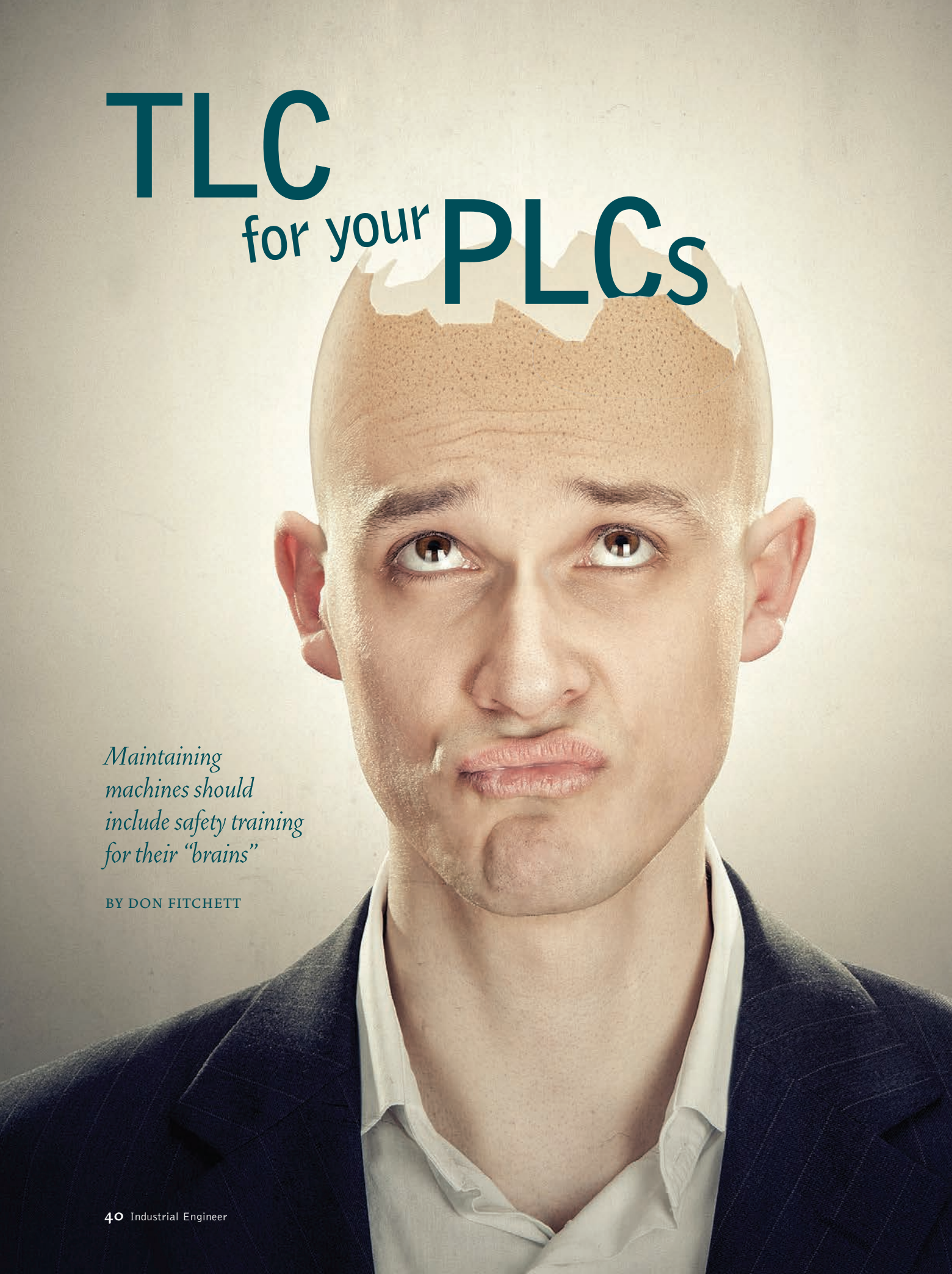
TLC for your PLCs



Maintaining machines should include safety training for their "brains"

BY DON FITCHETT

The standard operations of companies involve managing risk, whether that risk comes from safety or financial factors. Despite this fact, most companies do little or nothing to manage the safety and financial risks related to their controller automation. This is quite surprising for manufacturing and production companies that depend primarily on equipment and process automation. Those involved in industrial management, plant safety, maintenance and installation of automation equipment should give serious consideration to the risks involved with their PLCs. This article focuses on automation control, but the following approach should be applied to all aspects of manufacturing and production automation.

