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1.0 Documentation

Project Goal: Design part of an electrical system for a storm water handling facility for a large plant site. We were given the following design information:

- Building has a 480VAC, 3-phase, 34 wire, 60Hz power supplied to it.
- One building shown in the attached site drawing with the following loads:
    - 2 10Hp motors, 208VAC, 3-phase, 4-wire, 60Hz, p.f.=0.85, eff=93%
    - Lighting should be 40W per 8 square feet or higher
    - 1 200A load center, 208VAC, 3-phase, 4-wire, 60Hz, p.f.=0.9
    - 1 480V(delta)/208(wye), 3-phase, 4-wire, 60Hz, transformer

We were required to choose the materials for the building such as the transformer, load centers (panelboards), protection, disconnects, conduits, conductor ampacity, wire size, motor starters, overloads, and protection devices, lighting, etc.

1.3 Engineering Design Calculations

1.3.1 Motors

P_{out} = 10hp*(746W/hp) =7460W

P_{in} = P_{out} /(93%) = 8021W

S_{in} = P_{in} / .85 = 9437VA

I = S_{in} / (208*sqrt(3)) = 26.19A

S_{total} = 2*S_{in} = 18874VA

I_{total} = 52.38A

1.3.1.i Motor Protection

I_{FL} = 26.19A

Circuit breakers should be rated for 800% of full load current:

$I_{breaker}$ = 8.00*26.19A = 209.5A

Time delay fuses should be rated for 175% of full load current:

I_{fuse} = 1.75*26.19A = 45.83A

The motor protection fuse should be rated for 50A.

Overload relay must be set to match I_{FL} = 26.19A.

The Square D 9065ST220 can be set in the range of 15-45A.

1.3.2 Lights

P_{min} = 40W/(8ft^2)*(40ft*64ft)=12800W

Watts per fixture: 110W

Total fixtures required: 12800W/110[W/fixture] = 117 fixtures

P_{actual} = 117 fixtures * 110W/fixture = 12870W

I = P_{actual} / 120V = 107.25A

1.3.2.i Light Protection

I_{phase} = I / 3 = 35.75A

$I_{segment}$ = I_{phase} / 3 = 11.92A

$I_{breaker}$ = 1.25 * $I_{segment}$ = 14.89A

15A breakers are used for the lights as that is as close as possible to 14.89A

1.3.3 Load Center

S_{out} = S_{motor} + S_{lights} = 31744VA

S_{in} = 0.9 / S_{out} = 35271VA

1.3.3 Transformer

S_{out} = $S_{load\ center}$ = 35271VA

$S_{in} = S_{out} / 98\% = 35991VA$

$S_{safe} = S_{in} * 1.25 = 44988VA$

$I_{secondary} = I_{motor} + I_{lights} = 159.63A$

$I_{primary} = I_{secondary} * 208V / 480V = 69.177A$

A 45kVA transformer may suffice however we recommend using a 75kVA in case more loads need to be added in the future and to account for any extraneous losses

$I_{rated, primary} = 75kVA /480V / sqrt(3) = 90.21A$

$I_{rated, secondary} = 75kVA /208V / sqrt(3) = 208.18A$

1.3.3.i Transformer Protection

Secondary Fuse = $I_{rated, secondary} * 1.25 = 260.225$ A

=> Round up to 300A secondary fuse

Secondary Breaker = $I_{secondary} * 1.25 = 198.75$ A

=> Round up to 200A secondary breaker

Primary Fuse = $I_{primary} * 2.5 = 112.76A$

=> Round down to 110A primary fuse

1.3.5 Wiring

Require 10 AWG for Lighting and Motors

Max Length: Distance from switch to switch = 116ft

9 Arrays x 2 sets of wire per/Array = 18 wires

1 Neutral Line for all Light Arrays totals 19 wires.

250 ft. of wire required for transformer-lighting switch and transformer-motor

In total, we require approximately 3000 ft. of wire.

Will purchase 3 colors of wire to help with wire management.

Will overestimate to 3,750ft. to ensure we have extra wire of all 3 colors.

1.3.6 Conduit

Wire Diameter = 0.205 inches => cross-sectional area = 0.031 inches.

