



**SMART COOLING™**

MEASUREMENT TOOLS AND METHODOLOGY

**2020**

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## What tools are used:



### **BTU Meter RIF600**

The wall-mounting flow meter can be applied to a wide range of pipe flow measurements.

Applicable liquids include pure liquids as well as liquid with small quantity of tiny particles.



### **Eniscope 8**

A multi-channel, three phase energy meter and sensing system combined with a processing facility designed to gather, summarize, store and transmit energy related information to web based servers for presentation and analysis. Data can be viewed in real-time on any computer, or across a range of portable devices, from anywhere in the world. Historical data can be accessed and analysed, at one-minute resolution via the BEST Analytics Platform.

## What data is measured:

**Equipment tested:** Trane RTAF.

**Test description:** Compare total kWh consumed by rack “B” AC system for 7 consecutive days with **Smart Cooling™** system **OFF** to 7 consecutive days with **Smart Cooling™** system **ON** (with comparative Temp. & R.H. data).

**Test method:** Ultrasonic BTU metter, mesuring leaving and returning water flow & water temperature from chiller to cooling system.

- Example:** COP Technical report for chiller efficiency with and without **Smart Cooling™** adiabatic pre-cooling system

**Test Nr. 1 Chiller BTU & COP without Smart Cooling™ adiabatic chiller booster system**

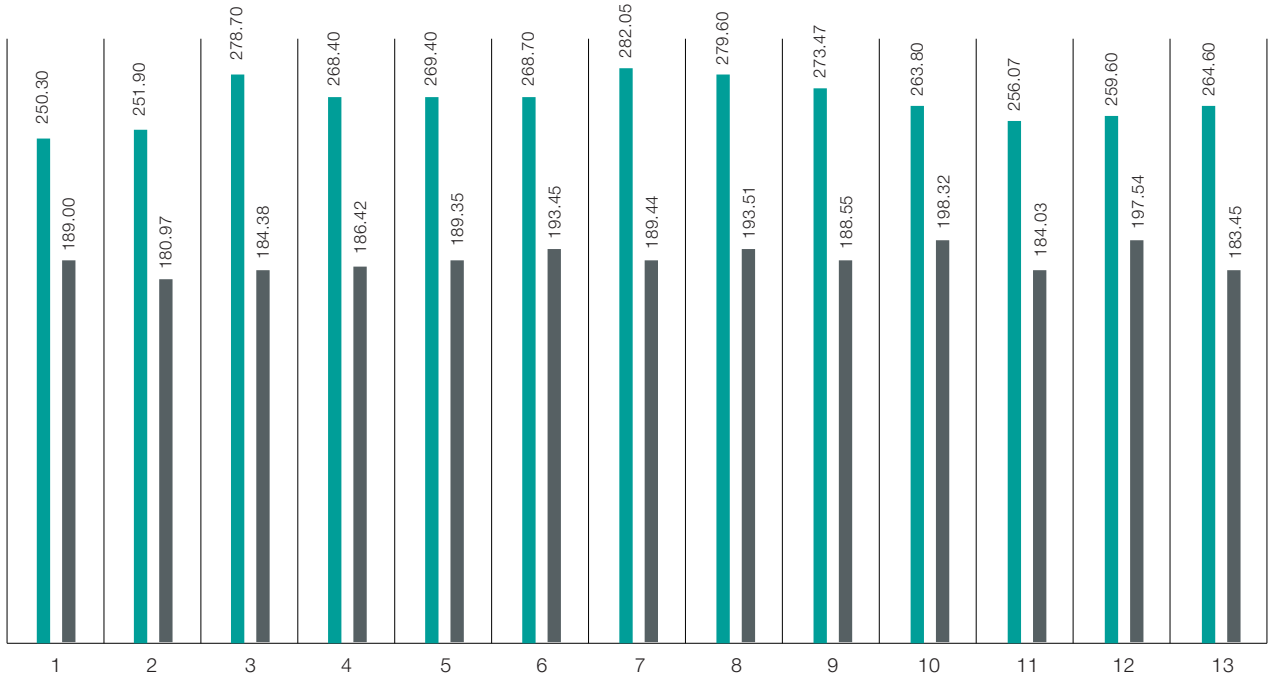
NR	DATE	TIME	SC SYSTEM STATUS	HOURS USED	COMPR. POWER (%)	ENERGY ABSORPTION (kW)	COP	COOLING CAPACITY	MEASURED COOLING CAP. (kW)	MEASURED WATER FLOW RATE (M <sup>3</sup> /H)	COP IN	AMBIENT AIR TEMP. (°C)	RELATIVE HUMIDITY (%)	COP AVERAGE	COP INCREASE	COP INCREASE (%)	AVERAGE COOLING (kW)	COOLING (kW)
						TEST TIME	DATA SHEET	DATA SHEET	TEST TIME	TEST TIME	TEST TIME			TEST TIME	TEST TIME	TEST TIME	TEST TIME	INCREASE
1	14.10.2019	10:00	OFF			77.94			189.00	28.39	2.42	32.5	19%					
2	14.10.2019	10:10	OFF			77.01			180.97	26.52	2.35	32.2	21%					
3	14.10.2019	10:20	OFF			76.38			184.38	27.31	2.41	32.3	18%					
4	14.10.2019	10:30	OFF			77.01			186.42	27.03	2.42	32.5	18%					
5	14.10.2019	10:40	OFF			77.32			189.35	28.02	2.45	32.7	15%					
6	14.10.2019	10:50	OFF			78.94			193.45	27.54	2.45	32.6	13%					
7	14.10.2019	11:00	OFF			77.94			189.44	27.78	2.43	32.6	13%					
8	14.10.2019	11:10	OFF			78.75			193.51	28.12	2.46	32.9	13%					
9	14.10.2019	11:20	OFF			77.01			186.55	27.48	2.45	33.1	13%					
10	14.10.2019	11:30	OFF			79.06			196.32	28.03	2.51	33.2	13%					
11	14.10.2019	11:40	OFF			75.70			184.03	27.35	2.43	33.6	13%					
12	14.10.2019	11:50	OFF			79.00			197.54	28.03	2.50	33.3	13%					
13	14.10.2019	12:00	OFF			77.32			183.45	27.90	2.37	33.7	13%					
<b>TOTAL</b>						<b>77.64</b>			<b>189.11</b>	<b>27.65</b>	<b>2.44</b>	<b>32.86</b>	<b>15%</b>	<b>2.44</b>	<b>0</b>	<b>0</b>	<b>189.11</b>	<b>0</b>

**Test Nr. 2 Chiller BTU & COP with Smart Cooling™ adiabatic chiller booster system**

NR	DATE	TIME	SC SYSTEM STATUS	HOURS USED	COMPR. POWER (%)	ENERGY ABSORPTION (kW)	COP	COOLING CAPACITY	MEASURED COOLING CAP. (kW)	MEASURED WATER FLOW RATE (M <sup>3</sup> /H)	COP IN	AMBIENT AIR TEMP. (°C)	RELATIVE HUMIDITY (%)	COP AVERAGE	COP INCREASE	COP INCREASE (%)	AVERAGE COOLING (kW)	COOLING (kW)
						TEST TIME	DATA SHEET	DATA SHEET	TEST TIME	TEST TIME	TEST TIME			TEST TIME	TEST TIME	TEST TIME	TEST TIME	INCREASE
1	15.10.2019	09:00	ON			76.07			250.30	27.50	3.29	36.3	21%					
2	15.10.2019	09:10	ON			78.57			251.90	27.90	3.21	37	21%					
3	15.10.2019	09:20	ON			77.63			278.70	30.90	3.59	32.3	22%					
4	15.10.2019	09:30	ON			77.00			288.40	30.40	3.49	33	18%					
5	15.10.2019	09:40	ON			78.00			269.40	30.10	3.45	34	17%					
6	15.10.2019	09:50	ON			77.00			268.70	30.60	3.49	33	17%					
7	15.10.2019	10:00	ON			76.20			282.05	31.10	3.70	30.8	17%					
8	15.10.2019	10:10	ON			76.00			279.60	30.80	3.68	32	15%					
9	15.10.2019	10:20	ON			77.00			273.47	30.20	3.55	32	14%					
10	15.10.2019	10:30	ON			78.00			288.80	30.30	3.38	33	14%					
11	15.10.2019	10:40	ON			76.82			256.07	30.40	3.33	33	14%					
12	15.10.2019	10:50	ON			77.00			259.60	30.40	3.37	34	14%					
13	15.10.2019	11:00	ON			77.32			264.60	31.40	3.42	32.2	14%					
<b>TOTAL</b>						<b>77.12</b>			<b>266.66</b>	<b>30.15</b>	<b>3.46</b>	<b>33.28</b>	<b>17%</b>	<b>3.46</b>	<b>1.02</b>	<b>0</b>	<b>266.66</b>	<b>77.55</b>

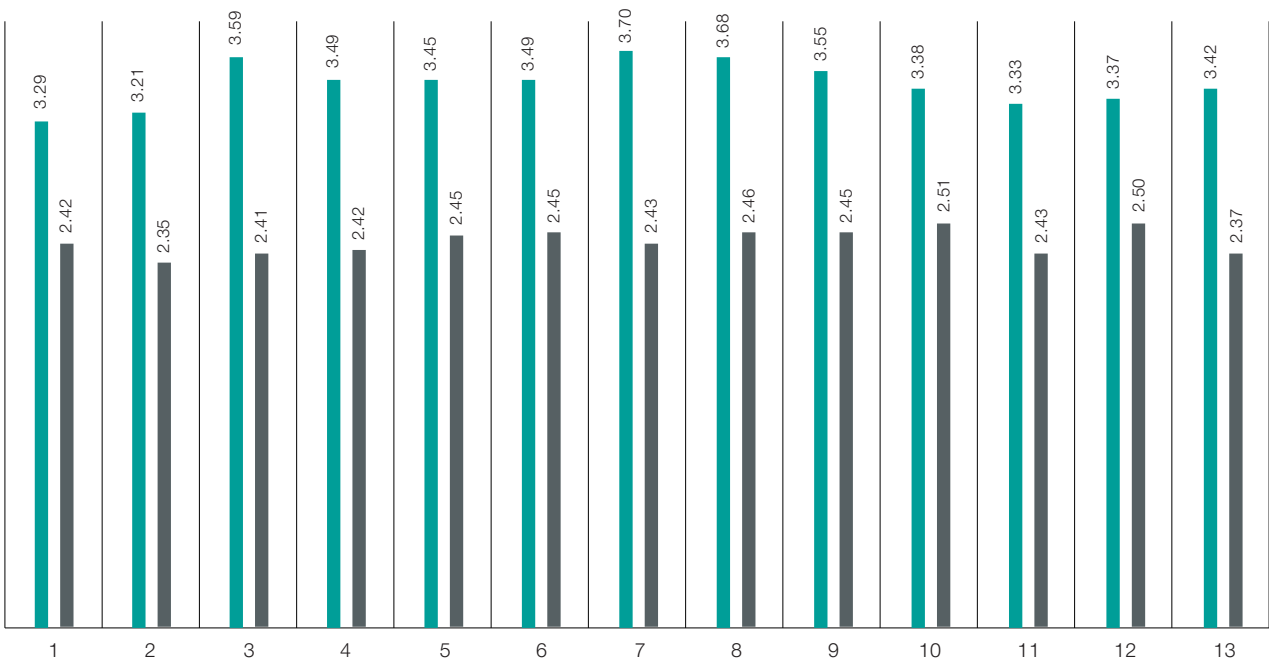
**CHILLER COOLING CAPACITY SMART COOLING™ ON VS SMART COOLING™ OFF**

Average chiller cooling capacity increase ..% or .. kW



**CHILLER (COP) SMART COOLING™ ON VS SMART COOLING™ OFF**

Average chiller COP increase ..% or .. kW



## What methodology is used:

Action	Details
Brief description of the work	Carry out Energy Meter Installation – One day Job.
Requirements from the CLIENT	<ul style="list-style-type: none"> <li>Three-Phase Connection, 1 meter far from Energy meter Control Box.</li> </ul> <p><b>Note:</b></p> <ul style="list-style-type: none"> <li>Load needed 30W as follow:</li> <li>Eniscope power consumption: 20 W (see attached Eniscope Hybrid Technical Specification).</li> <li>Wireless router power consumption: 10 W.</li> </ul> <p>Why Three-phase Connection required? The ENISCOPE needs to monitor Three-Phase Voltage (see attached Eniscope Installation Summary).</p> <ul style="list-style-type: none"> <li>Switch-off chiller main power for not more than 10 mins during CT's installation (see attached Eniscope Installation Summary).</li> </ul>
Manpower	<ol style="list-style-type: none"> <li>Supervisor.</li> <li>Two qualified electricians.</li> </ol>
Required Materials	<ol style="list-style-type: none"> <li>5 core 2.5mm<sup>2</sup> electrical cable.</li> <li>2 core 1mm<sup>2</sup> control cable.</li> <li>Waterproof Enclosure Control Box (including Eniscope, Wireless Router, 16 amps 4-Pole Disconnect switch, 6 amps 2-POLE MCB, 6 amps 3-POLE MCB).</li> <li>500A CT's.</li> <li>20mm Flexible Conduit GI (PVC Coated).</li> <li>Temperature Sensor.</li> </ol>

Action	Details
Tools to be used	<ol style="list-style-type: none"> <li>1. Clamp meter.</li> <li>2. HILTI drill machine.</li> <li>3. Wire cutter.</li> <li>4. Tester.</li> </ol>
Sequence of work	<ol style="list-style-type: none"> <li>1. Get <b>work permit</b>.</li> <li>2. Supply required tools and materials to site.</li> <li>3. Brief risk assessment to the team.</li> <li>4. Brief Eniscope installation manual for the team.</li> <li>5. Install Energy Meter Control Box in the agreed location.</li> <li>6. Connect Three-phase connection to energy meter control box.</li> <li>7. Route CT's cables from Energy Meter Panel to chiller MDB's.</li> <li>8. Turn <b>OFF</b> chiller Main Power for not more than 10 mins by the client site electrician.</li> <li>9. Connect CT's.</li> <li>10. Connect Eniscope to the Network.</li> <li>11. Eniscope Commissioning.</li> <li>12. Clear up: remove tools and materials.</li> <li>13. Clean area of work.</li> </ol>
Identification of hazards.	<ol style="list-style-type: none"> <li>1. Electricity.</li> <li>2. Foot injury.</li> <li>3. Head injury.</li> <li>4. Hand injury.</li> <li>5. Cuts and abrasions</li> </ol>
Control measures	<ol style="list-style-type: none"> <li>1. Supervisor.</li> <li>2. Two Qualified Electricians.</li> </ol>
Site Access permit	Works permits will be required.
Site supervision	Mr. Ali Soufan will be responsible for site safety.

