PUMP TROUBLESHOOTING MODULE (PART 2)
INSTRUCTOR LESSON PLAN

Overview

Integral to industrial processes, pumps are mechanical devices that move a fluid from one location to another without changing the fluid's temperature while increasing its pressure. Pumps are used in a variety of applications within the process industries including providing circulation for a system; filling or emptying tanks; lubricating equipment; transferring products inter-facility; introducing feed, additives and reactants to a system; drawing samples; and providing cooling and fire water. Because of their criticality within the process and expense, the process technician must have a basic understanding of troubleshooting techniques to recognize and prevent damage to a pump during abnormal conditions.

<table>
<tr><th>Competency</th><th>Performance Standards</th></tr>
<tr><td rowspan="2">Troubleshoot over-heating and over-pressurization problems associated with a pump</td><td>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).</td></tr>
<tr><td>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.</td></tr>
</table>

Funded by NSF ATE Grant # 1457711

Learning Objectives

1. Recall the purpose, applications, and types of pumps.
2. Recall and discuss over-heating and over-pressurization problems associated with pumps.
3. Describe immediate actions a process technician could take to solve a pump over-heating and over-pressurization problem.
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 actions.

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 and types of pumps and over-heating and over-pressurization problems associated with pumps (if provided).	Deliver a brief presentation on pumps and associated problems.		Lecture Equipment	Address first two learning objectives.
	REVIEW the process background, equipment specifications, normal operating conditions and normal design conditions sections.	Choose a specific problem/s for learners to solve. Lead discussion of process to assure learners understand all aspects.	Process Description		
	COMPLETE Self-Check Questions worksheet.	Introduce activity Review worksheet with learners after completion.	Self-Check Questions worksheet		Reinforce learning objectives 1, 2 and 4.
	BRAINSTORM immediate actions a process technician could take to solve a pump over-heating and over-pressurization problem 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 pump over-heating and over-pressurization to another group's work.	Write all actions on board or flipchart.			

Time Frame	Learning Activity	Teaching Activity	Instructional Materials	Supplies and Equipment	Notes
	LISTEN to instructor expand on actions a process technician could take to solve pump over-heating and over-pressurization problem.	Lecture on actions not captured and elucidate on those listed.		Lecture Equipment	Address the third learning objective.
	SOLVE at least one paper-based problem associated with pump over-heating and over-pressurization including the completion of a 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. Three problems (w/o corresponding information) are listed in this lesson plan. Address learning objective 5.
	OBSERVE a normal and/or abnormal condition on the simulator associated with a pump (if simulator is available).	Set up simulation Guide learners as needed during the activity.		Simulator	
	SOLVE at least one simulator-based problem associated with pump over-heating and over-pressurization including the completion of a Troubleshooting Form (if simulator is available).	Choose a specific problem/s for learners to solve. Guide learners as needed during the activity. Do a quick de-brief after activity.	Troubleshooting Form	Simulator	Information to program the fault for one simulation problems is provided in this lesson plan. Address learning objective 5.

PUMP TROUBLESHOOTING MODULE (PART 2)
PROCESS DESCRIPTION

Introduction

Integral to industrial processes, pumps are mechanical devices that move a fluid from one location to another without changing the fluid's temperature while increasing its pressure. Process stream fluids pumped can be single or multi-component liquids or multi-phase, multi-component slurries.

Pumps are used in a variety of applications within the process industries including providing circulation for a system; filling or emptying tanks; lubricating equipment; transferring products inter-facility; introducing feed, additives and reactants to a system; drawing samples and providing cooling and fire water.

Pumping devices are typically divided into two major categories: dynamic pumps and positive displacement pumps.

Dynamic pumps include centrifugal and axial flow designs. Dynamic pumps experience varying degrees of internal recycle or “slippage” of fluid from the impeller blade or its tip (higher pressure area) back to the impeller eye (lowest pressure area). Internal recycle increases: (a) when discharge flows are throttled or stopped, (b) when ‘prime’ or suction flow is lost, (c) with open-faced versus semi- or fully enclosed impellers, (d) when significant clearance exists between the impeller tip and the pump casing, and (e) when pump cavitation is occurring.

Uncorrected over time, extreme internal recycle can lead to serious overheating of the fluid within the pump system. Subsequently, high pressures are generated from thermal expansion and/or vaporization of the liquid.

Positive displacement pumps include reciprocating and rotary designs. As the name implies, whatever is drawn into the suction of the pump must be discharged, otherwise the pressure will rise abnormally high. For that reason, one should never close or throttle the discharge side of an operating positive displacement pump. While most positive displacement pumps are equipped with either internal or external pressure relief devices, there is a chance that a relief may malfunction. Internal or external recycle from the pressure relief devices goes directly back into the pump suction and yields the same recycled fluid overheating as with dynamic pumps.

Although pumps convert mechanical energy into useful pressure and flow energies, pumps are not totally efficient in this conversion. Some of the input mechanical energy is constantly converted to heat, vibration, and sound energies, reducing the efficiency of the pump.

Pump manufacturers issue pump curves and other information that detail the specific efficiencies of their pumps at various operating conditions. Pumps are generally selected to yield the highest possible efficiency at the normal process operating conditions. Heat energy is generated from the mechanical energy input due to friction and other factors. The heat energy generated is typically removed from the pump system by the fluid being discharged by the pump.

If the forward flow is substantially reduced or stopped and the pump continues to run and recycle fluid internally, heat will buildup in the recycled fluid. For example, O'Connor (2006) observed that the heat buildup with blocked discharge flow can be fairly rapid (80-100°F increase in 30 minutes).

In O'Connor's tests, catastrophic equipment failure happened in approximately 3 hours. This was a result of the substantial pressure increase caused by the volumetric thermal expansion and/or vaporization of the trapped recycle fluid. For trapped water being converted to steam, the pressure will be 1,000 PSI at 545°F and it increases to 2,000 PSI at 635°F (O'Connor, 2006).

Table 1. First Example of the Relationship Between Temperature and Pressure for Trapped Water Within a Pump

Temperature	Pressure
545°F	1,000 PSI
635°F	2,000 PSI

In another example, if water is trapped (e.g., in a pump casing), a 150°F temperature increase (possibly less than two minutes run time) could result in a 5,000 PSI pressure increase and a 300°F increase could result in a 10,000 PSI increase (Tecumseh Group, 2007).

Table 2. Second Example of the Relationship Between Temperature and Pressure for Trapped Water Within a Pump

Temperature	Pressure
150°F increase	5,000 PSI increase
300°F increase	10,000 PSI increase

Flow interruption can occur abruptly, especially when pumping slurries and sludges due to solids dropping out. Fermentation, pulp and paper, resin, pharmaceutical, and food processing plants typically require movement of such streams. The accumulation of dropped-out solids can plug suction, recycle and discharge lines and instrument taps and block and bleeds.

Other conditions that may reduce or stop forward flow from pumps include:

- Purposely or accidentally closing suction, discharge or recycle valving
- Malfunctioning suction, discharge or recycle valving including reliefs and checks
- Fouled or plugged suction, discharge or recycle piping
- Plugged suction or discharge filters or screens
- Other loss of suction feed flow, e.g. low feed tank level
- Failure of internal valve reeds or internal poppets in positive displacement pumps
- Pump cavitation with either dynamic or positive displacement pumps.

It should be noted that bearing and seal failures, inadequate seal flush and/or cooling liquid flow, over-tightened packing glands, and misaligned couplings will result in additional mechanical energy conversion to heat, sound and vibration energies.

If left unchecked, pressure from thermal liquid expansion alone can build to levels which can result in catastrophic equipment failure, environmental releases, and injuries to or death of personnel. Where combustible or thermally decomposable materials are being pumped, serious fires and/or detonations may also occur**.** See illustrative slides by (O'Connor, 2006).

Process Background

Pumps 401A and 401B are capable of pumping high and low viscosity fluids (i.e., liquids and slurries). Process flow is cleaned upstream of the suction of PUMP-401A by Strainer-101. Pressure differential on the strainer is indicated by PDI-101. Fluid leaves the pump through a common header and exits through a flow control loop (FIC-103) on the discharge line. Pump discharge pressure is controlled by PIC-102, by bypassing liquid back to the suction side of the pump. Discharge bypass temperature is indicated by TI-41. Discharge pump temperature is indicated downstream of FIC-103 by TI-42.

The schematic for the process is shown in Figure 1.

Equipment Specifications

Strainer – The strainer removes solids and particulates from the process flow upstream of the pump suction.

Valves – The unit contains both manual/isolation and control valves, which are used in the control systems of the pump.

Pumps – Both pumps within the unit are horizontally-mounted centrifugal pumps. PUMP-401B is the auxiliary pump.

Instrumentation – Pump operation and safety is controlled on the discharge side of the pumps. Local temperature indicators are located on the recycle and discharge lines of the pumps.

Normal Design Conditions

The following table provides design values and output percentages for instrumentation and equipment associated with the specified process during normal operating conditions.

Table 3. Design Values and Output Percentages for Instrumentation and Equipment at Normal Operating Conditions in Figure 1

Tag ID	Description	Control	Design Value	Eng Units	Output Percent
FIC-103	DISCHARGE FLOW CONTROLLER	Auto	200	GPM	50.0%
PDI-101	STRAINER DIFF PRESSURE		4	PSIG	
PIC-102	RECYCLE/DISCHARGE PRESSURE	Auto	170	PSIG	NORMALLY CLOSED (0.0%)
PUMP-401A	CENTRIFUGAL PUMP		ON		
PUMP-401B	CENTRIFUGAL PUMP		OFF		
F-101	SUCTION STRAINER		IN SERVICE		
PI-45	INLET PUMP SUCTION PRESSURE		45	PSIG	
TI-41	RECYCLE TEMPERATURE		185	°F	
TI-42	DISCHARGE TEMPERATURE		185	°F	

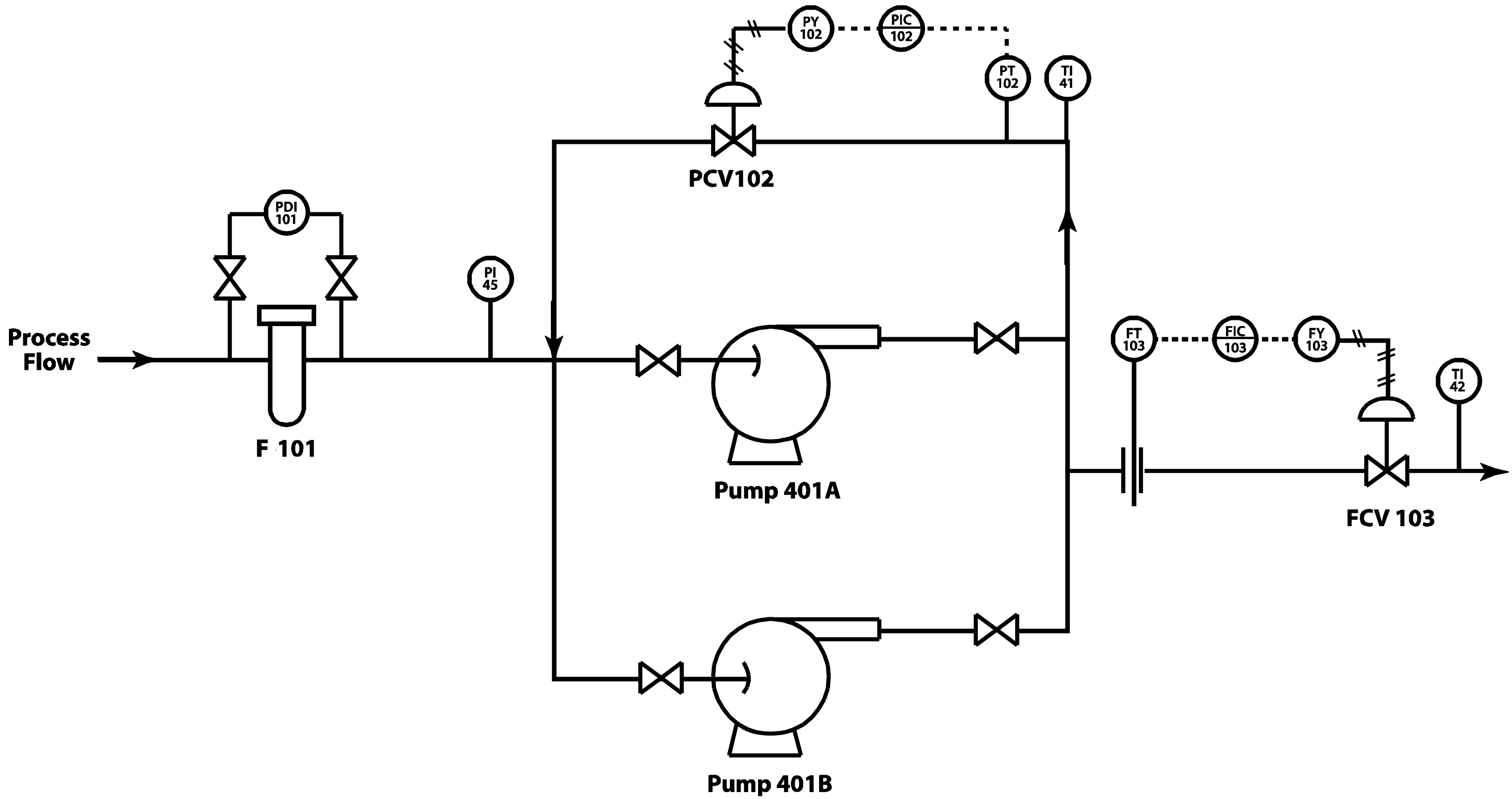

Figure 1. Process Schematic

Problem Detection and Actions

To avoid pump over-heating and over-pressurization situations requires a high level of observation and vigilance by the process technician. The process technician must routinely confirm that process line-ups are correct and that all system components are functioning properly in both process and auxiliary pumping systems.

The process technician must routinely apply his experience and visual, auditory, feeling, and olfactory senses as rounds are made. In addition to information from installed instrumentation, the process technician may need to also employ devices such as handheld digital infrared temperature, vibration, RPM, and amperage monitors and thermo-graphic cameras to assist in detecting and troubleshooting abnormal equipment and process operating conditions.

In critical operations, pump system fluid reliefs and driver interlocks should be provided to manage the possibility of pump over-heating/over-pressurization and the resulting catastrophic equipment failures or detonations. These measures include high temperature/high pressure shutdown of the driver, suction standpipes, and rupture discs or relief valves. Such devices are especially important when pumping slurries/sludges or flammable/detonable substances.

