CASTCONNEX®

HIGH STRENGTH CONNECTOR™ (HSC) MANUAL

For Use With:
CSA S16-24

CAST CONNEX®

High Strength Connector™ Design Manual

for use with

CAN/CSA-S16-24

Cast Connex Corporation

Fourth Edition, First Printing

Cover photograph by Yi Yang of Summit Engineering, Santa Rosa, California.

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innovative components for inspired designs

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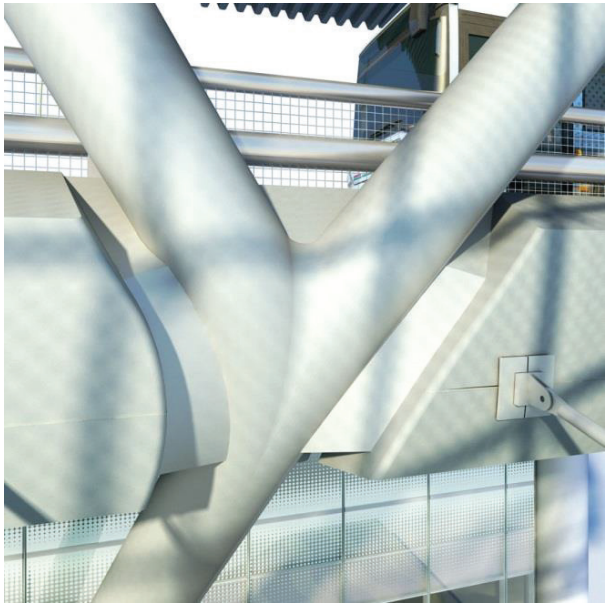


About High Strength Connectors

Concentrically braced frames are amongst the most popular lateral force resisting systems for medium- to low-rise steel structures. In the event of an earthquake, the diagonal brace members of braced frames dissipate seismic energy through yielding in tension and inelastic buckling in compression. This cyclic yielding and buckling imparts arduous loading on the brace's connections. Consequently, steel design codes require that seismic bracing connections be detailed such that they are significantly stronger than the nominal cross-sectional capacity of the brace member. The degree to which the connection strength must surpass the nominal cross-sectional yield capacity of the brace is dependent on the expected overstrength of the brace. Detailing connections to provide this strength can be rather difficult, particularly when dealing with hollow structural section (HSS) members, which are the preferred bracing elements due to their efficiency in carrying compressive loads, their improved aesthetic appearance, and the wide range of sections sizes that are readily available in North America.

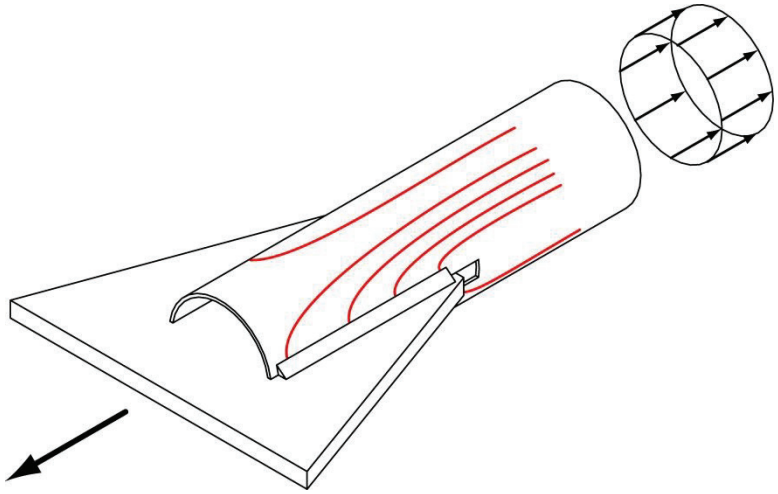
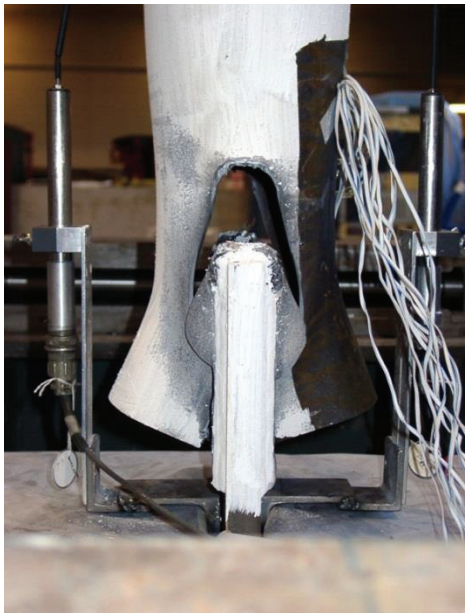


Figure 2 - Shear-lag in conventional slotted HSS-to-gusset connections



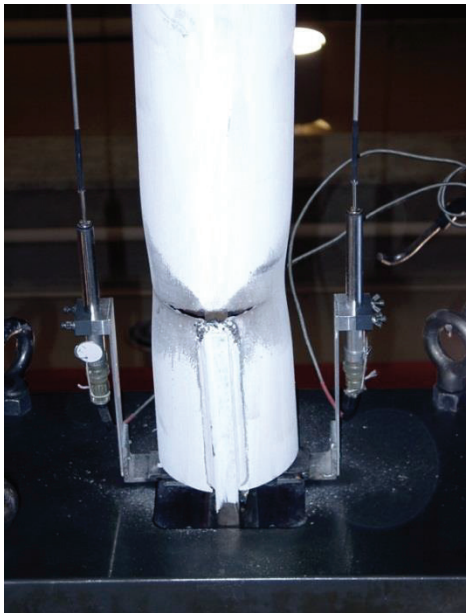


Figure 1 – Typical slotted HSS-to-gusset connection failures: tear-out failure (left); net-section fracture (right) [images courtesy of the University of Toronto]

End connections for HSS brace members are typically achieved through a gusset connection between the brace end and the beam-column intersection. In wind loaded bracing connections, a shear-lag inducing slotted HSS-to-gusset connection can be accommodated since axial loads are typically well below the cross-sectional capacity of the brace (Figure 2). However, both in the laboratory and in the field as witnessed during post-earthquake reconnaissance, conventional slotted HSS-to-gusset connections have been shown to be prone to failure when subjected to inelastic loading (Figure 1).

Recognizing the need for a simple solution to the seismic brace connection dilemma, a research team at the University of Toronto led by Professors Jeffrey A. Packer and Constantin Christopoulos developed standardized cast steel seismic-resistant connectors shaped to eliminate shear-lag in the HSS bracing connections. The geometric freedom that casting manufacturing provides allowed for the design of a connector that accommodates bolted or welded

connection to a gusset plate on one end and complete joint penetration (CJP) welded connection to a round HSS brace member on the other. Thus, in practice, the cast connectors can be welded to round HSS member braces in the shop, with the brace-connector assembly being bolted or welded to the gussets in the field. The resulting seismic-resistant connector technology is patented or patent pending in the US, Canada, and abroad.

Each CAST CONNEX® High Strength Connector™ is standardized to accommodate most round HSS and Pipe members of a given outer diameter. The use of a double-shear bolted connection halves the number of bolts that would otherwise be required in a spliced brace connection; spliced connections are sometimes specified to eliminate the need for field welding in conventional seismic-resistant reinforced brace connections. The specification of a CJP shop weld between the connector and the round HSS eliminates the need for field welding of the welds between the gusset plate and the brace member, if so desired (Figure 3). Alternatively, fillet welds applied in the field can be used to fasten the connector to the gusset.

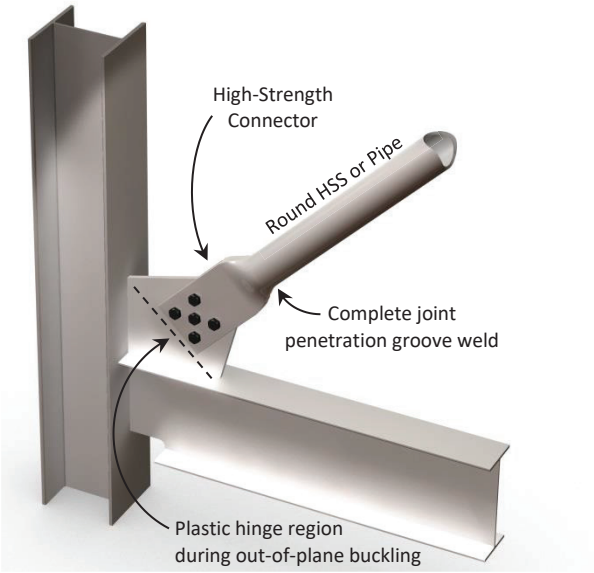


Figure 3 – High Strength Connector shown in field-bolted configuration

The connectors themselves are manufactured to ASTM A958 Grade SC8620 Class 80/50, and are each subjected to a battery of non-destructive testing to ensure their quality, including:

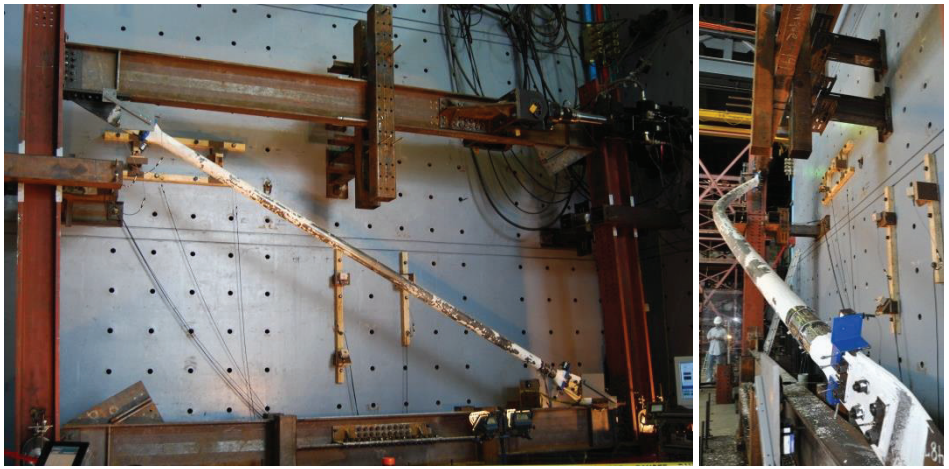
- visual examination,
- magnetic particle inspection,
- and ultrasonic testing.

Some of the many benefits of using High Strength Connectors at brace connections in braced frames are summarized below:

- elimination of field-welding of brace connections dramatically reduces erection cost and time as well as reduces the cost of special inspection; savings to the building owner which often exceed the cost of the connectors,
- use of the connectors results in more compact gusset plate connections which reduces the potential for the formation of undesirable failure modes in the column and beam members of the seismic force resisting system and also helps to ensure the structure behaves as it was modelled (as a braced frame rather than a fixed frame),
- in regions of delegated connection design, specification of High Strength Connectors mitigates risk by ensuring the building's braces can provide the ductility assumed in the design of the seismic force resisting system rather than relying on a third-party designing and detailing the connections correctly,
- though economical enough for industrial applications, the connectors' elegant shaping make them well suited for architecturally exposed applications, and
- High Strength Connectors are **Code Listed under ICC-ES ESR-3031**.

Testing of full-scale brace assemblies equipped with CAST CONNEX® High Strength Connectors™ has been carried out by researchers at the University of Toronto and École Polytechnique in Montreal.

A thorough summary of the development and testing carried out at the University of Toronto is described in the ASCE Journal of Structural Engineering, 134(3), 374-383. Papers on the full-scale testing carried out at École Polytechnique in Montreal were presented at the 14th World Conference of Earthquake Engineering and the 2011 SEAOC Convention. A more detailed report on the testing has also been published jointly by École Polytechnique in Montréal and the University of Toronto. All these publications and more are available for download at **www.castconnex.com**.



(a) (b) (c) (d) (e)

Figure 4 – Full-scale cyclic inelastic testing of a High Strength Connector-equipped brace: (above) braced frame test; (below) brace test – (a) undeformed; (b) experiencing inelastic buckling; plastic hinge formation in free length of gusset plate; (d) plastic hinge in HSS member; (e) fracture of brace at mid-length after the formation of a local buckle in the tube wall.

Designing with High Strength Connectors

The use of CAST CONNEX® High Strength Connectors™ vastly simplifies the design, detailing, and fabrication of HSS brace member connections that meet the requirements of CAN/CSA-S16-24 in Moderately Ductile (Type MD) Concentrically Braced Frames and Braced Steel Frames with Limited Ductility (Type LD).

Type MD and Type LD Concentrically Braced Frames

There are several options available to engineers for the lateral force resisting system (LFRS) of steel structures. Concentrically braced frames (CBF) are, in many cases, the most efficient choice of LFRS for medium- to low-rise steel structures for a variety of reasons. First, fabrication cost and erection time are both greatly reduced through the use of simple shear connections throughout the entire structure. Additionally, the nature of the bracing system itself, consisting of several diagonal braces located intermittently throughout the structure, allows for great design versatility. There is additional design flexibility in the variety of brace configurations that are at the designer's disposal (chevron, V, X, single brace, etc). Braced frames are also very stiff in comparison to other LFRS, reducing lateral displacements and thus lessening second-order effects.

Regardless of the CBF configuration, its response in a design-level earthquake is always the same, that is, the brace elements will fully yield in tension and buckle in compression (Figure 5). This yielding and buckling will occur cyclically throughout the duration of the strong ground motion. It is imperative that the brace connections, along with the other elements of the LFRS, are able to resist the forces that will develop during the cyclic tensile yielding and compressive buckling of the brace elements. This is the essence of “Capacity Design”.

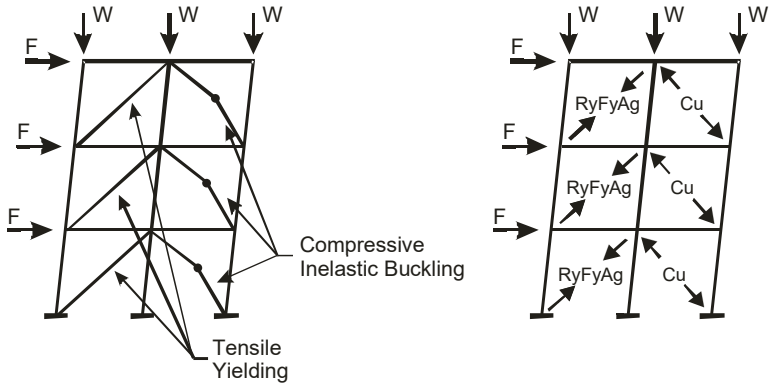


Figure 5 – Illustration of the plastic mechanism formed in a concentrically braced frame during strong-ground motion (left) and forces developed in a ductile concentrically braced frame during an earthquake (right) [adapted from Tremblay, R. (2003). Achieving a stable inelastic seismic response for multi-story concentrically braced steel frames. *AISC Engineering Journal, 40(2), 111-129*.]

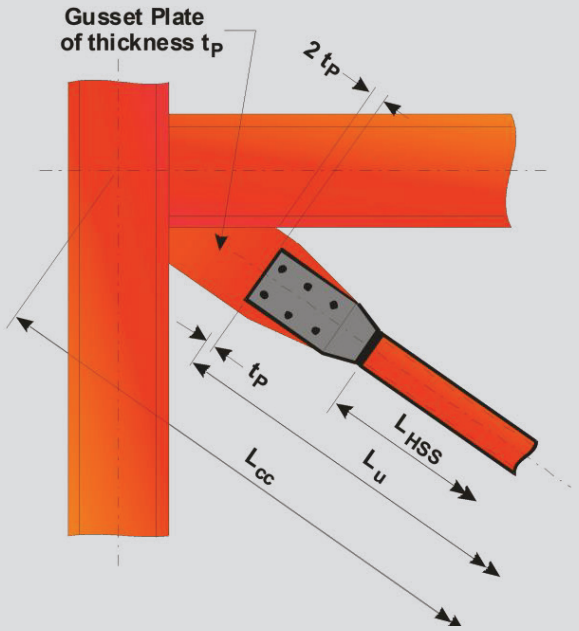
Brace Member Selection

The specification of High Strength Connectors in a structure does not change the way in which the engineer designs the other elements of the seismic-resistant braced frame in any way. For both Type LD and Type MD systems, the engineer should follow the governing building code to determine the appropriate story forces due to the design-level earthquake and subsequently size the elements of the LRFS following the requirements set out in the prevailing building code and CAN/CSA-S16-24. The only additional requirement is that the engineer should specify round HSS or Pipe members having outer diameters corresponding to those of the available line of High Strength Connectors. If the required brace member capacity cannot be achieved using round HSS or Pipe (i.e. all round HSS members having sufficient cross-sectional properties to carry the required load do not meet the D/t and/or KL/r requirements set out for ductile, seismic-resistant brace members), then the engineer should either provide additional braced frames on the particular story in question to reduce the required brace

USER NOTE:

On the unbraced length of diagonal bracing elements

A common engineering practice in preliminary sizing of the brace members in braced frames where the engineer can rely on the compressive capacity of the brace is to assume the unbraced length of the brace in compression is its center-to-center length as measured from the centers of the beams and columns to which either end of the brace connects (L_{cc} below). While this is a conservative estimate for the purpose of sizing the brace members themselves, it is unconservative for the estimation of the compressive forces which will develop in the brace during the design-level earthquake. Thus, when determining the compressive force the brace connections and other elements of the LFRS must be capable of transmitting, the unbraced length of the brace element should be taken as the distance measured from the center of each of the "free lengths" just beyond the ends of the HSC components (dimension labeled L_u in the illustration below).



forces in each frame or specify heavier brace elements (i.e. wide-flange sections), for which a conventionally-fabricated connection must be used.

Although the responsibility for designing and detailing structural steel connections varies from region to region, once the elements of the LFRS have been set by the structural engineer of record, the corresponding High Strength Connector for each brace member should be specified on the structural drawings to ensure they are utilized by the fabricator that is contracted for the project.

Brace Connection Design using High Strength Connectors

As per CAN/CSA-S16-24, the required factored tensile resistance of brace connections in all Type MD and in some Type LD braced frames must be equal to or exceed the probable tensile capacity of the brace, T_{prob}, given by $A_g R_{sh} R_y F_y$ with R_{sh} equal to 1.0. Similarly, the required factored compressive resistance of the brace connection must be equal to or exceed the probable compressive capacity of the brace, C_{prob}, given by the lesser of T_{prob} and $1.2C_r/\phi$, where Cr is computed using $R_{sh}R_yF_y$ with R_{sh} equal to 1.0, and the probable post-buckling compressive resistance of bracing members, C'_{prob}, which shall be taken equal to the lesser of $0.2T_{prob}$ and C_r/ϕ, where C_r is computed using $R_{sh}R_yF_y$ with R_{sh} equal to 1.0. In these expressions, $R_{sh}R_yF_y$ is the expected yield strength of the brace material and is not to be taken as less than 460 MPa for HSS sections.

The use of CAST CONNEX® High Strength Connectors™ makes providing the aforementioned connection resistance very simple.

At one end, the connectors are designed with a circular shape and beveled preparation to allow for complete joint penetration shop welding to a range of tubular braces of a given outer diameter for the full development of their expected yield strength. At the other end, the connectors are shaped such that a double shear bolted connection or field-applied fillet welds can be used for connecting the shop-welded brace-connector assembly to conventional gusset plates secured to the beam-column intersection (Figure 6).

