Use of temporary power equipment for shutdown and maintenance at a petrochemical facility in Canada

by Wolfgang Berner

Petrochemical facilities depend on electrical power availability to ensure a safe and profitable business. Periodic testing of the installed electrical equipment leads to a safe and reliable operation. Electrical apparatus, including switchgear, motor control centers (MCC) and uninterruptible power supplies (UPS) must be de-energized periodically and taken out of service for maintenance testing, repairs or installation of additional sections to accommodate growth. The process is lengthy, with planning starting years in advance to prepare for extensive inspection and testing activities.

This article discusses the experience, findings and lessons learned at one petrochemical facility during a 70 day operational turnaround. Significant investments were made in purchasing mobile temporary power equipment and hiring numerous electrical specialty contractors to perform maintenance testing of electrical equipment in nine substations, including nine secondary selective automatic transfer switchgear line-ups, low voltage MCC’s and UPS’s.

I. Introduction

The availability of electrical power and reliability of the overall power distribution system is essential to the successful operation, safety and production of the facility. Maintenance turnarounds occur every four years to inspect rotating and static equipment assets, repair critical systems and perform maintenance on many types of equipment. It is during this turnaround window that inspection, testing and repair of electrical systems are planned. In planning to execute a flawless turnaround, the electrical focal point identified known and potential flaws in all phases and a mitigation plan to prevent the flaw from occurring. Mitigation actions were implemented in work processes, practices, quality assurance, and quality control and incorporated into the integrated plan. The goal of executing a flawless turnaround increased the success rate of a flawless start-up.

II. Plant electrical safety program

A. Training

All electrical persons working at site must take four hours of site-specific electrical safety training to become a Qualified Electrical Person. This is in addition to the 4 hours of general site orientation which outlines the site hazards, rules, permitting requirements, lockout tag-out program, PPE requirements, mustering and alarms, etc. The Chief Electrical Person at the site maintains the documentation of training for each Qualified Electrical Person. Documentation is necessary to demonstrate that individuals have met the competency and experience requirements for the type of work being performed. The electrical safety training consists of the following components:

> NFPA 70E Electrical Safety Video
> Overview of owner Electrical Safety Standard and site Safe Work Practices
> Overview of site Power Distribution System
> Test Before Touch
> Metering Safety video
> Shock and Arc Flash videos
> Record of attendance, available PPE and Testing Equipment
B. Safety Meetings

All day and night shifts started with a safety focus meeting. This meeting, attended by all electrical contractors and owner representatives, was used to discuss safety issues, review safety statistics, incidents and near misses from the previous day, discuss PPE requirements, location of work, weather conditions, other work activities in the area and overall turnaround issues that may affect our team.

C. Job Hazard Analysis (JHA)

All of the electrical contractors were required to complete an activity based or job based job hazard analysis, which outlined the potential hazards, work tasks and preventative measures for safeguarding. Owner representatives audited the JHA for accuracy and completeness.

D. Personal Protective Equipment (PPE) & Testing Equipment

The owner's standard flame retardant coverall is adequate for a hazard/risk category 2 arc flash event. Workers performing tasks in areas where there are potential electrical hazards used PPE that is appropriate for the specific work to be performed. The electrical tools and protective equipment were approved, rated, and tested for the levels of voltage for which the worker may be exposed.

Electrical protective equipment consisted of arc flash suits rated for 25 cal/cm², 40 cal/cm² and 140 cal/cm², face shields 12 cal/cm², voltage rated gloves rated Class 0, 1, and 4. All of the required certifications were made for testing equipment, including hot sticks, high voltage gloves, meters, testers and ground chains prior to the turnaround. Devices such as lift trucks or breaker lifting devices, breaker test cabinets and switchgear ground trucks were also inspected and/or tested in advance of the turnaround.

E. Equipment Labeling

In accordance with Canadian Electrical Code Section 2-306, all MCC's and switchgear are marked with clearly visible arc flash and shock warning labels at the front, sides and rear (where accessible) of all line-ups. A sample label is shown in Figure 1.

