Managing the Reliability of an Industrial or Commercial Electrical Power System

by **Chuck Baker**

Chuck Baker is the President of PowerPro 360, a company offering power system reliability assessment and reliability maintenance programs for Industrial and commercial organizations. Chuck entered the world of Substation and Power System Maintenance 36 years ago and has spent a majority of that career on the operations side of power and distribution system maintenance and the development of power system maintenance programs.

Cast in Order of Appearance

Andy ..... Reliability Manager of Electrical Power System
(just recently hired by Brian, the Plant RVP)

Tim ..... Electrical Engineer
(who reports to Andy)

Tina ..... Maintenance Manager
(who reports to Brian also)

Brian ..... Regional Vice President
(head person for this plant)

Kevin ..... Director of Reliability

Jill ..... Director of Operations

You are Andy, and you have recently been hired into a newly created position at Smith Industries as the Reliability Manager of the Electrical Power System within their industrial manufacturing plant. This new position was created after Brian, the Regional Vice President for the plant, returned from a Power Reliability Summit.

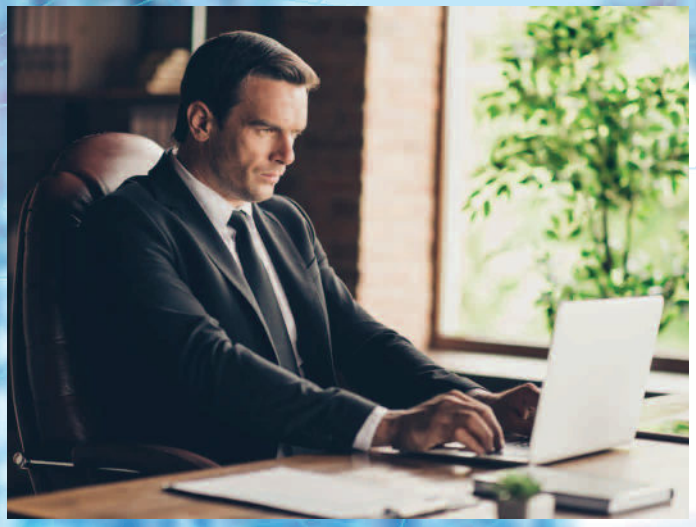
You get on-boarded, introduce yourself to the maintenance team and look over the team and their experience level.

Your first order of business is to sit down with Tim, your Electrical Engineer to find out as much as you can about the electrical system maintenance program history and the location of the maintenance files which include Dielectric Fluid Reports, Electrical Testing Reports and all services provided on the power system over the years.

Tim takes you to the maintenance office and you are shown to the file room where a long row of 6-inch 3-ring binders are located. They are labeled by substation and by year.

It is explained to you that after each test, they have corrected what they can afford to correct, however it is often normal for anything that is not an emergency to be postponed or the approval is denied. After all, money is tight and reactive maintenance comes first.

You ask if there is an updated one-line diagram for you to review. Tim walks over and pulls the binder that contains the one-lines for the plant.



He hands you the binder. Before you open it, you ask if he is aware of the last time it has been updated. He explains that he has been on board for 8 years and this is what was in place since his arrival. He further explains that they have not made any major changes to the system. You continue and ask him if he knows the date of the last arc flash study. This one he knows; the records and labeling show that it was performed in 2005 since he has seen that date on everything related to it.

Now it seems appropriate to add some additional team members to the meeting. You call over to the maintenance office and request that Tina, the Maintenance Manager, join you and Tim. Tina is glad to join, expressing her gratitude that she is getting some help since she is swamped with the production equipment maintenance and thinks adding an electrical system manager was probably a good move. She is excited to meet you.

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Your team assembles and your first question to the team is: Tell me how the reliability and maintenance of the power system flows?

