Troubleshooting

Troubleshooting Guidelines

1. Gather information using “Critical Thinking Questions” and “Critical Thinking Actions”

2. Apply solid engineering fundamentals.

3. Separate observations from hypotheses or conjectures.

4. Independently verify data using field measurements and observations, when possible.

Troubleshooting

Troubleshooting Guidelines

5. Make rigorous comparisons of faulty operation with satisfactory (normal) operations.

6. Spend time in the unit making direct observations
   -- Even if you are not sure what to expect.

7. Consider the entire system related to the problem.
   -- Not just one piece of equipment

Troubleshooting

Troubleshooting Guidelines

8. Practice good listening skills.
   Recall Steve Covey "Listen, Listen, Listen"

9. Do not reject serendipitous results.
   Joel Barker's "Paradigm Filter Effect"

10. Do not fall in love with a hypothesis
   – seek to reject, as well as to accept.

Troubleshooting Worksheet

Woods' Troubleshooting Worksheet

What is the problem? ____

____

What are the symptoms?

1)____

2)____

3)____

Who are the people you will talk to and why do you want to talk to them.

Who Why

____________ ____________________________________

- ___________ _____________________________________

Woods' Troubleshooting Worksheet

What data are to be double checked for accuracy?

____

Fundamentals

What are the guiding principles and equations?

____

____

List at least five working hypotheses as to the problem

1)______________________
2)______________________
3)______________________
4)______________________
5)______________________

.

Troubleshooting

- **Monitoring**

  If I make this measurement or take this action, what will it tell me?

Measurement/Action________ Reason/Possible Cause____________

Measurement/Action________ Reason/Possible Cause____________

Measurement/Action________ Reason/Possible Cause____________

Troubleshooting

Cause of the Problem	Result of the Cause	Does it fit the Observation/or Measurement	Steps Needed to Check Cause	Feasibility

Troubleshooting

- **Which hypotheses are consistent with all symptoms?**

  ________________________________,

  ________________________________,

  ____

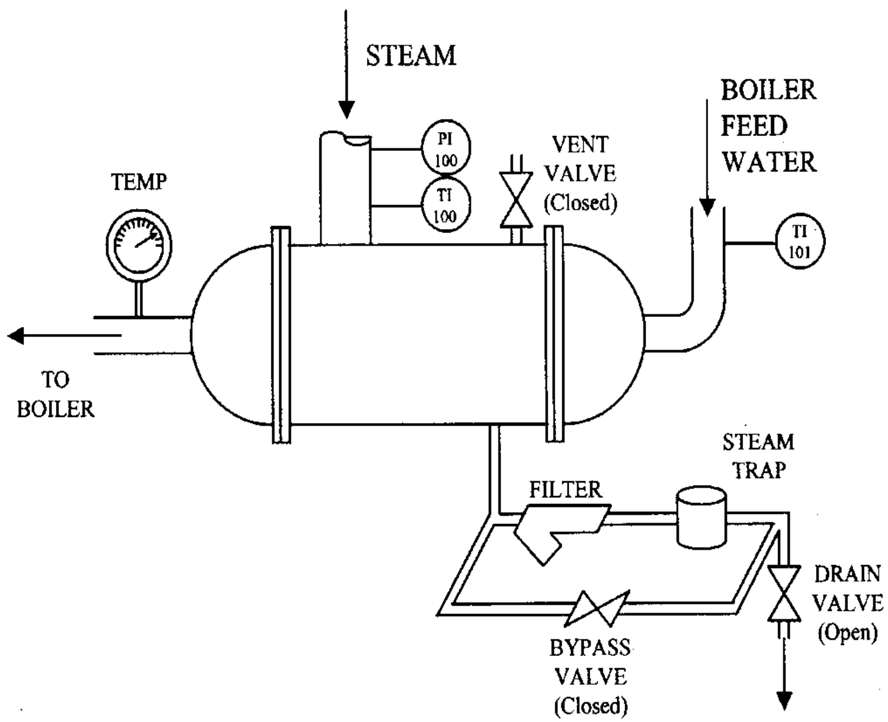
- **What are the steps to fix the problem/fault?**

  ____

.

