DESCRIPTION OF CONTROL CIRCUITS FOR HELIARC WELDING

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The Linde Air Products Company
Unit of Union Carbide and Carbon Corporation

General Office: New York, N. Y.

In Canada: Dominion Oxygen Company, Limited, Toronto
The term "HELIARC" is a registered trade-mark of The Linde Air Products Company.
A. Introduction

Certain characteristics of HELIARC welding practice are different from other welding processes. Proper control of these characteristics will cause the process to serve its users effectively and economically. The method of control is largely dependent upon the factors which follow:

1. Argon Conservation - Cost of the protective gas is relatively high - especially when wasted. Control devices can save sufficiently to cover the cost of the devices in a short time. By such conservation measures, the process will find wider application.

2. Safety - No particular hazard exists in many applications. However, in common with other welding methods, automatic controls for safety are important for welding in wet locations or on scaffolding when using AC. In such cases, open-circuit voltage lowering features are essential.

3. Protection of Equipment - Placing the torch on a grounded surface when high-frequency current is on results in arcing through the gas cup. Where no insulated place is provided for the torch, automatic means for turning off the power is highly desirable.

4. Water Shut-off - Flow of cooling water during non-welding periods may be costly. More important, moisture will condense on equipment during non-welding periods when atmospheric temperature and humidity are high, and cooling-water temperature is low. Where these conditions exist, installation of water flow control equipment is advocated.

5. Convenience - Convenient control by the operator is important. Failure to provide for convenient operation will often lead to circumventing proper operation of a control circuit.

6. Radio Interference - In some installations, high-frequency signal broadcast is strongest when the high-frequency generator is on during non-welding periods. Therefore, a circuit is important to control the high-frequency generator at the start and end of the weld.

7. Crater Control - Some materials (HASTELLOY C, STELLITE Grade 21, MULTIMET, and Inconel alloys) develop a slag coating when air strikes the weld puddle before solidification is complete. Interruption of welding current by means other than lifting the torch from the work, and continued argon protection aid to reduce crater cracking and make restarting easier.

B. Recommendations

In view of the foregoing factors, the following recommendations are made:

1. All users of the HELIARC process should be urged to use electrical controls, primarily for argon conservation.

2. Several types of controls should be suggested so that the simplest and least expensive control unit is obtained for a particular operation.

3. Where such control units cannot be procured from vendors, the customer is urged to build the unit, assisted by the descriptions and diagrams presented herein.

C. General Features

Some component parts of one circuit are common to other circuits. For this reason the general information applies to all circuits. Circuits are numbered and titled for easy reference.

The switch employed in Circuits No. 1, 2 and 3 is in the torch handle. For safety reasons, it is operated at low voltage rather than 110 volts used for the other parts of the circuit. In this case, 6 volts are used because transformers for this voltage are more readily available than for other low voltages.

In this arrangement, the switch short-circuits the 6-volt side of the transformer. The 110-volt side is connected in series with the 110-volt apparatus. With the switch open, resistance in the 110-volt side is sufficient to prevent closing the control circuit. Shorting the 6-volt side allows current to flow in the 110-volt side, thereby operating the 110-volt apparatus. This method is the simplest and least expensive method.

The torch switch is a commercial make adapted for the standard HELIARC torch. The torch handle is notched to accommodate the switch. Insulated tape is wrapped around the copper body of the torch (See Fig. 2). Two holes are drilled in the torch handle through which the wires pass. This insures against excessive strain at the switch connections. The switch is later taped in place (See Fig. 3).

Control Circuits No. 1 and 3 include contactors in the primaroy of the welding transformer to interrupt flow of alternating welding current and superimposed high-frequency. Substitution of an inexpensive relay will allow automatic turn-off of high-frequency current while welding power remains on.

Solenoid-operated water valves are included in all circuits. Because of the “sweating” problem which occurs in most localities, their use is highly recommended.

A summary giving approximate costs, relative merits, recommendations, etc., for the control units is in Table 5, Page 13.
D. No. 1 - Non-Automatic Switch-Type Control Circuit
For Power, High-Frequency,
Argon And Water

1. DESCRIPTION

Solenoid-operated argon and water valves are controlled by a momentary contact switch and a delay shutoff timer. A maintained contact switch (one that remains on or off without being held) is not recommended for this circuit. Failure by the operator to turn off the switch at the end of a weld defeats the primary purpose of the circuit - that of argon conservation.

