ALTRONIC RESEARCH, INC.

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U.S.A.

CALORIMETRY

MODEL DC3500-AH24

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CALORIMETRY MODEL 3500

LIMITED WARRANTY

We take pride in manufacturing products of the highest quality and we warrant them to the original purchaser to be free from defects in material and workmanship for the period of one year from date of invoice. Additionally, products of our manufacture repaired by us are warranted against defects in material and workmanship for a period of 90 days from date of invoice, with the provisions described herein.

Should a product, or a portion of a product of our manufacture prove faulty, in material or workmanship, during the life of this warranty, we hereby obligate ourselves, at our own discretion, to repair or replace such portions of the product as required to remedy such defect. If, in our judgment, such repair or replacement fails to be a satisfactory solution, our limit of obligation shall be no more than full refund of the purchase price.

This warranty is limited to products of our own manufacture. Equipment and components originating from other manufacturers are warranted only to the limits of that manufacturer's warranty to us. Furthermore, we shall not be liable for any injury, loss or damage, direct or consequential, arising out of the use, or misuse (by operation above rated capacities, repairs not made by us, or any misapplication) of the equipment. Before using, the user shall determine the suitability of the product for the intended use; and the user assumes all risk and liability whatsoever in connection therewith.

The foregoing is the only warranty of Altronic Research Incorporated and is in lieu of all other warranties expressed or implied.

Warranty returns shall first be authorized by the Customer Service Department and shall be shipped prepaid. **Warranty does not cover freight charges.**

INTRODUCTION

This handbook was prepared for technical personnel as an aid in understanding and performing installation procedures for the Calorimetry Model 3500. Personnel are considered to be skilled if they have the necessary knowledge and practical experience of electrical and radio engineering to appreciate the various hazards that can arise from working on radio transmitters, and to take appropriate precautions to ensure the safety of personnel.

SECTION I

DESCRIPTION AND LEADING PARTICULARS

1-1. **PURPOSE AND APPLICATION OF EQUIPMENT.** When RF energy is terminated into the broadband resistor/resistor network, it is transformed into heat by the resistor/resistor network. Forced air is passed over the resistors, carrying away the heat.

Calorimetry sequences require the precise measurement of the temperature difference of the inlet and outlet temperature and the flow rate. (see Section IV Theory of Operation). Considerable detail has been given to insure high accuracy. The electronics are housed in a shielded enclosure.

1-2. **GENERAL DESCRIPTION.** The temperature sensors are located in the supply and return lines to the load. A magnetic flow sensor is installed on the supply line. The sensors are all 4-20mA and are routed directly to the PLC.

1.3. **COMPUTER ASSEMBLY.** The computer assembly consists of a Programmable Logic Controller which has a 4-20mA analog input module. The program is stored in non-volatile memory. Display and interface functions are handled by a touch-screen Liquid Crystal Display. These devices operate on 24 VDC.

1-4. **DATA ACQUISITION MODULE.** The data acquisition module has been superseded by all native 4-20mA sensors. As such it is not included in this product.

1-5. **SENSORS.**

a. **Water Flow Meter/Sensor.**
Water flow is measured by passing the water through a manifold which houses magnetic flow sensor.

b. Temp Sensors

Altronic Research utilizes different temperature sensing devices for the various application requirements. This device uses two integrated platinum RTD temperature sensors with 4-20mA current loop output.

c. RTD

RTD's are linear over the wide operating ranges as experienced when utilized in an air load. They are interchangeable over extended ranges and exhibit excellent stability at high temperatures. They may be made up in any length which allows them to perform as an averaging temperature sensor.

1.6. SOFTWARE. The program for the PLC is written in ladder logic and may be updated by a RS-232 connection from a PC. The program for the display may be updated from a PC.

SECTION II
DEFINITIONS

DELTA TEMP
The difference between the Hot Temperature and the Cold Temperature

HOT or OUTLET TEMPERATURE
The temperature in degrees C. of the coolant that is exiting the system from the load.

COLD or INLET TEMPERATURE
The temperature in degrees C. of the coolant that is entering the load.

DISPLAY
Refers to the human machine interface. In this revision it is one or more Cmore-Micro EA1-T4CL.

FLOW
This is a quantitative measure of the coolant that is passing through the load.

HOT or OUTLET OFFSET
This is a calibration number that may be used to correct any errors in the hot temperature sensors.

COLD or INLET OFFSET
This is a calibration number that may be used to correct any errors in the cold temperature sensor.

HOT or OUTLET GAIN
This is a multiplier to convert the temperature in engineering units to degrees C.

COLD or INLET GAIN
This is a multiplier to convert the cold temperature in engineering units to degrees C.

FLOW OFFSET
This is used to calibrate the flow meter and represents the minimum flow measurement capabilities of the flow meter.

FLOW GAIN
This is a multiplier that is used to convert from engineering units to gallons per minute.

