DATS™ II FOULING MONITOR
OPERATIONS GUIDE

Bridger Scientific, Inc. English and Metric Models

Deposit Accumulation Testing System:

Software:

WARNING - WARNING - WARNING - WARNING - WARNING - WARNING

- EACH **DATS™** 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 **DATS™** POWER CIRCUIT.

- UNPLUG AND TURN OFF POWER WHEN WORKING INSIDE ANY **DATS™** ENCLOSURE.

- DURING NORMAL OPERATION, UP TO 1000 WATTS OF POWER MAY BE USED BY THE HEATING ELEMENT WITHIN THE **DATS™**. USE CAUTION WHEN DISASSEMBLING THE HEAT EXCHANGER AFTER RECENT OPERATION.

- **DATS™** COMPONENTS ARE CONTAINED WITHIN UNRATED MOISTURE AND SPLASH RESISTANT HOUSINGS WHICH ARE NOT RATED AS EXPLOSION PROOF.

WARNING - WARNING - WARNING - WARNING - WARNING - WARNING

DEPOSIT ACCUMULATION TESTING SYSTEM

LIST OF FIGURES

GENERAL NOTES

1.0 INTRODUCTION

The **D**eposit **A**ccumulation **T**esting **S**ystem (**DATS™**) Fouling Monitor is a microprocessor based, data acquisition system designed to control, monitor and record 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 Heat Transfer Resistance (HTR) is electronically recorded. Changes in HTR due to corrosion and corrosion products may also be detected.

1.1 General Principles

The **DATS™** 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 **DATS™** Fouling Monitor is used to determine the effect(s) of fouling deposits on heat transfer (i.e. condenser efficiency).

Specific operating conditions such as surface temperature, heat load and flow rate are adjusted on the **DATS™** to match specific components of the cooling water system (main condenser). All collected data is stored in the **DATS™** microprocessor and may be periodically transferred to a personal computer for analysis.

The **DATS™** is also equipped with four auxiliary 4-20 mA transducer signal inputs. These may be used with any customer selected transducer, but are typically connected to water quality measurement instruments which are relevant to the phenomena under study (i.e. pH, conductivity, chemical residuals, differential pressure).

Using these principles, the **DATS™** allows the customer to analyze fouling for specific process conditions, and generates information necessary for efficient fouling management programs.

The **DATS™** 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.

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

1.2 Standard Warranty Policy

The **D**eposit **A**ccumulation **T**esting **S**ystem, (**DATS™**) 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 1 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 ™** 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™** component configuration is shown in Figure 1. The components of the **DATS™** may be placed on a table horizontally or mounted vertically.

NOTE

The DATS™ Electronics, Heat Exchanger and Flow Controller are calibrated as numbered units. Make sure all components have the same serial number when used in systems with multiple units.

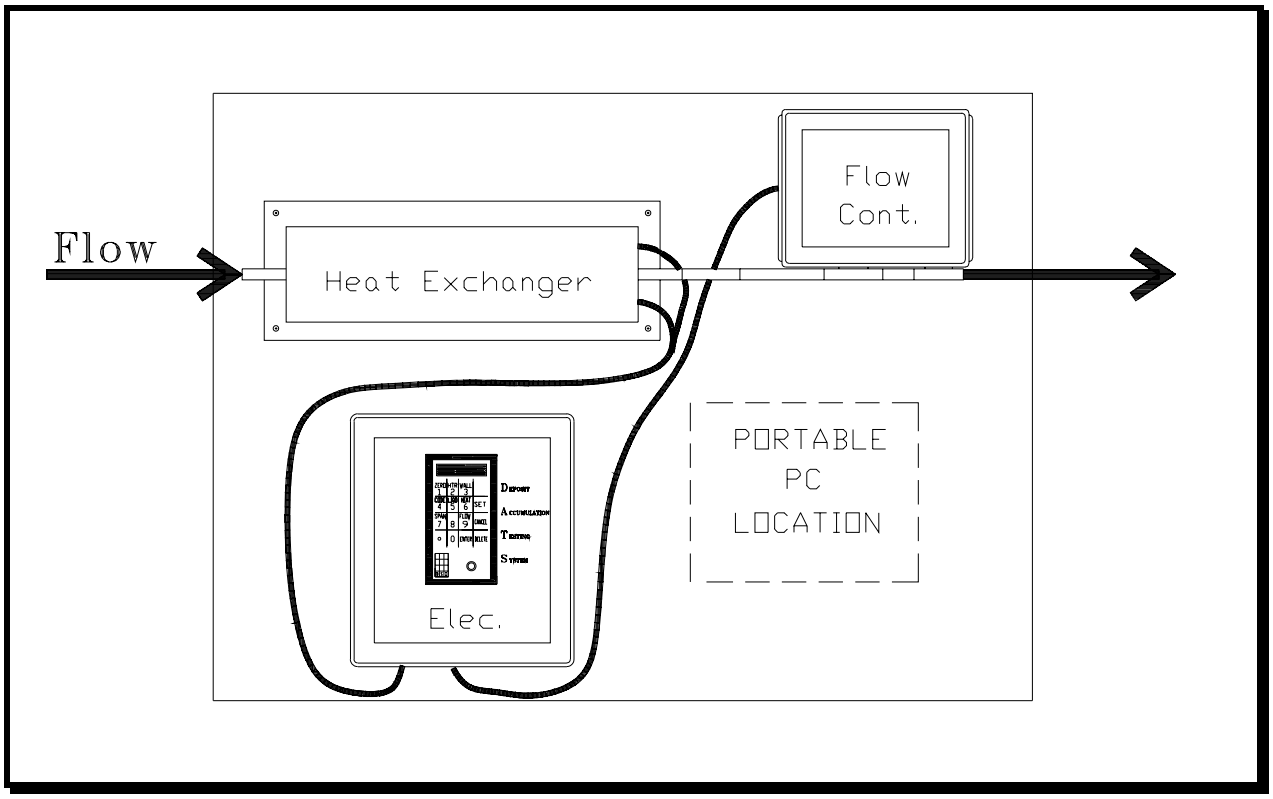

Figure 1. Typical DATS™ Component Configuration.

The essential on-site requirements for installing the **DATS™** system, i.e. fluid connections, electrical connections, and equipment mounting are:

1) Nylon reinforced tubing, plastic pipe, or similar fluid line (sizes 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 serial port

2.2 Space Requirements

System:

The complete **DATS™** 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 x 15in.**[**38cm**]**W x 7in.**[**18cm**]**D)

The electronic control unit 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 x 11in.**[**28cm**]**W x 6in.**[**15cm**]**D)

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

Heat Exchanger: (36in.**[**91.44cm**]**L x 9½in.**[**24cm**]**W x 7½in.**[**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:

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, and shorter tube end. 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 DATS™ Fouling Monitor matches that of the process equipment.

2.) Using a similar hose, connect the outlet side of the Heat Exchanger to inlet side of the Flow Controller.

- The **DATS™** 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 7.0). 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 relief valve at the inlet may be necessary to achieve stable flow.

NOTE

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 7.0).

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.

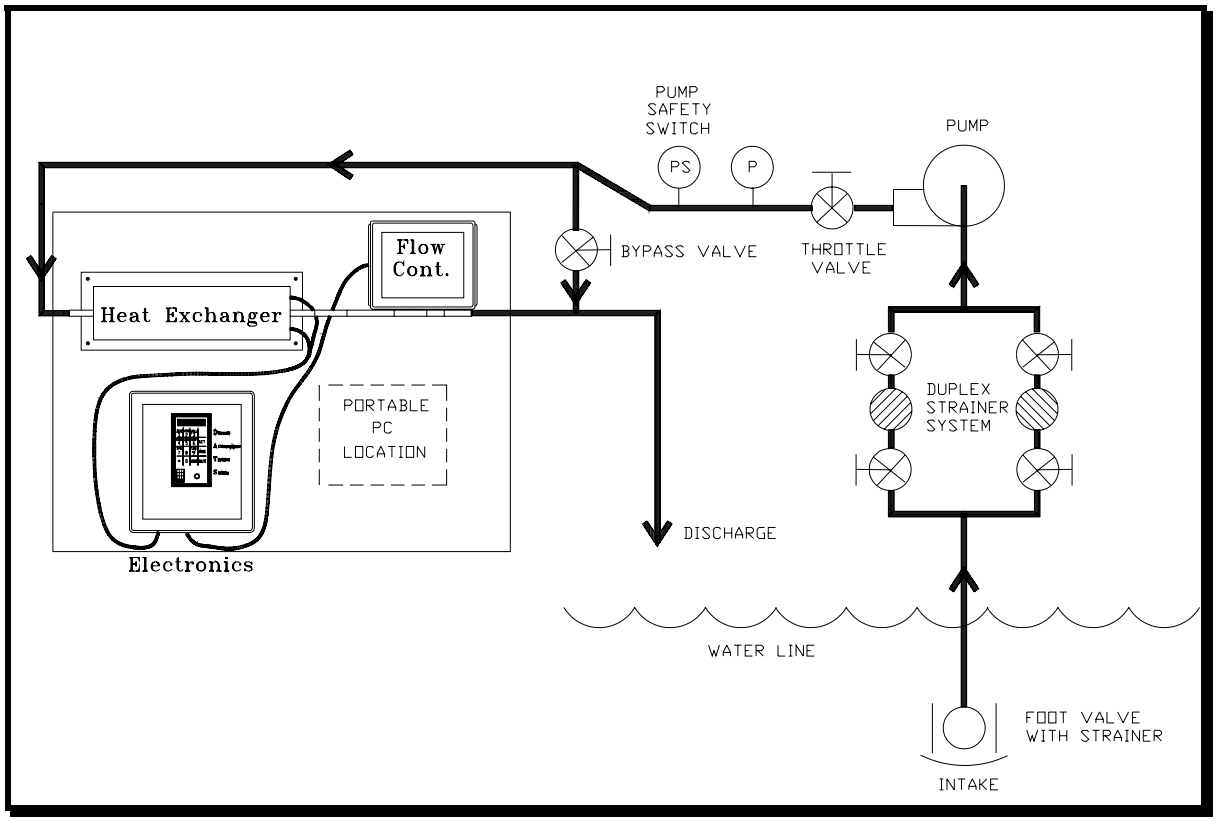

Figure 2. Typical DATS™ Fluid Connections

2.4 Cable Connections

2.41 AC Power Connection

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 ™** operation. Figure 3 indicates the external electrical connections for the **DATS™**.

