MC-4000 System
Installation Manual

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American Mine Research, Inc.
P.O. Box 234
Exit 64, I-77
Rocky Gap, VA 24366
Phone: (540) 928-1712
FAX: (540) 928-1814

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Introduction

We at American Mine Research would like to congratulate and thank you for choosing the MC-4000 Mine Monitoring and Control System. The system you purchased has been designed with simplicity in mind. Installation and operation is easier than ever, yet you will have one of the most technologically advanced and powerful systems on the market today.

Training is a very important part of system performance. The better trained your personnel the more streamlined the operation. American Mine Research provides valuable training at the time of installation and is available for further instruction and assistance down the road.

Communications Overview

The MC-4010 Master Station communicates with the remotes and sensors by means of a single twisted pair of wires. The communications standard used is EIA RS-485. This standard was selected because it allows relatively fast data transfer rates over long communication lines located in electrically noisy environments. The standard dictates that both wires of the communication line be driven differentially and both ends of the communication line be terminated with a resistance of approximately 120 ohms.

The MC-4000 Mine Monitoring and Control System can communicate with the remotes and sensors at two different speeds, 4,800 or 38,400 baud. Switches on the units allow the user to select the desired baud rate. When preparing for installation, special attention has to be given to the following areas:

- **Communication Cable Type**

  A two twisted pair 16 AWG low capacitance type cable with overall shield should be used with 38,400 baud systems. The second pair is used to power the sensors and the shield is needed to reduce induced noise levels that may create errors in the system. A low cost two twisted pair 18 AWG larger wire size unshielded cable may be used with 4,800 baud systems.

- **Communication Line Branching**

  When the communication line must branch into two or three different directions, a communication line splitter/repeater must be used. The repeater accepts the incoming signal and then drives up to three output lines with the regenerated signal.

- **Connecting to the Communications Line**

  When connecting a sensor, repeater, or remote to the communication system line, the line should be brought into the unit and connected to the terminal block. The continuing line should also be connected at the terminal block. Do not branch off of the communication line to reach a sensor or remote.

