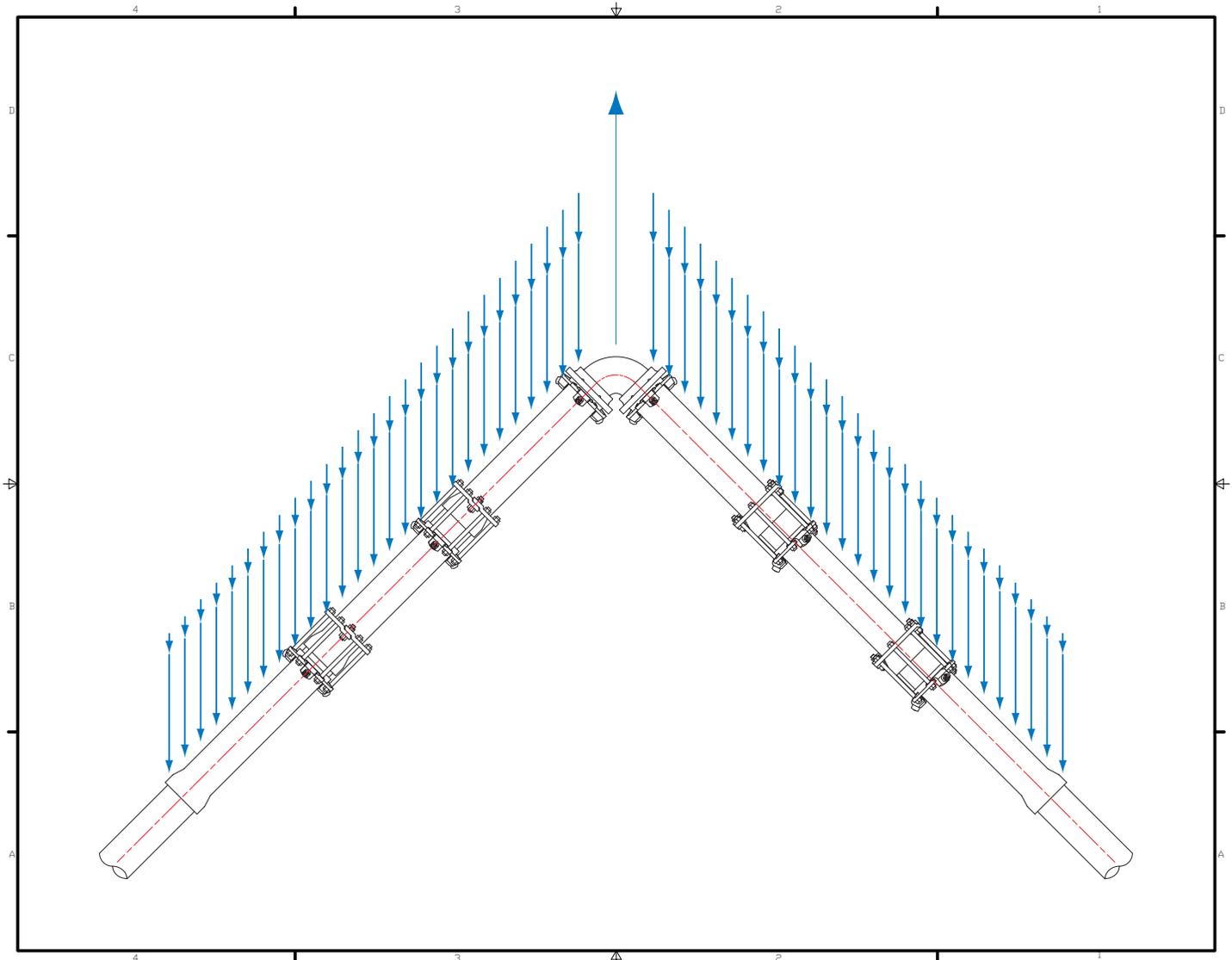




"Your Connection to the Future"™

# Using The Restraint Length Calculator v7.0



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## Introduction

The Restrained Length Calculator version (RLC) is a specifically designed calculator application, developed by EBAA Iron, Inc., that provides, in feet, the restrained values required to properly restrain one or more fittings in a pressurized water or wastewater pipeline design.

