# ARE YOUR PROCESS VARIABLES UNDER CONTROL?

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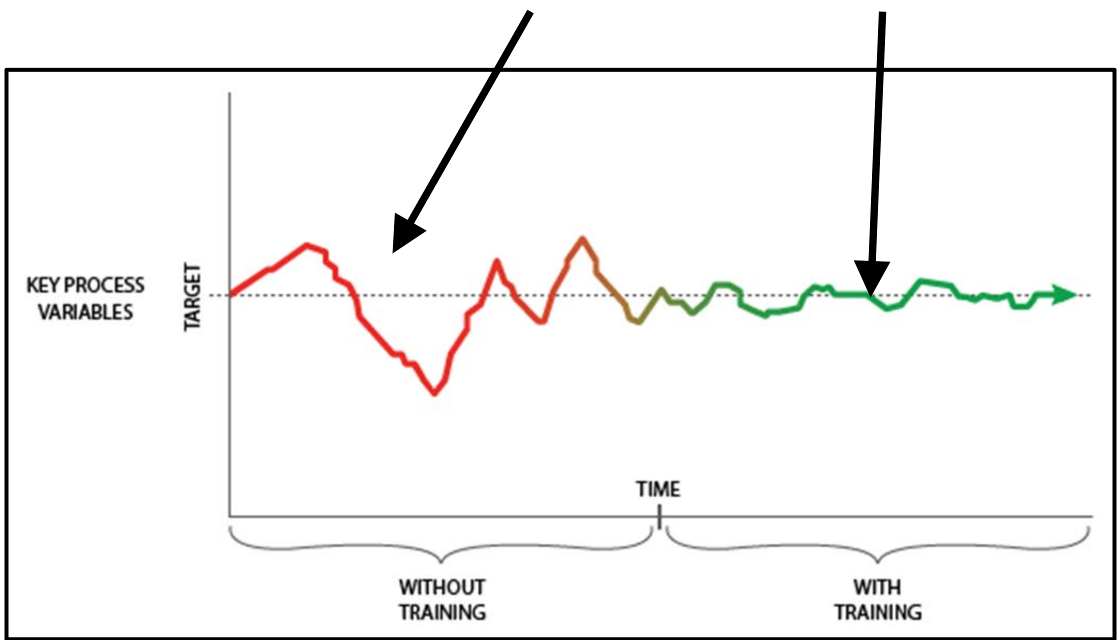
**Do trends of your key process variables look like this? Or, do they look like this?**



