PUMP TROUBLESHOOTING MODULE
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.

Competency	Performance Standards
Troubleshoot cavitation problems associated with a pump	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 ± 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, applications, and types of pumps.
2. Recall and discuss cavitation problems associated with pumps.
3. Describe immediate actions a process technician could take to solve a pump cavitation 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 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 cavitation 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 cavitation 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 cavitation 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 pump cavitation problem.	Lecture on actions not captured and elucidate 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 pump cavitation 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. Two 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 cavitation 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 three simulation problems is provided in this lesson plan. Address learning objective 5.

PUMP TROUBLESHOOTING MODULE
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.

Positive displacement pumps include reciprocating and rotary designs. For these types of pumps (as the name implies), whatever fluid is drawn into the suction of the pump must be discharged; otherwise, the pressure will rise abnormally high. Thus, the discharge side of an operating positive displacement pump must never be closed or throttled. Although most positive displacement pumps are equipped with either internal or external pressure relief devices, there is still a chance that a relief device could malfunction.

The process technician must have a basic understanding of troubleshooting techniques to recognize and prevent damage to a pump during abnormal conditions. A number of problems can occur with pumps that the process technician may need to address while working within a process unit. Potential problems include cavitation, vibration, over-heating, over-pressurization, and leaks.

Cavitation is one of the more serious problems affecting pump performance. One source defines cavitation in process pumps and certain other mechanical devices as, "The sudden formation and collapse of low-pressure bubbles in liquids by means of mechanical forces, such as those resulting from rotation of a marine propeller" (Farlex, Inc., 2012).

This form of cavitation, sometimes called **pure-cavitation**, results from the temperature/vapor pressure relationships of the liquid components of the stream being pumped. The formation and subsequent collapsing of the bubbles creates noise and vibration. The noise is often described as the erratic sound of "rattling" marbles.

Within a centrifugal pump, most cases of pure-cavitation begin at the suction eye where the flow area is smaller than that of the suction piping or impeller vanes.

"The decrease in flow area results in an increase in flow velocity accompanied by a decrease in pressure. The greater the pump flow rate, the greater the pressure drop between the pump suction and the eye of the impeller" (Engineers Edge, 2012b). Pump manufacturers specify a Net Positive Suction Head Required ($NPSH_R$) for a pump to effectively operate and pump a given stream (Note: NPSH is typically stated in absolute pressure, not gauge pressure.) The Net Positive Suction Head Available ($NPSH_A$) from the system at the pump suction must meet or exceed the manufacturer's $NPSH_R$ if the pump is to operate properly. When $NPSH_A$ is less than $NPSH_R$, "the pressure drop may be sufficient to cause the liquid to flash to vapor when the local pressure falls below the saturation pressure for the fluid being pumped...[The] vapor bubbles...are swept along the impeller vanes by the flow of the fluid. When the bubbles enter a region where local pressure is greater than saturation pressure farther out along the impeller vane, the vapor bubbles abruptly collapse" (Engineers Edge, 2012b).

A second type of cavitation, sometimes called **pseudo-cavitation**, can occur when non-condensable gases are present in excessive amounts in the stream being pumped. When non-condensable gases reach five to eight percent, pseudo-cavitation occurs. Because the bubbles do not collapse as happens in pure-cavitation, the gases tend to accumulate in the suction, flow is inhibited, and head is not generated. If this condition continues, the pump will lose its prime (LaBour Pumps, 2005). As these non-condensable bubbles do not collapse, a constant pitched whining sound occurs from the pump as the bubbles pass through.

Both types of pump, dynamic or positive displacement, can experience pure-cavitation and pseudo-cavitation.

The experienced operator, when troubleshooting a pump problem, can easily differentiate between pure-cavitation and pseudo-cavitation noises. Cavitation generally produces excessive pump vibration. Whether the problem is pure-cavitation or pseudo-cavitation, short-term impacts include reduced pumping efficiency and fluctuating discharge pressure and flow. This, in turn, serves to slow production. In severe cases, especially where combustible or easily decomposed materials are pumped through the process, the potential exists for catastrophic fires, explosions or equipment destruction. The loss of pump efficiency can lead to deterioration of product quality.

Cavitation in dynamic pumps can lead to varying degrees of internal recycle. Internal recycle is the slippage of fluid from the impeller blade or its tip (higher pressure area) back to the impeller eye (lowest pressure area). Internal recycle can also increase: (a) when discharge flows are throttled or stopped, (b) when prime or suction flow is lost, (c) with open-faced versus semi-faced or fully enclosed impellers and (d) when significant clearance exists between the impeller tip and the pump casing. Uncorrected, extreme internal recycle can lead to serious overheating of the fluid being pumped along with loss of process flow and pressure.

In the long-term, unchecked, prolonged cavitation will result in pitting and weakening of pump components. This is due primarily to: (a) the erosive mechanical forces of the collapsing bubbles and the attendant vibration in pure-cavitation and (b) inertial impacts caused by liquid voids in pseudo-cavitation. Excessive vibrations can damage pump bearings, seals and wearing rings. Chemical corrosion could also increase, resulting from composition changes and higher temperatures. Uncorrected, pump cavitation will lead to equipment failure.

Multiple solutions exist to avoid or correct a cavitation problem. Some solutions are within the immediate control of the process technician, while others require mechanical repairs and/or engineering changes to the system.

Process Background

Process feed flow liquid enters mix tank T-100 through FIC-201 flow controller. The feed flow is cooled by passing through the shell side of heat exchanger E-100 that utilizes cooling water on the tube side. Tank T-100 pressure is controlled with PIC-301 by either allowing nitrogen to enter the tank if pressure is low or allowing vapor to exit the tank via the vent line. Mixed feed liquid is pumped to the continuous reactor by PUMP-100 A or PUMP-100B. A level controller (LIC-202) controls the level in the tank by changing the flow of discharge liquid from the pump through FIC-202. The schematic for the process is shown in Figure 1.

Equipment Specifications

Heat Exchanger – The heat exchanger cools the process flow inlet upstream of the mix tank. The process flows through the shell side of the exchanger and is cooled with cooling water on the tube side of the exchanger.

Tank – A motor-driven agitator on a tank (T-100) mixes the cooled process flow with additive. The mixture is used as feed for a reactor.

Pumps – Both pumps within the unit are horizontally-mounted centrifugal pumps. PUMP-100B is the auxiliary pump.

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

Valves – The pumps (PUMP-100A and PUMP-100B) can be independently isolated by manual valves on the suction and discharge sides of the pump.

Instrumentation – Discharge to the reactor is set by the level in the mix tank. The FIC-202 flow controller can be run independently of the level if needed.

Pressure is maintained on the tank (T-100) by PIC-301 in split-range operation to either allow nitrogen into the tank or vapor to exit the tank through the vent line.

The level instrumentation is running in design mode with LIC-202 in automatic and FIC-202 in cascade.

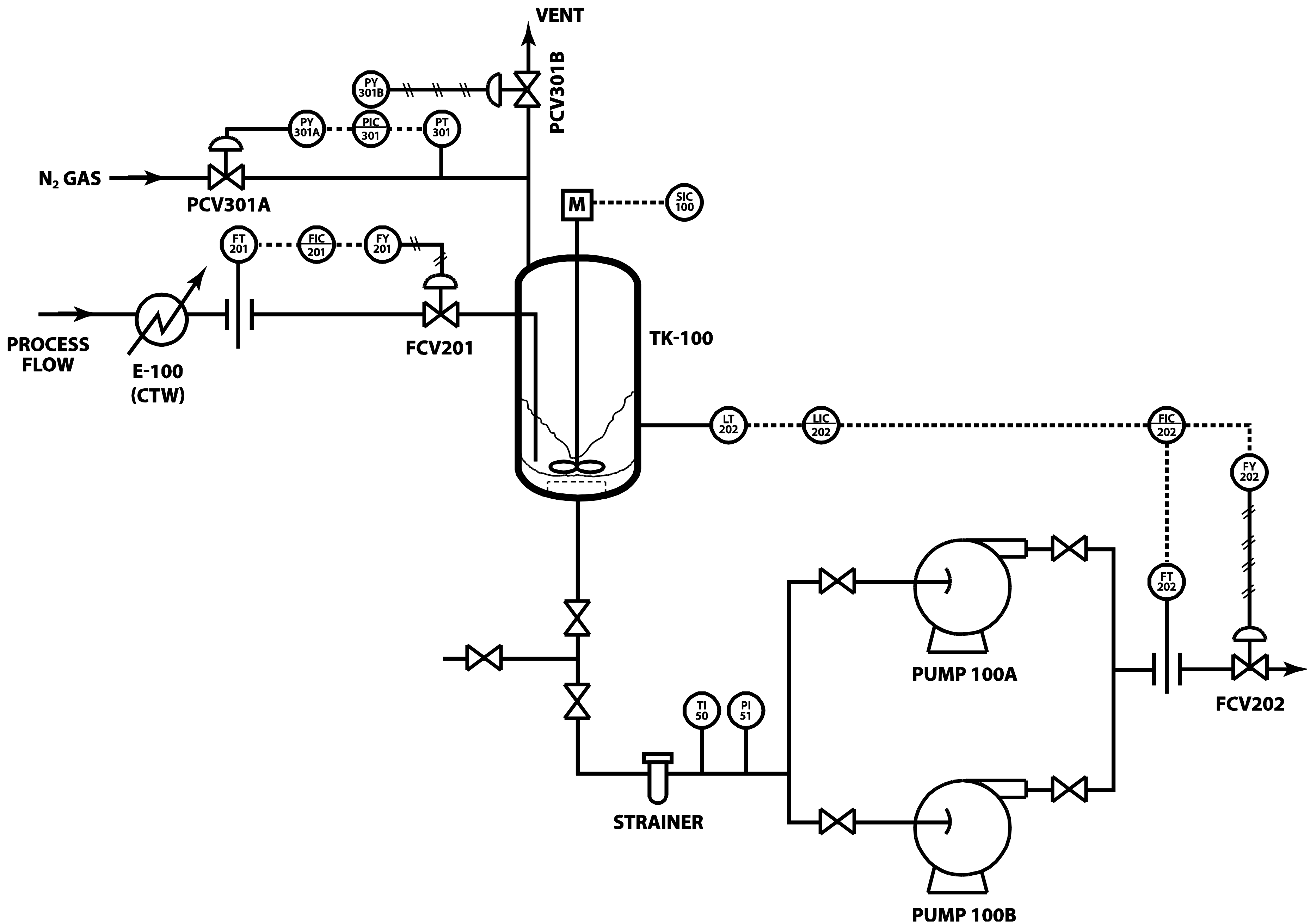

Figure 1. Process Schematic

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

Tag ID	Description	Design Value	Eng. Units	Output Percent
FIC-201	INLET FEED FLOW CONTROLLER	100	GPM	45.0%
FIC-202	PUMP DISCHARGE FLOW CONTROLLER	100	GPM	58.0%
LIC-202	TANK LEVEL CONTROLLER	50	%	
PI-51	PUMP SUCTION PRESSURE	33	PSI	
PIC-301	TANK PRESSURE CONTROLLER	27	PSI	
PUMP-100A	CENTRIFUGAL PUMP	ON	N/A	
PUMP-100B	CENTRIFUGAL PUMP	OFF	N/A	
PCV-301A	NITROGEN SUPPLY CONTROL VALVE	N/A	N/A	23.0%
PCV-301B	TANK VENT CONTROL VALVE	N/A	N/A	0.0% (NORMALLY CLOSED)
SIC-100	TANK MIXER SPEED CONTROL	500	RPM	
TI-50	PUMP SUCTION TEMPERATURE	100	°F	
CTW	COOLING TOWER WATER SUPPLY	75	°F	

Compensating and Corrective Actions

Compensating and corrective actions that the process technician might take if a pump is cavitating are highlighted following. If the problem is pure-cavitation, then the solution is taking actions to either increase the $NPSH_A$ or to reduce the $NPSH_R$ at the pump suction.

Increasing $NPSH_A$

a. Reduce resistances in the pump suction-side piping and arrangement:
   - — *If a suction-side valve is partially throttled, then open it.*
   - — *If a suction-side strainer or filter has a high pressure drop, then clean or backwash it.*
   - — *If the suction-side piping is partially plugged or fouled, then clear it.*

b. Increase suction-side liquid level or delivery pressure:
   - — *Increase process stream level (head) in an atmospheric or enclosed pump tank.*
   - — *Increase gas phase pressure on an enclosed pump tank.*
   - — *Increase upstream pressure of feed to pump if no pump tank.*
   - — *Reduce suction tank agitator speed if so equipped.*

c. Reduce agitator speed on the head tank to reduce vortex and increase effective level.

d. Reduce process stream temperature:
   - — *Cool process flow upstream if possible.*

Decreasing NPSHR

a. Throttle pump discharge valve or reduce variable pump speed, thereby slowing flow and reducing NPSHR (possible negative impact on production).

b. Place spare parallel pump in service if available, thereby reducing flow demand and NPSHR on individual pumps without affecting production.

Other Actions

a. Increase recycle on positive displacement pumps (quick, but also not preferred).

b. Check for process nitrogen or other non-condensable intrusion causing pseudo-cavitation by pressure or venturi effect:
   - — *Are there open or leaking suction line block and bleeds or air purge lines?*
   - — *Test for leaking pump seals by flow-flooding with water if permissible.*
   - — *Are there leaking suction flanges, pipe connections, or holes in the pipe?*
   - — *Is the air or nitrogen seal purge flow or pressure too high?*

c. Is the enclosed suction feed tank completely blocked in?

PUMP TROUBLESHOOTING MODULE
SELF-CHECK QUESTIONS

1. Explain the difference between pure-cavitation and pseudo-cavitation.

   In pure-cavitation, bubbles form and collapse within the liquid stream inside the pump. In pseudo-cavitation, bubbles are present within the liquid stream when it enters the pump and these bubbles do not collapse.

2. List four observations that would indicate pump cavitation is occurring.

   a. Unusual pump noise

   b. Unusual pump vibration

   c. Pump casing hotter than normal

   d. Discharge pressure and flow erratic and lower than normal

3. List five possible short-term impacts of pump cavitation.

   a. Reduced or loss of pressure and flow

   b. Production slowed

   c. Deteriorated product quality

   d. Pump overheating and parts damage

   e. Possible fire or explosion

4. List three possible long-term impacts of pump cavitation.

   a. Impellor and casing pitting, erosion and eventual failure

   b. Chemical corrosion of parts and eventual failure

   c. Rotary seal, bearing and piston ring failures

5. What must the relationship between $NPSH_A$ and $NPSH_R$ be to avoid cavitation?

   The Net Positive Suction Head Available ($NPSH_A$) from the system at the pump suction must meet or exceed the manufacturer's $NPSH_R$.

6. List five longer-term maintenance and engineering design actions that could solve chronic cavitation problems.

   - *Increase pump suction line size, change valve types or remove other restrictions*
   - *Install parallel pump for peak production or high ambient temperature periods*
   - *Install vortex breaker in suction feed tank bottom*
   - *Install new pump with less NPSH requirement*
   - *Change pump seals on preventive maintenance schedule*
   - *Increase relative suction line elevation or lower relative pump elevation*

PUMP TROUBLESHOOTING MODULE
SCENARIO #1 (PAPER-BASED)

Scenario Statement

The control room technician reports to the field operator that flow from the centrifugal solvent feed pump to the continuous reactor is oscillating wildly, creating reaction problems. The field technician investigates and confirms that the discharge flow is indeed oscillating. The pump is making a “rattling” noise. The solvent feed temperature is rising and the pump casing feels hotter to touch than normal (NOTE: Solvent feed is labeled process flow on Figure 1). Troubleshoot this situation.

Abnormal Operating Conditions

The values and output percentages for instrumentation and equipment during abnormal operating conditions for Scenario #1 are shown in Table 2.

Table 2. Values and Output Percentages for Instrumentation and Equipment During Abnormal Operating Conditions for Scenario #1

Tag ID	Description	Value	Eng. Units	Output Percent
FIC-201	INLET FEED FLOW CONTROLLER	25	GPM	78.0%
FIC-202	PUMP DISCHARGE FLOW CONTROLLER	20	GPM	89.0%
LIC-202	TANK LEVEL CONTROLLER	35	%	
PI-51	PUMP SUCTION PRESSURE	20	PSI	
PIC-301	TANK PRESSURE CONTROLLER	27	PSI	
PUMP-100A	CENTRIFUGAL PUMP	ON	N/A	
PUMP-100B	CENTRIFUGAL PUMP	OFF	N/A	
PCV-301A	NITROGEN SUPPLY CONTROL VALVE	N/A	N/A	35.0%
PCV-301B	TANK VENT CONTROL VALVE	N/A	N/A	15.0%
SIC-100	TANK MIXER SPEED CONTROL	500	RPM	
TI-50	PUMP SUCTION TEMPERATURE	155	°F	
CTW	COOLING TOWER WATER SUPPLY	75	°F	

Cause

Loss of process flow into tank

Investigative Actions

Check FCV-201 valve position in the field. Check FCV-201 valve positioner.

Check stem linkage to be intact.

Check air supply line to diaphragm.

If valve position and operation are normal, then problem is upstream.

Compensating Actions

Put FIC-202 in manual and lower the output percentage.

Check the tank level for increase.

Check the pump casing for return to normal temperature.

If not, switch to auxiliary pump.

Run at reduce rates and/or shut the system down if feed cannot be restored.

Corrective Actions

Correct problems associated with FCV-201 or upstream process.

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

7. Determine alternative solutions and select solution.

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

____

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.)*

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

PUMP TROUBLESHOOTING MODULE
SCENARIO #2 (PAPER-BASED)

Scenario Statement

The control room technician notices that FIC-201 is decreasing. As a result, LIC-202 also decreases, causing PUMP-100A to cavitate. The field technician reports that PI-51 is oscillating. Feed to the reactor is gradually dropping. The control room technician notices PIC-301 is above maximum but no alarms are indicated. 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 3.

Table 3. Values and Output Percentages for Instrumentation and Equipment During Abnormal Operating Conditions for Scenario #2

Tag ID	Description	Value	Eng. Units	Output Percent
FIC-201	INLET FEED FLOW CONTROLLER	15	GPM	100.0%
FIC-202	PUMP DISCHARGE FLOW CONTROLLER	12	GPM	23.0%
LIC-202	TANK LEVEL CONTROLLER	20	%	
PI-51	PUMP SUCTION PRESSURE	17	PSI	
PIC-301	TANK PRESSURE CONTROLLER	63	PSI	
PUMP-100A	CENTRIFUGAL PUMP	ON	N/A	
PUMP-100B	CENTRIFUGAL PUMP	OFF	N/A	
PCV-301A	NITROGEN SUPPLY CONTROL VALVE	N/A	N/A	0.0%
PCV-301B	TANK VENT CONTROL VALVE	N/A	N/A	100.0%
SIC-100	TANK MIXER SPEED CONTROL	500	RPM	
TI-50	PUMP SUCTION TEMPERATURE	78	°F	
CTW	COOLING TOWER WATER SUPPLY	75	°F	

Cause

Loss of feed to tank

Investigative Actions

Check the flow control loop.

