TANK TROUBLESHOOTING MODULE
INSTRUCTOR LESSON PLAN

Overview

Tanks are integral to the process industries, storing fluids (liquids and gases) as part of process operations. Tanks hold raw materials such as feed and additives, intermediate products, finished products (or process unit outputs), and recoverable or non-recoverable process wastes, such as off-spec products or byproducts.

Competency	Performance Standards
Troubleshoot problems with tanks	Performance will be satisfactory when: ☐ Learner recognizes the problem and captures the problem in written form. ☐ Learner evaluates HSE risks involved with continued operation. ☐ Learner recognizes when the HSE hazard/s warrants shutting down equipment. ☐ Learner collects and analyzes data associated with the problem. ☐ Learner rewords problem based on initial observations and reasoning. ☐ Learner identifies possible causes of the problem. ☐ Learner selects most probable root cause of the problem, one that explains every observation. ☐ Learner proposes corrective action that is rational and eliminates true cause (when possible). ☐ Learner accurately and completely documents problem and corrective action(s). ☐ Process equipment is stabilized (if simulator-based problem). ☐ System is returned to within $\pm$ 5% of design parameters (if simulator-based problem).
	Conditions: Given a paper-based (P&ID) and/or simulator-based problem (which may include a process description, equipment specifications, normal and abnormal operating conditions and appropriate tools), competence will be demonstrated by the completion of troubleshooting steps and subsequent documentation.

Learning Objectives

1. Recall the purpose, types, and applications of tanks.
2. Recall potential problems associated with tanks.
3. Describe immediate actions a process technician could take to solve various tank problems.
4. Explain the relationship between variables for a specific process under normal operating conditions.
5. Given normal and abnormal operating conditions for a specific process:
   - Recognize the problem.
   - Collect and analyze data associated with the problem.
   - Define the problem.
   - Identify possible causes and the most probable root cause of the problem.
   - Evaluate the effect of investigative, compensating and corrective actions.
   - Select an appropriate corrective action.
   - Document the problem and corrective action.

Learning Activities

Time Frame	Learning Activity	Teaching Activity	Instructional Materials	Supplies and Equipment	Notes
	PREVIEW learning objectives and performance standards for this competency.		Learning Plan		
	READ information provided in the Introduction section.		Learning Plan		
	LISTEN to the lecture on the purpose, types, and applications of tanks as well as problems associated with tanks in a process (if provided).	Deliver a brief presentation on tanks and associated problems.		Lecture Equipment	Address first two learning objectives.
	REVIEW the process flow, product specifications, equipment specifications, normal operating conditions, and normal design conditions sections for the specified process.	Choose a specific problem/s for learners to solve. Lead discussion of process to assure learners understand all aspects.	Process Description		
	COMPLETE the Self-Check Questions worksheet.	Introduce activity. Review worksheet with learners after completion.	Self-Check Questions worksheet		Reinforce learning objectives 1, 2, and 4.
	COMPLETE the Investigative Actions worksheet with a small group.	Divide learners into groups of 3 to 4. Introduce activity.	Investigative Actions worksheet		Address the third learning objective.
	PARTICIPATE in a class discussion regarding learner answers to the Investigative Actions worksheet.	Lead class discussion on actions not captured and elucidate on those listed.		Lecture Equipment	Address the third learning objective.

	SOLVE at least one paper-based tank problem including the completion of the Abnormal Operating Conditions table and Troubleshooting Form.	Choose a specific problem/s for learners to solve. Guide learners as needed during the activity. Do a quick de-brief after activity.	Problem Packet		Information for two Scenarios has been provided for students. Address learning objective 5.
	OBSERVE a normal and/or abnormal condition on the simulator associated with a tank (if simulator is available).	Set up simulation. Guide learners as needed during the activity.		Simulator	
	SOLVE at least one simulator-based tank problem including the completion of the Troubleshooting Form (if simulator is available).	Create a problem/s for learners to solve. Program fault for simulator-based problem. Guide learners as needed during the activity. Do a quick de-brief after activity.	Troubleshooting Form	Simulator	Information for one Scenario has been provided for students. Address learning objective 5.

TANK TROUBLESHOOTING MODULE
PROCESS DESCRIPTION

Introduction

Tanks are integral parts of virtually every type of process operation. Tanks are used to store various quantities of liquid or gas products used or produced during operations. Feedstocks and additives are pumped from tanks to process units. Intermediate products created during different steps of a process are stored for later use to create finished products. Process outputs, or final products, are stored before transmission to end users, through modes such as pipelines, barges, rail cars, or tank trucks. Off-specification products, byproducts, or wastes that are produced during normal or abnormal operations are stored for recovery (re-running) when possible or proper disposal.

Companies can increase their cost effectiveness and efficiency of their operations by using tanks. Feedstocks and additives can be purchased in larger quantities for later use when costs are low. Larger quantities of intermediate or finished products can be produced and stored as units operate around the clock.

Tanks vary greatly in design and type. While some storage tanks are located underground (USTs), the majority of storage tanks used in industry are the above ground type (ASTs). Tanks are categorized as atmospheric, low pressure, or pressure tanks. The type of tank used is determined by the characteristics of the product stored in it. Atmospheric tanks operate at or near atmospheric pressure; they are not pressurized nor do they operate under vacuum pressure conditions. Atmospheric tanks can be either floating roof (external or internal), fixed roof, or open top (Society of Petroleum Engineers (SPE) International, 2013).

Low pressure tanks operate at between .5 psig and 15 psig. Pressure tanks are used to store lighter, more volatile material, and operate at a pressure greater than 15 psig. Some common types of pressure tank designs include sphere, spheroid, cylindrical/bullet, and hemispheroid.

“No item of equipment is involved in more accidents than the storage tank, probably because storage tanks are fragile and easily damaged by slight overpressure and vacuum,” according to Treveor Kletz in the book (What Went Wrong? Case Histories of Process Plant Disasters). “Fortunately, the majority of accidents involving tanks do not cause injury, but they do cause damage, loss of material and interruption of production.”’

Tank accidents also involve the largest dollar amount losses for facilities, due to the high value of the large quantity of material stored in them.