Action	Details
Attachments	<ul style="list-style-type: none"> <li>• Eniscope Hybrid Technical Specification.</li> <li>• Eniscope Installation Summary</li> <li>• Risk Assessment</li> </ul>

## Eniscope hybrid technical specification

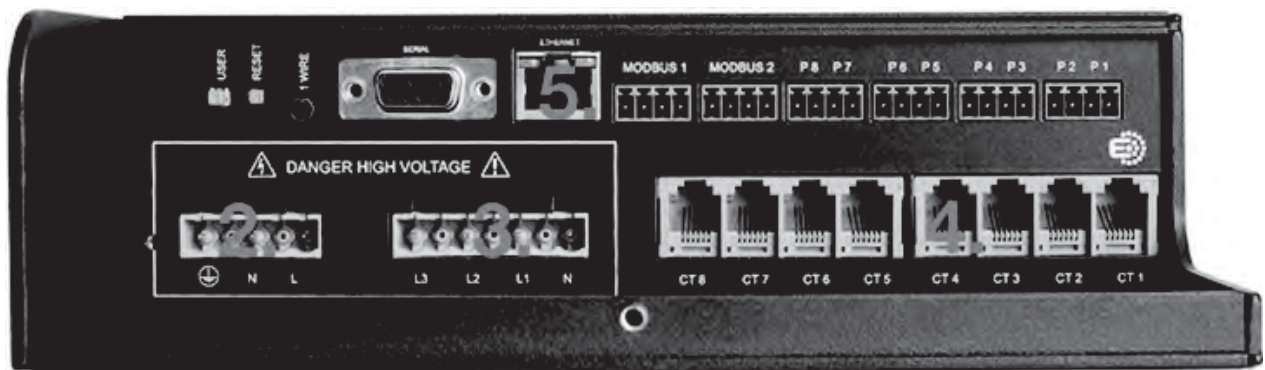
- **Environment**
  - Humidity: 0 - 80% (non condensing)
  - Meter operating temperature: 10 - 40°C nominal
  - Storage temperature: 0°C to 50°C nominal
  - Altitude: 2000m above sea level maximum
- **Aux Supply**
  - 100 – 240V~ 50/60 Hz nominal
  - Power Consumption: < 20W
  - Current: 20mA
- **Electrical Metering**
  - Nominal full scale voltage: 346V~LN/600V~LL - Voltage Category III
  - Withstand voltage: 1000V~ LN & LL
  - Input impedance: > 2MΩ
  - Metering frequency: 50/60 Hz nominal
  - Pickup voltage: 0V
  - Voltage accuracy: better than 1%
  - CT type split core - Measurement Category III compliant ONLY to UL2808,
  - 333 mV output per channel nominal, Max 1V
  - CT operating temperature: -40C to +55C
  - CT max primary voltage: 600V~
  - CT nominal current: according to available CT's
  - Metering range: 5 - 3000 Amps as standard and stocked
  - Withstand current: 6 x nominal CT current
  - Pickup current: 0A
  - Accuracy: +/-1% as per IEC60044-1, Table 11



## Eniscope installation summary

### What is It?

Eniscope 8 is a multi-channel, three phase energy meter and sensing system combined with a processing facility designed to gather, summarize, store and transmit energy related information to web based servers for presentation and analysis. Data can be viewed in real-time on any computer, or across a range of portable devices, from anywhere in the world. Historical data can be accessed and analysed, at one-minute resolution via the BEST Analytics Platform.



### Installation Requirements

**Electrician** – This person should be competent and have experience working with three-phase electrical distribution systems. They should also have a good working knowledge and understanding of electrical schematics and be able to assist you in identifying the most suitable monitoring locations, as well as to installing the Eniscope in accordance with local safety standards and regulations.

**IT Networking Technician** – An excellent knowledge of networking: both wired and wireless, for small and large configurations. With detailed understanding of router configurations that include port mapping, firewall rules and access lists. A broad knowledge of TCP/IP concepts. Whilst a theoretical understanding is good, you require someone with practical experience and who is able to troubleshoot.

### 1. Mount the Eniscope

The Eniscope 8 is designed to be mounted vertically on a wall or other suitable surface, using the supplied DIN rail next to the DB board or circuit that will be monitored.

- Installation Time: 15min
- Electrician

Mini Din Rail



Dimensions

Height	200mm
Width	207mm
Depth	60mm
Weight	1.4 kg

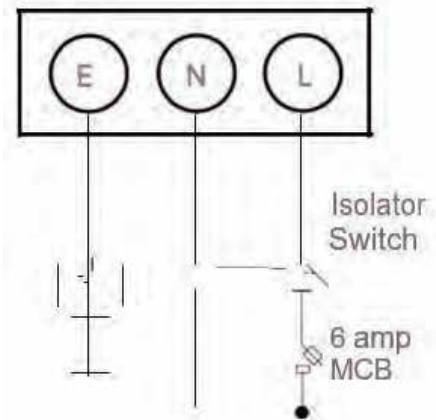


Additional Mounting Hole

### 2. Single-Phase Aux Power Supply

The Eniscope 8 requires an Aux power (100 to 240 V~ Nominal) supply to energise the processor and metering elements. The typical power consumption is low (20W) and can be supplied by an independent source (or by the three-phase voltage reference).

- Installation Time: 30min
- Electrician



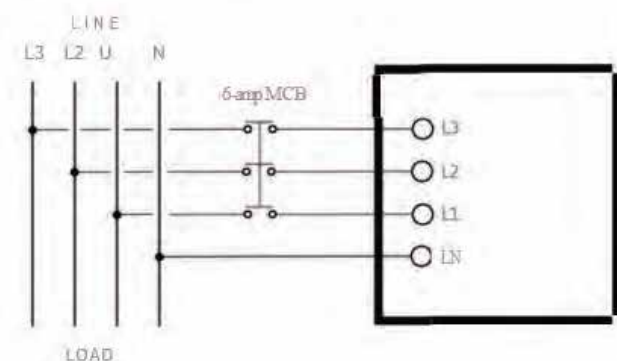
### 3. Three-Phase Voltage Reference

To provide all of the required electrical parameters the Eniscope 8 needs to monitor three-phase voltage. A 6-amp triple pole MCB 'B' trip curve should be used on the voltage measurement input terminals. Maximum input voltage for the Eniscope must not exceed 346LN/600LL V~ rms.

- Installation Time: 30min
- Electrician

Three Phase Connection (3LN)

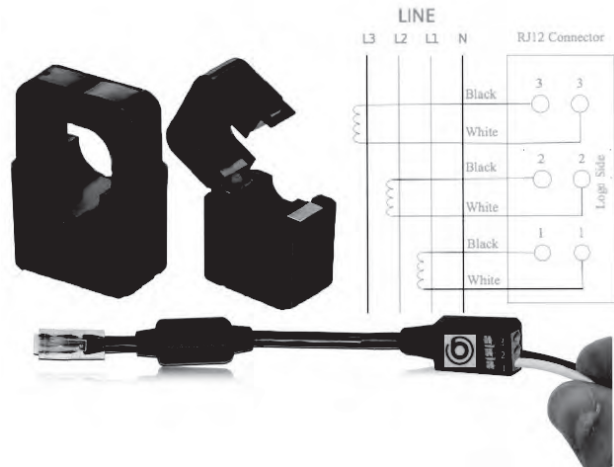
3-Phase 4-Line (Most common connection)



#### 4. Install Current Transformers (CT1s)

Each monitored circuit requires a CT placed on each phase to calculate the current flow. The CT's used are split-core and have an output of 0.333V. To speed up the installation special push-fit adaptors are used. Up to 8 three-phase or 24 single-phase circuits can be monitored per Eniscope Hybrid.

- Installation Time: 10min per circuit
- Electrician



#### 5. Connect to the Network

The Eniscope is a networked device designed to collect measured data and send this via HTTP to the cloud for historical data viewing. As such a network connection with internet access is required.

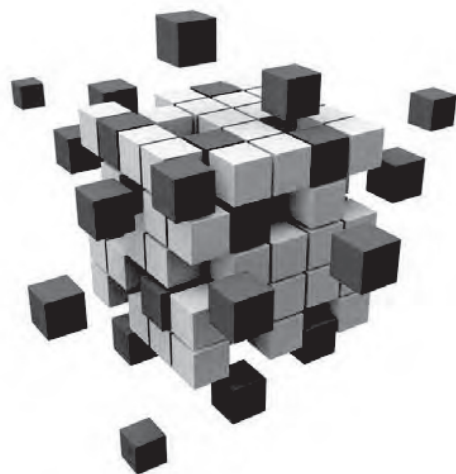
- Installation Time: 10min
- Network Administrator



#### 6. Configuration

The Eniscope is a networked device designed to collect measured data and send this via HTTP to the cloud for historical data viewing. As such a network connection with internet access is required.

- Installation Time: 10min
- Network Administrator



## Risk assessment:

RISK ASSESSMENT FOR ENERGY METER INSTALLATION									
Client:		EMPOWER ENERGY SOLUTION		Activity: ENERGY METER INSTALLATION		Date: 25/05/19		Persons @ Risk (Tick Box)	
Employer:				Location: Dubai Studio City		Rev-0		<input checked="" type="checkbox"/> Employees <input type="checkbox"/> Public	
Main Contractor:		Gerab Energy System		Equipment to be Used: Ladder, Pressure washer machine & tool box.					
Sub-Contractor:								<input checked="" type="checkbox"/> Sub-Contractors <input type="checkbox"/> Visitors	
S.N.	HAZARD (Consider Potential Hazards Mentioned at foot note)	RISK	RISK EVALUATION			CONTROL MEASURES Check: PPE Mandatory HSE requirements & Other Assessments Given @ Foot Note	Controlled By	Residual Risk (H.M.L)	Review Frequency
			P X S	RISK	H/M /L				
1	Electricity	Electrocution Burn / Shock / Fire / Fatality	3 x 5	15	H	Good Electrical Tools and Cables & its correct use. All electrical connections must be given by competent electrician only. Specified / recommended industrial sockets/plugs will be used for extension wires. Proper tagging (Lock-out / Tag-Out) and permit to work shall be implemented on energized panel. Earthing to be done prior to start.	Installation Team	L	
2	Working in open areas with high temperature	Sun stroke / Heat stroke	3 x 3	9	M	Comply with work/rest hours as per M.O.L orders (12:00 – 3:00 pm rest). Supply cold water at site and at work stations.	Installation Team	L	
3	Use of Hand and Power Tools	Electrical hazards / Presence of sharp edges	3 x 3	9	M	Only approved tools to be permitted for use, preferably with international quality marks, e.g. CE, EN. Use proper tool for the intended job. Trained operators only, especially for cartridge-operated tools. Electrical power tools must be double insulated or grounded. Power tools equipped with 'Deadman' type control switches. Use appropriate PPE. Inspect tool before each use. Ensure no broken/ bare power cords or damaged insulation or broken plugs/sockets. Ensure all guards are in place.	Installation Team	L	

