STAUFF ®

FILTRATION TECHNOLOGY

MODEL LPM1
LASER PARTICLE MONITOR
OPERATION MANUAL

Functional diagram

LPT 1 without Display — IR-Link for Setup & Programming — LPT 1 with Display

FLUID IN — IR-Link — IR-Link — FLUID IN

FLUID OUT — FLUID OUT

FIBER OPTIC CABLE

LIM 1 — LIM 3 without Display — LIM 4 with Display — LIM 5 with Display

Serial Connection PC (RS 232)

Output: 0...5V
ModBus (ASCII)

Display ISO 4406 plus additional info.
Alarm at increasing Signal

Display ISO 4406 plus additional info.
Alarm at decreasing Signal
(e.g. usage in filter carts)

Each LPM 1-Kit includes:

1 x LPT Laser Particle Transducer
        -includes 3 m *(10 ft.)* flying lead power cable (9 to 36 VDC required, not supplied)

1 x LIM Interface module
        -LIM-1, includes 6 m *(20 ft.)* interconnecting fiber optic cable
        -LIM-3, includes 6 m *(20 ft.)* interconnecting fiber optic cable and two 3 m *(10 ft.)* power cable with 3 pin connector.
        -LIM-4, includes 6 m *(20 ft.)* interconnecting fiber optic cable and one breakout cable with 15 pin connector
        -LIM-5, includes 6 m *(20 ft.)* interconnecting fiber optic cable and one breakout cable with 15 pin connector

1 x Quick Start Guide

1 x Operators Manual

1 x Software
        - Includes DDE server
        - Hex and terminal logger for RS-232
        - PDA Shareware

Contents

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Safety

Warnings and cautions are used in this manual, appearing before the procedure or step to which they apply. Take extreme care when performing   any procedures preceded by or containing a warning or caution.   A triangle with exclamation point indicates a general safety hazard and a triangle with lightning bolt indicates an electrical safety hazard.

WARNING

A WARNING indicates a hazard to you. It calls attention to a procedure which, if not correctly performed or adhered to, could result in injury or possibly death. Do not proceed beyond a WARNING until the indicated conditions are fully understood and met.

CAUTION

A CAUTION indicates a hazard to the LPM monitor. It calls attention to a procedure which, if not correctly performed or adhered to, could result in damage to the monitor. Do not proceed beyond a CAUTION until the indicated conditions are fully understood.

Note:
A Note highlights an important operating procedure or other important information not involving safety of equipment or personnel.

Laser Safety Information

WARNING

At no time should covers be removed. This is a laser-based instrument and the user risks injury if exposed to the laser.

The LPM1 monitor contains a laser-based sensor that is a Class 1 product (as defined by 21 CFR, Subchapter J, of the Health and Safety Act of 1968) when used in normal operation. This manual contains no procedures for service of internal parts. Service should be performed only by factory-authorized personnel.

The LPM1 has been evaluated and tested in accordance with EN 61010-1:1993, "Safety Requirements For Electrical Equipment For Measurement, Control, and Laboratory Use," IEC 825-1:1993, "Safety of Laser Products," and other applicable industrial standards (e.g., ISO 4406, ISO 6149-2).

A laser classification label is attached to the unit per 21CFR requirements. A reproduction of the label is shown below in Figure 1.
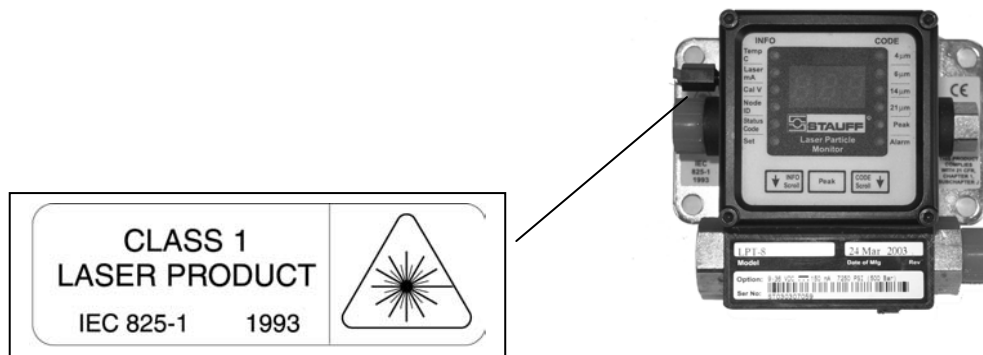
Figure 1. Safety Labeling

Unpacking and Initial Inspection

The LPM1 monitor is thoroughly inspected at the factory and is ready for use upon receipt. Inspect the shipping carton for damage. If the carton is damaged, notify the carrier and save the carton for carrier inspection. Inspect the monitor for broken parts, scratches, dents, or other damage. If the carton is not damaged, keep for reshipment in the event repair is necessary. Your carton should contain the following:

    One LPT and one LIM as ordered
    LPM1 CD-ROM
    FiberOptic Cable
    Operators Manual

Technical Support Information

If there is a need to contact Technical Support,   you may do so using any of the following methods:

    Phone: (734) 747-7300
    Fax: (734) 747-7342
    E-mail
    Website   www.stauffusa.com

Return Shipping Instructions

Should it become necessary to return any part of the LPM1 to the factory, you must first contact your local service representative or Customer Service for return authorization instructions. After you have received a Return Authorization number, follow the shipping instructions.

Introduction

The LPM1 is designed to monitor the contamination levels in fluid power and lubricating systems. The LPM1 provides cumulative particle concentration information at >4 µm, >6 µm, >14 µm sizes applicable to the new ISO 4406, ISO 11943, and ISO 11171 requirements for optical particle counters. A >21 µm channel is also provided for large particle concentration information.

Machine operators are alerted to changes in particle contamination levels in a machine's fluid by the indications provided from the LPM1. These indications can provide an early warning of component wear, filter or seal failures, water ingress, cavitation, oil oxidation, poor oil lubrication properties due to viscosity issues, changes in both additive and base oil stock, or other anomalies.

Identifying your product

A LPM1 system consists of two basic parts: a LPT Particle Transducer and an LIM Interface Module.

The LPT Particle Transducer contains the sensing device and electronics for detecting the level of contamination. The laser-based sensor uses light blocking (extinction) technology for particle detection whereby particles passing through an optical flow cell block an amount of laser light proportional to the size of the particle. The resultant particle concentration data from the LPT are sent to the LIM via a fiber optic cable. The data may also be directly collected through the IrDA port by any PDA device with IR capabilities (e.g., a Palm) or a PC with IR capabilities.

The LIM converts the raw particle count data from the LPT for display or use in acquisition, logging, or control systems. A terminal emulation program can be used to read the ASCII data string.

OR

9
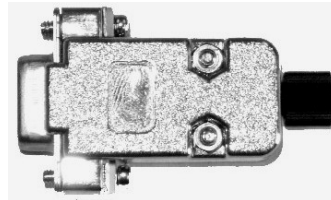
LPM1 System Options

The following options are available at the time of the initial order or any time thereafter by returning either the LPT or LIM to the factory. Conversion of your LPM1 to another configuration may require the return of both units to the factory depending upon the desired configuration. When ordering a LPM10 monitor, the model number will be followed by four digits (e.g., LPM-**T2**-**M3**) signifying the type of transducer (T2) and interface module (M3). These digits are defined below.

LPT Transducer:
-T1 Equipped with an internal flow regulator 28 to 500 bar *(400 to 0 PSI)*
-T4 Same as -T1 above but with integrated LED display
-T7 Same as -T1 above but with moderate pressure internal flow regulator 3.5 to 83 bar *(50 to 1200 PSI)*
-T8 Same as -T7 above but with LED display
-**T9** Same as -T1 above but with low pressure internal flow regulator 1.4 to 13.8 bar *(20 to 200 PSI)*
-T0 Same as –T9 above but with LED display

LIM Interface Module:
-M1 Optical Fiber to DB-9 for RS-232 output (DCE/computer usage)
-M3 Optical Fiber to DB-15 for 0 to 5 VDC analog output and ModBus protocol on RS-232/RS-485
-M4 Optical Fiber to 4-pin Samtec circular DIN with remote LED display and dry alarm contact closure for rising level
-M5 Optical Fiber to 4-pin Samtec circular DIN with remote LED display and dry alarm contact closure for falling level

LPM1-XXC Monitor:
  Option to verify the LPM1 calibration using ISO Medium Test Dust (MTD) (based on ISO 11171 and ISO11943).

LPM1Configuration

In this example a LPM-T1-M3 has been chosen, the components of which are shown in Figure 2.

The **-T1-M3** suffix describes the combination of a LPT-**1** and a LIM-**3**. Referring to the description of these components on the preceding pages, this system will operate on a fluid line that is pressurized and internally reduce the pressure to a near atmospheric level for return to a reservoir.

The output signal from the LPT-1 will be connected to the LIM-3 by a fiber optic cable up to 53 meters *(175ft.)* in length. This length allows the interface module to be installed in a remote location isolated from the machinery. A more suitable location for data collection and analysis may be a control cabinet, an adjacent room, or office. The LIM-3 output provides the data to a computer in several formats as described earlier.

Data collection directly at the transducer may be achieved using the IrDA port on the transducer and a device with IR capabilities (e.g., a Palm or Laptop PC). The LPT must be configured in text mode for this type of data collection (see "Setting LPT Parameters"). The data collected may later be downloaded to a PC for analysis.

LPT-1 Transducer   *LIM-3 Interface Module*
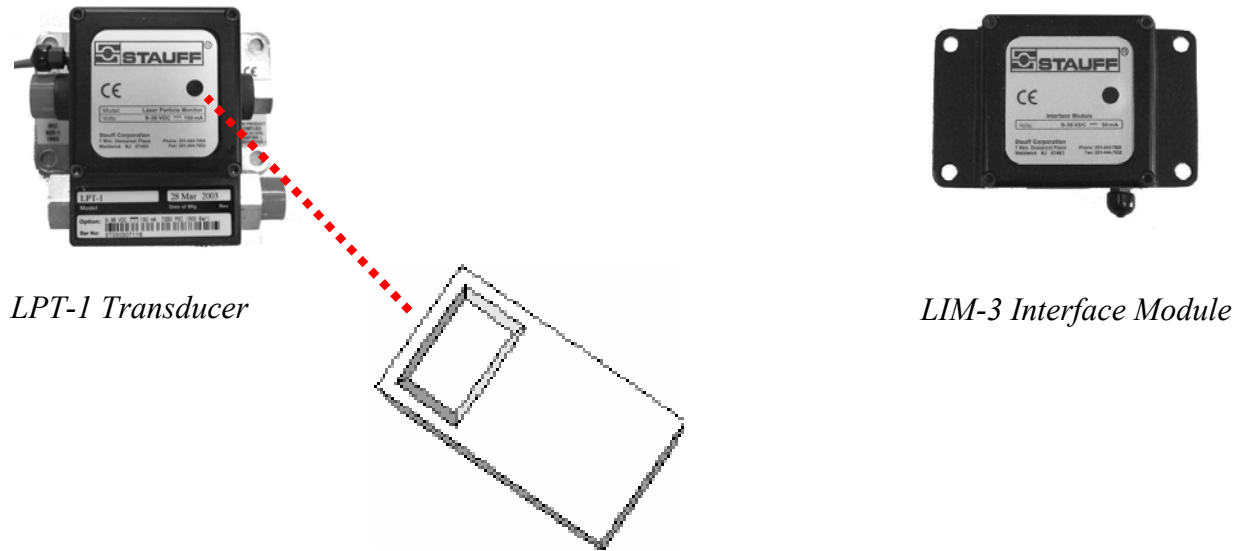
Figure 2. Sample Configuration

Other sample configurations may be created by combining any LPT variant with any LIM variant shown on the following pages. Note that the LPT-4, -8 and -0 are already configured with a built in display. When creating the best possible configuration for your monitoring needs, the capabilities and limitations of each component must be considered.

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Model LPM

LPT Description

The LPT transducer is available in four basic configurations (Figures 2 and 3) for different applications. Each version can be integrated with an LED display for a total of eight variants.

The **LPT-1**, **LPT-7** and **LPT-9** have a flow inhibitor downstream of the sensor that restricts and controls fluid flow from variable high-pressure sources. The pressure is reduced to near atmospheric for return to a hydraulic fluid reservoir. The inlet pressure range is 28 to400 to 7250 PSIi for the LPT-1, 50-1200 psi for the LPT-7 and 20 to 200 PSI for the LPT-9

The **LPT-2** is for in-line flow applications and uses a built-in check valve to divert flow from a varying pressure/flow system. The fluid flow rate for the LPT-2 is 1-12 GPM.

The **LPT-3** uses straight-through flow for operation in constant flow and pressure fluid systems. Flow rate must be externally controlled and must be between 50-500 ml/minute.

For any LPT, different fluid viscosities will effect the performance of the instrument. Further details concerning viscosity are provided in the "Installation" section of this manual.

A "Minimess" sampling port accessory is available with the LPT-1 and -2 configurations for easily extracting a sample for external analysis without disconnecting the unit. When drawing a sample in this fashion, disregard the data from the LPT because excessive flow rates are created.

-1,-4, -7, -8, -9, -0   -2, -5   -3, -6
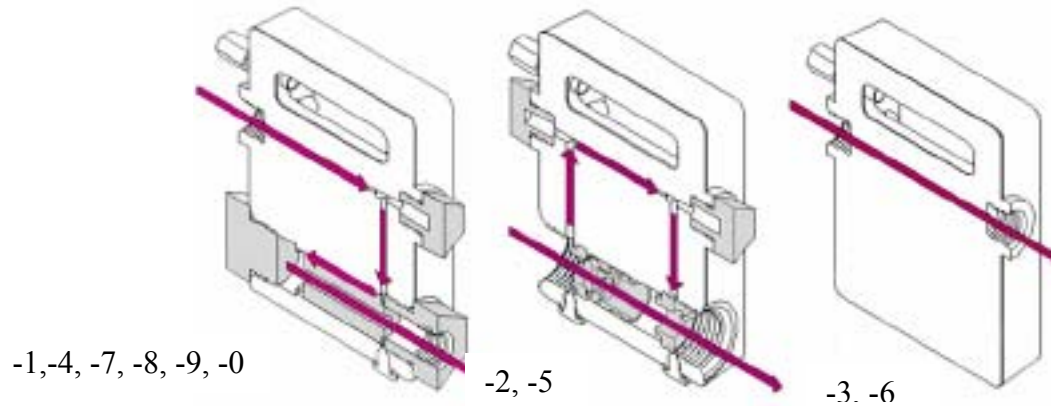
Figure 3. Basic LPT Options (cross-section view)

The LPT-4, -5, -6 and -8 transducers include an on-board 3-digit LED display that displays the selected ISO code value (in the selected size range). The ISO code may be converted to particle counts/ml (App. C). The LED display can also display other functions and parameters as described in the "Indicators and Controls" section.

LPT-X "Dash Number"	Flow control Method	Local Display	Delivery Info
LPT-1	Internal Flow Regulator	No	Standard Stock
LPT-2	Internal Check Valve	No	Special Order
LPT-3	None, External Flow Control Required	No	Special Order
LPT-4	Internal Flow Regulator	Yes	Standard Stock
LPT-5	Internal Check Valve	Yes	Special Order
LPT-6	None, External Flow Control Required	Yes	Special Order
LPT-7	Internal Flow Regulator (Moderate Pressure)	No	Standard Stock
LPT-8	Internal Flow Regulator (Moderate Pressure)	Yes	Standard Stock
LPT-9	Internal Flow Regulator (Low Pressure)	No	Standard Stock
LPT-0	Internal Flow Regulator (Low Pressure)	Yes	Standard Stock

Figure 4.   LPT Versions

LIM Description

The LIM interface module is available in four variants to meet a wide variety of applications. Refer to Figures 5 through 7 for illustration.
The **LIM-1** has a DCE configuration (9-pin female) for attachment directly to a computer's RS-232 serial port.
Power for the LIM-1 is supplied by the computer serial port through the DB-9 connector. The unit receives raw serial data from the LPT transducer via a fiber optic cable and transmit the data to the computer.
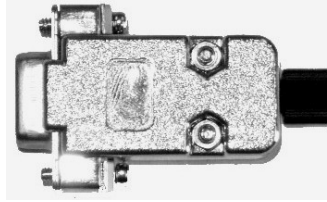
Figure 5. LIM-1

The **LIM-3** receives raw serial data input from the LPT transducer through a fiber optic cable. This data string is analyzed and converted into 0 to +5 VDC analog output voltages proportional to ISO codes and also into ModBus ASCII device protocol for interface to a PLC or computer via RS-485 and RS-232 serial. All signal outputs, as well as the input supply voltage (+9 to +36VDC), are connected to the LIM-3 through the DB-15 connector.

