

# Section 4

## Vacuum measurement

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# Vacuum measurement

## Introduction



- Bourdon gauge
- Thermocouple gauge tube
- Enclosed ionization gauge tube
- Nude ionization gauge tube

### Bourdon gauge

Deflection gauges measure true pressure via deflection of a bourdon tube, independent of the type of gas in a system. Bourdon tubes are constructed in either C-tube or helical coil geometries and of these two, helical Bourdon tubes provide the greatest sensitivity.

Caburn-MDC Bourdon gauges are designed for rough vacuum measurements in the range of 30 inches of mercury and positive pressures to 30psig. As a general rule, all vacuum components and chambers are rated for vacuum service and should never be internally pressurized. Bourdon gauges are offered with Del-Seal™ CF metal seal flanges, Kwik-Flange™ ISO KF flanges and male NPT pipe thread fittings.

### Thermocouple gauge tube

MDC thermocouple gauge tubes offer fast and reliable vacuum measurement from 1 to  $1 \times 10^{-4}$  mbar.

Thermocouple gauge tubes consist of two basic components, a resistive filament and a thermocouple junction used to measure its temperature. Thermocouple gauge tubes operate on the thermal conductivity principle. Basically, they measure the thermal conductivity of a residual gas inside a vacuum system, or its ability to conduct heat away from a heated filament. The higher the pressure inside a vacuum system the cooler the filament or conversely, the lower the gas pressure the hotter the filament becomes. The thermocouple junction inside the gauge tube is positioned on the heated filament and is used to

monitor its temperature during system evacuation. A temperature rise or drop in the filament produces a potential rise or drop in the thermocouple junction. This potential in millivolts is then calibrated to microns in a thermocouple gauge controller.

Because thermocouple gauge tubes and control electronics are available from a multitude of manufacturers, it is important to note that individual thermocouple gauge tubes are designed to operate at specific filament current ratings, which should be carefully matched with a control instrument's specifications. Always refer to the control electronics manufacturer for specifications on filament current requirements before purchasing or installing a thermocouple gauge tube.

Caburn-MDC UHV gauge tubes feature all-welded construction and stainless steel casing tubes that are bakeable to 150°C. Electrical connections are glass insulated and employ a standard eight pin interface with a polarized centre post. They are offered with Del-Seal™ CF flanges and Swagelok's VCR® fittings. HV gauge tubes are supplied with male NPT pipe thread fittings and a nickel plated steel shell assembly for maximum corrosion resistance and bakeable to 150°C.

Thermocouple gauge tubes are expendable vacuum components and must be replaced periodically. Most gauges are typically calibrated for service in air (nitrogen) and experience extreme variations in calibration when in the presence of



Bourdon type gauges

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Thermocouple gauge tube

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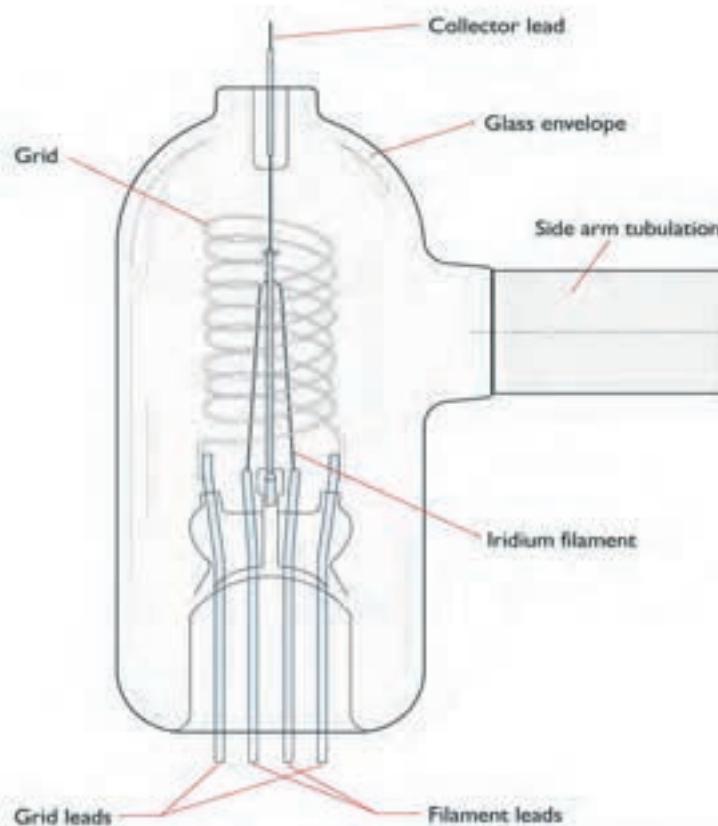


other gases, subsequently leading to erroneous vacuum measurement readings. An inexpensive solution would be to include a non-gas-dependent gauge such as a Bourdon gauge to verify calibration.