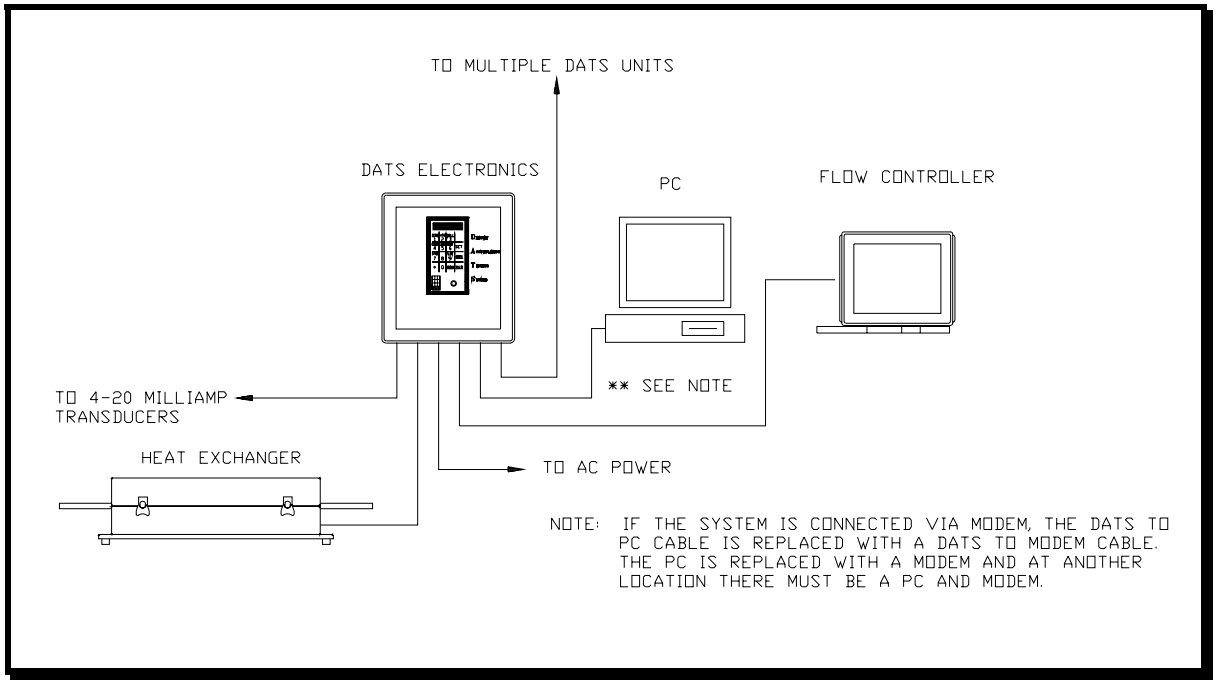

Figure 3. DATS™ Electrical Connections

2.42 Interface Cables and Plugs

The heat exchanger and flow controller are connected to the electronics using either the standard AMP connectors or optional cord grip connections. The location of the connectors is illustrated in Figure 4.

l.) Plug the Flow Controller and Heat Exchanger cables into their respective locations on the Electronics box, and turn the lock ring clockwise to secure the connection.

If the optional cord grips are used, insert the wire though the cord grip and tighten down on the securing nut. The wires must then be connected to the main terminal strip, TB1, within the electronics module as illustrated in Figure 5.

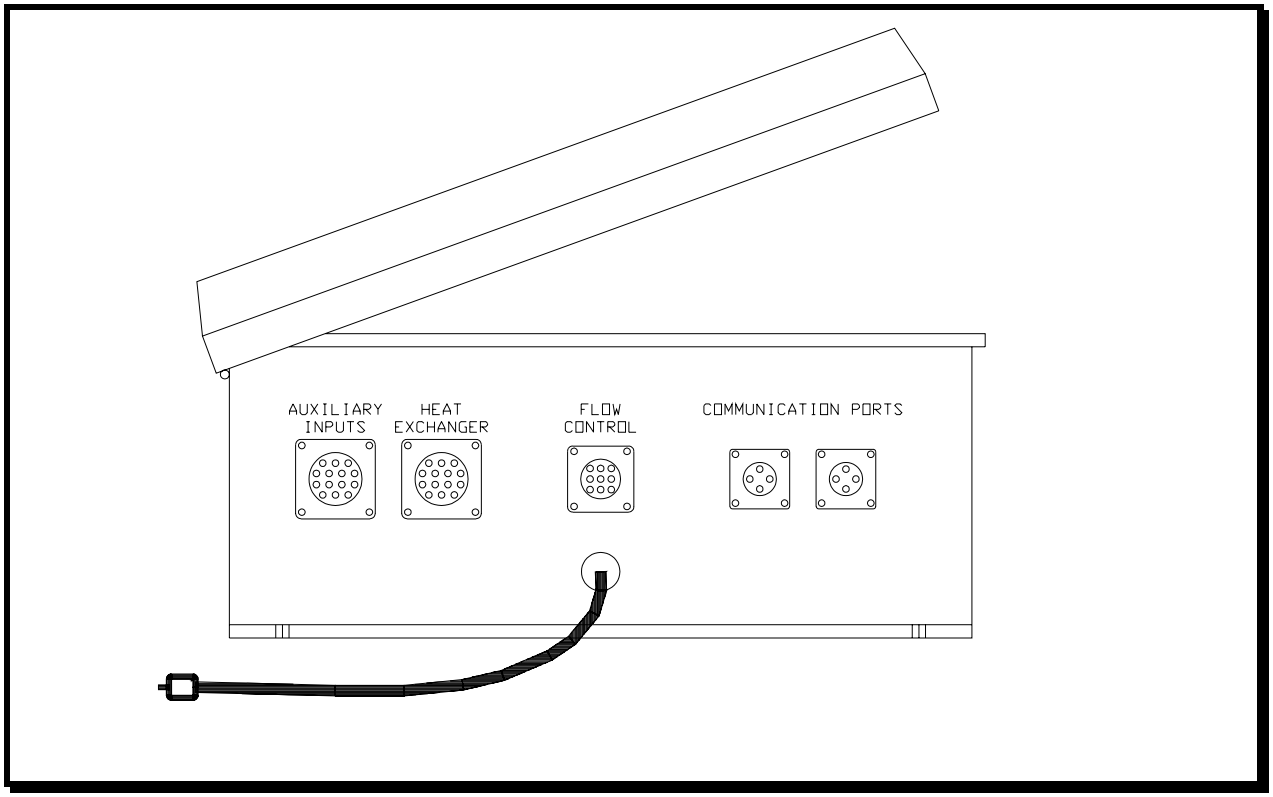

Figure 4. DATS™ Interface Cable Connections

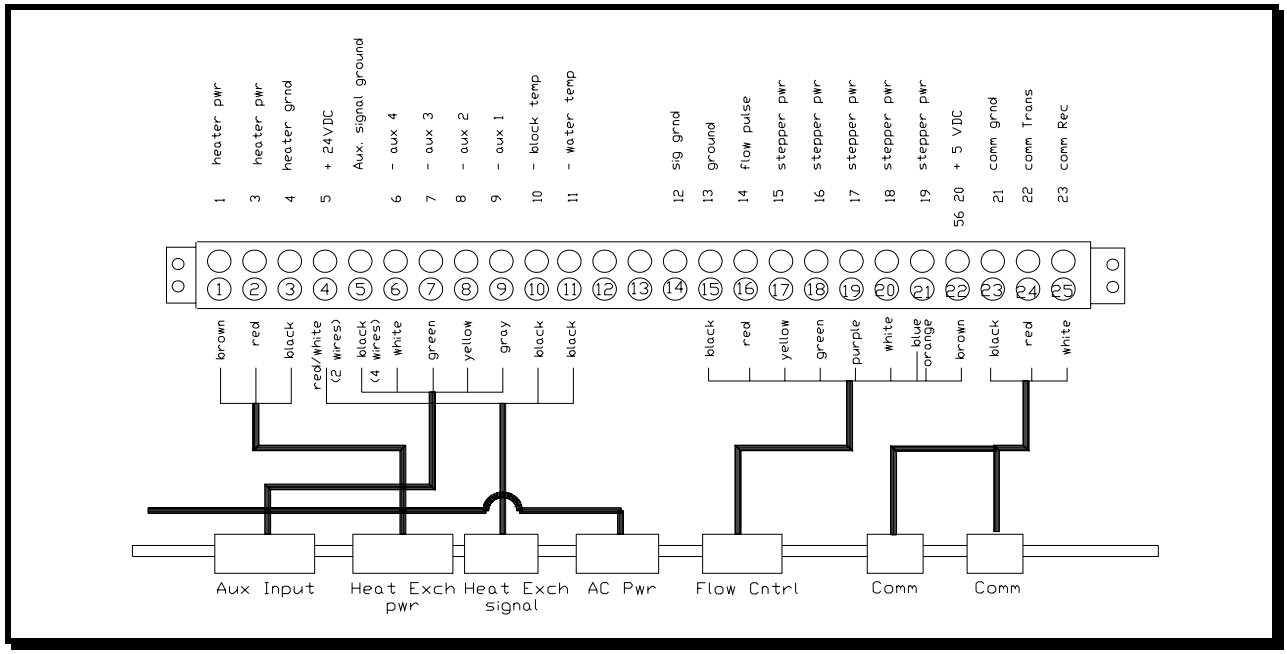

Figure 5. DATS™ Internal Cable Connections

2.) Auxiliary input: Wiring for the auxiliary input cable is shown in Figure 6. The loops are designed for external loop power, and will require an external DC power supply to drive the loops. Plug the auxiliary input cable connector into the auxiliary input port on the Electronics unit, and connect the other end to the desired transducer in accordance with Figure 6. If cord grips are being used, wire the auxiliary cable to the main terminal strip as shown in Figure 5. Connect a 24 VDC (or as specified by manufacturer) power supply to the loop if the transducer does not provide its own excitation.

NOTE

Use caution when plugging in the auxiliary input connector. The plug is physically similar to that of the Heat Exchanger.

3. When networking a series of **DATS™** Fouling Monitors, connect the **DATS** to **DATS** cables between the serial ports on each Electronics box as indicated in Figure 7.

NOTE

When operating more than 1 DATS™ unit simultaneously, be sure to change the "address" of any additional units (Section 6.2).