19 Wires x 003 per/Wire = Minimum Cross-Section of 0.627 inches.

=> We require conduit with at least 0.9 diameter

=> Overshoot by more than a quarter inch to ensure easy wire running

=> Choose 1-¼” diameter metal conduit (above ground)

Went through similar process for smaller conduit:

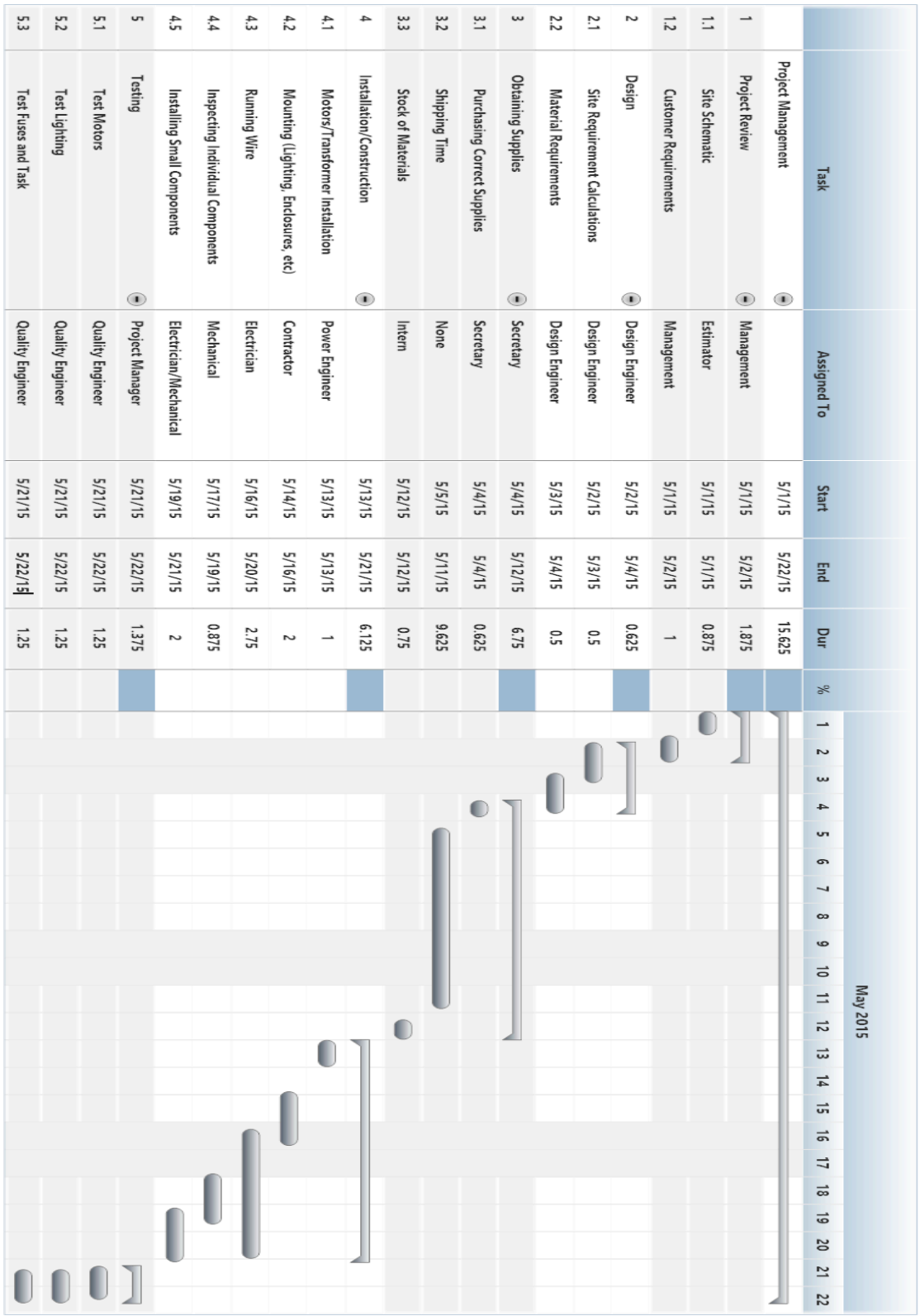
=> Choose ½” diameter conduit for Transfomer - Switch and Transfomer - Motor wiring.

