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1. DC-4 System Description

The DC-4 system is designed to monitor, control and indicate combustion chamber pressure, and, if necessary, automatically shut down the burner if inadequate pressure is sensed for a preset period of time. Factory-set jumpers enable operation on appropriate flame safeguards and parallel positioning systems. The standard DC-4 comes with a -3.0 to +3.0 inches water column (in. w.c.) differential pressure transmitter and a +0.07 to +0.15 in. w.c. adjustable low draft switch (low draft implies high combustion chamber pressure). Other ranges are available if required—consult factory (or refer to DC-4 Sequence Overfire Draft Controls: Model Identification and Pricing Worksheet). The panel-top mounted LCD text display indicates draft conditions between -3.0 and +3.0 in. w.c. and damper motor status. For example, the DC-4 system will work with a design combustion chamber pressure of +0.5 in. w.c. draft. Typical set points for a desired +0.5 in. w.c. are shown in Figure 1.

![Figure 1: Typical Draft Control Setpoints](image)

The control’s deadband (no movement of draft damper) is between the upper and lower setpoints. If the combustion pressure decreases below the lower activation point, the damper motor closes the draft damper and the combustion chamber pressure increases. If the combustion pressure increases above the upper activation point, the damper motor opens the draft damper and the combustion chamber pressure decreases. If the pressure reading is within either proportional band, the motor will pulse on and off, effectively slowing the damper motor as it nears the desired draft range to help prevent overshooting the desired draft setpoint.

The Open/Close/Auto selector switch is used to choose the operating mode of the DC-4 draft control system. In the Open mode, the burner will operate with the damper motor in the open position. The draft control will operate as described above while in the Auto mode. The Close
mode will shut the damper motor and disable the burner. This switch is useful for troubleshooting and during the installation of the system to stroke the linkage and for use as a local switch to shutdown the burner.

If the sensor should fail or if the sensor wiring becomes disconnected, the damper will open and the display will annunciate a “Sensor Out of Range” alarm. On the following call for heat cycle, the damper motor will still be held open. This will cause the burner to not progress in its firing sequence because the low fire start interlock circuit will not be complete.

2. DC-4 for Negative Draft Control

The system can be equipped with draft controlling devices suitable for natural or induced negative-draft applications. For example, the DC-4 system could be used on a boiler with a design combustion chamber pressure of -0.07 in w.c. draft. This system would be equipped with the standard -3.0 to +3.0 differential pressure transmitter and a low draft switch (i.e. high combustion chamber pressure switch) adjustable from +0.07 to +0.15 in w.c. The upper activation point is -0.05 in w.c., and the lower draft setpoint is -0.10 in w.c. The low draft switch prevents burner operation under positive pressure conditions by being set at +0.07 in w.c.

Figure 2: Example Draft Control Setpoints for Negative Draft Application

Figure 2 shows the setpoint relationship. If the combustion pressure decreases below the lower activation point, the damper motor closes the draft damper and the combustion chamber pressure increases. If the combustion chamber pressure increases above the upper activation point, the damper motor opens the draft damper and the combustion chamber pressure decreases. If the pressure reading is within either proportional band, the motor will pulse on and off, effectively slowing the damper motor as it nears the desired draft range to help prevent overshoot.
The included low draft switch interrupts the burner’s air switch (non-recycle interlock) circuit if the combustion pressure draft decreases below the setpoint of the switch (combustion pressure is too high). A low draft condition must exist until the delay-on-break timer has timed out (relay opens the circuit). Once the relay times out, the burner’s air switch circuit will open, and the low draft light will illuminate to annunciate the fault. The adjustable timer is typically set from 5 to 8 seconds. Do not exceed 8 seconds.

3. DC-4 Sequence of Operation for Modulation Motor Equipped Burners

Note: Active PLC input and Output LEDs designated by I-x.x or Q-x.x in parenthesis, respectively. Q-2.X refers to inputs on the PLC expansion module. Input I-0.0 is factory set for use with modulation motor equipped burners or with stand alone parallel positioning systems.

1. Initial conditions: Open/Close/Auto switch is in auto (I-0.3), system at standby, call for heat satisfied, flame safeguard is not locked out, and the stack damper is in the closed position. When a call for heat (I-2.6) is received, the burner’s flame safeguard energizes the blower motor (I-2.5). The draft control system detects the energized blower motor and the “drive to high fire purge” signal (I-2.0), the draft damper is driven to the full open position (Q-0.1 opens damper). The damper motor’s purge interlock switch is wired in series with the burner’s mod motor purge interlock switch, so that both motors must be in the full open position to begin the prepurge timing. After the prepurge timing is complete, the flame safeguard drives the burner’s mod motor to the closed position in preparation for light off. The damper motor is driven toward the closed position (Q-0.2) until it makes the low fire start interlock switch in the draft damper motor. The variable setting of this switch provides the user with an “adjustable start position”. When this adjustable start position switch makes (I-2.7) and the burner’s comparable switch makes, then the flame safeguard’s low fire start input is made allowing the flame safeguard to proceed to pilot light off.

2. Once pilot and main flame have been proven, the burner goes into modulation mode (I-2.1). The Modulation lamp will be illuminated and the draft controller is allowed to modulate the stack damper to maintain the desired draft condition by energizing Q-0.1 and Q-0.2 as needed. The LCD display will also state the status of these outputs-Damper Opening, Damper Closing, or Damper Inactive.

3. When the call for heat is satisfied and the modulation signal is removed, the flame safeguard begins the postpurge sequence and the stack damper is driven to the open position. Once the postpurge is complete, the stack damper is driven shut to retain heat in the boiler.

4. If a safety lockout/flame failure occurs (I-2.2), the damper motor drives open and keeps the damper in the full open position until the flame safeguard control is reset. The Flame Failure lamp is illuminated as well. If a low draft condition has occurred (I-2.4), the Low Draft lamp (Q-0.6) will illuminate in lieu of the Flame Failure lamp. In some control scenarios, both lamps may illuminate.

5. If the High Stack Temperature (-TC) option is present, the control will signal the PLC that an alarm has occurred through input I-2.3. The High Temp light (Q-0.4) will be illuminated
6. If the Open/Closed/Auto switch is in the Open position (I-0.2), the burner will be allowed to fire. The low fire start input will be bypassed by the switch, so its input, I-2.7, will be illuminated.

4. DC-4 Sequence of Operation for Parallel Positioning Systems

Note: Active PLC input and Output LEDs designated by I-x.x or Q-x.x in parenthesis, respectively. Input I-0.1 is factory set for use with parallel positioning equipped burners with integral flame safeguards.

1. Initial Conditions: Open/Close/Auto switch is in auto (I-0.3), system at standby, call for heat satisfied, flame safeguard is not locked out, and the stack damper is in the closed position. When a call for heat (I-2.6) is received, the burner’s flame safeguard energizes the blower motor (I-2.5). The draft control system detects the energized blower motor the draft damper is driven to the full open position (Q-0.1 opens damper). When the stack damper motor is proven open (I-2.0), the Prepurge timer begins to count (reference section 6.3). Q-0.7 makes to signal the flame safeguard or a relay to tell the system that the damper is open. The timer value should be set as required to closely match the speed of the burner’s servo motor moving to the purge position and prepurge time. After this timer times out, the stack damper motor is driven toward the closed position (Q-0.2) until it makes the low fire start interlock switch in the draft damper motor. The variable setting of this switch provides the user with an “adjustable start position”. When this adjustable start position switch makes (I-2.7) and the burner’s servo is at low fire, the flame safeguard will proceed to pilot light off. Q-1.0 makes to signal the flame safeguard or a relay that the unit is in this position.

2. Once pilot and main flame have been proven, the burner goes into modulation mode. This is detected by monitoring the fuel valve (I-2.1) which starts the modulation delay timer. (reference section 6.3) The Modulation lamp will be illuminated (Q-1.1) and the draft controller is allowed to modulate the stack damper to maintain the desired draft condition by energizing Q-0.1 and Q-0.2 as needed. The LED display will also state the status of these outputs- Damper Opening, Damper Closing, or Damper Inactive.

3. When the call for heat is satisfied and the fuel valve signal is removed, the flame safeguard begins the post purge sequence and the stack damper is driven to the open position. This opening time is determined by the postpurge timer (reference section 6.3). Once the postpurge is complete, the stack damper is driven shut to retain heat in the boiler.

4. If a safety lockout/flame failure occurs (I-2.2), the damper motor drives open and keeps the damper in the full open position until the flame safeguard control is reset. The Flame Failure lamp is illuminated as well. If a low draft condition has occurred (I-2.4), the Low Draft lamp (Q-0.6) will illuminate in lieu of the Flame Failure lamp. In some control scenarios, both lamps may illuminate.

5. If the High Stack Temperature (-TC) option is present, the control will signal the PLC that an alarm has occurred through input I-2.3. The High Temp light (Q-0.4) will be illuminated as well.
6. If the Open/Close/Auto switch is in the Open position (I-0.2), the burner will be allowed to fire. The low fire start and purge position outputs will be on as long as the damper is proven to be in the open position.

