



Hydronic Flow and Energy Metering: Best Practices for Selecting and Installing the ***RIGHT*** Metering Technology

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- ☐ The webinar will start promptly at 1:00 pm EDT (Boston time) and is scheduled to last sixty (60) minutes; including time for questions.
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Upcoming IDEA Conferences





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Today's Agenda

- Why Measure Flow?
- Flow Measurement Basics
- Flow Meter Technologies
- Installation Best Practices
- Serial Communications
- Questions

Why Measure Flow?

What's Driving the Need to Measure Flow in Today's HVAC Applications?



Recent Trends in the HVAC Industry

Driving the Need for Flow Measurement

- ASHRAE Standards
- Serves as the Basis for LEED Advanced Metering Credits
- Energy Service Contracts – Performance Verification
- Required for the Implementation of Complex Control -Strategies and Plant Optimization
- Provides the Basis for Meeting Sustainability and Energy Conservation Goals
- Provides the Basis for Billing and Cost Allocation in Multi-Tenant Buildings
- Identifies the “Energy Hogs”

Why Do We Need a Flow Meter?

How does buying a flow meter save energy?

Consider the scale....

The act of purchasing a scale won't reduce your weight, but....

Would you begin a weight loss program without first establishing a baseline and having the ability to measure progress?



Applications – Campus Environment & Mixed Use Buildings

Accurate Flow & Energy Measurement Provides:

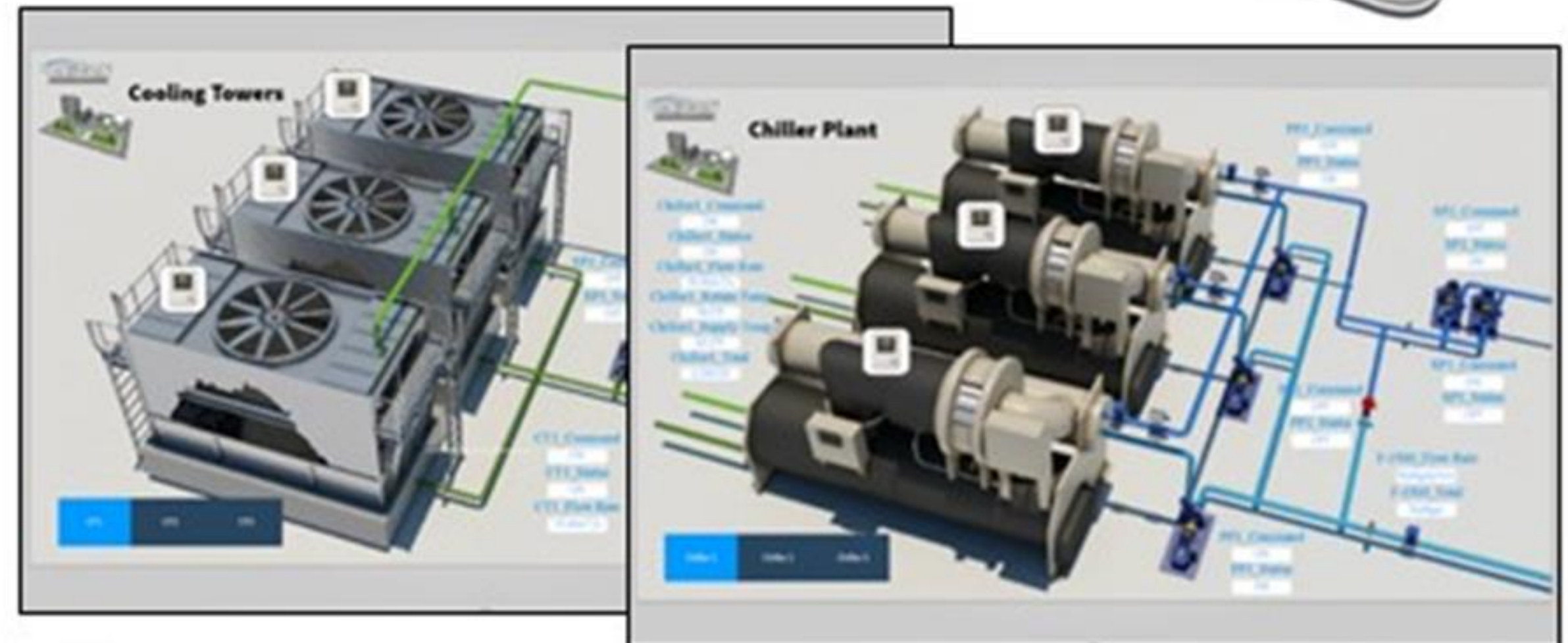
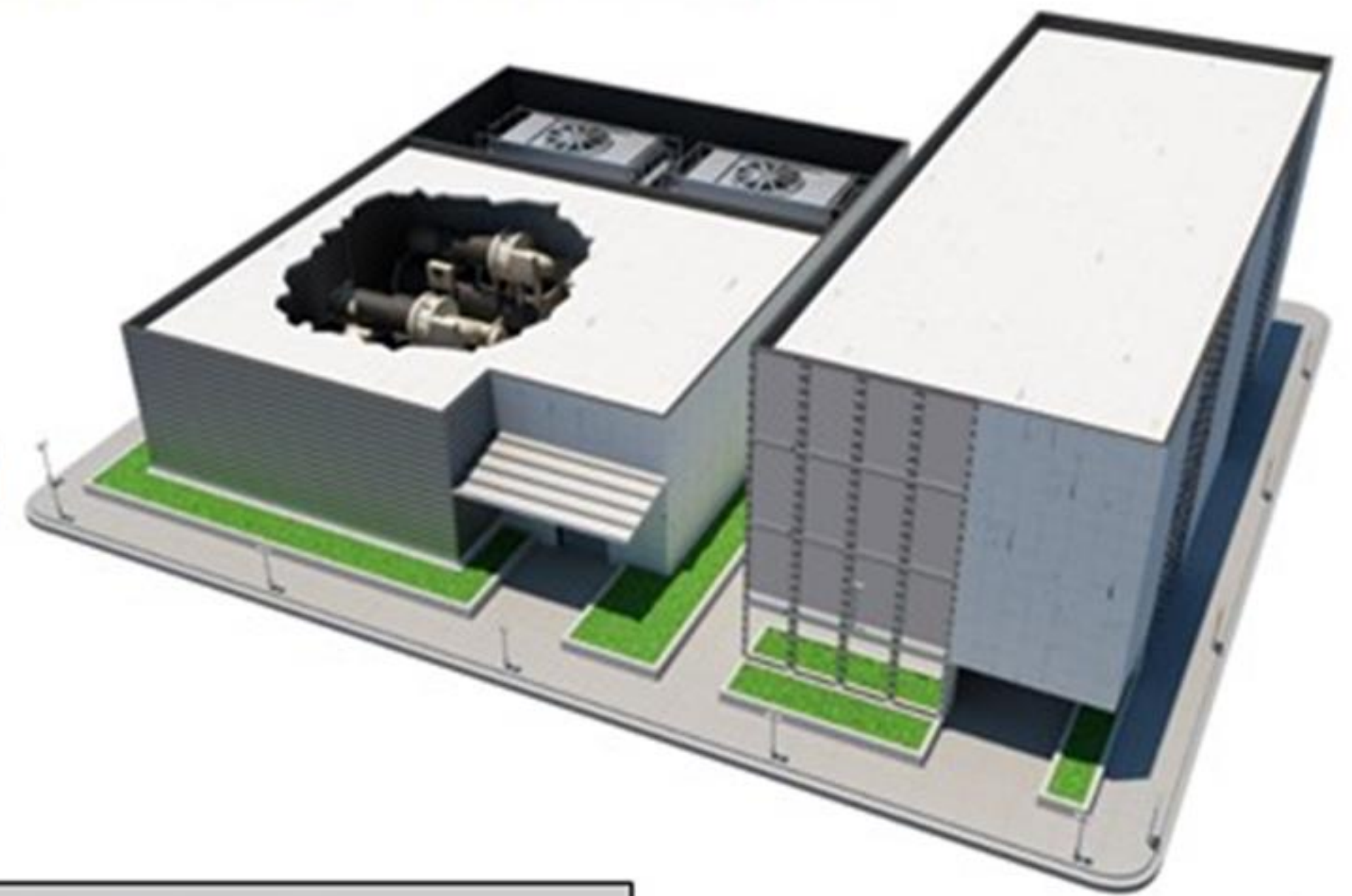
- Basis for cost allocation
- Growth planning
- Real-time commissioning and balancing data
- Basis for LEED® points
- Promotes conservation



Applications – CEP/Utility Buildings

Accurate Flow & Energy Measurement Provides:

- Information required for complex CEP optimization sequences
- Base-Line operational information - required for growth planning
- Real-time commissioning and balancing data
- Basis for LEED® points



Flow Meter Basics

What is actually being measured by the meter?

- Volume (gallons, cubic feet, etc.)
- Velocity (feet/sec, feet/min, meters/sec.)
- Mass (lb/hr, kg/hr)

Volumetric Flow Rate = Average Velocity x Internal Area

$$\text{GPM (gal / min)} = V \text{ (ft/s)} \times A \text{ (in}^2\text{)} \times (60 \text{ s/min}) \times (12 \text{ in/ft}) \times (\text{gal}/231 \text{ in}^3)$$

$$\text{GPM} = V \text{ (ft/s)} \times A \text{ (in}^2\text{)} \times (3.12)$$

Hydronic Cooling/Heating System

Hydronic Heat Load Calculation:

Energy (BTU) Rate =

Flow Rate x Density x Specific Heat x Delta-T (Sup. – Ret. Temp)

For most HVAC Applications, the equation simplifies to:

Energy Rate in BTU/Hr = GPM X Delta-T X 500



Typical Flow Meter Configurations

Full Bore (Inline) Flow Meter (Velocity)

A “full bore” or “inline” type flow meter occupies an entire section of pipe. All flow must go through it.



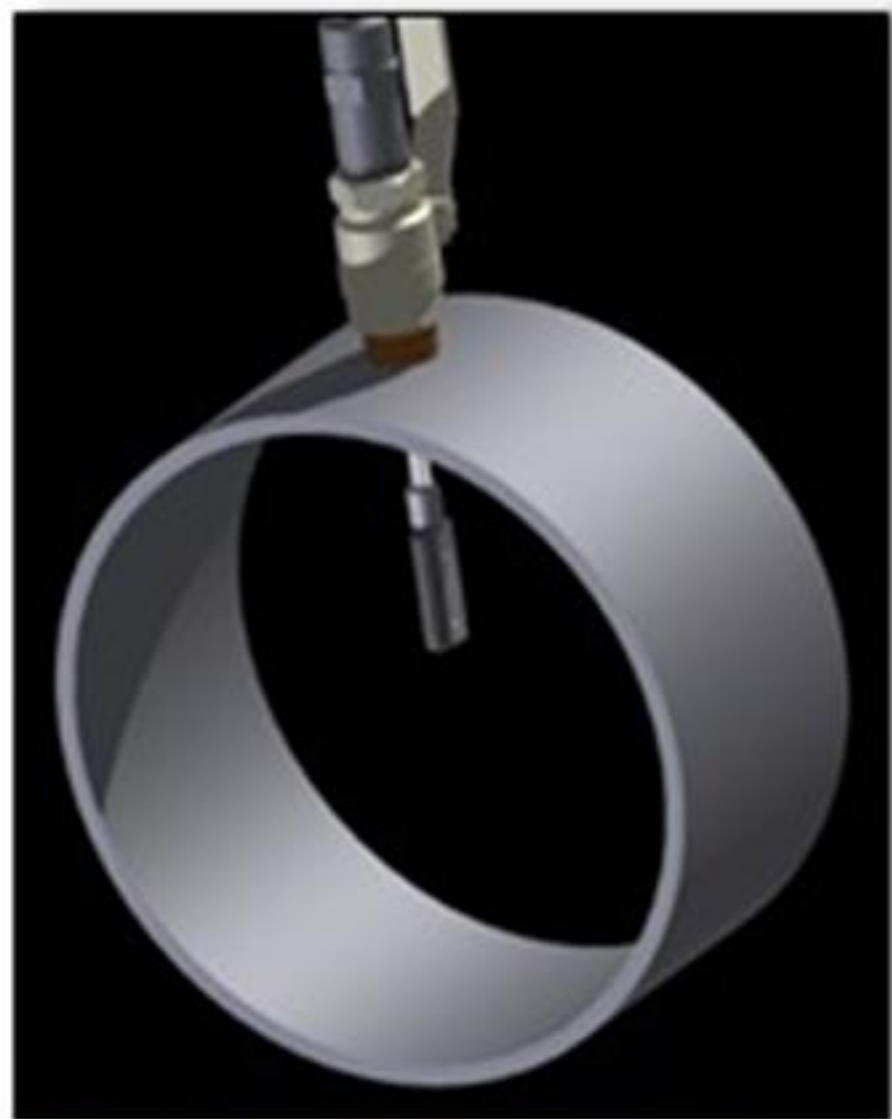
Basic Features:

- Controlled measurement area equals high accuracy.
- Cost increases with size.
- Installation, service, or calibration requires shutdown or bypass.

Typical Flow Meter Configurations

Insertion Style Flow Meter (Velocity)

An “insertion” type flow meter measures flow velocity at a specific point or several points inside the pipe.



Basic Features:

- Price is independent of pipe size.
- Hot tap capability allows installation, service, and calibration without shutdown or bypass.
- *Requires Adequate Straight Run to Achieve Accurate Results!*



Typical Flow Meter Configurations

Clamp-on Style Flow Meter (Velocity)

A “clamp-on” style flow meter is non-invasive and measures flow velocity along a specific pathway inside the pipe via ultrasonic sound waves (Doppler effect or transit-time differential).

Basic Features:

- Accuracy depends on proper installation.
- Ideal for test and balance work.
- Price is independent of line size.
- *Perceived* easy installation.