If working properly, then check the pressure control loop to the tank.

Compensating Action

Put FIC-202 in manual and lower the output percentage.

Check the tank level for increase.

Check the pump casing for return to normal operations. If not, switch to auxiliary pump.

Run at reduce rates and/or shut the system down if feed cannot be restored.

If available, open a bypass to vent.

Corrective Actions

Repair the pressure control valve that is not operating properly or disassemble and clean the process vent piping.

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

7. Determine alternative solutions and select solution.

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

____

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
SCENARIO #3 (SIMULATOR-BASED)

Simulator Programming

The following table includes information needed for the instructor to program the fault for a pump cavitation simulation exercise. The fault has 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 4. Fault Programming Information for Scenario #3

Descriptor	1- Pump Speed %	**Signal**	100.00	**Rise**	10.00
Status	Idle	**Normal**	100.00	**Start**	00:00:50
Direction	Fail High	**High**	100.00	**Stop**	00:00:00
Function	Sine Wave	**Low**	20.00	**Delay**	00:00:05

Scenario Statement

This Scenario is an example of cavitation on a centrifugal pump.

Cause

Mechanical issue with SIC-101 or the motor

Compensating Action

Compensating actions are documented in the event log.

Corrective Actions

Maintenance should check the motor on the primary pump and/or instrumentation technicians should check SIC-101.

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

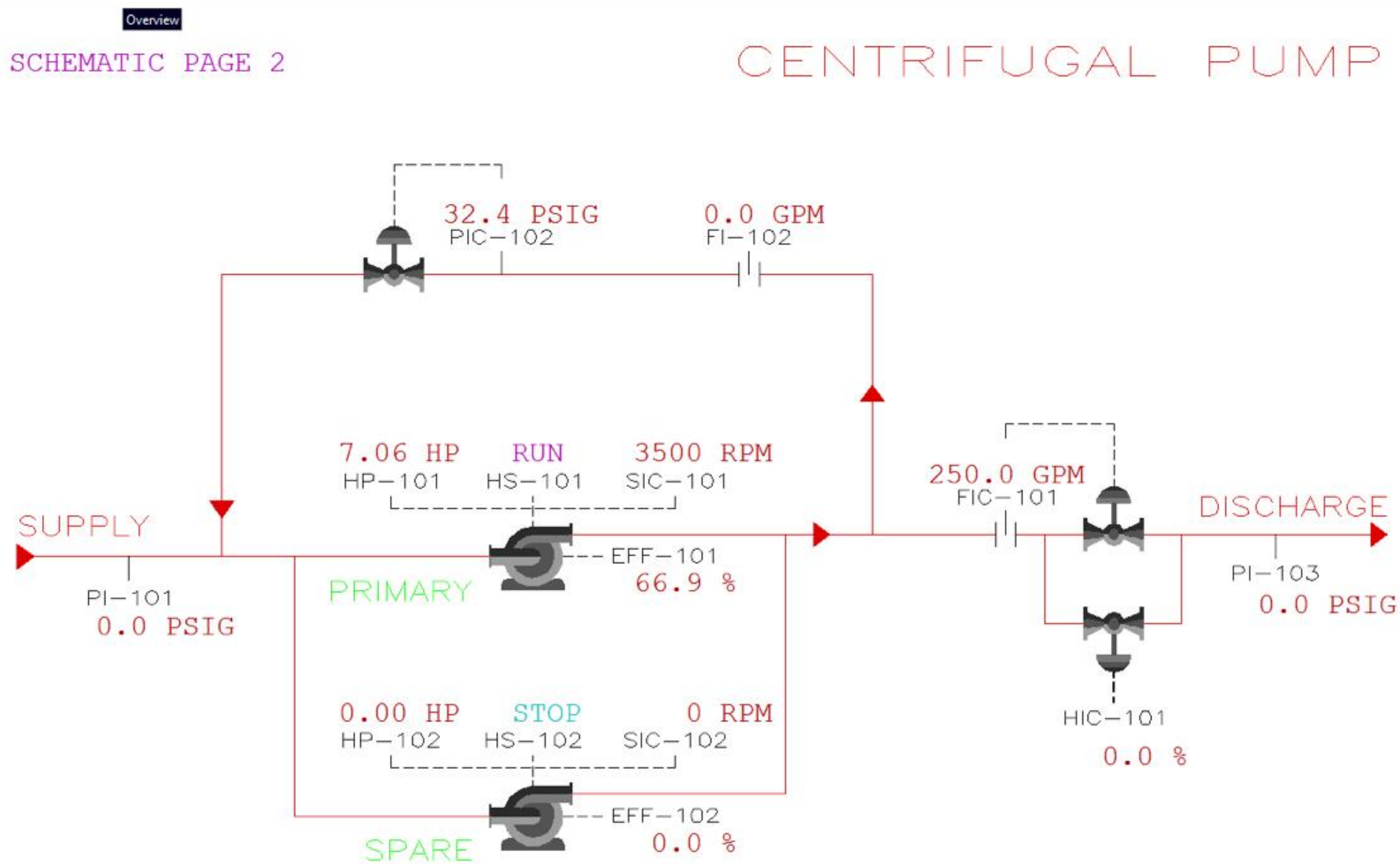


Figure 2. **Screen shot during normal operation (Scenario #3)**

Courtesy of Simtronics Corporation

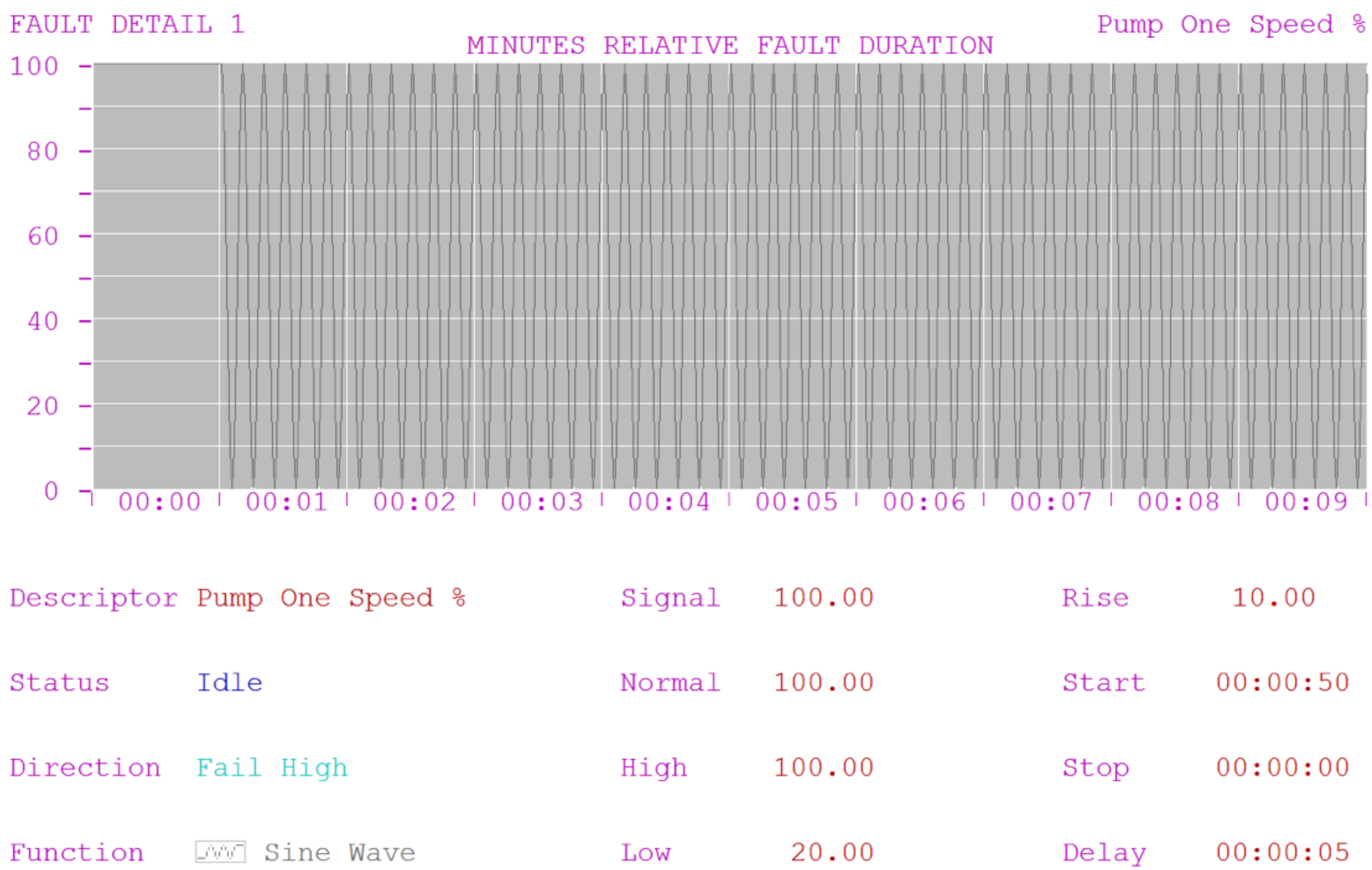


Figure 3. Fault function generator page (Scenario #3)

Courtesy of Simtronics Corporation

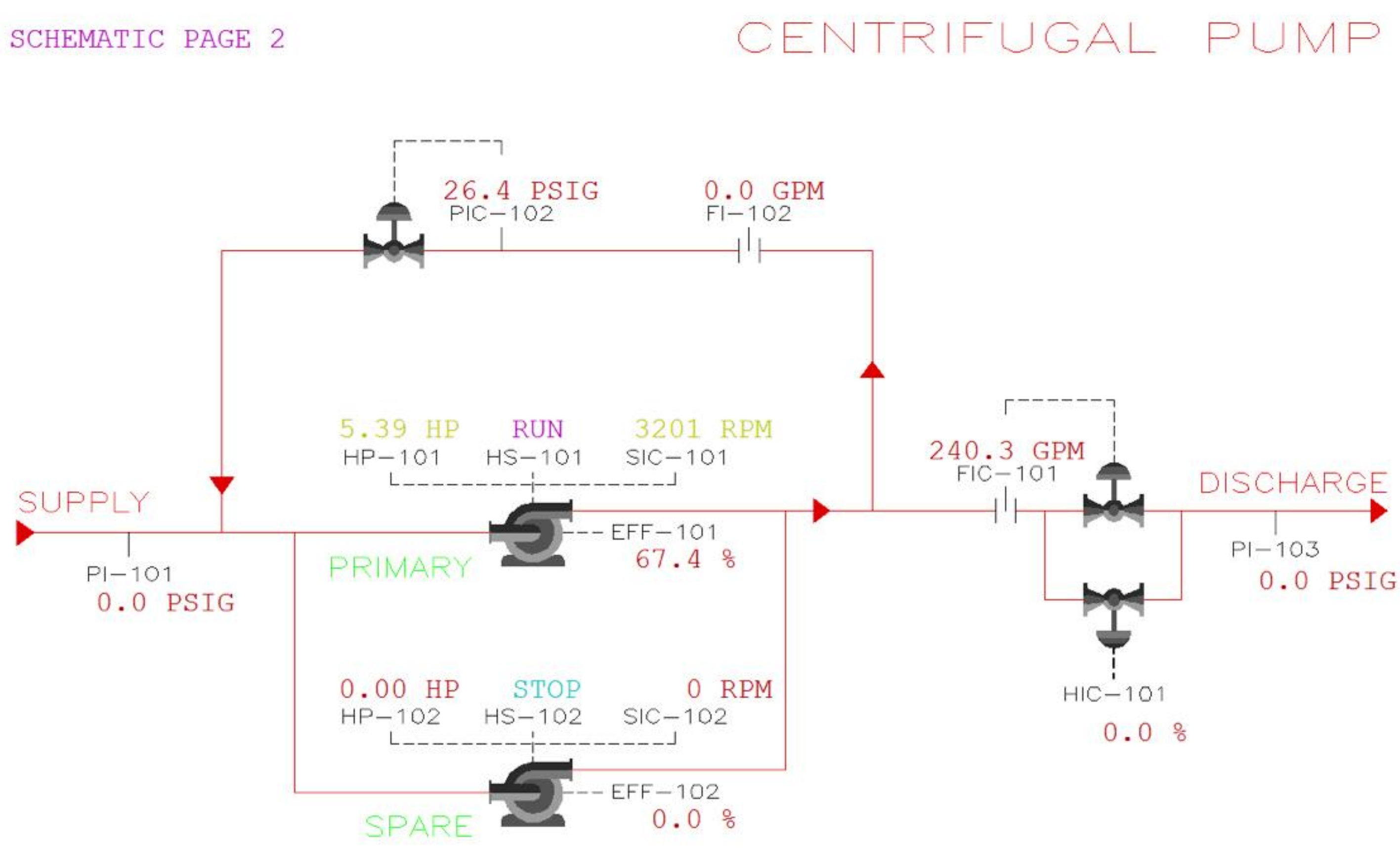


Figure 4. Abnormal conditions – 1st screen shot at 1 minute, 4 seconds (Scenario #3)

Courtesy of Simtronics Corporation

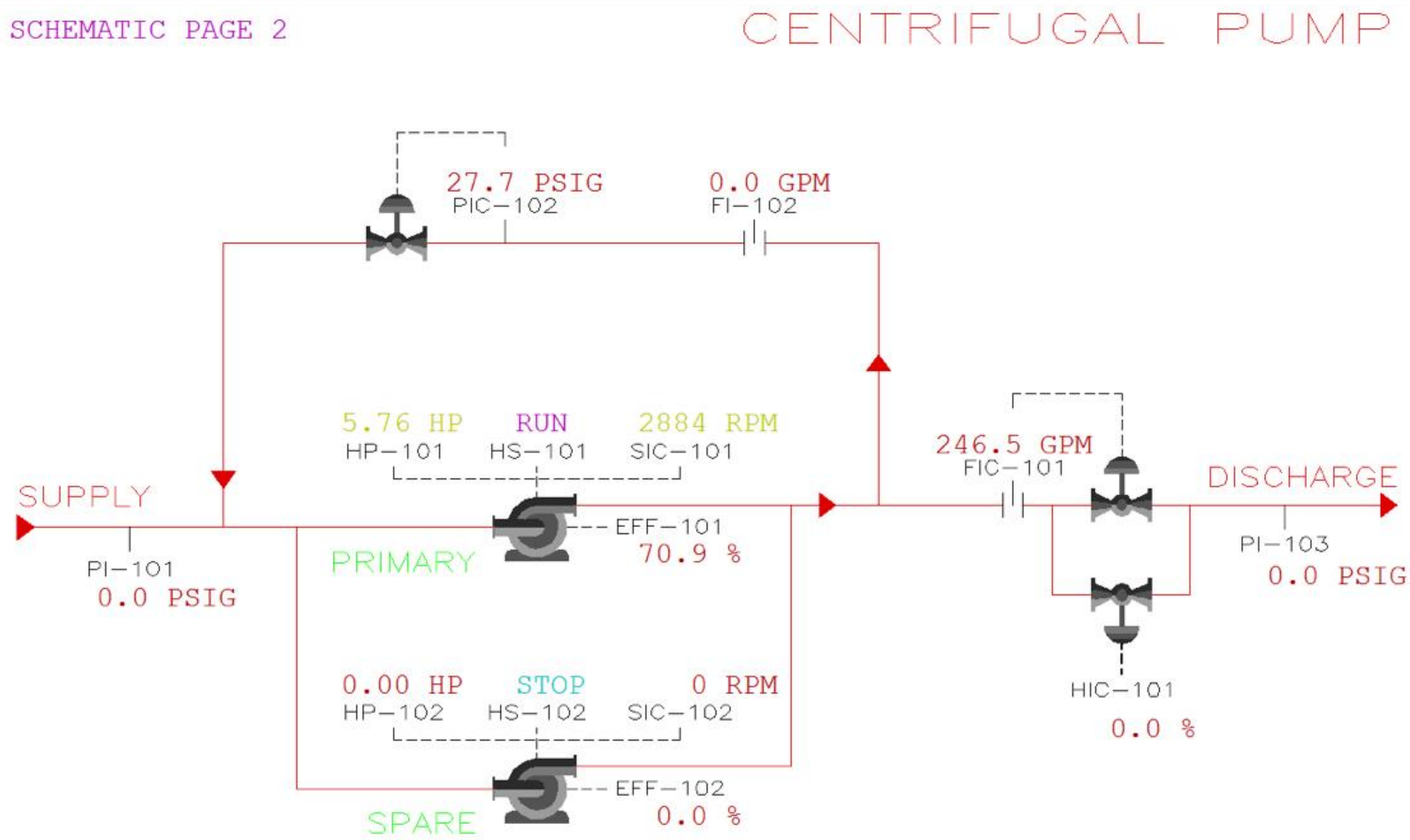
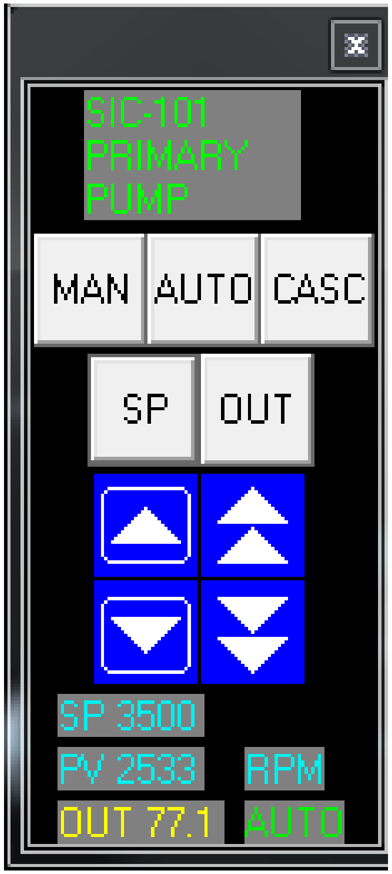


Figure 5. Abnormal Conditions – 2nd screen shot at 1 minute, 27 seconds (Scenario #3)

