Vapor Solutions by MSP
MSP, a division of TSI, offers a complete line of vaporization products for liquid source vaporization in gas-phase processing like Chemical Vapor Deposition (CVD) and Atomic Layer Deposition (ALD) used in semiconductor device fabrication and industrial coating applications. MSP Turbo™ Vaporizers use a droplet vaporization, direct liquid injection (DLI) technique designed to meet modern demanding vaporization needs.

The Turbo-Vaporizer Difference
MSP’s patented technology offers a broad range of advantages over older, more conventional techniques. The MSP Turbo™ Vaporizer applies advanced technology from aerosol science and thermo-dynamics to create a more refined solution to vaporization. In thin film applications, the stable and uniform vapor leads to a higher quality thin film and higher wafer yields. The precision and control of the vaporizer makes it possible to vaporize difficult precursors, which were not usable before, opening up new areas for process development. The unique design provides longer, stable operation resulting in less down time and more money saved for users.

This market-proven technology provides faster response time, precision flow control, and options for high temperature operation.

Other benefits include:
+ Extremely stable concentration output
+ Active heat exchanger for complete vaporization
+ Low temperature vaporization/reduced risk of thermal decomposition
+ Longer Mean Time Between Maintenance (MTBM)
+ Ability to vaporize difficult precursors
+ Direct liquid injection (DLI) - liquid on demand
+ Higher vapor concentration potential

Applications
The complete line of MSP Turbo™ Vaporizers are used in a variety of applications including most types of CVD and ALD processes and some types of etch/ashing processes. For the complete model line, please refer to the table on page 7.

The vaporizers are ideal for applications that require a high quality, stable vapor, some of which include:

+ Semiconductor Microelectronics
+ LEDs Optoelectronics
+ Protective Coatings
+ Nanoparticle Synthesis
+ Energy Production/Storage
+ Powder/Fiber Processing
+ Solar Photovoltaic
+ Medical Device
+ Bio Assays
Industry Leading Technology
State-of-the-art vaporization from MSP stands apart from other techniques. These older technologies, including liquid injectors, bubblers, and flash vaporization, are commonly used today, however they provide moderate or poor performance. See below how MSP's vaporization technique stands up to the other vaporization techniques.

<table>
<thead>
<tr>
<th>Stability</th>
<th>MSP Turbo™ Vaporizer</th>
<th>Liquid Injection</th>
<th>Bubbler</th>
<th>Flash Vaporization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H</td>
<td>M</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>Precision Flow Control</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>Complete Vaporization</td>
<td>H</td>
<td>L</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>No Thermal Decomposition</td>
<td>H</td>
<td>L</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Low Liquid Flow Rates</td>
<td>H</td>
<td>H</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>High Vapor Concentrations</td>
<td>H</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Longer MTBR</td>
<td>H</td>
<td>L</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Carrier Gas</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Fast Response Time</td>
<td>H</td>
<td>M</td>
<td>L</td>
<td>M</td>
</tr>
</tbody>
</table>

H = Superior; M = Moderate; L = Poor

Full Range of Precursors
A wide array of liquids can be vaporized with the MSP Turbo™ Vaporizer, including new precursors for high dielectric (K), low dielectric, barriers, interconnect, and gap-fill deposition processes. The flexibility and precision of the vaporizer enables vaporization of difficult precursors which may have a tight window between thermal decomposition and vaporization at concentrations necessary for processing. A partial list of liquid precursors which have been used in the MSP Turbo™ Vaporizer is listed below:

- + TEOS
- + TEMAHf
- + TEMAZr
- + THF
- + TDEAT
- + TDMAT
- + TTIP/TTP
- + TDMA
- + TEB
- + TEPO
- + TMA
- + TMB
- + TMOS
- + TMCTs
- + TMOGe
- + MTS
- + TMDAS
- + DMMP
- + SiCl₄
- + TiCl₄
- + GeCl₄
- + TIPCl₄
- + TCA
- + TCS
- + DEZ
- + DMCS
- + DMZ
- + DMDS
- + BDEAS/SAM24
- + BTBAS
- + HCD
- + LaCp₃
- + HDSO
- + HMDS
- + TaEOt
- + GafMD
- + OMCTS
- + PMCH
- + PDMAT
- + TDMATel
- + Acetic Acid
- + H₂O₂
- + Water
- + Alcohol
- + Benzene
- + Octane
- + Cyclo-Hexane
- + Toluene
- + SnCl₄
THE DIFFERENCE IS IN THE DESIGN

