REPLACE STEAM BOILERS

Northern Arizona VA Health Care System

649-22-104

Design Narrative & Option Descriptions – CD Set
06/29/2026

I. Project Summary (Executive Summary)

Useful Life Expectancy:

The useful life expectancy of the existing Water Tube boilers is 40 years. The existing campus steam boilers were manufactured and installed in 1975 approaching 46 years and are past their useful life. Boilers, condensate and DA tanks completed a useful life study in September 2024 with a satisfactory condition report for continued utilization. The associated plant PRV station and its associated valves, traps and specialties are beyond their useful life expectancy. The boiler plant header isolation valves, traps and warmup bypass valves are beyond their useful life expectancy. The boiler plant has been well maintained and safety device tested per the September 15-17, 2020 Boiler Plant Safety Device Training and Testing were 87% compliant.

This project will correct the below deficiencies:

- Replace boilers (economizers) and controls.
- Replace plant piping (with hangers / support), PRV and header.
- Replace deaerator, condensate and flash tanks.
- Replace condensate transfer pump, chemical feed pumps, water feed pumps, sump pumps and generator fuel pump.
- Replace gas fuel train.
- Replace electric, gas and steam meters.
- Construct new control room, with view for all boiler fronts.
- Add boiler lacking lockout / tagout capabilities.
- Install new MCC.
- Add fire suppression to plant.
- Install combustible gas monitoring near boiler plant roof.
- Remove ACM in boiler building.
- Install automatic chemical feed system.
- Add fire suppression to plant.
- Construct secondary means of egress from mezzanine.
- Replace roof membrane, near end-of-life expectancy.

- Replace roof exhaust fans.
- Install telecommunications enclosure.
- Replace fluorescent lighting with LED.
- Replace and expand air intake louvers.
- Add HVAC to control room.
- Replace windows and doors.
- Mezzanine flooring to be replaced.

Below deficiencies are not in project scope:

- Water softeners – New, resized softeners have been replaced 20th August 2025.
- Overhead paging – Addressed on separate contract.
- Air compressors - To be addressed in separate contract.
- Signage – To be addressed in separate contract.

Design Conditions:

The ASHRAE 99.6% winter outdoor design temperature for Prescott Arizona per the HVAC Design Manual (2019), is 17.7 degrees F. The 0.4% summer design temperature is 94.4 degrees F. Historical hourly load data from the boiler plants calibrated flow meters is summarized in Section V. of this report were utilized to determine maximum steam loads.

Existing Conditions:

The three existing boilers are each 12,000 LBS/HR, 350 BHP, High Pressure Water Tube boilers. Manufactured by E.Keeler Co., S.W.P. 200, W.W.H.S. 255, and B.H.S. 1,475. The total N capacity with two of the three boilers in operation is 24,000 LBS/HR with the third boiler an additional +1 of 12,000 LBS/HR. Boiler #1 burner has been modified to provide a slightly reduced capacity and is utilized during summer months of low load.

BOILER NAME PLATES

The boiler plant is currently being operated to provide 70 psig high pressure steam to the plant steam header. The 70 psig header has maintained 35 psig to the distribution system. The associated plant PRV station and its associated valves, traps and specialties are beyond their useful life expectancy. The boiler plant header isolation valves, traps and warmup bypass valves are beyond their useful life expectancy.

EXISTING 1/3-2/3 PRV STATION

EXISTING STEAM HEADER

Existing chart recorders have been abandoned and replaced with electronic indication. Control panels are outdated and in need of replacement. The existing control panels shown below will be removed and replaced with new boiler controls with a BACnet reporting interface to the new plant BAS system. The existing gas monitoring system has been upgraded and can be reused and modified to relocate the existing flammable sensors. The existing stack economizers are newer than the boilers but will be replaced with new units to match the new boiler capacities.

EXISTING PLANT CENTRAL CONTROL PANEL

EXISTING GAS MONITORING

EXISTING BOILER CONTROL

EXISTING STACK ECONOMIZER

During the 35% review, it became apparent that the existing Deaerator, DA tank, and Chemical Feed Systems needed to be added to the design. These items are past or close to life expectancy and were important to include in this scope of work to minimize down time and future down time to install and update these systems. This will also reduce the VA overall construction costs to include in this project. The Deaerator, DA tank, and Chemical Feed Systems were sent out as a change order and approved to be part of the scope of work on this project.

During the 95% review, the team realized the following deficiencies for the boiler plant. No fire suppression in the control room. No secondary egress from mezzanine. Roof membrane needs to be

replaced. Lockout / tagout capabilities lacking on existing valves and equipment. The Communications closet did not meet VA design guide requirements. The existing boiler blowdown tank and ventilation exhaust fans were also found to be past their useful life. The design was then updated to accommodate said deficiencies.

Fire Safety:

This project is to add a fire riser and fire suppression system to the control room for the Boiler Plant. This will tap into the existing 6 inch domestic waterline that has an existing 80 PSI. This is a small area that will not require much pressure or water flow. This fire suppression system will include flow valves, monitoring monitors, and adding monitoring into the existing fire alarm control panel for the fire suppression system.

Based on previous comments an Extra Hazard Group 2 (EH2) occupancy is the most demanding area for the project. From NFPA 13, and EH2 occupancy requires a density of 0.40 gpm/sq.ft. over 2500 sq.ft. for a water demand of 1000 gpm. Adding a safety factor (1.3) and a hose stream of 500 gpm the total anticipated demand is 1800 gpm. Using 6" PVC Class 200 at 1800 gpm and approximately 75' length we can expect a pressure loss of 8.5 psi. The latest water flow test information provided indicates 130 psi static available near the project site. Based on this information a 6" minimum fire line should be sufficient to support the project fire suppression system.

Hazardous Material Abatement:

The current 100% design submittal identifies several feet of existing piping and all associated fittings, supports and hangars requiring demolition, removal, and disposal off site to make way for the installation of the new proposed piping, fittings, accessories, supports, instrumentation, and insulation. Additional scope to demolish steam and steam condensate return piping has been added. We have included drawings that define the scope of work and demolition required.

Any additional asbestos that may be encountered during construction would require we set aside as a contingency a sum of funds to cover the costs of this unforeseen abatement should it occur. Our design documents will require the Contractor to randomly sample specific suspect materials prior to demolition to confirm no ACBM's are present.

The VA standard for testing existing materials will be followed. We will require the general contractor to test all insulations, and/or suspicious materials before demolition begins.

Required Boiler Capacity:

From section VI below the calculated required steam load for the facility assuming a 10% growth factor is 13,970 lbs/hr or approximately N=400 BHP. During the summer months the load decreases to 6,380 lbs/hr or approximately 200 BHP.

In conclusion the existing boiler system is oversized and the boilers are beyond their life expectancy. The recommended replacement is and will be three 300 BHP boilers to meet the N+1 requirement.

Recommended Options:

This project will provide the VA with new safe and reliable high pressure natural gas – fuel oil steam boilers that meet the required VHA safe operating requirements and safety device testing requirements. These new boilers will be safe, reliable, and efficient at a good cost to the government.

II. Applicable Standards

The design will comply with the latest adopted edition of all applicable codes and standards including, but not limited to:

- VA Directives and Design Manuals:
  - PG-18-1 Master Construction Specifications, 2004
  - PG-18-3 Design and Construction Procedures, 2020
  - PG-18-4 Standard Details and CAD Standards, 2008
  - PG-18-10:
    - 2014 Architectural Design Manual
    - 2019 Electrical Design Manual
    - 2015 Fire Protection Design Manual
    - 2017 HVAC Design Manual
    - 2020 Interior Design Manual
    - 2015 Lighting Design Manual
    - 2020 Physical Security & Resiliency Design Manual (Life Safety Protected Facilities)
    - 2018 Plumbing Design Manual
    - 2014 Structural Design Manual
  - Infrastructure Standard for Telecommunications Space
  - Directive 1810 – Boiler and Boiler Plant Operations
  - Boiler and Associated Plant Safety Device Testing Manual, Seventh Edition
  - Steam, Heating Hot Water, and Outside Distribution Systems Design Manual
- 2018 International Building Code (IBC) including International Mechanical and Plumbing Codes (Only when specifically referenced in VA Design Documents, see notes below)
- 2018 NFPA 101 Life Safety Code (see notes below)
- 2018 NFPA National Fire Codes with the exception of NFPA 5000 and NFPA 900.
- 2023 NFPA 85, Boiler and Combustion Systems Hazards Code
- Occupational, Safety and Health Administration (OSHA) Standards
- VA Seismic Design Requirements, H-18-8
- National Electrical Code (NEC)
- IEEE C2-2017 National Electrical Safety Code (NESC)
- International Plumbing Code (IPC)
- ASME Boiler and Pressure Vessel Code
- ASME Code for Pressure Piping

- 2015 Architectural Barriers Act Accessibility Standards (ABAAS) including VA Supplement, Barrier Free Design Guide (PG-18-13)
- Building Code Requirements for Reinforced Concrete, American Concrete Institute and Commentary (ACI 318)
- Manual of Steel Construction, Load and Resistance Factor Design Specifications for Structural Steel Buildings, American Institute of Steel Construction (AISC)
- Energy Policy Act of 2005 (EPAct)
- DOE Interim Final Rule: Energy Conservation Standards for New Federal, Commercial and Multi-Family High-Rise Residential Buildings and New LowRise Residential Buildings, 10 CFR Parts 433, 434 and 435.
- Federal Leadership in High Performance and Sustainable Buildings: Memorandum of Understanding (MOU)
- Executive Order 13423: Strengthening Federal Environmental, Energy, and Transportation Management
- The Provisions for Construction and Safety Signs to be stated in the General Requirements, Section 01 00 00, of the VA Construction Specifications
- Ventilation for Acceptable Indoor Air Quality – ASHRAE Standard 62.1- 2004.
- Electrical Standards – ASHRAE Standard 90.1
- IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems
- ASHRAE 55
- ASHRAE 62
- Occupational, Safety and Health Administration (OSHA) Standards
- VA Seismic Design Requirements, H-18-8 (2019)
- Building Code Requirements for Reinforced Concrete, American Concrete Institute and Commentary (ACI 318-14)
- TMS 402-16 Building code requirements & Specifications for Masonry
- Manual of Steel Construction, Load and Resistance Factor Design Specifications for Structural Steel Buildings, American Institute of Steel Construction (AISC)

NOTES:

1. NFPA 101 primarily addresses life safety and fire protection features while the IBC addresses a wide range of considerations, including, but not limited to, structural strength, seismic stability, sanitation, adequate light and ventilation, and energy conservation. VA buildings must meet the requirements of NFPA 101 and documents referenced by NFPA 101 in order to comply with the accreditation requirements of The Joint Commission. Therefore, designs shall comply with the requirements of the latest edition of NFPA 101 and documents referenced therein. Design features not addressed by NFPA 101 or documents referenced therein shall comply with the requirements of the latest edition of the IBC or as otherwise addressed above in this Program Guide. For design features that are addressed by both the IBC as well as NFPA 101 or a document referenced by NFPA 101, the requirements of NFPA 101 or the document referenced by NFPA 101 shall be used exclusively (this applies even if the IBC requirements are different). VHA PROGRAM GUIDE PG-18-3 September 2013 3 of 3
2. Conflicts between Nationally Recognized Codes and Standards and VA Requirements – Should a conflict exist between VA requirements and VA adopted nationally recognized codes and standards, the conflict shall be brought to the attention of VA. The resolution of the conflict shall be made by the authority having jurisdiction for VA to ensure a consistency system wide.

III. Design – Boilers

a. Rent two skid or trailer natural gas/ diesel 250 BHP and one 200 BHP temporary boilers. Temporary boilers to be located exterior to the boiler plant. Connect 100 PSI steam piping to plant distribution piping, condensate return, natural gas, diesel and feed water systems. Provide temporary office (Legacy Modular Building 12'x40' with restroom or equivalent), A prefabricated stair and deck assembly system with guard rails shall then be installed. Security Cameras and lighting shall be provided on temporary boilers and temporary control room.

b. Install piping, drainage, and electrical for temporary skid boilers. Two 250 BHP boilers 100psig.

c. Remove all ACM for the affected work area.

d. Install new steam and condensate return piping insulation.

e. Remove and replace existing boiler plant wall, window and catwalk to allow removal of existing and installation of new boilers.

f. After the Temporary boilers are operational and during low load summer months, remove existing boilers #1, #2 and #3 and associated stack economizers, deaerator, condensate storage tank, two condensate transfer pumps, two sump pumps and three automatic chemical feeders. Keep boiler 3 in service while replacing all the piping, catwalks, and boilers 1 and 2 demolition. This is to reduce time and costs.

g. Removal of abandoned condensate vacuum pump system and associated condensate return piping from existing boiler plant.

h. Install replacement of existing boiler plant 1/3 – 2/3 PRV system. Sequence work to minimize down time.

i. Install replacement of existing boiler plant header Isolation valves.

j. Modify existing gas detection system as necessary to allow for testing from ground level while gas detectors shall remain at roof level.

k. Install new steam, feedwater, makeup and natural gas metering.

l. Replace the electrical generator sub tank with a double walled sub tank. Install new electrical MCC, panels, and all associated circuits and equipment disconnects.

m. Replace lighting fixtures with LED, high efficiency light fixture.

n. Replace doors and provide new access control on two of the doors.

o. Provide CCTV per the VA standards, campus standards.

p. Remove local and central control systems for boilers #1, #2 and #3.

q. Install three new 300 BHP high pressure steam boilers and associated stack economizers, new deaerator, new condensate storage tank, two new condensate transfer pumps, two new sump pumps and three new automatic chemical feeders.

r. Install new louvers in wall with steam radiator to heat intake air as needed. Louvers have been sized to meet VA requirements for ventilation air and combustion air.

s. Replace four existing boiler room exhaust fans to provide adequate ventilation air to boiler plant. Calculations for sizing can be found on ME601.

t. Extend existing generator flue to upper roof area.

u. Replace existing boiler blowdown tank.

v. Replace existing evaporative cooling unit in control room with split system DX heat pump unit.

w. Install new boiler controls with associated LCD MMI in local panel. Include required safety device testing requirements. Include interface to existing BAS supervision.

x. Install new operator work stations with controls software interface and graphics for all three new boilers.

y. Change the boiler door swing.

z. Install wall and door to tunnel.

aa. Install E-Stops on egress doors

bb. After new boilers are on line, provide third party certification of new plant safety devices including lockout tagout procedures.

cc. Remove rental boilers piping and electrical, temporary stair and deck assembly with guard rails, and temporary modular office.

dd. Remove existing window, masonry wall, and concrete stem wall for placement of boilers. Reinstall window and rebuild masonry wall and concrete stem wall once boilers have been installed within the building.

ee. Provide temporary raised floor for boiler install, remove temporary floor after boilers are in place.

ff. Dismantle the existing catwalk steel beams columns etc. to allow for placement of new boiler and removal of old. Tag or track locations of catwalk elements for reassembly.

PLUS:

- Construction duration.
- Minimal campus steam system down time.

MINUS:

- Cost for boiler rental and piping.
- Additional boiler control systems and safety devices.

IV. Other Design Elements

a. Replace the existing roofing membrane.
b. Provide roof top fall protection. Provide non penetrating system.
c. Provide emergency new egress from mezzanine level to ground. Provide new door opening through existing window. Remove and reconfigure window opening to accept new door/window.
d. Provide steel HSS column door frame and out-of-plane window support.
e. Provide new steel stair at new egress. Provide steel channel stringers, beams, and columns.
f. Provide grating stairs tread and landing.
g. Provide guard rails and handrails for new stair.
h. Provide reinforced concrete footings. Patch and repair asphalt as needed.
i. Replace flooring throughout the mezzanine. New LVT shall be installed in the mezzanine office, and LVT shall be installed throughout the rest for the mezzanine.
j. Remove four windows in the control room and patch existing wall with brick to match existing.
k. Replace the remaining windows in the control room.
l. Remove the exterior door to the control room and replace it with a new door that swings out of the building.
m. Replace door between control room and boiler room with fully glazed door to optimize visibility.
n. Floor has been extended over a portion of the pit to facilitate an expansion of the control room to provide adequate site lines to all of the boilers.
o. Remove the existing door and adjacent portion of the wall separating the control room from the boiler space. Install new steel HSS columns and a double-angle steel header beam to support the modified opening.
p. Install new concrete topping over the new steel deck in the pit area north of the control room. Extend the control room footprint into this area. Construct new walls using metal studs with gypsum board, matching the finish of the existing control room. Relocate the existing catwalk and railing as necessary to accommodate the revised room layout.
q. Add a wall and door to the utility tunnel from the lower-level pump room.
r. Provide exterior roof access ladders to the three lower roofs.
s. Add fire suppression system to control room.
t. Add new enclosed telecommunications rack to the control room, update the power and HVAC to the space to meet the telecommunications requirements for Boiler.
u. Run new fiber lines to the building to meet ISTS requirements.
v. Update valves and disconnects to equipment that are lockable for lockout / tagout compatibility.

V. Historical Steam Load

Hourly maximum winter steam loads at the 99.6% outdoor winter design temperature for Prescott Arizona VA (17.7F), “HVAC Design Manual May 1, 2019”, for the winters of 2019 through 2021 are summarized in the following Boiler Plant Hourly Maximum tables. Boiler Plant calibrated steam meters recorded hourly steam consumption logs are utilized for the summarized data. Winter outdoor air temperatures (O.A.T.), near or below the design temperature are shown with the concurrent steam loads highlighted. Winter steam loads represent a single boiler in operation with a second boiler at idle operating at 70-75 psi header pressure.

- 1/31/2021 **12,700 lb/hr** steam.
- 2/12/2020 12,100 lb/hr steam.
- 2/20/2019 12,100 lb/hr steam.

Hourly maximum and minimum summer steam loads at the 0.4% outdoor summer design temperature for Prescott Arizona VA (94.4F), “HVAC Design Manual May 1, 2019”, for the summers of 2019 through 2021 are summarized in the following Boiler Plant Hourly Maximum/Minimum tables. Boiler Plant calibrated steam meters recorded hourly steam consumption logs are utilized for the summarized data. Summer outdoor air temperatures (O.A.T.), near or above the design temperature are shown with the concurrent steam loads highlighted. Summer steam loads represent a single boiler in operation with a second boiler at idle operating at 70-75 psi header pressure.

- 6/3/2021 **5,800 lb/hr** steam maximum. 6/29/2021 1,500 lb/hr minimum.
- 6/20/2020 5,800 lb/hr steam maximum. 8/28/2020 2,000 lb/hr minimum.
- 7/15/2019 5,000 lb/hr steam maximum. 8/15/2019 1,400 lb/hr minimum.

The 2020 hourly data included recent building additions to the campus with a maximum daily load of 254 Mlbs of steam and a maximum hourly steam load of 12.3 Mlbs/hr.

Boiler Plant Hourly Maximum 2021

Date	Outdoor 99.6% (17.7F) O.A.T. (F)	Maximum Hourly Steam Mlbs	Date	Outdoor 99.6% (17.7F) O.A.T. (F)	Maximum Hourly Steam Mlbs	Date	Outdoor 99.6% (17.7F) O.A.T. (F)	Maximum Hourly Steam Mlbs	Date	Outdoor 99.6% (17.7F) O.A.T. (F)	Maximum Hourly Steam Mlbs
1/1/2021	18.0	11.0	2/1/2021		10.5	3/1/2021	18.0	**11.7**	4/1/2021		8.7
1/2/2021		11.8	2/2/2021		10.0	3/2/2021		11.6	4/2/2021		7.0
1/3/2021		11.5	2/3/2021		9.1	3/3/2021		11.2	4/3/2021		7.9
1/4/2021		11.4	2/4/2021		10.2	3/4/2021		10.0	4/4/2021		8.2
1/5/2021		10.9	2/5/2021		10.9	3/5/2021		10.3	4/5/2021		8.3
1/6/2021		10.9	2/6/2021	25.0	**12.7**	3/6/2021		9.2	4/6/2021		7.1
1/7/2021		11.4	2/7/2021		10.6	3/7/2021		9.1	4/7/2021		8.3
1/8/2021		11.2	2/8/2021		11.6	3/8/2021		8.5	4/8/2021		8.0
1/9/2021		10.7	2/9/2021		9.6	3/9/2021		9.6	4/9/2021	31.0	**8.9**
1/10/2021	17.0	11.3	2/10/2021		9.6	3/10/2021		8.8	4/10/2021		7.6
1/11/2021	18.0	11.8	2/11/2021		9.5	3/11/2021		10.0	4/11/2021		7.6
1/12/2021	13.0	12.5	2/12/2021		9.5	3/12/2021		9.9	4/12/2021		8.3
1/13/2021		11.2	2/13/2021		9.6	3/13/2021		10.9	4/13/2021		7.3
1/14/2021		10.5	2/14/2021		9.6	3/14/2021		10.6	4/14/2021		8.0
1/15/2021		11.6	2/15/2021		11.0	3/15/2021		10.2	4/15/2021		8.2
1/16/2021		10.5	2/16/2021		10.1	3/16/2021		10.9	4/16/2021		7.5
1/17/2021		11.7	2/17/2021		11.7	3/17/2021		11.0	4/17/2021		7.9
1/18/2021		10.9	2/18/2021	18.0	11.6	3/18/2021		10.0	4/18/2021		8.0
1/19/2021		9.7	2/19/2021		11.2	3/19/2021		10.0	4/19/2021		8.0
1/20/2021		10.4	2/20/2021		10.0	3/20/2021		8.7	4/20/2021		7.2
1/21/2021		9.2	2/21/2021		10.2	3/21/2021		9.6	4/21/2021		7.3
1/22/2021		9.1	2/22/2021		11.1	3/22/2021		10.4	4/22/2021		6.9
1/23/2021		10.1	2/23/2021		10.7	3/23/2021		9.4	4/23/2021		6.8
1/24/2021		10.7	2/24/2021		8.9	3/24/2021		9.5	4/24/2021		7.8
1/25/2021		11.6	2/25/2021		10.5	3/25/2021		9.6	4/25/2021		6.9
1/26/2021		11.9	2/26/2021		11.4	3/26/2021		10.1	4/26/2021		7.2
1/27/2021	5.0	11.9	2/27/2021		9.6	3/27/2021		11.0	4/27/2021		7.8
1/28/2021	18.0	12.6	2/28/2021		10.7	3/28/2021		10.2	4/28/2021		8.3
1/29/2021		10.6				3/29/2021		9.0	4/29/2021		7.8
1/30/2021	17.0	12.0				3/30/2021		9.0	4/30/2021		7.6
1/31/2021	18.0	**12.7**				3/31/2021		10.3			
Janurary		**12.7**	**Feburary**		**12.7**	**March**		**11.7**	**April**		**8.9**

Table 1

Boiler Plant Summer Hourly Maximum/Minimum 2021

Date	Maximum Hourly Steam Mlbs	Outdoor 0.4% (94.4F) O.A.T. (F)	Minimum Hourly Steam Mlbs	Date	Maximum Hourly Steam Mlbs	Outdoor 0.4% (94.4F) O.A.T. (F)	Minimum Hourly Steam Mlbs	Date	Maximum Hourly Steam Mlbs	Outdoor 0.4% (94.4F) O.A.T. (F)	Minimum Hourly Steam Mlbs
6/1/2021	5.4		3.4	7/1/2021	5.0	90.0	**2.9**	8/1/2021	5.1		3.5
6/2/2021	4.7		3.4	7/2/2021	4.8		3.3	8/2/2021	5.2		3.6
6/3/2021	5.8	94.0	3.2	7/3/2021	4.7		3.4	8/3/2021	5.0	94.0	3.5
6/4/2021	5.7	95.0	3.4	7/4/2021	4.9		3.5	8/4/2021	4.6	98.0	3.7
6/5/2021	5.3	93.0	3.4	7/5/2021	5.3	95.0	3.0	8/5/2021	5.7	96.0	**2.2**
6/6/2021	5.7		3.5	7/6/2021	5.2	100.0	3.3	8/6/2021	4.8	93.0	3.3
6/7/2021	5.5		3.7	7/7/2021	5.8	101.0	3.0	8/7/2021	5.0	93.0	3.5
6/8/2021	5.3		3.7	7/8/2021	4.3	99.0	3.0	8/8/2021	**5.8**	93.0	3.5
6/9/2021	5.6		3.8	7/9/2021	5.2	105.0	3.3	8/9/2021	5.2	93.0	3.5
6/10/2021	5.3		3.8	7/10/2021	4.6	105.0	3.5	8/10/2021	5.0		3.9
6/11/2021	5.4		3.5	7/11/2021	4.6	103.0	3.3	8/11/2021	5.0		3.6
6/12/2021	5.5	97.0	3.5	7/12/2021	5.0	96.0	3.3	8/12/2021	5.2		3.7
6/13/2021	4.9	96.0	3.1	7/13/2021	4.9	94.0	3.2	8/13/2021			
6/14/2021	4.7	103.0	2.4	7/14/2021	4.5		3.5	8/14/2021			
6/15/2021	4.1	105.0	3.0	7/15/2021	5.1		3.5	8/15/2021			
6/16/2021	4.3	102.0	3.1	7/16/2021	4.6		3.6	8/16/2021			
6/17/2021	4.9	104.0	3.1	7/17/2021	4.7		3.5	8/17/2021			
6/18/2021	4.8	103.0	3.3	7/18/2021	4.7		3.6	8/18/2021			
6/19/2021	5.0	98.0	3.2	7/19/2021	5.0		3.5	8/19/2021			
6/20/2021	5.7	101.0	3.1	7/20/2021	4.8		3.6	8/20/2021			
6/21/2021	5.4	94.0	3.0	7/21/2021	5.2		3.6	8/21/2021			
6/22/2021	4.2	96.0	3.3	7/22/2021	5.1		3.5	8/22/2021			
6/23/2021	5.0		3.1	7/23/2021	5.4		3.4	8/23/2021			
6/24/2021	4.9		3.7	7/24/2021	**5.8**		3.8	8/24/2021			
6/25/2021	5.1		3.6	7/25/2021	4.9		3.7	8/25/2021			
6/26/2021	5.5		2.5	7/26/2021	5.3		3.8	8/26/2021			
6/27/2021	5.6	94.0	3.1	7/27/2021	5.1		3.5	8/27/2021			
6/28/2021	5.6	93.0	3.4	7/28/2021	5.3		3.4	8/28/2021			
6/29/2021	4.4	86.0	**1.5**	7/29/2021	5.0		3.3	8/29/2021			
6/30/2021	**6.3**	80.0	2.3	7/30/2021	5.0		3.8	8/30/2021			
				7/31/2021	5.2		3.9	8/31/2021			
June	**6.3**		**1.5**	**July**	**5.8**		**2.9**	**August**	**5.8**		**2.2**

Table 2

RDC + EA, LLLP

Boiler Plant Hourly Maximum 2020

Date	Outdoor 99.6% (17.7F) O.A.T. (F)	Maximum Hourly Steam Mlbs	Date	Outdoor 99.6% (17.7F) O.A.T. (F)	Maximum Hourly Steam Mlbs	Date	Outdoor 99.6% (17.7F) O.A.T. (F)	Maximum Hourly Steam Mlbs	Date	Outdoor 99.6% (17.7F) O.A.T. (F)	Maximum Hourly Steam Mlbs
1/1/2020		11.9	2/1/2020		10.0	3/1/2020		8.0	12/1/2020		11.1
1/2/2020		11.1	2/2/2020		10.1	3/2/2020		10.0	12/2/2020	19.0	11.5
1/3/2020		11.7	2/3/2020	19.0	10.1	3/3/2020		9.8	12/3/2020	19.0	10.8
1/4/2020		11.5	2/4/2020	14.0	11.9	3/4/2020		9.9	12/4/2020	16.0	12.0
1/5/2020		11.5	2/5/2020	12.0	**12.3**	3/5/2020		9.6	12/5/2020		10.8
1/6/2020		11.3	2/6/2020		12.3	3/6/2020		9.6	12/6/2020		11.1
1/7/2020		12.0	2/7/2020		10.7	3/7/2020		8.9	12/7/2020		11.4
1/8/2020		11.7	2/8/2020		9.9	3/8/2020		8.8	12/8/2020		10.5
1/9/2020		10.1	2/9/2020		9.9	3/9/2020		9.4	12/9/2020		11.0
1/10/2020	13.0	**12.0**	2/10/2020		9.3	3/10/2020		8.9	12/10/2020		10.1
1/11/2020	19.0	11.3	2/11/2020		9.7	3/11/2020		8.3	12/11/2020		10.2
1/12/2020		11.5	2/12/2020	18.0	12.1	3/12/2020		8.4	12/12/2020		10.5
1/13/2020		10.6	2/13/2020		11.1	3/13/2020		10.3	12/13/2020	13.0	11.3
1/14/2020		10.5	2/14/2020		10.8	3/14/2020		9.1	12/14/2020		10.4
1/15/2020		11.4	2/15/2020		10.5	3/15/2020		9.5	12/15/2020	18.0	11.0
1/16/2020		10.3	2/16/2020		9.7	3/16/2020		9.2	12/16/2020	18.0	11.6
1/17/2020		9.9	2/17/2020		10.6	3/17/2020		8.3	12/17/2020		11.0
1/18/2020		11.4	2/18/2020		9.9	3/18/2020		10.4	12/18/2020		11.6
1/19/2020		11.0	2/19/2020		9.6	3/19/2020		10.1	12/19/2020	18.0	11.3
1/20/2020		9.8	2/20/2020		9.7	3/20/2020		10.1	12/20/2020		10.6
1/21/2020		9.7	2/21/2020		9.4	3/21/2020		9.5	12/21/2020		10.9
1/22/2020		9.8	2/22/2020		9.1	3/22/2020		9.3	12/22/2020	25.0	**12.2**
1/23/2020		10.2	2/23/2020		9.6	3/23/2020		9.2	12/23/2020		11.1
1/24/2020		10.6	2/24/2020		9.9	3/24/2020		10.2	12/24/2020	16.0	11.7
1/25/2020		10.7	2/25/2020		10.7	3/25/2020		7.9	12/25/2020		11.2
1/26/2020		10.2	2/26/2020		10.9	3/26/2020		9.0	12/26/2020		10.4
1/27/2020		10.1	2/27/2020		10.2	3/27/2020		10.1	12/27/2020		10.7
1/28/2020		10.6	2/28/2020		9.6	3/28/2020	25.0	**10.7**	12/28/2020		10.9
1/29/2020		9.7	2/29/2020		9.5	3/29/2020		9.0	12/29/2020		11.0
1/30/2020		11.3				3/30/2020		9.4	12/30/2020	17.0	11.6
1/31/2020		10.9				3/31/2020		8.7	12/31/2020		11.9
Janurary		**12.0**	**Feburary**		**12.3**	**March**		**10.7**	**December**		**12.2**

Table 3

Boiler Plant Summer Hourly Maximum/Minimum 2020

Date	Maximum Hourly Steam Mlbs	Outdoor 0.4% (94.4F) O.A.T. (F)	Minimum Hourly Steam Mlbs	Date	Maximum Hourly Steam Mlbs	Outdoor 0.4% (94.4F) O.A.T. (F)	Minimum Hourly Steam Mlbs	Date	Maximum Hourly Steam Mlbs	Outdoor 0.4% (94.4F) O.A.T. (F)	Minimum Hourly Steam Mlbs
6/1/2020	5.8	90.0	2.9	7/1/2020	5.0		2.5	8/1/2020	4.0	98.0	2.5
6/2/2020	4.8	59.0	**2.4**	7/2/2020	4.7		2.5	8/2/2020	4.3	94.0	2.5
6/3/2020	5.0	96.0	2.8	7/3/2020	4.5		2.6	8/3/2020	4.0	96.0	2.5
6/4/2020	4.4	62.0	**2.4**	7/4/2020	5.1	94.0	2.7	8/4/2020	4.0	94.0	2.6
6/5/2020	4.9	90.0	2.7	7/5/2020	5.9	96.0	2.8	8/5/2020	4.1		2.7
6/6/2020	5.6		3.1	7/6/2020	4.5	96.0	2.7	8/6/2020	4.1		2.8
6/7/2020	7.6	78.0	3.1	7/7/2020	5.2	94.0	2.3	8/7/2020	3.9		2.6
6/8/2020	5.9		3.3	7/8/2020	4.9	94.0	2.5	8/8/2020	4.2	94.0	2.5
6/9/2020	5.5		3.1	7/9/2020	3.8	96.0	2.5	8/9/2020	3.8	95.0	2.6
6/10/2020	4.5		3.3	7/10/2020	5.2	96.0	2.4	8/10/2020	4.4	95.0	2.6
6/11/2020	5.4		2.6	7/11/2020	4.3	97.0	2.7	8/11/2020	4.4	95.0	2.5
6/12/2020	5.9		2.7	7/12/2020	3.9	102.0	2.5	8/12/2020	3.5	96.0	2.4
6/13/2020	5.1		3.3	7/13/2020	4.2	98.0	2.4	8/13/2020	3.5	100.0	2.2
6/14/2020	6.1		3.3	7/14/2020	5.3	94.0	2.5	8/14/2020	3.7	101.0	2.2
6/15/2020	4.5		2.8	7/15/2020	4.0	95.0	2.5	8/15/2020	4.0	102.0	2.3
6/16/2020	4.5		3.1	7/16/2020	4.6	93.0	2.6	8/16/2020	3.8	105.0	2.3
6/17/2020	5.3		3.0	7/17/2020	4.5	96.0	2.4	8/17/2020	4.4	100.0	2.3
6/18/2020	4.3		3.2	7/18/2020	4.0	95.0	2.5	8/18/2020	3.8	99.0	2.4
6/19/2020	5.2		2.8	7/19/2020	4.4	97.0	2.5	8/19/2020	3.7	102.0	2.3
6/20/2020	5.8	94.0	3.0	7/20/2020	4.4		2.6	8/20/2020	3.4	98.0	2.3
6/21/2020	4.7	94.0	2.7	7/21/2020	4.4		2.4	8/21/2020	3.3		2.5
6/22/2020	5.1	95.0	2.7	7/22/2020	4.2	95.0	2.4	8/22/2020	3.5	95.0	2.3
6/23/2020	5.0	98.0	2.8	7/23/2020	4.2		2.6	8/23/2020	3.7		2.5
6/24/2020	5.5	96.0	2.7	7/24/2020	5.1		2.7	8/24/2020	3.8	96.0	2.5
6/25/2020	4.7		2.8	7/25/2020	5.4		2.9	8/25/2020	3.7	94.0	2.7
6/26/2020	5.1	94.0	2.6	7/26/2020	4.9		2.7	8/26/2020	3.9	98.0	2.5
6/27/2020	4.8		3.0	7/27/2020	5.2	94.0	2.4	8/27/2020	4.0	97.0	2.1
6/28/2020	5.3	95.0	3.3	7/28/2020	4.7	99.0	2.4	8/28/2020	3.8	64.0	**2.0**
6/29/2020	5.4		2.6	7/29/2020	4.5	72.0	**2.2**	8/29/2020	4.4		2.1
6/30/2020	4.6	98.0	2.9	7/30/2020	4.5	73.0	**2.2**	8/30/2020	3.8		2.4
				7/31/2020	4.3	102.0	2.5	8/31/2020	3.9		2.5
June	**7.6**		**2.4**	**July**	**5.9**		**2.2**	**August**	**4.4**		**2.0**

Table 4

Boiler Plant Hourly Maximum 2019

Date	Outdoor 99.6% (17.7F) O.A.T. (F)	Maximum Hourly Steam Mlbs	Date	Outdoor 99.6% (17.7F) O.A.T. (F)	Maximum Hourly Steam Mlbs	Date	Outdoor 99.6% (17.7F) O.A.T. (F)	Maximum Hourly Steam Mlbs	Date	Outdoor 99.6% (17.7F) O.A.T. (F)	Maximum Hourly Steam Mlbs
1/1/2019	1.0	13.1	2/1/2019		11.3	3/1/2019		9.0	12/1/2019		10.8
1/2/2019	1.0	13.0	2/2/2019		10.2	3/2/2019		9.1	12/2/2019		10.8
1/3/2019	8.0	**13.2**	2/3/2019		9.9	3/3/2019		9.5	12/3/2019		11.0
1/4/2019		12.9	2/4/2019		10.8	3/4/2019		9.8	12/4/2019		9.5
1/5/2019		11.1	2/5/2019		10.8	3/5/2019		10.8	12/5/2019		9.9
1/6/2019		10.7	2/6/2019		11.4	3/6/2019		8.9	12/6/2019		10.0
1/7/2019		11.3	2/7/2019	16.0	12.1	3/7/2019		9.5	12/7/2019		9.6
1/8/2019		11.5	2/8/2019	16.0	**13.0**	3/8/2019		9.7	12/8/2019		8.7
1/9/2019		11.3	2/9/2019	24.0	11.5	3/9/2019		11.2	12/9/2019		9.8
1/10/2019		10.6	2/10/2019	17.0	11.8	3/10/2019		10.4	12/10/2019		10.2
1/11/2019		11.1	2/11/2019	17.0	11.5	3/11/2019		10.1	12/11/2019		10.4
1/12/2019		11.4	2/12/2019	17.0	11.6	3/12/2019		9.5	12/12/2019		10.8
1/13/2019		10.4	2/13/2019		11.1	3/13/2019		10.9	12/13/2019		10.0
1/14/2019		11.2	2/14/2019		10.3	3/14/2019	23.0	**11.4**	12/14/2019		9.3
1/15/2019		10.2	2/15/2019		10.9	3/15/2019		11.3	12/15/2019		10.4
1/16/2019		9.5	2/16/2019		10.7	3/16/2019		10.8	12/16/2019		10.7
1/17/2019		10.6	2/17/2019		11.4	3/17/2019		10.1	12/17/2019	15.0	11.8
1/18/2019		9.9	2/18/2019		11.7	3/18/2019		10.1	12/18/2019	18.0	11.7
1/19/2019		11.0	2/19/2019		12.0	3/19/2019		9.4	12/19/2019		11.7
1/20/2019		10.8	2/20/2019	17.0	12.1	3/20/2019		9.1	12/20/2019	18.0	11.3
1/21/2019		10.6	2/21/2019		11.4	3/21/2019		10.3	12/21/2019		10.7
1/22/2019		10.9	2/22/2019		11.9	3/22/2019		10.6	12/22/2019		10.8
1/23/2019	19.0	11.2	2/23/2019		11.7	3/23/2019		9.9	12/23/2019		9.7
1/24/2019		11.3	2/24/2019		11.2	3/24/2019		10.1	12/24/2019		10.4
1/25/2019		11.9	2/25/2019		12.4	3/25/2019		10.5	12/25/2019		10.0
1/26/2019		11.4	2/26/2019		12.4	3/26/2019		9.3	12/26/2019		11.5
1/27/2019		11.8	2/27/2019		10.1	3/27/2019		8.3	12/27/2019		10.5
1/28/2019		10.8	2/28/2019		10.3	3/28/2019		9.8	12/28/2019		11.7
1/29/2019		10.1				3/29/2019		9.5	12/29/2019	16.0	12.0
1/30/2019		9.4				3/30/2019		10.0	12/30/2019		11.2
1/31/2019		10.3				3/31/2019		10.1	12/31/2019	25.0	**12.2**
Janurary		**13.2**	**Feburary**		**13.0**	**March**		**11.4**	**December**		**12.2**

Table 5

Boiler Plant Summer Hourly Maximum/Minimum 2019

Date	Maximum Hourly Steam Mlbs	Outdoor 0.4% (94.4F) O.A.T. (F)	Minimum Hourly Steam Mlbs	Date	Maximum Hourly Steam Mlbs	Outdoor 0.4% (94.4F) O.A.T. (F)	Minimum Hourly Steam Mlbs	Date	Maximum Hourly Steam Mlbs	Outdoor 0.4% (94.4F) O.A.T. (F)	Minimum Hourly Steam Mlbs
6/1/2019	6.9	81.0	4.5	7/1/2019	4.5		2.1	8/1/2019	4.5		1.9
6/2/2019	6.5		4.7	7/2/2019	4.9		2.3	8/2/2019	4.6		1.8
6/3/2019	6.0		3.1	7/3/2019	4.5		2.4	8/3/2019	4.6		2.0
6/4/2019	5.4		2.8	7/4/2019	4.4		2.7	8/4/2019	4.4	94.0	2.4
6/5/2019	4.0		2.1	7/5/2019	4.5		2.1	8/5/2019	5.1	98.0	3.0
6/6/2019	4.3		2.4	7/6/2019	4.1		2.4	8/6/2019	5.2	90.0	3.1
6/7/2019	4.1		2.1	7/7/2019	4.7		2.1	8/7/2019	4.6		2.4
6/8/2019	3.2	47.0	**1.8**	7/8/2019	4.4		2.6	8/8/2019	3.7		2.3
6/9/2019	3.6	46.0	**1.8**	7/9/2019	4.9		2.8	8/9/2019	3.9		2.2
6/10/2019	4.2	51.0	**1.8**	7/10/2019	4.4		2.4	8/10/2019	4.1		2.6
6/11/2019	4.3	54.0	**1.8**	7/11/2019	4.6		2.6	8/11/2019	4.1		2.3
6/12/2019	4.8		2.0	7/12/2019	4.3		2.5	8/12/2019	3.9		2.3
6/13/2019	5.5		2.0	7/13/2019	4.3		2.3	8/13/2019	4.0	93.0	2.1
6/14/2019	5.7		2.8	7/14/2019	4.3		2.8	8/14/2019	4.6	97.0	1.9
6/15/2019	4.4		2.8	7/15/2019	5.0	96.0	1.7	8/15/2019	3.9	60.0	1.4
6/16/2019	5.0		2.8	7/16/2019	3.6		2.3	8/16/2019	4.2	94.0	2.3
6/17/2019	4.7		2.5	7/17/2019	4.3		2.3	8/17/2019	3.8		2.1
6/18/2019	5.0		2.0	7/18/2019	4.0		2.2	8/18/2019	3.9		1.9
6/19/2019	3.9		1.9	7/19/2019	4.4		2.0	8/19/2019	3.9		2.0
6/20/2019	3.6		2.1	7/20/2019	4.9		1.9	8/20/2019	4.7	97.0	2.0
6/21/2019	3.7		2.0	7/21/2019	3.7		2.0	8/21/2019	4.1	98.0	2.0
6/22/2019	3.5		1.9	7/22/2019	4.5		2.2	8/22/2019	3.9	94.0	2.0
6/23/2019	3.2		2.0	7/23/2019	4.6		2.6	8/23/2019	3.7		2.6
6/24/2019	4.4		1.9	7/24/2019	4.6		2.2	8/24/2019	4.4		2.2
6/25/2019	4.0		1.9	7/25/2019	4.2		2.0	8/25/2019	3.7		2.1
6/26/2019	4.7		2.3	7/26/2019	3.7		2.0	8/26/2019	4.1	96.0	2.4
6/27/2019	4.9		2.6	7/27/2019	3.5		1.8	8/27/2019	3.4	97.0	2.0
6/28/2019	5.0		2.5	7/28/2019	4.0		2.1	8/28/2019	4.3	95.0	2.1
6/29/2019	4.5		2.2	7/29/2019	4.0		2.1	8/29/2019	3.7	94.0	2.1
6/30/2019	4.3		2.3	7/30/2019	4.8		2.0	8/30/2019	4.2	97.0	2.4
				7/31/2019	3.8		2.1	8/31/2019	4.0	98.0	2.5
June	**6.9**		**1.8**	**July**	**5.0**		**1.7**	**August**	**5.2**		**1.4**

Table 6

VI. Calculations

From the data summary in Section V above, the Prescott VA winter steam load is 12,700 lbs/hr at the required 99.6% winter design temperature of 17.7F. With a 10% growth factor N=12,700*1.10=**13,970 lbs/hr,** approximately 400 BHP. The three existing equally sized boilers provide an oversized N=24,000 lbs/hr. The summer steam load is 5,800 lbs/hr. With a 10% growth factor N=5,800*1.10=**6,380 lbs/hr,** approximately 200 BHP. . In conclusion the existing boiler system is oversized, and the boilers are beyond their life expectancy. The recommended replacement is and will be three 300 BHP boilers to meet the N+1requirements year-round. Piping system stress analysis was performed on the steam and condensate return systems. Both systems were found to be within allowable stresses and the hanger loads calculated indicate minimal loading. The final contractor submitted hangers shall be in compliance with these calculations and industry standards.

