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Department of
Transportation
and
Public Facilities

Harbor Electrical Guidelines

For Maintenance & Operations
Design & Construction

1997 Revision

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This is a guideline and not a design standard. It was published in 1997. It may or may not agree with the current National Electric Codes and your local standards.

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Preface

These harbor electrical guidelines were written to provide technical assistance to State/local harbor owners and operators. The author, Leonard P. Lowell, P.E., has many years of experience in the field of harbor electrical design and construction. In this document, Mr. Lowell provides basic information on how the system operates, troubleshooting, maintenance, corrosion/electrolysis, material selection, testing equipment, codes, design loads, lighting systems, meter stands and receptacles, grounding, construction inspection, shop drawings, and system testing.

The information provided is a culmination of over 20 years of experience in the field. Most of the State's harbors have been built using the techniques and materials discussed herein. New State harbors, electrical renovation of existing State harbors, and electrical maintenance of existing State harbors should follow the guidelines presented.

First printed in 1991, this second edition includes revisions to codes and catalog references as of December 31, 1996. Also, a section on load factors now includes data from 3 harbors in Alaska.

Introduction

The purpose of this manual is to provide guidance in the maintenance and operations of existing harbor electrical systems and to provide criteria and guidance in the design and construction of new harbor electrical systems. The manual was expressly written for use on State harbors, however it is equally valuable for use on locally-owned public or private marinas.

Within boat harbors, the electrical systems are frequently one of the most maintenance intensive elements. A salt-water harbor is a very harsh environment for electrical components because of the ever present moisture, salt-spray, physical damage from vessels, and float motion. This is compounded by the addition of galvanic corrosion and direct current electrolysis which can occur when a vessel connects to the harbor electrical system.

The need for competent and timely inspection and maintenance is further underscored by the safety factor. Harbor electrical systems involve potentially fatal electric currents, and the presence of a wet environment compounds the danger.

It is hoped that this publication will provide an important reference on the harbormaster's desk, and allow Alaska's boat harbors to continue to serve the public with safe and efficient moorage.

1. Harbor Electrical Maintenance and Operations

1.1. Basic System Description

The harbor electrical system obtains the power from the utility primary. The harbor transformer is furnished with the harbor facilities or by the utility and reduces the voltage from 2.4, 4.16 or 12.47 kilovolts to 120/240 volts, single phase, 120/208 volts or 480 volts, 3 phase. The harbor main service disconnect and master meter are usually located adjacent to the transformer. The secondary service from the transformer to the harbor is normally installed below the dock and down the gangway to a distribution panel. The latter subdivides the circuits with one circuit to each side of each major float. Some harbors have a submarine cable for service. The distribution in the float system is a type "W" double jacketed neoprene composite cable impervious to oil, gasoline, etc., and suitable for immersion in salt water. On wood floats, the cable is attached to the stringer and is visible below the decking. On older concrete floats, the cable is in a notch between the wale and the concrete. In newer concrete float systems, the cable is either in a duct or trench.

The lighting system is normally overhead supported on the piling with a separate shore panel and control. Some of the three phase lighting systems can be operated at 1/3, 2/3 or all on as a possible energy savings or harbor utilization.

The power to the grid is generally derived from a separate ground fault breaker on the line side of the connector in the lighting panel. On a 480 volt system, the grid power is derived from a separate transformer with a ground fault circuit breaker on the secondary side. If a faulty piece of equipment is connected to the system, the circuit breaker will trip and disconnect the circuit with ground current flows exceeding 5 milliamperes (.005 amperes).

There are several harbors that have a combined overhead lighting and power distribution system. These systems have been installed with aluminum wire which is subject to corrosion and have a bare messenger ground contrary to the Code requirements for an insulated ground. The systems also generally lack circuit breaker or fuse protection for the feeders and the ability to isolate problems by systematically opening circuits.

Note: Some harbors with older systems employ aluminum wire which is subject to corrosion and lack fuses or circuit breakers. These should be scheduled for changeover.

1.2. System Operation

Generally, the electrical power flows from the utility primary through the transformer, master meter, disconnect, service, main distribution panel, individual float feeder, individual meter and shore power receptacle to the individual vessel.

In a 2-wire, 120 volt system, the energy flows through the hot lead and returns via the neutral. In a 120/240 volt single phase system, the energy flows through the two hot leads. Since the energy is alternating between the two hot leads, the neutral or white conductor carries only the unbalance of the system. In a three phase system, there are four conductors, but again the neutral or white wire carries only the unbalance of the system. The insulated ground wire of the system does not normally carry any energy but bonds the system and all the vessels together at the zero potential of salt water.

1.3. Trouble Shooting

When attempting to isolate some type of problem, any portion of the system may be isolated by opening each feeder circuit breaker, where installed, to determine which float and side is involved. Subsequently the individual circuit breaker or the shore plug may be opened to determine the vessel which is causing the fault. A common problem is a vessel's cord being connected to receive power between the hot and ground rather than the hot and neutral. This can be detected with an amprobe to measure current flow utilizing an adapter assembly as shown in Appendix A.

Note: *If more than one vessel is causing a fault, it may be necessary to disconnect all vessels and reconnect them individually in order to discover the vessels which are causing problems.*

The float feeder cable size is selected on the basis of 2%-5% voltage drop when fully loaded, normally in cold winter months. If the voltage at the panel is a nominal 120 volts and voltages below 115 volts are reported, look for loose terminals in a meter cabinet.

If a feeder circuit breaker trips the circuit breaker may be faulty, an unbalance may exist in the feeder, or an overload may exist. The services of an electrician will be necessary to evaluate the condition or change the circuit breaker.

1.4. Power Consumption

The majority of the harbors have a master meter to register kilowatt hours as energy and kilowatt demand. The latter records the maximum load in any 15 minute period until reset, usually each month. The maximum load should be compared to the previous years recordings to determine the growth rate in electrical demand and to predict the total power demand.

Each shore power outlet has an individual meter, and any substantial deviation from the previous month's reading may be electrolysis or may be caused by some other reason such as a refrigerator or space heater running continually.

1.5. Maintenance

When properly installed, the electrical system in a boat harbor facility should last over 20 years with reasonable care. Any deficiencies which occur should be promptly repaired, and deferring minor repairs may result in subsequent major repairs.

Heat is a good indication of a problem. Any circuit breaker frame, either in the panel or shore panel outlet, which feels warm may have loose connections or corrosion which increases the resistance and, in turn, results in heat. The type W cable should be checked periodically for rubbing or abrasion at the float hinge points, particularly if any swell is present. Some of the older harbors which have meter stands and cast boxes for the outlets and circuit breakers use Crouse-Hinds cast aluminum covers for the circuit breakers which were subject to corrosion. A light penetrating oil at the operating shaft would free the mechanism. In some harbors, the receptacle bodies are black porcelain which has a tendency to crack with abuse. If cracked, the receptacles should be replaced with nylon or melamine receptacles.

Note: Panels or circuit breaker frames which are warm to the touch should be checked for loose connections or corrosion.

If any components are made of steel, either galvanealed or galvanized, any rust spots should be sanded and cleaned and cold galvanizing sprayed on the surface. Galvanealing is a hot dip process on the initial sheet metal prior to fabrication, but galvanizing is a hot dip process after fabrication. Galvanealing is subject to rusting where the initial sheet is cut.

With the exception of light fixtures in areas of high winds near salt water, chemical corrosion has not been a serious problem in properly wired marine facilities. Where chemical corrosion occurs in panels, meter cabinets, etc., it will appear as a blotchy area generally white in appearance. If it does occur, the circuit should be de-energized and tagged prior to cleaning the area or terminal with a brass wire brush and applying a nonconductive, nonflammable corrosion inhibitor spray such as CRC or Hoffman A-HC123GS. If an electrical connection problem develops, particularly between copper wire and aluminum bus bars, an oxide inhibitor/sealer such as Ilsco DE-OX-A-35 or Burndy Penetrox A can be applied. The material will penetrate the oxide film, reduce the contact resistance and seal the joint from air and moisture.

The overhead lighting wiring should be checked each fall for excessive sag, rubbing on adjacent piling or broken insulators or the copperclad messenger not being fastened to the insulators and then repaired as required. The minimum clearance to the float at extreme high tide is ten (10) feet.

Also trollers with forward slanting bow poles or sail boats with spreader bars should not be moored where there is any possibility of interference with the overhead lighting circuits.

Note: Ensure that vessels are moored so as to avoid contact with overhead lighting conductors.

1.6. Galvanic Corrosion/Electrolysis

Galvanic corrosion is caused by a natural battery formed by two dissimilar metals connected together and immersed in an electrolyte such as salt water. For example, non-marine grade brass bolts or screws are an alloy of copper and zinc and can develop galvanic corrosion when immersed or subject to salt water and the zinc portion will deteriorate. A table of the galvanic series of metals is included in Appendix B. Included in Appendix C is a tabulation of corrosion potentials. As an example, the difference between zinc and bronze is 0.6 volts which is small but destructive over a long period of time.

Some possible sources of galvanic corrosion are:

a. Different types of metal immersed in salt water or moisture that are touching each other or connected with a conductor. See Appendixes B & C.
b. Vessels of incompatible hull construction such as aluminum and steel. Aluminum vessels should not be moored adjacent to steel vessels.
c. Bottom paint with different compositions, such as arsenic, copper or tin.

Note: Vessels with dissimilar metal hulls, types of battery grounds or bottom paint compositions should be segregated, if possible, to minimize galvanic or stray current corrosion.

Stray current corrosion or electrolysis is the result of a direct current potential difference between two items which could be within a vessel or from some other vessel. Stray current corrosion is much more destructive than galvanic corrosion due to the possibility of increased voltages involved.

Some possible sources of stray current corrosion are:

a. A direct current welder which uses the salt water as a partial return path as the result of poor or frayed cables. The ideal solution is to place the welder on the vessel.
b. An engine with a positive ground moored next to a vessel with a negative ground.
c. Two bilge pumps which have the connections reversed. (The frame of one pump is connected to the negative, and the frame of the other pump is connected to the positive.)
d. A common automotive battery charger which has an auto transformer (the primary and secondary windings are electrically connected). The primary and secondary windings should be completely separate and isolated. Only isolation transformer battery chargers should be allowed in the harbor.

   Note: Ensure that battery chargers used in the harbor are isolated between the primary and secondary windings.
e. A reverse polarity indicator on a boat with a resistance of less than 100,000 ohms at 120 volts, 60 Hz.
f. The ground and neutral of the vessel not completely isolated. This can be checked with a regular ohm meter at the ship's cord plug. The ohm meter should read infinite resistance to show complete isolation.
g. The vessel cord not properly connected to the hot, neutral and ground shore power outlet. Any vessel which is connected to receive power between the hot and ground in lieu of the hot and neutral should be disconnected. Power derived at the ground will result in a voltage drop in the ground system and, in turn, create another path for stray current corrosion between two vessels. Any new vessel in a harbor should be checked to insure that the ship's ground and neutral are isolated and the power is only taken between the hot and neutral terminals. As shown in Appendix A, a socket and plug with approximately 8" of color coded wire can be inserted between the shore outlet and ship's plug. A clamp-on ammeter can be used to measure the current flow in each conductor. The current flow in the green (ground) wire should be zero.

   Note: New vessels in the harbor should be checked to insure that the ship's ground and neutral are isolated and the power is only taken between the hot and neutral terminals. A similar survey of all the existing vessels is also recommended.

h. Leakage from the telephone system. A telephone has a positive 48 volts ground, and a fault within the telephone instrument in combination with salt water could impress a portion of the positive D.C. voltage across the vessel. Any severe corrosion near a telephone outlet should be checked thoroughly.
i. The ground conductor within the harbor not completely isolated from the neutral except at the main service. The current will flow in the ground conductor creating a difference in voltage between portions of the system and, in turn, between vessels.

At some harbors, primarily in western Alaska, the utilities require a wye-wye primary-secondary transformer or interconnect the primary and secondary neutrals which can result in current flow from the utility through the ground system to salt water. The preferred system is a delta-wye connection which effectively isolates the utility system from the harbor electrical system.

An ideal solution to all stray current corrosion or electrolysis is an isolation transformer for each vessel. However, the cost is prohibitive.

Individual isolated galvanized steel piling will not be affected by electrolysis but may be subject to galvanic corrosion, particularly where different metals such as welds or bolts are involved. Dock structure galvanized piling where electric systems are involved will be more subject to stray current corrosion as noted above.

The majority of all known problems of stray current corrosion are derived from vessels in the harbor rather than the shore power system. Any evidence of rapid deterioration of vessel zincs or pitting of exterior fittings should be checked and the trouble isolated and corrected.

Note: Most harbor electrical problems are due to the vessels rather than the harbor system.

1.7. Vessel/Shore Power Connection

In the majority of the harbors, the standard outlet is a NEMA L5-30, 30 ampere, 125 volt locking receptacle protected with a 20 ampere circuit breaker. The plug has 3 prongs with the ground prong being longer and having a turned edge. The longer ground terminal that the ground is connected prior to the hot or neutral connection. The neutral (white) and the hot (black) terminals are positioned in a counterclockwise direction from the ground (green). A 20 ampere, 125 volt plug or a 125/250 volt plug cannot be inserted in a 30 ampere, 125 volt receptacle.

Where a new vessel is proposed to connect to the shore power, the neutral and ground leads of the ship plug should be measured with an ohm meter which should read infinity indicating isolation. A similar survey of all the existing vessels is also recommended. A test plug/receptacle as shown in Appendix A should be inserted between the shore power and vessel cord. A clamp-on ammeter should be attached to the green wire which should read zero amperes. The cord between the ship and shore power outlet should be not less than 3/conductor (ground, neutral and hot) #12 (rated at 20 amperes) to insure the ship is properly grounded. Ordinary extension cords; should not be permitted since the carrying capacity is below the 20 ampere circuit breakers and normally are only 2 conductor or missing the separate ground conductor.

Note: Ordinary extension cords should not be permitted between the vessel and harbor power outlet unless they are adequate in current carrying capacity and include an insulated ground conductor.

1.8. Ground Fault Interrupter (GFI) Systems

A ground fault circuit interrupter is not provided for each outlet. Ground fault circuit interrupters such as the ones used in residential bathrooms, exterior outlets and swimming pools are set to trip on 5 milliamperes (.005 amperes). There is sufficient leakage around the salt water environment of a boat harbor to continually trip the circuit breaker and be of more nuisance than value.

A number of harbors are equipped with ground fault relays in the main or subpanels which will show a green light for no fault and red for ground faults drawing more than 5 amperes. When the red light is on, some vessel is drawing power more than 5 amperes through the ground conductor rather than the neutral as the result of improper connections. By turning off the float circuit breakers one at a time to determine the float involved and then turning off the individual shore power outlets until the vessel involved is isolated, the red light will change to green. The vessel should not be allowed to reconnect until the proper connections are made. If the red light is allowed to remain on and more than one vessel is involved, a test of each outlet with the adapter will be required to determine which vessels are involved.

Note: When a red light is displayed on a main or subpanel with a ground fault relay, the source of the ground fault should be located and corrected.

1.9. Materials

The materials used in a harbor electrical system should be high quality corrosion resistant marine grade. All of the electrical components should be copper. All of the exposed screws and small bolts should be stainless steel or marine grade bronze, and the larger bolts and lag screws should be hot-dip galvanized. Aluminum is used for some meter stands but is limited to marine grade 5052 or 5086. Some harbors have #316 stainless steel meter stands.

There are a number of manufacturers involved in furnishing materials for boat harbor electrical systems. However, the majority are wholesale and furnish the materials through the following distributors:

North Coast Electric Co. P. O. Box 80566 2424 8th Avenue South Seattle, Washington 98124 Telephone: (206) 682-4444	Debenham Electric Supply Co. 5333 Fairbanks St. Anchorage, Alaska 99518 Telephone: (907)-562-2800
Stusser Electric Co. 660 South Andover Street Seattle, Washington 98108 Telephone: (206) 623-1501	Delta Alaska Wholesale 2425 Industrial Blvd. Juneau, Alaska 99801 Telephone: (907)-789-2880

1.10. Lighting Upgrade

The majority of the older boat harbors have mercury vapor lights which can be replaced with high pressure sodium lights with a relatively short payback.

Type	Wattage	Lumens	Life	KWHR/YR
Mercury Vapor	175	8600	24,000 hrs.	701
High Pressure Sodium	100	9500	24,000 hrs.	438

Based upon 11 hours of operation per day (year round average), the following cost difference is calculated for the two types of lights, for 5 different electrical rates. Further, the bottom row shows the lifetime savings assuming 6 years of lamp life. If this figure is more than the difference in cost for the two lights, it would be beneficial to make the changeover.

