PIPING ISOMETRICS
What is an Isometric Drawing?

- An isometric drawing is a type of pictorial drawing in which three sides of an object can be seen in one view.
- It’s popular within the process piping industry because it can be laid out and drawn with ease and portrays the object in a realistic view.
What is an Isometric Drawing?

- Sometimes it is used in lieu of plans and elevations but typically it is used to supplement the plan drawings.
- Isometrics are used as fabrication & shop drawings for pipe run fabrication.
- Isometrics also provide a drafter with the ability to calculate angular offsets in the pipe run.
**Isometric Layout:**

Isometric lines: one vertical & two at 30° from horizontal

- Isometric lines *can* be measured

- Non-isometric lines: lines NOT parallel to the isometric lines – these lines *cannot* be measured
Isometric Layout:

In the example at left, note that all directions of the pipe match the three isometric axis lines.
Isometrics are rarely drawn to scale

However, pipe lengths should be shown proportionately

Many companies draw isometrics on b-size paper (11” x 17”) which is a limited space so sometimes proportion may be sacrificed

It’s IMPORTANT that the written dimensions are accurate
**ISOMETRIC DRAWINGS - Layout**

**Direction & location:**
- Location and direction help to properly orient the isometric drawing.
- A north arrow gives direction and should ALWAYS point to the upper-right corner of the paper.
- Structural reference points that provide location can be shown on isometric drawings.
- Dimensions MUST always be given to points of reference; such as structures, existing equipment...etc.
- Coordinates should also be shown on the isometric drawing.
FITTING SYMBOLS AND ORIENTATION

- When orienting fittings and valves it’s important to know that there are **good** methods and **poor** methods in this orientation process.

- The *general rule* for producing an isometric using GOOD techniques, is to draw the fittings so they are parallel to the last direction change or branch in the pipe.
Not following the “general rule” leads to a chaotic looking isometric ... it doesn’t look professional.
Fitting Symbols and Orientation

Fittings are drawn the same shape as they appear on the plan & elevation drawings EXCEPT they’re at an isometric angle.

Elbows can be drawn a couple of ways... check with company standards.

Square corner elbows

Curved Elbow Representation
# ISO SYMBOLS – Fittings

<table>
<thead>
<tr>
<th>Image</th>
<th>Fittings</th>
<th>Butt-weld Symbol</th>
<th>Socket Weld Symbol</th>
<th>Threaded Symbol</th>
<th>Fittings</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
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<td><img src="symbol" alt="Elbow 90° Symbol" /></td>
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</table>
ISO SYMBOLS - Flanges

<table>
<thead>
<tr>
<th>Flanges</th>
<th>Welding Neck</th>
<th>Socket Weld</th>
<th>Threaded</th>
<th>Slip-On</th>
<th>Lap-Joint</th>
<th>Blind</th>
<th>Flanges</th>
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</thead>
<tbody>
<tr>
<td>Symbol</td>
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<td>Lap-Joint</td>
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<td>Flanges</td>
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www.seabirdgroups.com
# ISO SYMBOLS – Valves

<table>
<thead>
<tr>
<th>Image</th>
<th>Valves</th>
<th>Butt weld Symbol</th>
<th>Flanged Symbol</th>
<th>Socket or Threaded Symbol</th>
<th>Valves</th>
<th>Image</th>
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<td>Flanged Symbol</td>
<td>Socket or Threaded Symbol</td>
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## ISO SYMBOLS – Special Components

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<thead>
<tr>
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<td>Flanged branch outlet</td>
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## ISO SYMBOLS – Special Components

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<th>Component</th>
<th>Symbol</th>
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<th>Component</th>
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<tr>
<td>Restriction orifice</td>
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<td>Field Weld</td>
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<tr>
<td>Pipe to pipe connection</td>
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<tr>
<td>Pipe bend with special radius</td>
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<td>Direction of hand wheel / wrench</td>
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<td>Conical strainer</td>
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<tr>
<td>Conical strainer built-in</td>
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<td>Orifice assembly (typical) showing position of taps</td>
<td><img src="image7.png" alt="Orifice assembly" /></td>
<td><img src="image8.png" alt="Orifice assembly" /></td>
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<tr>
<td>Meter run, orifice assembly (typical) flanged / butt-weld</td>
<td><img src="image9.png" alt="Meter run" /></td>
<td><img src="image10.png" alt="Meter run" /></td>
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</tbody>
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**Miscellaneous**
Example of double-line method showing existing piping

Dashed line showing pipe continuation and note providing reference drawing information.