First, do not assume that all responsible management personnel even know what a PLC or PAC is. PLC stands for programmable logic controller, and a PAC is a process automation controller. These two very different devices control hardware inside just about every machine in every industry worldwide. While their use in manufacturing machines and processes is commonly known, PLCs and PACs also control most of the world's infrastructure. SCADA (supervisory control and data acquisition) software is designed to interface operators and management with the PLC or PAC. So SCADA indirectly warrants the same risk management attention described below.

Most industrial companies do not give their people or management the instructions and training demanded by the risk that comes from their PLC (PAC/SCADA) automation. But a little PLC that you never knew existed can shut down your machine, your line, your entire facility, city power, water and more.

So a company's first step should be an inventory of all automation control equipment and software. Your personnel will compile a more accurate list if they are trained properly.

The most significant financial aspect of PLC risk management is downtime, which can total many hours and cost many dollars. Companies are saving thousands to millions of dollars by focusing on inventory of PLC automation, training, creating relevant policies and procedures, and including these in the company's safety program.

Proper training also reduces injuries and saves lives. As with other manufacturing and production processes, a lack of training is the No. 1 cause of safety incidents involving PLC automation. A lack of instituting or enforcing policies and procedures is a close second. Within these categories, safety problems usually are caused because employees don't understand how the PLC program works, although "forcing" inputs or outputs has the greatest risk potential. A "force" is a function in the PLC that allows a user to, for example, force a motor "on," bypassing all safety interlocks programmed into the PLC.

Online programming also is dangerous. Online programming changes the program in the PLC processor, while offline programming changes a copy of the program on your computer. Technically, your workers could switch the processor to program mode and do changes online, decreasing the risk somewhat. But experience has shown that most employees who make changes online do so while the process is running, which is a very risky proposition.

Ignoring these safety issues can cause network security problems in some manufacturing and production processes. It also can be fatal – literally. In one plant an employee was killed when an automated material transport car ran him over, smashing his head between the automated car and the conveyor eyebeam. A combination of several events had disabled three fail-safes to cause that fatal injury. First, personnel weren't trained properly to calibrate one fail-safe device. Second, a proximity switch that kept giving operators problems was bypassed. Third, a lack of preventive maintenance meant dust accumulated on the photo eyes so they could not see the operator. Just like you regularly clean your eyeglasses so you can see, the photoelectric sensors, or "photo eyes" in PLC vernacular, must be kept clean to ensure optimal performance.

In other cases, modifications to PLC programs were made without complete understanding of the whole program, breaking arms, crushing limbs and causing blindness. Many accidents that can be traced to a lack of PLC training are not reported as such because PLC programs are complex and expertise is lacking.

Inventory time

If the company does not have an up-to-date list of all PLC model types, part availability, program copies and other details, it must perform a PLC audit. Open every electrical panel and write down the PLC brand, model and other pertinent information recommended below. Analyze the audit information and risk and then act on that analysis. Using the PLC audit form in Figure 1 can help. If a company makes its own inventory sheet, it might collect some of the following:

- Machine or area name: Warehouse conveyor, pump station 3, strapper 2, line 7, traffic signal west main, etc.
- PLC program name: 1789GAA1, P3, Strap2, 5872443, WestMainTL, etc.
- Network node address: No two addresses will be the same. Examples would include 2, 3, 17, 21 or a unique IP address.
- Network name: It's common that this is the same as the program name, but it's helpful if the name describes the machine or area being controlled.
- PLC brand, such as Allen Bradley,

Siemens, Schneider, Mitsubishi, Direct-Soft, Omron
- PLC model number, such as PLC-5/25, SLC-504, SIMATIC S5, MELSEC FX1N, DL 405 (PAC-ControlLogix)
- Is a spare available? Answers could be yes, it's on the shelf; no; or only available for critical machines.
- The date the program was backed up last: Companies should make program backups part of their semiannual preventive maintenance program.
- A descriptored copy of the PLC program must be available. This describes all the elements of a program (bits, rungs, elements, etc.). See Figure 2. Without a descriptored copy of the program, troubleshooting and downtime are increased, and modifications are more costly.
- Does the PLC have an EEPROM (electrically erasable programmable read-only memory) or other method of storing the backup program in a chip on the PLC?
- The last date the program was changed: Companies should log when outside consultants or an OEM makes a program change, too.
- Last date the EEPROM was updated or burned: Every successful program change should be saved to the EEPROM.
- When the battery was changed last: See manufacturer's data for recommended change frequency.
- Other information: A company may need facility location when corporate headquarters is using this form, whether the SCADA system is tied to each PLC or whether the type of automation is PAC or PLC.

