Quality Control Plan for Puerto Rico Electrical and Power Restoration Project

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Abstract

A year ago Puerto Rico was dark for more than 9 months. After Hurricane Maria struck, federal, local and private corporations were forced to update their strategies due to the intensity of the Category 4 storm. The electric power system demonstrated its inefficiency when receiving the impact of such a phenomenon. Deficiencies that were identified, such as the weakness of the electric system and the lack of materials, forced the creation of a Quality Control Plan. There were countless companies providing support in the restoration of the electrical system. Lord Electric Company was committed to the electrical restoration for 6 months, working more than 12 hours a day and 7 days a week. The development and implementation of this Quality Control Plan remained true to Lord Electrical Company's commitment. The philosophy of "Do it right the first time" was the focus of the plan to successfully provide electricity service to thousands of families in Puerto Rico, adhering to the electrical quality standards.

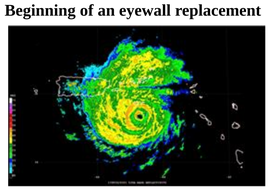
Introduction

Puerto Ricans will remember September 20, 2017, as the date on which Hurricane Maria unleashed all its forces to the Island of Enchantment. Puerto Rico was hit by the most powerful and catastrophic hurricane of its recent history. In less than 8 hours, the hurricane caused damages unseen by Puerto Ricans in the last 80 years. Hurricane Maria's center crossed the Island from the southwest to the northeast as a Category 4. The driving reasons for this investigation are the destruction of 80% of the electrical infrastructure of Puerto Rico and the complete halt of electrical generation. The purpose of this project is to present the Quality Control Plan developed by the Lord Electric Company after Puerto Rico was declared to be in state of emergency.

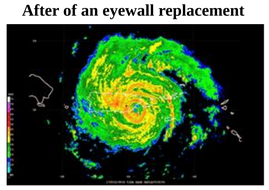
Background

Hurricane María, Category 4 on the Saffir-Simpson scale, with sustained winds of 155 MPH crossed the southeast coast of Puerto Rico near Yabucoa around 6:15 am on September 20, 2017. Just before Maria made landfall in Puerto Rico, the eye wall replacement cycle underwent a change in which a new eye developed around the initial one. Once completed, the intensity of hurricane Maria decreased from Category 5 to Category 4 and the eye wall that resulted was approximately three times the diameter of the initial one, from 9 nautical miles to about 28 nautical miles. The eye's increase spread the hurricane force winds out over a larger area. As a result, large part of Puerto Rico experienced the strongest winds. Winds, rain and floods devastated Puerto Rico. The combined destructive power of the wave of storms and the action of the waves caused extensive damage to the flora, fauna and infrastructure of Puerto Rico. María affected 80% of Puerto Rico's utility poles and all transmission lines. This situation caused power loss for the 3.4 million residents of the island. Eight months after Hurricane Maria, the Puerto Rico Electric Power Authority announced that it had reached 99.04% electrical generation capacity.

Beginning of an eyewall replacement



After of an eyewall replacement



Problem

In Puerto Rico the fossil fuel power generation is the predominant energy source. In the Island, oil dominates production with 47.6%, natural gas has seized 33.7% and coal is the third most used resource with 16.8%. The island is affected in numerous ways by the metric tons of carbon dioxide produced by the power plants, causing environmental damage. PREPA has become a facilitating entity for the development and safe integration of energy from renewable sources. PREPA's electrical system is composed of two phases of power generation, transmission and distribution, responsible for distributing power to 1,449,211 customers. Hurricane Maria caused the total collapse of the transmission and distribution systems. The strong winds, torrential rains and landslides exceeded the structural capacity of the electric power system. 200 transmission system towers and approximately 50,000 distribution poles were affected. The main challenge of repairing the electrical grid in Puerto Rico was the restitution of the transmission and distribution lines. The entire island was dark, the repair process was slow due to a shortage in both materials and personnel to rebuild the power grid. The lack of new materials forces to create a Quality Control Plan. Lord Electric's Quality Control Plan was based on electrical quality standards.

Methodology

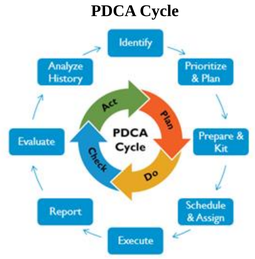
Lord Electric Company training and planning took priority over detection and correction of electrical systems. Procedures were developed to ensure compliance with electrical quality standards, contract requirements and good construction practices. This Quality Control Plan, served as the quality standard for Lord Electric Company and his subcontractors.

