

On-line Process Refractometer



ESSENTIAL INSTRUCTIONS

READ THIS PAGE BEFORE PROCEEDING!

Rosemount Analytical designs, manufactures, and tests its products to meet many national and international standards. Because these instruments are sophisticated technical products, you must properly install, use, and maintain them to ensure they continue to operate within their normal specifications. The following instructions must be adhered to and integrated into your safety program when installing, using, and maintaining Rosemount Analytical products. Failure to follow the proper instructions may cause any one of the following situations to occur: Loss of life; personal injury; property damage; damage to this instrument; and warranty invalidation.

- Read all instructions prior to installing, operating, and servicing the product. If this Instruction Manual is not the correct manual, telephone 1-800-654-7768 and the requested manual will be provided. Save this Instruction Manual for future reference.
- If you do not understand any of the instructions, contact your Rosemount representative for clarification.
- Follow all warnings, cautions, and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation, and maintenance of the product.
- Install your equipment as specified in the Installation Instructions of the appropriate Instruction Manual and per applicable local and national codes. Connect all products to the proper electrical and pressure sources.
- To ensure proper performance, use qualified personnel to install, operate, update, program, and maintain the product.
- When replacement parts are required, ensure that qualified people use replacement parts specified by Rosemount. Unauthorized parts and procedures can affect the product's performance and place the safe operation of your process at risk. Look alike substitutions may result in fire, electrical hazards, or improper operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified persons, to prevent electrical shock and personal injury.

Emerson Process Management

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MODEL REFRAC A1 ON-LINE PROCESS REFRACTOMETER

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MODEL REFRAC A1 ON-LINE PROCESS REFRACTOMETER

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SECTION 1.0

DESCRIPTION AND SPECIFICATIONS

- ONLINE REFRACTIVE INDEX OR BRIX measurement to monitor and control the concentration of dissolved solids or water soluble liquids in your process.
- LOW COST OF OWNERSHIP. One sensing head with integral electronics can be used to cover your entire measuring range from 1.33-1.53 RI (0-95 Brix).
- RELIABLE MEASURING HEADS featuring a sapphire, YAG prism, CIP capability, and photo diode array for resolution down to 0.0001 RI (.1 Brix).
- REAL TIME PROCESS CONTROL with digital, RS232 or RS485, and dual analog outputs, two alarms, and diagnostic/temperature correction.
- NO CALIBRATION REQUIRED.

1.1 FEATURES AND BENEFITS

Continuous, light-protected, drift-free measurement for tighter process control. The process refractometer continuously measures the refractive index (RI), and, thus, the concentration, of a binary or quasi-binary liquid mixture. This is an automatic, absolute measurement of the critical angle. It is independent of light intensity from the light emitting diode (LED) and is free of signal drift, granting critical precision and greater process control.

Measurement is not affected by color, turbidity, clouding, suspended solids, or flow rate.

Construction and materials minimize service and maximize reliability. The 316L SST sensing head features a sapphire or YAG prism which is both chemically and mechanically resistant to acids, slurries, and etchants. For processes where 316L is not appropriate (such as HCl), a teflon flow-through adapter is available to enable the refractometer to be applied to almost all processes. The Model Refrac A1 is compatible with both air and water cooling.

Super-sensitive light detector and temperature compensation boost resolution and accuracy. Reflected light is detected with a charged couple device (CCD) with 2048 elements, which allows for precise detection of the light/dark border region used to determine the RI of the solution. Three temperature-measuring elements are embedded in the sensor head and are used to compensate the RI measurement and convert the measurement to a scaled measurement such as Brix.

Versatile, unique design. The sensing head includes integral electronics that provides 0.1 BRIX resolution over the full 0-95 BRIX range. The signal from the measuring head is analyzed and processed by the electronics to provide both 4-20mA analog outputs and a digital output for recorders, printers, programmable logic controllers (PLC), and distributed control systems (DCS). The output can also be used for remote communication links and limit comparators for alarms, valves, and pumps. The 4-20mA signal and the measuring equation's slope and offset can be calibrated for specific applications.

THEORY OF OPERATION

Refractometer measurements are based on the physical properties of bent (refracted) light. When incident light is refracted from an optically thicker medium into a thinner one, the angle of refraction is determined by the refractive index. Comparison of the refractive indices of both mediums reveals the concentration of dissolved solids in the liquid, expressed as RI (Refractive Index). RI is used to correlate to the concentration of quasi or quasi-binary solutions such as HCl + H₂O and H₂O₂ + H₂O.

LIGHT PATH

The glass fiber transmits light from an LED into one side of the sapphire prism (see Figure 1). This is reflected through the sample to the other side of the prism, through a filter to the CCD array where the position of the incident light is determined. This angle depends on the amount of dissolved solids in the sample.