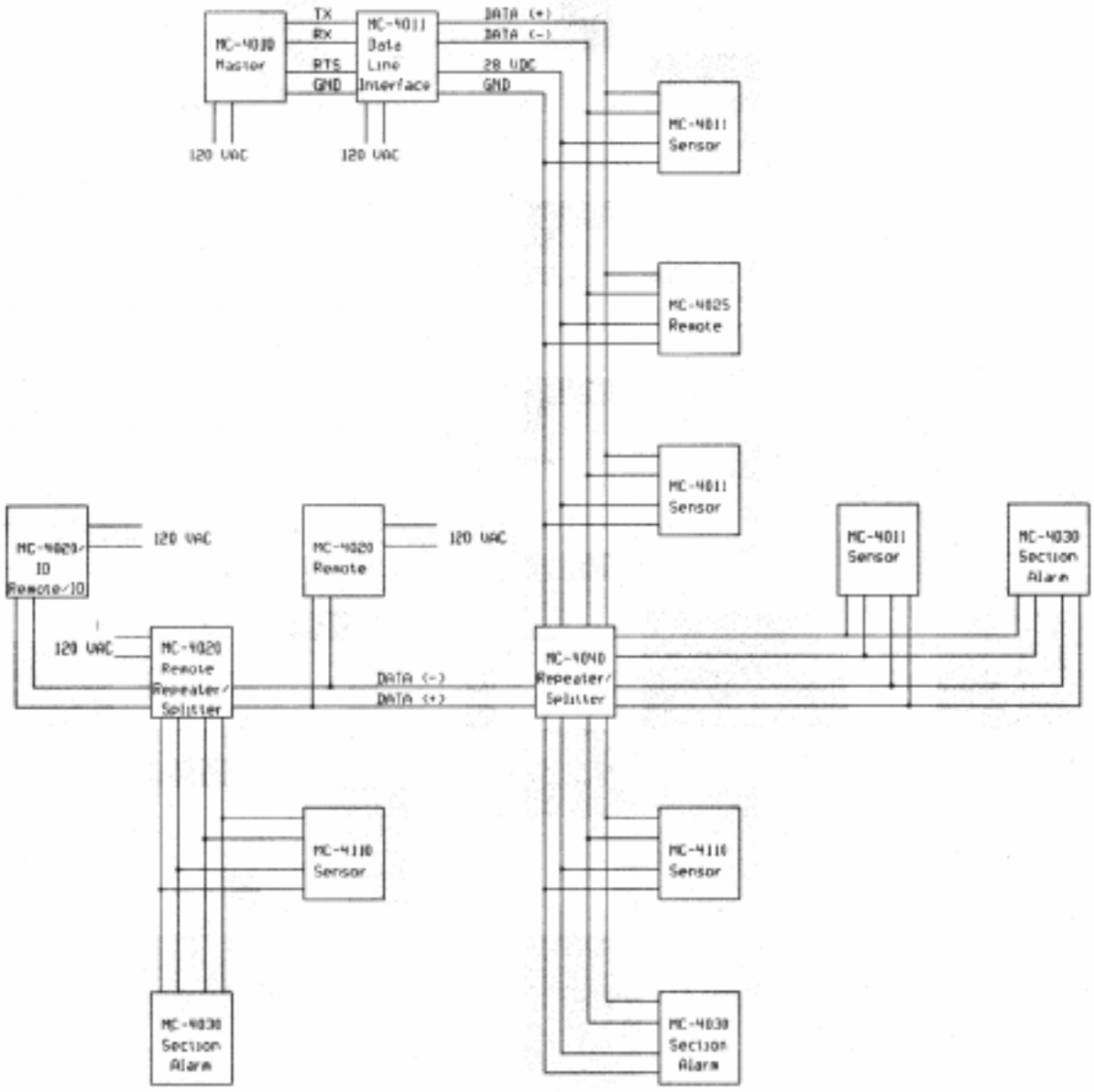
- **Trunk Line Power**

  To ensure that proper current and voltage limits are maintained, the gauge of the power conductors used and the amount of current must be considered. See the chapter on "System Power Requirements" for more information.

- **Communication Line Termination**

  Both ends of the communication system line must be terminated with a 120 ohm 0.5 watt resistor. The Data Line Interface (located at the Master Station) and the communication line repeater already have the terminating resistor in place. Place the terminating resistor across the communication line terminal block ONLY in the sensor that is located at the end of each communication system line.

Figure 1, A typical MC-4000 system schematic.



Master Station Setup

The MC-4010 Master Station is the heart of the mine monitoring and control system. This unit polls all devices in the system, generates alarms, stores calibrations, and records changing conditions on the printer.

Choosing the location of the Master Station and/or Graphics Station requires the following minimum considerations:

- **Accessibility to personnel using the system.**
- **Physical room for the placement of the components.**
- **Preferably a room with minimal traffic to reduce dust and dirt.**
- **Power requirements.**

Several devices connect to the Master Station computer including the monitor, printer, and data line interface.

Graphics Station

The MC-4015 Graphic Station adds further enhancement to the mine monitoring and control system. It can provide an animated graphic representation of the complete operation. Graphic Stations can be located next to the Master Station or anywhere on the data line. Graphic Stations can be used in several different ways: production monitoring only, safety monitoring, or complete monitoring and control.

Running The Cable

Typically recommended is a 16 AWG, two twisted pair, overall shield, TC type cable. Although 18 AWG is sufficient for some applications (see the section on Communications Overview, page 3), 16 AWG provides some additional mechanical strength.

In systems where Carbon Monoxide sensing is the primary function, the cable should be ran down the belt entry. The MC-4110 sensors can then be easily inserted into the trunk line at the 1,000 foot (or 2,000 foot) intervals.

Once the entry is chosen, hang the cable from roof bolts or some other permanent fixture at 20 to 30 foot increments with nylon ties or J hooks. Ensure that the cable is mounted high enough to avoid vehicles or machinery passing by. Avoid running parallel to high voltage cable; always cross these cables at right angles. To avoid damaging the cable, don't allow it to touch vibrating equipment such as belt structure or belt drives.

Cable can be obtained in various reel sizes and lengths. A good choice would be lengths on the same interval as your CO sensors. This allows you to drop in a sensor at the end of each length of cable avoiding unnecessary splices. When splices can't be avoided, use water tight junction boxes to make the connections. Troubleshooting is much easier when maintenance personnel can go to a junction box and make quick measurements without having to open splices.

Shielding

When the MC-4000 System is running at 38,400 baud, we recommend using an overall shielded cable. The shield in a cable is only effective when used as follows.

- **When making a splice the shield must be also be spliced. Most shielded cable is supplied with a drain wire which is used to carry the shield through the splice. Simply connect these drain wires together at the splice and the foil or braid will not have to be connected.**

- **When repeating power, separate the shield and leave the input open and ground the output shield to the negative side of the power supply.**

Lightning Protection

The MC-4011 Data Line Interface has built in surge protection for the data line which is enabled by configuring jumpers inside the enclosure (see the MC-4011 manual). The circuit ground should then be connected to a dedicated ground rod with an 8 - 12 AWG wire for the best results. Surge protection employs fuses which are intended to blow when the clamping devices turn on. For continued protection these fuses should be replaced with the same type and size as recommended in the manual. A surge protector should be installed at the portal and also connected to a dedicated ground rod.