Definitions and Relationships

Accuracy

The ability of an instrument to make the measurement as referenced to a standard



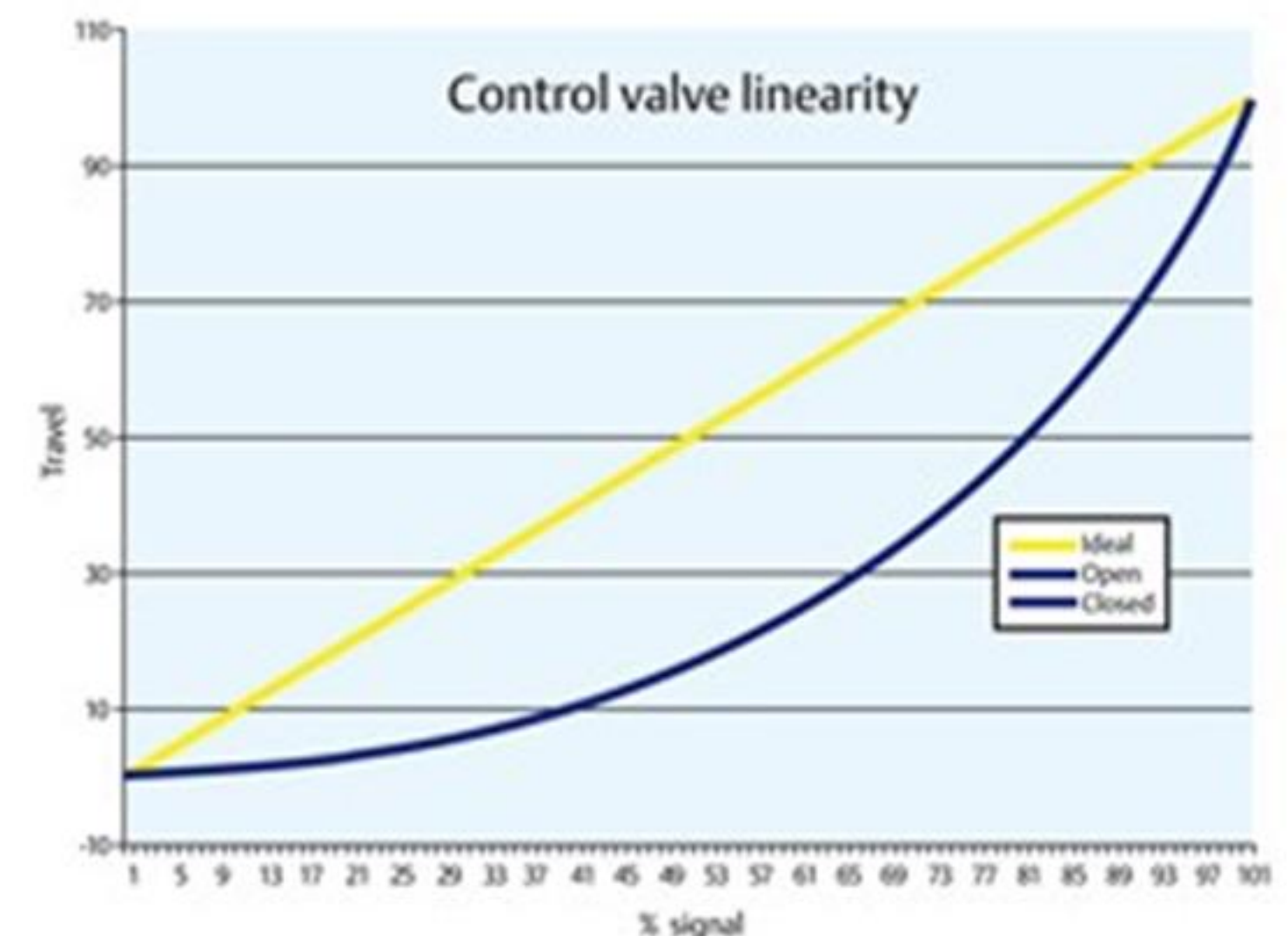
Repeatability

The deviation of multiple measurements of the same quantity under the same conditions - Not a measure of absolute accuracy.



Linearity

The amount of departure of the calibration curve from a straight line - Not a measure of absolute accuracy.



Definitions and Relationships

Turndown – The higher the better, right?

The instrument range specified as a ratio of high measured value to low measured value

Effective Turndown – This is where the money is!

The instrument range as related to the maximum flow of the specific application

Example: 1-30 ft/s range = 30:1 turndown (as published)

Application max flow at 4 ft/s = 4:1 effective turndown

Accuracy Statements

A valid accuracy statement consists of three components:

- % uncertainty
- Reference (% of what? "reading" or "rate," "full scale")
- Range over which the accuracy is specified

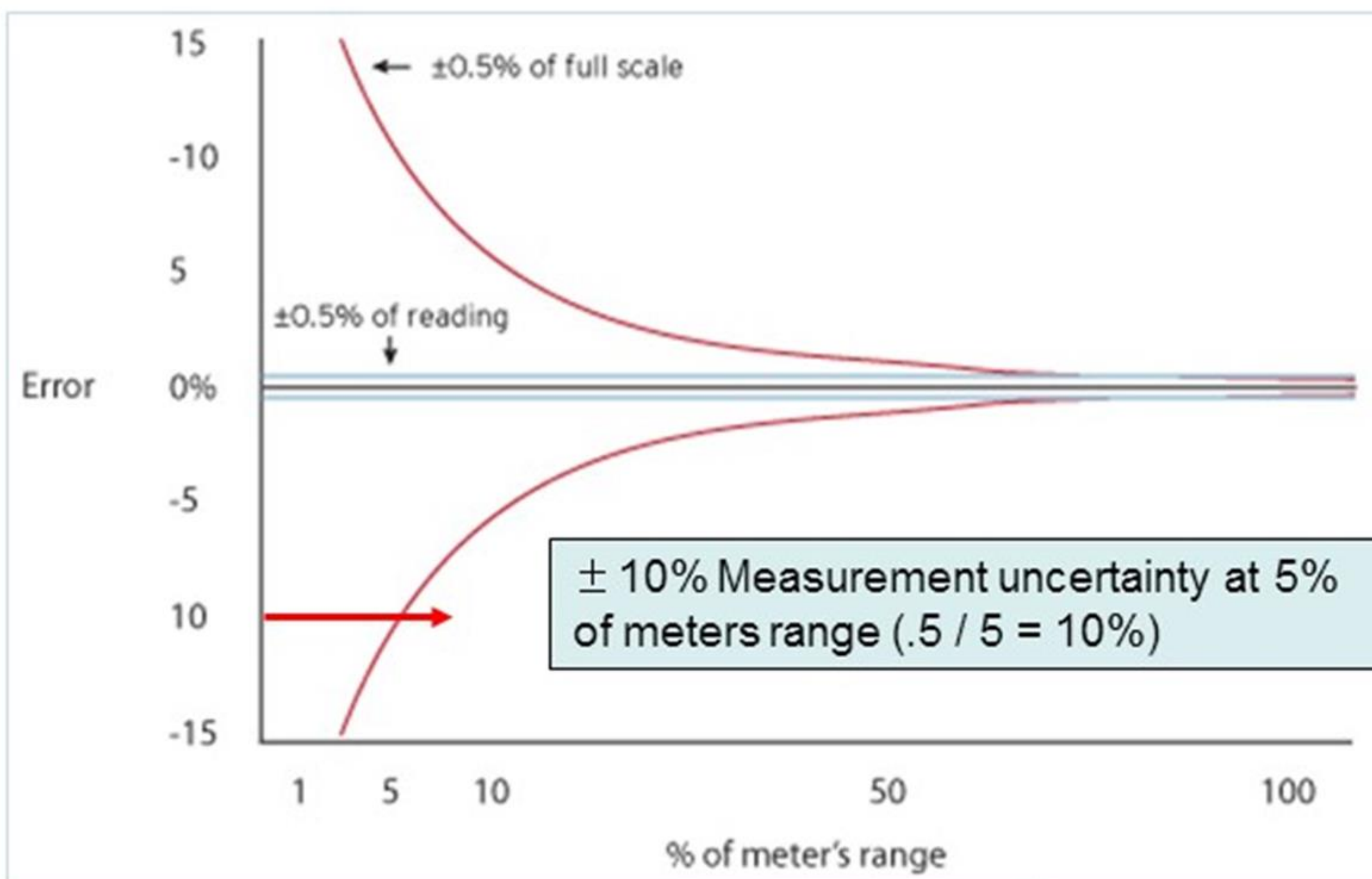
An accuracy statement is meaningless without all three components.

If the statement is incomplete or components are stated separately, you must assume the worst case.

Accuracy Statements

% of reading (or rate):

Measurement is **within** the stated percent of uncertainty throughout the stated range. $\pm 0.5\%$ of Reading Accuracy from 1:100



% of full scale:

Fixed quantity of uncertainty regardless of the flow rate; % uncertainty will change throughout the range.

$\pm 0.5\%$ of Full Scale Accuracy at 100

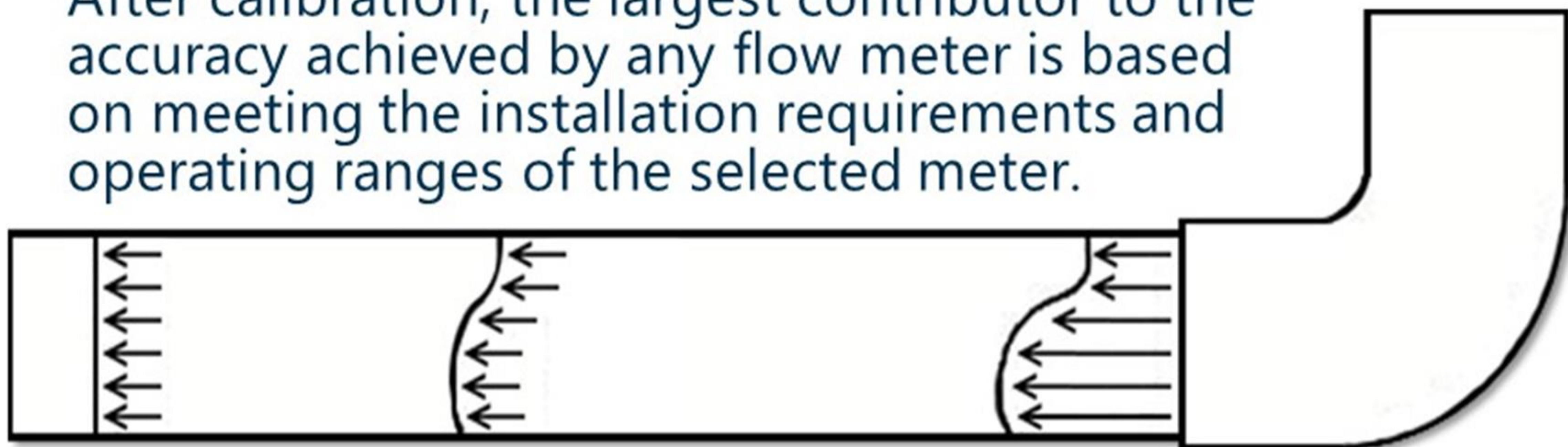
Calibration Method Matters

The calibration method ultimately determines the accuracy a flow meter can achieve. Wet calibrations are the most accurate.



Accuracy and Installation

After calibration, the largest contributor to the accuracy achieved by any flow meter is based on meeting the installation requirements and operating ranges of the selected meter.



- Velocity profile is distorted by pipe obstructions and flow direction changes.
- Friction from the pipe wall "conditions" the velocity profile, eventually flattening the profile (based on velocity and viscosity typically found in HVAC applications).

Straight Pipe Run Requirements

Minimum upstream dimensions depend on the type of pipe obstruction.

AVOID THESE:

- Control Valve
- Inflowing Tees
- Multiple Bends Out of Plane
- Multiple Bends In Plane

THESE ARE WORKABLE:

- Outflowing Tees
- Pipe Reduction or Enlargement
- Single Bend

IDEAL:

- Straight Pipe

Straight Pipe Run Requirements

A flow meter manufacturer's dream?
Literally miles and miles of straight run!!!

A flow meter manufacturer's reality!
With some planning, most plants have the straight run required to achieve accurate results.



