ORGANIZATIONAL DEVELOPMENT

IMPROVING PRODUCTIVITY AND REDUCING REWORK BY ESTABLISHING A BUILT-IN QUALITY (BIQ) PROGRAM

Quality in Construction

ELECTRI INTERNATIONAL
THE FOUNDATION FOR ELECTRICAL CONSTRUCTION INC.

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EXECUTIVE SUMMARY

Many definitions exist for the word "quality"; there is no single, generally accepted definition (Pyzdek 1999). Similarly, there are many definitions for Quality Assurance and Quality Control. Based on a review of how the word quality has evolved over time along with an examination of organizational, researcher, and practitioner definitions, the following will be adopted:

QUALITY *- producing a product that meets customer expectations and is fit for use*

QUALITY ASSURANCE *- the activity of providing evidence to establish confidence among all concerned that quality-related activities are being performed effectively*

QUALITY CONTROL *- a process of analyzing data collected through statistical techniques and comparing this data with actual requirements and goals to ensure compliance with standards*

A traditional quality process consists of Quality Planning, Quality Assurance (QA), and Quality Control (QC) (PMI 2008). This approach to design and construction project quality emphasizes QA at the beginning of a work process and QC at the end. During the construction phase, QC occurs after the completion of installation, followed by inspection, then acceptance/rejection of the work (Lichtig (2005).

In contrast, a Built-In Quality (BIQ) program focuses on the initial stages of a quality process by first identifying customer expectations, converting these expectations into requirements, developing work plans, and then performing the work. This aligns with the most recent edition of PMI's Project Management Body of Knowledge (PMBOK), which has added the need for prevention over inspection: "One of the fundamental tenets of modern quality management states that quality is planned, designed, and built in (emphasis added) – not inspected in."

A BIQ process strives for error-free results as opposed to a quality level that is deemed to be acceptable. BIQ is an application of lean construction that maximizes the value to a client and minimizes waste (Koskela 2000, Ohno 1988). The desire to limit (or eliminate) waste is fundamental since waste results in increased costs and reduced value.

BIQ process steps for each contractor work category include:

- ***1.*** *Developing and confirming a mutual understanding of the work expectations from all external and internal customers*
- ***2.*** *Preparing a specific operations plan for the fabrication and installation of each piece of work*
- ***3.*** *Training workers on each of these operations and ensuring they have everything necessary prior to beginning their work*
- ***4.*** *Implementing an audit assessment program that allows project participants to assess that (1) the process was followed and (2) the product conforms to expectations.*

A BIQ plan template was created, (derived from Glavinich 1995), and is included in Appendix A of this report. Note that this quality plan should be configured to meet the needs of the project, customer, stakeholders, and the contractor's own organization. It is a suggested template for the contractor to review and modify as required.

All NECA installation standards were reviewed and a summary of each standard is included in Appendix B, along with a link to the complete publication. Sample Record and Checklist Forms, including Test Records, Other Records, Installation/Construction Checklists, and Startup Checklists are available in Appendix C. Two additional BIQ examples are included: BIQ Narrative Examples for Work Activities in Appendix D, and Examples of a BIQ Approach to Technical Specifications, in Appendix E.

DEFINITIONS

Unfair payment practices are endemic in the construction industry and getting worse. Owners are extending payment terms, thereby having an impact on general contractors, subcontractors, vendors and material suppliers. The consequences of these practices affect all industry stakeholders; however, the burden falls most heavily on subcontractors. While subcontractors often pay labor weekly and suppliers monthly, they have collections that can take several months, severely affecting their working capital needs and profitability. Cash flow constraints can impact subcontractors in a number of ways, including:

Agile Project Management (APM)	An iterative method of determining requirements for engineering and information technology development projects in a highly flexible and interactive manner
Built-in Quality (BIQ)	The practice of controlling variables within a process, securing quality at one's own process, not passing on poor quality, and checking every piece (Quality Digest 2013)
Customer	"Anyone who is affected by the product or by the process used to produce the product"; also, "customers may be external or internal" Juran (1999)
Inspection	Activity performed by an owner-appointed inspector (e.g., Inspector of Record or A&E inspector); an assessment of the completed work of a construction activity to requirements
Inspection Success Rate	The rate of (Inspections Approved)/(Total Inspections) rounded to the closest integer
Just-in-Time (JIT)	Just-in-Time … Delivery, Manufacturing, etc.
Lean Project Delivery SystemTM (LPDS)	A lean conceptual framework developed to express the relationship between the five fundamental triads of project delivery (project definition, lean design, lean supply, lean assembly, use), work structuring, and production control (Ballard 2008)
Office of Statewide Health Planning and Development (OSHPD)	Responsible for overseeing all aspects of the design and construction of Essential Services Facilities
Plan-Do-Check-Act Cycle (PDCA)	An iterative four-step management method used for the control and continuous improvement of processes and products
Poka-Yoke	A behavior-shaping constraint designed as a mistake-proofing system to stop errors from becoming defects

Process	A set of interrelated or interacting activities that transforms inputs into outputs (CII 2013)
Quality Assurance (QA)	The systematic activities implemented in a quality system so that quality requirements for a product or service will be fulfilled (Stukhart 1985)
Quality Control (QC)	A universal managerial process for conducting operations so as to provide stability—to prevent adverse change and to "maintain the status quo" (Juran 1992)
Quality Management System (QMS)	The organizational structure, procedures, processes and resources needed to implement quality management (Coffey 2011)
Stakeholder	Individuals and organizations that are actively involved in the project, or whose interests may be positively or negatively affected as a result of project execution or project completion; they may also exert influence over the project and its results (PMI 2008)
Total Quality Management (TQM)	An integrative philosophy of management for continuously improving the quality of products and processes (Ahire1997)
Trade Partner (TP)	Term used to describe a trade contractor (specialty contractor) who has an Integrated Form of Agreement (IFOA) construction contract with a General Contractor

BACKGROUND

The Construction Industry Institute (CII 2012) estimates that failure to maintain quality during the design and construction of facilities costs the U.S. construction industry over $15 billion a year in rework expenses alone. Additional costs for other quality failures may bring the total to more than twice that amount.

A traditional quality process consists of Quality Planning, Quality Assurance (QA), and Quality Control (QC) (PMI 2008). This approach to design and construction project quality emphasizes QA at the beginning of a work process and QC at the end; during the construction phase QC occurs after the completion of installation, followed by inspection, then acceptance/rejection of the work, e.g., Lichtig (2005).

By contrast, a Built-In Quality (BIQ) program focuses on the initial stages of a quality process by first identifying customer expectations, converting these expectations into requirements, developing work plans, and then performing the work. Furthermore, the most recent edition of PMI's Project Management Body of Knowledge (PMBOK) has added the need for prevention over inspection: "One of the fundamental tenets of modern quality management states that quality is planned, designed, and built in (emphasis added) – not inspected in." Worker inspection is a continuous BIQ process while Inspector of Record or professional design engineer inspection are discrete activities that follow completion of a construction task with the objective of achieving a 100% inspection success rate. The focus is on designing the process with the goal of producing work that meets customer requirements and expectations.

The BIQ process strives for error-free results as opposed to a quality level that is deemed to be acceptable. BIQ is an application of lean construction that maximizes the value to a client and minimizes waste (Koskela 2000, Ohno 1988). The desire to limit (or eliminate) waste is fundamental since waste results in increased costs and reduced value.

Early research of the importance and applicability of quality costs relate to the manufacturing industry. Within the built environment, the focus in the past has been on QA (proactive) and QC (retroactive), while BIQ is a real-time, interactive process. Furthermore, unlike traditional construction, the BIQ process is based upon actively engaging construction trade partners in all work operations. Poka-yoke is incorporated into the BIQ process as a behavior-shaping constraint designed to prevent an incorrect operation by a worker. This type of mistake proofing either prevents a mistake from being made or makes the mistake obvious at a glance (Shingo 1986, Grout 2007). This prevents an error (improper installation) from becoming a defect (error that reaches a customer).

DEFINING QUALITY

As noted above, there are many definitions for the word ***"quality".*** Garvin (1988) describes five principal approaches to defining quality: Transcendent, Product-based, User-based, Manufacturing-based, and Value-based. The approach selected will depend upon the environment and process.

- ***1. TRANSCENDENT:*** *an intuitive basis of quality, independent from experience.*
- ***2. PRODUCT-BASED:*** *quality is viewed as quantifiable and measurable characteristics or attributes.*
- ***3. USER-BASED:*** *quality is an individual matter. Products that best satisfy one's own preferences are those with the highest quality.*
- ***4. MANUFACTURING-BASED:*** *quality is concerned primarily with engineering and manufacturing practices and the definition of conformance to requirements.*
- ***5. VALUE-BASED:*** *consumer's purchase decision is based on quality at an acceptable price.*

Pyzdek's view (1999) is that there is no single generally accepted definition of quality. However, assessment of a quality process first requires that the word "quality" be defined within the context of a quality program. The definition of quality is critical to the success of a program. The selected definition provides a reference point to those performing the work. Without a precise definition that applies to everyone, each individual may define quality in his/her own way. Instead of one definition that results in everyone working together toward a singular goal, there will be as many definitions of quality as there are people associated with the project. Multiple definitions will reduce effectiveness of the quality process.

Licensed engineers of record have a responsibility to meet a quality standard of care. The law provides that an engineer performing professional services for a client has a duty to have that degree of learning and skill ordinarily possessed by reputable civil engineers, practicing under similar circumstances. Per the American Society of Civil Engineers (ASCE 2000):

> ***"The engineer also has the duty to use the care and skill ordinarily used in like cases by reputable members of the profession practicing under similar circumstances. Also, the engineer has the duty to use reasonable diligence and best judgment in the exercise of skill and the application of learning."***

Applying this definition to a construction project, "entity" could be understood to mean the finished work in place at the project site, including future maintenance and operation of the completed facility. "Stated and implied needs" would refer to the requirements set forth in the project contract documents. "Stated needs" refers to the construction requirements explicitly called-out in the plans and specifications, while "implied needs" refers to the codes, standards, and other documents referenced in the contract document. Furthermore, "implied needs" also refers to achieving customer satisfaction.

Table 1 illustrates how the word ***quality*** has evolved over time.

Table 1: Definitions for Quality

ORGANIZATION (REFERENCE)	DEFINITION
Construction Industry Research and Information Association (CIRIA 1988)	"fitness for purpose"
Construction Industry Institute CII 1989)	"conformance to established requirements"
Associated General Contractors of America (AGC 1992)	"conformance to standards"
American Society of Civil Engineers (ASCE 2000)	"fulfillment of project responsibilities in the delivery of products and services in a manner that meets or exceeds the stated requirements and expectations of the owner, design professional and constructor"
International Organization for Standardization (ISO 9000)	"the totality of characteristics of an entity that bear upon its ability to satisfy stated and implied needs"
American Society for Quality (ASQ 2012)	"A subjective term for which each person has his or her own definition. In technical usage, quality can have two meanings: a. The characteristics of a product or service that bear on its ability to satisfy stated or implied needs b. A product or service free of deficiencies"
RESEARCHER (REFERENCE)	**DEFINITION**
Kuehn (1962)	"In the final analysis of the market place, the quality of a product depends on how well it fits patterns of consumer preference"
Edwards (1968)	"Quality consists of the ability to satisfy wants"
Gilmore (1974)	"Quality is the degree to which a specific product conforms to a design or specification"
Leffler (1982)	"Quality refers to the amounts of the unpriced attributes contained in each unit of the priced attribute"
Broh (1982)	"Quality is the degree of excellence at an acceptable price and the control of variability at an acceptable cost"
Feigenbaum (1991)	"Quality means best 'for certain customer conditions.' These conditions are (a) the actual use, and (b) the selling price of the product"
Crosby (1992)	"Quality (means) conformance to requirements"
Juran (1999)	"freedom from deficiencies" where deficiency is defined as "any fault (defect or error) that impairs a product's fitness for use"
Oakland (2006)	"Quality is meeting customer's requirements"
Ruman (2011)	"the fulfillment of the owner's needs per defined scope of works within a budget and specified schedule to satisfy the owner's/user's requirements"
Lichtig (2011A)	"consistently producing a product (outcome) that meets the customer's expectations and that is fit for the purpose intended"

The ASCE (2000) definition differs from the others in that it includes meeting or exceeding "the stated requirements and expectations of the owner …" However, exceeding the stated requirements does not produce value and may have a cost premium an owner is unwilling to pay.

One common thread in all quality definitions is "satisfaction" (meeting customer implied needs or stated requirements), "conformance" (either to established requirements or standards), and "fitness" of use.

Constructed work that is in conformance with the contract documents should be of sufficient quality to meet customer expectations. For the contract documents to have completely captured all expectations and be of sufficient quality to meet customer expectation assumes that:

- *The contract documents are also in compliance with all applicable codes,*
- *Field documents (such as material substitutions, change orders, and AE clarification bulletins) are well documented, and*
- *A process exists whereby customer approval is obtained.*

Within the context of electrical systems contract documents, there are many instances in which these assumptions are not met. Several specifications and drawings contain clauses stating that the contractor is responsible to provide a "complete and operable system" and "all work shall be in conformance with the latest edition of the National Electrical Code". These clauses are intended to mitigate the responsibility of the design engineer and transfer final design details to the contractor. Furthermore, the level of quality that needs to be placed on design drawings to satisfy code compliance associated with doors, frames, and hardware is very different from the quality needs of health care professionals working within the facility. A BIQ process needs to incorporate the needs of all stakeholders to fully meet customer expectations.

A definition for quality must include customer acceptance. While a "customer" is commonly defined as the "owner" on many projects; a BIQ approach includes all other subcontractors (trade partners), the architect/engineers, inspectors, regulatory agencies, as well as the owner within the definition of customer. This broader definition of customer maintains an integrated, collaborative focus, beginning in the design planning phases and carrying through design, construction, testing, commissioning, and occupancy.

Within the context of this report, the following quality definition will be adopted:

> ***Producing a product that meets customer expectations and is fit for use."***

The term "customer expectations" rather than "customer requirements" is preferred for the following reasons.

- *At the beginning of a project, design engineers initially prepare a design criteria to establish the basis for design.*
- *The design criteria codifies the design requirements, are accepted by the owner, and become the owner requirements.*
- *Issued for construction (IFC) drawings and specifications further develop these owner requirements in conformance with code requirements.*
- *Construction is performed in accordance with IFC drawings and specifications.*
- *If "customer requirements" differ from "customer expectations" then "customer requirements" should be revised to align with expectations.*

This adopted definition incorporates several of the elements from professional organizations and researchers, as well as customer acceptance of the final product. Customers may be both internal as well as external to the organization performing the work (Juran 1999). During the construction phase, internal customers are defined as construction trade contractors and external customers are those individuals or organizations affected by the project but are not performing construction. During this stage, external customers include, but are not limited to, architect and engineers of record, construction managers, inspectors, material suppliers, plus other regulatory personnel, commissioning agents, and the owner (Lichtig 2011B). Within a health care setting (during the construction phase), external customers would also include patients, families, nurses, doctors, lab technicians, housekeeping, food service, plant operations and maintenance, licensing agents, permitting agencies, and code enforcement officials.

Contractors must be able to perform their work, deliver a completed task to a sequential contractor or the inspector (their customers), and accept work from a predecessor contractor (as a customer). Contractors must consistently produce what both the client "customer" as well as another contractor or inspector "customer" is expecting, as well as focus upon process quality.

Per Oakland (2006) "by ***consistently*** meeting customer requirements, we can move to a different plane of satisfaction - ***delighting the customer***", producing customer loyalty. Customer (client) expectations for quality should be incorporated into the plans and specifications, which establish the technical requirements for a project (Glavinich 1994). Therefore, constructed work that is in conformance with the contract documents should be of sufficient quality to meet customer expectations.

QUALITY ASSURANCE AND QUALITY CONTROL DEFINITIONS

Similar to defining ***quality,*** there are many definitions for quality assurance and quality control. **(Table 2 and Table 3)**

Table 2: Quality Assurance Definitions

ORGANIZATION/RESEARCHER (REFERENCE)	DEFINITION
Stukhart (1985)	"systematic activities implemented in a quality system so that quality requirements for a product or service will be fulfilled"
Kerzner (2001)	"formal activities and managerial processes that are planned and undertaken in an attempt to ensure that products and services are delivered at the required quality level."
Gryna (2001)	"the activity of providing evidence to establish confidence that quality requirements will be met"
Oakland (2006)	"the prevention of quality problems through planned and systematic activities, including quality documentation"
ASQ (2012)	"all the planned and systematic activities implemented within the quality system that can be demonstrated to provide confidence a product or service will fulfill requirements for quality"
ISO 9000 (2013)	"those planned and systematic actions necessary to provide adequate confidence that product or service will satisfy given requirements for quality"

A meta-review (Ruman 2011) of quality assurance definitions concludes that:

> ***Quality assurance is the activity of providing evidence to establish confidence among all concerned that quality-related activities are being performed effectively."***

Table 3: Quality control Definitions

ORGANIZATION/RESEARCHER (REFERENCE)	DEFINITION
Feigenbaum 1991	"a process for delegating responsibility and authority for a management activity while retaining the means of assuring satisfactory results"
Juran 1999	"a review of all quality factors involved in a production process"
Chung 1999	"the activities that are carried out on the production line to prevent or eliminate causes of unsatisfactory performance"
Gryna 2001	"the process employed to consistently meet standards"
Kerzner 2001	"a collective term for activities and techniques, within the process, that are intended to create specific quality characteristics"
Oakland 2006	"the activities and techniques employed to achieve and maintain the quality of a product, process, or service"

Quality control can therefore be defined as:

> ***A process of analyzing data collected through statistical techniques and comparing this data with actual requirements and goals to ensure compliance with standards."***

An analysis of the aforementioned quality assurance definitions indicates the majority of definitions refer to the "planned and systematic activities" for a "product or service that will fulfill requirements". Quality control, however, refers to a "process" to "ensure satisfactory results". In a conventional QA/QC approach, quality assurance is focused on managing activities to ensure that stipulated goals are realized while quality control is focused on the initiation of an evaluation process to meet requirements. The emphasis is on process quality rather than product quality.

An example best illustrates this difference. Assume a buried water pipe provides drinking water to a community. The pipe develops a small fracture, allowing contaminants to infiltrate the water supply. If the focus is on product quality, a filter could be added to distill the contaminants, providing potable water of suitable quality (i.e., meeting regulatory requirements). However, the filter does not solve the crack in the pipe, the source of the contamination. The filter screens out the contaminants but adds no value. Instead of adding a filter, process quality requires that you repair the pipe (i.e., correct the process). A BIQ program relies upon process quality; designing a system with the correct process that will result in "consistently producing a product that meets customer requirements (stated or implied) and is fit for use."

CURRENT STANDARD FOR QUALITY IN THE ELECTRICAL CONSTRUCTION INDUSTRY

The current state of the built environment is a more collaborative design and construction approach with a Lean philosophy. The majority of construction quality programs are based on product quality rather than process quality. The current approach is on producing a product (by passing an inspection) without first establishing a quality process program. Missing process steps include establishing client expectations and designing work operations This gap in the quality process results in additional time or cost, generates waste, reduces value, and is not meeting customer expectations.

RECENT HISTORY OF QUALITY AND QUALITY MANAGEMENT

Quality and quality systems within the built environment are topics that have received increasing attention worldwide (Chan 2000; Low 1998). The history of quality management, from 'inspection only' to Total Quality Management[1] (TQM), and the more modern version of Six Sigma[2], has led to the development of essential processes, ideas, theories and tools that are central to organizational development and the performance management improvements generally desired for stakeholders and organizations.

Quality management concepts have developed through the work of several quality pioneers. Glavinich (1994) discusses the work of these pioneers, with the exception of Taguchi and Shingo.

- *Americans in 1950's Japan: W Edwards Deming, Joseph Juran, and Armand Feigenbaum*
- *Japanese who developed and extended the early American quality ideas and models: Kaoru Ishikawa, Genichi, and Shigeo Shingo*
- *Western advocates in the 1970-80s: Philip Crosby and Tom Peters, who further extended quality management concepts after the Japanese successes*

Taguchi believed it was preferable to design a product that is robust or insensitive to variation during manufacturing, rather than attempting to control all the many variations during this stage (Taguchi 2004). He used established knowledge on experimental design and made it more usable and practical for quality professionals. His message dealt with the routine optimization of a product and process prior to manufacture rather than quality through inspection. This methodology is fundamentally a prototype that enables a designer to identify the optimal settings to produce a robust product that can repeatedly survive manufacturing and provide what the customer wants. Quality and reliability are pushed back to the design stage, and off-line quality is separated into three distinct stages: System design, Parameter design, and Tolerance design (Taguchi 2004).

Tolerance design is important in the built environment. Engineering and construction tolerances are most often based on either functional requirements or tacit estimates of reasonable and achievable variation limits (Milberg 2006). However, process capability – the variation in a parameter of a process's output – is important when specifying tolerances for all construction processes. Poor estimation of a process capability can lead to substandard quality of the construction process. (Milberg 2010). Process capability – and variability – must be assessed first. Tolerance design needs to take into consideration materials and equipment tolerances both for a baseline process and also for different process scenarios.

1. *Integrative philosophy of management for continuously improving the quality of products and processes (Ahire 1997).*
2. *A manufacturing process in which 99.99966% of the products manufactured are statistically expected to be free of defects (3.4 defects per million).*

Shingo is associated with Just-in-Time (JIT) manufacturing and invented the single minute exchange of die (SMED) system (Shingo 1985). He also originated Poka-Yoke (mistake proofing), in which defects are examined, the production system is stopped, immediate feedback is provided so that the root causes of the problem may be identified, process changes are adapted, a feedback loop is deployed to validate the new process, and the root causes of the problem are prevented from occurring again (Shingo 1986).

Chase (2001) compared the philosophies of three quality pioneers: Crosby, Deming, and Juran; Ruman (2011) references this summarization **(Table 4).**

Table 4: Comparison of Quality Pioneers (from Ruman 2011)

TOPIC	DEMING	JURAN	CROSBY
Definition of quality	A predictable degree of uniformity and dependability at low cost and suited to the market	Fitness for use (satisfies customer's need)	Conformance to requirements
Degree of senior management responsibility	Responsible for 94% of quality problems	Less than 20% of quality problems are due to workers	Responsible for quality
General approach	Reduce variability by continuous improvement; cease mass inspection	General management approach to quality, especially human elements	Prevention, not inspection
Performance standard/motivation	Quality has many "scales"; use statistics to measure performance in all areas; critical of zero defects	Avoid campaigns to do perfect work	Zero defects
Structure	14 points for management	10 steps to quality improvement	14 steps to quality improvement
Statistical process control (SPC)	Statistical methods of quality control must be used	Recommends SPC but warns that it can lead to tool-driven approach	Rejects statistically acceptable levels of quality (wants 100% perfect quality)
Improvement basis	Continuous to reduce variations: eliminate goals without methods	Project-by-project team approach; set goals	A process, not a program; improvement goals
Teamwork	Employee participation in decision making; break down barriers between departments	Team and quality circle approach	Quality improvement teams, quality councils
Costs of quality	No optimum; continuous improvement	Quality is not free; there is no optimum	Cost of nonconformance; quality is free
Purchasing and goals received	Inspection too late; sampling allows defects to enter system; statistical evidence and control	Problems are complex; carry out formal surveys	State requirements; supplier is extension of business; most faults due to purchasers themselves
Vendor rating	No; critical of most systems	Yes; but help supplier improve	Yes; quality audits useless

Per Ruman (2011), the common features of their philosophies can be summarized as follows:

- *Quality is conformance to the customer's defined needs.*
- *Senior management is responsible for quality.*
- *Institute continuous improvement of process, product, and services through the application of various tools and procedures to achieve higher level of quality.*
- *Establish performance measurement standards to avoid defects.*
- *Take a team approach by involving every member of the organization.*
- *Provide training and education to everyone in the organization.*
- *Establish leadership to help employees perform a better job.*

QUALITY MANAGEMENT AS A PROCESS

Juran (1999) identifies the "quality gap" as the difference between customer expectations and customer perceptions of delivery. This gap consists of a series of smaller gaps **(Figure 1**):

Figure 1: Quality Gap and its Constitute Gaps (Juran 1999)

UNDERSTANDING
Understanding what the customer needs

DESIGN
Designing a product to meet those needs

PROCESS DESIGN
Establish a process that is capable of delivering the design

OPERATIONS PRODUCT
Ensure that operations and control can deliver the final product

Quality planning steps (Juran 1999) include:

- *Establishing the project*
- *Identifying customers*
- *Discovering customer needs*
- *Developing the product*
- *Developing the process*
- *Developing process controls*
- *Transferring to operations*

Oakland (2006) defines the quality process as "the transformation of a set of inputs into outputs that satisfy customer needs and expectations, in the form of products, information or services." Total Quality Management focuses upon customer-supplier interfaces (to both external and internal customers and suppliers) and the processes at each interface. An organizational commitment to quality – along with communicating and acknowledging this commitment – is essential for Total Quality Management. One central feature to both Total Quality Management and Six Sigma is that the need to understand a workflow process is essential before any attempt is made to improve the process.

Characteristics of Six Sigma (onesixsigma.com) include:

- *Achieve measurable and quantifiable financial returns to an organization's bottom-line*
- *Provide strong leadership and the support required for successful deployment*
- *Conduct problem solving, integrating human elements (culture change, customer focus, belt system infrastructure, etc.) and process elements (process management, statistical analysis of process data, measurement system analysis, etc.)*
- *Utilize tools and techniques for fixing problems in business processes in a sequential and disciplined fashion*
- *Create an infrastructure of champions, including master black belts, black belts, and green belts that lead, deploy, and implement the approach*
- *Emphasize decision making based on facts and data rather than on assumptions and hunches*
- *Utilize statistical thinking and encourage the application of well-proven statistical tools and techniques for defect reduction through process variability reduction methods (e.g. statistical process control and design of experiments)*

Oakland (2006) provides a framework for TQM based upon three "Cs" *(culture, communication, and commitment)* and four Ps:

1 PLANNING

The development and deployment of policies and strategies; setting up appropriate partnerships and resources; and designing in quality.

2 PROCESS

Understanding, management, design and redesign; quality management systems; continuous improvement.

3 PEOPLE

Managing human resources; culture change; teamwork; communications; innovation and learning.

4 PERFORMANCE

Establishing a performance measure framework - a 'balanced scorecard' for the organization; carrying out self-assessment, audits, reviews and benchmarking.

The Construction Industry Institute (CII) Quality Management Task Force developed a Quality Performance Management System (QPMS) to track quality costs using 11 rework causes and 15 quality management activities (CII 1989). The system focused upon a small number of major disciplines (civil, electrical, etc.) and major project phases (design, procurement, construction, and start-up). The CII QPMS was designed as a tool for project management in terms of identifying quality issues and their impact costs and in determining how to correct them in order to reduce project costs.

In another study focusing upon the capital facilities delivery industry, CII (2010) defines a quality management system as "a set of policies, processes, and procedures that govern the planning and execution of capital facilities delivery projects so that owners' business and project objectives are achieved." The report refers to the QMS as the organization's project execution "assembly line" and that the QMS defines how all disciplines participate and interact on a project, without limitation to quality assurance (QA) and quality control (QC).

The CII QMS process consists of three steps:

STEP #1

Developing an understanding of what constitutes a modern QMS, implementing a new process, or improving an existing process.

STEP #2

Evaluating the elements of the most common quality management and business excellence systems, building upon the foundation of project management practices.

STEP #3

Examining owners' and contractors' ratings of the effectiveness of their QMS and why these systems are implemented, evolve, and mature.

CII (2010) presents a Quality Management Matrix (QMM) of six QMS elements at five maturity levels. The contents of each cell describe the typical behaviors associated with an element at each maturity level. All categories show an increase in quality focus with a corresponding increase in level of commitment. For example, there is no QMS management support at level 1, while QMS management is considered an essential component of an organization's business process by level 5.

QUALITY WITHIN THE BUILT ENVIRONMENT

HOW QUALITY PROBLEMS OCCUR

Quality problems may manifest in many ways during construction, resulting in rework. A cause and effect diagram of the causes of rework (Fayek 2004) identified five categories:

1. ***Human Resource Capability:*** excessive overtime, insufficient skill levels, unclear instructions to workers, and inadequate supervision and job planning.

2. ***Leadership and Communication:*** lack of safety and QA/QC commitment, poor communications, ineffective management of project team, and lack of buy-in by Operations.

3. ***Engineering and Reviews:*** late design changes, scope changes, errors and omissions, and poor document control.

4. ***Construction Planning and Scheduling:*** late designer input, unrealistic schedules, constructability problems, and insufficient turnover and commissioning resourcing.

5. ***Material and Equipment Supply:*** untimely deliveries, non-compliance with specifications, prefabrication and construction not performed to project requirements, and materials not located in the right place when needed.

Feng (2009) expanded upon this to include categories of rework prior to construction:

6. ***Planning, Programming, and Budgeting:*** change in user groups, lack of owner commitment, lack of flexibility/knowledge, change in business case, escalation costs, and poor communications.

7. ***Design Review and Permitting:*** code changes and inappropriate review process.

8. ***Design Planning, and Scheduling:*** design changes, inappropriate design process, poor document control, unrealistic schedules, inappropriate batch size, improper equipment selection, and errors or omissions.

QUALITY MEASUREMENT

Abdul-Rahman claims (1996) the occurrence of non-conformance is relatively high in construction and can affect the profit margin and competitiveness of a construction firm. The authors developed a quality cost matrix to capture the cost of non-conformance during construction of a water treatment plant. The findings presented indicate the applicability of the matrix, its main problems, the potential for improvement, their frequency of occurrence, and the consequences of implementing the matrix on site management. The name and location of the project were kept anonymous to protect the identities of the participating company and its employees. Non-conformance was classified according to the following categories:

- *Design-related*
- *Geotechnical*
- *Coordination and planning*
- *Communication*
- *Material,*
- *Construction-related*
- *Plant and equipment*
- *Personnel*
- *Subcontractor*
- *Setting-out*
- *Supplier*
- *Client's requirement*
- *Buildability*

The authors postulate that non-conformance could arise as a consequence of inadequate management. However, they note it was also difficult to gather data on non-conformance arising out of poor management actions and decisions. Therefore, this data set was not considered. While most of the costs of non-conformance were obtained on-site when a problem occurred, some of these costs were not known until the end of the project.

The application of a quality cost matrix can facilitate continuous improvement. The usefulness of cost information must be appreciated by every person and at all levels in a project team before it can be a tool for improvement. By applying the model throughout the construction process and by learning from the results, those involved in the industry can reduce the impact of non-conformance on project time and cost and, at the same time, improve the quality of the constructed project.

Buchert (1984) comments on the decrease in the quality of construction in domestic nuclear and non-nuclear projects. He states that the trend of contractors to self-inspect their work, using their own QA and QC methods, has tended to reduce the quality of construction and has discouraged qualified inspectors from accepting positions on such projects. The author also maintains that construction quality must be maintained by methods different from those used in manufacturing, but does not recommend increasing the number of inspectors nor the number of QA and QC audits as a means toward increasing the quality of construction. Buchert (1984) also proposes the following recommendations as a means to increase the quality of construction:

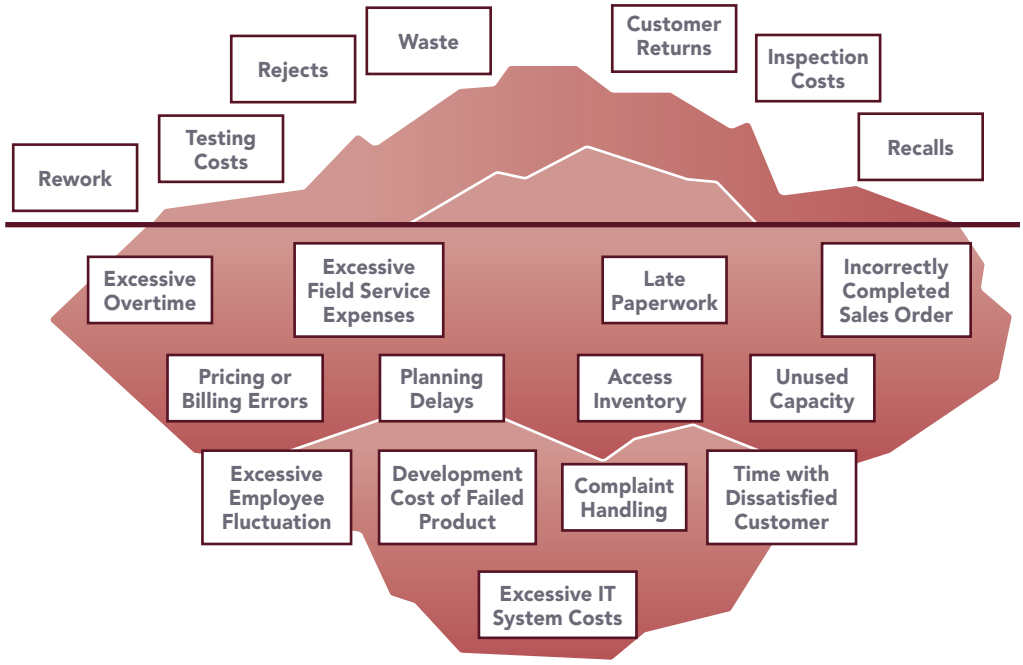
- *Using third-party independent inspections.*
- *Granting more authority to field and resident engineers.*
- *Tailoring designs and specifications to reflect the limitations on cost and time to meet safety requirements.*
- *Subjecting the engineering design to qualified third-party independent review.*

Chahal (2007) states that a quality assurance program should cover "all aspects of quality including quality control, quality audit, inspection and calibration." Further, the program should apply to all phases of a project including "design, procurement, manufacture, testing, site construction, erection and commissioning." Chahal states that the objectives of quality assurance are to:

- *Provide an expected level of standard*
- *Establish guidelines to validate quality*
- *Recommend and ensure that a proper method is available to control deviations from this standard.*

The lack of quality may be measured in several ways, including additional costs, waste, rework, and lost time. Some of these may be directly observed. Others are consequential and not as readily apparent, such as additional inspection, duplication of effort, and customer dissatisfaction. **Figure 2** shows how these lay below the surface.

