LOOP CHECKING:
A TECHNICIAN’S GUIDE

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ISA TECHNICIAN SERIES
INTRODUCTION TO LOOP CHECKING

Process control loops have a major impact on the financial performance of today’s manufacturing facilities. It is also recognized that a “good foundation” of the basic regulatory control loop is essential to the success of higher-level “Advanced Process Control (APC)” program (Ref. 6). Thus, it is critical that these facilities’ technicians focus on loop checking and performance. For this reason, this guide defines loop checking broadly to include control loop performance rather than merely in terms of plant start-up situations as in the traditional definition. Loop checking is also an important component in any plant’s continuous improvement planning program insofar as it helps define and reduce the variability of key process parameters on an ongoing basis.

The chapters of Loop Checking: A Technician’s Guide are arranged to follow a typical automation project from design checkout at the factory acceptance test (FAT) through to an ongoing sustaining loop performance program. The steps of such projects is as follows:

- loop checking basics
- the factory acceptance test (FAT)
- start-up
- performance benchmarking
- sustaining the performance

This guide is intended to discuss general methods and practices that can be applied across many processes or industries. The technician will encounter different plans and programs in his or her own company for addressing loop performance. These will, of course, affect how loop checking is defined and accomplished for the technician’s specific environment. However, the instrument technician typically has the best overall knowledge and skills for checking and maintaining control loop performance.
1.1 THE OPPORTUNITY

In today’s intensely competitive markets, manufacturers are striving to continually improve manufacturing performance to meet their business needs and goals. Typical business drivers are as follows:

- increased throughput
- increased yield
- increased quality
- minimized waste and off-spec

As we noted, the control loop (and the continual checking of performance) plays a vital role in the plant’s financial performance. However, it has been observed that up to 80 percent of all loops are not performing their intended function of reducing the variability that results from the problems caused by the factors shown in Figure 1-1. Such issues as measurement placement and the dead time or process mixing it causes, undersized headers and valves, loop tuning, and control strategy, all affect the loop’s ability to accomplish the desired objectives.

**FIGURE 1-1**  
*Control Loop Performance Issues*

<table>
<thead>
<tr>
<th>Issue</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Design</td>
<td>5%</td>
</tr>
<tr>
<td>Control Strategy</td>
<td>15%</td>
</tr>
<tr>
<td>Valve and Instrument Maintenance</td>
<td>30%</td>
</tr>
<tr>
<td>Adequate Tuning - Reduce Variability</td>
<td>20%</td>
</tr>
</tbody>
</table>

In addition, plant performance studies (such as those summarized in Figure 1-2) have shown that the largest opportunity for reducing costs (1.5%) is provided by field device performance and loop tuning, where loop checking methods can be applied.
The Control System Technician (CST) can become involved in the performance of the plant’s control loops, from the control implementation stage through to the checkout phase and then continuing through start-up, commissioning, and ongoing operations.

1.2 LOOP CHECKING: INTRODUCTION

The following section reviews the components of the control loop and the scope of loop checking.

Defining the Loop

The purpose of control loops has been defined in various ways:

- to force the process to perform in a predetermined, desirable manner. The process may be a flow, pressure, temperature, level, or some other variable in the manufacturing plant (Ref. 3).

- to adapt automatic regulatory procedures to the more efficient manufacture of products or processing of material (Ref. 4).

- to ensure safety, environmental regulation, and profit (Ref. 5).
Basic to any discussion of control loops is “feedback” control. In this control, the loop starts by measuring the process variable (PV). It then compares the PV to the desired value, that is, the set point (SP), and acts on the difference between SP and PV (error) using a control algorithm (typically PID). The loop then outputs to the final control element. The diagrams below indicate that the main elements of the loop are:

- transmitter/sensor (for measuring the PV)
- process controller (with an operator-entered SP and control algorithm)
- final control element (valve/actuator and accessories)

Control system engineers use the block diagram in Figure 1-3 to show the relationships of the control loop elements.

**FIGURE 1-3**

*Feedback Loop Block Diagram*

In a more practical view, the block diagram looks like Figure 1-4 when depicted with hardware for measurement, controller and final control element functions.
For the purposes of this guide, we’ll focus on the single input, single output control loop as depicted in Figures 1-3 and 1-4.