Savings at varying electrical rates:

Cost/KwH	8¢	12¢	16¢	24¢	36¢
Cost per fixture- MV	$56	$84	$112	$168	$253
Cost per fixture-HPS	$32	$48	$64	$96	$145
Savings-6 yr. typ. life	$144	$216	$288	$432	$648

1.11. Modifying/Maintaining the Electrical System

The harbor electrical system is only as good as the individual components. All the wire, bus bars etc., should be of copper. The mixing of copper and aluminum parts will lead to corrosion and electrolysis. If any type W cable requires replacing, be sure to specify and obtain only the premium grade such as Royal Powerflex 90. Due to the cost involved, several companies manufacture cheaper grades which will not be suitable for salt water. Also insist on a certificate attesting to the date of manufacture to insure that the cable is not surplus or has been stored in some warehouse for years. In one harbor, all the cable had to be replaced after three months of service as the result of old cable which had been in a warehouse for years and found to have SBR (styrene butadiene rubber) insulation rather than EPR (ethylene propylene rubber) insulation specified. Any replacement of the type W cable requires replacing the entire cable. No splices are to be introduced in the electrical system. If technical assistance is required, contact personnel familiar with the problem.

Note: Copper and aluminum conductors should not be mixed due to corrosion potential.

1.12. References

Unfortunately, written material on marina or boat harbor electrical problems is scarce. One reference which is recommended and would be of value is "Your Boat's Electrical System" written by Conrad Miller and E. S. Maloney. While the majority of the book is for the boat owner, there is a chapter on corrosion and electrolysis and some data on shore power and the proper connections. The book is written by engineers but the data is written in nontechnical language and easy to understand.

1.13. Accessories

Recommended test instruments for maintenance of boat harbor electrical systems are as follows:

Amprobe or clamp-on volt-ohm ammeter (Approximately $175.00)

j. TIF Instruments, Inc. Model 1000
9101 N. W. 7th Avenue
Miami, Florida 33150

k. Amprobe Instruments Model ACD-2
Lynbrook, New York 11563

l. Fluke Corp Model 33
P.O Box 9090
Everett, Washington 98206
(206-347-6100)

Digital Multimeter (Approximately $200.00)

m. Beckman Instruments, Inc.
Model Tech 310
2500 Harbor Boulevard
Fullerton, California 92634

n. Amprobe Instruments
Model AM-4
Lynbrook, New York 11563

o. Fluke Corp Model 73
P.O. Box 9090
Everett, Washington 98206
Telephone (206)-347-6100)

2. Harbor Electrical Design

2.1. Codes

The codes which influence the electrical design of a marina are:

p. National Fire Protection Association, NFPA 303, (Marinas and Boatyards),
q. National Fire Protection Association, NFPA 70 (National Electrical Code or NEC), and
r. National Electrical Safety Code (NESC), ANSI C2.

Article 555 of the National Electrical Code was first included in the 1968 NEC and was derived from NFPA 303. The latter was first adopted in 1940 and completely revised in 1963 and 1986. The majority of the pertinent requirements of NFPA 303 have been transferred to Article 555 of the NEC over the past 25 years.

Some of the major provisions of NFPA 303 are:

3-2 All wiring, conduit enclosures and equipment to conform to the NEC.

3-4 All areas above the pier deck or above the datum plane (2'-0" above the highest tide) to be classified as "Damp."

3-4 All areas below the datum plane to be classified as "Wet."

3-5.6 The service equipment to be located in a damp location and protected from the weather.

3-6 All noncurrent carrying parts of the system to be bonded and grounded with separately insulated ground wires.

3-12 All wiring to be in rigid metal conduit or rigid nonmetallic conduit except where flexibility is required. Type W conductor fastened with nonmetallic clips is permitted in lieu of conduit.

3-12.1 Circuit breakers to be required rather than fuses.

3-15.2 Receptacles to be not less than 20 amperes and of a locking and grounding type conforming to ANSI C73.

Some of the applicable provisions of NEC 70 are:

555-3 Shore power receptacles to be of the locking and grounding type and not less than 30 amperes except that 20 amperes may be used for boats less than 20'. Receptacles other than for shore power to be protected with ground fault circuit interrupters (GFI).

555-5 The electrical loads for the feeders and service to be calculated on a varying schedule from 100% to 20% of the sum of the ratings of the receptacles.

555-6 The wiring method to be of a type for wet locations.

555-7 The ground conductors to be insulated copper and terminate at the main service equipment.

The main applicable provisions of the NESC is the minimum overhead clearance of wires for lighting circuits. Table 232-2 provides for a minimum of 13' for "spaces and ways accessible to pedestrians only." Note "B" further reduces the clearance to 10' if the voltage to ground is less than 150 volts. Other provisions of this Code would apply to any pole line or underground service.

2.2. Load Factors

Section 555-2b of the 1968 NEC included a requirement for load factors for feeders and services to be calculated on the basis of 25 watts per lineal foot of slip or dock space for boat outlet circuits plus lighting and other electrical loads. The same requirement was included in the 1971 NEC as 555-5. The 25 watts per lineal foot was dropped in the 1975 Code in favor of:

1 - 4 Receptacles	100%
5 - 8 Receptacles	90%
9 - 13 Receptacles	80%
14 and over Receptacles	70%

The 1975 preprint of the NEC states the reason for the change is "the present wording and requirements are ambiguous, unrealistic and difficult to enforce."

The preprint of the proposed amendments for the 1978 NEC proposed to change the demand factor of NEC 555-5 and included the following summary of 3 California marinas.

	#1	#2	#3
Actual Maximum Demand KW	39.6	21.8	45.6
Design Based on 25 w/ft	86.6	45.4	126.25
Design Based on 1975 Code	186.2	92.4	396.0

The 1975 NEC changed the 100 and over outlets range to 30% demand which was changed again in the 1987 NEC to 20% demand.

Although the 25 watts per lineal foot of stall method is preferred for design purposes neither method will produce accurate results due to a number of variables involved such as:

s. The Cost of Electricity. The rate for electricity varies from 5.5 cents/KWHR to 38 cents/KWHR plus a fixed customer charge, if any, has a major impact on the harbor electrical demand. As an example, the Hoonah boat harbor constructed in 1981 has 6004 LF of stall but a density of 1.19 watts/ft summer and 4.0 watts/ft winter as the result of an electricity cost of 38 cents/KWHR.

t. The Type and Size of Vessel. A commercial vessel will generally require less demand than a pleasure boat as the result of the use of oil stoves and the more frequent absences from the harbor. The Haines harbor has a high percentage of transient gillnet vessels which results in a relatively high summer and low winter electrical load.

u. The Location of the Harbor. A remote harbor which is not adjacent to the harbor users may have a high demand load. As an example, the Whittier harbor primarily has pleasure boats for Anchorage residents together with a relatively low electrical rate resulting in the highest demand load of any harbor. The maximum load of 24.2 watts/lineal foot of stall was recorded in March 1979. Also, the actual load factor (total kilowatt hours consumption divided by the demand KW x 24 hours x period) is approximately 80%. The minimum summer load was 4.95 watts per lineal foot.

While the 25 watts/lineal foot of stall with some load factor is recommended for design, the parameters and composition of each harbor should be carefully considered before selecting the anticipated demand or load. The design should also provide for the demand if the rate of electricity decreases.

To facilitate future designs, the data and graphs of three existing harbor electrical load data is included as Appendixes D, E and F. The three harbors selected have low, average and high electrical loads. All harbors have 30 ampere, 120 volt (L5-30R) receptacles and are protected with 20 ampere single pole circuit breakers. The information given is an average for the harbor segment. The watts per lineal foot of stall will be fairly uniform across the harbor, however, the watts per outlet will vary with the stall length. Smaller boats will require less electrical energy and the number of vessels physically connected to shore power will decrease.

1. **Hoonah Boat Harbor** has 4 floats with stalls from 24 to 62 lineal feet. The electric rate is $0.38 per kilowatt hour which substantially affects the electric load. The maximum load in 1996 was 4.2 watts per lineal foot of stall and 157.7 watts per outlet. The minimum load was 1.5 watts per lineal foot of stall and 57.7 watts per outlet. The July electrical maximum almost equaled the winter maximum as the result of stateside pleasure boats visiting Hoonah enroute to Glacier Bay.

2. **Ketchikan Bar Harbor North** has 8 float systems with varying stall lengths from 24 to 62 lineal feet. The maximum load in 1996 was 9.6 watts per lineal foot of stall and 643.4 watts per outlet. The minimum load during the same period was 1.9 watts per lineal foot of stall and 124 watts per outlet. The load factor varies from 72.1% to 43.6%.

3. **Whittier Boat Harbor** (floats D, E, F &G)

has 4 floats with stalls from 24 to 32 lineal feet. The maximum electrical load in 1991 for these floats was 16.1 watts per lineal foot of stall and 865.8 watts per outlet. The minimum in 1991 was 8.3 watts per foot and 444.7 watts per outlet. The load factor varies from 80.1% in the winter to 69.0% in the summer. The electrical load in 1996 showed a drop of 22% from 1991. This drop could be related to the increase in electrical rate or temperature change. The meter for floats A, B & C includes the harbormaster’s office, restaurant, fuel dock and exterior lights and does not reflect a true value for the electrical load so these are not included in this report.

2.3. Primary System

The majority of the utility primary systems are 2400 volts, 3 phase delta, 2400/4160, 3 phase wye or 7200/12,470, 3 phase wye. Most of the utilities where available and particularly those involved with REA standards prefer and insist on wye-wye transformer connections. The purpose is to avoid or decrease any possibility of ferroresonance and destruction of the transformer. This can occur with single phase switching of a 3 phase transformer with an underground primary feeder if the inductive and capacitive reactance are equal.

The preferred connection in any boat harbor with 3-phase distribution is delta-wye to insure that any ground current in the utility neutral will not flow to salt water through the neutral and ground conductors and create a difference in potential between different parts of the harbor. One solution for averting ferroresonance with a delta-wye connection is to provide a 3-phase oil switch within the transformer to be used to energize the 3-phase circuit conductors simultaneously rather than a single phase operation at the pole.

If the boat harbor transformer is single phase, again the primary and secondary should be isolated. If no other solution exists, an isolation transformer is recommended.

2.4. Secondary System

There are a variety of systems available which require correlation with the size and layout of the harbor:

v. 120/240 volts, single phase;
w. 120/208 volts, three phase wye;
x. 480 volts, single phase with subsequent reduction to 120/240 volts;
y. 480 volts, three phase delta with subsequent reduction to 120/240 volts, single phase;
z. 480 volts, three phase delta with subsequent reduction to 120/208 volts, three phase.

If the float system contains a main float plus three or more finger floats, the system described in item "d" is preferred. Other advantages of "d" are the isolation of the ground system, reduction of the voltage drop and the use of standard meters. Items "b" and "e" require more expensive network meters. Items "c," "d" and "e" require marine transformers on the main float at the intersections of the fingers. Since the transformers are large and weigh approximately 600 pounds each, additional floatation and float width may be required.

The 120/240 volts, single phase shown in item "a" is generally used for small boat harbors. Item "b," 120/208 volts, 3 phase, 4 wire, is preferred for low voltage when available since a 25% increase in conductors will result in a capacity increase of 50%. The one disadvantage, however, is the requirement for network meters when connected across 208 volts.

The secondary service to the harbor is normally installed below the dock and down the gangway to a distribution panel. The latter subdivides the circuits with one circuit to each side of each major float. Some harbors do have a submarine cable for service.

2.5. Harbor Layout

The harbor layout has an impact on the electrical design. The electrical engineer should be involved at the initial phase to coordinate the gangway locations and the type of float system proposed. Electrically, the dock and gangway should be at the center of small harbors and at the 1/3 points for larger harbors. A dock and gangway at the ends of a harbor layout creates a problem of voltage drop, increased cable size and cost. If the dock and gangway cannot be located except at the end, a 480 volt system with transformers along the main float is recommended.

The piling layout will have an effect on the overhead lighting cables. A piling at each intersection is required to insure that the lighting cables will be above the floats rather than the waterway where they could be interfere with vessels.

2.6. Float System Types

There are several varieties of float systems.

aa. Treated timber floats with foam flotation. The float system may or may not have bull rails.
bb. Concrete floats with a notch recessed approximately 3"x 3" between the wale and concrete. This type of float was discontinued in 1980 in favor of "c."
cc. Concrete floats without the notch but with either a trench or duct system or a combination of both.

From the electrical design viewpoint, the preferred float system is item "a," timber floats, which has the maximum flexibility for the initial and future requirements. Item "c" is the least desirable, especially the duct system, because of the restricted space for any future expansion. The effect of sun on the trench covers will increase the trench temperature and shorten the cable life.

2.7. Conduit And Ducts

All conduit for underground upland electrical wiring should be rigid galvanized conduit with two coats of bitumastic paint. Rigid schedule 40 nonmetallic conduit or duct may be used either exposed or underground subject to the limitations of the NEC. All conduit should be assembled watertight. Rigid aluminum conduit is not recommended adjacent to salt water.

2.8. Wiring

All wiring should be stranded copper, 600 volts minimum. All upland wiring should be type THW, THWN or XHHW in conduit. Aluminum wiring is not recommended for marine wiring due to corrosion. All wiring down the gangway and throughout the float system should be type W copper stranded with type EPR (ethylene-propylene-rubber), or equal, insulation. The conductors should have a minimum of 259 strands. The insulation of type W cable using SBR (styrene butadiene rubber) compound is subject to cracking and should not be used. The outer jacket should be double jacketed neoprene, cured in lead and identified by size, number of conductors, voltage, temperature and a number such as P122MESA. The 122 is a designation for "Royal" and the P-MESA indicates approval of the Pennsylvania Department of Mines and the U. S. Mining Enforcement and Safety Administration. A UL label can also be applied if requested on type W cables.

There is also a type G cable which has been used in some marinas in the contiguous 48 states. Type G cable is similar to type W except the ground wires such as 3- #8 for #2 cable are not normally insulated and do not meet the requirements of an insulated ground in NEC 555-7b.

Some of the MESA numbers assigned to various manufacturers are:

P104	The Okonite Company
P105	Rome Cable Corporation
P108	General Electric (discontinued production)
P120	Hatfield Wire and Cable
P122	ITT (Royal Electric)
P123	Carol Cable Company
P125	Anaconda-Ericsson Inc.

Several firms manufacture type W cable in more than one grade. ITT (Royal) manufactures "Power Flex 90" as their premium grade besides manufacturing an industrial grade. Normally, the premium grades have a double neoprene or hypalon jacket whereas the lesser grades have only a single jacket.

Specifications for type W cable should specify the premium grade and require a certificate indicating the various tests conducted and the date of manufacture. This will insure that the cable is new and has not been stored in some warehouse for a number of years.

Type W cable has the capacity for continuous operation at 90° C or 194°F and 40˚C or 104˚F ambient. Since the maximum electrical load on the harbor will occur during the winter months, the operating current of the cable can be increased 15-20 per cent providing the overall system voltage drop is less than five per cent. The main feeder or the service from the main disconnect (usually located adjacent to utility transformer) to the float distribution panel is normally one or two runs of 4/O type W cable which can be increased in ampacity. The float feeders should be on each side of each float and are normally 4 conductors (2 hots, neutral and ground). The maximum feeder voltage drop should be 2.5 percent at 100 per cent power factor at maximum load. A long float will require two runs for each side.

The bending radius of type W cable is normally eight times the diameter.

All cable terminations on the float system must be in the pedestals. No splices or junction boxes are allowed in the float system. Clamps used to support type W cable need to be either wood or PVC coated to protect from wear.

Wiring for the overhead lighting should be stranded copper, 3/c for single phase or 4/c for three phase plus 30 per cent copper messenger and a PVC coated copper strap. The wiring assembly should be GE #SI58069, PIRELLI or Service Wire Co. cable.

2.9. Lighting

The lighting in practically all the marinas has been overhead. Many of the recently used fixtures have been Holophane 216C-120 v 100 W HPS installed on the pilings as shown in Exhibit A, sheet E-3. This fixture is no longer manufactured. A possible replacement is a Halophane Petrolux II Marine fixture, UL 595. The fixture should be suitable for a marine environment. One-hundred watt HPS fixtures installed on pilings with 75' spacing will provide the recommended foot-candle level of 0.3 with a uniformity ratio of 1-1.5 at mid-tide. Upland fixtures which are normally higher in elevation should be marine grade with a cutoff to preclude any light hindering navigation or impacting upland owners. The lighting is generally controlled by a contactor with a photoelectric cell. Where three phase power is used, each phase should control every third fixture through individual circuit breakers. Where the cost of electricity is high, a portion of the lights can be turned off as a cost saving if warranted. The electricity used as lighting can be metered separately and allocated accordingly.

A pole is required at the end of the approach dock for the transition of conduit to overhead as shown in Exhibit A, sheet E-4. The span to the float piling should be minimum to avoid side thrust of the float piling.

The minimum overhead clearance of the cable midspan should be not less than 10'-0" at 90° F above the float deck per the National Electrical Safety Code if 120 v. fixtures are used. A clearance of 12' is recommended for additional clearance and to leave room for a telephone circuit at 10', if required. The sag may be as noted on Exhibit A, sheet E-3. While the pole extension will provide clearance for the cables at the intermediate piling, an additional support as shown on Exhibit A, sheet E-3 is recommended.

Where the harbor configuration is such that boats tie parallel to the main float, overhead circuits should be placed as far from the parallel moorage as possible to eliminate potential contact with rigging, antennas, etc. This is depicted in Exhibit A, sheet E-l.

The disadvantage of overhead lighting circuits is the possibility of trolling boats with bow poles slanting forward or large vessels with anchors or similar gear contacting the overhead circuits particularly at high tide. Reversing the mooring of these vessels usually alleviates the problem.

