CAMBIADORES DE CALOR

Objetivo

1. Genérico: demostraciones prácticas y trabajos de laboratorio, con énfasis es en la adquisición de datos automatizada y el análisis avanzado.
2. Conocer los diversos tipos de cambiadores de calor, principalmente los de carcasa y tubos, y los de placas (los de contacto se vieron en la práctica de la torre de enfriamiento evaporativo).
3. Conocer otros tipos de circuitos fluidos y su instrumentación (e.g. diferencias con los circuitos de la torre húmeda).
4. Balances energéticos en un cambiador de calor: la diferencia de temperatura media logarítmica ΔT_{LMTD}.

Resumen de actividades

1. Inspección de distintos tipos de cambiadores. Desmontaje de un cambiador de calor de carcasa y tubos.
2. Calibración de caudalímetros de turbina.
3. Balance energético de la carga térmica: tiempo de calentamiento.
4. Medidas de las condiciones de funcionamiento de un cambiador de calor. Cálculo de la eficiencia del cambiador, y de su coeficiente global de transmisión de calor.
5. Ejercicio de selección de componentes y equipos para el diseño de una instalación de cambiador de calor.
6. Evaluación de la incertidumbre de los resultados obtenidos.

Equipo

Intercambiador tubular

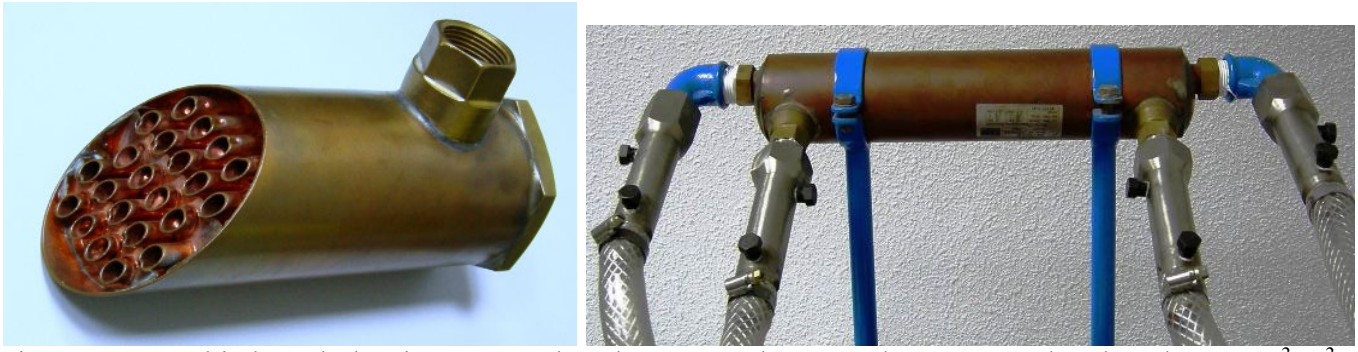


Fig. 1. Intercambiador tubular tipo RW-1, de cobre, con volúmenes de carcasa y de tubos de $0{,}5\cdot10^{-3}$ m^3 y $0{,}3\cdot10^{-3}$ m^3, áreas de paso de $3{,}4\cdot10^{-4}$ m^2 y $5{,}0\cdot10^{-4}$ m^2, hay nomogramas de uso; su potencia nominal es de 16 kW para calentar 0,11 kg/s de agua desde 10 ºC hasta 45 ºC.

