PROCESS/PRODUCT FLOW TROUBLESHOOTING MODULE
INSTRUCTOR LESSON PLAN

Overview

Within the process industries, process fluids flow from one location to another via a piping system. Process piping and its associated in-line components (e.g., fittings and valves) can be made of a variety of materials. Common problems associated with piping and the in-line components include leaks, erosion-corrosion, vibration, pluggage, and extreme temperatures and pressures. Because small initial piping failures can give rise to major events, the process technician must have a basic understanding of troubleshooting techniques to recognize, correct, and prevent piping system problems.

Competency	Performance Standards
Troubleshoot problems associated with process/product flow	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 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, competence will be demonstrated by the completion of troubleshooting steps and subsequent documentation.

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Learning Objectives

1. Recall the purpose and applications of a piping system.
2. Recall potential problems associated with piping.
3. Describe immediate actions a process technician could take to solve piping 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 cause of the problem.
    - Evaluate the effect of investigative, compensating and corrective actions.
    - 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 piping systems and their associated problems (if provided).	Deliver a brief presentation on piping systems 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 3.
	BRAINSTORM immediate actions a process technician could take to solve process flow problems with a small group of your peers.	Divide learners into groups of 3 to 4. Introduce activity.			
	COMPARE your list of immediate actions for solving process flow problems to another group's work.	Write all actions on board or flipchart.			
	LISTEN to instructor expand on actions a process technician could take to solve process flow problems.	Lecture on actions not captured and expand on those listed.		Lecture Equipment	Address the third learning objective.

Time Frame	Learning Activity	Teaching Activity	Instructional Materials	Supplies and Equipment	Notes
	SOLVE at least one paper-based problem associated with product flow including the completion of the 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 four Scenarios has been provided for students. Address learning objective 4.
	OBSERVE a normal and/or abnormal condition on the simulator associated with a product flow (if simulator is available).	Set up simulation. Guide learners as needed during the activity.		Simulator	
	SOLVE at least one simulator-based product flow 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	All Scenarios are available as simulator-based exercises. Address learning objective 4.

PROCESS/PRODUCT FLOW TROUBLESHOOTING MODULE
PROCESS DESCRIPTION

Introduction

Within the process industries, process fluids flow from one location to another via a piping system. “Piping carries water/wastewater into the plant for treatment, fuel oil to heating units, steam to steam services, lubricants to machinery, compressed air to pneumatic service outlets....and chemicals to unit processes” (Spellman & Drinan, 2001). Process piping and its associated in-line components (e.g., fittings and valves) can be made of steel, iron, brass, titanium, aluminum, copper, glass, plastic, wood, clay, and concrete (Silowash, 2010). The in-line components play a critical role in controlling the flow, temperature, and pressure of the transported fluid.

Valves are classified by general type (e.g., plug, ball, butterfly, globe, gate, needle, diaphragm), purpose (flow control, temperature regulating, pressure control, sampling, flow limiting, directional flow control), or flow characteristics (e.g., straight-through, full-flow, or throttled-flow). Valve selection is dependent on several factors including the transmitted fluid, functional requirements, operating conditions, flow characteristics, valve size, and cost (Dickenson, 1999) (Silowash, 2010).

Small initial piping failures can give rise to major events (e.g., 2” hydrogen piping failure at Chevron) (Niccolls, 2005). The more common problems associated with piping include:

Leaks – In the short-term, leaks can be the source of a slipping hazard and depending on the transported fluid, contact with a leaked substance can result in burns, acute or chronic illnesses, or death. In the long-term, leakage may result in damage or loss of equipment as well as fire or explosion. Both product quality and production may be negatively impacted. Regulatory fines may also be imposed.

Erosion-Corrosion – Both petrochemical and power plants are susceptible to piping failures due to erosion-corrosion. Because of the prevalence of single-phase erosion-corrosion within the process industries, key variables that contribute to this issue are:

- High fluid velocity
- Low fluid pH
- Low fluid oxygen content
- High fluid temperature (Bush, 1990)
- High fluid pH

Erosion-corrosion may damage pipes and lead to leaks and reduced carrying capacity.

Vibration – Piping vibrations fall into two major categories: steady-state vibration and transient vibrations. Steady-state vibration is generally caused by rotating equipment or fluid flow. Excess vibrations of this type can result in leaks, loosened connections, and eventually fatigue failure. Transient vibration can be caused by “pressure pulses traveling through the fluid” such as water hammer.

Pluggage – Pluggage can be caused by a change in process composition that increases viscosity and/or creates solids or particulates, an increase in velocity or vibration that damages and subsequently breaks loose some material associated with an in-line component, the presence of foreign body, and design errors. Immediately, loss of flow occurs. If the loss is complete, damage to the equipment and loss of production may result and eventually, a major event may occur.

Extreme Temperatures and Pressures – Extreme temperatures and pressures present serious design and operational issues. Strategies must be considered that prevent or minimize the impacts of thermal expansion, freezing, and pressures that are higher or lower than design parameters. Failure to do so may result in loss of structural integrity of the pipe (e.g., stress cracks or rupture) and subsequent cascading events.

Process Background

The plant contains a water distribution system capable of supplying 100 GPM of water. Typically, the system runs at 50 GPM. The system feeds a drip-irrigation unit.

The water distribution system includes three tanks which balance flows and chemically ready the water for use in irrigation. Tank 1 is supplied from the municipal water system. Tank 2 is gravity fed from Tank 1 and Tank 3 is gravity fed from Tank 2. The primary goal in designing and building the system was long-term, low cost maintenance. The gravity feed design allows the system to operate with no pump to maintain and replace.

The site chosen included buildings with a pre-determined inventory of chemicals. Because chemical addition steps were needed in this water system, three tanks were included and placed near the buildings containing the chemicals already in place.

Equipment Specifications and Instrumentation

NOTE: The equipment specifications and instrumentation are specific to the Tank schematics shown in Figures 1-9 and provided courtesy of Simtronics Corporation.

Water Supply System – The unit consists of three water holdup tanks in series. The water moves through the system by gravity. No pumps are required. The water supply system is isolated from the tank system with a block valve (HV-101). The water to the first tank is modulated by a control valve (V-101) with linear flow characteristics. The water drains from the first tank through a control valve (V-102) with linear flow characteristics. The water drains from the second tank through a control valve (V-103) with linear flow characteristics. The water drains from the third tank through a control valve (V-104) with linear flow characteristics.

Holdup Tanks – Each of the three holdup tanks are open topped cylindrical drums approximately 2 feet in diameter by 7 feet in height. Each tank has a total capacity of 22 ft^3 or 167 gallons of fluid. At design conditions each tank provides approximately 1.5 minutes of holdup running half full.

All the lines (valves and piping) are sized to provide a maximum flow capacity of approximately 100 GPM of water.

Basic Controls – The water supply system is isolated from the tank system with block valve HV-101. Each pipe in the system is outfitted with a flow controller that is calibrated to measure gallons per minute of water. The flow controllers are FIC-101, FIC-102, FIC-103, and FIC-104 respectively. The tank levels are maintained by level controllers LIC-101, LIC-102, and LIC-103 respectively.

Advanced Controls – The tank levels may be maintained manually by modulating the flow controllers' (FIC-102, FIC-103, and FIC-104) setpoints, or the tank level controllers (LIC-101, LIC-102, and LIC-103) may be cascaded to the flow controllers (FIC-102, FIC-103, and FIC-104) in a master-slave arrangement. In this manner, tank levels may be specified, with no further adjustments required by the operator.

Normal Operating Conditions

The schematic for normal operating conditions is shown in Figure 1.