RISK ASSESSMENT FOR ENERGY METER INSTALLATION										
Client:		EMPOWER ENERGY SOLUTION		Activity: ENERGY METER INSTALLATION		Date: 25/05/19		Persons @ Risk (Tick Box)		
Employer:				Location: Dubai Studio City		Rev-0		<input checked="" type="checkbox"/> Employees <input type="checkbox"/> Public		
Main Contractor:		Gerab Energy System		Equipment to be Used: Ladder, Pressure washer machine & tool box.						
Sub-Contractor:								<input checked="" type="checkbox"/> Sub-Contractors <input type="checkbox"/> Visitors		
S.N.	HAZARD (Consider Potential Hazards Mentioned at foot note)	RISK	RISK EVALUATION			CONTROL MEASURES Check: PPE Mandatory HSE requirements & Other Assessments Given @ Foot Note	Controlled By	Residual Risk (H.M.L)	Review Frequency	
			P X S	RISK	H/M/L					
4	Poor Housekeeping	Trips, falls causing injuries / Fire	2 x 3	6	L	All materials and other wastes to be disposed off by an authorized company. Wastes to be collected/ stored/ removed from site properly and regularly.	Installation Team	L		
<b>Note.</b> 1) Risk Assessment must be addressed to workers by Work-in Charge before starting Job 2) Risk Assessment is continual process hence to be reviewed depending on activity and risk involved										
RISK LEVEL		PPE REQUIRED (TICK BOX)			MANDATORY HSE REQUIREMENTS (TICK BOX)					
H - High-Potential to Cause death or permanent disability M - MEDIUM- Potential to cause loss time injury L - LOW- An injury treatable with First Aid		<input checked="" type="checkbox"/> Safety Helmet <input checked="" type="checkbox"/> Safety Boots <input checked="" type="checkbox"/> Goggles / Spectacle <input checked="" type="checkbox"/> Overalls <input checked="" type="checkbox"/> Gloves			<input checked="" type="checkbox"/> Mask <input checked="" type="checkbox"/> Ear Plugs / Defenders. <input checked="" type="checkbox"/> Respiratory / Breathing Apparatus <input checked="" type="checkbox"/> Full Body Safety Harness			<input checked="" type="checkbox"/> Safety Induction <input checked="" type="checkbox"/> Tool Box Talk <input checked="" type="checkbox"/> Proper PPE <input checked="" type="checkbox"/> Safe Work Place		<input checked="" type="checkbox"/> Work Permit <input checked="" type="checkbox"/> Proper Tools / Equipment's <input checked="" type="checkbox"/> Proper Supervision <input checked="" type="checkbox"/> Proper Barricade & Warning sign in the affected area.
PROBABILITY (P)	SEVERITY (S)	CLASS OF RISK			POTENTIAL HAZARDS / CONDITIONS CONSIDERED (TICK BOX)					
1. Improbable	1. Negligible	P X S - RISK			<input checked="" type="checkbox"/> Fire Risk <input checked="" type="checkbox"/> Electricity <input checked="" type="checkbox"/> Manual Handling <input checked="" type="checkbox"/> COSHH <input checked="" type="checkbox"/> Adverse Weather					<input checked="" type="checkbox"/> Deep Excavation <input checked="" type="checkbox"/> Slips / Tripping <input checked="" type="checkbox"/> Environmental Risk <input checked="" type="checkbox"/> General Public
2. Unlikely	2. Minor	High - 15 to 25								
3. Probable	3. Moderate	Medium - 07 to 14								
4. Occasional	4. Serious	Low - 01 to 06								
5. Frequent	5. Catastrophic									



## Annex:



Riels instruments srl  
Viale Spagna, 16  
35020 Ponte San Nicolò (PD) - ITALY  
Ph. +39 0498961771 | info@riels.it



### RIF600 | Clamp-on Ultrasonic Meter Calibration Report

Pipe diameter	DN80	Date	15/12/2018
Ambient temperature	29°C	Model:	RIF600W
Standard Device before test	Normal		
Standard Device After Test	Normal		
Test result	Qualified		
Measured Medium	Water		
Accuracy	1%		
Signal Strength	UP: 90 DOWN: 90		
Standard device name	Static volumetric method/standard Meter Method Water Flow/Standard Device		
Standard device accuracy	0,20%		

Test	Standard Meter flow		Temperature	Pressure	Tested Meter Flow		Basic Error	Repeatability	
Point	m3/h		°C	Mpa	m3/h		%	%	
Point 1	101,52	101,47	25,0	0,300	102,27	102,10	0,739	-0,147	0,147
	101,47		25,0	0,300	102,07		0,591		
	101,42		25,0	0,300	101,97		0,542		
Point 2	71,27	71,27	25,0	0,300	71,75	71,75	0,673	-0,146	0,147
	71,19		25,0	0,300	71,65		0,646		
	71,34		25,0	0,300	71,86		0,729		
Point 3	26,32	26,36	25,0	0,300	26,51	26,55	0,722	-0,132	
	26,36		25,0	0,300	26,56		0,759		
	26,39		25,0	0,300	26,58		0,720		

Verification Based on JJG 1030-2007 < Ultrasonic flowmeter verification procedures >  
Scale Factor=1

## Annex 2:



Riels instruments srl  
Viale Spagna, 16  
35020 Ponte San Nicolò (PD) - ITALY  
Ph. +39 0498961771 | info@riels.it



### RIF600 | Test Report misuratore di portata ad ultrasuoni clamp on

Diametro tubazione	DN80	Date	15/12/2018
Temperatura ambiente	29°C		
Dispositivo standard prima del test	Normale	Model:	RIF600W
Dispositivo standard dop il test	Normale		
Risultato del test	Qualified		
Liquido	Acqua		
Accuratezza	1%		
Potenza dei segnali	UP: 90 DOWN: 90		
Tipo di dispositivo standard	Metodo volumetrico statico/Misuratore di portata volumetrico		
Accuratezza del dispositivo standa	0,20%		

Test	Misuratore standard	Temperatura	Pressione	Misuratore testato	errore base	Ripetibilità
Punti	m3/h	°C	Mpa	m3/h	%	%
Punto 1	101,52	25,0	0,300	102,27	0,739	-0,147
	101,47	25,0	0,300	102,07	0,591	
	101,42	25,0	0,300	101,97	0,542	
Punto 2	71,27	25,0	0,300	71,75	0,673	-0,146
	71,19	25,0	0,300	71,65	0,646	
	71,34	25,0	0,300	71,86	0,729	
Punto 3	26,32	25,0	0,300	26,51	0,722	-0,132
	26,36	25,0	0,300	26,56	0,759	
	26,39	25,0	0,300	26,58	0,720	

Verification Based on JIG 1030-2007 < Ultrasonic flowmeter verification procedures >  
Scale Factor=1



Ver. RIF600W.01 year 2019

## **RIF600W**

### CLAMP-ON ULTRASONIC FLOW METER INSTALLATION MANUAL

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## 1.0 Manufacturer's data:

**Company:** Riels Instruments S.R.L.

**Company headquarters:** Viale Spagna, 16 - 35020 - Ponte San Nicolò (PD).

**P.IVA:** 02488080280

**Office phone:** +39 049 8961771

**Email:** info@riels.it

**Website:** www.riels.it

## 2.0 Summary:

Welcome to use new generation transit-time ultrasonic flow meter, please read the user manual carefully before using. The wall mount ultrasonic flow meter is designed to be installed in a fixed location for long term flow measurement.

### 2.1 Features:

- Linearity: **0.5%**,
- Repeatability: **0.2%**,
- Accuracy: **±1%**
- Easy to operate.
- Several type transducers for selection, measuring pipe size is from DN15 mm to DN6000 mm
- Adopt low voltage, multi-pulse technology to improve accuracy, useful life and reliability.
- Powerful Recording Function, record the totalizer data of the last 64 days/64 monthes/5 years.

### 2.2 Typical application:

The wall-mounting flow meter can be applied to a wide range of pipe flow measurements. Applicable liquids include pure liquids as well as liquid with small quantity of tiny particles.

• **Examples:**

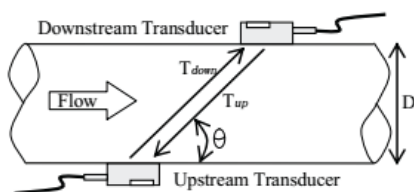
- Water (hot water, chilled water, city water, sea water, waste water, etc.)
- Sewage with small particle content
- Oil (crude oil, lubricating oil, diesel oil, fuel oil, etc.)
- Chemicals (alcohol, acids, etc.)
- Plant effluent
- Beverage, liquid food
- Ultra-pure liquids
- Solvents and other liquids

### 3.0 Working principle:

The RIF600W ultrasonic flow meter is designed to measure the fluid velocity of liquid within a closed conduit. The transducers are a non-contacting, clamp-on type, which will provide benefits of non-fouling operation and easy installation.

The RIF600W transit-time flow meter utilizes two transducers that function as both ultrasonic transmitters and receivers. The transducers are clamped on the outside of a closed pipe at a specific distance from each other. The transducers can be mounted in V-method where the sound transverses the pipe twice, or W-method where the sound transverses the pipe four times, or in Z-method where the transducers are mounted on opposite sides of the pipe and the sound crosses the pipe once. This selection of the mounting method depends on pipe and liquid characteristics.

The flow meter operates by alternately transmitting and receiving a frequency modulated burst of sound energy between the two transducers and measuring the transit time that it takes for sound to travel between the two transducers. The difference in the transit time measured is directly and exactly related to the velocity of the liquid in the pipe, show as follows:



$$V = \frac{MD}{\sin^2\theta} \times \frac{\Delta T}{T_{up} T_{down}}$$

**Where:**

- **V:** velocity of the liquid
- **θ:** is the include angle to the flow direction
- **M:** is the travel times of the ultrasonic beam
- **D:** is the pipe diameter
- **Tup:** is the time for the beam from upstream transducer to the downstream one
- **Tdown:** is the time for the beam from downstream transducer to the upstream one
- **ΔT:** Tup – Tdown

To measure the temperature, the two Pt1000 sensors are hooked to the outside of the pipe or inserted inside it and detect two temperature values.

The energy value is indicated/measured based on the following mathematical model:

$$Q = \int_{V_1}^{V_2} k \cdot (t_1 - t_2) dV$$

**Where:**

- **Q:** Amount of heat released
- **V:** Volume of the last liquid
- **k:** Heat coefficient, function of the properties of liquids that transmit heat at a relevant temperature and pressure
- **t<sub>1</sub>:** Liquid inlet temperature
- **t<sub>2</sub>:** Liquid outlet temperature

## 4.0 Basic parameter:

Power supply	85 ÷ 264 VAC or 8 ÷ 36 VDC
Repeatability	≥ 0.2%
Precision	≥ 1%
Outputs	<ul style="list-style-type: none"> <li>• RS485</li> <li>• 4 ÷ 20 mA or 0 ÷ 20 mA (active)</li> <li>• OCT with programmable pulses 6–1000 ms (default 200 ms)</li> <li>• Relay output for total flow or alarms</li> </ul>
Inputs	<ul style="list-style-type: none"> <li>• Two channel two wire input system with PT100 resistance, for the thermal energy display function</li> <li>• Optional three channel 4 ÷ 20 mA input, accuracy: 0.1%</li> <li>• Backlit 2 × 20 display</li> <li>• 4 × 4 keyboard</li> <li>• Capacity storage function for up to 10 years</li> <li>• Automatic storage of the switch-off / switch-on date</li> </ul>
Protection degree	<ul style="list-style-type: none"> <li>• Mainframe: IP65</li> <li>• Sensors: IP68</li> </ul>

## 5.0 Accessories:

Clamp-on sensors	Available in SMALL / MEDIUM / LARGE versions
Temperature sensors	<ul style="list-style-type: none"> <li>• For the calculation of thermal energy</li> <li>• Accuracy: 100 °C ±0.8</li> <li>• Combined well with the main unit the minimum temperature difference is <math>\leq 0.1</math> °C.</li> </ul>
Memory card	For saving the acquired data
Card reader usb	For downloading data purchases on PC
Fastening belts	For installation in cast iron, grp, pvc, etc. that do not support direct connection of transducers
111 Compound Gel	For ultrasound transducers

## 6.0 Installation of sensors:

### **Warnings!**

All devices are tested and set up by the manufacturer before shipment and delivery to the customer.

The preparation operations and how and where to use the product are listed and described below.

RIF600W is designed, manufactured and tested to meet all specific standards (see the declaration of conformity), when used and connected correctly.

The installation must be carried out in such a way as to ensure that the instrument can function properly. The environmental characteristics must be those indicated by the manufacturer. Improper use and maintenance will invalidate the warranty terms.

The RIF600W devices use sensors containing piezoelectric crystals that allow the emission and reception of ultrasonic signals, through the walls of the pipe. Although easy to install, for the most accurate measurement possible and optimal device operation, the positioning distance and alignment of the sensors are of crucial importance. The instructions must therefore be followed carefully.

### **The installation of ultrasonic sensors includes the following steps:**

- identification of the optimal position on the pipe;
- entering the required parameters in the device keyboard;
- based on the parameters entered, the instrument will calculate the most suitable distance for transducers positioning;
- pipeline preparation and transducer assembly.

