Condensors

THE CONDENSER

- Heat exchange surface that rejects system heat
- Rejects sensible heat
  - Sensible Cooling (Desuperheating) vapor refrigerant from the compressor
  - Subco ant at the outlet of the condenser
- Rejects latent during the condensing process
- The greatest am nt of heat is transferred during the change of state
- Condenser is on th e high pressure side of the system

Types of condensers

- Air Cooled

1. Natural convection air cooled 2. Forced convection air cooled

- Water Cooled

1. ube in tube 2. She nd tube 3. Shell and coil

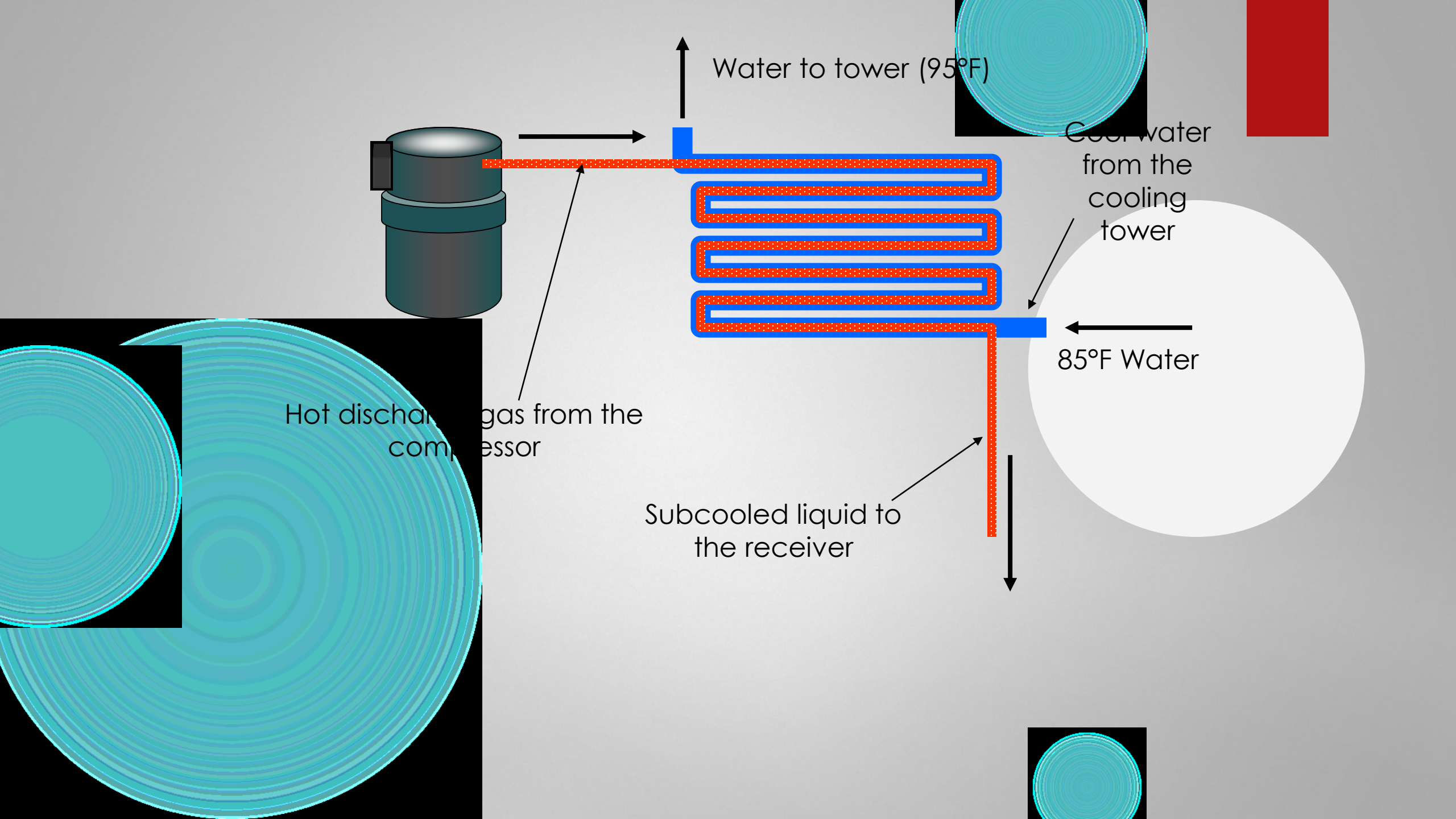
- Evaporative cooled

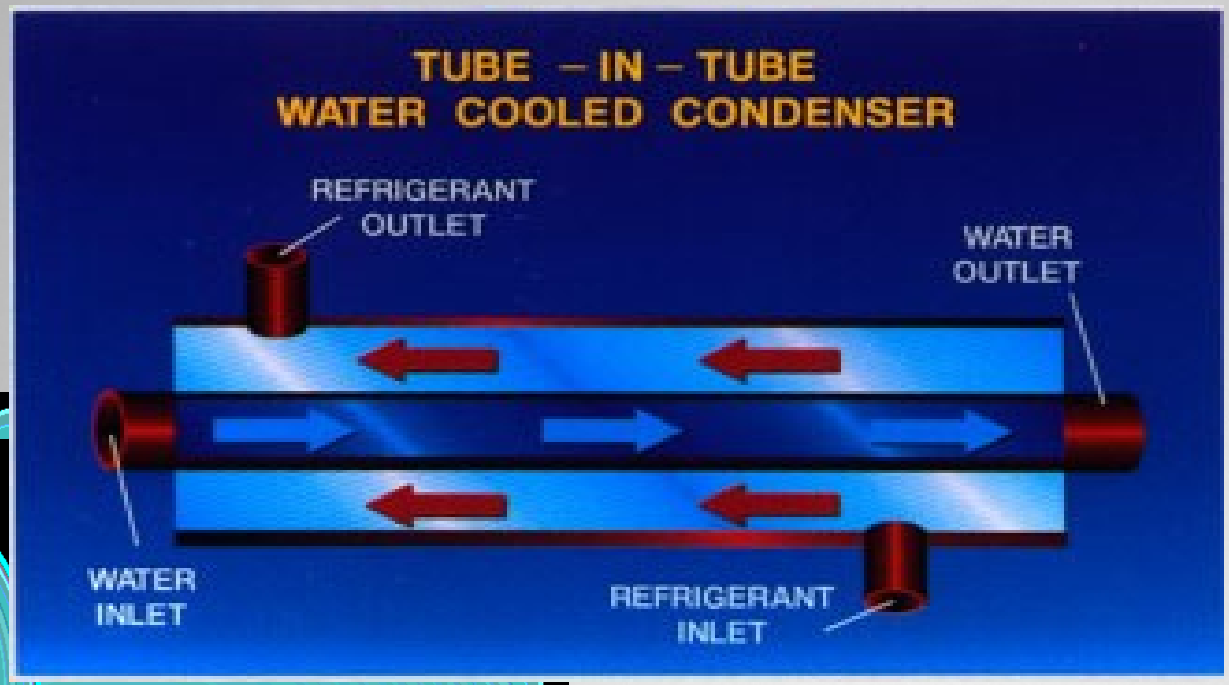
WATER-COOLED CONDENSERS

- More efficient than air-cooled condensers
- Water temperature can be maintained
- Water [illegible]ure directly affects system pressures
- Three types [illegible]ater-cooled condensers
  - Tube in tube [illegible]ondenser
  - Shell and coil [illegible]ondenser
  - Shell and tube [illegible]condenser

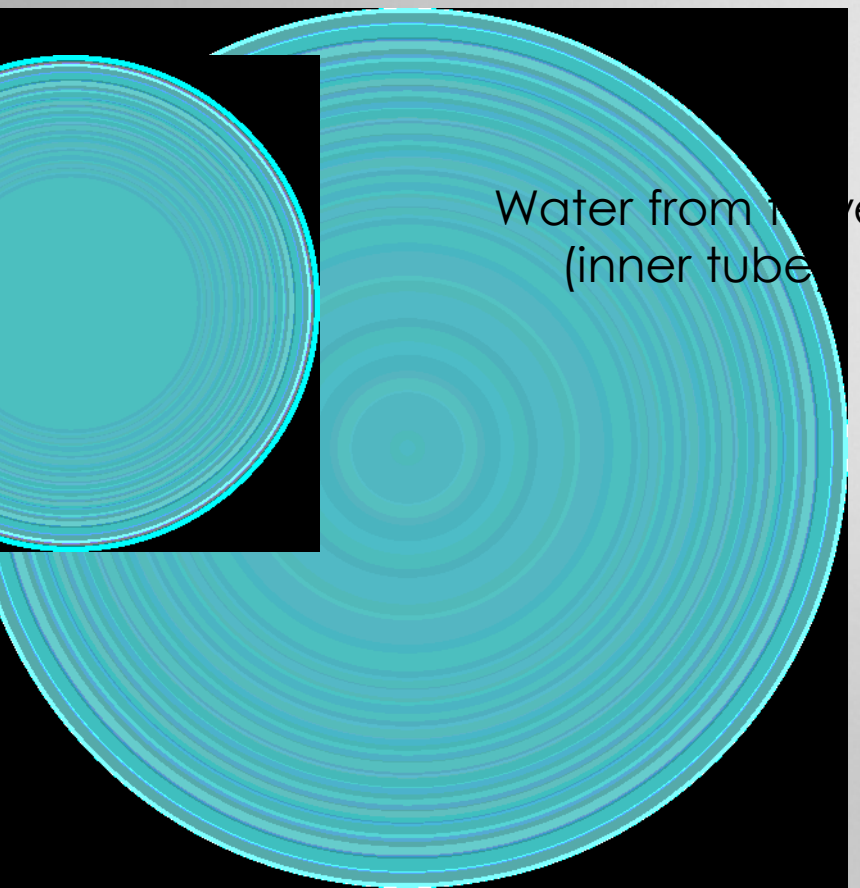
TUBE IN TUBE CONDENSER

- Heat exchange takes place between the fluids in the inner and outer tubes
- Refrigerant flows in the outer tube
- Water flows in the inner tube
- Refrigerant and water flow in opposite directions to maximize the heat transfer rate
- Depending on the construction, the condenser can be cleaned mechanically or chemically