Fig. 2. Intercambiador de 2 pasos desmontado

Intercambiador de placas

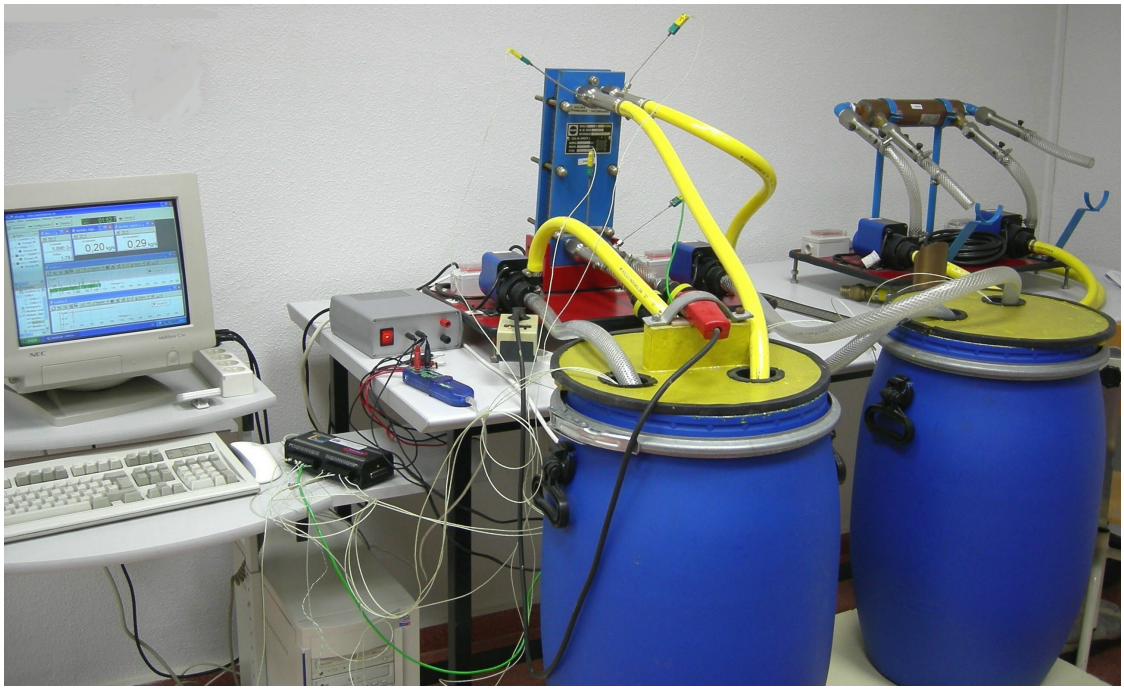


Fig. 3. Montaje de la práctica del intercambiador de placas

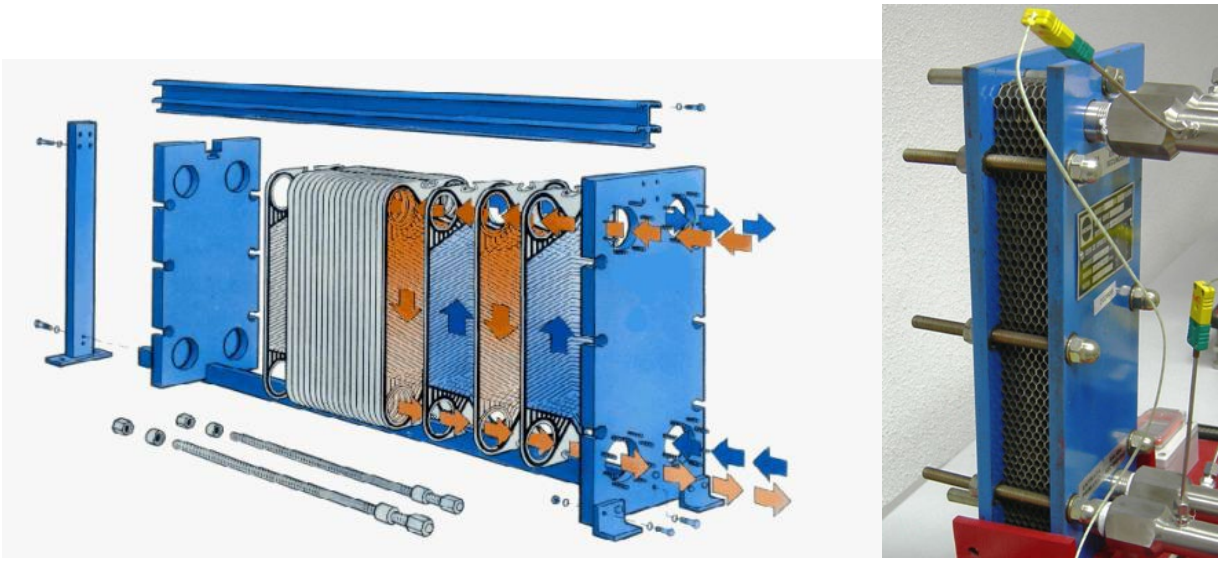


Fig. 4. Composición de un intercambiador de placas y foto.

