



OFFICE OF ASSISTANT VICE PRESIDENT – ENGINEERING SERVICES

General Specifications for Sub-grade and Above Grade Utility Crossings of Railway's Right-of-Way

I. General Provisions

- A. A plan and profile drawing containing all pertinent details measured in U. S. lineal feet for the proposed crossing shall be submitted to the Engineering Department for approval prior to the preparation of any agreement. (Metric units, not accepted). Plans shall illustrate the profile in relation to actual ground, track, and other facilities at the project site. All crossings (above grade/sub-grade) shall be substantially perpendicular to the Railroad Main Line and shall not be placed within a culvert or under bridges. The location of crossing shall be limited to crossing as few tracks as possible.
- B. The plan will show all information for the proposed crossing installation with reference to the nearest Railroad Mile Post or centerline of nearest street intersection.
- C. The method of installation will be detailed, including the location of jacking pit and receiving pit as measured from centerline of nearest track. Measurements should be made perpendicular to the track.
- D. Request for installation shall be accompanied with a letter signed by the owner, company officer, or government agent.
- E. The lessee will be responsible for any and all costs of repairs or maintenance of the Railroad's property and structures disturbed or damaged due to the installation or construction aftereffects.
- F. The lessee of an installation approved by agreement will be required to provide proof of protective insurance for and during construction.
- G. As-built drawing of the installation shall be submitted with the completion report, which will include exact location referenced to nearest Railroad milepost or centerline of nearest street intersection of installation, exact profile showing subgrade elevations, and cross-sections.
- H. All power and communication lines constructed over, under or parallel to the railroad shall meet or exceed the requirements of the National Electric Safety Code, latest revision.
- I. Where laws or orders of public authority prescribe a higher degree of protection than specified herein, then the higher degree of protection shall be deemed a part of these specifications.

II. Subgrade Pipelines and Cables

A. General

1. All subgrade carrier pipelines conveying liquids and wirelines shall be installed within a casing pipe (See exception for HDPE housing fiber-optic and other communication lines – Section A.5.). Gas pipelines may be installed without casing provided that installation is 10 feet or more below the bottom of tie and steel carrier pipe is used.
 - a. All casing pipes will extend from right-of-way line to right-of-way line and shall be equipped with shut-off valves each side, protecting the entire R/W crossing.
 - b. The Railroad will not permit casing installation by open-cut method through the track(s) roadbed.
 - c. The casing pipe may be omitted for non-pressure sewer or drainage crossings, where installation can be made by open cut (not normally allowed) or where reinforced concrete pipe can be jacked under the railroad,.
 - d. All electrical wirelines and gas pipelines (less than 10 feet below bottom of tie) shall be encased with steel pipe in accordance with Section II(F).
 - e. The casing pipe must be installed at least 5.5 feet below bottom of crosstie or a minimum of 4 feet from natural ground grade (whichever is greater).
 - f. Jacking pit locations must be outside of Railroad right-of-way lines. No open-cut crossings will be allowed. The pit will be protected with adequate sheeting, bulkheads, and sidewalls to protect the Railroad's roadbed. Proper barricades and lights, if necessary will be set around the pit for positive protection.
2. All pipelines (except those in streets where it would not be practical to do so) shall be prominently marked at right-of-way lines (on both sides of track for crossings) by durable, weatherproof signs located over the centerline of the pipe. Signs shall show the following:
 - Name and address of owner
 - Contents of pipe
 - Pressure in pipe
 - Pipe depth below graded at point of a sign
 - Emergency telephone number in event of pipeline rupture
3. For pipelines running longitudinally on the Railroad's property, signs shall be placed over the pipe (or offset and appropriately marked) at all changes in direction of the pipeline. Such signs should also be located so that when standing at one sign the next adjacent marker in either direction is visible. In no event shall they be placed more than 500 feet apart unless otherwise specified by the Railroad.
4. Owner must maintain all signs on Railroad's right-of-way as long as the occupational agreement is in effect.

5. Schedule 80 HDPE pipe is acceptable (with no casing pipe) for use when housing fiber optic or other communication lines. A metallic ribbon or wire must be included in the pipe to allow for radio locating at a later date.
 6. At no time will construction interfere with the normal and safe operation of the Railroad. No construction, manpower, or equipment will enter or operate on the right-of-way within a safety clearance of 25.0 feet from the centerline of near track. A railroad flagman must be present during any work on the railroad right-of-way.
 7. All casing or pipe installations where the diameter is greater than 48 inches, will require a pre-construction conference with all parties, at the project location.
 8. Pre-construction arrangements will be made with the Railroad at least one week prior to construction. A Railroad inspector must be present during the entire installation of the casing pipe. The inspector will have complete authority over the project on the Railroad's right-of-way.
 9. All Safety Inspection Costs will be borne by the lessee.
- B. Pipelines shall, where practicable, cross any railway where tracks are carried on an embankment.
- C. Pipeline shall not be placed within the limits of a turnout (switch) when crossing the track. The limits of the turnout extend from the point of switch to 15 feet beyond the last long timber.
- D. Pipeline shall not be placed within 50 feet of a railroad bridge, building or other important structure.
- E. Pipelines laid longitudinally on the Railroad's right-of-way shall be located as far as practicable from any tracks or other important structures and as close to the property line as possible. Longitudinal pipelines must not be located in earth embankments or within ditches located on the right-of-way.
- F. Casing Pipe Specifications:
1. Steel casing pipe: For carrier pipe less than 6 inches in diameter, the inside diameter of the casing pipe shall be at least 2 inches greater than the largest outside diameter of the carrier pipe joints or couplings. For carrier pipe 6 inches and over in diameter, the inside diameter of the casing pipe shall be at least 4 inches greater than the largest outside diameter of the carrier pipe joints or couplings. Steel pipe shall have a specified minimum yield strength, SMYS, of at least 35,000 psi. The ASTM or API specification and grade for the pipe are to be shown on the application form.
 2. All joints or couplings, supports, insulators or centering devices for the carrier pipe shall be considered in the selection of the casing diameter.
 3. Casing pipe shall have a minimum cover of 5.5 feet below bottom of tie (see Section II, Item A,1,e), and shall have a **minimum** wall thickness as shown in the table provided below, unless computations indicate that a thicker wall is required (see section F-4). All casing pipe shall be protected by black bituminous coating for protection against corrosion (Coated steel pipe that is bored or jacked into place shall conform to the wall thickness requirements for non-coated steel pipe since the coating may be damaged during installation). Wall thickness designations for steel casing pipe for Cooper E-80 loading including impact are as follows:

Nominal Diameter (inches)	Min. Thickness for Coated (inches)	Non Coated (inches)
14 and Under	0.188	0.188
16	0.219	0.281
18	0.250	0.312
20 and 22	0.281	0.344
24	0.312	0.375
26	0.344	0.406
28	0.375	0.438
30	0.406	0.469
32	0.438	0.500
34 and 36	0.469	0.531
38, 40 and 42	0.500	0.563
44 and 46	0.531	0.594
48	0.563	0.625
50	0.594	0.656
52	0.625	0.688
54	0.656	0.719
56 and 58	0.688	0.750
60	0.719	0.781
62	0.750	0.813
64	0.718	0.844
66 and 68	0.813	0.875
70	0.844	0.906
72	0.875	0.938

(*) = Casing Pipe diameters exceeding 72 inches require review and approval from Railroad AVP - Engineering Services prior to use.

4. All Casing thickness determinations will be based on Cooper E-80 Railway Loading, using applicable formulas and computations performed by a registered professional engineer, registration must be in the project State. The (Signed/Sealed) computation results will accompany the plans for review by the Engineering Department.
5. All casing pipe joints will be welded in accordance with AISC Specifications, Section 1-7-2. All joint welds will be full penetration.
6. The inside diameter of the casing pipe shall be such as to allow the carrier pipe to be removed subsequently without disturbing the casing or the roadbed.

G. Uncased Gas Pipelines

1. Must be a minimum 10 feet below bottom of tie.

2. Carrier pipe must be steel and conform to the requirements of ANSI B 31.8 Gas Transmission and Piping Systems, and other applicable ANSI Codes. All steel pipe must be coated and cathodically protected.
3. Joints for the carrier line pipe must be of an approved welded type. Steel pipe must have a specified minimum yield strength (SMYS), of at least 35,000 psi. The nominal wall thickness for the steel carrier pipe, SMYS, maximum allowable operating pressure (MAOP), and outside pipe diameter (D), are given in Appendix A.
4. Uncased gas pipelines shall be installed by boring or jacking.

H. Tunnel Liner Requirements:

1. All applicable preceding sections will govern tunnel liner usage.
2. Tunnel liner plate will be 12-gauge, galvanized, and all bolts and nuts will be galvanized.
3. Live load will be based on Cooper E-80 Railway Loading, using applicable formulas and computations performed by a registered professional engineer, registration must be in the Project State. The (signed/Sealed) computation results will accompany the plans for review by the Engineering Department.
4. Grout holes, if required will be provided at 10-foot intervals along the roof and sides.
5. The tunnel liner-jacking shield will protect 180 degrees of the upper section and material removed to allow for a minimum 1:1 slope, with a minimum 2.0 feet of undisturbed soil supporting the overburden.
6. The tunnel liner installation will progress with sufficient manpower and supervision for around-the-clock construction until the liner is completed, through the limits of the right-of-way.

I. Carrier Pipeline Specifications:

1. Reinforced concrete pipe:
 - a. Materials: Modified bell and spigot or tongue and groove in accordance with current ASTM Specification C76 Class V for Railway strength pipe or current specification for pre-stressed concrete pipe.
 - b. Joints: Rubber and steel joint for pre-stressed pipe in accordance with current Lock Joint Pipe Company Specification on SP5, or equivalent. Joints for bell and spigot and tongue and groove pipe to be in accordance with current standard practice. Joints may be made using confined continuous rubber gasket.
2. Cast iron pipe:
 - a. Materials: Pipe must conform to current ASTM Specification A142 for "Standard Pipe."
 - b. Joints: Bell and spigot, caulked with lead and oakum, or approved mechanical type joint.