Choosing the Right Flow Meter

**Reliability /
Water Quality**

**Straight
Pipe Run**

**Required System
Shut-down?**

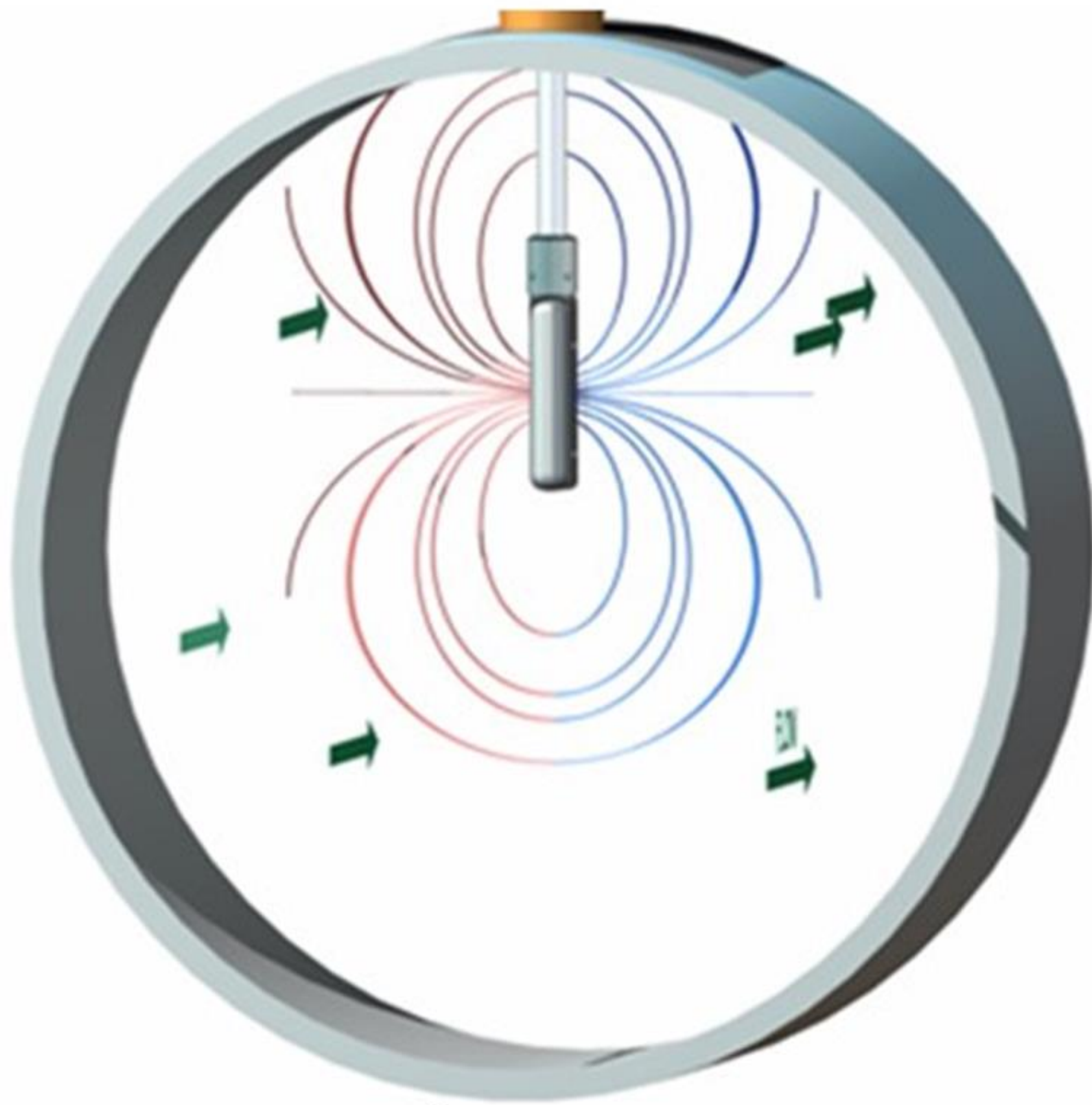
Cost

**Temperature /
Pressure**

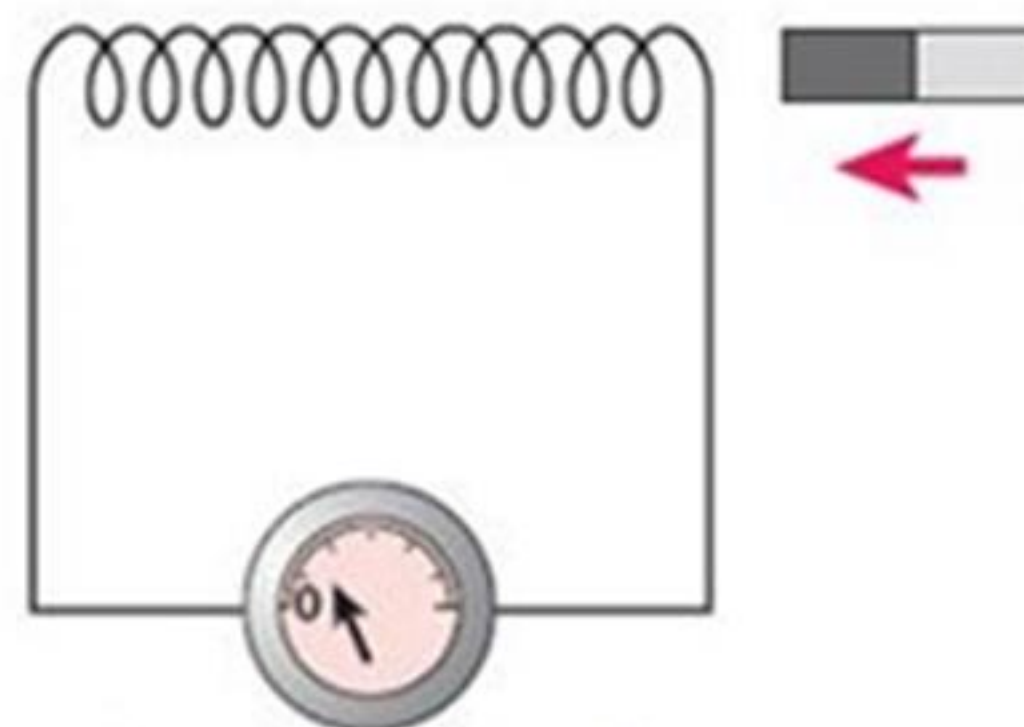
**Required Accuracy /
Turndown**

Pipe Size

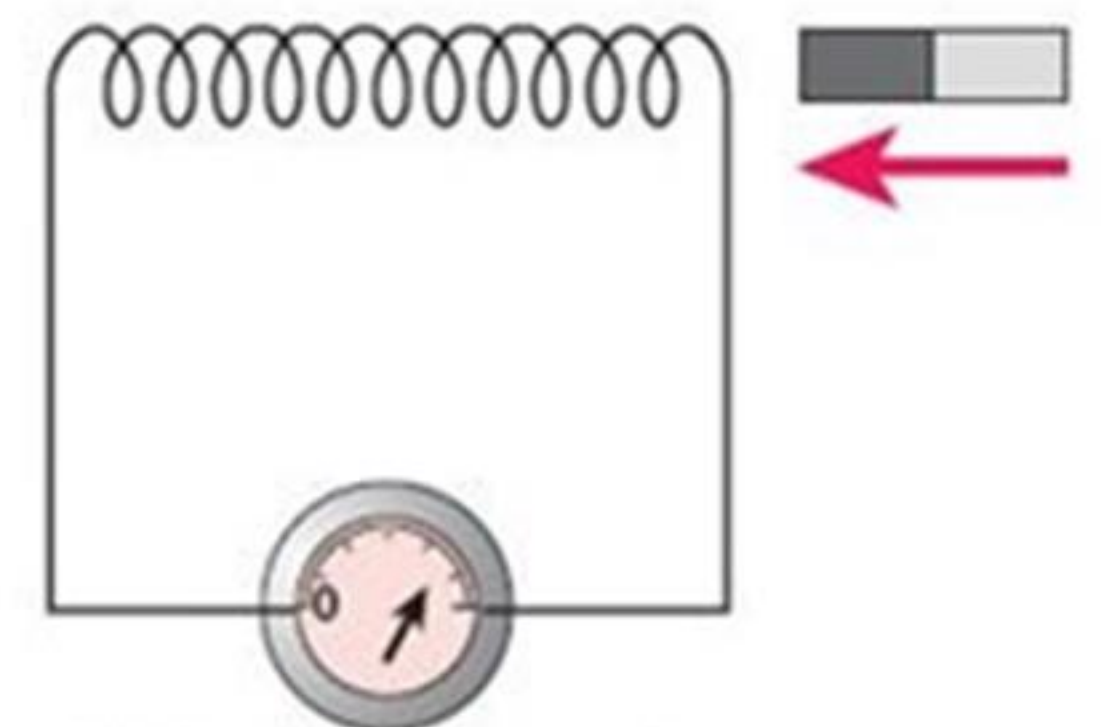
Insertion Electromagnetic Flow Meter (Magmeter)



Faraday's Law of Induction



slow movement
produces a small e.m.f.



faster movement
produces a bigger e.m.f.

Insertion Style Electromagnetic Flow Meter



Multiple Pipe Size
Insertion Magmeter

- Easy to install, immersion style sensor.
- Can be hot tapped into a live and pressurized system
- Now suitable for line sizes from 1.25" to 72"
- No moving parts
- High accuracy over wide turndown
- Best overall value in open loop, conductive fluid systems.

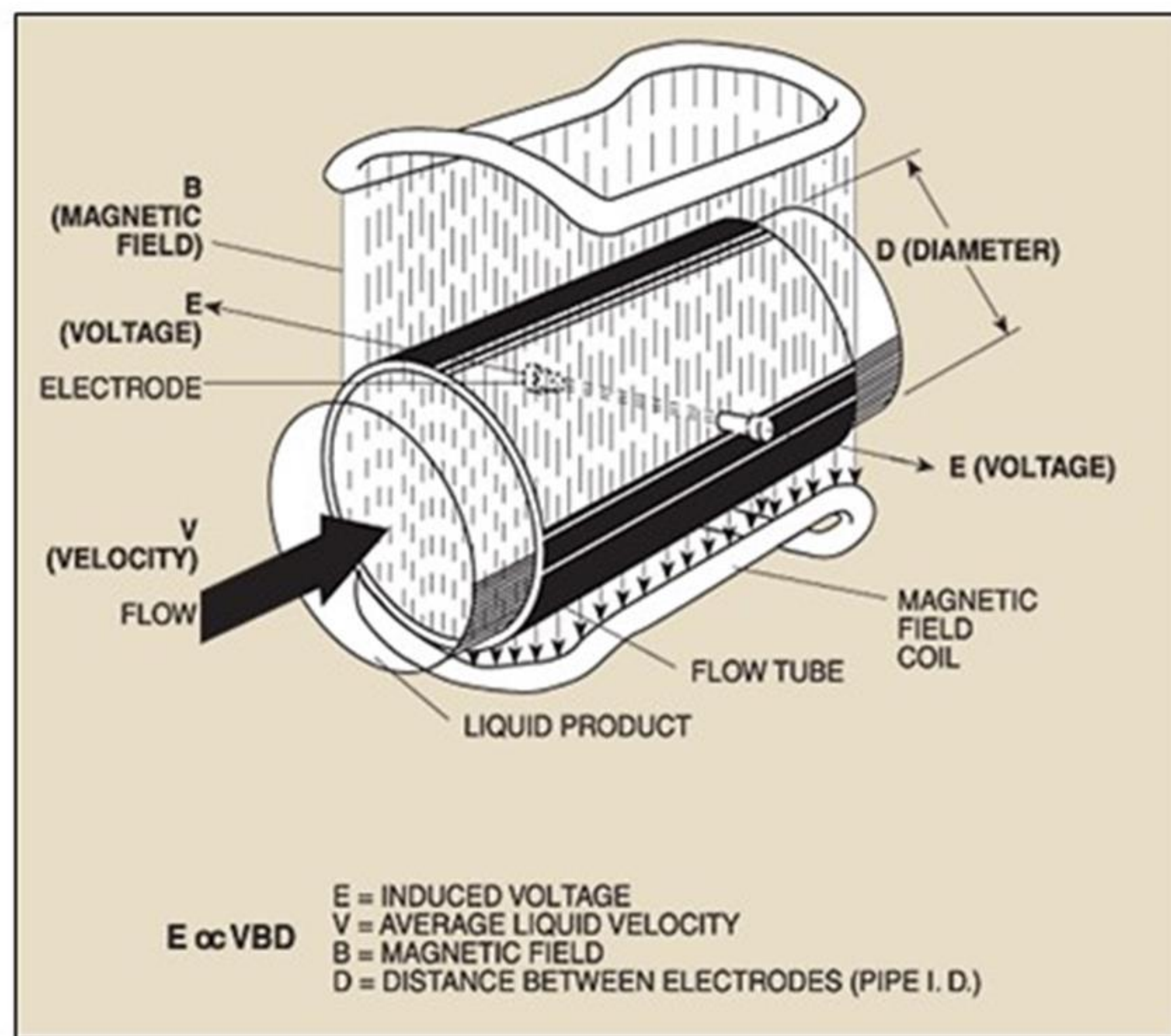


Fixed Pipe Size
Insertion Magmeter

Inline (Full Bore) Style Electromagnetic Flow Meter (Magmeter)



- Highest accuracy & reliability
- Shortest straight pipe run requirements
- Installation requires shutdown and drain
- Suitable for use in most hydronic HVAC systems.



Accurate measurement depends on the generation of a uniform magnetic field.

Axial Turbine Insertion Style Flow Meter

- Simple to install, one-piece design
- Can be hot tapped into a live, pressurized system
- Easily removed for service and recalibration
- Wet calibrated versions have a high accuracy over a wide turndown
- Best overall value in clean closed loop systems



Dual Insertion Turbine
Flow Meter



FLOW →



True Axial Turbine – Shaft is
parallel with flow direction

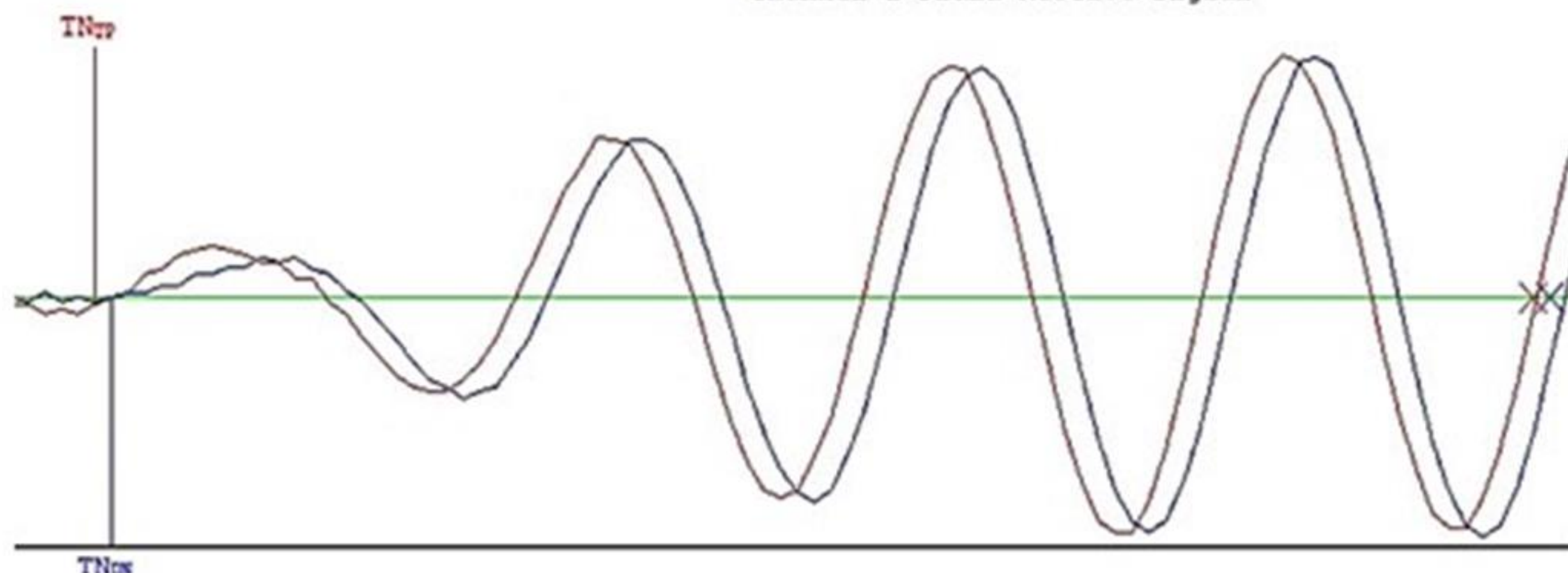
Clamp-on Style Ultrasonic Flow Meter

- High accuracy & turndown
- Measures bi-directional flow
- Non-invasive design - can be installed without shutting down or tapping the line



Transit Time Transducers

Channel 1 Fluid Receive Signal



By measuring the difference between transit times of ultrasonic waves traveling between two transducers, the flow velocity of the fluid in the pipe can be accurately determined.



Inline Wetted Ultrasonic Style Flow Meter

- High accuracy & turndown
- Non-moving parts construction provides long service life
- Ultrasonic technology is impervious to water quality issues
- Inline body conditions the flow, eliminating straight run requirements for most of the common piping configurations



Two direct beam, wetted ultrasonic transducers are utilized to determine the flow velocity in an inline body by measuring the difference in transit time between the ultrasonic signals.

