Improved Heating Operations at an L-Shaped Barracks: Assessment and Specifications

by
Eileen T. Westervelt

Data from earlier USACERL research that applied energy conservation retrofits to standard Army building types indicated that the retrofits were undermined by less than optimal building operations. This report documents follow-up work to measure the effect of improved building operations on one of the retrofit buildings, an L-shaped barracks. The results indicate that fuel savings from improved operations nearly equalled fuel savings resulting from the initial retrofit. Specific steps for improving operations are outlined, and it is recommended that the improvements implemented for this building be applied to other similarily constructed and operated buildings.
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FOREWORD

This work was performed for the U.S. Army Engineering and Housing Support Center (USAEHSC), under Facilities Engineering Application Program (FEAP) "Energy Conservation Retrofits for Standard Designs." B. Wasserman, CEHSC-FU, was the technical monitor. Operations improvement was funded in part by the U.S. Army Forces Command (FORSCOM) under reimbursable project Intra-Army Order FC-176-87, "Assessment of Energy Savings through Improved Operations of Heating Equipment." Naresh Kapoor, FCEN-RDF, was the FORSCOM Project Monitor.

The research was performed and coordinated by the Energy and Utility Systems Division (FE) of the Infrastructure Laboratory (FL), U.S. Army Construction Engineering Research Laboratories (USACERL). Some of this effort was done under contract by Arthur D. Little, Inc., where Richard Caron was principal investigator. Dr. David M. Joncich is Chief, CECER-FE, and Dr. Michael J. O'Connor is Chief, CECER-FL.

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COL Daniel Waldo, Jr., is Commander and Director of USACERL, and Dr. L.R. Shaffer is Technical Director.
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2 ORIGINAL BUILDING CONFIGURATION

Building Layout and Use

Building 811 is an L-shaped (Type 64) bachelor enlisted quarters constructed in 1956. Figures 1 and 2 show an original floor plan and exterior view for the barracks. It has a three-story barracks wing plus an adjoining single-story dining facility. The total floor area of about 38,000 sq ft* consists of about 11,000 sq ft for each of the three barracks floors and about 5,000 sq ft for the single story wing. The three-story barracks wing is oriented north and south and the single-story kitchen/mess hall wing is oriented east and west at the south end of the barracks wing.

The barracks wing has double- and single-occupancy sleeping quarters, ground level offices, lounging rooms, and laundry and bathing facilities. Originally an open-bay sleeping design with capacity for 178 residents, the barracks wing was converted to individual rooms in 1978. This wing is built above a combination of basement and crawl space. The basement is used for equipment storage and office area. The kitchen/mess hall wing is currently being used for a first-aid station, classrooms, and offices. The kitchen equipment has been removed (with the exception of a walk-in refrigerator) and the plumbing service has been capped. The south wing is built over a partial basement which houses the mechanical room.

Building Construction

The building was originally constructed of 8-in. concrete block exterior walls, 6-in. concrete ground floor, and a roof composed of 1/2 in. stone, 2 in. rigid insulation, 2 in. concrete, an air space, and acoustic tile. The building had numerous single pane windows. Energy retrofits in 1985 resulted in:

- the blocking of 50 percent of the window area
- the replacement of existing window units with double-glazed, double-hung, thermal-sash window units
- the addition of exterior wall insulation consisting of 2 in. of rigid polystyrene and a 3/8-in. polymer-modified portland cement stucco finish
- the replacement of two existing electric fixed-setpoint heating water controllers with pneumatic outdoor reset controllers
- and the blanking of the outside air intake to one of the south wing’s air handler units.

Heating

Heat is provided to the barracks wing through hot water fin-tube radiation. (The south wing also uses a steam unit heater.) The building is zoned for three hydronic heating loops: the east side barracks wing (zone 1), the west side barracks wing (zone 2), and the south wing mess hall area, now first-aid/classroom (zone 3).

The hot water heating pipes form a two-pipe reverse return system. The pipes for the barracks wing run through the crawl space and up several three-story risers on each side of the building. These pipes branch off at the risers on each floor to supply perimeter hot water to the fin-tube radiators running for a series of approximately five dormitory rooms or one stairwell. A two-pipe reverse return system is inherently self-balancing; no balancing valves were found on the hot water pipes. However, there were

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*Metric conversions are listed on p 28.
Figure 1. Original Floor Plan, L-Shaped Barracks.

Figure 2. Exterior View, Building 811.
a few shut-off valves. The dampers on the radiator cabinets originally had pull chains to close off the louvered openings for decreased heat exchange, but no operable dampers were found.

The circulation pumps for the three heating zones are controlled by an outside air sensor that turns the pumps off when the outside temperature is above a set point. The south zone also has an interior thermostat that overrides pump circulation for zone 3 below the pump cut off temperature. The indoor thermostats for the barracks zones (zones 1 and 2) which were indicated on the original building plans are no longer installed.

As a result of the 1985 retrofit, the circulating temperature of the hot water to zones 1 and 2 was reset based on outside temperature. The supply temperature ranges linearly from a minimum setting (during warmer weather) to a maximum setting (during colder weather.) The supply temperature of the hot water to the south zone was not reset.

**Boilers**

The hydronic heating system is serviced with one of two Kewanee gas-fired steam boilers with nameplate input ratings of 3.12 MBtu/hr. The operating boiler is currently firing at about 1.8 MBtu/hr, presumably from intentional derating. One boiler is used strictly for stand-by and brought on line as needed. The working boiler maintains a steam pressure currently set at 9 to 13 psi. Steam was provided to three hot water converters, a 645-gal domestic hot water storage tank, and a unit heater in the south wing. Steam pressure was maintained continuously during the heating season even when heating circulation pumps were off.

**Cooling**

Cooling is provided by chilled water, supplied from a central plant, and pumped to fan coil units in the rooms. Fans can be controlled individually. The occupants and the heating shop have observed that cooling in the summertime is insufficient. There is no in-building control to limit the amount of cooling because there is no excess capacity.

**Ventilation**

Four air handlers provided ventilation in the original building design. Two serviced the old kitchen area (one blanked off), one serviced the old dining area, and one serviced the hallways of the barracks wing. At the time of the last inspection, all forced ventilation had been disabled.

**Domestic Hot Water**

Domestic Hot Water (DHW) was provided by a direct-fired gas unit and by a steam heat exchanger serviced by the boiler. The boiler provided the primary heating, and the direct-fired unit cycled if the boiler was unable to meet the demand. DHW was maintained near 180 °F.
3 OPERATIONAL FINDINGS

General

The building was substantially overheated, a condition caused by a combination of inadequate equipment, improperly set equipment, and inappropriate actions of occupants and operators (e.g., leaving windows open in cold weather). The part-load efficiencies of the space heating and DHW heating systems were low due to various standby losses and control strategies.

Specific

The temperature control of the building was inadequate for three major reasons:

1. The steam valves on the heating hot water converters were too large. The resultant control was on/off rather than modulating.

2. The existing hot water controllers were not set for existing conditions and were also difficult to set and maintain.

3. Some control wiring was broken.

The boiler was controlled to maintain steam pressure regardless of a need for heat from mid-September through mid-May. The heat developed in the boiler was vented through the flue on the off-cycle. These factors caused significant standby losses in an area having a lengthy transition between seasons. Other problems with the heating equipment included a leak in the boiler, a need for boiler tune up and repair, a failed steam trap, and excessive vibrations in a circulating pump.

The DHW service posed both an energy and comfort concern. The plumbing for the DHW was valved so that most of the need was serviced by the steam boiler rather than the more efficient direct fired gas water heater. Further, the direct-fired water heater was underfiring and could not meet the DHW need alone. The shower heads were large or nonexistent, causing a heavier than needed DHW demand. Because there were no mixing valves, a scalding occurred if the toilet was flushed while others were in the shower. The setting for the circulating DHW temperature was higher than necessary, causing undue standby losses.

Although some building operators were highly skilled, other operators could improve their awareness of how the building systems operated and what the appropriate response was for a particular problem. Operators did not log or coordinate service responses and, therefore, could easily undo each others' fixes and over-tweak delicate instruments. Repairs were often makeshift, which focused on symptoms rather than causes, and left systems only semi-operative. Further, operators indiscriminately trusted that occupant complaints were founded and rarely verified the need for system attention.

The need for energy education for building occupants was also apparent. Some occupants were uncomfortable in rooms that were heated to 75 °F because they wore inappropriate clothing for winter conditions or failed to use a blanket on their bed. Other occupants had cold rooms because they barricaded their radiators with furniture. Rarely were occupants aware of opportunities for comfort control, such as thermostats or radiator dampers. Occupant education could reduce many unnecessary service calls.
4 IMPROVEMENTS IMPLEMENTED

After the original retrofits were made, various operational and housekeeping remedies were implemented to improve temperature control in the building and to increase efficiency and decrease the loads of the space and DHW heating systems. Modifications included equipment repair, replacement, augmentation, tune up, and control strategy changes.

Manufacturer specification sheets are included in the Appendix for the installed products used in retrofits. References to manufacturers are made to fully identify the equipment used in this project; these references are not endorsements of the products. After 1 year, all products were operating satisfactorily; other manufacturers’ products could perform as well.

1. The boiler control was modified by installing a double-pole, double-throw relay tied to the outside temperature sensor which activates the pumps. This allows the boiler to fire only when the circulator pumps call for heat to the building. This occurs when the temperature drops below a set value, usually 55 °F. An override switch was installed so that it would be possible to reset the original boiler system. Figure 3 shows the relay and override switch installation. An added benefit of this change is that the building operators do not need to turn the boiler off for the summer. It will turn itself off if the outdoor temperature control is set appropriately.

2. A damper motor was installed on the boiler to close the flue damper during the off cycle. The damper is fail-safe with a spring-open mechanism. Figure 4 diagrams the flue damper control. The existing steam pressure control activates the flue damper to open when the minimum setpoint steam pressure is reached. The boiler control circuit is now activated by an end switch on the damper motor, so that the burner can only come on after the flue damper is open.

3. The boiler leak was repaired.

4. The boiler was tuned up. This included cleaning the fire and water sides of the boiler, replacing broken parts (e.g., rusted cross-over tube), cleaning boiler blow down, and adjusting fuel air ratio.

5. The failed steam trap was replaced.

6. The vibrating circulation pump was serviced.

7. Smaller steam valves and actuators were installed at the hot water converters. The valves need to be normally open and linear. The steam valves were sized with the assistance of gathered energy data, indicating a maximum steam flow requirement near 400 lb/hr. Data gathered from another L-shaped barracks without the 1985 retrofits indicated a maximum steam flow requirement near 550 lb/hr for each zone. With the installation at Building 811, the manufacturer agreed to replace the steam valve if the sizing was inappropriate.

8. New pneumatic heating reset controllers were installed and adjusted for the barracks wings. Diagnostic sensors (temperature and pressure meters) were installed in the control lines. Figure 5 shows the control scheme. Table 1 gives the material list for the reset control and steam valves.

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2 Estimated hard calculation from data on Building 813.
Figure 3. Schematic of Relay and Override Switch Installation.
Figure 4. Flue Damper Control Diagram.

