Gathering System Rules of Thumb

Non-regulated gas gathering lines are frequently operated with considerably less experienced-engineering input into their design and operation than either regulated gathering lines or cross-country pipelines. This document is an attempt to provide some guidance to new engineers and operations personnel into the issues that need to be addressed to design and construct an "operable" gathering line. It not intended to address the issues involved in making a line meet industry standards or any of the various regulations – this document should be seen as a way to improve how well a system can be operated after it has been designed to industry standards and government regulations.

1. Pig Launchers and Receivers. There is no reason that a launcher-design should be significantly different from the design of a receiver. Historical differences have reduced the flexibility of the pipeline system without adding any value. Dual-diameter launchers should be avoided if at all possible since they limit the type of pigs that can be used (e.g., cup pigs cannot be used in a dual-diameter launcher) and make smart-pigging impossible.
   a) Closure: The closure should:
      i) Have a pressure telltale as an integral part of the seal mechanism.
      ii) Be supported by hinges or davits that would prevent the closure from becoming a projectile in an opened-under-pressure situation.
      iii) Be able to release pressure while still captured.

      The Tube Turns® brand of "Y-Yoke" closures meets all of these criteria while the Huber-type hammer closures fail in the first and third criteria.
   b) Barrel: The barrel is the pipe between the closure and the eccentric reducer and it should:
      i) Be one standard pipe size larger than the pipeline. Typically "the next pipe size" for 16-inch pipe is 20-inch since it can be difficult to find an 18X16 eccentric reducer or an 18-inch closure.
      ii) Be long enough. Barrel lengths have traditionally been fairly short (5' 7" on a 20-inch receiver) which limits the equipment that can be run. The minimum length for a 6-inch launcher barrel should be 6 feet. For each pipe size above 6-inch add 1 foot (i.e., 8-inch should be 7 feet, 20-inch should be 12 feet, etc.)
   c) Reducer: Use an eccentric reducer between the barrel and the launch-tube.
   d) Side Tee: This tee can come off either side of the pipe. For discussion purposes stand at the closure and if the bullnose of the tee comes off the left side of the pipe it is a "left-hand" device otherwise it is a "right-hand" device. If there is no particular reason to choose one side over another, make the launcher/receiver "left-hand".
   e) Launch Tube: Between the reducer and the barrel-isolation valve the launch tube should be 4 times the nominal pipeline pipe diameter.
   f) Pig Signal: A mechanical pig signal located in the below the side tee on launchers and in the launch tube for receivers.
   g) Sweeps: Leaving the barrel-isolation valve and the side-valve tee there should be a 45° 5D radius (i.e., the radius of the hot bend at the mid-line is 5 times the pipe diameter) hot bend, a pup, and another hot bend to start the pipeline. A 1-inch Lateral-O-Let with a nipple and a valve should be installed in the pup above

ground level. This valve can be used on launchers to inject chemicals or take pressure readings, on receivers it is used to take readings.

h) Valves:
   i) Barrel-isolation valve: this is a full port valve located between the launch-tube and the side valve tee.
   ii) Side valve: this is a full port valve located off the bullnose of the tee between the barrel-isolation valve and the top sweep.
   iii) Kicker/bypass valve: See below.

i) Vents: Vents should be 2-inch, have a 6-foot vent pipe (drilled near the bottom and with a rain cap), and should be located:
   i) 90° from kicker/bypass line in the same plane.
   ii) In the launch tube one pipe diameter from the flange that connects to the barrel-isolation valve.

j) Kicker/Bypass line: the kicker line on a launcher (the bypass line on a receiver) should be:
   i) Located one barrel-diameter plus the kicker/bypass line diameter from the closure (i.e., on a 20-inch launcher with a 24-inch barrel and an 8-inch kicker, the centerline of the kicker pipe should be 32” from the closure/barrel seam.
   ii) Should tie in:
      a) To the vertical side-valve downcomer on a single launcher/receiver
      b) To the pipeline beyond the lower sweeps on a co-located launcher/receiver pair (e.g., when a 16-inch receiver side valve is also the side valve for a 20-inch launcher).
   iii) Sized to provide less than 0.13 psi/ft pressure drop at 100 psi:

Mainline Size	Kicker size
4	2
6	4
8	4
10	4
12	6
14	6
16	6
18	6
20	8
24	8
30	10

2. Drips: Line drips are intended to collect liquid water that drops out in the pipeline. They work by either slowing the flow down and/or changing flow direction. “Side-stream drips” have been used extensively in the past, but have seldom proved to be very effective. These drips have a single line to a conventional drip and have a very short contact area. Side-stream drips should generally be avoided.

The components of any type of drip are: (1) top closure; (2) riser; (3) inlet/outlet nozzles; (4) build; (5) elbow; (6) barrel; and (7) blow down. The *top closure* on all types of drips should be a flange with a blind. The *Riser* is the vertical portion of the drip, it should be sized to the next pipe size at or over twice the outlet pipe diameter (e.g., a drip in a 20-inch line should have a 42-inch riser since 40-inch pipe is not readily available). The height of the riser should be three times the outlet-pipe diameter. On a Conventional drip (with or without a bypass), the *inlet/outlet nozzles* can be made from a reducing cross. For either type of piggable drip, the *inlet/outlet nozzles* must be set into reinforcing saddles. *Build* is the angle between the riser and the barrel and should be 93° (i.e., if the top closure is level then the barrel will be 3° below level). The most acceptable method of getting the necessary build is to miter the elbow end of the barrel to the full build angle. This requires shimming two of the feet of the beveling machine by $t=d*tan(3)=d*0.0524$. Where d is the distance between the leading edge of the two feet (i.e., if the seating surfaces of the opposing feet are 6-inchs apart, then the shim is 0.31" thick).

If the barrel and the riser are the same size, then the *Elbow* will be that size. If the riser and the barrel are a different size then the use a reducing elbow to match sizes. An in-line reducer can be used if there is no other option, but it should be an eccentric reducer located between the barrel and the elbow. The *Barrel* is the section of the drip that holds water. A 20-inch Schedule 20 barrel will hold 0.360 bbl/ft, 30-inch standard weight (about Schedule 15) will hold 0.831 bbl/ft, and 36-inch standard weight (about Schedule 15) will hold 1.207 bbl/ft. So a 30 bbl drip must be 83 feet long if made out of 20-inch, 36 feet long from 30-inch, and 25 feet long out of 36-inch. The *blow down* should extend all the way into the barrel and be mitered to 45° on the bottom.

