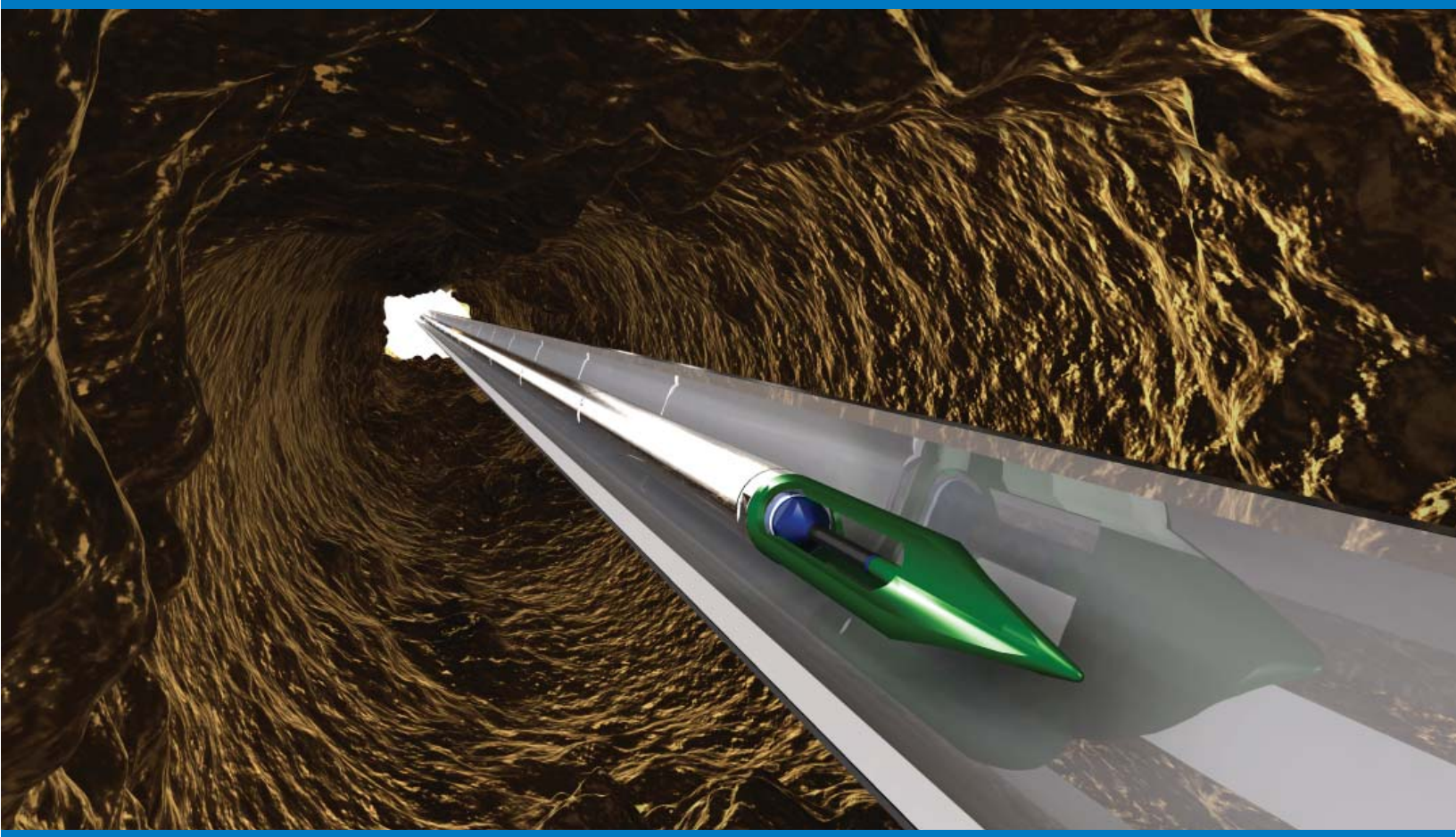
ROHRBACK COSASCO SYSTEMS

DCMS™ DOWNHOLE CORROSION MONITORING SYSTEM

User Manual



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IMPORTANT INSTRUCTIONS

Rohrback Cosasco Systems is committed to providing the safest and highest quality products, services, and training for the industries it serves. We are committed to ensuring that all users of our equipment work safely and efficiently. Fully anticipating the infinite variety of conditions that may be encountered in the field would be impossible, but we have designed this user manual to emphasize safe working practices and, as much as possible, to convey the full benefit of our knowledge and collective experience in the use of the DCMS Downhole Tool and Accessories. This user manual is not meant to be a sole source of instruction. Because these tools are used in a broad range of environments and applications, it is important that the owner and operation personnel have been assessed, certified, and deemed competent in all safety, work management and additional risk assessment requirements in the application of this user manual.

BE SURE ALL PERSONNEL READ AND FOLLOW THE INSTRUCTIONS IN THIS USER MANUAL AND ALL PRODUCT WARNINGS.

Product Owners (Purchasers):

1. Use the correct product for the environment and pressures present. If you are unsure, discuss your needs with your RCS representative.
2. Inform, educate, and train all personnel in the proper installation, operation, and maintenance of this product.
3. To ensure proper performance, only competent, field experienced and trained personnel should install, operate, repair and maintain this product.
4. Save this user manual for future reference.

Product Operation Personnel:

1. Read and understand all instructions and operating procedures for this product.
2. Follow all warnings, cautions, and notices marked on, and supplied with, this product.
3. Follow all instructions during the installation, operation, and maintenance of this product.
4. To prevent personal injury, ensure that all components are in place prior to and during operation of the product.
5. If you do not understand an instruction, or do not feel comfortable following the instructions, contact an RCS service technician for clarification or assistance.
6. If this user manual is not the correct user manual for your RCS product, contact RCS at +1-562-949-0123 and RCS will provide you with the requested manual.
7. Use only replacement parts specified by RCS. Unauthorized parts and procedures can affect this product's performance, safety, and invalidate the warranty. "Look-a-like" substitutions may result in improper operation and may result in serious injury or death.
8. Save this user manual for future reference.

NOTICE

WARNING	
	It is imperative that the safety warnings throughout this user manual are taken into important consideration during assembly, disassembly, installation, and removal of the Downhole Tool. Safety warnings are noted throughout this document to ensure precautions are taken for all procedures where there are risks involved. Failure to follow these warnings could result in serious injury or death.

Information provided in this User Manual should not be considered as all encompassing or suitable for all situations, conditions or environments. Each individual and the organization he/she represents is responsible for implementing training and its/his/her own safety/injury/illness prevention program in connection with this user manual, and should consult with their respective legal, medical or other advisors as to the suitability of using the information in connection with this user manual.

Application of information furnished by this user manual does not guarantee that the information furnished will meet applicable USA (including OSHA), United Kingdom, or any other country's health or safety standards or requirements or, by implementing any of the programs, that you or your company will be compliant with such rules and regulations.

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Introduction

CHAPTER 1

Downhole Corrosion Monitoring System (DCMS)

The RCS Downhole Corrosion Monitoring System (DCMS) is the only system which provides continuous corrosion history of Downhole tubing. The DCMS is a specific adaptation of the CORRDATA system for the severe Downhole environment and provides an accurate means of determining corrosion rates at various depths within a well bore. The corrosion data provided by the DCMS permits quantitative evaluation of inhibitors and treatment regimes for the most cost-effective results.

The DCMS consists of the following major components:

Downhole Tool (DHT)
CORRDATA® II Software
DHT Communications Adapter
Battery Depassivation Instrument
Probe Monitor Instrument
Cross-Flow Adapter (Customer Supplied)

Downhole Tool (DHT)

The Downhole Tool (DHT) is a tubular electronic instrument, as shown in Figure 1.1, that is designed to be run and retrieved by wire line operation into the production tubing of a well for an extended period of time. The DHT uses a CORROSOMETER Probe Element to determine the rate of metal loss within the well bore. The Probe Element is electrically isolated from the rest of the tool and the well bore to prevent galvanic corrosion from influencing measurement data. The Probe Element is made from the same or similar type material as the well bore being monitored. The DHT itself with 1.25” diameter provides a very small percentage restriction in the pipe. The Cross-Flow adapter and tubing lock from which the DHT is suspended provides the main flow restriction of approximately 50% area on the pipe. An RTD temperature sensor, internal to the DHT provides temperature data.

The DHT electronically measures the Probe Assembly and temperature sensor at user programmable intervals, and stores each reading in nonvolatile memory. Upon retrieval of the DHT, corrosion and temperature data may be downloaded to the CORRDATA Mate. The data may then be transferred from the Mate to a personal computer, containing the CORRDATA® II Software, for analysis.

The DHT consists of the following major components:

Instrument Body
Instrument Tube Assembly
Probe Assembly
Probe Shield
Probe Adapter
Mounting Head Adapter
Battery Assembly

When not in use, the DHT and other DCMS components may be stored in a protective carrying case. The arrangement of the carrying case is shown in Figure 1.2.

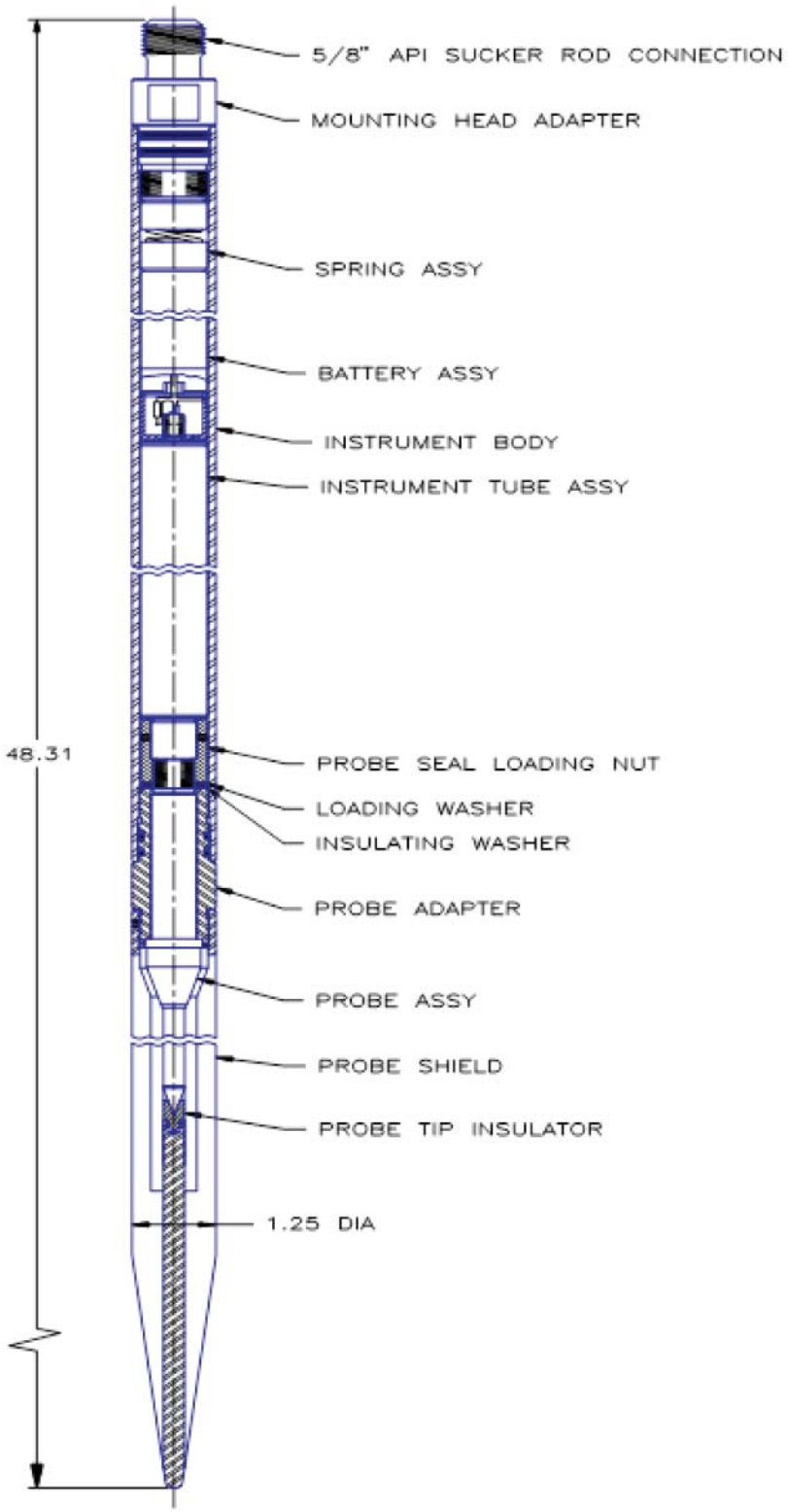


Figure 1.1 Cross-Sectional View of Fully Assembled DHT

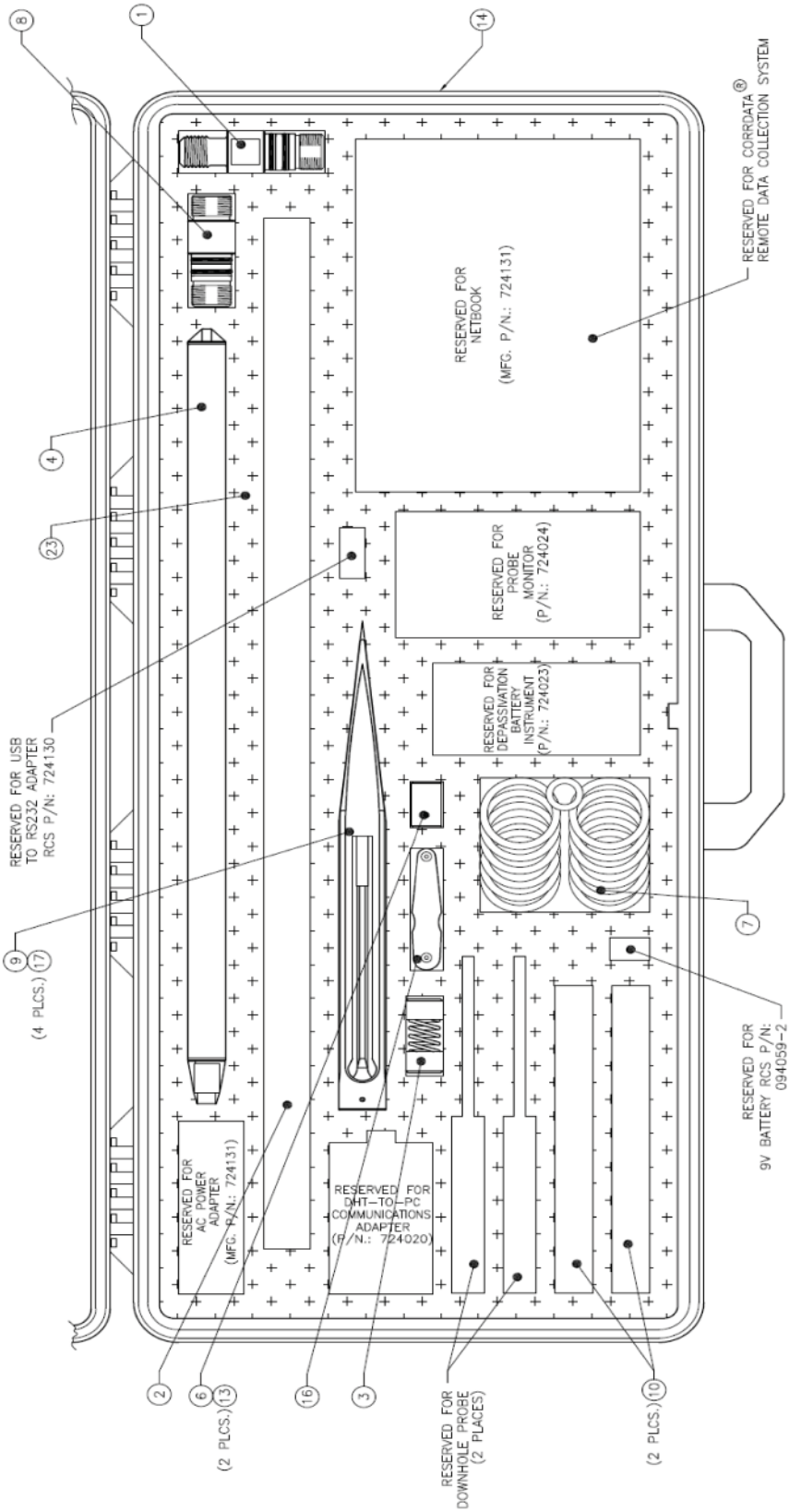


Figure 1.2 DHT Carrying Case Layout

Instrument Body

The Instrument Body is normally a 17-4 PH ferritic stainless steel tube designed to contain and protect the main components of the DHT from the hostile environment of the well.

