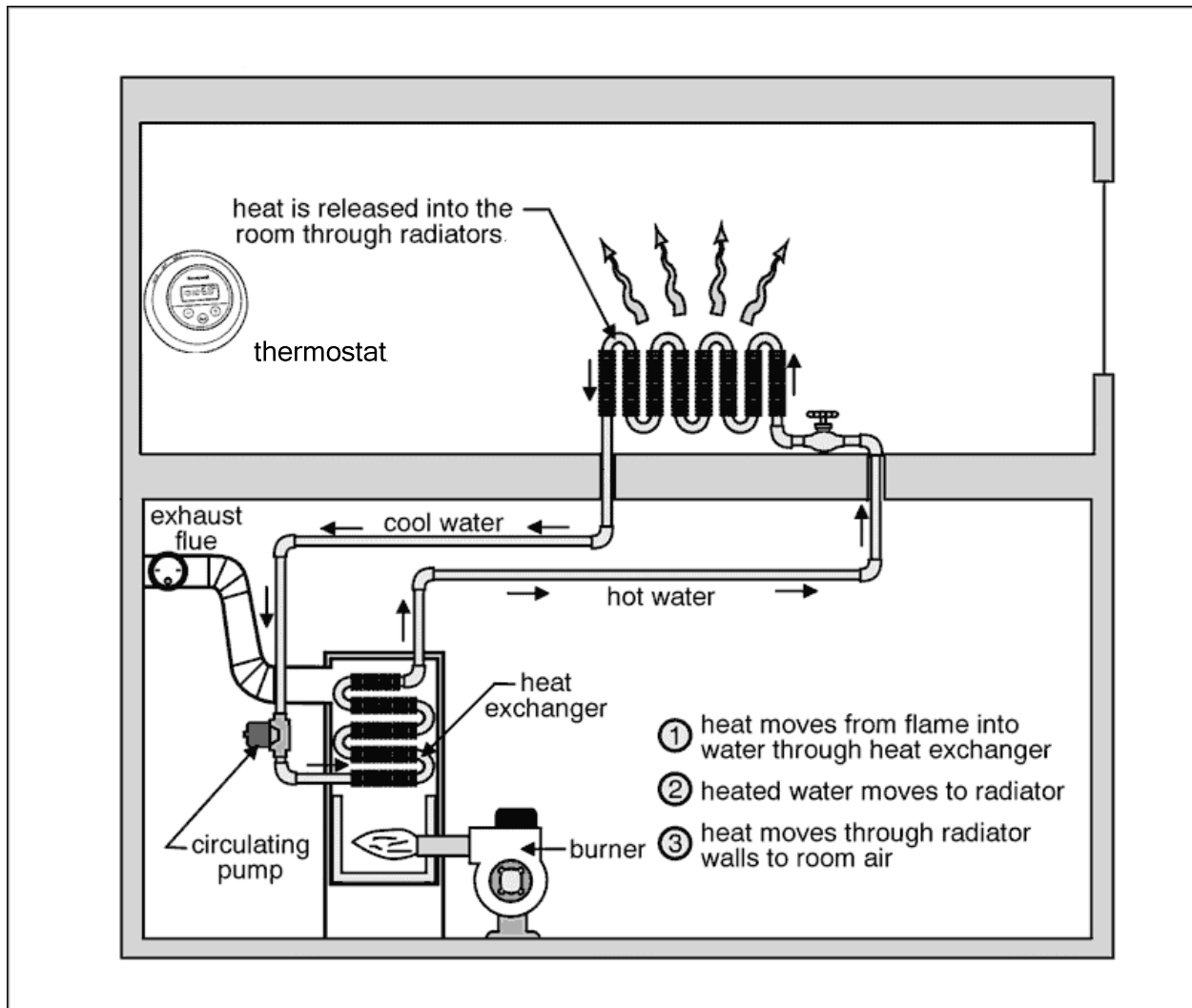


Home Heating System Requirements

Prose Requirements

The Home Heating System (HHS) software monitors room temperature and controls heating system hardware to maintain a desired temperature in the rooms of a house. A thermostat provides the user a switch to turn the HHS on and off, a device to set the desired temperature, and a temperature sensor that monitors the current air temperature at the thermostat.