Dedicated BTU Measurement System



- Dedicated Hydronic energy (BTU) measurement system
- Easily interfaced with common building automation protocols
- Best choice for accurate Hydronic energy measurement, provided:
 - Temperature sensors are matched over range
 - Flow Meter is wet calibrated
 - Provides serial communication

Grading Technologies

Metering Technology

		Turbine	Electromagnetic	Clamp On Ultrasonic	Vortex Shedding	Thermal Dispersion	Venturi / Differential Pressure	Positive Displacement
Applications	Closed Loop Chilled Water	A	A	B	NR	NA	D	D
	Closed Loop Hot Water Heating < 200°F	A	A	B	NR	NA	D	D
	Closed Loop Condenser Water	A	A	B	NR	NA	D	D
	Closed Loop GeoThermal Water	A	A	B	NR	NA	D	D
	Closed Loop Solar Hot Water	A	B	B	NR	NA	D	B
	Closed Loop High Temperature Heating Water > 200°F	B	C	A	B	NA	D	D
	Closed Loop Pumped Steam Condensate	B	B	B	C	NA	D	A
	Closed Loop Boiler Feed Water	C	C	B	B	NA	D	D
	Open Loop Condenser Water	D	A	B	NR	NA	D	D
	Open Loop Geothermal Water	D	A	B	NR	NA	D	D
	Open Loop Well, Pond, Pool, Water	D	B	B	D	NA	D	D
	Open Loop Cooling Tower Blow Down Water	D	A	B	D	NA	D	D
	Sea Water	B	A	B	D	NA	D	C
	Domestic Water, Potable Systems	C	A	B	NR	NA	D	A
	Domestic Hot Water	C	A	B	NR	NA	D	A
	Domestic Make Up Water	A	A	B	NR	NA	D	A
	Steam	C	NA	NA	A	NA	C	NA
	Natural Gas, Non Utility Metering	B	NA	NR	C	A	C	B

Types of Installations

Insertion



(Fixed Pipe Size Insertion)

Clamp-On



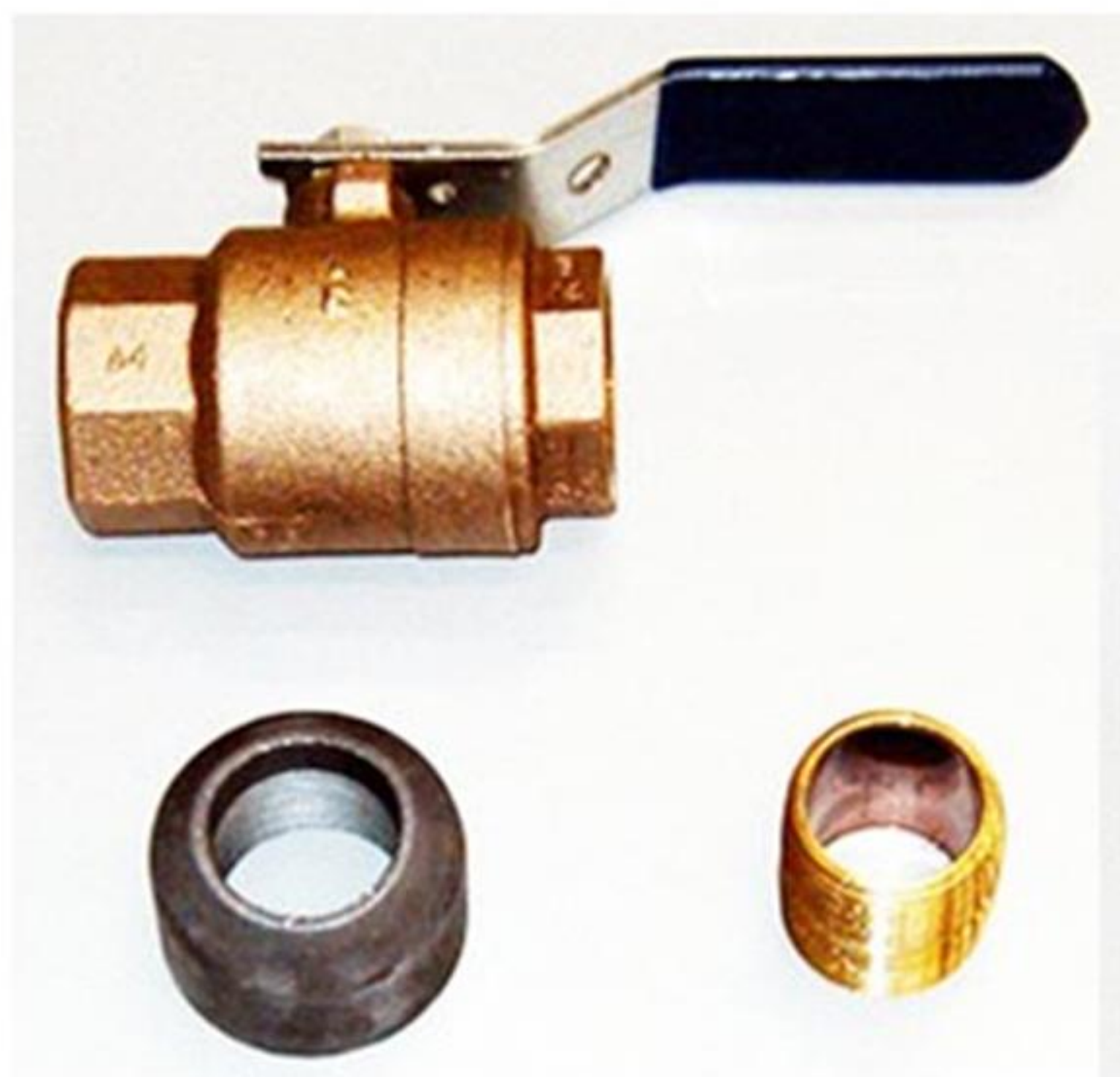
Inline



Installation Best Practices

Insertion Style Meters

Installation Hardware Depends on Pipe Material and Application



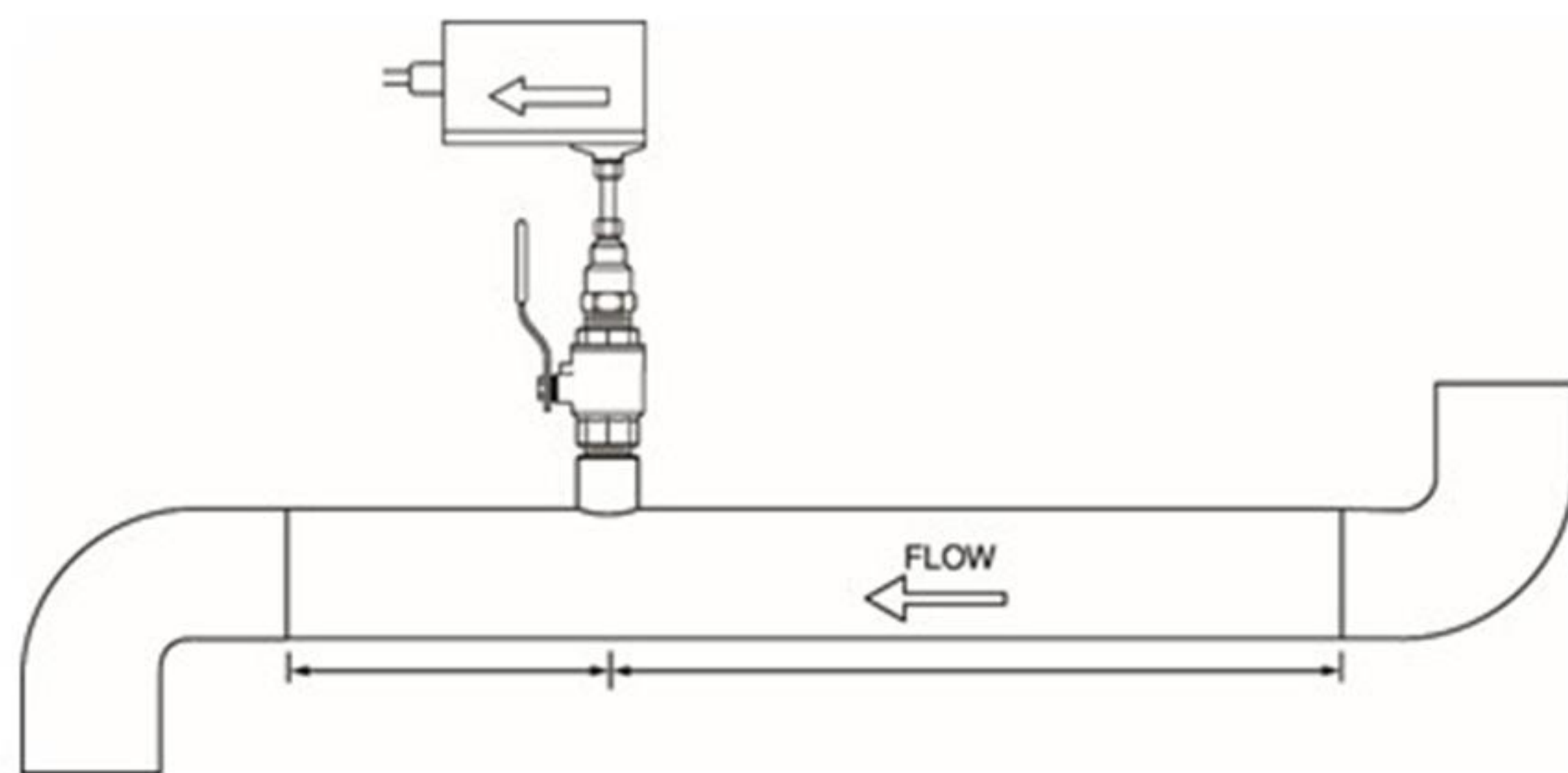
Note: Make sure the kit provided meets the installation requirements.

Saddles may fit on a given pipe size, but may not meet the system pressure required!

Installation Best Practices

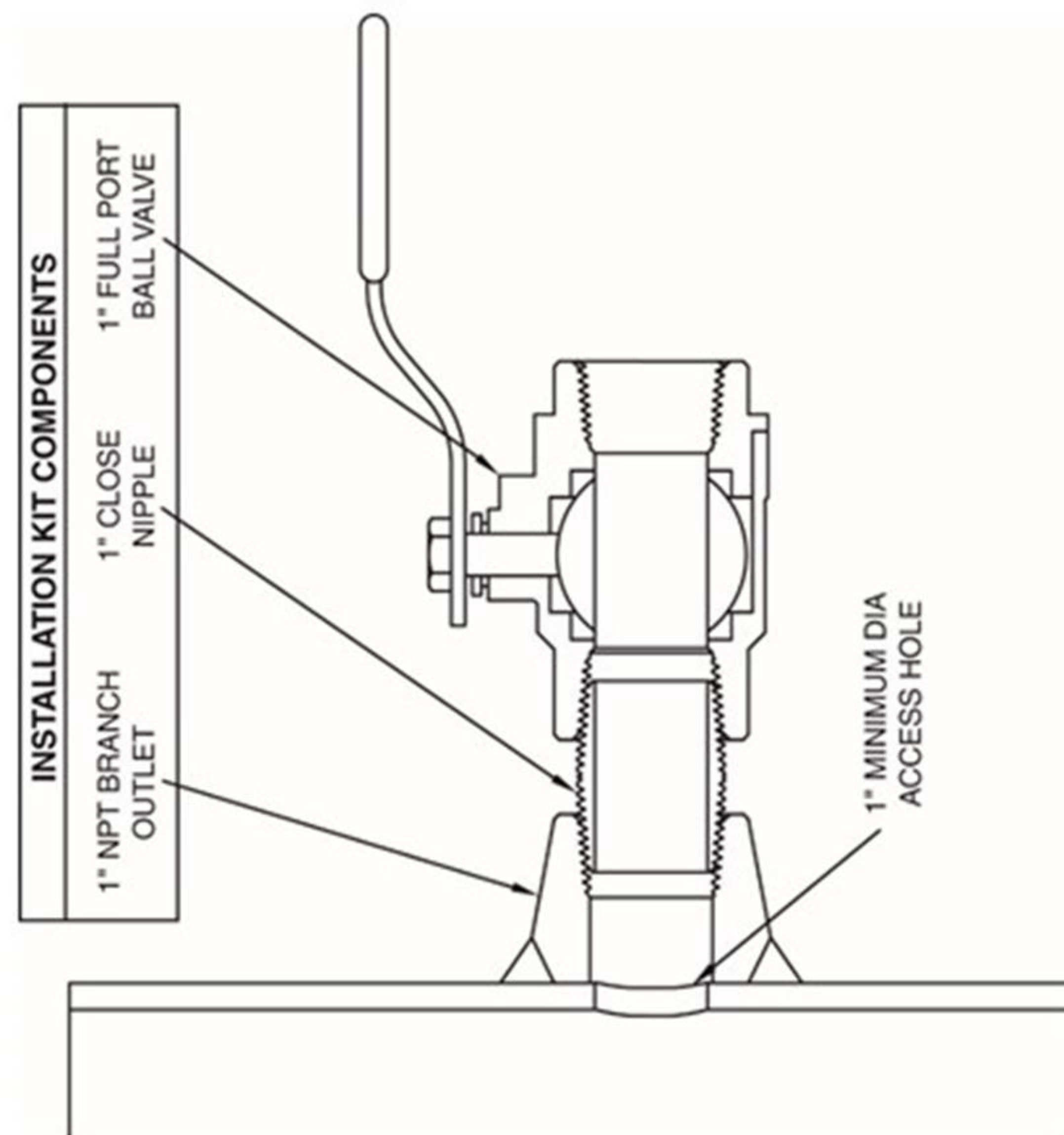
Insertion Style Meters

Installation Kit Hardware



Complete Installation Kit Includes:

- Isolation Valve
- Process Connection Fitting
- Transition Components / Fittings



