RESEARCH FOUNDATION

RESEARCH FOR THE NFPA MISSION

Evaluation of Electrical Feeder and Branch Circuit Loading: Phase 1

MEETING MINUTES

PROJECT TECHNICAL PANEL MEETING

CONFERENCE CALL

THURSDAY, 6 SEPTEMBER 2016; 10:30 AM

1) Call to Order and Attendees. The meeting was called to order at 10:30 am by Casey Grant of the Fire Protection Research Foundation. The following were in attendance:

- Robert Arno, Harris Corp. & IEEE Fellow (NY)
- Lou Galante, University of Iowa (IA)
- Tammy Gammon, Jasper Georgia (GA)
- Brett Garrett, Ohio State University (OH) (alt to Bob Wajnryb)
- Casey Grant, Fire Protection Research Foundation (MA)
- Dean Hansen, University of Texas Austin (TX)
- Mark Hilbert, IAEI & CMP-2 Chair (NH)
- Brian Liebel, Illuminating Engineering Society of North America (NY)
- Mark Lien, Illuminating Engineering Society of N.A. (NY) (Alt to B Liebel)
- Brian Meyers, University of Nebraska (NE)
- Bob Yanniello, Eaton Corporation (OH)

The agenda for the meeting was indicated to review the work plan with the project contractor, and clarify applicable details within the confines of the project RFP and available resources. Casey Grant reminded attendees that the project was being conducted in accordance with the Foundation Policies and Procedures and the role of the Panel is advisory in nature and intended to provide guidance back to the contractor. For reference, the updated Panel Roster is included herein as Attachment A, and the Project Summary is as included Attachment B.

2) Review of Project Workplan. Tammy Gammon provided an overview of the project and the work plan using the slides included in Attachment C, and this resulted in the following observations, questions and comments:

Overview

- This is intended to be a dialogue and not a monologue.
- Based on the slides, the following items were reviewed: questions leading to this project; need to focus on new installations and then work our way back; clarify the arc-flash hazard associated

with various sizes, large and small, of equipment; need to "right-size" without over-heating; will begin with NEC Article 220; lighting and receptacles will be a focus.

- The RFP had two simple objectives (as reflected in slide 4). First is to review the published work, and will start the literature wide in scope by characterizing commercial buildings, and their energy consumption and loading. The 2nd stage of the literature review will focus on load assessment.

Literature Review

- Minimal feedback expressed on the literature review.
- Clarification provided on why this topic is important to the Illuminating Engineering Society (IES). IES will be working with IEEE for commercial lighting, and this effort is underway and needs to be coordinated with the NEC and other documents.

Data Collection

- Focus on data collection that will support or influence change in the NEC.
- For data collection plan, the intent is to focus on case study of 5 office buildings (2 small, s medium and 1 large). For the large building, the present approach is to consider the NFPA Headquarters building.
- Concern with the number of facilities as being low, and would want a number greater than 5 would be more statistically valid.
- Defer to some published papers on statistical validity. In particular defer to IEEE papers on importance and reliability based on sample size.
- Consider ASHRAE 90.1 document for background support. There data will be helpful. In addition, Bob Arno and Larry Shaw may have data for data collection.

Data Sampling Geographic and Temporal Considerations

- Geographic location and regional impact is a possible consideration, including impact of regional environmental conditions. For example, the Northeast will be different than the Southwest. But this should be balanced with how the NEC does and does not address local and regional geographic influences,
- What about occupancies other than office buildings? For example, also consider healthcare, which could provide a critical link to sponsors for phase 2.
- Time frame of data sampling is important. Duration for monitoring, will need these over a larger period of time. For example, HVAC is certainly seasonal. But this is why utility data would be needed.

Other

- It's not only collecting the data, but also how it will impact possible code changes. These would be handled by others beyond this project and its report.
- The magnitude of the overall effort is an important question. This will be an on-going question. Phase 2 will not be a small project. Earlier indications suggested that Phase 2 would be approximately $750K to $1.5M.
- Funding for Phase 2 is important and needs to be considered during phase 1. It will likely be driven by organizations interested in reducing capital costs, and not necessarily for energy efficiency or safety.
- Based on the feedback during the meeting, Tammy will review the original data collection plan, and try to redevelop the plan to address the issues raised by the panel members and sponsors.

3) Next Steps. It was agreed that the Panel should plan another conference call around mid-October to re-visit some of the aforementioned issues and details. The next steps will be for Casey Grant to

circulate a scheduling poll for a conference call for the week of 17/Oct through 21/Oct, with late morning or early afternoon the preferred time frame. Once this is scheduled, staff will provide the necessary call-in details and other applicable information.