3. Plastic Pipe: The use of plastic carrier pipe for sewer, water, natural gas and other liquids is acceptable under specific circumstances. The use of plastic pipe is satisfactory if the pipe is designed to meet all applicable federal and state codes, and if the carrier pipe is encased within a steel casing pipe per AREMA standards. The casing must extend the full width of the right-of-way.
4. Polyethylene pipe (HDPE): Pipe must conform to the current ASTM Specifications D2104, Schedule 40, for standard pipe.
5. Steel pipe:
 - a. Materials: Pipe must conform to current ASTM Specification A120.
 - b. Joints: All joints must be welded or of an approved mechanical type.
- J. Carrier Pipe Shut-Off Valves - Carrier pipe under pressure shall have a sufficient shut-off valve(s) at each end outside of Railroad's right-of-way limits. The Utility Owner shall install accessible emergency shut-off valves within effective distances on each side of the Railroad. Valves shall not be located within the Railroad right-of-way.
- K. Casing Pipe Vents - All casing pipes shall be properly vented. Vent pipes shall be of sufficient diameter, but in no case less than four (4) inches in diameter and shall be attached near each end of casing, projecting through ground surface and located outside of Railroad property limits. Where possible, they shall be marked and located at the vent location. The markers shall display the Railroad Milepost location, the name and address of the utility owner, and a phone number contact in case of emergency. Vent pipes shall extend not less than four (4) feet above ground surface. Top of vent pipes shall be fitted with a down-turned elbow, properly screened; or a relief valve installed.
- L. All Casing pipe ends shall be sufficiently constructed as to prevent leakage of any substance from the casing throughout its length. Each end of the casing shall require a sufficient permanent seal to prevent the potential for leakage of any substance from the casing pipe. Grout fill is an acceptable method installed by pressure grouting. If used, the grout material should consist of non-shrink sand cement slurry or Railroad approved equivalent, and sufficiently seal the casing pipe ends to the satisfaction of the Railroad. If deemed necessary, and at the sole discretion of the AVP - Engineering Services, the entire void between the carrier pipe and casing pipe throughout the entire length of the casing pipe may be required to be filled upon notification from the Railroad.
- M. Abandoned Facilities
 1. The owner of all pipe crossings proposed for abandonment shall notify the Railroad, in writing, of the intention to abandon.
 2. Abandoned pipelines shall be completely filled with cement grout, compacted sand, or other methods, as approved by the Railroad.
 3. Abandoned manholes and other structures shall be removed to a minimum depth of 2 feet below finished grade and completely filled with cement grout, compacted sand, or other methods as approved by the Railroad.

N. Guidelines for Horizontal Directional Drilling (HDD) Under Tracks

1. For pipelines conveying gas or liquid substances, steel pipe only may be installed under track(s) and/or right-of-way utilizing horizontal directional drilling.
2. For wireline installations, including fiber optic cable, HDPE pipe may be installed as the outermost pipe. Bundling is prohibited. All innerducts must have an outer casing pipe.
3. Minimum cover for all pipelines with outside diameter of 6 inches or less, regardless of product, shall be 10 feet. For all liquid or gas installations regardless of product, with nominal pipe sizes exceeding 6 inches outside diameter, minimum cover (measured from bottom of tie to top of pipe) shall be a minimum of 25 feet. For fiber optics or electrical installations, with casing/conduit nominal size exceeding 6 inches, minimum cover shall be 15 feet.
4. Applicant submittal shall include actual planned depth of pipe under each railroad track. The plan and profile views must show the entire bore, including the sending and receiving pits, regardless of the right-of-way limits.
5. Applicant must provide pipe specifications for casing and carrier pipes. Pipe must satisfy all applicable government and industry regulations.
6. Applicant must provide qualifications of drilling contractor, including specific instances of previous successful experience in drilling under railroad and other sensitive surface facilities.
7. Prior to commencement of drilling:
 - a. The contractor must submit a Boring Plan that describes the anticipated rig capacity, the proposed equipment and the method for advancing the bore hole through expected soil conditions, angles, depth and exact location of the exit ditch, the pilot hole diameter, the proposed reaming plan, including the diameter of the pre-reams/back-reams and diameter of the final reamed bore hole, and the contingency equipment and plans for dealing with soil conditions that a soils engineer could reasonably expect to be encountered at the proposed HDD installation site. The Boring Plan should also address the anticipated hours of operation during the HDD bore hole drilling and installation process, the minimum number of personnel and their responsibilities on-duty and on-site during all HDD drilling operations. Consideration for working hours must be given to minimize risk to railroad operations during drilling operations. See "Additional Guidelines" (Item 10) for additional bore guidelines.
 - b. The contractor must provide a detailed Fracture Mitigation (frac-out) Plan, including method of monitoring quantity and capturing the return of drilling fluids with particular attention to variation from proposed plan (i.e. volumes, pressure, or consistency).
 - c. The contractor must establish a Survey Grid Line and provide a program of monitoring and documenting the actual location of the bore hole during drilling operations.
8. An engineering inspector is required to monitor the ground and track for movement during drilling, reaming, and pullback processes. The engineering inspector shall be provided by the applicant at their sole cost and expense. The installation process and all train movement must be immediately stopped if ground or track movement is detected. The damaged area must be immediately repaired. The installation process must be reviewed and modified as

required before the installation can proceed. Applicant must pay all expenses for review and inspection.

9. Upon completion of the HDD installation work the contractor shall provide an accurate as-built drawing of the installed HDD segment. As-built drawings will include both horizontal and profile plans. The latitude and longitude coordinates of the entry, exit, and turn points shall be provided on the as-built drawing(s).

10. Bore Plan Additional Requirements

In addition to all the requirements outlined in the above guidelines, the bore plan should include the following:

- Pre-bore survey grid line with angles and depths defined
- Statement that once the bore enters railroad property, the work will be continuous until the drilling is complete and the pipe is pulled into place.
- Statement that the bore will be tracked constantly, with the location and depth marked every 10 feet.
- If the commodity to be conveyed permits the use of HDPE pipe, it must be grade SDR 11 or better (thicker wall).
- The maximum size of the bore hole may not exceed Outside Diameter (OD) X 1.5 if OD is 10 inches or less. If the OD is greater than 10 inches, the bore hole may not exceed OD X 1.3.
- A defined slurry recovery method. Disposal on railroad property or within railroad ditches and facilities is prohibited.
- The launching and receiving pits must be situated at minimum outside the railroad right-of-way. In cases where the slope of the railroad grade extends beyond the right-of-way, pits must be located beyond the toe of the slope so as not to compromise the railroad grade.
- Statement of expected soil conditions, and statement of all drill heads on site for expected and unexpected soil conditions.
- Specifications and capacities of the bore machine. This includes:
 - Maximum capacities
 - Intended capacities
 - Maximum drilling RPM
 - Intended drilling RPM
 - Maximum drilling PSI
 - Intended drilling PSI
 - Maximum GPM
 - Intended GPM

III. Above Grade Structures

- A. Standard overhead clearances for fixed structures, such as bridges and other overhead fixed structures shall provide a minimum of 23 feet vertical clearance above top of rail (T/R).
- B. The bridge or other structure shall completely span the railroad right-of-way. Piers, columns or other structures must be located off the right-of-way.
- C. Pre-design conference with the Engineering Department will set forth horizontal clearance of subgrade, grade, and above grade construction and structural limits.