Figure 6.L IM-3

The **LIM0-4** receives raw serial data input from the LPT transducer through 1 mm fiber optic cable. Results are displayed on the front panel 3-digit LED display. The ISO 4406 code number displayed is categorized in four size channels: 4 µm, 6 µm, 14 µm and 21 µm. The ISO number represents a range of cumulative particle counts/ml as defined in Appendix A. The user can also select internal information about the transducer (Temp C, laser mA, Cal V, Node ID, status code).

Alarm levels can be programmed for any of the four particle size channels. When set, an alarm indicator will flash if the alarm level is exceeded. The alarm indicator is also activated if the associated LPT generates an error code. In this instance, both the "Alarm" and "Status" LEDs flash and the display shows the status code as a hexadecimal number. Refer to Common Error Codes in the Serial Protocol section to decode this number and determine the cause of the alarm. The alarm also drives a dry contact closure which can be used to energize an external alarm indicator (visual or auditory). The external alarm power must not exceed 35 VDC at 100 mA.

Alarms on the LIM-4 may be de-activated by pressing any button. Supply voltage is external and can be from a +9 to +36 VDC source or from an optional +6 VDC battery.

Figure 7.L IM-4

Pre-programming the LPT
The LPT may be programmed before installation.

Install the "Online" software from the LPM1 CD-Rom on a desktop PC. Then, using the software supplied with your PDA, copy it to your PDA .

Configuring the "Online" program

To change configuration settings in the Online communications program, launch the program, and then tap the "Menu" button (lower left corner of the graffiti area). Tap the "Communications" tab and verify port setting is IrCOMM, Baud is 9600, Data Bits is 8, Parity Bits is N(none), Stop Bits is 1, RTS/CTS is checked, and XON/XOFF is unchecked.

Tap "OK," and then tap the "Menu" button again. Select "Terminal," and verify Emulation Mode is VT100, Font is Small, Return is CR, Backspace is BS, and Display Follows Cursor is checked. All other check boxes should remain unchecked (default), and Pacing Option should be OFF. Tap "OK" to return to Online's Terminal Screen. The program is now configured for use.

Please Note: The box marked ON at the bottom of Online's Terminal Screen has to be tapped (it will turn black when enabled) before the PDA can communicate with the LPT.
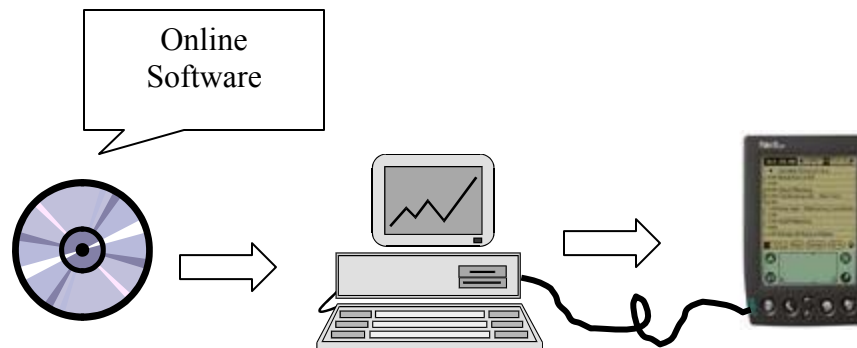
Online
Software

Figure 8. Installing the "Online" software

Configuring the PDA
This assumes the PDA device being configured is running Palm OS Version 3.x. Configuration of other PDA operating systems may vary slightly.

Go to your PDA "Preferences" section (usually in the system folder) and select the "Connection" pull down tab, tap on "IR to PC/Handheld," tap "Edit," and verify Connection Method is IrCOMM to PC. Tap "Details" tab and verify speed = 9600 bps and flow control is Automatic. Tap "OK" to return and the "House" symbol (upper left graffiti button) to leave preferences area.

Setting LPT Parameters
The LPM1 firmware allows for operating parameters to be changed via the IrDA port on the LPT transducer using a PDA device with IrDA capability running the appropriate terminal software. A shareware version of "Online" software is included on the LPM1 CD along with a users guide. The provider of this program may be contacted at 800-799-7299 or www.markspace.com. Instructions for configuring your PDA and the Online software are contained in Appendix E.
The LIM interface module need not be connected. Upon power up, the LPT scans the IrDA port, allowing the test parameters to be reprogrammed. If the setup dialog is not opened in the first 30 seconds, the previously saved setup will be used.

The internal setup program of a LPTmay be changed as follows:

1 Verify your PDA has IrDA capabilities and is running a terminal emulation program. Set the communication method to "Ir to PC/Handheld" and verify the following communication settings: 9600 baud, no parity, eight data bits, one stop bit.
2 Attach the DC power input cable of the transducer to an *unenergized* 9 to 36 VDC power source, white wire to +V, black wire to ground.
3 Point your PDA at the transducer's IrDA port. Then energize the power source connected in Step 2.
4 When prompted to enter the configuration mode, respond with a "Y." The factory default menu will be displayed as shown in Figure 21.
5 To change a specific parameter, enter the letter or number of the parameter to be changed and wait for the LPT to respond. Then, enter the updated configuration when prompted.
6 End the sequence by typing "Q." All the configuration information will be saved in nonvolatile memory.

CAUTION:

The IRDA port in the LED Display can be inadvertently activated during the first 30 seconds of operation (during the IrDA search cycle) when placed in close proximity to high power fluorescent lighting such as bench top lights placed at a right angle within 24 inches of the LPT/ LIM display. Although the LPT/ LIM will continue to process and transmit data via its fiber optic cable, the LED Display may be temporarily locked by its assumption that a transmission or reprogramming is in process. The interface may be reset by communicating momentarily with a PDA, or by a power off/on cycle. If it remains necessary to operate the unit in the presence of intense lighting, a piece of opaque material/tape may be placed over the LPT/ LIM display to temporarily shield the IRDA port.

```
              --LPT CONFIGURATION MENU—

1  SYSTEM ID #1 (0-9999)................................5281
2  SYSTEM ID #2 (0-9999)...............................1247
N NODE ID (1-247).........................................138
M SAMPLE MODE (TIME/EVENT)....................T
O SAMPLE OUTPUT (SINGLE/AVERAGE)........S
P SAMPLE PERIOD (MM:SS)..........................01:00
H SAMPLE HOLD (MM:SS).............................04:00
E EVENT LEVEL (0-10000).............................5000
F OUTPUT FORMAT (RAW/TERMINAL)..........R
Q QUIT
Command ?
```
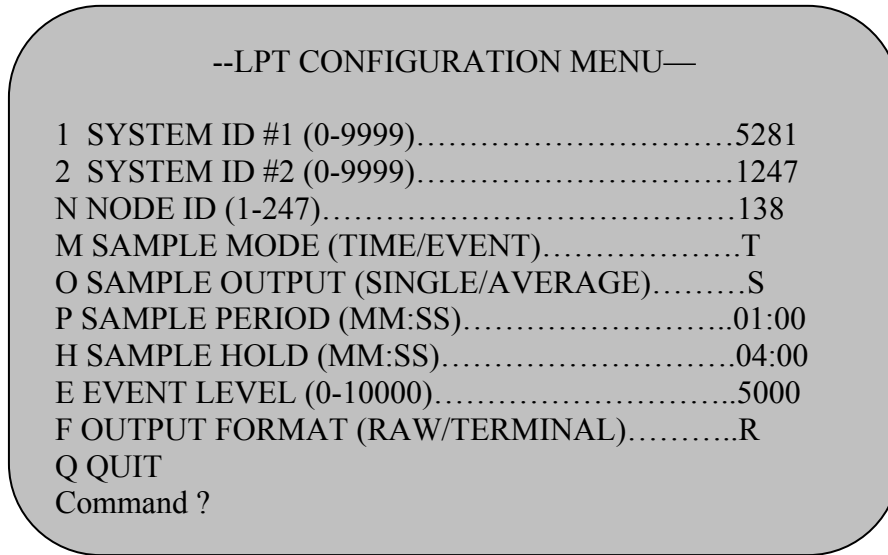
Figure 9. LPT Configuration Menu

Notes:

The LPT and PDA may take several seconds to respond via an IrDA port.

"**System ID**" and "**Node**" parameters provide a unique identification of each unit (required for networking of units).

"**Sample Mode**" is either based on accumulated time (defined by parameter P) or accumulated counts (channel 1 only). The event level is defined by parameter E.

"**Sample Output**" is either based on discrete sample events or a sliding window-weighted average of the last five samples.

"**Sample Period**" should be set to achieve a statistically significant number of particles in the sample. For expected ISO code ranges of 12 and greater, a one minute sample time should be sufficient. Below that, the sample period should be doubled for each additional ISO code level. For example, use a two minute sample at ISO code 11.

"**Sample Hold**" times may be automatically extended at higher operating temperatures to protect laser life, see "Specifications" on page 58 for details.

"**Event Level**" refers to the number of channel 1 events required if the sample mode is event driven.

Period and **Hold** times in **"Raw"** data mode range from 00:05 to 59:59 (MM:SS). In **"Terminal"** mode the minimum hold time is 15 seconds to allow time for the IrDA interface.

Basic Installation Considerations

Figure 10 represents a simplified diagram of a possible fluid system, containing the common elements found in actual systems. Potential sampling points are labeled S1 through S14, other components are labeled as follows: R1=Reservoir, P1=Pressure Pump, F1=Pressure Filter, F2 = Return Line Filter, Rs = Restriction.

These sample points potentially exist on systems as standard oil sampling ports. If a sample port is not in place, then one can be added using a "T" in the pipe work or by tapping a 1/4 inch sampling port into the pressure line. Sampling ports should be placed in active lines, ideally at points where there is some turbulent flow; e.g., at elbows and bends.

Connection to the LPT can be made using hose, microbore tube, or rigid pipe work. Consider using a minimess or similar quick disconnect sampling port on the system. This will allow you to disconnect the LPT for service or to relocate onto another sampling point, without shutting down the machine. If the unit is being hard plumbed, then a valve incorporated in the system would serve the same isolation function.

The fittings on the LPT are female SAE JI926 O ring which are easily adapted to 37 JIC flares using an adapter (4 req'd). Use of a minimess to SAE "O" type fitting, with microbore hose, is recommended if the unit is connected and disconnected frequently. The microbore tubing provides faster clean up time and better particle transportation due to the lower internal volume.
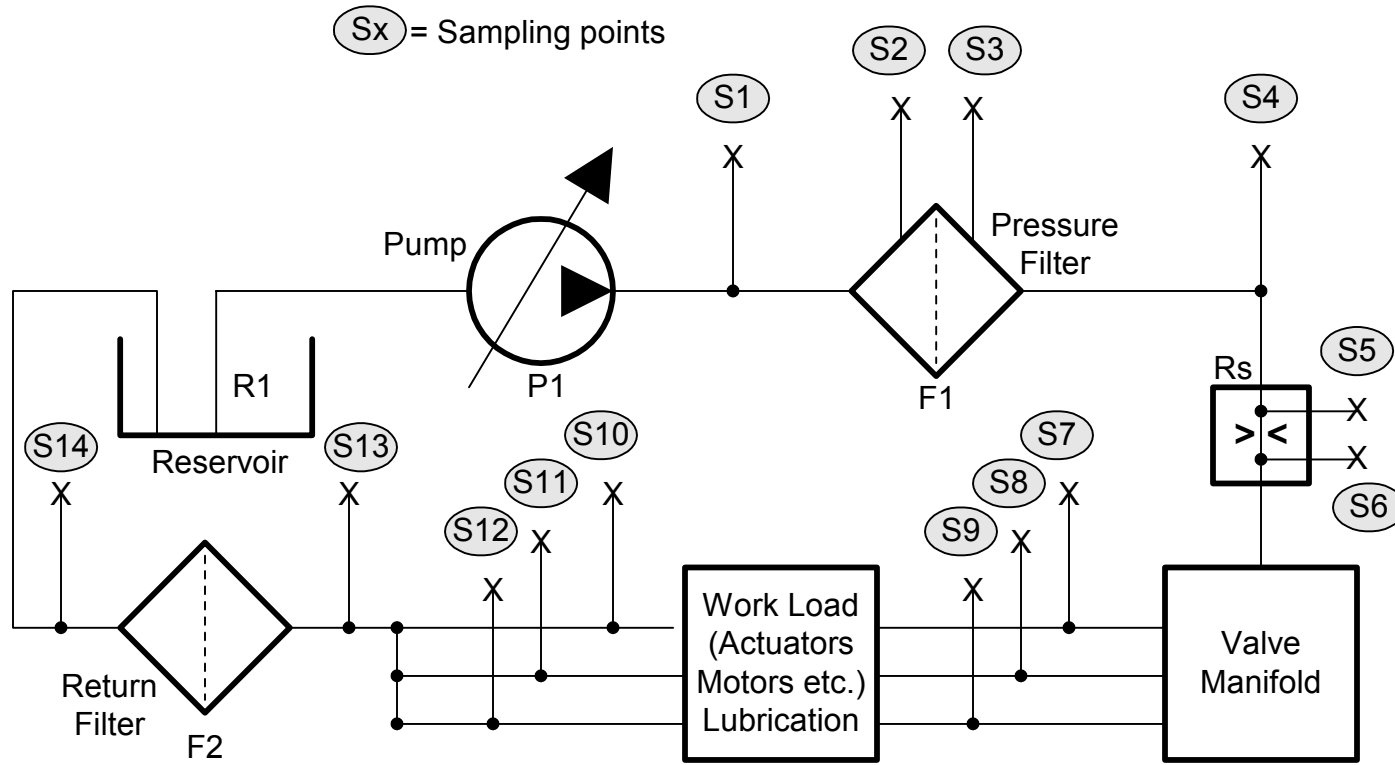
Figure 10. Simplified Fluid System Diagram

LPT-1, LPT-7 and LPT-9 Installation Examples

A LPT-1 connection could be made to online sample points S1-S9 with return to reservoir R1. S10-13 are also options provided there is enough pressure in the return lines.* Figure 11shows an installation at S2 at the filter inlet with the return line to the reservoir. Refer to the charts on page 23 and 24 for viscosity considerations.
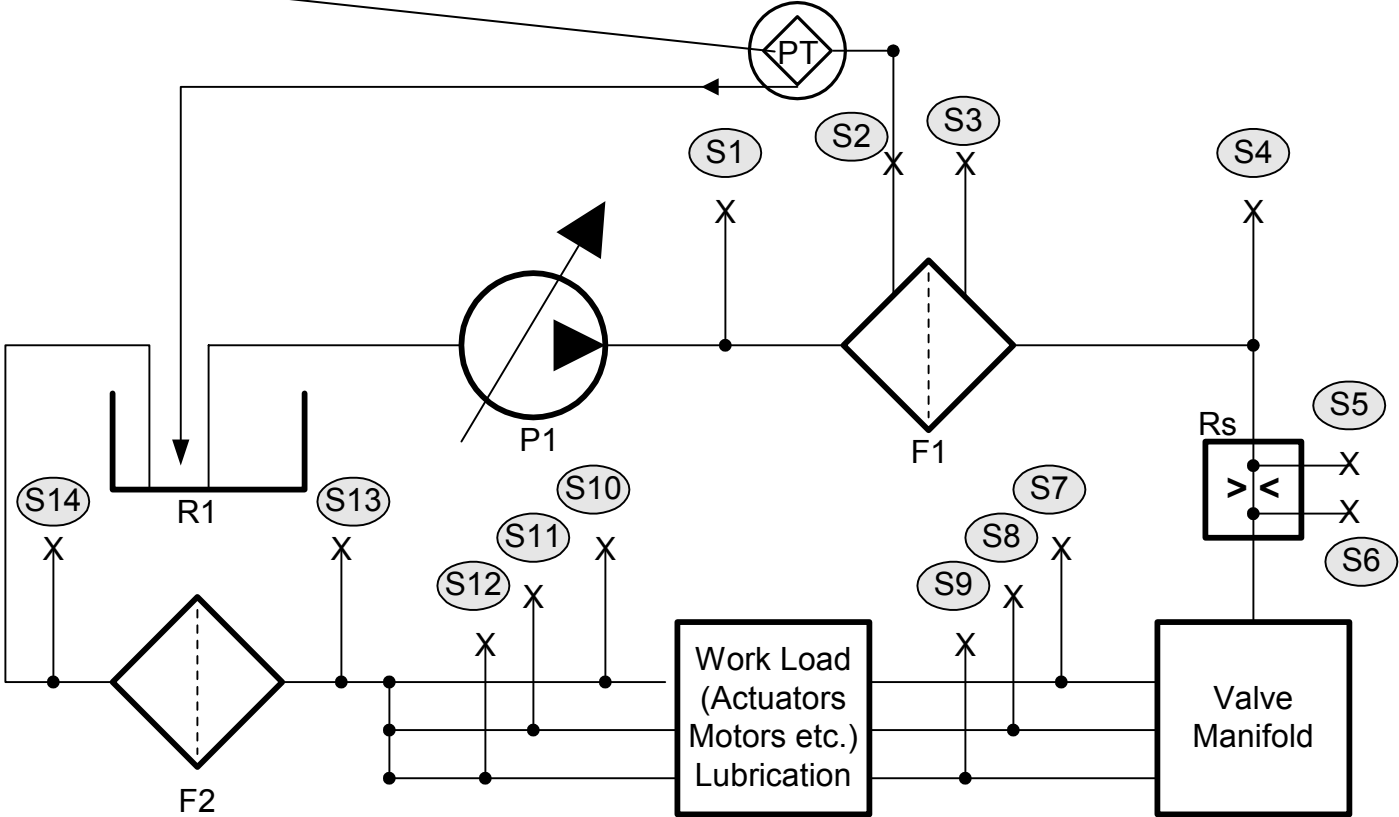
Figure 11. Sample LPT-1 or LPT-7Installation

