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Instruction manual

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CoriCalc
Calculation tool
for (mini) CORI-FLOW™
instruments

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ATTENTION
Please read this instruction manual carefully before installing and operating the instrument.
Not following the guidelines could result in personal injury and/or damage to the equipment.



Disclaimer

The information in this manual has been reviewed and is believed to be wholly reliable. No responsibility, however, is assumed for inaccuracies. The material in this manual is for information purposes only.

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Symbols

Important information. Discarding this information could cause injuries to people or damage to the Instrument or installation.



Helpful information. This information will facilitate the use of this instrument.



Additional info available on the internet or from your local sales representative.

Warranty

Bronkhorst® products are warranted against defects in material and workmanship for a period of three years from the date of shipment, provided they are used in accordance with the ordering specifications and the instructions in this manual and that they are not subjected to abuse, physical damage or contamination. Products that do not operate properly during this period may be repaired or replaced at no charge. Repairs are normally warranted for one year or the balance of the original warranty, whichever is the longer.



See also paragraph 9 of the Conditions of sales:

http://www.bronkhorst.com/files/corporate_headquarters/sales_conditions/en_general_terms_of_sales.pdf

The warranty includes all initial and latent defects, random failures, and undeterminable internal causes.

It excludes failures and damage caused by the customer, such as contamination, improper electrical hook-up, physical shock etc.

Re-conditioning of products primarily returned for warranty service that is partly or wholly judged non-warranty may be charged for.

Bronkhorst High-Tech B.V. or affiliated company prepays outgoing freight charges when any party of the service is performed under warranty, unless otherwise agreed upon beforehand. However, if the product has been returned collect to our factory or service center, these costs are added to the repair invoice. Import and/or export charges, foreign shipping methods/carriers are paid for by the customer.

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1 GENERAL DESCRIPTION

CoriCalc is software to calculate important sizing parameters for applications with (mini) **CORI-FLOW™** instruments using mathematical models of the sensors and valves and physical fluid properties.

The following can be calculated/advised:

- Pressure drop over sensor related to flow
- Minimum inlet pressure for sensor/controller related to flow and outlet pressure
- Maximum outlet pressure for sensor/controller related to flow and inlet pressure
- Maximum flow based on the inlet- and outlet pressure
- Orifice diameter
- Sensor and valve type
- Density, viscosity and phase of fluid (if available in FLUIDAT®)

This instruction manual has been written based on the online version of CoriCalc.



Some program features described in this manual are optional. Bronkhorst High-Tech has the right to enable or disable certain parts of the program to adjust CoriCalc to the needs of the user. Too many features can lead to trouble. Too few features can lead to inconvenience. Please contact your sales representative or Bronkhorst High-Tech in Ruurlo, The Netherlands, to discuss this issue.



Although calculations by the program are found to be reliable and can be used for instrument sizing in the field, checking by Bronkhorst sales support might sometimes lead to a different instrument advice.

2 OPERATION

2.1 Main window layout

When CoriCalc is started, the main window is shown.

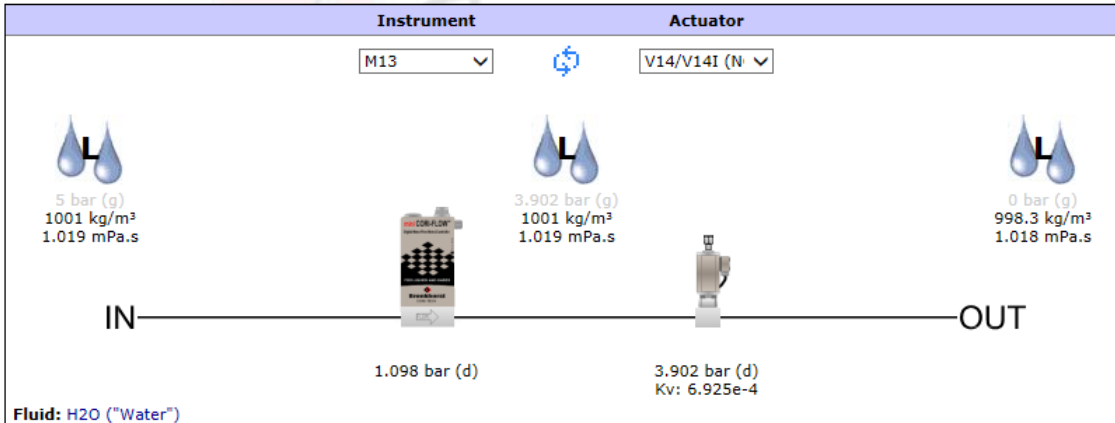
FLUIDAT® on the Net

H2O ("Water")

CoriCalc V1.14.4

About

Calculations and sizing for Coriolis Mass Flow Meters and Controllers, series ML120, M12 - M15 and M53 - M55.