Precision flow control directly upstream of the vaporization zone results in extremely fast response times. Annular gas entry creates axially homogenous vapor concentrations. Pair these features with active heating downstream of the liquid breakup zone and the result is the most stable and uniform vapor delivery system available. Carrier gas type, carrier gas flow rate, liquid flow rate, and temperature can all be easily adjusted providing more process flexibility.

Operating Principle
+ Carrier gas at a high pressure passes through a small orifice to produce a high velocity gas jet (Ar, N₂, typical carrier gases; He not required)
+ Liquid is introduced into this high velocity gas jet to form extremely small droplets
+ Nano-droplets pass through high-efficiency heat exchanger for almost instantaneous vaporization

Ultra-fast, Low Heat
By breaking the liquid flow into nanometer-sized droplets, the surface area of the liquid is increased >10⁴, drastically increasing heat transfer rate which is directly proportional to liquid surface area. Fast heat transfer provides ultra-fast vaporization while minimizing heat load.

MSP Performance Enhanced (PE) Turbo™ Vaporizers
MSP Performance Enhanced (PE) Turbo™ Vaporizers are designed to handle demanding applications in ALD and CVD. These vaporizers (identified by PE in the model number) include on-board precision liquid flow control, and are designed to generate extremely small droplets and to minimize dead volume.
Benefits include:
+ Extremely stable concentration output
+ Precision liquid control/vapor concentration
+ Fast response time/minimal dead volume
+ Able to vaporize higher liquid flow rates
+ Uniform axial droplet/vapor concentration
+ Liquid bubble elimination/suppression
+ Factory adjustable gas orifice

![Flow Control Valve Diagram](image)

Data taken with 2950-30 LFC and 2841PE Turbo Vaporizer
**High-Efficiency Heat Exchanger**
+ 2-stage heating process ensures complete droplet vaporization
+ High velocity nano-droplet/gas jet establishes recirculating flow in the first stage to heat the gas uniformly to the vaporizer temperature
+ Vaporization then occurs by mixing the nano-droplets with the recirculating hot gas flow
+ Droplet temperature remains low due to evaporative cooling
+ Heat transfer occurs indirectly through the gas to the suspended droplets

**Clog-Resistant Design**
+ Nano-droplets increase efficiency and speed of vaporization and reduce internal vaporizer deposition
+ Clean carrier gas flow surrounds droplets, minimizing deposition inside the vaporizer
+ Heat exchanger has wide internal pathways to prevent clogging
+ Vaporizer designed to minimize thermal decomposition of liquid which can lead to clogging
MEETS YOUR APPLICATION NEEDS