Due in part to the quantities of material stored in them, tanks are not usually placed in the middle of operating unit areas. Groups of tanks are situated together in large areas called tank farms. Tanks are separated by their contents, which limits the number of product pipelines that need to be run in each area.

Hazards associated with tanks can include chemical exposure, hazardous atmospheres, environmental releases, confined spaces, falls, fire, and explosion. Since tanks can contain large quantities of liquids, secondary containment systems such as dikes and firewalls are in place should containment be lost.

Tank fires and explosions are potentially catastrophic to the process facility and surrounding area. Measures taken to prevent and address tank fire situations include the use of lightning/flame arrestors, foam and deluge systems, and the placement of extinguishers and fire monitors. Grounding systems are used to minimize the possible ignition of stray vapors by static electricity buildup or lightning strikes.

Blanketing systems are used to add an inert gas, such as nitrogen, into the vapor space above the liquid level in a tank. This blanket or pad of gas prevents air from entering a tank and reacting with vapors and reduces fire and explosion hazards (Yanisko, Zheng, Dumoit, & Carlson, 2011); it also improves operational efficiency by reducing emissions and lowering the cost of product loss through evaporation, and helps to reduce tank corrosion by keeping contaminants and moisture out of the tank.

Tanks are equipped with pressure/venting systems to relieve excessive pressure and prevent vacuum from forming as a result of pressure and temperature changes in the tank. These changes can occur as a result of normal filling and emptying operations, a change in the variables of material entering the tank and atmospheric conditions.

Tanks have emergency relief systems to address situations involving overfilling or over-pressuring. These systems can vent to the atmosphere, a flare system, or a recovery system. Tanks might also have a sprinkler or deluge system to reduce fire or explosion hazards.

Corrosion is a leading cause of tank leaks and failures. The corrosive nature of some of the materials stored in tanks and the presence of water makes them susceptible to internal corrosion, while their construction materials and close contact with the surrounding environment exposes tanks to the risk of external corrosion. Cathodic protection systems and specialized coatings are employed to prevent tank leaks and failures caused by external corrosion and internal surface linings help to prevent internal corrosion.

Proper PPE, including protective clothing, hard hat, and eye protection should be worn at all times when working around tanks. Additional protective equipment, such as respirators or supplied breathing air, fall protection system, or hearing protection, may be required depending on the tasks to be conducted and the material stored in the tanks or used to clean them.

Problems that tanks can experience include those such as loss of containment including leaks and ruptures, corrosion, and contamination. These issues may not only affect the tank, but also associated equipment and processes.

Thus, it is prudent to prevent any potential issues by the watchful monitoring and control of tanks and all associated equipment and instrumentation, and the application of sound troubleshooting methods, approaches, and tools to reduce or eliminate issues.

NOTE: The following information describes general tank specifications. Specific tank details will be provided for the troubleshooting scenarios.

Process Flow

Products enter and leave tanks through a system that includes pumps or compressors, piping, valves, and instrumentation/controls. The exact equipment and configuration depends on product stored, type of tank, process requirements, and other factors

Product Specifications

Products stored in tanks include a wide range of fluids, such as water, hydrocarbons, chemical additives, and process gases.

Equipment Specifications

Tank specifications are based on type and design, as dictated by process requirements. Atmospheric tanks operate at ambient temperature and pressure around 14.7 PSIA (0 psig) at sea level. Low pressure tanks typically operate at .5 PSIG to 15 PSIG, and pressure tanks operate above 15 PSIG.

Normal Operating Conditions

Normal operating conditions vary by process requirements. The standard process variables, which are pressure, temperature, level, and flow, are vital to tank operations. Changes in ambient temperature will affect tank operation since liquids and gases expand and contract with both small and large temperature changes.