Flow unit	Pressure Unit	Temperature
Mass Flow	Gauge Pressure	20 °C
kg/h	bar (g)	

Pressure Inlet	Flow	Kv	Orifice	Pressure Outlet
5 bar (g)	1.368 kg/h	0.0006925	0.2 mm	0 bar (g)
	1.368 kg/h			

Calculation

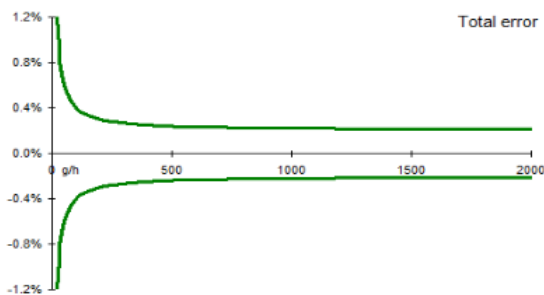
Calculate minimum required pressure inlet
 Calculate flow
 Calculate orifice
 Calculate maximum allowed pressure outlet

Calculate

Instrument	Actuator	Flow kg/h	Orifice mm	(advised)	Minimum flow kg/h	Total error* %	Sensor Δp bar (d)
M13	V14/V14I (NC)	1.368	0.2000	0	1.000e-3	0.2101	1.098 use advise

Max FS %	Pressure inlet bar (g)	Flow kg/h	Total error* %	Pressure outlet bar (g)	Sensor Δp bar (d)
98.8	5	1.368	0.2101	0	1.098
50	5	1.000	0.2200	2.200	0.7161
25	5	0.5000	0.2400	4.180	0.2994
10	5	0.2000	0.3000	4.811	0.1057
5	5	0.1000	0.4000	4.929	5.049e-2
2.5	5	0.05	0.6000	4.970	2.466e-2
1.25	5	0.025	1.000	4.987	1.218e-2

* Total error = accuracy reading ± [(zero stability / flow) × 100] [% reading]. Accuracy reading = 0.2% for liquids and 0.5% for gasses.



Remarks:

2.1.1 Instrument

Based on the example of controller for water application as shown in the figure above.

The upper part of the window shows a schematic overview of a (**mini**) **CORI-FLOW™** instrument. For a meter, only the sensor part is shown, whereas both the sensor and the valve are shown for a controller.

Above the sensor image, the desired sensor for which a calculation is to be made, can be selected from the **Instrument** list. In case a calculation for a **Controller** is to be made, a valve can be selected from the **Valve** list.

Apart from choosing a specific sensor and/or valve for making calculations, **Advise...** can be selected to get an advice for the right sensor or valve.

After a calculation has been performed, this part also shows the phase of the fluid at two (sensor only) or three (controller) positions in the instrument, at the inlet, between the sensor and the valve and at the outlet. Graphically the phases are indicated by bubbles for gases and droplets for liquids. At these positions two important fluid properties (the density in kg/m^3 and the viscosity in $\text{mPa}\cdot\text{s}$) are shown as well.

2.1.2 Input parameters

Before any calculation can be made, the fluid (gas or liquid) needs to be selected at **Fluid**, either in the main window or at the top to the window, the regular FLUIDAT on the Net fluid selection.

Search and select a fluid

2 matching fluids

Formula	Name
H2O	Water
H2O2	Hydrogen peroxide

Search for:

custom x Search Cancel

If the fluid of your interest is not included in the FLUIDAT® database, you can still perform calculations by searching for 'custom' and entering the relevant properties yourself.

In case the fluid is unknown, **Custom** may be entered. The 'Custom fluid' screen will appear. This way CoriCalc will ask for the density, the viscosity and the phase of an unknown fluid. This might be the case if FLUIDAT® doesn't contain the right fluid properties.

Custom fluid properties

Custom selected.

Set the properties of the custom fluid.