Installation Best Practices

Clamp-on Style Meters

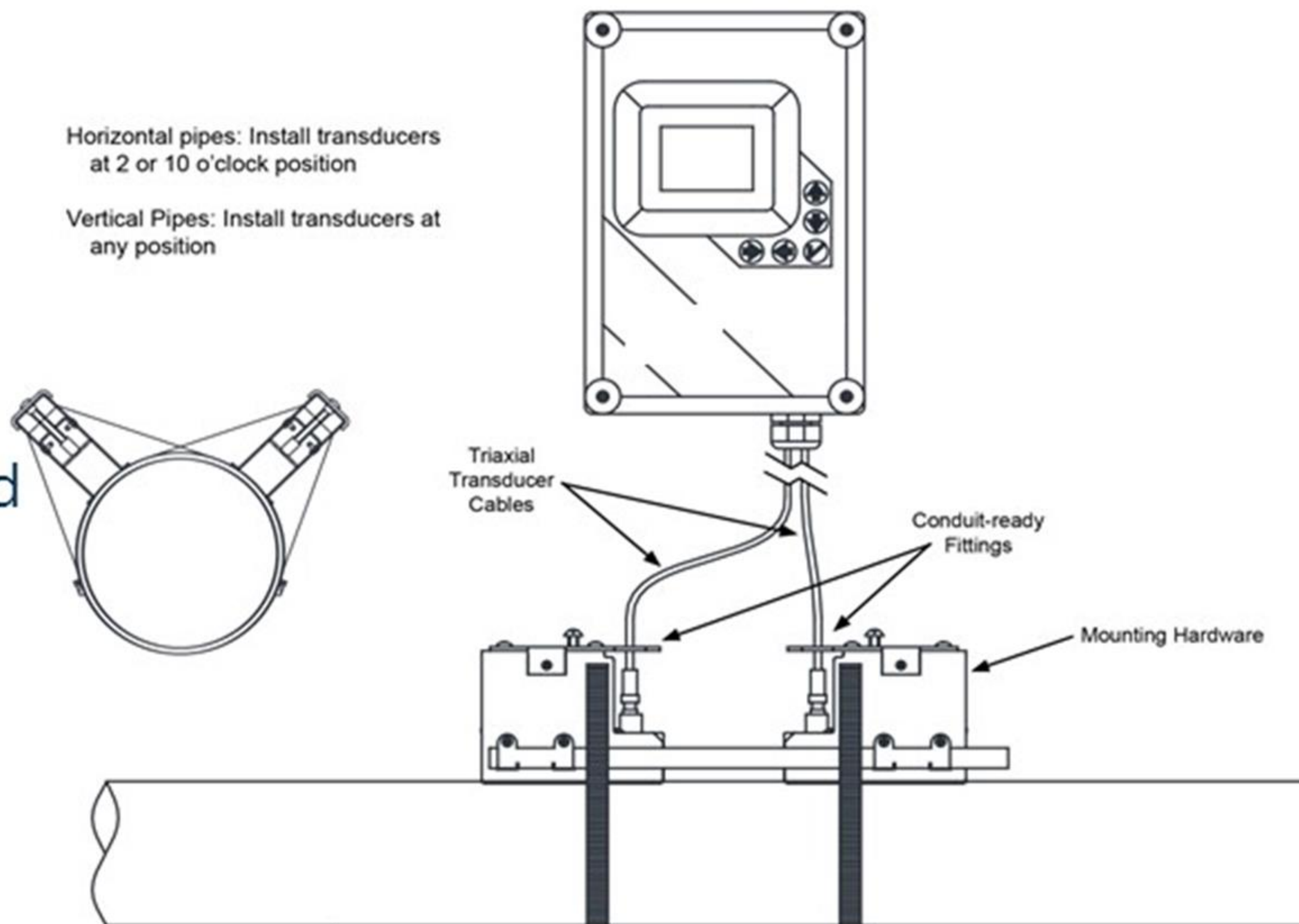
Carefully Follow Instructions

Complete Installation Kit Includes:

- Transducer Mounting Bracket(s)
- Clamping System
- Ultrasonic Couplant or Pad

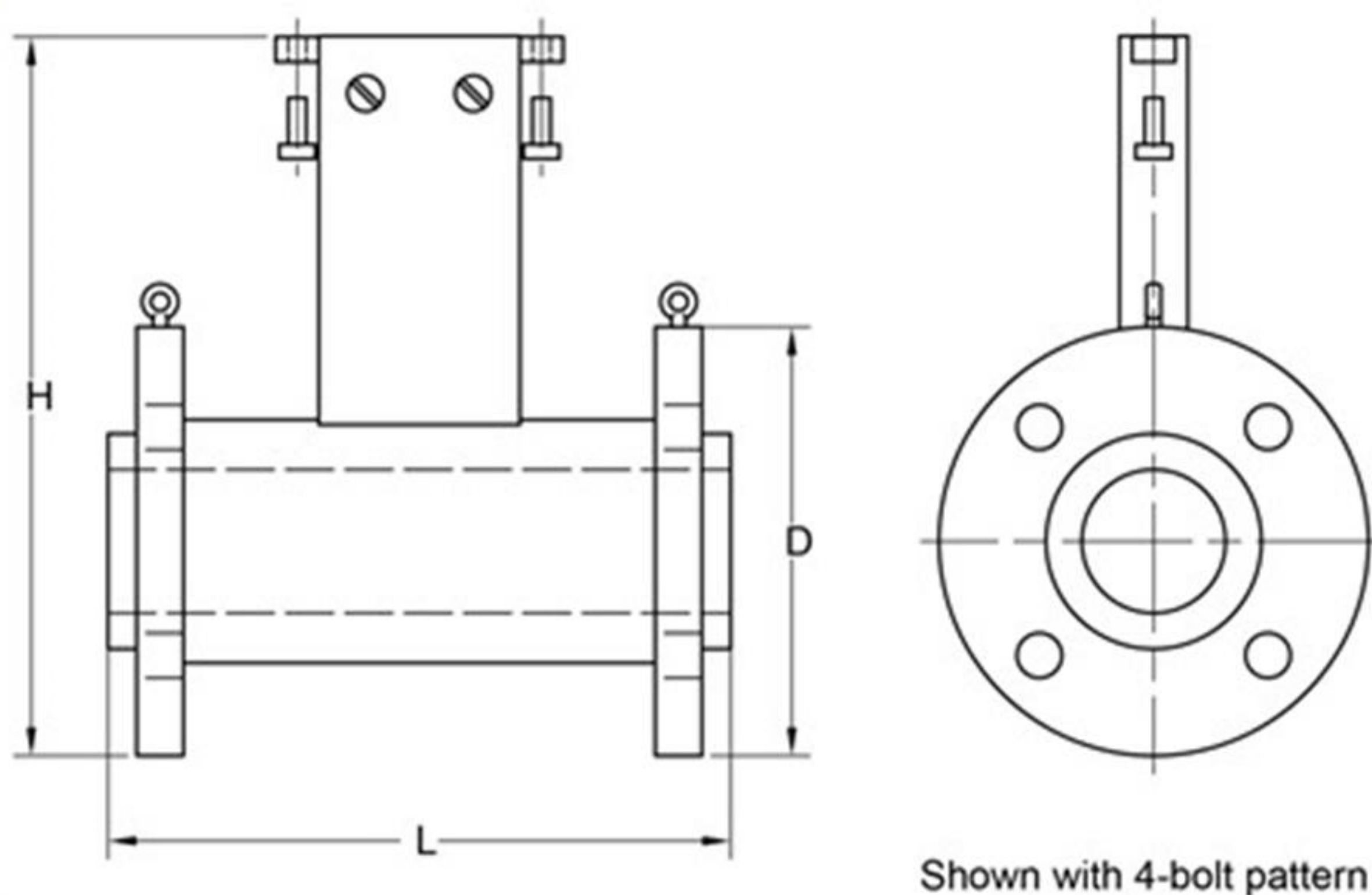
Note: Be careful of "Zero Maintenance" claims regarding Clamp-On transducers.

Changes occurring at the pipe wall and transducer interface, expansion / contraction, rust and scaling, may require periodic reseating of the transducers.



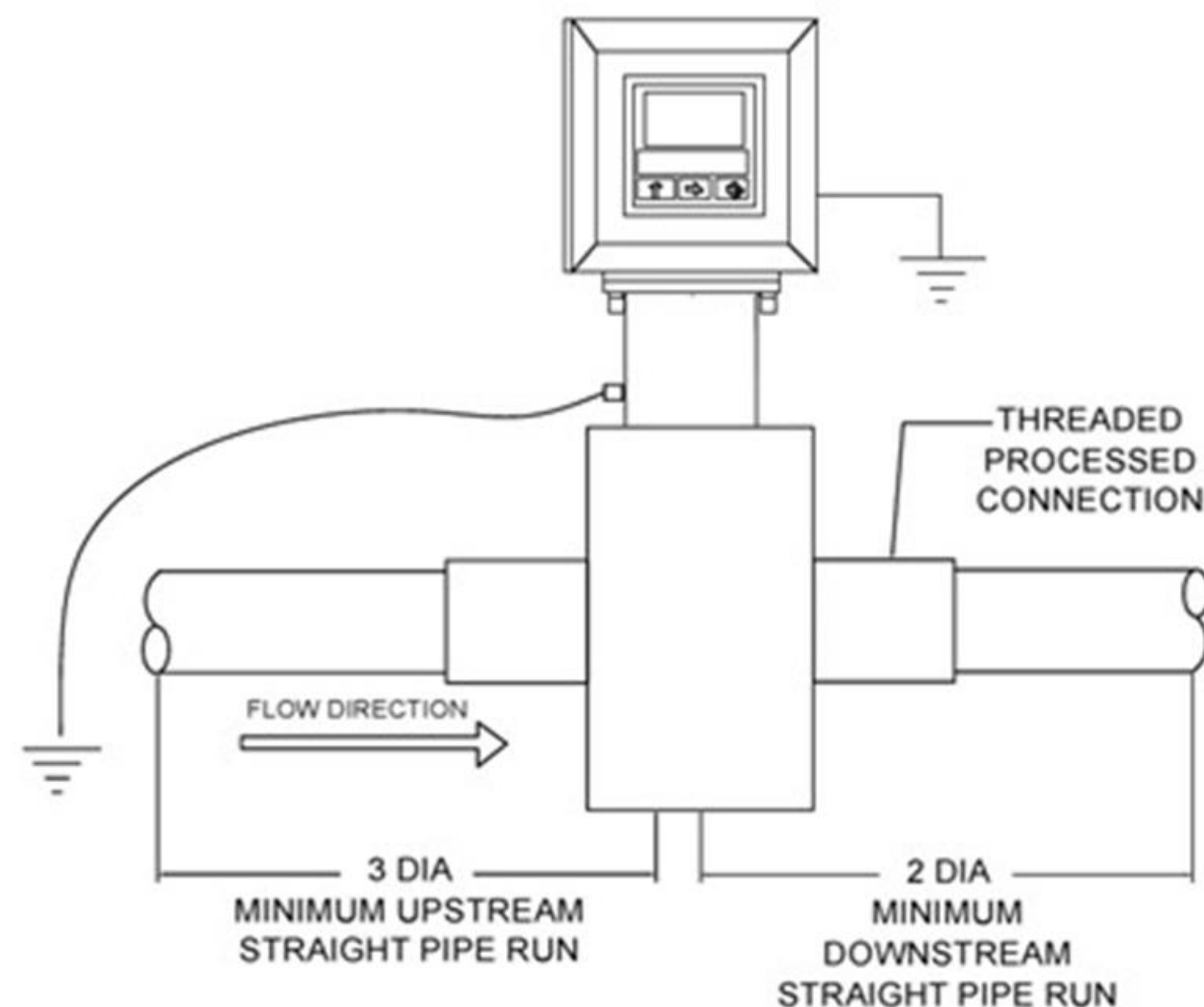
Installation Best Practices

Inline Style Meters (Flanged or NPT)



Note: Confirm the flange rating matches the system rating, Class 150 and Class 300 flanges cannot be interchanged.

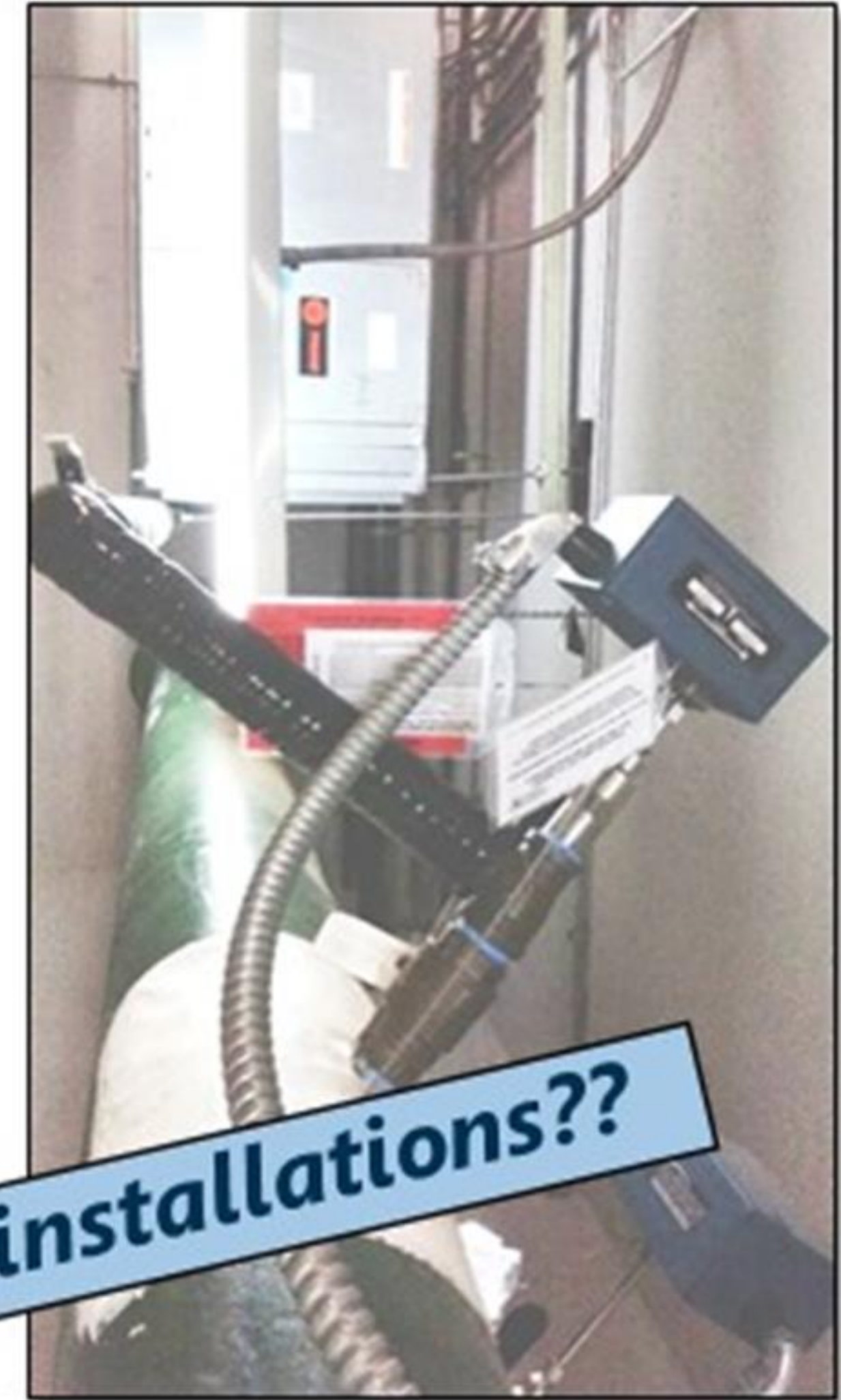
Make sure the right gasket is used based on system pressure and fluid type.



