

# 11

## Index & Reference



# Section 11

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## Converting from one unit to another

The following tables provide the most frequent conversions for use in vacuum applications. Text books or other reference manuals offer additional conversion factors.

In all of the tables below, the original units are listed in the left-hand column. Locate the conversion factor by intersecting the row of the original units with the column of the final units. Multiply the number of original units by the factor to obtain the number of final units.

Using the sample table at the right, gram weight is multiplied by 3.527E-02 to obtain ounce weight. For example, 281 grams would convert to ounces by:  $281 \times .03527 = 9.911 \approx 10$  oz. Note that conversion factors are intended for reference use only.

Sample conversion: grams to ounces

**Weight**

	lb	oz	g
lb	1	1.600E+01	4.54E+02
oz	6.250E-02	1	2.84E+01
g	2.205E-03	3.527E-02	1
kg	2.205E+00	3.527E+01	1.00E+03

Annotations: "equals" points to the intersection of lb and oz (1.600E+01). "Multiplied by" points to the intersection of g and oz (3.527E-02).

## Pressure

	Pa N·m <sup>-2</sup>	mbar millibar	Torr mm Hg	micron mTorr	atm atmos	kg <sub>f</sub> cm <sup>-2</sup>	psi lb <sub>f</sub> in <sup>-2</sup>
Pa	1	1.00E-02	7.50E-03	7.50E+00	9.87E-06	1.02E-05	1.45E-04
mbar	1.00E+02	1	7.50E-01	7.50E+02	9.87E-04	1.02E-03	1.45E-02
Torr	1.33E+02	1.33E+00	1	1.00E+03	1.32E-03	1.36E-03	1.93E-02
micron	1.33E-01	1.33E-03	1.00E-03	1	1.32E-06	1.36E-06	1.93E-05
atm	1.01E+05	1.01E+03	7.60E+02	7.60E+05	1	1.03E+00	1.47E+01
kg <sub>f</sub> cm <sup>-2</sup>	9.80E+04	9.80E+02	7.36E+02	7.36E+05	9.68E-01	1	1.42E+01
psi	6.89E+03	6.89E+01	5.17E+01	5.17E+04	6.81E-02	7.03E-02	1

Example:

2.00E-05 Torr	2.66E-03	2.66E-05	2.00E-05	2.00E-02	2.64E-08	2.72E-08	3.86E-07
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## Leak Rate

	Pa·ls <sup>-1</sup>	mbar·ls <sup>-1</sup>	Torr·ls <sup>-1</sup>	std cc·s <sup>-1</sup>
Pa·ls <sup>-1</sup>	1	1.00E-02	7.50E-03	9.87E-03
mbar·ls <sup>-1</sup>	1.00E+02	1	7.50E-01	9.87E-01
Torr·ls <sup>-1</sup>	1.33E+02	1.33E+00	1	1.32E+00
std cc·s <sup>-1</sup>	1.01E+02	1.01E+00	7.60E-01	1

Example:

1.00E-07 mbar·ls <sup>-1</sup>	1.00E-05	1.00E-07	7.50E-08	9.87E-08
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## Flow Rate

	gpm	gps	l·m <sup>-1</sup>	l·s <sup>-1</sup>
gpm	1	1.67E-02	3.79E+00	6.31E-02
gps	6.00E+01	1	2.27E+02	3.79E+00
l·m <sup>-1</sup>	2.64E-01	4.40E-03	1	1.67E-02
l·s <sup>-1</sup>	1.59E+01	2.64E-01	6.00E+01	1

Example:

2.5 gpm	2.50E+00	4.17E-02	9.46E+00	1.58E-01
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### Length

	foot ft	inch in	meter m	centimeter cm	millimeter mm	micron μm	Angstrom Å
foot	1	1.20E+01	3.05E-01	3.05E+01	3.05E+02	3.05E+05	3.05E+09
inch	8.33E-02	1	2.54E-02	2.54E+00	2.54E+01	2.54E+04	2.54E+08
meter	3.28E+00	3.94E+01	1	1.00E+02	1.00E+03	1.00E+06	1.00E+10
centimeter	3.28E-02	3.94E-01	1.00E-02	1	1.00E+01	1.00E+04	1.00E+08
millimeter	3.28E-03	3.94E-02	1.00E-03	1.00E-01	1	1.00E+03	1.00E+07
micron	3.28E-06	3.94E-05	1.00E-06	1.00E-04	1.00E-03	1	1.00E+04
Angstrom	3.28E-10	3.94E-09	1.00E-10	1.00E-08	1.00E-07	1.00E-04	1

