iSchematic©

A New Generation and a New Process:

An Application that Can Do for Technicians What CAD Does for Engineering

Introduction

Today, industry is faced with a serious shortage of skilled technicians, while the drives and controls of steelmaking equipment become ever more sophisticated. An increasing demand for machine uptime in order to offset non-recoverable downtime also compounds the industry's skills shortage problem. This white paper introduces a troubleshooting and training application that enables new maintenance technicians to perform as good as veterans that have more experience on-the-job. The outlined process provides for more efficient future troubleshooters through use of new technology, formatted, and applied into the industry at an ever-growing pace.

A recently patented application titled iSchematic™, engineered particularly for generation Y, (Gen Y) is set to accomplish what CAD has achieved for engineering purposes. Many baby boomer-aged maintenance technicians witnessed AutoCAD®'s adaptation throughout 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 importantly, CAD technology revolutionized engineering design and has been a major factor in the increase in industrial productivity over past two decades.[1] Although we are far from predicting how technology will change troubleshooting processes of sophisticated industrial machines, assuredly change in the current method is approaching. The following is an example: Filtering and sorting existing machine documentation for maintenance applications to make it contextually specific, and deliverable over mobile devices, makes troubleshooting equipment more efficient. This becomes ever-more important as veteran maintenance personnel continue to retire and Generation Y rapidly replaces them. Throughout this transition, tribal knowledge, skills, and procedures can be digitally captured and therefore delivered to a new generation in a format relevant to their skill set.

A New Generation

The Y Generation, sometimes referred to as Millennials, is the name given to those born between the late seventies and early 2000.[2] Gen Y consists of approximately 79.8 million people in the United States.[3] They are currently the fastest growing demographic in the U.S. workplace and marketplace. Gen Y is an emerging adult population that exerts more influence due to their numbers, longevity, and connectivity. By 2020, nearly 50% of the U.S. workforce will be made up of Gen Y.[4]

As Baby Boomers and Generation Y come together in the workplace, integrating learned skills, procedures, and general knowledge will have its challenges. However, this situation gives companies an opportunity to work toward leveraging skills and knowledge from their retiring workforce to their replacements. Capturing veteran knowledge through documentation technology will increase overall maintenance reliability as a result of applying proven knowledge from the past.

A New Process

When learning a machine's operation, a technician begins surveying any documentation that accompanied the equipment at the time of installation and commission. Most machine documentation is innately found in a paper manual, on a compact disc, or on the web supplied from the original equipment manufacturer (OEM). Although the information is readily available, these formats are often difficult to search through and have contextual issues as it relates to specific maintenance. Using the current forms

of documentation makes it nearly impossible for even a skilled technician to quickly locate information relevant to a specific issue a machine is experiencing. Additionally, changes that have been made to the drawings and schematics during commissioning often have been ignored in the documentation. Frequently, documentation is presented as an asset however, it is often challenging to use for assisting troubleshooting during unscheduled machine downtime.

Consider an additional aspect of maintenance process training. Training is a critical element for any technician's growth and skills development. In today's industrial maintenance processes, training is offered in many formats through varied methods of delivery. In order to have a positive return on investment, workforce training must have pre-defined objectives that address skills needed to reduce downtime from equipment failures. The Skills Learning and Development Triangle, Figure 1, outlines several training formats that have been selected purposely for efficiency and overall outcomes to achieve calculated performance results.

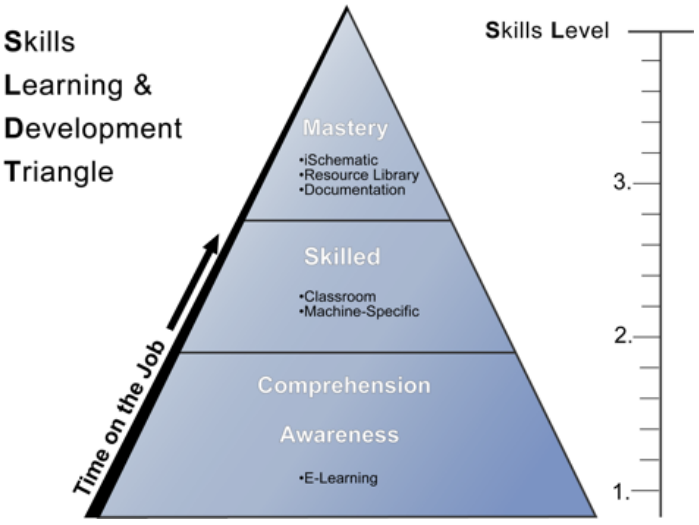

Figure 1. Skills Learning and Development Triangle

As referenced in the figure above, E-Learning is a widely-used training format that today's facilities employ to move a technician from awareness to comprehension. Its interactive nature helps maintenance teams efficiently achieve specific training goals by delivering on-demand and engaging content. Classroom training, on the other hand, places a dedicated instructor with a group of off-the-floor technicians. The instructor-led approach to technical skills training is uniquely successful at training for more specialized and intricate skills however, it is less efficient and more expensive training format. New Training technology also advances workers with very little cost and, if developed correctly, even better results than classroom delivery.