Figure 2: The Iceberg Model of Cost of Quality (adapted from iSixSigma)



QUALITY VALIDATION

Many contractors base their quality assurance program on the ISO 9000 series of quality management and assurance standards. These standards are internationally recognized for quality assurance in both manufacturing and service industries. In the United States, the ISO 9000 standards have been adopted by the American National Standards Institute (ANSI) through the American Society of Quality Control (ASQC) as the ANSI/ASQC Q9000 standard series, which is equivalent to the ISO 9000 standard series. Five individual standards comprise the ANSI/ASQC Q9000 standard series and each of these standards has an ISO standard counterpart. These standards are shown in **Table 5.**

Table 5: ANSI/ASQC Standard Series and ISO Standard Counterparts

ANSI/ASQC STANDARD	ISO STANDARD	ANSI/ASQC Q9000 STANDARD TITLE
Q9000	9000	Quality Management and Quality Assurance Standards – Guidelines for Selection and Use
Q9001	9001	Quality Systems – Model for Quality Assurance in Design, Development, Production, Installation, and Servicing
Q9002	9002	Quality Systems – Model for Quality Assurance in Production, Installation, and Servicing
Q9003	9003	Quality Systems – Model for Quality Assurance in Final Inspection ad Test
Q9004	9004	Quality Management and Quality System Elements - Guidelines

ISO 9000 presents the principal quality concepts and lays the groundwork for ISO standards 9001, 9002, and 9003. ISO 9001 is the most comprehensive standard and deals with the design, development, production, installation, and servicing of the product or service. ISO 9002 is more restrictive in its scope, excluding design and development. Even more focused is ISO 9003, which deals with only the final inspection and testing of product or service. ISO 9004 provides guidance regarding the design and implementation of quality systems within the firm itself.

Bubshalt (1999) identified and contacted 34 major construction contractors located in the Eastern Province of Saudi Arabia to participate in a study of contractor compliance with ISO 9000. The authors evaluated the quality systems of the 15 contractors who agreed to participate in the study. The assessment consisted of personal structured interviews with key representatives and inspection of documents. Each interview took from two to four hours. A questionnaire form was used as a checklist. The questionnaire consisted of two parts, the first part being general and intended to get information about the contractors' general interest in and perception towards the ISO 9000 standards. Specific questions about ISO 9000 clauses include:

- *4.1 Management Responsibility*
- *4.2 Quality system*
- *4.3 Contract review*
- *4.4 Design control*
- *4.5 Document and data control*
- *4.6 Purchasing*
- *4.7 Purchaser supplied product*
- *4.8 Product identification and traceability*
- *4.9 Process control*
- *4.10 Inspection and testing*
- *4.11 Inspection measuring and testing*
- *4.12 Inspection and test status*
- *4.13 Control of nonconforming product*
- *4.14 Corrective and preventive action*
- *4.15 Handling, storage, packaging, & delivery*
- *4.16 Quality records*
- *4.17 Internal audits*
- *4.18 Training*
- *4.19 Servicing*
- *4.20 Statistical techniques*

Contractors were asked if they have a means in their quality system that satisfies each ISO 9001 clause, and whether or not these means are documented and implemented. The authors evaluated contractor input and rated contractor compliance according to the following criteria:

• A contractor who had a system that fully complied with the respective clauses of the ISO 9001 standard was rated "Y" and given a value of 1.0 point.

• A contractor who had a system that partially complied with the respective clauses of the ISO 9001 standard was rated "NF" and given a value of 0.5 points.

• A contractor's system that did not meet the requirement of the ISO 9001 standard was rated "N." It was given a value of 0 points.

ISO 9000 clauses achieving the most frequent compliance were those dealing with:

> ***4.10 inspection and testing and 4.14 inspection and test status (80% EACH)***
> ***4.13 control of nonconformance product (60%)***
> ***4.15 handling, storage, and preservation (53.3%)***

The clauses achieving the least compliance were those concerned with:

> ***4.4 design control (0%)***
> ***4.17 internal auditing and 4.18 training (13.3% EACH)***
> ***4.20 statistical techniques and 4.5 document and data control (20% EACH)***

Coffey (2011) discusses how quality principles and quality management system implementation relate to the performance of ISO 9000 certified contractors in Indonesia. Based upon an extensive literature review, the author identified eight ISO 9000 quality management systems (QMS) variables:

- **1.** *Customer focus*
- **2.** *Leadership*
- **3.** *Involvement of people*
- **4.** *Process approach*
- **5.** *Systems approach to management*
- **6.** *Continual improvement*
- **7.** *Factual approach to decision making*
- **8.** *Mutually beneficial supplier relationships*

and eight key performance indicators (KPI):

- **1.** *Profitability for the proceeding two years*
- **2.** *Sales growth for the proceeding two years*
- **3.** *Market shares in company region for the most recent years*
- **4.** *Global market contracts acquired*
- **5.** *Quality of services and products*
- **6.** *Sustainable construction products*
- **7.** *New product innovation and development*
- **8.** *Generating employee satisfaction*

Study results indicate that for every increase in the ISO 9000 QMS, the KPIs increased by 78%, validating the hypothesis that "there is a significant relationship between the QMS-ISO9000 principals and the contractor's KPIs".

VALIDATION CASE STUDIES

In order to further examine a BIQ process, four potential validation case study projects have been identified for comparison to a BIQ subject project. All case studies are located in Northern California, close to one another, and all are medical facilities with a constructed cost greater than $200M, similar to the subject project. These potential case studies have been selected based upon availability of data and similarity to the BIQ project in terms of type of facility, location, and constructed cost. None of the potential validation case study projects have a defined BIQ program. Instead, all potential case studies follow a traditional quality process relying upon individual subcontractor quality plans.

CASE STUDY 1

Comparison project 1 is a County Medical Center in San Jose, CA. The project involves the replacement of an existing building to provide Intensive Care and Acute Care hospital beds, a rehabilitation therapy center, aquatic therapy pool, offices and facilities for medical staff, and supply storage. The general contractor was also involved in the design-build of the central plant upgrade and underground utility infrastructure.

CASE STUDY 2

Comparison project 2 is a Hospital Satellite Acute Care Tower (SAT) and medical office building (MOB) in Oakland, CA. The project provides nine stories of critical care in the acute care tower (currently under construction) and three floors of MOB in the SAT.

CASE STUDY 3

Comparison project 3 is an HMO Medical Center Replacement in Oakland, CA. The project includes a five-story, 165,000 square foot MOB with a cancer care facility. The MOB includes the following departments: radiation therapy, material services, health education, neurology, pharmacy, clinical lab, pediatrics rehabilitation, physical and occupational therapy, hospice and palliative care, chronic pain management, hematology, oncology, infusion center, dermatology, human resources and medicine clinic.

CASE STUDY 4

Comparison project 4 is another Medical Center in Castro Valley, CA. The $320 million project includes a new 220,000 square foot hospital with 130 private patient beds, 80,000 square foot MOB, additional parking, and demolition of the old hospital once the new hospital is complete.

Contractors engaged in design and construction of healthcare facilities also have expressed the need for this research. The project manager in one validation case study noted that the company is seeing more reference to quality program requirements listed in client specifications and requested on bid forms. However, this contractor did not anticipate the total costs for quality and did not have an established BIQ program; this impacted both schedule and budget.

In another validation case study, punch list inspections performed by the lighting designer revealed lighting installation problems. These problems could have been detected by using either a poka-yoke process or process checklist established prior to initially conducting work. A third validation case study, also without a BIQ process, shows a lower inspection success rate for similar types of construction work. Process metrics will be examined to determine if initial successes continue.

The subject BIQ program resulted in many contractors rethinking their quality program. Some of these contractors have discovered efficiencies with the BIQ process and have begun an internal company-wide program based on their BIQ work on the project. Other contractors have requested documents created by the BIQ team. They intend to compete for new projects using BIQ to demonstrate their capabilities.

QUALITY PLANS

QUALITY PLAN EXAMPLES

Glavinich (1995) recommended a specific quality corporate plan template for inside electrical contractors:

1. CORPORATE PROFILE
- 1.1 Corporate Structure
- 1.2 Market Served
- 1.3 Mission Statement
- 1.4 Strategic Planning Process

2. CORPORATE COMMITMENT TO QUALITY
- 2.1 Quality Assurance Program
- 2.2 Quality Policy
- 2.3 Responsibility for Corporate Quality
- 2.4 Management Review

3. QUALITY SYSTEM
- 3.1 Quality System Defined
- 3.2 Quality System Objectives
- 3.3 Quality System Processes

4. CONTRACT DOCUMENT REVIEW
- 4.1 Process Scope & Objectives
- 4.2 Document Review Process

5. DOCUMENT CONTROL
- 5.1 Process Scope & Objectives
- 5.2 Document Control Procedures

6. DESIGN MANAGEMENT
- 6.1 Process Scope & Objectives
- 6.2 Design Quality Defined
- 6.3 Responsibility for Design Quality
- 6.4 Client Need Identification
- 6.5 Codes & Standards Review
- 6.6 Design Criteria Definition
- 6.7 Constructability & Value Analysis
- 6.8 Design Documentation
- 6.9 Design Review Procedures
- 6.10 Design Change & Modification Procedures

7. PROCUREMENT & EXPEDITING
- 7.1 Process Scope & Objectives
- 7.2 Supplier & Subcontractor Assessment
- 7.3 Requests for Quotation
- 7.4 Purchasing Policies & Procedures
- 7.5 Submittals
- 7.6 Owner-Furnished Materials & Equipment
- 7.7 Identification & Traceability

8. TOOL & EQUIPMENT MAINTENANCE, CALIBRATION, & TESTING
- 8.1 Process Scope & Objectives
- 8.2 Selection of Tools & Equipment
- 8.3 Transportation & Storage - Tools & Equipment
- 8.4 Calibration & Testing - Tools & Equipment
- 8.5 Repair of Tools & Equipment
- 8.6 Operating Instructions & Procedures
- 8.7 Operator Training & Certification

9. MATERIAL & EQUIPMENT MANAGEMENT
- 9.1 Process Scope & Objectives
- 9.2 Receiving & Inspection
- 9.3 Storage & Protection
- 9.4 Inventory Control Procedures
- 9.5 Material & Equipment Documentation

10. CONSTRUCTION MANAGEMENT
- 10.1 Process Scope & Objectives
- 10.2 Field Quality Defined
- 10.3 Responsibility for Field Quality
- 10.4 Organization for Field Quality
- 10.5 Work Force Qualifications & Training
- 10.6 Interface with Other Project Participants
- 10.7 Construction Means & Methods
- 10.8 Project Planning & Scheduling
- 10.9 Activity Preplanning
- 10.10 Safety & Accident Prevention
- 10.11 As-Built Construction Documents

11. INSPECTION, TESTING, & STARTUP
- 11.1 Process Scope & Objectives
- 11.2 Verifying Contract Compliance
- 11.3 Correction of Nonconforming Work
- 11.4 Start Up & Testing Procedures
- 11.5 Inspection & Test Records
- 11.6 Warranties & Guarantees

12. ANSI/ASQC Q9001 CROSS REFERENCE

Glavinich (1995) also recommend a specific quality corporate plan template for outside electrical contractors. This is the same template structure as that for inside electrical contractors with the exception of deleting Section 6, Design Management

A *project-specific* BIQ plan applicable to inside contractors also was reviewed. Elements included:

1. CORPORATE PROFILE

2. RESPONSIBILITY AND AUTHORITY

3. DELEGATION OF WORK

4. ORGANIZATION
- 4.1 Project Manager
- 4.2 QA/QC Manager
- 4.3 QC/Designate
- 4.4 General Foreman
- 4.5 Foreman

5. CONTROL OF MATERIAL AND EQUIPMENT
- 5.1 Receiving Inspection
- 5.2 Handling, Storage, Packaging, Preservation, and Delivery

6. INSPECTION AND TESTING

7. INSPECTION AND TEST STATUS

8. CONTROL OF MEASURING AND TEST EQUIPMENT

9. NON-CONFORMANCE

10. CORRECTIVE AND PREVENTATIVE ACTION

11. PROCESS CONTROL / SPECIAL PROCESSES
- 11.1 Process Control
- 11.2 Special Processes

12. DOCUMENT CONTROL / QUALITY RECORDS
- 12.1 Document Control
- 12.2 Quality Records

ELEMENTS OF A BIQ PLAN

Based on these, and other quality plans, a BIQ plan template was developed (Appendix A). Additional elements include BIM, to insure BIQ is achieved prior to start of construction, and preconstruction planning, integral to BIQ.

1. INTRODUCTION AND PURPOSE

2. QUALITY POLICY
- 2.1 Quality Policy Objective
- 2.2 Quality Policy Dissemination
- 2.3 Responsibilities for Quality
- 2.4 Management Review
- 2.5 Training
- 2.6 Distribution
- 2.7 Revisions and Updates

3. DELEGATION OF WORK AND ORGANIZATION
- 3.1 Project Manager
- 3.2 QA/QC Manager (Main Office)
- 3.3 QC / Designate (Site Representative)
- 3.4 Production Supervision

4. QUALITY SYSTEM
- 4.1 Quality System Defined
- 4.2 Quality System Objectives
- 4.3 How Quality Problems Occur
- 4.4 Quality System Processes

5. CONTRACT DOCUMENT REVIEW
- 5.1 Process Scope and Objectives
- 5.2 Document Review Process

6. DOCUMENT CONTROL
- 6.1 Process Scope and Objectives
- 6.2 Quality Records
- 6.2 Document Management System

7. DESIGN MANAGEMENT

7.1 Process Scope and Objectives
7.2 Design Quality Defined
7.3 Responsibility for Design Quality
7.4 Client Need Identification
7.5 Codes & Standards Review
7.6 Design Criteria Definition
7.7 Constructability and Value Analysis
7.8 Design Review Procedures
7.9 Design Change and Modification Procedures
7.10 Building Information Model

8. PROCUREMENT AND EXPEDITING

8.1 Process Scope and Objectives
8.2 Receiving Inspection
8.3 Handling, Storage, Packaging, Preservation and Delivery
8.4 Inspections and Testing
8.5 Suppliers and Subcontractors
8.6 Requests for Quotation
8.7 Purchasing Policies and Procedures
8.8 Submittals
8.9 Owner-Furnished Materials and Equipment
8.10 Identification and Traceability

9. TOOL AND EQUIPMENT MAINTENANCE, CALIBRATION, AND TESTING

9.1 Process Scope and Objectives
9.2 Selection of Tools and Equipment
9.3 Transportation and Storage of Tools and Equipment
9.4 Calibration and Testing of Tools and Equipment
9.5 Repair of Tools & Equipment
9.6 Operating Instructions and Procedures
9.7 Operator Training and Certification

10. MATERIALS & INSTALLED EQUIPMENT MANAGEMENT

10.1 Process Scope and Objectives
10.2 Receiving and Inspection
10.3 Storage and Protection
10.4 Inventory Control Procedures
10.5 Material and Equipment Documentation
10.6 Installation Forms and Standards
10.7 Site Security

11. CONSTRUCTION MANAGEMENT

11.1 Process Scope and Objectives
11.2 Field Quality Defined
11.3 Responsibility for Field Quality
11.4 Organization for Field Quality
11.5 Work Force Qualifications and Training
11.6 Interface with Other Project Participants
11.7 Construction Means and Methods
11.8 Project Planning and Scheduling
11.9 Activity Preplanning
11.10 Pre-Fabrication
11.11 Communications Management
11.12 Safety & Accident Prevention
11.13 As-Built Construction Documents

12. INSPECTION, TESTING, & STARTUP

12.1 Process Scope and Objectives
12.2 Verifying Contract Compliance
12.3 Correction of Nonconforming Work
12.4 Startup and Testing Procedures
12.5 Inspection and Test Records
12.6 Warranties and Guarantees
12.7 Special Processes

LEAN CONCEPTS

LEAN MANUFACTURING AND PRODUCTION

Although traditional manufacturing doctrine espouses incompatibility between high levels of quality and high levels of productivity, the results of one study (MacDuffie 1992) demonstrated otherwise. This study of auto plant performance found a surprising number of plants that achieved both better than average productivity and quality performance. Furthermore, the study identified a small group of "world-class" plants that simultaneously achieved both very high levels of productivity and quality.

At the time of the study (1990), the simultaneous achievement of better than average quality and productivity occurred in six American, one European, and three "New Entrant" plants. However, the world-class performance zone contained only Japanese plants -- four in Japan and two in North America. The researchers also noted that, for the majority of the plants in their sample, quality levels and productivity levels were closely linked. In other words, there was a strong correlation between above average quality and above average productivity, and a similar correlation between below average quality and below average productivity. The authors concluded that the auto plants with lean production systems had dramatically better productivity (fewer hours per car) and quality (fewer defects per car) than mass production plants (MacDuffie 1992).

LEAN CONSTRUCTION

Lean Construction has been inspired by lean manufacturing and lean production principles and also by other paradigms. TQM, SPC, six-sigma, have all found their way into Lean Construction. The Lean Construction Institute (2013) defines lean construction as "a production management-based approach to project delivery – a new way to design and build capital facilities. Lean Construction extends from the objectives of a lean production system – maximize value and minimize waste – to specific techniques and applies them in a new project delivery process". Ballard (2008) described how the Lean Project Delivery System emerged in 2000 from theoretical and practical investigations.

Chen (2007) described two major contributions concerning lean construction:

- *Koskela's (2000, 1992) Transformation–Flow–Value theory that construction is a series of value-adding and non-value-adding activities, and*
- *Ballard's (1993) Last Planner construction process employing a master schedule and 5–8 week look-ahead plan*

Lean construction has been defined as a "way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value (Koskela 2002)." Bertelsen (2004) describes lean construction as the adaptation and implementation of the Japanese manufacturing principles within the construction process. Koskela (2000) added that lean construction maximizes the value to the client and minimizes waste. Ohno's seven wastes (1988) include: 1. Overproduction, 2. Motion waste of workers, 3. Process Waste, 4. Transportation waste, 5. Inventory/Staging of excess (buffer) inventory, 6. Idle time of workers, and 7. Rework of defects. Chahal (2007) states that "quality should be built into the project, and it cannot be injected in it."

A BIQ process instills a lean culture and embraces many of the elements of lean construction, including waste minimization, value to the client, and built-in quality. A comparison between a Lean Construction approach to quality and that espoused by the Project Management Institute (PMI) is shown in **Table 6.**

Table 6: Comparison between Lean and PMI

LEAN APPROACH	PMI APPROACH	REFERENCE
A successful project involves interaction between project and production management	Projects are managed at a macro level	Abdelhamid, 2008
Emphasizes continuous improvement in the process, workflow, and product	Little attention is paid to continuous improvement	Howell, 1999
Optimization efforts focus on making workflow reliable	Focuses upon improving productivity of each activity	Ballard, 2008
Tries to mitigate variation in every aspect – including product quality and rate of work – and manages the remaining variation	Variation mitigation and management are not considered	Ballard, 2008
Seeks to remove the sources of waste in the design/production processes to promote better and more reliable workflow	Guided by the time/cost/quality trade-off paradigm	Abdelhamid, 2013
Manages the interaction between activities and combined effects of dependence and variation	Interactions between activities are not considered	Howell, 1999
Structured and managed as a value generating process, with value defined as satisfying customer requirements	Less cost as value	Howell, 1999
Downstream stakeholders are involved in front end planning and design through cross functional teams	Not considered	Ballard, 2000
Project control has the job of execution	Control relies on variance detection after-the-fact	Ballard, 2000
Pull techniques govern the flow of information and materials, from upstream to downstream	Push techniques govern the release of information and materials.	Ballard, 2000
Capacity and inventory are adjusted to absorb variation	Doesn't consider adjustments	Ballard, 2000
Decision making is distributed in design production control systems	Decision making is centered to one manager	Ballard, 2000
Tries to increase transparency between the stakeholders, mangers and laborers, to know the impact of their work on the whole project	Doesn't consider transparency in its methods	Howell, 1994
A buffer of sound assignments is maintained for each crew or production unit	Doesn't consider a backlog for crews	Ballard, 2000
Commercial contracts give incentives to suppliers for reliable workflow and optimization	Doesn't have such a policy	Howell, 1994
Production system design resists the tendency toward local sub optimization	Persists on optimizing each activity	Ballard, 2000

AGILE PROJECT MANAGEMENT AND CONSTRUCTION

Agile project management is an iterative method of determining requirements for engineering and information technology development projects in a highly flexible and interactive manner. Lean and agile paradigms, though distinctly different, can be combined within successfully designed and operated supply chains (Mason-Jones 2000). Naylor (1999) defined this legality as:

> ***"...the combination of the lean and agile paradigm within a total supply chain strategy by positioning the decoupling point so as best to suit the need for responding to a volatile demand downstream yet providing level scheduling upstream from the decoupling point."***

Differentiated from lean production, agile manufacturing focuses on how to respond to constant changes or adapt proficiently in an unpredictable environment (Dove 2001; Sanchez 2001). This can only be accomplished through well-established and maintained relationships between the customer, manufacturer, and suppliers as well as a win-win system of cooperation within the manufacturing organization as emphasized in Deming's 14 principles (Deming 1982). In particular, in an agile manufacturing system, the interface between the designer and manufacturer should be well coordinated through efficient communication. The APM approach, based on the principle of human interaction management, is highly dependent on human collaboration. Working practices of APM focus on frequent, sustainable iterative deliveries by multi-functional, intercommunicative teams.

Compared with a conventional structured sequential PMI project management approach (Royce 1970), agile project management reportedly delivered defect rate improvements of 61% in two case studies (Bowers 2002). In another study based upon an online survey, 83% of 131 companies reported better or significantly better quality (Shine 2003). The reasons for the improvements in both defect rates and perceived quality are not fully understood. However, it is probable that defects are caught and corrected much earlier due to the nature of agile project management teams, work structures, and feedback mechanisms. Agile project management also concentrates on evolving customer perceptions, rather than conformance to an early plan. A comparison between lean and agile production (Court 2006) is shown in **Table 7**.

Table 7: Comparison between Lean and Agile Production (adapted from Court 2006)

FACTORY	SUPPLY CHAIN	PRODUCT TYPE
Efficient (lean)	*Efficient (lean)*	*Responsive (agile)*
Efficient (lean)	*Responsive (agile)*	*Responsive (agile)*
Commodity items with predictable demands	*Mass-customized items*	*Innovative products with unpredictable demand*

A BIQ PROCESS

Taiichi Ohno originated and first applied the BIQ concept while at Toyota. The Toyota Production System (TPS) was a task force headed by Ohno that looked for ways to meet productivity challenges Toyota faced when the company first entered the automotive manufacturing industry in the mid-1940s. One outcome of the task force was the concept of in-process built-in quality control. (Ohno 1988)

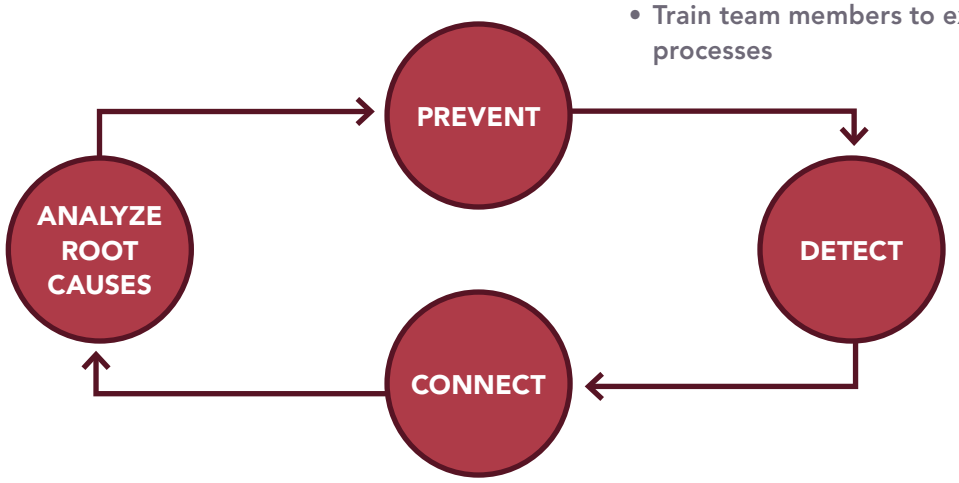
A BIQ cycle is shown in **Figure 3**. The process (Lichtig 2011A) is based on the following assumptions:

- *Simplifying production and assembly will enable cost-effective quality.*
- *Eliminating product- and process-variability will make production-to-expectations easier.*
- *The people doing the work are in the best position to control quality.*
- *Each performer must treat the next process as a customer; including both internal (contractors) as well as external (stakeholders, including the owner).*
- *Quality depends upon assuring that craft workers understand each internal customer's expectations.*
- *First run studies and mock-ups should be used to physically confirm that what is "clear" is also "understood".*
- *By focusing on building quality in (to a product), productivity improvement will follow.*

Figure 3: Built-In Quality Cycle (Lichtig 2011B)

- Use 5 Why's
- Act on root causes of defects

- Use poka-yoke devices that prevent or reduce defects.
- Design and test processes for capability to meet criteria
- Train team members to execute capable processes

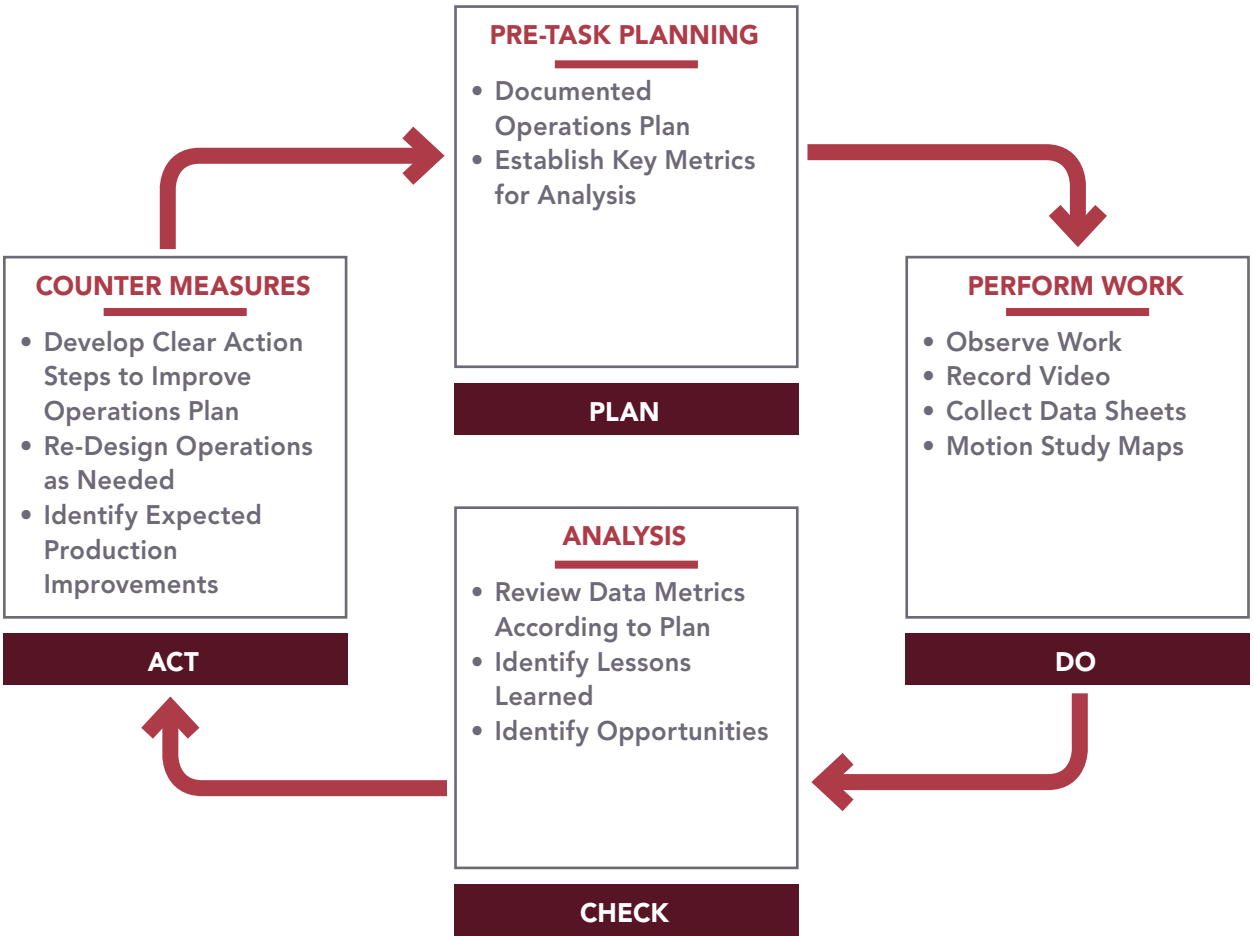


- Stop the line rather than handoff defective work
- Provide help immediately to find and correct defects and ripple effects

- Detect defects at the point of origin; self inspection, small batches, use poka-yoked devices that automatically detect defects
- Check conditions of satisfaction at handoffs

A Game Tape Process Map (Figure 4) expands upon this cycle and correlates the process steps into a chronological sequence of construction activities. This includes pre-task planning, performing the work, analyzing the work outcome and comparing it to the planned work outcome, and implementing counter measures to improve the work plan.

Figure 4: Game Tape Process Map (Lichtig 2011A)



Pre-task planning involves providing information to workers as well as defining expectations of stakeholders prior to preforming the work. **Figure 5** highlights the expectations of an electrical systems trade partner in accepting and delivering work. This document could form the basis for discussion between the electrical systems trade partner and the BIQ process team. Note that the predecessor trade partner is expected to:

1. "remove bottleneck and constraints", and
2. complete "everything that will support trade partner work"

Figure 5: Example of Trade Partner Expectations in Accepting and Delivering Work

INFORMATION TO WORKERS:

- Electrical Contractor (EC) will have a full-time person who will review project documents for details and constraints.
- Shop drawings are created to detail requirements.
- Consumables are set-up in gang boxes.
- All gang boxes for the same process are set-up identically.
- Only specified and approved materials ate delivered to the job site.
- All information needed by workers is detailed on shop drawings.
- In many cases, materials are pre-fabricated to allow faster, more straight-forward assembly in the filed.
- Work tasks are assigned to groups of workers.
- Each work group has a task and the document associated with that task.
- Shop drawings are available in a central location in each group-specific work area.
- EC watchwords:
  - **Material>Tools>Information>Access**

EXPECTATIONS OF EC FOR PREDECESSOR TRADE PARTNERS BEFORE STARTING WORK:

- Predecessor trade partner uses pre-construction planning to remove bottlenecks and constraints.
- Everything that will support EC work is completed prior to EC start.

EXPECTATIONS OF SUCCESSOR TRADE PARTNERS:

- Startup planning by trade partners for power to systems and equipment
  - System Type
  - Equipment Type
  - Which Equipment
  - Scheduling priorities

POTENTIAL POSTERS:

- Detailed corner and wall intersections
  - Identify each type
  - Map locations of different types
- Challenge to other trade partners:
  - Can they reliably identify that they can build everything in their scope on the drawing
  - Do they have a plan for installing everything in their scope on the drawings

EXPECTATIONS FOR ACCEPTING AND DELIVERING WORK

The results of a BIQ process can provide input into QA/QC inspection. A schematic of a quality process overlays the project BIQ process with a Quality Assurance /Quality Control approach. (Customer) Expectations, (planning of) Design Operations, and Performing Work are core to the BIQ quality process. If the inspection results meet the quality requirements (green light) the work is accepted. If not (red light), the work is rejected.

The BIQ process (Lichtig 2011B) shown in Figure 6 consists of:

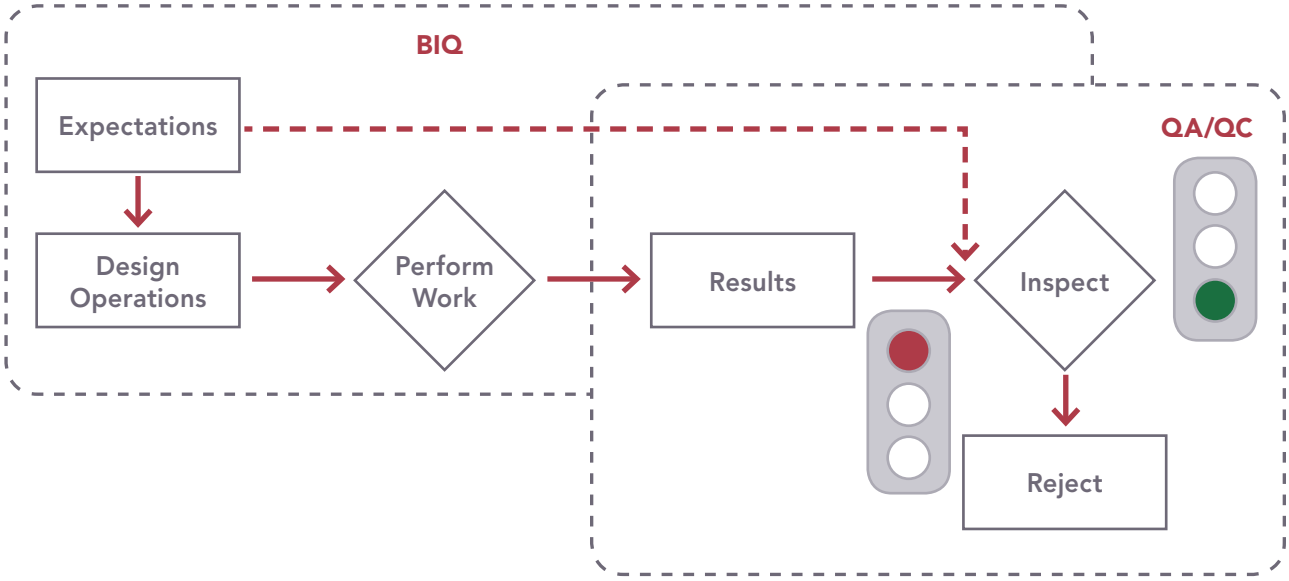
1. ***IDENTIFYING CUSTOMER EXPECTATIONS (EXPECTATIONS)*** – develop and confirm a mutual understanding of the work from all customers; identify contractor work that will be inspected.

2. ***CONVERTING EXPECTATIONS INTO REQUIREMENTS (DESIGN OPERATIONS)*** – develop an operations plan for fabrication and installation; address past quality problems using error-proofing strategies/ countermeasures.

3. ***FABRICATING AND CONSTRUCTING THE WORK (PERFORM WORK)*** – develop a plan to train workers on design operations and assure that they have everything necessary prior to beginning the work.

4. ***INSPECTING THE WORK FOR CONFORMANCE TO REQUIREMENTS (RESULTS)*** – develop and implement an audit/assessment program to ensure that a process was followed and confirm that the product conforms to expectations.

Figure 6: Schematic of the Quality Process (Lichtig 2011B)



NEED FOR BIQ

The need for BIQ has been cited within the literature for many years. Inque (1984, pg. 137) advocates that equipment supplied to the construction industry should be "designed and constructed with quality built-in." Feng (2008) notes that according to the AIA, the integrated project delivery approach promotes the need for built-in quality.