KT FACTOR

The kt factor is a measure of the coolant to transport heat when water is used. This value is .264 and is corrected for temperature changes in the power measurement calculations. If coolants with different values are used, the appropriate kt factor should be entered at the temperature of operation. When a power-on reset is run or the reset push button is pressed, the system will change back to the default value of .264.

POWER

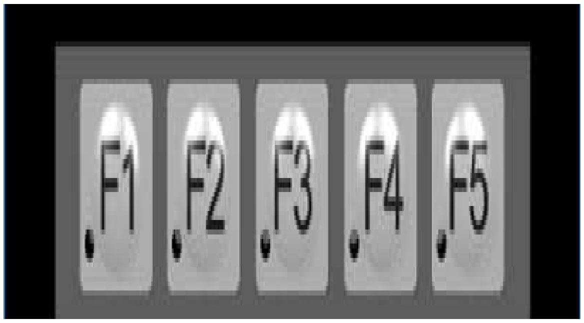
Power is displayed in KW and is derived from the formula Kt x GPM x DeltaT.

SCREEN

Refers to the actively shown page on the Display.

SOFTKEYS

The lower row of almost every screen will display the softkey definitions above the softkeys themselves. The softkeys are permanently labeled F1 to F5. Pressing the softkey **or** the definition above it have identical effects. For example, touching Alarms or the corresponding F4 key will display the alarms screen.



THE More SOFTKEY

In order to provide more than five software defined functions for the softkeys, the More button is used. Pressing More acts as a shift-key to assign additional functions to the softkeys.

THE Alarms SOFTKEY

The Alarms softkey is mapped to F4. See the section on Alarms and Troubleshooters for more information.

ACTIVE ALARM INDICATOR (F4 LED)

There is an LED built into the F4-softkey which when blinking indicates an active alarm. The F4 LED will continue to blink in the event of an alarm even when screens which utilize an alternate F4-softkey definition are displayed.

SECTION III

PREPARATION FOR USE

3-1. UNPACKING EQUIPMENT

1. Remove the calorimetry unit from cardboard shipping container.
2. Inspect for damage.

3-2. FIELD INSTALLATION

1. Transmitter Interlock:
The transmitter interlock should be connected to the screw terminals located on the side of the assembly. The terminals present a closed or latched condition when the proper operating conditions have been met. If conditions fall outside of acceptable limits the interlock will open or unlatch to signal the transmitter to power down.

2. Plumbing Hook Up:
Facing the screen:
The Cold water from the system should be connected to the top right fitting.
The Hot water out to the system should be connected to the bottom right fitting.
The Cold Water to the load should connect to the top left fitting.
The Hot water from the load connects to the bottom left fitting.

3-3. CALIBRATION

Calibration is done at the factory and should only be altered in the event of unintended operation or erroneous readings. In certain situations it may be necessary to restore the calibration settings to the factory defaults. This can be accomplished via the 'Config' screen. See section IV for further information.

3-4. CONNECTORS AND SENSOR WIRING

All wiring is internal to the assembly. This provides EMI/RFI protection.

3-5. TROUBLE SHOOTING

Certain troubleshooters have been provided in software. If the system halts or fails to run, cycle the off/on power switch. If the problem persists please contact customer care.

SECTION IV

OPERATION

4-1. <u>THEORY OF OPERATION.</u> RF energy is terminated into a cermet film resistor network, housed in a broadband cavity. The electromotive energy is transformed into heat by resistive action. A medium flows over the resistor and carries away the heat. The amount of heat the medium absorbs is directly proportional to the applied energy, the amount of medium, and the temperature differences between the inlet and outlet streams. This describes the operation basics for both air and water-cooled loads.

Air calculations utilize the following equation with K representing the specific heat of air:

$$kW = \frac{7.27\,\text{GramCalories} * K * \text{Flow} * \text{Delta Temperature}}{14330\ \text{GramCalories}}$$

Water, having a significantly higher specific heat capacity, utilizes the following equation:

$$kW = \ * \text{Flow} * \text{Delta Temperature} * \text{The Specific Heat of Water}$$

Altronic Research Inc. utilizes a unique approach which incorporates a data acquisition unit located in the RF hardened enclosure. This unit samples and digitizes the output from flow and temperature sensors.

Different temperature-sensing devices are used for the various application requirements. RTD's are generally used in air-cooled loads and thermistors in water-cooled loads. The RTD's used are linear over the wide operating ranges as experienced in an air-cooled load. They are interchangeable over extended ranges and exhibit excellent stability at high temperatures. Air flow is measured by bypassing a representative sample of the exchange air through the rotary sensor in the flow measurement assembly.

<u>Measurements</u>

On current models all temperature measurements are displayed in degrees Celsius. All flow measurements are displayed in cubic feet per minute. Water flow measurements are in gallons/minute. Power measurements auto range from watts to megawatts.