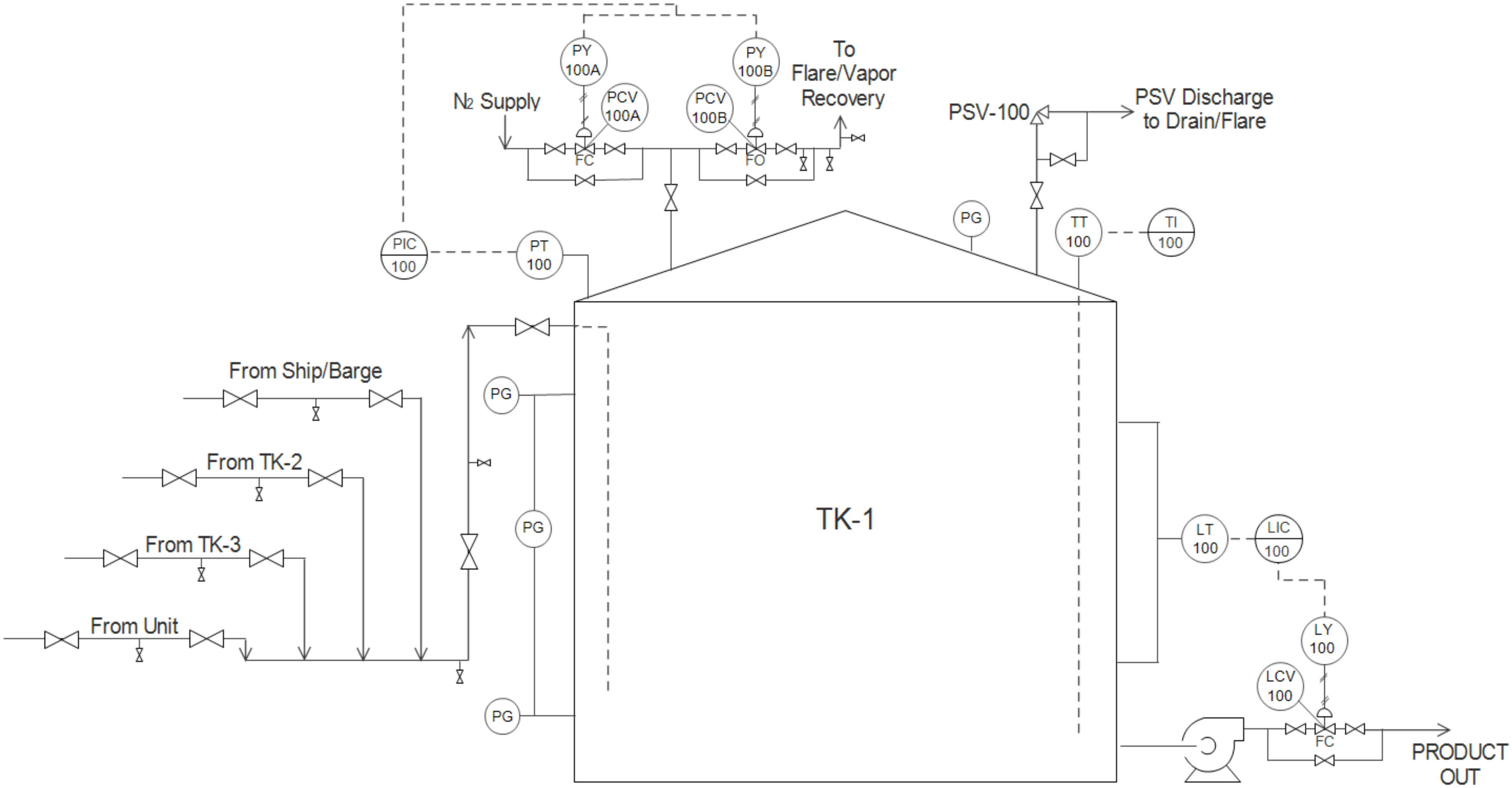

Figure 1. Tank System

Tank Troubleshooting Module
Self-Check Questions

1. What are the three major classifications of tanks?

   Atmospheric, low pressure and pressure tanks

2. A leading cause of tank leaks and failures is ___________.

   Corrosion is a leading cause of tank leaks and failures

3. How do tanks help with a company's cost effectiveness?

   Feedstocks and additives can be purchased in larger quantities for later use when costs are low. Larger quantities of intermediate or finished products can be produced and stored as units operate around the clock.

4. Four common types of pressure tanks are:

   Sphere, spheroid, cylindrical/bullet, and hemispheroid

5. What is the most common type of inert gas used in a blanketing system?

   Nitrogen

6. Tanks are grouped together in areas called ________________________.

   Groups of tanks are situated together in large areas called tank farms

7. Identify three purposes of blanketing systems.

   Blanketing systems prevent air from entering a tank and reacting with vapors and reduces fire and explosion. It also improves operational efficiency by reducing emissions and lowering the cost of product loss through evaporation, and helps to reduce tank corrosion by keeping contaminants and moisture out of the tank.

8. What methods are used to prevent external corrosion in tanks?

   Cathodic protection systems and specialized coatings are employed to prevent tank leaks and failures caused by external corrosion

9. Tanks have _______________ ______________ ____________ to deal with overfilling or over pressuring situations.

   Tanks have <u>emergency relief systems</u> to address situations involving overfilling or over-pressuring

10. What happens to the pressure of gas vapors in a tank as temperature increases?

    Pressure increases

11. List at least three safety hazards related to tanks.

    a. Chemical exposure (leaks or loss of containment)

    b. Hazardous atmospheres

    c. Fire/explosion

    d. Confined space

    e. Fall from height

    f. Environmental releases

12. What causes pressure and temperature changes in a tank during normal operation?

    Pressure and temperature changes can occur as a result of normal filling and emptying operations, a change in the variables of material entering the tank and atmospheric conditions.

TANK TROUBLESHOOTING SCENARIO

This tank farm is comprised of 12 low pressure tanks, each with a maximum capacity of 100,000 bbl. of hydrocarbons, operating at 6 PSIG and ambient temperature. The tanks are of fixed roof design. The tanks use a split range pressure control system that utilizes a nitrogen blanket input to maintain pressure and flare relief system to remove excess pressure.

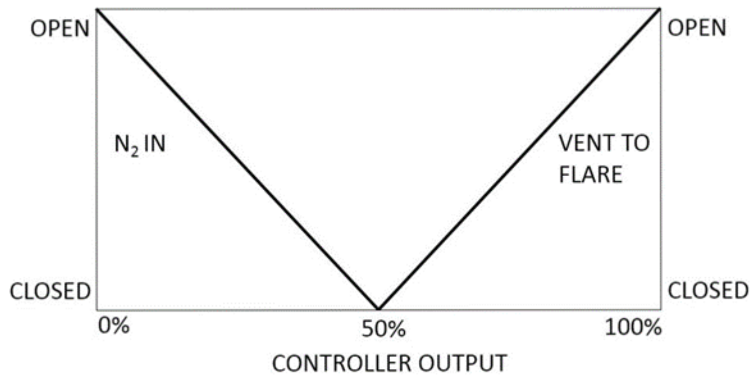

Figure 2. Split-Range Controller Output

This split range controller uses one controller which outputs to two control valves. When the controller's output signal is at 50%, both the valve to the flare and the N_2 into the tank are closed. As the controller's signal moves from 50% to 0%, N_2 into the tank opens, until it is wide open at 0% controller output signal. As the controller's signal moves from 50% to 100%, the tank's vent valve to the flare opens; until it is wide open at 100% output signal.

Table 1. Instrumentation List

PIC-100	TK-1 Split Range Pressure Controller	Normal pressure is 6 PSIG
LIC-100	TK-1 Level Controller	Normal level is 25%
TI-100	TK-1 Average Temperature Indicator	Normal average temperature is 75°F

Table 2. Normal Operating Conditions

Tag ID	Instrument Range	Normal Value	Instrument Indication	Eng. Units	Output %
PIC-100	0-20	6 PSIG	30%	PSIG	50%
LIC-100	0-100	25%	25%	%	25%
TI-100	0-300	75°	25%	°F	---

Tank Troubleshooting Module
Scenario #1 (Paper Based)

Scenario Statement

The Oil Movements board operator has been moving material from TK-2 into TK-1 for the last two hours. While the level reading for TK-2 has been down gauging at the expected rate, TK-1's level reading has not increased since the transfer started. Troubleshoot the situation by completing the Troubleshooting Form and listing investigative, compensating, and corrective actions.