Example:

24 inch	2.00E+00	2.40E+01	6.10E-01	6.10E+01	6.10E+02	6.10E+05	6.10E+09
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### Weight

	lb	oz	g	kg
lb	1	1.600E+01	4.54E+02	4.54E-01
oz	6.250E-02	1	2.84E+01	2.84E-02
g	2.205E-03	3.527E-02	1	1.00E-03
kg	2.205E+00	3.527E+01	1.00E+03	1

Example:

10 kg	2.21E+01	3.53E+02	1.00E+04	1.00E+01
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### Force

	lb <sub>f</sub>	oz <sub>f</sub>	N	kg <sub>f</sub>
lb <sub>f</sub>	1	1.60E+01	4.45E+00	4.54E-01
oz <sub>f</sub>	6.25E-02	1	2.78E-01	2.83E-02
N	2.25E-01	3.60E+00	1	1.02E-01
kg <sub>f</sub>	2.21E+00	3.53E+01	9.81E+00	1

Example:

5 lb	5.00E+00	8.00E+01	2.22E+01	2.27E+00
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### Torque

	lb <sub>f</sub> -ft	oz <sub>f</sub> -in	N-m	kg <sub>f</sub> -m
lb <sub>f</sub> -ft	1	1.92E+02	1.36E+00	1.38E-01
oz <sub>f</sub> -in	5.21E-03	1	7.09E-03	7.25E-04
N-m	7.38E-01	1.41E+02	1	1.02E-01
kg <sub>f</sub> -m	7.23E+00	1.38E+03	9.81E+00	1

Example:

15 lb-ft	1.5E+01	2.88E+03	2.03E+01	2.07E+00
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Note: The “<sub>f</sub>” for “force” is frequently omitted in tables or text when the meaning is clear from the context.



**18-8 ss** A grade of stainless steel including 18% chromium and 8% nickel; typically used on bolts, screws and nuts

**300 Series ss** Generic reference to any stainless steel grade in the numerical 300 series family

**304 ss** Vacuum grade stainless steel; can be easily machined and welded; very low outgassing properties

**304L ss** Very low-carbon stainless steel

**316 ss** Vacuum grade stainless steel; low magnetic permeability

**A or Amp** Ampere; unit of electric current

**Å** Angstrom; unit of length;  $1 \text{ Å} = 10^{-10} \text{ m}$

**Abbe Error** Linear off-axis error introduced through amplification of tilt and wobble with a long moment arm. This type of error occurs when the point under measurement is at a relatively long distance from the axis of motion, typically greater than 12"

**AC** Alternating current

**Accuracy** The maximum expected difference between the actual and a desired position for a given input. Highly dependent on method of actual position measurement

**Accuracy, Absolute** The output of a system versus the commanded or ideal input

**Accuracy, On-Axis** The uncertainty of position after all sources of linear error are eliminated. Some linear errors: cosine error, leadscrew pitch error, abbe error and thermal expansion effects

**Actuator** A portion of a device that provides motion to the internal parts of the device; typically manual or electropneumatic

**Adapter** Provides a transition from one method of sealing to a different method of sealing, such as metal seal to elastomer seal

**AKA** The abbreviation for "also known as"

**AL or Al** Aluminum

**Aluminum 6061-T6** Vacuum grade aluminum

**AM-350** A precipitation hardened stainless steel used in welded bellows; similar to 304L with a longer life in cycling

**Amp or amps** Ampere; unit of electric current

**ANSI** American National Standards Institute

**ASA** American Standards Association, replaced by ANSI

**ASME** American Society of Mechanical Engineers

**ASTM** American Society for Testing and Materials

**Atm or atmos** Atmosphere; used in pressure measurement reference

**Austenitic stainless steels** Iron-chromium-nickel alloys, provides good corrosion resistance, machining and welding properties; 304ss and 316ss are examples