In the course of taking a measurement in air-cooled loads, the applied energy has to heat up the load resistors and the load itself. This takes several minutes and the displayed power lags behind the actual power. The projected power is derived by tracking measurements related to the rise in temperature over a period of time and calculating the final temperature. The projected power normally will project within 8% of the actual reading in approximately one minute. The projected power is blanked when within 4% of the actual power. In water, the power measurement is more dynamic since heat change in water is more instantaneous. Taking measurements in water-cooled loads requires less time than air, although accurate measurements should be available after unit has stabilized, usually within 1 minute.

4-2. GENERAL OPERATION

Installation

The calorimetry system is self-contained and requires only plumbing hook-up and connection to 24V DC and common ground. Power connections are made via screw terminals on the side of the unit. If the load ground and DC power supply ground are at different potentials damage may result so a proper earth-ground is recommended.

4-3. OPERATION MANUAL

CONVENTIONS USED IN THIS SECTION

Touch responsive controls will be shown by name or description within single quotes (' ') and whenever possible a graphic will be provided to facilitate identification. Ex: 'CALIBRATION'

Softkeys-

Softkeys will, whenever possible, be referenced by their definitions and will be highlighted blue.	Ex: Alarms
Occasionally, softkeys may be referenced by an F number in regular font and color.	Ex: F4

If shown in a procedure the arrow ' --> ' will indicate to proceed to the next step.

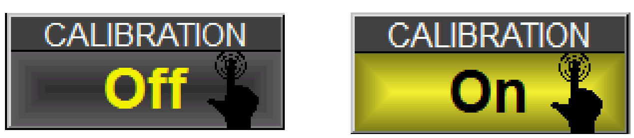
INITIAL SETUP

Ensure that all plumbing is complete and mechanical considerations are met before operating the unit.
Upon powering the unit the operator will be presented with the main control screen.

MAKING POWER MEASUREMENTS

To make a power measurement:

1. Ensure proper water flow through the RF Load for a minute or more until inlet and outlet temperature readings stabilize.
2. Verify that the Alarms **(F4)** softkey LED is **not flashing** and the **interlock is latched closed.**
3. **Without** RF applied to the unit touch the CALIBRATION button to turn it from OFF to ON.



Calibration button OFF/ON graphic.

a. Apply RF to the unit.

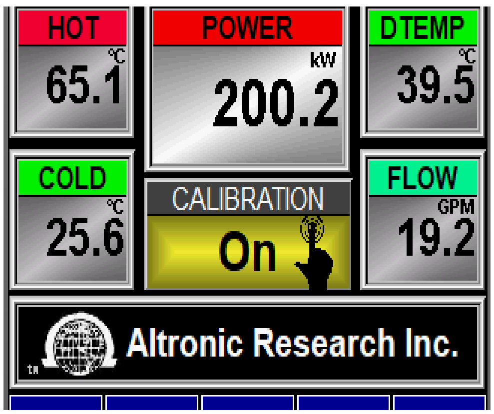
Power measurements may now be made.

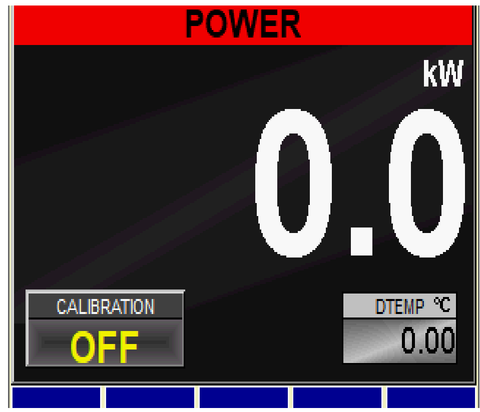
WARNING:
Never apply RF to the unit:

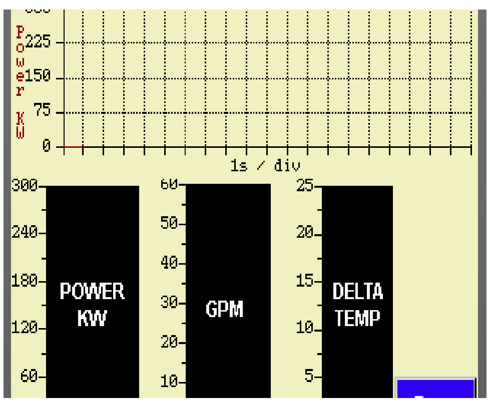
2- Without the transmitter interlock connected,
3- Without power to the calorimeter,
4- Without the proper water flow through the RF load,
5- While there are any Alarms active (**F4** softkey LED **flashing**),
6- Or without proper system grounding.