Immediate actions that a process technician could take to solve pump over-heating/over-pressurization include:

Check for and correct pump suction, recycle and discharge restrictions

- *Are valves including automatics, checks, pressure regulator and reliefs lined-up properly and functioning normally?*
- *Is there a plugged strainer or filter?*
- *Is there plugged, fouled or damaged piping?*
- *Is production purposely reduced?*

Check for excessive recycle flow

- *Is the recycle through a misaligned spare pump?*
- *Is the auto recycle valve functioning properly?*
- *What is the manual recycle bypass position?*
- *Are internal positive displacement poppets and valves functioning properly?*

Overcome or remove suction liquid restrictions; increase flow

— *Increase level in suction tank if tank exists*
— *Increase gas space pressure on enclosed suction tank if present*
— *Increase upstream pressure of feed to pump if no pump tank*
— *Reduce suction tank agitator speed if so equipped*
— *Unplug or de-scale suction line*

Remove excess heat; reduce heat generation

— *Reduce upstream temperature of feed to pump if possible*
— *Temporarily rig process water hose over pump housing if permissible*
— *Check flush/cooling water flow to bearings and seals*

PUMP TROUBLESHOOTING MODULE (PART 2)
SELF-CHECK QUESTIONS

1. List five observations that pump over-heating/over-pressurization may be occurring.
    a. *Unusual* pump noise
    b. *Unusual pump vibration*
    c. *Unusual odors such as burning paint or oil*
    d. *Pump casing, bearings or seals, and related piping are hotter than normal*
    e. *Discharge pressure and flow erratic and/or lower than normal*

2. What are possible detrimental impacts of pump over-heating/over-pressurization?
    a. *Blown gaskets or seals with environmental impact and danger to personnel*
    b. *Catastrophic failure of equipment*
    c. *Fire, explosion or detonation*
    d. *Injury to or death of personnel*
    e. *Deteriorated product quality and lost production*

3. What are immediate actions a process technician may take to solve pump over-heating/over-pressurization?

    See section above.

4. What longer-term maintenance and engineering design actions could control pump over-heating and over-pressurization?
    a. *Install re-engineered pump generating or requiring less recycle*
    b. *Increase pump suction line size, change valve types or remove other restrictions (cavitation effect)*
    c. *Install vortex breaker in suction feed tank bottom (cavitation effect)*
    d. *Install new pump with less NPSH requirement (cavitation effect)*
    e. *Increase relative suction line elevation or lower relative pump elevation (cavitation effect)*
    f. *Change pump seals and bearings on preventive maintenance schedule*

5. A slurry pump discharge is equipped with temperature and pressure indicators interlocked to the pump driver.
    a. What observations or checks should the process technician make on the response of these indicators?
        — *Are the indicators changing with changing process conditions?*
        — *Or do they seem to indicate the same values over time and process changes?*
    b. What can cause malfunction?
        — *The devices may be damaged, perhaps by pump vibration or corrosion.*
        — *The instrument taps may have plugged with solids from the slurry or corrosion particles from the process equipment.*

6. Review Figure 1 and Table 3. What would happen to PDI-101 if suction flow pressure increases?
   a. ***Increases***
   b. Decreases
   c. Remains the same
7. Review Figure 1 and Table 3. What would happen to FV-103 output if FIC-103 increases?
   a. Increases
   b. ***Decreases***
   c. Remains the same
8. If suction flow temperature increases in Figure 1, what would happen to TI-41 and TI-42?
   a. ***Increases***
   b. Decreases
   c. Remains the same
9. If both pumps are lost in Figure 1, what would happen to FIC-103?
   a. Increases
   b. ***Decreases***
   c. Remains the same
10. In both pumps are lost in Figure 1, what would happen to PIC-102?
    a. Increases
    b. ***Decreases***
    c. Remains the same
11. If PIC-102 decreases in Figure 1, what would happen to PV-102 output?
    a. Increases
    b. ***Decreases***
    c. Remains the same

PUMP TROUBLESHOOTING MODULE (PART 2)
SCENARIO #1 (PAPER-BASED)

Scenario Statement

Plant production is temporarily halted; however, the production outage becomes extended.

The process technician observes that the unit raw material feed pump, which is equipped with a recycle line for such temporary outages, seems abnormally hot. The technician checks the pump casing temperature with a handheld infrared temperature gun.

Concerned, the technician rechecks the pump casing temperature 15 minutes later and finds it an additional 50°F hotter. This time there is an odor of scorching paint in the air. Troubleshoot this situation.

Abnormal Operating Conditions

The design values and output percentages for instrumentation and equipment during abnormal operating conditions for Scenario #1 are shown in Table 4

Table 4. Design Values and Output Percentages for Instrumentation and Equipment During Abnormal Operating Conditions for Scenario #1

Tag ID	Description	Control	Design Value	Eng. Units	Output Percent
FIC-103	DISCHARGE FLOW CONTROLLER	Manual	0	GPM	0.0%
PDI-101	STRAINER DIFF PRESSURE		10	PSIG	
PIC-102	RECYCLE/DISCHARGE PRESSURE	Auto	140	PSIG	42.0%
PUMP-401A	CENTRIFUGAL PUMP		ON		
PUMP-401B	CENTRIFUGAL PUMP		OFF		
F-101	SUCTION STRAINER		IN SERVICE		
TI-41	RECYCLE TEMPERATURE		235	°F	
TI-42	DISCHARGE TEMPERATURE		Ambient	°F	

Cause

Strainer-101 is plugged.

Corrective Actions

Shut the pump down.

Take strainer out of service and backwash or replace the elements.

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.)

PUMP TROUBLESHOOTING MODULE (PART 2)
SCENARIO #2 (PAPER-BASED)

Scenario Statement

Suction flow to PUMP-401A is severely reduced. PUMP-401A shows increased discharge temperature. TI-41 has increased and is rising. Process flow pressure upstream of the strainer is 28 PSIG. Troubleshoot this situation.

Abnormal Operating Conditions

The values and output percentages for instrumentation and equipment during abnormal operating conditions for Scenario #2 are shown in Table 5.

Table 5. Values and Output Percentages for Instrumentation and Equipment During Abnormal Operating Conditions for Scenario #2

Tag ID	Description	Control	Value	Eng Units	Output Percent
FIC-103	DISCHARGE FLOW CONTROLLER	Auto	89	GPM	100.0%
PDI-101	STRAINER DIFF PRESSURE		1	PSIG	
PIC-102	RECYCLE/DISCHARGE PRESSURE	Auto	100	PSIG	0.0%
PUMP-401A	CENTRIFUGAL PUMP		ON		
PUMP-401B	CENTRIFUGAL PUMP		OFF		
F-101	SUCTION STRAINER		IN SERVICE		
PI-45	INLET PUMP SUCTION PRESSURE		28	PSIG	
TI-41	RECYCLE TEMPERATURE		245	°F	
TI-42	DISCHARGE TEMPERATURE		245	°F	

Cause

Loss of design feed flow to the pump.

Corrective Actions

Change FIC-103 to Manual and then reduce the valve output.

Check PIC-102 and PDI-101 pressure indicators to be within design parameters (they are not according to the abnormal conditions table).

Check the inlet process flow pressure.

IF FLOW CANNOT BE RESTORED, THE PUMP MUST BE SHUT DOWN.

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.)

PUMP TROUBLESHOOTING MODULE (PART 2)
SCENARIO #3 (SIMULATOR-BASED)

Simulator Programming

The following table includes information needed for you to program the fault/s for a pump over-pressurization simulation exercise. The faults have been written for use with Simtronics Corporation's SPM-800 Centrifugal Pumps model.

A discussion of fault/s and fault parameters begins on page 70 of Simtronics Corporation's Instructor and Standard DSS-100 User's Guide, Version 6.2. Instructions for creating a new exercise begins on page 75 of the same manual. For the process and instrumentation descriptions associated with the model, please consult http://www.simtronics.com/site/spm-800.htm#.UPbou2du6So.

Table 6. Fault programming Information for Scenario #3

Descriptor	1- Pump Speed %	**Signal**	100.00	**Rise**	10.00
Status	Idle	**Normal**	100.00	**Start**	00:02:00
Direction	Fail Low	**High**	100.00	**Stop**	00:00:00
Function	Step Change	**Low**	0.00	**Delay**	00:00:01
Descriptor	3- FCV-101 %	**Signal**	100.00	**Rise**	10.00
Status	Idle	**Normal**	100.00	**Start**	00:00:43
Direction	Fail Low	**High**	100.00	**Stop**	00:00:00
Function	Step Change	**Low**	0.00	**Delay**	00:00:01
Descriptor	6- PI-101 Suction	**Signal**	0.00	**Rise**	10.00
Status	Idle	**Normal**	0.00	**Start**	00:00:45
Direction	Fail High	**High**	100.00	**Stop**	00:02:00
Function	Ramp	**Low**	0.00	**Delay**	00:02:01
Descriptor	7- PI-103 Process	**Signal**	10.000	**Rise**	10.00
Status	Active	**Normal**	0.000	**Start**	00:00:00
Direction	Fail High	**High**	10.000	**Stop**	00:00:44
Function	Step Change	**Low**	0.000	**Delay**	00:02:01

Scenario Statement

This Scenario is an example of over-pressurization of a centrifugal pump.

Cause

FCV-101 is experiencing a mechanical issue (either plugged or broken or has a disconnected linkage).

Compensating Action:

Compensating actions are documented in the event log.

Corrective Action:

Repair or replace FCV-101.

NOTE: Screen shots and faceplate shots are provided courtesy of Simtronics Corporation.

