Transformer Control Cabinet Standardization via Industry Best Practices and Hierarchy of Controls for Workplace Safety

Abstract

This paper will address the continuing concerns from the Electrical Utility Industry Safety and Human Performance Concerns with nonstandard control cabinets on power transformers within the North America.

The Utilities within North America now procure small to large power transformers from around the world and from many different suppliers. Although most of the Utilities within the US specify transformers to be provided to the IEEE Standards there is no consistency of control cabinets being supplied to the end user which allows for human performance and safety concerns to Utility field technicians in the field.

Within this paper we will further discuss the opportunity of standardizing control cabinets to create a safer product and environment for the utility personnel and many other utility concerns such as engineering time management for design approval, lead time of cabinet, spare parts, and integrating monitoring diagnostic systems.

Product in Discussion

Specifically for the purposes of this paper we are discussing the primary control cabinets on small, medium, and large power transformers or class I or Class II transformers where the control panel may contain relays, cooling controls, alarms, auxiliary power, monitoring devices for diagnostics, and related circuits for the user connection to the substation system.

Besides internal components for controls also the construction of the cabinet must be considered such as size, weight, materials, lifting, environmental conditions, compartments, sealing gasket systems, swing panels, doors, hinge type, ventilation, entry and exit points, drainage, finish coats, grounding, and mounting.

History

Historically control cabinet designs have been specific to each transformer order and/or project with most orders consisting of three transformers and maybe a spare. In this scenario Utilities and Industrials within North America would receive control cabinets with no standardization between shop orders or projects. As this scenario has continued over the last 40-50 years the end users, within North America, are left with tens of thousands of transformers in which the end user field service groups are on unfamiliar ground each time working on product in the field not knowing the components nor the layout of cabinets until they open the door. This is a major concern today with aging fleet and attrition of experienced personnel within the electrical industry

When ordering a power transformer most end users have a transformer requirement specification document that orders specific product such as electrical, mechanical, and

thermal requirements and many times specific bushing apparatus and tap changers, both onload and off load, and components such as gauges.

With such specifics with the transformer being stated we would think a component such as the control cabinet would also be very specific and there would be consistency between transformers project to project and shop order to shop order to standardize within the fleet for many valuable reasons.

Change in Procurement

As the world has changed within the North American electrical industry arena with procurement for power transformers, we see more global business with no consistency of the components being used nor layout of the components within the control cabinet itself.

Specifying Product

Specifying product by style number or approved designs of bushings and components, such as gauges, is due to interchangeability in the field if there is an issue with the product so basically it is fit. Having interchangeability or a standard bushing also helps on spare bushing inventory in which most utilities have lost or downsized inventory for immediate change out if there is a failure. With on load tap changers the transformer requirement is specific for two reasons, parts inventory also knowing how to work on fewer field products that are complicated mechanical and electrical devices.

So, if bushings, components, and on load tap changers are so important then why have the utilities not pushed for closer standardization and specification of the final product on control cabinets?

Participation in the IEEE Standards

Utilities and Industrials have been trying to move to more standardization within the electrical industry within North America with the Transformer IEEE Standards and specifically the IEEE Standard for Control Cabinets PC57.148.

Within this control cabinet standard there is a tremendous number of specifics and guidelines to help identify ways to standardize control cabinets. The issue with standardization with end users is that the electrical systems, applications, and environments are very different from end user to end user.

For example, a utility in South Florida will most likely have different environments than a utility in North Dakota, such as temperatures and contamination: therefore, the cabinets cannot be identical, nor standard, nor interchangeable between the end users.

Next Step

Find a Control Cabinet Company that understands and utilizes IEEE Standards and highly participates in IEEE Control Cabinet Standardization or as Chair of Committee.

Participation and knowledge of the industry IEEE transformer committees is very important to sustainability to the company and system.

- General
  IEEE C57 Series, as applicable,
- Performance
  IEEE C57.12.00-2015,
- Design/Construction
  IEEE C57.12.10-2010,
- Testing
  IEEE C57.12.90-2015 (Procedures),

What are your Utility Requirements for Control Cabinets???

Standardization Process

Where do we start to standardize within North America on Control Cabinets is the question? First, we would suggest being involved in the IEEE Transformer standards. Second, we would suggest that the end user review their transformer specifications, size and type of transformers being procured. Look at the most common designs on system or most common designs being procured.