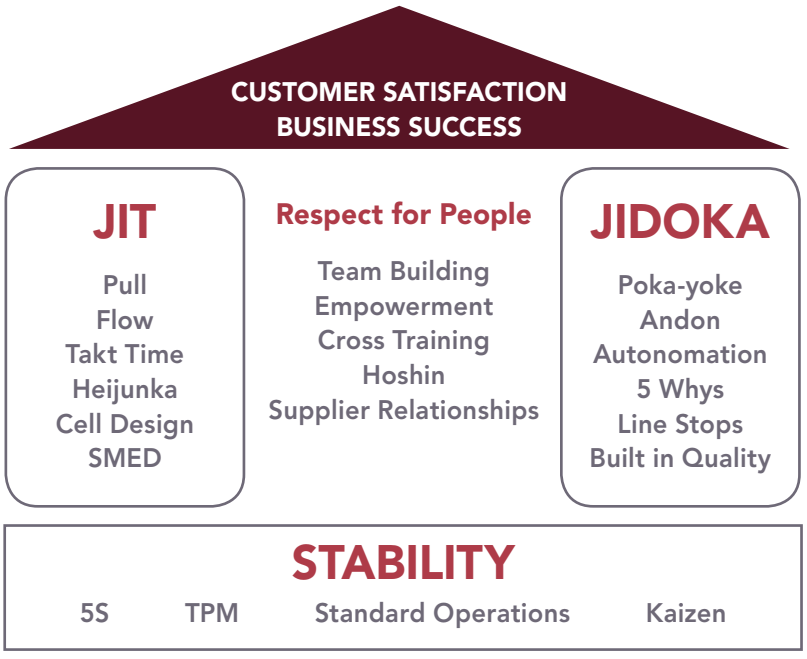
Orr (2005) encourages the use of a clearly understood process when a quality abnormality is identified to inspire confidence that the work is valued and that leaders care that it is managed effectively. This escalation process is

core to jidoka (autonomation, or automation with a human touch), one of the two pillars of the Toyota Production System. The Toyota Production System is frequently drawn as a house with a triangular roof, a rectangular foundation and two rectangular columns between the foundation and roof. The two columns represent Just-in-Time and Jidoka (Miller 2013), with built-in quality listed as a key component of Jidoka **(Figure 7).**

Autonomation prevents the production of defective products, eliminates overproduction, and focuses attention on understanding a problem, then ensuring that it never recurs (Toyota Production System 2013). It is a quality control process that applies the following four principles:

- ***1.*** *Detect an abnormality or problem*
- ***2.*** *Stop production*
- ***3.*** *Fix or correct the problem / condition*
- ***4.*** *Investigate the root cause and install a countermeasure*

Figure 7: Toyota Production System House (Lean Manufacturing Tools, 2013)



Lichtig (2005) cites that the goal of a built-in quality plan is to cause the integrated project delivery team to openly develop ways to ensure that the expectations of the firms and individuals who will be responsible for accepting the work are communicated to the workers who will be executing the work.

There is a difference between "errors", which are inevitable, and "defects", which result when an error reaches a customer. Defects arise because there is a cause and effect relationship between errors and defects. The goal of poka-yoke is to stop errors from becoming defects. An example of poka-yoke applied to a BIQ process is shown in **Figure 8**, where the color-coded backing layout also proved to be a good mistake proofing (poka-yoke) mechanism. The photo clearly shows a conflict with the in-wall electrical box installed in the spray painted backing layout. Had the layout been in marker rather than bright orange, it might not have been so obvious. The high visibility of the orange backing layout resulted in the in-wall electrical box being relocated. Poka-yoke prevented the installation error of the in-wall electrical box from becoming a defect.

Zero quality control is the ideal production system and this requires both Poka-Yoke and source inspections to provide continuous improvement. By implementing source inspections, errors are examined before they become defects, and the system is either stopped for correction or the error condition is automatically adjusted to prevent the error from becoming a defect.

Figure 8: BIQ Poka-Yoke Example (the Boldt Company)

A BIQ program implements a new quality process into design and construction operations. BIQ is a proposed innovation that reflects a change in strategy with achievable objectives relative to how quality is managed in construction today. The BIQ process (Prevent-Detect-Correct-Analyze [PDCA]) is an adaptation of the Plan-Do-Check-Act (PDCA) Cycle (Deming 1950). This BIQ PDCA process utilizes Poka-Yoke as a lean manufacturing process mechanism to help avoid mistakes. This figure shows a BIQ process that differs from a conventional QA/QC approach, in that contractors and their customers, both internal as well as external, strive toward an integrated approach.

Orr (2005) encourages the use of a clearly understood process when a quality abnormality is identified. Although Orr does not define what constitutes an abnormality, the context suggests that it is a deviation from a typical or usual outcome. One of the goals of a BIQ process is standardizing operations, eliminating deviations to process outcomes. As previously discussed, one of the core characteristics of quality is conformance to requirements.

The built-in quality plan goals of meeting customer expectations, assuring that craft workers have everything needed to conduct their work, simplifying production, and eliminating variability, align with the TPS principals of customer satisfaction, JIT, Jidoka, and standardization.

The cited validation case study illustrates the need for BIQ. This project manager noted that the company is seeing more reference to quality program requirements listed in specifications and requested on the bid forms. However, the electrical systems contractor on this project did not anticipate the total costs for quality and did not have an established BIQ program, thus impacting both schedule and budget.

KEY BIQ METRICS

Several possible metrics could measure the success of a BIQ program. Per Oakland (2006), a good starting point for deciding what to measure includes looking at:

- *Key goals of senior management*
- *Problems that need to be solved*
- *Opportunities that may be taken advantage of*
- *Key ingredients that influence customer satisfaction*

Oakland (2006) also cites the need to measure progress in five areas:

1. ***Effectiveness***
2. ***Efficiency***
3. ***Productivity***
4. ***Quality and safety***
5. ***Impact.***

With regard to impact, passing an inspection the first time will eliminate the need for a second inspection and should result in less rework. A cumulative inspection success rate quantitatively defines the frequency of passing multiple inspections. Classification categories could include:

	ISSUE	EXAMPLE
1	Map/Inspection; process issue	No sign-off prior to the inspection; targeted inspection and inspection report are not aligned; or inspection request submitted after deadline
2	Work incomplete; didn't finish scope	Lighting fixtures not connected to a source of power or control
3	Work incomplete; corrections not complete	Corrections indicated on last failed attempt were not performed
4	Work installed incorrectly	The completed work was not in agreement with the drawings or specifications
5	Work missing components	Electrical cable missing support straps, electrical boxes not grounded
6	Work not acceptable	The inspection area is inaccessible (e.g., drywall is covering electrical raceway)
7	Detail/Design issue	A detail is unclear, the design is insufficient/ incomplete, or the design is subject to interpretation

BIQ process for each contractor work category involves:

- *Developing and confirming a mutual understanding of the work expectations from all external and internal customers*
- *Preparing a specific operations plan for the fabrication and installation of each piece of work*
- *Training workers on each of these operations and assuring they have everything necessary prior to beginning their work*
- *Implementing an audit assessment program that allows project participants to assess that the process was followed and the product conforms to expectations*

The process steps include:

- *BIQ Introduction Meeting*
- *Prioritize BIQ Development*
- *Standardize Work Process Mapping*
- *Standard Work Process Integration*
- *Assemble Field Book*
- *Review Field Book and Confirm Training Implementation Plan*
- *Superintendent and Inspector of Record Integration*
- *Employee Training*
- *BIQ in Use, Checked, and Improved*

Within a PDCA cycle, all but the last step could be regarded as Planning; the last step encompasses Doing, Checking, and Acting. The Planning steps include discussion and interaction between trade partners, inspector of record, and BIQ team, superintendent, and engineers. The DCA steps include distributing the BIQ field book to craftsmen, addressing opportunities for continuous improvement, and process improvement procedures.

BIQ ALIGNMENT

Deming, Juran, and Feigenbaum were early quality pioneers and contemporaries. Some of their main contributions and areas where their quality philosophies are in agreement **(Figure 9)** include:

- *All believe in continuous process improvement*
- *All believe that senior management are responsible for the majority of quality problems*
- *All support worker education and training*
- *All agree that statistical process control should be used*

Figure 9: Comparison of Deming, Juran, and Feigenbaum Quality Philosophies

AMERICANS IN 1950'S JAPAN

Deming's fourteen-point quality plan:

1. Create constancy of purpose
2. Adopt the new philosophy
3. Cease mass inspections
4. Stop awarding business based on price
5. Find problems
6. Institute methods or training
7. Institute methods of worker supervision
8. Drive out fear
9. Break down barriers between departments
10. Eliminate numerical goals
11. Eliminate numerical quotas
12. Remove barriers between workers and pride of workmanship
13. Institute a vigorous program of education and retraining
14. Create a management structure that will advocate these points

Juran's ten steps to quality improvement:

1. Build awareness of the need to improve a process
2. Set goals for improvement
3. Organize/reorganize to reach these goals
4. Provide training
5. Carry out projects to solve problems
6. Report progress
7. Give recognition
8. Communicate results
9. Keep score of improvements
10. Maintain momentum

Feigenbaum's three steps to quality:

1. Quality leadership
2. Modern quality technology
3. Organizational commitment

CENTRAL TOPICS:

- Continuous Improvement Approach
- Management Involvement
- Training of Workers
- Statistical Process Control

FOCUS UPON PEOPLE AND PROCESS

Points of departure include:

- *Deming focuses on continuous improvement through a cultural change within an organization; Feigenbaum proposes integrating development, maintenance, and improvement within an organization; while Juran recommends a series of small changes throughout the entire supply chain.*
- *Deming advocates worker participation in decision making. Juran recommends a team and quality circle approach.*

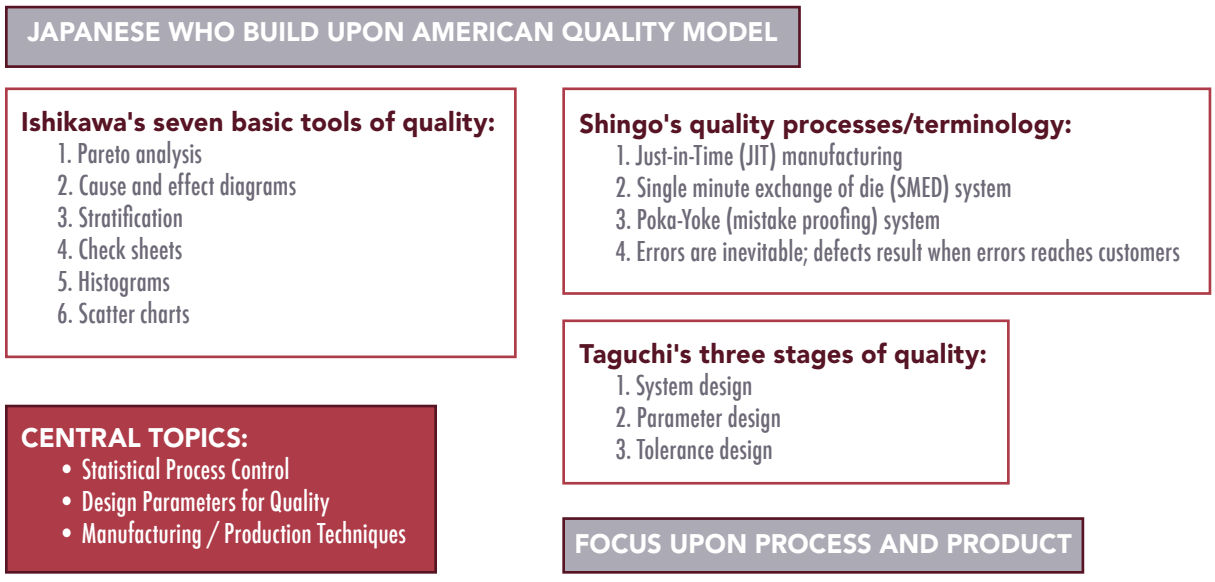
Gap analysis:

Although all acknowledge the need for customer satisfaction, none specifically addresses customers within their multi-point quality plans or improvement process.

Ishkawa, Taguchi, and Shingo were post WWII Japanese who built upon the foundations of early American pioneers. All three focused upon the quality process and product design **(Figure 10)**, but empathized different aspects:

- *Ishikawa advocates graphical approaches to quality problems, quality circles, and providing quality to internal customers.*
- *Taguchi emphasizes off-line quality control, designing robust product design and processes.*
- *Shingo focuses on reducing process set-up times and use of Poka-yoke mistake proofing.*

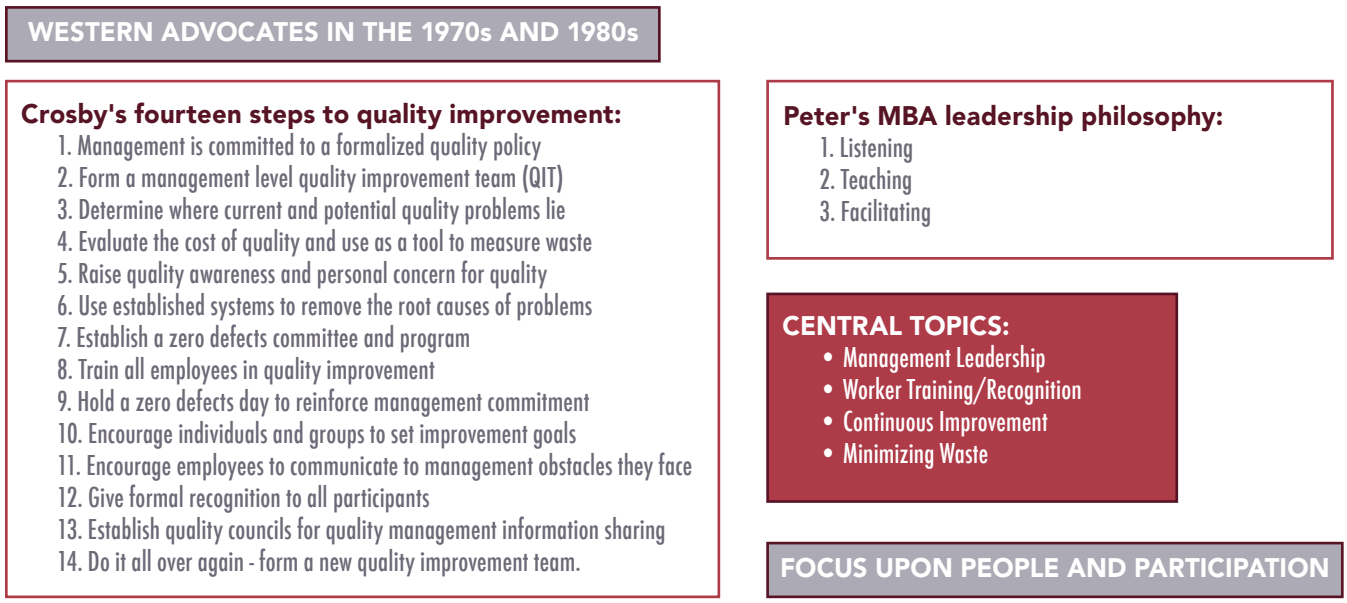
Figure 10: Comparison of Ishikawa, Taguchi, and Shingo Quality Philosophies



Crosby and Peters were contemporaries in the 1980s who built their quality philosophies based on actively engaging workers. Both emphasized that upper management also must be leaders and have a passionate commitment to quality. Areas where their quality philosophies are in agreement **(Figure 11)** include:

1. **"LISTENING"** – Encourage employees to communicate to management the obstacles they face
2. **"TEACHING"** – Train all employees in quality improvement
3. **"FACILITATING"** –
   - a. Raise quality awareness and personal concern for quality
   - b. Establish a zero defects committee and program, hold a zero defects day
   - c. Encourage individuals and groups to set improvement goals
   - d. Give formal recognition to all participants
   - e. Establish quality councils for quality management information sharing

Figure 11: Comparison of Crosby and Peters Quality Philosophies



There are several differences between a Lean Construction approach to quality and that espoused by the Project Management Institute (PMI). These differences include:

- *PMI stresses the need for a rigorous "command and control" approach (e.g., projects are managed at a macro level, decision making is centered to one manager)*
- *PMI focuses on one level (e.g., focuses on improving productivity of each activity, interactions between activities are not considered, persists on optimizing each activity)*
- *PMI does not readily respond to variance (e.g., variation mitigation and management are not considered, control relies on variance detection after-the-fact)*

A comparison of the thirteen non-conformance categories of Abdul-Rahman's (1996) with the eight categories of rework from Fayek (2004) and Feng (2009) from Section 2.3 indicates a correlation with the topics of people, communication, design and construction process, suppliers and products, and planning **(Table 8)**. This aligns with the central topics of the early quality pioneers.

Table 8: Comparison between Abdul-Rahman's (1996) Fayek (2004) and Feng (2009)

ABDUL-RAHMAN'S (1996)	FAYEK (2004)	FENG (2009)
Personnel	Human Resource Capability	
Communication	Leadership and Communication	
Design-related, buildability	Engineering and Reviews	
Construction-related, Coordination and planning	Construction Planning and Scheduling	
Material, Plant and Equipment, Supplier	Material and Equipment Supply	
Coordination and planning		Planning, Programming, and Budgeting
Design-related, buildability		Design Review and Permitting
Design-related		Design Planning, and Scheduling

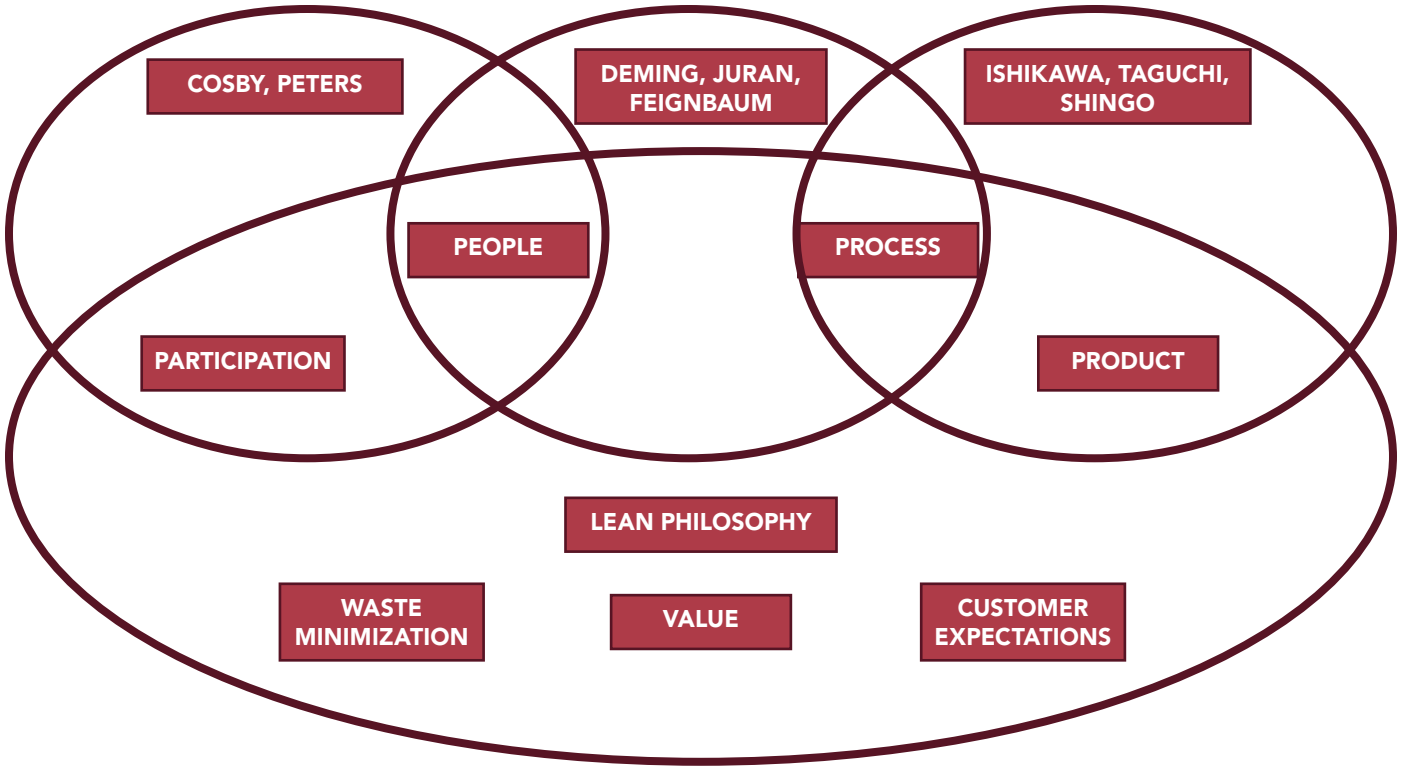
Both Buchert (1984) and Chahal (2007) agree that quality cannot be achieved by inspecting the final product and both lament the decrease in the recent quality of construction, even though there is a 23-year difference in their time perspectives. They attribute this decline to a lack of quality consciousness amongst all the people associated with the construction industry. Within this context, "lack of quality consciousness" refers to the absence of a quality process. As espoused by all of the quality pioneers, this would include no regard for a continuous improvement philosophy, senior management support, worker education and training, and statistical process control. Furthermore, based upon a lean philosophy, this approach does not strive for waste minimization or value to the customer.

Bubshalt's (1999) study of construction contractors' compliance with ISO 9000 identified that the majority (>60%) of contractors use inspection and testing, and control nonconformance products. However, very few (<20%) were concerned with design control, training, or statistical process techniques. This is in direct opposition to the quality philosophies and central topics of Ishikawa, Taguchi, and Shingo (Figure 20). Bubshalt's study also confirms the findings of Buchert (1984) and Chahal (2007). Furthermore, Coffey (2011) directly ties adherence to ISO 9000 with KPIs, making a business case for compliance.

The view of quality has developed significantly over time. The evolution of the quality movement and quality management has continued to progress and build upon earlier work. The work of Deming, Juran, and Feigenbaum focused on people (the importance and responsibility of management, training for workers) and Process (removing dependence on mass inspections, looking for opportunities to improve work process). Ishikawa, Taguchi, and Shingo built upon this earlier work; their collective focus was on Process (graphical analysis tools, process optimization, JIT production, poka-yoke) and Product (robust design, product optimization). Crosby and Peters reinforced the earlier emphasis on people, but with a strong focus on the role of management. Their emphasis was on People (listening, teaching, training, communication, recognition) and [Management] Participation (leadership, and manager- quality commitment, QIT, waste measurement, zero defects committee/program/day, facilitating).

The current state of the art in quality today is toward a more collaborative design and construction environment with a Lean philosophy. Advances in Building Information Modeling, integrated project delivery, relational contracting, integrated forms of agreement, material supplier alliances, and subcontractors as trade partners are all based upon collaboration. Lean embodies a collaborative environment; specifically advocating waste minimization, value to customers, and meeting client expectations while at the same time maintaining the earlier philosophies based on People, Process, Product, and Participation. A Venn diagram representing of all these quality philosophies and progression is shown in **Figure 12**.

Figure 12: Quality Philosophies and Progression of the Quality Movement



A BIQ PROCESS

Juran (1999) states that there are two levels of product features; "fitness for use" and "conformance to specifications." A flow diagram **(Figure 13)** illustrates Juran's decision process overlaid with BIQ quality process steps. This flow diagram includes requirements, results (of work), inspection, and pass/fail; but lacks critical BIQ steps for establishing customer expectations and design operations.

Figure 13: Decision Flow Diagram on Conformance and Fitness of Use (Adapted from Juran (1999)

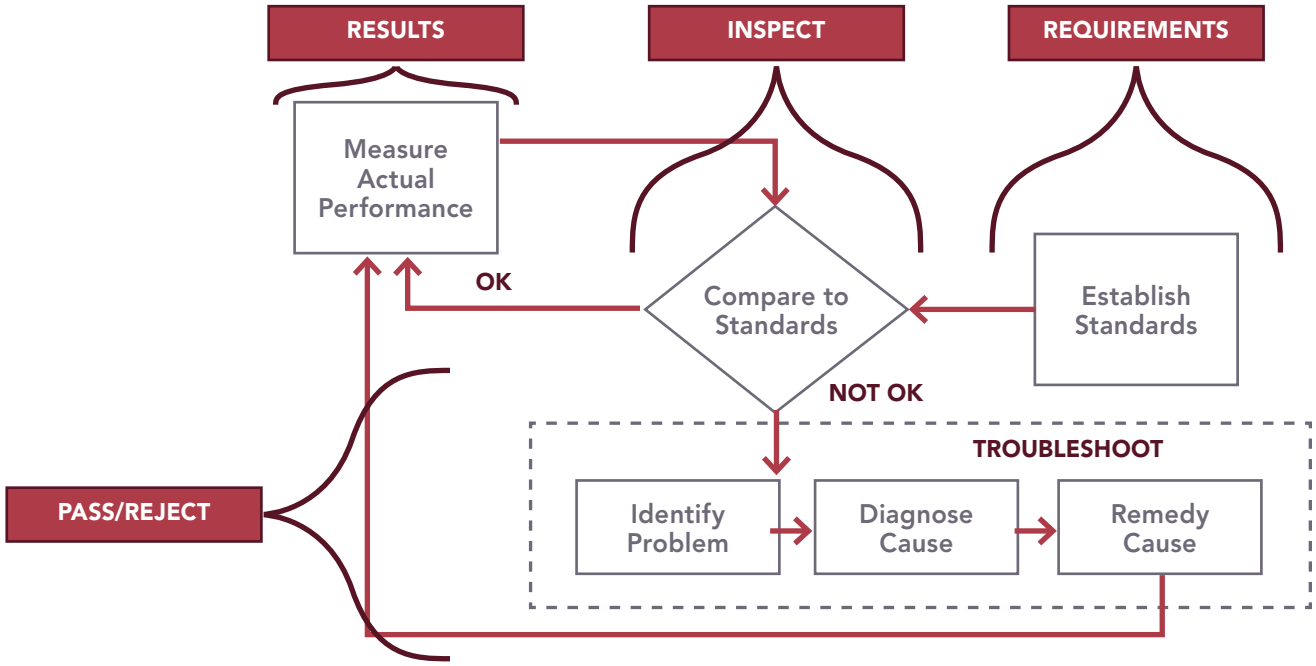
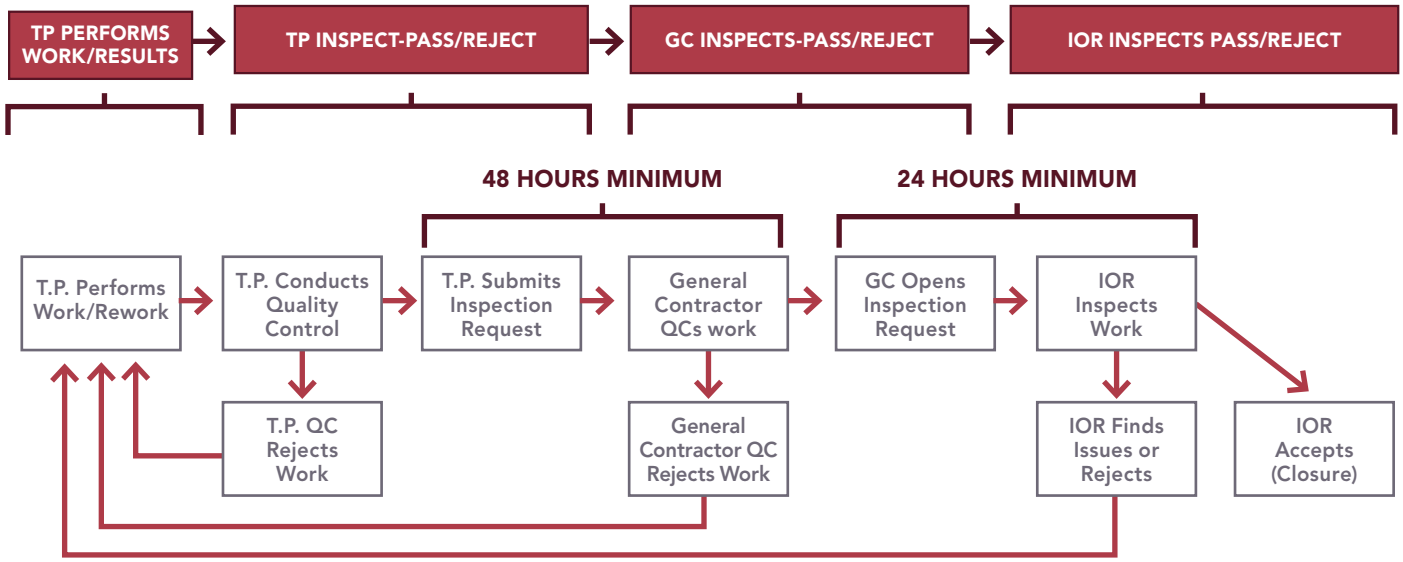


Figure 14 is a quality flow diagram from potential case study 3. The process flow consists of the performance of work by a project trade partner followed by a series of repetitive inspection steps by the trade partner, general contractor, then inspector. Each of these steps results in the acceptance of work by the next customer downstream until the final product is accepted, or the work is rejected at an intermediate level of inspection followed by rework. All of the back-end QA/QC steps (results, inspect, reject) from Figure 8 are represented, while none of the front-end BIQ process steps (expectations, design operations, performing the work) are included. The focus is retroactive; validating work that has been performed rather than proactively establishing customer expectations, then designing operations and performing the work to meet those expectations.

Furthermore, this process is very time intensive. Due to the iterative inspection process, 48 hours are needed from the time the trade partner submits an inspection request until the general contractor performs a QC inspection. An additional 24 hours are required from the time the general contractor accepts the work (and opens an inspection request) until the IOR is available to inspect the work. Therefore, assuming there is no rework, a minimum of 72 hours is required from the time that the trade partner submits an inspection request until that work is accepted by the IOR.

Figure 14: HMO Medical Center Project Quality Validation (Inspection) Process



BIQ EXAMPLES

Refer to the Appendix for BIQ examples:

- ***Appendix A:*** *BIQ Plan Template (derived from Glavinich 1995)*
- ***Appendix B:*** *References to NECA Installation Standards*
- ***Appendix C:*** *Sample Record and Checklist Forms*
- ***Appendix D:*** *BIQ Narrative Examples for Work Activities*
- ***Appendix E:*** *Examples of a BIQ Approach to Technical Specifications*

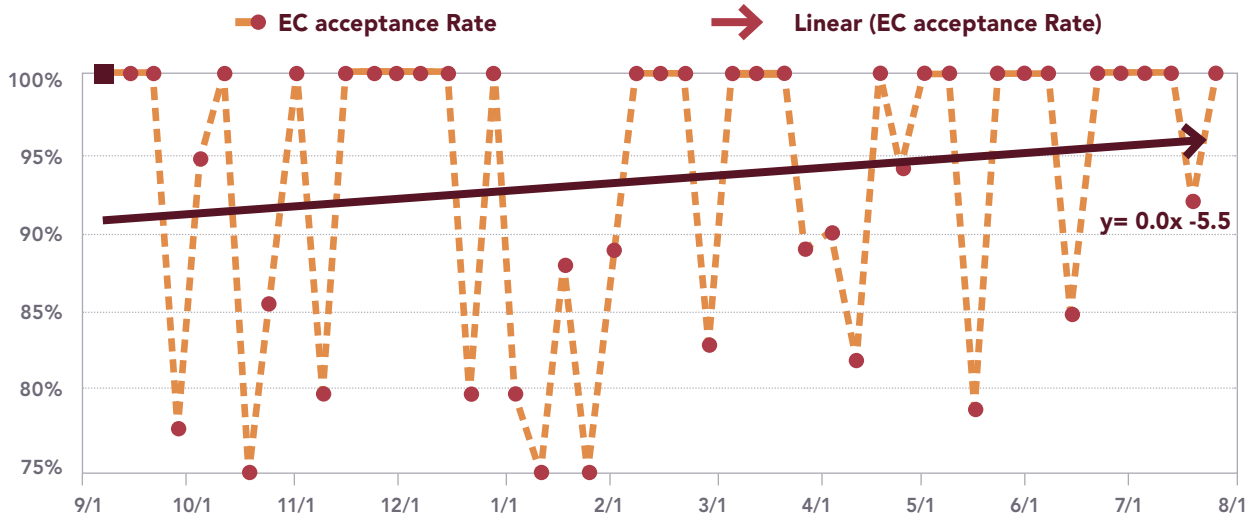
RESULTS OF A BIQ PROCESS

A project database was maintained of all inspections conducted over approximately one year for the subject BIQ project. Data were extracted from the database and weekly reports were produced for all inspections **(Table 9)**. During this time, the EC success rates varied from a low of 75% to a high of 100%, with a weighted average of 93%. EC weekly inspection acceptance rates were plotted during the same time period **(Figure 15)** with a linear trend line, indicating an improvement in the inspection success rate.

Table 9: Weekly Summary of all EC Inspections

DATE	EC ACCEPTANCE RATE	DATE	EC ACCEPTANCE RATE	DATE	EC ACCEPTANCE RATE	DATE	EC ACCEPTANCE RATE
9/7	100%	11/30	100%	2/22	100%	5/17	79%
9/14	100%	12/7	100%	3/1	83%	5/24	100%
9/21	100%	12/14	100%	3/8	100%	5/31	100%
9/28	78%	12/22	80%	3/15	100%	6/7	100%
10/5	95%	12/29	100%	3/22	100%	6/14	85%
10/12	100%	1/4	80%	3/29	89%	6/21	100%
10/19	75%	1/11	75%	4/5	90%	6/28	100%
10/26	86%	1/18	88%	4/12	82%	7/5	100%
11/2	100%	1/25	75%	4/19	100%	7/12	100%
11/9	80%	2/1	89%	4/26	94%	7/19	92%
11/16	100%	2/8	100%	5/3	100%	7/26	100%
11/23	100%	2/15	100%	5/10	100%		

Figure 15: EC Weekly Inspection Acceptance Rates with Linear Trend Line



CASE STUDY 1

The electrical systems contractor for case study 1 originally budgeted 1.5% of its total productive hours (222,100) for its quality program, based upon an originally proposed 30-month schedule. This results in an allowance of 3,360 hours. Assuming an hourly rate of $105, this equates to $352,800, or $11,760 per month. This case study project did not have a BIQ program developed and in-use.

After the start of construction, based upon initial inspection results, their projected budget was revised to 4% of the total productive hours (222,100) for QA/QC based upon a revised 40-month schedule. This resulted in an allowance of 8,884 hours. Assuming the same hourly rate of $105, this equates to $932,820, or $23,321 per month. The total allocated cost for quality increased by more than $580,000 and monthly cash flow cost increased by 100% while the total production hours remained constant. The schedule also was extended by 10 months (a 30% time increase).

CASE STUDY 2

Case study 2 had punch list inspections conducted during a two-month time period. During this time discipline, design engineers discovered 55 electrical issues involving several electrical subsystems, including: CCTV, security, fire detection, nurse call, power, lighting, and telecommunication.

Punch list inspections performed by the lighting designer revealed two lighting installation problems. One involved coordinating the lighting design with a California Energy Code Title 24 energy requirement for bi-level switching of lights **(Figure 16).**

Figure 16: Lighting Code Violation

5TH FLOOR INFUSION AREA:

Contractor to ensure that bi-level switching is provided for all 2X2 recessed fluorescent fixtures where necessary to comply with Title 24 energy code requirements.

Another lighting issue **(Figure 17)** relates to improper coordination between the architectural reflected ceiling plan and electrical lighting layout. Note that both lighting problems could have been avoided by using three of the seven design operations previously discussed in the Research Process section:

- *Analyzing mistake proofing processes to assure process quality*
- *Analyzing process checklists*
- *Analyzing visual controls for completeness*

Figure 17: Lighting Discipline Coordination Issue

MAIN LOBBY:

F4 fixtures at lobby reception area to be shifted so that all fixtures align in a regularly spaced grid.

