Installation & Operation Manual

Chromalox Medium Voltage Controllers

DirectConnect™
Medium Voltage System

CHROMALOX
Advanced Thermal Technologies
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Throughout the DirectConnect™ Control Panel manual, these symbols will alert you to potential hazards. Safety precautions should always be followed to reduce the risk of fire, electrical shock, injury and even death to persons.

Please read all instructions before operating your Medium Voltage Control Panel.

To avoid electrical shock or injury, always remove power before servicing a circuit. Personnel working with or near high voltages should be familiar with modern methods of resuscitation. Contact an area supervisor or safety personnel for more information.

**IMPORTANT SAFEGUARDS**

**WARNING**

HIGH VOLTAGE is used in the operation of this equipment; DEATH ON CONTACT may result if personnel fail to observe safety precautions.

Learn the areas containing high-voltage connections when installing or operating this equipment.

Be careful not to contact high-voltage connections when installing or operating this equipment.

Before working inside the equipment, turn power off and ground all points of high potential before touching them.

**WARNING**

ELECTRIC SHOCK HAZARD

Any installation involving control equipment must be performed by a qualified person, who is trained and certified with the proper Medium Voltage credentials, and must be effectively grounded in accordance with the National Electrical Code to eliminate shock hazard.
1...General

1.1 General Information

This manual provides instructions for receiving, handling, storage, installation, startup (commissioning) & operation and general maintenance of Chromalox’s Medium Voltage Controllers. A chapter is also included for system observations and troubleshooting.

2...Precautions & Warnings

2.1 Precautions and Warnings

ALL PERSONNEL WORKING ON MEDIUM VOLTAGE ELECTRICAL EQUIPMENT SHALL ADHERE TO OSHA, NEC, NFPA 70E AND LOCAL SPECIFICATIONS AND STANDARDS. FAILURE TO ADHERE TO PROPER MEDIUM VOLTAGE SAFETY STANDARDS INCLUDING PROPER USE OF PPE MAY RESULT IN INJURY OR EVEN DEATH. CHROMALOX WILL NOT BE LIABLE FOR FAILURE OF CUSTOMER TO ADHERE TO GOVERNING STANDARDS.

2.2 Deenergize

DE-ENERGIZE ALL EQUIPMENT BEFORE OPENING JUNCTION BOXES AND CONTROL PANELS. DO NOT WORK ON LIVE CIRCUITS.

Controllers and heater junction boxes are equipped with Kirk-Key locking system that prevent opening of certain compartments unless specific conditions are met. For example the heater junction box lock requires a key that is captured in the disconnect door and is not released until disconnect is turned OFF, thus the output of controllers feeding heaters is disabled and safe.

The Medium Voltage Section of control panel consists of incoming feed section (IFS), Disconnect switch compartment (DSC), contactor & fuses section (CFS) which is located below the switch compartment and the SCR section. The DSC door is screwed in and requires tools to open. The CFS door is mechanically interlocked with the DSC and can’t be opened until the switch is turned OFF. Likewise, the SCR section is interlocked with the CFS and can’t be opened until the switch is turned OFF. The Kirk Key master is located in the DSC door and it is captured until disconnect is turned OFF this arrangement provide a complete and safe interlocking system using only two Kirk Key Locks.

The hinged door in the low voltage section can be locked using lock & key provided in the door handle.

2.3 Design and Purpose

This equipment was specifically designed for its intended purpose and should not be used for any other application without a complete re-evaluation by the manufacturer. The operator should ensure these instructions are kept with the equipment to prevent any misuse for which the equipment has not been designed.

2.4 Complete System Only

The Chromalox DirectConnect™ Medium Voltage System is comprised of both a Chromalox Medium Voltage controller and a Chromalox Medium Voltage heater. One may not be employed without the other. All written and implied warranties are voided if one DirectConnect™ component is used without the other.

2.5 Startup/Commissioning

All Chromalox DirectConnect™ Medium Voltage Systems MUST be commissioned by Chromalox Service Personnel. All written and implied warranties are voided if non-Chromalox Service personnel are utilized for DirectConnect™ System commissioning.
3...Receiving & Handling

3.1
The modular design of Chromalox Controllers makes installation easier but care should be exercised as modules are heavy and can tip over. Therefore do not attempt to handle controllers without securing properly and using only proper equipment capable of handling heavy loads.