CONFIGURATION

The Model Refrac A1 can be used as a factory-configured simple RI (or BRIX) transmitter for simple applications where a single online parameter is desired. However, it also includes a powerful Windows-based configuration program that can be used when more data is needed. This program allows the user to do the following:

- Set 4 and 20 mA output values
- Calibrate and automatically clean the head
- Configure special as needed for applications
- Customize temperature compensation
- Test outputs and switches
- And much, much more

1.2 SPECIFICATIONS

REFRAC A1 STREAM VARIABLES:

Measuring Ranges: BRIX: 0-95, RI: 1.33-1.53

Resolution: 0.1 BRIX, 0.0001 RI

Pressure: 145 psig

Temperature: up to 120°C with water cooling. Compatible with both air and water cooling.

Current Outputs: two (2) galvanically isolated 4-20 mA outputs

Alarm Relays: Two open collector; max. 30V, 100mA

PHYSICAL CONFIGURATION:

Power Supply: 100-240 VAC; 47-63 Hz

Power Consumption: 0.11A

Wetted Part: Sapphire, optional 316L SST or Teflon

Cable: 15 ft (5 m) standard, other lengths available on request

Insertion/Mounting: Standard 2.5 in. triclamp

Flow-Through: Teflon tee with ¼ in. NPT connection (optional)

Environment: NEMA 4X (IP65)

1.3 ORDERING INFORMATION

Model Refrac A1 measures BRIX and Refractive Index (RI) over the wide range of 0 - 95 BRIX (1.33 - 1.53 RI). The Refrac A1 features electronics integral to the sensing head to ease installation requirements and is compatible with both air and water cooling to meet your temperature requirements up to 120°C. The Refrac A1 includes a switching power supply for use in 100-240 VAC power. Configuration of the refractometer is performed via RS232 or RS485 communication to a PC.

MODEL	DESCRIPTION
Refrac A1	All-in-one refractometer with electronics integral to sensing head
CODE	MOUNTING (Required Selection)
01	316L SST 2-1/2 inch Triclamp

1.4 ACCESSORIES AND SPARE PARTS

PN	DESCRIPTION
9200292	5 meter, IP 67 Cable with connector for power supply, analog output or RS 232
9200293	2 meter, RS 232 Cable with 9 pol D-sub-connector to PC

The Refrac A1 can be equipped with special scales according individual needs and allows the user to set-up the instrument for his specific measurement needs. The Software is based on Windows, allowing the instrument to perform perfectly with a PC connected. All this results in a modern process refractometer fitting perfectly in the line of highly sophisticated process control and computer controlled data acquisition.

SECTION 2.0

GENERAL OVERVIEW

2.1 WHAT IS REFRACTOMETRY?

Refractometry is the measurement of refractive index and its interpretation under different conditions. Refractometric measurements can be used to determine purity, identify specific samples or determine composition. It is also used for characterization of various substances, especially organic liquids.

One important area of application is in food analysis. Refractive index is an excellent way to determine sugar content. Certain oils and fats are also easily measured. Beer and other alcoholic beverages can also be measured by refractometry, though it is important to analyze the results knowing that both alcohol and sugars will contribute to the refractive index. Some liquid chromatography columns also rely on the refractometric measurement, providing quality control for process optimization. The process refractometer Refrac A1 is an automatic critical angle refractometer.

2.2 SHORT INTRODUCTION TO THE THEORY

Refraction of light is caused by differences in the speed of light as it passes through different media. As light crosses an interface between dissimilar materials, it will change direction (i.e. bend) somewhat depending on the speed difference. This bending phenomenon is called "refraction". Refractometry is the method that uses refractive index measurement for determining substance properties. The Refractive index n_{12} for light going from Medium 1 into Medium 2 is exactly equal to the ratio of speed of light in these two media:

$$n_{12} = c_1 / c_2$$

c_1 = speed of light in Medium 1

c_2 = speed of light in Medium 2

The refractive index is also dependent on the wavelength of light. It is in general higher for blue light than for red wavelength. This behavior is called "dispersion". That is why a complete measurement of the refractive index must include the wavelength. Normally refractive index is given for the yellow line of sodium (D-Line), which corresponds to a wavelength of 589.3 nm.

When light is incident on an interface between a high refractive index material and a lower refractive media, some light will pass through at a refracted angle and some will be reflected (and not pass through the interface). The amount of light reflected and the refracted angle are determined by the refractive index and the incident angle. Further increase of the incident angle results in a totally reflected beam where the surface behaves as a perfect mirror. If one now brings a third medium onto this totally reflecting prism surface, then for some incident angles the total reflection will be disturbed and light can escape into the third medium, which normally is a liquid. Using the total internal reflection technique, a very sharp borderline in the reflected light is produced. The position of this borderline can be easily detected by the CCD and is used in the electronics to determine the refractive index. An increase in the sample refractive index will result in a movement of the borderline, which is interpreted by the calibrated electronics as a specific quantity of refractive index.

