

Project Electrical Best Practices

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IEEE SAS/NCS IAS-PES Chapter Seminar

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Overview – Common Issues on Projects

- Poor Project Definition (Scope)
 - What's Included
 - What's the Drivers, e.g. Schedule, Cost, Quality, and their order
 - Changes throughout the project, e.g. Schedule becomes Cost
 - Operations and Maintenance constraints
 - Scope Creep
- Unrealistic Schedule
- Insufficient and/or pre-set Budget, especially “front end”
- Owner Issues
 - Project competency
 - Technical competency
 - Design, Equipment, Installation Standards
 - Construction competency
 - Including Safety Codes
 - Team alignment (not driving alignment)
 - Owner (Project, Technical, O&M), Engineering, Construction, Quality Management, Inspection, Key Suppliers (Equipment, Services)

Overview - Opportunities for Improvement

- Project Definition (Scope)
 - What's included
 - What's the Drivers e.g. Schedule, Cost, Quality
 - Consideration of Operations & Maintenance requirements
 - Operating costs, manning reqts, reliability/availability criteria , etc.
- Schedule
 - Front End
 - Overall
- Budget, especially “front end”
 - Defined by Scope and Schedule
- Owner Issues
 - Project competency
 - Technical competency
 - Design and Equipment Standards
 - Construction competency
 - Including Safety Codes
 - Team alignment
 - Owner (Project, Technical, O&M), Engineering, Construction, Quality Management, Inspection, Key Suppliers (Equipment, Services)

Project Electrical Best Practices

THE BAD

Opportunities for Success – the Bad

- Recipe for Failure
 - Improperly defined projects – no process development
 - Improperly defined – no technical definition
 - Specifications and standards undefined
 - Schedule development unrealistically based
 - Budgets development improperly based
 - Due to above

Opportunities for Success – the Bad

- Poor project definition
 - Fundamental process development inadequate
 - Major process changes – significantly impact project definition
 - No plot plan
 - Mechanical equipment not defined
 - Control systems not adequately defined
 - Electrical systems not adequately defined

