

# CEM

## Liquid Delivery System with Vapour Control



### Liquids

(selection of some references)

- ETOH
- HMDSO
- HMDS<sub>n</sub>
- SiHCl<sub>3</sub>
- SiH<sub>3</sub>Cl
- Cupraselect™
- Organic compounds (such as Acetone, Alcohol, Butanol, Ethanol, Hexane, Methanol, etc.)
- SnCl<sub>4</sub>
- TCA
- TEOS
- TIBA
- TiCl<sub>4</sub>
- TMB
- Water
- Zn(C<sub>2</sub>H<sub>5</sub>)<sub>2</sub>

### CEM

Mixing chamber for liquid and carrier gas with heat exchanger for total evaporation

## > Introduction

In a number of processes two or more components must be mixed together. In instances where it comprises a vapour of a liquid in a carrier gas, traditional Bubbler Systems and the more recent Vapour Source Controllers have been used. These devices, however, can often not handle sufficient quantities of liquid with a low vapour pressure, or perform in an imperfect way. Moreover, they cannot instantaneously provide vapour of a mixture of liquids with different vapour pressures.

Bronkhorst High-Tech B.V. have therefore developed a unique patented system to realise Mass Flow Control of Vapours with an innovation: the CEM-Liquid Delivery System (LDS). It can be applied for atmospheric, pressurized and vacuum processes, vaporising liquid flows from 0,25 to 1200 g/h of water; for most other fluids the maximum capacity will even be higher.

## > Description

At room temperature the liquid, for instance TEOS, HMDSO, Cupraselect™ or water, is drawn from a container with an inert gas blanket, or membrane, and measured by a liquid mass flow meter

type  $\mu$ -FLOW, LIQUI-FLOW™ or mini CORI-FLOW™. The required flow rate is controlled to the setpoint value by a control valve (C) forming an integral part of the patented liquid flow and carrier gas mixing valve (M). The then formed mixture is subsequently led into the evaporator to achieve total evaporation (E). This explains the abbreviation of CEM viz.: Control - Evaporation - Mixing, the 3 basic functions of the Liquid Delivery System.

A complete system also incorporates a readout/control unit, including power supply, for operation of the CEM-system devices.

## > Features

- ◆ accurately controlled gas/liquid mixture
- ◆ fast response
- ◆ high reproducibility
- ◆ very stable vapour flow
- ◆ flexible selection of gas/liquid ratio
- ◆ lower working temperature than conventional systems
- ◆ optional control by PC/PLC (RS232/fieldbus)

## > Specifications

The set-up of a CEM-system usually consists of:

### 1) Mass Flow Controller for Gases

For measurement and control of the carrier gas flow. The amount of carrier gas required for the evaporation depends on the application (flow range, liquid, pressure, temperature). We advise a certain minimum of carrier gas flow for the transportation of the liquid source from the mixing valve into the heat-exchanger (see the diagrams below). To avoid a large pressure drop across the system, the gas flow should be restricted to approx. 100 l<sub>n</sub>/min for the 1000 W unit and approx. 10 l<sub>n</sub>/min and 4 l<sub>n</sub>/min respectively for the smaller units. For more information about Bronkhorst® MFCs see brochures EL-FLOW® and Metal Sealed Digital Mass Flow / Pressure Meters and Controllers.

### 2) Mass Flow Meter for Liquids

For measurement of the liquid source flow. Bronkhorst® offers liquid flow meters for 1,5...30 mg/h up to 0,4...20 kg/h of water equivalent. For more information see our leaflets describing the LIQUI-FLOW™, μ-FLOW and mini CORI-FLOW™ series.

### 3) CEM 3-way Mixing Valve and Evaporator

For control of the liquid source flow and mixing the liquid with the carrier gas flow resulting in total evaporation; complete with Temperature Controlled Heat-Exchanger to add heat to the mixture to realise complete vaporization. (Tmax 200°C / Pmax 100 bar).

model	description	max. capacity approx.*	
W-101A-9N0-K	10 W (for μ-FLOW)	2 g/h liquid	4 l <sub>n</sub> /min gas
W-102A-NN0-K	10 W	30 g/h liquid	4 l <sub>n</sub> /min gas
W-202A-NN0-K	100 W	120 g/h liquid	10 l <sub>n</sub> /min gas
W-303B-NN0-K	1000 W	1200 g/h liquid	100 l <sub>n</sub> /min gas

\* depends on liquid and process pressure; table based on water at 1 atmosphere. For other liquids or pressure conditions apply to factory.