- D. The railroad shall be furnished as-built drawings showing the actual clearances as constructed.
- E. Crashwalls, per AREMA Specifications, Chapter 8, Article 2.1.5, are required when the face of pier is closer than 25' 0" from the centerline of track, measured perpendicular to the track.
- F. Drainage from the bridge shall be preferably collected with drain pipes and drained away from the railroad's right-of-way. Scuppers from the bridge must not drain on to railroad right-of-way.
- G. Projects involving stormwater systems shall be designed for a 100 year storm event as a minimum.
- H. All highway structures shall have a protective barrier fence that extends at least 8'-0" from the top of sidewalk or driving surface adjacent to the barrier wall. The fence may be placed on top of barrier wall and should also include anti-climb shields or be of a configuration to minimize the likelihood of climbing on the outside of the protective fencing.

IV. Above Grade Wirelines

- A. All installations of aerial lines and cables will provide a minimum clearance above top of rail (T/R) of highest track. Standard overhead clearance for all aerial line crossings, both power and non-power line crossings, shall provide the following clearances:

Nominal Voltage	Overhead Clearance	Minimum between Wires
0 – 750	27' – 0"	4' – 0"
To 15,000	28' – 0"	6' – 0"
To 50,000	30' – 0"	6' – 0"
69,000	30' – 8"	6' – 8"
115,000	32' – 2"	8' – 2"
138,000	33' – 0"	9' – 0"
345,000	39' – 10"	15' – 10"
500,000	45' – 0"	21' – 0"
745,000	53' – 2"	29' – 2"
765,000	53' – 10"	29' – 10"

- B. At Roadway Grade Crossings, provide safe clearances between warning devices and electrical transmission, distribution cables (including messenger and neutral wires), and all communication lines. All overhead utility crossings shall provide the minimum vertical clearance from top of rail (T/R) of highest track as shown in A above plus additional clearances necessary to obtain operational clearances from crossing warning device assemblies as follows:

1. 6'0" vertical clearance from Gate tips in vertical position or structure mast (whichever is greater).
2. 13'-6" vertical clearance from Cantilever arm or structure mast (whichever is greater).
3. The minimum clearance from crossing gate tips, cantilever structures, signal masts, signal and other bridges, etc. shall conform to the National Electric Safety Code, section 23, rule 234, but in no case shall the overhead clearances shown in the table above or the additional clearances as outlined in 1 and 2 above be reduced.

- C. The poles or towers supporting the crossing span should be located outside the railroad's right-of-way. If locating poles or towers outside the right-of-way is not possible, the side clearance of poles and towers from the nearest track shall be not less than 25 feet.
- D. Wireline crossings not to be installed within 500 feet of the end of any railroad bridge or 300 feet from the centerline of any culvert or turnout (switch).
- E. Wires and cables running longitudinally along the railroad's right-of-way shall be constructed as close to the property lines as possible, except in cases where doing so will interfere with Railroad operations, surface drainage or soil stability.
- F. Poles and towers near public road crossings shall be located so as to not interfere with the sight-distance along the railroad from motorists on the public roadway.
- G. Should the Railroad add or modify existing crossing warning devices or facilities at any highway grade crossings, existing wire lines or cables shall be raised or relocated immediately on notice from Railroad to lessee and at the sole cost and expense of the lessee.

V. Miscellaneous

- A. Cathodic protection of pipelines, cables, or casings:
 - 1. When cathodic protection is provided, it shall be installed so as not to induce currents, which will interfere with the signal apparatus of the Railroad. Any change required in the manner, method, or location of such cathodic protection shall be made at the sole cost and expense of the lessee and to the satisfaction of the Engineering Department of the Railroad.
 - 2. Cathodic protection shall be applied to all pipelines carrying flammable substances on the Railroad's right-of-way.
 - 3. Uncased gas carrier pipes must be coated and cathodically protected to industry standards. Test sites, for monitoring the pipeline, must be provided within 50 feet of the crossing and shall be off Railroad right-of-way if possible.
- B. Proposed structures must maintain a minimum 10-foot horizontal clearance to the face of any signal, post, crossing gate or other above grade obstruction.

VI. Standard Drawings

- A. The following Standard Reference drawings in reference to these written specifications are available upon request:
 - 1. **ES8049.1** – Mainline Design & Installation of CMP
 - 2. **ES8090.2** – Overhead Wire Line Permit Information (2 pages)
 - 3. **ES8090.3** – Overhead Bridge Permit Information
 - 4. **ES8090.4** – Information Required for Typical Directional Bore
 - 5. **ES8090.5** – Information Required for Typical Jack & Bore (Carrier Pipe Not Under Pressure)
 - 6. **ES8090.6** – Information Required for Typical Jack & Bore (Carrier Pipe Under Pressure)