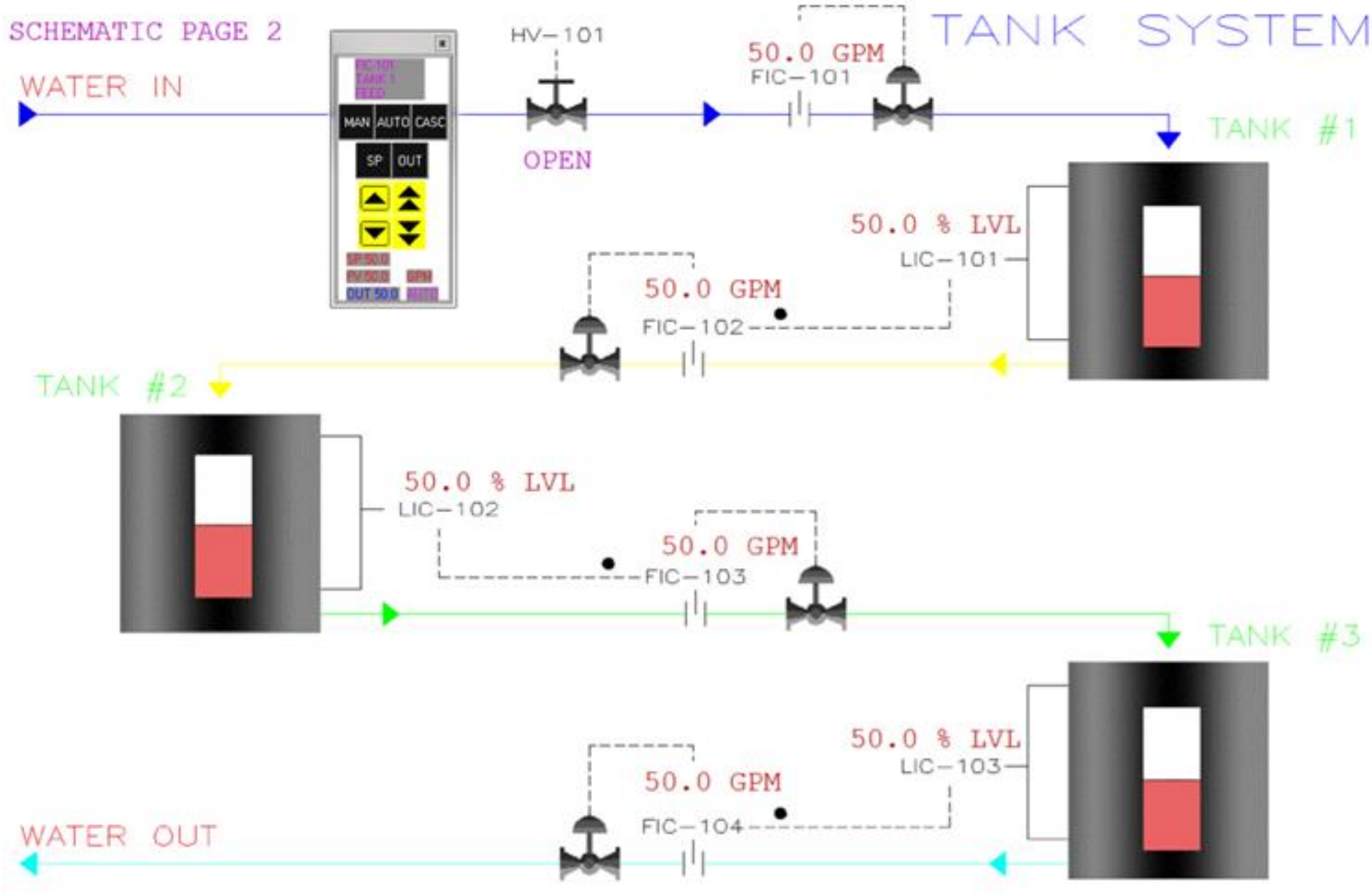

Figure 1. Process Schematic

Courtesy of Simtronics Corporation

Table 1. Normal Operating Conditions

Tag ID	Description	Normal Design Value	Normal Output Percent
FIC-101	TANK 1 FEED	50 GPM	50%
FIC-102	TANK 2 FEED	50 GPM	50%
FIC-103	TANK 3 FEED	50 GPM	50%
FIC-104	TANK 3 FLOW OUT	50 GPM	50%
HV-101	FEED BLOCK VALVE	Open	100%
LIC-101	TANK 1 LEVEL	50%	50%
LIC-102	TANK 2 LEVEL	50%	50%
LIC-103	TANK 3 LEVEL	50%	50%

PROCESS/PRODUCT FLOW TROUBLESHOOTING MODULE
SELF-CHECK QUESTIONS

1. List five applications for piping within the process industries.
    - ***Transport water/wastewater into plant for treatment***
    - ***Transport fuel oil to heating units***
    - ***Transport steam to steam services***
    - ***Transport lubricants to machinery***
    - ***Transport compressed air to pneumatic service outlets***
    - ***Transport chemicals to unit processes***
2. List five common problems associated with piping.
    - ***Leaks***
    - ***Erosion-corrosion***
    - ***Vibration***
    - ***Pluggage***
    - ***Extreme Temperatures and Pressures***
3. List five short-term or long-term impacts of pipe leaks.
    - ***Slipping hazard***
    - ***Burns, acute or chronic illnesses, or death***
    - ***Damage or loss of equipment***
    - ***Fire or explosion***
    - ***Reduced product quality***
    - ***Loss of production***
    - ***Imposed regulatory fines***
4. Explain how the following conditions contribute to erosion-corrosion.

    A <u>high-fluid velocity</u> could lead to a swirling action of the fluid at the point of a restriction (elbow, valve, etc.) causing erosion, vibration, etc.

    A <u>low-fluid pH</u> indicates an acidic solution that could cause or accelerate corrosion of the piping and equipment, depending on the material of construction.
5. List three potential causes of pipe pluggage.
    - ***Change in process composition that increases viscosity and/or creates solids or particulates***
    - ***Increase in velocity or vibration that damages and subsequently breaks loose some material associated with an in-line component***
    - ***Presence of foreign body***
    - ***Design errors***
6. Identify an engineering design strategy for piping that minimizes:

    <u>Thermal Expansion</u>: Expansion loops

***<u>Freezing</u>*: Jacketing and Insulation**

7. If HV-101 in Figure 1 closes, what happens to FIC-101?
    a. Increases
    b. Decreases
    c. Remains the same
8. If the water in decreases in Figure 1, what happens to FIC-101 output?
    a. Increases
    b. Decreases
    c. Remains the same
9. If FIC-101 in Figure 1 increases, what happens to FIC-102?
    a. Increases
    b. Decreases
    c. Remains the same
10. If LIC-101 in Figure 1 is running in automatic and the level increases, what happens to FIC-102?
    a. Increases
    b. Decreases
    c. Remains the same
11. If FIC-102 is in manual and FIC-101 increases in Figure 1, what happens to LIC-101?
    a. Increases
    b. Decreases
    c. Remains the same
12. If LIC-102 increases in Figure 1, what happens to the output of FIC-103?
    a. Increases
    b. Decreases
    c. Remains the same
13. If the output of FIC-103 increases, what happens to LIC-103 in Figure 1?
    a. Increases
    b. Decreases
    c. Remains the same

Process/Product Flow Troubleshooting Module
Scenario #1 Description (Paper or Simulator-based)

Scenario Statement

The flow into Tank 1 has decreased gradually to 0 (zero) GPM. HV-101 indicates it is open, while FIC-101 output indicates 100%. All downstream flows and levels are decreasing.

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

Causes

Plugged line

Plugged or broken hand valve

Plugged or broken flow control valve (FCV-101)

Leak in line

Loss of supply water

Investigative Actions

Check HV-101 position.

Open and close FCV-101.

Check water supply.

Put FIC-101 in Manual and raise and lower output.