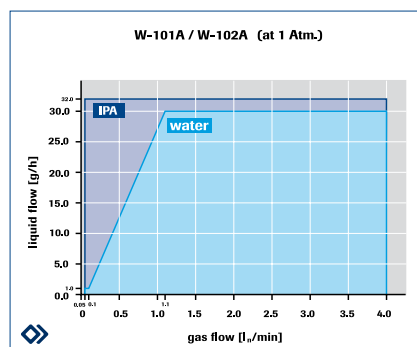
#### Connections:

- inlet liquid
- inlet gas
- outlet mixture

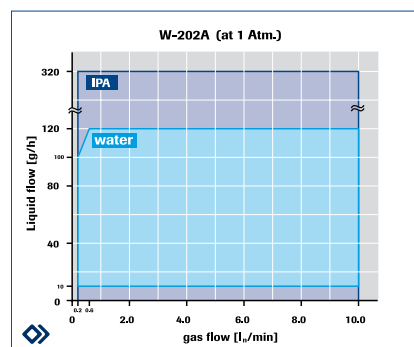
0	None
1	1/8" OD compression type
2	1/4" OD compression type
3	6 mm OD compression type
7	1/4" Face Seal female
8	1/4" Face Seal male
9	Other

#### Optional

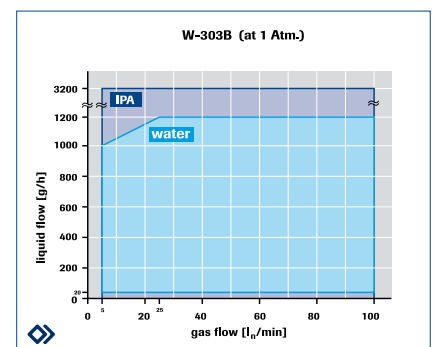
- ◆ Separate control valves for mixing gas and liquid.
- ◆ Separate heat exchanger / evaporator.



Capacities of the 10 Watt CEM-system, models W-101A/W102A



Capacities of the 100 Watt CEM-system, model W-202A



Capacities of the 1000 Watt CEM-system, model W-303B



## > Specifications

### 4) Power Supply/Readout System

For the control of the gas flow, liquid flow and temperature of the heat-exchanger.

Typical example:

E-8113-0-1WATU-1A-1A (see picture)

1/2 19" rack or table top housing for 2 channels + temperature control

### 5) Interconnecting Cables

1 x cable MFC - electronics,

1 x cable LFM - electronics,

1 x cable heat-exchanger - electronics,

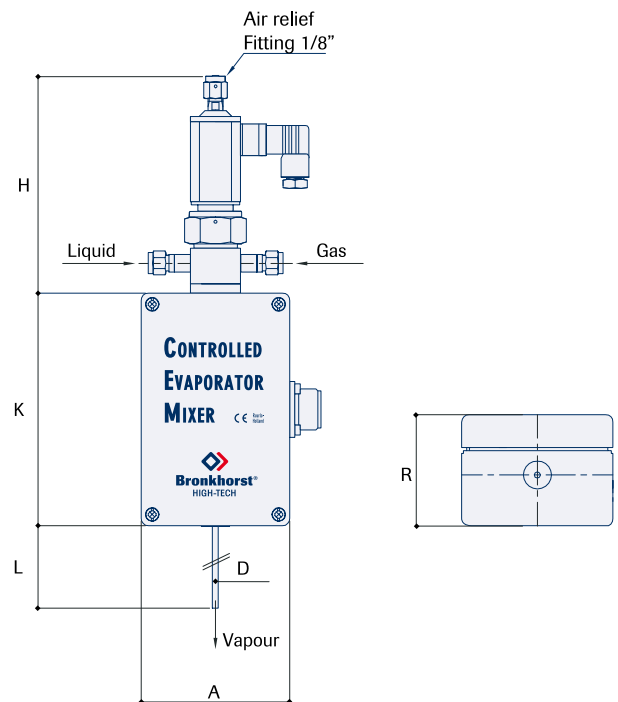
1 x power cord heat-exchanger - electronics (1000 W only).