Process Control Procedures

Lord Electric Company guaranteed that this project was carried out under controlled conditions, planned and inspected installation processes. The Project Manager and Quality Control Manager (QCM) prepares Construction Work Plans (CWP) for each phase of the project. Each CWP includes instructions, descriptions of the methods used to carry out the work, and personnel training, so that the work met the quality requirements. The CWP defined how the work of the overall project should be carried out and approved. When carrying out the construction process plan, meetings with key personnel, subcontractors and suppliers were arranged. The tool used to determine the quality assurance was the PDCA model which stands for:

- **Plan** - Establish objectives and procedures required to deliver the desired results.
- **Do** - Implement the procedure developed.
- **Check** - Monitor and evaluate the implemented procedure by testing the results against the predetermined objectives.
- **Act** - Apply actions necessary for improvement, if the results require changes.

PDCA Cycle



Inspection

The inspection was carried out during all phases of the project to ensure that the work performed was in accordance with the contract requirements and quality specifications. The QA / QC staff were required to document these inspections in the Surveillance Report. This procedure specified the methods that were used to identify, perform, document and track quality surveillance activities. The work had to comply with the electrical quality standards, otherwise Lord QCM would issue a nonconformity report and would begin a corrective action process. The main objective was to quickly identify the facts that can somehow affect the quality of the project. Progress inspections were performed daily, or as required by its progress, on each definable feature of the project:

- Initial assessment of damages that occurred in the distribution line.
- Analyze the best route to start working according to the materials available.
- Verify the materials available for use and their condition.
- Perform the installation methods in accordance to quality and safety standards.
- Perform pre-commission and start-up testing on equipment.
- Perform the energization.
- Inspect after the energization.

Non-conformance Controls

This procedure establishes the mechanisms for processing non-conformances works as per Quality Control Plan. If non-conformance is identified by an inspection, there is a systematic method to control, correct and ensure that project quality is not adversely impacted by the event.

Identification of the Non-conforming Condition

The worker identifying the non-conforming condition documents the description and signs the Non-conformance Report "NCR". The NCR is forwarded to the Contractor Quality Control Manager for processing. The Contractor takes immediate corrective action once notified.

Disposition Implementation and NCR Closure

When the Quality Control Manager receives a Nonconformance Report, he assesses the effect of the reported non-conformance. The QCM would assign a disposition of either:

- Replacing: The non-conformance can be brought into conformance with the original specification requirements by replacing the nonconforming product or material with a conforming product or material.
- Repair: The nonconformance can be brought into conformance with the original requirements.

Methodology

Initiation and Issuance of Corrective Action Requests (CARs)

Significant conditions adverse to quality or repetitive violation of quality requirements would be documented on a Corrective Action Request (CAR) form. The requirement that was violated would be listed in the space provided and the adverse condition clearly and concisely described. Recommendations for correcting the condition is also to be detailed in the space provided on the CAR form. The CAR would be reviewed by the Contractor Quality Control Manager to determine that the adverse condition is clearly described and valid. If the condition is valid, a unique number was assigned to the CAR and then the number were logged into a CAR log. The normal response time was ten working days, but this time was adjusted (increased or decreased) depending upon the criticality and complexity of the adverse condition. The CAR was then forwarded to the responsible organization for resolution of the adverse condition.

Corrective Action Response

The following processes were used to implement the Corrective Action. They included, among others, the following:

- Investigate the root cause of the breach and determine the corrective action necessary to avoid repetition.
- Analyze the processes, work operations, customer complaints and non-conformance reports to detect and avoid potential problems.
- Apply controls to ensure that the corrective action is implemented and is adequate to solve the problem.
- Document, review and report results for effectiveness.

The responsible organization would respond to the CAR, addressing each of the above points by the response date specified by the Contractor Quality Control Manager. If the responsible organization was unable to respond by the date specified, they could request, in writing, an extension to the response date. The response was evaluated by the Contractor QCM and, if acceptable, is approved. If not deemed acceptable, an amended response was requested from the responsible organization.

Corrective Action Verification and Closure

Upon completion of the actions specified by the responsible organization in the approved CAR response, the Contractor Quality Control Manager or his designee would verify that the corrective actions were properly implemented. This verification would take the form of document reviews, surveillance, or audit as appropriate. Upon satisfactory completion of this verification, the CAR shall be signed off and closed.

Electrical Transmission and Distribution Lines Acceptance Procedure

This standardized procedure established the acceptance process for turning the completed lines over back to the Puerto Rico Electric Power Authority (PREPA):

- Completed construction and repair work as described in the assessment report.
- Contractor quality control inspection shall be completed, and accepted, prior to proceeding with further procedure steps.
- Contact with PREPA's personnel was made and inspection of line segment was requested.
- PREPA completed inspection and delivered inspection report.
- Any deficient items noted in the inspection report were corrected prior to proceeding with energization of the line.
- In coordination with Customer and PREPA, all grounds, locks, tags and flags were removed from completed system.
- Upon final signatures, Contractor released custody and control back to PREPA.