SEQUENCE: On a fall in boiler steam pressure, pressure controller contacts make and damper motor circuit is energized. Damper motor opens flue damper. End switch makes enabling boiler control circuit.

Honeywell

304 INVERNESS WAY SOUTH

FORT CARSON
FLUE DAMPER CONTROL

DRAWN BY: J.W.
DATE 12-22-87
DRAWING NUMBER 941-17042
REVISIONS
SUPERSSEDES
DRAWN BY: J.W.
DATE 12-22-87
DRAWING NUMBER 941-17042
REV.
0

Figure 4. Flue Damper Control Diagram.

12
Figure 5. Reset Control Scheme.
The appropriate settings for the reset controllers were originally determined by trial and error. These settings will be different for each building and each controller. Controls governing interior comfort should be adjusted by control specialists. Figures 6 through 11 show the interior temperature trends by zone and the effective reset schedules during these periods. Table 2 shows the zone controller settings which brought about these reset schedules.

9. Broken control wires in zone 3 were repaired. Figure 12 shows the heating control scheme for zone 3.

10. Superfluous controls were removed. Operating controls were labeled.

11. The valving for the DHW was changed to isolate the steam boiler from the water heating function. Figure 13 shows this valving arrangement.

12. The direct-fired gas state water heater was adjusted to increase its firing rate from 450,000 Btu/hr to 500,000 Btu/hr.

13. Anti-scald flow-restricting shower heads (2.75 gpm) were installed in the 15 showers in the building. During installation, the absence of zoned water shut-off valves caused some difficulty. To keep the building operational during shower retrofit, existing shower valves were left in the piping (handles removed) and mixing valves were installed downstream. See Figures 14 and 15.

14. The DHW temperature setting was turned down from 180 °F to 160 °F.

15. At various times throughout the investigation, zone 3 experienced both underheating and overheating. Figure 16 illustrates the zone 3 floor plan. This zone consists of three different subzones: (1) the classroom area, men’s room and medical treatment room, with perimeter heat controlled by a single thermostat on the north wall, (2) the ladies’ room with perimeter hydronic heat controlled by a separate thermostat in the ladies’ room, and (3) the first-aid waiting and sick bay area with no perimeter heating. This area is heated by a steam unit heater with its own thermostat.

In one case, underheating in the classroom area was caused by the combination of an incorrectly set thermostat (which was set near 50 °F rather than 68 °F), a closed steam valve that prevented steam from servicing the zone heat exchanger, and a broken electric control wire to the modulating steam valve. This underheating was corrected by repairing these problem areas. Another case of underheating was also caused by an incorrectly set thermostat. The thermostat in the ladies’ room was turned completely down and occupants were unaware of its existence. This problem was corrected by resetting the thermostat.

A third case of underheating was caused by a broken thermostat control on the fan of the steam space heater. The fan ran continuously, even during the off cycle of the steam flow to the coil. This caused circulation of cool air and increased occupant discomfort. The thermal switch on the condensate return was modified so that the fan would only operate when the coil was at setpoint.

Overheating in zone 3 was caused by high aquastat settings and valving which bypassed the thermostat’s control capabilities. The thermostat in the classroom was turned down and a complaint call was made. To provide heat, the maintenance person opened the by-pass valve from zone 2 to zone 3 (Figure 17). With valve 11 open and valve 6 closed, the zone 2 pump supplies all the water to zone 2 and zone 3. The water returns from these zones through the hot water converters and is mixed before re-entering the zone 2 pump. The hot water converter on zone 2 is set up for reset control, and for zone 3, it is set at a constant temperature of 195 °F. Therefore, the 195 °F water is mixing with the return of the zone 2 water which makes the zone 2 water too hot.
With this arrangement two anomalies occur: zone 2 overheats because supply water temperatures are too high, and zone 3 overheats because the flow to that zone is continuous. It would normally be cycle controlled by the thermostat. To correct these problems the valving was changed to the original settings and the heating water aquastat was adjusted from 195 °F to 160 °F. The valve handles were removed on valves 11 and 6 to prevent the maintenance people from easily opening these valves as part of a "quick fix" solution. Associated valves were labeled.

16. At times during the investigation, a combination of underheating and overheating occurred in the barracks wing. A call for heat in some rooms prompted an adjustment of the reset controls to provide higher temperature heating water. Upon inspection of the cold rooms, various causes were revealed concerning occupants' lack of awareness and education. Suggestions were made on furniture placement, bedding, and clothing adjustments to improve comfort. When the hot water heating system was found to be airbound, the piping was bled of air with manual valves on the radiators. In all these cases controls were reset to their original settings.

### Table 1

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Figure 6. West Zone Interior and Exterior Temperature Profiles.

Figure 7. West Zone Reset Schedule.
Figure 8. East Zone Interior and Exterior Temperature Profiles.

Figure 9. East Zone Reset Schedule.
Figure 10. South Zone Interior and Exterior Temperature Profiles.

Figure 11. South Zone Heating Hot Water Supply Temperature.
Figure 12. Zone 3 Wiring Diagram, Building 811.

Figure 13. Valving for Isolation of Domestic Hot Water.
Figure 14. Shower Piping Before Retrofit.

Figure 15. Shower Piping After Retrofit.
Figure 16. Illustration of Zone 3 Floor Plan.

Figure 17. Illustration of Bypass Valves Between Zones.
5 DATA ANALYSIS

Data collected from this field test over the 1987-1988 heating season was reviewed to assess improvement. Analysis results were encouraging. Improvements in interior temperature trends, control capabilities, system part-load efficiencies, and heating and DHW loads resulted in substantial fuel savings.

Enhanced Controls/Improved Interior Temperature Trends

The standard L-shaped barracks design at Fort Carson provides heating with hot water at a fixed setpoint, usually near 200 °F, regardless of the thermal load (differential indoor/outdoor temperature) on the building. The resultant overheating requires occupants to open windows for comfort in all but the coldest weather. Initial retrofit efforts to reset control on the heating hot water in the L-shaped barracks yielded limited success. Several factors hampered these efforts:

- the oversized steam valves on the hot water converters (causing on/off rather than modulating control)
- the complexity of the controllers (making adjustments difficult)
- and the lack of coordination and education of the service staff.

During the improved operations period, interior temperatures in the test building were brought into the comfort range. This was accomplished through (1) new, properly adjusted heating controls that reset heating water temperatures as outdoor temperatures change; (2) appropriately sized steam valves on the hot water converters which allow modulated steam control, yielding fewer temperature excursions on heating hot water and room temperatures; and (3) diligent data monitoring and collaboration with site service staff.

Figure 18 shows a dramatic example of the enhanced control capabilities during the improved operations period. The hot water reset schedule (heating hot water supply temperature versus outside air temperature) with the new set of reset controllers and new steam valves is significantly lower in temperature, more shallow in slope, and tighter in throttling range than the previous year’s attempt at reset control. This example is not representative of the entire heating season, however, since insufficient coordination between USACERL and base personnel, before the on-site monitoring period, led to inappropriate and frequent adjustment of control settings. In spite of these difficulties, reset control improvement was still significant over the previous year’s attempt.

Figure 19 shows typical temperature improvements obtained in the building. The improved operations period, May 1987 through May 1988, shows temperatures averaging about 7 °F cooler in the heating season (September through May) than the operations between May 1986 and May 1987. Temperature reductions for the entire building averaged about 5 °F during this period.

Part-Load Efficiency

Based on the system load, heating system efficiency varies. At 100 percent load, the system is operating at its maximum efficiency, while at less loaded conditions, the efficiency decreases until it reaches 0 percent efficiency at no load. An improvement in a system’s efficiency needs to be evaluated over the operating range or part-load conditions of the system.
Figure 18. Reset Control.

Figure 19. Interior Temperature Profiles.
Several system modifications during the improved operations period lead to increased part-load efficiencies of the combined space heating and DHW heating system. These modifications included:

- installing a flue damper on the boiler to minimize off cycle losses
- revalving the DHW heating system to isolate the domestic water heating function to the direct-fired gas unit
- rewiring the boiler controls to produce steam for heating only during heating conditions
- tuning up the boiler, including adjusting the fuel/air ratio, to maximize steady state efficiency
- repairing the leaks in the boiler
- repairing failed steam traps to reduce venting of live steam.

Figure 20 shows the part-load data for the original and improved operations. The comparison of part-load data was challenging since the original operations of the heating/DHW system did not clearly show efficiency as a function of system load. The reason for this is not known. Improved operations did show a strong, classical relationship of increased efficiency with increased load. For comparison, the classical form of the part-load curve was superimposed on the original data. The curve fit is extremely poor. With this qualification, the following conclusions were drawn. The improved operations curve is both higher and less scattered than the original curve, yielding more consistent and, on average, more efficient operation over the operating range of the system.
Heating Load Reductions

Heating load reductions occurred because of reduced interior temperatures which caused occupants to close the windows. The heating load reduction during the improved operations period was 1033 MBtu/yr or 50 percent of the previous year's load corrected for weather differences. (Complete data tables are included in Tables 3 through 5.)

Domestic Hot Water Energy Savings

Savings in energy for DHW production occurred due to the installation of restricted flow shower heads, which reduced the thermal load, and reduced water temperature settings (from 180 °F to 160 °F), which decreased the standby losses. The DHW load reduction during the improved operations period was 86 MBtu/yr or 11.7 percent of the previous year's load. This estimate is conservative since the reduced flow shower heads were only installed during 6.5 months of the 12-month comparison period.

System Efficiency

Overall annual system efficiency decreased a nominal 2 percent, from 40.6 to 38.5 percent.* This 2 percent is the net effect of decreasing system loads by 34 percent and increasing part-load efficiencies by 5 to 7 percent. Anticipated system efficiency reductions, due only to decreased load, are on the order of 10 percent (see Figure 20) which further substantiates the part-load improvements.

Table 3

Savings of Initial L-Shaped Barracks Retrofit Package, Normalized to 1987-88 Heating Season

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† These data are from 1986-87, and have been normalized to the 1987-88 heating season.

Notes:
- Building 811 == Test 86-87 is June 1986 - May 1987
- Building 812 == Reference 87-88 is June 1987 - May 1988
- Building 813 == Reference
- 1 Kbtu = 10^3 Btu 1986-87 HDD = 5968
- 1 MBtu = 10^6 Btu 1987-88 HDD = 6095

*Efficiencies are calculated by [(heating total)+(DHW total)]/[gas total].
## Table 4

### Incremental Savings of Improved Operations

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- These data are from 1986-87, and have been normalized to the 1987-88 heating season.

**Notes:**
- Building 811 = Test 86-87 is June 1986 - May 1987
- Building 812 = Reference 87-88 is June 1987 - May 1988
- Building 813 = Reference

### Table 5

### Savings of Total L-Shaped Retrofit:
**Initial Retrofit Plus Improved Operations**

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Annual Energy Tests</th>
<th>Energy Savings</th>
<th>Percent Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bldg</td>
<td>Bldg</td>
<td>811</td>
<td>811</td>
</tr>
<tr>
<td>811†</td>
<td>-vs-</td>
<td>811†</td>
<td>-vs-</td>
</tr>
<tr>
<td>MBtu</td>
<td>MBtu</td>
<td>811†</td>
<td>811†</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Annual Energy Tests</th>
<th>Energy Savings</th>
<th>Percent Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>4540.1</td>
<td>8327.6</td>
<td>3787.5</td>
</tr>
<tr>
<td>Heating Total</td>
<td>1022.5</td>
<td>2545.2</td>
<td>1522.7</td>
</tr>
<tr>
<td>DHW</td>
<td>646.3</td>
<td>828.0</td>
<td>181.7</td>
</tr>
</tbody>
</table>

- These data are from 1986-87, and have been normalized to the 1987-88 heating season.