### Glass enclosed ionization Gauge tube

Caburn-MDC glass enclosed ionization gauge tubes are designed for high and ultrahigh vacuum measurements between  $1 \times 10^{-3}$  to  $2 \times 10^{-10}$  mbar. Glass enclosed ionization tubes, commonly referred to as Bayard-Alpert gauge tubes, consist of several components including a resistive filament, a positively charged grid and a negatively charged collector. The resistive filament is heated to incandescence for the purpose of emitting electrons. The grid, a positively charged wire, coiled in the shape of a spiral, attracts and accelerates filament emitted electrons. The collector, a negatively charged wire, is strategically placed in the path of oncoming electrons. As electrons collide with air molecules inside the tube, the air molecules lose an electron and become positively charged or ionized and thus attracted to the negatively charged collector. Upon colliding with the collector air molecules regain their lost electron and return to their original neutral charge. The flow of electrons from the collector to air molecules is measured and calibrated for vacuum measurement. The number of air molecules is directly proportional to their ionization and in direct proportion to the flow of electrons surrendered by the collector.

#### Unique VacOptix® hermetic seal design



### Nude ionization gauge tube

MDC nude ionization gauge tubes are designed for high and ultrahigh vacuum measurements between  $1 \times 10^{-3}$  to  $2 \times 10^{-11}$  mbar. Like their glass enclosed counterparts, these are also hot cathode ionization types. The main difference being their method of construction.

Nude gauges allow for easy replacement of perishable filaments and the added durability of ceramic-to-metal electrical feedthrough insulation which makes them bakeable to  $450^{\circ}\text{C}$ . Two nude gauge styles are offered, these utilize resistive heating or electron bombardment degas.



Nude ionization gauge tube

page 210



Glass-enclosed ionization gauge tube

page 218



Replacement filaments

page 211



# Vacuum measurement

## Nude ionization gauge tubes



### Features

- 10<sup>-3</sup> to 10<sup>-11</sup> mbar range
- DN40CF flange mounted
- Resistive heating degas
- Replaceable filament assemblies
- Mount in any position
- Bayard-Alpert type tube

### Vacuum specifications

Vacuum range	10 <sup>-3</sup> to 4x10 <sup>-11</sup> mbar
Maximum operating pressure	1x10 <sup>-3</sup> mbar
Sensitivity ±20%	10 mbar
X-ray limit	4x10 <sup>-11</sup> mbar

### Construction specifications

Flange	304SS
Grid	Tungsten
Filament	Dual Tungsten or Iridium
Collector	Tungsten
Shield coating	Platinum
Base leads	Soft nickel 1.5mm dia
Collector lead	Soft nickel 1.0mm dia

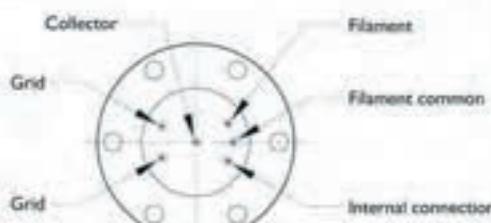
### Operating specifications

Collector	-30V DC
Grid	+150V DC
Filament	+30V DC
Filament voltage	3 - 5V
Filament current	4 - 6A
Degas by PR	70W
Emission	10mA
Maximum bakeout temperature	450°C

### UHV Series

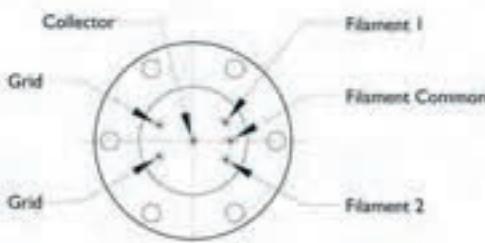
#### Pin-out pattern

Single filament



#### Pin-out pattern

Dual filament



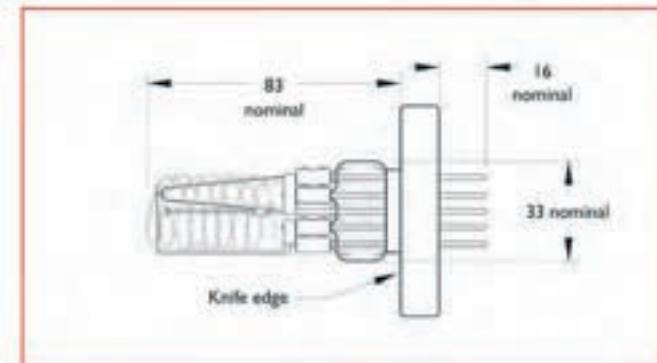
■ Requires minimum 34.8mm ID clearance for installation