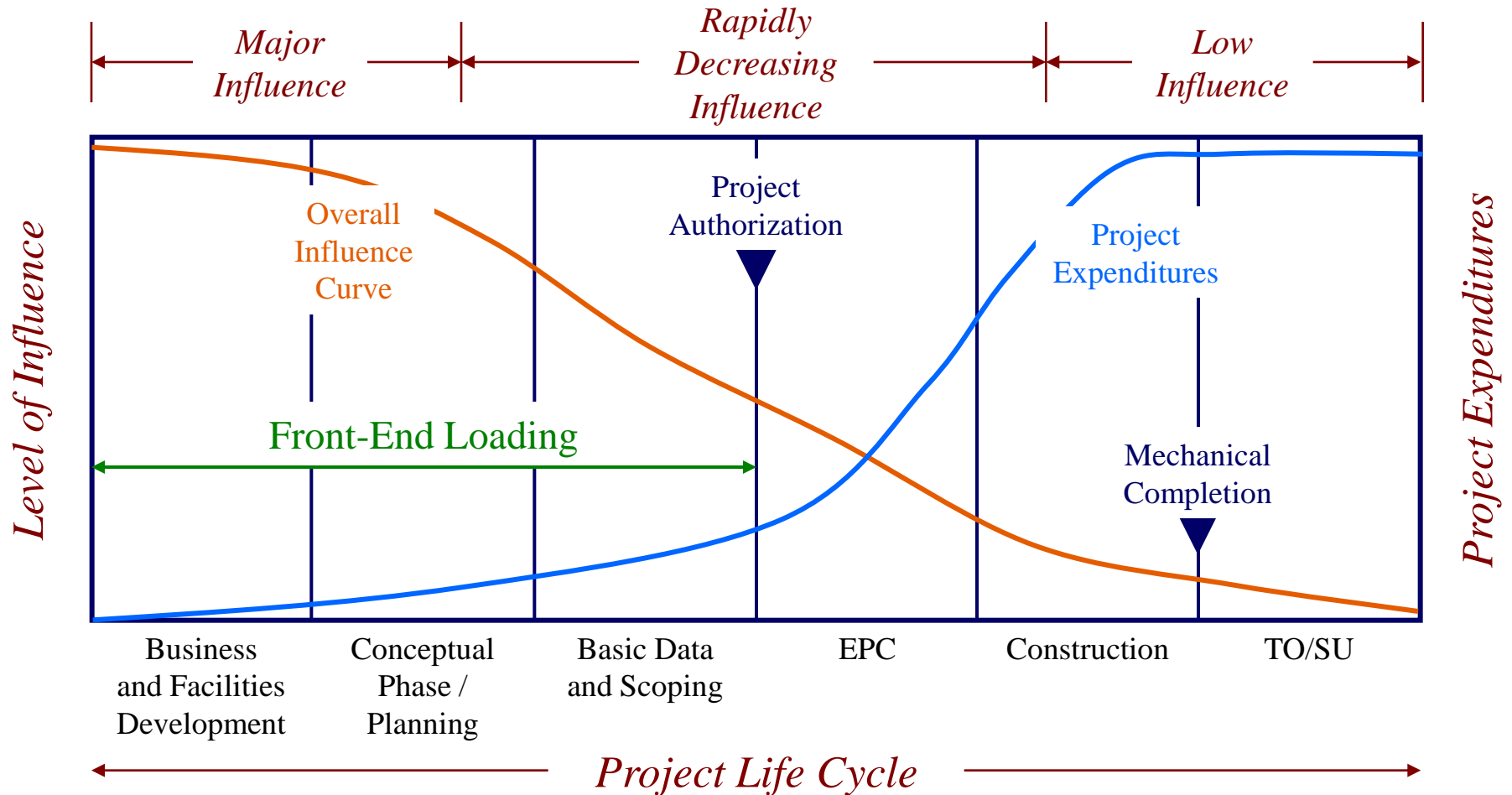
Opportunities for Success – the Bad

- Ambitious schedules
 - Because of the things described above, we see schedules that are often extremely ambitious
 - Often arbitrarily determined
 - Often not revised as project scope, process, etc. changes
 - Frequently are based on when the project needs to be complete and not on what needs to be done

Opportunities for Success – the Bad

- Unrealistic budgets
 - Schedule has a large impact on budget
 - Lack of project definition has large affect on budget
 - Re-work – a significant effect on costs

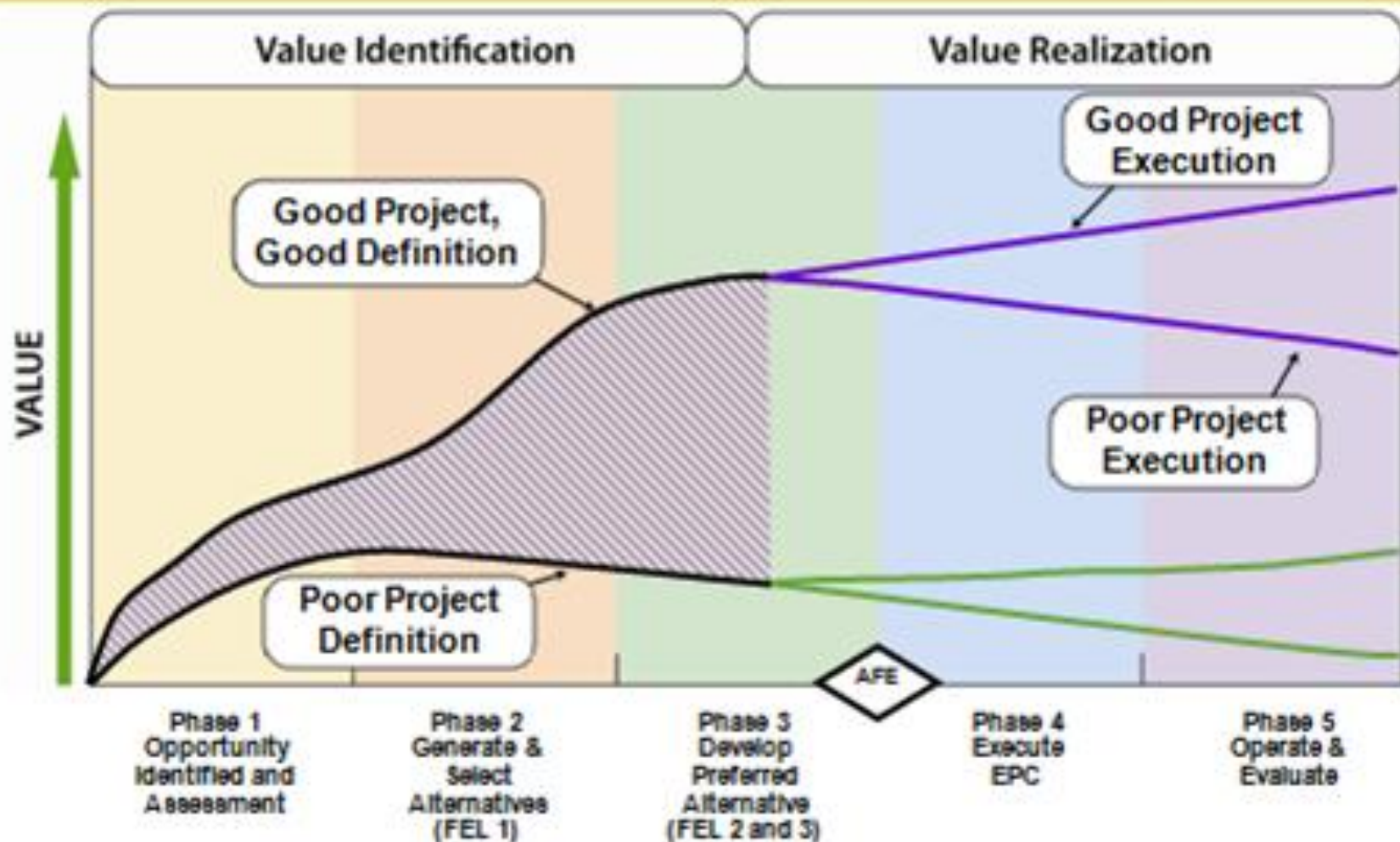
Phased Project Execution: Opportunity to Influence Costs



