

## LEWA metering pumps for CO<sub>2</sub> applications

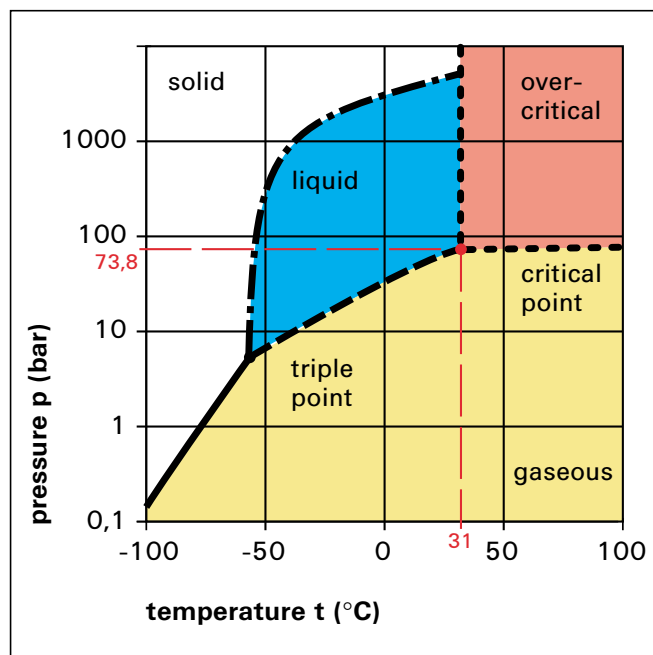
Highly specialised knowledge and many years of experience make LEWA a leader in CO<sub>2</sub> -metering. The high demands on LEWA metering pumps, metering- systems and packages are shown with characteristic examples and the most important processes are mentioned.

### What is carbon dioxide?

Carbon dioxide, colloquially called carbonic acid, under atmospheric pressure, is a three-atom gas. On the one hand it can be obtained from natural sources (mineral wells, oil- and gas reservoirs), on the other hand it is produced during combustion processes and fermentation procedures. Industrially used processes mainly are the ammonia synthesis and the combustion of substances containing carbon.

CO<sub>2</sub> is a colourless, odourless gas, non-toxic, non-inflammable which can be used in the food industry without any requirement for declaration.

Carbon dioxide can quite easily be turned into a gaseous, liquid, solid, supercritical state. This feature is used for many industrial applications.



*p.T-diagram of CO<sub>2</sub>*

The gaseous sector is not relevant for LEWA except when related to the cavitation in liquid gas metering. The interesting market for LEWA includes the liquid and supercritical range only.

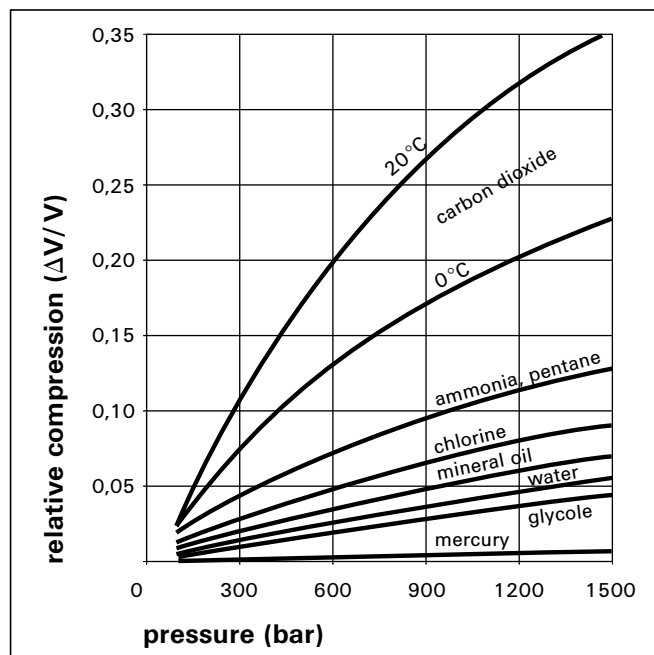
The ambient conditions of metering pumps for liquefied gases must be clarified precisely at the project stage already. Non-observance can lead to extensive and costly alterations.