In the case of **Figure 16**, California Energy Code Title 24 requires bi-level (two way) switching in all rooms greater than 100 square feet. The drop-in ceiling tiles indicate that the room is at least 144 sq. ft. [8′ wide (4 tiles x 2′ per tile) by 18′ long (9 tiles x 2′per tile)]. A suitable mistake-proofing process would be highlighting switch gang boxes using colored markers whenever the ceiling grid exceeds 25 tiles. For Figure 17, visual controls (markers or adhesive colored "dots") could have been used to show that the lights were skewed.

Alternately, process checklists could have been incorporated for both cases. A checklist requiring code c ompliance would have discovered the Title 24 code violation for Figure 16. An interdisciplinary checklist between the architectural ceiling plan and the lighting fixture plan would have indicated the coordination problem.

CASE STUDY 3

Case study 3 had inspection data collected during a seven-month time period. The Electrical Contractor had a total of 182 inspections during the time period of review and achieved a total success rate (as defined by the project) of 94%. The project subcontractor analysis is shown in **Table 10.**

Table 10: Electrical Inspection Summary

INSPECTION TYPE	PASSED	REJECTED	CANCELLED	TOTAL	SUCCESS RATE
130-Electrical	7		1	8	100%
425-Electrical Seismic	7		1	8	100%
440-Seismic Equipment	1			1	100%
Anchors	1			1	100%
Dry Pack / Grout	1	1		2	50%
Electrical	108	5	4	117	96%
Equipment Controls	1			1	100%
Equipment Electrical	3			3	100%
Fire Alarm	34	5	1	40	88%
Fire Caulking	1			1	100%
TOTAL	**164**	**11**	**7**	**182**	**94%**

The inspection success rates for the subject project was compared to the case study project 3 rate **(Table 11)**. Interestingly, these two projects use a different interpretation for "Success Rate".

THE SUBJECT PROJECT DEFINES THE SUCCESS RATE AS:

Success Rate = (Approved) / (Total Inspections) rounded to the closest integer.

THE CASE STUDY 3 PROJECT DEFINES THE SUCCESS RATE AS:

Success Rate = (Total Passed) / (Total Passed-IR Rejected) rounded up to the next integer.

These definitions result in different interpretations for their respective success rates. The subject project has a more conservative definition that discounts the success rate for dispensations such as "Approved with Exceptions" and "Cancelled", which tend to lower their success rate. The case study 3 project definition of success rate does not include these other dispensations, which tends to raise their success rate. Furthermore, the subject project rounding approach is inherently more conservative than the case study 3 project approach. These differences are captured within the last two columns of **Table 11**.

When the success rate is calculated on a uniform basis, the subject project success rate is greater than the case study 3 project rate (93% compared to 90%).

Table 11: Comparison of Subject Project versus Case Study 3 Project Success Rates

PROJECT	APPROVED (PASSED)	APPROVED W/ EXCEPTION	RESUBMIT (REJECTED)	CANCELLED	TOTAL	SUCCESS RATE
Subject project	106	2	5	1	114	93%
Case study 3 project	164	Not Tracked	11	7	182	90%

REFERENCES

Abdelhamid, T.S. (2013). "Lean Construction." Michigan State University. <https://www.msu.edu/user/tariq/Learn_Lean.html> (Jan. 6, 2013).

Abdelhamid, T.S., El-Gafy, M., and Salem, O. (2008). "Lean Construction: Fundamentals And Principles." *The American Professional Constructor Journal,* American Institute of Constructors – Fall 2008.

Abdul-Rahman, H., Thompson, P. A., and White, I.L. (1966). " Capturing the cost of non-conformance on construction sites - An Application of the Quality Cost Matrix." *The International Journal of Quality and Reliability Management*, 13. 1, 48-60.

Ahire, S. L. (1997). "Management Science- Total Quality Management interfaces: An integrative framework." *Interfaces* v 27, Nov./Dec. (6) 91-105.

American Society for Quality (ASQ). (2012). < http://asq.org/glossary/q.html> (Dec. 10, 2012).

American Society of Civil Engineers (ASCE) (2000). "Quality in the Constructed Project: A Guide for Owners, Designers, and Constructors." Second edition. *Manual of Practice No. 73*, Reston, VA.

Associated General Contractors of America (1992). "An Introduction to Total Quality Management." *AGC of America*, Washington, D. C.

Ballard, G. (2008). "The lean project delivery system: an update." Lean Construction Journal, 2008, 1-19.

Ballard, H. G. (2000) "The last planner system of production control." PhD Dissertation, School of Civil Engineering, The University of Birmingham.

Ballard, G. (1993). "Lean construction and EPC performance improvement." IGLC-1, *Lean Construction.*

Bertelsen, S. (2004). "Lean construction: where are we and how to proceed." Lean Construction Journal, v 1, October 2004.

Bowers, J., May, J., Melander, E., Baarman, M., and Ayoob, A. (2002). "Tailoring XP for Large System Mission Critical Software Development", Lecture Notes in Computer Science, 2418, (2418/2002), 100-111.

Broh, R. A. (1982). "Managing quality for higher profits." *McGraw Hill*, New York.

Bubshait, A. A., and Al-Atiq, T. H. (1999). "ISO 9000 quality standards in construction." *Journal of Management in Engineering*, Nov./Dec., 41-46.

Chahal, K. S., and Emerson, P. (2007). "Quality control and quality assurance in building design and construction." Journal of the Institution of Engineers (India), Architectural Engineering Division, v 88, Oct., 16-20.

Chan, A. P. C., and Tam, C. M. (2000). "Factors affecting the quality of building projects in Hong Kong." The International Journal of Quality and Reliability Management, 17. 4/5, 423-441.

Chase, R., Aquilano, N., and Jacobs, F. (2001). "Operations Management for Competitive Advantage." Ninth edition. McGraw-Hill, New York.

Chen, Q., Reichard, G., and Beliveau, Y. (2007). "Interface management – a facilitator of lean construction and agile project management." Proceedings IGLC – 15, July 2007, 57-66.

Chung, H.W. (1999). "Understanding Quality Assurance in Construction: A Practical Guide to ISO 9000 for Contractors." *E & FN SPON*, London.

Coffey, V., Willar, D., and Trigunarsyah, B. (2011). "Quality management system and construction performance." *Proceedings of the IEEE ICQR*, 403-407.

Construction Industry Institute (CII) (2010). "Implementing and Improving Quality Management Systems in the Capital Facilities Delivery Industry." *CII Implementation Resource 254-2*, March 2010

Construction Industry Institute (CII) (1989). "Measuring the cost of quality in design and construction." *Bureau of Engineering Research, The University of Texas at Austin*, Publication 10-2, May 1989

Construction Industry Research and Information Association (CIRIA) (1988). "A client's guide to quality assurance in construction (SP55)." January 1988

Crosby, P. (1992). "Quality Is Free: The Art of Making Quality Certain." *McGraw-Hill Companies*

Court, P., Pasquire, C., Gibb, A., and Bower, D. (2006). "Design of a lean and agile construction system for a large and complex mechanical and electrical project." 2006 – IGLC 14 – Santiago, Chile.

Deming, W. E. (1982). "Quality productivity and competitive position." Massachusetts Institute of Technology.

Deming, W. E. (1950). "Lecture to Japanese Management". <http://hclectures.blogspot.com/1970/08/demings-1950-lecture-to-japanese.html> (Dec. 12, 2012)

Dove, R. (2001). "Response Ability: The Language, Structure, and Culture of the Agile Enterprise." *John and Sons, New York.*

Edwards, C. D. (1968). "The meaning of quality." *Quality Progress*, Oct 1968. 36-39.

Fayek, A. R., Dissanayake, M., and Campero, O. (2004) "Developing a standard methodology for measuring and classifying construction field rework." *Canadian Journal of Civil Engineering*, v 31, 1077–1089.

Feigenbaum, A.V. (1991). "Total Quality Control", Third edition. *McGraw-Hill*, New York

Feng, P. P., and Tommelein, I. D. (2009). "Causes of rework in California hospital design and permitting: augmenting an existing taxonomy." *Proceedings of IGLC17: 17th Annual Conference of the International Group for Lean Construction*, 407-416.

Feng, P. P., Tommelein, I. D., and Booth, L. G. (2008). "Modeling the effect of rework timing, case study of a mechanical contractor." *Proceedings of IGLC16: 16th Annual Conference of the International Group for Lean Construction.*

Garvin, D.A. (1988) "Managing Quality: the strategic competitive edge." *The Free Press Macmillan*, New York.

Gilmore, H. L. (1974). "Product conformance cost." *Quality Progress*, June 1974. 16-19.

Glavinich, T. E., and Rowlings, J. E. (1994). "Total quality management for the electrical contracting industry." *The Electrical Contracting Foundation, Inc.*, Bethesda, Md.

Glavinich, T. E. (1995). "Quality Assurance Guide for Inside and Outside Electrical Contractors." *The Electrical Contracting Foundation, Inc.*, Bethesda, Md.

Gryna, F.M. (2001). Quality Planning and Analysis, Fourth edition. *Irwin, McGraw-Hill*, New York.

Howell, G. A. (1999). "What is Lean Construction." *Lean Construction Institute*

iSixSigma. (2013). "Cost of Quality: Not Only Failure Costs". <http://www.isixsigma.com/implementation/financial-analysis/cost-quality-not-only-failure-costs/> (August 11, 2013).

Inque, A. S. (1984). "Total quality in plant construction industry." *Proceedings of the World Quality Congress*, Brighton, England, Jun. 19-21, 127-139.

Ishikawa, K., (1985). "How to Operate QC Circle Activities." *QC Circle Headquarters, Union of Japanese Scientists and Engineers*, Tokyo

Juran, J. M., (1999). "Juran's Quality Handbook." Fifth edition. *McGraw-Hill*, New York

Kerzner, H. (2001). "Project Management: A Systems Approach to Planning, Scheduling and Controlling." Seventh edition. *John Wiley & Sons*, New York.

Koskela, L., Howell, G., Gallard, G., and Tommelein, I. (2002). "The Foundations of Lean Construction." In R. Best & G. de Valence (Eds.), Design and Construction: Building in Value. Oxford, UK: Butterworth- Heinemann.

Koskela, L. (2000). "An exploration toward a production theory and its application to construction." *VVT Technical Research Centre of Finland.*

Kuehn, A. A. and Day, R. L. (1962). "Strategy of product quality." *Harvard Business Review*, Nov-Dec. 1962, 100-110

Lean Construction Institute. (2013). < http://www.leanconstruction.org/whatis.html> (January 3, 2013).

Lean Manufacturing Tools. (2013). < http://leanmanufacturingtools.org> (July 11, 2013).

Leffler, K. B. ((1982) "Ambiguous changes in product quality." *American Economic Review*, Dec. 1982. 956-967.

Lichtig, W. A. (2011A). "The game tape process - a standard approach to continuous improvement in production." *The Boldt Company*, whitepaper.

Lichtig, W. A. (2011B). "Developing a built-in quality plan for SMCS/WCC." *The Boldt Company*, whitepaper, Jun.6.

Lichtig, W. A. (2005). "Sutter health: developing a contracting model to support lean project delivery." *Lean Construction Journal*, v 2, no 1, Apr., 105-112.

Low, S. P., and Yeo, H. K. C. (1998). "A construction quality costs quantifying system for the building industry." The International Journal of Quality and Reliability Management, v 15, no 3, 329-349.

MacDuffie, J. P., and Krafcik, J. F. (1992). "Integrating Technology and Human Resources for High-Performance Manufacturing: Evidence from the International Auto Industry". Kochan, T. A., and Useem, M. (editors), *Transforming Organizations*, Oxford University Press, 209-226.

Mason-Jones, R., Naylor, B., and Towill, D., (2000). "Engineering the Leagil Supply Chain." *International Journal of Agile Management Systems*, 2/1, 54-61.

Milberg, C. (2006). "Application of tolerance management to civil systems." PhD Dissertation, University of California, Berkeley, CA.

Milberg, C. T. and Tommelein, I. D. (2010). "Tolerance and Constructability of Soldier Piles in Slurry Walls". *Journal of Performance of Constructed Facilities*, ASCE, Mar./Apr. 2010.

Miller, J. (2013). "The four pillars of built-in quality." *Kaizen Institute Consulting Group.* <http://www.gembapantarei.com> (July 7, 2013).

Naylor, J. B., Naim, M. M., and Berry, D., (1999). "Leagility: Integrating the Lean and Agile Manufacturing Paradigms in the Total Supply Chain". International Journal of Production Economics (1999), No. 62, pp. 107-18.

Oakland, J. and Marosszeky, M. (2006) "Total Quality in the Construction Supply Chain." Elsevier Ltd.

Office of Statewide Health Planning and Development Facilities Development Division. (2012). "Guide for Working on Projects Under OSHPD Jurisdiction – Tips From the Experts." Dec. 2012.

Ohno, T. (1988). "Toyota Production System: Beyond Large-Scale Production." Productivity Press.

Onesixsigma. (2013) "Pros and cons of Six Sigma: an academic perspective". http://web.archive.org/web/20080723015058/http://www.onesixsigma.com/node/7630> (August 15, 2013).

Orr, C. (2005). "Lean leadership in construction." *Proceedings of the 13th Annual Conference of the International Group for Lean Construction*, Jul. 13, 345-351.

Peters, T. J., and Waterman, R. H. (2004). "In Search of Excellence: Lessons from America's Best-Run Companies." HarperBusiness.

Peters, T (2013). "A Brief History of the 7-S ("McKinsey 7-S") Model."<http://www.tompeters.com/dispatches/012016.php> (July 17, 2013).

Project Management Institute (PMI) (2008) "A Guide to the Project Management Body of Knowledge." Fourth edition, ANSI/PMI 99-001-2008, Newton Square, PA., 189-214.

Pyzdek, T. (1999). "Quality Engineering Handbook." *CRC Press.* Boca Raton, Florida.

Royce, D. W. W. (1970). "Managing the Development of Large Software Systems." Proceedings, IEEE WESCON, August, 1-9.

Ruman, A. R. (2011) "Quality Management in Construction Projects." *CRC Press.* Boca Raton, Florida.

Sanchez, L. M. and Nagi, R. (2001) "A review of agile manufacturing systems." *International Journal of Production Research,* 2001, vol. 39, no. 16, 3561-3600

Shine. (2003). "Shine Technologies Agile Methodologies Survey Results" <http://www.shinetech.com/dosearchsite.action?quickSearch=true&searchQuery.queryString=agile+survey> (December 10, 2012).

Shingo, S., (1986). "Zero Quality Control: Source Inspection and the Poka-Yoke System." *Productivity Press*

Shingo, S., (1985). "A Revolution in Manufacturing: The SMED System." Fifth edition. *Productivity Press*

Stukhart, G. (1985). "Quality assurance/quality control: case studies." *Proceedings of the ASCE Convention,* May 1, 1-4.

Taguchi, G., (2004). "Taguchi's Quality Engineering Handbook." *Wiley-Interscience*

Toyota Production System. (2013). <http://www.toyota-global.com/company/vision_philosophy/toyota_production_system/>

APPENDIX A: BIQ PLAN TEMPLATE (derived from Glavinich 1995)

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INTRODUCTION AND PURPOSE

THIS QUALITY PLAN SHOULD BE CONFIGURED TO MEET THE NEEDS OF THE PROJECT, CUSTOMER, STAKEHOLDERS, AND THE CONTRACTOR'S OWN ORGANIZATION. THE FOLLOWING IS A SUGGESTED TEMPLATE, HOWEVER, IT IS INCUMBENT UPON THE CONTRACTOR TO REVIEW AND MODIFY AS REQUIRED.

TO CUSTOMIZE THIS FORM FOR YOUR BUSINESS, CLICK HERE TO DOWNLOAD AS A WORD DOCUMENT. **DOWNLOAD ▶**

The following text describes ABC Electric's guideline for quality assurance. This ABC Electric Quality Program is designed and adheres to industry standards, design and installation codes, regulations, and recommended practices.

The purpose of the Quality System Manual is to set forth guidelines for the ABC Electric Quality Program. These guidelines define the system, describe system operation, identify the responsibilities of personnel affected by the system, and assure ABC Electric's internal and external customers that measures are being implemented to meet their requirements.

ABC Electric has implemented a Built-in Quality (BIQ) program -- a new quality process into our design and construction operations. Our BIQ process is based on a Prevent-Detect-Correct-Analyze (PDCA) cycle and is an adaptation of the Plan-Do-Check-Act (PDCA) cycle used throughout the manufacturing industry. This BIQ PDCA process utilizes a lean manufacturing process approach to help avoid mistakes. Our BIQ goals of meeting customer expectations, ensuring that craft workers have everything needed to conduct their work, simplifying production, and eliminating variability, align with the principals of achieving customer satisfaction, eliminating waste and delivering value.

Our quality assurance program is based on ANSI/ASQ Standard Q9001[3]. This provides a systematic means of identifying an organization's quality system that has an impact on the quality of what we deliver to our customers. ISO 9001 requires the system to be documented according to certain requirements. ISO 9001 is a set of requirements that assists ABC Electric in:

- *Documenting what must be accomplished ("SAY WHAT WE DO")*
- *Demonstrating that we actually do what is documented ("DO WHAT WE SAY")*
- *Providing a means to verify what we do through an audit process that measures and records nonconformities ("PROVE IT")*
- *Improving ABC Electric systems by correcting deficiencies and identifying continuous improvement.*

There are three levels of documentation in the Quality System: Level I - Quality System Manual, Level II — Work Instructions Manual, and Level III - Quality System Records. Master copies of the documentation for Levels I and II are kept by the Administrative Assistant for the Quality Department.

The ABC Electric QA/QC Site Specific Quality Manual and Field Inspection Manuals have been designed to be reviewed for implementation by ABC Electric for this project. The scope and use of the manuals is designed to meet a variety of project/client and governmental needs.

Because these needs may vary widely, it is our intent to meet with the client to determine which specific QA/QC goals it would like to accomplish through the use of these procedures and forms. In the absence of specific client QAIQC goals, ABC Electric will make its best determination in implementing the QA/QC Manuals for the assurance of the installation of a quality product.

3 ANSI/ASQ Q9001: 2015, Quality Management Systems, American Society for Quality, Milwaukee, Wisconsin, 2015.

QUALITY POLICY

ABC Electric is committed to 100% Customer Satisfaction. Our commitment to cooperation among all parties assures a timely completion. The results are measured through repeat customers, profitable jobs, low insurance rates, and workforce stability. ABC Electric defines delivered quality as:

> ***CONSISTENTLY PRODUCING A PRODUCT THAT MEETS CUSTOMER EXPECTATIONS AND IS FIT FOR USE.***

QUALITY POLICY OBJECTIVE

The objective of ABC Electric's quality policy is to ensure each employee understands that he or she is responsible for quality and empowered to ensure that customers' needs and expectations, as expressed in the contract documents, are met.

QUALITY POLICY DISSEMINATION

ABC Electric's quality policy is posted in conspicuous places throughout the home office and at all job sites. This policy is reinforced verbally at all company and project meetings that deal with quality and continuous improvement.

RESPONSIBILITIES FOR QUALITY

Quality is achieved and maintained through ABC Electric's quality system that is designed to adhere to specific requirements. Those who have been assigned responsibility for performing work shall ensure compliance to these quality standards.

LEVELS OF RESPONSIBILITY

ABC Electric recognizes its responsibility to customers for providing quality electrical work. Within ABC Electric, there are three levels of responsibility for quality:

- *Corporate*
- *Project*
- *Individual*

CORPORATE-LEVEL RESPONSIBILITY

The primary responsibility for quality at ABC Electric is the Quality Steering Committee. It consists of the following three members of senior management:

- *President*
- *Senior Vice President*
- *Vice President Of Operations*

The Senior Vice President serves as the Corporate Quality Officer for ABC Electric. The Corporate Quality Officer is responsible for ensuring that the organization adopts and adheres to the quality policy. The Corporate Quality Officer is also responsible for getting feedback from customers and ensuring that ABC Electric's Quality Program is committed to customer satisfaction and continuous improvement.

PROJECT-LEVEL RESPONSIBILITY

ABC Electric's project managers assist the Corporate Quality Officer. Project managers are responsible for overseeing quality in the field and for customer satisfaction. Section 11 addresses the project manager's responsibility for field quality in greater detail.

INDIVIDUAL RESPONSIBILITY

The key to the successful implementation of any quality assurance program is the individual employee. The employee performing the work is the only person who can truly control quality during the construction process. ABC Electric empowers employees to control quality through its quality policy and encourages open communications between employees and management about quality improvement.

MANAGEMENT REVIEW

The Corporate Quality Officer and designated staff conduct regular internal semi-annual reviews to ensure that the quality assurance program is being properly and effectively implemented. These management reviews include close scrutiny of the following:

- *Organization structure and its impact on quality*
- *Effective implementation of the quality policy*
- *Internal evaluation of construction and maintenance services*
- *Performance as measured by customer feedback and construction quality.*

These management reviews are documented and submitted to the Quality Steering Committee which takes corrective action as necessary. In addition, data and information from previous reviews are used to identify trends and determine if corrective measures are effective.

TRAINING

All ABC Electric employees received training in the Quality Assurance/Quality Control Program within three months of its acceptance by the Board of Directors on _____ (date). Every employee who has joined ABC Electric since _____ (date) has received training in the Quality Assurance/Quality Control Program within one week of his or her employment date.

Field employees working with ABC Electric receive training on the specific portions of the quality assurance program that apply directly to their work. Training of field employees is carried out at the job site by the project manager or the project's designated trainer. Employees working in ABC Electric's home office are trained by the employee's department head or the department's designated trainer.

A record of all formal training is kept in each employee's personnel file.

DISTRIBUTION

A copy of this manual is provided to all ABC Electric permanent employees at the time of their quality assurance training. These manuals are registered to the individual employee. A copy of this manual is also available in the ABC Electric job trailer at each construction site for field employee reference.

REVISIONS AND UPDATES

Revisions and updates to ABC Electric's Quality Program are issued to all registered holders of this manual. All registered holders of this manual are responsible for updating the manual as required. At each job site, the project superintendent is responsible for maintaining and updating the manual as required. The Corporate Quality Officer periodically checks the quality assurance manuals to ensure all revisions and updates have been included.

Employees are responsible for understanding and implementing revisions and updates to the quality assurance program. When there are a number of significant revisions or an overall update of the quality assurance program, each employee is required to attend a formal training session covering the revisions or update. Project and department managers are responsible for disseminating changes and updates that affect employees.

DELEGATION OF WORK AND ORGANIZATION

ABC Electric is ultimately responsible for all quality activities directly related to its work. In response to varying workloads, the designated ABC Electric representative shall have the authority to assign any or all work to qualified person(s). Although most of the positions are aimed at production, each has an obligation toward the quality product to be delivered.

PROJECT MANAGER

ABC Electric's primary representative with the client. Responsible for all aspects of the work and manages all resources.

QA/QC MANAGER (Main Office)

Ensures that all quality activities are performed. Assists field QA/QC Designate to ensure all field project responsibilities are met. Helps develop any needed change in operation to achieve compliance. Ensures that field QAJQC Designate has sufficient authority, freedom and independence to perform his/her duties.

QC / DESIGNATE (ABC Electric Site Representative)

Reports directly to the QA/QC Manager on Quality matters. The QC/Designate has the primary responsibility and function for performance at all times during the course of the project. This position expedites the flow of information and resources needed by field production personnel to ensure quality activities are supported.

Shall have sufficient authority, access to work areas and organizational freedom to:

- *Identify quality problems*
- *Initiate, recommend, or provide solutions to quality problems through designated channels*
- *Verify implementation of solutions*
- *Ensure proper disposition of a nonconformance, deficiency or unsatisfactory condition.*

Shall have direct access to responsible ABC Electric Management at a level where appropriate action can be executed. Access at this level will provide the authority and organizational freedom to effect change as needed. It also provides sufficient independence from cost and schedule considerations.

PRODUCTION SUPERVISION

Works directly with the owner's representative in compiling all information needed to perform job duties. Reviews original scope and documents with estimator and crew supervision to ensure a clear understanding before work commences. On an ongoing basis, will monitor job sites for adherence to original or revised scope, job schedules, appropriate materials, documentation, as-built drawings and test forms. Uses the scope of work, prints, estimate and schedule to pass on to craftsmen the needed information to ensure professional, smooth flowing, productive and cost effective job for the client. Performs accurate and complete inspections and completes the test forms required by the contract.

QUALITY SYSTEM

QUALITY SYSTEM DEFINED

ABC Electric's quality system is outlined in this manual. The quality system defines the organizational structure, responsibilities, procedures, and processes put in place to achieve ABC Electric's quality system objectives.

QUALITY SYSTEM OBJECTIVES

The objectives of ABC Electric's quality system are fourfold:

- *Provide a quality electrical installation that meets the customer's needs and expectations as expressed in the contract documents.*
- *Avoid rework and delays during construction through early detection and correction of problems.*
- *Provide a safe and productive work environment for ABC Electric employees.*
- *Support achieving the corporate mission and strategic objectives.*

HOW QUALITY PROBLEMS OCCUR

ABC Electric has found five main quality problem categories:

- ***1. HUMAN RESOURCE CAPABILITY:*** *excessive overtime, insufficient skill levels, unclear instructions to workers, inadequate supervision and job planning.*
- ***2. LEADERSHIP AND COMMUNICATION:*** *lack of safety and QA/QC commitment, poor communications, ineffective management of the project team, and lack of Operations buy-in.*
- ***3. ENGINEERING AND REVIEWS:*** *late design changes, scope changes, errors and omissions, and poor document control.*
- ***4. CONSTRUCTION PLANNING AND SCHEDULING:*** *late designer input, unrealistic schedules, constructability problems, and insufficient turnover and commissioning resourcing.*
- ***5. MATERIAL AND EQUIPMENT SUPPLY:*** *untimely deliveries, non-compliance with specifications, prefabrication and construction not performed to project requirements, and materials not located in the right place when needed.*

QUALITY SYSTEM PROCESSES

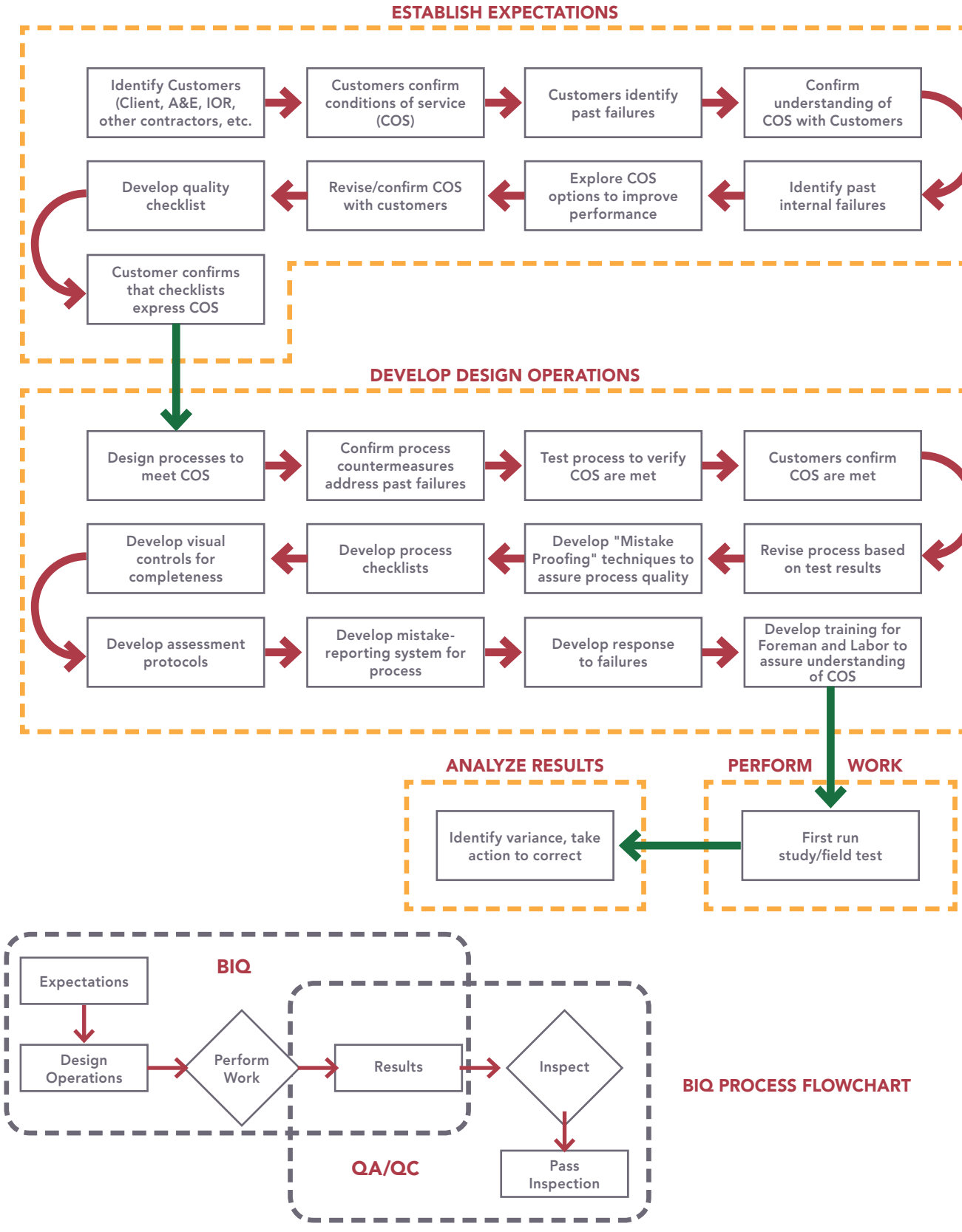
ABC Electric's Built-in Quality process BIQ process consists of:

- ***1. IDENTIFYING CUSTOMER EXPECTATIONS** – develop and confirm a mutual understanding of the work from all customers; identify contractor work that will be inspected.*
- ***2. CONVERTING EXPECTATIONS INTO REQUIREMENTS** – develop an operations plan for fabrication and installation; address past quality problems using error-proofing strategies/countermeasures.*
- ***3. FABRICATING AND CONSTRUCTING THE WORK** – develop a plan to train workers on design operations and ensure they have everything necessary prior to beginning the work.*
- ***4. INSPECTING THE WORK FOR CONFORMANCE TO REQUIREMENTS** – develop and implement an audit/assessment program to ensure that a process was followed and confirm that the product conforms to expectations.*

ABC Electric's Process Flowchart is shown in **Figure 1**. ABC Electric's quality process improvement program designates the Project Manager as ultimately responsible for process control, consisting of the control of the eight processes listed below. These activities are performed according to established procedures that ensure these processes are carried out under controlled conditions.

PROCESS	QA MANUAL SECTION
Contract Document Review	5
Document Control	6
Design Management	7
Procurement & Expediting	8
Tool & Equipment Maintenance, Calibration, & Testing	9
Materials & Installed Equipment Management	10
Construction Management	11
Inspection, Testing, & Startup	12

Figure 1


ESTABLISH EXPECTATIONS
Identify Customers (Client, A&E, IOR, other contractors, etc.
Customers confirm conditions of service (COS)
Customers identify past failures
Confirm understanding of COS with Customers
Identify past internal failures
Explore COS options to improve performance
Revise/confirm COS with customers
Develop quality checklist
Customer confirms that checklists express COS
DEVELOP DESIGN OPERATIONS
Design processes to meet COS
Confirm process countermeasures address past failures
Test process to verify COS are met
Customers confirm COS are met
Revise process based on test results
Develop "Mistake Proofing" techniques to assure process quality
Develop process checklists
Develop visual controls for completeness
Develop assessment protocols
Develop mistake-reporting system for process
Develop response to failures
Develop training for Foreman and Labor to assure understanding of COS
ANALYZE RESULTS
Identify variance, take action to correct
PERFORM WORK
First run study/field test
BIQ
Expectations
Design Operations
Perform Work
Results
Inspect
QA/QC
Pass Inspection
BIQ PROCESS FLOWCHART

CONTRACT DOCUMENT REVIEW

PROCESS SCOPE & OBJECTIVES

This process involves the review of the project contract documents to ensure that these documents accurately define the scope of ABC Electric's work. The objective of this process is to ensure that ABC Electric understands the customer's needs and requirements as expressed in the contract documents and can meet those needs and requirements.

DOCUMENT REVIEW PROCESS

BID DOCUMENTS

The document review process begins with the review of bid documents. These documents define the scope and requirements of the project. The bid documents normally include the following information:

- *Invitation to Bid*
- *Bid Form*
- *Construction Agreement*
- *General, Supplemental, & Special Conditions*
- *Insurance & Bond Requirements*
- *Work Included & Excluded*
- *Drawings & Specifications*
- *Addenda*
- *Owner Furnished Materials & Equipment*
- *Project Milestone Dates*

SITE VISIT

A site visit is scheduled with the customer prior to bidding. The purpose of the site visit is for ABC Electric to become familiar with the site and its condition. In addition to the physical site, ABC Electric will investigate project logistics and local conditions that may impact the construction process.

PREBID MEETING

ABC Electric will attend any scheduled pre-bid meetings in order to interact with the customer and clarify the project scope and requirements. Where no formal pre-bid meeting is scheduled, ABC Electric will contact the customer in order to resolve any questions concerning the project scope and requirements prior to bidding.

CONTRACT AWARD

Prior to executing the contract, ABC Electric will meet with the customer to review the contract scope and requirements and agree on any administrative procedures not previously addressed. Once an understanding of all outstanding details and questions has been resolved, ABC will execute the contract.

PRECONSTRUCTION PLANNING PROCESS

ABC will conduct a Pre-Construction review to establish submittal requirements and ensure that products will meet or exceed customer expectations. The availability and/or initiation of electronic file/information sharing systems shall be discussed. The review will include an assessment of products for fit, future service needs, and constructability issues. The Project Schedule shall be reviewed to insure products and services are available when needed. These procedures will:

- *Facilitate a faster review and approval process*
- *Eliminate the need for re-submittals*
- *Save time and administrative expenses*

POST-CONTRACT AWARD

Following contract execution, ABC Electric will start work as directed by the contract. During construction, ABC Electric will keep the customer informed of any problems, delays, or deviations from the specified requirements in accordance with the contract documents.

DOCUMENT CONTROL

PROCESS SCOPE & OBJECTIVES

All contract documents will be received by the project manager. These documents will be checked against transmittal for completeness. Any omissions will be identified and a request will be issued for missing documents. All documents will be stamped according to established procedures.

A complete document list will be kept in the field office trailer and new revisions transmitted will be inserted to replace old ones. The field set will be handled similar to the office set and QA/QC will inspect periodically. All documents shall be available to anyone with a need for such information.

New forms to document needs for this project will be developed as needed. These forms may parallel any that exist and shall address any changes or added information that is needed. When no form exists, one will be created to increase information flow. Forms will be maintained on a master list.

