AERCO

Instruction No. **GF-114**

AERCO INTERNATIONAL, Inc., Northvale, New Jersey, 07647 USA

MODBUS®

Communication Manual

For

C-More Boiler Controllers and Boiler Management Systems

Printed in U.S.A

REVISED 11/17/06

TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

SECTION 1 INTRODUCTION & GENERAL DESCRIPTION

1.1 INTRODUCTION.

The information contained in this manual provides general guidelines for implementing a Modbus® communications network utilizing AERCO's Boiler Management System (BMS) and C-More Boiler Controllers.

All Modbus networks are implemented utilizing a Master-Slave technique where only one device, the Master, can initiate a communication sequence. AERCO C-More Controllers can only function as Slave devices in a Modbus network. However, the AERCO BMS can function both as a Master controlling C-More Slaves, or as a Slave controlled by an Energy Management System (EMS) or Building Automation System (BAS) developed by other manufacturers.

1.2 AERCO BMS AND C-MORE CONTROLLER MODELS COVERED

To easily determine if your AERCO BMS or C-More Boiler Controller is equipped with Modbus capabilities, check the current software version as follows:

For BMS:

- Apply power to the BMS
- The BMS will display: ***INITIALIZING*** followed by ***EPROM REV K***
- If ***REV K*** or higher is displayed, the BMS Controller can support Modbus
- If the *REV* level is lower than **K,** the BMS Controller cannot support Modbus

For C-More:

- Apply external power to the C-More Controller
- Scroll through the Setup Menu and observe the displayed ***Software Version***
- If ***2.00*** or higher is displayed, the C-More Controller can support Modbus
- If a ***Software Version*** lower than ***2.00*** is displayed, the C-More Controller cannot support Modbus

1.3 MINIMUM MODBUS SUPPORT REQUIREMENTS

Implementation of a Modbus communication network utilizing the AERCO C-More Controller and BMS will be limited to the minimum support requirements listed in Table 1-1 which follows. The remaining paragraphs in this Section provide more detailed descriptions for each of the items listed.

Table 1-1. Modbus Communication and Support Requirements

Characteristic	Requirement
Communication Medium: • EMS Master-To-BMS Slave • BMS Master-To-C-More Slave • EMS Master-To- C-More Slave	 RS232 (or RS485 With Optional Converter) RS485, 2-Wire Differential Bus With Shield RS485, 2-Wire Differential Bus With Shield
Allowable Cable Lengths • RS232 • RS485 • PWM	 50 Feet, Maximum 4,000 Feet, Maximum 1,000 Feet, Maximum
Address Support From Master: • BMS • C-More Controller (Slave) • Broadcast Messages	 128 to 247 (From a Master EMS) 1 to 127 (From Master BMS or EMS) Address 0 is Reserved for Broadcast Messages
Transmission Mode Support	RTU (Remote Terminal Unit)
Timing Specifications: • Baud Rate Message Framing • Character Framing • Heartbeat Timeout	 Fixed at 9600 For C-More Adjustable For BMS: 2400, 4800, 9600, 14.4k, 19.2k Default = 9600 Silent period of at least 3.5 character times Before first character and After last character of message No more than 1.5 character times of silence between received and transmitted characters Fixed at 10 seconds For C-More Adjustable For BMS: 5 to 240 Seconds

1.3.1 Communication Medium

The communication medium for each of the possible Modbus network configurations may vary depending on the Master/Slave scenario being implemented. Detailed installation procedures and wiring diagrams for the configurations described in the following paragraphs are provided in Section 4 of this manual.

1.3.1.1 EMS Master To BMS Slave

The Modbus network connections between the EMS and BMS will depend on the type of port provide on the EMS Master. If the EMS contains a RS232 port, a direct connection can be made directly to the BMS RS232 port. For optimum results the wire length between the EMS and BMS RS232 connection should not exceed 50 feet. If the EMS Master contains a RS485 port, a RS485-to-RS232 converter will be required to implement the Modbus network.

1.3.1.2 BMS Master To C-More Boiler Controller Slaves

Up to a total of 32 C-More Boiler Controllers can be connected to a BMS Master on the Modbus Network. Multi-point drop network connections are made using shielded, twisted-pair wire. In addition to the Modbus Network Boilers, up to 8 additional Legacy Boilers can be connected using the BMS Pulse Width Modulation (PWM) wiring connection provided on connector J2.

1.3.1.3 EMS Master To C-More Boiler Controller Slaves

The number of C-More Boiler Controllers which can be connected to a Modbus Network which utilizes a third party EMS Master will depend on the EMS's limitations. Theoretically, the maximum number of Slave devices is limited to 127. If the EMS contains a RS232 port, a RS232-to-RS485 converter will be required to provide the necessary RS485 interfaces and signal levels for the C-More Boiler Controllers. Multi-drop network connections are made using shielded, twisted-pair wire.

1.3.2 Address Support

Address support is assigned as follows:

- BMS Address Support From EMS Master: 128 – 247 (80 – F7 hex)
- C-More Address Support From BMS or EMS Master: 1 – 127 (01 – 7F hex)
- Broadcast Messages: Address 0 is reserved for all Broadcast messages

1.3.3 Modbus Transmission Modes

Many Modbus Controllers can be set up to transmit using either the ASCII (American Standard Code for Information Interchange) transmission mode, or the RTU (Remote Terminal Unit) transmission mode. However, since RTU messages can be formatted using far fewer binary bits than the corresponding ASCII message, it is far more efficient. Therefore, all Modbus messages for the AERCO BMS and C-More Boiler Controllers use RTU transmission ONLY. If a third-party EMS Master is being used in the Modbus network, ensure that it is set for RTU transmission.

1.3.4 Timing Specifications

As Table 1-1 shows, Baud Rate and Heartbeat Timeout will vary depending on the Configurations of the AERCO BMS and C-More Boiler Controllers being used in the Modbus Network. Ensure that the Baud Rate used by the controlling Master (BMS or EMS) matches the appropriate Baud Rate supported by the Network Slaves (BMS or C-More Controllers). Also, ensure that the Modbus Master can refresh the control information to all C-More Slaves before the Heartbeat Timeout period expires.

1.4 MODBUS FUNCTION SET SUPPORT

The complete Modbus protocol includes a total of 24 Function Codes. However, for AERCO BMS and C-More Boiler Controllers, only the Codes listed in Table 1-2 are supported. The supported Diagnostic Sub-Function Codes associated with Diagnostic Function Code 08 are listed in Table 1-3.

Table 1-2. Required Function Code Set

Function Code	Function Name
03	Read Holding Register (Read Multiple Registers)
04	Read Input Registers
06	Preset (Write) Single Register
08	Diagnostics (See Table 1-3 for supported Sub-Function Codes)
17	Report Slave ID

Table 1-3. Minimum Diagnostic (Function Code 08) Sub-Function Set

Sub-Function Code	Sub-Function Name	Comments
00	Return Query Data	Loop-Back
01	Restart Communications Options	Resets the Slave. Cancels Listen Only Mode.
02	Return Diagnostic Register	Not Used
04	Force Listen Only Mode	Reset by Restart Communications Option
10	Clear Counters and Diagnostic Register	Also cleared at power up. Clears only the counters
12	Return Bus Communication Error Count	Slave CRC errors only.
13	Return Bus Exception Error Count	Slave Exception Response count.
14	Return Slave Message Count	Number of messages addressed to the slave and successfully processed. Includes broadcast messages.
15	Return Slave No Response Count	Number of messages addressed to the slave for which no response was returned.
18	Return Bus Character Overrun Count	Number of overrun and framing errors.

1.5 EXCEPTION RESPONSES

With the exception of Broadcast Messages, queries transmitted by the Master expect a normal response from the addressed Slave on the network. However, if the addressed Slave cannot process or interpret the message, it will respond with one of the Exception Codes listed in Table 1-4.

Table 1-4. Minimum Exception Code Set

Exception Code	Description	Comments
01	Illegal Function	The function code received is not valid or is not supported.
02	Illegal Data Address	The data address received is invalid or is not accessible due to security setting.
03	Illegal Data Value	The data value received is not valid

1.6 PHRASES, ABBREVIATIONS & ACRONYMS

The phrases, abbreviations and acronyms used in this manual are listed in Table 1-5.

Table 1-5. Phrases, Abbreviations and Acronyms

Phrase, Abbreviation or Acronym	Meaning
ASCII	American Standard Code for Information Interchange
BAS	Building Automation System
Baud	Bits per Second (bps)
BMS	Boiler Management System
C-More Controller (or Control Box)	A control system developed by AERCO International and currently used in all Benchmark and KC Series product lines
EMS	Energy Management System
FDX	Full-Duplex
HDX	Half-Duplex
Hex	Hexadecimal Number (0 - 9, A - F)
I/O Box	Input/Output (I/O) Box currently used on all Benchmark and KC Series products
LSB	Least Significant Byte
Modbus®	A serial, half-duplex data transmission protocol developed by AEG Modicon
MSB	Most Significant Byte
RS232	A standard for serial, full-duplex (FDX) transmission of data based on the RS232 Standard
RS422	A standard for serial, full-duplex (FDX) transmission of data based on the RS422 Standard
RS485	A standard for serial, half-duplex (HDX) transmission of data based on the RS485 Standard
RTU	Remote Terminal Unit

SECTION 2 STANDARD REGISTER ASSIGNMENTS

2.1 INTRODUCTION

This Section provides the standard data register addresses assigned to the AERCO and C-More Boiler Controllers and the AERCO Boiler Management System (BMS). These data registers consist of Input Registers and Holding Registers. All register addresses provided throughout this manual are expressed as hexadecimal numbers.

2.1.1 Input Registers

The Input Registers for the AERCO C-More Boiler Controllers and AERCO BMS are intended for information and functions that cannot or should not be controlled remotely. Therefore, unless otherwise specified, ALL Input Register data are READ ONLY.

2.1.2 Holding Registers

The Holding Registers for the AERCO C-More Boiler Controllers and AERCO BMS are intended for information and functions that can be read or written (R/W). Therefore unless otherwise specified, all Holding Register data are R/W.

CAUTION

DO NOT write in any Register Addresses marked as “Reserved” in the Input Register and Holding Register Tables which follw. Failure to observe this precaution may result in unstable operation.

2.2 C-MORE BOILER CONTROLLER STANDARD REGISTER ASSIGNMENTS

2.2.1 C-More Boiler Controller Standard Input Register Assignments

The Read Only Input Register addresses are listed in Table 2-1 which follows:

Table 2-1. C-More Boiler Controller Standard Input Register Address Mapping

Modbus Data Address (Hex)	Menu Item	Units and Range	Default/Comments
0x0000	Default Message Display Code	Enum (1 to 47)	See Appendix A, Table A-1 for listing
0x0001	Unit Status	Enum (0, 1, 2, 3, 4, 5) 0 = Unit Status Disabled 1 = Unit Status Standby 2 = Unit Status Manual 3 = Unit Status Remote 4 = Unit Status Auto 5 = Unit Status Fault	
0x0002	Outlet Temp	DEGREES_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions
0x0003	Inlet Temp	DEGREES_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions
0x0004	Aux Temp	DEGREES_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions
0x0005	Outdoor Temp	DEGREES_2 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions
0x0006	Exhaust Temp	DEGREES_2 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions
0x0007	FFWD Temp	DEGREES_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions
0x0008	Fire Rate Out	% (0 to 100)	
0x0009	O2 Level	% (0 to 25)	
0x000A	CO Level	PPM (0 to 500)	
0x000B	Run Cycles Low (LSB)	int (0 to 65535)	The actual range for run cycles is from 0 to 999,999
0x000C	Run Cycles High (MSB)	Int (0 to 15)	

Table 2-1. C-More Boiler Controller Standard Input Register Address Mapping - Cont

Modbus Data Address (Hex)	Menu Item	Units and Range	Default/Comments
0x000D	Run Hours Low (LSB)	int (0 to 65535)	The actual range for run hours is from 0 to 999,999
0x000E	Run Hours High (MSB)	int (0 to 15)	
0x000F	Flame Strength	% (0 to 100)	
0x0010	Active Set point	DEGREES_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions
0x0011	Fire Rate In	% (0 to 100)	
0x0012	Manual Fire Rate	% (0 to 100)	Only applicable when in the Manual Mode and controlled by the front panel interface
0x0013	Comm Address	Int (0 to 127)	Default = 0 Comm Address 0 disables the Controller's Modbus communications
0x0014	Software Version	int (0 to 65535)	
0x0015 0x0016	(Reserved)		
0x0017	Fault Log Code		Fault Log
0x0018	Fault Log Cycle (LOW)	int (0 to 65535)	The internal variable type for fault log display cycle is long and the range is 0 to 999999
0x0019	Fault Log Cycle (HIGH)	Int (0 to 15)	
0x001A	Fault Log Date	Int (1 to 65535) 1 count/day	
0x001B	Fault Log Time	Int (0 to 1439) 1 count/min.	

Table 2-1. C-More Boiler Controller Standard Input Register Address Mapping - Cont

Modbus Data Address (Hex)	Menu Item	Units and Range	Default/Comments
0x001C	Sensor Log Active Setpoint	DEGREES_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions
0x001D	Sensor Log Outlet Temp	DEGREES_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions
0x001E	Sensor Log Inlet Temp	DEGREES_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions
0x001F	Sensor Log FFWD Temp	DEGREES_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions
0x0020	Sensor Log Exhaust Temp	DEGREES_3 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions
0x0021	Sensor Log Outdoor Temp	DEGREES_2 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions
0x0022	Sensor Log Aux Temp	DEGREES_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions
0x0023	Sensor Log CO xmitter	PPM_UNITS	
0x0024	Sensor Log O2 xmitter	% (0 to 100)	
0x0025	Sensor Log Flow Meter	GPM_UNITS	
0x0026	Time Log Status	73 (“I”) = Ignition 74 (“O”) = Off 80 (“P”) = Power Up 82 (“R”) = Run	
0x0027	Time Log Fire Rate	% (0 to 100)	
0x0028	Time Log Flame Strength	% (0 to 100)	
0x0029	Time Log Run Length	Int (0 to 65535)	
0x002A	Time Log Date	Int (0 to 65535) 1 count/day	
0x002B	Time Log Time	Int (0 to 1439) 1 count/min.	