4) Adjournment. Panel members were thanked for their participation, and the meeting adjourned at 11:10 am.

(Meeting Summary by C. Grant, 27/September/2016)

Attachments

Attachment	Description	No. of Pages
A	Project Panel Roster	2
B	Project Summary	1
C	PowerPoint Slide of Project Work Plan	2

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Evaluation of Electrical Feeder and Branch Circuit Loading: Phase 1

PROJECT CONTACTS

Last Updated: 5 September 2016

Project Technical Panel

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Project Sponsors

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Other Project Contacts

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RESEARCH FOUNDATION

RESEARCH FOR THE NFPA MISSION

Evaluation of Electrical Feeder and Branch Circuit Loading: Phase 1

PROJECT SUMMARY

Last Updated: 25 August 2016

Background: Interest has been growing in recent years to investigate and clarify the degree to which the feeder and branch circuit load design requirements in NFPA 70, *National Electrical Code®* (NEC®) need to be adjusted based on the increasing pace of technological innovation along the entire span of the electrical power chain. For example, today's Energy Codes are driving down the electrical load presented by end use equipment and thus load growth assumptions that justify "spare capacity" should be re-examined. In addition, larger than necessary transformers that supply power to feeder and branch circuits expose unnecessary flash hazard to electricians working on live equipment.

Research Goal: The goal of this project is to develop a data collection plan to provide statistically significant load data for a variety of occupancy and loading types to provide a technical basis for considering revisions to the feeder and branch circuit design requirements in the National Electrical Code®. This initial effort will have an emphasis on general commercial (office) occupancies. The deliverables from this project represent a Phase 1 study to review the literature and develop a data collection plan, in support of a potential second phase (not included in the scope of this effort).

Affected NFPA Documents: NFPA 70, *National Electrical Code®*, Articles 210 through 230.

Project Tasks: With guidance from a Project Technical Panel of subject matter experts (in accordance with Foundation Policies), this project involves the following tasks:

1) **Task 1: Review of Literature.** Perform a comprehensive review of the electrical literature over the past ten years, with a focus on previous studies on electrical loading in various occupancy types and data that has been collected to address this topic, with a particular emphasis on general commercial (office) occupancies.
2) **Task 2: Development of a Detailed Data Collection Plan.** Analyze and summarize the information from Task 1 to generate a detailed data collection plan that when implemented will provide a comprehensive evaluation of electrical feeder and branch circuit loading. The data collection plan should be based on guidance from the Project Technical Panel and include details on proposed scope of work, tasks (including details on collecting and analyzing data), anticipated deliverables, and budget.
3) **Task 3: Final Report.**

A final report for this phase 1 effort is scheduled for five months after project initiation. A subsequent phase 2 effort (separate from phase 1) is anticipated and will consist of implementation of the data collection plan, its analysis and development of recommendations related to circuit loading.

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Fire Protection Research Foundation

Evaluation of Electrical Feeder & Branch Circuit Loading: Phase 1

Tuesday September 6, 2016, 10:30 EDT

Selected Contractor: Tammy Gammon, PhD, PE

Project Technical Panel: Mark Hilbert, Robert Arno, & Mark Early

Sponsors: University of Minnesota, Ohio State, University of Iowa, UT-Austin, Michigan State, Michigan Assoc. of Physical Plant Administrators, Notre Dame, University of Nebraska, Ohio State, Eaton

Questions Leading to this Project

- Technology improvements and energy codes have driven down the power requirements for building loads, which include lighting, receptacle loads, and HVAC systems. Is Article NEC 220 in sync with today's world?
- Are the load growth assumptions that justify spare capacity usually realized? What can we substantiate about current design practices on spare capacity?
- Does NEC 220 result in oversized branch circuits, feeders, and transformers?
- What are safe operating points for electrical equipment? Can we substantiate "oversizing", "rightsizing", and overheating, and the impacting factors?
- Does oversizing equipment pose a greater "arc flash" hazard? Conversely, would improperly "rightsizing" increase electrical shock and arc flash injuries?

Where to Begin: NEC Article220

- NEC 220 provides requirements for calculating branch-circuit, feeder, and service loads for all types of buildings. The emphasis here will be on office buildings.
- References to other NEC articles are provided for many load types, including: HVAC, refrigeration, motor (and elevator), electric vehicle charging stations and PV systems.
- Of special interest for office buildings …
  - Branch circuit loads in NEC 220.12 & 220.14 for lighting and receptacles
  - Feeder calculations in NEC 220.44 for receptacle demand factor

Stated Phase I Research Objectives

- Obective 1
- To review the published work on electrical loading in the past ten years, with emphasis on commercial office buildings.