# Vacuum measurement

## Nude ionization gauge tubes



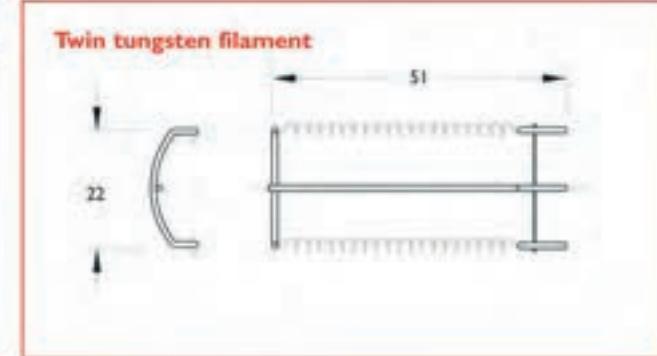
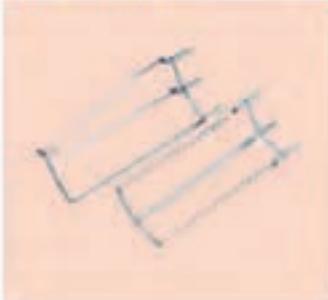
### I'R degas



### Features

- High temperature
- UHV compatible
- CF flange
- Replaceable filaments

### Filaments



### Features

- High temperature
- UHV compatible
- Replacement filament assemblies for above ionization gauge tubes

### Replacement for

### Description

### Wt kg

### Reference

### Part number

BATT Twin tungsten filament, Bayard-Alpert gauge 0.3 BAIR

BAIR Single iridium filament, Bayard-Alpert gauge 0.3 BARI

Each pack contains two filaments

### Tube interchange / Cross reference table

Several of the Caburn-MDC tubes will directly interchange with models of various manufacturers as noted in the cross reference table.

While tubes may have identical electrical specifications with tubes from other manufacturers not listed, pin-out dimensions may vary.

### Description

### Replacement for

### Caburn-MDC reference

### Caburn-MDC part number

Single iridium filament, BA gauge tube

274028

BART

432002

Replacement filament for 432002

274029

BAIR

432003

\* These gauge heads are supplied as replacements for customers existing gauges only

Caburn-MDC does not supply a suitable controller for these gauges



# Vacuum measurement

## Nude ionization gauge tubes



### UHV Series

#### Features

- $10^{-3}$  to  $10^{-11}$  mbar range
- DN40CF flange mounted
- Electron bombardment degas
- Replaceable filament assemblies
- Mount in any position

### Vacuum specifications

Vacuum range	$10^{-3}$ to $2 \times 10^{-11}$ mbar
Maximum operating pressure	$1 \times 10^{-1}$ mbar
Sensitivity $\pm 20\%$	25 mbar
X-ray limit	$2 \times 10^{-11}$ mbar

### Construction specifications

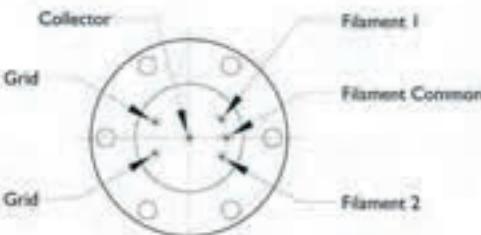
Flange	304SS
Grid	Tungsten
Filament	Dual Tungsten or Iridium
Collector	Tungsten
Shield coating	Platinum
Base leads	Soft nickel 1.5mm dia
Collector lead	Soft nickel 1.0mm dia

### Operating specifications

Collector	0V DC
Grid	+180V DC
Filament	+30V DC
Filament voltage	3 – 4.5V
Filament current	2 – 4A
Degas by EB	30 – 40W
Emission	4mA
Maximum bakeout temperature	450°C