**AVS** American Vacuum Society

**AWG** American Wire Gauge; corresponds with the number of operations of drawing a wire, thus a larger number, which represents more operations, results in a smaller diameter wire; AKA Brown & Sharpe gage; there are many wire gage methods

**BA** Bayard-Alpert (gauge); method of vacuum measurement

**Backlash** The maximum magnitude of an input that produces no measurable output upon reversing direction. Typically the result of poor meshing between drivetrain components as in lead screw threads

**Bar** A unit of pressure measurement; in vacuum applications, used as millibar

**BC** Bolt circle; the center to center distance of two bolt holes on the same diameter; generally may be used in specifying any centerline to centerline distance of elements on the same diameter; sometimes used in place of the connector circle (CC) for pins on an electrical connector

**Best way** A method of shipment to be selected by MDC which would be appropriate for the type of product to be shipped; see Ordering Information section

**Blind hole** A drilled hole that does not break through the metal; maintains the vacuum integrity of the drilled piece

**Blind tapped** A tapped blind hole; female threads inside a hole that does not break through the metal; maintains the vacuum integrity of the drilled and tapped piece

**BNC** Bayonet Naval Connector; a specific type of electrical connector that attaches without threads; used in 50 ohm and 75 ohm coaxial low power instrumentation transmission lines

**Bolt length** The portion of a bolt excluding the head; may be threaded completely or have a shank with partial threading

**Bonnet** The flanged connection of two parts of a valve; the flanges between the actuator and body of a valve

**Buna-N®** A DuPont Dow Elastomers registered trademark brand name of a type of elastomer seal; butyl material which has excellent resistance to gas permeation; an early vacuum seal, generally displaced by FKM / FPM fluoroelastomer

**Capture groove** A counterbore in a flange that a gasket seats into; keeps a gasket from moving outside its range of correct positioning

**Carriage** The movable parts in a gate valve, including wheels, pins, springs, supports, etc.; the back side of the flat O-ring sealed gate in a gate valve

**cc** Cubic centimeter; metric unit of volume measurement

**CC** Connector circle; the center to center distance of two pins on the same diameter of an electrical connector

**CCW** Counterclockwise

**CE Compliance** European safety standard; similar to UL listing in the USA

**CERN** Centré Européenne pour la Recherche Nucléaire (French); European Organization for Nuclear Research; specifications standard limited to France

