Module vs. Compartment Design

The use of pulse type fabric filters has increased, due to size and cost, for boilers and other hot gas applications. Pulse units needed to be updated to meet the application requirements. Of particular note today's units must have good distribution, handle high grain loadings and temperature variations. The old shop designed boxes needed updating.

The Modular Units were originally designed for Hopper Entry – Not Good
The Modular Units utilized square or round inlets – Not Optimal
The Modular Units utilized center walkways and access – Not Good
The Modular Units were difficult to field insulate (shop insulation is a no-no)
The Modular Units and inlet/outlet manifolds had expansion differences
The Modular Units were not designed to handle high grain loadings

BES has performed a thorough and comprehensive study of pulse fabric filter design considerations and configuration to obtain optimum performance and economics. Considerations such as inlet grain loading, gas/dust distribution, differential thermal expansion, fabrication costs, erection costs, maintainability, etc. were part of the study. The economic study was aimed at least overall cost of an erected unit with new and advanced features.

Pulse designs are basically identical from one manufacturer to another and are based on least equipment cost without consideration of optimizing performance or least overall cost. Groups of "stand alone" modules are placed either is a single row or double row. The inlet and outlet manifolds are individually supported and either are located down the center of the module grouping or placed on one or both sides of the grouping. The access walkway to the pulse cleaning system is located in the center of double row configurations.

BES has used this design approach in the past. A number of problems were identified with this design configuration, both BES's design and competitor's designs, which led to BES's study of design and configuration considerations. The design addressed low inlet loading but did not consider high dust loading that accompany SO_2 and HG removal systems. Differential thermal expansion led to field problems or required the additional of expansion joints at the inlet and outlet of each "stand alone" module. The center access walkway environment was often too hot to support maintenance personnel in their duties. The individual module gas inlets are usually round or square and do not adequately address or support uniform gas/dust distribution to individual compartments that is very important in SO_2 and HG control.

BES's study concluded that an integral inlet/outlet manifold design eliminated any potential differential thermal expansion problems and eliminated the need of expansion joints at the compartment inlet and outlet, provided excellent gas/dust distribution to the individual compartments, removed the access from an enclosed area being beneficial to maintenance personnel and allowed process turn-down without causing dust build-up problems in the inlet manifold. The integral manifold design has been utilized for many years in major reverse gas and shaker design installations. Model studies and full scale operation has proven that uniform gas/dust distribution, even with inlet dust loadings of up to 300 gr/acf, is obtained with the integral manifold design and with turn-down to 25%.

The study further concluded by grouping compartments into a module design and cutting the compartments horizontally for shipping, along with the integrated manifolds, reduced equipment cost. The design requires fewer or an equal number of crane lifts as “stand-alone” designs depending on the system size. There is potentially a minor amount more of field welding with the BES design but it is far out weighed by the decreased amount of thermal insulation required by the design. Thermal insulation costs are reduced by approximately 40%; a large cost savings compared to a potential increase in a small amount of field labor.

The BES design optimizes pulse fabric filter performance for modern process requirements and provides least overall equipment and installation costs to the User.

Looking at a Typical Fabricated Pulse Fabric Filter. Typical 6 Compartment Design

Hopper Sections Ready to Ship

Middle Sections – Ready to Ship

Top Sections – Ready to Ship

Pulse Operating Description

The pulse jet fabric filter (PJFF) is utilized to remove solid particulate matter that is air borne is a gaseous effluent such as products of combustion. The solid particulate is removed from the gas stream by passing the gases through a filter fabric where the particulate is removed on the outside surface of the fabric. The basic PJFF is comprised of the following components:

1. An inlet manifold distributes the incoming dust laden gas to individual filter compartments.
2. Individual compartment inlet dampers, manually operated, that can be used to assist in isolating a compartment from the gas stream.
3. Multiple compartments aligned either in a single row or a double row that contain the filter fabric.
4. Each compartment has a gas tight tube sheet to isolate the incoming dust laden gas from the clean gas side of the compartment.
5. Each compartment has a hopper to capture particulate as it is removed from the filter fabric. Material handling equipment is required to remove the particulate from the hoppers for disposal.
6. Filter bags that are suspended from the tube sheet and supported by an internal wire cage. A venturi is located in the top of each cage to assist in fabric cleaning.
7. Compartment outlet poppet dampers, air cylinder operated, to isolate an individual compartment for fabric cleaning or maintenance.
8. An outlet manifold that channels the clean gases from the individual compartments to the I.D. fan.
9. A compressed air system to periodically clean the particulate from the filter fabric.
10. System bypass damper(s) to allow the particulate laden gases to bypass the filter fabric under high temperature conditions if permit allows.
11. A PLC based control system to manage the filter fabric cleaning cycle and isolate individual compartments for maintenance.
12. Individual compartment Magnehelic gauges to indicate the pressure differential across the tube sheet and filter fabric. This is for field observation.
13. Photohelic Pressure Switch/Gauge to initiate cleaning cycle by monitoring the differential across the fabric filter.

The compressed air filter fabric cleaning system consists of a common compressed air manifold for each row of compartments, a pulse diaphragm valve for each row of filter bags that is attached to the compressed air header, a solenoid valve for each pulse valve, a blowpipe for each row of bags that is attached to the pulse valve, and a pressure relief and a condensate drain valve attached to the compressed air manifold. A differential pressure switch or timer activates the PLC controls for opening and closing of the poppet dampers and activating the fabric cleaning cycle. The fabric cleaning cycle will clean one compartment at a time in a predetermined sequence. This sequence can be changed within the PLC. Once the cleaning cycle is activated the PLC closes the outlet poppet damper on a pre-selected compartment and a pre-determined dwell time occurs to allow particulate to settle and gas hydraulics to calm. The PLC also sends a signal to the compartment sequence panel that controls the signals to the individual solenoid valves controlling the diaphragm pulse valves. The pulse valves on the compartment are opened for a short time (milliseconds) that sends a burst of compressed air down the blowpipe, located above a row of filter bags, into the filter bag removing the collected particulate. Each pulse valve is sequenced on and off in turn for the selected compartment. After cleaning the compartment outlet poppet damper is opened placing the compartment on line. The next compartment is cleaned in the same manner until all compartments have been cleaned. All time elements can be changed either in the PLC or compartment sequence panel.