Elements of the Loop

Let’s discuss each element in the loop. Although several chapters could be dedicated to each element of the loop (a good resource is Reference 1), we will try to keep the discussion brief and highlight important features for our expanded definition of loop checking, which includes performance.

Sensor / Transmitter

The loop starts here and cannot do a good job unless the measurement is accurate, reproducible (reproducibility is the closeness of agreement of an output for and input approaching from either direction at the same operating conditions over a period of time and is a better number for control and measurement evaluations – see Reference 6). Total Probable Error is another important performance specification that you may use for comparison purposes. Measurement resolution of the signal within the control system is usually not an issue with today’s control...
systems I/O design, but if you configure the loop for large spans (watch for temperature loops), then small changes can go undetected. Of course, proper selection and installation of the sensor and transmitter is critical based on service conditions, accuracy, reproducibility, stability, reliability, and other plant standards. Deadtime and noise introduced by measurement installation location can really hurt the loop performance (the typical controller, proportional, integral and derivative [PID] does not handle deadtime very well). For example, mounting a consistency transmitter so that it is convenient to work on versus placing it near the dilution source can introduce unwanted deadtime, while a sensor installed near the valve outlet instead of upstream of the valve will have excessive noise.

Controller

The controller compares the transmitter measurement (PV) to the operator-entered set point (SP), calculates the difference (error), acts on the error with a PID algorithm and outputs a signal to the valve. Today’s control systems all have very capable controllers but you need to be aware of the type PID algorithm that your plant’s control system manufacturer has implemented. The two (2) common types are called “classic” and “non-interacting” (Ref. 5). Others have called them “series” and “parallel”. There is a difference in how you tune the loop with these two types of controllers. If your plant has just one control system, then your plant standard tuning methods can be used without worrying about this difference. However, as plant purchases come from different vendors/OEM’s, different control system types are employed (e.g., programmable logic controller [PLC] vs. distributed control system [DCS]). You need to pay attention when tuning the different controllers to make sure the right tuning methods are applied. The microprocessor-based systems have also introduced us to configurable loop scan (execution) times, which can also be critical to loop performance. You’ll want to make sure your controller is executing fast enough for the process dynamics. Table 1-1 suggests a starting point for some typical measurement types.

Final Control Element

The final control element takes the signal from the controller and attempts to position the flow controlling mechanism to this signal. There are various types of final control elements and some have better performance in terms of “positioning” the device. Final control elements can be variable speed drives for pumps or fans, dampers/louvers, heater
controls, but the most common is the control valve. The valve receives the most attention in the loop check because it receives an electrical signal from the controller (i.e., 4–20 mA current or digital value on a bus), converts the electronic signal to a pneumatic signal that must then drive an actuating device to a precise location. We’ll talk more about valve and loop performance in later chapters but you’ll be hard pressed to beat a sliding stem valve with spring-and-diaphragm actuator and a two-stage positioner for performance. In addition to the controller performance enemies of deadtime and noise mentioned previously, the valve could also introduce non-linearities and deadband into the loop – neither of which is good for the PID controller. In receiving an electronic signal and converting it to a valve plug/ball/disk position in the pipe, various sources of non-linearity and deadband can build up. Friction from seals and packing, backlash of mechanical parts, relay dead zones, shaft windup can keep the valve from maintaining the signal required by the control system. Proper valve sizing and selection of valve characteristic can help linearize the flow response to controller output changes – again very important to how the PID can perform.

**Other Loop Types**

In addition to feedback control, technicians will encounter several other control strategies when performing loop checking, such as cascade,
ratio, and feedforward control. The process control example in this chapter briefly discusses these techniques but the same basics apply to verify the input/control and design/output of the loop.

In some plants, the term “loop” may also include other control system functions such as Analog Indicate Only, Motor Start/ Stops, On-off Valves, Discrete Input/Output type control functions. A detailed discussion of these functions is not included in this guide although you could easily expand the methods and techniques to include them in your plant’s loop check plan.

There are several excellent resources that go into more depth on each of the elements of the loop. Vendor literature and application papers are good sources of information as are a variety of industry publications (e.g., ISA, TAPPI, etc. – Ref. 5 and 6).

**Loop Checking**

Some think of loop checking as a process to confirm that the components of the loop are wired correctly and is typically something done prior to start-up. However, due to factors described in the introduction above, the loop check’s scope has expanded to also include tests to confirm that it is “operating as designed” and then to ongoing programs for benchmarking and monitoring performance. The block diagram in Figure 1-5 illustrates the components of this expanded loop checking process.