After a company collects the above information, it is imperative that personnel analyze it to develop an action plan based on risk analysis. In the risk analysis, bottlenecks and other factors help assess priorities. Starting with the highest priority PLC, the company will ask more important questions like the following:

- Does the company have the most common spare parts for the PLC?
- Is the original equipment manufacturer available 24/7? Or is it even in business anymore?
- Does the company have a backup copy of all PLC programs?
- Does the company's PLC program copy have descriptions so personnel can work reliably and efficiently with the PLC?
- Does the company have the software needed to view the PLC program?
- Are the maintenance personnel trained on the PLC brands in inventory?

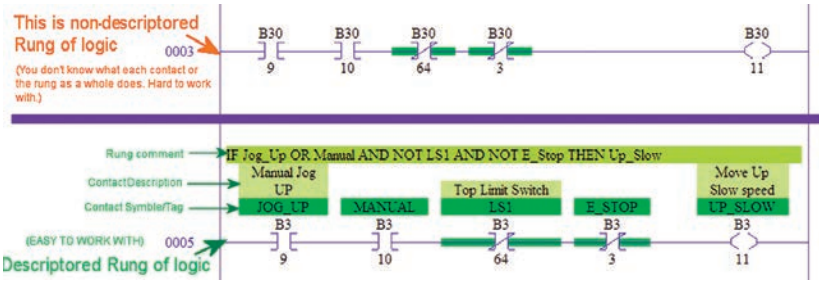
CHECKING IT TWICE

Figure 1. This is an example of a recommended PLC checklist for your facility.

Machine name	Example	Example 2
PLC program name	YC1234R2.rss	YC5678.rss
Network node address	6	2
Network name	Aircompressor1	Shipping3
PLC brand	Allen Bradley	Allen Bradley
PLC model number	SLC500 5/03	PLC 5/04
Spare available	Yes	NO
Last backed up	8/15/04	9/15/03
Descriptored copy	NO	Yes
EEPROM	NO	Yes
Last program change	7/1/03	6/4/00
EEPROM burned	NO	Yes

SALVATION THROUGH DESCRIPTION

Figure 2. A descriptored copy of the PLC program details each element, information that can decrease downtime and improve troubleshooting.



The training regimen

Most of a company's PLC automation-related downtime is due to lack of proper PLC training.

Company personnel who work with PLCs and their managers need training that focuses on safety, reliability and best practices of working with PLCs, which goes beyond typical scholastic, textbook or PLC vendor training. People in maintenance, electricians, maintenance managers and industrial engineers who find these PLC concepts new to their ears most likely need additional training. OEMs that provide this equipment to manufacturing and process industries also could use this additional training.

Those who make decisions on equipment purchases and production design can benefit as well. These maintenance managers and industrial engineers not only need to understand what to specify for new purchases, they need to know what their employees who work with PLC automation deal with. Employees actually working with PLC automation should receive refresher training every two years, along with vendor specific training on new equipment. Those who manage employees who have access to the PLCs should have minimum PLC training. The managers must know about the associated risk with "forces," online programming and other critical terminology.

Vetting your instructors, whether they are community college instructors or consultants, is key. Ask your training provider about what safety topics, reliability and best practices will be covered in the training. Make sure they have attended independent PLC safety and reliability training courses within the last two years.

Schedule sessions to accommodate the training, not to accommodate a predetermined timeframe. For instance, instead of asking your provider for two days of PLC training, ask how long it will take to train your employees properly. Two days of training may be just enough knowledge transfer for employees to be dangerous. Employees may walk away with the skill to access PLC programming without knowing how to work with it safely and reliably. Improper training can cause more downtime and safety risk than no training. Without any training, your workers couldn't access and change preprogramming, so they wouldn't have false confidence and the opportunity to take more risk. When it comes to PLC and automation training, the old cliché "some training is better than none" may not be true.

If your managers haven't had PLC training, they can't judge whether five days is enough time to teach their employees PLC, PAC, SCADA and VFDs (variable frequency drive). Because of the risk to man and machine, the training provider's ethical responsibility is to insist on the proper amount of time to train employees. The company's responsibility is to ask and consider the training provider's recommendation on time needed.

I recommend three days as the absolute minimum for PLC basics and relevant safety training, although five days are preferred. For a PAC or SCADA, five days is the absolute minimum.

A potential solution to scheduling conflicts is a train the trainer approach. While on-site, hands-on training for each

THE NO-ALIGNMENT BREAKDOWN

Industrial engineers and managers fighting downtime problems should add alignment issues to their preventive maintenance programs, according to SKF.