5. Installation

The DC-4 system is mounted in the burner’s electrical enclosure. Remote wall mounted or free standing enclosures are optional. In these two cases, the box should be mounted in a vibration-free area where the ambient temperature remains between 20 and 120 degrees Fahrenheit. Note that the pressure sensing line should be kept to a minimum length; long sensing lines will dampen detection of chamber pressure fluctuations and may increase the response time of the system. The sensing line attached to the boiler must be installed to sense combustion chamber pressure. For Firebox boilers, if there is no connection on the side of the boiler for a sensing line, the sensing line may be connected to a fitting placed in the firebox door. For Scotch Marine Boilers, the sensing line may be connected at the observation port in the back of the boiler. The sensing line size and sensing location in the heat exchanger must comply with any applicable local approval agencies.

The Power Flame recommended minimum sampling line size is as follows:

<table>
<thead>
<tr>
<th>Length of line from sensing point to control</th>
<th>Pipe I.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 40 feet</td>
<td>3/4”</td>
</tr>
<tr>
<td>40 to 60 feet</td>
<td>1”</td>
</tr>
<tr>
<td>60 to 80 feet</td>
<td>1-1/4”</td>
</tr>
</tbody>
</table>

Runs should not exceed 80 feet.

When designing the pipe run, use a tee or cross fitting with plugs at each turn to allow for easier pipe cleaning.

Note that tee or cross fittings have an effect equivalent to four feet of pipe. Add four feet for each tee or cross when calculating overall line length.

When installing the pipe run, use piping dope to insure air-tight joints. The final connection to the DC-4 panel is a 1/4” OD one touch tubing fitting.

All DC-4 systems ship with a #69 drilled orifice installed in the sampling line to dampen pulsations. If the system response seems sluggish after lowering the damping factor to the lowest value, remove the orifice from the line and replace with a 1/8” NPT short nipple.

The DC-4 system installer must build a bracket to properly support the damper motor. The bracket design should be such that heat from the exhaust stack is not transferred to the damper motor. The damper motor shaft should be mounted near the boiler flue at a height nearly equal to the stack damper’s shaft. The stack damper shaft and the damper motor shaft should be parallel. The linkage kit provided connects the damper motor shaft to the damper shaft. The –HD option requires that a user-supplied ¾” NPT pipe of appropriate length be attached to the included stack damper actuator ends. The Open/Close/Auto selector switch is useful to ensure full stroke and smooth operation of the linkage. The wiring diagram provided with the burner and/or panel depicts the electrical connections between the damper motor, the DC-4 panel (if applicable), and the burner control panel. Follow all applicable National and Local Electrical Codes.
6. DC-4 Setup

**WARNING!**
Do not setup the draft control system with burner running!

User settings 6.1 through 6.4 are set through the LCD text display mounted on the DC-4 electrical panel. The main screen displays the current furnace pressure and the state of the damper motor’s movement signals- opening, closing, or inactive. Figure 3 below shows a typical LCD display with interface buttons.

![Figure 3: LCD Text Display](image)

Pressing the ESC button (escape) will bring the user to the menu screen. The up and down directional buttons will scroll through the menus. Pressing the Enter button will enter the menu and allows access to the sub menus as listed below. Other menu screens not listed below are for factory use, and should not be modified. Each value may be modified by pressing the enter button, which will make the cursor flash. The up and down arrow keys can be used to change the value. The values will reset to the min or max values if the entered values are outside of the limits listed for some of the below options. Pressing ESC will return the value to its previous setting without modification. ESC will revert out of each submenu back to the menu selection screen.
6.1 User Settings

1. **Lower Activation Point:** Value where damper motor will close if draft is less than setpoint. Will reset to minimum transmitter value if entered value is less than min. transmitter value.

2. **Upper Activation Point:** Value where damper motor will open if draft is more than setpoint. Will reset to maximum transmitter value if the entered value is more than the max transmitter value. Note: If the Upper Activation Point is lower than the Lower Activation Point, the DC-4 will reset the lower value to the value of the upper value.

3. **Proportional Band:** Band above upper activation point and below lower activation point where damper motor moves in a slower manner by pulsing the motor. Limited to 0.0-0.20.

4. **Damping Factor:** Incoming draft value is averaged to this factor. A value of 2 will have a fast response with little damping, a larger value will slow the response due to averaging over a greater time period. Limited to 2-200.

6.2 Transmitter Setup

1. **Minimum Transmitter Value:** Entered in inches w.c. Factory set per ordered pressure transmitter. May be changed in the field if transmitter range is changed.

2. **Maximum Transmitter Value:** Entered in inches w.c. Factory set per ordered pressure transmitter. May be changed in the field if transmitter range is changed.

6.3 P.P.S. Setup

   Only applicable to parallel positioning systems with built in flame safeguard. Settings have no effect otherwise.

   1. **Prepurge Timer:** Entered in seconds. Factory set to match the settings of the applicable Parallel Positioning System plus the servo’s full-stroke movement time.

   2. **Postpurge Timer:** Entered in seconds. Factory set to match the setting of the applicable Parallel Positioning System plus the servo’s full-stroke movement time.

   3. **Damper Modulation Delay:** Entered in seconds. Factory set to match the setting of the applicable Parallel Positioning System.
6.4 Modbus Setup

1. **Address**: Slave address of DC-4 system. Limited to 1-247. Cycle power to panel after changing this value.

2. **Baud Rate**: Set to match the Baud rate of the Modbus Master. Limited to 9600 or 19200. See Appendix A for available Modbus addresses.


6.5 Low Draft Switch & Delay-On-Break Time Delay Relay Adjustment

To adjust the delay-on-break time delay relay:

1. Adjust the setpoint of the Dywer 1910 Differential Pressure switch by removing the cover from the switch. A retaining screw on the bottom of the switch must be loosened, then the cover may be removed by pulling up and out from the bottom. Turn the slotted adjustment screw at the top of the switch clockwise to raise the pressure set point or counter clockwise to lower the pressure setpoint.

   **WARNING!**
   Do not setup the draft control system with burner running!

2. Connect one lead of a voltmeter to any neutral terminal strip, such as “2”, on the DC-4 panel. Connect the other lead to the normally open terminal of the low draft switch (negative control systems connect to the normally closed terminal). When the low draft switch is made, the meter will indicate 120 Volts AC.

3. Disconnect the sampling line from the bulkhead fitting on the bottom of the enclosure. Connect plastic hose or tubing to the bulkhead fitting. Gently blow into the hose or tubing (for negative systems gently inhale) until the draft switch trips as indicated by the voltmeter. Hold your finger tightly over the end of the hose to “trap” the air in the draft switch and transmitter sensing line for the purpose of adjusting the setpoint. Bleed the line down slowly to the desired switch setpoint.

4. Reconnect the voltmeter to terminal “1” of the time delay relay. The relay will open after the time delay period has lapsed. Time delay periods of 5-8 seconds are normal.

5. Repeat the procedure above until the desired time delay period is achieved.

6. Reconnect the draft sampling line to the bulkhead fitting on the panel box. Sequence the burner to verify operation of the draft control system, or proceed to section 6.6.
6.6 Zeroing the Differential Pressure Transmitter

1. Disconnect the sampling line from the bulkhead fitting on the bottom of the enclosure.

2. Apply power to the DC-4 panel and allow the transmitter to stabilize for 10 minutes. Ensure that the correct transmitter settings are set in the system. Reference section 6.2 for procedure.

3. Draft pressure should read 0.00" w.c. on the DC-4 text display. If it does not, adjust the zero setting on the Dwyer differential pressure transmitter with a small screwdriver until it reads 0.00". Counterclockwise rotation will lower the value, clockwise will raise it. The span should not need to be adjusted in the field. Reference Figure 4 for typical transmitter detail.

4. Reconnect the draft sampling line to the bulkhead fitting on the panel box. Sequence the burner to verify operation of the draft control system.
6.7 Optional Stack Temperature Monitor Adjustment (-TC option)

1. Install the thermocouple probe assembly provided into the stack. The thermocouple comes with a stainless steel compression fitting that mounts into a customer-supplied 1/8" NPT half coupler. The end of the thermocouple should be placed near the center of the exhaust stack. See Figure 5 below for illustration.

![Figure 5. Thermocouple Installation Detail](image)

2. Connect the thermocouple wire between the thermocouple probe and the DC-4 panel per the wiring diagram. Ensure the properly colored wires are installed on their respective terminals for proper temperature reading. The white wire is positive, and the red is negative on a J-type thermocouple. Run the thermocouple wire in separate conduit and route away from higher voltage lines within the panel to avoid potential noise issues. The display will show “ooo” if the probe is not connected. The display will show “---” if the value is out of range. Either of these errors will cause the control’s alarm to sound.