Step by Step

- Process
- Review specifications
- Determine mandatory requirements (80%)
- Isolate specific options (20%)
- Propose a standard
- Develop from specifications
- Able to fulfill the requirements of any transformer
- List mandatory features
- Layout
- Design according to preferences
- Key project similarities
- Component selection
- Preference given to reliable brands
- Limit surplus stock on hand
- Modernize components as technology evolves

The process of standardization can be divided into two phases

- Design
- Manufacturing

Step by Step Design Phase

In the first phase, all important information regarding cabinet design is gathered.

Including, but is not limited to specifications, standard alarm layout, CT layout, standardized control drawings, and personal preferences (devices, brands, and layouts).
Technical meetings are organized to start the process. A single point of contact is designated on both ends.

Each transformer type is going to have its own standard control cabinet, including schematics, physical layouts, and wiring diagrams. Realize that in many cases within types of transformers styles of cabinets can be combined within different kV and/or BIL levels.

Schematic drawings are designed for each transformer type and sent to the utility for comments. Utility only needs to comment and approve the drawings.

Physical layouts and wiring diagrams are completed as part of a standardized drawings package. This set is the pre-approved master file from which all other cabinets will be manufactured from. The Control cabinet company keeps the control cabinet specifications for the utility saving time, helping the utility engineering team, and acting as an intermediary for Transformer OEM orders.

The end user control cabinet prototype is manufactured, using pre-approved drawings, and subsequently reviewed by an end user representative.

The end user is now able to point OEMs directly to the control cabinet company to procure control cabinets by style number. Using this product for future transformer orders, slowly standardizing the utility transformer fleet.

Step by Step Manufacturing Phase

For each order,

- controls respect what was pre-approved by the utility
- personalizing of units is possible (cooling scheme, device brands)

In order for the standardization process to be successful, the utility has to enforce the use of the standardized cabinet in their specifications, and in their discussions with OEMs. We understand this represents a new way of manufacturing transformers for some Transformer OEMs, but in the long run both the End User and the Transformer OEM will save time and money while enforcing and benefiting from the Hierarchy of Controls for Workplace Safety!

Extended Engineering Team

Once completed, the standardization of a specific type of transformer control cabinet creates a catalog product, complete with detailed specs, entirely built to the utility specification, that is pre-approved and that can be manufactured in advance for fast delivery response.

Control Cabinet Company engineering team become an extension of your engineering and takes care of all questions related to transformer controls directly with the OEM, removing this important but time-consuming workload from your engineering team. By controlling the

cabinet design, we keep control on all the external devices installed on the transformer in the process, increasing device consistency from project to project.

The Control Cabinet Company engineering will grow into being the guardian of the end user's transformer control specification.

Any future specification change or upgrade can be applied to all future cabinets within a single call to the control cabinet manufacturer, due to the ownership of the standard control cabinet drawings, so that the end user can be informed on obsolete parts and replace them with parts compatible with installed units.

If the End User is moving towards online monitoring systems for diagnostics the new product can be engineered into exiting designs across the board or installed fleet or integrate easily with the Control Cabinet Company.

Changing World of Online Monitoring for Diagnostics

Many end users are moving to Online Monitoring for Diagnostics. These monitoring devices can be designed into the standard cabinet for new transformers, designed to be retrofitted in the field into existing control cabinets, or a standalone design to be mounted on the transformer being a separate cabinet containing the monitoring device.

As the industry moves forward in this technology, if an end user had a standard design cabinet and wanted to change technology, it could be as simple as changing just a few drawings within engineering with the field retrofit across the board if the end user has move to control cabinet standardization program.

Without the standardization program in place the end user would have to research with the transformer OEM drawings for each order and review 100's of designs and the fleet changeout would be almost impossible in a timely manner. There is also the cost of the research and many different designs to be considered to make changes.

