# 10. Bridge Crossings.

## a. Conceptual Design.

1) The design of a pipeline crossing on a bridge structure is considered a special design in every case due to the varied nature of bridge designs. The preferred conceptual design of a pipeline bridge crossing consists of a straight alignment using either restrained mechanical joint DIP or butt welded steel pipe on a roller system with a pipe expansion joint which allows the pipeline to act independently of the bridge superstructure. This scenario is considered the ideal case because it is void of fittings and minimizes pipe joint deflections, which create thrust forces. However, due to the particular bridge configuration other scenarios can be designed with approval. The guidelines which follow present design considerations that must be taken into account when preparing a specially designed bridge crossing.

## b. General.

1) Attaching pipelines (water, sewer, force main, etc.) to a bridge structure can materially affect the structure, the safe operation of traffic and the efficiency of the maintenance of the pipeline and the bridge. Attaching a pipeline to a bridge structure will not be considered unless the bridge structure is of a design that is adequate to support the additional load and any thrust of the pipeline.

   Where it is feasible and reasonable to locate the pipeline elsewhere, attachments to bridge structures will not be approved by WSSC. To locate a pipeline on a bridge, demonstrate that the proposed pipeline on the bridge can be constructed, maintained and is more cost effective than a direct buried alignment. Consider in the design, the accessibility for inspection and maintenance of the pipeline on the bridge structure.

## c. Predesign Submittals and Approvals.

1) Submit the following information to the WSSC, to obtain conceptual approval to locate the proposed pipeline on the bridge prior to proceeding with the design:

   a) A copy of the Bridge Authority's guidelines for attaching a pipeline on its bridge.

   b) Preliminary design calculations for the pipeline on the bridge showing the additional load and any thrust on the bridge structure. Along with the calculations, provide plan and profile sketches, information on the pipeline (size, proposed pipe material, etc.) and sketches of the proposed means of supporting the pipeline.

   c) Provide a statement describing alternative methods with relative cost estimates for constructing the pipeline around the bridge structure verse the cost of attaching the pipeline on the bridge.

   d) <u>Bridge Authority approval</u>. Submit one of the following statements:

      (1) <u>Existing bridge structures</u>. A letter from the Bridge Authority, stating that it has reviewed the conceptual design sketches/drawings and calculations and will allow the pipeline to be attached to its structure.

      (2) <u>Proposed bridge structures</u>. A letter from the Bridge Authority and the bridge designer, stating that they have reviewed the conceptual design sketches/drawings and will allow the pipeline to be attached to their structure and also stating that the bridge structure will be

designed for the additional pipe load.

e) Right of Way Authority approval. Provide a letter from the authority whose right of way is being crossed by the bridge/pipeline, stating its guidelines for having a pipeline being on a bridge above its property or jurisdiction, are being complied with and that it approves of the crossing.

**d. Predesign Bridge Crossing Meeting.**

1) Due to the specialized nature of bridge crossing designs, and in the interest of minimizing revisions, schedule a pre-design meeting with the WSSC and technical staff with expertise in structural, civil and corrosion design. Representative(s) of the Bridge Authority and/or Right of Way Authority should attend the meeting if there are design issues which are contingent to the authorities' approval of the crossing.

2) The predesign meeting can be scheduled following the receipt of the bridge crossing conceptual approval from the WSSC, the Bridge Authority and the Right of Way Authority. Prepare for the meeting with the submittals indicated above, along with the proposed conceptual design to include items such as the proposed method of pipe support, pipe material and joint type, number and location of expansion joints, proposed coating/lining, etc.

**e. Allowable Pipeline Material.**

1) Ductile Iron Pipe (DIP). Provide in accordance with Specifications and give special consideration to the design of the wall thickness (pipe class) for the DIP, see Part One, Section 4 (Selection of Pipe Material) and any special requirements of the Bridge Authority and/or the Right of Way Authority. WSSC generally prefers that crossings using DIP, are short crossings with restrained mechanical joints, see Part One, Section 3 (Pipe and Fitting Joints) for limitations.

a) Allowable pipe joints. Provide in accordance with Specifications and Part One, Section 3 (Pipe and Fitting Joints), and the design considerations listed below.

(1) Restrained mechanical joints. Generally, WSSC prefers that pipeline bridge crossing designs, which use DIP, have restrained mechanical joints in combination with a roller support system and a pipe expansion joint. Restrained mechanical joint systems allow for the following:

(a) Resists thrust forces.

(b) Effectively separates the pipeline from the bridge structure allowing each to act independently.

(c) Transmits movement of the pipe due to thermal expansion and contraction to the respective expansion joint without pipe joint separation.