LPT-1 Flow Dynamics
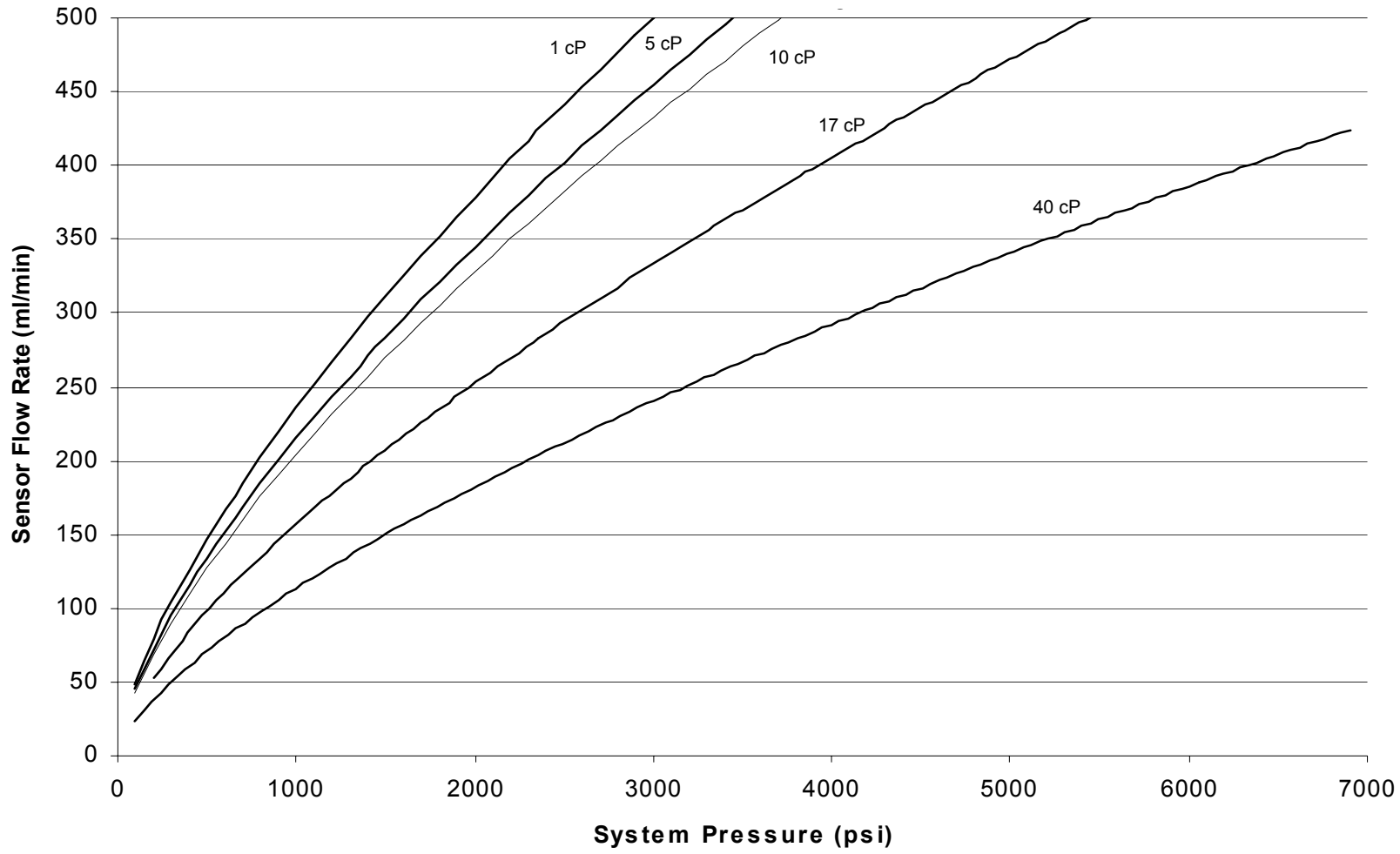
LPT-7 Flow Dynamics

LPT-9
Flow Dynamics
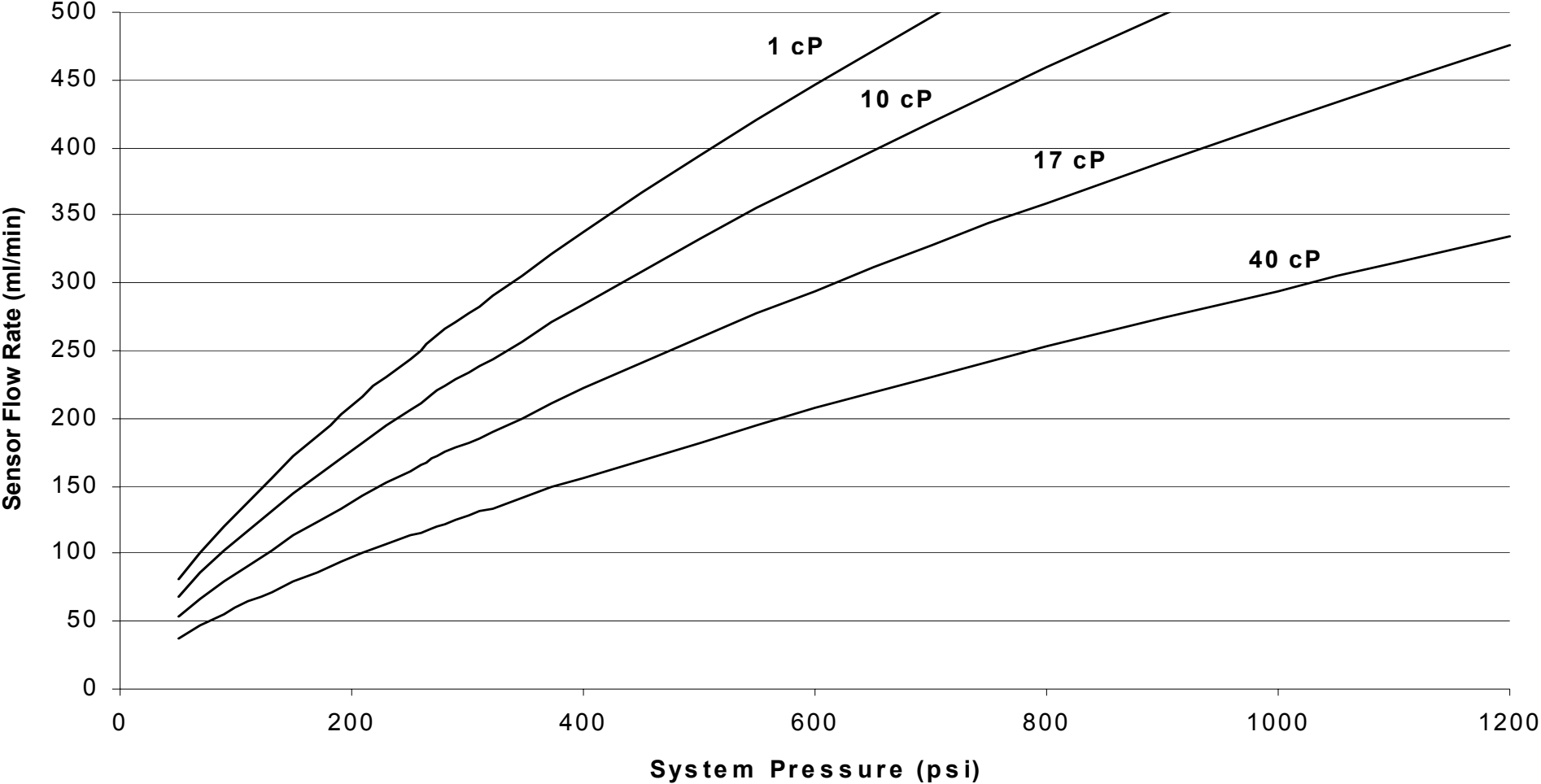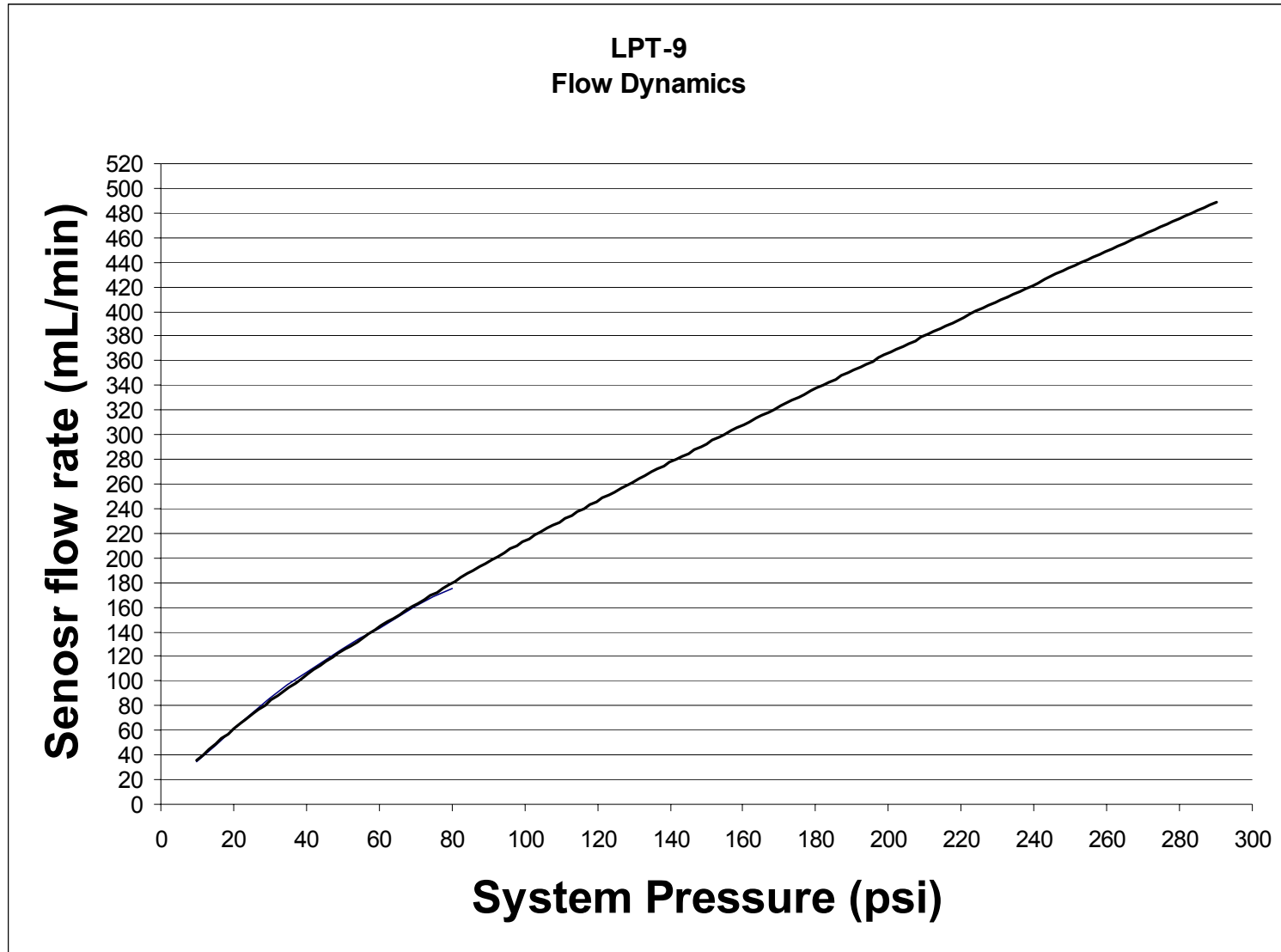
LPT-2 Installation Examples

Connect a LPT-2 in-line at any point providing the flow is between 1-12 GPM (45LPM) and the pressure is within specifications. Install between two points of varying pressure in a bypass mode (differential pressure >20 psi (1.3 bar), where fluid is not diverted from work; e.g., between S3-S5 where the pipe and elbow create a pressure loss). Figure 12 shows a LPT-2 installed between the valve manifold and the work load. See the chart on page 27 for system flow rate considerations.

Note: The LPT-2 uses an internal check flow control flow through the transducer.
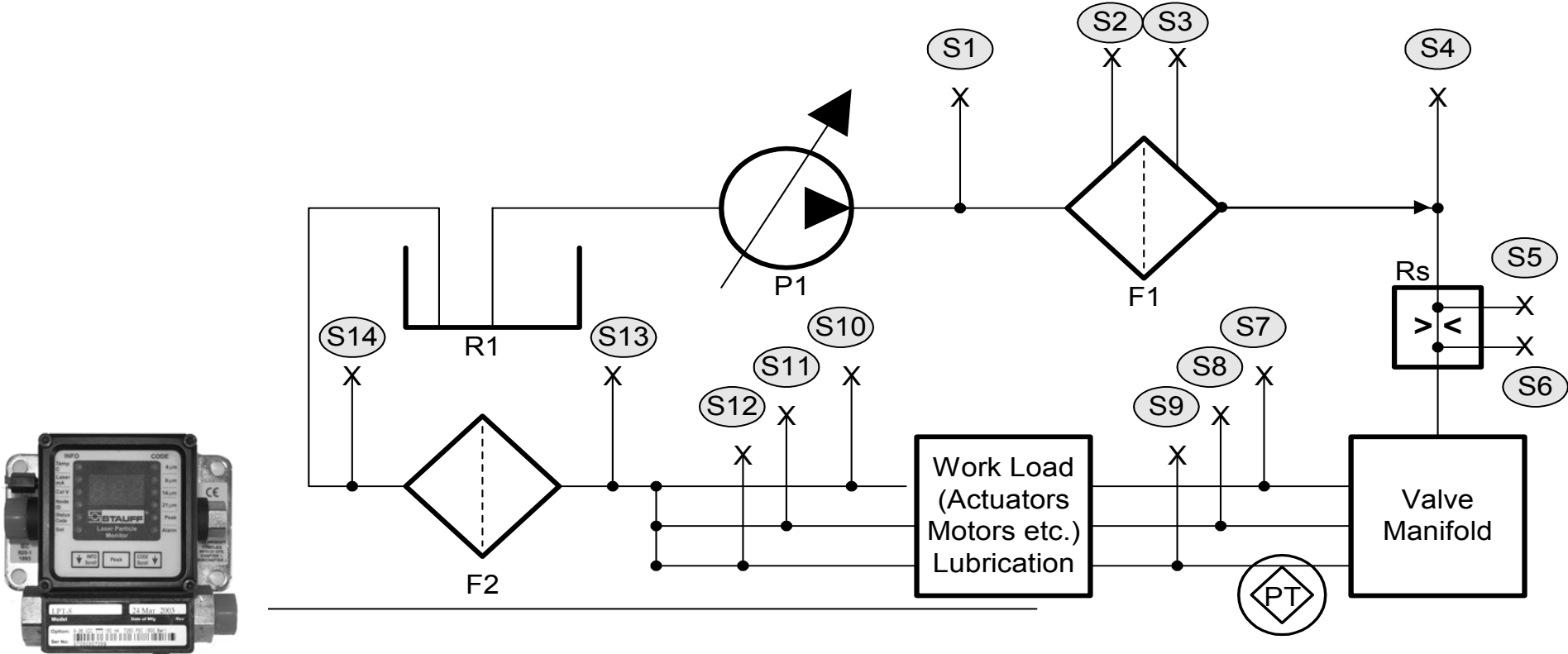
Figure 12. Sample LPT-2 installation