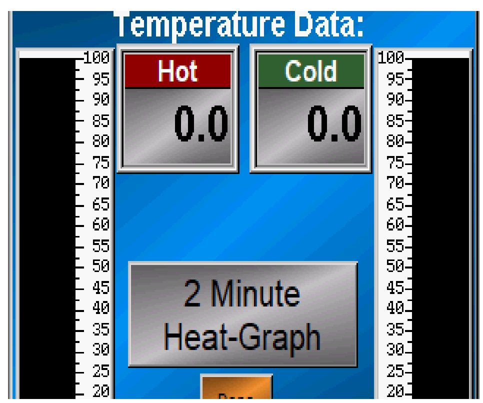
MONITOR SCREENS

Touch Monitors to select from the following screens:



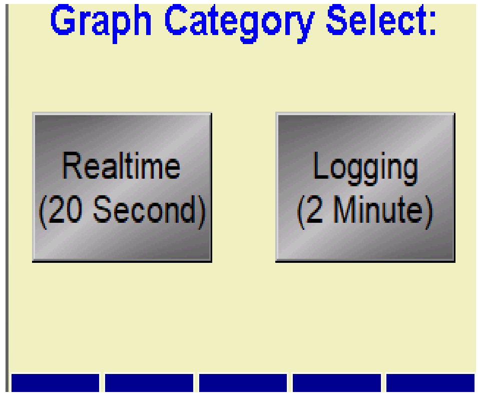






GRAPHS

Touch Graphs and select from either 'Realtime (20 Second)' or 'Logging (2 Minute)' graphs.



All available graphs from each category are listed below:

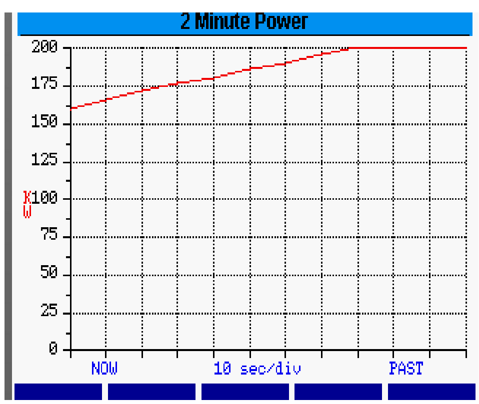
<u>Real-time</u>

- Running Graph
- Combo Graph
- Heat Graph
- Flow Graph

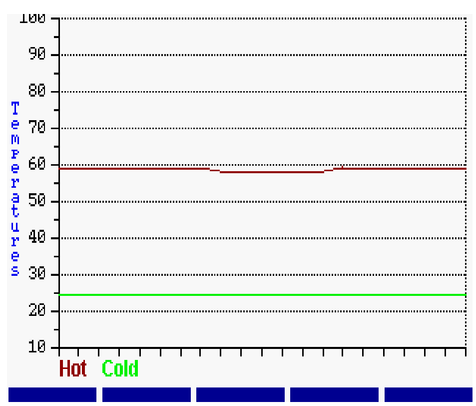
<u>Logging</u>

- Power
- Temperature
- Flow

Graph selection may vary by model.



Example Two-Minute Logging



Example 20-Second Real-Time

Due to the number of graphs available, images and details of each are omitted from this document for purposes of brevity.

ALARMS AND TROUBLESHOOTERS

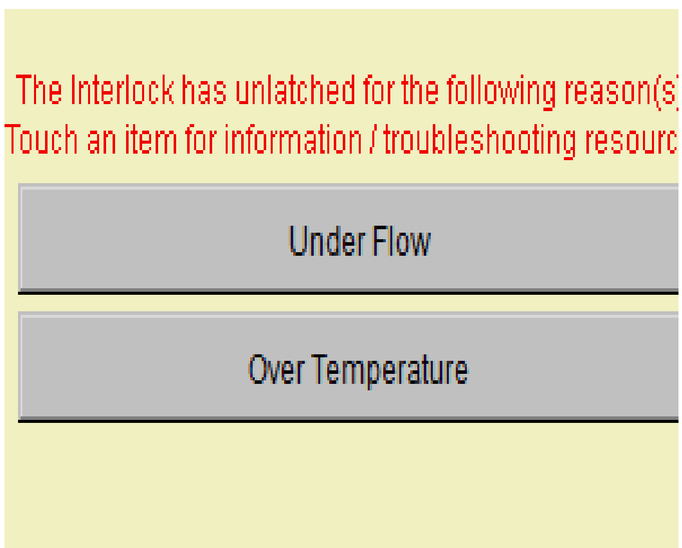
Alarms are triggered by any of the following conditions:

- Over Temperature
- Low / No Flow
- Over Current (on some models)
- Over-Power (RF)

When an alarm is triggered the transmitter interlock will be automatically unlatched and the LED in the F4 softkey will oscillate on and off.

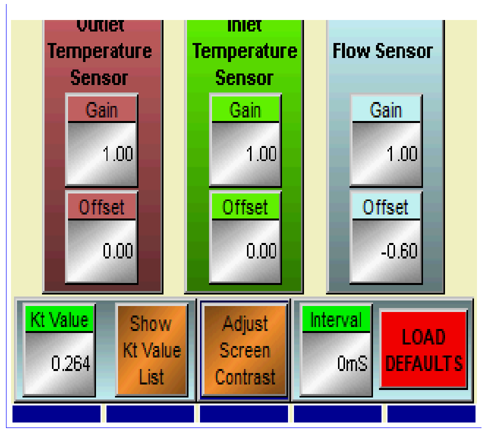
NOTE: F4 is defined as the Alarms softkey. Pressing More does not change this functionality. However, in some screens the softkeys are disabled and the associated tab of definitions is not shown. To exit these screens and restore softkey functionality the user must touch the 'Done' button.