See Attachment A: Structural Calculations
See Attachment B: Condensate Return Stress Analysis
See Attachment C: Steam Piping Stress Analysis

End of Design Option Narrative & Calculations

Attachment A

STRUCTURAL CALCULATIONS

SLC1 Dunnage Generator Support Frame

Northern VA Health Care System 500 N. State HWY 89 Prescott AZ, 86313

WCA Structural Engineering Inc.

Project #: 23116

Construction Documents

Engineer of Record
Cliff Cole
Prepared by:
Timothy P. Thurgood

JUNE 6, 2025

Project Name:	Replace Steam Boilers	Client Name:	EA Solutions
Street Number:	Northern VA Health Care System 500 N. State HWY 89	Street Number:	324 S State Street
City/State:	Prescott AZ, 86313	City/State	SLC, UT

WCA Structural Engineering 442 North Main Street Bountiful UT, 84010

Calculation Index

1. Design Criteria and Scope PG#
2. Loading PG#
3. Foundation Elements/Boiler PG#
4. Stairs PG#

WCA Structural Engineering 442 North Main Street Bountiful UT, 84010

1. Design Criteria and Scope

Project Information

Address/City/State/Zip	Northern VA Health Care System 500 N. State HWY 89 Prescott AZ, 86313
Area/Subdivision	NA
County	Salt Lake

Jurisdiction/ Occupancy

Jurisdiction	NA
Building Code	IBC 2018
Use and Occupancy classification	VA Medical
Risk Category	IV

Deferred Submittals

Gravity Load Parameters

Dead			**Description**
Boiler	37,000	#	Superior Boiler
Dead	20	psf	Dead Load on Platform
Live			**Description**
Live Load	40	psf	Live Load on Platform
Snow			**Description**
Roof Snow	26	psf	Live load on Platform
Ground Snow	34	psf	Ground Snow

Seismic		**Description**
S_{DS}	0.344	Design Short Sprectral Resonse

Wind

Wind Speed	111	mph	Ultimate
Wind Pressure	55	psf	

Soil

Geotechnical design basis

Min Frost	=	30	in
Site Class	=	D	
Soil Bearing Pressure	=	1500	psf

WCA Structural Engineering 442 North Main Street Bountiful UT, 84010

Scope

Design/Verify the existing boiler foundation elements to support new boilers. Remove the exsiting north foundation wall and window for install of new boilers. Replace foundation wall and window after install of boiler. Remove and replace existing mezzanine for install of boilers. Design new steel stair for second entrance. Design new header and window opening to stairs.

2. Loading

This is a beta release of the new ATC Hazards by Location website. Please contact us with feedback.

The ATC Hazards by Location website will not be updated to support ASCE 7-22. Find out why.

Hazards by Location

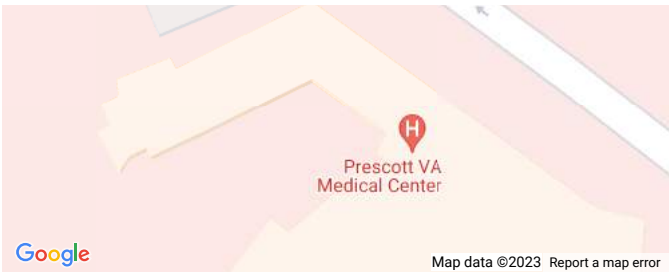
Search Information

Coordinates: 34.55389376354381, -112.45270965332031

Elevation: 5329 ft

Timestamp: 2023-08-15T18:58:08.313Z

Hazard Type: Wind



ASCE 7-16

MRI 10-Year	71 mph
MRI 25-Year	77 mph
MRI 50-Year	82 mph
MRI 100-Year	87 mph
Risk Category I	95 mph
Risk Category II	101 mph
Risk Category III	107 mph
Risk Category IV	111 mph

ASCE 7-10

MRI 10-Year	76 mph
MRI 25-Year	84 mph
MRI 50-Year	90 mph
MRI 100-Year	96 mph
Risk Category I	105 mph
Risk Category II	115 mph
Risk Category III-IV	120 mph

ASCE 7-05

ASCE 7-05 Wind Speed	90 mph

The results indicated here DO NOT reflect any state or local amendments to the values or any delineation lines made during the building code adoption process. Users should confirm any output obtained from this tool with the local Authority Having Jurisdiction before proceeding with design.

Please note that the ATC Hazards by Location website will not be updated to support ASCE 7-22. Find out why.

Disclaimer

Hazard loads are interpolated from data provided in ASCE 7 and rounded up to the nearest whole integer. Per ASCE 7, islands and coastal areas outside the last contour should use the last wind speed contour of the coastal area – in some cases, this website will extrapolate past the last wind speed contour and therefore, provide a wind speed that is slightly higher. NOTE: For queries near wind-borne debris region boundaries, the resulting determination is sensitive to rounding which may affect whether or not it is considered to be within a wind-borne debris region.

Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.

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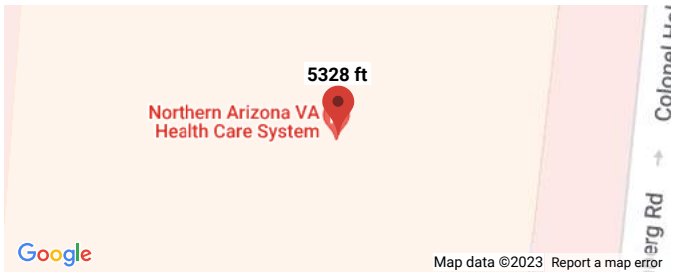
This is a beta release of the new ATC Hazards by Location website. Please contact us with feedback.

The ATC Hazards by Location website will not be updated to support ASCE 7-22. Find out why.

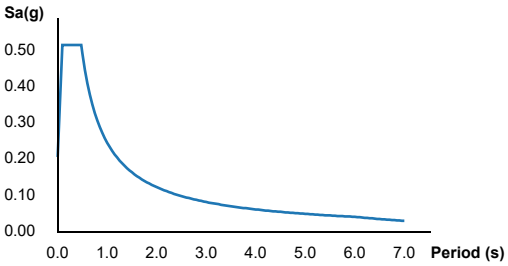
Hazards by Location

Search Information

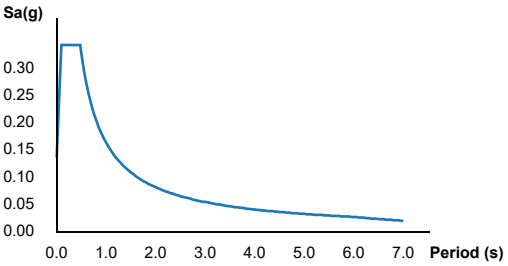
Address:	prescott AZ VA Hospital
Coordinates:	34.5538766, -112.45247
Elevation:	5328 ft
Timestamp:	2023-07-17T16:56:50.994Z
Hazard Type:	Seismic
Reference Document:	ASCE7-16
Risk Category:	IV
Site Class:	D-default



MCER Horizontal Response Spectrum



Design Horizontal Response Spectrum



Basic Parameters

Name	Value	Description
S_S	0.337	MCE_R ground motion (period=0.2s)
S_1	0.102	MCE_R ground motion (period=1.0s)
S_{MS}	0.515	Site-modified spectral acceleration value
S_{M1}	0.245	Site-modified spectral acceleration value
S_{DS}	0.344	Numeric seismic design value at 0.2s SA
S_{D1}	0.164	Numeric seismic design value at 1.0s SA

Additional Information

Name	Value	Description
SDC	D	Seismic design category
F_a	1.531	Site amplification factor at 0.2s
F_v	2.395	Site amplification factor at 1.0s
CR_S	0.906	Coefficient of risk (0.2s)
CR_1	0.918	Coefficient of risk (1.0s)
PGA	0.151	MCE_G peak ground acceleration
F_{PGA}	1.499	Site amplification factor at PGA
PGA_M	0.226	Site modified peak ground acceleration
T_L	6	Long-period transition period (s)
SsRT	0.337	Probabilistic risk-targeted ground motion (0.2s)
SsUH	0.372	Factored uniform-hazard spectral acceleration (2% probability of exceedance in 50 years)
SsD	1.5	Factored deterministic acceleration value (0.2s)
S1RT	0.102	Probabilistic risk-targeted ground motion (1.0s)
S1UH	0.112	Factored uniform-hazard spectral acceleration (2% probability of exceedance in 50 years)

S1D	0.6	Factored deterministic acceleration value (1.0s)
PGAd	0.5	Factored deterministic acceleration value (PGA)

The results indicated here DO NOT reflect any state or local amendments to the values or any delineation lines made during the building code adoption process. Users should confirm any output obtained from this tool with the local Authority Having Jurisdiction before proceeding with design.

Please note that the ATC Hazards by Location website will not be updated to support ASCE 7-22. Find out why.

Disclaimer

Hazard loads are provided by the U.S. Geological Survey Seismic Design Web Services.

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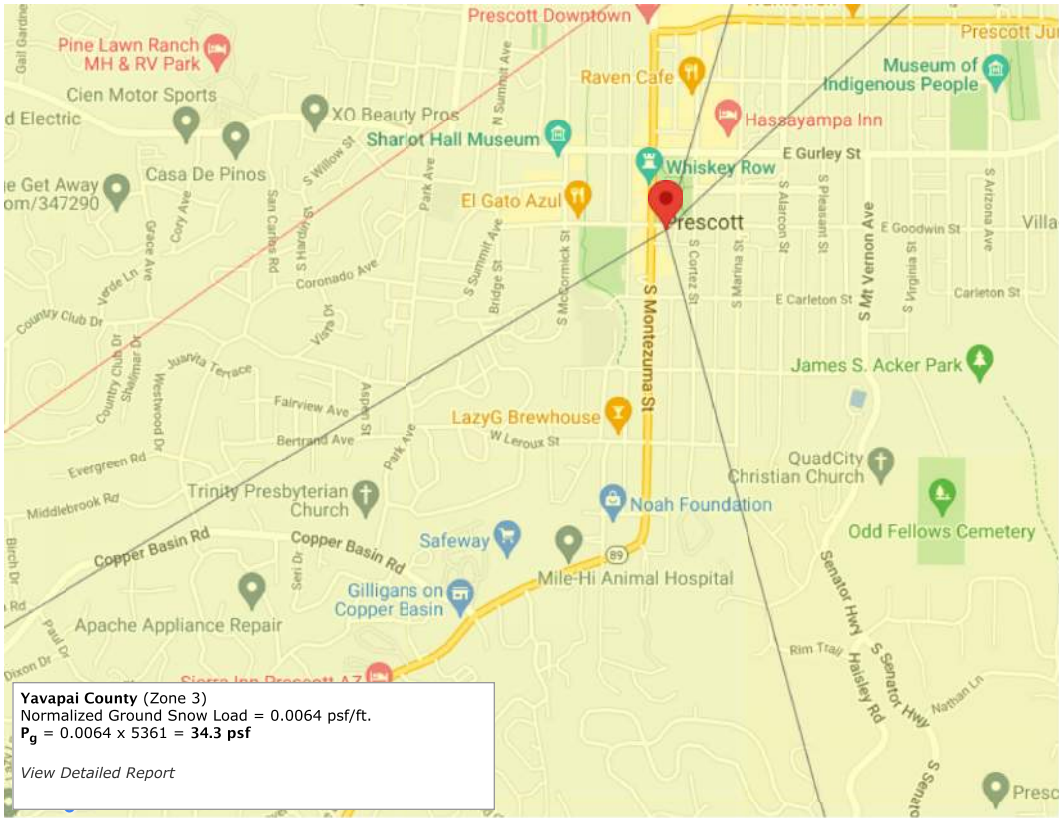
Arizona Ground Snow Loads BETA

Use our **Arizona Ground Snow Loads** map to easily determine the ground snow load for any location in the State of Arizona. You can click on the l
load for that location.

The calculated ground snow loads are based on data from over 500 climate monitoring stations across Arizona. The map uses an inverse distance
ground snow loads based on the 2006 snow load report (*A Review of Climatological Data for Ground Snow Loads in Arizona*) by Scott Free

Street: City: State: Arizona Zip:



* Ground snow loads derived from A Review of Climatological Data for Ground Snow Loads in Arizona, 2006. Local codes and ammendments may govern,verify v

Use our *Roof Snow Load Calculator* to determine your design roof snow loads.
If you have any questions or concerns about specific ground snow loads within the State of Arizona please call us at 1-425-420-5715.

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3. **Foundation Elements/Boiler**

SUPERIOR BOILER

BUILT TO OUTPERFORM

SHAWNEE

Ds & O TYPE

J&B Sales,

Project Proposal: VA Prescott
Proposal Number: 4100679 R1
Date: October 14, 2022

1. Specifications

A. Design		
Boiler gross capacity at MCR	10,500	lb/hr
Blowdown Rate at MCR	210	lb/hr
Boiler Net Capacity at MCR	10,500	lb/hr
Fuel	NG	
Maximum heat input	12.7	MM btu/hr
Maximum allowable working pressure	160	psig
Boiler operating pressure at steam drum	70	psig
Saturated steam temperature at steam drum	316	^{o}F
Feed water temperature (DA to economizer)	227	^{o}F
Ambient air temperature	70	^{o}F
Relative humidity	60	%
Elevation (FASL)	<1000	ft
Design blow-down rate	2	%
Installation type	Indoor	
Electrical supply power available	460V/3Ph/60Hz	
Control supply power available	120V	
Project location specific		

B. Boiler Specifications			
Boiler type	Ds	O	
Flue gas discharge location	Top	Top	
Boiler overall height	10’- 0”	10’- 0”	ft-in
Boiler overall width	8’- 4”	8’- 2”	ft-in
Boiler length over casing (less burner)	10’- 4”	10’- 6”	ft-in
Boiler length including burner (assumed)	15’- 4”	15’- 6”	ft-in
Estimated shipping weight	28,000	28,000	lbs
Estimated weight at operation	37,000	37,000	lbs
Steam outlet line size at saturated steam drum	6”	6”	in
Boiler feed water inlet line size	1.50”	1.50”	in
Steam drum diameter (I.D.) and thickness	24” x 0.75”	24” x 0.75”	in
Steam drum material of construction	SA-516-Gr.70	SA-516-Gr.70	
Lower drum diameter (I.D.) and thickness	24” x 0.75”	24” x 0.75”	in
Lower drum material of construction	SA-516-Gr.70	SA-516-Gr.70	
Convection bank tube diameter and thickness	2.0 x 0.105	2.0 x 0.105	in
Membrane tube diameter and thickness	2.0 x 0.120	2.0 x 0.120	in
Boiler tube material	SA-178-Gr.A	SA-178-Gr.A	
Furnace width	5’- 7”	5’- 0”	ft-in
Furnace height	4’- 10”	4’- 0”	ft-in
Furnace length	7’- 7”	7’- 8”	ft-in
Furnace volume	211	169	ft^3

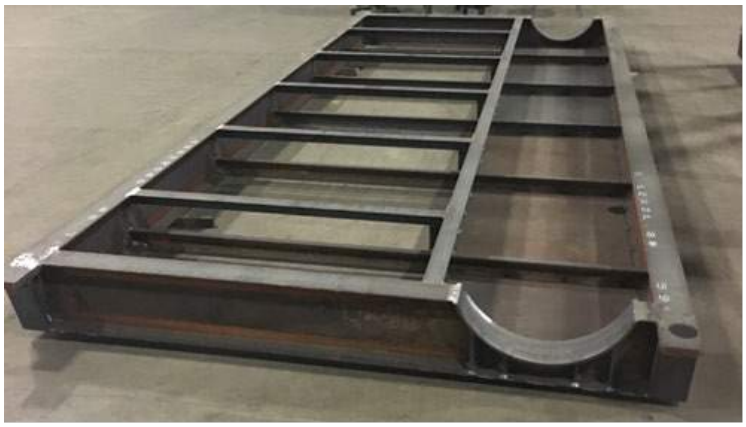
Boiler bank convection heating surface area	942	1293	ft^2
Furnace flat projected heating surface per ABMA	190	162	ft^2

C. Economizer Specifications		
Design type	Counter Flow	
Water flow direction	Vertical Down	
Flue gas flow direction	Vertical Up	
Maximum design pressure	490	psig
Design temperature	700	^oF
Tube material specification	SA-178 Gr. A	

5. Construction Details

A. Package Boiler

Boiler Base:



The boiler base shall be constructed of welded beams and channels such that the boiler weight is uniformly distributed over the entire base. The base is designed to be installed on a level concrete pad or supported on concrete piers. The base is designed so as to permit the boiler to freely expand and contract without placing any undue stress on any part of the boiler or setting.

The lower drum shall be placed in the saddles of the base module and shall be load bearing on the saddles in the base. The lower drum shall then be anchored at the burner end of the base and shall be free to expand within the base toward the rear of the boiler. At the rear end of the base, the lower drum is secured to the base during shipment. Lugs are welded to the lower drum and the structural steel base. The lugs are connected together with high strength bolts and nuts. The lugs, bolts and nuts are painted safety yellow to easily spot.

The floor plate is seal welded to the lower drum, independent of the base, free to expand with the lower drum so as to prevent any stresses that would be created had the floor plate been attached to the base. The floor plate expansion is controlled by specially designed expansion guide lugs. The controlled expansion of the floor plate with the lower drum eliminates failure of the air seal at the lower drum.

The area under the mud drum shall be supplied with insulation to maintain as much heat as possible inside of the mud drum to minimize the corrosive effects of thermal cycling.

Lower Mud Drum:

The lower drum shall be complete with all the necessary drum connections. The drum shall be designed and fabricated in accordance with the latest revision of Section I of the ASME Code and stamped accordingly with the appropriate code symbol stamp. The drum shall be of material specification SA-106-B or SA-516 Gr. 70, carbon steel plate, welded, x-rayed and stress relieved. A 12" x 16" man way opening shall be installed in each head. The man way openings shall be complete with yokes, nuts, bolts, washers, and gaskets. A bottom blow down connections shall be placed in the rear head so that the boiler can be completely drained. All tube holes shall be drilled true and radial so as to afford full parallel bearing of the tube through the drum plate. All tube holes shall be grooved regardless of the design pressure and temperature.

Upper Steam Drum:

The upper steam drum shall be complete with all the necessary drum connections. The drum shall be designed and fabricated in accordance with the latest revision of Section I of the ASME Code and stamped accordingly with the appropriate code symbol stamp. The drum shall be of material specification SA-516 Gr. 70 steel plate, welded, x-rayed and stress relieved. A 12" x 16" manway opening shall be installed in each head. The man way openings shall be complete with yokes, nuts, bolts, washers, and gaskets.

The drum connections shall consist of:

1.	ASME Safety Valves	Steam Drum	ASME Code
2.	Steam Outlet	Steam Drum	One (1)
3	Feedwater Inlet	Steam Drum	One (1)
4	Blow-Off	Lower Drum	One Pair/Drum
5.	Water Column	Steam Drum	One (1)
6.	Feedwater Control Valve	Steam Drum	By Customer
7.	Vent Valve	Steam Drum	One (1)
8.	Continuous Blowdown	Steam Drum	One (1)
9.	Drum Level Controller	Steam Drum	By Customer
10.	Atomizing Steam	Steam Drum	One (1)
11.	Nitrogen Blanketing	Steam Drum	One (1)
12.	Low Water Cut-Outs	Steam Drum	Two (2) (1 Pair)

The upper drum shall be provided with internal piping for feed water, chemical feed, and continuous blow down. All internal fittings and pipe shall be adequately supported and removal for maintenance purposes. All tube holes shall be drilled true and radial so as to afford full parallel bearing of the tube through the drum plate. All tube holes shall be grooved regardless of the design pressure and temperature.

Steam Drum Internals:

The steam drum shall include adequate steam separating equipment to assure the specified steam quality and to maintain a stable water level under a fluctuating load. The boiler internals "Steam / Water Separators" are designed so that the steam which enters the upper drum is directed to the top of the separators and through the primary separating screens. As the steam passes through the perforated demister screens, there is a reduction in velocity of the steam which allows the water droplets to separate from the steam and return to the boiler water. The steam then travels through the secondary steam separators, which again separate the steam from the remaining water droplets prior to leaving the boiler. The primary and secondary separators as well as the internal side baffle plates are removable. These baffle plates are bolted into angle supports and frames and can be readily removed through the 12" x 16" manway opening provided

at each end of the steam drum. Once the internals are removed, all ends of the boiler tubes are accessible and can be readily cleaned with conventional tube cleaning tools.

The moisture content of the steam leaving the boiler outlet shall be within ABMA guidelines when the boiler is operating under continuous load design, with normal water level and with boiler drum water having a total dissolved solid concentration, total alkalinity, and total suspended solids not in excess of the guidelines as established by the ABMA. (American Boiler Manufactures Association)

Front and Rear Wall Construction:

The front and rear exterior walls shall be fabricated of 3/8" thick steel plate that is structurally reinforced with 4" steel channels and shall be 100% water-cooled. The entire front and rear wall exteriors are covered with 10ga. galvanized steel plate so as to provide a smooth uniform surface impervious to rust.

Steam Generating Tubes:

The convection bank boiler tubes shall not be less than 2" minimum outside diameter, material specification SA-178A ERW (Option for SA-192 seamless) and of such thickness as determined by the design calculations as per Section I of the ASME Code plus 1/16” Corrosion allowance. All tubes are designed and arranged for natural circulation in the proper direction at all loads. The radius of all bends shall be such that a standard turbine type tube cleaner can be easily passed through the tube for cleaning of the full length.

All tubes in the furnace shall be finned tube, membrane wall design, except those in the area where the gases leave the furnace and enter the convection zone. The inboard row of tubes between the furnace and the convection zone shall be finned forming a membrane wall to prevent short circuiting of the flue gas from the furnace to the boiler flue gas outlet. Water cooling shall be provided on the sides, roof, and floor, Front and rear walls *without the use of headers.*

Upon completion of the installation of the boiler tubes, prior to applying any refractories, insulation, or casing materials, the boiler shall be hydrostatically tested at a pressure of one and one-half the maximum allowable working pressure per ASME Section1 requirements. The test shall be conducted in the presence of the Authorized Inspector of Hartford Steam Boiler Inspection & Insurance Company and any other inspector as required by the contract specifications.

Casing / Access Doors / Observation Ports:

The inner casing shall be formed by a finned wall and a finned membrane wall forming the outside row of the convection bank and shall be fully welded forming a gas tight inner seal. The membrane furnace walls are designed to withstand an internal pressure of 15" water column.

Before applying insulation and casing onto the boiler, the boiler shall be pressure tested for air tightness. This test shall be conducted by temporally sealing off all normal openings to the boiler and applying a minimum air pressure of 10" water column. The drop in air pressure shall not exceed 10% loss water column after a period of 5 minutes.

Casing shall be 10 GA A36 Carbon steel. The casing shall completely enclose the unit with the exception of the drum ends.

The side walls, roof, and floor of the boiler are to be completely covered with a minimum thickness of four (4) inches of 1,200ºF insulating blanket of the mineral wool type. Insulation over the top of the steam drum is to be a minimum of three (3) inches thick 1,200ºF insulation blanket.

The surface of the external casing shall not exceed 140ºF in an ambient air temperature of 80ºF, and a surface velocity of 2 fps (feet per second) while the boiler is operating at full capacity.

An access opening, 18" x 15", shall be provided to the furnace area. The opening shall be located in the rear wall.

Two (2) air-cooled and heat resistant furnace observation ports will be provided; and located in the rear wall.

Platforms and Ladders (*Not Included)*

Access platforms and ladders will be provided for access to the safety valves and non-return valve located on top of the boiler, and access to the economizer. A maintenance platform will be provided for entrance into the upper drum and is to be located at the rear of the boiler.

Air & Gas Ducts

The combustion air duct an integral part of the burner shall be furnished, un-insulated. Any additional breeching external of the modular enclosure shall be furnished and installed by others.

The steel duct from the economizer to the stack shall be included; insulation and lagging is required and shall be provided by others. The gas duct from the boiler outlet into the economizer inlet, and inlet expansion shall be furnished for field installation. The boiler is designed for a top discharge of flue gas.

Economizer

The economizer shall be of a rectangular configuration, finned tubes, up flow of gases, and down flow of water. The inlet transition, expansion joint, and the economizer support steel are provided as an integral part of the system.

The inner casing shall be a 10 gauge carbon steel plate. The enclosure shall be insulated with 2” thick 1,200 deg F mineral wool insulation and covered with 0.020” thick corrugated galvanized carbon steel jacket.

The economizer will comply with Section I of the ASME Code. All tubing shall be carbon steel shall be SA-178 Gr. A.

The boiler outlet duct shall be fabricated of 10-gage, carbon steel plates, SA-36. All required couplings and nozzles shall be provided in accordance with the contract specifications.

The boiler is designed for a side gas outlet.

Mud Drum Heating Coil (*Not Included)*

A steam heated mud drum coil shall be supplied. By the use of the Mud Drum Heating Coil, the boiler will remain in “Hot Standby” to provide the facility a means of an accelerated start-up and the prevention of corrosion caused by thermal cycling. Isolation valves for the coils are included, shipped loose for field installation by others.

Anchorage Design Of Generator

Wind

F_w= 2124.721 lbs Remarks: Worst case wind load applicable

Seismic Design Category: D-Default

S_{DS}= 0.344 Remarks: Short Period Design Acceleration

F_p= 0.1032 x W_p

F_p= 3818.4 lbs Remarks: Seismic Force actting at Center of Gravity

1	I_p=	Impotance Factor
2.5	R_p=	component response modification factor
1	a_p=	component amplification factor
0	z=	height in structure at point of attachment
1	h=	average roof height

Wind ASCE7-16 29.4 Design Wind Loads" Other Structures

1 mph	Desing Wind Speed per ASCE7-16 for site		
C	Exposure=	Exposure Class per ASCE7-16 26.26.7	
0.0 psf	qz=	Velocity pressure evaluated at height z per 26.10 at centroid of Af	$qz=.00256K_zK_{zt}K_dK_eV^2$
5.0 ft	z=	Centroidal height of eqipment	
0.85	G=	Gust Effect Factor from section 26.11	
1.3	C_{f1}=	force coefficient from Fig 29.4-1 throug 29.4-4	Wind Override HxL
103 sq ft	A_{f1}=	projected area normal to wind (HxL)	
1.30395189	C_{f2}=	force coefficient from Fig 29.4-1 throug 29.4-4	Wind Override HxD
84 sq ft	A_{f2}=	projected area normal to wind (HxD)	
0 lbs	F_L=	Wind force acting on Length Face of Unit	
0 lbs	F_D=	Wind Force acting on Depth Face of Unit	

Dimensions

Height H=		120 in	Remarks:	Unit height
Length L=		124 in	Remarks:	Unit length or width
Depth =		97 in	Remarks:	Unit depth
Weight W_p =		37000 lbs	Remarks:	Overall Weight of unit
CG_{EQ}=		80 in	Remarks:	Center of Gravity
CG_W=		60		
L_b=	x	in	Remarks:	Length between base anchor points
D_b=	x	in	Remarks:	Depth between base anchor points

Design Summary

T_{acnhor}=	171.8323 lbs	Remarks:	Maximum tension load per anchor
V_{anchor}=	300.51 lbs	Remarks:	Maximum shear load per anchor
Tallowable	5136 lbs	Remarks:	Allowable Tension per anchor
Vallowable	2270 lbs	Remarks:	Allowable Shear per anchor
Ω	2	Remarks:	Omega Factor for seismic connection in conc.
CSR=	0.231291	Remark:	Stress Ratio- Must be less than or equal to 1

Therefore

T		sheet	1 of 3
Out put in blue		Client	CVE
		Job:	VA Medical
		Job#	23116

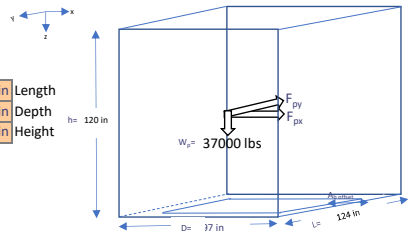
Subject: Anchor and Slab Design for Pad Mounted Electrical Equipment — Revised By: TPT

By: TPT — DATE: 11/1/2023 — Chk By: TPT — Date: 11/1/2023 — Revision Date: 3/8/2023

Post Installed Anchor Design

Equipment Dimensions

Equipment Type	Boiler		
Name	Superior Boiler	Seismic	
L=	124 in	124 in	Length
D=	97 in	97 in	Depth
h=	120 in	120 in	Height
CG_{EQ}=	80.0		Center of Gravity
CG_{EQover}=			CG overide
h_{stand}=			Stand Height
CG_{wind}=	60 in		Wind CG



Anchor Design Parameters

Select Anchor: 3/4" Ø Hilti HIT RE 500 V3 +HAS-R 304/316 SS 3/4 w/12 ED & 6 embed and tmin= 8

Concrete Strength	3000 psi
Edge Distance	12 in
Embedment	6 in
Min Concrete t (in)	8 in
T=Max Tension (LRFD)	10271 lbs
V=Max Shear (LRFD)	4540 lbs
T/Ω=	5136 lbs
V/Ω=	2270 lbs

Loading — Load Combination: LRFD

TYPE

Dead		W_p=	37000 lbs	Weight			
EQ_h	S_{DS}=		0.344	EQ-Ω-TENSION	2	EQ-Ω-SHEAR	2
	F_{PL}*W_p=		3818 lbs		F_p=	0.1032	
	F_{PD}*W_p=		3818 lbs		I_p=	1	
EQ_V	+/- Eqv= 0.2$S_{DS}W_p$		2546 lbs				
Wind	F_{WL}=		0 lbs				
	F_{WD}=		0 lbs				

Force Acting on Length (Overturning about Depth)

Design Force	EQ	Wind	Equation LRFD	Equation ASD	Ten=+; Comp=-
OTM	25.46 k-ft	0.00 k-ft	=F_p*CG	=(0.6,0.7)F_p*CG	OTM= Overturning Moment
MR_t (Tension)	124.30 k-ft	134.59 k-ft	=(0.9-0.2S_{DS})W_p*D/2	=(0.6-0.2S_{DS})Wp*D/2	RM = Restoring Moment
MR_c (Compresssion)	189.74 k-ft	179.45 k-ft	=(1.2+0.2S_{DS}))Wp*D/2	=(1.0+0.2S_{DS}))Wp*D/2	Factor of Width and Length used
Moment (Tension)	0.00 k-ft	0.00 k-ft	=OTM-MR_t	=OTM-MR_t	D=100%
Moment (Compression)	215.19 k-ft	179.45 k-ft	=OTM+MR_c	=OTM+MR_c	Weight Adjustment

Anchor Bolt Design and Check with overturning about depth of the eqipment

Select # of Connectors		Long Side=4	Total # of bolts for shear	8				
Select off set of Connector		0 in						
Shear/bolt or bolt group,EQ		525 lbs	+ Accidental Torsion	10%	Anchorage Interaction check ($T/T_{all}^{(5/3)}$+$V/V_{all}^{(5/3)}$<=1)			
Shear/bolt or bolt group,W		0 lbs				$T/T_{all}^{(5/3)}$ +	$V/V_{all}^{(5/3)}$	<1
	OTM_T/D	**Total**	**Per Bolt**		EQ	0	0.2313	0.231
Tension	EQ	0 lbs	0 lbs		W	0	0.0000	0.000
	w =	0 lbs	0 lbs					
	OTM_C/D	**Total**	**Per ft**					
Compression	EQ=	26622 lbs	3293 plf					
	Wind =	22200 lbs	2746 lbs					

Force Acting on Depth (Overturning about Length)

Design Force	EQ	Wind	Equation LRFD	Equation ASD	Ten=+; Comp=-
OTM	25.46 k-ft	0.00 k-ft	=F_p*CG	=(0.6,0.7)F_p*CG	OTM= Overturning Moment
MR_t (Tension)	158.90 k-ft	172.05 k-ft	=(0.9-0.2S_{DS})W_p*L/2	=(0.6-0.2S_{DS}))Wp*L/2	RM = Restoring Moment
MR_c (Compresssion)	242.55 k-ft	229.40 k-ft	=(1.2+0.2S_{DS}))Wp*L/2	=(1.0+0.2S_{DS}))Wp*L/2	Factor of Width and Length used
Moment (Tension)	0.00 k-ft	0.00 k-ft	=OTM-MR_t	=OTM-MR_t	L=100%
Moment (Compression)	268.01 k-ft	229.40 k-ft	=OTM+MR_c	=OTM+MR_c	Weight Adjustment

Anchor Bolt Design and Check with overturning about Length of the eqipment

Select # of Connectors		Short Side=2	Total # of bolts for shear	8				
Select off set of Connector		0 in						
Shear/bolt or bolt group,EQ		525 lbs	+ Accidental Torsion	10%	Anchorage Interaction check ($T/T_{all}^{(5/3)}$+$V/V_{all}^{(5/3)}$<=1)			
Shear/bolt or bolt group,W		0 lbs				$T/T_{all}^{(5/3)}$ +	$V/V_{all}^{(5/3)}$	<1
	OTM_T/D	**Total**	**Per Bolt**		EQ	0	0.2313	0.231
Tension	EQ	0 lbs	0 lbs		W	0	0.0000	0.000
	w =	0 lbs	0 lbs					
	OTM_C/D	**Total**	**Per ft**					
Compression	EQ=	25936 lbs	2510 plf					
	Wind =	22200 lbs	2148 lbs					

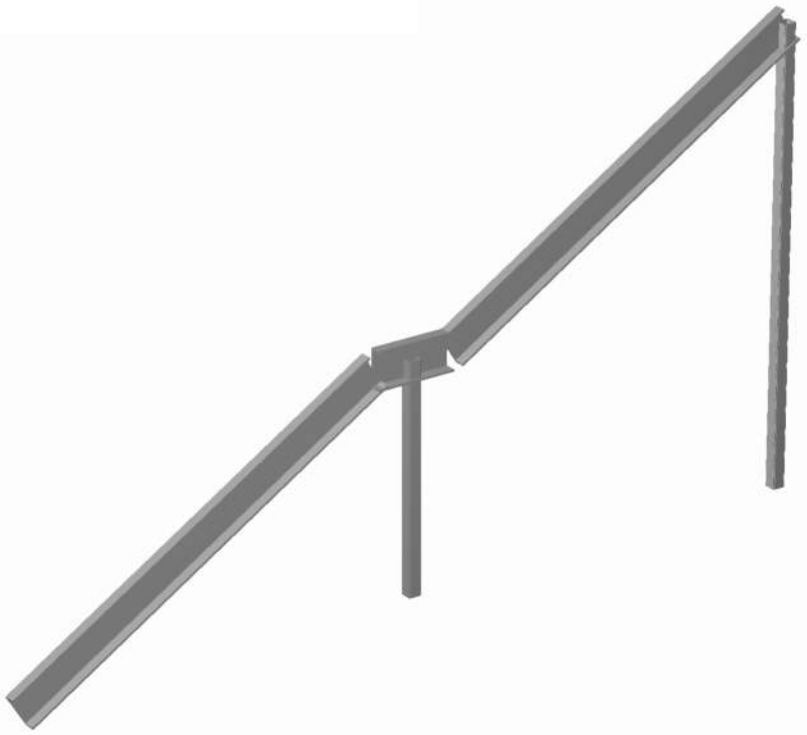
Combined Anchorage Check

Anchorage Interaction check ($T/T_{all}^{(5/3)}$+$V/V_{all}^{(5/3)}$<=1)				**EQ**	T_{anchor}=	0 lbs	**W**	T_{anchor}=	0 lbs
	$T/T_{all}^{(5/3)}$ +	$V/V_{all}^{(5/3)}$	<1 (CSR)		V_{anchor}=	525 lbs		V_{anchor}=	0 lbs
EQ	0	0.2313	**0.231**	(8) 3/4" Ø Hilti HIT RE 500 V3 +HAS-R 304/316 SS 3/4 w/12 ED & 6 embed and tmin= 8 anchors					
W	0	0.0000	**0.000**	are adequate					

4. **Stairs**

RAM Elements

Current Date: 11/1/2023 7:55 AM
Units system: English
File name: I:\2023\23116 - EA Solutions - Prescott AZ Boiler\Calculations\STAIRS.retx



RAM Elements

Current Date: 11/1/2023 7:58 AM
Units system: English
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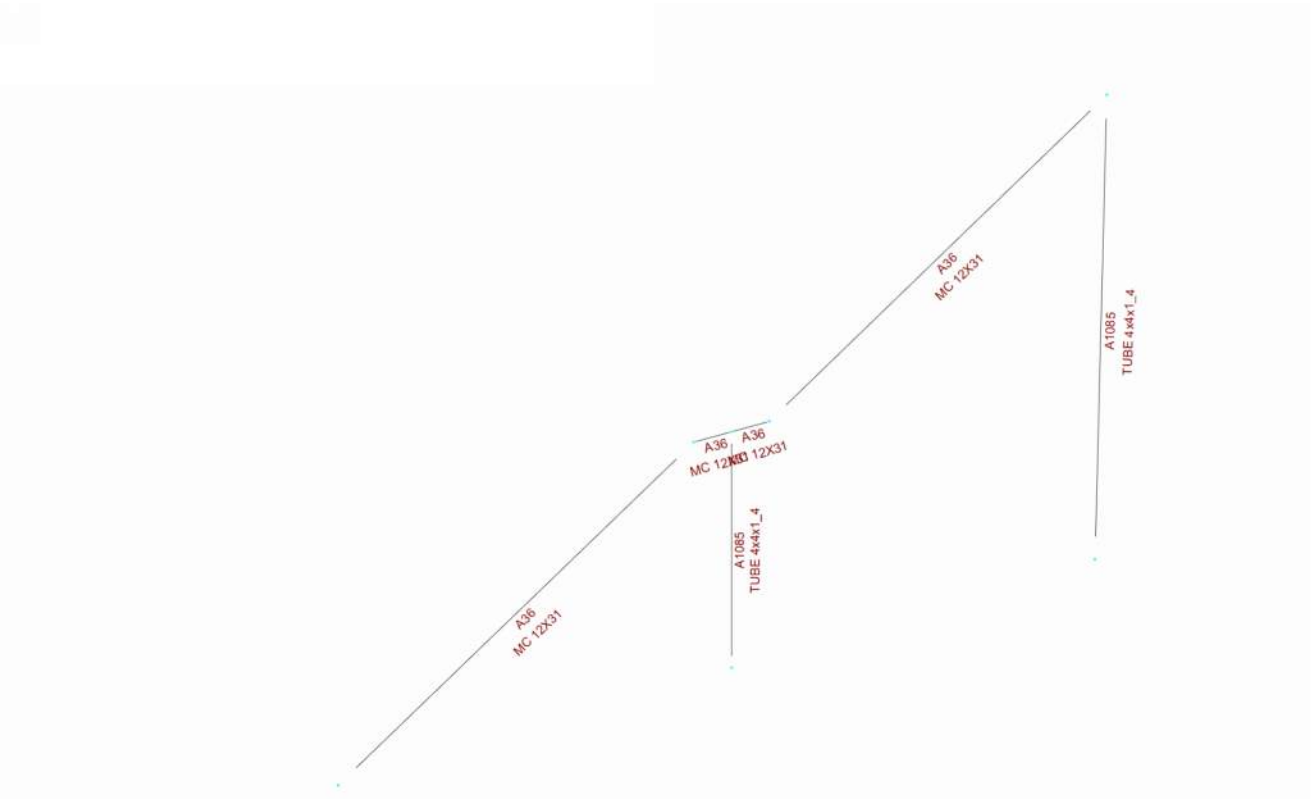
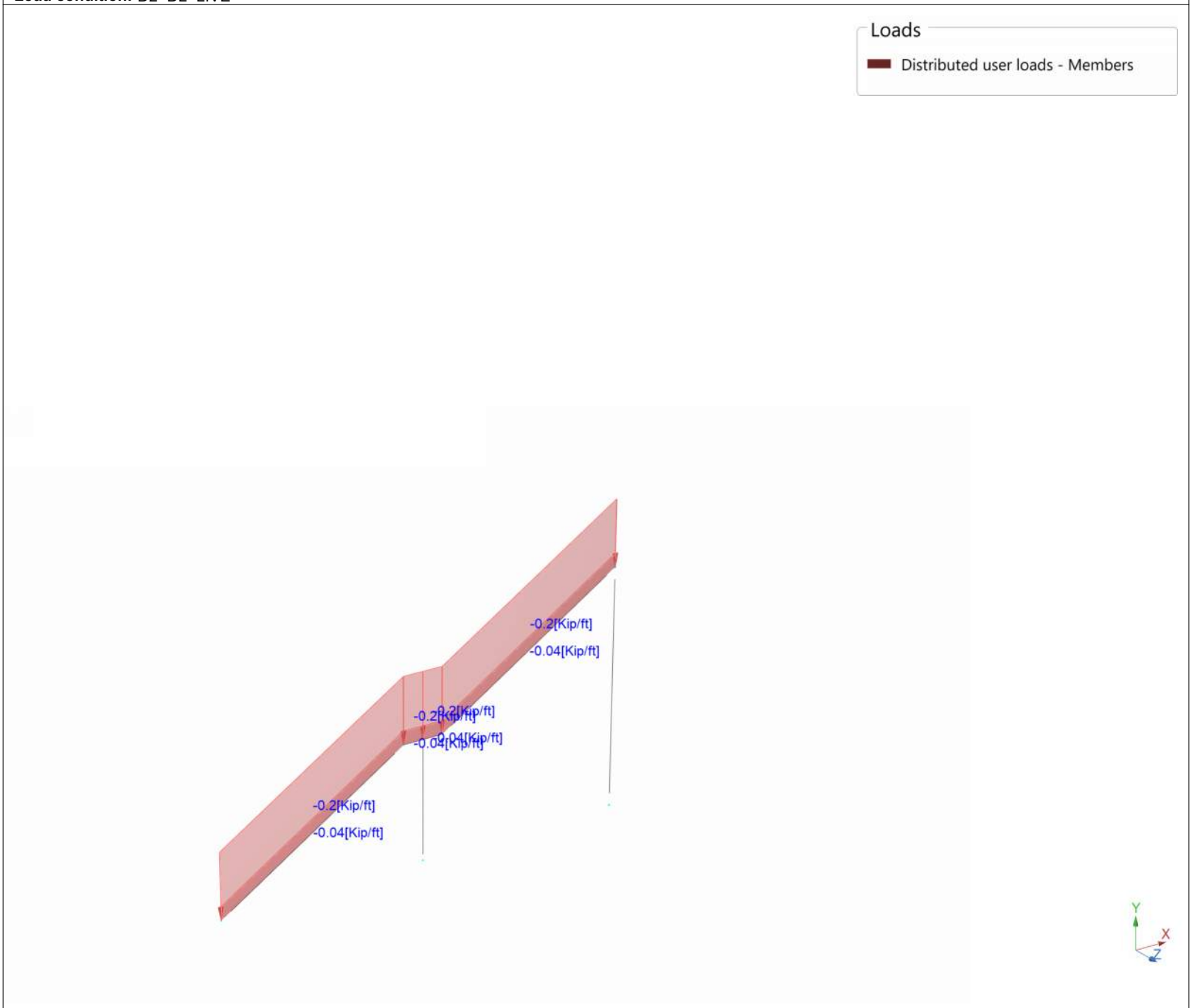


RAM Elements

Current Date: 11/1/2023 7:56 AM
Units system: English
File name: I:\2023\23116 - EA Solutions - Prescott AZ Boiler\Calculations\STAIRS.retx
Load condition: D2=DL+LIVE



RAM® Elements CONNECT Edition

Current Date: 8/14/2023 4:56 PM
Units system: English

Steel Code Check

Report: Comprehensive

Members: Hot-rolled
Design code: AISC 360-2016 LRFD

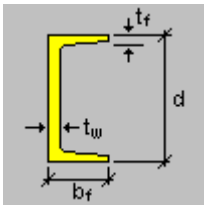
Member	**:**	**1**
Design status	**:**	**OK**

DESIGN WARNINGS

Section information

Section name: MC 12X31 **(US)**

Dimensions



bf	=	3.670	[in]	Width
d	=	12.000	[in]	Depth
k	=	1.310	[in]	Distance k
tf	=	0.700	[in]	Flange thickness
tw	=	0.370	[in]	Web thickness