3. The temperature control on the DC-4 panels displays the temperature the probe is sensing. To change the high stack temperature setpoint:
   a. Press SET button. SP text will appear on the display
   b. Press SET again. The setpoint value will be shown on the screen. The value can be modified with the UP and DOWN arrow buttons.
c. Press SET and DOWN at the same time to quit programming or wait one minute for the control to automatically exit the programming mode.

4. The temperature control will sound an alarm, light the High Temperature lamp, and shut the burner off if the Setpoint is exceeded. The alarm may be silenced by pressing the SET and Down arrows at the same time. The display will alternate “Al” and the current temperature. The alarm LED will be illuminated as well.

5. When the stack has cooled one degree below the setpoint, the control can be manually reset by pressing RST button. At this time, the burner will be allowed to restart if all other conditions are met.

6. All parameters are set at the Power Flame factory prior to shipment. All are the default settings except r3=hoL and c3= Yes. See Appendix E for cutsheet.

6.8 Tuning Stack Damper Adjustable Start Switch

The DC-4 system requires adjustment to the draft damper motor’s end switch (also see Section 3, Item 2 for details on the adjustable start draft role in the burner sequence of operation). Note: this section only applicable for standard duty actuator. Please refer to Appendix B for details on the Herculine motor included with the –HD option.

1. Cycle the burner and watch the draft indication on the TD200 to determine the desired draft condition. Notice the position of the draft damper when the desired start draft is measured.

2. Remove the damper motor cover. The inner auxiliary switch cam is coded blue. This switch is factory set to make when the damper motor is in the full open position. The outer auxiliary switch cam is coded red and must be set to the position where the desired start draft is measured. Note that the outer switch is set to make on the “slow” rise portion of the cam when the desired start draft is achieved. Consult M6184 end switch adjustment details in Appendix C. This switch is factory set to make at approximately 50% of the motor’s full stroke.

3. Cycle the burner again to ensure proper operation. The stack damper will move to the full open position and then move back to the adjustable start position, and then allow the burner system to proceed with light off and run periods.
Appendix A

Modbus Address Mapping

The DC-4 system functions as a slave device on a Modbus network. The following PLC inputs and outputs, selected values, and the draft value are available as read-only values to the Modbus master. Refer to section 6.4 for selecting the Modbus address and Baud rate. Non-selectable values are 8 data bits, 1 stop bit, no parity.

<table>
<thead>
<tr>
<th>Modbus Address</th>
<th>DC-4 Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>40001</td>
<td>Averaged Draft value x 100</td>
</tr>
<tr>
<td>40002</td>
<td>Lower Activation Point x 100</td>
</tr>
<tr>
<td>40003</td>
<td>Upper Activation Point x 100</td>
</tr>
<tr>
<td>40004</td>
<td>Proportional Band setting x 100</td>
</tr>
<tr>
<td>40005</td>
<td>Damping Factor setting</td>
</tr>
<tr>
<td>40006: Least significant bit at top of list, to most significant bit at bottom of list.</td>
<td></td>
</tr>
</tbody>
</table>

(LSB) Open Switch position
Auto Switch position
Drive to high fire input (FSG mode) or damper purge switch made, PPS mode
Modulation mode input (FSG mode) or Fuel valve input, PPS mode
Flame Failure/Lockout input
Motor On input
Limit Circuit Closed input
Damper Adjustable start switch input made in auto mode
Output to close Damper motor
Output to open damper motor
High stack temperature condition
Flame Failure condition
Low Draft condition
Start release relay, PPS mode
Low Fire relay, PPS mode

(MSB) Closed switch position
Appendix B

Troubleshooting Tips

The following troubleshooting guide can help the service technician to quickly diagnose and solve many problems.

Problem: Motor will not move as expected
   Solutions: Ensure Open/Close/Auto switch is in the correct position.
              Move Open/Close/Auto switch to the close position. Damper should close.
              Move Open/Close/Auto switch to the open position. Damper should open.
              Check connection to damper motor if the motor does not move accordingly.

Problem: Text display will not function
   Solutions: Ensure the 9 pin cable is securely attached to the display and the PLC.

Problem: Stack temperature reads too high.
   Solutions: Ensure J-type thermocouple wire is used to connect control to thermocouple.
              This wire is polarity sensitive. Red is – and White is +.

Problem: Text display reads “Sensor out of range”
   Solutions: Thermocouple has failed, or became disconnected. Refer to section 6.7

The PLCs input and output LEDs can be a valuable troubleshooting tool. Refer to applicable section to see which LEDs should be illuminated during the sequencing of the control. A job-specific I/O list is written at the bottom of the wiring diagram.
Appendix C

M6184 Damper Actuator (standard system)

The following sheets give details on mounting, wiring, and the adjustment of end switches.
Wiring

**CAUTION**
Electrical Shock or Equipment Damage Hazard.
Can shock individuals or short equipment circuitry.
Disconnect all power supplies before installation.
Motors with auxiliary switches can have more than one disconnect.

**IMPORTANT**
All wiring must agree with applicable codes,
ordinances and regulations.

1. Ensure that the voltage and frequency stamped on the
   motor correspond with the power supply characteristics.
2. When connecting several motors in parallel, ensure that
   the power supply VA rating is large enough to provide
   power to all motors used without overloading.
3. Fig. 5 shows that motor terminals are quick-connects
   located on top of the printed circuit board.
4. To access the wiring compartment:
   a. Remove the four screws from the junction box top.
   b. Lift off the cover.
5. Refer to Fig. 6 through 8 for typical wiring, and Fig. 9 for
   internal auxiliary switch connections.

**NOTE:** Reverse motor rotation by switching wires at either
the motor or panel. Reverse rotation on Series 61
models by reversing wires at terminals W and B.
Reverse rotation on Series 62 models by reversing
wires at terminals 1 and 2 (to correct motor rotation)
and reverse wires at terminals Y and G (to maintain a
feedback signal that corresponds with shaft rotation).

---

Fig. 4. Mounting the motor on a Q5001 Valve Linkage.

Fig. 5. Terminals and adjustments.
**NOTE:** Vibration does not affect Modutrol IV Motor performance (as it did in earlier Modutrol Motors). When replacing a motor that was connected to an R927C or R9107A Relay, Honeywell recommends performing a retrofit to remove the relay and the old motor. Replace both with one Series 90 Modutrol IV motor (that is, do not replace the relay).

**Fig. 6. Series 61 motor wiring.**

**Fig. 7. Series 62 motor wiring.**

**Fig. 8. Connections to R927C or R9107A Relay.**

**Fig. 9. Auxiliary switch schematic.**

---

**SETTINGS AND ADJUSTMENTS**

**Adjustable Stroke**

On adjustable stroke motors, stroke is field-adjustable between 90° and 160°.

- The mechanical adjustment (cams) establishes the fully open (clockwise, as viewed from the power end) and fully closed positions of the motor shaft.
- The electrical adjustment (trim potentiometer) matches the feedback resistance change to the motor stroke.
- TRADELINE® motors are shipped with stroke set at 160°.

---

**CAUTION**

Careless Installation Hazard.
Use of excessive force while adjusting cams damages the motor.
To avoid damaging motor end switches, set cams by moving only the screwdriver top.

**CAUTION**

Equipment Damage Hazard.
Can damage the motor beyond repair.
Never turn the motor shaft by hand or with a wrench. Forcibly turning the motor shaft damages the gear train and stroke limit contacts.

**Before Setting Stroke**

1. Remove the top cover from the motor.
2. Disconnect the controller from the motor.
3. For models with an internal transformer (line voltage motors), ensure that power (and nothing else) remains connected to the motor.

**IMPORTANT**

Detach linkage from motor before adjusting stroke.
Setting Stroke at 90° or 160°

1. Adjust the trim potentiometer:
   a. For 160° stroke, turn fully clockwise.
   b. For 90° stroke, turn fully counterclockwise.

2. Drive the motor to the mid-position as follows:
   a. For models with an internal transformer (line voltage motors), connect a jumper across terminals R and 2 to drive motor open (clockwise, as viewed from power end), or across terminals R and 1 to drive motor closed (counterclockwise) until motor reaches mid-position.
   b. For models with no internal transformer (low voltage motors), connect 24 Vac across terminals 2 and 3 to drive motor open (clockwise, as viewed from the power end), or across terminals 1 and 3 to drive motor closed (counterclockwise) until motor reaches mid-position.

3. Insert 1/8 in. screwdriver blade into a slot on inner cam and proceed as follows:
   a. For 90° stroke: Move the screwdriver top as far as possible counterclockwise (viewed from the power end).
   b. For 160° stroke: Move the screwdriver top as far as possible clockwise (viewed from the power end).

   See Fig. 10. Repeat in successive cam slots until the inner cam is against the stop.

   NOTE: For low torque motors (75 lb-in. or less), omit step 4 and proceed to step 5.

4. Insert 1/8 in. screwdriver blade into a slot on outer cam and proceed as follows:
   a. For 90° stroke: Move the screwdriver top as far as possible clockwise (viewed from the power end).
   b. For 160° stroke: Move the screwdriver top as far as possible counterclockwise (viewed from the power end).