(d) Provides extra security in the event of a support failure or damage by minimizing the possibility of pipe joint separation.

(e) When utilizing restrained joints, proper design techniques should include provisions for extending each joint so as to engage its restraints. Some restrained joints are subject to significant joint extension.

(2) Proprietary push-on restrained joints. Generally, the use of proprietary bell push-on restrained joints for bridge crossings should be limited, due to the unique design and construction requirements when using these joints in above ground installations. These joints have an inherent amount of joint slack, which must be extended for the full length of the exposed pipeline following installation to prevent "snaking" and/or elongation of the pipeline following pressurization. Include provisions for extending each joint following pipe installation to remove slack from the joints.

(3) Push-on joints. In most cases, WSSC will not permit DIP with push-on joints to be specified. Typically, most bridge configurations do not lend themselves to the use of unrestrained push-on joints. This type of joint is not restrained, therefore, the supports need to be designed and constructed (axially, laterally and vertically) to resist thrust forces, dead loads, impact and shock loads and thermal changes. If the design includes push-on joints, consider the following:

(a) The pipe needs to be fixed securely to the supports or bridge structure at least behind each pipe joint.

(b) The pipe should not be installed on hangers using rods with little or no lateral supports.

(c) If properly fixed to the bridge to resist lateral and axial movements, this type of pipe joint can be used to relieve some of the expansion and contraction of the pipe and bridge structure due to temperature changes. Each joint should be brought fully home and then, depending on the ambient temperature conditions at the time of installation, backed out slightly to provide for the anticipated thermal expansion of the bridge structure. Provide calculations and indicate the withdrawal dimension on the drawings.

(d) If the bridge has an expansion joint(s), give special attention to account for the concentrated bridge expansion at the bridge expansion joint location(s) since the pipe is fixed to the bridge. The pipeline may require an expansion joint at this location or a design using restrained joint pipe may prove to be a better alternative depending on the amount of anticipated movement at the bridge expansion joint, see Design of the Pipeline for Expansion and Contraction in this section.

(4) Unrestrained mechanical joints. Typically, the same as push-on joints, except give consideration to the relative expansion and contraction of the pipeline. If the pipeline is rigidly fixed at each joint to the bridge structure and the design intent is to allow the thermal expansion and contraction at the pipe joints, mechanical joint pipe may not be the best alternative because the pipe socket bell depth is shallower than push-on joints.

(5) Flanged joints. Typically, flanged joints are only used for the installation of the expansion joint and insulating joints. Provide flanged joints in accordance with Specifications and for design information, see Part One, Section 3 (Pipe and Fitting Joints).

2) Steel pipe. Generally, the WSSC prefers the use of steel pipe for long bridge crossings and crossings with pipe diameters greater than 24-inch, for steel pipe design information, see Part One, Section 2 (Pipe Materials and Fittings).

a) The steel pipe conceptual design is the same as for ductile iron with restrained joints, i.e. supported on a roller system with a pipe expansion joint(s). Steel pipe allows for the following:

(1) Resists thrust forces.

(2) Effectively separates the pipeline from the bridge structure.

(3) Transmits movement of the pipe due to thermal expansion and contraction to the respective expansion joint.

(4) Provides extra security in the event of a support failure or damage.

(5) Eliminates the possibility of a leak at a joint due to failed gasket, etc.

(6) When steel pipe is designed for a bridge crossing, the design must include an insulating joint between the steel pipe and the buried ductile iron pipeline.

**f. Fittings on Bridge Structures.**

1) Do not use fittings on aerial bridge crossings, particularly bends.

**g. Joint Deflections on Bridge Structures.**

1) Joint deflections should be avoided or minimized, if possible. When the design requires joint deflections, see requirements under Part One, Section 12 (Allowable Joint Deflections).

2) Joint deflections create a thrust force, which can be calculated similar to a bend. Small vertical joint deflections typically are counteracted by the weight of the pipe or the support system. Horizontal joint deflections, however, create a lateral force, which may require a special support design. In either case, avoid joint deflections, if possible. If the design requires joint deflections, provide calculations for the thrust forces at the joint deflections and design the support system accordingly.

**h. Pipeline Coating Requirements.**

1) Provide pipeline, appurtenances, and the pipe support system with an exterior coating comparable with the life expectancy of the bridge coating system and suitable for the corrosive effects of road salts, atmospheric and weather conditions.

2) Include in the Specifications, installation precautions and special provisions for the protection, application and repair of the exterior coatings during construction.