Apart from the compressibility of liquefied gases, which has considerable influence on the flowrate of the metering pump in the higher pressure range, the heat produced during compression plays an important role. It leads to a warming up of the pump chamber surface area. This can cause cavitation during the suction stroke in spite of the suction pressure being higher than the vapour pressure. This cavitation, over a longer period of time, can lead to a total break down of the pumping process.

**What information is required for a safe pump selection in liquefied gas metering?**

fluid designation	e.g. CO <sub>2</sub>
flow max./min. (l/h)	.....
suction pressure max./min. (bar)	.....
discharge pressure max./min. (bar)	.....
storage temperature °C max./min.	.....
vapour pressure max./min. (bar abs)	.....
length / diameter of the suction line (m/mm)	.....

Description of the storage and pump supply, e.g. bottle supply, high pressure-, low pressure tank, booster pump, circulation line, heat exchanger in the suction line (type, length of the pipes, max. possible reduction of temperature), permissible flow pulsation in the discharge line.



*Compressibility of different fluids*

**At LEWA's headquarters computer programs are available which are absolutely essential for the pump selection.** Thermo-dynamic state values are available for carbon dioxide, ammonia, i-/n- butane, pentane, propane. The calculation yields: fluid temperature, sub-cooling temperature, compressibility (important for the flowrate), density (mass flow), sonic speed (for resonance calculation).

**Pump designs**

In the pressure range < 100 bar mainly plunger metering pumps with special plunger seals are used. In the pressure range > 100 bar glandless diaphragm metering pumps are used almost exclusively.

The design of the pump head, e.g. with optimised dead space, with/without cooling jacket, cooled hydraulic fluid, material combinations of the valves, diaphragm material PTFE or stainless steel, depends on the requirements.

## Application areas for metering pumps

### CO<sub>2</sub> bottling

For this application mainly plunger metering pumps are used. Liquid CO<sub>2</sub>, at a suction pressure of approx. 15 – 20 bar, i.e. approx. 15 to 30°C must be boosted to a discharge pressure of approx. 70 – 80 bar. With this system pressure high pressure storage tanks or bottles are filled. The filling process is controlled gravimetrically, the metering pump is used for conveying and pressure boosting. Therefore, mainly pumps with constant stroke length are used.



*LEWA triplex plunger pump G3S in a CO<sub>2</sub> bottling plant*

Following are some examples for the before mentioned application:

order no.	contr.	fluid	Q <sub>max</sub> l/h	discharge pr. bar	suction pr. bar	drive unit type	stroke freq. 1/min.	pump head series	plunger ø mm
211103	DE	CO <sub>2</sub>	850	120	15	G3H	116	M510S*	44
236471	DE	CO <sub>2</sub>	450	95	20	G3H	145	K110**	30
270811	DE	CO <sub>2</sub>	2000	110	20	G3S	117	K111	52
288021	DE	CO <sub>2</sub>	2500	70	20	G3H	192	K112	60
292827	DE	CO <sub>2</sub>	800	70	20	G3H	141	K110	44
323482	DE	CO <sub>2</sub>	650	80	12	GH	225	K211	52
323482	DE	CO <sub>2</sub>	650	80	12	GH	212	K212	52
323482	DE	CO <sub>2</sub>	650	80	12	GH	212	K211	52
324488	RO	CO <sub>2</sub>	240	70	17	GH	143	M510S	44
325415	RO	CO <sub>2</sub>	240	70	17	GH	143	M510S	44
325116	FI	CO <sub>2</sub>	500	70	17	GH	173	K111	52
325638	S	CO <sub>2</sub>	500	75	15	GH	173	K112	52
330892	NL	CO <sub>2</sub>	335	80	20	GH	143	K210	44
333623	NL	CO <sub>2</sub>	600	65	20	GH	225	K211	52
400792	NL	CO <sub>2</sub>	600	65	14	GH	225	K211	52
400900	DE	CO <sub>2</sub>	600	80	12	GH	225	K211	52
333623	NL	CO <sub>2</sub>	600	65	20	GH	225	K211	52
405718	AT	CO <sub>2</sub>	140	70	20	EH	113	M510S	30
406770	DK	CO <sub>2</sub>	43	70	20	GL	112	M710S	25
407558	NL	CO <sub>2</sub>	600	70	20	GH	225	K211	52
407868	NL	CO <sub>2</sub>	210	80	20	GH	141	K210	36
414511	ES	CO <sub>2</sub>	1000	100	20	G3H	173	M510S	44
414867	NL	CO <sub>2</sub>	1000	80	15	GS1	146	K112	52
414867	NL	CO <sub>2</sub>	2000	80	15	GS2	146	K112	52
303591	CN	CO <sub>2</sub>	340	70	20	EH	170	K210	44