2.2.2 C-More Boiler Controller Standard Holding Register Assignments

The Read/Write Input Register address assignments are listed in Table 2-2 which follows. Unless otherwise specified, all Holding Register menu items are Read/Write (R/W)

Table 2-2. C-More Controller Standard Holding Register Address Mapping

Modbus Data Address (Hex)	Menu Item	Units and Range	Comments
0x0000	Net Remote Set Point	DEGREES_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions. R/W ONLY in Remote Set Point Mode
0x0001	Net Direct Drive	% (0 to 100)	Normally Read Only. R/W ONLY in Direct Drive Mode.
0x0002	Modbus Password	int (0 to 65535)	Default = 0
0x0003	Password	int (0 to 65535)	Default = 0
0x0004	Internal Set Point	DEGREES_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions Default = 130°F
0x0005	(Reserved)		
0x0006	Time	Int (0 to 1439) 1count/min	
0x0007	Date	int (0 to 65535) 1count/day	Date count starts with Jan. 1, 2000. For Example: Jan. 1 2001 would equal 365 counts
0x0008	Unit of Temp	bool (0, 1) 0= Degrees Fahrenheit (°F) 1=Degrees Celsius (°C)	Default = °F
0x0009	Baud Rate	enum (0, 1, 2, 3, 4) 0 = 2.4k 1 = 4.8k 2 = 9.6k 3 = 19.2k	For C-More RS232 port ONLY Default = 2 (9.6k)
0x000A	Unit Type	bool (0, 1) 0 = Boiler 1 = Water Heater	Default = Boiler
0x000B	Unit Size	enum (0, 1, 2, 3, 4, 5) 0 = 0.5 MBTU 1 = 1 MBTU 2 = 1.5 MBTU 3 = 2 MBTU 4 = 2.5 MBTU 5 = 3 MBTU	Default = 1 (1 MBTU)

Table 2-2. C-More Controller Standard Holding Register Address Mapping-Cont.

Modbus Data Address (Hex)	Menu Item	Units and Range	Comments
0x000C	Boiler Mode	enum (0, 1, 2, 3, 4): 0 = Constant Setpt 1 = Remote Setpt 2 = Direct Drive 3 = Combo Unit 4 = Outdoor Reset	Default = 0 (Constant Setpt)
0x000D	Remote Signal	enum (0, 1, 2, 3): 0 = 4 - 20 mA /1 - 5V 1 = 0 -20mA/0 - 5V 2 = PWM Input 3 = Network	Default = 0 (4 - 20 mA/1 - 5V)
0x000E	Bldg Ref Temp	DEGREES_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions
0x000F	Reset Ratio	Int (1 to 99 counts) Actual Range = 0.1 to 9.9 (Counts = Actual x 10)	Actual Default = 1.2 Therefore: 1.2 x 10 = 12 counts
0x0010	Outdoor Sensor Enable	bool (0,1) 0 = False 1 = True	Default = 0 (False)
0x0011	System Start Temp	DEGREES_2 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions Default = 60°F
0x0012	Set Point Lo Limit	DEGREES_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions Default = 60°F
0x0013	Set Point Hi Limit	DEGREES_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions Default = 200°F
0x0014	Temp Hi Limit	DEGREES_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions Default = 210°F
0x0015	Max Fire Rate	% (40 - 100)	Default = 100%
0x0016	Pump Delay Timer	MIN_UNITS (0 to 30) 1count/min	Default = 0 min.
0x0017	Aux Start On Delay	SEC_UNITS (0 to 120) 1count/sec	Default = 0 sec.

Table 2-2. C-More Controller Standard Holding Register Address Mapping-Cont.

Modbus Data Address (Hex)	Menu Item	Units and Range	Comments
0x0018	Failsafe Mode	enum (0, 1) 0=Shutdown 1=Constant Setpoint	Default = 0 (Shutdown)
0x0019	Low Fire Timer	SEC_UNITS (2 to 60) 1count/sec	Default = 2 sec.
0x001A	Prop Band	ABS_DEG_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions
0x001B	Integral Gain	0.00 to 2.00 (0.01 increments)	Actual x 100 Counts Defaults: Boiler: 0.10 (10 counts), Heater:1.60 (160 counts)
0x001C	Derivative Time	MIN_UNITS (0.00 to 2.00) (0.01 min. increments) 1count/0.01min	Actual x 100 Counts Defaults: Boiler: 0.00 min. (0 counts) Heater: 0.10 min (10 counts)
0x001D	Min Load Adjust	ABS_DEG_1 (0 to 1000)	Water Heater ONLY See Appendix A, Tables A-2 and A-3 for Conversions
0x001E	Max Load Adjust	ABS_DEG_1 (0 to 1000)	Water Heater ONLY See Appendix A, Tables A-2 and A-3 for Conversions
0x001F	Outlet Feedback	bool (0, 1) 0 = Off 1 = On	Default = 1 (On) Water Heater ONLY
0x0020 Thru 0x003B	(Reserved)		
0x003C	Set Point Limiting	bool (0, 1) 0 = Disabled 1 = Enabled	Default = 0 (Disabled)
0x003D	Set Point Limit Band	ABS_DEG_1 (0 to 1000)	See Appendix A, Tables A-2 and A-3 for Conversions
0x003E Thru 0x0042	(Reserved)		

Table 2-2. C-More Controller Standard Holding Register Address Mapping-Cont.

Modbus Data Address (Hex)	Menu Item	Units and Range	Comments
0x0043	Sensor Log Interval	Enum (0 to 8) 0 = Off 1 = 1 Min. 2 = 5 Min. 3 = 15 Min. 4 = 30 Min. 5 = 1 Hr. 6 = 6 Hrs 7 = 12 Hrs. 8 = 24 Hrs.	Default = 4 (30 min)
0x0044	Fault Log Pointer	int 0 - 9	
0x0045	Sensor Log Pointer	int 0 - 1199	
0x0046	Time Log Pointer	int 0 - 10239	
0x0047 Thru 0xFFFF	(Reserved)		Available for future expansion.

2.3 BMS CONTROLLER STANDARD REGISTER ASSIGNMENTS

2.3.1 BMS Controller Standard Input Register Assignments

The Read Only Input Register address assignments for the BMS are listed in Table 2-3 which follows on the next page.

Table 2-3. BMS Standard Input Register Address Mapping

Modbus Data Address (Hex)	Menu Item	Units and Range	Default/Comments
0x0000	(Reserved)		
0x0001	Header Temperature	40 to 220°F	
0x0002	Outside Air Temperature	-60 to 120°F	
0x0003	Indoor Air Temperature	40 to 160°F	
0x0004	Fire Rate Out	0 to 100% (out to boilers)	
0x0005	Header Set Temperature	40 to 220°F	
0x0006	Network Address	0, 128 to 247	Default = 0 (If Address = 0, BMS is Off-Line as a Slave)
0x0007	Total Boilers Fired	0 to 40	
0x0008	Total Boilers On Line	0 to 40	
0x0009	(Reserved)		
0x000A	Fault/Message Code	0 to 65535 Bit: 0 = Outside Air Sensor 1 = Header Sensor Error 2 = Interlock 1 Error 3 = Interlock 2 Error 4 = Indoor Air Sensor Error 5 = 4-20mA Input Error	
0x000B thru 0x000F	(Reserved)		
0x0010	Lead Boiler Number	1 to 40	

Table 2-3. BMS Standard Input Register Address Mapping-Cont.

Modbus Data Address (Hex)	Menu Item	Units and Range	Comments
0x0011	Boiler 1 Status	119 = Not On-Line 120 = On-Line But Not Fired 1–40 = Fired & Sequence	Boilers 1 - 8 are referred to as the Legacy Boilers.
0x0012	Boiler 2 Status	(Same As Above)	(Same As Above)
0x0013	Boiler 3 Status	(Same As Above)	(Same As Above)
0x0014	Boiler 4 Status	(Same As Above)	(Same As Above)
0x0015	Boiler 5 Status	(Same As Above)	(Same As Above)
0x0016	Boiler 6 Status	(Same As Above)	(Same As Above)
0x0017	Boiler 7 Status	(Same As Above)	(Same As Above)
0x0018	Boiler 8 Status	(Same As Above)	(Same As Above)
0x0019	Boiler 9 Status (Net Boiler 1)	119 = Not On-Line 120 = On-Line But Not Fired 1–40 = Fired & Sequence 121 = On-Line But Disabled 122 = On-Line But Faulted	Boilers 9 - 32 are the Network Boilers
0x001A	Boiler 10 Status (Net Boiler 2)	Same As Above	
0x001B	Boiler 11 Status (Net Boiler 3)	Same As Above	
0x001C	Boiler 12 Status (Net Boiler 4)	Same As Above	
0x001D	Boiler 13 Status (Net Boiler 5)	Same As Above	
0x001E	Boiler 14 Status (Net Boiler 6)	Same As Above	
0x001F	Boiler 15 Status (Net Boiler 7)	Same As Above	
0x0020	Boiler 16 Status (Net Boiler 8)	Same As Above	
0x0021	Boiler 17 Status (Net Boiler 9)	Same As Above	
0x0022	Boiler 18 Status (Net Boiler 10)	Same As Above	
0x0023	Boiler 19 Status (Net Boiler 11)	Same As Above	

Table 2-3. BMS Standard Input Register Address Mapping-Cont.

Modbus Data Address (Hex)	Menu Item	Units and Range	Comments
0x0024	Boiler 20 Status (Net Boiler 12)	119 = Not On-Line 120 = On-Line But Not Fired 1–40 = Fired & Sequence 121 = On-Line But Disabled 122 = On-Line But Faulted	
0x0025	Boiler 21 Status (Net Boiler 13)	Same As Above	
0x0026	Boiler 22 Status (Net Boiler 14)	Same As Above	
0x0027	Boiler 23 Status (Net Boiler 15)	Same As Above	
0x0028	Boiler 24 Status (Net Boiler 16)	Same As Above	
0x0029	Boiler 25 Status (Net Boiler 17)	Same As Above	
0x002A	Boiler 26 Status (Net Boiler 18)	Same As Above	
0x002B	Boiler 27 Status (Net Boiler 19)	Same As Above	
0x002C	Boiler 28 Status (Net Boiler 20)	Same As Above	
0x002D	Boiler 29 Status (Net Boiler 21)	Same As Above	
0x002E	Boiler 30 Status (Net Boiler 22)	Same As Above	
0x002F	Boiler 31 Status (Net Boiler 23)	Same As Above	
0x0030	Boiler 32 Status (Net Boiler 24)	Same As Above	
0x0031	Boiler 33 Status (Net Boiler 25)	Same As Above	
0x0032	Boiler 34 Status (Net Boiler 26)	Same As Above	
0x0033	Boiler 35 Status (Net Boiler 27)	Same As Above	
0x0034	Boiler 36 Status (Net Boiler 28)	Same As Above	

Table 2-3. BMS Standard Input Register Address Mapping-Cont.

Modbus Data Address (Hex)	Menu Item	Units and Range	Comments
0x0035	Boiler 37 Status (Net Boiler 29)	119 = Not On-Line 120 = On-Line But Not Fired 1–40 = Fired & Sequence 121 = On-Line But Disabled 122 = On-Line But Faulted	
0x0036	Boiler 38 Status (Net Boiler 30)	Same As Above	
0x0037	Boiler 39 Status (Net Boiler 31)	Same As Above	
0x0038	Boiler 40 Status (Net Boiler 32)	Same As Above	
0x0039 thru 0xFFFF	(Reserved For Future Expansion)		

2.3.2 BMS Controller Standard Holding Register Assignments

The Holding Register address assignments for the BMS are listed in Table 2-3 which follows. Unless otherwise specified, all Holding Register Menu items are Read/Write (R/W).

Table 2-4. BMS Standard Holding Register Address Mapping

Modbus Data Address (Hex)	Menu Item	Units and Range	Default/Comments
0x0000	(Reserved)		
0x0001	(Reserved)		
0x0002	(Reserved)		
0x0003	(Reserved)		
0x0004	Net Header Set Temp	40 to 220°F	Valid when Remote Signal = Network
0x0005	System Start Temp	32 to 120°F	Default = 70°F
0x0006	System Start Mode	0 or 1 0 = Temp Only, 1 = Temp and Load	Default = 0
0x0007	Manual Hdr Set Temp	40 to 220°F	Default = 160°F
0x0008	Reference Temp	40 to 220°F	Default = 70°F
0x0009	Indoor Prop Band	0.0 to 20.0°F/°F (0.5°F/°F increments)	Default = 00.0°F/°F (Value x 10)
0x000A	Indoor Setpoint Temp	50 to 150°F	Default = 70°F
0x000B	Reset Ratio	0.3 to 3.0 (0.1 increments),	Default = 1.2 (Value x 10)
0x000C	Max Header Temp	40 to 220°F	Default = 220°F
0x000D	Min Header Temp	40 to 220°F	Default = 40°F
0x000E	Start Percent	25 to 100%	Default = 45%
0x000F	Stop Percent	10 to 45%	Default = 18%
0x0010	Integral Gain	0.00 to 9.99 Rep/Min (in 0.01 increments	Default = 0.15 Rep/Min (Value x 100)
0x0011	Header Set Mode	0, 1, or 2 0 = Constant Setpt 1 = In/Outdoor Reset 2 = Remote Setpt	Default = 1 (In/Outdoor Reset)

Table 2-4. BMS Standard Holding Register Address Mapping

Modbus Data Address (Hex)	Menu Item	Units and Range	Default/Comments
0x0012	Derivative Gain	-2.00 to 2.00 (0.00 increments)	Default = 0.1 (Value x 100)
0x0013	Header Temp Bandwidth	5 to 100°F	Default = 70°F
0x0014	Aux Relay Open	0 to 99%	Default = 45%
0x0015	Aux Relay Mode	0 or 1 0 = 100% Fire Rate 1 = 100% Fire Rate and Off	Default = 1 (100% Fire Rate & Off)
0x0016	Temp Sensor Fail Mode	0 or 1 0 = Shutdown 1 = Switch Inputs	Default = 0 (Shutdown)
0x0017	Fault Alarm Relay Mode	0, 1, 2, 3 0 = All Faults, 1 = No Interlock 2 = Interlock 1 3 = Interlock 2	Default = 0 (All Faults)
0x0018	Fault Alarm Clear Method	0 or 1 0 = Automatic 1 = Manual	Default = 0 (Automatic)
0x0019	Boiler Operation Mode	0, 1 or 2 0 = Parallel 1 = Sequential 2 = Combination	Default = 1 (Sequential)
0x001A	Number Of Combination Mode Boilers	0 to 4	Default = 0 (Start at Boiler 8 and work back to Boiler 5 to assign Combo Boilers)
0x001B	(Reserved)		
0x001C	(Reserved)		
0x001D	(Reserved)		
0x001E	Max Power Input	50 to 100%	Default = 100% (Fire Rate)
0x001F	Interlock 1 Method	0 or 1 0 = Always Enabled 1 = Start Enabled	Default = 1 (Start Enabled)

Table 2-4. BMS Standard Holding Register Address Mapping-Cont.