Appendix A

Minimum Nominal Wall Thickness (in.) for Uncased Carrier Pipe

D (in.)	SMYS (psi)					SMYS (psi)				
	35000	42000	52000	60000	70000	35000	42000	52000	60000	70000
	MAOP ≤ 100 psi					MAOP ≤ 200 psi				
≤ 18.0	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188
20.0	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219
22.0	0.226	0.226	0.226	0.226	0.226	0.226	0.226	0.226	0.226	0.226
24.0	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
26.0	0.281	0.281	0.281	0.281	0.281	0.281	0.281	0.281	0.281	0.281
28.0	0.281	0.281	0.281	0.281	0.281	0.312	0.281	0.281	0.281	0.281
30.0	0.312	0.312	0.312	0.312	0.312	0.344	0.312	0.312	0.312	0.312
32.0	0.344	0.344	0.344	0.344	0.344	0.344	0.344	0.344	0.344	0.344
34.0	0.344	0.344	0.344	0.344	0.344	0.406	0.344	0.344	0.344	0.344
36.0	0.375	0.375	0.375	0.375	0.375	0.406	0.375	0.375	0.375	0.375
38.0	0.406	0.406	0.406	0.406	0.406	0.438	0.406	0.406	0.406	0.406
40.0	0.406	0.406	0.406	0.406	0.406	0.469	0.406	0.406	0.406	0.406
42.0	0.438	0.438	0.438	0.438	0.438	0.500	0.438	0.438	0.438	0.438

Appendix A

D (in.)	SMYS (psi)					SMYS (psi)				
	35000	42000	52000	60000	70000	35000	42000	52000	60000	70000
	MAOP ≤ 300 psi					MAOP ≤ 400 psi				
≤ 12.75	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188
14.0	0.188	0.188	0.188	0.188	0.188	0.203	0.188	0.188	0.188	0.188
16.0	0.188	0.188	0.188	0.188	0.188	0.281	0.188	0.188	0.188	0.188
18.0	0.219	0.188	0.188	0.188	0.188	0.281	0.219	0.188	0.188	0.188
20.0	0.250	0.219	0.219	0.219	0.219	0.312	0.250	0.219	0.219	0.219
22.0	0.281	0.226	0.226	0.226	0.226	0.344	0.281	0.226	0.226	0.226
24.0	0.312	0.250	0.250	0.250	0.250	0.375	0.281	0.250	0.250	0.250
26.0	0.344	0.281	0.281	0.281	0.281	0.406	0.312	0.281	0.281	0.281
28.0	0.375	0.312	0.281	0.281	0.281	0.438	0.344	0.281	0.281	0.281
30.0	0.406	0.312	0.312	0.312	0.312	0.469	0.375	0.312	0.312	0.312
32.0	0.438	0.344	0.344	0.344	0.344	0.500	0.406	0.344	0.344	0.344
34.0	0.469	0.375	0.344	0.344	0.344	0.531	0.438	0.344	0.344	0.344
36.0	0.500	0.406	0.375	0.375	0.375	0.562	0.469	0.375	0.375	0.375
38.0	0.531	0.438	0.406	0.406	0.406	0.625	0.500	0.406	0.406	0.406
40.0	0.562	0.469	0.406	0.406	0.406	0.656	0.531	0.406	0.406	0.406
42.0	0.594	0.500	0.438	0.438	0.438	0.688	0.562	0.438	0.438	0.438
	MAOP ≤ 500 psi					MAOP ≤ 600 psi				
≤ 8.625	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188
10.75	0.188	0.188	0.188	0.188	0.188	0.203	0.188	0.188	0.188	0.188
12.75	0.219	0.188	0.188	0.188	0.188	0.250	0.203	0.188	0.188	0.188
14.0	0.250	0.188	0.188	0.188	0.188	0.281	0.210	0.188	0.188	0.188
16.0	0.281	0.219	0.188	0.188	0.188	0.312	0.250	0.188	0.188	0.188
18.0	0.312	0.250	0.188	0.188	0.188	0.344	0.281	0.219	0.188	0.188
20.0	0.344	0.281	0.219	0.219	0.219	0.375	0.312	0.250	0.219	0.219
22.0	0.375	0.312	0.250	0.226	0.226	0.438	0.344	0.281	0.226	0.226
24.0	0.406	0.344	0.281	0.250	0.250	0.469	0.375	0.312	0.250	0.250
26.0	0.469	0.375	0.281	0.281	0.281	0.500	0.406	0.344	0.281	0.281
28.0	0.500	0.406	0.312	0.281	0.281	0.562	0.469	0.375	0.312	0.312
30.0	0.531	0.438	0.344	0.312	0.312	0.594	0.500	0.406	0.344	0.312
32.0	0.562	0.469	0.375	0.344	0.344	0.625	0.531	0.406	0.375	0.344
34.0	0.625	0.500	0.406	0.344	0.344	0.688	0.562	0.438	0.375	0.344
36.0	0.656	0.531	0.438	0.375	0.375	0.719	0.594	0.469	0.406	0.375
38.0	0.688	0.562	0.469	0.406	0.406	0.750	0.625	0.500	0.438	0.406

Appendix A

Minimum Nominal Wall Thickness (in.) for Uncased Carrier Pipe (Continued)