Note: Threaded systems may require union fittings in order to allow for future meter removal. Fitting selection may impact straight run requirements.

Common Mistakes When Installing Flow Meters

DON'Ts



Can you find what's wrong with these installations??

Common Mistakes When Installing Flow Meters

DON'Ts

Don't modify the flow meter – if it doesn't fit, re-evaluate the installation!



Insertion meters need overhead clearance for future removal! Installing meter at a 45 deg. angle may alleviate this situation.

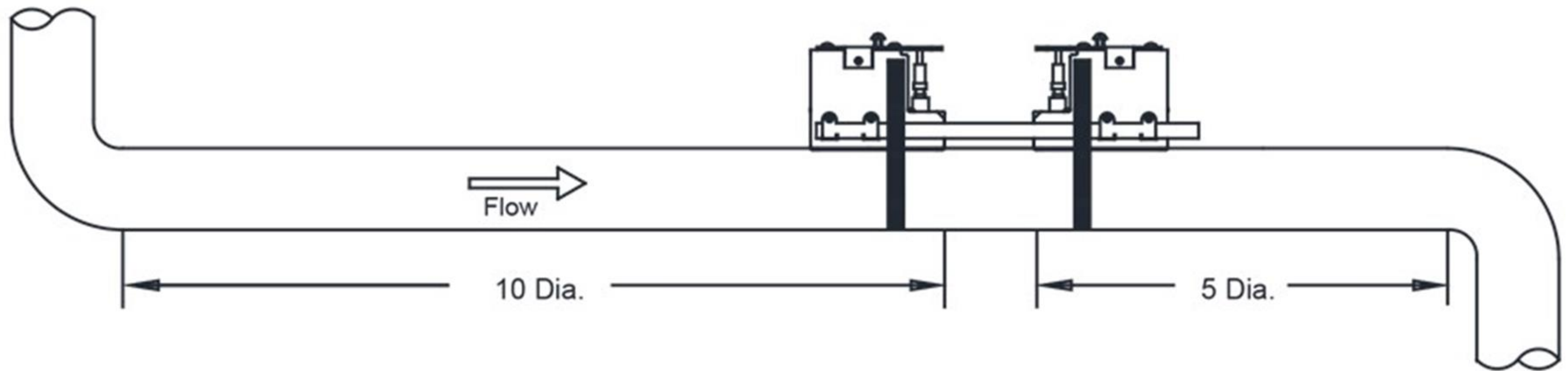


Make sure the right flow meter is selected for the application and installation. The installation kit cannot be used as a take off.



DON'T #1

Ignore Straight Run

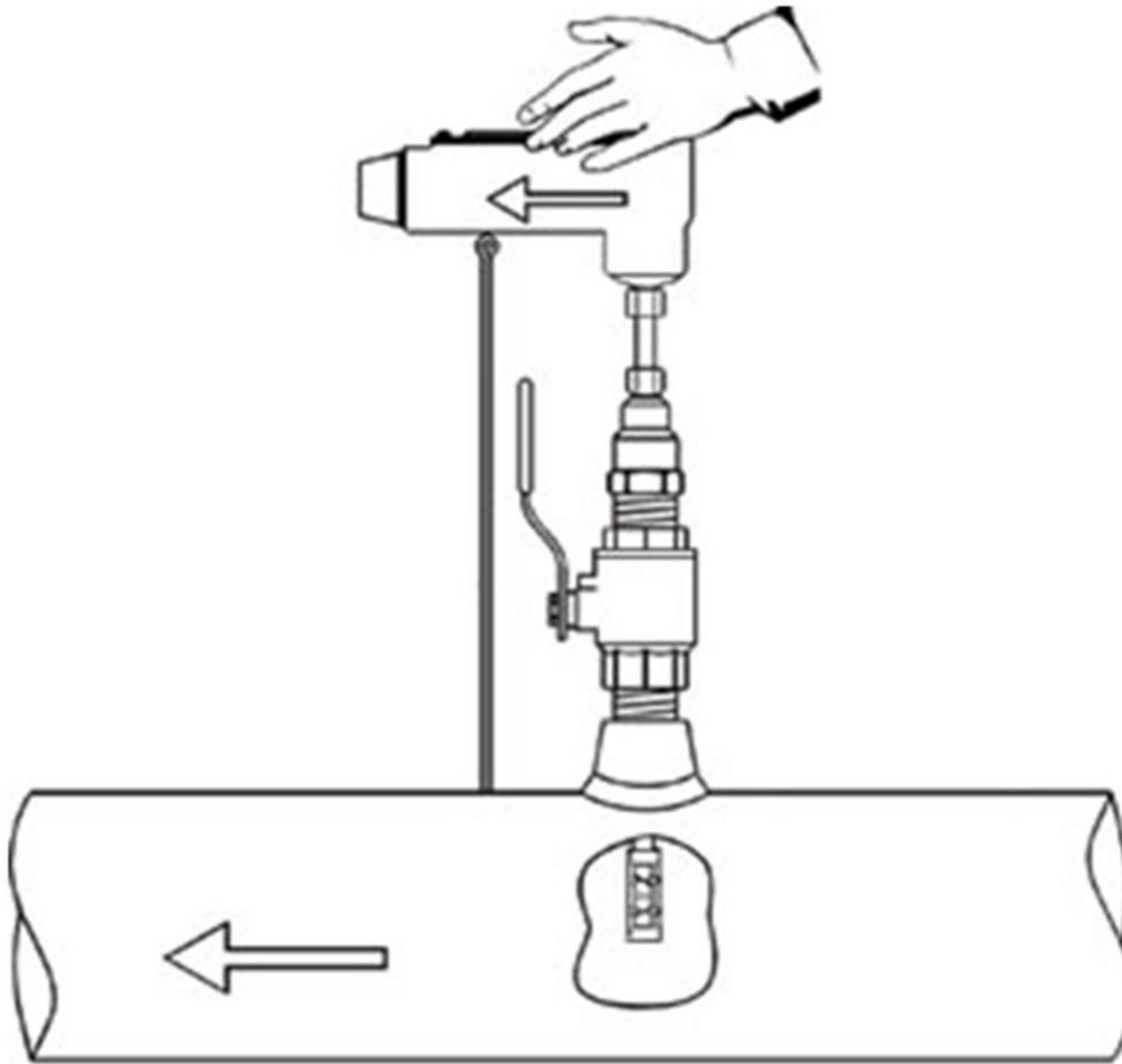


Refer to published upstream and downstream straight run requirements – **Before meter rough-in!**

Straight run is one of the most important criteria for achieving the specified meter performance!

DON'T #2

Ignore Insertion Depth



DON'T #3

Forget to Confirm Pipe Size

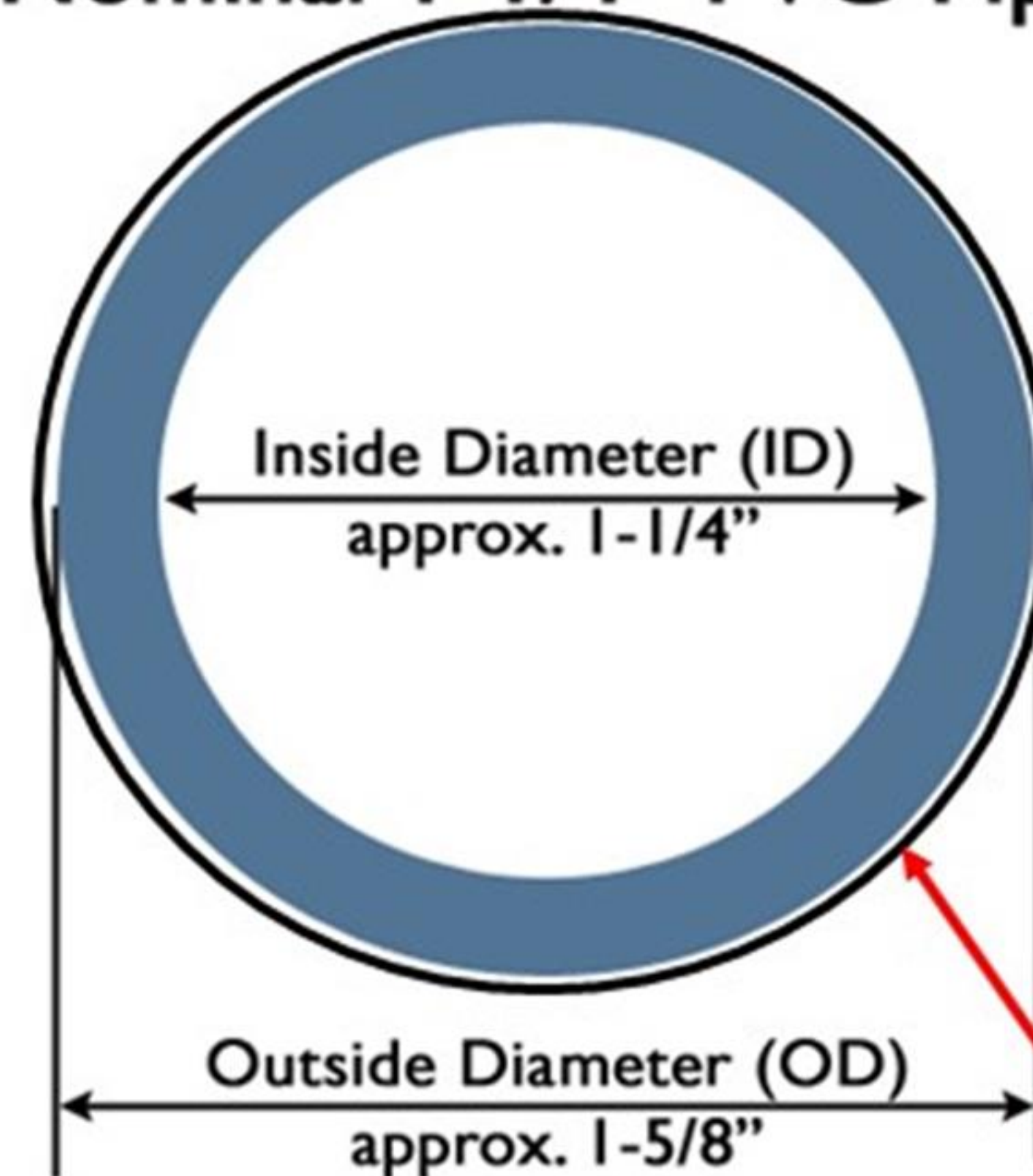
Use the Circumference to determine actual pipe Outside Diameter (OD), don't try to measure the OD directly in the field.

$\text{Circumference} / \pi = \text{Dia.}$

$\pi = 3.142$

It's easier to measure within 6" then to guess, when holding a tape measure across a 10" pipe, 10' in the air!

Nominal 1-1/4" PVC Pipe



Measured Circum. for 1.25" PVC = 5.1"
Measured circumference for 1.5" PVC = 6.0"