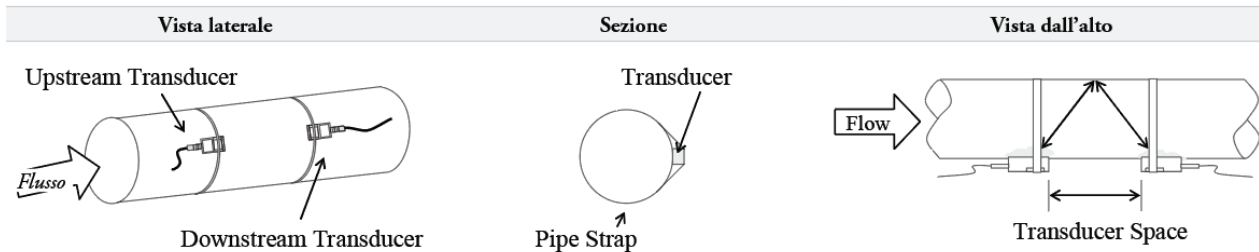
### **Depending on the type of pipe and the characteristics of the liquid, the sensors can be installed:**

- in position V (method V), the generated signal passes through the pipe twice;
- in position Z (method Z), the generated signal passes through the pipe only once;
- in position W (method W), the generated signal passes through the pipe four times.

### 6.1 V method:

The V method is considered the standard method.

It is usually used on diameters between about 50 mm and about 700 mm.



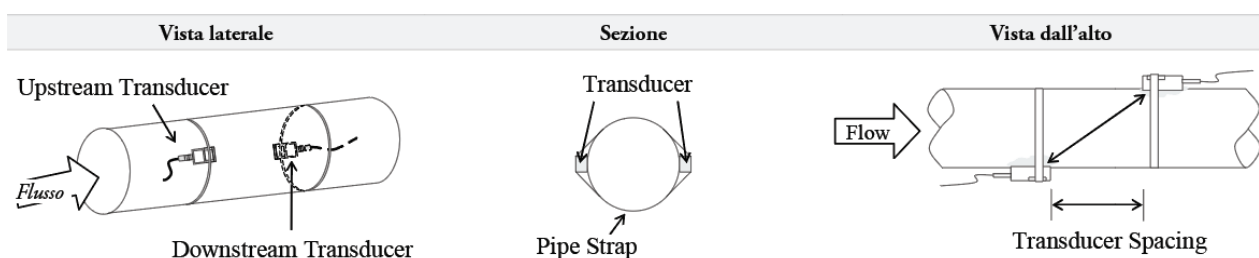
### 6.2 Z method

The signal transmitted in an installation with the Z method is subject to less disturbance, compared to the V method seen in the previous paragraph.

This is because the signal is transmitted directly (rather than reflected) and flows through the liquid only once.

It is preferable to install the sensors according to the Z method when the pipes are very large, if there are solids suspended in the fluid or if the inner lining of the pipe is too thick.

The Z method is able to measure approximately on pipe diameters from 300 mm to 6000 mm.



### 6.3 W method

The W method is used on diameters between about 15 mm and about 100 mm.



## 7.0 Mounting positions:

The first step in the installation process is the selection of an optimum location in order to obtain a more accurate measurement. For this to be completed effectively, a basic knowledge about the piping and its plumbing system would be advisable.

An optimum location would be defined as a straight pipe length full of liquid that is to be measured. The piping can be in vertical or horizontal position.

## 8.0 Choice of assembly point:

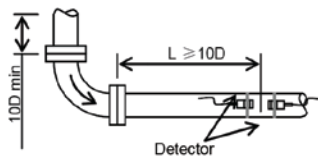
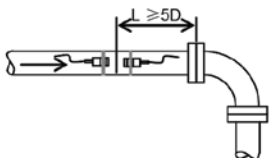
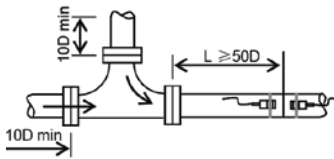
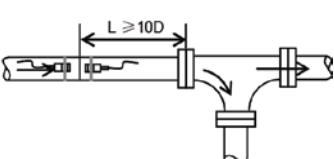
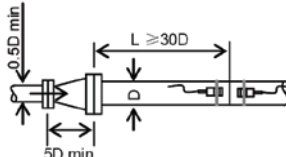
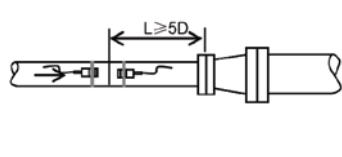
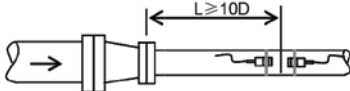
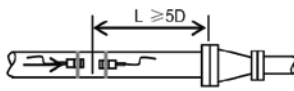
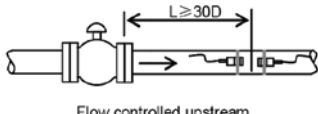
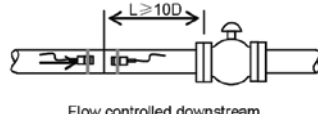
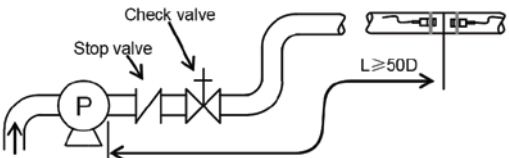
### Warnings!

To ensure accuracy and stability of the measurement, the installation point of the sensors should be on the straight pipe filled with well distributed fluid (during installation, the pipe must be filled with liquid).

- The tube must be full of uniformly distributed liquid and suitable to be crossed by the ultrasonic beam (vertical tube or horizontal tube).
- The sensors must be installed in a pipe position that has a straight section of 10D in length before the upstream sensor positioning point and a straight section equal to 5D after the downstream sensor positioning point. D means the outside diameter of the pipe. The portion of pipe must also be away from valves, pumps, high pressure currents, transformers that can be a source of interference.
- Avoid installing the sensors in the highest section of the system, or in a section of pipeline with downward flow with free exit.
- For systems with open or not completely full piping, install the U-tube sensors.
- The temperature and pressure at the point of installation must be compatible with the operating values of the sensors.

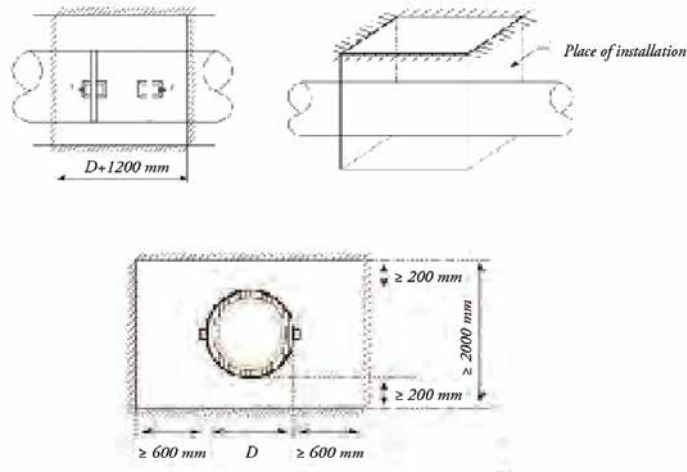


- It is advisable to use pipes that do not have too large diameter reductions due to internal coatings.
- The two sensors must be installed in a horizontal direction on the plane of the pipe axis, within  $\pm 45^\circ$  from the axis line, firmly anchored to the pipe in total absence of bubbles / particles between the transducers and the pipe.

Name	Straight sections before the upstream sensortails	Straight sections after the downstream sensor
90° curve		
T		
Enlargement		
Shrinking		
Valve		
Pump		

## 9.0 Assembly room:

In order to guarantee an operating environment suitable for the access of an operator, use distances between the pipe and the walls of the room equal to or greater than those indicated in the following figure:



## 10.0 Installation of clamp-on sensors:

### Warnings!

Before installation, clean the installation area of the chosen pipe, removing any rust or paint residue.

We recommend using an angle grinder for polishing, and then wipe a cloth soaked in alcohol or acetone to remove oil and dust.

Once the surface has been cleaned, spread a good quantity of gel 111 and apply the sensors, without any air bubbles or dust particles remaining between the sensor and the pipe.

The available clamp-on sensors are as follows:

Sensor	S1 standard	M1 standard	L1 standard	S1H high temperature	L1H high temperature	L1H high temperature
Range	DN15÷DN100	DN50÷DN700	DN300÷DN6000	DN15÷DN100	DN50÷DN700	DN300÷DN6000
Temperature of the fluid	0°C÷70°C	0°C÷70°C	0°C÷70°C	0°C÷160°C	0°C÷160°C	0°C÷160°C
Dimensions	45×30×30	60×45×45	80×70×55	90×85×24	90×82×29	80×70×55
Weight	75g	250g	650g	94g	150g	150g

Once you have chosen the type of sensor best suited to the measurement to be carried out, you will need to configure the sensor parameters manually, following the instructions in the following sections of this manual.

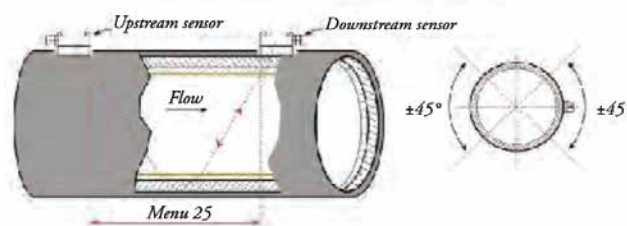
- The installation spaces between the transducers are indicated in menu 25.

The standard positioning method is the V-shaped method, ideal for pipes with diameters between DN15 and DN40.

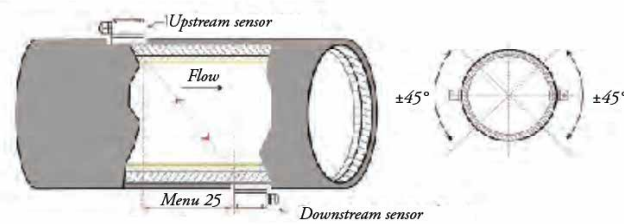
With larger pipes, too thick coatings or the presence of suspended solids in the fluid it is recommended to switch to the Z method.

It is very important that the angle between the position of the sensor and the horizontal axis of the pipe does not exceed  $\pm 45^\circ$ .

### V method

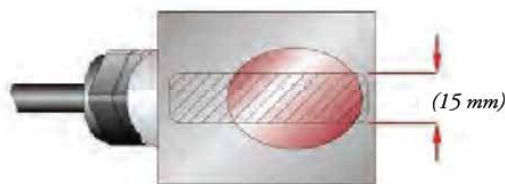


## Z method



## 10.1 Installation of V method sensors:

- Insert a strip of dough, about 15 mm wide, onto the flat surface of the transducer, as shown in the following figure. Generally, silicone grease is used, but any fat-like substance may be used provided it is estimated that it does not melt at the operating temperature of the tube.



- Position the transducer upstream and secure it with a strap. The belts must be placed in the curved channel of one end of the transducer. A screw allows to fix the belt on the transducer. Check that the transducer is firmly fixed on the tube and adjust it if necessary. Tighten the strap on the transducer to secure it.
- Position the downstream transducer on the pipe at the specified distance. By exerting firm pressure with your hand, slowly move the transducer both in the direction of the upstream transducer and in the opposite direction to it and observe the power signal. Hook the transducer in the position where the highest power signal is present (menu 90); this signal must be between 60 and 95.
- If, once the transducers are positioned, the power signal does not exceed 60, it is necessary to select another method of installation. If the V-position of the transducers was chosen, configure the device again by selecting the Z position, then reset the device and move the transducer downstream to the new position; then repeat the point described above.

The arrangement and alignment of the transducers is of crucial importance in transit time measuring devices.

Therefore, the user must respect the exact distance indicated on the screen of the menu window 25 on the basis of the parameters that he has entered.

## 10.2 Installation of Z method sensors:

- It requires the use of a roll of resistant paper (for example, wrapping paper and insulating tape) and a marker.
- Wrap the tube as shown in the following figure. Align the ends of the paper up to a maximum of 6mm.
- Mark the intersection of the two edges of the paper to indicate the circumference. Remove the model and spread it on a flat surface. Fold it in half, bisecting the circumference.

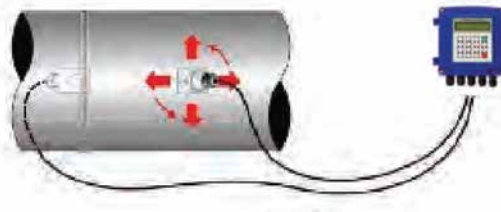


- Crack the card on the line. Mark the folding. Mark the tube at the point where one of the transducers will be positioned. Wrap the paper around the tube again, placing the two ends at the demarcation point on the tube. Move to the other side of the tube and mark it in the fold. Measure from the end of the crusher to the opposite side. Mark this point on the tube.
- The two demarcations are now measured and aligned. If it is not possible to wrap the paper around the tube, cut a piece of paper of this size and place it on top of the tube.