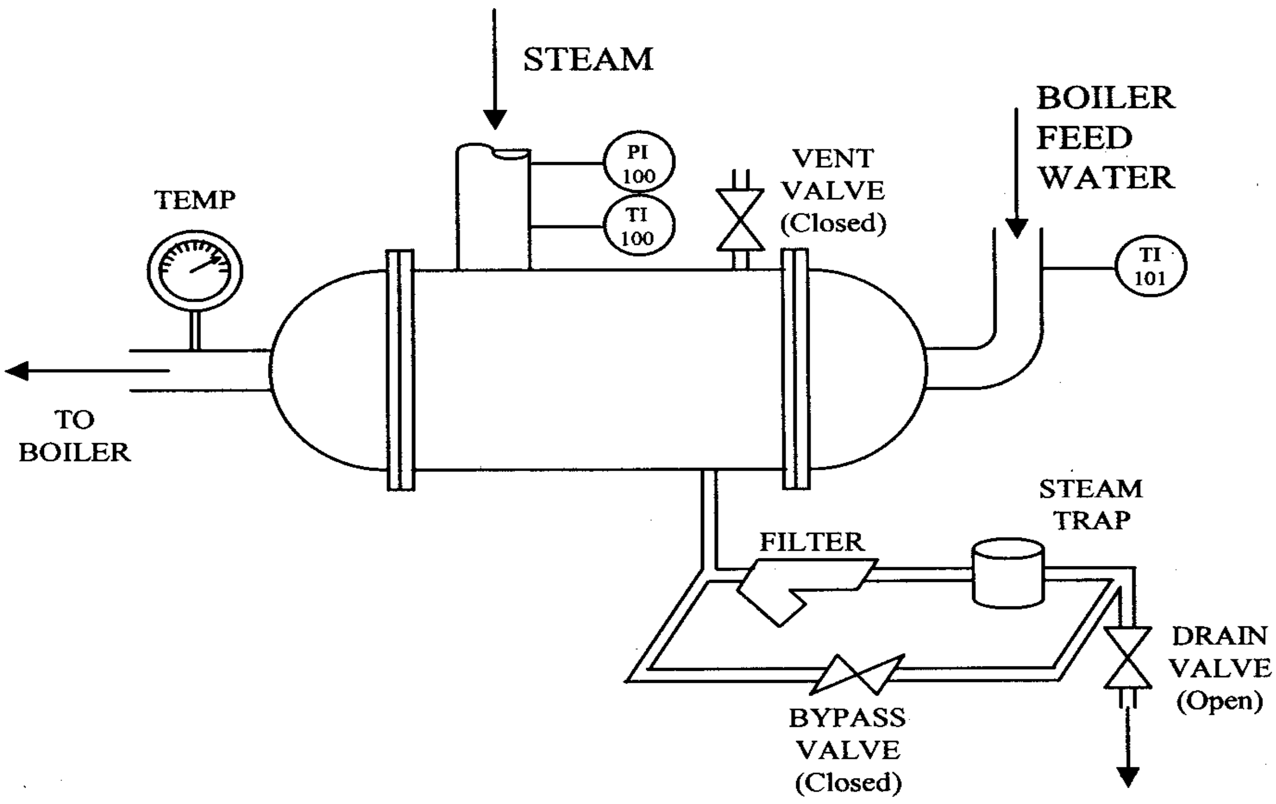
Troubleshooting

- <u>TROUBLESHOOTING: THE BOILER FEEDWATER HEATERCASE #1 Marlin and Woods.</u>

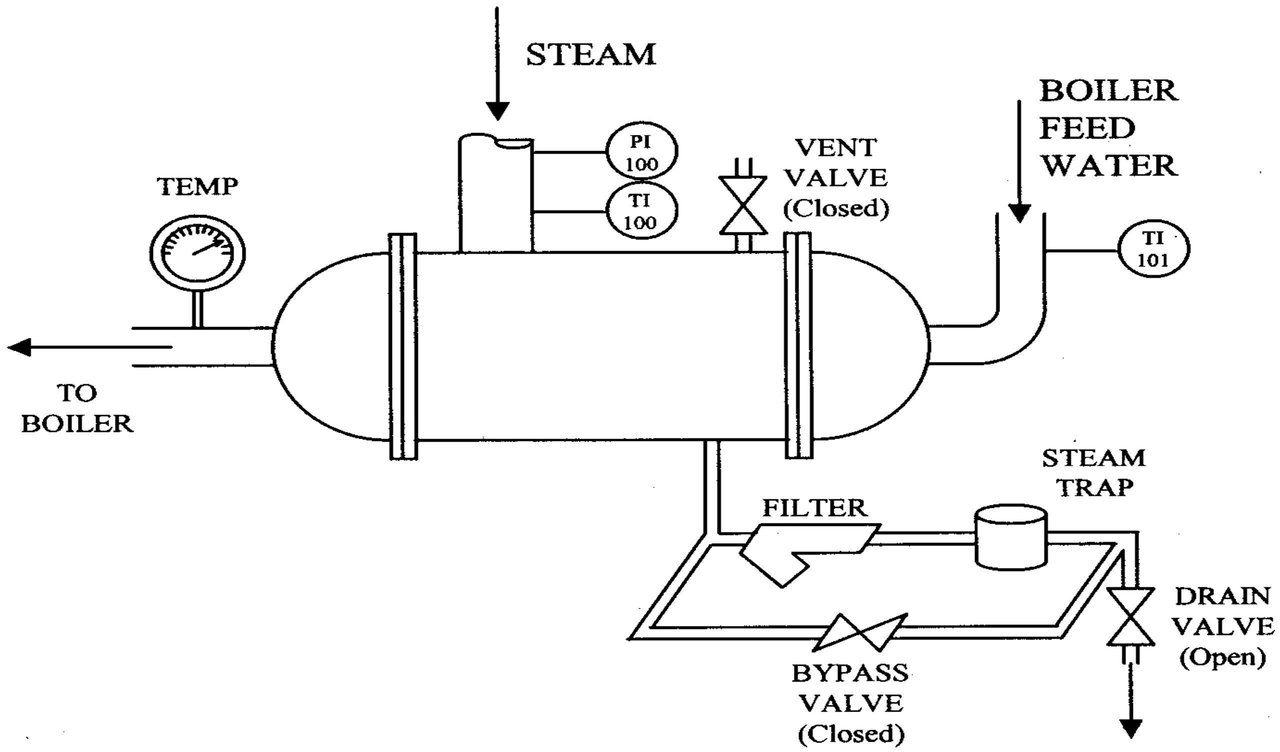


Troubleshooting

- **Waste flash steam from the ethyl acetate plant is saturated at slightly above atmospheric pressure. It is sent to the shell of a shell and tube heat exchanger to preheat the boiler feed water to 70°C for the nearby boiler house.**