3) During design, take into consideration how the pipe will be installed; i.e., if a shop coated pipe will be launched across the supports, non-metallic rollers will minimize damage.

**i. Pipeline Identification.**

1) Provide identification markings as listed below, on the bottom exterior of the pipeline, when the Bridge Authority requires pipeline identification; also see MSHA utility policy.

a) Utility name (WSSC).

b) Pipeline working pressure (psi).

c) Contents (water, sewer, etc.).

d) Conform to industry standards for the contents for pipe coating color, when required. Typically, match the pipeline coating color to the bridge structure unless otherwise directed.

e) Size of the lettering, one third the pipe outside diameter, but not larger than 4-inch in height and installed on the pipeline by decals or stenciling with a high quality print.

f) Provide the above information on the pipeline within 50 feet from the bridge abutment and at intervals of 200 feet in between. Adjust the spacing to have one identification marking in every bay bounded by beams and diaphragms through which the pipeline passes.

**j. Design of Pipelines in Casing Pipes.**

1) If required by the Bridge Authority or by the Right of Way Authority, design the pipeline in a steel casing pipe.

2) If a casing pipe is required, provide provisions to drain condensation from the casing pipe.

**k. Isolation Valves.**

1) Pipelines that will be attached to bridge structures must have valves placed on each side of the bridge for isolating the pipeline on the bridge. For sewerage force mains, place a valve on the pumping station side. Unless the Bridge Authority requires valves on both sides of the bridge for sewerage force main, valves are not required.

2) The valves must be located and designed for thrust restraint in the closed position, see Part Three, Section 27 (Thrust Restraint Design for Buried Piping) under "When and How to Restrain Valves". Valves must be located far enough away from the bridge abutment/backwall, so that any maintenance on the bridge structure/foundation will not disturb the valves or compromise the valve restraint system.

**l. Location of the Pipeline on the Bridge Structure.**

1) There are three general locations on bridges where a pipeline could be located. They include under the bridge between two adjacent girders, on the exterior side of the bridge, and within a designated utility corridor. The location chosen for design will depend on factors such as the configuration and material construction of the bridge, accessibility for maintenance of the pipeline and the bridge, etc. In any case, the following guidelines apply and approval of the location is required.

a) Horizontal location.

(1) Pipelines on MSHA bridge structures are typically placed under the bridge between the bridge girders, preferably between the fascia and the first interior girder. This alignment places the pipeline on the shoulder of the approaches to the bridge as it enters and exits the bridge structure and also prevents the pipe from being visible from below to approaching traffic/etc.

(2) Pipelines on other jurisdictional bridge structures are to be located according to the requirements of the particular Bridge Authority. Preferably, locate the pipeline according to the requirements of MSHA, as noted above. In cases when the pipeline is not located under the bridge between two adjacent girders, contain the pipeline within the confines of the bridge superstructure.

b) Vertical location.

(1) Vertical clearance between the bridge and the roadway, railroad, etc. must not be reduced. Entire installation (pipeline, pipe supports, supporting brackets, etc.), must be above the bottom of the highest adjacent bridge girder.

(2) Provide a minimum 6-inch vertical clearance between the top of the pipe or pipe bells/flanges and the underside of the bridge deck or structural members, unless otherwise approved or required. Evaluate the possible vertical travel of the pipe due to deflection of the bridge structure and provide adequate clearance accordingly.

**m. Buried Pipelines Entering the Bridge Structure.**

1) Design the pipeline so that thrust forces of the buried pipeline are not transferred to the bridge structure.

2) The piping is to pass through the bridge backwall/abutment in a sleeve.

a) Design the sleeve using steel pipe with a seep ring sized large enough to allow for installation and removal of the pipeline.

b) If a fabricated pipe such as a mechanical joint by flanged pipe (MJ by FLG) must pass through the sleeve, then provide the diameter of the sleeve large enough to allow the smallest pipe joint to pass through.

c) Seal the void between the pipeline and the sleeve to prevent seepage of ground water through the sleeve.

d) If the area in front of the bridge backwall/abutment has a concrete approach slab, consider installing the pipeline in a sleeve or casing pipe. Extend the sleeve or casing pipe through the backwall/abutment and two (2) feet beyond the limits of the approach slab. Support the pipeline in the sleeve with suitable pipe supports or insulated casing spacers. The void between the pipeline and the sleeve must be sealed to prevent seepage of ground water through the sleeve.

