the present test plan, along with their operating and water draw schedules as Tables 2, 3 and 4. These tests are summarized as follows:

## Space Cooling Mode, Tests 1, 5, 6 and 7

Test 1 (required) is identical to the Department Test A, Test 5 (required) is identical to Department Test B, Test 6 (optional) is identical to Department Test C, and Test 7 (optional) is identical to Department Test D, except for the following: The refrigerant-to-water heat exchanger is filled with water. In order to not have the water pump cycle on during tests 1 and 5, it may be necessary to disable the water pump. If natural convection within the water system proves significant, it will be necessary to close an isolation valve between the heat pump and the water heater tank.

### Space Heating Mode, Tests 11, 12, 13 and 15

Test 11 (required) is identical to the Department High Temperature Test, Test 12 (optional) is identical to the Department Cyclic Test, Test 13 (required) is identical to Department Frost Accumulation Test, and Test 15 (required) is identical to the Department Low Temperature Test, except for the following: the refrigerant-to-water heat exchanger is filled with water. In order to not have the water pump cycle on during tests 11, 13 and 15, it may be necessary to disable the water pump. If natural convection within the water system proves significant, it will be necessary to close an isolation valve between the heat pump and the water heater tank.

# Space Cooling/Domestic Water Heating Mode, Tests 2 and 4

Test 2 is the Department Test A, combined with water heating. Air side conditions are held constant and the system runs continuously, while a series of water draws are imposed as outlined in Table 2.

Test 4 is the Department Test D, which involves cyclic operation of the heat pump, with a series of water draws imposed as outlined in Table 3.

The system cyclic schedule is for energizing of the compressor and indoor blower control terminal. Actual system operation will be controlled by the system internal controls. Depending on internal controls, the compressor and one of the system fans may start or continue to run irrespective of the compressor terminal being energized. There shall be no air flow through the coil with the idle fan. When the indoor blower is off, the duct shall be blocked.

### Space Heating/Domestic Water Heating Mode, Tests 10 and 14

Test 10 is the Department Cyclic Test with a series of water draws imposed, as outlined in Table 3.

Test 14 is the Department Low Temperature Test combined with water heating. Air side conditions are held constant and the system runs continuously, while a series of water draws are imposed, as outlined in Table 2.

The system cyclic schedule is for energizing of the compressor and indoor blower control terminal. Actual system operation will be controlled by the system internal controls. Depending on internal controls, the compressor and one of the system fans may start or continue to run irrespective of the compressor terminal being energized. There shall be no air flow through the coil with the idle fan. When the indoor blower is off, the duct shall be blocked.

# Domestic Water Heating Modes, Tests 3, 8 and 9

Tests 3, 8 and 9 involve cyclic operation of the heat pump in selfcontrolled response to a series of water draws, as outlined in Table 4.

Test 3 (required) uses the same conditions as the Department Test D, and will result in a cooling effect on the indoor room.

The conditions of Tests 8 and 9 (both required) are specified in Table 1. Their temperatures do not correspond to any Department tests, but, with the exception of the temperatures specified in Table 1, they shall follow the requirements of Department Test D.

Tests 8 and 9 will result in a cooling effect on the outdoor room ("O" terminal de-energized). When the indoor blower is off, the ductwork shall be blocked.

In addition to the normal components required for indoor space heating and cooling, the unit shall be connected, as specified by the heat pump manufacturer, to a conventional electric domestic hot water storage tank. The hot water storage tank shall have a nominal rated volume of 52 gallons, with an actual internal volume of 47±1 gallons. The hot water storage tank shall have an Energy Factor (EF) rating that is within  $\pm .02$  of the EF specified as the Federal Energy Conservation Standard for 52 gallon electric water heaters, (presently 0.87), as determined by the Department test and rating standards, contain two electric heater elements each rated at nominal 4500 Watts and be connected to a source of supply water having a temperature of 58±2 °F. The electrical voltage supplied to the water heater

shall be adjusted such that the measured electrical power input is 4275±75W when the lower resistive element is heating water. The water heater instrumentation: six internal thermocouples plus entering and leaving water temperature measurements and energy use, is to be installed according to the standard Department test and rating procedure. The water heater thermostats are to be replaced with manual controls operated to turn off the upper element at 135 °F and on at 115 °F based on the internal thermocouple located closest to the upper thermostat location. The lower element shall be operated, as specified by the heat pump manufacturer, but to turn off and on at not lower than 110 °F and 100 °F respectively (unless a new thermostat is supplied specifically for the purpose) based on the internal thermocouple located closest to the lower thermostat. The lower element shall also be controlled to not operate coincident with the upper element. The purpose of the manual controls is to simulate the normal thermostats, but with improved repeatability. The heat pump system shall be installed per the manufacturers installation instructions. Unless otherwise specified by the manufacturer, the water heater is to be installed in the indoor room, as is the compressor section, if it is separate from the outdoor unit. The water heater is to be connected to the compressor section with 15 feet of interconnecting tubing (30 feet total for two lines), insulated (both) with R4 insulation. The refrigerant sections are to be connected with a total of 25 feet of 3/4'' insulated vapor line and 25 feet of 3/8''uninsulated liquid line. The line lengths between the compressor section and the indoor coil shall be between 5 and 10 feet, with the balance of the 25 feet connected between the compressor section and the outdoor unit. with 10 feet located in the outdoor room.

#### Calculation of Seasonal Performance Factors

The overall performance of the integrated heat pump system shall be expressed in terms of seasonal performances. In addition to the Seasonal Energy Efficiency Ratio (SEER) and Heating Seasonal Performance Factor (HSPF) currently required by the Department, a Combined Cooling Performance Factor (CCPF) shall be calculated for the cooling season and a **Combined Heating Performance Factor** (CHPF) shall be calculated for the heating season. These two combined performance factors reflect the energy efficiency of the heat pump when providing both space conditioning and