## > Dimensions CEM 3-way Mixing Valve and Evaporator

Model	A	D	H	K	L	R	Weight (kg)
W-101A/W-102A/W-202A	80	1/8"	120	125	70	60	1,7
W-303B	180	1/4"	169	280	50	103	9,3

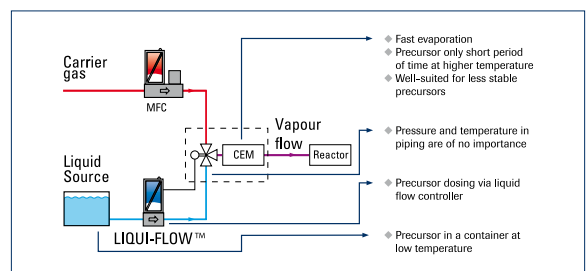
Dimensions in mm. All dimensions are subject to change without notice.  
Certified drawings are available on request.



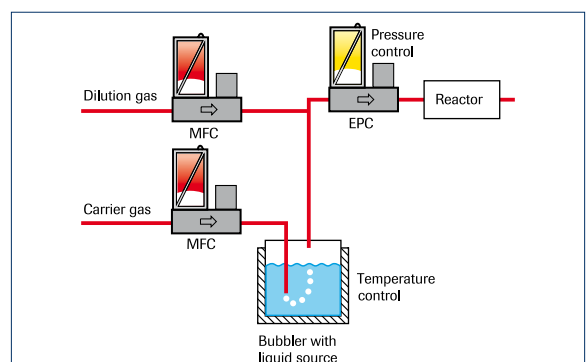
## > Advantages of exchanging Bubbler Systems with a CEM

In many cases small concentrations of vapours are made by bubbling a carrier gas through the fluid. This method requires optimum pressure and temperature control of the bubbler system, which is expensive. Moreover, the response time is very slow, the absolute accuracy is low and the bubbler system has a poor long term stability.

Bronkhorst High-Tech B.V. propose a much more direct approach, viz., control the required quantity of liquid to reach the desired concentration, under room temperature, with a LIQUI-FLOW™, μ-FLOW or mini CORI-FLOW™ Mass Flow Meter; this instrument forms part of a CEM-system in which the defined quantity of liquid is mixed with the carrier gas and vapourized. The method is straightforward, and virtually any concentration can be made in a matter of seconds with high accuracy and repeatability.



CEM: Controlled Evaporation Mixing



Classical Bubbler System

## > Applications

### Introduction

The CEM-system has been successfully applied in a large number of different applications in wide variety of markets. For example, tools (drills, screwdrivers, saw blades, etc.) and machine parts are coated to improve their wear resistance, electric and dielectric (insulating) layers are deposited in semiconductor and solar cell manufacturing processes, the heat insulation of glazing is improved by a coating applied to its surface and the humidity in reactor/process chambers is controlled to ensure optimum performance.

### CVD (Chemical Vapour Deposition)

Chemical Vapour Deposition (CVD) is a chemical process used to produce high-purity, high-performance solid materials. The process is not only used in the semiconductor industry to produce thin films for LEDs, transistors and DRAMs, but also in surface treatment, hardening processes and manufacturing of high temperature superconductors. In a typical CVD process, the surface (wafer or substrate) is exposed to one or more volatile precursors, which react and/or decompose on the substrate surface to produce the desired deposit.

The CEM-system is used in various types of CVD processes. For example:

- ◆ ALD (Atomic Layer Deposition) or ALCVD (Atomic Layer CVD): deposits successive layers of different substances to produce layered, crystalline films.
- ◆ APCVD (Atmospheric pressure CVD): CVD processes at atmospheric pressure.
- ◆ MOCVD (Metal Organic CVD) - CVD processes based on metalorganic precursors.
- ◆ PECVD (Plasma-Enhanced CVD): CVD processes that utilize a plasma to enhance chemical reaction rates of the precursors.