Properties

Section properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	9.120	
Moment of Inertia (local axes) (I)	[in4]	202.000	11.300
Moment of Inertia (principal axes) (I')	[in4]	202.000	11.300
Bending constant for moments (principal axis) (J')	[in]	0.000	6.288
Radius of gyration (local axes) (r)	[in]	4.706	1.113
Radius of gyration (principal axes) (r')	[in]	4.706	1.113
Saint-Venant torsion constant. (J)	[in4]	1.000	
Section warping constant. (Cw)	[in6]	267.000	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	-2.291	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	33.700	4.370
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	33.700	10.524
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	33.700	4.370
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	33.700	10.524
Plastic section modulus (local axis) (Z)	[in3]	39.700	8.150
Plastic section modulus (principal axis) (Z')	[in3]	39.700	8.150
Polar radius of gyration. (ro)	[in]	5.340	

Area for shear (Aw)	[in2]	5.140	4.440
Torsional constant. (C)	[in3]	1.411	

Material : A36

Properties	Unit	Value
Yield stress (Fy):	[Kip/in2]	36.00
Tensile strength (Fu):	[Kip/in2]	58.00
Elasticity Modulus (E):	[Kip/in2]	29000.00
Shear modulus for steel (G):	[Kip/in2]	11507.94

DESIGN CRITERIA

Description	Unit	Value
Length for tension slenderness ratio (L)	[ft]	11.30

Distance between member lateral bracing points

Length (Lb) [ft]	
Top	Bottom
11.30	11.30

Laterally unbraced length

Length [ft]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
11.30	11.30	11.30	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Sway
Minor axis frame type	Sway

DESIGN CHECKS

AXIAL TENSION DESIGN ✔

Axial tension

Ratio	:	0.00			
Capacity	:	295.49 [Kip]	Reference	:	Cl.D2
Demand	:	0.83 [Kip]	Ctrl Eq.	:	D2 at 100.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(ϕP_n):	[Kip]	295.49	Cl.D2
Nominal axial tension capacity (P_n)	[Kip]	328.32	Eq.D2-1

AXIAL COMPRESSION DESIGN ✔

Compression in the major axis 33

Ratio	:	0.00			
Capacity	:	282.86 [Kip]	Reference	:	Cl.E3
Demand	:	0.59 [Kip]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	5.24	
Unstiffened element limiting slenderness (λ_r)	--	15.89	Table.B4.1a.Case1
Stiffened element classification	--	Non slender	
Stiffened element slenderness (λ)	--	25.35	
Stiffened element limiting slenderness (λ_r)	--	42.29	Table.B4.1a.Case5
Factored flexural buckling strength(ϕP_{n33}):	[Kip]	282.86	Cl.E3
Unbraced length (L_{33})	[ft]	11.30	Cl.E2
Effective slenderness ($(KL/r)_{33}$)	--	28.81	Cl.E2
Elastic critical buckling stress (F_{e33})	[Kip/in2]	344.89	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	9.12	
Critical stress for flexural buckling (F_{cr33})	[Kip/in2]	34.46	Eq.E3-2
Nominal flexural buckling strength (P_{n33})	[Kip]	314.28	Eq.E3-1

Compression in the minor axis 22

Ratio	:	0.00			
Capacity	:	135.32 [Kip]	Reference	:	Cl.E3
Demand	:	0.59 [Kip]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	5.24	
Unstiffened element limiting slenderness (λ_r)	--	15.89	Table.B4.1a.Case1
Stiffened element classification	--	Non slender	
Stiffened element slenderness (λ)	--	25.35	
Stiffened element limiting slenderness (λ_r)	--	42.29	Table.B4.1a.Case5
Factored flexural buckling strength(ϕP_{n22}):	[Kip]	135.32	Cl.E3
Unbraced length (L_{22})	[ft]	11.30	Cl.E2
Effective slenderness ($(KL/r)_{22}$)	--	121.80	Cl.E2
Elastic critical buckling stress (F_{e22})	[Kip/in2]	19.29	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	9.12	
Critical stress for flexural buckling (F_{cr22})	[Kip/in2]	16.49	Eq.E3-2
Nominal flexural buckling strength (P_{n22})	[Kip]	150.36	Eq.E3-1
Factored torsional or flexural-torsional buckling strength(ϕP_{n11}):	[Kip]	227.72	Cl.E4
Unbraced length (L_{11})	[ft]	11.30	Cl.E2
Flexural constant (H)	--	0.82	Eq.E4-8
Torsional or flexural-torsional elastic buckling stress (F_{e11})	[Kip/in2]	57.84	Eq.E4-3
Elastic torsional buckling stress (F_{ez})	[Kip/in2]	59.98	Eq.E4-7
Effective area of the cross section based on the effective width (A...	[in2]	9.12	
Critical stress for torsional or flexural-torsional buckling (F_{cr11})	[Kip/in2]	27.74	Eq.E3-2
Nominal torsional or flexural-torsional buckling strength (P_{n11})	[Kip]	253.02	Eq.E4-1

FLEXURAL DESIGN ✔

Bending about major axis, M33

Ratio	:	0.02			
Capacity	:	107.19 [Kip*ft]	Reference	:	Cl.F2.1
Demand	:	-2.33 [Kip*ft]	Ctrl Eq.	:	D2 at 100.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	5.24	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	28.38	
Limiting slenderness for compact unstiffened element (λ_p)	--	10.79	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	25.35	
Limiting slenderness for noncompact stiffened element (λ_r)	--	161.78	
Limiting slenderness for compact stiffened element (λ_p)	--	106.72	
Factored yielding strength(ϕM_n):	[Kip*ft]	107.19	Cl.F2.1
Yielding (M_n)	[Kip*ft]	119.10	Eq.F2-1
Factored lateral-torsional buckling strength(ϕM_n):	[Kip*ft]	107.19	Cl.F2.2
Limiting laterally unbraced length for yielding (L_p)	[ft]	4.63	Eq.F2-5
Effective radius of gyration used in the determination of Lr (r_{ts})	[in]	1.28	Eq.F2-7
Lateral-torsional factor (c)	--	1.16	Eq.F2-8b
Limiting laterally unbraced length for inelastic lateral-torsional bucklin...	[ft]	19.76	Eq.F2-6
Lateral-torsional buckling modification factor (C_b)	--	1.33	Eq.F1-1
Nominal lateral-torsional buckling moment strength (M_n)	[Kip*ft]	119.10	Eq.F2-2

Bending about minor axis, M22

Ratio	:	0.00			
Capacity	:	18.88 [Kip*ft]	Reference	:	Cl.F6.1
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	5.24	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	28.38	
Limiting slenderness for compact unstiffened element (λ_p)	--	10.79	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	25.35	
Limiting slenderness for noncompact stiffened element (λ_r)	--	161.78	
Limiting slenderness for compact stiffened element (λ_p)	--	106.72	
Factored yielding strength about a geometric axis(ϕM_n):	[Kip*ft]	18.88	Cl.F6.1
Yielding (M_n)	[Kip*ft]	20.98	Eq.F6-1

DESIGN FOR SHEAR ✔

Shear in major axis 33

Ratio	:	0.00			
Capacity	:	99.88 [Kip]	Reference	:	Cl.G1
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	99.88	Cl.G1
Web buckling coefficient (k_v)	--	1.20	Cl.G6
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	110.98	Eq.G6-1

Shear in minor axis 22

Ratio	:	0.02			
Capacity	:	86.31 [Kip]	Reference	:	Cl.G1
Demand	:	1.36 [Kip]	Ctrl Eq.	:	D2 at 100.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	86.31	Cl.G1
Web buckling coefficient (k_v)	--	5.34	Eq.G2-5
Web buckling coefficient (C_v)	--	1.00	-
Nominal shear strength (V_n)	[Kip]	95.90	Eq.G2-1

COMBINED ACTIONS DESIGN ✔

Combined flexure and axial

Ratio	:	0.02			
Ctrl Eq.	:	D2 at 100.00%	Reference	:	Eq.H1-1b

Intermediate results	Unit	Value	Reference
Interaction of flexure and axial force:	--	0.02	Eq.H1-1b
Available flexural strength about strong axis (M_{c33})	[Kip*ft]	107.19	Cl.H1.1
Available flexural strength about weak axis (M_{c22})	[Kip*ft]	18.88	Cl.H1.1
Available axial strength (P_c)	[Kip]	295.49	Cl.H1.1

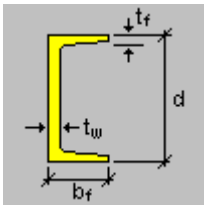
Member : 2
Design status : OK

DESIGN WARNINGS

Section information

Section name: MC 12X31 **(US)**

Dimensions



bf	=	3.670	[in]	Width
d	=	12.000	[in]	Depth
k	=	1.310	[in]	Distance k
tf	=	0.700	[in]	Flange thickness
tw	=	0.370	[in]	Web thickness

Properties

Section properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	9.120	
Moment of Inertia (local axes) (I)	[in4]	202.000	11.300
Moment of Inertia (principal axes) (I')	[in4]	202.000	11.300
Bending constant for moments (principal axis) (J')	[in]	0.000	6.288
Radius of gyration (local axes) (r)	[in]	4.706	1.113
Radius of gyration (principal axes) (r')	[in]	4.706	1.113
Saint-Venant torsion constant. (J)	[in4]	1.000	
Section warping constant. (Cw)	[in6]	267.000	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	-2.291	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	33.700	4.370
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	33.700	10.524
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	33.700	4.370
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	33.700	10.524
Plastic section modulus (local axis) (Z)	[in3]	39.700	8.150
Plastic section modulus (principal axis) (Z')	[in3]	39.700	8.150
Polar radius of gyration. (ro)	[in]	5.340	
Area for shear (Aw)	[in2]	5.140	4.440
Torsional constant. (C)	[in3]	1.411	

Material : A36

Properties	Unit	Value
Yield stress (Fy):	[Kip/in2]	36.00
Tensile strength (Fu):	[Kip/in2]	58.00
Elasticity Modulus (E):	[Kip/in2]	29000.00
Shear modulus for steel (G):	[Kip/in2]	11507.94

DESIGN CRITERIA

Description	Unit	Value
Length for tension slenderness ratio (L)	[ft]	1.04

Distance between member lateral bracing points

Length (Lb) [ft]	
Top	Bottom
1.04	1.04

Laterally unbraced length

Length [ft]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
1.04	1.04	1.04	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Sway
Minor axis frame type	Sway

DESIGN CHECKS

AXIAL TENSION DESIGN ✔

Axial tension

Ratio	:	0.00			
Capacity	:	295.49 [Kip]	Reference	:	Cl.D2
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(ϕP_n):	[Kip]	295.49	Cl.D2
Nominal axial tension capacity (P_n)	[Kip]	328.32	Eq.D2-1

AXIAL COMPRESSION DESIGN ✔

Compression in the major axis 33

Ratio	:	0.00			
Capacity	:	295.38 [Kip]	Reference	:	Cl.E3
Demand	:	0.01 [Kip]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	5.24	
Unstiffened element limiting slenderness (λ_r)	--	15.89	Table.B4.1a.Case1
Stiffened element classification	--	Non slender	
Stiffened element slenderness (λ)	--	25.35	
Stiffened element limiting slenderness (λ_r)	--	42.29	Table.B4.1a.Case5
Factored flexural buckling strength(ϕP_{n33}):	[Kip]	295.38	Cl.E3
Unbraced length (L_{33})	[ft]	1.04	Cl.E2
Effective slenderness ($(KL/r)_{33}$)	--	2.66	Cl.E2
Elastic critical buckling stress (F_{e33})	[Kip/in2]	40574.03	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	9.12	
Critical stress for flexural buckling (F_{cr33})	[Kip/in2]	35.99	Eq.E3-2
Nominal flexural buckling strength (P_{n33})	[Kip]	328.20	Eq.E3-1

Compression in the minor axis 22

Ratio	:	0.00			
Capacity	:	293.15 [Kip]	Reference	:	Cl.E4
Demand	:	0.01 [Kip]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	5.24	
Unstiffened element limiting slenderness (λ_r)	--	15.89	Table.B4.1a.Case1
Stiffened element classification	--	Non slender	
Stiffened element slenderness (λ)	--	25.35	
Stiffened element limiting slenderness (λ_r)	--	42.29	Table.B4.1a.Case5
Factored flexural buckling strength(ϕP_{n22}):	[Kip]	293.53	Cl.E3
Unbraced length (L_{22})	[ft]	1.04	Cl.E2
Effective slenderness ($(KL/r)_{22}$)	--	11.23	Cl.E2
Elastic critical buckling stress (F_{e22})	[Kip/in2]	2269.74	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	9.12	
Critical stress for flexural buckling (F_{cr22})	[Kip/in2]	35.76	Eq.E3-2
Nominal flexural buckling strength (P_{n22})	[Kip]	326.15	Eq.E3-1
Factored torsional or flexural-torsional buckling strength(ϕP_{n11}):	[Kip]	293.15	Cl.E4
Unbraced length (L_{11})	[ft]	1.04	Cl.E2
Flexural constant (H)	--	0.82	Eq.E4-8
Torsional or flexural-torsional elastic buckling stress (F_{e11})	[Kip/in2]	1899.58	Eq.E4-3
Elastic torsional buckling stress (F_{ez})	[Kip/in2]	1916.69	Eq.E4-7
Effective area of the cross section based on the effective width (A...	[in2]	9.12	
Critical stress for torsional or flexural-torsional buckling (F_{cr11})	[Kip/in2]	35.72	Eq.E3-2
Nominal torsional or flexural-torsional buckling strength (P_{n11})	[Kip]	325.73	Eq.E4-1

FLEXURAL DESIGN ✔

Bending about major axis, M33

Ratio	:	0.04			
Capacity	:	107.19 [Kip*ft]	Reference	:	Cl.F2.1
Demand	:	-4.12 [Kip*ft]	Ctrl Eq.	:	D2 at 100.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	5.24	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	28.38	
Limiting slenderness for compact unstiffened element (λ_p)	--	10.79	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	25.35	
Limiting slenderness for noncompact stiffened element (λ_r)	--	161.78	
Limiting slenderness for compact stiffened element (λ_p)	--	106.72	
Factored yielding strength(ϕM_n):	[Kip*ft]	107.19	Cl.F2.1
Yielding (M_n)	[Kip*ft]	119.10	Eq.F2-1

Bending about minor axis, M22

Ratio	:	0.00			
Capacity	:	18.88 [Kip*ft]	Reference	:	Cl.F6.1
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	5.24	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	28.38	
Limiting slenderness for compact unstiffened element (λ_p)	--	10.79	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	25.35	
Limiting slenderness for noncompact stiffened element (λ_r)	--	161.78	
Limiting slenderness for compact stiffened element (λ_p)	--	106.72	
Factored yielding strength about a geometric axis(ϕM_n):	[Kip*ft]	18.88	Cl.F6.1
Yielding (M_n)	[Kip*ft]	20.98	Eq.F6-1

DESIGN FOR SHEAR ✔

Shear in major axis 33

Ratio	:	0.00			
Capacity	:	99.88 [Kip]	Reference	:	Cl.G1
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	99.88	Cl.G1
Web buckling coefficient (k_v)	--	1.20	Cl.G6
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	110.98	Eq.G6-1

Shear in minor axis 22

Ratio	:	0.02			
Capacity	:	86.31 [Kip]	Reference	:	Cl.G1
Demand	:	1.84 [Kip]	Ctrl Eq.	:	D2 at 100.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	86.31	Cl.G1
Web buckling coefficient (k_v)	--	5.34	Eq.G2-5
Web buckling coefficient (C_v)	--	1.00	-
Nominal shear strength (V_n)	[Kip]	95.90	Eq.G2-1

COMBINED ACTIONS DESIGN ✔

Combined flexure and axial

Ratio	:	0.04			
Ctrl Eq.	:	D2 at 100.00%	Reference	:	Eq.H1-1b

Intermediate results	Unit	Value	Reference
Interaction of flexure and axial force:	--	0.04	Eq.H1-1b
Available flexural strength about strong axis (M_{c33})	[Kip*ft]	107.19	Cl.H1.1
Available flexural strength about weak axis (M_{c22})	[Kip*ft]	18.88	Cl.H1.1
Available axial strength (P_c)	[Kip]	293.15	Cl.H1.1

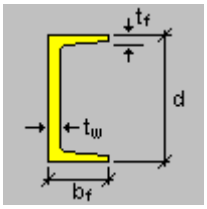
Member : 3
Design status : OK

DESIGN WARNINGS

Section information

Section name: MC 12X31 **(US)**

Dimensions



bf	=	3.670	[in]	Width
d	=	12.000	[in]	Depth
k	=	1.310	[in]	Distance k
tf	=	0.700	[in]	Flange thickness
tw	=	0.370	[in]	Web thickness

Properties

Section properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	9.120	
Moment of Inertia (local axes) (I)	[in4]	202.000	11.300
Moment of Inertia (principal axes) (I')	[in4]	202.000	11.300
Bending constant for moments (principal axis) (J')	[in]	0.000	6.288
Radius of gyration (local axes) (r)	[in]	4.706	1.113
Radius of gyration (principal axes) (r')	[in]	4.706	1.113
Saint-Venant torsion constant. (J)	[in4]	1.000	
Section warping constant. (Cw)	[in6]	267.000	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	-2.291	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	33.700	4.370
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	33.700	10.524
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	33.700	4.370
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	33.700	10.524
Plastic section modulus (local axis) (Z)	[in3]	39.700	8.150
Plastic section modulus (principal axis) (Z')	[in3]	39.700	8.150
Polar radius of gyration. (ro)	[in]	5.340	
Area for shear (Aw)	[in2]	5.140	4.440
Torsional constant. (C)	[in3]	1.411	

Material : A36

Properties	Unit	Value
Yield stress (Fy):	[Kip/in2]	36.00
Tensile strength (Fu):	[Kip/in2]	58.00
Elasticity Modulus (E):	[Kip/in2]	29000.00
Shear modulus for steel (G):	[Kip/in2]	11507.94

DESIGN CRITERIA

Description	Unit	Value
Length for tension slenderness ratio (L)	[ft]	1.04

Distance between member lateral bracing points

Length (Lb) [ft]	
Top	Bottom
1.04	1.04

Laterally unbraced length

Length [ft]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
1.04	1.04	1.04	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Sway
Minor axis frame type	Sway

DESIGN CHECKS

AXIAL TENSION DESIGN ✔

Axial tension

Ratio	:	0.00			
Capacity	:	295.49 [Kip]	Reference	:	Cl.D2
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(ϕP_n):	[Kip]	295.49	Cl.D2
Nominal axial tension capacity (P_n)	[Kip]	328.32	Eq.D2-1

AXIAL COMPRESSION DESIGN ✔

Compression in the major axis 33

Ratio	:	0.00			
Capacity	:	295.38 [Kip]	Reference	:	Cl.E3
Demand	:	0.01 [Kip]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	5.24	
Unstiffened element limiting slenderness (λ_r)	--	15.89	Table.B4.1a.Case1
Stiffened element classification	--	Non slender	

Stiffened element slenderness (λ)	--	25.35	
Stiffened element limiting slenderness (λ_r)	--	42.29	Table.B4.1a.Case5
Factored flexural buckling strength(ϕP_{n33}):	[Kip]	295.38	Cl.E3
Unbraced length (L_{33})	[ft]	1.04	Cl.E2
Effective slenderness ($(KL/r)_{33}$)	--	2.66	Cl.E2
Elastic critical buckling stress (F_{e33})	[Kip/in2]	40574.03	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	9.12	
Critical stress for flexural buckling (F_{cr33})	[Kip/in2]	35.99	Eq.E3-2
Nominal flexural buckling strength (P_{n33})	[Kip]	328.20	Eq.E3-1

Compression in the minor axis 22

Ratio	: 0.00		
Capacity	: 293.15 [Kip]	Reference	: Cl.E4
Demand	: 0.01 [Kip]	Ctrl Eq.	: D2 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	5.24	
Unstiffened element limiting slenderness (λ_r)	--	15.89	Table.B4.1a.Case1
Stiffened element classification	--	Non slender	
Stiffened element slenderness (λ)	--	25.35	
Stiffened element limiting slenderness (λ_r)	--	42.29	Table.B4.1a.Case5
Factored flexural buckling strength(ϕP_{n22}):	[Kip]	293.53	Cl.E3
Unbraced length (L_{22})	[ft]	1.04	Cl.E2
Effective slenderness ($(KL/r)_{22}$)	--	11.23	Cl.E2
Elastic critical buckling stress (F_{e22})	[Kip/in2]	2269.74	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	9.12	
Critical stress for flexural buckling (F_{cr22})	[Kip/in2]	35.76	Eq.E3-2
Nominal flexural buckling strength (P_{n22})	[Kip]	326.15	Eq.E3-1
Factored torsional or flexural-torsional buckling strength(ϕP_{n11}):	[Kip]	293.15	Cl.E4
Unbraced length (L_{11})	[ft]	1.04	Cl.E2
Flexural constant (H)	--	0.82	Eq.E4-8
Torsional or flexural-torsional elastic buckling stress (F_{e11})	[Kip/in2]	1899.58	Eq.E4-3
Elastic torsional buckling stress (F_{ez})	[Kip/in2]	1916.69	Eq.E4-7
Effective area of the cross section based on the effective width (A...	[in2]	9.12	
Critical stress for torsional or flexural-torsional buckling (F_{cr11})	[Kip/in2]	35.72	Eq.E3-2
Nominal torsional or flexural-torsional buckling strength (P_{n11})	[Kip]	325.73	Eq.E4-1

FLEXURAL DESIGN ✔

Bending about major axis, M33

Ratio	: 0.04		
Capacity	: 107.19 [Kip*ft]	Reference	: Cl.F2.1
Demand	: -4.11 [Kip*ft]	Ctrl Eq.	: D2 at 100.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	5.24	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	28.38	
Limiting slenderness for compact unstiffened element (λ_p)	--	10.79	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	25.35	
Limiting slenderness for noncompact stiffened element (λ_r)	--	161.78	

Limiting slenderness for compact stiffened element (λ_p)	--	106.72	
Factored yielding strength(ϕM_n):	[Kip*ft]	107.19	Cl.F2.1
Yielding (M_n)	[Kip*ft]	119.10	Eq.F2-1

Bending about minor axis, M22

Ratio	:	0.00		
Capacity	:	18.88 [Kip*ft]	Reference	: Cl.F6.1
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	: D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	5.24	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	28.38	
Limiting slenderness for compact unstiffened element (λ_p)	--	10.79	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	25.35	
Limiting slenderness for noncompact stiffened element (λ_r)	--	161.78	
Limiting slenderness for compact stiffened element (λ_p)	--	106.72	
Factored yielding strength about a geometric axis(ϕM_n):	[Kip*ft]	18.88	Cl.F6.1
Yielding (M_n)	[Kip*ft]	20.98	Eq.F6-1

DESIGN FOR SHEAR ✔

Shear in major axis 33

Ratio	:	0.00		
Capacity	:	99.88 [Kip]	Reference	: Cl.G1
Demand	:	0.00 [Kip]	Ctrl Eq.	: D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	99.88	Cl.G1
Web buckling coefficient (k_v)	--	1.20	Cl.G6
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	110.98	Eq.G6-1

Shear in minor axis 22

Ratio	:	0.02		
Capacity	:	86.31 [Kip]	Reference	: Cl.G1
Demand	:	1.84 [Kip]	Ctrl Eq.	: D2 at 100.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	86.31	Cl.G1
Web buckling coefficient (k_v)	--	5.34	Eq.G2-5
Web buckling coefficient (C_v)	--	1.00	-
Nominal shear strength (V_n)	[Kip]	95.90	Eq.G2-1

COMBINED ACTIONS DESIGN ✔

Combined flexure and axial

Ratio	:	0.04			
Ctrl Eq.	:	D2 at 100.00%	Reference	:	Eq.H1-1b

Intermediate results	Unit	Value	Reference
Interaction of flexure and axial force:	--	0.04	Eq.H1-1b
Available flexural strength about strong axis (M_{c33})	[Kip*ft]	107.19	Cl.H1.1
Available flexural strength about weak axis (M_{c22})	[Kip*ft]	18.88	Cl.H1.1
Available axial strength (P_c)	[Kip]	293.15	Cl.H1.1

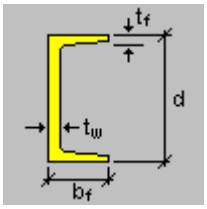
Member : 4
Design status : OK

DESIGN WARNINGS

Section information

Section name: MC 12X31 **(US)**

Dimensions



bf	=	3.670	[in]	Width
d	=	12.000	[in]	Depth
k	=	1.310	[in]	Distance k
tf	=	0.700	[in]	Flange thickness
tw	=	0.370	[in]	Web thickness

Properties

Section properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	9.120	
Moment of Inertia (local axes) (I)	[in4]	202.000	11.300
Moment of Inertia (principal axes) (I')	[in4]	202.000	11.300
Bending constant for moments (principal axis) (J')	[in]	0.000	6.288
Radius of gyration (local axes) (r)	[in]	4.706	1.113
Radius of gyration (principal axes) (r')	[in]	4.706	1.113
Saint-Venant torsion constant. (J)	[in4]	1.000	
Section warping constant. (Cw)	[in6]	267.000	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	-2.291	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	33.700	4.370
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	33.700	10.524
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	33.700	4.370
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	33.700	10.524
Plastic section modulus (local axis) (Z)	[in3]	39.700	8.150
Plastic section modulus (principal axis) (Z')	[in3]	39.700	8.150
Polar radius of gyration. (ro)	[in]	5.340	
Area for shear (Aw)	[in2]	5.140	4.440

Torsional constant. (C)	[in3]	1.411

Material : A36

Properties	Unit	Value
Yield stress (Fy):	[Kip/in2]	36.00
Tensile strength (Fu):	[Kip/in2]	58.00
Elasticity Modulus (E):	[Kip/in2]	29000.00
Shear modulus for steel (G):	[Kip/in2]	11507.94

DESIGN CRITERIA

Description	Unit	Value
Length for tension slenderness ratio (L)	[ft]	11.30

Distance between member lateral bracing points

Length (Lb) [ft]	
Top	Bottom
11.30	11.30

Laterally unbraced length

Length [ft]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
11.30	11.30	11.30	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Sway
Minor axis frame type	Sway

DESIGN CHECKS

AXIAL TENSION DESIGN ✔

Axial tension

Ratio	:	0.00			
Capacity	:	295.49 [Kip]	Reference	:	Cl.D2
Demand	:	0.58 [Kip]	Ctrl Eq.	:	D2 at 100.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(ϕP_n):	[Kip]	295.49	Cl.D2
Nominal axial tension capacity (P_n)	[Kip]	328.32	Eq.D2-1

AXIAL COMPRESSION DESIGN ✔

Compression in the major axis 33

Ratio	:	0.00			
Capacity	:	282.86 [Kip]	Reference	:	Cl.E3
Demand	:	0.84 [Kip]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	5.24	
Unstiffened element limiting slenderness (λ_r)	--	15.89	Table.B4.1a.Case1
Stiffened element classification	--	Non slender	
Stiffened element slenderness (λ)	--	25.35	
Stiffened element limiting slenderness (λ_r)	--	42.29	Table.B4.1a.Case5
Factored flexural buckling strength(ϕP_{n33}):	[Kip]	282.86	Cl.E3
Unbraced length (L_{33})	[ft]	11.30	Cl.E2
Effective slenderness ($(KL/r)_{33}$)	--	28.80	Cl.E2
Elastic critical buckling stress (F_{e33})	[Kip/in2]	345.07	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	9.12	
Critical stress for flexural buckling (F_{cr33})	[Kip/in2]	34.46	Eq.E3-2
Nominal flexural buckling strength (P_{n33})	[Kip]	314.29	Eq.E3-1

Compression in the minor axis 22

Ratio	:	0.01			
Capacity	:	135.38 [Kip]	Reference	:	Cl.E3
Demand	:	0.84 [Kip]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	5.24	
Unstiffened element limiting slenderness (λ_r)	--	15.89	Table.B4.1a.Case1
Stiffened element classification	--	Non slender	
Stiffened element slenderness (λ)	--	25.35	
Stiffened element limiting slenderness (λ_r)	--	42.29	Table.B4.1a.Case5
Factored flexural buckling strength(ϕP_{n22}):	[Kip]	135.38	Cl.E3
Unbraced length (L_{22})	[ft]	11.30	Cl.E2
Effective slenderness ($(KL/r)_{22}$)	--	121.77	Cl.E2
Elastic critical buckling stress (F_{e22})	[Kip/in2]	19.30	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	9.12	
Critical stress for flexural buckling (F_{cr22})	[Kip/in2]	16.49	Eq.E3-2
Nominal flexural buckling strength (P_{n22})	[Kip]	150.42	Eq.E3-1
Factored torsional or flexural-torsional buckling strength(ϕP_{n11}):	[Kip]	227.73	Cl.E4
Unbraced length (L_{11})	[ft]	11.30	Cl.E2
Flexural constant (H)	--	0.82	Eq.E4-8
Torsional or flexural-torsional elastic buckling stress (F_{e11})	[Kip/in2]	57.85	Eq.E4-3
Elastic torsional buckling stress (F_{ez})	[Kip/in2]	59.99	Eq.E4-7
Effective area of the cross section based on the effective width (A...	[in2]	9.12	
Critical stress for torsional or flexural-torsional buckling (F_{cr11})	[Kip/in2]	27.75	Eq.E3-2
Nominal torsional or flexural-torsional buckling strength (P_{n11})	[Kip]	253.03	Eq.E4-1

FLEXURAL DESIGN ✔

Bending about major axis, M33

Ratio	:	0.02			
Capacity	:	107.19 [Kip*ft]	Reference	:	Cl.F2.1
Demand	:	-2.32 [Kip*ft]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	5.24	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	28.38	
Limiting slenderness for compact unstiffened element (λ_p)	--	10.79	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	25.35	
Limiting slenderness for noncompact stiffened element (λ_r)	--	161.78	
Limiting slenderness for compact stiffened element (λ_p)	--	106.72	
Factored yielding strength(ϕM_n):	[Kip*ft]	107.19	Cl.F2.1
Yielding (M_n)	[Kip*ft]	119.10	Eq.F2-1
Factored lateral-torsional buckling strength(ϕM_n):	[Kip*ft]	107.19	Cl.F2.2
Limiting laterally unbraced length for yielding (L_p)	[ft]	4.63	Eq.F2-5
Effective radius of gyration used in the determination of Lr (r_{ts})	[in]	1.28	Eq.F2-7
Lateral-torsional factor (c)	--	1.16	Eq.F2-8b
Limiting laterally unbraced length for inelastic lateral-torsional bucklin...	[ft]	19.76	Eq.F2-6
Lateral-torsional buckling modification factor (C_b)	--	1.35	Eq.F1-1
Nominal lateral-torsional buckling moment strength (M_n)	[Kip*ft]	119.10	Eq.F2-2

Bending about minor axis, M22

Ratio	:	0.00			
Capacity	:	18.88 [Kip*ft]	Reference	:	Cl.F6.1
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	5.24	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	28.38	
Limiting slenderness for compact unstiffened element (λ_p)	--	10.79	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	25.35	
Limiting slenderness for noncompact stiffened element (λ_r)	--	161.78	
Limiting slenderness for compact stiffened element (λ_p)	--	106.72	
Factored yielding strength about a geometric axis(ϕM_n):	[Kip*ft]	18.88	Cl.F6.1
Yielding (M_n)	[Kip*ft]	20.98	Eq.F6-1

DESIGN FOR SHEAR ✔

Shear in major axis 33

Ratio	:	0.00			
Capacity	:	99.88 [Kip]	Reference	:	Cl.G1
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	99.88	Cl.G1
Web buckling coefficient (k_v)	--	1.20	Cl.G6
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	110.98	Eq.G6-1

Shear in minor axis 22

Ratio	:	0.02			
Capacity	:	86.31 [Kip]	Reference	:	Cl.G1
Demand	:	1.35 [Kip]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	86.31	Cl.G1
Web buckling coefficient (k_v)	--	5.34	Eq.G2-5
Web buckling coefficient (C_v)	--	1.00	-
Nominal shear strength (V_n)	[Kip]	95.90	Eq.G2-1

COMBINED ACTIONS DESIGN ✔

Combined flexure and axial

Ratio	:	0.02			
Ctrl Eq.	:	D2 at 0.00%	Reference	:	Eq.H1-1b

Intermediate results	Unit	Value	Reference
Interaction of flexure and axial force:	--	0.02	Eq.H1-1b
Available flexural strength about strong axis (M_{c33})	[Kip*ft]	107.19	Cl.H1.1
Available flexural strength about weak axis (M_{c22})	[Kip*ft]	18.88	Cl.H1.1
Available axial strength (P_c)	[Kip]	135.38	Cl.H1.1

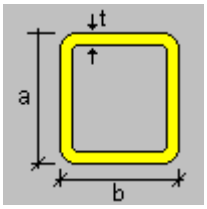
Member : 5
Design status : OK

DESIGN WARNINGS

Section information

Section name: TUBE 4x4x1_4 **(US)**

Dimensions



a	=	4.000	[in]	Height
b	=	4.000	[in]	Width
t	=	0.250	[in]	Thickness

Properties

Section properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	3.597	
Moment of Inertia (local axes) (I)	[in4]	8.219	8.219
Moment of Inertia (principal axes) (I')	[in4]	8.219	8.219
Bending constant for moments (principal axis) (J')	[in]	0.000	0.000
Radius of gyration (local axes) (r)	[in]	1.512	1.512
Radius of gyration (principal axes) (r')	[in]	1.512	1.512
Saint-Venant torsion constant. (J)	[in4]	13.504	
Section warping constant. (Cw)	[in6]	0.052	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	0.000	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	4.110	4.110
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	4.110	4.110
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	4.110	4.110
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	4.110	4.110
Plastic section modulus (local axis) (Z)	[in3]	4.975	4.975
Plastic section modulus (principal axis) (Z')	[in3]	4.975	4.975
Polar radius of gyration. (ro)	[in]	2.138	
Area for shear (Aw)	[in2]	1.875	1.875
Torsional constant. (C)	[in3]	6.969	

Material : A1085

Properties	Unit	Value
Yield stress (Fy):	[Kip/in2]	50.00
Tensile strength (Fu):	[Kip/in2]	65.00
Elasticity Modulus (E):	[Kip/in2]	29000.00
Shear modulus for steel (G):	[Kip/in2]	11153.85

DESIGN CRITERIA

Description	Unit	Value
Length for tension slenderness ratio (L)	[ft]	5.92

Distance between member lateral bracing points

Length (Lb) [ft]	
Top	Bottom
5.92	5.92

Laterally unbraced length

Length [ft]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
5.92	5.92	5.92	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Sway
Minor axis frame type	Sway

DESIGN CHECKS

AXIAL TENSION DESIGN ✔

Axial tension

Ratio	:	0.00			
Capacity	:	161.86 [Kip]	Reference	:	Cl.D2
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(ϕP_n):	[Kip]	161.86	Cl.D2
Nominal axial tension capacity (P_n)	[Kip]	179.85	Eq.D2-1

AXIAL COMPRESSION DESIGN ✔

Compression in the major axis 33

Ratio	:	0.00			
Capacity	:	137.75 [Kip]	Reference	:	Cl.E3
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	13.00	
Unstiffened element limiting slenderness (λ_r)	--	33.72	Table.B4.1a.Case6
Stiffened element classification	--	Non slender	
Stiffened element slenderness (λ)	--	13.00	
Stiffened element limiting slenderness (λ_r)	--	33.72	Table.B4.1a.Case6
Factored flexural buckling strength(ϕP_{n33}):	[Kip]	137.75	Cl.E3
Unbraced length (L_{33})	[ft]	5.92	Cl.E2
Effective slenderness ($(KL/r)_{33}$)	--	46.97	Cl.E2
Elastic critical buckling stress (F_{e33})	[Kip/in2]	129.74	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	3.60	
Critical stress for flexural buckling (F_{cr33})	[Kip/in2]	42.55	Eq.E3-2
Nominal flexural buckling strength (P_{n33})	[Kip]	153.06	Eq.E3-1

Compression in the minor axis 22

Ratio	:	0.00			
Capacity	:	137.75 [Kip]	Reference	:	Cl.E3
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	13.00	
Unstiffened element limiting slenderness (λ_r)	--	33.72	Table.B4.1a.Case6
Stiffened element classification	--	Non slender	
Stiffened element slenderness (λ)	--	13.00	
Stiffened element limiting slenderness (λ_r)	--	33.72	Table.B4.1a.Case6
Factored flexural buckling strength(ϕP_{n22}):	[Kip]	137.75	Cl.E3
Unbraced length (L_{22})	[ft]	5.92	Cl.E2
Effective slenderness ($(KL/r)_{22}$)	--	46.97	Cl.E2
Elastic critical buckling stress (F_{e22})	[Kip/in2]	129.74	Eq.E3-4

Effective area of the cross section based on the effective width (A...	[in2]	3.60	
Critical stress for flexural buckling (F_{cr22})	[Kip/in2]	42.55	Eq.E3-2
Nominal flexural buckling strength (P_{n22})	[Kip]	153.06	Eq.E3-1

FLEXURAL DESIGN ✔

Bending about major axis, M33

Ratio	:	0.00			
Capacity	:	18.66 [Kip*ft]	Reference	:	Cl.F7.1
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	13.00	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	33.72	
Limiting slenderness for compact unstiffened element (λ_p)	--	26.97	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	13.00	
Limiting slenderness for noncompact stiffened element (λ_r)	--	137.27	
Limiting slenderness for compact stiffened element (λ_p)	--	58.28	
Factored yielding strength(ϕM_n):	[Kip*ft]	18.66	Cl.F7.1
Yielding (M_n)	[Kip*ft]	20.73	Eq.F7-1

Bending about minor axis, M22

Ratio	:	0.00			
Capacity	:	18.66 [Kip*ft]	Reference	:	Cl.F7.1
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	13.00	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	33.72	
Limiting slenderness for compact unstiffened element (λ_p)	--	26.97	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	13.00	
Limiting slenderness for noncompact stiffened element (λ_r)	--	137.27	
Limiting slenderness for compact stiffened element (λ_p)	--	58.28	
Factored yielding strength about a geometric axis(ϕM_n):	[Kip*ft]	18.66	Cl.F7.1
Yielding (M_n)	[Kip*ft]	20.73	Eq.F7-1

DESIGN FOR SHEAR ✔

Shear in major axis 33

Ratio	:	0.00			
Capacity	:	50.62 [Kip]	Reference	:	Cl.G1
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	50.62	Cl.G1
Web buckling coefficient (k_v)	--	5.00	Cl.G4
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	56.25	Eq.G4-1

Shear in minor axis 22

Ratio	:	0.00			
Capacity	:	50.62 [Kip]	Reference	:	Cl.G1
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	50.62	Cl.G1
Web buckling coefficient (k_v)	--	5.00	Cl.G4
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	56.25	Eq.G4-1

TORSION DESIGN ✔

Torsion

Ratio	:	0.00			
Capacity	:	15.68 [Kip*ft]	Reference	:	Cl.H3.1
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored torsion capacity(ϕT_n):	[Kip*ft]	15.68	Cl.H3.1
Critical torsional buckling stress (F_{cr})	[Kip/in2]	30.00	Eq.H3-3
Nominal torsion capacity (T_n)	[Kip*ft]	17.42	Eq.H3-1

COMBINED ACTIONS DESIGN ✔

Combined flexure and axial

Ratio	:	0.00			
Ctrl Eq.	:	D2 at 0.00%	Reference	:	Eq.H1-1b

Intermediate results	Unit	Value	Reference
Interaction of flexure and axial force:	--	0.00	Eq.H1-1b
Available flexural strength about strong axis (M_{c33})	[Kip*ft]	18.66	Cl.H1.1
Available flexural strength about weak axis (M_{c22})	[Kip*ft]	18.66	Cl.H1.1
Available axial strength (P_c)	[Kip]	137.75	Cl.H1.1

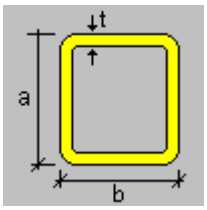
Member : 6
Design status : OK

DESIGN WARNINGS

Section information

Section name: TUBE 4x4x1_4 **(US)**

Dimensions



a	=	4.000	[in]	Height
b	=	4.000	[in]	Width
t	=	0.250	[in]	Thickness

Properties

Section properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	3.597	
Moment of Inertia (local axes) (I)	[in4]	8.219	8.219
Moment of Inertia (principal axes) (I')	[in4]	8.219	8.219
Bending constant for moments (principal axis) (J')	[in]	0.000	0.000
Radius of gyration (local axes) (r)	[in]	1.512	1.512
Radius of gyration (principal axes) (r')	[in]	1.512	1.512
Saint-Venant torsion constant. (J)	[in4]	13.504	
Section warping constant. (Cw)	[in6]	0.052	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	0.000	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	4.110	4.110
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	4.110	4.110
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	4.110	4.110
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	4.110	4.110
Plastic section modulus (local axis) (Z)	[in3]	4.975	4.975
Plastic section modulus (principal axis) (Z')	[in3]	4.975	4.975
Polar radius of gyration. (ro)	[in]	2.138	
Area for shear (Aw)	[in2]	1.875	1.875
Torsional constant. (C)	[in3]	6.969	

Material : A1085

Properties	Unit	Value
Yield stress (Fy):	[Kip/in2]	50.00
Tensile strength (Fu):	[Kip/in2]	65.00
Elasticity Modulus (E):	[Kip/in2]	29000.00
Shear modulus for steel (G):	[Kip/in2]	11153.85

DESIGN CRITERIA

Description	Unit	Value
Length for tension slenderness ratio (L)	[ft]	11.83

Distance between member lateral bracing points

Length (Lb) [ft]	
Top	Bottom
11.83	11.83

Laterally unbraced length

Length [ft]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
11.83	11.83	11.83	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Sway
Minor axis frame type	Sway

DESIGN CHECKS

AXIAL TENSION DESIGN ✔

Axial tension

Ratio	:	0.00			
Capacity	:	161.86 [Kip]	Reference	:	Cl.D2
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(ϕP_n):	[Kip]	161.86	Cl.D2
Nominal axial tension capacity (P_n)	[Kip]	179.85	Eq.D2-1

AXIAL COMPRESSION DESIGN ✔

Compression in the major axis 33

Ratio	:	0.01			
Capacity	:	84.91 [Kip]	Reference	:	Cl.E3
Demand	:	1.12 [Kip]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	13.00	
Unstiffened element limiting slenderness (λ_r)	--	33.72	Table.B4.1a.Case6
Stiffened element classification	--	Non slender	
Stiffened element slenderness (λ)	--	13.00	
Stiffened element limiting slenderness (λ_r)	--	33.72	Table.B4.1a.Case6
Factored flexural buckling strength(ϕP_{n33}):	[Kip]	84.91	Cl.E3
Unbraced length (L_{33})	[ft]	11.83	Cl.E2
Effective slenderness ($(KL/r)_{33}$)	--	93.93	Cl.E2
Elastic critical buckling stress (F_{e33})	[Kip/in2]	32.44	Eq.E3-4

Effective area of the cross section based on the effective width (A...	[in2]	3.60	
Critical stress for flexural buckling (F_{cr33})	[Kip/in2]	26.23	Eq.E3-2
Nominal flexural buckling strength (P_{n33})	[Kip]	94.34	Eq.E3-1

Compression in the minor axis 22

Ratio	: 0.01			
Capacity	: 84.91 [Kip]	Reference	:	Cl.E3
Demand	: 1.12 [Kip]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	13.00	
Unstiffened element limiting slenderness (λ_r)	--	33.72	Table.B4.1a.Case6
Stiffened element classification	--	Non slender	
Stiffened element slenderness (λ)	--	13.00	
Stiffened element limiting slenderness (λ_r)	--	33.72	Table.B4.1a.Case6
Factored flexural buckling strength(ϕP_{n22}):	[Kip]	84.91	Cl.E3
Unbraced length (L_{22})	[ft]	11.83	Cl.E2
Effective slenderness ($(KL/r)_{22}$)	--	93.93	Cl.E2
Elastic critical buckling stress (F_{e22})	[Kip/in2]	32.44	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	3.60	
Critical stress for flexural buckling (F_{cr22})	[Kip/in2]	26.23	Eq.E3-2
Nominal flexural buckling strength (P_{n22})	[Kip]	94.34	Eq.E3-1