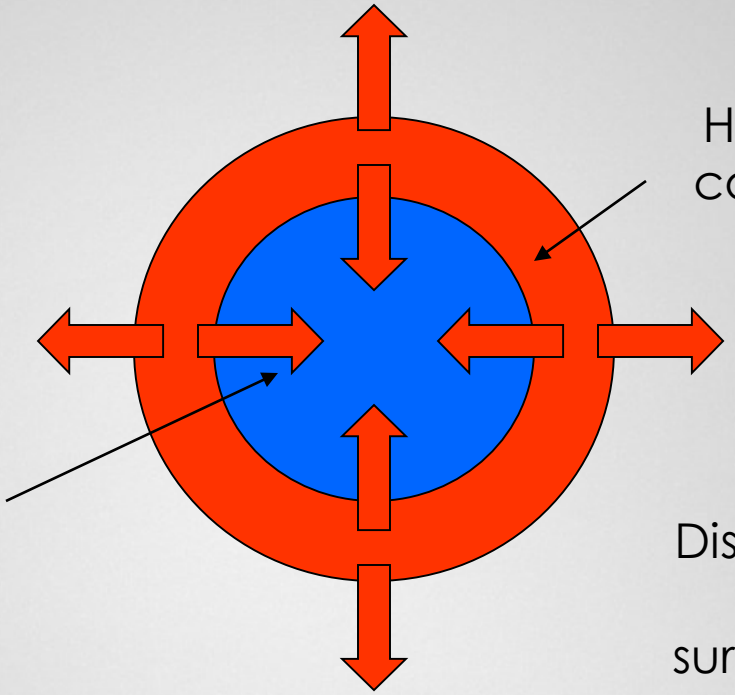

Water to tower (95°F)
Cool water from the cooling tower
85°F Water
Hot discharge gas from the compressor
Subcooled liquid to the receiver


TUBE – IN – TUBE
WATER COOLED CONDENSER
REFRIGERANT OUTLET
WATER OUTLET
WATER INLET
REFRIGERANT INLET

Cross-Section of a tube within a tube condenser



Surrounding air



Hot discharge gas from compressor (outer tube)

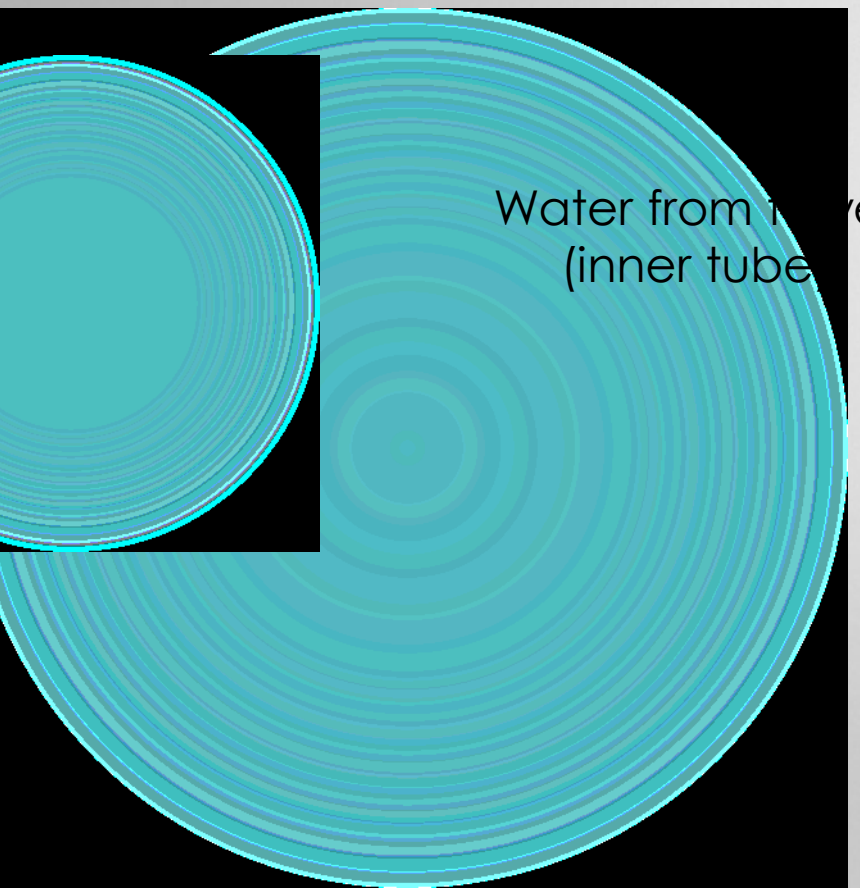
Water from [illegible]er (inner tube)

Discharge gas transfers heat to both the surrounding air and the water in the inner tube

MINERAL DEPOSITS

- Heat from the discharge gas causes minerals in the water to come out of solution
- These minerals form scale that adhered to the pipes
- The scale c[illegible] an insulator and reduces the rate of heat transfer between the [illegible]igerant and the water
- Water is chemic[illegible]ally treated to reduce the rate of scale formation on the interior pipe surfaces
- Dirty condensers lead to high head pressures

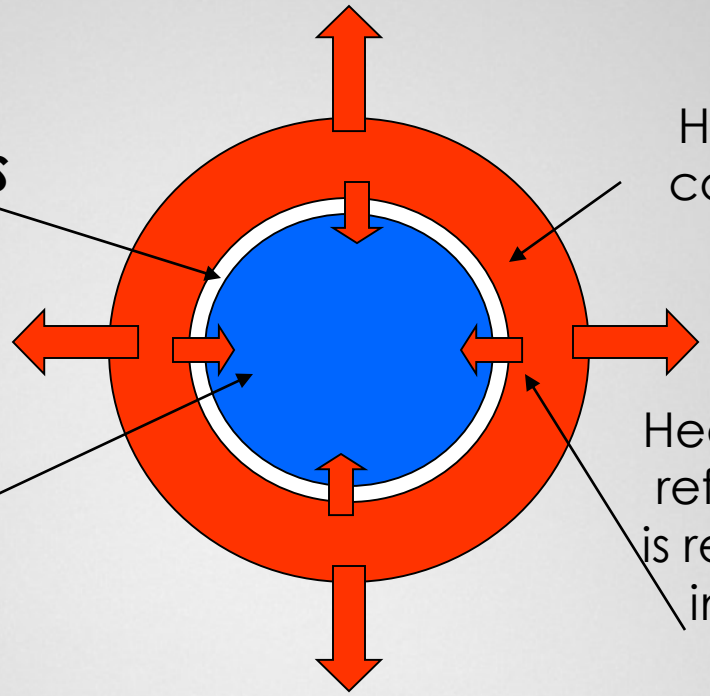
Cross-Section of a tube within a tube condenser



Surrounding air

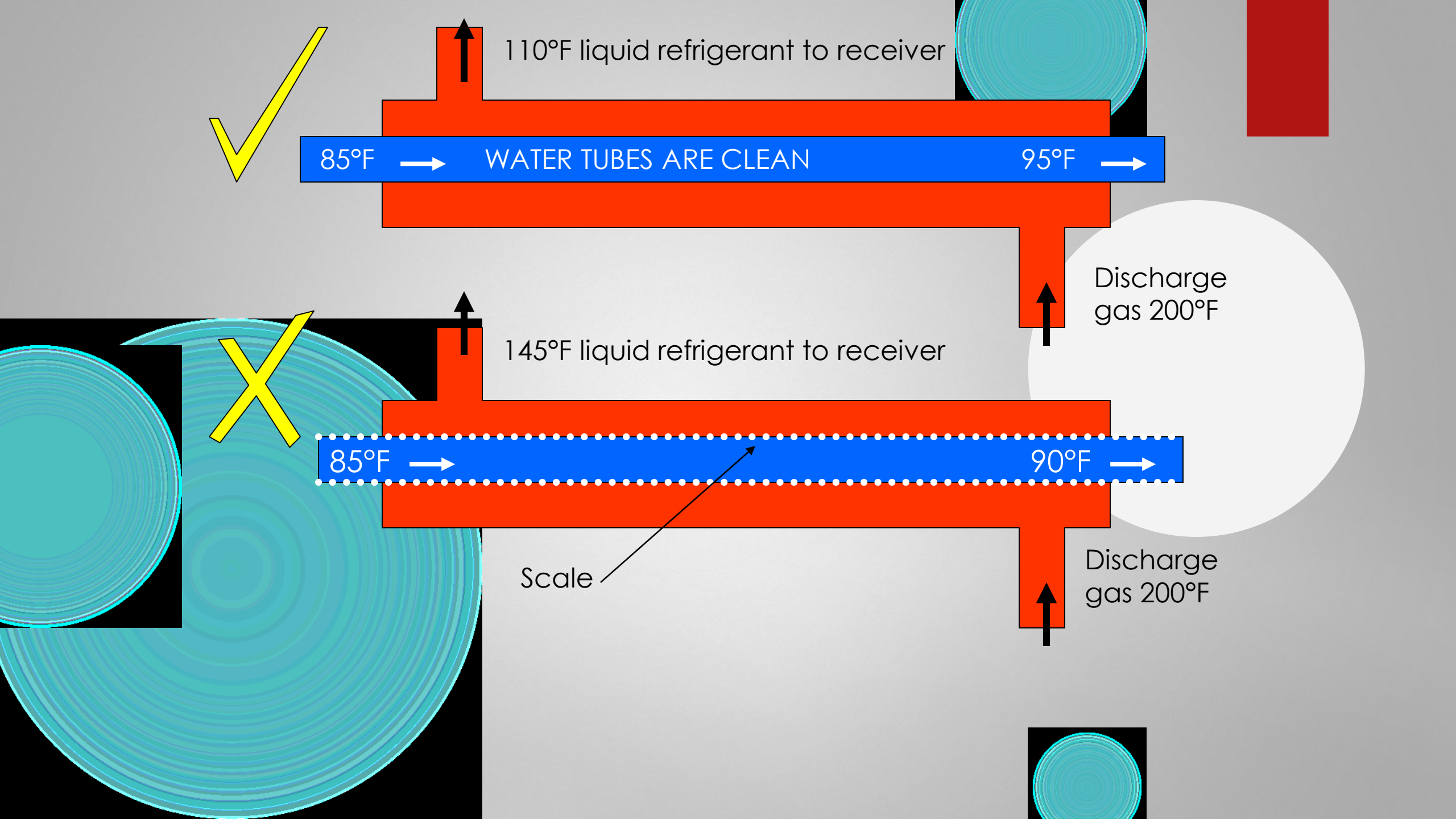
MINERAL DEPOSITS

Water from
(inner tube



Hot discharge gas from compressor (outer tube)