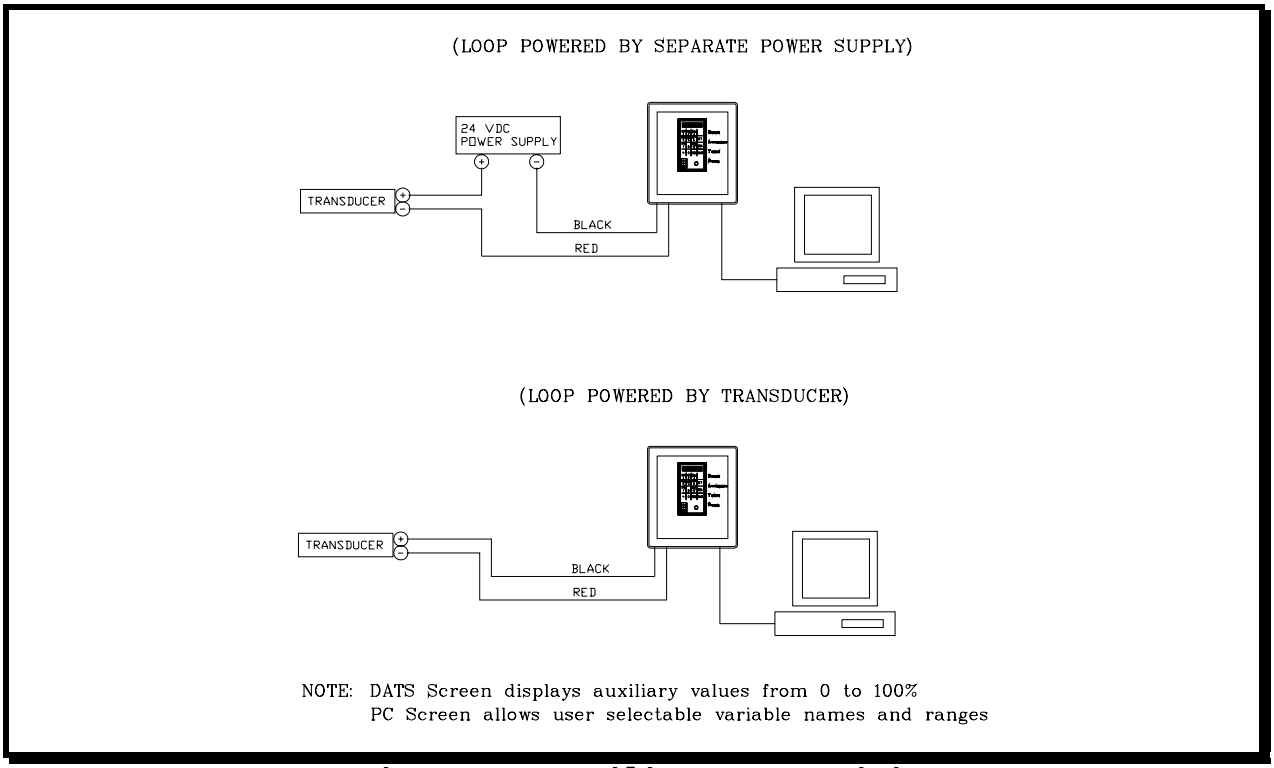

Figure 6. Auxiliary Input Wiring

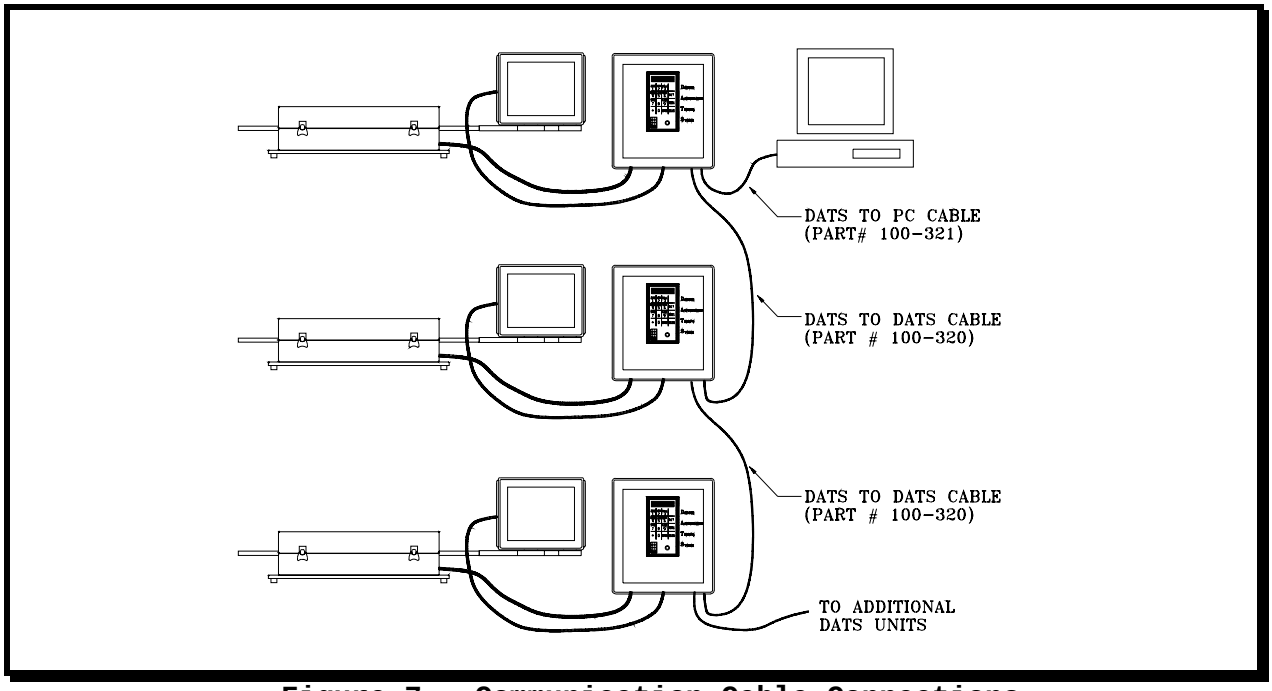

Figure 7. Communication Cable Connections

2.43 Direct PC Cable Connections

To access **DATS™** stored data, communication between the **DATS™** and an IBM PC/XT/AT or BIOS compatible computer(clone) must be established. The PC requires a graphics card and a serial port. For remote PC cable connections, refer to Section 2.44.

l.) Connect the **DATS™** to PC cable from one of the two communications ports on the **DATS™** electronics to one of the serial ports on the PC (Figure 7). Both serial communication ports on the **DATS™** are electrically identical. On multi-unit installations refer to Figure 7 for communications cable connections.

2.) IBM and compatible PC's will have a DB25 pin connector(female) on the communication port. AT and portable computers will have a DB9 pin. The **DATS™** communications cable is supplied with a DB9 pin connector. An adapter cable (DB25 pin to DB9 pin) is available in any local computer shop.

3.) When connecting more than one **DATS™** to the PC, use a **DATS-DATS** cable to connect the remaining communications port on the first **DATS™** to the next unit and connect the second unit to the third, etc.

2.44 Remote PC Cable Connections

The **DATS™** may be remotely accessed by phone through conventional modems. One modem is connected directly to one of the two communications ports on the **DATS™** (or a series of multiple **DATS™** units) and the other to the serial communications port of a PC.

A. Typical Phone Line Modem Configuration:

1. Modem: A Hayes-compatible 1200 baud modem which is switch selectable for "Auto Answer", "Send Result Codes", and "Switch Result Codes in English" is required. Status lights and a speaker are recommended for troubleshooting communication problems. One modem is required for the PC, and one for each DIFFERENT **DATS™** location. If multiple **DATS™** units are "daisy chained" together, and are located within 30 feet [9.1 m] of one another, only one modem is required.

2. Cables:
   (a) One PC-Modem cable (DB25 female to DB25 male)
   (Supplied with modem)

   (b) One **DATS™**-Modem cable for each **DATS™** site
   (Part number 100-319)

   (c) **DATS™-DATS™** cables if more than one unit is being monitored.
   (Part number 100-320)

3. Phone Lines: One phone number for the PC and one phone number for each modem at a **DATS™** site.

4. Configuration Hardware: Refer to the PC manual for configuring the PC, monitor and serial port. Modem configuration is as follows:

   Baud Rate: 1200
   Data Bits: 8
   Stop Bits: 1
   Parity: None

5. Internal FAX/Modem card: If using an internal FAX/modem card, the internal S-registers may have to be modified to establish communications. Consult Modem manual, or contact Bridger Scientific, Inc. for further details.

NOTES

3.0 INSTALLATION CHECK

3.1 Power Connections

With all the components connected, 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 Flow Connections

Before full operation, the **DATS™** must be pressure tested for leaks, and the control valve and diaphragm of the Flow Controller manually tested for proper operation.

1.) Connect the Flow Controller to the water source with the gate valve fully closed.

2.) Open the door of the electronics box, turn on the main power, and place the MANUAL/AUTO switch in the **MANUAL** position.

3.) Holding the OPEN/CLOSE toggle switch in the **CLOSE** position, close the diaphragm control valve in the flow controller until it stops.

4.) Slowly open the gate valve, and check the piping upstream from the diaphragm control valve for leaks.

5.) Holding the OPEN/CLOSE toggle switch in the **OPEN** position, open the diaphragm control valve fully and then adjust the gate valve to obtain a flow 1-3 ft/sec **[**0.3 - 1 m/sec**]** higher than the maximum desired operating velocity. Check to insure that no leaks are evident downstream from the diaphragm control valve.

NOTE **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.**

6.) Manually adjust the diaphragm control valve to the approximate desired flow rate.

7.) Return the MANUAL/AUTO switch to the **AUTO** position. Allow the flow to stabilize for 15 - 30 minutes. If no new value has been entered for flow, the flow should stabilize at the factory set value of 5 ft/sec **[**2 m/s**]**.

3.3 Operation Verification

The primary features and functions of the **DATS™** system are monitored through interaction with the keypad, LCD display and observation of the power status lights. All components of the **DATS™** should be interconnected prior to the application of power.

1. Upon initial application of power, the power switch should illuminate indicating that electrical power is supplied to the computer power supply within the **DATS™**.

2. The red neon light, located below the keypad, should illuminate at partial brightness after approximately 30 seconds. This light remains on for 10-15 seconds, and indicates that power is being applied to the heating element for electrical power impedance measurements.

3. Check the LCD display above the keypad for system parameters. After approximately 60 seconds, the display should scan through the following values:

TLIQ:	xxx.xx	(Water temperature in °F **[**°C**]**)
TBLK:	xxx.xx	(Heater block temperature in °F **[**°C**]**)
FLOW:	xxx.xx	(Flow velocity in ft/sec **[**m/sec**]**)
TWALL:	xxx.xx	(Wall temperature in °F **[**°C**]**)
HTR:	x.xxxx	(Calculated heat transfer resistance in hr-ft²-°F/Btu **[**m²-°C/Watt**]**)
HEAT:		(Applied heat in Btu/hr **[**Watts**]**)
AUX1-AUX4:	xx.xx	(Values for first - fourth auxiliary channels. Values are displayed in % of full scale)

These values are not accurate until the system has been operational for at least five data acquisition intervals. If **ERROR** is indicated on any of the displays, check the cable and device connected to the system. If there is no applied heat, an error will also be displayed.

4. Proper function of the flow controller is indicated by observation of the flow control valve. After the flow has stabilized, the valve will only be actuated for a short time period during the scan cycle (typically, 0.1 second over a 60 second time interval).

The Manual/Auto switch on the electronics box must be in the AUTO position for the microprocessor to actuate the valve and control the flow rate.