Planification Meeting

Inspection

Repair Work

DO IT RIGHT THE FIRST TIME

Case of Study

The work on the electrical lines that was carried out required a visual inspection of the distribution and sub-transmission circuits for each energization. To avoid electrical risks, Occupational Safety and Health Administration (OSHA) measures were applied when all the segments energized by the circuit breaker were closed and in the high voltage line opening. The Surveillance Report is the backup documentation that supports daily inspections. This detailed individual report was made for each electrical line that was worked on and to which all the PREPA standards were applied to individually. If any disagreement occurred, it was also detailed in the report to carry out the corrective action 10 days before the non-conformance report was emitted. This report was made by Surveillance Personnel and approved by the Quality Control Manager. The Surveillance Report was carried out on December 31, 2017. The extensive work, over the span of over two weeks, on the electrical lines of Morovis and the completion of the inspections that were carried out by professionals, concluded with the goal of energizing more than 1,000 customers on New Year's Eve. After the approval of the quality standards required by PREPA, USACE and subcontractors, power was back up after 8:00pm.

Surveillance Report

SURVEILLANCE REPORT				ID A0006-8801-04
Location: Morovis	Subcontractor/Activity: Repair	Date 12/31/17	Completed Work ☑ Yes ☐ No	Report No. PR-06
W.O Number: 1483	Substation: Arecibo, Manati	Feeder 8801-04		Voltage 8.32kV

Inspection Checklist, Specification, Or Drawing Used As Reference:
- Section 26, Part 2.3 – "Patrones de Construcción Aérea", Salvaging of materials.
- Section 4.16/8.32 Spacer Cable S2, 366mcm ACSR, "Patrones de Construcción Aérea", CP-81, M1-2.
- Section 26, Part 2.1 – Wood Pole, T-1 "Patrones de Construcción Aérea"
- Section 26, Part 2.1 – Concrete Pole, T-1, AC-M-2, "Patrones de Construcción Aérea"

RESULTS: Follow-up Required ☐ Satisfactory ☑

Description Of Item/Work Inspected/Observed:
- It was verified that the auxiliary bar and open breaker was open
- Test grounds installed
- Cleaning of Work Areas.
- Straightening/Removal of Broken Poles
- Salvaging of Materials if Possible
- Three (3) metal pole where straightened
- One (1) grey wire was installed
- Safety grounds were removed from conductors.
- Feeder 04 can be energized Urb. Bambora to Urb. Valle San Luis, 1,000 residences.

Observation/Deficiency:
- No deficiency was observed or found.

Person Notified Of Deficiency: N/A (Name) N/A (Title)

Recommended Corrective Action:
- N/A

Corrective Actions Implemented/Accepted:
- N/A

Project Manager / 31-Dec/17 — Zuleika Perez Lorenzo/ 31/Dec/17
Surveillance Personnel/Date — Site Quality Manger/Date

Conclusions

The evident climate changes demand that Puerto Rico have a quality plan that addresses environmental resources. That is one of the reasons that Hurricane Maria arrived with such high intensity. As time passes, the atmospheric systems will be stronger. Because of this, it is imperative to establish island-wide Emergency Plans, including a detailed Quality Control Plans for private companies as well as the governmental agencies of the Commonwealth of Puerto Rico. The development of such plans must include all the basic services, such as Electrical Services, Water Services, Communications, Health Services, debris disposition, among others. In the Puerto Rico Electric Restoration Project, Lord Electric Company supported the quality control plan and procedures established and required by Contractor and PREPA, guaranteeing the safety and general quality of the project. Lord is committed to a policy of "zero defects" as the standard for management. The purpose of the Quality Control Plan is to ensure that all work meets or exceeds the requirements. Non-conforming work has a cost for both our clients and the company. Satisfying customer requirements is necessary for giving a positive attitude towards non-conformity or the prevention of defects, based on the firm belief that things can be done right the first time.

Acknowledgements

As with any major project, it takes a great team to make all the elements come together in this investigative project. I want to extend my personal and sincere thanks to Miriam Pabón, Ph.D. for her support and guidance in the design and development of this project. Also, I want to acknowledge my immediate family, -" you know me the best, you love me the most, and have supported me in all my endeavors during my life". And I would like to express my special gratitude to Lord Electric Company and their staff, for the trust and opportunity given to me to develop the Quality Control Plan.

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