This unit is low in cost and satisfactory for argon and water conservation, safety, equipment protection, minimizing radio interference, and crater control. It is recommended for short downhand welds. Because the switch must be held in the closed position while welding, it is not recommended for position or long welds.

2. MATERIAL REQUIREMENTS

2 Contactors - Square "D" Company A.C. Magnetic Contactor - Class 850 - Type J-10 Single Pole - Double Throw - 110 volts - 60 cycle
1 Line Switch - Arrow Hart & Hedgeman Switch Double Pole - Single Throw - Cat. No. 80602
4 Condensers - P. R. Mallory & Co. "TP" Paper Tubular No. 17-123 Type 420 (Condenser A, B, C, D used for A.C.) 600 volts - .25 Mfd. (Condenser D only for D.C.)
1 Timer T.D. - Haydon Manufacturing Co. #5901-2 Adjustable Reset Timer - 60 Seconds - Normally closed Contacts - 110 volts - 60 cycle
2 Water & Argon Valves - Automatic Switch Co.
"Asco" Solenoid Valve - 110 volts - 60 cycle,
Cat. No. X82652 for Water or Argon 125 lb./sq. in. max. Resilient Seat
1 Primary Contactor - E C & M or Clark Controller Co., Welding Contactor - 110 volt Coil 60 cycle 2 pole - 75 amp. or larger
1 Transformer - 110 V. to 8 V. - Northstar Winding Laboratories 111-113 Albemarle Ave., Trenton, N. J., Insulating Transformer - Open Type Primary 110 volts Secondary 6 volts - 3 amperes
1 Terminal Block - Howard B. Jones - Terminal Block No. 142 - Cat. No. 10-142
1 Discharge Resistor - Some Generators have this built-in. If not, check with manufacturer for proper value.
1 Momentary Contact - General Electric Company - Switchette Size J, No. CR1070-C-122B3

<table>
<thead>
<tr>
<th>OPERATING CYCLE</th>
<th>OPERATING COMPONENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>All apparatus connected</td>
<td>De-energized - Contacts 9 and 10 open</td>
</tr>
<tr>
<td>Welding generator running Control unit line switch off</td>
<td>Closed</td>
</tr>
<tr>
<td>Control unit line switch turned on</td>
<td>Open</td>
</tr>
<tr>
<td>Control switch held on Generator or transformer on to energized output leads</td>
<td>Energized - Contacts 9 and 10 closed</td>
</tr>
<tr>
<td>Control switch released turns off generator or transformer</td>
<td>Open</td>
</tr>
<tr>
<td>After time interval</td>
<td>Closed</td>
</tr>
</tbody>
</table>

*If arc is not established before time period of timer, contacts L3 and 4 will open thereby closing the argon and water valves.
"HELIARC" A.C. OR D.C. WELDING—CONTROL CIRCUIT NO.1
SWITCH CONTROL OF WELDING CURRENT, WATER AND ARGON WITH DELAYED WATER AND ARGON SHUT-OFF.
E. No. 2 Semi-Automatic Switch-Type Control Circuit For High-Frequency, Argon And Water

1. DESCRIPTION

The arc is started by depressing the momentary contact switch. Voltage-operated relay Rg drops out, closing normally open contacts and shorting the switch, making it unnecessary to hold the switch down. High-frequency remains on until the arc is broken. This circuit cannot discontinue welding power because open-circuit voltage from the welding transformer energizes relay Rg.

This unit is satisfactory from the standpoint of equipment protection and minimizing radio interference. Its low cost is another advantage. It is recommended for bench work done in the downhand position with alternating welding current.

It is somewhat disadvantageous from the safety viewpoint since the operator must turn off welding power to readjust the electrode. The unit is not recommended for welding high-temperature and other alloys that require argon protection to avoid crater problems.