On the first page of this leaflet we already mentioned a selection of (precursor) fluids that were successfully handled using the CEM-system.

### Defined Humidification of Gases

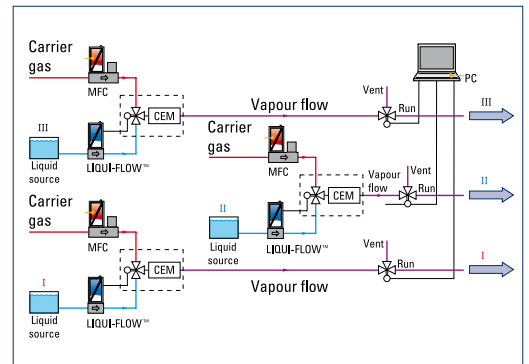
The CEM-system is ideally suited to the accurate adjustment of dew or moisture. The intrinsic characteristics of large dynamic range and high accuracy ensure that the moisture level can be controlled with great flexibility from only a few ppm up to virtually 100%, whilst also maintaining a very high stability in dew point. Full functionality is retained with operating pressures as high as 100 bar.

### Calibration of Gas Chromatographs, Mass Spectrometers and Gas Sensors

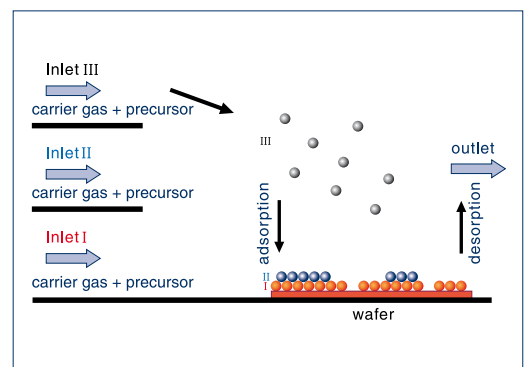
Through the combination of Mass Flow Controllers for liquids and the CEM-system, gas phase concentrations can be produced as desired. Thus Mass Spectrometers or Gas Chromatographs can be calibrated as the reference stream from the CEM is both highly reproducible and highly accurate due to the direct action of the Mass Flow Controllers.

### Miscellaneous

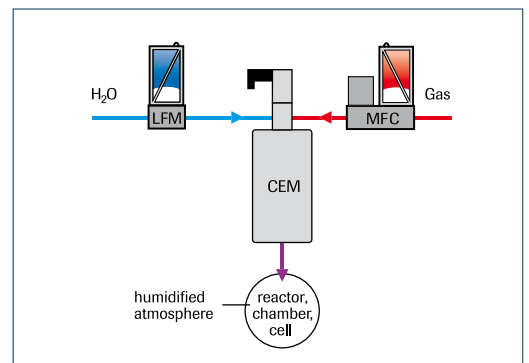
- ◆ analysers with reference gas vapour concentrations
- ◆ toxic gas effects on protective clothing
- ◆ analysers with reference H<sub>2</sub>O vapour concentrations
- ◆ anaesthetics
- ◆ humidification of fuel cells
- ◆ crystal breeding installations
- ◆ dosage of additives, e.g. perfume, vitamins, etc.



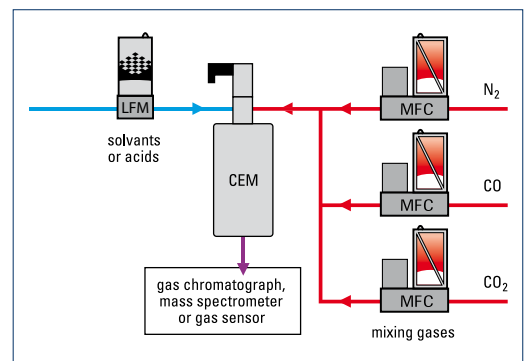
Example of a Direct Liquid Injection (DLI) System for ALD Processes



Schematic representation of an ALD process



Defined humidification



Calibration of chromatographs