Mastery is situated as the highest level of development as it is measured by a technician's ability to efficiently and safely troubleshoot a machine's failure. Understanding the unique qualities and characteristics of novice technician is essential to selecting these skill development strategies. Careful consideration should be given to how content is delivered, when it is delivered, and when matching training procedures with a workforce. Remember that Generation Y learns differently than the veteran technicians, yet this older generation holds vast amounts of knowledge and skill sets that are powerful assets in assisting with transferring knowledge to the incoming generation.

Time on-the-job is essential to progressing through each category. OJT time is frequently the prevailing factor used to determine job competency, as a performance metric is infrequently used to measure training outcomes. The skills development triangle illustrates that training, over time on-the-job, facilitate learning and skill development.

Although time on-the-job will always determine a technician's skill set, it is possible that the mastery level of skills development is achieved faster while developing a safer troubleshooting process. This can be achieved by organizing the machine's documentation into the correct context while using an intuitive application designed to help technicians find the correct information quickly. The application must also be able to update the content and deliver it over the web for integrated 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

iSchematic as a construct of skill development and machine-specific troubleshooting advances most technicians immediately from comprehension to the skilled level of machine troubleshooting. It also has shown to help a skilled technician to achieve mastery when applied to a particular machine.

Organizing the Documentation

iSchematic's process of organizing documentation begins with collecting all of the machine data, including engineering drawings, schematics, operating and maintenance manuals, controls data from the PLC, as well as all other documents that are relevant to the operation, maintenance, and troubleshooting process of the machine or equipment.

A subject matter expert reviews the documentation and then separates it into the following categories:

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

Every file is verified for accuracy and any required revisions are performed. Drawings and schematics are re-drawn and color-coded to be saved as CAD files similar to Figure 2. The digital schematics contain the original documentation that include any revisions. Critical component symbols are identifiable and will be hyper-linked inside iSchematic to an image of their respective device. Additionally, video of each component are added to the tool.

Every component on the machine that is identified as an asset is assigned an animation that has been developed to illustrate the functional description of the device.

The machine's controls data (PLC) is also 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 that are associated with each event. The controls documentation is put into context to assist the technician in associating inputs with outputs by viewing the PLC ladder logic.

iSchematic Tool

Once all of the machine's assets are entered into the database, they are pulled together into the application editor. iSchematic provides the technician with a user interface, displaying the machine's events, as well as other specific troubleshooting categories.

A machine's functions and failures often are communicated first by referencing the specific event or events that are malfunctioning. This establishes a firm base from which to begin troubleshooting equipment. Any number of events, which are determined by the type of drives that are preforming the machine's work cycles, work with iSchematic and are listed on the user interface.

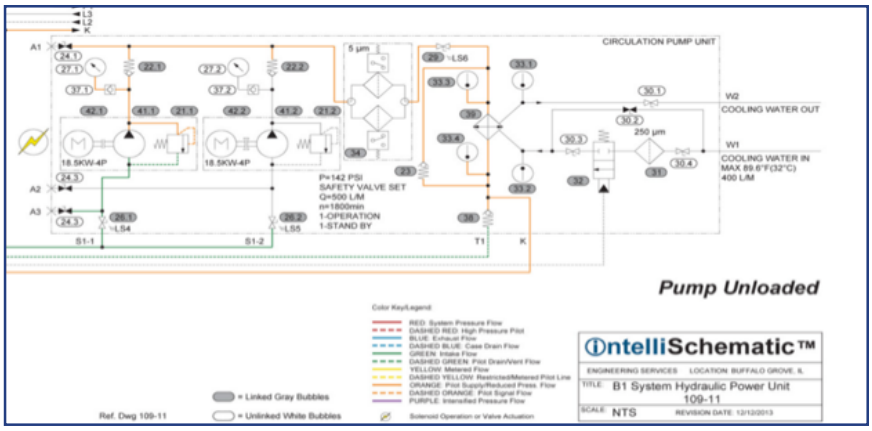

Figure 2. Re-drawn schematics

When the technician selects the event, it is immediately linked to the appropriate schematic, showing the circuit with the applicable coloring. The color legend indicates flow direction, flow control, pressure variations, and mapping, through the symbols that represent the specific components associated with the malfunctioning

event. This screen also includes a sequence of operations document that describes in detail what is illustrated by the circuit color legend.

As the technician evaluates the data associated with the event, they are learning to inspect the schematic and learn the symbol logic, which is an invaluable skill needed for troubleshooting hydraulic, electrical, mechanical, or pneumatic failures. Each worker also has immediate and accurate data on what circuits are under pressure allowing for safe repair of the machine.