Instrument Tube Assembly

The Instrument Tube Assembly is a stainless steel tube approximately 1.25”dia. x 15”L. It has a large probe connector at one end and a small battery connector at the other end. The Instrument Tube Assembly contains electronic circuitry which accurately measures the Probe Element and internal temperature sensor.

Probe Assembly

The Probe Assembly is a specially modified CORROSOMETER probe. The Probe Assembly contains an element made from the same or similar material as the well bore. A reference element of the same material is contained within the Probe Assembly to compensate for resistance changes due to temperature. Since the Probe Assembly is very delicate, care must be taken to avoid damage.

WARNING! **The tip of the Probe Assembly is extremely sharp. Handle with care to avoid injury or damage.**

Probe Shield

The Probe Shield is used to protect the Probe Assembly from damage and debris in the well, and provide as smooth a flow as possible over the Probe Element surface. The Probe Shield slides over the Probe Assembly and is threaded onto the Probe Adapter.

Probe Adapter

The Probe Adapter is a fitting used to adapt the Probe Assembly to the Instrument Body.

Mounting Head Adapter

The Mounting Head Adapter is a fitting equipped with a 5/8” API sucker rod connection (Spec. 11B). The Mounting Head Adapter is used to attach the Cross-Flow Adapter to the Instrument Body.

Battery Assembly

WARNING! **Violent explosion, fire and severe burn hazards . Do not short circuit, recharge, disassemble, overheat, incinerate, or expose contents to water. Refer to Appendix A for handling and storage information. Failure to follow these warnings could result in serious injury or death.**

CAUTION! An internal fuse in the Battery Assembly may open if the Battery Assembly terminals are short circuited or if current in excess of 1 Amp is otherwise produced externally.

CAUTION! A new Battery Assembly must be depassivated immediately prior to use.

The Battery Assembly is a custom engineered, lithium thionyl chloride battery used to provide easy assembly and long life Downhole. The Battery Assembly contains a coaxial connector which mates directly with the small connector on the Instrument Tube Assembly.

A new, depassivated Battery Assembly must be used before installing the DHT in a well. Battery Assemblies are **not rechargeable!** Do not attempt to defeat the safety connector at the end of a Battery Assembly. Battery Assemblies are protected with an internal fuse, but **may explode** if either recharged or short circuited, **especially at high temperatures! Failure to follow these warnings could result in serious injury or death.**

Be sure to read the paragraph titled “Battery Depassivation Instrument” in Chapter 3 before installing the battery pack. Also refer to Appendix A at the end of this manual for safe handling and storage of lithium thionyl chloride batteries.

CORRDATA® II Software

The CORRDATA II Software is supplied with the DCMS Tool Kit. Please refer to the CORRDATA II Corrosion Management Solutions Manual on the USB stick for details.

Battery Depassivation Instrument

A new Battery Assembly must be depassivated just prior to use in order to remove a passivation layer that naturally inhibits energy transfer from the Battery Assembly to the DHT electronics. The depassivation procedure requires that a Battery Depassivation Instrument (P/N 724023) be connected to the Battery Assembly for a period of time.

The Battery Depassivation Instrument initially loads the Battery Assembly to begin depassivation. It then monitors the output voltage of the Battery Assembly, under load, until it rises to an acceptable level. While the Battery Assembly is being depassivated a yellow lamp on top of the Battery Depassivation Instrument will remain illuminated. When the depassivation process is complete, the yellow lamp will extinguish and a flashing green lamp will illuminate. The Battery Assembly is now ready for immediate use. The depassivation procedure should not last more than 60 minutes. The Battery Depassivation Instrument provides test terminals to monitor the battery voltage with an external voltmeter.

Probe Monitor

To confirm that the Downhole Tool (DHT) is functioning correctly, after complete assembly, a non-intrusive Probe Monitor (P/N 724024) has been designed. The Probe Monitor continuously monitors the voltage across the Probe Element and detects when the probe is energized. Counting these events provides high confidence that the DHT is functioning properly. Since the DHT performs periodic measurements based on a programmed cycle time, a countdown timer has been provided in the Probe Monitor to indicate when the next probe measurement will be made.

When the DHT performs a measurement of the Probe Assembly, the probe is actually energized for two consecutive intervals, each lasting about 3 seconds. There is about 5 second's duration between these intervals where the probe is not energized. The two intervals have been named CYCLE ONE and CYCLE TWO. The Probe Monitor indicates which cycle is presently occurring during the measurement. Both cycles must be measured before the Instrument will decrement the countdown timer.

The countdown timer should be accurate to within a few seconds of actual DHT measurements as long as the cycle time for the Probe Monitor is the same as the DHT configured cycle time. The Probe Monitor is powered by a 9V battery. Alkaline or lithium batteries are recommended. The Probe Monitor will operate for approximately 24 hours continuously with a fresh alkaline battery (longer with a lithium battery). The Probe Monitor may not store the total number of DHT measurements made if the battery is completely depleted.

Cross-Flow Adapter

A Cross-Flow Adapter is attached to the Mounting Head Adapter end of the DHT. While holding the DHT in the center of the production tubing, the Cross-Flow Adapter serves to transfer the well bore flow from the outside of the DHT to the inside of the lock mandrel. The Cross-Flow Adapter must minimize pressure drop as well as provide the strength required to support the DHT. Typically, a Cross-Flow Adapter will drop only a few psi. The DHT is capable of mounting on a variety of lock systems. The lock mandrel and Cross-Flow Adapter are usually customer specific items, and are chosen or manufactured to be compatible with the wire line running tools to be used.

Running Tools

Running Tools and running procedures are critical to the successful operation of the DCMS system. Consultations between RCS, the customer, and the wire line company are required to ensure correct tools are available and correct running procedures are used.

RCS offers a custom DCMS Tool Kit (P/N: 724121) to provide for the complete assembly and disassembly of the DHT. In addition to mechanical tools, four custom electronic instruments are included which are necessary to setup and monitor the DHT. The contents and layout of the DCMS™ Tool Kit are shown in Figure 1.3.

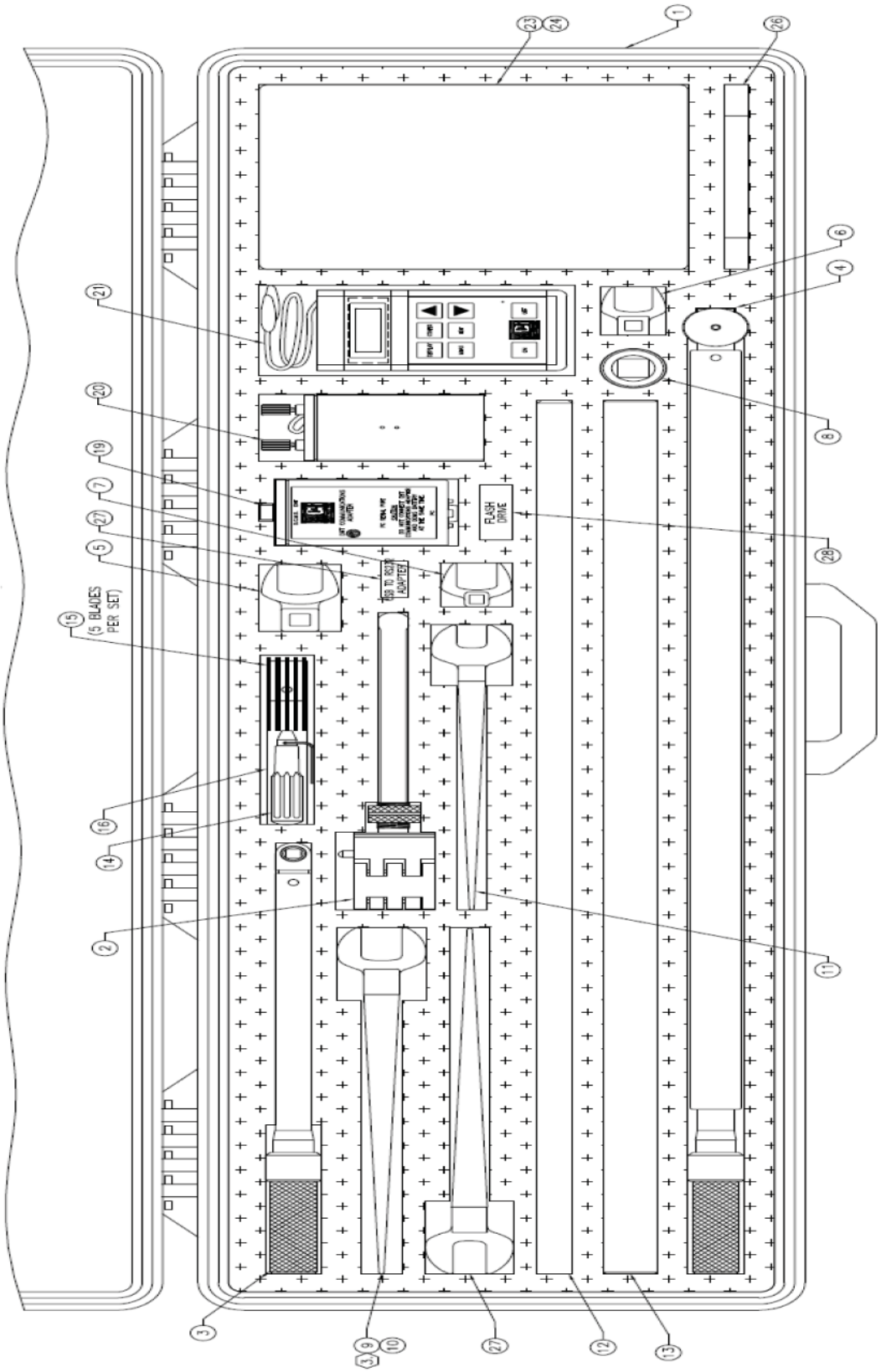


Figure 1.3 DCMS Tool Kit

Specification

CHAPTER 2

Downhole Tool Specification

• Environment:	Oil, Gas, Water production (Sweet or Sour Service subject to running tool specifications)
• Shock:	30 G's Max
• Random Vibration:	30 to 300 Hz at 2.22 G^2/Hz, 25 G rms
• Temperature:	325°F (163°C) maximum
• Pressure:	10,000 psi (69 MPa) maximum
• Flow Velocity:	90 feet per second maximum gas flow, 20 feet per second maximum liquid flow
• Body Material (Standard):	UNS S17400 (17-4 S.S.) Conforming to NACE MR0175
• CORROSOMETER Probe Assembly:	Repeatability: ± 0.5% of Span Resolution: 0.1% of Span
• Temperature Sensor:	Accuracy: ± 3°F Repeatability: ± 3°F Resolution: 0.1°F
• Memory Capacity:	1024 Measurements
• Measurement Intervals:	15 min., 30 min., 1 hr., 2 hr., 4 hr.
• Thread Attachment:	5/8" API Sucker Rod Connection Spec. 11B

Battery Assembly Specification

- RCS Part No.: 724089
- Type: Lithium Thionyl Chloride
- Li Weight: 9.4 grams
- Voltage: 7.34 Voc (open circuit)
- Operating Temp: +20 °C to +150 °C
- Shock: 250 G's Max at 150 °C
- Random Vibration: 30 to 300 Hz at 2.22 G^2/Hz
  25 Grms

DHT Operating Duration

DHT Programmed Measurement Interval	Approximate Operating Time (with a new Battery Assembly)
30 min.	22 days
1 hr.	45 days
2 hr.	90 days
4 hr.	150 days

DHT Operational Pretest

CHAPTER 3

The user may wish to determine that the Instrument Tube Assembly, Probe Assembly and Battery Assembly are operational before complete assembly of the DHT. A Pretest may be performed by following the steps below:

WARNING! ***Always perform a Pretest at "room temperature". Do not perform a Pretest at temperatures above 125 °F.***

It is highly recommended that new batteries are used on the DHT Communications Adaptor and the Probe Monitoring Tool before a new session.

Assembly Sequence

Step 1: Depassivate New Battery Assembly:

WARNING! ***Use only the RCS supplied Depassivation Instrument (P/N 724023) to depassivate the battery and verify voltage.***

NOTE: The Battery Depassivation Instrument is used in this step. It automatically monitors the Battery Assembly output voltage while applying a nominal load. The Battery Depassivation Instrument will remove the load when the output voltage of the Battery Assembly reaches a value which indicates that the passivation has been adequately removed.

WARNING! ***A new Battery Assembly must be depassivated less than four hours prior to connecting it with the Instrument Tube Assembly. Refer to Chapter 1 and Appendix A for Battery Assembly warnings and cautions.***

1. Verify that the ambient temperature and the Battery Assembly Temperature is greater than or equal to 21 °C (70 °F).

2. If desired, monitor the voltage between the red and black terminals on the Battery Depassivation Instrument with a high impedance voltmeter.

3. Connect the Battery Assembly to the Battery Depassivation Instrument. The yellow lamp will illuminate immediately. Depending on the degree of battery passivation, the battery voltage may initially drop below 5.0V.

CAUTION! If no status lamps on the Battery Depassivation Instrument are illuminated while the Battery Assembly is connected, then the Battery Assembly is either excessively passivated or depleted and should not be used.

4. Monitor the Battery Depassivation Instrument status lamps until the yellow lamp extinguishes and the green lamp begins to flash. Depassivation may take from several minutes to one hour.

CAUTION! If the green lamp doesn't flash within one hour of connecting the Battery Assembly, then the Battery Assembly is either excessively passivated or depleted and should not be used.

5. Disconnect the Battery Assembly from the Battery Depassivation Instrument. The Battery Assembly is now ready for immediate use.

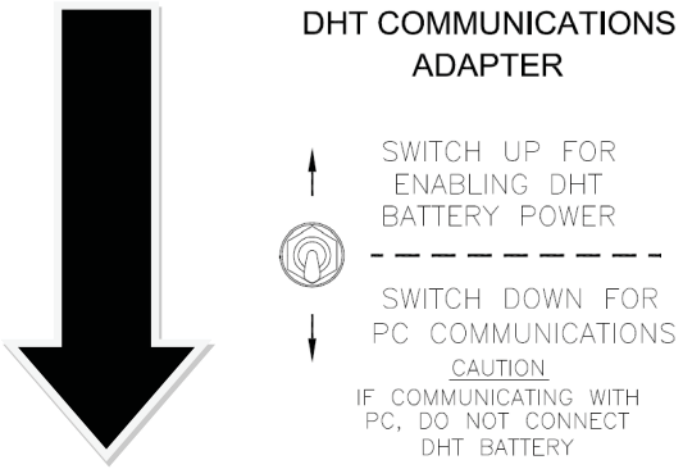
Step 2: Program Instrument Tube Assembly.

WARNING! The Instrument Tube Assembly must NOT be programmed while connected to the Battery Assembly.