Modbus Data Address (Hex)	Menu Item	Units and Range	Default/Comments
0x0020	Real Time Clock Minutes	00 to 59 Minutes	Present Time
0x0021	Real Time Clock Hours	00 to 23 Hours	Present Time
0x0022	Real Time Clock Day of Week	1 to 7	Present Day
0x0023	Real Time Clock Year	00 to 99	Present Year
0x0024	Real Time Clock Day of Month	01 to 31	Present Day of Month
0x0025	Real Time Clock Month	01 to 12	Present Month
0x0026	Offset Temp Day 1	-50 to 50°F	Default = 0°F
0x0027	Offset Temp Day 2	-50 to 50°F	Default = 0°F
0x0028	Offset Temp Day 3	-50 to 50°F	Default = 0°F
0x0029	Offset Temp Day 4	-50 to 50°F	Default = 0°F
0x002A	Offset Temp Day 5	-50 to 50°F	Default = 0°F
0x002B	Offset Temp Day 6	-50 to 50°F	Default = 0°F
0x002C	Offset Temp Day 7	-50 to 50°F	Default = 0°F
0x002D	Offset On Time Day 1 – Minutes	00 to 59 Minutes	Default = Zero
0x002E	Offset On Time Day 2 – Minutes	00 to 59 Minutes	Default = Zero
0x002F	Offset On Time Day 3 – Minutes	00 to 59 Minutes	Default = Zero
0x0030	Offset On Time Day 4 – Minutes	00 to 59 Minutes	Default = Zero
0x0031	Offset On Time Day 5 – Minutes	00 to 59 Minutes	Default = Zero
0x0032	Offset On Time Day 6 – Minutes	00 to 59 Minutes	Default = Zero
0x0033	Offset On Time Day 7 – Minutes	00 to 59 Minutes	Default = Zero

Table 2-4. BMS Standard Holding Register Address Mapping-Cont.

Modbus Data Address (Hex)	Menu Item	Units and Range	Default/Comments
0x0034	Offset On Time Day 1 – Hours	00 to 23 Hours	Default = Zero
0x0035	Offset On Time Day 2 – Hours	00 to 23 Hours	Default = Zero
0x0036	Offset On Time Day 3 – Hours	00 to 23 Hours	Default = Zero
0x0037	Offset On Time Day 4 – Hours	00 to 23 Hours	Default = Zero
0x0038	Offset On Time Day 5 – Hours	00 to 23 Hours	Default = Zero
0x0039	Offset On Time Day 6 – Hours	00 to 23 Hours	Default = Zero
0x003A	Offset On Time Day 7 – Hours	00 to 23 Hours	Default = Zero
0x003B	Offset Enable	0 or 1 0 = Disabled 1 = Enabled	Default = 0 (Disabled)
0x003C	Header Offset	0 to 5°F	Default = 0°F
0x003D	System Start Relay Contact Operation With Interlocks	0, 1, 2 or 3 0 = No Action 1 = Either Intlk Opens Start Relay 2 = Intlk1 Opens Start Relay 3 = Intlk 2 Open Start Relay	Default = 0 (No Action)
0x003E Thru 0x0045	(Reserved)		
0x0046	Offset Off Time Day 1 – Minutes	0 to 59 Minutes	Default = Zero
0x0047	Offset Off Time Day 2 – Minutes	0 to 59 Minutes	Default = Zero
0x0048	Offset Off Time Day 3– Minutes	0 to 59 Minutes	Default = Zero
0x0049	Offset Off Time Day 4– Minutes	0 to 59 Minutes	Default = Zero
0x004A	Offset Off Time Day 5 – Minutes	0 to 59 Minutes	Default = Zero
0x004B	Offset Off Time Day 6 – Minutes	0 to 59 Minutes	Default = Zero

Table 2-4. BMS Standard Holding Register Address Mapping-Cont.

Modbus Data Address (Hex)	Menu Item	Units and Range	Default/Comments
0x004C	Offset Off Time Day 7 – Minutes	0 to 59 Minutes	Default = Zero
0x004D	Offset Off Time Day 1 – Hours	0 to 23 Hours	Default = Zero
0x004E	Offset Off Time Day 2 – Hours	0 to 23 Hours	Default = Zero
0x004F	Offset Off Time Day 3 – Hours	0 to 23 Hours	Default = Zero
0x0050	Offset Off Time Day 4 – Hours	0 to 23 Hours	Default = Zero
0x0051	Offset Off Time Day 5 – Hours	0 to 23 Hours	Default = Zero
0x0052	Offset Off Time Day 6 – Hours	0 to 23 Hours	Default = Zero
0x0053	Offset Off Time Day 7 – Hours	0 to 23 Hours	Default = Zero
0x0054	(Reserved)		
0x0055	Indoor Air Input	0 or 1 0 = 4 - 20 mA 1 = Thermistor	Default = 1 (Thermistor)
0x0056	Remote Signal	0 or 1 0 = 4 - 20 mA 1 = Network	Default = 0 (4 - 20 mA)
0x0057	RS232 Mode	0 or 1 0 = Normal 1 = Modbus	Default = 0 (Normal)
0x0058	RS232 Baud Rate	2400, 4800, 9600, 14.4k, 19.2k	Default = 9600
0x0059	Number Of Network Boilers	0 to 32	Default = 0
0x005A	Min Slave Address	0 to 127	Default = 0
**0x005B	Max Slave Address	0 to 127,	Default = 0
**0x005C	Net Boiler 1 Address	Address for Network Boiler 1 (same as Boiler #9)	
**0x005D	Net Boiler 2 Address	Address for Network Boiler 2 (same as Boiler #10)	

Table 2-4. BMS Standard Holding Register Address Mapping-Cont.

Modbus Data Address (Hex)	Menu Item	Units and Range	Default/Comments
**0x005E	Net Boiler 3 Address	Address for Network Boiler 3 (same as Boiler #11)	
**0x005F	Net Boiler 4 Address	Address for Network Boiler 4 (same as Boiler #12)	
**0x0060	Net Boiler 5 Address	Address for Network Boiler 5 (same as Boiler #13)	
**0x0061	Net Boiler 6 Address	Address for Network Boiler 6 (same as Boiler #14)	
**0x0062	Net Boiler 7 Address	Address for Network Boiler 7 (same as Boiler #15)	
**0x0063	Net Boiler 8 Address	Address for Network Boiler 8 (same as Boiler #16)	
**0x0064	Net Boiler 9 Address	Address for Network Boiler 9 (same as Boiler #17)	
**0x0065	Net Boiler 10 Address	Address for Network Boiler 10 (same as Boiler #18)	
**0x0066	Net Boiler 11address	Address for Network Boiler 11 (same as Boiler #19)	
**0x0067	Net Boiler 12 Address	Address for Network Boiler 12 (same as Boiler #20)	
**0x0068	Net Boiler 13 Address	Address for Network Boiler 13 (same as Boiler #21)	
**0x0069	Net Boiler 14 Address	Address for Network Boiler 14 (same as Boiler #22)	
**0x006A	Net Boiler 15 Address	Address for Network Boiler 15 (same as Boiler #23)	
**0x006B	Net Boiler 16 Address	Address for Network Boiler 16 (same as Boiler #24)	
**0x006C	Net Boiler 17 Address	Address for Network Boiler 17 (same as Boiler #25)	
**0x006D	Net Boiler 18 Address	Address for Network Boiler 18 (same as Boiler #26)	
**0x006E	Net Boiler 19 Address	Address for Network Boiler 19 (same as Boiler #27)	
**0x006F	Net Boiler 20 Address	Address for Network Boiler 20 (same as Boiler #28)	
**0x0070	Net Boiler 21 Address	Address for Network Boiler 21 (same as Boiler #29)	

Table 2-4. BMS Standard Holding Register Address Mapping-Cont.

Modbus Data Address (Hex)	Menu Item	Units and Range	Default/Comments
**0x0071	Net Boiler 22 Address	Address for Network Boiler 22 (same as Boiler #30)	
**0x0072	Net Boiler 23 Address	Address for Network Boiler 23 (same as Boiler #31)	
**0x0073	Net Boiler 24 Address	Address for Network Boiler 24 (same as Boiler #32)	
**0x0074	Net Boiler 25 Address	Address for Network Boiler 25 (same as Boiler #33)	
**0x0075	Net Boiler 26 Address	Address for Network Boiler 26 (same as Boiler #34)	
**0x0076	Net Boiler 27 Address	Address for Network Boiler 27 (same as Boiler #35)	
**0x0077	Net Boiler 28 Address	Address for Network Boiler 28 (same as Boiler #36)	
**0x0078	Net Boiler 29 Address	Address for Network Boiler 29 (same as Boiler #37)	
**0x0079	Net Boiler 30 Address	Address for Network Boiler 30 (same as Boiler #38)	
**0x007A	Net Boiler 31 Address	Address for Network Boiler 31 (same as Boiler #39)	
**0x007B	Net Boiler 32 Address	Address for Network Boiler 32 (same as Boiler #40)	
**0x007C	Network Baud	2400, 4800, 9600, 14.4k, 19.2k	Default = 9600
0x007D	Network Timeout	5 to 240 sec	Default = 60 sec.
0x007E	Password Lo	0 to 255 (73)	Default = 0
0x007F	Password Hi	0 to 255 (79)	Default = 0
0x0080	Modbus Control Type	0 = Round-Robin 1 = Broadcast	Default = 0 (Round Robin)
0x0081	Modbus Pass-Thru	0 = Disabled 1 = Enabled	Default = 0 (Disabled)
0x0082 Thru 0xFFFF	(Reserved For Future Expansion)	Undefined	

SECTION 3 STANDARD APPLICATION OPERATIONS

3.1 INTRODUCTION

This Section describes the standard application operations for AERCO C-More Boiler Controllers and the AERCO Boiler Management System (BMS) and how they are achieved utilizing Modbus. Paragraphs 3.2 through 3.2.7 provide information for the C-More Boiler Controllers which can only function as Slaves in a Modbus Network. Paragraphs 3.3 through 3.3.4 provide similar information for the BMS which can function as either a Master or Slave in a Modbus Network.

NOTE

Additional information on Modbus hardware and software set up and installation are provided in Section 4 and Section 5 of this manual.

3.2 C-MORE CONTROLLER STANDARD APPLICATION OPERATIONS

The information in the following paragraphs apply to C-More Boiler Controllers with the following exceptions:

- C-More Boiler Controllers utilize a Fixed 10 second “Heartbeat” timer.
- C-More Boiler Controllers, require temperature readings to be converted from “counts” to °F or °C.

3.2.1 Password Protection for Input and Holding Register Access

Access to the C-More Input Register and Holding Register addresses are protected via security level passwords. Two separate Holding Register addresses (0x0002, 0x0003) are assigned for password entries, one for the Modbus (RS485) Network and one for the RS232 front panel user interface. If desired, separate security passwords can be entered for each interface.

Each C-More Controller menu parameter is assigned a preset security level that controls access from the front panel user interface. If the current communication password of the front-end software does not match the C-More Slave addresses security level, access is denied. When this occurs, an Illegal Data Address Exception Code (02) is generated and the data is not changed. If a Modbus message is received to read multiple Input or Holding Registers (Function Codes 03 or 04) and one or more of the register addresses is not accessible, an Illegal Data Address Exception Code will also be generated and no data is supplied to the Master. It should be noted that Modbus “Write Multiple Registers” command (Function Code 16) is not supported by AERCO C-More Controller Slaves and will cause an Illegal Function Exception Code to be generated.

The Holding Register data can be viewed without a password. However, the data cannot be changed without entering the appropriate password. The communications port security operation will mirror the security operation for viewing and adjusting parameters via the front panel keypad. Refer to C-More Operation Manual GF-112 for additional information on security passwords and menu access.

3.2.2 Simultaneous RS232 & RS485 Access to C-More Controller Variables

As previously mentioned, read and write access of the C-More Controller variables are protected from unauthorized access by an internal security level hierarchy. Passwords may be entered in the Slave's Holding Registers using any of the following methods:

- Locally via the front panel keypad and display
- Remotely via the front panel RS232 port
- Remotely via the Modbus (RS485) interface

It is imperative that the user understands that the LAST change made to any menu variable (including passwords) will supersede any previous change, regardless of which of the above methods is used. There is no priority structure assigned to any of the above methods and since they are not interlocked, they may be performed concurrently.

3.2.3 Direct Drive Control

In the Direct Drive Mode, the holding register parameter "Net Direct Drive" (address 0x0001) must be written or broadcast periodically from the BMS (or EMS Master) to all Slave Controllers on the network. The Modbus message will specify the Fire Rate (0 to 100%) for the addressed Slave(s). If the Net Direct Drive message is broadcast, all enabled network Slaves will be set to the same fire rate percentage. However, if different fire rates are required for specific Slaves, each Slave must be addressed individually. Each time a network Slave successfully receives the Net Direct Drive message, it will reset its Heartbeat Timer which has a fixed 10 second timeout. If this timeout period is exceeded, the C-More Controller Slave will default to "Fail-Safe Mode" (Shutdown or Constant Setpoint) stored in holding register address 0x0018. When this occurs, "Modbus Comm Fault" will be displayed.

During operation in the Direct Drive Mode, only the Net Direct Drive variable in the Slave's Holding Register can be remotely adjusted. If desired, manual control via the C-More Controller front panel can be invoked by pressing the AUTO/MAN switch on the front panel.