**Notes:**
- Building 811 = Test 86-87 is June 1986 - May 1987
- Building 812 = Reference 87-88 is June 1987 - May 1988
- Building 813 = Reference

1 KBtu = $10^3$ Btu
1 MBtu = $10^6$ Btu

1986-87 HDD = 5968
1987-88 HDD = 6095
Fuel Savings

Fuel savings during the improved operations period were significant. Gas consumption was reduced by 1741 MBtu/yr, or 28 percent of the previous year's consumption, adjusted for weather conditions.

Return on Investment

The measured fuel savings of 1741 MBtu/yr corresponds to an annual dollar savings of $6094/yr, if natural gas can be purchased at $3.5/MBtu. The initial investment for these improvements is estimated at $19,150, yielding a simple payback period of 3 years. Over an assumed 15 year life of the building, this investment would pay for itself 5 times. However, continued return on the investment requires minimal upkeep of the mechanical equipment including:

- periodic boiler tune up,
- elimination of air from the hydronic heating system,
- servicing of the air compressor which supports the controls (bleeding out excess water, supplying oil when needed), and
- repair of equipment as it fails (especially steam traps).

Continued return on the investment also assumes informed responses to heating calls and lack of vandalism to any of the installed equipment.
6 CONCLUSIONS AND RECOMMENDATIONS

Potential energy savings from improved building operations are high. In this test, fuel savings of 1741 MBtu/yr from improved operations (Table 4) nearly equalled fuel savings of 2046 MBtu/yr resulting from the initial retrofit on an as-operated building (Table 3). The cost of improved operations is significantly lower than the cost of envelope improvements, and improved operations are essential for envelope improvements to achieve their full savings potential. The lessons learned in the L-shaped barracks are not unique; neither is the level of building operations found at this test installation. There is vast opportunity for fuel and dollar savings throughout the Army by recognizing the cost effectiveness of routine mechanical upkeep and enhancements on outdated methods of heating control, and by educating occupants and operators.

It is recommended that the improvements implemented in Building 811 be applied to other similarly constructed and operated buildings and that the retrofits detailed in this document, or similar changes, be used where appropriate. Because not all L-shaped barracks are exactly alike, detailed building inspections should take place to verify original conditions.

Much of the opportunity for savings depends on adequate occupant and operator education and coordination. To maximize savings, increase occupant comfort, and reduce service calls, it is recommended that:

- job-specific training programs for building operators (e.g., troubleshooting guidelines and operator testing) be investigated
- occupant education programs be expanded
- clothing, bedding, and furniture positioning be adjusted
- selected occupants be taught the heating control capabilities in these buildings, (e.g., thermostats in the south zone, radiator dampers which could be made operable, fan controls on cooling coils, and air bleed valves on hydronic heating loops)
- an in-building log book of service calls, including reported problems and responses, be kept
- a designated controls staff, exclusively authorized to make adjustments to building controls, be appointed
- air be permanently eliminated from the heating system by increasing the water pressure and bleeding the piping (If air introduction continues to be a problem, the installation of automatic air bleed valves on hydronic heating loops should be investigated.)
- radiator damper chains be repaired.

METRIC CONVERSION FACTORS

1 Btu = 1055.87 J
°F = (°C + 17.78) × 1.8
1 gal = 3.78 L
1 in. = 25.4 mm
1 lb = 0.453 kg
1 psi = 6.89 kPa
1 sq ft = 0.093 m²
APPENDIX:

Manufacturers' Specification Sheets
Motors

M945A-D,F,G
Modulating motors used to operate dampers and valves.

ACCESSORIES:
See PARTS and ACCESSORIES, page 201.

AUXILIARY SWITCH RATING FOR M945C,D (A):
One spdt V3 switch—

<table>
<thead>
<tr>
<th>ONE CONTACTS</th>
<th>120 V</th>
<th>240 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Load</td>
<td>7.2</td>
<td>3.6</td>
</tr>
<tr>
<td>Locked Rotor</td>
<td>43.2</td>
<td>21.6</td>
</tr>
</tbody>
</table>

*TRADELINE model.

Order Number  Power Consumption  Internal Balance  Normal Position Stroke Timing Includes

<table>
<thead>
<tr>
<th>Number</th>
<th>W VA</th>
<th>Circuit*</th>
<th>Position</th>
<th>(degrees)</th>
<th>(sec)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>*M945A1017</td>
<td>23</td>
<td>30.0</td>
<td>Yes</td>
<td>Closed</td>
<td>160</td>
<td>60</td>
</tr>
<tr>
<td>M945A1082</td>
<td>23</td>
<td>30.0</td>
<td>Yes</td>
<td>Closed</td>
<td>90</td>
<td>30</td>
</tr>
<tr>
<td>M945B1057</td>
<td>20</td>
<td>25.5</td>
<td>No</td>
<td>Closed</td>
<td>160</td>
<td>60</td>
</tr>
<tr>
<td>M945B1065</td>
<td>20</td>
<td>25.5</td>
<td>No</td>
<td>Closed</td>
<td>90</td>
<td>30</td>
</tr>
<tr>
<td>M945C1015</td>
<td>20</td>
<td>25.5</td>
<td>No</td>
<td>Closed</td>
<td>160</td>
<td>60</td>
</tr>
<tr>
<td>M945D1006</td>
<td>23</td>
<td>30.0</td>
<td>Yes</td>
<td>Closed</td>
<td>160</td>
<td>60</td>
</tr>
<tr>
<td>M945F1004</td>
<td>23</td>
<td>30.0</td>
<td>Yes</td>
<td>Open</td>
<td>160</td>
<td>60</td>
</tr>
<tr>
<td>M945G1037</td>
<td>20</td>
<td>25.5</td>
<td>No</td>
<td>Open</td>
<td>160</td>
<td>60</td>
</tr>
</tbody>
</table>

*Models less balance circuit are for use with electronic panels, reset systems, and R927C Balance Relay (with external O181 Auxiliary Pot).

M644A-E
Reversing 2-position motors used to operate valves and dampers.
M644 motors are used with series 60, 2-position controllers (spdt switching). Crankshaft: 3/8 in. [10 mm] square, double-ended, untapped. Ambient Temperature Range: Minus 40 F to plus 130 F [minus 40 C to plus 54 C] at 25% duty cycle. Approximate Dimensions: 7-5/32 in. [182 mm] high, 5-5/8 in. [143 mm] wide, 7-7/18 in. [189 mm] deep. Listed by Underwriters Laboratories Inc.—M644A,B,D,E; Canadian Standards Association certified—M644B,D,E,F.

TRADELINE

Figure courtesy of ITT McDonnell & Miller.
Motors

M644A-E continued

TORQUE:

<table>
<thead>
<tr>
<th>Timing</th>
<th>Normal Running Torque</th>
<th>Break-away Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 deg. stroke 180 deg. stroke</td>
<td>lb.-in.</td>
<td>N-m</td>
</tr>
<tr>
<td>15 sec 30 sec</td>
<td>75</td>
<td>8.5</td>
</tr>
<tr>
<td>1/2,1,2 min</td>
<td>12.4</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The maximum torque available to overcome occasional large loads such as a seized damper or valve. MOTOR NOT TO BE USED CONTINUOUSLY AT THIS RATING.

AUXILIARY SWITCH RATINGS (A):
One spdt V3 switch—M644D,E

<table>
<thead>
<tr>
<th>ONE CONTACT®</th>
<th>120 V</th>
<th>240 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Load</td>
<td>7.2</td>
<td>3.6</td>
</tr>
<tr>
<td>Locked Rotor</td>
<td>43.2</td>
<td>21.6</td>
</tr>
</tbody>
</table>

*40 VA pilot duty, 120/240 Vac on opposite contact.

See PARTS and ACCESSORIES, page 201.

*TRADELINE model.

<table>
<thead>
<tr>
<th>Order Number</th>
<th>Voltage (50/60 Hz)</th>
<th>Power Consumption</th>
<th>Timing</th>
<th>Stroke (degree)</th>
<th>Includes</th>
</tr>
</thead>
<tbody>
<tr>
<td>M644A1016</td>
<td>24</td>
<td>15</td>
<td>16.6</td>
<td>60 sec</td>
<td>160</td>
</tr>
<tr>
<td>M644A1024</td>
<td>100</td>
<td>30 sec</td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M644B1049</td>
<td>420</td>
<td>30 sec</td>
<td>160</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M644C1006</td>
<td>24</td>
<td>15</td>
<td>16.6</td>
<td>15 or 30 sec</td>
<td>Sel. 90 or 160</td>
</tr>
<tr>
<td>M644C1014#</td>
<td>24</td>
<td>15</td>
<td>16.6</td>
<td>2 or 4 min</td>
<td>Sel. 90 or 160</td>
</tr>
<tr>
<td>M644D1005#</td>
<td>24</td>
<td>15</td>
<td>16.6</td>
<td>30 or 60 sec</td>
<td>Sel. 90 or 160</td>
</tr>
<tr>
<td>M644E1012#</td>
<td>24</td>
<td>15</td>
<td>16.6</td>
<td>30 sec</td>
<td>90</td>
</tr>
</tbody>
</table>

*Shipped in 90-degree position.
#Shorter timing applies when 90-degree stroke is selected.

130810
Cover Mounted Transformer

40 VA transformer used to supply power to a 24-volt motor.

Replaces standard motor top cover on M744, M745, M845, M644, M941, M944, M945, M954, M955 (old series motors). Listed by Underwriters Laboratories Inc.; Canadian Standards Association certified (when used with motor).

*TRADELINE model.

<table>
<thead>
<tr>
<th>Order Number</th>
<th>Primary Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>130810A</td>
<td>120 V, 60 Hz</td>
</tr>
<tr>
<td>*130810B</td>
<td>120/208/240 V, 60 Hz</td>
</tr>
<tr>
<td>130810C</td>
<td>220 V, 50 Hz</td>
</tr>
<tr>
<td>130810D#</td>
<td>24 V, 50/60 Hz</td>
</tr>
</tbody>
</table>

*Use with W938 Multizone Logic Panel.
Service packages of complete cover assembly consists of:

- **ITEM 1** Thermostat assembly
- **ITEM 2** Float ball and valve assembly
- **ITEM 3** Floating ball valve lever assembly and collar pin, valve seat, seal, yoke, and gasket.
- **ITEM 4** Cover gaske
- **ITEM 5** Cover casting and gasket.