Hot water provides the system's heat source. When heat is needed, the HHS turns on a furnace to heat water to 80 degrees Fahrenheit. When the water reaches minimum operating temperature (initially 80° F.), the system must turn on the circulating pump causing hot water to flow to the radiators in the house. When heat is no longer needed, the system turns off the pump and shuts down the furnace. To prevent the system from turning the furnace on and off too rapidly, the system should not initiate the heat cycle until the temperature falls two degrees below the desired temperature (i.e., desired-temperature - 2°). Likewise, it should continue to supply heat until the temperature is two degrees above the desired temperature (i.e., desired-temperature + 2°).

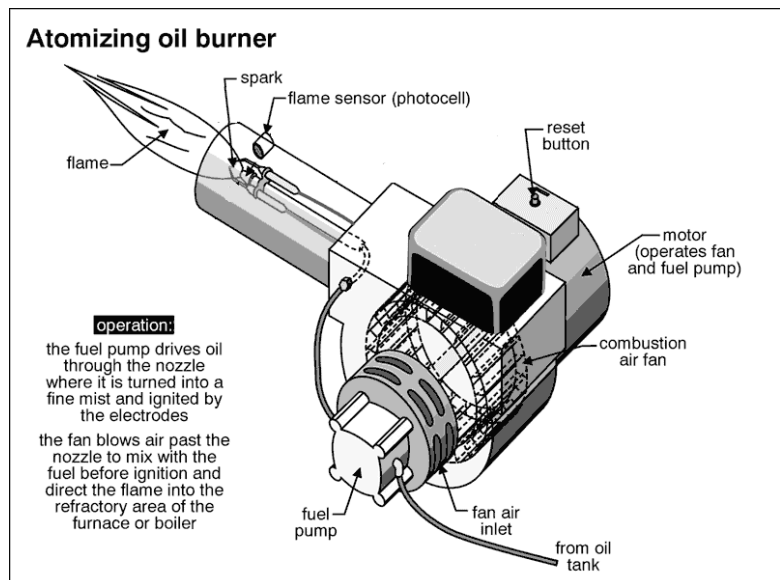


The HHS is required to monitor and control the operation of a furnace that heats the water in the system. The furnace hardware consists of a boiler, an oil valve, an ignitor, and a blower. It also includes a set of sensors: an RPM sensor for the Blower motor, a sensor that detects whether or not fuel is flowing, a combustion sensor that detects whether or not the fuel is burning, and a water-temperature sensor in the boiler.

Furnace Ignition: When the water must be heated, the HHS is required control furnace startup to ensure proper ignition. The system is required to first turn on the blower. Once the blower motor reaches 2000 RPM, the system should open the oil valve. Once the fuel is flowing, the system turns on the igniter – the ignitor is turned off again once combustion occurs.

Furnace Shutdown: When heat is no longer needed or the water in the boiler exceeds a pre-set temperature (initially 100° F), the system shuts the furnace down. The shutdown sequence ensures that no fuel or fumes are left in the system after shutdown. First, the system shuts the oil valve. Once the system detects that the fuel is no longer flowing, it waits five (5) seconds then turns the blower off. Once the blower RPMs drop below 2000, the furnace returns to a standby state.

Furnace Safety Shutdown: If the furnace runs out of fuel or loses combustion while running, it must be shutdown and a fault signaled. If, while the furnace is running, the system detects that fuel has ceased flowing or that combustion has ceased, then the system must shut the furnace down and turn on the fault indicator. The fault-shutdown sequence is the same as the usual furnace shutdown sequence. However, the system must remain in a fault state until it is reset. The system is reset by pressing the reset button on the furnace for at least one second. When the furnace is reset, the fault indicator should be turned off and the furnace returned to standby.



SCR Specification

Dictionaries

Type Dictionary

Name	Base Type	Units	Legal Values	Comment
AirTemperature	Integer	degrees Fahrenheit	[40, 120]	Models possible values of the air temperature within the operating range of the thermostat.
Flow	Enumerated	N/A	flowing, notflowing	
IgniteState	Enumerated	N/A	ignited, notignited	
RPM	Integer	revolutions/minute	[0, 5000]	
Seconds	Integer	seconds	[0, 100]	
Switch	Enumerated	N/A	off, on	
Valve	Enumerated	N/A	open, closed	
WaterTemperature	Integer	degrees Fahrenheit	[40, 200]	Models possible values of the water temperature in the boiler.