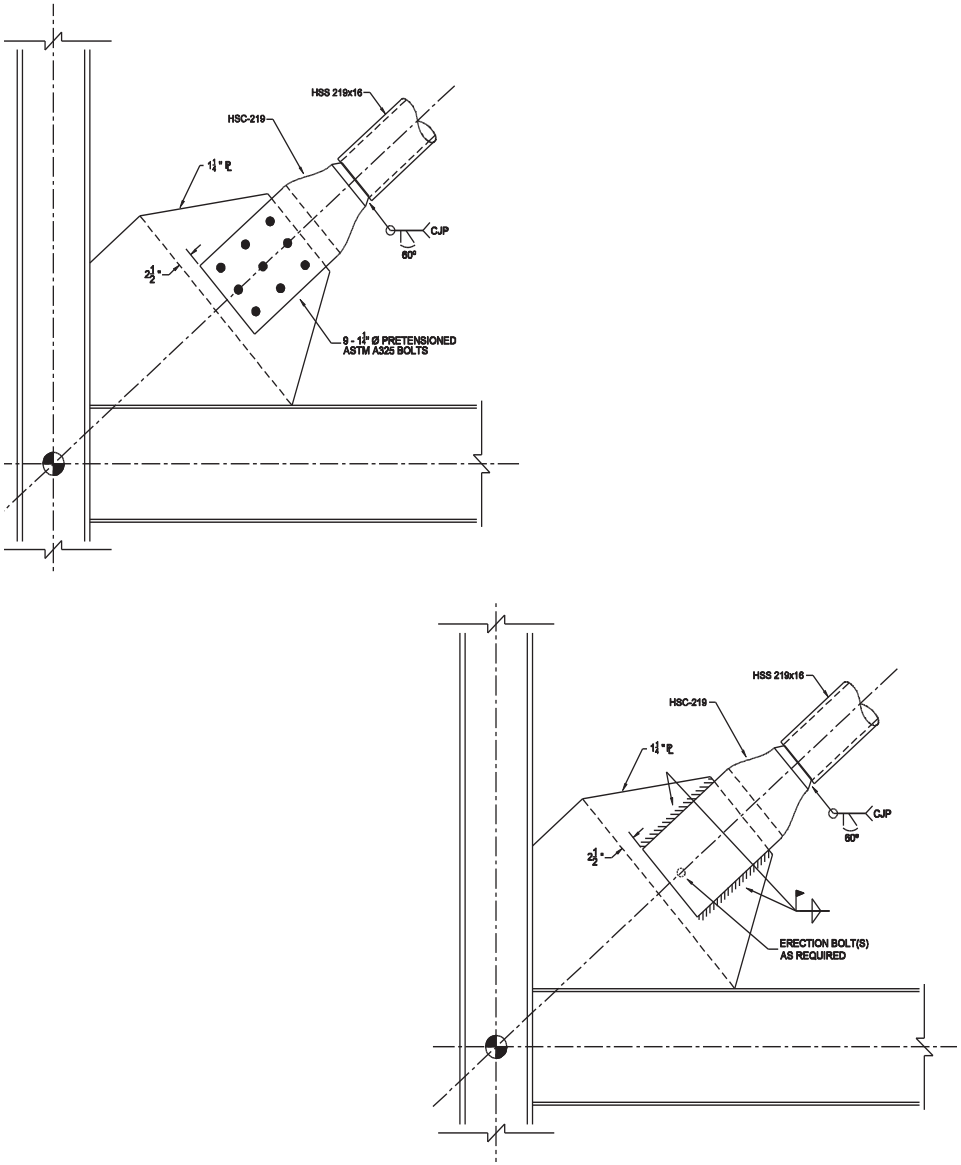


Figure 6 – Field bolted (top) and field welded (bottom) brace connection configurations using High Strength Connectors

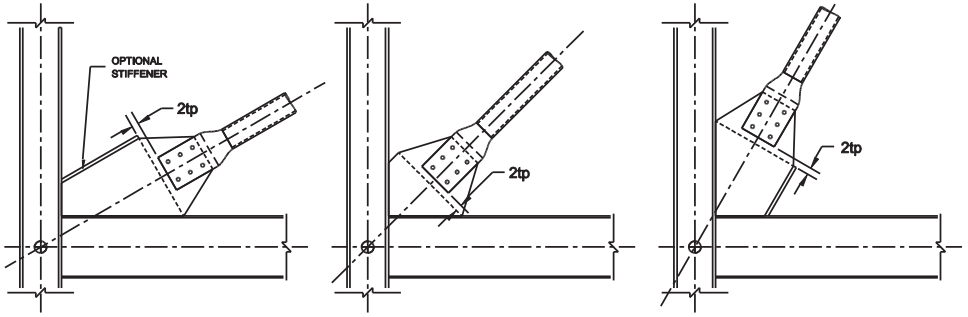


Figure 7 – Gusset plate detailing to accommodate out-of-plane inelastic deformation of a brace for various bracing angles [adapted from Astaneh-Asl, A., Goel, S.C., and Hanson, R.D., (1985). Cyclic out-of plane buckling of double-angle bracing. [*ASCE Journal of Structural Engineering, 111(5): 1135-1153*.]

An additional requirement for the use of High Strength Connectors in Type MD CBF is that a free length of gusset plate should be provided beyond the ends of each connector to accommodate the inelastic end rotations that will be induced during out-of-plane buckling of the brace. The CAN/CSA-S16-24 commentary suggests that the width of this hinge-region should be at least twice the thickness of the gusset plate. This detail is illustrated above for various brace angles (Figure 7).

Although the use of High Strength Connectors makes the design of seismic-resistant brace end connections straightforward, detailing the gusset plate to which the brace-assembly connects remains a complex issue. Detailing of the gusset must be carried out with a clear understanding of the loads which must be transmitted and with an appreciation for the stability issues which may arise.

A good practical resource that discusses the design of gusset plates in seismic-resistant braced frames is the December 2006 issue of Steel Tips, entitled "*Seismic Detailing of Gusset Plates for Special Concentrically Braced Frames*" by Abolhassan Astaneh-Asl, Michael L. Cochran, and Rafael Sabelli. Steel Tips is published by the Structural Steel Educational Council (SSEC).

Specification Language – Division 05 12 00

Besides calling for the connectors in the appropriate brace frame elevations of the structural steel drawings, the appropriate specification language should be included in the Division 05 12 00 specification for structural steel, typically under a products subsection. Suggested specification language can be downloaded from **www.castconnex.com**.

Design Table and Detailing Assumptions

The design tables provided in this User Manual present suggested bolted connection details for the connection between a given HSC and gusset plate for a variety of HSS or Pipe brace members, each having unique probable tensile resistance ($A_g R_{sh} R_y F_y$). For every unique HSS or Pipe element, a suggested detail for a bearing-type bolted connection is indexed by: number of bolts required, bolt diameter (3/4", 7/8", 1", 1 1/8", or 1 1/4"), and bolt grade (ASTM F3125, grade A325 or grade A490). **CAN/CSA-S16-24 requires that all seismic-resistant bolted connections have pretensioned high-strength bolts**. Because pretensioning of bolts is labour intensive, the number of bolts in each of the suggested connection details has been minimized.

It is the responsibility of the Engineer of Record to confirm the connection resistance for each detail prior to use. As the connection resistance is often governed by "block shear rupture", changes to the gauge and pitch of bolts indicated in the details can adversely affect the resistance of the connection.

For the details provided, the following material properties were assumed unless otherwise noted:

HSC	F_y = 345 MPa, F_u = 550 MPa
Gusset	F_y = 300 MPa, F_u = 450 MPa

Material of equal or higher strength than that which is listed above (or noted on the connection detail) for the gusset plate must be provided if a detail provided in this user manual is to be followed.

Bolt capacities for bearing-type connections are calculated according to CAN/CSA-S16-24. High Strength Connectors have been designed such that bolt threads are excluded from the shear planes. Although not covered in this design guide, slip-critical bolted connections can be designed by the Engineer of Record. Slip-critical bolted connections could be advantageous, as CAN/CSA-S16-24 permits the use of oversized holes in slip-critical connections provided the holes are oversized in one ply only.

Sample Connection Design

Assume that an engineer has sized all of the main structural members in a Type MD steel braced frame according to the governing building code and CAN/CSA-S16-24, and that these members are as shown below.

Detail a bearing-type brace end connection for the HSS 168x13 brace element at Joint J-1 assuming the HSS member is produced according to ASTM A500, Grade C and that pretensioned ASTM F1325 grade A490 bolts of 1-inch diameter are to be used.

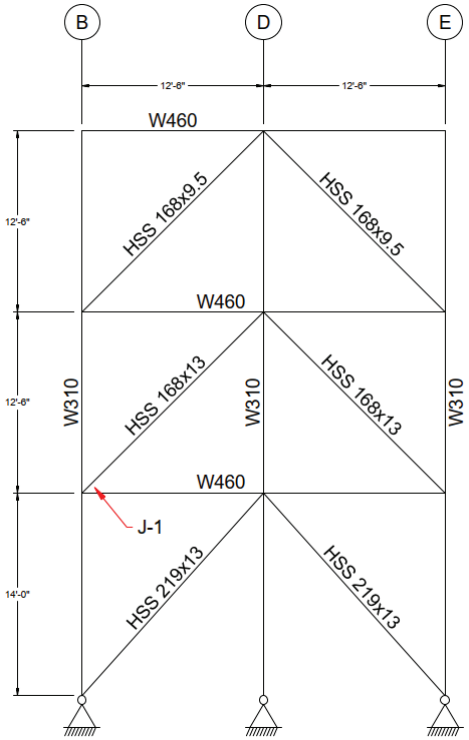


Figure 8 – Frame for sample connection design

Using High Strength Connectors and this User Manual, the design procedure is simple:

As the HSS brace member has an outer diameter of 168 mm, we must specify HSC-168 connectors. We begin by opening the User Manual to the HSC-168 design table and find the ASTM A500 Grade C, HSS 168x13 section on the table. Reading across the row, we can see that for 1-inch, ASTM F1325 grade A490 bolts in a bearing-type connection, the required connection detail index is **6-1”-490**. Flipping to detail 6-1”-490 in the HSC-168 section of the manual, we find the detail that is shown below (Figure 9).

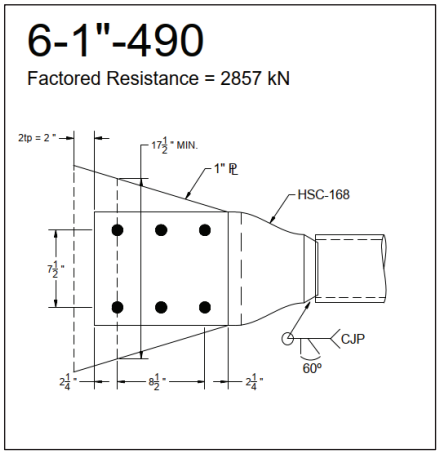


Figure 9 – Sample connection detail

We know that, according to CAN/CSA-S16-24, an HSS 168x13 brace member produced to ASTM A500, Grade C has an expected yield strength of $A_g R_{sh} R_y F_y$ = (6207 mm^2)(460 MPa) = 2855 kN (note that this information is also provided in the design table). As the connection detail shows a resistance of 2857 kN (which should be confirmed by the connection designer prior to using the detail), we know that the detail selected is suitable. We then simply insert the detail into the drawing using the minimum net-section dimension given and the rules for the 2tp free length.

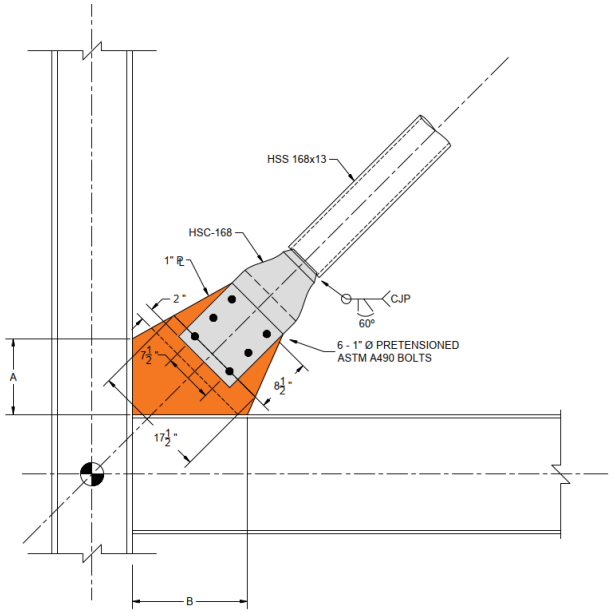


Figure 10 – Sample connection detail inserted into beam-column intersection

The design of the brace end connection is now complete.

The next step involves checking the adequacy of the gusset and detailing the connection between the gusset and beam, column, or beam and column, which should be done in accordance to CAN/CSA-S16-24. When detailing these connections, it is best to consider the preferences of local fabricators and erectors with respect to field bolting versus field welding, erection practices, etc.

Adequacy checking and detailing of the gusset connection is outside of the scope of this User Manual. An excellent practical resource that discusses the design of gusset plates in seismic-resistant braced frames is the December 2006 issue of Steel Tips, entitled "Seismic Detailing of Gusset Plates for Special Concentrically Braced Frames" by Abolhassan Astaneh-Asl, Michael L. Cochran, and Rafael Sabelli. Steel Tips is published by the Structural Steel Educational Council (SSEC).

In all likelihood, the resulting connections between the gusset and the beam, column, or beam and column will require larger dimensions "A" and "B" than were provided based on using the optimized connection detail provided in this User Manual. When increasing the size of the gusset, be sure to respect the 2tp requirements, as illustrated below.

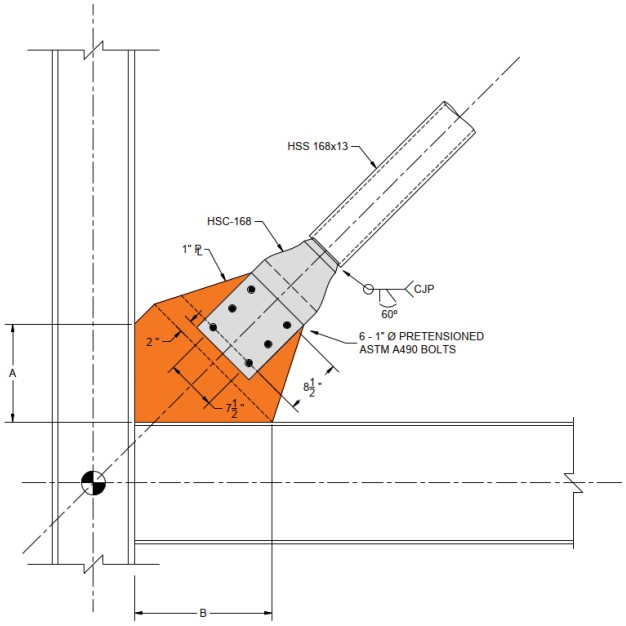


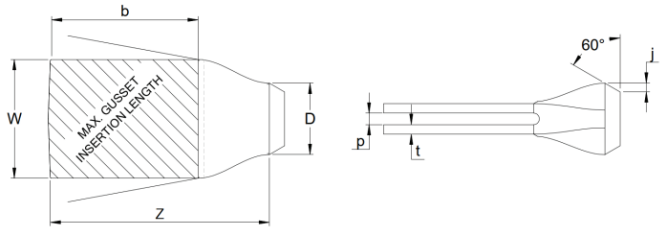
Figure 11 – 2tp requirements should be maintained when increasing dimensions "A" and "B"

The final check that must be carried out by the designer is to **confirm that the brace can be installed in the field**. Refer to the Site Erection section of this User Manual for more information on field installation of braces equipped with HSC.

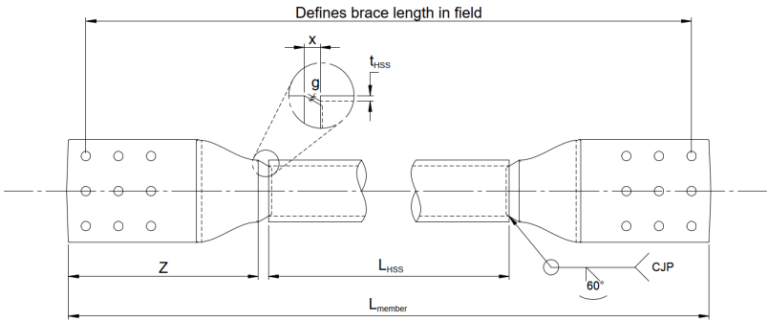
Fabrication with High Strength Connectors

Detailing

The following figures, table, and equations are meant to assist in detailing HSC brace assemblies. Electronic versions of HSC geometry are available upon request at **info@castconnex.com**.



	Z [mm]	D [mm]	b [mm]	w [mm]	t [mm]	p_{min} [mm]	p_{max} [mm]	j [mm]
HSC-102	362	102	254	178	13	14	16	15
HSC-141	484	141	330	229	16	21	22	15
HSC-168	518	168	330	279	22	27	29	20
HSC-219	689	219	445	356	25	33	35	22
HSC-273	651	273	406	406	32	40	41	22
HSC-324	705	324	432	483	32	46	48	22
HSC-356	756	356	432	483	38	46	48	22



$$L_{HSS} = L - 2[Z + X]$$

$$X = 2g + t_{HSS} \cdot \sqrt{3}$$

When using these equations to estimate the length of HSS required for a given brace, note that the actual t_{HSS} can be significantly thinner than the nominal value. Refer to the relevant HSS or Pipe specification

Fitting

When fitting a bolted brace assembly, it is important to note that the actual length of the brace is set by the distance between the bolt pattern at each end of the brace and that the **HSC should be carefully aligned in all directions (including roll) prior to welding**. For brace assemblies which are to be field bolted, some users have found it helpful to drill the bolt patterns into the HSC after having welded both connectors to the hollow section as this has allowed for improved control of brace length. However, other methods for fitting have also been successful.

Figure 12 – Fitting of HSC brace assembly. Fitter simultaneously ensures:
1) the HSC connectors are level and in-line
2) the appropriate weld root gap is provided at the joints
3) the overall length of the brace assembly is correct

Drilling

HSC are produced with steel that is very tough. As a result, drilling should be carried out using a high quality carbide-tipped tool operated at the correct drill

speed. When drilling, the tool should past through both HSC flanges. Failure to clear the slug produced during the drilling of the first flange before starting the second core may result in tool fracture. Consider tack-welding a tie bar between the connector's tabs to reduce chatter during drilling.

Welding

HSC are manufactured using material produced to ASTM A958 Grade SC8620 Class 80/50. **Heat treatment for this material may include quenching and tempering (QT).** As a result, it is important to follow good welding practices for QT materials for welds applied to the HSC. In all seismic applications, **the welded joints must meet all the requirements stipulated in CAN/CSA-S16-24 and CAN/CSA W59 for seismic-resistant welded connections.**

Although ASTM A958 Grade SC8620 Class 80/50 is a weldable base metal with both mechanical and chemical properties similar to those of a standard wrought steel grades, it is not a pre-approved base metal according to the Canadian Welding Bureau (CWB). Because of this, and because of the nature of the weld that must be applied between the HSC and the HSS or Pipe member, **the CWB must approve a Welding Procedure Specification (WPS) and a Procedure Qualification Record (PQR) must be produced.**

<u>Complete Joint Penetration Groove Weld</u>

The weld between the HSC and the HSS or Pipe member **must provide complete joint penetration (CJP).** Note that the significant mass of the HSC in the region of the CJP necessitates the application of pre-heating prior to welding.