LPT-2 Flow Dynamics

μ = 17 cP
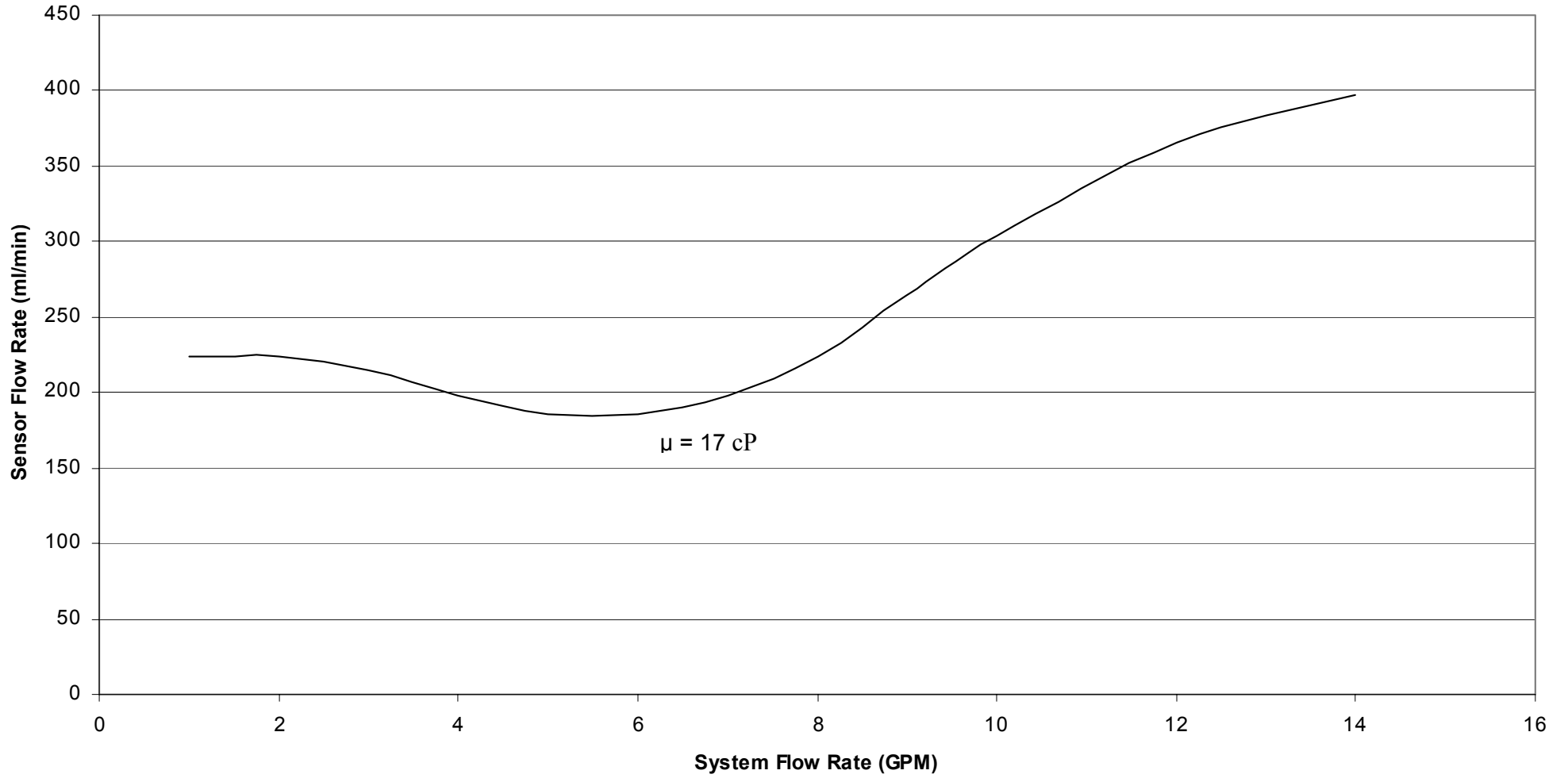
LPT-3 Installation Examples

A LPT-3 may be connected inline around any relatively constant pressure drop in the system of ~5 - 20 psi (1.3 bar); e.g., S5 -S6 in Figure 13. Note that fluid will be able to return via the sensor, so do not install around an existing check valve where no return flow is acceptable. This unit may also be installed between S13 and S14 using the differential pressure drop across the return line filter F2 to provide the required flow. Refer to the chart on page 29 for viscosity and flow considerations.
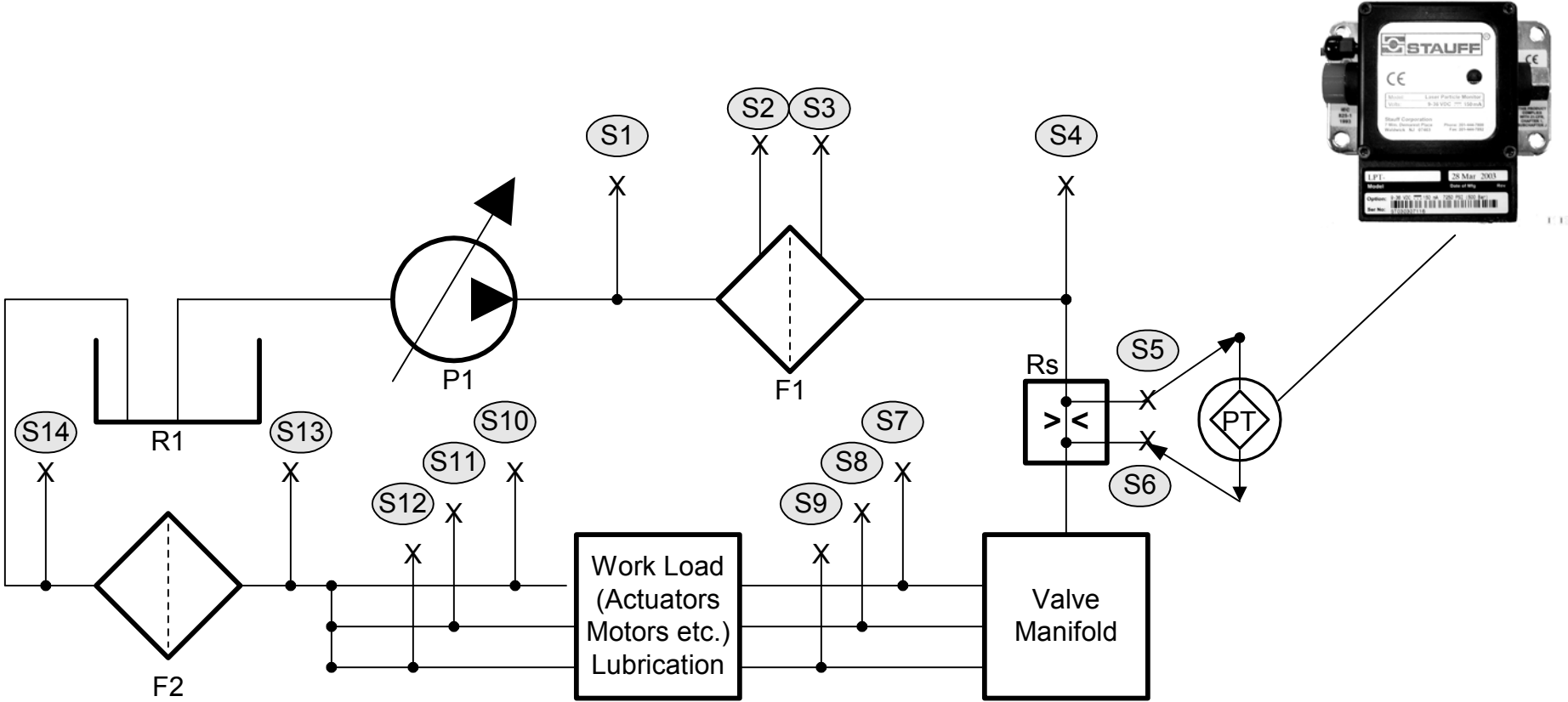
Figure 13. Sample LPT-3 Installation

Flow through the sensor of a LPT-3 is laminar at the maximum flow of 500 ml/min down to 4 cP. Laminar flow is directly proportional to differential pressure and inversely proportional to viscosity by the following equation:

$$Q \quad \alpha \quad \frac{\mu}{\Delta P}$$

Where Q is in ml/min, μ is viscosity, and ΔP is the differential pressure across the sensor.

LPT-3 FLOW DYNAMICS
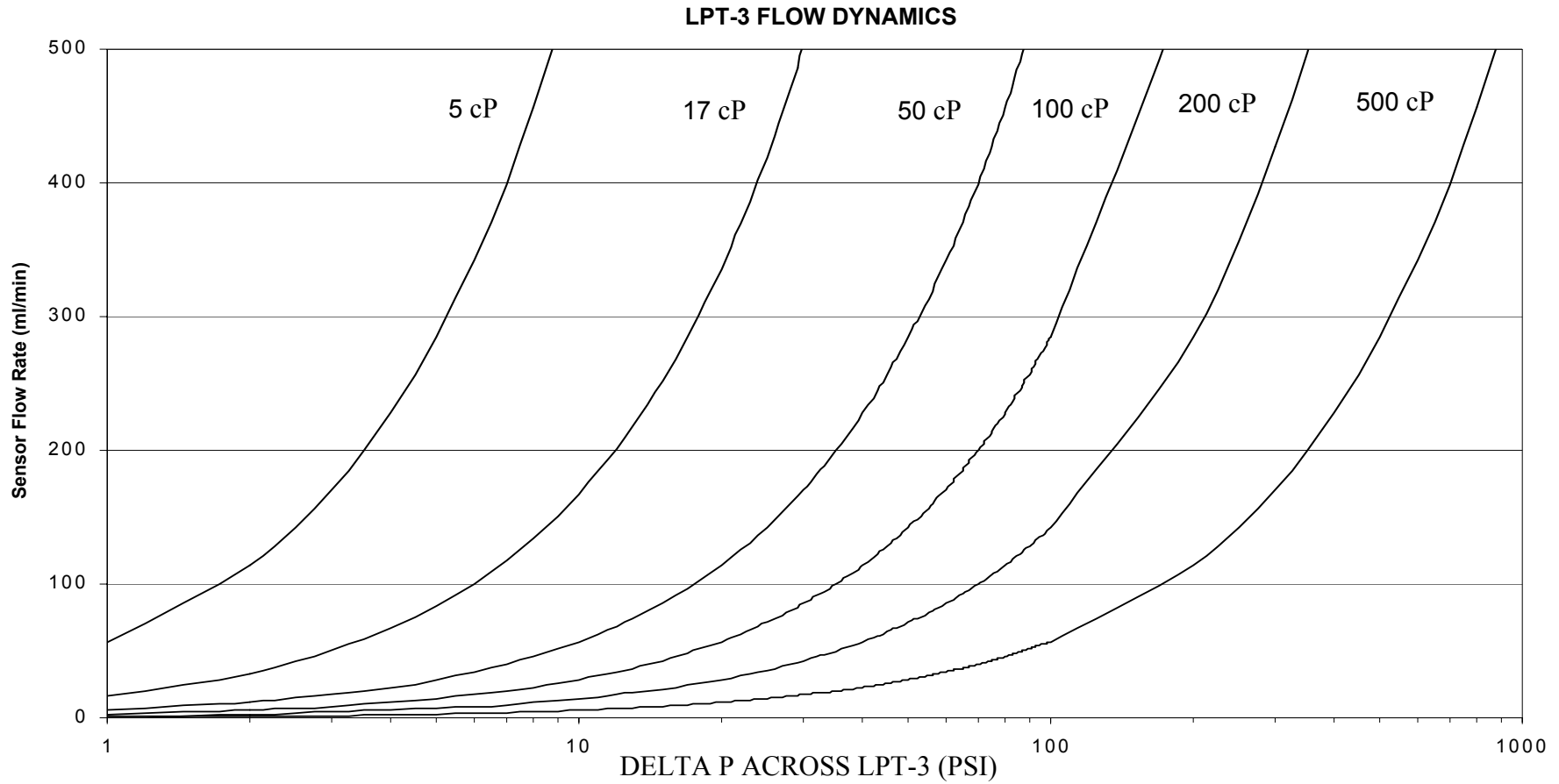
WARNING

Ensure power lines are de-energized before beginning procedure

Installation

The steps below and accompanying figures show a typical installation of the LPM system. There are five basic tasks:

1) Mounting transducer and interface module. The same mounting plate is used for LPT, LIM-3 and LIM-4, as shown in Figure 14.
2) Plumbing fluid sample inlet and outlet lines to LPT.
3) Electrical connection of DC power to both modules lines and data cable between LIM and data collection system.
4) Connecting fiber optic cable between LPT and LIM.
5) Connecting the data cable between the LIM and the data collection system

Instructions

1) Fasten mounting plate (with attached LPT) to a wall or other permanent fixture using standard construction practices. Refer to mounting plate dimensions in Figure 14.
2) If you ordered the LIM-3 or LIM-4 fasten it at the desired location (typically within 20' of the transducer) by repeating step 1 above. Maximum distance between the two units is 175' (53m). 20' of fiber optic cable is supplied.
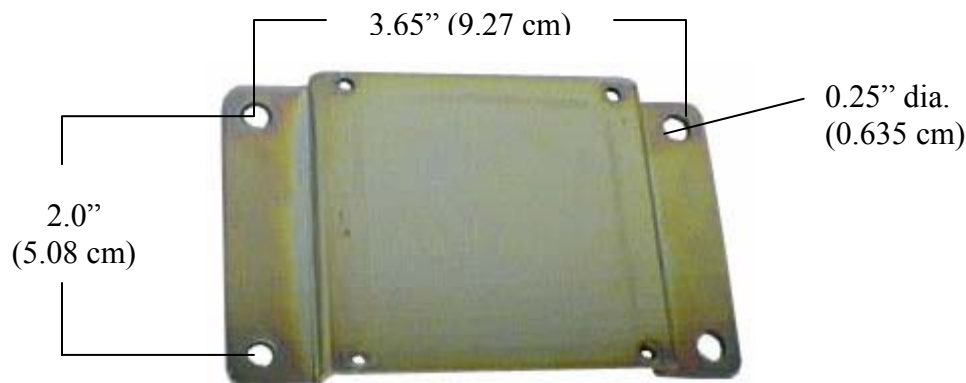
Figure 14. Mounting Plate Dimensions

WARNING

Verify that all hoses, microbore tube, rigid pipe, and fittings are rated at the maximum operating pressure of the fluid source before applying pressure.

CAUTION

Ensure the LPT you are installing is equipped with O-rings and seals compatible with the fluid in the system on which it is being installed. Some units are not compatible with fluids such as Skydrol.

3)   Connect the sample inlet hose to the proper fitting on the LPT in your system.
4)   Connect the other end of the hose to desired sample point in your system.
5)   Tighten the hose fitting to standard specifications. Connect the return hose between outlet port on the transducer in your system and the return reservoir or a downstream sample port. Tighten the hose fitting to standard specifications.

SAE-4 (1/4" dia.) inlet port

SAE-4 (1/2" dia.) inlet port

SAE-4 (1/4" dia.) inlet port

-1.-4.-7.-8

-2.-5

-3,-6

SAE-4 (1/4" dia.) outlet port (either end-swap fitting and plug)

SAE-8 (1/2" dia.) outlet port

SAE-4 (1/4" dia.) outlet port
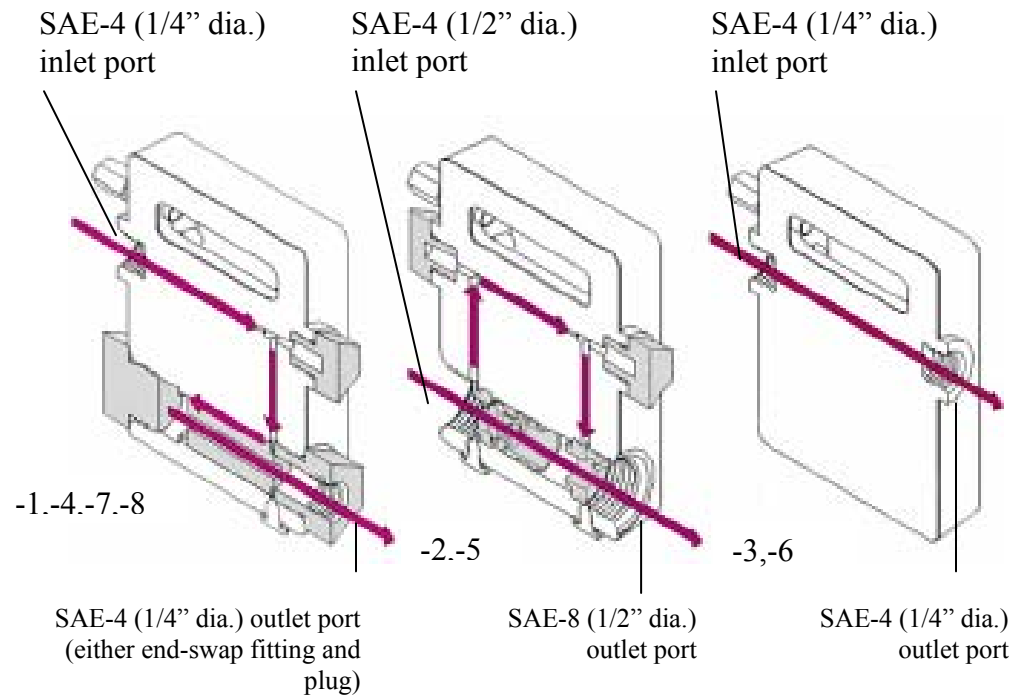
Figure 15. Transducer Inlet and Outlet Port Identification

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6) Apply a fluid source to the transducer; allow fluid to flow through the transducer to purge the system of <u>all</u> air bubbles. An indication of remaining air bubbles will be received power less than + 4.7 V and/or laser current greater than 60 mA.

