# AX Spray Ring Lower Lifting Tab Analysis

## Project Number: T2R02

### Design Verification Required:
- **Yes** ☑️
- **No** ☐

### USQ Number:
- **N/A** ☑️
- **N/A-8** ☐

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- PRHA-02040 00
- PRHA-02041 00

## Approvals

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- **Design Authority** BELLOMY, JIM 02/16/2017
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- **Responsible Engineering Manager** HANSON, CARL E 02/16/2017
- **USQ Evaluator** SMITH, RYAN D 02/16/2017

## Description of Change and Justification

Original issue.

Design checks were performed in accordance with ARES Quality Assurance Procedure (QAP) 3.1. Because of the relatively simple nature of the design and the General Service status of the equipment, a graded approach was applied and design verification was not performed as allowed by ARES QAP 3.5, "Design Verification"

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AX Spray Ring Lower Lifting Tab Analysis

Author Name:

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Abstract: The purpose of this calculation is to analyze the new lifting tabs at the base of the Type 2 (H-14-110686), Type 3 (H-14-110691), and Type 4 (H-14-110756) Spray Rings per ASME BTH-1. The lifting tabs are designed to aid in handling of the split spray ring halves. This calculation also checks the collar of the mated spray ring assemblies for the event that one of the lower lifting tabs is utilized for removal of a connected spray ring assembly.

The objective is to verify the lifting tabs for handling of the spray ring halves and to determine if using the lifting tabs to rotate the mated spray ring assemblies could cause catastrophic failure.

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DATE: Feb 21, 2017
Approved For Public Release

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Title:
AX Spray Ring Lower Lifting Tab Analysis

Purpose and Objective:
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## Calculation Review Checklist

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<td>5. Calculation objective clearly described.</td>
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### Calculation Checking Method

- **Direct Step-by-Step Check**: ✓
- **Applicable Pages**: All sheets.

### Reference Chart(s) or Book(s) Comparison

- **Append Documentation**

### Alternate Calculation

- **Append Documentation**

### Comments:

Checker (Print Name and Sign): RB Campbell, P.E.  
Date: 2/13/17

Originator (Print Name and Sign): NW Sieler  
Date: 2/13/2017

Signatures obtained only after discrepancies are corrected and comments are resolved.
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Attachments

Attachment 1
SAE J429 Bolt Strength
1.0 PURPOSE

The purpose of this calculation is to analyze the new lifting tabs at the base of the Type 2 (H-14-110686), Type 3 (H-14-110691), and Type 4 (H-14-110756) Spray Rings per ASME BTH-1. The lifting tabs are designed to aid in handling of the split spray ring halves. This calculation also checks the collar of the mated spray ring assemblies for the event that one of the lower lifting tabs is utilized for removal of a connected spray ring assembly.

The objective is to verify the lifting tabs for handling of the spray ring halves and to determine if using the lifting tabs to rotate the mated spray ring assemblies could cause catastrophic failure.

2.0 METHODOLOGY

The weights of the spray ring assemblies are gathered from the original structural analyses performed on the three spray ring types. The heaviest spray ring is used in order to verify adequacy of lifting tabs on all spray ring types. The minimum allowable sling angle of 45 degrees per RPP-8360, Lifting Attachment and Lifted Item Evaluation, is also applied to create a bounding condition.

The lifting tabs are checked using ASME BTH-1, Design of Below-the-Hook Lifting Devices. The weld between the lifting tab and the body of the spray ring is checked using Blodgett, Design of Welded Structures, and ASME BTH-1.

The structure of the spray ring halves is deemed to be adequate for handling from the lower lifting tab by inspection. The original method for handling the spray ring halves was by crane attached at the top two Actek hoist rings and with a sling wrapped around the bottom at the location of the new lower lifting tab. Using the lower lifting tab instead of a sling will not change the way forces transfer through the component.

The spray rings are installed on cover plates above riser pits as halves and bolted together at their tops. A dangerous condition could be created if the lower lifting tabs are used to rotate the mated spray ring assemblies from vertical to horizontal, which would leave the bottom spray ring half unsupported. Catastrophic failure modes of bolt failure and weld failure are checked against using AISC, however large deformation of the mounting plates would be expected. Do not use the lower lifting tabs if the spray ring halves have been bolted together.