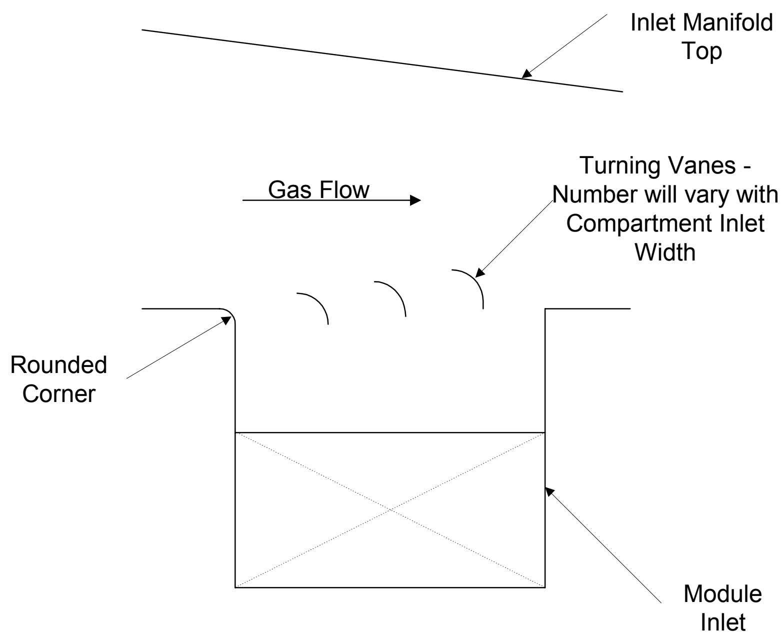
The PLC is capable of providing fabric cleaning based on time or differential pressure across the PJFF through the PLC based on-screen selection. Manual cleaning is also available. The compartment sequence panel contains a selector switch to isolate that compartment for maintenance with on-screen indication.

The PLC can be interfaced with the plant DCS using a Gateway Interface Device. The Gateway, supplied or specified by the Client, and software programming and mapping supplied and coordinated by Beaumont, provides the interface to the Plant DCS System if required.

Beaumont has devised a design based on their years of experience that provides optimum distribution of both gas and dust within the fabric filter. We have found that if the gas/dust is closely controlled from the initial entrance into the fabric filter inlet manifold then optimum uniform distribution can be achieved to each compartment and each bag.

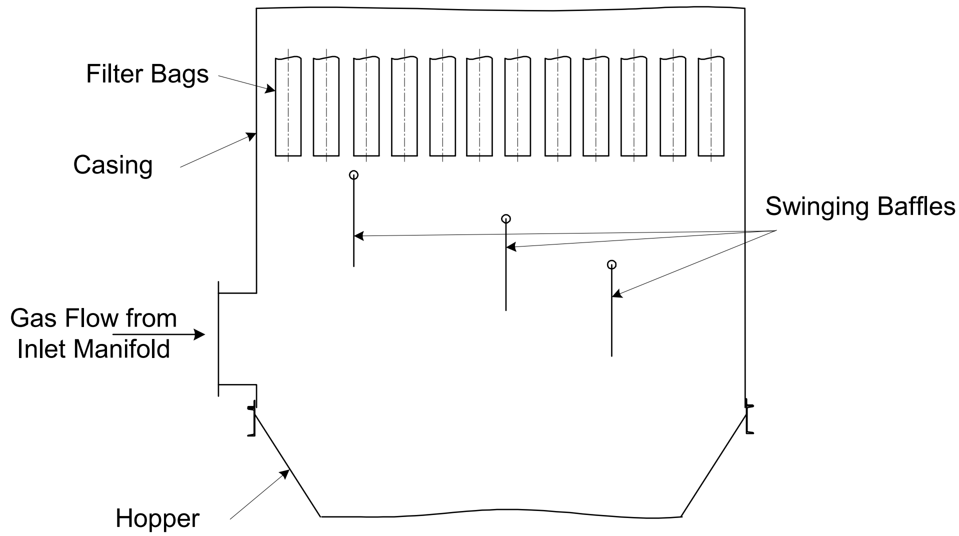
Dust tends to settle towards the bottom of the duct/manifold more than gas due to its greater density. Proper selection of gas velocity assists in maintaining the dust more uniformly disbursed in the gas stream. A tapered inlet manifold is utilized to maintain the proper gas velocity as a constant as gas/dust is distributed to compartments located along the manifold.

The constant gas velocity assists in maintaining a uniform dust/gas mixture. Curved baffles are utilized at the gas/dust entrance to the compartment from the inlet manifold. These baffles are located low in the inlet manifold, where dust particles tend to accumulate, and act as impingers to force the dust into the compartment inlet. Gas is also channeled into the compartment inlet. Without the impingers the dust particles will continue along the inlet manifold to the rear compartments due to their mass and inertia.



The upstream side of the compartment inlet is rounded to prevent gas separation as the gas/dust turns the 90^{o} required to direct the mixture from the inlet manifold to the compartment. Refer to Figure No. 2. The gas and dust would create a circular, whirling motion as it enters the compartment if the impingers and rounded edge were not utilized. This condition would force the gas and dust to one side of the compartment inlet and create an uncontrollable distribution of the dust and gas. It would also create pockets of high gas velocity that can be very detrimental to bag life due to dust impingement and bag movement.

The above design provides a uniform gas velocity and gas/dust distribution as the composition enters the compartment. A large area is provided beneath the filter bags to reduce the gas and dust velocity to a low level and allow the gas/dust to expand over the compartment cross sectional area and to the filter bags. Several swinging baffles are provided below the filter bags to assist the gas/dust distribution and expansion process.



