A New Generation and a New Process — An Application That Can Do for Technicians What CAD Has Done for Engineering

Today, industry is faced with a serious shortage of skilled technicians, while the drives and controls of steelmaking equipment are becoming ever more sophisticated. Compounding the problem is the increasing demand for more uptime to offset non-recoverable downtime. This paper presents a process that combines the new generation of technicians with a technology tool that can put them on par with those having much more experience, hence growing a more efficient upcoming generation of troubleshooters — more efficient because of the incredible technology tools that are now available, formatted and applied to the industry at an ever-growing pace.

A recently patented application called iSchematic™, engineered particularly for the Y generation (referred to here as Gen Y) of technicians, may very well do for them what CAD has done for engineering. Many in the baby-boomer generation (referred to here as boomers) remember and have followed the birth and evolution of AutoCAD® in industry, developed and marketed by Autodesk Inc. AutoCAD was first released in December 1982, and by 1986 became the most ubiquitous microcomputer design program worldwide. More important, CAD technology has changed how engineering design is practiced and has been a major element in the increase in industrial productivity over the past two decades. Although far from being able to predict the exact technology that will change the process of troubleshooting sophisticated industrial machines, the current approach of the process is beginning to evolve. The following is an example. The process of taking existing machine documentation and converting or filtering it to become contextually specific for maintenance application and deliverable over mobile devices will forever change for better the way troubleshooting of equipment is done. The boomer generation of maintenance technicians is passing the baton to Gen Y. As this transition takes place, tribal knowledge, skills, and procedures can be captured and digitally passed on to a new generation that is inherently prepared to combine that captured knowledge with technology tools.

A New Generation

The Y Generation, sometimes referred to as Millennials, is the tag given to those born between 1977 and 1995, more broadly

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expressed as those born between the late 1970s and early 2000s. Gen Y consists of approximately 79.8 million people in the United States. They are currently the fastest-growing demographic in the workplace and the marketplace. They are an emerging adult population that exerts a great deal of influence due to their sheer numbers, expected longevity and hyperconnectivity. By 2020, nearly 50% of the U.S. workforce will be Gen Y.

As this new generation replaces the boomers in industrial maintenance positions, they bring with them some interesting characteristics and background:

- In short, those in Gen Y want stimulating work that gives them a large amount of opportunity for learning and growth.
- They are not necessarily tech savvy, although they are absolutely tech dependent.
- They were born with computers and software programs — not the least of which are gaming programs.
- They are tremendously versatile with Web delivery and mobile technology.
- They are extremely visual and rather impatient for data.
- Generally speaking, they prefer to communicate digitally.
- They seem to have an inherent ability to understand a software program’s algorithms, being able to navigate within minutes.

As boomers and Millennials come together in the workplace, the integration and handoff of learned skills, procedures and general knowledge can have its challenges. However, this is also a time of tremendous opportunity to work together in transferring the skills and knowledge from a retiring generation to a new generation. This transfer will greatly increase maintenance reliability, combining knowledge of the past with present and future technology.

A New Process

In learning about a machine’s operation, maintenance and troubleshooting, most likely the technician begins with the documentation that accompanied the equipment at the time of installation and commissioning. This is usually found in a paper manual, on a CD-ROM or on the Web, and supplied from the original equipment manufacturer (OEM). Although the content is readily available in abundance, it is often difficult to search and can have contextual issues as it relates to maintenance. In the current world of technology, this type of documentation is cumbersome and difficult to use, making it nearly impossible to quickly locate information relevant to a specific issue with the machine. Additionally, changes made to the drawings and schematics during commissioning often have not been updated. Frequently the way in which documentation is presented is challenging at best, especially when used for troubleshooting during unscheduled machine downtime.