**Length** = external tube dimension  $\times$  1.57

**Width** = the distance entered in the menu 25

- Mark the opposite sides of the paper on the tube. Place the two transducers in these points.
- Introduce a strip of dough, about 15 mm wide, on the flat surface of the transducer.
- Position the transducer upstream and secure with a steel belt or other. The straps are positioned in the curved channeling of the transducer. A screw is also supplied. Tighten the belt to the transducer. Verify that the transducer is firmly attached to the tube. Adjust it if necessary, then tighten the belt.
- Larger tubes may require more than one belt. Place the transducer downstream on the tube at the positioning distance indicated in the following figure with firm pressure of the hand, slowly move the transducer both in the direction of the upstream transducer and in the opposite direction to it and observe the signal strength. Engage the transducer at the point where the most powerful signal is observed. This signal must in any case be between 60 and 90. On certain tubes, a slight screwing of the transducer can increase the signal to the acceptable level.
- Fasten the transducer with a steel strap or other.



## 11.0 Installation of insertion sensors:

The new RIF600W insertion sensors combine the advantages of clamp-on and in-line sensors.

These translators can be installed directly in carbon steel pipes, while the use of special belts for installation is required for cast iron, fiberglass reinforced plastic, PVC and cement pipes.

Users in this situation will inform Riels Instruments of the exact outside diameter of the pipe-line, in order to avoid leakage.

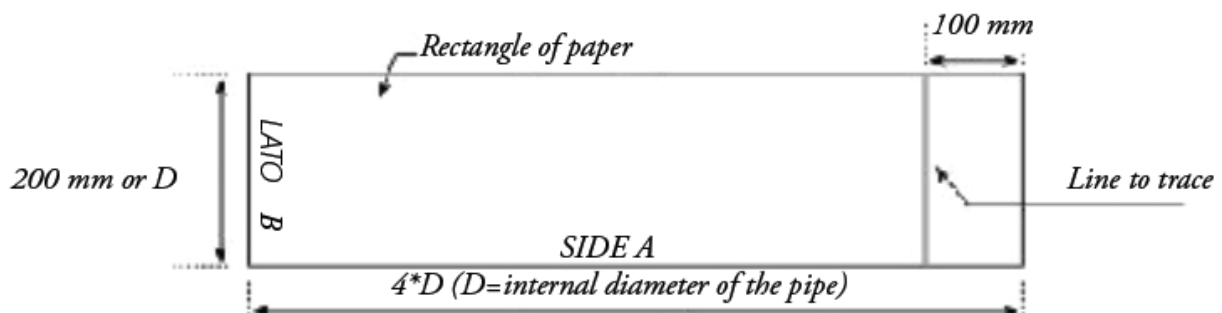
Sensor	Type B entry Direct insertion	Type B entry Cement version
Range	DN15÷DN100	DN50÷DN700
Installation spaces	≥ 550 mm	≥ 700 mm
Fluid temperature	-40°C÷160°C	-40°C÷160°C
Material	Stainless steel 316L	Stainless steel 316L

For the installation it is advisable to use a rotary drill of 400W (preferably high speed adjustable), a wrench and a screwdriver.

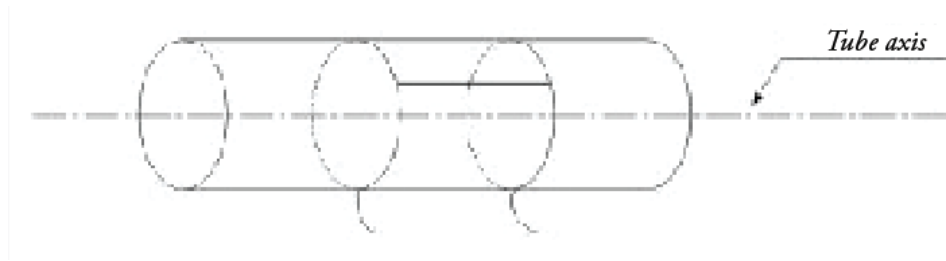
Insertion sensors can only be installed with the Z method and can be applied to all pipes with a diameter greater than DN80.

#### Proceed as follows:

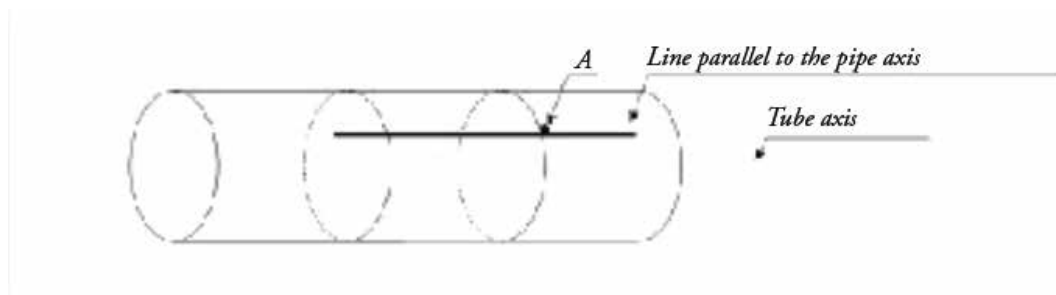
- Access menu 25 to display the installation spaces between the sensors. The spacing of the insertion transducers is calculated based on the distance between the centers of the two transducers along the pipe axis.
- Cut out a rectangle of paper / cardboard that has side A of length  $4 \cdot D$  ( $D$  is the internal diameter of the piping) and side B of 200mm length (or length  $D$ ). Once prepared the rectangle, draw a line parallel to the side B at a distance of 100mm.



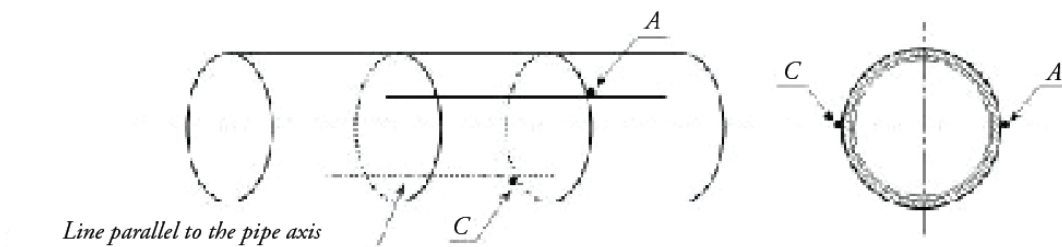
- Wrap the sheet created around the pipe, taking care to keep the line drawn parallel to the tube axis.



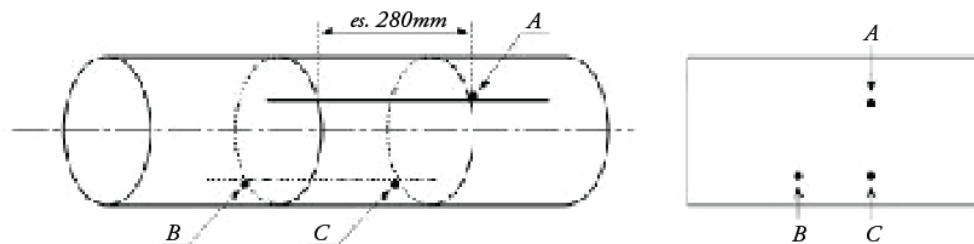
- Extend the drawn line identifying point A as in the following figure:



- Starting from A, cover the side of the sheet measuring half the circumference of the tube, thus identifying point C



- At this point, use the line parallel to the tube axis passing through point C to locate point B, which is the intersection with the side of the sheet of paper. Points A and B indicate the positions in which to install the sensors.





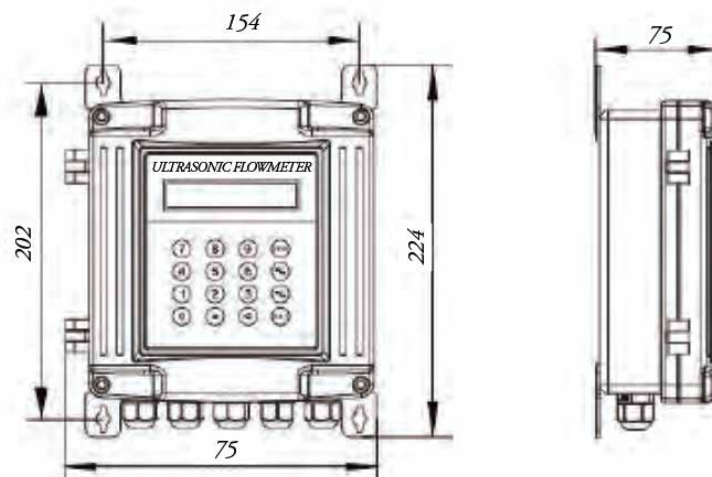
## 12.0 Transmitter installation:

After opening the package, it is advisable to keep the packaging material in case of storage or shipping to the factory.

Check that the carton and the equipment have not been damaged during shipment.

The device must be arranged to facilitate maintenance, calibration, and the screen view.

- Arrange the transmitter for the length of the cable supplied with the device. If this is not possible, it is recommended to exchange the supplied cable with a suitable one; cables up to 300 meters are available.
- Install the transmitter in a position where:
  - The oscillations are at a minimum,
  - Be protected from the release of corrosive liquids,
  - The temperature is from -40 to 131 °F [-40 to 55 °C],
  - Do not be exposed to sunlight, these could overheat the transmitter.
- Assembly: refer to the following diagram for details on device dimensions and assembly. Make sure there is enough space to allow door opening and access for maintenance and wiring. Fix the recess on a flat surface with four suitable bolts.
- Passage holes: The wiring centers are for the cables. Unused holes must be plugged.



### Warnings!

Use NEMA 4 qualified caps [IP65] to keep the recess intact.

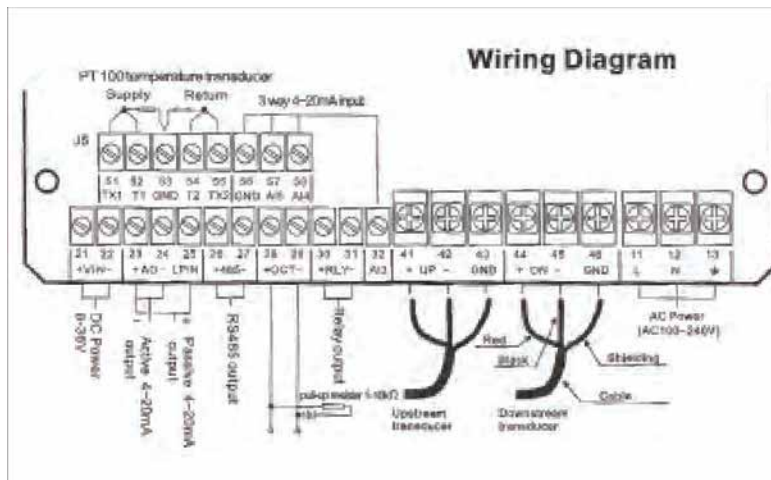
Generally the leftmost passage hole (seen from the front) is used for feeding; the central passage hole for the transducer connections and the rightmost port for the output wiring (OUTPUT).

- If you need to add holes, pierce them at the bottom of the sag. Be careful not to damage the wires or internal circuits of the device.

## 13.0 Cabling:

To access the terminals of the electronic connectors, loosen the two screws and open the door. Thread the transducer cables through the conduit hole at the bottom of the center of the sag.

The transmitter terminals are of the plug type, can be detached and hung up. Attach suitable cables to the corresponding terminals.



- “UP+ & GND-” it is used for the upstream transducer (red line),
- “DN+ & GND-” it is used for the downstream transducer (blue line).

Connect the power supply to the L, N and GND (mandatory) terminals of the transmitter.

DC power connection: the device can be used with a 12–36 VDC source able to supply at least 3W.

The transducer cable provides a low level of high frequency signals.

Generally, it is not advisable to extend the cable supplied for the transducers.

If this is necessary, contact Riels Instruments to request replacement of the cable with one of the desired length. In fact, cables of different lengths are available, up to 300 meters.

#### Warnings!

This instrument requires a noise-free power supply. Do not operate on circuits with interference components (for example, fluorescent lights, relay circuits, compressors, or with a variable frequency hard disk).

It is not recommended to use the same wiring for power and signal cables.

## 14.0 Final verification of the installation:

Is the device intact (visual inspection)? ☐

Does the meter comply with the measuring point specifications? ☐

- Process temperature
- Room temperature
- Measuring range
- Measured fluid

Are the measurement point identification and labeling correct (visual inspection)? ☐

Is the meter sufficiently protected against precipitation and direct solar radiation? ☐

Have the fixing screws been tightened with the correct tightening torque? ☐

## 15.0 Commissioning of the meter:







After making all the wiring and closing the meter door, it is sufficient to power the instrument to start it.

At this point it is possible to start programming.

In general, no error message should appear and the device menu number 01 will appear on the device, the most common, which displays speed, range, positive totalizer, signal strength and signal quality, the values of which are based on parameters entered first by the user or by the system itself.

### 15.1 Key functions

The RIF600W keyboard consists of 16 keys, of which 10 are numeric keys from 0 to 9 to enter parameters or menu numbers, while the keys for point, backward, enter, down/-, on/+ have specific functions, indicated in following table:

Button	Functions
 ENTER	Enter the edit mode of a menu, confirm the entered data.
 DOWN/-	Go to the previous menu, or as a subtraction key
 UP/+	To go to the next menu, or as an addition button
 MENU	Reach a specific menu. Press this key followed by the desired menu es. if you want to display the menu 11 press MENU+1+1
 POINT	Arithmetic point
 BACK	Go back, delete the character on the left.