For alarm status, information, or troubleshooters touch Alarms or the F4 softkey. A screen similar to the one shown below will appear.



Touch any item for information and/or troubleshooters. For example, touching 'Over Temperature' will display the Heat Monitor screen shown in the Monitors section of this document.

CONFIGURATION



NOTE: The values shown in the above graphic are the proper settings for your device as it was calibrated at the factory.

This screen enables the configuration of the system variables for a specific application. To change a specific item, press the screen at that area. When the item is pressed, a numeric keypad screen is overlaid. Extra buttons are included for Escape, Backspace, Clear and Entry. After the change has been made, press the "Ent" button to program the data and return to the configuration screen.

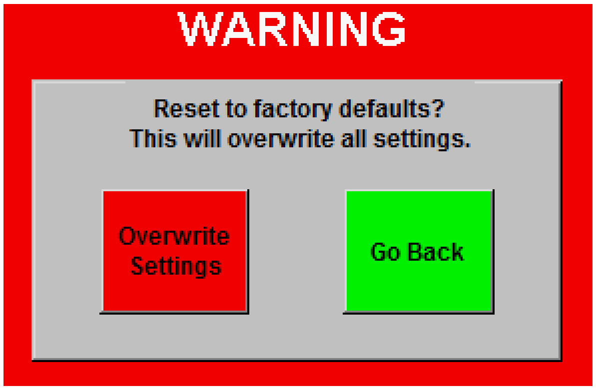
Preset Configuration data:

Outlet Temperature Gain	1.00
Outlet Temperature Offset	0.00
Inlet Temperature Gain	1.00
Inlet Temperature Offset	0.00
Flow Sensor Gain	1.00
Flow Sensor Offset	-0.60
Kt Value (adjust for installation)	0.264
Interval (unused)	0.00

NOTE: These values are calibrated at the factory and should only be changed if the system is reconfigured.

RESETTING DEFAULT CONFIGURATION

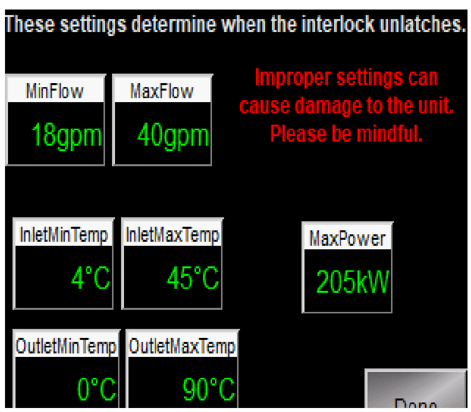
A user level pass code is required to reset defaults to the above settings.
The pass code for this device is: **5623**



Load Defaults screen.

SECURED CONFIGURATION

The secured configuration screen facilitates changes to the system in order to rectify any unintended or undesirable operation.



As changes to these settings could cause damage to the load, transmitter or other components of the installation this screen is protected by a manufacturer-level pass code. Contact customer care for instructions on accessing and safely changing these settings.

NOTE: The values shown in the above graphic are the proper settings for your device as it was calibrated at the factory.

SECTION V

REPLACEMENT PARTS LIST

MODEL DC3500-AH24

(CONSULT FACTORY)

SECTION VI

SPECIFICATIONS
Calorimetry Model DC3500-AH24

INPUT POWER

Voltage -- 24V DC +/- 10%

Maximum peak to peak ripple -------------------------- 400mV

Current --- 750mA

MECHANICAL VARIATIONS

Flow Sensing Limits --------------------------------------- 3 – 49 GPM

Coolant Temperature -------------------------------------> 0°C – 85°C

Temperature Sensing Limits----------------------------------> -40°C – 100°C

ENVIRONMENTS

Operating Temperature-----------------------------------> 0°C – 50°C

Storage Temperature -------------------------------------> -20°C – 70°C

Humidity --- 95% R.H. (non-condensing)

Serial No. 101 **Software Revision** 001-062017

Model DC3500-AH24 **Inspected by** JCD **Date** 21 June 2017

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CRAFTED WITH PRIDE IN ARKANSAS, U.S.A.

APPENDIX I

Much of this manual, the contents of section 4.1 and this appendix are taken from the work of several of the engineers who created the first generation of these devices. It is included to aid in understanding the method of operation.

CALORIMETRY

There are two methods/devices currently available from Altronic Research, Inc. to perform calorimetric measurements. The following information pertains to the original method and is included here for better understanding of the principles of calorimetry.

See Section VIII Program Instructions for complete instructions on electronic calorimetry which is installed on this load system.