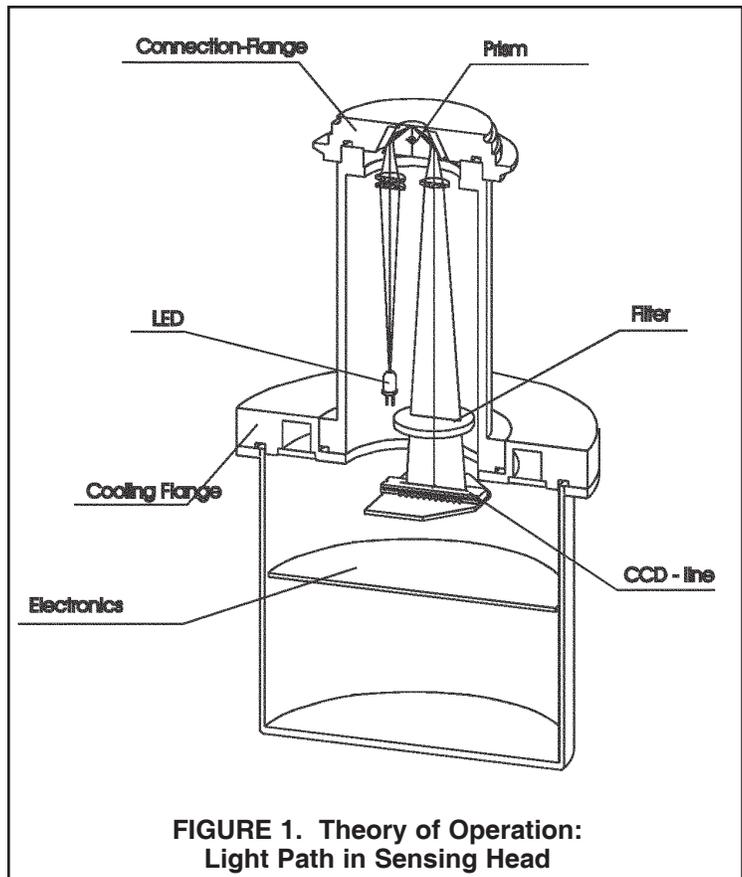
Theory and experiment show that even in the case of total internal reflection, the light enters a small distance into the second medium (about $\frac{1}{2}$ wavelength) and returns back again. This means that only a very thin layer of the sample will actually be measured. This is important to know, because in process refractometry the liquid must have intimate contact with a clean prism since even the slightest dirt or crust on it would immediately lead to erroneous readings. To prevent the effects of coating, Emerson Process Management offers two different cleaning accessories, one for use in a tee (or cross) and another for insertion in a tank. Cleaning can be achieved using water, steam, dilute acid, or a mixture for optimum operation. Ask Emerson Process Management for details about these accessory products.

2.3 HOW DOES THE REFRAC A1 WORK?

Light from a superluminescent LED (wavelength 589 nm) passes through a lens and onto the back surface of the measurement prism. The light is bent and focussed on the front surface. After being totally reflected the light passes out of the prism and is projected towards the CCD line array.

Light will normally be totally reflected at the interface prism-air interface because the incident angles are larger than the critical angle for total reflection. When the measurement surface is in contact with the sample, some of the incident angles will no longer be internally reflected and light will pass into the liquid and no longer measured by the CCD. This will cause a sharp border in the light distribution on the 2048 element CCD line. The position of this border is translated into a refractive index by calibrated onboard electronics. The electronics are also capable of calculating a Brix value for sugar processing or customers who desire a standard industrial scale. Custom scales can also be calibrated, if needed.

Temperature effects on the LED, CCD and Prism are automatically compensated for. The refractive index measurement will be extremely stable since the Refrac A1 has no moving parts. In addition, the Refrac A1 is unlikely to be damaged by mechanical wear or other external stress.



SECTION 3.0 INSTALLATION

3.1 INSTALLATION OF MEASURING HEAD

For direct and continuous in-line measurement, the measuring head must be installed in a suitable position. The Refrac A1 measuring head is contained in a 2½" triclamp. Mating flanges and outer clamp are not included. The triclamp can be mounted on the side of a tank, in a tee, or in a cross. Insert the measuring head in the mating flange without the use of force. Tighten the surrounding clamp around the connection flange and o-ring.

⚠ CAUTION

Danger when leakage of hot or aggressive materials!
At sample temperature of >60°C or environmental temperature of ≥45°C, a water-cooled measuring head must be used!