M510S\* diaphragm pump head  
K110/K211\*\* plunger pump head

## CO<sub>2</sub> metering pumps for separation and spraying processes

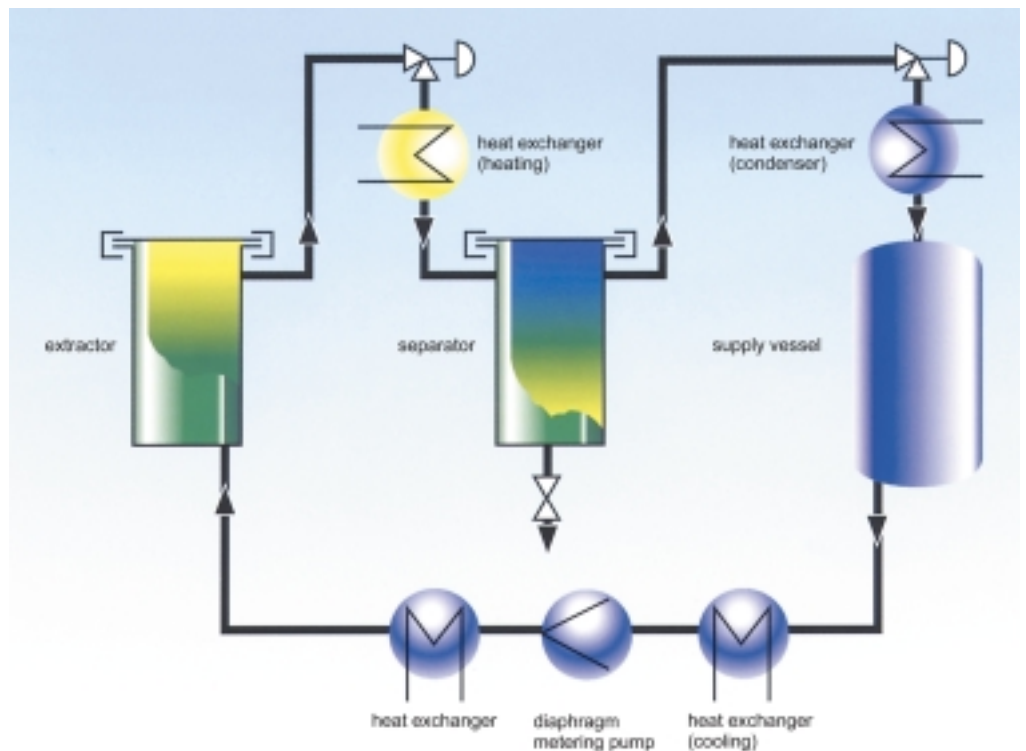
### High pressure extraction using supercritical CO<sub>2</sub>

Extraction procedures are used to separate mixtures into single components. Typical separation procedures are e.g. oil seeds extraction with hydrocarbons, the liquid/liquid-extraction via columns with fillers (catalysts) using LEWA bellows or diaphragm pulsators. These processes always operate in the low pressure range.

Industrially used separation processes in the higher pressure range e.g. are the preparative chromatography and the high pressure extraction using supercritical CO<sub>2</sub>. Both processes are typical applications for LEWA diaphragm metering pumps.

CO<sub>2</sub> shows very good solvent capabilities in the supercritical state. It is economical, inert, non-inflammable and without any health risks. The extraction capability can be influenced by pressure and temperature variation. The separation of substances and the CO<sub>2</sub> recovery is relatively easy from a technical point of view.

For the production of natural product extracts, e.g. hop, flavours, colourants, spices, caffeine etc., and for the separation of substances in the pharmaceutical sector the process of supercritical extraction has proven for many years in the laboratory and pilot plant sector as well as for industrial use.