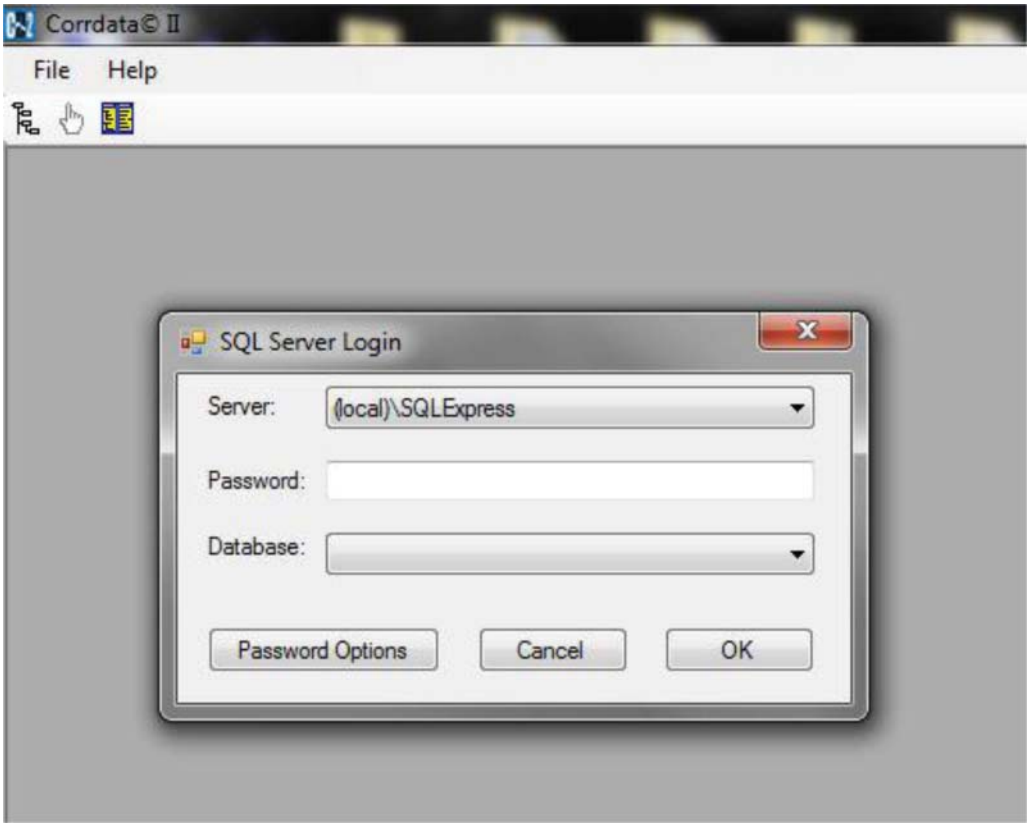
1. Program the DHT from the PC with the Communications Adapter. Set Toggle Switch on communications adapter to middle "off" position before connecting to DHT. Connect Serial connection from DHT to PC and verify COM port being used. Follow the steps below to set up the DHT manually.

   Note: For further details on Corrdata II, refer to the CORRDATA II User Manual for details on setting a DHT.

   I. Toggle the communications **SWITCH DOWN FOR PC COMMUNICATIONS** to enable power and configuration to the DHT from the communications adapter.



II. Run **Corrdata II** and input **Password** and select **Database:**



To change the password, select ‘Password Options’, and the following dialog will pop up.

SQL Server Login:

Server:

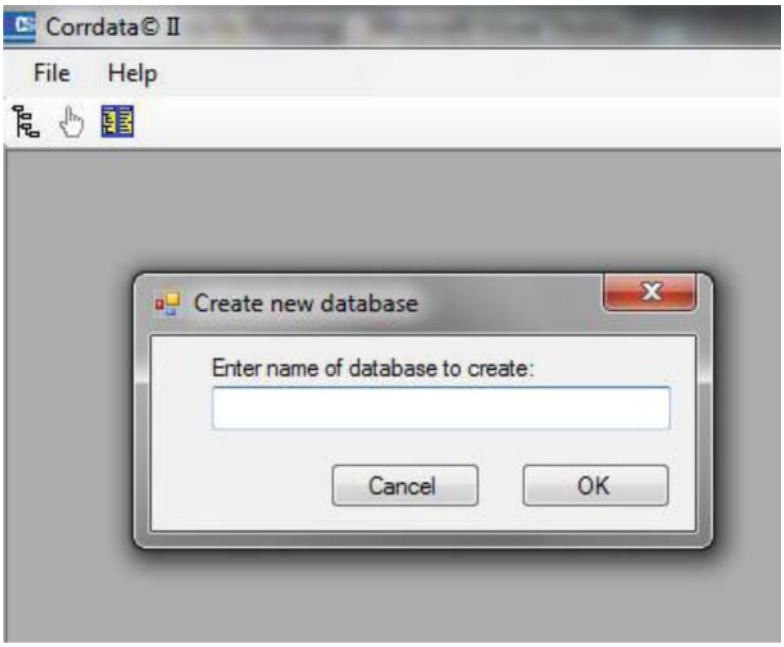
Select (local) if you have a standard Microsoft SQL Server installed.
Select (local)\SQLExpress if you have an Express Server installed. Depending on SQL Server installed, SQLExpress may be (local) for login.
Select Manual Entry to enter the Server Name of another SQL Server.

Password:

Enter the Password that was set in last step.

Database:

Select the database created during an earlier running of this software, or select *** Create New Database *** to create a new database.
If this is the first time being run, you must select *** Create New Database *** Then hit the OK button.



Select a name for your new Database and then hit the OK button.

III. Configure DHT with Corrdata II:

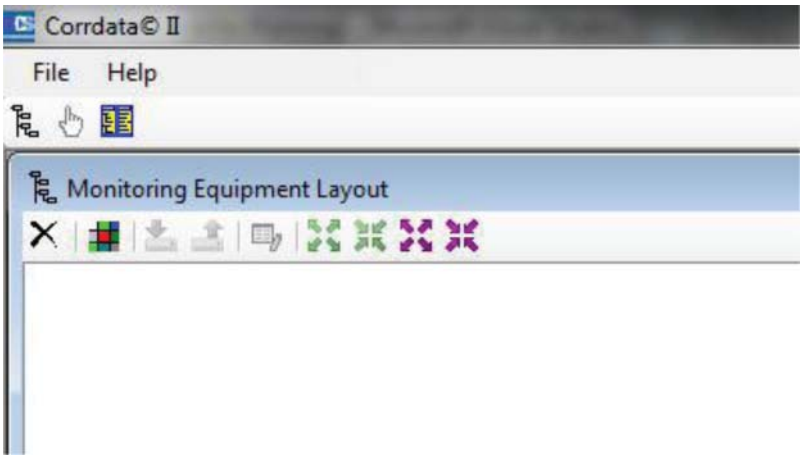
Main Screen:

Equipment Layout:
Clicking this icon will bring up the Equipment Layout screen. This is where you will configure your System, Sub-Systems, Devices, and Probes. The Equipment Layout screen is shown as a Tree View and works like the Explorer tool in Windows.

Selection Tool:
Clicking this icon will bring up the Selection Tool screen. You will drag items from the Equipment Layout for selecting graph points. The Selection Tool screen is shown in a list view.

Equipment Layout + Selection Tool:
Clicking this icon will bring up both the Equipment Layout and the Selection Tool screens.

Equipment Layout Screen:



Remove Item:
Clicking this icon will remove a node and all children of that node that you have selected on the Equipment Layout screen.

Item Palette:
Clicking this icon will bring up the Palette screen, where you will select Devices and Probes for placing on the Equipment Layout screen.

Download Data from Device:
Clicking this icon will allow you to download from an attached device to the Corrdata® II software database.

Configure Device: 

Clicking this icon will allow you to configure an attached device from the Corrdata® II database.

Data Entry (Manual): 

Clicking this icon will allow you to enter data to a selected probe on the Equipment Layout screen. This can be used for correcting data or entering data into a manual entry device, such as the CK-4.

Expand All: 

Clicking this icon will expand the Tree view. The F5 key is also a short-cut.

Collapse All: 

Clicking this icon will collapse the Tree view. The F6 key is also a short-cut.

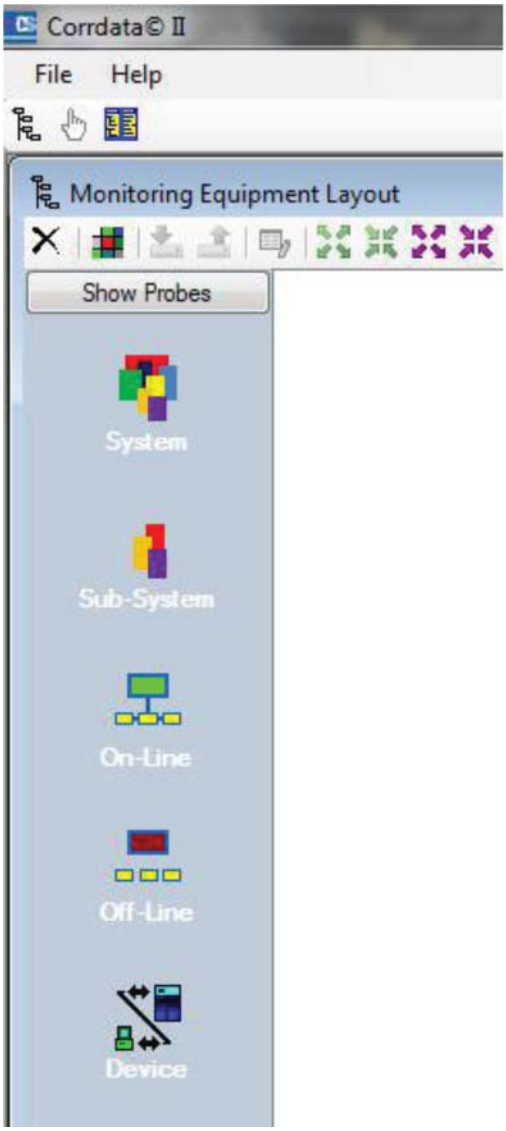
Expand Node: 

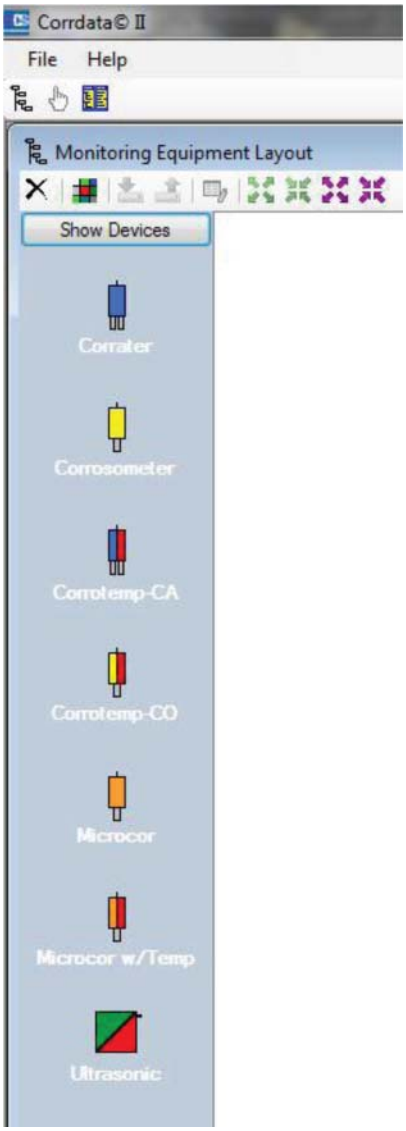
Clicking this icon will expand the selected Node. The F7 key is also a short-cut.

Collapse Node: 

Clicking this icon will collapse the selected Node. The F8 key is also a short-cut.

Palette Screen:





System: 

You Drag and Drop the System onto the Equipment Layout screen. At least one System is required to be dropped on the Equipment Layout screen. The System can only be dropped on the main screen, and not on any other item.

Sub-System: 

You Drag and Drop the Sub-System onto a System or another Sub-System. Sub-Systems are not required to be used. You can only drop Sub-Systems on a System or another Sub-System.

On-Line: 

The On-Line is a Device group for holding On-Line Devices, e.g., Microcor® System (MT-9485). The On-Line group is not required for On-Line devices to be used. The On-Line can be dropped on Systems or Sub-Systems.

Off-Line: 

The Off-Line is a Device group for holding Off-Line Devices, e.g., Checkmate™, RDC, CK-4. The Off-Line group is not required for Off-Line devices to be used. The Off-Line can be dropped on Systems or Sub-Systems.

Device: 

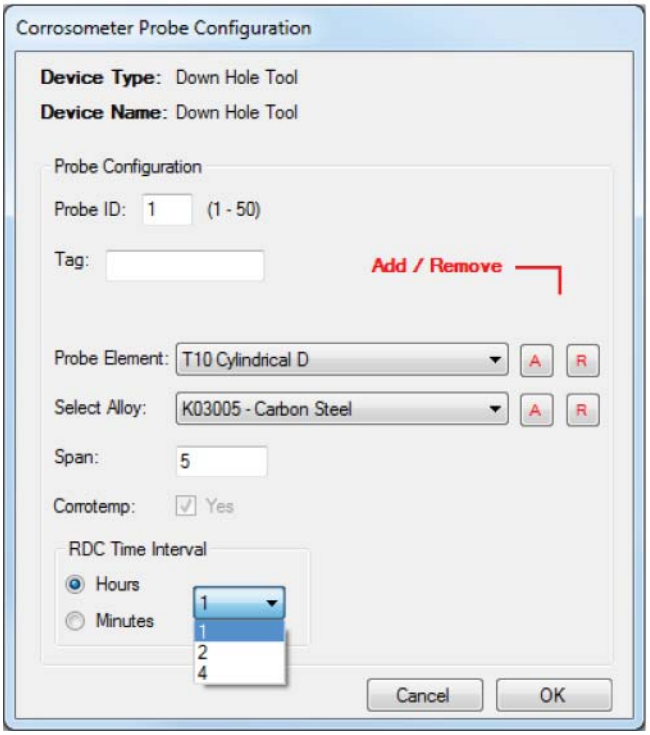
The Device is used to drop a device, e.g., Corrdata System (E9020), Checkmate™ Plus, Aquamate on the Equipment Layout screen. A Device may be dropped on a System, Sub-System, On-line and Off-Line Groups, and in some cases other devices. When the Device is dropped a dialog window will pop-up for you to select the actual device to use.

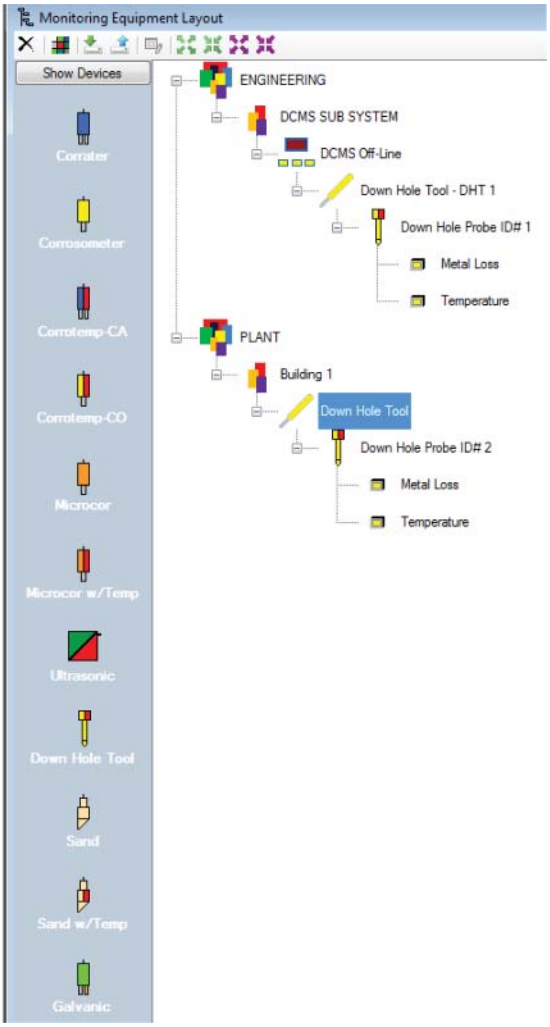
Probes: 

Probes can only be dropped on devices and then only if the device accepts the type of probe being dropped. When a probe is dropped it will show the measurement attributes for that probe, e.g., Metal Loss, Temperature.

Sample Configuration:

Here is a sample configuration consisting of a System (Plant), Sub-System (Building1), Device (RDC-Down Hole Tool), and Probe (Down Hole Probe ID # 2).