2. MATERIAL REQUIREMENTS

- Line Switch - Arrow Hart & Hedgeman Switch
  - Double Pole Single Throw - Cat. No. 80602
- Adjustable Resistor - Ohmite "Diveoehm" 75 watt
  - 50 Ohm (Adjust SO Rg picks up at 50 V; drop out at 25 V)
- Relay - Square "D" Co. A.G. Magnetic Relay Class 8501 - Type H-24 Double Pole - Double Throw - 6 volts - 60 cycle
- Contactor - General Electric A.C. Magnetic Contactor CR2810-1265 - G.I. - Cat. No. 2686530G-1
  - 110 volts - 60 cycle - Single Pole - Normally Open
- Contactor - Square "D" Company A.C. Magnetic Contactor Class 8501 - Type J-10 Single Pole - Double Throw - 110 volts - 60 cycle
- Timer T.D. - Haydon Manufacturing Co., #6901-2 Adjustable Reset Timer 60 Seconds - Normally Closed Contacts - 110 volts - 60 cycle
- Water & Argon Valves - Automatic Switch Co.
  - ASCO Solenoid Valve - 110 volts - 60 cycle
  - Cat. No. X82652 for Water or Argon - 125 lbs./sq. in. Resilient Seat
- Terminal Block - Howard B. Jones - Terminal Block No. 142 - Cat. No. 10-142
- Transformer - Insulating Transformer - Open Type
  - Primary - 110 volts, Secondary - 6 volts, 3 amperes
- Control Switch Momentary Contact - General Electric Company - Switchette Size 1, No. CR1070-C12213B3

<table>
<thead>
<tr>
<th>OPERATING CYCLE IN TIME SEQUENCE</th>
<th>OPERATING CYCLE FOR CONTROL CIRCUIT NO. 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>All apparatus connected</td>
<td>Relay (Rg)</td>
</tr>
<tr>
<td>All disconnect and line switches in &quot;off&quot; position</td>
<td>De-energized - Contacts L3-7 and 1-3 closed</td>
</tr>
<tr>
<td>Disconnect switch closed</td>
<td>De-energized - Contacts L3-4 and 1-3 closed</td>
</tr>
<tr>
<td>Welding transformer turned on</td>
<td>De-energized - Contacts 9-10 open</td>
</tr>
<tr>
<td>Line switch turned to &quot;on&quot; position</td>
<td>Open until contacts L3-4 time out if arc is not established</td>
</tr>
<tr>
<td>Electrode moved to work</td>
<td>Energized - Contacts L3-7 closed; 1-3 closed</td>
</tr>
<tr>
<td>open and control switch depressed</td>
<td>Energized - Contacts L3-4 closed; contacts L3-5 open</td>
</tr>
<tr>
<td>Welding arc extinguished by moving torch from workpiece - Secondary voltage increases</td>
<td>Energized - Contacts 9-10 open</td>
</tr>
<tr>
<td>After time period</td>
<td>De-energized - Contacts 9-10 open</td>
</tr>
<tr>
<td>Disconnect switch opened</td>
<td>De-energized - Contacts L3-5</td>
</tr>
</tbody>
</table>

TABLE 2
Argon, water, power and high-frequency are turned on by momentarily touching a normally open switch on the torch handle. If welding is not started immediately, services will remain on for a time equal to the argon delay period. However, it may be turned off immediately by touching the switch momentarily a second time. If welding is started during the argon delay interval, services will remain on until the arc is broken or the switch is pressed again.

This unit incorporates the most advantages. It is satisfactory for argon conservation, water shutoff, safety, equipment protection, convenience and crater control. Where radio interference becomes a major problem, the addition of an extra time clock will correct this condition. In general, this unit is best for the major variety of work.

