Request for Proposals (RFP) for Removal of Four Wind Turbines in Selawik, Alaska

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General Information

Project Title: Selawik Wind Turbine Removal

Project Location: Selawik, Alaska

RFP No. FY25-04

Client/Contract Manager: Ingemar Mathiasson, Energy Manager, Northwest Arctic Borough

Contact Information: imathiasson@nwabor.org, 231-709-3614

Period of Performance: April 11, 2025 – May 31, 2025

RFP Milestone Schedule:

Item	Date
RFP Issuance	Tuesday, March 18, 2025
RFP Question Deadline	Tuesday, March 25, 2025
Response to Questions - Posting Deadline	Thursday, March 27, 2025
Proposal Deadline	Tuesday, April 1, 2025
Notice of Intent to Award	Friday, April 4, 2025
Contract Signed	Friday, April 11, 2025

Table 1. RFP Milestone Schedule

Submit Proposals electronically to: clerksmail@nwabor.org by 5:00 PM (AKST) on Tuesday, April 1. Proposals received after that date and time will not be considered.

Introduction and Project Background

Introduction

The Northwest Arctic Borough (NAB) is requesting proposals for the removal of four decommissioned 50kW Entegrity EW50 (formerly Atlantic Orient Corporation model 15/50) wind turbines and associated decommissioned electrical components in Selawik, AK. The project must be complete by May 31, 2025.

This RFP does not include removal of the concrete piles or any of the electrical conduit/wiring and components inside the wind turbine building.

Northwest Arctic Borough Background

The NAB is a regional government in northwest Alaska, encompassing an area slightly larger than Indiana. It includes eleven communities, many of which are isolated and accessible only by air or sea. The Borough's population is predominantly Iñupiat Eskimo, deeply rooted in rich cultural traditions and a subsistence lifestyle.

The NAB works closely with other regional stakeholders, specifically NANA Regional Corporation (NRC) and their public benefits subsidiary Atautchikun. NRC is the largest landholder in the region, is the owner of the Red Dog mine, and supports all the communities in the region in numerous ways, including through their Village Energy Program.

In terms of resiliency and energy efficiency, the Northwest Arctic Borough is focused on sustainable development and the adaptation to climate change impacts, which are profound in Arctic regions. This includes initiatives to improve energy efficiency, reduce reliance on costly imported fuels, and incorporate renewable energy sources such as wind and solar power as well as a battery energy storage system (BESS). The NAB aims to enhance the resilience of its communities by promoting local energy production, improving infrastructure, and fostering economic self-sufficiency. These efforts are crucial in a region facing unique environmental challenges, where traditional ways of life are directly impacted by the changing climate. The NAB's commitment to sustainability and resiliency is aimed at preserving its cultural heritage while advancing economic and environmental well-being for its residents.

NAB and NRC have secured funding for the design and construction of utility scale solar PV and BESS systems for all communities in the region. This RFP is specific to the removal of the four wind turbines and associated electrical components in Selawik, AK.

Project Overview

The four 50kW Entegrity EW50 (formerly Atlantic Orient Corporation model 15/50) wind turbines were installed in 2004. For various reasons, the turbines have not been operational for a number of years and are no longer connected to the grid. The wind turbines were decommissioned and DC wiring from the nacelle has been disconnected at the junction box that is mounted on the wind turbine (See Figure 5 in Attachment 1.). The wind turbines are located on land where a solar PV array that will be constructed in the fall of 2025. The wind turbines need to be taken down and removed from the site this spring prior to the ground thawing.

This project is subject to the Davis-Bacon Act's prevailing wage requirements as required under Division D of the Bipartisan Infrastructure Law (BIL). All laborers and mechanics employed by NAB, subrecipients, contractors or subcontractors in the performance of construction, alteration must be paid wages at rates not less than those prevailing on similar projects in the locality, as determined by the Secretary of Labor.

Proposals in response to this RFP must be submitted April 1, 2025. Selection of the qualified contractor will occur by April 4, 2025. It is expected that an executed contract will be in place by April 11, 2025.

Project Location

The solar PV site will be located just north of the AVEC power plant at the site currently occupied by the wind turbines, as shown in the map below.

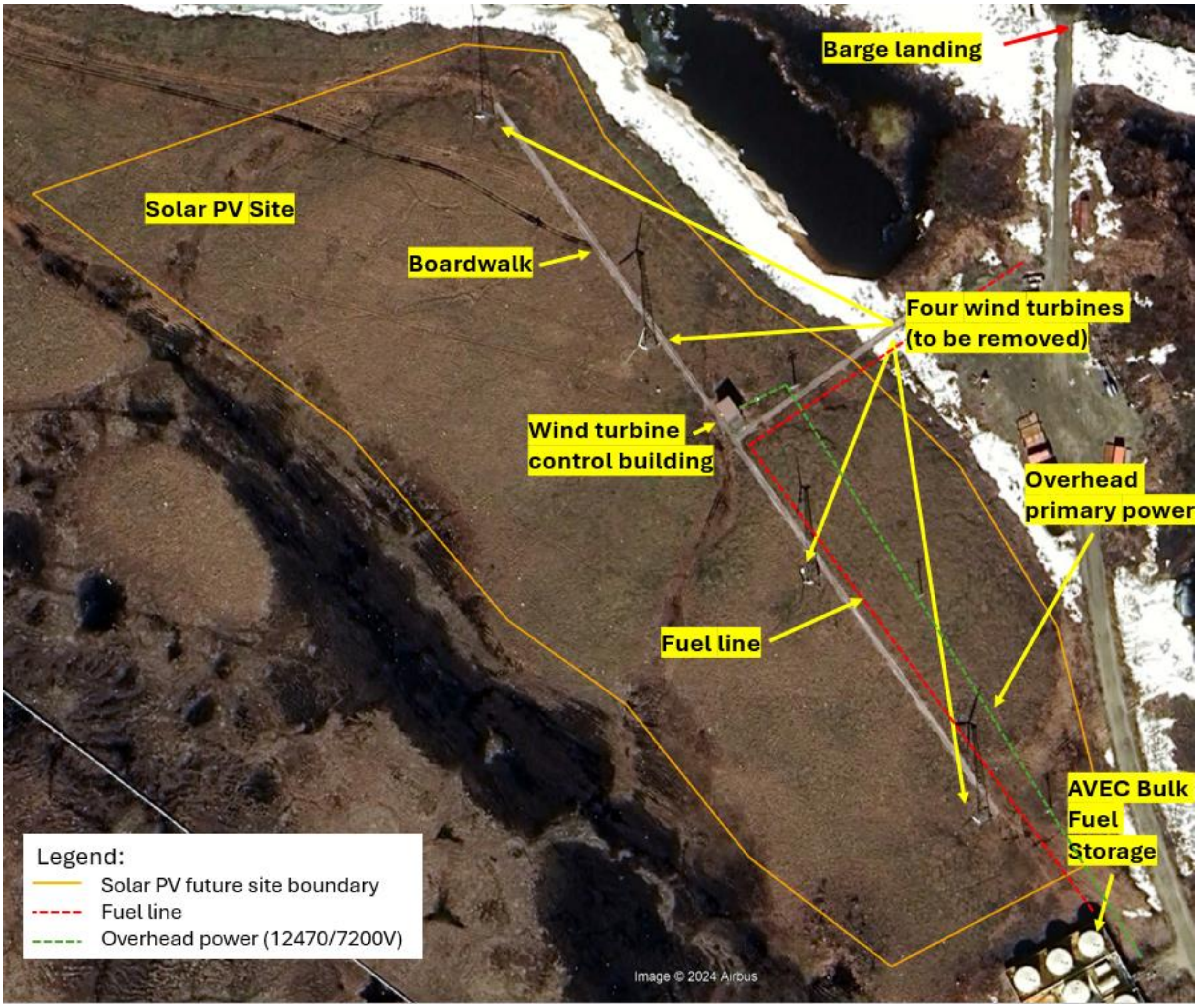

Figure 1: Existing Wind Turbine and Future Solar PV Locations

Project Timeline

The towers and associated components must be lowered and removed from AVEC land prior to spring 2025 thaw to minimize damage to the tundra by heavy equipment. All work shall be conducted prior to when ground conditions limit ability to use heavy equipment without risk of damaging the tundra, dependent on local weather and seasonal thaw.

RFP Review and Protests

Offerors must carefully review the RFP for defects and questionable or objectionable material. Such defects must be reported to NAB in writing and received at least ten days prior to the deadline for receipt of proposals. This will allow sufficient time for NAB to issue an addendum, if warranted, and will help prevent the evaluation of proposals based on a defective RFP. Protests based on an omission, error, or the content of the RFP will be disallowed if notice of the defect is not made as set out above.

Addenda to the RFP

Addenda to this request for proposals may be issued at the NAB's option. All addenda will be in writing and issued to all persons who are known to have received a copy of this RFP.

Correction, Modification, or Withdrawal of Proposals

A proposal may be corrected, modified or withdrawn by providing a written request from an authorized agent of the offeror to the contact person before the time and date set for receipt of the proposals. After proposals are opened, modifications may be allowed prior to completion of the evaluation process if the Evaluation Committee determines that it is in the best interest of NAB to solicit modifications for best and final offers.

Authorized Signature

Proposals must be signed by an individual authorized to bind the offeror to its provisions. The proposal must remain valid for at least sixty (60) days from the proposal receipt deadline.

In responding to this RFP, the individual signing the response is certifying under penalty of perjury that the price submitted was independently arrived at without collusion.

Proposals in response to this RFP must be submitted by the date indicated in the RFP milestone table in the General Information section.

Scope of Work

The scope of work is outlined below and must be completed by the contractor under a firm fixed price contract in the spring of 2025 prior to when ground conditions limit ability to use heavy equipment without risk of damaging the tundra. Reference the attached site photos and O&M manual for the wind turbines for additional information.

1. **Lowering of the four 80-ft tall wind turbine towers.** The wind turbine nacelle, blades, towers and associated wiring/conduit from the base of the wind turbine up shall be removed from the site and delivered to the City's landfill.

a. The towers must be broken down/consolidated into smaller sections to reduce volume. Broken down sections must be no longer than 20 feet and reduced to a single side of tripod form, at a minimum.
b. Electrical wiring/conduit from the base of the wind turbine tower to the wind turbine building can remain in place for removal by the NAB at a later date. AVEC will disconnect and lock out all electrical components associated with this project; however, the contractor is responsible for verifying with AVEC that the system is electrically safe prior to conduiting any work.
c. The contractor shall sever the electrical wiring/conduit just above ground level at the base of each tower.

The NAB and City of Selawik are exploring options for recycling and/or reusing the towers to avoid sending the material to the landfill; however, no definitive plan is in place at the time of posting the RFP.

The contractor shall be responsible for field verification of obstructions to ensure that the overhead power lines, boardwalk, fuel lines, and tundra remain undisturbed and undamaged throughout the duration of the project. In the event of any damage, the contractor shall promptly undertake all necessary repairs to restore the affected area(s) to their condition prior to the start of this project in a timely and professional manner. NAB will inspect the site once the work has been completed to verify no damage has occurred.

The scope of work <u>does not</u> include the following:

1. Removal of any electrical components from the base of the wind turbines to the wind turbine building. The building shall not be modified in any way.
2. Removal of the wind turbine foundation pilings.

Eligibility and Qualifications

To be considered for this project, the Proposer must meet the minimum eligibility and qualification requirements below.

1. **Experience and Track Record:** The Proposer must demonstrate proven experience with maintaining, erecting and/or removing towers.

   Minimum Requirement: Proposers should list projects that relate to erecting and/or removing towers.

2. **Technical Expertise:** The Proposer must possess the necessary technical skills and resources to remove the towers and ensure that the system is electrically safe.

   Minimum Requirement: The Proposer's team must include qualified personnel with experience working on towers. Additionally, the Proposer's team must include someone who can ensure the system is electrically safe.

3. **Safety and Compliance Record**: The Proposer must demonstrate a strong commitment to safety and regulatory compliance. A record of compliance with relevant safety regulations, environmental standards, and building codes is required.

   Minimum Requirement: No serious or repeated violations of safety, environmental, or building code regulations in the past five years.

4. **Insurance and Bonding:** The Proposer must maintain adequate insurance coverage to protect against project risks, including general liability, worker's compensation, and equipment insurance. All insurance must be in force for the duration of the contract. Payment and performance bonds are required per Alaska Statute 36.25.010.

5. **Licenses and Certifications:** The Proposer and any subcontractors must hold all required licenses and certifications to remove towers and verify systems are electrically safe in compliance with local and state regulations.

6. **Subcontractor Qualifications:** If the Proposer plans to use subcontractors, the Proposer must ensure that all subcontractors meet the eligibility and qualification requirements outlined in this RFP. Subcontractor qualifications must be submitted for approval by the Owner as part of the Proposer's response to this RFP.

7. **Disqualification Criteria:** Proposers may be disqualified for the following reasons:
   - Failure to meet any of the above eligibility criteria.
   - History of contract defaults, litigation, or disputes that reflect poorly on the Proposer's ability to complete similar projects.
   - Submitting false or misleading information in the proposal.
   - Proposers that have been debarred from public contracts or have significant violations of regulatory requirements.

Proposal Requirements

At a minimum, each proposal must contain the following bulleted items. Proposals must be typed and submitted via email. No other forms of proposals will be accepted. Please use the below list as a checklist to verify your proposal includes all required components and will be eligible for consideration.

- Cover Letter – Signed by authorized representative
  - Letter must be concise, well organized and demonstrate an understanding of the scope of work
  - Contact information
  - Total proposed cost

- Cost Breakdown – Budget sub-sections required
    - Mobilization/demobilization
    - Tower and turbine take-down
    - Tower breakdown/consolidation
    - Tower and turbine relocation
- Project milestone schedule – Include the following with expected start and end dates
    - Mobilization
    - Tower and turbine take-down
    - Tower and turbine relocation
    - Demobilization
- Knowledge, Experience and Qualifications
    - Technical qualifications and expertise
    - Demonstrate key staff's experience, certifications and resumes
    - Experience with similar scopes of work. Include a brief description of work completed, dates of work and budget (include examples as an attachment)
- Identify any potential conflicts of interest for the project
- Proof of insurance
- Proof of Alaska Construction Contractors license
- At least one reference with contact information and scope of work for previous project provided. Work must be relevant to this RFP.

Submission of Proposals

Submit Proposals electronically to: clerksmail@nwabor.org by 5:00 PM on Tuesday, April 1, 2025. Proposals received after that date and time will not be considered.

Proposers assume full responsibility for timely delivery at the location designated for receipt of Proposals. Proposals received after the time and date for receipt of proposals will be rejected.

A proposal may be corrected, modified, or withdrawn by providing a written request from an authorized agent **before** the deadline for receipt of proposals.

Proposal Review and Selection

Selection Process

Proposals will be evaluated by a committee established by Ingemar Mathiasson, NAB Energy Manager. Proposals must contain all required components (see list above) to be eligible for consideration. Evaluation of eligible proposals will be based on the Proposer's response to the evaluation criteria provided below and how effectively the proposer demonstrates their ability to provide the services outlined in the "Scope Of Work" section. Proposal scores will be submitted to the Borough Assembly and/or Mayor for final approval and execution of a signed contract.

NAB reserves the right to reject any proposals that do not meet the requirements of the RFP.

The Evaluation Committee may require Proposers to provide clarification of certain points in their proposals prior to completion of the evaluation process. The purpose of these interviews is to ensure that the Evaluation Committee has a more complete understanding of the Proposal. Material changes to proposals or negotiations are not allowed in this process. Information requested for the purposes of clarification will be limited to verification of statements made in the offeror's proposal. All Proposers will be given similar opportunities, as required, for clarification. Interviews will be conducted in such a manner that information derived from competing Proposers is not disclosed. Interviews may be scheduled at the convenience of the NAB and the Evaluation Team.

Evaluation Criteria

The proposals will be scored, based on 100 points possible, and weighted as follows:

- Experience — 20 Points
  - Specific experience in rural Alaska
  - Capacity to use local hire as part of the project's workforce
  - Specific experience with projects with similar scope of work (including constructing, maintaining, removing towers)
  - Key staff and subcontractors' relevant experience and qualifications
- References — 15 Points
  - Ability to complete projects on time and within budget
  - References for key subcontractors
  - NAB is not limited to references provided and can investigate clients from previous projects at their discretion
- Project Workplan and Schedule — 25 Points
  - Clear and realistic workplan detailing understanding of removing the wind turbines, execution methodology (equipment needed, transportation, technical understanding of tower removal and electrical safety, etc.)
  - Clear project timeline with tasks/milestones
  - Subcontractor scope of work, as applicable ability
  - Stewardship of the land and minimizing environmental impacts due to construction
- Budget — 40 Points
  - Note: Davis-Bacon Act labor rates and schedules are required to be adhered to for all contractors and subcontractors.

Recommendation & Award

Upon receipt of the evaluation committee's recommendation, the NAB may reject any defective or nonresponsive proposals or reject all proposals.

If all proposal prices are in excess of the money available, the NAB may authorize negotiation with the three lowest qualified proposers, re-advertise the project after making substantial changes in the project plans to bring the cost within the limit of the money available, or make additional funds available so that the submitted bids come within the range of the NAB's budget.