End Elevation
Compartment Baffle Arrangement

Fabric Filter Dust Cake

The filter fabric, in itself, does not provide the efficient removal of particulates. It is necessary to establish and maintain a dust cake to attain high efficiency particulate removal rates and provide for extended fabric life. A portion of the dust cake is permanently attached to the filter fabric and is never removed. This permanent dust cake is established early in the life of filter fabric, therefore, care is required in the start-up and initial operation of the fabric filter. Diatomaceous earth, coal fired fly ash or other acceptable materials are utilized to pre-coat the filter fabric prior to the first introduction of gases as a preparatory step in establishing a good ash cake.

The temporary dust cake can be as thin as 1/16" to as thick as ½" or more depending on the size and shape of the particulate. The RAP Process creates a very desirable particle as the particle is large, average 45 microns, and has a large surface area. This particle builds a thick, very porous dust cake on the filter fabric that provides low-pressure loss.

The systems are normally cleaned using a combination of on-line and off-line cleaning using an air pulsing system. We prefer to use on-line cleaning until the pressure drop increases beyond the maximum pressure drop design point. At this point we remove one compartment at a time and clean them off-line.

Fabric Cleaning Cycle

Initiation of cleaning pulse fabric filters may be by either differential pressure across the filter or by a pre-determined time interval. Each method of fabric cleaning initiation produces an overall pressure drop vs time curve that is quite different. Initiation of cleaning by filter differential pressure produces a pressure/time curve that is saw-toothed and a major difference in maximum and minimum overall pressure drop across the filter. Initiation of cleaning by time produces a pressure/time curve that is fairly smooth and confined to a narrow band of maximum and minimum overall pressure drop across the filter.

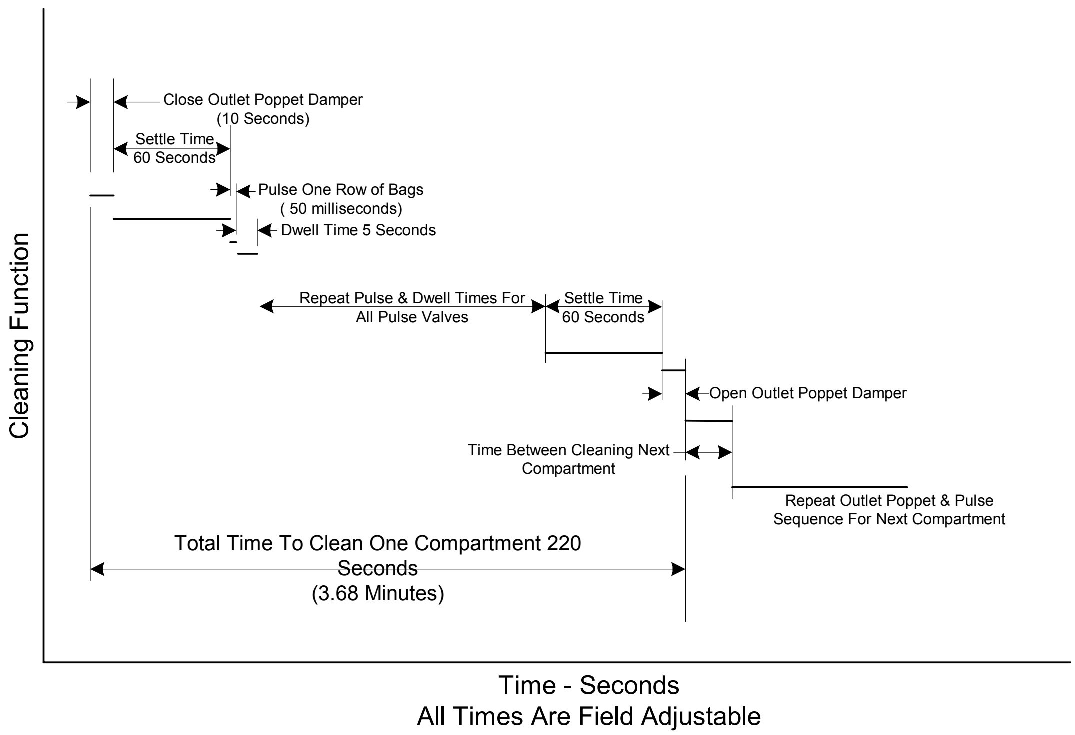
Since time based fabric cleaning produces a narrow band of maximum and minimum pressure drop there is less potential to upset the process being ventilated due to major pressure drop fluctuations. There are practical applications for each method of initiating fabric cleaning. Processes that produce steady state off-gas conditions are best suited to time based fabric cleaning. Processes that are constantly changing or have the requirement for turndown require pressure initiated fabric cleaning. If time based fabric cleaning is utilized for the latter type processes the risk of over cleaning the fabric is high when turndown or reduced flow conditions occur.

The time and sequence of events to clean the fabric in an individual compartment does not vary for either fabric cleaning initiation method. The major difference in the two cleaning methods is as follows:

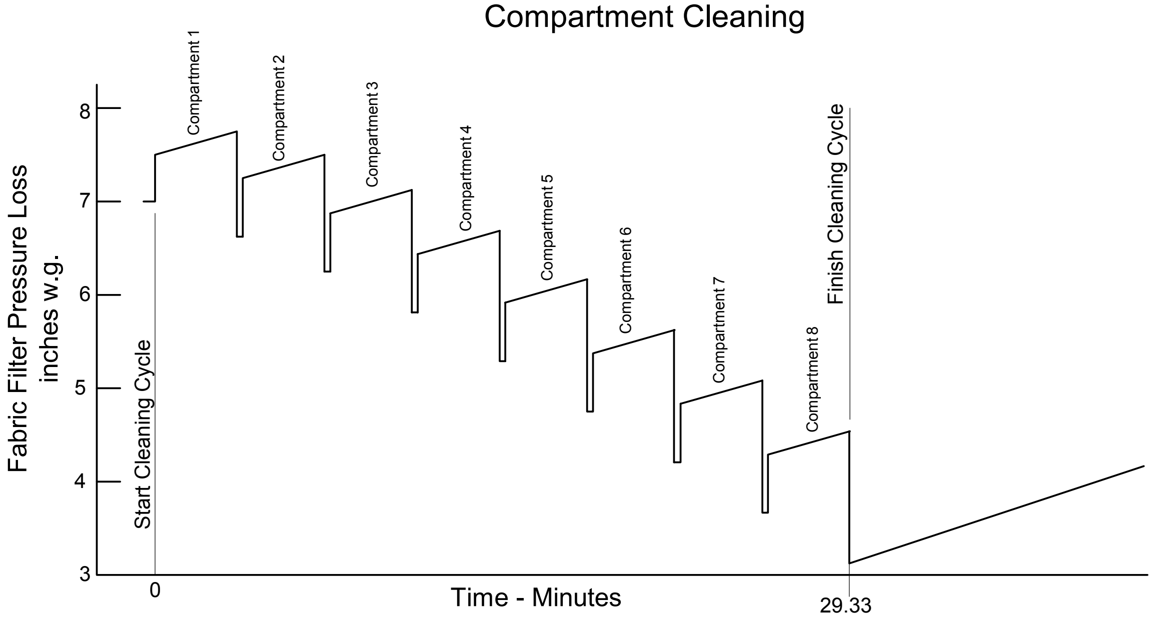
- Time based fabric cleaning is based on setting a pre-determined cleaning cycle to initiate cleaning on a set time basis; i.e. once an hour, twice an hour, etc (capable of field adjustment). Once the cleaning cycle is initiated each compartment is cleaned in turn is until all compartments are cleaned.
- Differential pressure initiated cleaning is based on initiating the cleaning cycle when the fabric filter pressure loss reaches a pre-determined value (field adjustable). Once the cleaning cycle is initiated each compartment is cleaned in turn is until all compartments are cleaned.