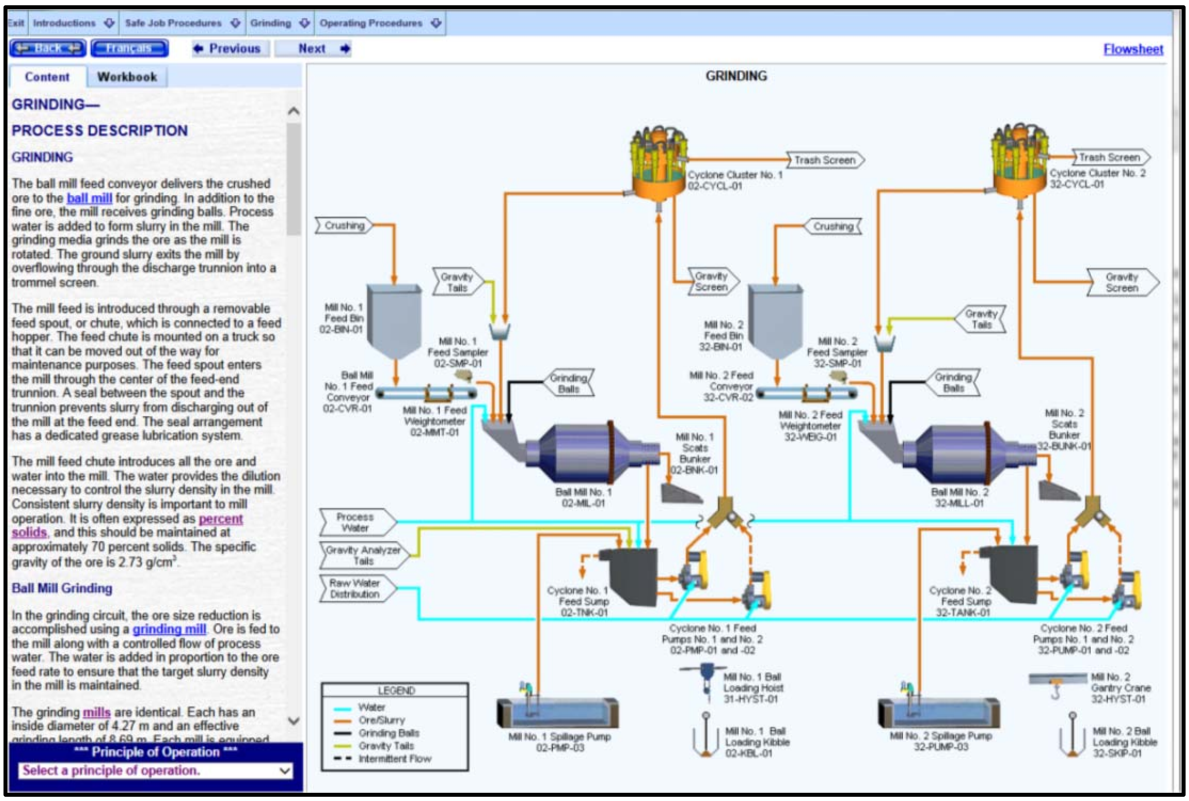

- What would it mean to your process if the variation in your key process variables could be could be cut in half? For example, consider greatly reduced variation in:
  - Leach circuit pH.
  - Thickener flocculant concentration.
  - CIL circuit cyanide concentration.
  - Cyclone feed density.
- Do your operators know if  variation is random or non-random?
- If your operators were more familiar with the process control methodology would it make a difference?
- What would be the result if your operators could troubleshoot and optimize each process control loop?

There is no doubt that minimizing variation in key process variables improves recovery. Optimizing the control of any process variable requires knowledge of:

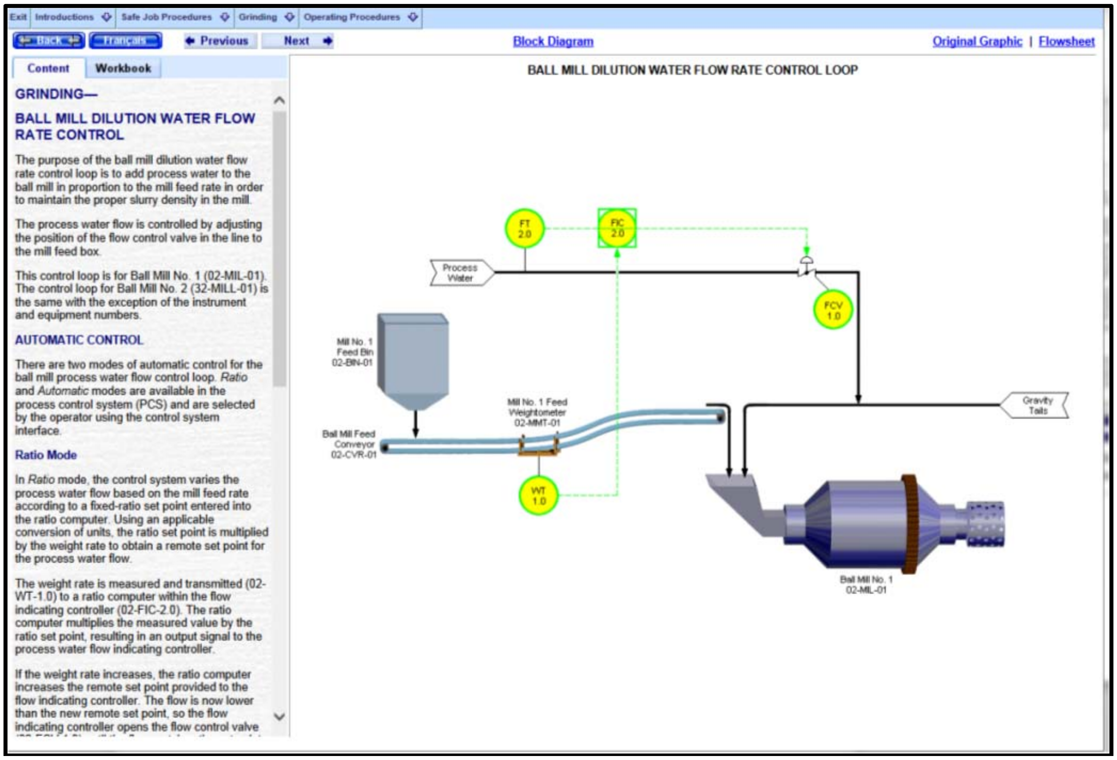
- The physical layout of the process including the associated equipment, piping, sensors, and control devices.
- Physical, chemical, and/or thermodynamic changes occurring in the process.
- The process control logic including the sensitivity of the controller output to changes in the error signal.
- The sensitivity of the control device to changes in controller output.