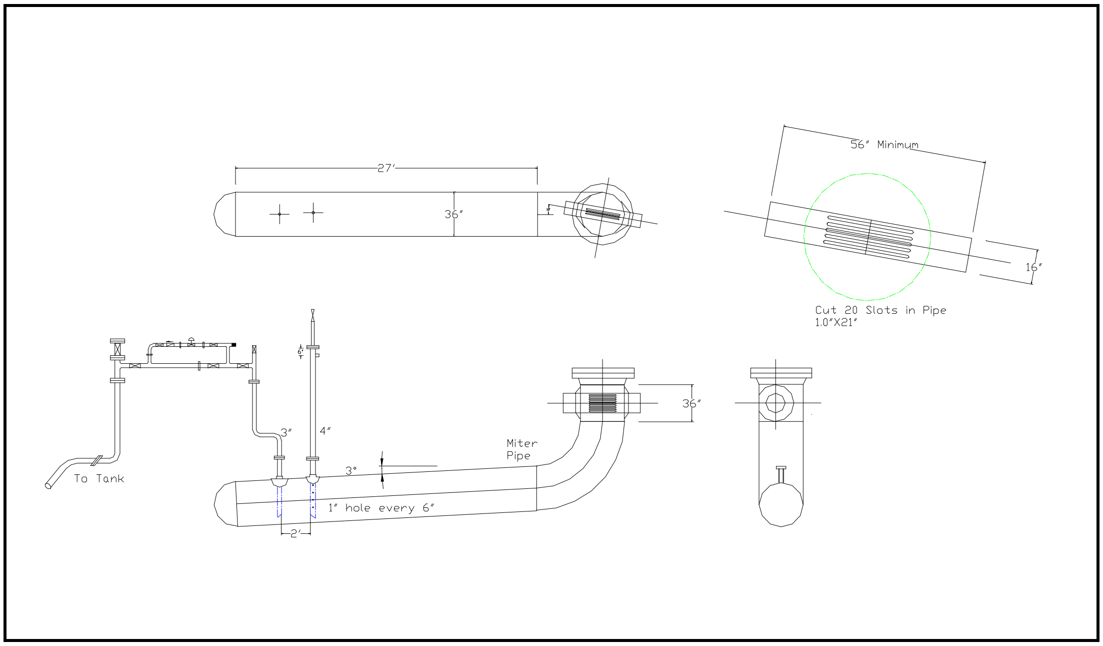
Types of drips that have proven to be effective are:

a) Conventional: liquids are removed from a gas stream by both a change in velocity and a change in direction. The change in direction is caused by a diverter plate located to block the full stream. The diverter plate is attached to the blind plate, is ½" smaller than the riser I.D., is ½" thick, and it extends at least ½ inlet pipe diameter below the bottom of the inlet pipe normal to the flow. Three 30-60-90 triangle supports (with the short side equal to 1/3 of the riser I.D. and attached to the blind) are attached to the diverter plate with one located in the center of the plate on the upstream side and the other two located 1/3 of the plate width from either edge on the downstream side.
   i) Top Closure: blind flange equal to nominal riser size.
   ii) Riser: On this type of drip, the riser is made from a reducing cross. The flange for the top closure and the elbow are welded to the full-size pipe of the cross. This distance is not precisely three times the outlet-pipe diameter but it is acceptably close.
   iii) Inlet/Outlet Nozzles: weld flanges on the small outlets.
   iv) Elbow: use a standard or reducing elbow as necessary.

   v) Barrel: the barrel diameter and length should be determined by expected water influx during pigging.

b) Conventional with a bypass. This drip is identical to the conventional drip except that the piping into it has fittings and valves to allow the line to be pigged. Many of these drips were installed in the early '90's with only a reduced-diameter outlet and a full-size bypass valve (the reasoning was that we would force the drip into side-stream service during pigging operations). This choice has significantly limited operational flexibility and three valves should be used.

c) Piggable single-line. These drips are a recent innovation that relies only upon velocity changes to drop out water. Component sizing is based on traditional scrubber-sizing algorithms. The pipeline pipe-diameter continues through the drip and the velocity change is achieved through slots cut into the pipeline within the drip.



The width of each slot is 2.5 times pipe wall-thickness, terminated on both ends by a half circle to reduce stresses. Total slot-area must be at least twice the outlet-nozzle area. There are an odd number of slots in each quadrant of the pipe (with the center of each set located at 0°, 90°, 180°, and 270°). The slots are located 2.5 pipe widths apart. With this configuration the slot length is:

$$l = \frac{p}{nt}\left(\frac{D^2}{5} - \frac{5}{8}nt^2\right)$$

l = length of slots

n = number of slots

D = Outlet pipe nominal diameter

t = pipe wall thickness

Increase the number of slots until *l* is less than the riser I.D. To determine if the slots will fit use:

$$\boxed{Extra = pD - 2.5t(2n-1)}$$

As long as *Extra* is greater than zero, the slots should fit if they are cut true to the longitude of the pipe. For standard-wall 10-inch pipe (in a 20-inch riser) you would have:

$$\boxed{\begin{array}{l} l = \dfrac{p}{(40)(12)(0.365)}(8*10^2 - 25*12*0.365^2) = 13.6 \text{ in} \\ Extra = p*10 - 2.5*0.365*(2*12-1) = 10.4 \text{ in} \end{array}}$$

For standard-wall 20-inch in a 42-inch riser you would need 20 slots 0.937 inches wide and you would have 26-inches of extra pipe girth. Cutting the slots in the pipe should be done by a machine shop to get the size, spacing, and run-direction right.

i) Top Closure: blind flange equal to nominal riser size.

