ChemFlare™ Flared PFA & FEP Tubing Manual
Section 1: Material Properties of PFA

PFA (PERFluoRoAlkoxy)

Description and Performance
PFA is a fluoropolymer resin or fluorocarbon. Fluorocarbons are those polymers in which the carbon atoms of the polymer are bonded fluorine atoms which encircle the carbon backbone of the PFA polymer. PFA is a fluorinated polymer with the same chemical resistance and high temperature performance as PTFE, has much lower porosity than PTFE which makes it translucent instead of opaque white and is mechanically stronger. PFA can be extruded to make pipe or tubing, or injection molded for tube fittings and has application temperature to 150°C (300°F). PFA is the best choice of fluoropolymer tubing.

Molecular Formula
\[-\{(CF_2CF_2)nCF_2CF_m\}x\]

Chemical and Thermal Resistance
The carbon-fluorine single bond is among the strongest known and results in PFA being virtually chemically inert and also accounts for the excellent thermal properties of PFA.

In general, PFA is inert to virtually all chemicals. It is chemically resistant to strong mineral and oxidizing acids, bases, halogens, metal salt solution, organic acids and anhydrides. Aromatic and aliphatic hydrocarbons, alcohols, aldehydes, ketones, ethers, amines, esters, chlorinated compounds and common cleaning solvents have little effect. PFA is not inert to molten alkali metals, fluorine at elevated temperatures and certain complex halogenated compounds at elevated temperatures and pressures.

Creep Resistance
Of all the fluorocarbon materials, PFA displays the highest resistance to creep.

Absorption and Permeation
Absorption in PFA is unusually low and a chemical reaction between the resin and other substances is rare.

Specifications and Physical Properties
PFA is manufactured from 100% Virgin PFA complying with ASTM D 6867-03 and ASTM D 3307. PFA tubing is FDA approved for repeated contact with food (21 CFR 177.1550), meets the requirements for USP Class VI materials, resists combustion, does not promote flame spread and it is UL 94 VO rated. NSF 51, 61 and 372 Certified.

PFA tube is tested as per ASTM D2837. PFA fittings for flared connection are injection molded and tested per ASTM D3307-10 Type I.

<table>
<thead>
<tr>
<th>PFA Physical Properties</th>
<th>ASTM Test</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Service Temperature</td>
<td>–</td>
<td>305°C (580°F)</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>D792</td>
<td>2.15</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>D1708</td>
<td>4200 PSI</td>
</tr>
<tr>
<td>Elongation</td>
<td>D638</td>
<td>400%</td>
</tr>
<tr>
<td>Flex Modulus</td>
<td>D790</td>
<td>90,000 PSI</td>
</tr>
<tr>
<td>MIT Flex Life</td>
<td>D2176</td>
<td>500,000 +</td>
</tr>
<tr>
<td>Hardness</td>
<td>D2240</td>
<td>D60</td>
</tr>
</tbody>
</table>
FEP (FLUORINATED ETHYLENE PROPYLENE)

Description & Performance
FEP is a fluoropolymer resin or fluorocarbon and is a copolymer of hexafluoropropylene and tetrafluoroethylene. Compared to PFA, FEP has similar chemical resistance, similar low porosity and translucency, but mechanical properties and temperature ratings are not as good.

Molecular Formula
-\[(\text{CF}_2\text{CF}_2)_n\text{CF}_2\text{CF}_m\]-

FEP tubing is not as expensive as PFA and is an economical choice for applications requiring chemical resistance in combination with broad temperature exposure. FEP tubing is usually chosen for the containment or outer tubing of dual containment PFA tube systems. The outstanding UV transmission rate of FEP makes it a good choice for UV water purification systems.

FEP tubing has low permeability, moisture absorption nearly zero and superior electrical insulation properties.

Specifications & Physical Properties
FEP tubing is manufactured from 100% Virgin FEP complying with ASTM D3296-98. FEP tubing is FDA approved for repeated contact with food (21 CFR 177.1550), meets the requirements for USP Class VI materials. It resists stress cracking, combustion, does not promote flame spread and it is UL 94 VO rated. FEP tubing is tested per ASTM D2837. NSF 51, 61 and 372 Certified.