Consider another aspect of the maintenance process: training. While training is a critical element of the technician’s growth and skill development, it is very often misapplied. If no strategic outcomes are developed around training, it can be a very expensive element of the process, with little or no return. Training must be considered an event, while learning ought to be looked at as a process. In today’s industrial maintenance processes, training is offered in many formats, with various methods of delivery. For training to have a positive return on investment (ROI), it must have defined outcomes that always connect to reducing unscheduled downtime from equipment failures; or it should always be considered an element of learning. In the skills learning and development triangle in Figure 1, notice that training is offered in several formats, selected purposely for efficiency with specific outcomes. For example, the e-learning format allows a technician to move from awareness to comprehension. This can be accomplished efficiently with on-demand delivery on the company’s time and often on the company’s premises. Although the same outcome could be achieved, placing a dedicated instructor in a classroom with a group of off-the-floor technicians is an inefficient and expensive choice for delivery. Technology now allows for good results with very little cost and, if developed correctly, even better results than classroom delivery, provided the subject matter is foundational and movement is from awareness to comprehension. Notice that when skill advancement passes the comprehension level and moves into the skilled level, classroom instructor-led training provides the more effective outcome.

In the skills learning and development triangle, time on the job is essential to progressing up the levels. This has sometimes been erroneously used to determine skill levels, while no metrics are used to measure outcomes. The triangle suggests that various formats and deliveries of training facilitate learning and skill development over time. Mastery is shown as the highest level of development and is measured by a technician’s ability to efficiently and safely troubleshoot a machine’s failure. Understanding the unique qualities and characteristics of the Gen Y technician is essential to selecting skill development strategies, including tactical approaches. Careful consideration should be given to selecting how content is delivered, when it is delivered and to whom. Remember, Gen Y learns differently than the boomer technicians, yet
the older generation holds vast amounts of knowledge and skill, and can be a powerful asset in transferring this knowledge to the incoming generation.

Though time on the job will always be required to some degree, the mastery level of skill development can be reached in a much shorter period of time, while developing a safer process for troubleshooting. This is achieved by organizing the machine’s documentation content into the right context, while using technology to place it no more than three clicks away. The content must also be easily updated and delivered to the Web for complete access and collaboration. This process is called iSchematic, patented in April 2013 as “Methods and Systems for Machine-Related Information Delivery,” U.S. Patent No. 8,401,675 B2. The process of applying the iSchematic tool as a construct of skill development and machine-specific troubleshooting moves most technicians immediately from the comprehension level to the skilled level. It also enables the more skilled technician to have mastery when applied to a particular machine.

**Organizing the Documentation**

The iSchematic process of organizing the documentation begins with collection of all the machine data, including engineering drawings, schematics, operating and maintenance manuals, controls data from the programmable logic controller (PLC), and all other documents relevant to the operation, maintenance, and troubleshooting of the equipment.

A subject matter expert reviews the documentation and then separates and categorizes it into the following metadata files:

- Machine operating events.
- Hydraulic, pneumatic and electrical schematics.
- Process flow diagrams.
- Bill of material documents.
- Input/output (I/O) listings.
- Controls ladder logic.
- Component images.
- Image files.
- Video files.

The file assets are verified for accuracy and any required revisions. Drawings and schematics are redrawn with color-coded legends and saved as CAD files for quick updating, as illustrated in Figure 2. The schematics contain the original documentation and include any revisions. Critical components symbols are identifiable and will be hyperlinked in the tool to an image of their respective device.

Images are prepared of all relative components with their specific part numbers, manufacturer’s data, stock codes and PLC addressing, and then entered into the database (Figure 3).

Additional files that are added to the tool are applicable MP4 audio component learning modules. Every component on the machine that is identified as an asset of the project is assigned an animation to illustrate the functional description of the device. The
illustration is generic and not manufacturer-specific. For example, if a machine uses an inductive proximity switch as an input device in its controls, then an animation of this type of proximity switch (Figure 4) is hyperlinked to the component data page of the iSchematic tool.

The machine’s controls data (PLC) is organized and separated into files containing the I/Os with their respective component data and electrical schematics. The PLC ladder logic files are reviewed to help formulate the machine’s events listing and also reference the specific I/Os associated with each event. The controls documentation is put into context that assists the technician in associating inputs with outputs by viewing the PLC ladder logic, as shown in Figure 5.

**iSchematic Tool**

Once all of the machine’s documentation assets are entered into the database, they are pulled together into the application editor, creating a tool called
iSchematic. The iSchematic tool provides the technician with a user interface, displaying the machine’s events, as well as other drilldown titles, with content mapped and hyperlinked. Figure 6 shows an example of the user interface page for the B1 shear at Nucor Steel–Hertford County.

