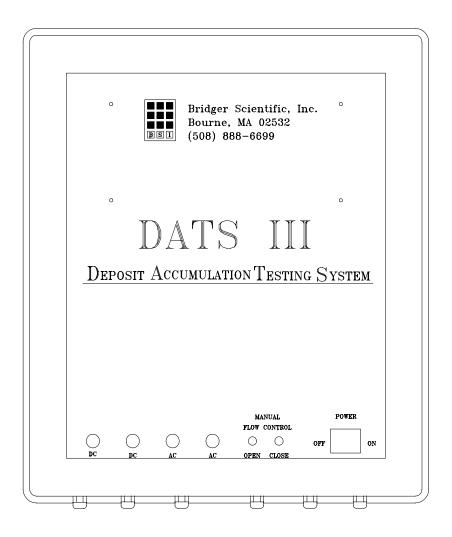
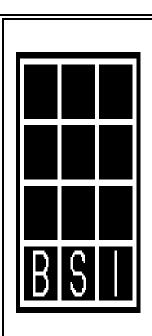
DATSTMIII FOULING MONITOR SYSTEM OPERATIONS GUIDE



DATS[™]-III Deposit Accumulation Testing System



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DATSTMIII FOULING MONITOR
OPERATIONS GUIDE

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Deposit Accumulation Testing System:

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! WARNING ! WARNING ! WARNING ! WARNING ! WARNING !

- EACH DATSTM SYSTEM REQUIRES A SEPARATE 115 VAC, 15 AMP, 50/60 HERTZ, GROUND FAULT INTERRUPT CIRCUIT. (EQUIPMENT MANUFACTURED FOR THE INTERNATIONAL MARKET IS WIRED FOR 240 VAC, 7.5 AMP, 50/60 HERTZ).
- NO OTHER EQUIPMENT SHOULD BE CONNECTED TO EACH DEDICATED DATSTM POWER CIRCUIT.
- UNPLUG AND TURN OFF POWER WHEN WORKING INSIDE ANY DATSTM ENCLOSURE.
- DURING NORMAL OPERATION, UP TO 1000 WATTS OF POWER MAY BE USED BY THE HEATING ELEMENT WITHIN THE DATSTM. USE CAUTION WHEN DISASSEMBLING THE HEAT EXCHANGER AFTER RECENT OPERATION.
- DATSTM COMPONENTS ARE CONTAINED WITHIN UNRATED MOISTURE AND SPLASH RESISTANT HOUSINGS WHICH ARE NOT RATED AS EXPLOSION PROOF.

! WARNING ! WARNING ! WARNING ! WARNING ! WARNING !

DEPOSIT ACCUMULATION TESTING SYSTEM

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GENERAL NOTES

Introduction 1

1.0 INTRODUCTION

The **D**eposit **A**ccumulation **T**esting **S**ystem (**DATS**TM) Fouling Monitor is a microprocessor based, data acquisition system designed to control, monitor and report all parameters necessary to perform heat transfer analysis. As deposits (scaling, microbial slime, sediments) accumulate, the tube surface becomes thermally insulated, and the change in **H**eat **T**ransfer **R**esistance (**HTR**) is electronically reported. Changes in **HTR** due to corrosion and corrosion products may also be detected.

1.1 General Principles

The DATSTM system is designed to simulate the geometry and heat flux of a shell and tube heat exchanger, where the cooling fluid circulates on the tube side. An electrical heating element is mechanically bonded to the exterior side of a customer specified tube, and simulates heat application by the shell side fluid or gas. Precise measurements of the thermal gradient across the fluid-tube-heater system establishes the heat transfer relationship. In this way, the DATSTM Fouling Monitor is used to determine the effect(s) of fouling deposits on heat transfer (i.e. condenser efficiency).

Specific operating conditions such as heat load and flow rate are controlled by the $\mathtt{DATS^{TM}}$ to match specific components of the cooling water system (main condenser). As the heat transfer surface becomes covered with a fouling layer, the change in thermal gradient is correlated to an increase in Heat Transfer Resistance. Computations are performed continuously and the resultant outputs are available through analog or digital signal lines for interfacing to customer equipment.

Using these principles, the $\mathtt{DATS^{TM}}$ allows the customer to analyze fouling for specific process conditions, and generates information necessary for efficient fouling management programs.

2 Introduction

The $DATS^{TM}$ has been used to:

- 1. Determine the rate and extent of fouling.
- 2. Evaluate physical and/or chemical treatments for fouling control.
- 3. Optimize fouling control feed rates and cleaning schedules.
- 4. Continued monitoring of treatment effectiveness.
- 5. Monitor improvements in utility heat rates.
- 6. Evaluate condenser retube materials.
- 7. Evaluate the impact of applied tube coatings.

NOTE: Throughout this manual, English and [Metric] values are listed for the equipment. Where applicable, metric units will be shown in brackets [].

Introduction 3

1.2 Standard Warranty Policy

The **D**eposit **A**ccumulation **T**esting **S**ystem, ($\mathtt{DATS^{TM}}$) with all associated components is warranted to be free from defects for a period of one year from the date of purchase. The system and/or components will be repaired or replaced, at no cost to the customer, if sent freight **pre-paid** to Bridger Scientific Inc. Equipment purchased from a non US location should be returned to the local distributor for repair/replacement, or returned to Bridger Scientific, Inc. directly.

At the customer's option and expense, a technician may be sent to the installation location to troubleshoot and repair the system. Travel costs, including travel time, will be billed to the customer. If the problem was caused by failure of material or workmanship in manufacture, repair labor and costs for replacement parts will be paid by Bridger Scientific, Inc. Problems related to installation deficiencies will be identified by the technician for correction by the purchaser.

1.3 Extended Warranty Policy

An extended warranty is available which extends the standard one year warranty on parts and labor for an additional 2 years. The extended warranty includes the following advantages;

- Includes one factory re calibration and inspection (including parts and labor)
- Includes free upgrades on all software and modifications (DATS TM or PC)
- Unlimited phone support for technical and installation assistance

Contact Bridger Scientific, Inc. for latest pricing information.

2.0 SYSTEM INSTALLATION

2.1 General Layout

A typical $DATS^{TM}$ component configuration is shown in Figure 1. The components of the $DATS^{TM}$ may be placed on a table horizontally or mounted vertically.



The DATS $^{\text{TM}}$ Electronics, Heat Exchanger and Flow Controller are calibrated as numbered units. Make sure all components have the same serial number.

NOTE

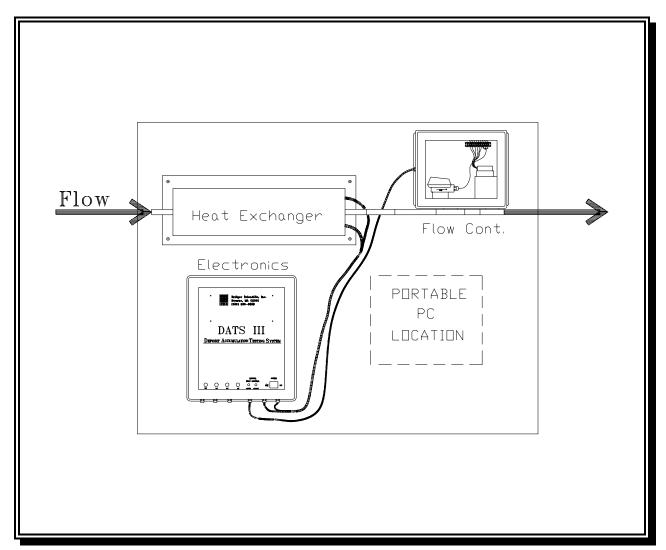


Figure 1 Typical $\mathtt{DATS^{TM}}$ System Configuration

The essential on-site requirements for installing the ${\tt DATS^{TM}}$ system, i.e. fluid connections, electrical connections, and equipment mounting are:

- 1) Nylon reinforced tubing, plastic pipe, or similar fluid line (sized to fit standard tube OD's e.g. 0.625", 0.875", 1.00")
- 2) Compression fittings for tube connections, if required
- 3) Gate-type isolation valve
- 4) Bypass valve
- 5) 115 VAC/15 amp (220 VAC/7.5 amp) dedicated service power supply
- 6) "Unistrut" (or similar mounting framework), or desk top for equipment support
- 7) An IBM PC/XT/AT or BIOS compatible computer(clone) for data retrieval and analysis, with a graphics card and RS232 serial port
- 8) Data acquisition system: If desired, a customer supplied data acquisition system can be used to measure the 6 system outputs and supply the 2 system control inputs. All analog outputs are powered by the DATSTM electronics with a common 24 volts DC power supply. Analog inputs are unpowered and have an input impedance of approximately 470 ohms. Alternatively, the output signals are available on the digital communications port.
 - a) Analog Inputs: Two control signal inputs to set system flow velocity and heat flux, unpowered.
 - b) Analog Outputs: Six analog output signals transmitted to customer electronics proportional to water temperature, block temperature, wall temperature, flow velocity, applied heat, and heat transfer resistance.