**CF flange** Del-Seal™ CF metal seal flange; originally developed by

- Varian Corporation under the Conflat® Flange brand name; requires metal gasket for UHV seal, usually copper material
- CIF** Carriage and Insurance paid to customer's delivery address
- Clearance holes** Holes that are drilled completely through a metal piece without threads; also called through holes or thru holes
- Counterbore** A straight bore partially through a metal piece; sometimes concentric with a smaller bore
- CSA** Canadian Standards Association; comparable to United Laboratories approval in the USA
- CSR** Customer Service Representative
- CVD** Chemical vapor deposition; a method of depositing material on a substrate using a chemical reaction
- CW** Clockwise
- DC** Direct current
- Del-Seal™** The MDC trademark name for a metal seal UHV flanges; also written Del-Seal™ CF; compatible with Conflat® flanges
- DIA or dia** Diameter
- Dicronite** A dry film lubricant used on linear and ball bearings; modified tungsten disulfide in lamellar form; inert, corrosion resistant, non-magnetic and UHV compatible throughout a wide temperature range
- DIN** Deutsche Industrie Norm (German); German industry standard
- Display Resolution** The smallest motion detectable by a motion device's precision rule, micrometer or motor controls
- DN** Diamètre Nominal (French); nominal diameter, usually referring to vacuum tubing internal diameter
- DWDM** Dense Wavelength Division Multiplexing; the process of splitting or multiplexing the light traveling through fiber (optics) into different wavelengths
- EB, E-B, e-beam or other variations** Electron beam
- Eccentricity** Sometimes called concentricity; eccentricity in a rotary device is the deviation of the center of rotation from its mean position as the device turns
- Elastomer** A flexible material for completing a vacuum seal between two flat surfaces, usually ISO flanges; colloquially "rubber"
- Electropneumatic** Method of actuating a device using a compressed gas which is controlled by an electrical solenoid valve
- Electropolish** Removes a small amount of surface metal from any shape of stainless steel; provides an attractive high-luster finish plus deburring
- Error** The difference between an obtained performance parameter and the ideal or desired result. Errors fall into two primary categories, on-axis and off-axis errors
- Fixed flange** Nonrotatable; composed of a single machined piece; when welded to tubing or a chamber, the bolt holes cannot be rotated to align with bolt holes of another flange
- FKM / FPM fluoroelastomer** Fluorocarbon-based fluoroelastomer (FKM / FPM)
- Flush mount** One flange is welded directly to the back of either another larger flange or a flat surface; typically the total thickness is the sum of the two individual thicknesses
- FOB** Freight on board; the point at which transfer of ownership of a product occurs
- FPT** Commonly used abbreviation for female pipe thread
- Friction** Friction is defined as the resistance to motion between surfaces in contact. Friction can be constant or it can vary with speed. Elements contributing to overall friction may be in the form of drag, sliding friction, system wear or lubricant viscosity
- Friction, Static** The friction that must be overcome to impart motion to a body at rest. Since static friction is higher than sliding friction, the force which must be applied to impart motion is greater than the force required to keep the body in motion. As a result, when a force is initially applied, the body will begin to move with a jump in some unpredictable and unrepeatable manner, producing non-linear, non-repeatable motion
- FT or ft** Foot; unit of length measurement
- F/T or f/t** Abbreviation for feedthrough
- Gasket** Any material between two sealing surfaces; either metal or elastomer material; typically rectangular in cross-section but may also be circular in cross-section
- Gate** The flat plate in a gate valve that makes a seal between the two sides of a valve; includes a groove to hold an elastomer O-ring that completes the seal
- Gear Ratio, Drive Train** A motion instrument's drive train gear ratio is the relationship between received input motion and the delivered output motion. Ratios are expressed in the numerical notation a:b, where "a" represents the received motion or device input in revolutions or some other unit, and "b" represents the delivered or resulting output motion in revolutions for rotary devices or 1" of travel in linear motion instruments
- gpm** Gallons per minute; unit of liquid volume flow
- gps** Gallons per second; unit of liquid volume flow
- Graded seal** The portion of a glass component that changes from one material to another; typically the transition from Pyrex® to quartz tubing
- HF** High frequency; the range of frequencies in the radio spectrum between 3 and 30 megahertz
- HV** High vacuum; typically between 10<sup>-3</sup> to 10<sup>-8</sup> Torr
- Hybrid** A combination of two different methods of sealing, such as metal seal to elastomer seal; an adapter
- Hysteresis** The difference in the absolute position of an object for a given commanded input when approached from opposite directions. It is due to elastic forces accumulated in various drivetrain components, leadscrew wind-up, for instance. Often confused with backlash
- Hz** Hertz; cycles per second