Generally, adhere to these guidelines:

- **Ensure that fuses used on the communication line do not exceed ¼ amp.**

- **Ensure that drain wires in the communication line are tied to the negative side of the power supply and not to frame ground.**

- **Ensure that the surge protector is well grounded. The optimal grounding method is to attach the unit to a copper rod driven in the ground near the unit.**

If your installation has a particularly problem with lightning strikes, we recommend installing a Fiber Optic Barrier (MC-4012) near the portal. This will electrically separate the surface portion of the system from underground. If problems still persist, you may segment your system further by installing one or more Fiber Optic units underground. Using these steps, the MC system can be made nearly impervious to all but the most direct lightning strikes.

System Power Requirements

The operating ranges and currents of the line-powered system components are as follows:

Component	Operating Max (VDC)	Operating Min (VDC)	Current Max (mA)	Current Min (mA)
MC-4110-CO	28	14	10	8
MC-4110-CH4	28	14	50	30
MC-4025	28	14	35 Add 15 for each control channel. Add 20 for each current loop.	35
MC-4031-CO	28	14	10 70 with alarms.	8
MC-4040	28	14	30	15

The MC-4020 unit is used to repeat power in the system and has a minimum of 4 hour battery backup. ***To maintain the required 4 hours of battery backup, the load on the MC-4020 must not exceed 300 mA.*** To ensure that your system meets MSHA requirements, use the above chart to calculate the load on your MC-4020. If it exceeds 300 mA you must install another MC-4020 at an appropriate point to repeat power and provide battery backup.

The second consideration to ensure proper operation is line voltage. The voltage on the communications line steadily drops as the distance from the power source increases due to line resistance and load. Calculations can be made to determine what the theoretical voltage should be at the end of the communication line using the resistance of the power conductors and the loads as listed in the above table. However, the simplest approach is to measure the voltage at each sensor or remote location to ensure that it exceeds the minimum requirements.

The final consideration involves the use of an MC-4020 that is loaded near the 300mA limit. When AC power is lost and the unit operates on battery, the voltage supplied by the batteries begins to fall until the relay in the unit drops and disconnects both AC and DC power (required by MSHA). When a unit is loaded near the 300 mA limit, the DC voltage will drop nearly two volts below the normal level near the end of the 4 hour backup requirement Consequently, two to three volts of overhead should be considered to ensure proper operation of sensors and remotes during battery backup.

Locating And Mounting The Components

Selecting the mounting techniques of the sensors and remotes is basically common sense. You wouldn't mount a remote under a water fall or bad top, neither would you locate a multi-channel unit one hundred feet away from the monitored devices.

Thought should also go into selecting the addressing scheme of sensors and remotes. You might want all sensors on belt number 3 to be addressed 30, 31, 32, etc., and the remote at belt number 5 drive set to address 5, and so on. Developing a scheme like this will aid in system configuration, installation, and maintenance.

Carbon Monoxide Sensors (MC-4110-CO)

The location of carbon monoxide sensors depends on your ventilation and fire protection plans but you can use the following typical guidelines:

- Sensors should be placed in the middle of the entry above the belt.
- Keep in mind that these sensors are to be calibrated on a regular basis, so avoid jeopardizing personnel safety by locating in precarious positions.
- A sensor should be located at every belt drive and every tail piece. Sensors can be within 50 feet of this equipment either inby or outby (depending on direction of air flow).
- A sensor should be located at every split of air.
- Mounting techniques for sensors are typically simple: nylon ties or ropes hanging from roof bolts.

Remote Stations (MC-4020, MC-4025)