3.2
Inspect for shipping and handling damage. Proceed only if there is no visible damage.

3.3
Know the capabilities of the lifting equipment available to handle the weight of the system.

3.4
Keep the system secured to the shipping skid to prevent distortion of the frame during moving and to minimize tipping.

3.5
Exercise care during any movement and placement operations to prevent falling or unintentional rolling or tipping.

4...Storage

4.1
Any system that is not installed and energized immediately should be stored in a clean, dry space where a uniform temperature prevents condensation. It should be stored in a heated building with adequate air circulation and protected from dirt and water. The system shall be stored off of the ground.

4.1.1. In non-humidity controlled environments, an anti-condensate heater or desiccant shall be used in each enclosure cabinet to prevent condensation on interior surfaces.

4.1.2. Shipping containers are temporary protective covers. The systems should not be stored outdoors for more than 24 hours. If the system remains outdoors, the entire system must be protected from the outdoor elements with appropriate coverings.

4.2 Short Term Storage of Controllers
4.2.1. Unit should be stored in-door in a clean, dry environment.

4.2.2. If storage area is not heated, a form of desiccant should be used to prevent the formation of moisture.

4.2.3. Once unit is taken out of storage, all desiccant, internal packing, caps, plugs, wrappings, etc. need to be removed before operation.

4.3 Long Term Storage of Controllers
4.3.1. Long term storage is the repeat of the short term, except the entire unit should be heat sealed in plastic barrier bag with the proper amount of desiccant included.

4.4 All written and implied warranties are voided if these storage guidelines above are not followed.
5...Installation

5.1 Mechanical Installation
5.1.1 Lifting and moving provisions

Controllers are shipped on heavy duty pallet and can be lifted and moved using fork trucks or heavy duty rollers.

For installations where solid flat moving surface is not available, lifting eyes are provided, shipped with controllers in a separate box. Do not discard those as you may need for lifting and moving controllers. There is a provision for four lifting eyes per bay as shown in the TOP VIEW

5.2 Preparations
5.2.1. The heater skid & controller should be adequately protected against mechanical damage, extreme temperatures and other adverse conditions.

5.2.2. Ensure that all precautions are taken regarding the weight of the equipment. Lifting equipment should have capacity for the given weight.

5.2.3. The foundation must be sufficiently strong to withstand the load of equipment.

5.2.4. Controllers should be inspected for foreign material. Protective plugs, covers and silica gel desiccant should not be removed until immediately prior to startup. The entire system should be cleaned before start up.

5.2.5. General safety precautions listed in the plant Safety Manual should be closely complied with to prevent injury to personnel or damage to equipment.

5.2.6. Ensure that the area safety supervisor and others in the vicinity are aware that work is being undertaken and post warning notices. Ensure that the appropriate PPE and clothing is worn. Beware of wet or slippery ladder rungs and working areas if working aloft.

5.2.7. Where possible hazards have been eliminated or reduced as far as is reasonably practicable by design but the additional warnings listed below should be followed to ensure continued safe use

5.3 Controller Installation & Wiring

Medium Voltage Controllers consists of several sections/bays (See Figure 5.1)
1) Incoming Power Bay
2) Disconnect Switch Section
4) Contactor & fuse Section
5) SCR Power Controller Bay which also have a Low Voltage Section for instrumentation and sensor wiring

5.3.1 Incoming Bus & Cable Termination
This section is provided for easy termination of incoming power wiring. Enough space is provided for wiring bending of cables suitable for load. Follow instruction listed in documents accompanying the controller or/and by the terminal manufacturer. THIS SECTION IS LOCKED AND SHOULD ONLY BE OPENED WHEN THE POWER FEED IS TURNED OFF AND GROUNDED

5.3.2 Disconnect Switch, Contactor & Fuse Section
Main components in this section are load fuses and shut down contactor. Optional inductors are also installed in this section.

