POWER PLANT – RELAY REPLACEMENT
DELIVERABLE
SAFE OPERATION OF METAL CLAD SWITCHGEAR

ISU Senior Design Group: Dec15-22

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1. SUMMARY

This project is part of the Power Plant – Relay Replacement senior design project. This document is to demonstrate clearly the required deliverable as stated in the Project Plan and Design Document.

This part of the senior design project will provide engineering solutions to operate the switchgear safely. By researching alternatives and analysis of the potential of arc flash, engineering solutions shall be provided to advise the choosing of safety precautions during operations.

2. PROJECT BRIEF

The main objective is to provide two engineering solutions to operate metal clad switchgear safely. The following will be included as part of this project: Evaluation of both solutions, compliance regulation, cost estimate, bill of material, and operational guides.

3. PROJECT REQUIREMENTS

The following list of requirements was established with CIPCO and in accordance with the CIPCO document “Project Scope” included under section design documents. The template for the CIPCO Project Scope was provided by CIPCO.

3.1. SPRING SEMESTER 2015 DELIVERABLES

- Research and identify two possible engineering solutions
- Evaluation of both solutions

3.2. FALL SEMESTER 2015 DELIVERABLES

- Compliance regulation
- Bill of material
- Cost estimates
- Operation guides

4. ENGINEERING SOLUTIONS

I researched and discussed with CIPCO staff, two engineering solutions that would meet the requirements of the project. A remote controlled option and a time controlled option to meet the needs of CIPCO and fulfilled the project requirements. Both options allow the operator to operate the equipment at a safe distance from the arc flash area.

4.1. REMOTE CONTROL

The remote control option would utilize the capability and functionality of the newly installed Schweitzer Engineering Laboratories (SEL) microprocessor-based relay. One large benefit of upgrading the relays from electromechanical to microprocessor-based is the new SEL relays are capable of remote control through the hardware and software.

This remote control could allow an operator to control the metal-clad switchgear at a safe distance from the arc flash area. This location could be in the same facility or across the country. Below are pros and cons of controlling the equipment this way.

4.1.1. PROS & CONS OF SOLUTION

The remote control option would utilize the capability and functionality of the newly installed microprocessor.

- Pros
  - Equipment can be operated with people far away from energized or operating equipment.
  - Human control – people control the equipment operation even when operated remotely.
  - Limited cost due to using new capacity of relay equipment.

- Cons
  - No direct view of equipment by remote operator which could be a safety issue; would still require on-site technician to confirm closure.
  - Relying on equipment to function correctly during operation.
  - Potential latency between the equipment and the remote operator.

4.2. TIMED CONTROL SWITCH

The time control option would utilize a replacement control switch for the metal-clad switchgear. This control switch is currently a manually-operated switch to trip or close the switchgear. A replacement switch built by Electroswitch model TS-CSR includes features that would meet project requirements. This switch utilizes two front panel mounted push buttons integrated into the nameplate. These push buttons provide the ability to manually initiate a time-delayed breaker trip or close operation with a factory preset time delay. This time delay should allow appropriate time to evacuate the arc flash area. Below are pros and cons of controlling the equipment this way.

Figure 1: Electroswitch Time Delay Control Switch Relay (TD-CSR)

4.2.1. PROS & CONS OF SOLUTION

The time-delayed option would utilize the capability and functionality of a new manually-indicated time delay switch.

- Pros
  - Direct view before and after operation.
  - Human control – people control equipment operation.

- Cons
  - Additional cost for new equipment.
  - Additional cost for new installation
  - Additional training.

5. COMPLIANCE AND REGULATION

Compliance is also discussed under the Arc Flash Deliverable document. Both parts of this project are required to be compliant with regulators, meet industry standards, and most of all keep workers and equipment safe.

In this situation the minimum approach distance is not very large and workers would be compliant staying outside the calculated distance. As for most company safety rules and regulations, CIPCO's are more conservative than the industry standard. This is for general safety purposes and ease of complying. CIPCO tries to complete all work on de-energized equipment with visual disconnects such as open switches. This allows the work to be completed in a much safer environment by eliminating the electrical hazard. When equipment cannot be completely de-energized, the CIPCO Safety Manual will be followed. The approach distance is different for different equipment, voltages, and employee training. For instance, unqualified individuals will maintain a boundary of at least 10 feet during energized work. For 2400 VAC equipment, the minimum distance for qualified worker is 3 feet. This approach distance covers voltages between 480V<34.5kV.