#### Pin-out pattern

Dual filament



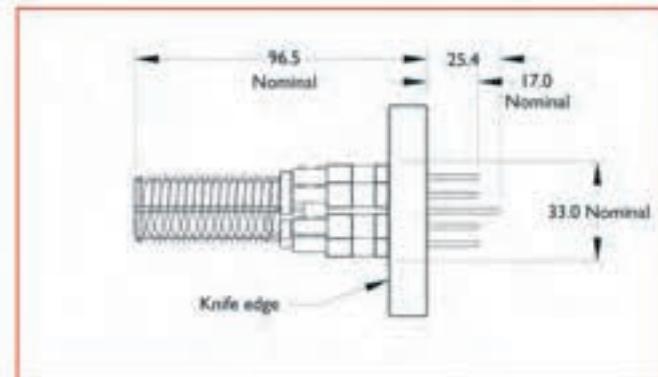
■ Requires minimum 34.8mm ID clearance for installation

# Vacuum measurement

## Nude ionization gauge tubes



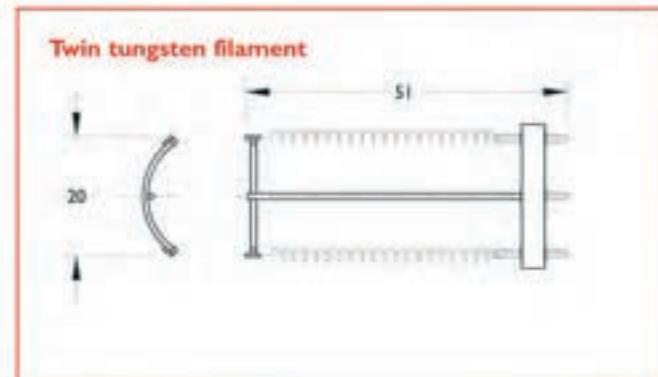
### EB degas



### Features

- High temperature
- UHV compatible
- CF flange
- Stainless steel construction

### Filaments



### Features

- High temperature
- UHV compatible
- Replacement filament assemblies for above ionization gauge tubes

Replacement for	Description	Per pack	Wt kg	Reference	Part number
UHTT	Twin tungsten filament, UHV gauge	2	0.3	UHRT	432005
UHIR	Single iridium filament, UHV gauge	2	0.3	UHRU	432007

Each pack contains two filaments.

### Tube interchange / Cross reference table

Several of the Caburn-MDC tubes will directly interchange with models of various manufacturers as noted in the cross reference table. While tubes may have identical electrical specifications with tubes from other manufacturers not listed, pin-out dimensions may vary.

Description	Replacement for Granville-Phillips	Replacement for Perkin-Elmer	Caburn-MDC Reference	Caburn-MDC part number
Twin tungsten filament, UHV gauge tube	274022	605-7673	UHTT	432004
Replacement filament for 432004	274024	605-7671	UHRT	432005
Twin iridium filament, UHV gauge tube	274023	605-7672	UHIR	432006
Replacement filament for 432004	274025	605-7676	UHRU	432007

All dimensions are nominal in millimetres unless specified - Weights given are approximate



# Vacuum measurement

## Thermocouple gauge tubes



### Features

- 0.1 micron to 1000 micron Hg range
- UHV and HV tubes
- Interchangeable with other brands
- Choice of connectors

### General description

Caburn-MDC thermocouple gauge tubes offer a fast and reliable means of measuring vacuum from 0.1 to 1000 micron Hg. They can be read continuously and remotely under severe operating conditions.

Individual thermocouple gauges operate with specific heater current ratings. Gauge tubes must be matched to the instrument's specifications. Refer to the manufacturer's instructions for heater current and thermocouple output.

**Note** Although some units are fitted with eight pins, only four pins are actively used. See tube pin-out configurations on page 215.

**UHV Series tubes** feature all-welded construction, stainless steel casings, and are bakeable to 150°C. Electrical connections are glass insulated. They are offered with CF mini-flanges and Cajon VCR® fittings.

**HV Series tubes** are supplied with nickel plated steel shell and stem assemblies for corrosion resistance. They are bakeable to 150°C.