1.4 *Bill of Materials*

Quantity	Manufacturer	Part Number	Product	Price	Extended Price
1	Federal Pacific	T4T75E	Transformer	$1,765.67	$1,765.67
1	Square D	QO342MQ200RB	Load Center	$2,053.04	$2,053.04
117	LUMAPRO	2UWU5	Light Fixture	$100.10	$11,711.70
234	Sylvania	22173	Light Bulb	$6.98	$1,633.32
18	Leviton	3033-2W	Light Switch	$16.10	$289.80
9	Square D	HOM115CP	15A Circuit Breaker - Lights	$3.72	$33.48
2	Square D	QBL32225	225A 3 Pole Circuit Breaker - Motor	$539.50	$1,079.00
1	Square D	MJL36500	500A 3 Pole Circuit Breaker - Overall	$2,118.14	$2,118.14
3	Wire & Cable To Go	10 AWG	1,000 ft. Spool of Wire (Multicolor)	$290.00	$870.00
3	Wire & Cable To Go	10 AWG	250 ft. Spool of Wire (Multicolor)	$72.50	$217.50
12	Grainger	5ZM14	EMT Conduit (1-1/4")	$35.95	$431.40
7	Grainger	6XC30	EMT Conduit (1/2")	$5.00	$35.00
4	Grainger	11Y570	Conduit Body (1/2", Corner)	$8.25	$33.00
4	Grainger	11Y574	Conduit Body(1-1/4", Corner)	$20.96	$83.84
15	Grainger	11Y562	Conduit Body(1-1/4", Straight)	$21.33	$319.95
10	Grainger	11Y564	Conduit Body(1/2", Straight)	$8.21	$82.10
14	Grainger	11Y591	Conduit Body Cover (1/2")	$2.35	$32.90
19	Grainger	11N688	Conduit Body Cover(1-1/4")	$5.13	$97.47
3	LittleFuse	JLLN-110	110A Fuse - Transformer Primary	$26.50	$79.50
3	LittleFuse	JLLN-300	300A Fuse - Transformer Secondary	$55.12	$165.36
2	Ferraz Shawmut	64003J	400A Fuse Block - Transformer	$408.04	$816.08
2	Eaton	DH322NDK	60A 3 Pole NEMA 12 Disconnect - Motor	$314.47	$628.94
2	Square D	9065ST220	Overload Relay	$198.98	$397.96
2	Baldor	ECP3774T-4	10HP Motor	$2,154.00	$4,308.00

1	Wiegmann	WA723024FSDA	NEMA 12 Enclosure - Transformer	$1,705.00	$1,705.00
1	Wiegmann	WA72P30F1	NEMA 12 Back Panel - Transformer	$269.00	$269.00
1	Wiegmann	B423609CH	NEMA 12 Wall Mount Enclosure - Load Center	$664.00	$664.00
2	Wiegmann	B141206CH	NEMA 12 Wall Mount Enclosure - Motor Starter	165	$330.00
2	Square D	EAN 0785901081524	10hp Motor Starter	$145.00	$290.00
6	Bussman	FRS-R-50	50A Time Delay Motor Protection Fuse	$25.50	$153.00
2	Bussman	H60060-3CR	Motor Protection Fuse Holder	$54.45	$108.90
1	Eritech	611380	1/2 in. x 8 ft. Copper Ground Rod	$10.39	$10.39
	TOTAL				**$32,813.44**

1.5 *Project Schedule*



	Task	Assigned To	Start	End	Dur	%
	Project Management		5/1/15	5/22/15	15.625	
1	Project Review	Management	5/1/15	5/2/15	1.875	
1.1	Site Schematic	Estimator	5/1/15	5/1/15	0.875	
1.2	Customer Requirements	Management	5/1/15	5/2/15	1	
2	Design	Design Engineer	5/2/15	5/4/15	0.625	
2.1	Site Requirement Calculations	Design Engineer	5/2/15	5/3/15	0.5	
2.2	Material Requirements	Design Engineer	5/3/15	5/4/15	0.5	
3	Obtaining Supplies	Secretary	5/4/15	5/12/15	6.75	
3.1	Purchasing Correct Supplies	Secretary	5/4/15	5/4/15	0.625	
3.2	Shipping Time	None	5/5/15	5/11/15	9.625	
3.3	Stock of Materials	Intern	5/12/15	5/12/15	0.75	
4	Installation/Construction		5/13/15	5/21/15	6.125	
4.1	Motors/Transformer Installation	Power Engineer	5/13/15	5/13/15	1	
4.2	Mounting (Lighting, Enclosures, etc)	Contractor	5/14/15	5/16/15	2	
4.3	Running Wire	Electrician	5/16/15	5/20/15	2.75	
4.4	Inspecting Individual Components	Mechanical	5/17/15	5/19/15	0.875	
4.5	Installing Small Components	Electrician/Mechanical	5/19/15	5/21/15	2	
5	Testing	Project Manager	5/21/15	5/22/15	1.375	
5.1	Test Motors	Quality Engineer	5/21/15	5/22/15	1.25	
5.2	Test Lighting	Quality Engineer	5/21/15	5/22/15	1.25	
5.3	Test Fuses and Task	Quality Engineer	5/21/15	5/22/15	1.25	