HSC are supplied with a 60° weld preparation, thus HSS or Pipe members need only be square-cut to the appropriate length (refer to the Fitting section of this User Manual) and tack-welded to the HSC prior to CJP welding. Past users have welded successfully using a motorized turning roll.

A sample Welding Procedure Specification can be downloaded from our website **www.castconnex.com**

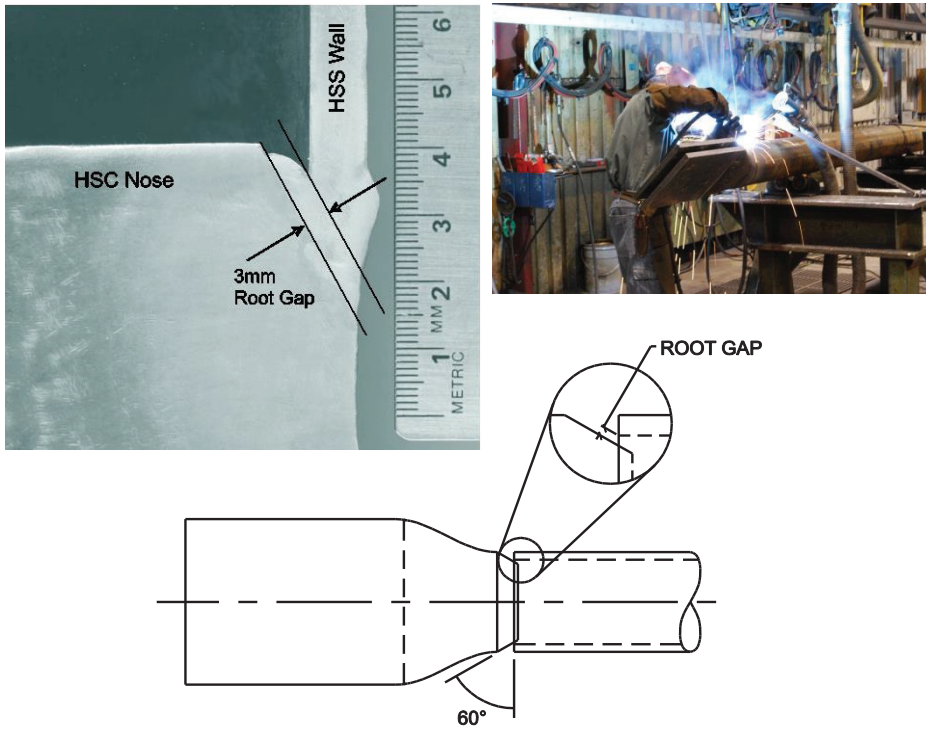


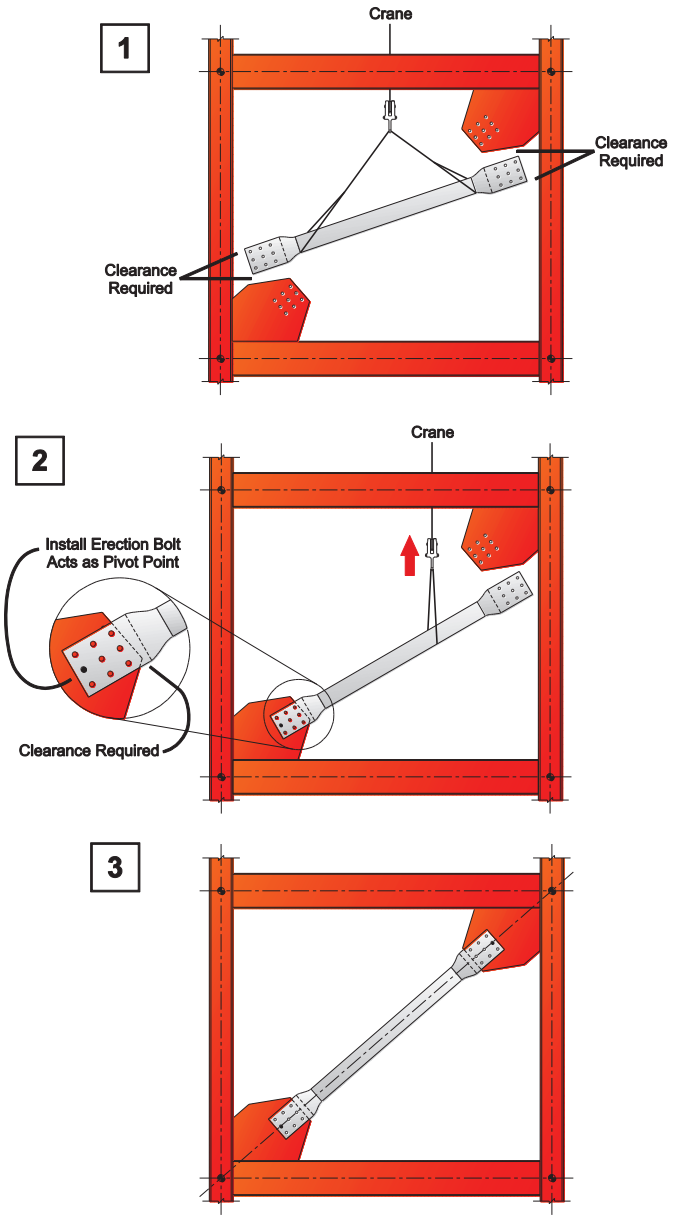
Figure 13 – Welded joint configuration

WARNING: If the Complete Joint Penetration Weld between the HSC and the hollow section brace element is not applied correctly, or if fillet welds that may be applied in the field between the HSC and gusset plate are not applied correctly, fracture of these welds or of the base metal may occur during a seismic event or as a result of fatigue. CAST CONNEX CORPORATION, ITS AFFILIATES, SUBSIDIARIES OR RELATED COMPANIES, ASSUME NO LIABILITY WHATSOEVER WITH RESPECT TO THE QUALITY OF ANY WELDS APPLIED TO HSC BY ANY END USER OF THE HSC PRODUCT.

Site Erection

It is quite common for the beams and columns in a steel braced frame to be erected prior to the installation of the brace member. In these cases, the designer should ensure that the brace can be installed in the field given the specific geometry of the frame, gusset plates, and brace assembly. The diagrams below illustrate the most common sequence for brace installation in this circumstance and should help the designer understand some of the constraints that arise in this situation. **When gusset plate to connector connections are too compact to allow for erection as illustrated here, a note should be added to the brace elevation calling for the brace member to be installed prior to the installation of the beam above or for the brace to be installed in tandem with the beam above**.

Depending on the specifics of a given project, the erection schemes for primary structural steel elements can vary widely, particularly with respect to braced frames. Whenever possible, the design team should consult with the contractors involved in the project to gain an understanding of their preferred practices and any specific erection constraints. The images below are only meant to make users of this manual aware of some of the issues that may arise and do not present the only possible erection scheme for braced frames.



Design Tables and Connection Details

Please visit **www.castconnex.com** or contact **info@castconnex.com** to access the latest version of the design tables and connection details.

HSC-102

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

CAN/CSA G40.20/21
Grade 350W, Class C or H

Fy = 350 MPa

Ry·Fy = 460 MPa

thus D/t ≤ 28.6

Designation	Wall Thick-ness	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	3/4	7/8	1	3/4	7/8	1
HSS 102										
x8.0	7.94	12.8	2,336	1,074	5-3/4"-325	4-7/8"-325	4-1"-325	5-3/4"-490	4-7/8"-490	4-1"-490
x6.4	6.35	16.0	1,900	874	4-3/4"-325	3-7/8"-325	3-1"-325	4-3/4"-490	3-7/8"-490	3-1"-490
x4.8	4.76	21.3	1,449	666	4-3/4"-325	3-7/8"-325	3-1"-325	4-3/4"-490	3-7/8"-490	3-1"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   2¾" Long bolt for 3/4" and 7/8" ASTM F3125 - Grade A325 or Grade A490
   3" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490

HSC-102

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A500
Grade B

Fy = 315 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	3/4	7/8	1	3/4	7/8	1
HSS 102										
x8.0	7.94	12.8	2,336	1,074	5-3/4"-325	4-7/8"-325	4-1"-325	5-3/4"-490	4-7/8"-490	4-1"-490
x6.4	6.35	16.0	1,900	874	4-3/4"-325	3-7/8"-325	3-1"-325	4-3/4"-490	3-7/8"-490	3-1"-490
x4.8	4.76	21.3	1,449	666	4-3/4"-325	3-7/8"-325	3-1"-325	4-3/4"-490	3-7/8"-490	3-1"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   2¾" Long bolt for 3/4" and 7/8" ASTM F3125 - Grade A325 or Grade A490
   3" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A500 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-102

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A500
Grade C

Fy = 345 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	3/4	7/8	1	3/4	7/8	1
HSS 102										
x8.0	7.94	12.8	2,336	1,074	5-3/4"-325	4-7/8"-325	4-1"-325	5-3/4"-490	4-7/8"-490	4-1"-490
x6.4	6.35	16.0	1,900	874	4-3/4"-325	3-7/8"-325	3-1"-325	4-3/4"-490	3-7/8"-490	3-1"-490
x4.8	4.76	21.3	1,449	666	4-3/4"-325	3-7/8"-325	3-1"-325	4-3/4"-490	3-7/8"-490	3-1"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   2¾" Long bolt for 3/4" and 7/8" ASTM F3125 - Grade A325 or Grade A490
   3" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A500 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-102

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A53
Grade B

Fy = 241 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
	mm		mm^2	kN	3/4	7/8	1	3/4	7/8	1
Pipe 3½										
XS	8.08	12.6	2,373	1,092	5-3/4"-325	4-7/8"-325	4-1"-325	5-3/4"-490	4-7/8"-490	4-1"-490
STD	5.74	17.7	1,729	795	4-3/4"-325	3-7/8"-325	3-1"-325	4-3/4"-490	3-7/8"-490	3-1"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   2¾" Long bolt for 3/4" and 7/8" ASTM F3125 - Grade A325 or Grade A490
   3" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A53 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-102

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A1085
Grade A

Fy = 350 MPa

Ry·Fy = 460 MPa

thus D/t ≤ 28.6

Designation	Wall Thick-ness	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	3/4	7/8	1	3/4	7/8	1
HSS 102										
x8.0	7.94	12.8	2,336	1,074	5-3/4"-325	4-7/8"-325	4-1"-325	5-3/4"-490	4-7/8"-490	4-1"-490
x6.4	6.35	16.0	1,900	874	4-3/4"-325	3-7/8"-325	3-1"-325	4-3/4"-490	3-7/8"-490	3-1"-490
x4.8	4.76	21.3	1,449	666	4-3/4"-325	3-7/8"-325	3-1"-325	4-3/4"-490	3-7/8"-490	3-1"-490

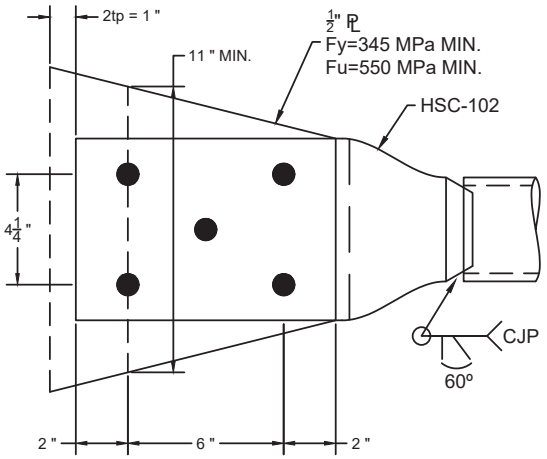
1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:

2¾" Long bolt for 3/4" and 7/8" ASTM F3125 - Grade A325 or Grade A490

3" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490

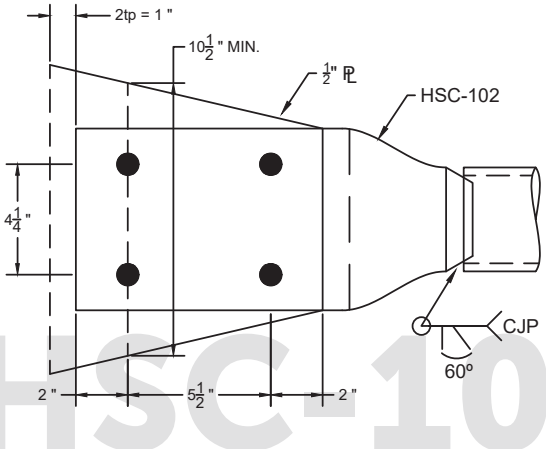
5-3/4"-325

Factored Resistance = 1102 kN



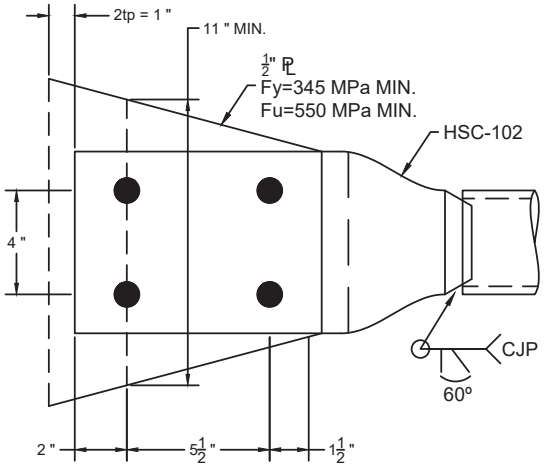
4-3/4"-325

Factored Resistance = 887 kN



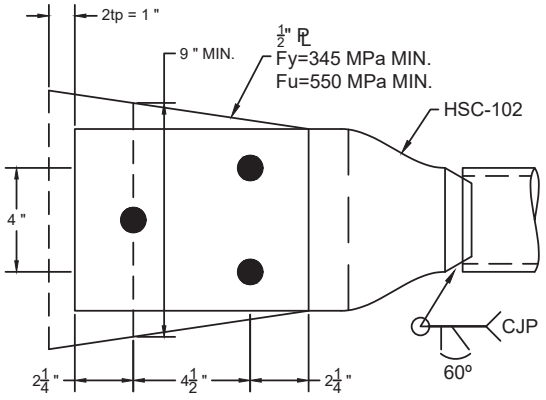
4-7/8"-325

Factored Resistance = 1095 kN



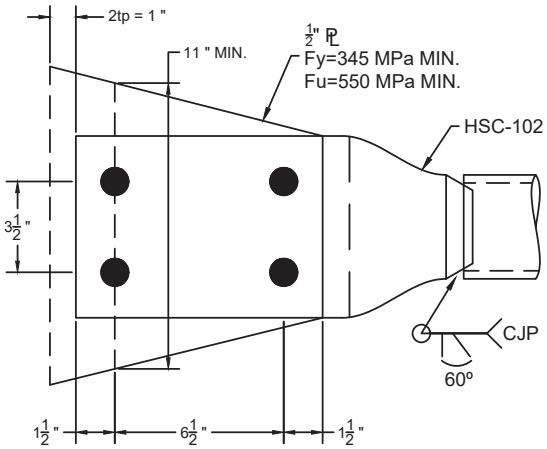
3-7/8"-325

Factored Resistance = 892 kN



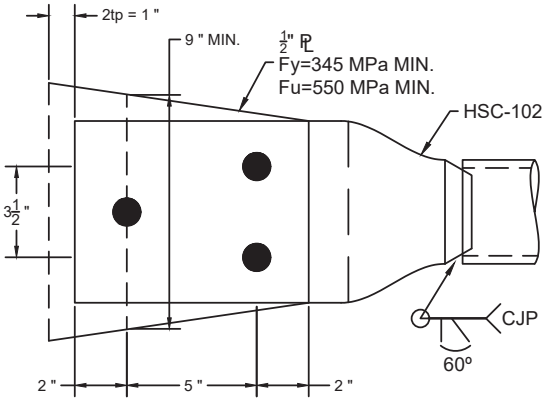
4-1"-325

Factored Resistance = 1099 kN



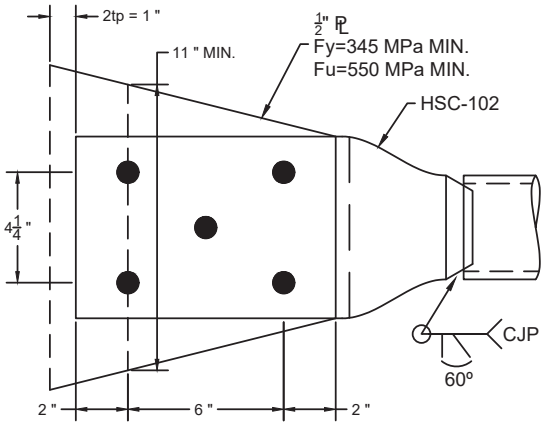
3-1"-325

Factored Resistance = 901 kN



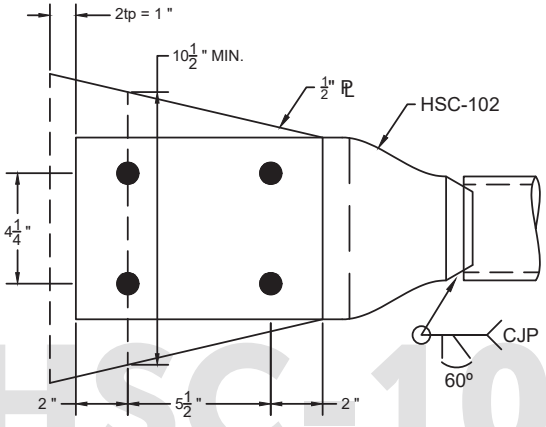
5-3/4"-490

Factored Resistance = 1102 kN



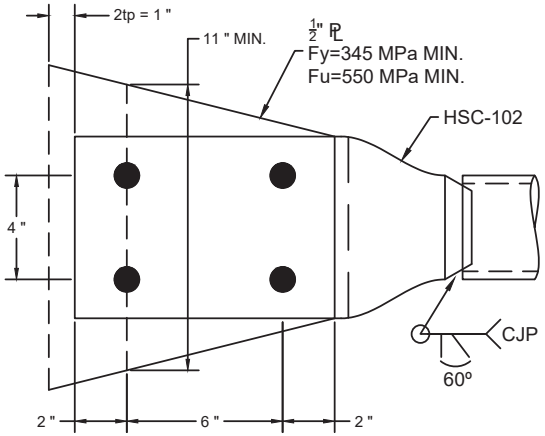
4-3/4"-490

Factored Resistance = 915 kN



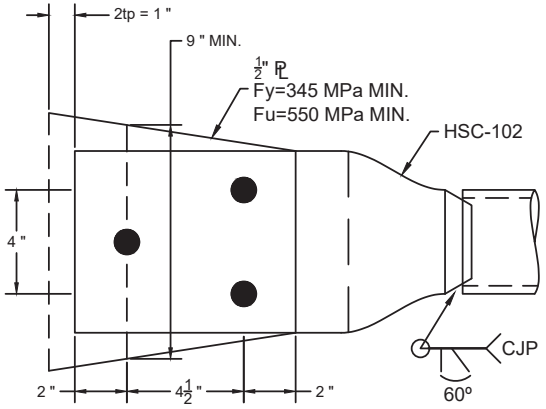
4-7/8"-490

Factored Resistance = 1095 kN



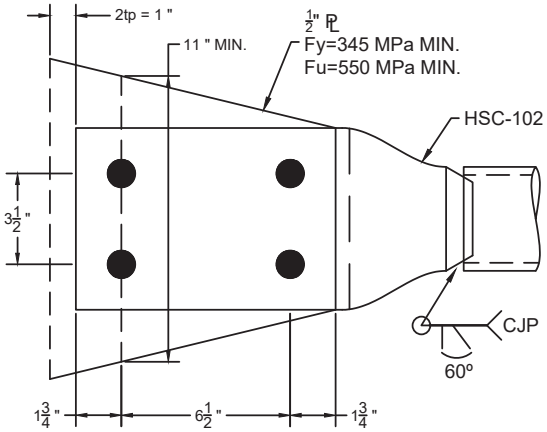
3-7/8"-490

Factored Resistance = 892 kN



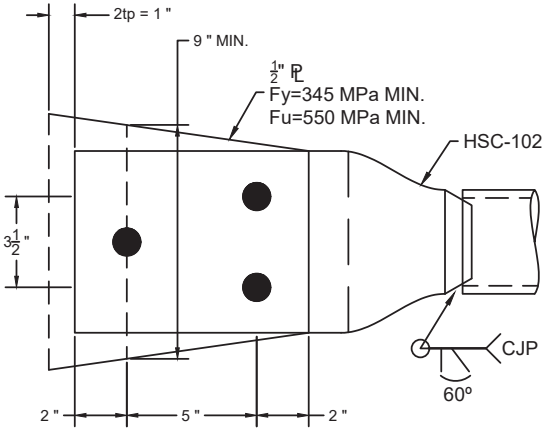
4-1"-490

Factored Resistance = 1102 kN



3-1"-490

Factored Resistance = 901 kN



HSC-141

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

CAN/CSA G40.20/21
Grade 350W, Class C or H

Fy = 350 MPa

Ry·Fy = 460 MPa

thus D/t ≤ 28.6

Designation	Wall Thick-ness	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	3/4	7/8	1	3/4	7/8	1
HSS 141										
x9.5	9.53	14.8	3,943	1,814	9-3/4"-325	6-7/8"-325	5-1"-325	7-3/4"-490	5-7/8"-490	5-1"-490
x6.4	6.35	22.3	2,692	1,238	6-3/4"-325	5-7/8"-325	4-1"-325	5-3/4"-490	4-7/8"-490	3-1"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   3¼" Long bolt for 3/4" and 7/8" ASTM F3125 - Grade A325 or Grade A490
   3½" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490