### Tube interchange / Cross reference table

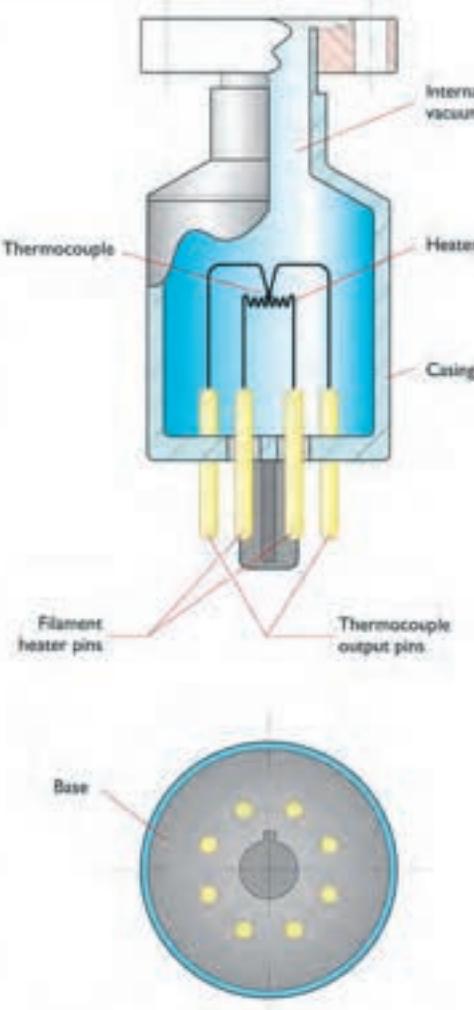
Several of the Caburn-MDC tubes will directly interchange with models of various manufacturers as noted in the cross reference table. Standard series tubes are equal or superior in performance while the high temperature/UHV series offer even higher specifications. Other models are available on request.

**Note** Although some units are fitted with eight pins, only four pins are actively used.

### UHV and HV series

#### Thermocouple gauge parts

Simplified TGT-2AM shown



## Vacuum measurement

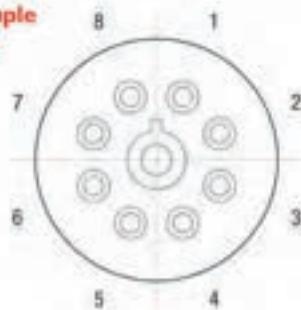
## Thermocouple gauge tubes



## Tube pin-out

Generally, for all thermocouple gauge tubes the pin out patterns employ four active pins. Two of the pins supply current to the heater inside the gauge head and two of the pins provide a return signal which is dependent on pressure inside the vacuum vessel. In the case of gauge tubes having eight pins, four of the pins are active and the other four are used for support only.

Thermocouple gauge tube pin-out



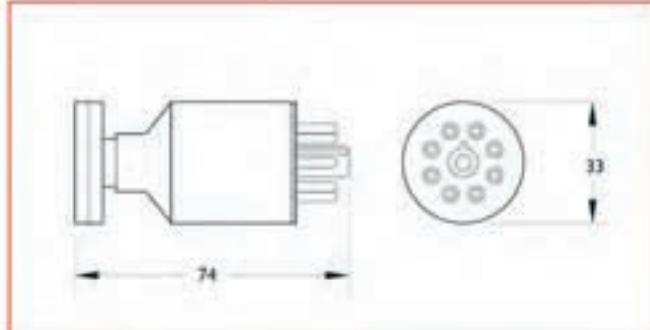
Reference	Heater pins	Thermocouple pins	Part number
	TC+	TC	
TGT-2A	1	8	S11013
TGT-2AM	1	8	S11010
TGT-1S1B	1	7	S11004
TGT-1S1BM	1	7	S11000
TGT-1S1BW	1	7	S11002
TGT-5310	1	3	S11008
TGT-531M	1	3	S11001
TGT-531W	1	3	S11003
TGT-531S	1	3	S11009
TGT-1504	1	7	S11005
TGT-1000'	3	5	S11006
TGT-6000'	3	5	S11007

AC connection on heater pins; DC connection on TC pins

## DN16CF



TGT-2AM



## Features

- 150°C bakeout
- UHV compatible
- CF flange
- Stainless steel construction

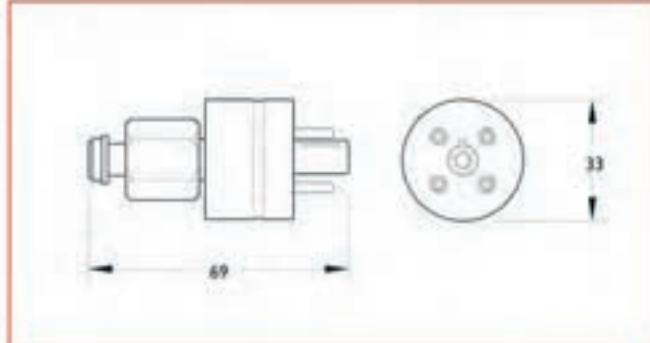
## Description: Pressure range (mbar) Heater current (mA) Response time (sec) Output @ 55°C and 0.01μHg (mV) Wt kg Reference Part number

DN16CF	0.1 - 1000	95	< 0.2	9.1	0.1	TGT-2AM	S11010
DN16CF	0.1 - 1000	15 - 18.5	< 0.1	10	0.1	TGT-1S1BM	S11000
DN16CF	0.1 - 2500	163	< 0.1	13.5 - 14.5	0.1	TGT-531M	S11001