3.0 DESIGN INPUTS

1. The Type 2 Spray Ring is detailed in H-14-110686.
2. The Type 3 Spray Ring is detailed in H-14-110691.
3. The Type 4 Spray Ring is detailed in H-14-110756.

All other Design Inputs can be found in Section 8, CALCULATIONS.
4.0 ASSUMPTIONS

1. A shackle with a minimum 1/4” diameter pin and adequate capacity is used in conjunction with the lower lifting tabs.
2. No other catastrophic failure mode will occur besides bolt failure or weld failure should the lifting tabs be inadvertently used to handle a mated split spray ring assembly.

There are no other unverified assumptions used in this calculation. Engineering judgments are used and justified in the body of the calculation.

5.0 COMPUTER SOFTWARE

No unverified computer software was used in this analysis. Mathcad® release 15 was used for the hand calculations. All hand calculations are checked using a handheld calculator.

6.0 RESULTS

1. The governing tension force analyzed as acting on the Lower Lifting Tabs is approximately 2500lbf.
2. The governing failure mode for the Lower Lifting Tab is bearing of the shackle pin, resulting in a DCR of 0.89.
3. The weld between the Lower Lifting Tab and the body of the spray ring halves is adequate for the governing tension force with a DCR of 0.11, loaded in the plane of the lifting tab.
4. Catastrophic failure of a mated spray ring assembly should not occur if a mated spray ring assembly is inadvertently handled using the lower lifting tabs. **Do not use the Lower Lifting Tabs for handling a mated split spray ring assembly.**

All other Results can be found in Section 8, CALCULATIONS.

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Title: AX Spray Ring Lower lifting Tab Analysis
Prepared By: NW Sieler Date: 02/13/2017 Checked By: RB Campbell Date: 02/13/2017

7.0 REFERENCES


H-14-110681, Sh. 1-2, 3-4, Rev. 1, 0, AX Farm Pit Split Spray Ring Assembly Type 1, U.S. Department of Energy, Richland, WA.

H-14-110683, Sh. 1-5, Rev. 1, AX Farm Pit Spray Ring & Work Platform Type 1, U.S. Department of Energy, Richland, WA.

H-14-110686, Sh. 1-4, 5, Rev. 1, 0, AX Farm Pit Split Spray Ring Assembly Type 2, U.S. Department of Energy, Richland, WA.

H-14-110691, Sh. 1-7, 8, Rev. 1, 0, AX Farm Pit Split Spray Ring Assemblies Type 3, U.S. Department of Energy, Richland, WA.

H-14-110756, Sh. 1-5, Rev. 0, AX Farm Pit Split Spray Ring Assembly Type 4, U.S. Department of Energy, Richland, WA.


RPP-CALC-60841, Rev. 0, AX Farm Pit Spray Ring Type 1 Lifting and Operational Evaluation, 05/19/2016, ARES Corporation for WRPS, Richland, WA.

RPP-CALC-60882, Rev. 0, Structural Evaluations of the AX Farm Work Platform Type 2 with Split Spray Ring Type 2, 07/07/2016, ARES Corporation for WRPS, Richland, WA.

RPP-CALC-60948, Rev. 0, AX Farm Pit Work Platform and Spray Ring Structural Analysis for P-10 and P-200 Pump Removals, 10/11/2016, ARES Corporation for WRPS, Richland, WA.
8.0 CALCULATIONS

Figure: Snip showing typical spray ring and lower lifting tab location. Note that the water piping and some other items are not shown for clarity.

8.1 Starting Values and Material Properties

\[
\begin{align*}
F_{yA36} & := 36\text{ksi} & & \text{Yield strength of A36 steel. (AISC 14th Ed., Table 2-4)} \\
F_{uA36} & := 58\text{ksi} & & \text{Ultimate strength of A36 steel. (AISC 14th Ed., Table 2-4)} \\
E & := 29000\text{ksi} & & \text{Modulus of elasticity for steel. (AISC 14th Ed., Table B4.1b)}
\end{align*}
\]
8.2 Determine Loads on the Lifting Tab

**Type 2 Spray Ring:**

The Type 2 Spray Ring is detailed in H-14-110686 and analyzed in RPP-CALC-60882. Section 2.1.2 of RPP-CALC-60882 refers to RPP-CALC-60841 for lifting analysis of the spray ring. RPP-CALC-60841 does not list the weight of the spray ring assembly, but does give sling forces during lifting with 4 slings at 45 degrees in its Table 8-5. Note that the Type 1 assembly (analyzed in RPP-CALC-60841 and shown on drawing H-14-110681) is approximately identical to the Type 2 assembly.