Success to the Process and Program

Success to Control Cabinet Standardization requires buy in from or participation from the following:

- End User Projects Managers
- End User Transformer Design Engineering
- End User Field Operations Engineering
- Control Cabinet Component Supplier
- Control Cabinet Designer Team
- Control Cabinet Manufacturing Team
- End User Controls Engineering
- Transformer OEM Controls Engineering
- Transformer OEM Mechanical Engineering
- End User Operations Maintenance and Operation Field Service
- IEEE Transformer/Control Cabinet Standards and Guidelines

End User Concerns within the Industry

Improved safety, including preventing injuries, promotes increased productivity and enhances a company's bottom line. Workplace safety is also essential to a utility company's right to operate; if regulatory safety standards are not being met, the entire operation can and will be shut down.

- Safety
- Human Performance Improvement
- Security
- Resiliency
- Reliability
- Aging Fleet
- Losing Field Experience
- Losing Engineering Product Experience
- Cutting Maintenance Programs or extending periods between outages
- Outages
- Training

Time and Money Saved

Real hours saved…. End User normal interaction with initial design and drawing approval is 20 engineering hours for less complicated control cabinet designs and up to 80 engineering hours in more complicated control cabinet designs, if no standardization process is in place.

Again, how much are your engineers' worth per hour? Many times, it is not the cost of the engineer, but do you have the resources in time or expertise.

End User Surveys Results

- Time (Engineering)
  - #1 with Engineering/#2 with Management
- Quality
  - Quality is more consistent with Standard product
- Lead Times
  - Stocking or Quick Ship Program
- Cost
- Resiliency
- Safety
  - #1 with Management
- Spare Parts
  - #2 with Management
- Communication
  - #1-2 with Engineering
- Human Performance Issues
  - #1 with Management…. basically, ties with Safety
  - Field Maintenance or Field Service

BEST Practices

What is "Best Practice"? Best practice means finding - and using - the best ways of working to achieve your business objectives. It involves keeping up to date with the ways that successful businesses operate - in your sector and others - and measuring your ways of working against those used by the market leaders.

Reasons to Standardize

- No matter what Transformer OEM you purchase from, or multiple Transformer OEM's, you will receive the same control cabinet
- Standardize wire markings lead to better efficiency, less mistakes
- Bar code scanning for better field technical support
- Engineering support for field modifications or additional monitoring
- All in class changes applies so each cabinet does not require hours of engineering
- Warranty direct with Control Cabinet Manufacturer. Time and Efficiency by not going through OEM for drawings for specific transformer
- Part identification support with inventory for immediate shipment
- No more control cabinet design reviews
- No more waiting on drawings
- Field technicians will become more efficient by knowing what TB and number
- Same cabinet footprint for all in class designs. No delays in construction
- Cabinet Manufacturer will support all field questions freeing up Utility Engineer
- Fast shipments for standard cabinets
- If transformer fails or has issues standard cabinet can be utilized on similar same in class transformer
- Reliability improvement by utilizing best components available.

Day to Day Perspective

So, let's put this situation with control cabinets with a field service worker in perspective into an everyday life experience.

Travel these days and renting cars can be a challenge. Difficulty is not reserving the car online or getting the automated billing, but once you get into the car.

With technology changes within the vehicle most cars are totally different than the one car that you own and everyday driver that you are familiar with.

First when you sit in the seat of the rental car, is it a key type ignition or is it a push button. Where is the push button? Is it located on the column, dash, center console? Once you start the car and want to adjust the radio, air system, blue tooth, or GPS is the controls all in one or separate component devices.

Once you are on the move and you have other distractions driving, or watching other drivers, or direction finding we need to adjust a one of the car's component….we then find ourselves in unfamiliar territory in which you have put yourself in a position to make an error or have a wreck.

