AutoCAD MEP (R2011) Enhanced Piping Design

AutoCAD MEP has been committed to strengthening piping design features in the past several releases. Release 2011 has powerful piping design functionality compared to previous releases. With more content, the pipe catalog was reorganized to facilitate piping design. This white paper discusses the piping enhancements in AutoCAD MEP and explains functionality associated with piping design tools.

1 Defining Pipe and Fittings in AutoCAD MEP

When designing a piping system, designers usually follow these steps:

1. Select pipe material per its application.
2. Define appropriate connection type (to choose pipe diameter and pressure rating).
3. Lay out pipeline with the best route.

To align with the design process, pipe catalog classifies the main category with material, sub-category with connection type. Those most closely aligned with design, such as connection type, material and pressure rating, are included in pipe fitting names. Therefore, the naming gives users a straightforward way of recognizing pipe and fittings.

As illustrated in Figure 1, Plastic in the left pane is the main category, Glued and Threaded are sub-categories; fitting names which involve connection type, pressure rating, material and part type, show in the right pane. Any information above which is not included in the fitting will be exclusive in its name.

Note 1: Pipe or Tube is classified as the main category to help finding.

![Figure 1 Plastic Pipe Catalog in AutoCAD MEP](image)

All pipe and fittings provided in AutoCAD MEP are named according to the below rule, see Figure 2. Understanding this rule will be quite helpful in finding wanted pipe fittings.
Figure 2  Pipe and Fittings Naming Rule

2  Content of Pipe Catalog

To meet the needs of design, AutoCAD MEP supplements pipe and fitting catalog with multiple materials: Cast Iron, Ductile Iron, Plastic, Steel, Copper, HDPE and Generic Pipe (as shown in Figure 3).

Note 2: Any reference to materials in the name of AutoCAD MEP objects is based on common industry language and does not necessarily reflect the actual material specifications for the pipe and fittings.

As a pipe has diverse sizes due to different materials and pressure rating, we also need appropriate fittings to constitute a pipeline system, so pipe catalogs are divided into several groups according to materials. As mentioned above, under each pipe material, pipe fittings are classified by connection type and with a unified naming rule, making the whole pipe catalog legible so that designers can find fitting under multiple groups.

Figure 3  All Pipe Catalogs in AutoCAD MEP
AutoCAD MEP supplements the function to manage multiple catalogs. Users can set the catalog to be loaded or not with the “Add” and “Remove” buttons, and adjust their orders with the “Move Up” and “Move Down” buttons (see Figure 4).

![Figure 4: Manage Multiple Pipe Catalogs](image)

AutoCAD MEP provides diverse connection types (flanged, threaded, socket welded, etc) for each pipe material. Those connection types included in different materials are shown in Figure 5. The abundant connection types give strong support to designers to build up a diversified pipeline system.
In AutoCAD MEP, the connection between fittings and a pipe is determined by the “connectors” on the pipe. In Release 2011, a fitting can have diverse connection types, while the fitting in previous versions could only have a unique connection type.

All pipe or tube connections in AutoCAD MEP are configured as “Undefined”. Once a pipe is connected, it inherits the suited connection type of the object it is connected to. Note that the connector 1 (C1) of the pipe in Figure 6 has not connected to anything; the connector 2 (C2) connects to an elbow with butt welded connection. Accordingly, the connection type of C1 and C2 are “Undefined” and “Butt Welded”. Therefore, a pipe can’t connect to anything that has an “Undefined” connection type.
As per different behavior, the connection types are classified in 3 categories (see Table 1).