2.2 Space Requirements

SYSTEM:

The complete $\mathtt{DATS^{TM}}$ system, when installed horizontally, requires approximately 8' x 3' [2.5 m x 1 m] of surface area. For wall mounted installations, refer to the General Specifications sheet (Appendix A) for component weights and mechanical specifications.



Electronics:

 $(17in.[43cm]L \times 15in.[38cm]W \times 7in.[18cm]D)$

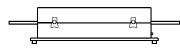
The control electronics is mounted in a free standing, moveable housing, fabricated from modified NEMA 4 enclosures of fiberglass reinforced plastic. This should be located in close proximity to the heat exchanger and flow controller, allowing 10" [25cm] on each side for connections. Flanges on the top and bottom of the enclosure provide bolt holes for mounting.



Flow Controller:

 $(13in.[33cm]L \times 11in.[28cm]W \times 6in.[15cm]D)$

The flow controller and sensor are also housed in a modified NEMA 4 enclosure, and should allow 15in.[38cm] on each end for fluid connections. (DO NOT change the length of the inlet tube)



Heat Exchanger:

 $(36in.[91.44cm]L \times 9\%in.[24cm]W \times 7\%in.[19cm]D)$

The heat exchanger is housed in a fabricated aluminum enclosure, which is in turn attached to an aluminum plate resting on four rubber feet. A minimum of 15" [38cm] must be available on each end for fluid connections. Provisions for brush cleaning the tube inner diameter should be addressed in any permanent installation.

2.3 Fluid Connections

The general layout for fluid connections is illustrated in Figure 2. When plumbing the system, the following configuration is recommended:

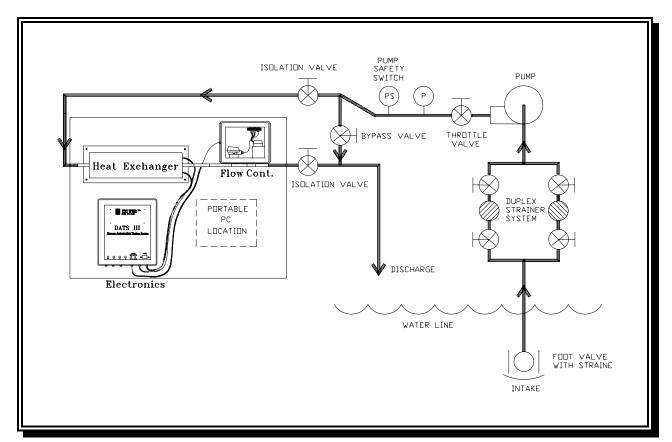


Figure 2 Typical DATSTM Fluid Connections

1) High pressure flexible hose should be used between the water source and the inlet side of the heat exchanger. Compression fittings may be used for increased system integrity, or if required by local regulation. Ferrules on the compression fittings should be nylon or Teflon (metal ferrules will permanently deform the tube).



NOTES

If it is absolutely necessary to shorten the heat exchanger tube, the inlet side of the tube may be cut as long as the minimum length is maintained. To maintain a fully developed flow profile, the distance between the inlet end of the tube and the heater block must not be less than 20 times the tube inner diameter.

The flow direction through the heat exchanger is critical. The outlet is on the same end as the interface cables. Do not rotate the tube when plumbing the system, as damage to internal wiring may result.

The Heat Exchanger unit should be as close as possible to the water source. This will insure that the water quality in the DATSTM Fouling Monitor matches that of the process equipment.

- 2) Using a similar hose, connect the outlet side of the Heat Exchanger to the inlet side of the Flow Controller.
 - The DATSTM Flow Controller requires a pressure drop of approximately 15 psi [103 KPa] for normal operation.
 - To insure the diaphragm valve operates within the most linear range, the inlet pressure should not exceed 30 psi [206 KPa] if flow discharge is to atmospheric pressure.
 - Taps should be provided to divert flow during manual calibration of the Flow Controller (Section 4.4). A drain line open to atmospheric pressure is recommended and will suffice for discharge and flow measurements.
 - A pressure booster pump may be required if water pressure is insufficient to provide the desired flow rate.
 - A pressure regulating valve, at the inlet, may be necessary to achieve stable flow.



When the flow controller is wall mounted, the box must be mounted with the tube section located on the bottom side of the box. This is required for reliable operation of the sensor, and drainage in the event of a leak.

Bridger Scientific, Inc. recommends an installation design such that the flow controller unit is readily accessible for cleaning and/or calibration (Section 4.4).

3) Connect a section of hose material to the outlet of the Flow Controller, and run the line to the discharge tank. The discharge should be at atmospheric pressure to prevent siphoning or changes in flow due to back pressure.

2.4 Cable Connections

2.41 AC Power

Each Heat Exchanger unit and Flow Controller pair requires a **dedicated** 120(240) VAC, 15(7.5) amp **ground fault** interrupted line. Other large fluctuating loads on the same bus will interfere with **DATS**TM operation. Figures 3 and 4 indicate the cable connections for the **DATS**TM.

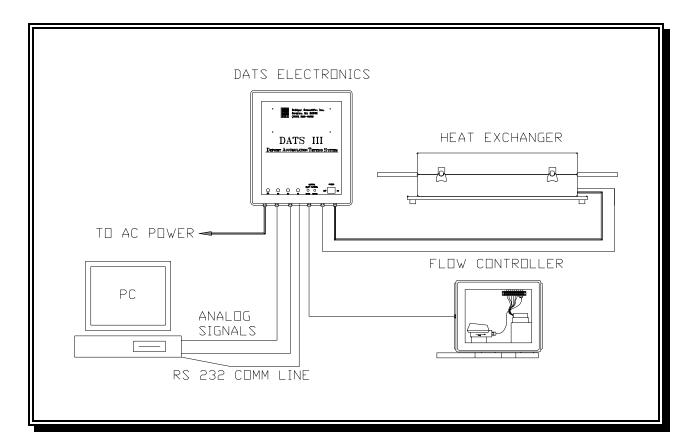


Figure 3 System Cable Connections

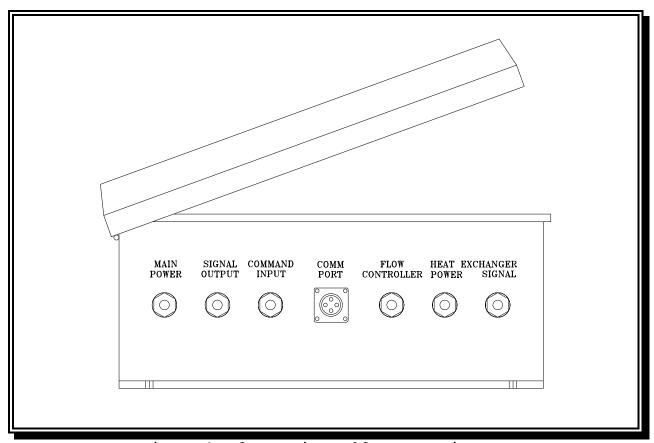


Figure 4 Electronics Cable Connections

2.42 Flow Controller / Heat Exchanger

Using Figure 5 as a guide, connect the flow controller to the PC I/O board in the electronics by passing the cable through the compression fitting, and making the individual connections to the blue terminal block TB3. No power should be applied to the unit while the electrical connections are being made. Each wire should be tinned with solder to make it stiffer than standard stranded wire, but no connector should be crimped on its end. Tighten the top screw on the terminal block to fix the wire in place.