### Table: Service Packages

<table>
<thead>
<tr>
<th>Trap No.</th>
<th>Item 2 Part No.</th>
<th>Item 3 Part No.</th>
<th>Item 4 Part No.</th>
<th>Item 5 Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>53F:FT</td>
<td>36-15476</td>
<td>35-11443</td>
<td>35-11447</td>
<td>36-16300</td>
</tr>
<tr>
<td>54F:FT</td>
<td>36-15477</td>
<td>35-11450</td>
<td>35-11447</td>
<td>36-16301</td>
</tr>
<tr>
<td>55F:FT</td>
<td>36-15480</td>
<td>35-11773</td>
<td>35-12046</td>
<td>36-16305</td>
</tr>
<tr>
<td>57F:FT</td>
<td>36-15481</td>
<td>35-12528</td>
<td>35-20230</td>
<td>36-16305</td>
</tr>
<tr>
<td>58F:FT</td>
<td>36-15482</td>
<td>35-10962</td>
<td>35-20233</td>
<td>36-16310</td>
</tr>
<tr>
<td>54F:FT</td>
<td>36-15478</td>
<td>35-11450</td>
<td>35-11447</td>
<td>36-16301</td>
</tr>
<tr>
<td>54F:FT</td>
<td>36-15479</td>
<td>35-11450</td>
<td>35-11447</td>
<td>36-16301</td>
</tr>
<tr>
<td>54F:FT</td>
<td>36-15480</td>
<td>35-11773</td>
<td>35-12046</td>
<td>36-16306</td>
</tr>
<tr>
<td>56F:FT</td>
<td>36-15481</td>
<td>35-11773</td>
<td>35-12046</td>
<td>36-16307</td>
</tr>
<tr>
<td>56F:FT</td>
<td>36-15483</td>
<td>35-11773</td>
<td>35-12046</td>
<td>36-16308</td>
</tr>
<tr>
<td>58F:FT</td>
<td>36-15486</td>
<td>35-10992</td>
<td>35-20233</td>
<td>36-16311</td>
</tr>
<tr>
<td>58F:FT</td>
<td>36-15487</td>
<td>35-10992</td>
<td>35-20233</td>
<td>36-16312</td>
</tr>
<tr>
<td>58F:FT</td>
<td>36-15488</td>
<td>35-10992</td>
<td>35-20233</td>
<td>36-16313</td>
</tr>
</tbody>
</table>

**NOTE:**

- DISCONTINUED MODEL 50 SERIES TRAP WITH THERMOSTAT AND SEAT INSTALLED IN COVER.

**DISCONTINUED MODEL 50 SERIES TRAP WITH THERMOSTAT AND SEAT INSTALLED IN COVER.**

**CURRENT THERMOSTAT ASSEMBLY ITEM 1 WILL FIT DISCONTINUED MODELS "T" AND "V".**

**HOFFMAN SERIES 50 FLOAT AND THERMOSTATIC TRAPS MODELS "F", "F&T", "T", "A", "V", "M"**

---

Figure courtesy of ITT McDonnell & Miller.
Honeywell

V5011A-E
Single Seated Valves

GENERAL

V5011 single-seated, two-way, straight-through valves provide proportional control of steam, liquids, air, or other noncombustible gases in HVAC systems requiring tight shutoff. They are available in bronze bodies with screwed NPT end connections or cast iron bodies with flanged end connections.

FEATURES

- Direct or reverse acting.
- Stainless steel stem with removable composition disc and self-adjusting, spring-loaded Teflon packing.
- Bronze, brass, or stainless steel plugs provide equal percentage or linear flow characteristics.
- High pressure models available (V5011D or E).
- Stainless steel, metal-to-metal seating available in smaller valve sizes.
- Suitable for pneumatic (1/2- to 6-inch valve) or electric (1/2- to 4-inch valve) actuation with proper linkage.

SPECIFICATIONS

Models:
See Table 1.

Flow Characteristics:
Equal Percentage or Linear. See Table 1 and Figure 1.

Dimensions:
See Table 4 and Figures 2 through 4.

Close-off Ratings:
See Table 5 and Figure 8.

Valve Ratings:
See Table 2.

Controlled Mediums and Temperatures:
See Table 3.

Stem Travel:
1/2- to 3-in. valves: 3/4-in. (19 mm).
4-, 5-, and 6-in. valves: 1-1/2-in. (38 mm).

Trim Materials:
Stem: Stainless steel.
Packing: Teflon cone for 125 psi (860 kPa) flanged and 150 psi (1034 kPa) screwed valves, all sizes. Teflon V-ring for 250 psi (1725 kPa) valves, 1-1/2- to 6-inch size.
Disc: Removable composition.
Disc Holder:
Screwed bodies—brass.
Flanged bodies—cast iron.
Plug:
Screwed bodies with composition disc—contoured brass.
Screwed bodies with metal-to-metal seating—contoured stainless steel.
Flanged bodies—V-ported, skirt guided bronze.

Seat:
Screwed bodies—brass (replaceable, screwed into body).
Screwed bodies, metal-to-metal-stainless steel (recommend replacing valve).
Flanged bodies—brass (replaceable, screwed into body).

Valve Actuators:
The V5011 valves require either MP953 actuators or electric/electronic Modutrol motors as listed in Table 6. Refer to Fig. 5, 6, and 7 for actuator dimensions.

Figure courtesy of Honeywell, Inc.
Accessories:

Packing Conversion Kits (for converting to high-pressure applications):
- 14002920-001 Rubber V-ring for 1/2- to 1-1/4-inch valves (1/4-inch diameter stem).
- 14002920-002 Teflon V-ring for 1-1/2- to 3-inch valves (3/8-inch diameter stem).

When Ordering, Specify:
1. Model number, size, and direct or reverse acting.
2. Accessories.
3. Actuator and linkage (refer to Valve/Actuator Selection, Table 6).

### Table 1. V5011 Model Descriptions and Body Specifications.

<table>
<thead>
<tr>
<th>Model Number and Plug Characteristic</th>
<th>Action</th>
<th>End Connections</th>
<th>Body Size in Inches</th>
<th>Capacity Index (C_v)</th>
<th>Nominal Body Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pressure (psl) (kPa)</td>
</tr>
<tr>
<td>V5011A Equal Percentage and V5011C Linear</td>
<td>Direct</td>
<td>Screwed</td>
<td>1/2</td>
<td>0.4, 0.63, 1.0, 1.6, 2.5, 4.0</td>
<td>150 (1034) or 200 (1379)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3/4</td>
<td>6.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1-1/4</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1-1/2</td>
<td>25</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td>2</td>
<td>40</td>
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<td></td>
<td></td>
<td></td>
<td>2-1/2</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>V5011A Equal Percentage</td>
<td>Direct</td>
<td>Flanged</td>
<td>2-1/2, or 3</td>
<td>63; 2-1/2 in. 100; 3 in.</td>
<td>125 (860) or 175 (1207)</td>
</tr>
<tr>
<td>V5011D Equal Percentage</td>
<td>Direct</td>
<td>Flanged</td>
<td>4, 5, or 6</td>
<td>160; 4 in.</td>
<td>125 (860) or 175 (1207)</td>
</tr>
<tr>
<td>V5011B Equal Percentage</td>
<td>Reverse</td>
<td></td>
<td>250; 5 in.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V5011D Equal Percentage</td>
<td>Direct</td>
<td></td>
<td>360; 6 in.</td>
<td>250 (1725) or 400 (2758)</td>
<td>400 (204) or 150 (66)</td>
</tr>
<tr>
<td>V5011E Equal Percentage</td>
<td>Reverse</td>
<td></td>
<td></td>
<td>250 (1725) or 400 (2758)</td>
<td>400 (204) or 150 (66)</td>
</tr>
</tbody>
</table>

Δ Direct: stem down to close.
Reverse: stem up to close.

![Fig. 1. V5011 Average Flow Characteristics.](image-url)
Table 2. Valve Ratings.

<table>
<thead>
<tr>
<th>Body</th>
<th>Screwed, cast-bronze</th>
<th>Flanged, cast iron</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>150 psi at 366°F max. (1034 kPa at 185°C)</td>
<td>125 psi at 353°F max. (860 kPa at 178°C) or 175 psi at 150°F max. (1207 kPa at 66°C).</td>
</tr>
<tr>
<td></td>
<td>200 psi at 150°F max. water (1379 kPa at 66°C).</td>
<td>250 psi at 400°F max. (1725 kPa at 204°C) or 400 psi at 150°F max. (2758 kPa at 66°C).</td>
</tr>
</tbody>
</table>

| Max. Pressure          | Composition Discs   | Water          | Proportional, 25 psi (170 kPa) |
| Differential for       |                      |                | 2-Position, 50 psi (345 kPa)    |
| Normal Life of         |                      |                | Steam (A, B, & C) only)        |
| Trim                  |                      |                | Proportional, 35 psi (240 kPa) |
|                       |                      |                | 2-Position, 70 psi (480 kPa)    |
|                       | Metal-to-metal only  | Steam only     | 100 psi (690 kPa)              |
| Max. Pressure          |                      |                | Refer to Fig. 8 and Table 5.   |
| Differential for       |                      |                |                               |
| Quiet Water Service    |                      |                |                               |
| Max. Pressure          | Teflon Cone Packing  | Water          | 150 psi at 250°F max. (1034 kPa at 121°C); 40°F min. (4°C) |
| Differential for       | (V5011A & C)         |                |                               |
| Close-Off              |                      | Steam          | 100 psi at 337°F max. (680 kPa at 169°C) |
|                       | Teflon V-ring Packing| Water          | 250 psi at 250°F max. (1725 kPa at 121°C); 40°F (4°C) |
|                        |, 3/8-in. Stem        |                |                               |
|                       | (V5011D & E and      |                |                               |
|                       | 14002920-002 Kit)    |                |                               |
|                       | Rubber V-ring Packing| Water          |                               |
|                       |, 1/4-in. Stem        |                |                               |
|                       | (14002920-001 Kit)   |                |                               |

△ For high fluid temperatures, the valve and/or piping should be insulated to prevent ambient temperatures from exceeding ratings at the actuator location.

△ Maximum temperature differential in alternate hot-cold water use, 140°F (60°C).

△ Modified with high pressure packing kit.

Table 3. Recommended Controlled Mediums and Temperatures.

<table>
<thead>
<tr>
<th>Model Number</th>
<th>End Connections</th>
<th>Recommended Controlled Medium</th>
<th>Temperature Range F (°C) (Composition Disc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V5011A &amp; D</td>
<td>Screwed</td>
<td>Water</td>
<td>35 to 200 (2 to 99)</td>
</tr>
<tr>
<td></td>
<td>Flanged</td>
<td>Water</td>
<td>115 to 275 (46 to 135)</td>
</tr>
<tr>
<td>V5011B</td>
<td>Flanged</td>
<td>Water</td>
<td>35 to 275 (2 to 135)</td>
</tr>
<tr>
<td>V5011C*</td>
<td>Screwed</td>
<td>Steam</td>
<td>115 to 275 (46 to 135)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>275 to 425 (135 to 218)</td>
</tr>
<tr>
<td>V5011D</td>
<td>Flanged</td>
<td>Water</td>
<td>35 to 275 (2 to 135)</td>
</tr>
<tr>
<td>V5011E</td>
<td>Flanged</td>
<td>Water</td>
<td>35 to 275 (2 to 135)</td>
</tr>
</tbody>
</table>

*Metal-to-metal seats available in 1/2 to 1-1/2 inch valve sizes.