Check water line for plugs and/or leaks.

Compensating Actions

Hook up alternative water supply.

Bypass FCV-101.

Bypass plugged section.

Corrective Actions

Unplug line.

Open HV-101 fully.

Replace HV-101.

Restart water supply.

Repair leak.

Abnormal Operating Conditions

The schematics during abnormal operating conditions for Scenario #1 are shown in Figure 2, Figure 3, and Figure 4.

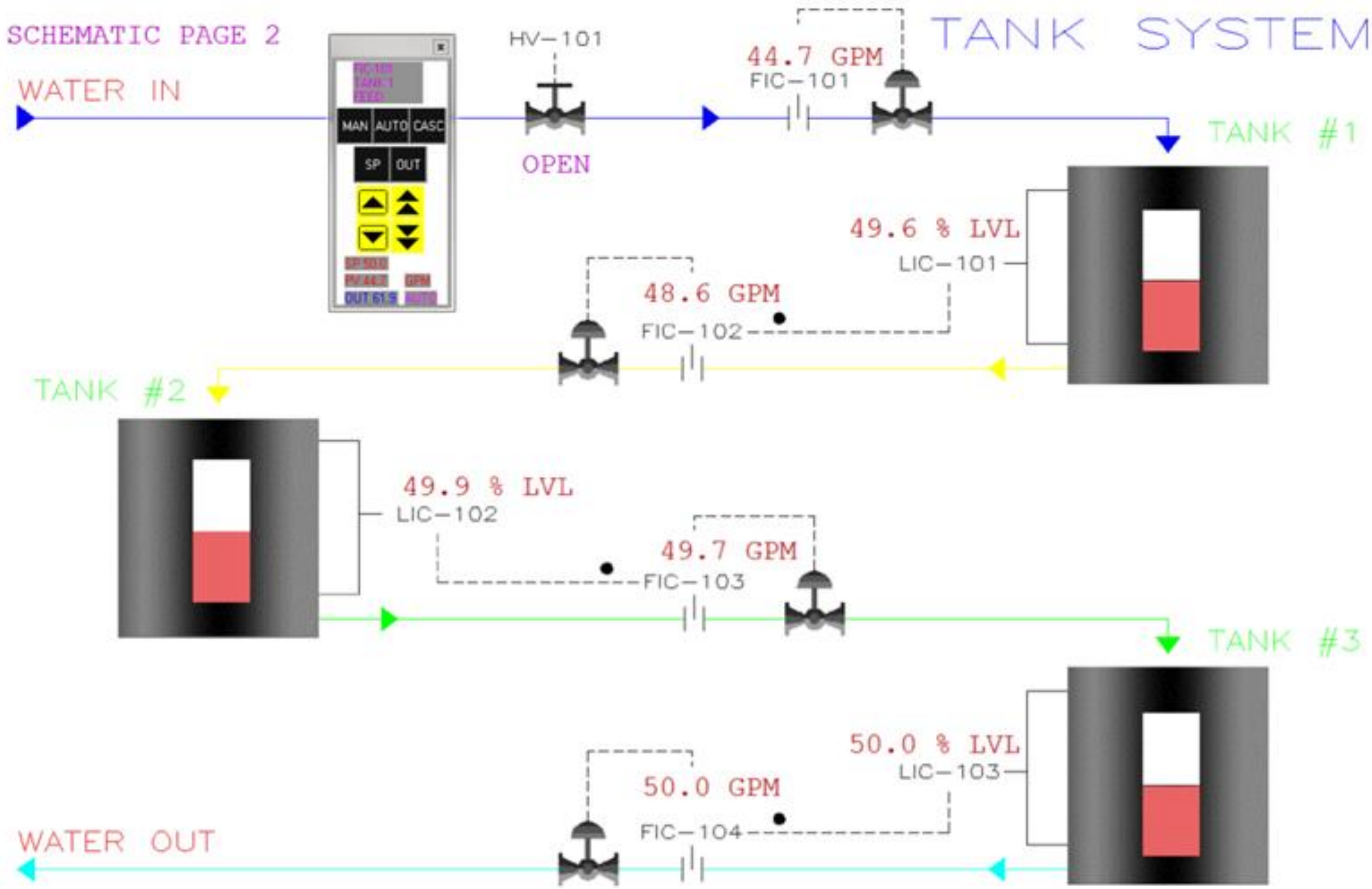

Figure 2. Schematic During Abnormal Operating Conditions for Scenario #1 (1 Minute, 16 Seconds)

Courtesy of Simtronics Corporation

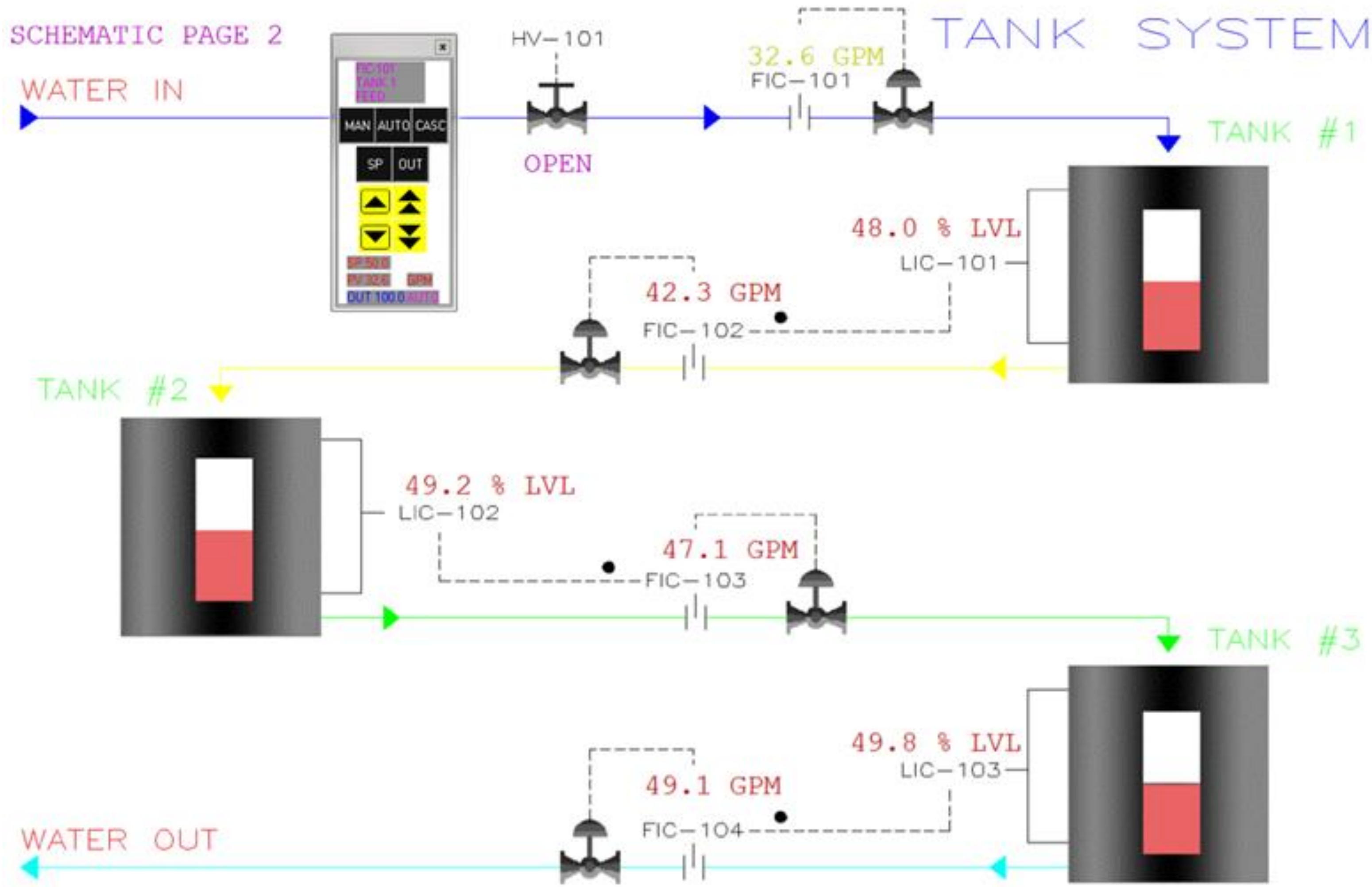

Figure 3. Schematic During Abnormal Operating Conditions for Scenario #1 (1 Minute, 40 Seconds)