3) Provide the following minimum cover over the buried pipeline:

a) Typically, the pipeline minimum cover is 4'-0" of cover over the top of the pipe, see Part One, Section 11 (Vertical Alignment – (Profiles)).

b) At the bridge backwall/abutment, the minimum cover can be reduced to 3'-0". Provide the first and subsequent buried pipe joints with vertical deflections down, so that 4'-0" cover over the pipeline is achieved as soon as possible.

c) In some cases, the minimum cover requirement can be modified to allow for cover less than the 3'-0" stated above, submit the design along with calculations, see Part One, Section 4 (Selection of Pipe Material).

4) Pipeline provisions for differential settlement of bridge/backfill.

a) Due to the potential for settlement of the backfill behind the bridge abutment wall, provide provisions to prevent damage to a pipeline where it passes rigidly through the abutment wall.

b) One method used for this purpose includes providing two pipe joints several feet apart just outside of the wall in the buried portion of the pipeline to allow the pipe in the fill to settle independently of the pipe fixed in the abutment wall.

**n. Pipe Thrust on the Bridge Structure.**

1) Good design practice is to avoid fittings, which create thrust forces on the bridge structure. The alignment of the pipeline should be in such a way that the bridge structure is not subject to residual thrust forces.

2) For pipeline material, see Allowable Pipeline Material, in this section. Restrain all joints to prevent joint separation. Also see the requirements for Design of the Pipeline for Expansion and Contraction in this section.

**o. Pipe Load on the Bridge Structure.**

1) When the pipeline is designed in a straight alignment, the primary pipe loading on the bridge structure is the pipe dead load which includes the weight of the pipe full of water, the weight of the pipe appurtenances (expansion joints, couplings, etc.), and the weight of the pipe support system.

2) Other pipe loads that should be evaluated are as specified by AASHTO. (Wind, Earthquake, shock, impact, etc.).

**p. Attaching the Pipeline to the Bridge Structure.**

1) Special bridge design requirements to accommodate the pipeline.

a) Coordinate the design of the pipeline support system with the Bridge Authority's engineer.

b) The design should not include welding directly to the bridge structural members, unless otherwise approved by the Bridge Authority.

c) Consider the pipe location and various components of the bridge structure, so that the design of the pipeline will not interfere with the bridge components.

2) Supporting the pipeline on the bridge structure.

a) Design the support system based on the following standards:

(1) DIPRA (Ductile Iron Pipe Research Association), Design of Ductile Iron Pipe on Supports.

(2) MSS (Manufacturer Standardization Society), Standard Practice SP-69, Pipe Hangers and Supports - Selection and Application.

(3) ASTM F 708, Design and Installation of Rigid Pipe Hangers.

b) Attaching the supports to the bridge.

(1) Support the pipeline by the bridge diaphragms. If this is not possible, a cross member will be needed to attach the pipe hanger/support to the bridge girders.

(2) Additional supports may be required and must be attached to the bridge girders or beams by nuts and bolts. No welding directly to the bridge structural members will be permitted in the design, unless otherwise approved by the Bridge Authority.

c) Coordinate the support location, type of supports, etc. with the Bridge Authority.

d) Design the pipeline supports such that any movements due to thermal expansion and contraction of the pipeline on the supports will not damage the pipe coatings or linings. Design the supports for free axial movement of the pipeline, unless the pipeline is designed to be restrained by the supports, (i.e. fixed to the bridge at each pipe joint).

e) Select pipe support materials which do not promote galvanic action and electrically insulate the pipeline from the pipe supports.

f) Design the supports to prevent lateral and vertical movement. Any anticipated shock or impact loading needs to be considered when selecting and specifying the pipe hangers, rollers, supports, etc.

g) <u>Support Spacing</u>. For DIP, provide supports behind each bell joint, and at a nominal spacing of ten (10) feet on center i.e., a minimum of two (2) supports per pipe length. For steel pipe, provide design calculations for support spacing.

**q. Design of the Pipeline to Prevent Freezing.**

1) MSHA requires all pipelines 12-inch and smaller diameter on MSHA bridges to be designed with insulation to prevent freezing. Verify with MSHA, if the insulation will be required <u>prior</u> to proceeding to incorporate it into the design.

2) For all pipeline bridge crossings, evaluate freezing in the design. Provide calculations with the assumptions and method used for the analysis. If required, provide insulation to protect the pipeline from freezing. Provide a design to facilitate any future maintenance. Support and protect the insulation from damage with a suitable shield.

**r. Design of the Pipeline for Expansion and Contraction.**

1) Conditions.

a) Fluid flow inside a pipeline as well as ambient temperature changes throughout the year will affect expansion and contraction of the pipeline with respect to the bridge.

(1) Consider thermal expansion and contraction of the pipeline and the bridge and provide the necessary provisions in the design.