![ARC FLASH and SHOCK HAZARD](image-url)

Figure 1: Sample Shock and Arc Flash Warning Label

III. Flawless operation

A. Flawless Program

The cost of a turnaround consumes a substantial portion of a plant’s annual maintenance budget. Executing turnarounds efficiently and effectively are necessary to maximize plant availability and production, and keep turnaround cost at a minimum at the same time.

The flawless turnaround approach is designed to help maintain control and achieve a step change in reliability and operational availability by:

- Reducing the time from start-up to steady plant performance
- Reduce rework and promoting a quality approach
- Increase confidence in meeting turnaround targets
- Establish a controlled and repeatable turnaround process that achieves sustainable results.

B. Key Success Areas (KSA)

A list of key success areas and their champions was created for the turnaround. Under the integrity key success area, one of six priority KSA’s for the turnaround, were focus areas of static, rotating, civil (scaffolding and insulation), electrical, and instrumentation.

C. Electrical Focal Point

The facility Chief Electrical Engineer invested 15% of his time for one year in advance of the turnaround start date to support the Flawless initiative. The responsibilities included developing a list of electrical discipline events from the identified work scope, identify specific flaws for the particular event, identify the proposed mitigation plan for this flaw, risk rank the list and create action items to prevent or reduce the likelihood of the flaw from occurring.

D. Flaw list examples

Mitigation actions were implemented in work processes, practices, quality assurance/control and incorporated into the integrated plan.
experience that the supply of hazardous (classified) location rated temporary power equipment such as distribution panels and cords are not.

For this reason, a decision was made to invest in Class I, Zone 2, Group IIC rated temporary power equipment for the turnaround. A further reason to invest in the hazardous (classified) location rated equipment was to have it available for future maintenance work and on-the-run repair activities.

3) Safety:
Plant shutdowns can be one of the most prone times for accidents. During the turnaround, the plant is populated with a large number of outside contractors, not as intimately familiar with the facility and its processes as the owner’s site personnel or long term contractors.

Therefore, one of the main questions when planning and executing the plant turnaround was how do we maintain a safe work environment for the influx of contractors and site personnel?

General key components to ensure a safe electrical system during turnarounds are:

- Awareness of hazardous and non-hazardous areas
- Equipment design and selection – non-hazardous versus and hazardous location rated equipment
- Adequate lighting
- Ground fault protected circuits for personnel protection
- Proper cable and extension cord management
- Tested equipment and cord sets providing proper safe grounding
- Good housekeeping

### IV. Temporary power equipment

#### A. Justification

1) Why temporary power?
During plant turnarounds, hundreds of contractors are hired to inspect pressure equipment, repair equipment and upgrade plant systems. There is a need for significant numbers of power points throughout the plant to provide power for supplemental lighting, welders, grinders and other tools. Having properly distributed power points available during turnarounds prevents delays and prevents cost overruns.

2) Why select hazardous (classified) location rated equipment?
Setting up for a lengthy turnaround involves considerable pre-work activities, including installation of temporary piping systems to pump out and drain vessels and piping systems. Many pre-work activities require supplemental power, including additional lighting.

The majority of the site process areas are Class I, Zone 2 rated. At this facility, there are two process trains connected with some common equipment. Shutting down one process train with the second train still at full production results in a period where the plant area cannot be de-classified to a non-hazardous area. Thus, all temporary power equipment must be rated for the areas in which it is installed. Similarly, during the start-up of a process train after the shutdown and with post turnaround work activities, it is evident that the plant area is to be classified as a hazardous area.