Courtesy of Simtronics Corporation

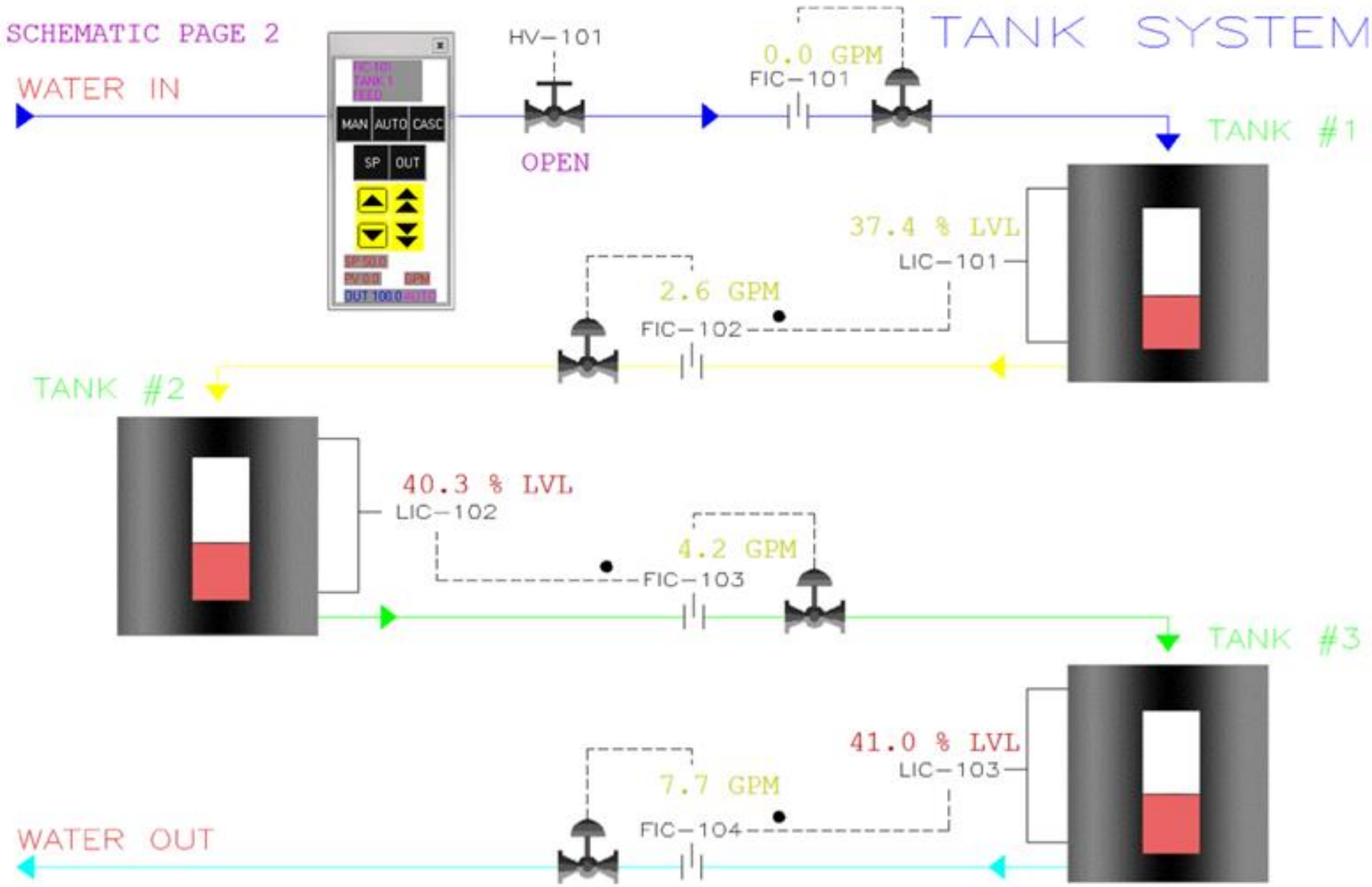

Figure 4. Schematic During Abnormal Operating Conditions for Scenario #1 (3 Minutes, 22 Seconds)

Courtesy of Simtronics Corporation

Complete the following table to compare normal design values and output percentages to abnormal conditions for Scenario #1 as shown on Figures 1-4.

Table 2. Comparison of Values and Output Percentages for Normal and Abnormal Operating Conditions for Scenario #1

Tag ID	**Description**	**Normal Design Value**	**Normal Output Percent**	**Abnormal Value – Figure 2 at 1 Min, 16 Sec**	**Abnormal Output Percent – Figure 2 at 1 Min, 16 Sec**	**Abnormal Value – Figure 3 at 1 Min, 40 Sec**	**Abnormal Output Percent – Figure 3 at 1 Min, 40 Sec**	**Abnormal Value – Figure 4 at 3 Min, 22 Sec**	**Abnormal Output Percent – Figure 4 at 3 Min, 22 Sec**
FIC-101	TANK 1 FEED	*50 GPM*	*50%*	*44.7 GPM*	*61.9%*	*33.1 GPM*	*98.7%*	*0 GPM*	*100%*
FIC-102	TANK 2 FEED	*50 GPM*	*50%*	*48.6 GPM*	*48.7%*	*42.5 GPM*	*43.8%*	*2.6 GPM*	*3.4%*
FIC-103	TANK 3 FEED	*50 GPM*	*50%*	*49.7 GPM*	*49.7%*	*47.1 GPM*	*47.7%*	*4.3 GPM*	*5.2%*
FIC-104	TANK 3 FLOW OUT	*50 GPM*	*50%*	*50 GPM*	*50%*	*49.1 GPM*	*49.2%*	*8.0 GPM*	*9.3%*
HV-101	FEED BLOCK VALVE	*Open*	*100%*	*Open*	*Same*	*Open*	*Same*	*Open*	*Same*
LIC-101	TANK 1 LEVEL	*50%*	*50%*	*49.6%*	*47.9%*	*48.1%*	*40.3%*	*37.5%*	*0%*
LIC-102	TANK 2 LEVEL	*50%*	*50%*	*49.9%*	*49.6%*	*49.3%*	*46.2%*	*40%*	*0%*
LIC-103	TANK 3 LEVEL	*50%*	*50%*	*50%*	*49.9%*	*49.8%*	*48.8%*	*41%*	*1.4%*

TROUBLESHOOTING FORM

1. **Recognize (and write) the problem.**
*(What **is** happening that should not be or what **is not** happening that should be?)*

____

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

____

____

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. ____
why? because____
why? because____
why? because____

Y N b. ____
why? because____
why? because____
why? because____

Y N c. ____
why? because____
why? because____
why? because____

Y N d. ____
why? because____
why? because____
why? because____

Y N e. ____
why? because____
why? because____
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.

____

____

5. List **<u>possible</u> causes** of the problem.

Y N a. ______________________________

Y N b. ______________________________

Y N c. ______________________________

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.)*

____

***** Does this <u>cause</u> 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?

____

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

____

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

____

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

____

____

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.)*

____

____

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

Process/Product Flow Troubleshooting Module
Scenario #2 Description (Paper or Simulator-based)

Scenario Statement

The flow from Tank 2 to Tank 3 has decreased to 0 (zero) GPM. FIC-103 output indicates 100%. The level in Tank 2 has increased. All other flow and tank levels upstream are normal and steady-state. LIC-102 is normally in cascade mode.