Tim and Tina take turns explaining the process and it is very straightforward:

- Annually all transformers are sampled and inspected by the sample company. This company sends out their own technicians who do visual inspections, pull oil samples and send them to their lab.
- Results come in with recommendations for what to do in the case of anything that is either not acceptable or questionable. These results can be accessed via a web portal dashboard and can be trended, however Tim rarely accesses the dashboard and simply prints out the reports, filing them in one of the binders.
- The most serious problems are reviewed and a request for repair authorization is created and sent to purchasing after being reviewed and approved by the Maintenance Manager, Tina.
- Those requests that are approved are sent to several contractors for review and are completed according to the Contractor Program.
- Periodically we have reactive problems, like leaks and then we get emergency approval.
- We try to electrically test transformers, breakers and cables every three years, but because of the required outages it has been five to seven years since all of that has been done. When we did do the testing, we did all of the recommendations that the test companies provided.

You ask if there have been any major problems with the power system in recent years.

Tina jumps in and explains that there have been three major incidents in recent history. Four years ago, a distribution transformer in the transfer station faulted. It did some damage to the primary knife switch and there was a release of fluid throughout that section of the plant.

You ask her to explain the recovery and impact from that failure:

- Thankfully there were no injuries!
- The cleanup was performed by a hazmat team they had contracted.
- The transformer was replaced in two weeks with a new unit that had been located and was a perfect fit.
- The primary disconnect was rebuilt and returned to service at the same time as the transformer. Total down time was 16 days.

You asked about the final cost of the fault and they recalled that the total calculated loss and recovery was around $325,000.

They went on to explain that there had also been a cable fault and a low voltage breaker failure. Both the cable fault and breaker fault were repaired by your electrical contractor and did not result in any downtime. You thank them for their help and head back to your office.

What you have learned so far certainly points to the fact that the standards required for electrical system testing, maintenance and reliability are not well established, which means you have some work to do. You call Brian's Executive Assistant and request a two-hour meeting in two weeks. You request that the following people attend the meeting:

- Brian, Plant Regional Vice President
- Kevin, Director of Reliability
- Jill, Director of Operations
- Tim, the electrical engineer

An hour later she confirms that the meeting is set up for two weeks from Thursday at 1:30 but Brian has asked for you to provide a write up of the meeting purpose and desired conclusions by the end of today.

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You draft the email, read it over and send it to Brian cc'ing the Executive Admin and other attendees.

It reads as follows:

From: Andy
Subject: Special meeting to review electrical system program reliability
To: Brian

Brian,
as you know I have requested a meeting with those responsible for the reliability and safety of the power system and the required uptime for production. The points I would like to discuss are:

1. Who holds authority in the organization for Safety, Compliance, Reliability and the Maintenance Philosophy for Smith Industries?
2. Who holds the authority for approval of electrical system maintenance funding each year?
3. I would like to walk out of this meeting with unity in our reliability and maintenance strategy of our electrical system to avoid any more costly downtime.

The two-week period passes quickly, and you have your presentation complete. You walk into the scheduled meeting; all are present and after some polite chit-chat you begin your presentation.

You make the following key points as they listen intently:

"Tim knows the electrical power system very well and could answer every question I asked of him. Tina has excellent maintenance programs and approach. They just haven't made it into the power program at this plant. Thank you, both, your efforts are much appreciated."

You continue: "**The electrical power system in this plant is not reliable.** All equipment is treated as equal and it is clear that some components are critical, and some are not actually in active service, and a lot are in between those applications. There is no Criticality Analysis of the major assets." (Brian fidgets in his chair at this revelation.)

"Kevin and Jill, it looks as if you look at maintenance requests throughout the year and approve based on available funds, but since you are not provided with the probability or severity of failure, it makes approvals a very tough decision. There simply is not enough money to do everything."

"We have had three significant failures in the past five years totaling just under $500,000 in damage and lost production. Worse than that, I have spent many, many hours going through some of the binders of maintenance records and I am finding trending towards failure in some of the most critical assets, especially our transformers. While the reactive maintenance or repair requests are usually approved, there are some very critical preventative maintenance requests that are nearly ever approved."