DON'T #4

Forget to Confirm Meter is Going Into the Right Pipe

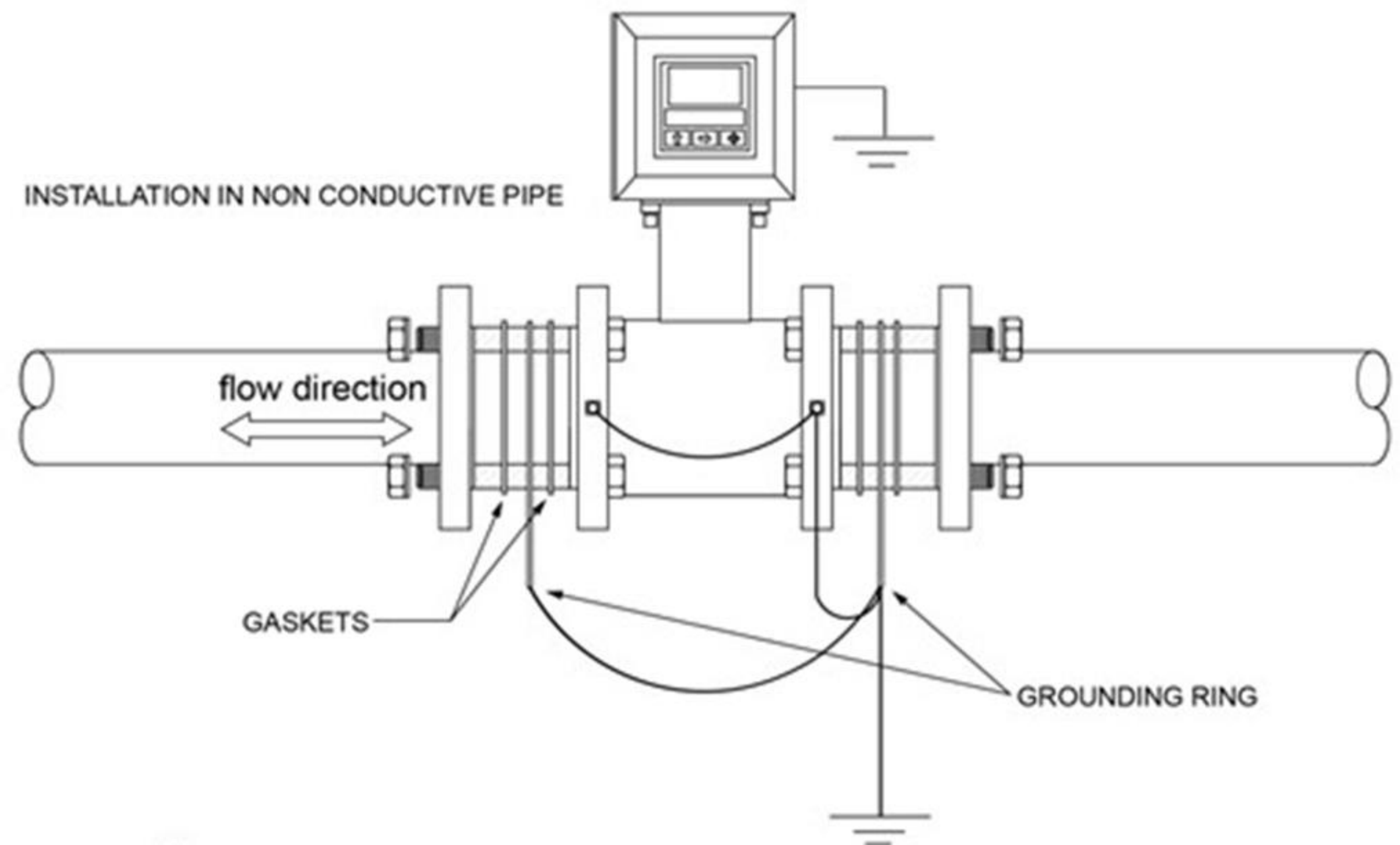
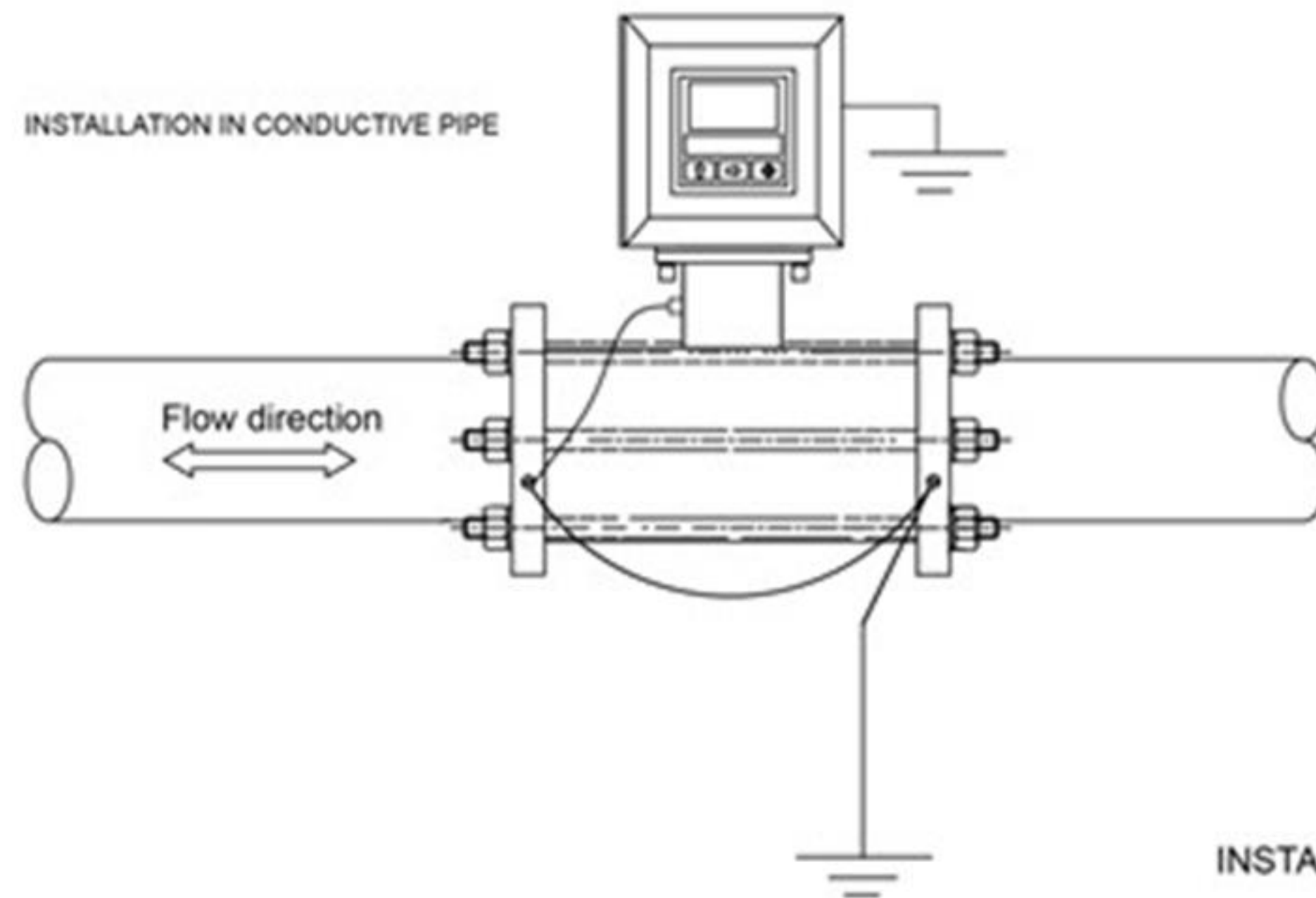
Make sure the schedule, if there is one, matches the print!

Insertion meters must be installed in the correct pipe size in order to provide accurate, volumetric flow information.



DON'T #5

Forget Grounding for Electromagnetic Meters



Signal ground and electrical safety grounds are not the same!

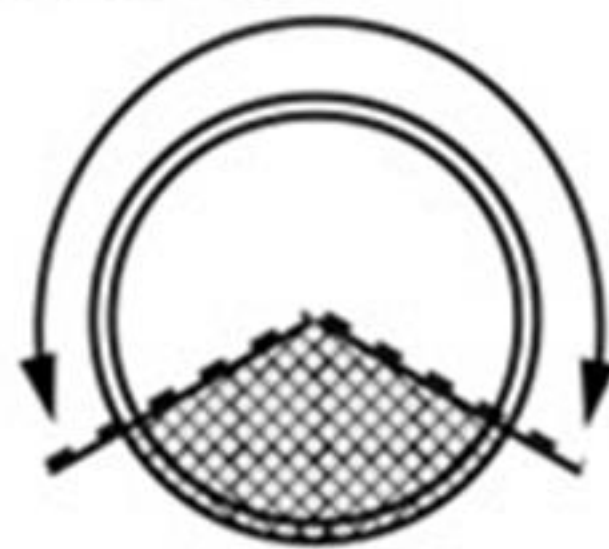
Refer to IOM for best practices when grounding magmeters.

DON'T #6

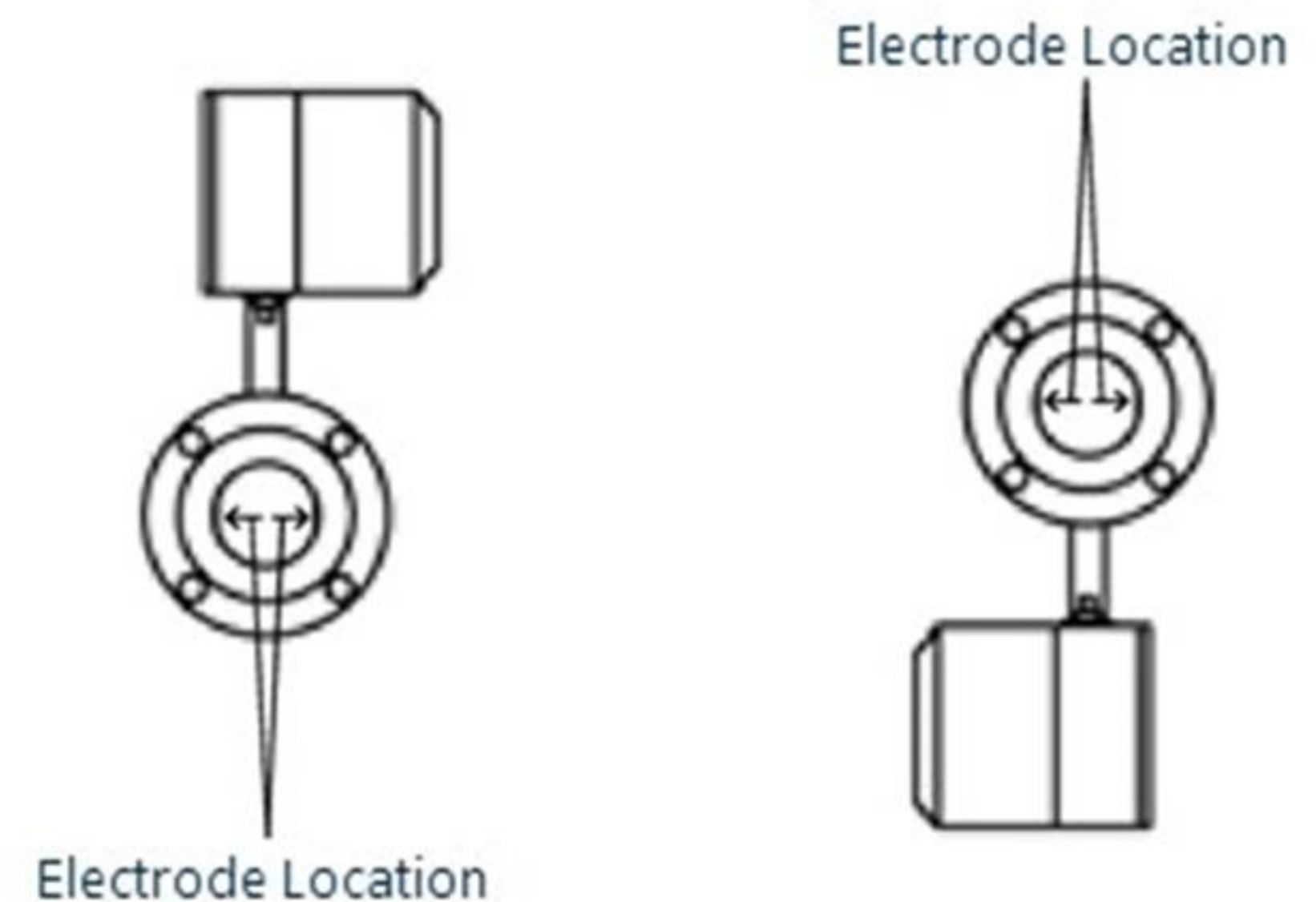
Ignore Meter Orientation

Insertion Meters

- Install in vertical or horizontal pipe.
- For horizontal pipe position meter anywhere in upper 240°.