With a first-class training program, your operators *can* become expert on each of these requirements!

A proper training program would include a description of the process, flowsheets, and detailed descriptions of the principle of operation of key equipment items and process fundamentals. The following example flowsheet and description applies to a grinding circuit.




In the training program, the specifics of the control methodology are taught to the trainee using control loop descriptions and diagrams. The following images depict a ball mill dilution water flow rate control loop and diagrams.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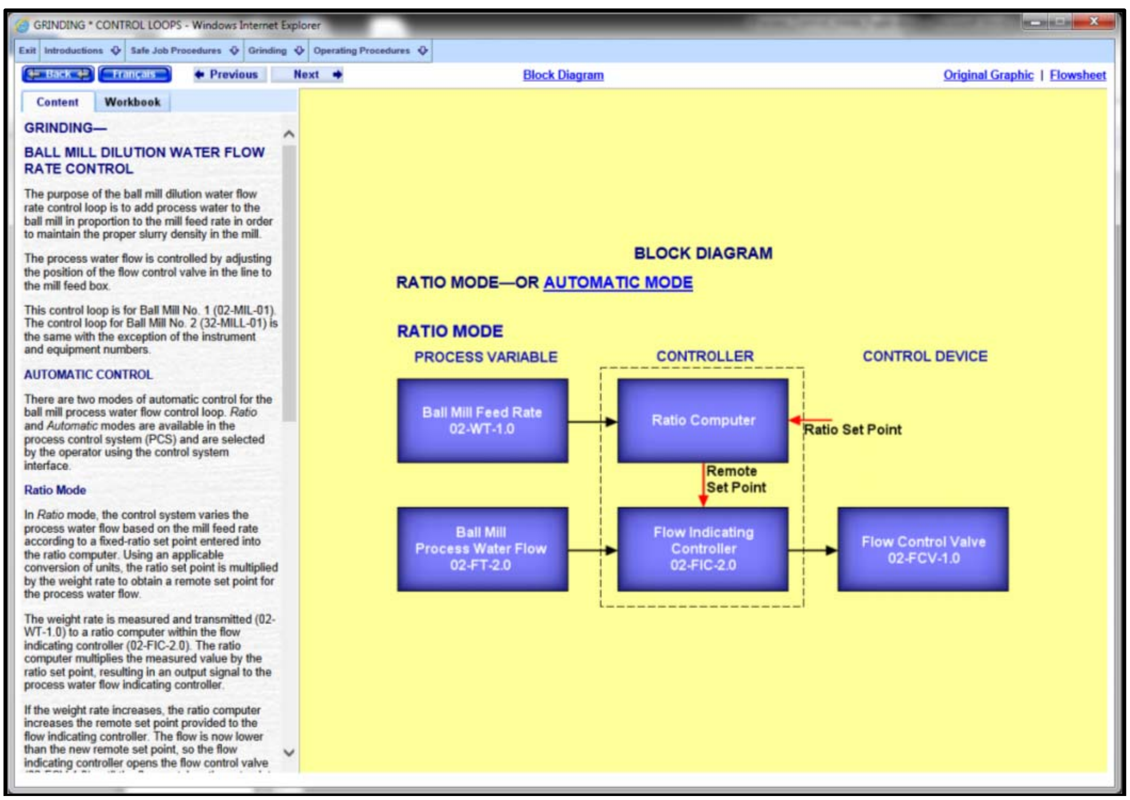
GRINDING—
BALL MILL DILUTION WATER FLOW RATE CONTROL
The purpose of the ball mill dilution water flow rate control loop is to add process water to the ball mill in proportion to the mill feed rate in order to maintain the proper slurry density in the mill.
The process water flow is controlled by adjusting the position of the flow control valve in the line to the mill feed box.
This control loop is for Ball Mill No. 1 (02-MIL-01). The control loop for Ball Mill No. 2 (32-MILL-01) is the same with the exception of the instrument and equipment numbers.
AUTOMATIC CONTROL
There are two modes of automatic control for the ball mill process water flow control loop. Ratio and Automatic modes are available in the process control system (PCS) and are selected by the operator using the control system interface.
Ratio Mode
In Ratio mode, the control system varies the process water flow based on the mill feed rate according to a fixed-ratio set point entered into the ratio computer. Using an applicable conversion of units, the ratio set point is multiplied by the weight rate to obtain a remote set point for the process water flow.
The weight rate is measured and transmitted (02-WT-1.0) to a ratio computer within the flow indicating controller (02-FIC-2.0). The ratio computer multiplies the measured value by the ratio set point, resulting in an output signal to the process water flow indicating controller.
If the weight rate increases, the ratio computer increases the remote set point provided to the flow indicating controller. The flow is now lower than the new remote set point, so the flow indicating controller opens the flow control valve
BALL MILL DILUTION WATER FLOW RATE CONTROL LOOP
FT 2.0
FIC 2.0
Process Water
FCV 1.0
Mill No. 1 Feed Bin 02-BIN-01
Mill No. 1 Feed Weightometer 02-MMT-01
Ball Mill Feed Conveyor 02-CVR-01
WT 1.0
Gravity Tails
Ball Mill No. 1 02-MIL-01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BLOCK DIAGRAM
RATIO MODE—OR AUTOMATIC MODE
RATIO MODE
PROCESS VARIABLE
CONTROLLER
CONTROL DEVICE
Ball Mill Feed Rate 02-WT-1.0
Ratio Computer
Ratio Set Point
Remote Set Point
Ball Mill Process Water Flow 02-FT-2.0
Flow Indicating Controller 02-FIC-2.0
Flow Control Valve 02-FCV-1.0