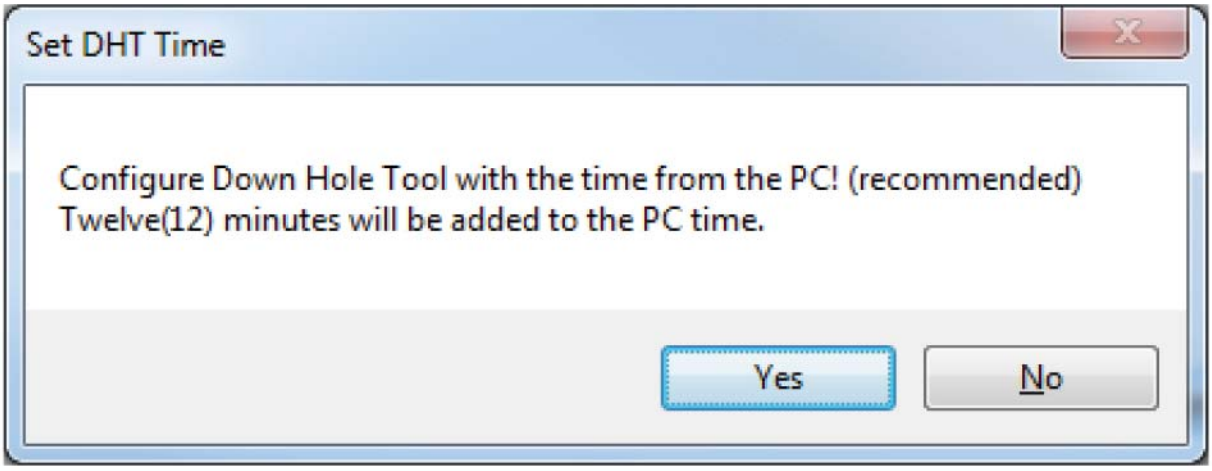


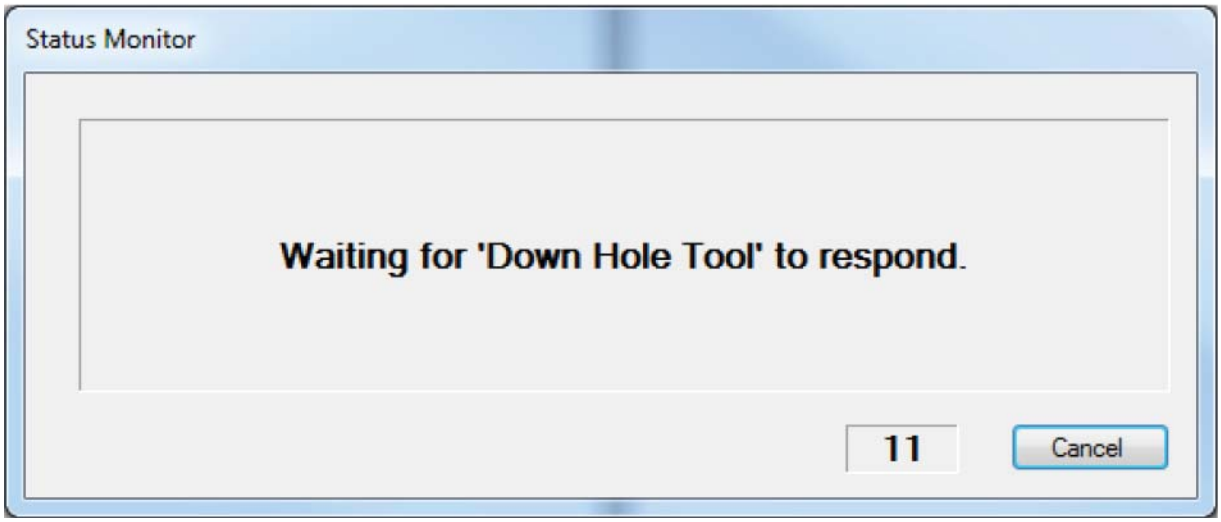
NOTE: A one (1) hour reading interval is most commonly used. The Probe Assembly type is **D** (cylindrical) with a 5 mil span for “T10” model or a 10 mil span for “T20” model and the probe is a **Corrotemp** type.

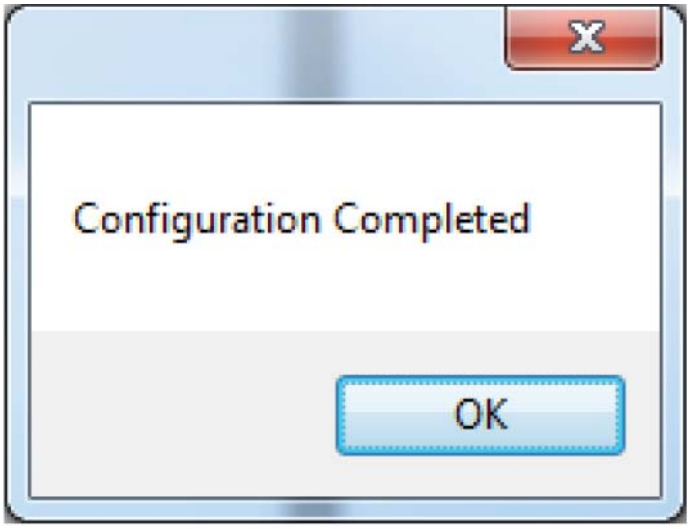
CAUTION! The minimum read time interval for the DHT is 15 minutes. User may set up the read time to 15 or 30 minutes, or 1, 2, or 4 hour increments. If an increment other than the above is chosen, the DHT will default the read time interval to the nearest valid time increment.

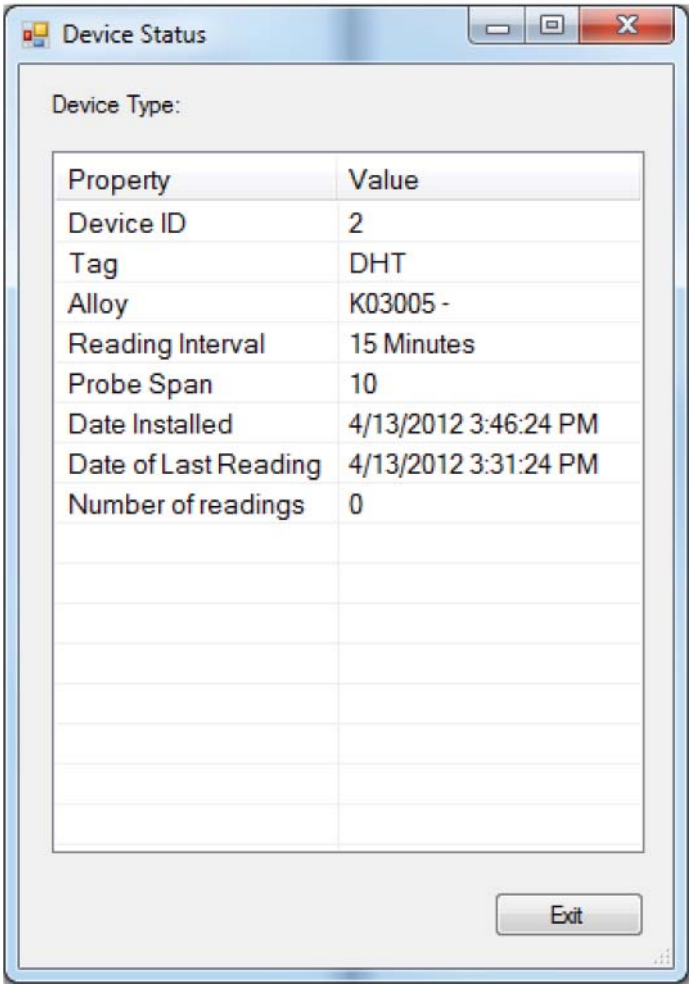
IV. Select **Configure Device** icon to program **DHT:**

WARNING! ***This is the recommended method to successfully configure the DHT to the time and date of the PC. Performing the configuration will erase all previously saved data on the DHT. The DHT will have 12 minutes added ahead to allow for complete assembly time of the DHT and battery, covered in the next step.***






Configuration Completed
OK

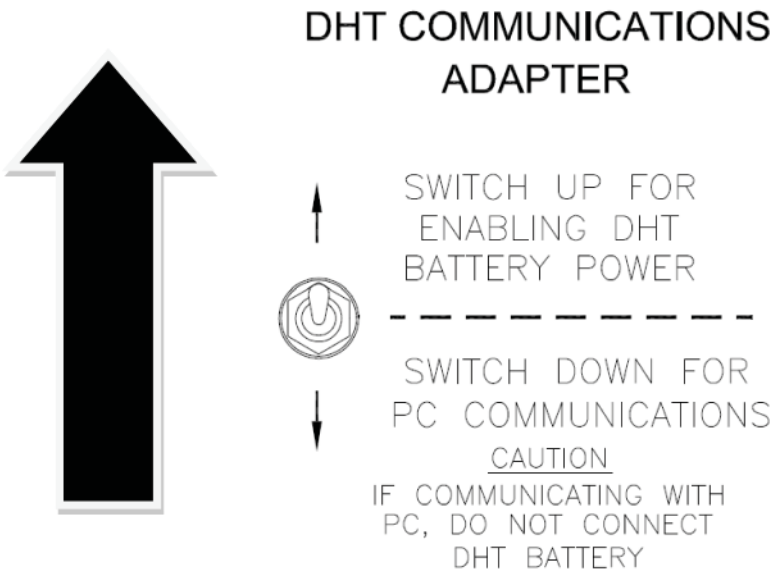

Device Status
Device Type:
Property
Value
Device ID
2
Tag
DHT
Alloy
K03005 -
Reading Interval
15 Minutes
Probe Span
10
Date Installed
4/13/2012 3:46:24 PM
Date of Last Reading
4/13/2012 3:31:24 PM
Number of readings
0
Exit

Step 3: Attach Battery Assembly to Instrument Tube Assembly.

WARNING! ***Always use a new Battery Assembly and depassivate immediately before use.***

1. Maintain the Probe Assembly, Instrument Tube Assembly and the Battery Assembly on a table or other flat, horizontal surface.

2. Attach the DHT Communications Adapter to the DHT. Set Toggle Switch on the communications adapter to middle "**off**" position before connecting to DHT. Once both sides are connected (Battery and communication adapter in off position). Toggle the communications **SWITCH UP FOR ENABLING DHT BATTERY POWER. Disconnect DHT Communications adapter after 30 seconds. The 12 minute window for connecting the probe begins immediately after enabling the battery.**



3. Once the Battery has been enabled with the communications adapter, the assembly is energized and will take the first Probe Element reading after about 12 minutes. This will be the first stored reading in the non-volatile memory. Next reading will commence at the specified interval from this reading. It is possible **(and highly recommended)** for the user to validate the performance of the DHT by using the Probe Monitoring Tool (see step 5 below).

NOTE: The instrument will **NOT** work until the DHT Communications Adapter has enabled the battery for 30 seconds (Step 3). Also, the Instrument Tube Assembly does **NOT** contain a real-time clock. Therefore, the date/time setting does **NOT** change with time. Instead, the date/time setting is purely a reference time to denote when the Instrument Tube Assembly actually begins recording data. Whenever the Battery Assembly is connected, the Instrument Tube Assembly collects readings at the programmed interval and time stamp the readings starting from the user programmed time. This is the reason for setting

the time 12 minutes later than the present time, to let the user finish the rest of the steps and have enough time to begin the readings at the current time.

CAUTION! DHT can store a maximum of 1024 readings on its non-volatile memory. Once this limit is met, the DHT will not store anymore readings.

Step 4: Attach Probe Assembly to Instrument Tube Adapter.

1. Lay the Instrument Tube Assembly and the Probe Assembly on a table or other flat, horizontal surface.

2. Connect the Probe Assembly to the Instrument Tube Assembly by mating the connector end of the Probe Assembly to the large connector on the Instrument Tube Assembly.

3. Carefully rotate the Probe Assembly until the connector keys are aligned and then push in the connectors together as far as possible.

Step 5: Test DHT Operation with Probe Monitor.

Use the DHT Probe Monitor (P/N 724024) as described below to determine if the DHT is operational.

NOTE: Regardless of the preprogrammed time setting, the DHT will take the first Probe Element reading about 12 minutes, 30 seconds after the Battery Assembly is connected to the Instrument Tube Assembly. This allows sufficient time for final assembly of the DHT and attachment of the Probe Monitor to catch the first reading made by the Instrument Tube Assembly.

1. Connect the **RED** lead to the exposed metal surface of the Probe Element near the Probe Wrench-Flats.

2. Connect the **BLACK** lead to the exposed metal surface of the Probe Element near the probe tip. The best sensitivity is achieved when the BLACK and RED leads are spaced as far apart as possible while making positive electrical contact to the Probe Element.

3. Press the **ON** key. Wait for the display prompt “Ready to Test DHT”

4. Press the **CONFIG** key. If the cycle time, which is expressed in minutes, is correct, proceed to step 6.

5. If the cycle time is not correct, press the **EDIT** key followed by the **UP** and **DOWN** arrow keys to correctly program the cycle time. When the cycle time is correct, press

the **EDIT** key again to store the reading (the old value will be lost) or press the **CONFIG** key to abort (no changes will occur).

NOTE: It is suggested setting the cycle time with few extra minutes compared to the actual reading interval to avoid and erroneous timeouts.

6. Press the **DISPLAY** key to determine how many measurements were made. This will be zero for initial use.

7. Press the **MEAS** key to initiate monitoring the Probe Element. It may be necessary to let the Probe Monitor warm up for a couple of minutes before performing measurements. The countdown timer will be activated, counting from the cycle time down toward zero. If zero is reached before a Probe Element measurement is detected, a time-out message is displayed.

8. Press any key to stop the measurement process. If the **MEAS** key is pressed again, the number of measurements will be initialized to zero and the measurement process will start over. If the OFF key is selected, the number of measurements will be saved to be viewed the next time the Probe Monitor is turned on.

9. When the DHT Probe Element is read, the display of the Probe Monitor will first show "**CYCLE ONE**", and shortly thereafter change to "**CYCLE TWO**" to account for the two energization cycles of one DHT Probe Element reading. Immediately following each Probe Element reading, the Probe Monitor will display the current tally of Probe Element readings (i.e. "DHT = N", where N = the total number of Probe Element readings) and the countdown timer will be reset to its programmed value.

NOTE: A typical DHT Probe Element reading takes a total time period of about 45 seconds including a warm-up period and a post-processing period. Allow the Instrument Tube Assembly to operate long enough to collect the desired number of readings before proceeding with the Disassembly Sequence below.

Disassembly Sequence (Verify Test Data)

Step 1: Remove Battery Assembly from Instrument Tube Assembly.

1. Maintain the Probe Assembly, Instrument Tube Assembly and Battery Assembly on a flat, horizontal surface.

2. **Disconnect** the Battery Assembly from the Instrument Tube Assembly.

NOTE: Due to the short duration of the pretest, the Battery Assembly can still considered "new" and should be saved for future use.

Step 2: Detach Probe Assembly from Instrument Tube Adapter.

1. **Disconnect** the Probe Assembly from the Instrument Tube Assembly by pulling the Probe Assembly connecter from the Instrument Tube Assembly.

Step 3: Read Data from Instrument Tube Assembly.