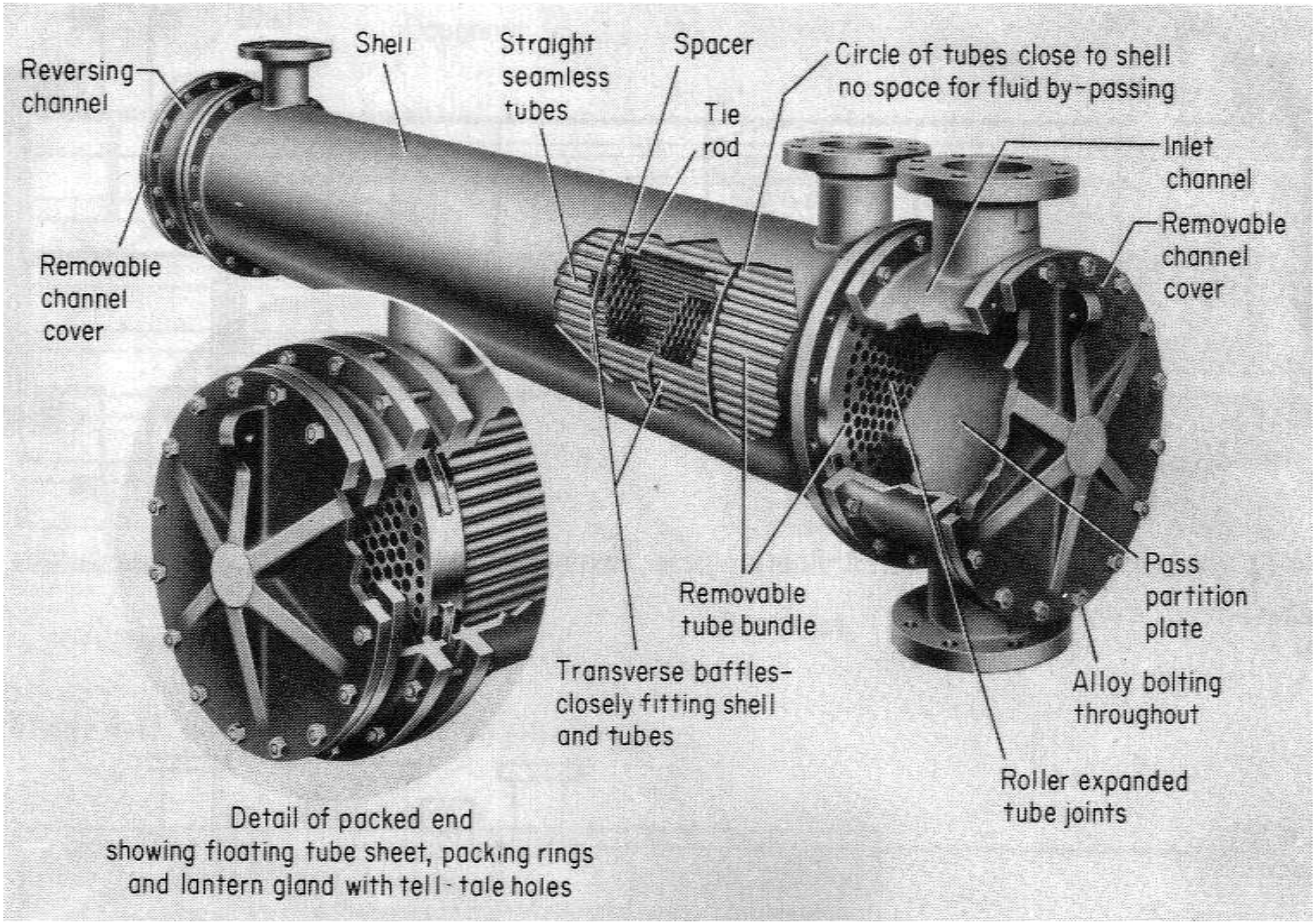
Troubleshooting



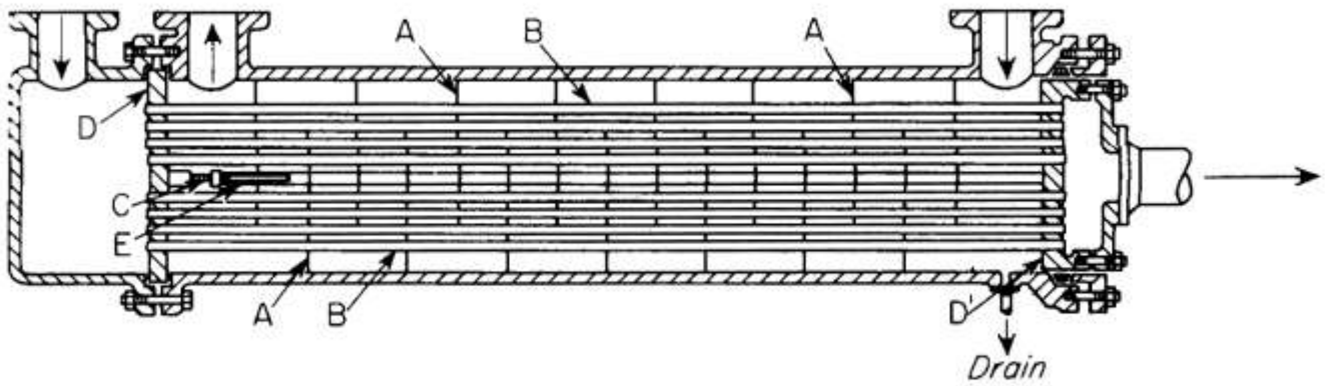
Condensate is withdrawn through a thermodynamic steam trap at the bottom of the shell. The water flows once through the 3/4" nominal tubes. There are 1000 tubes. "When the system was put into operation 3 hours ago everything worked fine," says the supervisor. "Now, however, the exit boiler feed water is 42°C instead of the design value. What do we do? This difficulty is costing us extra fuel to vaporize the water at the boiler." Fix it.