Light fixtures and poles mounted on the floats have been used on several installations. However, the illumination level is quite low and the poles are susceptible to damage by vessels.

2.10. Meter Stands

Prior to 1976, all the meter stands specified in the various harbor electrical projects were angle iron galvanized frames with separate components as shown on Exhibit A, sheet E-5. This 1982 project used the original angle iron frames assembled to match a previous project at Ketchikan Bar Harbor. After 1977, meter stands from various manufacturers (primarily Midwest, Unicorn and Daniel Woodhead) have been used. The latter utilized a fiberglass enclosure which was not susceptible to rust. The standard production models of the other two manufacturers used galvanealed sheet metal for the enclosure. In this process, the initial metal sheets are hot dipped, galvanized and rolled. The rolling process produces a flat smooth surface for the bonding of the paint. The problem with the galvanealed process is that during the fabrication process, the sheet metal is cut and the only protection from rusting at the cut is the finish paint. The base plate attached to the deck is particularly susceptible to rust. Meter stands constructed of #316 stainless steel or type 5052 or 5086 marine grade aluminum stands have been specified. In some installations, a flared skirt is required to accommodate the cable train either along the float or perpendicular to the bull rail. A flared skirt is not required if a trench is used which is of sufficient depth to accommodate the cable train as shown in Exhibit B, sheet E-5. Meter stands should be attached to the bull rail to avoid the use of inserts on concrete decks. Receptacles in the meter stands should be in the bottom to protect the receptacle from the elements.

Harbormasters have expressed a desire to utilize the galvanized angle iron frame meter stand (see Exhibit A, sheet E-5) because of the ease with component replacement and less initial cost. The designer should receive guidance from the facility owner as to the type to be installed.

2.11. Receptacles

Receptacle outlets should be standardized to allow interchangeability within Alaska. The recommended receptacles and circuit protection is as follows:

dd. 120 volt, single phase, 30 ampere receptacle NEMA L5-30R protected by a 20 ampere circuit breaker.

ee. 120 volt single phase 50 ampere receptacle (no NEMA standard) Hubbell #63CM70 or Marinco 6370CR with 50 ampere single pole circuit breaker.

ff. 120/240 volt single phase 30 ampere receptacle NEMA L14-30R protected by either a 20 or 30 ampere 2-pole circuit breaker.

gg. 120-240 volt single phase 50 ampere receptacle (no NEMA standard) Hubbell #63CM69 or Marinco 6369CR (isolated neutral and ground) with 50 ampere 2-pole circuit breaker.

hh. 120/208 volt three phase (no NEMA standard) Crouse-Hinds #AR1041 or to match ship (isolated neutral and ground).

2.12. Tides

The tides in southeastern Alaska range from 15 feet near the ocean to 26 feet in Juneau and slightly less in Ketchikan, Wrangell and Petersburg. The Homer-Seldovia area has a tide range of over 27 feet, and the Aleutian Island areas less than 6 feet.

The electrical power from the dock or shore to the float system is normally routed down the gangway, and the cabling will be required to accommodate the tidal range. The amount of gangway travel is related to the extreme low to extreme high tide and the gangway length. At the dock, the gangway will swing approximately 30˚ from the horizontal for a 50' gangway and 20° for a 75' gangway. A junction box is required at the dock end for terminating the wire and conduit and as a transition to the flexible type W cable. A loop or slack span with grips will accommodate the gangway hinge action.

A support column is required at the gangway float as shown in Exhibit B, sheet E-4. The slack in the cable at the foot of the gangway should be calculated so that at high tide the cable does not droop into the water and at low tide the cable is long enough to prevent strain on the cable. The midpoint between the point on the gangway and the point on the post should be the area where the vertical and horizontal travel of the gangway is equal from extreme high water to extreme low water. This point can be calculated or plotted graphically. The portion of the cable along the gangway can be protected with conduit, but this is usually not necessary. Stainless steel grips and a spring should be used as shown on Exhibit A, sheet E-4 to support the cable.

2.13. Materials

All materials exposed to salt water should be marine grade. Sheet metal should be type 316 stainless steel. Marine grade aluminum #5052 or #5086 are optional materials. Bus bars, if used in meter stand panels and transformers, should be copper rather than aluminum. All bolts, nuts, washers and rivets 1/4" and smaller should be either stainless steel or marine grade brass. Exterior bolts, lags and washers larger than 1/4" should be hot dipped galvanized. The preferred junction box is either fiberglass or plastic. Panels should be mounted in NEMA type 12 enclosure with stainless steel hinges and padlock handle. If required, the panel should have legs as shown in Exhibit B, sheet E-4.

2.14. Grounding

The ground system of any marine facility is very important. The NEC requires the neutral and ground to be bonded together at the service and to a ground rod not less than 8'-0" long. A separately derived neutral and ground system as shown in Exhibit B, sheets E-5 and E-7 should be grounded to a separate heavy duty copper pipe (minimum 3/4" x 8'-0") to salt water. A copper clad steel ground rod will deteriorate in salt water. According to NEC 555-7b, the ground conductor is required to be insulated and completely separate from the neutral except at the service or a separately derived system. The ground circuit as a minimum should be grounded with bare stranded conductor of a size not less than the feeder to salt water at all distribution panels and at the end of each float. The preferred solution is to reinforce the ground system at each pedestal with bare #2 stranded copper to salt water. The purpose is to insure that all vessels connected are at equal potential and that any stray circulating current from a vessel will be shunted back to the vessel rather than to some distant vessel. It is also recommended that a metal gangway be grounded on each side either to salt water or to a steel member for fault protection of the service or feeder cable.

2.15. Ground Fault Interrupter (GFI)

Household or swimming pool ground fault interrupters (GFI) are normally set at 5 milliamps or .005 amperes. In a salt water environment, there is sufficient leakage to trip a branch circuit breaker and a GFI is therefore not recommended.

A ground fault relay such as Square D type GA set for 5 amperes has been used in the main panel to detect a current flow in the ground wire. The relay is connected with a visible green light for no fault and a red light for fault. The relay is not connected to trip the main circuit breaker. While the relay is a useful tool to detect an improperly wired vessel, some harbormasters have had the relay disconnected to avoid the "red light always on" rather than locating the vessel that is improperly connected. A 5 ampere current flow in a #2 ground wire at 200 feet will result in a voltage drop in the conductor of 1 volt. This voltage drop will result in a voltage differential between vessels and contribute to stray current corrosion.

Note: The red light signal on a ground fault relay should never be disabled as a nuisance; it indicates a potentially serious problem which needs to be isolated and corrected.

2.16. Grid Power

If a gridiron is a part of the project, electrical power is generally provided. A standard 120v., 20 amp. marine type receptacle in a cast brass box such as Russellstoll #3920G mounted adjacent to each approach ladder above extreme high tide is required. It is recommended that each outlet be protected by a ground fault interrupter (GFI) and a publicly accessible circuit breaker.

2.17. Submarine Cable Application

Where no above water routing is available, type W double neoprene jacketed cable has been used under water with depths of less than 100 feet and a relatively smooth bottom. After 3 months on the bottom, test samples of type W cable do not appear affected by crab or other marine life.

If the bottom is rocky, uneven or subject to wave action, a submarine cable is recommended. Armored submarine cable is more costly than type W cable and requires a longer time frame to acquire.

3. Harbor Electrical Construction Phase

3.1. Background

The typical boat harbor electrical system as shown in Exhibits A and B is not common to any other system except perhaps a ship. The majority of the items are specialty items selected for a marine environment to maximize safety and minimize corrosion.

An electrical contractor who has never installed the electrical system in a boat harbor may have considerable difficulty, and the contractor's and the individual worker's qualifications should be carefully evaluated before approval. Similarly, the inspector should have working knowledge of electricity and applicable codes. If all the parties involved are familiar with marine work and boat harbors, the project will be smoother with a minimum of problems.

As a minimum, the inspector should have the following reference material: National Electrical Code (NEC); National Electrical Safety Code (NESC); and the National Fire Protection Association (NFPA), 303 Marinas and Boatyards.

3.2. Plans and Specifications

The plans and specifications should be prepared by an electrical engineer specializing in marine related work. The inspector should be thoroughly familiar with these documents.

The symbols normally used in an electrical design are shown in Exhibits A & B. The one-line diagram as shown in Exhibit B, sheet E-7, identifies all the wire sizes and types, conduit, transformers, panels, circuit breakers and accessories for the system assembly and function. The reference to an assembly followed by a number such as "C-7" refers to the Rural Electrical Authority (REA) standards. "C-7" is a 3-phase 7.2/12.47 KV dead-end with two cross arms. Similarly, M2-1 specifies the grounding assembly with a ground rod. Typical assemblies are shown as Exhibits C and D.

The aerial lighting circuits should be substantially as shown in Exhibit A and B. An intermediate support as shown in Exhibit A, sheet E-3 should be used to maintain clearance over adjacent piling. A clevis or dead-end assembly is required at each corner or end. A piling is required for support of the aerial lighting circuit at each intersection. If there is no other alternative, a midpole tap can be used. The circuit should not cross any usable waterway. The span between the shore support and float piling should be minimal to reduce the side tension on the piling.

3.3. Shop Drawing Process

Contract specifications normally require the electrical contractor to submit a manufacturer's brochure with literature (usually called a "catalog - cut") and shop drawings for approval. The purpose is to insure that the electrical contractor has a firm understanding of the design concept contained in the contract drawings and specifications. Each item in the submittal should be checked and approved or rejected with applicable notations by the electrical design engineer. The submittals are generally submitted by the electrical contractor through the general contractor, if any, through the state's (or city's) project engineer to the electrical design engineer.

After the review is completed, the reverse procedure is used to insure that each entity will be familiar with the design and comments. The evaluation of proposed substitutes is the responsibility of the electrical design engineer with the concurrence of the state (or city).

3.4. On-Site Inspection

The materials specified and incorporated in the electrical project should be all new and, where appropriate, packed in the original containers. Each item in the project should be checked for conformance to the specifications and submittal. Any item which does not conform to the submittal or specific notation should not be incorporated in the project without a new submittal and approval.

Damaged or used material should be rejected and not installed in the project. Minor scratches or abrasions can be repainted or refinished with Galvcote, or equal.

The minimum overhead clearance for 120 volt wires as shown in the National Electrical Safety Code is 10 feet above the float at extreme high tide. A clearance of 12 feet is recommended for additional clearance and to leave room for a telephone circuit at 10 feet, if required. These clearances are at the midspan at 90° F. The sag of the overhead conductor should be as shown or noted on the design drawings. The sag of wire has many variables; however, the approximate sag for 4/c #6 with messenger based on 25% factor of the tension strength will result in the following sags:

Temperature (^{O}F)	**50'**	**75'**	**100'**
30°	5"	11"	l9"
60°	6"	13"	23"
90°	7"	15"	27"

The sag may be increased or decreased approximately 0.5% per degree of temperature change.

The pedestal clearances are covered in NFPA 303. The clearances within panels is covered by Article 384, NEC. Where type W cable is terminated within a panel, additional side clearance is required. The clearance outside and around electrical equipment is covered by Article 110, NEC.

The splicing of conductors, either type W or aerial, should not be permitted. Taps for overhead light fixtures should be made with split bolt bronze connectors and taps. Type W cable should terminate only at the circuit breaker or lugs in the meter stands. The connection of type W cable to the service at the junction box should be split bolt bronze on a connector such as Burndy Variline taped and covered with a heat shrink cover.

Connectors of any type should be marked "CU" (copper) or "AL/CU" (aluminum/copper). Connectors marked "AL" (aluminum) should not be used. All wire insulation should be trimmed to be flush with the terminal, the wire assembly inserted in the connector body and the nut or bolt tightened to the torque recommended by the manufacturer. Loose connections are the primary cause of marine electrical system problems, and the proper tightening of the connectors is important.

3.5. System Tests

After the system is completed, it is recommended that the following checks be made.

ii. Turn the Hand-Off-Auto selector of the lighting contactor to the Hand position and observe that each light operates. Turn one circuit breaker off and observe that every other light for single phase or every third light for 3 phase is off to insure that the load and distribution is balanced. Observe that the system operates in the automatic mode.

jj. The voltage at each transformer should be checked by the contractor and recorded. The taps may require adjustment for a nominal voltage.

kk. The ground current at each ground should be checked by the contractor and recorded. Any reading in excess of 0.5 ampere should be corrected.

ll. Each outlet should be tested with a circuit device such as a panel Woodhead tester to insure that the receptacle is wired correctly. An adapter and additional receptacles will be required.

The bolts and other fasteners should be spot checked with a magnet to insure that steel or cadmium plated bolts have not been used. Stainless steel or brass bolts are not attracted to a magnet.

3.6. Mistakes and Short Cuts

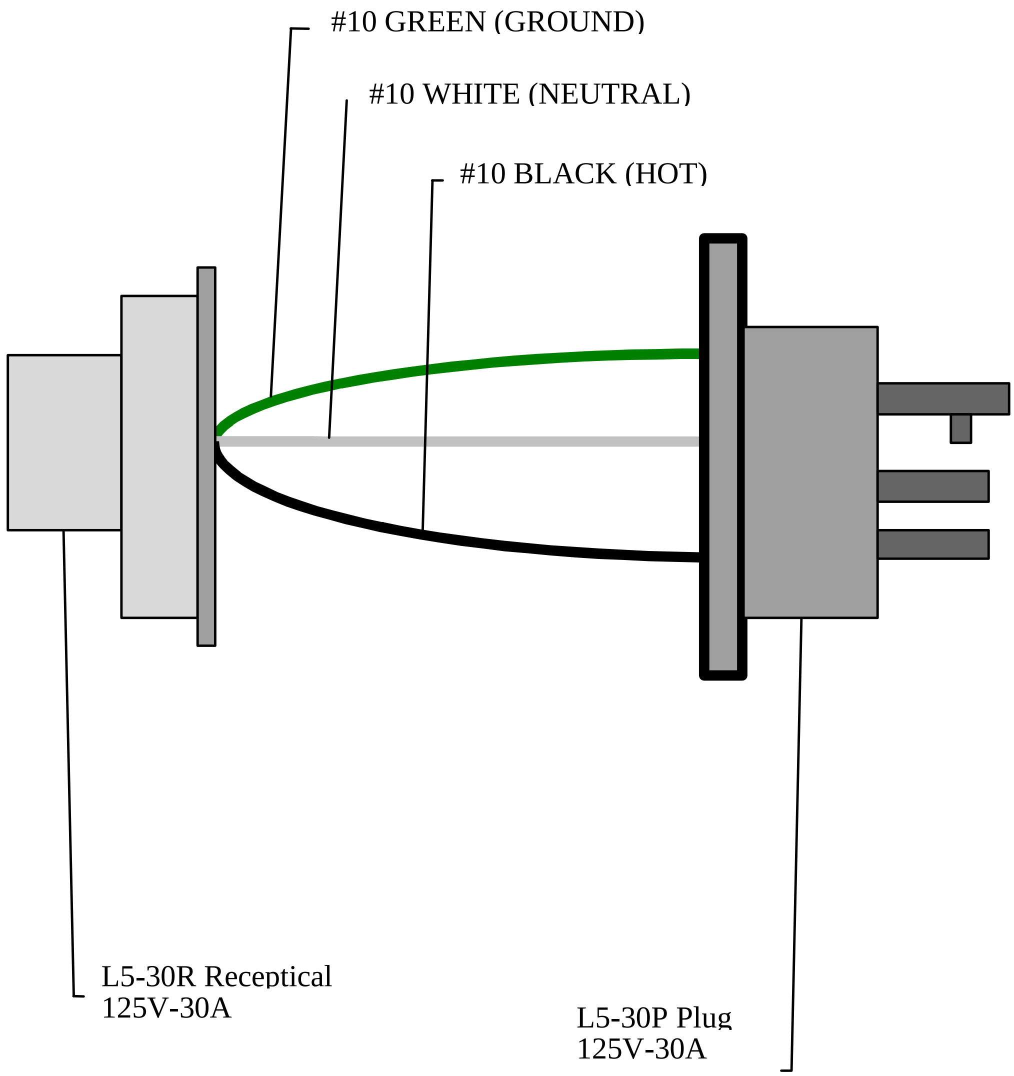
The majority of the mistakes by either the contractor or inspector have been the result of lack of experience on marine related facilities. This problem can also extend to the supplier who may offer substitutes which are not equal as the result of lack of experience or for cost savings.

The inspector should be on the site full time when the type W cable is installed. The end of the cable should be sealed to insure that no salt water enters the cable ends. Each run of cable should be inspected to insure that the cable is adequately supported, is not immersed or does not droop in salt water, or is not subjected to damage from floating debris. The clamps used to support type W cable should be either wood or PVC coated clamps. The cable at the intersection of each float should not be subject to chafing, particularly if any float movement is anticipated.