\[
sling := 1248 \text{lbf}
\]

Resulting sling tension from lifting the Type 2 Spray Ring with 4 slings. (RPP-CALC-60841, Table 8-5)

\[
\theta_{\text{sling}} := 45 \text{deg}
\]

Angle of sling used for analyzing lifting of the Type 2 Spray ring. (RPP-CALC-60841, Section 8.4.3)

\[
\text{vert}_\text{component} := \text{sling} \cdot \sin(\theta_{\text{sling}}) = 882.47 \text{lbf}
\]

Vertical component of each of the angled slings used to lift the Type 2 Spray Ring.

\[
\text{wt}_{\text{type2}} := \text{vert}_\text{component} \cdot 4 = 3529.88 \text{lbf}
\]

Total vertical force (i.e., weight) for lifting of the Type 2 Spray Ring.

**Type 3 Spray Ring:**

Total weight of Type 3 Spray Ring and top hat, conservatively used in this evaluation. (RPP-CALC-60948, Section 2.1.4) Note that the Type 3 Spray Ring is detailed in H-14-110691.

\[
\text{wt}_{\text{type3}} := 2672 \text{lbf}
\]

**Type 4 Spray Ring:**

From observing the differences between the Type 2 Spray Ring (H-14-110686) and the Type 4 Spray Ring (H-14-110756), it is determined that they are close enough to be considered identical for the purposes of this analysis.

\[
\text{wt}_{\text{type4}} := \text{wt}_{\text{type2}} = 3529.88 \text{lbf}
\]

**Governing Lifting Tab Forces:**

\[
\text{Load} := \frac{\max(\text{wt}_{\text{type2}}, \text{wt}_{\text{type3}}, \text{wt}_{\text{type4}})}{2} = 1764.94 \text{lbf}
\]

Lifting load. The total weight of the spray rings (both halves, plus top hats) is divided by two to represent distribution of forces between the slings connecting to the top plate and to the lower lifting tab (see figure above). This is conservative because the sling at the lifting lug is further from the CG and will therefore see a lower load. Also note that the original structural evaluations for the spray rings already include RPP-8360 dynamic lifting and contingency factors.

\[
T_{\text{sling}} := \frac{\text{Load}}{\sin(\theta_{\text{sling}})} = 2496.1 \text{lbf}
\]

Governing tension force used in this calculation to bound all possible loads acting on the lower lifting tab.
8.3 Analyze Lower Lifting Tab per ASME BTH-1

8.3.1 Check Pin Connected Plate

\[ N_d := 2.0 \]
\[ F_y := F_{y_{A36}} = 36 \text{ ksi} \]
\[ F_u := F_{u_{A36}} = 58 \text{ ksi} \]

Nominal design factor for Design Category A. (BTH-1-2011, Section 3-1.3)

Redefine material yield strength to simplify equations in the following section.

Redefine material ultimate strength to simplify equations in the following section.

Service Class 0 will be used per BTH-1-2011. It is unlikely that the spray ring assemblies will be lifted more than 20,000 times throughout their usable life span. Fatigue need not be analyzed for members and connections subjected to fewer than 20,000 cycles. (BTH-1-2011, Section 3-1.4)

BTH-1-2011, Section 3-3.3.1 Static Strength of the Plates commentary identifies that "A pin-connected plate may fail in the region of the pinhole in any of four modes. These are tension on the effective area on a plane through the center of the pinhole perpendicular to the line of action of the applied load, fracture on a single plane beyond the pinhole parallel to the line of action of the applied load, shear on two planes beyond the pinhole parallel to the line of action of the applied load, and by out of plane buckling, commonly called dishing."

\[ T_{sling} = 2496 \text{ lbf} \]

Maximum force at the pin hole. (previously defined)