5. If the **DATS™** does not perform as specified, turn the system off for a few seconds. Then restore power to the unit. The microprocessor will reinitialize certain values. If the system still fails to perform properly, refer to the Troubleshooting Guide (Appendix B) or contact the regional vendor for technical assistance.

NOTES

4.0 INITIAL SETTINGS

As shipped from the factory, the **DATS™** is set for an applied heat of 1200 BTU/Hr **[400 watts]**, a flow rate of 5 ft/sec **[2 m/s]**, and a record interval of 0.25 Hr. Before the setting of any new values, the applied heat for the particular installation must be calculated. Refer to the specifications worksheet supplied with the unit to aid in the calculation of necessary parameters.

4.1 Applied Heat Calculation

(Range: 250 - 4500 Btu/hr **[**75 - 1320 Watts**]**)

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

DATS™ Applied Heat = Condenser Design Heat Flux x **DATS™** Heat Exchanger Surface Area

Heat flux = Btu/hr-ft^2 **[**Watts/m^2**]**

Surface Area = Heated Surface area of heat exchanger tube
= π x D x L

where: π = 3.1415
D = O.D. of tube in ft **[**m**]**
L = heated length of tube in ft **[**m**]**

∴ **For English Units**

Surface Area (ft^2) = 3.1415 x (O.D. (inches) x 1/12) x 5/12

= 0.1091 x (O.D. (inches))

∴ **For Metric Units**

Surface Area **[**m^2**]** = 3.1415 x O.D.**[**m**]** x l **[**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, along with selection of the heat control mode. Flow must be initiated prior to the setting of applied heat. These selections may be made using either the communications software (Section 5.4), or the keypad (Section 6.1). To change the data record interval, the communications software must be used.

4.2 Applied Heat Control Mode

Two modes of applied heat are available on the **DATS™**,as described below. Mode selection may be done either by the communications software (Section 5.4) or the keypad (Section 6.1). The factory set control mode is constant applied heat, mode 0.

A. Constant Applied Heat, (Mode 0)

In this mode, the applied heat flux per unit area is held constant by the microprocessor. The inside tube wall temperature is allowed to vary with fouling, water temperature and flow rate.

B. Constant Wall Temperature, (Mode 1)

In this mode, the applied heat flux per unit area is adjusted to maintain a constant wall temperature. To utilize this mode effectively, some experimentation is required. The **DATS™** must **FIRST** operate in the constant applied heat mode. The selected heat value should equilibrate and the Heat Transfer Resistance (HTR) should be zeroed (see Section 6.1). The unit may then be switched to controlled operation by wall temperature.

Allow the heat exchanger to equilibrate for approximately 30 minutes. Confirm steady state conditions by verifying stability in measured parameters (velocity, block temperature and power). After the heat exchanger control mode has been selected and the unit has equilibrated, the HTR must be zeroed (Section 6.1). If the tube is clean, the correct wall temperature will be calculated when the heat transfer resistance(HTR) is zeroed.

NOTE **The wall temperature (beneath the fouling layer) is a computed value and will not be correct until this operation has been performed with a clean tube.**

NOTES

5.0 PC COMMUNICATIONS SOFTWARE

***** Make a back-up copy of the original software *****

The **DATS96™** software package, supplied with each **DATS™** monitor, is a DOS® based, Windows® compatible program, which is used to set the data record interval, retrieve collected data, generate graphs, and set experimental parameters. Experimental parameters may also be set/changed using the keypad as described in Section 6.1.

It should be noted that the **DATS96™** program it is **NOT** a full Windows® product, and has not been tested on Windows95®.

5.1 Installation

The **DATS96™** program may be run from either the floppy drive, or installed on your hard drive. If you wish to run only from a floppy, skip to Section 5.3. To install the program to your hard drive, use the following steps:

1) From the File Manager in Windows®, or at the DOS® prompt, create a directory named C:\DATS96 to hold the **DATS96™** files.

2) Copy the files from the supplied disk into the DATS96 directory you just created. At this point, you may run the program from this directory by typing **"DATS96"** at the prompt. If you wish to setup the program to be called from the Windows® Program Manager, follow the Windows Setup instructions in Section 5.2 below.

5.2 Windows® Setup Instructions

5.21 DATS96 Main Program Setup

1) Start Windows®, and open the folder into which you want to place the **DATS96™** program icon.

2) In the upper left hand corner of the menu bar, select **F**ile and then **N**ew.

3) At the New Program Object Window, select Program Item and then click on OK.

4) Under Program Item Properties Window, enter **DATS96** in the description field, and then press TAB to move the cursor to the Command Line Field.

5) Click on the Browse Button, and select DATS96.PIF from the DATS96 directory created in Section 5.1 . Click on OK.

6) In the Working Directory field, enter C:\DATS96.

7) Click on the Change Icon button. A message will appear stating that **" There are no icons available for the specified file. You can choose an icon from those available for Program Manager"** Click on OK.

8) In the Change Icon Window, click on the Browse button and select DATS96.ICO from the DATS96 directory created in Section 5.1. Click on OK.

9) Click on OK in the Change Icon Window.

10) Click on OK in the Program Item Properties Window. The program may now be called by double clicking on the DATS96 program icon.

5.22 DATS96 Graphing Program Setup

If desired, a separate program icon may be setup to use the graphing only feature of the DATS96 software as follows:

1) Start Windows®, and open the folder into which you want to place the **DATS96™** program icon.

2) In the upper left hand corner of the menu bar, select **F**ile and then **N**ew.

3) At the New Program Object Window, select Program Item and then click on OK.

4) Under Program Item Properties Window, enter **GRAPH96** in the description field, and then press TAB to move the cursor to the Command Line Field.

5) Click on the Browse Button, and select GRAPH96.PIF from the DATS96 directory created in Section 5.1 . Click on OK.

6) In the Working Directory field, enter C:\DATS96.

7) Click on the Change Icon button. A message will appear stating that **" There are no icons available for the specified file. You can choose an icon from those available for Program Manager"** Click on OK.

8) In the Change Icon Window, click on the Browse button and select DATS96.ICO from the DATS96 directory created in section 5.1. Click on OK.

9) Click on OK in the Change Icon Window.

10) Click on OK in the Program Item Properties Window. The program may now be called by double clicking on the GRAPH96 program icon.

5.3 Initiating DATS™-PC Communications

l) Start the **DATS96™** program using one of the methods listed below:

- Insert a copy of the **DATS96™** software into the PC floppy disk drive, change to the floppy drive, and type "DATS96" at the DOS® prompt.
- Change to the directory created in Section 5.1, and type "DATS96" at the DOS® prompt.
- Double click on the DATS96 icon in Windows®.

2) After displaying the copyright information, the program will ask for **English or Metric Units [E/M]**. Enter the correct response.

4) The next prompt asks **Is this a new experiment [Y/N]**. Respond with a **"Y"**(es)or **"N"**(o).

NOTE

If this is a continuation of an old experiment, be sure the previous data disk is in the specified drive.

NOTE

If a new experiment is selected, the program will write over any previously recorded data. The set points for heat and flow will be overwritten to the default values, and the record interval must be re-entered before any data will be stored.

a) For a **"Y"**(es) response enter:

l. The number of **DATS™** units connected.
2. **D**irect or **P**hone data access.
3. COM port being used.
4. The maximum number of records in a file before a new file is created. (This refers to the records on the data disk only).

5) The phone number, and **T**one or **P**ulse dial if Phone communication is being used.

b) For a **"N"**(o) response the program will prompt with:

"Edit run parameters (Y/N)".

"Y"(es) response allows communications (direct/phone), COM port and the maximum number of files to be reviewed or changed.

"N"(o) response resumes experiment at previous settings.

NOTE

If communications between the DATS™ and PC cannot be established, refer to Section 5.9 for communication verification procedures.

5.4 PC Menu

After the PC communications has been initiated, the program enters the monitor mode. A menu is displayed at the top of the screen, along with the date, time, run-time and disk capacity. The menu is comprised of the following functions which may be accessed from the computer keyboard. Pressing the highlighted letter activates each function.

Change DATS set points	Use to change the heat control mode, flow rate and heat set points for each **DATS™** unit. The heat control mode is set to **"0"** for constant applied heat, and **"1"** for constant wall temperature.
Display	Allows operator to select which **DATS™** unit to display in multiple unit configurations
Error reset	Use to reset an error, such as a disk error which has been rectified.
Graph data	Use to graph stored data which has been uploaded. Refer to Section 6.0 Graphing for commands.
Quit	Terminates communications program and returns the user to DOS®. **THIS COMMAND MUST BE USED TO PROPERLY CLOSE THE DATS™ FILES SO THEY ARE AVAILABLE FOR FUTURE COMMUNICATIONS.**

NOTE

The program MUST be stopped by using the "Quit" command prior to shutting off the power. Failure to do so will cause errors when attempting to resume communications.

start **R**ecording

Initiates uploading of data from the **DATS™**, and sets the data record and **auto-upload** intervals. Until values for these intervals are entered (in hrs), no data will be stored. The **record** interval is entered in hours and hundredths of hours. The minimum interval is 0.05 hr.

The **auto-upload** interval is used to set the time interval for automatically retrieving **DATS™** data. This function may ONLY be used if the **DATS™** is connected to a dedicated PC. Be sure there are less than 124 data collection intervals per auto upload.

NOTE

The DATS is capable of storing a maximum of 124 records before data is overwritten (e.g. if the record interval is 0.5 hr, data should be uploaded from the DATS before 62 hrs has elapsed). If this time is exceeded, only the LAST 124 records will be available for transfer. If problems occur, Bridger Scientific, Inc. is available for assistance in data retrieval.

Swap disk

Active only when operating program from a floppy disk drive. Transfers the configuration data to a new data disk when the experiment requires more than one data disk. When less than 5% of the disk space is available an audio tone warns the user.

Entering the "swap disk" routine and selecting "No" at the prompt will close out old data files regardless of their size, and start new files. This is a useful way of marking events in the **DATS™** data.

NOTE

Do not change data storage or program disks in the middle of an experiment without using the "Swap disk" routine.

define **V**ariables	Use to define the name and range of "auxiliary" variables. To change the default names (AUX1, AUX2, AUX3, AUX4), type **V** and specify the name and range of the variable. The default range for all AUX inputs is 0 - 100. Retain the name and range of designated variables for modification of the spreadsheet header (Appendix D).

5.5 Graphing

The graphing routine is used to graph data sets which have been uploaded from the **DATS™** unit. Data sets may be graphed independent of **DATS™** connection, or graphed during program execution by using one of the following methods listed below:

- By pressing **G** on the keyboard during normal program execution
- By typing **"DATS96 -G"** at the DOS® prompt.
- By double clicking on the GRAPH96 icon in Windows®.

Once in the graphing routine, the following commands are available. Pressing the highlighted letter, and pressing return will invoke the command.