## 19.1 ¼" VCR®



TGT-1S1BW



## Features

- 150°C bakeout
- UHV compatible
- ¼" VCR® fitting
- Stainless steel construction

## Description: Pressure range (mbar) Heater current (mA) Response time (sec) Output @ 55°C and 0.01μHg (mV) Wt kg Reference Part number

19 (½") VCR®	0.1 - 1000	15 - 18.5	< 0.1	10	0.1	TGT-1S1BW	S11002
19 (½") VCR®	0.1 - 2500	163	< 0.1	13.5 - 14.5	0.1	TGT-531M	S11003



# Vacuum measurement

## Micro Pirani transmitters



### Micro pirani

Measuring range	$1 \times 10^{-4}$ to $1 \times 10^1$ mbar
Maximum pressure	3000 mbar
Output voltage	0-10V
Temperature effect on offset	<0.3 mV/ $^{\circ}$ C
Materials exposed to vacuum	Silicon, SiO <sub>2</sub> , Si <sub>3</sub> N <sub>4</sub> , gold, epoxy resin, stainless steel, aluminium
Accuracy	$\pm 3\%$ typical in $10^{-4}$ to $10^1$ mbar range

### Description

New pirani sensor technology incorporating careful design of the temperature compensation circuit has made it possible to extend the measuring range of the pirani gauge downwards by an order of magnitude to  $1 \times 10^{-4}$  mbar.

Thermal conductivity of the gas is measured in a very small cavity integrated in a 1x1mm silicon chip. The nonlinear 0-10V DC output is easily converted to pressure by using a simple algorithm with only three calibration constants for each gas.

Micro pirani model MPI is supplied complete with lead and mounted on a DN16KF flange. (Other flange mounts are available to order). All models are offered with either aluminium or stainless steel bodies.

Dual trans and dual trans+ models combine the advantages of a piezo and a micro pirani transmitter in one instrument mounted on a DN16KF flange.

All transmitters are supplied with a 3 metre cable.

### Features

- Fast response
- Very small internal volume
- Integrated electronics
- High temperature stability
- Easy pirani calibration
- Small dimensions
- Accuracy

### Micro pirani $1 \times 10^{-4}$ to $1 \times 10^1$ mbar

The micro pirani measures the thermal conductivity of the residual gas. It is based on a 1x1mm micro mechanic chip with resistors for measuring the thermal conductivity and the ambient temperature. This technology together with advanced circuit design offers excellent performance. The micro pirani cannot be used in corrosive environments. The measured gas must be compatible with silicon, SiO<sub>2</sub>, Si<sub>3</sub>N<sub>4</sub>, gold, epoxy resin, FKM/FPM, stainless steel and nickel. Normally a standard pirani cannot be used in explosive environments because the filament is kept at a constant temperature of 150°C or higher. The sensor element of the micro pirani is kept at a temperature only 30°C above ambient allowing the use in some explosive environments.

### Dual trans $1 \times 10^{-4}$ to 2000 mbar

The dual trans is a combination of a piezo and a micro pirani into one transmitter. The advantages of the piezo from overpressure down to 1 mbar combined with the wide measuring range of the micro pirani results in a transmitter covering more than 8 decades with high accuracy. For media compatibility of the dual trans refer to the micro pirani and the piezo.

### Dual trans+ $1 \times 10^{-4}$ to 4000 mbar

The dual trans+ is designed for vacuum applications where overpressure may occur. It can measure up to 4000 mbar.

### Accuracy

Typical values are normally  $\pm 10$  to 15% in a range down to  $10^{-4}$  mbar.

Description	Pressure range	Body material	Reference	Part number
Micro pirani	$1 \times 10^{-4}$ to $1 \times 10^1$ mbar	Aluminium	MPI-K16	2604010
Dual trans	$1 \times 10^{-4}$ to 1999 mbar	Aluminium	DUT1-K16	2604030
Dual trans+	$1 \times 10^{-4}$ to 3999 mbar	Aluminium	DUT2-K16	2604032
Micro pirani	$1 \times 10^{-4}$ to $1 \times 10^1$ mbar	Stainless steel	SMPI-K16	2604015
Dual trans	$1 \times 10^{-4}$ to 1999 mbar	Stainless steel	SDUT2-K16	2604035
Dual trans+	$1 \times 10^{-4}$ to 3999 mbar	Stainless steel	SDUT4-K16	2604037

All dimensions are nominal in millimetres unless specified - Weights given are approximate