Opportunities for Success – the Bad

- Opportunity to influence cost curves
 - Blue line is the project expenditure curve
 - The red line is the opportunity to influence curve (the later in the project a change happens, the greater the impact to the project and the cost to the project)
 - Today's fast track projects have no front end so we are immediately into the high impact of late changes to a project and their subsequent impacts to both schedule and budget

Project Management and Value Creation



Opportunity for value creation maximized in Phases 1, 2 and 3

Opportunities for Success – the Bad

- Projects start out as schedule driven and end up as cost driven
 - As described above projects start out as schedule driven
 - Cost is not important at the beginning as it is usually significant low due to lack of proper definition
 - As the project progresses, the schedule and the budget grow as the project definition develops.
 - Soon, the schedule is what ever the schedule develops into
 - But the budget continues to rise and the project becomes budget driven

Opportunities for Success – the Bad

- Today's projects are single stage “Construction Driven Projects”.
- Projects used to be developed in multiple phases with strict “gate checks” to ensure each phase was complete before proceeding to the next phase.

Opportunities for Success – the Bad

- Lack of owner organization and definition
 - Owners today do not have the technical sophistication to do projects because of
 - Increased process technology (high tech.)
 - Increased design technology (LED lighting)
 - Increased design sophistication (Smart Plant)
 - Many new organizations do not even have the fundamentals such as those in next slides

Opportunities for Success – the Bad

- People

- Skills, knowledge and experience should be matched to the task/activity, but often are not
- Training and mentoring are not provided to less experienced, knowledgeable
 - Training budgets are usually inadequate
 - Transferring knowledge from the senior individuals to the junior people is almost non-existent
- New players to a project are often just thrown into the job without the understanding of goals, what's been done already, etc.

Opportunities for Success – the Bad

- General electrical design spec
 - Often not available or only partially developed
 - This spec should detail all electrical aspects of the project.
 - It should include everything from the description of the electrical service to the type of lighting, wire, raceway, etc.
 - It should describe the types of things like arc resistant switchgear, MCC type and control, EHT philosophy, electrical distribution management system and interface definition between electrical and other disciplines such as controls, mechanical and process.

Opportunities for Success – the Bad

- Projects with no design specs
 - Drawing systems requirements and definitions not available
 - EHT systems requirements and details not available
 - Area classification not available
 - Grounding philosophy not available

Opportunities for Success – the Bad

- Poor or no equipment specs
 - Switchgear
 - MCC
 - Transformers
 - Motors
 - UPS
 - Batteries and chargers

Opportunities for Success – the Bad

- Alberta Safety Codes Act (SCA)
 - Many owners today do not understand the SCA
 - Consequently, many owners do not take advantage of the opportunities afforded by the SCA
 - The SCA was originally put in place to download the responsibility for Inspection processes to Corporations and Municipalities in Alberta
 - Electrical inspection of industrial facilities is significantly improved by the SCA

Opportunities for Success – the Bad

- Accreditation
 - Many companies we work for today are accredited corporations but not all
 - An Accredited Corporation is a company that can show through a Quality Plan that they have the necessary sophistication to self inspect to the required Provincial standards (CE Code)
 - This has allowed these companies to provide better inspection where required to bring about safer installations.
 - Many companies are not taking advantage of the opportunities offered to an accredited corporation

Opportunities for Success – the Bad

- Variances
 - The SCA allows accredited corporations to vary the expected interpretations of the code where better or equivalent safety can be achieved.
 - These variances often involve new or developing technology or other such things
 - Variances are significantly under utilized in today's projects

Opportunities for Success – the Bad

- OBIEC – *CSA CEC Part IV*
 - The “Objective Based Industrial Electrical Code”
 - All the advantages of being an accredited corporation and many, many more.
 - OBIEC also mandates that the project get organized including full alignment of Owner (O&M), Quality, Engineering, Construction, etc.
 - COMPANIES ARE NOT REQUESTING AND USING THE “OBJECTIVE BASED INDUSTRIAL ELECTRICAL CODE”.

Project Electrical Best Practices

THE GOOD

The Good – Opportunities for success

- Mike McFadden, key note speaker at 2010 ESTMP stated Alberta Oilsands projects are in the bottom 1/3 of major projects around the world, in deliver on cost, schedule in past decade
 - From IPA, Independent Project Analysis, New York
- Owners should have the desire to have lowest Total Cost of Ownership, but many do not
 - Look at Schedule, Cost only
 - Factors also – safety, Op cost, Availability, etc.
- So let us talk about improvements:

The Good – Opportunities for success

- Many of these are the opposites of those discussed previously
 - Get organized
 - Develop a General Electrical Design Specification
 - Develop detailed Design Specification
 - Develop Equipment Specifications
 - Get Alberta Accreditation
 - Write Code Variances to allow you to streamline your installation processes
 - Become qualified to use the OBIEC
 - Issue in Alberta currently on regulatory acceptance

The Good – Opportunities for success

- Proper project definition
 - Fundamental “process” development
 - Significant “process” changes impact project definition
 - Plot Plan defined
 - Mechanical equipment defined
 - Control systems adequately defined – system architecture set
 - Electrical systems adequately defined- configuration and equipment sized
 - Construction input is important

The Good – Opportunities for success

- Projects need to get back to the appropriate stages of project development
 - DBM
 - Pre-feed
 - Feed
 - Detailed design
 - Equipment selection
 - Construction
- A “Gate check” to ensure full completion of each phase is required.