2. **MATERIAL REQUIREMENTS**

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condenser</td>
<td>&quot;B&quot; P. R. Mallory &amp; Co. - &quot;TP&quot;</td>
</tr>
<tr>
<td>Paper Tubular No. 17-123 - Type 420 - 50 volts - 200 Mfd.</td>
<td></td>
</tr>
<tr>
<td>Rectifier</td>
<td>Federal Selenium Rectifier - 115 volts - 100 milliamperes</td>
</tr>
<tr>
<td>Potentiometer</td>
<td>P. R. Mallory - 50 MP - 50,000 Ohm</td>
</tr>
<tr>
<td>Fixed Resistor</td>
<td>I.R.C. BT2 - 20,000 Ohms - 2 watt</td>
</tr>
<tr>
<td>Relay</td>
<td>General Electric Co., &quot;Telephone Type&quot;</td>
</tr>
<tr>
<td>CR-2791-H10 with 2 Form C Contacts</td>
<td></td>
</tr>
<tr>
<td>D.P.D.T. - Coil 24 volts D.C. - 6500 Ohm</td>
<td></td>
</tr>
<tr>
<td>Line Switch</td>
<td>Arrow Hart &amp; Hedgeman - Switch Double Pole - Single Throw - Cat. No. 80602</td>
</tr>
<tr>
<td>Timer T.D.</td>
<td>Haydon Manufacturing Co. - #5601-2 Adjustable Reset Timer - 60 Seconds - Normally Closed Contacts - 110 volts - 60 cycle</td>
</tr>
<tr>
<td>Relay</td>
<td>Advance Electric &amp; Relay Co. - Impulse Relay Type 9044A - Double Pole - Double Throw (600 volt Insul.) 3-1/2-in. Contact - 100 volts - 60 cycle</td>
</tr>
<tr>
<td>or Struther Dunn Inc. - Ratchet Type Relay (600 volt Insul.) Type 85AXA - Double Pole - Double Throw - 110 volt - 60 cycle</td>
<td></td>
</tr>
<tr>
<td>or Guardian Electric Mfg. Co. - Ratchet Relay Type S-120 A.C. - Double Pole, Double Throw - 110 volt - 60 cycle (600 volt Insul.)</td>
<td></td>
</tr>
<tr>
<td>Argon and Water Valves</td>
<td>Automatic Switch Co. - &quot;Asco&quot; Solenoid Valve - 110 volt - 60 cycle - Cat. No. X92652 for Water or Argon - 125 lbs./sq. in. Max.</td>
</tr>
<tr>
<td>Terminal Block</td>
<td>Howard B. Jones - Terminal Block No. 142 - Cat. No. 10-142</td>
</tr>
<tr>
<td>110 volts to 6 volts Transformer</td>
<td>Insulating Transformer - 50 watts - Open Type - Primary 110 volt - secondary 6 volt</td>
</tr>
<tr>
<td>Condenser</td>
<td>&quot;C&quot; P. R. Mallory &amp; Co. - Dry Electrolytic Condenser - 8 Mfd. - 250 volt</td>
</tr>
<tr>
<td>Control Switch</td>
<td>General Electric Co. - Switchette Size 1 - Cat. No. CR1070 - C101F3 (IN.O. &amp; IN.C.)</td>
</tr>
</tbody>
</table>

**TABLE 3**

<table>
<thead>
<tr>
<th>OPERATING CYCLE IN TIME SEQUENCE</th>
<th>RELAY</th>
<th>RELAY</th>
<th>CONTACTOR</th>
<th>PRIMARY CONTACTOR</th>
<th>ARGON WATER VALVE</th>
<th>TIMER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line switch turned to &quot;on&quot; position.</td>
<td>Energized only when control switch is held down. Contacts L3-4, L3-5 and L3-6 reverse every time control switch is operated.</td>
<td>Energized Contacts L3-8 closed</td>
<td>Energized Contacts L3-8 closed</td>
<td>Energized Contacts L3-8 closed</td>
<td>Open</td>
<td>Energized motor running. Contacts L3-4 open at end of time interval if arc not established.</td>
</tr>
<tr>
<td>Electrode moved to work and control switch depressed. Welding transformer, high-frequency, water and argon turned on. Arc is established.</td>
<td>Energized by open-circuit voltage and will shut off transformer if control switch is not operated. Contacts 1-3A closed, 14-15 open.</td>
<td>Energized by Contacts 1-3A or by depressing control switch. Contacts L3-4 and L3-6 open, Contacts L3-5 close</td>
<td>De-energized Contacts L3-8 open.</td>
<td>De-energized Contacts L3-8 open.</td>
<td>Open until time period of Contacts L3-4 open.</td>
<td>Energized motor running (motor stops running but remains energized). Contacts L3-4 remain open as long as time switch is closed.</td>
</tr>
<tr>
<td>Line switch opened.</td>
<td>De-energized</td>
<td>De-energized</td>
<td>De-energized</td>
<td>De-energized</td>
<td>De-energized</td>
<td>De-energized</td>
</tr>
</tbody>
</table>