**Figure:** Snip from H-14-110756 showing lifting tab analyze per ASME BTH-1

**Dimensions of the Lower Lifting Tab**

\[ t_{eye} := 0.50 \text{in} \]
\[ w_{eye} := 4.0 \text{in} \]
\[ \text{dia}_\text{hole} := 1.0 \text{in} \]
\[ \text{dia}_\text{pin} := 0.25 \text{in} \]
\[ b_e := (4.5 \text{in} - 2.5 \text{in}) - \frac{\text{dia}_\text{hole}}{2} = 1.5 \text{ in} \]
\[ b_{\text{eff}} := \min \left[ b_e, 0.6 \left( \frac{F_u}{F_y} \right) \sqrt{\frac{\text{dia}_\text{hole}}{b_e}}, 4t_{\text{eye}} \right] = 1.18 \text{ in} \]

Thickness of eye. (H-14-110756)

Width of the eye at hole location, conservatively taken as the diameter of the radius corner. (H-14-110756)

Diameter of pin hole. (H-14-110756)

Minimum diameter of pin. (See Section 4.0)

Actual distance from edge of plate to edge of hole, perpendicular to the line of action. (H-14-110756) Note that a 45 degree angle of the sling would create a longer distance. Therefore this is a conservative value.

Effective edge width. (BTH-1-2011, Eq. 3-47 and 3-48)
Failure Mode 1: Tensile failure of the lifting tab

\[ C_r := 1 - 0.275 \left(1 - \frac{\text{dia}_{\text{pin}}}{\text{dia}_{\text{hole}}} \right)^2 = 0.73 \]  
(BTH-1-2011, Equation 3-46)

\[ P_t := C_r \frac{F_u}{1.20 \cdot N_d} \left(2 \cdot t_{\text{eye}} \cdot b_{\text{eff}} \right) = 21.0 \text{-kip} \]
Allowable tensile strength through the pin hole.  
(BTH-1-2011, Equation 3-45)

\[ \text{DCR}_{\text{tension}} := \frac{T_{\text{sling}}}{P_t} = 0.12 \]
DCR for tensile failure of the lifting tab.

Failure Mode 2: Fracture of single plane perpendicular to line of action

\[ R := b_e + \frac{\text{dia}_{\text{hole}}}{2} = 2 \cdot \text{in} \]
Distance from center of hole to edge of plate parallel to the applied load.  
(BTH-1-2011, Section 3-3.3.1)  
Note that this is conservative due to choice of value for \( b_e \).

\[ P_b := C_r \left(\frac{F_u}{1.20 \cdot N_d}\right) \left[1.13 \left(\frac{R - \text{dia}_{\text{hole}}}{2}\right) + \left(\frac{0.92 \cdot b_e}{\text{dia}_{\text{hole}}} + 1\right)\right] \cdot t_{\text{eye}} = 19.9 \text{-kip} \]
Allowable single plane shear strength of the lifting eye.  
(BTH-1-2011, Equation 3-49)

\[ \text{DCR}_{\text{fracture}} := \frac{T_{\text{sling}}}{P_b} = 0.13 \]
DCR for fracture perpendicular to applied load.

Failure Mode 3: Shear on two planes beyond the pinhole parallel to line of action

\[ \phi := 55 \cdot \frac{\text{dia}_{\text{pin}}}{\text{dia}_{\text{hole}}} = 13.75 \]
(BTH-1-2011, Equation 3-52)

\[ a := R - \frac{\text{dia}_{\text{hole}}}{2} = 1.5 \cdot \text{in} \]
Distance from edge of pinhole to edge of plate in direction of applied load.

\[ A_v := 2 \left[a + \frac{\text{dia}_{\text{pin}}}{2} \left(1 - \cos(\phi \text{-deg})\right)\right] \cdot t_{\text{eye}} = 1.50 \cdot \text{in}^2 \]
Total area of the two shear planes beyond the pin hole.  
(BTH-1-2011, Equation 3-51)

\[ P_v := \frac{0.70 \cdot F_u}{1.20 \cdot N_d} A_v = 25.4 \text{-kip} \]
Allowable double plane shear strength beyond the pinhole.  
(BTH-1-2011, Equation 3-50)

\[ \text{DCR}_{\text{shear}} := \frac{T_{\text{sling}}}{P_v} = 0.10 \]
DCR for shear on two planes parallel to applied load.
Failure Mode 4: Dishing of the plate  
Limiting the effective width with the use of BTH-1-2011 Equation 3-47 eliminates the possibility of dishing.