5.3.3 SCR Section
SCR stacks and cooling fans are located in this section. Bus bars are provided for load termination. This section is interlocked with Disconnect section with Kirk Key Lock system and can’t be opened until main disconnect is de-energized.

Low Voltage Section
SCR trigger circuit and all controls are located in this section. This section is completely isolated from medium voltage sections and therefore can be opened without de-energizing the main power.
Install Controller on a solid foundation as shown in Figures 5.1, Figure 5.2 & Figure 5.4

Figure 5.1 shows all sections and major sub-sections of each described in paragraph 5.3 in final configuration ready to wire

![Figure 5.1 Controller Front View with Doors closed](image)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Disconnect/Isolator Section</td>
</tr>
<tr>
<td>2</td>
<td>Lock insertion location (Lock not provided with panel. Must be installed and locked before energizing the feed upstream)</td>
</tr>
<tr>
<td>3</td>
<td>Incoming Section/bus system</td>
</tr>
<tr>
<td>4</td>
<td>Low voltage control section</td>
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<tr>
<td>5</td>
<td>Contactor &amp; fuses section</td>
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<tr>
<td>6</td>
<td>Low voltage section with SCR trigger circuit</td>
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<tr>
<td>7</td>
<td>SCR section with ventilation</td>
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</tbody>
</table>
Run incoming power wires into the incoming bay shown in Figure 5.4 & 5.5 and torque properly for cable size and lugs. Run load cables from SCR sections shown in Figure 5.4 & Figure 5.6 torque properly for cable sizes and lugs.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Disconnect/Isolator Section</td>
<td>4</td>
<td>Contactor</td>
</tr>
<tr>
<td>2</td>
<td>Control Power Transformer</td>
<td>5</td>
<td>Inductors (optional)</td>
</tr>
<tr>
<td>3</td>
<td>Fuses &amp; Fuse Holder</td>
<td>6</td>
<td>SCR Stack</td>
</tr>
</tbody>
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**Figure 5.2 Foundation Pad and Anchoring Details**

**Figure 5.3 Wire-ways for Top Entry & Exit**

**Figure 5.4 Controller Front View with Doors Open (Typical)**
Install Field wiring as shown in Figure 5.8 and wiring diagram enclosed in the print pocket.

Figure 5.8  Field Wiring Termination
5.4 Heater Junction Box Installation

See Heater Installation Manual. The following views give general information.

Dimensions are Inches (mm)
6...Startup and Operation

6.1 Introduction
Chromalox Medium Voltage Controllers are designed & tested to meet UL specifications for medium voltage heater controllers. Successful operation of this equipment depends as much on proper installation and maintenance by the user as it does upon careful design and testing by Chromalox. This document is provided to assist user with safe and efficient installation, maintenance and operation of the equipment.

Dangerous Potentials:

Never work on this equipment without de-energizing and grounding the bus system.

NOTE: OVERHEAD BUS IS ELECTRICALLY LIVE EVEN WITH DISCONNECT/ISOLATOR TURNED OFF. FOR THIS REASON, THIS SECTION IS ISOLATED FROM THE REST OF THE PANEL IN ITS OWN COMPARTMENT. DO NOT ATTEMPT TO TAMPER WITH ISOLATION BARRIERS.

• Always de-energize and ground the system before performing tests, maintenance, or repair.

• Always let the interlock devices provide with the system performs their intended function without forcing or defeating the devices.

6.1.1. Startup/Commissioning - All Chromalox DirectConnect™ Medium Voltage Systems MUST be commissioned by Chromalox Service Personnel. All written and implied warranties are voided if non-Chromalox Service personnel are utilized for DirectConnect™ System commissioning.

6.2 Features
The Medium Voltage portion of Chromalox Controllers consists of three main sections:
1) Incoming bus & cable termination section
2) Disconnect Switch, contactor & fuse section
3) SCR section

Low voltage section is located in SCR bay but it is completely isolated from medium voltage. A hinged door is provided for easy access to the low voltage section.