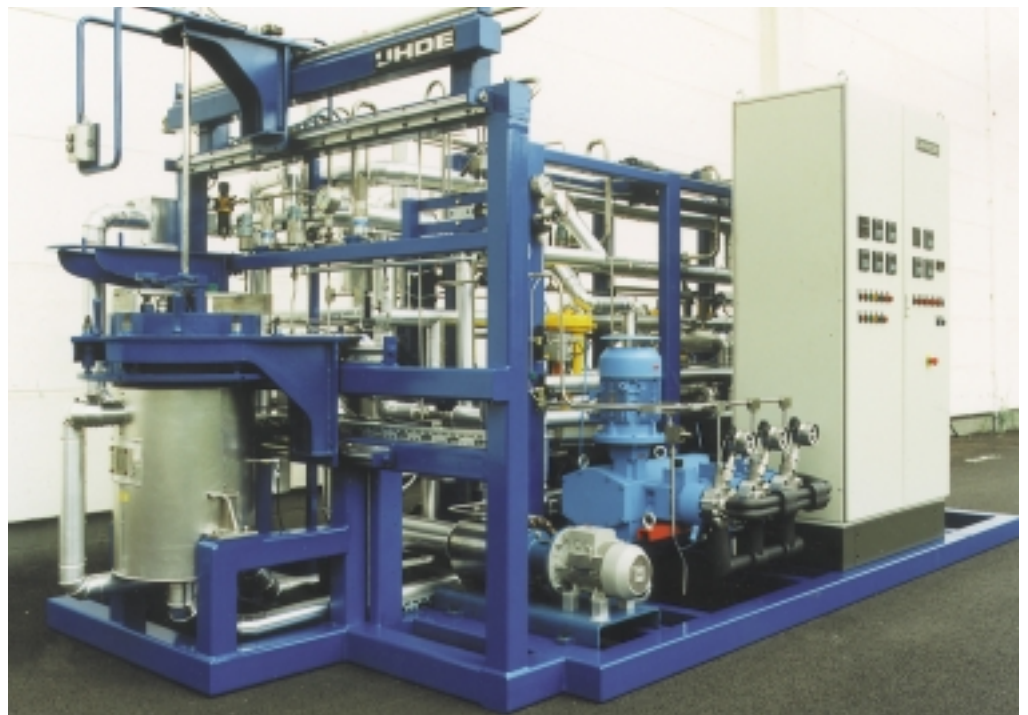
*Principle of a high pressure extraction plant  
(Company drawing UHDE high pressure technology GmbH)*

Liquid CO<sub>2</sub> flows via a cooler to the metering pump which is responsible for metering and the pressure boosting. CO<sub>2</sub> is brought up to supercritical temperature in the heat exchanger and, in the extraction vessel, extract the substances desired from the product used. This procedure can be operated in a batch or a continuous counter-flow process. By changing pressure and temperature the extract is precipitated in the separator, the gaseous CO<sub>2</sub> is liquefied in the condenser and returned to the pump suction.



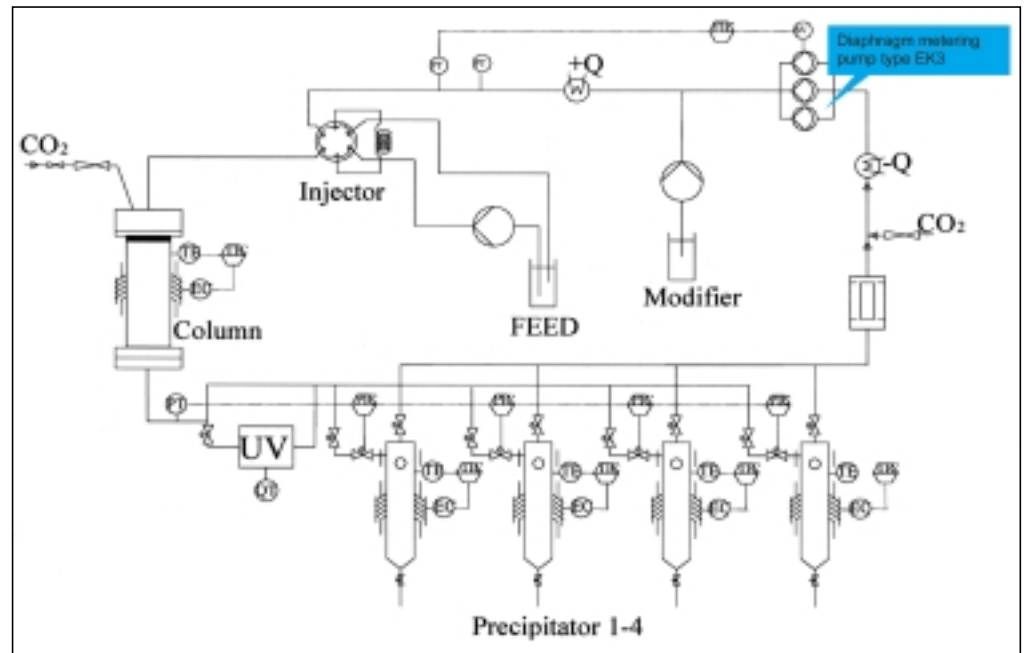
*High pressure extraction plant with diaphragm metering pump EH1  
(Company picture UHDE high pressure technology GmbH)*