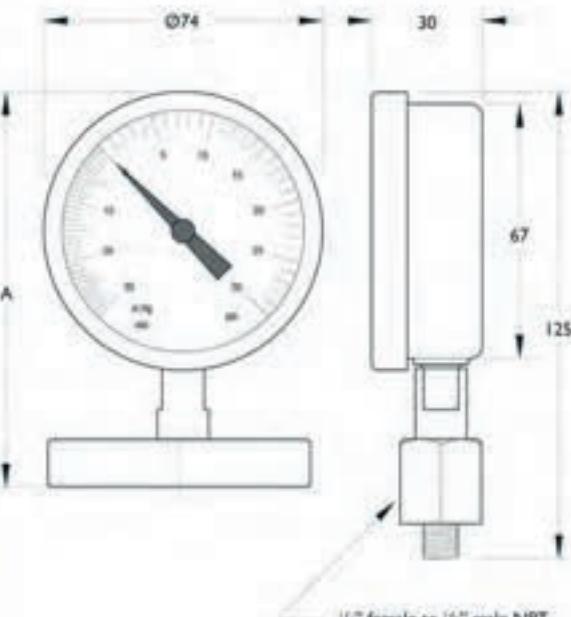
**Vacuum measurement****Bordon gauges****Features**

- Large easy-to-read dial
- Measures vacuum to 1 bar and overpressure to 1 bar
- CF, KF, or NPT mounting
- Stainless steel construction

**Description**

Provides a quick visual check of roughing line pressures.

**Note** These gauges are intended for vacuum use with other Caburn-MDC components and as such are not rated for oxygen service.

**Low vacuum series****Pressure / vacuum gauge**

1/4" female to 1/4" male NPT adaptor – supplied with unflanged model only.

- 63.5 diameter gauge face
- On NPT model only, removable adaptor allows either 1/4" or 1/2" NPT thread mounting

Nominal flange	Flange OD	O	A	Wt kg	Reference	Part number
<b>Flanged</b>						
DN16CF	34		102	0.1	075-VG	432014
DN40CF	70		107	0.3	150-VG	432016
DN16KF	30		107	0.2	K075-VG	432010
DN25KF	40		107	0.2	K100-VG	432011
DN40KF	55		107	0.3	K150-VG	432012
DN50KF	75		107	0.3	K200-VG	432013
<b>Pipe thread</b>						
NPT thread	Includes one 1/4" female to 1/4" male air fitting			0.1	VG	432020

All dimensions are nominal in millimetres unless specified - Weights given are approximate



# Vacuum measurement

## Glass envelope ionization gauge tubes



Side arm glass envelope ionization gauge tubes

### Vacuum specifications

Vacuum range	$10^{-1}$ to $2 \times 10^{-6}$ mbar
Maximum operating pressure	$1 \times 10^{-4}$ mbar
Pumping speed Ionic	0.06 litres/sec - N <sub>2</sub> (1mA)
X-ray limit	$2 \times 10^{-6}$ mbar - N <sub>2</sub> (approx.)

### Construction specifications

Envelope	Nonex
Grid	"Non-sag" tungsten 0.7mm dia
Filament	Hairpin thoriated iridium
Collector	Tungsten, 0.254mm dia
Shield coating	Platinum, internally connected to filament
Base leads	Soft nickel 1.5mm dia
Collector lead	Soft nickel 1.0mm dia
Internal volume	220cm <sup>3</sup> (not including tubulation)

### Operating ratings

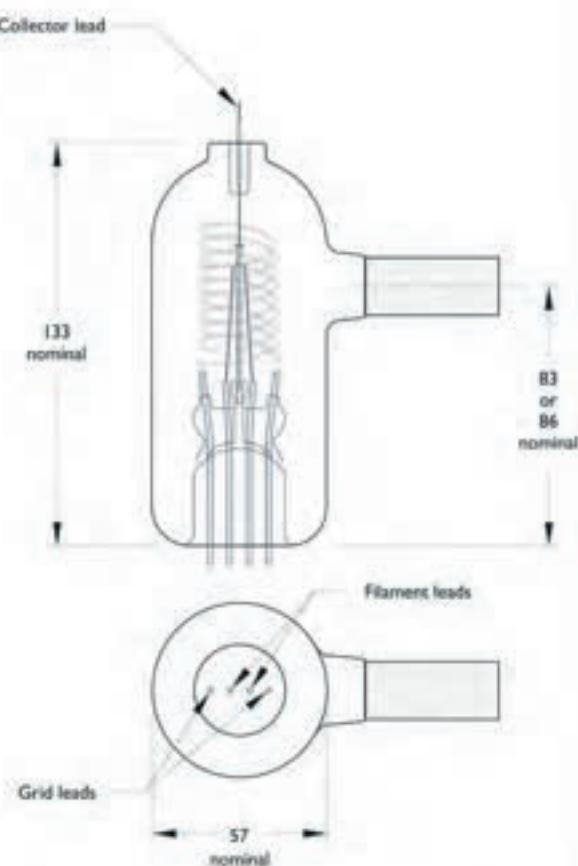
Collector	0V DC (ground)
Shield	Internally connected to filament
Grid	+150V DC to ground
Filament	+30V DC to ground
Filament volts AC	4.0V
Filament current AC	3.5A (1 mA grid current)
Absolute maximum filament volts AC	6.0V
Absolute maximum filament current AC	6.0A
Absolute maximum filament temperature	1400°C