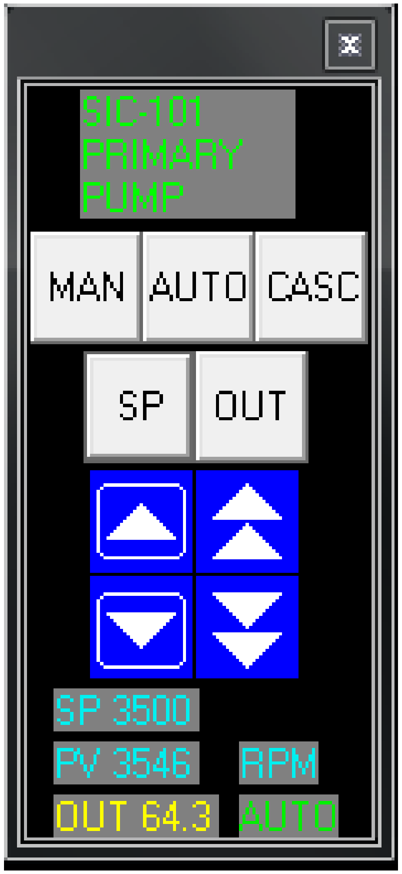
Courtesy of Simtronics Corporation

Speed controller SIC-101 on Pump 101

Auto, Speed Down



Auto, Speed Up Slightly



Switch to Manual While Pump 101 Online (Attempt to Slow Down Surge)

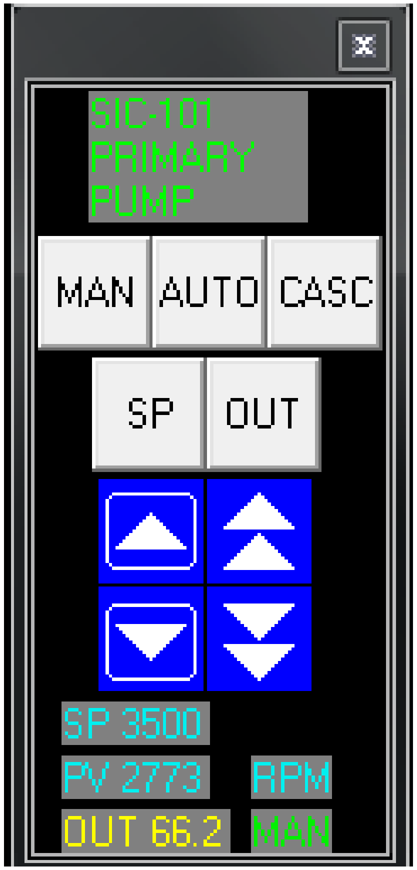


Figure 6. Faceplates when technician is trying to compensate (Scenario #3)

Courtesy of Simtronics Corporation

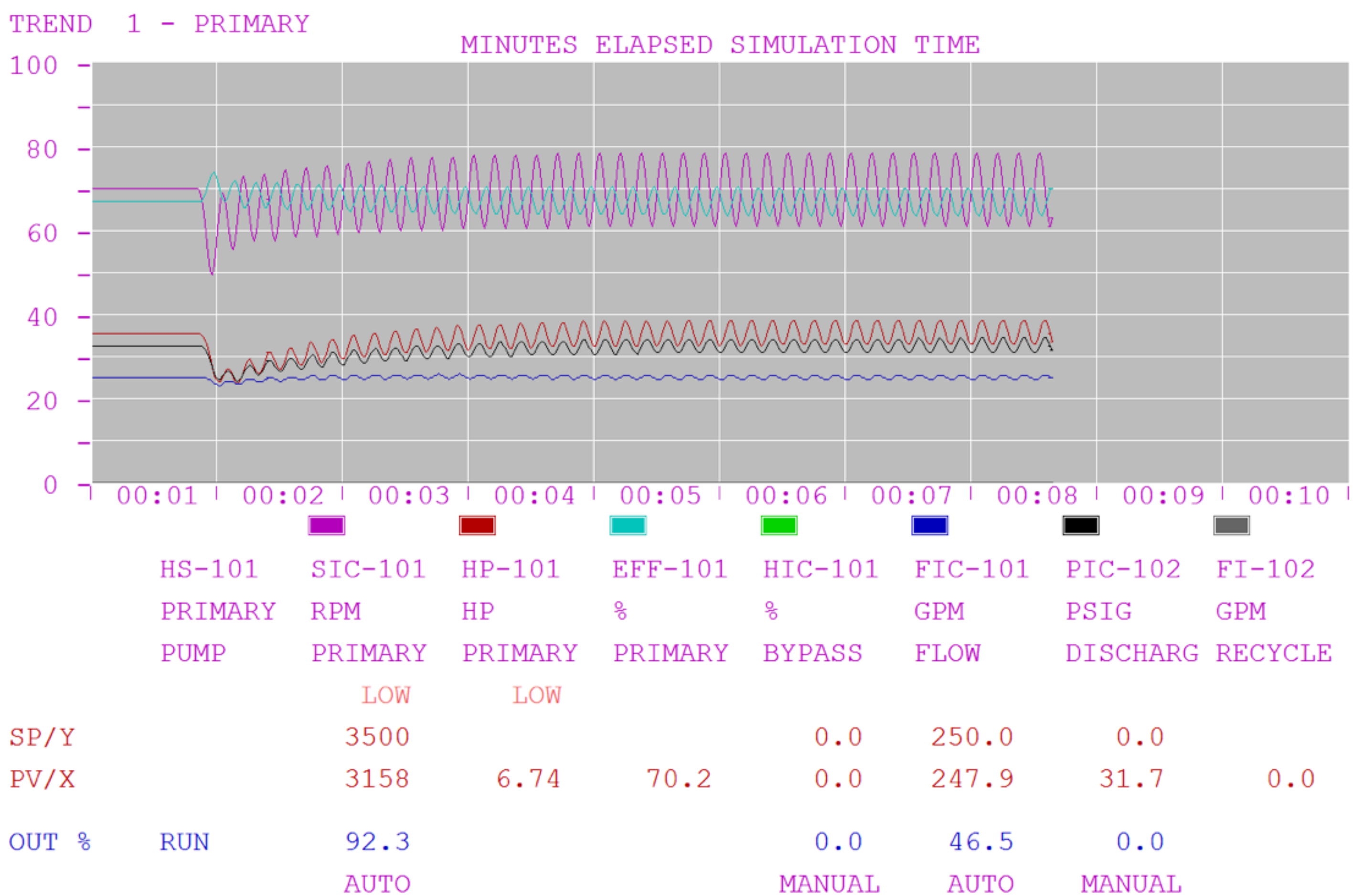


Figure 7. Trend during Scenario (Scenario #3)

Courtesy of Simtronics Corporation

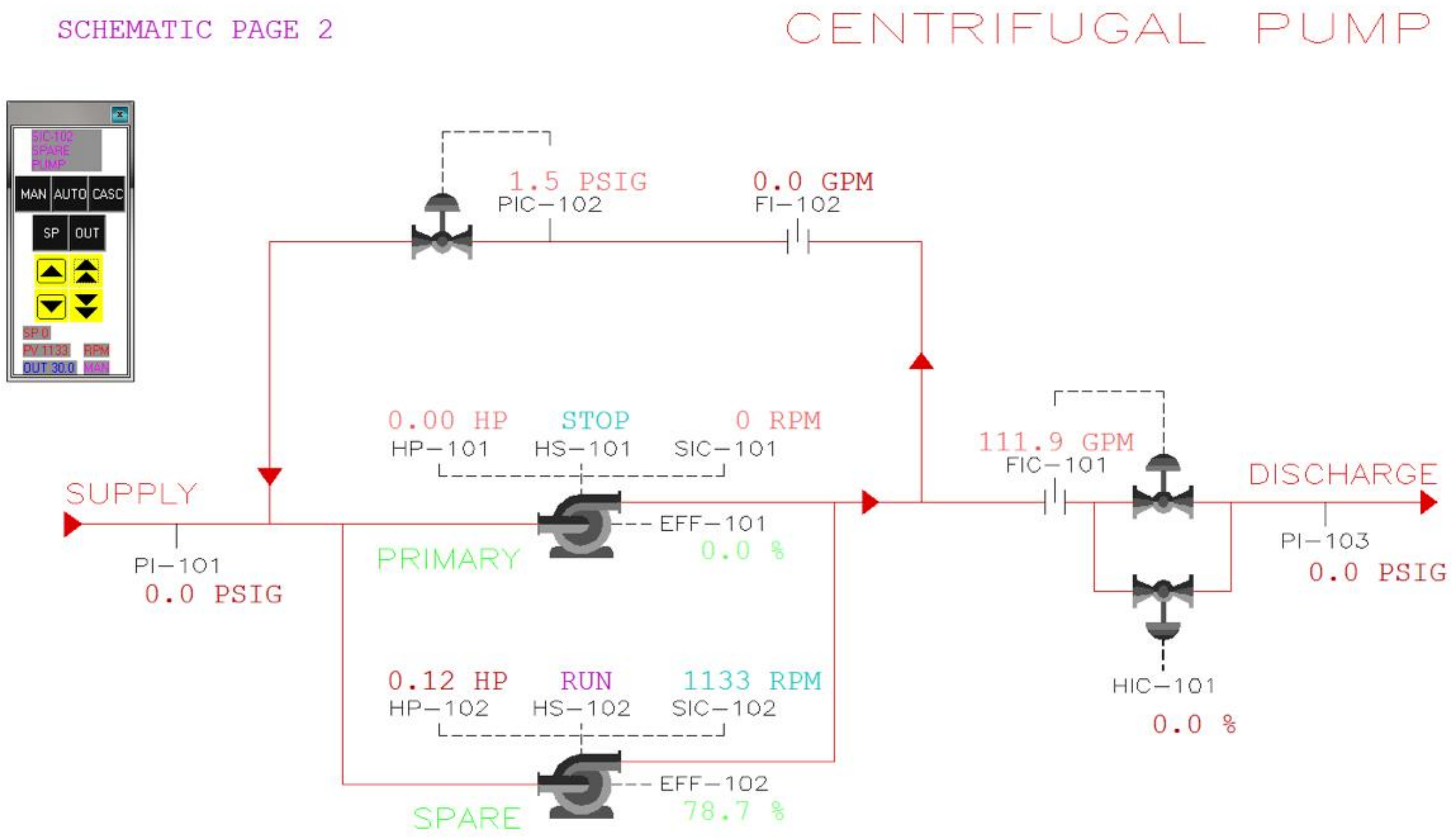


Figure 8. Screen shot after switching pumps (Scenario #3)

Courtesy of Simtronics Corporation

Speed controller SIC-102 on Pump 102

Manual

Manual

Auto

Figure 9. Faceplate – bringing on spare pump (Scenario #3)

Courtesy of Simtronics Corporation

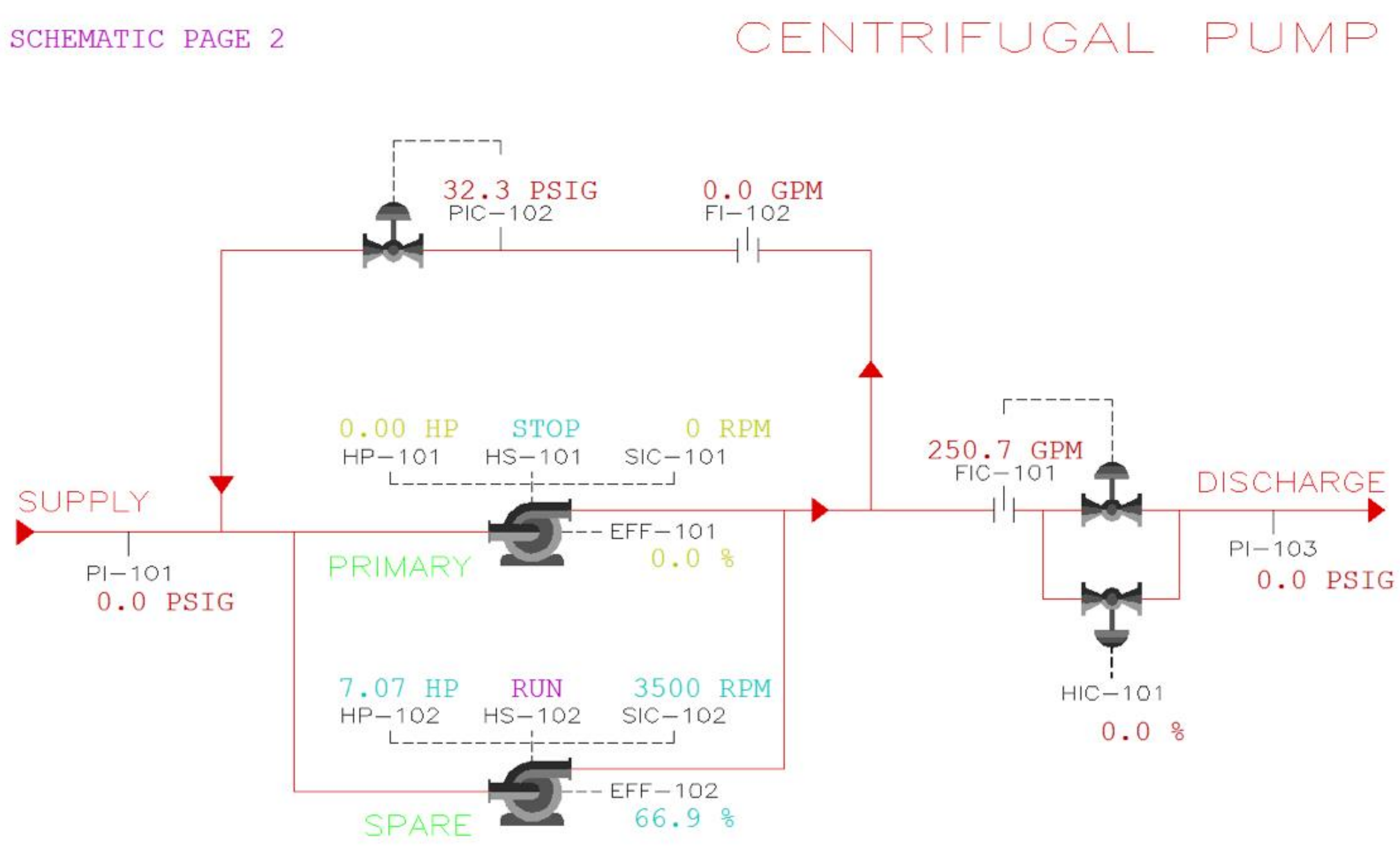


Figure 10. Process at steady-state after compensating actions (Scenario #3)

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
00:00:03 RUN STATUS = FREEZE
00:00:03 SCHEMATIC PAGE 2
00:00:03 INSTRUCTOR PAGE 2 - Initial Conditions
00:00:03 INSTRUCTOR PAGE 27 - Faults
00:00:03 FAULT POINT - Pump One Speed %
00:00:03 FAULT DETAIL 1 - Pump One Speed %
00:00:03 Pump One Speed % FUNCTION = SQUARE WAVE
00:00:03 Pump One Speed % DELAY = 00:00:01
00:00:03 Pump One Speed % FUNCTION = STAIRCASE
00:00:03 Pump One Speed % DELAY = 00:00:01
00:00:03 Pump One Speed % FUNCTION = STAIRS
00:00:03 Pump One Speed % DELAY = 00:00:01
00:00:03 Pump One Speed % FUNCTION = RAMP
00:00:03 Pump One Speed % DELAY = 00:00:01
00:00:03 Pump One Speed % FUNCTION = SAWTOOTH
00:00:03 Pump One Speed % DELAY = 00:00:01
00:00:03 Pump One Speed % FUNCTION = SLOPE
00:00:03 Pump One Speed % DELAY = 00:00:01
00:00:03 Pump One Speed % FUNCTION = SINE WAVE
00:00:03 Pump One Speed % DELAY = 00:00:01
00:00:03 Pump One Speed % FUNCTION = STEP CHANGE
00:00:03 Pump One Speed % DELAY = 00:00:01
00:00:03 Pump One Speed % FUNCTION = SINE WAVE
00:00:03 Pump One Speed % DELAY = 00:00:01
00:00:03 Pump One Speed % DELAY = 00:00:01
00:00:03 Pump One Speed % LOW =  20.00
00:00:03 Pump One Speed % START = 00:00:10
00:00:03 Pump One Speed % START = 00:00:20
00:00:03 Pump One Speed % START = 00:00:30
00:00:03 Pump One Speed % START = 00:00:40
00:00:03 Pump One Speed % START = 00:00:50
00:00:03 Pump One Speed % DELAY = 00:00:02
00:00:03 Pump One Speed % DELAY = 00:00:03
00:00:03 Pump One Speed % DELAY = 00:00:04
00:00:03 Pump One Speed % DELAY = 00:00:05
00:00:03 Pump One Speed % DELAY = 00:00:06
00:00:03 Pump One Speed % DELAY = 00:00:05
```

Figure 11. Event log – Instructor programming fault (Scenario #3)

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 2

00:00:03 Pump One Speed % STATUS = IDLE
00:00:03 RUN STATUS = GO
00:00:09 SCHEMATIC PAGE 2
00:00:50 Pump One Speed % ACTIVATED
00:00:54 SIC-101   - Low Alarm
00:00:57 ALARM SUMMARY PAGE 1
00:00:58 SIC-101   - Low Alarm Acknowledged
00:00:58 ALARM SUMMARY POINT - SIC-101
00:00:59 HP-101    - Low Alarm
00:01:00 SIC-101   - Low Alarm Cleared
00:01:00 SCHEMATIC PAGE 2
00:01:02 ALARM SUMMARY PAGE 1
00:01:03 HP-101    - Low Alarm Acknowledged
00:01:03 ALARM SUMMARY POINT - HP-101
00:01:04 HP-101    - Low Alarm Cleared
00:01:05 SIC-101   - Low Alarm
00:01:07 HP-101    - Low Alarm
00:01:07 SIC-101   - Low Alarm Acknowledged
00:01:07 ALARM SUMMARY POINT - SIC-101
00:01:08 HP-101    - Low Alarm Acknowledged
00:01:08 ALARM SUMMARY POINT - HP-101
00:01:09 SIC-101   - Low Alarm Cleared
00:01:11 SCHEMATIC PAGE 2
00:01:12 HP-101    - Low Alarm Cleared
00:01:14 SCHEMATIC POINT - SIC-101
00:01:16 SIC-101   - Low Alarm
00:01:16 SIC-101   - Low Alarm Acknowledged
00:01:19 SIC-101   - Low Alarm Cleared
00:01:21 SIC-101   = MANUAL
00:01:24 SIC-101   OUTPUT =    75.7 PERCENT
00:01:25 SIC-101   OUTPUT =    73.7 PERCENT
00:01:26 SIC-101   OUTPUT =    71.7 PERCENT
00:01:27 SIC-101   - Low Alarm
00:01:27 SIC-101   OUTPUT =    70.7 PERCENT
00:01:27 SIC-101   - Low Alarm Acknowledged
00:01:27 SIC-101   OUTPUT =    69.7 PERCENT
00:01:29 SIC-101   - Low Alarm Cleared
00:01:29 SIC-101   OUTPUT =    66.7 PERCENT
00:01:30 SIC-101   OUTPUT =    65.7 PERCENT
00:01:31 SIC-101   OUTPUT =    63.7 PERCENT
```