- ID** Internal diameter or inner dimension; usually of tubing or a hollow bore through a metal piece
- IEEE** Institute of Electrical and Electronics Engineers
- IGT** Ionization gauge tube; used with a gauge to measure pressure
- J or Joule** The SI unit of work or energy; newton-meter
- Insert** Part of a rotatable flange; the smaller part of a rotatable flange that is welded to a tube; includes the sealing knife-edge; requires a receiver to complete a vacuum seal
- ISO** International Standards Organization
- Kalrez® 4079** A perfluoroelastomer useful in corrosive or high temperature applications
- Kapton®** The DuPont Dow Elastomers registered trademark brand name of a UHV compatible polyimide film typically used for wire insulation; provides an extremely tough abrasion resistant and tenacious insulator
- KF flange** The smaller ISO flanges; originally Klein Flange developed in Germany, “Klein” meaning small; Kwik-Flange™ is the MDC trademark name for the smaller components of a complete ISO flange family
- Knife-edge** The sealing detail on a metal seal flange; the portion of a metal seal flange that bites into a gasket between two identical size flanges
- Kovar® - Alloy 29-17** The Carpenter Technology registered trademark brand name of a highly magnetic nickel-iron alloy; provides a transition between stainless steel and glass materials in viewports or other components; has a phase shift at -80°C and therefore not suitable for cryogenic applications
- kV** Kilovolts; measurement of electrical voltage
- kW** Kilowatts; measurement of electrical power
- LB or lb** Pound; unit of weight measurement
- LB<sub>f</sub> or lb<sub>f</sub>** Pound; unit of force measurement; frequently the “f” is omitted when the context is clear
- lb-ft** Pound-foot; unit of torque measurement; sometimes written lb<sub>f</sub>-ft
- LCD** Liquid crystal display; typically used on instrumentation
- Leak check grooves** Narrow radial grooves machined into a metal seal flange between the outer surface and the capture groove for a gasket; typically not on flanges larger than 10" OD
- LF flange** The larger ISO flanges; Large-Flange™ is the MDC trademark name for the larger components of a complete ISO flange family
- Live length** The portion of a bellows that can provide motion; the convoluted portion of a formed bellows
- LN<sub>2</sub> or LN** Liquid nitrogen
- Load Capacity, Stage** The maximum centered load that can be placed directly on an XYZ motion stage and is typically limited by the load capacity of the bearings
- Load Capacity, Lateral or Moment** Also called side or bending load capacity, it is the maximum load that can be applied perpendicular to a shaft's axis of motion
- Load Capacity, Axial** The maximum centered and balanced compressive or tensile load that can be applied to a stage's or shaft's longitudinal or parallel axis of motion.
- Load-Lock** A method of introducing product into a vacuum chamber via an intermediate chamber; allows sample manipulation without significantly affecting the vacuum of the main chamber
- LV** Low vacuum; typically between atmosphere and 10<sup>-3</sup> Torr
- Matte finish** A bead blast finish on standard tubing
- MAX or max** Maximum
- MESA** Modular Equipment Standards Architecture; replaced by MESC
- MESC** Modular Equipment Standards Committee
- MHV** Miniature high voltage; used in medium power applications; similar to BNC series, but do not intermate with BNC
- micron** unit of length equal to .000001 meter
- mil** unit of length equal to .001 inch
- min** Minimum or minute, depending on context
- Minimum Incremental Motion** The smallest motion a device is capable of delivering reliably, not the smallest display resolution increment
- MPI** Mechanical position indicator; available on most electro-pneumatic valves; utilizes mechanical microswitches to provide open/closed circuits which may be used for position indication, interlock circuitry, etc.; requires customer wiring
- MPT** Commonly used abbreviation for male pipe thread
- Mu-metal** A composite of rare earth metals used to provide a magnetic shield around sensitive instrumentation
- NEMA** National Electrical Manufacturers Association
- NIST** National Institute of Standards and Technology
- Nominal** The approximate or rounded-off dimension used to designate the size of an object, such as a flange or tube; abbreviated “Nom.” or “nom.”
- Nonrotatable** A flange machined from a single piece of material; once welded to tubing or a chamber, the bolt holes are no longer rotatable for alignment purposes
- NPT** National Pipe Taper; a specific taper to a threaded hole which provides a pressure seal between male and female threads; sometimes referred to as National Pipe Thread
- NW** Nenn Weite (German); nominal diameter, usually referring to vacuum tubing internal diameter
- OD** Outside diameter or outer dimension; usually of tubing or any circular or spherical piece, but can also apply to any shape
- OEM** Original equipment manufacturer
- OFE copper** Oxygen free electronic grade copper; also called oxy-