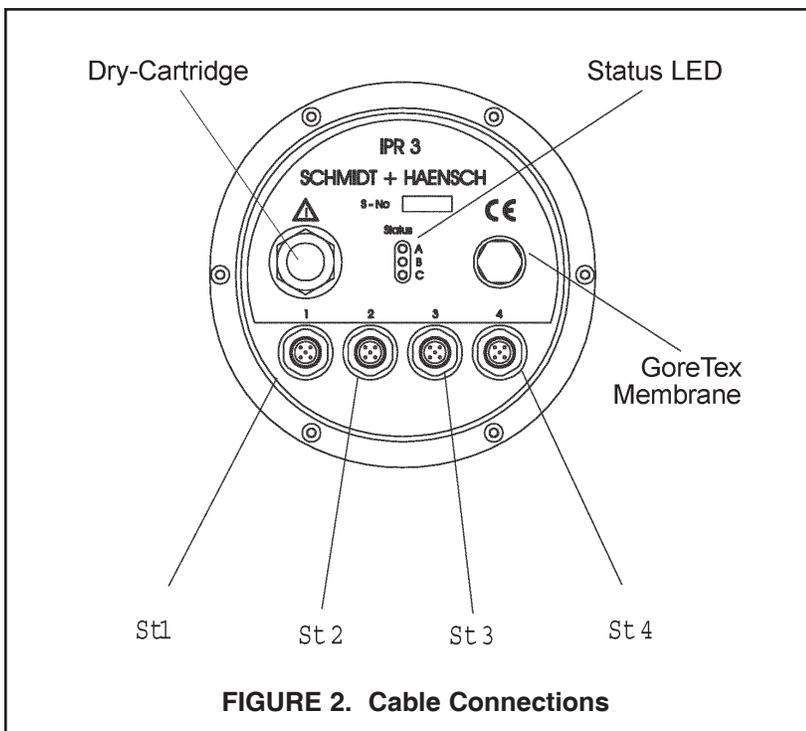
After the process has started, check the assembly for leaks as temperature can affect the seal.

3.2 CABLE CONNECTIONS

The Refrac A1 includes sockets for up to four plugs (see Figure 2). Four plugs are supplied with the Refrac A1, though some may not be required for your application. Five conductor cable is used. See Section 4.1 for detailed listing of the connector leads.

Power is applied to the measuring head at St4. Use the 24 volt power supply that comes with the Refrac A1. Connect the Adapter cables to the power supply and the St4 socket. The Status LED should light up. This socket is also used for relay outputs, if desired (see Figure 7).

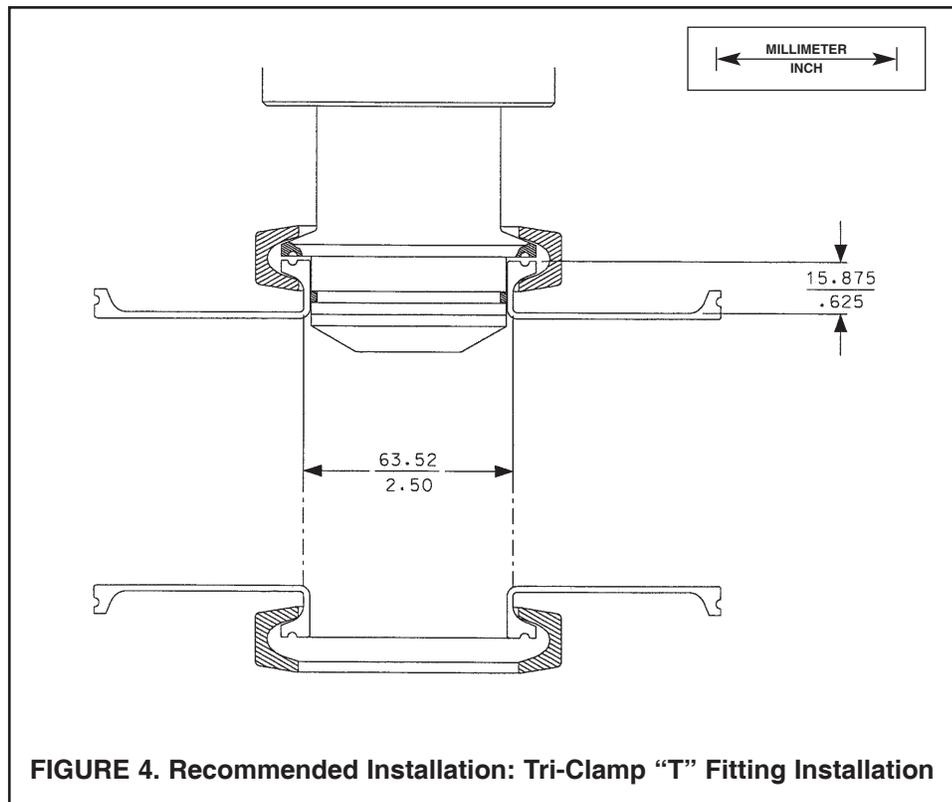
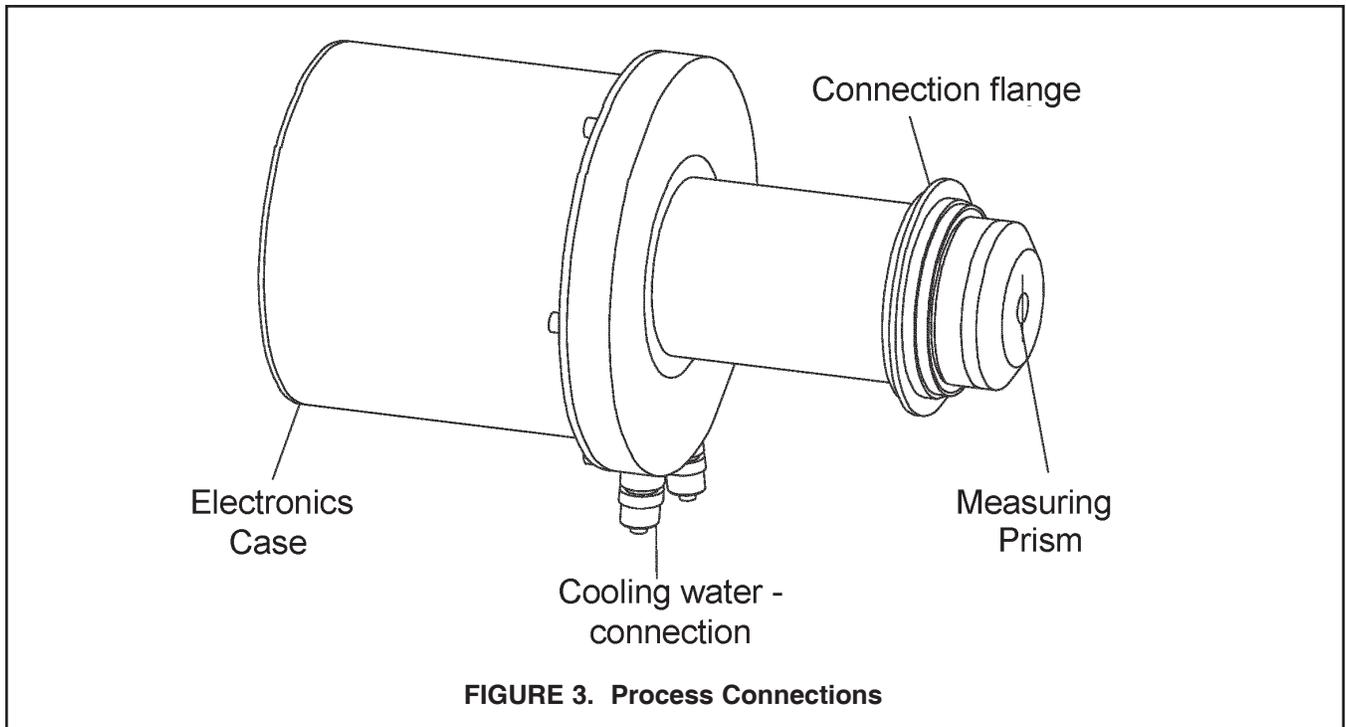
The two current outputs are connected at socket St3. Current output settings (4 mA and 20 mA setpoints) can be configured using the windows interface.