Figure courtesy of Honeywell, Inc.
Table 4. V5011A-E Approximate Dimensions in Inches (Millimeters). Refer to Figures 2, 3, and 4.

<table>
<thead>
<tr>
<th>Body Style and Figure Reference</th>
<th>Valve Size (in.)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>No. of Flange Bolt Holes</th>
</tr>
</thead>
<tbody>
<tr>
<td>V5011A &amp; C Screwed, Direct Body</td>
<td>1/2</td>
<td>1-3/4 (44)</td>
<td>1-3/4 (44)</td>
<td>3/3/8 (86)</td>
<td>1-13/16 (46)</td>
<td>1-5/8 (41)</td>
<td>4-3/4</td>
<td>4-7/8</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3/4</td>
<td>1-5/8 (41)</td>
<td>1-3/4 (44)</td>
<td>3/3/8 (86)</td>
<td>1-13/16 (46)</td>
<td>1-5/8 (41)</td>
<td>4-3/4</td>
<td>4-7/8</td>
<td>4</td>
</tr>
<tr>
<td>V5011A Screwed (Fig. 2)</td>
<td>1</td>
<td>1-3/4 (44)</td>
<td>1-3/4 (44)</td>
<td>3-3/8 (86)</td>
<td>1-13/16 (46)</td>
<td>1-5/8 (41)</td>
<td>4-3/4</td>
<td>4-7/8</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>1-1/4</td>
<td>1-15/16 (49)</td>
<td>1-1/2 (33)</td>
<td>5 (120)</td>
<td>2-9/16 (65)</td>
<td>1-15/16 (49)</td>
<td>5-1/16</td>
<td>5-1/16</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>1-1/2</td>
<td>2-3/4 (70)</td>
<td>1-3/8 (33)</td>
<td>5-3/4 (146)</td>
<td>3-9/16 (90)</td>
<td>2-11/16 (68)</td>
<td>5-3/16</td>
<td>5-3/16</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3 (76)</td>
<td>2 (51)</td>
<td>5-3/4 (146)</td>
<td>3-9/16 (90)</td>
<td>2-11/16 (68)</td>
<td>5-3/16</td>
<td>5-3/16</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>2-1/2</td>
<td>2-9/16 (65)</td>
<td>2-3/8 (60)</td>
<td>7-1/2 (194)</td>
<td>4-3/8 (104)</td>
<td>3-1/16 (77)</td>
<td>5-11/16</td>
<td>5-11/16</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3 (76)</td>
<td>2-3/8 (60)</td>
<td>8-7/8 (226)</td>
<td>4-15/16 (125)</td>
<td>3-5/8 (92)</td>
<td>6-1/8</td>
<td>6-1/8</td>
<td>10</td>
</tr>
<tr>
<td>V5011B Flanged, Direct Body (Fig. 3)</td>
<td>1-1/4</td>
<td>4-13/16 (122)</td>
<td>4 (102)</td>
<td>9-1/2 (241)</td>
<td>7 (178)</td>
<td>2-1/2 (19)</td>
<td>3-5/8 (92)</td>
<td>6-1/8</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>5-3/8 (116)</td>
<td>4-5/8 (117)</td>
<td>11 (279)</td>
<td>7-1/2 (190)</td>
<td>4 (102)</td>
<td>6-1/8</td>
<td>6-1/8</td>
<td>12</td>
</tr>
<tr>
<td>V5011B Flanged, Reverse Body (Fig. 3)</td>
<td>4</td>
<td>7-9/16 (192)</td>
<td>5-3/16 (132)</td>
<td>13 (330)</td>
<td>9 (229)</td>
<td>4 (102)</td>
<td>6-1/8</td>
<td>6-1/8</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>7 (178)</td>
<td>6-1/8 (155)</td>
<td>15 (381)</td>
<td>10 (254)</td>
<td>5 (127)</td>
<td>7/8 (22)</td>
<td>8-1/2 (215)</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>8 (203)</td>
<td>7-1/16 (179)</td>
<td>16-1/2 (419)</td>
<td>11 (279)</td>
<td>6-1/8 (152)</td>
<td>7/8 (22)</td>
<td>8-1/2 (215)</td>
<td>15</td>
</tr>
<tr>
<td>V5011B Flanged, Direct Body (Fig. 3)</td>
<td>4</td>
<td>4-11/16 (119)</td>
<td>8-1/16 (205)</td>
<td>13 (330)</td>
<td>9 (229)</td>
<td>4 (102)</td>
<td>6-1/8 (152)</td>
<td>7/8 (22)</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>5-5/8 (143)</td>
<td>7-1/2 (190)</td>
<td>15 (381)</td>
<td>10 (254)</td>
<td>5 (127)</td>
<td>7/8 (22)</td>
<td>8-1/2 (215)</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>6-9/16 (167)</td>
<td>8-1/2 (216)</td>
<td>16-1/2 (419)</td>
<td>11 (279)</td>
<td>6-1/8 (152)</td>
<td>7/8 (22)</td>
<td>8-1/2 (215)</td>
<td>18</td>
</tr>
<tr>
<td>V5011D Flanged, Direct Body (Fig. 3)</td>
<td>1-1/4</td>
<td>4-13/16 (122)</td>
<td>3-3/4 (95)</td>
<td>11-1/2 (292)</td>
<td>7-1/2 (178)</td>
<td>2-1/2 (19)</td>
<td>3-5/8 (92)</td>
<td>6-1/8</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>5-3/8 (116)</td>
<td>4-1/4 (108)</td>
<td>12-1/2 (317)</td>
<td>8-1/4 (209)</td>
<td>3-5/8 (92)</td>
<td>6-1/8</td>
<td>6-1/8</td>
<td>20</td>
</tr>
<tr>
<td>V5011D Flanged, Reverse Body (Fig. 4)</td>
<td>4</td>
<td>7-9/16 (192)</td>
<td>5-1/2 (140)</td>
<td>16-3/4 (425)</td>
<td>11 (279)</td>
<td>5 (127)</td>
<td>7/8 (22)</td>
<td>8-1/2 (215)</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>7 (178)</td>
<td>5-1/2 (140)</td>
<td>16-3/4 (425)</td>
<td>11 (279)</td>
<td>5 (127)</td>
<td>7/8 (22)</td>
<td>8-1/2 (215)</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>8 (203)</td>
<td>6-1/4 (159)</td>
<td>18-5/8 (473)</td>
<td>12-1/2 (318)</td>
<td>6 (152)</td>
<td>7/8 (22)</td>
<td>8-1/2 (215)</td>
<td>23</td>
</tr>
<tr>
<td>V5011E Flanged, Direct Body (Fig. 4)</td>
<td>4</td>
<td>4-3/4 (120)</td>
<td>7-5/16 (186)</td>
<td>14-1/2 (368)</td>
<td>10 (254)</td>
<td>4 (102)</td>
<td>7/8 (22)</td>
<td>9-1/4 (235)</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>6-11/16 (170)</td>
<td>8-1/2 (216)</td>
<td>16-1/2 (419)</td>
<td>11 (279)</td>
<td>6 (152)</td>
<td>7/8 (22)</td>
<td>9-1/4 (235)</td>
<td>26</td>
</tr>
</tbody>
</table>

Fig. 2. V5011A and C Screwed, Direct Acting Body Dimensions (Refer to Table 4).

Fig. 3. V5011A and D Flanged Body Dimensions (Refer to Table 4).

Fig. 4. V5011B and E Flanged Body Dimensions (Refer to Table 4).

Figure courtesy of Honeywell, Inc.
Fig. 5. Approximate Dimensions in Inches (Millimeters) of Typical Electric/Electronic Actuator with Q601 Linkage (M644 Shown).

Fig. 6. MP953C to F Dimensions in Inches (Millimeters).

Table 5. Close-Off Ratings for V5011A-E with Electric Actuators.

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Linkage Seal-Off Force</th>
<th>Body Size in Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>160 lb (711 N)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>80 lb (356 N)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( C_s )</td>
</tr>
<tr>
<td>V5011A &amp; C</td>
<td>150 (1034)</td>
<td>0.40</td>
</tr>
<tr>
<td>Screwed Con-</td>
<td>150 (1034)</td>
<td>0.63</td>
</tr>
<tr>
<td>nections</td>
<td></td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>100 (691)</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>100 (691)</td>
<td>1.63</td>
</tr>
<tr>
<td></td>
<td>141 (970)</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>141 (970)</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>91 (627)</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>91 (627)</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>55 (379)</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td>55 (379)</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td>32 (221)</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>32 (221)</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>20 (138)</td>
<td>3/4</td>
</tr>
<tr>
<td></td>
<td>20 (138)</td>
<td>3/4</td>
</tr>
<tr>
<td>V5011A &amp; D</td>
<td>26 (179)</td>
<td>1.0</td>
</tr>
<tr>
<td>Flanged</td>
<td>10 (69)</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>6 (41)</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>4 (28)</td>
<td>1.0</td>
</tr>
<tr>
<td>V5011B &amp; E</td>
<td>10 (69)</td>
<td>1.0</td>
</tr>
<tr>
<td>Flanged</td>
<td>6 (41)</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>4 (28)</td>
<td>1.0</td>
</tr>
</tbody>
</table>

\( 160 \text{lb} - \text{Q618A (160 lb model); Q601D, E, I, K; Q455B, C, D.} \)

\( 80 \text{lb} - \text{Q618A (80 lb model); Q601F, G, H, L, M; Q455A, E, F, G.} \)

Fig. 7. Approximate Dimensions of Q618 Linkage with Modutrol Motor in Inches (Millimeters). (Note: Motor shown is representative, other motors may vary in size.)

Figure courtesy of Honeywell, Inc.
Fig. 8. Close-Off Pressures at Various Control Air Pressures for V5011A-E Single-Seated Valves and MP953 Pneumatic Actuators.

77-5315
### Table 6. V5011 Valve/Actuator Selection.

<table>
<thead>
<tr>
<th>Valve</th>
<th>Size (inches)</th>
<th>( C_n )</th>
<th>( \Delta ) Pneumatic Actuators</th>
<th>( \Delta ) Electric Actuators</th>
<th>( \Delta ) Electronic Actuator</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{V5011A} )</td>
<td>1/2 NPT</td>
<td>0.63</td>
<td>A1, C1 A2, C2 B1, D1</td>
<td>E or F</td>
<td>J, L, or T M, N, or U</td>
</tr>
<tr>
<td></td>
<td>3/4</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-1/2</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-1/2</td>
<td>63</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 NPT</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-1/2 FLG</td>
<td>63</td>
<td>A1, C1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{V5011B} )</td>
<td>4 FLG</td>
<td>160</td>
<td></td>
<td>A2, C2 B1, D1</td>
<td>E or F</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>250</td>
<td></td>
<td>A3, C3</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>6 FLG</td>
<td>360</td>
<td></td>
<td>A3, C3</td>
<td>F</td>
</tr>
<tr>
<td>( \text{V5011C} )</td>
<td>4 FLG</td>
<td>160</td>
<td>A1, C1 A2, C2 B1, D1</td>
<td>E or F</td>
<td>J, L, or T M, N, or U</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>250</td>
<td></td>
<td>A3, C3</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>6 FLG</td>
<td>360</td>
<td></td>
<td>A3, C3</td>
<td>F</td>
</tr>
</tbody>
</table>

*Not recommended for tight close-off. Use pneumatic actuator.