Next Graph	Allows the user to select the next data set and/or variable to be graphed from a list of uploaded data sets.
Set New X Bounds	Allows the minimum and maximum values along the X axis to be adjusted to zoom in on particular time frame.
Compare Graphs	Allows comparison of the last two data graphs.
Quit Graph Mode	Exits graph mode and returns to normal operation or the DOS® prompt depending on how graph mode was entered.

5.6 Uploading data from the DATS™

If a dedicated PC and the auto-upload feature is not used, the data stored within the **DATS™** must be periodically uploaded via a modem or portable PC using the following sequence;

1. Establish PC communications, and then use the start **R**ecording function by pressing **"R"**

2. Answer **"N"**(o) to the prompts **"Set record interval?"** and **"Set auto-upload interval?"**

3. Answer **"Y"**(es) to the **"Upload All Data Now?"** prompt. This key sequence uploads data from the **DATS™** to the .prn file on the disk.

Data is transferred between the **DATS™** and the PC at a rate of 1200 baud. Several minutes may be required to upload all data stored within the **DATS™**, depending upon experiment run time and data record interval. Data will be stored on the designated disk as **DATXXYY.**prn, where **XX** indicates the **DATS™** address and **YY** indicates the file number.

5.7 Importing data for analysis

1. The files created by the **DATS™** are in a .prn format. They may be directly imported to a LOTUS 123™ compatible spreadsheet or other similar commercial software programs.

2. The software package supplied by Bridger Scientific includes two directories which contain header files consisting of column definitions and data units for English and metric units. See Appendix D for a sample header and data format. To use the header provided, retrieve the header file from the appropriate directory **before** the .prn file is imported.

3. After the header has been retrieved, position the cursor below the time column of the header. Use the LOTUS-123™ spreadsheet commands: **[FILE]**, **[IMPORT]**, **[NUMBERS]** followed by the data file name to import the data to a spreadsheet file.

4. Some data from the factory operation of the **DATS™** is stored on the software disk, along with a testdata.wk1 file which contains the factory data already imported and saved along with the header file. Refer to Appendix E for the file directory, and a hard copy of the factory test data has also been supplied. These data sets may be used to experiment with LOTUS-123™ software routines and data manipulations. They may also be reviewed to examine some of the capabilities of the **DATS™**.

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5.8 Data Interpretation and Calculations

l. General Principles

The following guide explains the general principles involved in calculation of **DATS™** 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).

a. Heat Transfer Resistance:

The geometry and physical relationship of the elements within the Heat Exchanger are shown in Figure 8.

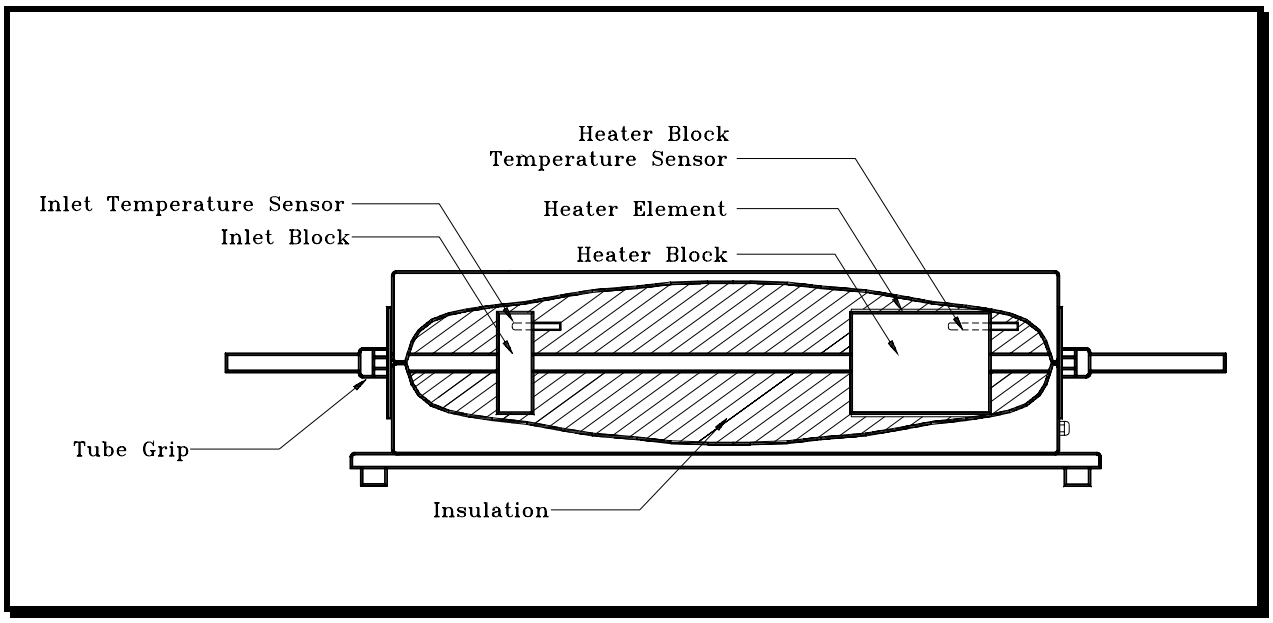


Figure 8. DATS™ Heat Exchanger

The **DATS™** calculates the Heat Transfer Resistance (HTR) from the following equation:

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

where:

HTR_{total} = Total Heat Transfer Resistance ($hr\text{-}ft^2\text{-}^oF/Btu$, **[**$m^2\text{-}^oC/Watt$**]**)
Area = Tube outside surface area (ft^2, **[**m^2**]**)
T_{block} = Heater block temperature (^oF, **[**^oC**]**)
T_{water} = Water temperature (^oF, **[**^oC**]**)
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:

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

where:

T_{block} = Temperature (^oF, **[**^oC**]**) 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
k = Thermal conductivity of water (Btu/hr-ft-^oF, **[**Watts/m-^oC**]**)
d = Tube inside diameter (ft,**[**m**]**)

When the **DATS™** 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_{ti} = Initial total HTR for a clean tube (includes the HTR for the heater block)
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™** 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 **DATS™** HTR equation becomes:

$HTR = HTR_t - HTR_0 - HTR_c$

where:

HTR = Differential HTR
HTR_t = Total current HTR
HTR_0 = Total conductive HTR with a clean tube
HTR_c = Total convective HTR with a clean tube.

The differential HTR is set to zero during the **DATS™** 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 **DATS™** 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 **DATS™** 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-ft^2-^{o}F

The deposit HTR determined by the **DATS™** after six weeks =

0.0005 hr-ft^2-^{o}F/Btu

Fouled HTR (HTR_{fouled}) = ($1/U_{design}$) + **DATS™** HTR

= (1/650) + 0.0005 (hr-ft^2-^{o}F/Btu)

= 0.00154 + 0.0005

= 0.00204 hr-ft^2-^{o}F/Btu

Fouled heat transfer coefficient (U_{fouled}) = $1/HTR_{fouled}$

= 1/0.00204

= 490 Btu/hr-ft^2-^{o}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.

5.9 Communications Verification

The following procedure will aid in verifying proper electrical connections and operation of the system components when communication cannot be established between the **DATS™** and the PC communication software (**DATS96™**).

1. Insure that the communications cable is securely connected between the **DATS™** and the serial port on the PC.
2. Insert a copy of the **DATS96™** software into the PC floppy disk drive, and run the TTY.EXE program by typing **TTY** and **ENTER**.
3. When prompted, enter the following communication parameters;

   (If in doubt, use the default values.)

PORT:	Comm port on your PC that you are connected to
BAUD:	1200
DATABITS:	8
STOPBITS:	1
PARITY:	None

4. With the program running, press the **[Ctrl]** and **[C]** keys on the PC keyboard simultaneously. The **DATS™** should respond with "Break in line YYY". This indicates the point of interruption in the program. If this message appears, the hardware within the PC and the **DATS™** is properly configured. Enter "**CONT**" and press the **[ENTER]** key to resume normal program operation, or proceed with a GOTO 9000 as described below.

   If there is no response, or the "Timeout" prompt is displayed, PC communications have not been established. Alter the settings for the communications software and re attempt communications. (i.e. another comm port setting)

CAUTION

THE NEXT PROCEDURE WILL ERASE ALL FACTORY CALIBRATION VALUES FROM MEMORY. THIS REQUIRES REENTERING ALL CALIBRATION VALUES (SECTIONS 6.2 AND 7.1) LISTED IN THE SPECIFICATIONS SHEET. THIS PROCEDURE SHOULD BE USED ONLY IF REPEATED ATTEMPTS AT OPERATION WITH THE DATS™ SOFTWARE ARE UNSUCCESSFUL, AND PROPER COMMUNICATIONS HAVE BEEN VERIFIED ABOVE. BE SURE YOU HAVE THE ORIGINAL WORKSHEET BEFORE PROCEEDING.

5. Assuming proper communications have been established, type "**GOTO 9000**" and press the **[ENTER]** key. The program will respond with a **CAUTION** message asking you if you wish to continue. Press '**C**' to continue. The program will then clear all default memory locations within the **DATS™**. This procedure is particularly useful if the **DATS™** electronics box does not normally operate as an independent device. Enter "**RUN"** and press the **[ENTER]** key to restart normal program operation, or proceed with a GOTO 10000 below.
6. Use this procedure only if an error in the recorded data has caused the **DATS™** to stop operation.

   Type "**GOTO 10000**" and press the **[ENTER]** key to clear those memory locations used to store experimental data. This procedure will reset the data record and transfer flags to the new experiment location on the **DATS™** electronics box. A new experiment must be started after using this procedure. Enter "**RUN"** and press the **[ENTER]** key to restart normal program operation.

NOTES

6.0 KEYPAD OPERATIONS

The **DATS™** keypad is used to enter factory calibration and default parameters, zero heat transfer resistance, zero and calibrate flow, and may also be used to set/change flow and heat set points during an experiment.

This section is designed to function as an easy reference to the **DATS™** keypad operations. Figure 9 diagrams the keypad layout and will serve as a convenient reference when reviewing the key functions. The keys may be pressed in a variety of sequences to obtain the desired results. Exercise caution when using the **[ENTER]** key since calibration values may be overwritten. When in doubt, use the **[CANCEL]** key to exit a routine without altering values. Variations from these sequences are possible with some custom software configurations.

NOTE

Press keys sharply and only once to avoid multiple entries. The DATS™ may require several seconds to respond to keypad input - this is normal operation.