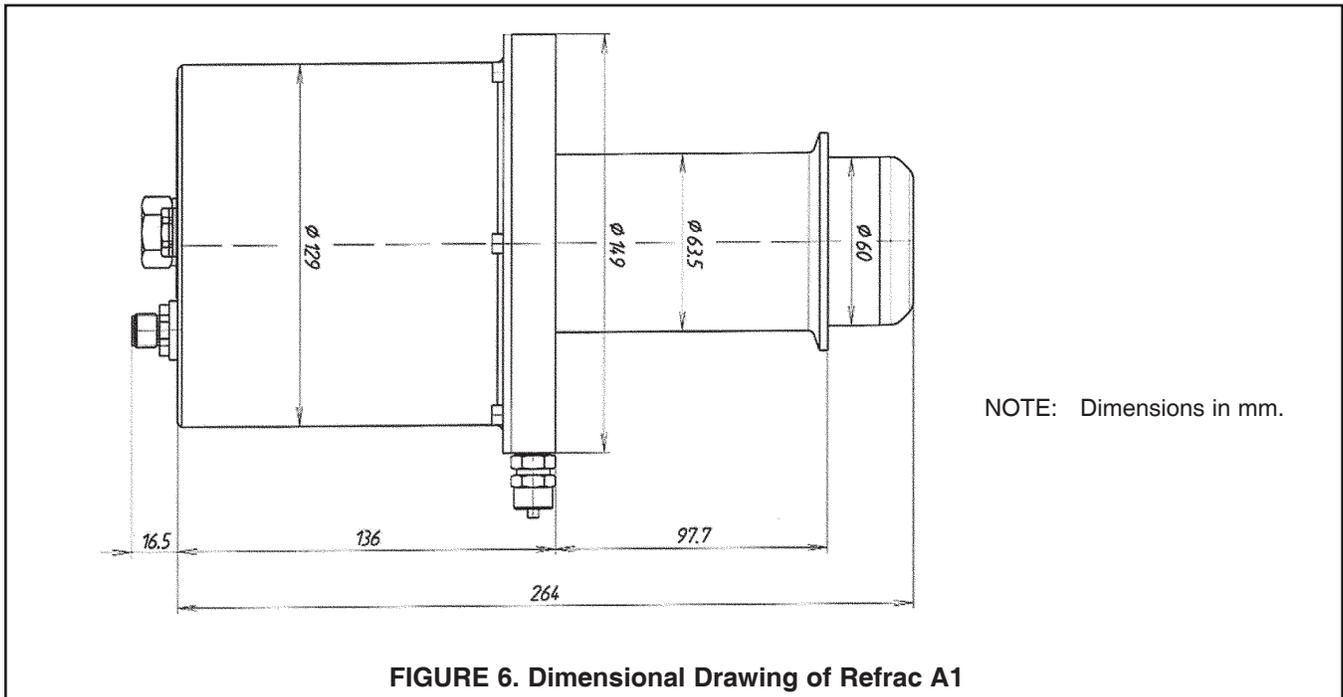
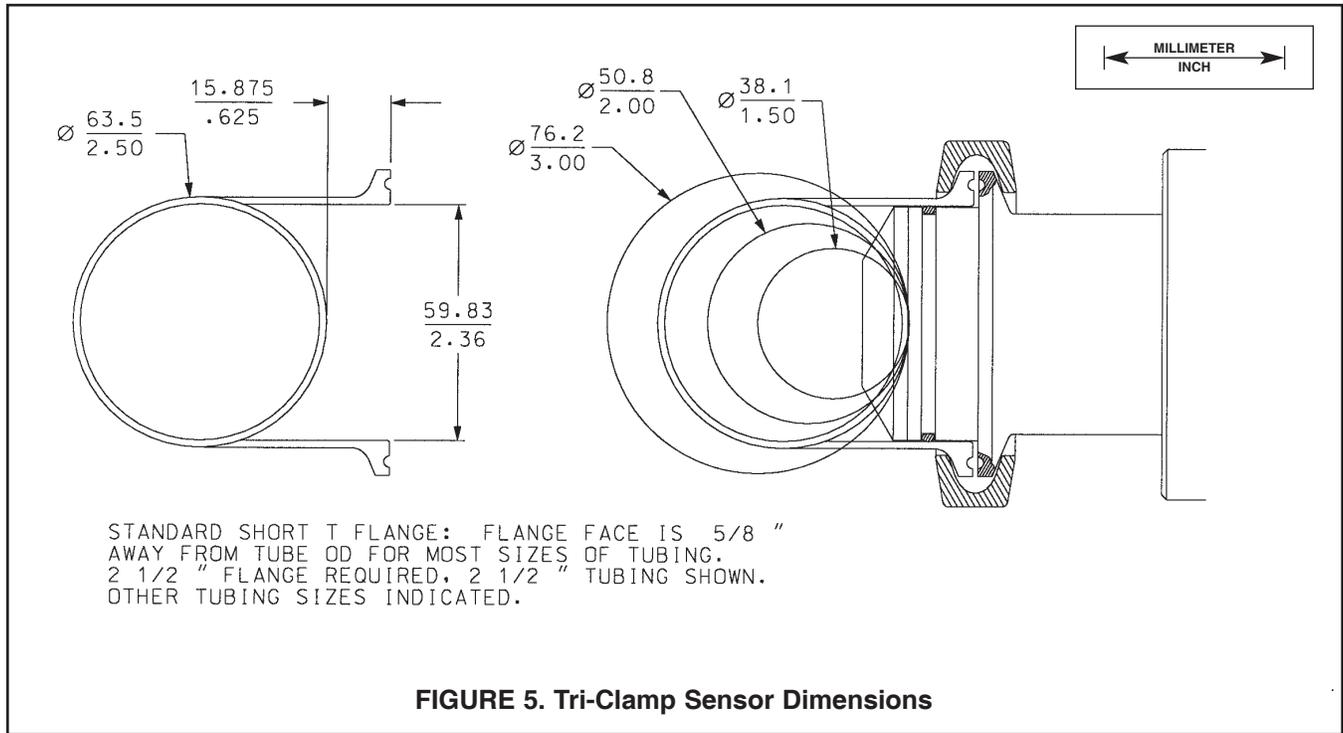