Figure 12. Event log – Simulation begins and actions taken are captured (Scenario #3)

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 3

00:01:32 SIC-101  OUTPUT =    62.7 PERCENT
00:01:33 SIC-101  OUTPUT =    59.7 PERCENT
00:01:34 SIC-101  OUTPUT =    58.7 PERCENT
00:01:35 SIC-101  - Low Alarm
00:01:35 SIC-101  OUTPUT =    57.7 PERCENT
00:01:35 SIC-101  - Low Alarm Acknowledged
00:01:35 SIC-101  OUTPUT =    56.7 PERCENT
00:01:37 HP-101   - Low Alarm
00:01:37 SIC-101  OUTPUT =    54.7 PERCENT
00:01:39 SIC-101  OUTPUT =    51.7 PERCENT
00:01:40 PIC-102  - Low Alarm
00:01:46 SIC-101  OUTPUT =    50.7 PERCENT
00:01:47 SCHEMATIC POINT - HP-101
00:01:47 HP-101   - Low Alarm Acknowledged
00:01:48 EFF-101  - High Alarm
00:01:49 SCHEMATIC POINT - PIC-102
00:01:49 PIC-102  - Low Alarm Acknowledged
00:01:51 SCHEMATIC POINT - EFF-101
00:01:51 EFF-101  - High Alarm Acknowledged
00:01:52 EFF-101  - High Alarm Cleared
00:01:57 EFF-101  - High Alarm
00:01:57 SCHEMATIC POINT - SIC-101
00:02:16 SIC-101  OUTPUT =    51.7 PERCENT
00:02:17 SIC-101  OUTPUT =    52.7 PERCENT
00:02:19 SIC-101  OUTPUT =    53.7 PERCENT
00:02:26 SIC-101  OUTPUT =    54.7 PERCENT
00:02:33 SIC-101  OUTPUT =    55.7 PERCENT
00:02:35 SCHEMATIC POINT - EFF-101
00:02:35 EFF-101  - High Alarm Acknowledged
00:02:36 EFF-101  - High Alarm Cleared
00:02:40 SCHEMATIC POINT - SIC-101
00:02:52 SCHEMATIC POINT - SIC-102
00:02:57 SIC-102  OUTPUT =     5.0 PERCENT
00:02:59 SIC-102  OUTPUT =    10.0 PERCENT
00:03:01 SCHEMATIC POINT - HS-102
00:03:02 HS-102   = RUN
00:03:04 SCHEMATIC POINT - SIC-102
00:03:07 SIC-102  OUTPUT =    15.0 PERCENT
00:03:12 SIC-102  OUTPUT =    20.0 PERCENT
00:03:22 SIC-102  OUTPUT =    25.0 PERCENT
```

Figure 13. Event log - Page 3 (Scenario #3)

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 4

00:03:24 EFF-102   - High Alarm
00:03:33 SIC-102   OUTPUT =    26.0 PERCENT
00:03:35 SIC-102   OUTPUT =    27.0 PERCENT
00:03:38 SIC-102   OUTPUT =    28.0 PERCENT
00:03:43 SIC-102   OUTPUT =    29.0 PERCENT
00:03:44 SIC-102   OUTPUT =    31.0 PERCENT
00:03:50 SIC-102   OUTPUT =    32.0 PERCENT
00:03:55 SIC-102   - High Alarm
00:03:55 SIC-102   - High Alarm Acknowledged
00:03:56 SIC-102   OUTPUT =    34.0 PERCENT
00:03:57 SIC-102   OUTPUT =    35.0 PERCENT
00:04:11 SIC-102   OUTPUT =    37.0 PERCENT
00:04:19 SIC-102   OUTPUT =    38.0 PERCENT
00:04:20 SIC-102   OUTPUT =    39.0 PERCENT
00:04:22 SIC-101   - Low Alarm Cleared
00:04:23 SIC-101   - Low Alarm
00:04:28 SIC-102   OUTPUT =    41.0 PERCENT
00:04:34 HP-102    - High Alarm
00:04:34 SCHEMATIC POINT - HS-101
00:04:35 HS-101    = STOP
00:04:36 SCHEMATIC POINT - SIC-101
00:04:36 SIC-101   - Low Alarm Acknowledged
00:04:37 SCHEMATIC POINT - SIC-101
00:04:45 EFF-101   - Low Alarm
00:04:45 SIC-101   OUTPUT =    50.7 PERCENT
00:04:47 SIC-101   OUTPUT =    45.7 PERCENT
00:04:49 SIC-101   OUTPUT =    40.7 PERCENT
00:04:50 SIC-101   OUTPUT =    35.7 PERCENT
00:04:51 SIC-101   OUTPUT =    30.7 PERCENT
00:04:52 SIC-101   OUTPUT =    20.7 PERCENT
00:04:53 SIC-101   OUTPUT =    10.7 PERCENT
00:04:54 SIC-101   OUTPUT =     0.7 PERCENT
00:04:55 SIC-101   OUTPUT =     0.0 PERCENT
00:04:57 SCHEMATIC POINT - SIC-102
00:05:03 SIC-102   OUTPUT =    42.0 PERCENT
00:05:12 SIC-102   SETPOINT =   3000 RPM
00:05:15 SIC-102   = AUTOMATIC
00:05:22 SIC-102   SETPOINT =   3050 RPM
00:05:45 SIC-102   SETPOINT =   3100 RPM
00:05:56 PIC-102   - Low Alarm Cleared
```

Figure 14. Event log - Page 4 (Scenario #3)