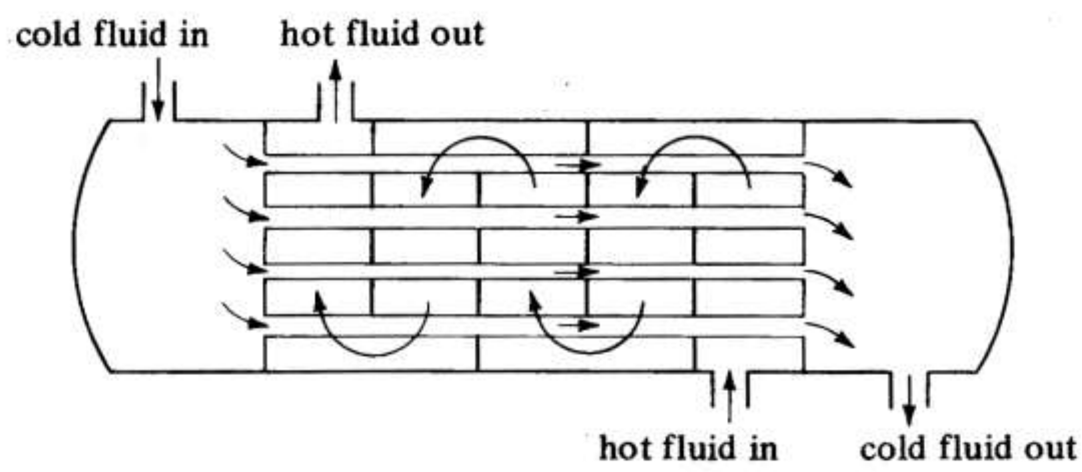
- What are the fundamentals of heat exchange?

Fundamentals



Tube and Shell Heat Exchangers

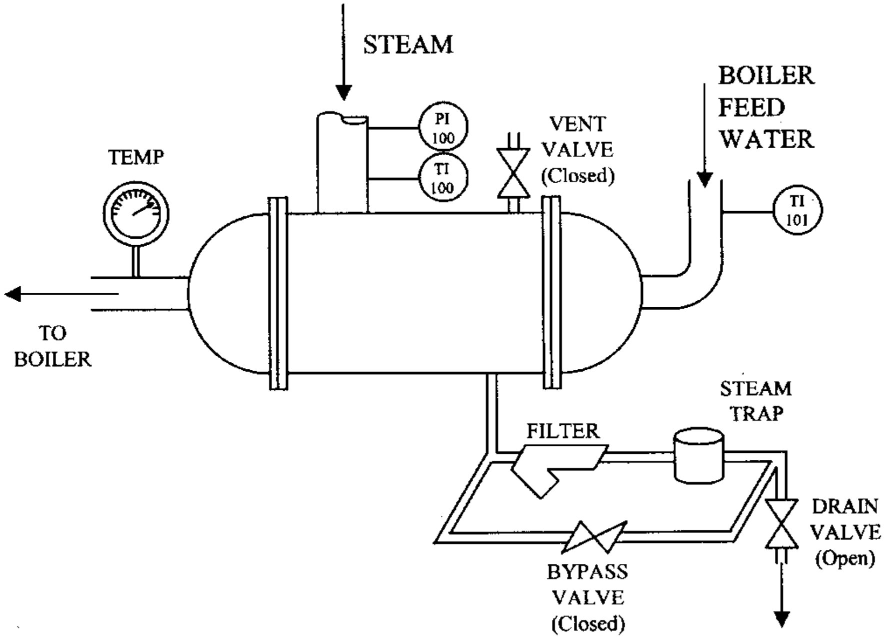




Fundamentals

Recall the Fundamentals:

$$T_{out} = T_{steam} - (T_{steam} - T_{in}) \exp(-UA/mC_P)$$



Fundamentals

$T_{out} = T_{steam} - (T_{steam} - T_{in}) \exp(-UA/mC_P)$

The overall heat transfer coefficient U is related to the individual heat transfer coefficients inside (hi) and outside (ho) by the equation

$$1/U = 1/ho + 1/hi$$

The shell side (outside) heat transfer coefficient would be about

For water: ho=1500 W/m^2 °C (outside)

For air: ho=10 W/m^2 °C (outside: shell side)

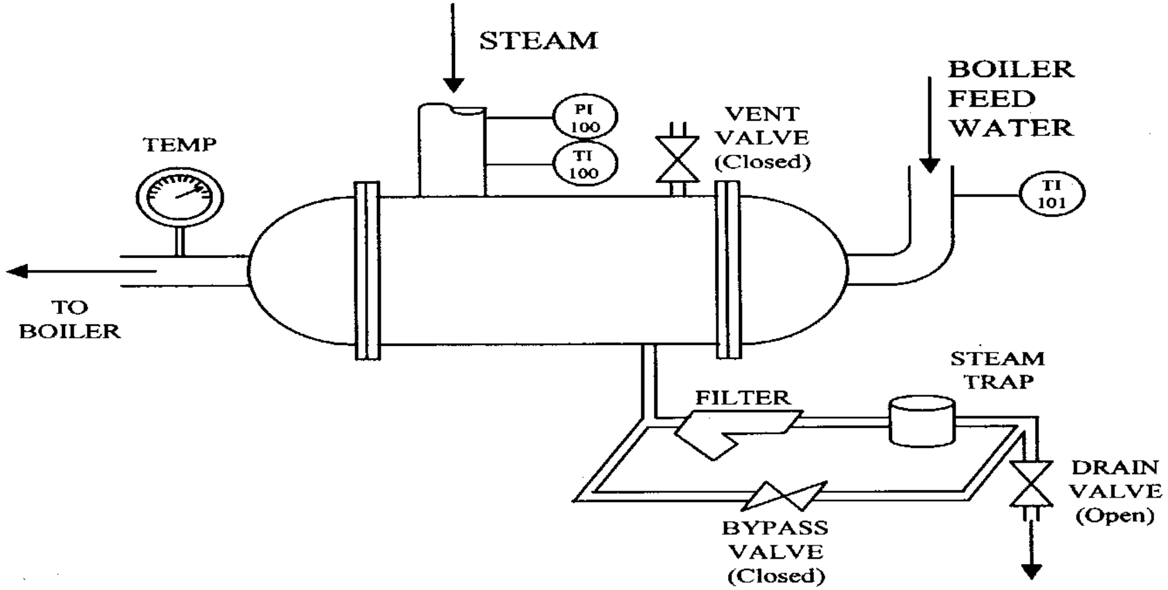
For steam: ho=20,000 W/m^2 °C (outside: shell side)