For the heat exchanger, feed the power and signal cables through their respective compression fittings, and make connections as per Figure 5. The 3 power wire connectors use spade lugs connectors which have been crimped and soldered. These must be routed to the black terminal block on the right side of the electronics enclosure. Insure connections are tightened securely, and wires are carefully routed around the edge of the electronics as 120/240 VAC at 10/5 Amps will pass through them. Connect the signal wires in the same manner as the connections made for the flow controller to TB2.

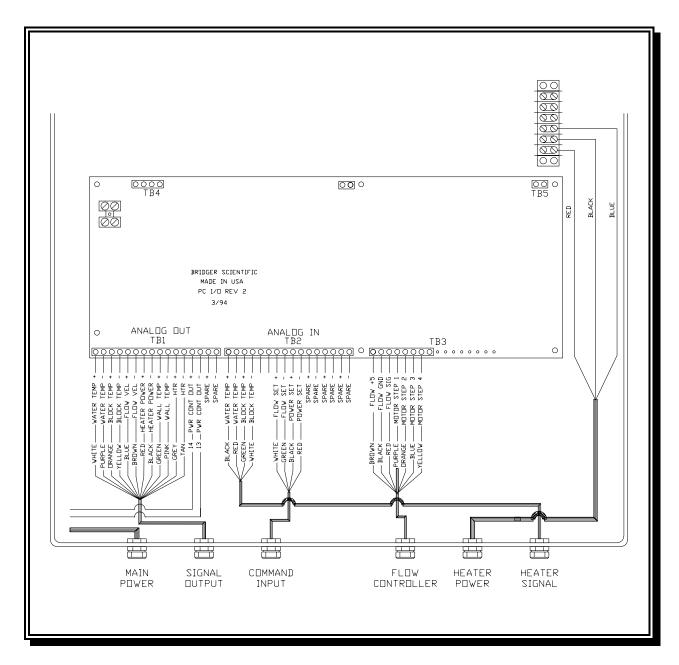


Figure 5 Internal Cable Connections

2.43 Communications Port / Analog Signals

A communications cable is provided which allows the ${\tt DATS^{TM}}$ to be connected to the comm port of any PC compatible computer for RS232 communications. To install the cable, unscrew the dust cap from the comm port of the ${\tt DATS^{TM}}$, and plug in the AMP end of the cable, turning the lock ring clockwise to secure the connection. The other end of the cable is a standard DB9 communications port connector for connection to the PC.

Cables for the analog input and output signals are shipped from the factory pre connected to the DATSTM electronics. Labels on the user end of the cables designate the signal names and polarity. Connect to customer supplied data acquisition system using wire labels and Figure 5 as a guide. The analog output signals are all powered by a common 24 volt power supply within the DATSTM electronics. All analog control inputs must be powered by the customer selected data acquisition system, and have an input impedance of approximately 470 ohms.



If the analog input and/or output cables will not be connected to customer supplied data acquisition system immediately, they should be disconnected to prevent damage to the DATS $^{\text{TM}}$ electronics.

2.5 Analog Input Configuration

The analog input channels come from the factory set for $4-20\,\text{ mA}$ or $1-5\,\text{ VDC}$ input signals - specified at time of order placement. The input signals are configured for external power to be provided by the customer supplied data acquisition system. refer to Figure 6 for proper wiring of external power supply for $4-20\,\text{ mA}$ operation.

Internal powering of inputs is possible if using fully isolated control inputs. Contact Bridger Scientific prior to using internal power for proper configuration information. To re-configure control inputs, use the following steps:

- 1) Unplug the power cord from the AC voltage receptacle, and open the front door and face plate of the electronics.
- 2) Locate the PC I/O board within the electronics as shown in Figure 6.
- 3) Using Figure 7 as a guide, add or remove the two 250 Ohm precision shunt resistors in locations R19 and R21.

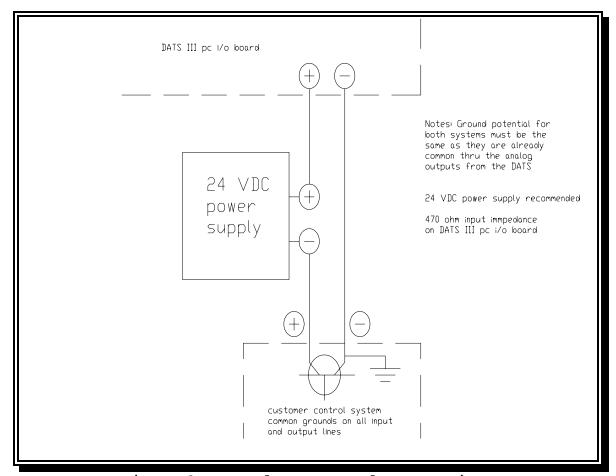


Figure 6 External Power Supply Connections

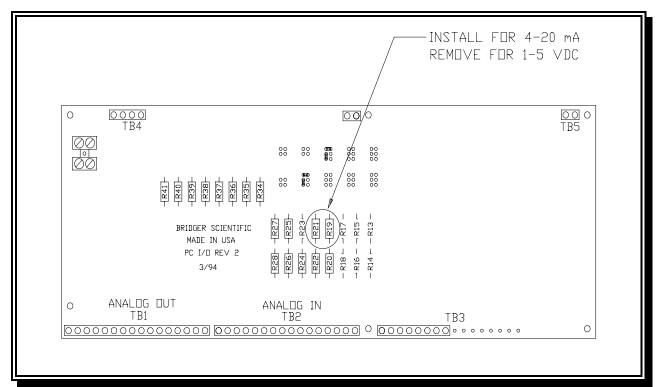


Figure 7 Analog Input Configuration

2.51 Analog Input Spans

In order for the analog inputs to correctly control the $\mathtt{DATS^{TM}}$, the control software must apply the proper scale and offset values to the input signals. Configure the scale and offset values within the control software based on the following spans:

SIGNAL NAME	LOWER VALUE (4 mA/1 VDC)	UPPER VALUE (20 mA/5 VDC)
APPLIED HEAT SETPOINT	0 Btu/Hr [O Watts]	4778 Btu/Hr [1400 Watts]
FLOW VELOCITY SETPOINT	0 ft/sec [0 m/sec]	13.124 ft/sec [4 m/sec]

2.6 Octagon 5750 Analog Output Board

The following sections are taken from 5750 Octal DAC Card User's Manual by Octagon Systems Corporation®, Copyright 1993.

2.61 Description

The 5750 Quad/Octal DAC Card can provide up to eight channels of 12-bit, high resolution analog output. It supports both voltage and 4-20 mA outputs simultaneously. The analog voltages are generated on-card so that only 5V is needed for operation. Options for supplying +12V/+24V for current loop operation is also available. This card is ideal as a feedback element with multiple channels of motion control.

2.62 Voltage Range Selection

Each channel on the 5750 can be either voltage output or 4-20~mA current loop output. If a voltage output is required, a range of 0-10V, 0-5V or +/-5V can be selected via jumper block W2 and W3. Jumper block W2 selects the output voltage for channels 0-3~and W3 selects the output voltage for channels 4-7. The following table shows the jumper configurations and voltage levels for each channel. Default configuration is 0-5V output on the DACs. Each channel may be set to a different output range.

5750 DAC Output Voltage:				
Output	W2/W3			
Range	Ch 0/Ch 4	Ch 1/Ch 5	Ch 2/Ch 6	Ch 3/Ch7
0-5V	[1-3]*	[11-13]*	[2-4]*	[12-14]*
0-10V	[7-9]	[17-19]	[8-10]	[18-20]
+/-5V	[3-5]	[13-15]	[4-6]	[14-16]

*=default

2.63 Current Loop Range Selection

If current loop output is required, the voltage range for the channel must be set for 0-5V. When a zero value is sent to the output channel, the system translates the output to a value of 4 mA, while the value of FFFH translates to a value of 20 mA. The value of the least significant bit is 16 mA/4096 or 3.90625 uA.