HSC-141

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A500
Grade B

Fy = 315 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	3/4	7/8	1	3/4	7/8	1
HSS 141										
x9.5	9.53	14.8	3,943	1,814	9-3/4"-325	6-7/8"-325	5-1"-325	7-3/4"-490	5-7/8"-490	5-1"-490
x6.4	6.35	22.3	2,692	1,238	6-3/4"-325	5-7/8"-325	4-1"-325	5-3/4"-490	4-7/8"-490	3-1"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   3¼" Long bolt for 3/4" and 7/8" ASTM F3125 - Grade A325 or Grade A490
   3½" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A500 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-141

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A500
Grade C

Fy = 345 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	3/4	7/8	1	3/4	7/8	1
HSS 141										
x9.5	9.53	14.8	3,943	1,814	9-3/4"-325	6-7/8"-325	5-1"-325	7-3/4"-490	5-7/8"-490	5-1"-490
x6.4	6.35	22.3	2,692	1,238	6-3/4"-325	5-7/8"-325	4-1"-325	5-3/4"-490	4-7/8"-490	3-1"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   3¼" Long bolt for 3/4" and 7/8" ASTM F3125 - Grade A325 or Grade A490
   3½" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A500 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-141

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A53
Grade B

Fy = 241 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
	mm		mm^2	kN	3/4	7/8	1	3/4	7/8	1
Pipe 5										
XS	9.53	14.8	3,943	1,814	9-3/4"-325	6-7/8"-325	5-1"-325	7-3/4"-490	5-7/8"-490	5-1"-490
STD	6.55	21.6	2,774	1,276	6-3/4"-325	5-7/8"-325	4-1"-325	5-3/4"-490	4-7/8"-490	3-1"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   3¼" Long bolt for 3/4" and 7/8" ASTM F3125 - Grade A325 or Grade A490
   3½" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A53 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-141

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A1085
Grade A

Fy = 350 MPa

Ry·Fy = 460 MPa

thus D/t ≤ 28.6

Designation	Wall Thick-ness	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	3/4	7/8	1	3/4	7/8	1
HSS 141										
x9.5	9.53	14.8	3,943	1,814	9-3/4"-325	6-7/8"-325	5-1"-325	7-3/4"-490	5-7/8"-490	5-1"-490
x6.4	6.35	22.3	2,692	1,238	6-3/4"-325	5-7/8"-325	4-1"-325	5-3/4"-490	4-7/8"-490	3-1"-490

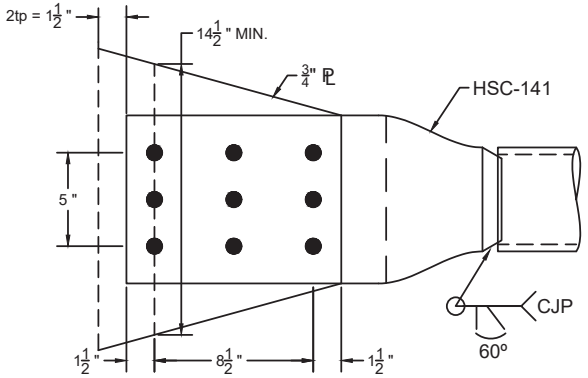
1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:

3¼" Long bolt for 3/4" and 7/8" ASTM F3125 - Grade A325 or Grade A490

3½" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490

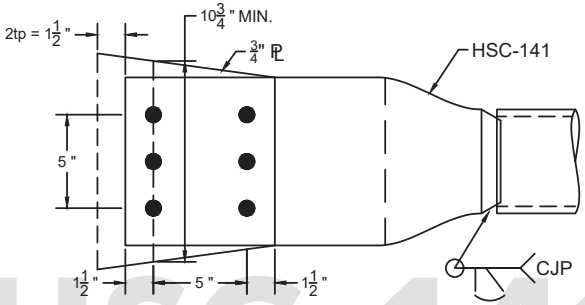
9-3/4"-325

Factored Resistance = 1849 kN



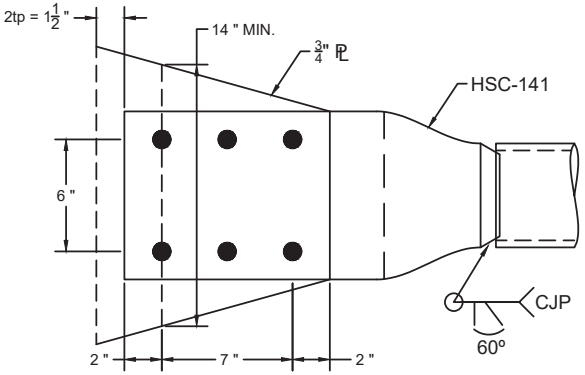
6-3/4"-325

Factored Resistance = 1306 kN



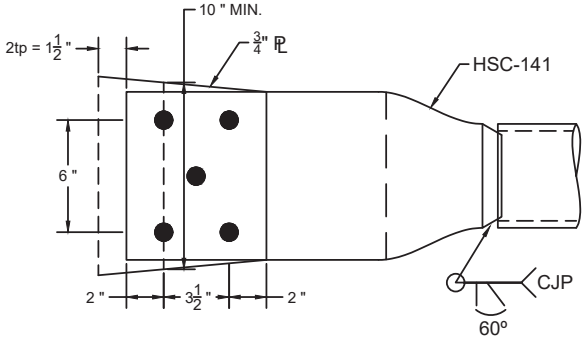
6-7/8"-325

Factored Resistance = 1829 kN



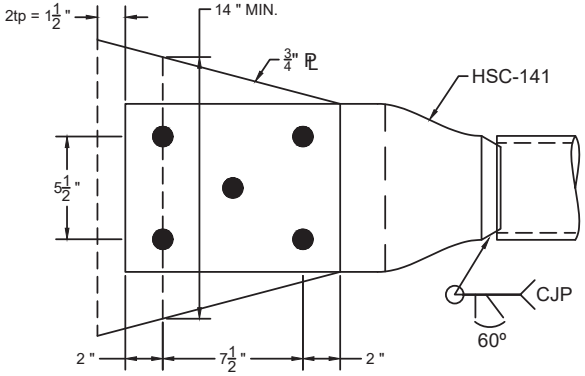
5-7/8"-325

Factored Resistance = 1297 kN



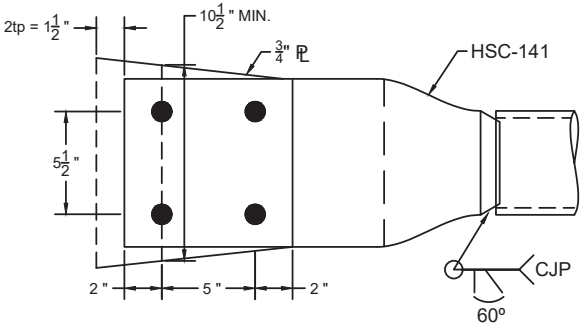
5-1"-325

Factored Resistance = 1826 kN



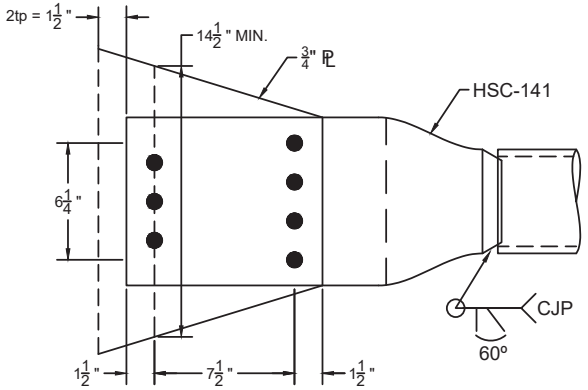
4-1"-325

Factored Resistance = 1315 kN



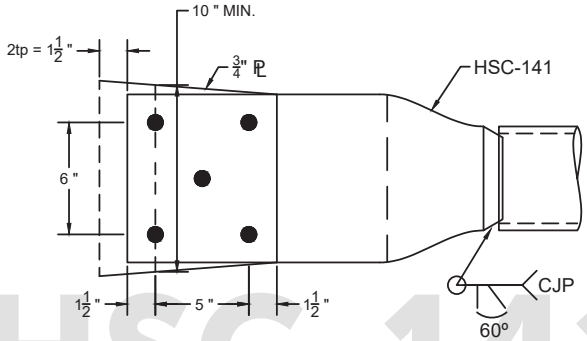
7-3/4"-490

Factored Resistance = 1823 kN



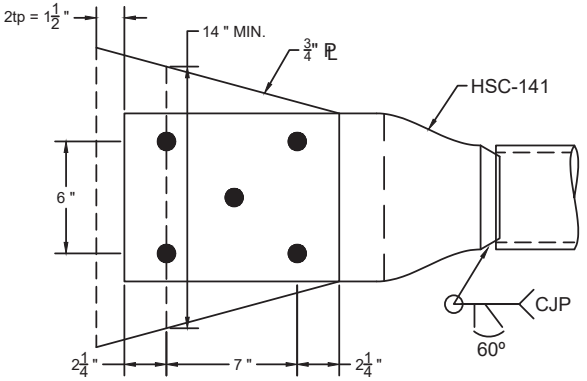
5-3/4"-490

Factored Resistance = 1306 kN



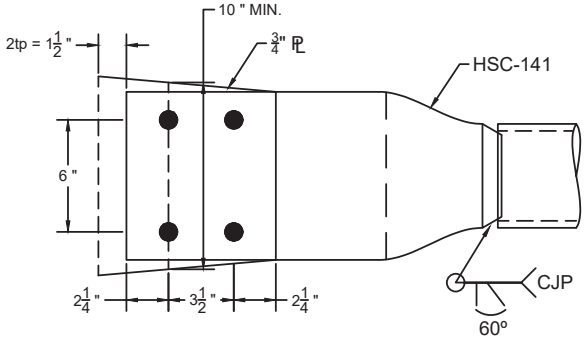
5-7/8"-490

Factored Resistance = 1829 kN



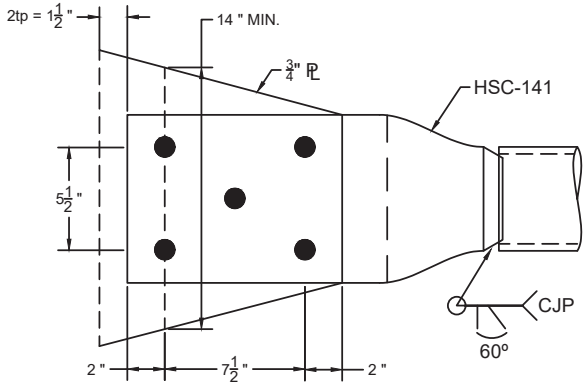
4-7/8"-490

Factored Resistance = 1297 kN



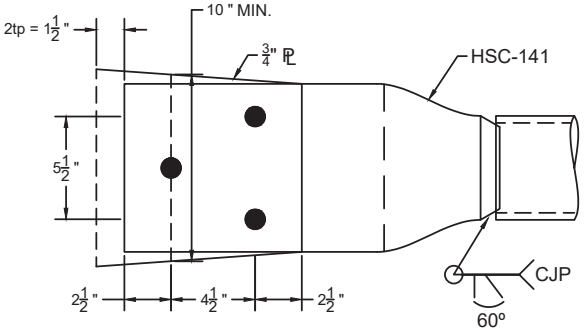
5-1"-490

Factored Resistance = 1826 kN



3-1"-490

Factored Resistance = 1306 kN



HSC-168

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

CAN/CSA G40.20/21
Grade 350W, Class C or H

Fy = 350 MPa

Ry·Fy = 460 MPa

thus D/t ≤ 28.6

Designation	Wall Thick-ness	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	3/4	7/8	1	3/4	7/8	1
HSS 168										
x13	12.70	13.3	6,207	2,855	13-3/4"-325	10-7/8"-325	8-1"-325	11-3/4"-490	8-7/8"-490	6-1"-490
x9.5	9.53	17.7	4,750	2,185	10-3/4"-325	8-7/8"-325	6-1"-325	8-3/4"-490	6-7/8"-490	5-1"-490
x8.0	7.94	21.2	3,998	1,839	9-3/4"-325	6-7/8"-325	5-1"-325	7-3/4"-490	5-7/8"-490	4-1"-490
x6.4	6.35	26.5	3,230	1,486	7-3/4"-325	5-7/8"-325	4-1"-325	6-3/4"-490	4-7/8"-490	3-1"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   4" Long bolt for 3/4" and 7/8" ASTM F3125 - Grade A325 or Grade A490
   4¼" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490

HSC-168

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A500
Grade B

Fy = 315 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	3/4	7/8	1	3/4	7/8	1
HSS 168										
x13	12.70	13.3	6,207	2,855	13-3/4"-325	10-7/8"-325	8-1"-325	11-3/4"-490	8-7/8"-490	6-1"-490
x9.5	9.53	17.7	4,750	2,185	10-3/4"-325	8-7/8"-325	6-1"-325	8-3/4"-490	6-7/8"-490	5-1"-490
x8.0	7.94	21.2	3,998	1,839	9-3/4"-325	6-7/8"-325	5-1"-325	7-3/4"-490	5-7/8"-490	4-1"-490
x6.4	6.35	26.5	3,230	1,486	7-3/4"-325	5-7/8"-325	4-1"-325	6-3/4"-490	4-7/8"-490	3-1"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   4" Long bolt for 3/4" and 7/8" ASTM F3125 - Grade A325 or Grade A490
   4¼" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A500 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-168

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A500
Grade C

Fy = 345 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	3/4	7/8	1	3/4	7/8	1
HSS 168										
x13	12.70	13.3	6,207	2,855	13-3/4"-325	10-7/8"-325	8-1"-325	11-3/4"-490	8-7/8"-490	6-1"-490
x9.5	9.53	17.7	4,750	2,185	10-3/4"-325	8-7/8"-325	6-1"-325	8-3/4"-490	6-7/8"-490	5-1"-490
x8.0	7.94	21.2	3,998	1,839	9-3/4"-325	6-7/8"-325	5-1"-325	7-3/4"-490	5-7/8"-490	4-1"-490
x6.4	6.35	26.5	3,230	1,486	7-3/4"-325	5-7/8"-325	4-1"-325	6-3/4"-490	4-7/8"-490	3-1"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   4" Long bolt for 3/4" and 7/8" ASTM F3125 - Grade A325 or Grade A490
   4¼" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A500 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-168

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A53
Grade B

Fy = 241 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
	mm		mm^2	kN	3/4	7/8	1	3/4	7/8	1
Pipe 6										
XS	10.97	15.3	5,423	2,494	12-3/4"-325	9-7/8"-325	7-1"-325	10-3/4"-490	7-7/8"-490	6-1"-490
STD	7.11	23.7	3,601	1,656	8-3/4"-325	6-7/8"-325	5-1"-325	6-3/4"-490	5-7/8"-490	4-1"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   4" Long bolt for 3/4" and 7/8" ASTM F3125 - Grade A325 or Grade A490
   4¼" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A53 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-168

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A1085
Grade A

Fy = 350 MPa

Ry·Fy = 460 MPa

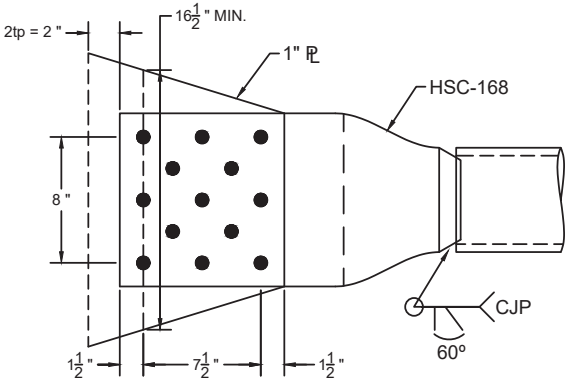
thus D/t ≤ 28.6

Designation	Wall Thick-ness	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	3/4	7/8	1	3/4	7/8	1
HSS 168										
x13	12.70	13.3	6,207	2,855	13-3/4"-325	10-7/8"-325	8-1"-325	11-3/4"-490	8-7/8"-490	6-1"-490
x9.5	9.53	17.7	4,750	2,185	10-3/4"-325	8-7/8"-325	6-1"-325	8-3/4"-490	6-7/8"-490	5-1"-490
x8.0	7.94	21.2	3,998	1,839	9-3/4"-325	6-7/8"-325	5-1"-325	7-3/4"-490	5-7/8"-490	4-1"-490
x6.4	6.35	26.5	3,230	1,486	7-3/4"-325	5-7/8"-325	4-1"-325	6-3/4"-490	4-7/8"-490	3-1"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   4" Long bolt for 3/4" and 7/8" ASTM F3125 - Grade A325 or Grade A490
   4¼" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490