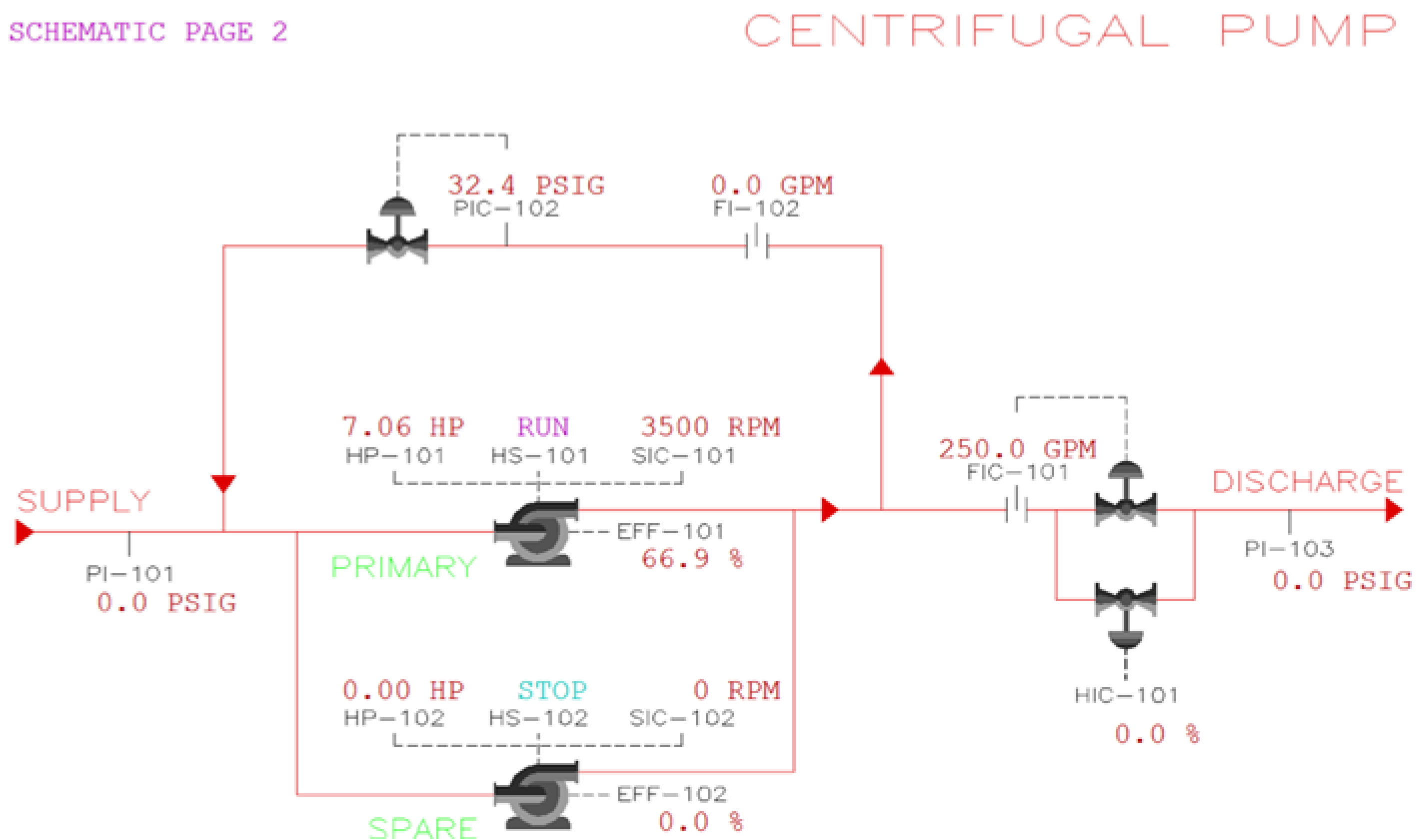

Figure 2. **Schematic of Normal Operations**

Courtesy of Simtronics Corporation

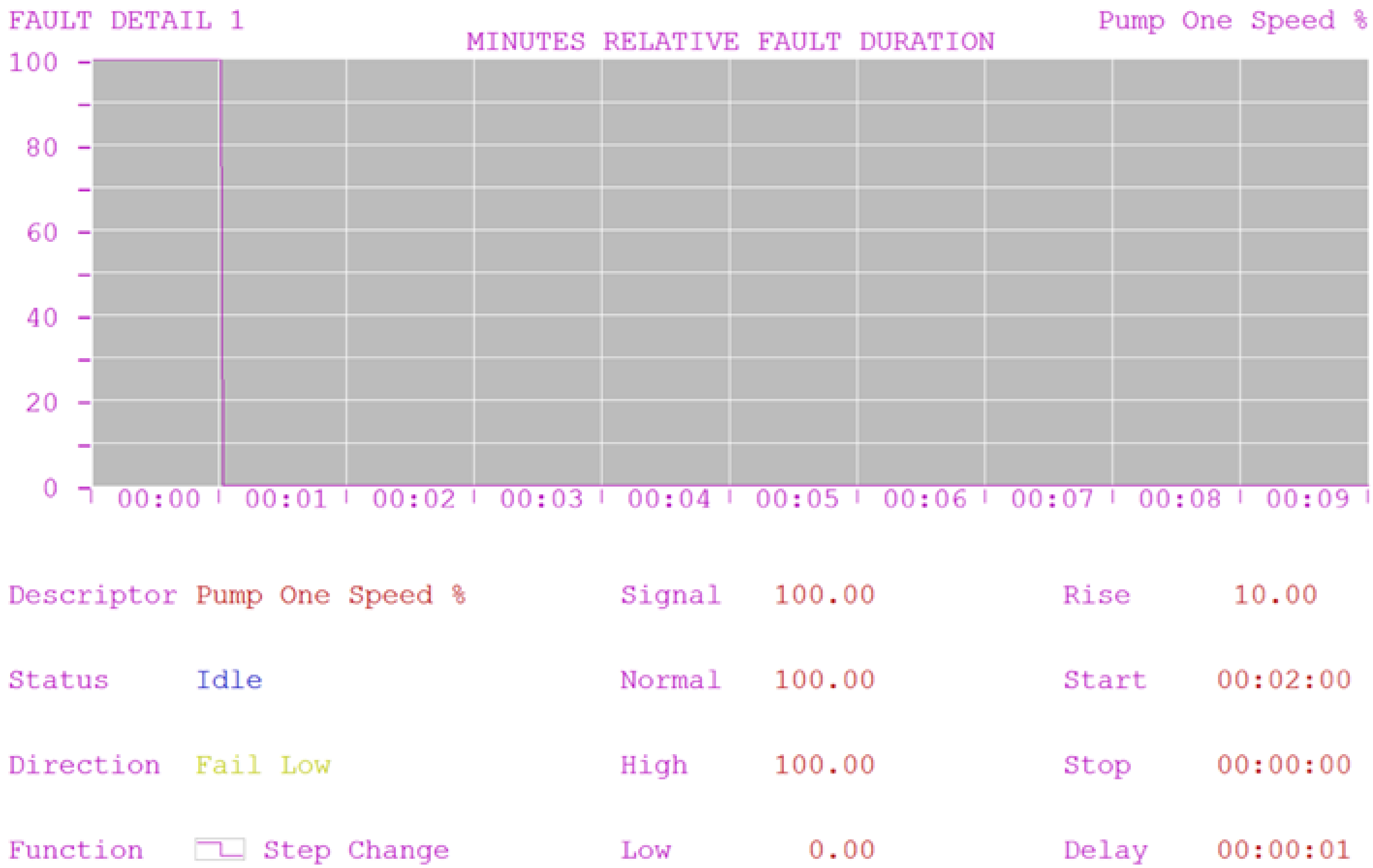

Figure 3. Fault 1 Function Generator Page

Courtesy of Simtronics Corporation

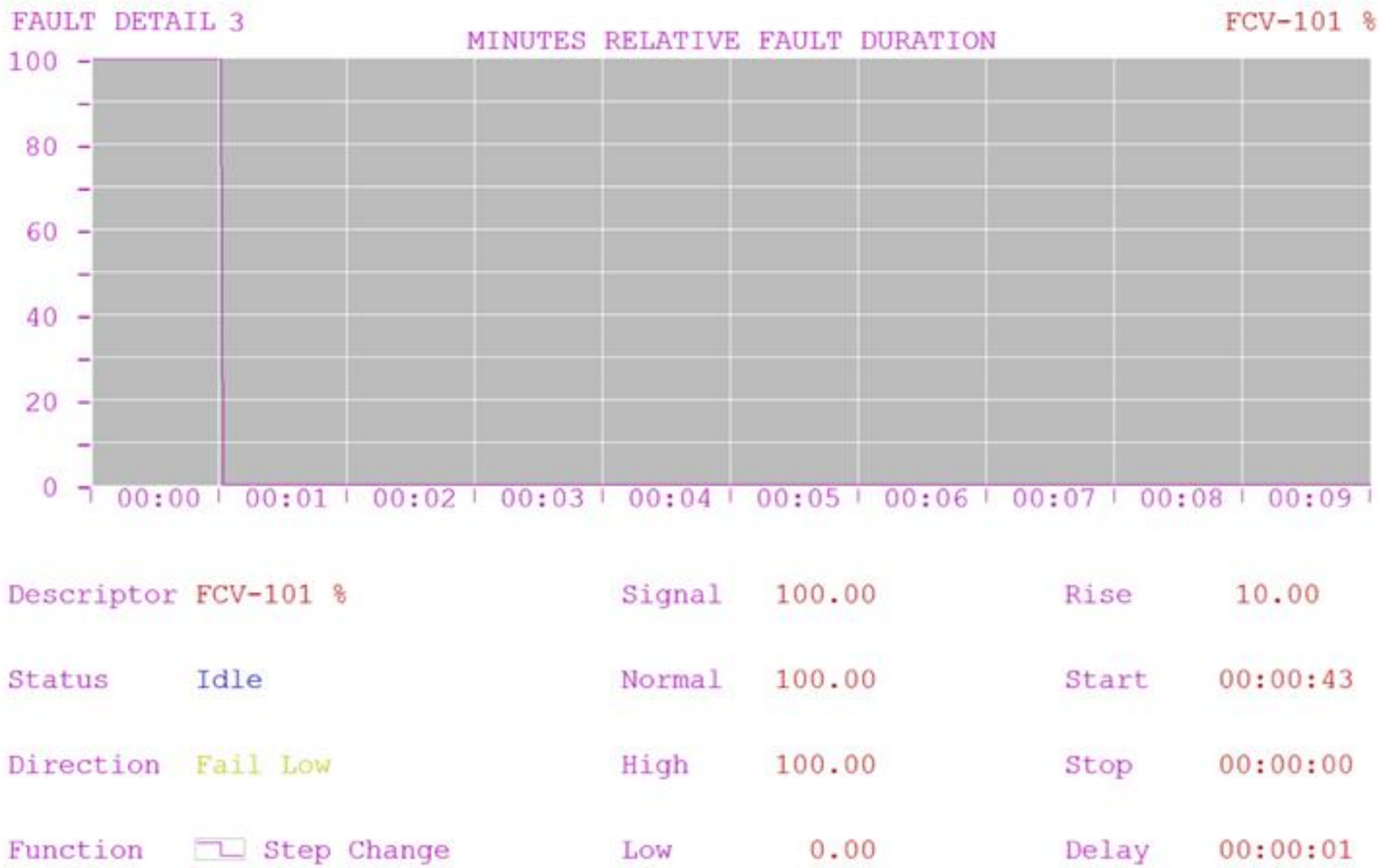

Figure 4. Fault 2 Function Generator Page

Courtesy of Simtronics Corporation

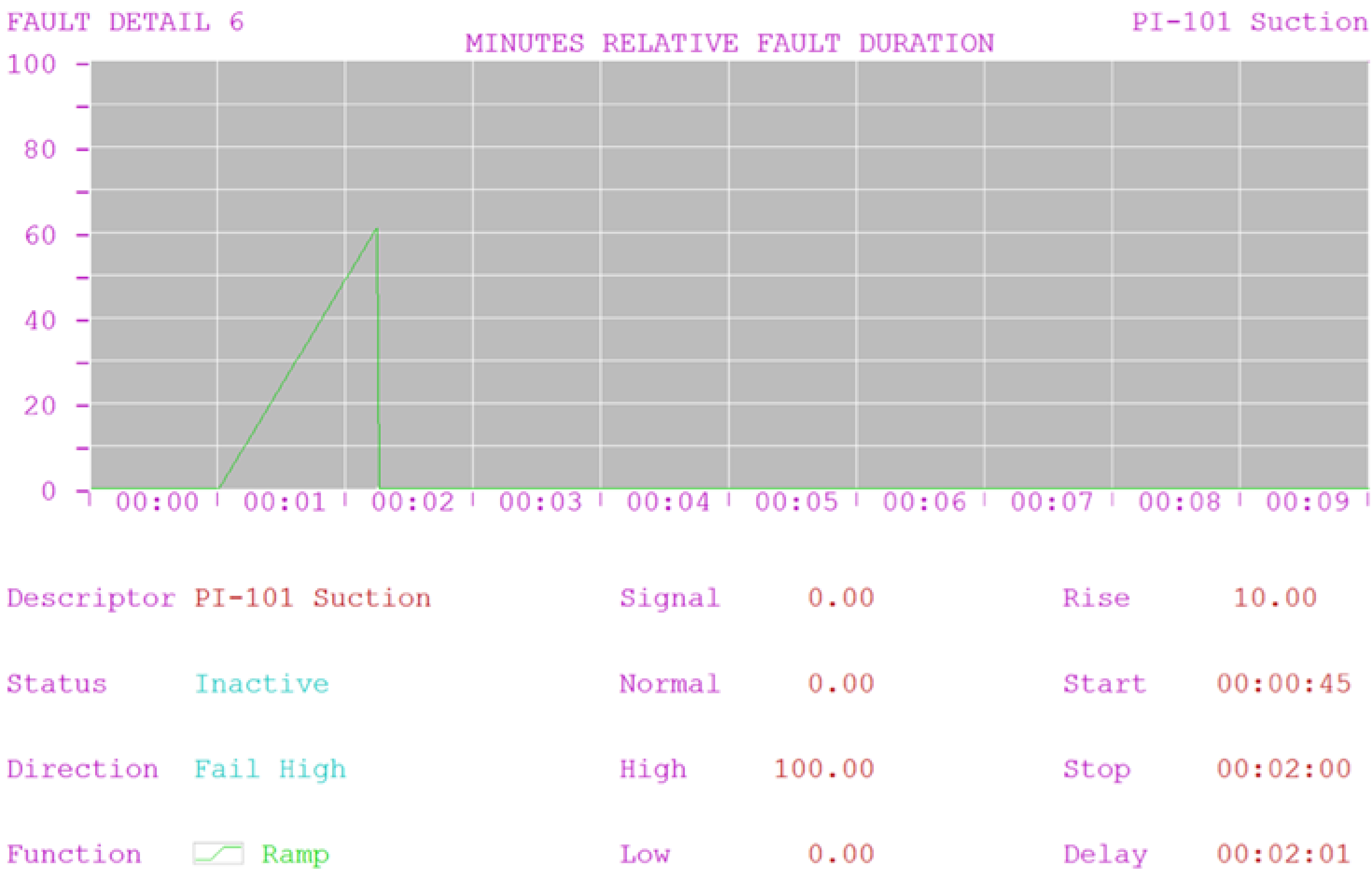

Figure 5. **Fault 3 Function Generator Page**

Courtesy of Simtronics Corporation

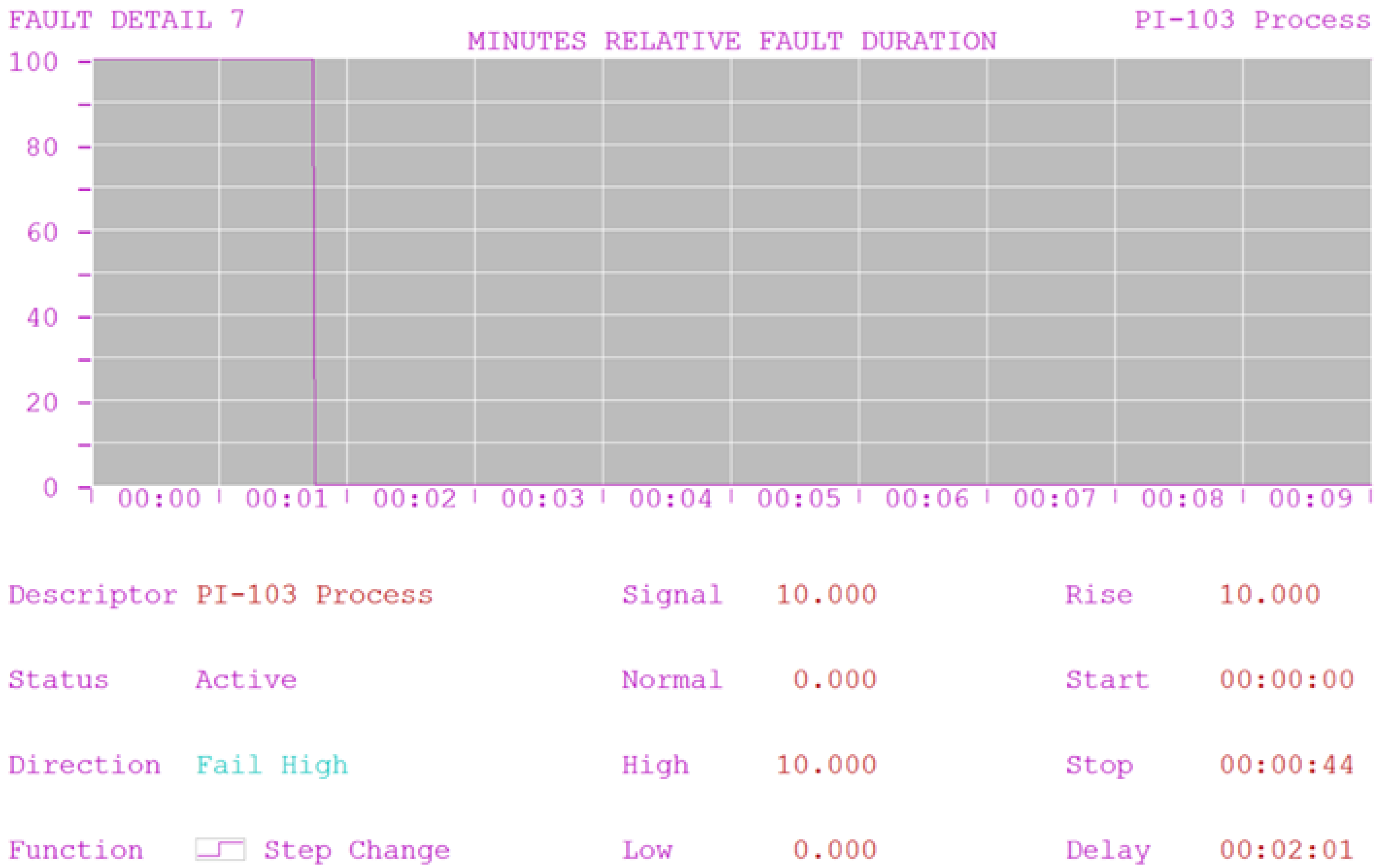

Figure 6. Fault 4 Function Generator Page

Courtesy of Simtronics Corporation

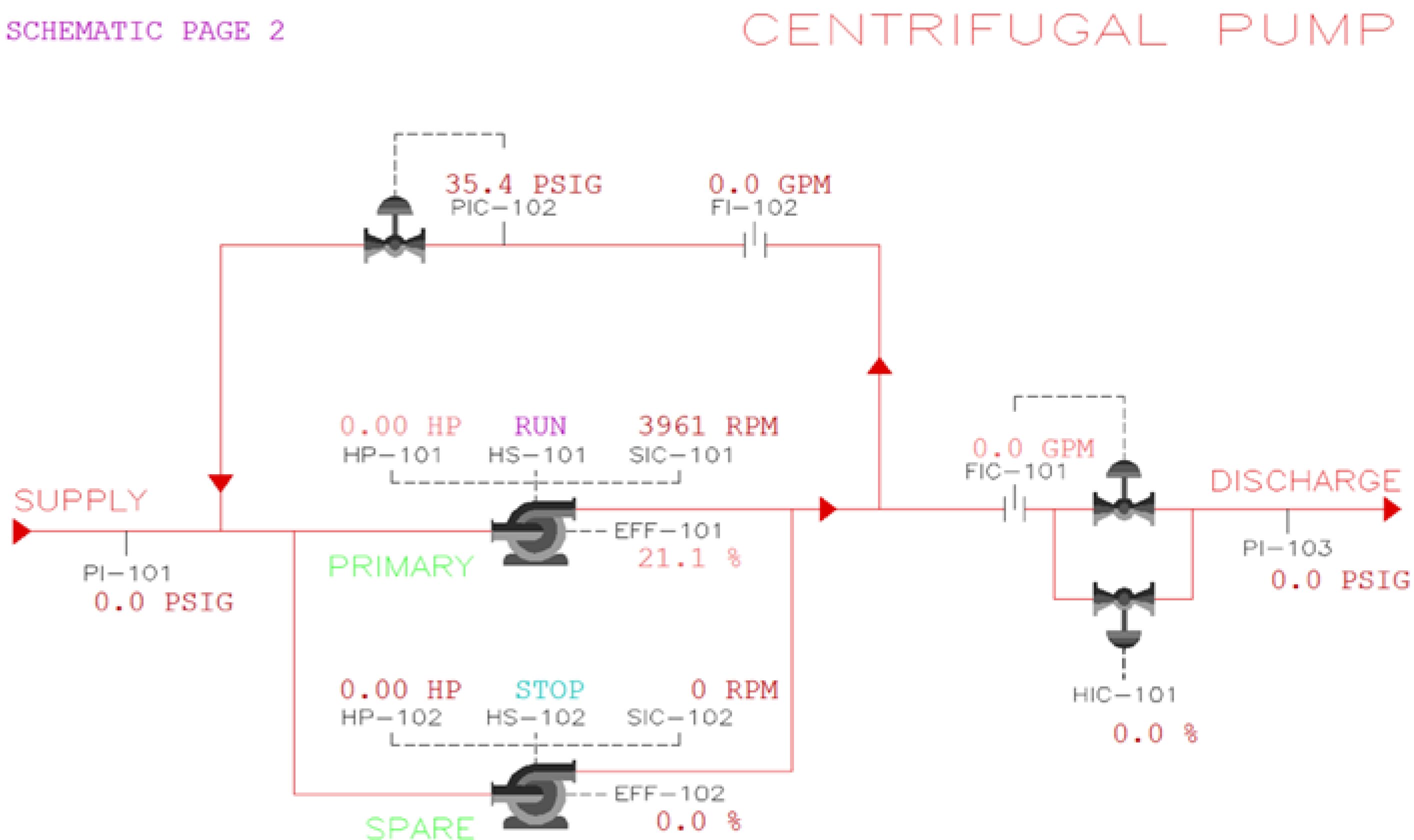

Figure 7. **Abnormal Conditions – 1st Screen Shot at 46 Seconds**

Courtesy of Simtronics Corporation

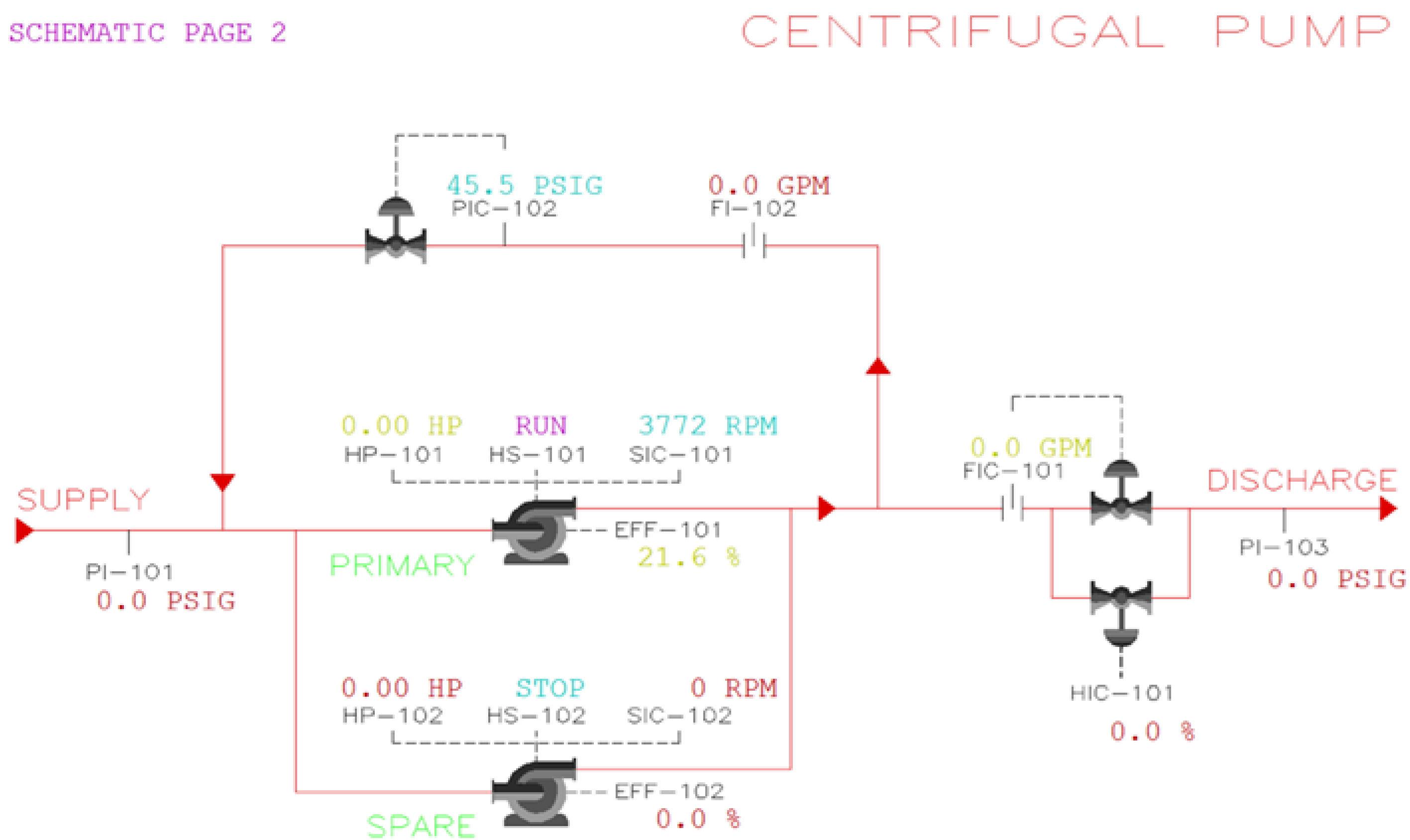

Figure 8. Abnormal Conditions – 2nd Screen Shot at 1 minute, 9 seconds

Courtesy of Simtronics Corporation

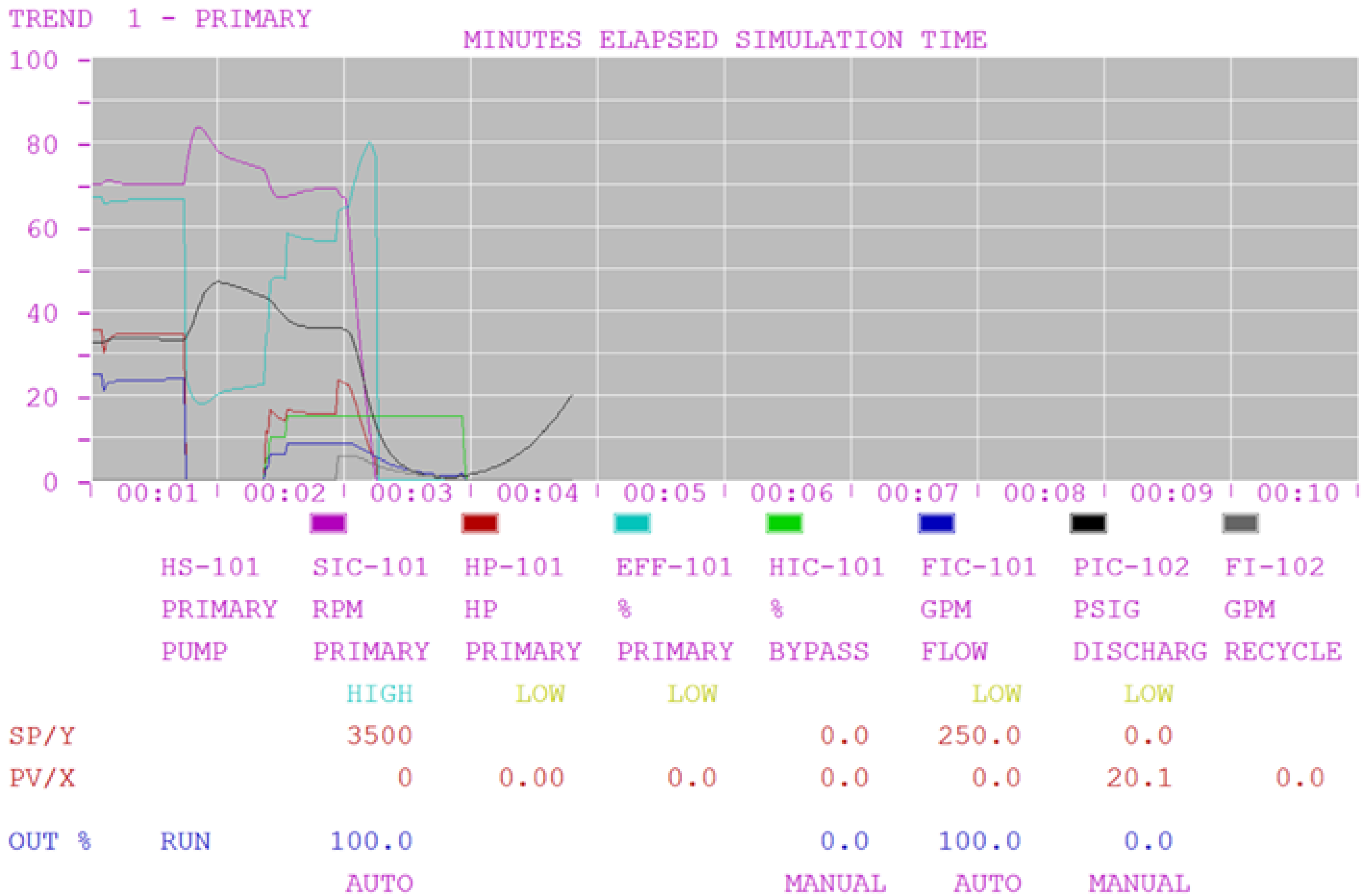

Figure 9. **Trend During Scenario for Primary Pump**

Courtesy of Simtronics Corporation

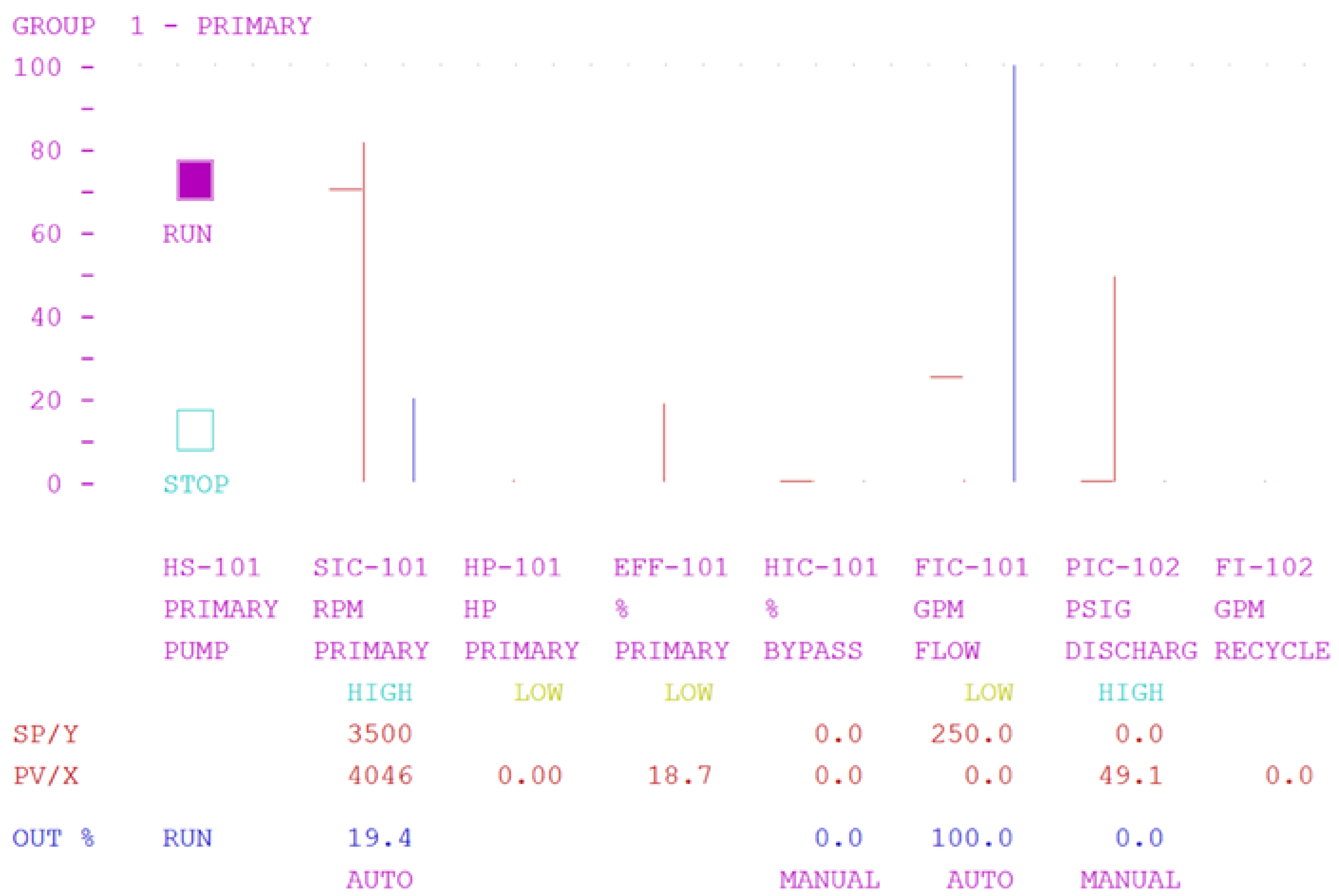

Figure 10. Group Display for Primary Pump

Courtesy of Simtronics Corporation

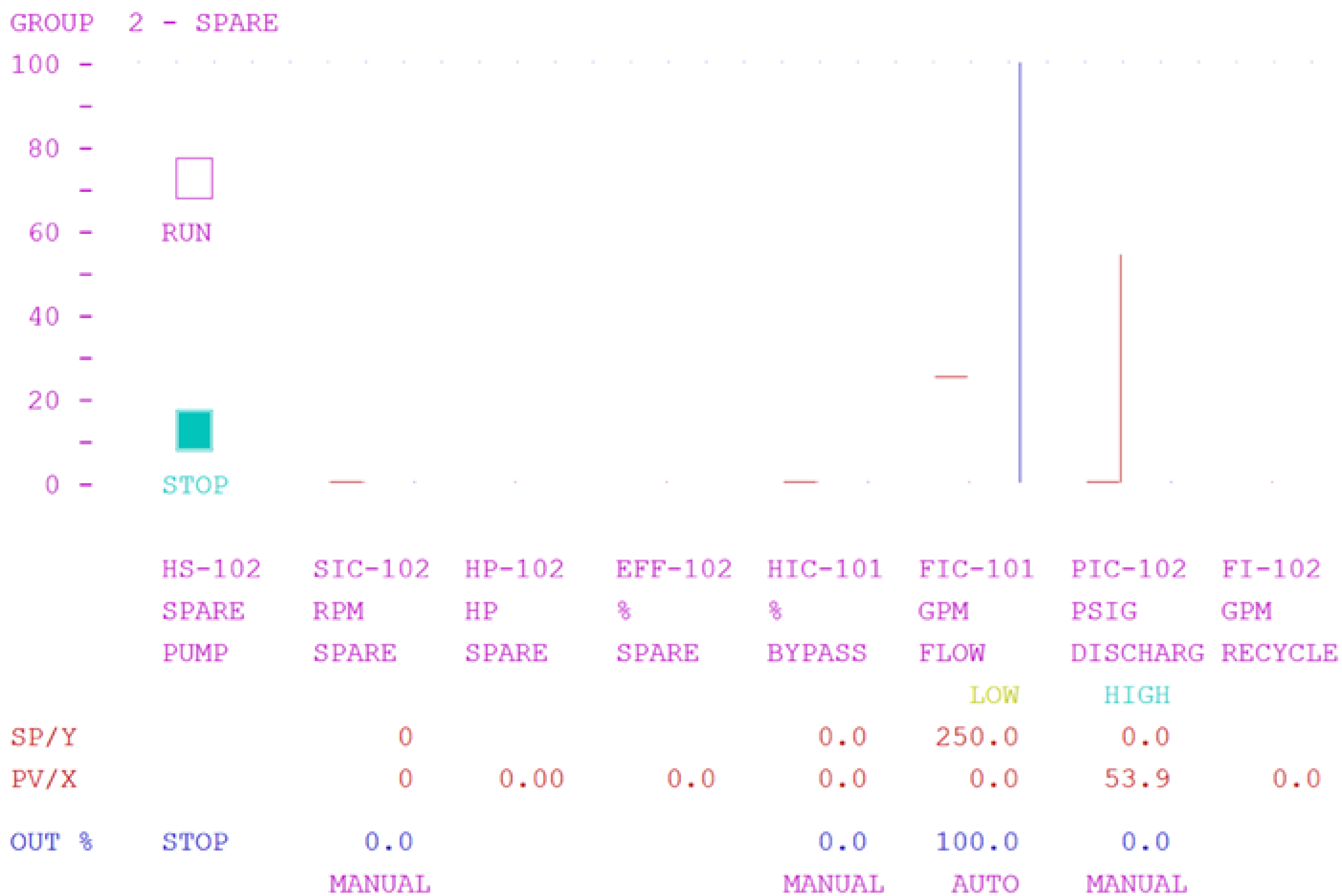

Figure 11. **Group Display for Spare Pump**

Courtesy of Simtronics Corporation

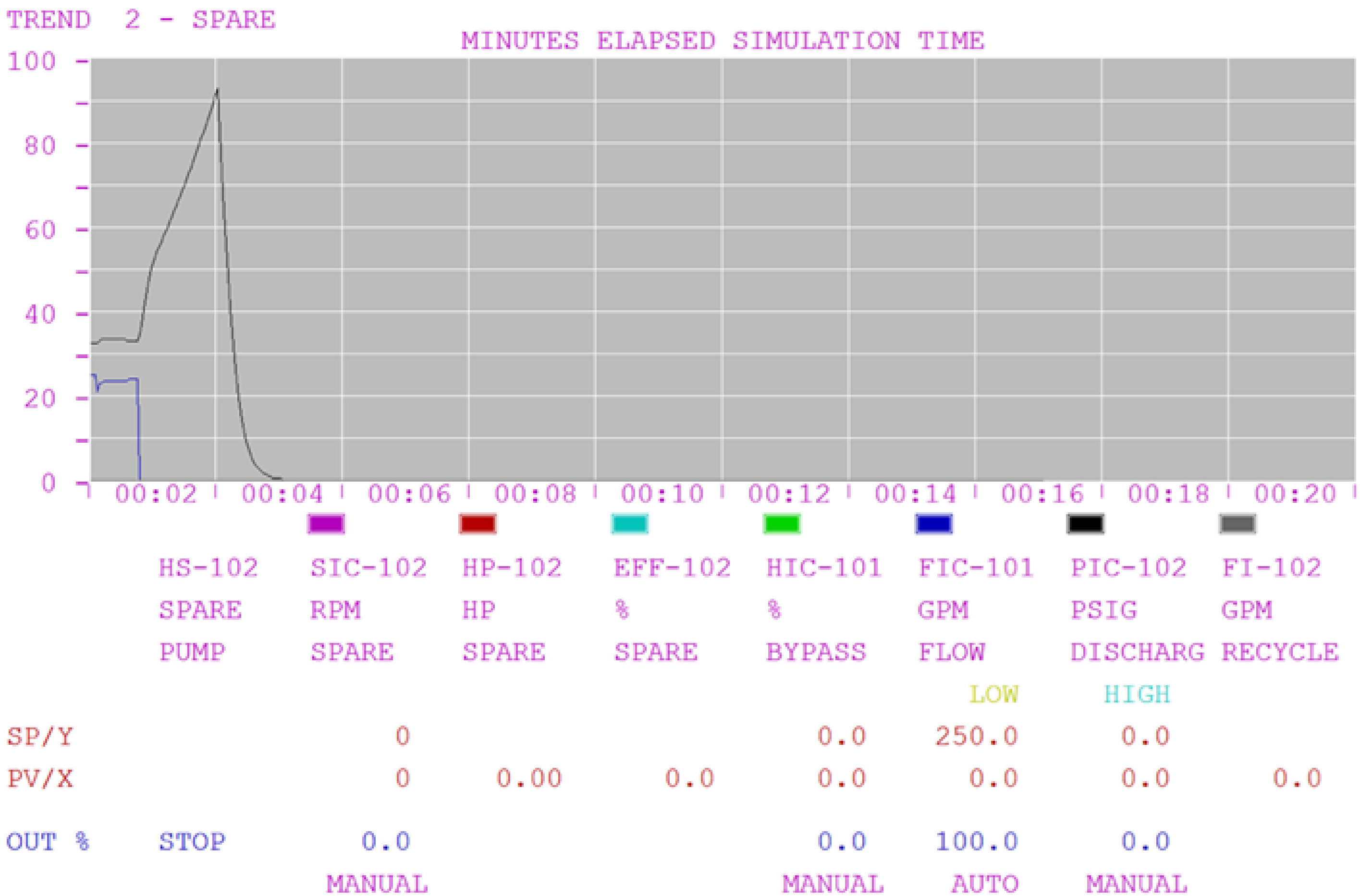

Figure 12. **Trend for Spare Pump**

Courtesy of Simtronics Corporation

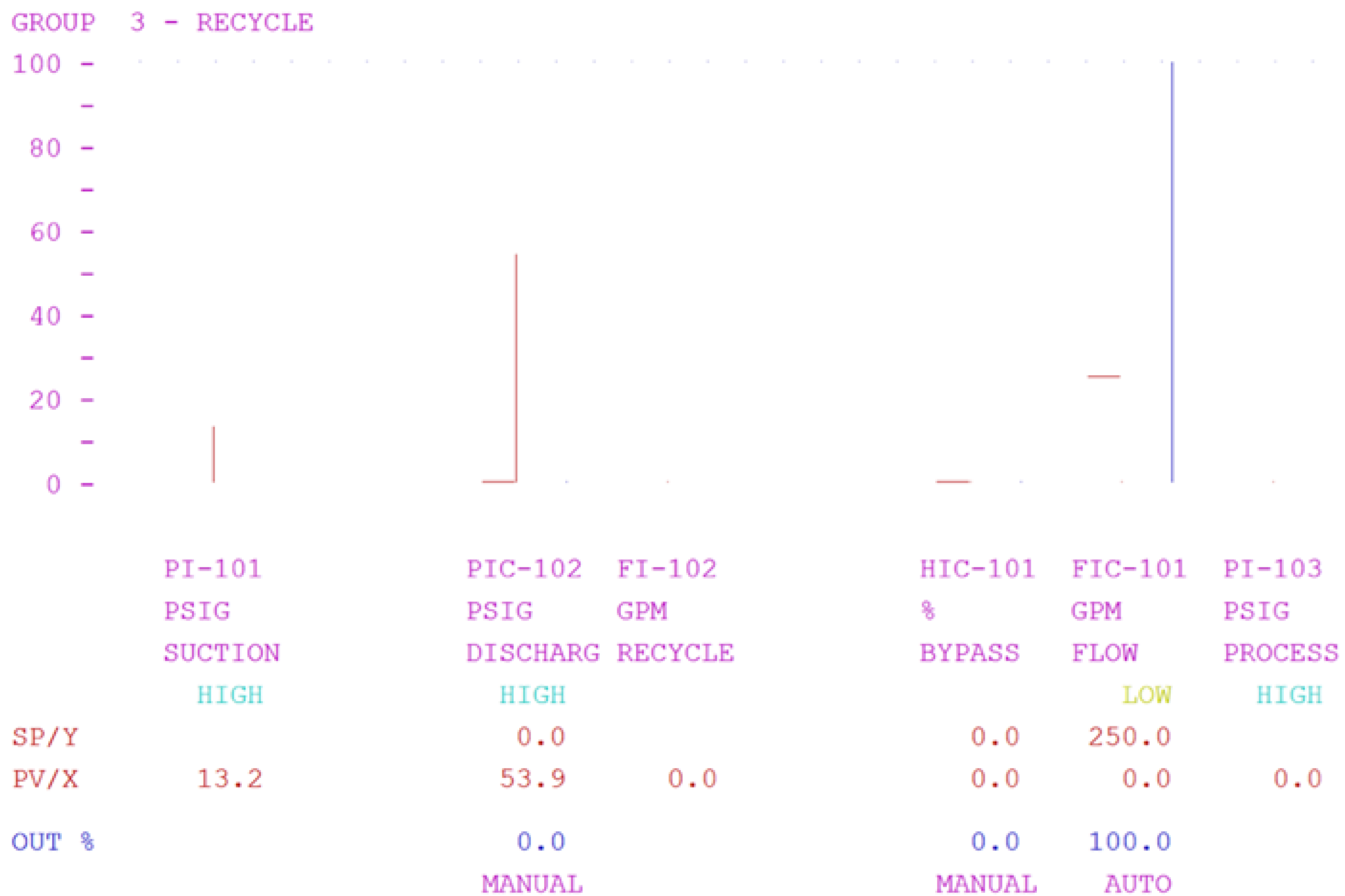

Figure 13. **Group Display for Recycle**

Courtesy of Simtronics Corporation

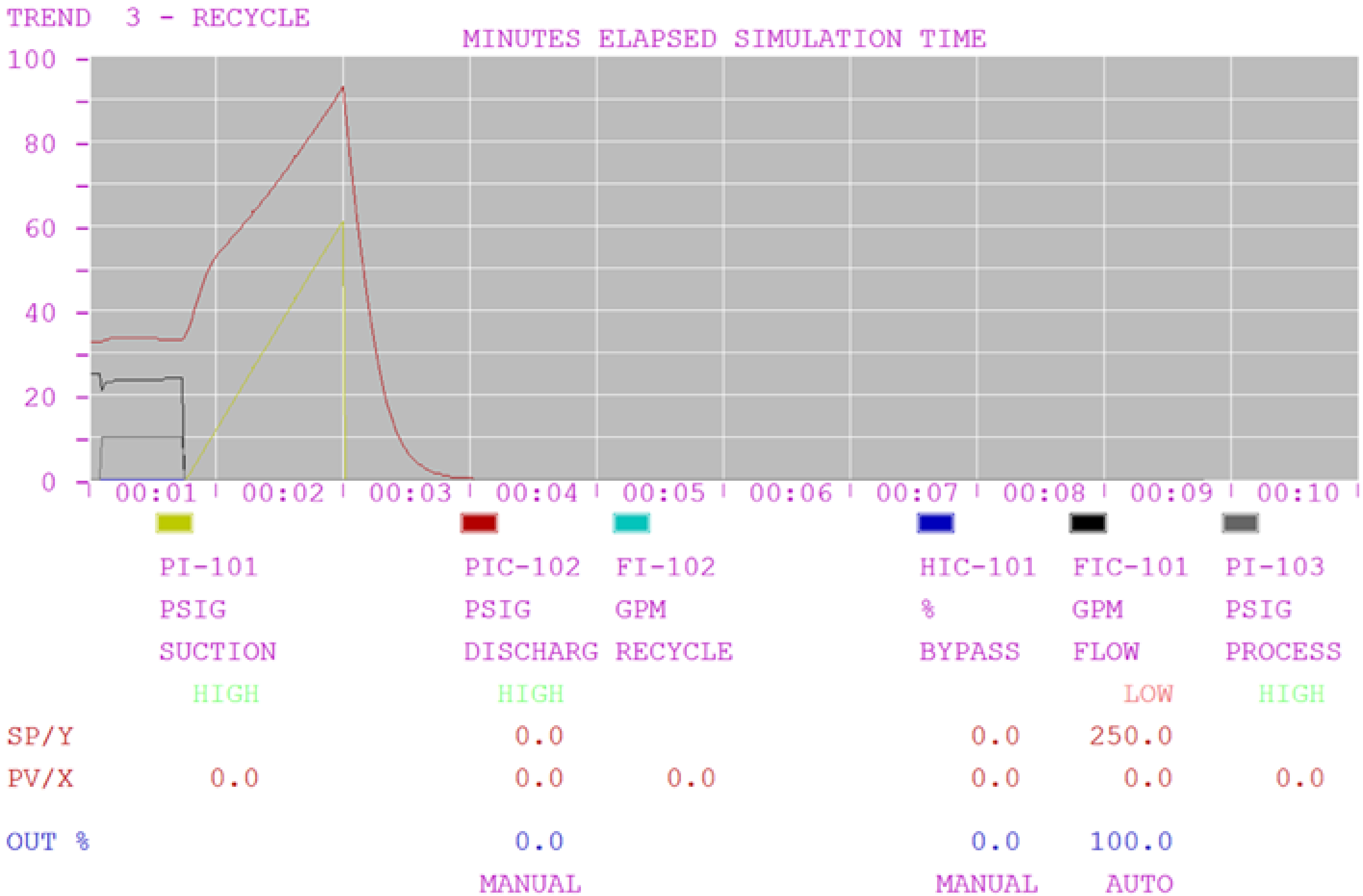

Figure 14. Trend for Recycle

Courtesy of Simtronics Corporation

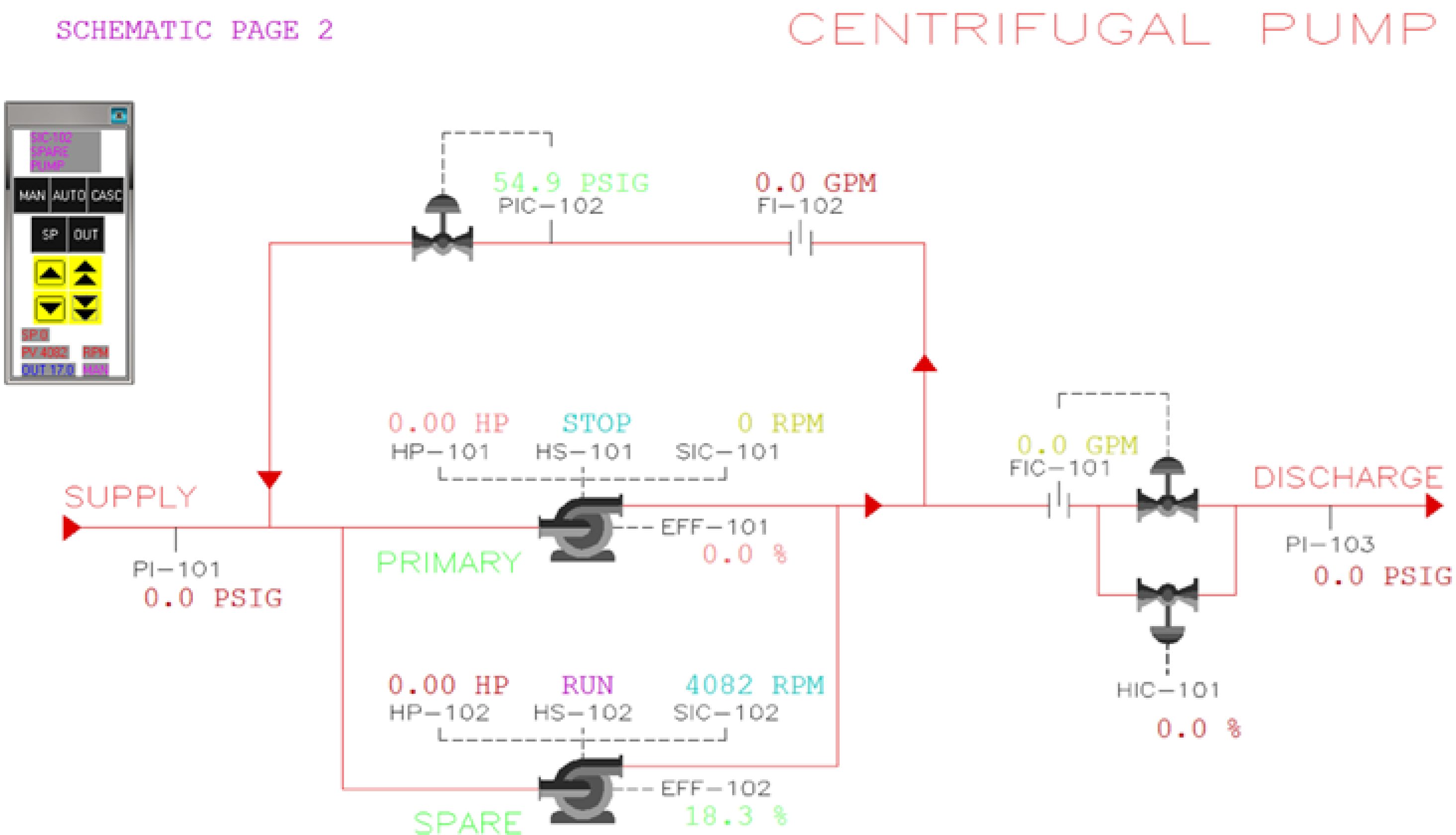

Figure 15. **Screen Shot After Switching Pumps**

Courtesy of Simtronics Corporation

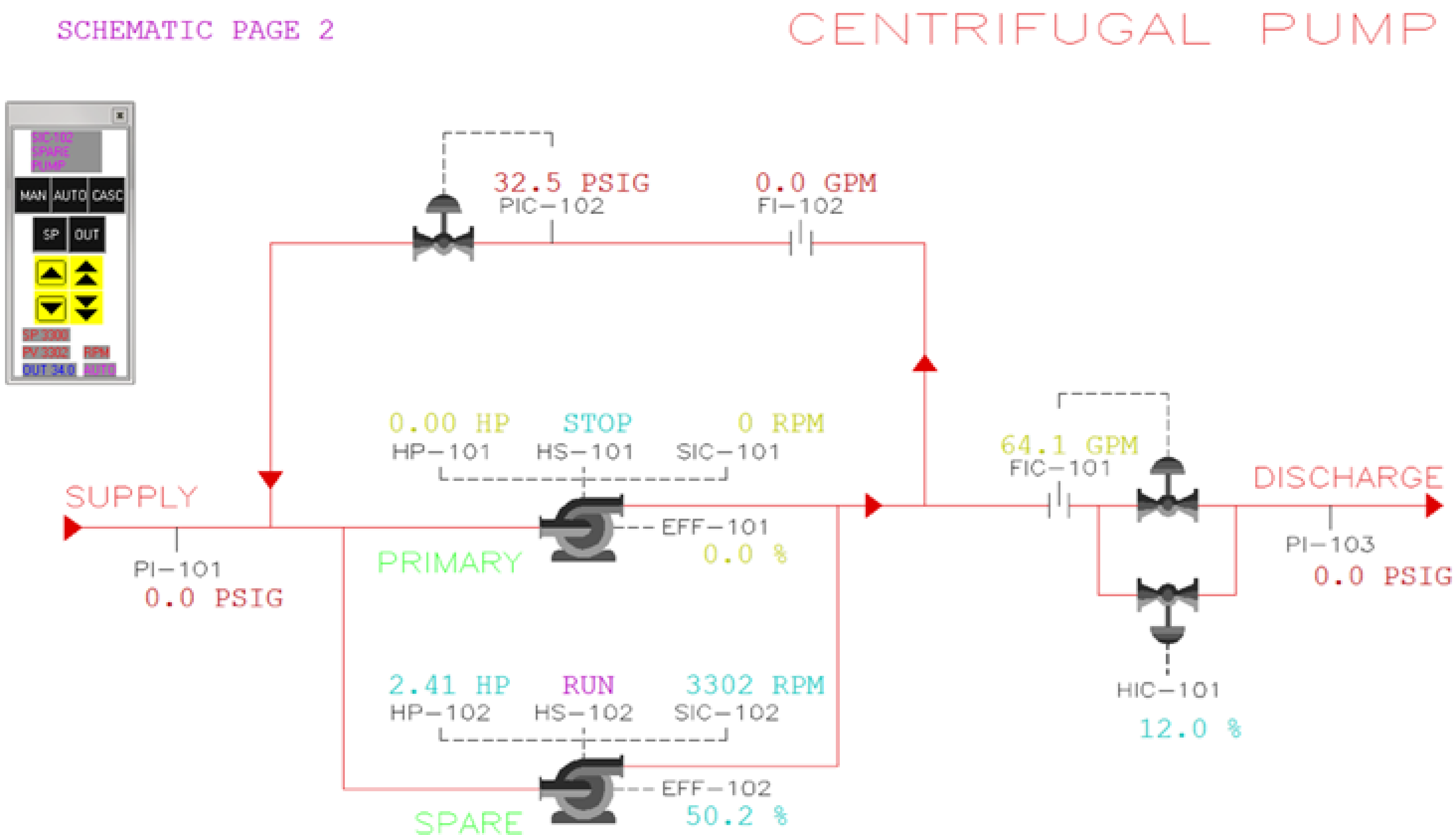

Figure 16. Screen Shot for Stabilizing Process

Courtesy of Simtronics Corporation

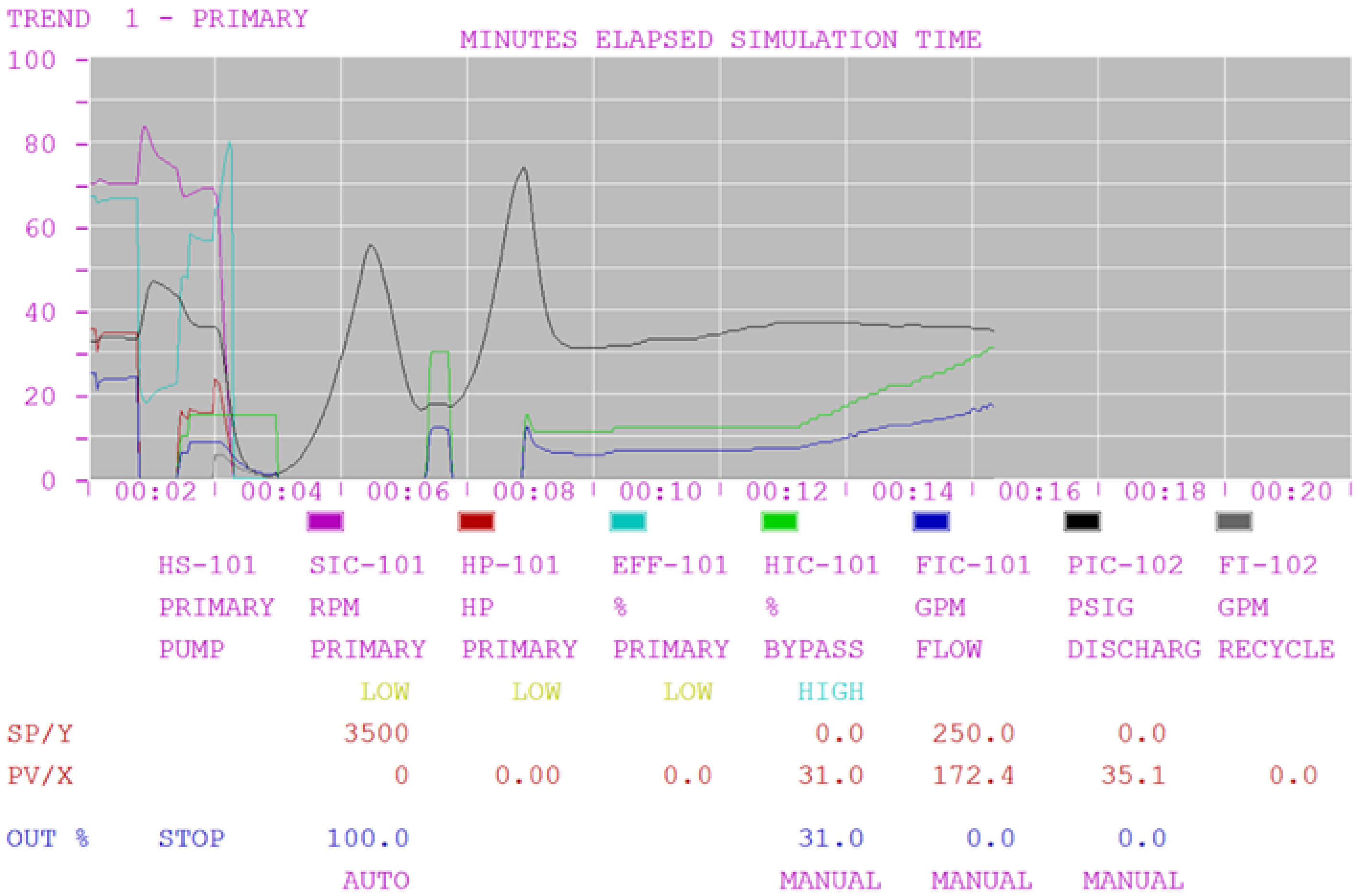

Figure 17. Trend After Compensating Actions

Courtesy of Simtronics Corporation

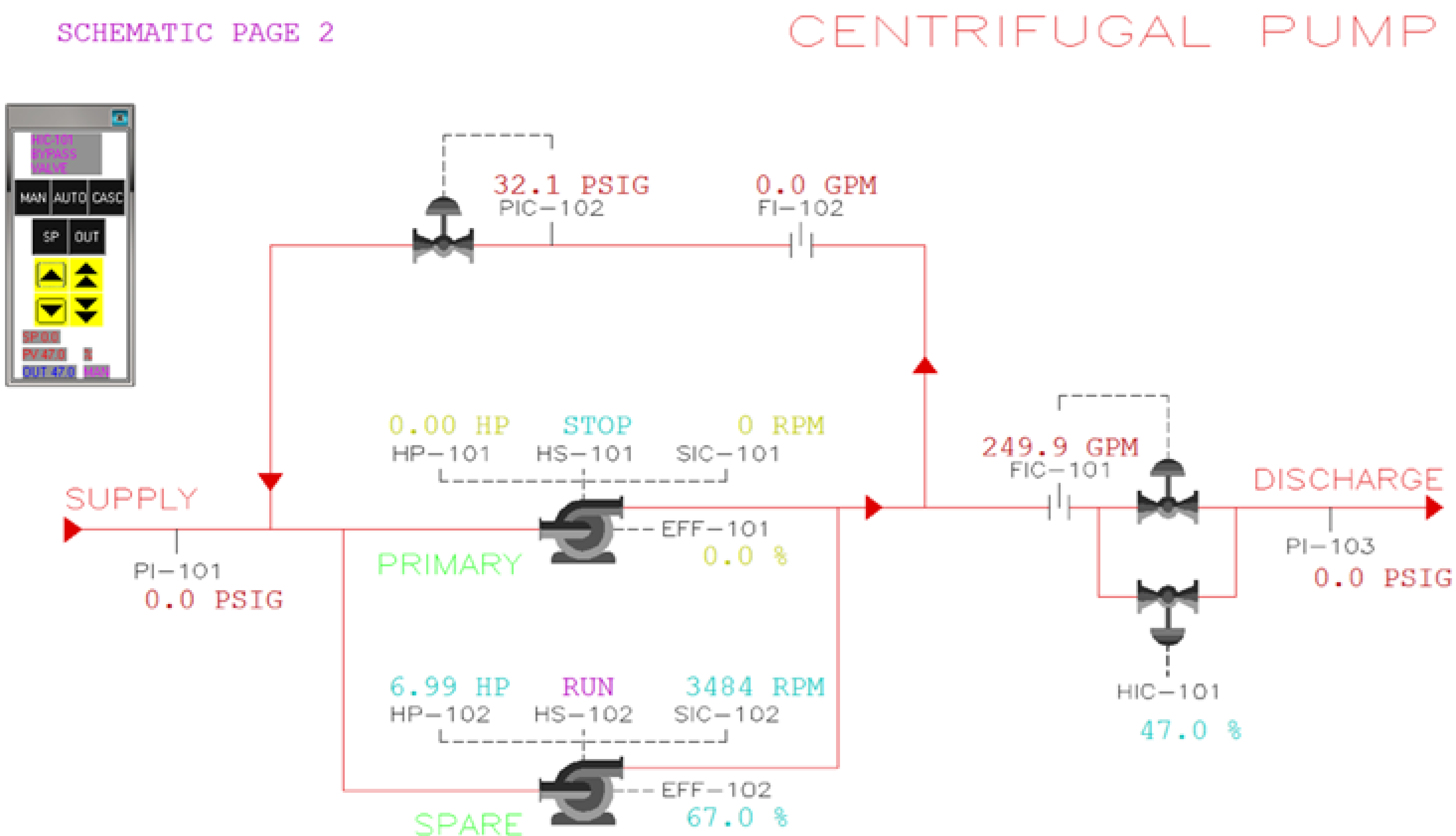