FEP Physical Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>ASTM Test</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Service Temperature</td>
<td>D792</td>
<td>205°C (400°F)</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>D792</td>
<td>2.15</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>D1708</td>
<td>4000 PSI</td>
</tr>
<tr>
<td>Elongation</td>
<td>D638</td>
<td>400%</td>
</tr>
<tr>
<td>Flex Modulus</td>
<td>D792</td>
<td>90,000 PSI</td>
</tr>
<tr>
<td>MIT Flex Life</td>
<td>D2176</td>
<td>200,000 +</td>
</tr>
<tr>
<td>Hardness</td>
<td>D2240</td>
<td>D57-60</td>
</tr>
</tbody>
</table>
Section 2: Formulas for System Designing

Sizing of Tube Diameters

Sizing a thermoplastic tube system is similar to a piping system. Flow of fluid in a tubing system follows the following formulae:

\[ Q = V \times A \]

\[ Q = \text{volume of flow} \]

\[ V = \text{flow velocity} \]

\[ A = \text{Inside cross sectional area of the tube} \]

In using the above formulae ensure that you are using compatible units (ie \( Q = \text{ft}^3/\text{sec} \), \( V = \text{ft/sec} \) and \( A = \text{ft}^2 \)). By substituting \( \pi d^2/4 \) for \( A \) and solving for \( d \) and adjusting for units of measurement you can use any of the following formulae to determine a preliminary inside diameter (inches) of the tube. Inside diameters of tubes are shown in the chart on page 7.

\[ d_i = 0.74 \sqrt{\frac{Q_i}{v_1}} \quad d_i = 1.41 \sqrt{\frac{Q_2}{v_2}} \quad d_i = 0.639 \sqrt{\frac{Q_3}{v_3}} \]

\( d_i \) = inside tube diameter (inches) 
\( Q_i \) = flow volume (m³/h) 
\( v_1 \) = flow velocity (m/s)

\( d_i \) = inside tube diameter (inches) 
\( Q_2 \) = flow volume (l/s) 
\( v_2 \) = flow velocity (m/s)

\( d_i \) = inside tube diameter (inches) 
\( Q_3 \) = flow volume (USGPM) 
\( v_3 \) = flow velocity (ft/sec)

Typical values for flow velocities for fluids are:

Suction side of pump \( v \sim 0.5 \) to \( 1.0 \) m/s (1.5 to 3 ft/sec)

Pressure side of pump \( v \sim 1.0 \) to \( 3.0 \) m/s (3 to 10 ft/sec)

Typical values for flow velocities for gases are \( v \sim 10 \) to \( 30 \) m/s (30 to 100 ft/sec)
Section 2: Formulas for System Designing

Calculating System Pressure Drop
For a simplified approach to calculating pressure drop across an entire pressure tubing system consisting of tube, fittings and valves use the following equation:

\[ \Delta P_{\text{total}} = \Delta P_{\text{tube}} + \Delta P_{\text{fittings}} + \Delta P_{\text{valves}} \]

**Pressure Drop for Tube (\(\Delta P_{\text{tube}}\))**

To determine the pressure drop for tube the Hazen-Williams formula is valid for turbulent flow.

\[ h_f = 0.2083 \left( \frac{100}{C} \right)^{1.85} \times \left( \frac{Q^{1.85}}{d^{4.87}} \right) \]

Where:
- \( h_f \) = friction head (ft of water/100 ft of tube)
- \( Q \) = flow rate (USGPM)
- \( d \) = inside diameter of tube (in), See page 7
- \( C \) = flow coefficient = 155 for PFA tube and fittings

For pressure loss in psi multiply \( h_f \) by 0.4335 (ie: 1 foot of waterhead = 0.4335 psi). Therefore:

\[ \Delta P_{\text{tube}} (\text{psi}) = h_f \times 0.4335 \]

\[ \Delta P_{\text{tube}} (\text{psi}) = 0.0401 \frac{Q^{1.85}}{d^{4.87}} \]  \( \text{for } C = 155, \text{ [pressure loss (psi/100ft of tube)]} \)

**Pressure Drop for Fittings (\(\Delta P_{\text{fitting}}\))**

The Pressure losses of fittings can be calculated as equivalent lengths of tube. Add up the number of fittings and multiply by the equivalent lengths of tube in the chart below. Add this total length to the length of tube used to calculate the pressure loss in the tube (above).

<table>
<thead>
<tr>
<th>Fitting</th>
<th>1/4&quot;</th>
<th>3/8&quot;</th>
<th>1/2&quot;</th>
<th>3/4&quot;</th>
<th>1&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>90° Elbow</td>
<td>0.04</td>
<td>0.06</td>
<td>0.09</td>
<td>0.16</td>
<td>0.22</td>
</tr>
<tr>
<td>45° Elbow &amp; Sweep Elbow</td>
<td>0.20</td>
<td>0.33</td>
<td>0.49</td>
<td>0.81</td>
<td>1.14</td>
</tr>
<tr>
<td>Tee (Flow through Run)</td>
<td>0.03</td>
<td>0.04</td>
<td>0.06</td>
<td>0.11</td>
<td>0.15</td>
</tr>
<tr>
<td>Tee (Flow through Branch)</td>
<td>0.78</td>
<td>1.26</td>
<td>1.88</td>
<td>3.13</td>
<td>4.38</td>
</tr>
</tbody>
</table>

