as it should achieve mechanical requirements easily, is more readily accessible than 4340, is more economical than 4340, and has slightly lower propensity to quench cracking than 4340.

4. SAE J429 includes built-in Checks and Balances. One of these is "Minimum Tempering Temperature". Explain how this acts as a material limiter.

Per Table 2 for Grade 8, minimum tempering temperature is 425°C (800F). When we temper at these temperatures we drop significant hardness points. Therefore, a material with low hardenability will drop below the required final hardness. *

5. Exhibit 7 represents expected hardness achieved in a variety of .4%C alloy steels at different tempering temperatures. Use this chart to determine the expected tempering temperature required to achieve the mechanical requirements specified in SAE J429 Table 1 for Grade 8 for the material you choose in 3. Does this suggest that you will fulfill the SAE J429 requirement?

Hint: Notice that the hardness expressed in Exhibit 7 is in Brinnel. You will need to convert to Rockwell. See Exhibit 8. HRC 33 = HB 311
HRC 39 = HB 362

Hint: Locate where in the hardness band your minimum hardness resides for the chosen alloy and then project a line downward to find the associated temperature. Compare this with the minimum temperature in SAE Table 2.

According to Exhibit 7:

4140: HRC 33 ⇒ 980°-990°F
HRC 39 ⇒ 800°-850°F

4340: HRC 33 ⇒ 1050°-1160°F
HRC 39 ⇒ 900°-1000°F

All values predict that HRC 33-39 can be achieved at values equal to or exceeding the minimum tempering temperature of 800°F

6. Review Exhibit 5 and read Footnote 8. Although it is actually difficult to determine the exact % of Martensite present in a sample, what is the intention with this footnote?

This is another check and balance (like tempering temperature) to guide the user into making wise/proper material choices.

Key (15)

7. Sean's purchasing agent reviews SAE J429 and becomes intrigued with Grade 8.2. (See Exhibit 5). He sees that the mechanical requirements are the same as Grade 8 but the allowable material options may be cheaper than some or all of those required by Grade 8. He suggests to Sean that maybe he can purchase a screw to these requirements. Why should Sean reject this idea? Explain?

Grade 8.2 allows a low carbon boron steel for sizes 1/4" – 1". Of course, this is interesting because the allowable material is assuredly cheaper than that specified in grade 8. However, The only way to achieve The mechanical requirements specified in Table 1, The minimum tempering temperature must be lowered to 340°C (650°F). Assuredly these parts possess less toughness (i.e more brittle) than genuine grade 8. It is a substandard product!

8. Sean did not pursue this option, but he did note during the brainstorming phase of the project that the original tightening strategy may have been flawed. How could this have potentially contributed to the problem? How did the fix they made possibly help? What tightening method would you recommend to Sean? Explain?

It is possible That variability in The installation could take parts above Their elastic limit. If The liquid going Through This pipeline is hot, it is entirely possible That the flange could see service pre-load That could exceed the screw's tensile strength resulting in overload failures. This is most likely addressed by The change to Grade 8 as The available pre-load goes up. If The original preload value was sufficient, Then with grade 8 bolts, They don't need to be as highly loaded, significantly reducing The risk of exceeding The elastic limit. Additionally, Some coated finishes to Xylan (Teflon) which will reduce installation variability and is recommended installation techniques That are less variable than The original torque-only strategy