In principle the processes for the re-processing of contaminated soil, for degreasing/ de-oiling of machined items, for the separation of grinding sediments are structured similarly. Further processes which are partly used in industrial applications already and partly are still being developed e.g. are the dry cleaning of textiles or textile dyeing with supercritical CO<sub>2</sub>.

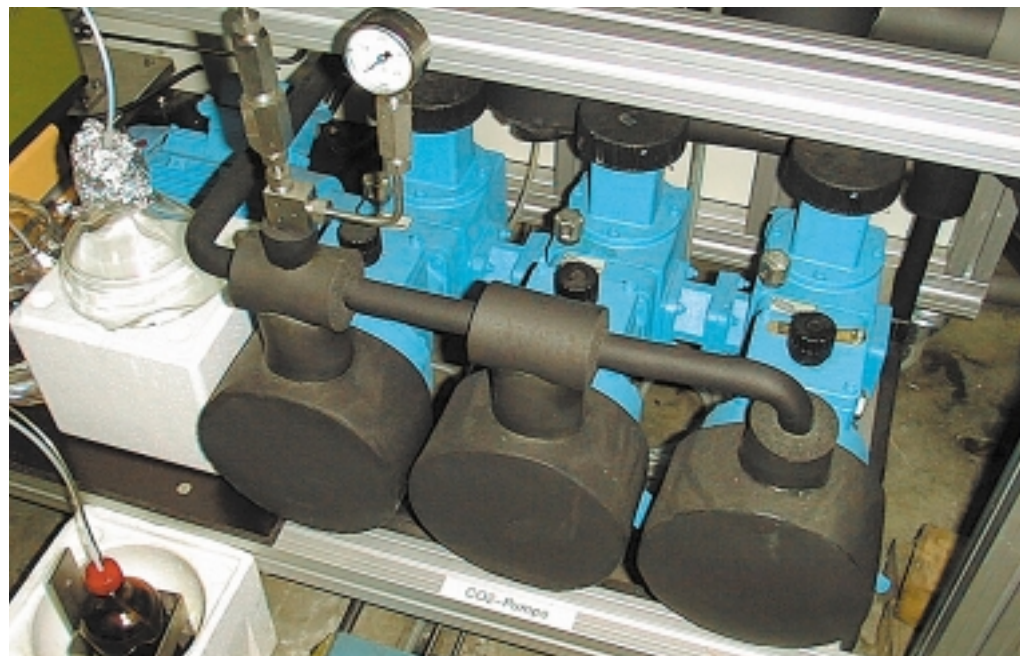


*Pilot plant for dyeing synthetic fabrics with supercritical CO<sub>2</sub>  
(Picture by UHDE high pressure technology GmbH)*

The following P&ID's show further processes for the separation of substances with supercritical CO<sub>2</sub>.