Table 1 The Classification of Connection Type in AutoCAD MEP

<table>
<thead>
<tr>
<th>Main Classification</th>
<th>Sub-Classification</th>
<th>Connection Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender Neutral ☐</td>
<td>All fitting connectors are female</td>
<td>Brazed, Capillary, Compression, Clamped, Crimped, Glued, Slip joint, Socket, Socket Welded</td>
</tr>
<tr>
<td></td>
<td>Only couplings have female connectors, all other fitting connectors are male</td>
<td>Grooved</td>
</tr>
<tr>
<td>Male – Male Connection</td>
<td>All fitting connectors are male</td>
<td>Fusion, Butt Welded</td>
</tr>
<tr>
<td></td>
<td>All fitting connectors are male (flanged connection), only flange has one side with female or male connection</td>
<td>Flanged</td>
</tr>
<tr>
<td>Male – Female Connection</td>
<td>The coupling has female connectors, all the other fitting connectors are male or female</td>
<td>Bell - Spigot, Hub - Spigot, Push On - Plain End, Flared - Plain End, Mechanical Joint - Plain End</td>
</tr>
<tr>
<td></td>
<td>Only coupling has female connectors, all the other fitting connectors are male</td>
<td>Hub - No Hub</td>
</tr>
<tr>
<td></td>
<td>The nipple, bushing and union ☐ are male connections, all the others are male-female connections</td>
<td>Female Threaded - Male Threaded</td>
</tr>
</tbody>
</table>
Note 3: Gender Neutral refers to connection types that can be designated as male or female depending on their CER value. A CER value of 0 is male, and any positive value is female.

Note 4: Adapter is not included in the fittings that are listed in the table above.

When specifying connections between pipe and fittings, designers must take into account the length of pipe that sits inside the fitting when actually constructed. In fact, this length is so important that it is known in the industry as engagement length. The engagement length or CEL (Connector Engagement Length) value is assigned to the connectors in AutoCAD MEP and can be found in the catalog. The CEL number corresponds to the connector number, for instance, Connector 1 is known as C1 and has a corresponding CEL1 value.

The behaviors of connections and CEL described above will be introduced below.

3.1 Brazed Connections

Brazed connection is one of the most common connection types for jointing copper or copper alloy pipe. The intention of quoting brazed connection here is to introduce how to build up the pipeline system with gender neutral joints and how to work with CEL in AutoCAD MEP.

![Figure 7 - Pipe with Brazed Connection](image)

As shown in Figure 7, all fitting ends with brazed connections are female. When connecting to a fitting, pipe goes into the female end, the length which corresponds to the CEL. The CEL values relate to pipe size that can be found in the pipe catalog. The physical location of the fitting connector is on the side where the pipe connects. Since all pipe connections are always male in AutoCAD MEP, so the relevant CEL values are set to 0.

Soldering, Capillary, Compression, Clamped, Crimped, Glued, Slip Joint, Socket, and Socket Welded are all bisexual connection types, which have same behaviors with brazed connection. We won’t repeat them here.

3.2 Grooved Connections

Grooved is a gender neutral connection type as well, while all fittings (except coupling) merely have male ends. Grooved coupling is always required to joint Pipe-to-Pipe, Pipe-to-Fitting and Fitting-to-
Fitting. Therefore, grooved connection has distinct behaviors with the other gender neutral connections.

![Diagram of Pipe with Grooved Connection](image)

**Figure 8  Pipe with Grooved Connection**

In Figure 8, when connecting pipe and fitting with coupling in AutoCAD MEP, the physical location of the coupling connector is inside body, the CEL values defined in the catalog are the amount of piping that should go into the grooved couplings, so that the male connectors are placed inside.

### 3.3 Butt Welded Connections

Butt Welded is male-male connection where no "joint" object is required to constitute a piping system. In AutoCAD MEP, all the fitting ends with this connection are simply configured as “Butt Welded”. Figure 9 illustrates how to join pipe with butt welded connection. The connector position is on the face of the fitting end which has a butt welded connection. So, all butt welded fittings have CEL values with 0. Notice that C1 is a butt welded connection, while C2 is undefined.

Note 5: Here the configuration refers to the connector setting under Content Builder circumstances. This configuration will reflect the Connection Details on the Property Palette. The connection setting below is the as the connection type set in Content Builder.
3.4 Flanged Connections

Although flanged is a male-male connection, it is different than the butt welded connection. The most typical characteristic is that the joint object “flange” is always required when connecting pipe-to-pipe and pipe-to-fitting.