QUALITY RECORDS

Project Manager shall assist Field Supervisor in completing all requests, as-builts and test sheets. All field information shall ultimately pass through QC hands to ensure completeness and that filing systems are kept up-to-date. All job records shall be identified, indexed, and kept in the office trailer to assure their availability when needed.

DOCUMENT MANAGEMENT SYSTEM

ABC Electric can support the use of an online document management system to increase project efficiency and accountability by streamlining and mobilizing project communication and documentation. ABC Electric will engage in the collaborative use of a system, should this be beneficial to the project.

DESIGN MANAGEMENT

PROCESS SCOPE & OBJECTIVES

This process involves the design of power, control, and/or communications systems by ABC Electric and/or its engineering partner for the customer. The objective of this process is to determine the customer's needs and produce a set of accurate and complete construction documents that can be used to install and/or construct the required systems.

DESIGN QUALITY DEFINED

Design quality as defined by the construction documents translates the customer's needs and requirements into functional power, control, and communications systems that can be efficiently built and operated.

RESPONSIBILITY FOR DESIGN QUALITY

The project engineer is responsible for design quality. The project engineer will be registered as an electrical engineer in the state in which the project is located and affix his/her seal to studies, plans and specifications, and other design documents as required by the licensing laws of that state.

CLIENT NEED IDENTIFICATION

The first step in the design process is identifying the customer's needs and requirements. ABC Electric and/or its engineering partner will meet with the customer and end users of the system(s) or facility to determine the project scope and system performance requirements. The project scope and system requirements will be documented and provided to the customer for review and comment.

CODES & STANDARDS REVIEW

Once the project scope and system requirements have been identified and agreed upon, the next step is to determine what codes and standards are applicable to the project. Applicable codes and standards will be researched to determine specific requirements. The results of the codes and standards review will be documented.

DESIGN CRITERIA DEFINITION

Based on the project scope and system requirements along with the results of the codes and standards review, ABC Electric and/or its engineering partner will define specific design criteria for the project. In this step, ABC Electric and/or its engineering partner will convert the customer's system performance criteria into specific quantifiable and measurable design requirements. Design criteria will be documented and reviewed with the customer to ensure accuracy and completeness. Any conflicting or ambiguous requirements will be resolved prior to proceeding with the design.

CONSTRUCTABILITY & VALUE ANALYSIS

ABC Electric and/or its engineering partner will identify viable design alternatives that meet the customer's design criteria. These alternatives will then be analyzed to determine the preferred alternative based on construction, operation, and maintenance considerations. Constructability reviews will be performed to determine how the design can be modified to improve construction efficiency. Value analyses will be performed to select equipment and systems that result in a low life-cycle cost. The goal is to select design alternatives that meet the customer's requirements at a low life-cycle cost.

DESIGN REVIEW PROCEDURES

INTERNAL DESIGN REVIEWS

Internal design reviews will be performed by ABC Electric and/or its engineering partner at regular intervals, as required by the complexity and size of the project. The Project Manager will be responsible for scheduling performing, and documenting the results of these reviews. Internal design reviews should include members of the design team, construction personnel, key suppliers and manufacturers, outside specialists, and others who must interface with the design process. The internal design review will include not only technical reviews but also a review of the projected construction schedule and budget. The review will also assess cost saving opportunities and product value analysis.

CUSTOMER DESIGN REVIEWS

Customer design reviews will be scheduled in accordance with the agreement between the customer and ABC Electric and/or its engineering partner. The Project Manager is responsible for scheduling, coordinating, and responding to the results of the customer design reviews.

DESIGN CHANGE & MODIFICATION PROCEDURES

The Project Manager is responsible for establishing and documenting design change and modification procedures with the customer. All design changes and modifications are to be reviewed with the customer and documented.

BUILDING INFORMATION MODEL

ABC Electric can support the use of Building Information Modeling (BIM) to improve project quality, increase efficiency, support lean construction and prefabrication, reduce rework, improve coordination and project management, and resolve clash conflicts prior to construction. ABC Electric will engage in the collaborative use of BIM should this be beneficial to the project.

PROCUREMENT & EXPEDITING

Materials and equipment that are procured and accepted shall be subject to the same set of receiving inspection, identification, and storage protocol, regardless of supplier.

PROCESS SCOPE & OBJECTIVES

This process involves the procurement of materials and equipment for incorporation into the work by ABC Electric. In addition, this process involves procuring the services of qualified specialty subcontractors to assist ABC Electric in performing the work.

RECEIVING INSPECTION

All purchased bulk materials are subject to a visual inspection. Accepted material and equipment are placed in a designated area. Nonconforming products are segregated and prevented from use in production.

HANDLING, STORAGE, PACKAGING, PRESERVATION AND DELIVERY

The general policy ensures providing methods and means of handling that prevent product damage and deterioration. The condition of stored products is assessed regularly. Products are adequately protected during production, storage and delivery.

The stockrooms and storage areas are segregated. Only products that have been properly identified and have passed inspection are authorized to enter or leave the stockrooms.

INSPECTIONS AND TESTING

Inspection and testing activities are conducted when purchased materials and components are received, at significant stages of production, and final inspection. The objective of inspection and testing is to verify product conformance with project specific requirements.

Instruments, upon acceptance by ABC Electric, shall be stored adequately to prevent any damage or deterioration.

SUPPLIERS AND SUBCONTRACTORS

SUPPLIER MATERIALS & EQUIPMENT

Only those suppliers of materials and equipment who are acceptable to the customer, as defined in the contract documents, are considered. Acceptable suppliers are then assessed by ABC Electric based on past experience, commitment to quality and customer satisfaction, ability to meet the construction schedule, material and equipment installation characteristics, and after-sale service and support.

SUPPLIER PRE-CONSTRUCTION REVIEW

A Pre-Construction review shall be conducted to establish submittal requirements and ensure that the Supplier's products will meet or exceed the specifications. The availability and/or initiation of an electronic submittal process shall be discussed. ABC Electric will review specified products for fit, future service needs, and constructability issues. ABC will also review the Project Schedule to ensure products and services are available when needed. These procedures will:

- *Facilitate a faster review and approval process*
- *Eliminate the need for re-submittals*
- *Save time and administrative expenses*

SUPPLIER VALUE-ADDED SERVICES

ABC Electric will discuss value-added services that Suppliers could perform, including:

ORDERING SERVICES

- *Repair/return support*
- *Technical assistance*
- *Product training/education*
- *Warranty*
- *Processing rebates or incentives*
- *Design alternatives*
- *Collection & credit*
- *Co-location of personnel*

SHIPPING AND RECEIVING SERVICES

- *Job site delivery*
- *Emergency deliveries*
- *Early AM deliveries*
- *Staging orders*
- *Material tracking*
- *Coordination of special delivery*
- *Vendor managed inventory*
- *Material scheduling*
- *Multiple delivery locations at site*
- *On-site containers delivery*

WAREHOUSING SERVICES

- *Bin restocking for prefabrication*
- *Inventory reduction*
- *Bin restocking for service trucks*
- *Storeroom management*

PRE-INSTALLATION SERVICES

- *Wire paralleling*
- *Wire & cable cutting & stripping*
- *Customized packing or pallet configurations*
- *Lighting layout and design*
- *Pulling heads*
- *Sequencing of orders to customer's schedule*
- *Lighting fixture package removal/palletization*
- *Kitting or assembly services*
- *Customized labels & markings*
- *Energy efficiency design alternatives*
- *Layout and design alternatives*

JOB SITE MANAGEMENT SERVICES

- *Staging at distributor site*
- *Staging at job site*
- *Material bagged/tagged by area*
- *Onsite Storage*
- *Job boxes*
- *Commissioning*

SUBCONTRACTORS

ABC Electric shall assess each subcontractor based on:

- *Safety*
- *Pricing*
- *Expertise*
- *Past Experience*
- *Commitment to Quality*
- *Customer Satisfaction*
- *Quality of Product*
- *Service & Responsiveness*
- *Ability to meet the construction schedule*
- *Value Recommendations*

ABC Electric will make suggestions for improvements to the products and/or services of the subcontractor or vendor. Any subcontractor or vendor who does not meet the quality standards of ABC Electric or does not improve to required standards will no longer be utilized.

REQUESTS FOR QUOTATION

Only those suppliers and subcontractors approved by ABC Electric are asked to submit a quotation. Requests for quotation sent to suppliers and subcontractors will include ABC Electric's standard agreement as well as a detailed written scope of work. Applicable drawings and specification sections are made available to suppliers and subcontractors to facilitate their quotation preparation. ABC Electric provides suppliers and subcontractors with as much time as possible to prepare complete and accurate quotations.

PURCHASING POLICIES & PROCEDURES

ABC Electric selects a supplier or subcontractor based on the criteria outlined in the request for quotation. In most cases, ABC Electric selects the successful bidder based on price since the successful supplier or subcontractor is selected from a prequalified pool of equal bidders. Following selection and prior to contract execution, ABC Electric reviews the successful bidder's quotation for completeness and accuracy and then meets with the successful bidder to review the scope of work, technical requirements, inspection and testing requirements, submittal requirements, and construction schedule. Once an agreement is reached on all technical and administrative issues, the contract is executed.

SUBMITTALS

Shop drawings, catalog cuts, and test and inspection data required to be submitted to the customer for approval by ABC Electric will be thoroughly reviewed for completeness and technical requirements prior to submission. ABC Electric will stamp each submittal as having been reviewed along with the reviewer's name and the date of the review. The goal of this procedure is to avoid delays due to inadequate or erroneous submittals.

OWNER-FURNISHED MATERIALS & EQUIPMENT

ABC Electric will work with the owner to ensure owner-furnished materials and equipment meet the technical requirements of the project. In addition, ABC Electric will provide the owner with schedule milestones and information so that owner-furnished materials and equipment do not delay or otherwise affect the construction process. If the installation of materials and equipment are ABC Electric's responsibility, ABC Electric will inspect the materials and equipment when delivered and properly store them until needed. Records of the receipt and inspection of materials and equipment will be forwarded to the owner.

IDENTIFICATION & TRACEABILITY

Records will be kept of all materials and equipment incorporated into the work.

TOOL & EQUIPMENT MAINTENANCE, CALIBRATION, & TESTING

PROCESS SCOPE & OBJECTIVES

This process involves the maintenance, calibration, and testing of tools and equipment. The objective of this process is to ensure that employees in the field have the tools and equipment necessary to work effectively, safely, and efficiently.

SELECTION OF TOOLS & EQUIPMENT

Tools and equipment supplied by ABC Electric will be selected based on their suitability for the work to be performed. Wherever possible, ABC Electric will review tool and equipment selection both before and during the performance of the work to ensure the proper selection has been made. In addition, ABC Electric will provide sufficient quantities of tools and equipment to allow employees to work productively.

TRANSPORTATION & STORAGE OF TOOLS & EQUIPMENT

Tools and equipment will be transported and stored in such a way that they will be protected from damage and deterioration.

CALIBRATION AND TESTING OF TOOLS & EQUIPMENT

Tools and equipment requiring calibration and/or testing will be calibrated and/or tested at regular intervals or just prior to use. Calibration will be carried out by qualified technicians in a controlled environment in accordance with manufacturer recommendations. Testing will also be performed in accordance with manufacturer recommendations. Records of tool and equipment calibration and testing will be kept with an attached stamp indicating the tool or equipment's calibration and/or test status.

ABC Electric's Tool Department maintains records for test equipment and for routine or periodic calibrations. Periodic calibration time parameters satisfy the minimum suggested by the test equipment manufacturer. This check on equipment status shall be identified on equipment as per date calibrated and date due for recalibration.

Because of test equipment storage and transport, the field may want to check one instrument against a similar one to verify results at times, especially if the results do not concur with other information available when assessed together. If needed, items may be returned to shop for re-calibration.

1.Test equipment shall be stored in a central place or where all necessary individuals have access.

2.Dates for last equipment calibration and next due shall be on all log sheets.

REPAIR OF TOOLS & EQUIPMENT

When tools and equipment require repair, they will be marked or tagged as soon as the damage or defect is detected to avoid accidental use. In a controlled environment, qualified technicians will carry out repairs in accordance with manufacturer recommendations and instructions by. Following repair, the tools and equipment will be calibrated and tested as described in paragraph 8.4. Records of all tool and equipment repairs will be kept.

OPERATING INSTRUCTIONS & PROCEDURES

Operating instructions and procedures will be available with the tool or equipment or maintained on file at the project site for employee reference and use.

OPERATOR TRAINING & CERTIFICATION

When tools and equipment require training for proper use, ABC Electric will provide employee training by qualified instructors. Records of all formal training will be kept. If employee certification is required, ABC Electric will ensure that the employee is certified prior to using the tool or equipment.

MATERIALS & INSTALLED EQUIPMENT MANAGEMENT

PROCESS SCOPE & OBJECTIVES

This process involves managing materials and equipment from the time they are delivered to the site until they are incorporated in the work. The objective of this process is to ensure that the right materials and equipment are delivered and protected from damage and deterioration until they are installed.

RECEIVING & INSPECTION

At the time of delivery, all materials and equipment are inspected to ensure items are what was ordered, are intact and were not damaged during shipment, and that the proper quantity was delivered. Only after a successful inspection are materials and equipment accepted. If a problem is encountered during inspection, the materials and equipment are either rejected or corrective action is worked out with the supplier prior to acceptance. A record is kept of all material and equipment receipts and inspections.

STORAGE & PROTECTION

Material and equipment delivered prior to when it is needed will be properly stored and protected to prevent damage or deterioration.

INVENTORY CONTROL PROCEDURES

For bulk materials, ABC Electric will establish inventory control procedures to ensure that the correct materials and equipment are used where required.

MATERIAL & EQUIPMENT DOCUMENTATION

Documentation such as installation instructions, testing and startup procedures, and operation and maintenance manuals will be cataloged and filed. This documentation will be provided to the owner in accordance with the contract documents.

INSTALLATION FORMS AND STANDARDS

Refer to Appendix B for References to NECA Installation Standards and Appendix C for Sample Record and Checklist Forms

SITE SECURITY

The ABC Site Security Monitor is the designated ABC person responsible for administering, coordinating, and reporting all security related issues.

These duties shall include:

- *Enforcement of Project Site Security requirements and restrictions*
- *Project badge control administration and implementation*
- *Materials deliveries protocol and coordination*
- *Perimeter security fencing monitoring, inspection and reporting*
- *Site access control report log*
- *Preparation and submittal of security status documents*

CONSTRUCTION MANAGEMENT

PROCESS SCOPE & OBJECTIVES

This process involves the installation of materials, equipment, and systems at the site. The objective of this process is to ensure the work is completed efficiently and in accordance with the construction documents.

FIELD QUALITY DEFINED

Quality in the field is defined in accordance with ABC Electric's quality as stated in Section 2.

RESPONSIBILITY FOR FIELD QUALITY

The Project Manager is ultimately responsible for quality in the field. However, ABC Electric believes that quality cannot be controlled and must be built into the project by the employee performing the work. Therefore, field quality is everyone's responsibility.

ORGANIZATION FOR FIELD QUALITY

The Project Manager is responsible for organizing for field quality and documenting responsibilities. The project organization and delegation of authority and responsibility for quality will vary from project to project depending upon the project's complexity and size.

WORK FORCE QUALIFICATIONS & TRAINING

ABC Electric employs only the best employees with the training, skills, and experience necessary to perform the work assigned. Each employee is responsible for the quality of his/her own work and has the authority to alter or correct the work when it does not comply with specified requirements.

INTERFACE WITH OTHER PROJECT PARTICIPANTS

ABC Electric will plan and coordinate its work with other project participants as required.

CONSTRUCTION MEANS & METHODS

ABC Electric will use construction means and methods appropriate for the project. The means and methods will be reviewed with the employee(s) performing the work prior to implementation.

PROJECT PLANNING & SCHEDULE

ABC Electric will plan and schedule work within the framework of the customer's schedule and the contract requirements. ABC Electric will work closely with the customer and other affected parties when scheduling requires shutdowns and cutovers.

ACTIVITY PREPLANNING

In order to ensure that employees have the necessary information, materials and equipment, and tools and production equipment to perform the work, ABC Electric will preplan its construction activities. Preplanning is the responsibility of production supervision and performed with the assistance of the employee(s) who will be assigned to perform the work. Preplans will be documented and distributed as required.

PRE-FABRICATION

ABC Electric shall explore all opportunities for project pre-fabrication. Benefits of pre-fabrication include the ability to deliver value to the customer and reduce waste by:

- *Significantly reducing project duration*
- *Improving productivity*
- *Reducing labor needs and costs*
- *Improving safety*

Some of the opportunities for pre-fabrication include:

- *Device boxes and assemblies*
- *Light fixtures/whips*
- *Panelboard connections*
- *Electrical equipment room build-out*
- *Service/feeder conductors*
- *Conduit bending*
- *Support hangers/racks*

COMMUNICATIONS MANAGEMENT

ABC Electric shall post appropriate project communications information at the job site, including a project communication list in the job trailer with names, titles and phone numbers for key project personnel. Key personnel shall include customer, general contractor, specialty and subcontractors, major suppliers, engineers of record, safety personnel, and municipal support services. Listed services shall include hospital, police, fire department, etc.

SAFETY & ACCIDENT PREVENTION

Safety and accident prevention are synonymous with quality at the site. ABC Electric is dedicated to providing a safe work environment for employees. The Project Manager is responsible for safety and accident programs at the construction site. These programs include regular review of construction means and methods for safety, inspection of the condition of tools and production equipment, and the scheduling of regular safety meetings and training. ABC Electric believes that safety and accident prevention are everyone's responsibility.

The ABC Electric Project Supervisor shall hold weekly Tool Box Talks with crews to discuss safety, job conditions, and employee concerns or ideas. At these meetings, employees shall learn how to work more safely and help expose unsafe conditions that may exist. Task Specific Safety Talk Sheets shall be included in the Production Supervision Handbook to assist with the discussion and provide a visual aid for employees. All employees shall sign an attendance report in which the items discussed are noted. Copies are reviewed by all levels of management for communication purposes and filed for record.

AS-BUILT CONSTRUCTION DOCUMENTS

As-built construction documents will be maintained throughout construction at the site. At the end of the project, these as-built construction documents will be provided to the customer, in accordance with the contract documents.

INSPECTION, TESTING, & STARTUP

CONSTRUCTION MEANS & METHODS

This process involves the inspection, testing, and startup of materials, equipment, and the systems that they comprise. The objective of this process is to ensure that materials and equipment are supplied and installed in accordance with the technical specifications and that systems operate as required.

VERIFYING CONTRACT COMPLIANCE

VERIFICATION PROCESSES

The following three processes are used for verifying contract compliance:

- *Work-In-Process Inspection & Testing*
- *Final Inspection & Testing*
- *Third-Party Inspection & Testing*

WORK-IN-PROCESS INSPECTION & TESTING

Ongoing inspection and testing of work-in-process is carried out throughout the construction in accordance with manufacturer recommendations, specified requirements, and ABC Electric's quality assurance procedures. Records are kept of all work-in-process inspection and testing.

FINAL INSPECTION & TESTING

ABC Electric performs final inspection and testing on all completed work in accordance with manufacturer recommendations, specified requirements, and ABC Electric's quality assurance procedures prior to turning the completed work over to the owner. Records are kept of all final inspections and testing.

THIRD-PARTY INSPECTION & TESTING

ABC Electric assists third parties (such as the owner, owner's representative, architect and/or engineer, manufacturer, code officials, or others) in the performance of required inspection and testing of work in process and completed work. Records are kept of all third-party inspections and testing.

CORRECTION OF NONCONFORMING WORK

Preventive measures will be taken to ensure a nonconforming product is not used or installed. In-progress work discrepancies or omissions shall be identified to immediate supervisor for corrective action. Nonconforming material, equipment, and work in place will be corrected in one of the following three ways:

- *Reworked or modified in order to meet specified requirements.*
- *Accepted with or without rework or modification by the owner, owner's representative, architect and/or engineer, or other authorized entity.*
- *Removed and replaced in total.*

Completed work shall be inspected as to final correctness of the installation. Any concerns, omissions, or discrepancies
will be identified to the immediate supervisor for action. Follow-up inspections will be necessary to ensure all concerns are corrected or explained satisfactorily.

Causes of product and quality system nonconformities are investigated and corrective actions are implemented to prevent their recurrence. If an action is deemed necessary, the immediate supervisor shall be notified. Steps will be taken to identify the root cause of the non-conformance and come up with a course of remedial action. Documentation and follow- up by QC shall verify compliance.

When nonconforming material, equipment, or work in place is accepted as is, ABC Electric will document the nonconformance and the fact that it has been accepted. Reworked, modified, or replaced material, equipment, or work in place must be inspected and tested in accordance with manufacturer recommendations, the technical specifications, and ABC Electric's quality assurance procedures.

STARTUP & TESTING PROCEDURES

Startup and testing procedures for materials, equipment, and the systems they comprise will be performed in accordance with manufacturer recommendations, the technical specifications, and ABC Electric's quality assurance procedures. A manufacturer's representative will be brought to the site to inspect the installation, perform final adjustments, perform required tests, and/or startup the equipment or system when required by contract, for technical reasons, or for warranty compliance.

INSPECTION & TEST RECORDS

All inspection and test records will be maintained by ABC Electric along with records of any corrective action(s) taken. Copies of the inspection and test records will be provided to the owner, owner's representative, or architect and/or engineer, in accordance with the contract documents.

WARRANTIES & GUARANTEES

ABC Electric will ensure that all requirements to put warranties and guarantees in force are met. Copies of all warranties and guarantees will be provided to the owner in accordance with the contract documents.

SPECIAL PROCESSES

Workmen capable of performing the below mentioned duties will be prequalified by field supervisors. Individuals are evaluated based upon prior training, work experience, knowledge and abilities. All welding activities are performed in accordance with the industry standard requirements.

Motor control installation, termination, and testing will be performed by those possessing the skills necessary. No confirmation is necessary, but the individual will be evaluated for prior training, work experience, knowledge and abilities. Instrumentation calibration, installation, loop checking and system selling will be handled in the same manner as motor control.

APPENDIX B: REFERENCES TO NECA INSTALLATION STANDARDS

NECA 101-2013, Standard for Installing Steel Conduits (Rigid, IMC, EMT)

NECA 102-2004, Standard for Installing Aluminum Rigid Metal Conduit

NECA/AA 104-2012, Recommended Practice for Installing Aluminum Building Wire and Cable

NECA/NEMA 105-2015, Recommended Practice for Installing Metal Cable Tray Systems

NECA 111-2003, Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC)

NECA/NACMA 120-2012, Standard for Installing Armored Cable (AC) and Metal-Clad Cable (MC)

NECA 121-2007, Standard for Installing Nonmetallic-Sheathed Cable (Type NM-B) and Underground Feeder and Branch-Circuit Cable (Type UF)

NECA 130-2016, Standard for Installing and Maintaining Wiring Devices

NECA 200-2016, Recommended Practice for Installing and Maintaining Temporary Electric Power at Construction Sites

NECA 202-2013, Standard for Installing and Maintaining Industrial Heat Tracing Systems

NECA 230-2016, Standard for Selecting, Installing, and Maintaining Electric Motors and Motor Controllers

NECA/FOA 301-2009, Standard for Installing and Testing Fiber Optic Cables

NECA 303-2005, Standard for Installing Closed-Circuit Television (CCTV) Systems

NECA 400-2007, Standard for Installing and Maintaining Switchboards

NECA 402-2014, Standard for Installing and Maintaining Motor Control Centers

NECA/EGSA 404-2014, Standard for Installing Generator Sets

NECA 406-2014, Standard for Installing Residential Generator Sets

NECA 407-2015, Standard for Installing and Maintaining Panelboards

NECA 408-2015, Standard for Installing and Maintaining Busways

NECA 409-2015, Standard for Installing and Maintaining Dry-Type Transformers

NECA 410-2013, Standard for Installing and Maintaining Liquid-Filled Transformers

NECA 411-2014, Standard for Installing and Maintaining Uninterruptible Power Supplies (UPS)

NECA 412-2012, Standard for Installing and Maintaining Photovoltaic (PV) Power Systems

NECA 413-2012, Standard for Installing and Maintaining Electric Vehicle Supply Equipment

NECA 430-2006, Standard for Installing Medium-Voltage Metal-Clad Switchgear

NECA/IESNA 500-2006, Standard for Installing Indoor Commercial Lighting Systems

NECA/IESNA 501-2006, Standard for Installing Exterior Lighting Systems

NECA/IESNA 502-2006, Standard for Installing Industrial Lighting Systems

NECA 503-2005, Standard for Installing Fiber Optic Lighting Systems

NECA 505-2010, Standard for Installing and Maintaining High Mast, Roadway and Area Lighting

NECA/BICSI 568-2006, Standard for Installing Commercial Building Telecommunications Cabling

NECA/NCSCB 600-2014, Standard for Installing and Maintaining Medium-Voltage Cable

NECA/NEMA 605-2005, Recommended Practice for Installing Underground Nonmetallic Utility Duct

NECA 700-2010, Standard for Installing Overcurrent Protection to Achieve Selective Coordination

STANDARD FOR INSTALLING STEEL CONDUITS (RIGID, IMC, EMT)

(For complete publication, see NECA 101-2013)

SCOPE

This standard describes installation procedures for steel rigid metal conduit (RMC), steel intermediate metal conduit (IMC), and steel electrical metallic tubing (EMT). Conduit with supplementary PVC coating is also included.

This publication is intended to enhance electrical safety by:

1. *Aiding installers in meeting the "neat and workmanlike" requirements*
2. *Reducing future repair needs*
3. *Providing for future expansion to avoid electrical overload*
4. *Creating an installation which will protect the wire conductors from mechanical abuse*
5. *Providing electrical continuity of the raceway system*

SPECIFIC INSTALLATION REQUIREMENTS

- All exposed raceways shall be run parallel or perpendicular to walls and ceilings.
- A sufficient number of home run raceways shall be installed so that excessive circuit loading will be eliminated.
- If home runs are to be concealed by the finish of the building (suspended ceilings accepted), the minimum size of home run conduit and tubing shall be MD 21 (trade size 3/4). NOTE: Minimum size requirements to provide room for future expansion of circuits in locations that are difficult to access.
- The minimum size for raceways in industrial occupancies shall be MD 21 (trade size 3/4). NOTE: Minimum size requirements to provide room for future expansion of circuits in locations that are difficult to access.
- Overhead service conductors shall be run in RMC, IMC or EMT. EMT shall not be used for mast installations supporting the overhead drop.
- EMT shall not be used where damage severe enough to damage the conductors within is likely to occur.
- Sufficient expansion fittings for the application shall be installed (see 4.3.2).
- An approved conductive coating is to be applied to all field-cut threads. In wet or damp environments it is desirable to also apply this coating to exposed factory threads.
- Do not use raceways to support enclosures except as permitted by the NEC.
- Splices or taps shall not be made inside RMC, IMC, or EMT.
- All conductors and neutrals of the same circuit and all equipment grounding conductors shall be contained within the same raceway. NOTE: This is extremely important in alternating current (AC) applications.
- The raceway system shall be installed complete, including tightening of joints, from termination point to termination point prior to the installation of conductors.

STANDARD FOR INSTALLING ALUMINUM RIGID METAL CONDUIT

(For complete publication, see NECA 102-2004)

PRODUCTS AND APPLICATIONS

This standard describes installation procedures for aluminum rigid metal conduit, including aluminum RMC conduit with a supplementary PVC coating.

PRODUCT DESCRIPTION

NEC 344.10 permits aluminum rigid conduit (RMC) to be installed in all environments. It has no temperature limitations and can be used indoors, outdoors, underground, concealed, or exposed. Aluminum RMC with supplemental protective coatings may have temperature or other limitations; consult manufacturers' listings and markings. *(NOTE: For installation in concrete or directly buried in soil, supplementary corrosion protection is required.)*

SPECIFIC INSTALLATION REQUIREMENTS

- Install all exposed conduits parallel or perpendicular to walls and ceilings, where possible.
- The minimum size of home run conduits concealed by building finishes should be trade size 3/4. This does not apply to conduits installed in suspended ceiling cavities.
- The minimum size raceways in industrial occupancies should be trade size 3/4. Raceways for control wiring may be trade size 1/2.
- All conductors, neutrals, and equipment grounding conductors of the same circuit must be contained within the same raceway. (NOTE: This is extremely important in alternating current applications.)
- The raceway system must be installed complete, including tightening of joints, from termination point to termination point, prior to the installation of conductors.

STANDARD FOR INSTALLING ALUMINUM BUILDING WIRE AND CABLE

(For complete publication, see NECA 104-2012)

SCOPE

This standard describes installation procedures and design considerations for aluminum building wire and cable in residential, commercial, institutional and industrial applications not exceeding 2000 volts.

PRODUCTS AND APPLICATIONS

- This publication covers aluminum alloy building wire and cable types USE, USE-2, RHH, RHW, RHW-2, THW, THW-2, THHN, THWN, THWN-2, XHHW and XHHW-2; and AC, MC, TC and SE.
- Type AC cable is used primarily for branch circuits and feeders in dry locations where it is not subject to physical damage.
- MC cable is permitted, under various NEC Articles, to be used for a wide range of applications including branch circuits, feeders, service conductors, control circuit, wet locations, direct burial, places of public assembly, health care facilities, and certain hazardous locations.

BASIC INSTALLATION TECHNIQUES

Installation procedures for aluminum alloy building wire products are typical of the procedures required for electrical wire and cable products.

STANDARD FOR INSTALLING METAL CABLE TRAY SYSTEMS

(For complete publication, see NECA 105-2015)

SCOPE

This standard addresses shipping, handling, storing, and installing cable tray systems and provides information on maintenance and system modification.

GENERAL INSTALLATION

This standard is intended as a practical guide for the proper installation of cable tray systems. Cable tray system design shall comply with NEC Article 392, NEMA VE 1, and NEMA FG 1, and shall follow safe work practices as described in NFPA 70E.

STANDARD FOR INSTALLING NONMETALLIC RACEWAYS (RNC, ENT, LFNC)

(For complete publication, see NECA 111-2003)

SCOPE

This standard describes installation procedures for nonmetallic raceways of circular cross-section used for electrical power wire and cable, communications wiring, or fiber optic cables.

PRODUCTS AND APPLICATIONS

This publication covers the following, when installed for commercial, institutional, and industrial applications in nonhazardous locations within the confines of the building structure, including raceways installed under floor slabs:

1. *Rigid nonmetallic conduit (RNC)*
2. *Electrical nonmetallic tubing (ENT)*
3. *Liquidtight flexible nonmetallic conduit (LFNC)*

GENERAL INSTALLATION

- Install raceways in accordance with manufacturer recommendations. Maintain manufacturer recommended and Code required clearances and wiring methods. Use manufacturer recommended raceways, fittings, boxes, and accessories designed, identified, and listed for the intended purpose and environment.
- Install raceways, boxes, fittings, and accessories level and plumb, and parallel and perpendicular to nearby surfaces, exposed structural members, and other building systems and components.
- Clean and dry raceways, boxes, fittings, and accessories before installation.
- Run exposed, parallel or banked conduits together on common supports where practical.
- Install raceway systems giving right-of-way priority to other systems, such as plumbing, that are required to be installed at a specified slope.
- Make raceway runs mechanically continuous. Provide a bushing or adapter where raceways enter boxes, fittings, cabinets, or other enclosures to protect wires from abrasion unless the box, fitting, cabinet, or enclosure design provides equivalent protection. Securely connect raceways to boxes, cabinets, and enclosures.
- Complete installation of electrical raceways before starting installation of cables/wires within raceways and fittings.
- Install raceways so that they do not damage or run through structural members. *NOTE: Raceways may be run in notches in wood studs, joists, rafters, or other structural members where those notches do not reduce their load bearing ability. Protect raceways at those points against nails or screws by a steel plate at least 1/16 inch thick installed before the building finish is applied.*
- Do not install soiled, damaged, broken, or marred material or products. Repair or replace.
- Run raceways for outlets on waterproof walls exposed. Set anchors for supporting raceway on waterproof walls in waterproof cement. Preferably, use supports that provide a space between the conduit and the wall.
- Do not use LFNC at locations where ambient temperature may be 25°F (-4°C) or lower unless marked and listed by the manufacturer for lower temperature conditions. *NOTE: Extreme cold may cause some types of nonmetallic raceways to become brittle and therefore more susceptible to damage from physical contact.*
- Do not install ENT or RNC where subject to ambient temperatures in excess of 122°F (50°C) unless otherwise listed in manufacturer's recommendations. Do not install ENT, LFNC, or RNC for conductors whose operating temperatures would exceed the listing of the raceway.
- Avoid moisture traps where possible. Where moisture traps are unavoidable, provide junction boxes with drain fittings at raceway low points. NOTE: There are no listed outlet boxes or flush device boxes that come provided with drain fittings.
- Do not install angle connectors when LFNC is installed concealed.
- Install polyethylene rope having not less than 200 pounds tensile strength in empty raceways. Leave a minimum of 12 inches of slack at each end of the rope. Test spare raceways with ball mandrel. Clear or replace any raceway that rejects ball mandrel.
- Provide bushings or grommets in holes punched in metal framing members, or use suitable tools in forming holes that raceways are not subjected to physical damage.

STANDARD FOR INSTALLING ARMORED CABLE (AC) AND METAL-CLAD CABLE (MC)

(For complete publication, see NECA 120-2012)

SCOPE

This standard covers the installation of Type AC and Type MC cables, which are used for electrical wiring for residential, commercial and industrial occupancies. It also includes information on fittings and other accessories necessary for a quality installation of these cable systems.

DESCRIPTIONS

Type AC cable is a factory assembly of insulated conductors protected in an overall flexible interlocked metallic armor (sheath). The metallic sheath may be of aluminum or steel material. Armored cable having an aluminum sheath is suitable for use in alternating current circuits only.

Type AC cable is permitted to have from two to four conductors in sizes 14 through 1 AWG copper with or without an equipment grounding conductor. All conductors with thermoplastic insulation have an individual moisture-resistant fiber wrap and are cabled together in the manufacturing process. Typical branch circuit Type AC cables have copper conductors with THHN insulation.

Type MC cable is a factory assembly of one or more insulated current-carrying conductors and one or more equipment grounding conductors (if required) in an overall metallic sheath. MC cable is manufactured with three different types of armor in the following configurations:

1. *Interlocking metal-tape (steel or aluminum) – (MCI)*
2. *Interlocking metal-tape (steel or aluminum) Armor ground – (MCI-A)*
3. *Smooth metal tube (aluminum only) – (MCS)*
4. *Corrugated metal tube (copper or aluminum) – (MCC)*

Type MC cable consists of one or more current- carrying conductors, one or more equipment grounding conductors if required, and in some cases optical fibers. MC cables containing optical fibers are designated Type MC-OF and are considered composite cables in accordance with NEC Article 770.

GENERAL INSTALLATION PROCEDURES

In addition to complying with the specific installation requirements of the NEC, Type AC and Type MC cables are required to be installed in a "neat and workmanlike manner." To the extent practicable, visible cables should be installed in vertical or horizontal lines or otherwise follow building lines. Cables must be supported properly where they are routed around obstacles as they are inherently flexible.