Electrical Connections

7) Using standard electrical wiring practices, connect the red-jacketed DC input cable from the LPT to an *unenergized* +9 to +36 volt source with the white wire to positive (+) terminal of source, black wire to ground (-). The green wire on the cable should be attached to earth ground. Wire the power so that the LPM System can be turned off when the sample point or machine is inactive. A local power switch will allow the unit to be reset as is often required. Make remaining electrical connections using **one** of the following steps **a)**, **b)**, or **c)**, depending on the LIM in your system. Note that the computer must be a Pentium or better class of computer and have the communications port enabled in order to power the LIM correctly.
8) Connect the LPT transducer to the LIM interface module using the supplied fiber optic cable per instructions on page 38. (Ref: figure 19, page 38)

a) LIM-1: Power for theLIM-1 comes from the monitoring device (computer). Make connections as shown in Figure 16. Start a count cycle by energizing the power source to the LPT.

Hexadecimal Data
String to PC

IrDA link to
PDA

+9 to +36 VDC power
source
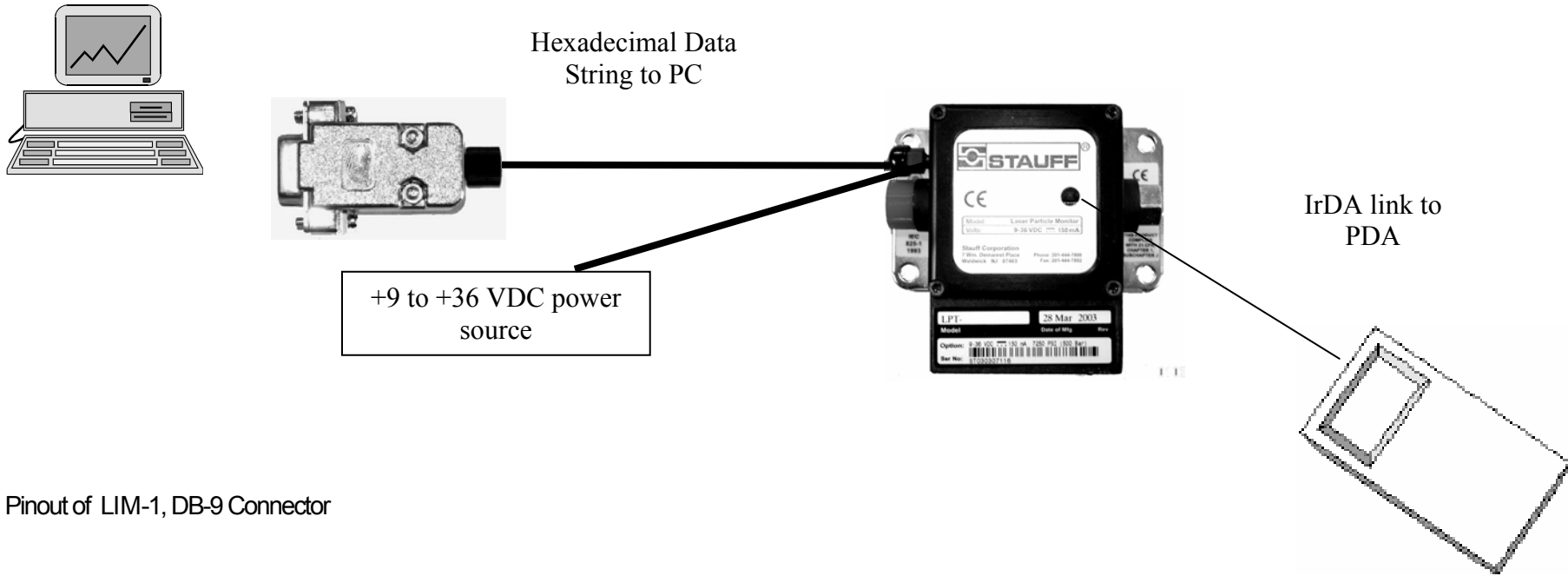
Pinout of LIM-1, DB-9 Connector

PIN	SIGNAL NAME	LIM -1	-2
1	(CD)	O	I
2	(RxD)	O	I
3	(TxD)	O	I
4	(DTR)	I	O
5	(GND)	-	-
6	(DSR)	O	I
7	(RTS)	I	O
8	(CTS)	O	I
9	(RI)	O	I

Note:
O = output
I = input

Figure 16. LIM-1, Signal Connections

b) LIM-3: The LIM-3 and the LPT in this configuration are each powered by their own external +9 to +36 V power source. Make connections as shown in Figure 17.

    1) Plug the break-out cable into the DB-15 connector of the LIM-3 interface module.

    2) Set up the LPT for Raw Data output as described under "Changing Operating Configuration" in the "Technical Data" section of this manual.

    3) a) for Modbus communications, connect the LIM-3 to a data acquisition system such as a PLC. Refer to Appendix B for protocol details.

      b) for greater distances to your readout device or for multiple LPM uses (-x3 only), connect RS485A, RS485B, and ground leads to an RS232-to-RS485 converter which, in turn, connects to the RS-232 port of your computer.

    4) A total of eight analog voltage channels are available for direct monitoring and logging of the LPT's data output. Analog channels 1-4 output a 0-5 V signal that is proportional to the ISO 4406 codes reported by the LPT. The remaining four channels may be assigned to report any of the following as analog voltages:

      Peak ISO 4406 code for any of the four particle size classifications

      Laser Current

      Photosensor Received Power

      Ambient Temperature

      The upper four analog output channels are assigned by writing to assigned Modbus registers. The specific Instructions are given in Appendix B.

    5) To start a count cycle, energize the power source to the Transducer and the Interface Module.

Fiber Optic Cable

IrDA link to PDA

breakout cable

+9 to +36 VDC power source (connect per step 10B)

+9 to +36 VDC power source (connect per step 8)

Pin	Signal Name
1	Pwr GND
2	DAC out 8
3	DAC out 6
4	DAC out 4
5	DAC out 2
6	RS 485 A
7	Shield GND
8	TxD
9	9 to 36 VDC in
10	DAC out 7
11	DAC out 5
12	DAC out 3
13	DAC out 1
14	RS 485 B
15	RxD

RS-232 to RS-485 converter

To computer

TxD

RxD

GND

Raw Data string using ModBus protocol to RS 232 port of a computer or to a PLC (transducer Node ID is required)

DAC 1

DAC 2

DAC 3

DAC 4

DC outputs equivalent to ISO 4406 Codes for 4 μm, 6 μm, 14 μm, and 21 μm channels DAC1 thru DAC4 respectively, where 2.8 vdc = ISO code 28

To data acquisition system (e.g., PLC)

Figure 17. LPM-4 Signal Connections (breakout cable shown)

c) **LIM-4:** The LPT in this configuration is powered using an external +9 to +36 VDC source and the LIM-4 can be powered with an external +9 to +36 VDC source or by an optional VDC source or by an optional +6 V battery. Make connections as shown in Figure 8.

1) Referring to LIM-4 pinout of Figure 18, connect leads from the voltage source selected to the appropriate pins of the cable connectors using safety-related wiring practices

2) If using the dry alarm contact closure feature to energize an external alarm indicator (light, siren, etc.), connect alarm leads to the appropriate pins of the connector.

3) Verify the LPT output format is set to R ("raw data") as established under "Changing Operating Configuration" in the "Technical Data" section.

4) To start a count cycle, energize the power source to the transducer (the 3-digit display will illuminate for 10 seconds when any key is pressed).

Pin	Signal
1	GND
2	Alarm Closure
3	Not Used

Alarm closure maximum rating: 35 VDC 100 mA.

Fiber Optic Cable

IrDA link to PDA

+9 to 36 VDC power source (connect per step 9C) or Battery Pack

+9 to +36 VDC power source (connect per step 8)

Pin	Signal
1	Battery (+)
2	Battery (-)
3	DC Supply (+)
4	DC Supply (-)
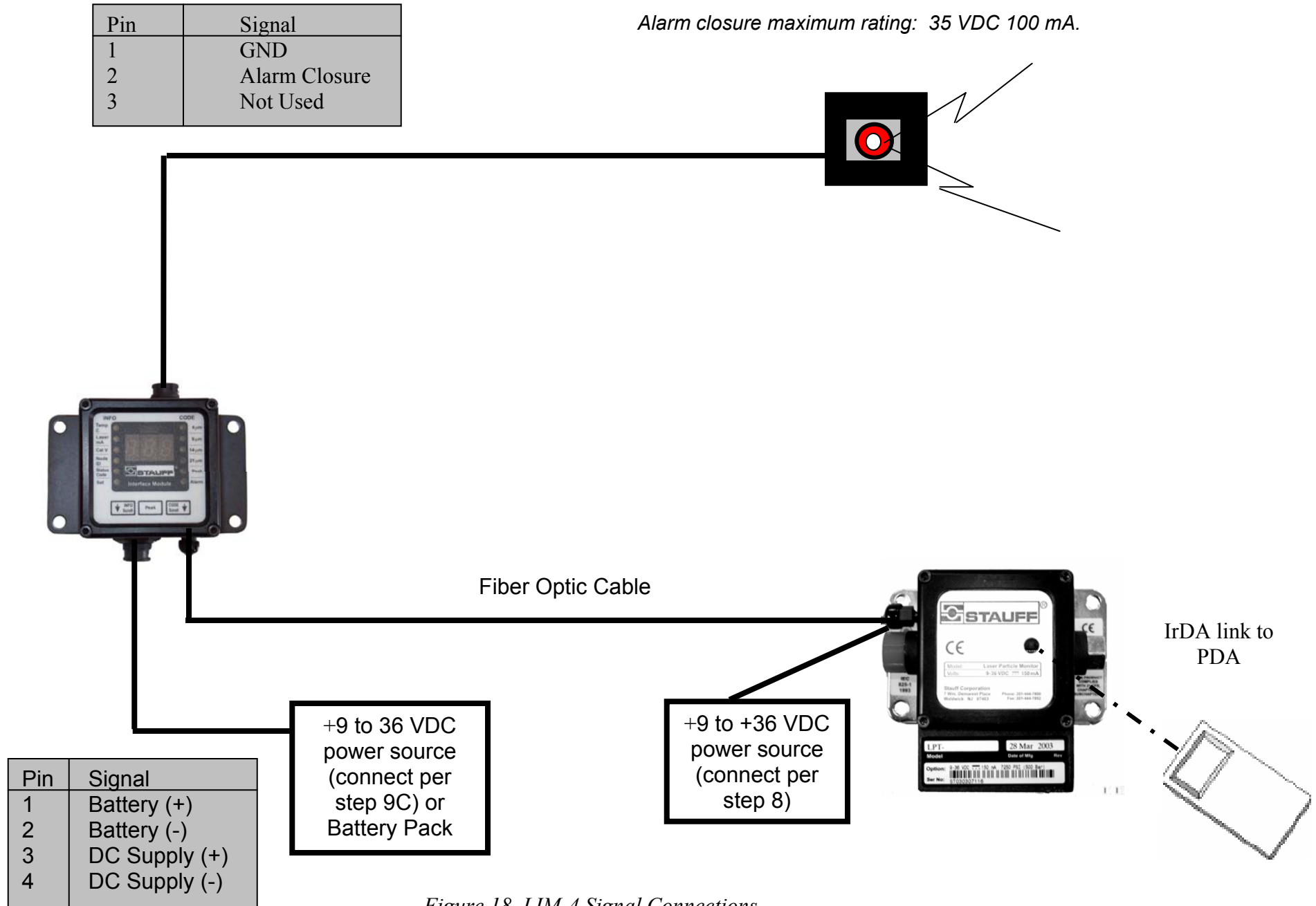
Figure 18. LIM-4 Signal Connections

Fiber Optic Connections

When connecting the supplied fiber optic cable between Transducer and Interface Module, cable ends must be precisely trimmed to a flat face for optimum light transmission. The maximum fiber optic length is 175' before signal degradation begins. Connect the fiber optic to the LPT using steps a) through e) below.

a) Remove nut and ferrule from LPT or LIM module

b) Slide nut then ferrule onto one end of the fiber optic cable

c) Insert fiber optic cable end into hole in LPT or LIM module where nut and ferrule were removed until cable stops

d) Tighten nut to 15 in-lbs

e) Repeat for each LPT and LIM module in system

After power is applied, check the LIM end of the fiber optic for a red glow to verify the installation was successful.

Fiber optic cable to LIM

OR

Fiber optic cable from LPT

fiber optic nut, ferrule

DC power input cable (red)
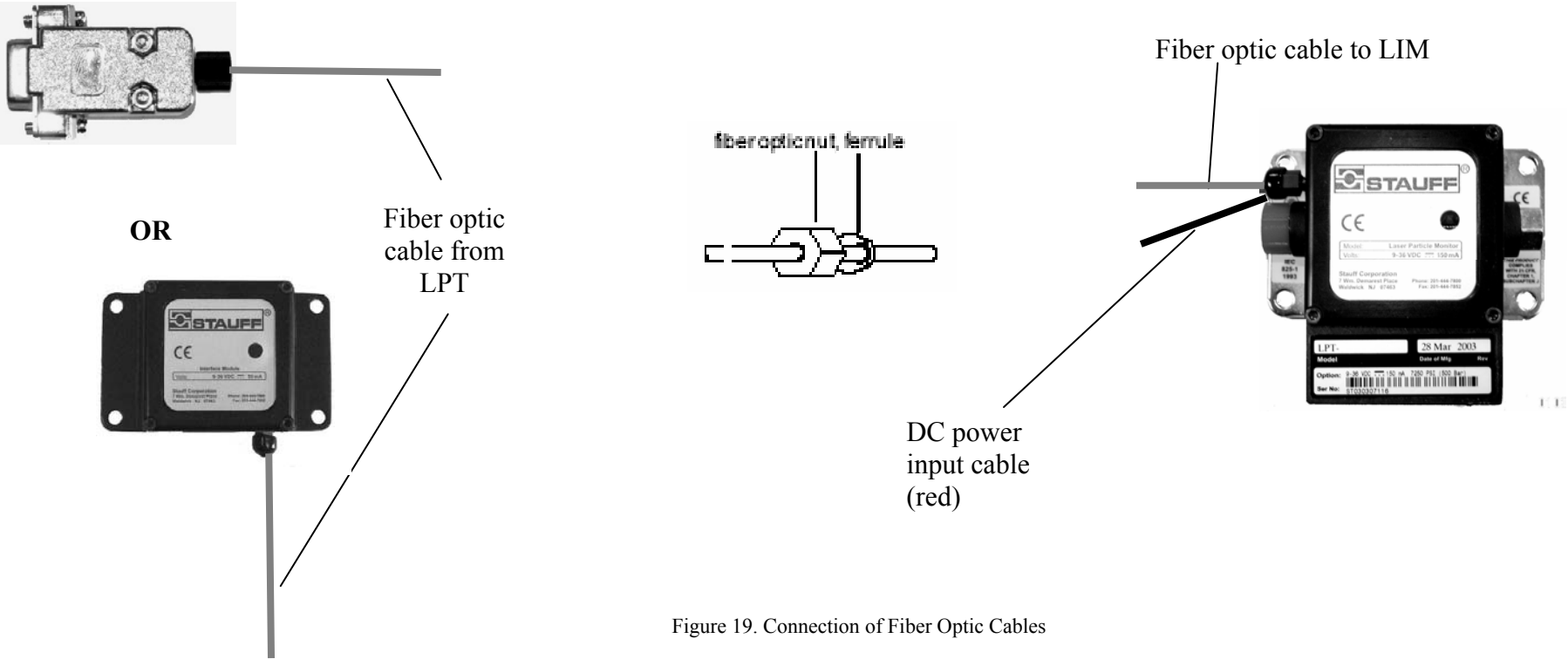
Figure 19. Connection of Fiber Optic Cables

Data Acquisition

In any data acquisition setup, it takes approximately two seconds to complete the data transmission. This time is added into the operating cycle of the system.

Using the LPM DDE Driver with the LIM-1

The LPM DDE Server interfaces between the LPM and DDE enabled software. It provides the links between the monitoring or analytical software and the counter's system data, sample data, and diagnostic data.