**Pressure Drop for Valves (\(\Delta P_{\text{valves}}\))**

To determine the pressure drop across a valve you require the valve coefficient of flow or \( C_v \) value. The \( C_v \) value represents the flow of water in U.S. gallons per minute with one psi pressure drop across the valve. For Chemline Valves these are available from our data pages. Use the following equation to determine the pressure drop across each valve in the system.

\[ \Delta P_{\text{valves}} = \text{s.g.} \left( \frac{Q}{C_v} \right)^2 \]

- \( Q \) = actual flow (USGPM)
- \( \Delta P_{\text{valves}} \) = pressure drop (psi)
- s.g. = liquid specific gravity
Section 2: Formulas for System Designing

Component Operating Pressure
Operating pressure for water at 20°C is based on the material’s strength. Here the calculation involves using the material’s reference strength expressed in psi and that material’s applicable safety factor to determine the allowable operating pressure in the charts below.

Pressure vs. Temperature

**PFA Tubing**

![Graph showing the relationship between temperature and operating pressure for PFA tubing.](image)

**Warning:** Not for use in applications exceeding 120°C (248°F).

Pressure ratings based on 0.047” wall for 1/4” tubing and 0.062” wall for 3/8”, 1/2”, 3/4” and 1” tubing.

**PFA Tube Pressure Ratings/Dimensions**

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Tubing OD</th>
<th>Wall Thickness</th>
<th>Tubing ID</th>
<th>Working Pressure PSI @ 22°C (72°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TT250-047</td>
<td>1/4&quot;</td>
<td>0.047&quot;</td>
<td>0.156&quot;</td>
<td>352</td>
</tr>
<tr>
<td>TT375-062</td>
<td>3/8&quot;</td>
<td>0.062&quot;</td>
<td>0.251&quot;</td>
<td>310</td>
</tr>
<tr>
<td>TT500-062</td>
<td>1/2&quot;</td>
<td>0.062&quot;</td>
<td>0.376&quot;</td>
<td>232</td>
</tr>
<tr>
<td>TT750-062</td>
<td>3/4&quot;</td>
<td>0.062&quot;</td>
<td>0.626&quot;</td>
<td>155</td>
</tr>
<tr>
<td>TT1000-062</td>
<td>1&quot;</td>
<td>0.062&quot;</td>
<td>0.876&quot;</td>
<td>116</td>
</tr>
</tbody>
</table>

**Vacuum Service**
Chemline recommends using 0.062” wall tubing at ambient temperature, with minimum bends for service down to –7.5 psi of vacuum.
Section 2: Formulas for System Designing

Calculating Tubing Supports
To provide trouble-free service, long lengths of PFA/FEP tubing must be supported. Supporting the tube minimizes the stress and strain within the tube wall as well as accommodates drainability. Tube support distances are dependent on the tubing size, the specific gravity of the fluid being transported through the tube, the average temperature of the tubing and the acceptable amount of vertical tubing deflection between supports. This can be done from basic principles using the following formulae for a simply supported beam. Note: Deflection should be less then L/200.

\[
D = \frac{5wL^4}{384EI}
\]

\(D\) = Deflection (inches)
\(E\) = Modulus of elasticity of the material (psi)
\(I\) = Moment of inertia of the tube (in\(^4\))
\(w\) = Weight per unit length of tube and liquid (lbs/in)
\(L\) = Length between supports (inches)

Substituting L/200 for D in the above equation you get:

\[
L = \left(\frac{0.384EI}{w}\right)^{1/3}
\]

Formula for the moment of inertia \(I\) for the tube is:

\[
I\ (\text{inches}^4) = \frac{\pi(R_0^4 - R_1^4)}{4}
\]

Values for tubing weights, weight of water, \(I\) (moment of Inertia) and \(E\) (modulus of elasticity) are shown in the table below:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Weight of Tubing (lbs/in)</th>
<th>Weight of Water (lbs/in)</th>
<th>(I) (in(^4))</th>
<th>(E) (22^\circ\text{C}) (72(^\circ\text{F})) (psi)</th>
<th>(E) (82^\circ\text{C}) (180(^\circ\text{F})) (psi)</th>
<th>(E) (148^\circ\text{C}) (300(^\circ\text{F})) (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TT250-047</td>
<td>0.0028</td>
<td>0.0007</td>
<td>0.00016</td>
<td>90,000</td>
<td>42,500</td>
<td>18,000</td>
</tr>
<tr>
<td>TT375-062</td>
<td>0.0048</td>
<td>0.0018</td>
<td>0.0008</td>
<td>90,000</td>
<td>42,500</td>
<td>18,000</td>
</tr>
<tr>
<td>TT500-062</td>
<td>0.0067</td>
<td>0.0039</td>
<td>0.0021</td>
<td>90,000</td>
<td>42,500</td>
<td>18,000</td>
</tr>
<tr>
<td>TT750-062</td>
<td>0.0105</td>
<td>0.0109</td>
<td>0.008</td>
<td>90,000</td>
<td>42,500</td>
<td>18,000</td>
</tr>
<tr>
<td>TT1000-062</td>
<td>0.0172</td>
<td>0.0217</td>
<td>0.0203</td>
<td>90,000</td>
<td>42,500</td>
<td>18,000</td>
</tr>
<tr>
<td>TT1250-075</td>
<td>0.0217</td>
<td>0.0343</td>
<td>0.0479</td>
<td>90,000</td>
<td>42,500</td>
<td>18,000</td>
</tr>
</tbody>
</table>