This process starts when the instruments are received at the plant site. It continues through installation and start-up and into the ongoing plant operation. In addition, the control system should perform the intended function properly. This includes verifying the transmitter’s process variable (PV) for display to the operator, for use in the control strategy, and for historical trending. This verification testing prior to start-up is known as the factory acceptance test (FAT) which, as an option, can be duplicated at site with the actual hardware and software installed, termed site acceptance test (SAT). Further discussed in Chapter 2, the FAT can be performed prior to shipment of the hardware or in parallel with the hardware installation at site if the overall start-up schedule is compressed.

Once the technician checks the control strategy to verify that the expected output to the final control element is produced, the loop can then be commissioned and start-up can proceed.

Finally, the loop check can include defining the loop performance benchmark and providing a method for monitoring the performance over time.
Because of the scope of this manual, we will not cover the receiving, calibration, or installation aspects of the loop check (see Ref. 7). Instead, we will focus more on the verification, start-up, and monitoring phases.

**Technology Improvements**

Recent developments in “smart” instruments, I/O buses, and software products have made possible increased flexibility and productivity in the loop checking process. Such smart digital technology makes it possible to access and use new types of information that were not available from the analog 4-to-20-mA transmitter and valve. For example, HART® and FOUNDATION™ Fieldbus devices give the technician access to significant amounts of diagnostic, calibration, and performance information, not only about the device but the process as well. Software packages store the extensive data for analysis, future reference, and regulatory agency documentation as well as include sophisticated troubleshooting assistance. As a result, fewer people and less time are required to perform the conventional tasks involved in the checkout process. However, along with the new technology, new tool and training requirements must be followed in order for plants to be able to capitalize...
on the advertised benefits. Subsequent chapters of this guide will discuss the impact of smart technology on the various phases of loop checking.

1.3 PROCESS CONTROL EXAMPLE

The following example of boiler drum level, feedwater, and steam flow (three-element control) will be used throughout this guide to illustrate the loop check (see Figure 1-6). By combining feedback, cascade, and feedforward control techniques, we can cover several aspects of loop checking simultaneously.

The control objective in this example is to maintain drum level at an operator-entered set point within close tolerances throughout the boiler’s operating range. This is achieved by controlling the feedwater inlet flow, with assistance from steam flow to compensate for load disturbances. Close control to the level set point is desired because of process equipment safety issues. These include concerns over water carryover into steam lines resulting from high drum levels and the potential for boiler tube damage as a result of low water levels.

FIGURE 1-6
Example of Boiler Drum Process Control Loops
Loop Checking

**Measurement.** For the purposes of this example, the flow and level measurements are accomplished using differential pressure devices. The feedwater and steam flows utilize orifice plates to develop a differential pressure that is proportional to the square of the flow. The drum level transmitter reads a differential pressure signal between the water and steam in the drum and an ambient water column.

**Control System.** We assume either a distributed control system (DCS) or programmable logic controller (PLC) control system are being used. All controller algorithms are proportional-integral-derivative (PID). The control strategy involves the following loop types:

- **Feedback Control**—The output of the feedwater flow loop controls the feedwater valve in accordance with a set point cascaded from the drum level loop and compared to the feedwater flow measurement. This closed loop control of the feedwater flow in a cascade system allows the feedwater flow loop to correct for any disturbances in the feedwater flow before those disturbances affect the drum level.

- **Cascade Control**—The drum level controller (primary/master loop) compares the drum level measurement to the operator set point and outputs to the set point of the feedwater flow controller (secondary/slave loop).

- **Feedforward Control**—The feedforward action is accomplished by summing the steam flow measurement together with the corrective output from the drum level controller. This signal is then used as the set point for the feedwater flow loop.

**Final Control Element.** This example assumes a pneumatic-operated, sliding stem control valve with a digital valve controller for manipulating the feedwater.

### 1.4 OTHER LOOP CHECKING CONSIDERATIONS

Summarized below are some other considerations for designing, implementing, checking, and benchmarking control loops. These guidelines are based on the philosophy that control systems should minimize product variability and improve the overall efficiency of an
operation. Instrument and control system manufacturer’s installation and
maintenance guidelines should also be followed.