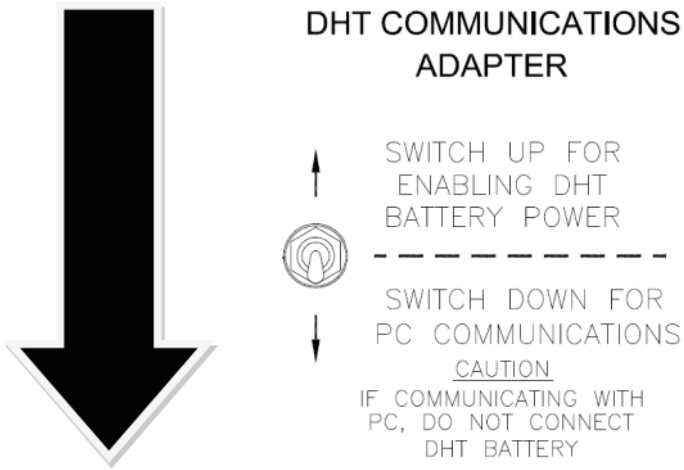
WARNING! ***Disconnect Battery Assembly prior to downloading Data from the Instrument Tube Assembly.***

1. Download DHT data from the PC with the Communications Adapter. Set Toggle Switch on communications adapter to middle "**off**" position before connecting to DHT. Connect Serial connection from DHT to PC and verify COM port being used. Follow the steps below to set up the DHT manually.

   Note: For further details on Corrdata® II, refer to the CORRDATA® II User Manual for instructions on configuring a DHT.

2. Read data from the Instrument Tube Assembly by following the steps below:

   I. Toggle the communications **SWITCH DOWN FOR PC COMMUNICATIONS** to enable power and configuration to the DHT from the communications adapter.



   II. Run **Corrdata® II.**

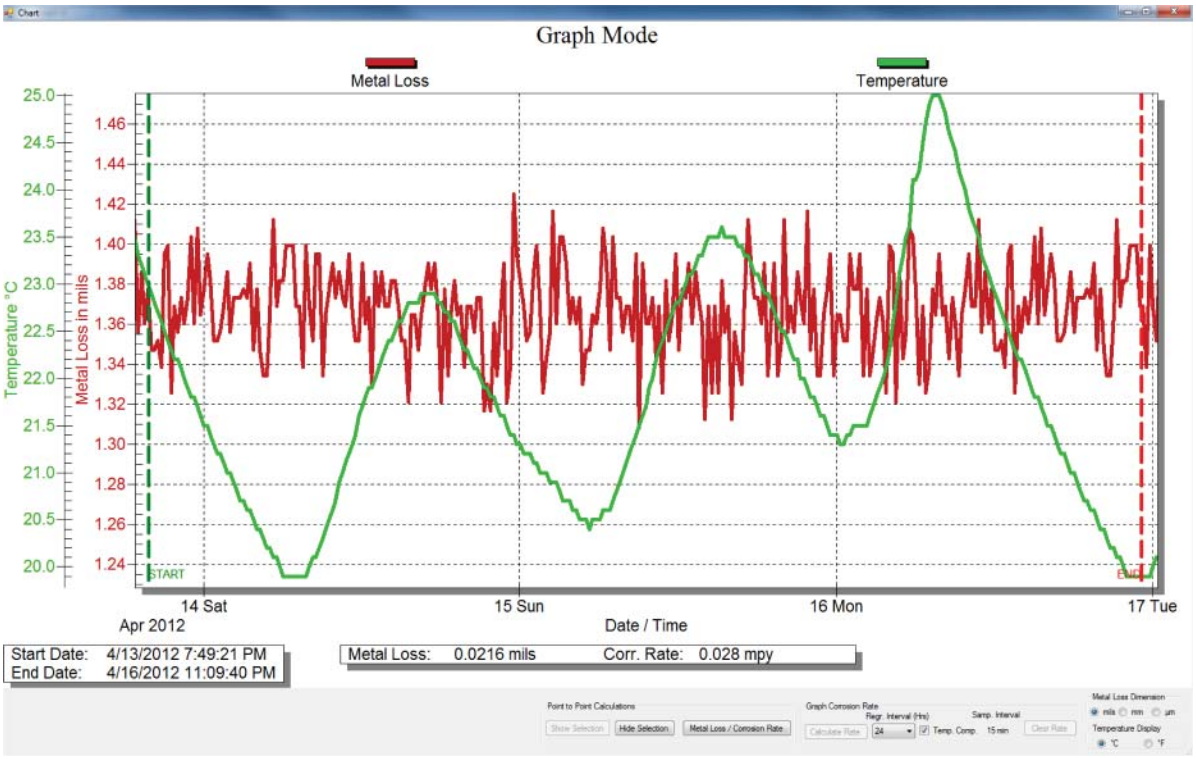
   III. Click **Equipment Layout + Selection Tool:**

   IV. Expand down to your configured DHT.

   V. Click to **Download Data from Device** and wait for download to complete.

VI. Drag the Metal Loss and Temperature data to the Selection Tool window and click on **Graph Data.**

Sample DHT Data:



Data should display close to zero Metal Loss and Corrosion Rate.

DHT Assembly

CHAPTER 4

Recommended Tools

The DCMS Tool Kit (P/N: 724005) is required for the proper assembly set up, disassembly and data retrieval of the DHT.

WARNING! ***Use of tools other than those listed may result in damage to DHT components which may impact seal integrity, pressure rating, and accuracy. DO NOT hold any portion of the DHT with a vice or common pipe wrench!***

The following tools are contained in the DCMS Tool Kit:

ITEM	*QTY*	*UNIT*	*PART NUMBER*	*DESCRIPTION*
1	1	EA	724101	Girth grip Pipe wrench Assembly, 1.25” O.D.
2	1	EA	000490	Torque Wrench, 5 to 75 ft-lbs, ” Drive
3	1	EA	000491	Torque Wrench, 100-600 ft-lbs, ¾” Drive
4	1	EA	000492	Crowfoot Wrench, 1”, ½” Drive
5	1	EA	000493	Crowfoot Wrench, 1”, ” Drive
6	1	EA	000494	Crowfoot Wrench, 13/16”, ” Drive
7	1	EA	000466	Adapter, ¾” Female X ½” Male
8	1	EA	000495	Open End Wrench, 1”
9	1	EA	000496	Open End Wrench, 13/16”
10	1	EA	000497	Open End Wrench, ”
11	1	EA	028050-8021-36.00	Cheater Bar, 36” Long (for open end wrench)
12	1	EA	660045-S31600-36.00	Cheater Bar, 36” Long (for girth grip wrench)
13	1	EA	000498	Hex Key Handle, 1/16”
14	1	EA	000499	Hex Key Blade, 1/16”
15	1	EA	129341	O-ring Pick Set
16	1	EA	724100	DHT Tool Kit Case
17	1	EA	724020	DHT-to-MATE Communications Adapter
18	1	EA	724023	Battery Depassivation Instrument
19	1	EA	724024	Probe Monitor Instrument

Assembly Sequence

Prior to assembly, be sure to thoroughly clean all threads (inner and outer) and O-ring grooves. The following Steps refer to the DHT Assembly Drawing of Figure 4.1

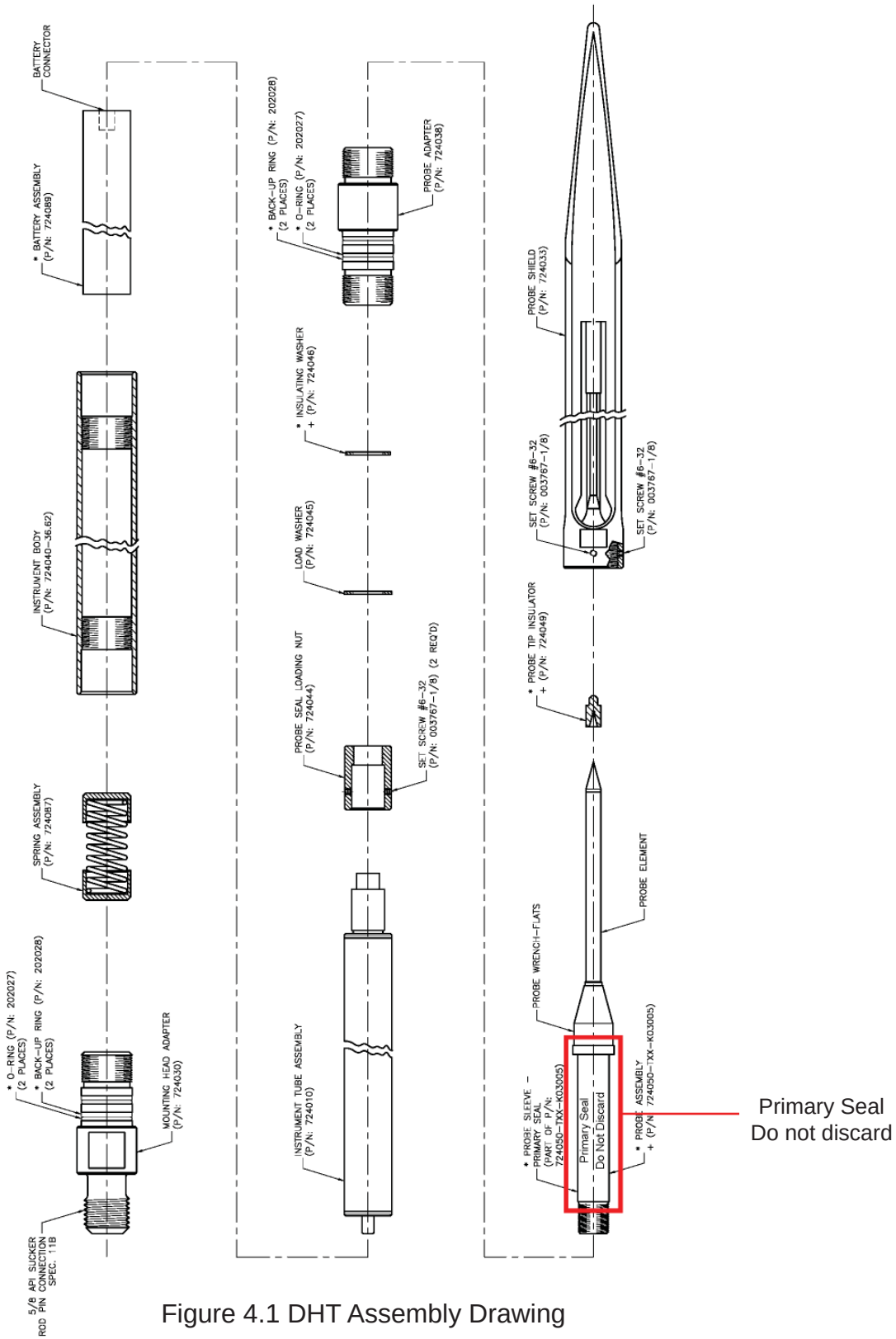


Figure 4.1 DHT Assembly Drawing

CAUTION! Leave on the protective paper that covers the Probe Element until instructed to remove. This prevents grease from contaminating the Probe Element.

Step 1: Inspect Installation of O-Rings and Back-up Rings.

WARNING! ***To avoid damage to O-rings and O-ring grooves, only use an O-ring Pick Set to install or replace O-rings and Back-up Rings.***

1. On the Mounting Head Adapter, there are two grooves between the fine threaded end and the wrench flats. A new O-ring and a new Back-up Ring must be placed in each groove before each Downhole run. The Back-up Ring in each groove must be positioned nearest the threads, as shown in Figure 4.2.

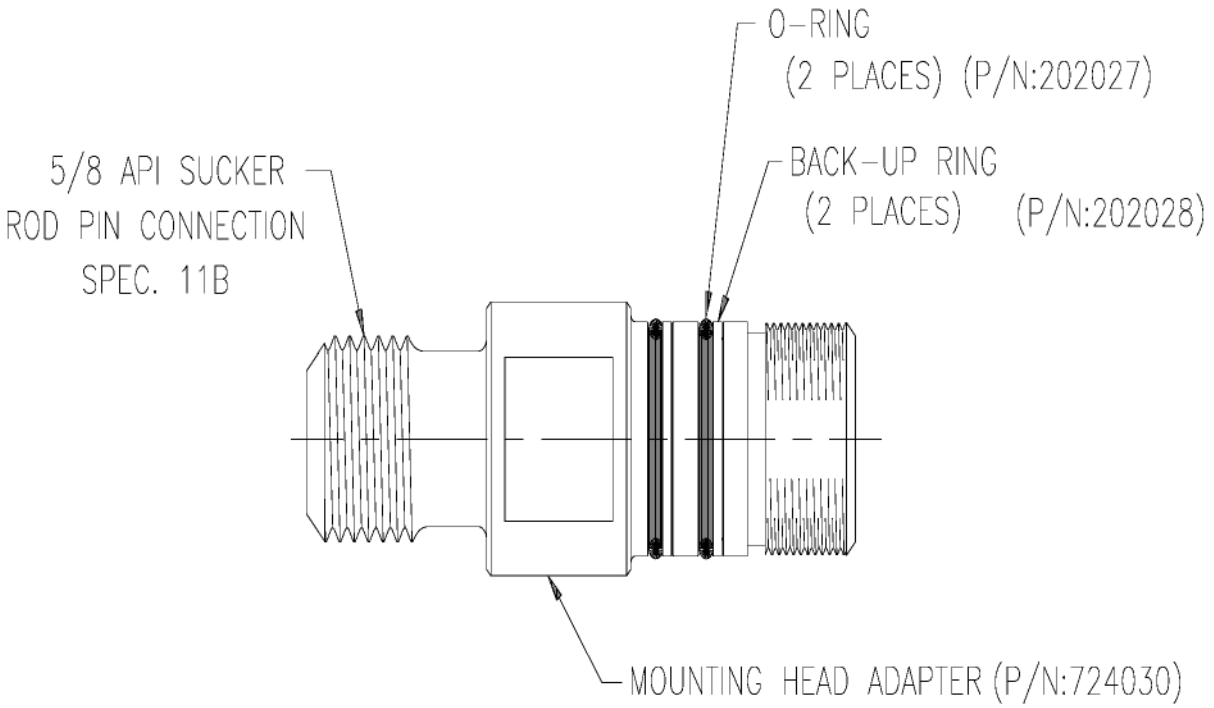


Figure 4.2 Mounting Head Adapter
O-Ring and Back-Up Ring Placement

WARNING! ***Never use O-Rings or Back-up Rings for more than one Downhole run to prevent leakage and damage to the DHT internals. Make sure that O-Rings and Back-up rings are positioned as shown in FIGURE 4.2 for the Mounting Head Adapter and FIGURE 4.3 for the Probe Adapter.***

2. In the Probe Adapter, there are two grooves between one threaded end and the wrench flats. A new O-ring and a new Back-up Ring must be placed in each groove before each Downhole run. The Back-up Ring in each groove must be positioned nearest the threads, as shown in Figure 4.3.

Step 2: Depassivate New Battery Assembly:

NOTE: The Battery Depassivation Instrument is used in this step. It automatically monitors the Battery Assembly output voltage while applying a nominal load

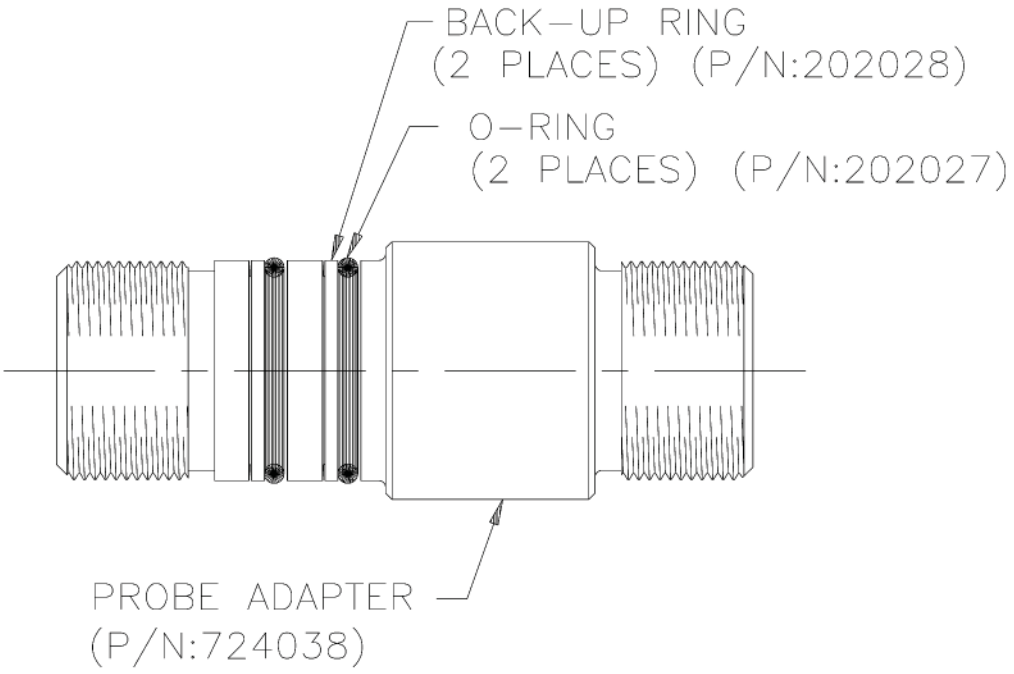


Figure 4.3 Probe Adapter O-Ring and Back-Up Ring Placement

The Battery Depassivation Instrument will remove the load when the output voltage of the Battery Assembly reaches a value which indicates that the passivation has been adequately removed.