The Good – Opportunities for success

- Project alignment and Team-building
 - Developing a strong working relationship between the owner(Sponsor, O&M), project management, engineering, supply chain, construction contractors, quality assurance and inspectors.
 - Align Goals, Drivers of all major project participants
 - Ensure all understand the final project deliverables and their roles in achieving them
 - Celebrate successes

The Good – Opportunities for success

- Realistic project schedules
 - Do not let overall project schedules become a liars contest when bidding the work!
 - Too often today, the work is let to the firm that is willing to promise the best schedule.
 - Unrealistic schedules are **demoralizing** to project staff.
 - Project schedules need to be realistic and achievable.

The Good – Opportunities for success

- Schedules
 - Be sure schedule allows for adequate/appropriate input to the project cost estimate
 - Ensure the schedule allows for Vender Data to be available to properly perform the estimate
 - Need sufficient time for realistic Vender Data to support the Design

The Good – Opportunities for success

Schedules (cont'd)

- PROJECTS NEED TO LEARN TO GO SLOW AT THE BEGINNING SO THEY CAN GO FAST AT THE END!
 - Design the facility before building the facility
 - The more complete the design, the fewer changes in the field, the faster construction proceeds (and start-up), resulting in an overall lower “Total Installed Cost”
 - Design to the Estimate

The Good – Opportunities for success

- Gate reviews
 - Adequate time for each phase of project development with proper gate reviews to ensure ready for the next phase
 - **Do not drop items from gate review check lists** or otherwise modify gate reviews in order to pass gate reviews otherwise unachievable

Getting organized – to be successful

- Interfaces
 - Recognize that there are key interfaces
 - Develop strong interfaces and define how they operate
 - Engineering – instrumentation and controls, machinery, process (area classification)
 - Supply Chain – specification and equipment data
 - Construction
 - Quality assurance and inspection
 - Owners operating and maintenance rep.s

Getting organized – to be successful

- Company procedures, standards, and specifications all fully developed at the inception of the project.
- Procedures, standards and specifications are updated as necessary as the project develops

Getting organized – to be successful

- Plot plan and area class development
 - In today's highly modularized projects, time must be taken to develop the plot plan
 - The area classification must be considered to optimize plot plan layout
 - *Note: API 505 is going to ballot now, expected issue is Jan. 2016*
 - This is often a re-iterative process
 - Electrical is a follow up discipline but is a very key “in-putter” to this process.
 - This design requires the input of very senior experienced people.

Getting organized – to be successful

- Company procedures, standards, and specifications all fully developed and available
- Follow the procedures!
- Use the standards and specifications!

Getting organized – to be successful

- Procedures
 - Operating
 - Engineering and design
 - Construction
 - Turnover, Testing and Commissioning
 - Safety Codes Accreditation
 - People competence
 - Energized Work
 - RASCI (*Responsible, Accountable, Support, Consult, Inform*) process
 - Chart identifying people against project activities and their roles in those activities

RASCI Chart

Chart identifying people against activities and their roles in those activities
- Can be used for Projects, Maintenance, portions of Projects, etc.

| | Person 1 | Person 2 | Person 3 | Person 4 | Person 5 | Person 6 | Person 7 |
|------------|----------|----------|----------|----------|----------|----------|----------|
| Activity A | A | R | | S | C | I | I |
| Activity B | | | A | | R | S | I |
| Activity c | A | | R | | C | S | I |
| Activity D | | R | A | | I | C | S |

A=Accountable, R=Responsible, S=Support, C=Consult, I=Inform

Getting organized – to be successful

- People

- Match skills, knowledge and experience to the task/activity
- Ensure training and mentoring are provided to less experienced, knowledgeable
- Provide for adequate indoctrination /transition for new people

Getting organized – to be successful

- Standards
 - Drawings
 - Installation details
 - Equipment /Product Industry Standards
 - Owners Specifications should use industry standards where ever possible
 - CSA
 - Installation code
 - Product/equipment standards
 - OBIEC



Objective-based industrial electrical code



C22.4 No. 1-09

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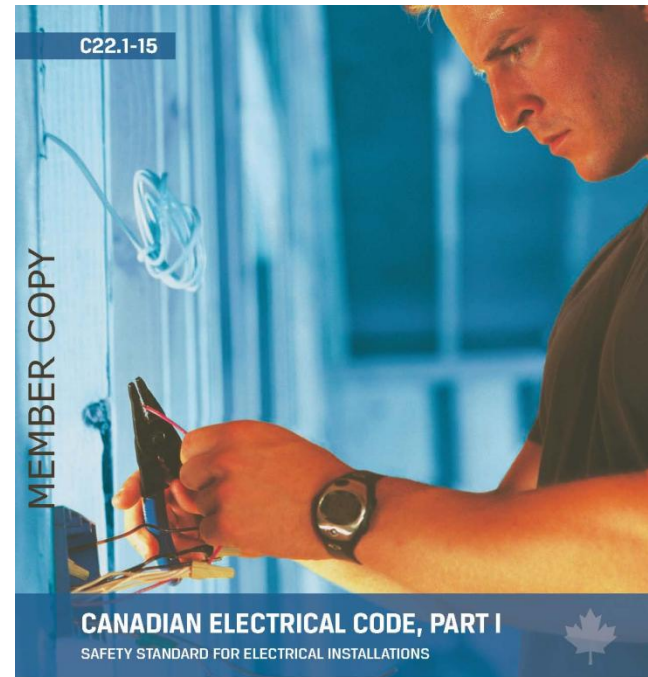