A machine’s functional operations and/or failures often are communicated first by referencing the machine’s specific event(s) that are malfunctioning, thus establishing a firm base from which to begin the troubleshooting process. Any number of events, determined by the type of drives that are performing the machine’s work cycles, can be used and are listed on the user interface. Most often these events are established from the PLC registry, or ladder logic, relative to the machine’s inputs and outputs. The B1 shear’s event type on this machine is hydraulic. Although not shown on this user interface, the PLC controls are also included for most of the hydraulic events, which is critical for the technician to distinguish and separate hydraulic failures from electrical failures.

As an example, the shear cylinder down event is emphasized on the user interface, indicating an event that is not functioning correctly (section 2 in Figure 6). When the technician clicks on this event, it is immediately hyperlinked to the hydraulic schematic, showing the circuit with the applicable coloring that indicates flow direction, flow control, pressure variations and mapping, through the symbols that represent the specific hydraulic components associated with this particular event. This screen also has a dropdown text box that describes in detailed text form what is illustrated by the circuit color legend, i.e., the screen will have a step-by-step explanation of the sequence of operation and its related components, as seen in Figure 7.

As the technician evaluates the data associated with the event, he or she is learning to read the schematic and the symbol logic, an invaluable skill in troubleshooting hydraulic failures. Immediate and accurate data is also provided on which circuits are under pressure — an invaluable safety tool. Although lockout/tagout procedures prevent a multitude of hydraulic-related injuries from occurring each year, they generally never give protection against trapped pressure exhaust hazards.

Another challenge is faced at this point in the process. Normally when reading or analyzing a schematic, a technician may be successful in determining which components may be contributing to the outage. Yet even some experienced specialists find it difficult,
if not impossible, to know where a particular symbolically identified device actually is on the hydraulic valve stand or elsewhere in the circuit — a real problem in troubleshooting and in safety. By hyperlinking the circuit symbol to the image of the actual device, a costly error has been avoided. Figure 8 illustrates an example of clicking on bubble number 9.2, a crossover relief valve in the shear cylinder down circuit. Figure 9 illustrates the component screen to which it hyperlinks.

At the component data screen, a wealth of information is just one click away. The information that can be attached to the component at this point is limited only by how much data the technician wants to connect.

The default data includes the following:

- Component drawing number.
- Component description.
- Manufacturer.
- Manufacturer’s part number.
- CMMS stock code.
- Stores location.
- Component application (What is the device doing in this circuit?).
- Actual device image, showing location.
- Animation, showing functional description.
- Video of adjustment or removal.
- Safety-related data or procedures.
- Manufacturer’s data sheet.

Note that the learning module or animation on each device’s data page is the same module — basic hydraulics, pneumatics, electrical, mechanical, or drives and controls — used during e-learning to progress from awareness to comprehension. With each new machine application that has a missing animation describing the functionality of a device, a learning module is created. The module can now be used in the machine’s iSchematic and can be accessed in e-learning or in a wiki search format. The animation attached to a crossover relief logic valve, shown in Figure 9, has a default animation on pressure control logic valves, shown in Figure 10.

Once the machine assets are in the database, they can be pulled up from a number of locations. One such place is from section 5 of the user interface (Figure 6). With all the machine’s components tagged and a search engine in the tool, users can search by
Component search.

Figure 11

part number, manufacturer or description. For example, in Figure 11 the word “logic” is entered in the search box, and immediately the component is filtered from 421 components, identified and linked to the component data screen.

Figure 12

Beyond the actual iSchematic troubleshooting tool itself is a vast library of growing assets contained in the systems metadata. The technician can access this through an Internet connection. It is a resource library of growing assets that are shared by all utilizing this technology. It was built on the concept of wiki technology and allows the technician to simply type in a keyword for a device he or she wants to learn more about. Once the topic is selected, the system opens a screen that allows the technician to view animations on the device’s functionality, view a movie on a procedure, or view descriptions or definitions, in addition to images that show component applications. Figure 12 is a screenshot of a video showing a change or configuring of the X and Y porting on a pilot-operated directional control valve.