Density:	<input type="text" value="1.293"/>	kg/m ³ (at normal conditions for gases, at actual conditions for liquids)
Viscosity:	<input type="text" value="0.01715"/>	mPa.s
Phase:	<input type="text" value="Gas"/> ▼	(select correct phase)
<input type="button" value="Submit"/>		

[Select fluid by name](#)

For gases the density is of importance for pressure drop calculations. The viscosity is less important for this type of calculation. The lower the density, the higher the volume flow needs to be for the same mass flow, which results in high pressure drops over the sensor. E.g. He and H₂ are very light gases which result in relative high pressure drops.

For liquids the dynamic viscosity is of importance for pressure drop calculations. The density is less important for this type of calculation, although a higher density will give a lower pressure drop in practice.

High viscous fluids, like oils or glycerin, need more pressure to get through the sensor tubes at the same flow as e.g. water. Low viscous fluids, like alcohols give less pressure drop at the same flow rate.



Please take care if you want to make calculations on a fluid in (actual) gas phase and if this fluid has a different phase under the normal conditions (@ 0 °C and 1013.25 mbar (a)). This will result in errors. E.g. for steam at 120 °C and 1.5 bar (a) (for **CORI-FLOW™** with external electronics only) it is not possible to enter the density and viscosity for the situation @ 0 °C and 1013.25 mbar (a), because the fluid will be liquid or even solid (ice). In those cases best results can be obtained, if the actual properties are entered.

With water (steam) the values from the vapor-pressure tables (density and viscosity) gave reliable results.

Flow unit		Pressure Unit		Temperature	
Mass Flow	kg/h	Gauge Pressure	bar (g)	20	°C
Pressure Inlet	Flow	Kv	Orifice	Pressure Outlet	
5 bar (g)	1.368 kg/h 1.368 kg/h	0.0006925	0.2 mm	0 bar (g)	

The main input parameters for each calculation are the inlet pressure, the flow, the orifice size and the outlet pressure. One of these can be calculated when all others are supplied.

At **Pressure inlet**, the inlet pressure can be entered in the selected unit, at **Flow** the flow and at **Outlet pressure**, the outlet pressure can be entered. In case a valve is selected, the orifice can be entered at **Orifice**.

The unit in which the pressures and the flow can be supplied can be selected at the **Units** frame. For pressure, the unit types **Absolute Pressure** and **Gauge Pressure** are available. For flow, the unit types **Mass Flow**, **Volume Flow**, **Normal Flow** and **Standard Flow** are available. The latter two are most likely to be used for gases only.



Changing the unit will not convert any flow values from the previous to the new unit.

2.1.3 Calculation

After selecting the desired units, the desired gas, at the **Calculation** frame following options can be selected for calculation:

- **Minimum pressure inlet**
- **Flow**
- **Orifice** (for controllers)
- **Maximum pressure outlet** (for sensors only)

If all other input parameters (pressure inlet, flow, orifice, pressure outlet) are entered, the selected parameter can be calculated by pressing the **Calculate** button.

The result is shown below the graphical representation of the instrument. In case no warnings or errors have occurred, it shows OK in green. A warning is indicated in orange, whereas an error turns the indicator red. An explanation of the warning and/or error is given in the text frame at the bottom.

2.1.3.1 Minimum pressure inlet

When this option has been selected, the minimum pressure needed for a given flow and outlet (back) pressure will be calculated.

2.1.3.2 Flow

When this option has been selected, the maximum possible flow through the sensor at a given inlet pressure and outlet pressure will be calculated.

2.1.3.3 Orifice (controller only)

When this option has been selected, the orifice for the valve will be calculated and advised for a given flow, inlet pressure and outlet pressure.

The advised orifice can be taken-over by pressing the \wedge -button. The program will switch into minimum pressure calculation mode. After pressing **Calculate** again, the advised minimum inlet pressure needed for this orifice and flow conditions will be calculated additionally (if possible).



An important check here will be the pressure across the sensor in relation to the pressure across the valve to guarantee a proper control function.