Keeping Score

How do we know when a loop is performing well? We need some
kind of “measure” that will identify the loop performance. As we’ll
discuss further in Chapters 4 and 5, many different methods are used to
measure the performance of the loop. You’ll need to discuss with your
performance team which approach is best for your plant.

Some people have mentioned the following as performance
measurements (Ref. 11):

- The plant didn’t blow up
- The process measurements stay close enough to the set point
- They say it’s fine, and you can go home now

Seriously, there are a host of mathematical techniques to measure
how the loop is performing. This section briefly discusses a few of these
measurements that have been used in process control applications.

One method is to calculate the “variability” of the loop so that we can
get an idea of the relative performance compared to other loops.
Variability can be defined as two times the standard deviation divided by
the mean. Let’s look at each of these terms. In Figure 1-7, as the process
variable (PV) changes, there will be a band of values, which typically form
a distribution or spread (2σ) about some “mean” (average) value.

FIGURE 1-7

Loop variability

The “mean value” is the desired set point
Standard Deviation (Sigma), $\sigma$, is a statistically derived parameter that describes the “spread” of data about the mean value. The larger the value of $\sigma$, the greater the spread. The “mean” is simply the average of the values, and in loop analysis, this typically calculates closely to the set point.

Statistics again tell us that the spread of data represented by 1-Sigma will encompass about 68% of the total data values while 3-Sigma will get 99.73%. See Figure 1-8 for a representation. As sort of an industry benchmark, we’ve settled on the 2-Sigma value to use for our process control variability calculation.

FIGURE 1-8

*Picking the Data Spread*

Thus, when you divide 2-Sigma by the mean, you now will have a value in % that will then allow you to compare loops that, for example, control flow (perhaps measured in gallons per minute or GPM) with level loops (engineering units in feet). Of course, some loops such as the secondary cascade loops or certain level loops are designed to absorb some of the process variability and thus a higher variability is fine.

Consider the following example:

Figure 1-9 shows data on a recorder from a flow loop transmitter while the loop is in MANUAL with random disturbances causing the flow to vary. By using commercially available spreadsheet tools or loop analysis software, the statistics of two times standard...
deviations (2σ, Sigma) of 26.6 GPM, mean (µ, average) of 603 GPM and resulting variability (2s / µ ) of 4.4% can be calculated.

FIGURE 1-9
Flow Example with Statistics

You would hope that by placing the loop to automatic and repeating the test in Figure 1-9 that the calculated variability would be reduced. If it’s not, then read on in Chapters 4 and 5 for loop troubleshooting techniques that can help reduce variability.

So, what is “good variability” for a loop? The table below suggests a variability range for key loops in your process as a rule of thumb.

**TABLE 1-2. Variability Rating**

<table>
<thead>
<tr>
<th>VARIABILITY</th>
<th>RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 0.5%</td>
<td>Excellent</td>
</tr>
<tr>
<td>Less than 1.0%</td>
<td>Very Good</td>
</tr>
<tr>
<td>Less than 2.0%</td>
<td>Good</td>
</tr>
<tr>
<td>Less than 5.0%</td>
<td>Fair</td>
</tr>
<tr>
<td>Less than 10%</td>
<td>Unacceptable</td>
</tr>
<tr>
<td>Greater than 10%</td>
<td>Terrible</td>
</tr>
</tbody>
</table>
In addition, there are a number of software packages on the market that are very capable of evaluating control loop performance. The following examples are from vendor information describing their evaluation techniques:

**Variability Index** - a comparison of current loop operation to minimum variance control. For example, if the variability index is zero(0), then the control loop performance can not be improved. If the variability index is 100, then the loop is doing nothing to reduce process variation (i.e., its performance isn’t any better than if it were on manual). Variability index is not fooled by noise or load disturbances (i.e., it is a true indication of how far off current performance is). A variability index of zero(0), for example, indicates no improvement is possible; a variability index of 100 indicates that the loop is providing no benefit in reducing variability.