3.2.4 Remote Setpoint Control

In the Remote Setpoint Mode, the holding register parameter "Net Remote Setpoint" (address 0x0000) must be written or broadcast periodically from the BMS (or EMS Master) to all Slave Controllers on the network. The Modbus message will specify the Setpoint Temperature for the addressed Slave(s). If the Net Remote Setpoint message is broadcast, all enabled network Slaves will be set to the same setpoint temperature. However, if different setpoint temperatures are required for specific Slaves, each Slave must be addressed individually. Each time a network Slave successfully receives the Net Remote Setpoint message, it will reset its "Heartbeat". For C-More Controllers, the "Heartbeat" timeout is fixed at 10 seconds. If this timeout period is exceeded, the C-More Controller Slave will default to "Fail-Safe Mode" and display a "Modbus Comm Fault".

During operation in the Remote Setpoint Mode, only the "Net Remote Setpt" variable in the Slave's Holding Register can be remotely adjusted. If desired, manual control via the C-More Controller front panel can be invoked by pressing the AUTO/MAN switch on the front panel.

3.2.5 Combination Control

At the present time, the Combination Control Mode is not implemented via the Modbus network.

3.2.6 Broadcast Commands

Address 0 is reserved for Broadcast Messages sent by the Modbus Master. At the current time, only two holding register variables can be written by broadcast to the C-More Controller Slaves. These variables are Net Remote Setpoint and Net Direct Drive (addresses 0x0000, 0x0001). No password is required to write either of these variables. Broadcast write commands to all other holding registers will be ignored. Therefore, write commands to all other holding registers must be individually transmitted to a valid Network Slave address. Valid Slave device addresses must be within the range of 1 to 127.

3.2.7 Physical Slave Address Zero

Normally, each Modbus Network Slave Controller will be assigned its own unique Comm. Address (Input Register Address 0x0013). Valid entries are from 1 to 127. However, if the default address of 0 is assigned, the C-More Slave, will not respond or process any Modbus Network messages. This effectively disables the Slave's Modbus communication link.

3.3 BMS STANDARD APPLICATION OPERATIONS

For an AERCO BMS Controller, the first eight Boilers are reserved for Legacy Boilers. These Legacy Boilers are wired to the J2 connector terminals and are controlled utilizing Pulse Width Modulation (PWM) signals, just as with earlier BMS Models, prior to implementation of Modbus. Therefore, Boiler No. 9 will be the first Modbus Network Boiler, Boiler No. 10 will be the second and so on. Up to 32 Network Boilers can be connected on a Modbus Network, in addition to the 8 Legacy Boilers. The BMS will operate the Network Boilers and the Legacy Boilers as one complete System.

3.3.1 Password Protection for BMS Input and Holding Register Access

Access to BMS register addresses are protected by a password in virtually the same manner as the C-More Controllers. For the BMS, a communications security code holding register "Password Lo" and "Password Hi" (addresses 0x007E, 0x007F) must be written with the proper password for writing data in the BMS through the RS232 communications port. If an attempt is made to write data to a single holding register using an incorrect password, write access is denied. If this occurs, an Illegal Data Address Exception Code (02) is generated and the data is not changed. Reading data is allowed, even if the password is incorrect. If a Modbus message is received to read multiple Input or Holding Registers and one or more of the addresses is not accessible, an Illegal Data Address Exception Code will be sent to the EMS Master and no data is affected.

Only the network control variable "Net Header Set Temp" (address 0x0004) can be written without a password and only if the BMS is programmed for Remote Setpoint Control by an EMS Master.

3.3.2 Remote Setpoint Control of BMS Slave By EMS Master

All Modbus communication between a BMS Slave and an EMS Master is accomplished via the RS232 port on the BMS. If the EMS Master also contains a RS232 port, it can be directly connected to the BMS. However, if the EMS Master contains a RS485 port, a RS232-to-RS485 Converter is required.

To enable the Remote Setpoint Mode, the parameters “Remote Signal” and “RS232 Mode” must be set to “Network” and “Modbus” respectively. These parameter are stored in Standard Holding Register addresses 0x0056 and 0x0057 respectively. Also, ensure that the RS232 Baud Rate setting (address 0x0058) matches the EMS Baud Rate being used.

In the Remote Setpoint Mode, the holding register parameter “Net Header Set Temp” (Holding Register address 0x0004) must be broadcast periodically from the EMS Master to the BMS Slave. A “Heartbeat” Timer with a timeout period defined by the variable “Network Timeout” (Holding Register address 0x007D), is reset each time the signal is successfully received. If the timeout period is exceeded, the BMS will default to its “Fail-Safe” mode and display a Network Comm Fault.

3.3.3 BMS Master Control of C-More Slaves Via Network

In addition to the 8 “Legacy” Boilers, the BMS can also communicate with the up to 32 Network C-MORE Boiler Control Slaves via the BMS RS485 port. Parallel and Sequential control can be selected as before. See BMS Manual GF-108 for additional information.

The “Number Of Network Boilers” must be entered at location 0x0059 in the Standard Holding Registers. The C-More Slave communication addresses (“Net Boiler 1 Address” To “Net Boiler 32 Address”) can either be manually entered in a pre-defined order in the BMS, or they can be detected from the network and operated in the order they are detected by the BMS. To manually enter Network Boiler communication addresses, leave the “Min Slave Address” and “Max Slave Address” set to their default values of 0. To allow the BMS to automatically detect the Network Boilers, enter the respective “Min Slave Address” and “Max Slave Address” in their proper location in the Standard Holding Registers (0x005A, 0X005B). The Max Slave Address must be no more than 31 above the Min Slave Address.

The fire rate information will be transmitted periodically from the BMS to the CMORE boiler controls. A “heartbeat” timer will be reset in the slave each time the control information is successfully received from the BMS. If a timeout occurs, the slave will default to its “Fail-Safe Mode” and display “Modbus Comm Fault”.

3.3.4 BMS Combination Mode Boiler Control of C-More Slaves

At the current time, only Legacy Boilers 5 through 8 can be selected as Combination Boilers. These Boilers are connected to the BLR 5 - BLR 8 PWM terminal connections (J2). None of the Network -Controlled Boilers (1 - 32) should be assigned as a Combination Boiler. An AERCO Combination Control Panel (CCP) is necessary to configure this type of setup. However, It should be noted that the assigned PWM Combination Boilers can still be monitored and configured on the Modbus Network by assigning a Comm Address between 1 and 127. Refer to BMS Manual GF-108 for additional information on installation and setup.

SECTION 4 MODBUS NETWORK HARDWARE SETUP & INSTALLATION

4.1 INTRODUCTION

This Section provides basic information on planning and setup of a Modbus Communication Network utilizing AERCO C-More Boiler Controllers and a Boiler Management System (BMS). It also provides basic information on Modbus Network setup utilizing AERCO BMS/C-More Slaves with a Master EMS (or BAS) provided by other manufacturers.

4.2 PHYSICAL MODBUS RS485 NETWORK WIRING CONNECTIONS

Modbus RS485 devices should be wired in a "Daisy-Chain" configuration similar to the example shown Figure 4-1. DO NOT wire the units in a "Star" configuration where all devices are connected to a central point (node).

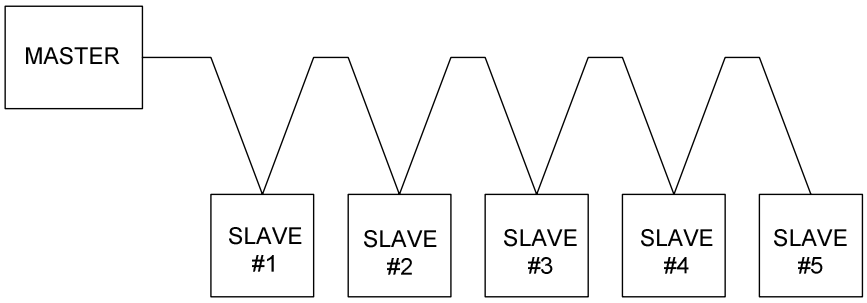


Figure 4-1. Typical Daisy-Chain Modbus/RS485 Network

The physical wiring connections for a Modbus Network utilizing an AERCO BMS and C-More Boiler Controllers should be made using shielded twisted-pair wire, from 18 to 24 AWG. Examples of suitable wire are: Belden # 9841, #8761, #3105A, or equivalent.

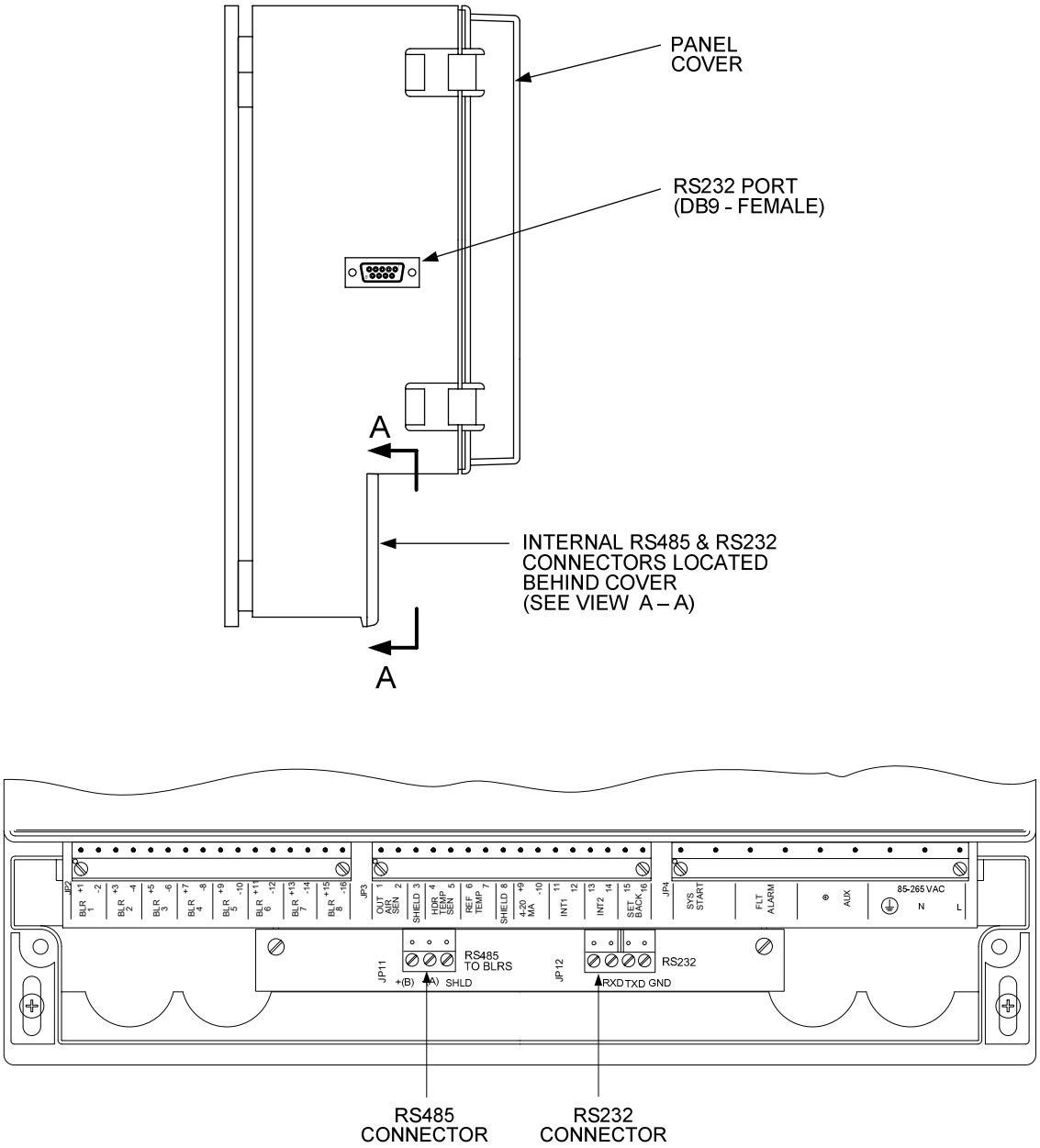
The actual locations of the wiring connectors necessary for Modbus Network implementation utilizing the AERCO BMS and C-More Boiler Controllers follow. Where necessary, connector pinout information is also provided.

4.2.1 BMS Slave To EMS Master Wiring Connections

Wiring connections between an EMS Master and an AERCO BMS Slave can be made at either the RS232 (DB9) port on the left side of the BMS, or at the internal RS232 connector located on the terminal board behind the connection cover on the BMS. These connections are shown in Figure 4-2. The internal RS232 connections are used when interfacing with an EMS Master via a conduit connection at the bottom edge of the BMS enclosure. If the internal RS232 connections are used, it is recommended that nothing be connected to the external RS232 (DB9) port.

If the EMS Master being used contains only an RS485 port (2-wire or 4-wire), an RS485-to-RS232 Converter is required. A BMS option is available with a built-in RS485-to-RS232 Converter to permit a conduit connection between the EMS and BMS. If the external RS232 port on the left side of the BMS is used, a separate external converter is required.