While the **DATS™** is in any keypad routine, there is NO function control, communication, or data acquisition. **EXIT ALL ROUTINES TO RESUME NORMAL OPERATION. THIS IS ACCOMPLISHED BY REPEATEDLY PRESSING THE [CANCEL] KEY UNTIL THE SCREEN PROMPT READS "ERROR" OR "OK".**

Function Keys:

[SET]
[CANCEL]
[DELETE]
[ENTER]

Function and Numerical Entry Keys:

[SET]
[ZERO]/1
[WALL]/3
[CODE]/4
[LIQD]/5
[HEAT]/6
[SPAN]/7
/8
[FLOW]/9

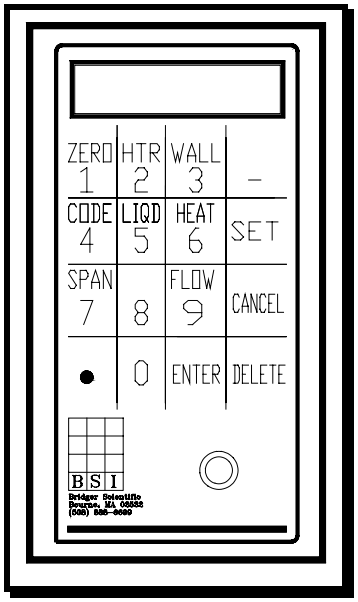


Figure 9. DATS™ Keypad

Function Keys:

[SET]	Initiates command functions (listed below).
[CANCEL]	a) Move through a command sequence b) Cancel entered operation/number c) Exit a routine without altering preset values.
[DELETE]	Backspaces l digit when entering numerical values.
[ENTER]	Prompts and enters numerical values.

Command functions:

Press the **[SET]** key first to shift keys to the command function mode.

[SET] then;

[ZERO]/1	Use to zero the heat transfer resistance and for the flow calibration.
[HTR]/2	Use to zero the heat transfer resistance after pressing **[ZERO]**.
[WALL]/3	Set the applied heat mode by controlling wall temperature.
[CODE]/4	Initiates the command sequence.
[LIQD]/5	Reserved (No function).
[HEAT]/6	Set the applied heat (Btu/hr, **[**Watts**]**).
[SPAN]/7	Enter the high point for flow calibration.
[FLOW]/9	a) Use to zero the flow rate after pressing **[ZERO]**. b) Set the flow rate (ft/sec, **[**m/sec**]**).

6.1 Entering/Changing Experimental Parameters

The following keypad sequences may be used to change experimental parameters after the **DATS™** is operational.

Operation	Keypad Entry	System Prompt
Set Flow	**[SET]**	WHICH VARIABLE?
	[FLOW]	FSET-S: x.xx ? **(Displays the current or default setting)**
	[ENTER]	VALUE?
	Enter the flow rate in ft/sec [m/s]	
	[ENTER]	OK
	(Allow the flow to stabilize for 15-30 minutes before applying heat.)	
Set Constant Applied Heat	**[SET]**	WHICH VARIABLE?
	[HEAT]	HEAT-S: xxx.? **(Displays the current or default setting)** **Note:** If the **DATS™** is in the constant wall temperature mode, the prompt will be; NOT SET ?
	[ENTER]	VALUE: ?
	Enter the calculated numerical value for applied heat (Btu/hr, [Watts])	
	[ENTER]	OK
Set Constant Wall Temp	**[SET]**	WHICH VARIABLE?
	[WALL]	HEAT-S: xxx.? **(Displays the current or default setting)** **Note:** If the **DATS™** is in the constant applied heat mode, the prompt will be; NOT SET ?
	[ENTER]	VALUE ?
	Enter the control temperature value (°F, [°C])	
	[ENTER]	OK

Operation Keypad Entry System Prompt

Zero HTR

[SET]	WHICH VARIABLE?
[ZERO]	ZERO FLOW/HTR ?
[HTR]	HTR-Z: x.xxxx? **(Displays the current zeroed HTR value)**
[ENTER]	ARE YOU SURE ?
[ENTER]	OK

Following this procedure, the heat transfer has been zeroed to the current tube conditions, and the tube wall temperature is now accurate (if the tube was clean).

6.2 Factory Calibration Parameters

The **DATS™** has been factory calibrated for the following parameters: (1) tube I.D., (2) tube O.D., (3) heater resistance in ohms, (4) flow dead band, and (5) voltage. **DO NOT OVERWRITE THESE VALUES UNLESS A NEW CALIBRATION HAS BEEN PERFORMED.** Use the **[CANCEL]** key (as indicated) to move to the next function without altering these values.

NOTE

Exit the keypad routine to restore DATS™ data acquisition and control functions. This is accomplished by repeatedly pressing the [CANCEL] key until "OK" or "Error" is displayed.

To view/change calibrated parameters, use the sequence shown below. For each setting, press **[ENTER]** to change the value or **[CANCEL]** to move to the next parameter;

Parameter	Keypad Entry	System Prompt
	[SET]	WHICH VARIABLE?
ADDRESS	**[CODE]**	ADDRESS-S: 1.0? **(The address is used to distinguish between multiple DATS™ units)**
	[CANCEL] or	**<NEXT PARAMETER>**
	[ENTER]	VALUE? **(If only one unit is being used, the address entered should be "1". Multiple units should be numbered consecutively. The default value is "1".)**
	Enter DATS Address Value	
	[ENTER]	
TEMPERATURES		TEMPERATURES?
	[CANCEL] or	**<NEXT PARAMETER>**
	[ENTER]	TLIQ: xxx.xx? **(Displays the current water temperature)**
	[ENTER]	TBLK: xxx.xx **(Displays the current block temperature)**
	[ENTER]	

Parameter	Keypad Entry	System Prompt
TUBE ID		TUBE ID: x.xxx? **(Displays the tube inner diameter in inches [cm]. This is a factory set value according to customer specifications. The default value is 1" [1.1cm])**
	[CANCEL] or **[ENTER]**	**<NEXT PARAMETER>** VALUE?
	Enter tube ID value in inches [cm] **[ENTER]**	
TUBE OD		TUBE OD: x.xxx?" **(Displays the outside tube diameter in inches [cm]. This is a factory set value according to customer specifications. The default value is 1.2" [1.4cm])**
	[CANCEL] or **[ENTER]**	**<NEXT PARAMETER>** VALUE?
	Enter tube OD value in inches [cm] **[ENTER]**	
OHMS		OHMS: x.xx? **(Displays the heater element resistance in ohms. This value is factory calibrated. The default value is 12 ohms)**
	[CANCEL] or **[ENTER]**	**<NEXT PARAMETER>** VALUE?
	Enter the heater element resistance in Ohms **[ENTER]**	

Parameter	Keypad Entry	System Prompt
FLOW DB		FLOW DB: x.xx? **(Displays the flow dead band in ft/sec [m/sec]. When the flow is within this range, the valve will not adjust. This is a factory set value. The default value is 0.06 ft/sec [0.02 m/sec])**
	[CANCEL] or [ENTER]	**<NEXT PARAMETER>** VALUE?
	Enter flow deadband in ft/sec [m/sec]	
	[ENTER]	
ACV CAL		ACV Cal? **(This begins the AC voltage calibration routine. These values are set during factory calibration and are listed on the specifications sheet)**
	[CANCEL] or [ENTER]	**<NEXT PARAMETER>** QM: x.xxx **(Momentarily displays the current value of the slope)** QB: x.xxx **(Momentarily displays the current value of the intercept)** 1-ENTER 2-CAL
	To enter the values for Q_m and Q_b, press [1]	NEW QM= VALUE?
	Enter value for Q_m	
	[ENTER]	NEW QB= VALUE?
	Enter value for Q_b	
	[ENTER]	
	To calibrate, press [2]	**"Factory Calibration Procedure"**

Parameter	Keypad Entry	System Prompt
MIN FLOW		MIN FLOW: x.x?
		(Displays the minimum flow rate in ft/sec [m/sec]. If the flow is below this value, the heat applied to the block is automatically discontinued. This is a safety feature which prevents overheating of the system in the event flow is disrupted. The default value is 1.5 ft/sec [0.5 m/sec])
	[CANCEL] or	**<NEXT PARAMETER>**
	[ENTER]	VALUE?
	Enter the minimum flow in ft/sec [m/sec]	
	[ENTER]	
CLOCK		Clock: xxxxxxxx
		(Displays the clock in a year, month, day and time (hours and minutes) format. The day and time must be set to match values on the PC to insure proper operation of the communications software. The clock value is rounded to the nearest hour when displayed)
	[CANCEL] or	**<Return to normal operations>**
	[ENTER]	YEAR (00-99) VALUE?
	Enter a value for the current year	
	[ENTER]	MONTH (1-12) VALUE?
	Enter a value for the current month	
	[ENTER]	DATE (1-31) VALUE?
	Enter a value for the current date	
	[ENTER]	HOURS (0-23) VALUE?
	Enter a value for the hour (24 hour clock)	

Parameter	Keypad Entry	System Prompt
CLOCK	**[ENTER]**	MINUTE (0-59)
Cont.		VALUE?
	Enter a value for the minute	
	[ENTER]	

After these experimental parameters have been entered, the **DATS™** returns to the process and display data screen. Check to be sure that the display screen on the unit is cycling and that the values have stabilized.

NOTES

7.0 FLOW CALIBRATION

Fouling significantly affects the **DATS™** 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, first determine the time for a specified quantity of fluid to pass through the flow meter, or to fill a container of known volume. Then calculate the actual flow rate as follows:

NOTE

Set the flow switch to MANUAL so that the flow rate will not change during the calibration.

Flow Velocity (ft/sec) = Flow (gal/min)/((2.448 x (tube I.D. (in^2))

Flow Velocity [m/sec] = Flow **[**l/min**]** /((4.712 x (tube I.D. **[**m^2**]**)

After calculating the actual flow velocity, compare the actual flow to the display reading. If the system pressure is stable, the readings should be accurate to +/- 0.12 ft/sec **[**0.04 m/sec**]**. If the readings are not within specification, re-calibrated the flow meter as follows:

1. Shut off the flow.

2. Switch the flow control valve switch to **MANUAL**.

3. Wait until the flow reading (on the **DATS™** or PC display) is zero. If the flow does not read zero, zero the flow from the keypad as follows;

Keypad Entry	System prompt
[SET]	WHICH VARIABLE?
[ZERO]	ZERO FLOW/HTR?
[FLOW]	FLOW-Z: x.xx? **(Displays the current zero value)**
[ENTER]	1-ENTER 2-CAL
press [2] To calibrate the zero flow value,	OK

4. Wait l minute to insure the flow reads "0" on the **DATS™**.

5. Turn flow back on leaving control valve switch set to **MANUAL**. Wait until the **DATS™** has cycled through all values at least once and the flow rate has stabilized. Re measure the actual flow rate, and enter flow span value as follows;

Keypad Entry	System prompt
[SET]	WHICH VARIABLE?
[SPAN]	FSPAN-S: x.xxx? **(Displays the current span value)**
[ENTER]	1-ENTER 2-CAL
press [2] To calibrate the fspan flow value,	VALUE?
Enter the value of the measured flow in ft/sec [m/sec]	
[ENTER]	OK

7. Confirm that the flow velocity has stabilized by observing the **DATS™** display for several cycles.

8. Verify flow calibration and flow control:

   a. Manually alter the flow velocity away from the set point.
   b. Switch the flow controller switch to the **AUTO** position.
   c. Allow approximately 15 minutes for the system to drive the flow control valve to the correct position.
   d. Measure the flow rate by filling a container of known volume with discharge water from the system.
   e. Calculate the actual flow velocity (described above).
   f. This value should be within +/- 0.12 ft/sec **[**0.04 m**]** of the value displayed on the **DATS™**.
   g. If these values do not agree, insure that the flow has reached equilibrium at the set point, and perform the calibration again.