WARNING! ***Use only the RCS supplied Depassivation Instrument (P/N 724023) to depassivate the battery and verify voltage.***

WARNING! ***A new Battery Assembly must be depassivated less than four hours prior to connecting it with the Instrument Tube Assembly. Refer to Chapter 1 and Appendix A for Battery Assembly warnings and cautions.***

1. Verify that the ambient temperature and the Battery Assembly Temperature is greater than or equal to 21 °C (70 °F).

2. If desired, monitor the voltage between the red and black terminals on the Battery Depassivation Instrument with a high impedance voltmeter.

3. Connect the Battery Assembly to the Battery Depassivation Instrument. The yellow lamp will illuminate immediately. Depending on the degree of battery passivation, the battery voltage may initially drop below 5.0V.

   CAUTION! If no status lamps on the Battery Depassivation Instrument are illuminated while the Battery Assembly is connected, then the Battery Assembly is either excessively passivated or depleted and should not be used.

4. Monitor the Battery Depassivation Instrument status lamps until the yellow lamp extinguishes and the green lamp begins to flash. Depassivation may take from several minutes to one hour.

   CAUTION! If the green lamp doesn't flash within one hour of connecting the Battery Assembly, then the Battery Assembly is either excessively passivated or depleted and should not be used.

Disconnect the Battery Assembly from the Battery Depassivation Instrument. The Battery Assembly is now ready for immediate use.

Step 3: Attach Probe Assembly to Probe Adapter. (See Figure 4.4)

CAUTION! Be careful not to get any lubricant on the Probe Element.

1. Check that the protective paper is over the Probe Element.

2. Lubricate the entire Probe Sleeve with a thin coat of High-Temperature Silicone Grease (P/N128371).

3. Slide the threaded end of the Probe Assembly through the Probe Adapter, opposite the O-ring end.

4. Lubricate one Insulating Washer (P/N 724046) and one Load Washer (P/N 724045 with High-Temperature Silicone Grease.

5. Place the Insulating Washer over the threaded end of the Probe Assembly.

6. Place the Load Washer over the threaded end of the Probe Assembly.

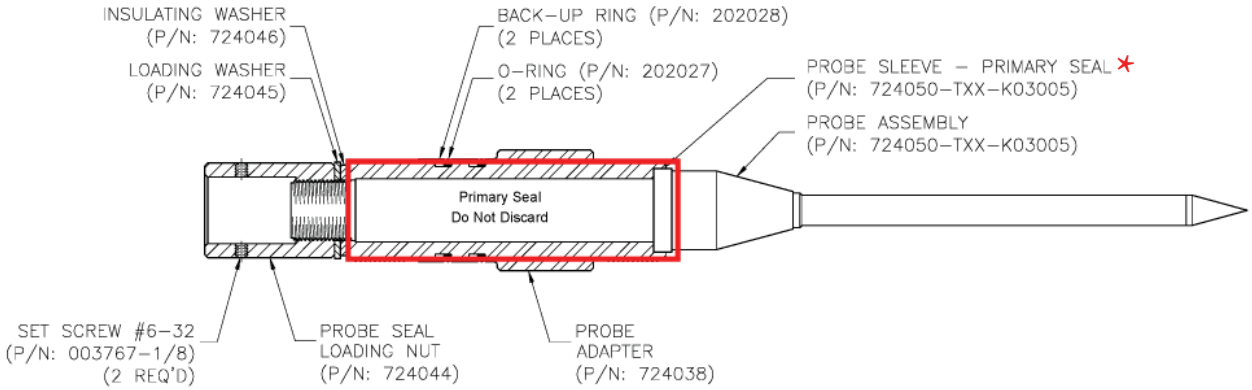


Figure 4.4 Probe Assembly Attached to Probe Adapter

*__CAUTION!__ Primary Seal - Do not discard

7. Coat the Probe Assembly threads with High-Purity Goop (P/N 006308). This is an anti-galling agent.

8. Install the Seal Loading Nut on the threaded end of the Probe Assembly.

9. Hold the flat portion of the Probe Assembly with a 5/8” open end wrench, and then torque the Seal Loading Nut to 30 foot-pounds with a 13/16” open end torque wrench (30 lbs on a 12” wrench).

Step 4: Temporarily Install Probe Shield.

1. Check that the protective paper is over the Probe Element.

2. Verify that the Probe Shield Set Screws are backed out enough to clear the threads.
3. Carefully install the Probe Shield over the Probe Assembly and screw onto the Probe Adapter. It is not necessary to install the Probe Tip Insulator at this time.

4. Install the Probe Shield hand tight to protect the Probe Element during the following operations. DO NOT tighten either the Probe Shield or the Set Screws at this time.

Step 5: Program Instrument Tube Assembly.

Repeat steps 1-4 of Chapter 3. Data analysis covered in step 6 of Chapter 3 is not necessary since that has already been performed.

Step 6: Attach Probe Assembly to Instrument Tube Assembly.

1. Verify that the Seal Loading Nut Set Screws are backed out enough to clear the connector opening.

2. Connect the Probe Assembly to the Instrument Tube Assembly by sliding the Seal Loading Nut end of the Probe Assembly over the large connector on the Instrument Tube Assembly.

3. Carefully rotate the Probe Assembly until the connector keys are aligned and then push the connectors together as far as possible.

4. Torque the Seal Loading Set Screws to 10 inch-pounds with a 1/16" Allen torque wrench, or as tight as a standard 1/16" Allen key will allow.

Step 7: Attach Battery Assembly to Instrument Tube Assembly.

WARNING! ***Always use a new Battery Assembly and depassivate immediately before use (Refer to Step 2 above). A battery that was used in a DHT Operational Pretest, as described in Chapter 3, is considered a "new" battery.***

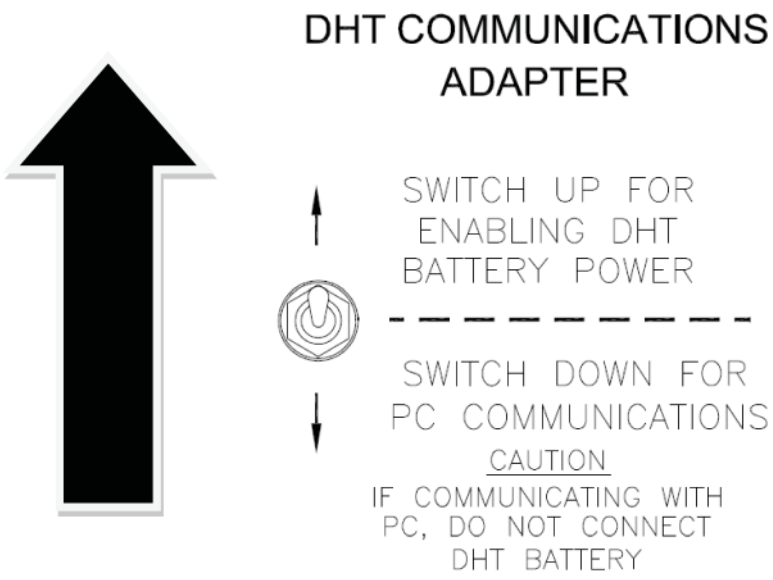
1. Lay the Instrument Tube Assembly and the Battery Assembly on a table or other flat, horizontal surface.

2. Attach the DHT Communications Adapter to the DHT. Set Toggle Switch on the communications adapter to middle "off" position before connecting to DHT. Once both sides are connected (Battery and communication adapter in off position). Toggle the communications **SWITCH UP FOR ENABLING DHT BATTERY POWER. Disconnect DHT Communications adapter after 30 seconds. The 12 minute window for connecting the probe begins immediately after enabling the battery.**

3. Once the Battery has been enabled with the communications adapter, the assembly is energized and will take the first Probe Element reading after about 12 minutes. This will be the first stored reading in the non-volatile memory. Next reading will commence at the specified interval from this reading.

NOTE: The instrument will **NOT** work until the DHT Communications Adapter has enabled the battery for 30 seconds (Step 3). Also, the Instrument Tube Assembly does **NOT** contain a real-time clock. Therefore, the date/time setting does **NOT** change with time. Instead, the date/time setting is purely a reference time to denote when the Instrument Tube Assembly actually begins recording data. Whenever the Battery Assembly is connected, the Instrument Tube Assembly collects readings at the programmed interval and time stamp the readings starting from the user programmed time. This is the reason for setting the time 12 minutes later than the present time, to let the user finish the rest of the steps and have enough time to begin the readings at the current time.

CAUTION! DHT can store a maximum of 1024 readings on its non-volatile memory. Once this limit is met, the DHT will not store anymore readings.



2. Coat the Probe Adapter threads, near the O-rings, with High-Purity Goop and the O-rings themselves, with High-Temperature Silicone Grease.

3. When the present time is equal to the preset time value entered in Step 5 above, immediately slide the small connector on the Instrument Tube Assembly into the Battery Assembly connector as far as possible.

4. Once the Battery Assembly is connected, the Instrument Tube Assembly is powered and will take its first Probe Element reading after about 12 minutes, 30 seconds.

<u>WARNING!</u> If the battery is removed at any time after this step, steps 3-5 of chapter 3 must be repeated! The DHT will not work without the battery enabled!

<u>Step 8:</u> Place Instrument Tube Assembly / Battery Assembly into Instrument Body.

1. Lay the Instrument Body on the same flat, horizontal surface as the Instrument Tube Battery Assembly.

2. If not already done, coat the Probe Adapter threads, near the O-rings, with High Purity Goop and the O-rings themselves, with High-Temperature Silicone Grease.

3. Support the Battery Assembly to keep it in line with the Instrument Tube Assembly (to avoid connector damage), then carefully slide these two items into the Instrument Body.

4. Carefully screw the Probe Adapter into the Instrument Body, until shouldered, being careful not to lift the end so high that the Battery Assembly might become disconnected inside the Instrument Tube Assembly.

5. Maintain the whole assembly as horizontal as possible.

Step 9: Install Spring Assembly and Mounting Head Adapter.

1. Insert the Spring Assembly into the open end of the Instrument Body such that the outward end extends beyond the Instrument Body threads by no more than ¼". If the spring assembly extends further than this, check that the battery is still correctly engaged.

2. Coat the Mounting Head Adapter threads, near the O-rings, with High-Purity Goop and the O-rings themselves, with High-Temperature Silicone Grease.

3. Insert the Mounting Head Adapter behind the Spring Assembly.

4. Gently push the Mounting Head Adapter against the Spring Assembly and maintain pressure while starting to screw the Mounting Head Adapter into the Instrument Body. Once the threads have engaged, use a 1" open end wrench to tighten the Mounting Head Adapter until shouldered.

Step 10: Tighten Adapter Seals.

1. Use a girth grip wrench to hold the Instrument Body.

2. With a 1" open end torque wrench, tighten the Probe Adapter into the Instrument Body to 175 ft-lbs torque minimum.

3. Use a 1" open end torque wrench to tighten the Mounting Head Adapter into the Instrument Body to 175 ft-lbs torque minimum.

Alternate Method

1. Place a 1" open end wrench on the Probe Adapter.

2. Place a 1" open end torque wrench on the Mounting Head adapter.

3. Tighten to 175 ft-lbs minimum.

Step 11: Remove Probe Shield.

1. Carefully remove the Probe Shield from the Probe Adapter.

2. Carefully remove the protective paper from the Probe Element.

Step 12: Test DHT Operation with Probe Monitor.

Use the DHT Probe Monitor (P/N 724024) as described below to determine if the DHT is operational.

> **NOTE:** Regardless of the preprogrammed time setting, the DHT will take the first Probe Element reading about 12 minutes, 30 seconds after the Battery Assembly is connected to the Instrument Tube Assembly. This allows sufficient time for final assembly of the DHT and attachment of the Probe Monitor to catch the first reading made by the Instrument Tube Assembly.

1. Connect the **RED** lead to the exposed metal surface of the Probe Element near the Probe Wrench-Flats.

2. Connect the **BLACK** lead to the exposed metal surface of the Probe Element near the probe tip. The best sensitivity is achieved when the BLACK and RED leads are spaced as far apart as possible while making positive electrical contact to the Probe Element.

3. Press the **ON** key. Wait for the display prompt “Ready to Test DHT”

4. Press the **CONFIG** key. If the cycle time, which is expressed in minutes, is correct, proceed to step 6.

5. If the cycle time is not correct, press the **EDIT** key followed by the **UP** and **DOWN** arrow keys to correctly program the cycle time. When the cycle time is correct, press the **EDIT** key again to store the reading (the old value will be lost) or press the **CONFIG** key to abort (no changes will occur).

   > **NOTE:** It is suggest setting the cycle time with few extra minutes compared to the actual reading interval to avoid and erroneous timeouts.

6. Press the **DISPLAY** key to determine how many measurements were made. This will be zero for initial use.

7. Press the **MEAS** key to initiate monitoring the Probe Element. It may be necessary to let the Probe Monitor warm up for a couple of minutes before performing measurements. The countdown timer will be activated, counting from the cycle time down toward zero. If zero is reached before a Probe Element measurement is detected, a time-out message is displayed.

8. Press any key to stop the measurement process. If the **MEAS** key is pressed again, the number of measurements will be initialized to zero and the measurement process will start over. If the **OFF** key is selected, the number of measurements will be saved to be viewed the next time the Probe Monitor is turned on.

9. When the DHT Probe Element is read, the display of the Probe Monitor will first show "**CYCLE ONE**", and shortly thereafter change to "**CYCLE TWO**" to account for the two energization cycles of one DHT Probe Element reading. Immediately following each Probe Element reading, the Probe Monitor will display the current tally of Probe Element readings (i.e. "DHT = N", where N = the total number of Probe Element readings) countdown timer will be reset to its programmed value.

Step 13: Install Probe Shield.

CAUTION! Do **NOT** handle or get any lubricant on the Probe Element.

1. Remove the protective paper from the Probe Element.

2. Install the Probe Tip Insulator on the tip of the Probe Element.

3. Coat the exposed threads of the Probe Adapter with High-Purity Goop.

4. Carefully install the Probe Shield over the Probe Assembly and screw onto the Probe Adapter.

5. Place a 1" open end torque wrench on the Probe Adapter and a girth grip wrench on the Probe Shield.

6. Torque the Probe Shield to 30 ft-lbs.

7. Torque the Probe Shield Set Screws to 10 inch-pounds with a 1/16" Allen torque wrench or as tight as a standard 1/16" Allen key will allow.

8. The DHT is now ready to be attached to Cross-Flow adapter and tubing lock and run into the well.

Step 14: Attach DHT to Cross-Flow Adapter.

CAUTION! The DHT should only be attached to the running tools immediately prior to running into the well by wireline.

1. Attach the 5/8" API sucker rod connection on the DHT's Mounting Head Adapter to the Cross-Flow Adapter on the running tools immediately prior to running into the well.

2. Torque the connection to 175 ft-lbs minimum.

WARNING! ***During this time the temperature of the tool should be kept above 21°C (70°F).***

Disassembly Sequence

Step 1: Detach DHT from Cross-Flow Adapter.

CAUTION! Clean the DHT thoroughly with an appropriate solvent prior to disassembly.