1 Intercambiador de placas, con 15 placas.
2 Caudalímetros, RS 257-026
1 Resistencia: 1,32 kW.
2 Bombas de acoplamiento magnético
1 Potenciómetro

Desarrollo

Intercambiador tubular:

- Desmontaje de un intercambiador tubular e identificación del tipo y componentes.

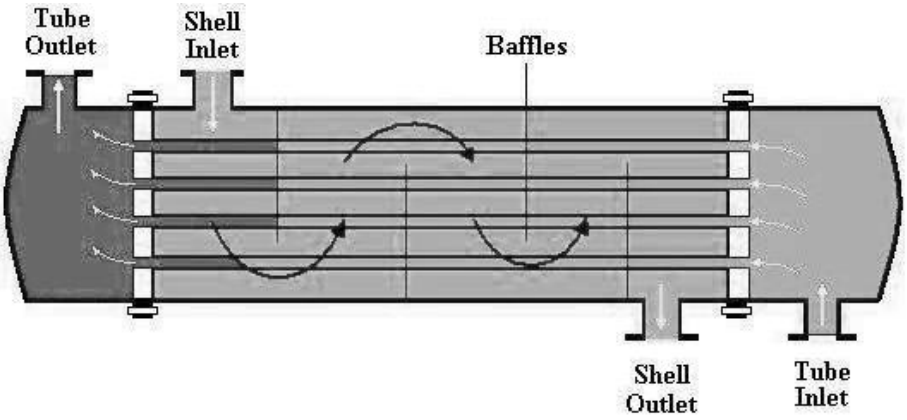


Fig. 5. Intercambiador tubular de 1 paso.

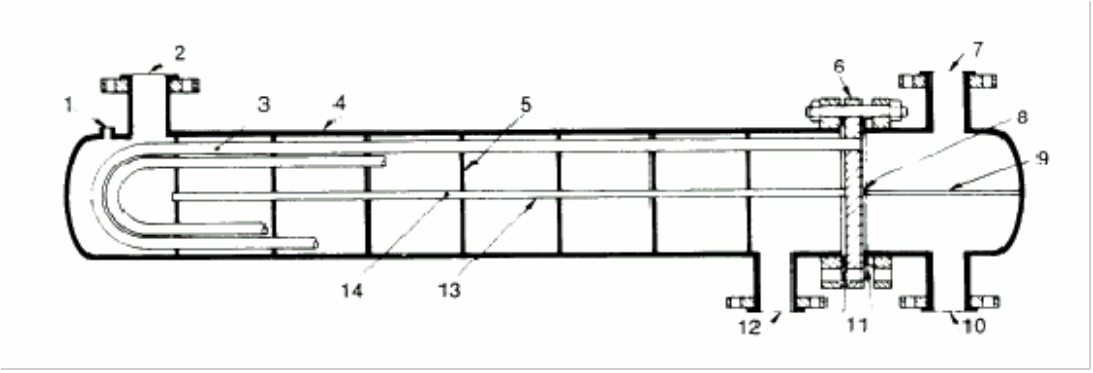


Fig. 6. Intercambiador tubular de 2 pasos.

Intercambiador de placas:

- Calibración de los caudalímetros teniendo en cuenta los datos de la hoja de características adjunta.
- Toma de datos de temperaturas y caudales durante el funcionamiento del intercambiador de placas.
- Medida aproximada de la superficie de intercambio
- Cálculo de la eficiencia del cambiador, y de su coeficiente global de transmisión de calor.

Formulario:

$$\dot{Q} = \dot{m}_1 c_1 \left(T_{1,\text{in}} - T_{1,\text{out}}\right) = \dot{m}_2 c_2 \left(T_{2,\text{out}} - T_{2,\text{in}}\right) \overset{\text{contra.}}{=} KA \frac{\left(T_1 - T_2\right)_{x=L} - \left(T_1 - T_2\right)_{x=0}}{\ln \dfrac{\left(T_1 - T_2\right)_{x=L}}{\left(T_1 - T_2\right)_{x=0}}}$$