The RLC can save one or more fitting restrained lengths in a single or multiple project file along with displaying and or printing all the restrained lengths in a tabular format with the supporting equations for submittal purposes.

The RLC Graphic User Interface (GUI) is an easy to use point and click application that enables you to quickly and effectively choose your existing parameters in your pipeline design applications.

Version 7 of the RLC is a web or on-line based application and supports contemporary Internet Browsers: Internet Explorer (8 through 10), Chrome, Safari, Firefox, iOS Safari and Android.

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## Supporting Documentation

The Restrained Length Calculator (RLC) has several supporting technical papers that have been published by EBAA Iron, Inc. in a series called "**Connections**" *Technical Data For The Water and Wastewater Professional*. The support documents can be found within the RLC and a complete listing and access to the series is available on EBAA's website in the Technical Support section ([www.ebaa.com](http://www.ebaa.com)).

The *Connection* papers listed below pertain to the RLC as well as pipeline design. Supporting equations, tables and more can be found in them.

### **Connections**

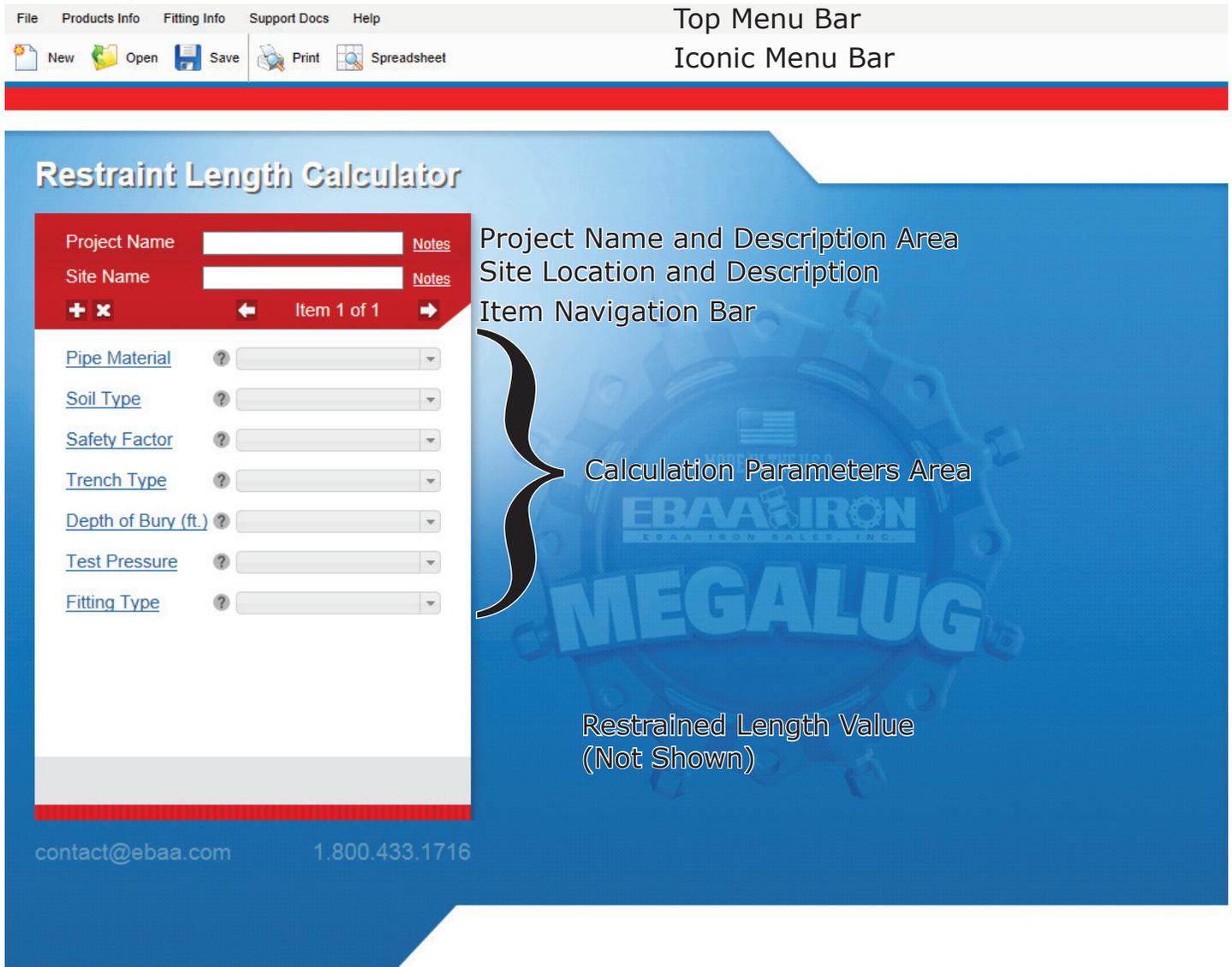
<b>Series</b>	<b>Summary</b>
PD-1	Joint Restraint vs. Thrust Blocks
PD-2	Restrained Pipeline Design and Horizontal Bends
PD-3	Thrust Restraint Design of Vertical Offsets and Tees
PD-4	Thrust Restraint Design of Reducers, Dead Ends, and Valves
PD-5	Bearing and Frictional Resistances – The Building Blocks of a Restrained System
PD-6	Thrust Restraint Design Equations and Tables for Ductile Iron and PVC Pipe