The LPM software will run on Windows 98, Windows ME, Windows 2000, and Windows NT. The system should be a Pentium or higher level with at least 64MB of RAM. To install the software, place the LPM DDE Server CD in your CD-ROM drive. Click on "Start," then "Run," and type the path to the "setup.exe" on the CD-ROM drive. For example, if your CD-ROM is drive D then you would type: d:\setup.exe. Choose your destination directory and click the button to continue. Choose the folder group where the program shortcut should be installed. This group will appear in the Start menu.

Windows 2000 and NT users note: *The program installation is user specific. If you install the program logged on as 'user A' and then log on later as 'user B' you will not see the LPM DDE Server shortcut in the Start Menu. Your system administrator should be able to add a shortcut for all users who will be using the software. Follow the rest of the prompts to complete the rest of the installation*
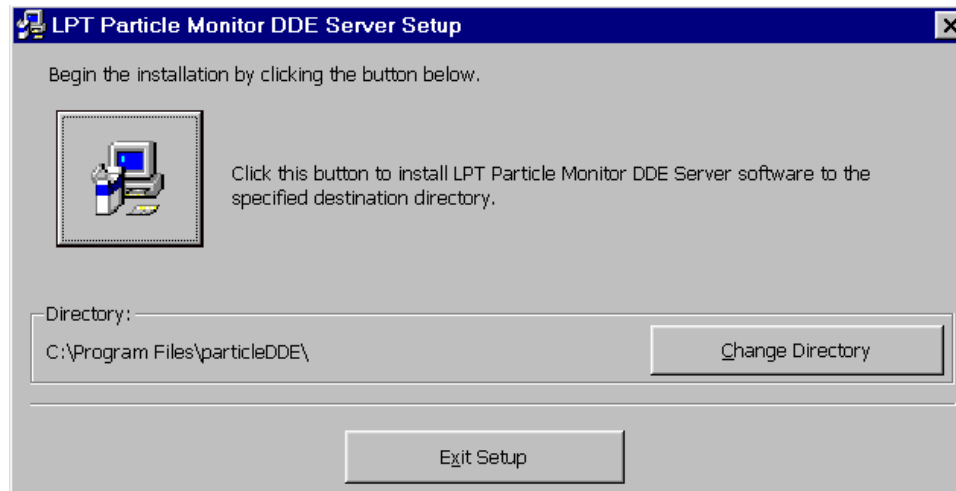
Security
     The LPM DDE Server software can be protected by a simple password to prevent unauthorized users from changing system settings or shutting down the software. The security system is activated by checking the box in the options menu and entering a password in the password field.   When the program is started, the Close menu and the Options menu will be grayed out. To access these menus, log on by using the Security menu.

Setting Up A Counter For The First Time
     Log on to the software and choose the Options Menu. Click on the Set-up Com Ports button.
     Check the box to enable the unit. Select the COM port from the drop down list to which the LPM is connected. A name can also be defined in this screen.
     To setup multiple counters, increase the number of supported counters in the Options screen (up to four) and click on the Set-up Com Ports button. Associate each counter with its appropriate COM port.
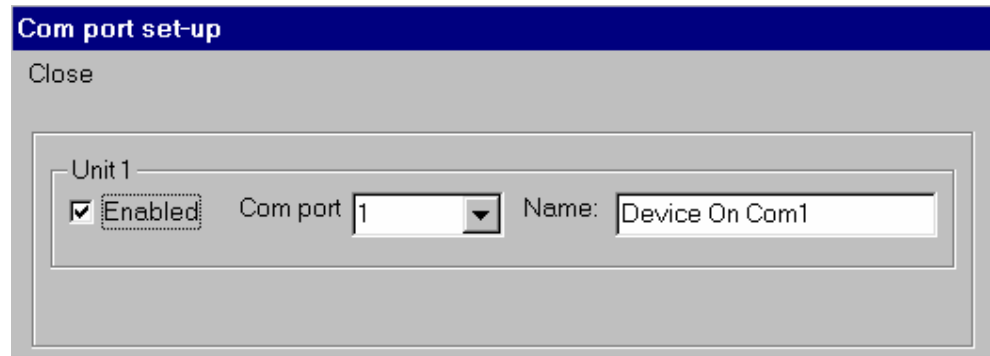
DDE Configuration

Once a counter has been configured, the DDE server waits for the updates from the counter and then makes that data available through DDE. The Raw Data screen displays the data from the counter and has the DDE connection instructions.

The Raw Data Screen can be accessed by selecting the View menu then Raw Data. Each box's data are available via DDE except the two boxes with the yellow background. To connect to the DDE Server, use the following information for Server, Topic, and Item names:

Server*: PARTICLEDDE*
Topic*: UNIT1-4*
Item*: Label of box*

For Example, Excel would use the following to connect to the 4 µm Counts:
=PARTICLE|unit1!ISOcode4um

Examples of Item labels
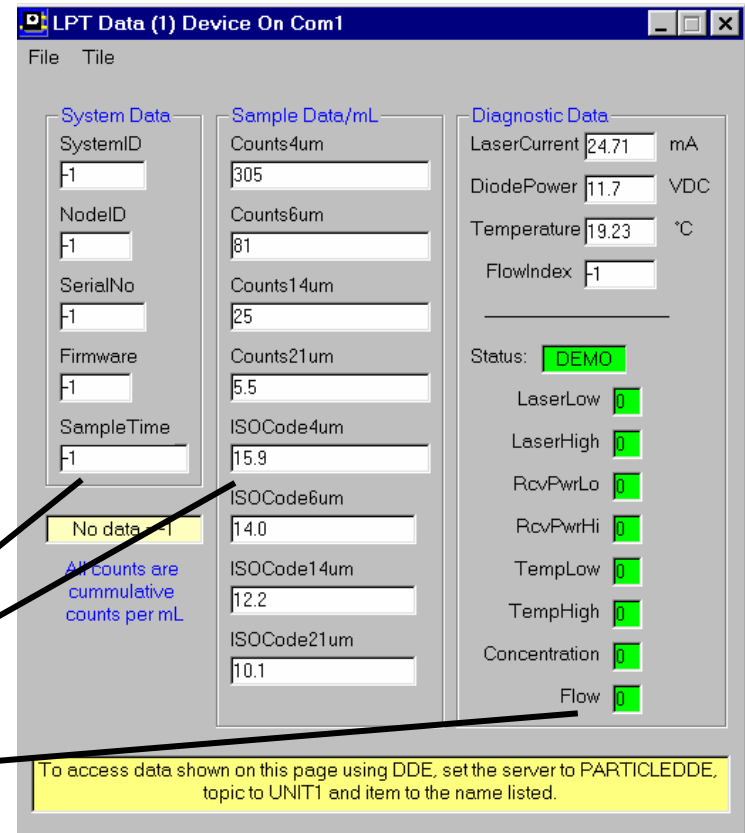
Figure 22. Raw Data Screen

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Multiple Installation Considerations Using Modbus Protocol

The LIM-3 has the capability for serial RS-485 data communication for networking with a controlling computer. The host computer controls activity on the serial link using protocol which is compatible with systems supplied by STAUFF.

Since single twisted-pair wiring is used, only one station can transmit at a time. It is a requirement of the system that each LPT have a unique node identification number. These ID numbers must be set prior to usage (see "Setting LPT parameters"). Data and commands are in the ASCII range while select numbers are not. Valid select numbers are in the range 1(1 Hex) to 247(FF Hex) and are sent as a single character.

To accommodate multiple monitor (RS-485) networking, you may need the following items:

RS-232/RS-485 converter — changes typical RS-232 serial output of computers to RS-485 (figure 23)

Wire, shielded, twisted pair (e.g., Belden PN 9841) — for connecting multiple LPM monitors

Figure 23 displays connecting information to an RS232-to-RS485 converter in applications of multiple LIM modules

RS485-type shielded cable only
(Belden 9841 or exact equivalent)

RS-485B to pin 6 of
each LIM-3 connector

FR.GND

Shield Gnd 1

Data (B) 2

Data (A) 3

GND 4

GND 5

+12V 6

S
B
A

RS-232 to RS-485
CONVERTER
P/n 2082382

To
Computer

To multiple LPM's

RS-485A to pin 14
of each LIM-3
connector

Jumpers shown in normal
configuration: RTS open, ECHO
off

AC Power Adapter

To Facility
Power
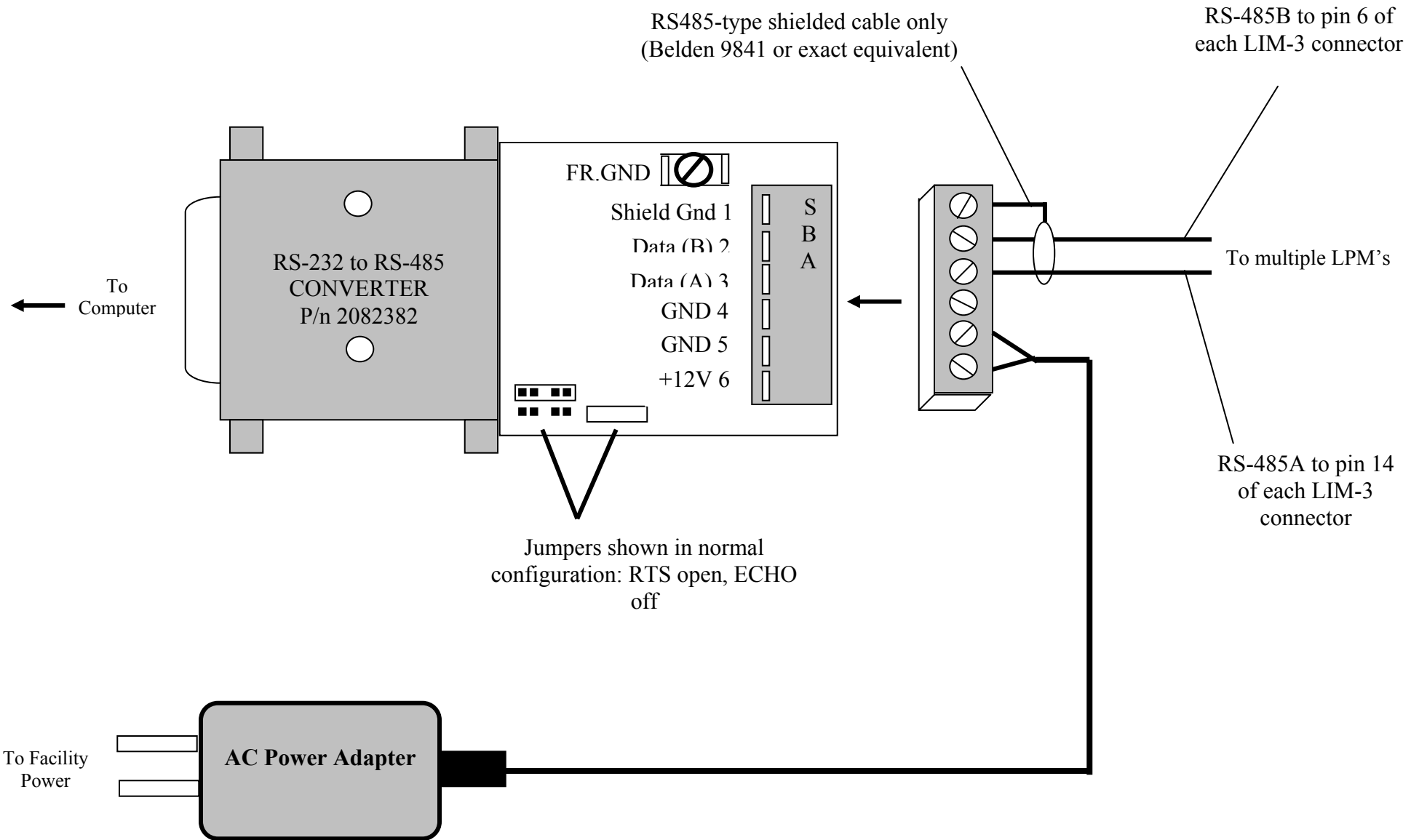
Figure 23. Using the RS232-to-RS485 Converter in Multiple Applications

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Raw Data Record Format

Each LPT transducer, regardless of model version, sends a record of its data. The raw data record is a serial bit stream of ASCII characters, where the position in the string identifies a character's meaning.

A sample string appears as follows:

;A10034A234A304dfA41AB102027a4B201e0140B300f003cB401cae2fB50003d8B60003d8B7001C11824C21824C311fC409c4C50caC60caC70c5C8122 D13bD21e0D321D480f4

Refer to "Serial Protocol Definitions" for complete description of the data record.

The system tracks the minimum and maximum levels of several parameters and reports the overall status as part of the post-sample data output transmission. In the example above, a flow index alarm (hex = 80; see App. A, Sect. 3e) was reported as active. The 4 µm Cumulative Counts/ml value (1186442) identifies this size channel as having a high level.

A system alarm appears on this line if system parameters are not operating within the following limits:

1. Particle concentration = up to ISO 28 (2.5 million counts/ml, based on 4 mchannel)
2. Sensor received power (Cal V) = 4.70 to 4.90 VDC
3. Laser drive current (Laser mA) = 30 to 62 mA
4. System temperature (Temp C) = -20 to 80° C
5. Flow Index = 40 to 350

Terminal Output Format

Terminal output format is used to provide a user friendly display on the IrDa device or other Terminal programs in your PC

Figure 24 is a typical example of a Terminal Output display:

SAMPLE RECORD #1537

Sample Duration = 15 Secs

4 μm Cumulative Counts/ml = 1186442
6 μm Cumulative Counts/ml = 1568
14 μm Cumulative Counts/ml = 390
21 μm Cumulative Counts/ml = 0.133

4 μm ISO Code = 27.8
6 μm ISO Code = 18.2
14 μm ISO Code = 16.2
21 μm ISO Code = 4.6
Flow Index = 130

RECEIVED POWER	=	4.83 VDC
LASER DRIVE CURRENT	=	0.048 A
SYSTEM POWER	=	5.03 VDC
SYSTEM TEMPERATURE	=	31.5 C
SYSTEM ALARMS	=	82
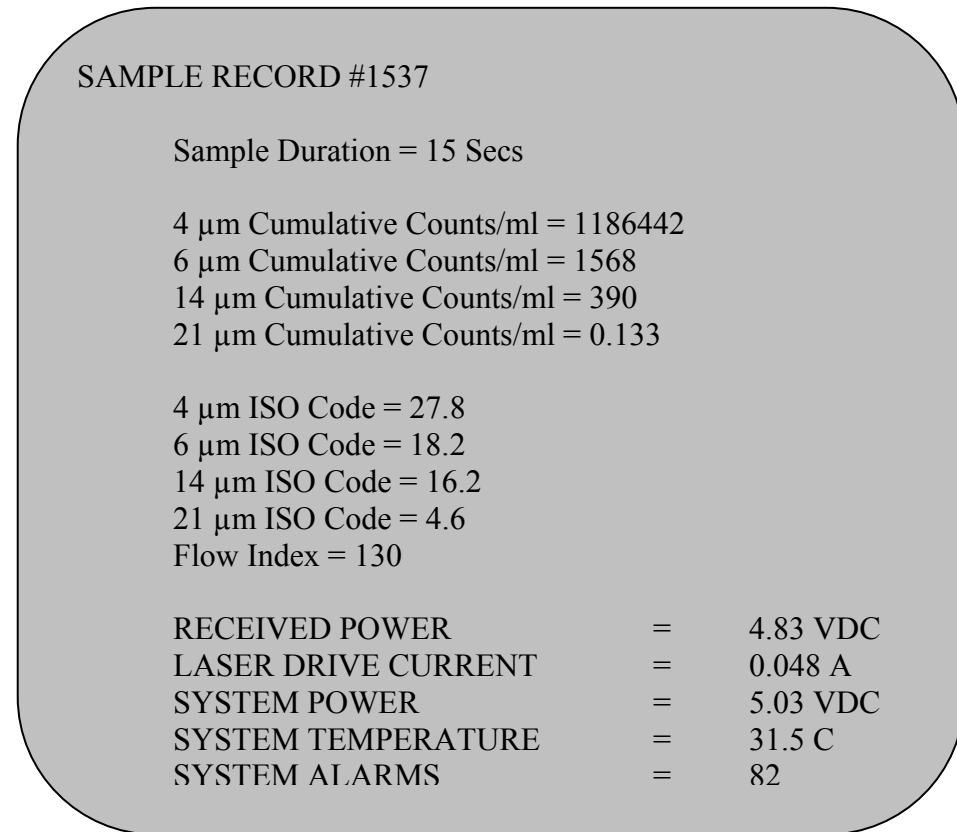
Figure 24. Terminal Output Display

Changing Interface Module DAC Assignments *(DAC 5-8)*

DAC outputs are assignable between the following two sets of parameters:

1. Laser Current, Received Power, System Power, System Alarms (default parameters)

2. Peak ISO codes for Ch 1 since power up, (same for Ch 2, Ch 3, Ch 4)

To change from one to the other, you must be familiar with and be able to communicate using ModBus protocol. Refer to "Standard Modbus Protocol Information" for detailed information on standard ModBus protocol.