Note: For dual containment calculation, use containment tube size and both tube weights and fluid weight.
Example Calculation

For Dual Containment tubing .750" containment x .500" carrier

\[ w = \text{Weight per unit length} = (.750 \text{ tube}) \times .0105 + (.500 \text{ tube}) \times .0067 + (\text{water}) \times .0039 = 0.0211 \text{ lbs/in} \]

\[ I = \text{Moment of Inertia of .750 tube} = 0.008 \text{ in}^4 \]

\[ E = \text{Modulus of elasticity} @ 22°C (73°F) = 90,000 \text{ psi} \]

\[ L = \left( \frac{0.384 \times 90,000 \times 0.008}{0.0211} \right)^{1/3} \]

\[ L = 23.57 \text{ inches} \]

When using fluid with a specific gravity greater than 1.0 (water) multiply the support distance by the appropriate factor to acquire the adjusted support spacing length.

<table>
<thead>
<tr>
<th>Specific Gravity</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>1.25</td>
<td>0.93</td>
</tr>
<tr>
<td>1.50</td>
<td>0.87</td>
</tr>
<tr>
<td>1.75</td>
<td>0.83</td>
</tr>
<tr>
<td>2.00</td>
<td>0.79</td>
</tr>
<tr>
<td>2.25</td>
<td>0.76</td>
</tr>
<tr>
<td>2.75</td>
<td>0.71</td>
</tr>
<tr>
<td>3.00</td>
<td>0.69</td>
</tr>
</tbody>
</table>
Section 3: Assembly & Installation Instructions

General
PFA and FEP are chemically inert and will not cause injury in normal handling. Tubing properties are not affected by storage time and have virtually unlimited shelf life.

Proper installation is not complete without ensuring that tensile loads, side loads, kinking, flattening, potential abrasion, thread damage or damage to sealing surfaces are corrected or eliminated.

The tubing assembly should be routed in such a manner so if a failure does occur, the escaping media will not cause personal injury or property damage. If this is not possible or practical then Chemline’s dual containment PFA/FEP system should be used.

Caution: If fluid media comes in contact with hot surfaces, open flame or sparks, a fire or explosion may occur.

PFA and FEP tubing will withstand virtually all commercial cleaning agents and bactericides without danger of corrosion (as with metals) or oxidation (as with rubber).

Component Inspection
Prior to assembly, a careful examination of the tubing and fittings should be performed. All components should be checked for correct style, size, catalog number, and length. The tubing should be examined for cleanliness, obstructions, blisters, cover looseness, kinks, cracks, cuts or any other visible defects. Fitting sealing surfaces should be inspected for burrs, nicks, corrosion or other imperfections.

Do not reuse any tube fitting that has blown off or pulled off a tube. Complete tubing assemblies may only be reused after proper inspection. Do not assemble fittings to any previously used hydraulic tubing that was in service, for use in a fluid power application. Do NOT use any component that displays any signs of non-conformance.

Tubing
Tubing should be stored in original packaging or a plastic bag and should be loosely coiled or laid straight on a clean dry shelf, free from contact with painted surfaces, rubber, oils, and greases. Do not hang tubing over a sharp edge.

When tubing is removed from its packaging, storage conditions should be designed to avoid airborne contamination, dust and water condensation. Care should be taken when handling tubing to avoid kinking.

For reeled lengths of tubing, the tubing reel should be support off the ground with a rod through the center hole of the reel. The tubing reel should be allowed to turn freely as the tubing unreels during installation keeping the tubing from kinking or twisting.

Tubing must not be allowed to scrape on the ground or other rough surface during unreeling / installation to avoid possible damage and should be unreeled directly into supports / trays if possible.

It may be necessary to restrain, protect, or guide the tubing to protect it from damage by unnecessary flexing, pressure surges, and contact with other mechanical components. Care must be taken to insure such restraints do not introduce additional stress or wear points. Clips and restraints must be used to hold tubing directly into supports such as cable trays, at approximately every 2 meters. Care must be taken when bending tubing inside supports/trays. Tubing must be clipped down at the start of, in the middle of, and at the end of the bend. Do not overlap with other tubing. Spacing between parallel tubing runs should be as much as necessary to operate clips or restraints without interference. All changes in direction or elevation should also be treated as bends and the tubing should be supported as much as possible during tubing transitions. Continuous support should be used for tube support. When this is not possible, clips shall be used as per support spacing calculations (see page 8).