Mode Class Dictionary

Name	Modes	Initial Mode	Comment
HeatCycle	Off, Standby, Ignition, Running, Shutdown, FaultShutdown	Off	Possible states of the heating cycle: 1. Off: the heating system is turned off. 2. Standby: the heating system is on but idle (not heating). 3. Ignition: the furnace burner is being lit. 4. Running: the furnace is heating the water. 5. Shutdown: the water has reached temperature and the furnace is shutting down (ceasing combustion). 6. FaultShutDown: the furnace is shutting down due to occurrence of a fault.

Constant Dictionary

Name	Type	Value	Comment
MaxWaterTemp	WaterTemperature	100	Maximum water temperature allowed before the boiler will shut down.
MinContactTime	Seconds	1	Minimum contact time the reset switch must be held before the system will initiate a reset.
MinWaterTemp	WaterTemperature	80	Minimum water temperature the system will circulate.
Tolerance	Float	0.5	Float rather than RoomTemp which requires integers in the range [40, 104]

Monitored Variable Dictionary

Name	Type	Initial Value	Accuracy	Comment
BlowerSpeed	RPM	0	10	The speed of the blower motor.
Combustion	IgniteState	notignited	N/A	Combustion = ignited indicates that the burner is maintaining proper combustion. Otherwise the burner is not maintaining proper combustion.
DesiredTemp	AirTemperature	68	1	The position of the thermostat needle on the numbered scale labeled "Fahrenheit."
FuelFlow	Flow	notflowing	N/A	FuelFlow = flowing indicates that fuel flowing to the burner. Otherwise fuel is not flowing.
HeatSwitch	Switch	off	N/A	HeatSwitch indicates that the heat switch is in the position labeled "ON." Otherwise it is in the "OFF" position.
ResetSwitch	Switch	off	N/A	ResetSwitch indicates that the owner is pressing the switch labeled "RESET." Otherwise the switch is in the release position.
RoomTemp	AirTemperature	68	1	Air temperature in room five feet from the floor along an inside wall.
time	Integer	0	1	Time passed since system initialization.
WaterTemp	WaterTemperature	68	1	Temperature of the water in the boiler.

Term Dictionary

Name	Type	Initial Value	Accuracy	Comment
BlowerUptoSpeed	Boolean	FALSE	N/A	The blower motor has reached operating speed.
FaultReset	Boolean	FALSE	N/A	FaultReset = true indicates that the system has detected the conditions indicate a fault has occurred in the furnace operation.
HeatAvail	Boolean	FALSE	N/A	Water in the system is at operating temperature for the heater.
NeedHeat	Boolean	FALSE	N/A	NeedHeat should be true when room temperature is below threshold.

Controlled Variable Dictionary

Name	Type	Initial Value	Accuracy	Comment
Blower	Switch	off	N/A	When Blower = on the blower motor is on. Otherwise the motor is off.
FaultIndicator	Switch	off	N/A	FaultIndicator = on indicates that the light labeled "FAULT" is lit. Otherwise the light is not lit.
Ignitor	Switch	off	N/A	Ignitor = on indicates that the oil burner ignitor is on. Otherwise the ignitor is off.
OilValve	Valve	closed	N/A	OilValve = open indicates that the oil valve is open. Otherwise the valve is closed.
WaterPump	Switch	off	N/A	WaterPump = on indicates that the valve that the pump that controls the flow of water to the heaters running. Otherwise the pump is off and water is not circulating.

Blower Condition Function		
Modes for HeatCycle	Conditions	
Standby, Off	False	True
Ignition, Running	True	False
Shutdown, FaultShutdown	(DURATION (FuelFlow = notflowing)) < 5	(DURATION (FuelFlow = notflowing)) >= 5
Blower =	on	off
Description The blower is turned on for Ignition and stays on while the furnace is running. When the furnace is shutting down, the blower is required to remain on until the fuel has been off for at least 5 seconds.		