Figure 10 shows how to work with a flanged connection. In AutoCAD MEP, all fitting ends with flanged connections are assigned to “flanged”. Since flanged faces mate directly to each other, the CEL1 value is set to 0. “Flange” is a special case in all congener fittings; one side which connects to other flanged connections is set to “flanged”, connector position is on the face of flanged face, the other side may be male or female, where the connector locations determined by its gender and CEL value.
3.5 Bell - Spigot Connection

Bell - Spigot is a typical male-female mate joint. Those fittings with Bell and Spigot connections mostly have both Bell and Spigot connections, while the coupling merely has Bell connections on both ends.

As listed in Table 1, some other connections have similar behavior with Bell - Spigot connections. Herein, the Bell - Spigot connections will be quoted to introduce how to use these male-female mate connections in AutoCAD MEP.

In AutoCAD MEP, the configurations between Bell and Spigot are rather different. The former is simply assigned to “Bell”; the latter is assigned to “Undefined” under Content Builder circumstance. When mating a Spigot connection to a Bell connection, it will change from previously set “Undefined” to “Spigot” to match the Bell connection. We’ll discuss this later in this paper.

Figure 11 shows the Connection Details of a pipe fitting with Bell - Spigot connections. Notice that C1’s connection type is “Undefined”. It will change to “Spigot” if connected to a Bell connection. As CEL1 corresponding to C1 is 0 inch, so its connector is on the face of this end. C2’s connection type is “Bell”; when connecting to a pipe® or Spigot end, the piping goes inside and the amount that should go into is on the side where the Bell connector is.

Note 6: In the real world, the Cast Iron pipe usually has single or both Bells on its ends; however, AutoCAD MEP is not able to replicate this, so a special “Coupling” is added in to make up for the deficiency. The coupling is used to connect a piping to Spigot end. Similarly, Push On - Plain End, Mechanical Joint - Plain End and Hub - Spigot supplement this kind coupling as well. Please notice that the coupling should be exclusive when scheduling tables, as it plays a supporting role in pipe connection for this application.

3.6 Hub - No Hub Connections

In fact, the behavior of Hub - No Hub connections is pretty similar to that of a Grooved connection. The same point is that Pipe-to-Pipe, Pipe-to-Fitting and Fitting-to-Fitting joints all rely on couplings, and all fittings’ (the coupling is exclusive) connections are male.
The difference is that all the fittings (including coupling) with Grooved connectors have the unified connection name no matter what gender it is; while only the coupling in Hub - No Hub fittings has Hub connection, the others have a unique No Hub connection, in other words, their names are different.

Since No Hub is a male connection, it is assigned to “Undefined” in AutoCAD MEP. After connecting with a Hub end, its connection type changes from “Undefined” to “No Hub” (as shown in Figure 12). C1 of the elbow connects to a Hub coupling, its connection type shows as “No Hub”; C2 connects to anything, so it still keeps “Undefined”. C1 of the elbow goes into the coupling and connects with its C2; the length going inside is exactly the CEL2 of coupling.

![Pipe with Hub - No Hub Connections](image)

**Figure 12** Pipe with Hub - No Hub Connections

### 3.7 Threaded Connections

Before AutoCAD MEP 2010, the application didn’t differentiate between inner threaded and outer threaded, so the threaded connection in previous versions is a gender neutral connection type. From the AutoCAD MEP 2010 on, inner threaded is defined as Female Threaded, outer threaded is defined as Male Threaded. As introduced above, the Male Threaded on the fitting end is assigned to “Undefined”; when connecting to a Female Threaded, the male end transforms to “Male Threaded”. The previous Threaded connection is still kept for use in the application.
In Figure 13, both C1 and C2 of the elbow have the previous **Threaded** connection type, and C1 of the pipe segment, which has connected to the elbow, has the matching **Threaded** connection, C2 connects to nothing, so its connection type is still “Undefined”.

In Figure 14, both C1 and C2 of the elbow have **Female Threaded** connection type, and C1 of pipe segment, which has connected to the elbow, has the matching **Male Threaded** connection, C2 connects to nothing, so its connection type is still “Undefined”.