1.6 *Man Hour Budget*

Pricing/Laboring Worksheet					
Worker	Qualification	# of Workers	Cost/Hour	Total Hours	Total Cost
Electrician	Apprenticeship Completed	3	$54.00	32	$5,184.00
Mechnical Engineer	Professional Engineer	2	$50.00	24	$2,400.00
Design Engineer	Professional Engineer	1	$60.00	15	$900.00
Secretary	5 Years Experience	1	$20.00	8	$160.00
Project Manager	Professional Engineer	1	$60.00	10	$600.00
Power Engineer	Professional Engineer	1	$80.00	16	$1,280.00
Quality Engineer	Professional Engineer	2	$70.00	9	$1,260.00
Contractor	State Certified	2	$54.00	16	$1,728.00
Intern	Pursuing BSEE	1	$12.00	5	$60.00
Estimator	Professional Engineer	1	$40.00	7	$280.00
				Total Cost of Labor	$13,852.00

1.7 *Cost Tabulation*

Materials Cost	$32,813.44
Labor Cost	$13,852.00
Grand Total Cost	**$46,665.44**

2.0 Maintenance Program

2.1 *Yearly Maintenance*

- Remove and inspect fuses
- Re-evaluate load and fuse sizing
- Run electrical load tests on circuit breakers
- Run electrical load tests on motor starter and relay
- Run electrical load tests on the transformer
- Run electrical load tests on the motor
- Check disconnect mechanisms
- Inspect enclosures for any damage

2.2 *Monthly Maintenance*

- Inspect all fuses and circuit breakers for any apparent damage
- Inspect transformer and motors for any apparent damage
- Inspect wiring for any apparent damage
- Inspect lighting for and light switches for any damage

2.3 *Daily Maintenance*

- Check breakers and fuses for any temperature irregularities

2.4 *Failure Maintenance*

- Blown Light Bulb:
    - Turn off switch and circuit breaker for the affected lighting circuit then replace on a ladder with one person holding the ladder
- Tripped Circuit Breaker:
    - Report and record the circuit breaker that was tripped. Inspect the connected circuit for the cause of the trip or any damage. If no damage is found, reconnect the circuit.
- Blown Fuse
    - Report and record the fuse that was blown. Inspect the connected circuit for the cause of the break. Once the cause is determined, replace the fuse and continue normal operation

3.0 Installation

Preparation: Contractors prepare walls and ceiling for mounting of conduit and light fixtures.

Physical Mounting of Parts: Contractors mount conduits to walls, ceiling, and central support beams adjacent to motors, mount lights to ceiling, mount load center, starters, and disconnects to walls. Fasten motors and transformer to floor.

Interconnection: Electricians run wires through conduits to each electrical component, then connect the conductors to the appropriate terminals as specified by the interconnection diagram, following standard procedure for connecting wires to all terminals.

An Electrician, Mechanical Engineer or Technician inspects individual components and installs small components.

A Power Engineer or Electrician installs the transformer and motors and performs tests on the equipment. (See section 4)

Caution: Power supply must be disconnected for the entire process of interconnection.

Professionals Required for Installation:

2 Contracters, 3 Electricians, 2 Mechanical Engineers/Technicians, and 1 Power Engineer.

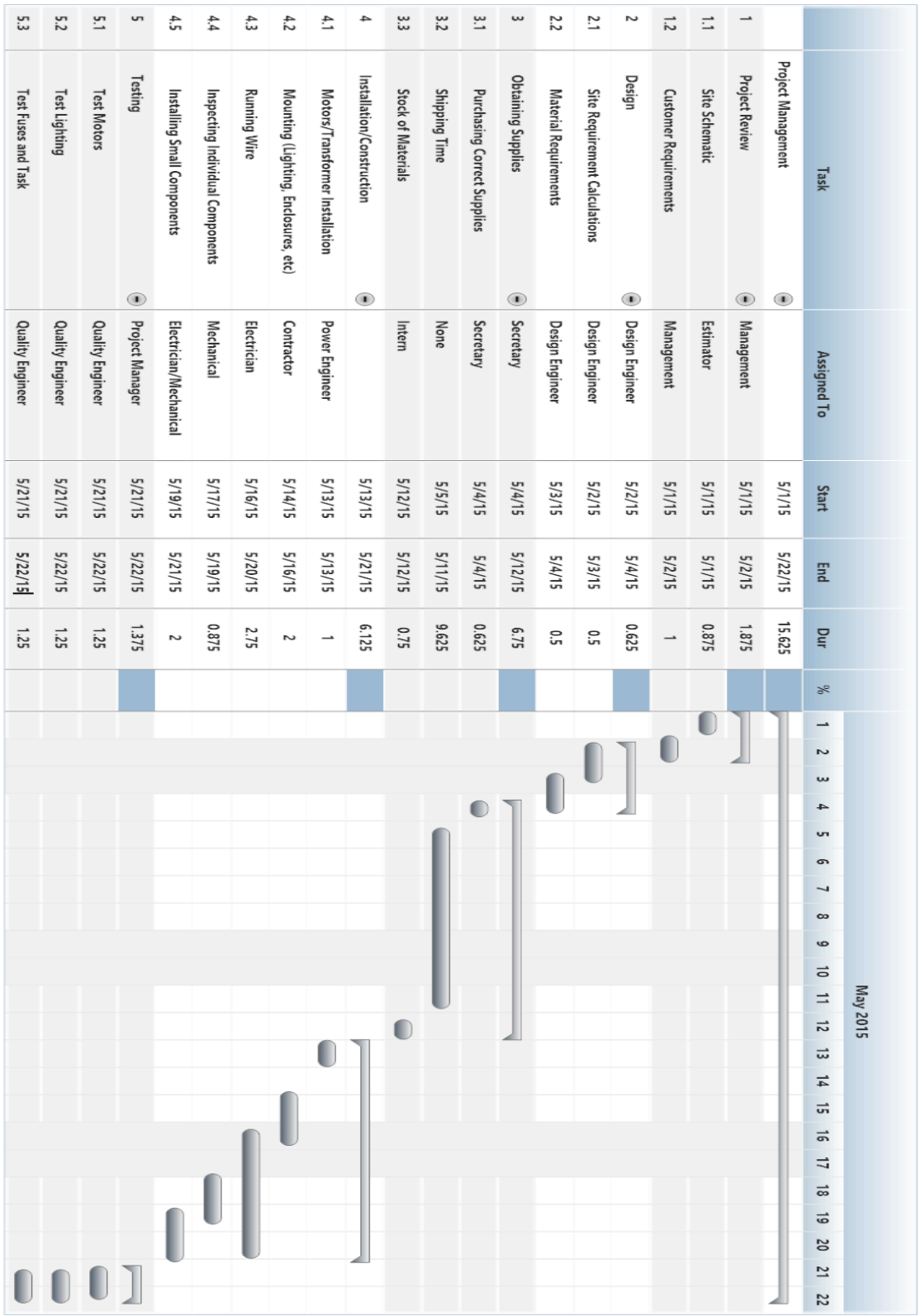
Time Required for Installation:

Approximately 50 hours.

4.0 Testing

- Hall Effect test on the transformer to ensure proper performance
- Hall Effect test on the motor to ensure proper performance
- Test the performance and connection of all fuses as they are installed
- Test wiring as it is run to ensure the proper wire is being connected to each terminal
- Test ON / OFF functionality of breakers, disconnects, and switches
- Test start and emergency stop feature of motor starter

5.0 Management Plan



	Task	Assigned To	Start	End	Dur	%
	Project Management		5/1/15	5/22/15	15.625	
1	Project Review	Management	5/1/15	5/2/15	1.875	
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4.5	Installing Small Components	Electrician/Mechanical	5/19/15	5/21/15	2	
5	Testing	Project Manager	5/21/15	5/22/15	1.375	
5.1	Test Motors	Quality Engineer	5/21/15	5/22/15	1.25	
5.2	Test Lighting	Quality Engineer	5/21/15	5/22/15	1.25	
5.3	Test Fuses and Task	Quality Engineer	5/21/15	5/22/15	1.25	

May 2015

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

6.0 Project Cost

Materials Cost	$32,813.44
Labor Cost	$13,852.00
Grand Total Cost	**$46,665.44**

Appendix A: Product Data Sheets & Sourcing

Appendix B: References

NFPA 70B Maintenance Guide, 2006:

ftp://ftpdoe.water.ca.gov/MandEprojects/Electrical/desarno/NFPA/NFPA%2070B.pdf

IBEW Construction Wage and Benefit Schedule, 2015:

http://www.ibew46.org/area_wage_reports/ConstructionWage_and_BenefitSchedule.pdf