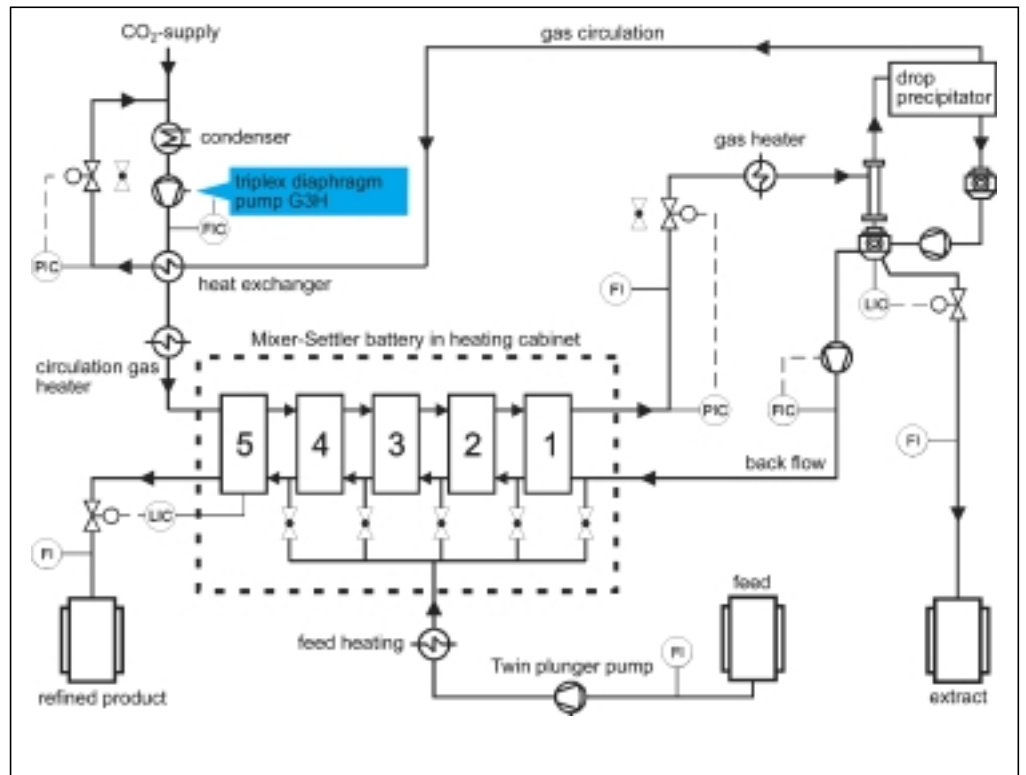


*Preparative SFC*



*LEWA modular diaphragm metering pump EK3*





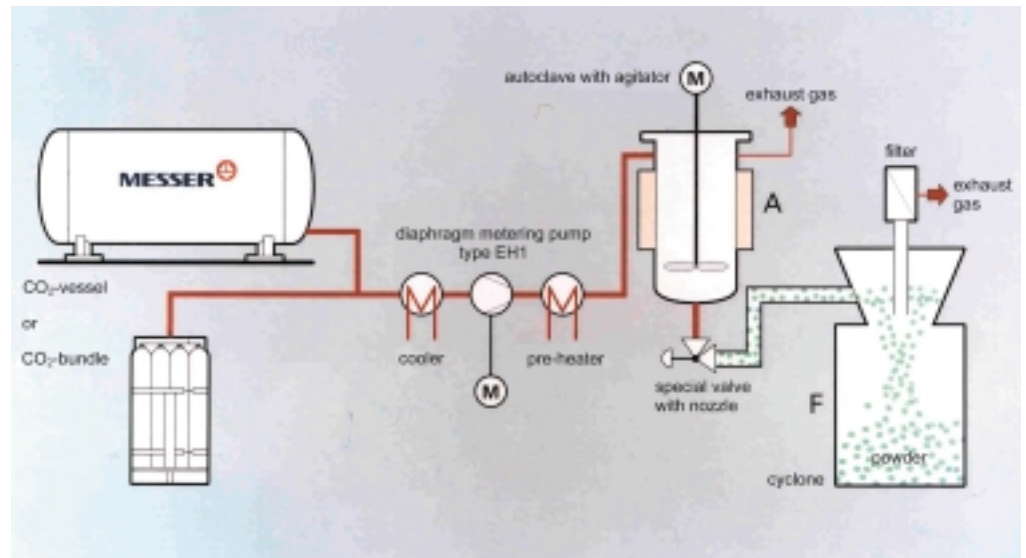
Mixer-Settler Extraction - P&ID



LEWA triplex diaphragm metering pump G3H in Mixer-Settler Extraction



The RESS-process (Rapid Expansion of Supercritical Solutions) derived from the high pressure extraction. Here substances are solved under high pressure in supercritical CO<sub>2</sub> up to the saturation limit. The precipitation/crystallisation is effected by pressure relief of the autoclave. The particle size can be influenced by varying the pressure/temperature/relief rate.



*Schematic of RESS plant, diagram by Messrs. Messer Griesheim*

**Further applications**

Further applications for metering pumps are the CO<sub>2</sub> injection into a spray drying system. Here the carbon dioxide leads to a reduction of the product viscosity. Also the particle size can be influenced.