- Objective 2
- To develop a feasible plan to evaluate branch circuit and feeder loading, with emphasis on commercial office buildings.
- The plan must include data collection method, data analysis, deliverables, and budget.

Review of Published Work

- What is needed? The published literature review should justify the need for a large scale research project to collect data on feeder and branch circuit loading which may ultimately prove buildings house oversized electrical equipment (associated with energy losses, higher equipment costs, and potentially greater electrical safety hazards). Such research might benefit:
  - Large Institutions (Reduce energy costs)
  - Manufacturers (Sell "safer" equipment which will reduce energy cost)
  - Government Agencies (Meet national energy goals and policies)
  - Electric Utilities (with Incentive to reduce peak and total demand)
  - NEC
- Where to Start: 1st Stage of Literature Review
  - Characterize the magnitude, scope, and trends in building loading with emphasis on commercial offices.

2nd Stage Literature Review: Load Assessment

- Lighting
  - NEC 2017, IES, ASHRAE, ANSI, current engineering practice
- Receptacle
  - NEC 2017 and current engineering practice
- Other Loads and Total Load
  - NEC 2017 and current engineering practice
- Transformer Loading, Sizing and Selection
  - Address arc flash hazard
  - Energy efficiency requirements in 10 CFR 431.196.
  - "Rightsizing" versus over-utililizing

Electrical Feeder and Branch Circuit Loading: Data Collection Plan & Motivation

- Articles by Mike Anthony have reported that electrical systems in existing buildings are grossly underloaded, and at least one paper has suggested a massive data effort is needed.
- Probably true, but maybe not the best next step.
- Proposal suggested a less ambitious but more doable Phase 2 to evaluate building loading on select "new construction" in accordance with NEC.
- 5 Office buildings constructed in the past 2 years ("new installation")
  - 2 small offices (2,000 to 10,000 ft²)
  - 2 medium offices (around 50,000 ft²)
  - 1 large office building (100,000+ ft²)

Electrical Feeder and Branch Circuit Loading: Data Collection Plan

- Spot measurement for all branch circuits and feeders (small/medium)
- Monitor loading on all panels (3+ days small/medium, 1+ day large)
- Inventory receptacle loads (small), inventory IT equipment (med/large)
- Obtain drawings and lighting schedule. Obtain utility load data.

- Idea: Use current renovation to NFPA office, approximately 100,000 square feet, for large office. A carefully written article focusing on the technology changes and energy savings with mention of this project might be an excellent NFPA Journal article.

Electrical Feeder and Branch Circuit Loading: Evaluation of Specific Loads

- Lighting
  - Compare NEC and data with connected and demand load on kVA panel schedule and actual manufacturer luminaire kW (small & medium offices only).
- Receptacle
  - Compare NEC and data and connected and demand load on kVA panel schedule with receptacle count from drawings and any inventoried branch circuit loads.
- Other Loads – Heating, Cooling, Motor, etc.
  - Compare NEC (as applicable) with data and power requirements of equipment.

Electrical Feeder and Branch Circuit Loading: Evaluation of Feeders, Transformers & Spare Capacity

- Compare panel data with listed panel schedule connected and demand kVA and spare capacity.
- Compare calculated transformer and feeder sizes with sizes required *if no spare capacity had been added.*
- Compare calculated results with transformer and feeder sizes required *to meet load measurements (not design calculations).*

Service Equipment, Feeder Size, and Transformer Rating

- Compare measured load with utility data.
- Compare equipment sizes with sizes calculated for measured load of peak season.

Project Perspective

- Phase 1 Literature Review – To provide a foundation and to justify the need for a much larger research project.
- Phase 1 Data Collection Plan – To provide a plan for a very doable Phase 2.

- Phase 2 results will help establish the loading levels for *new* installations and provide valuable data to the appropriate NEC CMP on Article 220.
- A larger data collection effort in Phase 3 might justify replacing old equipment and technology for energy savings and safety.

Project Phase 1 – Team Roll Call What do you think?

- Project Technical Panel:
  - Mark Hilbert? Robert Arno? Mark Early?
- Project Sponsors:
  - Michael Berthelsen? Brett Garrett? Lou Galante?
  - Don Guckert? Dean Hansen? Kane Howard?
  - Michael Hughes? Jim Jackson? Paul Kempf?
  - Brian Meyers? Bob Wajnryb? Bob Yanniello?
- Anyone else?
  - Mike Anthony? Jim Harvey? Richard Robben?