FLEXURAL DESIGN ✔

Bending about major axis, M33

Ratio	: 0.00			
Capacity	: 18.66 [Kip*ft]	Reference	:	Cl.F7.1
Demand	: -0.08 [Kip*ft]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	13.00	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	33.72	
Limiting slenderness for compact unstiffened element (λ_p)	--	26.97	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	13.00	
Limiting slenderness for noncompact stiffened element (λ_r)	--	137.27	
Limiting slenderness for compact stiffened element (λ_p)	--	58.28	
Factored yielding strength(ϕM_n):	[Kip*ft]	18.66	Cl.F7.1
Yielding (M_n)	[Kip*ft]	20.73	Eq.F7-1

Bending about minor axis, M22

Ratio	: 0.00			
Capacity	: 18.66 [Kip*ft]	Reference	:	Cl.F7.1
Demand	: 0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	13.00	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	33.72	
Limiting slenderness for compact unstiffened element (λ_p)	--	26.97	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	13.00	
Limiting slenderness for noncompact stiffened element (λ_r)	--	137.27	
Limiting slenderness for compact stiffened element (λ_p)	--	58.28	
Factored yielding strength about a geometric axis(ϕM_n):	[Kip*ft]	18.66	Cl.F7.1
Yielding (M_n)	[Kip*ft]	20.73	Eq.F7-1

DESIGN FOR SHEAR ✔

Shear in major axis 33

Ratio	:	0.00			
Capacity	:	50.62 [Kip]	Reference	:	Cl.G1
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	50.62	Cl.G1
Web buckling coefficient (k_v)	--	5.00	Cl.G4
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	56.25	Eq.G4-1

Shear in minor axis 22

Ratio	:	0.00			
Capacity	:	50.62 [Kip]	Reference	:	Cl.G1
Demand	:	0.01 [Kip]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	50.62	Cl.G1
Web buckling coefficient (k_v)	--	5.00	Cl.G4
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	56.25	Eq.G4-1

TORSION DESIGN ✔

Torsion

Ratio	:	0.00			
Capacity	:	15.68 [Kip*ft]	Reference	:	Cl.H3.1
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored torsion capacity(ϕT_n):	[Kip*ft]	15.68	Cl.H3.1
Critical torsional buckling stress (F_{cr})	[Kip/in2]	30.00	Eq.H3-3
Nominal torsion capacity (T_n)	[Kip*ft]	17.42	Eq.H3-1

COMBINED ACTIONS DESIGN ✔

Combined flexure and axial

Ratio	:	0.01			
Ctrl Eq.	:	D2 at 0.00%	Reference	:	Eq.H1-1b

Intermediate results	Unit	Value	Reference
Interaction of flexure and axial force:	--	0.01	Eq.H1-1b
Available flexural strength about strong axis (M_{c33})	[Kip*ft]	18.66	Cl.H1.1
Available flexural strength about weak axis (M_{c22})	[Kip*ft]	18.66	Cl.H1.1
Available axial strength (P_c)	[Kip]	84.91	Cl.H1.1

Steel Beam Design - Simple span w/ uniform and point loads - HSS shapes

Member: **SB-1**

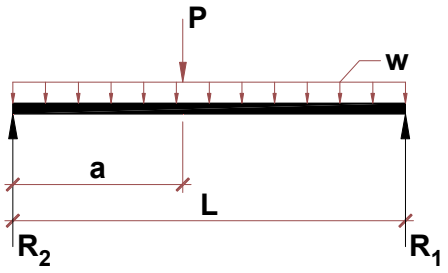
AISC 360-16 Specification for Structural Steel Building and Steel Construction Manual, 15th Edition
(Load calculation for ASD and LRFD are pre-design)

Loading criteria:

Span: $L := 12.5ft$

Uniform load (x-axis): $w_x := 60psf \cdot 3ft + 0plf$

Uniform load (y-axis): $w_y := 0 \cdot (28.2psf) \cdot 9ft$



Point loads & Point load locations:

(x-axis):

$P_{x_1} := 0kip$ $a_{x_1} := 0ft$

$P_{x_2} := 0kip$ $a_{x_2} := 0ft$

$P_{x_3} := 0kip$ $a_{x_3} := 0ft$

(y-axis):

$P_{y_1} := 0kip$ $a_{y_1} := 0ft$

$P_{y_2} := 0kip$ $a_{y_2} := 0ft$

$P_{y_3} := 0kip$ $a_{y_3} := 0ft$

Deflection limits (x-axis): $\Delta_x := 360$

(y-axis): $\Delta_y := 240$

Permit deflection reduction for wind forces: X-axis only

Material and beam shape:

Steel Grade: ASTM A500 Gr. C

Yield Stress: $F_y = 50 \cdot ksi$ $E = 29000 \cdot ksi$

Design methodology: ASD Design

Beam shape: HSS4X4X1/4

Design bending moment and shear:

Member reactions:

(x-axis): $R_{x.1} = 1.13 \cdot kip$ $R_{x.2} = 1.13 \cdot kip$

(y-axis): $R_{y.1} = 0 \cdot kip$ $R_{y.2} = 0 \cdot kip$

Maximum shears:

(x-axis): $V_x = 1.13 \cdot kip$

(y-axis): $V_y = 0 \cdot kip$

Maximum bending moment:

(x-axis): $M_x = 3.52 \cdot kip \cdot ft$

(y-axis): $M_y = 0 \cdot kip \cdot ft$

Flexure Design (AISC 360-16 Chapter F):

ASD/LRFD capacity:

(x-axis) $M_{x.capacity} = 12 \cdot kip \cdot ft$ $\frac{M_x}{M_{x.capacity}} = 0.3$

$X\_Flexure_{Check} = \begin{pmatrix} \text{"Mx < Mn.x (ASD), Flexure OK"} \\ \text{"ASD X-axis Flexure ratio = 0.3"} \end{pmatrix}$

(y-axis) $M_{y.capacity} = 12 \cdot kip \cdot ft$ $\frac{M_y}{M_{y.capacity}} = 0$

$Y\_Flexure_{Check} = \text{"Y-axis Flexure N.A."}$

Combined Flexure design (AISC 360-16, Chapter H):

$CF\_Check = \text{"Combine Forces Calculations N.A."}$

Shear Design (AISC 360-16 Chapter G):

ASD/LRFD capacity:

(x-axis) $V_{x.capacity} = 27.6 \cdot kip$ $\frac{V_x}{V_{x.capacity}} = 0.041$

$X\_Shear_{Check} = \begin{pmatrix} \text{"V.x < Vn.x (ASD), Shear OK"} \\ \text{"Unstiffened webs OK"} \\ \text{"ASD Shear ratio = 0.041"} \end{pmatrix}$

(y-axis) $V_{y.capacity} = 27.6 \cdot kip$ $\frac{V_y}{V_{y.capacity}} = 0$

$Y\_Shear_{Check} = \begin{pmatrix} \text{"V.y < Vn.y (ASD), Shear OK"} \\ \text{"Unstiffened webs OK"} \\ \text{"ASD Shear ratio = 0"} \end{pmatrix}$

Service Deflection Design:

(x-axis) $\delta_x = 0.306 \cdot in < \Delta_{allow.x} = 0.42 \cdot in$ $\frac{\delta_x}{\Delta_{allow.x}} = 0.73$

$X\_Deflection_{Check} = \begin{pmatrix} \text{"Service deflection OK"} \\ \text{"Service deflection ratio = 0.73"} \end{pmatrix}$

(y-axis) $\delta_y = 0 \cdot in < \Delta_{allow.y} = 0.63 \cdot in$ $\frac{\delta_y}{\Delta_{allow.y}} = 0$

$Y\_Deflection_{Check} = \begin{pmatrix} \text{"Service deflection OK"} \\ \text{"Service deflection ratio = 0"} \end{pmatrix}$

Concrete Footing Design (reinforcing in both directions

ACI 318-14, Footing Design is for both Axial and Moment
(Bearing area is based on ASD Basic Load Combination per 2015 IBC

Footing Designation
FTG- **PANTOGRAPH FOOTING**

1. Footing Load (Unfactored)

Unfactored Axial Loading

P-axial			P-axial		
Dead (D)	0.5	kips	Live Roof (Lr)	0.0	kips
Live (L)	2.7	kips	Seismic (E)	0.0	kips
Snow (S)	0.0	kips	Wind (W)	0.0	kips
eccentricity=	0 in		Axial load		

Unfactored Lateral Load/Moment h_v= 0 ft

V-Lateral			M-moment		
Seismic (E)	0.0	kip	Seismic (EQ)	0.0	kip-ft
Wind (W)	0.0	kip	Wind (W)	0.0	kip-ft

User Input Moment

User Input Moment EQ 0 kip-ft

Live Load Factors: Other live loads / Other roof

Allowable Bearing Pressure	1500	psf
Short term load increase	No	
Distance from grade to bottom of footing (ds)	2	T
Dsitance from ground to the water table (WT)	6	ft
Weigth of Foundation	0.56	kip
Weight of Soil above footing	0.3	kip
Pore Water pressure at bottom of footing	0	kip
Adjsuted bearing pressure	1288	psf

2. Footing Design Criteria

Select Type of Footing	Square Spot Footing	
Footing Width (W)	2.0	ft
Footing Length (b)	2.0	ft
Footing depth (d_f)	12.0	in
Depth to Flexural Steel (d)	8.0	in
Select type of column,base plate,wall	Steel column w/ base plate	
Critical Section per ACI Table 13.2.7.1	m=	3
Wall or Column/BP Width (short dimension)	6	in
Length (long dimension	6	in
Two-way shear constant (ACI 318-14 22.6.5.3)	Interior Column	

3. Concrete Design Criteria

Concrete Strength (F`c)	4000 psi	
Concrete Weight	Normal weight	
LRFD Strength reduction facotrs	$\varphi_{f=}$	0.9
	$\varphi_{v=}$	0.75
Reinforcing Steel Yiled Strength (F_y)	60000 psi	

Service Level Loads

Concentric Vertical Load (p)	3.2	kips
Moment Load (M or P_2e)	0.0	k-ft
Allowable Bearing Pressure Check	**Adequate**	
Minimim Bearing Pressure (q_{min})	1010	psf
Maximum Bearing Pressure (q_{max})	1010	psf

Two Way Punching Shear

Max Factored net soil bearing pressure
Min Factored net soil bearing pressure

β= 1.0 Net Factored Shear Vu 3.68905 kips

Conc. Shear Cap. ϕVc1 66.7873 kips

Conc. Shear Cap. ϕVc 66.7873 kips

Punching Shear Check **Adequate Shear**

One Way Flexural Shear

1436 psf
1436 psf

Max factored shear @ crtical 1436 psf

Factored Shear Force on footing -3.7 kip

Min factored shear @ critical 1436 psf

Factored Shear Force on footing 3.47 kip

Concrete shear ϕV_c = 18.21 kip

Flexure Shear check **Adequate Shear**

Flexural Design Moment

Factored shear rightside @ face qr 1.44 ksf
Factored Moment Right side Mur 0.20 kip-ft
Ffactored shear lefttside @ face qf 1.44 ksf
Factored Moment Left side Mlf 6.48 kip-ft

Design Moment M_u 6.48 kip-ft

Flexural Reinforcement Design

Reinforcement Steel Ratio ρ 0.00095
As, min $0.0018A_g$ 0.5184
Required steel area 0.18163 in2
As Required 0.5184 in2/ft

Descrip. Bar in^2 Quanitity Spacing in2/ft

Select Rebar Size and Spacing from Chart Below M Reduction No

Top and Bottom Reinforcement Layer

Area (in^2)	Bar Size	# of bars	Spacing (in)	Development Length	
0.2	#4	3.0	9.0	11	ADEQUATE
0.31	#5	2.0	18.0	15	ADEQUATE
0.44	#6	2.0	18.0	21	ADEQUATE
0.6	#7	1.0	18.0	29	INADEQUATE
0.79	#8	1.0	18.0	38	INADEQUATE

Concrete Footing Design (reinforcing in both directions

ACI 318-14, Footing Design is for both Axial and Moment
(Bearing area is based on ASD Basic Load Combination per 2015 IBC

Footing Designation
FTG- **PANTOGRAPH FOOTING**

1. Footing Load (Unfactored)

Unfactored Axial Loading

P-axial			P-axial		
Dead (D)	1.0	kips	Live Roof (Lr)	0.0	kips
Live (L)	5.4	kips	Seismic (E)	0.0	kips
Snow (S)	0.0	kips	Wind (W)	0.0	kips
eccentricity=			0 in	Axial load	

Unfactored Lateral Load/Moment h_v= 0 ft

V-Lateral			M-moment		
Seismic (E)	0.0	kip	Seismic (EQ)	0.0	kip-ft
Wind (W)	0.0	kip	Wind (W)	0.0	kip-ft

User Input Moment

User Input Moment EQ 0 kip-ft

Live Load Factors: Other live loads / Other roof

Allowable Bearing Pressure	1500	psf
Short term load increase	No	
Distance from grade to bottom of footing (ds)	0	T
Dsitance from ground to the water table (WT)	6	ft
Weigth of Foundation	0.88	kip
Weight of Soil above footing	0.0	kip
Pore Water pressure at bottom of footing	0	kip
Adjsuted bearing pressure	1360	psf

2. Footing Design Criteria

Select Type of Footing	Square Spot Footing	
Footing Width (W)	2.5	ft
Footing Length (b)	2.5	ft
Footing depth (d_f)	12.0	in
Depth to Flexural Steel (d)	8.0	in
Select type of column,base plate,wall	Steel column w/ base plate	
Critical Section per ACI Table 13.2.7.1	m=	3
Wall or Column/BP Width (short dimension)	6	in
Length (long dimension	6	in
Two-way shear constant (ACI 318-14 22.6.5.3)	Interior Column	

3. Concrete Design Criteria

Concrete Strength (F`c)	4000 psi	
Concrete Weight	Normal weight	
LRFD Strength reduction facotrs	$\varphi_{f=}$	0.9
	$\varphi_{v=}$	0.75
Reinforcing Steel Yiled Strength (F_y)	60000 psi	

Service Level Loads

Concentric Vertical Load (p)	6.4	kips
Moment Load (M or P_2e)	0.0	k-ft
Allowable Bearing Pressure Check	**Adequate**	
Minimim Bearing Pressure (q_{min})	1164	psf
Maximum Bearing Pressure (q_{max})	1164	psf

Two Way Punching Shear

Max Factored net soil bearing pressure 1714 psf

Min Factored net soil bearing pressure 1714 psf

β= 1.0 Net Factored Shear Vu 8.39943 kips

Conc. Shear Cap. ϕVc1 66.7873 kips

Conc. Shear Cap. ϕVc 66.7873 kips

Punching Shear Check **Adequate Shear**

One Way Flexural Shear

Max factored shear @ crtical	1714	psf
Factored Shear Force on footing	-4.5	kip
Min factored shear @ critical	1714	psf
Factored Shear Force on footing	6.25	kip
Concrete shear ϕV_c =	22.77	kip
Flexure Shear check	**Adequate Shear**	

Flexural Design Moment

Factored shear rightside @ face qr	1.71	ksf
Factored Moment Right side Mur	0.03	kip-ft
Ffactored shear lefttside @ face qf	1.71	ksf
Factored Moment Left side Mul	12.09	kip-ft
Design Moment M_u	12.09	kip-ft

Flexural Reinforcement Design

Reinforcement Steel Ratio ρ				0.00142	
As, min	$0.0018A_g$			0.648	
Required steel area				0.34002	in2
As Required				0.648	in2/ft
Descrip.	Bar	in^2	Quanitity	Spacing	in2/ft

Select Rebar Size and Spacing from Chart Below — M Reduction No

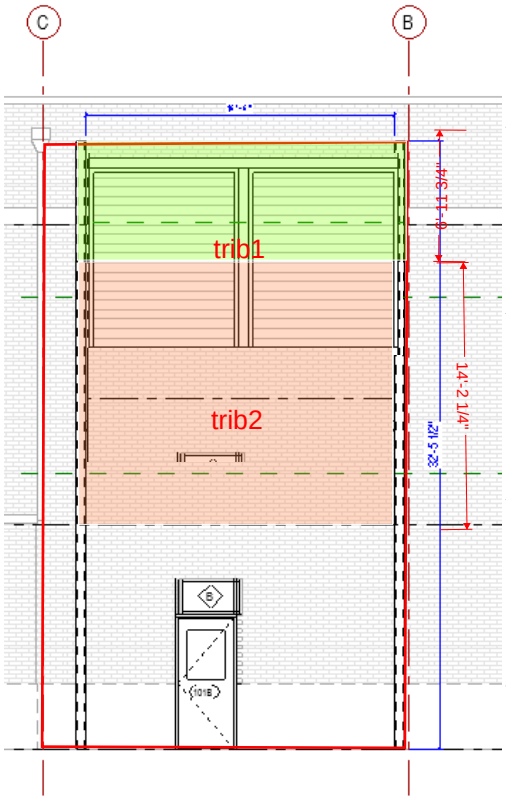
Top and Bottom — Reinforcement Layer

Area (in^2)	Bar Size	# of bars	Spacing (in)	Development Length	
0.2	#4	4.0	8.0	11	ADEQUATE
0.31	#5	3.0	12.0	15	ADEQUATE
0.44	#6	2.0	18.0	21	ADEQUATE
0.6	#7	2.0	18.0	29	INADEQUATE
0.79	#8	1.0	18.0	38	INADEQUATE

Louver Opening Design

Structural Engineering inc.
442 North Main Street, Suite 200, Bountiful, Utah 84010
(801) 298-1118, Office 298-1122 Fax
e-mail: wca@wcaeng.com

PROJECT: Spectrum Engineers PROJECT #: 22131
CLIENT: Spectrum Engineers DATE: 06.22.23
TOPIC: Pantograph ENGINEER: TPT



	Location	Tributary Area (ft^2) <10	50	100	500
Walls:	Within (a) of building corner (zone 5)	-39	-33	-30	-24
	All other areas (zone 4)	-31	-28	-27	-24
Roof:	All other areas (zone 1)	-50	-43	-39	-32
	Within (a) of building edge (zone 2)	-66	-56	-52	-42
	Within (a) of building corner (zone 3)	-90	-70	-62	-42
	All Zones Positive	16	16	16	16

wind load cc =

TRIB1 = 7'*18'*42 PSF=5292LBS/16.5=320 PLF
TRIB2 = 14.25'*18'*42=10773/16.5=652 PLF

EQ LOAD

ARCHITECTURAL COMPONENTS SEISMIC COEFFICIENTS

Architectural Component : Body of wall panel connections
Importance Factor (Ip) : Ip = 1.0 all other components
Component Amplification Factor (a_p) = 1 h= 18.0 feet
Comp Response Modification Factor (R_p) = 2.5 z= 18.0 feet z/h = 1.00
Over-Strength Factor (Ω_o) = NA
$Fp = 0.4a_pSdsIpWp(1+2z/h)/Rp$ = 0.165 Wp
not greater than $Fp = 1.6SdsIpWp$ = 0.550 Wp
but not less than $Fp = 0.3SdsIpWp$ = 0.103 Wp use Fp = 0.165 Wp

W=80 PSF

Fp= 80*.165=13.2 psf ... WIND CONTROLS DESIGN

FASTENERS

ARCHITECTURAL COMPONENTS SEISMIC COEFFICIENTS

Architectural Component : Fasteners of the connecting system
Importance Factor (Ip) : Ip = 1.0 all other components
Component Amplification Factor (a_p) = 1.25 h=
Comp Response Modification Factor (R_p) = 1 z= G z/h = 1.00
Over-Strength Factor (Ω_o) = 1
$Fp = 0.4a_pSdsIpWp(1+2z/h)/Rp$ = 0.516 Wp
not greater than $Fp = 1.6SdsIpWp$ = 0.550 Wp
but not less than $Fp = 0.3SdsIpWp$ = 0.103 Wp use Fp = 0.516 Wp

FP= 41.25 PSF FOR FASTENERS

GRAVITY.

DEAD LOAD

WALL 100 PLF

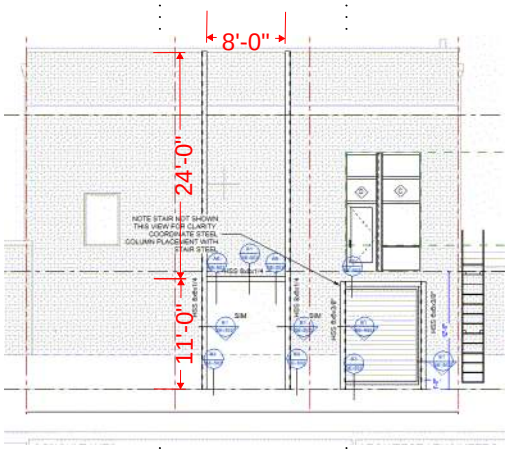
ROOF LOAD - 3.5'*60PSF= 210 PLF

SNOW LOAD - 26 psf * 3.5'=91 PLF

steel design per ASCE7-16.

Structural Engineering inc.
442 North Main Street, Suite 200, Bountiful, Utah 84010
(801) 298-1118, Office 298-1122 Fax
e-mail: wca@wcaeng.com

PROJECT: Spectrum Engineers PROJECT #: 22131
CLIENT: Spectrum Engineers DATE: 06.22.23
TOPIC: Pantograph ENGINEER: TPT



Trib = 35(4) = 140 psf

4(27) = 108 plf

Location		Tributary Area (ft^2) <10	50	100	500
Walls:	Within (a) of building corner (zone 5)	-39	-33	-30	-24
	All other areas (zone 4)	-31	-28	-27	-24
Roof:	All other areas (zone 1)	-50	-43	-39	-32
	Within (a) of building edge (zone 2)	-66	-56	-52	-42
	Within (a) of building corner (zone 3)	-90	-70	-62	-42
	All Zones Positive	16	16	16	16

wind load cc =

TRIB1 = 7'*18'*42 PSF=5292LBS/16.5=320 PLF
TRIB2 = 14.25'*18'*42=10773/16.5=652 PLF

EQ LOAD

ARCHITECTURAL COMPONENTS SEISMIC COEFFICIENTS

Architectural Component : Body of wall panel connections
Importance Factor (Ip) : Ip = 1.0 all other components
Component Amplification Factor (a_p) = 1 h= 18.0 feet
Comp Response Modification Factor (R_p) = 2.5 z= 18.0 feet z/h = 1.00
Over-Strength Factor (Ω_o) = NA
$Fp = 0.4a_pSdsIpWp(1+2z/h)/Rp$ = 0.165 Wp
not greater than $Fp = 1.6SdsIpWp$ = 0.550 Wp
but not less than $Fp = 0.3SdsIpWp$ = 0.103 Wp use Fp = 0.165 Wp

W=80 PSF

Fp= 80*.165=13.2 psf ... WIND CONTROLS DESIGN

FASTENERS

ARCHITECTURAL COMPONENTS SEISMIC COEFFICIENTS

Architectural Component : Fasteners of the connecting system
Importance Factor (Ip) : Ip = 1.0 all other components
Component Amplification Factor (a_p) = 1.25 h=
Comp Response Modification Factor (R_p) = 1 z= G z/h = 1.00
Over-Strength Factor (Ω_o) = 1
$Fp = 0.4a_pSdsIpWp(1+2z/h)/Rp$ = 0.516 Wp
not greater than $Fp = 1.6SdsIpWp$ = 0.550 Wp
but not less than $Fp = 0.3SdsIpWp$ = 0.103 Wp use Fp = 0.516 Wp

FP= 41.25 PSF FOR FASTENERS

GRAVITY.

DEAD LOAD

WALL 100 PLF

ROOF LOAD - 3.5'*60PSF= 210 PLF

SNOW LOAD - 26 psf * 3.5'=91 PLF

steel design per ASCE7-16.

RAM Elements

Current Date: 11/7/2023 12:33 PM
Units system: English

Steel Code Check
Comprehensive Report

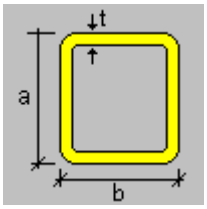
AISC 360-2016 LRFD (Hot-rolled)

Member : 1 - OK

Section information

Section name: TUBE 12x6x1_4 **(US)**

Dimensions



a	=	12.000	[in]	Height
b	=	6.000	[in]	Width
t	=	0.250	[in]	Thickness

Properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	8.597	
Moment of Inertia (local axes) (I)	[in4]	161.426	55.183
Moment of Inertia (principal axes) (I')	[in4]	161.426	55.183
Bending constant for moments (principal axis) (J')	[in]	0.000	0.000
Radius of gyration (local axes) (r)	[in]	4.333	2.534
Radius of gyration (principal axes) (r')	[in]	4.333	2.534
Saint-Venant torsion constant. (J)	[in4]	132.256	
Section warping constant. (Cw)	[in6]	98.618	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	0.000	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	26.904	18.394
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	26.904	18.394
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	26.904	18.394
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	26.904	18.394
Plastic section modulus (local axis) (Z)	[in3]	33.238	20.572
Plastic section modulus (principal axis) (Z')	[in3]	33.238	20.572
Polar radius of gyration. (ro)	[in]	5.020	
Area for shear (Aw)	[in2]	2.875	5.875
Torsional constant. (C)	[in3]	33.719	

Material : A500 GrB rectangular

Properties	Unit	Value
Yield stress (Fy):	[Kip/in2]	46.00
Tensile strength (Fu):	[Kip/in2]	58.00
Elasticity Modulus (E):	[Kip/in2]	29000.00
Shear modulus for steel (G):	[Kip/in2]	11153.85

Design Criteria

Description	Unit	Value
Length for tension slenderness ratio (L)	[ft]	1.00

Distance between member lateral bracing points

Length (Lb) [ft]	
Top	Bottom
1.00	1.00

Laterally unbraced length

Length [ft]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
1.00	1.00	1.00	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Sway
Minor axis frame type	Sway

Design Checks

Axial Tension Design ✔

Axial tension

Ratio	:	0.00			
Capacity	:	355.91 [Kip]	Reference	:	Cl.D2
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(ϕP_n):	[Kip]	355.91	Cl.D2
Nominal axial tension capacity (P_n)	[Kip]	395.46	Eq.D2-1

Axial Compression Design ✔

Compression in the major axis 33

Ratio	:	0.00			
Capacity	:	320.03 [Kip]	Reference	:	Cl.E3
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	21.00	
Unstiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Stiffened element classification	--	Slender	
Stiffened element slenderness (λ)	--	45.00	
Stiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Factored flexural buckling strength(ϕP_{n33}):	[Kip]	320.03	Cl.E3
Unbraced length (L_{33})	[ft]	1.00	Cl.E2
Effective slenderness ($(KL/r)_{33}$)	--	2.77	Cl.E2
Elastic critical buckling stress (F_{e33})	[Kip/in2]	37322.01	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	7.73	
Critical stress for flexural buckling (F_{cr33})	[Kip/in2]	45.98	Eq.E3-2
Nominal flexural buckling strength (P_{n33})	[Kip]	355.59	Eq.E7-1

Compression in the minor axis 22

Ratio	:	0.00			
Capacity	:	319.78 [Kip]	Reference	:	Cl.E3
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	21.00	
Unstiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Stiffened element classification	--	Slender	
Stiffened element slenderness (λ)	--	45.00	
Stiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Factored flexural buckling strength(ϕP_{n22}):	[Kip]	319.78	Cl.E3
Unbraced length (L_{22})	[ft]	1.00	Cl.E2
Effective slenderness ($(KL/r)_{22}$)	--	4.74	Cl.E2
Elastic critical buckling stress (F_{e22})	[Kip/in2]	12758.48	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	7.74	
Critical stress for flexural buckling (F_{cr22})	[Kip/in2]	45.93	Eq.E3-2
Nominal flexural buckling strength (P_{n22})	[Kip]	355.31	Eq.E7-1

Flexural Design ✔

Bending about major axis, M33

Ratio	:	0.05			
Capacity	:	114.67 [Kip*ft]	Reference	:	Cl.F7.1
Demand	:	6.03 [Kip*ft]	Ctrl Eq.	:	D6 at 100.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	21.00	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	35.15	
Limiting slenderness for compact unstiffened element (λ_p)	--	28.12	

Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	45.00	
Limiting slenderness for noncompact stiffened element (λ_r)	--	143.12	
Limiting slenderness for compact stiffened element (λ_p)	--	60.76	
Factored yielding strength(ϕM_n):	[Kip*ft]	114.67	Cl.F7.1
Yielding (M_n)	[Kip*ft]	127.41	Eq.F7-1

Bending about minor axis, M22

Ratio	:	0.00			
Capacity	:	56.18 [Kip*ft]	Reference	:	Cl.F7.2
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	21.00	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	35.15	
Limiting slenderness for compact unstiffened element (λ_p)	--	28.12	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	45.00	
Limiting slenderness for noncompact stiffened element (λ_r)	--	143.12	
Limiting slenderness for compact stiffened element (λ_p)	--	60.76	
Factored yielding strength about a geometric axis(ϕM_n):	[Kip*ft]	70.97	Cl.F7.1
Yielding (M_n)	[Kip*ft]	78.86	Eq.F7-1
Factored web local buckling strength about a geometric axis(ϕM_n):	[Kip*ft]	56.18	Cl.F7.2
Local web buckling (M_n)	[Kip*ft]	62.42	Eq.F7-3

Shear Design ✔

Shear in major axis 33

Ratio	:	0.00			
Capacity	:	71.42 [Kip]	Reference	:	Cl.G1
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	71.42	Cl.G1
Web buckling coefficient (k_v)	--	5.00	Cl.G4
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	79.35	Eq.G4-1

Shear in minor axis 22

Ratio	:	0.04			
Capacity	:	145.94 [Kip]	Reference	:	Cl.G1
Demand	:	6.03 [Kip]	Ctrl Eq.	:	D6 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	145.94	Cl.G1
Web buckling coefficient (k_v)	--	5.00	Cl.G4
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	162.15	Eq.G4-1

TORSION DESIGN ✔

Torsion

Ratio	:	0.00			
Capacity	:	69.80 [Kip*ft]	Reference	:	Cl.H3.1
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored torsion capacity(ϕT_n):	[Kip*ft]	69.80	Cl.H3.1
Critical torsional buckling stress (F_{cr})	[Kip/in2]	27.60	Eq.H3-3
Nominal torsion capacity (T_n)	[Kip*ft]	77.55	Eq.H3-1

Combined Actions Design ✔

Combined flexure and axial

Ratio	:	0.05			
Ctrl Eq.	:	D6 at 100.00%	Reference	:	Eq.H1-1b

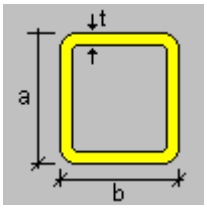
Intermediate results	Unit	Value	Reference
Interaction of flexure and axial force:	--	0.05	Eq.H1-1b
Available flexural strength about strong axis (M_{c33})	[Kip*ft]	114.67	Cl.H1.1
Available flexural strength about weak axis (M_{c22})	[Kip*ft]	56.18	Cl.H1.1
Available axial strength (P_c)	[Kip]	355.91	Cl.H1.1

Member : 2 - OK

Section information

Section name: TUBE 12x6x1_4 **(US)**

Dimensions



a	=	12.000	[in]	Height
b	=	6.000	[in]	Width
t	=	0.250	[in]	Thickness

Properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	8.597	
Moment of Inertia (local axes) (I)	[in4]	161.426	55.183
Moment of Inertia (principal axes) (I')	[in4]	161.426	55.183
Bending constant for moments (principal axis) (J')	[in]	0.000	0.000
Radius of gyration (local axes) (r)	[in]	4.333	2.534
Radius of gyration (principal axes) (r')	[in]	4.333	2.534
Saint-Venant torsion constant. (J)	[in4]	132.256	

Section warping constant. (Cw)	[in6]	98.618	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	0.000	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	26.904	18.394
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	26.904	18.394
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	26.904	18.394
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	26.904	18.394
Plastic section modulus (local axis) (Z)	[in3]	33.238	20.572
Plastic section modulus (principal axis) (Z')	[in3]	33.238	20.572
Polar radius of gyration. (ro)	[in]	5.020	
Area for shear (Aw)	[in2]	2.875	5.875
Torsional constant. (C)	[in3]	33.719	

Material : A500 GrB rectangular

Properties	Unit	Value
Yield stress (Fy):	[Kip/in2]	46.00
Tensile strength (Fu):	[Kip/in2]	58.00
Elasticity Modulus (E):	[Kip/in2]	29000.00
Shear modulus for steel (G):	[Kip/in2]	11153.85

Design Criteria

Description	Unit	Value
Length for tension slenderness ratio (L)	[ft]	31.50

Distance between member lateral bracing points

Length (Lb) [ft]	
Top	Bottom
31.50	31.50

Laterally unbraced length

Length [ft]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
2.00	2.00	31.50	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Sway
Minor axis frame type	Sway

Design Checks

Axial Tension Design ✔

Axial tension

Ratio	:	0.00			
Capacity	:	355.91 [Kip]	Reference	:	Cl.D2
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(ϕP_n):	[Kip]	355.91	Cl.D2
Nominal axial tension capacity (P_n)	[Kip]	395.46	Eq.D2-1

Axial Compression Design ✔

Compression in the major axis 33

Ratio	:	0.02			
Capacity	:	319.64 [Kip]	Reference	:	Cl.E3
Demand	:	6.75 [Kip]	Ctrl Eq.	:	D3 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	21.00	
Unstiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Stiffened element classification	--	Slender	
Stiffened element slenderness (λ)	--	45.00	
Stiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Factored flexural buckling strength(ϕP_{n33}):	[Kip]	319.64	Cl.E3
Unbraced length (L_{33})	[ft]	2.00	Cl.E2
Effective slenderness ($(KL/r)_{33}$)	--	5.54	Cl.E2
Elastic critical buckling stress (F_{e33})	[Kip/in2]	9330.50	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	7.74	
Critical stress for flexural buckling (F_{cr33})	[Kip/in2]	45.91	Eq.E3-2
Nominal flexural buckling strength (P_{n33})	[Kip]	355.16	Eq.E7-1

Compression in the minor axis 22

Ratio	:	0.02			
Capacity	:	318.66 [Kip]	Reference	:	Cl.E3
Demand	:	6.75 [Kip]	Ctrl Eq.	:	D3 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	21.00	
Unstiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Stiffened element classification	--	Slender	
Stiffened element slenderness (λ)	--	45.00	
Stiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Factored flexural buckling strength(ϕP_{n22}):	[Kip]	318.66	Cl.E3
Unbraced length (L_{22})	[ft]	2.00	Cl.E2
Effective slenderness ($(KL/r)_{22}$)	--	9.47	Cl.E2
Elastic critical buckling stress (F_{e22})	[Kip/in2]	3189.62	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	7.74	
Critical stress for flexural buckling (F_{cr22})	[Kip/in2]	45.72	Eq.E3-2
Nominal flexural buckling strength (P_{n22})	[Kip]	354.06	Eq.E7-1

Flexural Design ✔

Bending about major axis, M33

Ratio	:	0.36			
Capacity	:	114.67 [Kip*ft]	Reference	:	Cl.F7.1
Demand	:	41.68 [Kip*ft]	Ctrl Eq.	:	D6 at 66.67%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	21.00	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	35.15	
Limiting slenderness for compact unstiffened element (λ_p)	--	28.12	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	45.00	
Limiting slenderness for noncompact stiffened element (λ_r)	--	143.12	
Limiting slenderness for compact stiffened element (λ_p)	--	60.76	
Factored yielding strength(ϕM_n):	[Kip*ft]	114.67	Cl.F7.1
Yielding (M_n)	[Kip*ft]	127.41	Eq.F7-1
Factored lateral-torsional buckling strength(ϕM_n):	[Kip*ft]	114.67	Cl.F7.4
Limiting laterally unbraced length for yielding (L_p)	[ft]	17.55	Eq.F7-12
Limiting laterally unbraced length for inelastic lateral-torsional bucklin...	[ft]	476.63	Eq.F7-13
Lateral-torsional buckling modification factor (C_b)	--	1.39	Eq.F1-1
Nominal lateral-torsional buckling moment strength (M_n)	[Kip*ft]	127.41	Eq.F7-10

Bending about minor axis, M22

Ratio	:	0.00			
Capacity	:	56.18 [Kip*ft]	Reference	:	Cl.F7.2
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	21.00	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	35.15	
Limiting slenderness for compact unstiffened element (λ_p)	--	28.12	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	45.00	
Limiting slenderness for noncompact stiffened element (λ_r)	--	143.12	
Limiting slenderness for compact stiffened element (λ_p)	--	60.76	
Factored yielding strength about a geometric axis(ϕM_n):	[Kip*ft]	70.97	Cl.F7.1
Yielding (M_n)	[Kip*ft]	78.86	Eq.F7-1
Factored web local buckling strength about a geometric axis(ϕM_n):	[Kip*ft]	56.18	Cl.F7.2
Local web buckling (M_n)	[Kip*ft]	62.42	Eq.F7-3

Shear Design ✔

Shear in major axis 33

Ratio	:	0.00			
Capacity	:	71.42 [Kip]	Reference	:	Cl.G1
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	71.42	Cl.G1
Web buckling coefficient (k_v)	--	5.00	Cl.G4
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	79.35	Eq.G4-1

Shear in minor axis 22

Ratio	:	0.02			
Capacity	:	145.94 [Kip]	Reference	:	Cl.G1
Demand	:	3.39 [Kip]	Ctrl Eq.	:	D6 at 66.67%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	145.94	Cl.G1
Web buckling coefficient (k_v)	--	5.00	Cl.G4
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	162.15	Eq.G4-1

TORSION DESIGN ✔

Torsion

Ratio	:	0.02			
Capacity	:	69.80 [Kip*ft]	Reference	:	Cl.H3.1
Demand	:	-1.62 [Kip*ft]	Ctrl Eq.	:	D6 at 66.67%

Intermediate results	Unit	Value	Reference
Factored torsion capacity(ϕT_n):	[Kip*ft]	69.80	Cl.H3.1
Critical torsional buckling stress (F_{cr})	[Kip/in2]	27.60	Eq.H3-3
Nominal torsion capacity (T_n)	[Kip*ft]	77.55	Eq.H3-1

Combined Actions Design ✔

Combined flexure and axial

Ratio	:	0.37			
Ctrl Eq.	:	D7 at 66.67%	Reference	:	Eq.H1-1b

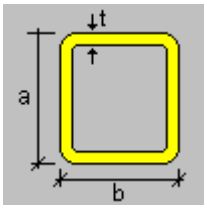
Intermediate results	Unit	Value	Reference
Interaction of flexure and axial force:	--	0.37	Eq.H1-1b
Available flexural strength about strong axis (M_{c33})	[Kip*ft]	114.67	Cl.H1.1
Available flexural strength about weak axis (M_{c22})	[Kip*ft]	56.18	Cl.H1.1
Available axial strength (P_c)	[Kip]	318.66	Cl.H1.1

Member : 4 - OK

Section information

Section name: TUBE 12x6x1_4 **(US)**

Dimensions



a	=	12.000	[in]	Height
b	=	6.000	[in]	Width
t	=	0.250	[in]	Thickness

Properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	8.597	
Moment of Inertia (local axes) (I)	[in4]	161.426	55.183
Moment of Inertia (principal axes) (I')	[in4]	161.426	55.183
Bending constant for moments (principal axis) (J')	[in]	0.000	0.000
Radius of gyration (local axes) (r)	[in]	4.333	2.534
Radius of gyration (principal axes) (r')	[in]	4.333	2.534
Saint-Venant torsion constant. (J)	[in4]	132.256	
Section warping constant. (Cw)	[in6]	98.618	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	0.000	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	26.904	18.394
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	26.904	18.394
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	26.904	18.394
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	26.904	18.394
Plastic section modulus (local axis) (Z)	[in3]	33.238	20.572
Plastic section modulus (principal axis) (Z')	[in3]	33.238	20.572
Polar radius of gyration. (ro)	[in]	5.020	
Area for shear (Aw)	[in2]	2.875	5.875
Torsional constant. (C)	[in3]	33.719	

Material : A500 GrB rectangular

Properties	Unit	Value
Yield stress (Fy):	[Kip/in2]	46.00
Tensile strength (Fu):	[Kip/in2]	58.00
Elasticity Modulus (E):	[Kip/in2]	29000.00
Shear modulus for steel (G):	[Kip/in2]	11153.85

Design Criteria

Description	Unit	Value
Length for tension slenderness ratio (L)	[ft]	1.00

Distance between member lateral bracing points

Length (Lb) [ft]	
Top	Bottom
1.00	1.00

Laterally unbraced length

Length [ft]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
1.00	1.00	1.00	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Sway
Minor axis frame type	Sway

Design Checks

Axial Tension Design ✔

Axial tension

Ratio	:	0.00			
Capacity	:	355.91 [Kip]	Reference	:	Cl.D2
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(ϕP_n):	[Kip]	355.91	Cl.D2
Nominal axial tension capacity (P_n)	[Kip]	395.46	Eq.D2-1

Axial Compression Design ✔

Compression in the major axis 33

Ratio	:	0.00			
Capacity	:	320.03 [Kip]	Reference	:	Cl.E3
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	21.00	
Unstiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Stiffened element classification	--	Slender	
Stiffened element slenderness (λ)	--	45.00	
Stiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Factored flexural buckling strength(ϕP_{n33}):	[Kip]	320.03	Cl.E3
Unbraced length (L_{33})	[ft]	1.00	Cl.E2
Effective slenderness ($(KL/r)_{33}$)	--	2.77	Cl.E2
Elastic critical buckling stress (F_{e33})	[Kip/in2]	37322.01	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	7.73	
Critical stress for flexural buckling (F_{cr33})	[Kip/in2]	45.98	Eq.E3-2
Nominal flexural buckling strength (P_{n33})	[Kip]	355.59	Eq.E7-1

Compression in the minor axis 22

Ratio	:	0.00			
Capacity	:	319.78 [Kip]	Reference	:	Cl.E3
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	21.00	
Unstiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Stiffened element classification	--	Slender	
Stiffened element slenderness (λ)	--	45.00	
Stiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Factored flexural buckling strength(ϕP_{n22}):	[Kip]	319.78	Cl.E3
Unbraced length (L_{22})	[ft]	1.00	Cl.E2
Effective slenderness ($(KL/r)_{22}$)	--	4.74	Cl.E2
Elastic critical buckling stress (F_{e22})	[Kip/in2]	12758.48	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	7.74	
Critical stress for flexural buckling (F_{cr22})	[Kip/in2]	45.93	Eq.E3-2
Nominal flexural buckling strength (P_{n22})	[Kip]	355.31	Eq.E7-1

Flexural Design ✔

Bending about major axis, M33

Ratio	:	0.05			
Capacity	:	114.67 [Kip*ft]	Reference	:	Cl.F7.1
Demand	:	6.03 [Kip*ft]	Ctrl Eq.	:	D6 at 100.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	21.00	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	35.15	
Limiting slenderness for compact unstiffened element (λ_p)	--	28.12	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	45.00	
Limiting slenderness for noncompact stiffened element (λ_r)	--	143.12	
Limiting slenderness for compact stiffened element (λ_p)	--	60.76	
Factored yielding strength(ϕM_n):	[Kip*ft]	114.67	Cl.F7.1
Yielding (M_n)	[Kip*ft]	127.41	Eq.F7-1

Bending about minor axis, M22

Ratio	:	0.00			
Capacity	:	56.18 [Kip*ft]	Reference	:	Cl.F7.2
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	21.00	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	35.15	
Limiting slenderness for compact unstiffened element (λ_p)	--	28.12	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	45.00	
Limiting slenderness for noncompact stiffened element (λ_r)	--	143.12	

Limiting slenderness for compact stiffened element (λ_p)	--	60.76	
Factored yielding strength about a geometric axis(ϕM_n):	[Kip*ft]	70.97	Cl.F7.1
Yielding (M_n)	[Kip*ft]	78.86	Eq.F7-1
Factored web local buckling strength about a geometric axis(ϕM_n):	[Kip*ft]	56.18	Cl.F7.2
Local web buckling (M_n)	[Kip*ft]	62.42	Eq.F7-3