## Using the Graphical User Interface

The Restraint Length Calculator version (RLC) has an easy to use graphical user interface (GUI). This point and click system easily allows the user to quickly input application parameters to retrieve quick and accurate restrained length values. In the next few pages the input fields and their functions will be identified and defined.

The GUI is divided into seven categories: the Top Menu Bar, Iconic Menu Bar, Project Name and Description, Item Navigation Bar, Site Location and Description, Calculation Parameters Area, and finally the returned Restraint Length Calculation. The following pages will look at each one of these categories individually.

*Restraint Length Calculator User Interface*



The screenshot shows the Restraint Length Calculator user interface. At the top, there is a **Top Menu Bar** with options: File, Products Info, Fitting Info, Support Docs, and Help. Below it is an **Iconic Menu Bar** with icons for New, Open, Save, Print, and Spreadsheet. The main content area is titled **Restraint Length Calculator** and contains several input fields and a navigation bar.

Annotations on the right side of the screenshot identify the following areas:

- Project Name and Description Area**: Points to the Project Name and Site Name input fields.
- Site Location and Description**: Points to the Site Name input field.
- Item Navigation Bar**: Points to the navigation controls (back, forward, and page indicators) below the input fields.
- Calculation Parameters Area**: Points to the dropdown menus for Pipe Material, Soil Type, Safety Factor, Trench Type, Depth of Bury (ft.), Test Pressure, and Fitting Type.
- Restrained Length Value (Not Shown)**: Points to the area where the result would be displayed.

At the bottom of the interface, contact information is provided: [contact@ebaa.com](mailto:contact@ebaa.com) and 1.800.433.1716.



## Top Menu Bar



The Top Menu Bar is located at the top of the calculator.

Listed here, are the five available menus: File, Product Info, Fitting Info, Tools, and Help.

**File** - Within the File Menu, the user can create a New project file, Open an existing project file, Save current project files and Print.

**Product Info** - The Product Info Menu is a Internet Link that will open the user's browser to EBAA's web site ([www.ebaa.com](http://www.ebaa.com)).

**Fitting Info** - Defines the array of fittings found within the calculator. The definitions include short summaries of the fittings as well as the equation used to determine the restrained length and graphical representation of the fitting. The Fitting Types listed are: Bends, Offsets, Tees, Reducers, Dead Ends, Fire Hydrants, Sleeves, Valves, and Thrust Collars.

**Support Docs** - Provides easy access to all the support documentation, tables, definition of terms (explanations of the variables used in the equations) and equations used by the RLC.

**Help** - Help contains several resources. They include EBAA's contact information, EBAA's website address, References, and the About Restraint Length Calculator showing the current version of the RLC and the version history.

## Iconic Menu Bar



The Iconic Menu Bar is directly below the Top Menu Bar. It's a short cut to the most popular functions found inside the menu system of the Top Bar.

Listed here are the six available menus: New, Open, Save, Print, and Spreadsheet.

**New** - Create a new project file.

**Open** - Open an existing project file.

**Save** - Save current project file.

**Print** - Print existing project file, with or without equations.

**Spreadsheet** - Downloads a Comma Separated Value (csv) file of your existing project and fittings, which may be opened in Excel.