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

Abnormal Operating Conditions

The schematic during abnormal operating conditions for Scenario #2 is shown in Figure 5.

Complete the following table to compare normal design values and output percentages to abnormal conditions for Scenario #2 as shown in Figure 1 and Figure 5.

Table 3. Comparison of Values and Output Percentages for Normal and Abnormal Operating Conditions for Scenario #2

Tag ID	Description	Normal Design Value	Normal Output Percent	Abnormal Value – Figure 5	Abnormal Output Percent – Figure 5
FIC-101	TANK 1 FEED	*50 GPM*	*50%*		
FIC-102	TANK 2 FEED	*50 GPM*	*50%*		
FIC-103	TANK 3 FEED	*50 GPM*	*50%*	*0 GPM*	*100%*
FIC-104	TANK 3 FLOW OUT	*50 GPM*	*50%*	*8.3 GPM*	*?*
HV-101	FEED BLOCK VALVE	*Open*	*100%*		
LIC-101	TANK 1 LEVEL	*50%*	*50%*		
LIC-102	TANK 2 LEVEL	*50%*	*50%*	*72%*	
LIC-103	TANK 3 LEVEL	*50%*	*50%*	*39.7%*	

Cause

Loss of instrument air supply to FY-103 positioner

Investigative Actions

Check FCV-103 valve position.

Call control room operator (CRO) and compare value of FIC-103 output signal to FCV-103 valve position.

Confirm level in LIC-102 is high.

Check FY-103 positioner.

Check FT-103 output signal.

Check process line for closed block valve.

Compensating Actions

Bypass FCV-103.

Bypass FY-103 positioner.

Ask CRO to take LIC-102 out of cascade mode, put FIC-103 in manual mode and open/close FCV-103.

Reduce or stop flow at FIC-101.

Corrective Action

Restore instrument air supply to FY-103.

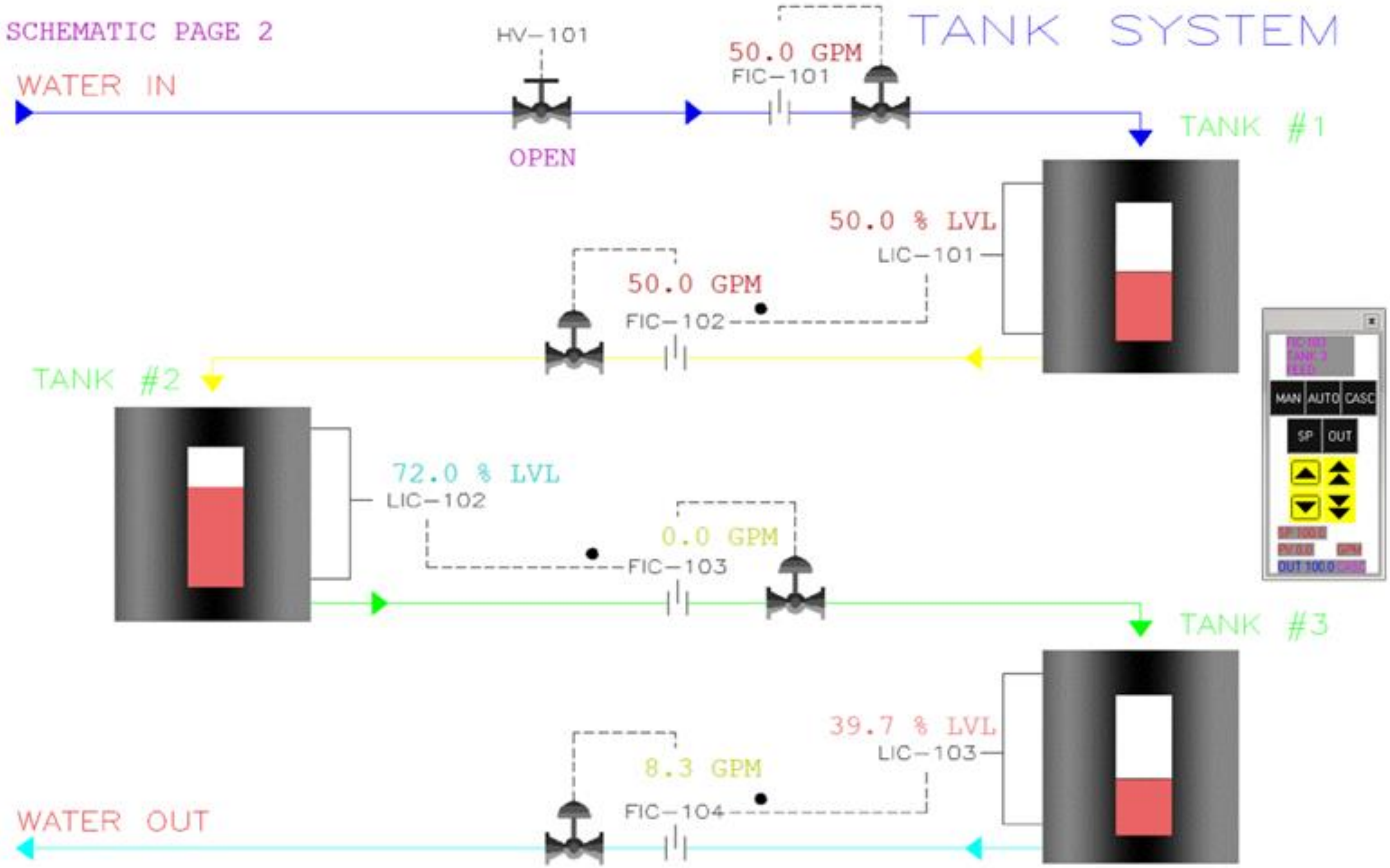

Figure 5. **Schematic During Abnormal Operating Conditions for Scenario #2**

Courtesy of Simtronics Corporation

TROUBLESHOOTING FORM

1. **Recognize (and write) the problem.**
*(What **is** happening that should not be or what **is not** happening that should be?)*

____

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

____

____

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. ______________________________
why? because______________________________
why? because______________________________
why? because______________________________

Y N b. ______________________________
why? because______________________________
why? because______________________________
why? because______________________________

Y N c. ______________________________
why? because______________________________
why? because______________________________
why? because______________________________

Y N d. ______________________________
why? because______________________________
why? because______________________________
why? because______________________________

Y N e. ______________________________
why? because______________________________
why? because______________________________
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.

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____

5. List <u>**possible**</u> **causes** of the problem.

Y N a. ______________________________

Y N b. ______________________________

Y N c. ______________________________

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.)*

____

***** Does this <u>cause</u> 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?

____

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

____

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

____

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

____

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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.)*

____

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

PROCESS/PRODUCT FLOW TROUBLESHOOTING MODULE
SCENARIO #3 DESCRIPTION (PAPER OR SIMULATOR-BASED)

Scenario Statement

The flow from Tank 3 decreases. Its level increases. FIC-104 output increases. The level in Tank 3 has increased slightly. All other flow and tank levels upstream are normal and steady-state. FIC-104 is normally in cascade mode.

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

Simulator Programming

The following table includes information needed for you to program the fault for a process simulation exercise.

Table 4. Fault Programming Information for Scenario #3

Description	Water Supply GPM	**Signal**	0.00	**Rise**	10:00
Status	Active	**Normal**	100.00	**Start**	00:01:00
Direction	Fail Low	**High**	100.00	**Stop**	00:00:00
Function	Ramp	**Low**	0.00	**Delay**	00:01:01

Abnormal Operating Conditions

The schematics during abnormal operating conditions for Scenario #3 are shown in Figure 6 and Figure 7.