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 5

00:06:08 SIC-102  SETPOINT =   3150 RPM
00:06:22 SIC-102  SETPOINT =   3200 RPM
00:06:27 SCHEMATIC POINT - EFF-101
00:06:27 EFF-101   - Low Alarm Acknowledged
00:06:31 SCHEMATIC POINT - EFF-102
00:06:31 EFF-102  - High Alarm Acknowledged
00:06:32 SCHEMATIC POINT - HP-102
00:06:32 HP-102   - High Alarm Acknowledged
00:06:38 SCHEMATIC POINT - SIC-102
00:06:56 SIC-102  SETPOINT =   3250 RPM
00:07:10 SIC-102  SETPOINT =   3300 RPM
00:07:31 SIC-102  SETPOINT =   3350 RPM
00:07:44 SIC-102  SETPOINT =   3400 RPM
00:08:10 SIC-102  SETPOINT =   3450 RPM
00:08:22 SIC-102  SETPOINT =   3500 RPM
00:08:48 EVENTLOG PAGE 1
00:09:03 EVENTLOG PAGE 2
00:09:10 EVENTLOG PAGE 1
00:10:15 EVENTLOG PAGE 2
00:10:48 EVENTLOG PAGE 3
00:11:18 EVENTLOG PAGE 4
00:11:43 EVENTLOG PAGE 5
```

Figure 15. Event log - Page 5 (Scenario #3)

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 **__possible__ 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
SCENARIO #4 (SIMULATOR-BASED)

Simulator Programming

The following table includes information needed for you to program the fault for a pump cavitation simulation exercise. The fault has 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 5. Fault Programming Information for Scenario #4

Descriptor	1- Pump Speed %	**Signal**	100.00	**Rise**	10.00
Status	Idle	**Normal**	100.00	**Start**	00:00:50
Direction	Fail High	**High**	100.00	**Stop**	00:00:00
Function	Sine Wave	**Low**	0.00	**Delay**	00:00:05

Scenario Statement

This Scenario is an example of a centrifugal pump cavitating hard.

Cause

Mechanical issue with SIC-101 or the motor

Compensating Actions

Compensating actions are documented in the event log.

Corrective Actions

Maintenance should check the motor on the primary pump and/or instrumentation technicians should check SIC-101.

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

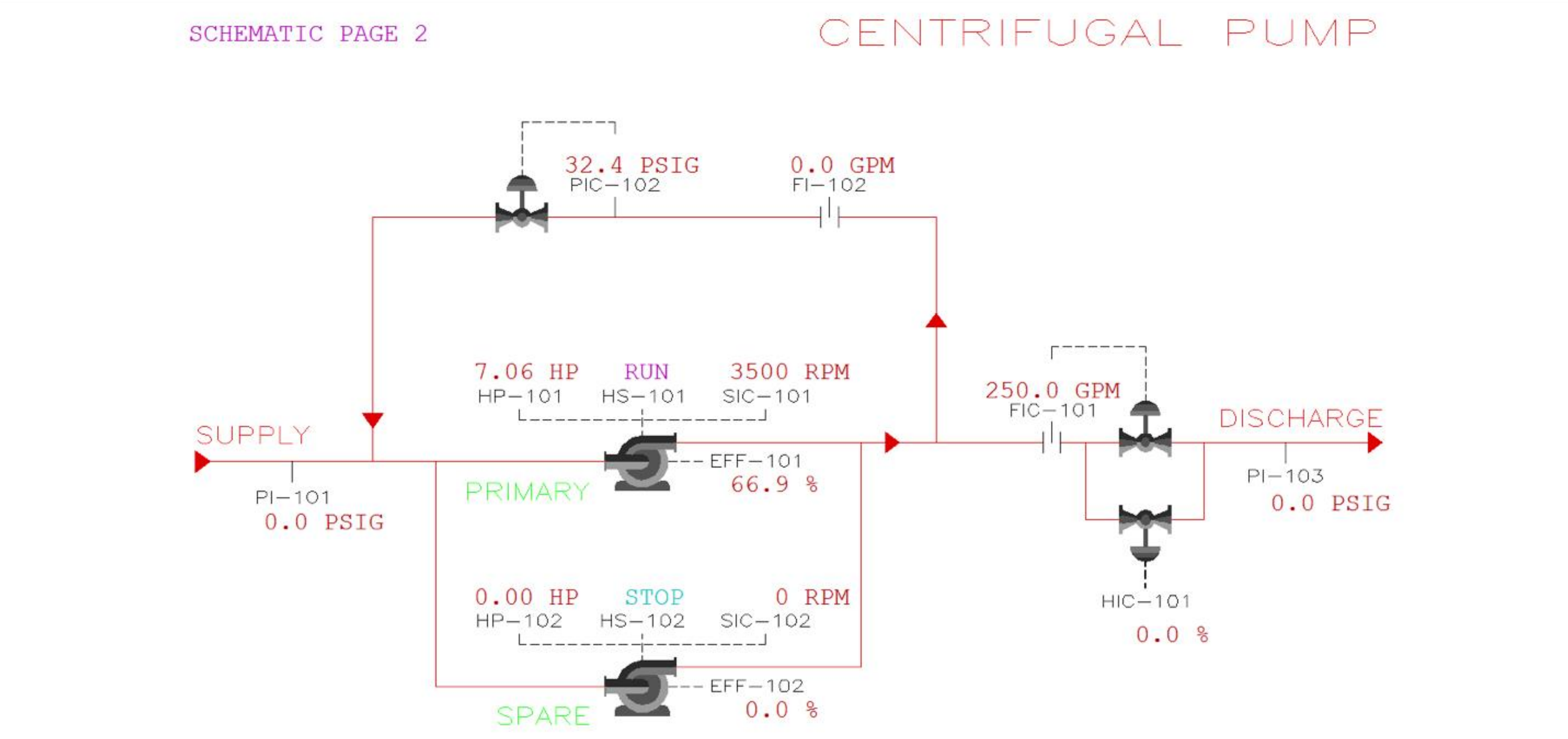


Figure 16. Screen shot during normal operation (Scenario #4)

Courtesy of Simtronics Corporation

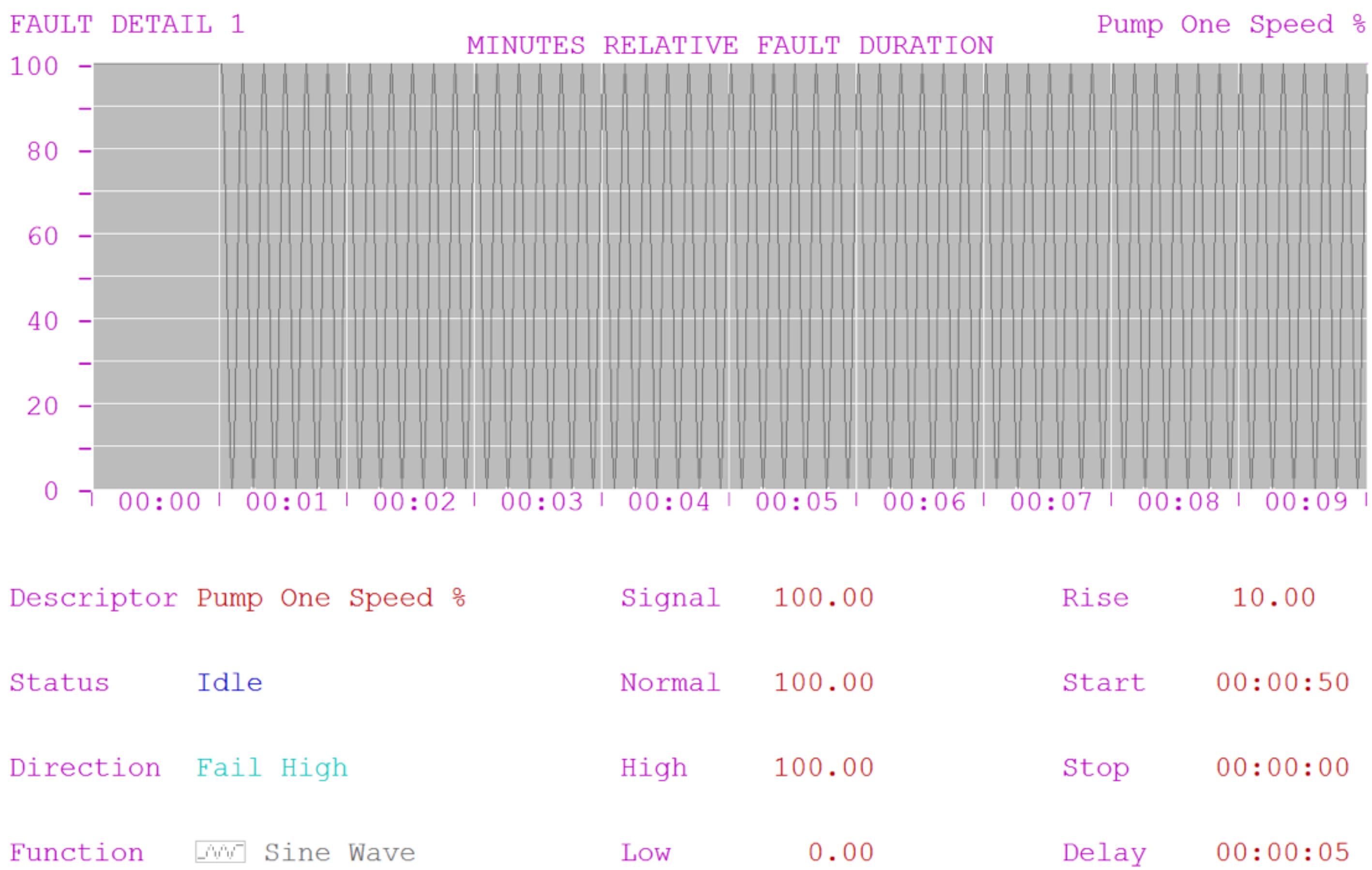


Figure 17. Fault function generator page (Scenario #4)

Courtesy of Simtronics Corporation

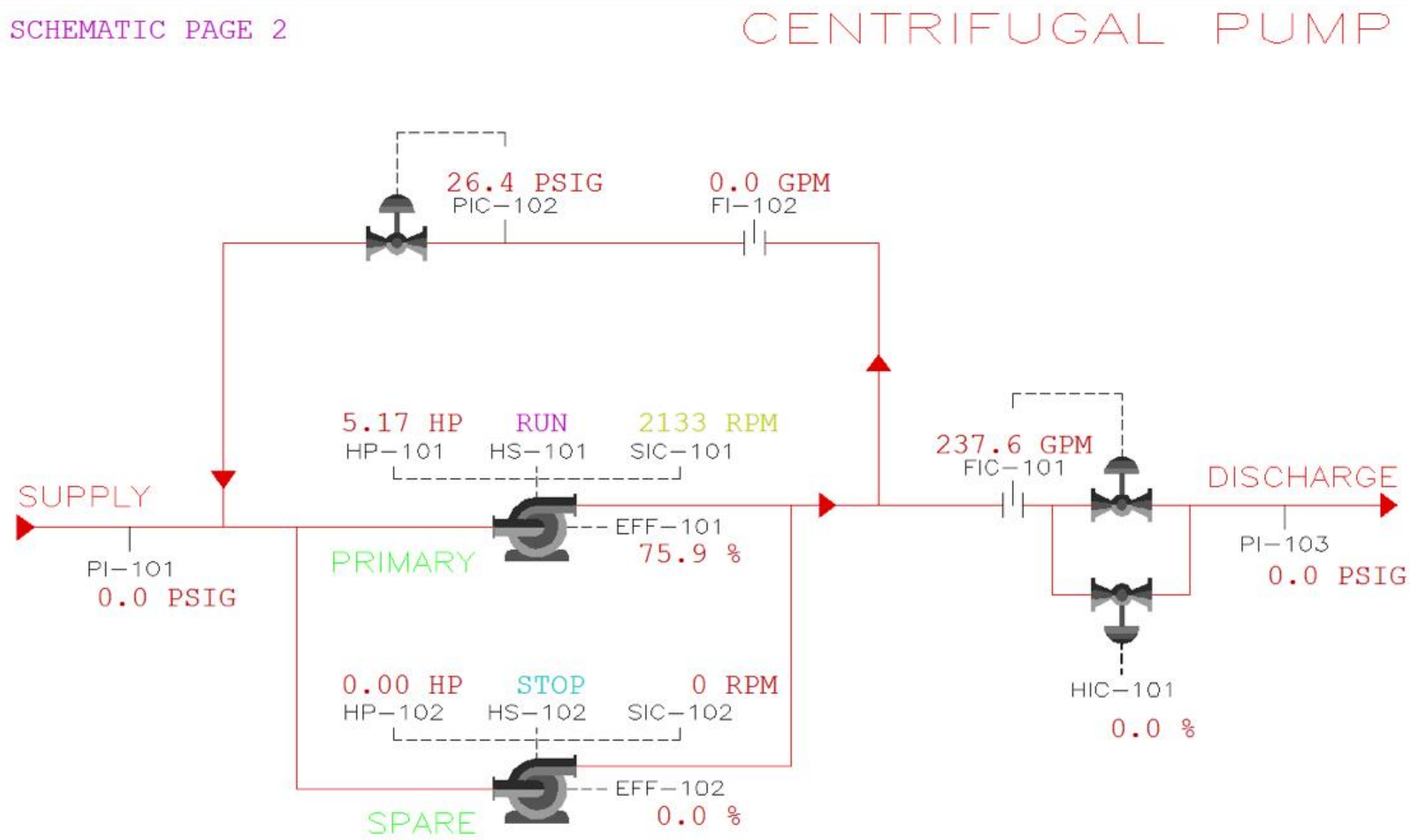


Figure 18. Abnormal conditions – 1st screen shot at 57 seconds (Scenario #4)

Courtesy of Simtronics Corporation

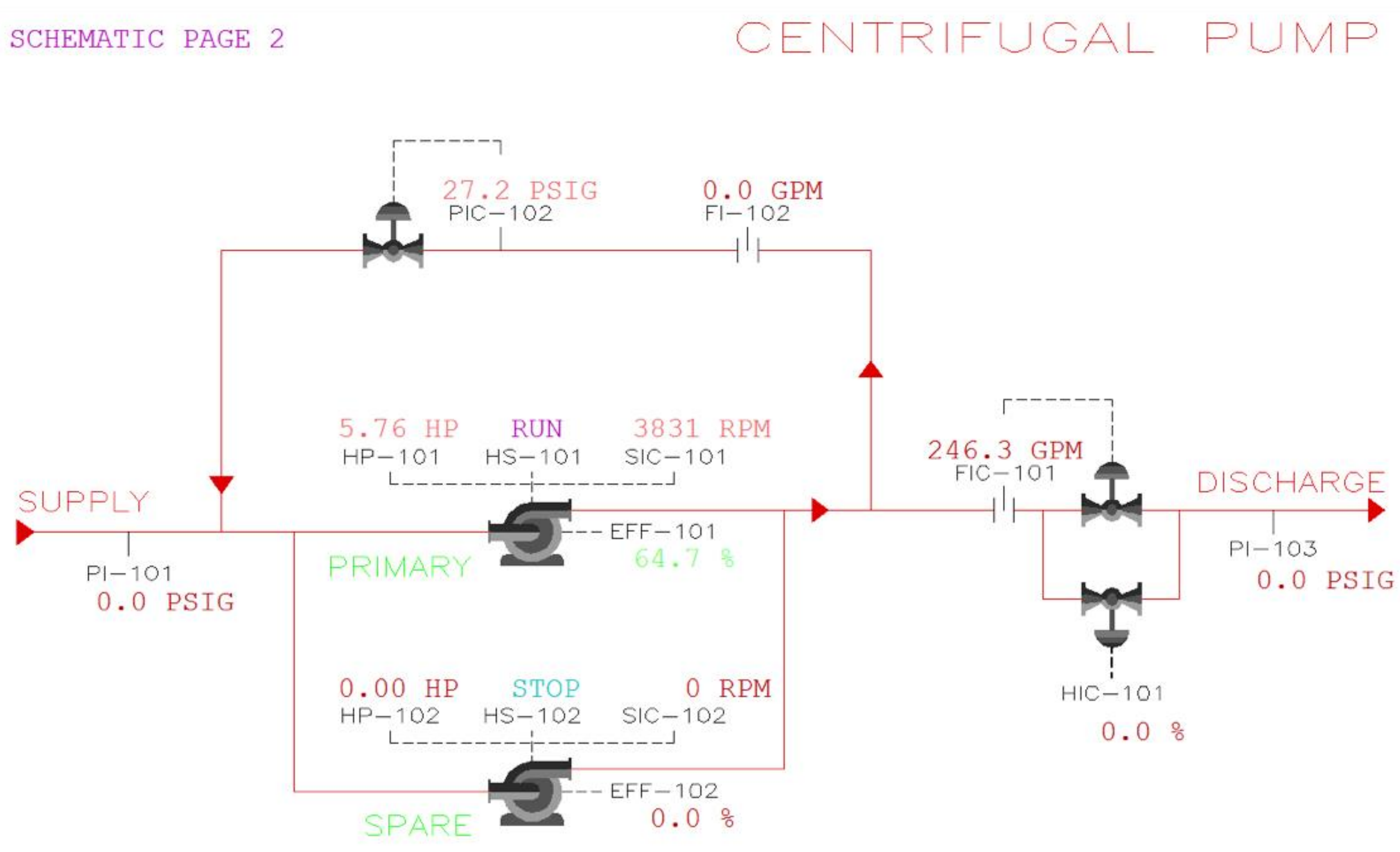


Figure 19. Abnormal conditions – 2nd screen shot at 1 minute, 42 seconds (Scenario #4)

Courtesy of Simtronics Corporation

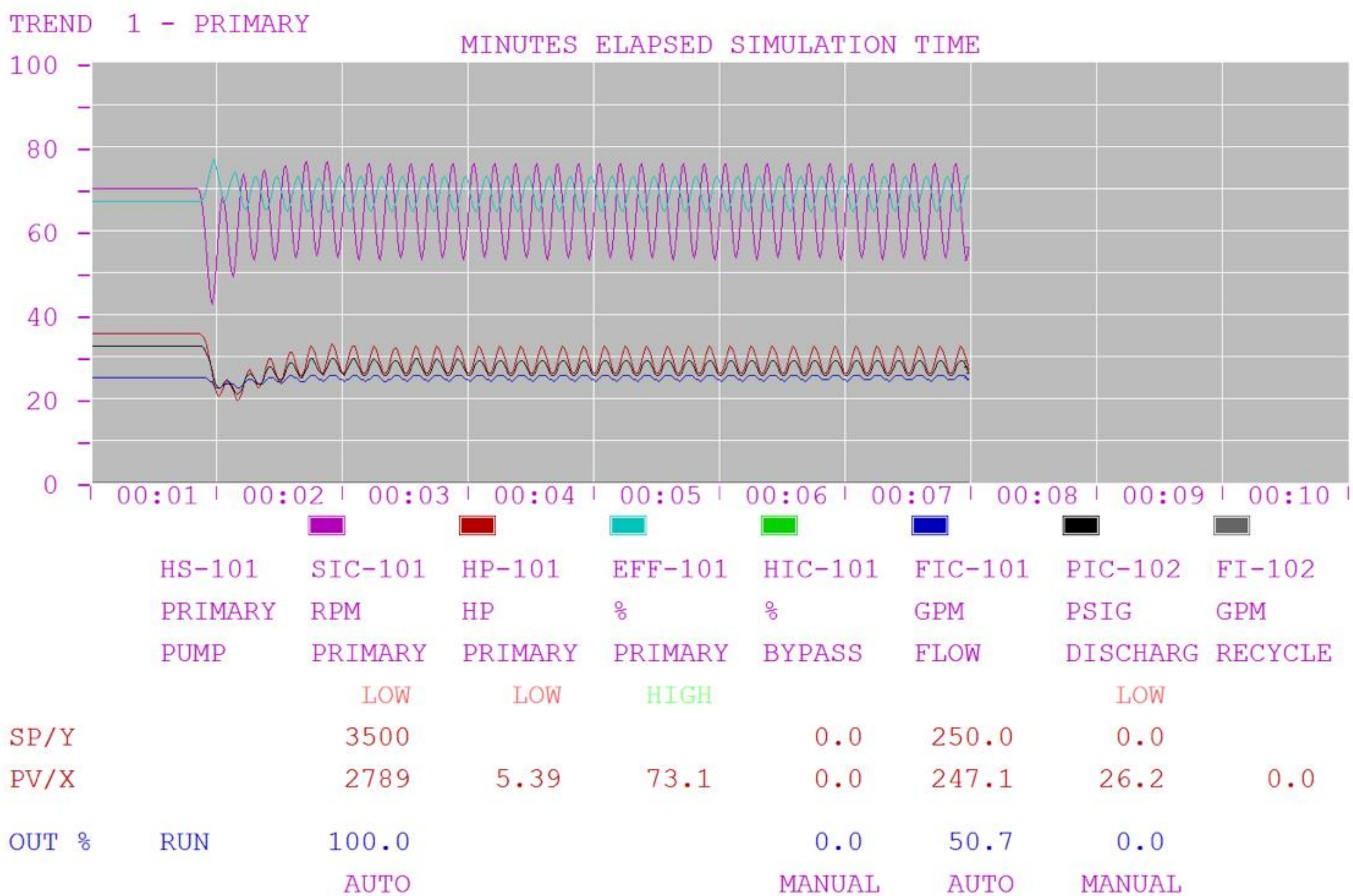


Figure 20. Trend during Scenario (Scenario #4)

Courtesy of Simtronics Corporation

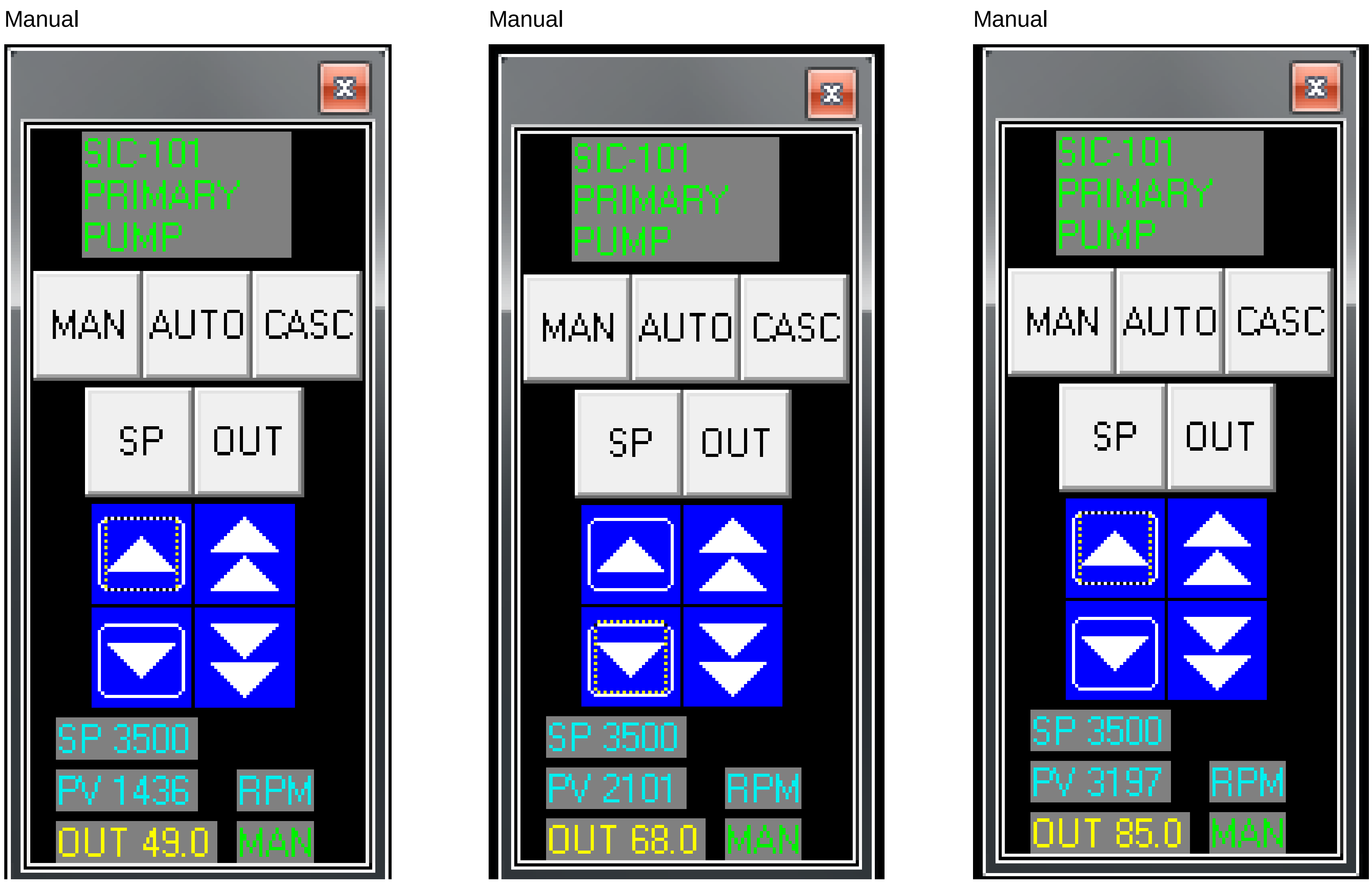


Figure 21. Faceplates - compensating by switching SIC-101 to manual while in alarm; RPMs continue to drop despite changes to output (Scenario #4)

Courtesy of Simtronics Corporation

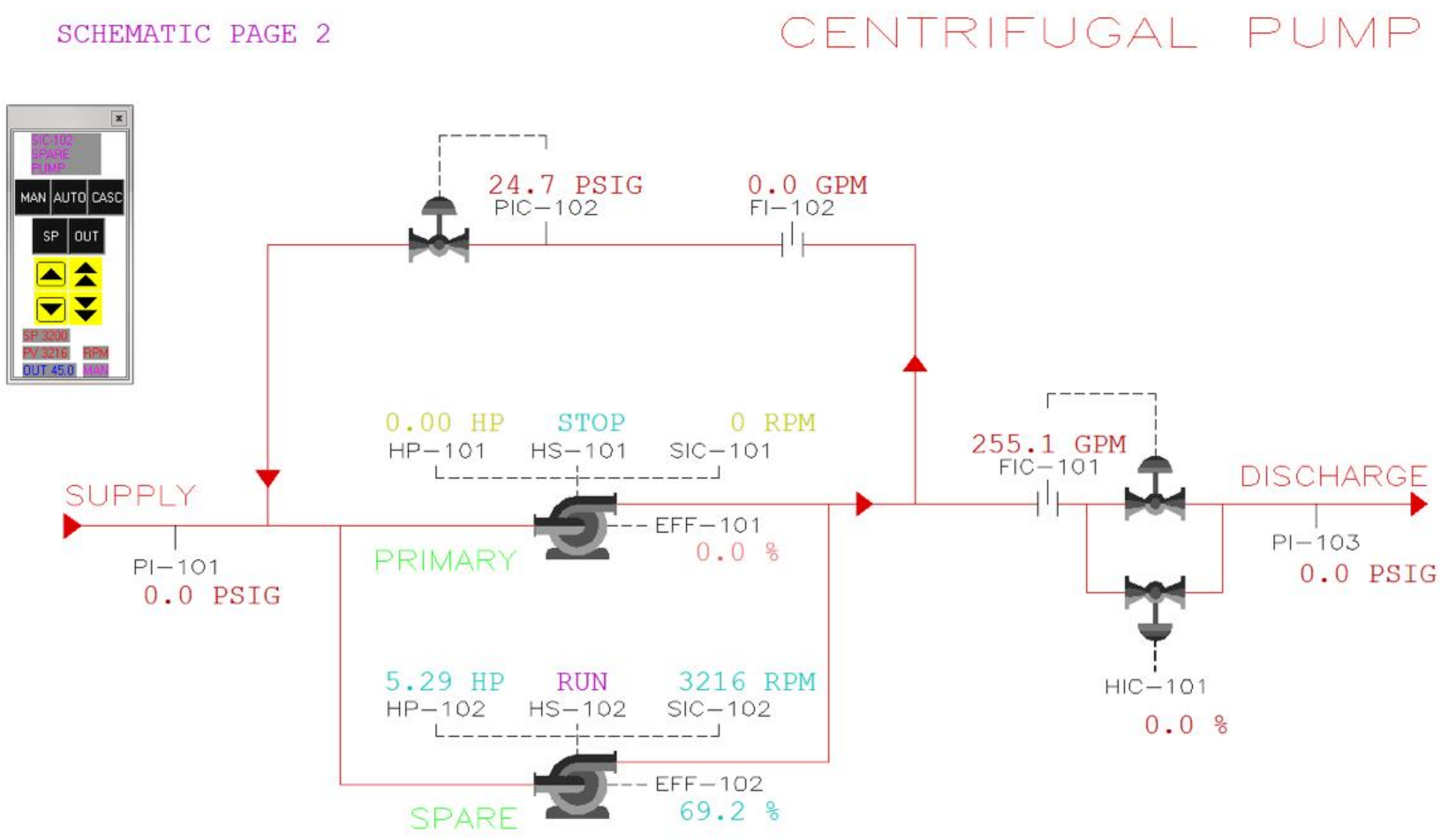
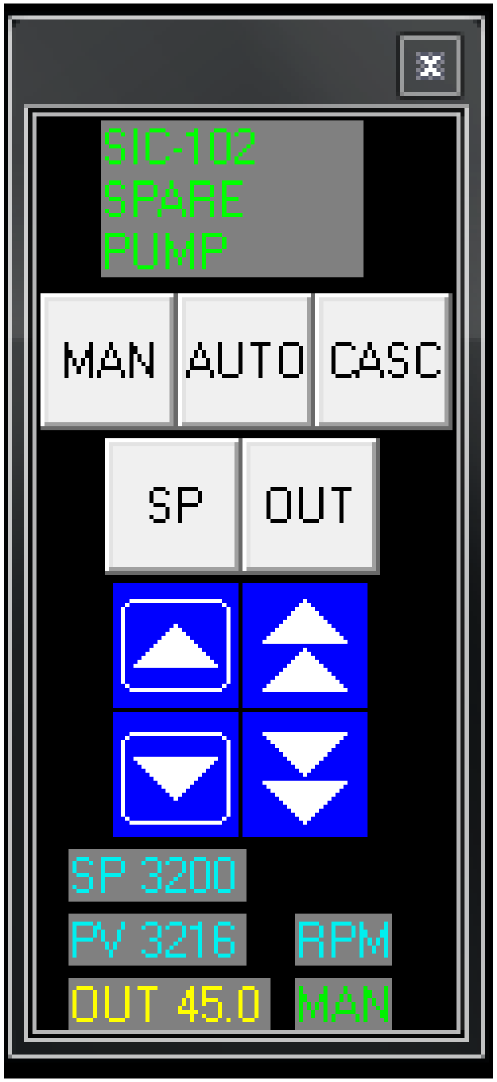


Figure 22. Screen shot after switching pumps (Scenario #4)

Courtesy of Simtronics Corporation

Speed controller SIC-102 on Pump 102

Manual



Auto

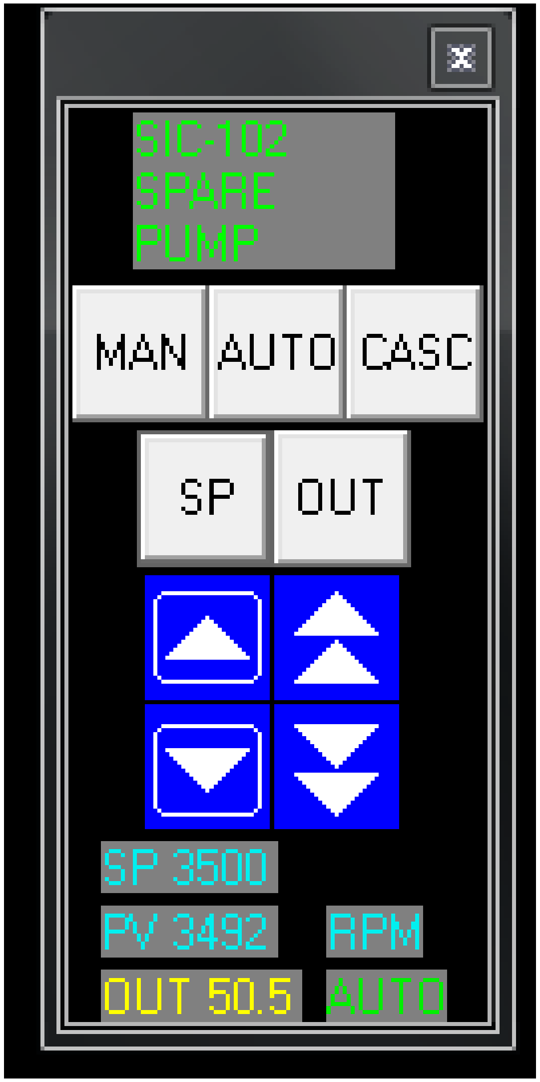


Figure 23. Faceplate – bringing on spare pump (Scenario #4)

Courtesy of Simtronics Corporation

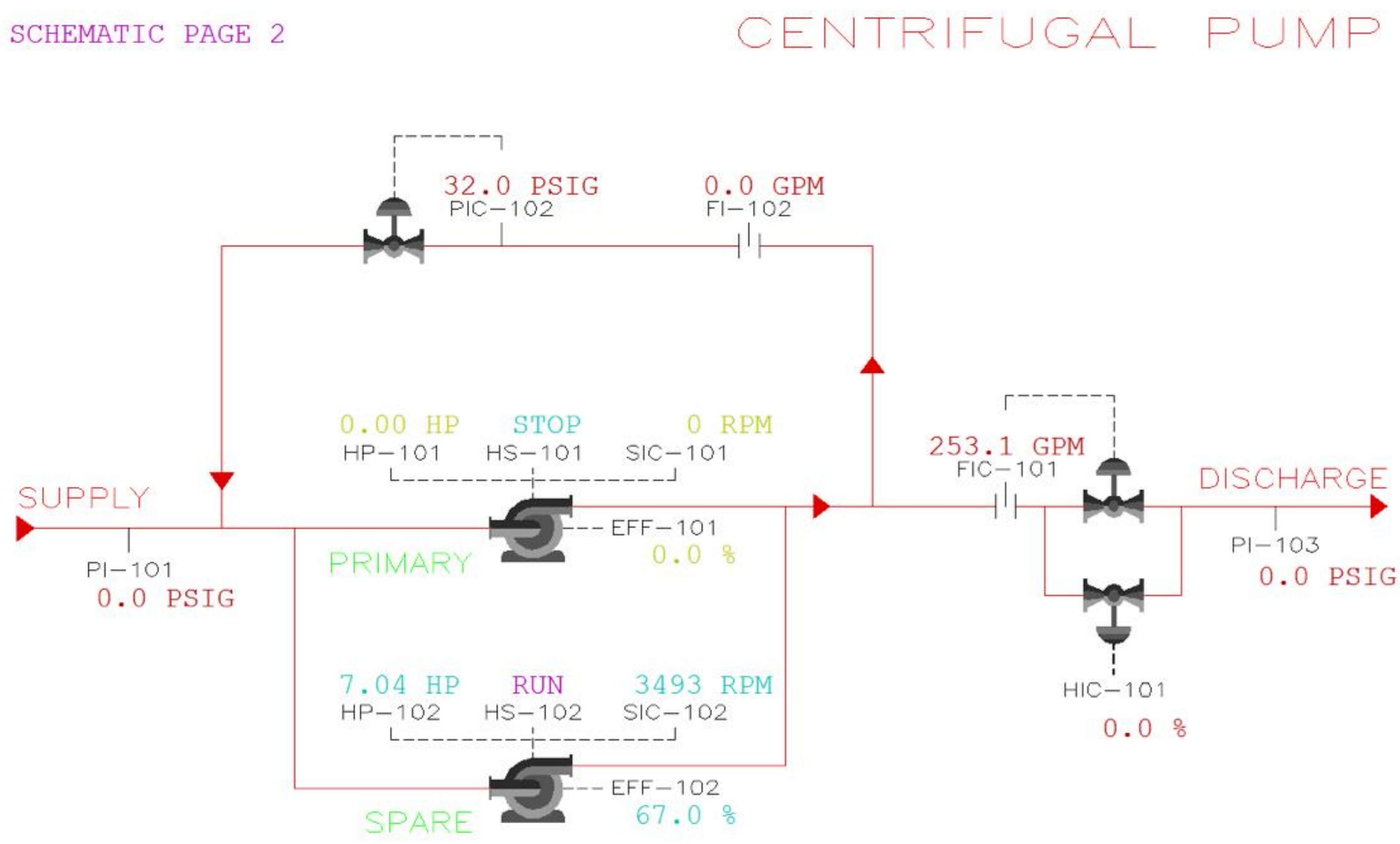


Figure 24. Process at steady-state after compensating actions (Scenario #4)

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
00:00:03 RUN STATUS = FREEZE
00:00:03 SCHEMATIC PAGE 2
00:00:03 INSTRUCTOR PAGE 2 - Initial Conditions
00:00:03 INSTRUCTOR PAGE 27 - Faults
00:00:03 FAULT POINT - Pump One Speed %
00:00:03 FAULT DETAIL 1 - Pump One Speed %
00:00:03 Pump One Speed % FUNCTION = SQUARE WAVE
00:00:03 Pump One Speed % DELAY = 00:00:01
00:00:03 Pump One Speed % FUNCTION = STEP CHANGE
00:00:03 Pump One Speed % DELAY = 00:00:01
00:00:03 Pump One Speed % FUNCTION = SINE WAVE
00:00:03 Pump One Speed % DELAY = 00:00:01
00:00:03 Pump One Speed % START = 00:00:10
00:00:03 Pump One Speed % START = 00:00:20
00:00:03 Pump One Speed % START = 00:00:30
00:00:03 Pump One Speed % START = 00:00:40
00:00:03 Pump One Speed % START = 00:00:50
00:00:03 Pump One Speed % DELAY = 00:00:02
00:00:03 Pump One Speed % DELAY = 00:00:03
00:00:03 Pump One Speed % DELAY = 00:00:04
00:00:03 Pump One Speed % DELAY = 00:00:05
00:00:03 REFRESH FAULT TRACE WINDOW
00:00:03 REFRESH FAULT TRACE WINDOW
00:00:03 Pump One Speed % STATUS = IDLE
00:00:03 RUN STATUS = GO
00:00:04 SCHEMATIC PAGE 2
00:00:50 Pump One Speed % ACTIVATED
00:00:54 SIC-101   - Low Alarm
00:00:58 HP-101    - Low Alarm
00:00:58 EFF-101   - High Alarm
00:01:00 PIC-102   - Low Alarm
00:01:02 RUN STATUS = FREEZE
00:01:02 RUN STATUS = GO
00:01:42 RUN STATUS = FREEZE
00:01:42 RUN STATUS = GO
00:01:49 SCHEMATIC POINT - SIC-101
00:01:49 SIC-101   - Low Alarm Acknowledged
```