$$\eta \equiv \frac{\dot{Q}}{\dot{Q}_{\max}} = \frac{\dot{m}_1 c_1 \left(T_{1,\text{in}} - T_{1,\text{out}}\right)}{\left(\dot{m}c\right)_{\min} \left(T_{1,\text{in}} - T_{2,\text{in}}\right)} = \frac{\dot{m}_2 c_2 \left(T_{2,\text{out}} - T_{2,\text{in}}\right)}{\left(\dot{m}c\right)_{\min} \left(T_{1,\text{in}} - T_{2,\text{in}}\right)} = \frac{KA\Delta T_{\text{LMTD}}}{\left(\dot{m}c\right)_{\min} \left(T_{1,\text{in}} - T_{2,\text{in}}\right)} \overset{\text{contra.}}{=} \frac{1 - e^{-N(1-c)}}{1 - ce^{-N(1-c)}}$$

$$c \equiv \frac{(\dot{m}c)_{\min}}{(\dot{m}c)_{\max}}, \quad N \equiv \frac{KA}{(\dot{m}c)_{\min}} \overset{\text{contra.}}{=} \frac{1}{1-c} \ln \frac{1-c\eta}{1-\eta}$$

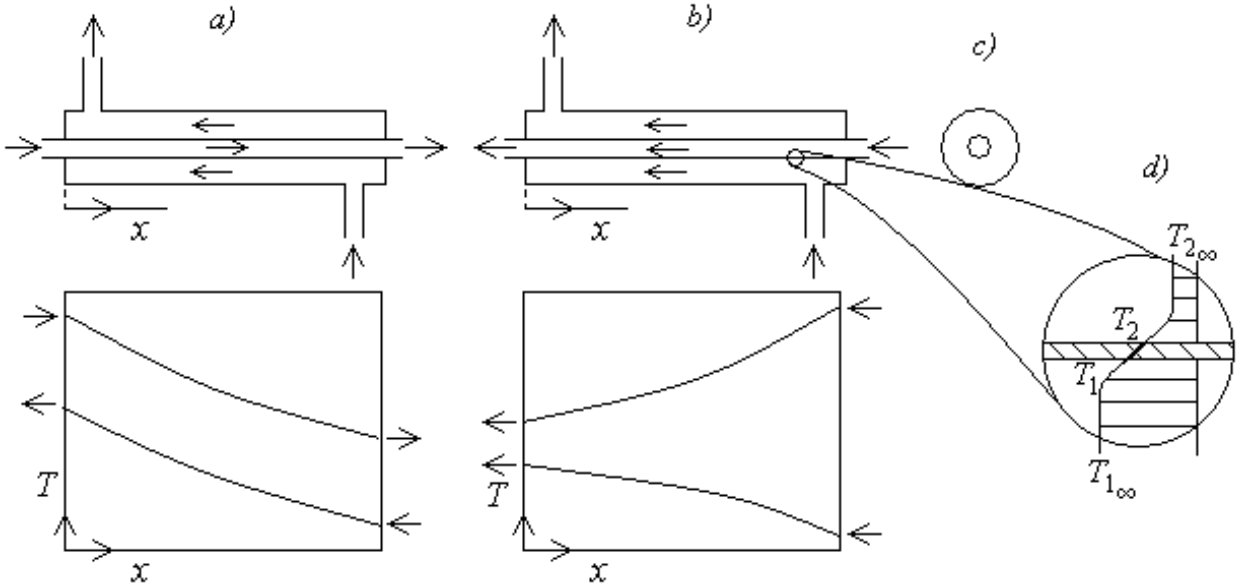


Fig. 7. Intercambiador tubular de un paso: a) croquis y perfil de temperaturas en una configuración a contracorriente, b) croquis y perfil de temperaturas en una configuración concurrente, c) croquis de la sección, d) detalle del perfil de temperaturas en la superficie de intercambio.

Notas y datos

Tabla 1. Valores del orden de magnitud del coeficiente global de transmisión de calor, *K*, para intercambiadores de calor.

Configuración	K [W/(m^2·K)]
Intercambiador de calor a presión normal: gas-a-gas	3..30
intercambiador de calor a alta presión : gas-a-gas	50..500
Intercambiador de calor: líquido-a-gas o gas-a-líquido	10..100
Intercambiador de calor tubular: líquido-a-líquido	200..2000
Intercambiador de calor de placas: líquido-a-líquido	500..5000
Condensador, a un gas	10..50
Condensador, a un líquido	500..6000
Vaporizador, a un gas	10..40
Vaporizador, a un líquido	500..10 000
Vaporizador, a un gas en condensación	600..6000