Figure 18. **Process Stabilized Within Parameters**

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 1

00:00:00  Instructor: System Programmer
00:00:00 Process Model: Centrifugal Pump
00:00:00 Initial Condition: DESIGN
00:00:04 RUN STATUS = FREEZE
00:00:04 INSTRUCTOR PAGE 27 - Faults
00:00:04 FAULT POINT - Pump One Speed %
00:00:04 FAULT DETAIL 1 - Pump One Speed %
00:00:04 Pump One Speed % DIRECTION = DOWN
00:00:04 Pump One Speed % STOP = 00:00:00
00:00:04 Pump One Speed % FUNCTION = SQUARE WAVE
00:00:04 Pump One Speed % DELAY = 00:00:01
00:00:04 Pump One Speed % FUNCTION = STAIRCASE
00:00:04 Pump One Speed % DELAY = 00:00:01
00:00:04 Pump One Speed % FUNCTION = STAIRS
00:00:04 Pump One Speed % DELAY = 00:00:01
00:00:04 Pump One Speed % FUNCTION = RAMP
00:00:04 Pump One Speed % DELAY = 00:00:01
00:00:04 Pump One Speed % FUNCTION = SAWTOOTH
00:00:04 Pump One Speed % DELAY = 00:00:01
00:00:04 Pump One Speed % FUNCTION = SLOPE
00:00:04 Pump One Speed % DELAY = 00:00:01
00:00:04 Pump One Speed % FUNCTION = SINE WAVE
00:00:04 Pump One Speed % DELAY = 00:00:01
00:00:04 Pump One Speed % FUNCTION = STEP CHANGE
00:00:04 Pump One Speed % DELAY = 00:00:01
00:00:04 Pump One Speed % START = 00:01:00
00:00:04 Pump One Speed % START = 00:02:00
00:00:04 Pump One Speed % STATUS = IDLE
00:00:04 INSTRUCTOR PAGE 27 - Faults
00:00:04 FAULT POINT - FCV-101 %
00:00:04 FAULT DETAIL 3 - FCV-101 %
00:00:04 FCV-101 %         DIRECTION = DOWN
00:00:04 FCV-101 %         STOP = 00:00:00
00:00:04 FCV-101 %         START = 00:00:10
00:00:04 FCV-101 %         START = 00:00:20
00:00:04 FCV-101 %         START = 00:00:30
00:00:04 FCV-101 %         START = 00:00:40
00:00:04 FCV-101 %         START = 00:00:41
00:00:04 FCV-101 %         START = 00:00:42
00:00:04 FCV-101 %         START = 00:00:43
```

Figure 19. Event Log Page 1

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 2

00:00:04 FCV-101 %          STATUS = IDLE
00:00:04 REFRESH FAULT TRACE WINDOW
00:00:04 INSTRUCTOR PAGE 27 - Faults
00:00:04 FAULT POINT - Pump One Speed %
00:00:04 FAULT DETAIL 1 - Pump One Speed %