Normally when studying a schematic, an experienced technician can determine what components are contributing to the outage at hand. However, safety and troubleshooting problems occur when specialists struggle to translate a particular symbol to where the device is located on the physical machine. By linking the circuit's symbol to the image of the actual device, this costly error has been avoided.

On the component screen of iSchematic, a wealth of information is readily available:

1. Component drawing number
2. Component description
3. Manufacturer
4. Manufacturer's part number
5. CMMS stock code
6. Stores location
7. Component application (What is the device doing in this circuit?)
8. Actual device image, showing location
9. Animation, showing functional description
10. Video image of adjustment or removal
11. Safety related data or procedures
12. Manufacturer's data sheet

iSchematic also houses a large library of component information that go beyond the troubleshooting tool itself. The resource library is a machine documentation archive of troubleshooting and training information. It was built on a unique platform that allows the technician to search for and contribute to an archive of critical maintenance information. Once a topic is selected, the system directs them to animations on the device's functionality, a video on a procedure replacement, or document that gives descriptions or definitions.

Another important consideration when integrating troubleshooting tools into complex maintenance processes is the ability to perform necessary edits as machinery advances and knowledge grow. The editing capability must be an intuitive process for maintenance departments to remain consistent.

The iSchematic tool is iOS compatible though downloading an app at the Apple App Store, and is fully compatible with the Windows 8 software running on mobile devices.

Results

At Nucor Hertford, iSchematic has become a key element for assisting in the successful reduction of unscheduled downtime through improving troubleshooting processes. It 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 EAF and Rolling Mill, with scheduled integration as part of an ongoing process. Over the past five years, iSchematic has been applied to approximately 60 segments of steel production equipment throughout the industry. Nucor Hertford assisted in analyzing its performance to show results relative to ROI within their applications. Although this is an ongoing study, Figure 15 gives current results of one aspect of the ROI as applied to nonscheduled machine downtime in mill bending.

The first half of year 2013 shows an slight increase in downtime due to a scheduled situation. This is left in to insure an accurate metric. The trend however as shown in the graph in Figure 16

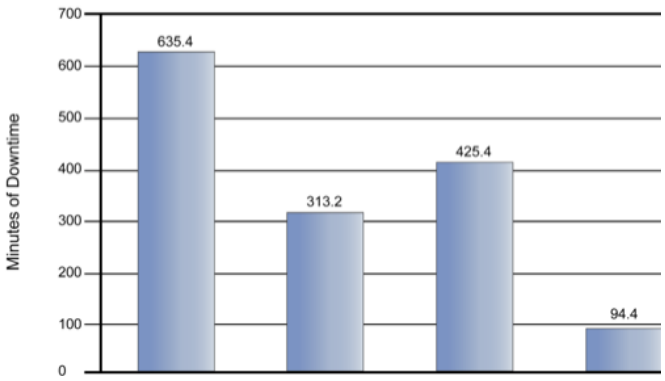

Figure 15. Downtime – mill bending

shows a continuous improvement in unscheduled downtime in year 2013 from year 2012. A closer study in 2014 will trend another aspect of the total ROI—tracking skills improvement with respect to technicians assigned to equipment that has integrated iSchematic technology.

Currently, different technicians are assigned to assist in each new integration, giving them unique training on the equipment to foster an understanding and application of the technology. During the process of upgrading to iSchematic, the hydraulic technician becomes fully engaged in understanding how the machine's hydraulic system works and is fully included in any modifications that need to be made in the machine's documentation. The constant interaction between the hydraulic technician and the iSchematic project engineer builds a greater understanding on the machine's operation and functionality. This process helps prepare the technician for future situations that will occur and also gives them the applied knowledge to help train others.

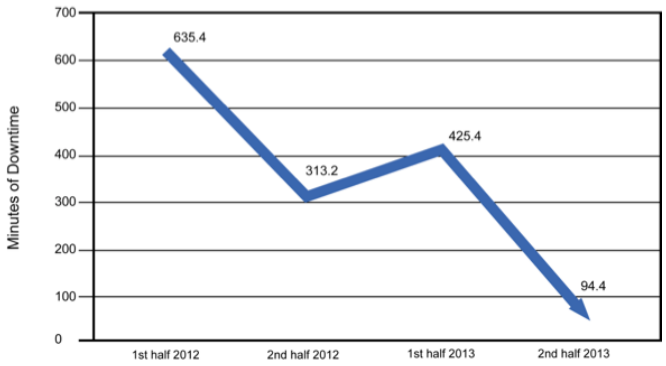

Figure 16. Downtime trend – mill bending

Results from other industries trend in a very similar way as Nucor's. To date, iSchematic is 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 positive ROI results over the past five years. Industry trends that are associated with this technology, such as the use of mobile devices, web integration, and video, 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 the subparts of documentation, troubleshooting, skills 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.

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