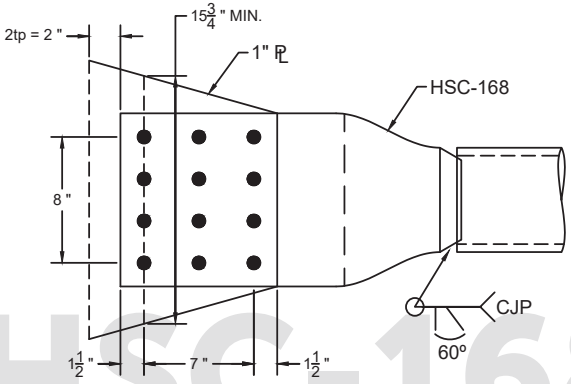
13-3/4"-325

Factored Resistance = 2874 kN



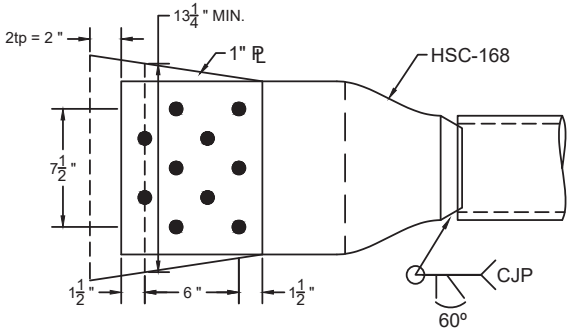
12-3/4"-325

Factored Resistance = 2562 kN



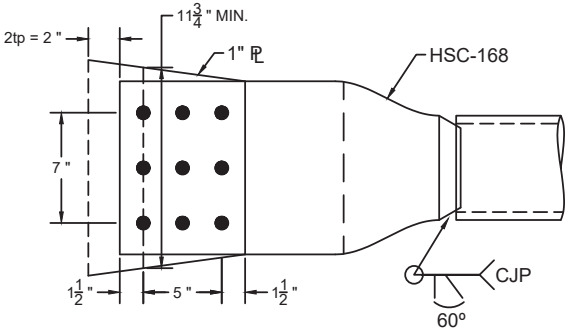
10-3/4"-325

Factored Resistance = 2192 kN



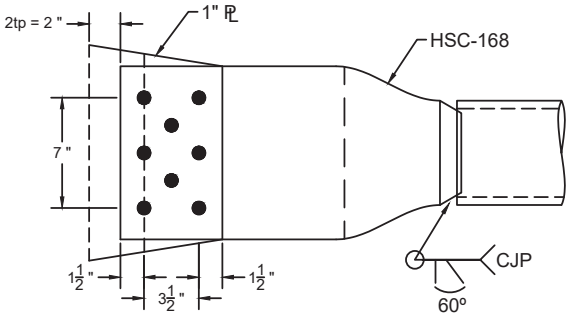
9-3/4"-325

Factored Resistance = 1974 kN



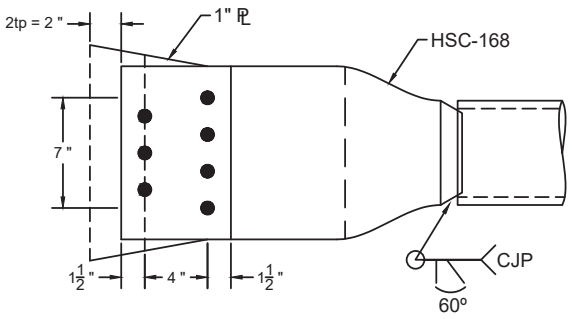
8-3/4"-325

Factored Resistance = 1806 kN



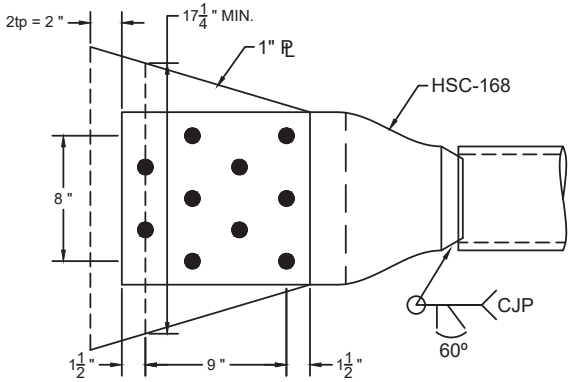
7-3/4"-325

Factored Resistance = 1580 kN



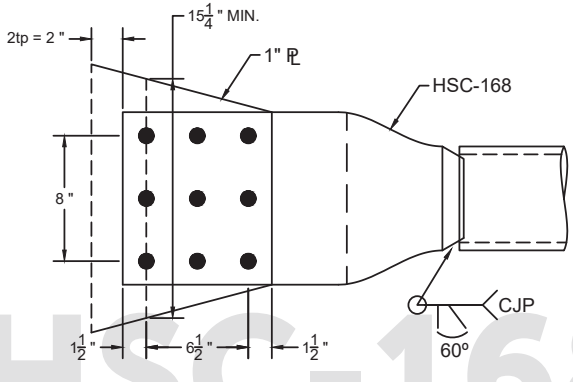
10-7/8"-325

Factored Resistance = 2873 kN



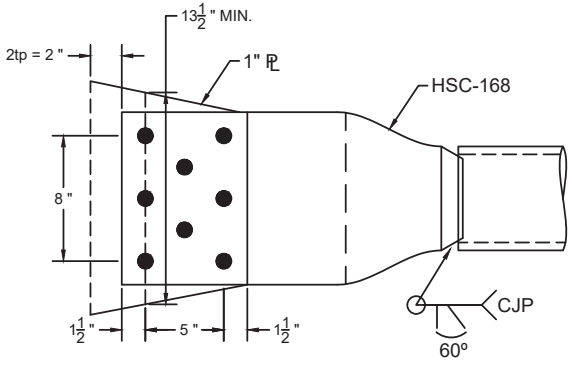
9-7/8"-325

Factored Resistance = 2579 kN



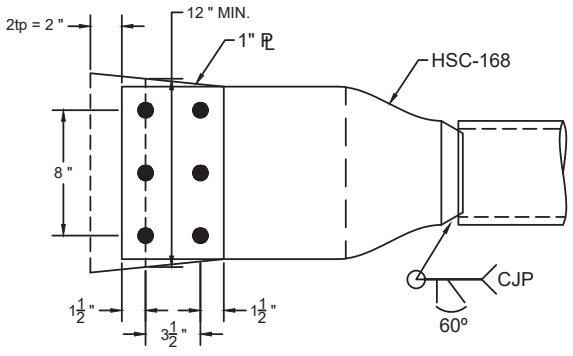
8-7/8"-325

Factored Resistance = 2244 kN



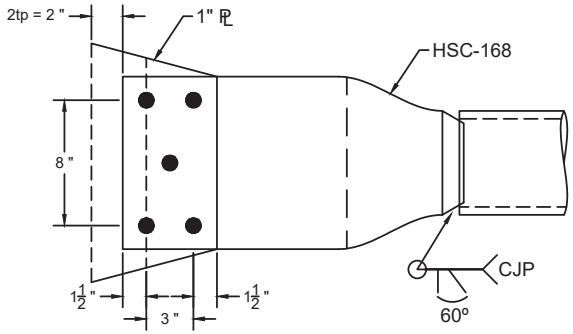
6-7/8"-325

Factored Resistance = 1844 kN



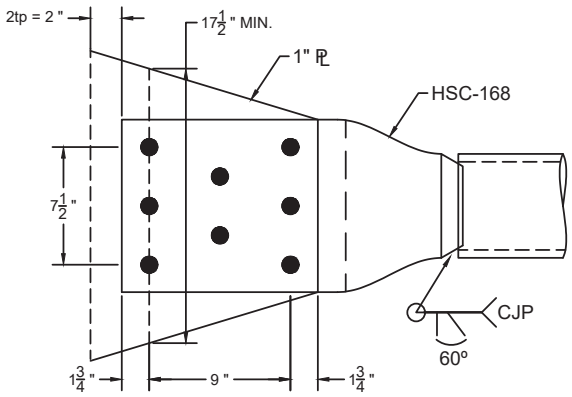
5-7/8"-325

Factored Resistance = 1536 kN



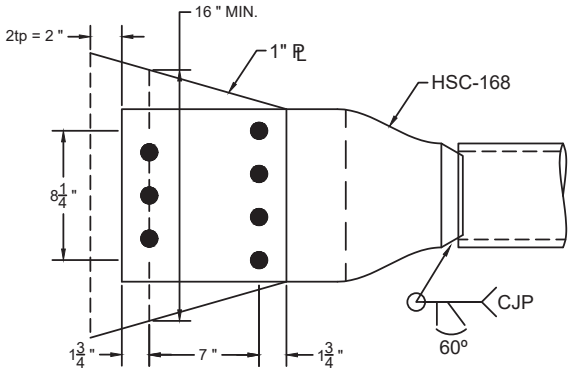
8-1"-325

Factored Resistance = 2887 kN



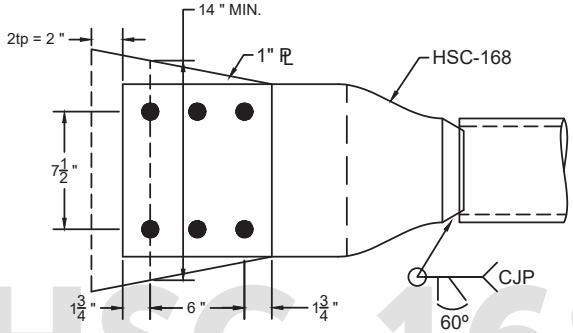
7-1"-325

Factored Resistance = 2568 kN



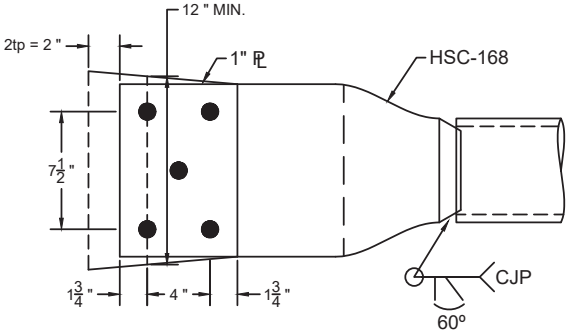
6-1"-325

Factored Resistance = 2224 kN



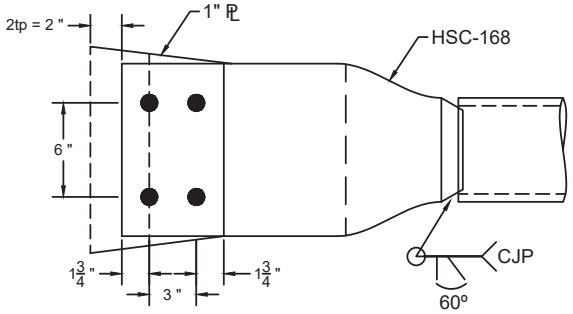
5-1"-325

Factored Resistance = 1943 kN



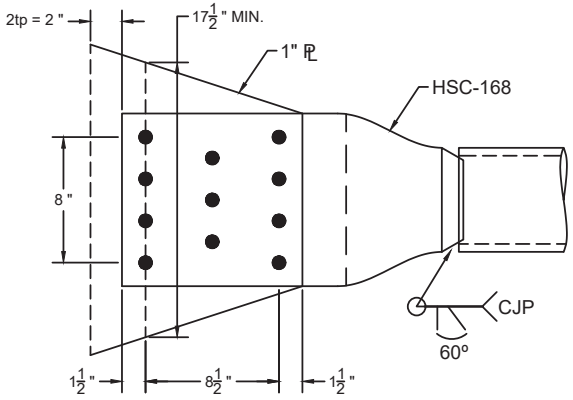
4-1"-325

Factored Resistance = 1526 kN



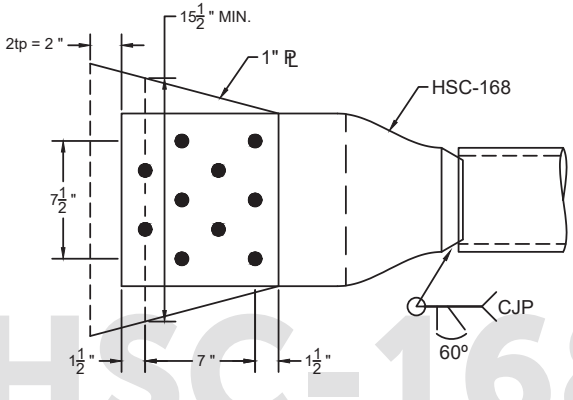
11-3/4"-490

Factored Resistance = 2886 kN



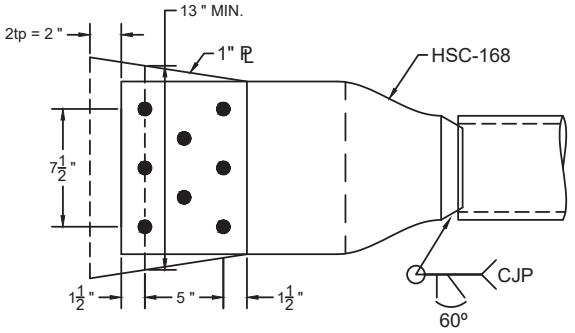
10-3/4"-490

Factored Resistance = 2574 kN



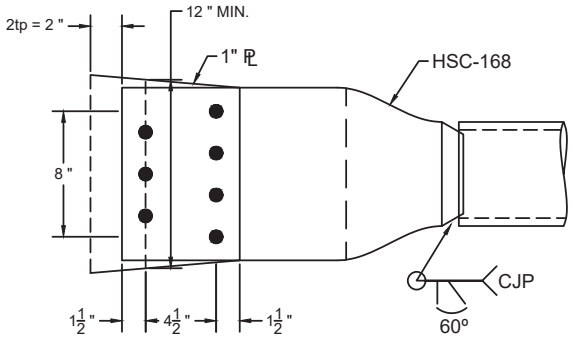
8-3/4"-490

Factored Resistance = 2228 kN



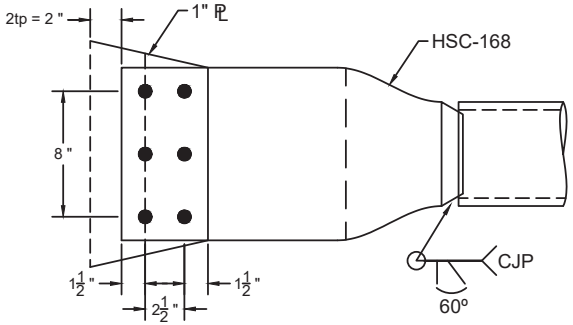
7-3/4"-490

Factored Resistance = 1982 kN



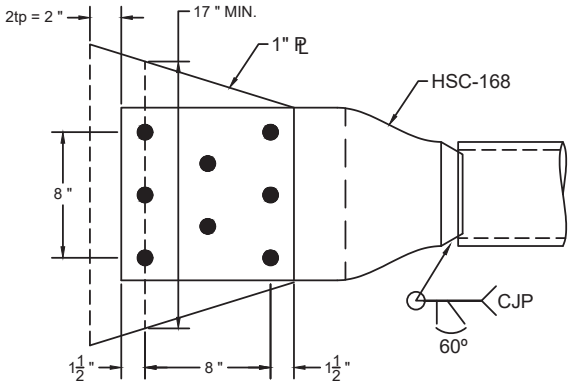
6-3/4"-490

Factored Resistance = 1699 kN



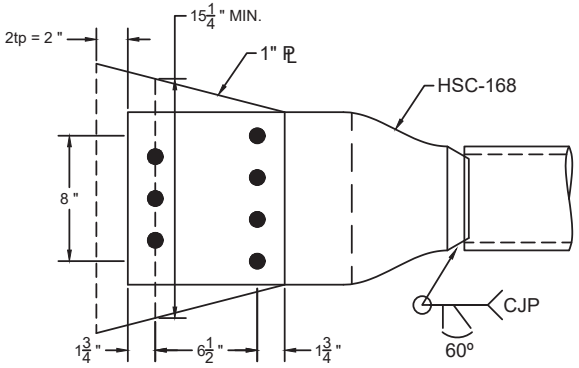
8-7/8"-490

Factored Resistance = 2904 kN



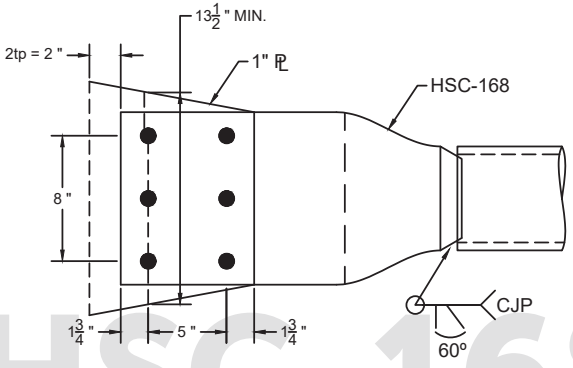
7-7/8"-490

Factored Resistance = 2556 kN



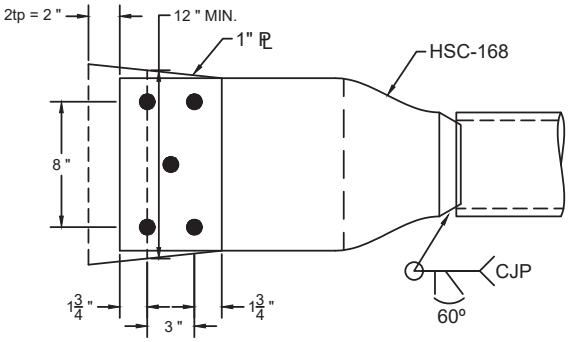
6-7/8"-490

Factored Resistance = 2246 kN



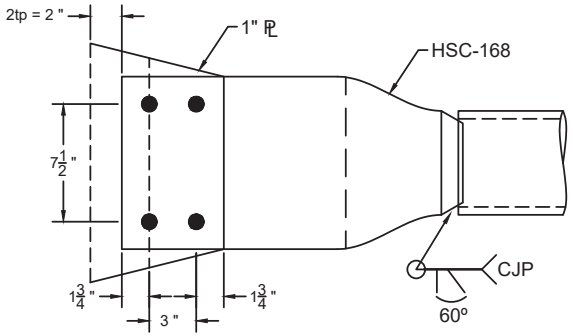
5-7/8"-490

Factored Resistance = 1894 kN



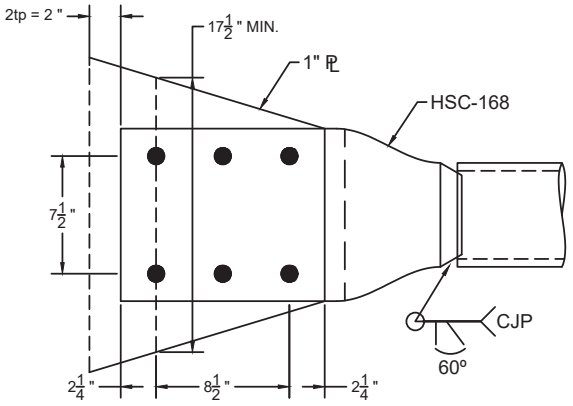
4-7/8"-490

Factored Resistance = 1533 kN



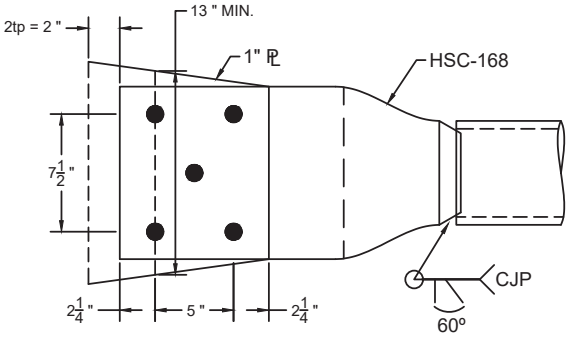
6-1"-490

Factored Resistance = 2857 kN



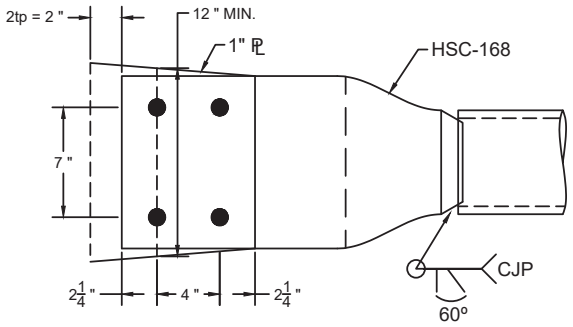
5-1"-490

Factored Resistance = 2226 kN



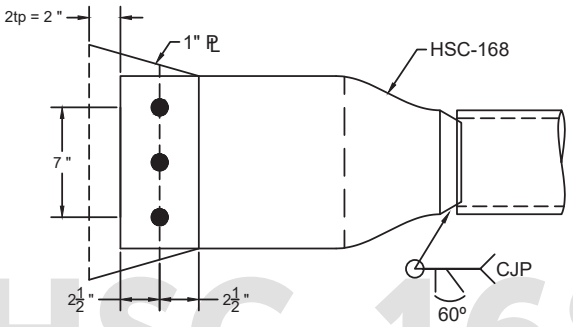
4-1"-490

Factored Resistance = 1987 kN



3-1"-490

Factored Resistance = 1510 kN



HSC-219

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

CAN/CSA G40.20/21
Grade 350W, Class C or H

Fy = 350 MPa

Ry·Fy = 460 MPa

thus D/t ≤ 28.6

Designation	Wall Thick-ness	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
HSS 219										
x16	15.88	13.8	10,134	4,662	12-1"-325	11-1 1/8"-325	9-1 1/4"-325	10-1"-490	8-1 1/8"-490	6-1 1/4"-490
x13	12.70	17.3	8,234	3,788	10-1"-325	9-1 1/8"-325	7-1 1/4"-325	8-1"-490	6-1 1/8"-490	5-1 1/4"-490
x9.5	9.53	23.0	6,271	2,884	8-1"-325	7-1 1/8"-325	6-1 1/4"-325	6-1"-490	5-1 1/8"-490	4-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:

4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490

5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490

HSC-219

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A500
Grade B

Fy = 315 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
HSS 219										
x16	15.88	13.8	10,134	4,662	12-1"-325	11-1 1/8"-325	9-1 1/4"-325	10-1"-490	8-1 1/8"-490	6-1 1/4"-490
x13	12.70	17.3	8,234	3,788	10-1"-325	9-1 1/8"-325	7-1 1/4"-325	8-1"-490	6-1 1/8"-490	5-1 1/4"-490
x9.5	9.53	23.0	6,271	2,884	8-1"-325	7-1 1/8"-325	6-1 1/4"-325	6-1"-490	5-1 1/8"-490	4-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A500 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-219

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A500
Grade C

Fy = 345 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
HSS 219										
x16	15.88	13.8	10,134	4,662	12-1"-325	11-1 1/8"-325	9-1 1/4"-325	10-1"-490	8-1 1/8"-490	6-1 1/4"-490
x13	12.70	17.3	8,234	3,788	10-1"-325	9-1 1/8"-325	7-1 1/4"-325	8-1"-490	6-1 1/8"-490	5-1 1/4"-490
x9.5	9.53	23.0	6,271	2,884	8-1"-325	7-1 1/8"-325	6-1 1/4"-325	6-1"-490	5-1 1/8"-490	4-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   - 4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   - 5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A500 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-219

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A53
Grade B

Fy = 241 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
Pipe 8										
XS	12.70	17.3	8,234	3,788	10-1"-325	9-1 1/8"-325	7-1 1/4"-325	8-1"-490	6-1 1/8"-490	5-1 1/4"-490
STD	8.18	26.8	5,419	2,493	7-1"-325	6-1 1/8"-325	5-1 1/4"-325	5-1"-490	4-1 1/8"-490	4-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   - 4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   - 5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A53 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-219

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A1085
Grade A

Fy = 350 MPa

Ry·Fy = 460 MPa

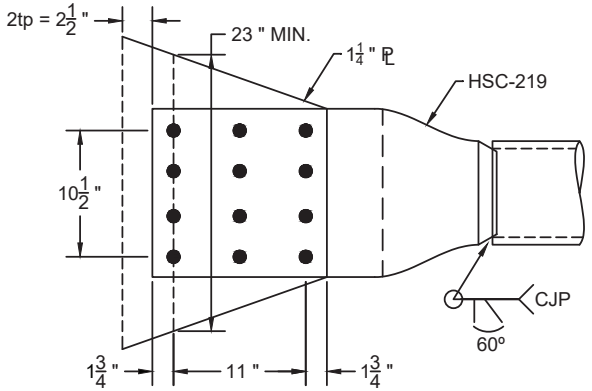
thus D/t ≤ 28.6

Designation	Wall Thick-ness	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
HSS 219										
x16	15.88	13.8	10,134	4,662	12-1"-325	11-1 1/8"-325	9-1 1/4"-325	10-1"-490	8-1 1/8"-490	6-1 1/4"-490
x13	12.70	17.3	8,234	3,788	10-1"-325	9-1 1/8"-325	7-1 1/4"-325	8-1"-490	6-1 1/8"-490	5-1 1/4"-490
x9.5	9.53	23.0	6,271	2,884	8-1"-325	7-1 1/8"-325	6-1 1/4"-325	6-1"-490	5-1 1/8"-490	4-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490