BlowerUptoSpeed Condition Function		
	Conditions	
	BlowerSpeed < 2000	BlowerSpeed >= 2000
BlowerUptoSpeed =	FALSE	TRUE
Description The blower must reach 2000 RPM to sustain ignition and combustion.		

FaultIndicator Event Function		
Modes for HeatCycle	Events	
FaultShutdown	@T(INMODE)	@F(INMODE)
Off, Standby, Ignition, Running, Shutdown	NEVER	NEVER
FaultIndicator' =	on	off
Description Defines the rules for when the fault indicator light should be turned on and when it should be turned off.		

FaultReset Event Function		
	Events	
	@T(DURATION (ResetSwitch = on) < MinContactTime)	@T(DURATION (ResetSwitch = on) >= MinContactTime)
FaultReset' =	FALSE	TRUE
Description Defines the rules for when a system reset is initiated. The software should detect a reset when the reset button has been held down for the minimum contact time (MinContactTime)		
Notes Whether the reset has any effect depends on the current system state (mode).		

HeatAvail Condition Function		
	Conditions	
	WaterTemp < MinWaterTemp	WaterTemp >= MinWaterTemp
HeatAvail =	FALSE	TRUE
Description Specifies the rules for determining when the water has reached sufficient temperature. The system will not circulate the water through the radiators unless the water temperature is above a fixed minimum temperature set at sysgen time.		

HeatCycle Mode Transition Function		
Source Mode(s)	Events	Destination Mode
Off	@T(HeatSwitch = on) WHEN (NOT NeedHeat)	Standby
Off	@T(HeatSwitch = on) WHEN NeedHeat	Ignition
Standby	@T(HeatSwitch = off)	Off
Standby	@T(NeedHeat)	Ignition
Ignition	@T(Combustion = ignited)	Running
Ignition	@T(HeatSwitch = off) WHEN (Combustion = notignited)	Shutdown
Running	@F(NeedHeat)	Shutdown
Running	@T(HeatSwitch = off)	Shutdown

Running	@F(FuelFlow = flowing)	FaultShutdown
Running	@F(Combustion = ignited)	FaultShutdown
Running	@T(WaterTemp > MaxWaterTemp)	Shutdown
Shutdown	@F(BlowerUptoSpeed)	Standby
FaultShutdown	@T(FaultReset)	Standby
Description		
Description of table		
Notes		
Currently cannot find any way to express the requirement that the system should declare a fault if it has been in Ignition mode for more than 5 seconds without ignition.		

Ignitor Event Function		
Modes for HeatCycle	Events	
Ignition	@T(FuelFlow = flowing)	@T(Combustion = ignited)
Off, Standby, Running, Shutdown, FaultShutdown	NEVER	@T(INMODE)
Ignitor' =	on	off
Description		
Defines the rules for when the fuel ignitor is turned on and when it is turned off.		
Notes		
The ignitor is turned on once the system detects that fuel is flowing. It is turned off once combustion is detected.		

NeedHeat Event Function		
	Events	
	@T(RoomTemp < DesiredTemp - 2)	@T(RoomTemp >= DesiredTemp +2)
NeedHeat' =	TRUE	FALSE
Description		
Term NeedHeat specifies when the system should provide heat based on the requested temperature and the current room temperature. A hysteresis value of plus and minus 2 degrees is built in to ensure a		

reasonable interval between times the furnace is turned on.

OilValve Condition Function

Modes for HeatCycle	Conditions	
Running	True	False
Ignition	BlowerUptoSpeed	NOT BlowerUptoSpeed
Off, Standby, Shutdown, FaultShutdown	False	True
OilValve =	open	closed
Description		
OilValve defines the rules for when the valve supplying oil to the furnace should be open and when it should be closed.		

WaterPump Condition Function

Modes for HeatCycle	Conditions	
Running	HeatAvail	NOT HeatAvail
Off, Standby, Ignition, Shutdown, FaultShutdown	FALSE	TRUE
WaterPump =	on	off
Description		
WaterPump defines the rules for when the pump circulating heated water to the radiators should be turned on and when it should be turned off.		