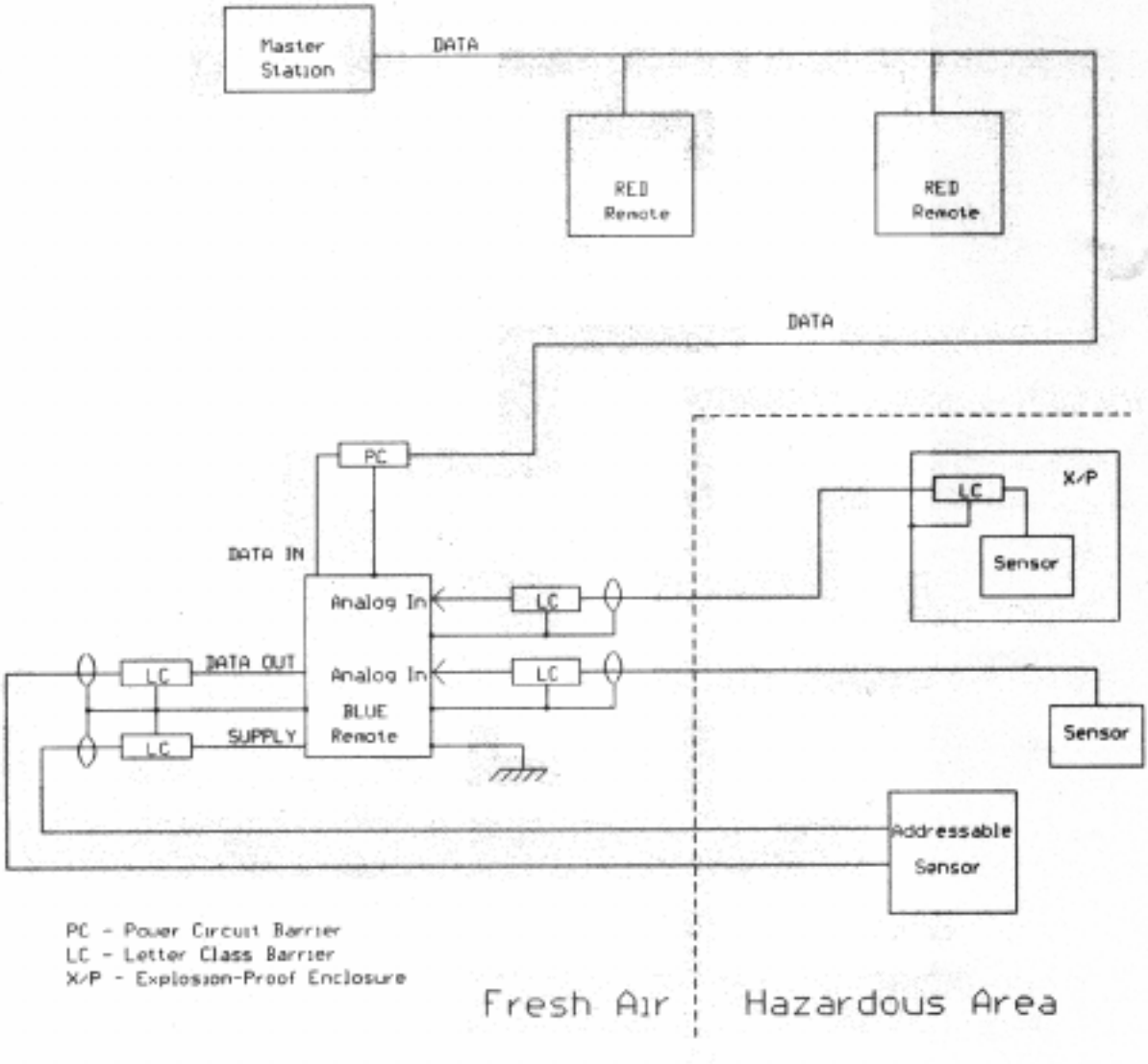
Multi-channel remotes should be mounted near the monitored devices to reduce the amount of cable running back and forth. Mount the remote station with bolts at a comfortable working height on a rigid timber or roof jack. In some applications remotes can be mounted inside the equipment, such as power centers or belt drives. For AC powered units, keep in mind the availability of 120 VAC. For remote areas where power is not available, use line powered units.

Alarm Devices (MC-4030 & MC-4031)

Underground alarm devices should be located at every working section. Mount them in an area where someone will always be able to see or hear them. A good place on a miner section would be beside the belt feeder/breaker where the shuttle car operators continuously dump material. On a longwall section the alarm device has to be 150 feet outby the last open cross cut unless the device is permissible. For surface alarm devices the same common sense applies: locate them where they can be seen and heard.

Mounting techniques for alarms depend on the application: nylon ties or J hooks are convenient for constantly moving working sections where bolts are more applicable for surface installations.

Figure 2, MC-4000 System Block Diagram
Drawing Number 219-1007 Rev. A 08-31-92



Monitoring In Hazardous Areas

Document # 180-0015 08-31-92 Rev B

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NOT TO BE CHANGED WITHOUT APPROVAL OF MSHA

The following Checklist is provided to insure that the system is installed and maintained in accordance with MSHA guidelines for Mine-Wide Monitoring Systems. Refer to Figure 2, MC-4000 System Installation Block Diagram for a graphic view of the basic requirements.