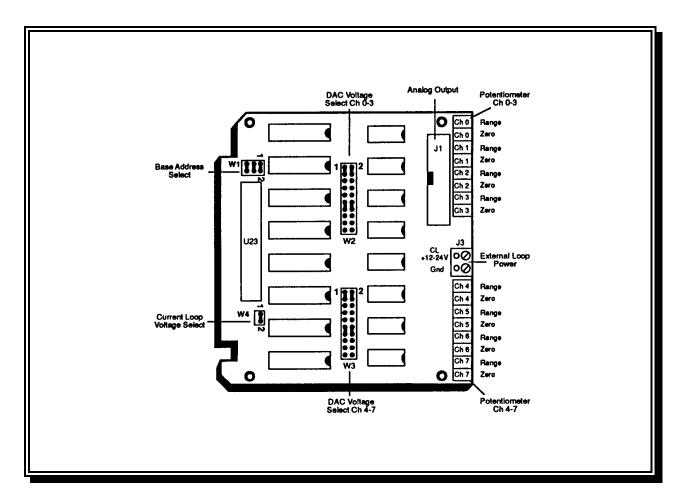


Figure 8, 5750 Component Diagram

2.64 Analog Output Spans

In order for the analog outputs to be properly displayed within the data acquisition software, the software must apply the proper scale and offset values to the output signals. Configure the scale and offset values within the software based on the following spans unless utilizing user defined options:

SIGNAL NAME	LOWER VALUE	UPPER VALUE	
	(4 mA or 1 VDC)	(20 mA or 5 VDC)	
WATER	32 °F	280 °F	
TEMPERATURE*	[0 °C]	[137.8 °C]	
BLOCK	32 °F	280 °F	
TEMPERATURE*	[0 °C]	[137.8 °C]	
WALL TEMPERATURE	32°F	280 °F	
	[0 °C]	[137.8 °C]	
MEASURED FLOW	0 ft/sec	13.124 ft/sec	
VELOCITY	[0 m/sec]	[4 m/sec]	
MEASURED APPLIED	0 Btu/Hr	4778 Btu/Hr	
HEAT	[O Watts]	[1400 Watts]	
* HEAT TRANSFER	-5.45e-4 Hr•ft ² •°F/Btu	22.716e-3 Hr•ft ² •°F/Btu	
RESISTANCE	[-9.6e-5 m ² °C/Watt]	[4.0e-3 m ² °C/Watt]	

^{*} See Section 4.2 for information on user defined maximum water and block temperature measurements, and heat transfer resistance minimum and maximum values.

NOTES

3.0 INSTALLATION CHECK

3.1 AC Power

With all wire connections made, plug the Electronics into a 115 VAC, 50/60 Hz (240 VAC, 50/60 Hz) power receptacle which is protected with a **ground fault** interruption line. Systems designed for operation on 240 VAC, 50/60 Hz will have a "Schuko" continental standard 230 VAC power connector.

3.2 System Startup

If a personal computer will be used to communicate with the DATSTM via the comm port, start the terminal emulation package that will be used (i.e.: PROCOMM, PROCOMM+,..)prior to powering on the DATSTM. The baud rate, parity, data bits, stop bits should be set to 9600, N, 8, 1 respectively. If a data acquisition system is to be used, start the data acquisition system and enter the setpoints for flow velocity and applied heat. If no personal computer is connected, the DATSTM will still operate correctly at the factory default setpoints of 400 Watts applied heat and 2 m/s flow velocity. Verify proper operation using the following as a guide:

- 1) Establish fluid flow for the system by opening valves or starting pump as necessary, and watching closely for any leaks. As shipped from the factory, the valve position should be in a position that allows for a flow rate of approximately 2 m/s.
- 2) Open the door of the electronics, and turn on the main power switch. The power switch should illuminate indicating power is supplied to the electronics. After power up memory tests, the DATS TM internal program will check the state of the analog control input lines. If a signal is present, the electronics will begin to control the flow rate and applied heat based on the signal input. Any time the signal input falls below a threshold level equivalent to 3.5 mA (0.875 VDC) or less, the system will control as described in #3 below.
- 3) If no signals are present on the command input lines, the DATSTM internal program will begin controlling based on the last default setpoints. These values are stored in the battery backed memory of the electronics and are initially set at an applied heat of 400 Watts, and flow rate of 2.0 meters/second. If control inputs are not being utilized, the setpoints may be changed using the communications port as described in section 4.2.
- 4) The applied heat will slowly increase and reach the selected setpoint in approximately 10 seconds. The flow controller will drive towards the selected setpoint for approximately 1/4 second every 2 seconds until the setpoint or valve limit is reached.

Installation Check

Verify proper operation of flow controller by observing the motor action inside the flow controller, or opening the face plate of the electronics and observing the LED's flashing on the PC I/O board. OPEN and CLOSE buttons on the face plate of the electronics allow the valve to be opened or closed manually. Adequate fluid pressure must be supplied for the system to reach the desired set point or the valve will reach its open limit and control of the flow velocity will not be accomplished.



The maximum flow velocity is 10 ft/sec [3.0 m/sec]. Do not set the rate higher than this value or the flow controller will not be able to measure and control the flow correctly.

NOTE

5) System is now ready for operation verification.

3.3 Operation Verification

The primary features and functions of the $\mathtt{DATS^{TM}}$ system are monitored and controlled by either the RS-232 communications port, or the customer supplied data acquisition system.

3.31 RS-232 Communications Port

When using the RS-232 communications port to control and monitor the $\mathtt{DATS^{TM}}$, verify system operation using the following procedure:

1) With the customer selected terminal emulation package running, power up of the DATSTM electronics will produce a message similar to the following on the PC screen. If the message does not appear, recheck that the emulation software has been set to the correct port, and is set for 9600 baud, No Parity, 8 Data bits, and 1 Stop bit.



Octagon 5012/6012 BIOS Vers. 2.01 Copyright (c) 1991-1994 Octagon Systems Corp. (TM) All Rights Reserved 640 K BYTES

5012/6012 MEMDRIVE.SYS V2.01, expanded memory present

5012/6012 MEMDRIVE.SYS V2.01, formatting expanded memory (384KB) as drive D

5012/6012 MEMDRIVE.SYS V2.01, assigning SSD1A (256KB) as drive E:

5012/6012 MEMDRIVE.SYS V2.01, memory device

5012/6012 MEMDRIVE.SYS V2.01, formatting SSD2 (128KB) as drive F:

5012/6012 MEMDRIVE.SYS V2.01, assigning BIOS drive as drive G:

A:\>AINSTR2

A:\>PCD

2) Press M on the keyboard to display the command menu screen as shown below. This screen displays the menu selection items that are available during $DATS^{TM}$ operation. A full description of all keystrokes can be found in section 4.2.



command menu

oommana mona

- A setup/disable autocontrol
- D display data continuously
- T interval time to enable file output string
- S set default flow rate (no input signal present)
- H set default power/heat (no input signal present)
- F span flow
- P span and zero power
- R enter resistance value of heater
- I enter tube inner diameter
- O enter tube outer diameter
- Z zero HTR
- X disable watchdog timer and exit program

command>

3) Press the $\bf D$ key to display the following screen, which shows the current setpoints and data points being read by the $\bf DATS^{TM}$. Verify that the Control Input Values and Output Values correspond with one another.



All values shown are in metric units, i.e. °C, meters/second, and Watts. Values will not be accurate until system has stabilized.

Installation Check



Inputs from Sensors

water temp: 33.11 block temp: 44.90 flow: 3.03 power: 399.9

Control Input Values

flow setpoint: 3.00 power setpoint: 400.00

Output Values

water temp: 33.11 block temp: 44.90 flow: 3.03 power: 399.9 wall temp: 41.14 HTR: 0.000015

Control Input Signals (milliamps)

flow setpoint: 7.66 power setpoint: 8.57

Output Signals (milliamps)

water temp: 7.85 block temp: 9.21 flow: 7.69 power: 8.57 wall temp: 8.78 HTR: 4.433

to power controller: 8.56

4) Press the $\bf S$ key, and enter a new flow rate in [m/s] as shown below:



enter default flow setpoint [2.00]> 2.50 note: Default setpoint will become active if external signal dips below 3.5 ma.