The PC interface cable should be connected to socket St2. This socket is used for configuration of current outputs, calibration, special scales, etc... This is also referred to as Com-A.

The Com-B (St1) socket is for use in logging data from the refrac A1 and is optional. Connections to Com-B will not be able to change the configuration of the Refrac A1.

For high temperature applications, the refrac A1 should be connected to cooling water to prevent overheating the electronics. The cooling water connections shown in Figure 3 are suitable for use with ordinary tap water or with a thermostat.





SECTION 4.0 OPERATION

4.1 PLUG-WIRING SCHEME

ST1 COM-B		
Wiring	Function	remarks
1	TXD	receiving data from Refrac A1
2	RXD	writing data to Refrac A1
3	RTS	always high, if instrument switched on
4	CTS	data transfer only possible if CTS high
5	GND	ground

ST2 COM-A Connection to configuration program		
wiring	Function	remarks
1	TXD	Data from Refrac A1
2	RXD	Data to Refrac A1
3	RTS	always high, if instrument switched on.
4	CTS	data transfer only possible if CTS high
5	GND	ground

ST3 Analog-output's 4-20mA		
wiring	Function	remarks
1	---	
2	+ Analog-B	the analog-outputs are galvanically separated from the rest of the connections, but not separated from each other.
3	- Analog-B	
4	+ Analog-A	
5	- Analog-A	

ST4 power supply, relays outputs		
wiring	Function	remarks
1	+24V	voltage supply
2	SA	relay output A
3	SB	relay output B
4	GND	

The power supply to the measuring head must be connected according to the wiring scheme below.