Complete the following table to compare normal design values and output percentages to abnormal conditions for Scenario #3 as shown in Figure 1, Figure 6, and Figure 7.

Table 5. Comparison of Values and Output Percentages for Normal and Abnormal Operating Conditions for Scenario #3

Tag ID	**Description**	**Normal Design Value**	**Normal Output Percent**	**Abnormal Value –** Error! Reference source not found. **at 1 Min, 14 Sec**	**Abnormal Output % –** Error! Reference source not found. **at 1 Min, 14 Sec**	**Abnormal Value –** Error! Reference source not found. **at 1 Min, 55 Sec**	**Abnormal Output % –** Error! Reference source not found. **at 1 Min 55 Sec**
FIC-101	TANK 1 FEED	*50 GPM*	*50%*				
FIC-102	TANK 2 FEED	*50 GPM*	*50%*				
FIC-103	TANK 3 FEED	*50 GPM*	*50%*				
FIC-104	TANK 3 FLOW OUT	*50 GPM*	*50%*	*49.0 GPM*	*53.4%*	*48.7 GPM*	*69.8%*
HV-101	FEED BLOCK VALVE	*Open*	*100%*				
LIC-101	TANK 1 LEVEL	*50%*	*50%*				
LIC-102	TANK 2 LEVEL	*50%*	*50%*				
LIC-103	TANK 3 LEVEL	*50%*	*50%*	*50%*		*50.7%*	

Causes

Leak in the instrument air line to position FY-104

Incremental plugging of Tank 3 outlet line

Investigative Actions

Verify Tank 3 level is high.

Check FCV-104 valve position.

Call CRO and compare the value of FIC-104 output signal to FCV-104 valve position.

Check FY-104 positioner.

Check FT-104 output signal.

Check process line for closed block valve.

Compensating Actions

Bypass FCV-104.

Bypass FY-104 positioner.

Ask CRO to take LIC-103 out of cascade mode, put FIC-104 in manual mode and open/close FCV-104.

Corrective Actions

Repair or replace instrument air line to FY-104.

Backflush Tank 3 outlet line.

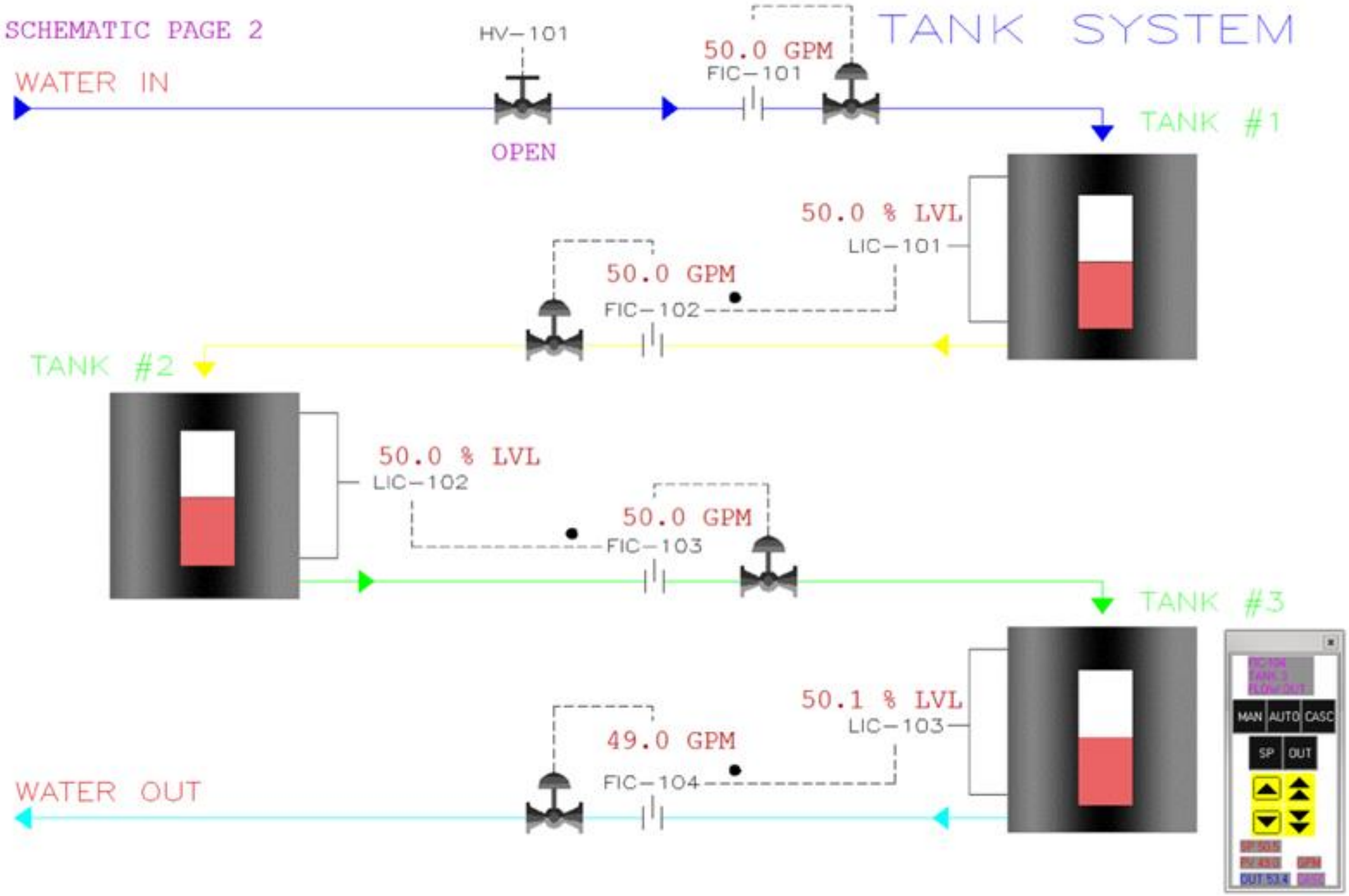

Figure 6. **Schematic During Abnormal Operating Conditions for Scenario #3 (1 Minute, 14 Seconds)**