Whenever work will be performed within the approach distance the qualified worker shall wear all required arc-rated flame-retardant (FR) clothing and personal protective equipment (PPE). The level of FR and PPE is determined by the amount of exposure as listed in the Safety Manual. For this case, if a qualified worker had to perform within the minimum approach distance, the worker would be required to wear arc-rated flame-retardant long-sleeve shirt, arc-rated flame-retardant pants, hard hat, safety glasses, leather gloves over rated rubber gloves, arc-rated face shield, and leather work shoes with toe protection.

Safety is a top priority for CIPCO and by following the CIPCO Safety Manual, OSHA compliance rules and standards, work can be completed safely.

6. COST ESTIMATES

A cost estimate should include all material, equipment, and labor to complete the project. Budgetary bids can be requested from vendors to get current material cost and lead times. Cost estimates and lead times can help with project budget planning and scheduling. Estimates can also help determine the most economical choice to fit budgets and project requirements. Below is the project cost estimate for using a timed control switching device.

PROJECT COST ESTIMATE
Power Plant - Relay Replacement

Required Material					
Material Description	**Manufacturer**	**Model**	**Qty**	**Unit Cost**	**Total**
Microprocessor relay	SEL	351A	4	$2,380.00	$9,520.00
Test switch 10 position	ABB	129A501G01	4	$56.00	$224.00
Test switch 14 position	ABB	129A514G01-6C	4	$64.00	$256.00
6 Amp fuse, 600V, medium time lag	Littelfuse	G-Class	8	$7.00	$56.00
Fuse holder - 2 pole - panel mount	Square D	9080FB2	4	$12.00	$48.00
Communication cable	MonoPrice	CAT6	4x500'	$0.094	$188.000
				sub total	$10,292.00

Optional Equipment					
Fiber-Optic transceiver/modem	SEL	2800	8	$102.00	$816.00
Fiber-Optic cable	SEL		4x500'	$1.98	$3,960.00
(for communication line interference)				**sub total**	$4,776.00
Control switch with time delay	Electroswitch	TD-CSR	4	$1,573.00	$6,292.00
(Arc flash safety switch option)				**sub total**	$6,292.00

Installation Cost				
Labor Description	Hours per Unit	Hours for 4 units	Cost per Hour	Total Cost
Relay installation	8	32	$160.00	$5,120.00
Checkout and testing	3	12	$160.00	$1,920.00
			sub total	$7,040.00

Optional Equipment Installation Cost				
Control Switch with time delay	1	4	$160.00	$640.00
(Arc flash safety switch option)			**sub total**	$640.00

TOTAL COST	
Standard Equipment option - Total	**$17,332.00**
Fiber-Optic Cable option - Total	**$21,920.00**
Arc Flash and Fiber-Optic Cable option - Total	**$28,852.00**

Table 1: Project Cost Estimate

7. OPERATION GUIDES

Both solutions would need basic instructions to operate the metal clad switchgear in a safe manner.

7.1. REMOTE CONTROL OPERATIONAL GUIDE

The operator could control the equipment remotely though Supervisory Control and data Acquisition (SCADA). SCADA communicates with the 2032 SEL communication processor, which in turn communicates with the microprocessor relay. The communication between the relay and the communication processor is SEL protocol communication logic. SEL protocol was developed by SEL and is a proprietary communication protocol. The connection between the 2032 and the SCADA controller is fiber with Distributed Network Protocol (DNP). DNP is becoming the standard SCADA communication protocol for the electrical utility industry. With this communication path, SCADA can send and receive many types of data depending on the attached equipment, settings, and desired information. The operator can trip or close the switchgear from a remote location and far from harm's way. This control is typical for other equipment such as line relays and substation circuit breakers.

7.2. TIME CONTROL SWITCH OPERATIONAL GUIDE

The time controlled operation would utilize the time controlled switch in place of the existing control switch. The operator would select delay trip or close and then turn the switch to the desired position. The operator would then move away to a safe distance before the switchgear operates. The delay is factory set and would need to give the operator enough time to reach the safe area.

8. ASSESSMENT OF ENGINEERING SOLUTION

After taking into consideration cost and the learning curve of new equipment, the engineering solution best suited for CIPCO needs will be the remote control option. This option utilizes current equipment and operation. This solution would save money by eliminating the need to purchase new equipment or engage in training associated with it.

9. CONCLUSION

This senior design project has helped me improve my knowledge significantly in the area of equipment operation and safety controls. Combining these elements with project management topics such as budgets and cost benefits has improved my overall understand of the requirements and the amount of detail that goes into engineering projects. The review process helped immensely. Having completed multiple reviews gave me a chance to ask questions and learn from the review comments. The review process was also setup to help catch mistakes before they were carried though out the design which help keep the project on schedule.

10. REFERENCES

Figure 1:
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