Figure 25. Event log – Last entry at 03 seconds is where simulation begins (Scenario #4)

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 2

00:01:50 SIC-101  - Low Alarm Cleared
00:01:52 SIC-101  = MANUAL
00:01:56 SIC-101  - Low Alarm
00:01:56 SIC-101  - Low Alarm Acknowledged
00:01:59 SIC-101  OUTPUT =    74.9 PERCENT
00:02:00 SIC-101  - Low Alarm Cleared
00:02:00 SIC-101  OUTPUT =    73.9 PERCENT
00:02:01 SIC-101  OUTPUT =    72.9 PERCENT
00:02:04 SIC-101  - Low Alarm
00:02:04 SIC-101  - Low Alarm Acknowledged
00:02:08 SIC-101  OUTPUT =    73.9 PERCENT
00:02:09 SIC-101  OUTPUT =    74.9 PERCENT
00:02:11 SIC-101  OUTPUT =    75.9 PERCENT
00:02:12 SIC-101  - Low Alarm Cleared
00:02:13 SIC-101  - Low Alarm
00:02:13 SIC-101  - Low Alarm Acknowledged
00:02:14 SIC-101  OUTPUT =    74.9 PERCENT
00:02:18 SIC-101  OUTPUT =    76.9 PERCENT
00:02:21 SIC-101  OUTPUT =    77.9 PERCENT
00:02:22 SIC-101  - Low Alarm Cleared
00:02:24 SIC-101  - Low Alarm
00:02:24 SIC-101  - Low Alarm Acknowledged
00:02:26 SIC-101  OUTPUT =    78.9 PERCENT
00:02:27 SIC-101  OUTPUT =    79.9 PERCENT
00:02:31 SIC-101  - Low Alarm Cleared
00:02:31 SIC-101  OUTPUT =    81.9 PERCENT
00:02:35 SIC-101  - Low Alarm
00:02:35 SIC-101  OUTPUT =    82.9 PERCENT
00:02:35 SIC-101  - Low Alarm Acknowledged
00:02:36 SIC-101  OUTPUT =    83.9 PERCENT
00:02:40 SIC-101  - Low Alarm Cleared
00:02:45 SIC-101  - Low Alarm
00:02:45 SIC-101  - Low Alarm Acknowledged
00:02:48 SIC-101  OUTPUT =    85.9 PERCENT
00:02:50 SIC-101  - Low Alarm Cleared
00:02:55 SIC-101  - Low Alarm
00:02:55 SIC-101  - Low Alarm Acknowledged
00:03:00 SIC-101  - Low Alarm Cleared
00:03:00 SCHEMATIC POINT - PIC-102
00:03:00 PIC-102  - Low Alarm Acknowledged
```

Figure 26. Event log – Page 2 (Scenario #4)

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 3

00:03:01 PIC-102   - Low Alarm Cleared
00:03:01 SCHEMATIC POINT - HP-101
00:03:01 HP-101    - Low Alarm Acknowledged
00:03:03 HP-101    - Low Alarm Cleared
00:03:05 SIC-101   - Low Alarm
00:03:08 HP-101    - Low Alarm
00:03:08 HP-101    - Low Alarm Acknowledged
00:03:09 SCHEMATIC POINT - EFF-101
00:03:09 EFF-101   - High Alarm Acknowledged
00:03:10 EFF-101   - High Alarm Cleared
00:03:13 HP-101    - Low Alarm Cleared
00:03:17 HP-101    - Low Alarm
00:03:17 SCHEMATIC POINT - SIC-101
00:03:17 SIC-101   - Low Alarm Acknowledged
00:03:19 PIC-102   - Low Alarm
00:03:20 SIC-101   - Low Alarm Cleared
00:03:25 SIC-101   - Low Alarm
00:03:25 SIC-101   - Low Alarm Acknowledged
00:03:30 SIC-101   - Low Alarm Cleared
00:03:35 SIC-101   - Low Alarm
00:03:35 SCHEMATIC POINT - HP-101
00:03:35 HP-101    - Low Alarm Acknowledged
00:03:36 HP-101    - Low Alarm Cleared
00:03:36 SCHEMATIC POINT - HP-101
00:03:36 SCHEMATIC POINT - SIC-101
00:03:36 SIC-101   - Low Alarm Acknowledged
00:03:37 HP-101    - Low Alarm
00:03:40 SIC-101   - Low Alarm Cleared
00:03:41 SCHEMATIC POINT - SIC-102
00:03:45 SIC-101   - Low Alarm
00:03:45 SIC-102   OUTPUT =    15.0 PERCENT
00:03:46 SIC-102   OUTPUT =    20.0 PERCENT
00:03:50 SCHEMATIC POINT - HS-102
00:03:50 HS-102    = RUN
00:03:56 SCHEMATIC POINT - SIC-102
00:03:59 SIC-102   OUTPUT =    25.0 PERCENT
00:04:01 EFF-102   - High Alarm
00:04:06 SIC-102   OUTPUT =    30.0 PERCENT
00:04:13 SCHEMATIC POINT - HP-101
00:04:13 HP-101    - Low Alarm Acknowledged
```

Figure 27. Event log – Page 3 (Scenario #4)

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 4

00:04:14 HP-101    - Low Alarm Cleared
00:04:14 SCHEMATIC POINT - PIC-102
00:04:14 PIC-102   - Low Alarm Acknowledged
00:04:15 PIC-102   - Low Alarm Cleared
00:04:15 SCHEMATIC POINT - SIC-101
00:04:15 SIC-101   - Low Alarm Acknowledged
00:04:16 HP-101    - Low Alarm
00:04:17 SCHEMATIC POINT - SIC-102
00:04:19 SIC-101   - Low Alarm Cleared
00:04:19 PIC-102   - Low Alarm
00:04:22 SIC-102   OUTPUT =   32.0 PERCENT
00:04:26 SIC-101   - Low Alarm
00:04:29 SIC-102   - High Alarm
00:04:29 SIC-102   - High Alarm Acknowledged
00:04:30 SIC-102   OUTPUT =   34.0 PERCENT
00:04:36 SIC-102   OUTPUT =   36.0 PERCENT
00:04:43 SIC-102   OUTPUT =   38.0 PERCENT
00:04:47 SIC-102   OUTPUT =   40.0 PERCENT
00:04:50 SIC-102   OUTPUT =   42.0 PERCENT
00:04:53 HP-102    - High Alarm
00:04:53 SCHEMATIC POINT - HS-101
00:04:54 HS-101    = STOP
00:04:56 SCHEMATIC POINT - SIC-101
00:04:56 SIC-101   - Low Alarm Acknowledged
00:05:00 SIC-101   OUTPUT =   80.9 PERCENT
00:05:02 SIC-101   OUTPUT =   70.9 PERCENT
00:05:03 SIC-101   OUTPUT =   65.9 PERCENT
00:05:04 SIC-101   OUTPUT =   60.9 PERCENT
00:05:05 SIC-101   OUTPUT =   55.9 PERCENT
00:05:08 EFF-101   - Low Alarm
00:05:08 SIC-101   OUTPUT =   50.9 PERCENT
00:05:09 SIC-101   OUTPUT =   45.9 PERCENT
00:05:10 SIC-101   OUTPUT =   40.9 PERCENT
00:05:11 SIC-101   OUTPUT =   30.9 PERCENT
00:05:12 SIC-101   OUTPUT =   25.9 PERCENT
00:05:13 SIC-101   OUTPUT =   15.9 PERCENT
00:05:14 SIC-101   OUTPUT =    5.9 PERCENT
00:05:15 SIC-101   OUTPUT =    0.9 PERCENT
00:05:16 SIC-101   OUTPUT =    0.0 PERCENT
00:05:18 SCHEMATIC POINT - SIC-102
```

Figure 28. Event log – Page 4 (Scenario #4)

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 5

00:05:22 SIC-102  OUTPUT =    43.0 PERCENT
00:05:29 SCHEMATIC POINT - PIC-102
00:05:29 PIC-102  - Low Alarm Acknowledged
00:05:31 SCHEMATIC POINT - HP-101
00:05:31 HP-101   - Low Alarm Acknowledged
00:05:32 PIC-102  - Low Alarm Cleared
00:05:35 SCHEMATIC POINT - HP-102
00:05:35 HP-102   - High Alarm Acknowledged
00:05:39 SCHEMATIC POINT - SIC-102
00:05:41 SCHEMATIC POINT - EFF-102
00:05:41 EFF-102  - High Alarm Acknowledged
00:05:42 SCHEMATIC POINT - SIC-102
00:05:51 SIC-102  SETPOINT =   3200 RPM
00:05:57 SIC-102  OUTPUT =    45.0 PERCENT
00:06:10 RUN STATUS = FREEZE
00:06:10 RUN STATUS = GO
00:06:25 SIC-102  OUTPUT =    44.0 PERCENT
00:06:32 SIC-102  OUTPUT =    45.0 PERCENT
00:06:47 SIC-102  = AUTOMATIC
00:06:58 SIC-102  SETPOINT =   3250 RPM
00:07:03 SCHEMATIC POINT - EFF-101
00:07:03 EFF-101  - Low Alarm Acknowledged
00:07:05 SCHEMATIC POINT - HP-102
00:07:07 SCHEMATIC POINT - SIC-102
00:07:12 SIC-102  SETPOINT =   3300 RPM
00:07:28 SIC-102  SETPOINT =   3350 RPM
00:07:53 SIC-102  SETPOINT =   3400 RPM
00:08:15 SIC-102  SETPOINT =   3450 RPM
00:08:35 SIC-102  SETPOINT =   3500 RPM
00:09:51 RUN STATUS = FREEZE
00:09:51 EVENTLOG PAGE 5
00:09:51 EVENTLOG PAGE 4
00:09:51 EVENTLOG PAGE 3
00:09:51 EVENTLOG PAGE 2
00:09:51 EVENTLOG PAGE 1
00:09:51 EVENTLOG PAGE 2
00:09:51 EVENTLOG PAGE 3
00:09:51 EVENTLOG PAGE 4
00:09:51 EVENTLOG PAGE 5
```

Figure 29. Event log – Page 5 (Scenario #4)

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.)

PUMP TROUBLESHOOTING MODULE
SCENARIO #5 (SIMULATOR-BASED)

Simulator Programming

The following table includes information needed for you to program the fault for a pump pseudo-cavitation simulation exercise. The fault has 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 #5

Descriptor	1- Pump Speed %	**Signal**	100.00	**Rise**	10.00
Status	Idle	**Normal**	100.00	**Start**	00:00:40
Direction	Fail Low	**High**	100.00	**Stop**	00:00:00
Function	Step Change	**Low**	50.00	**Delay**	00:00:01

Scenario Statement

This Scenario is an example of pseudo-cavitation on a centrifugal pump.

Cause

The cause of pseudo-cavitation may not be determined but learners can eliminate issues with SIC-101.

Compensating Actions

Compensating actions are documented in the event log.