4. Appendices

Appendix A. Adaptor Assembly
Appendix B. Galvanic Series: Anodic or Least Noble--Active
Appendix C. Galvanic Series: Corrosion Potentials in Flowing Seawater
Appendix D. Tables and Charts of Load Data
Appendix E. Watts Per Lineal Foot of Stall
Appendix F. Watts Per Outlet

4.1. Appendix A. Adaptor Assembly



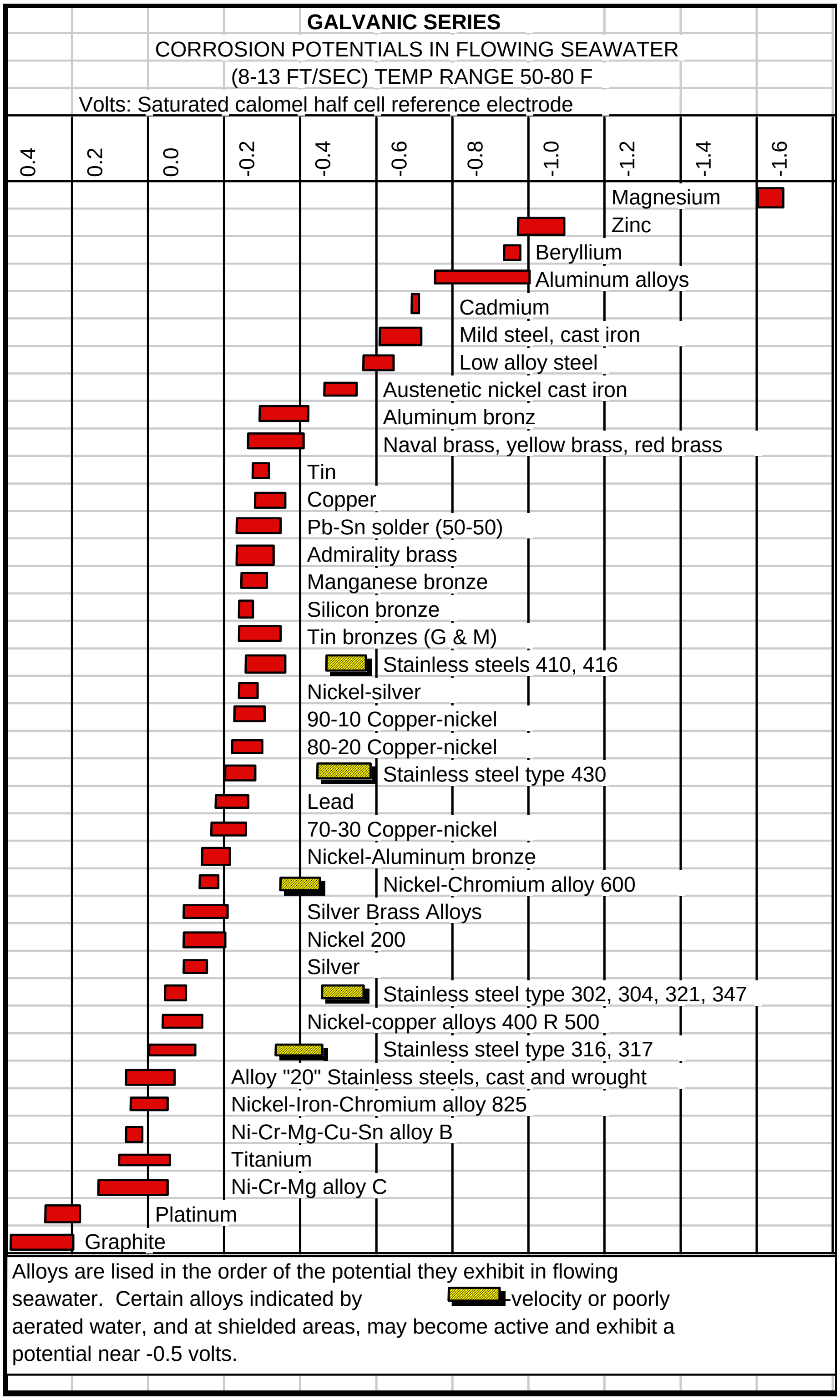
ADAPTOR ASSEMBLY
Not to scale

4.2. Appendix B. Galvanic Series

Anodic or Least Noble--Active

1. Magnesium and magnesium alloys
2. CB75 aluminum anode alloy
3. Zinc
4. B605 aluminum anode alloy
5. Galvanized steel or galvanized wrought iron
6. Aluminum 7072 (cladding alloy)
7. Aluminum 5456
8. Aluminum 5086
9. Aluminum 5052
10. Aluminum 3003, 1100, 6061, 356
11. Cadmium
12. 2117 aluminum rivet alloy
13. Mild steel
14. Wrought iron
15. Cast Iron
16. Ni-Resist
17. 13% chromium stainless steel, type 410 (active)
18. 50-50% lead tin solder
19. 18-8 stainless steel, type 304 (active)
20. 18-83% NO stainless steel, type 316 (active)
21. Lead
22. Tin
23. Muntz metal
24. Manganese bronze
25. Naval Brass (60% copper-39% zinc)
26. Nickel (active)
27. 78% nickel,13.5% chromium, 6% iron (Inconel) (Active)
28. Yellow brass (65% copper-35% zinc)
29. Admiralty brass
30. Aluminum bronze
31. Red brass (85% copper-15% zinc)
32. Copper
33. Silicone bronze
34. copper-20% nickel-5% zinc
35. copper-10% nickel
36. copper- 30% nickel
37. CU.27.Zn-10% Sn. (composition G bronze)
38. copper 3% zinc-6.5% Sn-1.5% PB (composition M-bronze)
39. Nickel (passive)
40. Nickel-13.5% chromium-6% iron (Inconel) (passive)
41. nickel-30% copper
42. 18-8 stainless steel type 304 (passive)
43. Mo. stainless steel, type 316 (passive)
44. Hastellov C
45. Titanium
46. Platinum

4.3. Appendix C. Galvanic Series Corrosion Potentials in Flowing Seawater



4.4. Appendix D. Tables and Charts of Load Data

Table 1 ***Whittier***

Table 2 ***Ketchikan***

Table 3 ***Hoonah***

4.4.1 Table 1. Whittier

Date	KW Power	Lights	Total	Watts/lf stall	watts/ outlet
Jun-90	35.2	(7.8)	27.4	6.7	360.5
Jul	35.2	(7.8)	27.4	6.7	360.5
Aug	36.8	(7.8)	29.0	7.1	381.6
Sep	40.0	(7.8)	32.2	7.9	423.7
Oct	54.4	(7.8)	46.6	11.4	613.2
Nov	64.0	(7.8)	56.2	13.7	739.5
Dec	68.8	(7.8)	61.0	14.9	802.6
Jan-91	68.8	(7.8)	61.0	14.9	802.6
Feb	68.8	(7.8)	61.0	14.9	802.6
Mar	67.2	(7.8)	59.4	14.5	781.6
Apr	67.2	(7.8)	59.4	14.5	781.6
May	64.0	(7.8)	56.2	13.7	739.5
Jun	56.0	(7.8)	48.2	11.8	634.2
Jul	41.6	(7.8)	33.8	8.3	444.7
Aug	41.6	(7.8)	33.8	8.3	444.7
Sep	54.4	(7.8)	46.6	11.4	613.2
Oct	54.4	(7.8)	46.6	11.4	613.2
Nov	68.8	(7.8)	61.0	14.9	802.6
Dec-91	73.6	(7.8)	65.8	16.1	865.8
data gap					
Jan-96	54.4	(7.8)	46.6	11.4	613.2
Feb	56.0	(7.8)	48.2	11.8	634.2
Mar	56.0	(7.8)	48.2	11.8	634.2
Apr	44.8	(7.8)	37.0	9.0	486.8
May	43.2	(7.8)	35.4	8.7	465.8
Jun	32.0	(7.8)	24.2	5.9	318.4
Jul	30.4	(7.8)	22.6	5.5	297.4
Aug	35.2	(7.8)	27.4	6.7	360.5
Sep	28.8	(7.8)	21.0	5.1	276.3
Oct					
Nov	51.2	(7.8)	43.4	10.6	571.1
Dec	52.8	(7.8)	45.0	11.0	592.1

Floats D,E,F, &G totaling 4089.5 lineal feet of stall floats
76 metered slips with 30A~120V Outlets with 20A/1~ C.B.
Data does not include lights (7.8 KW)

4.4.2 Table 2. Ketchikan

Date	#1 KW	#2 KW	Lights	Total	Watts/lf stall	watts/ outlet
Dec-95	70.0	19.0	(8.0)	81.0	9.4	627.9
Jan-96	69.0	19.0	(8.0)	80.0	9.3	620.2
Feb	71.0	20.0	(8.0)	83.0	9.6	643.4
Mar	57.0	16.0	(8.0)	65.0	7.5	503.9
Apr	50.0	12.0	(8.0)	54.0	6.3	418.6
May	31.0	10.0	(8.0)	33.0	3.8	255.8
Jun	23.0	9.0	(8.0)	24.0	2.8	186.0
Jul	26.0	8.0	(8.0)	26.0	3.0	201.6
Aug	18.0	6.0	(8.0)	16.0	1.9	124.0
Sep	26.0	7.0	(8.0)	25.0	2.9	193.8
Oct	25.0	9.0	(8.0)	26.0	3.0	201.6
Nov	58.0	14.0	(8.0)	64.0	7.4	496.1

Floats D,E,F, &G totaling 8268 lineal feet of stall floats
129 metered slips with 30A~120V Outlets with 20A/1~ C.B.

4.4.3 Table 3. Hoonah

Date	Float B&C	Float D&E	Lights	Total	Watts/lf stall	watts/ outlet
Jan-94	22.4	7.6	(10.2)	19.8	3.4	126.9
Feb	24.4	7.6	(10.2)	21.8	3.7	139.7
Mar	24.8	7.6	(10.2)	22.2	3.8	142.3
Apr	19.6	6.4	(10.2)	15.8	2.7	101.3
May	20.0	5.6	(10.2)	15.4	2.6	98.7
Jun	17.2	2.4	(10.2)	9.4	1.6	60.3
Jul	20.4	5.2	(10.2)	15.4	2.6	98.7
Aug	21.6	5.6	(10.2)	17.0	2.9	109.0
Sep	16.8	6.4	(10.2)	13.0	2.2	83.3
Oct	27.2	4.4	(10.2)	21.4	3.7	137.2
Nov	18.8	6.8	(10.2)	15.4	2.6	98.7
Dec	22.8	9.6	(10.2)	22.2	3.8	142.3
Jan-95	26.4	8.4	(10.2)	24.6	4.2	157.7
Feb	22.4	7.6	(10.2)	19.8	3.4	126.9
Mar	23.2	7.6	(10.2)	20.6	3.5	132.1
Apr	22.8	5.6	(10.2)	18.2	3.1	116.7
May	18.8	4.4	(10.2)	13.0	2.2	83.3
Jun	18.8	5.6	(10.2)	14.2	2.4	91.0
Jul	27.2	6.4	(10.2)	23.4	4.0	150.0
Aug	27.6	5.2	(10.2)	22.6	3.9	144.9
Sep	23.6	6.8	(10.2)	20.2	3.5	129.5
Oct	14.8	4.4	(10.2)	9.0	1.5	57.7
Nov	16.0	6.4	(10.2)	12.2	2.1	78.2
Dec	24.8	9.2	(10.2)	23.8	4.1	152.6
Jan-96	23.2	7.2	(10.2)	20.2	3.5	129.5
Feb	23.2	10.4	(10.2)	23.4	4.0	150.0
Mar	21.6	9.2	(10.2)	20.6	3.5	132.1
Apr	18.0	6.4	(10.2)	14.2	2.4	91.0
May	16.0	4.8	(10.2)	10.6	1.8	67.9
Jun	18.4	7.6	(10.2)	15.8	2.7	101.3
Jul	27.2	5.6	(10.2)	22.6	3.9	144.9
Aug	24.4	5.6	(10.2)	19.8	3.4	126.9
Sep	18.4	4.4	(10.2)	12.6	2.2	80.8
Oct	18.8	5.6	(10.2)	14.2	2.4	91.0

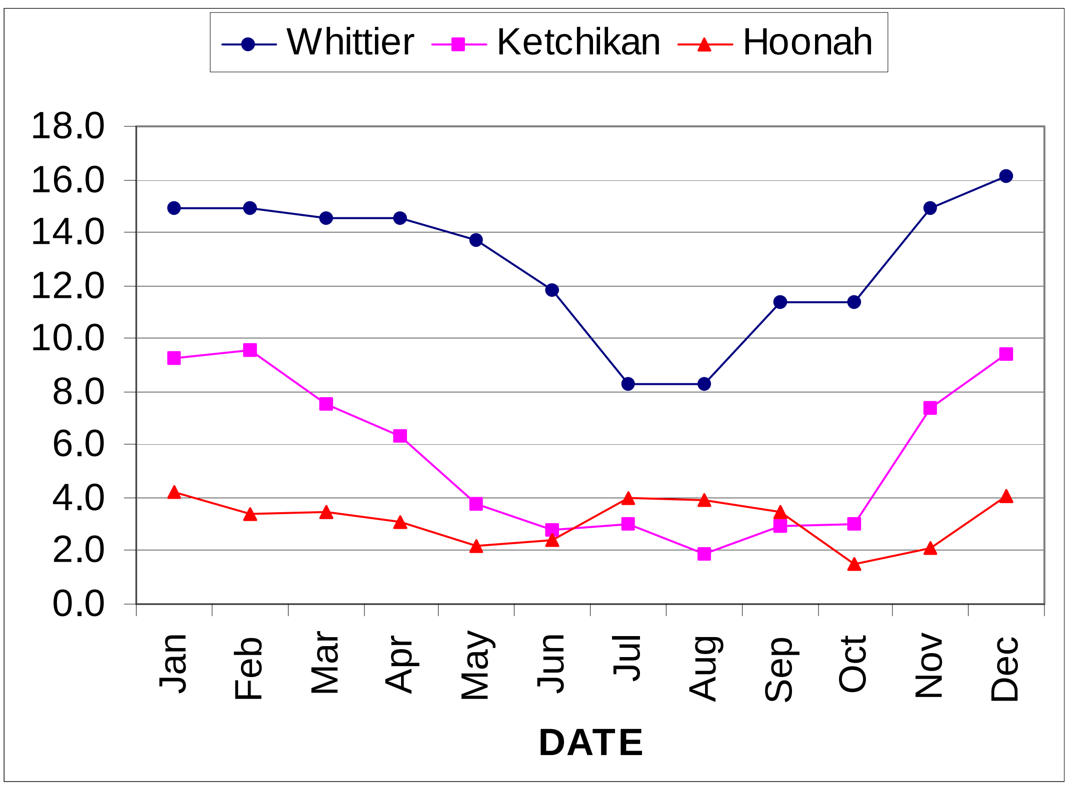
Floats D,E,F, &G totaling 4089.5 lineal feet of stall floats
76 metered slips with 30A~120V Outlets with 20A/1~ C.B.
Data does not include lights (7.8 KW)

4.5. Appendix E

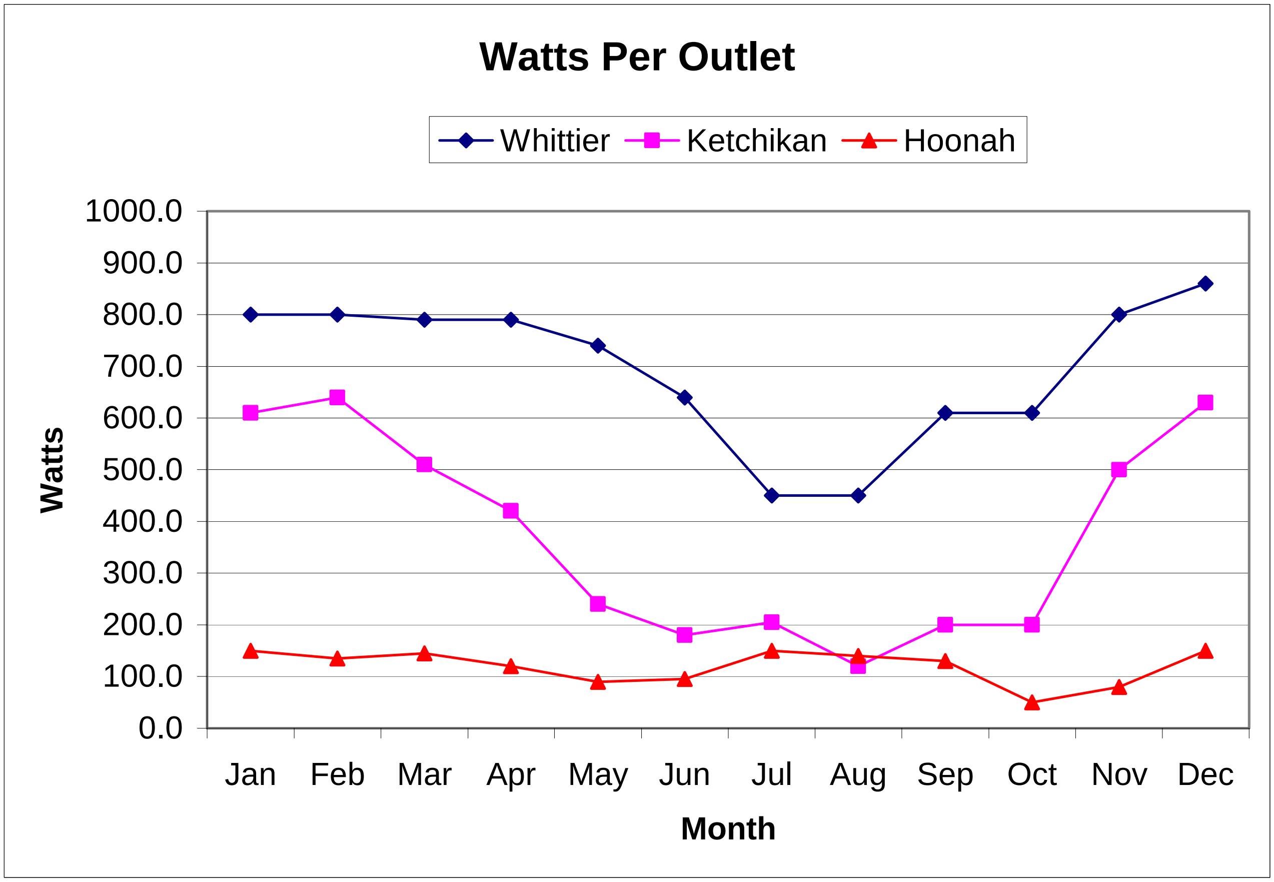
Date	WHITTIER	WHITTIER	KETCHIKAN	KETCHIKAN	HOONAH	HOONAH
	WATTS PER LF STALL	WATTS PER OUTLET	WATTS PER LF STALL	WATTS PER OUTLET	WATTS PER LF STALL	WATTS PER OUTLET
Jan	14.9	802.6	9.3	620.2	4.2	157.7
Feb	14.9	802.6	9.6	643.4	3.4	126.9
Mar	14.5	781.6	7.5	503.9	3.5	132.1
Apr	14.5	781.6	6.3	418.6	3.1	116.7
May	13.7	739.5	3.8	255.8	2.2	83.3
Jun	11.8	634.2	2.8	186.0	2.4	91.0
Jul	8.3	444.7	3.0	201.6	4.0	150.0
Aug	8.3	444.7	1.9	124.0	3.9	144.9
Sep	11.4	613.2	2.9	193.8	3.5	129.5
Oct	11.4	613.2	3.0	201.6	1.5	57.7
Nov	14.9	802.6	7.4	496.1	2.1	78.2
Dec	16.1	865.8	9.4	627.9	4.1	152.6