00:00:04 INSTRUCTOR PAGE 27 - Faults
00:00:04 FAULT POINT - FCV-101 %
00:00:04 FAULT DETAIL 3 - FCV-101 %
00:00:04 INSTRUCTOR PAGE 27 - Faults
00:00:04 FAULT POINT - PI-101 Suction
00:00:04 FAULT DETAIL 6 - PI-101 Suction
00:00:04 PI-101 Suction    FUNCTION = SINE WAVE
00:00:04 PI-101 Suction    DELAY = 00:00:01
00:00:04 PI-101 Suction    FUNCTION = STEP CHANGE
00:00:04 PI-101 Suction    DELAY = 00:00:01
00:00:04 PI-101 Suction    FUNCTION = SQUARE WAVE
00:00:04 PI-101 Suction    DELAY = 00:00:01
00:00:04 PI-101 Suction    FUNCTION = STAIRCASE
00:00:04 PI-101 Suction    DELAY = 00:00:01
00:00:04 PI-101 Suction    FUNCTION = STAIRS
00:00:04 PI-101 Suction    DELAY = 00:00:01
00:00:04 PI-101 Suction    FUNCTION = RAMP
00:00:04 PI-101 Suction    DELAY = 00:00:01
00:00:04 PI-101 Suction    START = 00:00:10
00:00:04 PI-101 Suction    START = 00:00:20
00:00:04 PI-101 Suction    START = 00:00:30
00:00:04 PI-101 Suction    START = 00:00:40
00:00:04 PI-101 Suction    START = 00:00:41
00:00:04 PI-101 Suction    START = 00:00:42
00:00:04 PI-101 Suction    START = 00:00:43
00:00:04 PI-101 Suction    START = 00:00:44
00:00:04 PI-101 Suction    START = 00:00:45
00:00:04 PI-101 Suction    STOP = 00:01:00
00:00:04 PI-101 Suction    STOP = 00:02:00
00:00:04 PI-101 Suction    DELAY = 00:01:01
00:00:04 PI-101 Suction    DELAY = 00:02:01
00:00:04 REFRESH FAULT TRACE WINDOW
00:00:04 INSTRUCTOR PAGE 27 - Faults
00:00:04 FAULT POINT - Pump One Speed %
00:00:04 FAULT DETAIL 1 - Pump One Speed %
```

Figure 20. Event Log Page 2

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 3

00:00:04 REFRESH FAULT TRACE WINDOW
00:00:04 REFRESH FAULT TRACE WINDOW
00:00:04 REFRESH FAULT TRACE WINDOW
00:00:04 REFRESH FAULT TRACE WINDOW
00:00:04 INSTRUCTOR PAGE 27 - Faults
00:00:04 FAULT POINT - FCV-101 %
00:00:04 FAULT DETAIL 3 - FCV-101 %
00:00:04 REFRESH FAULT TRACE WINDOW
00:00:04 INSTRUCTOR PAGE 27 - Faults
00:00:04 FAULT POINT - PI-103 Process
00:00:04 FAULT DETAIL 7 - PI-103 Process
00:00:04 PI-103 Process    SIGNAL =  10.00