Some important rules of thumb:

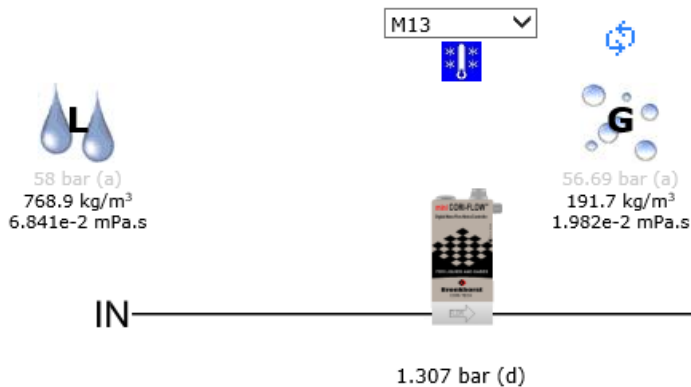
- For liquids: pressure drop across valve \geq 50% of total pressure drop across instrument
- For gases: pressure drop across valve \geq 75% of total pressure drop across instrument (preferably)
pressure drop across valve \geq 50% of total pressure drop across instrument (advice).

2.1.3.4 Maximum pressure outlet (sensor only)

When this option has been selected, the maximum pressure outlet available after the sensor at a given flow and inlet pressure can be calculated.

2.2 Phase changes of fluid

CoriCalc, when not using a custom fluid, will use the fluid properties to check the phase of the selected fluid for a certain pressure and temperature. Normally it is not recommended to have phase changes in either the sensor nor the valve. Besides the cooling effect, also the working of the sensor and valve will be far from optimal. Therefore, phase transitions in the instruments should be avoided. A transition from liquid phase into gas phase will have a strong cooling effect on both valve and sensor and will be indicated with the blue pictogram as shown below.



3 TROUBLESHOOTING, ERRORS AND WARNINGS

When calculating, CoriCalc performs many checks. Good results, which may lead to reliable applications, will be shown in green. Any error will be displayed in red. Warnings in orange. In the lower area of the screen the (red) text will show the error specifications.

In the example below there is no data for dynamic viscosity available for Ethylene under these conditions, so calculation is not possible. In such a case it is advisable to enter the density and viscosity manually as custom fluid.


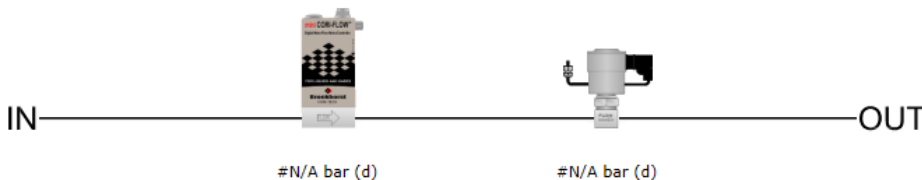
FLUIDAT® on the Net

C2H4 ("Ethylene")

CoriCalc V1.14.4

[About](#)

Calculations and sizing for Coriolis Mass Flow Meters and Controllers, series ML120, M12 - M15 and M53 - M55.

Instrument		Actuator		
M13		CSI (NC)		
				
Fluid: C2H4 ("Ethylene")				
Flow unit		Pressure Unit		Temperature
Mass Flow	kg/h	Gauge Pressure	bar (g)	20 °C
Pressure Inlet	Flow	Kv	Orifice	Pressure Outlet
100 bar (g)	1 kg/h 1 kg/h	0	0.2 mm	#N/A bar (g)
Calculation				
<input type="radio"/> Calculate minimum required pressure inlet	<input type="radio"/> Calculate flow	<input type="button" value="Calculate"/>	<input type="radio"/> Calculate orifice	<input checked="" type="radio"/> Calculate maximum allowed pressure outlet
<p>Viscosity of C2H4 could not be calculated. Fluid property calculation failed... results may be inaccurate. Consider manual input by using a 'custom' fluid. Maximum pressure difference at no flow (101.0 bar (d)) is higher than the maximum valve pressure difference (40 bar (d)).</p>				
Remarks:				