   Refer to the Troubleshooting Guide (Appendix B) if problems persist.

7.1 Factory Flow Calibration Values

Occasionally, it may be necessary to re-enter the factory calibration values for flow zero and flow span. This should be done anytime a GOTO 9000 routine is performed (Section 5.9), or problems are experienced during a normal calibration. The factory values are valid only for a clean flow meter, with no or little wear on the paddlewheel and pin. As the components wear, a full calibration should be performed to retain full accuracy. Enter the factory values as follows;

Keypad Entry	System prompt
[SET]	WHICH VARIABLE?
[ZERO]	ZERO FLOW/HTR?
[FLOW]	FLOW-Z: x.xx? **(Displays the current zero value)**
[ENTER]	1-ENTER 2-CAL
press [1] To enter a new zero flow value,	NEW ZERO= (Pause) Value?
Enter Flow Zero Cal value from factory worksheet	
[ENTER]	OK

Keypad Entry	System prompt
[SET]	WHICH VARIABLE?
[SPAN]	FSPAN-S: x.xxx? **(Displays the current span value)**
[ENTER]	1-ENTER 2-CAL
press [1] To enter a new span flow value,	NEW SPAN (Pause) VALUE?
Enter Flow Span Cal from factory worksheet	
[ENTER]	OK

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 ™**.

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: 60 sec.

10. Data Storage: Maximum 124 records.
    Minimum storage interval: 0.05 hrs
    Maximum storage interval: 99 + hrs

11. 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 Ceramic Paddle wheel Pin or optional Magnetic Flow meter with PVDF or Polypropylene housing and Titanium, Tantalum or 316SS contacts

12. 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, running DOS® or Windows®.

13. Data File Compatibility:

Data files generated from the software are in a space delimited, ASCII format, and may be imported into Lotus-123™, Quatro-Pro™, or any Lotus™ compatible program.

14. Mechanical Mounting Specifications

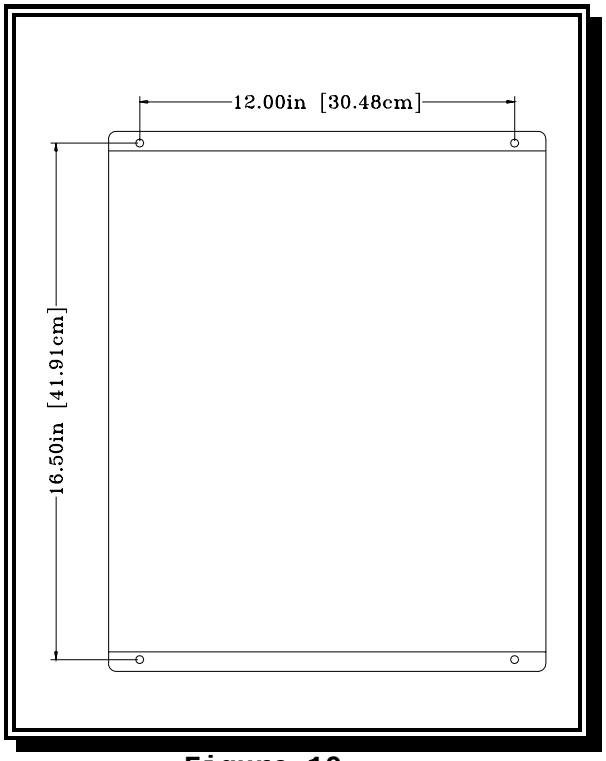


Figure 10
Electronics Mounting

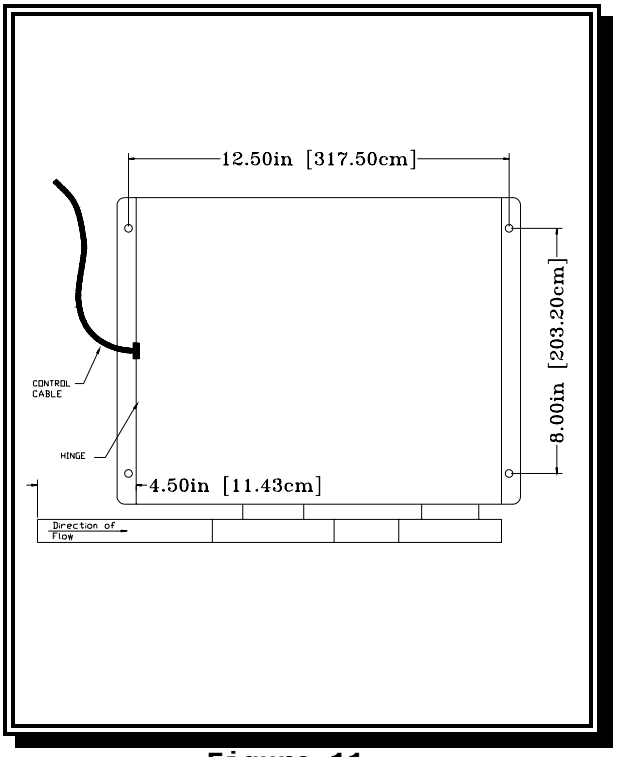


Figure 11
Flow Controller Mounting

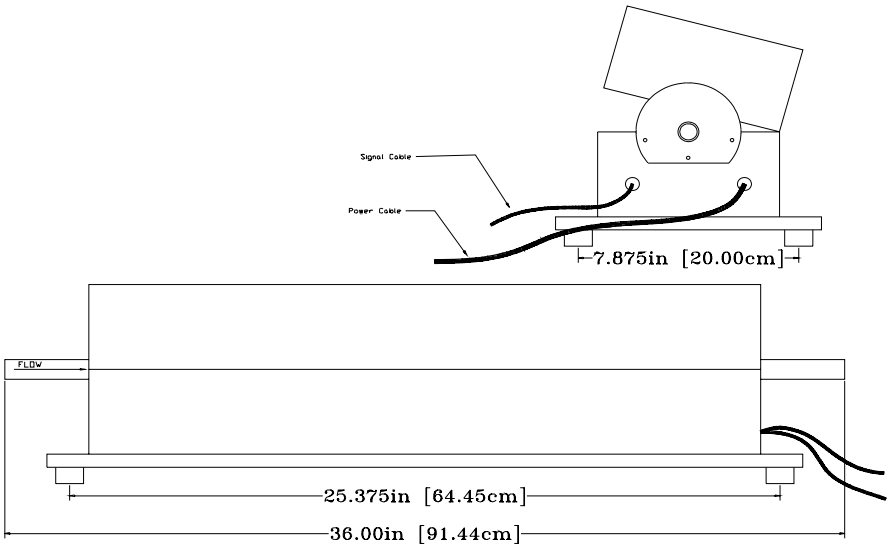


Figure 12 Heat Exchanger Mounting

Appendix B: DATS™ Troubleshooting Guide

PROBLEM	REMEDY
No DATS™-PC Communication "Timeout" is displayed on the PC Screen	1) Addresses set incorrectly. Reset according to Section 6.2, and re attempt communication. 2) The Comm port has not been appropriately specified. Try communication with a new specification (e.g. COM2 instead of COM1). 3) The serial port has not been set up properly. Refer to the PC manufacturers instructions and verify operation using another program. 4) The **DATS™** is in one of the keypad function routines. Press **[CANCEL]** until the **DATS™** is in the normal cycling mode. 5) The **DATS™** program is not operational due to improperly stored program values. Check the **DATS™** display for proper operation. If correct, proceed with TTY.EXE software as described in Section 5.9. 6) The **DATS™** power switch is not on, or the program has stopped. Turn the power off and back on again. Confirm that the red power light is illuminated. The **DATS™** should begin to cycle after 1 minute. 7) The **DATS™**- PC communications cable is faulty or not connected at one or both ends.
The DATS™ will not download data	1) The data has already been downloaded 2) The disk is filled with data. Use the Swap disk routine described in Section 5.4. 3) The record interval has not been set. Set the record interval as described in Section 5.4.