**Harris Index** - a performance measure typically discussed by academics is the Harris Index. The Harris Index looks at the error signal, which is the process variable or measurement minus the set point. The Harris measures the ratio between the error variance and the variance achievable by a minimum variance controller. The larger the value, the poorer the performance of the loop. The Harris Index calculation results in a number between 1 and infinity. A value of 1 is perfection or minimum variance control. Larger numbers might be considered worse.

\[
\text{CLPA} = 1 - \frac{1}{(\text{Harris Index})}
\]

With the CLPA:

- 0 = perfect control
- 1 = poorest control
**ExperTune Index** - measures how well a control loop responds to process upsets. The index uses a process model combined with current and optimal PID tuning values. The index can be found by simulating the response of the control loop to a load upset with both sets of tuning values. The simulation provides the data to calculate the integrated absolute error (IAE) between the set point and process variable for each case. With the IAE for each case, the comparison can be made. The ExperTune index is:

\[
100 \times \frac{\text{Current IAE} - \text{Optimal IAE}}{\text{Current IAE}}
\]

With the ExperTune Index:

- 0 = perfect control
- larger = % performance improvement possible

The metric is unitless and provides a meaningful comparison between loops. This metric will catch those loops that have been de-tuned.

Based on performance demographics of twenty-six thousand PID controllers collected over the last two years across a large cross sample of continuous process industries, an algorithm combining a minimum variance benchmark and an oscillation metric tuned for each measurement type (flow, pressure, level, and so on) was used to classify performance of each controller into one of five performance categories. These classifications were refined through extensive validation and industry feedback to reflect controller performance relative to practical expectations for each measurement type. Unacceptably sluggish or oscillatory controllers are generally classified as either “fair” or “poor” while controllers with minor performance deviations are classified as “acceptable” or “excellent”.

**Loop Nonlinearities and Deadtime – The Bad Guys**

By far the most widely used control algorithm in process control loops is the proportional – integral - derivative (PID) controller. Although there are many techniques to “tuning” the PID settings (which is beyond the scope of this guide) for best response to process upsets, a basic underlying assumption is that the process response is approximately linear with little change in installed/process gain and minimal deadtime. The more nonlinearities and deadtime that creep into a loop, the more the loop has to be de-tuned and thus may not be able to meet your objectives.
Loop Checking

In fact, nonlinearities and deadtime can even cause a loop to amplify the disturbances so that control is worse in automatic than if the loop was in manual! Obviously, being able to identify and fix/minimize nonlinearities and deadtime is key to loop performance.

The above mentioned guidelines discussed some methods for reducing nonlinearities and deadtime from a design standpoint in the loop checking process but you’ll also want to be aware of other sources. For example, control valves introduce friction, backlash, shaft-windup, and relay dead zones while transmitters can have damping filter and sample time issues and the control system also can introduce filter and control strategy nonlinearities. To help minimize these problems, purchase high-performance valves/positioners and transmitters and then utilize maintenance programs to sustain this performance over time.

Control valve sizing and selection can also play a large part in the overall loop linearity.

As mentioned previously, we want the overall response of the process—that is, when the valve moves and the process responds—to be as linear and as constant gain as possible over the operating range. This overall process response is called the “installed characteristic” of the loop. Let’s look at how the installed gain is important. For example, in looking at the pump and system A curve in Figure 1-10, as the flow through the system increases, the outlet pressure, or head, of the pump drops off while the system losses through pipe tees, elbows check valves, and so on increases. The throttling control valve absorbs the difference between the two pressures. Notice the difference in the pump and system B curve shown in Figure 1-11, where the pressure drop in which the valve must throttle does not change as much as it does in system A.

So, how do you select valves to handle these varying pump/system applications and still provide a linear response for the PID loop? The control valve “trim” (the internal parts of the valve that control the flow passage—for example, plug, seat ring, and cage) is engineered to fit the application by shaping the plug or cage windows to provide what’s called the “inherent characteristic.” You select the trim with the inherent characteristic that will best linearize the pump/system curve. Most valve vendors develop a table/curve by testing each valve that shows the flow resulting from valve movement with a constant pressure drop. In general, the three most common “inherent characteristics” that are available to choose from include “equal percentage,” “linear” and “quick opening” (see Figure 1-12).
Let's see how this works. For the pump and system curve A where the throttling pressure drop across the valve decreases as flow increases, the selection of an “equal percentage” inherent characteristic would be best because the reduction in pressure drop is “canceled out” by the increasing flow area of the valve. The net result is that the “installed characteristic” now becomes more of a linear response for the range of flowing conditions – good news for the PID loop and your chance to tune for tight control. Similarly, for a header pressure control example, the inlet and outlet pressures do not change much over the flowing range and a “linear inherent characteristic” would be your best choice.
You’re not out of the woods yet. Even though you know the inherent valve characteristic, you must also take into account valve type (rotary, sliding stem) to get the true picture of what you’re up against for loop checking.