Figure Nos. 1 and 2 follow to depict the difference in the fabric filter pressure drop curve during both types of fabric cleaning initiation.

It will be noted that the change in fabric filter pressure loss based on time is a small value and the system I.D. fan should have no problem in following the pressure changes during cleaning. BES personnel have experience with hundreds of systems at flue gas flow rates ranging from a few hundred acfm to 3.8 million acfm. These systems were equipped with I.D. fans, pressure fans and a combination of booster fans and I.D. and pressure fans. In no case was there ever a problem in the system fan controls following the fabric filter pressure changes and causing system pressure or flow upsets.

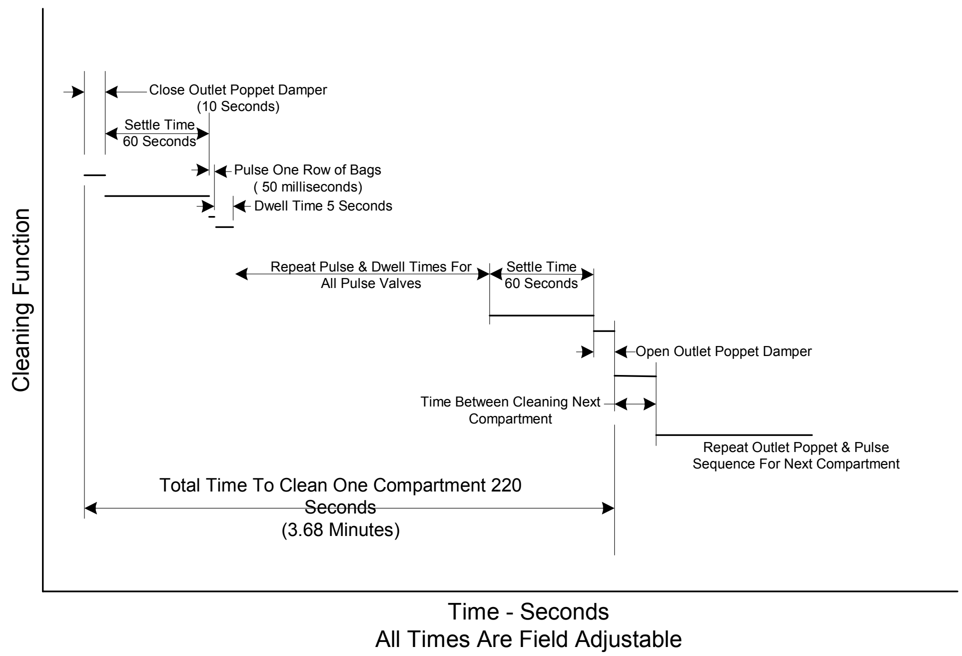


Typical Time Cycle For One
Compartment Cleaning

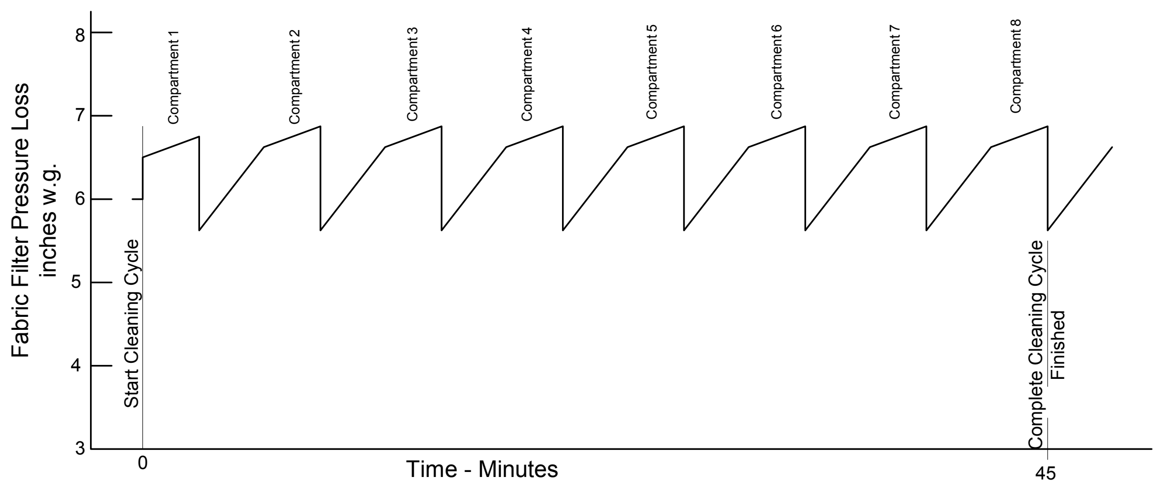


Typical Pressure Drop Cycle For
All Compartments To Clean