The connection of a relay is also shown in the picture below. Use this type of wiring in cases where a signal or warning instrument has to be connected to the Refrac A1.

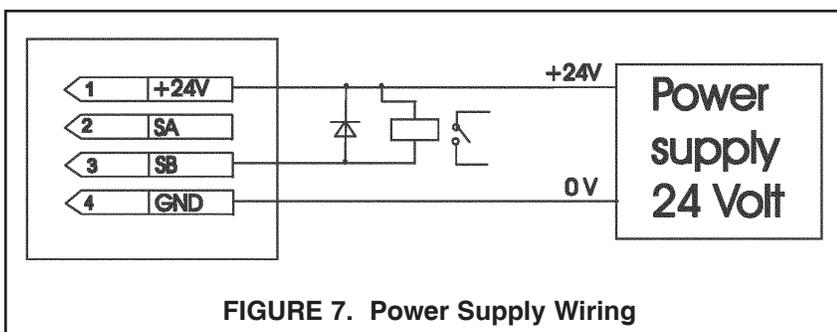


FIGURE 7. Power Supply Wiring

4.2 STATUS LED'S

The Refrac A1 has 3 LED's that indicate the operational state:

LED	Description
A green	Displays the state of power-supply, should be on if instrument is connected to power.
B red	This LED is on for some seconds after starting of the software. If it does not turn off, a fatal program error may have occurred.
C yellow	If on, the refractive index measuring range is exceeded.

4.3 PC CONFIGURATION

The refrac A1 can be configured using the windows based software included with the unit. Install the software onto your PC and run it. The first display screen will ask for a password and/or allow you to access the extensive help files. Use the appropriate password to access the software. Among other things, the software will allow you to:

- Set 4 and 20 mA setpoints
- Calibrate and automatically clean the sensor head
- Configure up to 3 custom scales
- Customize temperature compensation
- Test outputs and switches

The Password for the function "writing" is : 4712

The Password for the function "configuration" is : 241030162

See Figure 8 for some sample screens.