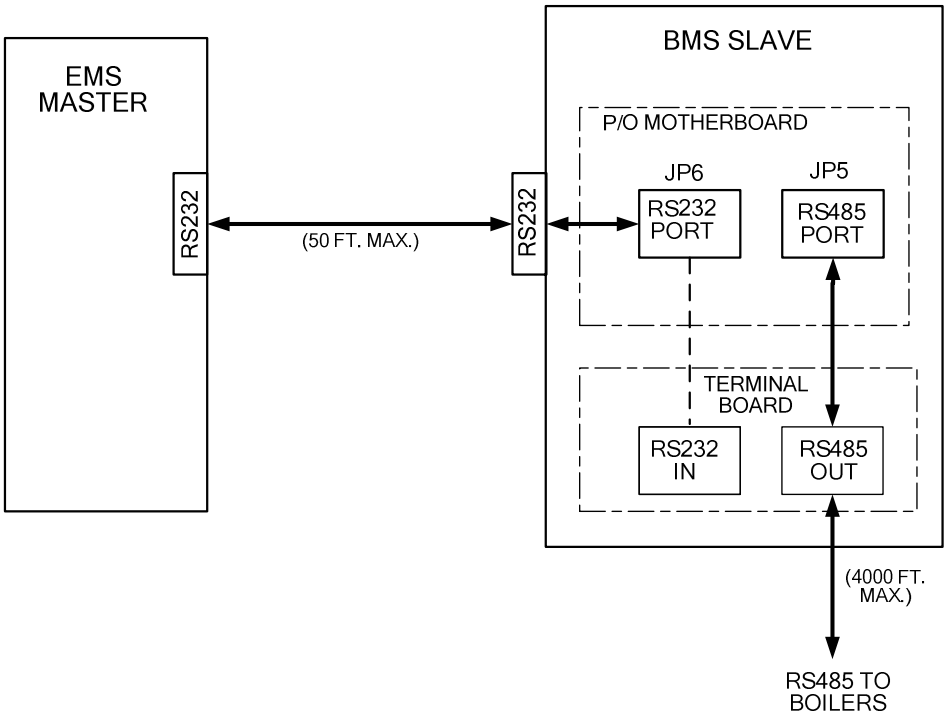
Simplified block diagrams showing the internal and external connection options between the BMS and EMS are shown in Figure 4-3. Connector pinouts for the external RS232 (DB9-Female) and internal RS232 connector are shown in Figure 4-4. In addition, Figure 4-4 shows the pin assignments for the internal RS485 connector mounted on the BMS terminal board. This connector is used to interface the boilers to the Modbus network.



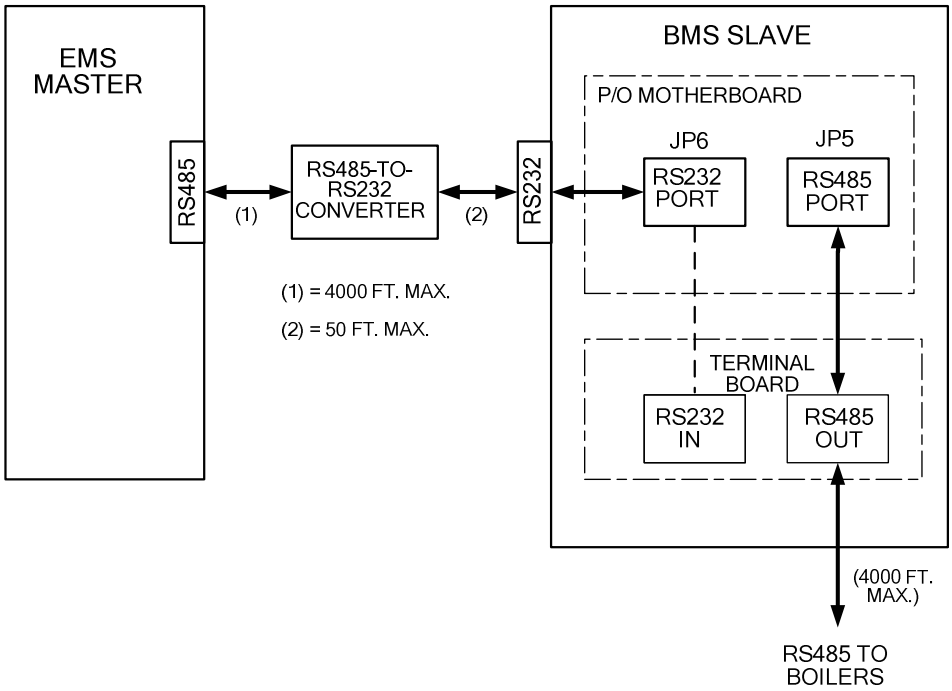
VIEW A – A

(PARTIAL FRONT VIEW WITH COVER REMOVED)

Figure 4-2. BMS Left Side View

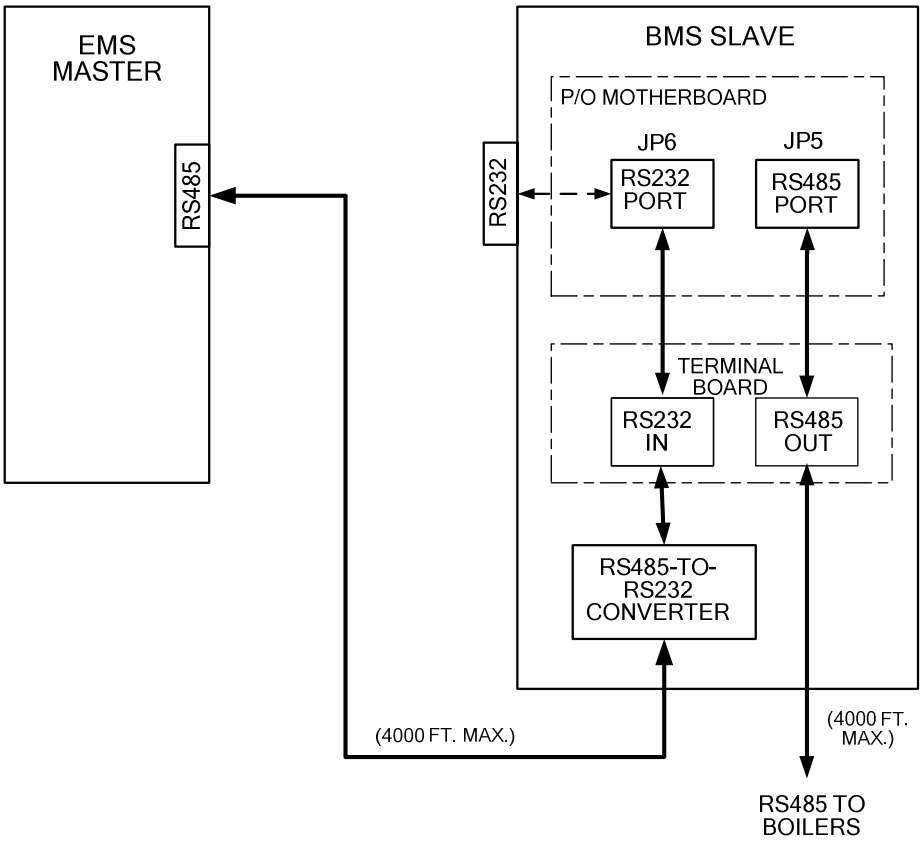


EMS RS232 PORT TO BMS RS232 PORT



EMS RS485 PORT TO BMS RS232 PORT USING EXTERNAL CONVERTER

Figure 4-3. EMS Master-To-BMS Slave Connection Diagrams (Sheet 1 of 2)



EMS RS485 PORT TO BMS RS232 PORT USING INTERNAL CONVERTER

Figure 4-3. EMS Master-To-BMS Slave Connection Diagrams (Sheet 2 of 2)

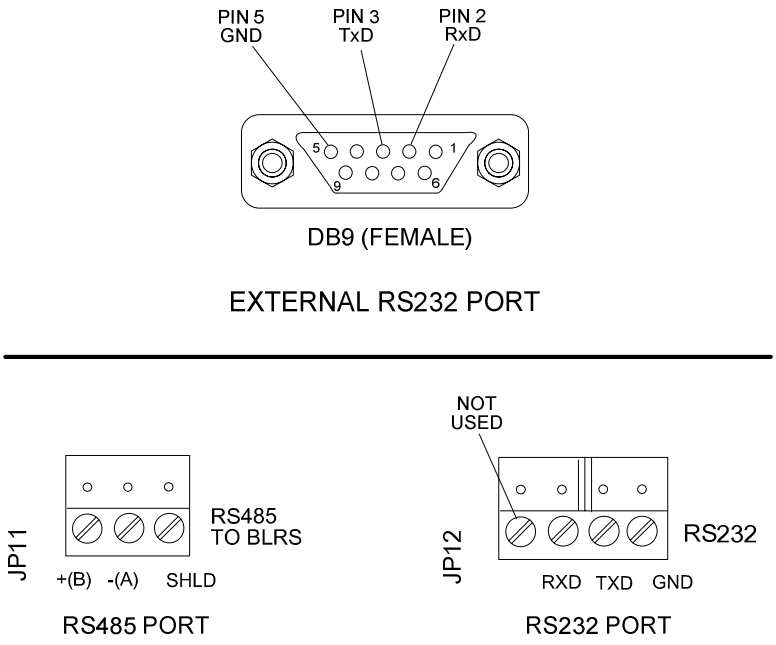


Figure 4-4. BMS RS232 & RS485 Connectors

4.2.2 BMS Master To C-More Boiler Controller Slaves

Wiring connections for Modbus operation between a BMS Master and C-More Boiler Controller Slaves are made between the BMS internal RS485 connector (Figure 4-1) and the I/O Box for the associated C-More Boiler Controller. The BMS internal RS485 connector pinouts are shown in Figure 4-4. The RS485 COMM connections at each Boiler's I/O Box are shown in Figure 4-5. Identical I/O Boxes are used for both Benchmark and KC1000 Boilers.

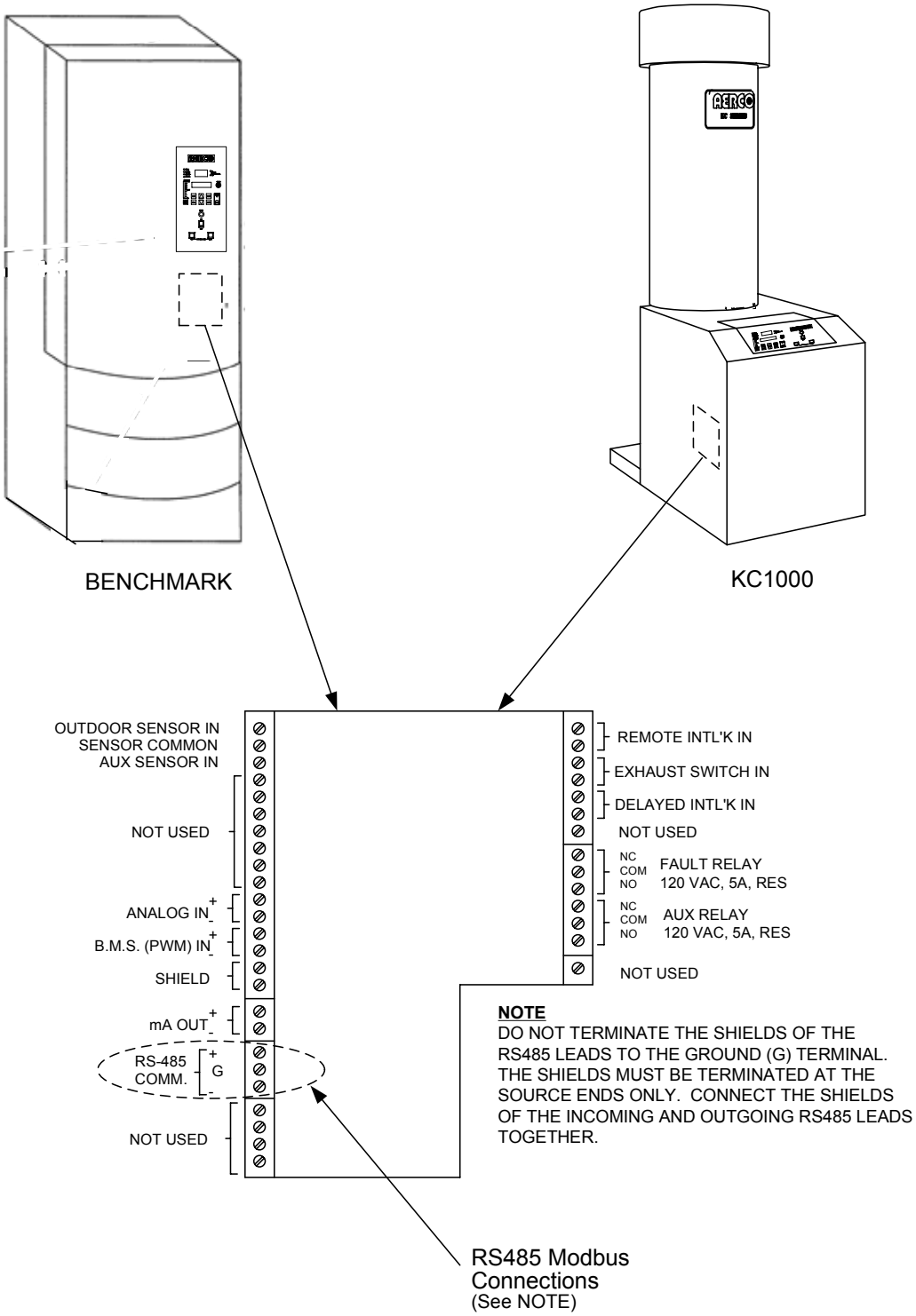


Figure 4-5. I/O Box RS485 COMM Terminal Connections

4.2.3 C-More Slaves To BMS or EMS Master

Wiring connections between a BMS Master and up to 32 Network C-More Boiler Controller Slaves are made directly between the BMS internal RS485 terminals (Figure 4-4) and the RS485 COMM terminals in each Boiler's I/O Box (Figure 4-5).

If a third-party EMS Master is used in place of the BMS, the Modbus Network connections will depend on the available communication port(s) on the EMS. Many EMS Models contain only a RS232 (DB9) port, while others contain either a 2-Wire or 4-Wire RS485 port. Some EMS models contain both a RS232 and a RS485 port. If the EMS is equipped with only a RS232 port, a RS232-to-RS485 converter will be required (such as a B&B Electronics, Model 485SD9TD).

4.3 RS485 LOOP TERMINATING RESISTORS AND BIAS

A terminating resistor (120 ohms) on each end of the RS485 loop is designed to match the electrical impedance characteristic of the twisted-pair loop and prevent echoes or cross-talk from corrupting data on the line. Short or medium length Modbus/RS485 loops (less than 1000 feet) can usually operate satisfactorily without the terminating resistor. However, longer loop runs (over 1000), may require terminating resistors.

Bias may be necessary on the RS485 loop to minimize noise on the circuit. Loop bias is accomplished by activating pull-up/pull-down resistors on the last C-More Boiler Controller in the chain.

AERCO recommends that both terminating resistors and bias be implemented on the RS485 circuit as described in paragraphs 4.3.1 and 4.3.2 which follow.