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

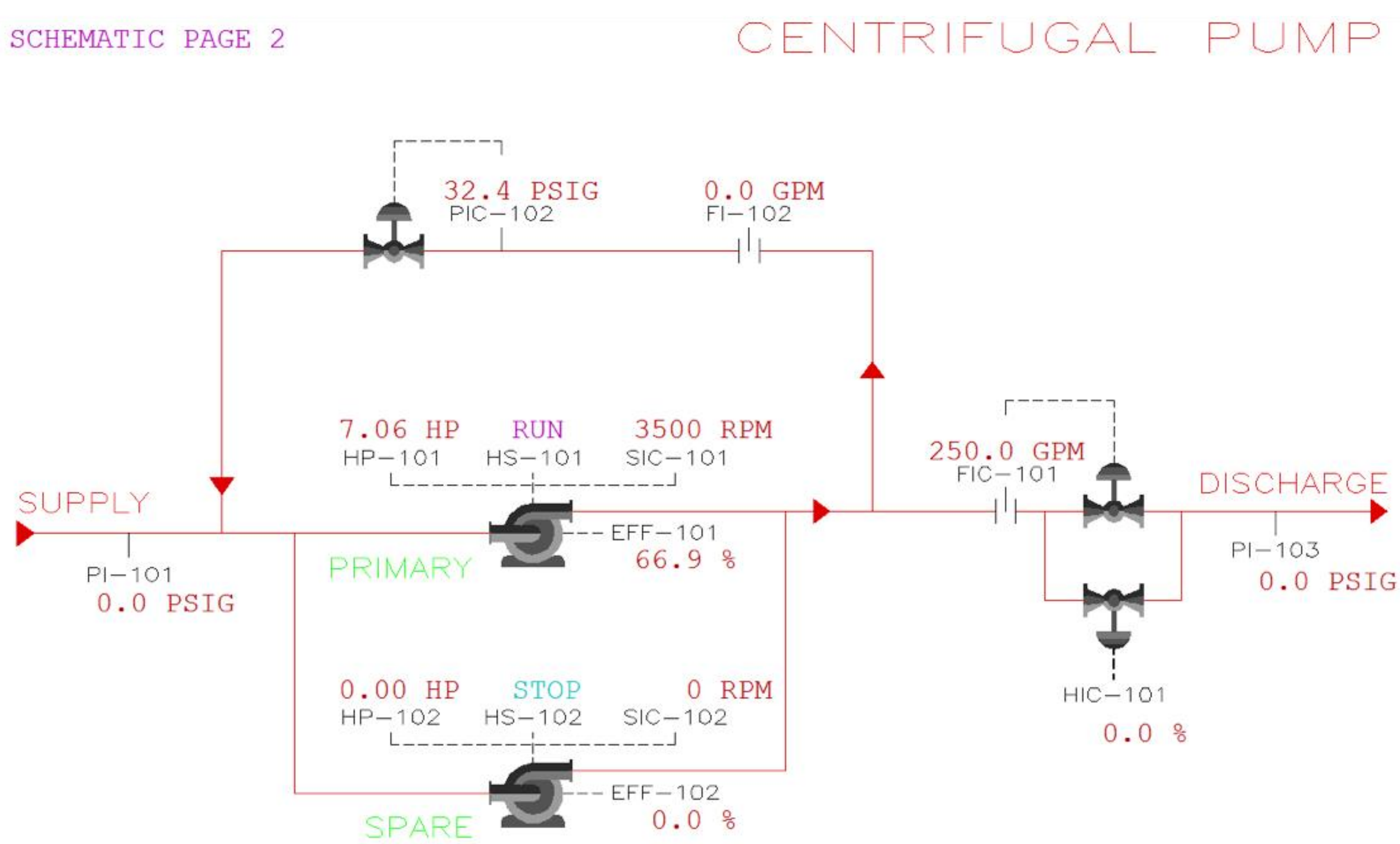


Figure 30. **Screen shot during normal operation (Scenario #5)**

Courtesy of Simtronics Corporation

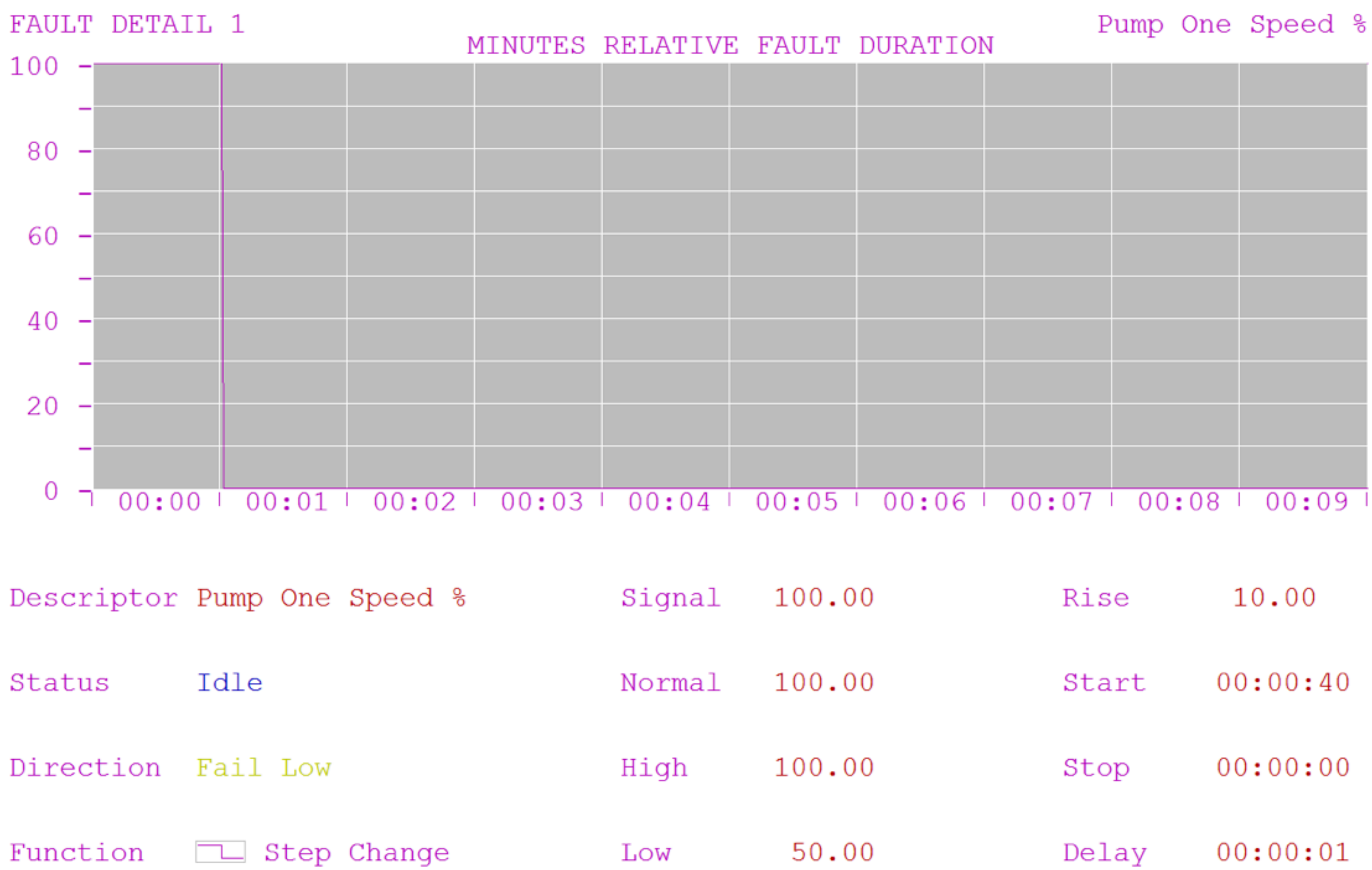


Figure 31. Fault function generator page (Scenario #5)

Courtesy of Simtronics Corporation

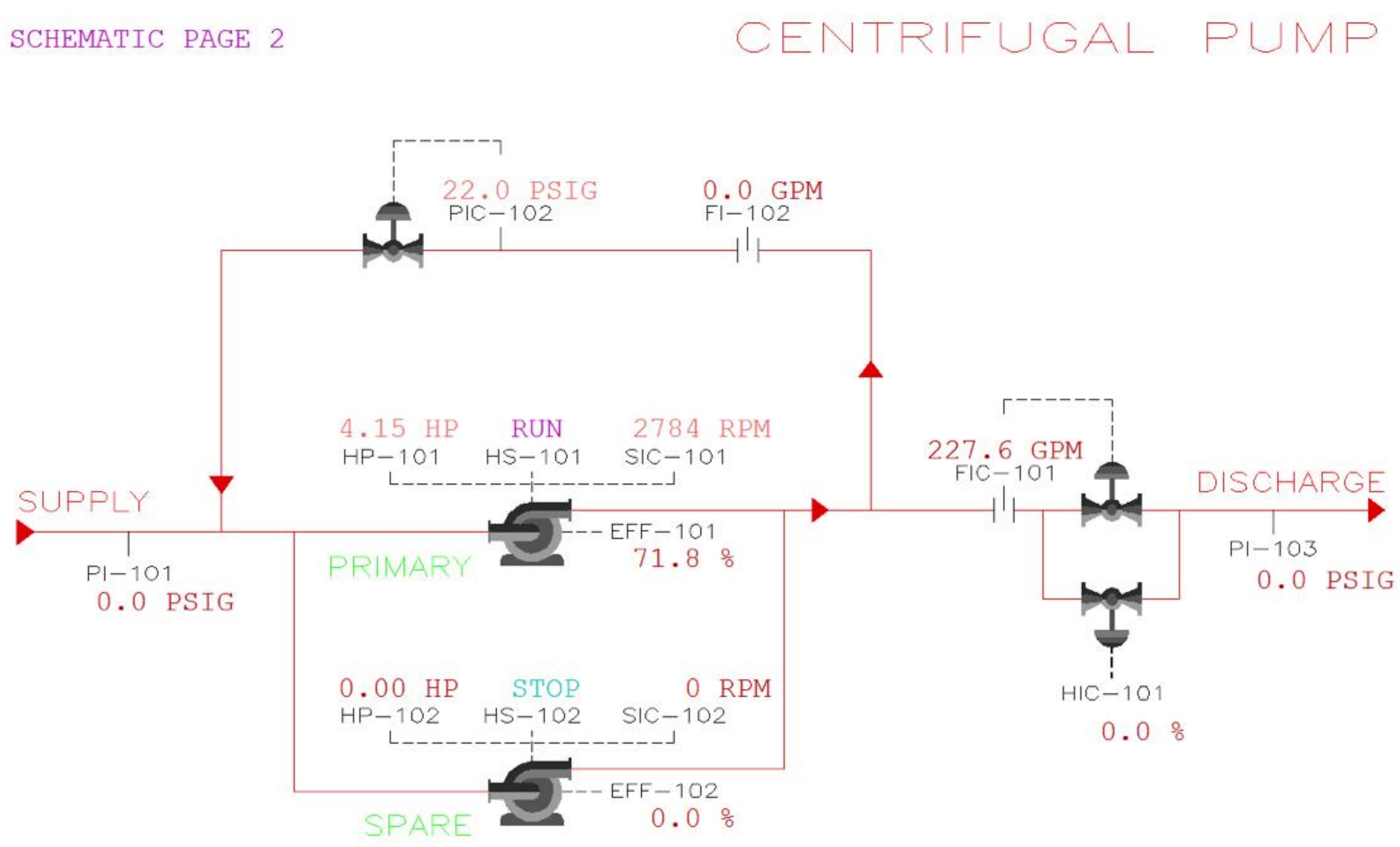


Figure 32. Abnormal conditions – 1st screen shot at 54 seconds (Scenario #5)

Courtesy of Simtronics Corporation

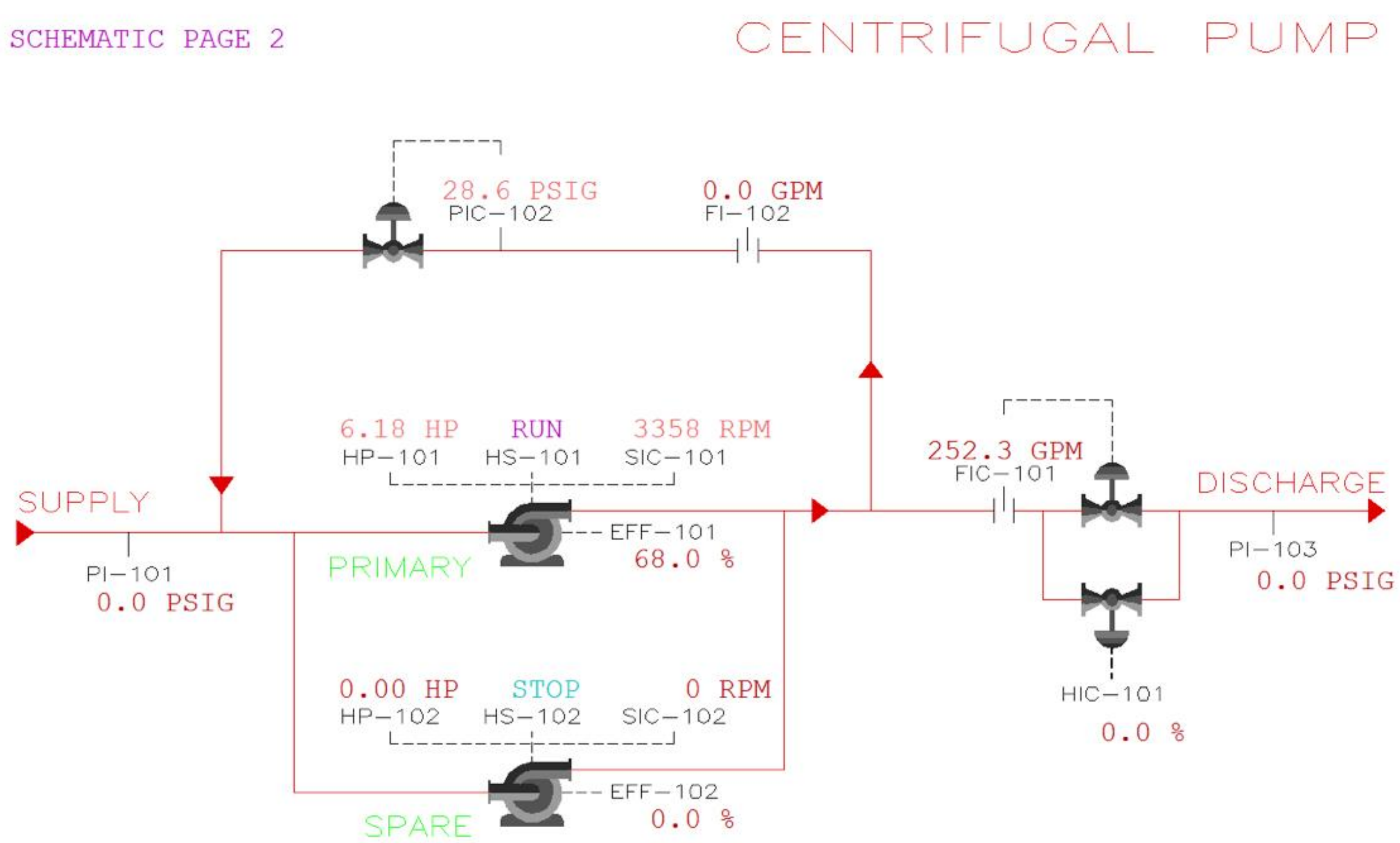


Figure 33. Abnormal conditions – 2nd screen shot at 2 minutes, 6 seconds (Scenario #5)

Courtesy of Simtronics Corporation

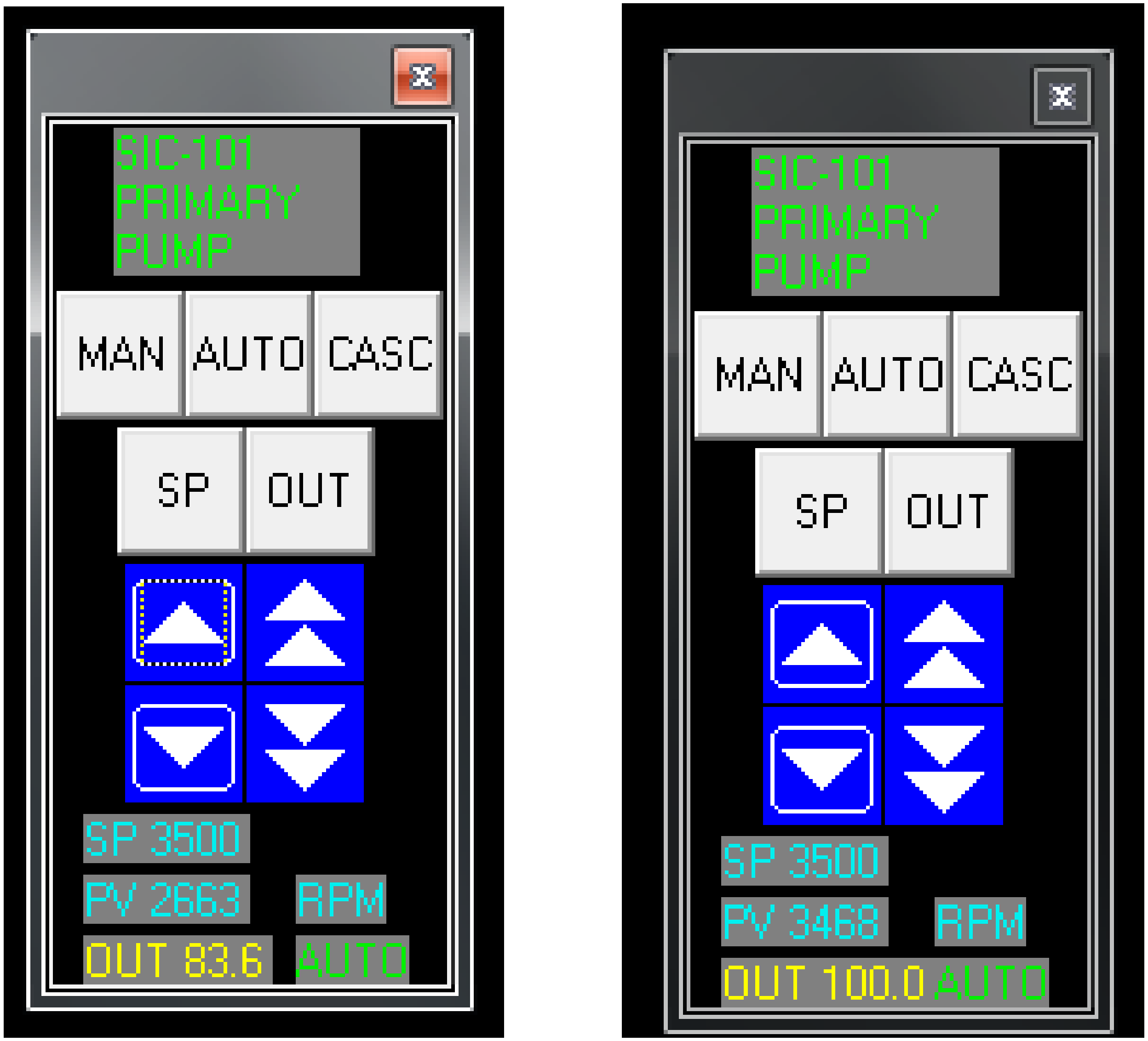


Figure 34. Faceplates during Scenario with no action taken - Primary pump is trying to speed up but SIC-101 is not having much effect (Scenario #5)