Figure 1



Typical Time Cycle For One Compartment Cleaning



Typical Pressure Drop Cycle For All Compartments To Clean

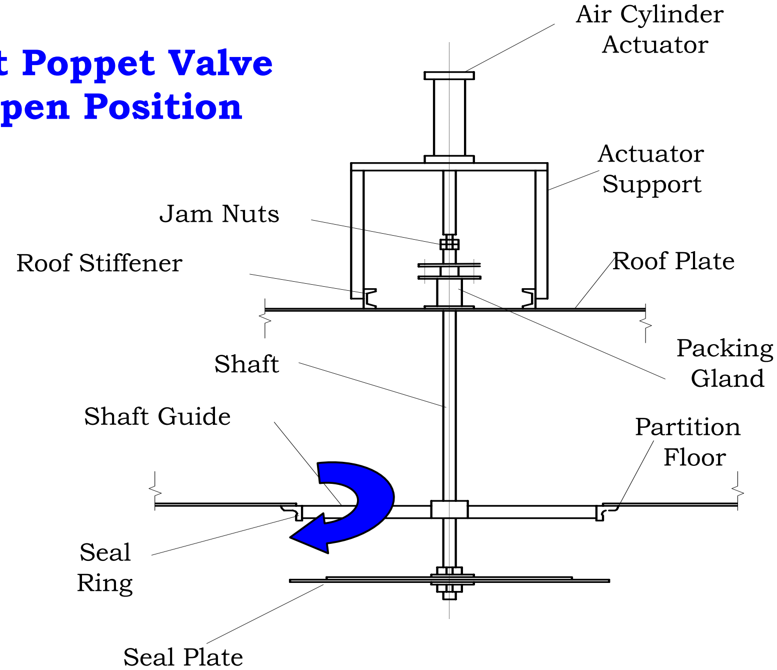
Figure 2

Fabric Compartment Isolation

Isolation of individual compartments is required for *Inspections*, *Bag Repair* or other routine maintenance requirements.

Flow through a compartment is controlled by an outlet poppet valve. This valve is pulled upward to close the opening between the compartment outlet and the gas flow outlet exiting the baghouse.

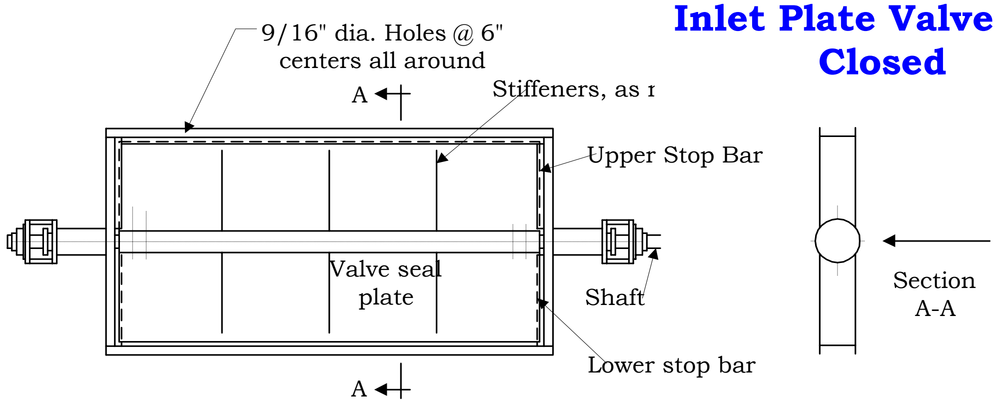
Outlet Poppet Valve Open Position



Upon closing the valve, the compartment is under a negative pressure (assumes fan follows baghouse) making it difficult to open the access door.

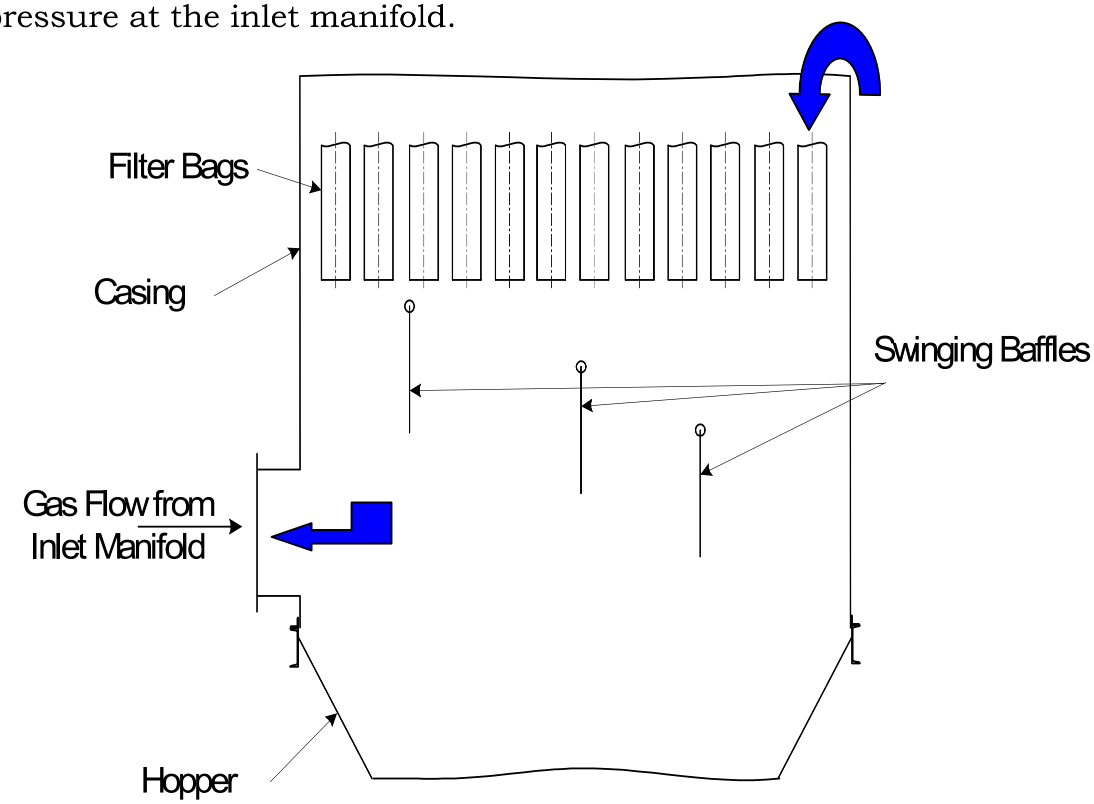
The manual inlet valve is now closed to reduce the negative pressure (from the inlet manifold) allowing to open the walk in plenum door (or lift off roof).