The NAB shall have the authority to waive any and all irregularities on any or all proposals. In the event of a proposer's potential conflict of interest, the NAB shall evaluate the nature of the conflict and determine whether in its opinion a conflict of interest exists. This decision shall be made solely in the NAB's best interest. If the NAB determines that there is a conflict of interest the proposal shall be deemed non-responsive. If a conflict of interest is discovered after contract award, the NAB, after review of the facts surrounding the conflict, may terminate the contract.

Terms and Conditions

Davis-Bacon Requirement

The Proposer must comply with the Davis-Bacon Act's prevailing wage requirements. This project is funded under Division D of the Bipartisan Infrastructure Law (BIL). All laborers and mechanics employed by the NAB, subrecipients, contractors or subcontractors in the performance of construction, alteration, or repair work in excess of $2,000 on an award funded directly by or assisted in whole or in part by funds made available under this project shall be paid wages at rates not less than those prevailing on similar projects in the locality, as determined by the Secretary of Labor in accordance with Subchapter IV of Chapter 31 of Title 40, United States Code commonly referred to as the "Davis-Bacon Act" ("DBA"). Prevailing wage information can be obtained through the Department of Labor or SAM.Gov.

Post Award

Insurance and Bonding

The Proposer shall maintain adequate insurance coverage, including:

- General comprehensive and professional liability insurance
- Worker's compensation insurance in accordance with local law
- The Proposer shall maintain performance and payment bonds in accordance with Alaska Statute 36.25.010.

Payment

The NAB will pay the selected contractor upon completion of scope of work, as verified through photos and site inspection. Prior to payment, invoice will be reviewed to verify billing reflects agreed-upon services. Final payment is contingent upon site inspection and acceptance from a NAB appointed representative that the above scope of work is complete.

NAB is not responsible for costs incurred by the contractor in preparation of this proposal or due to negligence or any errors or omissions in the contractor's work, including but not limited to inaccurate estimates, delays caused by the contractor, or failure to comply with project design drawings, specifications and requirements. Specific milestone payment schedule will be developed with selected contractor.

Contract Negotiation

NAB reserves the right to include additional terms and conditions during the contract negotiations. These terms and conditions must be within the scope of the original RFP and contract documents, and will be limited to cost, clarification, definition, and administrative and legal requirements.

If the NAB is unable to negotiate a satisfactory contract with the contractor selected at a price that is determined to be fair and reasonable, negotiations with that contractor will be terminated in writing. Another contractor will then be selected, and the process continued until an agreement is reached or the process is terminated. Unsuccessful proposals will not be notified.

If after award of a contract: 1) a conflict arises between terms offered in the Proposal and the terms of the contract or RFP, the terms of the contract or RFP will prevail; and 2) If NAB's rights would be diminished as a result of application of the Proposer's supplemental term or condition included in the Proposal, the supplemental term or condition will be considered null and void.

This RFP does not commit NAB to enter into a contract, nor does it obligate NAB to pay for any costs incurred in the preparation and submission of responses to this RFP. NAB reserves the right at its sole discretion: to make selections, to reject any or all submissions, to issue subsequent RFPs, to remedy technical errors in the RFP process, and to enter into a contract for all or some of the services described in this RFP.

Termination for Default

If the selected contractor refuses or fails to perform the work, or any separable part thereof, with such diligence as will ensure its completion within the written contracted time frame, NAB may, by written notice to the contractor, terminate the right to proceed with the work or such part of the work as to which there have been delays. This clause does not restrict NAB termination rights under provisions of the approved contract.

Contract Changes

While performing the work required by this contract, the contractor may be requested to perform additional work within the general scope of the contract. When additional work is required, NAB shall provide the contractor with a scope of work and request that a cost proposal is provided within a given time period. No additional work shall commence by the contractor without an approved written contract amendment by NAB. Additional work may be executed on a lump sum or time and material basis.

Change Orders

Any changes to the scope of work must be submitted in writing and approved by the NAB before any additional work is performed. Approved changes may affect the contract price or schedule.

Reimbursement to NAB for Unacceptable Deliverables

The selected contractor is responsible for quality, occurrence and completion of all work identified by the contract. All work shall be subject to evaluation and inspection by NAB or their representative at all times to assure satisfactory progress, to be certain that work is being performed in accordance with the contract specifications, terms and conditions, and to determine if corrections and modifications are necessary. Should such inspections indicate substantial failure on the part of the contractor, NAB may terminate the contract for default. Furthermore, NAB may require the contractor to reimburse any monies paid (pro rata based on the identified proportion of unacceptable products received) and any associated damage costs.

Subcontractors

In all cases NAB's business relationship will be solely with the selected offeror. The Proposer who is selected will be responsible for the completeness and quality of all work performed by subcontractors. If it is not outlined in the original proposal, proposers may obtain written approval from NAB to subcontract additional portions of the project. Subcontractor substitution must be approved by NAB prior to commencing work. Proposers are required to submit the names and addresses of all subcontractors and the type and percentage of work they will be providing. Proposers are encouraged to submit joint proposals to meet the separate components of the project if a single contractor does not meet all the required criteria to complete the project in its entirety.

The successful Proposer must supply proof of appropriate subcontractors' Alaska business licenses and the necessary applicable business licenses for those businesses that will be doing work inside Alaska within a reasonable time after the Notice of Intent to Award is issued.

Conflict of Interest

Each proposal shall include a statement indicating whether or not the firm or any individual working on the contract has a possible conflict of interest. If there is a conflict of interest or appearance of such a conflict, a brief description of the nature of the conflict must be included in the statement. NAB will evaluate the nature of the conflict and the bidders' statement and make a determination whether in its opinion a conflict of interest exists. This decision shall be made solely in NAB's best interest. If NAB determines that there is a conflict of interest the offer shall be determined to be non-responsive. If a conflict of interest is discovered after contract award, NAB, after review of the facts surrounding the conflict, may terminate the contract.

Attachment 1 – Reference Photos

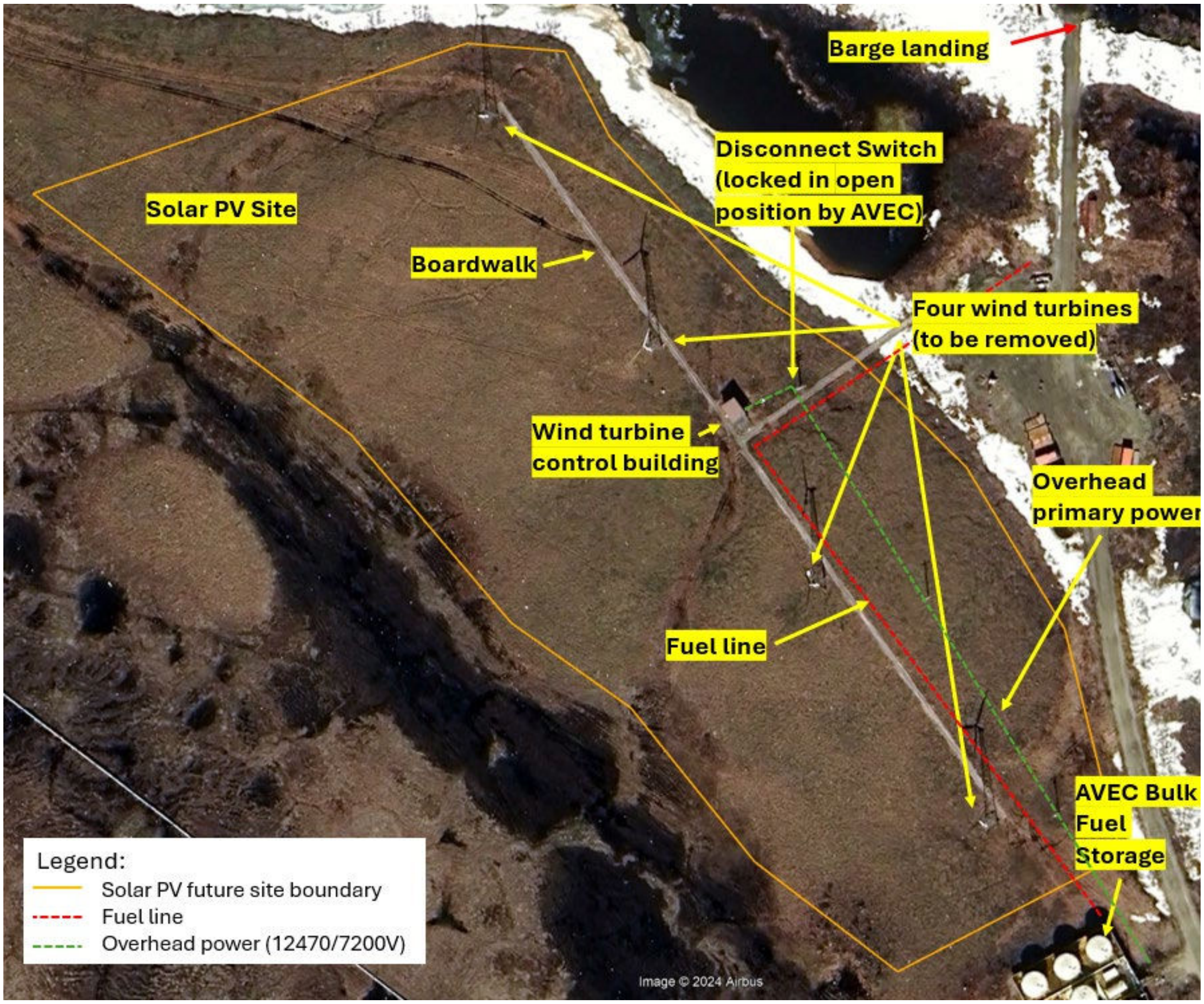

Figure 1: Overview Map of Selawik Wind Turbines, Wind Turbine Building, and Switch

Figure 2: Selawik Wind Turbines

Figure 3: Wind Turbine (80ft tall tower)

Figure 4: Wind Turbine Piling and Tower Connection

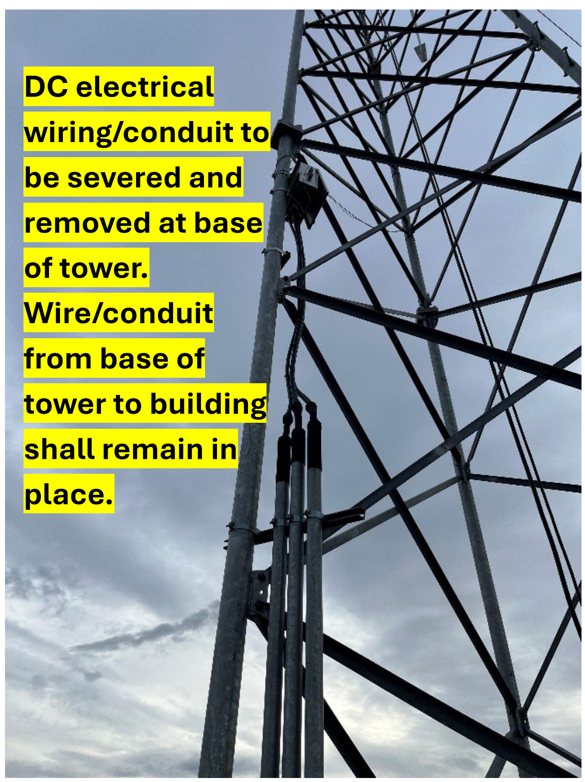

Figure 5: Wind Turbine Electrical Conductors (DC) and Junction Box

Figure 6: Wind Turbine Electrical Junction Box

Figure 7: Wind Turbine Building

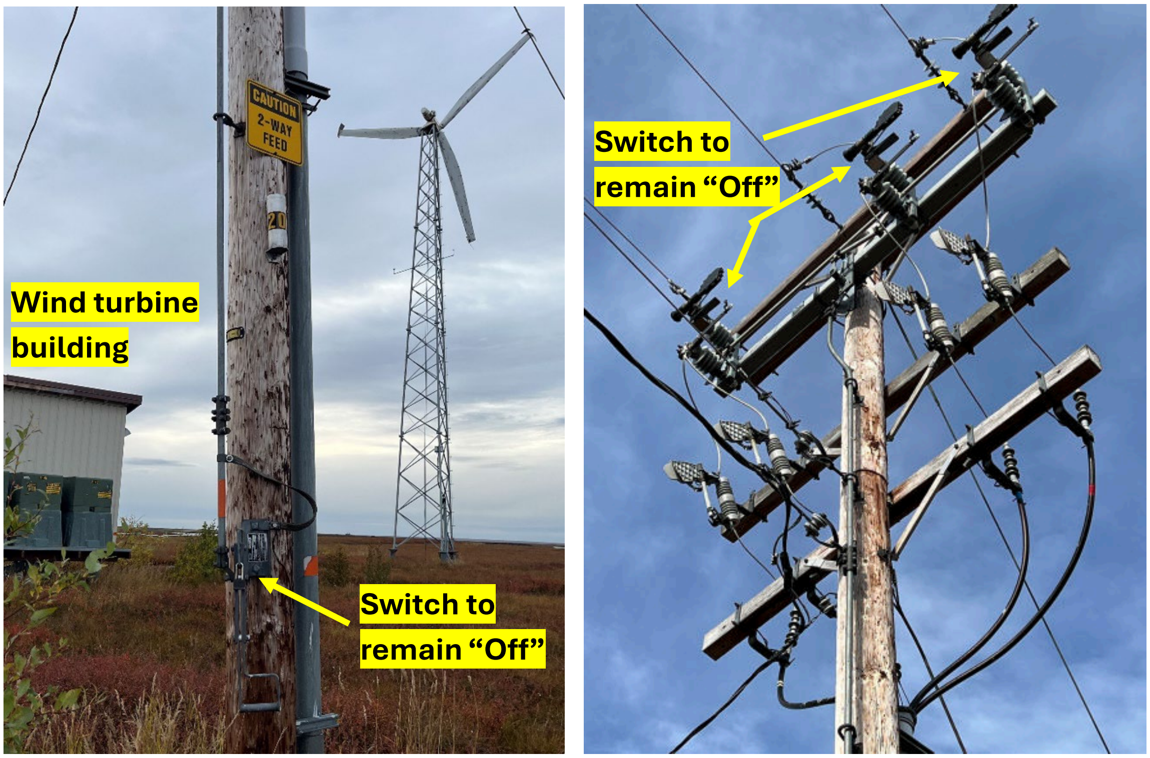

Figure 8: Wind Turbine Primary Voltage (12470/7200Vac) Disconnect Switch

Attachment 2 – Wind Turbine O&M Manual

Atlantic Orient Corporation
Wind Energy Systems for the World

AOC 15/50 Wind Turbine Generator User Manual

DOC012R02 Nov 2001

U.S. $55.00

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WARNING

THE INSTALLATION OF A WIND TURBINE GENERATOR REQUIRES SPECIALIZED SKILLS, EQUIPMENT AND EXPERIENCE. INFORMATION SUPPLIED BY ATLANTIC ORIENT CORPORATION AND ITS SUPPLIERS, FOR THE PURPOSES OF INSTALLING, OPERATING AND MAINTAINING ALL EQUIPMENT, ASSUMES THAT PERSONNEL HAVE THE SKILLS, EXPERIENCE AND EQUIPMENT NEEDED. NO ONE SHOULD ATTEMPT TO CLIMB TOWERS AND OPERATE OR MAINTAIN WIND TURBINES WITHOUT THE NECESSARY SKILLS, EXPERIENCE, TOOLS AND SAFETY EQUIPMENT.

ATLANTIC ORIENT CORPORATION ASSUMES NO DIRECT OR CONSEQUENTIAL LIABILITY IF FAULTY OR DANGEROUS INSTALLATION OR MAINTENANCE PRACTICES ARE USED. TRAINED AND EXPERIENCED PERSONNEL ARE AVAILABLE TO ASSIST IN INSTALLATION, OPERATION, MAINTENANCE AND TROUBLE SHOOTING. CONTACT ATLANTIC ORIENT CORPORATION OR ITS AUTHORIZED REPRESENTATIVE IF CONSULTATION OR ASSISTANCE IS REQUIRED.

ATLANTIC ORIENT CORPORATION AND ITS SUPPLIERS RECOMMEND RESTRICTING ACCESS, WITH ANTI-CLIMB SECTIONS OR FENCES FOR ALL TOWERS, TO PREVENT UNAUTHORIZED PERSONS FROM CLIMBING THEM. APPROPRIATE WARNING SIGNS SHOULD ALSO BE PLACED ON EACH TOWER.

THE AOC 15/50 IS CONSIDERED A HEAVY DUTY INDUSTRIAL MACHINE AND SHOULD BE SITED ACCORDINGLY. ATLANTIC ORIENT CORPORATION RECOMMENDS AN EXCLUSION ZONE CONTROLLING PUBLIC ACCESS. ALL MOVING PARTS SHOULD BE CONSIDERED DANGEROUS.

TOWERS SHOULD NOT BE INSTALLED NEAR UNPROTECTED POWER LINES. ALL ELECTRIC WIRES AND CABLES SHOULD BE CONSIDERED DANGEROUS.

To ensure optimal performance, all wind turbine installations should be thoroughly inspected by qualified personnel within 60 days of their completion, as well as at least biannually and after any major windstorm, earthquake or other severe event. The inspection and service intervals identified by Atlantic Orient Corporation must be followed for any Atlantic Orient Corporation warranty to remain valid.