- gen free electrolytic or simply oxygen free; replaces OFHC
- OFHC copper** Oxygen free, high conductivity; a trade name for vacuum compatible copper that is no longer being manufactured; replaced by OFE copper
- O-ring** An elastomer vacuum seal available in various materials; torus or doughnut shaped, typically circular in cross-section; may be a dynamic or static seal
- oz** Ounce; unit of weight measurement
- oz<sub>f</sub>** Ounce; unit of force measurement; frequently the “**f**” is omitted when the context is clear
- oz-in** Ounce-inch; unit of torque measurement
- PEEK** Polyether-etherketone; a high-temperature resistant thermoplastic that is vacuum compatible; suitable for wire coating, injection molding, film and advanced composite fabrication
- pf** Picofarad; unit of electrical capacitance measurement
- PI** Position indicator; available on most valves; utilizes stationary magnetic Reed switches and a moveable magnet
- Pitch** The spacing of threads on a shaft; related to threads per inch
- Play** Uncontrolled movement due to looseness of mechanical parts. Usually increases with the components age. Play is a contributor to backlash
- Poppet** The movable portion of an angle valve; includes a groove to hold an elastomer O-ring which completes the seal
- Position Stability** The ability to maintain a constant position over time. Variation from stable position is called drift. Contributors to drift include worn parts, migration of lubricant, and thermal variation
- Precision** Also known as repeatability, it is the range of deviations in output position that will occur for 95% of the motion excursions from the same error-free input. Accuracy and precision are not the same
- PSI** Pounds per square inch; unit of pressure measurement
- PSIA** Pounds per square inch absolute; pressure measured with respect to zero pressure
- PSIG** Pounds per square inch gauge; pressure measured with respect to that of the atmosphere
- PTFE** Polytetrafluorethylene; self-lubricating, non-compressible, inert and low outgassing material for dynamic seals
- PVC** Polyvinyl chloride; typically used in low vacuum applications such as roughing lines
- PVD** Physical vapor deposition; a method of depositing material on a substrate using evaporation
- QMS** Quadrupole mass spectrometer
- Quad-Ring** An elastomer used in dynamic seals; typically “U” shaped in cross-section
- Receiver** Part of a rotatable flange; the larger outer part of a rotatable flange that includes bolt holes; may be rotated to align bolt holes prior to completing a vacuum seal
- Reducer** A fitting that changes diameter from one size to another within a single method of sealing, such as metal seal to metal seal; contrasted with Adapter
- Repeatability** The ability of a motion instrument to reliably achieve a commanded position over many attempts regardless of the direction from which the position is approached
- RF** Radio frequency
- RGA** Residual gas analyzer
- RMS** Root-mean-square; a calculation to determine an average of fluctuating values; electrical or surface finish measurement
- Roll-up** A cylindrical shaped section of stainless steel that is welded internally for vacuum integrity and stitch welded externally for strength; for vacuum chambers or “tubing” greater than 10 inches in outer diameter
- Rotatable flange** Composed of two machined pieces: an insert and a receiver; used for bolt hole alignment only; the insert is welded to tubing and the receiver slides over the insert; the receiver bolt holes can be rotated to align with bolt holes of another flange, once bolts are inserted the receiver cannot be rotated
- RPM or rpm** Revolutions per minute; measurement of rotational speed
- Runout** The linear, not angular, portion of off-axis error. It is the deviation between ideal straight line motion and actual measured motion in a translation stage. Runout has two orthogonal components, straightness, a measure of in-plane deviation, and flatness, the out-of-plane deviation
- SAE** Society of Automotive Engineers
- SEMI** Semiconductor Equipment and Materials International
- Sensitivity** The minimum input required to produce output motion or the ratio between output motion and input drive; applicable particularly to manually actuated motion devices
- Setback** The distance from the sealing face of a flange to the tubing counterbore
- SHV** Safe high voltage; similar to MHV series, except SHV cable connector center contacts do not protrude from connector ends which makes them safer in a disconnected condition
- SI** Système International d’Unités (French); unified system of measurement including the metric system, electrical units such as Amperes, Volts, etc.
- Spring rate** The amount of force required to compress a guided bellows one linear inch; given in pounds per inch (lbs/in)
- Squirm** Arbitrary lateral movement of a bellows
- SS, SST, ss or sst** Abbreviation for Stainless Steel, any grade
- Stainless steel** In general, an iron-chromium alloy; corrosion resistance is enhanced by the addition of nickel
- Static bend radius** The minimum radius a bellows can be curved without encountering permanent deformation
- Std Atm cc/sec He** Leak rate measurement