Tube side (Inside) heat transfer coefficient

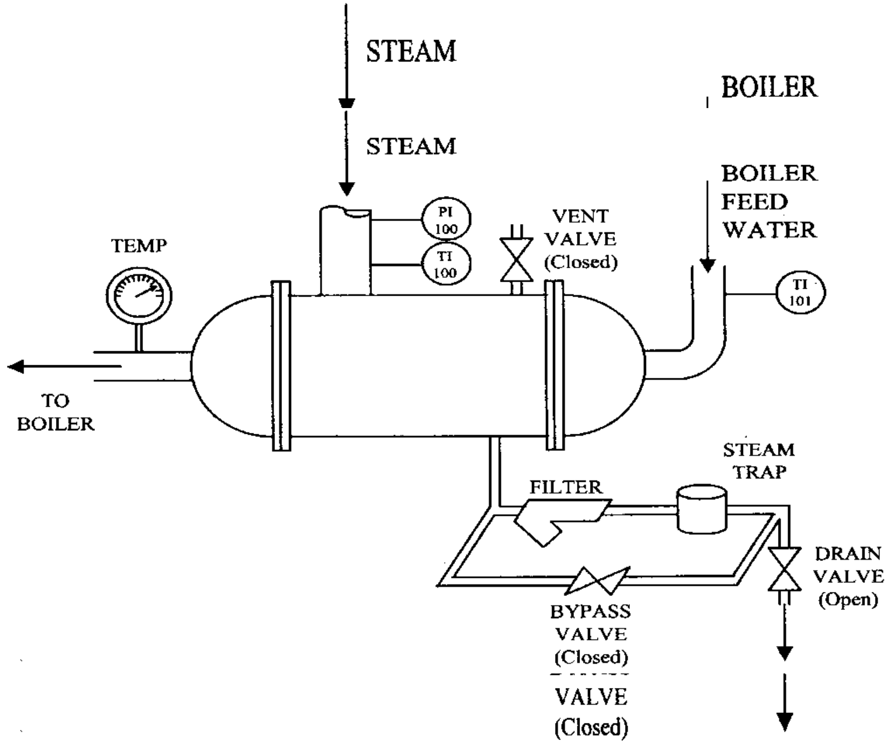
For water: h_i=1500W/m^2 °C. (inside :tube side)

Brainstorming Possible Faults

1) The steam trap is blocked causing liquid condensate to back up in the heat exchanger so the steam does not contact the pipes in the exchanger.
2) The entering water is sub-cooled.
3) The steam pressure and temperature have dropped.



Brainstorming Possible Faults



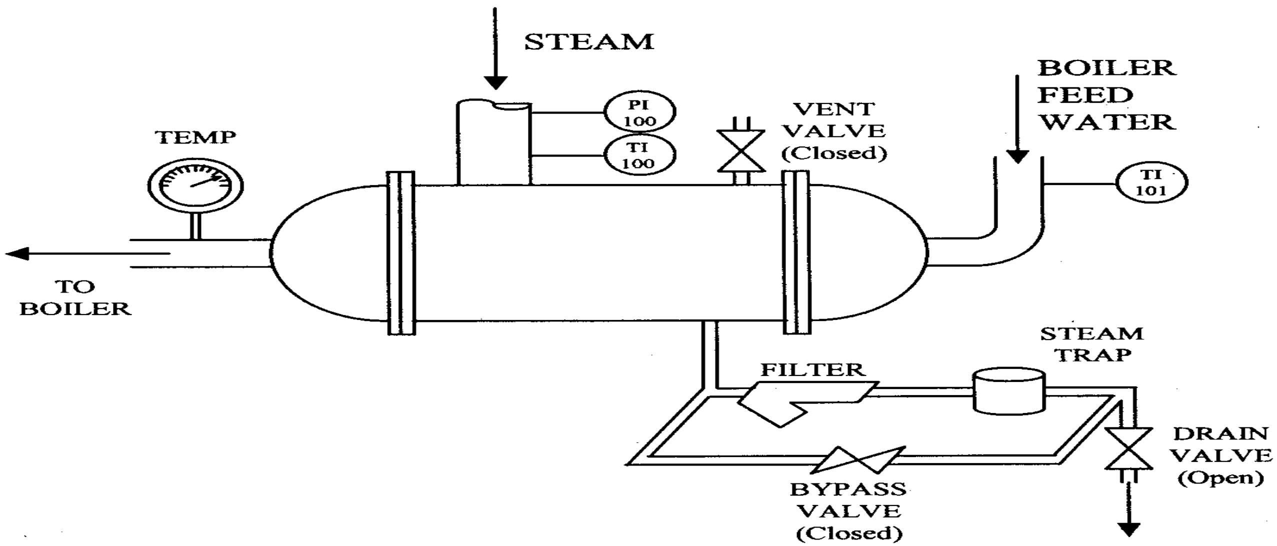
4) The heat exchanger has become fouled.