   See Fig. 10. Repeat in successive cam slots until the outer cam is against the stop.

5. Check the motor stroke before connecting the linkage.
6. Reconnect the controller, replace the motor top cover and attach the linkage to the motor.

Setting Stroke Between 90° and 160°

1. Adjust the trim potentiometer fully clockwise.

2. Drive the motor to the mid-position as follows:
   a. For models with an internal transformer (line voltage motors), connect a jumper across terminals R and 2 to drive motor open (clockwise, as viewed from power end), or across terminals R and 1 to drive motor closed (counterclockwise) until motor reaches mid-position.
   b. For models with no internal transformer (low voltage motors), connect 24 Vac across terminals 2 and 3 to drive motor open (clockwise, as viewed from the power end), or across terminals 1 and 3 to drive motor closed (counterclockwise) until motor reaches mid-position.

3. Insert 1/8 in. screwdriver blade into a slot on inner cam and move the screwdriver top as far as possible clockwise (viewed from the power end). See Fig. 10. Repeat in successive cam slots until the inner cam is against the clockwise stop.

4. Drive the motor to the fully-open position as follows:
   a. For models with an internal transformer (line voltage motors), connect a jumper across terminals R and 2 until the motor reaches the fully-open position.
   b. For models with no internal transformer (low voltage motors), connect 24 Vac across terminals 2 and 3 until motor reaches the fully-open position.

   NOTE: The motor should now be in the 90° position.

IMPORTANT

During step 5, allow the motor to reposition after each move of the cam.

5. Insert 1/8 in. screwdriver blade into a slot on inner cam and move the screwdriver top slowly clockwise (viewed from the power end). Repeat this procedure until the motor reaches the desired fully-open position.

   NOTE: Each click of the cam provides approximately 2 degrees of rotation.

IMPORTANT

If the motor turns past the desired position, do not move the cam.

6. If the motor turns past the desired position, drive the motor to mid-position, then move the cam clockwise to the stop and repeat steps 4 and 5.

   NOTE: Drive the motor to mid-position as follows:
   a. For models with an internal transformer (line voltage motors), connect a jumper across terminals R and 2 to drive motor open (clockwise, as viewed from power end), or across terminals R and 1 to drive motor closed (counterclockwise) until motor reaches mid-position.
   b. For models with no internal transformer (low voltage motors), connect 24 Vac across terminals 2 and 3 to drive motor open (clockwise, as viewed from the power end), or across terminals 1 and 3 to drive motor closed (counterclockwise) until motor reaches mid-position.

7. Once the desired position is reached, set the electrical stroke limit:
   a. Slowly adjust trim potentiometer counterclockwise until the motor starts to move.
   b. Stop and turn trim potentiometer 1/8 turn clockwise.

   NOTE: This last adjustment ensures total motor movement over the full range of the controller.

8. Check for proper electrical stroke setting by opening the W lead. The motor should not move.
Feedback Potentiometer Configuration (Series 62 TRADELINE® Motors Only)
Select and install one of four shunt resistors to obtain the appropriate feedback characteristic for your application. See the Specifications section for details on feedback resistance without a shunt resistor.

- Linear feedback provides linear indication of shaft position with no shunt resistor. With no shunt resistor, full stroke feedback resistance is 600 ohms for 160° stroke motors and 355 ohms for 90° stroke motors.
- W902 Control requires full stroke feedback resistance of 115 ohms. Select and attach the proper shunt resistor across terminals Y and G (see Table 5 and Fig. 11).
- Slaving a Series 90 Motor requires full-stroke feedback resistance of 142 ohms. Select and attach the proper shunt resistor across terminals Y and G (see Table 5 and Fig. 11).

### Table 5. Shunt Resistor Selections.

<table>
<thead>
<tr>
<th>Stroke</th>
<th>Linear Feedback</th>
<th>W902 Control&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Slaving Series 90 Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>90°</td>
<td>None</td>
<td>Green (174 ohms)</td>
<td>Purple (274 ohms)</td>
</tr>
<tr>
<td>160°</td>
<td>None</td>
<td>White (143 ohms)</td>
<td>Red (187 ohms)</td>
</tr>
</tbody>
</table>

<sup>a</sup> Note that the W902 Control is obsolete, replaced by the W964F, which does not require a feedback signal.

### Auxiliary Switches
Adjustable cams actuate the auxiliary switches. These cams can be set to actuate the switches at any angle within the motor stroke. Select switch differential of 1° or 10°.

Motors with factory-added auxiliary switches are shipped in the closed position (fully counterclockwise, as viewed from the power end). Auxiliary cam default actuates the switches 30° from fully open with a 1° differential. With the motor in the closed (fully counterclockwise) position, the auxiliary switch breaks contacts R-B. See Fig. 9 (or the auxiliary switch Installation Instructions) for auxiliary switch wiring.

TRADELINE Motors are shipped with auxiliary switch cams that permit acceptance of 220736A,B Internal Auxiliary Switch Kits. Refer to form 63-2228 for 220736A,B Installation Instructions.
Auxiliary Switch Adjustment

**IMPORTANT**

When adjusting the auxiliary switch cams use the following procedure:
1. Insert 1/8 in. screwdriver blade into a slot on cam and move the screwdriver top as far as possible in the required direction. See Fig. 12.
2. Repeat step 1 in successive cam slots until the cam is in the required position.

Use the following procedure to obtain the desired auxiliary switch settings:
1. Remove the top cover from the motor to gain access to the motor terminals and auxiliary cams.
2. Disconnect the controller from the motor.
3. Drive the motor to the position where the auxiliary equipment is to be switched as follows:
   a. For Non-Spring Return models without a transformer, connect 24 Vac to terminals 2 and 3 to drive motor open (clockwise as viewed from the power end), or to terminals 1 and 3 to drive motor closed (counterclockwise).
   b. For Non-Spring Return models with a transformer, jumper across terminals R and 2 to drive motor open (clockwise as viewed from the power end), or across terminals R and 1 to drive motor closed (counterclockwise).
   c. For Spring Return models, connect a jumper across terminals 2 and 4 to drive the motor open, or across terminals 1 and 4 to drive the motor closed.

4. Once motor reaches correct position, disconnect the jumper.
5. For a switch differential of 1°, check continuity of auxiliary switch contacts R-B and rotate the cam as follows:
   a. If the contacts are open, rotate the cam clockwise until the R-B contacts close.
   b. If the contacts are closed, rotate the cam counterclockwise until the R-B contacts open.
6. For a switch differential of 10°:
   a. For Spring Return models, rotate the cam approximately 180° so the slow-rise portion of the cam actuates the switch. Then check continuity of the auxiliary switch contacts R-B.
   b. For Non-Spring Return models, check continuity of the auxiliary switch contacts R-B.
7. Rotate the cam as follows:
   a. If the contacts are open, rotate the cam counterclockwise until the R-B contacts close.
   b. If the contacts are closed, rotate the cam clockwise until the R-B contacts open.
8. Check for the proper differential and switching of the auxiliary equipment by driving the motor though the full stroke in both directions.
9. Disconnect the jumper, reconnect the controller, and replace the top cover on the motor.

**NOTE:** Changing the differential from 1° to 10° reverses the switching action. For example, with a 10° differential, switch contacts R-B make and R-W break on a counterclockwise (closed) rotation. With a 1° differential, switch contacts R-W make and R-B break on a counterclockwise (closed) rotation.

---

**Fig. 12. Auxiliary switch adjustment.**
Appendix D

Herculine Damper Actuator Detail (-HD option)

The following sheets give details on mounting, wiring, and the adjustment of end switches.
Installation

Installation Overview

The procedures to install the HercuLine® 2000 Series actuator and place it in service require that you:

- Select a suitable location for installation. (See Installation Considerations below.)
- Mount the actuator securely.
- Install mechanical connections or linkage between control arm and final control element. Use HAL software application to aid in mechanical installation.
- Make all electrical connections for actuator according to local and national electrical codes.
- Power up actuator.
- Enter, verify and adjust set up parameters for proper operation.
- Adjust control arm linkage for accurate operation of final control element.

This section provides you with mechanical and electrical installation information required to mount and connect the HercuLine® 2000 Series Actuator to your specific application. Unpacking instructions, installation considerations, electrical and safety precautions also included in this section should be observed.

Mechanical Stops

**CAUTION**

Factory set at 90° or 150° (+/-5°).

See Figure 2 for location.

**Attention:** Do not adjust the mechanical stops. Adjusting the stops will void the warranty.
Before Starting

Unpacking

If there are visible signs of damage to the shipping container, notify the carrier and Honeywell immediately.

If there is no visible damage, compare the contents with the packing list. Notify the carrier and Honeywell immediately if there is equipment damage or shortage.

Please do not return goods without contacting Honeywell Applications Center in advance. The contact number is 1-800-423-9883.

Installation Considerations

Mount the actuator in a location where it will be easily accessible for maintenance and for manual operation by means of the handwheel. The exact location must be determined in accordance with the linkage used.