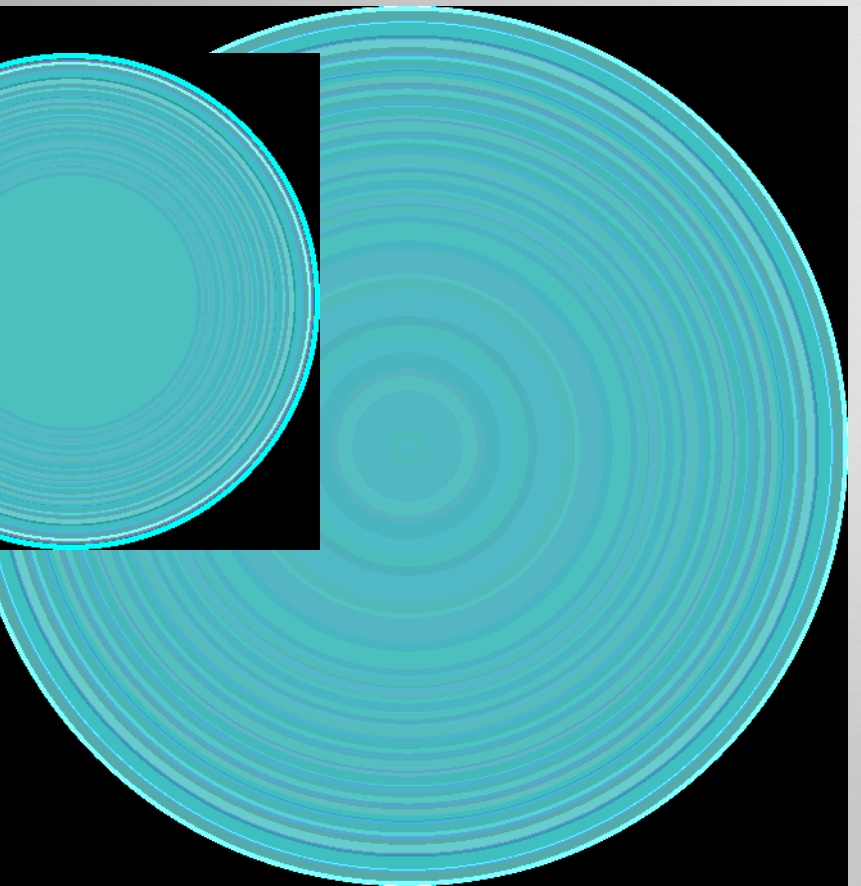
Heat transfer between the refrigerant and the water is reduced because of the insulating effect of the mineral deposits

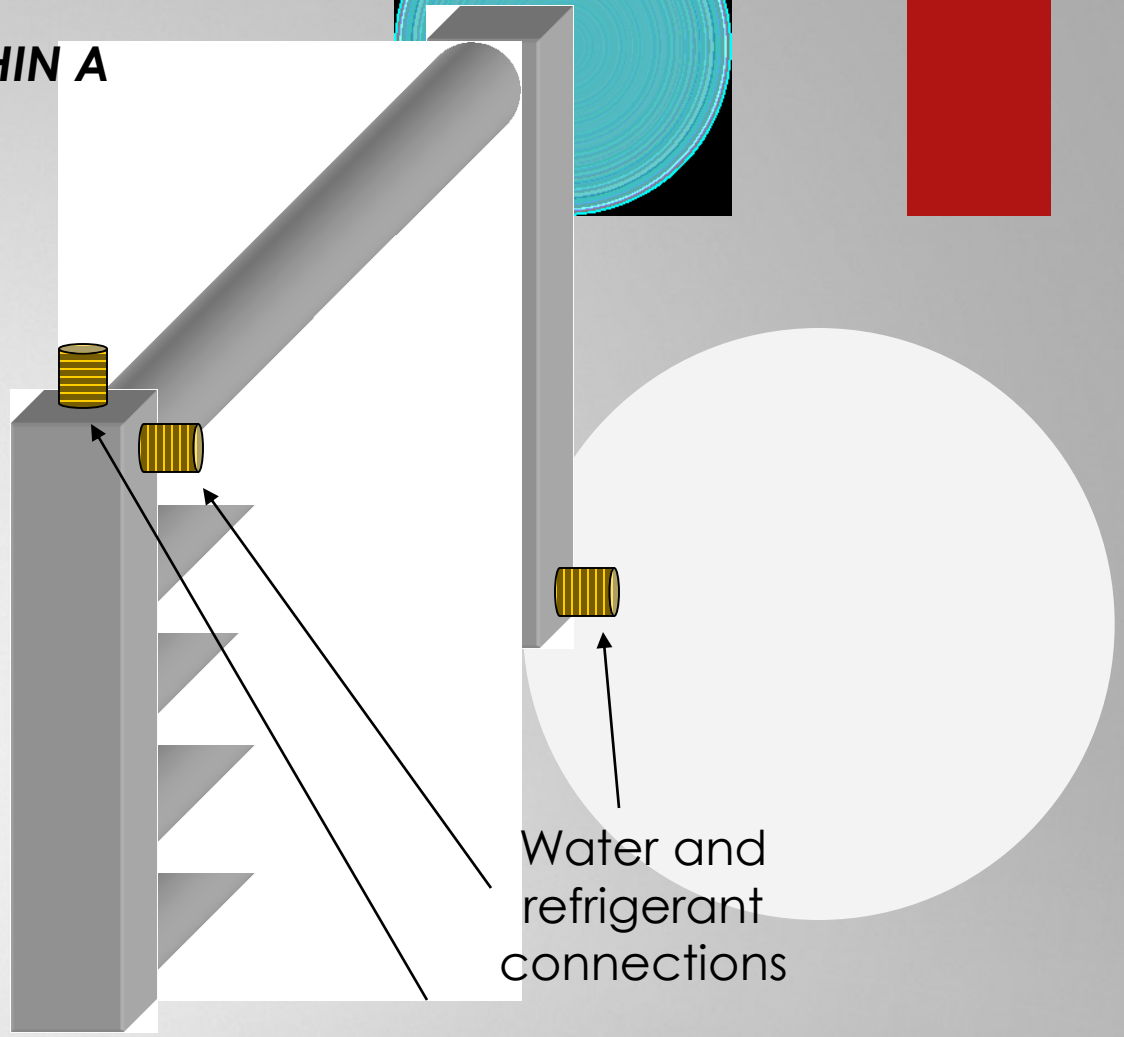

110°F liquid refrigerant to receiver
85°F
WATER TUBES ARE CLEAN
95°F
Discharge gas 200°F
145°F liquid refrigerant to receiver
85°F
90°F
Scale
Discharge gas 200°F

MECHANICALLY CLEANABLE CONDENSERS

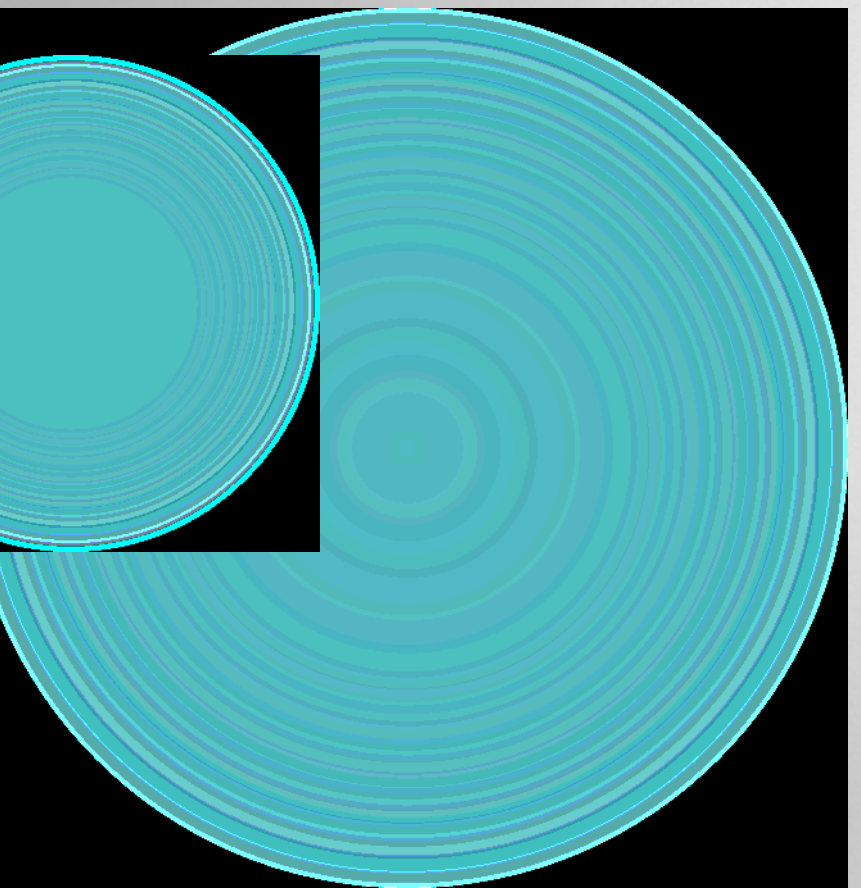
- Tube in tube condenser has end flanges
- Flanges are removed to access the water circuit
- The refrig circuit remains sealed while the water circuit is open
- The mechani ally cleanable tube-in-tube condenser is more costly than the chemically cleanable version of the condenser