### 4 Create a Piping Layout

The fastest and easiest way to add a pipe to an AutoCAD MEP model is by using the PIPEADD command. The application provides a fully functional interface for piping design and integrates all into the Property Palette. Figure 15 shows the piping design interface. Understanding the related functionalities on the Property Palette will help to improve the efficiency of your piping design.
The PIPEADD command provides an efficient way of drawing a pipe with the correct piping components automatically inserted. To support this automated behavior, AutoCAD MEP provides a unique layout functionality based on the type of fittings inserted and the connection type used. To better understand these unique behaviors, first consider the most common layout scenarios: pipe to fitting, pipe to pipe, and fitting to fitting. Then consider the different types of pipe connections: Butt Welded, Grooved, Socket Welded, Brazed, Soldering, Capillary, Glued, Threaded, Fusion, Flanged, Socket, Bell - Spigot, Mechanical Joint - Plain End, Push On - Plain End, Hub - No Hub and Flared - Plain End, etc.

Brazed, Soldering, Capillary, Compression, Clamped, Crimped, Glued, Slip joint, Socket and Socket Welded connections all have the same behavior with respect to how the joint objects are to be inserted. The fittings are all female, so no separate joint object is necessary to connect to a fitting. However, when connecting a pipe to pipe, one coupling object is used to hold the pipes together (see Figure 16).
Figure 16  Brazed, Soldering, Capillary, Compression, Clamped, Crimped, Glued, Slip joint, Socket and Socket Welded Connections

Grooved connections have a rather consistent behavior in that a joint object is always required in order to join a pipe to a fitting or to another piece of pipe (see Figure 17).

Figure 17  Grooved Connections

Butt welded and Fusion connections do not require the insertion of a separate joint object because this connection method welds the body of the fitting or pipe together (see Figure 18).

Figure 18  Butt Welded and Fusion Connections

Flanged connections can be tricky simply because the fittings are made with the flanges on them. Only one flange object is required when connecting a pipe to a fitting. However, two flange objects are required when connecting pipe to pipe (see Figure 19).
Figure 19  Flanged Connections

Bell - Spigot, Hub - Spigot, Push On - Plain End, Mechanical Joint - Plain End and Flared - Plain End connections all have similar behaviors to joint pipe and fittings (see Figure 20). As described above (Note 6), in the real world, no joint object is required for this kind of Pipe-to-Pipe and Pipe-to-Fitting connecting, but due to limitations in the application, the special joint coupling is imported.

Figure 20  Bell - Spigot, Hub - Spigot, Push On - Plain End, Mechanical Joint - Plain End and Flared - Plain End Connections

Hub - No Hub connections are similar with Grooved connections in that the coupling is required in order to join a pipe to a fitting or to another piece of a pipe (see Figure 21).
Male - Female Threaded connections still keep the consistent behavior with previous Threaded connections. The fittings are all female, so no separate joint object is needed to connect to a fitting. However, when connecting a pipe to a pipe, one coupling object is used to hold the pipes together (see Figure 22).

4.1 Routing Preferences

The PIPEADD command provides an efficient way to draw a pipe with the correct piping components inserted automatically. Routing Preferences are the key to this automated behavior, and are referred to as Autolayout in AutoCAD MEP. Routing Preferences define which parts to use, depending on the size of the pipe being laid out (see Figure 23).
Even though Autolayout behavior is based on the fittings and connection type being inserted, Routing Preferences provide flexibility to define parts based on a range of sizes. For example, in Figure 23, Socket Welded joints are defined for pipe sizes 1/8 inches to 3 inches (refer to Size Upper Limit value); however, Butt Welded joints are defined for pipe sizes 4 inches to 24 inches. Filtering of parts within Routing Preferences makes selecting a part easier to define. For each part, the associated part list is filtered according to the specified size upper limit, or size range. Therefore, only parts that span the size range are included in the part list.

4.2 Connection Assignments

The paragraphs above introduced pipe connection types and how to achieve pipe connection in AutoCAD MEP.

In previous versions, AutoCAD MEP didn’t support male-female mate connections, such as Bell - Spigot and Mechanical Joint - Plain End connections.