5) The steam is dirty, i.e., contains
non condensable gases.

Monitoring

- Make a list of the measurements to be made
- For each measurement give the reason you are making the measurements.
- What are possible outcomes of the measurement and what will they tell you.

Monitoring



If I make this measurement or take this action, what will it tell me?

Measurement: Calibrate Temperature Gages **Measurement:** Inlet Temperature	**Reason:** Temperature of the Exit Stream is not 42 degrees **Reason**: Sub-cooled inlet
Measurement: Water flow rate	**Reason**: Higher than normal flow rate could cause the fluid not to reach 70°C

Troubleshooting

- **Monitoring**

  If I make this measurement or take this action, what will it tell me?

Measurement/Action________ Reason/Possible Cause____________

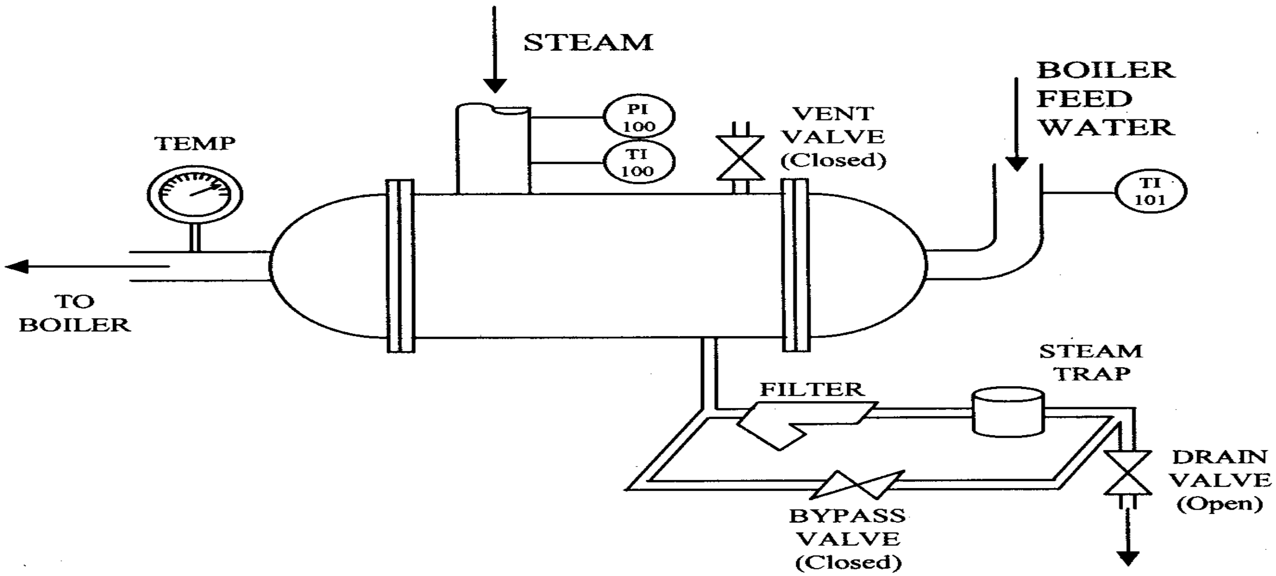
Measurement/Action________ Reason/Possible Cause____________

Measurement/Action________ Reason/Possible Cause____________

Monitoring

- Make a list of the actions you will carry out.

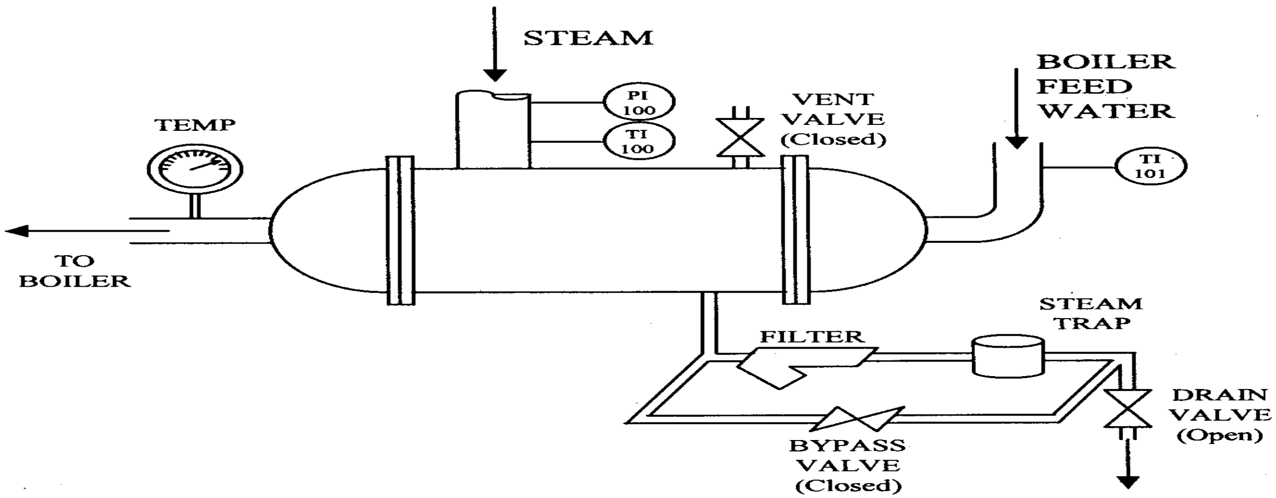
Monitoring



If I make this measurement or take this action, what will it tell me?

Action: Check to make sure the drain valve is open	**Reason**: If someone has closed the drain valve, water may be filling up the shell side of the exchanger reducing the condensing steam heat transfer coefficient.
Action: Check the inlet steam temperature and pressure	**Reason**: If either of these has decreased, the enthalpy of the entering steam will be less than expected, reducing the outlet water temperature.