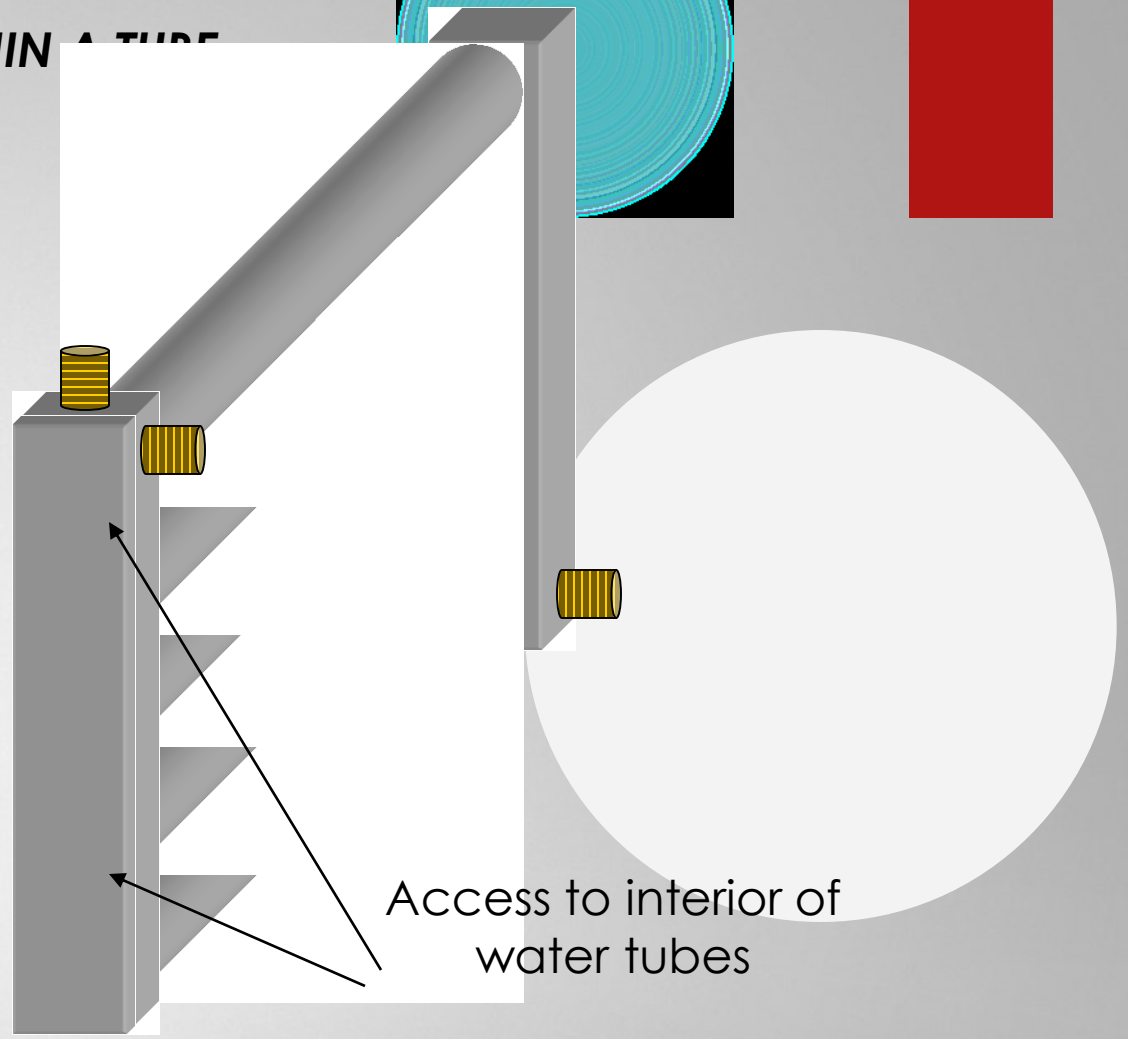
MECHANICALLY CLEANABLE TUBE WITHIN A TUBE CONDENSER





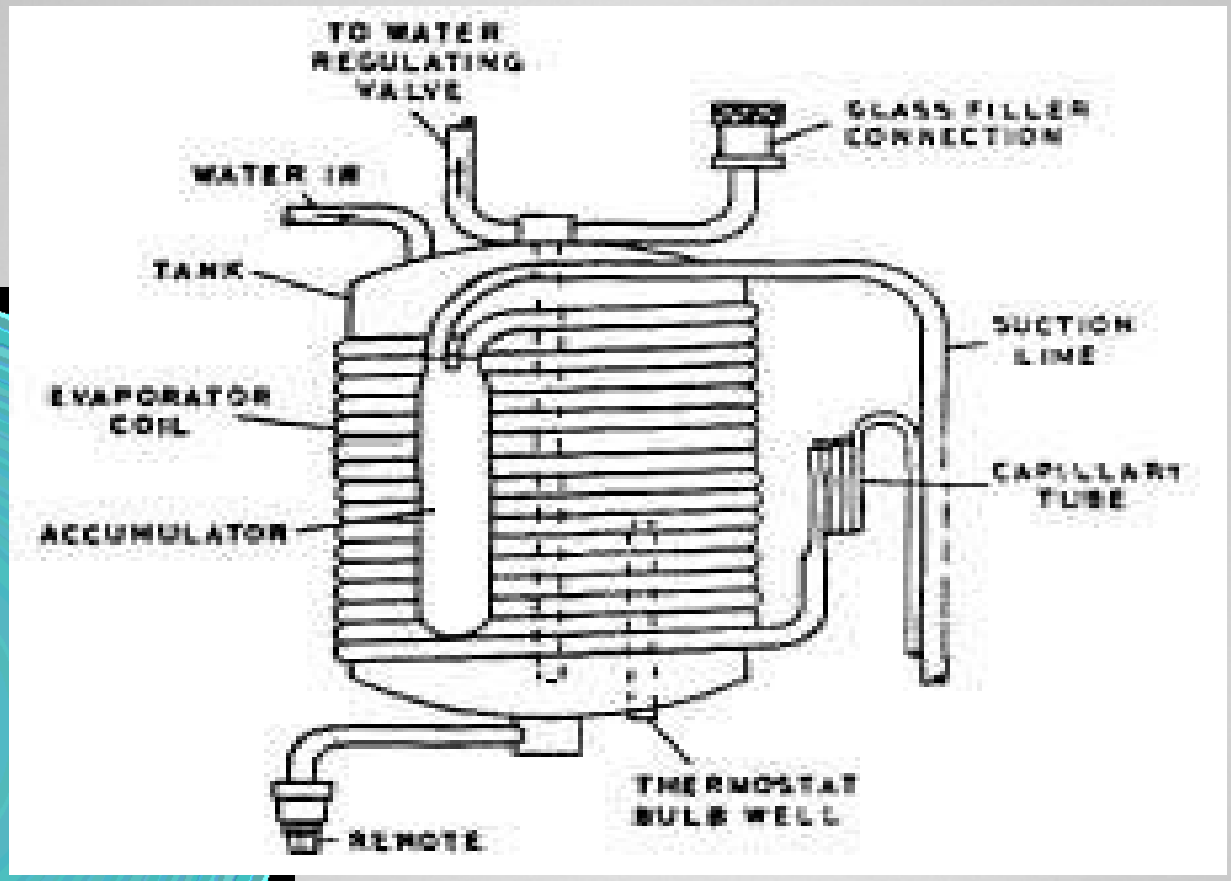
MECHANICALLY CLEANABLE TUBE WITHIN A TUBE CONDENSER



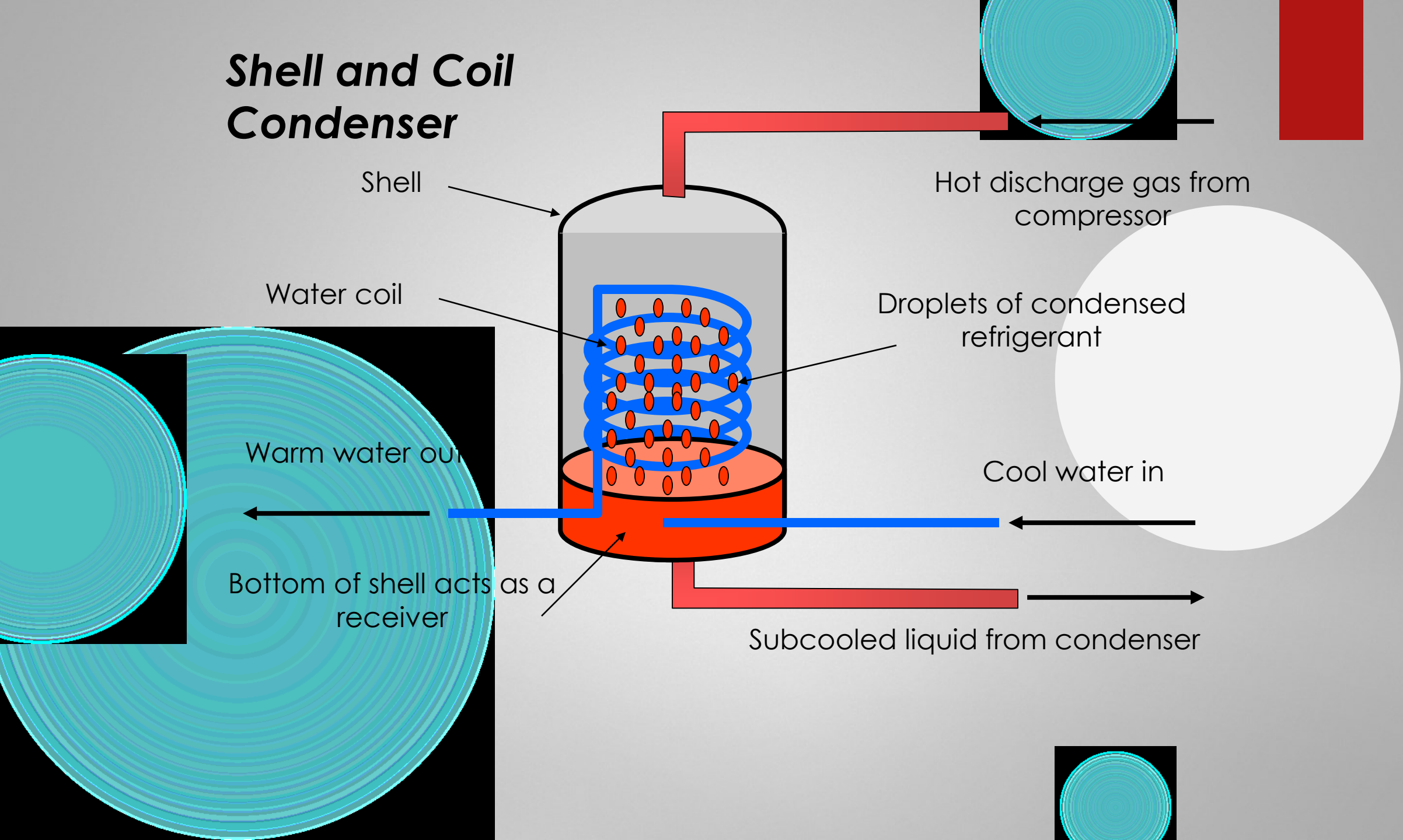


SHELL AND COIL CONDENSERS

- Coil of tubing enclosed in a welded shell
- Water flows through the coil
- Refrige[illegible]n the compressor is discharged into the shell
- The shell a[illegible]cts as the receiver
- When refriger[illegible]nt comes in contact with the cool coil, it condenses and falls to the bottom
- This condenser must be cleaned chemically

