

OPERATION MANUAL

for the

CD600B-100J BLASTING MACHINE

including the

BT250 BLASTING MACHINE TESTER

and the

BO199.9-1 and BO1999-1 BLASTER'S OHMMETERS

SEE PAGE 9 FOR USER INFORMATION AND LIMITED WARRANTY

PERMISSION IS GRANTED TO PRINT THIS MANUAL FOR OWN
USE OR FOR DISTRIBUTION PURPOSES



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INTRODUCTION

The Research Energy of Ohio, Inc. (REO) CD600B-100J Blasting Machine is a single circuit capacitor discharge blasting machine using solid state electronics. The Blasting Machine can detonate up to 1000 U.S. manufactured electric detonators wired in a balanced parallel series circuit. The energy for the detonator circuit is supplied by two capacitors in series which provide a nominal equivalent capacitance of 550 microfarads charged to 600 volts. Primary power to charge the capacitor and to operate the electronics is derived from internal alkaline dry cell batteries.

ACCESSORIES

The accessories listed below are available for testing the CD600B-100J Blasting Machine and for testing electric detonator circuits. Please refer to the APPENDIX for additional information

BT250 Blasting Machine Tester. (See APPENDIX A.)
BO199.9-1 and BO1999-1 Blaster's Ohmmeters (See APPENDIX B)

CAUTION: WE URGE YOU TO USE ONLY RESEARCH ENERGY OF OHIO, INC. REPLACEMENT PARTS AND ACCESSORIES. We are aware of other replacement products for the REO system, and feel that they do not meet all of our technical and safety standards. We have observed in products manufactured by others frayed and poorly made solder connections which may allow circuit to circuit and/or circuit to case shorts, unprotected connectors which may allow excessive leakage current and subsequent voltage breakdown, unshunted circuits during shot wiring and connection of the electric detonators and incorrect wiring which may result in misfires and may present a shock hazard. Furthermore, some of these products violate, in our opinion, the Federal Coal Mine Safety Standard 30CFR77, Part 77.1303 "Explosives Handling and Use".

GENERAL INFORMATION

The CHARGE and FIRE pushbutton switches are on the top panel. The two lead line terminals are also on the top panel.

The CHARGING/READY TO FIRE indicator on the panel flashes when the energy storage capacitor is being charged, and is on steady when the energy storage capacitor reaches the design voltage. It does not indicate energy and therefore does not guarantee that the energy storage capacitor has enough energy output to fire the electric detonators. Energy output must be determined as discussed in Operational Test Procedure.

The output terminals are shunted until the FIRE switch is depressed.

The Blasting Machine will shut down upon release of the CHARGE switch.

The machine cannot be fired until the voltage on the capacitor reaches the design voltage and the safety circuit is released.

Indicator

<u>Quantity</u>	<u>Indicator (LED)</u>	<u>Function</u>
1	CHARGING/READY TO FIRE	When flashing, indicates the energy storage capacitor is charging. When on steady, indicates the energy storage capacitor is at the design voltage. (Does <u>not</u> indicate energy. Energy output must be determined as discussed in <u>Operational Test Procedure</u> .)

SPECIFICATIONS

Output:

Number circuits:	1
Nominal Capacitance:	550 MFD
Nominal Voltage:	600 VDC
Internal Resistance:	1.5 ohms at 75 F (24 C), 2 ohms at 20 F (-7 C), 2.5 ohms at 0 F (-32 C).
Nominal Energy:	100 Joules
Electric Detonator Capacity:*	
	Straight Series: 130 detonators
	Parallel Series: 1000 detonators**

* 2 ohm max lead line and 2 ohm electric detonators, based on U.S. standard detonator rating of 20 mj/ohm delivered in 5 ms.

** 11 series of 91, or 12 series of 84, or 13 series of 77

electric detonators of 2 ohms each.

Power Source:

Type: Internal D cell ALKALINE batteries.
Quantity: Fifteen.
Access: Remove the cover on the end of the blasting machine.

WARNING: USE ONLY ALKALINE TYPE BATTERIES. Do not use carbon-zinc type batteries as these do not have the amperage capacity to operate the Blasting Machine.

WARNING: DO NOT OPERATE THE BLASTING MACHINE IF THE BATTERY COVER IS NOT IN PLACE.