LEWA has extensive experience concerning all aforementioned applications. The following table shows some reference examples.

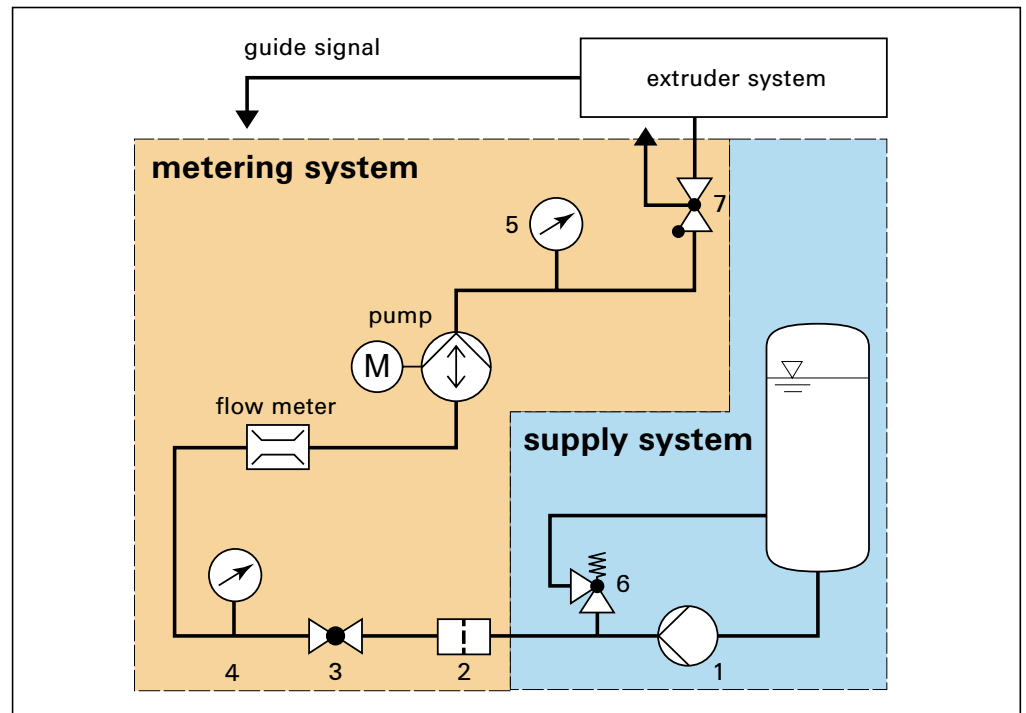
order no.	count.	fluid	Q <sub>max</sub> l/h	discharge pr. bar	suction pr. bar	drive unit type	stroke freq. 1/min.	pump head series	plunger ø mm
329923	GB	CO <sub>2</sub>	88	340	52	EH	168	M210S	16
331120	FR	CO <sub>2</sub>	18	350	60	EL	113	M510S*	16
331238	DE	CO <sub>2</sub>	20	240	50	EL	170	M510S	16
331306	DE	CO <sub>2</sub>	20	240	50	EL	170	M510S	16
331489	CH	CO <sub>2</sub>	30	500	50	EH	170	M210S	16
333097	DE	CO <sub>2</sub>	300	330	55	G3H	170	M510S	25
331679	DE	CO <sub>2</sub>	25	500	56	EH	170	M210S	16
403405	FR	CO <sub>2</sub>	64	340	56	EH	113	M510S	25
403419	IT	CO <sub>2</sub>	60	350	50	EH	113	M510S	20
403986	US	CO <sub>2</sub>	3	400	48	EK	138	M210	8
405091	DE	CO <sub>2</sub>	35	650	50	EH	168	M211S	16
405092	DE	CO <sub>2</sub>	94	290	50	GH	170	M510S	25
405646	DE	CO <sub>2</sub>	2	700	58	EK	165	M210	2 x 5
409394	IT	CO <sub>2</sub>	20	300	45	EL	170	M510S	16
410535	GB	CO <sub>2</sub>	18	300	60	EL	140	M510S	16
411843	DE	CO <sub>2</sub>	15	320	57	EL	170	M510	12
412231	IN	CO <sub>2</sub>	76	350	40	EH	225	M510S	20
412876	US	CO <sub>2</sub>	90	325	55	GH	175	K211**	25
411843	DE	CO <sub>2</sub>	15	320	57	EL	170	M510	12
413712	FR	CO <sub>2</sub>	6	350	45	GK	165	M210	8
414211	US	CO <sub>2</sub>	14	379	33	EH	210	K110**	16
414768	FR	CO <sub>2</sub>	25	500	20	EH	113	M210	16
416516	ES	CO <sub>2</sub>	20	700	60	EH	170	M211	16