Figure 6.1.1

Figure 6-6.1 above show the complete electrical system as a single line diagram
6.3 Theory of Operation

The controls systems functions automatically to control heater output as demanded by the customer supplied 4-20 mA proportional demand signal. The power output of the heaters is controlled using solid state SCR (Silicon Controlled Rectifier) switches. Given that the demand signal is 12 mA (50% demand); the SCR switches would be “gated” into conduction to allow 50% of the available power to be sent to the heater. This power proportioning is controlled in two, selectable methods:

Phase Angle

Phase angle controlled (PA) gates the SCR switches into conduction at various angles of the incoming sine wave. Given a 50% demand, the SCR switches would be gated into conduction at 90 degrees into the positive sine wave and 90 degrees into the negative sine waves. This type of control is very precise but can cause harmonic distortion and electromagnetic interferences (EMI) problems. To minimize total harmonic distortion (THD) & EMI this control should only be used during soft start and dry-out functions of the control scheme which will be discussed later.

Zero Crossover Control

Zero Crossover Control (ZC) proportions power to the load by time proportioning full sine waves of power to the load. This is accomplished by gating the SCR switches into conduction at the zero volt point thus the di/dt is much lower resulting in much lower harmonic distortion & EMI. The ZC control is based on a 1 second time base so in the 50% demand example, the SCR switches would be conducting full Sine of power for ½ second and no power for 1/2 second resulting in 50% of the available power being delivered to the load. This is the control mode used in normal operation of the heater.

As mentioned above, there are two special modes of operation that the MV heater controller provides:

Soft Start

Soft Start Capability (SS) as the name implies in this mode, power to the heater is supplied at a very low level and gradually increased. The heater can be started in the SS mode. In this mode, when the heater start sequence is initiated, the heater controller starts in the PA mode even if which mode is selected and ramps the demand up over a 100 second interval until either 100% output is achieved or the ramping output reference equals the power demand. At that time the SS feature will shut down and the controller will control to the demand signal in whichever control mode is selected.

Dry-Out Mode

Dry-out Mode (DM). The dry out mode feature, as the name implies, is used to “dry out” heaters that may have accumulated moisture during long down time periods. This is a very useful feature in MV heating systems due to the large amount of energy that can be delivered in a single burst. The DM can be accomplished in two ways:

Manual: If the Manual Dry-out is selected from the HMI, the heater will remain in the dry-out mode until turned off.

Automatic: The automatic dry-out mode utilizes a feedback from the Ground Fault (GF) monitoring system and compares it with a preset from the HMI. If this preset is exceeded-- note the preset is expressed in percent of the full scale setting of the GF module; given that the GF module trip point was 5 amps, and the preset was set a 10%, the automatic dry-out mode would enter at 0.5 amps—the controller will enter the automatic dry out mode for and stay in that mode for the number of minutes set on the HMI. Once the automatic dry-out mode is finished, the controller will return to its previous control. In both DM actions, the maximum output is set by the HMI. If the demand signal is lower than the Max setting on the HMI, the lower of the two signals will be used.

6.3.1 Interlocks

There are five basic interlocks that will disable the controller output:

Sheath Temperature Overtemp (OTC). There are up to 3 Sheath Temperature overtemp Limit Controllers. If the over temperature setpoint is exceeded on any over temperature controller, the over temperature alarm will be enabled and the safety contactor opens which shuts down the SCR. This alarm may only be manually cleared after the over temperature condition is resolved. The manual reset of this alarm is done on the touchscreen (or HMI, Human-Machine Interface).

Ground Fault (GFI). If ground currents exceed the trip point of the GF module the GFI will trip the safety contactor and remove the SCR enable. This is additional to the automatic dry-out discussed above. The GFI must be manually reset and the HMI alarm cleared before system restart.

The Disconnect Switch Auxiliary contact is in the start permissive circuit and must be closed prior to starting.

The Blown Fuse Auxiliary contact is in the start permissive circuit and must be closed prior to starting.

The External ESD relay (24VDC coil) must be powered before starting.

The Local ESD switch must be cleared before starting.
6.4 Before Powering Up

Chromalox takes great pride in knowing that we have provided to you a product of premium quality and workmanship. We have taken every precaution to ensure that your equipment arrives safe and secure.