Serial Protocol Definitions

1. Physical Layer:

    a. Serial bit stream - Optical fiber (plastic)

2. Data Link Control

    a. Asynchronous frame = 8 bits data (lsb first), 1 stop, no parity, 9600 baud rate

    b. Unidirectional, point-to-point link only

3. Message Format:

At the end of each sample period the LPT outputs a complete data message consisting of system data, sample data, diagnostics data and message checksum groups. Messages consist of a unique start character followed by specific groups of data. Each data field in the message group consists of a message identifier (2 alpha/numeric bytes) followed by 1 or more bytes of data. Data (sent in ASCII encoded hexadecimal 0-9/A-F) may represent whole integer or fixed decimal values as specified in the message field definitions that follow. Messages conclude with an 8-bit checksum followed by a carriage return - line feed. This checksum value is the sum (no carry) of all bytes in the message.

  a. Start of new message discriminator = ;

  b. LPT system data
      1. System Identifier = A1, 4 bytes (0xFFFF)
      2. Node Identifier = A2, 2 bytes (0 to 0xFF)
      3. Serial Number = A3, 4 bytes (0 to 0xFFFF)
      4. Firmware Version = A4, 2 bytes (0 0xFF)

  c. 1. B1, 7 bytes, reserved
      2. B2, 7 bytes, reserved
      3. B3, 7 bytes, reserved
      4. B4, 7 bytes, reserved
      5. B5, 6 bytes, reserved
      6. B6. 6 bytes, reserved
      7. Total sample time = B7, 3 bytes (0 to 0xE0F represents 00:00 to 59:59 mm:ss)

d. Sample data = see Note 1
    1. Channel 1 cumulative counts/ml=C1, 4 bytes (0 to 0xFFFF)
    2. Channel 2 cumulative counts/ml=C2, 4 bytes (0 to 0xFFFF)
    3. Channel 3 cumulative counts/ml = C3, 4 bytes (0 to 0xFFFF)
    4. Channel 4 cumulative counts/ml = C4, 4 bytes (0 to 0xFFFF)
    5. Channel 1 ISO code = C5, 3 bytes (0x0A to 0x121 represents 01.0 to 28.9)
    6. Channel 2 ISO code = C6, 3 bytes (0x0A to 0x121 represents 01.0 to 28.9)
    7. Channel 3 ISO code = C7, 3 bytes (0x0A to 0x121 represents 01.0 to 28.9)
    8. Channel 4 ISO code = C8, 3 bytes (0x0A to 0x121 represents 01.0 to 28.9)

e. Diagnostics data
    1. Laser Drive Current = D1, 2 bytes (0 to 0x46 represents .000 to .070 A)
    2. Photodiode Received Power = D2, 3 bytes (0 to 0x1F4 represents 0.00 to 5.00 vdc)
    3. Ambient Temperature = D3, 2 bytes (0 to 0x7F = positive C/0x80 to 0xFF = negative C).
    4. System alarm status = D4, 2 bytes (0 to 0xFF) - bit map, decode as follows:

        Bit 0 = laser drive current low alarm
        Bit 1 = laser drive current high alarm
        Bit 2 = photo diode received power low alarm
        Bit 3 = photo diode received power high alarm
        Bit 4 = system temperature low alarm
        Bit 5 = system temperature high alarm
        Bit 6 = concentration alarm
        Bit 7 =flow index alarm

Common Error Codes

LED display	Alarm Condition	Set Bits
001	Laser Current Low	Bit 0
002	Laser Current High	Bit 1
004	Photodiode Low Power	Bit 2
008	Photodiode High Power	Bit 3
010	Temperature Low	Bit 4
020	Temperature High	Bit 5
040	Concentration High	Bit 6
080	Flow Index	Bit 7

In some cases, multiple alarms may occur as shown below.

LED display	Alarm Condition	Set Bits
044	Concentration High and Photodiode Low	Bits 6, 2
005	Laser Current Low and Photodiode Low	Bits 0, 2
006	Laser Current High and Photodiode Low	Bits 1, 2
0A0	Flow Index and Temperature High	Bits 5, 7

     f. Message checksum

4. Example output message format:

```
;A12107A28aA304dfA41CB10000000B20000000B30000000
B40000000B5000000B6000000B7005C10000C20000C30000C4
0000C500C600C700C800D141D2009D319D44698<cr><lf>
```

Note 1 : Cumulative counts are scaled to fit 4 bytes as follows:

For ISO codes < 11.0, output represent counts in the form of x.xxx

For ISO codes > 23.6, output represent counts/1000.

For ISO codes 11.0 thru 23.6, output represents true counts.

Standard ModBus Protocol Information
This is a listing of the register map for the LIM Interface Module in accordance with Modbus standard protocol.

The Decoder recognizes:

Modbus standard Command 03: Read Holding Registers

Modbus standard Command 06: Preset Single Register (I.E., Load Single Register).

The Modbus Protocol stipulates that data is exchanged in the form of a Register, which consists of **2 Bytes**.
A 'Read' inquiry (Command 03) comes in thus:

Start Character(Colon)
Device Address (one byte HEX)—>our "Node" Identifier
Function Type (one byte HEX) —> Code 03, "Read Registers"
Start Address Hi Byte (HEX—always zero for us)
Start Address Low Byte (HEX-address of the Register the requestor wants output)
Number of Registers Hi Byte (HEX—always zero for us)
Number of Registers Lo Byte (HEX)
LRC Checksum of message (HEX 1 Byte)
ASCII Carriage Return-Line Feed

 The message returned is in the same standard Modbus format:
Start Character(Colon)
Device Address (one byte HEX)—>our "Node" Identifier
Function Type (one byte HEX) —> in this case Code 03, "Read Registers"
Byte Count (HEX)   **TWO bytes** per requested Register.
The data bytes, **TWO bytes** per requested number of Registers, higher address FIRST
LRC Checksum of message (HEX 1 Byte)
ASCII Carriage Return-Line Feed

Note:
In the event of a checksum error, the LED on the LIM-3 will blink steadily. See Figure 19 for illustration.

One special message is sent out using Code 03 to request the unit's assigned Node Identifier. The Node Identifier is the ID that Modbus uses to communicate with a particular unit. The request goes out in the form of a Broadcast with the Node Identifier set to 00. Technically, this violates the Modbus standard, since if a group of Enumerators were all attached to one RS485 control line, ALL would respond to this broadcast. However, we need a way to determine what a given unit's node ID is set to before we can talk to it. Therefore, this command must be used with ONLY ONE Interface Module hooked up to the controller's Comm port.

Model LPM

An example of a Broadcast Message would be: :000300220001DA
This says, in effect, "Send Command 3 to Node ID 0 and request one Register's worth of data located at Address 0022 (the address of the Node ID) as returned information."
A response from the Interface Module, assuming its Node ID is set to 0xA0, would be ":A0030200A0BB", translated as "Node A0 is sending back one register (2 Bytes) of data. The data are 00 A0".

The list of registers available for output via Modbus protocol using Command 03 are as follows:

Address		Function
HEX	DEC	
0x21	33	A1=Unit ID #1: 1 Register HEX (0 to 0xFFFF)
0x23	35	A2=Node ID: 1 Register HEX (0 to 0x00FF)
0x25	37	A3=Unit ID #2: 1 Register HEX (0 to 0xFFFF)
0x27	39	A4=Firmware Version: 1 Register HEX (0 to 0x00FF)
0x29	41	B1=Reserved
0x2D	45	B2=Reserved
0x31	49	B3=Reserved
0x35	53	B4=Reserved
0x39	57	B5=Reserved
0x3D	61	B6=Chan 4 event count: 2 Registers HEX (0 to 0x00FFFFFF)
0x41	65	B7=total sample time: 1 Register HEX (0 to 0x0E0F=0 to 59:59 minutes/seconds)
0x43	67	C1=Channel 1 cumulative counts/ml: 1 Register HEX (0 to 0xFFFF)
0x45	69	C2=Channel 2 cumulative counts/ml: 1 Register HEX (0 to 0xFFFF)
0x47	71	C3=Channel 3 cumulative counts/ml: 1 Register HEX (0 to 0xFFFF)
0x49	73	C4=Channel 4 cumulative counts/ml: 1 Register HEX (0 to 0xFFFF)
0x4B	75	C5=Channel 1 ISO Code: 1 Register HEX (0x0A to 0x0121=1.0 to 28.9)
0x4D	77	C6=Channel 2 ISO Code: 1 Register HEX (0x0A to 0x0121)
0x4F	79	C7=Channel 3 ISO Code: 1 Register HEX (0x0A to 0x0121)
0x51	81	C8=Channel 4 ISO Code: 1 Register HEX (0x0A to 0x0121)
0x53	83	D1=Laser Drive Current: 1 Register HEX (0 to 0x0046=0 to 70 ma)
0x55	85	D2=Photodiode Rcv Power: 1 Register HEX (0 to 0x01F4=0 to 5.00 VDC)
0x57	87	D3=Ambient Temperature: 1 Register HEX (0 to 0x007F=positive deg C 0x0080 to 0x00FF=negative deg C)
0x59	89	D4=System Alarm Status: 1 Register HEX (each bit decodes as an alarm status bit)
0x5B	91	Holds register# to put out to DAC port 5 (1 Register)
0x5D	93	Holds register# to put out to DAC port 6 (1 Register)

0x5F   95   Holds register# to put out to DAC port 7 (1 Register)
0x61   97   Holds register# to put out to DAC port 8 (1 Register)
0x63   99   holds peak ISO codes for C1 since power-up. (Power-up clears)(1 Register)
0x65   101   holds peak ISO codes for C2 since power-up. (Power-up clears)(1 Register)
0x67   103   holds peak ISO codes for C3 since power-up. (Power-up clears)(1 Register)
0x69   105   holds peak ISO codes for C4 since power-up. (Power-up clears)(1 Register)

A "Write to Single Register" Command 06 is used ONLY to assign a register's value to one of the assignable DAC voltage outputs 5,6,7,or 8. This is done by writing a register number corresponding to the storage address for the desired information into a pointer, or holding register, assigned to a given DAC channel.

The Pointer registers are:
0x5B   Holds register# to put out to DAC port 5 (1 Register)
0x5D   Holds register# to put out to DAC port 6 (1 Register)
0x5F   Holds register# to put out to DAC port 7 (1 Register)
0x61   Holds register# to put out to DAC port 8 (1 Register)

Valid entries for these 4 addresses are:
 0x0053 (Laser Current), 0x0055 (Rcv'd Power), 0x0057 (Ambient Temp)
 0x0063 (Peak ISO Ch 1), 0x0065 (Peak ISO Ch 2), 0x0067 (Peak ISO Ch 3), 0x0069 (Peak ISO Ch 4)

For example, if the user wishes to have DAC channel 5 latch a DC voltage which corresponds to the Ambient Temperature in degrees C, and DAC channel 6 latch Received Power, then the Register at 0x5B will be loaded with 0x0057 and the Register at 0x5D will be loaded with 0x0055.

   Subsequent data from the Interface Module Enumerator, will cause a DC voltage corresponding to the Ambient Temperature to appear at DAC Output 5, and DAC output 6 will show photodiode Received Power.

A 'Write Inquiry (Command 06) comes in thus:

Start Character(Colon)
Device Address (one byte HEX)—>our"Node" Identifier
Function Type (one byte HEX) —> Code 06, "Write Single Register"
Start Address Hi Byte (HEX—always zero for us)
Start Address Low Byte (HEX-address of the Register the requestor wants output)
Data first Byte (goes into FIRST address; e.g., 0x30)
Data second Byte (goes into SECOND address; e.g.., 0x31)
LRC Checksum of message (HEX 1 Byte)
ASCII Carriage Return-Line Feed

If received and correct, this message will be echoed back verbatim.

Operatrion

Operation of the LPM monitoring system is by remote data collection at a PC station using monitoring software, , by reading the LED display, of by using a PDA device running terminal software to collect data directly from the IrDA Port on the LPT at the point of use.

Indicators and Controls

The only LPM system components with user controls or indicators are the LIM –3, -4 and -5; along with the LPT-4, -8 and -0 which are similar to the LIM-4 and -5. It is important to remember the distinction between the IrDA window on the LPT and the status LED on the LIM-3.

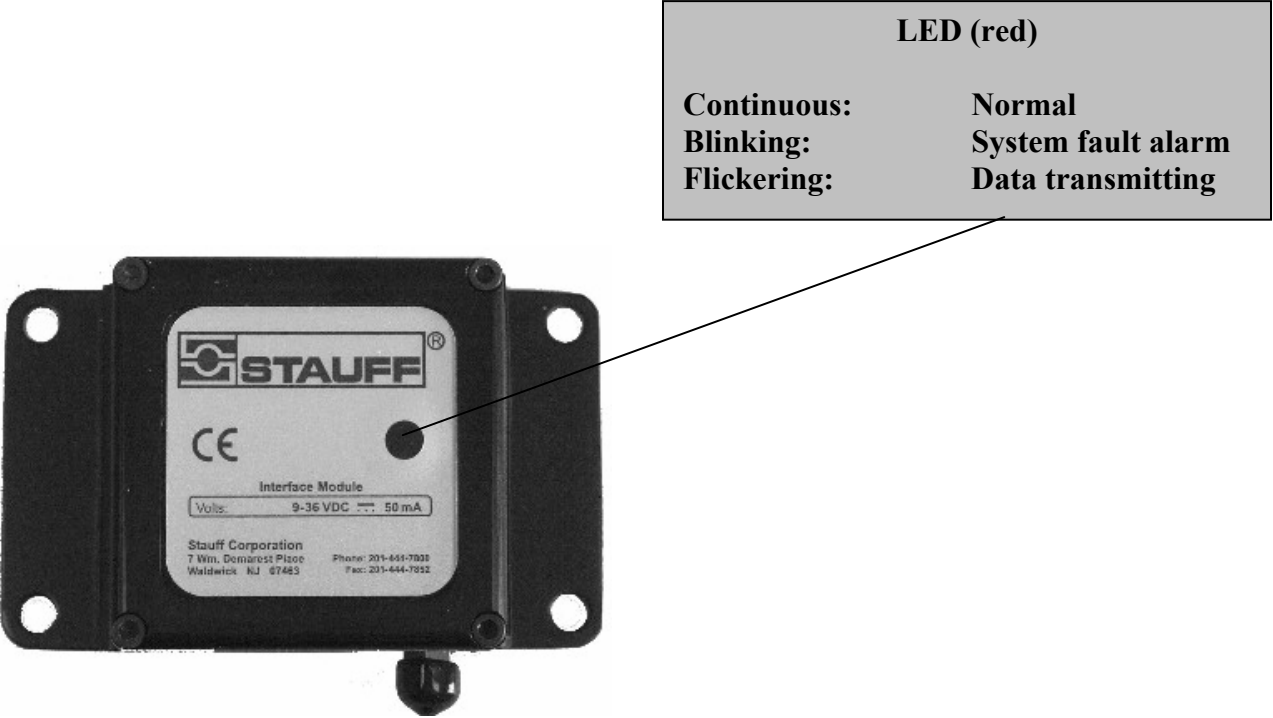| LED (red)	
Continuous:	Normal
Blinking:	System fault alarm
Flickering:	Data transmitting

Figure 25. LIM-3 Indicator Location

In the LIM-4 and -5 interface module and LPT-4, -8 and -0 transducers, each key has a specific function and each indicator has a specific meaning when illuminated. Figure 20 shows the location of each key and indicator.

(1) **ISO** LEDs: 4 µm, 6 µm, 14 µm, 21 µm when on steady indicates selected size range for display, when flashing indicates alarm limits have been exceeded for that size.

(2) **Peak** LED indicates the peak value recorded since the last time power was turned off.

(3) **Alarm** LED flashes 4 times during power up, and flashes along with the selected size range LED when a set alarm limit has been exceeded.

(4) **ISO Scroll Down** key - for selecting one of four ISO codes. When pressed with INFO Scroll Down key, allows for setting the right hand digit of an ISO code alarm value. Press both keys when finished setting alarm.

(5) **Peak** key - activates the peak value recorded since the last reset; also when setting an ISO code alarm value (see   and   ) sets the center digit.

(6) **INFO Scroll Down** key - for scrolling through INFO selections and viewing the status code. Also, when pressed with ISO Scroll Down key, allows for setting the left hand digit of an ISO code alarm value. Press both keys when finished setting alarm.

(7) **SET** LED illuminates during an alarm and while setting an alarm level. Alarm levels are non-volatile and will remain set until set again

(8) **Status Code** LED flashes during a system alarm. The LED display shows the status code message if a system alarm occurs (code is in hexadecimal format--see "Serial Protocol Definitions" for more information).