- To activate/deactivate the typing beep function, use menu 77.
- The parameter settings entered and the measurements are displayed in more than 100 independent windows.
- The user can view the menu, the parameter setting windows, change the setting or view the results of the readings.

- These windows are indicated by 2-digit serial numbers from 00...95, and then from .9, etc.
- Each window number, so-called address code, has a well-defined function.
- For example, window M11 indicates the parameter entered for the outer diameter of the tube, while window M25 indicates the mounting distance between the transducers.
- To browse the menu, use the digit keys, press the MENU key to select the desired menu number, then press the ENTER key to access it.
- You can also scroll the menu windows with the UP/+ and DOWN/- keys.
- To exit a menu, press the BACK key.

**Example:**

- To enter the outer diameter of the tube, the procedure is as follows:
- Press MENU + 1 + 1 to choose M11 window.
- Then press the ENTER key.
- The symbol “\*” and the cursor are displayed on the left of the second line.
- The new digits can then be typed pressing the 0–9 and ENTER keys.

M 11  
Outer Diameter  
108 mm

M 11  
Outer Diameter  
108 mm  
> 218.6

**Example:**

- If the tube is made of stainless steel, press MENU + 1 + 4 keys to select the M14 window, then ENTER to change the option.
- Select “1. Stainless steel” and then press ENTER to confirm the change.

If this is not possible it means that the system is blocked by a password. To unlock it press “Unlock” in window M47 and enter the password. The keyboard does not respond if it is locked: it opens only with the original password. Select the keyboard lock functions in the M48 window. If necessary, contact Riels Instruments for a new password.

For normal measurements, the following parameters are entered:

- outer diameter of the tube
- tube thickness
- tube material
- coating material parameters (including sound thickness and speed if necessary)
- type of fluid
- type of transducer
- transducer mounting methods
- for “clamp-on” transducers, follow the transducer positioning distance displayed in M25 and keep the M91 digit around 97...103%.

---

## 16.0 List of menus:

---

- 00** Instant flow rate, net totalizer and operating status.  
PORT. 0.0000 m<sup>3</sup>/h \*R (R = system/regular operation)  
NET 0x1 m<sup>3</sup>
- 
- 01** Instant flow rate, flow rate and operating status.  
PORT. 0.0000 m<sup>3</sup>/h \*R (R = system/regular operation)  
VELOC 0.0000 m/s
- 
- 02** Instant flow rate, positive totaliser and operating status.  
PORT. 0.0000 m<sup>3</sup>/h \*R (R = system/regular operation)  
POS 0x1 m<sup>3</sup>
- 
- 03** Instant flow rate, negative totalizer and operating status.  
PORT. 0.0000 m<sup>3</sup>/h \*R (R = system/regular operation)  
NEG 0x1 m<sup>3</sup>
- 
- 04** Date (YY-MM-DD), time (HH: MM: SS), instantaneous flow rate and operating status.  
19-01-01 10:00:00 \*R (R = system/regular operation)  
PORT. 0.0000 m<sup>3</sup>/h
- 
- 05** Total energy, instant energy and operating status.  
EFR 0.0000 kW \*R (R = system/regular operation)  
E. T. 0E+0 kWh
- 
- 06** Temperature value T1 in °C, °F and temperature value T2 in °C, °F.  
T1 = xx.xx°C, xx.xx  
T2 = xx.xx°C, xx.xx
- 
- 07** View the AI3 and AI4 inputs.
- 
- 08** Operating error code and operating status.
- 
- 09** Total capacity of the day/month/year.
- 
- 10** Enter the value of the circumference of the pipe in mm.
-

---

**11** Enter the value of the external diameter of the pipe in mm.

---

**12** Enter the value of the pipe thickness in mm.

---

**13** Enter the value of the internal diameter of the pipe in mm.  
If the parameters have been set in the MENU windows 11, 12 the value is automatically calculated.

---

**14** Select the piping construction material.

- 0. Carbon steel
  - 1. Stainless Steel
  - 2. Cast iron
  - 3. Spheroidal cast iron
  - 4. Copper
  - 5. PVC
  - 6. Aluminum
  - 7. Asbestos
  - 8. Glass fiber
  - 9. Others
- 

**15** Enter the speed of sound transmission in the construction material of the pipe in m/s.  
MENU window visible only if you select "9. Other materials" in the MENU window 14.

---

**16** Select the inner lining of the pipe.

- 0. No coating.
  - 1. Tar Epoxy
  - 2. Rubber
  - 3. Mortar
  - 4. Polypropylene
  - 5. Polistirolo
  - 6. Polistirolo
  - 7. Polyester.
  - 8. Polyethylene
  - 9. Ebonite
  - 10. Teflon
  - 11. Others
-



- 17** Enter the speed of sound transmission in the construction material of the inner lining in m/s.

MENU window visible only if you select "11. Other materials" in the MENU window 16.

---

- 18** Enter the thickness value of the inner lining in mm.

MENU window visible only if you select "11. Other materials" in the MENU window 16.

---

- 19** Absolute degree of roughness of the inner lining of the pipe.

MENU window visible only if you select "11. Other materials" in the MENU window 16.

---

- 20** Select the type of liquid to be measured.

- 0. Water
  - 1. Sea water
  - 2. Kerosene
  - 3. Gasoline
  - 4. Fuel oil
  - 5. Raw oil
  - 6. Propane at -45 °C
  - 7. Butane at 0 °C
  - 8. Others\*
  - 9. Diesel oil
  - 10. Ricino oil
  - 11. Peanut oil
  - 12. #90 Benzine
  - 13. #93 Petrol
  - 14. Alcohol
  - 15. Hot water at 125 °C
- 

- 21** Enter the speed of sound transmission in the liquid to be measured in m/s.

MENU window visible only if you select "8. Other liquids" in the MENU window 20.

---

- 22** Enter the viscosity value of the liquid to be measured in cSt.

MENU window visible only if you select "8. Other liquids" in the MENU window 20.

---

- 23** Select the type of transducers used to make the measurement.

- 0. Standard-M
-

1. Type C listing
2. Standard-S
3. Customer sensor
4. Standard-B
5. Listing B (45)
6. Standard-L
7. JH-Polysonics
8. Standard-HS
9. Standard-HM
10. Standard-M1
11. Standard-S1
12. Standard-L1
13. Type-PI
14. Fuji FS410
15. FS510 of Fuji
16. Clamp-on TM-1
17. Inserts TC-1
18. Clamp-on TS-1
19. Clamp-on TS-2
20. Clamp-on TL-1
21. Inserts TLC-2
22. Clamp-on M2
23. Clamp-on L2

For the RIF600W clamp-on ultrasonic flowmeter, choose:

10. Standard-M1 for TM-1-HT sensors suitable for detecting pipes from DN50 to DN700
11. Standard-S1 for TS-1-HT sensors suitable for detecting pipes from DN15 to DN100
12. Standard-L1 for TL-1-HT sensors suitable for detecting pipes from DN300 to DN6000

---

**24** Select the transducer installation method.

0. Suitable V mounting on pipes from DN50 to DN700
1. Suitable Z mounting on pipes from DN300 to DN6000
3. W fitting suitable on pipes from DN15 to DN100

---

**25** Transducer mounting distance calculated automatically based on the parameters entered.

---

**26** Saving set parameters.

1. Save set parameters

---

**27** Save or load the set parameters.

Possibility to save the parameters set to multiple positions from 0 to 8, to then be loaded when needed.

Useful function if you use the meter to check the flow rate on many different pipes, to quickly recall the parameters set in a previous configuration.

---

**28** Warning weak signal.

SI is the default setting. If the weak signal warning appears, the instrument will show the previous survey.

---

**29** Enter the value for the empty tube function.

20 is the default setting.

Enter the value of the maximum capacity.

Select the unit of measurement.

0. METRIC is the default setting.

---

**30** Select the unit of measurement for the instantaneous flow rate.

0. Cubic meters (m<sup>3</sup>) per second (SEC.), per minute (MIN.), per hour (HOUR), per day (DAY)

1. Liters (l) per second (SEC.), per minute (MIN.), per hour (HOUR), per day (DAY)

2. US (Gal) gallons per second (SEC.), per minute (MIN.), per hour (HOUR), per day (DAY)

3. UK Gallons (IGL) per second (SEC.), per minute (MIN.), per hour (HOUR), per day (DAY)

4. Millions of US Gallons (Mg) per second (SEC.), per minute (MIN.), per hour (HOUR), per day (DAY)

5. Cubic feet (CF) per second (SEC.), per minute (MIN.), per hour (HOUR), per day (DAY)

---

- 6. US oil barrels (OB) per second (SEC.), per minute (MIN.), per hour (HOUR), per day (DAY)
  - 7. UK oil barrels (IB) per second (SEC.), per minute (MIN.), per hour (HOUR), per day (DAY)
- 

**31** Select the unit of measurement for the totalizer.

- 0. Cubic meters (m3)
  - 1. Liters (l)
  - 2. US Gallons (Gal)
  - 3. Galloni UK (IGL)
  - 4. Millions of US Gallons (Mg)
  - 5. Cubic feet (CF)
  - 6. US oil barrels (OB)
  - 7. UK oil barrels (IB)
- 

**32** Select the unit of measurement for the totalizer.

- 0. Cubic meters (m3)
  - 1. Liters (l)
  - 2. US Gallons (Gal)
  - 3. Galloni UK (IGL)
  - 4. Millions of US Gallons (Mg)
  - 5. Cubic feet (CF)
  - 6. US oil barrels (OB)
  - 7. UK oil barrels (IB)
- 

**33** Select the multiplier factor of the totalizer.

- 3. x1 is the default setting.
- 

**34** Turn on or off the net totalizer.

- 0. **OFF** is the default setting, for detections in a single direction
  - 1. **ON** for two-way surveys
- 

**35** Turn the positive totalizer on or off.

- 0. **OFF**
-

1. **ON** is the default setting

---

**36** Turn the negative totalizer on or off.

0. **OFF** is the default setting, for detections in a single direction

1. **ON** for two-way surveys

---

**37** Reset the instrument to the initial parameters.

Reset system: press the • and BACK

Take note of the previous parameters before restoring.

---

**38** Manual totalizer.

Press "ENTER" to start, "ENTER" to stop. It is used to measure flow, and for manual calibration and calculation.

---

**39** Choice of language.

Scherm. current.

255 is the default setting.

---

**40** Set the value for signal damping in seconds.

Flow compensation for stable detection.

The input range is from 0 to 999 seconds. The common setting value is between 1 and 10 seconds.

0 Sec = no compensation

10 Sec is the default setting

---

**41** Set the cutoff value for low flow rates in m/s.

Function used to avoid the increase of the totalizer, in the presence of vibrations or noises, or to cut the low flow rates not relevant to the total measurement. For example, if a value of 0.1 m/s is set, the instrument will not increase the accumulated total, until the flow velocity does not exceed the set value of 0.1 m/s.

---

**42** Setting the zero point.

With completely full piping and zero flow, the value of instantaneous flow detected must be equal to 0.

If a flow is detected, it will be necessary to start the zero point calibration procedure, only after having configured all the essential parameters for the measurement detection and having correctly installed the transducers.

---

**43** Delete the reference zero point value.

If you cancel, reset the zero point to the MENU window 42 again.

---

**44** Manual setting of the zero point.

It is preferable to use automatic sampling in the MENU window 42.

---

**45** Calibration factor.

Refer to the issued calibration certificate.

---

**46** Serial address for RS485 ModBus communication.

---

**47** Set the device lock password to avoid parameter changes by non-enabled users.

Unlock only with password.

If you forget to contact Riels Instruments.

---

**48** Enter the degree of non-linearity.

---

**49** Communication test.

---

**50** Data Logger setting.

---

**51** Set the exit time at the scheduled time.

---

---

START TIME = \*\*:\*\*:\*\* with the following configuration, obtainable by pressing the POINT key, the registration will be 24h/24h  
INTR. MEAS = HH:MM:SS set the sampling frequency

---

**52** Internal data recording management:

- 0. Internal serial bus on SD card
  - 1. Send data via ModBus RS485
- 

**53** Display of the AI5 input (if available).

---

**54** Setting OCT totalizer pulse output, interval: 6-1000 ms.

---

**55** Current loop mode.

---

**56** Selection of the data to be transmitted at the output in current 4mA/0mA.

---

**57** Selection of the data to be transmitted at the output in current 20mA.

---

**58** Check current output display.

---

**59** Indicates the presence of the current loop

---

**60** Set the device's date and time. Check again after installing updates.

---

**61** Device Version Information and Serial Number.

---

**62** Setting the serial port parameters.

---

**63** Choice of the communication protocol between MODBUS-RTU binary and MODBUS-ASCII.

---

**64** Analog Input AI3.

By entering the measurement range, the flowmeter will transform the current signal into the data range needed by the users, then display the corresponding analogue input corresponding to the physical parameter data.