<table>
<thead>
<tr>
<th>MSP Turbo™ Vaporizer Model</th>
<th>Description</th>
<th>Flow Rate</th>
<th>Features</th>
</tr>
</thead>
</table>
| Model 2840PE               | Extremely stable output, perfect for ALD | Low Flow | + Compact design  
                      |                          |           | + Excellent for low flow applications  
                      |                          |           | + Ultra-fast response time |
| Model 2820                 | Classic system, great for easy to vaporize precursors | Medium Flow | + Wide internal orifices for minimized clogging  
                      |                          |           | + Compact design  
                      |                          |           | + Great for high vapor pressure precursors |
| Model 2820D               | Dual liquid inlet | Medium Flow | + Wide internal orifices for minimized clogging  
                      |                          |           | + Compact design  
                      |                          |           | + Great for R&D applications |
| Model 28000PE             | Good for thermolabile liquids | Medium Flow | + Ultra-fast vaporization  
                      |                          |           | + Excellent for thermally sensitive liquids  
                      |                          |           | + Dual pass heat exchanger |
| Model 2800                | High temperature vaporization | Medium Flow | + <300ºC operating temperature  
                      |                          |           | + Fast vaporization  
                      |                          |           | + Dual pass heat exchanger |
| Model 2801PE              | Low vapor pressure liquids | High Flow | + Long heat exchanger residence time  
                      |                          |           | + Low maintenance  
                      |                          |           | + Wide internal pathways allow room for expansion |
| Model 2841PE              | High flow, perfect for water vapor | High Flow | + Dual heaters  
                      |                          |           | + 600W heater power  
                      |                          |           | + Generates over 30,000 sccm of water vapor |
| Model 2821                | Stable vaporization at very high flow | Very High Flow | + 3600W heater  
                      |                          |           | + Up to 6000g/hr (TEOS equivalent)  
                      |                          |           | + Three controlled heated zones |
| Model 2860PE              | Drop-in replacement for direct injection valve | Medium Flow | + Compact design  
                      |                          |           | + Low maintenance  
                      |                          |           | + Extremely stable output |

* Since absolute flow ranges are dependent on liquid and carrier gas types, flow ranges are meant to be comparative across models.
### SOLUTIONS FOR ADVANCED PROCESSING

<table>
<thead>
<tr>
<th>Model</th>
<th>Flow Rate</th>
<th>Description</th>
<th>ALD</th>
<th>CVD</th>
<th>Etch/ Water Vapor</th>
<th>R&amp;D</th>
<th>Industrial</th>
<th>Thermo-labile Liquids</th>
<th>High Temp</th>
<th>Liquid Injection Valve Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>2840PE</td>
<td>Very Low</td>
<td>Extremely Stable Output</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2820</td>
<td>Medium</td>
<td>Easy to Use Precursors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2820D</td>
<td>Medium</td>
<td>Dual Liquid Inlet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2800PE</td>
<td>Medium</td>
<td>Thermolabile Liquids</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2800</td>
<td>Medium</td>
<td>High Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2841PE</td>
<td>High</td>
<td>High Heat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2801PE</td>
<td>High</td>
<td>Low Vapor Pressure Liquids</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2821</td>
<td>Very High</td>
<td>High Output</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2860PE</td>
<td>Medium</td>
<td>Injection Valve Replacement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specifications</th>
<th>2840PE</th>
<th>2820</th>
<th>2820D</th>
<th>2800PE</th>
<th>2800</th>
<th>2801PE</th>
<th>2841PE</th>
<th>2821</th>
<th>2860PE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perform Enhanced (PE) Design</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Max. Liquid Flow* DI Water (g/hr)</td>
<td>60</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>120</td>
<td>120</td>
<td>600</td>
<td>60</td>
</tr>
<tr>
<td>Max. Flow Flow* TEOS equivalent (g/hr)</td>
<td>720</td>
<td>900</td>
<td>900</td>
<td>900</td>
<td>900</td>
<td>1200</td>
<td>1200</td>
<td>6000</td>
<td>720</td>
</tr>
<tr>
<td>Max Gas Flow* N₂ @70psi (SLPM)</td>
<td>8.5</td>
<td>30</td>
<td>30</td>
<td>8.5</td>
<td>10</td>
<td>8.5</td>
<td>8.5</td>
<td>50</td>
<td>3.5</td>
</tr>
<tr>
<td>Temperature Range* (ºC)</td>
<td>40-200</td>
<td>40-300</td>
<td>30</td>
<td>30</td>
<td>40-200</td>
<td>40-200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical Power (W)</td>
<td>300</td>
<td>300</td>
<td>500</td>
<td>3600</td>
<td>300</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensions HxWxD (cm)</td>
<td>29x8x11</td>
<td>22x18x14</td>
<td>22x14x18</td>
<td>29x17x12</td>
<td>31x12x17</td>
<td>30x12x12</td>
<td>42x14x18</td>
<td>24x8x9</td>
<td></td>
</tr>
<tr>
<td>Dimensions HxWxD (in)</td>
<td>11.4x3.3x4.3</td>
<td>8.8x7.2x5.5</td>
<td>8.8x7.2x5.5</td>
<td>11.6x6.8x4.8</td>
<td>12.2x4.7x6.8</td>
<td>11.7x4.7x4.8</td>
<td>16.4x5.5x7.2</td>
<td>3.9x32x3.5</td>
<td></td>
</tr>
<tr>
<td>Line Voltage, Frequency</td>
<td>120VAC, 60Hz</td>
<td>220VAC, 60Hz</td>
<td>120VAC, 60Hz</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Liquid and gas flow ranges are effected by liquid and gas type; assuming medium vacuum or lower downstream of the vaporizer
SUPERIOR CONTROL FOR SUPERIOR PROCESSES