It is important that the actuator be mounted securely to a solid foundation commensurate with the maximum torque developed. Use studs or bolts that are as large as the foot mounting holes.

Allocate sufficient clearance around the actuator for the removal of all covers to permit inspection of internal parts and to provide access to the handwheel.

Actuator Mounting

Firmly bolt the actuator to a mounting surface that will not distort when subjected to the torque stresses generated by the actuator. The output shaft of the actuator should be parallel to the output shaft of the driven device. The output shaft crank arm is fully adjustable through 360°.

Mounting holes (bottom and side) and location of shaft/crank arm duplicate mounting for Honeywell Actionators M640A, 740A, 940A for drop-in replacement. Optional adaptor plates available for replacing Landis and Staefa SQM53/56 and Barber Coleman series MP495 models.
Figure 3  Outline and Dimensions of HercuLine® 2000 Series Actuators
Mechanical Installation

Linkage Set-up

Many applications require the use of a linkage assembly and often the final control element does not have a linear torque curve. The actuator linkage can be set up to achieve an optimal delivered torque distribution for specific applications. To assist with linkage design, Honeywell offers a linkage analysis software application (HAL). The software can be ordered as P/N 51197910-001.

Constant Torque Linkage (typical)

A constant torque linkage is employed when it is desired to provide a linear torque profile throughout the full range of final control element travel. In this situation, the actuator and driven crank arms will be set-up proportionally with respect to each other. Figure 4 shows a general linkage setup to achieve a linear torque profile.

![Figure 4 Constant Torque Linkage](image)

Variable Torque Linkage

A variable torque linkage is employed when it is desired to provide a non-linear torque profile throughout the full range of final control element travel. In this general situation, the actuator and driven crank arms will be set up to provide a higher torque for seating or unseating the final control element. Figure 5 shows a general linkage setup to achieve a non-linear torque profile. Note that this linkage can be characterized in many different ways by varying start angles and rotation requirements of both the Actuator Crank Arm and the Driven Arm.
**Actuator Crank Arms**

The HercuLine® 2000 Series Actuator comes standard with a crank arm with adjustable radius of 1.0 in (25.4mm) to 2.80 in (71.12mm). See Figure 6.
Electrical Installation

General Wiring Recommendations

⚠️ **WARNING** Only qualified personnel should perform wiring.
Wiring must conform to national and local electrical codes.

In general, copper wire used. Unless locally applicable codes dictate otherwise, the recommended minimum wire sizes in Table 2 should be observed.

<table>
<thead>
<tr>
<th>AWG</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Earth ground wire to common power supply.</td>
</tr>
<tr>
<td>18</td>
<td>Earth ground wire to single actuator. 120/240 V ac line leads. +24 V and common signal leads. Common signal leads, relays, and aux switches.</td>
</tr>
</tbody>
</table>

Safety Precautions

⚠️ **WARNING** An external disconnect switch must be installed to break all current carrying conductors connected to the actuator. Turn off power before working on conductors. Failure to observe this precaution may result in serious personal injury.

Actuator Connections

⚠️ **ATTENTION** The ground terminal must be connected to a reliable earth ground.

⚠️ **WARNING** While the unit is powered, a potentially lethal shock hazard exists inside the case. Do not open the case while the unit is powered. Do not access the terminals while the unit is powered.

The actuator terminal connections for the field wiring are located behind the cover on the actuator case as shown in Figure 2. Power and field wiring is brought into the actuator through two access holes located on the side of the actuator case.

⚠️ **CAUTION** Use both openings: one for low level wiring (control signal) and the other for high level wiring (120Vac). **Do not run both the High Level and Low Level wiring through the same opening.**

The screw terminals, locations, and descriptions for all customer connections are identified in the tables and figures that follow.
## HercuLine® 2000 Terminal Connections

### Table 3 Terminal Connections: HercuLine® 2000

<table>
<thead>
<tr>
<th>Connection</th>
<th>Terminal Numbers and LABEL</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot</td>
<td>1</td>
<td>Hot wire for 120/240VAC mains supply. Use only if Auto/Manual switch is present.</td>
</tr>
<tr>
<td>Neutral</td>
<td>2</td>
<td>Neutral wire for 120/240VAC mains supply</td>
</tr>
<tr>
<td>Auto/Manual Switch Contact</td>
<td>3</td>
<td>Switch contact to indicate setting of actuator AUTO/MANUAL switch.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Switch is closed when actuator is “NOT-IN-AUTO”</td>
</tr>
<tr>
<td>CW from Controller</td>
<td>5</td>
<td>CW motor drive</td>
</tr>
<tr>
<td>CCW from Controller</td>
<td>6</td>
<td>CCW motor drive</td>
</tr>
<tr>
<td>Potentiometer #1</td>
<td>7</td>
<td>Clockwise-End</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Slider</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Counterclockwise-End</td>
</tr>
<tr>
<td>Potentiometer #2</td>
<td>10</td>
<td>Clockwise-End</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Slider</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Counterclockwise-End</td>
</tr>
<tr>
<td>Protective Ground</td>
<td></td>
<td>Ground wire connection for mains supply</td>
</tr>
</tbody>
</table>

### Figure 8 HercuLine® 2000 connections

158 ohm 158 ohm ← Install resistors to convert 1000 ohm potentiometer to 135 ohms

![Diagram showing terminal connections for HercuLine® 2000 actuators](image-url)
Setting End-of-Travel Limit Switches

**ATTENTION**

Referring to Figure 31. The first two cams (starting from the front) are for the 0% and 100% limit switches (Switch #1 and Switch #2) and should not need any adjustments as they are factory set to stop the drive at 0% and 100%. See Figure 30 for limit switch settings.

![Diagram of End of Travel Limit Switch Settings](image)

Clockwise and counterclockwise rotation is the direction of the output shaft when facing the end of the shaft. As shown, full clockwise rotation of the output shaft activates SW1 and CCW rotation activates SW2.

Figure 30 End of Travel Limit Switch Settings

**REFERENCE**

An unactuated switch will have its normally closed (NC) contacts closed and its normally open (NO) contacts open.

An actuated switch will have its NC contacts become open and its NO contacts become closed. Both NC and NO contacts are available at the terminal block. See Figure 8 (page 18) and Figure 9 (page 19).

An unactuated switch has its roller arm in the up position when adjacent to the reduced diameter portion of the cam.

If it becomes necessary to do adjust the limit switch cams in the field, use the procedure given in Table 32.

**WARNING**

While the unit is powered, a potentially lethal shock hazard exists inside the case.
## Table 32 End-of-Travel Limit Switch Setting Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Remove AC power to the actuator.</td>
</tr>
<tr>
<td>2</td>
<td>Remove the six screws and the cover from the actuator case. See Figure 2. Lay cover assembly on a flat surface.</td>
</tr>
</tbody>
</table>
| 3    | Using a flat blade screwdriver in the slots at the edge of the cams, or your finger, rotate thecams until the switches are set. (See Figure 31).  
  - Rotate the actuator shaft, using the manual handwheel or the auto-manual switch, to the 0% position (this is the 0% for CCW operation using the bottom scale or 100% for CW operation using the top scale). If the actuator is installed on a damper or valve, also make sure that this position is synchronized with the travel of the final control element.  
  - Rotate the #1 limit switch operating cam to activate at this position. The switch roller arm should go from being in an up, not depressed state, to a depressed state as the cam is rotated in the direction of the shaft rotation going toward the limit position. This will cause the switch to go from NC to NO and turn off the power to the motor when the switch activates. Switch activation may be detected by the clicking sound or with a continuity tester connected to the terminals.  
  - Rotate the actuator shaft, using the manual handwheel or the auto-manual switch, to the 100% position (this is 100% for CCW operation using the bottom scale or 0% for CW operation using the top scale). If the actuator is installed on a damper or valve, also make sure that this position is synchronized with the travel of the final control element.  
  - Rotate the #2 limit switch operating cam to activate at this position. The switch roller arm should go from being in an up, not depressed state, to a depressed state as the cam is rotated in the direction of the shaft rotation going toward the limit position. This will cause the switch to go from NC to NO and turn off the power to the motor when the switch activates.  
  - If optional auxiliary switches were ordered, these switches may also be set at this time. (See Setting Auxiliary Switches (page 81). |
| 4    | Double check limit switch actuation by first manually driving the actuator to each end of travel and hearing the switch click or by detecting it with a continuity tester. Secondly, drive the actuator to both ends of travel (using the auto/manual switch or by providing minimum and full input signal) and make sure the switches activate and turn off the motor. |
ATTENTION

Make sure you do not set the switches too close to the hard stop.

Figure 31 Location of End-of-Travel Limit and Auxiliary Switches
Setting Auxiliary Switches

ATTENTION

Referring to Figure 31. The first two cams (starting from the front) are for the 0% and 100% end of travel limit switches (Switches #1 and #2) and should not need any adjustments as they are factory set to stop the actuator precisely at 0% and 100%. See Setting End-of-Travel Limit Switches (page 78).