OPERATION

Operational Test

WARNING: BLASTING PROCEDURES, ELECTRIC DETONATOR SELECTION, CIRCUIT DESIGN AND TIMING ARE THE RESPONSIBILITY OF THE USER. Consult with the mine Explosives Engineer and with the explosives suppliers for necessary information and training for safe, efficient blasts.

IMPORTANT: The following procedure will check out most of the functions of the CD600B-100J Blasting Machine. Since capacitor stored energy can only be measured when discharging, the blasting machine must be connected to a BT250 Blasting Machine Tester (or other suitable test method), prior to each use, to determine if the energy output of the blasting machine is sufficient to fire electric detonators.

CAUTION: The output of the CD600B-100J Blasting Machine is a "pulse" of voltage of relatively short duration. Multimeters, voltmeters and other field instruments cannot respond to this short duration voltage and therefore cannot be used to determine if the blasting machine output voltage is normal.

WARNING: DO NOT TEST THE BLASTING MACHINE NEAR ACTIVE BLAST SITES OR USING LIVE OR DANGEROUS EXPLOSIVE DEVICES.

1. Connect the blasting machine to a BT250 or other suitable test load. (See APPENDIX C for using a BT250).
2. Depress the CHARGE pushbutton switch and hold it down. The CHARGING/READY TO FIRE indicator should flash as the machine charges, and come on steady after 10 to 30 seconds. It should remain on steady as long as the CHARGE pushbutton switch is held down.

IMPORTANT: The CHARGING/READY TO FIRE indicator lights steady when the energy storage capacitor reaches the design voltage. It does not indicate energy and therefore cannot indicate if the blasting machine has sufficient energy to detonate the electric detonators.

WARNING: DANGER - HIGH VOLTAGE - SHOCK HAZARD. KEEP BODY AND HANDS CLEAR OF TERMINALS AND CONDUCTORS. CONTACT WITH ELECTRICAL CONDUCTORS COULD CAUSE SERIOUS INJURY OR DEATH.

3. After the CHARGING/READY TO FIRE indicator is on steady continue holding the CHARGE pushbutton switch down and depress the FIRE pushbutton switch. Continue holding both switches down for 3 seconds.
 - A. Verify that the test load was energized approximately 1/4 second after the FIRE pushbutton switch was depressed.
 - B. Verify that the CHARGING/READY TO FIRE indicator is unlit.
 - C. Verify that the energy output of the blasting machine was at least 100% of rated energy.

4. After observing the above, release both pushbutton switches.
5. Secure the blasting machine.

General Operating Procedure

Note: The following procedure is intended as a guide only, and each user must prepare and verify his own procedure consistent with Local, State, and Federal regulations.

CAUTION - USE OF THIS MACHINE REQUIRES THAT THE OPERATOR HAS BEEN TRAINED IN BLASTING TECHNIQUES.

WARNING: BATTERIES ALONE CAN FIRE ELECTRIC DETONATORS. KEEP BATTERIES AWAY FROM THE BLASTING CIRCUITS.

WARNING: NEVER CONNECT THE BLASTING CIRCUIT TO THE BLASTING MACHINE UNTIL YOU ARE READY TO FIRE THE BLAST.

1. Perform the Operational Test Procedure (including measurement of energy output) prior to bringing the blasting machine into the blast area.
2. Obtain electric detonator firing recommendations from the detonator manufacturer. Check the blasting circuit calculations prior to connecting to the Blasting Machine.
3. Connect the detonator wires to the lead lines using balanced series-parallel circuits as recommended by the detonator manufacturer.

CAUTION: Keep the lead lines shunted during wiring of the electric detonators by connecting the lead line wires to the SHUNTED terminals on the cable reel or by twisting them together.

4. MAKE SURE THAT ALL PERSONNEL HAVE BEEN REMOVED TO A SAFE LOCATION.
5. Check the electric detonator circuit continuity and resistance (including the lead lines) using an approved Blaster's Ohmmeter.
6. Shunt the lead lines after checking the circuits by connecting the lead lines to the SHUNTED terminals on the cable reel or by twisting the cable wires together until the blast is ready to be initiated.
7. Remove the wires from the SHUNT terminals on the cable reel and connect the wires to the terminals on the blasting machine. KEEP HANDS AND BODY CLEAR OF CONDUCTORS. CONTACT WITH ELECTRICAL CONDUCTORS COULD CAUSE SERIOUS INJURY OR DEATH.
8. Depress the CHARGE switch and hold it down. The CHARGING/READY TO FIRE indicator flashes as the capacitor charges and comes on steady when the

capacitor reaches the design voltage. Release of the CHARGE switch will discharge the capacitor within 10 seconds.