2950 MSP Turbo™ Liquid Flow Controller
Built upon field-proven technology and designed specifically for leading edge microelectronic applications; this highly accurate, high-speed liquid flow controller contains a custom engineered high-precision flow sensor and meticulously designed flow control electronics to provide the world-class performance necessary for advanced semiconductor processing.

Precision Flow Control
The MSP Turbo™ LFC is designed to control the Piezo liquid control valve on MSP Performance Enhanced (PE) Turbo™ Vaporizers. For MSP vaporizers without an on-board liquid control valve, a Piezo control valve accessory (2950-V) pairs with the 2950 LFC.

MSP Turbo™ LFC Key Features
+ Exceptional accuracy
+ Ultra-fast response time
+ Superior repeatability
+ Stable, tightly controlled flowrate
+ PID tuning made easy
+ Change Liquids WITHOUT Factory Calibration
+ EtherCAT, RS485 or Analogue Communications

Specifications
For complete specification refer to MSP Turbo™ LFC System Brochure or 2950 LFC Data Sheet

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Turndown Ratio</strong></td>
<td>50:1</td>
</tr>
<tr>
<td><strong>Accuracy</strong></td>
<td>±1.0 % F.S.</td>
</tr>
<tr>
<td><strong>Linearity</strong></td>
<td>≤0.6 % F.S.</td>
</tr>
<tr>
<td><strong>Reproducibility</strong></td>
<td>±1.0 % F.S.</td>
</tr>
<tr>
<td><strong>Response time</strong></td>
<td>&lt;0.3 to ±1% S.P.</td>
</tr>
<tr>
<td><strong>Dimensions</strong></td>
<td>128x139x54/5.0x5.5x2.1</td>
</tr>
</tbody>
</table>

1. Accuracy, repeatability, linearity and reproducibility tested to SEMI E56-0309 using TEOS at 23±2°C.
2. Response time determined using TEOS as reference liquid at 23±2°C.
3. Nominal max flow determined using TEOS as reference liquid at 23±2°C. Flow rate range is a function of specified liquid.
MSP Turbo™ LFC + MSP Turbo™ Vaporizer

The 2950 was engineered to pair with MSP Turbo™ Vaporizers to provide a reliable, high-performance liquid vapor delivery solution. Now you can procure a vaporizer and a high-end liquid flow controller from a single, trusted manufacturer, ensuring your process system has unmatched liquid source vapor delivery performance, versatility and longevity.

Models

<table>
<thead>
<tr>
<th>Model Number</th>
<th>TEMOS Full Scale (g/min)</th>
<th>TEMAZr Full Scale (g/min)</th>
<th>H₂O Full Scale (g/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2950-002</td>
<td>0.2</td>
<td>0.038</td>
<td>0.14</td>
</tr>
<tr>
<td>2950-01</td>
<td>1</td>
<td>0.19</td>
<td>0.73</td>
</tr>
<tr>
<td>2950-05</td>
<td>5</td>
<td>0.95</td>
<td>3.6</td>
</tr>
<tr>
<td>2950-10</td>
<td>10</td>
<td>1.9</td>
<td>7.3</td>
</tr>
<tr>
<td>2950-20</td>
<td>20</td>
<td>3.8</td>
<td>14</td>
</tr>
<tr>
<td>2950-30</td>
<td>30</td>
<td>5.7</td>
<td>21</td>
</tr>
<tr>
<td>2950-40</td>
<td>40</td>
<td>7.6</td>
<td>29</td>
</tr>
<tr>
<td>Liquid Viscosity (cP)</td>
<td>0.65</td>
<td>3.4</td>
<td>0.89</td>
</tr>
</tbody>
</table>

Other Liquids

The full scale of the 2950 LFC is a function of liquid viscosity \( \mu_{\text{liquid (cP)}} \).