Additional switch settings should be set so that switch #3 operates in synchronism with switch #1 (i.e., both activating when the actuator is going in the same direction) and switch #4 to operate in synchronism with switch #2, etc. See Figure 32 for auxiliary switch settings.

![Diagram of auxiliary switch settings](image)

**Figure 32 Auxiliary Switch Settings**

If it becomes necessary to do adjust the auxiliary switch cams in the field, use the procedure given in Table 33.

WARNING  While the unit is powered, a potentially lethal shock hazard exists inside the case.
### Table 33 Auxiliary Switch Setting Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Remove AC power to the actuator.</td>
</tr>
<tr>
<td>2</td>
<td>Remove the six screws and the cover from the actuator case. See Figure 2. Lay cover assembly on a flat surface.</td>
</tr>
</tbody>
</table>
| 3    | Using a flat blade screwdriver on the slots on edge of cams, or your fingers, rotate the cams until the switches are set. (See Figure 31)  
  - The auxiliary switches should be set so switches #3 and #5 operate in synchronism with switch #1 (i.e., both activating when the drive is going in the same direction) and set switches #4 and #6 to operate in synchronism with switch #2. See Figure 32 for auxiliary switch settings. |
| 4    | For Switches #3 and #5:  
  - Rotate the actuator shaft, using the manual handwheel or the auto-manual switch, to the desired low scale position.  
  - Rotate the #3 switch operating cam to activate at this position. The switch roller arm should go from being in an up, not depressed state, to a depressed state as the cam is rotated in the direction of the shaft rotation going toward the limit position. This will cause the switch to go from NC to NO and turn off the power to the motor when the switch activates. Switch activation may be detected by the clicking sound or with a continuity tester connected to the terminals.  
  - Repeat for Switch #5 if applicable. |
| 5    | For Switches #4 and #6:  
  - Rotate the actuator shaft, using the manual handwheel or the auto-manual switch, to the desired up scale position.  
  - Rotate the #4 switch operating cam to activate at this position. The switch roller arm should go from being in an up, not depressed state, to a depressed state as the cam is rotated in the direction of the shaft rotation going toward the limit position. This will cause the switch to go from NC to NO and turn off the power to the motor when the switch activates.  
  - Repeat for Switch #6 if applicable. |
| 6    | Double check limit switch actuation by first manually driving the actuator to each end of travel and hearing the switch click or by detecting it with a continuity tester. Secondly, drive the actuator to both ends of travel (using the auto/manual switch or by providing minimum and full input signal) and make sure the switches activate and turn off the motor. |
Appendix E

Dwyer TSF High Stack Temperature Limit Control Detail (-TC option)

The following sheets give details on mounting, wiring, and the adjustment of the temperature limit control.
The Series TSF Thermocouple FM Approved Limit Control provides audible alarm status along with a robust 15 amp relay output. Unit allows the user to easily select automatic or manual reset along with 10 other parameters. The TSF series has a built in reset button on the front panel or can accept an external reset.

The ease of programming and low price make the TSF series the best value limit control on the market.

Model References:
The model reference is given by TSF-WXYZ. Where each suffix can take the following values:

- W: Thermocouple Type
  - 4=J
  - 0=Red, 1=Green
- X: Display Color
  - 1=115 VAC
  - 2=230 VAC
  - 3=12 VAC
  - 4=24 VAC
- Y: Supply Voltage
  - 0′F, 1=°C

INSTALLATION
NOTE: Unit must be mounted away from vibration, impacts, water and corrosive gases.

Cut hole in panel 2.80 x 1.14 inches (71 X 29 mm).

Apply silicone (or rubber gasket) around the perimeter of the hole to prevent leakage.

Insert unit into the hole of panel.

SPECIFICATIONS
Probe Range: 0 to 700°C (32 to 999°F) for thermocouple J type. 0 to 999°C (32 to 999°F) for thermocouples K or S type.
Input: J, K, or S type thermocouple.
Output: 15 A SPDT relay @ 250 VAC resistive.
Horsepower Rating (HP): 3/4 HP.
Control Type: ON/OFF; manual/automatic reset.
Power Requirements: 110 VAC, 230 VAC, 12 VAC/VDC or 24 VAC/VDC (depending on model).
Power Consumption: 4 VA.
Accuracy: ±1% FS.
Display: 3-digit, red, 1/2" (12.7 mm) digits, plus sign.
Resolution: 1°.
Memory Backup: Nonvolatile memory.
Ambient Operating Temperature: 14 to 131°F (-10 to 55°C).
Storage Temperature: -4 to 176°F (-20 to 80°C).
Weight: 2.3 oz (65 g).
Front Panel Rating: IP64.
Agency Approvals: CE, FM, UL.

Wiring Diagram:
**List of Parameters**

<table>
<thead>
<tr>
<th>Description</th>
<th>Units</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP Set Point</td>
<td>Degrees</td>
<td>r1 to r2</td>
</tr>
<tr>
<td>r0 Differential or Hysteresis</td>
<td>Degrees</td>
<td>1 to 99</td>
</tr>
<tr>
<td>r1 Lower Value for SP</td>
<td>Degrees</td>
<td>0 to r2</td>
</tr>
<tr>
<td>r2 Higher Value for SP</td>
<td>Degrees</td>
<td>r1 to 999</td>
</tr>
<tr>
<td>r3 Reset of Control</td>
<td>Option</td>
<td>Aut/hoL</td>
</tr>
<tr>
<td>d0 High or low limit temperature</td>
<td>Option</td>
<td>Hi/Lo</td>
</tr>
<tr>
<td>c0 Minimum stopping time</td>
<td>Seconds</td>
<td>0 to 999</td>
</tr>
<tr>
<td>c2 Output status with probe</td>
<td>Range</td>
<td>Off/On</td>
</tr>
<tr>
<td>c3 Alarm energize condition</td>
<td>Option</td>
<td>No/Yes</td>
</tr>
<tr>
<td>P1 Ambient Probe Adjustment</td>
<td>Degrees</td>
<td>-30 yp 30</td>
</tr>
<tr>
<td>P5 Ambient Probe Type</td>
<td>Range</td>
<td>tCJ, tCH, tCS</td>
</tr>
<tr>
<td>H5 Access code to parameters</td>
<td>Numeric</td>
<td>0 to 255</td>
</tr>
</tbody>
</table>

**Parameter Descriptions:**
- **SP** = Set Point. Temperature we wish to activate relay output.
- **r0** = Differential or hysteresis.
- **r1** = Lower value for SP.
- **r2** = Higher value for SP.
- **d0** = High or low temperature control.

Where **TS** is the ambient temperature of the probe.

If d0 = Hi and r3 = Aut:
- If TS ≥ SP relay output ON, Buzzer ON, AL displayed.
- If TS ≤ SP - r0 relay output OFF, buzzer OFF, TS displayed.

If d0 = Hi and r3 = hoL:
- If TS ≥ SP relay output ON, buzzer ON, AL displayed.
- If TS ≤ SP - r0 it waits for reset of relay output OFF, buzzer, TS displayed.

If d0 = Lo and r3 = Aut:
- If TS ≥ SP relay output ON, buzzer ON, AL displayed.
- If TS ≤ SP - r0 relay output OFF, buzzer OFF, TS displayed.

If d0 = Lo and r3 = hoL:
- If TS ≥ SP relay ON, buzzer ON, AL displayed.
- If TS ≤ SP - r0 it waits for reset to relay output OFF, buzzer OFF, TS displayed.

- **c0** = Minimum stopping time of the load.
- **c2** = Output status with probe error.
- **c3** = Energize relay on alarm condition (Determines fail state during power loss).
  - Yes = Relay energized during alarm condition,
  - No = Relay de-energized during alarm condition.
- **P1** = Ambient probe adjustment,
- **P5** = Ambient probe type,
- **P2** = tCJ (J Type), P2 = tCH (K Type), P2 = tCS (S Type).
- **H5** = Access code to parameters (It is set to 0 from factory).

**PARAMETER PROGRAMMING**

**Set Point (SP)** is the only parameter the user can access with code protection.

Press SET. SP text will appear on the display.

Press SET again. The real value is shown on the display.

The value can be modified with the UP and DOWN arrows.

Press SET to enter any new values.

Press SET and DOWN at the same time to quit programming or wait one minute and the display will automatically exit the programming mode.

**Access to all code protected parameters:**
Press SET for 8 seconds. The access code value 0 is shown on the display (unit comes with code set at 0 from the factory).

With the UP and DOWN arrows, code can be set to user needs.

Press SET to enter the code. If the code is correct, the first parameter label is shown on the display (SP).

Move the desired parameter with the UP and DOWN arrows.

Press SET to view the value on the display.

The value can be modified with the UP and DOWN arrows.

Press SET to enter the value and exit.

Repeat until all necessary parameters are modified.

Press SET and DOWN at the same time to quit programming or wait one minute and the display will automatically exit programming mode.