M510S\* diaphragm pump head  
K110/K211\*\* plunger pump head

## CO<sub>2</sub> metering pumps for foaming of plastics

Foaming of plastics is a CO<sub>2</sub> application LEWA covers world-wide in a leading position. Here we have changed from a metering pump to a system supplier.

The application requires reliable, low pulsation metering of physical foaming agents (CO<sub>2</sub>, propane, butane, propane-butane mixtures, halogenated hydro-carbons) at pressures between 250 – 500 bar into a plastics melt.



*Schematic design of a foaming agent metering system: TB foaming agent vessel, 1 booster pump, 2 strainer, 3 shut-off valve, 4 contact pressure gauge, 5 pressure gauge, 6 safety valve, 7 constant pressure retaining valve*

As the metering of foaming agents has an elementary influence on the quality of the final product (insulation characteristics, density, size of pores) the packages for plastics foaming, for the most part, are designed as self-monitoring systems. Normally the speed of the extruder is the guide signal for the metering pump. The metering pump, which is often designed as duplex or triplex pump, adds the foaming agent into the polymer melt proportionally to the extruder speed. The FIS-DIALOG micro processor, developed by LEWA (see information D 7 - 820), carries out a continuous plausibility check between the characteristics of the metering pump (signals of stroke length and/or stroke frequency) and the signal from the flow meter installed after the metering pump. The signals are compared within an adjustable error gap width, deviations are recorded and signalled. The FIS-DIALOG micro-processor can be integrated into existing process guiding systems.



CO<sub>2</sub>-metering system EH2

**LEWA metering systems for foaming agent metering offer considerable advantages to the customer**

- compact, internally piped, wired-up and function tested unit
- design to customers specifications
- single source responsibility for
  - process engineering (material characteristics, cooling systems)
  - proper selection of metering pump and adjusting elements
  - proven flow meters for pulsating flows
  - equipment specific open and closed loop control instruments
  - comprehensive know-how

Following are some examples of CO<sub>2</sub> metering pumps and systems in plants for the production of plastic foams:

order no.	countr.	fluid	Qmax l/h	discharge pr. bar	suction pr. bar	drive unit type	stroke freq. 1/min.	pump head series	plunger ø mm
326186	DE	CO <sub>2</sub>	50	200	58	EH2	170	M510S	20
326628	AT	CO <sub>2</sub>	20	500	56	EL1	76	M210S	12
327313	DE	CO <sub>2</sub>	2	350	58	EL1	141	M210S	8
328663	GR	CO <sub>2</sub>	47	300	58	EH3	110	M510	20
329228	IT	CO <sub>2</sub>	30	300	58	EL3	140	M510S	12
329636	DE	CO <sub>2</sub>	4	350	58	EL2	141	M510S	12
331845	DE	CO <sub>2</sub>	4	350	65	EL2	113	M510S	10

order no.	countr.	fluid	Qmax l/h	discharge pr. bar	suction pr. bar	drive unit type	stroke freq. 1/min.	pump head series	plunger ø mm
404961	US	CO <sub>2</sub>	16	414	28	EH2	175	M210	12
407184	BE	CO <sub>2</sub>	0.7	400	67	EK1	83	M210S	5
408882	GR	CO <sub>2</sub>	13	300	58	EL3	170	M510S	12
410628	DE	CO <sub>2</sub>	10	350	10	EL3	140	M510S	12
410629	DE	CO <sub>2</sub>	10	350	56	EL3	140	M510S	12
412521	DE	CO <sub>2</sub>	88	390	60	EH3	140	M210S	16
414199	DE	CO <sub>2</sub>	4	350	4	EL2	141	M510S	12
414947	US	CO <sub>2</sub>	36	207	21	EL1	175	M510S	20
416687	DE	CO <sub>2</sub>	4	350	56	EK2	110	M210S	8

M210(s)/M510S\* diaphragm pump head