- 5) Press the **D** key to return to the display data screen and verify that the system controls flow at the new setpoint.
- 6) When the flow has stabilized at the new setpoint, press the **H** key and enter a new power setpoint in [Watts] as shown below:



enter default power setpoint [400]> 600 note: Default setpoint will become active if external signal dips below 3.5 ma.

7) Return to the data display screen by pressing \mathbf{D} , and verify that the power is being controlled to the new setpoint.

8) System is now ready for normal operations. Refer to section 4.2 for full description of normal serial port operations.

3.32 Data Acquisition System

When using a customer installed data acquisition system, verify proper system operation using the following as a guide:

- 1) Set the flow rate and applied power to 6 ft/sec [1.83 m/s] and 1200 BTU/hour [352 Watts], and verify that the analog output signals correspond to these values once the system has stabilized. If the values do not correspond, check to see that the data acquisition system has been setup with the correct offset and scale values (Sections 2.52 and 2.64) Refer to data acquisition software manual.
- 2) With the system stabilized at the above values, change the flow rate and applied power to 4 ft/sec [0.61 m/s] and 800 BTU/Hr [235 Watts], and verify that the system controls to the new setpoints. Refer to section 4.3 for normal operations.

NOTES

4.0 SYSTEM OPERATION

4.1 Applied Heat Calculation

```
(Range: 250 - 3413 Btu/hr [75 - 1000 Watts])
```

The $DATS^{TM}$ Applied Heat is calculated from the desired or designed heat flux (condenser flux) and heat exchanger tube dimensions as follows;

∴ For English Units

```
Surface Area (ft<sup>2</sup>) = 3.1415 x (0.D. (inches) x 1/12) x 5/12
= 0.1091 x (0.D. (inches))
```

∴ For Metric Units

```
Surface Area [m^2] = 3.1415 x O.D.[m] x 1 [m] = 3.1415 x (O.D.[cm] x 1/100) x 12.7/100 = 0.00399 x (O.D.[cm]
```

With the applied heat calculated, the set points for flow velocity and applied heat may then be set. Flow must be initiated prior to the setting of applied heat. These selections may be made using either the communications software (Section 4.2), or the customer supplied data acquisition software (Section 4.3).

4.2 Serial Port Operation

Using any customer supplied terminal emulation package, the ${\tt DATS^{TM}}$ may be calibrated and operated using the RS-232 port and any PC compatible computer. The communications cable supplied with each unit connects to an available comm port on the computer and allows the PC to communicate with the internal program of the ${\tt DATS^{TM}}$.



When communicating via the serial port, all values will be in metric units, i.e. °C, meters/second, and Watts.

NOTE

1) Establish Communications: With the terminal emulation package running, power up the DATSTM electronics and a message similar to the following should be displayed on the PC screen. If the message does not appear, recheck that the emulation software has been set to the correct port, and is set for 9600 baud, No Parity, 8 Data bits, and 1 Stop bit.



Octagon 5012/6012 BIOS Vers. 2.01 Copyright (c) 1991-1994 Octagon Systems Corp. (TM) All Rights Reserved 640 K BYTES

5012/6012 MEMDRIVE.SYS V2.01, expanded memory present 5012/6012 MEMDRIVE.SYS V2.01, formatting expanded memory (384KB) as drive D 5012/6012 MEMDRIVE.SYS V2.01, assigning SSD1A (256KB) as drive E: 5012/6012 MEMDRIVE.SYS V2.01, memory device 5012/6012 MEMDRIVE.SYS V2.01, formatting SSD2 (128KB) as drive F: 5012/6012 MEMDRIVE.SYS V2.01, assigning BIOS drive as drive G:

A:\>AINSTR2

A:\>PCD

2) Display Command Menu: Press **M** on the keyboard to display the command menu screen as shown below. This screen displays the menu selection commands that are available during normal **DATS**TM operation.



command menu

- A setup/disable autocontrol
- D display data continuously
- T interval time to enable file output string
- S set default flow rate (no input signal present)
- H set default power/heat (no input signal present)
- F span flow
- P span and zero power
- R enter resistance value of heater
- I enter tube inner diameter
- O enter tube outer diameter
- Z zero HTR
- X disable watchdog timer and exit program

command>

- 3) <u>Operation Commands:</u> From the command menu, the following commands may be selected by pressing the appropriate key:
 - A setup/disable auto control: This command allows the user to step through heat flux ranges and/or flow velocity ranges to test system operations over a variety of operating values. All values shown in brackets [] are the current values, and are in metric units. The time interval must be set back to zero to obtain full system functionality again.



Enter the autocontrol interval in minutes [0.00]>

Enter the heat start value [0]>
Enter the heat end value [0]>
Enter the desired step change in heat [0]>

Enter the flow start value [0.00]>
Enter the flow end value [0.00]>
Enter the desired step change in flow [0.00]>

D - display data continuously: This command will display a variety of input and output data values on the PC screen for 100 cycles of program operation. The data will be refreshed approximately every 4 seconds. After 100 cycles, the D key must be pressed again to resume updating the screen. All data is displayed in metric units.



Inputs from Sensors

water temp: 33.11 block temp: 44.90 flow: 3.03 power: 399.9

Control Input Values

flow setpoint: 3.00 power setpoint: 400.00

Output Values

water temp: 33.11 block temp: 44.90 flow: 3.03 power: 399.9 wall temp: 41.14 HTR: 0.000015

Control Input Signals (milliamps)

flow setpoint: 7.66 power setpoint: 8.57

Output Signals (milliamps)

water temp: 7.85 block temp: 9.21 flow: 7.69 power: 8.57 wall temp: 8.78 HTR: 4.433

to power controller: 8.56

T - interval time to enable file output string: This command alters the normal operation of the display data continuously command by sending a string of output data out the serial port only. When this function is invoked, other system features are not available. The time interval must be set back to zero to obtain full system functionality again. The primary use of this feature is to gather the data via the system serial port while using the auto download feature of most communication packages.



enter interval in minutes [0.00]> 60 note: Newly entered interval will disable normal display mode until it is reentered as a 0.

S - set flow rate (default value): This command is used to set the default system flow rate in [m/s]. Any time the analog input signal is not present, or below the minimum threshold, the system will control to this value.



enter default flow setpoint [0.00]> 2 note: Default setpoint will become active if external signal dips below 3.5 ma.

H - set power (heat, default value): This command is used to set the default system applied heat in [Watts]. Any time the analog input signal is not present, or below the minimum threshold, the system will control to this value. The minimum setting is 1 Watt.



enter default power setpoint [0]> 500 note: Default setpoint will become active if external signal dips below 3.5 ma.

- F span flow (calibration): This command is used to calibrate the flow controller as described in section 4.4.
- P span and zero power: This command is used to calibrate the power
 measurement circuit. FACTORY SERVICE PROCEDURE ONLY!
- R enter resistance value of heater: This command is used to enter/change the value of the heater element resistance in ohms. This value should match the resistance measured with a calibrated ohm meter across the heater element in a cold state. Changing of this value should not be necessary unless a new heating element has been installed.



enter resistance of heater element [0.0]> 42.00

I - enter tube inner diameter: This command is used to enter/change the value of the heat exchanger tube inner diameter in [cm]. Changing of this value is necessary only when replacing the tube with one of a different inner diameter.



enter inner diameter of tube [0.0]>2.118

O - enter tube outer diameter: This command is used to enter/change the value of the heat exchanger tube outer diameter in [cm]. Changing of this value is necessary only when replacing the tube with one of a different outer diameter.



Changing to a different outer diameter also requires a new heater block.



enter outer diameter of tube [0.0]>2.54

Z - zero heat transfer resistance: This command is used to establish a zero point for heat transfer resistance calculations. This function may also be performed by simultaneously depressing the OPEN and CLOSE manual flow control buttons on the face of the electronics.



CAUTION!

This procedure should be done at the start of each experiment with a CLEAN tube, and STEADY STATE conditions for POWER and FLOW. A minimum of 15 minutes is required for system to stabilize.

FAILURE TO DO SO WILL RESULT IN INACCURATE DATA.



<enter> to zero HTR, any other key to exit.