**NOTES:**

\( \Delta \) The MP953C-F are rolling type diaphragm actuators which provide proportional control of V5011 valves.

A1—MP953E D.A. 5 in. dia. with positioner.
A2—MP953E D.A. 8 in. dia. with positioner.
A3—MP953E D.A. 13 in. dia. with positioner.
B1—MP953F R.A. 7-1/8 in. dia. with positioner.
C1—MP953C D.A. 5 in. dia. without positioner.
C2—MP953C D.A. 8 in. dia. without positioner.
C3—MP953C D.A. 13 in. dia. without positioner.
D1—MP953D R.A. 7-1/8 in. dia. without positioner.

\( \Delta \) Example Linkages:
Q601E:1000—160 lb seal-off force.
Q618A1024—160 lb seal-off force.
Q618A1032—80 lb seal-off force.
TYPICAL OPERATION

In a normally open valve assembly application (direct acting valve with a direct acting pneumatic actuator), an increase in branch line pressure from a sensor or controller moves the valve stem toward the closed position.

In a normally closed valve assembly (reverse acting valve with a direct acting pneumatic actuator), an increase in branch line pressure moves the valve stem toward the open position.

Fig. 9. Typical Operation.
General

MP953 Pneumatic Actuators operate V5011 and V5013 Valves to provide proportional control of steam or hot and cold liquids of HVAC systems.

Features

- Rolling diaphragm for long life and low hysteresis
- Easily attached to valve
- May be installed after piping valve
- Slide lock feature permits simple engagement to valve stem
- Direct- or reverse-action control
- Models available with positive positioning relay
DESCRIPTION

The MP953 Pneumatic Actuators operate V5011 and V5013 Valves to provide proportional control of steam or hot and cold liquids of HVAC systems.

SPECIFICATIONS

Models:
See Table below

Maximum Diaphragm Temperature:
160°F (71°C) standard
250°F (121°C) high-temperature model (MP953D only)

Maximum Safe Operating Pressure:
25 psi (172 kPa)

Accessories:
Position Indicator for:
5-inch (127 mm) dia: 316028A
7-inch (178 mm) dia: 316035A
8-inch (203 mm) dia: 316037A
13-inch (330 mm) dia: 316036A

Valve Bonnet Extension Kit: 14000501-001
(separates actuator 2-1/2 inches [64 mm] from valve for high-temperature applications)
Corrosion-Resistant Spray: CCT 3858

MP953A APPROXIMATE DIMENSIONS IN INCHES (MILLIMETERS)

<table>
<thead>
<tr>
<th>Model</th>
<th>Action</th>
<th>Positive</th>
<th>Diaphragm Dia. in Inches (mm)</th>
<th>Effective Area of Diaphragm in Square Inches</th>
<th>Stroke in Inches (mm)</th>
<th>Operating Range in psi (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP953C</td>
<td>Direct</td>
<td>No</td>
<td>5 (130)</td>
<td>11</td>
<td>1/2 (12) or 3/4 (19)</td>
<td>2 to 7 (12 to 50) or 4 to 11 (30 to 75) or 8 to 12 (55 to 85)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8 (203)</td>
<td>33</td>
<td>3/4 (19) or 1-1/2 (38)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>13 (330)</td>
<td>99</td>
<td>1-1/2 (38)</td>
<td></td>
</tr>
<tr>
<td>MP953D</td>
<td>Reverse</td>
<td>No</td>
<td>7 (180)</td>
<td>21.6</td>
<td>1/2 (12) or 3/4 (19)</td>
<td>3 to 7 (20 to 50) or 4 to 11 (30 to 75) or 8 to 13 (55 to 90)</td>
</tr>
<tr>
<td>MP953E</td>
<td>Direct</td>
<td>Yes</td>
<td>5 (130)</td>
<td>11</td>
<td>3/4 (19)</td>
<td>3, 5, or 10 (20, 35, or 70)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8 (203)</td>
<td>33</td>
<td>3/4 (19) or 1-1/2 (38)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>13 (330)</td>
<td>99</td>
<td>1-1/2 (38)</td>
<td></td>
</tr>
<tr>
<td>MP953F</td>
<td>Reverse</td>
<td>Yes</td>
<td>7 (180)</td>
<td>21.6</td>
<td>3/4 (19)</td>
<td>Same as MP953E</td>
</tr>
</tbody>
</table>

⚠️ Start point is adjustable from 1-1/2 (10) to 13 psi (90 kPa) in 1/4 psi (1-1/2 kPa) increments.

Honeywell

77-3001
Commercial Bldg Group
MLF TAB: II. C. 7.

Figure courtesy of Honeywell, Inc.
GENERAL

The RP920 Modular Pneumatic Controllers, in conjunction with remote sensors, provide proportional or proportional plus integral control of temperature, humidity, pressure, or dewpoint in heating and air-conditioning systems.

FEATURES

- Proportional plus integral control minimizes offset.
- Miniature diaphragm technology provides high degree of accuracy and reliability.
- Field adjustable compensation start point.
- Local or remote setpoint field optional.
- Integral action cut-off provides trouble-free automatic startup.
- Transparent cover (optional) provides protection while allowing easy reading of settings and gages.
- Corrosion resistant construction.

Figure courtesy of Honeywell, Inc.
RP920A-D Modular Pneumatic Controller

DESCRIPTION

The RP920 Modular Pneumatic Controllers, in conjunction with remote sensors, provide proportional or proportional plus integral control of temperature, humidity, pressure, or dewpoint in heating and air-conditioning systems.

SPECIFICATIONS

Models:
- RP920B: Dual Input Proportional Controller.
- RP920C: Single Input Proportional plus Integral Controller.
- RP920D: Dual Input Proportional plus Integral Controller.

All models available Direct or Reverse Acting.

All models available with Control Point Adjustment (CPA).

Dimensions:
See Figure 1.

Air Connections:
Combination 5/32-inch (4 mm) and 1/4-inch (6 mm) push-on barb.

Main Air Supply:
18 psi (125 kPa) minimum.

Maximum Safe Air Pressure:
30 psi (200 kPa).

Input Signals:
3 to 15 psi (21 to 104 kPa).

Output Signal:
3 to 13 psi (21 to 91 kPa).

Air Consumption:
Add sensor consumption for total. Values valid for 18 psi MLP and 8.5 psi BLP (125 kPa MLP and 58 kPa BLP).

RP920A and C: 0.021 scfm (10.0 m³/s).

RP920B and D: 0.046 scfm (21.7 m³/s).

Normal Sensor: 0.019 scfm (9.0 m³/s) depending on sensor selected.

Air Capacity:
0.07 scfm (33.0 m³/s) with 1 psi (6.9 kPa) pressure difference and 18 psi (124.1 kPa) MLP.

Proportional Band:
2.5 to 50%, field adjustable.

Authority (RP920B and D only):
5 to 300% of primary sensor span.

Compensation Start Point (RP920B and D Only):
0 to 100% of compensation sensor span.

Control Point Adjustment (Orderable Option):
±15% of primary sensor span with 3 to 15 psi (20 to 100 kPa) input.

Remote Setpoint (Field Option):
0 to 100% of primary sensor span with 3 to 15 psi (20 to 100 kPa) input.

Integral Reset Time:
0.5 to 20 minutes, field adjustable.

Ambient Temperature:
40 to 130 °F (5 to 55 °C).

Accessories:
1. Barb fitting 14003755-001 for port 4, 6, 7, or 8 if connection required.
2. Gages.
3. Remote setpoint device, SP970 or equivalent.
7. Rail Mounting Bag Assembly 14004322-001 (25 sets per bag assembly).

Fig. 1. RP920 Dimensions in Inches (Millimeters).

Figure courtesy of Honeywell, Inc.
Honeywell

LP914A and LP915A
Pneumatic Temperature Sensors

GENERAL

The LP914A and LP915A Sensors are proportional-type temperature sensors used with a pneumatic receiver controller for control of pneumatic valves and damper actuators in fanroom applications. The LP915A is a duct-mounted, liquid-filled, averaging type sensor. The rod and tube insertion element of the LP914A can be duct-, well-, or through-the-wall mounted.

FEATURES

• May be used with a calibrated gage for continuous temperature indication.

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Figure courtesy of Honeywell, Inc.
LP914A and LP915A Temperature Sensors

DESCRIPTION

The LP914A and LP915A Sensors are proportional-type temperature sensors used with a pneumatic receiver controller for control of pneumatic valves and damper actuators in fanroom applications. The LP915A is a duct-mounted, liquid-filled, averaging type sensor. The rod and tube insertion element of the LP914A can be duct-, well-, or through-the-wall mounted.

SPECIFICATIONS

Models:
- LP914A: Insertion element, direct acting.
- LP915A: Averaging element, direct acting.

Sensing Range:
- Nonadjustable.

<table>
<thead>
<tr>
<th>LP914A</th>
<th>LP915A</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40 to +160°F (-40 to +71°C)</td>
<td>0 to 200°F</td>
</tr>
<tr>
<td>+40 to +240°F (+5 to +115°C)</td>
<td>(-18 to +93°C)</td>
</tr>
<tr>
<td>-20 to +80°F (-29 to +27°C)</td>
<td>25 to 125°F</td>
</tr>
<tr>
<td>+25 to +125°F (-4 to +56°C)</td>
<td>(-1 to 54°C)</td>
</tr>
</tbody>
</table>

Maximum Safe Temperature at the Element:
- LP914A: 265°F (128.3°C)
- LP915A: 225°F (118.2°C)

Supply Air Pressure:
- 18 psi (124 kPa) nominal for both LP914A and LP915A.

Maximum Safe Air Pressure:
- 25 psi (172 kPa) for both LP914A and LP915A.

Pressure Output:
- 3 to 15 psi (21 to 103 kPa).

Air Consumption:
- 0.019 scfm (9.0 m³/s).

Air Connections:
- Push-on combination barb connector for 5/32 in. (4 mm) and 1/4 in. (6 mm) O.D. tubing.

Mounting:
- Duct-mounted, LP914A and LP915A.
- Well-mounted, LP914A.
- Through-the-wall mounted (up to 12 in. [304.8 mm] thick), LP914A.

Element (Type and Size):
- LP914A: Rod and tube, 6 in. (152.4 mm) and 15 in. (381 mm) lengths for water and air.
- LP915A: Liquid filled, 8 ft 8 in. (2.6 m) or 20 ft (6.1 m) averaging.

Dimensions:
- See Figures 1 and 2.

Finish:
- Gray styrene plastic cover, nonremovable, for LP914A; brass forging for LP915A.

Accessories Available:
- Wells for LP914A only:
  - Copper: Dimensions:
    - 315046A 15-3/18 (385 mm)
    - 315046B 7-3/8 (187 mm)
  - Stainless Steel: Dimensions:
    - 315904A 15-5/16 (389 mm)
    - 315904B 7-5/16 (186 mm)
- Averaging element clip 314439 for LP915A.