Tubing assembly installation must be such that relative motion of machine components does not produce twisting.

Minimum Bend Radius
Installation of tubing at less than the minimum listed bend radius may significantly reduce the tubing life. Particular attention must be given to preclude sharp bending at the tubing to fitting juncture. Any bending during installation at less than the minimum bend radius must be avoided. If any tubing is kinked during installation, the tubing must be discarded. For dual containment tubing installation refer to the bend radius of the containment (outer) tubing. Minimum Bend Radius’s are shown in the table below.

<table>
<thead>
<tr>
<th>Minimum Bend Radius</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Order Size</th>
<th>Tube Outside Diameter</th>
<th>Wall Thickness</th>
<th>Bend Radius</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inch / mm</td>
<td>Inch / mm</td>
<td>Inch / mm</td>
</tr>
<tr>
<td>1/4”</td>
<td>0.250 / 6.35</td>
<td>0.047 / 1.200</td>
<td>0.75 / 19.05</td>
</tr>
<tr>
<td>3/8”</td>
<td>0.375 / 9.52</td>
<td>0.062 / 1.580</td>
<td>1.0 / 25.4</td>
</tr>
<tr>
<td>1/2”</td>
<td>0.50 / 12.70</td>
<td>0.062 / 1.580</td>
<td>2.0 / 50.8</td>
</tr>
<tr>
<td>3/4”</td>
<td>0.75 / 19.05</td>
<td>0.062 / 1.580</td>
<td>6.0 / 152.4</td>
</tr>
<tr>
<td>1”</td>
<td>1.00 / 25.40</td>
<td>0.062 / 1.580</td>
<td>15.0 / 381.0</td>
</tr>
</tbody>
</table>
**Section 3: Assembly & Installation Instructions**

**Tubing and Fitting Assembly**
Chemline fittings must only be used with Chemline tubing that is specifically listed for that fitting in the Chemline literature. Flare Chemline tubing only with the listed flaring mandrels in accordance with Chemline published instructions. Do not connect another manufacturer’s fitting to any Chemline tubing. Do not use any Chemline fitting part except with the correct Chemline mating part, in accordance with Chemline published instructions. Heated flaring should only be attempted with tubing that has not been exposed to chemicals.

To prevent the possibility of problems such as leakage at the fitting or system contamination, it is important to completely remove all debris from the cutting operation before installation of the fittings. The Chemline published instructions must be followed for assembling the fittings on the tubing (see Section 4: Flaring PFA/FEP Tubing).

Proper physical installation of the tubing assembly requires a correctly installed port connection insuring that no twist or torque is transferred to the tubing when the fittings are being tightened or otherwise during use.
**Section 4: Flaring PFA/FEP Tubing**

**General**
The hot flaring process provides a permanent expansion (flare) of the tubing end, allowing insertion of the Chemflare™ fitting body. Proper tube flaring and Chemflare™ fitting assembly results in secure tubing connections. Chemline recommends this procedure for flaring standard wall tubing only (0.047” wall thickness for ¼” tubing, 0.062” wall thickness for 3/8”, ½”, ¾” and 1” tubing).

**NOTE:** Tube flaring should be done by personnel trained by Chemline Plastics. Please read all instructions before attempting to flare tubing. Tubing cools very rapidly and any flare may fail if stopped in mid-process. For flaring Tools, see Section 5: Flaring Tools, page 15).

**Tubing Preparation**

1. Ensure that the tube end to be flared is clean.
2. Cut the tubing end squarely (.070” maximum squareness tolerance) using a tubing cutter.
3. Insert the cut end of the tubing through the non-threaded end of the nut.

**WARNING:** If you do not put the nut on the tube now you will not be able to put it on after you complete the flare.

**Heat Flaring**

1. If using a hot air gun, open the table-top stand and set the gun on a flat work surface. Set the hot air gun on high.
2. Hold the tubing end flush with the heater edge and 1/2” to 3/4” above the heater and slowly rotate the tubing 360° for the approximate time specified in Table 1 or until a fine, clear line appears around the tubing.

**NOTE:** It is very important to fully rotate the tubing over the heat source so all surface areas receive an equal amount of heat. Uniform heating is essential to making a good flare.
3. Remove the tubing from the heat source. Immediately push the flaring mandrel (model CF-FFM-xx or 213-81F for 3/8” to 3/4”) into the tubing until the end of the tubing reaches the tube stop.

**NOTE:** Flaring 1/4” tubing is the most challenging because of its small size. To get a firm grip on the small tube diameter, we recommend using a grip pad.
4. Firmly hold the tubing onto the mandrel for the cooling time specified in the Table 1.
5. After the cooling time, the flaring process is complete and the mandrel may be removed from the tubing end.
6. If using the bench-top flaring machines TF416 or MTF416-110 refer to the Operating Manuals.
7. To tighten the nuts use the Chemline CF-TW-xx TrueFastner Torque Wrenches to the required torque in Table 1.