Another important consideration when integrating this type of digital tool is the ability to make edits. Machine specifications, components and circuit drawings can change over time. The editing capability needs to be somewhat intuitive and have few steps in the process. Editing tools have advanced quickly with technology, allowing text changes to be less than four clicks away. Replacement or addition of images and video is a few steps more but is easy to accomplish in a short period of time. Uploading CAD drawing changes can be time consuming, but thanks to more illustrative user manuals and instructional video, this too can be learned in a reasonable amount of time.

Figure 13 is an example of the text field editor, showing the component data referenced earlier on a pressure valve in the shear cylinder down event. Notice that it requires only opening to the text field, making the needed changes, and then saving it.

As the use of mobile device technology grows, the devices themselves become increasingly more compatible with metadata storage and suggest a powerful way of troubleshooting industrial equipment. The iSchematic tool is already iOS compatible for use on the iPad, with a downloadable app at the Apple store, and is fully compatible with the Windows 8 software running on mobile devices. Security may be an issue in some cases; however, the tool can be placed inside a company’s firewall. Figure 14 is iSchematic’s tool system data.

Results

At Nucor Steel–Hertford County, iSchematic technology has been
applied as a key element in the successful reduction of unscheduled downtime. The technology has been integrated into several areas, with specific application to machines that are critical to reliability. Currently, it is being utilized as a troubleshooting tool for hydraulic circuits in the electric arc furnace and rolling mill, with scheduled integration as part of an ongoing process. Over the past five years, the iSchematic technology has been applied to approximately 60 segments of steel production equipment throughout the industry. Nucor Steel–Hertford County assisted in creating metrics that show results relative to an ROI within their applications. Although this is an ongoing study, Figure 15 gives current results of one aspect of the ROI as applied to non-scheduled machine downtime in mill bending.

The first half of 2013 shows an uptick in downtime due to one situation; during a scheduled downturn, a problem occurred that had to be calculated in part as non-scheduled. This is left in to ensure an accurate metric. The trend, however, as shown in Figure 16, shows a continuous improvement of more than 50% in unscheduled downtime in 2013 from 2012. A closer study in 2014 will trend another aspect of the total ROI — tracking skills improvement among the technicians assigned to equipment that has integrated iSchematic technology.

Currently, different technicians are assigned to assist in each new integration, giving them unique training not only on the equipment itself but in the understanding and application of the technology. During the process of upgrading to the iSchematic, the hydraulic technician becomes fully engaged in understanding how the company’s hydraulic system works and is 100% included in any modifications that need to be made in the machine’s documentation, including errors in the schematics. The constant interaction between the hydraulic technician and the iSchematic project engineer builds new understanding on the machine’s operation and functionality, and also builds understanding of how the technology can quickly identify failure sources by component. In summary, the technician’s involvement is a course in iSchematic application for that specific machine. This process helps prepare the technician for future situations that will occur and also gives him/her the applied knowledge to help train others.

Other industries’ application results trend in a very similar way as Nucor Steel–Hertford County’s. To date, iSchematic technology is being applied extensively in the following industries: steel, pulp and paper, oil and gas, mining, and aerospace machine tooling. Companies such as Boeing, Halliburton and Barrick Goldstrike have measured outcomes that have produced similar results over the past five years. Industry trends that are associated with this technology, such as mobile devices, Web delivery, video capturing and
other growing applications, will assist in improving these metrics. Additionally, this same technology will be justified in areas beyond power transmission and motion control technology — areas such as steel industry vacuum tank degassers, system water management, plant air and aspects of lockout/tagout. The results can be significant in maintenance and reliability, with its subparts of documentation, troubleshooting, skill development and safety.

Conclusion

During a transition from some of industry’s most skilled technicians to a new incoming generation of maintenance workers, it is crucial for companies to capture and transfer any critical knowledge held by these company veterans. It is possible to leverage company-specific information — documented and undocumented — and acquired skills to a new level of maintenance and reliability efficiency. The iSchematic tool can assist in this process. By leveraging information as an asset, facilities can reduce unscheduled downtime with equipment, while simultaneously advancing the expertise of these incoming technicians in their skills and development.

References


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