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DISCLAIMER

This manual is intended as a guide only. It should not be considered as a replacement for professional services or as a definitive text for assembling and installing wind turbine generating systems.

Atlantic Orient Corporation, its affiliates and representatives make no warranties either expressed or implied that the information contained herein is accurate or complete. Atlantic Orient Corporation makes no warranties of merchantability or fitness for a particular purpose and/or site. Atlantic Orient Corporation will not be responsible for any direct or consequential damages, or any incidental expense.

All instructions and diagrams are believed to be accurate at the time of publishing. Note that success and safety in working with tools depend greatly on individual accuracy, skill and caution. For this reason, Atlantic Orient Corporation or its affiliates are not able to guarantee the result of any procedure contained herein, nor can they assume responsibility for any damage to property or injury to persons resulting from the procedures contained in this manual. Persons engaging in the procedures do so at their own risk.

Actual wind resources and site conditions impact on energy production, which will vary with wind turbine maintenance, altitude, temperature, topography and the proximity to other structures. Therefore, Atlantic Orient Corporation makes no representation or warranties regarding energy production.

Atlantic Orient Corporation is constantly striving to improve its products and, therefore, the information contained within this manual is subject to change without notice.

Atlantic Orient Corporation
Wind Energy Systems for the World

Part I

NOTICE: Use of the material contained in this document is subject to the warning on page Iv and the disclaimer on page v of this document.

1.0 Introduction

Photo Courtesy of KEA

KOTZEBUE ELECTRIC ASSOCIATION WIND FARM

1.1 Manual Use

This manual has been developed for use by qualified technicians for the operation and maintenance of the wind turbines manufactured by Atlantic Orient Corporation (AOC). The information provided specifically applies to the AOC 15/50 wind turbine and is valid for both the 50 Hz and the 60 Hz versions, unless otherwise stated.

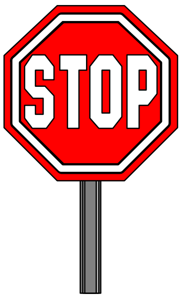
It is essential for the reader to become familiar with the manual prior to preparing the site, installing equipment, operating the system or servicing any equipment. The site should be prepared, maintained, operated and managed to allow work to be performed safely and efficiently. **Special consideration should be given to installing, operating and maintaining the wind turbine system under unusual conditions such as lightning, high winds or icing (where applicable).** For any operation or service related questions, please contact AOC for clarification.

Many of the safety guidelines in this manual are based on recommendations made in the International Electro-technical Commission's *Wind Turbine Generator Systems Part I: Safety Requirements, Second edition, 1999,* 61400-1 or its latest edition. In case of questions or doubts concerning a potentially hazardous or harmful situation, please contact AOC for assistance. The following standards were considered in the design of the controller and selection of components: *US National Electrical Code 196 DFPA 70, Canadian Electrical Code, Part I, 1994, International Electro-technical Commission IEC TC88 – Safety of Wind Turbine Generators 1400-1* or the latest edition.

If there are any questions that are not adequately addressed in this manual, please contact AOC at its corporate headquarters in NORWICH, VERMONT, USA or one of its authorized representatives. Improvements or suggestions from field experience are always welcome.

1.2 Cautionary Icons

1.2.1 Warning Icon



The warning icon denotes actions or procedures that may lead to equipment failure or death to personnel, if not carried out correctly.

1.2.2 Caution Icon

The caution icon denotes actions or procedures that may lead to severe equipment damage or injury to personnel, if not carried out correctly.

1.3 Personnel Definitions

1.3.1 Installation Personnel

Installation personnel are defined as technical staff with training and/or experience in climbing towers and the use of safety equipment, as well as rigging and lifting heavy industrial machinery. **ONLY TRAINED AND QUALIFIED TECHNICIANS SHOULD ATTEMPT TO CLIMB A WIND TURBINE TOWER AND SHOULD USE OSHA/ANSI APPROVED PRACTICE AND EQUIPMENT.**

1.3.2 Operational Personnel

Operational personnel are defined as persons trained and qualified to operate a wind turbine's control panel. They are responsible for monitoring the wind turbine's mechanical and production performance, as well as for performing routine visual inspections of all equipment. See Chapter 10 for the parameters to be monitored. The operation personnel should also ensure that proper maintenance is routinely performed as described in Chapter 11.

1.3.3 Maintenance Personnel

Maintenance personnel are defined as technical staff with training and/or experience in climbing towers and the use of safety equipment, as well as a firm understanding of the wind turbine's mechanical and control system. Knowledge of rigging and lifting heavy industrial machinery may also be necessary. **ONLY TRAINED AND QUALIFIED TECHNICIANS SHOULD ATTEMPT TO CLIMB A WIND TURBINE TOWER AND SHOULD USE OSHA/ANSI APPROVED PRACTICE AND EQUIPMENT.**

Atlantic Orient Corporation
Wind Energy Systems for the World

2.0 System Description

Photo Courtesy of KEA

ALASKA FIELD SERVICE

NOTICE: Use of the material contained in this document is subject to the warning on page Iv and the disclaimer on page v of this document.

The following sections provide a general description of the AOC 15/50 and its control system.

2.1 General Description and Features of the Turbine

The designation 15/50 refers to the 15 m diameter wood/epoxy or fibreglass rotor and its projected rated output of 50 kW. This rated output is achieved at 12 m/s (26.8 mph) by the 50 Hz version and at 11.3 m/s (25.3 mph) by the 60 Hz one.

The AOC 15/50 includes the following design features:

- Advanced NREL thick series airfoils
- High strength to weight ratio wood/epoxy or fiberglass blades
- Electro-magnetically/actively controlled tip brakes
- Single piece hub casting
- Rotary transformer to power the tip brake magnets
- Integrated planetary gearbox
- Induction generator
- Single piece cast tower top with turn table yaw bearing
- Uniformly tapered lattice tower
- Dynamic brake
- PLC based controller with adaptive features
- Optional tilt-up lattice tower

Both turbine versions are designed to cut in at 4.6 m/s (10.2 mph). The 50 Hz version reaches its peak continuous output of 55 kW at 15 m/s (34 mph); the 60 Hz one achieves its peak of 65 kW (60 Hz) at 16 m/s (36 mph). Assuming 100% availability and average wind speeds of 8 m/s (18 mph), the 50 Hz wind turbine is calculated to produce approximately 190,000 kWh per year and the 60 Hz one, 215,000 kWh. In average wind speeds of 6.7 m/s (15 mph), the 50 Hz version produces approximately 145,000 kWh annually and the 60 Hz one, 153,000 kWh.

NOTE: Energy production is site specific and varies with altitude, temperature, topography, climate and the wind turbine's proximity to other structures, as well as its maintenance condition.

The standard tower is a 24.4 m (80 ft) tall, self-supporting lattice structure. The gearbox is integrated in the single piece cast housing. See Figure 2-2 for a more detailed view of the drive train assembly. The generator is flange mounted to the planetary gearbox, with the parking brake coupled directly to the generator.

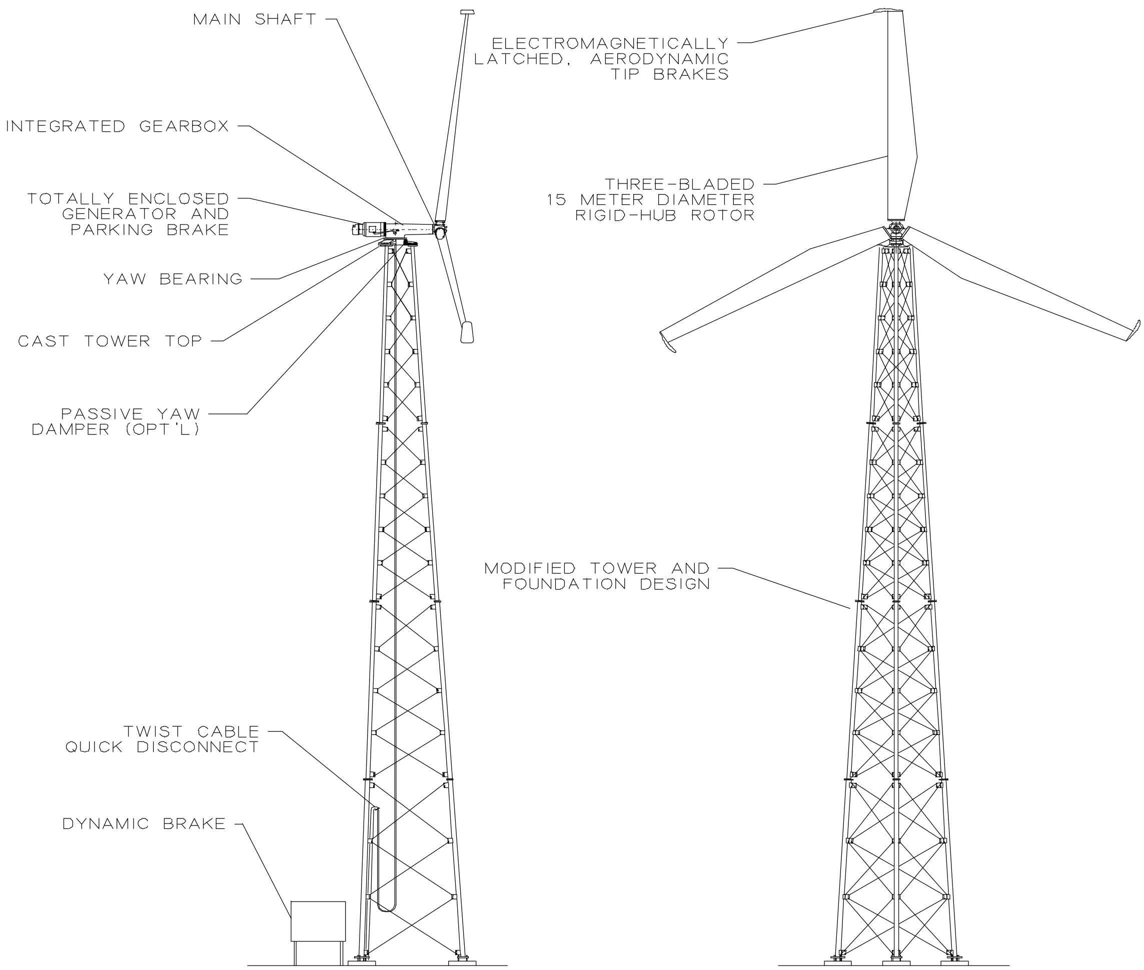


Figure 2-1 AOC 15/50 Wind turbine

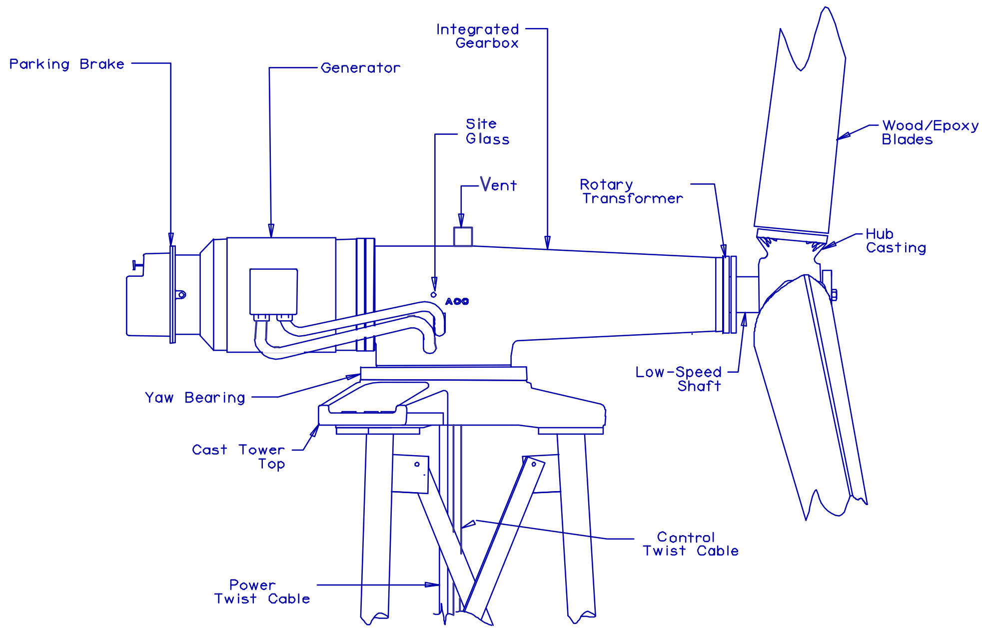


Figure 2-2 AOC 15/50 Wind turbine assembly, drive train detail

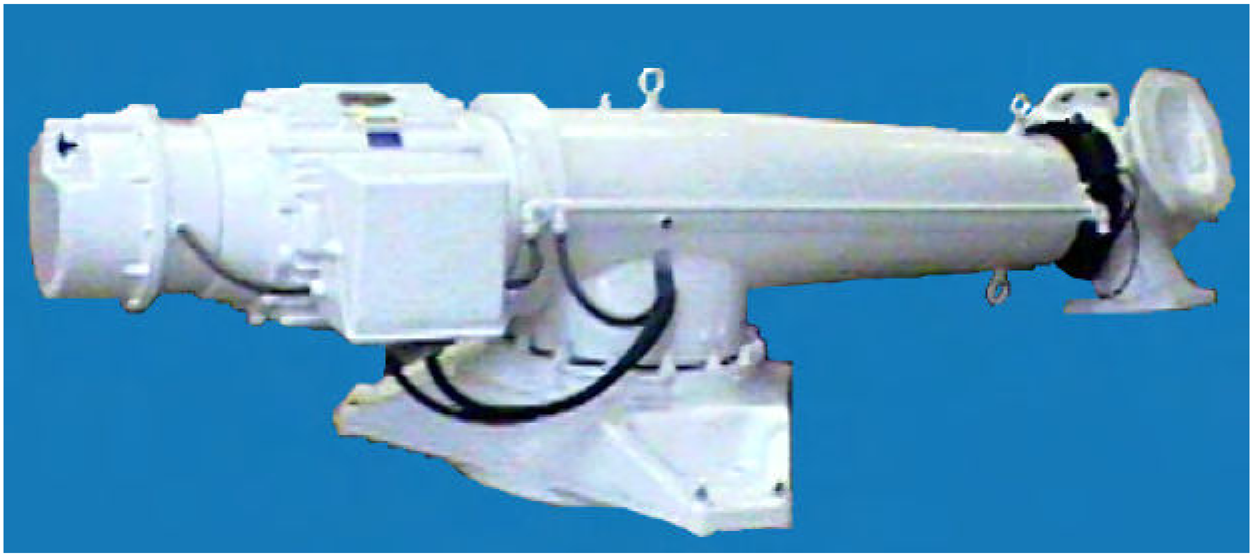


Figure 2-3 AOC 15/50 Drive train assembly

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2.2 Control System Description

The following parameters are monitored by the wind turbine's control system. It initiates shutdowns when faults have been detected to protect the wind turbine from mechanical and electrical damage.

UTILITY NETWORK:
- Over/under voltage
- Phase loss
- Phase reversal
- Over/under frequency (optional)

TURBINE:
- Generator temperature
- Rotor speed
- Power (derived from rotor speed)
- Parking brake current

SYSTEM:
- Wind speed (redundant anemometers)
- Ambient temperature switch (optional)

2.3 Operation Description

The AOC 15/50 is a downwind turbine, i.e. its blades rotate downwind of the drive train assembly. Furthermore, it has no active yaw control and depends on its blades to track the wind. In winds outside of the required wind band, the PLC (Programmable Logic Controller) disconnects the wind turbine from the grid and parks it; the wind turbine is brought to a complete stop. The parking brake remains applied, thereby preventing the blades from rotating. However, they will still track the wind and the wind turbine will pivot about its yaw bearing accordingly.

The AOC 15/50 has three main modes of operation: test, off and on. The setting of the TEST/OFF/ON switch determines the parameters monitored by the PLC and which other switches can be activated. When the turbine TEST/OFF/ON switch is set to OFF, the PLC only monitors grid faults.

Once the turbine TEST/OFF/ON switch is set to ON, the PLC starts evaluating the wind speed data which, together with the generator rotor speed, is the most important source of input data to the PLC; grid related parameters and thermal relays play a secondary role.

The wind speed is measured using two cup anemometers. For the wind turbine operation the wind speed has to fall within the specified speed band of 3.6-22.3 m/s (8-50 mph). The cut-in speed of 4.9 m/s (11 mph) is slightly higher than its minimum operational speed because of the inertia of the rotor and drive train that must be overcome initially. Once the wind speed conditions are met, the parking brake is released and the generator starts rotating, at which point PLC starts monitoring the generator rotor speed.

Once the parking brake has released and the rotor speed is in band,the wind turbine is connected to the grid automatically. The wind turbine will then stay on-line until wind conditions fall outside the operating band or until a fault or shutdown is registered. The generator shaft speed is measured using two speed sensors from which the PLC can tell whether the shaft speed falls within the required range. Since power produced is proportional to rotor speed, the rotor speed is also used to check for excessive power generation.