**Retightening**
After exposing the connections to operating conditions for a minimum of 1 hour, all connections should be retightened to the minimum torque values in Table 1. After initial exposure to temperatures over 74°C, all flare fitting connections should be retightened to the minimum torque values in Table 1.
To retighten use the Chemline CF-TW-xx TrueFastner Torque Wrenches to the required torque in Table 1.

<table>
<thead>
<tr>
<th>Tubing &amp; Fitting Size</th>
<th>1/4”</th>
<th>3/8”</th>
<th>1/2”</th>
<th>3/4”</th>
<th>1”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating time for PFA/FEP tubing (sec.) – Air Gun</td>
<td>15</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Minimum cooling time on mandrel (min.)</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Minimum nut torque (inch-pounds) PVDF or PFA nut</td>
<td>6</td>
<td>30</td>
<td>12</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Maximum nut torque (inch-pounds) PVDF or PFA nut</td>
<td>11</td>
<td>48</td>
<td>23</td>
<td>30</td>
<td>48</td>
</tr>
</tbody>
</table>
Section 4: Flaring PFA/FEP Tubing

**ChemFlare™ End Connectors**

**ChemFlare™ Tube End Connections**
ChemFlare™ Tube end connection have the standard male spigot which goes inside the flared tube. They come standard with the nut that goes over the tube before flaring.

**ChemFlare™ Tight Flare End Connections**
ChemFlare™ Tight Flare end connection have the female flare that accepts the male spigot of another fitting. They are used to reduce the distance between fittings (ie tight flare). They come standard with the nut that go onto the male spigot. This nut comes attached to the fitting.

**Tube vs. Tight Flare**

**ChemFlare™ Tube End Connections**

**ChemFlare™ Tight Flare End Connections**

Shown without captive Tight Flare Nuts.

**Tube End Connections**

**Tight Flare End Connections**
# TROUBLESHOOTING

<table>
<thead>
<tr>
<th>Problem</th>
<th>Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>After flaring the tubing, one side of the expanded portion of the tubing is wrinkled and shorter than its original length.</td>
<td>The tubing was not heated evenly before flaring. The wrinkled areas were overheated.</td>
<td>The wrinkles can be avoided by rotating and moving the tubing through the heat source with more uniformity. Cut off the flared tubing end and reflare.</td>
</tr>
<tr>
<td>The tubing kinks when pushing it onto the flaring mandrel.</td>
<td>The tubing was not heated evenly before flaring.</td>
<td>1/2” to 3/4” of the tubing end needs to be heated for proper flaring. Closely follow the recommended heating times in Table 1. Cut off the flared tubing end and reflare.</td>
</tr>
<tr>
<td>When the flared tubing is pushed onto the fitting body, the tubing is more than 0.150” away from the threaded area of the fitting body.</td>
<td>The tubing was not pushed onto the flaring mandrel all the way to the tube stop or the tubing was removed from the mandrel before the minimum cooling time.</td>
<td>Tubing may need longer heating time or longer cooling time on the flaring mandrel. Cut off the flared tubing end and reflare.</td>
</tr>
<tr>
<td>The flared tubing will not fit onto the fitting body.</td>
<td>The tubing was removed from the mandrel before the minimum cooling time.</td>
<td>Reheat and reflare the undersized flared tubing end. Allow adequate cooling time prior to removing from the flaring mandrel. Cut off the flared tubing end and reflare. Make sure the tubing is cool before removing it from the flaring mandrel.</td>
</tr>
<tr>
<td>Tube connection leaks.</td>
<td>Inadequate torque on fitting nut. Possible damaged flaring mandrel.</td>
<td>Retighten according to the torque value in Table 1. Replace mandrel. Cut off the flared tubing end and reflare.</td>
</tr>
</tbody>
</table>
ChemFlare™ PFA/FEP Tube Flaring System

Heating Tools

TF416 Flaring Tool

MTF416-110 Flaring Tool

The TF416 ChemFlaring Tool is a bench-top moulding machine and MTF416-110 is a portable moulding machine for the production of flares directly onto the tubing from 1/4” to 1” in any location. The semi-automated function ensures proper timing and temperature for each size of tubing while at the melt stage.

Tube Flare Tools

Universal Flare Tool, 213-81F

PTFE Flare Tool, CF-FFM-xx-P

Cold Flaring Tool, FT-xx

SS Flare Tool, CF-FFM-xx

Torque Wrenches

Torque Wrench Set, CF-TWS-1

Torque Wrenches, CF-TWxx (individual sizes)
Section 6: Dual Containment PFA/FEP Tube & Fittings

DUAL CONTAINMENT

Description
The carrier (inner) tube of High Purity PFA is used for primary transportation of harsh chemicals. The containment (outer) tube, extruded from FEP is used for containment, is translucent, which permits effortless examination of the carrier tube.