In AutoCAD MEP 2011, all connection types whose genders are male are assigned as “Undefined”, except Butt Welded and Fusion connections (male-male connections). The connection type of male connector which connects to a female connector will change from undefined to match the female end. To make this come true, the application added a new concept called “Connection Assignments”. Through the configurations in Connection Assignments, the male and female connections are appropriately connected in AutoCAD MEP.
As shown in Figure 24, the first column is a female connection and can’t be modified; this column includes all gender neutral connections as well. The second column is male connection; users can select a male connector to match with a female connector. The application achieves male-female connection according to this configuration. See Figure 11 and Figure 14 to refer to connection details after joints.

### 4.3 Choosing a Part

Routing Preferences provide a flexible method for determining how pipes should be laid out based on user-defined standards. However, even after the user has defined Routing Preferences, AutoCAD MEP may still require additional information to determine which part to insert based on the unique routing behavior used during Autolayout. In cases such as these, the Choose a Part dialog box appears.

The most common layout behavior that results in prompting the Choose a Part dialog box is connecting a pipe to a flanged part when Routing Preferences is defined as Butt Welded (see Figure 25). In this case, the Choose a Part dialog box returns a list of parts from the Pipe and Fittings catalog that have Flange connectors and fit the size requirements.

Note 7: If Routing Preferences are defined as Flanged, the Choose a Part dialog box does not appear.
The Choose a Part dialog box also appears when the user inserts an MvPart (that is, inline valve) into a piece of pipe that requires a joint object for the connection, specifically Flanged and Grooved connections (see Figure 26).

“Slope” is a new feature in AutoCAD MEP 2011 for gravity piping design. Users can select their favorite slope format on the Property Palette when laying out a piping or setting in Pipe Layout Preferences (see Figure 27).
As shown above, the application provides 7 slope formats commonly used for piping design. Figure 28 illustrates the contrast of a piping with a slope of 5 degrees in Top view and Front view respectively.

4.5 Joint Direction

When adding a piping with male-female joints, designers have to consider female connection and male connection, prior to layout. AutoCAD MEP implements a “Joint Direction” tool on the Property Palette for users to alternate the sequences.

Figure 29 shows the differences between two piping layouts that are drawn from Left to Right, and one with Male into Female, another with Female Out to Male joint direction. Notice that female joints in Layout 1 are drawn prior, while Layout 2 is drawn the other way. So the joint direction is not only determined by the joint direction setting on the Property Palette, but is also determined by the drawing direction. Comparing the drawing from Left to Right, even with the same joint direction setting, the layout will be totally different if drawn from Right to Left.
Figure 29  Pipe Joint Direction

4.6  Pipe Lengths

For pipe layout, knowing how much material is required can be helpful from a constructability standpoint. A key benefit of creating an accurate piping layout in AutoCAD MEP is the ability to quickly determine the length of pipe needed.

As per the introduction above, the Connector Engagement Length (CEL) has been considered in the application when connecting pipe and fittings. Therefore, the required pipe length for construction is just the pipe length on the layout that users design. This is much improved over previous versions; the additional work to count in CEL is removed. As shown in Figure 30, the pipe length is shown as “Cut Length” on the Property Palette, while the CEL value of the elbow is the amount of that pipe that goes inside.

Figure 30  Pipe Cut Length with Threaded Connections
4.7 PIPELENGTH Command

AutoCAD MEP includes a PIPELENGTH command that provides the ability to lay out piping systems based on specified pipe lengths. As mentioned earlier, knowing how much material is required can be helpful from a constructability standpoint. By being able to specify a standard length of pipe that is referenced during layout, users can design piping systems that minimize the need to cut a pipe in the field during construction—a potential cost savings that could be significant on projects that require extensive piping.

The PIPELENGTH command can be used to effectively lay out a pipe in two ways: have the pipe “broken” into segments during layout or after the pipe layout is complete. Neither method has a benefit over the other. Let’s take a closer look at both methods.

Assume that a pipe will arrive onsite in 20-foot segments. A design for a long pipe run connected to a single pump needs to be laid out in AutoCAD MEP. Figure 31 shows the steps required to take advantage of the PIPELENGTH command during layout.