Whenever the wind and/or shaft speeds deviate from the specified values the PLC initiates a shutdown of the wind turbine system. In order to avoid unnecessary shutdowns, each fault is monitored for a set period to confirm that it is not due to a temporary deviation but to a definite change in the operating conditions. Since faults impact on the system with varying degrees of severity, in terms of possible electrical or mechanical damage, the time delays after which a shutdown is initiated differ.

Should the PLC register a fault that requires the wind turbine to be shut down, it does so in a set sequence. The tip brakes and dynamic brake are deployed immediately. The parking brake is then deployed after a variable time delay, generally set to 4 seconds. Following any deployment of the brakes the wind turbine enters a cooling cycle, generally set to 15mins. The turbine will not be available to comeback on line until the end of the cooling cycle to prevent overheating of the brake components.

The dynamic and parking brakes can be tested individually when their test switches are set to ON and the TEST/OFF/ON switch is set to TEST. See section 9.1 for a more detailed description of the individual switches.

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3.0 Safety Guidelines

Photo Courtesy of BED

TOWER ERECTION AT BURLINGTON ELECTRIC DEPARTMENT

NOTICE: Use of the material contained in this document is subject to the warning on page Iv and the disclaimer on page v of this document.

This section covers the safety information needed by a technician to install, operate and maintain the AOC 15/50 safely. Special safety considerations for specific circumstances are highlighted throughout this manual.

CAUTION

THE RESPONSIBILITY FOR SAFE CONDUCT AND OPERATION ULTIMATELY RESTS WITH THE OPERATOR/ TECHNICIAN.

3.1 Personnel Training

It is essential that installation, operation and maintenance personnel be instructed in the safe operation procedures outlined in this section. Standard safety procedures should be established and a program of regular safety training should be carried out to ensure consistent information, regularized safety habits and efficient communication while working at the wind turbine site(s).

3.2 Safety Equipment

AOC recommends the use of approved safety equipment for any work carried out within 30.5 m (100 ft) of an AOC 15/50.

For climbing and positioning on the erected wind turbine, an ANSI approved full body harness should be used. AOC also recommends using a Rohn-Loc Climbing System. Positioning lanyards are usually necessary for turbine installation and maintenance and should be ANSI approved. AOC recommends the use of fall arresting lanyards in conjunction with positioning lanyards, as the latter are not designed for fall protection. The fall arresting lanyards should be no longer than 1.8 m (6 ft) and incorporate deceleration devices. All connections and anchor points should be capable of supporting 2,270 kg (5,000 lbs.). Self-locking snap hooks and self-locking carabiners are required.

Equipment should be visually inspected for excessive wear and abrasion before each use. All damaged or questionable equipment should be discarded immediately. Any equipment, which has been subject to a fall, should be removed from service and discarded.

When working on electrical equipment and/or wiring, technicians must wear protective gloves rated for the voltage level involved or be certain that the system is not, and will not, be energized by employing a visual open/lockout process. Whenever any hazard exists, appropriate safety glasses/shields must be worn.

3.3 Start-up and Shut-down Safety Procedures

Prior to starting up a wind turbine, the operator should warn any personnel in the area that it will be started and to visually inspect the area to ensure that they are clear of it. In addition, the operator should ensure that there are no visual signs indicating problems with the wind turbine. During a shutdown sequence, no personnel should approach the wind turbine, until it has come to a complete stop.

3.4 Securing Machine for Maintenance and Repair

The wind turbine should be switched off and the yaw lock engaged before any maintenance is performed. The parking brake automatically engages whenever the wind turbine is shut down, preventing the rotor from turning. The yaw lock must be engaged manually and once engaged prevents the wind turbine from yawing, providing a safe working environment. To engage it, trained personnel must climb the tower to immediately below the tower top. The yaw lock bolt must be screwed clockwise until its top endplate engages the yaw bearing between two of the yaw bearing’s interfacing bolts.

Figure 3-1 Yaw lock

If personnel safety or environmental conditions warrant securing the rotor or if the work carried out requires the parking brake to be released to change the rotor position, it is recommended that one blade be strapped to the tower or to the gearbox housing to prevent unintended rotor motion.

Ropes may replace straps provided care is taken not to damage the blade surface; cables or chains should not be used.

CAUTION

NEVER USE METAL CHAINS OR CABLES TO SECURE THE BLADE, SINCE DAMAGE TO THE BLADE IS LIKELY.

3.5 Climbing Safety

For all activities where persons could be subject to a fall of 1.8 m (6 ft) or more, appropriate fall protection equipment should be used, which should be fastened to a secure anchor point, preferably above the climber. Only the tower leg fitted with climbing pegs should be used for ascending and descending the tower. Once the technician has reached the top, he/she should attach himself to a secure anchor point. The drive train has four hoist rings that can be used as anchor points. See Figure 3-2. Holes in the tower brace clips also provide secure anchor points.

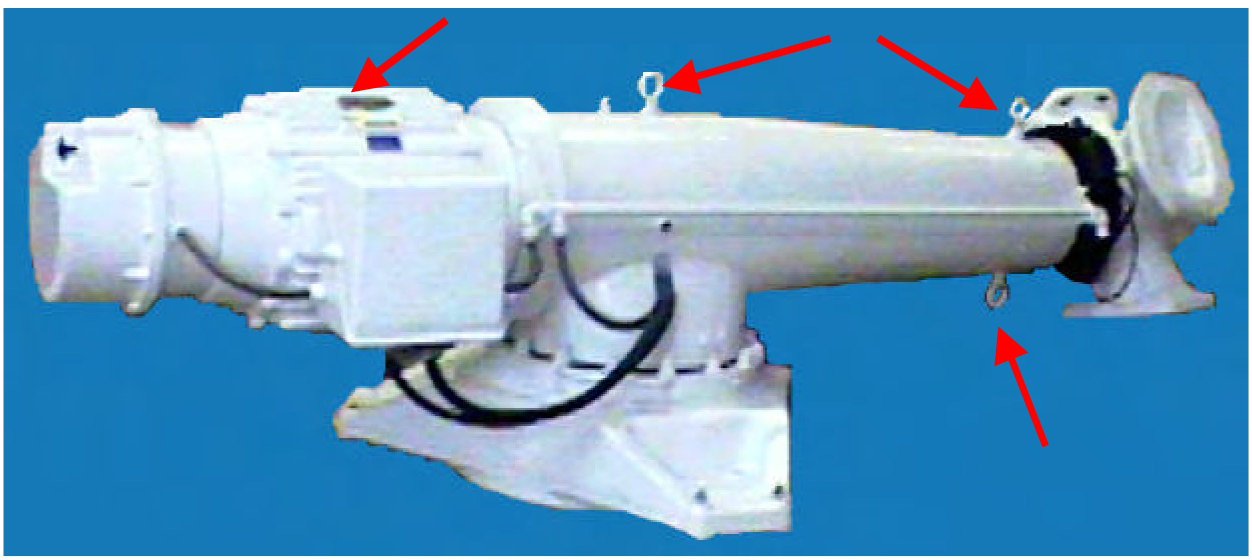


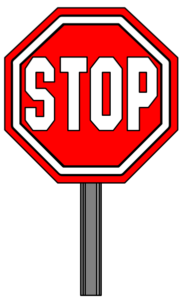
Figure 3-2 Secure anchor points for service work

Only trained and qualified technicians should attempt to climb a wind turbine tower and should use OSHA/ANSI approved practice and equipment. All climbers should be trained in the proper use of fall protection equipment. AOC strongly discourages climbing when the wind turbine is operating or when wind speeds exceed 11 m/s (25 mph).

Whenever climbing a tower or performing a service function above ground level AOC recommends at least two service personnel working together. Wireless communication devices (preferably hands-free) are recommended to facilitate communication between tower and ground personnel. The area around the tower should also be roped off with appropriate warning signs indicating falling objects.

Finger rings should not be worn while climbing structures or vehicles, or while performing any task where the ring might be caught under or snagged by a projecting or moving item.

3.6 Electrical Safety



WARNING

WHENEVER POSSIBLE, ELECTRICAL EQUIPMENT SHOULD BE DE-ENERGIZED AND GROUNDED PRIOR TO SERVICING. CAUTION MUST BE TAKEN TO ENSURE THAT THE DYNAMIC BRAKE AND THE POWER FACTOR CORRECTION CAPACITORS ARE DISCHARGED BEFORE SERVICING.

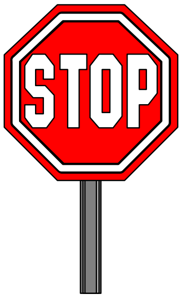
Electrical equipment should not be serviced while standing in water, on wet surfaces or during significant precipitation. Hands must be dry. Any electrical power supply to tools and conveniences should be grounded.

A shirt or jacket with full-length sleeves rolled down and buttoned up, as well as an electrical safety hat should be worn when working on or near live parts.

Loose, dangling metal chains, key chains, or conductive jewelry of any kind should not be worn while working on or near energized parts. Each employee should wear gloves suitable for the work. Rubber glove protectors should not be used as work gloves. Wristwatches with metal cases and watchbands should not be worn while working on or near energized equipment.

3.7 Weather Related Safety

It is important to observe weather conditions and to take appropriate action when a weather related safety hazard arises. No service work should be performed in the presence or threat of lightning. Wet and/or ice laden towers should not be climbed, nor should electrical equipment be worked on during significant precipitation. Towers should not be climbed when average wind speeds approach 11 m/s (25 mph) or wind gusts exceed 13 m/s (29 mph).



WARNING

NO SERVICE WORK SHOULD BE PERFORMED ON A WIND TURBINE IN THE PRESENCE OR THREAT OF LIGHTING. WET AND/OR ICE LADEN TOWERS SHOULD NOT BE CLIMBED. EXTERIOR ELECTRICAL EQUIPMENT SHOULD NOT BE WORKED ON DURING SIGNIFICANT PRECIPITATION.

3.8 Emergency Procedure

CAUTION

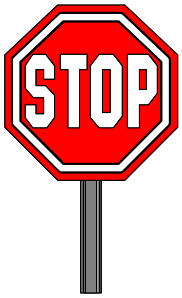
WHEN A HAZARD EXISTS, PERSONNEL SAFETY MUST BE ENSURED BEFORE ADDRESSING THE SAFETY OF THE WIND TURBINE EQUIPMENT. IN ALL CASES, SAFE EFFORTS SHOULD BE MADE TO BRING THE WIND TURBINE TO A FULL STOP OR TO PREVENT OVER SPEEDING.

AOC takes extreme care to design a safe and reliable product and the AOC 15/50 has been designed to meet strict and extensive safety guidelines. However, due to the variety of unpredictable and possibly extreme conditions it may experience, operators should prepare and have on hand site-specific emergency procedures to effectively address the following hazards:

- Turbine over-speed
- Loose fasteners
- Structural damage
- Earthquakes
- Sand storms
- High vibration
- Cable over-wrap and/or separation
- Complete braking failure
- Electric fires
- Lighting
- Hurricanes
- Blade damage/separation
- Tower damage

AOC recommends the following as a generic safety plan in the unlikely case of an emergency:

1. Do not approach the AOC 15/50 or any of its components if one of the safety hazards mentioned above is suspected. Always maintain a safe distance (at least 90 m, 300 ft) upwind of the wind turbine.
2. If the controller area is deemed safe, depress the emergency stop button. The wind turbine should come to a complete stop and the main contactor should de-energize.
3. Contact the local emergency officials if necessary (i.e. fire marshal, 911, utility, etc.).
4. Contact the wind turbine owner.
5. Do not attempt to operate the AOC 15/50 without first contacting AOC. It may be necessary to schedule an inspection by AOC personnel.



WARNING

DO NOT ATTEMPT TO OPERATE THE AOC 15/50 WITHOUT AOC CONSULTATION AFTER A SERIOUS EVENT HAS OCCURRED. AOC RECOMMENDS A COMPLETE INSPECTION OF THE TURBINE AND ITS COMPONENTS BY TRAINED PERSONNEL AFTER ANY SUCH EVENT. FAILURE TO DO SO MAY RESULT IN POOR PERFORMANCE, INJURY OR DEATH.

Atlantic Orient Corporation
Wind Energy Systems for the World

Part II

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4.0 Planning and Installation Checklist

Photo Courtesy of KEA

SITE CONSTRUCTION AT KOTZEBUE ELECTRIC ASSOCIATION

The following sections are intended to assist customers in addressing the relevant installation details in a logical sequence. Although most points apply to both large and small projects, not all will apply to every project. To ensure thorough planning, it is strongly recommended that customers understand why a particular detail is or is not appropriate to their installation.

By reviewing the entire list repeatedly throughout the project, the customer should be able to ensure that none of the details, necessary to complete it, have been overlooked.

4.1 Siting Factors

Site selection has a significant effect on annual energy production. It is, therefore, worth the additional time and effort to locate the most suitable site to ensure optimal energy production and maximize the wind turbine's lifespan. When selecting a site, the following factors should be considered:

- Wind resource characteristics
  - Average wind speed
  - Makeup of wind speed average (frequency and duration of power producing winds)
  - Prevailing wind direction(s)
  - Turbulence
  - Peak wind speeds
- Height and location of obstructions
- Distance from utility service point
- Local restrictions relative to height, proximity to boundaries, etc.
- Tower height
- Proximity to other wind turbines
- Site accessibility and its effect on construction and maintenance costs
- Safety zone preventing public access

4.2 Utility Factors

The AOC 15/50 includes an induction generator, which depends on the interfacing electrical system for excitation. Each wind turbine has a fixed set of power factor correction capacitors installed in the dynamic brake capacitor box. To ensure a safe and efficient installation, the following utility related factors should be considered:

- Buy back rates, contract options, green pricing and net billing
- Available line capacity (in kVA)
- Available fault current
- Voltage and phase configuration of the primary circuit and the local utility line
- Distance to nearest substation
- Size and winding configuration of the step down transformer required at the site (in kVA)

- Line protection required
- Cogeneration standards for small power producers
- Interconnection hardware and wiring standards
- System operation requirements:
  - Voltage regulation
  - Power factor
  - Protective devices
  - Utility/wind turbine interface responsibilities

To interface with the utility network correctly all power factor correction capacitors or unique loads connected to the utility system need to be identified by the customer. Furthermore, the Required Customer Power Grid Information sheet should be completed to assist AOC in designing the most suitable interface. See Appendix K.

4.3 Permits and Approvals

Local authorities often require a wind turbine operator to obtain permits or approvals, some of which have been identified below. It is important to determine which of these apply to a site and whether any independent inspections are required.

Issuing Authority:
- Municipality or local council
- Country
- State or Province
- Federal (FAA, FCC, etc.)
- Commission (energy, conservation, historic, etc.)
- Utility

Type:
- Construction
- Foundation engineering
- Electrical works
- Interconnection
- Zoning
- Communication interference
- Aviation interference
- Environmental impact

4.4 Plans and Drawings

The following list contains suggested documentation to prepare in advance and have on hand to ensure efficient and proper site development, as well as for submittal for the necessary approvals:

- Plot plan
- Site layout
- Tower foundation drawing
- Tower assembly drawing
- Site wiring layout
- Control house interior wiring (if applicable) diagram
- Control house physical layout (if applicable)
- Utility interface - single line drawing
- Utility interface - three line drawing
- Wind turbine generator to control box wiring schematic
- Wind turbine generator wiring diagram

4.5 Construction Planning Considerations

To reduce delays later and to minimize cost, the following items should be considered during the planning process:

- Subcontractor roles and responsibilities
- Cable trenches (type, length and depth)
- Control enclosure design
- Site specific weather extremes
- Tower foundation type
- Foundation forming details
- Site accessibility and road conditions
- Crane availability and cost
- Concrete availability and cost
- Backhoe availability and cost
- Concrete reinforcing bar availability and cost
- Labor skills and related costs
- Soil characteristics
  - Soil stability
  - Depth to water table
  - Depth to significant frost
  - Allowable bearing capacities
- Blasting needs
- Tripod or backhoe for tower assembly
- Availability of hand tools
- Concrete working tools
- Anchor bolt template and verification of proper placement
- Fencing materials and security

4.6 Electrical Planning Considerations

The local wiring inspector should review the design of the electrical installation before work starts at the site. The following items should be considered in the design/installation of the electrical system:

- Wire sizes, length and type as described in Appendix M
- Conduit type and size
- Service entrance hardware
- Revenue meter specifications
- Protective hardware required by the interfacing utility
- Distribution panel(s) with properly sized circuit protection
- Single phase power for control house lights and receptacles
- Step down transformer characteristics
- Control house interior wire ways
- Control house junction box(es)
- Multiple unit control for wind power stations
- Twist cable termination box
- Foundation/conduit interfaces

4.7 Installation Tools and Equipment

The installation of the AOC 15/50 requires specific tools and equipment (see Appendix I). Below is a breakdown of steps to take or equipment to have on hand for the three main installation phases.