"Kevin and Jill, from what I understand, Brian is assuming that the power system that produces the product and our revenue is secure and reliable. You have brought me on board to manage this for you and I have some significant recommendations to this team. Interested?"

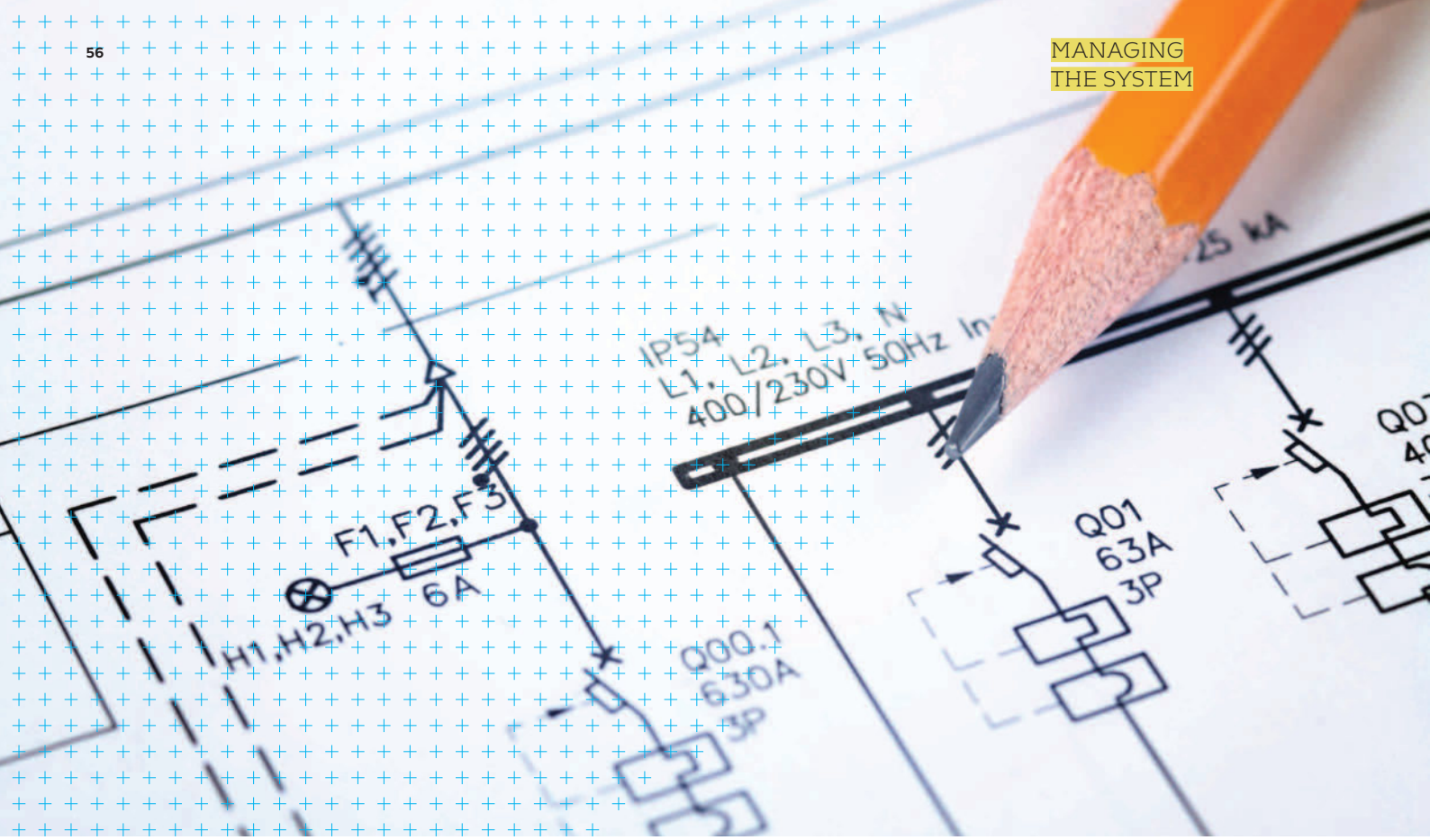
Within moments Brian replies:

From: Brian
Subject: Re: Special meeting
To: Andy

Andy,
I am looking forward to finding what you have discovered and what you propose.