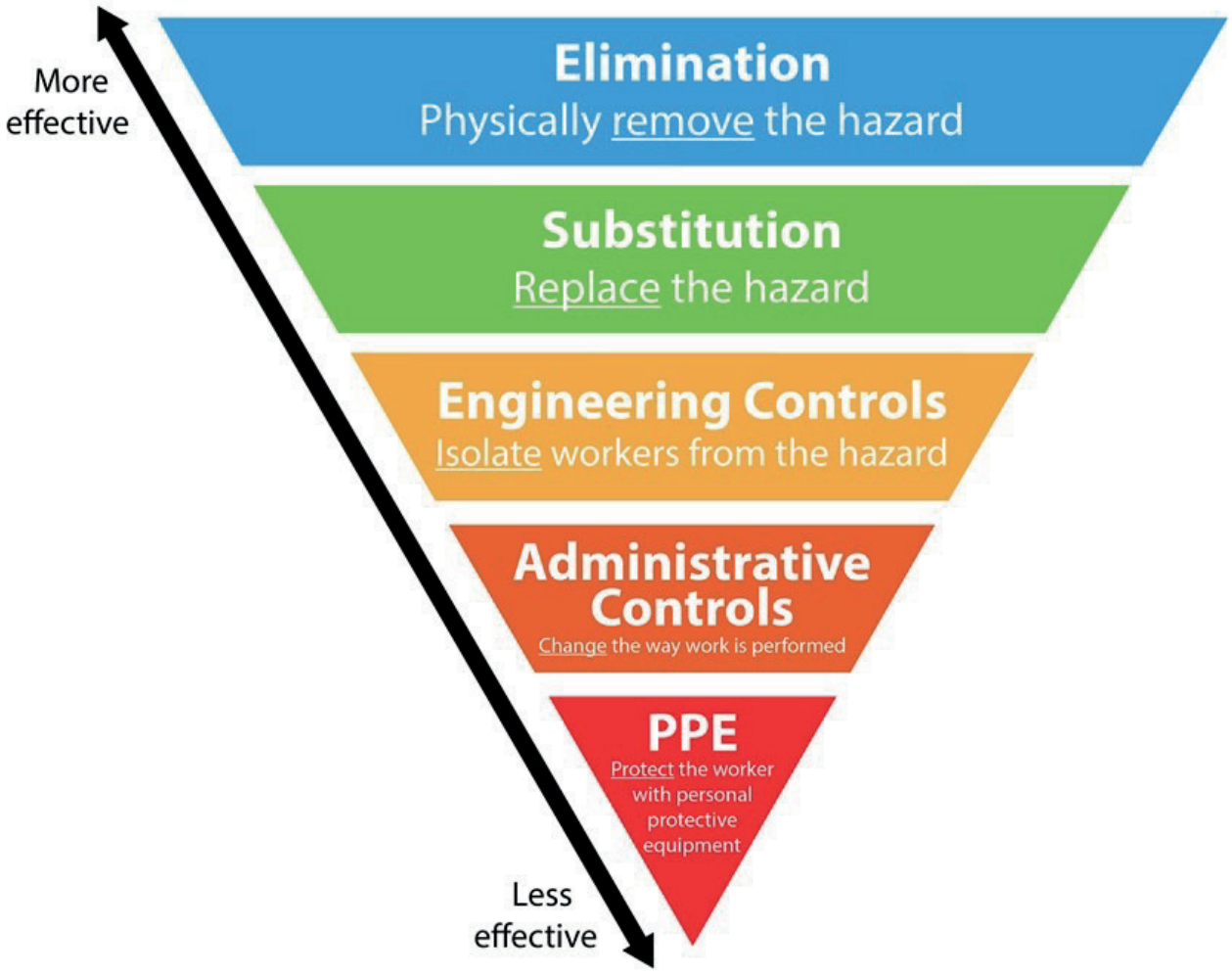
Think about a Utility Field Service Person that has to work on hundreds of types of control cabinets with many different manufacturers designs, different manufacturing practices, along with the other distractions such as weather, application, and/or environment in the middle of the night with no documentation to work on the equipment properly. Not the best of scenarios.

It's time to change the process and utilize the Hierarchy of Controls for Workplace Safety for a better outcome!