00:00:04 PI-103 Process    STOP = 00:00:00
00:00:04 PI-103 Process    HIGH = 10.000
00:00:04 PI-103 Process    STOP = 00:00:10
00:00:04 PI-103 Process    STOP = 00:00:20
00:00:04 PI-103 Process    STOP = 00:00:30
00:00:04 PI-103 Process    STOP = 00:00:40
00:00:04 PI-103 Process    STOP = 00:00:41
00:00:04 PI-103 Process    STOP = 00:00:42
00:00:04 PI-103 Process    STOP = 00:00:43
00:00:04 PI-103 Process    STOP = 00:00:44
00:00:04 PI-103 Process    DELAY = 00:01:01
00:00:04 PI-103 Process    DELAY = 00:02:01
00:00:04 PI-103 Process    STATUS = IDLE
00:00:04 PI-103 Process    STATUS = ACTIVE
00:00:04 REFRESH FAULT TRACE WINDOW
00:00:04 INSTRUCTOR PAGE 27 - Faults
00:00:04 SCHEMATIC PAGE 2
00:00:04 RUN STATUS = GO
00:00:05 PI-103    - High Alarm
00:00:13 SCHEMATIC POINT - PI-103
00:00:13 PI-103    - High Alarm Acknowledged
00:00:43 FCV-101 %         ACTIVATED
00:00:44 PI-103 Process    TERMINATED
00:00:44 FIC-101   - Low Alarm
00:00:44 PI-103    - High Alarm Cleared
00:00:44 HP-101    - Low Alarm
00:00:44 EFF-101   - Low Alarm
00:00:47 SIC-101   - High Alarm
```

Figure 21. Event Log Page 3

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 4

00:00:50 RUN STATUS = FREEZE
00:00:50 TREND    1 - PRIMARY
00:00:50 SCHEMATIC PAGE 2
00:00:50 GROUP    1 - PRIMARY
00:00:50 SCHEMATIC PAGE 2
00:00:50 GROUP    1 - PRIMARY
00:00:50 SCHEMATIC PAGE 2
00:00:50 RUN STATUS = GO
00:00:52 PIC-102   - High Alarm
00:01:14 RUN STATUS = FREEZE
00:01:14 TREND    1 - PRIMARY
00:01:14 SCHEMATIC PAGE 2
00:01:14 RUN STATUS = GO
00:01:17 SCHEMATIC POINT - HIC-101
00:01:21 HIC-101  OUTPUT =     5.0 PERCENT
00:01:23 HIC-101  OUTPUT =    10.0 PERCENT
00:01:31 HIC-101  OUTPUT =    15.0 PERCENT
00:01:32 HIC-101   - High Alarm
00:01:32 HIC-101   - High Alarm Acknowledged
00:01:52 SCHEMATIC POINT - PIC-102
00:01:52 PIC-102   - High Alarm Acknowledged
00:01:53 PIC-102   - High Alarm Cleared
00:01:55 PIC-102  OUTPUT =    10.0 PERCENT
00:02:00 Pump One Speed % ACTIVATED
00:02:09 PIC-102   - Low Alarm
00:02:09 PIC-102   - Low Alarm Acknowledged
00:02:27 SCHEMATIC POINT - SIC-102