For tower assembly:
- Tower manufacturer's assembly drawings
- Checklist of tower parts, hardware and tools
- Torque specifications
- Tripod, bucket, backhoe or boom truck
- Personnel for lifting and assembly
- Anemometer boom and brackets

To prepare machine:
- If wind turbine generator was shipped in a crate, remove from crate
- Check components
- Open blade crate

For installation:
- Slings, ropes, buckets and tools
- Adequately trained personnel

- Platform or bucket for blade installation
- Appropriate safety equipment
- Crane
- Forklift or boom truck

4.8 Installation Personnel Considerations

The installation and maintenance of a wind turbine requires specialized skills, equipment and experience. AOC assumes that all installation and operation personnel will have these skills, experience and equipment. Only trained and qualified technicians should attempt to climb a wind turbine tower and should use OSHA/ANSI approved practice and equipment. It is highly recommended that a trained AOC representative be present for the erection and assembly of the wind turbine (see Section 4.9). The following personnel should also be present, as and when required, during installation:

- One to two qualified technicians trained in climbing safety to erect and install wind turbine
- Qualified crane operator to operate the crane during tower and wind turbine lifting
- Certified electrician and/or utility personnel to install cables and wire controllers
- Additional labor for non-technical tasks such as tower assembly

4.9 General Installation/Commissioning Timeline

The following timeline represents the minimum installation schedule for one wind turbine under ideal circumstances. Three to five days is usually a reasonable estimate. Poor weather conditions, logistic problems and poor planning may extend the timeline considerably.

Site Preparations and Construction:

- Pour foundation
- Create cableways, wiring, power cables
- Install and wire control boxes, capacitor, and dynamic brakes
- Inspect wind turbine and hardware

Day 1:

- Plan and prepare erection
- Assemble tower
- Test generator and use it as a motor to test drive train
- Clean blades and install tip brake cable
- Prepare tip brake studs and cavity
- Prepare blade bolt inserts
- Attach twist cable
- Install two of three blades if time permits (fork lift, boom truck, etc.)

Day 2:

- Lift and install tower on foundation (crane)
- Install blades on hub
- Install tip brakes on blade ends
- Lift and mount machine onto the tower
- Torque tower top fasteners
- Torque all tower bolts and add pal nuts

Day 3:

- Install and wire anemometers
- Wire twist cable junction box and disconnect (if applicable) at tower base
- Grout tower legs
- Mount warning signs as required
- Troubleshoot and commission

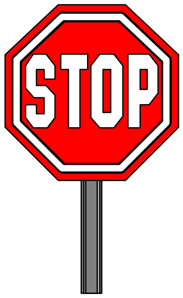
Day 4:

- Complete any further installation details
- Carry out final QA check
- Monitor performance (wind permitting)

5.0 Site Preparation

Photo Courtesy of BED

FOUNDATION CONSTRUCTION AT THE BURLINGTON ELECTRIC DEPARTMENT PROJECT



WARNING

DURING THE INSTALLATION OF A WIND TURBINE, THE SITE SHOULD BE MAINTAINED SO THAT IT DOES NOT PRESENT A SAFETY RISK/HAZARD TO PERSONNEL.

The following sections discuss some of the siting factors, which must be considered before the wind turbine arrives.

5.1 Site Access

Access to the site is a prime consideration when installing a wind turbine. Limitations in site access will determine the type of installation and equipment that can be used. Potentially limiting factors include:

- Roadways (existence, permits, size, surface, restricted use, weight bearings)
- Bridges (size, load capacity, width and height clearances)
- Physical clearances (overhead wires, lamp posts, turning radii, grade)
- Traffic (movement to and at the site)
- Lay down area (space to assemble the tower and locate components prior to installation)

5.2 Foundation Installation

Foundation types and installation approaches are site specific and the foundations must be designed for the load conditions expected at the site in question. Refer to *IEC Standards for Wind Turbines* for additional information. Since AOC offers a standard and tilt-up tower, it should be noted that the chosen configuration will affect the position of the anchor bolts. For planning purposes regarding the tilt-up towers, it should be remembered that AOC only supplies the hinges not the erection equipment.

See Appendix F for foundation loads and details. The civil engineer responsible for the foundation design should consider site specific conditions.

Each tower leg should be grounded as per EIA standards. Rohn recommends using three 5/8" galvanized ground rods, 8 feet long and mechanically connected to each leg using #4 gage wire.

It may be advisable to excavate trenches for power and control cables at the time of digging the foundations. For wire and cable information, refer to Appendix M.

CAUTION

CAREFUL MEASUREMENT AND USE OF AN ACCURATE ANCHOR BOLT TEMPLATE BEFORE, DURING AND AFTER CONCRETE POURING CAN MINIMIZE ALIGNMENT PROBLEMS OR FOUNDATION REPAIRS.

5.3 Receiving the Wind Turbine at the Site

Wind turbines are often installed on uneven terrain. Moving components and assembling them is easier on level ground. It is, therefore, suggested that a level lay-down area is either excavated (taking care to prevent erosion) or built, on which the wind turbine can be assembled and erected. Items such as blades may need to be anchored and covered if the site experiences strong winds or other hazardous environmental conditions.

The wind turbine will normally be shipped in four crates. Their nominal weights and sizes are listed in Appendix E. For containerized shipping please note that both the tower sections and the blades are too long to fit a 20 ft container.

Once the shipment has been offloaded from the truck:

- The packing list should be checked to confirm that all items have been received. The items should be inspected for damage and if any damage is suspected the shipping company should be contacted regarding claims procedures. AOC should also be notified of the parts needed. Particular care should be taken to inspect the twist cable and the blade surfaces.
- Any scratches obtained during transit should be touched up. CRC Industrial SP Corrosion Inhibitor or an equivalent can be used as an anticorrosive on any bare metal surface. Failure to properly coat bare metal may result in significant corrosion.
- With the wind turbine on level ground, the oil level in the gearbox sight glass should be checked. See Figure 2-2 for the sight glass location. It should be half way up the sight glass.
- All grease fittings should be intact. These are located on the generator housing, yaw bearing, yaw lock.

The checklist is provided in Appendix G.

6.0 Tower and Wind Turbine Generator Installation

Photo Courtesy of BED

TOWER ASSEMBLY AT THE BURLINGTON ELECTRIC DEPARTMENT PROJECT

The following sections describe the assembly of the tower, as well as its erection and the installation of the wind turbine generator.

6.1 Tower Assembly

For the assembly details refer to the manufacturer's instruction packet shipped with the tower. The tower assembly drawings for the standard 24.4 m (80 ft) tower are supplied in Appendix C; for those of the 30.5 m (100 ft) tower see Appendix D.

The tower will generally be assembled horizontally with two of its three legs near the ground. Blocks should be used to support these two legs at several locations along their length. The height of the blocks should be chosen to ensure that the tower is straight and to allow cross-braces to be bolted to the legs. The blocks must have sufficient strength and stability for the tower to be worked on safely.

After laying out the tower leg sections, the braces should be matched to their respective brace clips on the legs. Braces and legs are clearly stamped with their part numbers and are referenced in the tower drawings (see Appendix C or D). The bottom leg flanges of the bottom tower section and the upper leg flanges of the topmost tower section are angled. This ensures that they are parallel to the foundation and the turbine tower top casting once the tower is vertical.

The cross-braces between two legs from each section should be installed. The third leg then has to be lifted above the two lower legs for the remaining cross-braces to be installed. The leg can be raised using a bucket loader, fork lift or similar aid.

The open angle on the cross-braces should face towards the tower base, to shed any water. The longer distance between the middle and the outer bolt hole in the cross-brace should also be positioned facing down, towards the base. This configuration should be repeated down the tower and around its sides. The top braces of each section start in the top hole of the brace clips, and the bottom braces of each section terminate at the bottom hole of the brace clips. The cross-brace holes may not line up with the brace clip hole easily but they can be aligned using a pair of drift pins and two vise grips to hold the brace in place while a bolt is inserted.

Brace bolts should be installed with the head on the inside of the tower and the nut on the outside. Flange bolts should be inserted from the bottom up, with the nut on the flange top. The flange bolts on the top and bottom most sections should be left slightly loose until the tower is in place, as should the cross-brace bolts on these sections. It is helpful to use templates on the top and bottom sections when assembling the tower. This ensures a better fit when the tower is erected on the foundation. The bolts on the middle sections may be tightened to their required torques after the tower has been completely assembled.

The 1" flange bolt nuts should be torqued to 340 Nm (250 ft-lbs) and the 5/8" nuts on the braces, to 200 Nm (150 ft-lbs). Pal nuts should be placed snug tight on every bolt after the nut has been torqued, thereby indicating that the bolt has been torqued to specification.

NOTE: A template identical to the anchor bolt template can be bolted to the bottom leg flanges during tower assembly to insure a proper fit during the tower erection. Using both templates should theoretically allow all bolts to be torqued before erection.

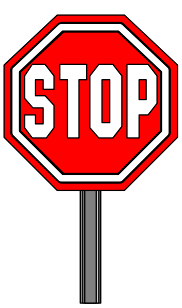
6.2 Tower Erection

Appendix G contains the Installation QA checklist that should be used during the installation process.

Much time can be saved if a crane capable of lifting the tower as one complete unit is used. When considering crane capacity, the erection load and local wind conditions should be taken into account. The centerline of the drive train is approximately 1.2 m (4 ft) above the chosen tower height. The 24.4 m (80 ft) tower weighs approximately 3,180 kg (7,000 lbs) and the 30.5 m (100 ft) tower, approximately 4,550 kg (10,000 lbs). The wind turbine generator weighs approximately 2,480 kg (5,450 lbs). See Appendix E. The length of the crane ball, lifting sling and the height lost due to boom angle reach should also be taken into account.

Before the tower is set on the foundation, an anchor nut should be placed on each anchor bolt to serve as a base for the tower flanges to rest upon. These nuts should be leveled before the tower is placed on them, using a survey transit and straight rod or a long straightedge with a bubble level, for example. Tolerance is not important initially, as the nuts may need to be adjusted in order to level the gearbox.

The tower can be lifted using three appropriately rated, separate slings or cables of equal length, each of which is hooked to the crane ball at one end and to the tower, near the top of its top section legs, at the other. **The lifting devices should be inspected for correct attachment before raising the tower.** Special care should be taken not to damage the lifting webbing on sharp edges. The tower should be lifted slowly and set on the anchor bolts carefully. The tower base flanges may not fit the anchor bolts precisely, especially if a base template was not used.



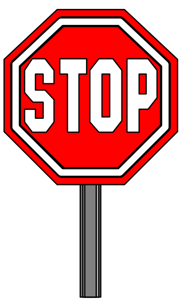
WARNING

DO NOT HAMMER OR BEND ANCHOR BOLTS TO FIT THE TOWER BASE. THIS MAY CAUSE CATASTROPHIC STRUCTURAL FAILURE AND RESULT IN SEVERE INJURY OR DEATH.

The tower legs may have to be twisted along their axes, to obtain the correct alignment between the flange holes and the anchor bolts. This can be done using a come-along and pry-bar. As the tower is lowered onto the base nuts, the top locking nuts should be placed on the anchor bolts as soon as the first threads protrude from the flanges. The nuts should be tightened incrementally as the tower is lowered. Once the tower is in place, the lock nuts should be tightened hand snug, after which the tension on the crane cable can be relaxed. A technician should verify that the tower top is level by climbing the tower. Any adjustments required to level the tower top should be made by adjusting the anchor nuts.

The 1½ " anchor bolt nuts should be torqued to AISC snug tight standards after the tower has been erected; snug tight being defined as the tightness needed to bring all plies in a joint into firm contact. This may be obtained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Following this, the tower grounding rods should be connected (see Section 5.2) and the slings released.

WARNING



ONLY TRAINED AND QUALIFIED TECHNICIANS SHOULD ATTEMPT TO CLIMB A WIND TURBINE TOWER AND SHOULD USE OSHA/ANSI APPROVED PRACTICE AND EQUIPMENT. ANY ACTIVITIES WHERE PERSONS COULD BE SUBJECT TO A FALL OF SIX FEET OR MORE SHOULD BE PERFORMED USING APPROPRIATE FALL PROTECTION EQUIPMENT FASTENED TO A SECURE ANCHOR POINT. SEE APPENDIX S FOR A DESCRIPTION OF SAFETY EQUIPMENT AND SECURE ANCHOR POINTS.

A DESIGNATED PERSON SHOULD BE CLEARLY IDENTIFIED AS THE LIFT COORDINATOR. THE LIFT COORDINATOR SHOULD DIRECT ALL EQUIPMENT AND PERSONNEL DURING THE LIFT. HAND SIGNALS (APPENDIX R) MUST BE CAREFULLY COORDINATED WITH THE CRANE OPERATOR IN ADVANCE. SUPPLEMENTARY RADIO CONTACT IS STRONGLY RECOMMENDED.

6.3 Wind Turbine Component Preparation

6.3.1 Tip Brake Installation

After removing the top of the blade crate, the blade tips should be slid on to the edge of the crate end. The blades should then be pulled out of their crate completely, inspected for damage and laid on support blocks. The foam packing inserts can be used to separate and support the blades. Both conduit ends should be free of debris and epoxy!

CAUTION

THE BLADES SHOULD NOT BE SCRATCHED OR GOUGED DURING SITE HANDLING AS THIS CAN CAUSE A LOSS OF ROTOR PERFORMANCE AND/OR BLADE DEGRADATION FROM ENVIRONMENTAL EFFECTS.

The string in the conduit should be used to pull a #10 gage wire through the conduit. The blade cable should then be attached to the wire (with tape, for example) and pulled through the blade conduit, with the molded 3-pin connector at the root end of the blade. Lubricating the blade cable facilitates this operation. Female connectors should be crimped to the black and red wires and a fork-tongue connector to the blue wire. The female connectors should be connected to the rectifier and the fork-tongue connector to the ground point on the damper bracket (see Figure 6-2).

To avoid damaging the tip brakes during blade installation, it is preferable to install them once the blades have been attached to the hub. Till then, the blade ends should be protected with foam to prevent damage, should they strike the ground or any hard object.

After connecting the electromagnet, the tip brake assembly should be inserted carefully into the end of the blade without pinching the electromagnet wires. Each tip brake should be bolted to its blade using low profile nylon-insert lock nuts over the blade end studs. The lock nuts should be torqued to 14.8 Nm (11 ft-lbs) for the 5/16" studs and 24 Nm (18 ft-lbs) for the 3/8" studs, using ½" and 9/16" socket wrenches, respectively. It is recommended to step torque each nut to distribute the force over all studs.

CAUTION

FORCING THE TIP BRAKE INTO THE BLADE CAVITY CAN DAMAGE BOTH THE BLADE AND THE TIP BRAKE. TIP BRAKES SHOULD SLIDE INTO THE BLADE CAVITY EASILY.

After the tip brake has been mounted on the blade and wired, the blade should be positioned so that the tip brake can open and close freely. The tip brake should be opened and let go; it should close completely.

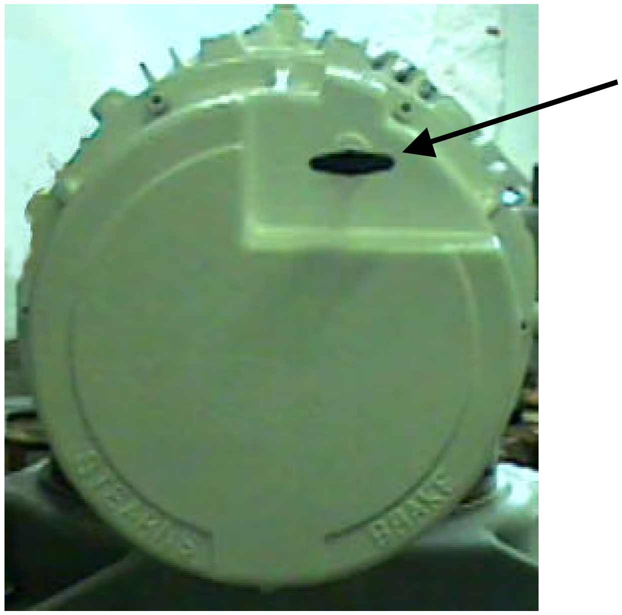


Figure 6-1 Parking brake manual release

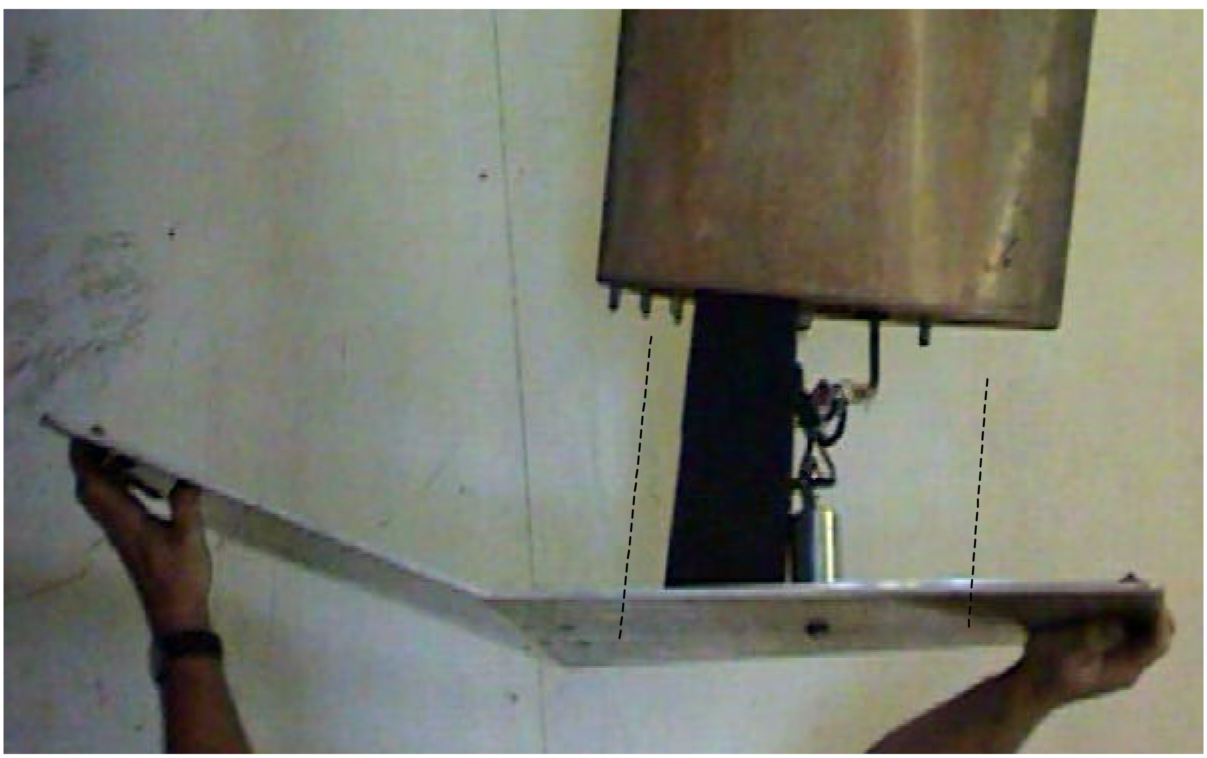


Figure 6-2 Tip brake installation

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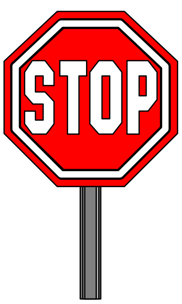
6.4 Blade Installation

This procedure should be carried out by a minimum of three technicians. Each blade weighs 135 kg (300 lbs) and can be lifted by a crew of three or four or using equipment such as a back hoe or a boom truck fitted with nylon slings or ropes. Metal slings or chains should never be used to move a blade.