Once the operators have a good grasp of the process and the particular control loop, trainees would be taught to troubleshoot process variable problems logically, by drawing on their knowledge of the process equipment, flows, and control methodology. Operators must often check to see if the process controller output makes sense based on the deviation between the variable and set point. For example, addressing an issue with a sump level controlled by a discharge control valve, may involve the following steps:

- If the operator notices that the sump level is too high, possibly because an alarm activated, his or her first step is to check the output from the level controller. We would expect to see the output high and increasing in order to open the discharge control valve (assuming the controller output is direct acting).
- If the controller output is not doing what the operator expects, check to see that the controller is in *Automatic* mode.
- If it is not in *Automatic* mode, the controller will do nothing more than maintain its output signal. If the controller is in *Automatic* mode and is not acting correctly, check the set point.
- If the set point is not correct, adjust it as necessary. If the set point is correct, the operator can switch to *Manual* mode. In *Manual*, the operator can increase the output by hand. This will modulate the discharge control valve to a more open position to control the level. If the controller output is not working as it should, the instrument department is then notified.
- If the operator determines that the controller is acting correctly, the next step is to check the final control device in the field to determine whether it is working correctly.
- In our example, the final control device is a control valve operated by an air actuator. For the control valve to operate correctly, it requires compressed instrument air. First, check to see whether the valve (or other device) has moved as requested by the controller output.
- In the example, it should be fully open or moving in that direction. If it is not, check that there is enough instrument air pressure.
- The valve will not work if there is insufficient air pressure at the transducer. The transducer converts the Delta V or electronic signal from the controller to an air signal (3 to 15 psi). The pressure can be checked at the pressure gauge located at the transducer.
- If the controller and final control device both seem to be operating correctly, check the process that the final control device is acting on. In our example, the high level in the sump may be caused by a physical blockage in the discharge box upstream of the controlling valve. The blockage may be blocking the flow, preventing the control valve from doing its job.

- Finally, check the sensor in the field. The sensor in the example provides the level measurement to the controller. This check can normally be accomplished by going out to the sensor and checking an independent measuring device such as a level gauge glass or by physically inspecting the sump level.

Once the details of the process and control methodology, as well as control loop troubleshooting techniques are covered in the classroom, simulation drills can be conducted by the instructor with the operator trainees.

For example, the instructor might say that the field operator in the ball mill area has just reported that the mill discharge slurry appears to be very thick (high slurry density). The target slurry density is 60 percent solids, but the calculated discharge is running at about 70 percent solids and seems to be increasing. The trainee group would then discuss the symptom of the problem and, given their classroom knowledge of the process and control methodology, tell the instructor what they would do. For example, they will know from the training that there is a ratio control loop that modulates process water flow rate into the mill in proportion to the solids entering the mill. The trainee team might say that they would check the ratio controller and the output to the process water control valve. The instructor would then explain what they would see regarding the flow controller set point and output to the flow control valve. This back-and-forth process goes on until the trainee group finds the answer. The instructor can then critique the troubleshooting methods used by the trainees.

With proper training on the layout of the plant equipment, the process flow, process control methodologies, and troubleshooting techniques, variation in key process variables can be significantly reduced, optimizing the process and increasing mineral recovery and profits.