---

- 
- 65** Analog Input AI4.  
By entering the measurement range, the flowmeter will transform the current signal into the data range needed by the users, then display the corresponding analogue input corresponding to the physical parameter data.
- 
- 66** Analog Input AI5.  
By entering the measurement range, the flowmeter will transform the current signal into the data range needed by the users, then display the corresponding analogue input corresponding to the physical parameter data.
- 
- 67** Sets the frequency range of the frequency output signal (default: 0-1000Hz, maximum range: 0-999 Hz).
- 
- 68** Minimum flow limit in frequency signal output.
- 
- 69** Maximum frequency output signal flow limit.
- 
- 70** LCD backlight option. "Always Log In", "Always Off", "Lighting for" option, enter a second digit, which indicates the backlight seconds.
- 
- 71** Contrast of the LCD.
- 
- 72** Chronograph indicating the activation time of the device.  
Can be reset using the ENTER key, and then YES. The instrument is calibrated and examined before being packaged so the chronograph is not reset.
- 
- 73** Activation of an alarm for minimum flow limit in frequency signal output.
- 
- 74** Activation of an alarm for maximum frequency signal output flow limit.
- 
- 77** Activate or deactivate the typing beep.
- 
- 78** OCT output settings.
- 
- 79** RLY relay output settings.
- 
- 80** Choose the input signal of the batch controller
-



---

**81** Batch controller

---

**82** Register of the net totalizer.

- Net of the day
  - Net of the month
  - Net of the year
- 

**83** Automatic correction. Automatic increase of the totalizer when it is switched off.

---

**84** Heat flow unit

- 0. Gja Joule (GJ)
  - 1. Kilocalorie (Kc)
  - 2. kWh
  - 3. BTU
- 

**85** Select origin of the temperature signal.

---

**86** Specific Heat selection

---

**87** Thermal Flow totalizer

---

**88** Thermal Flux multiplier

---

**89** Displays the difference in temperature and allows setting the temperature difference.

---

**8+** Installation options of temperature probes in the delivery or return pipe.

---

**90** Signal strength displayed. Signal quality,  
 IMPORTANT: when the transducers are installed, digit Q: at least  $\geq 60$   
 M90 Strength + Quality S=00.00, 00.0 Q=00

---

**91** Displays the time ratio between total transit time and calculated time. If the pipe parameters are correct and the transducers installed correctly, the ratio should be about  $100 \pm 3\%$ . Otherwise the transducer parameters must be checked.

---

---

**92** Displays the speed of the sound of the fluid. Normally this value must be more or less the same as in menu 21 when M20 is set to 'Other'. If this value is obviously different from that of the actual sound velocity, the tube parameters and the installation of the transducers must be checked again.  
If 'Other' is not selected in the M20, this window is not used.

---

**93** View total transit time.

---

**94** Shows the Reynolds number and the tube coefficient.

---

**95** Displays the negative and positive totaliser of thermal energy.

---

**+0** Displays the total flow rate and the number of switching on/off the device.

---

**+1** Displays the total operating time of the device.

---

**+2** Displays the time of the last shutdown.

---

**+3** Displays the flow rate measured at the time of the last shutdown.

---

**+4** Displays the total number of starts

---

**+5** Calculator.

---

**+6** Threshold value of the fluid speed.

---

**+7** Net current account month.

---

**+8** Current year net total.

---

**+9** Operating time including also the switch-off time.

---

**.+2** Store the static zero point.

---

**.+5** Sets the threshold value of the Q value.

---

**.+8** Maximum current flow rate for day and month.

---

- 
- .+9** Serial port test window, with CMM output.
- 
- 0** From here you enter the protected internal menus of the instrument, you need to enter the password to access the subsequent menus.
- 
- 1** 4-20mA output calibration
- 
- 2** Calibration of the 4mA value for the analog input AI3.
- 
- 3** Calibration of the 20mA value for the analog input AI3.
- 
- 4** Calibration of the 4mA value for the analog input AI4.
- 
- 5** Calibration of the 20mA value for the analog input AI4.
- 
- 6** Calibration of the 4mA value for the analog input AI5.
- 
- 7** Calibration of the 20mA value for the analog input AI5.
- 
- 8** Setup of the zero point of the temperature probes a for temperatures <40 °C.
-

## 17.0 Configuration of the outputs:

### 17.1 4-20mA output

Connect to the “+VDC” and “GND” terminals (the 4-20 mA output does not require an external power supply).

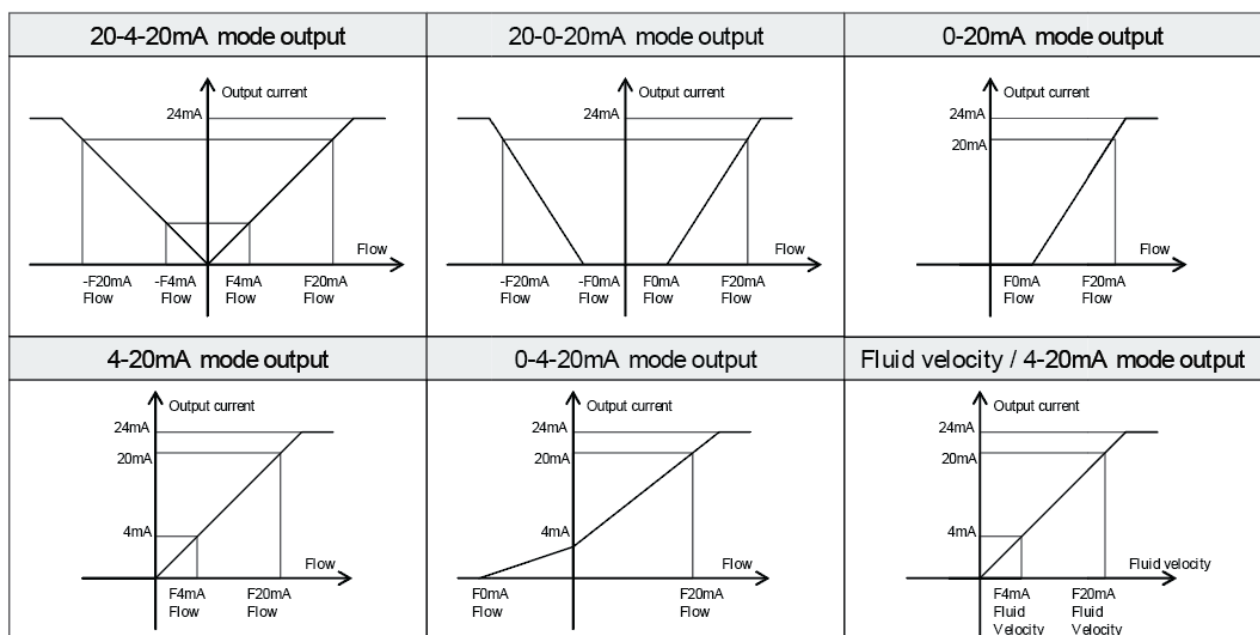
The reference names are: 5V, 5V+, 5V-.

With a motor source current of 18V, the ultrasonic flow meter RIF600W programmable with more outputs, for example 4-20 mA and 0-20 mA, selectable from menu 55.

CL Mode Select (55)

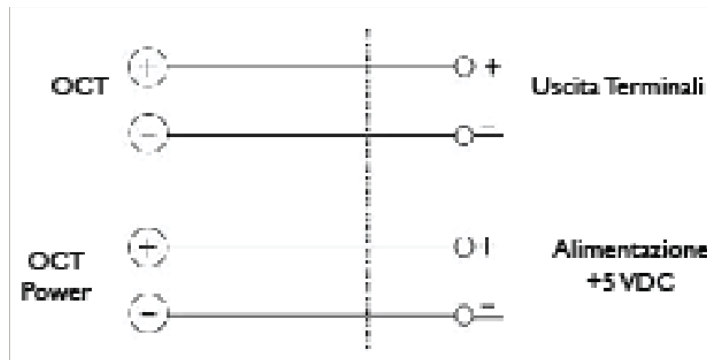
0. 4 - 20 mA

1. 4-20 mA sets the 4-20 mA output range.
2. 0-20 mA sets the output range from 0-20 mA.
3. 0-20mA via RS232 configured to send directly the data port.
4. 4-20mA sets CL output range from 4-20 mA.
5. 0-4.20mA sets CL output range from 0-20 mA.
6. 4-20mA sets CL output range from 4-20 mA.
7. 4-20 mA vs vel sets 4-20 mA output range corresponding to the flow rate.
8. 4-20 mA vs energy sets 4-20 mA output range corresponding to the thermal energy.



## 17.2 OCT pulse output

The output wiring as follows:



When the OCT output is low, the pulse output is used to connect external meters and DMI instruments through a frequency proportional to the flow rate of the device.

The pulse frequency output is approximately 0-5000 Hz. The displayed light follows the frequency output indicates the maximum and minimum detection.

The user can set both the frequency output and the desired flow rate. For example, if the scope of one pipe is about 0-2000 m<sup>3</sup>/h, the required frequency output is 20-1000 Hz and the configuration is as follows in the M75 window set TO: 0-2000; then frequency output is between 0-1000; and the K value set accordingly.

When the frequency output is between 0-5000 Hz. When the OCT output is low, the pulse output is used to connect external meters and DMI instruments through a frequency proportional.

When the OCT output is used, the total positive flow, total negative flow, instantaneous flow and net increment can be shown in the Menu.

Each time the totalizer increases according to the digit entered in the Map, the OCT "+" will make a pulse.

## 17.3 Relay output

Connect to the RLY "+" terminals the relay generates a contact open/close to give an alarm.

The relay is capable of 125VAC/30VDC 0.5A.

Relay type: normal open.

Switch time max. 20 ms.

contact resistance: 0.1 ohms, PC.

terminal insulation resistance: 1000 Mohms.

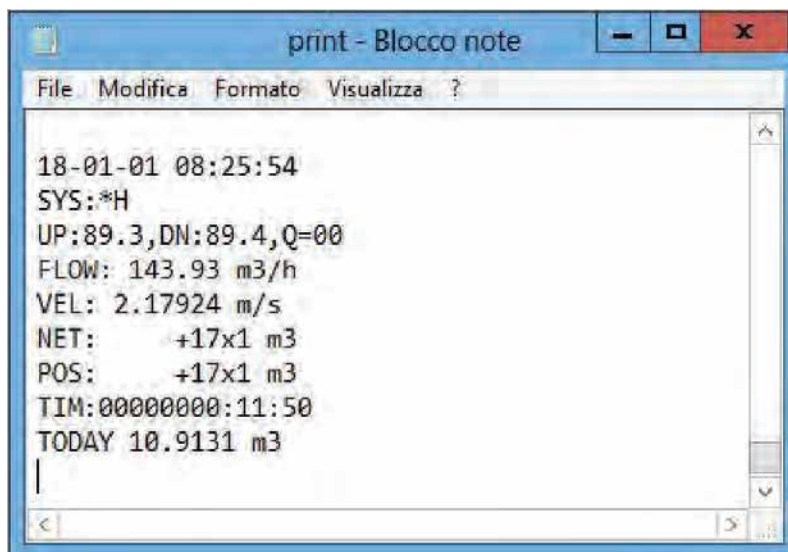
When switched off, the "RLY" "+" output is normally in the open state.

## 18.0 Reading of recorded data:

RIF600W creates a file of type .txt containing up to 2000 records inside the SD card. Once the 2000 limit is reached a new file will be created.

To read the binary or encoded files:

- Remove the SD card from the meter.
- Insert the SD card into the card reader supplied with the meter.
- Insert the card reader into the USB port on your PC.
- If the card reader does not open automatically, look for it in “my computer”. The device will be named “removable disk”.
- Open the file (called “print”) to read and process the data if possible with the file in text editor.



Example of data logging

## 19.0 Troubleshooting:

### 19.1 Error handling

The RIF600W ultrasonic flowmeter has advanced self-diagnosis functions and makes every error in the upper right part of the LCD through predefined codes, in order of date/-time. Device diagnostics are usually performed on each boot and some errors are detected during normal operation. The undetectable errors due to incorrect settings or incorrect parameters are displayed in the same way. This function detects errors and quickly determines their causes, so that problems can be solved according to the solutions listed in the following tables.

The errors displayed in the RIF600W are divided into two categories:

- Errors during self-diagnosis at startup. You can display “\* E” at the top left of the screen after setting the measurement mode. When this happens, you need to restart for a new self-diagnosis. If the problem persists, contact Riels Instruments.
- Errors caused by incorrect settings and during operation, displayed in Window M08.