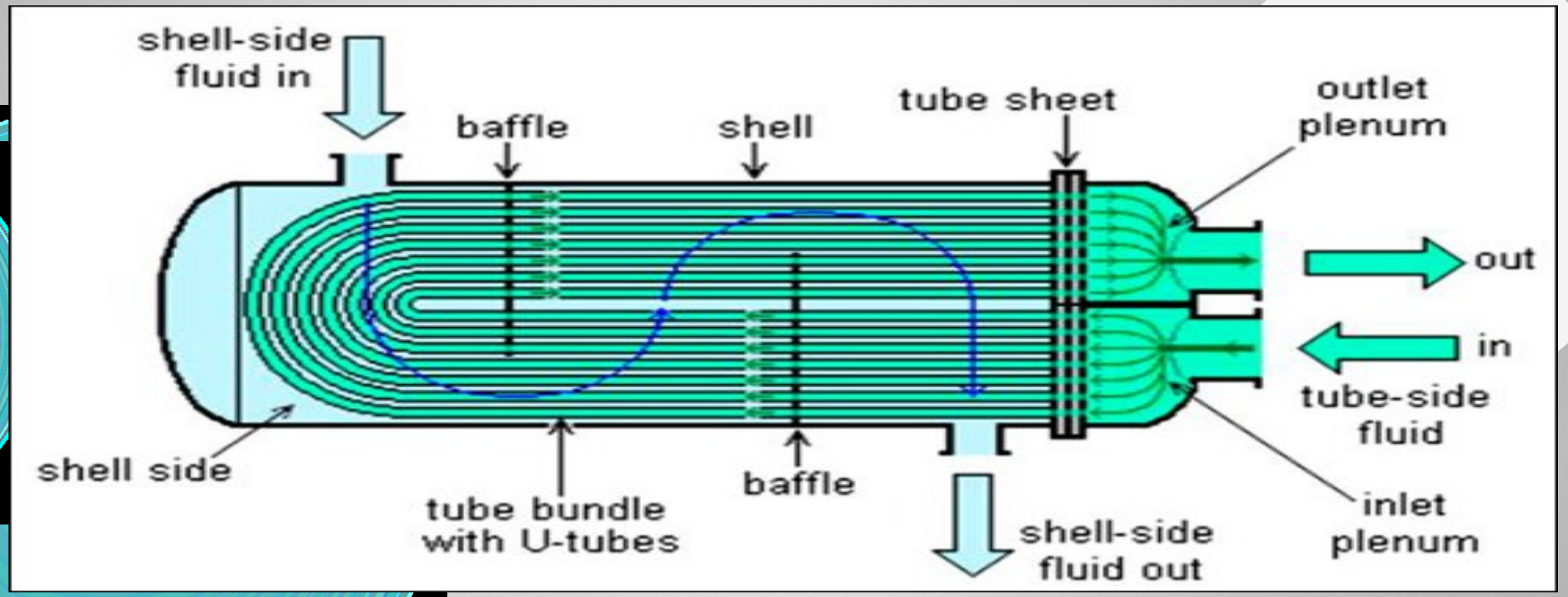

TO WATER REGULATING VALVE
GLASS FILLER CONNECTION
WATER IN
TANK
SUCTION LINE
EVAPORATOR COIL
CAPILLARY TUBE
ACCUMULATOR
THERMOSTAT BULB WELL
REMOTE