However, vibration and temperature changes during shipping can cause some components to become loose. Additionally, throughout the life span of this product, other environmental and application conditions may have affected the mechanical and electrical continuity of several internal components. Therefore, for your safety and overall product performance, please take the time to familiarize yourself with the GENERAL MAINTENANCE & PRESERVATION INSTRUCTIONS found in Section 8 of this manual.

Since it is not uncommon for electrical wiring and mechanical connections to become slightly loosened during shipment, we ask that you pay particular attention to Section 8-3 Wiring and Connections.

8.3 WIRING AND CONNECTIONS. Check wiring and connections as follows:

- a. Inspect wiring for wear, fraying, chipping, nicks, and evidence of overheating. Repair minor defects with a good grade of electrical tape, or replace if needed.
- b. Inspect for loose electrical and mechanical connections. Tighten or replace defective crimp-style lugs. Re-solder loose solder connections. Tighten or replace all loose or missing hardware.

6.5 Operation

Low Voltage Section

NOTE: The Low Voltage Section should be checked and verified before energizing the medium voltage.

6.5.1. Energize Low Voltage 120VAC Supply.

Heater Dry-Out Functions

6.5.2. On Main Screen select “Go to Setup” On Setup Screen; enter values for “Dry-out SCR Interval Time” and “Dry-out SCR Trigger Value”.

1. Dry-out time interval is selected in minutes.
2. Dry-out Trigger Value is % of setpoint for leakage current limit. For example, ground fault trip current limit is set at 5 Amps then 20% will force system to go to dry-out mode when leakage reaches 1 Amp.
3. Dry-out trigger % can be selected but it is restricted to maximum of 15% to avoid heater damage.

After completing the above described setup touch (F4 GOTO DRYOUT), bottom right hand of the display.

![Dry-Out Setup Menu](image)

The following display will appear.

![Dry-Out Control Display](image)
6.5.3. If manual Dry-out is required, touch (START DRYOUT) to initiate dry-out mode. It will stay in dry-out mode until STOP DRYOUT is pushed.

**Main Control Mode**

Touch (F3 GO TO MAIN)

Following screen will appear:

![Main Menu % Demand & % Trigger Displays](image)

**Heater Control Functions**

6.5.4. Select “Go to Load 1 Control” Select PA or ZC control. Select Soft Start On or Off. Status should indicate “Ready to Run”

1. Repeat step 6.5.4 for Load 2 Control
2. Press Start. Status should indicate “Running”.

![Ready to Run](image)

![Running](image)
7...Observations & Troubleshooting

7.1 Critical Components
The following critical components are constantly monitored and applicable alarm conditions are displayed.

- Disconnect/Isolator 1
- Disconnect/Isolator 2
- Load Contactor 1
- Load Contactor 2
- SCR fuses circuit 1
- SCR fuses circuit 2
- All Overtemp alarm conditions
- GFI (Ground Fault Interrupt)
- E-Stop (Emergency Stop)
- Firing Circuit fault alarm

If any of the above goes into fault condition the associated load contactor is turned off.

When checking the fault conditions, disconnect all power and ground the bus system before making any attempt to repair or replace a defective component.

Fault and Abnormal Conditions Indications

7.2 E-STOP
If E-Stop is activated, the red ESTOP FAULT appears for one second, then followed by a black screen with “HEATER IS OFF BY EMERGENCY STOP SWITCH” is displayed as long as E-Stop is active.

7.3 Disconnect OFF
If the DISCONNECT OFF yellow alarm is present, this indicates that the Disconnect Switch is open. Determine the reason and re-close after safe conditions are established.

7.4 SCR Fault
If a red SCR FAULT alarm warning appears, the trigger circuit has malfunctioned. Consult the SCR Stack manual for further instructions.

7.5 Main Fuse Open
If any of the main power fuses become open, a fuse open alarm warning appears. Determine the cause of the blown fuse(s) and replace. All safety precautions detailed in earlier chapters must be followed.

NEVER OPEN OR INSPECT THE CONTROL CABINET WITHOUT TURNING OFF POWER AND GROUNDING THE BUS WHICH FEEDS THE MAIN FUSE.
7.6 Overtemp Fault
Run mode can only be activated after the overtemperature condition is resolved and the alarm is cleared (reset). The overtemperature alarm is a latching type alarm and it must be manually reset via the HMI touch screen.