Figure courtesy of Honeywell, Inc.
Pneumatic Indication, Receiver & Target Gages

GENERAL

Pneumatic gages provide continuous indication in a pneumatic control system. They are flush or stem mounted in the factory or field. The three gage types are applied as follows:

- Indication gages indicate pneumatic system pressures such as main air, branch line, or compressor tank.
- Receiver gages indicate sensor line values. These may be either the 3 to 15 psi (21 to 103 kPa) signal or its analog equivalent.
- Target Gages indicate pneumatic control system status such as Day-Night, Summer-Winter, or Closed-Modulating-Open.

FEATURES

- High accuracy and dependability.
- Easily calibrated from the front.
- Scaleplates replaceable for 2-1/2 and 3-1/2 inch Receiver Gages.
Pneumatic Indication, Receiver, and Target Gages

DESCRIPTION

Pneumatic Indication, Receiver, and Target Gages are accurate instruments providing continuous indication in a pneumatic control system. The gages are factory or field mounted.

SPECIFICATIONS

ALL GAGES

Pressure Range:
- Indication gages: See Table 2.
- Receiver gages: 3 to 15 psi (21 to 103 kPa).

Maximum Safe Pressure:
- Indication gages: See Table 2.
- Receiver gages: 25 psi (175 kPa).

Dimensions:
- See Figures 1 and 2 and Table 1.

STEM-MOUNTED GAGES

Models:
- Indication Gages: See Table 2.
- Receiver Gages: 1-1/2 inch dial see Table 3 for ranges and model numbers.

Accuracy:
± 2% of scale range.

Mounting:
- Back-connected stem.

Air Connection:
- See Figure 1.

Replacement Crystal:
- 1-1/2 inch dial—Not available.
- 2 inch dial—Not available.
- 2-1/2 inch dial—14505882-001.
- 3-1/2 inch dial—14505883-001.

FLUSH-MOUNTED GAGES

Models:
- Indication Gages: See Table 2.
- Receiver Gages: 2-1/2 inch dial 14505895-001, -101.
- 3-1/2 inch dial 14505896-001, -101, and -201.

See Table 3 for ranges and part numbers of interchangeable scaleplates.

Accuracy:
- Indication gages: ± 2% of scale range at 9 psi.
- Receiver gages:
  - 001 suffix, ± 2% of scale range at 9 psi.
  - 01 suffix, ± 1% of scale range at 9 psi.
  - 0201 suffix, ± 1/4% of scale range at 9 psi.

Mounting:
- Flush mounted in panel up to 7/16 in. (11 mm) thick.

Air Connection:
- See Figure 2.

Replacement Crystal:
- 1-1/2 inch dial—Not available.
- 2-1/2 inch dial—14505882-001.
- 3-1/2 inch dial—14505883-001.

Table 1. Gage Dimensions in Inches (Millimeters). Refer to Figures 1 and 2.

<table>
<thead>
<tr>
<th>Gage</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2 inch</td>
<td>2(64)</td>
<td>3(76)</td>
<td>7-32(5.6)</td>
<td>1-7/8(48)</td>
<td>2-19-32(66)</td>
</tr>
<tr>
<td>3-1/2 inch</td>
<td>2(64)</td>
<td>4.1-8(105)</td>
<td>5/16(7.9)</td>
<td>1-7/8(48)</td>
<td>3-21-32(93)</td>
</tr>
<tr>
<td>3-1/2 inch</td>
<td>3-11-18(43)</td>
<td>1-21-32(92)</td>
<td>2-19-32(66)</td>
<td>2.3-4(70)</td>
<td></td>
</tr>
<tr>
<td>Targets</td>
<td>3(76)</td>
<td>1-1/4(6)</td>
<td>1-15-16(49)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure courtesy of Honeywell, Inc.
### Table 2. Indication Gage Ranges and Models.

<table>
<thead>
<tr>
<th>Units</th>
<th>Range</th>
<th>Stem-Mounted</th>
<th>Flash-Mounted</th>
<th>Maximum Safe Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-1/2 in.</td>
<td>2 in.</td>
<td>2-1/2 in.</td>
<td>3-1/2 in.</td>
</tr>
<tr>
<td>psi</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 30</td>
<td>305965</td>
<td></td>
<td>80491B</td>
<td>32 psi</td>
</tr>
<tr>
<td>0 to 60</td>
<td></td>
<td></td>
<td>80491C</td>
<td>65 psi</td>
</tr>
<tr>
<td>0 to 100</td>
<td></td>
<td></td>
<td>80491E</td>
<td>170 psi</td>
</tr>
</tbody>
</table>

Δ Used on PP902.
Δ 1-4 inch MPT Connection.

**Replaceable Scaleplate:**

Figure 3 shows a typical scaleplate.

![Figure 3. Typical Receiver Gage Replaceable Scaleplate.](image)

### Table 3. Receiver Gage and Scaleplate Ranges and Models.

<table>
<thead>
<tr>
<th>Units</th>
<th>Range</th>
<th>Stem-Mounted Gages</th>
<th>Scaleplates 14505846-</th>
<th>Scale Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degrees</td>
<td>50 to 100</td>
<td>305972</td>
<td>005 105</td>
<td></td>
</tr>
<tr>
<td>Fahrenheit</td>
<td>25 to 125</td>
<td>305931</td>
<td>001 101</td>
<td></td>
</tr>
<tr>
<td>Degrees</td>
<td>10 to 38</td>
<td>305973</td>
<td>010 110</td>
<td></td>
</tr>
<tr>
<td>Celsius</td>
<td>5 to 115</td>
<td>305934</td>
<td>009 109</td>
<td></td>
</tr>
<tr>
<td>Inches H₂O</td>
<td>-1 to 0</td>
<td>305615</td>
<td></td>
<td>In. H₂O</td>
</tr>
<tr>
<td>1 to 5</td>
<td>305616</td>
<td></td>
<td>013 113</td>
<td></td>
</tr>
<tr>
<td>2 to 4</td>
<td>305617</td>
<td></td>
<td>014 114</td>
<td></td>
</tr>
<tr>
<td>3 to 5</td>
<td>305618</td>
<td></td>
<td>015 115</td>
<td></td>
</tr>
<tr>
<td>4 to 6</td>
<td>305619</td>
<td></td>
<td>016 116</td>
<td></td>
</tr>
<tr>
<td>0 to 5</td>
<td>305620</td>
<td></td>
<td>017 117</td>
<td></td>
</tr>
<tr>
<td>Millimeters</td>
<td>0 to 25</td>
<td>305621</td>
<td>018 118</td>
<td>mm H₂O</td>
</tr>
<tr>
<td></td>
<td>25 to 50</td>
<td>305622</td>
<td>020 112</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50 to 100</td>
<td>305623</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>75 to 125</td>
<td>305624</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100 to 150</td>
<td>305625</td>
<td>019 119</td>
<td></td>
</tr>
<tr>
<td>psi</td>
<td>0 to 50</td>
<td>305626</td>
<td>024 124</td>
<td></td>
</tr>
<tr>
<td>0 to 20</td>
<td>305988</td>
<td>025 125</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 100</td>
<td>305989</td>
<td>026 126</td>
<td></td>
<td></td>
</tr>
<tr>
<td>kPa</td>
<td>20 to 100</td>
<td>305990</td>
<td>027 127</td>
<td></td>
</tr>
<tr>
<td>Percent</td>
<td>65 to 95</td>
<td>305991</td>
<td>028 128</td>
<td></td>
</tr>
<tr>
<td>Relative</td>
<td>30 to 80</td>
<td>305992</td>
<td>029 129</td>
<td></td>
</tr>
<tr>
<td>Humidity</td>
<td>15 to 75</td>
<td>305993</td>
<td>030 130</td>
<td></td>
</tr>
<tr>
<td>15 to 85</td>
<td>305994</td>
<td>031 131</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dewpoint F</td>
<td>40 to 75</td>
<td>305995</td>
<td>032 132</td>
<td></td>
</tr>
<tr>
<td>Dewpoint C</td>
<td>5 to 25</td>
<td>305996</td>
<td>033 133</td>
<td></td>
</tr>
<tr>
<td>Percent</td>
<td>0 to 100</td>
<td>305997</td>
<td>034 134</td>
<td></td>
</tr>
<tr>
<td>Air Velocity</td>
<td>150 to 600</td>
<td>305998</td>
<td>035 135</td>
<td></td>
</tr>
<tr>
<td>Fr/Min</td>
<td>300 to 1500</td>
<td>305999</td>
<td>036 136</td>
<td></td>
</tr>
<tr>
<td>Fr/Min</td>
<td>400 to 2500</td>
<td>306000</td>
<td>037 137</td>
<td></td>
</tr>
</tbody>
</table>

Figure courtesy of Honeywell, Inc.
TARGET GAGES

Models:
See Table 4.

Dimensions:
See Figure 2 and Table 1.

Maximum Safe Pressure:
25 psi (172 kPa).

Gage Accuracy:
±2%.

Degrees Travel:
270 degrees with 108-degree viewing window.

Mounting:
Flush.

Air Connection:
1/4-inch (6mm) barbed fitting.

Table 4. Target Gage Specifications.

<table>
<thead>
<tr>
<th>Number</th>
<th>Indication</th>
<th>Range</th>
<th>Gage Calibration in psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>317086E</td>
<td>DAY-NIGHT</td>
<td>12.5-18.5</td>
<td>12.5-13.5—white, black DAY at 13.</td>
</tr>
<tr>
<td>317086G</td>
<td>DAY-NIGHT</td>
<td>0-20</td>
<td>0-9—white, black DAY at 3.</td>
</tr>
<tr>
<td>317086K</td>
<td>DAY-WARM UP-NIGHT</td>
<td>0-22.5</td>
<td>0-14.5—white, black DAY at 3.</td>
</tr>
<tr>
<td>317086L</td>
<td>OCCUPIED-UNOCCUPIED</td>
<td>0-18</td>
<td>0-9—white, black OCCUPIED at 3.</td>
</tr>
<tr>
<td>317086H</td>
<td>SUMMER-WINTER</td>
<td>12.5-18.5</td>
<td>12.5-13.5—green, black SUMMER at 13.</td>
</tr>
<tr>
<td>317086M</td>
<td>WINTER-SUMMER</td>
<td>0-18</td>
<td>0-9—white, black WINTER at 3.</td>
</tr>
<tr>
<td>317086A</td>
<td>OFF-ON</td>
<td>0-18</td>
<td>0-9—white, green OFF at 3.</td>
</tr>
<tr>
<td>317086P</td>
<td>ON-OFF</td>
<td>0-18</td>
<td>0-9—green, black ON at 3.</td>
</tr>
<tr>
<td>317086B</td>
<td>HIGH-ALARM</td>
<td>0-18</td>
<td>0-9—white, green HIGH at 15.</td>
</tr>
<tr>
<td>317086C</td>
<td>LOW-ALARM</td>
<td>0-20</td>
<td>0-9—red, white LOW at 1.5.</td>
</tr>
<tr>
<td>317086D</td>
<td>HIGH &amp; LOW ALARM</td>
<td>0-19.5</td>
<td>0-3—red, white LOW at 1.5.</td>
</tr>
<tr>
<td>317086J</td>
<td>OPEN-CLOSED</td>
<td>0-20</td>
<td>0-9—white, green OPEN at 3.</td>
</tr>
<tr>
<td>317086N</td>
<td>CLOSED-OPEN</td>
<td>0-18</td>
<td>0-9—green, white CLOSED at 1.5.</td>
</tr>
<tr>
<td>317086R</td>
<td>CLOSED-MODULATING-OPEN</td>
<td>0-18</td>
<td>0-13—green, white MODULATING at 1.5.</td>
</tr>
</tbody>
</table>

⚠️ To convert psi to approximate kPa, multiply psi by 7.