*This is an impulse relay.*
"HELIARC" A.C. WELDING-CONTROL CIRCUIT NO.3
SWITCH CONTROLLED AUTOMATIC STARTING FOR HIGH-FREQUENCY CURRENT, WATER AND ARGON WITH H-F SHUT-OFF WHEN NOT WELDING AND DELAYED WATER AND ARGON SHUT-OFF.
G. No. 4 - Automatic Semi-Touch Control For Argon And Water With Direct Current Welding

1. DESCRIPTION

Argon and water are controlled by this unit. When the welding generator is running, the electrode is constantly energized. The unit is actuated by the difference between open-circuit voltage (about 60 volts) and arc voltage (about 10 to 25 volts). Touching the electrode to the work causes relay R3 to drop out, closing contacts 1 and 2 of R3, which in turn open the argon and water valves. R4 is added to prevent argon and water valves from remaining open when the welding generator is turned off and the unit is left on. When the generator is turned off, contacts 3 and L4 of R4 become de-energized. Adjustable resistors A and B fix the operating ranges of relays R3 and R4 respectively. Connections 5 and 7 are made at the generator binding post to avoid voltage drop in the output leads.

This unit is satisfactory from the standpoint of argon and water conservation, and convenience. It is recommended for DCSP welding of such materials as stainless steel, carbon steel, etc. Radio interference presents no problem with DCSP welding.

Because there is slight delay from the time the electrode is touched to the work until full argon protection is established, it is not recommended for AC welding of aluminum and magnesium. It is not satisfactory for crater control and therefore, should not be used for welding high-temperature alloys.

2. MATERIAL REQUIREMENTS

- **Contactor** - General Electric A.C. Magnetic Contactor - CR 2810 - 1265 - GI - Cat. No. 2666530-1 - 110 volts - 60 cycle - Single Pole - Normally open - (Pick up at 24 volt D.C. - Drop out at 5 volt D.C.)
- **Line Switch** - Arrow Hart & Hedgeman Switch - Double Pole - Single Throw - Cat. No. 80602
- **Time Delay Timer** - Haydon Manufacturing Co. - #5901-2 Adjustable Reset Timer - 60 Seconds - Normally Closed Contacts - 110 volts - 60 cycle
- **Water & Argon Solenoid Valve** - Automatic Switch Co. - "Asco" Solenoid Valve - 110 volts - 60 cycle - Cat. No. X82651 - for Water or Argon - 125 lbs./sq. in. max. - Resilient Seat
- **Terminal Block** - Howard B. Jones - Terminal Block No. 142 - Cat. No. 10-142

---

**TABLE 4**

**OPERATING CYCLE FOR CONTROL CIRCUIT NO. 4**

<table>
<thead>
<tr>
<th>OPERATING CYCLE IN TIME SEQUENCE</th>
<th>RELAY (R4)</th>
<th>RELAY (R3)</th>
<th>ARGON SHUTOFF TIMER (TD)</th>
<th>RELAY (R5)</th>
<th>ARGON VALVE (AV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All apparatus connected, Welding generator not running. Control unit line switch in &quot;off&quot; position.</td>
<td>De-energized Contacts 3-14 open</td>
<td>De-energized Contacts 2-4 open; Contacts 1-2 closed</td>
<td>De-energized Motor not running</td>
<td>De-energized Contacts 1-2 open.</td>
<td>Closed</td>
</tr>
<tr>
<td>Control unit line switch turned to &quot;on&quot; position.</td>
<td>Energized Contacts 3-14 closed</td>
<td>Energized Contacts 2-4 closed; Contacts 1-2 open</td>
<td>Energized Motor running</td>
<td>Energized Contacts 1-2 closed</td>
<td>Open</td>
</tr>
<tr>
<td>Welding generator turned on to energize current output leads.</td>
<td>Energized Contacts 3-14 closed</td>
<td>Energized Contacts 2-4 closed; Contacts 1-2 open</td>
<td>Energized Motor running</td>
<td>Energized Motor stopped.</td>
<td>De-energized Closed</td>
</tr>
<tr>
<td>Welding electrode touched to workpiece. Open-circuit welding voltage decreases.</td>
<td>De-energized</td>
<td>Energized</td>
<td>Energized Motor running</td>
<td>Energized</td>
<td>Open</td>
</tr>
<tr>
<td>Welding electrode removed immediately from workpiece. Welding circuit returns to full voltage.</td>
<td>Energized</td>
<td>De-energized</td>
<td>De-energized Motor stopped</td>
<td>De-energized Motor stopped</td>
<td>Energized</td>
</tr>
<tr>
<td>Welding arc established, to begin welding.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welding arc extinguished by removing torch from workpiece</td>
<td>Energized</td>
<td>De-energized</td>
<td>Energized Motor running</td>
<td>De-energized</td>
<td>De-energized Closed</td>
</tr>
<tr>
<td>Welding generator shut off. Control unit line switch turned to &quot;off&quot; position.</td>
<td>De-energized</td>
<td>De-energized</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10
"HELIARC" DC WELDING-CONTROL CIRCUIT NO. 4
AUTOMATIC ARGON AND WATER DELAYED SHUT-OFF
H. No. 5 - Automatic Full-Touch Control For Power, High-Frequency, Water And Argon

