

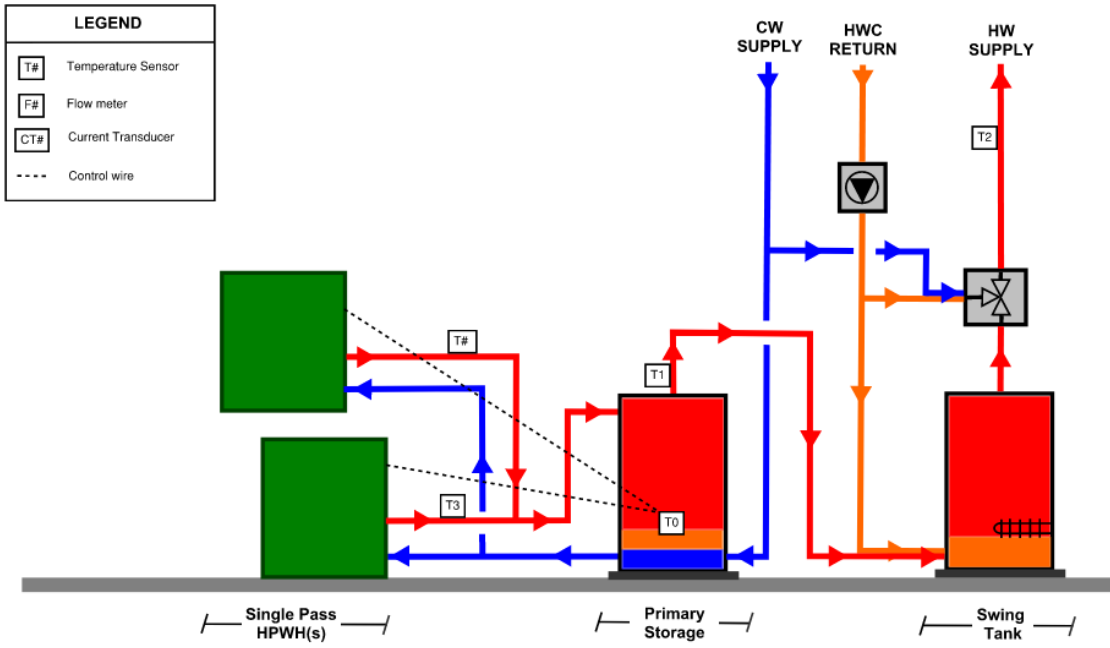
## REFERENCE CONTROLS NARRATIVE FOR DHW HPWH SYSTEM

### SYSTEM DESCRIPTION

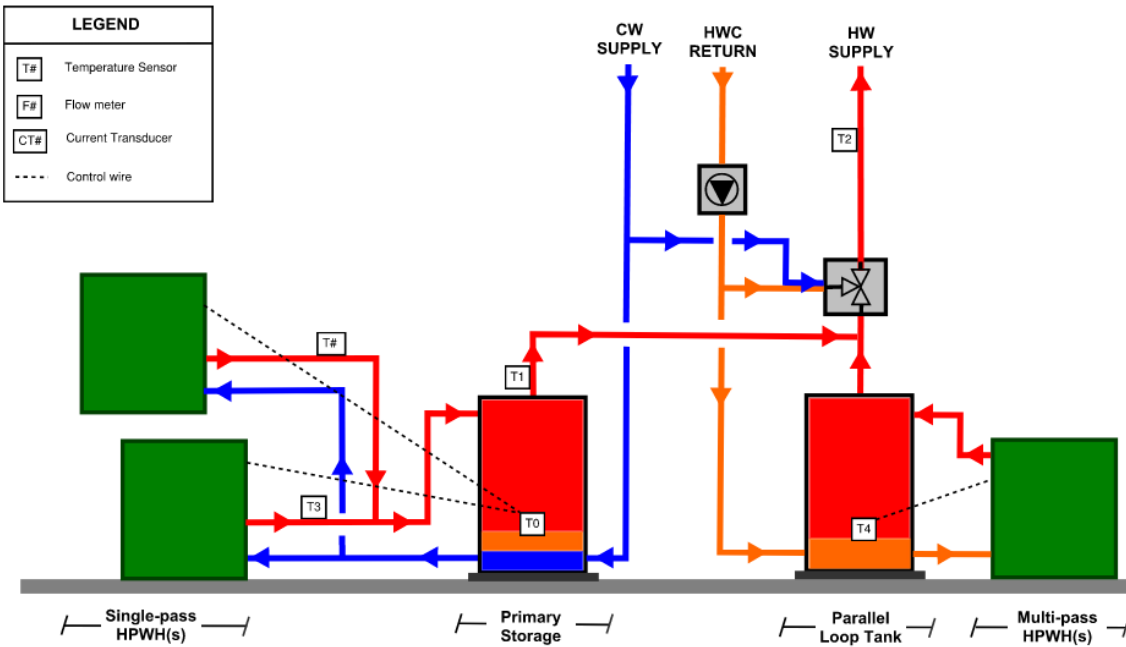
#### A. Basic Control, Monitor and Alarm System:

1. Shall control the primary HPWH(s) heating cycle based on the primary storage tank temperature and the temperature maintenance heating system based on the temperature maintenance storage temperature. The control sequence of operations shall be per the manufacture's recommendations or the HPWH design guidelines.
2. Shall monitor the system parameters listed below.
  - a. Water temperature in the primary storage (T0)
  - b. Water temperature leaving the primary storage (T1)
  - c. Water temperature leaving the tempering valve (T2)
  - d. Water temperature leaving the heat pumps (T3, T#)
  - e. Water temperature of parallel loop tank (T4)
3. Shall send email and/or SMS text alarms to the building operators, maintenance personal, and service contractor for the alarms below.
  - a. Alarm if any heat pump is in alarm state.
  - b. Temperature of the water flowing out of the primary storage is below 120F.
  - c. Temperature of water flowing into the distribution loop downstream of the mixing valve is below 120F.
4. Sample Reference Schematics:

### Basic Control System - Single Pass HPWH(s) with Swing Tank

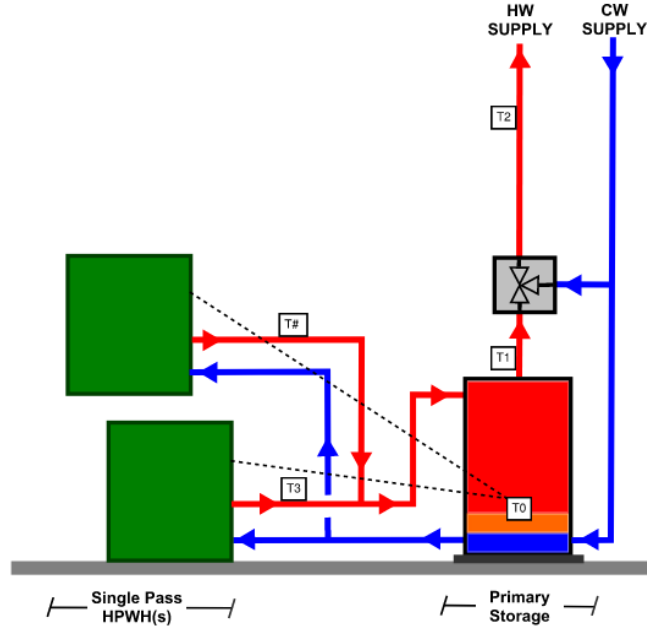


### Basic Control System - Single Pass HPWH(s) with Parallel Loop Tank



### Basic Control System - Single Pass HPWH(s) without Hot Water Circulation

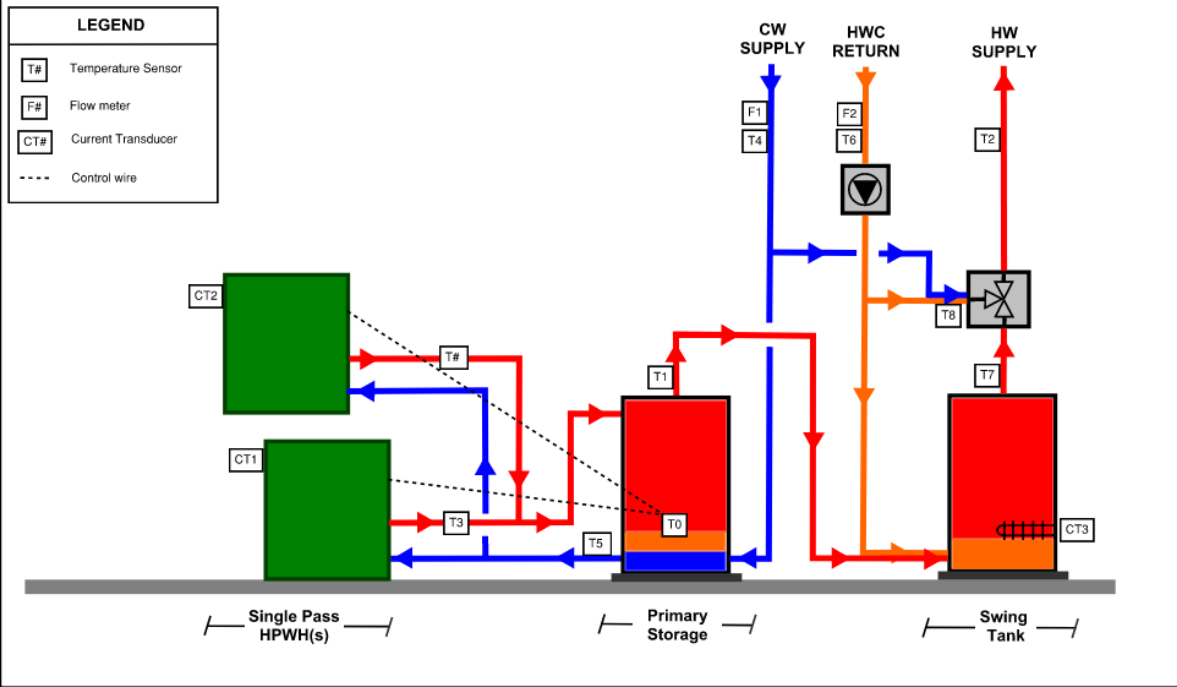
LEGEND	
T#	Temperature Sensor
F#	Flow meter
CT#	Current Transducer
----	Control wire



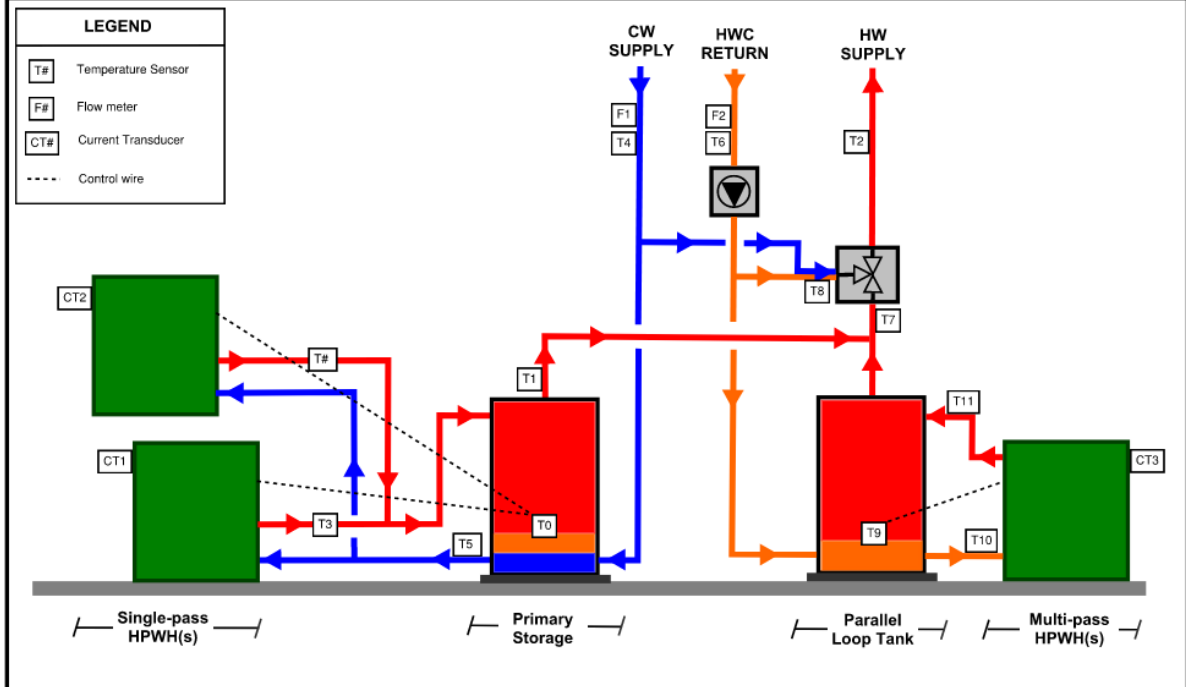
**B. Advanced Control, Monitor and Alarm System:**