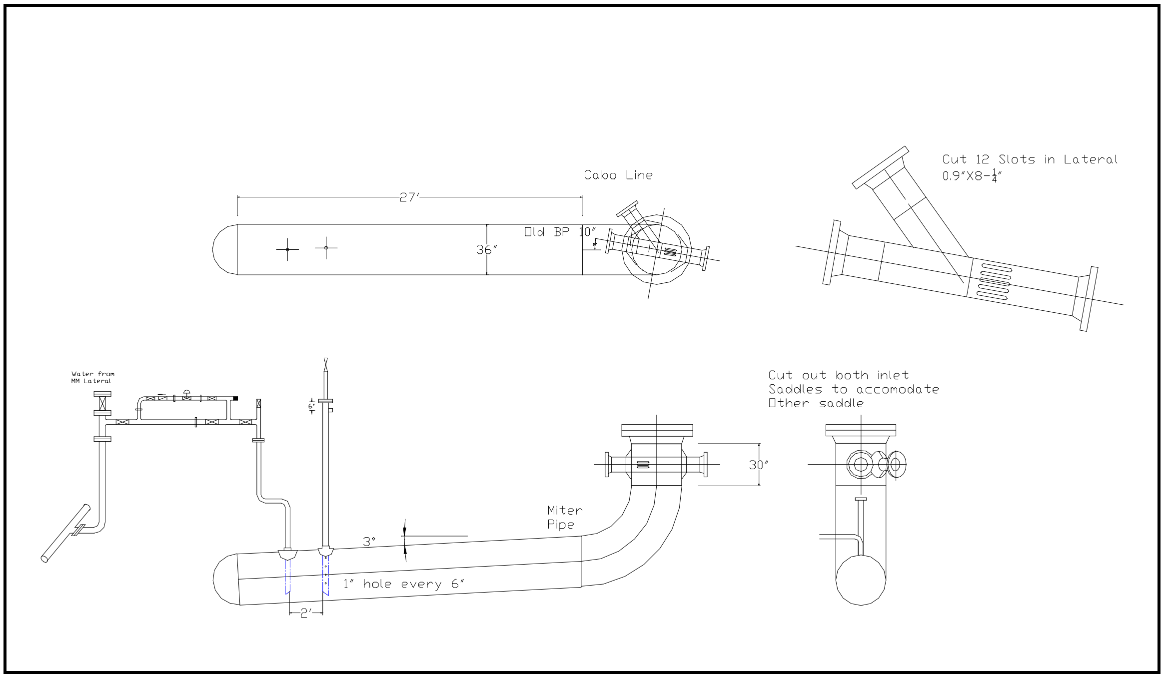
ii) Riser: riser diameter is next generally available pipe diameter over twice the pipeline diameter (e.g., for an 8-inch pipeline use a 16-inch riser, for a 16-inch pipeline use a 36-inch riser, and for a 20-inch pipeline use a 42-inch riser). Pipe over 20-inch should have the riser custom-made in a vessel-fabrication shop. The seam-to-seam length of the riser is three times the pipe-outlet size.

iii) Inlet/Outlet Nozzles: use weld saddles for both the inlet and outlet nozzles. The slotted pipe slides through the saddles and has flanges welded on either end.

iv) Elbow: use a standard or reducing elbow as necessary.