9. When the CHARGING/READY TO FIRE indicator is on steady, continue holding the CHARGE switch down, and firmly depress the FIRE switch. Continue holding both switches down until the firing operation is complete.

IMPORTANT: The CHARGING/READY TO FIRE indicator does not indicate energy and therefore cannot indicate if the blasting machine has sufficient energy output to detonate the electric detonators. Output energy must be determined as discussed in the Operational Test Procedure.

10. After the firing operation is complete, wait 5 seconds then release both switches.
11. Disconnect and shunt the blasting cable.
12. The blaster should secure the machine again after use.
13. If the Blasting Machine should fail to fire, release both switches, disconnect and shunt the blasting cable, notify personnel of blast delay and consult this manual.

BATTERIES

WARNING: USE ONLY ALKALINE TYPE BATTERIES. Do not use carbon-zinc type batteries as they do not have the amperage capacity to operate the Blasting Machine.

Battery Life

Battery replacement is required when the time required to charge the blasting machine (i.e., the time required for the CHARGING/READY TO FIRE indicator to come on steady after depressing the CHARGE pushbutton switch) exceeds about 30 seconds. This is an arbitrary figure and is chosen only because an operator usually feels uncomfortable if the charge time is greater than about 30 seconds. When the CHARGING/READY TO FIRE indicator lights steady, even if the charge time is greater than 30 seconds, the energy storage capacitor is charged to the design voltage.

Test firing a blasting machine into a tester or charging to test the READY TO FIRE indicator depletes battery life the same as firing an actual blast.

Battery Replacement

Remove the battery cover on the side to gain access to the batteries. The Blasting Machine requires twelve Alkaline "D" cell type batteries. After battery replacement, replace the battery cover.

CAUTION: OBSERVE POLARITY WHEN REPLACING THE BATTERIES. Insert the batteries according to the label on the battery holders. INCORRECT POLARITY WILL DAMAGE THE BLASTING MACHINE.

CAUTION: WHEN REPLACING THE BATTERIES, USE ALL NEW BATTERIES. DO NOT USE PARTIALLY USED BATTERIES AS THESE WILL BECOME EXHAUSTED BEFORE THE OTHERS AND MAY LEAK CHEMICALS CAUSING SEVERE DAMAGE TO THE BLASTING MACHINE.

CAUTION: REMOVE THE BATTERIES AND EXAMINE THEM FOR CHEMICAL LEAKAGE AT LEAST EVERY SIX MONTHS. REPLACE THE BATTERIES AT LEAST YEARLY EVEN IF NOT EXHAUSTED. DO NOT STORE THE BLASTING MACHINE FOR PROLONGED PERIODS WITH THE BATTERIES INSTALLED.

WARNING: DO NOT OPERATE THE BLASTING MACHINE IF THE BATTERY COVER IS NOT IN PLACE.

REPAIRS

The CD600B-100J Blasting Machine, BT250 Blasting Machine Tester, BO199.9-1 Blaster's Ohmmeter and BO1999-1 Blaster's Ohmmeter must be repaired only at the factory to ensure quality workmanship, and for updating to current production standards. Quality control tests are performed and exact replacement parts are used. Each item repaired is subjected to the same quality control tests as new production. Such procedures and the specialized test equipment required are not available in the field or at other generalized repair shops.

If repair is required, please return the item with shipping charges prepaid to the factory at the address listed below. Include a note or letter describing the problem and include the name and telephone number of the person(s) knowledgeable of the problem. If the equipment is sent by Greyhound Bus Lines, there is a pickup charge which will be added to your repair bill.

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USER INFORMATION AND LIMITED WARRANTY

Disclaimer

The information contained in this manual is the instructions and recommendations of Research Energy of Ohio, Inc. Federal, State and/or Local laws, rules and regulations may alter the sequence of operating the equipment. It is the responsibility of the purchaser and user to insure use consistent with Federal, State and/or Local laws, rules and regulations. It is the responsibility of the receiving office to register this document to the appropriate department and person(s) responsible for mine and blasting safety.