1. Shall control the primary HPWH(s) heating cycle based on the primary storage tank temperature and the temperature maintenance heating system based on the temperature maintenance storage temperature. The control sequence of operations shall be per the manufacture's recommendations or the HPWH design guidelines. It shall also be controlled to allow for utility grid demand response integration with a CT-2045 communication port and supporting control logic.
2. Shall monitor, and trend as described in this section:
  - a. Monitor: the controller shall monitor the system parameters listed below.
    - 1) Water temperature in the primary storage at control sensor (T0)
    - 2) Water temperature leaving the primary storage (T1)
    - 3) Water temperature leaving the tempering valve (T2)
    - 4) Water temperature leaving the HPWH(s) (T3, T#)
    - 5) Entering water temperature to the central plant (T4)
    - 6) Water temperature entering the HPWH(s) (T5)
    - 7) Return water temperature from circulation loop (T6)
    - 8) Hot side water temperature entering the tempering valve (T7)
    - 9) Cool side water temperature entering the tempering valve (T8)
    - 10) Water temperature in the parallel loop tank (T9)
    - 11) Water temperature entering the parallel loop tank HPWH (T10)
    - 12) Water temperature leaving the parallel loop tank HPWH (T11)
    - 13) CW supply flowrate entering the central plant (FM1). This is equal to the HW supply flowrate leaving the central plant.
    - 14) HW return flowrate of the building circulation system (FM2)
    - 15) Primary heating equipment energy use (CT1, CT2, CT#)
    - 16) Temperature Maintenance heating equipment energy use (CT3)
    - 17) Auxiliary HPWH system equipment energy use when present
  - b. These parameters shall also be trended at a 1-min frequency with storage for greater than 1-year of data, and report performance metrics as described below.
    - 1) System COP:  $COP_{sys} = \frac{\text{Energy Delivered}}{\text{Energy In Primary HPWH} + \text{Energy In Temperature Maintenance Heaters}}$ 
      - a) Energy In Primary HPWH = Electrical energy into the primary HPWHs and any backup Primary heaters in units of Btu/hr
      - b) Energy In Temperature Maintenance Heaters = Electrical energy into the temperature maintenance Heaters and accessories in units of Btu/hr
      - c) Energy Delivered = HW Flow Out (GPM) \* 500 \* (Temp. HW Out (F) – Temp. CW In (F))
3. Shall send email and/or SMS text alarms to the building operators, maintenance personal, and service contractor for the alarms below.
  - a. Alarm if any heat pump is in alarm state.
  - b. Temperature of the water flowing out of the primary storage is below 120F.
  - c. Temperature of water flowing into the distribution loop downstream of the mixing valve is below 120F.
4. Sample Reference Schematics:

### Advanced Control System - Single Pass HPWH(s) with Swing Tank



### Advanced Control System - Single Pass HPWH(s) with Parallel Loop Tank



# Advanced Control System - Single Pass HPWH(s) without Hot Water Circulation

LEGEND	
T#	Temperature Sensor
F#	Flow meter
CT#	Current Transducer
----	Control wire