The containment tube works as a safeguard against possible leaks that might occur during the chemical delivery process. The “tube-in-tube” design does not introduce contaminants during the installation process and long, continuous lengths can be maintained without welding or heat bending processes.

Special Fittings & Accessories
CDL Drip Legs are designed for installation in low points of the system, in transition points between rooms or floors and at termination of tubing runs. Drip legs isolate sections of containment tubing by terminating the containment tubing and enabling visual observation or instrument installation. Drip leg tubes are connected to Type 21 Ball valves with Chemflare connections on the tube side.

CDC Dual containment tubing assemblies are installed any time the carrier tube is terminated. Double containment tubing assemblies isolate sections of containment tubing by terminating it.

HDPE Dual containment splitter boxes (CSB1216X3) are used anytime the tube needs to be split. All tubing connections into the box isolate sections of containment tubing by terminating it. Splitter box include venting and drain ball valves and bolt-on removable cover.

CDL1216-SM Half Drip Leg Assembly with straight union

CDL1216-E Drip Leg Assembly built on 90 degree elbow

CDC1216-S Dual Containment Tube Ending Assembly
Section 6: Dual Containment PFA/FEP Tube & Fittings

Flaring of Dual Containment Tubing

Flaring dual containment tubing uses the same procedure as single tubing (see Section 4: Flaring PFA Tubing) except two flares per end connection need to be done.

1. Cut tubing to the appropriate length and run between fittings and/or equipment. At the initial connection point, slide the containment tube outwards by a few inches and flare; allow the flare to cool then slide the carrier tube outwards by a few inches and flare.

2. Install both flared tubes in place on the fittings or equipment.

3. Check the unflared end for length and fit, and adjust if necessary. Undo the initial flared connections and remove the tubing from the fittings. At the end connection point, slide the containment tube outwards by a few inches and flare; allow the flare to cool then slide the carrier tube outwards by a few inches and flare.

4. Re-install flared connections at both ends and check.

For runs longer than 25’ use the **CF-DC-WRENCH–Adjustable Grip for 1/2" to 3/4" tubing** to hold the carrier tubing in place when it is pulled out of the containment tube for flaring.

[CF-DC-WRENCH Image]
Section 7: Maintenance & Replacement Instructions

Even with proper selection and installation, tubing life may be significantly reduced without a continuing maintenance program. The severity of the application, risk potential from a possible tubing failure, and experience with any tubing failures in the application or in similar applications should determine the frequency of the inspection and the replacement for the products.

Tubing assemblies will eventually age, harden, wear and deteriorate under thermal cycling and compression set. Tubing should be inspected and replaced at specific replacement intervals, based on previous service life, government or industry recommendations, or when failures could result in unacceptable downtime, damage, or injury risk. Tubing and fittings may be subjected to internal mechanical and/or chemical wear from the conveying fluid and may fail without warning.

A maintenance program must be established and followed by the user.

Visual Inspection Tubing/Fitting
Any of the following conditions require immediate shut down and replacement of the tubing assembly:
• Fitting slippage on tubing;
• Damaged, cracked, cut or abraded tubing
• Hard, stiff, heat cracked, or charred tubing;
• Cracked, damaged, or badly corroded fittings;
• Leaks at fitting or in tubing;
• Blistered, soft, degraded, kinked, crushed, flattened or twisted tubing

Tubing Inspection and Failure
From time to time, tubing assemblies may fail if they are not replaced at proper time intervals. Usually these failures are the result of some form of misapplication, abuse, wear or failure to perform proper maintenance.

If a tubing failure occurs, immediately shut down the equipment and leave the area until pressure has been completely released from the tubing assembly. Shutting down the hydraulic pump may or may not eliminate the pressure in the tubing assembly as check valves, etc., in a system can cause pressure to remain in a tubing assembly. Never touch or examine a failed tubing assembly unless it is obvious that the tubing no longer contains fluid under pressure.

Once the pressure has been reduced to zero, the tubing assembly may be taken off the equipment and examined. If a failure has occurred replace the failed section with new tube and or fittings. Never attempt to patch or repair a tubing assembly that has failed. Consult Chemline Plastics for tubing assembly replacement information.

Caution: Matches, candles, open flame or other sources of ignition shall not be used for tubing inspection. Leak check solutions should be rinsed off after use.

Note: Fluids under pressure can be dangerous and potentially lethal. Extreme caution must be exercised when working with fluids under pressure and handling the tubing transporting the fluids. If personnel are exposure to the media they should be treated immediately by a physician.
Procedures for testing installed sections of any system must take into account factors affecting all tubing (carrier and containment tubes on dual-containment systems). Basic recommendations may be given, but a comprehensive testing program should be developed for each and every system design. The program should be developed based on the needs and characteristics of the particular system at hand. Personnel must avoid potential hazardous areas while testing and using the system.