CAUTION

NICKS OR GOUGES IN THE BLADE SURFACE CAN AFFECT THE PERFORMANCE AND THE EXPECTED LIFE OF THE BLADE SIGNIFICANTLY. TAKE EVERY PRECAUTION TO PROTECT THE BLADE SURFACE DURING HANDLING AND INSTALLATION.

The first two blades should be installed with the machine still set on the ground. The yaw lock should be engaged, to restrict the turbine from rotating about the yaw axis. See Figure 6-4 for the yaw locking position. The parking brake is released by pulling on the manual release, after which the hub can be rotated so that a blade can be mounted with its tip or tip brake supported above the ground (see Figure 6-1). The blade should rest on a piece of packing foam to prevent surface damage. A drift pin or bolt placed in a blade bolt hole on the hub will help align the blade with the hub.



WARNING

BLADE WASHERS SHOULD LIE FLAT AGAINST THE HUB COUNTERBORE. FAILURE TO INSTALL WASHERS PROPERLY CAN RESULT IN LOOSENING AND FAILURE OF FASTENERS. THIS MAY RESULT IN BLADE DETACHING, SEVERELY DAMAGING THE MACHINE AND CAUSING SERIOUS INJURY OR DEATH.

The red protective plugs should be removed from the blade inserts in the root end. The blade should be slid onto the hub, with the concave (upwind) side of the blade towards the machine. The tip brake wire, which exits the trailing edge of the blade near the root, must not be damaged. It is helpful to tape this down to the blade during assembly.

Note: The concave ('bottom' of the airfoil) MUST face the machine. Only the blade bolt washers supplied with the wind turbine should be used. These washers are oval shaped and designed for the blade mounting. The washer must be oriented in the correct position for the required pitch, as the washers are not symmetric. **It is extremely important that the washers are seated entirely in the hub slot counter bores and rest flat on the bottom of these counter bores.** If the washers are even slightly misaligned, the bolts and washers should be reassembled.

> **DO NOT SUBSTITUTE BOLTS**. Only the AOC supplied Grade 8, fine thread bolts, 5/8" x 3", should be used to secure the blades to the hub. The tip brakes can be unlatched or removed (if necessary) to prevent damage during the mounting process.

The four corner bolts on the blade should be installed, initially without the washers, to hold the blade in place. The pitch tool should be inserted first, in slot #1 (see Figure 6.10), and secured with a bolt inserted snug tight.

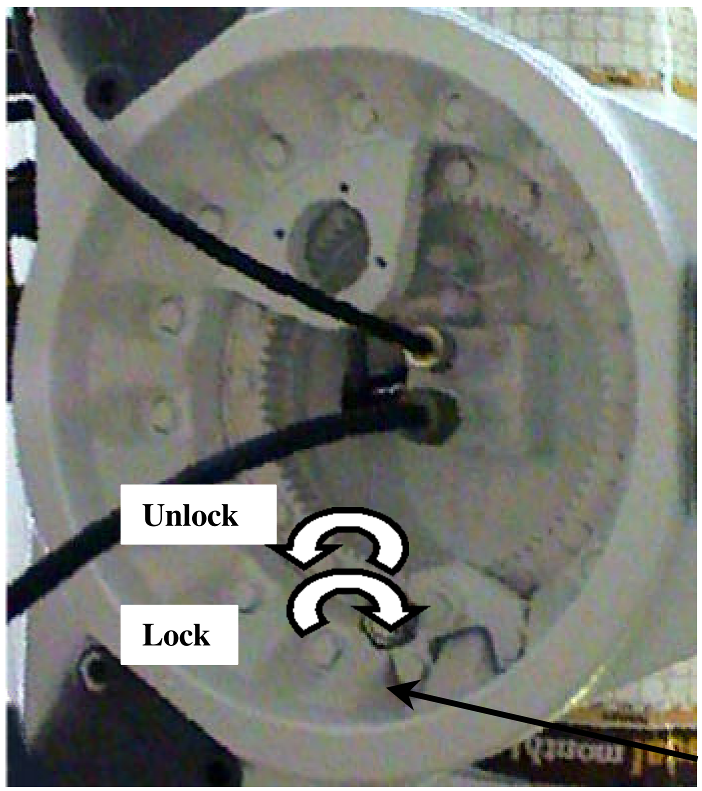


Figure 6-4 Yaw lock on tower top

Figure 6-5 Yaw lock

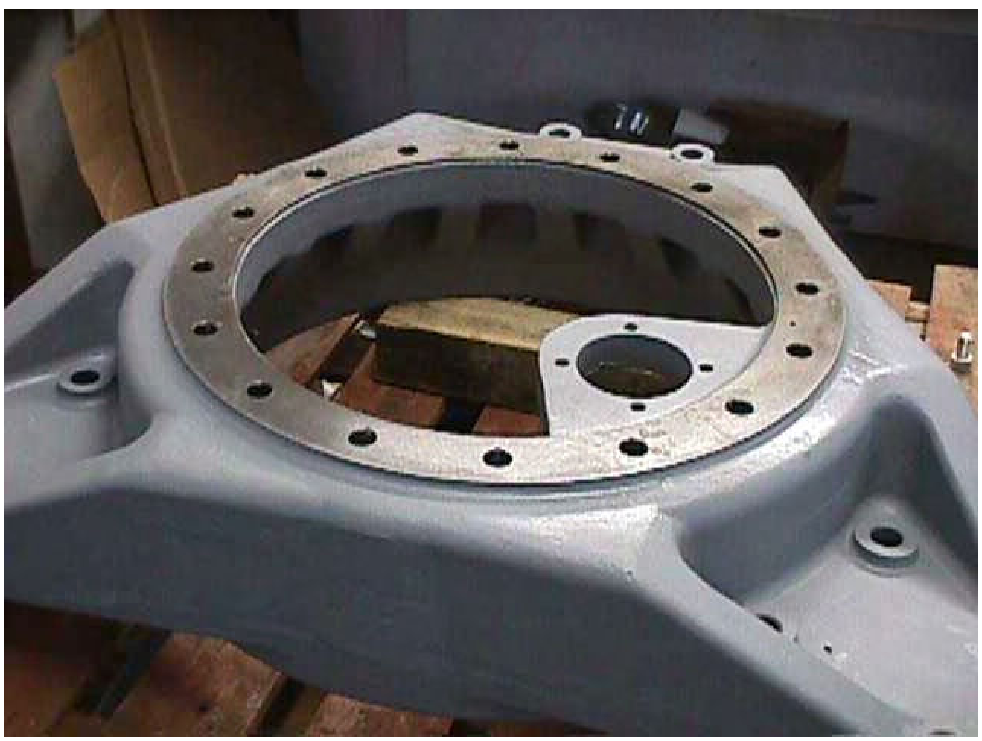


Figure 6-6 Tower top casting

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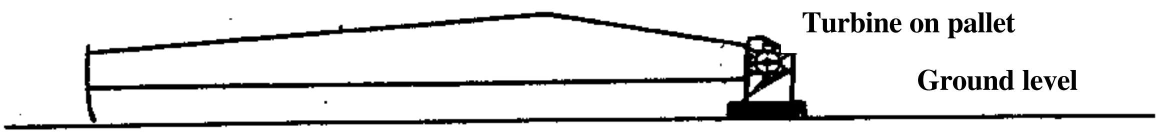

Figure 6-7 Positioning the blade for attachment

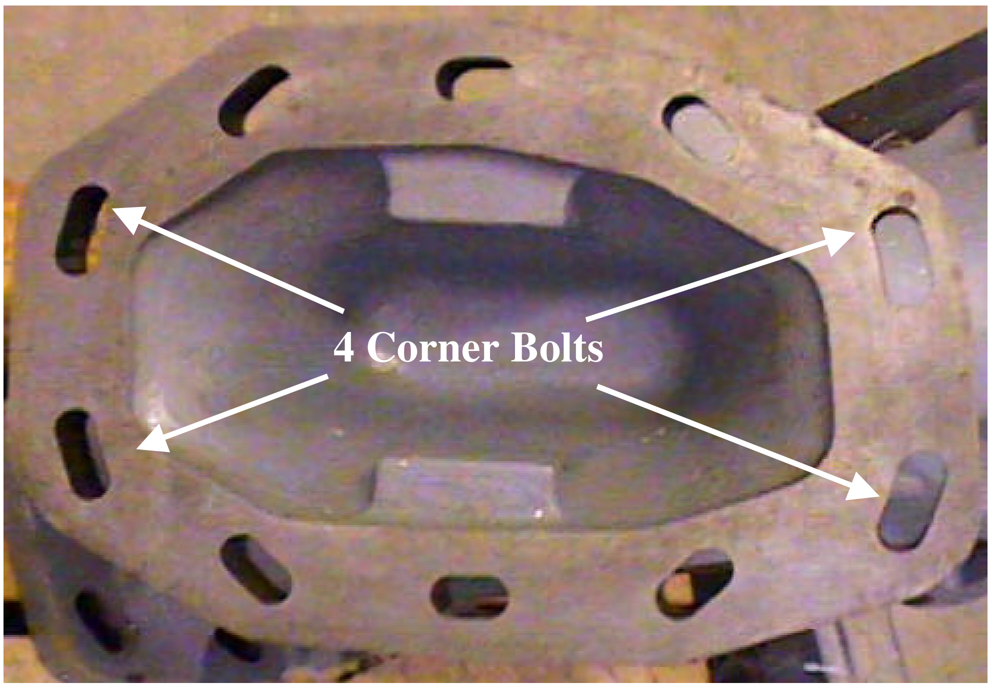

Figure 6-8 Bolting blade to a hub

The blade pitch can be adjusted to set the peak power production and to accommodate various wind resources. For pitch setting, consistency between blades and optimum power capture, AOC recommends that a pitch tool be used which may be purchased from AOC. Currently a standard, an aggressive and a conservative pitch setting tool are available. (See figure 6-9 for pitch variance.) Custom pitch tools may also be designed for specific sites.

At this point the remaining six bolts and ten washers should be installed and the pitch tool removed. Loctite 271 should be applied to each of the bolts **strictly** following the procedure outlined in Appendix J-3. All the blade bolts should be torqued in two stages using a 15/16" socket: first to 180 Nm (130 ft-lbs) and then to 243 Nm (180 ft-lbs). The blade bolts should be torqued in a star pattern starting with #1 as shown in Figure 6-10. **The blade washers MUST be**

aligned properly and be seated completely in the slot counter bore of the hub. If a washer becomes misaligned while torque is applied, the bolt must be loosened and the washer realigned.

For the attachment of the second blade, the hub is rotated so that the blade can be mounted with its tip supported, as was done for the first blade. The first blade will need to be supported initially by slings attached to a boom truck or crane. Once the hub is in the correct position the parking brake can be applied and the boom truck released. The procedure for mounting and aligning the second blade is as for the first one. The procedure for attaching the third blade is described in the Section 6.5.

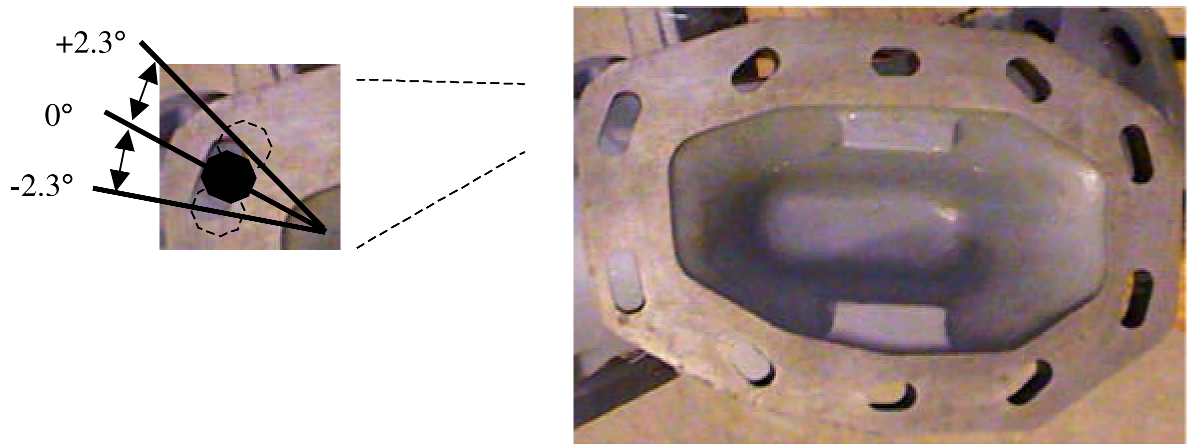

Figure 6-9 Pitch adjustment

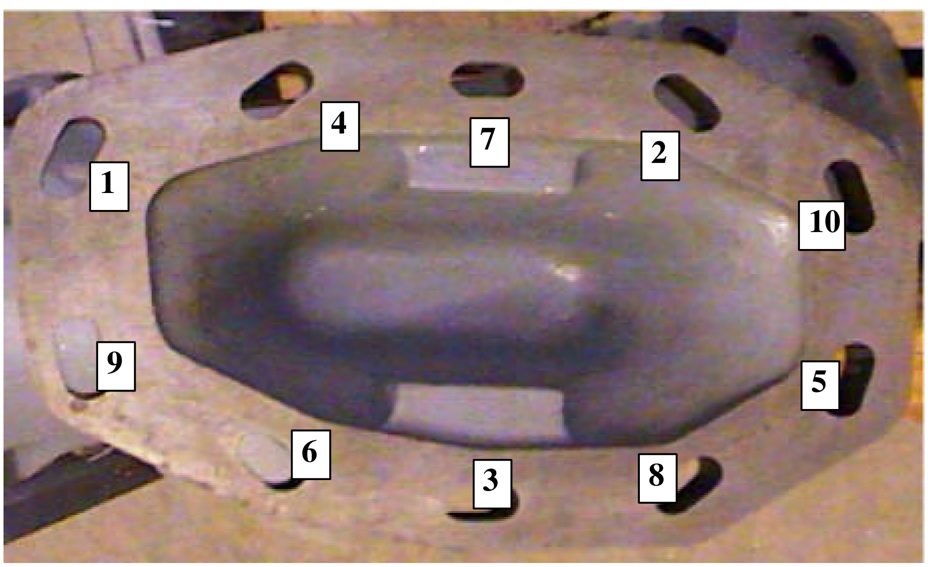

Figure 6-10 Blade Torque Pattern

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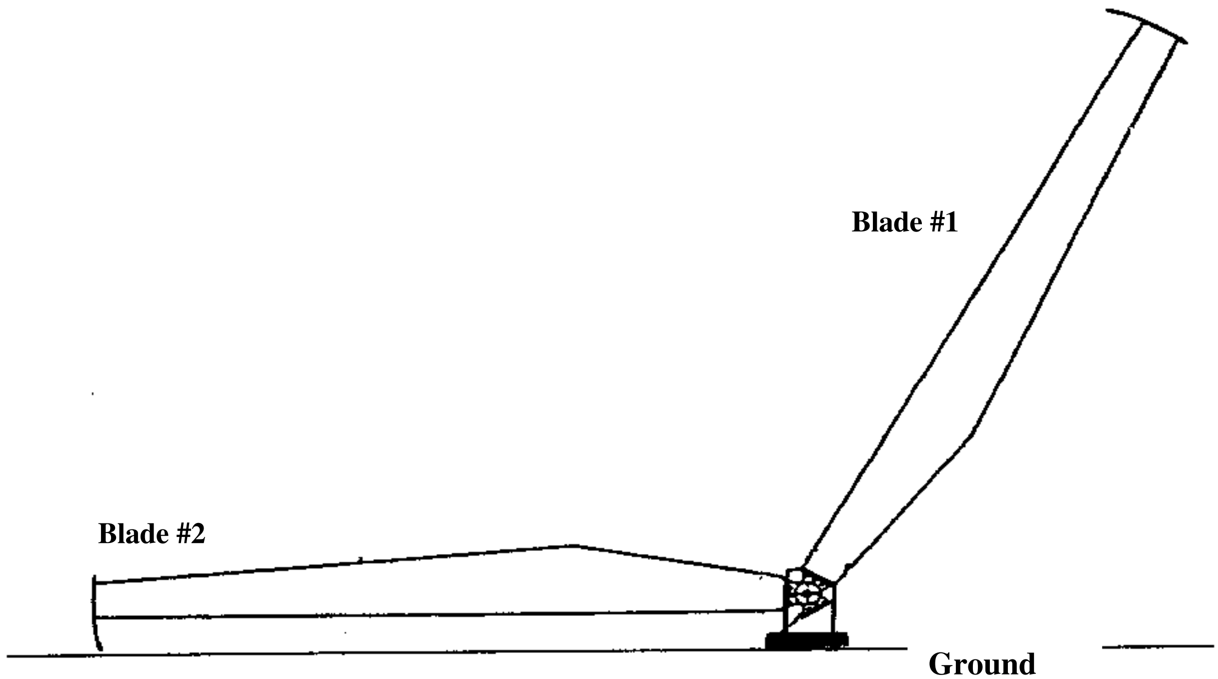


Figure 6-11 Attachment of the second blade

6.5 Lift Preparation

CAUTION

TOWERS AND DRIVE TRAIN ASSEMBLIES SHOULD NOT BE LIFTED INTO POSITION IN WINDS ABOVE 9 M/S (20 MPH), DURING LOW VISIBILITY OR WHEN LIGHTNING COULD POSSIBLY OCCUR. ALL TOWER AND GROUND PERSONNEL MUST BE PROPERLY TRAINED, BRIEFED AND FITTED OUT WITH SAFETY EQUIPMENT.