Table 3. Abnormal Conditions

Tag ID	Instrument Range	Current Value	Instrument Indication	Eng. Units	Output %
PIC-100	0-20	7 PSIG	35%	PSIG	58%
LIC-100	0-100	25%	25%	%	25%
TI-100	0-300	75°	25%	°F	---

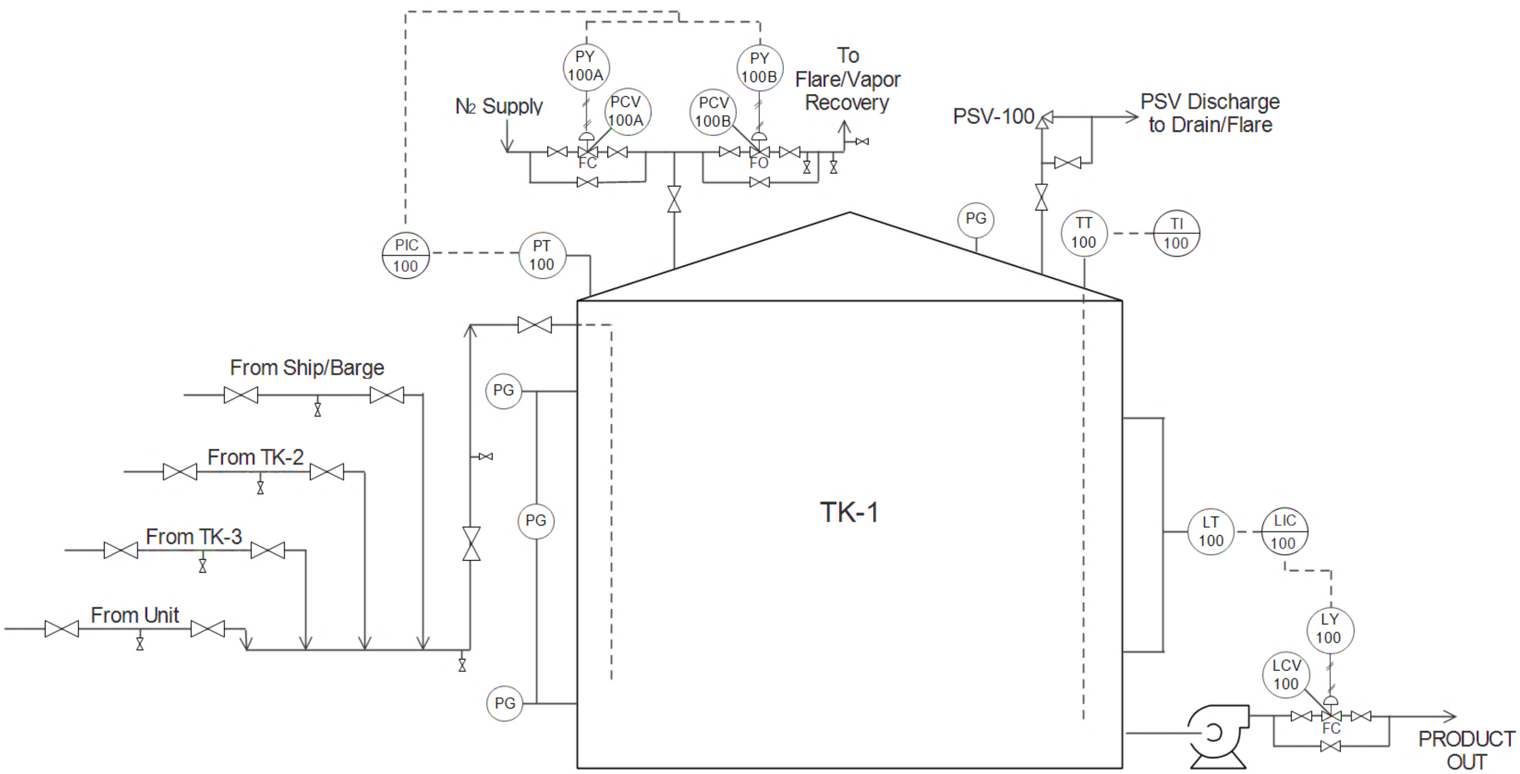

Figure 3. Tank System

Observations

TK-1 level, LIC-100 appears to be unchanged

TI-100 appears normal (unchanged)

PIC-100 has increased to 7 PSIG, and output has increased to 58%

Causes

A leak in the system – spilling product on the ground between TK-2 and TK-1

LIC-100 problem – instrument is not showing increased level

Improper line-up – product going to another tank

Pump from TK-2 failed

Investigative Actions

Have LIC-100 checked

Manually check levels in both TK-2 and TK-1

Perform material balance calculation, based on results of manual gauging

Check other tanks for unexpected level increase

Check that pump is running

Check that no product lines are leaking

Check pressure gauge to confirm increase in pressure

Check delta p and compare to previous reading

Confirm valve line-ups are correct

Compensating Actions

Stop transfer until problem is resolved

Corrective Actions

Restart pump,if it's found to be off

Repair level instrument

Correct line-up, if incorrect

TROUBLESHOOTING FORM

1. Recognize (and write) the problem.

*(What **is** happening that should not be or what **is not** happening that should be?)*

TK-1 level not increasing as expected

2. Stabilize the system.

(Does it need fixing? Stabilize the unit. Can we keep the unit running? Do we need to shut it down?)

Transfer cannot continue until problem is resolved

3. Collect and analyze the data.

(Look for changes, differences, readings that have not changed, etc. Write down all observations. After every observation, write down the reason why. Then answer why for each reason.

Ex. Observation why? Because Reasoning why? Because Reasoning why? Because Reasoning...)