To estimate the full scale (F.S.) of each model for your liquid, use the equation below:

\[
F.S._{\text{Other Liquid}} = F.S._{\text{TEOS}} \times \frac{0.65cP}{\mu_{\text{liquid (cP)}}}
\]

Accessories

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2950-V</td>
<td>Optional piezo control valve. For use with MSP Turbo™ Vaporizers which do not have an on-board Piezo Valve</td>
</tr>
</tbody>
</table>
FLEXIBLE CONTROL SOLUTIONS

Stable Vapor Flow Starts With Stable Liquid Control
The liquid flow control solution used with MSP Turbo™ Vaporizers has a large effect on vapor concentration stability, chamber pressure stability and response time. With the addition of the MSP Turbo™ LFC and the 2950-V Piezo control valve you can choose a high performance flow control and vaporization solution from a single source.

Other Control Options
MSP Turbo™ Vaporizers can also be used with many commercially available liquid measurement/control solutions; so if it’s important to you to use a specific flow measurement solution, MSP Turbo™ Vaporizers provide the flexibility you need.

<table>
<thead>
<tr>
<th>MSP Flow Control Solutions</th>
<th>Other Flow Control Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>High performance liquid control and vaporization from a single supplier</td>
<td>Other options for liquid flow measurement and control</td>
</tr>
</tbody>
</table>

**MSP PE Turbo™ Vaporizers**
- MSP Turbo™ LFC + MSP PE Turbo™ Vaporizer
- Liquid to vaporizer
- Flow control at point of vaporization
- Ultra-fast response, wider process window
- Models: 2840PF, 2800PE, 2841PE

**2950 Turbo LFC Controls**
- Liquid to vaporizer
- Flow control at point of vaporization
- Ultra-fast response, wider process window
- Models: 2820, 2820D, 2800, 2821

**2910 Multi-function Controller**
This versatile precision controller can be used to control the on-board liquid controller in MSP PE Turbo™ Vaporizers, when paired with almost any commercially available liquid flow meter (LFM). It can be used to maintain a steady liquid flow, or to generate repeatable short duration vapor pulses for ALD applications.

**2910 Controller**
- Liquid to LFM
- Flow control at point of vaporization
- Ultra-fast response, wider process window
- Models: 2840PE, 2800PE, 2801PE, 2841PE

**2950-V Piezo control valve**
- Liquid to vaporizer
- Flow control at point of vaporization
- Ultra-fast response, wider process window
- Models: 2820, 2820D, 2821

**2950 Turbo LFC + 2950-V + MSP non-PE Turbo™ Vaporizer**
- Liquid to vaporizer
- Flow control at point of vaporization
- Ultra-fast response, wider process window
- Models: 2820, 2820D, 2821

**LFC + MSP non-PE Turbo™ Vaporizer**
- Liquid to vaporizer
- Flow control at point of vaporization
- Ultra-fast response, wider process window
- Models: 2820, 2820D, 2821

Stable Vapor Flow Starts With Stable Liquid Control
The liquid flow control solution used with MSP Turbo™ Vaporizers has a large effect on vapor concentration stability, chamber pressure stability and response time. With the addition of the MSP Turbo™ LFC and the 2950-V Piezo control valve you can choose a high performance flow control and vaporization solution from a single source.

Other Control Options
MSP Turbo™ Vaporizers can also be used with many commercially available liquid measurement/control solutions; so if it’s important to you to use a specific flow measurement solution, MSP Turbo™ Vaporizers provide the flexibility you need.