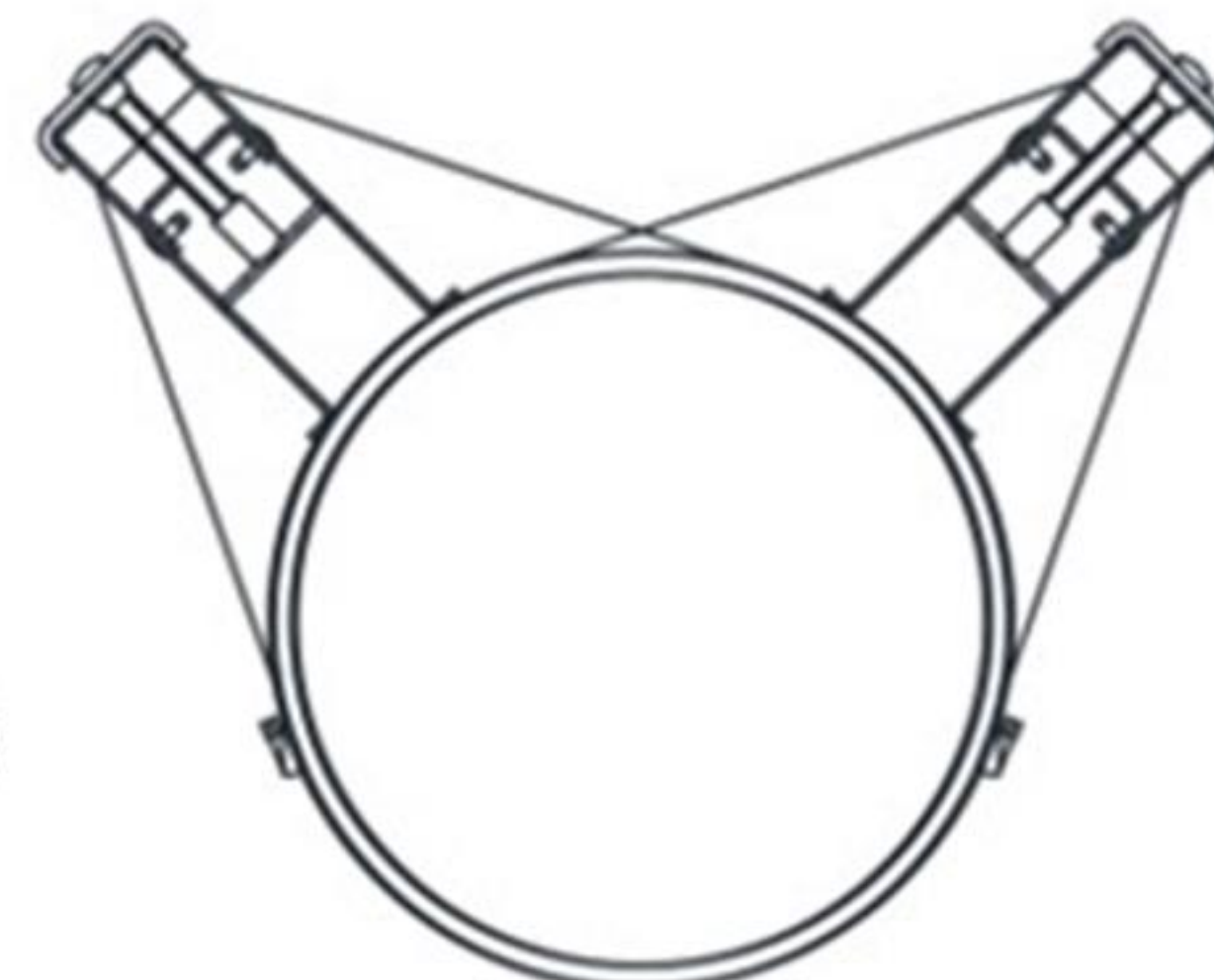
Inline Meters



Clamp-On Meters

Horizontal pipes: Install transducers at 2 or 10 o'clock position

Vertical Pipes: Install transducers at any position



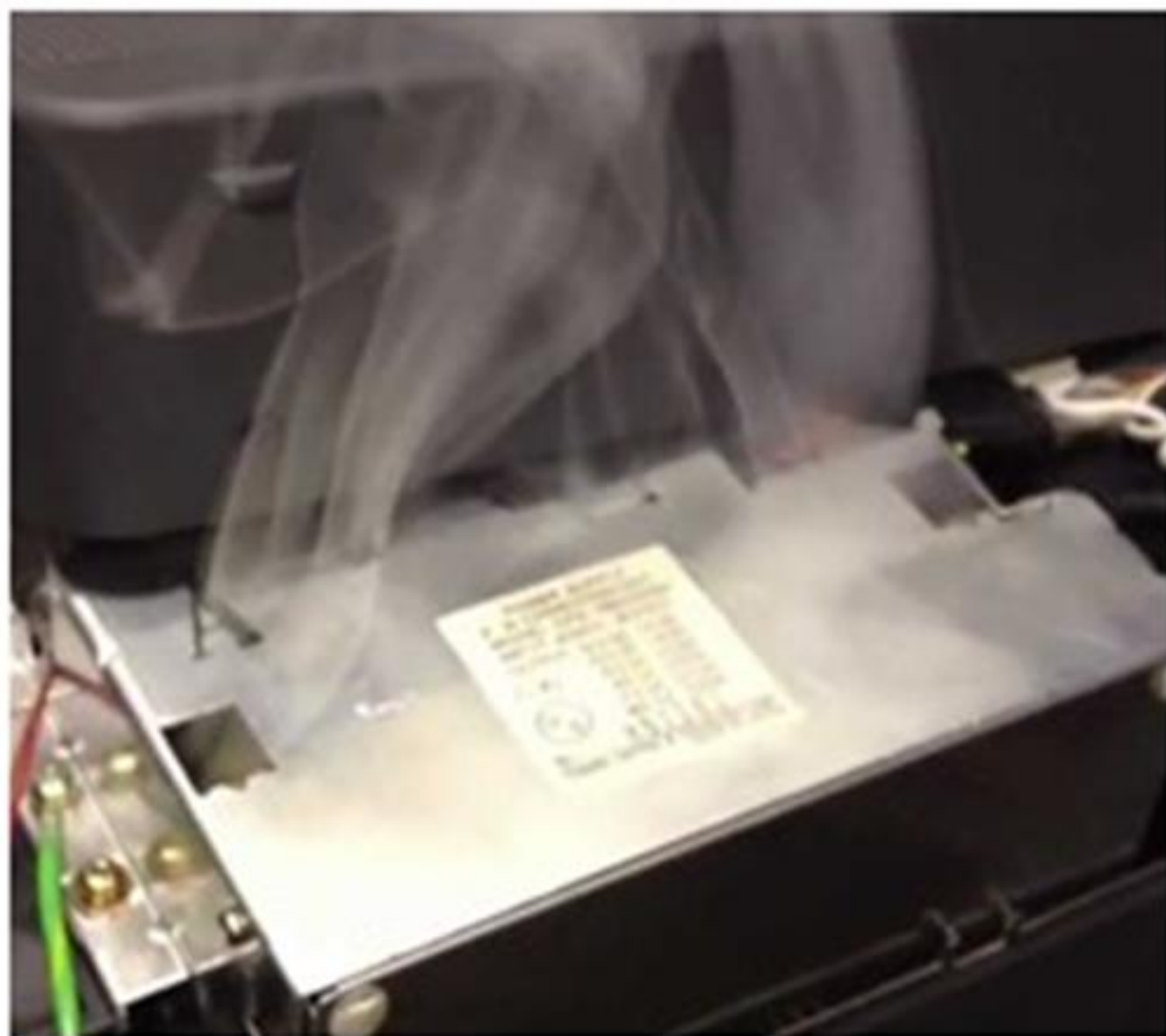
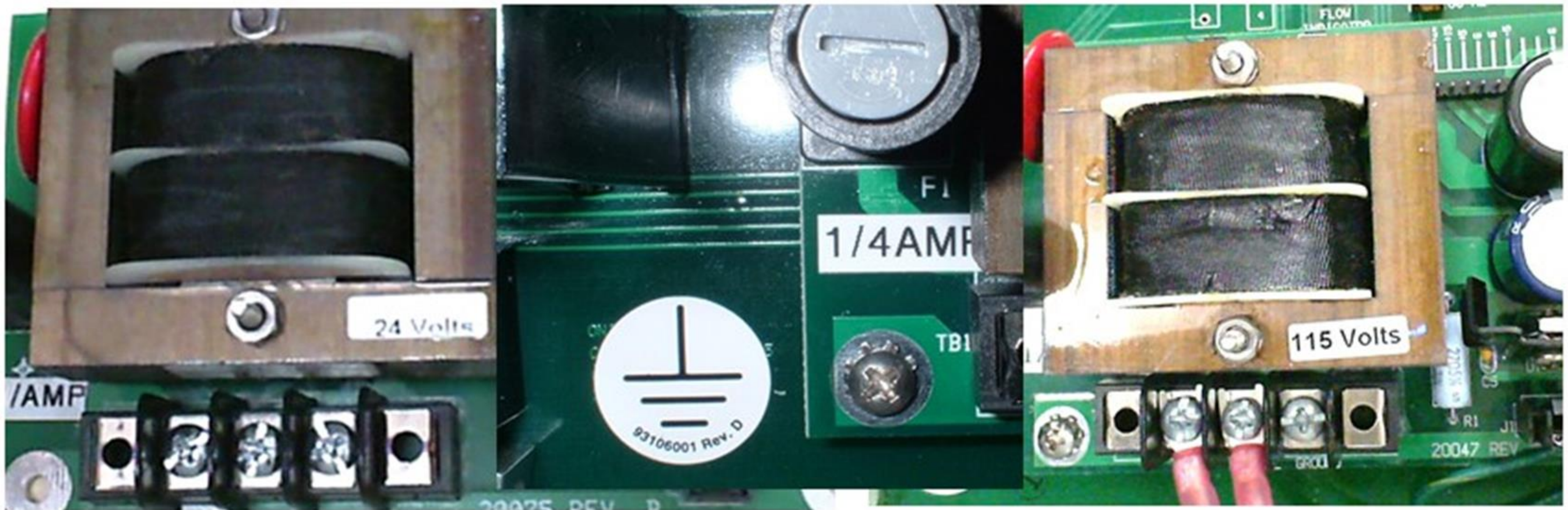
DON'T #7

Separate the Tag/Information from Meter



DON'T #8

Ignore the Power Supply



Confirming the power supply requirements **prior** to connecting the meter to mains power will keep from letting the "magic smoke" out.

Best Practices When Installing a Flow Meter

DO's

- Keep the IOM and all Calibration Certificates!
- Make sure there is adequate clearance to install and remove the meter
- Pay attention to Straight Run
- Pay attention to Insertion Depth
- Confirm Pipe Size – Circumference is better than diameter
- Confirm meter is going into the correct pipe
- Pay attention to grounding for electromagnetic meters

Best Practices When Installing a Flow Meter

DO's

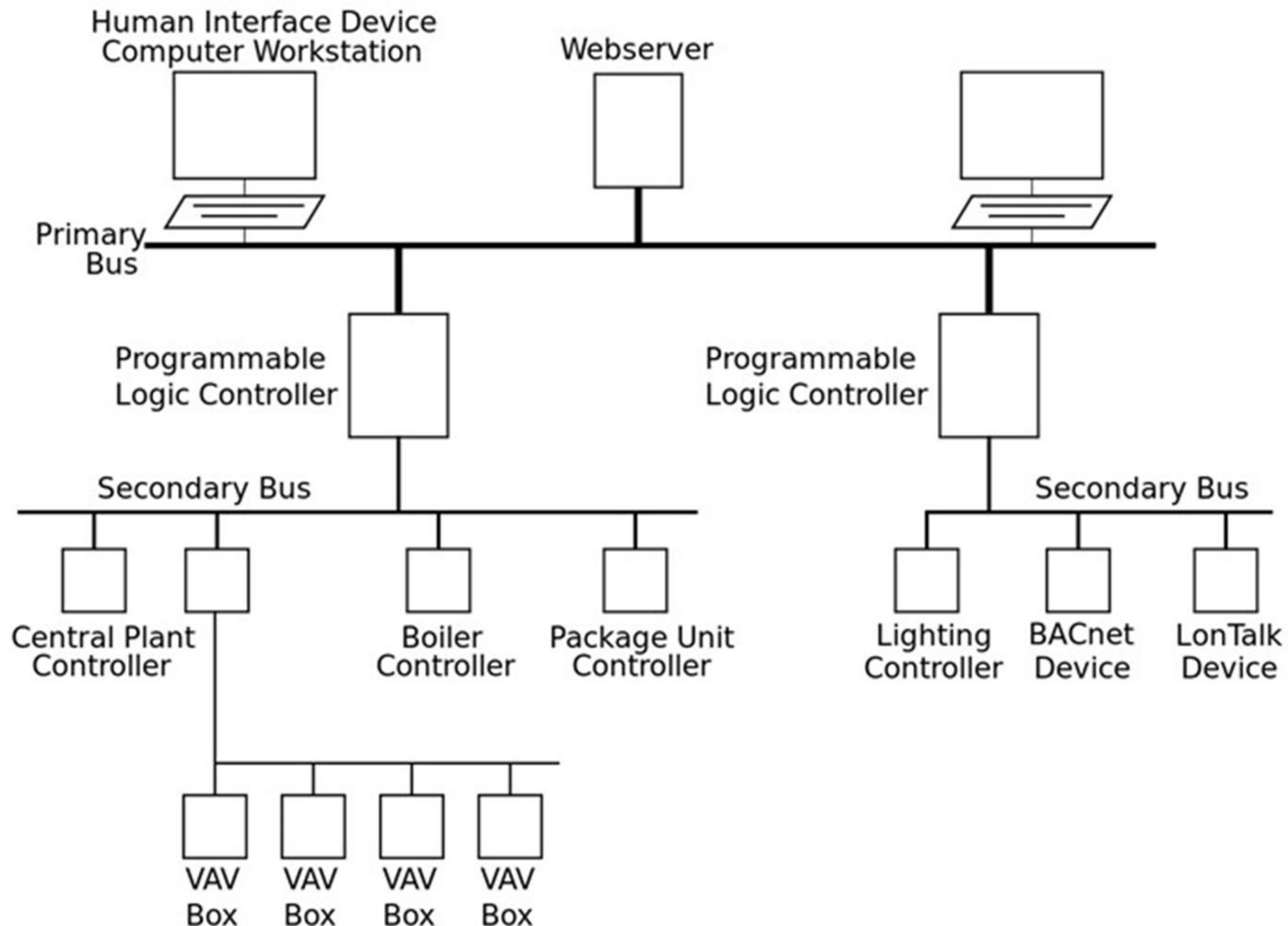
- Pay attention to meter orientation
- Keep the tag with the meter
- Pay attention to the power supply
- Use the correct output signals from the meter – based on the intended application
- Commission the meter per the manufacturers instructions

Building Automation and Control Network

Why BACnet??

- Eliminates proprietary communications protocols
- BACnet is a standardized building automation protocol
- Interoperability

Typical HVAC Serial Network



Typical HVAC BACnet Applications

- **HVAC Control**
- **Fire Detection and alarm**
- **Lighting control**
- **Security**

Trouble Shooting BACnet MS/TP

Where is my Device or Where did it Go?

- **Wrong baud rate**
- **MS/TP polarity reversed**
- **Wrong MAC address**
- **Duplicate addresses**
- **Open or shorted wire**
- **Max Master too low**

Troubleshooting BACnet IP

- **Device IP address and BACnet instance need to be unique**
- **Managed IP networks may require a gateway IP address**
- **BACnet Broadcast Management Devices (BBMD) are used to forward broadcast messages between IP subnets**

Serial Communication

Don't Use Duplicate Serial Addresses

Meter 1

ordered in April
asked for defaults

Baud Rate	IP Address	NetworkAddress	Device Instance
38400	0	017	57017

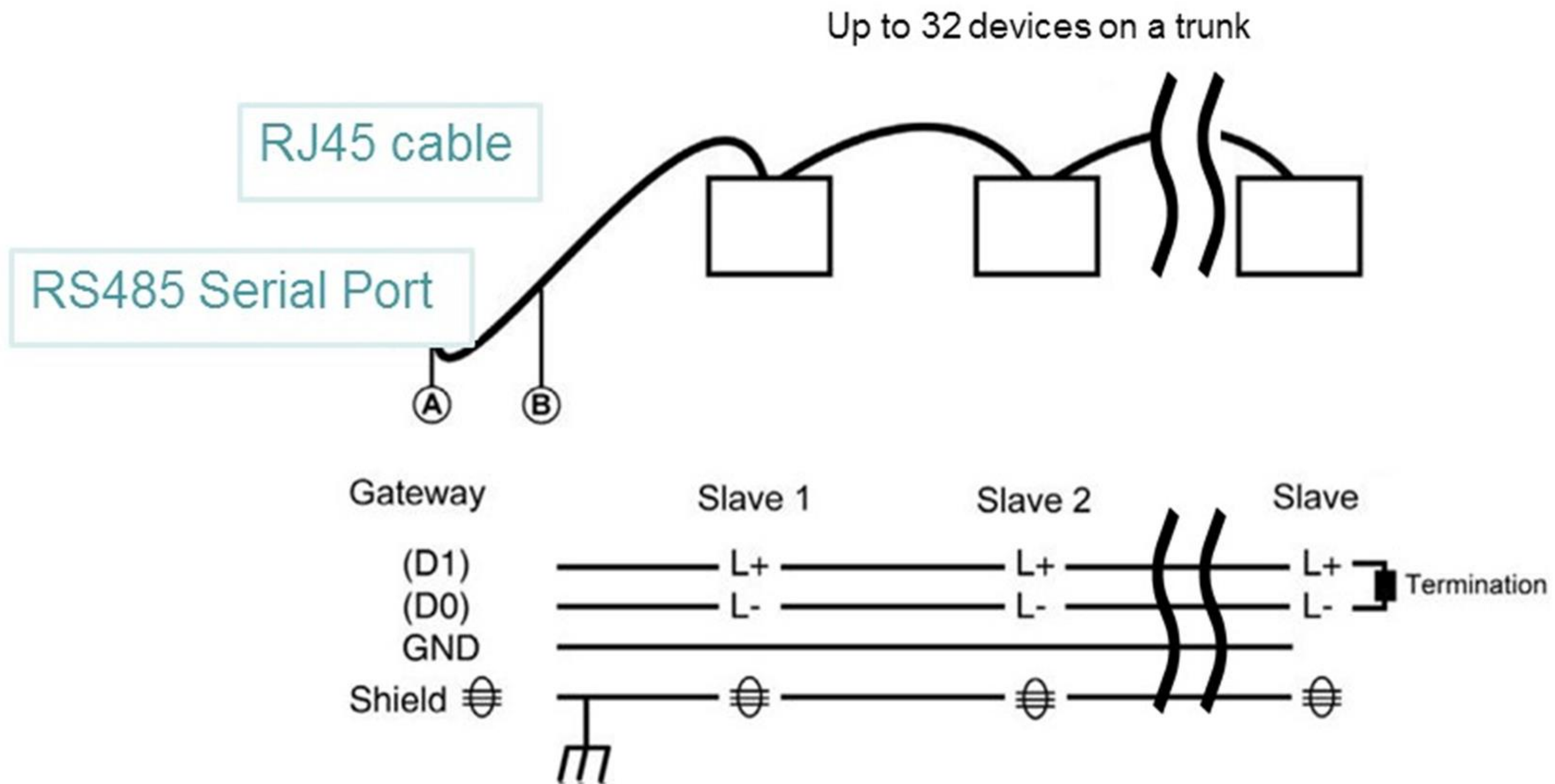
Meter 2

ordered in June
ALSO asked for defaults

Baud Rate	IP Address	NetworkAddress	Device Instance
38400	0	017	57017

Serial Communication

Don't Add Too Many Devices on a Trunk





Thank you.
Any questions?