C22.4 No. 2-09

Objective-based industrial electrical code — Safety management system requirements



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2015
23RD EDITION



Getting organized – to be successful

- *Variances, some examples are*
 - Random loading of branch cable trays
 - Rebar grounding recognizing the structural steel as the ground electrode
 - *Voltage drop: the 2015 code finally recognized an industrial relaxation from the 3 and 5 % rules*
 - There are approximately one dozen other typical variances used on most projects in Alberta by Accredited Corporations.

Getting organized – to be successful

- Specifications

- Design

- General Electrical Design
 - HV Substation design
 - Electric Heat Tracing design
 - Arc Flash Requirements
 - Electrical Distribution Management System
 - Modularized Electrical Buildings (E-houses)
 - Area Classification

Getting organized – to be successful

- Specifications (cont'd)
 - Equipment and Material
 - Transformers – large, oil filled, dry, etc
 - Switchgear – LV, MV
 - Motor Control Centers – LV, MV
 - Adjustable Speed Drives – LV, MV
 - Uninterruptible Power Supplies
 - Motors
 - EHT Materials
 - Bulk Materials
 - Cable – LV, MV
 - Specialty equipment – HV, etc.
 - These specifications should be based on Industry Standards (CSA, IEEE, API, IEC, etc.)

Getting organized – to be successful

- Vendor Agreements

- Vendor Partnering (or Alliance) arrangements, if possible, offer some significant advantages

- Assist with developing Specifications

- May provide alternative equipment solutions, not available with simple bid & buy process

- Can help improve quality

- Can make it easier to set up for commissioning

- **Access to Vendor data much earlier in the design process**

- *Note – in general, initial purchase price is about 25% of the total cost of ownership of the equipment*



Substation

E-House





MV Switchgear



LV TEFC
Vertical
Motor



MV MCC



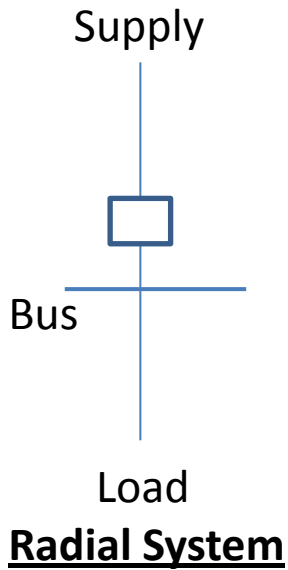
MV Motor



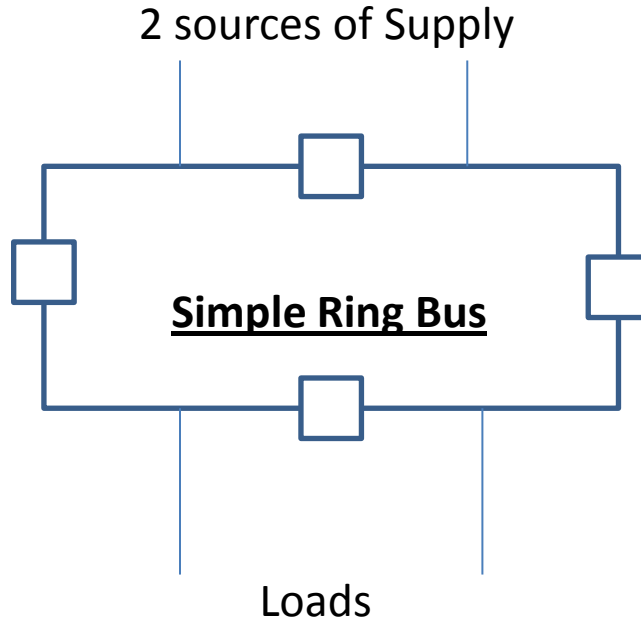
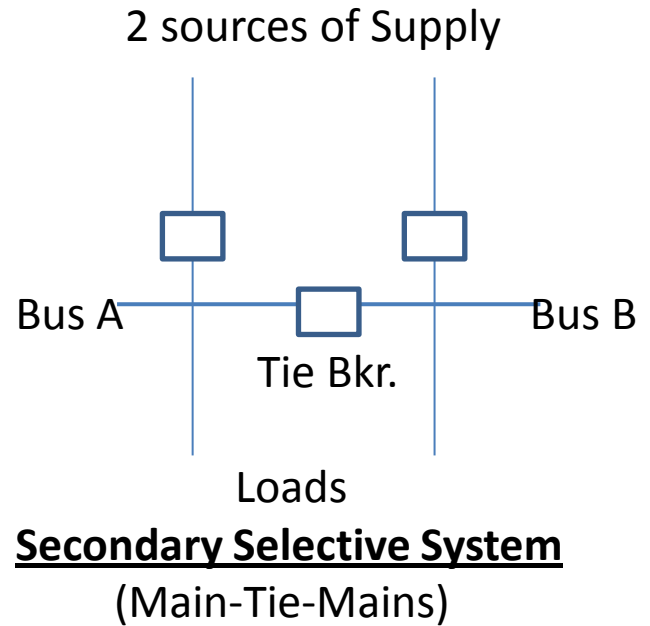
Power
Transformer