4 FLUID PROPERTIES FOR MANUAL INPUT

Fluid		Density (kg/m ³)	Dynamic Viscosity (mPa.s)	Phase	Remark
AIR	Air	1.293	1.715e-2	Gas	Normal conditions: @ 0 °C, 1013.25 mbar (a)
N2	Nitrogen	1.250	1.653e-2	Gas	Normal conditions: @ 0 °C, 1013.25 mbar (a)
Ar	Argon	1,784	2.13e-2	Gas	Normal conditions: @ 0 °C, 1013.25 mbar (a)
CO2	Carbon Dioxide	1.977	1.351e-2	Gas	Normal conditions: @ 0 °C, 1013.25 mbar (a)
CO	Carbon Monoxide	1.250	1.575e-2	Gas	Normal conditions: @ 0 °C, 1013.25 mbar (a)
C2H4	Ethylene	1.261	9.455e-3	Gas	Normal conditions: @ 0 °C, 1013.25 mbar (a)
He	Helium (4-)	0.178	1.908e-2	Gas	Normal conditions: @ 0 °C, 1013.25 mbar (a)
H2	Hydrogen	8.989e-2	8.401e-3	Gas	Normal conditions: @ 0 °C, 1013.25 mbar (a)
CH4	Methane	0.717	1.031e-2	Gas	Normal conditions: @ 0 °C, 1013.25 mbar (a)
N2O	Nitrous Oxide	1.978	1.336e-2	Gas	Normal conditions: @ 0 °C, 1013.25 mbar (a)
O2	Oxygen	1.429	0.019	Gas	Normal conditions: @ 0 °C, 1013.25 mbar (a)
C3H8	Propane	2.012	7.516e-3	Gas	Normal conditions: @ 0 °C, 1013.25 mbar (a)
C4H10 #1	Butane	2.705	6.811e-3	Gas	Normal conditions: @ 0 °C, 1013.25 mbar (a)
C3H6 #2	Propylene	1.914	8.0e-3	Gas	Normal conditions: @ 0 °C, 1013.25 mbar (a)
H2O	Water	1000	1	Liquid	@ 20 °C, 3 bar (a)
C3H8O #2	Isopropyl Alcohol (IPA)	794	2.31	Liquid	@ 20 °C, 3 bar (a)
	Diesel Oil	890	76.2	Liquid	@ 20 °C
	Fuel Oil	870	2.6	Liquid	@ 20 °C
	Gasoline	710	0.5	Liquid	@ 15 °C
	Crude Oil	860	75	Liquid	@ 15 °C
	Acetic acid	1050	1.23	Liquid	@ 20 °C
	Kerosene	800	2.2	Liquid	@ 15 °C
	Nitric Acid	1370	2.6	Liquid	@ 20 °C
	Soybean Oil	920	79.1	Liquid	@ 15 °C
	Ethylene Glycol	1120	19.5	Liquid	@ 20 °C
	Sulfuric Acid (conc.)	1830	26.7	Liquid	@ 20 °C
	Glucose (sugar solution)	1440	31680	Liquid	@ 38 °C
	Crankcase Oil SAE 20	940	173.9	Liquid	@ 54 °C
	Crankcase Oil SAE 30	940	211.5	Liquid	@ 54 °C
	Crankcase Oil SAE 40	940	376	Liquid	@ 54 °C
TiCl4	Titanium Tetrachloride	1523	1	Liquid	@ 20 °C
SiCl4	Silicon Tetrachloride	1480	48	Liquid	@ 20 °C
	Citric Acid 10% solution	1035	1.5	Liquid	@ 25 °C
	Citric Acid 30% solution	1131	2.3	Liquid	@ 25 °C
	Citric Acid 60% solution	1294	17	Liquid	@ 25 °C
CH4N2O	Urea 32% solution	1090	1.4	Liquid	@ 25 °C
CH4O	Methanol	767	0.55	Liquid	@ 20 °C, 3 bar (a)
C2H6O #2	Ethanol	806	1.15	Liquid	@ 20 °C, 3 bar (a)
C4H10 #1	Butane	573	1	Liquid	@ 20 °C, 3 bar (a)
C3H8	Propane	488	9.77	Liquid	@ 20 °C, 10 bar (a)

For more fluid properties visit: www.fluidat.com.



Bronkhorst High-Tech B.V. disclaims any liability for use of these data in calculations for applications using (mini) CORI-FLOW™ instruments. Values under actual conditions might differ. Although CoriCalc has been thoroughly tested, Bronkhorst High-Tech B.V. takes no responsibility for any failure which could result in personal injury and/or damage to any customer equipment.

5 SERVICE

For current information on Bronkhorst and service addresses please visit our website:

 <http://www.bronkhorst.com>

Do you have any questions about our products? Our Sales Department will gladly assist you selecting the right product for your application. Contact sales by e-mail:

 sales@bronkhorst.com

For after-sales questions, our Customer Service Department is available with help and guidance. To contact CSD by e-mail:

 support@bronkhorst.com

No matter the time zone, our experts within the Support Group are available to answer your request immediately or ensure appropriate further action. Our experts can be reached at:

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