Bearing Stress between the pin and the plate

\[
F_p := \frac{1.25 \cdot F_y}{N_d} = 22.5 \text{ ksi}
\]

The allowable bearing stress on the contact area.  
(BTH-1-2011, Equation 3-53)

\[
A_{\text{bear}} := t_{\text{eye}} \cdot \text{dia}_{\text{pin}} = 0.13 \text{ in}^2
\]

Projected bearing area.

\[
P_{\text{bear}} := F_p \cdot A_{\text{bear}} = 2.8 \text{ kip}
\]

Allowable bearing force.

\[
\text{DCR}_{\text{bearing}} := \frac{T_{\text{sling}}}{P_{\text{bear}}} = 0.89
\]

DCR for bearing of the pin on the lifting tab.

Shear of the pin  
See Section 4.0

Demand-to-Capacity Ratio Summary and Conclusions

\[
\text{DCR}_{\text{govern}} := \max \left( \text{DCR}_{\text{tension}}, \text{DCR}_{\text{fracture}}, \text{DCR}_{\text{shear}}, \text{DCR}_{\text{bearing}} \right)
\]

\[
\text{DCR}_{\text{govern}} = 0.89
\]

DCR < 1.0, OK. The lower lifting tabs are adequate for lifting per ASME BTH-1.
8.3.2 Check Weld Between Lifting Tab and Spray Ring Body

This section checks the weld between the lower lifting tab and the split spray ring body.

**Weld Geometry:**

- \( b := \frac{1}{2} \text{ in} \)  
  Width of weld. (H-14-110756)
- \( d := 8 \text{ in} \)  
  Length of weld. (H-14-110756)
- \( w_{\text{act}} := \frac{1}{4} \text{ in} \)  
  Weld size. (H-14-110756)
- \( F_{\text{EXX}} := 70000-\text{psi} \)  
  Ultimate stress of the weld metal.

**Connection forces and moments.**

- \( P := T_{\text{sling}} \sin(\theta_{\text{sling}}) = 1764.94 \text{ lbf} \)
- \( V_2 := 0 \text{ ft-lbf} \)
- \( M_3 := 0 \text{ ft-lbf} \)
- \( T := 0 \text{ ft-lbf} \)
- \( V_3 := T_{\text{sling}} \cos(\theta_{\text{sling}}) = 1764.94 \text{ lbf} \)
- \( M_2 := V_3 (2.5 \text{ in}) = 367.7 \text{ ft-lbf} \)

**Weld Properties Per Blodgett 1991, Table 5, Page 7.4-7.**

- \( A_w := 2 \cdot d = 16 \text{ in} \)  
  Linear area of the weld.
- \( C_x := \frac{b}{2} = 0.25 \text{ in} \)  
  Distance to the outer fiber in the x-direction. (V2-V2)
- \( C_y := \frac{d}{2} = 4 \text{ in} \)  
  Distance to the outer fiber in the y-direction. (V3-V3)
- \( S_{wx} := \frac{d^2}{3} = 21.33 \text{ in}^2 \)  
  Linear section modulus about the x-axis. (V2-V2)
- \( S_{wy} := b \cdot d = 4 \text{ in}^2 \)  
  Linear section modulus about the y-axis. (V3-V3)
- \( J_w := \frac{d \left(3 \cdot b^2 + d^2\right)}{6} = 86.33 \text{ in}^3 \)  
  Linear polar moment of inertia.

**Linear weld stress.**

\[
A_{\text{lin}} := \sqrt{\frac{P}{A_w} + \frac{M_2}{S_{wx}} + \frac{M_3}{S_{wy}}} \quad \left(\frac{V_2}{A_w + T \cdot C_y} + \frac{V_3}{A_w + T \cdot C_x}\right) = 335.77 \text{ lbf/in} \\
R_u := \frac{A_{\text{lin}}}{0.707 w_{\text{act}}} = 1.9 \text{ ksi}
\]

**Actual stress in the weld.**

\[
R_n := \frac{0.60 \cdot F_{\text{EXX}}}{1.20 \cdot N_d} = 17.5 \text{ ksi}
\]

**Design strength of the weld. (BTH-1-2011, Eq. 3-55)**

\[
\text{DCR}_{\text{tab-weld}} := \frac{R_u}{R_n} = 0.11
\]

**DCR < 1.0, OK.** The parallel fillet welds are adequate.
8.4 Check Worst Case Condition for Removal of Assembly By Lower Lifting Tab

Do not use the lower lifting tabs for handling a mated split spray ring assembly. The purpose of this section is to ensure that a catastrophic failure will not occur should one of the lower lifting tabs be inadvertently used out of error. Follow original directions for removal and handling of mated split ring assemblies.