v) Barrel: the barrel diameter and length should be determined by expected water influx during pigging.

d) Piggable dual-line. These drips serve two functions: (1) they bring a pair of lines together in a way that allows both lines to share a pig receiver; and (2) they remove liquids from the lines. The two streams impinging upon each other provides significant mechanical separation, so the slot area is smaller than in the single-line piggable drip above. Simply put, the two lines (which can either be the same size or have a smaller branch let into the larger mainline) are joined inside a pressure vessel with a “lateral fitting” which has the two pipes connected at a 45° angle. The position of the fitting is controlled by the size of the two welding saddles—there must be room to weld both the inlet through-pipe saddle and the inlet branch saddle to the pipe. All of the slots are cut into the through-pipe downstream of the branch.



The pipeline pipe-diameter continues through the drip and the velocity change is achieved through slots cut into the pipeline within the drip downstream of the branch. The width of each slot is 2.5 times pipe wall-thickness, terminated on both ends by a half circle to reduce stresses. Total slot-area must be at 1.25 times the outlet-nozzle area. There are slots in each quadrant of the pipe (with the center of each set located at 0°, 90°, 180°, and 270°). The top and bottom sets should have an odd number of slots; the side sets can be either even or odd. The slots are located 2.5 pipe widths apart. With this configuration the slot length is:

$$l = \frac{\pi}{8nt}\left(D^2 - 5nt^2\right)$$

l = length of slots

n = number of slots

D = Outlet pipe nominal diameter

t = pipe wall thickness

Increase the number of slots until *l* is less than the available diameter within the riser I.D. To determine if the slots will fit the circumference use:

$$Extra = \pi D - 2.5t(2n-1)$$

As long as *Extra* is greater than zero, the slots should fit if they are cut true to the longitude of the pipe. For standard-wall 10-inch pipe (in a 20-inch riser) you would have:

$$l = \frac{\pi}{(8)(16)(0.365)}(10^2 - 5*16*0.365^2) = 5.8 \text{ in}$$

$$Extra = \pi * 10 - 2.5*0.365*(2*16-1) = 2.3 \text{ in}$$

Cutting the slots in the pipe should be done by a machine shop to get the size, spacing, and run-direction right.

i) Top Closure: blind flange equal to nominal riser size.
ii) Riser: riser diameter is next generally available pipe diameter over twice the pipeline diameter (e.g., for an 8-inch pipeline use a 16-inch riser, for a 16-inch pipeline use a 36-inch riser, and for a 20-inch pipeline use a 42-inch riser). Pipe over 20-inch should have the riser custom-made in a vessel-fabrication shop. The seam-to-seam length of the riser is three times the pipe-outlet size.
iii) Inlet/Outlet Nozzles: use weld saddles for both the inlet, branch, and outlet nozzles. The lateral must be installed as close to the inlet side of the drip as the reinforcing weld-saddles will allow. Slots are cut dowstream of the confluence of flows.
iv) Elbow: use a standard or reducing elbow as necessary.
v) Barrel: the barrel diameter and length should be determined by expected water influx during pigging.