Y N a. LIC-100 appears to be unchanged

why? because no increase in level has been detected

why? because no flow is entering tank

why? because transfer is not operating

Y N b. LIC-100 appears to be unchanged

why? because no increase in level has been detected

why? because there is a problem with the instrument

why? because of wear, vibration, poor design, improper installation or maintenance, improper operation, or manufacturing issue

Y N c. TI-100 appears to be unchanged

why? because temperature in tank is steady

why? because

why? because

Y N d. PIC-100 has increased to 7 PSIG, and output has increased to 58%

why? because pressure in tank has increased

why? because level in tank has increased

why? because of transfer of material into tank

Y N e. PIC-100 has increased, but no level increase has occurred

why? because LIC-100 is not working properly

why? because of wear, vibration, poor design, improper installation or maintenance, improper operation, or manufacturing issue

why? because

Y N f.

why? because

why? because

why? because

Y N g.

why? because

why? because

why? because

Y N h. ______________________________

why? because______________________________

why? because______________________________

why? because______________________________

Y N i. ______________________________

why? because______________________________

why? because______________________________

why? because______________________________

Y N j. ______________________________

why? because______________________________

why? because______________________________

why? because______________________________

4. After initial observations and reasoning, **reword the problem** as specifically as possible.

TK-1 level is not increasing as expected, but pressure in tank (PIC-100) has increased

____

5. List **possible causes** of the problem.

Y **N** a. A leak in the system piping spilling product between TK-1 and TK-2

Y N a. LIC-100 not functioning properly

Y **N** b. Improper line-up

Y **N** c. Pump from TK-2 failed

Y N d. ______________________________

*******Would each possible cause explain the problem? Circle **Y** or **N** beside each possible cause.

6. List the **most probable cause** of the problem. *(Use your knowledge, experience and best judgment.)*

LIC-100 not functioning properly

******* Does this cause explain every observation? Circle **Y** or N beside every observation.

7. Determine alternative solutions and select solution.

a. What would be an **investigative** action you could take at this point? What would be the effect?

Have LIC-100 checked by instrument tech.______________________________

b. What would be a **compensating** action you could take at this point? What would be the effect?

Stop transfer until problem is identified and corrected______________________________

c. What would be a **corrective** action you could take at this point? What would be the effect?

Repair level instrument______________________________

d. What will be the **effect** of the above actions? *(Would any of the actions cause other problems?)*

Stopping transfer from TK-2 to TK-1 may impact production schedule. Slowdown of upstream processes may be necessary______________________________

8. Take the **corrective action** *(if empowered or within your responsibility).*

9. **Follow-up.** *(Was the problem eliminated? Was the "real" cause eliminated? What caused the real cause? You may need to start the problem-solving process again.)*

Once LIC-100 is repaired, transfer can be resumed

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10. **Document and share** with others.
(Document problem and actions taken in logbook or report; communicate with others.)

TANK TROUBLESHOOTING MODULE
SCENARIO #2 (PAPER BASED)

Scenario Statement

It is mid-March, and the weather has been warm during the day, but cool at night, with the ambient temperature at around 75 degrees Fahrenheit. The barometric pressure has been holding steady and humidity is normal for the area and season.

A control room technician, coming in on the night shift, is checking the readings on the DCS for the facility's tank farm. The technician observes that the normal vapor pressure of Tank 1, which should be 6 PSIG, is decreasing. The tank level is normally at 25%, but the level is increasing.

The technician checks the reading for PIC-100 and sees the output signal for PIC-100 is at 40% and steady. PCV-100A is open to allow N_2 to enter the tank.

Given the abnormal set of readings, what is the most likely cause of the problem? Troubleshoot the situation by completing the Troubleshooting Form and listing investigative, compensating, and corrective actions.

Table 4. Abnormal Conditions

Tag ID	Instrument Range	Current Value	Instrument Indication	Eng. Units	Output %
PIC-100	0-20	4 PSIG	20%	PSIG	40%
LIC-100	0-100	30%	30%	%	30%
TI-100	0-300	75°	25%	°F	---

Observations

TK-1 pressure is normally 6, but is now 4 PSIG and decreasing. PIC-100 output signal is normally 50%, but is now holding steady at 40%.

TK-1 level (LIC-100) is normally 25%, but is now 30%. LIC-100 output signal is normally at 25%, but is now 30% and increasing.

Cause

A technician on the previous shift shut a block valve on the N_2 into TK-1, at PCV-100A for an unknown reason. This action was not recorded in the log or mentioned during the shift change briefing. It had not been noticed during the earlier shift, since pressure was higher during the daylight hours and PCV-100B had been open and venting to the flare for most of the afternoon.

Investigative Actions

Visually inspect the valve line-ups at PCV-100A & B

Check the pressure gauge on the tank to confirm the pressure instrument reading

Visually inspect for leaks

Check the position of the valves at PVC-100A & B

Compensating Actions

Crack open bypass valve on PCV-100A to see if tank pressure responds and starts to increase

Put LIC-100 controller in Manual to prevent it from overreacting to the introduction of N_2, *and overshooting the setpoint, going low.*

Corrective Actions

Slowly return PCV-100A to service to add N_2 *and increase the pressure of TK-1. Review the shift log for any information about the controller.*

Return LIC-100 to Automatic mode

Monitor PIC-100 to see if the vapor pressure rises once the controller is back in service. If not, continue troubleshooting efforts. Follow up to see why block valve was shut on PCV-100A.

TROUBLESHOOTING FORM

1. **Recognize (and write) the problem.**
*(What **is** happening that should not be or what **is not** happening that should be?)*
TK-1 pressure is below normal and continuing to decrease

2. **Stabilize the system.**
(Does it need fixing? Stabilize the unit. Can we keep the unit running? Do we need to shut it down?)
Pressure in tank needs to be stabilized before damage occurs to tank

3. **Collect and analyze the data.**
(Look for changes, differences, readings that have not changed, etc. Write down all observations. After every observation, write down the reason why. Then answer why for each reason.
Ex. Observation why? because Reasoning why? because Reasoning why? because Reasoning...)

Y N a. PIC-100 decreased from 6 PSI to 4 PSI
why? because instrument not functioning properly
why? because of wear, vibration, poor design, improper installation or maintenance, improper operation, or manufacturing issue
why? because

Y N b. PIC-100 output signal decreased from 50% to 40%
why? because PIC-100 pv decreased from 6 PSI to 4 PSI
why? because
why? because

Y N c. LIC-100 increased from 25% to 30%
why? because more liquid is present in tank
why? because something is getting into tank
why? because there is an improper line-up

Y N d. LIC-100 increased from 25% to 30%
why? because more liquid is present in tank
why? because there is less vapor pressure in tank
why? because N2 is not getting into tank

Y N e. N2 is not getting into tank
why? because there is a problem with the N2 supply
why? because of N2 line failure
why? because

Y N f. N2 not getting into tank
why? because PCV-100A is not open
why? because there is an instrument problem with controller
why? because

Y N g. N2 not getting into tank
why? because valve is closed somewhere on the N2 line
why? because of operator error
why? because

Y N h. ____

why? because______________________________________

why? because______________________________________

why? because______________________________________

Y N i. ____

why? because______________________________________

why? because______________________________________

why? because______________________________________

Y N j. ____

why? because______________________________________

why? because______________________________________

why? because______________________________________

4. After initial observations and reasoning, **reword the problem** as specifically as possible.

At the beginning of the night shift, PIC-100 is decreasing even though PCV-100A is opening. Pressure in the tank does not appear to be responding to this increase in N2 addition.