Getting organized – to be successful

- Power Distribution
 - Radial and Secondary selective systems
 - Secondary selective (main-tie-main) provide superior reliability for equipment failures/faults and therefore are the choice for major process plants
 - Radial systems are often used for simpler plants that can be easily restarted after a distribution equipment failure or fault
 - More complex systems such as maintenance bus, ring bus or breaker and an half are utilized for large complex process facilities that require very high availability and reliability.

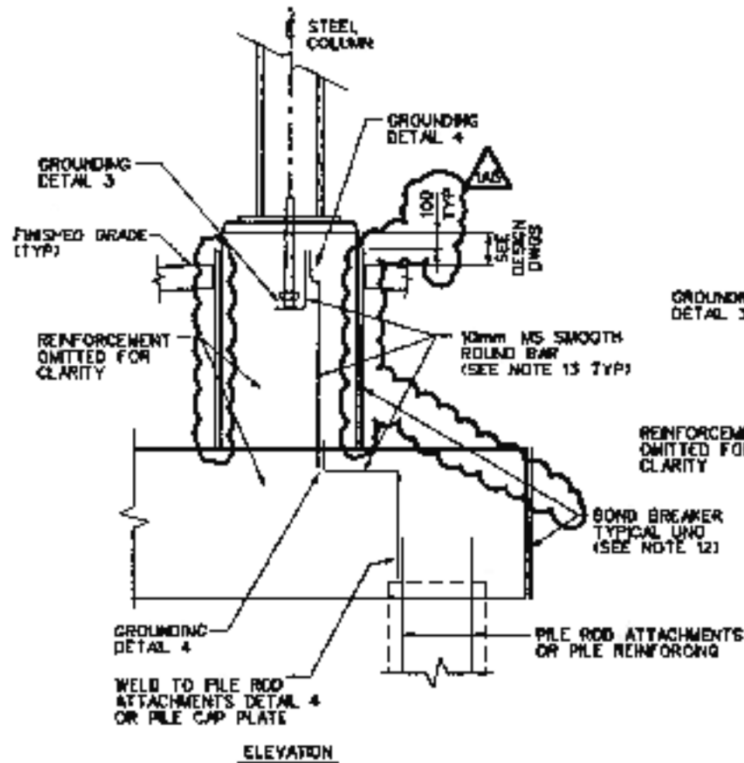


Examples of some Base Distribution System Configurations

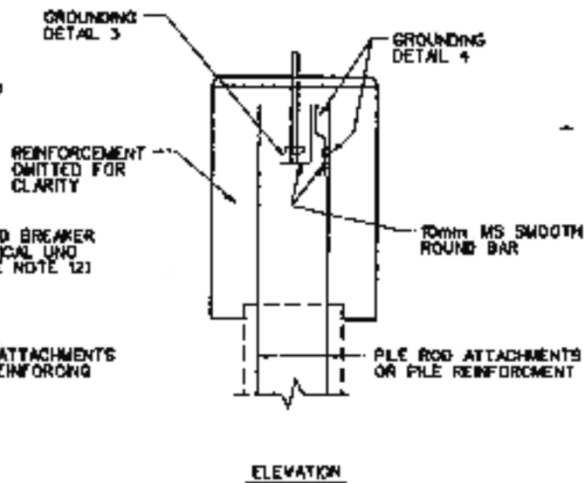


Getting organized – to be successful

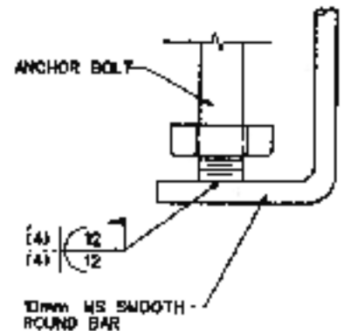
- Grounding
 - Use Pile/Rebar grounding to eliminate significant portions of other underground grounding and bonding systems
 - This significantly lowers ground impedance and enhances equipment bonding
 - This recognizes the structural steel as the grounding electrode.
 - Any equipment directly connected to the structural steel is then considered bonded to ground.