- X- to halt program and disable watchdog timer: This command is used to halt normal execution of the program, and provide access to special program features as described below. Enter X and then one of the number sequences listed below at the prompt:
 - **1234 -** This sequence is used to halt the program, disable the watchdog timer, and exit to the ${\tt DATS^{TM}}$ internal ${\tt DOS^{TM}}$ command prompt. From here, all normal ${\tt DOS^{TM}}$ commands are available to gain access to the ${\tt DATS^{TM}}$ operating system.



Enter the number 1234 to stop program and disable watchdog >1234

A:\>

1111 - This sequence is used to allow the power measurement circuit to be linerized by entering the coefficients of a 4th order polynomial. For each prompt, enter the values for AO, A1, A2, and A3. The default values are shown on brackets[]. These values should not have to be changed unless poor power measurement is suspected. Contact B.S.I. on the proper procedure prior to using this feature.



Enter the number 1234 to stop program and disable watchdog >1111

Enter a0 [0]>

Enter a1 [1]>

Enter a2 [0]>

Enter a3 [0]>

Enter a4 [0]>

2222 - This sequence is used to allow the user to define the zero and span values for the heat transfer resistance output signal. Any change of these values will require a change in the scale and offset values of the data acquisition software.



Enter the number 1234 to stop program and disable watchdog >2222 HTR output modes: 1-default linear 2-user selectable linear

enter HTR output mode [2]>
enter HTR value corresponding to 4ma [-9.6e-05]>
enter HTR value corresponding to 20ma [0.004]>

The following relationship can be used to convert HTR milliamp output into HTR:

HTR=((milliamps-4)/16 x (0.004--9.6e-05))+-9.6e-05

<enter> to continue

3333 - This sequence is used to allow the user to define the maximum water/block temperatures to be measured by the temperature sensors, and/or to set the existence/non-existence of the flow controller. A change in maximum temperature measurement must be accompanied by a change of the sensor amplifiers located within the heat exchanger enclosure. When no flow controller is present, the flow setpoint should be set to the approximate flow rate as this value will be used in the convective heat transfer algorithm. Under normal operations, neither of these settings should need to be changed.



Enter the number 1234 to stop program and disable watchdog >3333 Enter maximum temperature [137.80]> Enter 1 if flow meter present, 0 if not present [1]>

4.3 Analog I/O Operation

With a customer supplied data acquisition and control system, the DATSTM may be operated as a "black box" providing heat transfer data as "live" signals on the analog output lines. Two analog input lines allow the flow rate and applied heat to be controlled via the control system. Signal outputs are updated approximately every 4 seconds. For configuration of the acquisition and control system - Refer to sections 2.51 and 2.64 in this manual and the manuals provided with the customer supplied data acquisition system.



Any time the DATSTM is running and the analog input signals are either not present or disconnected, the default setpoints as described in Section 4.2 will be used.

NOTE

4.31 Zeroing of the HTR

When operating under analog input control, the HTR may be zeroed by simultaneously depressing the **OPEN** and **CLOSE** manual flow control buttons on the face of the electronics.



This procedure should be done at the start of each experiment with a CLEAN tube, and STEADY STATE conditions for POWER and FLOW. A minimum of 15 minutes is required for system to stabilize.

CAUTION!

FAILURE TO DO SO WILL RESULT IN INACCURATE DATA.

4.4 Flow Calibration

Fouling significantly affects the **DATS**TM paddle wheel flow controller and flow meter fittings. It is important to check/calibrate the flow often and to maintain the PVC flow meter fittings in a clean state. The flow calibration should be monitored weekly, or whenever data is suspect. To check calibration, use the following procedure:



You should be prepared to measure and calculate the linear flow velocity in meters per second prior to starting this procedure. Flow should be established and in a steady state, and the tube I.D. in cm should be known.

- 1) Establish RS-232 communications as described in section 4.2, and enter ${\bf M}$ to display the command menu.
- 2) Determine the time for a specified quantity of fluid to pass through the flow meter, or to fill a container of known volume.
- 3) Calculate the actual flow rate as follows:

Flow Velocity [m/sec] = Flow [L/min] \times 0.2122 /(tube I.D. [cm])²

Flow Velocity [m/sec] = Flow [GPM] \times 0.8032 /(tube I.D. [cm])²

4) Enter \mathbf{F} to enter the span flow routine, while maintaining steady flow. At the 1st prompt, press enter, then enter the flow rate calculated above at the 2nd prompt.



<enter> to span flow, any other key to exit.

<enter> to span flow, any other key to exit.
enter measured flow value>x.xx
...wait

5) The system will then calculate a new calibration value and return the new value.



new calibration value> xxxx.xx

NOTES

5.0 DATA INTERPRETATION AND CALCULATIONS

5.1 General Principles

The following guide explains the general principles involved in calculation of $\mathtt{DATS^{TM}}$ parameters and in interpretation of data collected. The following assumptions have been made:

- Water, or fluid with similar characteristics is circulating in the system.
- Uniform radial steady state heat transfer.
- A fully developed thermal and hydrodynamic boundary layer exists in the tube.
- Fluid temperature range between 32 180 °F [0 82°C].
- Reynolds numbers between 10,000 100,000 (e.g. fluid properties similar to water).

5.11 Heat Transfer Resistance

The geometry and physical relationship of the elements within the Heat Exchanger are shown in Figure 9.

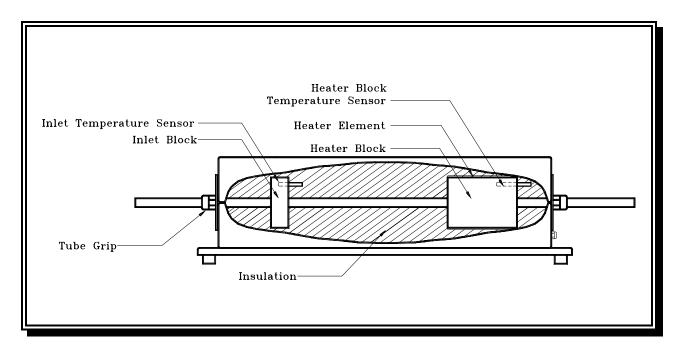


Figure 9 DATS™ Heat Exchanger

The ${\tt DATS^{TM}}$ calculates the Heat Transfer Resistance (HTR) from the following equation:

$$HTR_{total} = A (T_{block} - T_{water})$$
Heat

where:

 $\begin{aligned} \text{HTR}_{\text{total}} &= \text{Total Heat Transfer Resistance} \\ &\qquad \qquad (\text{hr-ft}^2\text{-°F/Btu}, \ [\text{m}^2\text{-°C/Watt}]) \end{aligned}$

A = Tube outside surface area (ft², [m²]) T_{block} = Heater block temperature (°F, [°C])

 T_{water} = Water temperature (°F, [°C]) Heat = Applied heat (Btu/hr, [Watts])

b) Wall Temperature:

Wall temperature is defined as the temperature of the tube inside wall (beneath any fouling layer which may develop), and is calculated by the relationship:

$$T_{\text{wall}} = T_{\text{block}} - (\text{Heat * Constant})$$

where:

 T_{block} = Temperature (°F, [°C]) of the heater block at a radius of 0.719 inches [1.826 cm]

The Constant is developed from an empirical relationship of the convective heat transfer coefficient, which is a derivation of the Colburn equation, and the measured total HTR.

$$HTR_{conv} = \frac{d}{0.023*Re^{0.25}*Pr^{1/3}*k} = \frac{A}{Constant}$$

where:

Re = Reynolds number Pr = Prandtl number

When the $\mathtt{DATS^{TM}}$ HTR is zeroed initially , the convective heat transfer coefficient is automatically calculated, the constant is calculated, and the wall temperature relationship is established.

c) Zero Heat Transfer Resistance:

Zero heat transfer resistance is a constant which is subtracted from the Total Heat Transfer Resistance:

 $HTR_0 = HTR_{ti} - HTR_{c}$

where:

 HTR_0 = Zero HTR value, calculated for a clean tube.

This value is automatically subtracted from

future HTR values

HTR_c = Convective heat transfer resistance

d) Water Temperature Compensation:

The convective heat transfer coefficient is also used to compensate for water temperature and flow velocity changes. Total HTR is the sum of the convective HTR and the conductive HTR. The convective heat transfer equation calculates the convective component. The conductive component of the heater block and tubing is assumed to remain constant. When the DATS TM has been properly zeroed and is operational, the fixed heat transfer resistance measured at the start of the experiment is automatically subtracted from the total current heat transfer resistance.