Inlet Plate Valve Closed



The manual inlet valve is designed not to seal tightly but allows some gas from the compartment back into the inlet manifold. You should be able to hear a hissing noise.

After opening the plenum door we can now open the manual inlet valve slightly to ventilate the compartment, by air flowing backward through the bags and out the inlet valve. The gas will flow from ambient pressure at the door to the negative pressure at the inlet manifold.



End Elevation
Compartment Baffle Arrangement

The outlet poppet valve is designed for a positive seal. This valve should always fail open, on a power or pneumatic air failure.

The outlet valve is roof mounted with roof access walkways and optional enclosure. It is equipped with a manual mechanical lockout for locking it in the closed position during on line maintenance work.

Bag failures do not happen very often. The opacity stack monitor will indicate a problem. Opening and closing each compartment, until the opacity monitor returns to normal can locate the problem compartment. Upon locating the problem compartment, it should be isolated, ventilated and the leaking bag hole plugged or removed and plugged. It does not require changing of the bag.

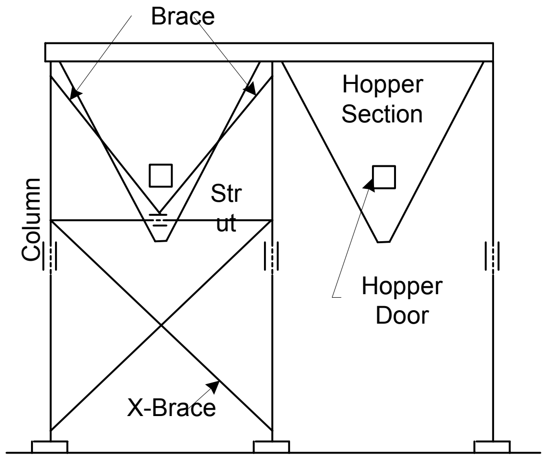
Beaumont Environmental Systems

Erection Sequence

Pulse Fabric Filter

----

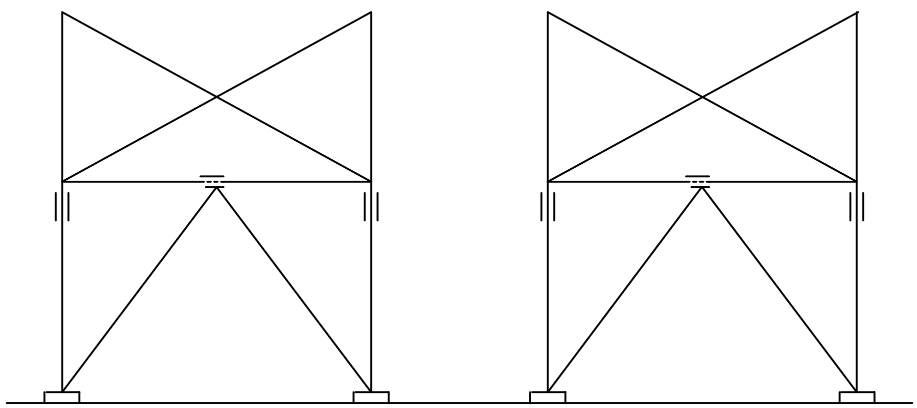
(1) Support Structure
(2) Setting Compartment Pieses
(3) Center Manifold
(4) Details
(5) Details



Elevation in Direction of Gas Flow

One Hopper Section Will Be Comprised of two, Three, or Four Individual Hoppers (two shown) depending on total number of compartments.

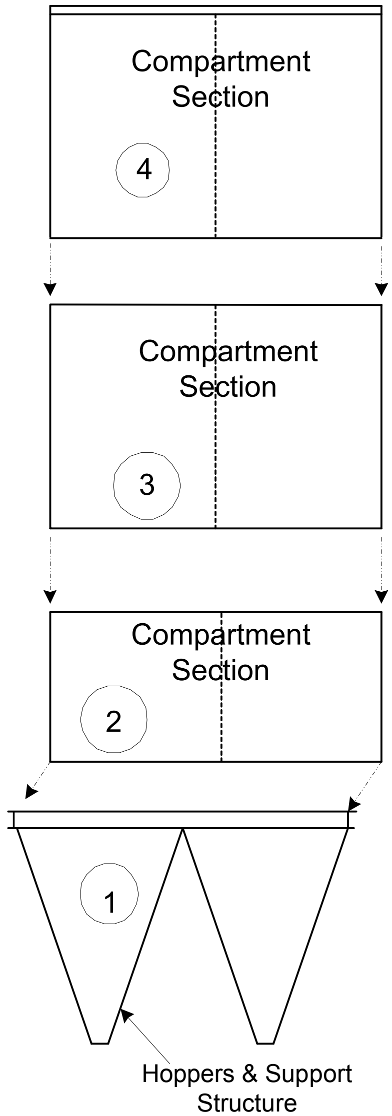
Step 2
Lift Preassembled Hopper Sections From Truck & Set on Support Steel. Align & Field Bolt to Support Steel