4.3.1 BMS Terminating Resistor

Each BMS is equipped with a built-in terminating resistor (120 ohms) on the RS485 port. Therefore, only one additional terminating resistor will be required at the other end of the RS485 loop. Ensure that the last C-More Boiler Controller Slave on the loop has its terminating resistor activated as described in paragraph 4.3.2.

4.3.2 C-More Boiler Controller Terminating Resistor and Bias

C-More Boiler Controllers can function only as Slave devices on a Modbus Network. Since the Slaves are connected in a "Daisy-Chain" configuration, the terminating resistor must be enabled only in the last C-More Boiler Controller in the chain. In addition, bias must also be implemented only in the last C-More Boiler Controller. This is accomplished by setting a DIP switches on the Primary Micro-Controller (PMC) Board contained in the applicable C-More Boiler Controller. The last unit in the chain must be energized (even if disabled) to enable bias.

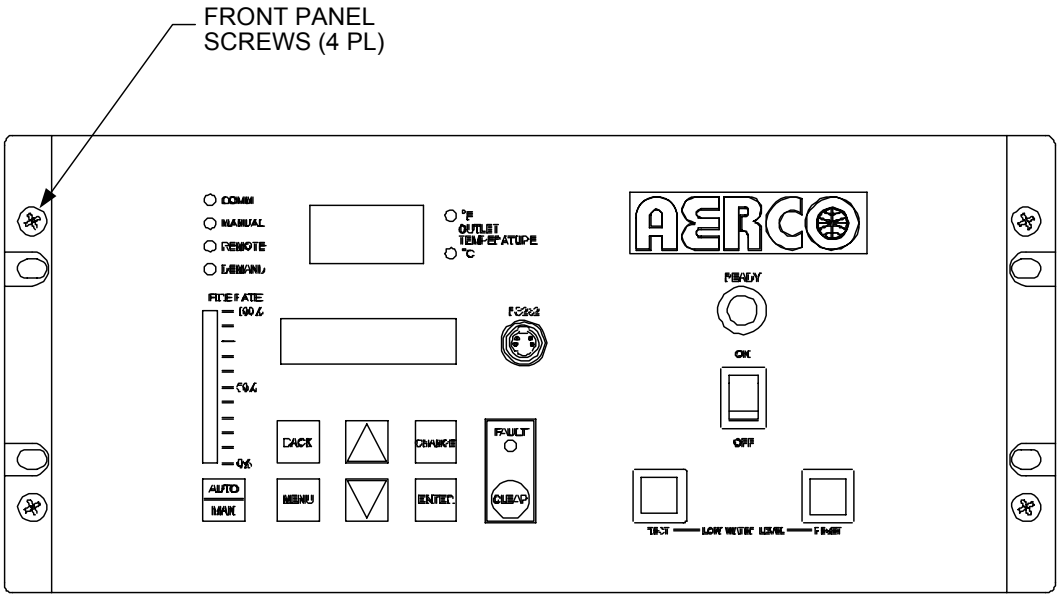
To activate the DIP switches, proceed as follows:

1. Remove power from the last C-More Boiler Controller in the RS485 loop.
2. Loosen and remove the four (4) screws securing the front panel assembly to the chassis as shown in Figure 4-6.
3. Carefully separate the panel from the chassis. Use care to avoid applying undue stress to the ribbon cable connected between the back of the panel and the chassis-mounted printed circuit boards.

CAUTION

The C-More Boiler Controller Printed Circuit Boards contain electronic components that are sensitive to electrostatic discharge (ESD). Prior to performing the following steps, put on an anti-static wrist strap and connect the clip lead to earth ground. Failure to observe this precaution may result in permanent damage to on-board ESD-sensitive components.

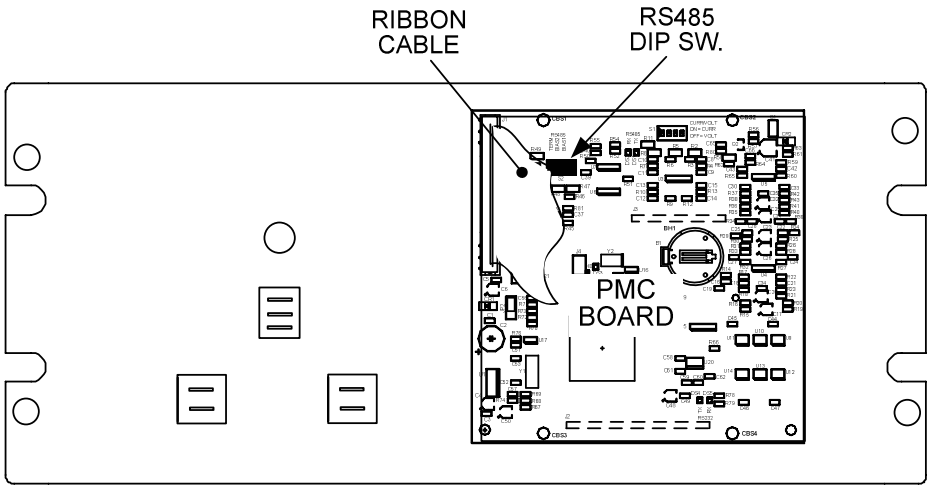
4. Put on an anti-static wrist strap and attach the clip lead to earth ground.
5. From the back of the Panel Assembly (Figure 4-7), locate the RS485 DIP switches on the PMC Board.
6. Refer to Figure 4-8 and set the “TERM” switch to the ON (Up) position.
7. Set the BIAS2 and BIAS1 switches to the ON (Up) position.
8. After the DIP switches have been set, reposition the Front Panel Assembly on the chassis and secure it in place with the four screws.



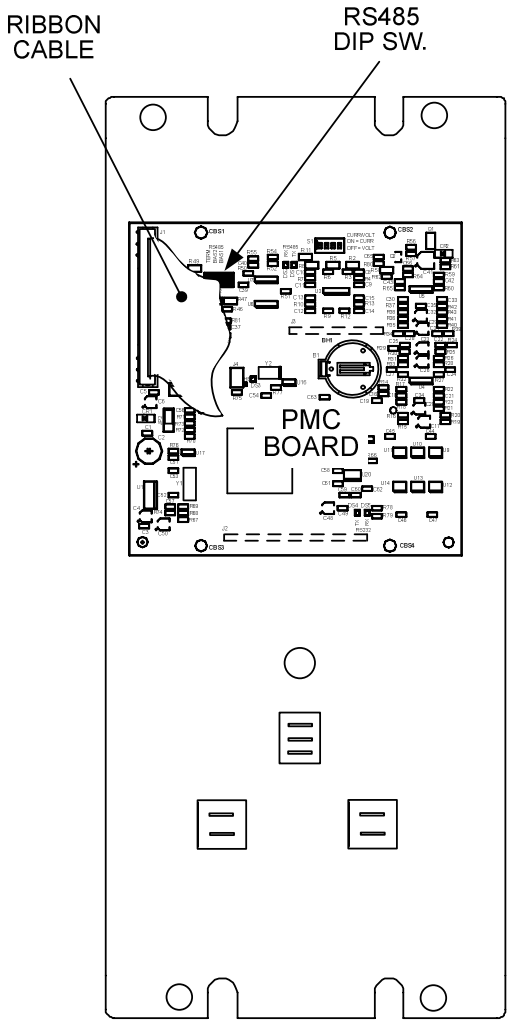
NOTE:

THE C-MORE CONTROLLER MODEL SHOWN WITH A HORIZONTAL PANEL CONTROL LAYOUT IS USED ON KC1000 BOILERS.
BENCHMARK BOILERS UTILIZE C-MORE CONTROLLERS WITH A VERTICAL PANEL CONTROL LAYOUT.

Figure 4-6. C-More Control Panel - Front View

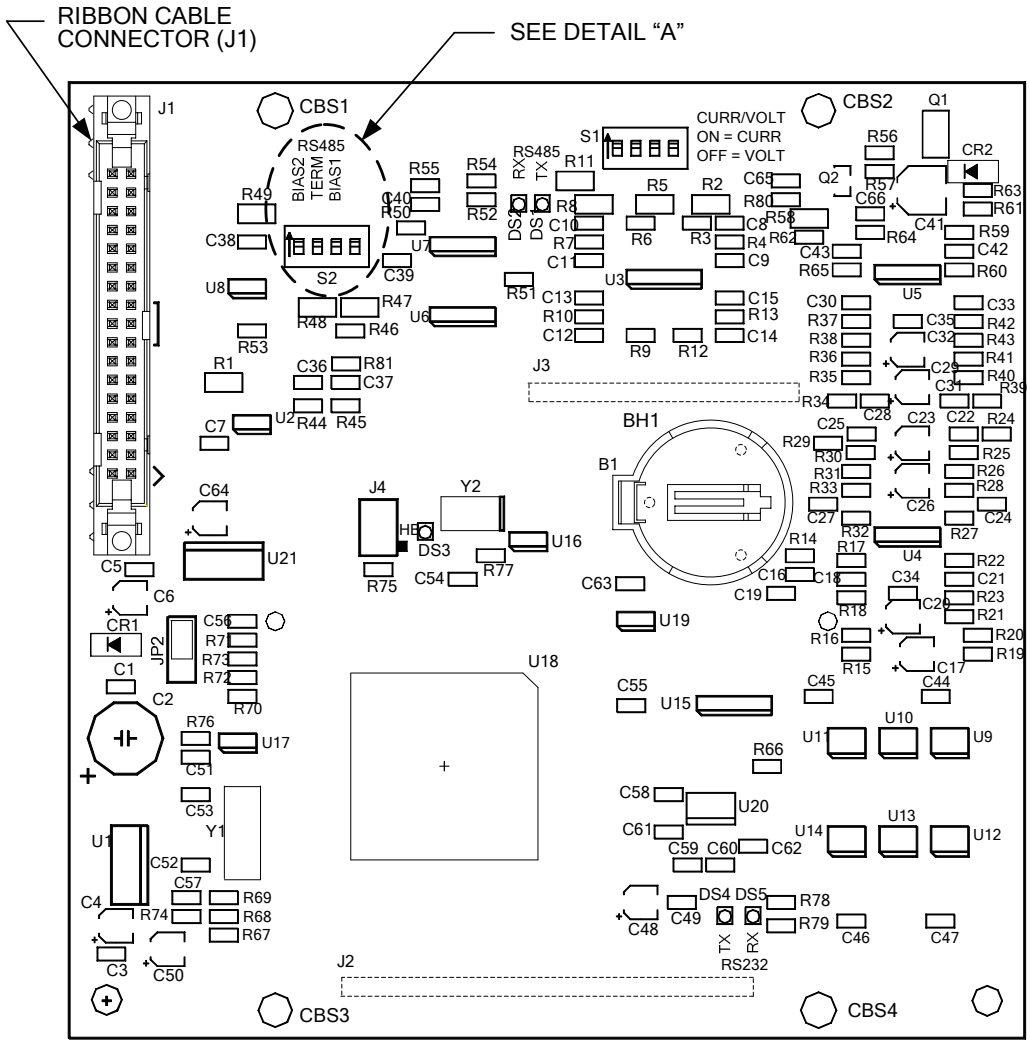


CONTROL PANEL REAR VIEW – KC1000

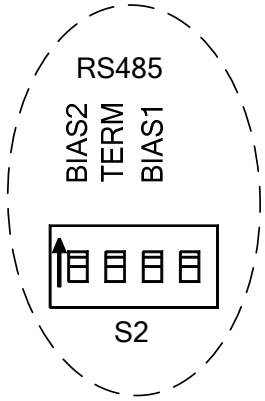


CONTROL PANEL REAR VIEW – BENCHMARK

Figure 4-7. C-More Control Panel - Rear Views



PMC BOARD



SET THE BIAS2, TERM & BIAS1 DIP SWITCHES TO THE ON (UP) POSITION TO ACTIVATE EACH FUNCTION

DETAIL "A"

Figure 4-8. C-More Control Panel PMC Board

4.4 MODBUS NETWORK WIRING DIAGRAMS

Sample Modbus Network wiring diagrams for the basic circuit configurations are provided in paragraphs 4.4.1 through 4.4.3. It should be noted that these diagrams are only intended as a guide and do not include all possible scenarios. If a third-party EMS is being utilized, refer to the manufacturer's manual prior to attempting any network wiring connections.