INSTALLING NONMETALLIC-SHEATHED CABLE (TYPE NM-B) AND UNDERGROUND FEEDER AND BRANCH-CIRCUIT CABLE (TYPE UF)

(For complete publication, see NECA 121-2007)

SCOPE

This standard describes installation procedures for nonmetallic-sheathed cable (Type NM) and under- ground feeder and branch-circuit cable (Type UF).

This publication covers the following:

1. *Nonmetallic-sheathed cable with insulation rated 90°C (194°F), listed as Type NM-B.*
2. *Underground feeder and branch-circuit cable, Type UF.*

Type MC cable consists of one or more current- carrying conductors, one or more equipment grounding conductors if required, and in some cases optical fibers. MC cables containing optical fibers are designated Type MC-OF and are considered composite cables in accordance with NEC Article 770.

PERMITTED USES

Type NM-B cable is permitted to be used in any one- or two-family dwelling, but its use in multifamily dwellings and other structures is permitted only in Types III, IV, or V fire-rated construction as defined in NFPA 220-1999. Model building codes show Type III (a combination of combustible and non-combustible), Type IV (heavy timber), and Type V (wood frame). Types III, IV, and V permit some or all of the structure to be combustible (wood).

In structures that are Types III, IV, or V construction, other than one- and two-family or multifamily dwellings, cables must be concealed in walls, floors, or ceilings that provide a thermal barrier that has at least a 15-minute finish rating as identified in listings of fire-rated assemblies.

Type NM-B cable can be used for both exposed and concealed work in normally dry locations and can be installed or fished in air voids in masonry block or tile walls.

Type UF cable is permitted to be used underground, including direct burial in the earth. Where installed as a single conductor cable, all conductors of the feeder or branch-circuit including the grounded conductor and the equipment-grounding conductor must be contained within the same raceway, auxiliary gutter, cable tray, or trench. Type UF cable can be used in wet, dry, or corrosive locations. Where used as non- metallic-sheathed cable, Type UF cable must be installed in compliance with Parts II and III of NEC Article 334 and must be of the multiconductor type.

RECOMMENDED INSTALLATION PROCEDURES

Type NM-B cable is a cable system, and changes or additions to an existing installation cannot be accomplished as readily as in a raceway system where additional conductors can be added. For this reason, it is recommended that wiring installations be done in a manner where both an unswitched ungrounded conductor and the grounded conductor be present in every outlet box.

The installation of direct buried Type UF cables must meet the requirements of NEC Table 300.5. Where used in residential branch circuits rated 120 volts or less with GFCI protection and maximum overcurrent protection of 20 amperes, the cable must have 12 inches (300 mm) of cover. Where necessary to prevent physical damage to the cable, protection must be provided by suitable running boards or suitable sleeves. The use of a running board is generally done by covering the Type UF cable with sand fill and then placing a wooden board over the cable to prevent rocks or other coarse material debris from damaging the cable. Direct buried Type UF cable not having ground-fault protection must be buried not less than 18 inches (450 mm).

STANDARD FOR INSTALLING AND MAINTAINING WIRING DEVICES

(For complete publication, see NECA 130-2016)

SCOPE

This standard covers the installation and maintenance of wiring devices that are rated 600V and less that are intended to be permanently connected to building premises wiring systems on non-hazardous (unclassified) branch circuits for residential, commercial, and industrial applications for new installations, replacements in existing installations, and new branch-circuit extensions in existing installations.

APPLICATIONS

- Receptacles non-locking-type and locking type
- Multi-outlet assemblies
- Attachment plugs, connector bodies, and motor attachment plugs (inlets), (both non-locking- type and locking-type)
- Pin-and-sleeve devices (Receptacles, Attachment plugs, connector bodies, and Motor attachment plugs (inlets))
- Switches
- Timers
- Combination devices
- Occupancy sensors
- Dimmers
- Coverplates and outlet box hoods

GENERAL INSTALLATION

Install wiring devices in accordance with the manufacturer installation instructions and in strict accordance with approved shop drawings and with equipment manufacturer instructions.

Verify that wiring devices are compatible with wiring methods, loads served, expected service life, construction materials, ampere and load ratings, fire ratings, type of occupancy, and installed environment. Consider installing a higher grade of wiring device in environments subject to heavier conditions of use. Ensure that wiring devices are at least rated for the nominal operating voltage of the branch circuit. Coordinate wiring device colors with the owner.

Install wiring devices in boxes or assemblies that are designed for the purpose and that are securely fastened in place. Install wiring devices only in boxes that are clean and free from excess building materials, dirt, and debris.

Install wiring devices and coverplates after all raceways, boxes, and conductors are installed, and after all wall preparation, painting, and finish work is complete.

Verify that box gaps and setbacks comply with applicable Code requirements:

- Ensure that openings or gaps around device boxes or plaster rings are effectively closed with no more than 3 mm (1/8 in.) gap between the opening and the surface finish.
- Ensure that the front edge of boxes, plaster rings, extension rings, or listed extenders that have flush-type coverplates are not set back from the finished surface more than a 6 mm (1/4 in.) in walls or ceilings constructed of noncombustible material, such as concrete, tile, gypsum, or plaster.
- Ensure that the front edge of boxes, plaster rings, extension rings, or listed extenders that have flush-type coverplates are flush with or extend past the finished surface in walls or ceilings constructed of combustible material, such as wood.

Use a torque screwdriver when torquing connectors in accordance with manufacturer instructions.

Test branch circuit wiring for short circuits and ground faults prior to energization and use. Test equipment grounding conductor continuity. Correct wiring deficiencies.

STANDARD FOR INSTALLING AND MAINTAINING TEMPORARY ELECTRIC POWER AT CONSTRUCTION SITES

(For complete publication, see NECA 200-2016)

PRODUCTS AND APPLICATIONS

This standard describes temporary electrical power and lighting systems at construction sites, operating at 600 volts or less. It covers the planning, installation, expansion, maintenance, cutover, and removal of the temporary power system. This standard is intended to ensure a safe, adequate, functional, and reliable temporary electrical power system for all trades at construction sites.

DESIGN, PERMITS, AND APPROVALS

When the temporary construction power system is not designed by the engineer of record, the electrical contactor shall design the system, submit necessary documentation, and obtain necessary permits from the local authority having jurisdiction (AHJ) and the serving electric utility.

The electrical contractor is not responsible for obtaining property surveys, right-of-ways, easements, environmental permits, or other similar requirements.

Install and maintain the temporary construction power distribution system throughout the period of construction and remove it at the end of the project. The exact scope and responsibilities are governed by the contract documents, but generally include the following:

- Moves, adds, changes, and repairs.
- Outages.
- Equipment owned and operated by others.

PLANNING THE INSTALLATION

Install temporary construction power in accordance with the overall project plan and schedule. Work with the party responsible for overall project coordination to ensure that temporary power is available when needed to support construction operations. Identify the following project milestones:

- When temporary power must be available at the construction site.
- When the temporary power supply needs to be increased, modified, or extended to meet the needs of specific construction operations.
- When the temporary power must be transferred (cutover) to the permanent building distribution system.
- When all or part of the temporary construction power distribution system is to be removed.
- Other milestones during construction that require a change, expansion, or removal of the temporary construction power distribution system.

STANDARD FOR INSTALLING AND MAINTAINING INDUSTRIAL HEAT TRACING SYSTEMS

(For complete publication, see NECA 202-2013)

PRODUCTS AND APPLICATIONS

This standard describes procedures for the installation, testing, and documentation of electrical freeze protection and process heat tracing systems. Heat tracing cable types covered by this publication include: self-regulating, constant wattage, and zone heating cables and mineral insulated (MI) heating cables.

System components used with these types of heat tracing cables included power transformers, control panels, temperature sensors, temperature controllers, contactors, circuit breakers, enclosures, conduit, wire, and all necessary auxiliary equipment and controls.

COORDINATION WITH OTHER TRADES

In general, heat tracing will be applied directly on pipes and other components to be electrically traced. Obtain direction from code officials or owner when conflicts or code issues exist. Expect the general contractor, architect/engineer, or owner to coordinate building systems and to reconcile conflicts.

GENERAL INSTALLATION PRACTICES

General trades

- Determine that all general construction is sufficiently complete to allow installation of electrical heat tracing systems without further removal or damage to components.
- Make design drawings agree with actual "as built" piping and electrical drawings. If not, appropriate changes should be made before proceeding with heat tracing installation.

Mechanical trades

- Determine that mechanical systems are sufficiently complete to allow installation of heat tracing systems without future removal or damage to material.
- Make certain thermal insulation tolerance is sufficient for future installation.

Electrical systems

- Determine that other electrical systems are sufficiently complete to allow installation of heat tracing systems without compromising design and requiring future removal or damage.
- Resolve conflicts among electrical systems in accordance with applicable codes.

STANDARD FOR SELECTING, INSTALLING, AND MAINTAINING ELECTRIC MOTORS AND MOTOR CONTROLLERS (1000 VOLTS AND LESS)

(For complete publication, see NECA 230-2016)

PRODUCTS AND APPLICATIONS

This standard describes recommended procedures for selecting and installing stationary electric motors and motor controllers rated 1000 volts or less. It also covers routine maintenance procedures to be followed after the installation is complete.

SELECTING MOTORS - GENERAL

Electric motors and controllers may be provided as individual components for installation in the field, or may be supplied as components of unitized equipment (assemblies of motors and their driven loads, such as gears, pumps, compressors, or other driven equipment, on a common base).

Electric motors must be closely matched to the mechanical load. In general, the architect and engineering consultants select the types of electric motors for the given applications. In many instances, the electrical contractor must coordinate the electrical characteristics of motors, such as identifying the configuration of available electrical power, with equipment suppliers to ensure that compatible equipment is provided.

Single-phase motors work on the same principles as three-phase motors, but have lower starting torques than three-phase motors, and cannot be started using line voltage alone. Do not operate single-phase motors with less than 25% of their nameplate load rating. NOTE: Operating single-phase motors at no-load can cause the motor to overheat.

INSTALLATION EXAMPLE

Step-by-step example for a three-phase motor installation

- Determine the FLC of the motor
- Determine the size of the motor
- Determine the fuse size (dual-element or time delay) required to be used as motor branch-circuit short circuit and ground-fault protection
- Determine the rating required for the motor disconnect switch
- Determine the motor and branch circuit overload protection required
- Determine requirements for motor control circuit conductor overcurrent protection

STANDARD FOR INSTALLING AND TESTING FIBER OPTIC CABLES

(For complete publication, see NECA 301-2009)

SCOPE

This standard describes procedures for installing and testing cabling networks that use fiber optic cables and related components to carry signals for communications, security, control and similar purposes. It defines a minimum level of quality for fiber optic cable installations.

APPLICATIONS

This standard covers fiber optic cabling installed indoors (premises installations) with the addition of outside plant (OSP) applications involved in campus installations where the fiber optic cabling extends between buildings

GENERAL INSTALLATION

Fiber optic cable may be installed indoors or outdoors using several different installation processes. Outdoor cable may be direct buried, pulled or blown into conduit or innerduct, or installed aerially between poles. Indoor cables can be installed in raceways, cable trays, placed in hangers, pulled into conduit or innerduct or blown though special ducts with compressed gas. The installation process will depend on the nature of the installation and the type of cable being used.

Installation methods for both wire and optical fiber communications cables are similar. Fiber cable is designed to be pulled with much greater force than copper wire if pulled correctly, but excess stress may harm the fibers, potentially causing eventual failure.

STANDARD FOR INSTALLING CLOSED-CIRCUIT TELEVISION (CCTV) SYSTEMS

(For complete publication, see NECA 303-2005)

SCOPE

This standard describes installation procedures for closed-circuit television system equipment installed for protection of building interiors, building perimeter, and surrounding property. This publication applies to closed-circuit television systems for security and monitoring activities in nonhazardous locations both indoors and outdoors. It also covers periodic routine maintenance procedures for closed-circuit television systems.

PRODUCTS AND APPLICATIONS

This publication applies to the following:

1. *Closed-circuit television camera*
2. *Monitors, switchers, multiplexers, and recording devices*
3. *Electronic hardware components*
4. *Conductor and cable installation*

GUIDELINES FOR INSTALLING CABLING AND CONDUCTORS

- Install wiring and cable in accordance with manufacturer recommendations and the NEC requirements.
- Solder and heat-shrink-wrap electrical connections to device manufacture supplied leads, or use high-quality insulating crimp connectors.
- Provide strain relief for all connections to ensure that tension is not transmitted to joints or terminals and will not damage or break connections.
- Provide a minimum of 2 inches of separation between conductors of lighting and power circuits and those of Class 3 circuits, unless one of the circuits is installed in metallic raceway.
- Use conductors and cables of the appropriate gauge, strands, insulation, and electrical properties as specified by the manufacture of the device to be connected.
- Install conductors and cables to provide access to equipment for maintenance and repairs.
- Prepare cable and conductors in accordance with manufacturer instructions. *NOTE: Some manufacturers provide unique instructions for their products. Stripping of sheathing as described in h) and i) below may not be an acceptable practice with products such as coaxial cable or category-rated network cable.*
- Strip cables and conductors to the length prescribed by the manufacture of the device to which they should be connected. Do not damage or remove any strands of stranded conductors.
- Remove the outside protective sheathing of cables a minimum of 2 inches from the end to expose the internal insulated conductors for making connections. Removal of the outside sheathing in excess of 2 inches to facilitate inserting the cable back into the opening is acceptable. Do not damage the insulation of the internal conductors of the wires or cables.
- Ensure that wires and cables extend at least 6 inches beyond the finished surface at the point of device installation.
- Use separate cables for power, control, and video, unless using one cable listed as suitable for combined use.
- Identify circuits within control panels, enclosures, pull boxes, etc. Identify circuits at field terminations and all accessible locations.

STANDARD FOR INSTALLING AND MAINTAINING SWITCHBOARDS

(For complete publication, see NECA 400-2007)

PRODUCTS AND APPLICATIONS

This standard describes installation procedures for deadfront distribution switchboards rated 600 volts or less. This standard also covers periodic routine maintenance procedures for switchboards, and special procedures to be used after adverse circumstances, such as a short circuit, ground-fault, or immersion in water.

GENERAL INSTALLATION

- Clean dirt and debris from the pad and surrounding area where the switchboard will be located before moving the switchboard into its final position.
- Remove the shipping skids before installing the switchboard on the pad.
- If the switchboard is equipped with bottom closure plates, temporarily remove these plates and set them aside. Cut holes for the conduits entering the bottom of each enclosure in the bottom plates (if supplied). Once the vertical sections have been installed, reinstall the bottom closure plates.
- Block the opening of each conduit with material that rodents will not be able to gnaw through, squeeze through, or push out of the way. Bottom closure plates will not keep out rodents that come in through the conduits.

STANDARD FOR INSTALLING AND MAINTAINING MOTOR CONTROL CENTERS

(For complete publication, see NECA 402-2014)

PRODUCTS AND APPLICATIONS

This standard describes the installation and maintenance procedures for low-voltage motor control centers (MCCs) rated 600 VAC or less with a horizontal bus rating of 2,500 amperes or less.

MCCs may be assembled with factory-installed dry-type transformers and panelboards. The testing and maintenance of such dry-type transformers is addressed in NECA 409, Standard for Installing and Maintaining Dry-Type Transformers (ANSI). The testing and maintenance of such panelboards is addressed in NECA 407, Standard for Installing and Maintaining Panelboards (ANSI).

GENERAL INSTALLATION

Install motor control centers in accordance with contract documents, manufacturer instructions, and approved shop drawings.

Install motor control center sections in final positions, progressively leveling each section and bolting frames of shipping splits together.

Secure the motor control center to walls or other supporting surfaces in accordance with manufacturer recommendations, if necessary. Do not secure motor control centers with wooden plugs driven into holes in masonry, concrete, plaster, or similar materials.

Install motor control center sections starting with the most restrictive section first. If the motor control center has incoming cables or busway near or in its center, start with that vertical section first and work outwardly on each side. If the motor control center is fed from the left-most section, start from the left and work toward the right. If the motor control center is fed from the right-most section, start from the right and work toward the left. If the motor control center is close-coupled to a transformer, start at the transformer and work away from the transformer.

Clean dirt and debris from the concrete equipment foundation and the surrounding area where the motor control center will be located before moving the motor control center into its final position. Remove shipping skids before installing the motor control center on the foundation.

STANDARD FOR INSTALLING GENERATOR SETS

(For complete publication, see NECA 404-2014)

PRODUCTS AND APPLICATIONS

This standard describes installation procedures for generators and related accessories and systems that are permanently installed for on-site standby or emergency power generation that are typically fueled by natural gas or diesel. Such generators may be defined as "emergency systems" or "legally-required standby systems" intended to supply power for emergency or life-safety applications in accordance with NFPA 70, National Electrical Code.

GENERAL INSTALLATION

Design of the generation system, generator sizing, fuel selection, fuel system design, and the selection of accessories is outside of the scope of this Standard.

Thoroughly study the manufacturer's instruction manuals, drawings, and other literature before installing generators and required accessories, such as engine water jacket heaters and remote annunciator panels. Install field-installed accessory kits in accordance with installation instructions.

Comply with the National Electrical Code (NEC) and local code requirements when installing generators. Locate generators in accordance with National Fire Codes. Check whether spark arrester protection, maintained in effective working order, is required by national, state, or local codes or regulations.

Obtain all necessary building permits. Contact the local utility locating service and locate all underground utilities prior to excavating or trenching. Notify the electric utility service provider when installing generators to provide backup power.

For warranty registration, complete the startup and installation checklists, and complete and sign the manufacturer's startup notification form and return copies as instructed on the form.

Generators installed to provide temporary electric power to circuits when loss of normal utility power occurs must be connected to listed transfer equipment in accordance with the NEC Articles 700, 701, and/or 702. The Listed transfer equipment must isolate the generator electrical system from the utility electrical power distribution system when the generator is operating. Failure to isolate an electrical system with approved transfer equipment will result in damage to the generator and can result in severe injury or death due to the backfeed of generator power onto the utility electrical power distribution system.

Multiple generators can be arranged to operate either in parallel or can be connected individually to dedicated emergency loads.

STANDARD FOR INSTALLING RESIDENTIAL GENERATOR SETS

(For complete publication, see NECA 406-2014)

PRODUCTS AND APPLICATIONS

This standard describes installation and maintenance procedures for residential generators fueled by gasoline, natural gas, or liquefied petroleum gas (LP or propane) and permanently installed at one-family dwellings to provide backup power. Residential generators are usually rated 240/120 volts, single- phase, three-wire. Some larger one-family dwellings have three-phase electrical systems and may use backup generators rated 208Y/120 volts, three-phase, four-wire.

This standard also covers the installation of related items such as non-automatic (manual) or automatic transfer switches (MTS or ATS), disconnect switches, control panels, and fuel supply systems, and describes some electrical power distribution system design consideration related to the use of generators to supply important, non-emergency loads in single- family dwellings.

Residential generators are considered to be "optional standby power systems" in accordance with the NEC.

GENERAL INSTALLATION

Comply with the National Electrical Code (NEC) and local code requirements when installing residential generators. Locate generators in accordance with national fire codes. Obtain all necessary building permits. Contact the local utility locating service and locate all underground utilities prior to excavating or trenching. Notify the electric utility service provider when installing generators to provide backup power. Check whether a spark arrester, maintained in effective working order, is required by Federal, State, or local codes or regulations.

Thoroughly study the manufacturer's instruction manuals, drawings, and other literature before installing generators. Verify that the nominal voltage and electrical configuration of the generator is compatible with the electrical power distribution system to which the generator will be connected.

Install field-installed accessory kits in accordance with installation instructions.

For warranty registration, complete the startup and installation checklists, and complete and sign the manufacturer's startup notification form and return copies as instructed on the form.

STANDARD FOR INSTALLING AND MAINTAINING PANELBOARDS

(For complete publication, see NECA 407-2015)

PRODUCTS AND APPLICATIONS

This standard describes installation and maintenance procedures for panelboards, and special procedures used after adverse operating conditions such as a short-circuit, ground-fault, or immersion in water.

This standard applies to panelboards rated 600 Volts (AC and DC) or less, with main disconnects or lugs, and with feeder or branch circuit overcurrent devices.

This publication applies to single panelboards and multi-section panelboards that are installed in the field and used for distributing power for commercial, institutional, and industrial loads in nonhazardous locations both indoors and outdoors.

GENERAL INSTALLATION

Install panelboards in accordance with manufacturer recommendations, specific panelboard markings, and all installation instructions.

Review manufacturer supplied shop drawings, arrangement drawings (front, end, and plan view), connection diagrams, approved submittals, approved shop drawings, and equipment schedules before installation.

Verify that supply overcurrent device(s) for panelboards and the panelboard feeders have a rating not greater than that of the panelboard and the panelboard feeder.
Ensure that panelboard withstand ratings and circuit breaker interrupting ratings exceed the available fault current from the system as indicated by the short-circuit and coordination study provided by the owner, if available. Verify that series-rated panelboards meet the manufacturer's Listing for series-rating. Check that panelboards are tested and marked with testing combinations of the line-side overcurrent device and load-side circuit breaker(s) as required by NEC Article 240 for series-rated devices.

Coordinate panelboard locations to ensure that the required minimum working space clearances are maintained in accordance with NEC Article 110. Ensure that the working space permits at least a 90-degree opening of equipment doors or hinged panels. Provide sufficient access to permit removing doors, covers, and panels for routine inspection, maintenance, and testing.

Ensure that illumination is provided for panelboard working spaces in accordance with NEC Article 110.

STANDARD FOR INSTALLING AND MAINTAINING BUSWAYS

(For complete publication, see NECA 408-2015)

PRODUCTS AND APPLICATIONS

This standard describes the installation and maintenance procedures for feeder and plug-in busways and accessories rated 600 Volts AC or less, and 100 Amperes or more, installed above ground. It also covers periodic routine maintenance procedures for busway, and special procedures used after adverse operating conditions such as a short- circuit, ground-fault, or immersion in water.

GENERAL INSTALLATION

Prior to the release of the busway to the job site, compare the manufacturer's shop drawings with field measurements for accuracy.

Busway and busway accessories must be accessible for maintenance and inspection purposes. Busway is permitted to be installed exposed, behind access panels, and through walls and floors. When installed behind access panels, busways must be totally enclosed and non-ventilated, and installed such that joints between sections and at fittings are accessible for maintenance purposes. When spaces behind access panels are used for environmental air, busway must be feeder-type busway with no provisions for plug-in connections.

Unbroken lengths of busways are permitted to extend through dry walls. Totally enclosed (unventilated) busways are permitted to pass vertically through dry floors and must extend a minimum of 1.8 m (6 ft) above the floor to provide protection from physical damage. In other than industrial establishments, where a vertical busway riser penetrates two or more dry floors, a 100 mm(4 in.) high curb must be installed around all floor openings to prevent spilled liquids from entering the opening, and electrical equipment must be located to prevent its damage from liquid that is contained by the curb.

Do not install busways where subject to severe physical damage or corrosive vapors. Do not install busways in hoistways. Do not install busways in any hazardous (classified) location unless specifically approved for such use. Do not install busways outdoors or in wet or damp locations unless identified for such use.

STANDARD FOR INSTALLING AND MAINTAINING DRY-TYPE TRANSFORMERS

(For complete publication, see NECA 409-2015)

PRODUCTS AND APPLICATIONS

This standard describes the installation and maintenance procedures for single- and three- phase general purpose dry-type transformers and associated accessories rated 1000 Volts AC or less, and 0.25 kVA or more.

This publication applies to indoor and outdoor, ventilated and non-ventilated, two-winding transformers used for supplying power, heating, and lighting loads for commercial, institutional, and industrial use in nonhazardous locations both indoors and outdoors.

It also covers periodic routine maintenance and troubleshooting procedures for transformers, and special procedures used after adverse operating conditions such as a short-circuit, ground-fault, or immersion in water.

GENERAL INSTALLATION

In general, transformers must be readily accessible to qualified personnel for inspection and maintenance. Transformers located in the open on walls, columns, or otherwise supported from structures are not required to be readily accessible. Transformers not exceeding 50 kVA located in hollow spaces of buildings that are not permanently closed in by structure are not required to be accessible, provided they meet the ventilation requirements and separation from combustible materials requirements of NEC Article 450.

Locate transformers rated 112-1/2 kVA and less a minimum of 300 mm (12 in.) from combustible material unless separated from the combustible material by a fire-resistant, heat-insulated barrier, unless the transformer is completely enclosed, with or without ventilation openings.

Locate transformers rated over 112-1/2 kVA in a transformer room of fire-resistant construction, with a minimum of a 1-hour fire rating. Transformers with Class 155 or higher insulation systems that are separated from combustible material by a fire- resistant, heat-insulating barrier or by not less than 1.83 m (6 ft) horizontally and 3.7 m (12 ft) vertically, or that are completely enclosed except for ventilating openings, are permitted to be installed in rooms of construction with less than a 1-hour rating in accordance with the NEC.

STANDARD FOR INSTALLING AND MAINTAINING LIQUID-FILLED TRANSFORMERS

(For complete publication, see NECA 410-2013)

PRODUCTS AND APPLICATIONS

This standard describes installation procedures for pad-mounted, sealed, self-cooled or fan-cooled, compartmental, single- and three-phase liquid filled distribution and power transformers with primary windings rated from 2400 volts to 35 kV AC, nominal, and rated from 75 kVA through 5000 kVA, and associated accessories, designed for outdoor installation at grade level with underground entrance of primary and secondary conductors, and used for supplying power, heating and lighting loads for commercial, institutional, and industrial use in non- hazardous locations.

It also covers periodic routine maintenance procedures for transformers, and special procedures used after adverse operating conditions such as short-circuit, ground-fault, or immersion in water

GENERAL INSTALLATION

- Observe safety procedures in accordance with 7.1. Verify that there is no voltage on the incoming cables.
- Locate and coordinate transformer installations in accordance with manufacturer instructions and specific transformer markings.
- Consult the manufacturer for high altitude applications. At altitudes above 100,650 m (3300 ft), decreased air density reduces transformer cooling efficiency.
- Coordinate installation of raceways and conductors at locations designated by the transformer manufacturer.
- Follow applicable national codes and any applicable local codes or ordinances when locating transformers in close proximity to public thoroughfares or buildings, considering that transformer insulating liquid may be flammable.
- Do not install transformers near heat-generating equipment or heat-sensitive equipment.
- Avoid opening transformer termination compartments during inclement weather conditions, unless the opening is completely protected from weather.
- Verify that site drainage is adequate to prevent groundwater from entering transformers.
- Install bollards, fences, barriers, etc., as required to protect transformers and transformer accessories from physical damage and vehicular traffic, if applicable.

STANDARD FOR INSTALLING AND MAINTAINING UNINTERRUPTIBLE POWER SUPPLIES (UPS)

(For complete publication, see NECA 411-2014)

SCOPE

This standard describes installation and maintenance procedures for permanently installed, static, three- phase Uninterruptible Power Supplies (UPSs) rated 30 kVA or more and rated 600 Volts or less, and related battery systems installed indoors or outdoors for commercial and industrial applications. UPSs described herein are solid-state power systems that provide continuous regulated AC power at the output terminals, while operating from either an AC power source or from a battery system.

PRODUCTS AND APPLICATIONS

Permanently installed UPS rated 30 kVA or more and 600 Volts or less, with related battery systems installed indoors or outdoors for commercial and industrial applications.

GENERAL INSTALLATION

- Install UPSs, accessories, and ancillary equipment in accordance with contract documents, the NEC, and manufacturer's installation drawings and wiring diagrams. Verify compliance with overall dimensions, front view, and sectional view, typical installation and module arrangement, conduit entry, and ventilation and exhaust systems.
- Ensure that the room and area around the UPS is kept clean during installation. Protect UPS equipment, including batteries, from physical damage, moisture, dust, and contamination. Take particular care to prevent metallic or other electrically conductive dust particles from being drawn into air inlets.
- Check that complete, appropriate, and properly sized overcurrent protective equipment is provided. Check that UPSs are protected from voltage transients due to lightning.
- Install remote monitoring panels, relay interface modules, supervisory contact modules, and similar accessories, in accordance with manufacturer recommendations. Ensure that the UPS system is turned off and all sources of power are removed before connecting monitoring or control devices.

STANDARD FOR INSTALLING AND MAINTAINING PHOTOVOLTAIC (PV) POWER SYSTEMS

(For complete publication, see NECA 412-2012)

SCOPE

This standard describes the application procedures for installing photovoltaic power systems and components.

PRODUCTS AND APPLICATIONS

This standard covers the installation of low-voltage AC and DC photovoltaic power systems, rated 1000V and less, for grid-connected and stand-alone operation for residential, commercial, and industrial applications.

GENERAL INSTALLATION

Review installation instructions for each component to become familiar with the installation process. Inverters, photovoltaic modules, photovoltaic panels, AC photovoltaic modules, source-circuit combiners and charge controllers intended for use in photovoltaic power systems must be identified and listed for the applications. Inverters and AC modules installed on interactive systems must be listed and identified as interactive. Comply with all warning and safety labels.

Determine the physical size and dimensions of the photovoltaic array and its primary components (See Annex A) to help identify where the array and ancillary equipment will be mounted. Examine location options for mounting the array.

Install monopole subarrays of a bipolar PV system physically separated where the voltage sum of two monopole subarrays of a bipolar PV system exceeds the rating of the conductors and the connected equipment.

Develop a preliminary drawing or sketch of the solar panel lay out on the roof or other structure. Determine any potential conflict with the proposed solar panel locations from any existing or potential plumbing, ventilation, or electrical penetrations of the roof. Determine the locations of any plumbing or combustible appliance vents that will impact the placement or shading of any solar panels.

Where such conflicts exist, determine whether it is possible to relocate obstructions to another portion of the roof. Ensure that the layout of the solar array provides the required space for circulation around solar panels, access for fire fighting and smoke ventilation and emergency egress from the roof in accordance with local codes. Locate roof access points where the building is structurally sound, where not in conflict with overhead obstructions, such as power lines or tree limbs, and where ladders are not placed over openings, such as doors or windows.

Where possible, configure solar panels following the dimensional shape of the roof, such as providing a rectangular array layout for rectangular roofs. Arrange solar panels symmetrically and group connection points for ease of installation and wiring.

Examine the main electrical service panel to determine if the panel has sufficient space to install the required overcurrent protective devices or spare circuit breakers or fuses to connect the solar photovoltaic power system. If adequate space is not available, consult the panel manufacturer for alternatives to replacing the panel. If the system includes a critical load sub-panel, such as for a bimodal PV system, determine which circuits are considered to be essential (See NECA 406 for information about determining what are considered to be essential loads and sizing critical load sub- panels). The critical load sub-panel must be adequately designed to handle the anticipated electrical loads. Determine the location of the critical load sub-panel. Install the critical sub-panel and relocate the essential circuits to the sub-panel.

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Check that the open-circuit voltage of the solar panels connected in series does not exceed the DC operating voltage range of the inverter. Do not exceed the inverter manufacturer's recommended maximum voltage. For two-wire circuits connected to a bipolar PV system, the maximum system voltage is considered the highest voltage between the conductors of the two-wire circuit if one conductor of a bipolar subarray is solidly grounded, each circuit is connected to a separate subarray, and the equipment is clearly marked with a label.

Check that the total current of the array is within the power ratings of the inverter. Additional inverters may be required to increase the power capacity of the solar photovoltaic power system.

Arrange the connections to solar modules or panels so that removal of a module or panel from a PV source circuit does not interrupt a grounded conductor or neutral to other PV source circuits during operation. Note that during construction, service, or maintenance, it may be necessary to temporarily open grounded circuits, but these circuits should not be left in an open state.

Photovoltaic system currents are considered to be continuous where the maximum load current is expected to continue for more than 3 hours. The maximum circuit current for PV source and PV output circuits is 125 percent of the sum of the parallel module rated short-circuit currents. The maximum inverter output circuit current is the inverter continuous output current rating. For standalone inverters, the maximum input circuit current is the standalone continuous inverter input current rating when the inverter is producing rated power at the lowest input voltage.

Install conductors with ampacity of 125 percent of the maximum circuit current without any additional correction factors for conditions of use, or with ampacity equal or greater than the maximum currents calculated after conditions of use have been applied. Where a common return conductor is installed for PV systems with multiple output circuit voltages, the ampacity of the common return conductor must be not less than the sum of the ampere ratings of the overcurrent devices of the individual output circuits.

Overcurrent protective devices must be rated to carry not less than 125 percent of the maximum circuit current, unless the device is rated for continuous operation at 100 percent of its rating. Observe the terminal temperature limitations and apply the manufacturer's temperature correction factors when operated at temperatures greater than 40°C. Install overcurrent protection to protect PV conductors within their ampacity. Overcurrent protective devices must be listed for use in DC circuits when used in any DC portion of a PV system, and must have appropriate voltage, current and interrupt ratings.

Secure plug-in type overcurrent protective devices that are back-fed and used to terminate field- installed ungrounded supply conductors using an additional fastener that requires other than a pull to release the device from the mounting means on the panel. Do not backfeed circuit breakers that are marked "LINE" and "LOAD."

Provide a listed DC arc-fault circuit protection, PV type, or other system components listed to provide equivalent protection for PV systems with DC source circuits and/or DC output circuits that operate at 80VDC or greater that penetrate a building. The DC arc-fault protection system must detect and interrupt arcing faults resulting from a failure in the intended continuity of a conductor, connection, module or other system component in the DC PV source and output circuits.

The arc-fault protection system is permitted to disable or disconnect inverters or charge controllers connected to the faulted circuit when the fault is detected, or to disable or disconnect system components within the arcing circuit. The arc-fault protection system must be manually reset, and must have a visual indication that the circuit interrupter has operated that must also be manually reset. Note at the time of publication, there are no listed devices for this purpose.

Label each junction box, combiner box, disconnect and device where energized, ungrounded circuits of the PV power source may be exposed during service.

STANDARD FOR INSTALLING AND MAINTAINING ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE)

(For complete publication, see NECA 413-2012)

SCOPE

This standard describes the procedures for installing and maintaining AC Level 1, AC Level 2 and fast charging DC (initially known in the industry as AC Level 3 and currently known in the industry as DC Level 2) Electric Vehicle Supply Equipment (EVSE).

PRODUCTS AND APPLICATIONS

This standard covers Electric Vehicle Supply Equipment (EVSE) that complies with applicable local, state and federal regulations, codes and standards for AC Level 1, AC Level 2 and fast charging DC (DC Level 2) EVSE intended for transferring energy between premises wiring systems and electric vehicles (EVs).

GENERAL INSTALLATION

The installation requirements for EVSE vary from manufacturer to manufacturer. Install EVSE in accordance with manufacturer recommendations and in accordance with applicable local, state and federal codes and regulations.

If trenching or boring, consider providing a minimum of one additional raceway for future growth, expansion or upgrade.

Consider providing a minimum of one spare power conductor for single-phase 208 VAC and 240 VAC circuits for future use as a neutral conductor, if needed.

Connect the EVSE to either the branch circuit or feeder equipment grounding conductor in accordance with NEC Article 250.