WARNING: BLASTING PROCEDURES, E.B. CAP SELECTION, E.B. CAP CIRCUIT DESIGN, SHOT LAYOUT AND TIMING ARE THE RESPONSIBILITY OF THE USER. Consult with the mine Explosives Engineer and with the explosives suppliers for necessary information and training for safe, efficient blasts.

Limited Warranty

Each unit is tested extensively before shipment and carries a 90 day LIMITED WARRANTY. If the unit fails to test or perform due to a defect in material or workmanship and is returned with shipping prepaid to Research Energy of Ohio, Inc., 200 East Bluegrass Drive, Norwalk, OH 44857, it will be repaired or replaced at our option. This LIMITED WARRANTY is void if the equipment has been dismantled, altered, or otherwise abused in any way.

The above LIMITED WARRANTY is exclusive and in lieu of all warranties, express or implied, including any implied warranty of merchantability or fitness for a particular purpose. Under no circumstances shall Seller or Manufacturer be liable for damages of any description occasioned by or resulting from operation or use of this equipment.

We cannot anticipate all conditions under which this information and our products, or our products in combination with the products of other manufacturers, may be used and therefore accept no responsibility for the results obtained, the suitability or the safety of our products when used alone or in combination with other products. The user must make his own tests to determine the suitability and safety of each product and product combination for his own purpose. We sell the product without warranty and the buyers and users assume all responsibility and liability for all losses (including anticipated profits), consequential damages, or incidental damages arising from the use of our products alone or in combination with other products.

Use of this equipment by persons not trained in blasting techniques will make the warranty null and void.

APPENDIX A

BT250 BLASTING MACHINE TESTER

GENERAL INFORMATION

WARNING: DO NOT TEST BLASTING MACHINES OR ACCESSORIES NEAR ACTIVE BLAST SITES.

The Research Energy of Ohio, Inc. (REO) Model BT250 Blasting Machine Tester measures the output energy of REO CD450-50J, CD450A-50J, CD450B-50J, CD600-100J, CD600B-100J and CD700-60J Capacitor Discharge Blasting Machines. Please note that the CD600B-100J Blasting Machine is electrically identical to the CD600-100J Blasting Machine. Therefore, use the CD600-100J setting on the BT250 Blasting Machine Tester if the Tester label does not list the CD600B-100J Blasting Machine. A ruggedized LED display allows the user to view the energy output of the REO CD Blasting Machines. The blasting machine tester contains an internal ten ohm load resistor across the terminals to which the CD blasting machine under test is connected. Two 24" leads with spade connectors on each end are supplied.

A machine selector switch on the BT250 tester is provided to select the model blasting machine being tested.

The BT250 automatically performs a self test when first turned on, and turns off automatically after approximately 8 seconds.

The BT250 turns on automatically the instant a blasting machine is fired into the unit. It turns off automatically after approximately 8 seconds.

The BT250 Blasting Machine Tester is not intended to be a precise instrument such as would be used for laboratory measurements of output energy. It is intended to be used in the field prior to each blast to compare the output with initial measurements made by a BT250 Blasting Machine Tester when the true output was known. IF ANY QUESTIONS ARISE AS TO THE OUTPUT OF THE CD BLASTING MACHINE, PLEASE CONSULT WITH THE MANUFACTURER BEFORE SHIPPING THE MACHINE BACK FOR LABORATORY TESTS.

OPERATION

Self Test

The BT250 will automatically perform a self test each time the machine selector switch is set to the test position. Illumination of the BAT and CAL "LED" indicates proper operation of the test instrument. This procedure will last approximately 8 seconds and then the tester will automatically shut off.

General Operating Procedure

1. Set the rotary switch on the BT250 CD Blasting Machine Tester to the correct blasting machine model to be tested.
2. Connect the tester to the blasting machine using the 2 leads provided.
3. Charge and fire the blasting machine into the tester.
 - A. The tester turns on automatically the instant the blasting machine fires.
 - B. The bar graph displays the PERCENTAGE OF RATED ENERGY output from the blasting machine.**

WARNING: DO NOT USE THE BLASTING MACHINE IF THE ENERGY OUTPUT IS LESS THAN 100 PERCENT.
 - C. If the bar graph does not illuminate or if the ERROR light illuminates, check the machine selection switch and confirm that the proper machine position has been selected.
4. The tester remains on for approximately 8 seconds after the blasting machine fires.
5. The tester turns off automatically after use.