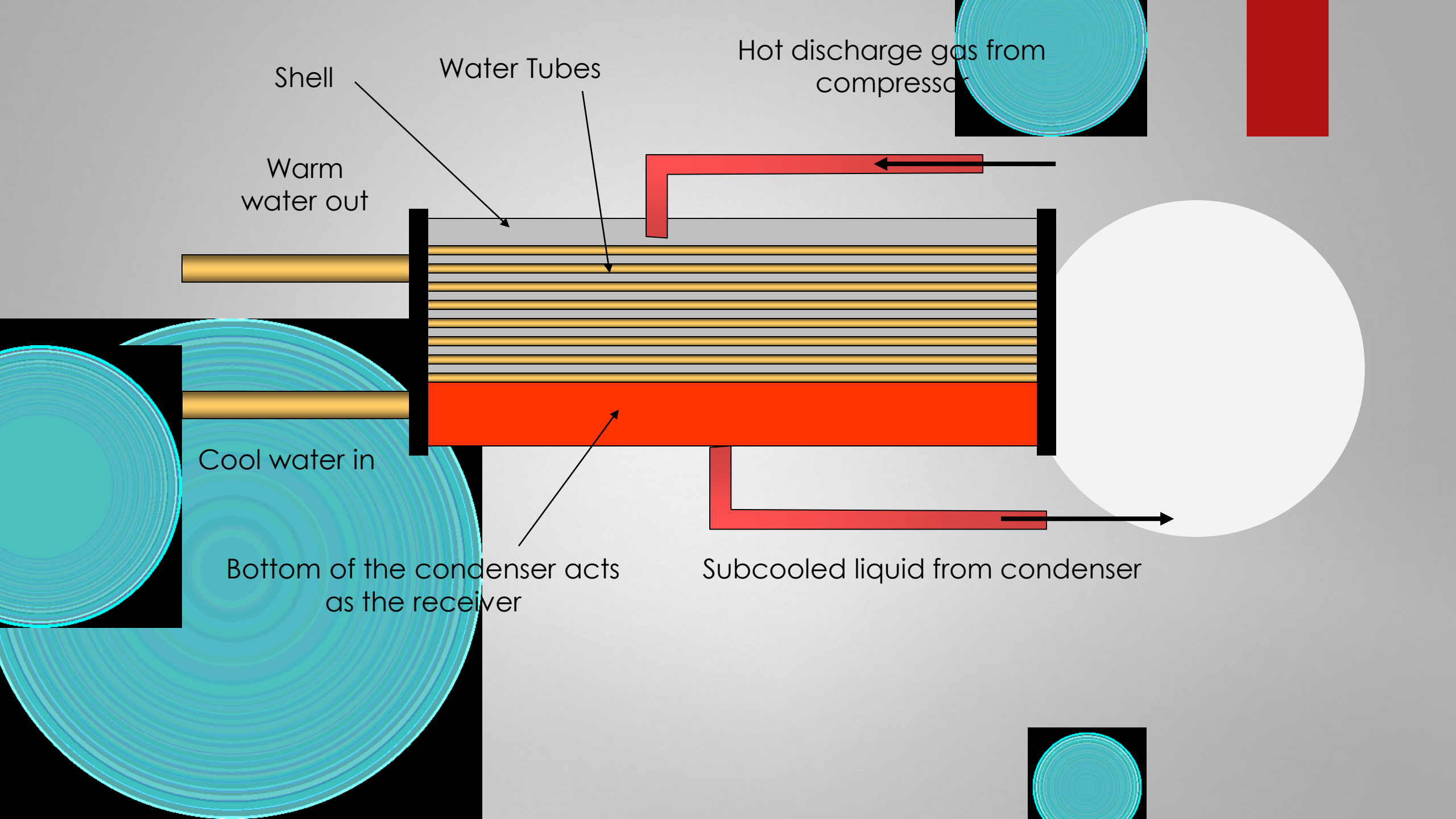
Shell and Coil Condenser

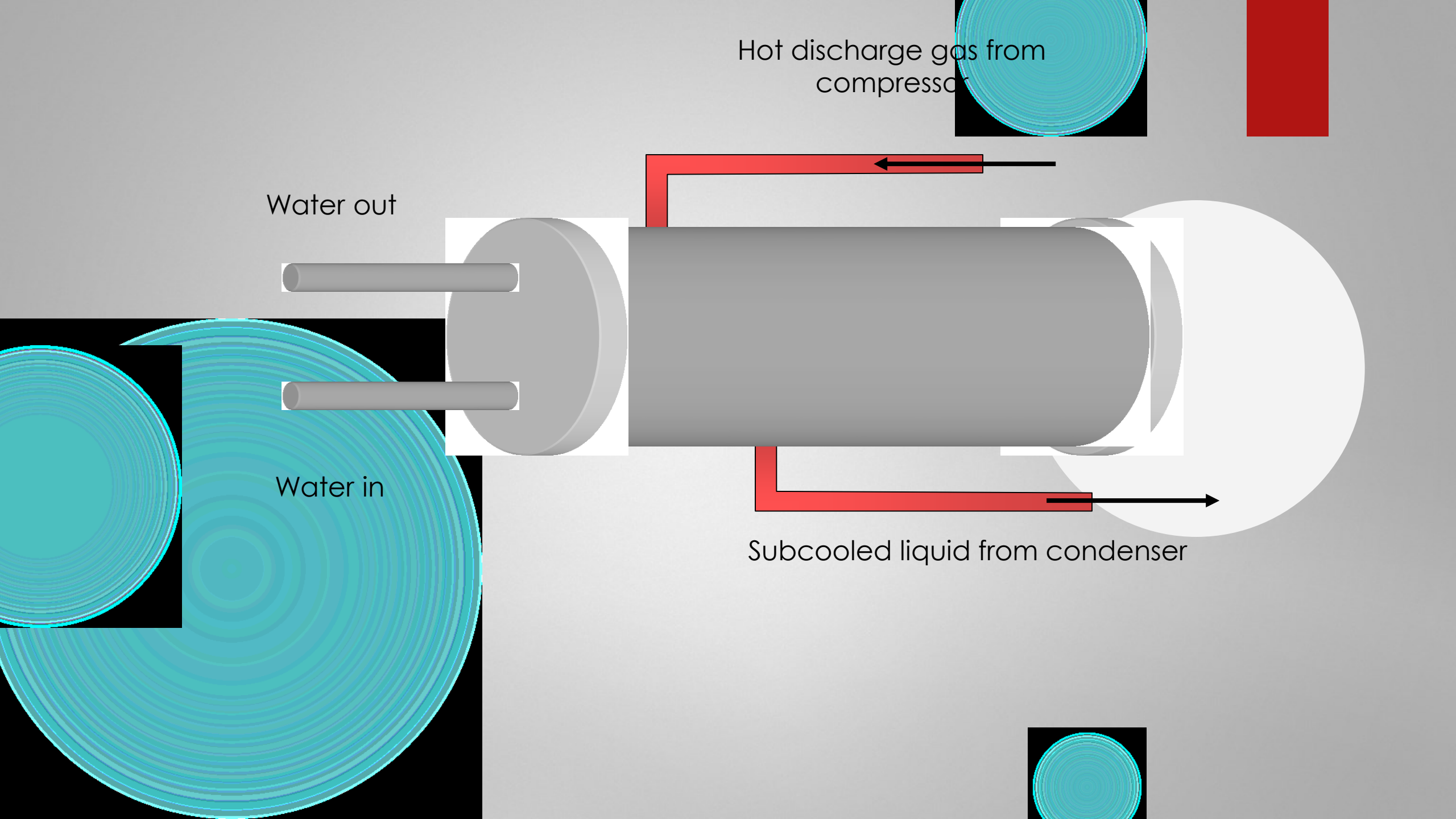


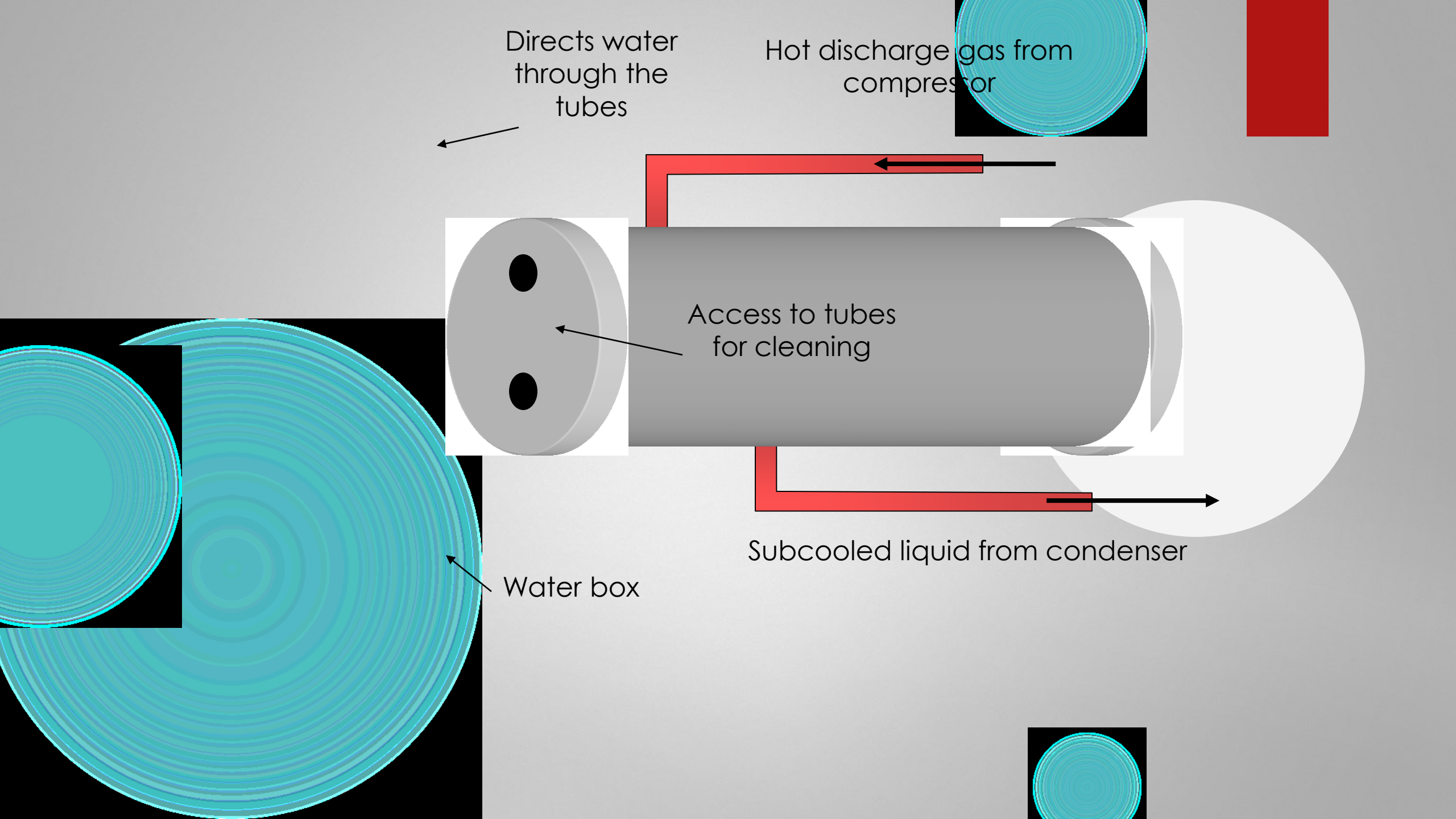
SHEL AND TUBE CONDENSERS

- Can be cleaned mechanically
- Compressor discharge gas is piped into the shell
- Water flows through the tubes in the condenser
- The ends of the shell are removed for cleaning
- The shell acts as a receiver
- Refrigerant circuit is not disturbed when the ends of the shell (water boxes) are opened
- Most expensive type of condenser


shell-side
fluid in
baffle
shell
tube sheet
outlet
plenum
out
in
tube-side
fluid
shell side
tube bundle
with U-tubes
baffle
shell-side
fluid out
inlet
plenum


Shell
Water Tubes
Hot discharge gas from compressor
Warm water out
Cool water in
Bottom of the condenser acts as the receiver
Subcooled liquid from condenser

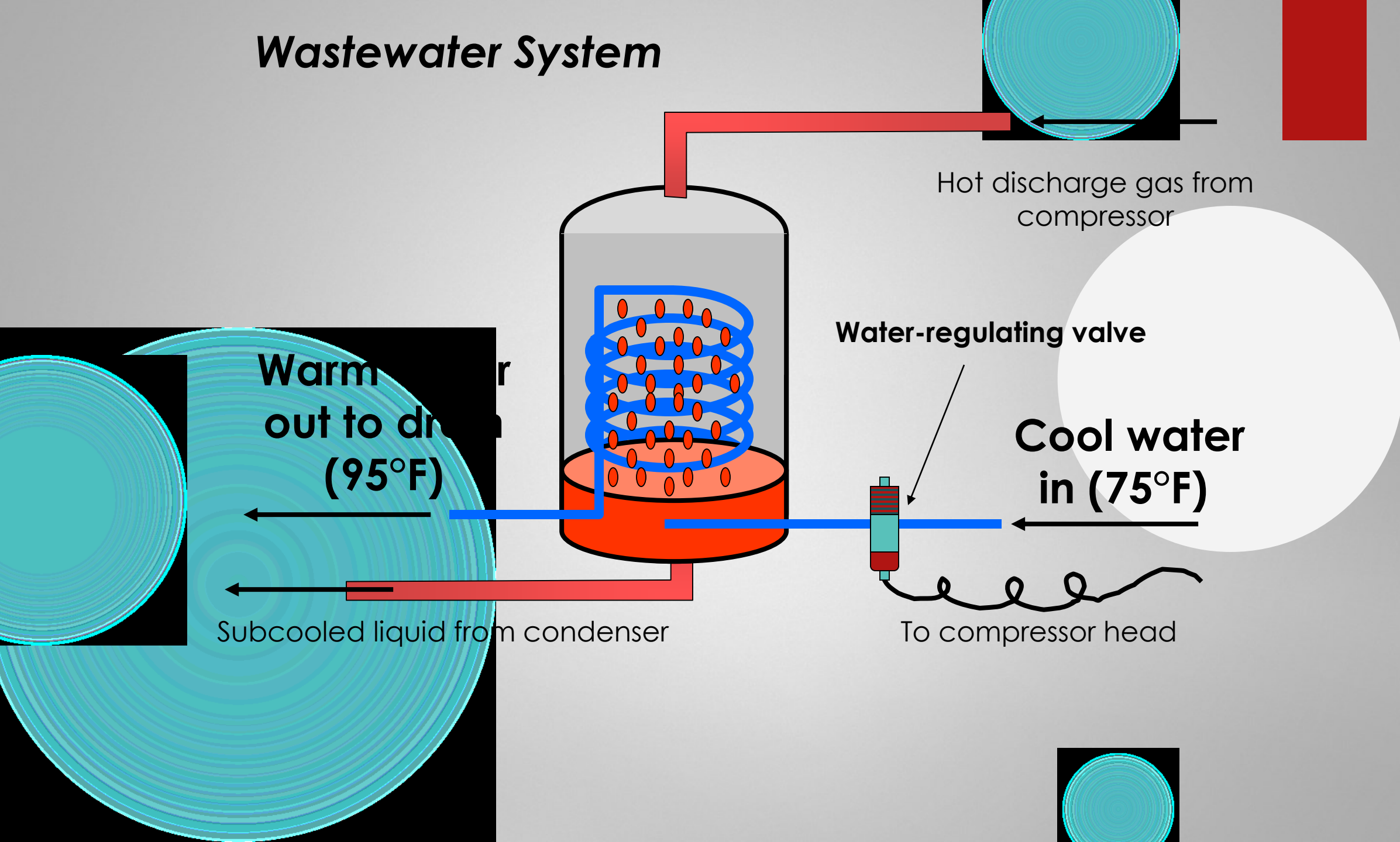

Hot discharge gas from compressor
Water out
Water in
Subcooled liquid from condenser