In this circuit, a low control voltage is supplied to the electrode by a resistor across the primary contactor. Welding services are off until the electrode is momentarily touched to the work. Argon and water are turned on immediately; high-frequency and welding power are delayed for about two seconds. This delay permits full argon protection from the very start of the weld. If the electrode is held close to the work, high-frequency will initiate welding action. If the arc is not started, a second timer will turn off power and high-frequency after a delay of about two seconds. Welding action is stopped by lifting the torch from the work, after which power and high-frequency are turned off by the timer within a few seconds. A third timer delays argon and water shut-off. Wiring and circuit diagrams are not provided for this unit.

A major advantage of this unit is its safety factor for welding in outdoor, wet or hazardous locations. It is not recommended for crater control because the torch must be lifted from the work to interrupt welding action. This is of little significance since materials that present crater control problems are seldom welded in outdoor locations. However, crater control can be had by adding a switch to the torch and a 6-110 volt transformer to the circuit. In this case, the switch is connected to the 6-volt side of the transformer and the 110-volt side in series with the 110-volt primary power contactor.

I. Control Panel For Mechanical Welding

Remote control of argon flow, welding current, and travel carriage may be had by use of a relatively simple control panel for mechanized welding. A wiring diagram of such a unit is shown below in Fig. 1. Power is supplied from a 110-volt, 60-cycle line. When the argon switch is in the "off" position, all other controls are also inoperative. Such an arrangement avoids faulty starting and waste of material. R4 is a 110-volt coil relay having a single set of contacts. It operates a contactor (for A.C. welding) or a field circuit interruption device (for D.C. welding). The unit is self-contained except for the argon valve.

![Control Panel Wiring Diagram for Mechanized Welding](image)

Figure 1
<table>
<thead>
<tr>
<th>Circuit No.</th>
<th>Approx. Mat. Cost</th>
<th>Service Controls</th>
<th>Operating Type</th>
<th>Relative Merit For</th>
<th>Recommended For</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>*118.00</td>
<td>X X X</td>
<td>X X</td>
<td>B A C B A</td>
<td>A A A A A A B</td>
</tr>
<tr>
<td>2</td>
<td>62.00</td>
<td>X X X</td>
<td>X X</td>
<td>B B B A E</td>
<td>A A D A E B D</td>
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<td>3</td>
<td>138.35</td>
<td>X X X</td>
<td>X X</td>
<td>B A B B A</td>
<td>A A A A A A B</td>
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<tr>
<td>4</td>
<td>53.00</td>
<td>X X X</td>
<td>X X</td>
<td>C C A D D</td>
<td>C A D D B B D</td>
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<tr>
<td>5</td>
<td>170.00</td>
<td>X X X</td>
<td>X X</td>
<td>A A A A E</td>
<td>A A A A D A A</td>
</tr>
</tbody>
</table>

A - Best  
B - Good  
C - Poor  
D - Not Recommended  
E - Cannot be Used  

*Cost includes $75.00 for main power contactor. This may be eliminated.
Figure 2 - Method of notching torch handle to accommodate switch. Note layer of insulating tape wrapped around copper body of torch below the notch.
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