Shear Design ✔

Shear in major axis 33

Ratio	:	0.00			
Capacity	:	71.42 [Kip]	Reference	:	Cl.G1
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	71.42	Cl.G1
Web buckling coefficient (k_v)	--	5.00	Cl.G4
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	79.35	Eq.G4-1

Shear in minor axis 22

Ratio	:	0.04			
Capacity	:	145.94 [Kip]	Reference	:	Cl.G1
Demand	:	6.03 [Kip]	Ctrl Eq.	:	D6 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	145.94	Cl.G1
Web buckling coefficient (k_v)	--	5.00	Cl.G4
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	162.15	Eq.G4-1

TORSION DESIGN ✔

Torsion

Ratio	:	0.00			
Capacity	:	69.80 [Kip*ft]	Reference	:	Cl.H3.1
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored torsion capacity(ϕT_n):	[Kip*ft]	69.80	Cl.H3.1
Critical torsional buckling stress (F_{cr})	[Kip/in2]	27.60	Eq.H3-3
Nominal torsion capacity (T_n)	[Kip*ft]	77.55	Eq.H3-1

Combined Actions Design ✔

Combined flexure and axial

Ratio	:	0.05			
Ctrl Eq.	:	D6 at 100.00%	Reference	:	Eq.H1-1b

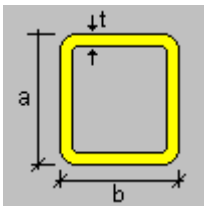
Intermediate results	Unit	Value	Reference
Interaction of flexure and axial force:	--	0.05	Eq.H1-1b
Available flexural strength about strong axis (M_{c33})	[Kip*ft]	114.67	Cl.H1.1
Available flexural strength about weak axis (M_{c22})	[Kip*ft]	56.18	Cl.H1.1
Available axial strength (P_c)	[Kip]	355.91	Cl.H1.1

Member : 6 - OK

Section information

Section name: TUBE 12x6x1_4 **(US)**

Dimensions



a	=	12.000	[in]	Height
b	=	6.000	[in]	Width
t	=	0.250	[in]	Thickness

Properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	8.597	
Moment of Inertia (local axes) (I)	[in4]	161.426	55.183
Moment of Inertia (principal axes) (I')	[in4]	161.426	55.183
Bending constant for moments (principal axis) (J')	[in]	0.000	0.000
Radius of gyration (local axes) (r)	[in]	4.333	2.534
Radius of gyration (principal axes) (r')	[in]	4.333	2.534
Saint-Venant torsion constant. (J)	[in4]	132.256	
Section warping constant. (Cw)	[in6]	98.618	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	0.000	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	26.904	18.394
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	26.904	18.394
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	26.904	18.394
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	26.904	18.394
Plastic section modulus (local axis) (Z)	[in3]	33.238	20.572
Plastic section modulus (principal axis) (Z')	[in3]	33.238	20.572
Polar radius of gyration. (ro)	[in]	5.020	
Area for shear (Aw)	[in2]	2.875	5.875
Torsional constant. (C)	[in3]	33.719	

Material : A500 GrB rectangular

Properties	Unit	Value
Yield stress (Fy):	[Kip/in2]	46.00
Tensile strength (Fu):	[Kip/in2]	58.00
Elasticity Modulus (E):	[Kip/in2]	29000.00
Shear modulus for steel (G):	[Kip/in2]	11153.85

Design Criteria

Description	Unit	Value
Length for tension slenderness ratio (L)	[ft]	31.50

Distance between member lateral bracing points

Length (Lb) [ft]	
Top	Bottom
31.50	31.50

Laterally unbraced length

Length [ft]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
2.00	2.00	31.50	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Sway
Minor axis frame type	Sway

Design Checks

Axial Tension Design ✔

Axial tension

Ratio	:	0.00			
Capacity	:	355.91 [Kip]	Reference	:	Cl.D2
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(ϕP_n):	[Kip]	355.91	Cl.D2
Nominal axial tension capacity (P_n)	[Kip]	395.46	Eq.D2-1

Axial Compression Design ✔

Compression in the major axis 33

Ratio	:	0.02			
Capacity	:	319.64 [Kip]	Reference	:	Cl.E3
Demand	:	6.75 [Kip]	Ctrl Eq.	:	D3 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	21.00	
Unstiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Stiffened element classification	--	Slender	

Stiffened element slenderness (λ)	--	45.00	
Stiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Factored flexural buckling strength(ϕP_{n33}):	[Kip]	319.64	Cl.E3
Unbraced length (L_{33})	[ft]	2.00	Cl.E2
Effective slenderness ($(KL/r)_{33}$)	--	5.54	Cl.E2
Elastic critical buckling stress (F_{e33})	[Kip/in2]	9330.50	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	7.74	
Critical stress for flexural buckling (F_{cr33})	[Kip/in2]	45.91	Eq.E3-2
Nominal flexural buckling strength (P_{n33})	[Kip]	355.16	Eq.E7-1

Compression in the minor axis 22

Ratio	:	0.02			
Capacity	:	318.66 [Kip]	Reference	:	Cl.E3
Demand	:	6.75 [Kip]	Ctrl Eq.	:	D3 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	21.00	
Unstiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Stiffened element classification	--	Slender	
Stiffened element slenderness (λ)	--	45.00	
Stiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Factored flexural buckling strength(ϕP_{n22}):	[Kip]	318.66	Cl.E3
Unbraced length (L_{22})	[ft]	2.00	Cl.E2
Effective slenderness ($(KL/r)_{22}$)	--	9.47	Cl.E2
Elastic critical buckling stress (F_{e22})	[Kip/in2]	3189.62	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	7.74	
Critical stress for flexural buckling (F_{cr22})	[Kip/in2]	45.72	Eq.E3-2
Nominal flexural buckling strength (P_{n22})	[Kip]	354.06	Eq.E7-1

Flexural Design ✔

Bending about major axis, M33

Ratio	:	0.36			
Capacity	:	114.67 [Kip*ft]	Reference	:	Cl.F7.1
Demand	:	41.68 [Kip*ft]	Ctrl Eq.	:	D6 at 66.67%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	21.00	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	35.15	
Limiting slenderness for compact unstiffened element (λ_p)	--	28.12	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	45.00	
Limiting slenderness for noncompact stiffened element (λ_r)	--	143.12	
Limiting slenderness for compact stiffened element (λ_p)	--	60.76	
Factored yielding strength(ϕM_n):	[Kip*ft]	114.67	Cl.F7.1
Yielding (M_n)	[Kip*ft]	127.41	Eq.F7-1
Factored lateral-torsional buckling strength(ϕM_n):	[Kip*ft]	114.67	Cl.F7.4
Limiting laterally unbraced length for yielding (L_p)	[ft]	17.55	Eq.F7-12
Limiting laterally unbraced length for inelastic lateral-torsional bucklin...	[ft]	476.63	Eq.F7-13
Lateral-torsional buckling modification factor (C_b)	--	1.39	Eq.F1-1
Nominal lateral-torsional buckling moment strength (M_n)	[Kip*ft]	127.41	Eq.F7-10

Bending about minor axis, M22

Ratio	:	0.00			
Capacity	:	56.18 [Kip*ft]	Reference	:	Cl.F7.2
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	21.00	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	35.15	
Limiting slenderness for compact unstiffened element (λ_p)	--	28.12	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	45.00	
Limiting slenderness for noncompact stiffened element (λ_r)	--	143.12	
Limiting slenderness for compact stiffened element (λ_p)	--	60.76	
Factored yielding strength about a geometric axis(ϕM_n):	[Kip*ft]	70.97	Cl.F7.1
Yielding (M_n)	[Kip*ft]	78.86	Eq.F7-1
Factored web local buckling strength about a geometric axis(ϕM_n):	[Kip*ft]	56.18	Cl.F7.2
Local web buckling (M_n)	[Kip*ft]	62.42	Eq.F7-3

Shear Design ✔

Shear in major axis 33

Ratio	:	0.00			
Capacity	:	71.42 [Kip]	Reference	:	Cl.G1
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	71.42	Cl.G1
Web buckling coefficient (k_v)	--	5.00	Cl.G4
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	79.35	Eq.G4-1

Shear in minor axis 22

Ratio	:	0.02			
Capacity	:	145.94 [Kip]	Reference	:	Cl.G1
Demand	:	3.39 [Kip]	Ctrl Eq.	:	D6 at 66.67%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	145.94	Cl.G1
Web buckling coefficient (k_v)	--	5.00	Cl.G4
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	162.15	Eq.G4-1

TORSION DESIGN ✔

Torsion

Ratio	:	0.02			
Capacity	:	69.80 [Kip*ft]	Reference	:	Cl.H3.1
Demand	:	1.62 [Kip*ft]	Ctrl Eq.	:	D6 at 66.67%

Intermediate results	Unit	Value	Reference
Factored torsion capacity(ϕT_n):	[Kip*ft]	69.80	Cl.H3.1
Critical torsional buckling stress (F_{cr})	[Kip/in2]	27.60	Eq.H3-3
Nominal torsion capacity (T_n)	[Kip*ft]	77.55	Eq.H3-1

Combined Actions Design ✔

Combined flexure and axial

Ratio	:	0.37			
Ctrl Eq.	:	D7 at 66.67%	Reference	:	Eq.H1-1b

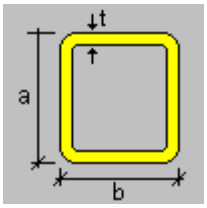
Intermediate results	Unit	Value	Reference
Interaction of flexure and axial force:	--	0.37	Eq.H1-1b
Available flexural strength about strong axis (M_{c33})	[Kip*ft]	114.67	Cl.H1.1
Available flexural strength about weak axis (M_{c22})	[Kip*ft]	56.18	Cl.H1.1
Available axial strength (P_c)	[Kip]	318.66	Cl.H1.1

Member : 7 - OK

Section information

Section name: TUBE 8x8x3_8 **(US)**

Dimensions



a	=	8.000	[in]	Height
b	=	8.000	[in]	Width
t	=	0.375	[in]	Thickness

Properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	11.093	
Moment of Inertia (local axes) (I)	[in4]	105.606	105.606
Moment of Inertia (principal axes) (I')	[in4]	105.606	105.606
Bending constant for moments (principal axis) (J')	[in]	0.000	0.000
Radius of gyration (local axes) (r)	[in]	3.085	3.085
Radius of gyration (principal axes) (r')	[in]	3.085	3.085
Saint-Venant torsion constant. (J)	[in4]	169.770	
Section warping constant. (Cw)	[in6]	1.732	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	0.000	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	26.402	26.402
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	26.402	26.402

Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	26.402	26.402
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	26.402	26.402
Plastic section modulus (local axis) (Z)	[in3]	31.353	31.353
Plastic section modulus (principal axis) (Z')	[in3]	31.353	31.353
Polar radius of gyration. (ro)	[in]	4.363	
Area for shear (Aw)	[in2]	5.719	5.719
Torsional constant. (C)	[in3]	43.397	

Material : A500 GrB rectangular

Properties	Unit	Value
Yield stress (Fy):	[Kip/in2]	46.00
Tensile strength (Fu):	[Kip/in2]	58.00
Elasticity Modulus (E):	[Kip/in2]	29000.00
Shear modulus for steel (G):	[Kip/in2]	11153.85

Design Criteria

Description	Unit	Value
Length for tension slenderness ratio (L)	[ft]	16.50

Distance between member lateral bracing points

Length (Lb) [ft]	
Top	Bottom
16.50	16.50

Laterally unbraced length

Length [ft]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
16.50	16.50	16.50	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Sway
Minor axis frame type	Sway

Design Checks

Axial Tension Design ✔

Axial tension

Ratio	:	0.00			
Capacity	:	459.26 [Kip]	Reference	:	Cl.D2
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D7 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(ϕP_n):	[Kip]	459.26	Cl.D2
Nominal axial tension capacity (P_n)	[Kip]	510.28	Eq.D2-1

Axial Compression Design ✔

Compression in the major axis 33

Ratio : 0.00
Capacity : 348.14 [Kip] Reference : Cl.E3
Demand : 0.00 [Kip] Ctrl Eq. : D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	18.33	
Unstiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Stiffened element classification	--	Non slender	
Stiffened element slenderness (λ)	--	18.33	
Stiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Factored flexural buckling strength(ϕP_{n33}):	[Kip]	348.14	Cl.E3
Unbraced length (L_{33})	[ft]	16.50	Cl.E2
Effective slenderness ($(KL/r)_{33}$)	--	64.17	Cl.E2
Elastic critical buckling stress (F_{e33})	[Kip/in2]	69.50	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	11.09	
Critical stress for flexural buckling (F_{cr33})	[Kip/in2]	34.87	Eq.E3-2
Nominal flexural buckling strength (P_{n33})	[Kip]	386.82	Eq.E3-1

Compression in the minor axis 22

Ratio : 0.00
Capacity : 348.14 [Kip] Reference : Cl.E3
Demand : 0.00 [Kip] Ctrl Eq. : D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	18.33	
Unstiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Stiffened element classification	--	Non slender	
Stiffened element slenderness (λ)	--	18.33	
Stiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Factored flexural buckling strength(ϕP_{n22}):	[Kip]	348.14	Cl.E3
Unbraced length (L_{22})	[ft]	16.50	Cl.E2
Effective slenderness ($(KL/r)_{22}$)	--	64.17	Cl.E2
Elastic critical buckling stress (F_{e22})	[Kip/in2]	69.50	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	11.09	
Critical stress for flexural buckling (F_{cr22})	[Kip/in2]	34.87	Eq.E3-2
Nominal flexural buckling strength (P_{n22})	[Kip]	386.82	Eq.E3-1

Flexural Design ✔

Bending about major axis, M33

Ratio	:	0.16			
Capacity	:	108.17 [Kip*ft]	Reference	:	Cl.F7.1
Demand	:	17.61 [Kip*ft]	Ctrl Eq.	:	D3 at 50.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	18.33	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	35.15	
Limiting slenderness for compact unstiffened element (λ_p)	--	28.12	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	18.33	
Limiting slenderness for noncompact stiffened element (λ_r)	--	143.12	
Limiting slenderness for compact stiffened element (λ_p)	--	60.76	
Factored yielding strength(ϕM_n):	[Kip*ft]	108.17	Cl.F7.1
Yielding (M_n)	[Kip*ft]	120.19	Eq.F7-1

Bending about minor axis, M22

Ratio	:	0.12			
Capacity	:	108.17 [Kip*ft]	Reference	:	Cl.F7.1
Demand	:	-12.51 [Kip*ft]	Ctrl Eq.	:	D6 at 50.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	18.33	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	35.15	
Limiting slenderness for compact unstiffened element (λ_p)	--	28.12	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	18.33	
Limiting slenderness for noncompact stiffened element (λ_r)	--	143.12	
Limiting slenderness for compact stiffened element (λ_p)	--	60.76	
Factored yielding strength about a geometric axis(ϕM_n):	[Kip*ft]	108.17	Cl.F7.1
Yielding (M_n)	[Kip*ft]	120.19	Eq.F7-1

Shear Design ✔

Shear in major axis 33

Ratio	:	0.02			
Capacity	:	142.05 [Kip]	Reference	:	Cl.G1
Demand	:	2.64 [Kip]	Ctrl Eq.	:	D6 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	142.05	Cl.G1
Web buckling coefficient (k_v)	--	5.00	Cl.G4
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	157.84	Eq.G4-1

Shear in minor axis 22

Ratio	:	0.03			
Capacity	:	142.05 [Kip]	Reference	:	Cl.G1
Demand	:	4.27 [Kip]	Ctrl Eq.	:	D3 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	142.05	Cl.G1
Web buckling coefficient (k_v)	--	5.00	Cl.G4
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	157.84	Eq.G4-1

TORSION DESIGN ✔

Torsion

Ratio	:	0.00			
Capacity	:	89.83 [Kip*ft]	Reference	:	Cl.H3.1
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored torsion capacity(ϕT_n):	[Kip*ft]	89.83	Cl.H3.1
Critical torsional buckling stress (F_{cr})	[Kip/in2]	27.60	Eq.H3-3
Nominal torsion capacity (T_n)	[Kip*ft]	99.81	Eq.H3-1

Combined Actions Design ✔

Combined flexure and axial

Ratio	:	0.25			
Ctrl Eq.	:	D7 at 50.00%	Reference	:	Eq.H1-1b

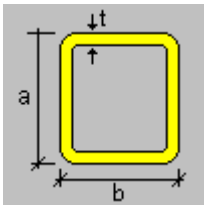
Intermediate results	Unit	Value	Reference
Interaction of flexure and axial force:	--	0.25	Eq.H1-1b
Available flexural strength about strong axis (M_{c33})	[Kip*ft]	108.17	Cl.H1.1
Available flexural strength about weak axis (M_{c22})	[Kip*ft]	108.17	Cl.H1.1
Available axial strength (P_c)	[Kip]	459.26	Cl.H1.1

Member : 8 - OK

Section information

Section name: TUBE 8x8x3_8 **(US)**

Dimensions



a	=	8.000	[in]	Height
b	=	8.000	[in]	Width
t	=	0.375	[in]	Thickness

Properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	11.093	
Moment of Inertia (local axes) (I)	[in4]	105.606	105.606
Moment of Inertia (principal axes) (I')	[in4]	105.606	105.606
Bending constant for moments (principal axis) (J')	[in]	0.000	0.000
Radius of gyration (local axes) (r)	[in]	3.085	3.085
Radius of gyration (principal axes) (r')	[in]	3.085	3.085
Saint-Venant torsion constant. (J)	[in4]	169.770	
Section warping constant. (Cw)	[in6]	1.732	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	0.000	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	26.402	26.402
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	26.402	26.402
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	26.402	26.402
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	26.402	26.402
Plastic section modulus (local axis) (Z)	[in3]	31.353	31.353
Plastic section modulus (principal axis) (Z')	[in3]	31.353	31.353
Polar radius of gyration. (ro)	[in]	4.363	
Area for shear (Aw)	[in2]	5.719	5.719
Torsional constant. (C)	[in3]	43.397	

Material : A500 GrB rectangular

Properties	Unit	Value
Yield stress (Fy):	[Kip/in2]	46.00
Tensile strength (Fu):	[Kip/in2]	58.00
Elasticity Modulus (E):	[Kip/in2]	29000.00
Shear modulus for steel (G):	[Kip/in2]	11153.85

Design Criteria

Description	Unit	Value
Length for tension slenderness ratio (L)	[ft]	16.50

Distance between member lateral bracing points

Length (Lb) [ft]	
Top	Bottom
16.50	16.50

Laterally unbraced length

Length [ft]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
16.50	16.50	16.50	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Sway
Minor axis frame type	Sway

Design Checks

Axial Tension Design ✔

Axial tension

Ratio	:	0.00			
Capacity	:	459.26 [Kip]	Reference	:	Cl.D2
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D7 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(ϕP_n):	[Kip]	459.26	Cl.D2
Nominal axial tension capacity (P_n)	[Kip]	510.28	Eq.D2-1

Axial Compression Design ✔

Compression in the major axis 33

Ratio	:	0.00			
Capacity	:	348.14 [Kip]	Reference	:	Cl.E3
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	18.33	
Unstiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Stiffened element classification	--	Non slender	
Stiffened element slenderness (λ)	--	18.33	
Stiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Factored flexural buckling strength(ϕP_{n33}):	[Kip]	348.14	Cl.E3
Unbraced length (L_{33})	[ft]	16.50	Cl.E2
Effective slenderness ($(KL/r)_{33}$)	--	64.17	Cl.E2
Elastic critical buckling stress (F_{e33})	[Kip/in2]	69.50	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	11.09	
Critical stress for flexural buckling (F_{cr33})	[Kip/in2]	34.87	Eq.E3-2
Nominal flexural buckling strength (P_{n33})	[Kip]	386.82	Eq.E3-1

Compression in the minor axis 22

Ratio	:	0.00			
Capacity	:	348.14 [Kip]	Reference	:	Cl.E3
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Non slender	
Unstiffened element slenderness (λ)	--	18.33	
Unstiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Stiffened element classification	--	Non slender	
Stiffened element slenderness (λ)	--	18.33	
Stiffened element limiting slenderness (λ_r)	--	35.15	Table.B4.1a.Case6
Factored flexural buckling strength(ϕP_{n22}):	[Kip]	348.14	Cl.E3
Unbraced length (L_{22})	[ft]	16.50	Cl.E2
Effective slenderness ($(KL/r)_{22}$)	--	64.17	Cl.E2
Elastic critical buckling stress (F_{e22})	[Kip/in2]	69.50	Eq.E3-4
Effective area of the cross section based on the effective width (A...	[in2]	11.09	
Critical stress for flexural buckling (F_{cr22})	[Kip/in2]	34.87	Eq.E3-2
Nominal flexural buckling strength (P_{n22})	[Kip]	386.82	Eq.E3-1

Flexural Design ✔

Bending about major axis, M33

Ratio	:	0.11			
Capacity	:	108.17 [Kip*ft]	Reference	:	Cl.F7.1
Demand	:	11.91 [Kip*ft]	Ctrl Eq.	:	D1 at 50.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	18.33	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	143.12	
Limiting slenderness for compact unstiffened element (λ_p)	--	60.76	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	18.33	
Limiting slenderness for noncompact stiffened element (λ_r)	--	35.15	
Limiting slenderness for compact stiffened element (λ_p)	--	28.12	
Factored yielding strength(ϕM_n):	[Kip*ft]	108.17	Cl.F7.1
Yielding (M_n)	[Kip*ft]	120.19	Eq.F7-1

Bending about minor axis, M22

Ratio	:	0.19			
Capacity	:	108.17 [Kip*ft]	Reference	:	Cl.F7.1
Demand	:	-20.57 [Kip*ft]	Ctrl Eq.	:	D6 at 50.00%

Intermediate results	Unit	Value	Reference
Section classification			
Unstiffened element classification	--	Compact	
Unstiffened element slenderness (λ)	--	18.33	
Limiting slenderness for noncompact unstiffened element (λ_r)	--	143.12	
Limiting slenderness for compact unstiffened element (λ_p)	--	60.76	
Stiffened element classification	--	Compact	
Stiffened element slenderness (λ)	--	18.33	
Limiting slenderness for noncompact stiffened element (λ_r)	--	35.15	

Limiting slenderness for compact stiffened element (λ_p)	--	28.12	
Factored yielding strength about a geometric axis(ϕM_n):	[Kip*ft]	108.17	Cl.F7.1
Yielding (M_n)	[Kip*ft]	120.19	Eq.F7-1

Shear Design ✔

Shear in major axis 33

Ratio	:	0.04			
Capacity	:	142.05 [Kip]	Reference	:	Cl.G1
Demand	:	5.38 [Kip]	Ctrl Eq.	:	D6 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	142.05	Cl.G1
Web buckling coefficient (k_v)	--	5.00	Cl.G4
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	157.84	Eq.G4-1

Shear in minor axis 22

Ratio	:	0.02			
Capacity	:	142.05 [Kip]	Reference	:	Cl.G1
Demand	:	2.89 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(ϕV_n):	[Kip]	142.05	Cl.G1
Web buckling coefficient (k_v)	--	5.00	Cl.G4
Web buckling coefficient (C_v)	--	1.00	Eq.G2-9
Nominal shear strength (V_n)	[Kip]	157.84	Eq.G4-1

TORSION DESIGN ✔

Torsion

Ratio	:	0.00			
Capacity	:	89.83 [Kip*ft]	Reference	:	Cl.H3.1
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored torsion capacity(ϕT_n):	[Kip*ft]	89.83	Cl.H3.1
Critical torsional buckling stress (F_{cr})	[Kip/in2]	27.60	Eq.H3-3
Nominal torsion capacity (T_n)	[Kip*ft]	99.81	Eq.H3-1

Combined Actions Design ✔

Combined flexure and axial

Ratio	:	0.28			
Ctrl Eq.	:	D6 at 50.00%	Reference	:	Eq.H1-1b

Intermediate results	Unit	Value	Reference
Interaction of flexure and axial force:	--	0.28	Eq.H1-1b
Available flexural strength about strong axis (M_{c33})	[Kip*ft]	108.17	Cl.H1.1
Available flexural strength about weak axis (M_{c22})	[Kip*ft]	108.17	Cl.H1.1
Available axial strength (P_c)	[Kip]	459.26	Cl.H1.1

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e-mail: wca@wcaeng.com

PROJECT: _____ PROJECT #: _____

CLIENT: _____ DATE: _____

TOPIC: _____ ENGINEER: _____

Load

D = 4"/12 (150) = 50 psf Dead

L = 60 psf

slab is 4" slab #4 @ 12" o.c.

Each way

USE PLB 36 WITH #4 BARS AT 12" O.C.

REACTION ON COLUMN,

USE 3X3x1/4" COLUMN IS OK

3.5K/15 PSF 18" USE 18" REINFORCE FOOTING - #4 BARS (3) BARS

Lateral load

NEW SLAB TIES INTO THE EXISTING SLAB ON GRADE AND WALLS. DIRECT LATERAL LOAD TRANSFER INTO THE EXISTIGN FLOOR SLAB.

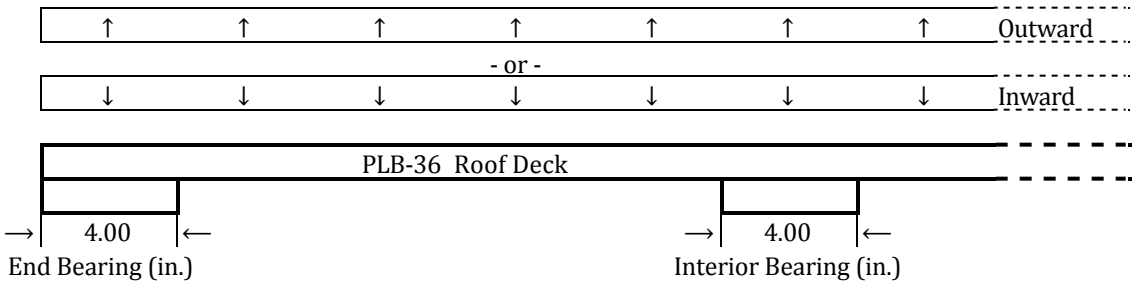
PLB-36 Grade 50 22

Uniform Allowable Load Table, ASD (psf)

For End Lapped Deck

36/4 Connection Pattern to Supports with
Simpson XL #12 Screw

Support Member A572 GR50
$0.125 \le t_2$ (in.) ≤ 0.61



Inward Uniform Allowable Load Table, ASD (psf)

Span	Span	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"
1	Wn/Ω	219	173	140	116	98	83	72	62
	L/240	182	128	93	70	54	42	34	28
2	Wn/Ω	229	182	148	122	103	88	76	66
	L/240	-	-	-	-	-	-	-	-
3	Wn/Ω	283	226	184	152	128	110	95	83
	L/240	-	-	-	143	110	87	69	56

Outward (Uplift) Uniform Allowable Load Table, ASD (psf)

Span	Span	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"
1	Wn/Ω	234	185	150	124	104	89	77	67
	Rn/Ω	166	147	133	121	110	102	95	88
	L/240	-	138	101	76	58	46	37	30
2	Wn/Ω	215	171	139	115	97	82	71	62
	Rn/Ω	133	118	106	96	88	82	76	71
	L/240	-	-	-	-	-	-	-	-
3	Wn/Ω	266	212	172	143	120	103	89	77
	Rn/Ω	151	134	121	110	100	93	86	80
	L/240	-	-	-	-	-	80	64	52

Steel Deck Properties

t in	Design Fy ksi	wdd psf	Id+ $in.^4/ft$	Id- $in.^4/ft$	Se+ $in.^3/ft$	Se- $in.^3/ft$	Mn+/Ω lbs-ft/ft	Mn-/Ω lbs-ft/ft	Vn/Ω lbs/ft
0.0299	50	1.90	0.178	0.192	0.176	0.188	439	469	2688

Where: $W \le Wn/\Omega$

W = Required strength of the governing ASD load combination
Wn/Ω = Allowable strength governed by the steel deck
Rn/Ω = Allowable strength governed by connection tension

Bare Deck Uniform Load V1.0.7 in accordance with:
AISI S100-16 (2020) w/ S2-20
IAPMO UES ER-0423
IAPMO UES ER-2018

Date: 6/6/2025

NOTICE: Design defects that could cause injury or death may result from relying on the information in this document without independent verification by a qualified professional. The information in this document is provided "AS IS". Nucor Corporation and its affiliates expressly disclaim: (i) any and all representations, warranties and conditions and (ii) all liability arising out of or related to this document and the information in it.

Steel Beam Design - Simple span w/ uniform and point loads - HSS shapes

Member: **SB-1**

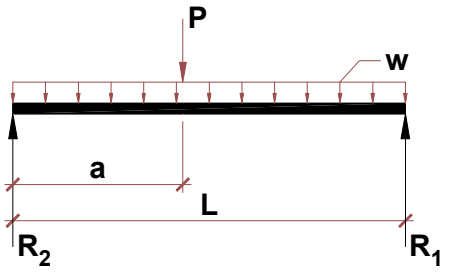
AISC 360-16 Specification for Structural Steel Building and Steel Construction Manual, 15th Edition
(Load calculation for ASD and LRFD are pre-design)

Loading criteria:

Span: $L := 9ft$

Uniform load (x-axis): $w_x := 90psf \cdot 5ft + 100plf$

Uniform load (y-axis): $w_y := 0 \cdot (28.2psf) \cdot 9ft$



Point loads & Point load locations:

(x-axis):

$P_{x_1} := 0kip$ $a_{x_1} := 0ft$

$P_{x_2} := 0kip$ $a_{x_2} := 0ft$

$P_{x_3} := 0kip$ $a_{x_3} := 0ft$

(y-axis):

$P_{y_1} := 0kip$ $a_{y_1} := 0ft$

$P_{y_2} := 0kip$ $a_{y_2} := 0ft$

$P_{y_3} := 0kip$ $a_{y_3} := 0ft$

Deflection limits (x-axis): $\Delta_x := 360$

(y-axis): $\Delta_y := 240$

Permit deflection reduction for wind forces: Y-axis only

Material and beam shape:

Steel Grade: ASTM A500 Gr. C

Yield Stress: $F_y = 50 \cdot ksi$ $E = 29000 \cdot ksi$

Design methodology: ASD Design

Beam shape: HSS8X2X1/4

Design bending moment and shear:

Member reactions:

(x-axis): $R_{x.1} = 2.48 \cdot kip$ $R_{x.2} = 2.48 \cdot kip$

(y-axis): $R_{y.1} = 0 \cdot kip$ $R_{y.2} = 0 \cdot kip$

Maximum shears:

(x-axis): $V_x = 2.48 \cdot kip$

(y-axis): $V_y = 0 \cdot kip$

Maximum bending moment:

(x-axis): $M_x = 5.57 \cdot kip \cdot ft$

(y-axis): $M_y = 0 \cdot kip \cdot ft$

Flexure Design (AISC 360-16 Chapter F):

ASD/LRFD capacity:

(x-axis) $M_{x.capacity} = 24 \cdot kip \cdot ft$ $\frac{M_x}{M_{x.capacity}} = 0.23$

$X\_Flexure_{Check} = \begin{pmatrix} \text{"Mx < Mn.x (ASD), Flexure OK"} \\ \text{"ASD X-axis Flexure ratio = 0.23"} \end{pmatrix}$

(y-axis) $M_{y.capacity} = 8 \cdot kip \cdot ft$ $\frac{M_y}{M_{y.capacity}} = 0$

$Y\_Flexure_{Check} = \text{"Y-axis Flexure N.A."}$

Combined Flexure design (AISC 360-16, Chapter H):

$CF\_Check = \text{"Combine Forces Calculations N.A."}$

Shear Design (AISC 360-16 Chapter G):

ASD/LRFD capacity:

(x-axis) $V_{x.capacity} = 61.1 \cdot kip$ $\frac{V_x}{V_{x.capacity}} = 0.04$

$X\_Shear_{Check} = \begin{pmatrix} \text{"V.x < Vn.x (ASD), Shear OK"} \\ \text{"Unstiffened webs OK"} \\ \text{"ASD Shear ratio = 0.04"} \end{pmatrix}$

(y-axis) $V_{y.capacity} = 10.9 \cdot kip$ $\frac{V_y}{V_{y.capacity}} = 0$

$Y\_Shear_{Check} = \begin{pmatrix} \text{"V.y < Vn.y (ASD), Shear OK"} \\ \text{"Unstiffened webs OK"} \\ \text{"ASD Shear ratio = 0"} \end{pmatrix}$

Service Deflection Design:

(x-axis) $\delta_x = 0.098 \cdot in < \Delta_{allow.x} = 0.3 \cdot in$ $\frac{\delta_x}{\Delta_{allow.x}} = 0.33$

$X\_Deflection_{Check} = \begin{pmatrix} \text{"Service deflection OK"} \\ \text{"Service deflection ratio = 0.33"} \end{pmatrix}$

(y-axis) $\delta_y = 0 \cdot in < \Delta_{allow.y} = 0.45 \cdot in$ $\frac{\delta_y}{\Delta_{allow.y}} = 0$

$Y\_Deflection_{Check} = \begin{pmatrix} \text{"Service deflection OK"} \\ \text{"Service deflection ratio = 0"} \end{pmatrix}$

Steel Column Design - Combined loading - Square HSS Sections

Member: **CL-1**

AISC 360-16 Specification for Structural Steel Building and Steel Construction Manual, 15th Edition
(Load calculation for ASD and LRFD are pre-design)

Loading criteria:

Effective unbraced length (x): $L_x := 9ft$

Effective length factor (x): $k_x := 1.0$

Effective unbraced length (y): $L_y := 9ft$

Effective length factor (y): $k_y := 1.0$

Service loads:

Axial load: $P := 5kip$

Moment in major axis (x): $M_x := P \cdot 0.007 \cdot L_x$

Moment in minor axis (y): $M_y := 0kip \cdot ft$

Section geometry

Design methodology:

ASD Design

$\Omega_c := 1.67 \quad \Phi_c := 0.90 \quad \Omega_b := 1.67 \quad \Phi_b := 0.90$

Column Material:

Steel Grade: ASTM A500 Gr. C

$F_y = 50 \cdot ksi \quad F_u = 62 \cdot ksi \quad E = 29000 ksi$

Shape: HSS3X3X1/4

Base plate criteria:

Steel Grade: ASTM A36

$F_{y\_P} = 36 \cdot ksi \quad F_{u\_p} = 58 \cdot ksi$

Compression Design (AISC 360-16 Chapter E):

ASD/LRFD capacity: $P_{capacity} = 36.6 \cdot kip$

$$\frac{P}{P_{capacity}} = 0.14$$

$$Compression_{Check} = \begin{pmatrix} \text{"P < Pn (ASD), Compression OK"} \\ \text{"ASD Compression ratio = 0.14"} \end{pmatrix}$$

Flexure Design (AISC 360-16, Chapter F):

ASD/LRFD capacity: $M_{x.capacity} = 6 \cdot kip \cdot ft$

$$\frac{M_x}{M_{x.capacity}} = 0.05$$

$$X\_Flexure_{Check} = \begin{pmatrix} \text{"Mx < Mn.x (ASD), Flexure OK"} \\ \text{"ASD X-axis Flexure ratio = 0.05"} \end{pmatrix}$$

ASD/LRFD capacity: $M_{y.capacity} = 6 \cdot kip \cdot ft$

$$\frac{M_y}{M_{y.capacity}} = 0$$

$$Y\_Flexure_{Check} = \text{"Y-axis Flexure N.A."}$$

Combined Forces Design (AISC 360-16, Chapter H):

$$CF\_Check_1 = \begin{pmatrix} \text{"Combine Forces OK"} \\ \text{"AISC 360-16 Eq. H1-1b Controls"} \\ \text{"Combine Forces ratio = 0.18"} \end{pmatrix}$$

Base plate design:

Column width: $W_{col} := B = 3 \cdot in$

Column depth: $D_{col} := HT = 3 \cdot in$

Base plate width: $B_p := W_{col} + 6in$

Base plate depth: $N_p := D_{col} + 6in$

$t_{min} = 0.23 \cdot in$

RAM Elements

Current Date: 6/6/2025 1:54 PM
Units system: English

Steel Code Check
Concise Report

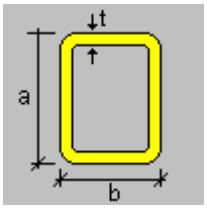
AISC 360-2016 ASD (Hot-rolled)

Member : 1 - OK

Section information

Section name: HSS_RECT 8X2X1_4 **(US)**

Dimensions



a	=	8.000	[in]	Height
b	=	2.000	[in]	Width
T	=	0.233	[in]	Thickness

Properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	4.300	
Moment of Inertia (local axes) (I)	[in4]	28.500	2.940
Moment of Inertia (principal axes) (I')	[in4]	28.500	2.940
Bending constant for moments (principal axis) (J')	[in]	0.000	0.000
Radius of gyration (local axes) (r)	[in]	2.574	0.827
Radius of gyration (principal axes) (r')	[in]	2.574	0.827
Saint-Venant torsion constant. (J)	[in4]	9.360	
Section warping constant. (Cw)	[in6]	6.791	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	0.000	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	7.120	2.940
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	7.120	2.940
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	7.120	2.940
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	7.120	2.940
Plastic section modulus (local axis) (Z)	[in3]	9.680	3.430
Plastic section modulus (principal axis) (Z')	[in3]	9.680	3.430
Polar radius of gyration. (ro)	[in]	2.703	
Area for shear (Aw)	[in2]	0.606	3.402
Torsional constant. (C)	[in3]	6.345	

Material : A1085

Properties	Unit	Value
Yield stress (Fy):	[Kip/in2]	50.00
Tensile strength (Fu):	[Kip/in2]	65.00
Elasticity Modulus (E):	[Kip/in2]	29000.00
Shear modulus for steel (G):	[Kip/in2]	11153.85

Design Criteria

Description	Unit	Value
Length for tension slenderness ratio (L)	[ft]	7.00

Distance between member lateral bracing points

Length (Lb) [ft]	
Top	Bottom
7.00	7.00

Laterally unbraced length

Length [ft]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
7.00	7.00	7.00	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Sway
Minor axis frame type	Sway

Design Checks

Axial Tension Design ✔

Axial tension

Ratio	:	0.00			
Capacity	:	128.74 [Kip]	Reference	:	Cl.D2
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(P_n/Ω):	[Kip]	128.74	Cl.D2

Axial Compression Design ✔

Compression in the major axis 33

Ratio	:	0.00			
Capacity	:	119.10 [Kip]	Reference	:	Cl.E3
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Factored flexural buckling strength(P_{n33}/Ω):	[Kip]	119.10	Cl.E3

Compression in the minor axis 22

Ratio	:	0.00			
Capacity	:	60.54 [Kip]	Reference	:	Cl.E3
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Factored flexural buckling strength(P_{n22}/Ω):	[Kip]	60.54	Cl.E3

Flexural Design ✔

Bending about major axis, M33

Ratio	:	0.14			
Capacity	:	24.15 [Kip*ft]	Reference	:	Cl.F7.1
Demand	:	-3.30 [Kip*ft]	Ctrl Eq.	:	D2 at 100.00%

Intermediate results	Unit	Value	Reference
Section classification			
Factored yielding strength(M_n/Ω):	[Kip*ft]	24.15	Cl.F7.1
Factored lateral-torsional buckling strength(M_n/Ω):	[Kip*ft]	24.15	Cl.F7.4

Bending about minor axis, M22

Ratio	:	0.00			
Capacity	:	7.77 [Kip*ft]	Reference	:	Cl.F7.2
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Factored yielding strength about a geometric axis(M_n/Ω):	[Kip*ft]	8.56	Cl.F7.1
Factored web local buckling strength about a geometric axis(M_n/Ω):	[Kip*ft]	7.77	Cl.F7.2

Shear Design ✔

Shear in major axis 33

Ratio	:	0.00			
Capacity	:	10.89 [Kip]	Reference	:	Cl.G1
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω):	[Kip]	10.89	Cl.G1

Shear in minor axis 22

Ratio	:	0.04			
Capacity	:	61.12 [Kip]	Reference	:	Cl.G1
Demand	:	2.40 [Kip]	Ctrl Eq.	:	D2 at 100.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω):	[Kip]	61.12	Cl.G1

Torsion Design ✔

Torsion

Ratio	:	0.00			
Capacity	:	9.50 [Kip*ft]	Reference	:	Cl.H3.1
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored torsion capacity(T_n/Ω):	[Kip*ft]	9.50	Cl.H3.1

Combined Actions Design ✔

Combined flexure and axial

Ratio	:	0.14			
Ctrl Eq.	:	D2 at 100.00%	Reference	:	Eq.H1-1b

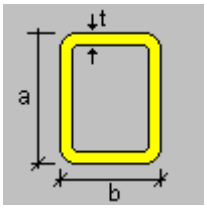
Intermediate results	Unit	Value	Reference
Interaction of flexure and axial force:	--	0.14	Eq.H1-1b

Member : 2 - OK

Section information

Section name: HSS_RECT 8X2X1_4 **(US)**

Dimensions



a	=	8.000	[in]	Height
b	=	2.000	[in]	Width
T	=	0.233	[in]	Thickness

Properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	4.300	
Moment of Inertia (local axes) (I)	[in4]	28.500	2.940
Moment of Inertia (principal axes) (I')	[in4]	28.500	2.940
Bending constant for moments (principal axis) (J')	[in]	0.000	0.000
Radius of gyration (local axes) (r)	[in]	2.574	0.827
Radius of gyration (principal axes) (r')	[in]	2.574	0.827
Saint-Venant torsion constant. (J)	[in4]	9.360	
Section warping constant. (Cw)	[in6]	6.791	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	0.000	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	7.120	2.940
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	7.120	2.940
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	7.120	2.940
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	7.120	2.940
Plastic section modulus (local axis) (Z)	[in3]	9.680	3.430
Plastic section modulus (principal axis) (Z')	[in3]	9.680	3.430
Polar radius of gyration. (ro)	[in]	2.703	
Area for shear (Aw)	[in2]	0.606	3.402
Torsional constant. (C)	[in3]	6.345	

Material : A1085

Properties	Unit	Value
Yield stress (Fy):	[Kip/in2]	50.00
Tensile strength (Fu):	[Kip/in2]	65.00
Elasticity Modulus (E):	[Kip/in2]	29000.00
Shear modulus for steel (G):	[Kip/in2]	11153.85

Design Criteria

Description	Unit	Value
Length for tension slenderness ratio (L)	[ft]	2.00

Distance between member lateral bracing points

Length (Lb) [ft]	
Top	Bottom
2.00	2.00

Laterally unbraced length

Length [ft]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
2.00	2.00	2.00	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Sway
Minor axis frame type	Sway

Design Checks

Axial Tension Design ✔

Axial tension

Ratio	:	0.00			
Capacity	:	128.74 [Kip]	Reference	:	Cl.D2
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(P_n/Ω):	[Kip]	128.74	Cl.D2

Axial Compression Design ✔

Compression in the major axis 33

Ratio	:	0.00			
Capacity	:	127.93 [Kip]	Reference	:	Cl.E3
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Factored flexural buckling strength(P_{n33}/Ω):	[Kip]	127.93	Cl.E3

Compression in the minor axis 22

Ratio	:	0.00			
Capacity	:	121.05 [Kip]	Reference	:	Cl.E3
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Factored flexural buckling strength(P_{n22}/Ω):	[Kip]	121.05	Cl.E3

Flexural Design ✔

Bending about major axis, M33

Ratio	:	0.14			
Capacity	:	24.15 [Kip*ft]	Reference	:	Cl.F7.1
Demand	:	-3.30 [Kip*ft]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Factored yielding strength(M_n/Ω):	[Kip*ft]	24.15	Cl.F7.1

Bending about minor axis, M22

Ratio	:	0.00			
Capacity	:	7.77 [Kip*ft]	Reference	:	Cl.F7.2
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Factored yielding strength about a geometric axis(M_n/Ω):	[Kip*ft]	8.56	Cl.F7.1
Factored web local buckling strength about a geometric axis(M_n/Ω):	[Kip*ft]	7.77	Cl.F7.2