Directs water through the tubes
Hot discharge gas from compressor
Access to tubes for cleaning
Subcooled liquid from condenser
Water box

WASTEWATER SYSTEMS

- Water used once and then "wasted" down the drain
- Economical if water is free or if the system is small
- The main drawback is that the water temperature can vary a great deal
- Typical water temperature is about 75°F
- 75°F wastewater requires a flow of about 1.5 gpm per ton of refrigeration to absorb the heat rejected by the condenser
- Water typically leaves the condenser at 95°F

Wastewater System



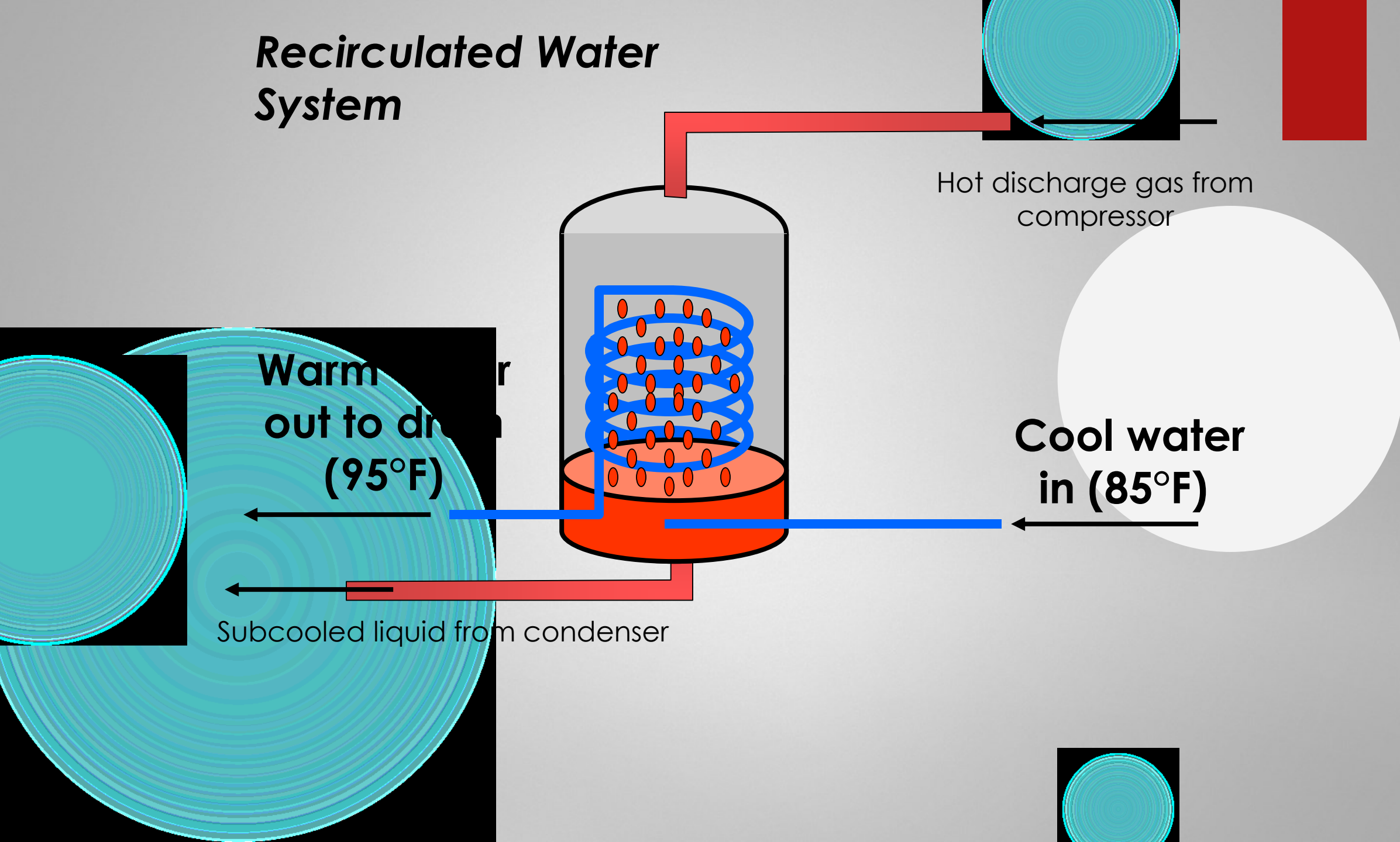
REFRIGERANT-TO-WATER TEMPERATURE RELATIONSHIP FOR WASTEWATER SYSTEMS

- Water flow is controlled by a water regulating valve
- Two p[illegible]ntrol the water regulating valve
  - The head [illegible]ure pushes to open the valve
  - The spring p[illegible]sure pushes to close the valve
- The valve opens when the head pressure rises
- Water temperature is higher in the warmer months
- Water temperature is lower in the cooler months

RECIRCULATED WATER SYSTEMS

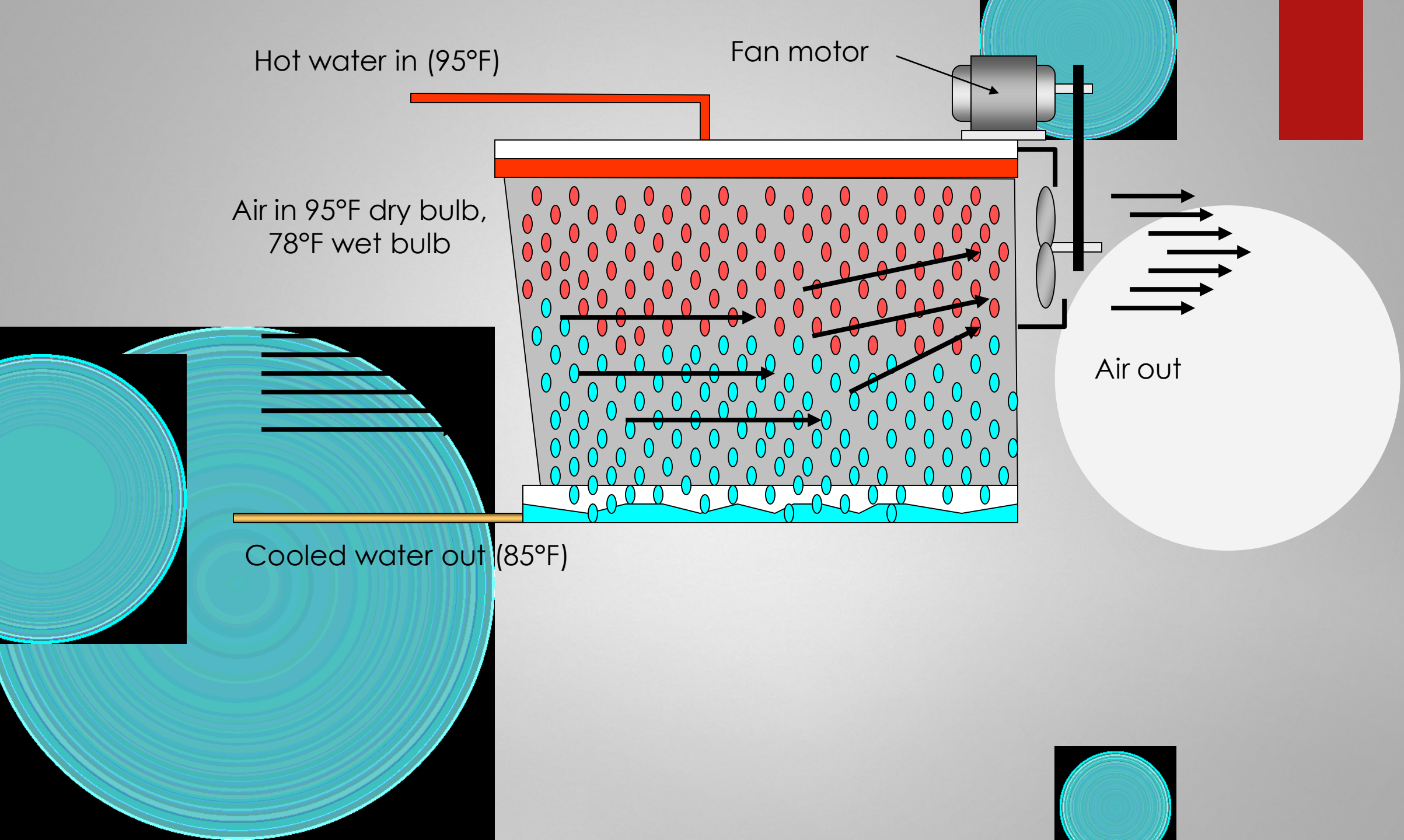
- The water flowing through the condenser is pumped to a remote location, cooled and reused
- Design water temperature is 85°F
- A wate[illegible]e of 3.0 gpm per ton of refrigeration is required to absorb the [illegible]t rejected by the system condenser
- The water lea[illegible]ng the condenser is about 95°F
- There is a 10 de[illegible]gree split across the water circuit