CAUTION

It is imperative that polarity be maintained between all Modbus Network connections. The Network will not operate if the proper polarity is not maintained. Also, twisted-pair wiring shield should only be terminated at the controlling Master Controller for the Modbus Network. Shields must not be le

4.4.1 Wiring Diagrams for Master EMS Controlling BMS Slave With Legacy (PWM) Boilers

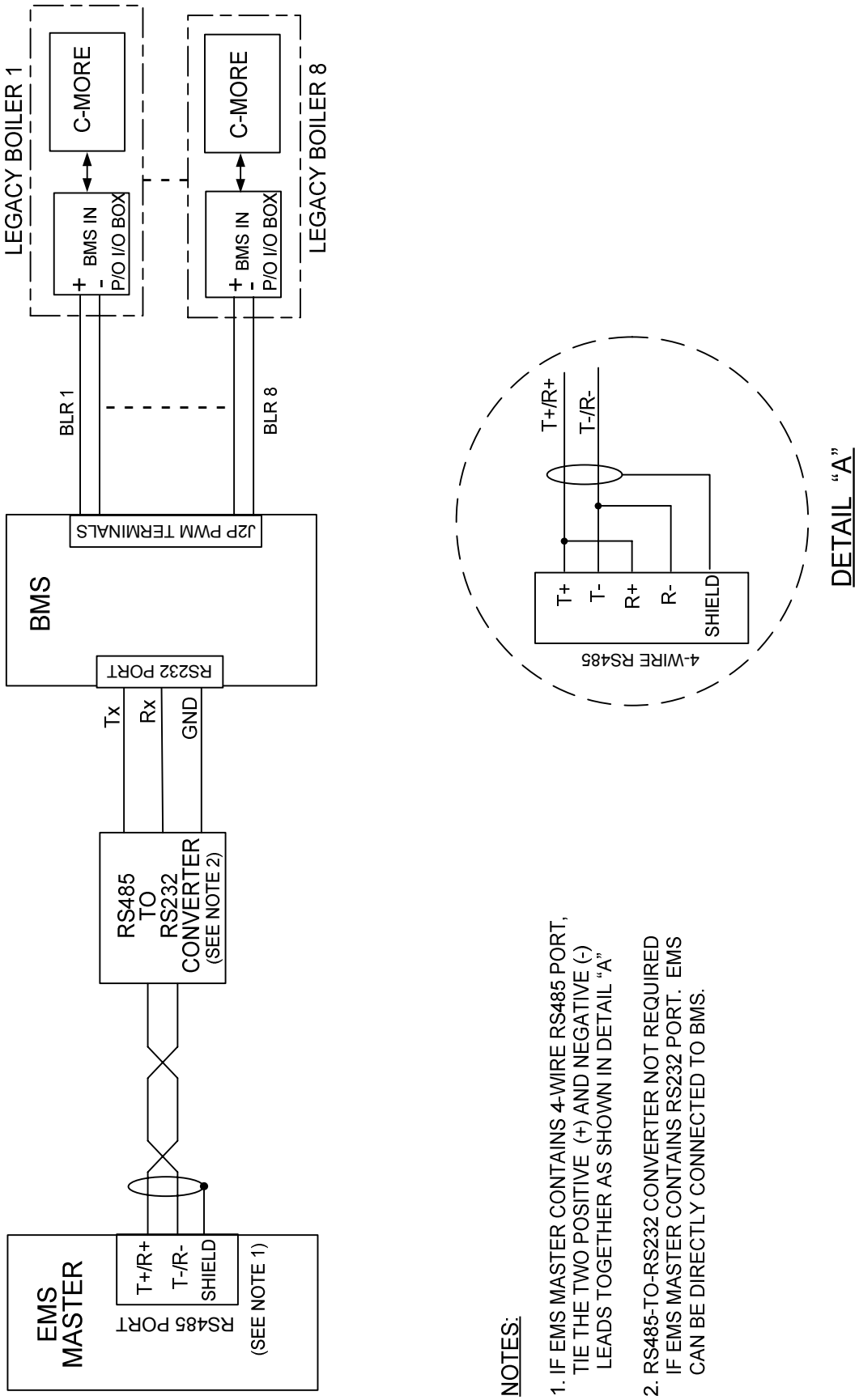
Figure 4-9 provides a sample wiring diagram for a BMS Unit being controlled by an EMS Master equipped with a RS485 port.

4.4.2 Wiring Diagram for Master BMS Controlling Networked C-More Slaves

Wiring connections for the "Network" Boilers are made at the BMS RS485 port as shown in Figure 4-10. In addition, up to 8 "Legacy" Boilers can be wired to the PWM J2P terminal strip to allow control of up to 40 Boilers by one BMS. The BMS PWM terminal connections can also be used to connect AERCO Boilers which utilize older types of control systems, such as Modular Control Boxes, or C-More Controllers equipped with software version 1.61 or lower. Refer to BMS Manual GF-108 for additional setup details for the PWM "Legacy" Boilers.

4.4.3 Wiring Diagram For EMS Master Controlling C-More Controller Slaves

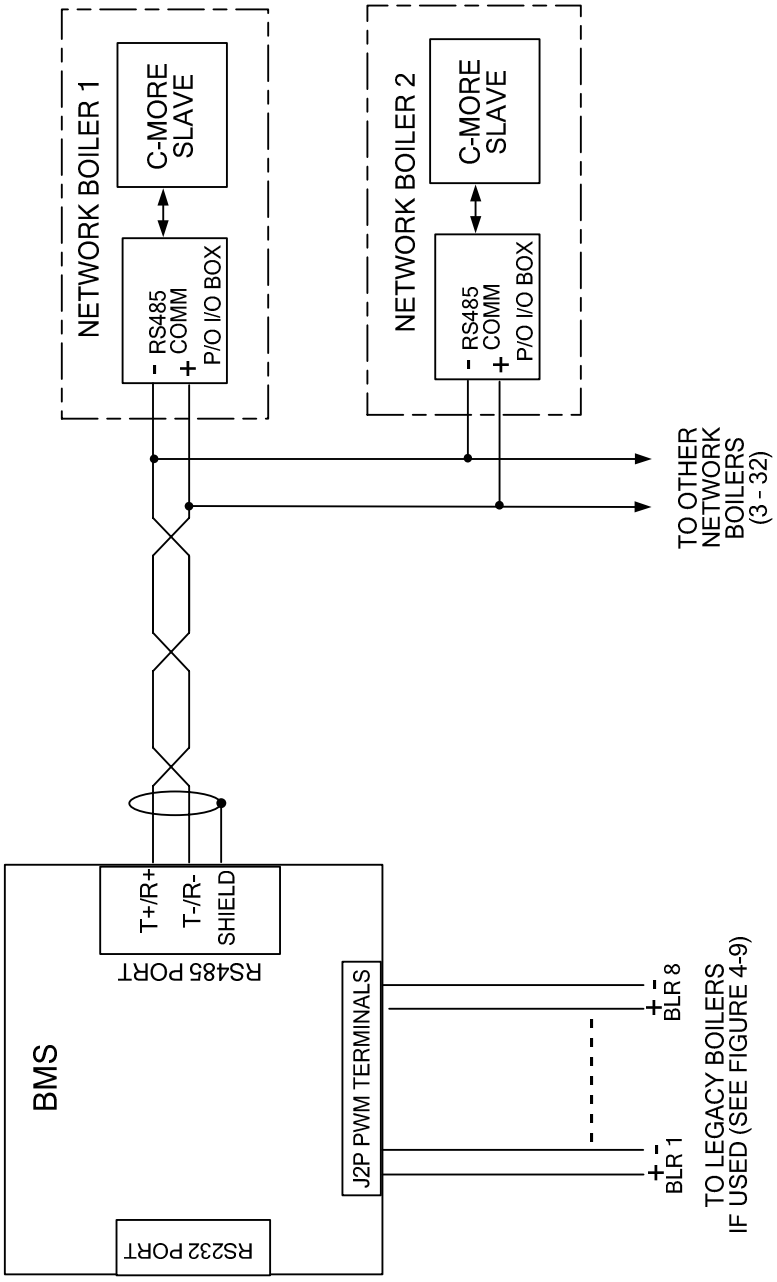
Figure 4-11 provides a sample wiring diagram for an EMS equipped with a RS485 port. If the EMS contains a 4-wire RS485 port, refer to Figure 4-9, Detail "A" for additional wiring details.



NOTES:

1. IF EMS MASTER CONTAINS 4-WIRE RS485 PORT, TIE THE TWO POSITIVE (+) AND NEGATIVE (-) LEADS TOGETHER AS SHOWN IN DETAIL "A"
2. RS485-TO-RS232 CONVERTER NOT REQUIRED IF EMS MASTER CONTAINS RS232 PORT. EMS CAN BE DIRECTLY CONNECTED TO BMS.

Figure 4-9. EMS Master Controlling BMS Slave



NOTE
THE LAST C-MORE SLAVE ON THE RS485 LOOP MUST HAVE ITS TERMINATION RESISTOR (TERM) AND BIAS (BIAS1, BIAS2) DIP SWITCHES TURNED ON.

Figure 4-10. BMS Master Controlling C-More Slaves

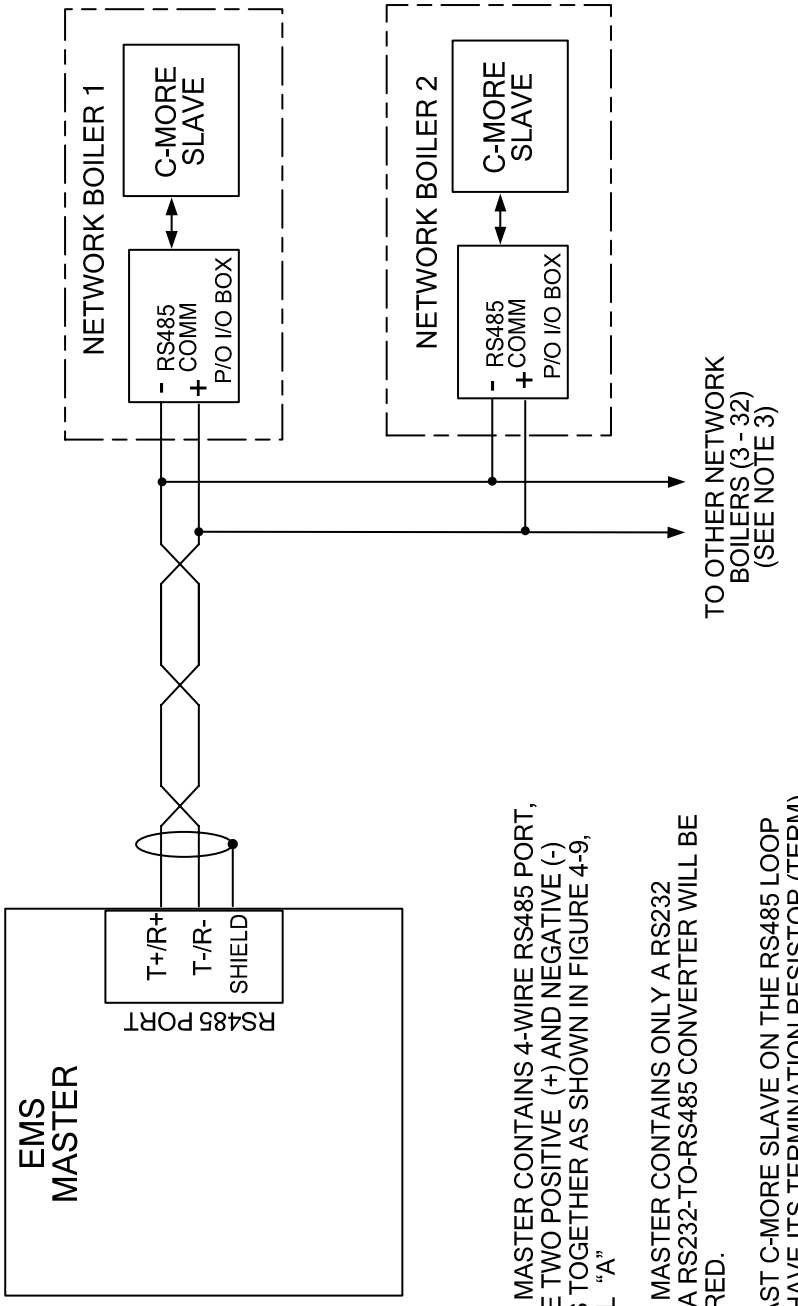


Figure 4-11. EMS Master Controlling BMS Controller Slaves

SECTION 5 MODBUS SOFTWARE SETUP

5.1 INTRODUCTION

This Section provides the information necessary to configure the AERCO C-More Boiler Controllers and a Boiler Management System (BMS) for operation on a Modbus Network. It also provides the basic setup procedures to operate the C-More Boiler Controller and BMS in each available Modbus Mode.

5.2 C-MORE BOILER CONTROLLER SETUP FOR MODBUS OPERATION

The C-More Boiler Controller can be set up for three types of Modbus operating modes. These modes are as follows:

- Monitoring and Configuration Only
- Modbus Direct Drive Control and Monitoring
- Modbus Remote Setpoint Control and Monitoring

The following paragraphs provide the procedures necessary to set up the C-More Boiler Controllers for each of the above modes of operation. These procedures assume that the required wiring connections for Modbus operation have already been accomplished as described in Section 4.

NOTE

The appropriate password must be entered in the Setup Menu of the C-More Boiler Controller, prior to changing any of the current settings. Refer to the appropriate Operation and Maintenance Manual (GF109 for KC1000, GF110 for Benchmark) for detailed information on menu items.

5.2.1 Monitoring and Configuration Control

In order for the C-More Boiler Controller to be recognized by the Modbus Master, a valid Network Comm Address must be entered in the Setup Menu as follows:

NOTE

A C-More Boiler Controller can be monitored or configured on the Modbus Network regardless of its mode of control.

1. Scroll through the Setup Menu until *Comm Address* is displayed.
2. With *Comm Address* displayed, press the **CHANGE** key.
3. Using the ▲ or ▼ arrow key, enter the appropriate *Comm Address* from 1 to 127.
4. Press the **ENTER** key to store the *Comm Address* in memory.

Once the *Comm Address* has been entered, the C-More Boiler Controller can be accessed the Modbus Network Master (BMS or EMS).

5.2.2 Modbus Direct Drive Control and Monitoring

Modbus Direct Drive Control of the C-More Boiler Controller is set up as follows:

1. Enter and store a valid Comm Address using the procedures in paragraph 5.2.1.
2. Scroll through the Configuration Menu and change the following menu items to the settings shown:

MENU OPTION	SETTING
Boiler Mode	*Direct Drive*
Remote Signal	*Network*

3. The C-More Controller is now set for Direct Drive operation via the Modbus Network.

AERCO recommends that the *Setpoint Limiting* feature in the Configuration Menu be enabled. Also, ensure that the *Failsafe Mode* setting is set to the desired setting (*Shutdown* or *Constant Setpoint*) in the event that the Modbus Network signal is lost.

5.2.3 Modbus Remote Setpoint Control

Modbus Remote Setpoint Control of the C-More Boiler Controller is set up as follows:

1. Enter and store a valid Comm Address using the procedures in paragraph 5.2.1.
2. Scroll through the Configuration Menu and change the following menu items to the settings shown:

MENU OPTION	SETTING
Boiler Mode	*Remote Setpoint*
Remote Signal	*Network*

3. The C-More Controller is now set for Remote Setpoint operation via the Modbus Network.

AERCO recommends that the *Setpoint Limiting* feature in the Configuration Menu be enabled. Also, ensure that the *Failsafe Mode* setting is set to the desired setting (*Shutdown* or *Constant Setpoint*) in the event that the Modbus Network signal is lost.

NOTE

The AERCO BMS can function as either a Slave or a Master on a Modbus Network. Paragraph 5.3 provides the programming setup procedures when the BMS is a Slave to an EMS (or BAS). Paragraph 5.4 provides the programming setup procedures when the BMS is the controlling Master for C-More Boiler Controllers.

5.3 BMS SETUP FOR OPERATION AS A SLAVE TO AN EMS MASTER

The BMS can be programmed as a Slave to an EMS Master on the Modbus Network in two ways:

- Monitoring and Configuration Only
- Modbus Remote Setpoint Control and Monitoring

The setup procedures for the above operating configurations are provided in paragraphs 5.3.1 and 5.3.2 which follow.