Note: Whittier is 1991 data

Watts per Lineal Foot of Stall



4.6. Appendix F



5. Exhibits

Exhibit A. Ketchikan Bar Harbor Electrical Sheets 29-34
Exhibit B. Petersburg Harbor Electrical Sheets 40-46
Exhibit C. 3-Phase Crossarm Construction Dead End (Single)
Exhibit D. Grounding Assembly-Ground Rod Type

5.1. Exhibit A. Ketchikan Bar Harbor Electrical Sheets 29-34

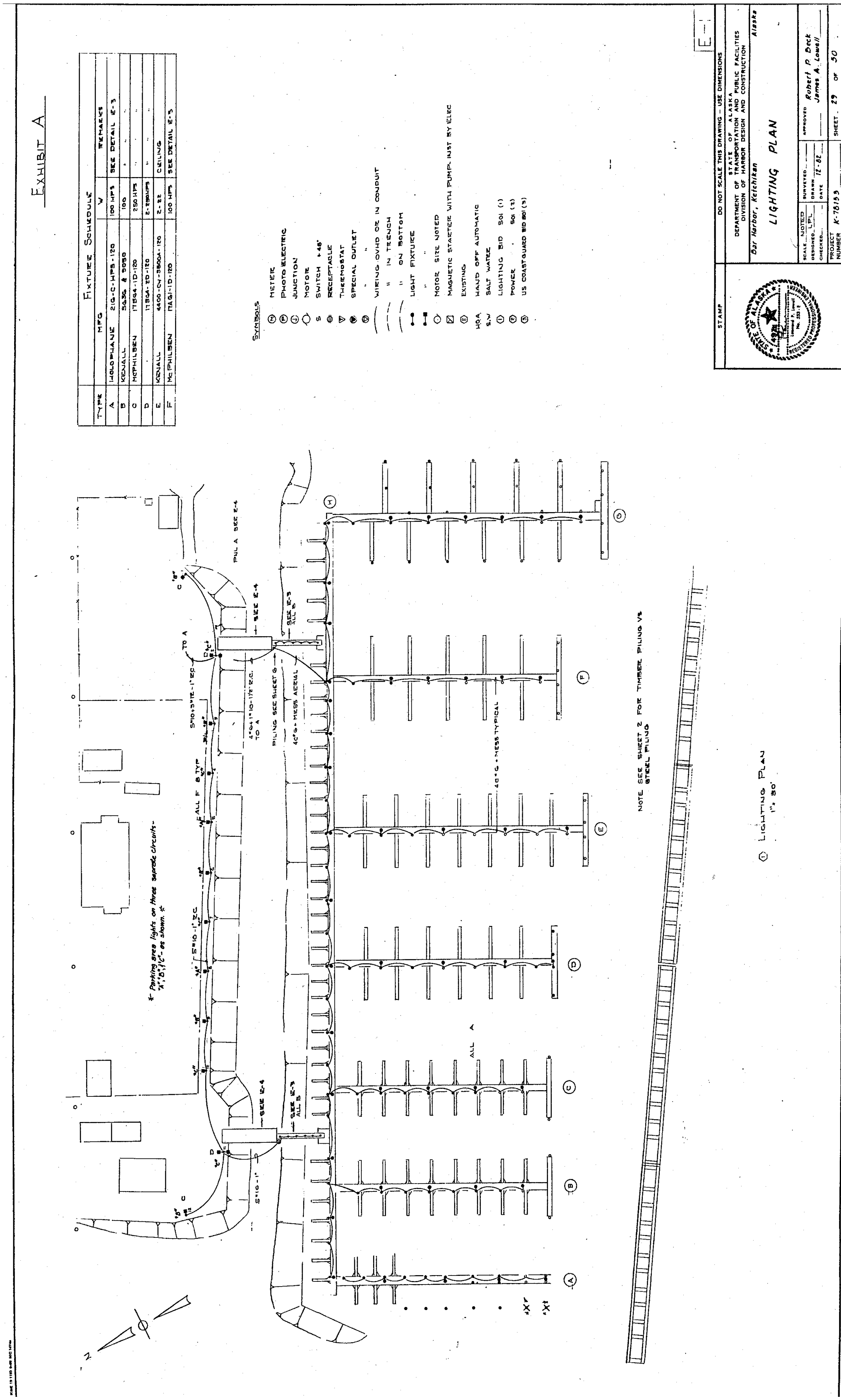
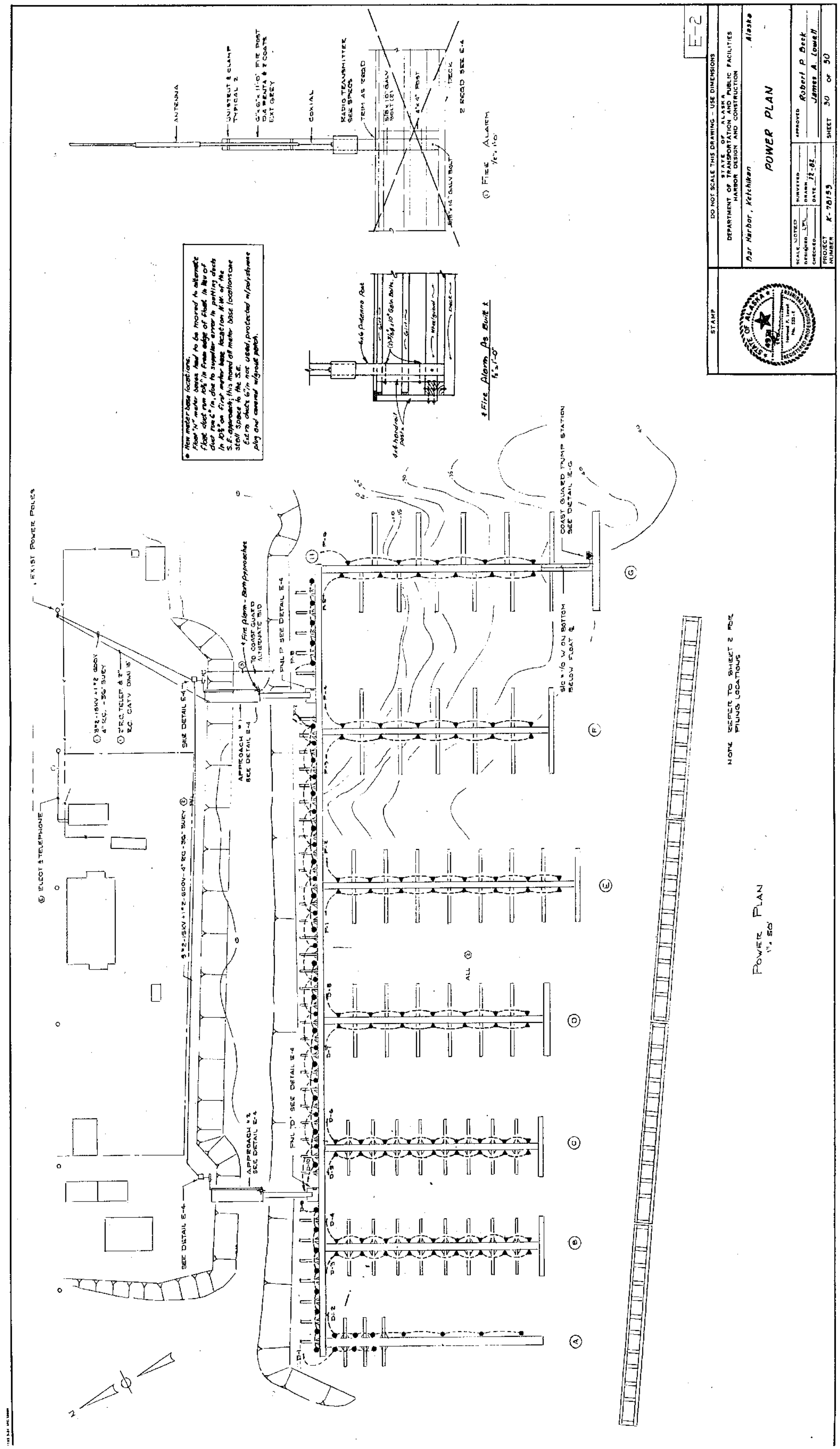
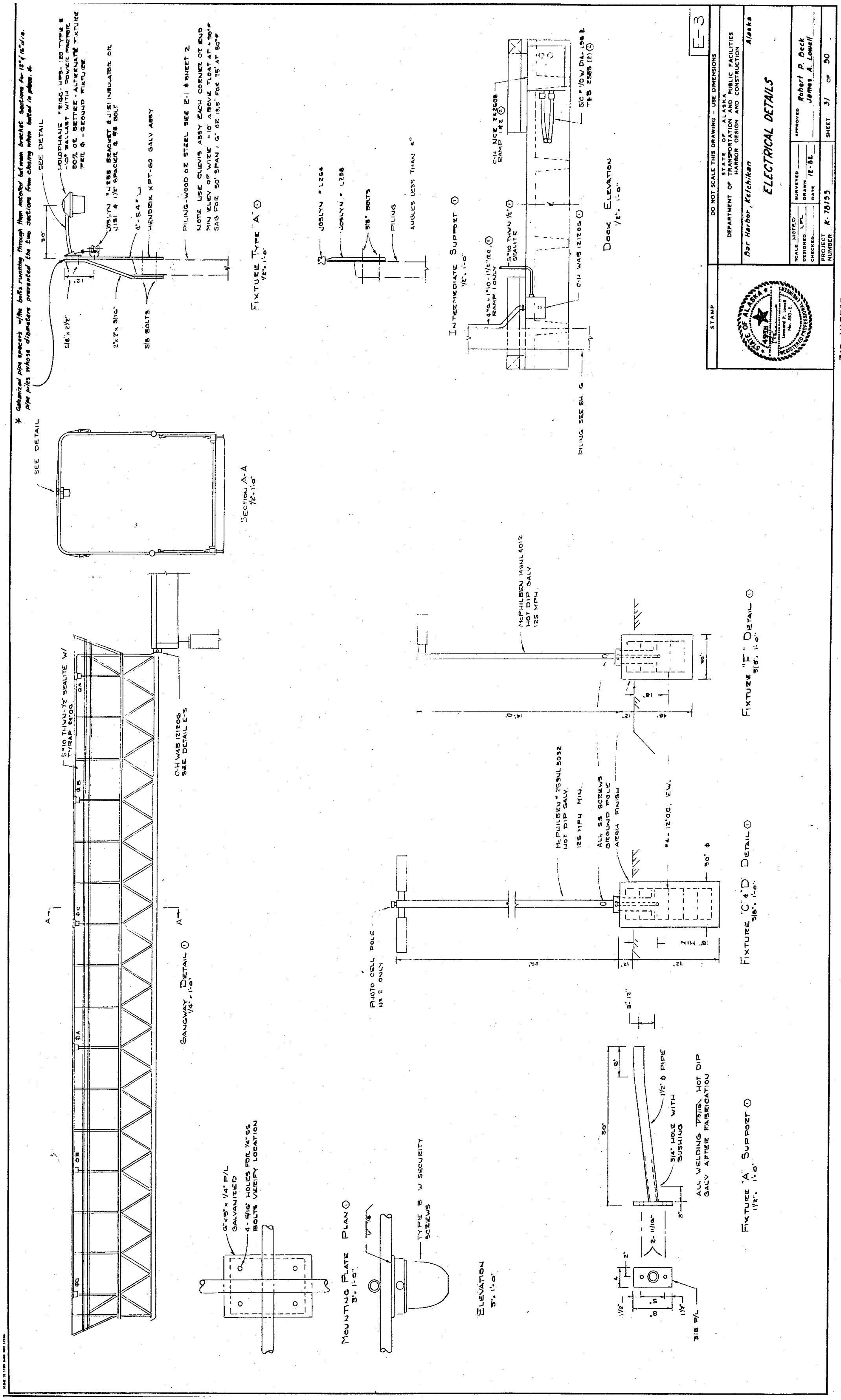
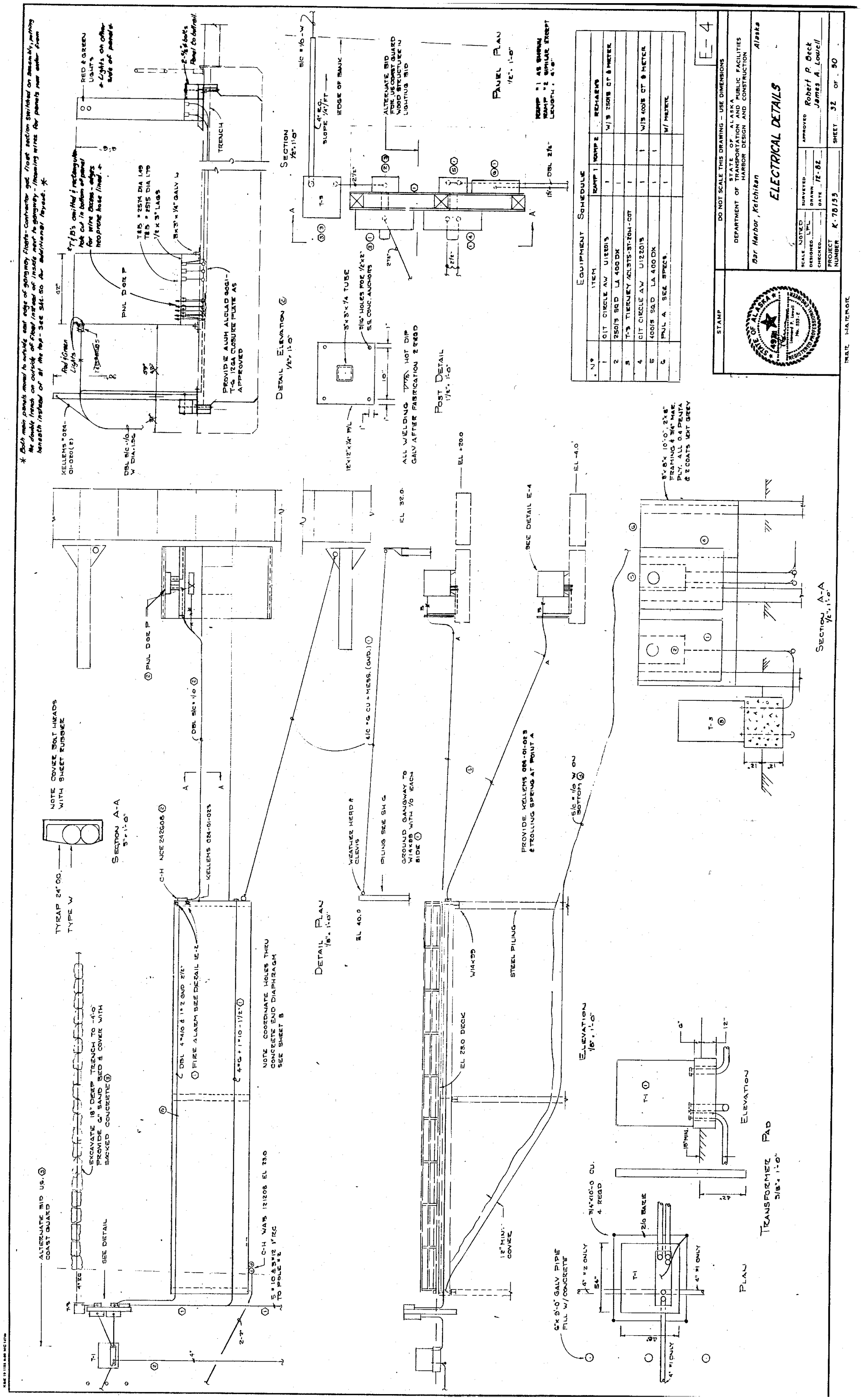