Monitoring



If I make this measurement or take this action, what will it tell me?

Action: Check to see if the steam trap is closed, and not functioning properly. If it is functioning, it should open and close periodically as condensate is formed in the shell.	**Reason**: Water may be filling up the shell side of the exchanger reducing the condensing steam heat transfer coefficient.
Action: Check to see if the filter is plugged	**Reason**: Would give same symptoms as a closed steam trap
Action: Carefully open the vent	**Reason**: If non-condensable gases have accumulated in the shell, the steam side heat transfer coefficient would be decreased, reducing U.

Monitoring

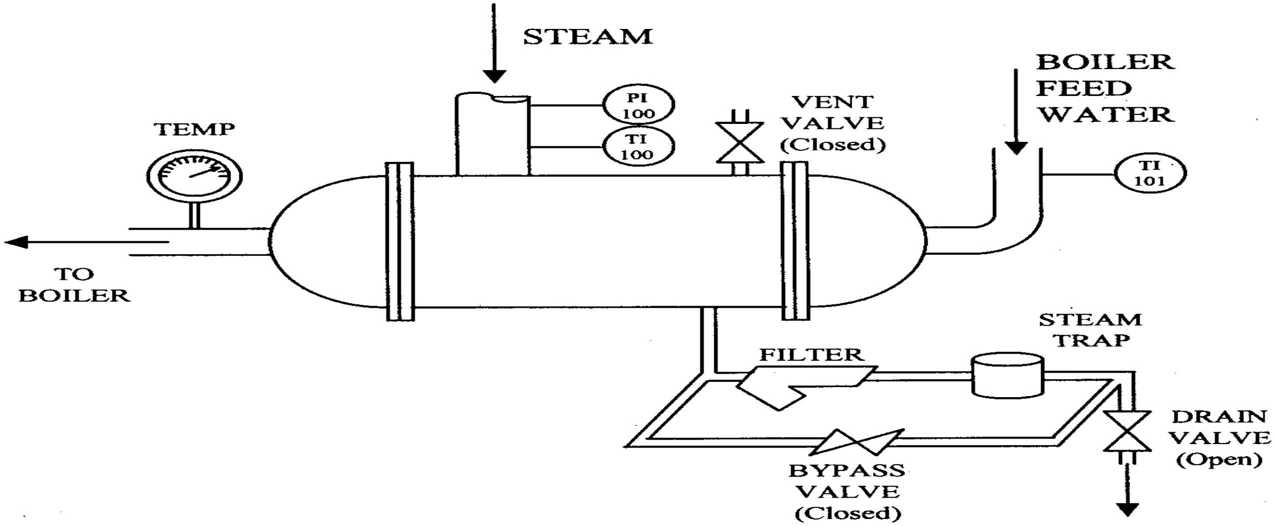
Monitoring If I make this measurement or take this action, what will it tell me?	
Measurement: Inlet Temperature	Reason: Sub-cooled inlet
Measurement: Water flow rate	Reason: Higher than normal flow rate could cause the fluid not to reach 70°C
Action: Check to see if the steam trap is closed, and not functioning properly. If it is functioning, it should open and close periodically as condensate is formed in the shell.	Reason: Water may be filling up the shell side of the exchanger reducing the condensing steam heat transfer coefficient.
Action: Check to see if the filter is plugged	Reason: Would give same symptoms as a closed steam trap
Action: Carefully open the vent	Reason: If non-condensable gases have accumulated in the shell, the steam side heat transfer coefficient would be decreased, reducing U.
Action: Check to make sure the drain valve is open	Reason: If someone has closed the drain valve, water may be filling up the shell side of the exchanger reducing the condensing steam heat transfer coefficient.
Action: Check the inlet steam temperature and pressure	Reason: If either of these has decreased, the enthalpy of the entering steam will be less than expected, reducing the outlet water temperature.

Troubleshooting

Cause of the Problem	Result of the Cause	Does it fit the Observation/or Measurement	Steps Needed to Check Cause	Feasibility

Does it fit the observation?

Cause	Result	Does it fit the Observation or Measurement?	Steps needed to check cause	Feasibility
Fouling/scale on water side, or on steam side.	Decrease in heat transfer coefficient.	Does not account for a temperature drop over short period.	Instrumentation and measurements to calculate H.T. coefficient / inspection of tubes.	Inspection of the tubes Time consuming and costly if instruments are not available.



CLASSIFICATION

FACT

vs.

OPINION

vs.

OPINIONATED FACTS

FACT

3 SOURCES

1. FACTUAL DATA - heard, felt, smelt, tasted
2. CONCLUSION OR RESULTS - (tables, figures, equations) drawn from data
   a. Validity of each step in derivation is valid
   b. There are sufficient steps to lead to a log   ical conclusion
3. BACK GROUND INFORMATION - secondary service interpretation of a primary source

CAUTION:

1. Interpretation depends on measurement technique
2. Results apply in a limited region.

OPINIONATE FACTS

1. Good and bad (may be right or wrong, experts opinion).
2. Not always able separate from fact when you get it from a secondary source.

OPINIONATE FACTS

1. PHRASES DENOTING THE SIGNIFICANCE OF THE FACT, LAST NOT LEAST

   The temperature was only 150°F

2. PHRASES ATTACHING VALUE TO FACTS

   This result is surprising

3. PHRASES SUGGESTING GENERALIZATION BASED ON FACTS

   All flows were steady. Winds higher than 30 mph were extremely rare.

4. PHRASES WHICH ADVOCATE THE READERS ACCEPTANCE OF THE FACT

   "Obviously it follows that this reaction is rate controlled."