BATTERIES

Battery Life

Under normal use, Alkaline type batteries will last up to 800 blasting machine tests. Battery replacement is required when the BAT. OK or CAL. OK LED bar does not illuminate, or decreases in intensity, during self test of the BT250 Blasting Machine Tester.

Battery Replacement

The BT250 Blasting Machine Tester uses two 9 volt Alkaline batteries, Eveready 522 or equal, available in most department stores, drug stores and electronic supply stores.

To replace the batteries, loosen the four screws on the back of the tester. Remove the cover. Remove the old batteries and insert the new alkaline batteries, observing polarity. After battery replacement, make sure that the gasket on the back cover is sealing properly and that the four screws are securely tightened.

WARNING: USE ONLY ALKALINE TYPE BATTERIES. Do not use carbon-zinc or any other type batteries as they do not have the capacity to operate the BT250 Blasting Machine Tester.

CAUTION: OBSERVE POLARITY WHEN REPLACING THE BATTERIES. INCORRECT POLARITY WILL DAMAGE THE ENERGY TESTER.

CAUTION: EXAMINE BATTERIES AT LEAST EVERY 3 MONTHS FOR CHEMICAL LEAKAGE. REPLACE BATTERIES AT LEAST YEARLY EVEN IF NOT EXHAUSTED. REMOVE BATTERIES FROM THE ENERGY TESTER IF IT IS NOT GOING TO BE USED FOR TWO OR MORE MONTHS.

APPENDIX B

BO1999-1 and BO199.9-1 BLASTER'S OHMMETER

INTRODUCTION

The REO BO1999-1 and BO199.9-1 Blaster's Ohmmeters are pocket-size SINGLE CIRCUIT models designed for general use. A nylon cord attached to the case allows the ohmmeter to hang from around the neck for convenient use. Long battery life, a rugged water resistant enclosure and heavy duty terminals provide the blaster with a dependable unit. This user-friendly digital ohmmeter speeds up circuit check-out and provides vital information necessary to assure a successful blast.

GENERAL INFORMATION

The REO BO1999-1 and BO199.9-1 Blaster's Ohmmeters provide nominal values of circuit resistance on a large easy-to-read digital display. Two terminals on the ohmmeter are provided for single circuit testing. The BO1999-1 Blaster's Ohmmeter measures resistance of 0 - 1999 ohms in one ohm increments, with an accuracy of +/- 1 ohm. The BO199.9-1 Blaster's Ohmmeter measures resistance of 0 - 199.9 ohms in one-tenth ohm increments, with an accuracy of +/- 0.1 ohm. The maximum test current is less than 3 milliamperes. The ohmmeter turns on automatically when a circuit is detected, and turns off automatically when the circuit is disconnected.

OPERATION

Operational Test

1. Do not connect a blasting circuit to the Blaster's Ohmmeter until this Operational Test has been performed.
2. Short the terminals on the ohmmeter with a short piece of wire.
3. The ohmmeter should turn on and indicate 000 (+/- 1) ohm for the BO1999-1 Ohmmeter, or 00.0 (+/- 0.1) ohm for the BO199.9-1 Ohmmeter.
4. If the battery is in need of replacement, BAT appears on the display.
5. Remove the short from the terminals on the ohmmeter. The ohmmeter should turn off and remain off.

General Operating Procedure

Note: The following procedure is intended as a guide only, and each user must prepare and verify his own procedure consistent with Local, State, and Federal regulations. Complete Operating Instructions appear on the back of the Blaster's Ohmmeter.

CAUTION - USE OF THIS EQUIPMENT REQUIRES THAT THE OPERATOR HAS BEEN TRAINED AND CERTIFIED IN BLASTING TECHNIQUES.

WARNING: BATTERIES ALONE CAN FIRE ELECTRIC DETONATORS. KEEP BATTERIES AWAY FROM THE BLASTING CIRCUITS.

WARNING: KEEP THE BLASTING CIRCUITS SHUNTED WHEN NOT CONNECTED TO THE OHMMETER. MINIMIZE THE TIME THE BLASTING CIRCUITS ARE CONNECTED TO THE OHMMETER BY TAKING RESISTANCE VALUES QUICKLY. RECORD THE DATA IN A LOG BOOK FOR ANALYSIS AND FUTURE REFERENCE.