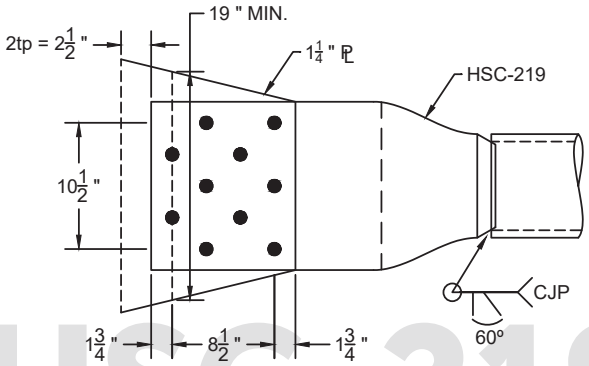
12-1"-325

Factored Resistance = 4667 kN



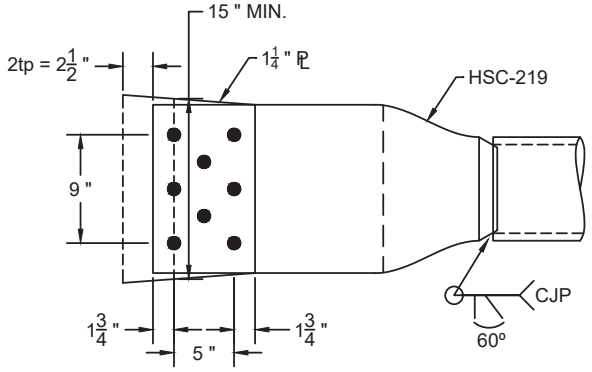
10-1"-325

Factored Resistance = 3819 kN



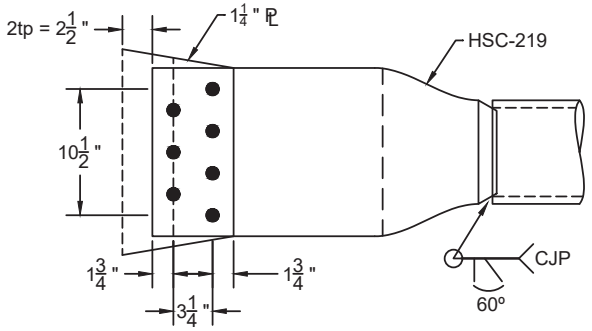
8-1"-325

Factored Resistance = 3034 kN



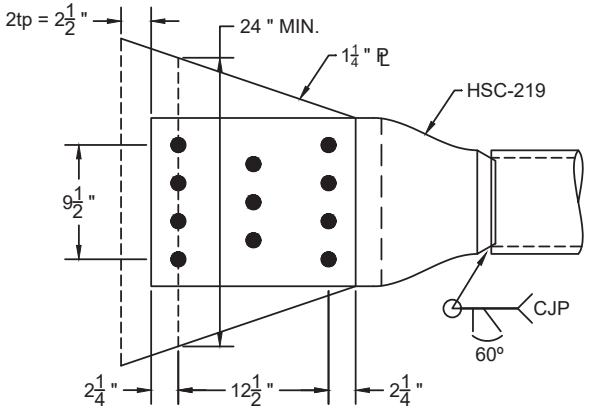
7-1"-325

Factored Resistance = 2809 kN



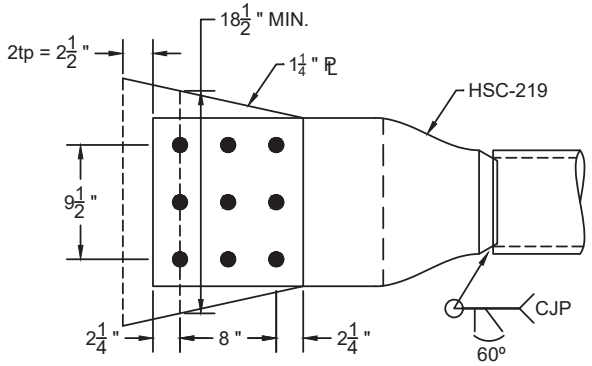
11-1 1/8"-325

Factored Resistance = 4768 kN



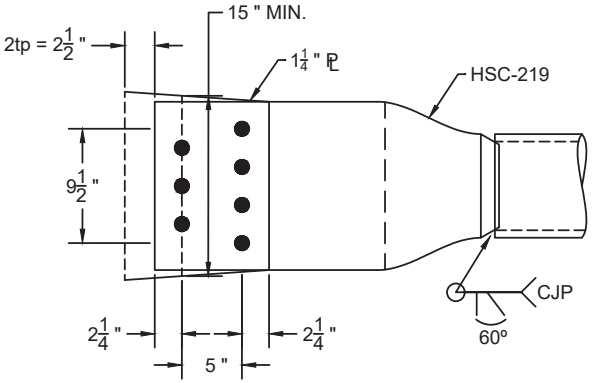
9-1 1/8"-325

Factored Resistance = 3866 kN



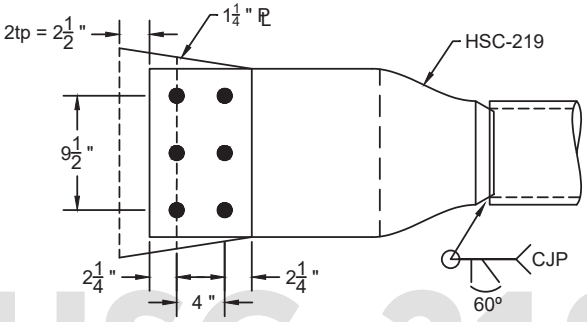
7-1 1/8"-325

Factored Resistance = 2989 kN



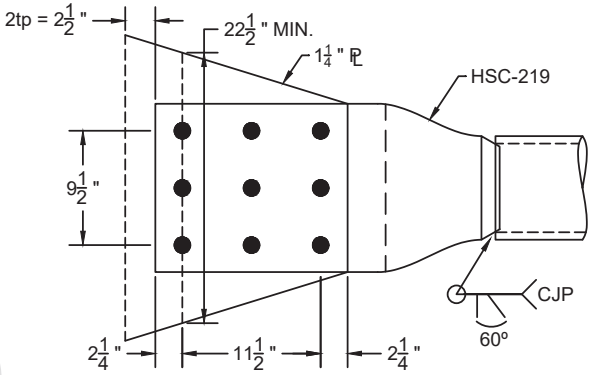
6-1 1/8"-325

Factored Resistance = 2726 kN



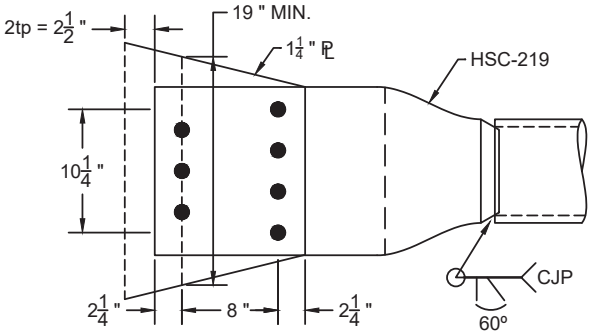
9-1 1/4"-325

Factored Resistance = 4706 kN



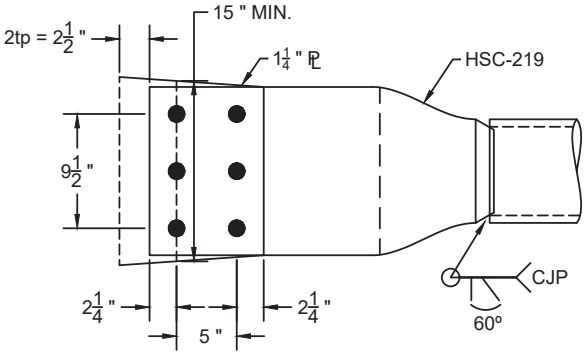
7-1 1/4"-325

Factored Resistance = 3845 kN



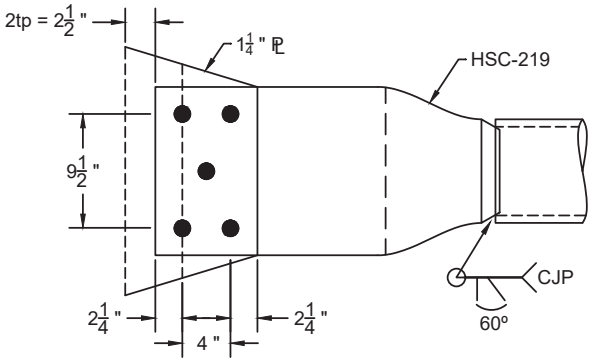
6-1 1/4"-325

Factored Resistance = 2890 kN



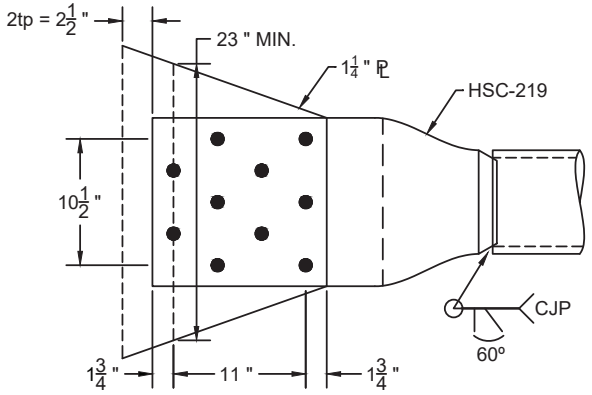
5-1 1/4"-325

Factored Resistance = 2738 kN



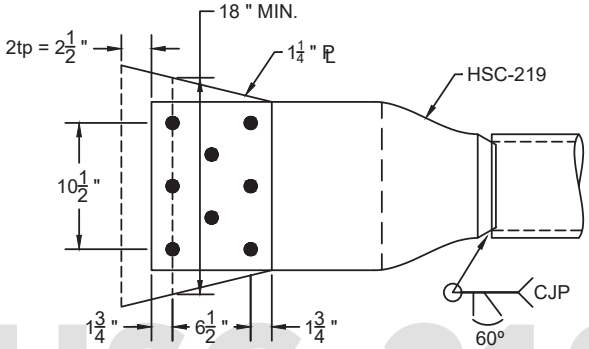
10-1"-490

Factored Resistance = 4718 kN



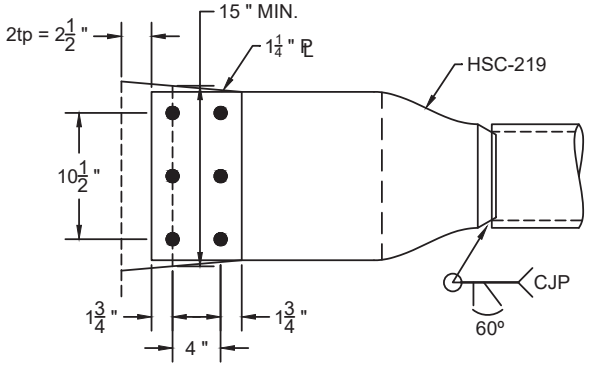
8-1"-490

Factored Resistance = 3831 kN



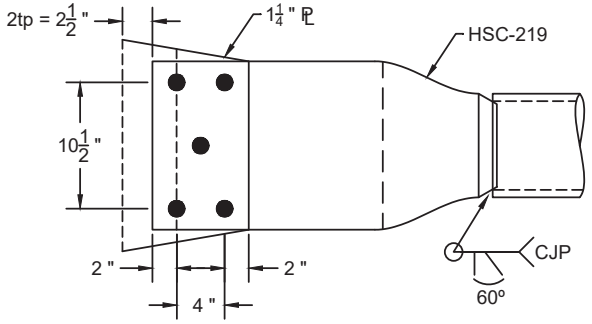
6-1"-490

Factored Resistance = 2939 kN



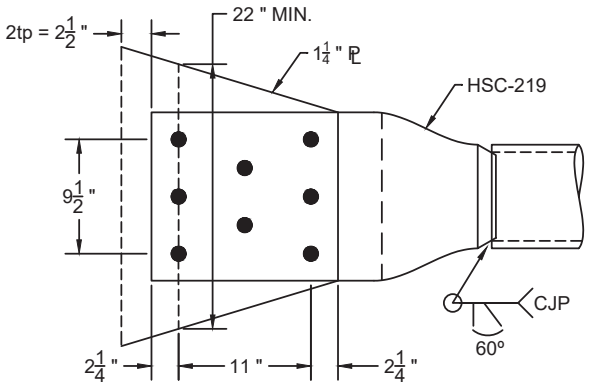
5-1"-490

Factored Resistance = 2517 kN



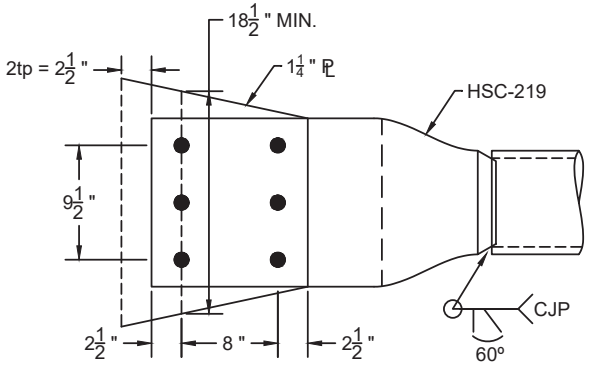
8-1 1/8"-490

Factored Resistance = 4690 kN



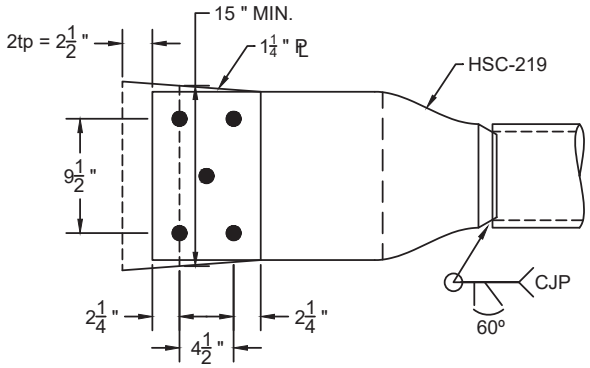
6-1 1/8"-490

Factored Resistance = 3823 kN



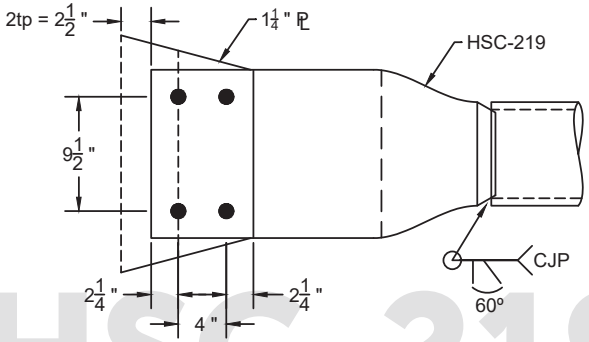
5-1 1/8"-490

Factored Resistance = 3060 kN



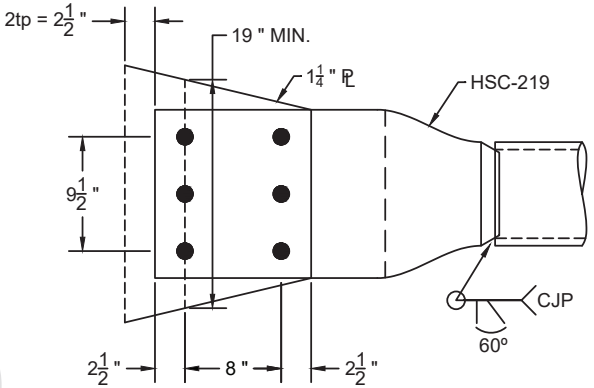
4-1 1/8"-490

Factored Resistance = 2499 kN



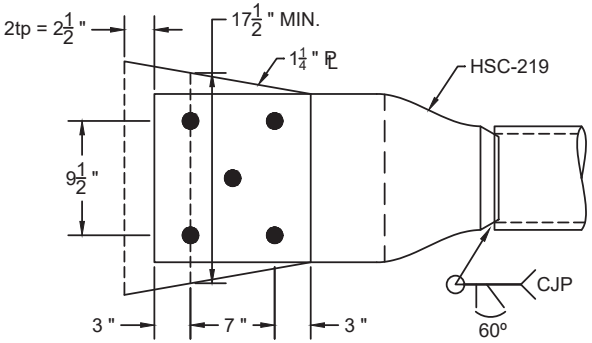
6-1 1/4"-490

Factored Resistance = 4671 kN



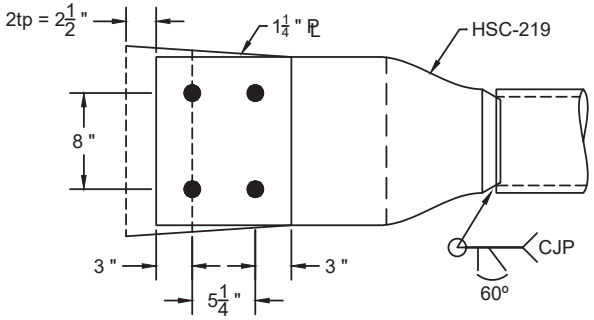
5-1 1/4"-490

Factored Resistance = 3810 kN



4-1 1/4"-490

Factored Resistance = 3019 kN



HSC-273

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

CAN/CSA G40.20/21
Grade 350W, Class C or H

Fy = 350 MPa

Ry·Fy = 460 MPa

thus D/t ≤ 28.6

Designation	Wall Thick-ness	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
HSS 273										
x16	15.88	17.2	12,826	5,900	15-1"-325	14-1 1/8"-325	10-1 1/4"-325	12-1"-490	10-1 1/8"-490	8-1 1/4"-490
x13	12.70	21.5	10,388	4,778	12-1"-325	10-1 1/8"-325	9-1 1/4"-325	10-1"-490	8-1 1/8"-490	7-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490

HSC-273

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A500
Grade B

Fy = 315 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
HSS 273										
x16	15.88	17.2	12,826	5,900	15-1"-325	14-1 1/8"-325	10-1 1/4"-325	12-1"-490	10-1 1/8"-490	8-1 1/4"-490
x13	12.70	21.5	10,388	4,778	12-1"-325	10-1 1/8"-325	9-1 1/4"-325	10-1"-490	8-1 1/8"-490	7-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A500 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-273

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A500
Grade C

Fy = 345 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
HSS 273										
x16	15.88	17.2	12,826	5,900	15-1"-325	14-1 1/8"-325	10-1 1/4"-325	12-1"-490	10-1 1/8"-490	8-1 1/4"-490
x13	12.70	21.5	10,388	4,778	12-1"-325	10-1 1/8"-325	9-1 1/4"-325	10-1"-490	8-1 1/8"-490	7-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   - 4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   - 5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A500 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-273

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A53
Grade B

Fy = 241 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
Pipe 10 XS	12.70	21.5	10,388	4,778	15-1"-325	14-1 1/8"-325	10-1 1/4"-325	12-1"-490	10-1 1/8"-490	8-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A53 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-273

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A1085
Grade A

Fy = 350 MPa

Ry·Fy = 460 MPa

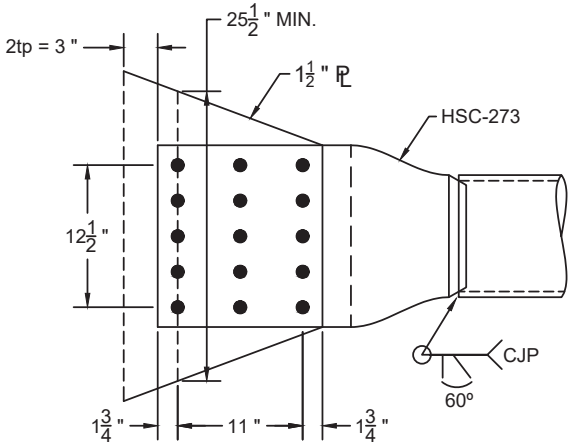
thus D/t ≤ 28.6

Designation	Wall Thick-ness	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
HSS 273										
x16	15.88	17.2	12,826	5,900	15-1"-325	14-1 1/8"-325	10-1 1/4"-325	12-1"-490	10-1 1/8"-490	8-1 1/4"-490
x13	12.70	21.5	10,388	4,778	12-1"-325	10-1 1/8"-325	9-1 1/4"-325	10-1"-490	8-1 1/8"-490	7-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490

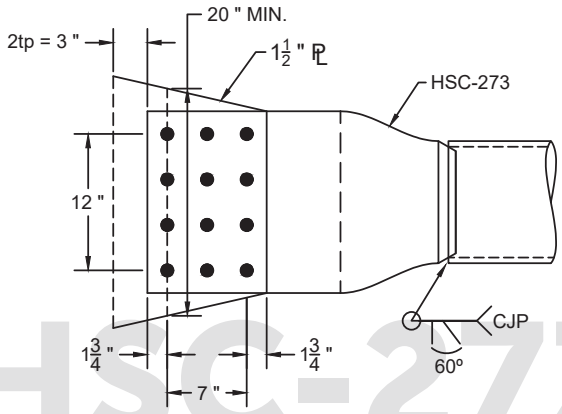
15-1"-325

Factored Resistance = 5907 kN



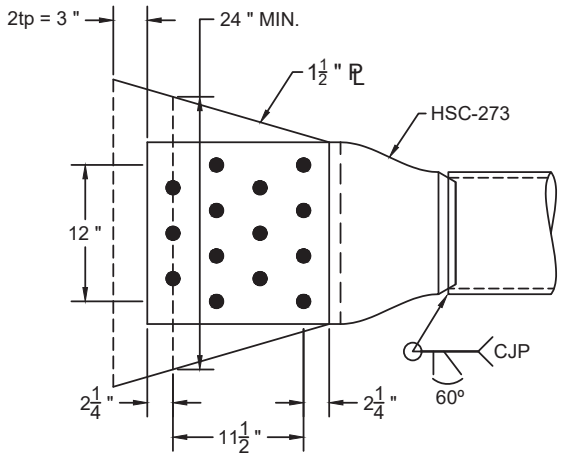
12-1"-325

Factored Resistance = 4816 kN



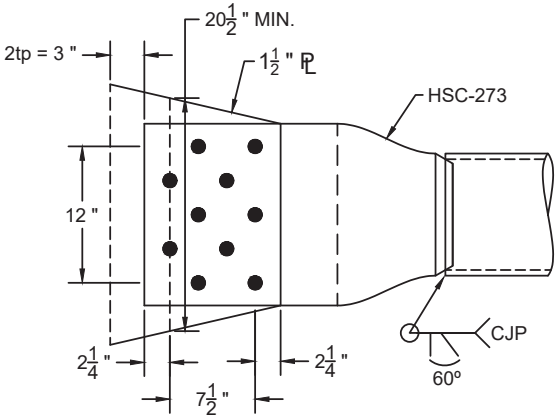
14-1 1/8"-325

Factored Resistance = 5953 kN



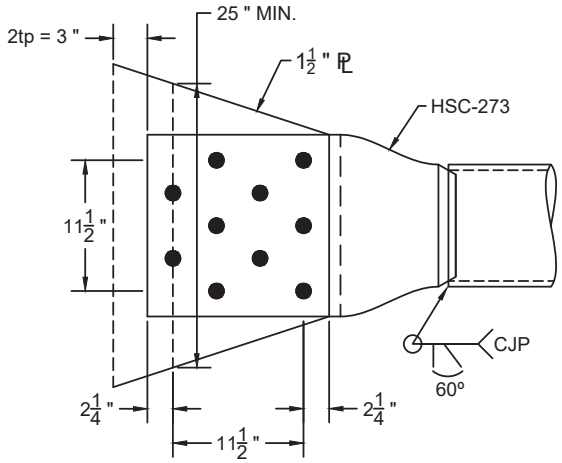
10-1 1/8"-325

Factored Resistance = 4832 kN



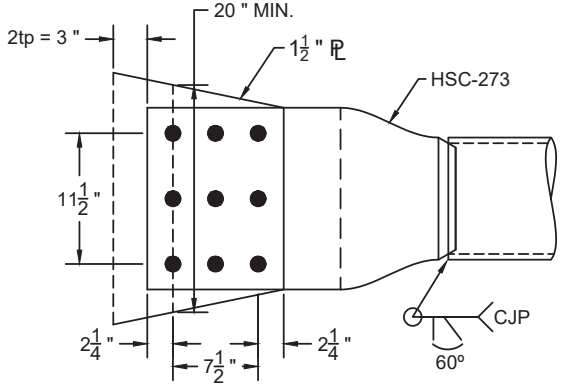
10-1 1/4"-325

Factored Resistance = 6021 kN



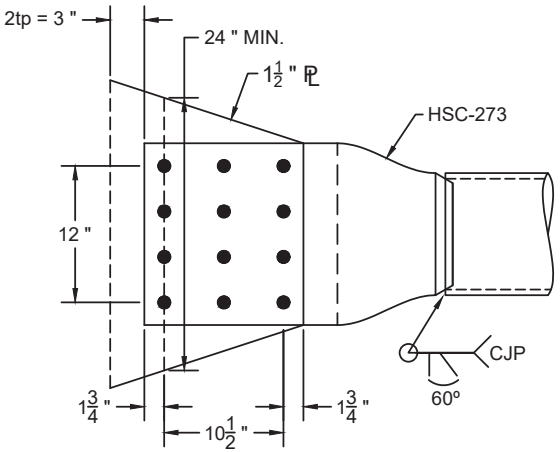
9-1 1/4"-325

Factored Resistance = 4948 kN



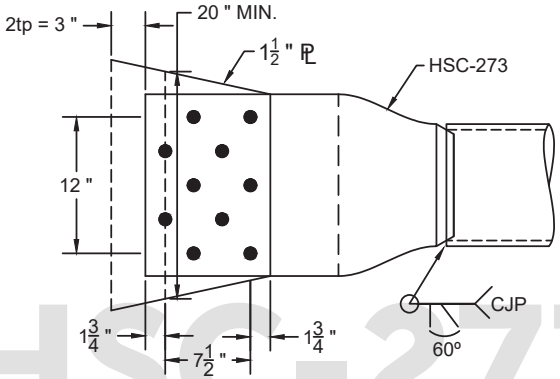
12-1"-490

Factored Resistance = 5983 kN



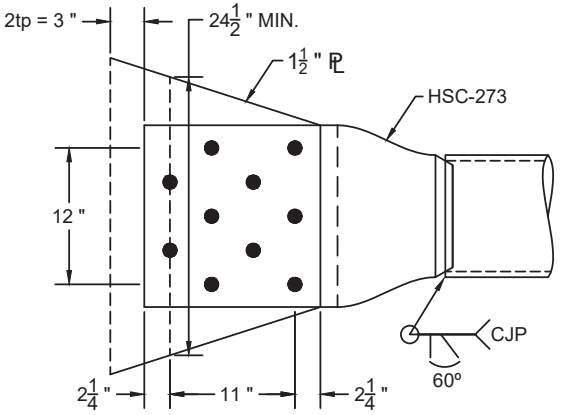
10-1"-490

Factored Resistance = 4871 kN



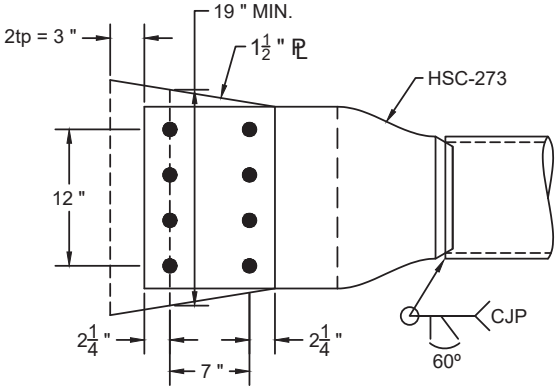
10-1 1/8"-490

Factored Resistance = 5998 kN



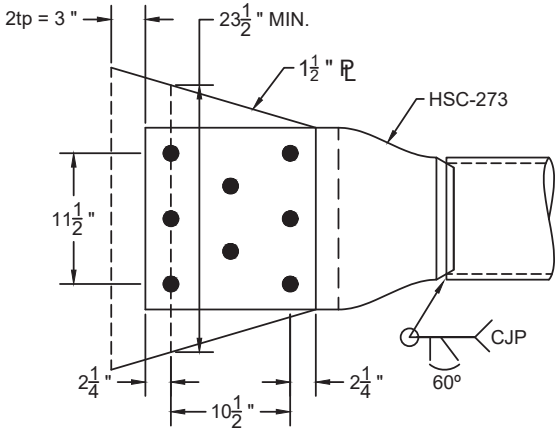
8-1 1/8"-490

Factored Resistance = 4860 kN



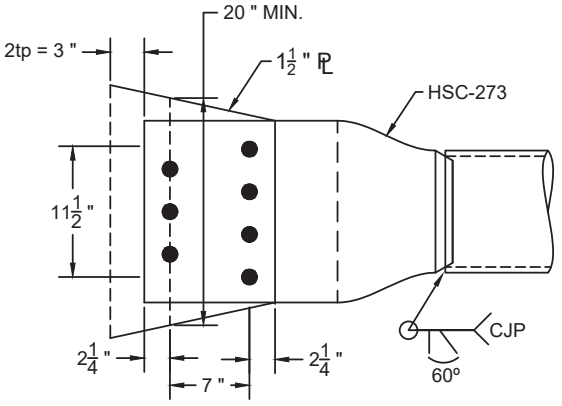
8-1 1/4"-490

Factored Resistance = 6017 kN



7-1 1/4"-490

Factored Resistance = 4866 kN



HSC-324

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

CAN/CSA G40.20/21
Grade 350W, Class C or H

Fy = 350 MPa

Ry·Fy = 460 MPa

thus D/t ≤ 28.6

Designation	Wall Thick-ness	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
HSS 324										
x16	15.88	20.4	15,360	7,065	18-1"-325	14-1 1/8"-325	12-1 1/4"-325	15-1"-490	12-1 1/8"-490	9-1 1/4"-490
x13	12.70	25.5	12,414	5,711	15-1"-325	12-1 1/8"-325	10-1 1/4"-325	12-1"-490	9-1 1/8"-490	8-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:

4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490

5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490

HSC-324

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A500
Grade B

Fy = 315 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
HSS 324										
x16	15.88	20.4	15,360	7,065	18-1"-325	14-1 1/8"-325	12-1 1/4"-325	15-1"-490	12-1 1/8"-490	9-1 1/4"-490
x13	12.70	25.5	12,414	5,711	15-1"-325	12-1 1/8"-325	10-1 1/4"-325	12-1"-490	9-1 1/8"-490	8-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A500 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-324

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A500
Grade C

Fy = 345 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
HSS 324										
x16	15.88	20.4	15,360	7,065	18-1"-325	14-1 1/8"-325	12-1 1/4"-325	15-1"-490	12-1 1/8"-490	9-1 1/4"-490
x13	12.70	25.5	12,414	5,711	15-1"-325	12-1 1/8"-325	10-1 1/4"-325	12-1"-490	9-1 1/8"-490	8-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A500 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-324

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A53
Grade B

Fy = 241 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
Pipe 12 XS	12.70	25.5	12,414	5,711	15-1"-325	12-1 1/8"-325	10-1 1/4"-325	12-1"-490	9-1 1/8"-490	8-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A53 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-324

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A1085
Grade A

Fy = 350 MPa

Ry·Fy = 460 MPa

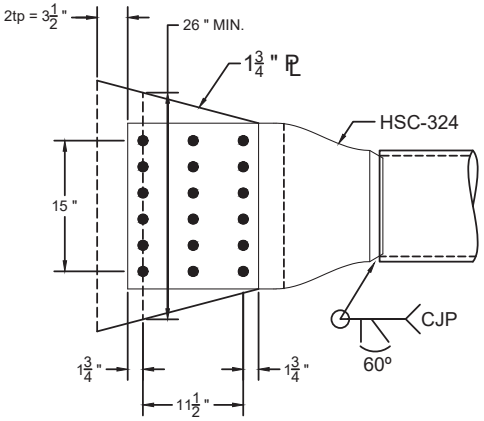
thus D/t ≤ 28.6

Designation	Wall Thick-ness	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
HSS 324										
x16	15.88	20.4	15,360	7,065	18-1"-325	14-1 1/8"-325	12-1 1/4"-325	15-1"-490	12-1 1/8"-490	9-1 1/4"-490
x13	12.70	25.5	12,414	5,711	15-1"-325	12-1 1/8"-325	10-1 1/4"-325	12-1"-490	9-1 1/8"-490	8-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490