Intercambiador tubular de 2 pasos

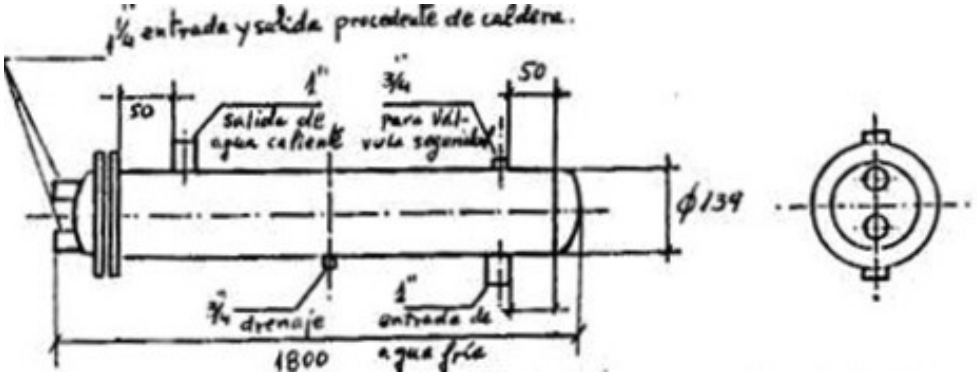


Fig. 8. Croquis del intercambiador tubular de 2 pasos disponible en el laboratorio.

Bombas utilizadas para los circuitos primario y secundario:

Magnetically Coupled Pump

RS Stock No. 266-597

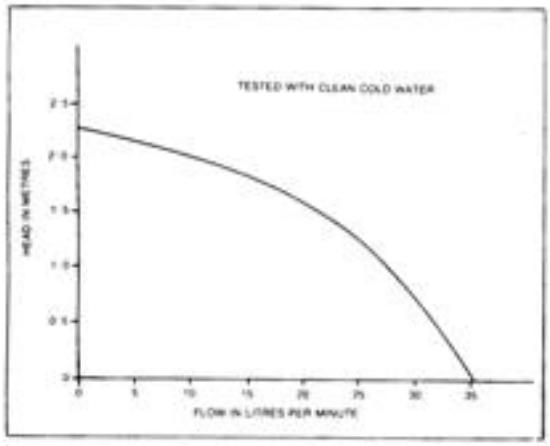
Description

This centrifugal pump is fully encapsulated, magnetically coupled and rated for continuous duty. The pump is ideally suited to recirculation applications and can be used with mild acids or alkalis, since the only components in contact with the pumped fluid are plastic and ceramic with a viton 'O' ring. (See Chemical Compatability).

Installation

Pump should be connected to pipework etc. using suitable fittings such as jubilee clips. Flexible hoses with internal diameters of 19mm may be used. (Avoid over tightening as this may cause damage to the ports). The pump and pipework should be adequately supported and correctly fitted to avoid shock loading and strain on the pump and it's ports. Do not mount pump vertically down (i.e. with ports below motor).

Performance



Operation and Maintenance

Pump should have flooded suction since it does not self prime. Filters or restrictions should not be situated before the pump inlet. When priming, operate pump in short 10 second cycles to facilitate clearing of air. Ensure there are no leaks or blockages in pipework.

Do not operate pump against closed valve for longer than 30 seconds.

Where pumped fluid causes coating or deposition, periodic cleaning of pump internals may be necessary. This can be achieved by flushing through with an appropriate solvent or cleaning agent. Pump must be adequately ventilated to avoid overheating of motor.

Do not run pump dry.

Motor Specification

Single phase 240V 50Hz
Input power 84W
Output power 18W
Maximum current 0·7A

CHEMICAL COMPATIBILITY

Aluminium Chloride (10%)
Ammonium Sulphate (50%)
Aniline
Antimony Trichloride (10%)
Arsenic Acid
Barium Chloride
Boric Acid
Calcium Chloride
Castor Oil
Chromic Acid
Citric Acid (10%)
Cod Liver Oil
Copper Sulphate
Cresols
Diesel Oil
Diethylene Glycol
Ferric Chloride
Formaldehyde (40%)
Freon - 113
Furfural
Glycerol
Hexane
Hydrochloric acid (10%)
Hydrochloric acid (36%)
Hydrogen peroxide (35%)
Hydrogen sulphide gas
Iso-propanol
Lactic Acid (90%)
Linseed Oil
Lubricating oil
Magnesium Chloride
Mercuric Chloride
Molasses
Nickel Chloride
Oleic Acid
Olive Oil
Paraffin Oil
Petrol
Potassium Cyanide