End Elevation

Step 1
Erect Structural Steel Pieces, Level, Plumb & Field Bolt

Support Structure & Hopper Erection

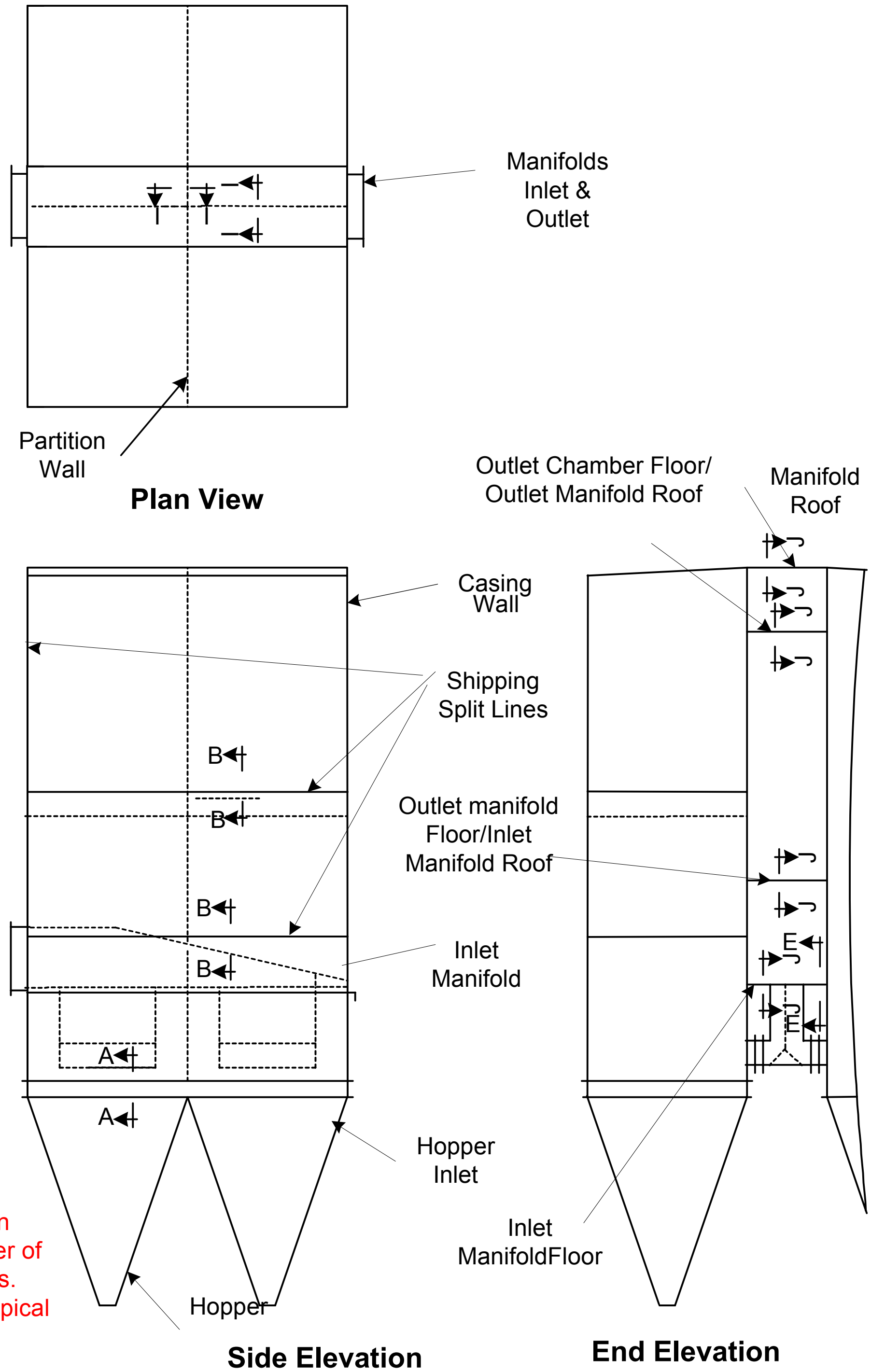


Side Elevation

Note: Refer to Erection Instructions for Number of Compartment Sections. Two Are Shown as Typical

Compartment Erection Sequence

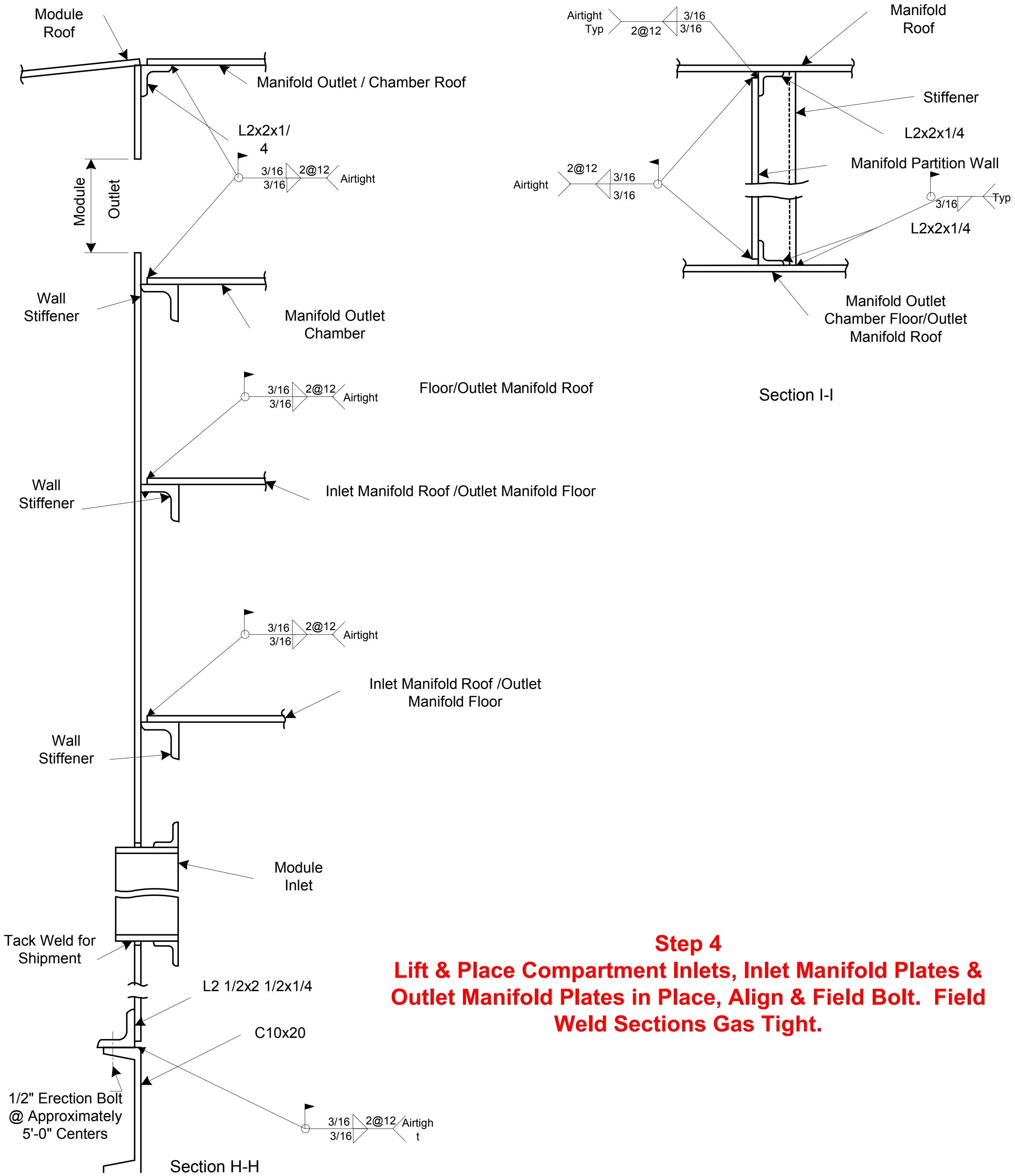
Step 3 - Lift Compartment Sections From Truck In Sequence, Set in Place, Align & Set Field Erection Bolts