00:02:30 SIC-102  OUTPUT =    15.0 PERCENT
00:02:31 SIC-102  OUTPUT =    30.0 PERCENT
00:02:33 SCHEMATIC POINT - HS-102
00:02:33 HS-102    = RUN
00:02:35 EFF-102   - High Alarm
00:02:40 SCHEMATIC POINT - PIC-102
00:02:46 PIC-102  OUTPUT =     0.0 PERCENT
00:02:48 SIC-102   - High Alarm
00:02:51 SCHEMATIC POINT - HIC-101
00:02:52 SCHEMATIC POINT - HIC-101
00:02:55 HIC-101  OUTPUT =     5.0 PERCENT
00:02:56 HIC-101   - High Alarm Cleared
00:02:56 HIC-101  OUTPUT =     0.0 PERCENT
```

Figure 22. Event Log Page 4

Courtesy of Simtronics Corporation

EVENTLOG PAGE 5

```
00:03:09 SCHEMATIC POINT - SIC-102
00:03:09 SIC-102   - High Alarm Acknowledged
00:03:14 SIC-102  OUTPUT =   32.0 PERCENT
00:03:34 TREND    1 - PRIMARY
00:03:50 PIC-102   - Low Alarm Cleared
00:03:53 RUN STATUS = FREEZE
00:03:53 GROUP    1 - PRIMARY
00:03:53 SCHEMATIC PAGE 2
00:03:53 SCHEMATIC POINT - HS-101
00:03:53 HS-101    = STOP
00:03:53 RUN STATUS = GO
00:03:58 SCHEMATIC POINT - SIC-101
00:03:58 SIC-101   - High Alarm Acknowledged
00:03:59 SIC-101   - Low Alarm
00:03:59 SIC-101   - Low Alarm Acknowledged
00:04:03 SCHEMATIC POINT - FIC-101
00:04:03 FIC-101   - Low Alarm Acknowledged
00:04:12 PIC-102   - High Alarm
00:04:13 SCHEMATIC POINT - SIC-102
00:04:18 SIC-102  OUTPUT =   27.0 PERCENT
00:04:19 SIC-102  OUTPUT =   22.0 PERCENT
00:04:21 SIC-102  OUTPUT =   17.0 PERCENT
00:04:33 RUN STATUS = FREEZE
00:04:33 SCHEMATIC POINT - SIC-102
00:04:33 SIC-102  OUTPUT =   16.0 PERCENT
00:04:33 SIC-102  SETPOINT =   3500 RPM
00:04:33 SIC-102  OUTPUT =   15.0 PERCENT
00:04:33 RUN STATUS = GO
00:04:42 SCHEMATIC POINT - PIC-102
00:04:42 PIC-102   - High Alarm Acknowledged
00:04:43 PIC-102   - High Alarm Cleared
00:04:44 SCHEMATIC POINT - HP-101
00:04:44 HP-101    - Low Alarm Acknowledged
00:04:49 SCHEMATIC POINT - EFF-101
00:04:49 EFF-101   - Low Alarm Acknowledged
00:04:49 SCHEMATIC POINT - SIC-102
00:04:52 SIC-102  OUTPUT =   16.0 PERCENT
00:04:54 SIC-102  OUTPUT =   17.0 PERCENT
00:04:55 SIC-102  OUTPUT =   18.0 PERCENT
00:04:57 SIC-102  OUTPUT =   19.0 PERCENT
```