Shear Design ✔

Shear in major axis 33

Ratio	:	0.00			
Capacity	:	10.89 [Kip]	Reference	:	Cl.G1
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω):	[Kip]	10.89	Cl.G1

Shear in minor axis 22

Ratio	:	0.04			
Capacity	:	61.12 [Kip]	Reference	:	Cl.G1
Demand	:	2.20 [Kip]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω):	[Kip]	61.12	Cl.G1

Torsion Design ✔

Torsion

Ratio	:	0.00			
Capacity	:	9.50 [Kip*ft]	Reference	:	Cl.H3.1
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored torsion capacity(T_n/Ω):	[Kip*ft]	9.50	Cl.H3.1

Combined Actions Design ✔

Combined flexure and axial

Ratio	:	0.14			
Ctrl Eq.	:	D2 at 0.00%	Reference	:	Eq.H1-1b

Intermediate results	Unit	Value	Reference
Interaction of flexure and axial force:	--	0.14	Eq.H1-1b

RAM Elements

Current Date: 6/6/2025 2:08 PM
Units system: English

Steel Code Check
Concise Report

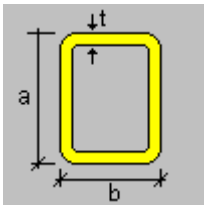
AISC 360-2016 ASD (Hot-rolled)

Member : 1 - OK

Section information

Section name: HSS_RECT 8X2X1_4 **(US)**

Dimensions



a	=	8.000	[in]	Height
b	=	2.000	[in]	Width
T	=	0.233	[in]	Thickness

Properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	4.300	
Moment of Inertia (local axes) (I)	[in4]	28.500	2.940
Moment of Inertia (principal axes) (I')	[in4]	28.500	2.940
Bending constant for moments (principal axis) (J')	[in]	0.000	0.000
Radius of gyration (local axes) (r)	[in]	2.574	0.827
Radius of gyration (principal axes) (r')	[in]	2.574	0.827
Saint-Venant torsion constant. (J)	[in4]	9.360	
Section warping constant. (Cw)	[in6]	6.791	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	0.000	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	7.120	2.940
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	7.120	2.940
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	7.120	2.940
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	7.120	2.940
Plastic section modulus (local axis) (Z)	[in3]	9.680	3.430
Plastic section modulus (principal axis) (Z')	[in3]	9.680	3.430
Polar radius of gyration. (ro)	[in]	2.703	
Area for shear (Aw)	[in2]	0.606	3.402
Torsional constant. (C)	[in3]	6.345	

Material : A1085

Properties	Unit	Value
Yield stress (Fy):	[Kip/in2]	50.00
Tensile strength (Fu):	[Kip/in2]	65.00
Elasticity Modulus (E):	[Kip/in2]	29000.00
Shear modulus for steel (G):	[Kip/in2]	11153.85

Design Criteria

Description	Unit	Value
Length for tension slenderness ratio (L)	[ft]	7.00

Distance between member lateral bracing points

Length (Lb) [ft]	
Top	Bottom
7.00	7.00

Laterally unbraced length

Length [ft]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
7.00	7.00	7.00	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Sway
Minor axis frame type	Sway

Design Checks

Axial Tension Design ✔

Axial tension

Ratio	:	0.00			
Capacity	:	128.74 [Kip]	Reference	:	Cl.D2
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(P_n/Ω):	[Kip]	128.74	Cl.D2

Axial Compression Design ✔

Compression in the major axis 33

Ratio	:	0.00			
Capacity	:	119.10 [Kip]	Reference	:	Cl.E3
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Factored flexural buckling strength(P_{n33}/Ω):	[Kip]	119.10	Cl.E3

Compression in the minor axis 22

Ratio	:	0.00			
Capacity	:	60.54 [Kip]	Reference	:	Cl.E3
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Factored flexural buckling strength(P_{n22}/Ω):	[Kip]	60.54	Cl.E3

Flexural Design ✔

Bending about major axis, M33

Ratio	:	0.29			
Capacity	:	24.15 [Kip*ft]	Reference	:	Cl.F7.1
Demand	:	7.03 [Kip*ft]	Ctrl Eq.	:	D2 at 42.86%

Intermediate results	Unit	Value	Reference
Section classification			
Factored yielding strength(M_n/Ω):	[Kip*ft]	24.15	Cl.F7.1
Factored lateral-torsional buckling strength(M_n/Ω):	[Kip*ft]	24.15	Cl.F7.4

Bending about minor axis, M22

Ratio	:	0.00			
Capacity	:	7.77 [Kip*ft]	Reference	:	Cl.F7.2
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Factored yielding strength about a geometric axis(M_n/Ω):	[Kip*ft]	8.56	Cl.F7.1
Factored web local buckling strength about a geometric axis(M_n/Ω):	[Kip*ft]	7.77	Cl.F7.2

Shear Design ✔

Shear in major axis 33

Ratio	:	0.00			
Capacity	:	10.89 [Kip]	Reference	:	Cl.G1
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω):	[Kip]	10.89	Cl.G1

Shear in minor axis 22

Ratio	:	0.06			
Capacity	:	61.12 [Kip]	Reference	:	Cl.G1
Demand	:	3.68 [Kip]	Ctrl Eq.	:	D2 at 100.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω):	[Kip]	61.12	Cl.G1

Torsion Design ✔

Torsion

Ratio	:	0.00			
Capacity	:	9.50 [Kip*ft]	Reference	:	Cl.H3.1
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored torsion capacity(T_n/Ω):	[Kip*ft]	9.50	Cl.H3.1

Combined Actions Design ✔

Combined flexure and axial

Ratio	:	0.29			
Ctrl Eq.	:	D2 at 42.86%	Reference	:	Eq.H1-1b

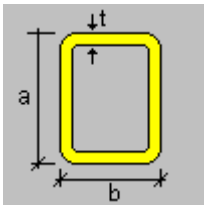
Intermediate results	Unit	Value	Reference
Interaction of flexure and axial force:	--	0.29	Eq.H1-1b

Member : 2 - OK

Section information

Section name: HSS_RECT 8X2X1_4 **(US)**

Dimensions



a	=	8.000	[in]	Height
b	=	2.000	[in]	Width
T	=	0.233	[in]	Thickness

Properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	4.300	
Moment of Inertia (local axes) (I)	[in4]	28.500	2.940
Moment of Inertia (principal axes) (I')	[in4]	28.500	2.940
Bending constant for moments (principal axis) (J')	[in]	0.000	0.000
Radius of gyration (local axes) (r)	[in]	2.574	0.827
Radius of gyration (principal axes) (r')	[in]	2.574	0.827
Saint-Venant torsion constant. (J)	[in4]	9.360	
Section warping constant. (Cw)	[in6]	6.791	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	0.000	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	7.120	2.940
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	7.120	2.940
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	7.120	2.940
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	7.120	2.940
Plastic section modulus (local axis) (Z)	[in3]	9.680	3.430
Plastic section modulus (principal axis) (Z')	[in3]	9.680	3.430
Polar radius of gyration. (ro)	[in]	2.703	
Area for shear (Aw)	[in2]	0.606	3.402
Torsional constant. (C)	[in3]	6.345	

Material : A1085

Properties	Unit	Value
Yield stress (Fy):	[Kip/in2]	50.00
Tensile strength (Fu):	[Kip/in2]	65.00
Elasticity Modulus (E):	[Kip/in2]	29000.00
Shear modulus for steel (G):	[Kip/in2]	11153.85

Design Criteria

Description	Unit	Value
Length for tension slenderness ratio (L)	[ft]	2.00

Distance between member lateral bracing points

Length (Lb) [ft]	
Top	Bottom
2.00	2.00

Laterally unbraced length

Length [ft]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
2.00	2.00	2.00	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Sway
Minor axis frame type	Sway

Design Checks

Axial Tension Design ✔

Axial tension

Ratio	:	0.00			
Capacity	:	128.74 [Kip]	Reference	:	Cl.D2
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(P_n/Ω):	[Kip]	128.74	Cl.D2

Axial Compression Design ✔

Compression in the major axis 33

Ratio	:	0.00			
Capacity	:	127.93 [Kip]	Reference	:	Cl.E3
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Factored flexural buckling strength(P_{n33}/Ω):	[Kip]	127.93	Cl.E3

Compression in the minor axis 22

Ratio	:	0.00			
Capacity	:	121.05 [Kip]	Reference	:	Cl.E3
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Factored flexural buckling strength(P_{n22}/Ω):	[Kip]	121.05	Cl.E3

Flexural Design ✔

Bending about major axis, M33

Ratio	:	0.14			
Capacity	:	24.15 [Kip*ft]	Reference	:	Cl.F7.1
Demand	:	-3.30 [Kip*ft]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Factored yielding strength(M_n/Ω):	[Kip*ft]	24.15	Cl.F7.1

Bending about minor axis, M22

Ratio	:	0.00			
Capacity	:	7.77 [Kip*ft]	Reference	:	Cl.F7.2
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Factored yielding strength about a geometric axis(M_n/Ω):	[Kip*ft]	8.56	Cl.F7.1
Factored web local buckling strength about a geometric axis(M_n/Ω):	[Kip*ft]	7.77	Cl.F7.2

Shear Design ✔

Shear in major axis 33

Ratio	:	0.00			
Capacity	:	10.89 [Kip]	Reference	:	Cl.G1
Demand	:	0.00 [Kip]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω):	[Kip]	10.89	Cl.G1

Shear in minor axis 22

Ratio	:	0.04			
Capacity	:	61.12 [Kip]	Reference	:	Cl.G1
Demand	:	2.20 [Kip]	Ctrl Eq.	:	D2 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω):	[Kip]	61.12	Cl.G1

Torsion Design ✔

Torsion

Ratio	:	0.00			
Capacity	:	9.50 [Kip*ft]	Reference	:	Cl.H3.1
Demand	:	0.00 [Kip*ft]	Ctrl Eq.	:	D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored torsion capacity(T_n/Ω):	[Kip*ft]	9.50	Cl.H3.1

Combined Actions Design ✔

Combined flexure and axial

Ratio	:	0.14			
Ctrl Eq.	:	D2 at 0.00%	Reference	:	Eq.H1-1b

Intermediate results	Unit	Value	Reference
Interaction of flexure and axial force:	--	0.14	Eq.H1-1b

Structural Engineering inc.
442 North Main Street, Suite 200, Bountiful, Utah 84010
(801) 298-1118, Office 298-1122 Fax
e-mail: wca@wcaeng.com

PROJECT: _____ PROJECT #: _____

CLIENT: _____ DATE: _____

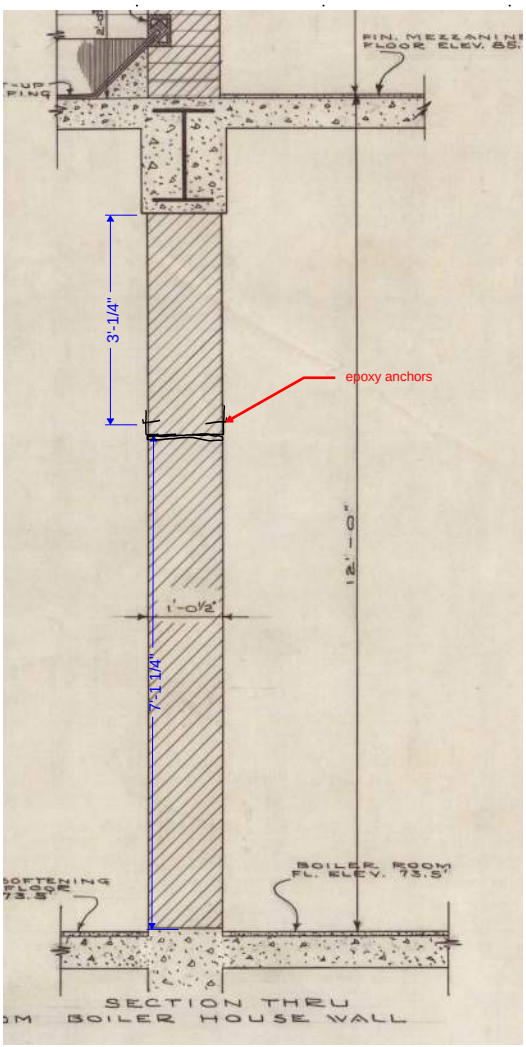
TOPIC: _____ ENGINEER: _____

CONTROL ROOM HEADER DESIGN

L=6'

CMU ABOVE = 36" USE 48" 3 WYTHE BRICK AT 40 PSF PER WYTHE TOTAL = 120 PSF

NO OTHER TRIB/LOAD ONLY SUPPORT



Double Angle - $120\ psf\left(\frac{48"}{12}\right) = 480\ plf$

L = 6'-0"

M = 2160 lb-ft = 25.92 k-ft

V = 1.44 k

Single Angle Flexural Design Equal Leg

Design per ASCI Chapter F10 Single Angles

Load Type	Distributed Load	LRFD				Span; L=	6.0 ft		72 in
Select Steel angle	L4X4X3/8			tan(α)=	1	α			45
Sx;Sy;SzB;SzC;SwC	1.5	1.5	1.08	1.27	2.56	in^3		ZC	
Ix;Iz;Iw	4.32	1.73	6.91	in^4					2.7

	Wx	Wy	a=2 FT	Factored Loads			Geometric	Principal
Dead	0.24 k	0 k		Wux	0.336	k/ft		
Live	0.00 k	0 k		Wuy	0.1	k/ft		
Snow	0.00 k	0 k	6.0 ft	Mux;Muw	1.512	k-ft	-1.512	-0.750947402
Liv Roof	0.00 k	0 k		Muy;Muz	0.45	k-ft	0.45	1.387343505
Wind	0.00 k	0 k		Vx	1.008	k-ft		
Seismic	0.00 k	0 k		Vy	0.3	k-ft		

1. Yielding

a.	Yielding	Mn=1.5My				
ΦMnz=1.5FySx	=	58.32	k-in	4.86	k-ft	
ΦMnw=1.5FySy		138.24	k-in	11.52	k-ft	

2. Lateral -Torsional Buckling

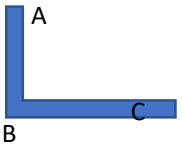
a)	when My/Mcr<1.0	Mn=(1.92-1.17sqrt(My/Mcr)My<1.5My				Is toe in compression or
	ΦMnz=	61.17316	k-in	4.86	k-ft	tension?
	ΦMnw=	127.766	k-in	10.64716	k-ft	
b)	when Mcr/My<1.0	Mn=(0.92-0.17sqrt(Mcr/My)MMcr				Compression
	ΦMnz=		k-in		k-ft	
	ΦMnw=		k-in		k-ft	
Mcr=	Lateral torsional buckling moment					

(i) Bending about one of the geometric axes of equal leg angle no lateral torsional restrraint

	a)	Compression in Toe	Mcr=	442.9963	k-in	36.91635837	k-ft
	b)	Tension in toe	Mcr=		k-in		k-ft

3. Leg Local Buckling

λ=b/t	10.7		ΦMnz=	1000	kip-in		83.33333333	k-ft
λp	15.32645		ΦMnw=	1000	kip-in		83.33333333	k-ft
λr	25.8279		Fcr=	179.841				
Compact								
Moment	ΦMnz=	58.32	kip-in	4.86	k-ft			
	ΦMnw=	127.766	kip-in	10.64716	k-ft			
Section H2	fra/Fra=frb/Frb+fbz/Fbz<1.0							
A	0.355992	<	1					
B	0.285462	<	1					
C	0.214931	<	1					



Tension= -

Compression= +

4. Deflection

Δ=L/Δmax	=	600			Δmax=	0.12	in
		920.6349		5wL^4/384EI	Δ=	0.078206897	in

LRFD	CSR=	0.355991908
SERVICE	CSRΔ=	0.651724138

Steel Column Design - Combined loading - Square HSS Sections

AISC 360-16 Specification for Structural Steel Building and Steel Construction Manual, 15th Edition
(Load calculation for ASD and LRFD are pre-design)

Member: **CL-1**

Loading criteria:

Effective unbraced length (x): $L_x := 7ft$

Effective length factor (x): $k_x := 1.0$

Effective unbraced length (y): $L_y := 7ft$

Effective length factor (y): $k_y := 1.0$

Service loads:

Axial load: $P := .5kip$

Moment in major axis (x): $M_x := P \cdot 0.007 \cdot L_x$

Moment in minor axis (y): $M_y := 0kip \cdot ft$

Design methodology:

ASD Design

$\Omega_c := 1.67$ $\Omega_b := 1.67$

$\Phi_c := 0.90$ $\Phi_b := 0.90$

Column Material:

Steel Grade: ASTM A500 Gr. C

$F_y = 50 \cdot ksi$ $F_u = 62 \cdot ksi$ $E = 29000ksi$

Shape: HSS12X2X3/16

Section geometry

$AISC :=$

	1	2	3	4	5	6	7	8
1	SC_Manual_Label"	"W"	"A"	"Ht"	"OD"	"B"	"ID"	"tnom"
2	"HSS20X12X5/8"	127.37	35	20	0	12	0	0.625
3	"HSS20X12X1/2"	103.3	28.3	20	0	12	0	0.5
4	"HSS20X12X3/8"	78.52	21.5	20	0	12	0	0.375
5	"HSS20X12X5/16"	65.87	18.1	20	0	12	0	0.3125
6	"HSS20X8X5/8"	110.36	30.3	20	0	8	0	0.625
7	"HSS20X8X1/2"	89.68	24.6	20	0	8	0	0.5
8	"HSS20X8X3/8"	68.31	18.7	20	0	8	0	0.375
9	"HSS20X8X5/16"	57.36	15.7	20	0	8	0	0.3125
10	"HSS20X4X1/2"	76.07	20.9	20	0	4	0	0.5
11	"HSS20X4X3/8"	58.1	16	20	0	4	0	0.375
12	"HSS20X4X5/16"	48.86	13.4	20	0	4	0	0.3125
13	"HSS20X4X1/4"	39.43	10.8	20	0	4	0	0.25

$w := lookup(Shape, AISC^{\langle 1 \rangle}, AISC^{\langle 2 \rangle})_{1,1} \cdot plf$ $w = 17.08 \cdot plf$ $D\_t := lookup(Shape, AISC^{\langle 1 \rangle}$

$A_g := lookup(Shape, AISC^{\langle 1 \rangle}, AISC^{\langle 3 \rangle})_{1,1} \cdot in^2$ $A_g = 4.67 \cdot in^2$ $I_x := lookup(Shape, AISC^{\langle 1 \rangle},$

$HT := lookup(Shape, AISC^{\langle 1 \rangle}, AISC^{\langle 4 \rangle})_{1,1} \cdot in$ $HT = 12 \cdot in$ $Z_x := lookup(Shape, AISC^{\langle 1 \rangle},$

$OD := lookup(Shape, AISC^{\langle 1 \rangle}, AISC^{\langle 5 \rangle})_{1,1} \cdot in$ $OD = 0 \cdot in$ $S_x := lookup(Shape, AISC^{\langle 1 \rangle},$

$B := lookup(Shape, AISC^{\langle 1 \rangle}, AISC^{\langle 6 \rangle})_{1,1} \cdot in$ $B = 2 \cdot in$ $r_x := lookup(Shape, AISC^{\langle 1 \rangle},$

$ID := lookup(Shape, AISC^{\langle 1 \rangle}, AISC^{\langle 7 \rangle})_{1,1} \cdot in$ $ID = 0 \cdot in$ $I_y := if(lookup(Shape, AISC^{\langle}$

$t_{nom} := lookup(Shape, AISC^{\langle 1 \rangle}, AISC^{\langle 8 \rangle})_{1,1} \cdot in$ $t_{nom} = 0.19 \cdot in$ $Z_y := if(lookup(Shape, AISC^{\langle}$

$t_{des} := lookup(Shape, AISC^{\langle 1 \rangle}, AISC^{\langle 9 \rangle})_{1,1} \cdot in$ $t_{des} = 0.17 \cdot in$ $S_y := if(lookup(Shape, AISC^{\langle}$

$b\_t := lookup(Shape, AISC^{\langle 1 \rangle}, AISC^{\langle 10 \rangle})_{1,1}$ $b\_t = 8.51$ $r_y := if(lookup(Shape, AISC^{\langle}$

$h\_t := lookup(Shape, AISC^{\langle 1 \rangle}, AISC^{\langle 11 \rangle})_{1,1}$ $h\_t = 66.1$ $J := lookup(Shape, AISC^{\langle 1 \rangle},$

$C_w := lookup(Shape, AISC^{\langle 1 \rangle},$

Section geometry

Compression Design (AISC 360-16 Chapter E):

ASD/LRFD capacity: $P_{capacity} = 15.9 \cdot kip$ $\frac{P}{P_{capacity}} = 0.03$

$Compression_{Check} = \begin{pmatrix} \text{"P < Pn (ASD), Compression OK"} \\ \text{"ASD Compression ratio = 0.03"} \end{pmatrix}$

Flexure Design (AISC 360-16, Chapter F):

ASD/LRFD capacity: $M_{x.capacity} = 38 \cdot kip \cdot ft$ $\frac{M_x}{M_{x.capacity}} = 0$

$X\_Flexure_{Check} = \begin{pmatrix} \text{"Mx < Mn.x (ASD), Flexure OK"} \\ \text{"ASD X-axis Flexure ratio = 0"} \end{pmatrix}$

ASD/LRFD capacity: $M_{y.capacity} = 6 \cdot kip \cdot ft$ $\frac{M_y}{M_{y.capacity}} = 0$

$Y\_Flexure_{Check} = \text{"Y-axis Flexure N.A."}$

Combined Forces Design (AISC 360-16, Chapter H):

$CF\_Check_1 = \begin{pmatrix} \text{"Combine Forces OK"} \\ \text{"AISC 360-16 Eq. H1-1b Controls"} \\ \text{"Combine Forces ratio = 0.03"} \end{pmatrix}$

Prescott VAMC Replace Steam Boilers

STEAM PIPING STRESS ANALYSIS

April 30, 2025

Layout (20)

#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = VA Prescott Condensate Return Piping								
2	10	From							Anchor
3	20	Bend		3'0"		A53	2	1	
4	30		1'10"			A53	2	1	Hanger
5	40		10'7"			A53	2	1	Hanger
6	50	Bend	1'4"			A53	2	1	
7	60				-8'3"	A53	2	1	Hanger
8	70				-9'8"	A53	2	1	Hanger
9	80				-8'0"	A53	2	1	
10	90				-7'1"	A53	2	1	Hanger
11	100	Bend			-5'6"	A53	2	1	
12	110		4'4"			A53	2	1	Hanger
13	120	Bend	0'9"			A53	2	1	
14	130	Bend		6'0"		A53	2	1	
15	140				-8'6"	A53	2	1	Hanger
16	150	Bend			-8'8"	A53	2	1	
17	160	Bend	-0'10"			A53	2	1	
18	170				5'1"	A53	2	1	Hanger
19	180	Bend			2'3"	A53	2	1	
20	190		-2'6"			A53	2	1	Anchor

Pipe material A53: A53 GRADE B

Density = 0.283 (lb/in3), Nu = 0.300, Joint factor = 1.00, Type = CS
Yield strength = 35000 (psi)
Tensile strength = 60000 (psi)

Temp (F)	E (psi)	Alpha (in/in/F)	Allowable (psi)
-20	29.9E+6	6.25E-6	20000
18	29.7E+6	6.31E-6	20000
70	29.4E+6	6.40E-6	20000
100	29.3E+6	6.47E-6	20000
200	28.8E+6	6.70E-6	20000
300	28.3E+6	6.90E-6	20000
400	27.4E+6	7.10E-6	19900
500	27.3E+6	7.30E-6	19000
600	26.5E+6	7.40E-6	17900
650	26.0E+6	7.50E-6	17300
700	25.5E+6	7.60E-6	16700
750	24.9E+6	7.70E-6	13900
800	24.2E+6	7.80E-6	11400
850	23.4E+6	7.85E-6	8700
900	22.5E+6	7.90E-6	5900
950	21.5E+6	8.00E-6	4000
1000	20.4E+6	8.10E-6	2500
1050	19.2E+6	8.15E-6	1600
1100	18.0E+6	8.20E-6	1000

Pipe Loads (1)

Name	T1 (F)	P1 (psi)	Desg.T (F)	Desg.Pr. (psi)	Specific gravity	Add.Wgt. (lb/ft)	Wind Load 1	Wind Load 2	Wind Load 3	Wind Load 4	Snow Load	Ice Load
1	316	70.0	388	100	0.8							

B31.3 (2022) Code compliance (Sorted stresses)

Sustained				Expansion			
Node	SL (psi)	SH (psi)	SL / SH	Node	SE (psi)	SA (psi)	SE / SA
170	3228	19984	0.16	20B	2079	29996	0.07
190	2473	19984	0.12	10	2033	29996	0.07
140	2109	19984	0.11	20A	1944	29996	0.06
90	2004	19984	0.10	50B	1657	29996	0.06
80	1936	19984	0.10	50A	1589	29996	0.05
70	1905	19984	0.10	30	1517	29996	0.05
160A	1559	19984	0.08	130B	1300	29996	0.04
160B	1551	19984	0.08	130A	1231	29996	0.04
150A	1541	19984	0.08	100A	1015	29996	0.03
150B	1530	19984	0.08	40	954	29996	0.03
30	1529	19984	0.08	100B	938	29996	0.03
110	1085	19984	0.05	60	859	29996	0.03
60	846	19984	0.04	120B	799	29996	0.03
40	845	19984	0.04	120A	795	29996	0.03
130B	603	19984	0.03	190	781	29996	0.03
120A	585	19984	0.03	160B	765	29996	0.03
180A	574	19984	0.03	160A	696	29996	0.02
130A	527	19984	0.03	110	646	29996	0.02
10	506	19984	0.03	150B	605	29996	0.02
20B	470	19984	0.02	150A	543	29996	0.02
20A	465	19984	0.02	90	450	29996	0.02
100A	405	19984	0.02	70	377	29996	0.01
120B	398	19984	0.02	180B	328	29996	0.01
50A	371	19984	0.02	170	290	29996	0.01
100B	353	19984	0.02	180A	276	29996	0.01
50B	334	19984	0.02	140	242	29996	0.01
180B	192	19984	0.01	80	110	29996	0.00

B31.3 (2022) Code Compliance

Node	Press. Allow. (psi)	Sustained SL (psi)	Sustained SH (psi)	Sustained SL / SH	Expansion SE (psi)	Expansion SA (psi)	Expansion SE / SA
10	100	506	19984	0.03	2033	29996	0.07
20A	3945	465	19984	0.02	1941	29996	0.06
20A	100	465	19984	0.02	1944	29996	0.06
20B	3945	470	19984	0.02	2079	29996	0.07
20B	100	470	19984	0.02	1887	29996	0.06
30	3945	1529	19984	0.08	1517	29996	0.05
30	100	1529	19984	0.08	1517	29996	0.05
40	3945	845	19984	0.04	954	29996	0.03

B31.3 (2022) Code Compliance

Node	Press. Allow. (psi)	Sustained SL (psi)	SH (psi)	SL/SH	Expansion SE (psi)	SA (psi)	SE/SA
40	100	845	19984	0.04	954	29996	0.03
50A	3945	371	19984	0.02	1205	29996	0.04
50A	100	371	19984	0.02	1589	29996	0.05
50B	3945	334	19984	0.02	1657	29996	0.06
50B	100	334	19984	0.02	1258	29996	0.04
60	3945	846	19984	0.04	859	29996	0.03
60	100	846	19984	0.04	859	29996	0.03
70	3945	1905	19984	0.10	377	29996	0.01
70	100	1905	19984	0.10	377	29996	0.01
80	3945	1936	19984	0.10	110	29996	0.00
80	100	1936	19984	0.10	110	29996	0.00
90	3945	2004	19984	0.10	450	29996	0.02
90	100	2004	19984	0.10	450	29996	0.02
100A	3945	405	19984	0.02	816	29996	0.03
100A	100	405	19984	0.02	1015	29996	0.03
100B	3945	353	19984	0.02	938	29996	0.03
100B	100	353	19984	0.02	780	29996	0.03
110	3945	1085	19984	0.05	646	29996	0.02
110	100	1085	19984	0.05	646	29996	0.02
120A	3945	585	19984	0.03	730	29996	0.02
120A	100	585	19984	0.03	795	29996	0.03
120B	3945	398	19984	0.02	799	29996	0.03
120B	100	398	19984	0.02	735	29996	0.02
130A	3945	527	19984	0.03	993	29996	0.03
130A	100	527	19984	0.03	1231	29996	0.04
130B	3945	603	19984	0.03	1300	29996	0.04
130B	100	603	19984	0.03	1026	29996	0.03
140	3945	2109	19984	0.11	242	29996	0.01
140	100	2109	19984	0.11	242	29996	0.01
150A	3945	1541	19984	0.08	444	29996	0.01
150A	100	1541	19984	0.08	543	29996	0.02
150B	3945	1530	19984	0.08	605	29996	0.02
150B	100	1530	19984	0.08	500	29996	0.02
160A	3945	1559	19984	0.08	565	29996	0.02
160A	100	1559	19984	0.08	696	29996	0.02
160B	3945	1551	19984	0.08	765	29996	0.03
160B	100	1551	19984	0.08	605	29996	0.02
170	3945	3228	19984	0.16	290	29996	0.01
170	100	3228	19984	0.16	290	29996	0.01
180A	3945	574	19984	0.03	223	29996	0.01
180A	100	574	19984	0.03	276	29996	0.01
180B	3945	192	19984	0.01	328	29996	0.01
180B	100	192	19984	0.01	264	29996	0.01
190	3945	2473	19984	0.12	781	29996	0.03

Hanger Report

Node	No of	Type	Figure No.	Size	Spring rate (lb/inch)	Vert travel (inch)	Horz travel (inch)	Hot load (lb)	Cold load (lb)	Var (%)
30	1	Grinnell	B-268	1	21	0.054	0.078	95	96	1
40	1	Grinnell	B-268	0	15	-0.027	0.705	75	75	0
60	1	Grinnell	B-268	0	15	-0.198	0.753	66	63	4
70	1	Grinnell	B-268	1	21	-0.398	0.620	103	95	8
90	1	Grinnell	B-268	1	21	-0.538	0.315	106	95	10
110	1	Grinnell	B-268	1	21	-0.446	0.378	99	90	9
140	1	Grinnell	B-268	1	21	-0.073	0.183	85	84	1
170	1	Grinnell	B-268	3	35	0.015	0.065	166	167	0

Support load summary for anchor at node 10

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)	FR (lb)	MR (ft-lb)	Displacem X (inch)	Y (i
Empty W	0	29	1	-8	-6	72	29	73	0.000	0.0
Sustained	0	15	-1	-20	10	-3	15	22	0.000	0.0
Operating1	-3	13	13	18	-108	-2	18	109	0.000	0.0
Maximum	0	29	13	18	10	72	29	109	0.000	0.0
Minimum	-3	13	-1	-20	-108	-3	15	22	0.000	0.0
Allowables	0	0	0	0	0	0	0	0	0.000	0.0

Support load summary for anchor at node 190

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)	FR (lb)	MR (ft-lb)	Displacem X (inch)	Y (i
Empty W	0	76	-1	37	0	201	77	205	0.000	0.0
Sustained	0	56	1	0	-4	142	56	142	0.000	0.0
Operating1	3	59	-13	7	41	154	61	160	0.000	0.0
Maximum	3	76	1	37	41	201	77	205	0.000	0.0
Minimum	0	56	-13	0	-4	142	56	142	0.000	0.0
Allowables	0	0	0	0	0	0	0	0	0.000	0.0

Support load summary for hanger at node 30

Load combination	Load (lb)	Displacements (global) X (inch)	Y (inch)	Z (inch)
Empty W	-95	-0.022	0.037	0.001
Sustained	-96	0.001	-0.004	-0.012
Operating1	-95	0.039	0.054	0.068
Maximum	-95	0.039	0.054	0.068
Minimum	-96	-0.022	-0.004	-0.012

Support load summary for hanger at node 40

Load combination	Load (lb)	Displacements (global) X (inch)	Y (inch)	Z (inch)
Empty W	-69	-0.022	0.372	0.039
Sustained	-75	0.001	-0.051	-0.071
Operating1	-75	0.256	-0.027	0.657
Maximum	-69	0.256	0.372	0.657
Minimum	-75	-0.022	-0.051	-0.071

Support load summary for hanger at node 40				
		Displacements (global)		
Load combination	Load (lb)	X (inch)	Y (inch)	Z (inch)

Support load summary for hanger at node 60				
		Displacements (global)		
Load combination	Load (lb)	X (inch)	Y (inch)	Z (inch)
Empty W	-58	0.008	0.358	0.044
Sustained	-66	-0.020	-0.198	-0.078
Operating1	-66	0.509	-0.198	0.555
Maximum	-58	0.509	0.358	0.555
Minimum	-66	-0.020	-0.198	-0.078

Support load summary for hanger at node 70				
		Displacements (global)		
Load combination	Load (lb)	X (inch)	Y (inch)	Z (inch)
Empty W	-89	0.040	0.270	0.044
Sustained	-102	-0.018	-0.357	-0.078
Operating1	-103	0.507	-0.398	0.357
Maximum	-89	0.507	0.270	0.357
Minimum	-103	-0.018	-0.398	-0.078

Support load summary for hanger at node 90				
		Displacements (global)		
Load combination	Load (lb)	X (inch)	Y (inch)	Z (inch)
Empty W	-92	0.087	0.141	0.044
Sustained	-104	0.006	-0.438	-0.078
Operating1	-106	0.311	-0.538	0.048
Maximum	-92	0.311	0.141	0.048
Minimum	-106	0.006	-0.538	-0.078

Support load summary for hanger at node 110				
		Displacements (global)		
Load combination	Load (lb)	X (inch)	Y (inch)	Z (inch)
Empty W	-85	0.106	0.206	0.060
Sustained	-97	0.009	-0.359	-0.079
Operating1	-99	0.376	-0.446	-0.039
Maximum	-85	0.376	0.206	0.060
Minimum	-99	0.009	-0.446	-0.079

Support load summary for hanger at node 140				
		Displacements (global)		
Load combination	Load (lb)	X (inch)	Y (inch)	Z (inch)
Empty W	-80	-0.006	0.161	0.000
Sustained	-87	-0.013	-0.135	0.002
Operating1	-85	0.183	-0.073	0.007
Maximum	-80	0.183	0.161	0.007

Support load summary for hanger at node 140

Load combination	Load (lb)	Displacements (global) X (inch)	Y (inch)	Z (inch)
Minimum	-87	-0.013	-0.135	0.000

Support load summary for hanger at node 170

Load combination	Load (lb)	Displacements (global) X (inch)	Y (inch)	Z (inch)
Empty W	-165	0.000	0.041	0.000
Sustained	-166	0.001	0.008	0.001
Operating1	-166	0.039	0.015	-0.053
Maximum	-165	0.039	0.041	0.001
Minimum	-166	0.000	0.008	-0.053

Loads on Anchors in Global Coordinates: Empty Weight (W)

Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10		0	29	1	-8	-6	72
190		0	76	-1	37	0	201

Loads on Anchors in Local Coordinates: Empty Weight (W)

Node	Tag	fx (lb)	fy (lb)	fz (lb)	mx (ft-lb)	my (ft-lb)	mz (ft-lb)
10		29	0	1	-6	8	72
190		0	76	1	-37	0	-201

Loads on Hangers: Empty Weight (W)

Node	Tag	Type	Load (lb)	No.of	Total (lb)
30		Grinnell	-95	1	-95
40		Grinnell	-69	1	-69
60		Grinnell	-58	1	-58
70		Grinnell	-89	1	-89
90		Grinnell	-92	1	-92
110		Grinnell	-85	1	-85
140		Grinnell	-80	1	-80
170		Grinnell	-165	1	-165

Pipe forces in local coordinates: Empty Weight (W)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb) Moment	SIF	Inplane(ft-lb) Moment	SIF	Outplane(ft-lb) Moment	SIF	Flex. Factors FFi	FFo	FFt
10	29	0	1	-6		72		8				
20A	48	0	1	-6		72		9				
20A	48	0	-1	-6	1.00	-72	1.32	-9	1.10	2.93	2.93	
20B	0	-50	-1	-9	1.00	-60	1.32	6	1.10	2.93	2.93	
20B	0	50	1	-9		60		-6				
30	0	61	1	-9		-28		-5				
30	0	-35	1	-9		-28		-5				
40	0	37	1	-9		-40		0				
40	0	-32	1	-9		-40		0				
50A	0	-25	1	-9		-9		1				
50A	0	-1	-25	-9	1.00	1	1.32	9	1.10	2.93	2.93	
50B	-1	0	-22	3	1.00	1	1.32	4	1.10	2.93	2.93	

Pipe forces in local coordinates: Empty Weight (W)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors		
				Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt
50B	-1	-22	0	3		-4		1				
60	-1	32	0	3		-41		1				
60	-1	-26	0	3		-41		1				
70	-1	39	0	3		-104		0				
70	-1	-50	0	3		-104		0				
80	-1	4	0	3		82		0				
80	-1	4	0	3		82		0				
90	-1	51	0	3		-114		-1				
90	-1	-40	0	3		-114		-1				
100A	-1	-5	0	3		4		-1				
100A	-1	0	5	3	1.00	1	1.32	4	1.10	2.93	2.93	
100B	0	1	2	5	1.00	1	1.32	-2	1.10	2.93	2.93	
100B	0	-2	1	5		-2		-1				
110	0	25	1	5		-49		2				
110	0	-60	1	5		-49		2				
120A	0	-57	1	5		-20		2				
120A	0	-57	1	5	1.00	-20	1.32	2	1.10	2.93	2.93	
120B	-54	0	1	2	1.00	-6	1.32	-5	1.10	2.93	2.93	
120B	-54	0	1	2		-6		-5				
130A	-17	0	1	2		-7		-2				
130A	-17	-1	0	2	1.00	-2	1.32	7	1.10	2.93	2.93	
130B	-1	14	0	7	1.00	-6	1.32	-2	1.10	2.93	2.93	
130B	-1	-14	0	7		6		2				
140	-1	41	0	7		-104		2				
140	-1	-39	0	7		-104		2				
150A	-1	17	0	7		-12		1				
150A	-1	0	17	7	1.00	1	1.32	12	1.10	2.93	2.93	
150B	0	1	20	16	1.00	1	1.32	-2	1.10	2.93	2.93	
150B	0	20	-1	16		2		1				
160A	0	22	-1	16		-5		1				
160A	0	1	22	16	1.00	1	1.32	5	1.10	2.93	2.93	
160B	1	0	25	11	1.00	1	1.32	-10	1.10	2.93	2.93	
160B	1	25	0	11		10		1				
170	1	57	0	11		-189		1				
170	1	-108	0	11		-189		1				
180A	1	-94	0	11		13		1				
180A	1	0	94	11	1.00	-1	1.32	13	1.10	2.93	2.93	
180B	0	-1	92	37	1.00	-1	1.32	12	1.10	2.93	2.93	
180B	0	-92	-1	37		12		1				
190	0	-76	-1	37		201		0				

Pipe forces in global coordinates: Empty Weight (W)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10	0	-29	-1	8	6	-72
20A	0	48	1	-9	-6	72
20A	0	-48	-1	9	6	-72
20B	0	50	1	-9	-6	60

Pipe forces in global coordinates: Empty Weight (W)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
20B	0	-50	-1	9	6	-60
30	0	61	1	-9	-5	-28
30	0	35	-1	9	5	28
40	0	37	1	-9	0	-40
40	0	32	-1	9	0	40
50A	0	-25	1	-9	1	-9
50A	0	25	-1	9	-1	9
50B	0	-22	1	-4	1	-3
50B	0	22	-1	4	-1	3
60	0	32	1	-41	1	-3
60	0	26	-1	41	-1	3
70	0	39	1	-104	0	-3
70	0	50	-1	104	0	3
80	0	4	1	82	0	-3
80	0	-4	-1	-82	0	3
90	0	51	1	-114	-1	-3
90	0	40	-1	114	1	3
100A	0	-5	1	4	-1	-3
100A	0	5	-1	-4	1	3
100B	0	-2	1	5	-1	-2
100B	0	2	-1	-5	1	2
110	0	25	1	5	2	-49
110	0	60	-1	-5	-2	49
120A	0	-57	1	5	2	-20
120A	0	57	-1	-5	-2	20
120B	0	-54	1	5	2	-6
120B	0	54	-1	-5	-2	6
130A	0	-17	1	2	2	-7
130A	0	17	-1	-2	-2	7
130B	0	-14	1	6	2	-7
130B	0	14	-1	-6	-2	7
140	0	41	1	-104	2	-7
140	0	39	-1	104	-2	7
150A	0	17	1	-12	1	-7
150A	0	-17	-1	12	-1	7
150B	0	20	1	-16	1	-2
150B	0	-20	-1	16	-1	2
160A	0	22	1	-16	1	5
160A	0	-22	-1	16	-1	-5
160B	0	25	1	-10	1	11
160B	0	-25	-1	10	-1	-11
170	0	57	1	189	1	11
170	0	108	-1	-189	-1	-11
180A	0	-94	1	-13	1	11
180A	0	94	-1	13	-1	-11
180B	0	-92	1	-37	1	-12

Pipe forces in global coordinates: Empty Weight (W)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
180B	0	92	-1	37	-1	12
190	0	-76	1	-37	0	-201

Displacements: Empty Weight (W)

	Displacements (global)					
Node	X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
10	0.000	0.000	0.000	0.0000	0.0000	0.0000
20A	-0.019	0.000	-0.002	-0.0076	-0.0073	0.0643
20B	-0.022	0.004	-0.002	-0.0097	-0.0083	0.0896
30	-0.022	0.037	0.001	-0.0159	-0.0113	0.0984
40	-0.022	0.372	0.039	-0.0577	-0.0196	0.1971
50A	-0.022	0.415	0.043	-0.0619	-0.0193	0.1888
50B	-0.021	0.422	0.044	-0.0641	-0.0189	0.1868
60	0.008	0.358	0.044	-0.0288	-0.0165	0.1769
70	0.040	0.270	0.044	-0.0909	-0.0150	0.1650
80	0.065	0.104	0.044	-0.0263	-0.0149	0.1551
90	0.087	0.141	0.044	0.0015	-0.0157	0.1463
100A	0.105	0.088	0.044	-0.0652	-0.0168	0.1398
100B	0.106	0.092	0.045	-0.0641	-0.0170	0.1394
110	0.106	0.206	0.060	-0.0551	-0.0164	0.1177
120A	0.106	0.218	0.061	-0.0541	-0.0162	0.1121
120B	0.100	0.224	0.060	-0.0528	-0.0160	0.1078
130A	-0.017	0.224	0.003	-0.0464	-0.0115	0.0964
130B	-0.022	0.221	0.000	-0.0451	-0.0114	0.0947
140	-0.006	0.161	0.000	-0.0743	-0.0067	0.0719
150A	0.002	-0.051	0.000	-0.1237	-0.0031	0.0485
150B	0.002	-0.060	0.000	-0.1272	-0.0027	0.0483
160A	0.002	-0.063	0.000	-0.1295	-0.0027	0.0485
160B	0.002	-0.059	0.000	-0.1326	-0.0024	0.0498
170	0.000	0.041	0.000	-0.0137	-0.0012	0.0722
180A	0.000	0.031	0.000	0.0416	-0.0006	0.0814
180B	0.000	0.024	0.000	0.0347	-0.0002	0.0797
190	0.000	0.000	0.000	0.0000	0.0000	0.0000

Loads on Anchors in Global Coordinates: Sustained (W+P)

Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10		0	15	-1	-20	10	-3
190		0	56	1	0	-4	142

Loads on Anchors in Local Coordinates: Sustained (W+P)

Node	Tag	fx (lb)	fy (lb)	fz (lb)	mx (ft-lb)	my (ft-lb)	mz (ft-lb)
10		15	0	-1	10	20	-3
190		0	56	-1	0	-4	-142

Loads on Hangers: Sustained (W+P)

Node	Tag	Type	Load (lb)	No.of	Total (lb)
30		Grinnell	-96	1	-96

Loads on Hangers: Sustained (W+P)