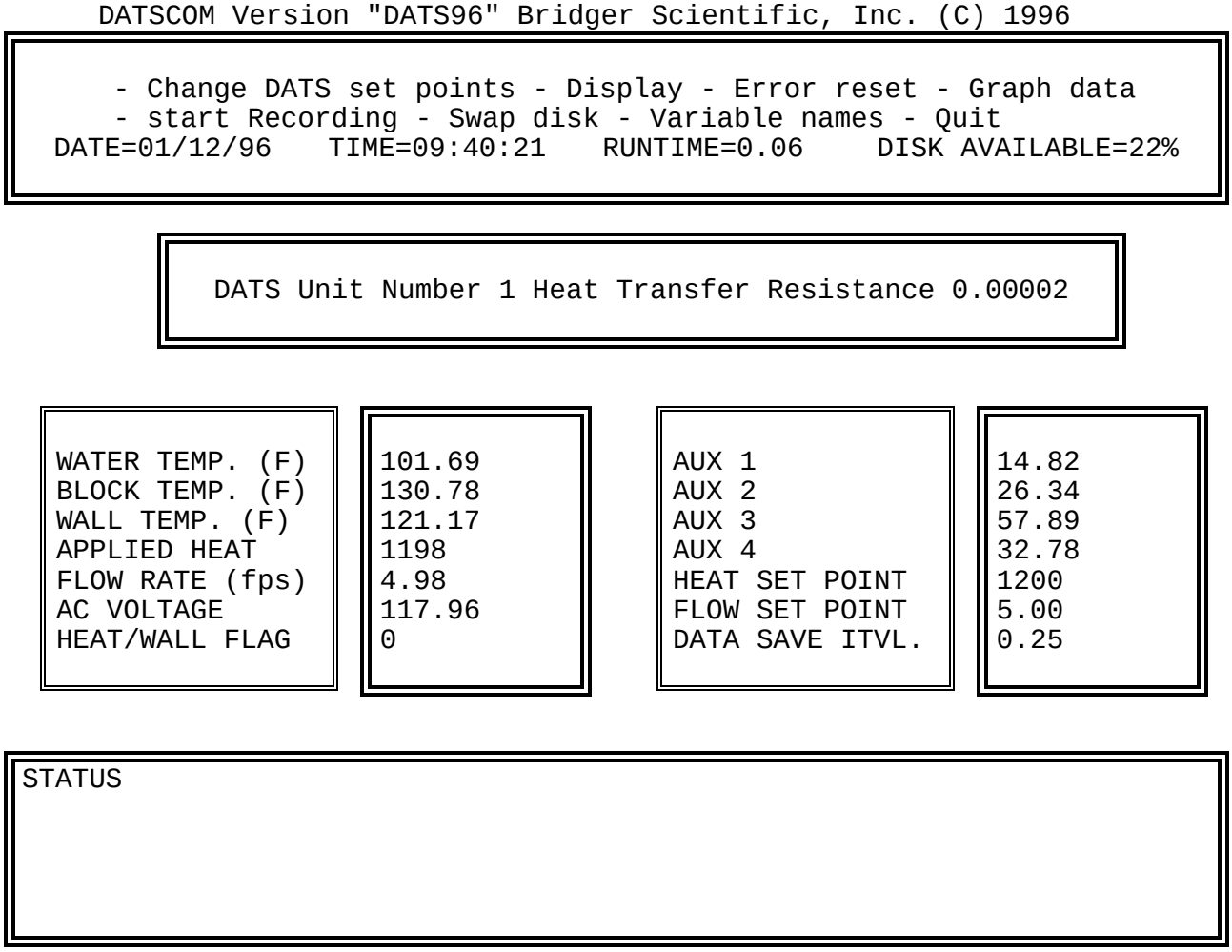
Problem	Remedy
Data scrambled when imported into the Lotus-123™ spreadsheet	1) Data imported as text instead of numbers. 2) Column width set too narrow for data. Increase column width in spreadsheet.
No Flow Control	1) The flow controller switch is in the MANUAL position. Switch to the AUTO mode. 2) Insufficient time for flow to stabilize. Allow at least 20 minutes for flow to equilibrate. 3) Flow is out of range. The **DATS™** has tried unsuccessfully to bring flow within range. In this event the **DATS™** display will read "FLOW=ERROR" and the PC display will show "Flow = -999". Adjust the flow to near the set point using the gate valve to the system, and allow flow to equilibrate. 4) The cable between the **DATS™** and the flow controller is not making connection. Check connections and correct deficiencies. 5) The **DATS™** is in one of the keypad routines. Press **[CANCEL]** until the **DATS™** is in the normal cycling mode. 6) The paddle wheel flow meter is fouled by foreign matter. Stop the flow and vent the system pressure. Remove the paddle wheel flow meter and clear any obstructions from the sensing element. 7) The fluid pressure on the system is insufficient to maintain the desired flow rate. Install a booster pump or relocate the pressure tap to provide an adequate fluid pressure and volume.

Problem	Remedy
Excessive variation in flow velocity	1) Pressure variations in the system. Install a pressure regulator 2) The paddle wheel sensor is fouled or obstructed. Shut off the flow and clean the sensor. 3) The paddle wheel bearing pin is corroded or worn. Remove the sensor and replace the pin. 4) The 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™** 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 7.0 2) The minimum flow for heat limit is set above the operating set point. The normal default value is 1.5 ft/sec **[**0.5 m/sec**]**. Reset minimum flow setting using the **[SET] [CODE]** routine in Section 6.2. 3) The flow or heater cable is not securely connected. Reconnect the cable and confirm that the temperature readings are correct. 4) The RTD on the heater block is damaged. Check the reading of the block temperature. If "ERROR" is indicated, check the continuity of the sensor with an Ohm meter. Replace faulty wire or sensor. 5) 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
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 is causing changes in the HTR. Correct any 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.
Wall temperature does not reach the set point	1) Required heat flux exceeds the maximum value noted on specification sheet. Reduce the flow velocity, or increase the bulk water temperature to raise the wall temperature. 2) The system has not been "zeroed" while clean. Set the system to a value approximately equal to the equipment operating point, and zero the HTR as described in Section 6.1. 3) The block temperature is higher than the 275°F [135°C] maximum. Increase the flow, decrease the heat flux, or increase the bulk water temperature to reach the wall set point.
Auxiliary Inputs are reading incorrectly	1) Incorrect electrical connections. Refer to Section 2.42 to ensure proper electrical connections.
Auxiliary Inputs reading "-25.00%"	1) No signal is connected, or loop power supply is not operational. Check signal connections and output of loop power supply
Auxiliary Inputs reading "-50.00%" with a 4 mA input signal	1) Signal wires are reversed. Rewire according to section 2.42.

Appendix C: PC Menu

The following is a sample of the software menu which appears on the PC Screen. The sample shown is for English Units, the Metric unit menu is similar. Refer to Section 5.4 for a description of the software functions.



Appendix D: Lotus™ Header Files

The following is a sample of the LOTUS-123™ header, which may be retrieved by uploading the HEADER.WK1 file from the appropriate directory (English or Metric) from the software supplied with the **DATS ™** (refer to Appendix E for the software directory).

ENGLISH

BRIDGER SCIENTIFIC INC. - DEPOSIT ACCUMULATION TESTING SYSTEM - PARAMETER DISPLAY - ENGLISH VERSION

TRIAL RUN TIME	DATE & TIME	INLET WATER TEMP.	HEATER BLOCK TEMP.	AUX CHANNEL 1	AUX CHANNEL 2	WATER FLOW VELOCITY	AC VOLTAGE	WALL TEMP.
HOURS	YEAR MONTH DAY	DEGREES F	DEGREES F	PERCENT FULL SPAN	PERCENT FULL SPAN	FT/SEC	VAC-MS	DEGREES F

HEAT TRANSFER RESISTANCE	APPLIED HEAT	DATA STORE INTERVAL	FLOW SET POINT	HEAT SET POINT	HEAT WALL POINT	AUX CHANNEL 3	AUX CHANNEL 4
HR-SQ FT DEG F/BTU	BTU/HR	HR	FT/SEC	BTU/HR	HEAT=0 WALL=1	PERCENT FULL SPAN	PERCENT FULL SPAN

METRIC

BRIDGER SCIENTIFIC INC. - DEPOSIT ACCUMULATION TESTING SYSTEM - PARAMETER DISPLAY - METRIC VERSION

TRIAL RUN TIME	DATE & TIME	INLET WATER TEMP.	HEATER BLOCK TEMP.	AUX CHANNEL 1	AUX CHANNEL 2	WATER FLOW VELOCITY	AC VOLTAGE	WALL TEMP.
HOURS	YEAR MONTH DAY	DEGREES C	DEGREES C	PERCENT FULL SPAN	PERCENT FULL SPAN	METERS/ SECOND	VAC-MS	DEGREES C

HEAT TRANSFER RESISTANCE	APPLIED HEAT	DATA STORE INTERVAL	FLOW SET POINT	HEAT SET POINT	HEAT WALL POINT	AUX CHANNEL 3	AUX CHANNEL 4
SQ. METER DEG C / WATT	WATTS	HR	METERS/ SECOND	WATTS	HEAT=0 WALL=1	PERCENT FULL SPAN	PERCENT FULL SPAN

Appendix E: Software Directory

DATS™ Software Version **DATS96:**

DATS96.PIF	Program Information File for running the DATS96 main program from Windows®.
GRAPH96.PIF	Program information File for running the graph only portion of the DATS96 program from Windows® .
DATS96.EXE	Main program for retrieving stored data from within the **DATS™**
DATS96.ICO	Windows® Program Icon for the DATS96 Software.
DATS96.INI	Information file containing the modem setup string
SETUP.CON	Accessory program required for auxiliary input names and data
TTY.EXE	Terminal emulation program for troubleshooting DATS to PC communication problems
STATUS.BIN	Runtime status file created and modified during program execution.
TESTDATA.WK1	Factory test data for the customer's specific **DATS™** unit
\ENGLISH	Directory to hold the unit specific files for English units as listed below:
HEADER.WK1	LOTUS-123™ file, header for **DATS™** data
SPECFILE.WK1	LOTUS-123™ spreadsheet file of calibration values and **DATS™** operating parameter calculations
\METRIC	Directory to hold the unit specific files for Metric units as listed below:
HEADER.WK1	LOTUS-123™ file, header for **DATS™** data
SPECFILE.WK1	LOTUS-123™ spreadsheet file of calibration values and **DATS™** operating parameter calculations

Appendix F: 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 G: 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 #
Cable, **DATS™** to PC (DB9 connector)	100-307
Cable, **DATS™** to Modem	100-319
Cable, **DATS™** to **DATS™**	100-320
Cable, **DATS™** to PC (DB25 connector)	100-321
Cable, Auxiliary Input (4 x 2 wire sets)	100-323
Diaphragm, EDPM replacement (1/2" valve)	099-304
Diaphragm, EDPM replacement (3/4" valve)	099-305
Paddle wheel and bearing pin replacement kit	202-121
Fuse, 4 amp for Electronics DC	106-101
Fuse, 15 amp for Electronics AC	106-103
DATS™-II Operations Manual replacement	200-201
Replacement Tube, 3' Section, 1008 Carbon Steel	200-001
Replacement Tube, 3' Section, 1010 Carbon Steel	200-002
Replacement Tube, 3' Section, 1018 Carbon Steel	200-003
Replacement Tube, 3' Section, 1020 Carbon Steel	200-004
Replacement Tube, 3' Section, 304 Stainless Steel	200-005
Replacement Tube, 3' Section, 316 Stainless Steel	200-006
Replacement Tube, 3' Section, 316L Stainless Steel	200-007
Replacement Tube, 3' Section, 70/30 Cu-Ni	200-008
Replacement Tube, 3' Section, 90/10 Cu-Ni	200-009
Replacement Tube, 3' Section, Admiralty Brass	200-010
Replacement Tube, 3' Section, AL6X	200-011
Replacement Tube, 3' Section, Aluminum Brass	200-012
Replacement Tube, 3' Section, Copper	200-013
Replacement Tube, 3' Section, Titanium	200-014

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

Appendix H: Shipping Checklist

1. **DATS™** serial number: _____

1. **DATS™**-ELECTRONICS EPROM/date: _____

2. **DATS™**-FLOW CONTROLLER: Paddle wheel _____ Magnetic _____

   1/2" _____ 3/4" _____

3. **DATS™**-HEAT EXCHANGER Tube type/size: _____

4. Cables:

   DATS™ to PC,DB9 _____

   DATS™ to Auxiliary Input _____

   DATS™ to **DATS™** _____

   DATS™ to Modem _____

5. PC Software: Version _____

   Disk Size: 5 1/4" _____ 3 1/2" _____

6. Operations Manual:

   with test and calibration sheets _____

7. Tube Cleaned/Oiled: _____

8. Spare Tubes: _____

9. Optional: _____

   _____

Quality Control Packing by: _____

Quality Control Inspection by: _____