1. Detach the 5/8” API sucker rod connection on the DHT’s Mounting Head Adapter from the Cross-Flow Adapter of the running tool immediately after removal from the well.

Step 2: Remove Mounting Head Adapter and Spring Assembly.

WARNING! ***Wear safety glasses, cover the joint, and carefully unscrew the Mounting Head Adapter during this step of disassembly in case any high pressure gas and/or liquid have been trapped in the Instrument Body while the DHT was Downhole.***

1. Use a girth grip wrench to hold the Instrument Body.

2. With a 1” open end wrench, carefully remove the Mounting Head Adapter.

3. Remove the Spring Assembly, if possible. The Spring Assembly need not be removed at this time.

Step 3: Remove Instrument Tube Assembly / Battery Assembly from Instrument Body.

1. Lay the Instrument Body on a flat, horizontal surface.

2. Use a girth grip wrench to hold the Instrument Body.

3. With a 1” open end wrench, remove the Probe Head Adapter from the Instrument Body.

4. Carefully slide the Instrument Tube Assembly / Battery Assembly completely out of the Instrument Body.
5. **Disconnect** the Battery Assembly from the Instrument Tube Assembly.

6. Mark the Battery Assembly with tape or a label to identify it as being “used” and handle in accordance with Appendix A of this manual.

7. Remove the Spring Assembly if not already done.

Step 4: Detach Probe Assembly from Instrument Tube Assembly.

1. Use a 1/16” Allen wrench to back out the Seal Loading Nut Set Screws enough to clear the connector opening.

2. **Disconnect** the Probe Assembly from the Instrument Tube Assembly by sliding the Seal Loading Nut end of the Probe Assembly away from the Instrument Tube Assembly.

Step 5: Read Data from Instrument Tube Assembly.

WARNING! Disconnect Battery Assembly prior to downloading Data from the Instrument Tube Assembly.

3. Download DHT data from the PC with the Communications Adapter. Set Toggle Switch on communications adapter to middle **“off”** position before connecting to DHT. Connect Serial connection from DHT to PC and verify COM port being used. Follow the steps below to set up the DHT manually.
   Note: For further details on Corrdata II, refer to the CORRDATA II User Manual for instructions on configuring a DHT.

4. Read data from the Instrument Tube Assembly by following the steps below:

   VII. Toggle the communications **SWITCH DOWN FOR PC COMMUNICATIONS** to enable power and configuration to the DHT from the communications adapter.

   VIII. Run **Corrdata II**.

   IX. Click **Equipment Layout + Selection Tool:**

   X. Expand down to your configured DHT.

   XI. Click to Download Data from Device and wait for download to complete.

   XII. Drag the Metal Loss and Temperature data to the Selection Tool window and click on Graph Data .

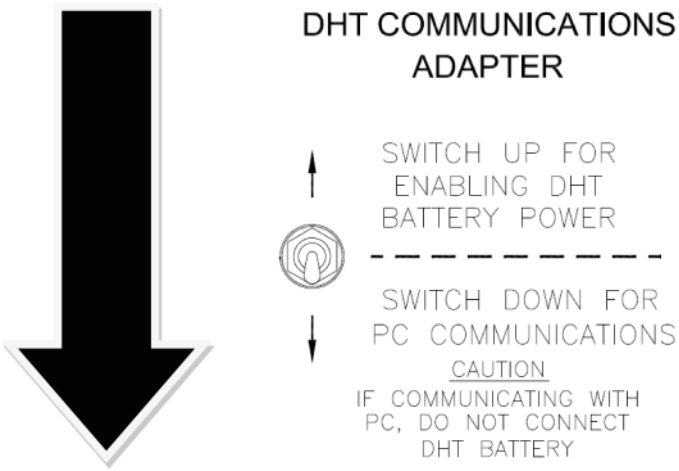
Step 6: Remove Probe Shield.

1. Back out the Probe Shield Set Screws with a 1/16” Allen wrench so that they clear the threads of the Probe Adapter.

2. Place a 1” open end wrench on the Probe Adapter and a girthgrip wrench on the Probe Shield.

3. Carefully remove the Probe Shield from the Probe Adapter.

4. Remove the Probe Tip Insulator from the tip of the Probe Element.



CAUTION! A new Probe Tip Insulator should be fitted each time the Probe Shield is attached. A new Probe Tip Insulator is included as part of the Probe Assembly.

Step 7: Detach Probe Assembly from Probe Adapter.

1. Hold the flat portion of the Probe Assembly with a 5/8” open end wrench, then detach the Seal Loading Nut with a 13/16” open end wrench.

2. Remove and keep the Load Washer from the threaded end of the Probe Assembly.

CAUTION! To establish a reliable seal, a new Insulating Washer and Probe Sleeve must be used each time the Probe Assembly is attached to the Seal Loading Nut. Both Insulating Washer and Probe Sleeve are included as part of the Probe Assembly.

3. Remove and discard the Insulating Washer from the threaded end of the Probe Assembly.

4. Slide the Probe Assembly out of the Probe Adapter and keep for further analysis.

NOTE: The Probe Assembly is preweighed so that it may also be used as a “coupon”. See the data supplied with the Probe Assembly for weight details. A serial number is marked on one of the Probe Assembly wrench flats as well as on the protective cardboard tube packaging.

APPENDIX A

Lithium Thionyl Chloride Batteries Handling, Storage, MSDS

Emergency Procedures

IN THE UNLIKELY EVENT OF VIOLENT BATTERY BEHAVIOR, the area should be evacuated immediately. Personnel should stay away from the area for 15 minutes rather than trying to correct the situation. Burning or fuming batteries should be left isolated until expert handling can correct the condition. Lithium fires should only be extinguished using “Lith-X” or a Class D fire extinguisher. The Material Safety Data Sheets for each cell of the DHT battery pack (2 cells per pack) as well as the main ingredient, Thionyl Chloride, are included in this section.

IN CASE OF LEAKAGE, leaking batteries should be isolated from all personnel and equipment. Since the electrolyte can be neutralized with common baking soda, leaking batteries should be placed in sealed plastic bags containing baking soda. The bags should be placed in a sealed drum with vermiculite. Personal protection devices should always be used around leaking batteries.

Emergency Conditions

Because of the high energy density inherent in lithium / thionyl chloride batteries, the potential for hazardous situations does exist. Most hazards are due to internal or external heating of a hermetically sealed battery. Overheating causes liquid electrolyte to expand, increasing hydrostatic pressure inside the can, which might cause the battery to burst. Further heating can cause the lithium anode to melt which, in turn, will react spontaneously with the electrolyte and bring about explosive behavior.

Causes of Hazardous Conditions- Electrical and Physical

Hazardous electrical conditions include recharging, short circuiting and forced discharging (voltage reversal). Battery Engineering, Inc.’s bobbin and moderate rate anode batteries are generally not capable of hazardous behavior unless external power is applied or they are short circuited at elevated temperatures.

Hazardous physical conditions include external heating due to uncontrolled storage, incineration and physical destruction of the battery case via crushing, puncturing and disassembly. Excessive heating can cause explosive behavior with any type of battery. Physical destruction can result in leakage of toxic and highly corrosive electrolyte.

For further information about the safe handling and storage of lithium / thionyl chloride batteries, contact a Battery Engineering, Inc. Applications Engineer at 1-800-685-4844.

Safe Storage

Shelf
Batteries should be stored in their original shipping containers, if possible, to keep them isolated from each other, preventing connector damage and potential short circuits. Do not store batteries loosely, and do not place batteries on metal surfaces. Batteries should be stored on end with the connector end pointing upward.

Temperature and Environment
Batteries should be stored in a cool, dry, well-ventilated area with an optimal storage temperature range of 0-25°C. If prolonged storage is anticipated, batteries should be protected from excessive humidity.

Hazard Consideration
Lithium battery storage areas should be clearly marked and provided with “Lith-X “ or a Class D fire extinguisher. Batteries may burst if subjected to excessive heating. In the event of fire only “Lith-X” or a Class D fire extinguishers should be used. DO NOT USE WATER, since water will cause exposed lithium to ignite. Signs should clearly state that water is not to be used in case of fire.

Safe Incoming Inspection

The proposed flow of batteries throughout the facility should be thoroughly reviewed by plant safety personnel to identify and eliminate potential sources of electrical and physical damage to the batteries. Conditions that can short circuit, recharge, over discharge, puncture, crush or overheat the batteries must be avoided, and all personnel involved in the handling should be properly trained.

Safe Testing

Physical dimensioning should be performed with all-plastic calipers and no electrical test should be performed without first consulting RCS engineering.

If testing batteries at elevated temperatures, the temperature chamber MUST HAVE reliable over temperature protection. DO NOT SHORT CIRCUIT batteries that are heated above 25°C. Batteries that have been heated above 100°C have been known to explode when short circuited for less than one minute.

NOTE: The batteries used in the DHT are custom built with an integral 1A safety fuse. The fuse will open the circuit if the battery is short circuited.

Safe Transportation

Because the shipping regulations are very complex, shippers of lithium batteries are urged to obtain copies of the 49 CFR (DOT regulations) and the IATA regulations. These regulations also explain how the paperwork is to be filled out.

All lithium/thionyl chloride batteries with a lithium content of greater than 0.5 grams and less than 12 grams are restricted, and they are subject to DOT (49 CFR) and International Air Transport Association (IATA) shipping regulations. Batteries that contain less than 0.5 grams lithium are unrestricted, and may be shipped by any means (ref. IATA section 4.5A45). Batteries with a lithium content of 12 grams must be individually approved by the governing authority, and cannot be shipped under these regulations.

NOTE: The Battery Assembly used in the DHT contains 7.4 grams of lithium when new.

The proper shipping name for lithium / thionyl chloride batteries is LITHIUM BATTERIES, LIQUID CATHODE (UN3090). The hazard class is CLASS 9 (Miscellaneous) and the packing group is PACKING GROUP II.

The regulations state that the batteries have to be separated to prevent external short circuits, and they have to be packed in inner fiberboard container (no more than 500 grams of lithium per inner container). The containers can then be packed with at least one inch of non-combustible packing material (such as vermiculite) separating each inner package in UN approved fiberboard boxes, steel drums, fiber drums, or wooden boxes. These packages have to be printed with a United Nations Marking Symbol (section 6.0 of IATA shipping regulations).

For cargo aircraft transportation, each package must have a gross weight no more than 35 kgs. A 24 hour emergency response number must be provided on the shipping papers in order to provide instructions if an emergency condition arises during transport. The batteries can be shipped by motor freight, rail freight, water, or Cargo Aircraft only. Lithium / thionyl chloride batteries cannot be carried aboard passenger-carrying aircraft. Boxes must be labeled with a MISCELLANEOUS (CLASS 9) label. If the batteries are to be shipped by air , then the package has to have a CARGO AIRCRAFT ONLY label attached. Also, boxes must be marked with the proper shipping name and the UN number near the shipping labels.

NOTE: Save the shipping packaging in which the batteries are received, since this packaging meets these requirements and may be re-used for returning batteries to RCS or a disposal facility.

Safe Disposal

Lithium / thionyl chloride batteries must be disposed of properly in accordance with 49 CFR. Lithium batteries for disposal are classified a WASTE LITHIUM BATTERIES FOR DISPOSAL, and they are shipped with the same regulations as those for new lithium / thionyl chloride batteries.

There is no long lasting contamination as a result of disposal of lithium / thionyl chloride batteries; there are only hazards associated with the neutralization and disposal process. The end products of lithium / thionyl chloride battery deactivation are not toxic, once neutralized. Lithium / thionyl chloride batteries should be disposed of by professional disposal companies. Contact Battery Engineering, Inc. for a recommendation of companies that can perform this disposal.

Because each state has different disposal regulations, contact your local environmental agency for instructions on how to dispose of lithium batteries.

MATERIAL SAFETY DATA SHEET

Battery Engineering, Inc.
1636 Hyde Park Ave.
Hyde Park MA 02136
Tel (617) 361-7555 Fax (617) 361-1835
24 Hour Emergency Telephone - (Chem-Tel) 1-800-255-3924

Date Prepared: November 27, 1995

Section 1 - IDENTIFICATION

Product Name:

25-102-180MR

LITHIUM THIONYL CHLORIDE CELL

Lithium Content: 4.7 grams

Hazardous Components (Approx %)

Lithium	4 %
Thionyl Chloride	39.5 %
Aluminum Chloride	6.5 %
Lithium Chloride	2 %

Non-Hazardous Components (Approx %)

Stainless Steel	42.5 %
Nickel	0.4 %
Paper	0.4 %
Carbon	4.7 %

SECTION 2 - PHYSICAL / CHEMICAL CHARACTERISTICS

Boiling Point:	Thionyl Chloride: 77°C
Vapor Pressure:	Thionyl Chloride: 92mm @ 20°C
Vapor Density:	Thionyl Chloride: 4.1
Solubility in Water:	Thionyl Chloride: Decomposes
Specific Gravity:	Thionyl Chloride: 1.63
Melting Point:	Thionyl Chloride: -105°C
Evaporation Rate:	N/A
Water Reactive:	Thionyl Chloride hydrolyzes to form SO_2 and HCL
Appearance and Odor:	Thionyl Chloride - Colorless to pale yellow; sharp, pungent odor.

SECTION 3 - FIRE AND EXPLOSION HAZARD DATA

Flash Point: N/A **Auto-Ignition Temp:** N/A **Flammable Limits:** N/A
Extinguisher Media: Dry Lithium Chloride, Graphite Powder, Pyrene G-1, Lith-X, Class D
Special Fire Fighting Procedures: Cover with dry lithium chloride, graphite powder, Lith-X powder or Class D fire extinguisher. DO NOT USE WATER, moist sand, carbon dioxide or soda ash extinguisher. Wear protective breathing apparatus.
Unusual Fire and Explosion Hazards: Do not short circuit, recharge, overdischarge, puncture, crush or expose to temperatures above **180°C**.

SECTION 4 - REACTIVITY HAZARD DATA

Stability: Stable
Conditions to Avoid: Temperatures in excess of **180°C**. High humidity for extended periods.
Incompatibility: N/A
Hazardous Decomposition Products: Sulfur Dioxide, Hydrogen Chloride
Hazardous Polymerization: Will not occur.
Other: N/A

SECTION 5 - HEALTH HAZARD DATA

Primary Routes of Entry: Inhalation.
Carcinogen Listed in: Not listed.
Health Hazards: Acute - Vapors very irritating to skin, eyes, and mucous membranes.
Chronic - Overexposure can cause symptoms of nonfibrotic lung injury.
Signs and Symptoms of Exposure: Eye and mucous membrane irritation.
Medical Conditions Generally Aggravated by Exposure: Asthma, other respiratory disorders, skin allergies, eczema.
Emergency First Aid Procedures: Seek medical assistance for further treatment.
Eye Contact: Flush with running water for at least 15 minutes. Hold eyelids apart. Seek immediate medical treatment.
Skin Contact: Rinse with large amounts of running water. If burns develop, seek medical treatment.
Inhalation: Remove to fresh air. If breathing is difficult, administer oxygen and seek medical treatment.
Ingestion: Seek medical treatment.

SECTION 6 - CONTROL AND PROTECTIVE MEASURES

Respiratory Protection: Acid Gas Filter Mask.
Protective Gloves: Butyl Rubber Gloves.
Eye Protection: Chemical Worker Safety Glasses.
Ventilation To Be Used: Local Exhaust.
Other Protective Clothing and Equipment: Chemical Laboratory Safety Glasses and Chemical Apron.
Hygienic Work Practices: N/A

SECTION 7 - PRECAUTIONS FOR SAFE HANDLING AND USE

Steps to be Taken if Material is Spilled or Released: Do not breathe vapors or touch liquid with bare hands.
Waste Disposal Methods: Neutralize spill with soda lime, seal leaking battery and soda lime in plastic bag and dispose of as hazardous waste.
Precautions to be Taken in Handling and Storage: Do not short circuit or expose to temperatures above **180 °C**. Do not recharge, overdischarge, puncture, or crush.
Other Precautions and/or Special Hazards: Do not store batteries in high humidity environments for long periods.