<table>
<thead>
<tr>
<th>MSP Flow Control Solutions</th>
<th>Other Flow Control Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>High performance liquid control and vaporization from a single supplier</td>
<td>Other options for liquid flow measurement and control</td>
</tr>
</tbody>
</table>

**MSP PE Turbo™ Vaporizers**
- MSP Turbo™ LFC + MSP PE Turbo™ Vaporizer
- Liquid to vaporizer
- Flow control at point of vaporization
- Ultra-fast response, wider process window
- Models: 2840PF, 2800PE, 2841PE

**2950 Turbo LFC Controls**
- Liquid to vaporizer
- Flow control at point of vaporization
- Ultra-fast response, wider process window
- Models: 2820, 2820D, 2800, 2821

**2910 Multi-function Controller**
This versatile precision controller can be used to control the on-board liquid controller in MSP PE Turbo™ Vaporizers, when paired with almost any commercially available liquid flow meter (LFM). It can be used to maintain a steady liquid flow, or to generate repeatable short duration vapor pulses for ALD applications.

**2910 Controller**
- Liquid to LFM
- Flow control at point of vaporization
- Ultra-fast response, wider process window
- Models: 2840PE, 2800PE, 2801PE, 2841PE

**2950-V Piezo control valve**
- Liquid to vaporizer
- Flow control at point of vaporization
- Ultra-fast response, wider process window
- Models: 2820, 2820D, 2821

**2950 Turbo LFC + 2950-V + MSP non-PE Turbo™ Vaporizer**
- Liquid to vaporizer
- Flow control at point of vaporization
- Ultra-fast response, wider process window
- Models: 2820, 2820D, 2821

**LFC + MSP non-PE Turbo™ Vaporizer**
- Liquid to vaporizer
- Flow control at point of vaporization
- Ultra-fast response, wider process window
- Models: 2820, 2820D, 2821

Stable Vapor Flow Starts With Stable Liquid Control
The liquid flow control solution used with MSP Turbo™ Vaporizers has a large effect on vapor concentration stability, chamber pressure stability and response time. With the addition of the MSP Turbo™ LFC and the 2950-V Piezo control valve you can choose a high performance flow control and vaporization solution from a single source.

Other Control Options
MSP Turbo™ Vaporizers can also be used with many commercially available liquid measurement/control solutions; so if it’s important to you to use a specific flow measurement solution, MSP Turbo™ Vaporizers provide the flexibility you need.
FILTERS FOR PROCESS VAPORS

**Designed for Vapor Delivery Solutions**
MSP’s patent-protected Vapor Process Gas (VPG) Filters were specifically engineered for the unique environment downstream of a vapor delivery solution.

**Extremely Low Pressure Drop**
The filters are designed to have extremely low pressure drops, minimizing risk of condensation and gas-conversions in the filter which are a unique concern in a vapor stream. The low pressure drop also makes it easier to work in an ultra-low pressure environment. Pump down is faster, and lower pressures are possible.

**Increased Thermal Mass**
MSP VPG Filters have increased thermal mass versus conventional filters so that, downstream of a vaporizer or liquid injector in a heated line, there is more thermal energy available to prevent cool spots and condensation (which can result in particle issues).

**Ultra-high Efficiency Filtration < 2nm**
With the nanometer sized structures used in today’s microelectronic circuits, there is no room for particulate contamination. Ensure your vapor is particle free by using MSP’s ultra-high efficiency VPG filters which filter particulates down to 2nm and below. The unique Nano-Filtration Media used in the VPG-A6 is comprised of sintered stainless steel fibers of a homogenous construction with efficiency and pressure drop capabilities not previously attainable by a conventional sintered metal filter media construction.

**Thermal/Chemical Resistance**
Made entirely out of 100% 316SS, MSP’s filters are chemically and thermally resistant providing reliable filtration even for chemically aggressive vapors/gases.