*The keyboard can be reset to ZERO by turning off the controller and turning it on again while keeping the SET key depressed.*

**Reset an alarm:**
When the parameter r3 = hoL, once the relay output and alarm are activated (because of temperature ambient TS), these remain activated until a reset is received (by pressing the reset key or by closing contact in rear input). When d0 = Hi the reset is accepted if temperature ambient is below TS ≤ SP - r0. When d0 = Lo the reset is accepted if temperature ambient TS is over TS ≥ SP + r0.

**LED indication, buzzer and display messages:**
The LED Alarm indicates if the relay output is connected or not. When the relay output is connected the message AL is displayed alternated with the temperature ambient of the probe.

In normal operation the probe temperature will be shown on the display.
In case of alarm or error, the following messages can be shown:

- ErI = memory error
- *** = open probe error
- --- = ambient temperature out of range

In case of alarm or error the internal buzzer is activated. The buzzer can be silenced by pressing the SET and DOWN arrows at the same time (when a new alarm or error occurs the buzzer will sound again).

**MAINTENANCE**
Upon final installation of the Series TSF Thermocouple Limit Control, no routine maintenance is required. A periodic check of the system calibration is recommended. The Series TSF is not field serviceable and should be returned if repair is needed (field repair should not be attempted and may void warranty). Be sure to include a brief description of the problem plus any relevant application notes. Contact customer service to receive a return goods authorization number before shipping.

**Cleaning and Repair:**
Clean the surface of the display controller with a soft damp cloth. Never use abrasive detergents, petrol, alcohol or solvents.
Appendix F

Dwyer 1910 Differential Pressure Switch Detail

The following sheets give details on the Low Draft Pressure switch.
Series 1910 Pressure Switch.

Advanced design and precision construction permit these switches to perform many of the tasks of larger, costlier units. Designed for air conditioning service, they also serve many fluidics, refrigeration, oven and dryer applications. For use with air and non-combustible gases. Series 1900 switches are available with set points of 0.07 to 20 inches water column. Set point adjustment can be made easily - before or after installation. Range screw is inside conduit enclosure to help prevent tampering. For easy mounting and access, pressure and electrical connections and set point adjustment are located on one side. This permits installation in corners or spaces too small for other switches.

SPECIAL MODELS & ACCESSORIES

Special close coupled street elbow for right angle pressure connections. Can be installed on switch anytime. Zinc plated aluminum.

SPECIFICATIONS

Service: Air and non-combustible, compatible gases.
Wetted Materials: Consult factory.
Temperature Limits: -30 to 180°F (-34 to 82.2°C) (32°F for non dry air).
Pressure Limits: 45 w.c. (11.2 kPa) continuous, 10 psig (68.95 kPa) surge.
Switch Type: Single-pole double-throw (SPDT).
Repeatability: ±3%.
Electrical Rating: 15 A @ 120-480 VAC, 60 Hz. Resistive 1/8 HP @ 125 VAC, 1/4 HP @ 250 VAC, 60 Hz. Derate to 10 A for operation at high cycle rates.
Electrical Connections: 3 screw type, common, normally open and normally closed.
Process Connections: 1/8" female NPT.
Mounting Orientation: Diaphragm in vertical position. Consult factory for other position orientations.
Set Point Adjustment: Screw type inside conduit enclosure.
Weight: 1 lb. 4.5 oz. (581 g).
Agency Approvals: CE, UL, CSA, FM.

Dwyer Instruments, Inc.
P.O. Box 373 • Michigan City, IN 46361, U.S.A.

Phone: 219/879-8000 www.dwyer-inst.com
Fax: 219/872-9057 e-mail: info@dwyer-inst.com

SERIES 1910 SWITCHES — MODELS OPERATING RANGES, DEADBANDS

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Operating Range, Inches W.C.</th>
<th>Approximate Dead Band</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At Min.</td>
<td>At Max.</td>
</tr>
<tr>
<td></td>
<td>Set Point</td>
<td>Dead Band</td>
</tr>
<tr>
<td>1910-00</td>
<td>0.07 to 0.15</td>
<td>0.04</td>
</tr>
<tr>
<td>1910-0</td>
<td>0.15 to 0.55</td>
<td>0.10</td>
</tr>
<tr>
<td>1910-1</td>
<td>0.40 to 1.6</td>
<td>0.16</td>
</tr>
<tr>
<td>1910-2</td>
<td>1.40 to 5.5</td>
<td>0.30</td>
</tr>
<tr>
<td>1910-10</td>
<td>3.0 to 11.75</td>
<td>0.40</td>
</tr>
<tr>
<td>1910-20</td>
<td>4.0 to 20.0</td>
<td>0.50</td>
</tr>
</tbody>
</table>
INSTALLATION
1. Select a location that is free from excessive vibration, corrosive atmosphere and where the ambient temperature is within the limits for these switches.

2. Mount standard switches with the diaphragm in a vertical plane and with switch lettering and Dwyer nameplate in an upright position. Some switches are position sensitive and may not reset properly unless they are mounted with the diaphragm vertical. (Special units can be furnished for other than vertical mounting arrangements if required.)

3. Connect switch to source of pressure, vacuum or differential pressure. Metal tubing with 1/4" O.D. is recommended, but any tubing which will not restrict the air flow can be used. Connect to the two 1/8” female NPT pressure ports as noted below:
   - Differential pressures - connect pipes or tubes from source of greater pressure to high pressure port marked HI-PR and from source of lower pressure to low pressure port marked LO-PR.
   - Pressure only (above atmospheric) - connect tube from source of pressure to high pressure port. The low pressure port is left open to atmosphere.
   - Vacuum only (below atmospheric pressure) - connect tube from source of vacuum to low pressure port. The high pressure port is left open to atmosphere.

4. Electrical connections to the standard single pole, double throw snap switch are provided by means of screw terminals marked “common”, “norm open”, and “norm closed”. The normally open contacts close and the normally closed contacts open when pressure increases beyond the set point.

5. Switch loads should not exceed the maximum specified current rating of 15 amps resistive. Switch capabilities decrease with high load inductance or rapid cycle rates. Whenever an application involves either of these factors, the user may find it desirable to limit the switched current to 10 amps or less in the interest of prolonging switch life.

OPERATION
Pressure acting on the power diaphragm rotates the amplifying lever, which in turn extends the range spring and rotates the snap switch input lever. When the set point is reached, the snap switch is actuated and the electrical contacts make or break.

ADJUSTMENT
To change the set point, proceed as follows:
A. Remove the snap-on cover from the conduit enclosure by loosening its retaining screw and pulling firmly at its bottom end. Turn the slotted adjustment screw at the top of range spring housing clockwise to raise the set point pressure and counter-clockwise to lower the set point.

B. The recommended procedure for calibrating or checking calibration is to use a “T” assembly with three rubber tubing leads, all as short as possible and the entire assembly offering minimum flow restriction. Run one lead to the pressure switch, another to the manometer of known accuracy and appropriate range, and apply pressure through the third tube. Make final approach to the set point very slowly. Note that manometer and pressure switch will have different response times due to different internal volumes, lengths of tubing, fluid drainage etc. Be certain the switch is checked in the position it will assume in use, i.e. with diaphragm in a vertical plane and switch lettering and Dwyer nameplate in an upright position.

C. For highly critical applications it is a good idea to check the set point adjustment and reset it as necessary once or twice in the first few months of operation. This will compensate for any change in initial tension which may occur in the spring and diaphragm. For most applications this change will not be significant and no resetting will be required.

MAINTENANCE
Moving parts of these switches are sealed in and are permanently tamper proof. The single adjustment is that of the set point. Care should be taken to keep the switch reasonably dry and free from dust or dirt. No lubrication or unusual precautions are required for normal use.
Appendix G

Dwyer 616 Differential Pressure Transmitter Detail

The following sheets give details on the differential pressure transmitter.
The Series 616 Differential Pressure Transmitter senses the pressure of air and compatible gases and sends a standard 4-20 mA output signal. A wide range of models are available factory calibrated to specific ranges as listed in the chart below. The span and zero controls are for use when checking calibration. They are not intended for re-ranging to a significantly different span. Versatile circuit design enables operation in 2, 3 or 4-wire current loops.

For applications requiring direct pressure readings or percent of full span output, the optional Model A-701 Digital Readout makes an ideal companion device. It provides a bright red 0.6" high, 3-1/2 digit LED display while supplying power to the Series 616 transmitter. For additional information on these and other transmitters, see the Dwyer Instruments, Inc. Full Line catalog.

**SPECIFICATIONS**

**Service:** Air and non-combustible, compatible gases.

**Wetted Materials:** Consult Factory.

**Accuracy:** 616: ±0.25% F.S.; 616C: ±1.0% F.S.

**Stability:** ± 1% F.S./yr.

**Temperature Limits:** 20 to 120°F (-6.67 to 48.9°C).

**Pressure Limits:** See Chart.

**Thermal Effect:** 616: ±0.055% F.S./°F (0.099% F.S./°C);
616C: ±0.070% F.S./°F (0.125% F.S./°C).

**Power Requirements:** 10-35 VDC (2, 3 or 4 wire); 16-26 VAC (4 wire).

**Output Signal:** 4 to 20 mA.

**Zero and Span Adjustments:** Potentiometers for zero and span.

**Loop Resistance:** DC: 0-1250 ohms maximum.

AC: 0-1200 ohms maximum.