OPINION

Based On

1. Years of experience
2. Self interests
3. Habit
4. The will to
    a. believe
    b. disbelieve

ANALYSIS

Identify

- Elements
- Relationships
- Omissions

Distinguish

- Fact From Opinion
- Conclusions From Evidence

Detect

- Fallacies In Logic
- Missing Information
- Incorrectly Defined Problems

Recognize

- Unstated Assumptions
- What Particulars Are Relevant

Troubleshooting

Troubleshooting Procedure

1) Compare the data obtained under normal operation with that obtained under faulty operating conditions.

2) Brainstorm all the things that could explain the fault.

Troubleshooting

Troubleshooting Procedure

3) Use K-T analysis (either PA or PPA modified form) and other troubleshooting strategies to deduce what happened during the faulty run.
Present an analysis in the form of a table or chart.

Troubleshooting

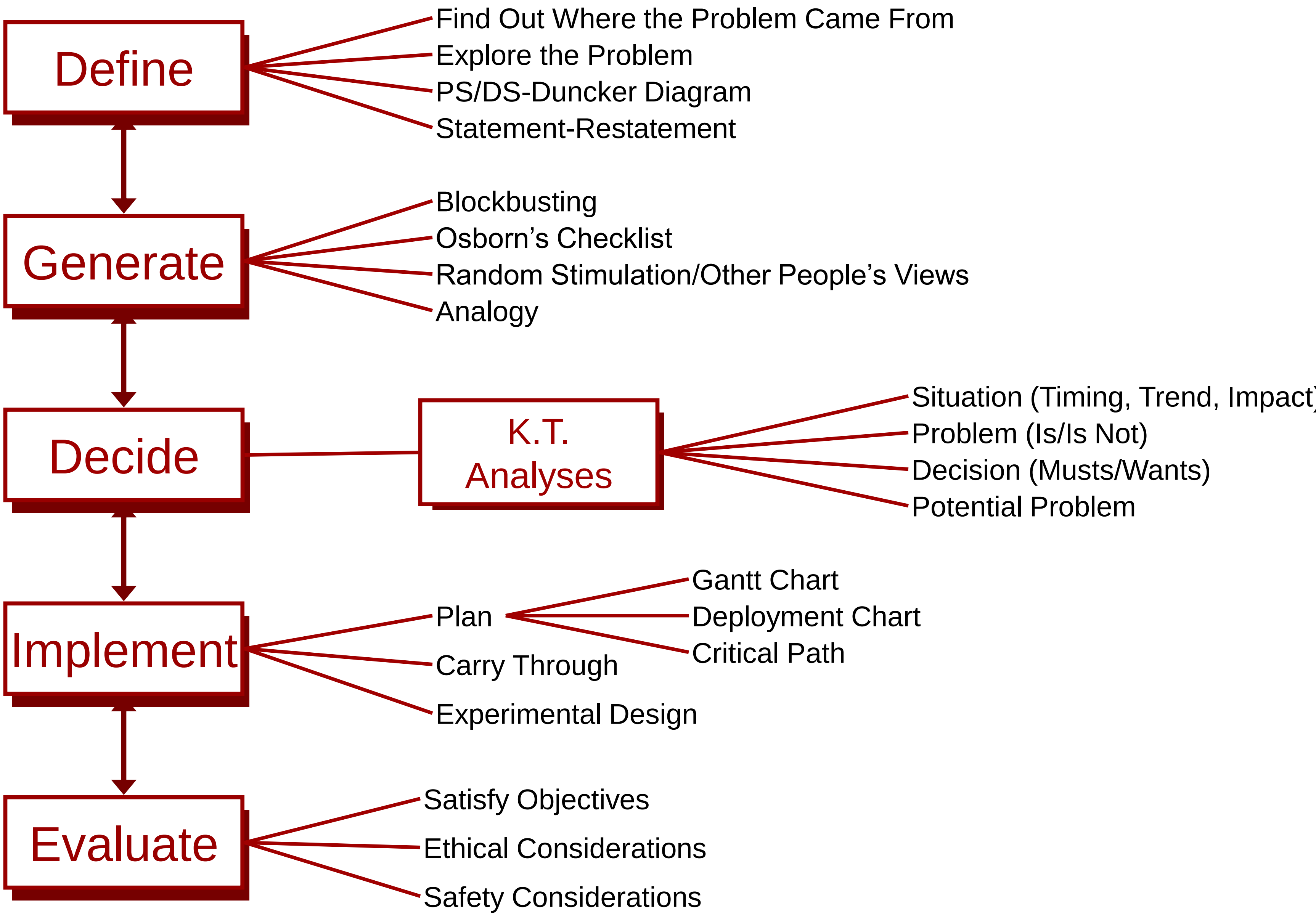
4) Choose the most likely cause or set of conditions that produced the data and then run the equipment at these incorrect conditions to attempt to reproduce the data to verify the hypothesis.

Troubleshooting

Troubleshooting Procedure

5) Suggest a new troubleshooting scenario. After supervisor approval, collect data and describe how another engineer should approach the problem.

A Heuristic


Define
Find Out Where the Problem Came From
Explore the Problem
PS/DS-Duncker Diagram
Statement-Restatement
Generate
Blockbusting
Osborn's Checklist
Random Stimulation/Other People's Views
Analogy
Decide
K.T. Analyses
Situation (Timing, Trend, Impact)
Problem (Is/Is Not)
Decision (Musts/Wants)
Potential Problem
Implement
Plan
Gantt Chart
Deployment Chart
Critical Path
Carry Through
Experimental Design
Evaluate
Satisfy Objectives
Ethical Considerations
Safety Considerations