8.4.1 Check Bolts Holding the Two Halves Together

![Sketch showing governing bolt checked if the lower lifting tab gets inadvertently used to lift the mated spray ring assembly]

**Figure:** Sketch showing governing bolt checked if the lower lifting tab gets inadvertently used to lift the mated spray ring assembly

Load = 1764.94 lbf  
Governing spray ring section weight. (previously defined)

bolt_space := 8in  
Distance between the two bolts connecting the tops of the spray ring halves. (H-14-110756)

height := 8ft + 11in  
Overall height of the longest spray ring. (H-14-110756)

CG := \( \frac{\text{height}}{2} = 4.46 \text{ ft} \)  
Conservatively take the center of gravity as being half way down the length of the assembly. (see sketch above)

\[
\text{bolt_force} := \frac{\text{Load} \cdot \text{CG}}{\text{bolt_space} \cdot 4 \text{bolts}} = 2.95 \text{-kip}
\]  
Required tension capacity of the bolts. (see sketch above and H-14-110683)

\( A_b := 0.196 \text{ in}^2 \)  
Cross sectional area of a 1/2" fastener. (AISC 14th Ed., Table 7-17)

\( \Omega_s := 2.00 \)  
ASD safety factor for fasteners (AISC 14th Ed., Section J.3.6)

\( f_{yb} := 130000 \text{psi} \)  
Yield strength of SAE J429, Gr. 8 bolts. (see Attachment 1)

\[
\text{bolt_allowable} := \frac{f_{yb} \cdot A_b}{\Omega_s} = 12.74 \text{-kip}
\]  
Allowable tensile strength of a 1/2" SAE J429, Gr. 8 bolts. (AISC 14th Ed., Eq. J3-1)

\[
\text{DCR}_{\text{bolts}} := \frac{\text{bolt_force}}{\text{bolt_allowable}} = 0.23
\]  
\( \text{DCR} < 1.0, \text{OK.} \) The bolts are adequate for the expected loading conditions.
8.4.2 Check Weld Between the Mounting Plate and the Flange

Factored connection forces and moments.

\[ P := 2 \cdot \text{bolt\_force} = 5901.51 \text{ lbf} \quad V_2 := 0 \text{ lbf} \quad M_2 := 0 \text{ ft\cdot lbf} \]
\[ T := 0 \text{ \cdot ft\cdot lbf} \quad V_3 := 0 \text{ lbf} \]

Weld Properties Per Blodgett 1991, Table 5, Page 7.4-7.

\[ C_3 := \frac{d}{2} = 3\text{-in} \quad \text{Distance from the neutral axis to the outer fiber along the 3-3 axis.} \]
\[ A_w := d = 6\text{-in} \quad \text{Linear area of the weld.} \]
\[ A_{w2} := d = 6\text{-in} \quad \text{Linear shear area of the weld along the 2-2 axis.} \]
\[ A_{w3} := \frac{2}{3} \cdot d = 4\text{-in} \quad \text{Linear shear area of the weld along the 3-3 axis} \]
\[ S_{w2} := \frac{d^2}{6} = 6\text{-in}^2 \quad \text{Linear section modulus about the 2-2 axis.} \]
\[ J_w := \frac{d^3}{12} = 18\text{-in}^3 \quad \text{Linear polar moment of inertia.} \]

\[ A_{\text{lin}} := \left( \frac{P}{A_w} + \frac{M_2}{S_{w2}} \right)^2 + \left( \frac{V_2}{A_{w2}} + \frac{T \cdot C_3}{J_w} \right)^2 + \left( \frac{V_3}{A_{w3}} \right)^2 = 0.98 \frac{\text{kip}}{\text{in}} \quad \text{Linear weld stress.} \]

\[ R_u := \frac{A_{\text{lin}}}{0.707 \cdot w_{\text{act}}} = 4.45 \text{-ksi} \quad \text{Actual stress in the weld.} \]
\[ R_n := 0.6 \cdot F_{\text{EXX}} = 42 \text{-ksi} \quad \text{Weld design strength. (AISC 14th Ed., Table J2.5)} \]
\[ \Omega_w := 2.0 \quad \text{Weld strength reduction factor. (AISC 14th Ed., Table J2.5)} \]
\[ \text{DCR}_{\text{weld}} := \frac{\Omega_w \cdot R_u}{R_n} = 0.21 \quad \text{DCR < 1.0, OK. The weld is adequate for its expected loading conditions.} \]
SAE J429

SAE J429 covers the mechanical and material requirements for inch series fasteners used in automotive and related industries in sizes to 1-1/2" inclusive.