## Project Name and Description

Project Name	<input type="text"/>	<a href="#">Notes</a>
--------------	----------------------	-----------------------

The Project Name dialogue box allows the user to name the particular Project being worked on. (i.e. the Hayward Ave Water Main)

The link (Notes) on the right side opens a dialog box where project notes may be added if necessary.

### Project Notes

## Items

An Item is a fitting that has been added to the project file. One or multiple Items within the project file can be expected.

## Item Navigation Icons

There are four blue background buttons which allows the user to navigate existing Items, Add to Items, or Delete Items.



-  **Add or Create New Item Button** - If multiple Items occur in a project, the required parameters must be filled out. After obtaining your restrained length, simply click this button to add it to the file; this will reset the parameters for the additional items.
-  **Back** - If multiple Items occur, this button will allow the user to scroll backwards through them and revisit each one. The user may edit them at this time as well.
-  **Forward** - Similar to the Back button, the forward button allows the user to scroll forward through the user's list.
-  **Delete** - Delete removes the shown item from the user's list.

## Site Location and Description

Site Name	Notes

The Site Location dialogue box allows the user to name each fitting item. This is helpful when several fittings are used in one project.

The notepad link opens a small text box window so the user can add notations and more defined descriptions.

### Site Notes

Save NotesCancel

## Calculation Parameters

The Calculation Parameters are the most essential part of the calculator. By defining these parameters, the calculator is able to complete the required equations and provide the requested restrained length values.

With each fitting type available, there are six standard parameters needed: Pipe Material, Soil Type, Safety Factor, Trench Type, Depth of Bury, and Test Pressure.

The fitting types available are Horizontal Bend, Vertical Offset, Tee, Reducer, and Dead End. Each of the fitting types may have specialty required parameters that only refer to them.

<u>Pipe Material</u>	?	<input type="text"/>	▼
<u>Soil Type</u>	?	<input type="text"/>	▼
<u>Safety Factor</u>	?	<input type="text"/>	▼
<u>Trench Type</u>	?	<input type="text"/>	▼
<u>Depth of Bury (ft.)</u>	?	<input type="text"/>	▼
<u>Test Pressure</u>	?	<input type="text"/>	▼
<u>Fitting Type</u>	?	<input type="text"/>	▼

Please **note** that each parameter is colored in blue and is underscored; this is an indicator that these are click-able. By clicking on the parameter text, the user can bring up a description of each parameter that includes a selection button. This button allows the user to chose which of the available parameters are required without having to close the defining window.

If the parameters needed are known, an experienced user may choose to simply select the required parameter from the provided drop down boxes. Using the Tab key will also speed the user's way through the drop down boxes.

The following pages will define each parameter.



## Calculation Parameters

**Pipe Material** - Three options are available:

- Ductile Iron pipe meeting ANSI/AWWA C151/A21.51
- Ductile Iron pipe in polyethylene encasement meeting the requirements of, and installed per ANSI/AWWA C105/A21.5
- Polyvinyl Chloride (PVC) pressure pipe meeting the requirements of ANSI/AWWA C900, C905, or ASTM D2241

**Soil Type** - Options available for soil that will be in contact with the pipe:

### *Coarse Grained Soils*

- GW – Well graded gravels and gravel-sand mixtures, little or no fines
- SW – Well graded sands and gravelly sands, little or no fines
- GP – Poorly graded gravels and gravel sand mixtures, little or no fines
- SP – Poorly graded sands and gravelly sands, little or no fines
- GM – Silty gravels, gravel sand silt mixture
- SM – Silty sands, sand silt mixtures
- GC – Clayey gravels, gravel sand clay mixtures
- SC – Clayey sands, sand clay mixtures

### *Fine Grained Soils*

- CL – Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, lean clays (backfilled using native soil)
- ML – Inorganic silts, very fine sands, rock flour, silty or clayey fine sands (backfilled using native soil)
- CL (granular) – CL native soil backfilled with granular material
- ML (granular) – ML native soil backfilled with granular material
- CH (granular)\* – Inorganic clays of high plasticity, backfilled with granular material
- MH (granular)\* – Inorganic silts, micaceous or diatomaceous fine sands or slits, elastic silts, backfilled with granular material

\*Soils require a granular bedding material instead of native soil bedding. Restrained lengths are calculated using GP or SP bedded material.