Mount EVSE such that wall mounted outlets are not more than 1.2 m (48 in.) above the ground. Provide a minimum of 600 mm (24 in.) clearance around all sides of outdoor pedestal-mounted EVSE.

Provide bollards, curbs or wheel stops to protect EVSE from vehicles.

Anchor EVSE to surfaces in accordance with manufacturer recommendations. For EVSE mounted to concrete surfaces, provide J-Bolts cast in concrete or drill holes for concrete anchors. Mark the mounting bolt pattern on the mounting surface using the manufacturer's template. Drill pilot holes in the mounting surface. Follow the manufacturer's recommendations for depth and diameter of pilot holes. Keep in mind that different materials, such as steel, concrete, wood, etc., will require different fasteners and different types of pilot holes.

Use not less than the manufacturer's recommended minimum number of fasteners to secure the EVSE base plate to concrete pads. Install the manufacturer's recommended fasteners and mounting hardware, and torque to manufacturer recommendations.

Use the manufacturer recommended raceway entry locations or conduit knockouts for EVSE. When provided by the manufacturer, select and remove the appropriate sized conduit knockouts, considering raceway diameter.

Install raceways and tighten connectors and fittings. Install cables and conductors and connect and terminate in accordance with manufacturer recommendations. Provide cable and conductor sizes and types in accordance with manufacturer recommendations.

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Branch circuit, feeder and service conductors, and overcurrent protective devices for EVSE and for ventilation systems, where required, must be sized not less than 125% of the maximum rated load current or the nameplate value, whichever is greater, or comply with the maximum ampacity and overcurrent protection indicated on the equipment, in accordance with NEC® requirements for supplying continuous loads. Install, insulate and coil a spare phase conductor for future use.

Provide a disconnecting means that is readily accessible from EVSE for circuits rated 60A and higher in accordance with NEC® requirements. Connect the branch circuit, feeder or service to the EVSE meter/disconnect terminals.

STANDARD FOR INSTALLING MEDIUM-VOLTAGE METAL-CLAD SWITCHGEAR

(For complete publication, see NECA 430-2006)

SCOPE

This standard describes site preparation and installation of medium-voltage metal-clad switchgear rated 5 kV and 15 kV AC.

PRODUCTS AND APPLICATIONS

This publication applies to the following:

1. *Metal-clad switchgear*
2. *Vacuum circuit breakers*
3. *Indoor and outdoor locations*
4. *Testing, energizing, and commissioning*

GENERAL INSTALLATION

- Review assembly drawings to ensure that switchgear shipped in sections will be assembled in the correct order.
- Verify that switchgear foundation is properly sized for the equipment, and located properly given required clearances, in accordance with manufacturer shop drawings. Verify that conduit placement on the foundation is accurate according to shop drawings. Errors in conduit placement may prohibit proper installation of switchgear.
- Sweep the concrete pad and remove debris before installing any sections.
- Carefully dry out switchgear that has been exposed to moisture using forced warm air. Test primary circuits using a megohm meter (See Annex A). Consult manufacturer for recommendations for any measurements below 200 megohms.

STANDARD FOR INSTALLING INDOOR COMMERCIAL LIGHTING SYSTEMS

(For complete publication, see NECA 500-2006)

PRODUCTS AND APPLICATIONS

This standard describes installation procedures for lighting systems commonly used in commercial and retail buildings, including but not limited to the following:

1. *Recessed lighting systems such as troffers, downlights, wallwashers, valance lights, and accent lights*
2. *Ceiling surface-mounted lighting systems such as surface troffers, wraparounds, surface downlights, monopoints, and decorative fixtures*
3. *Ceiling-suspended lighting systems such as pendant luminaires, warehouse or industrial luminaires, uplight systems, or decorative luminaires*
4. *Wall-mounted lighting systems such as sconces or wallpacks*
5. *Track lighting systems*

GENERAL INSTALLATION

Coordinate the installation of recessed luminaires with ceiling contractors. Some recessed-mounted wallwashers and other troffer-like luminaires may not completely fill the ceiling opening and are furnished with flanges or pans to permit filling the space with cut ceiling tile.

- Follow manufacturer's instructions for installing luminaires and accessories.
- Exercise care when installing recessed luminaires in suspended gypsum wallboard ceilings or gypsum wallboard ceilings directly attached to structural framing, as in conventional wood frame construction, to avoid damaging finished ceiling surfaces.
- Verify suitability of installation instructions for recessed luminaires for other ceiling materials such as wood or plaster.
- Verify the suitability of luminaires for recessed installation in fire rated ceilings, if applicable. Consult the UL Fire Resistance Directory to deter- mine if recessed luminaires are permitted, including the size, number, and spacing of luminaires and any special constructions required to maintain the specified fire rating.
- Make electrical connections to supply conductors while supply conductors are accessible. Do not install luminaires prior to making electrical connections when luminaire installation renders supply conductors inaccessible. See 6.1.
- After installation and prior to securing in place, ensure luminaires are level, plumb, and adjusted as required.
- Assist the HVAC contractor as necessary, to assure proper connection onto the luminaires of HVAC devices, such as supply and return air boots.

STANDARD FOR INSTALLING EXTERIOR LIGHTING SYSTEMS

(For complete publication, see NECA 501-2006)

PRODUCTS AND APPLICATIONS

This standard describes installation procedures for lighting systems commonly used in outdoor applications on and near commercial, institutional, industrial and storage buildings, including but not limited to the following:

1. *Pole mounted spot lights, area lights, sports lights and floodlights*
2. *Illuminated bollards*
3. *Wall mounted sconces, wall bracket lights, and wall pack lights*
4. *Above ground mounted floodlights and spot lights*
5. *In ground floodlights and spot lights*
6. *Step lights and other lights recessed into exterior walls and other concrete surfaces*
7. *Canopy and soffit mounted surface lights*
8. *Landscape lighting*

GENERAL INSTALLATION

- Install the luminaire in its intended manner. Make certain the unit is level and/or plumb and tighten mounting hardware securely. Observe bolt torque and other specific installation recommendations.
- Use only mounting hardware provided or specified by the manufacturer. Avoid using other hardware (such as spare or replacement bolts) because of problems such as poor fit or mismatched threads.

STANDARD FOR INSTALLING INDUSTRIAL LIGHTING SYSTEMS

(For complete publication, see NECA 502-2006)

PRODUCTS AND APPLICATIONS

This standard describes installation procedures for lighting systems commonly used in industrial and storage buildings, including, but not limited to, the following:

- High intensity discharge (HID) low-bay and high- bay lighting systems.
- Fluorescent strip lights and general purpose industrial overhead lighting systems.
- Common special-purpose and special-environment industrial luminaires.
- Lighting installed on industrial wireway and track lighting systems.

GENERAL INSTALLATION

Install luminaire in intended manner. Be certain to install gaskets and other parts in accordance with manufacturer's instructions. Make certain luminaire is level and/or plumb and tighten mounting securely.

STANDARD FOR INSTALLING FIBER OPTIC LIGHTING SYSTEMS

(For complete publication, see NECA 503-2005)

PRODUCTS AND APPLICATIONS

This standard describes installation procedures for glass fiber optics lighting systems.

GENERAL INSTALLATION

- Power and control wiring and lighting controls may be installed before, during, or after installation of glass tails.
- Glass harnesses are delivered ready for installation without further assembly.
- Large quantities of fittings can be ordered powder-coated at the factory as per sample. For a small number of fittings, which must be colored on site, order disassembled components. Before assembling fittings, provide ample time for painting the metal fitting surrounds if required to match the ceiling/wall/floor background. Use a small painter's brush to avoid getting paint on the glass tail ends.
- Arrange for auxiliary devices such as theatrical computers and dimmers to be delivered at the same time as the fiber optic components so as not delay the installation

STANDARD FOR INSTALLING AND MAINTAINING HIGH MAST, ROADWAY AND AREA LIGHTING

(For complete publication, see NECA 505-2010)

SCOPE

This standard describes the installation and maintenance procedures for high mast, roadway, area, and sport lighting systems installed outdoors for commercial, institutional, and industrial applications. This Standard applies to high intensity discharge lighting luminaires rated 600 Volts and less and mounted on poles.

GENERAL INSTALLATION

- Assemble and install poles, luminaires, and components in accordance with applicable requirements of the NEC, contract documents, approved shop drawings, manufacturer recommendations, and recognized industry practices.
- Ensure that components and accessories are compatible with other system components and are listed for the purpose and the installed environment. Use manufacturer -recommended fasteners. Ensure that luminaires meet the building code requirements for their particular zoning district.
- Install equipment plumb, square, level, and secure. Ensure that poles are aligned with the mast arms in a plane perpendicular to the roadway centerline where applicable.
- Sequence electrical pole installation work with other work to minimize possibility of damage and soiling during remainder of construction period.
- Install breakaway devices in strict compliance with the manufacturer's details and instructions. Ensure that in fiberglass poles or poles with break-away bases, fuseholders used are specifically designed as a breakaway device, disconnecting the fuse from supply power without damage to the terminals or conductors every time sufficient pulling force is placed on the line and load side conductors.
- In preparation for and while setting poles in place, examine pole sections for scratches, nicks, and mars. Recondition by removing any rust and coating the damaged area with an approved cold zinc coating compound. Remove all markings placed on the pole for the purposes of fabrication, shipping, or installation.

STANDARD FOR INSTALLING COMMERCIAL BUILDING TELECOMMUNICATIONS CABLING

(For complete publication, see NECA 568-2006)

PRODUCTS AND APPLICATIONS

A structured cabling system is a complete collective configuration of cabling and associated hardware on a premises which, when installed, provides a comprehensive telecommunications infrastructure. This infrastructure is intended to support a wide range of telecommunications services such as telephone and computer networks.

This Standard describes minimum requirements and procedures for installing the infrastructure for telecommunications including balanced twisted pair copper cabling and optical fiber cabling that trans- port telecommunications signals (e.g., voice, data, video). Installers should always follow applicable codes and manufacturers' instructions.

INSTALLATION VERIFICATION

Installation conformance is performed through a systematic method that ensures the installation has been completed in accordance with industry standards and the terms and conditions of the installation contract. Visual inspection and documentation are required for proof of proper installation conformance.

Performance test documentation of the installed cabling shall be provided to the building owner or agent per contract requirements, or, in lieu of contract requirements, in the format delivered by the certification test instrument. Certification of the cabling in commercial buildings determines whether the cabling meets expected ANSI/TIA 568-B Series performance (e.g., category 5e, category 6). This TIA performance specification is used by application standards organizations to develop future applications and ease the cabling burden of consumers. Consumers can then take advantage of these advances in application technology for their networks.

STANDARD FOR INSTALLING AND MAINTAINING MEDIUM-VOLTAGE CABLE

(For complete publication, see NECA 600-2014)

PRODUCTS AND APPLICATIONS

This standard describes installation procedures for shielded and non-shielded solid-dielectric medium- voltage cables rated from 2001 Volts to 35,000 Volts AC and installed in conduits or ducts, or direct- buried. This publication applies to single-and multi- conductor cables used for distributing power for commercial, institutional, and industrial loads in nonhazardous locations both indoors and outdoors.

This Standard also covers periodic routine maintenance and troubleshooting procedures for medium-voltage cable, and special procedures used after adverse operating conditions such as a short circuit or ground-fault.

GENERAL INSTALLATION

Install cables, terminations, and splices in accordance with manufacturers' instructions using the manufacturers' approved materials, tools, and installation methods.

Coordinate utility interruptions of occupied facilities with the owner, serving utility, general contractor, engineer of record, and others affected by outages.

Make provisions for supplying adequate slack to properly train and support cables.

Test cable on reels prior to installation. Consult the manufacturer for recommendations for any deficient test results.

Install all cables in one conduit at the same time. Do not pull cable into a conduit that already contains conductors. Do not reinstall cables for permanent use that have been removed from a conduit or duct.

Do not install cable in conduit bodies.

Clean manholes prior to cable installation. Provide temporary water diversion, such as sand bags, to prevent water from running into open manholes in sidewalks, streets, or parking lots. Install manhole rings at least 150 mm (6 in.) above the ground around manhole entrances to keep surface water from entering open manholes during cable installation.

When cables are to be installed in cold weather, place cables in a heated environment for a minimum of 24 hours prior to installation or as recommended by the manufacturer. Do not install cables at temperatures lower than the minimum recommended installation temperature unless approved by the manufacturer.

RECOMMENDED PRACTICE FOR INSTALLING UNDERGROUND NONMETALLIC UTILITY DUCT

(For complete publication, see NECA 605-2005)

SCOPE

This manual covers recommendations for shipping, handling, storage, installation, and joining of under- ground single bore nonmetallic duct for power, lighting, signaling, and communications applications.

This manual is not intended to assume or replace any responsibilities of engineers, customer representatives, owners, or other persons in establishing engineering design practices and procedures best suited to individual job conditions.

Although not specifically mentioned in this manual, variations of the products discussed may occasionally be specified. Users should follow installation recommendations of the manufacturer.

PROPER INSTALLATION – TRENCHING PROCEDURES

- A duct system is considered properly installed if the inside diameter of each duct is adequate to allow free passage of the specified deflection mandrel.
- To limit deflection, pay attention to trench bedding, duct separation, spacer intervals, type of back-fill material, and amount of compaction.

STANDARD FOR INSTALLING OVERCURRENT PROTECTION TO ACHIEVE SELECTIVE COORDINATION

(For complete publication, see NECA 700-2010)

SCOPE

This standard describes the application procedures for selecting and adjusting low-voltage overcurrent protective devices to achieve selective coordination.

PROPER INSTALLATION – TRENCHING PROCEDURES

This standard covers the installation of low-voltage overcurrent protective devices, circuit breakers and fuses, rated 600 volts and less, for selective coordination in electrical distribution systems for residential, commercial, and industrial applications. It applies to:

- Devices rated 600 V and less
- Fuses
- Circuit breakers

INSTALLATION – ACHIEVING SELECTIVE COORDINATION

It is important to install the exact equipment selected during the design process, and to install the equipment in accordance with applicable codes, standards and manufacturer recommendations. Substitutions for equipment specified in the design must be carefully analyzed to verify compatibility and compliance with selective coordination requirements, and can be considered a redesign of the electrical distribution system.

Short circuit and coordination studies are the basis for selecting overcurrent protective devices and the settings of adjustable-trip circuit breakers and should be completed during design by qualified personnel.

APPENDIX C: SAMPLE RECORD AND CHECKLIST FORMS

TO CUSTOMIZE THIS FORM FOR YOUR BUSINESS, CLICK HERE TO DOWNLOAD AS A WORD DOCUMENT. DOWNLOAD

Test Records

- Electrical Equipment Test Record
- Insulation Resistance Test Record
- Instrument Wire & Cable Test Record
- Power/Control Wire & Cable Test Record
- Dynamometer Test Record
- MV Power Cable Test Record - Continuity and Megger
- MV Power Cable Test Record – High Potential Insulation Test and Leakage Current Test
- Concrete Supply and Pouring

Other Records

- Letter of Transmittal
- Request for Information
- Record of Information Received
- Daily Work Report
- Activity Preplan
- Shop Drawing Approved
- Installation Hold
- Installation Approved
- Ground Resistance Record
- Tool/Equipment Maintenance & Repair Record
- Tool/Equipment Calibration Record
- Equipment out of Calibration
- Material/Equipment Procurement Log
- Construction Inspection Record
- Punchlist Correction Record
- Material Receiving Report
- Material Receiving Instruction
- Material Deficiency Report
- Storage Yard Inspection Report
- Deficiency Report
- Deficiency Report Log
- Project Identification
- Topographic References

Installation/Construction Checklists

- Cable Installation Checklist
- Raceway Installation Checklist
- Grounding System Installation Checklist
- Outdoor Bus Duct Installation Checklist
- Indoor Bus Duct Installation Checklist
- MCC Installation Checklist
- Panel Installation Checklist
- UPS Installation Checklist
- Motor Installation Checklist
- ATS Installation Checklist
- Generator Installation Checklist
- Switchgear Installation Checklist
- Transformer Installation Checklist
- Underground Duct Bank Installation Checklist
- Underground Raceway Installation Checklist
- Manhole Installation Checklist (After Concrete & Duct Bank Installation)
- Manhole Installation Checklist (Prior to Concrete Placement)
- Excavation and Backfilling Inspection Test Plan
- Foundation Inspection Test Plan
- Steel Structure and Supports Inspection Test Plan
- Cable Pulling
- Cable Pull Record
- Cable Termination
- Electrical Equipment And Instrumentation
- Light Fixture Installation
- Light Standards Installation

Startup Checklists

- Bust Duct Startup Checklist
- MCC Startup Checklist
- Panel Startup Checklist
- Motor Startup Checklist
- Switchgear Startup Checklist
- Transformer Startup Checklist
- VFD Startup Checklist

ELECTRICAL EQUIPMENT TEST RECORD

DESCRIPTION:							
TEST DESCRIPTION:							
EQUIPMENT TAG NUMBER	READINGS (OHMS)						CHECKED BY
	A to G	B to G	C to G	A to B	B to C	C to A	

INSULATION RESISTANCE TEST RECORD

DESCRIPTION:							
TEST DESCRIPTION:							
SWGR/PNL DESIGNATION							
TEST VOLTAGE:							
TEST DURATION:							
EQUIPMENT TAG NUMBER	**READINGS (OHMS)**						**CHECKED BY**
	A to G	**B to G**	**C to G**	**A to B**	**B to C**	**C to A**	

INSTRUMENT WIRE & CABLE TEST RECORD

DESCRIPTION:						
TEST DESCRIPTION:						
CABLE NUMBER	CABLE TYPE	READINGS				CHECKED BY
		CONDUTCOT TO CONDUCTOR (MEGOHMS)	CONDCTOR TO SHIELD (MEGOHMS)	SHIELD TO CONDUIT (MEGOHMS)	OTHER TEST (MEGOHMS)	

POWER/CONTROL WIRE & CABLE TEST RECORD

DESCRIPTION:

TEST DESCRIPTION:

CIRCUIT NUMBER	WIRE TAG	WIRE				READING (MEGOHMS)	CHECKED BY
		VOLTAGE	SIZE	FROM	TO		

DYNAMOMETER TEST RECORD

PROJECT:	DATE:
LOCATION	TEMPERATURE:
TEST BY:	HUMIDITY:
CIRCUIT NUMBER:	NUMBER OF CONDUCTORS:
MANUFACTURER:	CONDUCTOR SIZE:
RATED VOLTAGE:	INSULATION TYPE:
OPERATING VOLTAGE:	INSULATION THICKNESS:
LENGTH:	OUTER JACKET TYPE:
AGE:	RACEWAY TYPE:
MAXIMUM RECOMMENDED PULLING FORCE:	

INTERVALS	TIME (MINUTES)	PULLING FORCE (FOOT LBS)

MEDIUM VOLTAGE POWER CABLE TEST RECORD - CONTINUITY AND MEGGER

PROJECT:	DATE:
TESTED BY:	TEMPERATURE:
WITNESSED BY:	HUMIDITY:
TEST EQUIPMENT:	
TEST DESCRIPTION:	

CIRCUIT/CABLE INFORMATION	
CIRCUIT NUMBER	CABLE CONSTRUCTION
CIRCUIT FROM	CONDUCTOR SIZE
CIRCUIT TO	CONDUCTOR MATERIAL
MANUFACTURER	INSULATION RATING
RATED VOLTAGE	INSULATION TYPE
OPERATING VOLTAGE	

PHYSICAL INSPECTION & CHECKS	
CABLE SIZE & RATING PER DESIGN & CODE REQUIREMENTS	
CABLE/RACEWAY SUPPORT SYSTEM PER DESIGN & CODE REQUIREMENTS	
CABLE CHECKED FOR VISIBLE DAMAGE	
TERMINATIONS & SPICES INSPECTED FOR PROPER INSTALLATION	
CABLE/RACEWAY FITTINGS INSPECTED FOR PROPER INSTALLATION	

MEGGER TEST (2500 VOLTS @ 1 MINUTE)	READING (MEGOHMS)
PHASE "A" TO GROUND WITH PHASES "B" AND "C" GROUNDED	
PHASE "B" TO GROUND WITH PHASES "A" AND "C" GROUNDED	
PHASE "C" TO GROUND WITH PHASES "A" AND "B" GROUNDED	
NEUTRAL (IF PRESENT) TO GROUND WITH ALL PHASES GROUNDED	

CONDUCTOR CONTINUITY TESTS		
PHASE "A"	PHASE "B"	PHASE "C"

MEDIUM VOLTAGE POWER CABLE TEST RECORD - HIGH POTENTIAL INSULATION TEST AND LEAKAGE CURRENT TEST

PROJECT:	DATE:
TESTED BY:	TEMPERATURE:
WITNESSED BY:	HUMIDITY:
TEST EQUIPMENT:	
TEST DESCRIPTION:	
TEST VOLTAGE:	

CIRCUIT	CABLE
LOCATION	CABLE CONSTRUCTION
IDENTIFICATION	CONDUCTOR SIZE
LENGTH	CONDUCTOR MATERIAL
RACEWAY TYPE	INSULATION RATING
TERMINATION TYPE	INSULATION TYPE
SPLICES	MANUFACTURER

TEST DATA - MICROAMPERES			
PERCENT TEST VOLTS	PHASE A START TIME CURRENT	PHASE B START TIME CURRENT	PHASE C START TIME CURRENT
10 PCT			
20 PCT			
30 PCT			
40 PCT			
50 PCT			
60 PCT			
70 PCT			
80 PCT			
90 PCT			
100 PCT			
TIME IN SECONDS AFTER REACHING 100% TEST VOLTAGE & HOLDING CONSTANT			
30 SEC			
60 SEC			
90 SEC			
120 SEC			
180 SEC			
240 SEC			
300 SEC			

CONCRETE SUPPLY AND POURING PROTOCOL

PROJECT:							
IDENTIFICATION:							
PROCEDURE/MANUAL							
REFERENCE:							
DATE:							
DELIVERY NOTE	POURING TIME CONTROL		TEMPERATURE		SLUMP	LOCATION	LAB TEST #
	ARRIVAL	FINISH	CONCRETE	ANBIENT			

LETTER OF TRANSMITTAL

TO:	DATE:
	PROJECT:
	PROJECT NO.
REGARDING:	

WE ARE SENDING THE FOLLOWING ITEMS:					ATTACHED		SEPARATELY
	DRAWINGS		SHOP DRAWINGS		INFO REQUEST		QUOTE REQUEST
	SPECIFICATIONS		CATALOG CUTS		COPY OF LETTER		PURCHASE ORDER
	RECORD DRAWINGS		SAMPLES		QA INFORMATION		CHANGE ORDER
	O&M MANUALS		GUARANTEES		OTHER:		

DOCUMENT DATE	NUMBER OF COPIES	DESCRIPTION

THESE DOCUMENTS ARE BEING TRANSMITTED:			
	FOR YOUR APPROVAL		APPROVED AS SUBMITTED
	FOR YOUR USE		APPROVED AS NOTED
	AS YOU REQUESTED		RETURNED FOR CORRECTIONS
	FOR YOUR REVIEW AND COMMENT		RESUBMIT_____COPIES FOR APPROVAL
	DOCUMENTS RETURNED AFTER LOAN TO US		SUBMIT _____ COPIES FOR DISTRIBUTION
	OTHER:		RETURN_____ CORRECTED PRINTS

REMARKS:	
COPIES TO:	SIGNED:

REQUEST FOR INFORMATION

RFI NUMBER:	**DATE:**
TO:	**FROM:**
PLEASE RESPOND BY:	
PROJECT:	
DRAWING/DOCUMENT REFERENCE:	
INFORMATION REQUEST:	
RESPONSE:	
RESPONSE BY:	**DATE:**

RECORD OF INFORMATION RECEIVED

PROJECT:	
DATE/TIME:	
INFORMATION RECEIVED FROM:	
INFORMATION RECEIVED VIA: [MEETING] [LETTER] [PHONE] [FAX] [OTHER]	
SUBJECT:	
DRAWING/DOCUMENT REFERENCE:	
INFORMATION RECEIVED:	
PREPARED BY	**DATE:**

DAILY WORK REPORT

PROJECT:	
PROJECT NO.	REPORT BY:
DAY:	DATE:

DAILY EMPLOYEE REPORT			
CARRY OVER	NEW HIRES	LAID OFF	TOTAL WORKING

WORK PERFORMED TODAY:

INSPECTIONS/VISITS TODAY:

DELAYS/PROBLEMS	YES	NO	EXPLANATION
WAITING FOR MATERIALS			
WAITING FOR TOOLS OR EQUIPMENT			
TOOL AND/OR EQUIPMENT BREAKDOWN			
PROJECT/ACTIVITY DELAY			
CHANGES AND/OR REWORK			
WORK ACCESS PROBLEM			
DISRUPTION			
WAITING FOR INFORMATION			
WAITING FOR INSPECTION			
OTHER			

OTHER:

ACTIVITY PREPLAN

PROJECT:			
PROJECT NO.		PLAN BY:	
ACTIVITY DESCRIPTION:			
FOREMAN		PLAN DATE:	
SCHEDULED START:	DATE:	EXPECTED FINISH:	DATE:
	TIME:		TIME:
CREW:			
DRAWING/SPECIFICATION REFERENCES:			

MATERIALS/EQUIPMENT/EXPENDABLES REQUIRED	QUANTITY

TOOLS AND EQUIPMENT NEEDED	QUANTITY

WHEN FINISHED WITH THIS ACTIVITY:

SHOP DRAWING APPROVED

THIS SHOP DRAWING HAS BEEN REVIEWED AND IS IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS.	
REVIEWED BY:	DATE:

INSTALLATION HOLD

INSTALLATION IS NOT APPROVED DUE TO: **[ ] INSPECTION RESULTS** **[ ] TEST RESULTS** **[ ] OTHER:**	
INSPECTED BY:	**DATE:**
TESTED BY:	**DATE:**
HOLD BY:	**DATE:**

INSTALLATION APPROVED

INSTALLATION HAS BEEN INSPECTED AND TESTED AS REQUIRED AND IS IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS	
INSPECTED BY:	DATE:
TESTED BY:	DATE:
HOLD BY:	DATE:

GROUND RESISTANCE RECORD

PROJECT:	**DATE:**
TEST EQUIPMENT:	**IDENTIFICATION NUMBER:**
TEST DESCRIPTION:	

GROUND LOCATION	AMB TEMP (°F)	SOIL CONDITION	TEST PERFORMED BY	GROUND RESISTANCE (OHMS)	DATE TIME

TOOL/EQUIPMENT MAINTENANCE & REPAIR RECORD

EQUIPMENT:	
IDENTIFICATION NUMBER:	
MANUFACTURER:	**SERIAL NUMBER:**

DATE	WORK PERFORMED	WORK PERFORMED BY

TOOL/EQUIPMENT CALIBRATION RECORD

EQUIPMENT:	
IDENTIFICATION NUMBER:	
MANUFACTURER:	**SERIAL NUMBER:**
CALIBRATION PROCEDURE:	

DATE	CALIBRATION RESULTS	CALIBRATION PERFORMED BY	NEXT SCHEDULED CALIBRATION

EQUIPMENT OUT OF CALIBRATION

THIS EQUIPMENT IS NOT TO BE USED AND THIS TAG IS NOT TO BE REMOVED UNTIL EQUIPMENT HAS BEEN CALIBRATED	
TAGGED BY:	DATE:

MATERIAL/EQUIPMENT PROCUREMENT LOG

PROJECT:					
PROJECT NO.			PREPARED BY		
SPECIFICATION SECTION	MATERIAL/EQUIP DESCRIPTION	SUBMITTAL SUBMITTED (DATE)	SUBMITTAL APPROVED (DATE)	ORDER PLACED (DATE)	MAT/EQUIP RECEIVED (DATE)

CONSTRUCTION INSPECTION RECORD

PROJECT:			
AREA:			
INSPECTION PERFORMED BY:			
INSPECTION DATE:			
ITEM NUMBER	**DESCRIPTION OF DISCREPANCY**	**DATE CORRECTED**	**CORRECTED BY**

PUNCHLIST CORRECTION RECORD

PROJECT:			
AREA:			
PUNCHLIST PREPARED BY:			
PUNCHLIST DATE:			
ITEM NUMBER	**DESCRIPTION OF DISCREPANCY**	**DATE CORRECTED**	**CORRECTED BY**

MATERIAL RECEIVING REPORT

PROJECT:	MRR NO.:
AREA:	CONTRACT NO:
PUNCHLIST PREPARED BY:	PO NO:
PUNCHLIST DATE:	

QUANTITY RECEIVED	MATERIAL DESCRIPTION	REMARKS	SIGNED BY

MATERIAL RECEIVING INSTRUCTION

PROJECT:	**MRI NO.:**
CONTRACTOR:	**CONTRACT NO:**
SUPPLIER:	
ITEMS:	

RECEIVING, STORAGE AND MAINTENANCE REQUIREMENTS	DOCUMENTATION REQ'D. (✓)	
	INSTALLATION MANUAL	TEST REPORT
Mill test report		
Material Certification		
Welding procedure		
Non-destructive test report		

COMMENTS:

MATERIAL DEFICIENCY REPORT

PROJECT:	MDR NO.:
CONTRACTOR:	CONTRACT NO:
SUPPLIER:	REFERENCE MDR NO:
MATERIAL DESCRIPTION:	

DESCRIPTION OF LOSS, DAMAGE, OR UNSATISFACTORY CONDITION	CONTRACTOR	
	SIGNATURE	DATE

DISPOSITION	APPROVAL	
	SIGNATURE	DATE

COMMENTS:

STORAGE YARD INSPECTION REPORT

PROJECT:	CONTRACT NO:		
CONTRACTOR:			
STORAGE YARD LOCATION:			
ITEMS	**YES**	**NO**	**N/A**
1. 24-hour guard service is provided.			
2. Materials are properly cribbed and stacked to prevent sagging.			
3. Materials are properly banded and covered where required.			
4. Damaged materials are properly tagged for repair or replacement and have been properly segregated.			
5. Erosion control is properly maintained by the contractor. • Sedimentation basins are cleaned out and functional • Weed control adequate • Ditching is adequate and in working condition • Roads are free of ruts and any erosion			
6. Site is clean and free of all garbage and debris.			
7. Combustible materials are isolated as required and safety regulations are in force.			
8. Other verification performed.			

INSPECTED BY:

NAME / ORGANIZATION / DATE

DEFICIENCY REPORT

PROJECT:	**DR NO.:**
CONTRACTOR:	**CONTRACT NO:**
LOCATION:	

DESCRIPTION OF PROBLEM OR DEFICIENCY AND RECOMMENDED CORRECTIVE ACTION (IF ANY)	**CONTRACTOR**	
	SIGNATURE	**DATE**

DISPOSITION	**APPROVAL**	
☐ **REWORK** ☐ **REJECT** ☐ **ACCEPT AS-IS**	**SIGNATURE**	**DATE**
COMMENTS:		

CORRECTIVE ACTION AND WORK COMPLETED:

_____

NAME / ORGANIZATION / DATE

DEFICIENCY REPORT LOG

DR NO	INITIATED BY NAME/ ORGANIZATION	DATE WRITTEN	DATE OF WORK COMPLETED	REMARKS

PROJECT INFORMATION

PROJECT IDENTIFICATION	
INSTALLATION:	
CUSTOMER:	CUSTOMER REF:
DESCRIPTION:	PROJECT REF:
WORK START DATE:	IMPLEMENTATION PERIOD:
PROJECT MANAGER:	
CONSTRUCTION MANAGER:	
SUPERVISOR:	
IDENTIFICATION:	DATE:

CONTRACTOR IDENTIFICATION
COMPANY:
PROJECT MANAGER:
SITE MANAGER:

INDEX	NUMBER OF ELEMENTS	APPLICABLE Y/N
1:		
2:		
3:		
4:		
5:		
6:		
7:		
8:		
9:		
10:		

CONSTRUCTION MANAGER	SITE MANAGER:
NAME / ORGANIZATION / DATE	NAME / ORGANIZATION / DATE

TOPOGRAPHIC REFERENCE

PROJECT IDENTIFICATION		
PROJECT: **Attendees gathered on behalf of their companies on the day and date that relates to the foot of this act, they acknowledge:** **First –** Set delivery to the contractor for execution of the project referenced in the title system, including the implementation plan for the redesign with the coordinates of the axis of staking or installation singular points in the coordinates of the bases / vertices existing reference in the field of the work. **Second –** Both parties review documentation regarding it as to begin execution of the work. **Third –** Both parties checked the coordinates of the main points of the staking (Bases of the study, axes singular points staking or installation) considering this according to the characteristics of the work. **Fourth –** I have not detected any significant incidents that may interfere with the star of the Work.		
ARE THE MAIN LAYOUT POINTS PHYSICALLY MARKED ON THE GROUND DURING THE MEETING? (Only if so, fill the table below regarding the DATA-OUT)	**YES**	**NO**
TOPOGRAPHIC EQUIPMENT (SERIAL NO. – TYPE – MAKE – MODEL ACCURACY (ANGLE/DISTANCE):		
LAST DATE OF CALIBRATION:		
CERTIFICATION PROVIDED	**YES**	**NO**
COORDINATES U.T.M.	**YES**	**NO**
REFERENCE SYSTEMS:		

CHECKING THE BASES / VERTEX FOR STUDY AND LAYOUT									
	COOR. PROJECT		**COOR. LAYOUT**		**DIFFERENCES**		**THEIR MILESTONE / NAIL / SIGNAL PHYSICALLY IN LAND**		
BASE/VERTICLE 1	X =		X =		X =		**YES**	**NO**	
	Y =		Y =		Y =				
	Z =		Z =		Z =				
BASE/VERTICLE 2	X =		X =		X =		**YES**	**NO**	
	Y =		Y =		Y =				
	Z =		Z =		Z =				
BASE/VERTICLE 3	X =		X =		X =		**YES**	**NO**	
	Y =		Y =		Y =				
	Z =		Z =		Z =				

LAYOUT OF LONGITUDINAL AND CROSS AXIS OR SINGULAR POINTS OF THE INSTALLATION									
	PROJECT COOR.		**MARKED COOR.**		**DIFFERENCES**		**JUSTIFICATION**		
POINT 1	X =		X =		X =		**YES**	**NO**	
	Y =		Y =		Y =				
POINT 2	X =		X =		X =		**YES**	**NO**	
	Y =		Y =		Y =				
SQUARE POINT	X =		X =		X =		**YES**	**NO**	
	Y =		Y =		Y =				

CONTRACTOR:	**APPROVAL:**
NAME / ORGANIZATION / DATE	**NAME / ORGANIZATION / DATE**

CABLE INSTALLATION CHECKLIST

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	DRAWING NO(S):
	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Cable voltage class, insulation type, construction, material, and size are in accordance with the drawings and specifications.	
Cable pulling schedule has been checked for direction and method of pull. Cable pulling compound is in accordance with cable manufacturer recommendations.	
Instrument cable has been checked for continuity and isolation from drain wire on reel in accordance with manufacturer recommendations.	
Metalclad cables have been meggered before installation.	
Cables have been inspected after installation for damage.	
Power and control wire and cable have been meggered after installation and the results documented.	
Instrument cable has been meggered for continuity and isolation from drain and ground after installation and the results documented.	
High voltage shielded cables have been hi-potted following installation and the results documented.	
Cables have been identified and marked in accordance with drawings and specifications. Cable terminated properly.	
As-built drawings and cable and raceway schedules have been completed.	