5.3.1 BMS Monitoring and Configuration By An EMS Master

To set up the BMS to be monitored or configured on the Modbus Network, proceed as follows:

1. Press the **FIELD ADJ** key on the BMS front panel to enter the Field Adjust Mode. The yellow LED on the key should be lit.
2. Press the **AIR TEMP** key until *RS232 MODE* is shown on the top line of the display. If necessary, press the ▲ or ▼ arrow key until *MODBUS SLAVE* appears in the second line of the display.
3. Press the **AIR TEMP** key again until *RS232 BAUDRATE* is shown on the top line of the display. Press the ▲ or ▼ arrow key to select the appropriate baud rate.
4. Press the **AIR TEMP** key again until *MODBUS ADDRESS* is shown on the top line of the display. Press the ▲ or ▼ arrow key to set the desired address for the BMS on the Modbus Network.
5. Press the **FIELD ADJ** key to exit the Field Adjust Mode. The yellow LED on the key should go off.

The BMS is now set up to be monitored or configured on the Modbus Network. Remember that the configuration can only be changed on the Modbus Network by first entering a valid password for PASSWORD LO and PASSWORD HI.

5.3.2 BMS Modbus Remote Setpoint Control By An EMS Master

To configure the BMS for Remote Setpoint Control from an EMS Master, proceed as follows:

1. Press the **FIELD ADJ** key on the BMS front panel to enter the Field Adjust Mode. The yellow LED on the key should be lit.
2. Press the **AIR TEMP** key until *RS232 MODE* is shown on the top line of the display. If necessary, press the ▲ or ▼ arrow key until *MODBUS SLAVE* appears in the second line of the display.
3. Press the **AIR TEMP** key again until *RS232 BAUDRATE* is shown on the top line of the display. Press the ▲ or ▼ arrow key to select the appropriate baud rate.
4. Press the **AIR TEMP** key again until *MODBUS ADDRESS* is shown on the top line of the display. Press the ▲ and ▼ arrow keys to set the required address for the BMS on the Modbus Network.
5. Press the **AIR TEMP** key again until *NETWORK TIMEOUT* is shown in the top line of the display. Press the ▲ and ▼ arrow keys to select the maximum allowable time (in seconds) for the EMS (or BAS) to refresh the Remote Setpoint information being sent to the BMS.

   AERCO recommends that a time be selected that is at least 3 times the normal refresh rate. This will allow for the loss of 1 or 2 transmissions without timing out.
6. Press the **AIR TEMP** key again until *REMOTE SIGNAL* is shown in the top line of the display. Press the ▲ or ▼ arrow key to select *MODBUS.*
7. Press the **FIELD ADJ** key to exit the Field Adjust Mode. The yellow LED on the key should go off.
8. To set the BMS for Remote Operation, press the **CONFIG SYS** key to enter the System Configuration Mode. The red LED on the key will light.
9. Press the **FIELD ADJ** key until *HDR SET MODE* is shown in the top line of the display. Press the ▲ and ▼ arrow keys to select *REMOTE SET TEMP.*
10. *Press the* **CONFIG SYS** key to exit the System Configuration Mode. The red LED on the key will go off.

The BMS is now programmed for Remote Setpoint Operation from an EMS Master. In the event of a Modbus signal interruption, AERCO recommends that the *TEMP FAIL MODE* setting be set to *Switch Inputs* if you want the BMS to continue running the Boilers in the CONSTANT SET TEMP Mode. In this case, ensure that the *REF TEMP* is set to the desired setpoint temperature.

5.4 BMS SETUP AS MASTER TO C-MORE BOILER CONTROLLERS

To set up the BMS as a Master to Control C-More Boiler Slaves, proceed as follows:

1. Press the **FIELD ADJ** key on the BMS front panel to enter the Field Adjust Mode. The yellow LED on the key should be lit.
2. Press the **HDR TEMP** key until *RS485 BAUDRATE* is shown on the top line of the display. Press the ▲ and ▼ arrow keys if necessary to set the baud rate to 9600.
3. Press the **HDR TEMP** key again until *MIN SLAVE ADDR* is shown in the display. Use the ▲ and ▼ arrow keys to set the address to zero.
4. Press the **HDR TEMP** key again until *MAX SLAVE ADDR* is shown in the display. Use the ▲ and ▼ arrow keys to set the address to zero.
5. Press the **HDR TEMP** key until *NUMBER NETW BLRS* is shown on the top line of the display. Using the ▲ and ▼ arrow keys, set the number to the maximum number of C-More Boilers that will be controlled on this Modbus Network.

NOTE

DO NOT count the C-More Boilers or Water Heaters that will only be monitored on the Modbus Network. Only count the Boilers that will be controlled by the BMS using the Modbus connection.

6. Press the **HDR TEMP** key until *MODBUS CNTL TYPE* is shown on the top line of the display. Using the ▲ or ▼ arrow key, if necessary, set it to *ROUND ROBIN*.
7. Press the **HDR TEMP** key until *NETW BOILER 1* is shown on the top line of the display. Use the ▲ and ▼ arrow keys to set the address of the first Boiler being controlled on the BMS RS485 loop. (This address must be the same as the Comm Address setting in the C-More Boiler Controller).
8. Press the **HDR TEMP** key again until *NETW BOILER 2* is shown on the top line of the display. Use the ▲ and ▼ arrow keys to set the address of the second Boiler being controlled on the BMS RS485 loop. (This address must be the same as the Comm Address setting in the C-More Boiler Controller).
9. Repeat step 8 for each additional C-More Boiler being controlled on the BMS RS485 loop.
10. This completes programming for the BMS RS485 Network. Press the **FIELD ADJ** key to exit the Field Adjust Mode. The yellow LED on the key should go off.

IMPORTANT

Boilers #1 thru #8 are reserved for the Legacy Boilers connected to the Pulse Width Modulation (PWM) connections on the BMS. Therefore, *NETW BOILER 1* is the same as Boiler #9. *NETW BOILER 2* is the same as Boiler #10 and so on.

The BMS is now programmed to control the Networked Boilers, as well as any Legacy Boilers connected to it. The BMS will automatically detect any C-More Boiler that is programmed for Network Control as follows:

- Boiler Mode = Direct Drive
- Remote Signal = Network
- Comm Address = Matches one of the *NETW BOILER* addresses stored in the BMS

APPENDIX A

C-MORE BOILER CONTROLLER

STATUS & FAULT MESSAGES
AND
CONVERSION EQUATIONS

Table A-1. Status and Fault Messages

Code	MESSAGE	DESCRIPTION
1	DISABLED HH:MM pm MM/DD/YY	Displayed if ON/OFF switch is set to OFF. The display also shows the time and date that the unit was disabled.
2	STANDBY	Displayed when ON/OFF switch is in the ON position, but there is no demand for heat. The time and date are also displayed.
3	DEMAND DELAY XX sec	Displayed if Demand Delay is active.
4	PURGING XX sec	Displayed during the purge cycle during startup. The duration of the purge cycle counts up in seconds.
5	IGNITION TRIAL XX sec	Displayed during ignition trial of startup sequence. The duration of cycle counts up in seconds.
6	FLAME PROVEN	Displayed after flame has been detected for a period of 2 seconds. Initially, the flame strength is shown in %. After 5 seconds has elapsed, the time and date are shown in place of flame strength.
7	WARMUP XX sec	Displayed for 2 minutes during the initial warm-up only.
8	HIGH WATER TEMP SWITCH OPEN	The High Water Temperature Limit Switch is open.
9	LOW WATER LEVEL	The Water Level Control board is indicating low water level.
10	LOW GAS PRESSURE	The Low Gas Pressure Limit Switch is open.
11	HIGH GAS PRESSURE	The High Gas Pressure Limit Switch is open.
12	INTERLOCK OPEN	The Remote Interlock is open.
13	DELAYED INTERLOCK OPEN	The Delayed Interlock is open.
14	AIRFLOW FAULT DURING PURGE	The Blower Proof Switch opened during purge.
15	SSOV FAULT DURING PURGE	The SSOV switch opened during purge.
16	PRG SWTCH OPEN DURING PURGE	The Purge Position Limit switch on the Air/Fuel valve opened during purge.

Table A-1. Status and Fault Messages –Cont.

Code	MESSAGE	DESCRIPTION
17	IGN SWTCH OPEN DURING IGNITION	The Ignition Position Limit switch on the Air/Fuel valve opened during ignition.
18	AIRFLOW FAULT DURING IGN	The Blower Proof Switch opened during ignition.
19	AIRFLOW FAULT DURING RUN	The Blower Proof Switch opened during run.
20	SSOV FAULT DURING IGN	The SSOV switch closed or failed to open during ignition.
21	SSOV FAULT DURING RUN	The SSOV switch closed for more than 15 seconds during run.
22	FLAME LOSS DURING IGN	The Flame signal was not seen during ignition or lost within 5 seconds after ignition.
23	FLAME LOSS DURING RUN	The Flame signal was lost during run.
24	HIGH EXHAUST TEMPERATURE	The High Exhaust Temperature Limit Switch is closed.
25	LOSS OF POWER	A power loss occurred. The time and date when power was restored is displayed.
26	LOSS OF SENSOR	Not Currently Used
27	LOSS OF SIGNAL	Not Currently Used
28	HIGH O2 LEVEL	Not Currently Used
29	LOW O2 LEVEL	Not Currently Used
30	HIGH CO LEVEL	Not Currently Used
31	SSOV RELAY FAILURE	A failure has been detected in one of the relays that control the SSOV.
32	RESIDUAL FLAME	The Flame signal was seen for more than 60 seconds during standby.
33	HEAT DEMAND FAILURE	The Heat Demand Relays on the Ignition board failed to activate when commanded.
34	IGN SWTCH CLOSED DURING PURGE	The Ignition Position Limit switch on the Air/Fuel valve closed during purge.
35	PRG SWTCH CLOSED DURING IGNITION	The Purge Position Limit switch on the Air/Fuel valve closed during ignition.
36	SSOV SWITCH OPEN	The SSOV switch opened during standby.
37	IGNITION BOARD COMM FAULT	Communication fault between the Ignition board and the CPU board.
38	WAIT	Prompts the operator to wait.

Table A-1. Status and Fault Messages –Cont.

Code	MESSAGE	DESCRIPTION
39	DIRECT DRIVE SIGNAL FAULT	The direct drive signal is not present or is out of range.
40	REMOTE SETPT SIGNAL FAULT	The remote setpoint signal is not present or is out of range.
41	OUTDOOR TEMP SENSOR FAULT	The temperature measured by the Outdoor Air Sensor is out of range.
42	OUTLET TEMP SENSOR FAULT	The temperature measured by the Outlet Sensor is out of range.
43	FFWD TEMP SENSOR FAULT	The temperature measured by the FFWD Sensor is out of range.
44	HIGH WATER TEMPERATURE	The temperature measured by the Outlet Sensor exceeded the Temp Hi Limit setting.
45	LINE VOLTAGE OUT OF PHASE	The High AC voltage is out of phase from the low AC voltage.
46	STEPPER MOTOR FAILURE	The stepper motor failed to move the valve to the desired position.
47	SETPT LIMITING ACTIVE	Setpoint temperature has exceeded the maximum allowable setting.
48	MODBUS COMM FAULT	The RS485 (Modbus) network information is not present or is corrupted.

Table A-2. Conversion Equations for Temperature Variables – Variable Counts to Temp

Register Variable Type	Degrees Fahrenheit (°F)	Degrees Celsius (°C)
DEGREES_1	$\text{Temp(F)} = \left[\frac{(\text{RegVar}) * (230) + 500}{1000}\right] + 20$	$\text{Temp(C)} = \left[\frac{(\text{RegVar}) * (128) + 500}{1000}\right] - 7$
DEGREES_2	$\text{Temp(F)} = \left[\frac{(\text{RegVar}) * (220) + 500}{1000}\right] - 80$	$\text{Temp(C)} = \left[\frac{(\text{RegVar}) * (183) + 500}{1000}\right] - 62$
DEGREES_3	$\text{Temp(F)} = \left[\frac{(\text{RegVar}) * (520) + 500}{1000}\right] + 40$	$\text{Temp(C)} = \left[\frac{(\text{RegVar}) * (289) + 500}{1000}\right] - 4$
ABS_DEG_1	For (RegVar≥0): $\text{Temp(F)} = \left[\frac{(\text{RegVar}) * (230) + 500}{1000}\right]$ For (RegVar<0): $\text{Temp(F)} = \left[\frac{(\text{RegVar}) * (230) - 500}{1000}\right]$	For (RegVar≥ 0): $\text{Temp(C)} = \left[\frac{(\text{RegVar}) * (128) + 500}{1000}\right]$ For (RegVar< 0): $\text{Temp(C)} = \left[\frac{(\text{RegVar}) * (128) - 500}{1000}\right]$

Table A-3. Conversion Equations for Temperature Variables – Temp to Variable Counts

Register Variable Type	Degrees Fahrenheit	Degrees Celsius
DEGREES_1	$\text{RegVar} = \left[\frac{(\text{degF} - 20) * (1000) + 115}{230}\right]$	$\text{RegVar} = \left[\frac{(\text{degC} + 7) * (1000) + 64}{128}\right]$
DEGREES_2	$\text{RegVar} = \left[\frac{(\text{degF} - 80) * (1000) + 110}{220}\right]$	$\text{RegVar} = \left[\frac{(\text{degC} + 62) * (1000) + 91.5}{183}\right]$
DEGREES_3	$\text{RegVar} = \left[\frac{(\text{degF} + 40) * (1000) + 300}{600}\right]$	$\text{RegVar} = \left[\frac{(\text{degC} - 4) * (1000) + 144.5}{289}\right]$
ABS_DEG_1	For (degF≥0): $\text{RegVar} = \left[\frac{(\text{degF}) * (1000) + 115}{230}\right]$ For (degF<0): $\text{RegVar} = \left[\frac{(\text{degF}) * (1000) - 115}{230}\right]$	For (degC≥ 0): $\text{RegVar} = \left[\frac{(\text{degC}) * (1000) - 115}{128}\right]$ For (degC<0): $\text{RegVar} = \left[\frac{(\text{degC}) * (1000) - 64}{128}\right]$