## Calculation Parameters

**Safety Factor** – Safety Factor is used to add factors of conservatism to the equation. 1.5 to 1 is recommended as an explicit factor of safety for calculating restrained lengths in most installations. This factor, combined with conservative values used in these calculations, generate very conservative restrained lengths. Severe conditions and critical installations may require higher factors. Available factors are: 1:1, 1.5:1, 2:1, 2.5:1, and 3:1.

**Trench Type** – Pipe Bedding Types.

- Type 3 – Pipe bedded in 4 inches of minimum loose soil with backfill lightly consolidated to top of the pipe.
- Type 4 – Pipe bedded in sand, gravel or crushed stone to a dept of 1/8 pipe diameter, 4 inch minimum. Backfill compacted to top of pipe. (Approximately 80 percent Standard Proctor, AASHTO T-99)
- Type 5 – Pipe bedded in compacted granular material to the centerline of the pipe, 4 inches minimum under the pipe with compacted granular or select material to top of pipe. (Approximately 90 percent Standard Proctor, AASHTO T-99)

**Depth of Bury** – Depth of Bury is measured in feet to the top of the pipe for the calculations within this program. In the case of vertical offset, please enter the depth of the upper fitting at this time.

**Test Pressure** – Restrained length calculations are based on the highest pressure that the pipeline will be subject to. Since test pressures are typically higher than the operating pressure, they are used in the calculations. Please enter a test pressure between 50 PSI and 350 PSI. For test pressures above 350 PSI please contact EBAA for assistance.

## Calculation Parameters

**Fitting Type** – This program supports the nominal sizes of 3 inch through 48 inch, standardized mechanical joint fittings meeting the requirements of ANSI/AWWA C110/A21.10 or ANSI/AWWA C153/A21.53. There are five basic fitting types within a pipeline system that require restraints. They are Horizontal Bend, Vertical Offset, Tee, Reducer, and Dead End. (Valves are considered Dead Ends.) Some of these fitting types require special Calculation Parameters and will be defined in each fitting category.

**Note:** Couplings and 4-way Crosses are not included as the thrusts produced at their joints counter each other making the thrust null, and typically not requiring restraints other than the joints at the fitting itself. Tees that have one end capped or plugged are considered 90 degree bends. Valves, since they can be closed, are considered Dead Ends.

- **Horizontal Bend** are typically elbows
  - **Nominal Size** – This program supports the nominal pipe size of 3 inch through 48 inch for both ductile iron and PVC pipe.
  - **Bend Angle** – The restrained length calculations performed by this program are applicable to fittings in which restrained lengths do not interfere with the restrained lengths of other fittings. When restrained lengths do overlap, the designer must evaluate the combination as a whole. In some instances, combinations of fittings act to cancel some thrust forces, thus simplifying the necessary calculations. Angles supported are: 90°, 45°, 22½°, and 11¼°.
- **Vertical Offset** are typically a series of two elbows
  - **Nominal Size** – This program supports the nominal pipe size of 3 inch through 48 inch for both ductile iron and PVC pipe.
  - **Bend Angle** – The restrained length calculations performed by this program are applicable to fittings in which restrained lengths do not interfere with the restrained lengths of other fittings. When restrained lengths do overlap, the designer must evaluate the combination as a whole. In some instances, combinations of fittings act to cancel some thrust forces, thus simplifying the necessary calculations. Angles supported are: 45°, 22½°, and 11¼°.
  - **Low Side Depth** – Like the depth of bury entered earlier, the low side depth of a vertical offset is measured in feet to the top of the lower pipe. This program is able to calculate restrained lengths for pipelines buried up to 32 ft.

## Calculation Parameters

### Fitting Type – (cont.)

- **Tees**

- **Nominal Size** – This program supports the nominal pipe size of 3 inch through 48 inch for both ductile iron and PVC pipe.
- **Branch Size** – This program supports the calculation necessary for equal outlet, reduced outlet and bull head Tee's.
- **Length Along Run** - In a restrained joint system, the force at the tee is balanced by the soil in two areas. The first is the area of the pipe that is behind the tee. This is the area in which a thrust block would normally be poured. The restrained length of pipe ( $L_r$ ), along the run of the tee and on each side of the tee, encounters passive bearing resistance from the soil that acts perpendicularly to the tee. The restrained length along the branch of the tee connection, ( $L_b$ ), provides frictional resistance that involves the entire circumference of the branch piping.