7.1. General. Physicists have long known that it takes a definite amount of energy in the form of heat to raise the temperature of a certain mass of liquid and conversely, if you know the temperature rise and the mass of the liquid, you can determine the amount of heat and therefore, the amount of energy applied to the liquid. There are many variables in this equation. Among them are: specific heat of the fluid, specific gravity of the fluid, density of the fluid, thermometer accuracy and flow meter accuracy. These factors must be determined or minimized to yield accurate power measurements. The OMEGALINE® Power Test Load System is designed to provide the user with data which can be reduced to an accurate transmitted power measurement.

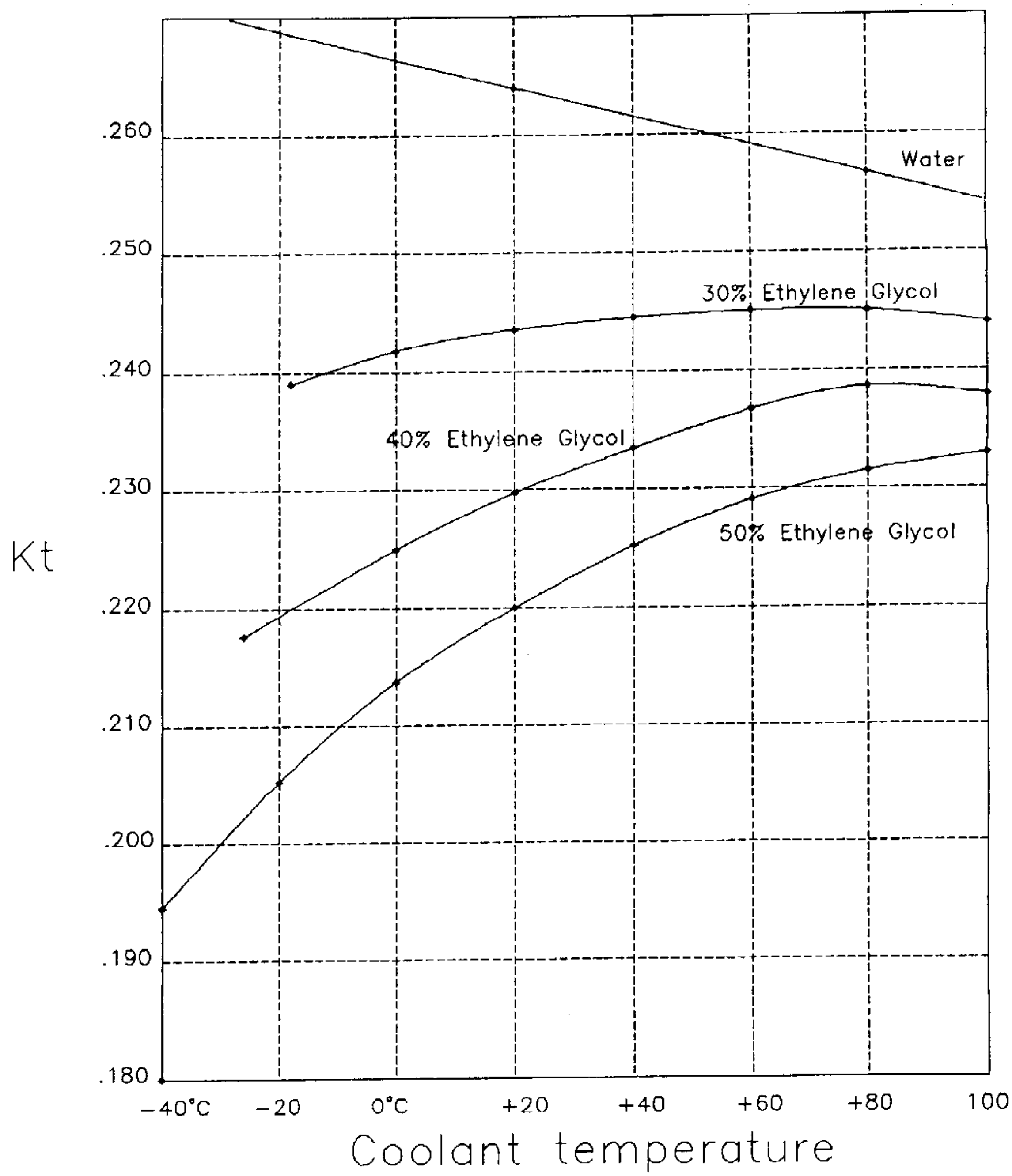
7.2. Calorimetry Theory. Since we know from physics that we can determine energy put into a system by measuring temperature and flow rate, we have only to adjust our readings to account for variance from classic values in order to accurately determine transmitter power. The theory of RF calorimetry requires a liquid-cooled coaxial load of low VSWR, accurate thermometry and accurate flow measurement. This information is used to obtain coolant and flow meter factors for use in calculating power values.

Some of the terms we use:

- **Specific heat (C_p)**: The number of calories required to raise one gram of a substance one °K.
- **Density**: The mass per unit volume of a substance at a certain temperature.