Hierarchy of Controls for Workplace Safety

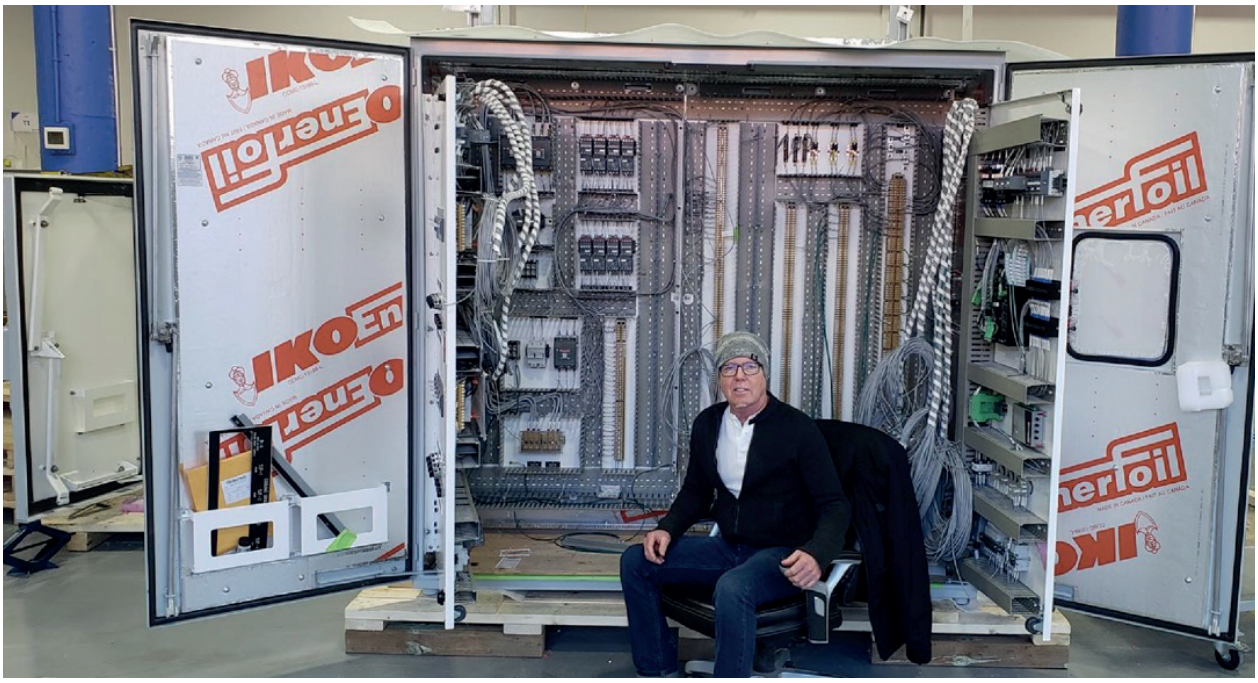
- Elimination of the Hazard –Elimination of the Hazard
- Substitution – replacing a factor that produces a Hazard
- Engineering Controls – Design the workers away from the Hazard
- Administrative Controls – Limit the exposure of the workers to the Hazard
- Personal Protective Equipment – Least effective way to protect people from the Hazard

Hierarchy of Controls for Workplace Safety



Real Look at Control Cabinet

A Power Transformer Control Cabinet can have 100s of components or devices, 3000 terminations, and miles of wire. Let's take a look at exhibit 1 below to see the detail of a control cabinet in manufacturing stage.



Education and Sustainability Utility Industry

More college students are hitching themselves to the technology train, which is shrinking the pool of graduates for other industries, including energy and utilities. According to a 2015 survey by the U.S. Department of Energy, 72 percent of energy employers reported having difficulty finding talent.

This problem is exacerbated greatly by the aging out of the current workforce. According to the Department of Labor, as much as 50 percent of the nation's utility workforce will retire in the next five to 10 years.

The era of the loyal worker who stays at a utility for decades, the era where workers brought their sons and grandsons into the industry, is waning.

Every kid I know who's 17 years old wants to design video games, wants to be a coder. They want a popcorn machine and a pool table – they want to be on the Google campus.

Some utilities are partnering with community colleges to offer placement for students that complete related programs and this is a must to be sustainable within the electric utility industry.

Randy Williams Bio

Randy Williams is presently the Development Manager with North American Services [NASS] and NOMOS concentrating on Standardization of Control Cabinets, Transformer Service, Breaker Service, and Protection and Controls Field Service.

Prior to his present position, Mr. Williams was Marketing Manager for ABB located in Alamo, TN and responsible for the marketing and sales to all utility and industrial end users for transformer components in the United States electrical utility arena. Mr. Williams's other previous positions include Bushing Engineering for Westinghouse/ABB with the most recent being Customer Service Manager and Master Scheduler of the ABB Alamo, TN Components Division. He has worked at Westinghouse and ABB with a total of 37 years of experience in bushing design, manufacturing, field testing, and field failure investigation.

Randy graduated with an associate degree in Business Management from Jackson State University and has prolific industry participation with IEEE and all major industry conferences within North America.

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