Troubleshooting: “The Triads”

Everyone participates!

1. The expert has already received a folder before the workshop that contains the following.

   a. The problem statement stapled to folder on the left side: **please do not mark**
   b. A solution stapled to folder’s right side: **please do not mark**

   The expert has thoroughly reviewed the problem and solution <u>before</u> the workshop.

   Do not share the information about your case with anyone!

2. The Triad Team will perform three exercises (about half hour each, with a few minutes to take a break, and write the summary report after each exercise).

   a. Each person will be Troubleshooter, the Expert and the Observer
   b. After about 25 minutes, the Expert will discuss the solution for a few minutes.
   c. After the answer is discussed, the Observer will provide feedback on the method

3. Each Triad Team will return:

   a. The folder with the problem statement, solution, and worksheets, i.e. all materials.
   b. Please ensure your names are on all the loose sheets: please DO NOT write your names on the binder or the stapled pages.

Extra instructions

For the ***troubleshooter***

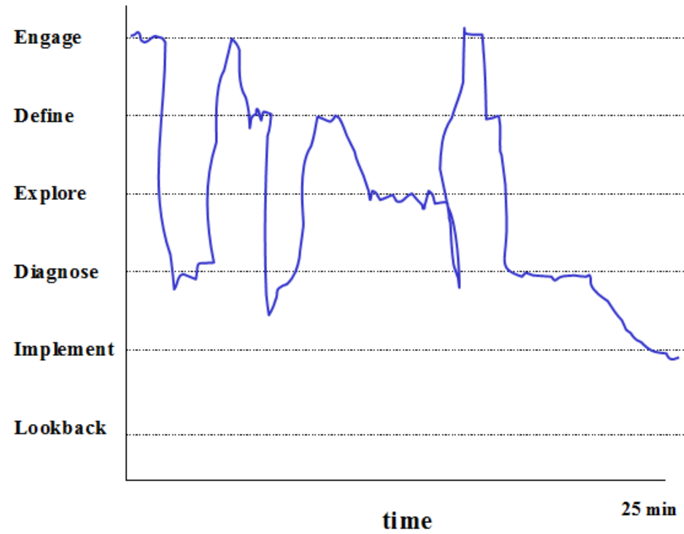
- *Verbalize your thought process* so the observer can track your progress. This is daunting at first, you might be embarrassed about your apparent lack of knowledge, but the purpose is to gain confidence on a system that does not matter, so that one day you can solve systems that do matter. You will also need to write down similar thoughts in the troubleshooting case in the final exam in December.
- Fill out the troubleshooting form and demonstrate following the systematic procedure.
- You can ask for information, data, or plant tests from the Expert.
- Please **make sure you reach stage 5** (Implement): where you propose 2 solutions:
  - a short-term solution to fix the problem
  - a longer-term solution to permanent fix the problem