1. Perform the Operational Test.
2. Connect the blasting circuit to the terminals on the Blaster's Ohmmeter.
3. Note the resistance displayed.
Note: 1--- will be displayed if the resistance exceeds the ohmmeter range.
4. Shunt the blasting circuit after testing.

BATTERY

Battery Life

Under normal use, an Alkaline type battery will last more than 2000 hours of operation. During use of the ohmmeter, BAT will appear on the display when the battery is in need of replacement.

Battery Replacement

The BO1999-1 and BO199.9-1 Blaster's Ohmmeters use one 9 volt Alkaline battery, Eveready 522 or equal, available in most department stores, drug stores, and electronic supply stores.

To replace the battery, loosen and remove the two 1/4" screws which fasten the back cover to the tester. Remove the back. Remove the old battery and insert the new alkaline battery, observing polarity. After battery replacement, make sure that the gasket on the back cover is sealing properly and that the two screws are securely tightened.

WARNING: USE ONLY AN ALKALINE TYPE BATTERY. Do not use a carbon-zinc type battery as it does not have the capacity to operate the BO1999-1 or BO199.9-1 Blaster's Ohmmeter.

CAUTION: OBSERVE POLARITY WHEN REPLACING THE BATTERY. INCORRECT POLARITY WILL DAMAGE THE BLASTING MACHINE.

CAUTION: EXAMINE BATTERY AT LEAST EVERY 3 MONTHS FOR CHEMICAL LEAKAGE. REPLACE THE BATTERY AT LEAST YEARLY EVEN IF NOT EXHAUSTED. REMOVE THE BATTERY FROM THE BLASTER'S OHMMETER IF IT IS NOT GOING TO BE USED FOR TWO OR MORE MONTHS.

APPENDIX C

LEAD LINES

GENERAL DESCRIPTION

The firing cable or lead lines are the fragile part of the blasting system. In some operations these are considered expendable. The life expectancy of the lead lines or firing cable is dependent on the conditions to which it is subjected and subsequent care. It is vital that the lead lines or firing cable be inspected and maintained after each blast if they are to be reused.

CONDITIONS WHICH CAUSE FIRING CABLE AND LEAD LINE FAILURE

1. If the firing cable or lead line is pulled or jerked by the blast, it may be damaged. To prevent this, allow enough hookup wire or leg wire from the electric detonator to wrap around a small 10 to 15 pound rock. The rock will be jerked instead of the line.
2. Reeling or pulling the firing cable or lead line through loose rocks or soil can also cause damage. Care must be taken to prevent the wire from catching in rock piles or crevices.
3. Flyrock damage.

WARNING: DAMAGED CABLES AND LEAD LINES CAUSE MISFIRES. Test your cables or lead lines before each shot.

APPENDIX D

MISFIRES

IF A MISFIRE OCCURS

If a misfire occurs for any reason, determine which holes are live and/or safe to fire. Also determine if insufficient burden, stemming or back break is observed, and the desirability of firing these holes.

WARNING: REVIEW FEDERAL, STATE, LOCAL, AND COMPANY REGULATIONS AND PROCEDURES IF A MISFIRE OCCURS.

SOME CAUSES OF MISFIRES

1. Open or overloaded circuits (too many electric detonators) will cause misfires.
2. Tight hookup wires from hole to hole may cause misfires.
3. Wet hole conditions, especially where deck charges are required, may cause misfires.
4. Water seeping into the holes may cause nitrate prills to melt, in turn allowing stemming to sink thus breaking the detonator leg wire.
5. Leaking bags may also allow stemming to settle thus breaking the detonator leg wire.
6. Floating bags of explosives must be prevented so that the stemming can settle without breaking the detonator leg wires.
7. Tamping pole use must be exercised with caution to prevent skinning or breaking the detonator leg wires and/or damage to the detonator.
8. Failure to test the blasting machine and cable before a shot to determine if the equipment is functioning properly.
9. Failure to test the electric detonator circuits before and after connecting them to the lead line may result in a misfire.
10. Poor wiring practices, failure to double check the electrical connections and the wiring, and poor supervision may allow undetected circuit errors, thus causing misfires.
11. Connections that lay in water (including connections to the lead line) can shunt electrical current thus causing insufficient electric detonator current and a misfire.
12. **Frayed, nicked or bared wires can shunt electrical current thus causing insufficient electric detonator current and a misfire.**