COMMENTS:

RACEWAY INSTALLATION CHECKLIST

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	DRAWING NO(S):
	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Conduit, box, and fitting types and sizes are per the drawings and specifications.	
Conduit and boxes are supported in accordance with the drawings and specifications. Installation is neat and workmanlike. Raceway material is free of burs, slivers, and sharp edges.	
Conduits are clean, stub-ups are protected, open ends are plugged, boxes are covered, and box openings are plugged. Any damage during construction has been repaired.	
Bend radii are per drawings and specifications. Bends are free of deformities.	
Expansion joints, conduit seals, and drains are installed in accordance with the drawings and specifications. Conduit seals have been poured and marked.	
Spacing between low-voltage communications, instrumentation, and control conduits and power conduits is maintained per the drawings and specifications. Distance from hot piping and surfaces has been maintained.	
Flexible metal conduit is installed in accordance with the plans and specifications with proper fittings.	
Metallic conduit and boxes are permanently and effectively grounded.	
Conduits and boxes have been marked and tagged in accordance with the plans and specifications.	
As-built drawings and raceway schedules have been completed.	

COMMENTS:

GROUNDING SYSTEM INSTALLATION CHECKLIST

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	DRAWING NO(S):
	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Size and type of grounding and bonding conductors are in accordance with the drawings and specifications.	
Grounding electrodes have been installed in accordance with the drawings and specifications.	
Connections to grounding electrodes have been made in accordance with manufacturer recommendations and inspected.	
Grounding conductors have been routed in accordance with the drawings and specifications.	
Grounding conductors been properly terminated at the service equipment or separately derived source. Bonding conductors have been installed as required.	
Resistance of the grounding system has been measured and recorded.	
As-built drawings for the grounding systems have been completed.	

COMMENTS:

OUTDOOR BUS DUCT INSTALLATION CHECKLIST

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	DRAWING NO(S):
	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Bus duct components, fittings, and terminations have been inspected to determine proper type, required quantity, and any damage during shipment.	
Bus duct shipping blocks and supports have been removed.	
Bus duct has been routed and securely supported in accordance with the drawings and specifications.	
All connections have been torqued in accordance with manufacturer recommendations. Where required for aluminum bus, a manufacturer recommended oxide inhibitor has been used on all connections.	
Drain holes have been unplugged and gaskets installed where required.	
Expansion fittings have been installed where required and in accordance with manufacturer recommendations.	
Completed bus duct installation has been successfully meggered and the results recorded.	
Proper bus phasing has been verified and bus bars identified accordingly.	
Space heaters and controls have been installed and connected and their operation verified.	
As-built drawings for the bus duct installation have been completed.	

COMMENTS:

INDOOR BUS DUCT INSTALLATION CHECKLIST

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	DRAWING NO(S):
	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Bus duct components, fittings, and terminations have been inspected to determine proper type, required quantity, and any damage during shipment.	
Bus duct shipping blocks and supports have been removed.	
Bus duct has been routed and securely supported in accordance with the drawings and specifications.	
All connections have been torqued in accordance with manufacturer recommendations. Where required for aluminum bus, a manufacturer recommended oxide inhibitor has been used on all connections.	
Expansion fittings have been installed where required and in accordance with manufacturer recommendations.	
Completed bus duct installation has been successfully meggered and the results recorded.	
Proper bus phasing has been verified and bus bars identified accordingly.	
As-built drawings for the bus duct installation have been completed.	

COMMENTS:

MOTOR CONTROL CENTER INSTALLATION CHECKLIST

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	DRAWING NO(S):
	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Perform visual inspection to check for damage.	
Verify proper working clearances for code compliance.	
Review manufacturer's installation requirements.	
MCC sections set in correct numbering sequence.	
Verify proper alignment of MCC sections.	
Verify all sections are anchored.	
Verify all sections bolted together.	
Verify installation of bus ties.	
Verify installation and termination of control conductors between sections.	
Check all bolts for proper torque.	
Protect from construction environment.	

COMMENTS:

PANEL INSTALLATION CHECKLIST

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	DRAWING NO(S):
	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Perform visual inspection to check for damage.	
Verify proper working clearances for code compliance.	
Review manufacturer's installation requirements.	
Panel sections set in correct numbering location.	
Verify proper alignment of panel interior and covers sections.	
Verify panel box is securely anchored.	
Check all bolts for proper torque.	
Protect from construction environment.	
Verify proper information on panel schedule and that schedule is clearly typed (not hand written)	

COMMENTS:

UPS INSTALLATION CHECKLIST

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	DRAWING NO(S):
	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Perform visual inspection to check for damage.	
Verify proper working clearances for code compliance.	
Review manufacturer's installation requirements.	
UPS unit matches submittal and specifications requirements.	
Verify proper alignment of UPS conduit entries for line and load connections.	
Verify UPS set is properly anchored.	
UPS unit is to have final connections to batteries and AC power applied by factory representative only.	
Verify proper torque of electrical connections as outlined by manufacturer.	
Verify installation and termination of control conductors to UPS unit for any field monitoring and alarms.	
Check all bolts for proper torque.	
Protect from construction environment.	

COMMENTS:

MOTOR INSTALLATION CHECKLIST

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	DRAWING NO(S):
	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Verify proper size short circuit protection.	
Verify proper size overload protection.	
Verify disconnect switch within sight of controller.	
Verify disconnect switch within sight of motor.	
Perform insulation test on motor.	
Check nameplate and verify proper circuit voltage.	
Check nameplate and verify proper winding connections.	

COMMENTS:

ATS INSTALLATION CHECKLIST

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	DRAWING NO(S):
	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Perform visual inspection to check for damage.	
Verify proper working clearances for code compliance.	
Review manufacturer's installation requirements.	
ATS unit matches submittal and specifications requirements.	
Verify proper alignment of ATS conduit entries for normal, emergency, and load connections.	
Verify ATS set is properly anchored.	
ATS unit is to have final connections to AC power applied by factory representative only. ATS unit programmable features to be set-up by factory representative only. Verify proper torque of electrical connections as outlined by manufacturer.	
Verify installation and termination of control conductors to ATS unit for any field monitoring and alarms.	
Check all bolts for proper torque.	
Protect from construction environment.	

COMMENTS:

GENERATOR INSTALLATION CHECKLIST

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	DRAWING NO(S):
	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Perform visual inspection to check for damage.	
Verify proper working clearances for code compliance.	
Review manufacturer's installation requirements.	
Generator matches submittal and specifications requirements.	
Verify proper alignment of generator electrical and mechanical connections.	
Verify generator set is properly anchored.	
Generator unit is to be connected to starter battery by factory representative only.	
Verify generator set has necessary fuel oil and exhaust connections.	
Verify installation and termination of control conductors to generator and paralleling switchgear.	
Check all bolts for proper torque.	
Protect from construction environment.	

COMMENTS:

SWITCHGEAR INSTALLATION CHECKLIST

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	DRAWING NO(S):
	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Perform visual inspection to check for damage.	
Verify proper working clearances for code compliance.	
Review manufacturer's installation requirements.	
Switchgear sections set in correct numbering sequence.	
Verify proper alignment of switchgear sections.	
Verify all sections are anchored.	
Verify all sections bolted together.	
Verify installation of bus ties.	
Verify installation and termination of control conductors between sections.	
Check all bolts for proper torque.	
Protect from construction environment.	

COMMENTS:

TRANSFORMER INSTALLATION CHECKLIST

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	DRAWING NO(S):
	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Verify transformer size, voltage, and nomenclature to insure correct location and placement.	
Perform visual inspection to check for damage.	
Verify proper working and ventilation clearances for code compliance.	
Install proper vibration isolation.	
Loosen shipping bolts at transformer core if required by manufacturer.	
Verify correct primary and secondary connections.	
Verify proper torque at terminations.	
Verify correct transformer tap.	
Ground neutral at secondary where required.	
Protect from construction environment.	

COMMENTS:

UNDERGROUND DUCT BANK INSTALLATION CHECKLIST

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	DRAWING NO(S):
	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Trenching has been checked for location, elevation, levelness, and debris removal. Manhole and handhole window sizes and locations have been checked. Stub up dimensions and locations have been verified and checked.	
Conduit and fitting types and sizes are per the drawings and specifications. Conduit ends have been sealed.	
Bend radii are per drawings and specifications. Bends are free of deformities.	
Conduit spacers, chairs, tie downs, and expansion joints are installed in accordance with the drawings and specifications.	
Forming and reinforcing is in accordance with the drawings and specifications.	
Concrete coverage is per the drawings and specifications. Spacers, chairs, and reinforcing steel have not been left exposed. Concrete color has been added where required.	
Installation has been backfilled and compacted in accordance with the drawings and specifications.	
Installation has been backfilled and compacted in accordance with the drawings and specifications.	
Conduit has been inspected and is free of damage and clear of any stoppages.	
Conduits have been marked and tagged in accordance with the plans and specifications.	
As-built drawings and raceway schedules have been completed. Spare conduits have been indicated on the as-built drawings.	

COMMENTS:

UNDERGROUND RACEWAY INSTALLATION CHECKLIST

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	DRAWING NO(S):
	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Trenching has been checked for location, elevation, levelness, and debris removal. Stub up dimensions and box locations have been verified and checked.	
Conduit, box, and fitting types and sizes are per the drawings and specifications. Conduit ends are sealed and boxes have been covered.	
Bend radii are per drawings and specifications. Bends are free of deformities.	
Conduit spacing supports, tie downs, and expansion joints are installed in accordance with the drawings and specifications.	
Forming and reinforcing is in accordance with the drawings and specifications where required.	
Concrete coverage is per the drawings and specifications. Spacers and reinforcing steel have not been left exposed. Concrete color has been added where required.	
Installation has been backfilled and compacted in accordance with the drawings and specifications.	
Conduit has been inspected and is free of damage and clear of any stoppages.	
Conduits and boxes have been marked and tagged in accordance with the plans and specifications.	
As-built drawings and raceway schedules have been completed.	

COMMENTS:

MANHOLE INSTALLATION CHECKLIST (AFTER CONCRETE & DUCT BANK INSTALLATION)

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	DRAWING NO(S):
	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Conduit entrances are clean and free of concrete.	
Pulling eyes are free of concrete and pulling lines are in place.	
Cable rack, hooks, saddles and tray are installed per drawings and specifications and properly supported. Cable supports have been inspected and are free of sharp edges. Required manhole ladders and/or rungs have been installed.	
All metallic supports and raceways are properly grounded in accordance with the drawings and specifications.	
Cables and conductors on racks and in trays have been properly positioned, spaced, and tied.	
Cable splices have been made in accordance with manufacturer requirements and properly supported. Drain wires on high voltage cable splices have been terminated in accordance with the drawings and specifications.	
Cables have been fireproofed in accordance with the drawings and specifications.	
Manhole convenience outlets, lighting, sump pump and other auxiliary systems have been installed in accordance with the drawings and specifications. Manhole has been cleaned and is free of debris.	
As-built drawings and cable and raceway schedules have been completed.	

COMMENTS:

MANHOLE INSTALLATION CHECKLIST (PRIOR TO CONCRETE PLACEMENT)

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	DRAWING NO(S):
	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Duct bank window sizes and locations are in accordance with the drawings and specifications.	
Forming and reinforcing is in accordance with the drawings and specifications.	
Grounding system is installed in accordance with the plans and specifications.	
Concrete inserts are installed per drawings and specifications and provided with fillers.	
Pulling eyes are in place.	
Concrete has been placed and cured in accordance with the drawings and specifications.	
Installation has been backfilled and compacted in accordance with the drawings and specifications.	
As-built drawings have been completed.	

COMMENTS:

EXCAVATION AND BACKFILL INSPECTION TEST PLAN

PROJECT:	IDENTIFICATION:
ACTIVITY:	REFERENCE:
ELEMENT:	OBSERVATION:
CONTRACTOR SIGANTURE / DATE:	APPROVAL SIGANTURE / DATE:

ITEM NO	DESCRIPTION	SPPECIFICATION / PROCEDURE	INSPECTION		CONTRACTOR		APPROVAL	
			TYPE	%	INITIAL	DATE	INITIAL	DATE
1	PREVIOUS WORK							
2	EXCAVATION							
3	ROCK FILL							
4	EMBANKMENT							
5	SUB-BASE FILL							
6	FINISHES							

FOUNDATION INSPECTION TEST PLAN

PROJECT:	IDENTIFICATION:
ACTIVITY:	REFERENCE:
ELEMENT:	OBSERVATION:
CONTRACTOR SIGANTURE / DATE:	APPROVAL SIGANTURE / DATE:

ITEM NO	DESCRIPTION	SPPECIFICATION / PROCEDURE	INSPECTION		CONTRACTOR		APPROVAL	
			TYPE	%	INITIAL	DATE	INITIAL	DATE
1	LAYOUT							
2	EXCAVATION							
3	MANUFACTURE / POUR CONCRETE							
4	INSTALL ANCHOR RODS							
5	SUPPLY / INSTALL REINFORCING BARS							
6	FORMWORK							
7	SUPPLY AND PLACE CONCRETE							
8	CONCRETE CURING							
9	STRIPPING							
10	EXCAVATE FOUNDATIONS AND EQUIPMENT PADS							
11	CONNECT TO GROUND GRID							

STEEL STRUCTURES AND SUPPORTS INSPECTION TEST PLAN

PROJECT:	IDENTIFICATION:
ACTIVITY:	REFERENCE:
ELEMENT:	OBSERVATION:
CONTRACTOR SIGANTURE / DATE:	APPROVAL SIGANTURE / DATE:

ITEM NO	DESCRIPTION	SPPECIFICATION / PROCEDURE	INSPECTION		CONTRACTOR		APPROVAL	
			TYPE	%	INITIAL	DATE	INITIAL	DATE
1	MATERIAL RECEIPT							
2	TRANSPORTATION AND HANDLING							
3	PROCESS LAYOUT DESIGN							
4	SUPPORTS AND HARDWARE REC'D							
5	POSTS AND BEAMS RECEIPT							
6	WELDERS CERTIFICATION							
7	VISUAL VERIFICATION OF WELDS							
8	ASSEMBLY							
9	TIGHTEN BOLTS							
10	ALIGNMENT							
11	LEVEL							
12	VERTICAL ALIGNMENT							
13	GROUND CONNECTIONS							
14	ANTICORROSION PROTECTION							

CABLE PULLING

PROJECT:		CONTRACT NO
LOCATION:		REPORT NO
CONTRACTOR;		
DRAWING NO(S):		SPEC SECTION(S):
CABLE CIRCUIT NO:		CABLE TYPE
FROM:	TO:	CABLE VIA/ROUTING:
LENGTH:		REEL INVENTORY NO:

ITEMS VERIFED	CONTRACTOR DATE	APPROVAL DATE
1. Raceway (conduit, tray, pull, and j boxes) installation is complete and satisfactory for cable installation.		
2. Cable pulling equipment is available and suitable for operation. a. Cable tension, type, amount and color are acceptable for pull b. Raceway is clean and clear c. Bend radii meets minimum requirement d. Lubricant pull setup and method is acceptable e. Cable end preparation is satisfactory f. Marker in place and cable ties complete		
3. Cable spacing and separation adequate.		
4. Cable ends are sealed		
5. Raceway covers are in place.		

CONTRACTOR:	APPROVAL:
NAME / ORGANIZATION / DATE	NAME / ORGANIZATION / DATE

CABLE PULL RECORD

PROJECT:	CONTRACT NO:
CONTRACTOR:	REPORT NO:
CABLE TYPE:	CABLE REEL NO:

FOOTAGE			PULL LOCATION	DATE
START	END	TOTAL		

CABLE TERMINATION

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	
DRAWING NO(S):	SPEC SECTION(S):

ITEMS VERIFED	CONTRACTOR DATE	APPROVAL DATE
1. Cable Marker complete. a. Cable lug and tool size acceptable. b. Connection is complete and acceptable. Wire # _____ Color _____		
2. Torquing of bus termination acceptable.		
3. Separation is acceptable. a. Cable ties completed as required. b, Device cover installed. c. Shield connected. d. Spare wire shaped and tied off.		

CONTRACTOR:	APPROVAL:
_____ NAME / ORGANIZATION / DATE	_____ NAME / ORGANIZATION / DATE

ELECTRICAL EQUIPMENT AND INSTRUMENTATION

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	
DRAWING NO(S):	SPEC SECTION(S):

ITEMS VERIFED	CONTRACTOR DATE	APPROVAL DATE
1. Work, safety permits, and clearances required by plant personnel obtained prior to the start of work.		
2. Equipment/materials installed are of specified type/model or substitutes have been approved.		
3. Equipment is identified as required.		
4. Equipment is properly located as required.		
5. Equipment alignment leveling is as required.		
6. Equipment installation has adequate clearance for maintenance and removal.		
7. Fasteners and mounting hardware are as required.		
8. All welded and bolted grounding connections are as required.		
9. Circuit breakers/overload relay ratings and settings are as required.		
10. Rows of lighting fixtures are as required.		

CONTRACTOR:	APPROVAL:
NAME / ORGANIZATION / DATE	NAME / ORGANIZATION / DATE

LIGHT FIXTURE INSTALLATION

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	
DRAWING NO(S):	SPEC SECTION(S):

ITEMS VERIFED	CONTRACTOR DATE	APPROVAL DATE
1. Work, safety permits, and clearances required by plant personnel obtained prior to the start of work.		
2. Light fixtures are installed at the specified locations and properly supported.		
3. Poles are installed plumb and properly.		
4. Light fixtures have been grounded.		
5. All cables are tested and terminated. All switches are installed and tested.		
6. Operational tests are performed and accepted.		
7. Illumination level and distribution are acceptable.		

CONTRACTOR:	APPROVAL:
NAME / ORGANIZATION / DATE	NAME / ORGANIZATION / DATE

LIGHT STANDARDS INSTALLATION

PROJECT:	CONTRACT NO
LOCATION:	REPORT NO
CONTRACTOR;	
DRAWING NO(S):	SPEC SECTION(S):

ITEMS VERIFED	CONTRACTOR DATE	APPROVAL DATE
1. Light standards have been modified to conform with current codes		
2. Light standards are installed at specified locations		
3. Light poles are plumb. Anchor bolt washers are installed and nuts are tightened.		
4. Light polls have been grounded.		
5. All cables are tested and terminated.		
6. Operational tests are performed and accepted.		

CONTRACTOR:	APPROVAL:
NAME / ORGANIZATION / DATE	NAME / ORGANIZATION / DATE

BUSDUCT STARTUP CHECKLIST

PROJECT:	DRAWING NO(S):
LOCATION:	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Verify all busway supports are installed and torqued.	
Verify all busway components are installed and complete.	
Verify all spring hangers have been adjusted per manufacturer.	
Verify all joint nuts have been torqued.	
Verify bus duct has been meggered and results recorded.	
Verify correct phasing.	
Verify proper voltage and amperage per drawings.	
Verify proper installation of bus plugs.	
Verify all bus plugs are open and locked out.	

COMMENTS:

MCC STARTUP CHECKLIST

PROJECT:	DRAWING NO(S):
LOCATION:	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Verify interior cleaned.	
Verify line and load cables terminated at correct location.	
Verify voltage and phasing at line terminals correct.	
Verify proper torque at bus ties.	
Verify correct starter size per motor.	
Verify correct overload heater sizing.	
Verify correct control transformer size and voltage.	
Verify auxiliary contact requirements.	

COMMENTS:

PANELBOARD STARTUP CHECKLIST

PROJECT:	DRAWING NO(S):
LOCATION:	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Verify all wiring is complete.	
Verify feeder wire has been meggered.	
Megger panel bus and record.	
Verify breaker dead front and panel cover are installed.	
Verify all breakers are open and locked out.	
Check and record voltage and phase rotation.	

COMMENTS:

MOTOR STARTUP CHECKLIST

PROJECT:	DRAWING NO(S):
LOCATION:	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Verify motor installation completed.	
Measure voltage and record.	
Verify correct rotation.	
Measure amps and record.	

COMMENTS:

SWITCHGEAR STARTUP CHECKLIST

PROJECT:	DRAWING NO(S):
LOCATION:	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Verify all circuit breakers are open and locked out.	
Disconnect control wiring and megger bus.	
Verify correct phasing on wire terminations.	
Verify no cross phasing on parallel feeders.	
Verify proper torque at terminations.	
Energize line side of main circuit breaker(s).	
Verify proper voltage at line side of main circuit breaker(s).	
Verify correct phase rotation.	
Close main circuit breaker(s).	
Verify correct voltage at load side of main circuit breaker(s).	
Verify in-phase voltages at tie breakers.	

COMMENTS:

TRANSFORMER STARTUP CHECKLIST

PROJECT:	DRAWING NO(S):
LOCATION:	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Remove cover and visually inspect.	
Wipe down transformer.	
Verify proper torque at terminations.	
Verify all grounding completed.	
Install cover.	
Energize and record voltage.	

COMMENTS:

STARTUP / VFD STARTUP CHECKLIST

PROJECT:	DRAWING NO(S):
LOCATION:	SPEC SECTION(S):

QUALITY ASSURANCE ACTIVITY	CHK'D BY DATE
Verify interior cleaned.	
Verify line and load cables terminated at correct location.	
Verify voltage and phasing at line terminals correct.	
Coordinate start up with factory technician.	

COMMENTS:

APPENDIX D: BIQ NARRATIVE EXAMPLES FOR WORK ACTIVITIES

ACTIVITY: ELECTRICAL ROOM BUILD-OUT

Scope

- Install panelboards, transformers and corresponding conduit & supports in the central electrical room on each floor.

Responsibilities

- Use MEP coordinated shop drawings showing floor plan and elevations of each wall. Install as per these drawings. If a change is required, consult with BIM coordinator before proceeding.
- Acquire panels and transformers dedicated to the room being worked on and install **exactly** to the seismic design for that equipment and location.

Process Features and Standards

- Install panel backbox tops level and aligned (when possible).
- Use correct size and number of screws as determined by seismic drawings
- When installing transformers, torque all anchors to the values called out in the seismic drawings and perform in the presence of the IOR unless told otherwise.
- Mount transformers on isolation pads that run the full length of the mounting channel.
- Use a minimum of 2' of flex when connecting a conduit to the transformer housing.
- Leave at least 6" of space between the transformer and the wall.
- Support conduit within 3' of boxes, cabinets, panels, transformers and every 10' of conduit run.
- Install ground bushings on all feeder conduit connectors at panelboards and transformers.
- When using strut for conduit, do not use punched or slotted. Use solid strut and drill mounting holes no larger than 1/8" clearance hole.
- Ensure all conduit connectors have insulated throat.
- Install conduit plumb, level and whenever possible square to the building.
- When passing through a gypboard wall, do not cut any studs.
- Install conduit support seismic bracing as per plans and torque all connections.

Bus Duct

- Megger each piece prior to installation. If less than 50 megohms do not install.
- Use factory supplied lifting device and connection tool for installation.
- Install as per seismic drawings and torque floor support anchors to specified levels.
- When entire run is complete, notify IOR and perform Megger test. Document the results.

ACTIVITY: HIGH OVERHEAD CONDUIT & SUPPORTS

Scope

- Install home run branch conduits, sub-feeder conduits and seismic bracing on high overhead conduit supports.

Responsibilities

- Install conduit supports, conduit and seismic bracing precisely as shown in the MEP coordinated shop drawings. Pay close attention to the placement of prefabbed bends in conduit runs (i.e. 90's, offsets) as referenced in shop drawings.
- Ensure that **all** material for the scheduled work on site prior to starting installation and all torque wrenches have current calibration sticker.

Process Features and Standards

- Install prefabbed trapeze conduit supports level and plumb. Set height above finish floor as per shop drawing. Torque hex nuts on ATR @ trapeze to values shown on Tolco table.
- At seismic locations attach brace arm assemblies to deck and trapeze, torqueing both using the values given in the Tolco table on page 10-40 and U.S. Bolt Torque Spec. Table (see attached) or tightening the break-off bolt head until it breaks off.
- Place pull points in conduit runs as indicated on shop drawings and 2001 CEC 348-12.
- Terminate conduit runs in panelboard or junction box using insulated throat connectors and if the conduit is a feeder conduit, include an insulated ground bushing.

ACTIVITY: IN-WALL ROUGH

Responsibilities

- Assure that proper shop and contract drawings are available and that the appropriate materials are on site prior to starting. Monitor material inventory to keep pace with the schedule demands.
- All tools and accessories are available and batteries (spares included) are fully charged. Housekeeping is an ongoing activity. All scrap materials will be deposited in a scrap container immediately. When an area is complete, remove trash and stored materials.

Process Features and Standards

- Conduit securely fastened in place at least every 10′ and within 3′ of box, cabinet or conduit body.
- MC Cable securely fastened in place at least every 6′ and within 12″ of a box.
- Tele/Data outlets have minimum 1″ conduit to accessible ceiling space with plastic bushing at stub end.
- All unused openings in boxes are sealed.
- Adjacent boxes are level with each other.
- Any stud penetrations done in the field must follow the guidelines set forth in Detail "9" (see attached).
- Do not bend MC Cable tighter than 7 times the external diameter of the cable.
- Do not install boxes directly back to back in rated walls.
- Make sure all connector and coupling screws are tight.
- Use #10 self-drilling truss head screws only for fastening to studs.
- Assure all outlets are installed to proper dimensions, both vertically and horizontally.
- Wrap conduit or MC Cable with tape where contact with other piping occurs.

Observations

- Is the correct depth device ring installed for the given wall type? (Caution: Design changes can happen after original wall layout is done on the floor. Check with Foreman for updates)
- Do all power outlets have grounding pigtail installed?
- Are device rings plumb?
- Are plastic bushings in place on tele/data stubs?

ACTIVITY: LOW OVERHEAD BRANCH CONDUIT, MC CABLE & JUNCTION BOXES

Responsibilities

- Assure that proper shop and contract drawings are available and that the appropriate materials are on site prior to starting. Monitor material inventory to keep pace with the schedule demands.
- All tools and accessories are available and batteries (spares included) are fully charged. Housekeeping is an ongoing activity. All scrap material will be deposited in a scrap container immediately. When an area is complete, remove trash and stored materials.
- Provide sufficient notice to other trades whose equipment requires electrical connections. Request that any equipment, cabinet, backbox, etc. supplied by others be mounted in place prior to our work in that area to facilitate final electrical connection.

Process Features and Standards

- Fasten conduit at least every 10′ and within 3′ of a box, cabinet or conduit body using #10 screw.
- Fasten MC Cable at least every 6′ and within 12″ of box or fitting using #10 screw.
- Do not use MC Cable or flex for Emergency System branch circuits except for lighting fixtures in acoustical ceiling grid or equipment connections requiring flexibility.
- Support junction boxes independently of conduit supports.
- Paint junction box covers as per the attached color code chart. Mark each cover with panel designation and circuit numbers enclosed within.
- Label wires within junction and outlet boxes with proper markers showing panel and circuit designation.
- If mounting a box over a conduit connector on a rated wall, seal the penetration before installing the box.
- Do not support more than 5 conduits on a ½″ support rod.
- Whenever possible install conduit or cable along the perimeter wall as opposed to crossing the room.
- Ensure that low voltage outlets are stubbed to accessible ceiling space.

Observations

- Is the junction box cover attached to one screw on the box with the correct color and circuit designation written on it?
- Do all junction boxes have a ground tail installed?
- Is everything supported as per specification and code?

APPENDIX E: EXAMPLES OF A BIQ APPROACH TO TECHNICAL SPECIFICATIONS

1. Specification # 16060 – Grounding and Bonding

- Provide grounding pigtails for bonding metal boxes to the ground system. Use minimum 12 AWG, insulated green conductor.
- Provide separate, insulated conductor within each feeder and branch circuit raceway.

2. Specification # 16070 – Supporting Devices

- Stud Wall Construction: Fasten conduit support straps, surface raceways or multioutlet assemblies directly to metal stud using size 10 pan head sheet metal screws.
- Provide ¼-inch rod above suspended ceilings for conduit and cable supports.
- Spring steel clips and clamps:
- Cable support: Use for above suspended ceiling attachment to rods or walls, and inside stud walls.
- Conduit support: Use for above suspended ceiling attachment to rods. Permitted for EMT conduit sizes ½-inch through 1-inch.

3. Specification 16075 – Electrical Identification

- Provide nameplates with pre-punches mechanical fastener mounting holes for electrical equipment. Nameplates to be colored as follows:
  - *277/480 VAC Normal – Yellow with black letters*
  - *277/480 VAC Emergency/Battery – Red with white letters*
  - *120/208 VAC Normal – Blue with white letters*
  - *120/208 VAC Emergency/Battery – Red with white letters*
  - *277/480 VAC UPS – Maroon with white letters*
  - *120/208 VAC UPS – Purple with white letters*
  - *DC Systems – Maroon with black letters*
  - *Emergency Power Off/Critical Operations – White with red letters*
- Provide self-adhering, pre-printed, machine printable or write-on, self-laminating vinyl wrap around strips for wire and terminal markers.
- Provide colored vinyl plastic electrical tape, ¾-inch wide, for identification of phase conductors.
- Conductors 8 AWG and smaller shall have colored insulation.
- Conductors 6 AWG and larger shall have black insulation but phase color-coded.
- Paint junction box covers, located above suspended ceiling and below ceilings in non-public areas, using the color-coding listed below:
  - *Normal 277/480 Volt Systems: Fluorescent yellow*
  - *Emergency 277/480 Volt Systems: Fluorescent orange*
  - *Normal 120/208 Volt Systems: Fluorescent blue*
  - *Emergency 120/208 Volt Systems: Fluorescent pink*
  - *Fire Alarm/Life Safety Systems: Fluorescent Red*
  - *UPS System: Purple*
  - *DC Systems: Maroon*
  - *Emergency Power Off/Critical Operations – Fluorescent red and white*
- Legibly mark the painted covers using black permanent ink felt pen; identify circuit(s) contained in the box by circuit number(s) and panel designation.
- Provide inscribed coverplates for receptacles, switches, outlet, plugmold, etc.

4. Specification # 16120 – Wires and Cables

- Provide Specified Technologies Inc. EZ-path fire rated pathway series for all low voltage cables crossing fire rated walls.
- Support cables every 4.5-feet and within 12-inches of box or fitting using separate metal strap or spring metal clip for each cable.
- It is permissible to combine up to 6 branch circuits for an individual homerun.

5. Specifications # 16130 – Conduits, Fittings and Boxes

- Use 4-inch square by 1-1/2-inch deep minimum box size. Use extra deep box for telephone, data devices.
- Provide 1" conduit to assessable ceiling space for low voltage system devices.
- Provide no more than 3 – 90 degree bends between pull or junction boxes for power wiring conduit.
- Keep 277/480 volt wiring independent of 120/208 volt wiring.
- Keep power wiring independent of communication system wiring.
- Keep life safety, critical branch and equipment systems wiring independent of other systems.
- Provide liquid type flexible metal conduit for termination at equipment subject to motion and vibration and where exposed to continuous or intermittent moisture.
- Stub-ups for underground PVC conduit or duct shall be rigid steel conduit.
- When installing raised device covers (plaster rings) on all switch and receptacle outlet boxes provide sufficient depth to suit the wall or ceiling finish.
- Support boxes located above accessible suspended ceilings from structure using ¼-inch rod.
- Offset outlet boxes shown to be installed back-to-back in fire rated walls and partitions a minimum of 24 inches horizontally.

6. Specification # 16131 – Surface Raceways

- Use non-metallic channel with fitted cover.
- Use dividers to separate emergency and normal power circuits; and to separate power from data or low voltage systems.

7. Specification # 16140 – Wiring Devices

- Check each device during start-up for proper connection and operation. Verify panelboard and circuit number for each device.

8. Specification # 16270 – Transformers

- Verify code-required clearances.
- Thoroughly wipe dirt and dust from devices and components. After cleaning devices vacuum transformer interior.

9. Specification # 16430 – Main Switchboards

- Thoroughly wipe dirt and dust from devices and components. After cleaning devices vacuum switchboard interior.

10. Specification # 16441 – Panelboards

- Verify code-required clearances.
- Provide spare conduits out of each recessed panelboard to an accessible location. Minimum spare conduits: Five empty 1-inch. Identify as SPARE.
- Thoroughly wipe dirt and dust from devices and components. After cleaning devices vacuum panelboard interior.

11. Specification # 16510 – Building Lighting

- Install clips to secure recessed grid-supported fixtures in place.
- Operate each fixture for proper connection and operation.

11. Specification # 16510 – Building Lighting

- Install clips to secure recessed grid-supported fixtures in place.
- Operate each fixture for proper connection and operation.

12. Specification # 16911 – Low Voltage Lighting Control

- Operate each relay for proper connection and operation.
- Thoroughly wipe dust from fixture trim and louvers. Clean finish and leave no fingerprints.

13. Specification # 16950 – Short-Circuit Analysis and Coordination Study

- Verify the installed equipment is in compliance with the evaluation study comparing the short-circuit ratings with the available fault currents.
- Verify all protective devices trip characteristics and settings match the device coordination study.

14. Specification # 16970 – Electrical Commissioning

- Verify that equipment-testing work is complete before starting functional performance of power equipment.
- Verify that operational manuals are complete and been approved by the Architect before starting functional performance testing.
- Inspect equipment and confirm that it is clean and ready for operation. All shipping tags removed, nameplates installed and equipment manuals in place.

APPENDIX F: BIQ TRAINING COURSE OUTLINE

SESSION	TOPICS	TIME
	Continental Breakfast	8:30 AM to 9:00 AM
	Greetings and Introduction	9:00 AM to 9:15 AM
1.	Standard For Quality In The Electrical Construction Industry	9:15 AM – 9:45 AM
2.	Sample Quality Plan Elements	9:45 AM – 10:15 AM
	Exercise – Examining Your Current Quality Plan	10:15 AM – 10:30 AM
	Morning Break	10:30 AM – 10:45 AM
3.	Lean Concepts Applied to BIQ	10:45 AM – 11:15 AM
4.	A BIQ Process	11:15 AM – 11:45 AM
	Exercise – Adding a BIQ Process to Your Quality Plan	11:45 AM – 12:00 PM
	Lunch	12:00 PM – 1:00 PM
5.	NECA Installation Standards	1:00 PM – 1:45 PM
6.	Sample Record and Checklist Forms	1:45 PM – 2:15 PM
	Exercise – Assessing Your Use of Installation Standards and Record/Checklist Forms	2:15 – 2:30 PM
	Afternoon Break	2:30 PM to 2:45 PM
7.	BIQ Narratives for Work Activities and Specifications	2:45 PM – 3:15 PM
8.	BIQ Plan Template	3:15 – 4:00 PM
	Discussion – Developing a BIQ Implementation Plan	4:00 PM

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