GROUNDING DETAIL 1
(SEE GENERAL NOTE 8)



GROUNDING DETAIL 2
(SEE GENERAL NOTE 8)



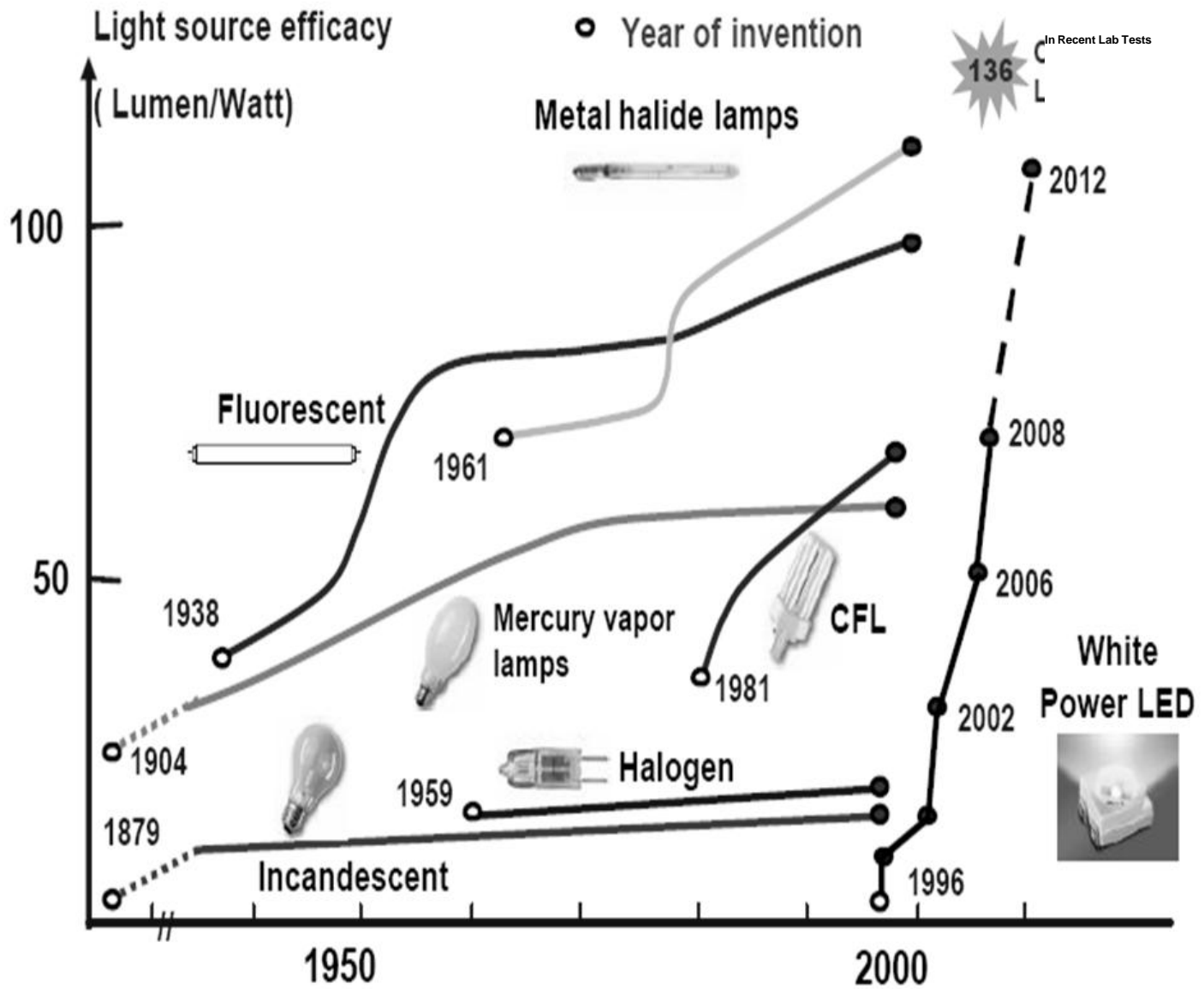
GROUNDING DETAIL 3
(SEE GENERAL NOTE 10)

| | |
|-----------------|-----------------------|
| 28000-1M-005-01 | CURB, I BEARN |
| 28000-1M-006-01 | SHM P |
| 28000-1M-007-01 | TYPICA FOR DI |
| 28000-1M-007-02 | TYPICA FOR M |
| 28000-1M-008-01 | TYPICA FOR DI |
| 28000-1M-009-01 | TYPICA PILE T |
| 28000-1M-031-01 | PILE C, EFFECT |
| 28000-1M-031-02 | PILE C, EFFECT |
| 28000-1M-032-01 | PILE C, EFFECT CLK TI |