Node	Tag	Type	Load (lb)	No.of	Total (lb)
40		Grinnell	-75	1	-75
60		Grinnell	-66	1	-66
70		Grinnell	-102	1	-102
90		Grinnell	-104	1	-104
110		Grinnell	-97	1	-97
140		Grinnell	-87	1	-87
170		Grinnell	-166	1	-166

Pipe forces in local coordinates: Sustained (W+P)

Node	Axial	y Shear	z Shear	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors			SL
	(lb)	(lb)	(lb)	Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt	(psi)
10	15	0	-1	10		-3		20					506
20A	36	0	-1	10		-2		16					465
20A	36	0	1	10	1.00	2	1.32	-16	1.10	2.93	2.93		465
20B	0	-39	1	-16	1.00	11	1.32	-10	1.10	2.93	2.93		470
20B	0	39	-1	-16		-11		10					470
30	0	51	-1	-16		-83		8					1529
30	0	-45	-1	-16		-83		8					1529
40	0	37	-1	-16		-40		-5					845
40	0	-38	-1	-16		-40		-5					845
50A	0	-30	-1	-16		-3		-7					371
50A	0	1	-30	-16	1.00	-7	1.32	3	1.10	2.93	2.93		371
50B	1	0	-27	-4	1.00	-7	1.32	9	1.10	2.93	2.93		334
50B	1	-27	0	-4		-9		-7					334
60	1	35	0	-4		-43		-5					846
60	1	-31	0	-4		-43		-5					846
70	1	44	0	-4		-107		-2					1905
70	1	-58	0	-4		-107		-2					1905
80	1	4	0	-4		109		0					1936
80	1	4	0	-4		109		0					1936
90	1	59	0	-4		-113		2					2004
90	1	-45	0	-4		-113		2					2004
100A	1	-4	0	-4		15		4					405
100A	1	0	4	-4	1.00	-4	1.32	15	1.10	2.93	2.93		405
100B	0	-1	1	16	1.00	-3	1.32	5	1.10	2.93	2.93		353
100B	0	-1	-1	16		5		3					353
110	0	31	-1	16		-56		-2					1085
110	0	-67	-1	16		-56		-2					1085
120A	0	-63	-1	16		-23		-2					585
120A	0	-63	-1	16	1.00	-23	1.32	-2	1.10	2.93	2.93		585
120B	-60	0	-1	-3	1.00	-8	1.32	-16	1.10	2.93	2.93		398
120B	-60	0	-1	-3		-8		-16					398
130A	-17	0	-1	-3		-6		-23					527
130A	-17	1	0	-3	1.00	-23	1.32	6	1.10	2.93	2.93		527
130B	1	14	0	6	1.00	-28	1.32	3	1.10	2.93	2.93		603
130B	1	-14	0	6		28		-3					603
140	1	50	0	6		-120		0					2109

Pipe forces in local coordinates: Sustained (W+P)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors			SL (psi)
				Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt	
140	1	-37	0	6		-120		0					2109
150A	1	29	0	6		-85		2					1541
150A	1	0	29	6	1.00	2	1.32	85	1.10	2.93	2.93		1541
150B	0	-1	32	92	1.00	2	1.32	2	1.10	2.93	2.93		1530
150B	0	32	1	92		-2		2					1530
160A	0	34	1	92		-13		3					1559
160A	0	-1	34	92	1.00	3	1.32	13	1.10	2.93	2.93		1559
160B	-1	0	37	21	1.00	3	1.32	-83	1.10	2.93	2.93		1551
160B	-1	37	0	21		83		3					1551
170	-1	75	0	21		-187		2					3228
170	-1	-92	0	21		-187		2					3228
180A	-1	-76	0	21		-19		1					574
180A	-1	0	76	21	1.00	-1	1.32	-19	1.10	2.93	2.93		574
180B	0	1	73	0	1.00	-1	1.32	-3	1.10	2.93	2.93		192
180B	0	-73	1	0		-3		1					192
190	0	-56	1	0		142		4					2473

Pipe forces in global coordinates: Sustained (W+P)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10	0	-15	1	20	-10	3
20A	0	36	-1	-16	10	-2
20A	0	-36	1	16	-10	2
20B	0	39	-1	-16	10	-11
20B	0	-39	1	16	-10	11
30	0	51	-1	-16	8	-83
30	0	45	1	16	-8	83
40	0	37	-1	-16	-5	-40
40	0	38	1	16	5	40
50A	0	-30	-1	-16	-7	-3
50A	0	30	1	16	7	3
50B	0	-27	-1	-9	-7	4
50B	0	27	1	9	7	-4
60	0	35	-1	-43	-5	4
60	0	31	1	43	5	-4
70	0	44	-1	-107	-2	4
70	0	58	1	107	2	-4
80	0	4	-1	109	0	4
80	0	-4	1	-109	0	-4
90	0	59	-1	-113	2	4
90	0	45	1	113	-2	-4
100A	0	-4	-1	15	4	4
100A	0	4	1	-15	-4	-4
100B	0	-1	-1	16	3	5
100B	0	1	1	-16	-3	-5
110	0	31	-1	16	-2	-56
110	0	67	1	-16	2	56
120A	0	-63	-1	16	-2	-23

Pipe forces in global coordinates: Sustained (W+P)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
120A	0	63	1	-16	2	23
120B	0	-60	-1	16	-3	-8
120B	0	60	1	-16	3	8
130A	0	-17	-1	23	-3	-6
130A	0	17	1	-23	3	6
130B	0	-14	-1	28	-3	-6
130B	0	14	1	-28	3	6
140	0	50	-1	-120	0	-6
140	0	37	1	120	0	6
150A	0	29	-1	-85	2	-6
150A	0	-29	1	85	-2	6
150B	0	32	-1	-92	2	2
150B	0	-32	1	92	-2	-2
160A	0	34	-1	-92	3	13
160A	0	-34	1	92	-3	-13
160B	0	37	-1	-83	3	21
160B	0	-37	1	83	-3	-21
170	0	75	-1	187	2	21
170	0	92	1	-187	-2	-21
180A	0	-76	-1	19	1	21
180A	0	76	1	-19	-1	-21
180B	0	-73	-1	0	1	3
180B	0	73	1	0	-1	-3
190	0	-56	-1	0	4	-142

Displacements: Sustained (W+P)

	Displacements (global)					
Node	X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
10	0.000	0.000	0.000	0.0000	0.0000	0.0000
20A	0.001	0.000	-0.005	-0.0160	0.0120	-0.0022
20B	0.001	-0.000	-0.006	-0.0210	0.0158	-0.0042
30	0.001	-0.004	-0.012	-0.0316	0.0204	-0.0275
40	0.001	-0.051	-0.071	-0.1023	0.0249	0.0100
50A	0.001	-0.050	-0.077	-0.1096	0.0228	0.0027
50B	-0.000	-0.055	-0.078	-0.1129	0.0202	0.0020
60	-0.020	-0.198	-0.078	-0.0724	0.0049	0.0157
70	-0.018	-0.357	-0.078	-0.1177	-0.0059	0.0322
80	-0.005	-0.541	-0.078	-0.0082	-0.0083	0.0459
90	0.006	-0.438	-0.078	0.0613	-0.0056	0.0580
100A	0.009	-0.420	-0.078	0.0083	-0.0006	0.0670
100B	0.009	-0.416	-0.078	0.0129	0.0007	0.0692
110	0.009	-0.359	-0.079	0.0404	0.0018	0.0498
120A	0.009	-0.354	-0.080	0.0438	0.0014	0.0435
120B	0.007	-0.352	-0.077	0.0483	-0.0003	0.0386
130A	-0.030	-0.352	-0.002	0.0837	-0.0067	0.0265
130B	-0.031	-0.347	0.002	0.0930	-0.0078	0.0247

Displacements: Sustained (W+P)

Node	Displacements (global)					
	X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
140	-0.013	-0.135	0.002	0.0874	-0.0118	0.0039
150A	0.007	-0.130	0.002	-0.0667	-0.0095	-0.0172
150B	0.007	-0.134	0.002	-0.0904	-0.0087	-0.0120
160A	0.007	-0.133	0.001	-0.1034	-0.0084	-0.0112
160B	0.007	-0.126	0.001	-0.1260	-0.0072	-0.0124
170	0.001	0.008	0.001	-0.0687	-0.0035	0.0310
180A	0.000	0.019	0.001	-0.0037	-0.0025	0.0490
180B	0.000	0.017	0.001	-0.0004	-0.0021	0.0530
190	0.000	0.000	0.000	0.0000	0.0000	0.0000

Loads on Anchors in Global Coordinates: Expansion (T1)

Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10		-3	-2	14	38	-118	1
190		3	3	-14	7	45	12

Loads on Anchors in Local Coordinates: Expansion (T1)

Node	Tag	fx (lb)	fy (lb)	fz (lb)	mx (ft-lb)	my (ft-lb)	mz (ft-lb)
10		-2	3	14	-118	-38	1
190		-3	3	14	-7	45	-12

Loads on Hangers: Expansion (T1)

Node	Tag	Type	Load (lb)	No.of	Total (lb)
30		Grinnell	1	1	1
40		Grinnell	0	1	0
60		Grinnell	0	1	0
70		Grinnell	-1	1	-1
90		Grinnell	-2	1	-2
110		Grinnell	-2	1	-2
140		Grinnell	1	1	1
170		Grinnell	0	1	0

Pipe forces in local coordinates: Expansion (T1)

Node	Axial	y Shear	z Shear	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors			SE	SA
	(lb)	(lb)	(lb)	Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt	(psi)	(psi)
10	-2	3	14	-118		1		-38					2033	30000
20A	-2	3	14	-118		-8		1					1941	30000
20A	-2	-3	-14	-118	1.00	8	1.32	-1	1.10	2.93	2.93		1944	30000
20B	-3	2	-14	-5	1.00	8	1.32	114	1.10	2.93	2.93		2079	30000
20B	-3	-2	14	-5		-8		-114					1887	30000
30	-3	-2	14	-5		-5		-92					1517	30000
30	-3	-1	14	-5		-5		-92					1517	30000
40	-3	-1	14	-5		0		58					954	30000
40	-3	0	14	-5		0		58					954	30000
50A	-3	0	14	-5		0		73					1205	30000
50A	-3	-14	0	-5	1.00	73	1.32	0	1.10	2.93	2.93		1589	30000
50B	-14	3	0	0	1.00	76	1.32	5	1.10	2.93	2.93		1657	30000
50B	-14	0	-3	0		-5		76					1258	30000
60	-14	0	-3	0		-4		52					859	30000

Pipe forces in local coordinates: Expansion (T1)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb) Moment	Torsion(ft-lb) SIF	Inplane(ft-lb) Moment	Inplane(ft-lb) SIF	Outplane(ft-lb) Moment	Outplane(ft-lb) SIF	Flex. Factors FFi	Flex. Factors FFo	Flex. Factors FFt	SE (psi)	SA (psi)
60	-14	0	-3	0		-4		52					859	30000
70	-14	0	-3	0		-2		22					377	30000
70	-14	-1	-3	0		-2		22					377	30000
80	-14	-1	-3	0		6		-2					110	30000
80	-14	-1	-3	0		6		-2					110	30000
90	-14	-1	-3	0		13		-23					450	30000
90	-14	-3	-3	0		13		-23					450	30000
100A	-14	-3	-3	0		29		-39					816	30000
100A	-14	-3	3	0	1.00	39	1.32	29	1.10	2.93	2.93		1015	30000
100B	-3	14	3	30	1.00	37	1.32	1	1.10	2.93	2.93		938	30000
100B	-3	-3	14	30		1		-37					780	30000
110	-3	-3	14	30		14		21					646	30000
110	-3	-5	14	30		14		21					646	30000
120A	-3	-5	14	30		16		28					730	30000
120A	-3	-5	14	30	1.00	16	1.32	28	1.10	2.93	2.93		795	30000
120B	-5	3	14	32	1.00	17	1.32	-27	1.10	2.93	2.93		799	30000
120B	-5	3	14	32		17		-27					735	30000
130A	-5	3	14	32		0		51					993	30000
130A	-5	-14	3	32	1.00	51	1.32	0	1.10	2.93	2.93		1231	30000
130B	-14	5	3	1	1.00	54	1.32	-31	1.10	2.93	2.93		1300	30000
130B	-14	-5	-3	1		-54		31					1026	30000
140	-14	-5	-3	1		-13		6					242	30000
140	-14	-4	-3	1		-13		6					242	30000
150A	-14	-4	-3	1		18		-20					444	30000
150A	-14	3	-4	1	1.00	-20	1.32	-18	1.10	2.93	2.93		543	30000
150B	3	14	-4	-19	1.00	-24	1.32	-2	1.10	2.93	2.93		605	30000
150B	3	-4	-14	-19		2		-24					500	30000
160A	3	-4	-14	-19		3		-29					565	30000
160A	3	14	-4	-19	1.00	-29	1.32	-3	1.10	2.93	2.93		696	30000
160B	14	-3	-4	-4	1.00	-31	1.32	18	1.10	2.93	2.93		765	30000
160B	14	-4	3	-4		-18		-31					605	30000
170	14	-4	3	-4		0		-17					290	30000
170	14	-3	3	-4		0		-17					290	30000
180A	14	-3	3	-4		7		-11					223	30000
180A	14	3	3	-4	1.00	11	1.32	7	1.10	2.93	2.93		276	30000
180B	3	-14	3	7	1.00	13	1.32	5	1.10	2.93	2.93		328	30000
180B	3	-3	-14	7		5		-13					264	30000
190	3	-3	-14	7		12		-45					781	30000

Pipe forces in global coordinates: Expansion (T1)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10	3	2	-14	-38	118	-1
20A	-3	-2	14	-1	-118	-8
20A	3	2	-14	1	118	8
20B	-3	-2	14	-5	-114	-8
20B	3	2	-14	5	114	8
30	-3	-2	14	-5	-92	-5

Pipe forces in global coordinates: Expansion (T1)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
30	3	1	-14	5	92	5
40	-3	-1	14	-5	58	0
40	3	0	-14	5	-58	0
50A	-3	0	14	-5	73	0
50A	3	0	-14	5	-73	0
50B	-3	0	14	-5	76	0
50B	3	0	-14	5	-76	0
60	-3	0	14	-4	52	0
60	3	0	-14	4	-52	0
70	-3	0	14	-2	22	0
70	3	1	-14	2	-22	0
80	-3	-1	14	6	-2	0
80	3	1	-14	-6	2	0
90	-3	-1	14	13	-23	0
90	3	3	-14	-13	23	0
100A	-3	-3	14	29	-39	0
100A	3	3	-14	-29	39	0
100B	-3	-3	14	30	-37	1
100B	3	3	-14	-30	37	-1
110	-3	-3	14	30	21	14
110	3	5	-14	-30	-21	-14
120A	-3	-5	14	30	28	16
120A	3	5	-14	-30	-28	-16
120B	-3	-5	14	27	32	17
120B	3	5	-14	-27	-32	-17
130A	-3	-5	14	-51	32	0
130A	3	5	-14	51	-32	0
130B	-3	-5	14	-54	31	-1
130B	3	5	-14	54	-31	1
140	-3	-5	14	-13	6	-1
140	3	4	-14	13	-6	1
150A	-3	-4	14	18	-20	-1
150A	3	4	-14	-18	20	1
150B	-3	-4	14	19	-24	-2
150B	3	4	-14	-19	24	2
160A	-3	-4	14	19	-29	-3
160A	3	4	-14	-19	29	3
160B	-3	-4	14	18	-31	-4
160B	3	4	-14	-18	31	4
170	-3	-4	14	0	-17	-4
170	3	3	-14	0	17	4
180A	-3	-3	14	-7	-11	-4
180A	3	3	-14	7	11	4
180B	-3	-3	14	-7	-13	-5
180B	3	3	-14	7	13	5
190	-3	-3	14	-7	-45	-12

Displacements: Expansion (T1)

Node	Displacements (global)					
	X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
10	0.000	0.000	0.000	0.0000	0.0000	0.0000
20A	0.001	0.056	0.006	0.0162	-0.1363	-0.0031
20B	0.006	0.061	0.015	0.0230	-0.1674	-0.0061
30	0.038	0.058	0.080	0.0198	-0.2202	-0.0095
40	0.255	0.024	0.728	-0.0017	-0.2788	-0.0183
50A	0.277	0.020	0.789	-0.0039	-0.2559	-0.0182
50B	0.295	0.019	0.796	-0.0051	-0.2279	-0.0185
60	0.530	0.001	0.633	-0.0160	-0.0631	-0.0174
70	0.525	-0.042	0.435	-0.0253	0.0524	-0.0160
80	0.406	-0.083	0.271	-0.0207	0.0786	-0.0149
90	0.305	-0.100	0.126	0.0007	0.0494	-0.0140
100A	0.278	-0.082	0.019	0.0366	-0.0040	-0.0132
100B	0.283	-0.081	0.015	0.0446	-0.0184	-0.0111
110	0.367	-0.087	0.040	0.0962	-0.0286	-0.0012
120A	0.377	-0.087	0.043	0.1026	-0.0246	0.0012
120B	0.382	-0.082	0.050	0.1082	-0.0184	0.0075
130A	0.362	0.031	0.175	0.0862	0.0550	0.0224
130B	0.358	0.040	0.174	0.0664	0.0634	0.0244
140	0.196	0.062	0.005	-0.0221	0.1127	0.0221
150A	0.003	0.017	-0.167	-0.0152	0.0942	0.0197
150B	-0.006	0.015	-0.167	-0.0103	0.0862	0.0182
160A	-0.013	0.014	-0.161	-0.0076	0.0834	0.0180
160B	-0.014	0.013	-0.152	-0.0029	0.0720	0.0183
170	0.037	0.007	-0.053	0.0112	0.0344	0.0108
180A	0.050	0.002	-0.012	0.0092	0.0256	0.0077
180B	0.046	0.002	-0.006	0.0070	0.0213	0.0061
190	0.000	0.000	0.000	0.0000	0.0000	0.0000

Loads on Anchors in Global Coordinates: Operating (W+P1+T1)

Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10		-3	13	13	18	-108	-2
190		3	59	-13	7	41	154

Loads on Anchors in Local Coordinates: Operating (W+P1+T1)

Node	Tag	fx (lb)	fy (lb)	fz (lb)	mx (ft-lb)	my (ft-lb)	mz (ft-lb)
10		13	3	13	-108	-18	-2
190		-3	59	13	-7	41	-154

Loads on Hangers: Operating (W+P1+T1)

Node	Tag	Type	Load (lb)	No.of	Total (lb)
30		Grinnell	-95	1	-95
40		Grinnell	-75	1	-75
60		Grinnell	-66	1	-66
70		Grinnell	-103	1	-103
90		Grinnell	-106	1	-106
110		Grinnell	-99	1	-99

Loads on Hangers: Operating (W+P1+T1)

Node	Tag	Type	Load (lb)	No.of	Total (lb)
140		Grinnell	-85	1	-85
170		Grinnell	-166	1	-166

Pipe forces in local coordinates: Operating (W+P1+T1)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors			Sopr (psi)
				Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt	
10	13	3	13	-108		-2		-18					1821
20A	34	3	13	-108		-10		18					1833
20A	34	-3	-13	-108	1.00	10	1.32	-18	1.10	2.93	2.93		1833
20B	-3	-37	-13	-21	1.00	19	1.32	104	1.10	2.93	2.93		1911
20B	-3	37	13	-21		-19		-104					1911
30	-3	49	13	-21		-88		-84					2163
30	-3	-46	13	-21		-88		-84					2163
40	-3	36	13	-21		-40		52					1265
40	-3	-38	13	-21		-40		52					1265
50A	-3	-30	13	-21		-3		66					1274
50A	-3	-13	-30	-21	1.00	66	1.32	3	1.10	2.93	2.93		1274
50B	-13	3	-27	-4	1.00	69	1.32	14	1.10	2.93	2.93		1285
50B	-13	-27	-3	-4		-14		69					1285
60	-13	35	-3	-4		-46		47					1212
60	-13	-31	-3	-4		-46		47					1212
70	-13	44	-3	-4		-110		20					1963
70	-13	-59	-3	-4		-110		20					1963
80	-13	3	-3	-4		115		-2					2022
80	-13	3	-3	-4		115		-2					2022
90	-13	58	-3	-4		-100		-21					1819
90	-13	-48	-3	-4		-100		-21					1819
100A	-13	-7	-3	-4		45		-36					1072
100A	-13	-3	7	-4	1.00	36	1.32	45	1.10	2.93	2.93		1072
100B	-3	13	4	46	1.00	33	1.32	6	1.10	2.93	2.93		1026
100B	-3	-4	13	46		6		-33					1026
110	-3	27	13	46		-42		19					1171
110	-3	-72	13	46		-42		19					1171
120A	-3	-68	13	46		-7		26					952
120A	-3	-68	13	46	1.00	-7	1.32	26	1.10	2.93	2.93		952
120B	-65	3	13	29	1.00	9	1.32	-43	1.10	2.93	2.93		946
120B	-65	3	13	29		9		-43					946
130A	-22	3	13	29		-6		28					761
130A	-22	-13	3	29	1.00	28	1.32	6	1.10	2.93	2.93		761
130B	-13	19	3	7	1.00	26	1.32	-28	1.10	2.93	2.93		771
130B	-13	-19	-3	7		-26		28					771
140	-13	45	-3	7		-133		6					2312
140	-13	-40	-3	7		-133		6					2312
150A	-13	25	-3	7		-67		-18					1277
150A	-13	3	25	7	1.00	-18	1.32	67	1.10	2.93	2.93		1277
150B	3	13	28	74	1.00	-21	1.32	0	1.10	2.93	2.93		1308
150B	3	28	-13	74		0		-21					1308
160A	3	31	-13	74		-10		-26					1349

Pipe forces in local coordinates: Operating (W+P1+T1)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors			Sopr (psi)
				Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt	
160A	3	13	31	74	1.00	-26	1.32	10	1.10	2.93	2.93		1349
160B	13	-3	34	18	1.00	-28	1.32	-66	1.10	2.93	2.93		1353
160B	13	34	3	18		66		-28					1353
170	13	71	3	18		-187		-15					3246
170	13	-95	3	18		-187		-15					3246
180A	13	-80	3	18		-13		-9					500
180A	13	3	80	18	1.00	9	1.32	-13	1.10	2.93	2.93		500
180B	3	-13	77	7	1.00	12	1.32	2	1.10	2.93	2.93		360
180B	3	-77	-13	7		2		-12					360
190	3	-59	-13	7		154		-41					2764

Pipe forces in global coordinates: Operating (W+P1+T1)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10	3	-13	-13	-18	108	2
20A	-3	34	13	-18	-108	-10
20A	3	-34	-13	18	108	10
20B	-3	37	13	-21	-104	-19
20B	3	-37	-13	21	104	19
30	-3	49	13	-21	-84	-88
30	3	46	-13	21	84	88
40	-3	36	13	-21	52	-40
40	3	38	-13	21	-52	40
50A	-3	-30	13	-21	66	-3
50A	3	30	-13	21	-66	3
50B	-3	-27	13	-14	69	4
50B	3	27	-13	14	-69	-4
60	-3	35	13	-46	47	4
60	3	31	-13	46	-47	-4
70	-3	44	13	-110	20	4
70	3	59	-13	110	-20	-4
80	-3	3	13	115	-2	4
80	3	-3	-13	-115	2	-4
90	-3	58	13	-100	-21	4
90	3	48	-13	100	21	-4
100A	-3	-7	13	45	-36	4
100A	3	7	-13	-45	36	-4
100B	-3	-4	13	46	-33	6
100B	3	4	-13	-46	33	-6
110	-3	27	13	46	19	-42
110	3	72	-13	-46	-19	42
120A	-3	-68	13	46	26	-7
120A	3	68	-13	-46	-26	7
120B	-3	-65	13	43	29	9
120B	3	65	-13	-43	-29	-9
130A	-3	-22	13	-28	29	-6
130A	3	22	-13	28	-29	6
130B	-3	-19	13	-26	28	-7

Pipe forces in global coordinates: Operating (W+P1+T1)

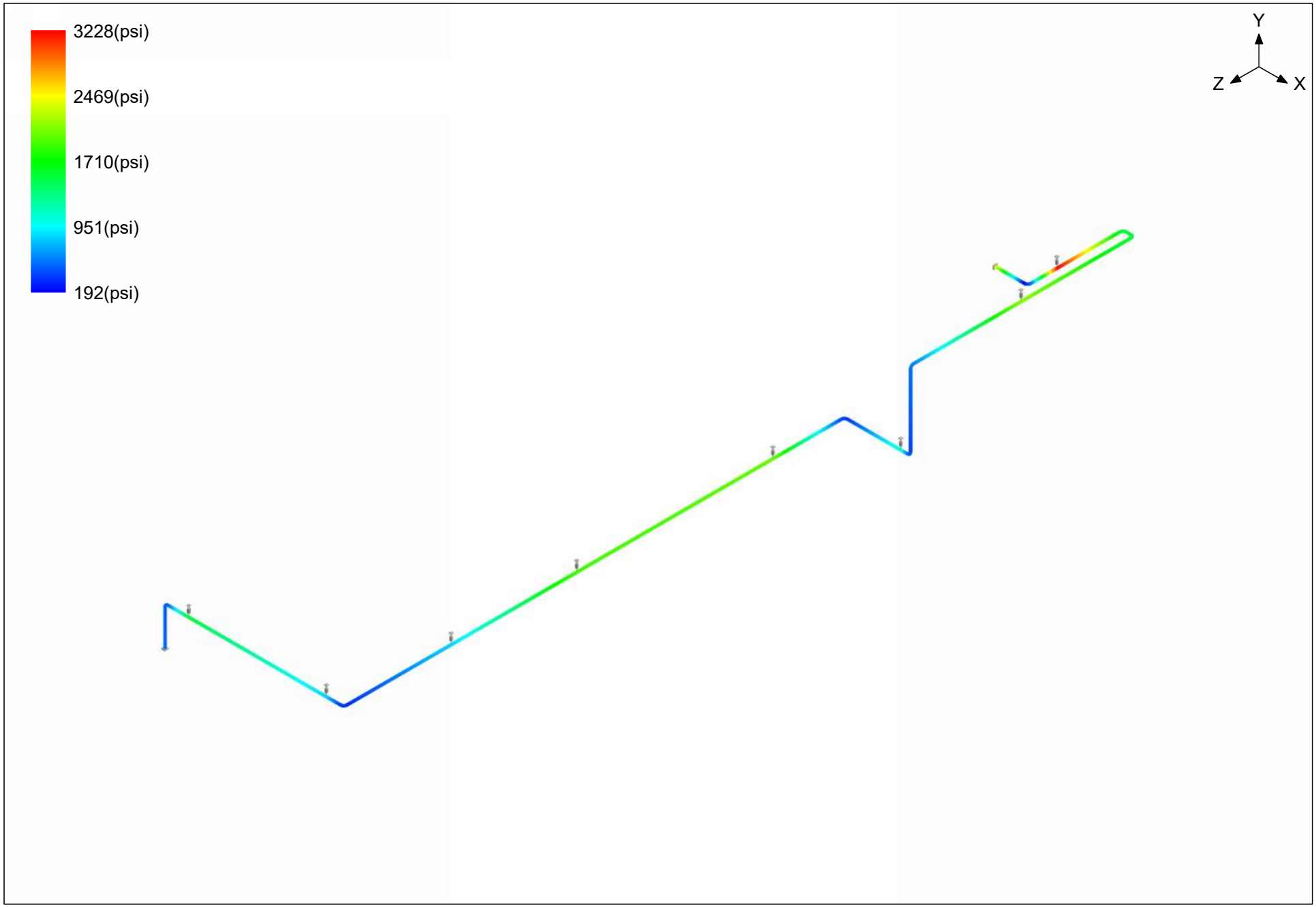
Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
130B	3	19	-13	26	-28	7
140	-3	45	13	-133	6	-7
140	3	40	-13	133	-6	7
150A	-3	25	13	-67	-18	-7
150A	3	-25	-13	67	18	7
150B	-3	28	13	-74	-21	0
150B	3	-28	-13	74	21	0
160A	-3	31	13	-74	-26	10
160A	3	-31	-13	74	26	-10
160B	-3	34	13	-66	-28	18
160B	3	-34	-13	66	28	-18
170	-3	71	13	187	-15	18
170	3	95	-13	-187	15	-18
180A	-3	-80	13	13	-9	18
180A	3	80	-13	-13	9	-18
180B	-3	-77	13	-7	-12	-2
180B	3	77	-13	7	12	2
190	-3	-59	13	-7	-41	-154

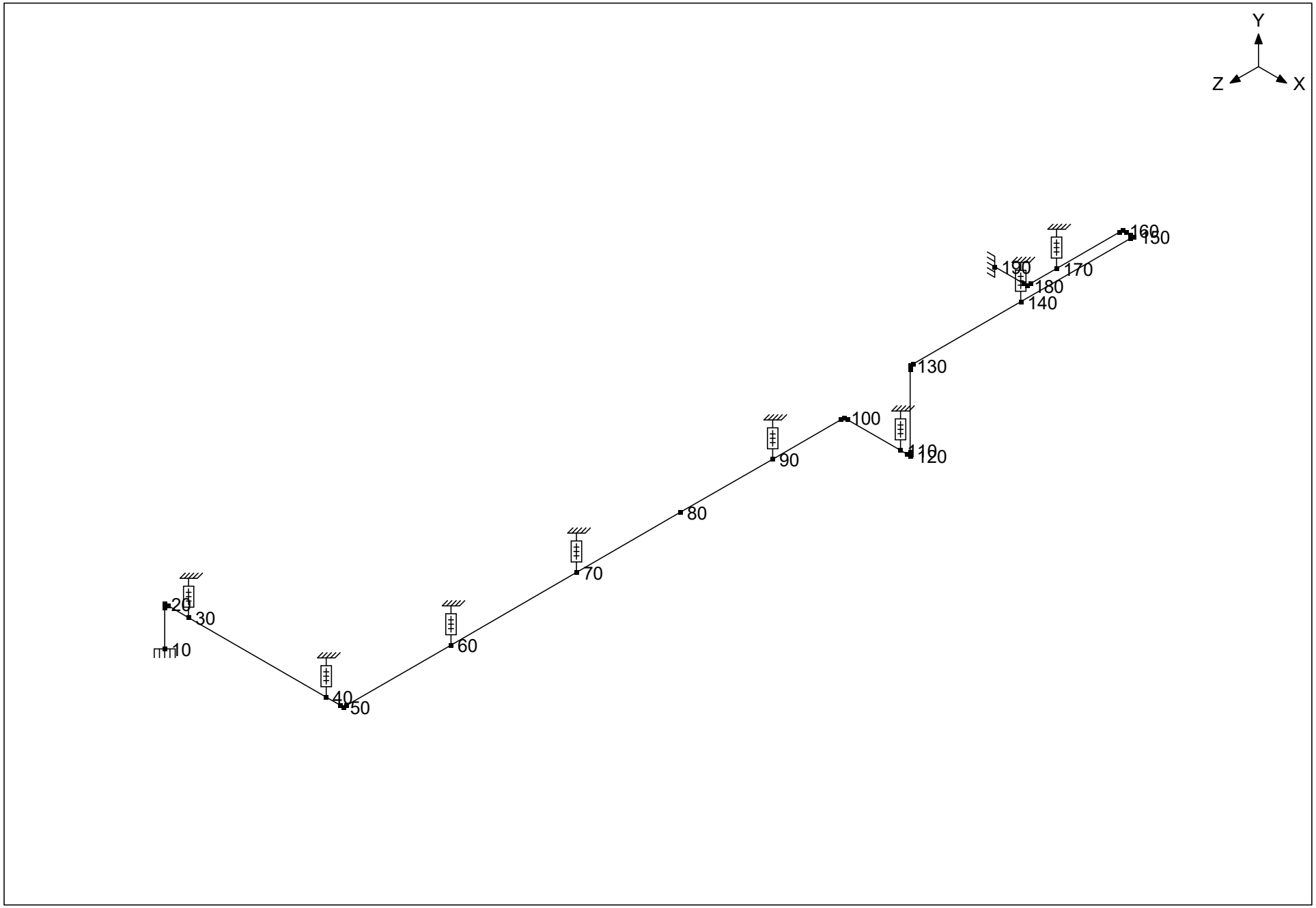
Displacements: Operating (W+P1+T1)

	Displacements (global)					
Node	X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
10	0.000	0.000	0.000	0.0000	0.0000	0.0000
20A	0.001	0.056	0.002	0.0002	-0.1243	-0.0053
20B	0.007	0.061	0.009	0.0020	-0.1516	-0.0103
30	0.039	0.054	0.068	-0.0118	-0.1998	-0.0370
40	0.256	-0.027	0.657	-0.1040	-0.2539	-0.0083
50A	0.278	-0.030	0.712	-0.1134	-0.2331	-0.0155
50B	0.294	-0.037	0.719	-0.1180	-0.2077	-0.0164
60	0.509	-0.198	0.555	-0.0884	-0.0582	-0.0016
70	0.507	-0.398	0.357	-0.1430	0.0465	0.0162
80	0.401	-0.624	0.193	-0.0290	0.0703	0.0310
90	0.311	-0.538	0.048	0.0621	0.0438	0.0441
100A	0.287	-0.502	-0.059	0.0449	-0.0047	0.0538
100B	0.293	-0.496	-0.063	0.0575	-0.0177	0.0581
110	0.376	-0.446	-0.039	0.1367	-0.0269	0.0486
120A	0.387	-0.441	-0.037	0.1464	-0.0232	0.0447
120B	0.389	-0.434	-0.028	0.1566	-0.0188	0.0460
130A	0.332	-0.321	0.173	0.1699	0.0483	0.0489
130B	0.327	-0.308	0.176	0.1595	0.0556	0.0491
140	0.183	-0.073	0.007	0.0653	0.1009	0.0260
150A	0.010	-0.113	-0.165	-0.0820	0.0847	0.0025
150B	0.001	-0.118	-0.166	-0.1007	0.0775	0.0062
160A	-0.006	-0.119	-0.160	-0.1110	0.0750	0.0068
160B	-0.008	-0.113	-0.151	-0.1289	0.0647	0.0059
170	0.039	0.015	-0.053	-0.0575	0.0310	0.0418

Displacements: Operating (W+P1+T1)

Node	Displacements (global)					
	X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
180A	0.050	0.022	-0.012	0.0055	0.0231	0.0567
180B	0.046	0.018	-0.005	0.0066	0.0193	0.0591
190	0.000	0.000	0.000	0.0000	0.0000	0.0000


3228(psi)
2469(psi)
1710(psi)
951(psi)
192(psi)
Y
Z
X


Y
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190

Prescott VAMC Replace Steam Boilers

STEAM PIPING STRESS ANALYSIS

April 30, 2025

Layout (18)

#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = P&G New Boiler Steam Piping								
2	10	From							Anchor
3	20	Bend		16'0"		A53	6	1	
4	30	Bend	7'7"			A53	6	1	
5	40				-13'3"	A53	6	1	Hanger
6	50	Bend			-5'10"	A53	6	1	
7	60		12'10"			A53	6	1	Anchor
8	70	From			1'0"				Anchor
9	80	Bend		16'0"		A53	6	1	
10	90		7'1"			A53	6	1	Hanger
11	100		13'5"			A53	6	1	Anchor
12	110	From			2'0"				Anchor
13	120	Bend		16'0"		A53	6	1	
14	130	Bend	9'1"			A53	6	1	
15	140	Bend			3'11"	A53	6	1	
16	150		2'0"			A53	6	1	Hanger
17	160	Bend	9'2"			A53	6	1	
18	170				13'8"	A53	6	1	Anchor

Pipe material A53: A53 GRADE B

Density = 0.283 (lb/in3), Nu = 0.300, Joint factor = 1.00, Type = CS
Yield strength = 35000 (psi)
Tensile strength = 60000 (psi)

Temp (F)	E (psi)	Alpha (in/in/F)	Allowable (psi)
-20	29.9E+6	6.25E-6	20000
18	29.7E+6	6.31E-6	20000
70	29.4E+6	6.40E-6	20000
100	29.3E+6	6.47E-6	20000
200	28.8E+6	6.70E-6	20000
300	28.3E+6	6.90E-6	20000
400	27.4E+6	7.10E-6	19900
500	27.3E+6	7.30E-6	19000
600	26.5E+6	7.40E-6	17900
650	26.0E+6	7.50E-6	17300
700	25.5E+6	7.60E-6	16700
750	24.9E+6	7.70E-6	13900
800	24.2E+6	7.80E-6	11400
850	23.4E+6	7.85E-6	8700
900	22.5E+6	7.90E-6	5900
950	21.5E+6	8.00E-6	4000
1000	20.4E+6	8.10E-6	2500
1050	19.2E+6	8.15E-6	1600
1100	18.0E+6	8.20E-6	1000

Pipe Loads (1)

Name	T1 (F)	P1 (psi)	Desg.T (F)	Desg.Pr. (psi)	Specific gravity	Add.Wgt. (lb/ft)	Wind Load 1	Wind Load 2	Wind Load 3	Wind Load 4	Snow Load	Ice Load
1	316	70.0	388	200	0.8							

B31.3 (2022) Code compliance (Sorted stresses)

Sustained				Expansion			
Node	SL (psi)	SH (psi)	SL / SH	Node	SE (psi)	SA (psi)	SE / SA
170	3913	19984	0.20	80B	6203	29996	0.21
40	2742	19984	0.14	80A	5877	29996	0.20
20A	2679	19984	0.13	70	4872	29996	0.16
20B	2219	19984	0.11	30B	3518	29996	0.12
150	2146	19984	0.11	120B	3401	29996	0.11
140B	2012	19984	0.10	110	3400	29996	0.11
160A	1685	19984	0.08	120A	3172	29996	0.11
120A	1641	19984	0.08	100	3054	29996	0.10
130B	1552	19984	0.08	10	3035	29996	0.10
50B	1536	19984	0.08	30A	2978	29996	0.10
130A	1509	19984	0.08	50A	2940	29996	0.10
160B	1396	19984	0.07	160A	2863	29996	0.10
50A	1319	19984	0.07	170	2722	29996	0.09
30B	1280	19984	0.06	50B	2701	29996	0.09
10	1262	19984	0.06	160B	2524	29996	0.08
30A	1222	19984	0.06	20A	2344	29996	0.08
120B	1133	19984	0.06	20B	1968	29996	0.07
100	1058	19984	0.05	130A	1941	29996	0.06
140A	993	19984	0.05	60	1866	29996	0.06
90	970	19984	0.05	130B	1707	29996	0.06
110	889	19984	0.04	90	825	29996	0.03
60	810	19984	0.04	140B	739	29996	0.02
80B	464	19984	0.02	140A	597	29996	0.02
80A	375	19984	0.02	40	554	29996	0.02
70	270	19984	0.01	150	210	29996	0.01

B31.3 (2022) Code Compliance

	Press.	Sustained			Expansion		
Node	Allow. (psi)	SL (psi)	SH (psi)	SL / SH	SE (psi)	SA (psi)	SE / SA
10	200	1262	19984	0.06	3035	29996	0.10
20A	1742	1732	19984	0.09	1210	29996	0.04
20A	200	2679	19984	0.13	2344	29996	0.08
20B	1742	2219	19984	0.11	1968	29996	0.07
20B	200	1500	19984	0.08	1330	29996	0.04
30A	1742	994	19984	0.05	1657	29996	0.06
30A	200	1222	19984	0.06	2978	29996	0.10
30B	1742	1280	19984	0.06	3518	29996	0.12
30B	200	1061	19984	0.05	1673	29996	0.06
40	1742	2742	19984	0.14	554	29996	0.02

B31.3 (2022) Code Compliance

Node	Press. Allow. (psi)	Sustained SL (psi)	Sustained SH (psi)	Sustained SL/SH	Expansion SE (psi)	Expansion SA (psi)	Expansion SE/SA
40	200	2742	19984	0.14	554	29996	0.02
50A	1742	1070	19984	0.05	1337	29996	0.04
50A	200	1319	19984	0.07	2940	29996	0.10
50B	1742	1536	19984	0.08	2701	29996	0.09
50B	200	1178	19984	0.06	1278	29996	0.04
60	1742	810	19984	0.04	1866	29996	0.06
70	200	270	19984	0.01	4872	29996	0.16
80A	1742	365	19984	0.02	2616	29996	0.09
80A	200	375	19984	0.02	5877	29996	0.20
80B	1742	464	19984	0.02	6203	29996	0.21
80B	200	422	19984	0.02	2772	29996	0.09
90	1742	970	19984	0.05	825	29996	0.03
90	200	970	19984	0.05	825	29996	0.03
100	1742	1058	19984	0.05	3054	29996	0.10
110	200	889	19984	0.04	3400	29996	0.11
120A	1742	1256	19984	0.06	1500	29996	0.05
120A	200	1641	19984	0.08	3172	29996	0.11
120B	1742	1133	19984	0.06	3401	29996	0.11
120B	200	1065	19984	0.05	1628	29996	0.05
130A	1742	1313	19984	0.07	1065	29996	0.04
130A	200	1509	19984	0.08	1941	29996	0.06
130B	1742	1552	19984	0.08	1707	29996	0.06
130B	200	1316	19984	0.07	886	29996	0.03
140A	1742	955	19984	0.05	458	29996	0.02
140A	200	993	19984	0.05	597	29996	0.02
140B	1742	2012	19984	0.10	739	29996	0.02
140B	200	1561	19984	0.08	400	29996	0.01
150	1742	2146	19984	0.11	210	29996	0.01
150	200	2146	19984	0.11	210	29996	0.01
160A	1742	1326	19984	0.07	1315	29996	0.04
160A	200	1685	19984	0.08	2863	29996	0.10
160B	1742	1396	19984	0.07	2524	29996	0.08
160B	200	1241	19984	0.06	1222	29996	0.04
170	1742	3913	19984	0.20	2722	29996	0.09

Hanger Report

Node	No of	Type	Figure No.	Size	Spring rate (lb/inch)	Vert travel (inch)	Horz travel (inch)	Hot load (lb)	Cold load (lb)	Var (%)
40	1	Grinnell	B-268	8	150	0.162	0.155	680	705	3
90	1	Grinnell	B-268	6	84	0.235	0.274	370	390	5
150	1	Grinnell	B-268	8	150	0.268	0.301	680	721	5

Support load summary for anchor at node 10

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)	FR (lb)	MR (ft-lb)	Displacem X (inch)	Y (i
Empty W	-5	-491	-14	200	132	-400	492	466	0.000	0.0
Sustained	-20	-809	2	347	143	-640	809	742	0.000	0.0

Support load summary for anchor at node 10

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)	FR (lb)	MR (ft-lb)	Displacem X (inch)	Y (i
Operating1	-121	-874	165	2179	-119	435	898	2225	0.000	0.0
Maximum	-5	-491	165	2179	143	435	898	2225	0.000	0.0
Minimum	-121	-874	-14	200	-119	-640	492	466	0.000	0.0
Allowables	0	0	0	0	0	0	0	0	0.000	0.0

Support load summary for anchor at node 60

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)	FR (lb)	MR (ft-lb)	Displacem X (inch)	Y (i
Empty W	5	-45	14	62	255	-1214	48	1242	0.000	0.0
Sustained	20	-253	-2	208	204	192	254	349	0.000	0.0
Operating1	121	-209	-165	-135	-946	-329	293	1011	0.000	0.0
Maximum	121	-45	14	208	255	192	293	1242	0.000	0.0
Minimum	5	-253	-165	-135	-946	-1214	48	349	0.000	0.0
Allowables	0	0	0	0	0	0	0	0	0.000	0.0

Support load summary for anchor at node 70

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)	FR (lb)	MR (ft-lb)	Displacem X (inch)	Y (i
Empty W	13	-317	0	0	0	-72	317	72	0.000	0.0
Sustained	1	-559	0	0	0	-6	559	6	0.000	0.0
Operating1	-343	-777	0	0	0	3416	849	3416	0.000	0.0
Maximum	13	-317	0	0	0	3416	849	3416	0.000	0.0
Minimum	-343	-777	0	0	0	-72	317	6	0.000	0.0
Allowables	0	0	0	0	0	0	0	0	0.000	0.0