Misaligned shafts and belts can damage seals and couplings, leading to lubrication problems on rotating equipment. Correcting alignment is the only way to prevent the failure of these seals in the future. And improperly aligned shafts or belts face an increased load, which can cause a host of problems:

- Increased friction, which can lead to excessive wear, excessive energy consumption and the likelihood of equipment breaking down prematurely
- Excessive wear on bearings and seals, resulting in premature failure
- Premature shaft and coupling failure
- Excessive seal lubricant leakage
- Failure of coupling and foundation bolts
- Increased vibration and noise

According to the Swedish company, the two kinds of shaft misalignment are parallel, where the center lines of both shafts are parallel to one another but are offset, and angular, where the shafts are at an angle to one other.

Don't rely on visual inspection. Dial indicators are more accurate. Even better are laser-guided tools that are quick, accurate and provide real-time values so technicians can measure and attain correct alignment simultaneously. Make sure you account for "soft foot," a condition where one foot of a machine does not sit flat on the base plate. Shim plates generally can be used to bring machines back into alignment.

individual is always best, you can build up the knowledge base and training skills of one employee who then conducts in-house training for the rest of your workers. It is recommended that every manufacturing and production process company have at least one person per shift properly trained in PLC automation.

Policies and procedures

Written policies and procedures for managing and working with PLC automation are absolutely critical, but true corporate success comes from following and enforcing the measures. Organizations often write guidelines about what they believe is important for the health of the entire corporate body, yet they leave out the brain, the PLCs. The following list is by no means complete, but it can help your company start adding to its policies and procedures:

- Backup copies of the PLC programs will be made every six months regardless of change status.
- All PLC programs that have been changed are to be documented in software, hard copy and in the computerized maintenance management software (CMMS) program.
- Additional backup copies of all programs are to be stored off site in case of flood or fire.
- The PLC inventory detail spreadsheet is to be updated anytime there is a change in hardware or new equipment is added.
- Only those who have had PLC safety and reliability training will be allowed access to PLCs and relevant software.
- PLCs that have EEPROMs or other backup integrated circuit chips will be updated (burned) after any change to the current program running the process.
- The maintenance or engineering department will be responsible for ensuring that all outside equipment vendors and consultants comply with these company policies.
- All future equipment purchases will include a request that new equipment contain PLC brands that match facility and personnel training.
- All new equipment purchases must include a vendor pre-purchase agreement that requires provision of a descriptor copy of PLC programs in the customer's native language.
- All PLC 120-volt control voltage will have a line filter on it.
- Any action that has to do with "forces" on the PLC's input or output will be considered a safety issue, and company safety protocol must be followed.
- No "force" shall be installed longer than 24 hours.
- No "force" shall be installed or changed unless the employee first has a clear understanding of the complete effect on the PLC program and machine, along with a second opinion for confirmation of this understanding.
- Online programming while equipment

is active greatly increases the risk to man and machine, so consider this only as a last resort.
- All automation equipment should be on its own isolated network that is not accessible by the office network or any other network that could give access to nontrained personnel.

Safety concerns

PLC automation safety should be a company's first and primary concern. When evaluating your company's PLC safety program, seek recommendations from your OEMs and outside experts. And considering the risk, it's a good idea to get your employees trained by a second source. Diversity in education greatly improves understanding and reduces risk to the company. When seeking additional PLC training for company personnel, the company should ask for examples of what best practices, safety and reliability will be covered in training.

For example, Windows-based software commonly allows several ways to perform the same task. One way may be the best-practice method, but the other two ways of performing the same task could damage people and/or the machine. The instructor should show the best way to perform the task and warn students not to use the other two ways.

Take a technician who adds or modifies a rung of logic on your Windows-based PLC software. A technician who does not know any better might choose to verify the change by picking "verify all" instead of "verify rung." The "verify all" function inadvertently could verify rungs that were changed improperly or accidentally years ago. If those bad rungs of logic, which have sat dormant for years, go active, the consequences could be enormous.

PLC training and understanding are connected directly to reducing unplanned downtime. The return on training investment, coupled with proper PLC management, is many times greater than the cost of the training.

Don Fitchett is president of Business Industrial Network, an industrial training company. After serving in the U.S. Marine Corps, he spent the last 30 years in the industry, starting out in maintenance for world-class companies like Toyota and Dana Corp. Fitchett founded Business Industrial Network in 1995. He is the author of The True Cost of Downtime, *now in its second edition.*