7.7 Remote Enable Off
If remote enable relay is de-energized following indication gives local indication of heater disable condition.

7.8 Ground Fault Interrupt Condition
This indicates that the maximum allowable current leakage has been violated. This event opens the SCR safety contactor which shuts down the SCR. The ground fault condition must be resolved and the alarm must be cleared prior to attempting RUN MODE.

Fault Trip Indications:
- Ground Fault Leakage - Trip
- Load Overtemp - Trip
- SCR Fault - Trip
7.9 Leakage Trend Chart
To view leakage trend chart select GOTO LOAD1 OR LOAD2 TREND
Preventive maintenance consists of inspections, tests and cleaning of equipment at scheduled intervals. It helps detect and correct conditions that could cause equipment malfunction. The scheduled maintenance instructions in this manual are intended to duplicate those furnished in the Planned Maintenance System (PMS). In case of conflicts, the PMS documentation takes precedence. Such conflicts should be reported immediately on the user comment sheet in accordance with the maintenance procedures for this manual.

Preventive Maintenance Schedule
The schedule for conducting preventive maintenance depends on how much the equipment is used. Table 8-1 lists the suggested maintenance schedule, which is based on average conditions. This schedule should be adjusted for each application as experience requires.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Title</th>
<th>Applicable Paragraph</th>
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<tbody>
<tr>
<td>6 months</td>
<td>Enclosure Exterior</td>
<td>8-1</td>
</tr>
<tr>
<td>6 months</td>
<td>Enclosure Interior</td>
<td>8-2</td>
</tr>
<tr>
<td>6 months</td>
<td>Wiring and Connections</td>
<td>8-3</td>
</tr>
<tr>
<td>6 months</td>
<td>Lights and Fuses</td>
<td>8-4</td>
</tr>
<tr>
<td>1 year</td>
<td>Contactor</td>
<td>8-5</td>
</tr>
</tbody>
</table>

8.1 Enclosure Exterior
Inspect the panel and temperature controller exterior as follows:

a. Wipe off all dust, moisture, and oil with lint-free cloth. Remove corrosion with sandpaper.
b. Remove heavy dust or grease with a wooden scraper.
c. Touch up all bare spots with primer and paint.
d. Inspect door gaskets and replace if worn and/or deteriorated.
e. Oil door hinges and latches with machine oil.

8.2 Enclosure Interior
Clean and inspect the panel and temperature controller interior as follows:

a. Remove dust and dirt from electrical components with a vacuum cleaner.
b. Remove sticky dust, grease, and oil with a dry, lint-free rag or small paint brush dampened with cleaning solvent.
c. Inspect for corrosion on metal parts. Repair or replace if found.
d. Inspect for worn or broken parts. Repair or replace if found.

e. Inspect for evidence of dripping water or liquids falling on equipment parts. If found, determine the cause and correct

8.3 Wiring and Connections
Check wiring and connections as follows:

a. Inspect wiring for wear, fraying, chipping, nicks, and evidence of overheating. Repair minor defects with a good grade of electrical tape, or replace if needed.
b. Inspect for loose electrical and mechanical connections. Tighten or replace defective crimp-style lugs. Solder loose solder connections. Tighten or replace all loose or missing hardware.

c. Replace or clean ceiling fans and filters

8.4 Lights and Fuses
Check lights and fuses as follows:

a. Check indicating lights for burned out lamps. Replace as required.
b. Check fuses for correct ratings. Replace as required.

8.5 Contactors
Vacuum Contactors are sealed units and require very little maintenance. Refer to contactor manufacturer manual included in the document package for care and maintenance of contactors.

8.6 SCR Stacks
SCR Stacks and associated electronics boards and wiring harnesses are designed for long trouble and trouble free operation.

Refer to manufacturer manual included in the document package for care and maintenance.
Limited Warranty:
Please refer to the Chromalox limited warranty applicable to this product at http://www.chromalox.com/customer-service/policies/termsofsale.aspx.

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