D (in.)	SMYS (psi)					SMYS (psi)				
	35000	42000	52000	60000	70000	35000	42000	52000	60000	70000
	MAOP ≤ 500 psi — Continued					MAOP ≤ 600 psi — Continued				
40.0	0.719	0.594	0.500	0.406	0.406	0.781	0.688	0.531	0.469	0.438
42.0	0.750	0.656	0.500	0.438	0.438	0.844	0.719	0.562	0.500	0.469
	MAOP ≤ 700 psi					MAOP ≤ 800 psi				
≤ 6.625	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188
8.625	0.188	0.188	0.188	0.188	0.188	0.203	0.188	0.188	0.188	0.188
10.75	0.219	0.188	0.188	0.188	0.188	0.250	0.203	0.188	0.188	0.188
12.75	0.281	0.219	0.188	0.188	0.188	0.312	0.250	0.188	0.188	0.188
14.0	0.312	0.250	0.188	0.188	0.188	0.344	0.281	0.219	0.188	0.188
16.0	0.344	0.281	0.219	0.188	0.188	0.375	0.312	0.250	0.219	0.188
18.0	0.375	0.312	0.250	0.219	0.219	0.438	0.344	0.281	0.226	0.219
20.0	0.438	0.344	0.281	0.226	0.226	0.469	0.406	0.312	0.250	0.250
22.0	0.469	0.406	0.312	0.281	0.226	0.500	0.438	0.344	0.281	0.250
24.0	0.500	0.438	0.344	0.281	0.250	0.562	0.469	0.375	0.312	0.281
26.0	0.562	0.469	0.375	0.312	0.281	0.625	0.500	0.406	0.344	0.312
28.0	0.594	0.500	0.406	0.344	0.281	0.656	0.562	0.438	0.375	0.312
30.0	0.656	0.531	0.438	0.375	0.312	0.719	0.594	0.469	0.406	0.344
32.0	0.688	0.562	0.469	0.406	0.344	0.750	0.625	0.500	0.438	0.375
34.0	0.750	0.625	0.500	0.438	0.375	0.812	0.688	0.531	0.469	0.406
36.0	0.781	0.656	0.531	0.469	0.375	0.844	0.719	0.562	0.500	0.438
38.0	0.844	0.688	0.562	0.500	0.406	0.906	0.750	0.625	0.531	0.438
40.0	0.875	0.750	0.594	0.500	0.438	0.938	0.812	0.656	0.562	0.469
42.0	0.938	0.781	0.625	0.531	0.469	1.000	0.844	0.688	0.594	0.500
	MAOP ≤ 900 psi					MAOP ≤ 1000 psi				
≤ 6.625	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188
8.625	0.219	0.188	0.188	0.188	0.188	0.250	0.188	0.188	0.188	0.188
10.75	0.279	0.219	0.188	0.188	0.188	0.307	0.250	0.188	0.188	0.188
12.75	0.312	0.281	0.219	0.188	0.188	0.344	0.281	0.250	0.188	0.188
14.0	0.344	0.312	0.250	0.203	0.188	0.375	0.312	0.250	0.219	0.188
16.0	0.406	0.344	0.281	0.219	0.188	0.438	0.375	0.312	0.250	0.219
18.0	0.469	0.375	0.312	0.250	0.219	0.500	0.406	0.344	0.281	0.250
20.0	0.500	0.438	0.344	0.281	0.250	0.562	0.469	0.375	0.312	0.281

Appendix A

Minimum Nominal Wall Thickness (in.) for Uncased Carrier Pipe (Continued)

D (in.)	SMYS (psi)					SMYS (psi)				
	35000	42000	52000	60000	70000	35000	42000	52000	60000	70000
	MAOP ≤ 900 psi - Continued					MAOP ≤ 1000 psi - Continued				
22.0	0.562	0.469	0.375	0.312	0.281	0.625	0.500	0.406	0.344	0.281
24.0	0.625	0.500	0.406	0.344	0.312	0.688	0.562	0.438	0.375	0.312
26.0	0.656	0.562	0.438	0.375	0.312	0.750	0.594	0.469	0.406	0.344
28.0	0.719	0.594	0.469	0.406	0.344	0.750	0.656	0.531	0.438	0.375
30.0	0.750	0.625	0.500	0.438	0.375	0.812	0.688	0.562	0.469	0.406
32.0	0.812	0.688	0.562	0.469	0.406	0.875	0.719	0.594	0.531	0.438
34.0	0.875	0.719	0.594	0.500	0.438	0.938	0.781	0.625	0.562	0.469
36.0	0.906	0.781	0.625	0.531	0.469	1.000	0.812	0.688	0.594	0.500
38.0	0.969	0.812	0.656	0.562	0.500	1.062	0.875	0.719	0.625	0.531
40.0	1.031	0.875	0.688	0.625	0.531	1.125	0.906	0.750	0.656	0.562
42.0	1.062	0.906	0.750	0.656	0.562	1.188	0.969	0.781	0.688	0.594
	MAOP ≤ 1100 psi					MAOP ≤ 1200 psi				
≤ 5.563	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188
6.625	0.188	0.188	0.188	0.188	0.188	0.203	0.188	0.188	0.188	0.188
8.625	0.250	0.203	0.188	0.188	0.188	0.277	0.219	0.188	0.188	0.188
10.75	0.307	0.250	0.203	0.188	0.188	0.344	0.277	0.219	0.188	0.188
12.75	0.375	0.312	0.250	0.219	0.188	0.406	0.330	0.281	0.226	0.188
14.0	0.406	0.344	0.281	0.226	0.219	0.438	0.375	0.312	0.250	0.219
16.0	0.469	0.406	0.312	0.281	0.219	0.500	0.406	0.344	0.281	0.250
18.0	0.531	0.438	0.344	0.312	0.250	0.562	0.469	0.375	0.344	0.281
20.0	0.594	0.500	0.406	0.344	0.281	0.625	0.531	0.438	0.375	0.312
22.0	0.625	0.531	0.438	0.375	0.312	0.688	0.562	0.469	0.406	0.344
24.0	0.688	0.594	0.469	0.406	0.344	0.750	0.625	0.500	0.438	0.375
26.0	0.750	0.625	0.500	0.438	0.375	0.812	0.688	0.562	0.469	0.406
28.0	0.812	0.688	0.562	0.469	0.406	0.875	0.719	0.594	0.500	0.438
30.0	0.875	0.750	0.594	0.531	0.438	0.938	0.812	0.625	0.562	0.469
32.0	0.938	0.781	0.625	0.562	0.469	1.000	0.875	0.688	0.594	0.500
34.0	1.000	0.844	0.688	0.594	0.500	1.062	0.875	0.719	0.625	0.531
36.0	1.062	0.875	0.719	0.625	0.531	1.125	0.938	0.750	0.656	0.562
38.0	1.125	0.938	0.750	0.656	0.562	1.188	1.000	0.812	0.719	0.594
40.0	1.156	0.969	0.812	0.688	0.594	1.250	1.031	0.844	0.750	0.625