Courtesy of Simtronics Corporation

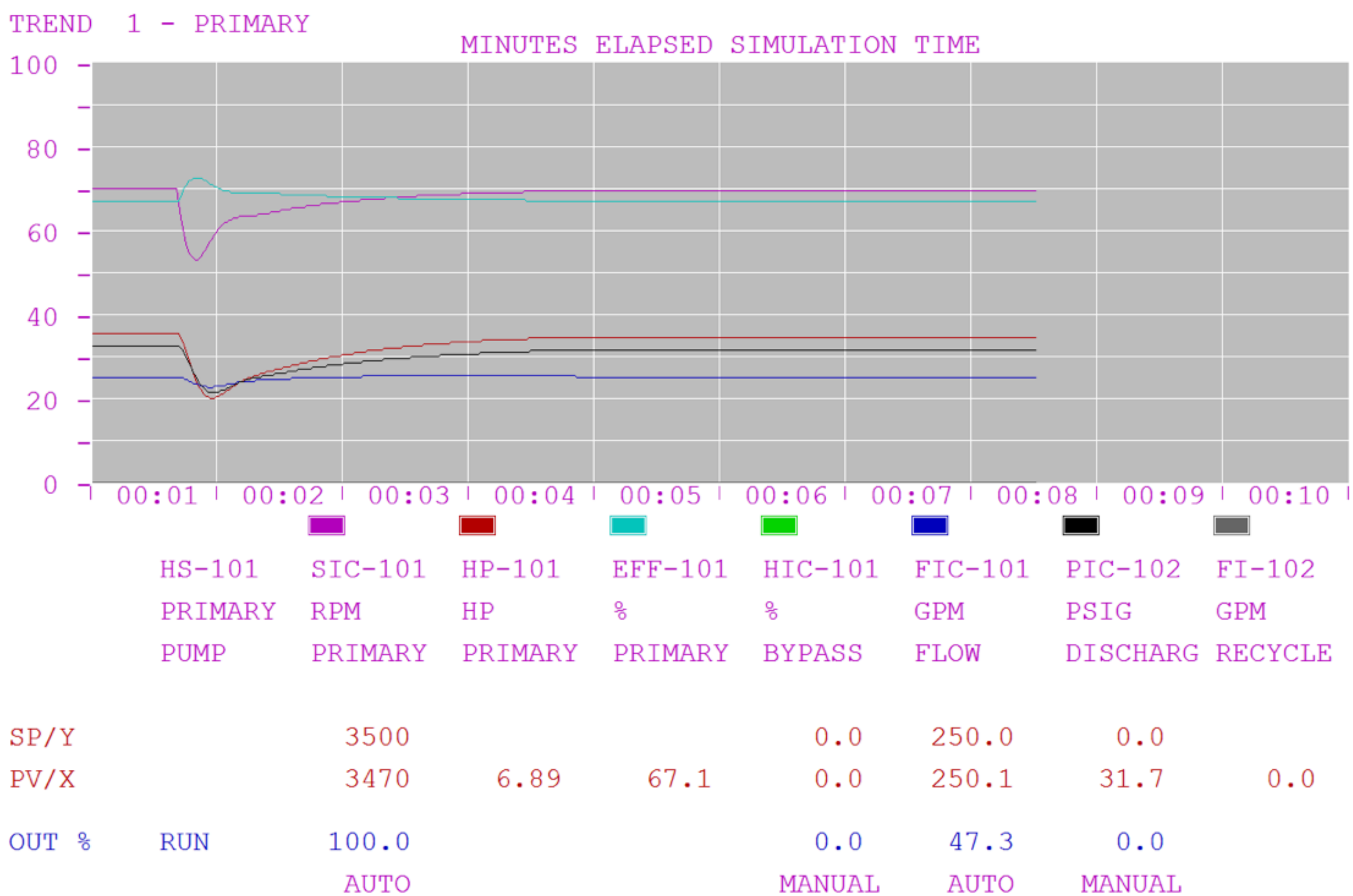


Figure 35. Trend – captured on "fast" time (Scenario #5)

Courtesy of Simtronics Corporation

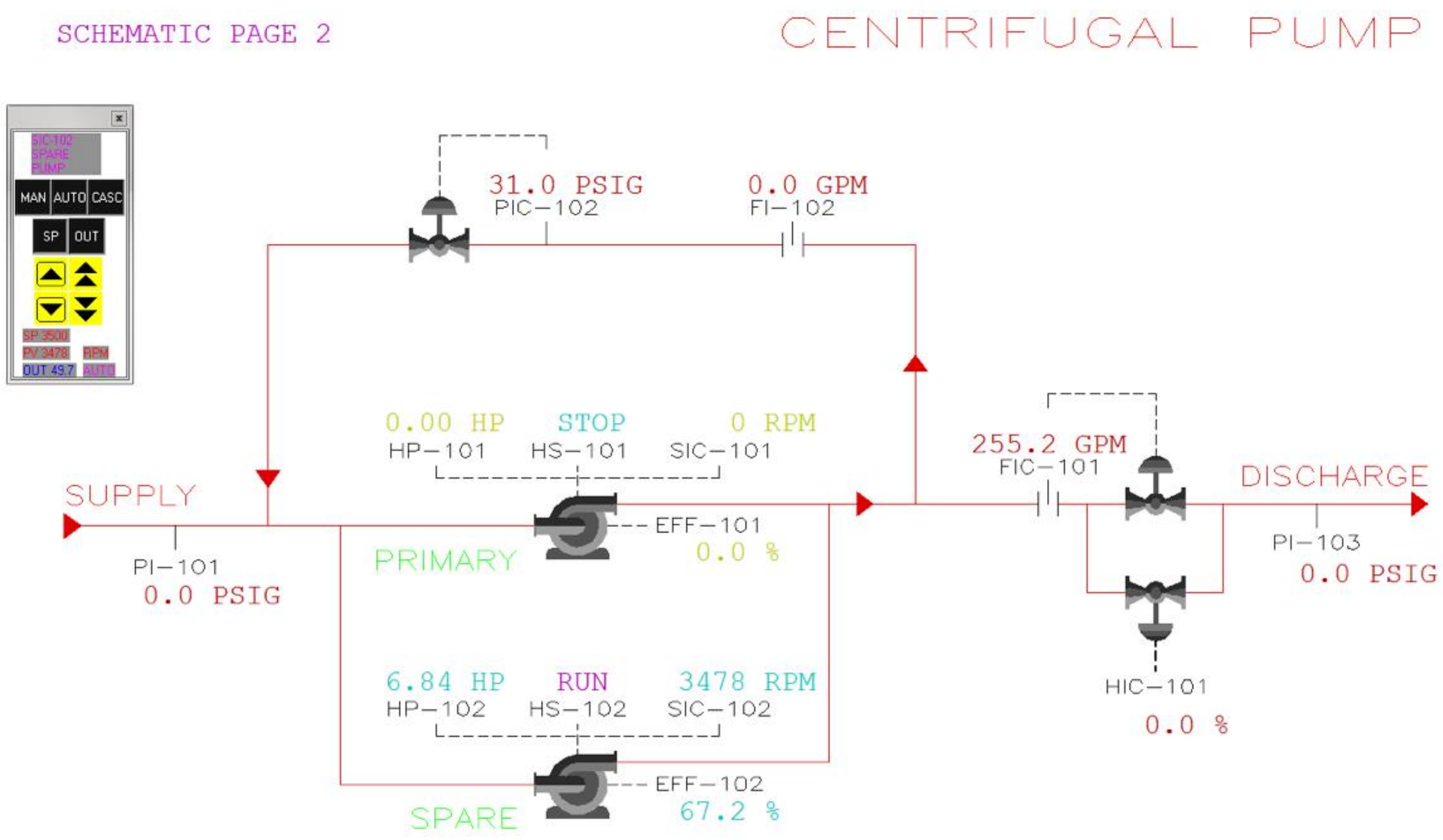


Figure 36. Screen shot after switching pumps – Process stabilized (Scenario #5)

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
00:00:05 RUN STATUS = FREEZE
00:00:05 INSTRUCTOR PAGE 27 - Faults
00:00:05 FAULT POINT - Pump One Speed %
00:00:05 FAULT DETAIL 1 - Pump One Speed %
00:00:05 Pump One Speed % DIRECTION = DOWN
00:00:05 Pump One Speed % STOP = 00:00:00
00:00:05 Pump One Speed % DELAY = 00:00:01
00:00:05 Pump One Speed % LOW =  50.00
00:00:05 Pump One Speed % START = 00:00:10
00:00:05 Pump One Speed % START = 00:00:20
00:00:05 Pump One Speed % START = 00:00:30
00:00:05 Pump One Speed % START = 00:00:40
00:00:05 Pump One Speed % STATUS = IDLE
00:00:05 REFRESH FAULT TRACE WINDOW
00:00:05 DECREASE FAULT TRACE SCALE
00:00:05 INCREASE FAULT TRACE SCALE
00:00:05 REFRESH FAULT TRACE WINDOW
00:00:05 DECREASE FAULT TRACE SCALE
00:00:05 RUN STATUS = GO
00:00:06 SCHEMATIC PAGE 2
00:00:08 SCHEMATIC POINT - SIC-101
00:00:40 Pump One Speed % ACTIVATED
00:00:44 SIC-101   - Low Alarm
00:00:44 SIC-101   - Low Alarm Acknowledged
00:00:49 HP-101    - Low Alarm
00:00:54 PIC-102   - Low Alarm
00:00:54 RUN STATUS = FREEZE
00:00:54 RUN STATUS = GO
00:00:55 SCHEMATIC POINT - SIC-101
00:00:56 SCHEMATIC POINT - HP-101
00:00:56 HP-101    - Low Alarm Acknowledged
00:00:58 SCHEMATIC POINT - PIC-102
00:00:58 PIC-102   - Low Alarm Acknowledged
00:01:00 SIC-101   - Low Alarm Cleared
00:01:04 PIC-102   - Low Alarm Cleared
00:01:09 SCHEMATIC POINT - SIC-101
00:01:17 HP-101    - Low Alarm Cleared
```

Figure 37. Event log – Page 1 (Scenario #5)

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 2

00:02:12 TREND   1 - PRIMARY
00:02:43 Simulation Speed = ( 1 /   0.00 ) times real time
00:07:30 Simulation Speed = ( 1 /   1.00 ) times real time
00:07:30 RUN STATUS = FREEZE
00:07:30 SCHEMATIC PAGE 2
00:07:30 SCHEMATIC POINT - SIC-102
00:07:30 SIC-102  OUTPUT =    15.0 PERCENT
00:07:30 SIC-102  OUTPUT =    25.0 PERCENT
00:07:30 SCHEMATIC POINT - HS-102
00:07:30 HS-102   = RUN
00:07:30 SCHEMATIC POINT - SIC-102
00:07:30 SIC-102  OUTPUT =    27.0 PERCENT
00:07:30 SIC-102  OUTPUT =    28.0 PERCENT
00:07:30 SIC-102  OUTPUT =    29.0 PERCENT
00:07:30 SIC-102  OUTPUT =    31.0 PERCENT
00:07:30 RUN STATUS = GO
00:07:32 EFF-102  - High Alarm
00:07:44 SIC-102  OUTPUT =    33.0 PERCENT
00:07:45 SIC-102  OUTPUT =    34.0 PERCENT
00:07:50 SIC-102  - High Alarm
00:07:50 SIC-102  - High Alarm Acknowledged
00:07:59 SIC-102  OUTPUT =    36.0 PERCENT
00:08:00 SIC-102  OUTPUT =    37.0 PERCENT
00:08:01 SIC-102  OUTPUT =    38.0 PERCENT
00:08:06 HP-102   - High Alarm
00:08:14 HP-101   - Low Alarm
00:08:14 SIC-102  OUTPUT =    39.0 PERCENT
00:08:17 RUN STATUS = FREEZE
00:08:17 RUN STATUS = GO
00:08:22 SIC-102  OUTPUT =    40.0 PERCENT
00:08:23 SIC-102  OUTPUT =    42.0 PERCENT
00:08:33 SCHEMATIC POINT - SIC-101
00:08:37 SIC-101  = MANUAL
00:08:45 RUN STATUS = FREEZE
00:08:45 RUN STATUS = GO
00:08:47 SCHEMATIC POINT - SIC-101
00:08:49 SIC-101  = MANUAL
00:08:55 SIC-101  OUTPUT =    76.1 PERCENT
00:08:56 SIC-101  OUTPUT =    73.1 PERCENT
00:08:57 SIC-101  OUTPUT =    71.1 PERCENT
```

Figure 38. Event log – Page 2 (Scenario #5)

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 3

00:08:58 SCHEMATIC POINT - HS-101
00:08:58 HS-101    = STOP
00:09:01 SIC-101   - Low Alarm
00:09:02 SCHEMATIC POINT - SIC-101
00:09:02 SIC-101   - Low Alarm Acknowledged
00:09:05 SIC-101  OUTPUT =    66.1 PERCENT
00:09:06 SIC-101  OUTPUT =    56.1 PERCENT
00:09:07 SIC-101  OUTPUT =    46.1 PERCENT
00:09:08 EFF-101   - Low Alarm
00:09:08 SIC-101  OUTPUT =    41.1 PERCENT
00:09:09 SIC-101  OUTPUT =    31.1 PERCENT
00:09:11 SIC-101  OUTPUT =    21.1 PERCENT
00:09:12 SIC-101  OUTPUT =    11.1 PERCENT
00:09:13 SIC-101  OUTPUT =     6.1 PERCENT
00:09:14 SIC-101  OUTPUT =     0.0 PERCENT
00:09:17 SCHEMATIC POINT - SIC-102
00:09:26 SIC-102  SETPOINT =    3100 RPM
00:09:30 SIC-102  OUTPUT =    43.0 PERCENT
00:09:31 SIC-102  OUTPUT =    44.0 PERCENT
00:09:35 SCHEMATIC POINT - HP-101
00:09:35 HP-101    - Low Alarm Acknowledged
00:09:37 SCHEMATIC POINT - SIC-101
00:09:39 SCHEMATIC POINT - SIC-102
00:09:43 SIC-102   = AUTOMATIC
00:09:46 SCHEMATIC POINT - HP-102
00:09:46 HP-102    - High Alarm Acknowledged
00:09:47 SCHEMATIC POINT - EFF-102
00:09:47 EFF-102   - High Alarm Acknowledged
00:09:50 SCHEMATIC POINT - EFF-101
00:09:50 EFF-101   - Low Alarm Acknowledged
00:09:55 SCHEMATIC POINT - SIC-102
00:09:59 SIC-102  SETPOINT =    3150 RPM
00:10:19 SIC-102  SETPOINT =    3200 RPM
00:10:30 SIC-102  SETPOINT =    3250 RPM
00:10:44 SIC-102  SETPOINT =    3300 RPM
00:11:42 SIC-102  SETPOINT =    3350 RPM
00:11:51 SIC-102  SETPOINT =    3400 RPM
00:12:07 SIC-102  SETPOINT =    3450 RPM
00:12:29 SIC-102  SETPOINT =    3500 RPM
00:13:33 RUN STATUS = FREEZE
```

Figure 39. Event log – Page 3 (Scenario #5)

Courtesy of Simtronics Corporation

```
EVENTLOG PAGE 4

00:13:33 EVENTLOG PAGE 1
00:13:33 EVENTLOG PAGE 2
00:13:33 EVENTLOG PAGE 3
00:13:33 EVENTLOG PAGE 4
```

Figure 40. Event log – Page 4 (Scenario #5)

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

7. Determine alternative solutions and select solution.

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

____

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
ADDITIONAL PROBLEMS

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

SCENARIO #6 (PAPER-BASED)

Scenario Statement

The control room technician reports to the field operator that flow from the centrifugal solvent feed pump to the continuous reactor is suddenly inadequate. The field technician investigates and confirms that the field indications of flow and discharge pressure are lower than SOP values. The pump is making an unusual high-pitched, whining noise.

SCENARIO #7 (PAPER-BASED)

Scenario Statement

The process technicians have observed that every time an attempt is made to increase production ten percent above current levels to satisfy marketing needs, the reactor feed pump immediately starts cavitating. This happens in spite of their carefully checking process and equipment conditions and taking every possible corrective measure for which they have been trained.

Performance Assessment Activity #1
Paper-based Problem

Learner Directions: In this assessment, you will analyze and solve a paper-based pump cavitation 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 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 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 cavitation 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 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 pump cavitation 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 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 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 problems with a pump.

CRITERIA	SCALE			
Product				
1. Process equipment is stabilized.	4	3	2	1
2. System is returned to within ± 5% of design parameters.	4	3	2	1
3. Documentation is accurate.	4	3	2	1
4. Documentation is complete.	4	3	2	1
5. Documentation reflects correct use of terminology.	4	3	2	1
Process				
1. Learner recognizes the problem and captures the problem in written form.	4	3	2	1
2. Learner evaluates and documents HSE risks involved with continued operation.	4	3	2	1
3. Learner recognizes and documents when the HSE hazard/s warrants shutting down equipment.	4	3	2	1
4. Learner collects and analyzes data associated with the problem.	4	3	2	1
5. Learner rewords problem based on initial observations and reasoning.	4	3	2	1
6. Learner identifies possible causes of the problem.	4	3	2	1
7. Learner selects most probable 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

Center for the Advancement of Process Technology. (2009). *Process Technology Equipment.* Prentice Hall.

Engineers Edge. (2012a). *Centrifugal Pump - Net Positive Suction Head*. Retrieved from Engineers Edge: http://www.engineersedge.com/pumps/net_positive_suction.htm

Engineers Edge. (2012b). *Centrifugal Pump Cavitation*. Retrieved from Engineers Edge: http://www.engineersedge.com/pumps/cavitation.htm

Engineers Edge. (2012c). *Centrifugal Pump Characteristic Curve*. Retrieved from Engineers Edge: http://www.engineersedge.com/pumps/pump_characteristics.htm

Engineers Edge. (2012d). *Preventing Cavitation Centrifugal Pump*. Retrieved from Engineers Edge: http://www.engineersedge.com/pumps/preventing_cavitation.htm

Farlex, Inc. (2012). *Definition of Cavitation*. Retrieved from The Free Dictionary: http://www.thefreedictionary.com/cavitation

Kernan, D. (2011, December). Learn to Effectively Operate and Maintain Pumps. *Chemical Engineering Progress*, 26-30.

LaBour Pumps. (2005). *Entrained Air in Centrifugal Pumps.* Retrieved from LaBour Taber: http://www.labourtaber.com/Entrained%20Air%20White%20Paper.pdf

McNally Institute. (n.d.). *Cavitation*. Retrieved from McNally Institute: Technical Information for Pumps and Seals: http://www.mcnallyinstitute.com/01-html/1-3.html