7.3. <u>Practical Calorimetry.</u> Practical calorimetry with the OMEGALINE® Power Test Load System can be reduced to a systematic process requiring no technical skills beyond the ability to read instruments, use graphs and tables and calculate final values (a handheld calculator helps with the multiplication).

<u>First, a warning!</u> If you don't know what the fluid is, you'll never get a correct answer! If your system uses "pure" water, i.e. tap water, distilled water, deionized water, etc., you know what the fluid is accurately enough for calorimetry. If your coolant is a mixture of water and ethylene glycol, you cannot be certain what your fluid is until you obtain the specific gravity of your fluid (corrected for temperature) with a laboratory grade hydrometer. Water evaporates from your coolant system, but ethylene glycol doesn't. Therefore, glycol concentrations vary almost daily in an operating system. In systems where fluid loss is made up with water/glycol mixtures, the concentration of glycol gradually increases. Be sure that you know what the specific gravity of your coolant is before you start! Use this value and the Ethylene Glycol Solution Densities chart to determine the percentage of ethylene glycol in your system. The percentage value is used in the calorimetry process.



.260
.250
.240
.230
.220
.210
.200
.190
.180
Kt
Water
30% Ethylene Glycol
40% Ethylene Glycol
50% Ethylene Glycol
-40°C
-20
0°C
+20
+40
+60
+80
100
Coolant temperature