⑨ Info LED's:
Temp C processor's internal temperature is being displayed (-40 degrees C to 85 degrees C).

Laser mA current of the sensor laser is being displayed (30 to 65 mA).

CAL V photo detector voltage is being displayed (4.7 to 4.9 vdc).

Node ID the identification assigned this unit is being displayed (1 to 247).

⑩ **3-digit LED** displays: a) value of selected function / parameter or b) the status code message if a system alarm occurs, (code is in hexadecimal format – see "Serial Protocol Definitions" for more information). If the PT4000 is not configured for Raw Data Mode, the LED Display is disabled and will display "000."

⑪ **IrDA port** for accessing the transducer's raw data record or for changing transducer test / operating parameters.

Figure 26. LIM-4,-5 and LPT4000-4,-8 ,-0 Indicators and Controls (LIM0 shown)

Notes:
When operating on battery power, the LIM-4,-5 will turn off after 10 seconds of inactivity to conserve battery life. Press any key to restore operation. If it becomes necessary to clean the LPM, take care not to inadvertently press keys on the front panel, as undesirable operations may be accidentally initiated.

Setting Alarm Limits on the LED Display

The LED Display can be programmed to alarm at a specified contamination level. Alarm limits are based on ISO codes and the channels may be set independently of one another (i.e., four different alarm levels for each of the four size channels may be set). The alarm limits are typically set to indicate when a fluid reaches a high contamination level (unacceptably dirty) with the LIM-4. Alarm limits are typically set to indicate when a fluid reaches a low contamination level with the LIM-5.

Programming is done at the LED Display's panel, using the buttons specified in Figure 26 on page 55. These buttons will be referred to as #4, #5, and #6, in keeping with the nomenclature in Figure 26.

1. Scroll through the size channels by pressing #4 until the ISO LED is beside the desired channel.
2. Press #4 and #6 simultaneously to begin programming.
3. You should now see the alarm level. "00.0" indicates there is no alarm limit for this channel (default).
4. Use #4, #5, and #6 to enter the ISO code alarm limit (maximum of 29):
    a. Use #6 to change the digit in the "tens" position to the desired number (0, 1 or 2).
    b. Use #5 to change the digit in the "ones" position to the desired number (0-9) .
    c. Use #4 to change the "tenths" position digit to the desired number (0-9).
5. Press #4 and #6 simultaneously to end programming.

At this point, the LPM will resume sampling and will monitor for the set alarms. When the programmed ISO code is exceeded, a visual alarm is seen on the display, as described on pages 54-55 of the manual.

The programmed alarm condition is also available on the LIM-4 data/signal-out line. These are the dry contact closures to drive external alarms such as strobe lights and sirens.

Troubleshooting Tips

The mechanical and electrical parts of the LPM are rugged enough to sustain routine operation for extended periods. The following tips may help solve problems that can occur during normal daily use. If additional assistance is required, contact Technical Support (see page 8 for contact information).

High laser current/low received power values may be caused by air bubbles or a blockage in the sensor. Check the flow rate through the sensor by taking a sample off the LPM output (e.g., via a minimess sampling port). While taking the sample, check the effluent for visible air bubbles. If the flow is unblocked and no air bubbles are present, the LPM may need servicing and you should contact Technical Support (page 8).

Counts/ml indication dropped to near zero may be a plugged flow control valve, if using a LPT-1. The flow control valve should only be removed with a flow control removal tool (PN #3050765); removal of the flow control by other means will void the warranty and could damage the LPT and/or flow control valve.

Erratic count levels and oil deposits on the IrDA window of your LPT are indications of an internal leak. Check to ensure that the system flow rate and pressure are within your LPM's operating specifications. If the system is within specifications and the LPM is still displaying erratic counts, check the flow for bubbles, as described above. If the erratic counts persist, contact Technical Support (page 8).

LED display shows all zeroes and disabled DDE is caused by having the mode set to "Terminal" rather than "Raw." Refer to "Setting the LPT Parameters" in the "Programming the LPT" section.

Uneven lighting in the LED display is normal and a function of the compact design of the LPM. It is normal for the digit "1" to appear brighter than the digit "8," for example.

Specifications

LPT:

Operating Power
   9 to 36 VDC (±10%) @150 mA (max.)
Weight (includes mounting bracket):
   LPT-1, -7, -9: 2 lbs., 12 oz. (1.26 kg.)
   LPT-4, -8, -0: 2 lbs., 13 oz. (1.28 kg.)
Dimensions (WxHxD, includes projections, excludes bracket):
   LPT-1, -7, -9: 3.7 x 3.4 x 1.4 in. (9.4 x 8.7 x 3.6 cm)
   LPT-4, -8, -0: 3.7 x 3.4 x 1.8 in. (9.4 x 8.7 x 4.6 cm)
Fluid Compatibility
   Mineral and synthetic-based hydraulic oils; lubricating oils; optional Phosphate Esters (e.g., Skydrol)
Wetted Materials
   SAE 1020 steel, Spring steel, Synthetic Sapphire, Chromium Zinc, Bronze, Aflas, Buna-N
   Note: Skydrol compatible units do not contain Buna-N
Fluid Pressure
   7,250 psig (500 bar) maximum
Fluid Temperature
   -4 °F to 176° F (-20 °C to 80 °C)
Viscosity Range
   2 cSt (15 SUS) and greater
Pressure/Flow Range
   LPT-1: 400-7250 psi
   LPT-7: 50-1200 psi
   LPT-9: 20-200 PSI

LIM:

ISO Code Ranges
   4 μm, 6 μm, 14 μm, 21 μm
Operating Power
   9 to 36 VDC (±10%) @150 mA (max.)
Weight (includes mounting bracket):
   LIM-3:   9.4 oz.   (266 g.)
   LIM-4, -5:   10.6 oz. (301 g.)
Dimensions (WxHxD), inc. projections, exc. bracket):
   LIM-1:   1.2 x 2.0 x 0.6 in. (3.1x5.1x1.5 cm)
   LIM-3:   2.4 x 2.6 x 1.0 in. (6.1x6.6x2.5 cm)
   LIM-4, -5:   2.4 x 2.6 x 1.4 in. (6.1x6.6x3.6 cm)

Both:

Environment -Operating:(see chart and Note)
      -4 °F to 140 °F (-20 °C to 60 °C) 20 to 95% relative humidity, non-condensing
   Storage:
      -40 °F to 185 °F (-40 °C to 85 °C) up to 98% relative humidity, non-condensing

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Note:

In order to protect the laser diode, The LPM will automatically adjust the "Duty Cycle" as temperature increases. The Duty Cycle is the ratio of the Sample Period to the total time between data output (which is the sum of the Sample Period and the Sample Hold, or hold time). The factory setting is for a Sample Period of one minute and a Sample Hold of four minutes.

When the operating temperature exceeds 60 °C, the Duty Cycle will decrease to 50%; above 70 °C, the Duty Cycle drops to 25%; above 75% the Duty Cycle drops to 10%; and at 80 °C, the Duty Cycle drops to 0.1%.

The LPM adjusts the Duty Cycle by changing the Sample Hold time only. The Sample Period will not change.

It is important to note that if the sensor detects a temperature above 80 °C, it will go into a 0.1% Duty Cycle and will be dormant for an extended period of time – approximately 17 hours, using factory settings. The LPM will <u>NOT</u> check the operating temperature again until the end of the cycle.

For example, if a LPM with factory settings detects an operating temperature of 42 °C, it will output data every five minutes: 1 minute of sampling and 4 minutes of hold time.

If the operating temperature rises to 72 °C, the unit makes no changes. Above 70 °C, the LPM is forced into a 25% Duty Cycle. However, the factory setting is already at 20%, so there is no change to the operation of the LPM so, the LPM would continue outputting data every five minutes.

If, at the end of one of these cycles, the operating temperature were found to be 83 °C, the LPM would force a duty cycle of 0.1% by adjusting the Sample Hold to 999 minutes. At this point, the LPM will not take another reading for 16 hours 40 minutes. Even if the operating temperature returned to 72 °C after only three minutes, the LPM will NOT resume normal sampling for 16 hours 40 minutes.

This can, of course, be circumvented by cycling power to the LPM; turning the unit off and then on again will reset the LPM.

There is a minimum hold time in Raw Data mode of 2 sec. and in Terminal mode of 15 sec

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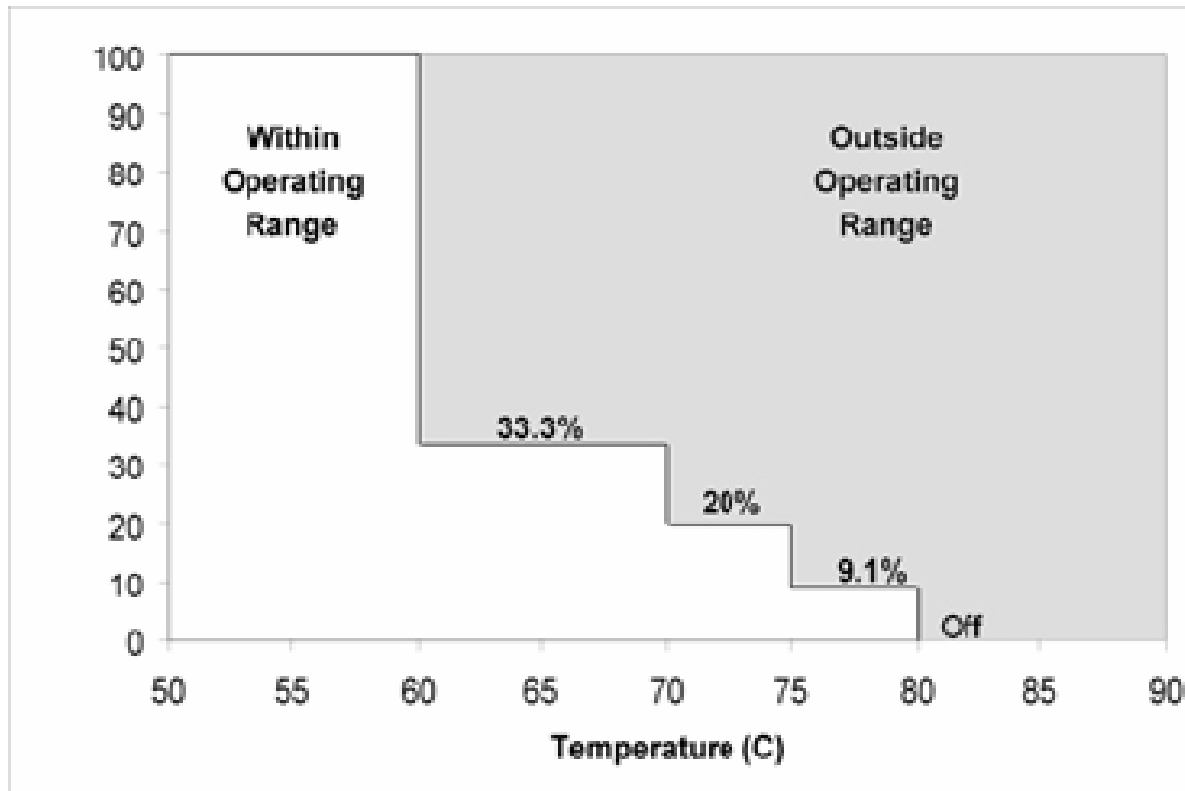
APPENDIX A - HIAC 4406 Codes
(Based on ISO 4406)

To convert HIAC codes to ISO codes, simply delete all digits to the right of the decimal point, **without** rounding. For example. A HIAC code readout of 7.2 would correspond to an ISO code of 7, and a HIAC code of 7.8 would also correspond to an ISO code of 7. The sample period should be set to achieve a statistically significant number of particles in the sample. For expected ISO code ranges of 12 And greater, a one minute sample time should be sufficient. Below that, the sample period should be doubled for each one ISO code level. For example, use a two minute sample at ISO code 11.

HIAC CODE #	Particle Count/ml >				
5.0	**0.160**	**8.0**	**1.300**	10.8	9.0
5.1	0.176	8.1	1.42	10.9	9.5
5.2	0.192	8.2	1.54	**11.0**	**10**
5.3	0.208	8.3	1.66	11.1	11
5.4	0.224	8.4	1.78	11.2	12
5.5	0.240	8.5	1.90	11.3	13
5.6	0.256	8.6	2.02	11.4	14
5.7	0.272	8.7	2.14	11.5	15
5.8	0.288	8.8	2.26	11.6	16
5.9	0.304	8.9	2.38	11.7	17
6.0	**0.320**	**9.0**	**2.50**	11.8	18
6.1	0.352	9.1	2.75	11.9	19
6.2	0.384	9.2	3.00	**12.0**	**20**
6.3	0.416	9.3	3.25	12.1	22
6.4	0.448	9.4	3.50	12.2	24
6.5	0.480	9.5	3.75	12.3	26
6.6	0.512	9.6	4.00	12.4	28
6.7	0.544	9.7	4.25	12.5	30
6.8	0.576	9.8	4.50	12.6	32
6.9	0.608	9.9	4.75	12.7	34
7.0	**0.640**	**10.0**	**5.0**	12.8	36
7.1	0.706	10.1	5.5	12.9	38
7.2	0.772	10.2	6.0	**13.0**	**40**
7.3	0.838	10.3	6.5	13.1	44
7.4	0.904	10.4	7.0	13.2	48
7.5	0.970	10.5	7.5	13.3	52
7.6	1.036	10.6	8.0	13 4	56
7.7	1.102	10.7	8.5		
7.8	1.168				
7.9	1.234				

HIACCODE #	Particle Count/ml	HIACCODE #	Particle Count/ml	HIACCODE #	Particle Count/ml	HIACCODE #	Particle Count/ml
		16.0	**320**	18.7	2140	21.5	15000
		16.1	352	18.8	2260	21.6	16000
		16.2	384	18.9	2380	21.7	17000
13.6	64	16.3	416	**19.0**	**2500**	21.8	18000
13.7	68	16.4	448	19.1	2750	21.9	19000
13.8	72	16.5	480	19.2	3000	**22.0**	**20000**
13.9	76	16.6	512	19.3	3250	22.1	22000
14.0	**80**	16.7	544	19.4	3500	22.2	24000
14.1	88	16.8	576	19.5	3750	22.3	26000
14.2	96	16.9	608	19.6	4000	22.4	28000
14.3	104	**17.0**	**640**	19.7	4250	22.5	30000
14.4	112	17.1	706	19.8	4500	22.6	32000
14.5	120	17.2	772	19.9	4750	22.7	34000
14.6	128	17.3	838	**20.0**	**5000**	22.8	36000
14.7	136	17.4	904	20.1	5500	22.9	38000
14.8	144	17.5	970	20.2	6000	**23.0**	**40000**
14.9	152	17.6	1036	20.3	6500	23.1	44000
15.0	**160**	17.7	1102	20.4	7000	23.2	48000
15.1	176	17.8	1168	20.5	7500	23.3	52000
15.2	192	17.9	1234	20.6	8000	23.4	56000
15.3	208	**18.0**	**1300**	20.7	8500	23.5	60000
15.4	224	18.1	1420	20.8	9000	23.6	64000
15.5	240	18.2	1540	20.9	9500	23.7	68000
15.6	256	18.3	1660	**21.0**	**10000**	23.8	72000
15.7	272	18.4	1780	21.1	11000	23.9	76000
15.8	288	18.5	1900	21.2	12000	**24.0**	**80000**
15.9	304	18.6	2020	21.3	13000	24.1	88000
				21.4	14000	24.2	96000

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24.3	104000	27.2	772000
24.4	112000	27.3	838000
24.5	120000	27.4	904000
24.6	128000	27.5	970000
24.7	136000	27.6	1036000
24.8	144000	27.7	1102000
24.9	152000	27.8	1168000
25.0	**160000**	27.9	1234000
25.1	176000	**28.0**	**1300000**
25.2	192000	28.1	1420000
25.3	208000	28.2	1540000
25.4	224000	28.3	1660000
25.5	240000	28.4	1780000
25.6	256000	28.5	1900000
25.7	272000	28.6	2020000
25.8	288000	28.7	2140000
25.9	304000	28.8	2260000
26.0	**320000**	28.9	2380000
26.1	352000	**≥ 29.0**	**2500000**
26.2	384000		
26.3	416000		
26.4	448000		
26.5	480000		
26.6	512000		
26.7	544000		
26.8	576000		
26.9	608000		

*To convert HIAC codes to ISO codes, simply delete all digits to the right of the decimal point, **without** rounding. For example. A HIAC code readout of 7.2 would correspond to an ISO code of 7, and a HIAC code of 7.8 would also correspond to an ISO code of 7.*

While the ISO 4406 scale represents a doubling of counts between each code, the added decimal value used in the HIAC codes represents a linear spacing of the counts between codes. The HIAC codes are intended to give a practical and easy to understand reading of the range of values between ISO codes.

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