____

5. List **possible causes** of the problem.

Y N a. PCV-100A in fail safe position (closed) due to instrument problem

Y **N** b. PIC-100 instrument problem - reading low

Y N c. Valve shut on N2 line into tank

Y N d. ____

Y N e. ____

*****Would each possible cause explain the problem? Circle **Y** or **N** beside each possible cause.

6. List the **most probable cause** of the problem. *(Use your knowledge, experience and best judgment.)*

PCV-100A in fail safe position or valve closed on N2 line into tank

***** Does this cause explain every observation? Circle **Y** or N beside every observation.

7. Determine alternative solutions and select solution.

a. What would be an **investigative** action you could take at this point? What would be the effect?

Field check PCV-100A to determine whether problem is controller being shut or valve being closed

b. What would be a **compensating** action you could take at this point? What would be the effect?

Crack open bypass valve on PCV-100A to stop pressure decrease in tank____________________

c. What would be a **corrective** action you could take at this point? What would be the effect?

Return PCV-100A to service to add N2 and re-establish TK-1 pressure to normal level. Close bypass valve.______________________________

d. What will be the **effect** of the above actions? *(Would any of the actions cause other problems?)*

Normal tank operations would result______________________________

____

8. Take the **corrective action** *(if empowered or within your responsibility).*

9. **Follow-up.** *(Was the problem eliminated? Was the "real" cause eliminated? What caused the real cause? You may need to start the problem-solving process again.)*

Follow up with day shift operator to find out why N2 valve was shut and not noted in log

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10. **Document and share** with others.
(Document problem and actions taken in logbook or report; communicate with others.)

TANK TROUBLESHOOTING MODULE
SCENARIO #3 (PAPER-BASED)

Scenario Statement

It is a Thursday evening in October. The shift has been relatively quiet. In the control room, a technician is monitoring a tank transfer operation into TK-1, and no flow is currently leaving the tank. A field technician is entering data into the shift log after making a round of the tank farm. The control room technician notices that the vapor pressure on TK-1 is 8 PSIG and increasing.

Troubleshoot the situation by completing the Troubleshooting Form and listing investigative, compensating, and corrective actions.

Table 5. Abnormal Conditions

Tag ID	Instrument Range	Current Value	Instrument Indication	Eng. Units	Output %
PIC-100	0-20	8 PSIG	40%	PSIG	100%
LIC-100	0-100	28%	28%	%	0%
TI-100	0-300	75°	25%	°F	---

Observations

The vapor pressure reading at PIC-100 is 8 PSIG and increasing. PCV-100B indicates that it is 100% open. PCV-100A indicates that it is closed.

Causes

The piping is plugged between the control valve PCV-100B and the relief flare header

There is a dropped gate on one of the valves

Increased flow from another source is holding TK-1 out of the flare

N2 is entering the tank - leaking through PVC-100A

PVC-100A is open

PVC-100B has not opened

Investigative Actions

Visually check the positions of PCV-100A & PCV-100B. Have board operator stroke PCV-100B to verify that it is functioning properly

Visually inspect the flare to confirm that it is working

Check the control valve and bypass valve on PCV-100A to confirm that they are closed

Visually check the field pressure gauge to confirm increased pressure

Check pressure at bleed valves along the relief flare system piping to determine location of pluggage

Compensating Actions

Open the bypass around PCV-100B. If pluggage is somewhere in the control valve piping, flow should increase and pressure should start to decrease

Stop the transfer until the problem is resolved

Shut a block valve on PCV-100A to confirm no N2 leakage into tank

If problem is with control valve, operator will have to stand by and manually control pressure until it is repaired

Corrective Actions

Notify maintenance of the plugging. Unplug the line between PCV-100B and the flare.

Replace valve, if dropped gate.

Repair PCV-100B, if it is not functioning properly

TROUBLESHOOTING FORM

1. **Recognize (and write) the problem.**
   *(What **is** happening that should not be or what **is not** happening that should be?)*
   <u>TK-1 pressure, PIC-100 is increasing</u>

2. **Stabilize the system.**
   (Does it need fixing? Stabilize the unit. Can we keep the unit running? Do we need to shut it down?)
   <u>Tank pressure needs to be stabilized before damage to tank occurs, transfer needs to be stopped until pressure increase issue is resolved</u>

3. **Collect and analyze the data.**
   (Look for changes, differences, readings that have not changed, etc. Write down all observations. After every observation, write down the reason why. Then answer why for each reason.
   Ex. <u>Observation</u> why? because <u>Reasoning</u> why? because <u>Reasoning</u> why? because <u>Reasoning</u>...)

Y N a. <u>PIC-100 is increasing</u>
why? because N2 is getting into tank
why? because PCV-100A is not closed
why? because there is an instrument problem with PIC-100

Y N b. <u>PIC-100 is increasing</u>
why? because PCV-100B has failed to open
why? because PCV-100B is not functioning properly
why? because

Y N c. <u>PIC-100 is increasing</u>
why? because there is an obstruction in the flare line - pluggage
why? because solids have accumulated somewhere in the line
why? because

Y N d. <u>PIC-100 is increasing</u>
why? because flare line pressure is holding out tank
why? because other contributors are overwhelming flare line
why? because other unit area upsets are occurring

Y N e. <u>PIC-100 is increasing</u>
why? because pressure is not being relieved through the flare line
why? because a block valve is shut on PVC-100B
why? because of operator error

Y N f. <u>PIC-100 is increasing</u>
why? because pressure is not being relieved through the flare line
why? because there is a dropped gate on a valve in the flare relief header
why? because