Courtesy of Simtronics Corporation

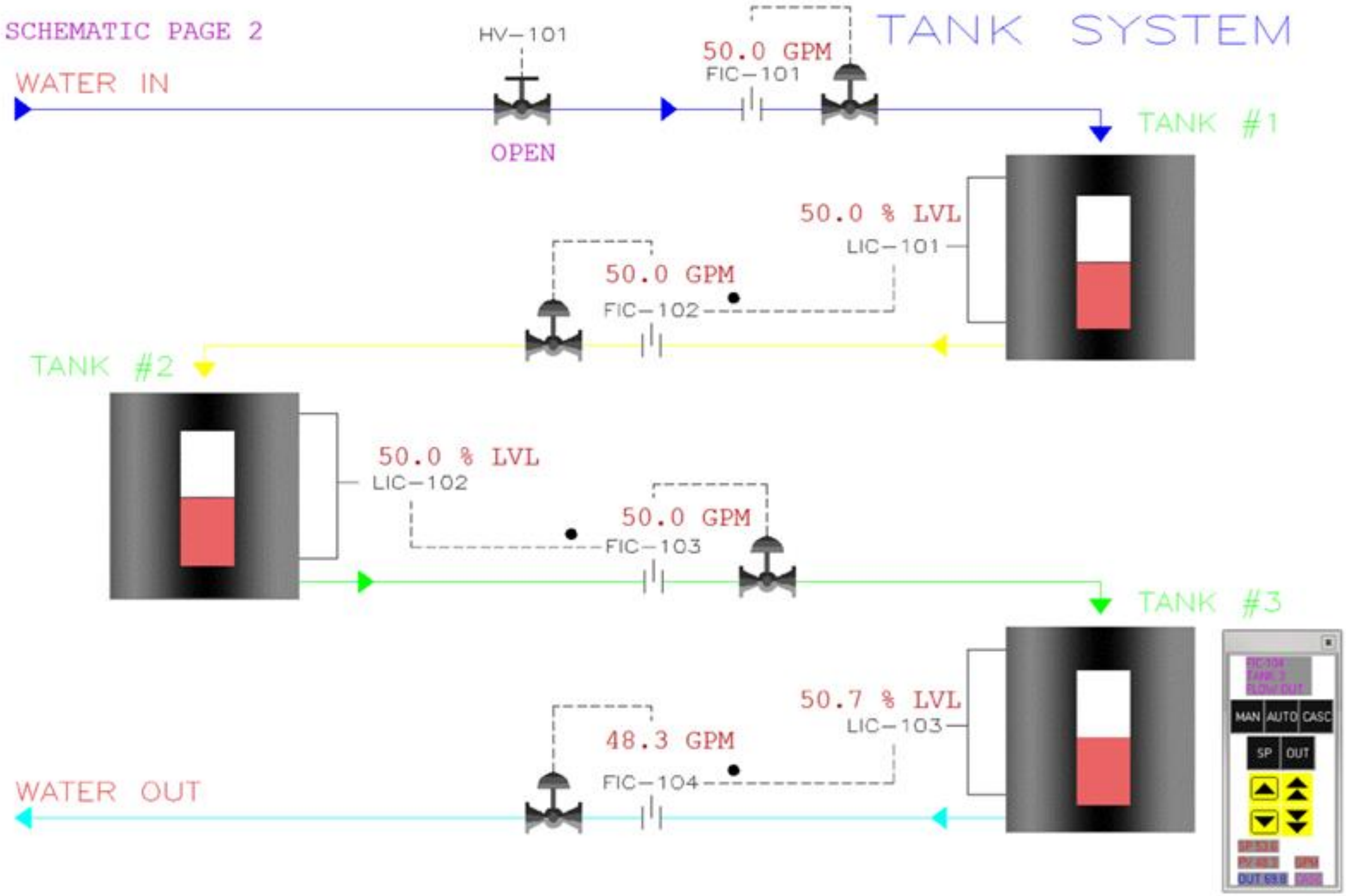

Figure 7. **Schematic During Abnormal Operating Conditions for Scenario #3 (1 Minute, 55 Seconds)**

Courtesy of Simtronics Corporation

TROUBLESHOOTING FORM

1. **Recognize (and write) the problem.**
*(What **is** happening that should not be or what **is not** happening that should be?)*

____

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

____

____

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. ____

why? because____

why? because____

why? because____

Y N b. ____

why? because____

why? because____

why? because____

Y N c. ____

why? because____

why? because____

why? because____

Y N d. ____

why? because____

why? because____

why? because____

Y N e. ____

why? because____

why? because____

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.

____

____

5. List **<u>possible</u> causes** of the problem.

Y N a. ______________________________

Y N b. ______________________________

Y N c. ______________________________

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.)*

____

***** Does this <u>cause</u> 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?

____

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

____

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

____

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

____

____

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.)*

____

____

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

PROCESS/PRODUCT FLOW TROUBLESHOOTING MODULE
SCENARIO #4 DESCRIPTION (PAPER OR SIMULATOR-BASED)

Scenario Statement

The flow from Tank 1 is cycling with corresponding cycling of the Tank 1 level. Flow into Tank 1 is steady-state and normal. Flows and levels downstream of Tank 1 are cycling.

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

Abnormal Operating Conditions

The schematic during abnormal operating conditions for Scenario #4 is shown in Figure 8 and Figure 9.

Complete the following table to compare normal design values and output percentages to abnormal conditions for Scenario #4 as shown in Figure 1, Figure 8, and Figure 9.

Table 6. Comparison of Values and Output Percentages for Normal and Abnormal Operating Conditions for Scenario #4

Tag ID	Description	Normal Design Value	Normal Output Percent	Abnormal Value – Figure 8 at 27 Sec	Abnormal Output Percent – Figure 8 at 27 Sec	Abnormal Value – Figure 9 at 43 Sec	Abnormal Output Percent – Figure 9 at 43 Sec
FIC-101	TANK 1 FEED	*50 GPM*	*50%*				
FIC-102	TANK 2 FEED	*50 GPM*	*50%*	*38.1 GPM*	*67.5%*	*59 GPM*	*47.7%*
FIC-103	TANK 3 FEED	*50 GPM*	*50%*	*48.9 GPM*		*48.4 GPM*	
FIC-104	TANK 3 FLOW OUT	*50 GPM*	*50%*	*50.5 GPM*		*49 GPM*	
HV-101	FEED BLOCK VALVE	*Open*	*100%*				
LIC-101	TANK 1 LEVEL	*50%*	*50%*	*50.2%*		*50.5%*	
LIC-102	TANK 2 LEVEL	*50%*	*50%*	*49.6%*		*49.7%*	
LIC-103	TANK 3 LEVEL	*50%*	*50%*	*50.1%*		*49.7%*	

Causes

FIC-102 has incorrect tuning parameters.

FCV-102 is sticking.

Investigative Actions

Check the FCV-102 to see if it is cycling.

Check the instrument air supply to ensure it is normal and steady.

Compare the level in Tank 1 to what the CRO is seeing in the Control Room.

Check FIC-102 output signal to see if it is cycling.

Compensating Actions

Put FIC-102 in Manual Mode and check for stabilization.

Bypass FCV-102.

Corrective Action

Contact instrument technician to investigate.