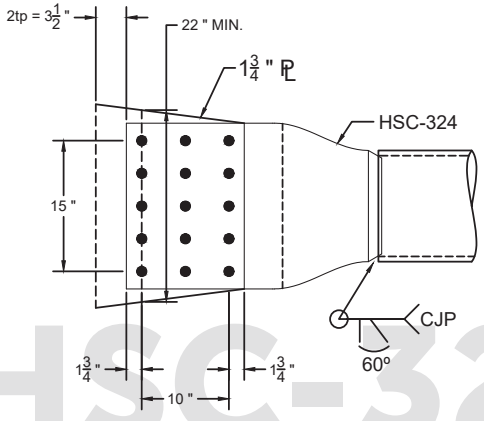
18-1"-325

Factored Resistance = 7130 kN



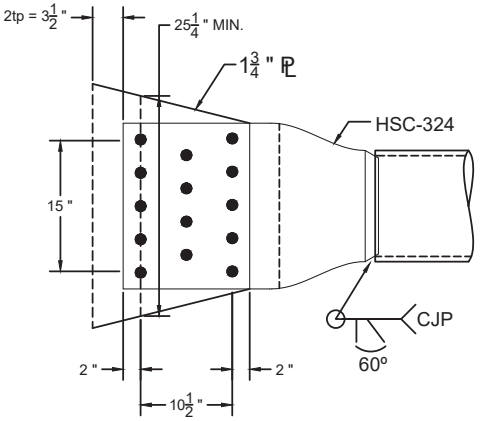
15-1"-325

Factored Resistance = 6020 kN



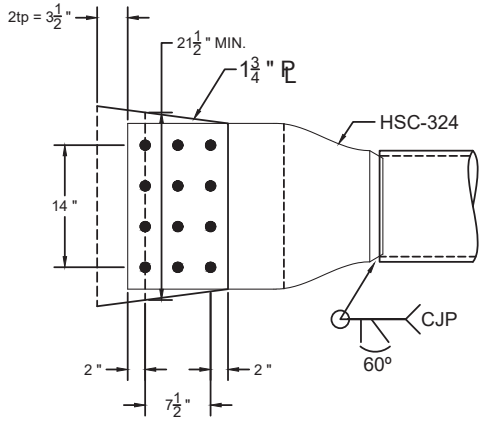
14-1 1/8"-325

Factored Resistance = 7068 kN



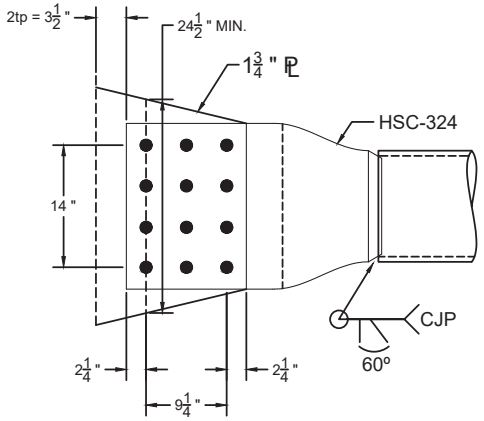
12-1 1/8"-325

Factored Resistance = 6095 kN



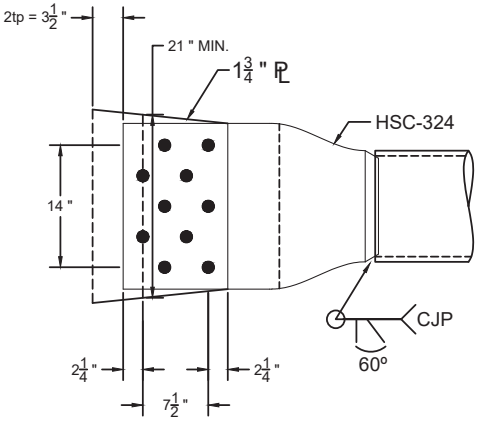
12-1 1/4"-325

Factored Resistance = 7078 kN



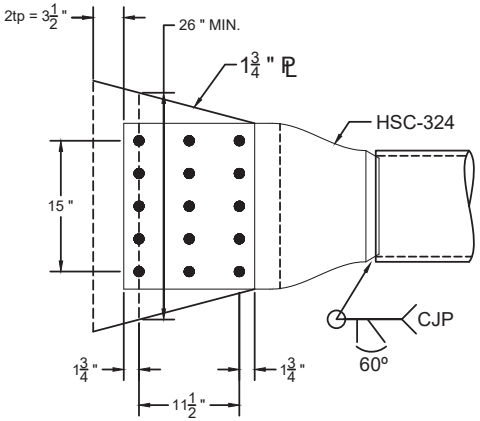
10-1 1/4"-325

Factored Resistance = 6032 kN



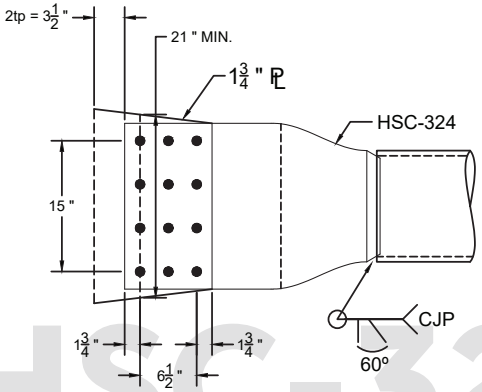
15-1"-490

Factored Resistance = 7552 kN



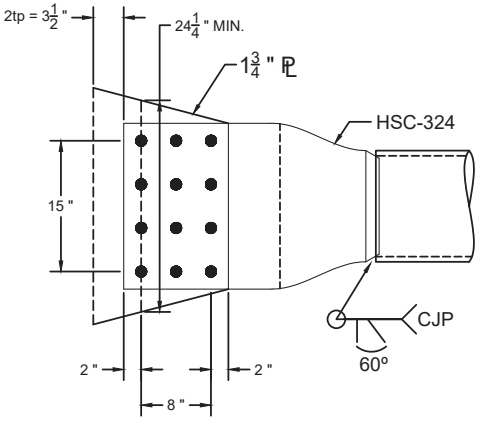
12-1"-490

Factored Resistance = 6042 kN



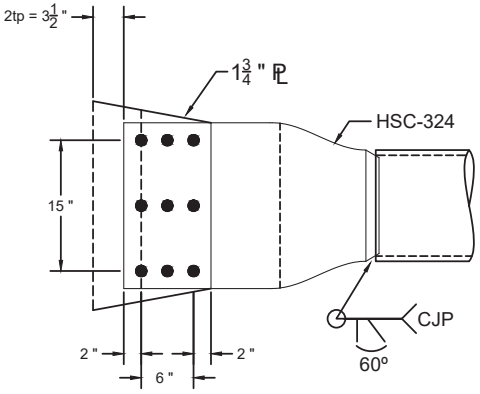
12-1 1/8"-490

Factored Resistance = 7161 kN



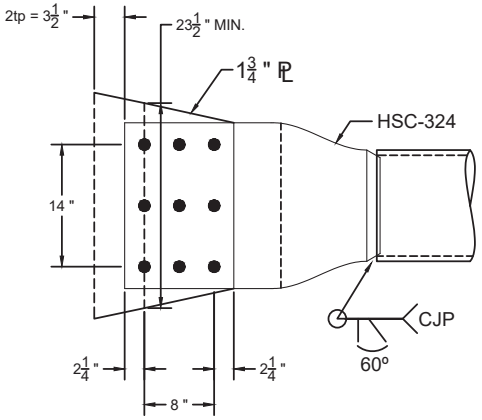
9-1 1/8"-490

Factored Resistance = 5735 kN



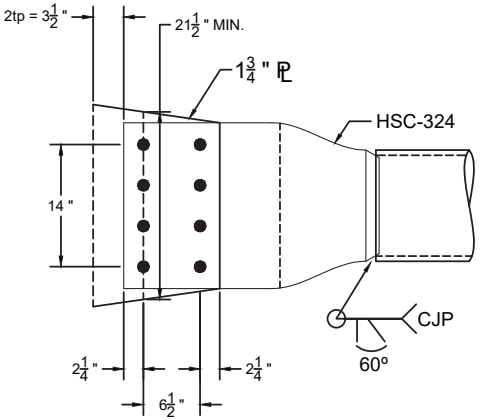
9-1 1/4"-490

Factored Resistance = 7080 kN



8-1 1/4"-490

Factored Resistance = 6054 kN



HSC-356

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

CAN/CSA G40.20/21
Grade 350W, Class C or H

Fy = 350 MPa

Ry·Fy = 460 MPa

thus D/t ≤ 28.6

Designation	Wall Thick-ness	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
HSS 356										
x16	15.88	22.4	16,943	7,794	20-1"-325	16-1 1/8"-325	13-1 1/4"-325	16-1"-490	13-1 1/8"-490	10-1 1/4"-490
x13	12.70	28.0	13,681	6,293	16-1"-325	13-1 1/8"-325	11-1 1/4"-325	13-1"-490	10-1 1/8"-490	9-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490

HSC-356

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A500
Grade B

Fy = 315 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
HSS 356										
x16	15.88	22.4	16,943	7,794	20-1"-325	16-1 1/8"-325	13-1 1/4"-325	16-1"-490	13-1 1/8"-490	10-1 1/4"-490
x13	12.70	28.0	13,681	6,293	16-1"-325	13-1 1/8"-325	11-1 1/4"-325	13-1"-490	10-1 1/8"-490	9-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   - 4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   - 5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A500 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-356

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A500
Grade C

Fy = 345 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
HSS 356										
x16	15.88	22.4	16,943	7,794	20-1"-325	16-1 1/8"-325	13-1 1/4"-325	16-1"-490	13-1 1/8"-490	10-1 1/4"-490
x13	12.70	28.0	13,681	6,293	16-1"-325	13-1 1/8"-325	11-1 1/4"-325	13-1"-490	10-1 1/8"-490	9-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   - 4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   - 5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A500 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-356

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A53
Grade B

Fy = 241 MPa

Ry·Fy = 460 MPa

thus[3] D/t ≤ 28.6

Designation	Nominal Wall Thick-ness[2]	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
Pipe 14 XS	12.70	28.0	13,681	6,293	16-1"-325	13-1 1/8"-325	11-1 1/4"-325	13-1"-490	10-1 1/8"-490	9-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490
2. Probable brace resistances of ASTM A53 HSS members are based on unreduced wall thickness. Clause 27.5.3.5
3. Probable yield stress taken as not less than 350 MPa when verifying width-to-tickness limits. Clause 27.1.7

HSC-356

CAN/CSA S16-24

$$\frac{D}{t} \leq \frac{10{,}000}{Fy}$$

ASTM A1085
Grade A

Fy = 350 MPa

Ry·Fy = 460 MPa

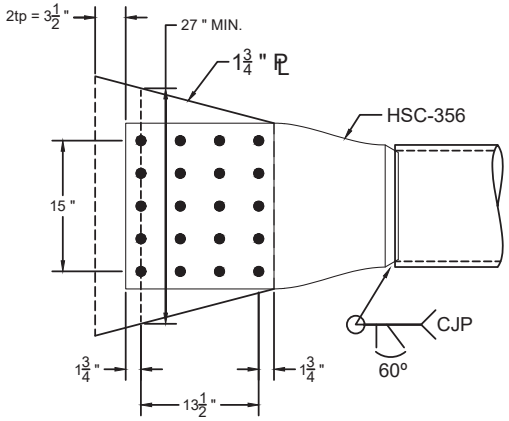
thus D/t ≤ 28.6

Designation	Wall Thick-ness	D/t	Area	A·Ry·Fy	BEARING-TYPE CONNECTIONS[1] Detail Number					
					ASTM F3125 - Grade A325			ASTM F3125 - Grade A490		
					Bolt Size			Bolt Size		
mm x mm	mm		mm^2	kN	1	1⅛	1¼	1	1⅛	1¼
HSS 356										
x16	15.88	22.4	16,943	7,794	20-1"-325	16-1 1/8"-325	13-1 1/4"-325	16-1"-490	13-1 1/8"-490	10-1 1/4"-490
x13	12.70	28.0	13,681	6,293	16-1"-325	13-1 1/8"-325	11-1 1/4"-325	13-1"-490	10-1 1/8"-490	9-1 1/4"-490

1. Connections must have pretensioned high-strength bolts. The following are suggested bolt lengths:
   - 4¾" Long bolt for 1" ASTM F3125 - Grade A325 or Grade A490
   - 5" Long bolt for 1¼" and 1⅛" ASTM F3125 - Grade A325 or Grade A490

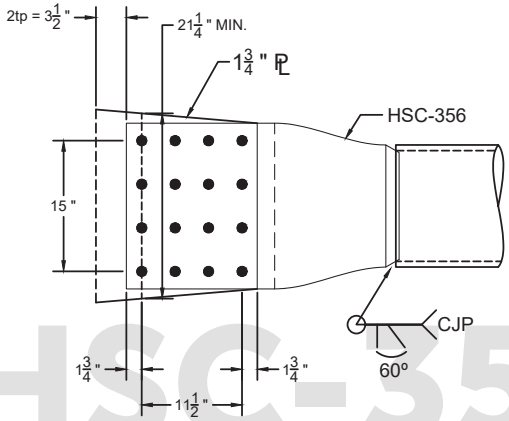
20-1"-325

Factored Resistance = 7924 kN



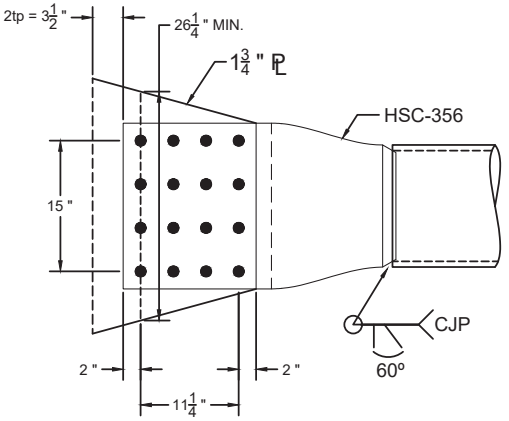
16-1"-325

Factored Resistance = 6370 kN



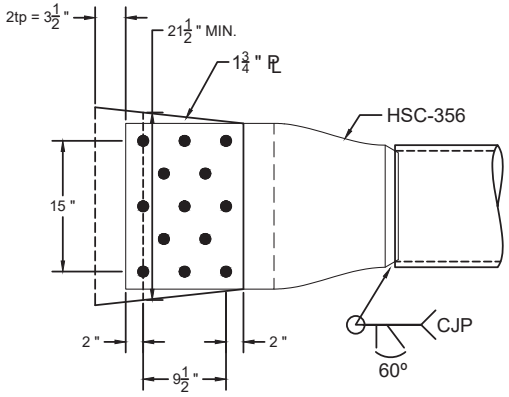
16-1 1/8"-325

Factored Resistance = 7873 kN



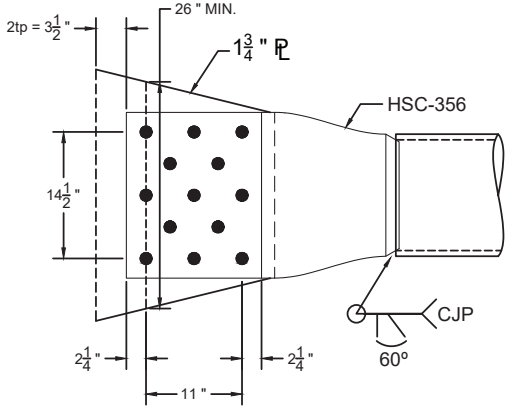
13-1 1/8"-325

Factored Resistance = 6384 kN



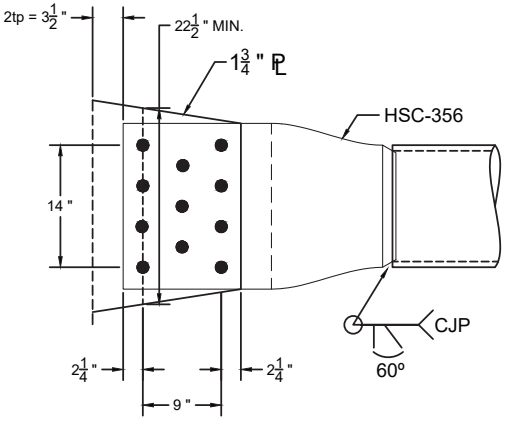
13-1 1/4"-325

Factored Resistance = 7926 kN



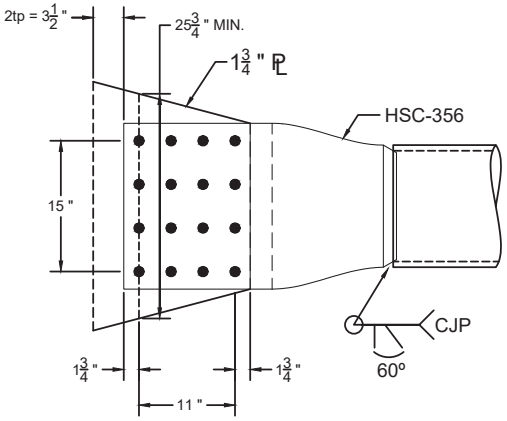
11-1 1/4"-325

Factored Resistance = 6420 kN



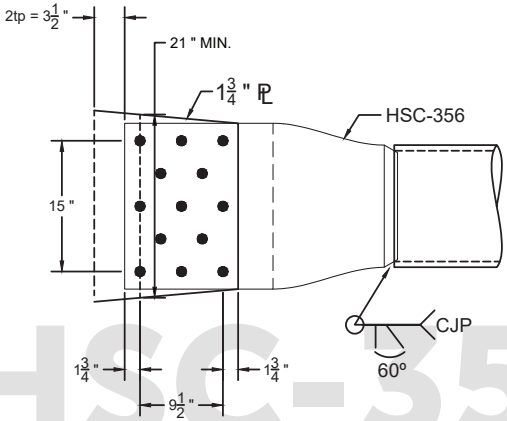
16-1"-490

Factored Resistance = 7850 kN



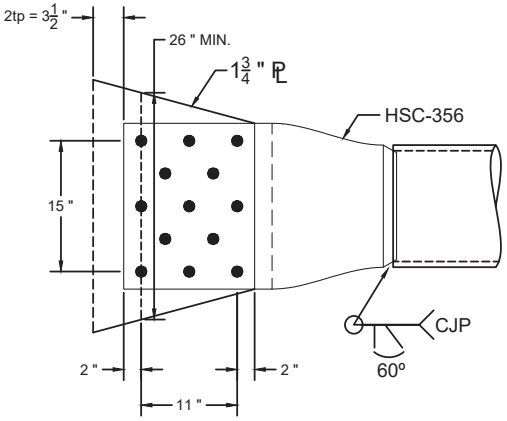
13-1"-490

Factored Resistance = 6402 kN



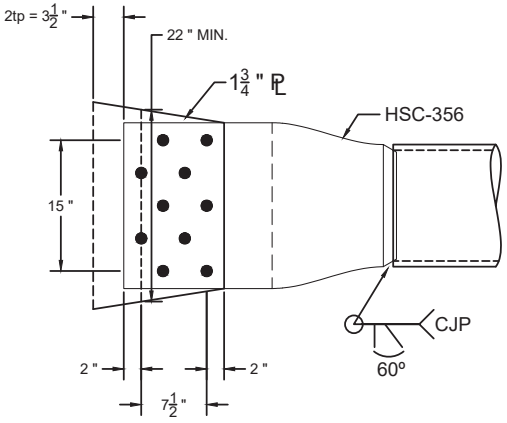
13-1 1/8"-490

Factored Resistance = 7926 kN



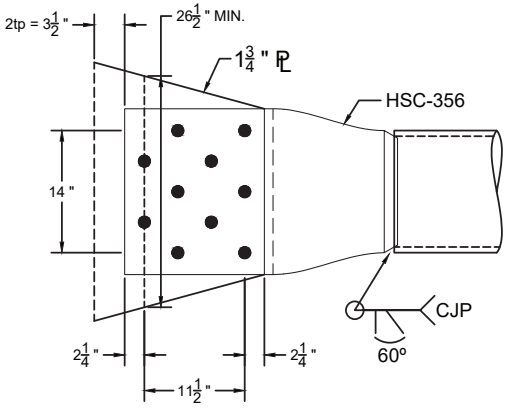
10-1 1/8"-490

Factored Resistance = 6372 kN



10-1 1/4"-490

Factored Resistance = 7799 kN



9-1 1/4"-490

Factored Resistance = 7080 kN