Appendix A

Minimum Nominal Wall Thickness (in.) for Uncased Carrier Pipe (Continued)

D (in.)	SMYS (psi)					SMYS (psi)				
	35000	42000	52000	60000	70000	35000	42000	52000	60000	70000
	MAOP ≤ 1100 psi - Continued					MAOP ≤ 1200 psi - Continued				
42.0	1.250	1.031	0.844	0.750	0.625	1.312	1.094	0.906	0.781	0.656
	MAOP ≤ 1300 psi					MAOP ≤ 1400 psi				
≤ 5.563	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188
6.625	0.219	0.188	0.188	0.188	0.188	0.250	0.188	0.188	0.188	0.188
8.625	0.277	0.250	0.188	0.188	0.188	0.312	0.250	0.219	0.188	0.188
10.75	0.344	0.307	0.250	0.203	0.188	0.365	0.307	0.250	0.219	0.219
12.75	0.438	0.344	0.281	0.256	0.219	0.438	0.375	0.312	0.256	0.250
14.0	0.469	0.375	0.312	0.279	0.226	0.500	0.406	0.344	0.281	0.281
16.0	0.531	0.438	0.375	0.312	0.281	0.562	0.469	0.375	0.344	0.312
18.0	0.594	0.500	0.406	0.344	0.312	0.625	0.531	0.438	0.375	0.344
20.0	0.656	0.562	0.438	0.375	0.344	0.688	0.594	0.469	0.406	0.375
22.0	0.719	0.594	0.500	0.438	0.406	0.750	0.656	0.531	0.469	0.375
24.0	0.812	0.656	0.531	0.469	0.406	0.844	0.688	0.562	0.500	0.438
26.0	0.844	0.719	0.594	0.500	0.438	0.906	0.750	0.625	0.531	0.469
28.0	0.906	0.781	0.625	0.531	0.469	0.969	0.812	0.656	0.594	0.500
30.0	0.969	0.812	0.688	0.594	0.500	1.031	0.875	0.719	0.625	0.531
32.0	1.031	0.875	0.719	0.625	0.531	1.094	0.938	0.750	0.656	0.562
34.0	1.125	0.938	0.750	0.656	0.562	1.156	1.000	0.812	0.719	0.594
36.0	1.188	1.000	0.812	0.719	0.625	1.250	1.062	0.875	0.750	0.656
38.0	1.250	1.062	0.844	0.750	0.656	1.312	1.094	0.906	0.781	0.688
40.0	1.312	1.094	0.906	0.781	0.688	1.375	1.156	0.938	0.844	0.719
42.0	1.375	1.156	0.938	0.844	0.719	1.469	1.219	1.000	0.875	0.750
	MAOP ≤ 1500 psi					MAOP ≤ 1600 psi				
≤ 4.5	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188
5.563	0.219	0.188	0.188	0.188	0.188	0.219	0.188	0.188	0.188	0.188
6.625	0.250	0.203	0.188	0.188	0.188	0.280	0.219	0.188	0.188	0.188
8.625	0.312	0.277	0.219	0.188	0.188	0.344	0.277	0.250	0.219	0.188
10.75	0.406	0.344	0.279	0.226	0.219	0.438	0.344	0.279	0.250	0.219
12.75	0.469	0.406	0.312	0.281	0.250	0.500	0.406	0.344	0.312	0.250
14.0	0.500	0.438	0.344	0.312	0.250	0.562	0.469	0.375	0.312	0.281
16.0	0.594	0.500	0.406	0.344	0.312	0.625	0.531	0.438	0.375	0.312

Appendix A

Minimum Nominal Wall Thickness (in.) for Uncased Carrier Pipe (Continued)