**FIGURE 1-12**

*Control Valve Inherent Characteristic*

For example, in Figure 1-13, a butterfly style valve is tested in a flow loop for the installed gain the loop will experience. Notice that only a small part (from about a 20 to 40 degree opening provides a linear response with a process gain that is within a desired range (called the EnTech Gain Specification). However, compare this to Figure 1-14 for a sliding stem control valve, which shows that the gain is within spec over a wider operating range. By looking at the valve constructions/flow paths, you can see why the butterfly valve has the narrower range.
Introduction to Loop Checking

**FIGURE 1-13**
Butterfly Valve Installed Gain

![Butterfly Valve Installed Gain Diagram](image)

**FIGURE 1-14**
Sliding Stem Valve Installed Gain

![Sliding Stem Valve Installed Gain Diagram](image)
TABLE 1-3.

Valve Type – Control Range Summary

<table>
<thead>
<tr>
<th>STYLE</th>
<th>CONTROL RANGE (% OF TRAVEL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Globe/Sliding Stem</td>
<td>60</td>
</tr>
<tr>
<td>Vee-ball/Rotary</td>
<td>55</td>
</tr>
<tr>
<td>Eccentric ball/Rotary</td>
<td>38</td>
</tr>
<tr>
<td>Butterfly</td>
<td>22</td>
</tr>
</tbody>
</table>

Now you can see why the oversized valve trying to throttle near the seat is not going to perform very well. Also, you can see why there is a significant difference at what the top-end control point should be. Imagine trying to tune the loop for a butterfly valve that has to operate near 70 degrees open for one product and 30 degrees for another—probably job security for your loop tuning people. Table 1-3 gives a summary of the different types of control valves and approximate control ranges. There are workarounds such as output signal characterization to ease some of the installed curve nonlinearities or gain scheduling in your controller but spending the time and money to install the correct size and style valve will provide the best solution for the loop checking performance.

1.5 CONTROL LOOP DESIGN GUIDELINES

In this section we summarize eleven guidelines that technicians should consider when designing, implementing, checking, and benchmarking control loops. These guidelines are based on the philosophy that control systems should minimize product variability and improve the overall efficiency of an operation. Technicians should also follow instrument and control system manufacturers’ installation and maintenance guidelines. We recommend the following guidelines:

1. Dead time or time delay as seen by the control loop should be minimized wherever possible. This means that (a) measurement devices should be located as close as practically possible to the control device without effecting their measurement characteristics, (b) long instrument tubing runs should be avoided, (c) transmitters with long processing delays should be avoided, and so on.

2. Process transport delay should be minimized.

3. Control devices (valves, air motors, damper drives, etc.) should exhibit repeatable dynamics, with virtually no nonlinearities over the
process’s complete operating range. Their speed of response should be reasonable for the application.

4. The control loop’s installed process gain from control device to measurement device should nominally be about 1-%span/%output over the process’s complete operating range. Process gains in the range of 0.5 to 2.0-%span/%output are acceptable.

5. Filtering of the control loop measurement should be kept to a minimum, and it should be at least five to ten times less than the closed-loop time constant of the loop.

6. Only linear control algorithms should be used. Control loop nonlinearities such as control dead bands, error dead bands, error characterization, and the like, should not be used.

7. The control loop should be tuned using nonoscillatory tuning techniques.

8. Process areas should be tuned in a coordinated manner to minimize loop interaction and disturbances to processes that rely on the ratioing of ingredients or raw materials.

9. The control loop should be stable over the process’s complete operating range.

10. The outer loop of a cascaded loop structure should be tuned five to ten times slower than the inner loop.

11. The less critical loop of a set of interacting loops should be tuned five to ten times slower than the more critical loop. (Ref. 8)

REFERENCES


Loop Checking


**QUIZ**

1. Why would a loop checking program be important to the plant manager/profit center manager? The project manager/engineer? The control system technician? The process engineer?

2. The typical plant can realize the best return on investment by which of the following programs? a) Advanced Control Packages b) Process Design Improvements c) Field Device Performance and Loop Tuning d) Process Data Access and Trending

3. What are the basic elements of the control loop? Which loop element would be most susceptible to long-term performance degradation and thus a candidate for specific device monitoring?

4. When does the loop checking process start? When does it end?