Brian answers that question with a strong and resounding YES! He explains that his plant needs to be safe, compliant, reliable and run with maximum productivity. He asks you to continue.

You then walk them through your proposed stages of an ***Electric Power Reliability Program***.



1. Arc Flash Study

Your latest Arc Flash Study is significantly out of compliance. NFPA 70E states in Article 130.5 that an Arc Flash Study needs to be reviewed every five years or whenever there is a significant change in the electric system. The five-year interval is a straightforward requirement. Your last study was performed in 2005. I recommend that we contract for this immediately for two reasons:

a) Safety of our employees and the contractors we bring on site;
b) The Arc Flash Study requires some key steps which will be a real benefit to our power reliability maintenance program and includes:
   i. A review and update of our one-line drawings: NFPA 70B directs that this should be done every five or six years and is critical for our electrical department and contractors we use. Considering that this directs lockout/tagout, it needs to be accurate for the protection and safety of those who work with it.
   ii. Short Circuit Study: This is required for arc flash calculations to determine the magnitude of currents that flow during an electrical fault – a key point to the program.
   iii. Protective Device Coordination Study: There are two components to this study, and I am recommending both:
      1. What are the current settings, which is required for the study, and
      2. Which settings need to be changed to provide a safer system?

This will determine if the protective devices are the proper devices with the proper settings, which is valuable on many fronts from safety to compliance to proper protection.

2. Full maintenance program

Institute a base maintenance program that will contain three fundamental components:

a) **Our Standards:** Develop our electric power system maintenance standards that we all agree to. These can be customized depending on the criticality of each piece of equipment with approval from this Senior Maintenance Team. We need to adjust the maintenance budget to the reality of what we have and truly need.
b) **All Equipment Data:** All equipment data and all historic and current maintenance results need to be in a digital format, not in 3-ring binders. This will provide current state, risk of failure, and recommended services that should be performed via our established standards. This will also give us trending to determine when the maintenance services need to be provided.
c) **Reliability Prioritization:** We need to contract a study to determine what the risk is with each piece of equipment. This has three key steps:
   i. How healthy is this unit? Looking at load and past test reports, how does it compare to our establish standards? How much remaining useful life does it have?
   ii. What is the impact of failure? If it were to go down immediately, what is the impact and cost? This includes tracing the power feed to its conclusion, understanding impact on safety, production and the time required to reinstate the power. It will look at lost production and potential effect on output and potential product shortages. From this we will identify options to minimize these effects.

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iii. Prioritize the equipment by failure impact and current health. From this we will need to determine what actions we need to take to correct or prevent these problems and what contingency or preparation we can make for the inevitable failures: things like spare equipment, pre-qualified contractors, parts or components that we can have on site. In some cases, we will proactively correct or replace, and in others, we will accept the risk.

"We will then approve the program and begin to implement it. When I ask this team for approval of a budget, I will include the logic for the request. I will explain the importance of the equipment, the danger of the problem and the urgency to correct. If we can't fund all required repairs, we will place this current year's funding on our most critical issues. We want to make sure that what we spend has the biggest impact on our goal of total reliability."

"Finally, we want to be compliant and provide a reliable power system. This doesn't mean unlimited funding – it means having a program to understand condition and risk and to guide our decisions."

Brian responded by saying:
"I want this group back together in 30 days with a report on progress and a projection for completion of the plan. In addition, I want to know within 48 hours how and when you are going to do the arc flash study. Funding for that is approved, let's make sure we bring in a quality team to do the study and let's make sure we get it into something better than 3-ring binders. Meeting adjourned."

"Thank you, Andy, I had no idea how critical it was to bring you on board. I want you to attend the next electrical reliability conference because it was there that I realized how important this issue really is."