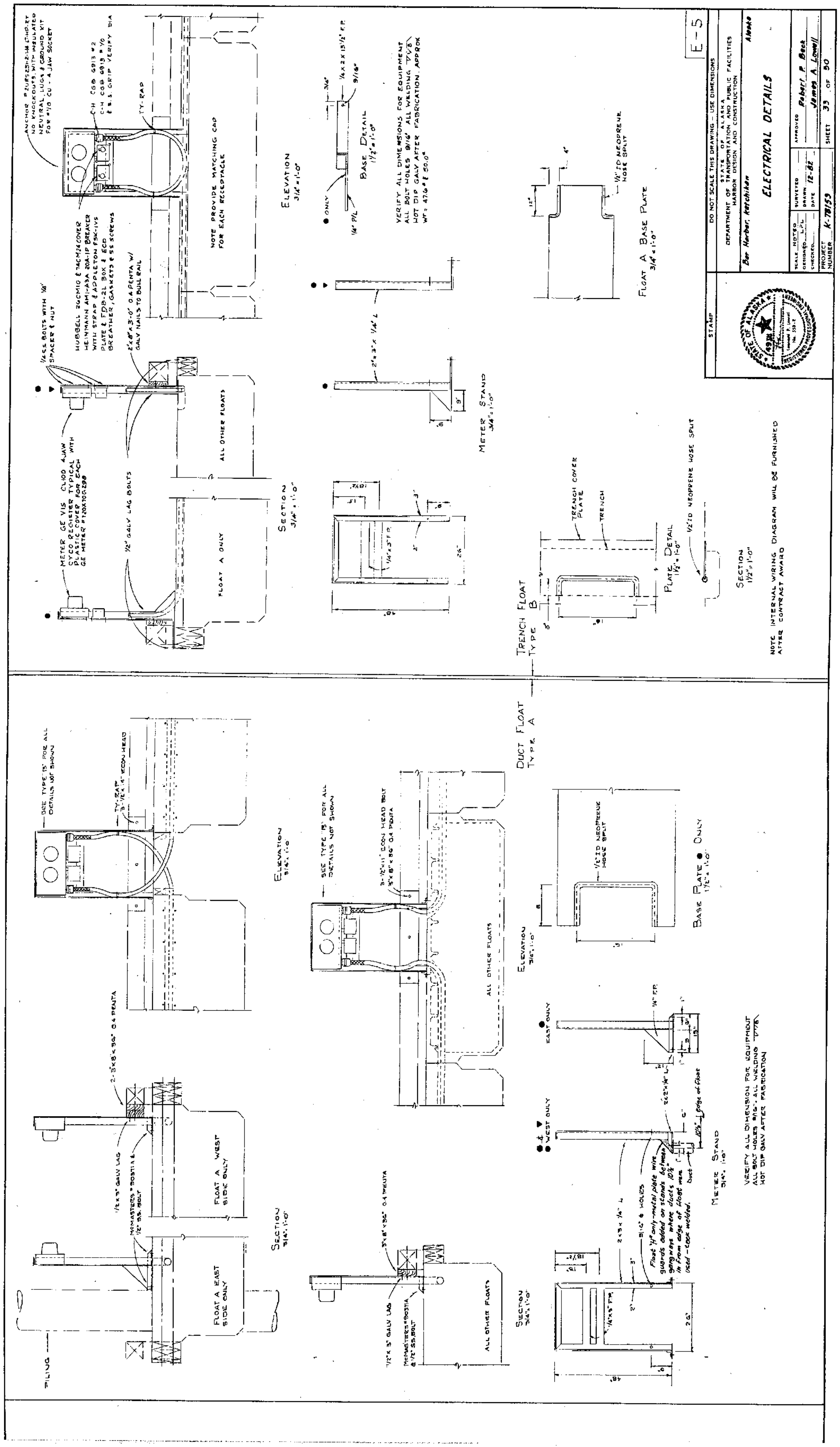
EXHIBIT A
FIXTURE SCHEDULE
TYPE
MFG
W
REMARKS
A HOLOPHANE 21G-C-HPS-120 100 HPS SEE DETAIL E-3
B KENALL 5636 & 5050 100
C MCPHILBEN 17BG4-1D-120 250 HPS
D 17BG4-2D-120 2-250HPS
E KENALL 4400-CY-3500A-120 2-22 CEILING
F McPHILBEN 17AG1-1D-120 100 HPS SEE DETAIL E-3
SYMBOLS
METER
PHOTO ELECTRIC
JUNCTION
MOTOR
SWITCH +48"
RECEPTACLE
THERMOSTAT
SPECIAL OUTLET
WIRING OVHD OR IN CONDUIT
IN TRENCH
ON BOTTOM
LIGHT FIXTURE
MOTOR SIZE NOTED
MAGNETIC STARTER WITH PUMP. INST BY ELEC
EXISTING
HAND OFF AUTOMATIC
SALT WATER
LIGHTING
POWER
US COASTGUARD
DO NOT SCALE THIS DRAWING – USE DIMENSIONS
STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
DIVISION OF HARBOR DESIGN AND CONSTRUCTION
Bar Harbor, Ketchikan
Alaska
LIGHTING PLAN
Robert P. Beck
James A. Lowell
PROJECT NUMBER K-78153
SHEET 29 OF 30
E-1
BAR HARBOR
① LIGHTING PLAN 1" = 30'
NOTE: SEE SHEET 2 FOR TIMBER PILING VS STEEL PILING
* Parking area lights on three separate circuits – "A", "B", "C" as shown. *

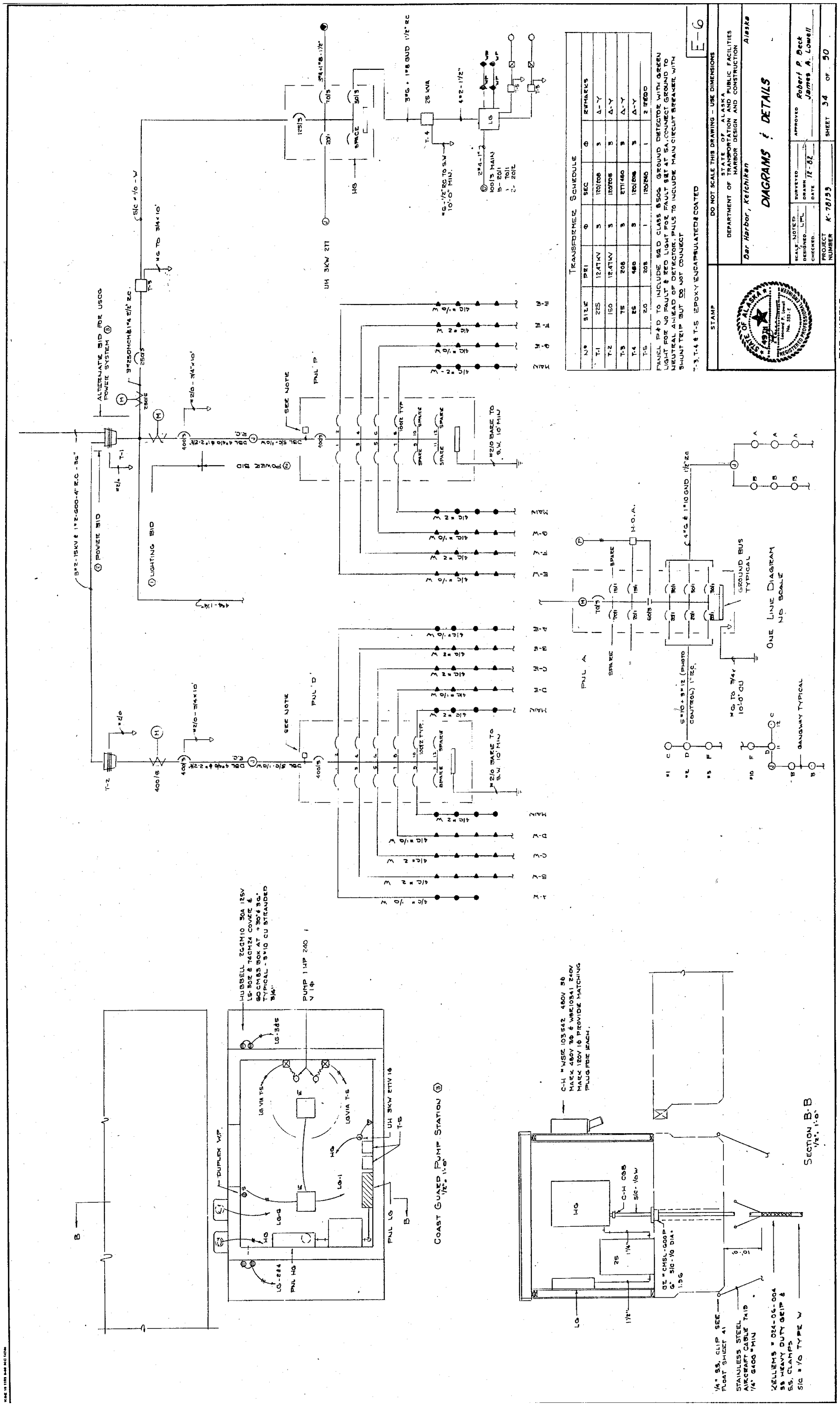

E-2
DO NOT SCALE THIS DRAWING - USE DIMENSIONS
STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
HARBOR DESIGN AND CONSTRUCTION
Bar Harbor, Ketchikan
Alaska
POWER PLAN
Robert P. Beck
James A. Lowell
SHEET 30 OF 30
POWER PLAN


ELECTRICAL DETAILS
Bar Harbor, Ketchikan
E-3



E-4
DO NOT SCALE THIS DRAWING - USE DIMENSIONS
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
HARBOR DESIGN AND CONSTRUCTION
Bar Harbor, Ketchikan
ELECTRICAL DETAILS
EQUIPMENT SCHEDULE


E-5
ELECTRICAL DETAILS
DO NOT SCALE THIS DRAWING - USE DIMENSIONS
DUCT FLOAT TYPE A
TRENCH FLOAT TYPE B
METER STAND
FLOAT A BASE PLATE
NOTE: INTERNAL WIRING DIAGRAM WILL BE FURNISHED AFTER CONTRACT AWARD



E-6
DIAGRAMS & DETAILS
Bar Harbor, Ketchikan
STATE OF ALASKA DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES HARBOR DESIGN AND CONSTRUCTION
DO NOT SCALE THIS DRAWING - USE DIMENSIONS
TRANSFORMER SCHEDULE
ONE LINE DIAGRAM
NO SCALE
COAST GUARD PUMP STATION
SECTION B-B