Notice spec change between “new” and existing pipe & note for reference drawing.
ISO DRAWINGS – Connected Piping

- One run of pipe per isometric drawing
- Branches of the pipe run or continuations are placed on other drawings ... typically shown as short portion of dashed line on main pipe run
  - Usually a note indicates the name or specification of the branch line
- Existing piping is sometimes shown using double line method or dashed lines

Example of double-line method showing existing piping

Dashed line showing pipe continuation and note providing reference drawing information.

Notice spec change between “new” and existing pipe & note for reference drawing
ISOMETRIC DRAWING TECHNIQUES

To increase drawing efficiency:

- Create a prototype for isometric drawings
  - Set up grid, snap, isometric plane orientation, border and title block, BOM, text styles & dimension settings
- Develop library of isometric symbols
  - Valves, fittings, instruments, equipment... common drawing components
- Create dimension styles in all three isometric planes
- Construct menus that you can pick symbols from
ISOMETRIC DRAWING OFFSETS

? Hatches on isometric drawings being applied, to indicate that a pipe runs at a certain angle and in which direction the pipe runs.

? Sometimes, small changes in the hatch, the routing of a pipe is no longer the east, but for example suddenly to the north.

? Is done with a fitting (typically a 45° elbow)

Types:
- Horizontal Offset
- Vertical Offset
**ISOMETRIC DRAWING OFFSETS**

**Horizontal Offsets:**

If you draw a horizontal pipe with a $45^\circ$ elbow running from southeast to northwest technically correct, it would look like a vertical line... to prevent confusion, the offset is drawn $22\ 1/2^\circ$ from vertical to give the illusion of the angle.
Vertical Offsets:

These offsets can get just as confusing as the horizontal offsets.
ISOMETRIC DRAWING OFFSETS

Squaring-in Plane:

That’s why many companies use a “squaring-in” plane within the plane of the offset
Routing starting point X

? Pipe runs up
? Pipe runs up and to the east
? Pipe runs up
Routing starting point X

?- Pipe runs up
?- Pipe runs up and to the north
?- Pipe runs up
Routing starting point $X$

- Pipe runs up
- Pipe runs up and to the north-west
- Pipe runs to the north
Calculating Isometric Offsets

Although you can “get away” with an educated guess as to making an angular offset easy to see when laying out an isometric, you can’t make a “guess-ti-mate” when it comes to determining pipe lengths and angles.

So, pull out the old calculator, paper, pencil & a BIG eraser and let’s get started.
Calculating Isometric Offsets

Pythagoras, a 6th century B.C. Greek philosopher, came up with a way to deal with calculations involving right angles... and it’s called the... Pythagorean Theorem

Simply, what Pythagoras concluded was that when working with right angle triangles the square of the hypotenuse is equal to the sum of the squares of the two sides.

\[ c^2 = a^2 + b^2 \]
Calculating Isometric Offsets

Start off with what’s given or what you can determine from the pipe drawing itself.

a) We are given an 45° angle rise, that clues us in on the fact that the two sides of our triangle are going to be the same length

b) By doing simple subtraction, we can come up with the length for side B: 200-100 = 100 mm OR you can subtract the elevations given and get the same dimension for side A.

Since B = A: side A = 100 mm as well. So, C = \sqrt{100^2 + 100^2} = 141.21 mm
Calculating Isometric Offsets

“TRIG” function formulas:

There are three basic “trig” function formulas that are frequently used in piping:

Sin = SO/HYP  
Cos = SA/HYP  
Tan = SO/SA

When angle A is used, a is the side opposite (SO) and b is the side adjacent (SA).
When angle B is used, a is the side adjacent (SA) and b is the side opposite (SO).
Calculating Isometric Offsets

“TRIG” function formulas:

Get familiar with the formulas for solving angles and lengths in piping offsets.

<table>
<thead>
<tr>
<th>Known</th>
<th>Required</th>
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<tbody>
<tr>
<td>A, b</td>
<td>( \tan A = \frac{a}{b} )</td>
</tr>
<tr>
<td>a, c</td>
<td>( \sin A = \frac{a}{c} )</td>
</tr>
<tr>
<td>A, a</td>
<td>90° - A</td>
</tr>
<tr>
<td>A, b</td>
<td>90° - A</td>
</tr>
<tr>
<td>A, c</td>
<td>90° - A</td>
</tr>
</tbody>
</table>
ISO DRAWINGS - Dimensions

Basic guidelines for lettering isometric drawings:

- If the pipe’s vertical, the lettering should be written vertically and at 30° angle.