1. **Single-Wall Tubing and Dual-Containment Carrier Tube, Pressure Test**

   If the carrier tubing is intended for pressure service greater than 10 feet of head (4.3 psi), a hydrostatic pressure test must be conducted. In any hydrostatic pressure test, provisions must be made to vent all air out of the carrier tube.

   Compressed air or gas should not be used for pressure testing of any carrier tube in excess of 10 psi. Pressure tests should be conducted at a maximum of 150 percent of the operating pressure of the lowest rated component of the system.

**Pressure Test - Carrier Tube**

   Hydrostatic testing should be done with water (for high purity applications use deionized water - quality level set by design conditions).

**Filling the System**

   Open the valves and vents to purge the system of any air. Introduce water slowly (less than 2 ft./sec) into the system at a low point, making sure that air does not become trapped in the system. Caution: Do not use city water pressure for testing if this is greater than the desired test pressure.

**Conducting the Test**

   **Note:** Obvious leaks can be found by emptying the system and placing a 10 psi charge of clean, dry nitrogen or air on the system. Each joint should then be individually checked using a soapy water solution.

   1. Begin pressurizing the system in increments of 10 psi for 150 psi systems, or 5 psi for 45 psi systems. Bring the system up to a maximum of 100 psi and hold for one hour.
      
      **Note:** There will be some gradual drop in pressure due to natural creep effects, elongation of the tube wall and possibly due to thermal expansion effects where there are sudden environmental temperature changes.

   2. After one hour, if pressure drop is less than 10%, increase the pressure back to the desired test pressure. Repeat this step until pressure stabilizes.

   3. Check the system for leaks or other problems. Continue the pressure test for a minimum of two hours up to a recommended duration of 12 hours or as required by local code requirements. If the pressure does not drop, consider the test a success.

   4. If after one hour the pressure has decreased more than 10% and ambient conditions are steady or if after several pressure increases (Step 2) pressure does not stabilize, consider the test a failure. Note the 10% value may need to be greater for larger systems.

   5. Test is to be witnessed by the quality control engineer, and be certified by the contractor.
2. Dual Containment, Containment Tube, Pressure Test

If containment tubing is designed and required to withstand the same pressure as the carrier tubing, then a hydrostatic pressure test should be conducted for both carrier and containment tubes.

When testing both tubes, the annular space is pressurized and equal pressure on the carrier and containment is necessary for the following reasons:

1. To prevent possible collapse of the carrier tubing during the test.
2. Both the carrier and containment tubing will elongate equally, thus minimizing any differential stress or stress buildup between the two tubes.
3. In the event of a carrier failure, the containment tubing must handle the same pressure as the carrier. The carrier tube will continue to pressurize the containment tube until the two reach equilibrium.

Pressure Test – Containment Tube

In many cases, it is not an advantage to conduct a hydrostatic test on the annular space, as it is difficult to dry the space after the test. An air test can be used as an alternative. The pressure should be no higher than 10 psi, and extra safety precautions must be made for surrounding personnel. In all cases, the ambient temperature should be above 0° C. The carrier tube should also be filled with water and pressurized any time a test is conducted on the annular space.

Filling the System

The containment tubing can be filled after the carrier tube test is conducted or at the same time as the carrier tube. The system should be filled in the exact same way as described for pressurized carrier tube. Caution: Do not use city water pressure for testing if this is greater than the desired test pressure.

Conducting the Test

Note: Obvious leaks can be found by emptying the system and placing a 10 psi charge of clean, dry nitrogen or air on the system. Each joint should then be individually checked using a soapy water solution.

Note: Do not use fabricated drainage fittings in pressurized systems where a pressure exceeding 10 feet of head is required. Use molded pressure fittings in these applications.

1. Begin pressurizing the system in increments of 10 psi for 150 psi systems, or 5 psi for 45 psi systems. Bring the system up to a maximum of 100 psi and hold for one hour.

   Note: There will be some gradual drop in pressure due to natural creep effects, elongation of the tube wall and possibly due to thermal expansion effects where there are sudden environmental temperature changes.

2. After one hour, if pressure drop is less than 10%, increase the pressure back to the desired test pressure. Repeat this step until pressure stabilizes.

3. Check the system for leaks or other problems. Continue the pressure test for a minimum of two hours up to a recommended duration of 12 hours or as required by local code requirements. If the pressure does not drop, consider the test a success.

4. If after one hour the pressure has decreased more than 10% and ambient conditions are steady or if after several pressure increases (Step 2) pressure does not stabilize, consider the test a failure. Note the 10% value may need to be greater for larger systems.

5. Test is to be witnessed by the quality control engineer, and be certified by the contractor.