Getting organized – to be successful

- Lighting

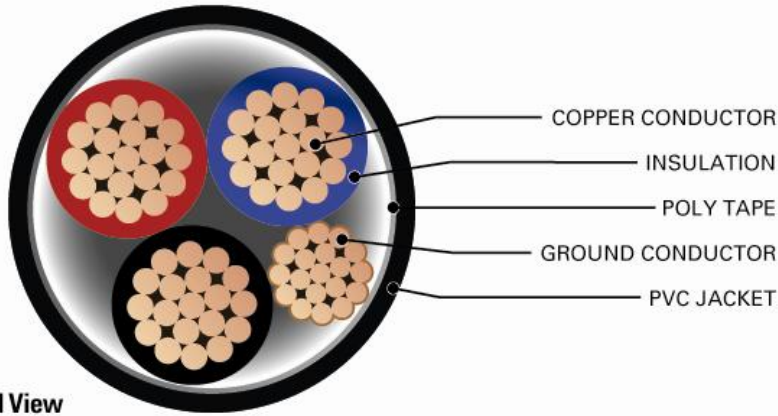
- Lighting has evolved from incandescent thru mercury vapour, metal halide, sodium vapour, to newer technologies such as Induction and LED lighting.
 - Fluorescent has been used, but generally only in office buildings, electrical and instrument rooms.
- LED is the up and coming leader due to the very fast pace of technology development.
 - High efficiency, long life, instant on/off, vibration resistance, etc.
- Today, more facilities are becoming aware of the requirements for “dark skies”
 - LED lighting and switching off unnecessary lighting is paramount in today’s designs
- Plug and Play – worth doing **if there is time** to develop
 - Need to coordinate cabling, fixtures, connectors



Getting organized – to be successful

- Cable

- Most industry is recognizing that Tray Cable is the accepted cable type for Zone 2 LV.
 - Lower overall costs, easier to install
 - Some companies are also using MV Tray Cable as an improvement to armoured cable.
- Where armour is required (Zone 1), an alternative to metallic is polymeric armoured cable
- Changes to equipment standards are underway to allow the use of 90°C cable to its full ampacity and not have to de-rate to 75°C or 60°C ampacities
- Installation Low Temp. is a key criteria, more so than the base Low Temp. marked on the cable
 - Installation below min. Temp, use appropriate mitigative measures

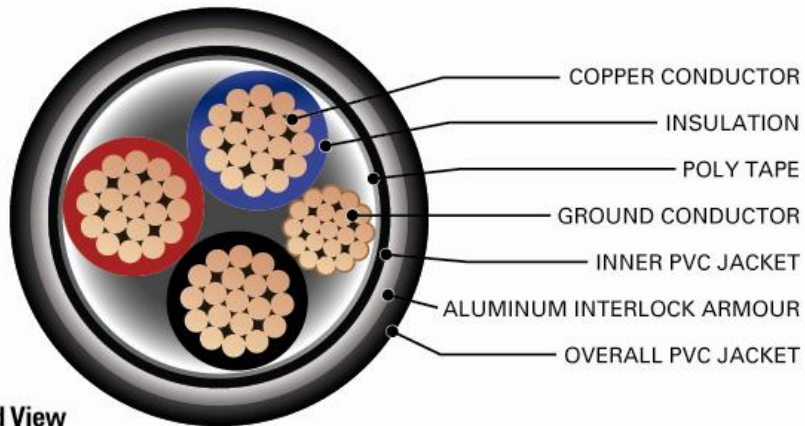


End View

Tray Cable

Polymeric Armoured Cable
More availability today
Alternate to metallic armoured
such as Teck or ACWU

Teck90 Cable



End View



ACWU Cable
Thicker Jacket
No Inner Jacket



Getting organized – to be successful

- Tray

- Pay attention to Cable & Tray systems, as they are a significant project cost (*as much as 40% total elect.*)
- Defined as “raceway” in the CE Code, but in reality it’s a Cable support system
 - 2015 CEC recognizes some of these differences
 - Basket tray is an option for small buildings and tight spaces
 - However more tray supports are required



Getting organized – to be successful

- Electrical Heat Tracing (EHT)
 - The terminology is in the process of changing to Electrical Trace Heating (ETH), *products and codes*
 - EHT can have a significant effect on the
 - **Electrical cost of your project**
 - **Construction schedule of your project**
 - Mineral Insulated (MI) is generally lower cost but requires more engineering than other technologies
 - Trace Heating design requires the input of very senior experienced people

Installing
Mineral Insulated
(MI) Trace
Heating Cable

Engineering
required



Installing Self
Regulating Trace
Heating Cable

Cut to length in
field, more
flexible



Getting organized – to be successful

- Construction
 - Constructability should be reviewed within each project phase, and electrical needs to input to each
 - The better the Design is and the Plan is, the better the construction proceeds – both cost and schedule
 - Engineer, engineer, engineer

Getting organized – to be successful

- Commissioning, Testing, Startup
 - Perform as much checkout and testing as possible in the factory prior to shipment to site
 - This includes at module and skid manufacturing/fabrication locations
 - Numerous industrial standards are available – manufacturer recommendations, NETA
 - Planning for Energizing and Start-up
 - Clear understanding of “who” has ownership / responsibility for energizing equipment and systems
 - Use Energized Work procedures
 - Clear plan of sequencing the activities – communicated to all – project management, operations, maintenance, etc.

Conclusions

- Projects are complicated
 - Even the small, seemingly simple ones can be complicated
- Many many ways for projects to come off the rails
 - Adversely affecting schedule, cost, performance, and some or all of these
- Attention to details is important in all projects
 - Some are project management issues that may or may not be able to be affected by electrical
 - But many technical areas that are directly affected by electrical and electrical innovation
 - Design and equip. specifications, code variances, etc.

Conclusions

PROJECTS NEED TO LEARN TO GO SLOW AT THE
BEGINNING SO THEY CAN GO FAST AT THE END!