⚠️ Light gray beige, behind lettering.

Honeywell

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In Canada: Scarborough, Ontario
Subsidiaries and Affiliates Around the World

Figure courtesy of Honeywell, Inc.
Symmons HYDAPIPE '64' Modern, Compact, Stainless Steel, Shower Units. The most economical method of designing and installing shower systems.

The Original Prefabricated Shower Unit, newly designed for wider application. More versatile for the specifier and the installer.

Available in two lengths, standard and short, with vertical or horizontal supply covers. No pipe chases and narrower walls mean lower construction costs. Neater and far less costly than massive panel showers. Complete unit vandal-proof.

No exposed piping to assemble. Unit and pipe covering in heavy brush finish, stainless steel with clean, straight line. All units equipped with famous Symmons Safetymix, the valve without equal.

Symmons Industries Inc.,
31 Brooks Drive, Braintree, Mass. 02184
FOR THRU-WALL SUPPLY PIPING

1-801S Hydapipe '64' Packaged Unit - (STANDARD LENGTH) Safety-mix pressure-balancing shower valve with integral stops. 'Super' Shower Head on institutional type Head Bracket fitting. Attached soap dish and Top cap. Stainless steel covering to be 18 gauge w/#4 brush finish.
Weight 12¼ lbs.
1-801 Same as above less soap dish.
Weight 11 lbs.

1-802S Hydapipe '64' Packaged Unit - (SHORT LENGTH) Safety-mix pressure-balancing shower valve with integral stops. 'Super' Shower Head on institutional type Head Bracket fitting. Attached soap dish and Top cap. Stainless steel covering to be 18 gauge w/#4 brush finish.
Weight 11¼ lbs.
1-802 Same as above less soap dish.
Weight 10 lbs.

FOR THRU-CEILING SUPPLY PIPING WITH MATCHING PIPE COVER

1-803S Hydapipe '64' Packaged Unit - (STANDARD LENGTH) Safety-mix pressure-balancing shower valve with integral stops. 'Super' Shower Head on institutional type Head Bracket fitting. Attached soap dish. Matching cover with ceiling flange to conceal supplies to ceiling. Stainless steel covering to be 18 gauge w/#4 brush finish.
1-803 Same as above less soap dish.

1-804S Hydapipe '64' Packaged Unit - (SHORT LENGTH) Safety-mix pressure-balancing shower valve with integral stops. 'Super' Shower Head on institutional type Head Bracket fitting. Attached soap dish. Matching cover with ceiling flange to conceal supplies to ceiling. Stainless steel covering to be 18 gauge w/#4 brush finish.
1-804 Same as above less soap dish.

MODIFICATIONS TO ALL HYDAPIPE UNITS
Prefix S - Integral Volume Control
All SAFETYMIX* systems are equipped with a 2.75 GPM water and energy saving shower head.

IMPORTANT: After completion of installation step 3, follow these instructions to set the SAFETYMIX Limit Stop Screw. This valve is equipped with a limit stop screw to be used to limit valve handle from being turned to excessively hot water discharge temperatures. To adjust, remove dome cover, open valve to maximum desired temperature and turn in limit stop screw until it seats.

WARNING: Failure to adjust the limit stop screw property may result in serious scalding.

WARNING: This shower system may not protect the user from scalding when there is a failure of other temperature controlling devices elsewhere in the plumbing system.

This instruction sheet shows the rough-in dimensions for 1-100(X), 1-210(X) or 4-500(X) units. See separate drawings for applicable other numbered units for applicable rough-in dimensions.

INSTALLATION OF 1-100

1-100 SAFETYMIX SHOWER UNIT
Concealed SAFETYMIX pressure balancing valve shower head with NU-ARM head bracket

Valve identification marked on escutcheon
Model O—Valve with temperature control only
**V—Valve with temperature control and volume control

1. Install rough piping and valve body as shown on installation drawing

IMPORTANT: Valve roughing is 2 3/4" min - 3" max from CENTER LINE OF SUPPLIES TO FACE OF FINISH WALL Supply connections must be on an accurate horizontal plane

INSTALL HOT ON LEFT AND COLD ON RIGHT ACCORDING TO VALVE BODY MARKINGS

Reverse core valves if 1-100 REV

2. When finishing the tile wall REMOVE ENTIRE PROTECTIVE ROUGH-IN SHIELD and fill area around valve body with grout or plaster DO NOT PLASTER OVER SC-2 CAP OR SERVICE STOPS IF SO EQUIPPED

3. Turn on hot and cold supplies VALVE WILL NOT OPERATE UNLESS BOTH HOT AND COLD WATER ARE TURNED ON. Allow valve to run in warm position for a few minutes to totally flush system. If system is quite dirty, remove valve spindle or stop spindles if so equipped to insure proper flushing

4. Set limit stop screw as directed in bold type above

5. Mount escutcheon onto valve using putty or other sealant around underside of flange. Fasten in place with screw install handle with short pointed end all off position. Put teflon tape or grease on spindle splines. Install NU-ARM head bracket and shower head

6. Do not install positive shut-off devices on the outlet of this valve or devices that do not allow the valve to flow at least 1 GPM @ 50 psi inlet pressure EXCEPTION if a self-closing or slow-closing valve is installed on the outlet, the supplies of the valve must be equipped with check stops to eliminate not to cold by-pass in the event the valves handle is not turned off after use. Contact your factory representative or Symmons directly for information on available checks

OPERATION

The main handle of the SAFETYMIX valve is for control of temperature only. From the OFF position the handle is turned counterclockwise through a minimum of one revolution to a warm and hot position for a maximum turn of approximately one revolution. This allows for infinite temperature adjustments to suit the requirements of any user

IMPORTANT

Read Entire Directions

53
This instruction sheet shows the rough-in dimensions for 1-100(X), 1-210(X) or 4-500(X) units. See separate drawings (enclosed with other numbered units) for applicable rough-in dimensions.

INSTALLATION OF 1-210

1. Install rough piping and valve body as shown on installation drawing. IMPORTANT: Valve roughing is 2½" min 3" max from CENTER LINE of SUPPLIES to FACE of FINISH WALL. Supply connections must be on an accurate horizontal plane. INSTALL HOT ON LEFT AND COLD ON RIGHT ACCORDING TO VALVE BODY MARKINGS. Reverse core valves (e.g., 1-210-REV) designed for piping simplicity on back to back installations are installed with hot on left and cold on right according to valve markings.

2. When finishing the tile wall REMOVE ENTIRE PROTECTIVE ROUGH-IN SHIELD and INSTALL HOT ON LEFT AND COLD ON RIGHT ACCORDING TO VALVE BODY MARKINGS. With GROUT OR PLASTER. DO NOT INSTALL POSITIVE SHUT-OFF DEVICES ON OUTLET OF THIS VALVE OR DEVICES THAT DO NOT ALLOW THE VALVE TO FLOW AT LEAST 1 GPM @ 50 psi INLET PRESSURE. EXCEPTION: If a self-closing or slow-closing valve is installed on the outlet, the supplies of the valve must be equipped with check stops to eliminate hot to cold bypass in the event the valve’s handle is not turned to off after use. Contact your factory representative or Symmons directly for information on available checks.

3. Turn on hot and cold supplies. VALVE WILL NOT OPERATE UNLESS BOTH HOT AND COLD WATER ARE TURNED ON. Allow valve to run in warm position for a few minutes to totally flush system. If system is quite dirty, remove valve spindle or stop spindles (if so equipped) to insure proper flushing.

4. Set limit stop screw as directed in bold type above.

5. Mount escutcheon onto valve, using putty or other sealant around underside of flange. Fasten in place with screw or bolt. Install NU-ARM head bracket and shower head. Mount escutcheon and knob on diverter.

6. Do not install positive shut-off devices on the outlet of this valve or devices that do not allow the valve to flow at least 1 GPM @ 50 psi inlet pressure. EXCEPTION: If a self-closing or slow-closing valve is installed on the outlet, the supplies of the valve must be equipped with check stops to eliminate hot to cold bypass in the event the valve's handle is not turned to off after use. Contact your factory representative or Symmons directly for information on available checks.

OPERATION

The main handle of the SAFETYMIX valve is for control of temperature only. From the OFF position, the handle is turned counterclockwise through a minimum cold position, through a warm and hot position for a maximum turn of approximately one revolution. This allows for infinite temperature adjustments to suit the requirements of any user. Initial flow will come from tub spout. Pressing diverter knob will control volume from shower head.
or panel walls and it is desired to sandwich wall between valve body and escutcheon. Follow instructions. Note: It is always recommended to secure valve piping to rough construction and not depend on fiberglass wall for valve mounting security.

Order valve with modification "C" for wall 1/4" - 3/4" thick.
Order valve with modification "CM" for wall 5/8" - 1 1/8" thick.
On panel walls over 1 1/8" thick, install in conventional manner.

Template for valve with stops
Template for valve less stops

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**SAFETY MIX WASHER & GASKET KIT-Q**

- SC-14 LEVER HANDLE
- SC-14B VOLUME CONTROL KNOB
- SC-14A LOCKING SCREW W WASHER
- SC-14C VOLUME DIAL
- SC-14A VOLUME CONTROL KNOB
- LC-14 LUCITE HANDLE (VAL. CONTROL)
- SC-14 LEVER HANDLE (VAL. CONTROL)
- SC-15 HANDLE SCREW
- SC-15 18 DOME COVER & LOCK NUT
- SC-7 PACKING NUT
- SC-12 ESCUTCHEON & SCREW
- SC-17 PACKING
- SC-26 LIMIT STOP W D-RING
- SC-2 CAP
- SC-19 CAP GASKET
- SC-9 COLD WASHER RETAINER
- SC-10 HOT & COLD WASHERS
- SC-10A HOT WASHER SCREW
- SC-3 RENEWABLE SEAT
- SC-20A 21 TOP SEAT D-RING & BOTTOM SEAT GASKET

**REPAIR UNITS (Complete with Washers)**

- SC 3 RENEWABLE SEAT UNIT COMPLETE
- SC-5 SPINDLE ASSEMBLY MODEL 0 (Less Volume Control)
- +SC-5 SPINDLE ASSEMBLY MODEL V (Volume Control)

Note: When valve has a high frequency of use and requires repair, replace Renewable Seat and Spindle Assembly simultaneously.
THIS PAGE IS MISSING IN ORIGINAL DOCUMENT

56 - 57
I-801S HYDAPipe packaged unit (STANDARD UNIT) complete with SAFETYMIX with integral stops, SUPER shower head & attached soap dish.
I-801 Same as above less soap dish.
I-802S (SHORT UNIT)
I-802 (SHORT UNIT) Less Soap Dish

This drawing to be used for rough-in installation only. For complete installation, adjustment and service information, see Safetymix Form #5-3.

thru wall supplies may enter at any position between minimum and maximum distances shown

floor line

throughout the document.