Caudalímetros utilizados para determinar los flujos másicos de los circuitos primario y secundario:

Combined Liquid Flow Transducer/Transmitter

Stock No. 257-026 (Type One)
Stock No. 285-790 (Type Two)

General

These two sturdy turbine flow sensors are designed to operate with most liquids. Two types are available with type one combining a 4-20mA flow transmitter within the same housing. The output signal of this device is 4-20mA, proportional to the flow. The unit is supplied factory calibrated to 4-100 l/minute but may be field calibrated as follows:-

a) Set system to zero flow and connect a multimeter between terminals 1 (+20mA) and ⏚ (0mA).

b) Adjust zero pot to read 4mA on meter.

c) Set system to full flow with multimeter still connected as (a) above. (Max. flow = 150 l/minute).

d) Adjust span pot to read 20mA on meter.

Type two provides a pulse output proportional to flow rate. This is factory calibrated (2 l/m-150 l/min.) and is not user adjustable.

WARNING

This product contains components manufactured from glass filled polyester and borosilicate glass. Although robustly constructed and rigorously tested, we recommend the following precautions are taken:-

1. DO NOT over-tighten pipe fittings (Max. Torque 60Nm).
2. Only use pipe fittings and sealing methods recommended for use with the End Couplings provided.

2a. DO NOT use tapered male pipe fittings.

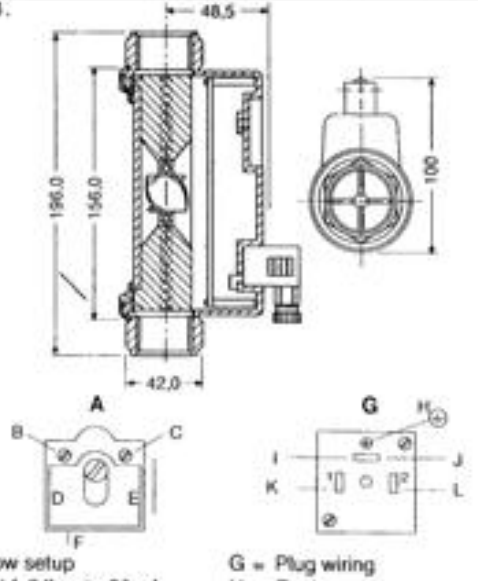
3. Although it should not be necessary, P.T.F.E. tape may be used, but must not be allowed to enter pipework.
4. Support pipework and mount the unit in such a way as to minimise side loading, mechanical shock loads and vibrations etc.
5. In use the glass body of this meter is subjected to pressure and must under NO circumstances be subjected to physical abuse.
6. DO NOT use if any form of damage occurs, or is suspected to have occurred during handling or installation.
7. Protect from frost.
8. This unit is intended for permanent installation and should not be used for temporary applications.

Maximum working temperature +80°C (+60° with water). Maximum working pressure 10 bar.

Technical Specification

Construction	
Body	Polyester
Glasstube	Borasilicone
Seals	Nitrile
Washers and shaft	Stainless steel
Rotor and locator	Acetal
Rotor tips	Stainless steel
Calibration (Type 1)	4-100 l/min. on water (as factory set)
	4mA - 0 l/min
	20mA - 100 l/min
Type 2 'K' factors	Oil - 51.14 pulses per litre
	Water - 44.25 pulses per litre
Maximum flow rate (field calibration)	150 l/min
Maximum working pressure	10 bar Oil/Water
Minimum flow indication	2 l/m (Max 150 l/m)
Temperature range	5 to 80°C Oil
	5 to 60°C Water
Accuracy	±2%
Connections	1" BSP Parallel threads
Electrical details	Supply 24V ⎓
Output (type 1)	4-20mA
(type 2)	Pulsed
Pulse output connections	
Pin 1	+ve o/p
Pin 2	+ve supply
Pin 3	-ve o/p (not shown on diagram)
Pin 4	Earth (-ve supply)

Figure 1.



A = Flow setup
B = Set full flow to 20mA
C = Set zero flow
D = Span
E = Zero
F = Slider

G = Plug wiring
H = Earth
I = 0mA
J = 0v power
K = +20mA
L = +24V power

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