While the supply of general-purpose temporary power equipment is readily available on a rental basis, it is the

<table>
<thead>
<tr>
<th>Flaw</th>
<th>Mitigation</th>
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<tbody>
<tr>
<td>Maintenance work scopes with insufficient detail.</td>
<td>Create review process to have work scopes reviewed by electrical engineering and planning team.</td>
</tr>
<tr>
<td>Damage to mineral insulated electric heat trace (EHT) cables due to removal and reinstallation of EHT around tie points and blind locations.</td>
<td>Awareness training for all contractors on how to handle mineral insulated EHT in the field and plan for availability of cable splice materials and electricians to perform splices.</td>
</tr>
<tr>
<td>Poor communication and alignment between electrical team and operations group.</td>
<td>Include a full time planner role on the electrical team to address schedule change and to attend daily update meetings.</td>
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<tr>
<td>Inability to restart motors after testing.</td>
<td>Add a checklist item for the relay tester to clear learned motor starting data after motor protection relay testing is completed.</td>
</tr>
<tr>
<td>Unidentified alarm during connection of electrical back-feeds.</td>
<td>Add a checklist item for the relay tester to clear learned motor starting data after motor protection relay testing is completed.</td>
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Electricity is needed to provide power to equipment and to light the interior and exterior of shutdown work areas. In many shutdowns, only portions of the plants are down, while others are still operational. In these cases, area classification might not change even during the shutdown. Therefore temporary power systems can be dangerous if they are not adequately addressed. A lot of times inadequate general purpose temporary and mobile power equipment and so called “cheater” cords are used to power the tools and supplemental lighting needed for the maintenance and turnaround shutdown. It also typically provides poor and unsafe cable management which looks like spaghetti wiring.

For this reason it was decided to use approved hazardous (classified) location rated temporary power products throughout the process areas. The temporary power equipment and cords selected and used during the turnaround were designed and tested to meet Canadian Electrical Code requirements and the relevant safety standards.

All temporary power panels throughout the facility included ground fault circuit interrupters providing personnel protection. Ground-fault protection was also provided on all temporary-wiring circuits, including all extension cords, used on the site.

A single cord assembled incorrectly has the potential to seriously injure personnel or start a dangerous and costly fire. Therefore it was important to use properly tested high grade cords like SOOW, where every cord has been tested for polarity, insulation resistance, ground bond and ground to case.

It was also important to select properly designed products and accessories for cable and cord management which kept the work
area uncluttered, and increased productivity and safety.

One key learning was to consider lighting equally important in non-process areas where the maintenance work does not occur by auditing the area lighting. One individual tripped in a poorly lit area when returning to a food trailer on a night shift.

4) Product Technologies/Advantages:
The work place demanded that the temporary power products met Canadian Electrical Code requirements as well as safety standards, and could be used many times over during the turnaround and future maintenance work and shutdowns.

Therefore, temporary power equipment is really not an accurate description for the product – it is actually more ›mobile power‹, used in a variety of challenging plant applications, including those such as the described shutdown and maintenance activities.

A typical temporary power electrical distribution system consists of main distribution, primary distribution and secondary distribution temporary power equipment. The equipment was provided with transformers, circuit breakers, disconnect switches, ground fault circuit interrupters and various configurations of receptacles.

The equipment was conveniently positioned throughout the work site on the ground or securely mounted to scaffold providing electrical outlets for various hand tools, lighting, equipment and machines. The scaffold is a temporary structure of metal pipes and platforms used to support people and material in a facility.

The combination of the panel assemblies distributed around the work areas greatly reduced the number of cords throughout the site. There was also a significant reduction in the number of extension cords used under a hot work permit, creating a safer working environment and reducing the number of tripping hazards in the units.

A basic temporary power plant layout is shown in Figure 2.

Figure 3 shows an example of a main power distribution unit specified as weatherproof type 4X enclosure and Class I, Zone 2, Group IIC hazardous location rated. This unit was supplied by either a welding receptacle or 600V area MCC. It houses up to twelve 3-phase, 208V receptacles to connect power to primary power distribution units, one welding receptacle and up to six 1-phase, 120V receptacles for local area tools and lighting.