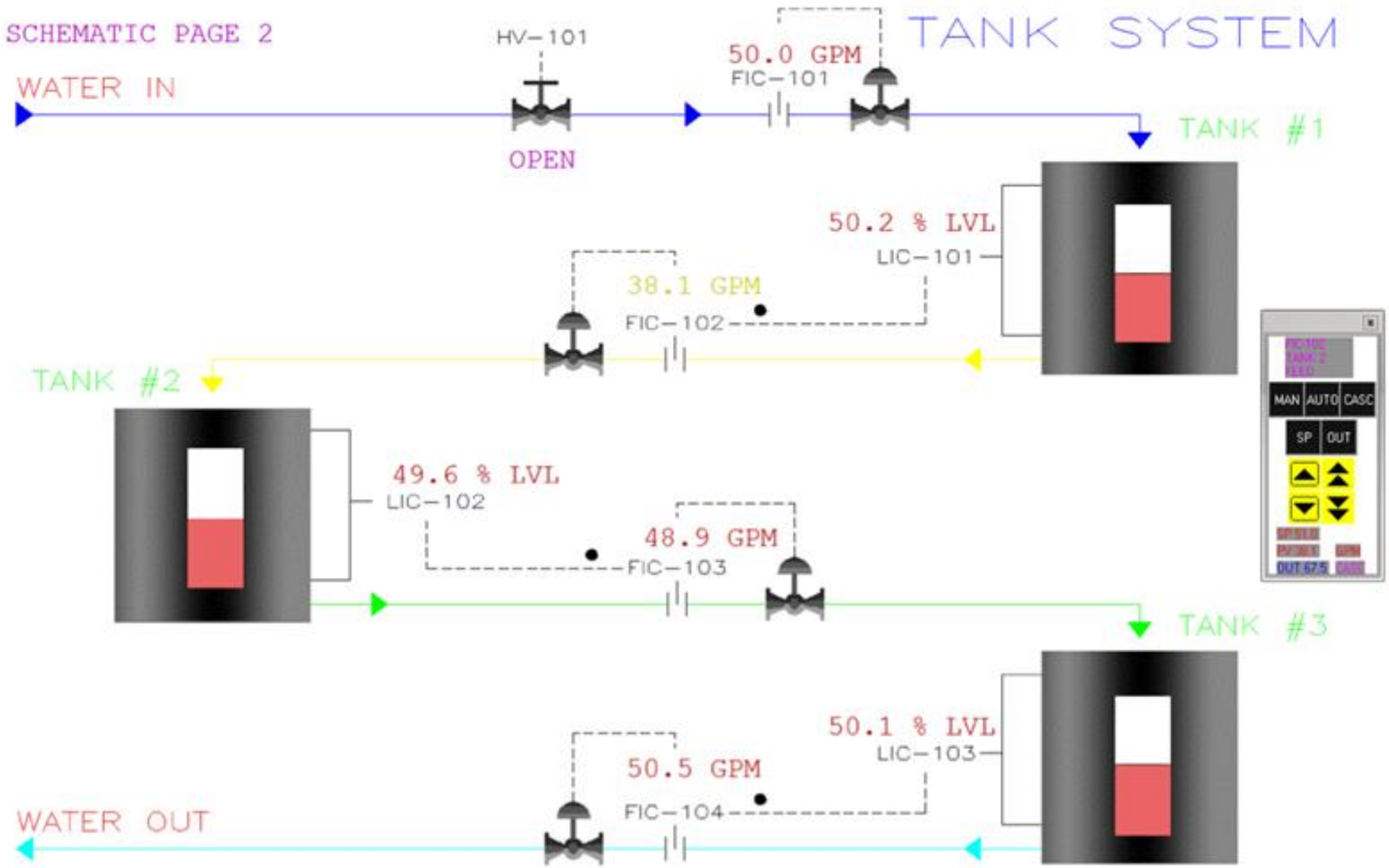

Figure 8. **Schematic During Abnormal Operating Conditions for Scenario #4 at 27 Seconds**

Courtesy of Simtronics Corporation

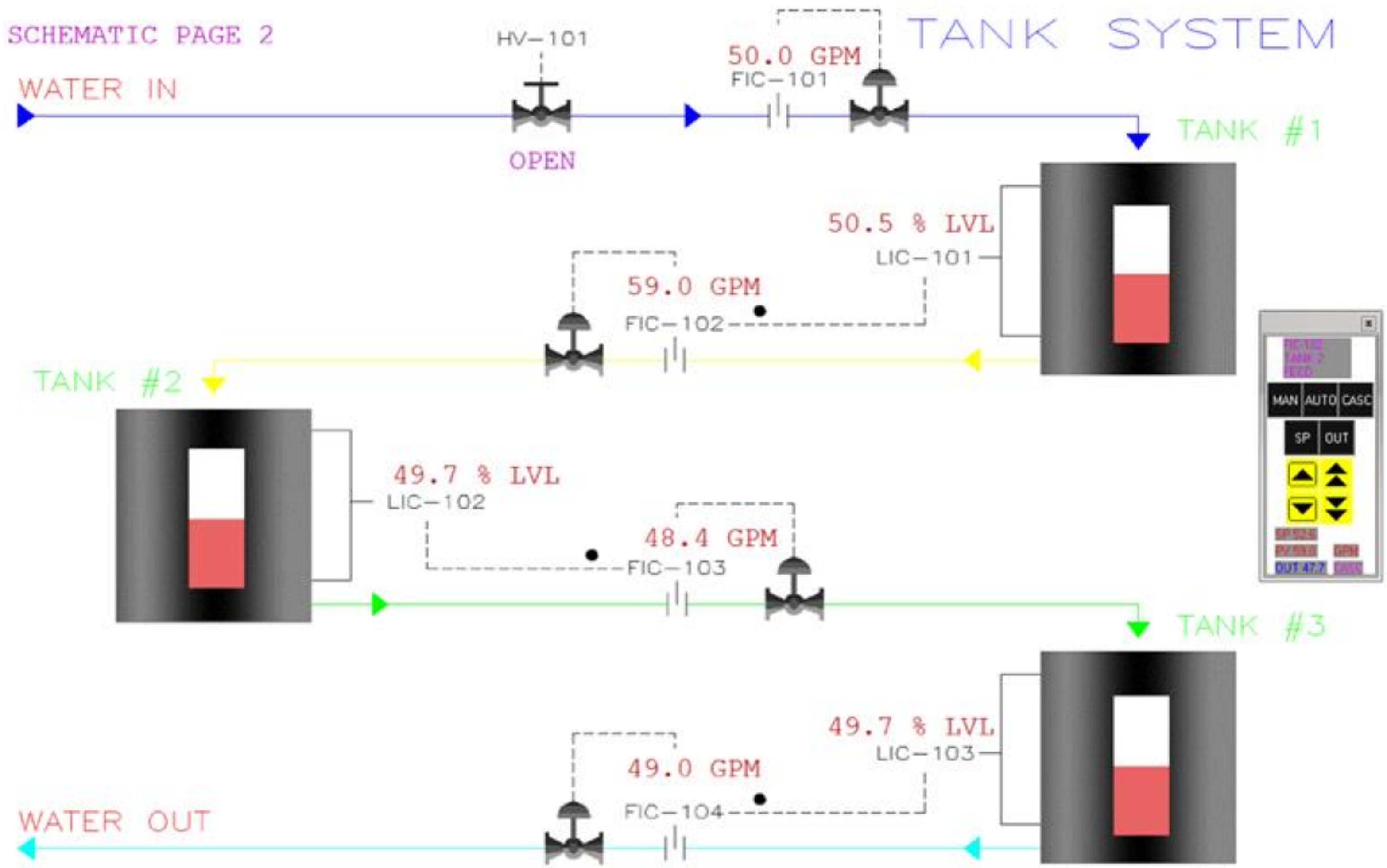

Figure 9. Schematic During Abnormal Operating Conditions for Scenario #4 at 43 Seconds

Courtesy of Simtronics Corporation

TROUBLESHOOTING FORM

1. **Recognize (and write) the problem.**
*(What **is** happening that should not be or what **is not** happening that should be?)*

____

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

____

____

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. ____
why? because______________________________________
why? because______________________________________
why? because______________________________________

Y N b. ____
why? because______________________________________
why? because______________________________________
why? because______________________________________

Y N c. ____
why? because______________________________________
why? because______________________________________
why? because______________________________________

Y N d. ____
why? because______________________________________
why? because______________________________________
why? because______________________________________

Y N e. ____
why? because______________________________________
why? because______________________________________
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.

____

____

5. List **<u>possible</u> causes** of the problem.

Y N a. ____________________

Y N b. ____________________

Y N c. ____________________

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.)*

____

***** Does this <u>cause</u> 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?

____

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

____

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

____

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

____

____

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.)*

____

____

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

Performance Assessment Activity #1
Paper-based Problem

Learner Directions: In this assessment, you will analyze and solve a paper-based process/product flow 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 process/product flow.

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 and/or the system.
- 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 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 investigative, compensating, 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: To be determined by the instructor. Example: Satisfactory performance requires learner must meet all criteria on the checklist.

Process/Product Flow Troubleshooting Rubric
Paper-based Problem

Competency: Troubleshoot problems with process/product flow.

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 and/or the system.	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 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 process/product flow problem. Your instructor will provide you with the problem scenario and supporting materials. Complete and submit all documentation requested including a Troubleshooting form to your instructor.

Competency: Troubleshoot problems with process/product flow.

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 and/or the system.
- 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 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 investigative, compensating, 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: To be determined by the instructor. 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.”

PROCESS/PRODUCT FLOW TROUBLESHOOTING RUBRIC
SIMULATOR-BASED PROBLEM

Competency: Troubleshoot problems with process/product flow.

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 and/or the system.	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 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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