**Swagelok®** The Swagelok Company registered trademark brand name tube fitting providing UHV compatible connections on fractional inch tube sizes; uses a compressible ferrule; requires clean tube end only

**Tangents** Lengths of straight tubing added to elbows so that centerlines of straight sections are tangent to curved centerline

**Tapped holes** Drilled holes that have female threads cut into them; also called threaded holes

**TC** Thermocouple; method of measuring heat and therefore indirectly measuring vacuum pressure

**Temp or temp** Abbreviation for temperature

**Threaded holes** Drilled holes that have female threads cut into them; also called tapped holes

**Through or Thru holes** Drilled holes that are smooth and completely through the material; also called clearance holes

**TIG** Tungsten inert gas; a method of welding which keeps the weld shielded from corrosive atmosphere by bathing the area with an inert gas during the process

**Tilt** The angular portion of off-axis error. It is the deviation between ideal straight line motion and actual measured motion in a translation stage. Tilt and wobble have three orthogonal components commonly referred to as roll, pitch, and yaw

**Torr** A unit of pressure measurement; one atmosphere equals 760 Torr; sometimes written torr

**TSE** Technical Sales Engineer

**Typ or typ** Typical; applies to all occurrences of a feature

**Type-D Subminiature feedthrough** Based on MIL-C-24308 specifications for pin arrangements; identified by a "D" or key-stone shape

**Type N feedthrough** Low instrumentation voltage feedthrough for matched 50 ohm impedance rating applications

**UHV** Ultrahigh vacuum; defined by the American Vacuum Society as the pressure range between  $7.5 \times 10^{-10}$  to  $7.5 \times 10^{-13}$  Torr; British and German standards define UHV as  $10^{-8}$  Torr or better

**UL** Underwriter's Laboratories; typically a stamp of approval for acceptable electrical safety standards in the USA

**UNC** Unified National Coarse; referring to bolt threads

**UNF** Unified National Fine; referring to bolt threads

**UNS** Unified Numbering System

**UPS** United Parcel Service; see Ordering Information section

**UTA** A common abbreviation for Up-to-Air

**V** Volt; unit of electrical voltage

**VAC** Alternating current voltage

**VCR®** The Swagelok Company registered trademark brand name tube fitting providing UHV compatible connections on fractional inch tube sizes; uses a replaceable metal gasket; requires mating connector installed on tubing

**VDC** Direct current voltage

**VespeI®** The DuPont Dow Elastomer registered trademark brand name of a high vacuum compatible polyimide material used for bearings; may be used without lubrication

**WDM** xxxxx

**Wobble** The angular deviation of the axis of rotation over one complete revolution

**WT or wt** Weight

**WxHxD** Rectangular dimensions

**XHV** Extreme high vacuum; defined by the American Vacuum Society as below  $7.5 \times 10^{-13}$  Torr

**Yield point** xxxxx

**Zero-length** Any flanged device that has a total overall thickness equal to the thickness of the flange itself

**&** ampersand; the symbol for "and"

**@** the symbol for "at"

**°C** degrees Centigrade or Celsius; unit of temperature

**°F** degrees Fahrenheit; unit of temperature

**μ** Mu; unit of magnetic permeability; also the symbol for micron as μin, micro-inch

**#** the symbol for "number" or "pound" weight, depending on context

**Ω** Omega; ohm, unit of electrical resistance or impedance







**Reference Page**

# The number symbol refers to the various sizes within a single model reference number, usually a flange or tube size.

## Numbered References

#-#CRNF	134
#-1	63
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275	2-3/4" flange
338	3-3/8" flange
450	4-1/2" flange
458	4-5/8" flange
600	6" flange
675	6-3/4" flange
800	8" flange
1000	10" flange
1200	12" flange
1325	13-1/4" flange
1400	14" flange
1650	16-1/2" flange