Pipeline Valves

1. Gate Valve:
    a) Operating mechanism: a wedge-shaped gate slides between matching seats. Seal is metal-to-metal. In larger sizes some manufactures use a gate that is two separate plates separated by springs to hold the gate more firmly on the seat.
    b) Primary Use: liquids and steam. Used in natural-gas applications where a bubble-tight seal is not required.
    c) Throttling characteristics: very poor, the valve will pass the entire stream within the first few percent of gate travel.
    d) Method of actuation: actuators are rarely used on gate valves outside of steam plants and then they are configured to simulate turning a valve handwheel.
    e) Flow path: directly through the valve, generally larger than the pipeline ID.
    f) Flow symmetry: valve can be installed with either side upstream.
    g) Advantages: somewhat lower costs.
    h) Disadvantages: extremely tedious to operate (e.g. a 12-inch Grove® gate valve requires almost 100 turns of the handwheel to operate), no provisions for double-block-and-bleed.
2. Globe Valve: includes “motor valves”, needle valves, and backpressure valves.
    a) Operating mechanism: a plug-shaped stem seats in a matching seat that is oriented 90° (relative to the flow direction) from the pipe centerline.
    b) Primary Use: throttling any fluid.
    c) Throttling characteristics: good across almost half the valve travel.
    d) Method of actuation: actuators in the oil and gas industry are usually diaphragms.
    e) Flow path: up through the seat, across the chamber, and down into the outlet. This flow path causes a pressure drop across even a fully opened valve.
    f) Flow symmetry: While a globe valve can be installed in either direction, the manufacturer’s generally recommend that they be installed with the upstream flow under the seat to minimize the pressure on the stem-packing.
    g) Advantages: throttling and easy actuation.

h) Disadvantages: significant pressure drop across a fully open valve and they do not provide a bubble-tight seal.

3. Butterfly Valve:
   a) Operating mechanism: a flat plate that pivots about its centerline is placed in the flow. Rotating the plate ¼ turn towards shut will put the plate against the seating surfaces.
   b) Primary Use: on/off in applications where considerable leakage is acceptable.
   c) Throttling characteristics: very poor.
   d) Method of actuation: quarter-turn piston actuators can be used.
   e) Flow path: straight through the valve, but the plate in the flow prevents them from being piggable.
   f) Flow symmetry: can be installed in either direction.
   g) Advantages: very inexpensive.
   h) Disadvantages: poor seal and not piggable.
4. Plug Valve:
   a) Operating mechanism: a drilled, cone-shaped stem (the plug) seats in a matching seat. When the valve is opened, the plug is jacked off the seating surface and rotated 90°. When shutting the valve, the plug is rotated and pushed down on the seat.
   b) Primary Use: none, it has been sold as an alternative to gate and/or ball valves, but the seating characteristics and the tendency to jam make them a very poor device for field operations.
   c) Throttling characteristics: very poor (worse than gate valves because they tend to not travel freely)
   d) Method of actuation: quarter-turn piston actuators can be used, but they need significantly over-sized torque characteristics to lift the plug off the seat.
   e) Flow path: straight through the valve, but the hole in the plug is smaller than the pipeline diameter so they are not generally piggable.
   f) Flow symmetry: can be installed in either direction.
   g) Advantages: none.
   h) Disadvantages: difficult to operate, poor sealing characteristics, require frequent maintenance.
5. Floating-Ball Valve:
   a) Operating mechanism: a drilled ball moves between seating surfaces. The ball is coupled to the valve body on the top only.
   b) Primary Use: low-replacement-cost on/off applications
   c) Throttling characteristics: poor.
   d) Method of actuation: quarter-turn piston actuators.
   e) Flow path: through the ball. Many floating-ball valves have reduced ports so they are often not piggable.
   f) Flow symmetry: can be installed in either direction.
   g) Advantages: are cheaper than trunion-mounted ball valves.
   h) Disadvantages: lack of a body bleed, they have more of a tendency to leak through (because of lateral ball movement as seals wear), and they have poor sealing characteristics in very-low dP installations.

6. Trunion-Ball Valve:
   a) Operating mechanism: a drilled ball moves between seating surfaces. The ball is held rigid top and bottom by trunion bearings.
   b) Primary Use: on/off applications
   c) Throttling characteristics: poor.
   d) Method of actuation: quarter-turn piston actuators.
   e) Flow path: through the ball. Generally, reduced-port (sometimes called "standard port") trunion valves can be purchased, but they are often more expensive than full-port valves.
   f) Flow symmetry: can be installed in either direction.
   g) Advantages: body bleeds allow a single valve to serve in many double-block-and-bleed applications. Sealing surfaces are very durable.
   h) Disadvantages: purchase cost is higher.