D (in.)	SMYS (psi)					SMYS (psi)				
	35000	42000	52000	60000	70000	35000	42000	52000	60000	70000
	MAOP ≤ 1500 psi - Continued					MAOP ≤ 1600 psi - Continued				
18.0	0.656	0.562	0.469	0.406	0.344	0.688	0.594	0.469	0.406	0.344
20.0	0.719	0.625	0.494	0.438	0.375	0.781	0.656	0.531	0.469	0.406
22.0	0.812	0.688	0.562	0.469	0.406	0.844	0.719	0.594	0.500	0.438
24.0	0.875	0.750	0.594	0.531	0.438	0.938	0.781	0.625	0.562	0.469
26.0	0.938	0.812	0.656	0.562	0.500	1.000	0.844	0.688	0.594	0.500
28.0	1.031	0.875	0.688	0.625	0.531	1.062	0.906	0.750	0.656	0.562
30.0	1.094	0.938	0.750	0.656	0.562	1.156	0.969	0.781	0.688	0.594
32.0	1.156	0.969	0.812	0.688	0.594	1.219	1.031	0.844	0.719	0.625
34.0	1.250	1.031	0.844	0.750	0.625	1.312	1.094	0.906	0.781	0.656
36.0	1.312	1.094	0.906	0.781	0.688	1.375	1.156	0.938	0.812	0.719
38.0	1.375	1.156	0.938	0.844	0.719	1.469	1.219	1.000	0.875	0.750
40.0	1.438	1.219	1.000	0.875	0.750	1.531	1.281	1.062	0.906	0.781
42.0	1.531	1.281	1.062	0.938	0.781	—	1.344	1.094	0.969	0.844
	MAOP ≤ 1700 psi					MAOP ≤ 1800 psi				
≤ 4.0	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188
4.5	0.188	0.188	0.188	0.188	0.188	0.203	0.188	0.188	0.188	0.188
5.563	0.258	0.188	0.188	0.188	0.188	0.258	0.219	0.188	0.188	0.188
6.625	0.280	0.250	0.188	0.188	0.188	0.312	0.250	0.219	0.188	0.188
8.625	0.375	0.312	0.250	0.219	0.188	0.375	0.312	0.250	0.219	0.188
10.75	0.438	0.365	0.312	0.256	0.219	0.469	0.406	0.312	0.279	0.250
12.75	0.531	0.438	0.375	0.312	0.281	0.562	0.469	0.375	0.344	0.281
14.0	0.594	0.500	0.406	0.344	0.312	0.625	0.500	0.406	0.375	0.312
16.0	0.656	0.562	0.438	0.406	0.344	0.688	0.594	0.469	0.406	0.344
18.0	0.750	0.625	0.500	0.438	0.375	0.781	0.656	0.531	0.469	0.406
20.0	0.812	0.688	0.562	0.500	0.406	0.875	0.719	0.594	0.500	0.438
22.0	0.906	0.750	0.625	0.531	0.469	0.969	0.781	0.656	0.562	0.500
24.0	1.000	0.812	0.656	0.594	0.500	1.031	0.875	0.719	0.625	0.531
26.0	1.062	0.906	0.719	0.625	0.531	1.125	0.938	0.750	0.656	0.562
28.0	1.156	0.969	0.781	0.688	0.594	1.219	1.000	0.812	0.719	0.625
30.0	1.219	1.031	0.844	0.719	0.625	1.312	1.094	0.875	0.750	0.656
32.0	1.312	1.094	0.875	0.781	0.656	1.375	1.156	0.938	0.812	0.688

Appendix A

Minimum Nominal Wall Thickness (in.) for Uncased Carrier Pipe (Continued)

D (in.)	SMYS (psi)					SMYS (psi)				
	35000	42000	52000	60000	70000	35000	42000	52000	60000	70000
	MAOP ≤ 1700 psi - Continued					MAOP ≤ 1800 psi - Continued				
34.0	1.375	1.156	0.938	0.812	0.688	1.500	1.219	1.000	0.875	0.750
36.0	1.469	1.219	1.000	0.875	0.750	1.562	1.312	1.062	0.906	0.781
38.0	1.562	1.312	1.062	0.906	0.781	—	1.375	1.125	0.969	0.844
40.0	—	1.375	1.094	0.969	0.844	—	1.438	1.156	1.000	0.875
42.0	—	1.438	1.156	1.000	0.875	—	1.500	1.219	1.062	0.906
	MAOP ≤ 1900 psi					MAOP ≤ 2000 psi				
3.5	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188
4.0	0.188	0.188	0.188	0.188	0.188	0.219	0.188	0.188	0.188	0.188
4.5	0.219	0.188	0.188	0.188	0.188	0.219	0.188	0.188	0.188	0.188
5.563	0.258	0.219	0.188	0.188	0.188	0.281	0.250	0.188	0.188	0.188
6.625	0.312	0.250	0.219	0.188	0.188	0.344	0.280	0.219	0.188	0.188
8.625	0.406	0.344	0.281	0.277	0.219	0.438	0.344	0.281	0.250	0.219
10.75	0.500	0.406	0.344	0.312	0.250	0.531	0.438	0.375	0.312	0.256
12.75	0.594	0.500	0.406	0.344	0.312	0.625	0.531	0.438	0.375	0.312
14.0	0.656	0.531	0.438	0.375	0.344	0.688	0.562	0.469	0.406	0.344
16.0	0.750	0.625	0.500	0.438	0.375	0.781	0.656	0.531	0.469	0.406
18.0	0.812	0.688	0.562	0.500	0.438	0.875	0.719	0.594	0.500	0.438
20.0	0.906	0.781	0.625	0.531	0.469	0.969	0.812	0.656	0.562	0.500
22.0	1.000	0.844	0.688	0.594	0.500	1.062	0.875	0.719	0.625	0.531
24.0	1.094	0.906	0.750	0.656	0.562	1.156	0.969	0.781	0.688	0.594
26.0	1.188	1.000	0.812	0.688	0.594	1.250	1.062	0.844	0.750	0.625
28.0	1.312	1.062	0.875	0.750	0.656	1.344	1.125	0.906	0.781	0.688
30.0	1.375	1.156	0.938	0.812	0.688	1.438	1.219	0.969	0.844	0.719
32.0	1.469	1.219	1.000	0.844	0.750	1.531	1.281	1.031	0.906	0.781
34.0	1.562	1.312	1.062	0.906	0.781	—	1.375	1.094	0.969	0.812
36.0	—	1.375	1.125	0.969	0.844	—	1.438	1.156	1.000	0.875
38.0	—	1.438	1.188	1.031	0.875	—	1.531	1.219	1.062	0.906
40.0	—	1.531	1.219	1.062	0.906	—	—	1.312	1.125	0.969
42.0	—	—	1.281	1.125	0.969	—	—	1.375	1.188	1.000

Allowable Hoop Stress Due to Internal Pressure

The maximum allowable hoop stress due to internal pressure shall be sixty percent of SMYS or per ANSI Code if lower allowable percentage of hoop stress applies.