(2) The bridge expansion could differ from the pipeline for the following reasons:

(a) Differences between the pipeline and bridge temperature. The pipe temperature being affected by the temperature of its contents (water or sewerage).

(b) Differences in the coefficients of thermal expansion, between the pipeline material and the bridge material.

**TABLE "24"**

Coefficients of Thermal Expansion

| Material | Coefficient |
|---|---|
| Ductile Iron Pipe | 0.0000062 inch/inch ° F |
| Steel Pipe | 0.0000063 inch/inch ° F |
| Structural Steel | 0.0000065 inch/inch ° F |
| Reinforced Concrete | 0.0000070 inch/inch ° F |

b) The location of the bridge expansion joint may concentrate movement relative to the pipeline.

c) Expansion and contraction in conjunction with thrust forces could introduce excessive stresses on the pipeline, pipe joints and/or the pipeline supports. Design the pipeline, so that axial thrust forces are not transmitted across the pipe expansion joint.

d) If DIP with push-on joints (not restrained) is specified. Restraining the pipe behind the bell to the bridge may be adequate to account for thermal expansion with proper joint assembly provided that special provisions are provided for pipe expansion/contraction for the concentrated movement at the location of the bridge expansion joint, see Push-on Joints in this section.

2) Location and number.

a) The location and number of expansion joints is determined by the length of the pipeline, the maximum anticipated temperature differential and the amount of movement which can be accommodated by the particular expansion joint being specified.

b) Expansion joints are utilized to accommodate thermal movements of the pipe and bridge in longer crossings and bridges with multiple spans. Expansion joints may be required at the location of the bridge expansion joints, especially if the pipeline is fixed to the bridge structure.

c) Where practical and permissible by the particular design, locate the expansion joint where it can be easily accessed for inspection and maintenance.

3) Restraint of expansion joints.

a) Type of joint ends. For ductile iron pipelines, design the expansion joint with flanged or restrained mechanical joint ends and for steel pipelines, design the expansion joint with flanged ends or beveled ends for welding.

b) Force required to actuate expansion joint. Due to the design of pipe expansion joints, they can often require a significant pulling force to actuate the joint. This force varies based on the design of the particular joint. Obtain this information from the manufacturer of the joint being specified. Therefore, the pipeline must be anchored sufficiently to resist this force and engage the expansion joint. Verify the force required to actuate the joint with the expansion joint manufacturer, and restrain or anchor the pipe accordingly. (As a conservative analytical practice, consider the pipeline empty when calculating the buried length of restrained pipe for two reasons; so the weight of the liquid will be considered as an additional safety factor and the possibility of the pipeline being empty during a period of time).

4) Types of pipe expansion joints.

a) Steel pipe and DIP. There are at least two types of expansion joints which are suitable for DIP and steel pipe. These include the steel single end type as well as a ductile iron expansion joint such as the Ex-Tend™ as manufactured by EBBA Iron, Inc.

(1) Single end type. This type of joint is most suitable for steel pipe crossings, however, it is also commonly used for DIP. It is generally fabricated from steel having a packing chamber to form a seal between a slip pipe and the body of the joint. Common manufacturers are Dresser Industries and Smith-Blair, Inc.

(2) Ductile iron expansion joint. The ductile iron expansion joint such as the joint manufactured by EBBA Iron, Inc. known as the Ex-Tend™, is available with mechanical joint ends and is well suited when designing a crossing using restrained mechanical joint DIP. It is also available with flanged ends allowing it to be used for steel pipe.

**s. Design of Dewatering and Air Release Appurtenances on Bridge Structures.**

1) Do not design air release and blowoff connections within the bridge structure.

2) Design the pipeline between the required isolation valves to allow the pipeline to be drained by gravity. Provide a blow-off connection in the buried portion of the pipeline according to Part One, Section 23 (Blowoff Connections).

**t. Pipelines to be Abandoned on the Bridge Structure.**

1) When the pipeline is no longer required on the bridge structure, WSSC will notify the Bridge Authority. If the Bridge Authority decides that the pipeline must be removed, the following will be required.

a) Abandonment plan, showing the limits of what is to be removed from the bridge structure.

b) Abandonment of the buried portion of the pipeline in accordance with Part Three, Section 5 (Pipeline Abandonment).

**u. References.**

1) MSHA (Maryland Department of Transportation-State Highway Administration), MSHA Utility Policy "July 1989" revised May 1994.

2) ASCE, Pipeline Division, "Pipeline Crossing Proceedings, Special Conference, Denver, CO., March 25-27, 1991, Bridge Crossings with Ductile Iron Pipe by Michael S. Tucker."