Fig. 7-1

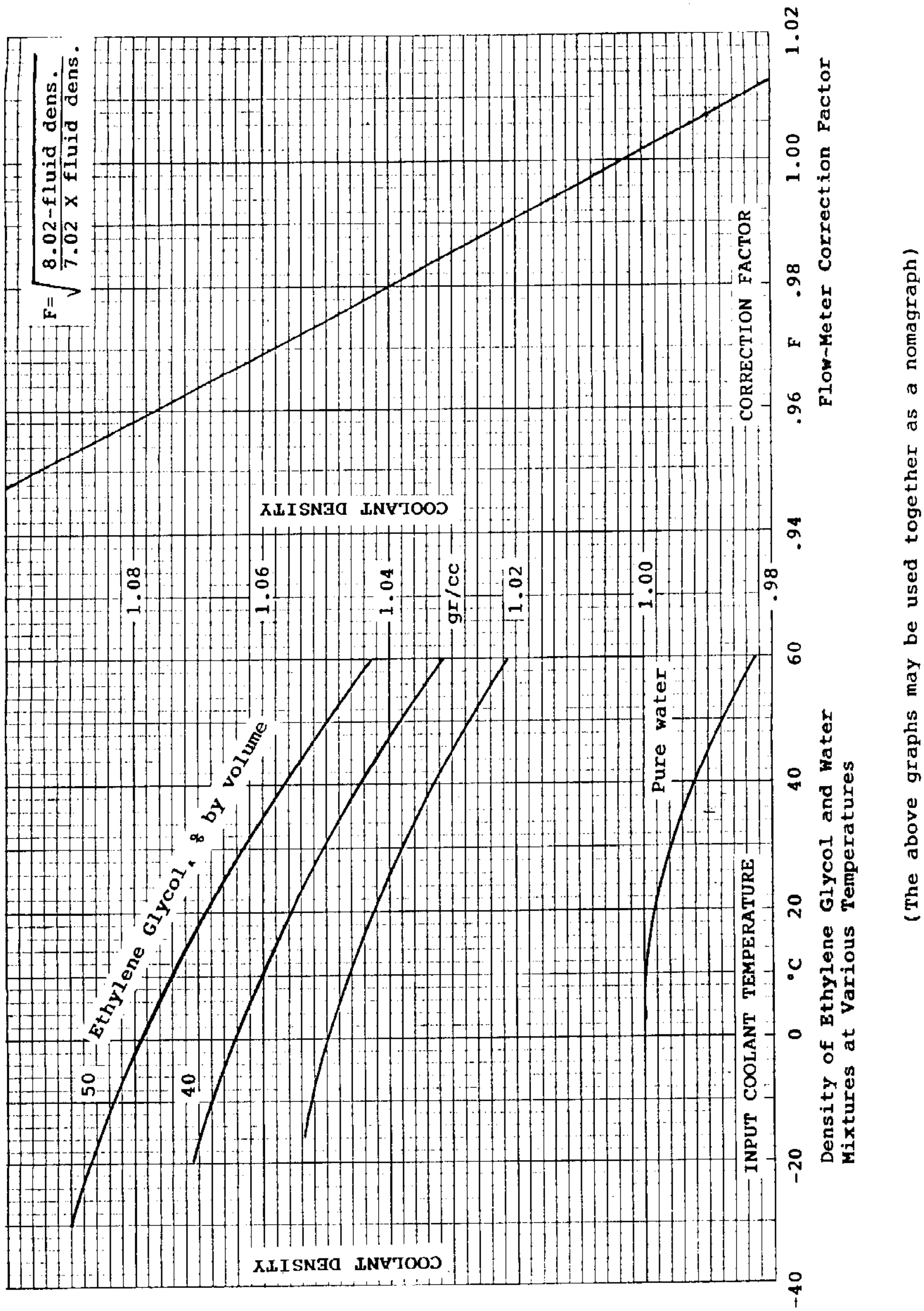

F= √(8.02-fluid dens. / 7.02 X fluid dens.)
CORRECTION FACTOR
.94 .96 F .98 1.00 1.02
Flow-Meter Correction Factor
COOLANT DENSITY
1.08
1.06
1.04
gr/cc
1.02
1.00
.98
Ethylene Glycol, % by volume
50
40
Pure water
INPUT COOLANT TEMPERATURE
-40 -20 0 °C 20 40 60
Density of Ethylene Glycol and Water
Mixtures at Various Temperatures
COOLANT DENSITY
(The above graphs may be used together as a nomagraph)

Fig. 7-2

ETHYLENE GLYCOL SOLUTION DENSITIES

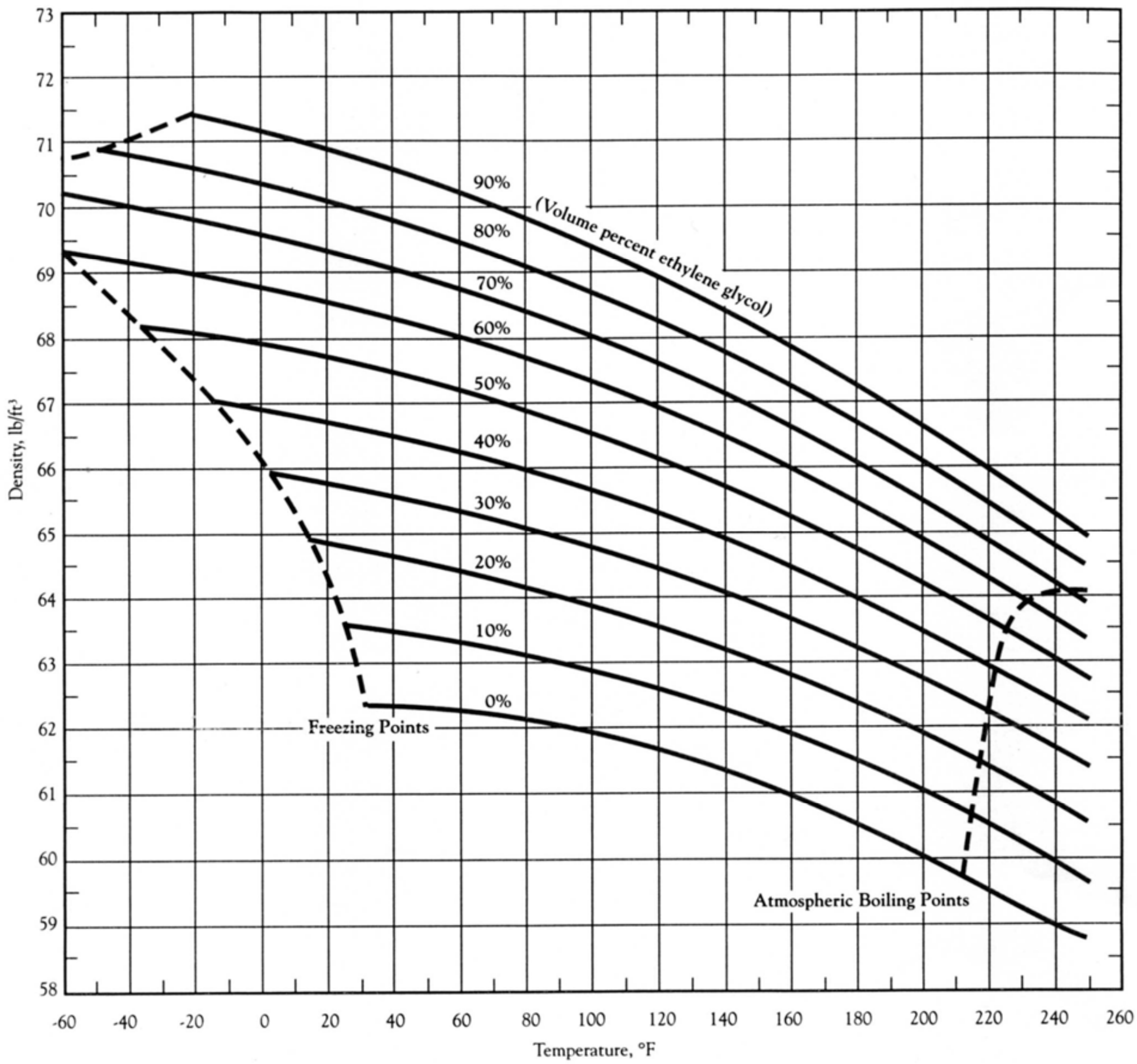


Fig. 7-3