- ☐ All Remotes are either RED or BLUE in color and are located in intake air.
- ☐ All interfaces to any data transmission line contain circuitry limiting the Data Transmission Line voltage to a maximum of 60 volts per conductor to ground.
- ☐ All blue outstations have MSHA power circuit (P.C.) classified input barriers in stalled in the data transmission line and that the barrier voltage classification is greater than or equal to the highest power circuit voltage being monitored.
- ☐ RED Remotes monitor sensors in non-permissible areas.
- ☐ Sensors monitoring in permissible areas are connected to BLUE Remotes using the proper barrier.
- ☐ Sensors that have cables passing through permissible areas have MSHA classification labels and are connected to BLUE Remotes using an MSHA classified barrier of the same classification.
- ☐ All sensors in permissible areas have MSHA classification labels.
- ☐ Cables from MSHA classified sensors terminate in an MSHA classified barrier of the same classification.
- ☐ Barriers or barrier enclosures are attached to the BLUE Remotes and are so labeled that barrier outputs identify the type of sensor to which the barrier cable is connected.

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- ☐ All BLUE Remotes that monitor power circuits use an MSHA power circuit (P.C.) classified barriers that is rated greater than or equal to the highest voltage being monitored.
- ☐ All outputs of power circuit (P.C.) barriers (inputs to BLUE Remotes) are 120VAC or less.
- ☐ All BLUE Remotes that supply power to sensors use MSHA classified barriers rated greater than or equal to the highest voltage being used.
- ☐ All cables entering BLUE Remotes, and all cables connecting a classified barrier with a classified sensor, and all cables connected to non-classified sensors are shielded with the shield connected to ground at the Remote.
- ☐ Grounding techniques for Remotes and barriers are employed using no less capacity than a No. 12AWG wire.
- ☐ All BLUE Remotes contain an MSHA evaluation label with the conditions of use as specified by MSHA.
- ☐ MWMS components and circuits (except under the conditions outlined in the next paragraph) underground automatically de-energize upon loss of mine ventilation. Manual de-energization from a centralized surface control area is acceptable. Manual re-energization of each underground outstation is required.
- ☐ Fire detection circuits that monitor conveyor belts or conveyor belt entries meet the conditions specified by 30 CFR, Part 75.1103, including the capability to monitor for 4 hours upon loss of mine power. Exception: circuits shall de-energize either manually or automatically upon loss of mine ventilation, unless the power supply and circuits have been accepted by MSHA as intrinsically safe. Such circuits must be manually re-energized at each individual underground outstation.

Monitoring In Hazardous Areas

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Cables from MSHA classified barriers that terminate in Explosion-Proof (X/P) enclosures located in permissible areas, must comply with the following conditions:

- Any modification to an X/P enclosure or circuitry within, shall be documented by the operator under acceptable Field Modification Applications.
- Cable termination's within an X/P enclosure are to barriers with a classification that matches the classification of the barrier at the BLUE Remote. A P.C. barrier with a voltage rating greater than or equal to the voltage input to the enclosure is required when power circuits are monitored or power is obtained from within the X/P enclosure.
- Connections to the data transmission line shall be between the data transmission line classified barrier and the P.C. barrier when a P.C. barrier is required.
- Physical isolation is provided within an MSHA certified enclosure by means of an insulated or grounded or grounded metallic shield around all barriers and cables.

All cables leaving an MSHA certified enclosure and terminating in a sensor must meet the following conditions:

- The sensor has a classification label.
- The cable is shielded and the shield is grounded at the MSHA certified enclosure.
- The sensor classification has the same letter classification as a barrier located within the MSHA certified enclosure and connected to each individual sensor cable. A barrier classification label shall be located on the exterior of the MSHA certified enclosure and in close proximity to each and every barrier cable entrance.
- In order to comply with the conditions stipulated by MSHA for Mine Wide Monitoring Systems, the operator must insure that the system is installed as outlined in this manual.

Installation Checklist

The following checklist is provided to assist you in installing your MC-4000 system. This will enable you to make sure that the basic aspects of the installation have been completed.

- ☐ Install cable (Page 5).
- ☐ Setup Master Station (Page 5).
- ☐ Select addressing scheme (Page 7).
- ☐ Install sensors and remotes (Page 8).
- ☐ Ensure the configuration will meet the 4 hour battery backup requirement (Page 7).
- ☐ For any BLUE remote/sensor installations, follow the checklist starting on page 10.
- ☐ Install section and surface alarms (Page 8).
- ☐ Install lightning protection (Page 6).
- ☐ Configure Master Station (See the MC-4000 MAC Software Manual).
- ☐ Setup Graphics Stations (Page 5).
- ☐ Draw graphics screens (See the Datavue users guide).
- ☐ Train users and maintenance personnel.