A crane with the appropriate height and load capacity is required to hoist the tower into position (see Appendix E).

Two cranes (large and small) may be needed to attach the third blade. A large crane will be needed to lift the drive train and a smaller crane or boom truck will be needed to lift the third blade. The small crane must be capable of lifting the blade at least 4 m (13 ft) (see Figure 6-14). The length of all rigging and harnessing must be taken into account. Releasing the yaw lock before hoisting the wind turbine generator will make alignment with the tower easier. The timing of yaw lock release should be determined by trained personnel.

Photo Courtesy of KEA

Figure 6-12 Lifting of tilt down tower at Kotzebue Electric Association

The large crane should lift the wind turbine generator using two slings as shown in Figure 6-13. The weight of the wind turbine is approximately 2,480 kg (5,450 lbs.). Any straps should be on the inside of the conduit. **THE HOIST RINGS SHOULD NOT BE USED FOR LIFTING THE WIND TURBINE GENERATOR!**

CAUTION

ALL LIFTING DEVICES SHOULD BE INSPECTED FOR INTEGRITY, SUITABILITY FOR PURPOSE AND CORRECT ATTACHMENT BEFORE LIFTING.

The wind turbine generator should be lifted slightly to see whether it sits level in its slings. If it does it should be lowered back to the ground and its slings readjusted.

The wind turbine generator should be lifted slowly to a height of approximately 4 m (13 feet), while the blade closest to the ground is held steady and rotate until it is directly vertical. The parking brake needs to be released. The third blade can now be mounted to the hub with the technician standing on a platform (see Figure 6-14). The same procedures for attaching and aligning the third blade should be used as were described in Section 6.4.

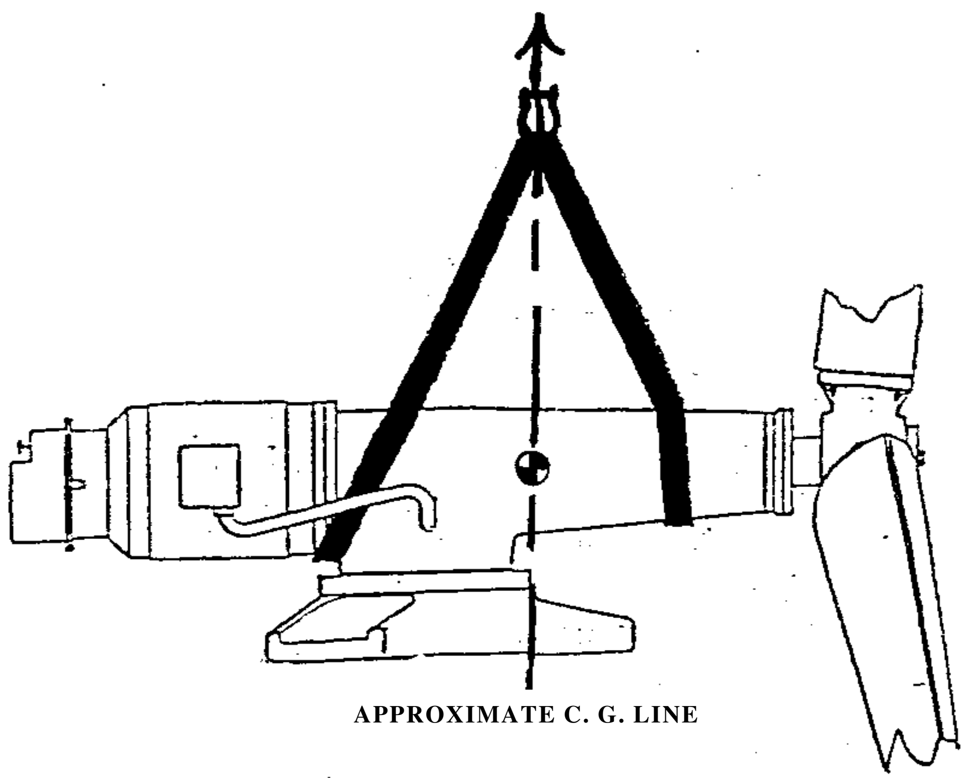


Figure 6-13 Wind turbine generator lift

When all blades and tip brakes have been mounted correctly, the parking brake should be engaged and a tagline attached to the two downward pointing blades, around the tip brake hinge point. The twist cable attached to the base of the wind turbine generator should be looped and tied so that it is lifted with the turbine.

All necessary tools (see Appendix I) and hardware (mounting bolts, nuts and washers) should be taken to the top of the tower. 1" non-locking nuts are useful as quick fasteners to secure the tower top casting to the tower temporarily. These items may be raised together with the wind turbine generator to make climbing easier.

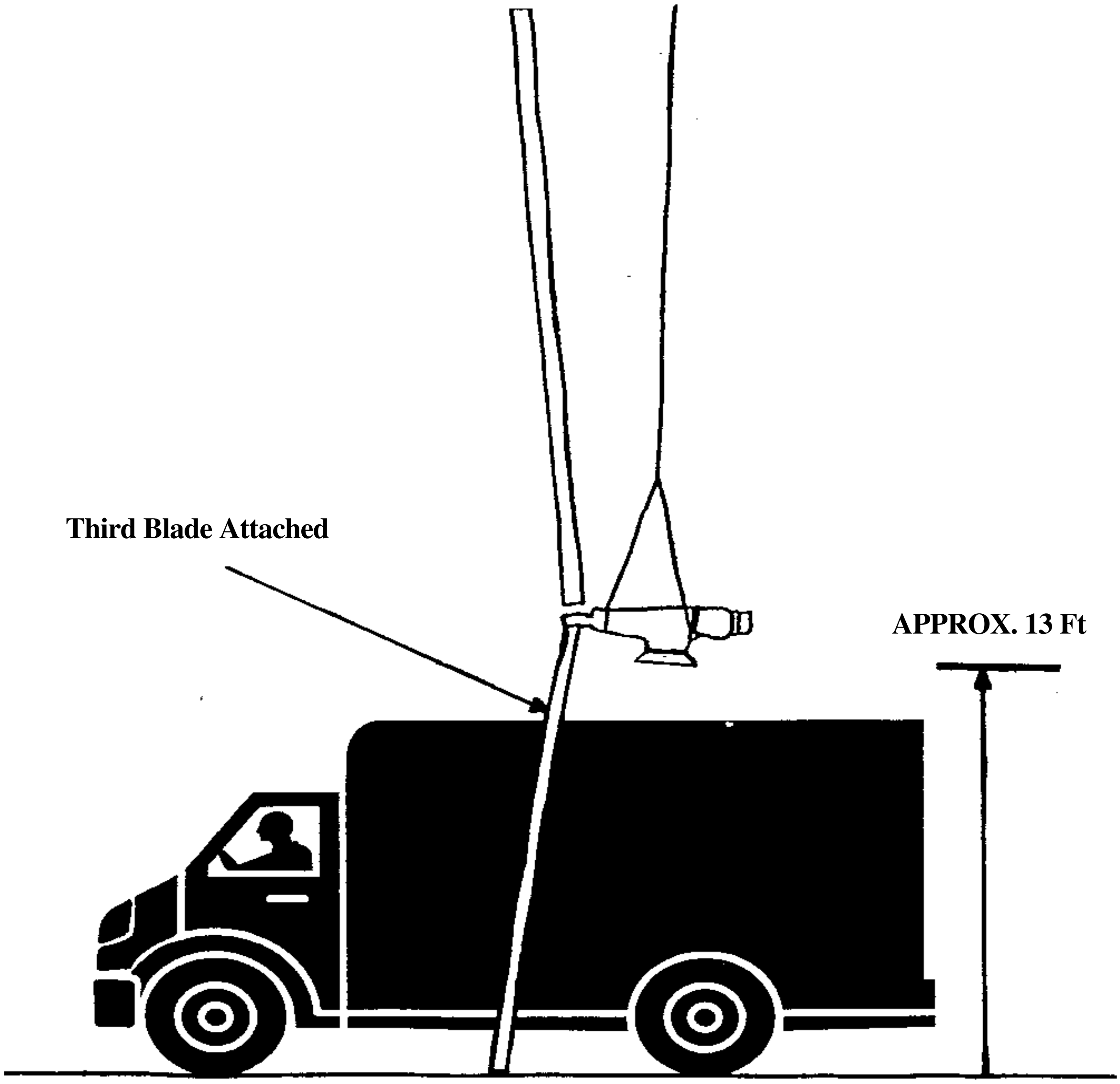
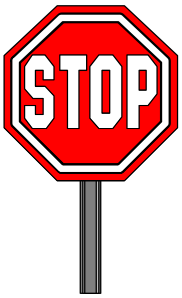


Figure 6-14 Third blade attachment

CAUTION

THE PARKING BRAKE MUST BE PROPERLY ENGAGED, TO LOCK ALL ROTATING PARTS INTO POSITION, PRIOR TO LIFTING THE WIND TURBINE GENERATOR.

6.6 Lifting and Securing the Wind Turbine



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A CLEARLY IDENTIFIED PERSON SHOULD BE DESIGNATED LIFT COORDINATOR. THE LIFT COORDINATOR SHOULD DIRECT ALL EQUIPMENT AND PERSONNEL DURING THE LIFT.

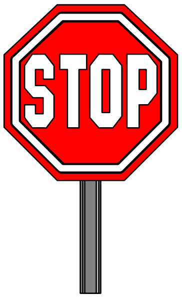
WARNING
The technicians on the tower, waiting to receive the wind turbine generator, need to be secured below the top of the tower, in case the machine swings or shifts unexpectedly. They should not attach themselves to the wind turbine generator until it is securely bolted to the tower.

The wind turbine generator should be lifted above the top of the tower, controlling the swing and direction via the taglines. Once it is approximately aligned with the top of the tower, it should be lowered slowly onto the top tower flanges. A large drift pin may be necessary to align bolt holes between the tower top casting and the tower flanges.

The bolts, with a washer under the head, should be inserted from the bottom up through each bolt hole in the tower flange and through the one in the tower top casting. Each bolt should then be secured with a washer and nut from above, making sure that at least one nut on each flange is snug tight. Since the self-locking nuts require a significant effort to turn, one can shorten the crane time by using temporary, non-locking nuts. These must be replaced with lock nuts **IMMEDIATELY** after the crane has been released.

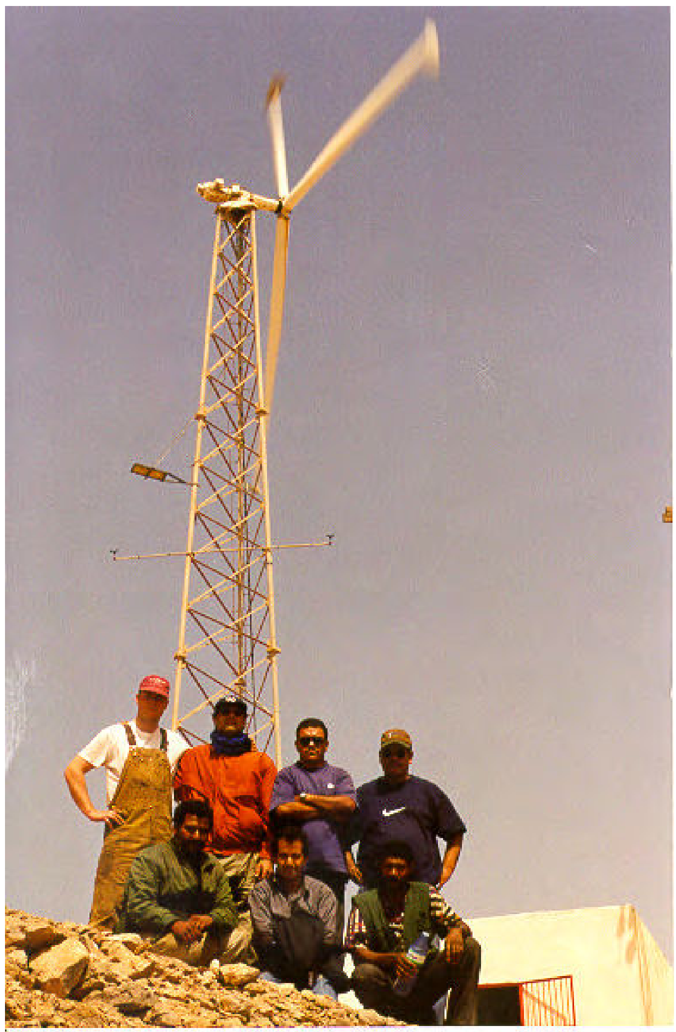
Once all bolts have been inserted, their locking nuts need to be tightened with a ratchet and extension until snug. The tower top lock nuts should be torqued to 810 Nm (600 ft-lbs), using a 1 7/16" socket torque wrench and 1½" combination wrench.

To remove the taglines, the parking brake needs to be released and each blade pulled down in turn until it is pointing straight down and can be reached from the tower climbing leg; the taglines can be unclipped after which the parking brake should be re-engaged.



WARNING

THE PARKING BRAKE OF THE WIND TURBINE SHOULD NEVER BE LEFT DISENGAGED, AS THIS MAY CAUSE SEVERE INJURY.



WIND TURBINE COMPLETE INSTALLATION IN MOROCCO

7.0 Electrical Installation

Photo Courtesy of BED

UTILITY INTERFACE

The following sections discuss the wind turbine wiring and utility connection requirements and procedures. Wire connections to the three-phase control box, dynamic brake boxes and twist cable junction box are site specific, but should follow the general guidelines and wiring drawings available from AOC.

7.1 Electrical Interface to Utility

The utility interface is site specific and must be coordinated with the local utility or other responsible party. A kWh meter for each machine is recommended.

The wind turbine may be interfaced with a preexisting low voltage 480V 60Hz (400V 50Hz) supply or it may require its own step up transformer to the system distribution voltage.

- Interface at the 400/480 VAC level:

  For single wind turbine installations the wind turbine can be interfaced directly with the 480/400 VAC utility system, if sufficient transformer capacity exists (75 kVA per turbine). This also applies to commercial and industrial installations with an adequately sized 480/400 VAC panel and distribution system. The wind turbine should be on a dedicated circuit breaker/fuse of proper capacity rating.

- Interface at voltage levels greater than 480/400 VAC:

  For single or multiple wind turbine installations it may be necessary and/or desirable to install a step up transformer between the 480/400 VAC wind turbine and the higher voltage utility system. For example, in a single unit installation interfacing with a 13.8 kV utility system, a minimum 75 kVA transformer with a 13.8 kV/480V ratio would be necessary. Since wind turbine output is variable, care must be taken to properly size the step-up transformer. The winding configuration may also affect system performance. The AOC 15/50 generator is WYE connected. The interfacing transformer is typically connected with WYE primary and DELTA secondary.

Figure 7-1 illustrates the simplest form of a utility interface. Utility interconnection should be specifically engineered for each site. This manual only suggests installation procedures from the control box to the wind turbine. Applicable national and local codes must be followed. Careful research and consultation during the planning stage can avoid expensive and dangerous mistakes. A licensed electrician may be required to install all interconnection wiring. See Appendix M for details on wire sizing.