Thus, the complete **DATSTM** HTR equation becomes:

 $HTR = HTR_{t} - HTR_{0} - HTR_{c}$

where:

HTR = Differential HTR HTR₊ = Total current HTR

 ${\rm HTR}_{\circ}$ = Total conductive HTR with a clean tube ${\rm HTR}_{\circ}$ = Total convective HTR with a clean tube.

The differential HTR is set to zero during the DATSTM Zero/HTR operation. With time, the HTR increases due to the change in the conductive HTR which corresponds to the changes in fouling deposit HTR. Variation in HTR due to water temperature or flow velocity variations may cause some variation in heat transfer resistance's values. This may be due to transient (non steady-state) behavior, or to limitations of the convective heat transfer equation.

2. Data Interpretation

The data calculated by the ${\tt DATS^{TM}}$ may be used to evaluate the efficiency, reliability and economic feasibility of various fouling control techniques for the system under test. The deposit HTR determined by the ${\tt DATS^{TM}}$ may be used to estimate the percent cleanliness based on the design CLEAN heat transfer coefficient of the process equipment (condenser or heat exchanger). This is a simple method of estimating the performance degradation of a fouled heat exchanger.

```
For example;
assume the design heat transfer coefficient (U_{design})
(from HEI standards) =
650 Btu/hr-ft2-°F
The deposit HTR determined by the DATS^{TM} after six weeks =
0.0005 hr-ft<sup>2</sup>-°F/Btu
                                     = (1/U_{\text{design}}) + \text{DATS}^{\text{TM}} \text{ HTR}
Fouled HTR (HTR<sub>fouled</sub>)
                                      = (1/650) + 0.0005 (hr-ft^2-\circ F/Btu)
                                      = 0.00154 + 0.0005
                                      = 0.00204 \text{ hr-ft}^2-\text{°F/Btu}
Fouled heat transfer
                                      = 1/HTR<sub>fouled</sub>
coefficient (Ufouled)
                                      = 1/0.00204
                                      = 490 \text{ Btu/hr-ft}^2-\text{°F}
Therefore:
% Cleanliness
                                      = (490/650) * 100
                                      = 75.47%
```

This is a simple calculation which gives some indication of the reduced capacity or efficiency of the heat exchanger. More complex methods must be used to obtain a realistic understanding of the economic impact of fouling in a particular situation.

Flow Calibration 39

NOTES

8.0 APPENDICES

Appendix A: General Specifications

1. Space Requirements: Approximately 8' x 3' [2.5 m x 1 m] mounted

vertically or horizontally

2. Shipping Weight: Flow meter: 13 lb [6 kg]

Electronics: 20 lb [9 kg] Heat Exchanger: 23 lb [11 kg]

3. Flow Rate Range: 0.5-10 ft/sec. [0.15 - 3.0 m/sec]

4. Fluid Temperature Range: 32°F - 180°F [0°C - 83°C].

5. Fluid Types: Fresh water, sea water or fluid with similar

viscosity, specific heat and density. (Reynolds number range 10,000 - 100,000)

6. Environmental Temperature Range: 32°F - 100°F [0°C - 38°C].

7. Power Supply: Separate 120 VAC 15 AMP (240 VAC, 7.5 AMP)

ground fault interrupt circuit for each DATS

TM .

8. Maximum Operating Pressure: 50 PSI [345 KPa] at 200°F[93°C]

standard CPVC

50 PSI [345 KPa] at 220°F[105°C]

optional PVDF

9. Average Sampling Time Interval: 4 sec.

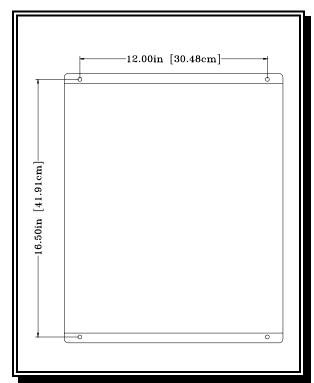
10. Standard Wetted Components:

Customer specified tube material; CPVC or optional PVDF/KYNAR Plumbing; EPDM Diaphragm Valve (Teflon optional); PVDF Paddle wheel Sensor with Polypropylene Paddle wheel body (PVDF optional) and Titanium Paddle wheel Pin or optional Magnetic Flow meter with PVDF or Polypropylene housing and Titanium, Tantalum or 316SS contacts

11. Computer Compatibility:

Software and hardware interface designed for compatibility with IBM PC XT, AT 286, 386 SX/DX, and 486 SX/DX computers, desk top or portable, with graphics capability.

12. Mechanical Mounting Specifications:



12.50in [317.50cm]

-4.50in [11.43cm]

-4.50in [11.43cm]

Figure 10
Electronics Mounting

Figure 11
Flow Controller Mounting

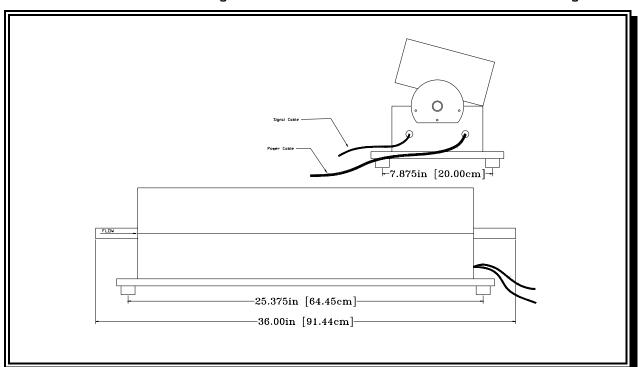


Figure 12 Heat Exchanger Mounting

Appendix B: ${\tt DATS^{TM}}$ Troubleshooting Guide

Problem Remedy

DATS TM program reports "Calibration file not found - creating new	1) Battery backed clock beneath ssd2 on 6012 CPU board is loose.
	[Re-seat IC and socket]
file" at each boot cycle.	2) Battery backed clock is dead.
	[Replace battery backed clock]
DATS™ Program does not hold calibration values	1) Battery backed clock beneath ssd2 on 6012 CPU board is loose.
for flow, power, tube ID,	[Re-seat IC and socket]
tube OD	2) Battery backed clock is dead.
	[Replace battery backed clock]
Maximum Power indicated	1) Heater element is cold.
by DATS™ does not match calculated power using	[Operate unit at full power for several minutes and recheck]
voltage and heater resistance at full power	2) Power calibration out of spec.
	[Return to Bridger Scientific, Inc. for factory calibration]
Excessive variation in HTR on analog output line	1) System flow and/or power not at steady state.
	[Operate unit through several cycles and verify steady state operations]
	2) Unit being operated at full power, not allowing compensation for AC line voltage variations.
	[Reduce applied heat]
	3) HTR output range set too sensitive.
	[Increase output range as described in section 4.2]
	4) Scale factor applied to analog signal in data acquisition software set incorrectly
	[Reset using section 2.64 as guide]

Problem	Remedy
---------	--------

No variation in HTR on	1) HTR output range set too wide.
analog output line	[Decrease output range as described in section 4.2]
	2) Scale factor applied to analog signal in data acquisition software set incorrectly
	[Reset using section 2.64 as guide]
Analog output values do	1) Program execution has halted
not update	[Reboot system by shutting DATS off and then back on]
	2) Program was halted by user entering "X" followed by "1234".
	[Resume program operation by entering PCD at the DATS TM A:\> prompt]
	3) DATS™ Electronics failing in initialization routine.
	[Verify initialization as described in section 4.2]
Analog input signals not	1) Signal input wires are reversed.
controlling DATS TM setpoints	[Check signal connections using Figure 5 in section 2.42 as a guide]
	2) Current loop power is inadequate or not applied.
	[Supply loop with external 24 VDC supply]
	3) Current loop power is wired with incorrect polarity.
	[Rewire power supply as shown in Figure 6, section 2.5]
	4) Input signal is below 3.5 mA or 0.875 VDC.
	[Verify signal level using a
	multimeter]