Below is a basic summary the most common grades, SAE J429 covers a number of other grades and grade variations not covered in this summary, including 4, 5.1, 5.2, 8.1, and 8.2.

### J429 Mechanical Properties

<table>
<thead>
<tr>
<th>Grade</th>
<th>Nominal Size, inches</th>
<th>Full Size Proofload, psi</th>
<th>Yield Strength, min, psi</th>
<th>Tensile Strength, min, psi</th>
<th>Elong, min, %</th>
<th>RA, min, %</th>
<th>Core Hardness, Rockwell</th>
<th>Tempering Temperature, min</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/4 thru 1-1/2</td>
<td>33,000</td>
<td>36,000</td>
<td>60,000</td>
<td>18</td>
<td>35</td>
<td>B7 to B100</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>1/4 thru 3/4</td>
<td>55,000</td>
<td>57,000</td>
<td>74,000</td>
<td>18</td>
<td>35</td>
<td>B80 to B100</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Over 3/4 thru 1-1/2</td>
<td>33,000</td>
<td>36,000</td>
<td>60,000</td>
<td>18</td>
<td>35</td>
<td>B70 to B100</td>
<td>N/A</td>
</tr>
<tr>
<td>5</td>
<td>1/4 thru 1</td>
<td>85,000</td>
<td>92,000</td>
<td>120,000</td>
<td>14</td>
<td>35</td>
<td>C25 to C34</td>
<td>800F</td>
</tr>
<tr>
<td></td>
<td>Over 1 thru 1-1/2</td>
<td>74,000</td>
<td>81,000</td>
<td>105,000</td>
<td>14</td>
<td>35</td>
<td>C19 to C30</td>
<td>800F</td>
</tr>
<tr>
<td>8</td>
<td>1/4 thru 1-1/2</td>
<td>120,000</td>
<td>130,000</td>
<td>150,000</td>
<td>12</td>
<td>35</td>
<td>C33 to C39</td>
<td>800F</td>
</tr>
</tbody>
</table>

Grade 2 requirements for sizes 1/4" thru 3/4" apply only to bolts 6" and shorter, and to studs of all lengths. For bolts longer than 6", Grade 1 requirements shall apply.

### J429 Chemical Requirements

<table>
<thead>
<tr>
<th>Grade</th>
<th>Material</th>
<th>Carbon, %</th>
<th>Phosphorus, %</th>
<th>Sulfur, %</th>
<th>Grade Marking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Low or Medium Carbon Steel</td>
<td>0.55 max</td>
<td>0.030 max</td>
<td>0.050 max</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>Low or Medium Carbon Steel</td>
<td>0.15 - 0.55</td>
<td>0.030 max</td>
<td>0.050 max</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>Medium Carbon Steel</td>
<td>0.28 - 0.55</td>
<td>0.030 max</td>
<td>0.050 max</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Medium Carbon Alloy Steel</td>
<td>0.28 - 0.55</td>
<td>0.030 max</td>
<td>0.050 max</td>
<td></td>
</tr>
</tbody>
</table>

### J429 Recommended Hardware

<table>
<thead>
<tr>
<th>Nuts</th>
<th>Washers</th>
</tr>
</thead>
<tbody>
<tr>
<td>J995</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### Alternate Grades

For fasteners larger than 1-1/2" in diameter, the following ASTM grades should be considered:

<table>
<thead>
<tr>
<th>SAE J429 Grade</th>
<th>ASTM Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>A307 Grades A or B</td>
</tr>
<tr>
<td>Grade 2</td>
<td>A307 Grades A or B</td>
</tr>
<tr>
<td>Grade 5</td>
<td>A449</td>
</tr>
<tr>
<td>Grade 8</td>
<td>A354 Grade BD</td>
</tr>
</tbody>
</table>

This chart compares SAE and ASTM specifications that are similar but not identical in diameters through 1½".

http://www.portlandbolt.com/technical-specifications/sae-j429/