Y N g.
why? because
why? because
why? because

Y N h. ______________________________

why? because ______________________________

why? because ______________________________

why? because ______________________________

Y N i. ______________________________

why? because ______________________________

why? because ______________________________

why? because ______________________________

Y N j. ______________________________

why? because ______________________________

why? because ______________________________

why? because ______________________________

4. After initial observations and reasoning, **reword the problem** as specifically as possible.

PIC-100 is increasing, even though PCV-100B appears to be wide open and PCV-100A is showing closed

5. List **possible causes** of the problem.

Y N a. PIC-100 instrument failure - controller not functioning properly

Y N b. PCV-100A or PCV-100B not functioning properly

Y N c. There is a dropped gate somewhere in the flare relief piping

Y N d. Increased flow from other unit areas is preventing PIC-100B from venting to flare line

Y N e. Line pluggage in the flare piping

*******Would each possible cause explain the problem? Circle **Y** or **N** beside each possible cause.

6. List the **most probable cause** of the problem. *(Use your knowledge, experience and best judgment.)*

Any of the above - field verification is necessary to rule out possible causes

******* Does this cause explain every observation? Circle **Y** or N beside every observation.

7. Determine alternative solutions and select solution.

a. What would be an **investigative** action you could take at this point? What would be the effect?

Verify valve position of PCV-100B

b. What would be a **compensating** action you could take at this point? What would be the effect?

Stop transfer of material into tank

c. What would be a **corrective** action you could take at this point? What would be the effect?

Unplug flare line, repair instrument

d. What will be the **effect** of the above actions? *(Would any of the actions cause other problems?)*

Stopping transfer will impact upstream unit production and other tank farm activities

8. Take the **corrective action** *(if empowered or within your responsibility).*

9. **Follow-up.** *(Was the problem eliminated? Was the "real" cause eliminated? What caused the real cause? You may need to start the problem-solving process again.)*

If pluggage was the problem, need to determine what caused it. If instrument problem, repairing it will solve the problem

10. **Document and share** with others.
(Document problem and actions taken in logbook or report; communicate with others.)

Tank Troubleshooting Module
Investigative Actions Worksheet

<u>Instructions</u>: Work in a small group to complete this What-If exercise. Answer the questions based on the schematic shown in the Tanks Trainer. The system consists of three tanks with water flow into Tank #1 that flows from that tank to Tank #2 and then to Tank #3. Process variables that are indicated and/or controlled are level and flow.

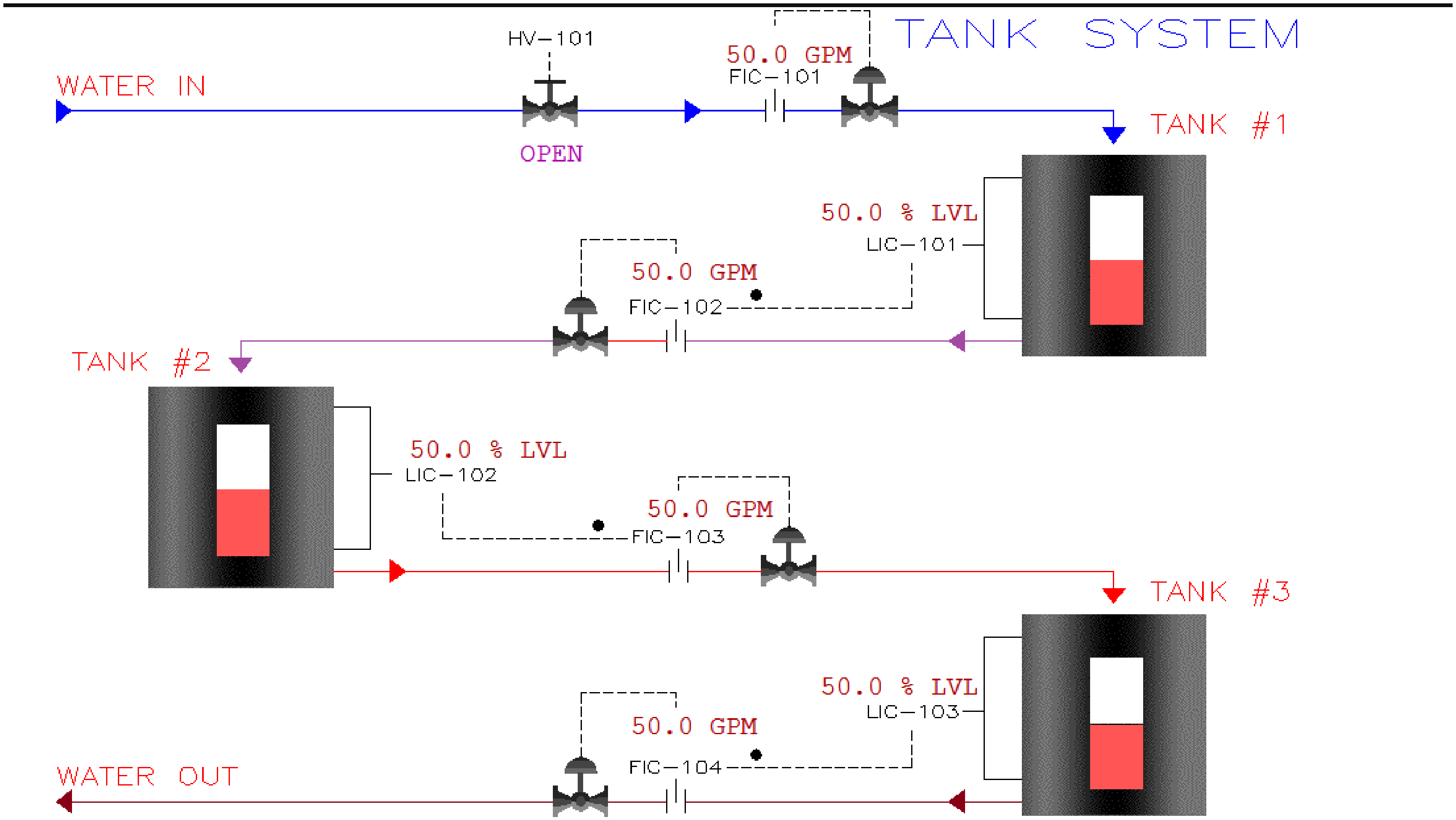

Figure 4. Tanks Trainer

Courtesy of Simtronics Corporation

What-if Exercise

What happens to the variables listed in the left column when the variables listed across the top change in the manner stated. Indicate whether the process variable will go up ⬆, down ⬇, or remain unchanged ⬌, by placing the appropriate arrow in the space provided.