The minimum attached length of pipe ( $L_r$ ) to extend in each direction along the run of the tee is a user specified quantity. This program is used to calculate the restrained length along the branch ( $L_b$ ). The length of pipe ( $L_r$ ) must be of solid pipe without joints, fittings, etc. Consideration in specifying this length must be given not only to the job layout, but also to the practicalities of installation.

- **Reducer** – Fitting used to transition two different sized pipe.
  - **Large Size** – Largest Pipe size. This program supports the nominal pipe size of 3 inch through 48 inch for both ductile iron and PVC pipe.
  - **Small Size** – Smallest Pipe size. This program supports the nominal pipe size of 3 inch through 48 inch for both ductile iron and PVC pipe.
- **Dead End** – Capped or Plugged end of a pipe system.
  - **Nominal Size** – This program supports the nominal pipe size of 3 inch through 48 inch for both ductile iron and PVC pipe.

## Calculated Restrained Length Value

The Calculated Restrained Length Value derived by the calculator is the total amount, in feet, that needs to be restrained. Depending on the fitting type you have selected, this may or may not include either side of the fitting. For example, if the user ran the calculation for a 90 degree bend and the restrained length was 19 ft, then restraints up to 19 ft on both sides of the fitting would be necessary. This means **any joint** that might fall within that 19 ft, including the joint at the fitting, would require a restraint mechanism. However it is not necessary to have a 19 ft or greater stick of solid pipe without joints.

Please note, when the calculator derives each restrained length value, it will inform the user which side of the line needs to be restrained.

### **Example: Bend**

Using these parameters:

- Pipe Material: PVC
- Soil Type: GW
- Safety Factor: 2.0 to 1
- Trench Type: 5
- Depth of Bury: 6 (ft)
- Test Pressure: 150 (PSI)
- Fitting Type: Horizontal Bend
- Nominal Size: 12 (inches)
- Bend Angle: 90 (degrees)
- Restrained Length returned from the calculator is:
  - 19 ft = Length to be restrained on each side of bend.

Notice the 19 ft to be restrained on each side of the bend.

### **Another Example: Tee**

Using these parameters:

- Pipe Material: PVC
- Soil Type: GW
- Safety Factor: 2.0 to 1
- Trench Type: 5
- Depth of Bury: 6 (ft)
- Test Pressure: 150 (PSI)
- Fitting Type: Tee
- Nominal Size: 12 (inches)
- Branch Size: 12 (inches)
- Length Along Run: 5 (ft)
- Restrained Length returned from the calculator is:
  - 15 ft = Length to be restrained along branch

Notice the 15 ft to be restrained along the branch.



## Frequently Asked Questions (FAQ)

Q. Where can I find trench types 1 and 2? I only see types 3, 4, and 5 listed.

A. The EBA A Iron Restraint Length Calculator only supports trench types 3, 4, and 5. We feel that types 1 and 2 do not provide sufficient compaction for the transfer of thrust forces to the wall of the trench.

Q. Can the "Low Side Depth" of a vertical offset be less than the "High Side Depth"?

A. Yes. A case in which this may occur is a vertical offset in a line running down an embankment where the depth of bury on the top of the embankment is less than that on the bottom.

Q. My design calls for a Tee with the branch four feet in length to a fire hydrant. The Restraint Length given to me by your calculator says I need 12 ft of restrained length. Do I need to extend my plug 12 ft? That's going to put it into an existing sidewalk.

A. No, the calculator assumes that the branch pipe line will extend at least 12 ft or more. If you require a shorter length than the 12 ft, then you need to make sure every joint is properly restrained.

Q. I do not see Couplings or Four Way Crosses listed as a fitting type. Why not?

A. Couplings and Four Way Crosses generate equal and opposite thrust at their joints. These thrusts cancel each other out and make the thrust null, requiring no restraint lengths for their applications. (A rule of thumb is to always restrain the joints on any fitting.)

Q. How do I handle a valve application?

A. Since a valve is close-able, this is considered a Dead-End application and calculated as one.