### UHV and HV series

#### Features

- Non-burnout design allows momentary exposure to atmosphere
- Choice of Pyrex®, Kovar® and CF flange
- ISO KF flange optional

#### Pin-out pattern



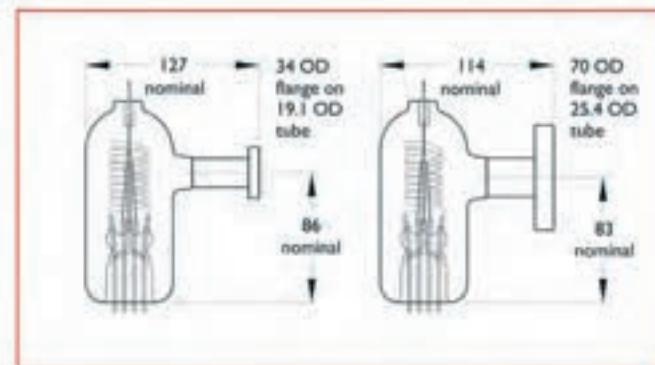
- For both grid and filament leads, one is positive and the other is ground
  - It does not matter which lead is positive and which lead is ground
- All four bottom leads are in a single line
- Pin-out pattern is the same industry-wide

# Vacuum measurement

## Glass envelope ionization gauge tubes



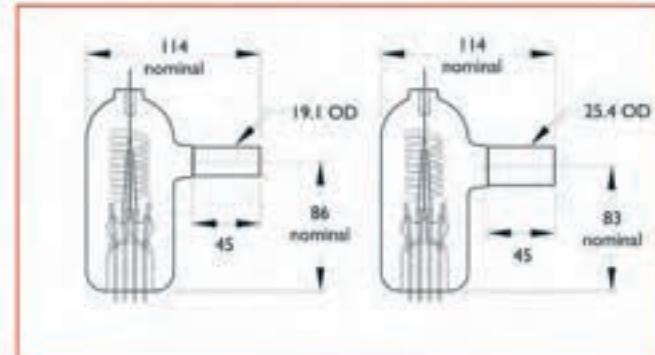
### CF Flange



### Features

- UHV compatible
- CF flange

### Tubulated



### Features

- HV compatible
- Pyrex® tube or Kovar® sleeve

Method of connection	Description	Wt kg	Reference	Part number
<b>Pyrex® tube</b>				
19.1	19.1 tube	0.2	IGT-075-P	432021
25.4	25.4 tube	0.2	IGT-100-P	432024
<b>Kovar® sleeve</b>				
19.1	19.1 tube	0.2	IGT-075-K	432022
25.4	25.4 tube	0.2	IGT-100-K	432025

### Tube interchange / Cross reference table

Description	Replacement for Granville-Phillips	Replacement for Perkin-Elmer	Replacement for Varian	Caburn-MDC Reference	Caburn-MDC part number
DN16CF Nominal size	274020	—	—	IGT-075-D	432023
DN40CF Nominal size	274008	605-7152	571-K2471-303	IGT-100-D	432026
Pyrex® with graded seal, 19.1 tube	274002	—	—	IGT-075-P	432021
Pyrex® with graded seal, 25.4 tube	274005	—	—	IGT-100-P	432024
Kovar® with graded seal, 19.1 tube	274003	605-7000	571-K2471-305	IGT-075-K	432022
Kovar® with graded seal, 25.4 tube	274006	—	571-K2471-302	IGT-100-K	432025

Several of the Caburn-MDC tubes will directly interchange with models of various manufacturers as noted in the cross reference table.

While tubes may have identical electrical specifications with tubes from other manufacturers not listed, pin-out dimensions may vary.