Recirculated Water System



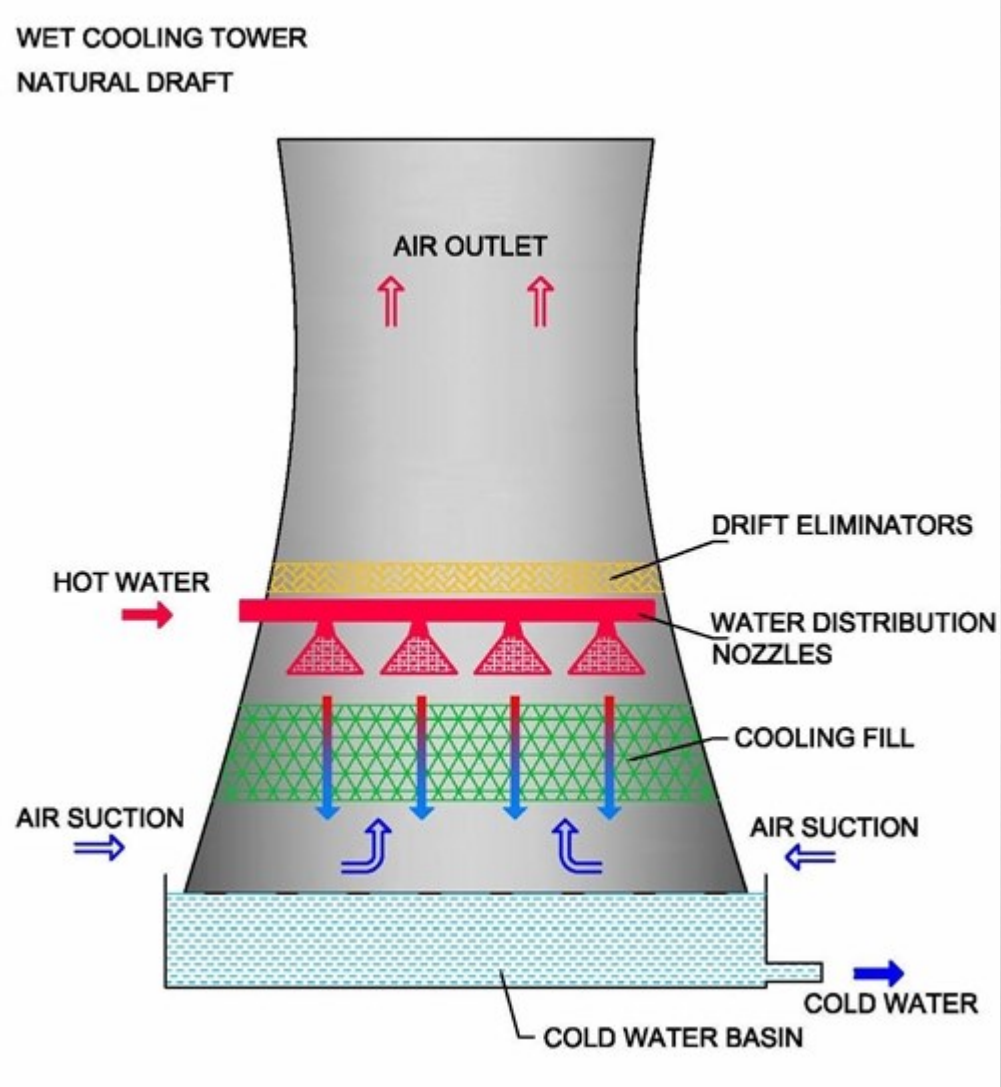
COOLING TOWERS

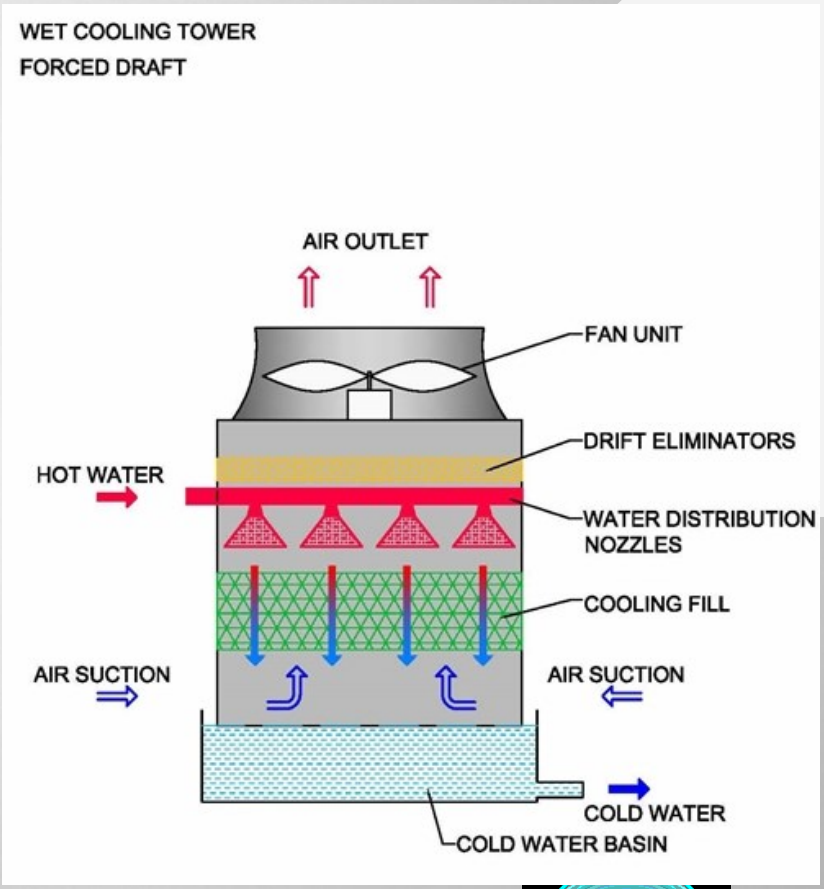
- Device used to remove heat from the water used in recirculated water systems
- Towe[illegible]l the water to a temperature within 7°F of the wet bulb tem[illegible]re of the air surrounding the tower
- If the wet bu[illegible]emperature is 90 degrees, water can be cooled to a temperat[illegible]re as low as 83°F
- Natural draft, forced draft, or evaporative


Hot water in (95°F)
Fan motor
Air in 95°F dry bulb,
78°F wet bulb
Air out
Cooled water out (85°F)

NATURAL DRAFT COOLING TOWERS

- Redwood, fiberglass or galvanized sheet metal
- There are no blowers to move air through the tower
- Natural [illegible]ove air through the tower
- Water enters [illegible]ower from the top and is cooled as the water falls to the bottom
- Some water evap[illegible]orates in the process, helping to cool the remaining water in the tower
- Additional water is added through a float valve


WET COOLING TOWER
NATURAL DRAFT
AIR OUTLET
DRIFT ELIMINATORS
HOT WATER
WATER DISTRIBUTION NOZZLES
COOLING FILL
AIR SUCTION
AIR SUCTION
COLD WATER
COLD WATER BASIN

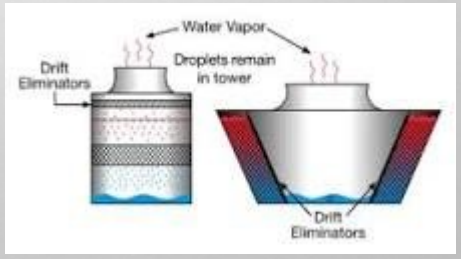

WET COOLING TOWER
FORCED DRAFT
AIR OUTLET
FAN UNIT
DRIFT ELIMINATORS
HOT WATER
WATER DISTRIBUTION NOZZLES
COOLING FILL
AIR SUCTION
AIR SUCTION
COLD WATER
COLD WATER BASIN

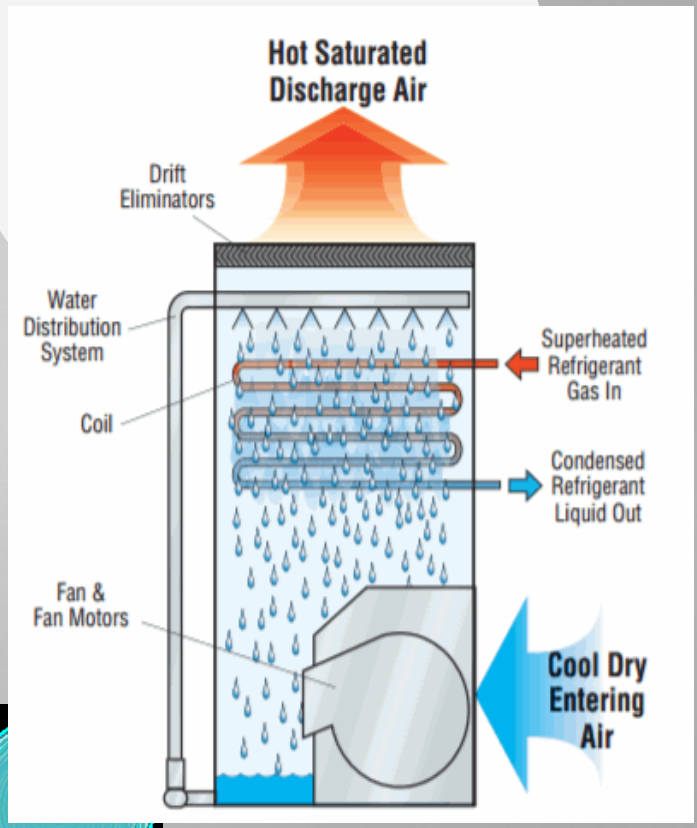
FORCED OR INDUCED DRAFT TOWERS

- Use a fan or blower to move air through the tower
- As the water falls through the tower, air is moved across it to aid in the co ess
- Can be loc almost anywhere
- The fan is cycle on and off to maintain the desired water temperature
- Forced draft – Air is pushed through the tower
- Induced draft – Air is pulled through the tower

EVAPORATIVE CONDENSERS

- Designed to operate full of liquid
- A latent heat transfer takes place throughout the coil
- Coil efficiency is maximized
- Other devices must be used to prevent liquid from entering the compressor
- Normally use a float-type metering device to keep the liquid level in the coil high





AIR-COOLED CONDENSERS

- Uses air to absorb heat rejected by the system
- Used in locations where water is difficult to use
- Horizontal, vertical, or side intake and top discharge
- Hot gas enters the condenser from the top
- For standard efficiency systems, the refrigerant will condense at a temperature about 30°F higher than the outside ambient temperature

HIGH-EFFICIENCY CONDENSERS

- Have larger surface areas than standard condensers
- Allow systems to operate at lower pressures
- Allow systems to operate more efficiently
- Co[illegible]with head pressures as low as 10°F higher than the outside [illegible]ent temperature