5.2. Exhibit B. Petersburg HarborElectrical Sheets 40-46

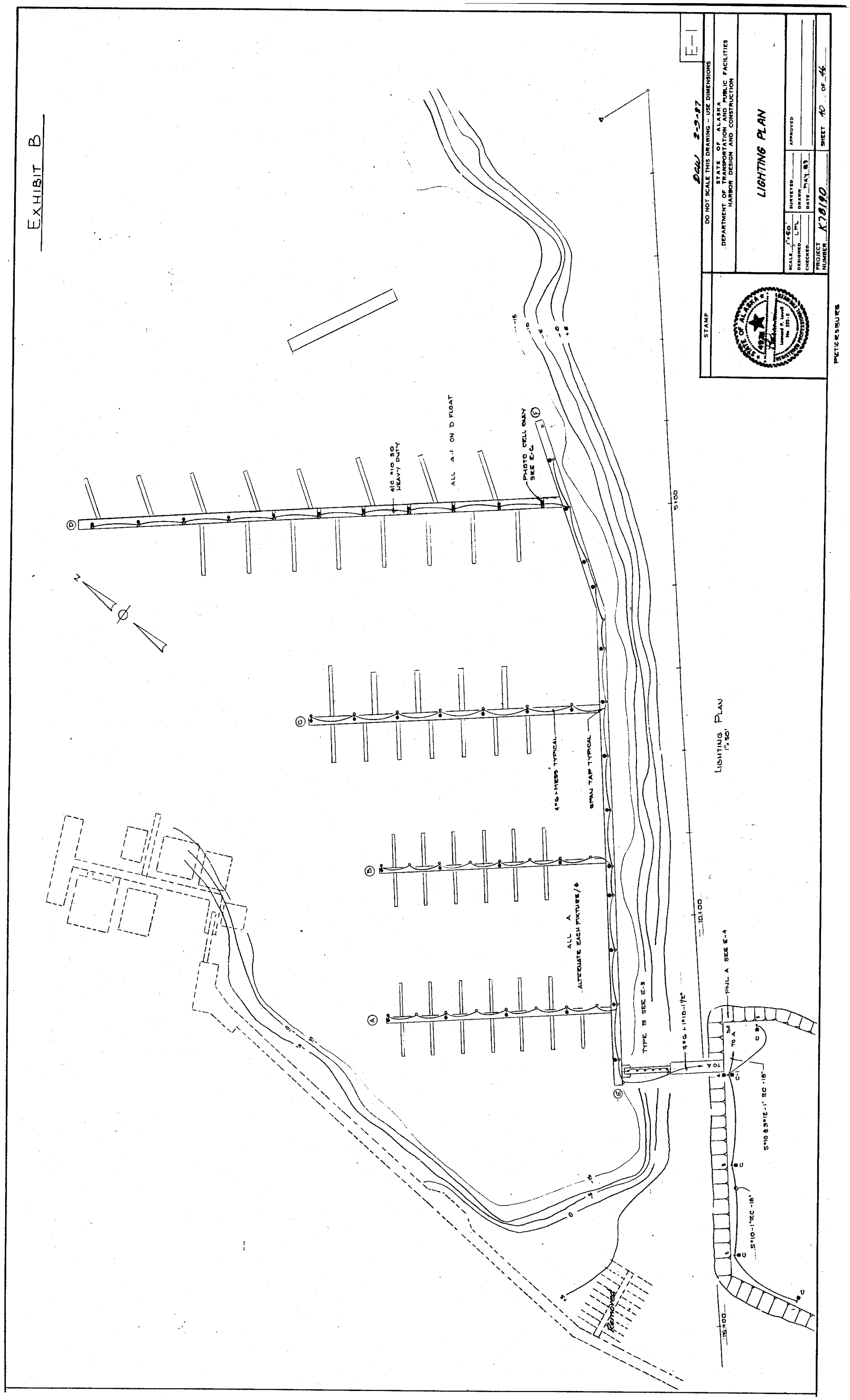
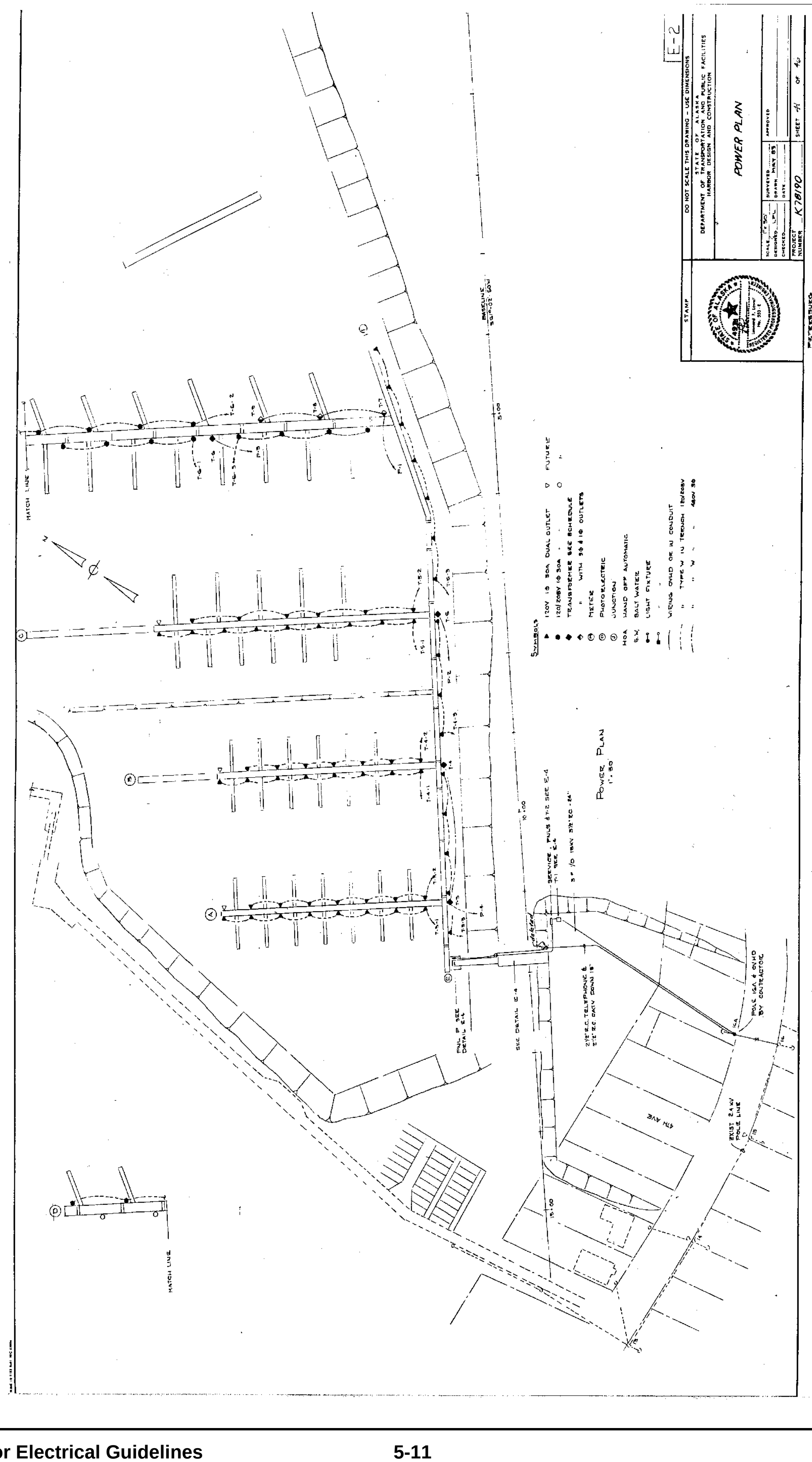
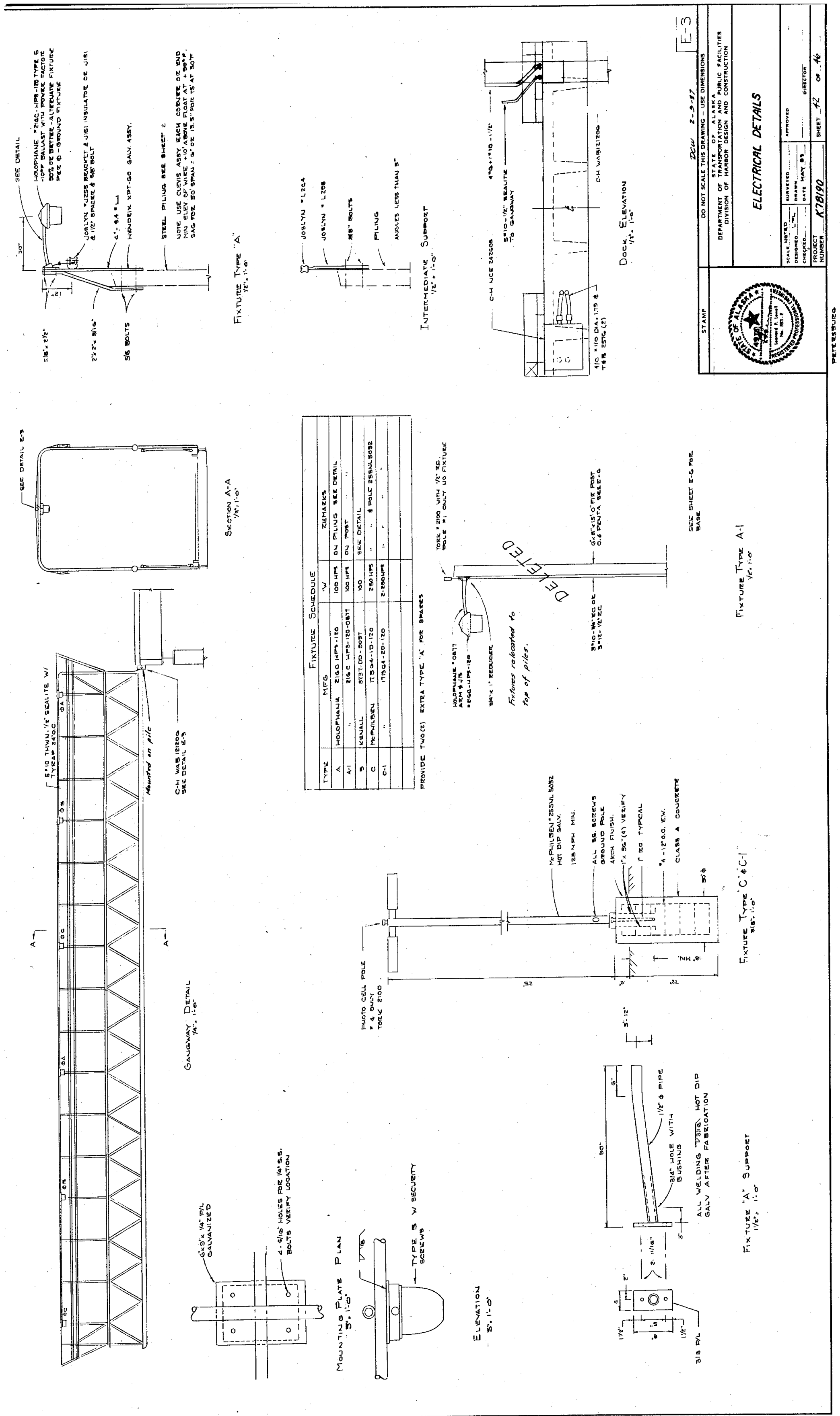
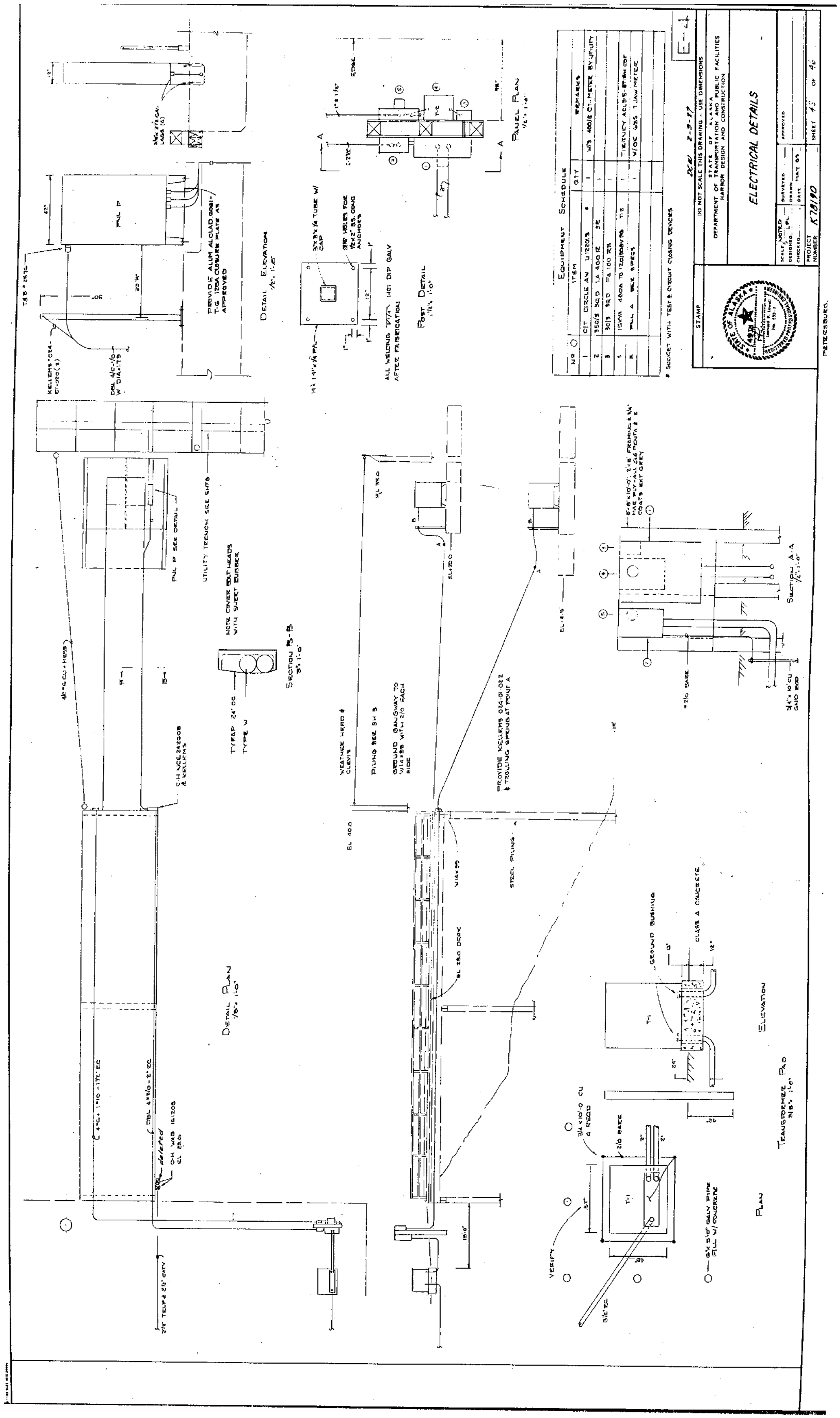
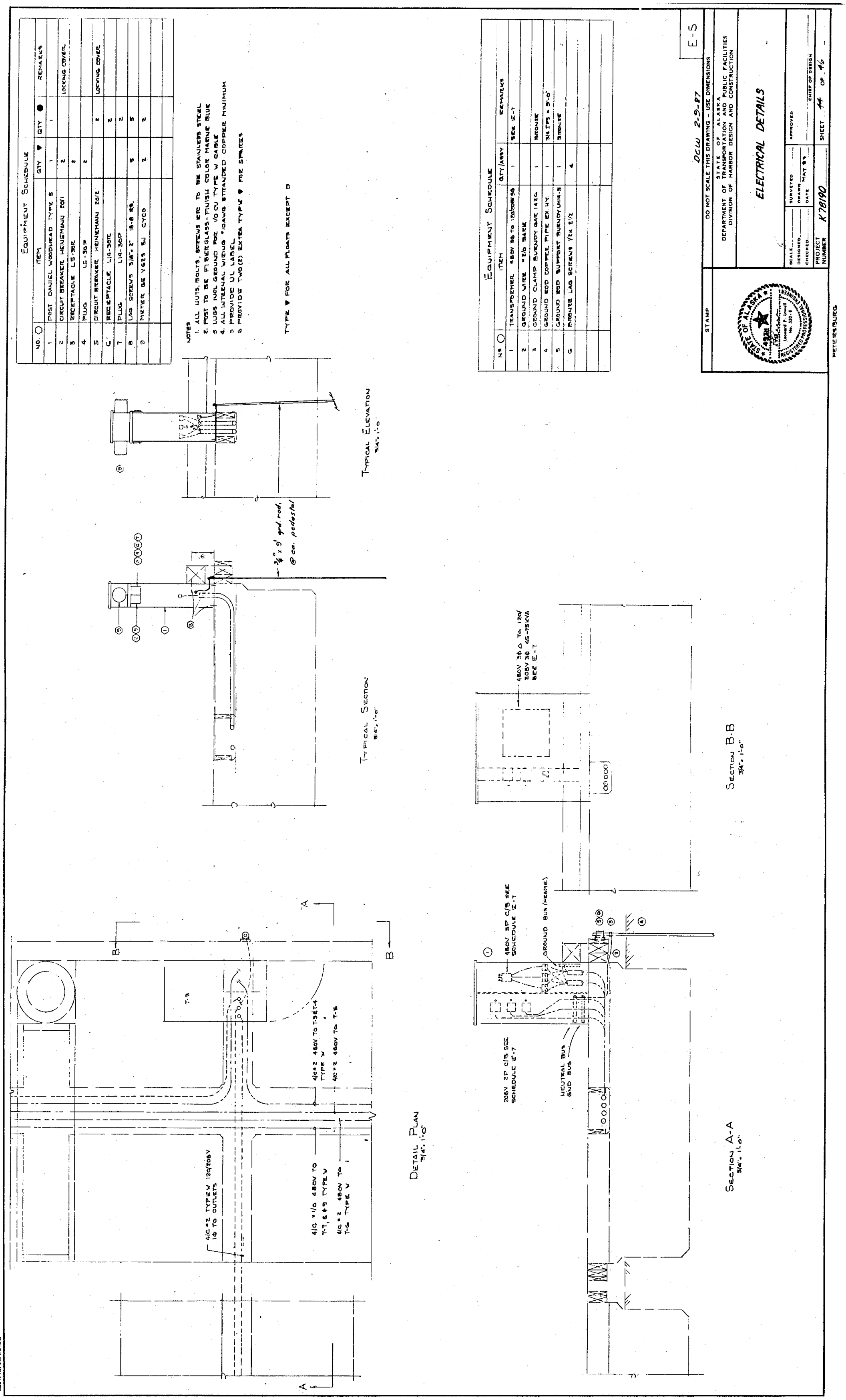


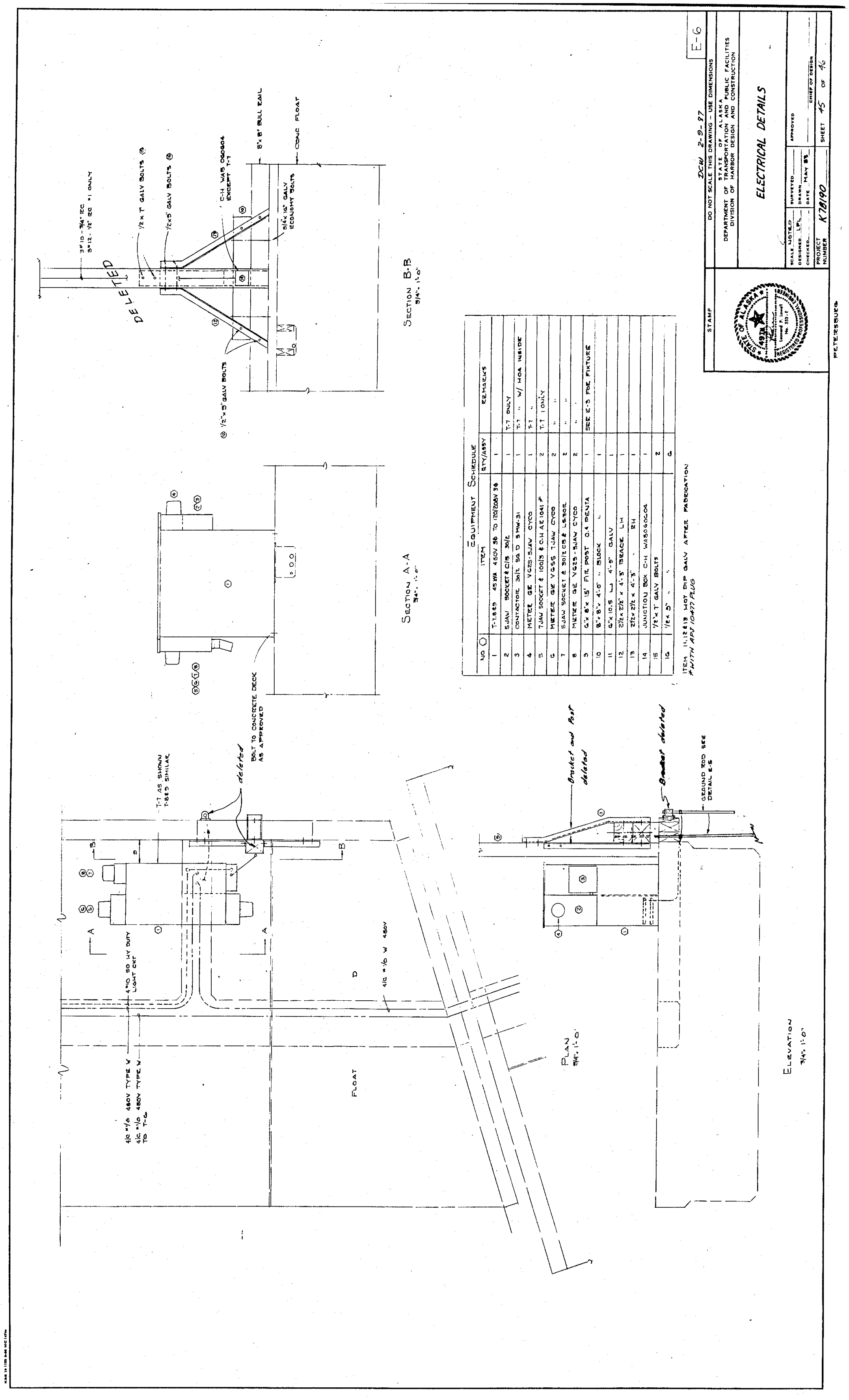
EXHIBIT B
LIGHTING PLAN
DO NOT SCALE THIS DRAWING - USE DIMENSIONS
STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
HARBOR DESIGN AND CONSTRUCTION
E-1
PETERSBURG


DO NOT SCALE THIS DRAWING - USE DIMENSIONS
STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
HARBOR DESIGN AND CONSTRUCTION
POWER PLAN
K78190
E-2
STAMP
MATCH LINE
Symbols
Power Plan