### 19.2 Self diagnosis and troubleshooting (on startup)

LCD display	Cause	Solution
ROM Parity Error	System ROM invalid/error	Contact Riels Instruments
Stored Data Error	Error of a data set	Restart or contact Riels Instruments
SCPU Fatal Error	SCPU Circuit Error	Restart or contact Riels Instruments
Timer Slow Error / Timer Fast Error	Chronograph error	Contact Riels Instruments
CPU or IRQ Error	CPU or IRQ problem	Restart
System RAM Error	System RAM lock	Restart or contact Riels Instruments
Time or Bat Error	System date and time error	Restart or contact Riels Instruments
No display, wrong operation	Wrong wiring	Check the wiring
Keyboard is not responding	Locked keyboard or incorrect plug connection	Enter Password if the keyboard is locked

### 19.3 Self diagnosis and troubleshooting (on startup)

Error code	Cause	Solution
* R	Normal System	No Errors
* J	Device defect	Contact the factory
* I	<ol style="list-style-type: none"> <li>Signal not detected.</li> <li>Incorrect placement of the transducers or there is not enough coupling paste between the transducer connectors.</li> <li>Transducers not installed correctly.</li> <li>Too thick plate.</li> <li>New coating.</li> </ol>	<ol style="list-style-type: none"> <li>Remove any rust, plaque or paint from the surface of the pipe and smooth it.</li> <li>Apply the dough generously to the outside of the tube</li> <li>Position and tighten the transducers well to the tube.</li> <li>Check the initial parameter settings.</li> <li>Normally, it is possible to change location. The instrument could work better in another place with less plaque and rust.</li> </ol>
* H	Low Signal Power	See the solutions above.
* H	Low Signal Quality	Solutions listed in previous boxes.
* E	<ol style="list-style-type: none"> <li>4-20mA current above 120%.</li> <li>Wrong settings on the current circuit</li> </ol>	<ol style="list-style-type: none"> <li>Check settings (M56)</li> <li>Confirm if actual flow is too high</li> </ol>
* Q	<ol style="list-style-type: none"> <li>Frequency output above 120%</li> <li>Wrong settings or Actual flow too high.</li> </ol>	Check settings (M67-M69) and confirm whether the actual frequency is too high
* F	<ol style="list-style-type: none"> <li>Error during start-up</li> <li>Permanent error</li> </ol>	Restart If problems persist, contact the factory.



## 19.4 Common questions and answers

No	Question	Answer
1	New pipe, high quality material, all parameters installed correctly. Why is no signal detected?	<ol style="list-style-type: none"> <li>1. Check the setting of the tube parameters, installation method and wiring connections.</li> <li>2. Make sure that the coupling paste is well applied, that the tube is filled with liquid, that the spacing of the transducers is as in M25 and that the orientation is correct.</li> </ol>
2	Old tube with a lot of plaque inside, no signal detected or weak signal. How to solve?	<ol style="list-style-type: none"> <li>1. Check that the tube is filled with liquid.</li> <li>2. Try installing the Z method.</li> <li>3. Carefully shave a section of the tube and clean it well, apply a large strip of paste on each surface of the transducers (at the bottom) and install well. Slowly move both transducers into the direction of the other and the installation point so that the maximum signal is taken.</li> <li>4. Make sure that the inside of the tube is smooth in the new positioning point and that the pipe is not distorted so that the sound waves do not bounce outside the chosen area.</li> <li>5. For thick plate inside or outside, clean the plate if possible.</li> </ol> <p><b>Note:</b> This method may not work and wave transmission may not be possible due to the plate layer between the transducers and the tube wall.</p>
3	Why is the CL output wrong?	<ol style="list-style-type: none"> <li>1. Check that the required current output mode is set in the M55 Window.</li> <li>2. Check whether the minimum and maximum current numbers are set appropriately in the M56 and M57 windows.</li> <li>3. Recalibrate CL and check in the M58 window.</li> </ol>
4	Why is the flow rate 0 when there is fluid in the tube and the "R" symbol is displayed?	<ol style="list-style-type: none"> <li>1. Check if "Set Zero" has been performed while the liquid flows into the pipe (refer to Window M42).</li> <li>2. If this has been ascertained, restore the default in the M43 window.</li> <li>3. Make sure that the number in M41 is lower than the actual range.</li> </ol>

No	Question	Answer
5	In an inadequate environment with an unstable power supply, can the instrument run 24/7 and last for years?	<ol style="list-style-type: none"> <li>1. The RIF600W is designed to be reliable even under such conditions.</li> <li>2. It automatically changes the signals through an intelligent internal circuit.</li> <li>3. It holds under strong interference conditions and can adapt to strong or weak waves.</li> <li>4. It also works with a wide voltage range: 90–240 VAC or 9–28 VDC.</li> </ol> <p>In any case, contact Riels Instruments for assessments regarding the conditions of use of the instrument.</p>
6	Why do you get an unstable or incorrect detection even when there is no liquid or flow inside the tube?	<p>There must be some liquid inside the tube; if not, in Window M29, set EMPTY PIPE VALUE to a level lower than the normal figure of Q (liquid filled tube), the device will make a detection of ZERO.</p>

## 20.0 Appendix I: characteristics of fluids

### 20.1 Fluid properties

FLUID	DENSITY kg/m <sup>3</sup>	SOUND SPEED		DELTA-V/DEGREE °C	KINEMATIC VISCOSITY	ABSOLUTE VISCOSITY
	20°C	m/s	ft/s	m/s/°C	mm <sup>2</sup> /s	
Butyl acetate	–	1270	4163.9	–	–	–
Ethyl acetate	901	1085	3559.7	-4.4	0.489	0.441
Methyl acetate	934	1211	3973.1	–	0.407	0.380
n-Propyl acetate	–	1280	4196.7	–	–	–
Acetone	790	1174	3851.7	-4.5	0.399	0.316
Alcohol	790	1207	3960.0	-4.0	1.396	1.101
Alcohol, butyl	830	1270	4163.9	-3.3	3.239	2.688
Ethyl alcohol	830	1180	3868.9	-4.0	1.396	1.159
Alcohol, methyl	791	1120	3672.1	-2.92	0.695	0.550
Alcohol, propyl	–	1170	3836.1	–	–	–
Alcohol, propyl	780	1222	4009.2	–	2.549	1.988
Ammonia	770	1729	5672.6	-6.7	0.292	0.225
Anillina	1020	1639	5377.3	4.0	3.630	3.710
Petrol	880	1330	4363.5	4.7	0.711	0.625
Benzene, ethyl	867	1338	4389.8	–	0.797	0.691
Bromine	2930	889	2916.7	-3.0	0.323	0.946
n-Butane	600	1085	3559.7	-5.8	–	–
Butirrato, etil	–	1170	3836.1	–	–	–
Carbon dioxide	1100	839	2752.6	-7.7	0.137	0.151
Carbon tetrachloride	1600	926	3038.1	-2.5	0.607	0.968
Chlorobenzene	1110	1273	4176.5	-3.6	0.722	0.799
Chloroform	1490	979	3211.9	-3.4	0.550	0.819
Ethic ether	710	985	3231.6	-4.9	0.311	0.222
Diethyl ketone	–	1310	4295.1	–	–	–
Dietilenglicole	1120	1586	5203.4	-2.4	–	–
Ethanol	790	1207	3960.0	-4.0	1.390	1.097
Ethyl alcohol	790	1207	3960.0	-4.0	1.396	1.101
Ether	710	985	3231.6	-4.9	0.311	0.222
Ethic ether	710	985	3231.6	-4.9	0.311	0.222
Ethylene glycol	1110	1658	5439.6	-2.1	17.208	19.153
Freon R12	–	774.2	2540	–	–	–
Diesel	700	1250	4098.4	–	–	–

FLUID	DENSITY kg/m <sup>3</sup>	SOUND SPEED		DELTA-V/DEGREE °C	KINEMATIC VISCOSITY	ABSOLUTE VISCOSITY
	20°C	m/s	ft/s	m/s/°C	mm <sup>2</sup> /s	
Glycerine	1260	1904	6246.7	-2.2	757.100	953.946
Glycol	1110	1658	5439.6	-2.1	–	–
Isobutanol	810	1212	3976.4	–	–	–
Iso-butane	–	1219.8	4002	–	–	–
Isopentane	620	980	3215.2	-4.8	0.340	0.211
Isopropanol	790	1170	3838.6	–	2.718	2.134
Isopropyl alcohol	790	1170	3838.6	–	2.718	2.134
Kerosene	810	1324	4343.8	-3.6	–	–
Linalool	1400	1400	4590.2	–	–	–
Linseed oil	925–939	1770	5803.3	–	–	–
Methanol	790	1076	3530.2	-2.92	0.695	0.550
Methylene alcohol	790	1076	3530.2	-2.92	0.695	0.550
Methylene chloride	1330	1070	3510.5	-3.94	0.310	0.411
Methylethyl alcohol	–	1210	3967.2	–	–	–
Engine oil (SAE 20/30)	880–935	1487	4875.4	–	–	–
Octane	700	1172	3845.1	-4.14	0.730	0.513
Oil	970	1477	4845.8	-3.6	0.670	0.649
Castor oil	800	1250	4101	–	–	–
Diesel	–	1530	5019.9	–	–	–
Oil (lubricant X200)	910	1431	4694.9	-2.75	100.000	91.200
Olive oil	940	1458	4783.5	–	–	–
Pneumatic oil	–	1420	4655.7	–	–	–
Pentane	626	1020	3346.5	–	0.363	0.227
Petroleum	876	1290	4229.5	–	–	–
1-Propanol	780	1222	4009.2	–	–	–
Refrigerant 11	1490	828.3	2717.5	-3.56	–	–
Refrigerant 12	1520	774.1	2539.7	-4.24	–	–
Refrigerant 14	1750	875.24	2871.5	-6.61	–	–
Refrigerant 21	1430	891	2923.2	-3.97	–	–
Refrigerant 22	1490	893.9	2932.7	-4.79	–	–
Refrigerant 113	1560	783.7	2571.2	-3.44	–	–
Refrigerant 114	1460	665.3	2182.7	-3.73	–	–
Refrigerant 115	–	656.4	2153.5	-4.42	–	–
Refrigerant C318	1620	574	1883.2	-3.88	–	–
Silicone (30cp)	990	990	3248	–	30.000	29.790
Methylbenzene	870	1328	4357	-4.27	0.644	0.558
Transformer oil	–	1390	4557.4	–	–	–

FLUID	DENSITY kg/m <sup>3</sup>	SOUND SPEED		DELTA-V/DEGREE °C	KINEMATIC VISCOSITY	ABSOLUTE VISCOSITY
	20°C	m/s	ft/s	m/s/°C	mm <sup>2</sup> /s	
Trichlorethylene	1050	1050	3442.6	–	–	–
1,1,1-Trichloro-Ethane	1330	985	3231.6	–	0.902	1.200
Turpentine	880	1255	4117.5	–	1.400	1.232
Distilled water	996	1498	4914.7	-2.4	1.000	0.996
Heavy water	1000	1400	4593	–	–	–
Sea water	1025	1531	5023	-2.4	1.000	1.025
Wood alcohol	791	1076	3530.2	-2.92	0.695	0.550
m-Xylene	868	1343	4406.2	–	0.749	0.650
o-Xylene	897	1331.5	4368.4	-4.1	0.903	0.810
p-Xylene	–	1334	4376.8	–	0.662	–

## 20.2 Sound speed of water

Temperature °C	Sound speed m/s	Temperature °C	Sound speed m/s	Temperature °C	Sound speed m/s
0	1402.3	34	1515.7	68	1554.3
1	1407.3	35	1519.7	69	1554.5
2	1412.2	36	1521.7	70	1554.7
3	1416.9	37	1523.5	71	1554.9
4	1421.6	38	1525.3	72	1555.0
5	1426.1	39	1527.1	73	1555.0
6	1430.5	40	1528.8	74	1555.1
7	1434.8	41	1530.4	75	1555.1
8	1439.1	42	1532.0	76	1555.0
9	1443.2	43	1533.5	77	1554.9
10	1447.2	44	1534.9	78	1554.8
11	1451.1	45	1536.3	79	1554.6
12	1454.9	46	1537.7	80	1554.4
13	1458.7	47	1538.9	81	1554.2
14	1462.3	48	1540.2	82	1553.9
15	1465.8	49	1541.3	83	1553.6
16	1469.3	50	1542.5	84	1553.2
17	1472.7	51	1543.5	85	1552.8
18	1476.0	52	1544.6	86	1552.4
19	1479.1	53	1545.5	87	1552.0
20	1482.3	54	1546.4	88	1551.5
21	1485.3	55	1547.3	89	1551.0
22	1488.2	56	1548.1	90	1550.4
23	1491.1	57	1548.9	91	1549.8
24	1493.9	58	1549.6	92	1549.2
25	1496.6	59	1550.3	93	1548.5
26	1499.2	60	1550.9	94	1547.5
27	1501.8	61	1551.5	95	1547.1
28	1504.3	62	1552.0	96	1546.3
29	1506.7	63	1552.5	97	1545.6
30	1509.0	64	1553.0	98	1544.7
31	1511.3	65	1553.4	99	1543.9
32	1513.5	66	1553.7		
33	1515.7	67	1554.0		

### 20.3 Speed of sound by type of pipe material

Tube material	Sound speed m/s	Coating	Sound speed m/s
Steel	3206	Teflon	1225
ABS	2286	Titanio	3150
Aluminum	9048	Cemento	4190
Brass	2270	Catrame Epossidico	2540
Iron	2460	Porcellana	2540
Bronze	2270	Vetro	5970
Fiber glass	3430	Plastica	2280
Glass	3276	Polietileno	1600
Polyethylene	1950	PTFE	1450
PVC	2540	Gomma	1600