SECTION 8 - TRANSPORTATION INFORMATION

US DOT (per 49 CFR 172.101) and IATA/ICAO

Proper Shipping Name: Lithium Batteries, Liquid Cathode.
UN Number: UN 3090
Hazard Classification: Class 9 (Miscellaneous)
Packing Group: II
Labels Required: MISCELLANEOUS
Other: CARGO AIRCRAFT ONLY
Non-Hazardous Batteries (per IATA): If the batteries contain less than 0.5 gram of lithium (see front of MSDS), they are not restricted for shipping purposes.

SECTION 9 - DISPOSAL INFORMATION

Proper Shipping Name: Waste Lithium Batteries
UN Number: UN 3090
Hazard Classification: Class 9 (Miscellaneous)
Packing Group: II
Labels Required: MISCELLANEOUS, HAZARDOUS WASTE
Waste Disposal Code: D003
Other: All lithium thionyl chloride batteries should be disposed of by a proper disposal facility.

Bayer

MATERIAL SAFETY DATA SHEET

BAYER CORPORATION
PRODUCT SAFETY & REGULATORY AFFAIRS
100 Bayer Road
Pittsburgh, PA 15205-9741

TRANSPORTATION EMERGENCY
CALL CHEMTREC: (800) 424-9300
DISTRICT OF COLUMBIA: (202) 483-7616

NON-TRANSPORTATION
BAYER EMERGENCY PHONE...: (412) 923-1800
BAYER INFORMATION PHONE.: (800) 662-2927

I. PRODUCT IDENTIFICATION:

PRODUCT NAME.....: Thionyl Chloride
PRODUCT CODE.....: V405
CHEMICAL NAME.....: Thionyl Chloride
SYNONYMS.....: Sulfurous Oxychloride; Sulfur Oxychloride
CAS NUMBER.....: 7719-09-7
FORMULA.....: SOCl2

II. HAZARDOUS INGREDIENTS:

INGREDIENT NAME /CAS NUMBER	EXPOSURE LIMITS		CONCENTRATION (%)
Thionyl Chloride			
7719-09-7	OSHA :	1.000 ppm Ceiling	minimum 99.6 %
		5.000 mg/m3 Ceiling	
	ACGIH:	1.000 ppm Ceiling	
		5.000 mg/m3 Ceiling	
Hydrochloric Acid, Sulfur Dioxide, Chlorine and Sulfur Chloride may be released by hydrolysis or thermal decomposition of Thionyl Chloride and may be encountered when Thionyl Chloride comes in contact with moisture in the air.			
Hydrochloric Acid			
7647-01-0	OSHA :	5.000 ppm Ceiling	% Not Noted
		7.000 mg/m3 Ceiling	
	ACGIH:	5.000 ppm Ceiling	
		7.500 mg/m3 Ceiling	
Sulfur Dioxide			
7446-09-5	OSHA :	2.000 ppm TWA	% Not Noted
		5.000 mg/m3 TWA	
		5.000 ppm STEL	
		10.000 mg/m3 STEL	
	ACGIH:	2.000 ppm TWA	
		5.200 mg/m3 TWA	
		5.000 ppm STEL	
		13.000 mg/m3 STEL	

Continued on next page

II. HAZARDOUS INGREDIENTS (Continued)

INGREDIENT NAME /CAS NUMBER		EXPOSURE LIMITS	CONCENTRATION (%)
Chlorine 7782-50-5	OSHA :	.500 ppm TWA 1.500 mg/m3 TWA 1.000 ppm STEL 3.000 mg/m3 STEL	% Not Noted
	ACGIH:	.500 ppm TWA 1.500 mg/m3 TWA 1.000 ppm STEL 2.900 mg/m3 STEL	
Sulfur Chloride 10025-67-9	OSHA :	1.000 ppm Ceiling 6.000 mg/m3 Ceiling	% Not Noted
	ACGIH:	1.000 ppm Ceiling 5.500 mg/m3 Ceiling	

III. PHYSICAL PROPERTIES:

PHYSICAL FORM.....: Liquid
COLOR.....: Colorless to slightly yellow
ODOR.....: Sharp, irritating
MOLECULAR WEIGHT.....: 119
pH .....: Not Applicable
BOILING POINT.....: Approx. 169 F (76 C)
MELTING/FREEZING POINT....: Approx. -156 F (-104.5 C)
VISCOSITY.....: Approx. 0.6 mPas @ 77 F (25 C)
SOLUBILITY IN WATER .....: Reacts
SPECIFIC GRAVITY .....: 1.64 @ 77 F (25 C)
BULK DENSITY.....: Not Established
% VOLATILE BY VOLUME.....: 100%
VAPOR PRESSURE .....: Approx. 97 mmHg @ 68 F (20 C)

IV. FIRE AND EXPLOSION DATA:

FLASH POINT.....: Not Applicable.
AUTO-IGNITION TEMPERATURE.....: Not Established.
EXTINGUISHING MEDIA.....: Carbon Dioxide; Dry Chemical
SPECIAL FIRE FIGHTING PROCEDURES: Thionyl Chloride is not combustible. However, if thionyl chloride is involved in a fire, use carbon dioxide or dry chemicals. Firefighters should wear full protective clothing including a self-contained breathing apparatus. Toxic and irritating gases may be present including hydrochloric acid, sulfur dioxide, chlorine, sulfur chloride or others. Drums exposed to excessive temperatures can rupture due to the decomposition of thionyl chloride. Water will react with

IV. FIRE AND EXPLOSION DATA (Continued)

thionyl chloride generating irritating gases. However, water spray should be used to keep fire exposed containers cool and to help scrub acid gases from the air.

V. HUMAN HEALTH DATA:

ROUTE(S) OF ENTRY.....: Eye Contact; Skin Contact; Inhalation

HUMAN EFFECTS AND SYMPTOMS OF OVEREXPOSURE:
ACUTE EFFECTS OF EXPOSURE.....: Direct contact with thionyl chloride can cause burns. It is corrosive to the skin, eyes and mucous membranes. The vapors of thionyl chloride are strong irritants to the eyes and respiratory tract. Symptoms of exposure include a burning sensation in the eyes and violent coughing. In contact with humid air, hydrogen chloride (HCl) and sulfur dioxide (SO2) are produced which are themselves irritating. Significant overexposure to thionyl chloride vapors and its related decomposition products (which could occur if a person is trapped or sprayed) may cause delayed pulmonary edema.
CHRONIC EFFECTS OF EXPOSURE...: Chronic overexposure to thionyl chloride can cause symptoms of nonfibrotic lung injury similar to other irritating vapors.

CARCINOGENICITY.....: This product is not listed by NTP, IARC or regulated as a carcinogen by OSHA.

MEDICAL CONDITIONS
AGGRAVATED BY EXPOSURE.....: Asthma, other respiratory disorders (bronchitis, emphysema, bronchial hyperreactivity), skin allergies, eczema.
EXPOSURE LIMITS.....: Refer to Section II.

VI. EMERGENCY AND FIRST AID PROCEDURES:

FIRST AID FOR EYES.....: Immediately flush eyes with running water for at least 15 minutes. To assure thorough flushing of all eye tissue, the eyelids should be held apart during irrigation. Permanent eye injury can occur, particularly if rinsing is delayed. Immediately refer to a physician, preferably an eye specialist, for medical treatment.
FIRST AID FOR SKIN.....: Rinse immediately with large amounts of cool, running water. Avoid using hot water and hard rubbing. When splashed with thionyl chloride, immediately proceed to an emergency shower and begin removing all contaminated clothing while rinsing. Flushing the body with large amounts of water should continue until all of the thionyl chloride is removed. If the eyes are not contaminated, do not remove safety goggles to avoid washing thionyl chloride into the eyes. If contact is extensive or burns develop, a physician should be contacted immediately.

VI. FIRST AID PROCEDURES (Continued)

FIRST AID FOR INHALATION: Remove to fresh air. Keep person calm and avoid any unnecessary exertion or movement. Trained persons should administer oxygen if breathing is difficult. If not breathing, give artificial respiration. Immediately contact a physician.

FIRST AID FOR INGESTION.: In case of ingestion, drink copious amounts of water (if available, give several glasses of milk). Do not induce vomiting. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON. If vomiting occurs spontaneously, keep airway clear and give more water. Immediately call a physician.

VII. EMPLOYEE PROTECTION RECOMMENDATIONS:

EYE PROTECTION REQUIREMENTS.....: Chemical worker safety glasses and full face shield.

SKIN PROTECTION REQUIREMENTS.....: Neoprene, PVC, Polyethylene or Viton (R) gloves, boots and aprons as appropriate for exposure conditions.

RESPIRATOR REQUIREMENTS.....: NIOSH approved for acid gases. Do not exceed the use limits of the respirator.

VENTILATION REQUIREMENTS.....: Use local exhaust or general room ventilation sufficient to prevent overexposure.

ADDITIONAL PROTECTIVE MEASURES.....: Full body acid resistant suits and positive pressure, self-contained breathing apparatus should be available in case of large spills or other similar emergencies. Emergency showers and eyewash fountains should be located in areas where thionyl chloride is handled. Educate and train employees in the safe use and handling of this product.

VIII. REACTIVITY DATA:

STABILITY.....: This is a stable material.

HAZARDOUS POLYMERIZATION...: Will not occur.

INCOMPATIBILITIES.....: Reacts violently with water. Avoid contact with reducing agents and organic matter. May react vigorously with Antimony, Sodium, Aluminum, Magnesium and Titanium. Iron and Zinc may catalyze violent reactions of Thionyl Chloride mixtures with organic chemicals. Thionyl Chloride mixtures with organic chemicals must be stored in containers free of iron and zinc and must be equipped with a pressure relief device. Refer to Section X (special precautions & storage data).

INSTABILITY CONDITIONS.....: Excessive temperatures.

DECOMPOSITION TEMPERATURE..: Decomposition begins at 284 F (140 C).

DECOMPOSITION PRODUCTS.....: By thermal decomposition: Chlorine, Sulfur Dioxide, Sulfur Chloride. In contact with water: Hydrochloric Acid, Sulfur Dioxide.

IX. SPILL AND LEAK PROCEDURES:

SPILL OR LEAK PROCEDURES....: Evacuate area and stay upwind. If it is safe to do so, trained personnel should attempt to stop or reduce leak. Large spills should be contained and pumped into salvage drums or other appropriate containers. Full acid resistant suits and self-contained breathing apparatus should be worn during emergency operations. Vapor clouds formed by reaction of the spilled thionyl chloride with atmospheric moisture can be controlled by water fog or water spray. After bulk of material is removed, large quantities of soda ash, lime or a combination of these can be used to soak up and neutralize the remaining thionyl chloride. Small spills can be handled by absorption and reacted with large amounts of dry alkali (soda ash and/or lime). Shovel into appropriate container for disposal.
WASTE DISPOSAL METHOD.....: Waste disposal must be in accordance with federal, state and local environment control regulations.

X. SPECIAL PRECAUTIONS & STORAGE DATA:

STORAGE TEMPERATURE(MIN/MAX): Ambient/122 F (50 C).
SHELF LIFE.....: Unlimited in closed containers and in the absence of moisture. In drums - one year maximum.
SPECIAL SENSITIVITY.....: Moisture or heat greater than 122 F (50 C).
HANDLING/STORAGE PRECAUTIONS: This product is extremely corrosive. Do not breathe vapors or mists. Do not get on eyes or on skin. Wash thoroughly after handling. Store containers in a cool, dry and well ventilated area, out of sunlight and away from fire hazards. Storage containers and associated equipment should be 304L or 316L stainless steel, nickel or lined with PTFE (Polytetrafluoroethylene), lead, porcelain enamel or galvanized steel. Do not allow moisture to enter storage containers as this will cause increased corrosion and release of Hydrochloric Acid and Sulfur Dioxide. Moisture and heat greater than 122 F (50 C) will result in build-up of internal pressure in containers. Each storage vessel should be equipped with pressure relief devices which are constructed with materials compatible with thionyl chloride.

XI. SHIPPING INFORMATION:

TECHNICAL SHIPPING NAME.....: Thionyl Chloride
FREIGHT CLASS BULK.....: Thionyl Chloride
FREIGHT CLASS PACKAGE.....: Thionyl Chloride
PRODUCT LABEL.....: Thionyl Chloride

XI. SHIPPING INFORMATION (Continued)

DOT (DOMESTIC SURFACE)

PROPER SHIPPING NAME.....: Thionyl Chloride
HAZARD CLASS OR DIVISION .....: 8; 6.1
UN/NA NUMBER.....: UN1836
PACKAGING GROUP .....: PG I
DOT PRODUCT RQ lbs (kgs).....: None
HAZARD LABEL(s).....: Corrosive; Poison
HAZARD PLACARD(s).....: Corrosive; Poison

IMO / IMDG CODE (OCEAN)

PROPER SHIPPING NAME.....: Thionyl Chloride
HAZARD CLASS DIVISION NUMBER...: 8
UN NUMBER.....: UN1836
PACKAGING GROUP.....: I
HAZARD LABEL(s).....: Corrosive; Toxic
HAZARD PLACARD(s).....: Corrosive; Toxic

ICAO / IATA (AIR)

HAZARD CLASS DIVISION NUMBER...: Forbidden

XII. ANIMAL TOXICITY DATA:

TOXICITY DATA FOR: Thionyl Chloride
ACUTE TOXICITY
ORAL LD50.....: Data not established for product.
DERMAL LD50.....: Data not established for product.
INHALATION LC50....: 1,274 ppm (Rat - 1 hour); 558 ppm (Rat - 4 hour). (1); 736 ppm (Rat - 1 hour). (2)
EYE EFFECTS.....: Corrosive
SKIN EFFECTS.....: Corrosive
SENSITIZATION.....: Data not established for product.
SUBCHRONIC TOXICITY...: Data not established for product.
CHRONIC TOXICITY.....: Data not established for product.
OTHER TOXICITY DATA...: (Mutagenic, Teratogenic, Reproductive Tests): Data not established for product.
AQUATIC TOXICITY.....: Do not allow to enter waters, wastewater or soil.

1 Tests conducted at the Institute for Toxicology of Bayer AG.
2 Bushy Run Research Center, October, 1993.

XIII. FEDERAL REGULATORY INFORMATION:

OSHA STATUS.....: This product is hazardous under the criteria of the Federal OSHA Hazard Communication Standard 29 CFR 1910.1200.
TSCA STATUS.....: On TSCA Inventory
CERCLA REPORTABLE QUANTITY..: None.
SARA TITLE III:
SECTION 302 EXTREMELY HAZARDOUS SUBSTANCES..: None.
SECTION 311/312 HAZARD CATEGORIES.....: Immediate Health Hazard; Delayed Health Hazard; Reactive Hazard
SECTION 313 TOXIC CHEMICALS.....: None.
RCRA STATUS.....: When discarded in its purchased form, this product meet the criteria of corrosivity (EPA Hazardous Waste Number D002) and reactivity (EPA Hazardous Waste Number D003) under 40 CFR (261.20-24).

XIV. OTHER REGULATORY INFORMATION:

The following chemicals are specifically listed by individual states; other product specific health and safety data in other sections of the MSDS may also be applicable for state requirements. For details on your regulatory requirements you should contact the appropriate agency in your state.

COMPONENT NAME /CAS NUMBER	CONCENTRATION	STATE CODE
Thionyl Chloride 7719-09-7	minimum 99.6 %	PA1, MA, NJ3

MA = Massachusetts Hazardous Substance List
NJ3 = New Jersey Special Health Hazardous Substance List
PA1 = Pennsylvania Hazardous Substance List

CALIFORNIA PROPOSITION 65
To the best of our knowledge, this product contains no levels of listed substances, which the state of California has found to cause cancer, birth defects or other reproductive effects.

XV. APPROVALS:

REASON FOR ISSUE.....: Revise Sections XI, XII (IMO) and XIV
PREPARED BY.....: D. P. Kelly
APPROVED BY.....: J. M. Mostowy
APPROVAL DATE.....: 11/08/95
SUPERSEDES DATE.....: 09/28/93
MSDS NUMBER.....: 01987