ELECTRICAL DETAILS
E-3
DO NOT SCALE THIS DRAWING - USE DIMENSIONS
STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
DIVISION OF HARBOR DESIGN AND CONSTRUCTION
Fixture Schedule
Gangway Detail
Section A-A
Fixture Type "A"
Intermediate Support
Dock Elevation
Fixture Type A-1
Fixture Type 'C' & C-1
Fixture "A" Support
Mounting Plate Plan
Elevation
DELETED


ELECTRICAL DETAILS
EQUIPMENT SCHEDULE
DETAIL PLAN
DETAIL ELEVATION
PANEL PLAN
POST DETAIL
SECTION A-A
TRANSFORMER PAD
ELEVATION
PLAN

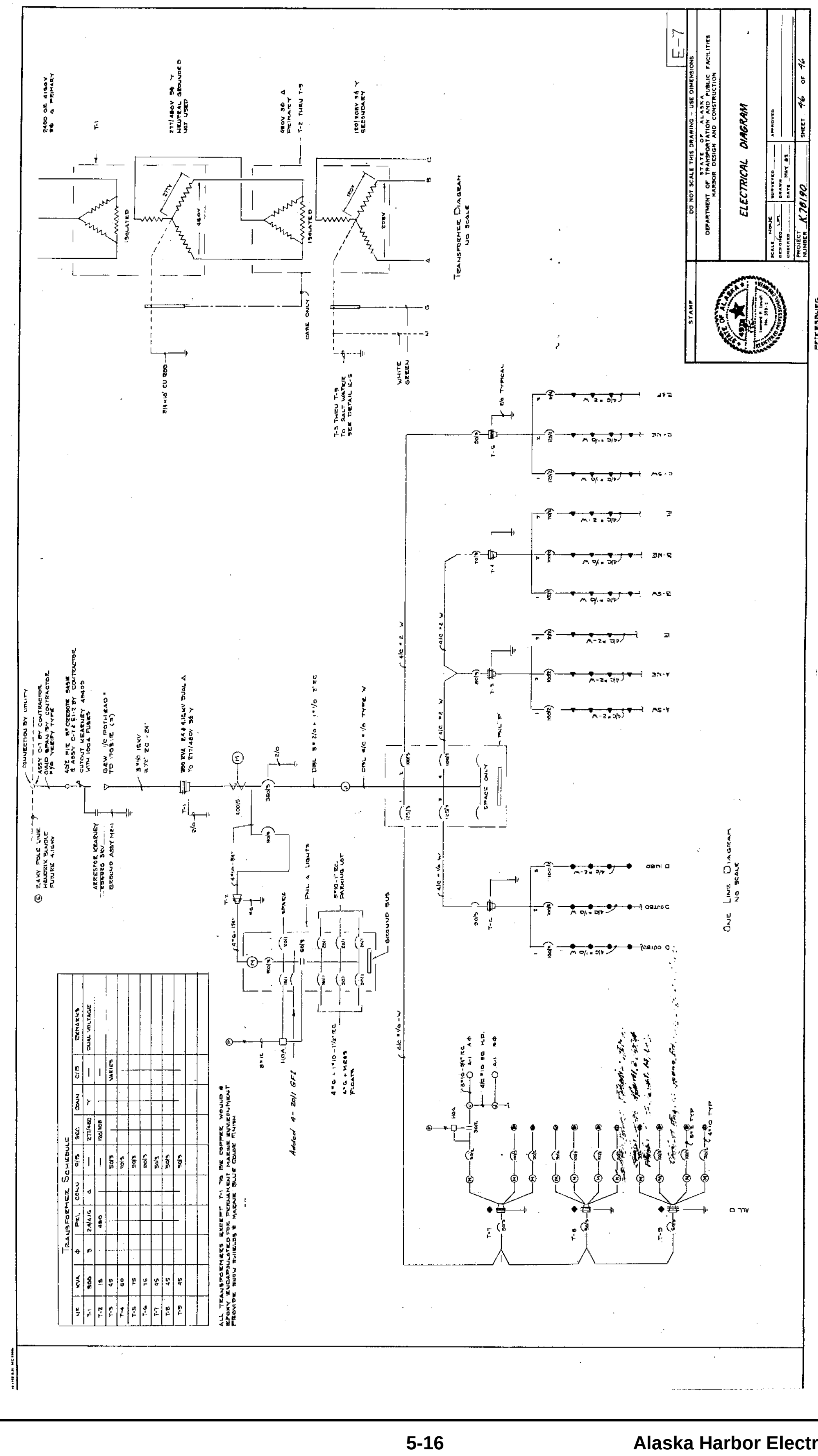

Equipment Schedule
No. | Item | Qty ▼ | Qty ● | Remarks
1 | Post Daniel Woodhead Type 5 | 1 | 1 |
2 | Circuit Breaker Heinemann 20/1 | 2 | | Locking cover
3 | Receptacle L5-30R | 2 | |
4 | Plug L5-30P | 2 | |
5 | Circuit Breaker Heinemann 20/2 | | 2 | Locking cover
6 | Receptacle L14-30R | | 2 |
7 | Plug L14-30P | | 2 |
8 | Lag screws 3/8" x 2" 18-8 SS. | 5 | 5 |
9 | Meter GE VG25 3J CYCO | 2 | 2 |
Notes
1. All nuts, bolts, screws etc to be stainless steel
2. Post to be fiberglass - finish color marine blue
3. Lugs incl ground for 1/0 CU type W cable
4. All internal wiring #10AWG stranded copper minimum
5. Provide UL label
6. Provide two (2) extra type ▼ for spares
Type ▼ for all floats except D
Equipment Schedule
No. | Item | Qty/Assy | Remarks
1 | Transformer 480V 3Ø to 120/208V 3Ø | 1 | See E-7
2 | Ground wire #2/0 bare | |
3 | Ground clamp Burndy GAR 1426 | 1 | Bronze
4 | Ground rod copper pipe ex hy | 1 | 3/4 IPS x 3'-0"
5 | Ground rod support Burndy UHI-3 | 1 | Bronze
6 | Bronze lag screws 3/8 x 2 1/2 | 4 |
Detail Plan
3/4" = 1'-0"
Typical Section
3/4" = 1'-0"
Typical Elevation
3/4" = 1'-0"
Section A-A
3/4" = 1'-0"
Section B-B
3/4" = 1'-0"
3/8" x 5' grd. rod. @ ea. pedestal
480V 3Ø to 120/208V 3Ø 45-75KVA see E-7
Ground bus (frame)
Neutral bus
Gnd bus
DCW 2-9-87
E-5
Do not scale this drawing – use dimensions
State of Alaska
Department of Transportation and Public Facilities
Division of Harbor Design and Construction
Electrical Details
Project Number K78190
Sheet 44 of 46
Petersburg



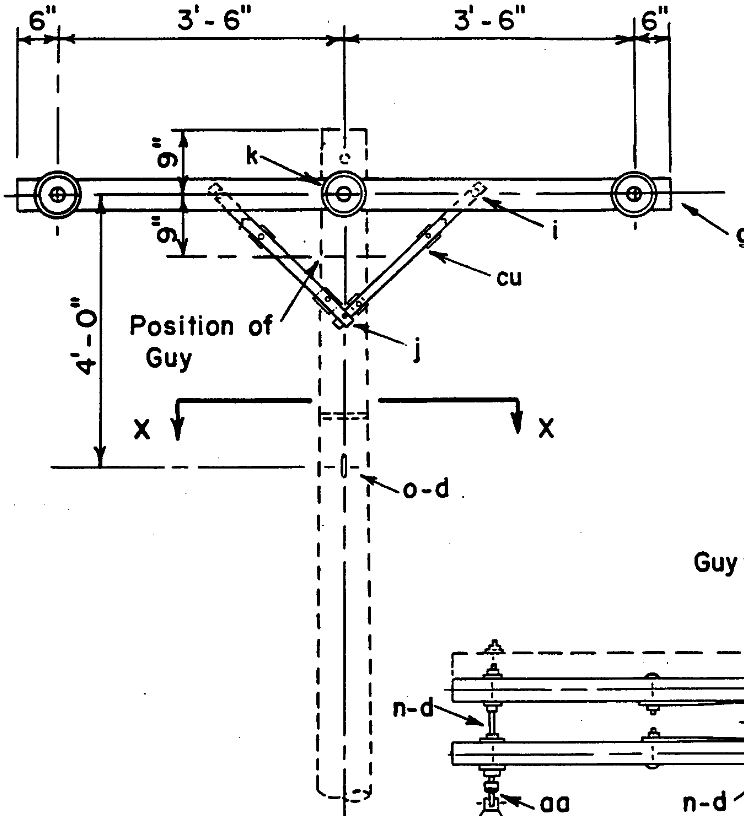
EQUIPMENT SCHEDULE

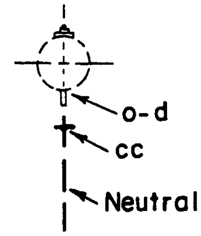
NO	ITEM	QTY/ASSY	REMARKS
1	T-7,8,&9 45 KVA 480V 3Φ TO 120/208V 3Φ	1	
2	5JAW SOCKET & C/B 30/2	1	T-7 ONLY
3	CONTACTOR 30/2 SQ D 8 MW-31	1	T-7 " W/ HOA INSIDE
4	METER GE VG2S-5JAW CYCO	1	T-7 "
5	7JAW SOCKET & 100/3 & C-H AR 1041 *	2	T-7 1 ONLY
6	METER GE VG5S 7JAW CYCO	2	" "
7	5JAW SOCKET & 30/2 C/B & L5-30R	2	" "
8	METER GE VG2S-5JAW CYCO	2	" "
9	6"x 8"x 15' FIR POST 0.4 PENTA	1	SEE E-3 FOR FIXTURE
10	8"x 8"x 4'-0" " BLOCK "	1	
11	6"x 10.5 ⊔ 4'-5" GALV	1	
12	2½x 2½" x 4'-3" BRACE LH	1	
13	2½x 2½ x 4'-3" " RH	1	
14	JUNCTION BOX C-H WA5060604	1	
15	½"x 7" GALV BOLTS	2	
16	½"x 5" "	6	

ITEM 11,12 & 13 HOT DIP GALV AFTER FABRICATION
*WITH APJ 10477 PLUG

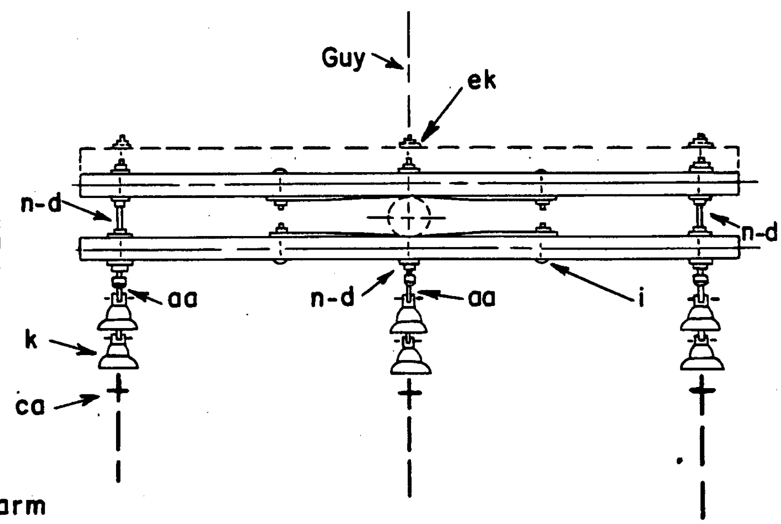

E-7
ELECTRICAL DIAGRAM
TRANSFORMER DIAGRAM
NO SCALE
ONE LINE DIAGRAM
NO SCALE
TRANSFORMER SCHEDULE

5.3. Exhibit C. 3-Phase Crossarm Construction Dead End (Single)





SECTION X-X



PLAN

Notes:

1. See dwg. E5-I for crossarm loading limitations.
2. Designate as C7-I for assembly with three crossarms.

ITEM	NO.	MATERIAL		ITEM	NO.	MATERIAL	
d	11	Washer, 2¼" x 2¼" x 3/16", 13/16" hole		n	3	Bolt, double arming, 5/8" x req'd l'gth	
g	2	Crossarm, 3½" x 4½" x 8'-0"		o	1	Bolt, eye, 5/8" x req'd length	
cu	4	Brace, wood, 28"		aa	3	Nut, eye, 5/8"	
i	4	Bolt, carriage, 3/8" x 4½"		ca	3	Deadend assembly, Primary	
j	2	Screw, lag, ½" x 4"		cc	1	Deadend assembly, Neutral	
k	6	Insulator, suspension		ek		Locknuts	

7.2/12.5 KV.

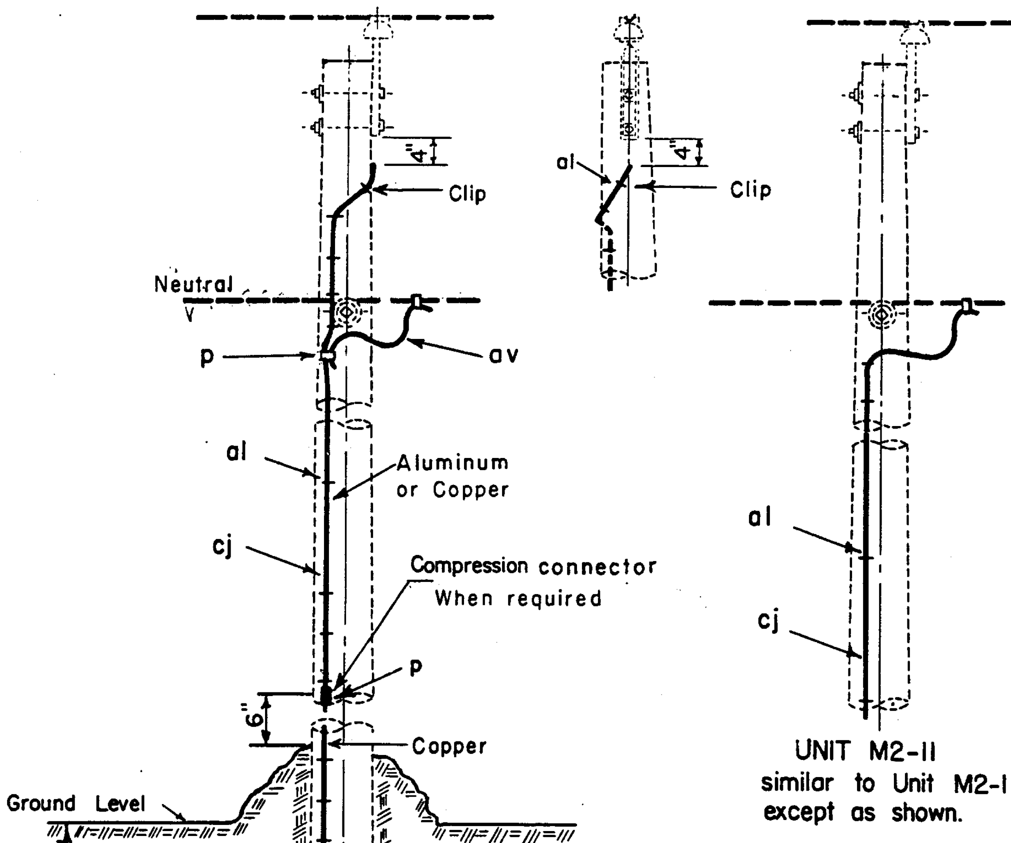
3-PHASE CROSSARM CONSTRUCTION

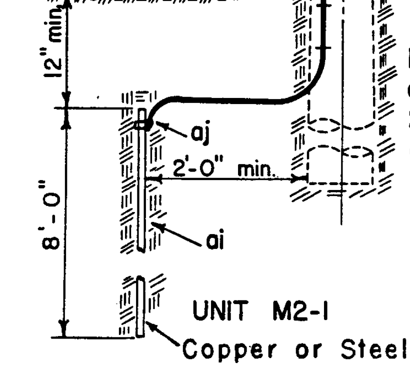
DEAD END (SINGLE)

Jan 1, 1962

C7, C7-1

5.4. Exhibit D. Grounding Assembly-Ground Rod Type





Notes:

1. Ground wire to be located on same side as Neutral Conductor and in quadrant opposite climbing space or pole top pin.
2. Staples on ground wire shall be 2'-0" apart, except for a distance of 8'-0" above ground and 8'-0" from top of pole where they shall be 6" apart.
3. Ground wire to clear all hardware by 2" min. and shall be stapled to maintain this position.
4. For use with V and 3-phase assemblies refer to guide drawings M30-I and M30-2.

ITEM	MATERIAL	ASSEMBLY UNIT M2-I	ASSEMBLY UNIT M2-II
p	Connectors	as req'd.	
ai	Rod, ground, 5/8" minimum diameter	I	I
aj	Clamp, ground rod	I	I
al	Staples, ground wire	as req'd.	as req'd.
al	Ground wire clip	I	
cj	Ground wire, No. 6 copper or equiv. conductivity	as req'd.	as req'd.
av	Jumper, stranded, No. 6 copper or equiv. conductivity	as req'd.	

GROUNDING ASSEMBLY - GROUND ROD TYPE

Apr. 1969

M2-I, M2-II