Ref	Vacuum Tubing
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037	3/8" O.D.
050	1/2" O.D.
075	3/4" O.D.
100	1" O.D.
125	1-1/4" O.D.
150	1-1/2" O.D.
175	1-3/4" O.D.
200	2" O.D.
250	2-1/2" O.D.
300	3" O.D.
400	4" O.D.
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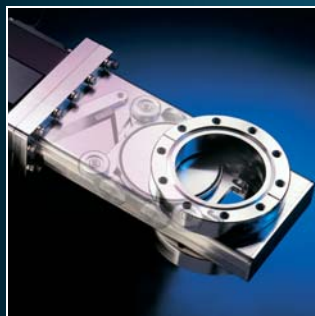
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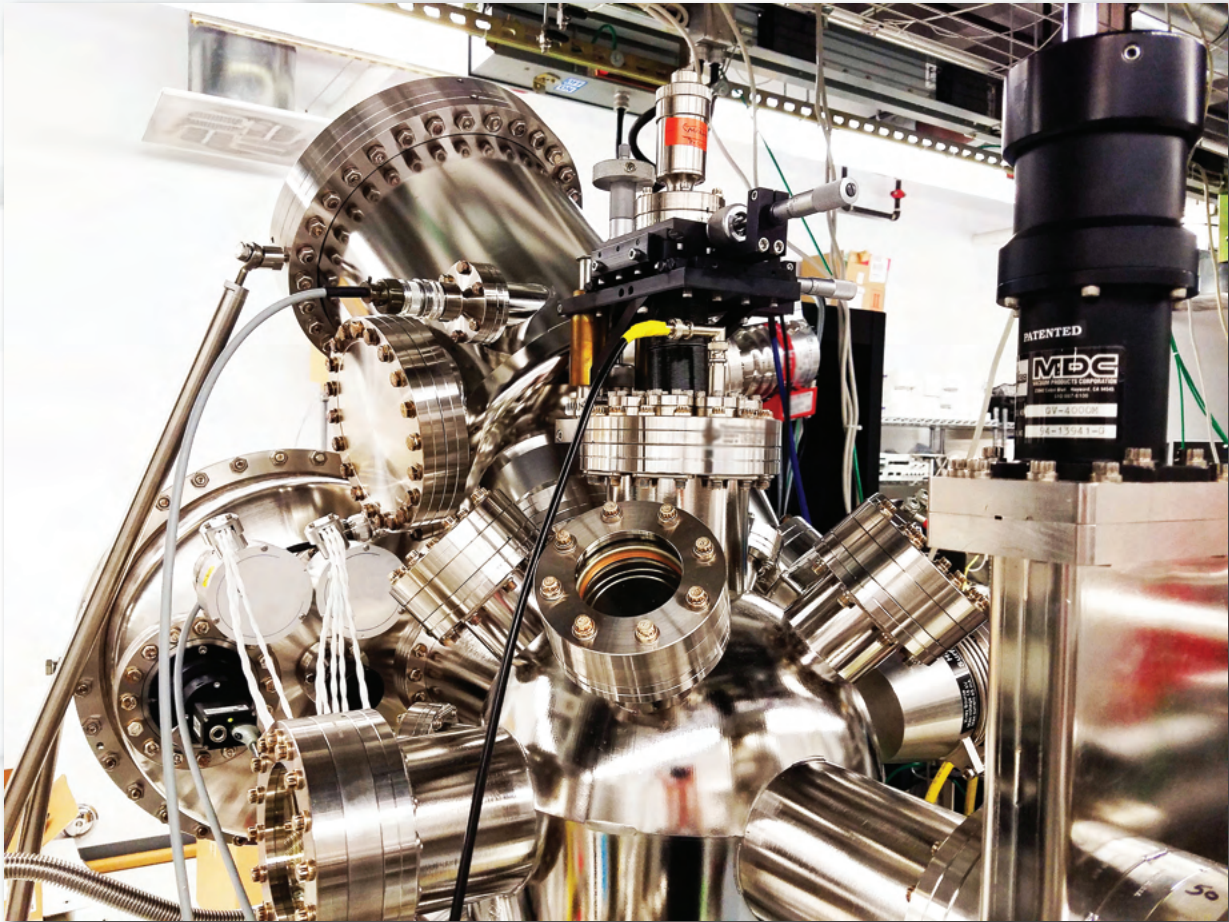
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**DRIVING YOUR PROCESS FORWARD**