Note: Refer to Erection Instructions for Number of Compartment Sections. Two Are Shown as Typical

Step 4

Lift & Place Compartment Inlets, Inlet Manifold Plates & Outlet Manifold Plates in Place, Align & Field Bolt. Field Weld Sections Gas Tight.

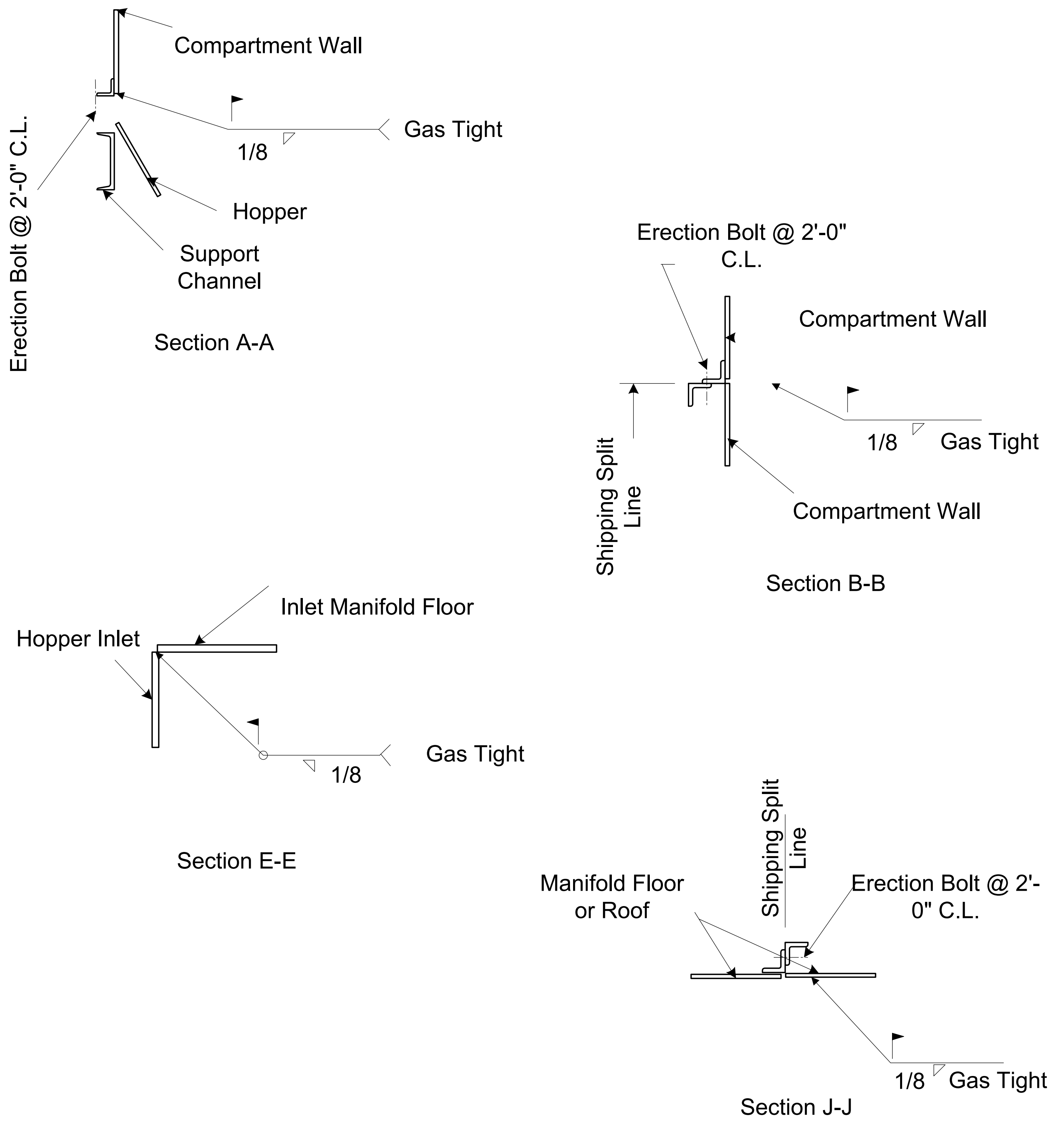


Step 4
Lift & Place Compartment Inlets, Inlet Manifold Plates & Outlet Manifold Plates in Place, Align & Field Bolt. Field Weld Sections Gas Tight.

Beaumont Environmental Systems

Design Manual - Pulse Fabric Filter

Erection Details



Beaumont Environmental Systems

Design Manual - Pulse Fabric Filter

Erection Details