**Current Consumption:** DC: 38 mA maximum.

AC: 76mA maximum.

**Electrical Connections:** Screw-type terminal block.

**Process Connections:** Barbed, dual size to fit 1/8" and 3/16" (3.12 mm and 4.76 mm) I.D. rubber or vinyl tubing.

**Mounting Orientation:** Vertical, consult factory for other position orientations.

**Weight:** 1.8 oz. (51 grams).

### Series 616 Transmitter Models and Ranges*

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>616-00</td>
<td>0-1 in. w.c.</td>
<td>5 psig</td>
<td>616-8</td>
<td>0-10 psid</td>
<td>58 psig</td>
</tr>
<tr>
<td>616-0</td>
<td>0-2 in. w.c.</td>
<td>5 psig</td>
<td>616-9</td>
<td>0-20 psid</td>
<td>58 psig</td>
</tr>
<tr>
<td>616-1</td>
<td>0-3 in. w.c.</td>
<td>5 psig</td>
<td>616-10</td>
<td>0-30 psid</td>
<td>58 psig</td>
</tr>
<tr>
<td>616-2</td>
<td>0-6 in. w.c.</td>
<td>5 psig</td>
<td>616-11</td>
<td>0-50 psid</td>
<td>150 psig</td>
</tr>
<tr>
<td>616-3</td>
<td>0-10 in. w.c.</td>
<td>5 psig</td>
<td>616-12</td>
<td>0-100 psid</td>
<td>150 psig</td>
</tr>
<tr>
<td>616-4</td>
<td>0-20 in. w.c.</td>
<td>11 psig</td>
<td>616-3B</td>
<td>1.5-0-1.5 in. w.c.</td>
<td>5 psig</td>
</tr>
<tr>
<td>616-5</td>
<td>0-40 in. w.c.</td>
<td>11 psig</td>
<td>616-6B</td>
<td>3-0-3 in. w.c.</td>
<td>5 psig</td>
</tr>
<tr>
<td>616-6</td>
<td>0-100 in. w.c.</td>
<td>29 psig</td>
<td>616-10B</td>
<td>5-5 in. w.c.</td>
<td>5 psig</td>
</tr>
<tr>
<td>616-7</td>
<td>0-200 in. w.c.</td>
<td>29 psig</td>
<td>616-20B</td>
<td>10-10 in. w.c.</td>
<td>11 psig</td>
</tr>
</tbody>
</table>

*All models available with 0.25% F.S. Accuracy.

*Models available with 1.0% F.S. Accuracy include 616-1 through 616-20B.*
Installation

1.0 Location
Select a clean, dry mounting location free from excess vibration where the temperature will remain between 20 and 120°F (-6.7 and 48.9°C). Distance from the receiver is limited only by total loop resistance. See Electrical Connections below. The tubing supplying pressure to the instrument can be practically any length required, but long lengths will increase response time slightly.

2. Position
A vertical position, with pressure connections pointing down, is recommended. That is the position in which all standard models are spanned and zeroed at the factory. They can be used at other angles, but final spanning and zeroing must be done while transmitter is in that alternate position.

Pressure Connections
Two integral barbed tubing connections are provided. They are dual-sized to fit both 1/8" and 3/16" (3.12 and 4.76 mm) I.D. tubing. Be sure the pressure rating of the tubing exceeds that of the operating ranges. On ranges over 20 psi, we recommend use of a suitable hose clamp to assure the integrity of the connection.

Electrical Connections

CAUTION: Do not exceed specified supply voltage ratings. Permanent damage not covered by warranty will result. This unit is not designed for 120 or 240 volts AC line operation.

Electrical connections are made to the terminal block located on the top of the transmitter. Terminals are marked 1, 2, 3 and 4 (see Fig. B below). Determine which of the following circuit drawings applies to your application and wire accordingly.

Wire Length
The maximum length of wire connecting transmitter and receiver is a function of wire size and receiver resistance. Wiring should not contribute more than 10% of the receiver resistance to total loop resistance. For extremely long runs (over 1000 feet), choose receivers with higher resistance to minimize size and cost of connecting leads. Where wiring length is under 100 feet, hook-up wire as small as 22 AWG can be used.

2-Wire Operation
An external power supply delivering 10-35 VDC with minimum current capability of 40 mA DC (per transmitter) must be used to power the control loop. See Fig. C for connection of the power supply, transmitter and receiver. Note the jumper between terminals 3 and 4. The range of appropriate receiver load resistance (R_L) for the DC power supply voltage available is expressed by the formula and graph in Fig. F. Shielded two wire cable is recommended for control loop wiring. If grounding is required, use the negative side of the control loop after the receiver. Otherwise, in 2-wire operation it is not necessary to observe polarity of control loop connections.

3-Wire Operation
An external power supply delivering 10-35 VDC with minimum current capability of 40 mA DC (per transmitter) is required. See Fig. D for connection of power supply, transmitter and receiver. The range of appropriate receiver load resistance (R_L) for the DC power supply voltage available is expressed by the formula and graph in Fig. F. Shielded cable is recommended for control loop wiring. Do not employ a separate ground in 3-wire operation. Unit will not function properly and/or damage could result. Control loop polarity must be observed in the following respect. Although power supply terminals 1 and 2 are not polarized, the receiver must be connected between terminal 3 of transmitter and negative side of power supply.

4-Wire Operation
An external power supply delivering 10-35 VDC with a minimum current capability of 40 mA DC (per transmitter) or 16-28 VAC with a minimum current capability of 80 mA AC (per transmitter) is required. See Fig. E for connection of power supply, transmitter and receiver. The range of appropriate load resistance (R_L) for the DC or AC power supply available is expressed by the formulas and graphs in Fig’s. F and G.
Shielded cable is recommended for control loop wiring. Do not employ a separate ground in 4-wire operation. Unit will not function properly and/or damage could result. Control loop polarity must be observed; terminal 3 is negative and terminal 4 is positive.

1. With the transmitter connected to the companion receiver, insert an accurate milliammeter in series with the current loop. Full scale range should be approximately 30 mA.

2. Connect a controllable pressure source to one leg of a tee with the other two legs connected to the high pressure port of the transmitter and the third leg to an accurate test gage or manometer, in an appropriate range. The low pressure port should be vented to atmosphere. Calibration must be performed with the unit in the same position in which it will be mounted.

3. Apply electrical power to the unit and allow it to stabilize for 10 minutes.
4. With no pressure applied to the transmitter, adjust ZERO control so that loop current is 4 mA.

5. Apply full range pressure and adjust loop current to 20 mA using SPAN control.

6. Relieve pressure and allow transmitter to stabilize for 2 minutes.

7. Zero and span controls are slightly interactive, so repeat steps 4 through 6 until zero and full range pressures consistently produce currents of 4 and 20 mA respectively.

8. Remove the milliammeter from the current loop and proceed with final installation of the transmitter and receiver.

Voltage Input
Series 616 Transmitters can be easily adapted for receivers requiring 1-5 or 2-10 VDC inputs. Insert a 249 ohm, 1/2 watt (1-5 VDC) or 499 ohm (2-10 VDC) resistor in series with the current loop but in parallel with the receiver input. Locate this resistor as close as possible to the input. Because resistor accuracy directly influences output signal accuracy, we recommend use of a precision ±0.1% tolerance resistor to minimize this effect. See Fig. H and J below.

3-Wire Connection (1-5 or 2-10 VDC Output)

Calibration Check
Each Series 616 Transmitter is factory calibrated to the range given in the model chart. To check calibration and adjust if necessary, the following procedure should be used. For purposes of clarification in these instructions, range is defined as that pressure which, applied to the transmitter, produces 20 millamps of current in the loop. Zero pressure is always assumed to be 4 millamps.
Multiple Receiver Installation
An advantage of the standard 4-20 mA DC output signal produced by the Series 616 Transmitter is that any number of receivers can be connected in series in the current loop. Thus, an A-701 Digital Readout, an analog panel meter, a chart recorder, process controlling equipment or any combination of these devices can be operated simultaneously. The only requirement is that each component be equipped for a standard 4-20 mA input and the proper polarity of the input connections be observed when inserting the device in the current loop. If any of the units display a negative or downscale reading, the signal input leads are reversed.

Maintenance
Upon final installation of the Series 616 Differential Pressure Transmitter and the companion receiver, including the A-701 Digital Readout, no routine maintenance is required. A periodic check of the system calibration is recommended following the procedures explained on page 3 under Calibration Check. The Series 616 Transmitter is not field serviceable and should be returned, freight prepaid, to the factory if repair is required. Please enclose a description of the problems encountered plus any available application information. The A-701 should be returned directly to its manufacturer for service. See the A-701 instructions for address.