Figure 23. Event Log Page 5

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 6

00:04:59 SIC-102  OUTPUT =    20.0 PERCENT
00:05:00 SIC-102  OUTPUT =    21.0 PERCENT
00:05:01 PIC-102  - Low Alarm
00:05:02 SIC-102  OUTPUT =    24.0 PERCENT
00:05:04 SIC-102  OUTPUT =    27.0 PERCENT
00:05:06 SIC-102  OUTPUT =    30.0 PERCENT
00:05:14 SCHEMATIC POINT - HIC-101
00:05:18 HIC-101  OUTPUT =     5.0 PERCENT
00:05:19 HIC-101  OUTPUT =    15.0 PERCENT
00:05:20 HIC-101  - High Alarm
00:05:20 HIC-101  OUTPUT =    20.0 PERCENT
00:05:20 HIC-101  - High Alarm Acknowledged
00:05:20 HIC-101  OUTPUT =    25.0 PERCENT
00:05:21 HIC-101  OUTPUT =    30.0 PERCENT
00:05:39 HIC-101  OUTPUT =    25.0 PERCENT
00:05:40 HIC-101  OUTPUT =    15.0 PERCENT
00:05:41 HIC-101  OUTPUT =     5.0 PERCENT
00:05:42 HIC-101  - High Alarm Cleared
00:05:42 HIC-101  OUTPUT =     0.0 PERCENT
00:05:53 SCHEMATIC POINT - PIC-102
00:05:53 PIC-102  - Low Alarm Acknowledged
00:05:55 SCHEMATIC POINT - SIC-102
00:05:58 SIC-102  OUTPUT =    31.0 PERCENT
00:05:59 SIC-102  OUTPUT =    32.0 PERCENT
00:06:00 PIC-102  - Low Alarm Cleared
00:06:00 SIC-102  OUTPUT =    33.0 PERCENT
00:06:13 SCHEMATIC POINT - FIC-101
00:06:22 PIC-102  - High Alarm
00:06:40 FIC-101  = MANUAL
00:06:45 FIC-101  OUTPUT =     0.0 PERCENT
00:06:47 SCHEMATIC POINT - HIC-101
00:06:50 HIC-101  OUTPUT =    10.0 PERCENT
00:06:51 HIC-101  - High Alarm
00:06:51 HP-102   - High Alarm
00:06:51 HIC-101  OUTPUT =    15.0 PERCENT
00:06:51 HIC-101  - High Alarm Acknowledged
00:06:55 HIC-101  OUTPUT =    14.0 PERCENT
00:06:56 HIC-101  OUTPUT =    13.0 PERCENT
00:06:57 HIC-101  OUTPUT =    12.0 PERCENT
00:06:59 HIC-101  OUTPUT =    11.0 PERCENT
```

Figure 24. Event Log Page 6

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 7

00:07:04 SCHEMATIC POINT - SIC-102
00:07:11 SIC-102  OUTPUT =    34.0 PERCENT
00:07:12 SIC-102  OUTPUT =    35.0 PERCENT
00:07:14 SIC-102  OUTPUT =    36.0 PERCENT
00:07:18 SIC-102  SETPOINT =   3100 RPM
00:07:20 SIC-102  = AUTOMATIC
00:07:28 SCHEMATIC POINT - PIC-102
00:07:28 PIC-102  - High Alarm Acknowledged
00:07:29 PIC-102  - High Alarm Cleared
00:07:33 SCHEMATIC POINT - SIC-102
00:07:37 SIC-102  SETPOINT =   3150 RPM
00:07:47 SCHEMATIC POINT - HP-102
00:07:47 HP-102   - High Alarm Acknowledged
00:07:48 SCHEMATIC POINT - EFF-102
00:07:48 EFF-102  - High Alarm Acknowledged
00:07:54 SCHEMATIC POINT - SIC-102
00:07:59 SIC-102  SETPOINT =   3200 RPM
00:08:10 SCHEMATIC POINT - HIC-101
00:08:15 HIC-101  OUTPUT =    12.0 PERCENT
00:08:21 SCHEMATIC POINT - SIC-102
00:08:24 SIC-102  SETPOINT =   3250 RPM
00:08:36 SIC-102  SETPOINT =   3300 RPM
00:09:31 SIC-102  SETPOINT =   3350 RPM
00:09:52 SIC-102  SETPOINT =   3400 RPM
00:10:08 SIC-102  SETPOINT =   3450 RPM
00:10:36 SIC-102  SETPOINT =   3500 RPM
00:11:10 SCHEMATIC POINT - HIC-101
00:11:13 HIC-101  OUTPUT =    13.0 PERCENT
00:11:21 HIC-101  OUTPUT =    14.0 PERCENT
00:11:30 HIC-101  OUTPUT =    15.0 PERCENT
00:11:44 HIC-101  OUTPUT =    16.0 PERCENT
00:11:51 HIC-101  OUTPUT =    17.0 PERCENT
00:11:59 HIC-101  OUTPUT =    18.0 PERCENT
00:12:08 HIC-101  OUTPUT =    19.0 PERCENT
00:12:18 HIC-101  OUTPUT =    20.0 PERCENT
00:12:27 HIC-101  OUTPUT =    21.0 PERCENT
00:12:35 HIC-101  OUTPUT =    22.0 PERCENT
00:12:39 TREND    1 - PRIMARY
00:12:43 DECREASE TREND DISPLAY TIME SCALE
00:12:44 DECREASE TREND DISPLAY TIME SCALE
```

Figure 25. Event Log Page 7

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 8

00:12:45 DECREASE TREND DISPLAY TIME SCALE
00:12:46 DECREASE TREND DISPLAY TIME SCALE
00:12:47 INCREASE TREND DISPLAY TIME SCALE
00:12:54 SCHEMATIC PAGE 2
00:12:56 SCHEMATIC POINT - HIC-101
00:12:59 HIC-101  OUTPUT =  23.0 PERCENT
00:13:08 HIC-101  OUTPUT =  24.0 PERCENT
00:13:19 HIC-101  OUTPUT =  25.0 PERCENT
00:13:32 HIC-101  OUTPUT =  26.0 PERCENT
00:13:40 HIC-101  OUTPUT =  27.0 PERCENT
00:13:41 FIC-101  - Low Alarm Cleared
00:13:50 HIC-101  OUTPUT =  28.0 PERCENT
00:13:56 HIC-101  OUTPUT =  29.0 PERCENT
00:14:06 HIC-101  OUTPUT =  30.0 PERCENT
00:14:12 HIC-101  OUTPUT =  31.0 PERCENT
00:14:17 TREND  1 - PRIMARY
00:15:03 SCHEMATIC PAGE 2
00:15:05 SCHEMATIC POINT - HIC-101
00:15:07 HIC-101  OUTPUT =  32.0 PERCENT
00:15:32 HIC-101  OUTPUT =  33.0 PERCENT
00:15:41 HIC-101  OUTPUT =  34.0 PERCENT
00:15:50 HIC-101  OUTPUT =  35.0 PERCENT
00:16:01 HIC-101  OUTPUT =  36.0 PERCENT
00:16:10 HIC-101  OUTPUT =  37.0 PERCENT
00:16:18 HIC-101  OUTPUT =  38.0 PERCENT
00:16:27 HIC-101  OUTPUT =  39.0 PERCENT
00:16:45 HIC-101  OUTPUT =  40.0 PERCENT
00:16:52 HIC-101  OUTPUT =  41.0 PERCENT
00:17:02 HIC-101  OUTPUT =  42.0 PERCENT
00:17:10 HIC-101  OUTPUT =  43.0 PERCENT
00:17:22 HIC-101  OUTPUT =  44.0 PERCENT
00:17:31 HIC-101  OUTPUT =  45.0 PERCENT
00:17:39 HIC-101  OUTPUT =  46.0 PERCENT
00:17:54 HIC-101  OUTPUT =  47.0 PERCENT
00:19:05 RUN STATUS = FREEZE
00:19:05 EVENTLOG PAGE 4
00:19:05 EVENTLOG PAGE 3
00:19:05 EVENTLOG PAGE 2
00:19:05 EVENTLOG PAGE 1
00:19:05 EVENTLOG PAGE 2
```

Figure 26. **Event Log Page 8**

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 9

00:19:05 EVENTLOG PAGE 3
00:19:05 EVENTLOG PAGE 4
00:19:05 EVENTLOG PAGE 5
00:19:05 EVENTLOG PAGE 6
00:19:05 EVENTLOG PAGE 7
00:19:05 EVENTLOG PAGE 8
00:19:05 EVENTLOG PAGE 9
```

Figure 27. Event Log Page 9

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.)

Pump Troubleshooting Module (Part 2)
Additional Problems

NOTE: Instructor will need to provide a schematic, P&ID, PFD and/or other tools for students to solve these problems.

Scenario #4 (Paper-Based)

Scenario Statement

Fermentation sludge in an ethanol plant is transferred by a centrifugal pump from an agitated holding tank to a filter system. The pump discharge pressure and temperature interlock to the pump driver.

The process technician has noticed that the pressure and temperature indicators do not vary much with changing process conditions. The technician feels the pump casing, which seems abnormally hot.

The technician checks the pump casing with a handheld infrared temperature gun and finds the temperature 35°F hotter than the pump discharge temperature indicator. Troubleshoot this situation.

Scenario #5 (Paper-Based)

Scenario Statement

A waste water treatment sludge pump discharge routinely becomes plugged in a low point in the discharge piping.

The pump is not equipped with any indicators or interlocks. The process technician has learned by experience that the pump must be shut down quickly whenever discharge flow either slowly begins to fall-off or abruptly stops.

The technician then back-flushes the discharge line, restarts the pump and re-establishes the flow. Troubleshoot this situation.

Scenario #6 (Paper-Based)

Scenario Statement

A fire water system pump is designed to occasionally start automatically to test the driver. The system design is such that the pump discharge is deadheaded during these automatic tests.

On a few occasions, the pump has failed to cut off at the end of the automatic driver test. Troubleshoot this situation.

SCENARIO #7 (PAPER-BASED)

Scenario Statement

An experienced process technician is mentoring a new-hire. The new-hire is instructed to switch from an operating positive displacement pump to its spare.

The arrangement has a common recycle header. The new-hire properly lines up the spare and successfully places it in parallel service with the operating pump.

Having been previously trained on centrifugal pump switching procedures, the new hire begins next to isolate the initial operating pump from the common recycle header and, following his centrifugal pump training, next begins to close the discharge on the initial operating pump. Troubleshoot this situation.

PERFORMANCE ASSESSMENT ACTIVITY #1
PAPER-BASED PROBLEM

Learner Directions: In this assessment, you will analyze and solve a paper-based pump over-heating/over-pressurization 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 over-heating/over-pressurization problems associated with a pump.

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: To be determined by the instructor. Example: Satisfactory performance requires learner must meet all criteria on the checklist.

PUMP TROUBLESHOOTING RUBRIC
PAPER-BASED PROBLEM

Competency: Troubleshoot over-heating/over-pressurization problems associated with a pump.

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 over-heating/over-pressurization pump 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 over-heating/over-pressurization problems associated with a pump.

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 ± 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.”

Pump Troubleshooting Rubric
Simulator-based Problem

Competency: Troubleshoot over-heating/over-pressurization problems associated with a pump.

Criteria	Scale			
Product				
1. Process equipment is stabilized.	4	3	2	1
2. System is returned to within $\pm$ 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

Bibliography

Andrews, D. B. (2011). *The Danger of Blocked-in Pumps*. Retrieved from Run Times, Lawrence Pumps, Inc.: www.lawrencepumps.com/Newsletter/news_v08_i1_jan11.html

Casey, B. (2007, March). *The Negative Effects of Overpressurization on Hydraulic Components*. Retrieved from Machinery Lubrication: www.machinerylubrication.com/Read/1006/overpressurization-hydraulics

Casey, B. (2008). *A Serious Consequence of Over-pressuring Your Hydraulic System*. Retrieved from Insider Secrets to Hydraulics: www.insidersecretstohydraulics.com/cylinder-block-separation.html

Casey, B. (2012). *The Negative Effects of Over-pressurization*. Retrieved from Fluid Power Journal: www.fluidpowerjournal.com/images/Articles/2012/MD/FPJMD12_Negative.pdf

Circulatory Technology, Inc. (1998). *The Better Header™*. Retrieved from Circulatory Technology, Inc.: www.cirtec.com/images/bhflyer.PDF

Driedger, W. (2000, May 20). *Controlling Positive Displacement Pumps*. Retrieved from Controlling Equipment: www.driedger.ca/ce2_pdp/CE2_PDP.html

Edwards Pentair Water. (n.d.). *Edwards Model 20/Model 80 Pump Maintenance Manual*. Retrieved from Edwards Pentair Water: http://edwardsmfg.com/manuals/Model%2020_Model%2080%20Manual%20LR.pdf

Filter Manufacturers Council. (2005, October). *Over Pressurized Lube Oil Filters*. Retrieved from Automotive Aftermarket Suppliers Association: www.aftermarketsuppliers.org/Councils/Filter-Manufacturers-Council/TSBs-2/English/83-1R2.pdf

Firstam Pumps. (2010). *Instruction and Maintenance Manual*. Retrieved from PureServe Systems: www.pureservesystems.com/assets/pdf/fristam-pumps-sanitary-positive-displacement-pd-fkl-series-25-580-instruction-maintenance-manual.pdf

Hazen, M. W. (2007, October 7). *MN471000, Pressure Safety Manual*. Retrieved from Sandia National Labratories: www.sandia.gov/esh/supplements/mn471000/m000c10.htm#20

O'Connor, B. P. (2006, March 16). *Centrifugal Pump Explosions*. Retrieved from Lawrence Pumps, Inc: www.lawrencepumps.com/Documents/Pump%20explosions%20Amplats.pdf

Pulsafeeder. (2011, January). *PULSAR Hydraulic and Mechanical Metering Pumps*. Retrieved from Pulsafeeder: www.pulsa.com/downloads/pdf/Pulsar-Brochure-EN.PDF

Risk Logic, Inc. (2007, April). *Changes to NPFA 20*. Retrieved from Risk Logic: www.risklogic.com/articles/apr2007.html#

SOR, Inc. (2011). *SOR Application Case Study: Sludge Pump Over Pressurization Protection*. Retrieved from SOR Measurement and Control: www.sorinc.com/docs/Press%20Switch%20App_Sludge%20Pump%20Protection_1520.pdf

Tecumseh Group. (2007, May). *Thermal Expansion of a Trapped Liquid*. Retrieved from Eng Tips: www.eng-tips.com/faqs.cfm?fid=1339

The Over Pressure Valve (OPV) or Expansion Valve. (n.d.). Retrieved from Coffeetime: http://coffeetime.wikidot.com/opv-over-pressure-valve

U.S. Nuclear Regulatory Commission. (1989, June 23). *Potential Overpressurization of the component Cooling Water System*. Retrieved from United States Nuclear Regulatory Commission: www.nrc.gov/reading-rm/doc-collections/gen-comm/info-notices/1989/in89054.html

Viking Pump, Inc. (2012). *Pumping Fuel and Fuel Oil*. Retrieved from Pump School: www.pumpschool.com/applications/fueloil.asp