The main panel of the power distribution center is shown in Figure 4. It consists of a main bus, and all outgoing 3-phase, 208V receptacles are protected with a molded case circuit breaker and all outgoing 1-phase, 120V receptacles are protected with a ground fault circuit interrupter unit.

A secondary power distribution unit specified as weatherproof type 4X enclosure and Class I, Zone 2, Group IIC hazardous area rated is shown in Figure 6. This unit plugs directly into the primary distribution panel or the main power distribution center. Three 1-phase, 120V receptacles are provided for tools and lighting.

As mentioned earlier, lighting is also an important part of the maintenance activities. It included flood lighting, task lighting as well as emergency lighting and was temporarily mounted to scaffolds using quick secure scaffold brackets, or more permanently with a scaffold maintainable swivel light assembly. Class I, Zone 2, Group IIC hazardous rated lighting was also

Figure 4: Main Panel of Power Distribution Center with internal Bus and Molded Case Circuit Breakers and Ground Fault Circuit Interrupter Units

Figure 5: Primary Distribution Panel, Scaffold mountable

Figure 6: Secondary Distribution Panel
used inside of static equipment for inspection purposes. Figure 7 shows a rugged Class I, Zone 2, Group IIC rated fluorescent lighting fixture.

All power distribution equipment was inter-connected using designed and tested cord sets assembled with harsh duty cable; each used specific gauges of wire, connectors and plugs as needed to meet the varying demands of the site. Figure 7 illustrates this.

Scaffold mount cable management systems as shown in an example in Fig. 8 were used in order to achieve the best level of site safety.

The advantages of having mobile power products include:

- Eliminate the costly inconvenience of on-site equipment fabrication which cannot be used in hazardous areas
- Easily move the power source to different areas within the work site or install it permanently
- Complete projects efficiently and safely
- Save money in reduced downtime
- Use equipment again for recurring shutdowns and maintenance turnarounds
- Decreased the number of cords throughout the units
- No concerns whether the equipment is properly rated for the areas that it is installed

5) Auditing installations in the field:

An audit of the installation of temporary / mobile power equipment prior to the start of the turnaround was performed. Key findings included grounding and bonding deficiencies such as using cable clamps too big for the ground conductor, bonding to aluminum tray instead of structural steel and cutting strands from bonding conductors to make it fit into a lug. Further findings included equipment mounted at grade and installation of unprotected cables.

Additional audits were performed every shift. Findings included non-hazardous location rated ‘cheater’ cords used inappropriately and standard extension cords tapped to steel or run along steel grating, leading to tripping hazards.

A key lesson learned is to be more involved with the contractor in the placement and installation methods of the equipment.
IV. Conclusions

The availability of electricity at petrochemical facilities is critical to uptime of production equipment. It is important from a reliability standpoint that inspection, testing and repair activities are being performed during plant turnarounds to ensure that protective devices operate when required.

Likewise, a thorough inspection and test plan will validate the performance criteria used to calculate arc flash levels. Failure to sufficiently maintain electrical equipment negates the validity of arc flash studies and may result in equipment failures or safety incidents.

Planning and up-front work activities should take place months or even years before the turnaround start date. Contractor selection well in advance allows time to agree upon the inspection and test plan, discussion of equipment operation and isolation, grounding points, format of deliverables and test reports.

The hazardous location mobile temporary power equipment provided safe, durable, versatile and ready to use power throughout the shutdown areas, helping to minimize overall downtime and costs. The equipment was used in rigorous abuse applications, and functioned reliable and safe. It also eliminated the inconvenient and costly on-site fabrication of traditionally available and used temporary power equipment.

The turnaround experience was invaluable in providing training and hands-on experience for site electrical personnel on equipment that is usually energized and inaccessible. A lesson learned session was completed at the end of the turnaround to capture improvement opportunities for future maintenance turnarounds.

References

[1] NFPA 70E, 2009, Standard for Electrical Safety in the Workplace, Quincy, MA