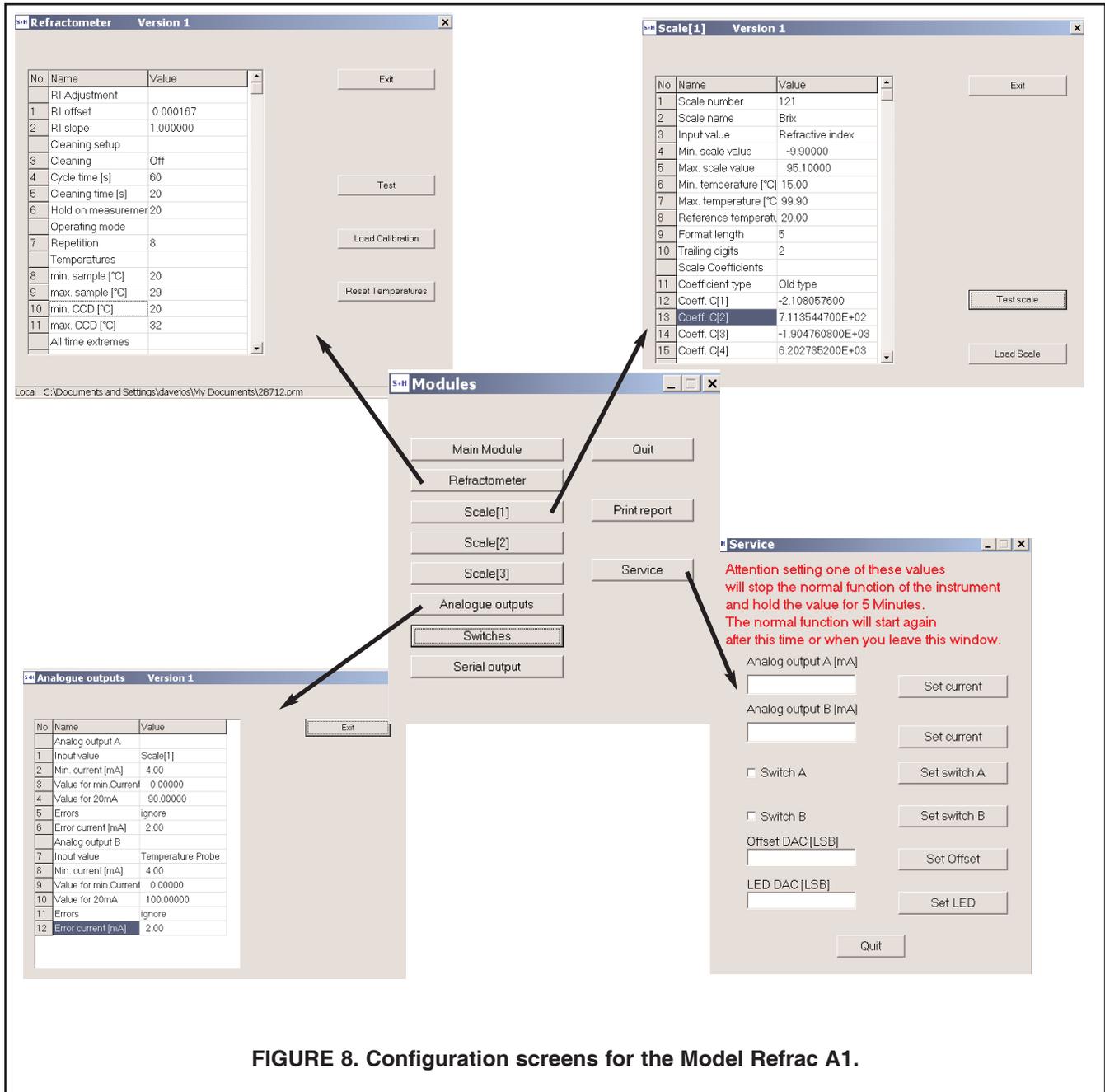


FIGURE 8. Configuration screens for the Model Refrac A1.

SECTION 5.0 RETURN OF MATERIAL

5.1 GENERAL.

To expedite the repair and return of instruments, proper communication between the customer and the factory is important. Before returning a product for repair, call 1-949-757-8500 for a Return Materials Authorization (RMA) number.

5.2 WARRANTY REPAIR.

The following is the procedure for returning instruments still under warranty:

1. Call Emerson Process Management for authorization.
2. To verify warranty, supply the factory sales order number or the original purchase order number. In the case of individual parts or sub-assemblies, the serial number on the unit must be supplied.
3. Carefully package the materials and enclose your "Letter of Transmittal" (see Warranty). If possible, pack the materials in the same manner as they were received.
4. Send the package prepaid to:

Emerson Process Management
Liquid Division
2400 Barranca Parkway
Irvine, CA 92606

Attn: Factory Repair

RMA No. _____

Mark the package: Returned for Repair

Model No. _____

8.3 NON-WARRANTY REPAIR.

The following is the procedure for returning for repair instruments that are no longer under warranty:

1. Call Emerson Process Management for authorization.
2. Supply the purchase order number, and make sure to provide the name and telephone number of the individual to be contacted should additional information be needed.
3. Do Steps 3 and 4 of Section 8.2.

NOTE

Consult the factory for additional information regarding service or repair.



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Hungary	Qatar	

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WARRANTY

Goods and part(s) (excluding consumables) manufactured by Seller are warranted to be free from defects in workmanship and material under normal use and service for a period of twelve (12) months from the date of shipment by Seller. Consumables, pH electrodes, membranes, liquid junctions, electrolyte, O-rings, etc. are warranted to be free from defects in workmanship and material under normal use and service for a period of ninety (90) days from date of shipment by Seller. Goods, part(s) and consumables proven by Seller to be defective in workmanship and / or material shall be replaced or repaired, free of charge, F.O.B. Seller's factory provided that the goods, parts(s), or consumables are returned to Seller's designated factory, transportation charges prepaid, within the twelve (12) month period of warranty in the case of goods and part(s), and in the case of consumables, within the ninety (90) day period of warranty. This warranty shall be in effect for replacement or repaired goods, part(s) and consumables for the remaining portion of the period of the twelve (12) month warranty in the case of goods and part(s) and the remaining portion of the ninety (90) day warranty in the case of consumables. A defect in goods, part(s) and consumables of the commercial unit shall not operate to condemn such commercial unit when such goods, parts(s) or consumables are capable of being renewed, repaired or replaced.

The Seller shall not be liable to the Buyer, or to any other person, for the loss or damage, directly or indirectly, arising from the use of the equipment or goods, from breach of any warranty or from any other cause. All other warranties, expressed or implied are hereby excluded.

IN CONSIDERATION OF THE STATED PURCHASE PRICE OF THE GOODS, SELLER GRANTS ONLY THE ABOVE STATED EXPRESS WARRANTY. NO OTHER WARRANTIES ARE GRANTED INCLUDING, BUT NOT LIMITED TO, EXPRESS AND IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

RETURN OF MATERIAL

Material returned for repair, whether in or out of warranty, should be shipped prepaid to:

**EMERSON Process Management
Rosemount Analytical Inc.
2400 Barranca Parkway
Irvine, CA 92606**

The shipping container should be marked:

Return for Repair

Model _____

The returned material should be accompanied by a letter of transmittal which should include the following information (make a copy of the "Return of Materials Request" found on the last page of the Manual and provide the following thereon):

1. Location type of service, and length of time of service of the device.
2. Description of the faulty operation of the device and the circumstances of the failure.
3. Name and telephone number of the person to contact if there are questions about the returned material.
4. Statement as to whether warranty or non-warranty service is requested.
5. Complete shipping instructions for return of the material.

Adherence to these procedures will expedite handling of the returned material and will prevent unnecessary additional charges for inspection and testing to determine the problem with the device.

If the material is returned for out-of-warranty repairs, a purchase order for repairs should be enclosed.



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