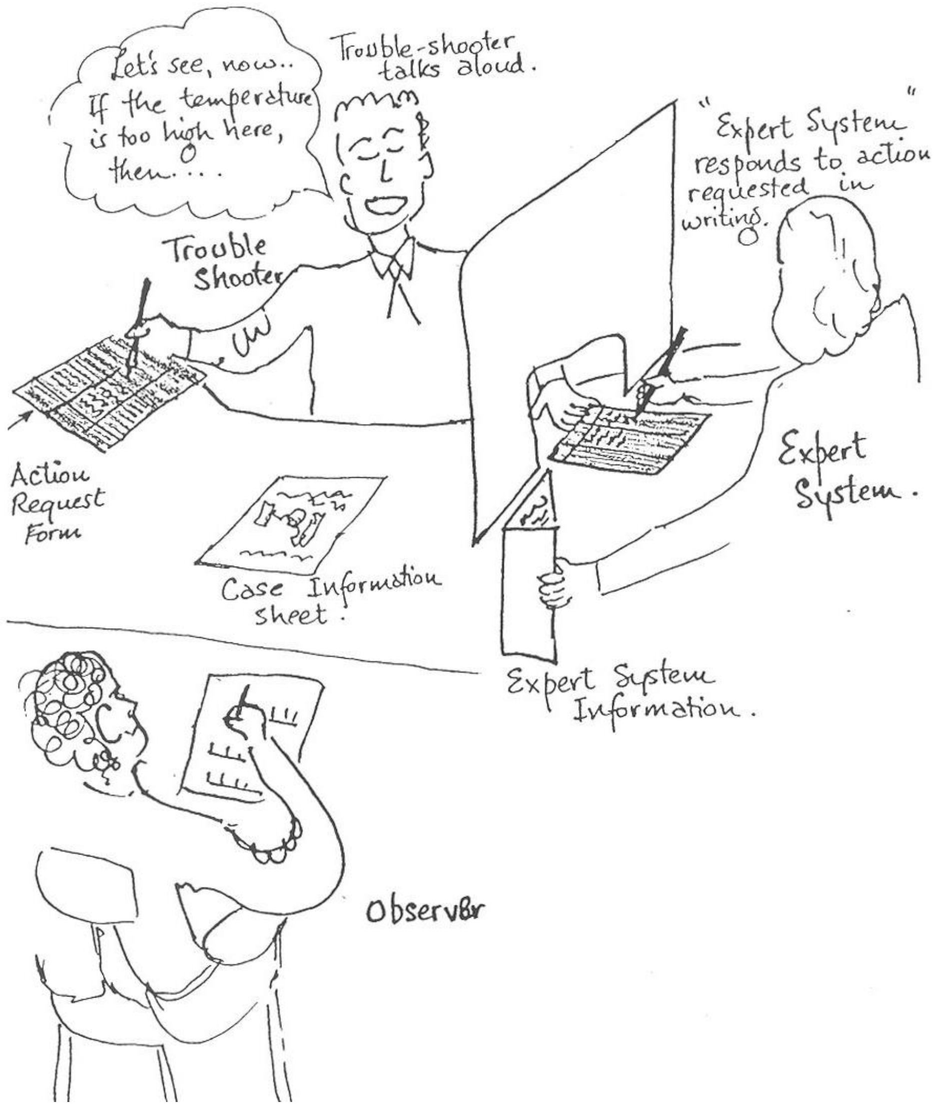
For the ***expert system***

- You are the plant / oracle / source of all true knowledge.
- When asked, provide short answers to the **exact** question the troubleshooter asks. If they ask, "Inspect the instrument" then respond "It's OK" or “It is there”. If they ask what you did, then say "I went out and looked at it." Be tough. Do not offer more information than they asked for.
- Do not elaborate and sometimes the response might be "that is not possible".
- The questions must preferably be in writing.
- You will discuss the actual solution with your two colleagues after the exercise.

For the ***observer***

- You evaluate the progress of the troubleshooter as shown in the example →
- At the end of the 25 minutes the expert will discuss the true answer. Then you will provide feedback to the troubleshooter on her/his progress.





Do not mark the stapled sheets in the folder; these folders are reused in future years and cost substantial time and money to prepare.

Some guidelines for the troubleshooter

Keep this sheet ... [*hint*: you'll need it for the final exam, and hopefully you'll use it the rest of your career]

1. Engage

- "I want to and I can"
- Anxiety is not productive to performance

2. Define (*Write down the following to help order your thoughts*)

- Is there a time criticality here?
- What should be happening?
- What is actually happening?
- So the deviation is .....
- Add notes to the sketch of the process
- What is .... When is .... Where is .... Who is .... and What is not .... *etc*
- The problem is .... The problem is not ......
- Is this start-up? Has there been maintenance? Calibration?
- Write down any information that is missing. Ask for it in the next phase.

3. Explore (bring all your engineering knowledge together here)
Write down any ideas to solve the problem right away in the "Plan and diagnose phase"

- What fundamental principles apply? E.g. heat transfer, fluid flow, reactors, control....
- What variables are normally important for this fundamental area?
- Are sensors working?
- Are measurements consistent? E.g. agreement; do the relationships between measurements make sense (remember heat exchanger example)
- What are typical cause → effect relationships under normal conditions for this process?
- What will feedback do to alter these normal relationships?
- Consider opinions *vs* facts
- Go back to the "Engage" phase if you need to.
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You can ask the Expert for answers at this stage to specific questions.