## VAPOR PROCESS GAS VPG FILTERS – 316SS

<table>
<thead>
<tr>
<th>Model</th>
<th>VPG-A3 Description</th>
<th>VPG-A6 Description</th>
<th>VPG-A15 Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part number</td>
<td>2920-01-5001</td>
<td>2920-01-1000</td>
<td>2715</td>
</tr>
<tr>
<td>Description</td>
<td>Ultra-low pressure drop, high filtration efficiency</td>
<td>Ultra low pressure drop, ultra high efficiency</td>
<td>Large surface area, long life</td>
</tr>
<tr>
<td>Flow Range (SLM)</td>
<td>0-100</td>
<td>0-30</td>
<td>0-100</td>
</tr>
<tr>
<td>2.5nm Filter Efficiency @1 SLPM (%)</td>
<td>99.99999999 (nine 9s)</td>
<td>99.9999999999 (twelve 9s)</td>
<td>99.9999999999 (twelve 9s)</td>
</tr>
<tr>
<td>10nm Filter Efficiency @1 SLPM (%)</td>
<td>99.9999 (six 9s)</td>
<td>99.999999 (ten 9s)</td>
<td>99.999999 (ten 9s)</td>
</tr>
<tr>
<td>50nm Filter Efficiency @1 SLPM (%)</td>
<td>99.99 (four 9s)</td>
<td>99.997 (five 9s)</td>
<td>99.999 (six 9s)</td>
</tr>
<tr>
<td>Pressure Drop</td>
<td>&lt;0.04 kPa@1 SLPM; kPa = 0.0439*Q(SLPM)-0.0516</td>
<td>&lt;0.04 kPa@1 SLPM; kPa = 0.0477Q(SLPM)-0.066</td>
<td>&lt;0.02 kPa@1 SLPM; kPa = 0.0151Q(SLPM)-0.0424</td>
</tr>
<tr>
<td>Filter Media</td>
<td>Sintered 316SS powder</td>
<td>Sintered 316SS fiber</td>
<td>Sintered 316SS fiber</td>
</tr>
<tr>
<td>Fittings</td>
<td>1/2” VCR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wetted Materials</td>
<td>316 Stainless Steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature Range (°C)</td>
<td></td>
<td>&lt;300</td>
<td></td>
</tr>
<tr>
<td>Length/Diameter (&quot;)</td>
<td>5/1.5</td>
<td>5/1.5</td>
<td>15.6/2.0</td>
</tr>
<tr>
<td>Weight (lb)</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>
Custom Solutions
Processes which require vapor created from a liquid cover an extremely wide spectrum of process conditions. Several important process parameters that affect vaporization include:
+ Liquid type and flow rate
+ Carrier gas type and flow rate
+ Process pressure and temperature
+ Ambient pressure and temperature
+ Distance between vaporizer and process zone

Designed for Your Application
MSP offers the widest range of standard vaporizer solutions commercially available. However, for many applications - particularly processes that will be rolled out to a large number of systems; a vaporizer solution specifically designed for your operating parameters may result in the highest quality, most stable and reliable vapor delivery solution. MSP routinely partners with industry leaders to co-develop and supply unique vaporization solutions for their leading edge technology process equipment.

Field Proven
MSP vaporizers have enabled leading edge processes for decades, with vaporizers installed in almost every 300mm fab worldwide. This field-proven vaporization technology is successfully used for a wide array of processes including: TEOS, high-flow TEOS, high κ dielectrics (like TEMAZr and TEMAHf), OMCTS, TiCl₄, MTS, and many others.

Vaporization Experts
For over 30 years MSP has embraced and researched the science of vaporization, becoming the foremost experts in this specialized field. MSP offers the widest range of standard vaporizer solutions commercially available, and routinely partners with CVD equipment manufacturers to provide custom solutions perfectly tailored to their unique needs.

Commitment to Innovation
Every year our MSP vaporization experts continue to innovate and drive vaporization technology to new heights to meet the demands of progressively challenging process requirements. With 40+ active designs patents, MSP continues to lead the way in vapor delivery solutions.

Global Footprint
MSP, a Division of TSI, has 11 offices worldwide including a dedicated facility in South Korea for sales, field service, inventory, and support of vaporizers in the semiconductor industry.