Support load summary for anchor at node 100

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)	FR (lb)	MR (ft-lb)	Displacem X (inch)	Y (i
Empty W	-13	-103	0	0	0	35	104	35	0.000	0.0
Sustained	-1	-222	0	0	0	492	222	492	0.000	0.0
Operating1	343	-23	0	0	0	-1627	344	1627	0.000	0.0
Maximum	343	-23	0	0	0	492	344	1627	0.000	0.0
Minimum	-13	-222	0	0	0	-1627	104	35	0.000	0.0
Allowables	0	0	0	0	0	0	0	0	0.000	0.0

Support load summary for anchor at node 110

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)	FR (lb)	MR (ft-lb)	Displacem X (inch)	Y (i
Empty W	35	-313	24	-179	-135	-176	316	285	0.000	0.0
Sustained	3	-609	15	-382	-150	-201	609	457	0.000	0.0
Operating1	-193	-697	-85	-1554	194	1860	728	2432	0.000	0.0
Maximum	35	-313	24	-179	194	1860	728	2432	0.000	0.0
Minimum	-193	-697	-85	-1554	-150	-201	316	285	0.000	0.0
Allowables	0	0	0	0	0	0	0	0	0.000	0.0

Support load summary for anchor at node 170

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)	FR (lb)	MR (ft-lb)	Displacem X (inch)	Y (i
Empty W	-35	-165	-24	-687	259	-614	171	957	0.000	0.0

Support load summary for anchor at node 170

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)	FR (lb)	MR (ft-lb)	Displacem X (inch)	Y (i
Sustained	-3	-375	-15	-2431	-107	-656	375	2520	0.000	0.0
Operating1	193	-323	85	-1801	-1876	-1034	385	2799	0.000	0.0
Maximum	193	-165	85	-687	259	-614	385	2799	0.000	0.0
Minimum	-35	-375	-24	-2431	-1876	-1034	171	957	0.000	0.0
Allowables	0	0	0	0	0	0	0	0	0.000	0.0

Support load summary for hanger at node 40

Load combination	Load (lb)	Displacements (global) X (inch)	Y (inch)	Z (inch)
Empty W	-682	0.033	0.152	0.034
Sustained	-702	0.057	0.016	0.037
Operating1	-680	-0.132	0.162	0.082
Maximum	-680	0.057	0.162	0.082
Minimum	-702	-0.132	0.016	0.034

Support load summary for hanger at node 90

Load combination	Load (lb)	Displacements (global) X (inch)	Y (inch)	Z (inch)
Empty W	-388	0.000	0.018	0.000
Sustained	-389	0.000	0.003	0.000
Operating1	-370	-0.274	0.235	0.000
Maximum	-370	0.000	0.235	0.000
Minimum	-389	-0.274	0.003	0.000

Support load summary for hanger at node 150

Load combination	Load (lb)	Displacements (global) X (inch)	Y (inch)	Z (inch)
Empty W	-695	-0.019	0.170	-0.032
Sustained	-717	0.024	0.027	-0.059
Operating1	-680	0.005	0.268	-0.301
Maximum	-680	0.024	0.268	-0.032
Minimum	-717	-0.019	0.027	-0.301

Loads on Anchors in Global Coordinates: Empty Weight (W)

Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10		-5	-491	-14	200	132	-400
60		5	-45	14	62	255	-1214
70		13	-317	0	0	0	-72
100		-13	-103	0	0	0	35
110		35	-313	24	-179	-135	-176
170		-35	-165	-24	-687	259	-614

Loads on Anchors in Local Coordinates: Empty Weight (W)

Node	Tag	fx (lb)	fy (lb)	fz (lb)	mx (ft-lb)	my (ft-lb)	mz (ft-lb)
10		-491	5	-14	132	-200	-400

Loads on Anchors in Local Coordinates: Empty Weight (W)

Node	Tag	fx (lb)	fy (lb)	fz (lb)	mx (ft-lb)	my (ft-lb)	mz (ft-lb)
60		5	-45	14	62	255	-1214
70		-317	-13	0	0	0	-72
100		-13	-103	0	0	0	35
110		-313	-35	24	-135	179	-176
170		-24	-165	35	-614	259	687

Loads on Hangers: Empty Weight (W)

Node	Tag	Type	Load (lb)	No.of	Total (lb)
40		Grinnell	-682	1	-682
90		Grinnell	-388	1	-388
150		Grinnell	-695	1	-695

Pipe forces in local coordinates: Empty Weight (W)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors		
				Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt
10	-491	5	-14	132		-400		-200				
20A	-151	5	-14	132		-473		-420				
20A	-151	-5	14	132	1.00	473	2.27	420	1.89	6.59	6.59	
20B	-5	124	14	431	1.00	376	2.27	-121	1.89	6.59	6.59	
20B	-5	-124	-14	431		-376		121				
30A	-5	12	-14	431		-33		33				
30A	-5	14	12	431	1.00	33	2.27	33	1.89	6.59	6.59	
30B	14	5	38	49	1.00	18	2.27	-410	1.89	6.59	6.59	
30B	14	38	-5	49		410		18				
40	14	317	-5	49		-1809		-41				
40	14	-365	-5	49		-1809		-41				
50A	14	-251	-5	49		-243		-66				
50A	14	-5	251	49	1.00	66	2.27	-243	1.89	6.59	6.59	
50B	-5	-14	225	-62	1.00	80	2.27	127	1.89	6.59	6.59	
50B	-5	-225	-14	-62		127		-80				
60	-5	45	-14	-62		1214		-255				
70	-317	-13	0	0		-72		0				
80A	24	-13	0	0		130		0				
80A	24	13	0	0	1.00	-130	2.27	0	1.89	6.59	6.59	
80B	13	-50	0	0	1.00	-109	2.27	0	1.89	6.59	6.59	
80B	13	50	0	0		109		0				
90	13	192	0	0		-658		0				
90	13	-196	0	0		-658		0				
100	13	103	0	0		-35		0				
110	-313	-35	24	-135		-176		179				
120A	27	-35	24	-135		359		550				
120A	27	35	-24	-135	1.00	-359	2.27	-550	1.89	6.59	6.59	
120B	35	-54	-24	-568	1.00	-353	2.27	116	1.89	6.59	6.59	
120B	35	54	24	-568		353		-116				
130A	35	223	24	-568		-696		68				
130A	35	24	-223	-568	1.00	-68	2.27	-696	1.89	6.59	6.59	
130B	24	-35	-249	-871	1.00	-60	2.27	389	1.89	6.59	6.59	
130B	24	249	-35	-871		389		60				
140A	24	303	-35	-871		-279		-25				

Pipe forces in local coordinates: Empty Weight (W)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors		
				Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt
140A	24	35	303	-871	1.00	-25	2.27	279	1.89	6.59	6.59	
140B	35	-24	330	514	1.00	-33	2.27	1111	1.89	6.59	6.59	
140B	35	330	24	514		-1111		-33				
150	35	358	24	514		-1541		-2				
150	35	-338	24	514		-1541		-2				
160A	35	-149	24	514		509		203				
160A	35	24	149	514	1.00	-203	2.27	509	1.89	6.59	6.59	
160B	24	-35	123	614	1.00	-195	2.27	-415	1.89	6.59	6.59	
160B	24	-123	-35	614		-415		195				
170	24	165	-35	614		-687		-259				

Pipe forces in global coordinates: Empty Weight (W)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10	5	491	14	-200	-132	400
20A	-5	-151	-14	420	132	-473
20A	5	151	14	-420	-132	473
20B	-5	-124	-14	431	121	-376
20B	5	124	14	-431	-121	376
30A	-5	12	-14	431	33	-33
30A	5	-12	14	-431	-33	33
30B	-5	38	-14	410	18	-49
30B	5	-38	14	-410	-18	49
40	-5	317	-14	-1809	-41	-49
40	5	365	14	1809	41	49
50A	-5	-251	-14	-243	-66	-49
50A	5	251	14	243	66	49
50B	-5	-225	-14	-62	-80	127
50B	5	225	14	62	80	-127
60	-5	45	-14	-62	-255	1214
70	-13	317	0	0	0	72
80A	13	24	0	0	0	130
80A	-13	-24	0	0	0	-130
80B	13	50	0	0	0	109
80B	-13	-50	0	0	0	-109
90	13	192	0	0	0	-658
90	-13	196	0	0	0	658
100	13	103	0	0	0	-35
110	-35	313	-24	179	135	176
120A	35	27	24	-550	-135	359
120A	-35	-27	-24	550	135	-359
120B	35	54	24	-568	-116	353
120B	-35	-54	-24	568	116	-353
130A	35	223	24	-568	68	-696
130A	-35	-223	-24	568	-68	696
130B	35	249	24	-389	60	-871
130B	-35	-249	-24	389	-60	871
140A	35	303	24	279	-25	-871

Pipe forces in global coordinates: Empty Weight (W)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
140A	-35	-303	-24	-279	25	871
140B	35	330	24	514	-33	-1111
140B	-35	-330	-24	-514	33	1111
150	35	358	24	514	-2	-1541
150	-35	338	-24	-514	2	1541
160A	35	-149	24	514	203	509
160A	-35	149	-24	-514	-203	-509
160B	35	-123	24	415	195	614
160B	-35	123	-24	-415	-195	-614
170	35	165	24	687	-259	614

Displacements: Empty Weight (W)

	Displacements (global)					
Node	X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
10	0.000	0.000	0.000	0.0000	0.0000	0.0000
20A	0.103	-0.000	0.066	0.0472	0.0260	-0.0664
20B	0.115	-0.014	0.071	0.0644	0.0234	-0.1002
30A	0.115	-0.150	0.038	0.0984	0.0280	-0.1085
30B	0.111	-0.149	0.034	0.1171	0.0299	-0.1019
40	0.033	0.152	0.034	0.0661	0.0285	-0.1098
50A	0.004	0.188	0.034	0.0165	0.0258	-0.1131
50B	0.000	0.172	0.030	0.0097	0.0202	-0.1135
60	0.000	0.000	0.000	0.0000	0.0000	0.0000
70	0.000	0.000	0.000	0.0000	0.0000	0.0000
80A	0.001	-0.000	0.000	0.0000	0.0000	0.0044
80B	0.000	0.002	0.000	0.0000	0.0000	0.0141
90	0.000	0.018	0.000	0.0000	0.0000	0.0015
100	0.000	0.000	0.000	0.0000	0.0000	0.0000
110	0.000	0.000	0.000	0.0000	0.0000	0.0000
120A	-0.000	-0.000	-0.073	-0.0554	-0.0266	0.0139
120B	-0.004	0.005	-0.080	-0.0788	-0.0213	0.0422
130A	-0.004	0.079	-0.043	-0.1347	-0.0231	0.0373
130B	-0.007	0.104	-0.040	-0.1408	-0.0177	0.0112
140A	-0.016	0.177	-0.040	-0.1424	-0.0172	-0.0161
140B	-0.019	0.190	-0.037	-0.1053	-0.0199	-0.0707
150	-0.019	0.170	-0.032	-0.0970	-0.0201	-0.0871
160A	-0.019	-0.038	-0.001	-0.0409	-0.0117	-0.1194
160B	-0.019	-0.050	0.000	-0.0309	0.0041	-0.1028
170	0.000	0.000	0.000	0.0000	0.0000	0.0000

Loads on Anchors in Global Coordinates: Sustained (W+P)

Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10		-20	-809	2	347	143	-640
60		20	-253	-2	208	204	192
70		1	-559	0	0	0	-6
100		-1	-222	0	0	0	492

Loads on Anchors in Global Coordinates: Sustained (W+P)

Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
110		3	-609	15	-382	-150	-201
170		-3	-375	-15	-2431	-107	-656

Loads on Anchors in Local Coordinates: Sustained (W+P)

Node	Tag	fx (lb)	fy (lb)	fz (lb)	mx (ft-lb)	my (ft-lb)	mz (ft-lb)
10		-809	20	2	143	-347	-640
60		20	-253	-2	208	204	192
70		-559	-1	0	0	0	-6
100		-1	-222	0	0	0	492
110		-609	-3	15	-150	382	-201
170		-15	-375	3	-656	-107	2431

Loads on Hangers: Sustained (W+P)

Node	Tag	Type	Load (lb)	No.of	Total (lb)
40		Grinnell	-702	1	-702
90		Grinnell	-389	1	-389
150		Grinnell	-717	1	-717

Pipe forces in local coordinates: Sustained (W+P)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors			SL (psi)
				Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt	
10	-809	20	2	143		-640		-347					1262
20A	-315	20	2	143		-950		-317					1732
20A	-315	-20	-2	143	1.00	950	2.27	317	1.89	6.59	6.59		2679
20B	-20	277	-2	315	1.00	746	2.27	-145	1.89	6.59	6.59		2219
20B	-20	-277	2	315		-746		145					1500
30A	-20	-80	2	315		341		156					994
30A	-20	-2	-80	315	1.00	156	2.27	-341	1.89	6.59	6.59		1222
30B	-2	20	-42	-391	1.00	143	2.27	-358	1.89	6.59	6.59		1280
30B	-2	-42	-20	-391		358		143					1061
40	-2	362	-20	-391		-1641		-111					2742
40	-2	-340	-20	-391		-1641		-111					2742
50A	-2	-176	-20	-391		-329		-214					1070
50A	-2	-20	176	-391	1.00	214	2.27	-329	1.89	6.59	6.59		1319
50B	-20	2	138	-208	1.00	228	2.27	505	1.89	6.59	6.59		1536
50B	-20	-138	2	-208		505		-228					1178
60	-20	253	2	-208		-192		-204					810
70	-559	-1	0	0		-6		0					270
80A	-66	-1	0	0		10		0					365
80A	-66	1	0	0	1.00	-10	2.27	0	1.89	6.59	6.59		375
80B	1	28	0	0	1.00	-42	2.27	0	1.89	6.59	6.59		464
80B	1	-28	0	0		42		0					422
90	1	177	0	0		-430		0					970
90	1	-212	0	0		-430		0					970
100	1	222	0	0		-492		0					1058
110	-609	-3	15	-150		-201		382					889
120A	-115	-3	15	-150		-156		615					1256
120A	-115	3	-15	-150	1.00	156	2.27	-615	1.89	6.59	6.59		1641
120B	3	77	-15	-627	1.00	85	2.27	139	1.89	6.59	6.59		1133

Pipe forces in local coordinates: Sustained (W+P)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors			SL (psi)
				Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt	
120B	3	-77	15	-627		-85		-139					1065
130A	3	168	15	-627		-429		-23					1313
130A	3	15	-168	-627	1.00	23	2.27	-429	1.89	6.59	6.59		1509
130B	15	-3	-206	-565	1.00	14	2.27	482	1.89	6.59	6.59		1552
130B	15	206	-3	-565		482		-14					1316
140A	15	284	-3	-565		-110		-21					955
140A	15	3	284	-565	1.00	-21	2.27	110	1.89	6.59	6.59		993
140B	3	-15	322	334	1.00	-12	2.27	797	1.89	6.59	6.59		2012
140B	3	322	15	334		-797		-12					1561
150	3	363	15	334		-1225		7					2146
150	3	-354	15	334		-1225		7					2146
160A	3	-81	15	334		606		136					1326
160A	3	15	81	334	1.00	-136	2.27	606	1.89	6.59	6.59		1685
160B	15	-3	43	656	1.00	-145	2.27	-291	1.89	6.59	6.59		1396
160B	15	-43	-3	656		-291		145					1241
170	15	375	-3	656		-2431		107					3913

Pipe forces in global coordinates: Sustained (W+P)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10	20	809	-2	-347	-143	640
20A	-20	-315	2	317	143	-950
20A	20	315	-2	-317	-143	950
20B	-20	-277	2	315	145	-746
20B	20	277	-2	-315	-145	746
30A	-20	-80	2	315	156	341
30A	20	80	-2	-315	-156	-341
30B	-20	-42	2	358	143	391
30B	20	42	-2	-358	-143	-391
40	-20	362	2	-1641	-111	391
40	20	340	-2	1641	111	-391
50A	-20	-176	2	-329	-214	391
50A	20	176	-2	329	214	-391
50B	-20	-138	2	-208	-228	505
50B	20	138	-2	208	228	-505
60	-20	253	2	-208	-204	-192
70	-1	559	0	0	0	6
80A	1	-66	0	0	0	10
80A	-1	66	0	0	0	-10
80B	1	-28	0	0	0	42
80B	-1	28	0	0	0	-42
90	1	177	0	0	0	-430
90	-1	212	0	0	0	430
100	1	222	0	0	0	-492
110	-3	609	-15	382	150	201
120A	3	-115	15	-615	-150	-156
120A	-3	115	-15	615	150	156
120B	3	-77	15	-627	-139	-85

Pipe forces in global coordinates: Sustained (W+P)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
120B	-3	77	-15	627	139	85
130A	3	168	15	-627	-23	-429
130A	-3	-168	-15	627	23	429
130B	3	206	15	-482	-14	-565
130B	-3	-206	-15	482	14	565
140A	3	284	15	110	-21	-565
140A	-3	-284	-15	-110	21	565
140B	3	322	15	334	-12	-797
140B	-3	-322	-15	-334	12	797
150	3	363	15	334	7	-1225
150	-3	354	-15	-334	-7	1225
160A	3	-81	15	334	136	606
160A	-3	81	-15	-334	-136	-606
160B	3	-43	15	291	145	656
160B	-3	43	-15	-291	-145	-656
170	3	375	15	2431	107	656

Displacements: Sustained (W+P)

	Displacements (global)					
Node	X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
10	0.000	0.000	0.000	0.0000	0.0000	0.0000
20A	0.180	-0.001	0.082	0.0504	0.0283	-0.1209
20B	0.203	-0.027	0.086	0.0623	0.0287	-0.1889
30A	0.203	-0.279	0.044	0.0871	0.0378	-0.1951
30B	0.196	-0.292	0.037	0.1103	0.0496	-0.1715
40	0.057	0.016	0.037	0.0828	0.0516	-0.1081
50A	0.006	0.073	0.037	0.0364	0.0433	-0.0823
50B	0.000	0.066	0.032	0.0325	0.0260	-0.0663
60	0.000	0.000	0.000	0.0000	0.0000	0.0000
70	0.000	0.000	0.000	0.0000	0.0000	0.0000
80A	0.000	-0.000	0.000	0.0000	0.0000	0.0003
80B	0.000	-0.000	0.000	0.0000	0.0000	0.0022
90	0.000	0.003	0.000	0.0000	0.0000	-0.0033
100	0.000	0.000	0.000	0.0000	0.0000	0.0000
110	0.000	0.000	0.000	0.0000	0.0000	0.0000
120A	0.045	-0.000	-0.112	-0.0758	-0.0297	-0.0271
120B	0.050	-0.006	-0.122	-0.1017	-0.0241	-0.0370
130A	0.050	-0.067	-0.077	-0.1633	-0.0302	-0.0447
130B	0.045	-0.048	-0.073	-0.1788	-0.0315	-0.0561
140A	0.029	0.044	-0.073	-0.1837	-0.0319	-0.0738
140B	0.024	0.057	-0.067	-0.1609	-0.0333	-0.1104
150	0.024	0.027	-0.059	-0.1555	-0.0333	-0.1230
160A	0.024	-0.222	-0.004	-0.1191	-0.0273	-0.1329
160B	0.021	-0.222	0.000	-0.1174	-0.0162	-0.1099
170	0.000	0.000	0.000	0.0000	0.0000	0.0000

Loads on Anchors in Global Coordinates: Expansion (T1)

Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10		-101	-66	163	1832	-262	1075
60		101	44	-163	-343	-1151	-522
70		-344	-218	0	0	0	3421
100		344	198	0	0	0	-2119
110		-196	-88	-100	-1172	344	2061
170		196	52	100	630	-1769	-378

Loads on Anchors in Local Coordinates: Expansion (T1)

Node	Tag	fx (lb)	fy (lb)	fz (lb)	mx (ft-lb)	my (ft-lb)	mz (ft-lb)
10		-66	101	163	-262	-1832	1075
60		101	44	-163	-343	-1151	-522
70		-218	344	0	0	0	3421
100		344	198	0	0	0	-2119
110		-88	196	-100	344	1172	2061
170		100	52	-196	-378	-1769	-630

Loads on Hangers: Expansion (T1)

Node	Tag	Type	Load (lb)	No.of	Total (lb)
40		Grinnell	22	1	22
90		Grinnell	20	1	20
150		Grinnell	36	1	36

Pipe forces in local coordinates: Expansion (T1)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors			SE (psi)	SA (psi)
				Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt		
10	-66	101	163	-262		1075		-1832					3035	30000
20A	-66	101	163	-262		-463		661					1210	30000
20A	-66	-101	-163	-262	1.00	463	2.27	-661	1.89	6.59	6.59		2344	30000
20B	-101	66	-163	-784	1.00	489	2.27	139	1.89	6.59	6.59		1968	30000
20B	-101	-66	163	-784		-489		-139					1330	30000
30A	-101	-66	163	-784		-89		855					1657	30000
30A	-101	-163	-66	-784	1.00	855	2.27	89	1.89	6.59	6.59		2978	30000
30B	-163	101	-66	40	1.00	902	2.27	734	1.89	6.59	6.59		3518	30000
30B	-163	-66	-101	40		-734		902					1673	30000
40	-163	-66	-101	40		88		-359					554	30000
40	-163	-44	-101	40		88		-359					554	30000
50A	-163	-44	-101	40		310		-872					1337	30000
50A	-163	-101	44	40	1.00	872	2.27	310	1.89	6.59	6.59		2940	30000
50B	-101	163	44	343	1.00	825	2.27	-7	1.89	6.59	6.59		2701	30000
50B	-101	-44	163	343		-7		-825					1278	30000
60	-101	-44	163	343		522		1151					1866	30000
70	-218	344	0	0		3421		0					4872	30000
80A	-218	344	0	0		-1824		0					2616	30000
80A	-218	-344	0	0	1.00	1824	2.27	0	1.89	6.59	6.59		5877	30000
80B	-344	218	0	0	1.00	1919	2.27	0	1.89	6.59	6.59		6203	30000
80B	-344	-218	0	0		-1919		0					2772	30000
90	-344	-218	0	0		-540		0					825	30000
90	-344	-198	0	0		-540		0					825	30000
100	-344	-198	0	0		2119		0					3054	30000

Pipe forces in local coordinates: Expansion (T1)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors			SE (psi)	SA (psi)
				Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt		
110	-88	196	-100	344		2061		1172					3400	30000
120A	-88	196	-100	344		-929		-352					1500	30000
120A	-88	-196	100	344	1.00	929	2.27	352	1.89	6.59	6.59		3172	30000
120B	-196	88	100	427	1.00	1010	2.27	-269	1.89	6.59	6.59		3401	30000
120B	-196	-88	-100	427		-1010		269					1628	30000
130A	-196	-88	-100	427		-342		-489					1065	30000
130A	-196	-100	88	427	1.00	489	2.27	-342	1.89	6.59	6.59		1941	30000
130B	-100	196	88	-276	1.00	417	2.27	-361	1.89	6.59	6.59		1707	30000
130B	-100	-88	196	-276		-361		-417					886	30000
140A	-100	-88	196	-276		-148		57					458	30000
140A	-100	-196	-88	-276	1.00	57	2.27	148	1.89	6.59	6.59		597	30000
140B	-196	100	-88	82	1.00	129	2.27	209	1.89	6.59	6.59		739	30000
140B	-196	-88	-100	82		-209		129					400	30000
150	-196	-88	-100	82		-99		4					210	30000
150	-196	-52	-100	82		-99		4					210	30000
160A	-196	-52	-100	82		339		-837					1315	30000
160A	-196	-100	52	82	1.00	837	2.27	339	1.89	6.59	6.59		2863	30000
160B	-100	196	52	378	1.00	764	2.27	-43	1.89	6.59	6.59		2524	30000
160B	-100	-52	196	378		-43		-764					1222	30000
170	-100	-52	196	378		630		1769					2722	30000

Pipe forces in global coordinates: Expansion (T1)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10	101	66	-163	-1832	262	-1075
20A	-101	-66	163	-661	-262	-463
20A	101	66	-163	661	262	463
20B	-101	-66	163	-784	-139	-489
20B	101	66	-163	784	139	489
30A	-101	-66	163	-784	855	-89
30A	101	66	-163	784	-855	89
30B	-101	-66	163	-734	902	-40
30B	101	66	-163	734	-902	40
40	-101	-66	163	88	-359	-40
40	101	44	-163	-88	359	40
50A	-101	-44	163	310	-872	-40
50A	101	44	-163	-310	872	40
50B	-101	-44	163	343	-825	-7
50B	101	44	-163	-343	825	7
60	-101	-44	163	343	1151	522
70	344	218	0	0	0	-3421
80A	-344	-218	0	0	0	-1824
80A	344	218	0	0	0	1824
80B	-344	-218	0	0	0	-1919
80B	344	218	0	0	0	1919
90	-344	-218	0	0	0	-540
90	344	198	0	0	0	540
100	-344	-198	0	0	0	2119

Pipe forces in global coordinates: Expansion (T1)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
110	196	88	100	1172	-344	-2061
120A	-196	-88	-100	352	344	-929
120A	196	88	100	-352	-344	929
120B	-196	-88	-100	427	269	-1010
120B	196	88	100	-427	-269	1010
130A	-196	-88	-100	427	-489	-342
130A	196	88	100	-427	489	342
130B	-196	-88	-100	361	-417	-276
130B	196	88	100	-361	417	276
140A	-196	-88	-100	148	57	-276
140A	196	88	100	-148	-57	276
140B	-196	-88	-100	82	129	-209
140B	196	88	100	-82	-129	209
150	-196	-88	-100	82	4	-99
150	196	52	100	-82	-4	99
160A	-196	-52	-100	82	-837	339
160A	196	52	100	-82	837	-339
160B	-196	-52	-100	43	-764	378
160B	196	52	100	-43	764	-378
170	-196	-52	-100	-630	1769	378

Displacements: Expansion (T1)

	Displacements (global)					
Node	X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
10	0.000	0.000	0.000	0.0000	0.0000	0.0000
20A	-0.137	0.312	0.244	0.0890	-0.0518	0.0466
20B	-0.127	0.331	0.263	0.0600	-0.0464	0.0084
30A	-0.003	0.328	0.315	-0.0018	-0.0246	-0.0092
30B	0.010	0.322	0.300	-0.0381	0.0455	-0.0274
40	-0.189	0.147	0.044	-0.0784	0.0793	-0.0338
50A	-0.259	0.068	-0.060	-0.0683	0.0481	-0.0365
50B	-0.247	0.053	-0.076	-0.0537	-0.0196	-0.0310
60	0.000	0.000	0.000	0.0000	0.0000	0.0000
70	0.000	0.000	0.000	0.0000	0.0000	0.0000
80A	-0.408	0.312	0.000	0.0000	0.0000	0.1214
80B	-0.404	0.331	0.000	0.0000	0.0000	-0.0279
90	-0.274	0.233	0.000	0.0000	0.0000	-0.1056
100	0.000	0.000	0.000	0.0000	0.0000	0.0000
110	0.000	0.000	0.000	0.0000	0.0000	0.0000
120A	-0.260	0.312	-0.162	-0.0623	0.0680	0.0861
120B	-0.254	0.333	-0.182	-0.0506	0.0742	0.0087
130A	-0.098	0.299	-0.301	-0.0087	0.0659	-0.0424
130B	-0.077	0.290	-0.294	0.0155	0.0285	-0.0647
140A	-0.064	0.281	-0.244	0.0216	0.0242	-0.0734
140B	-0.044	0.264	-0.233	0.0319	0.0337	-0.0866
150	-0.019	0.241	-0.243	0.0333	0.0346	-0.0885

Displacements: Expansion (T1)

Node	Displacements (global)					
	X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
160A	0.153	0.088	-0.283	0.0422	-0.0003	-0.0785
160B	0.162	0.071	-0.264	0.0378	-0.0647	-0.0633
170	0.000	0.000	0.000	0.0000	0.0000	0.0000

Loads on Anchors in Global Coordinates: Operating (W+P1+T1)

Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10		-121	-874	165	2179	-119	435
60		121	-209	-165	-135	-946	-329
70		-343	-777	0	0	0	3416
100		343	-23	0	0	0	-1627
110		-193	-697	-85	-1554	194	1860
170		193	-323	85	-1801	-1876	-1034

Loads on Anchors in Local Coordinates: Operating (W+P1+T1)

Node	Tag	fx (lb)	fy (lb)	fz (lb)	mx (ft-lb)	my (ft-lb)	mz (ft-lb)
10		-874	121	165	-119	-2179	435
60		121	-209	-165	-135	-946	-329
70		-777	343	0	0	0	3416
100		343	-23	0	0	0	-1627
110		-697	193	-85	194	1554	1860
170		85	-323	-193	-1034	-1876	1801

Loads on Hangers: Operating (W+P1+T1)

Node	Tag	Type	Load (lb)	No.of	Total (lb)
40		Grinnell	-680	1	-680
90		Grinnell	-370	1	-370
150		Grinnell	-680	1	-680

Pipe forces in local coordinates: Operating (W+P1+T1)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors			Sopr (psi)
				Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt	
10	-874	121	165	-119		435		-2179					3348
20A	-381	121	165	-119		-1413		344					2354
20A	-381	-121	-165	-119	1.00	1413	2.27	-344	1.89	6.59	6.59		2354
20B	-121	343	-165	-468	1.00	1236	2.27	-5	1.89	6.59	6.59		2188
20B	-121	-343	165	-468		-1236		5					2188
30A	-121	-146	165	-468		252		1012					1930
30A	-121	-165	-146	-468	1.00	1012	2.27	-252	1.89	6.59	6.59		1930
30B	-165	121	-108	-351	1.00	1045	2.27	377	1.89	6.59	6.59		1965
30B	-165	-108	-121	-351		-377		1045					1965
40	-165	296	-121	-351		-1553		-470					2671
40	-165	-384	-121	-351		-1553		-470					2671
50A	-165	-220	-121	-351		-19		-1086					1932
50A	-165	-121	220	-351	1.00	1086	2.27	-19	1.89	6.59	6.59		1932
50B	-121	165	181	135	1.00	1053	2.27	498	1.89	6.59	6.59		1995
50B	-121	-181	165	135		498		-1053					1995
60	-121	209	165	135		329		946					1766

Pipe forces in local coordinates: Operating (W+P1+T1)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb) Moment	Torsion(ft-lb) SIF	Inplane(ft-lb) Moment	Inplane(ft-lb) SIF	Outplane(ft-lb) Moment	Outplane(ft-lb) SIF	Flex. Factors FFi	Flex. Factors FFo	Flex. Factors FFt	Sopr (psi)
70	-777	343	0	0		3416		0					5048
80A	-284	343	0	0		-1814		0					2874
80A	-284	-343	0	0	1.00	1814	2.27	0	1.89	6.59	6.59		2874
80B	-343	246	0	0	1.00	1877	2.27	0	1.89	6.59	6.59		2952
80B	-343	-246	0	0		-1877		0					2952
90	-343	-41	0	0		-970		0					1671
90	-343	-411	0	0		-970		0					1671
100	-343	23	0	0		1627		0					2598
110	-697	193	-85	194		1860		1554					3672
120A	-204	193	-85	194		-1085		263					1922
120A	-204	-193	85	194	1.00	1085	2.27	-263	1.89	6.59	6.59		1922
120B	-193	165	85	-200	1.00	1095	2.27	-130	1.89	6.59	6.59		1907
120B	-193	-165	-85	-200		-1095		130					1907
130A	-193	80	-85	-200		-771		-512					1658
130A	-193	-85	-80	-200	1.00	512	2.27	-771	1.89	6.59	6.59		1658
130B	-85	193	-118	-841	1.00	430	2.27	122	1.89	6.59	6.59		1539
130B	-85	118	193	-841		122		-430					1539
140A	-85	196	193	-841		-258		36					1386
140A	-85	-193	196	-841	1.00	36	2.27	258	1.89	6.59	6.59		1386
140B	-193	85	234	415	1.00	118	2.27	1006	1.89	6.59	6.59		1854
140B	-193	234	-85	415		-1006		118					1854
150	-193	275	-85	415		-1324		12					2275
150	-193	-406	-85	415		-1324		12					2275
160A	-193	-133	-85	415		944		-701					2073
160A	-193	-85	133	415	1.00	701	2.27	944	1.89	6.59	6.59		2073
160B	-85	193	95	1034	1.00	619	2.27	-333	1.89	6.59	6.59		1983
160B	-85	-95	193	1034		-333		-619					1983
170	-85	323	193	1034		-1801		1876					4278

Pipe forces in global coordinates: Operating (W+P1+T1)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10	121	874	-165	-2179	119	-435
20A	-121	-381	165	-344	-119	-1413
20A	121	381	-165	344	119	1413
20B	-121	-343	165	-468	5	-1236
20B	121	343	-165	468	-5	1236
30A	-121	-146	165	-468	1012	252
30A	121	146	-165	468	-1012	-252
30B	-121	-108	165	-377	1045	351
30B	121	108	-165	377	-1045	-351
40	-121	296	165	-1553	-470	351
40	121	384	-165	1553	470	-351
50A	-121	-220	165	-19	-1086	351
50A	121	220	-165	19	1086	-351
50B	-121	-181	165	135	-1053	498
50B	121	181	-165	-135	1053	-498
60	-121	209	165	135	946	329

Pipe forces in global coordinates: Operating (W+P1+T1)

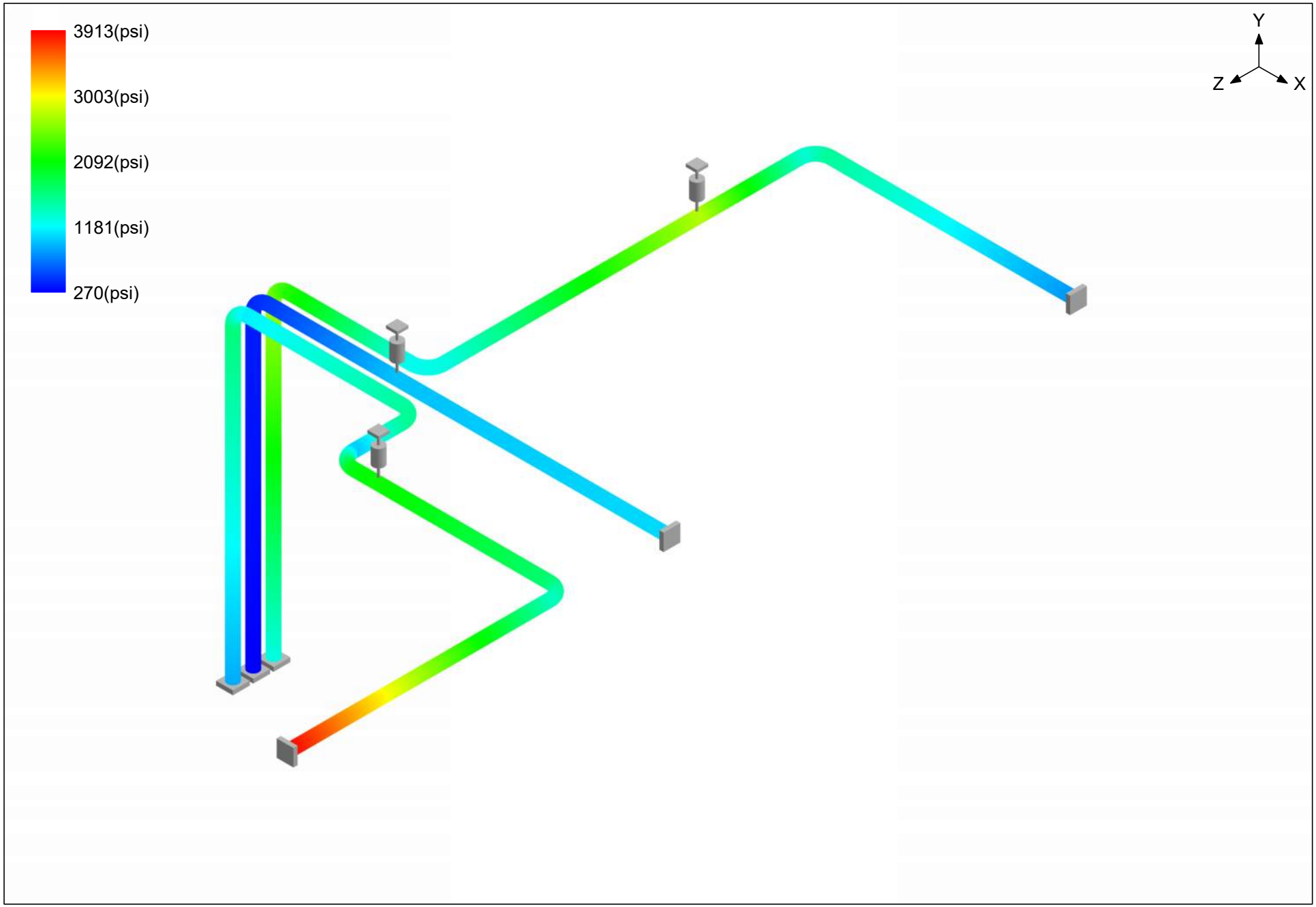
Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
70	343	777	0	0	0	-3416
80A	-343	-284	0	0	0	-1814
80A	343	284	0	0	0	1814
80B	-343	-246	0	0	0	-1877
80B	343	246	0	0	0	1877
90	-343	-41	0	0	0	-970
90	343	411	0	0	0	970
100	-343	23	0	0	0	1627
110	193	697	85	1554	-194	-1860
120A	-193	-204	-85	-263	194	-1085
120A	193	204	85	263	-194	1085
120B	-193	-165	-85	-200	130	-1095
120B	193	165	85	200	-130	1095
130A	-193	80	-85	-200	-512	-771
130A	193	-80	85	200	512	771
130B	-193	118	-85	-122	-430	-841
130B	193	-118	85	122	430	841
140A	-193	196	-85	258	36	-841
140A	193	-196	85	-258	-36	841
140B	-193	234	-85	415	118	-1006
140B	193	-234	85	-415	-118	1006
150	-193	275	-85	415	12	-1324
150	193	406	85	-415	-12	1324
160A	-193	-133	-85	415	-701	944
160A	193	133	85	-415	701	-944
160B	-193	-95	-85	333	-619	1034
160B	193	95	85	-333	619	-1034
170	-193	323	-85	1801	1876	1034

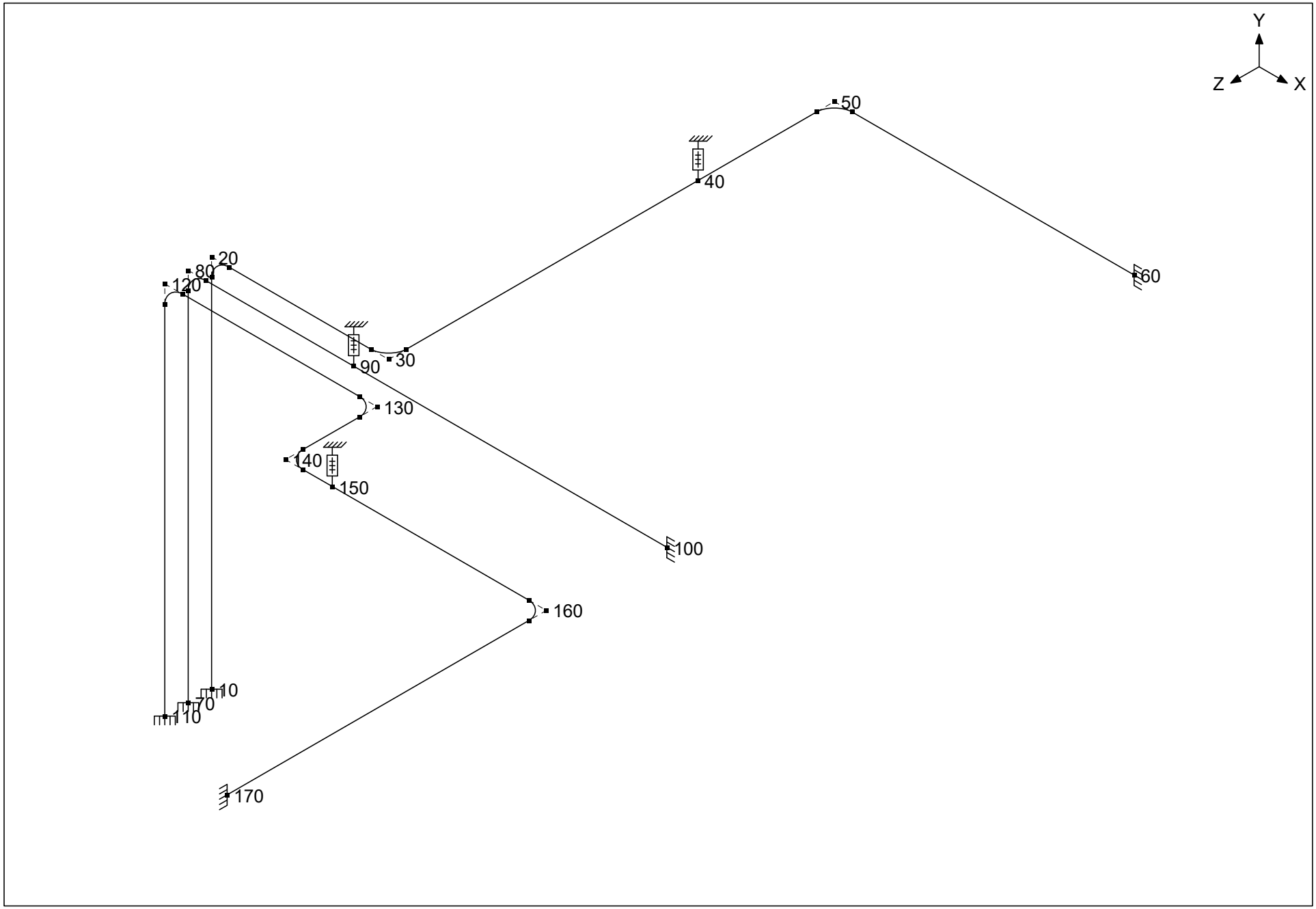
Displacements: Operating (W+P1+T1)

	Displacements (global)					
Node	X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
10	0.000	0.000	0.000	0.0000	0.0000	0.0000
20A	0.043	0.311	0.326	0.1395	-0.0235	-0.0743
20B	0.076	0.304	0.350	0.1222	-0.0176	-0.1805
30A	0.201	0.049	0.359	0.0853	0.0132	-0.2043
30B	0.206	0.030	0.337	0.0722	0.0951	-0.1988
40	-0.132	0.162	0.082	0.0044	0.1309	-0.1419
50A	-0.253	0.140	-0.022	-0.0319	0.0915	-0.1188
50B	-0.247	0.119	-0.043	-0.0212	0.0064	-0.0973
60	0.000	0.000	0.000	0.0000	0.0000	0.0000
70	0.000	0.000	0.000	0.0000	0.0000	0.0000
80A	-0.408	0.311	0.000	0.0000	0.0000	0.1218
80B	-0.404	0.331	0.000	0.0000	0.0000	-0.0258
90	-0.274	0.235	0.000	0.0000	0.0000	-0.1088
100	0.000	0.000	0.000	0.0000	0.0000	0.0000
110	0.000	0.000	0.000	0.0000	0.0000	0.0000

Displacements: Operating (W+P1+T1)

Node	Displacements (global)					
	X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
120A	-0.215	0.312	-0.273	-0.1382	0.0383	0.0590
120B	-0.204	0.327	-0.303	-0.1523	0.0501	-0.0283
130A	-0.048	0.232	-0.378	-0.1720	0.0357	-0.0871
130B	-0.031	0.242	-0.366	-0.1634	-0.0030	-0.1208
140A	-0.035	0.325	-0.317	-0.1621	-0.0077	-0.1472
140B	-0.020	0.321	-0.301	-0.1289	0.0005	-0.1971
150	0.005	0.268	-0.301	-0.1222	0.0013	-0.2115
160A	0.177	-0.133	-0.287	-0.0769	-0.0276	-0.2114
160B	0.183	-0.151	-0.264	-0.0796	-0.0809	-0.1732
170	0.000	0.000	0.000	0.0000	0.0000	0.0000


3913(psi)
3003(psi)
2092(psi)
1181(psi)
270(psi)
Y
Z
X


Y
Z
X
50
40
60
20
80
120
30
90
130
140
150
100
160
10
70
110
170