Table 6. Process Variable Response

PROCESS VARIABLE	HV-101 Fails Closed	FIC-102V Fails Closed	FIC-104V Fails Open	LIC-102 Fails High
LIC-101	⬇	⬆	⬌	⬌
FIC-102	⬇	⬇	⬌	⬌
LIC-102	⬇	⬇	⬌	⬆
FIC-103	⬇	⬇	⬌	⬆
LIC-103	⬇	⬇	⬇	⬆
FIC-104	⬇	⬇	⬆	⬆

PERFORMANCE ASSESSMENT ACTIVITY #1
PAPER-BASED PROBLEM

Learner Directions: In this assessment, you will analyze and solve a paper-based tank problem. Your instructor will provide you with the problem scenario and supporting materials. Complete and submit all documentation requested including an Abnormal Operating Conditions table and Troubleshooting Form to your instructor.

Competency: Troubleshoot problems with a tank.

Performance Criteria: Performance will be satisfactory when:

- Learner recognizes the problem and captures the problem in written form.
- Learner evaluates HSE risks involved with continued operation.
- Learner recognizes when the HSE hazard/s warrants shutting down equipment.
- Learner collects and analyzes data associated with the problem.
- Learner rewords problem based on initial observations and reasoning.
- Learner identifies possible causes of the problem.
- Learner selects most probable root cause of the problem, one that explains every observation.
- Learner proposes corrective action that is rational and eliminates true cause (when possible).
- Learner accurately and completely documents problem and corrective action/s.

Conditions: Given a paper-based problem (which may include a process description, equipment specifications, normal and abnormal operating conditions and appropriate tools), competence will be demonstrated by the completion of troubleshooting steps and subsequent documentation.

Assessment Strategy: Skill-based Performance Test

Standard: TBD. Example: Satisfactory performance requires learner must meet all criteria on the checklist.

TANK TROUBLESHOOTING RUBRIC
PAPER-BASED PROBLEM

Competency: Troubleshoot problems with a tank.

CRITERIA	SCALE			
Product				
1. Documentation is accurate.	4	3	2	1
2. Documentation is complete.	4	3	2	1
3. Documentation reflects correct use of terminology.	4	3	2	1
Process				
1. Learner recognizes the problem and captures the problem in written form.	4	3	2	1
2. Learner evaluates and documents HSE risks involved with continued operation.	4	3	2	1
3. Learner recognizes and documents when the HSE hazard/s warrants shutting down equipment.	4	3	2	1
4. Learner collects and analyzes data associated with the problem.	4	3	2	1
5. Learner rewords problem based on initial observations and reasoning.	4	3	2	1
6. Learner identifies possible causes of the problem.	4	3	2	1
7. Learner selects most probable root cause of the problem, one that explains every observation.	4	3	2	1
8. Learner proposes corrective action that is rational and eliminates true cause (when possible).	4	3	2	1

Key

4 =	Met and/or surpassed criteria
3 =	Met criteria
2 =	Showed progress toward meeting criteria
1 =	Did not meet criteria

Performance Assessment Activity #2
Simulator-based Problem

Learner Directions: In this assessment, you will analyze and solve a simulator-based tank problem. Your instructor will provide you with the problem scenario and supporting materials. Complete and submit all documentation requested including an Abnormal Operating Conditions table and Troubleshooting Form to your instructor.

Competency: Troubleshoot problems with a tank.

Performance Criteria: Performance will be satisfactory when:

- Learner recognizes the problem and captures the problem in written form.
- Learner evaluates HSE risks involved with continued operation.
- Learner recognizes when the HSE hazard/s warrants shutting down equipment.
- Learner collects and analyzes data associated with the problem.
- Learner rewords problem based on initial observations and reasoning.
- Learner identifies possible causes of the problem.
- Learner selects most probable root cause of the problem, one that explains every observation.
- Learner proposes corrective action that is rational and eliminates true cause (when possible).
- Learner accurately and completely documents problem and corrective action/s.
- Process equipment is stabilized.
- System is returned to within $\pm$ 5% of design parameters.

Conditions: Given a simulator-based problem (which may include a process description, equipment specifications, normal and abnormal operating conditions and appropriate tools), competence will be demonstrated by the completion of troubleshooting steps and subsequent documentation.

Assessment Strategy: Skill-based Performance Test

Standard: TBD. Example: Satisfactory performance requires learner must meet all criteria on the checklist.

NOTE: If the instructor uses simulator software that includes a performance scoring utility tool, then the instructor may wish to base the standard on the scoring tool. The instructor must describe the performance standards (generally by categories) for learners. Then, the instructor would have multiple options for the performance standard statement. For example, “Satisfactory performance requires learner to score a minimum of 80 for each of the performance category.”

Tank Troubleshooting Rubric
Simulator-based Problem

Competency: Troubleshoot problems with a tank.

Criteria	Scale			
Product				
1. Process equipment is stabilized.	4	3	2	1
2. System is returned to within ± 5% of design parameters.	4	3	2	1
3. Documentation is accurate.	4	3	2	1
4. Documentation is complete.	4	3	2	1
5. Documentation reflects correct use of terminology.	4	3	2	1
Process				
1. Learner recognizes the problem and captures the problem in written form.	4	3	2	1
2. Learner evaluates and documents HSE risks involved with continued operation.	4	3	2	1
3. Learner recognizes and documents when the HSE hazard/s warrants shutting down equipment.	4	3	2	1
4. Learner collects and analyzes data associated with the problem.	4	3	2	1
5. Learner rewords problem based on initial observations and reasoning.	4	3	2	1
6. Learner identifies possible causes of the problem.	4	3	2	1
7. Learner selects most probable root cause of the problem, one that explains every observation.	4	3	2	1
8. Learner proposes corrective action that is rational and eliminates true cause (when possible).	4	3	2	1

Key

4 =	Met and/or surpassed criteria
3 =	Met criteria
2 =	Showed progress toward meeting criteria
1 =	Did not meet criteria

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