- If pipe is in horizontal plane, the lettering will appear as if it is lying down and will be oriented on both 30° angles.

- Dimensions appear to be lying down if the pipe is horizontal or standing on end if the pipe is vertical.
Solving Compound Angles:

When piping has to be “snaked” through equipment, steel, and other pipe, the pipe may be rolled along with the offset.

This type of piping design is called a rolling offset and forms a compound angle.
Solving Compound Angles:

Four terms associated with a rolling offset configuration:

✓ RUN: Length of total offset in direction of pipe run
✓ SET: Depth of offset
✓ ROLL: Breadth of offset
✓ TRAVEL: True length of pipe through offset
ISO DRAWINGS - Dimensions

Dimensioning Calculations

- Given: A, B, C
  - D = \sqrt{A^2 + B^2 + C^2}
  - \tan \alpha = \frac{A}{B}
  - \tan \beta = \frac{B}{C}
  - \sin \gamma = \frac{C}{\sqrt{A^2 + B^2}}

- Given: A, B, \gamma
  - C = \sqrt{(B \tan \gamma)^2 - A^2}
  - D = \frac{B}{\cos \gamma}
  - \sin \alpha = \frac{C}{\sqrt{A^2 + B^2}}

- Given: A, B, \alpha
  - C = \frac{\sqrt{A^2 + B^2}}{\tan \alpha}
  - D = \frac{\sqrt{A^2 + B^2}}{\sin \alpha}
  - \cos \gamma = \frac{B \sin \alpha}{\sqrt{A^2 + B^2}}

- Given: A, C, \gamma
  - B = \sqrt{(C \tan \gamma)^2 - A^2}
  - D = \frac{C}{\cos \gamma}
  - \sin \alpha = \frac{C \sin \gamma}{\sqrt{A^2 + C^2}}

- Given: B, C, \alpha
  - A = \sqrt{(B \tan \alpha)^2 - C^2}
  - D = \frac{B}{\cos \gamma}
  - \tan \beta = \frac{B}{\sqrt{A^2 + B^2}}

- Given: B, C, \gamma
  - A = \sqrt{(B \tan \gamma)^2 - C^2}
  - D = \frac{B}{\cos \gamma}
  - \tan \beta = \frac{B}{\sqrt{A^2 + B^2}}

- When \alpha = 45°
  - A = \sqrt{(B \tan \alpha)^2 - C^2}
  - D = \frac{B}{\cos \alpha}
  - \cos \gamma = \frac{B \cos \alpha}{C}

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DIMENSIONING PRACTICES:

1. Best way to dimension a pipe is to its centerline at the intersection point

2. Try to keep all dimensions outside the piping view when possible

3. Dimensions should ALWAYS be shown between points in the same plane

4. One of the extension lines of the dimension should be a centerline of the run of pipe

5. Vertical lines of text should always be parallel with extension lines
ISO Vs ORTHOGRAPHIC

The image on the right shows a isometric view of the same pipe as here on the left.

The red lines show the pipe, the black dots are the butt welds and A, B & C are the dimensions of front to center line and center line to center line.
ISO Vs ORTHOGRAPHIC

? Simplicity (Only one line drawn to represent a pipe)

? In a orthographic view it is not a problem if the pipe runs in one plane, but when a pipe in two or three planes (north to south, then down and then to the west, etc.) to be drawn, a orthographic view can be unclear.

? More number of drawings needed in orthographic views than ISO to represent the same piping system.

? For example: for a complex pipeline system, 15 isometrics must be drawn. But in orthographic views maybe 50 drawings are needed to show the same as the ISO's.
ISOMETRIC Vs PLAN Vs ELEVATION
Routing starting point X
- Pipe runs to the east
- Pipe runs up
- Pipe runs to the north
- Pipe runs to the west
- Pipe runs down
Routing starting point X
- Pipe runs to the south
- Pipe runs up
- Pipe runs to the west
- Pipe runs to the north
- Pipe runs down
Routing starting point X
- Pipe runs to the south
- Pipe runs up
- Pipe runs up and to the west
- Pipe runs up
- Pipe runs to the west
- Pipe runs to the north-west
- Pipe runs to the north
Routing starting point X
- Pipe runs to the south
- Pipe runs up
- Pipe runs up and to the north-west
- Pipe runs to the north