Problem Remedy

	1	-
Digital output to PC screen stops	1)	100 Cycles of digital data has been sent.
		[Resume updating screen by pressing "D"]
	2)	Program execution has halted
		[Reboot system by shutting DATSTM off and then back on]
	3)	Program was halted by user entering "X" followed by "1234".
		[Resume program operation by entering PCD at the DATS TM A:\> prompt]
Flow controller valve not functioning using OPEN or CLOSE switch on front panel	1)	Stepper motor power supply fuse blown.
		[Check fuse at location F1 on PC I/O board]
	2)	Stepper motor drive circuit not functioning.
		[Operate OPEN or CLOSE switch while observing LED D4 on PC I/O board. LED should flash as step pulses are sent to stepper motor]
	3)	Valve is jammed fully open or fully closed.
		[Operate OPEN or CLOSED switch while holding exterior of valve located within the flow controller box. The valve train will vibrate when you attempt manual control, but no net rotation will occur if valve is jammed]

Problem	Remedy
---------	--------

Flow controller valve not functioning under program control	1)	Program execution has halted
		[Reboot system by shutting DATS TM off and then back on]
	2)	Program was halted by user entering "X" followed by "1234".
		[Resume program operation by entering PCD at the DATS TM A:\> prompt]
	3)	Stepper motor driver circuit not functioning.
		[Verify operation using OPEN and CLOSE switches on front panel]
DATS™ not measuring any flow	1)	Flow sensor paddle wheel is jammed with foreign matter.
		[Remove flow sensor and clean sensor and paddle wheel]
	2)	Signal from flow sensor to PC I/O board missing
		[Verify signal presence by removing flow sensor, rotating paddle wheel by hand, and observing LED D2 on PC I/O board. LED should flash at sensor pulse frequency]
Excessive variation in	1)	Pressure variations in the system.
flow velocity		[Install a pressure regulator]
	2)	Paddle wheel sensor is fouled or obstructed.
		[Shut off the flow and clean the sensor]
	3)	Paddle wheel bearing pin is corroded or worn.
		[Remove the sensor and replace the pin]

Problem Remedy

	,
Excessive variation in flow velocity - Cont.	4) Flow controller installation fitting has been shortened or modified by the installer.
	[Replace the installation fitting with a new full length fitting]
	5) A pressure regulator installed upstream is causing feedback in the DATS TM flow control loop.
	[Change the pressure regulator set point, or replace it with a pressure relief valve]
The DATS™ is not applying heat	1) No flow is established in the system, or the flow meter is out of calibration.
	[Restore flow, or check flow calibration, Section 4.4]
	2) The RTD on the heater block is damaged.
	[Check the reading of the block temperature, and check the continuity of the sensor with an Ohm meter. Replace faulty wire or sensor.]
	3) The block thermostat is damaged or tripped.
	[Check the continuity of the heater element through the power lead wires. If an open condition exists, repair the faulty wire or replace the faulty thermostat]

Problem	Remedy
---------	--------

	ı	
Excessive variation in heat transfer resistance	1)	Variations in the AC line voltage.
		[Check the line voltage with a multimeter for fluctuations. Install a voltage stabilizer or relocate the AC voltage source to eliminate the problem]
	2)	Variations in the flow velocity causing changes in the HTR.
		[Correct flow velocity fluctuations]
	3)	Temperature sensors need to be calibrated.
		[Return to B.S.I. for calibration]
	4)	Applied heat is set too high causing thermostat to open and close as the maximum block temperature is exceeded.
		[Lower applied heat setting]

Lotus TM Header File

Appendix E: Lotus TM Header File

The following is a sample of the LOTUS-123 $^{\text{TM}}$ header, which may be retrieved by uploading the HEADER.WK1 file from the test and calibration disk supplied with the **DATS ^{\text{TM}}**.

BRIDGER SC	IENTIFIC IN	C DEPOSI METER DISPLA			G SYSTEM		
=======	=======			=======			
INLET	HEATER	WALL	APPLIED	WATER	HEAT		
WATER	BLOCK	TEMP.	HEAT	FLOW	TRANSFER		
TEMP.	TEMP.			VELOCITY	RESISTANCE		
=======							
DEGREES	DEGREES	DEGREES	WATTS	M/SECDE	EG C-SQ M		
С	C	С			/WATT		
========	========	========	========	=======	=========		

Appendix F: Software Directory

 $\textbf{DATS}^{\textbf{TM}}$ Calibration and Test disk:

HEADER.WK1	LOTUS-123™ file, header for data
HEATxxxx.PRN	Factory test data stepping through heat, where xxxx is unit serial number.
FLOWxxxx.PRN	Factory test data stepping through flow, where xxxx is unit serial number.
WATRxxxx.PRN	Factory test data stepping through bulk water temperature, where xxxx is unit serial number.
CALxxxx.PRN	Calibration file downloaded from unit prior to shipping, where xxxx is unit serial number.
SPECFILE.WK1	LOTUS-123 $^{\text{TM}}$ spreadsheet file of calibration values and DATS^{TM} operating parameter calculations

Appendix G: Optional Tube Specifications

A. Material Types

a) Carbon Steel: 1014, 1018, 1020

b) Alloy Steel: 4130, 4140, 4150, 4340, 5130

c) Stainless Steel: 304, 316

d) Copper Alloy: Admiralty Brass, Copper-Nickel, Aluminum Bronze, Aluminum Brass

Other exotic tube materials may cost more and require additional delivery time. Contact Bridger Scientific, Inc. for price and availability of specific tubes.

B. Typical Fabrication Methods for Tubes

a) CDS: Cold Drawn Seamless b) DOM: Drawn Over Mandrel

c) HREW: Hot Rolled Electric Weld

- C. Common Outside Diameters (for which heater blocks are available)
 - a) 5/8 inch
 - b) 7/8 inch
 - c) 3/4 inch
 - d) 1 inch
 - e) 14 mm

Other sizes are available as a custom design. Contact Bridger Scientific, Inc. for price and availability of specific blocks.

- D. Typical Wall Sizes/Gauges:
 - a) 0.028 inch/22BWG
 - b) 0.035 inch/20BWG
 - c) 0.049 inch/18BWG
 - d) 0.065 inch/16BWG
 - e) 0.083 inch/14BWG
 - f) 0.095 inch/13BWG
 - g) 0.120 inch/11BWG

Appendix H: Replacement Parts

The following is a list of common replacement parts available from Bridger Scientific, Inc. Contact B.S.I. for latest pricing information.

PART DESCRIPTION

BRIDGER SCIENTIFIC PART

099-304
099-305
100-210
100-307
106-102
106-103
106-105
106-107
106-108
106-109
106-110
200-202
200-001
200-002
200-003
200-004
200-005
200-006
200-007
200-008
200-009
200-010
200-011
200-012
200-013
200-014
202-122

NOTE: When ordering replacement tubes, the O.D. and wall size must be specified

Appendix I: Schematics

DRAWING NO.	DRAWING TITLE
M-1	Main Wiring
M-2	Analog Output Cable
M-3	Analog Input Cable
M-4	Communications Cable, DB9
M-5	Flow Controller Internal Wiring

INSERT DRAWING

M-1: Main Wiring

INSERT DRAWING

M-2: Analog Output Cable

INSERT DRAWING

M-3: Analog Input Cable

INSERT DRAWING

M-4: Communications Cable, DB9

INSERT DRAWING

M-5: Flow Controller Internal Wiring

Appendix J: Shipping Checklist

1.	DATS TM serial number:						
	DATSTM-ELECTRONICS Control Program/Date:						
3.	DATSTM-FLOW CONTROLLER:	Paddle v	wheel	Magnetic			
			1/2"	3/4"			
	Owner's Manual						
4.	DATSTM-HEAT EXCHANGER Tuk	pe type/s	ize:				
	_						
5.	Cables:						
	DATS TM to PC:	DB9					
		DB25					
	Analog Input						
	Analog Output						
6.	Test/Calibration Disk:						
	Disk Size:	5 1/4" _		3 1/2"			
7.	Operations Manual:						
	with test and calibratio	n sheets					
8.	Tube Cleaned/Oiled:						
9.	Spare Tubes:						
10.	Optional:						
	Quality Control Packing	by:					
	Quality Control Inspecti	on by: _					