![Figure 31 Using Pipe Length command during layout](image)

Figure 31 Using Pipe Length command during layout

Notice that in Figure 31, the selected pipe layout has a cut length equal to 20 feet even though the length of pipe equals "VARIES". The cut length value is accurate for scheduling and aids in quantifying the total amount of pipe required, specifically how many lengths of pipe are required.

This same result, individual pipe segments based on a standard pipe length, can be achieved after the pipe layout is complete. Simply select the pipe to “break” and choose Pipe Length from the context-sensitive menu. The Pipe Length dialog box requires additional information to accurately “break” the pipe (see Figure 32).

- Determine how to cut the pipe—whether to apply the “breaks” to the entire pipe run or just to selected pipe objects.
- Consider which Routing Preference to use—what type of connections to use to join pipe segments together.

Note 8: The PIPELENGTH command can also be used to merge the pipe together to get rid of any joints that are holding two pipes together. This command can be useful if you need to chop up the pipe to different cut lengths.
When using PIPELENGTH to an existing pipe layout, Routing Preferences should be same as the existing one. Otherwise, the coupling which joints pipe segments won’t be consistent with the existing fittings. However, the other existing fittings in the pipe run wouldn’t be replaced.

4.8 Modify Run

Another significant function provided by AutoCAD MEP is “Modify Run” which helps users modify existing piping layout with Routing Preferences, Nominal Diameter, System and Elevation (see Figure 33). The quick way to invoke this function is to type the “ModifyRun” command. The function can be accessed from Ribbon Contextual Tab and right-click menu as well after selecting a pipe or fitting (Transition and those parts that can’t be Autolayout are exclusive).

To better understand this function, let’s first learn what a pipe run is. AutoCAD MEP provides such a function to show a connected run. Select a fitting inside a piping layout and then choose Show
Connected Run on the Ribbon (Command is IdentifyRun); the application will show connected run with hidden lines. Figure 34 illustrates a pipe run (Run1) in a Generic Flanged piping layout.

![Figure 34  Showing Pipe Run in Layout](image)

Notice that Tee is the node to separate a run in piping layout. There will be nothing to highlight if a tee is selected to show a connected run. So there are 5 runs total in this layout, as listed above. In a similar way, Lateral, Wye and Cross will be nodes to separate runs.

The Modify Run is a bit more complicated than the above one. There are several circumstances as below.

- **Modify Routing Preferences or Nominal Size**

If just Routing Preferences or Nominal Size is modified in a piping layout, this will impact nodes. Besides tee, lateral, wye and cross, transition is treated as a node as well (see Figure 35). Select the elbow (E6) before the transition in Run1 and modify Routing Preferences to Generic Threaded. The result which impacts those parts between two nodes (T1 and R1) is in accordance with the above analysis.

![Figure 35  Modify Routing Preferences in Piping Layout (From E6)](image)

If you select the first Tee (T1) and modify Routing Preferences to Generic Threaded, the result will be shown as in Figure 36.
Figure 36  Modify Routing Preferences in Piping Layout (From T1)

- Modify System Definition

If merely System Definition is modified for a piping layout, the whole layout would change (see Figure 37). The piping system changes from Standard to Existing.

Figure 37  Modify System Definition

- Modify Elevation

If only Elevation is modified for a piping layout, the connected pipe and fittings that have the same elevation will update accordingly. The nodes like Tee, Lateral, Wye, Cross and Transition will not break the elevation update (see Figure 38).
Figure 38  Modify Elevation

- Modify Multiple Options

If more than one item is modified, the changes of each option will be combined (see Figure 39). In this piping layout, the Routing Preferences, Nominal Sizes, System Definition and Elevation are changed by selecting the first Tee (T1).

Figure 39  Modify Multiple Options

5  Summary

AutoCAD MEP provides enhanced tools for accelerated production of piping design layouts. You can:

- Find pipe and fittings quickly in an easy-to-navigate pipe catalog.
- Take advantage of Autolayout behavior to efficiently lay out pipe.
- Define Routing Preferences to meet design standards.
- Design gravity pipe with slope.
- Benefit from additional tools such as Pipe Length to help minimize the amount of materials needed during construction.

For more information about AutoCAD MEP, go to www.autodesk.com/buildingsystems