4. Plan and diagnose

1. Brainstorm potential root causes. Remember a root cause is specific "There is a leak in the heat exchanger", **not** something like: "The problem is with the heat exchanger".
2. Write down all the pieces of evidence you currently have and evidence you already asked from the Expert. Use lower case letters: a, b, c, d, etc
3. If a piece of evidence does not support a potential root cause, then eliminate it.
4. Now what questions can you ask the "plant" to prove or disprove your other root causes? These are called diagnostic actions. Use upper case letters: A, B, C, D, etc
5. Ask the diagnostic actions in the order that will address safety issues first, then ask those that will eliminate/prove multiple hypotheses ("most value for your efforts")

5. Implement

- Select a solution that will solve the problem in the short term
- Describe a solution to permanently fix the problem

6. Lookback

- There is more to this part, but for now: "How could this problem be prevented in the future?"
- Are your suggested improvements safe?

Turn over to see how the tables were filled out for the example case study in class.

Keep this sheet: refer to it during and after the tutorial

Working hypotheses	Initial Evidence Support/Neutral/Disprove										
	a	b	c	d	e	f	g	h	i	j	
1. Nothing wrong	N	N	N	N	N	N	N	N	N	N	
2. ~~Tank not switched; feed flow low.~~	N	N	N	N	N	D	D	N	N	N	
3. Fuel gas heating value decrease	N	S	S	N	N	N	N	N	S	N	
4. Stack damper failed open	N	S	S	N	N	N	N	N	S	N	
5. Too little area in heater	N	S	S	N	N	N	N	N	S	N	
6. Fired heater tube rapid coke	N	S	S	N	N	N	N	N	S	N	
7. ~~TC-1 measurement fault, reading too~~ low	N	S	S	N	D	N	N	N	N	N	
8. TC-1 poorly tuned, unstable*	N	S	S	N	N	N	N	N	S	N	
9. ~~Fuel valve is faulty, opened more than~~ indicated	N	D	N	N	D	N	N	N	N	N	
10. Fired heater tube leak	N	N	N	N	N	N	N	N	N	N	
11. Air compressor motor failed	N	S	S	N	N	N	N	N	S	N	
12. Air compressor intake partially blocked	N	S	S	N	N	N	N	N	S	N	
13. Air flow constant; not enough air for fuel rate	N	S	S	N	N	N	N	N	S	N	
14. Endothermic reaction in process fluid in heater	N	S	S	N	N	N	N	N	S	N	
15. ~~Feed coming from the wrong tank~~	N	N	N	N	N	N	N	D	N	N	

Details for the initial evidence

a. Feed rate being increased in steps
b. Temperature TC-1 decreasing monotonically at increasing rate of change
c. Fuel flow increasing monotonically at increasing rate of change
d. Smell around the feed pump (opinion)
e. TC-1 and T4 consistent within 1 °C
f. FC-1 and F7 are consistent within 1.5%, F8 FAL not active
g. L100 is decreasing
h. L200 is increasing
i. All controllers are in automatic, and no controller output is saturated
j. Process behavior "normal" after first feed increase up to second feed increase

Diagnostic actions shown below are formatted differently to your worksheet, but the idea is the same.

Diagnostic Action	Working hypotheses affected	Time (min)	Likelihood of hypotheses (H/M/L)	Cost (H/M/L/None)	Risk of action (H/M/L/None)	Order of execution
A. Observe the status of the fired heater SIS (safety instrumented system that automates emergency shutdown) (1)	11	0.5	H	N	N	1a
B. Observe the status of all plant alarms (1)	many	5-20	H	N	N	1b
C. Wait and watch if temperature returns to its set point	1, 3	20-30	M	N	M-H (2)	Not done
D. Observe the air flow rate measurement and trend	11, 12, 13	1	H	N	N	1c
E. Observe the air pressure to the burner	11, 12, 13	1	H	N	N	1d
F. Place TC-1 in manual and control the temperature manually by adjusting the controller output	1, 8, 13	5-20	H	N	N	2a
G. Take stack gas and analyze for oxygen and carbon monoxide (to evaluate combustion products)	10, 11, 12, 13	60-360	H	L	L (3)	2b
H. Observe fire box visually for leaks of process fluid and observe the flue gas from stack for smoke	10	5	L	N	L (3)	3a
I. Contact utility plant operator regarding fuel gas composition, what is it and has it changed recently?	3	10-360	M	L	N	2c