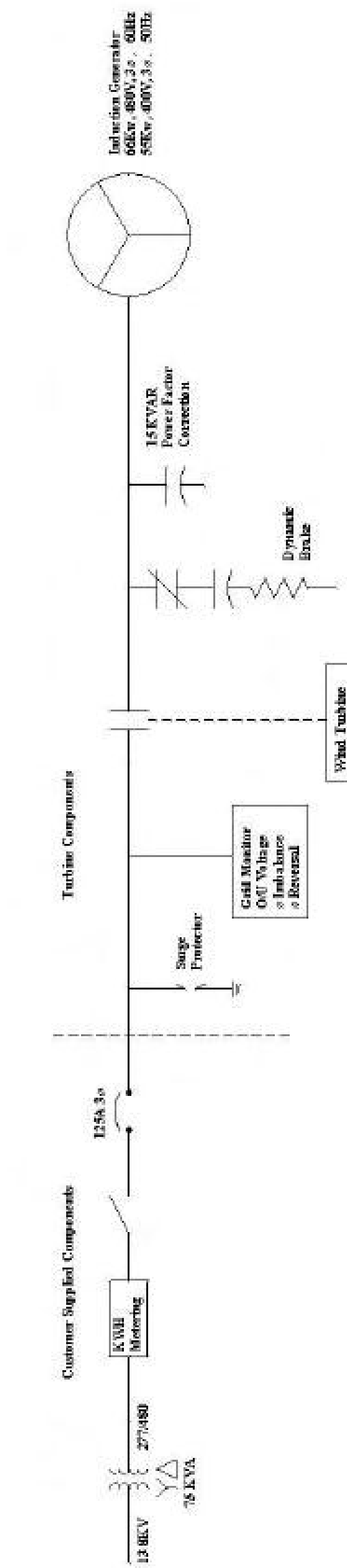


Figure 7-1 Typical electrical installation

CAUTION

AFTER THE POWER COLLECTION INTERFACE HAS BEEN INSTALLED, ALL POWER CABLES AND WIRES TO THE WIND TURBINE MUST BE DE-ENERGIZED. ALL ELECTRIC DISCONNECTS FEEDING INTO THE WIND TURBINE MUST BE LOCKED OUT AND TAGGED OUT.

7.2 Wiring and Cable Requirements

The following sections discuss the power, control and anemometer cable requirements.

7.2.1 Power and Control Cable

The power cable for an AOC 15/50 must be of a sufficient ampacity rating to carry the rated generator current (86 Amperes). The National Electrical Code and the IEC Code list the ampacity of various cable types.

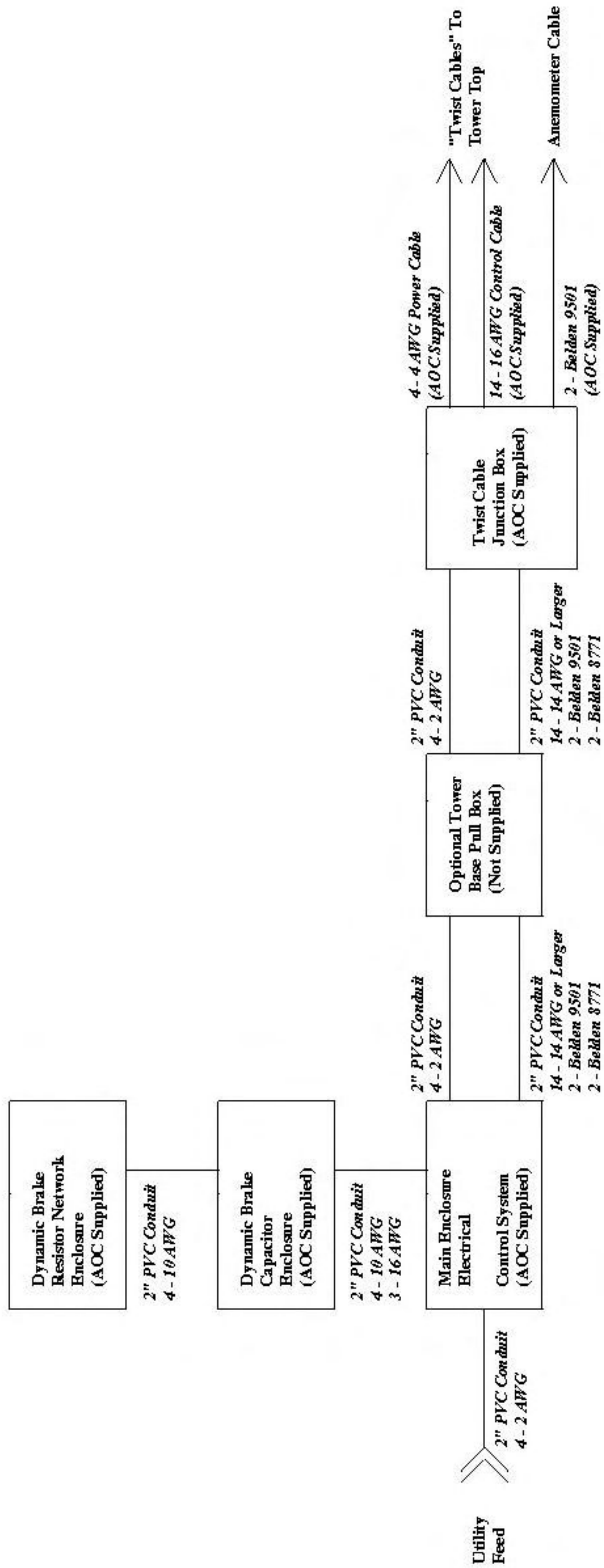
The minimum cable sizes (see Appendix M) were calculated based on general assumptions regarding service transformer rating and utility line capacity. Cable sizes were also selected to take varying distances between the tower and control boxes into account. They are meant for general planning only and should not replace site specific electrical engineering.

The power cable must be of appropriate insulation and construction to satisfy national and local electrical code specifications for the specific distribution system. AOC does not recommend the use of direct buried cable, unless it is armored, due to the increased potential for faults.

It is necessary to consider the economics associated with increasing power cable size from the minimum required, in order to increase the net energy output (in kWh) of the wind system through reduced line losses. The increase in revenue from a larger cable must be weighed against its higher initial cost. Determining the optimum cable size requires the following:

- Consideration of initial expenditures
- Effects of line loss on kWh production
- Projections of kWh production over time
- Interest rates as a reference in determining the economic value of increased initial investment

Figure 7-2 depicts the typical layout of the electrical enclosures with the dynamic brake boxes located near the main enclosure. Whenever holes (knockouts) are drilled through electrical boxes for a conduit installation the edges of the holes must be coated to prevent adverse corrosion. Please contact a professional engineer, AOC or an authorized representative, for further assistance in designing a suitable power distribution system.



Note:

Unless specified, all cables and conduits are to be supplied by the customer.

Figure 7-2 Standard layout

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7.2.2 Anemometer Mast and Cable Wiring

The AOC 15/50 uses a dual anemometer based control system for increased reliability. Figure 7-3 shows a typical anemometer. The cable between each of the two anemometers and the control enclosure must have the following characteristics:

- Consist of at least two conductors, #22 AWG or larger
- Be twisted and shielded against electrical interference
- Be resistant to ultraviolet radiation due to exposure on the tower
- Be rated for protected direct burial if not run in a conduit
- Be suitable for the ambient temperature and other conditions expected at site

To meet code requirements, the anemometer cable insulation must carry a 600V rating if it is to be run for any distance in the same conduit or raceway as the wind turbine power cable. For most sites BELDEN 9501 cable will be suitable for this purpose.

NOTE: Cable shields should only be grounded at the turbine control panel. Any other grounding scheme may lead to multiple grounds that could affect circuit function.

The anemometer boom should be mounted at the third set of brace clips below the topmost tower section, approximately 10 m (32 ft) from the top of the tower. It should be approximately perpendicular to the prevailing wind direction, with the anemometer masts vertical. Each anemometer should be fitted with one anemometer cable and attached to the mast. The cotter pin has to be inserted to secure the anemometer to its mast. The anemometers cables should be routed to a common point near one of the two adjacent tower legs and be attached to the anemometer masts using UV protected tie wraps. Each cable should be looped, approximately 30 cm (12 inches) across, before attaching it to the tower leg. The loop will provide extra cable for servicing. The two cables should be routed down one of the tower legs to either the twist cable junction box or directly to the control box. See Appendix B for additional details.

Figure 7-3 Anemometer

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7.3 Control Box Connections

Wires should be run in a conduit to the control box based on convenience, safety and applicable standards. Non-NEMA 4 electronic enclosures must be housed in a weatherproof service structure. However, it is recommended that all enclosures be housed in a weatherproof structure to facilitate maintenance in all weather conditions. Wires from the control box to the tower base should run in a conduit. Rigid metal conduit should be buried to a minimum depth of 92 cm (36 inches) and approved non-metallic direct burial conduit, to a minimum depth of 46 cm (18 inches) or 61 cm (24 inches) for roadways. Refer to the National Electrical Code, International Electrotechnical Commission standards and local inspectors for site specific requirements.

All wires between the control box, the dynamic brake capacitor box and the dynamic brake resistor box must be properly contained in conduits and be terminated correctly in the control box. When terminating wires in screw lugs, torque, release torque and retorque the lug screw to ensure the wire will not pull out of the lug connection. See Appendix M for wire connections.

Photo Courtesy of KEA

Figure 7-5 Control box at Kotzebue Electric Association

7.4 Twist Cables and Junction Box

The twist cable junction box should be mounted on the inside of a tower leg approximately 3.7 m (12 feet) above the tower base. This height may need to be adjusted, depending on twist cable length. The vertical cable droop must be approximately 1.8 m (6 ft) (see Appendix B).

Two Unistrut, split pipe clamps are used to secure the box to the tower leg. The box should be oriented with its door facing towards the center (inside) of the tower (see Appendix B).

The two twist cables can be connected to the junction box. Conduit should be installed between the twist cable junction box and the control enclosure. Please note that whenever holes are drilled through electrical boxes for conduit installation the edges of the holes must be coated to prevent adverse corrosion. Failure to adequately coat metal may lead to early deterioration of the enclosure.


Photo Courtesy of KEA

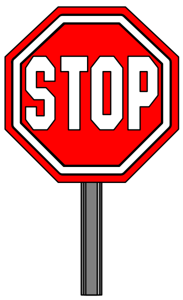
7-5 Turbine, tower and anemometer boom

8.0 Function Tests and Commissioning

The following section describes the procedures for testing a wind turbine's functions before it is officially commissioned.

8.1 Function Tests and Commissioning

Prior to placing the wind turbine into initial service and after any maintenance and/or repair work, the following must be carried out and the commissioning/checkout test sheet must be completed (see Appendix H).



WARNING

DO NOT ATTEMPT TO PERFORM COMMISSIONING UNLESS YOU HAVE BEEN PROPERLY TRAINED AND ARE EXTREMELY FAMILIAR WITH THE OPERATION OF THE WIND TURBINE AND ITS CONTROLS. IT IS HIGHLY RECOMMENDED THAT AN AOC REPRESENTATIVE PERFORM THE COMMISSIONING OF THE MACHINE.

- Power up the control system for the first time using the following steps.
    1. Set all control switches to OFF
    2. Open the three 15 Amp circuit breakers on the 120V side of the control transformer: 1CB, 2CB, 3CB
    3. Open the three-pole, 3 Amp breakers on the 480V bus which reads the control transformer and the grid monitor: 4CB, 5CB, 6CB
    4. Energize the 480V bus from the utility network
    5. Close the three-pole, 3 Amp breakers to energize the control transformer: 4CB, 5CB, 6CB
    6. Check for 120 VAC output on the control transformer
    7. Close the three 15 Amp circuit breakers on 120V side of the control transformer: 1CB, 2CB, 3CB
    8. Observe panel lights. They should run through a flash sequence and then turbine ready light should light up and remain on
    9. Carry out a generator test (See Section 8.2)
- Verify that the parking brake releases properly by conducting a parking brake release test (See Section 9.3.2)
- Verify that the anemometer signal is present and presents a realistic value (See Section 9.3.5)
- Verify that the speed sensor circuit is working properly (See Section 9.3.6)
- Test operation of the dynamic brake by running a dynamic brake test (See Section 9.3.4)
- Test normal start-up and manual shut down (See Section 9.3.7).

- Test emergency shut down (See Section 9.3.8)
- Test low wind shut down (See Section 9.3.9)

It is a good idea to observe the wind turbine running under normal conditions to verify its correct operation. After it has been observed in normal winds, it may be signed off and formally commissioned.

8.2 Generator Test

Each generator should be run briefly to determine proper phase rotation. The test can be carried out during commissioning by rotor jogging the wind turbine briefly and observing the rotation of the main shaft. If the phase rotation is correct the turbine will rotate counter clockwise when looking upwind. If the direction of rotation is incorrect, any two of the phase leads should be changed over and the test repeated. The only wires to be changed in the control box are the phase leads to the turbine, TB2.

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Part III

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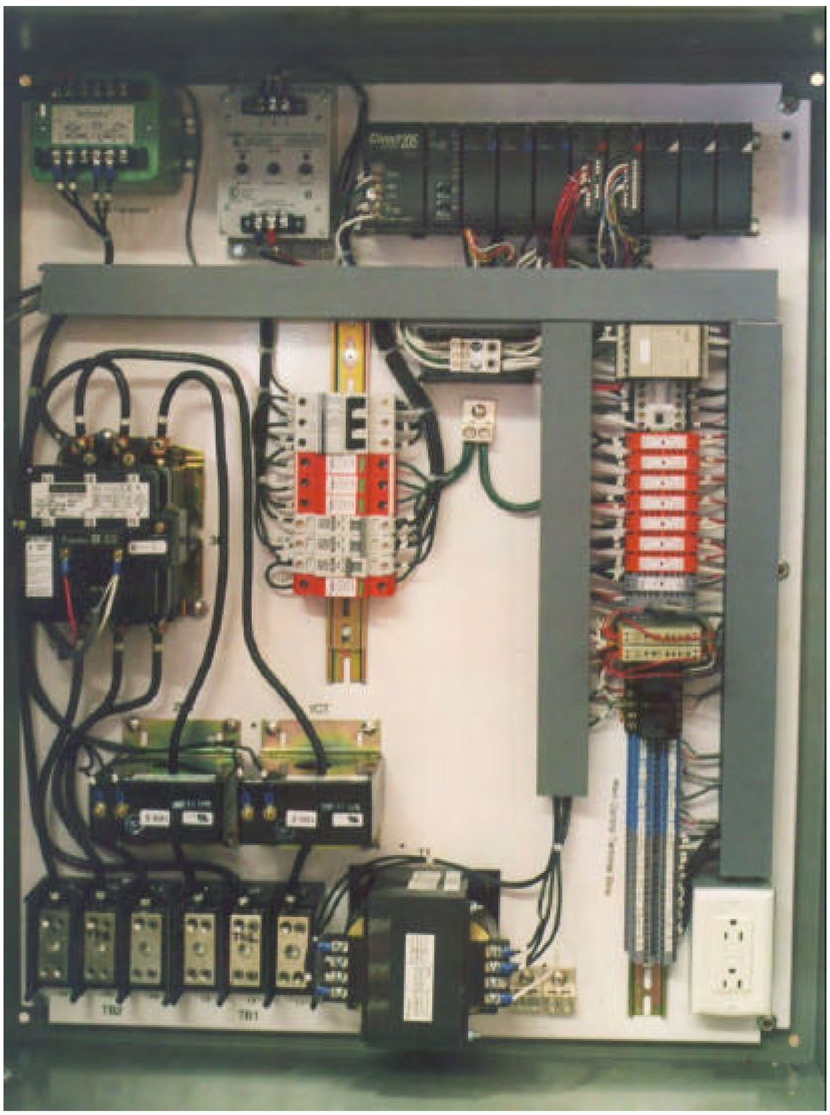
9.0 Wind Turbine Operation



AOC 15/50 Controller box

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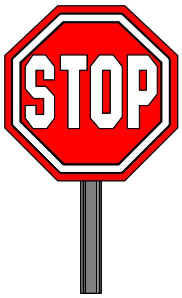


WARNING

BEFORE ENERGIZING THE SYSTEM, CAREFULLY REVIEW THIS CHAPTER AND ENSURE THAT ALL REQUIREMENTS ARE COMPLIED WITH. IMPROPER PROCEDURES IN ENERGIZING THE SYSTEM MAY CAUSE SEVERE INJURY OR DEATH FROM SHOCK.

9.1 Normal Operation

This section contains a description of the operational functions of the wind turbine in normal conditions. Normal conditions are defined as those in which the wind turbine was designed to operate in (see Appendix A for the design specifications).

The six switches on the front panel of the control box control the wind turbine (see Figure 9-1). The control system inputs available to the operator via the switches are listed below.

Function	Type	Description
Emergency Stop	Maintained	Overrides all PLC control to disconnect the turbine from the utility network. Requires an operator to manually reset the turbine control system.
Turbine Test/Off/On	Maintained	OFF – parks the turbine with all brakes deployed. OFF to ON – resets any fault indicator. ON – allows the wind turbine to start, conditions permitting. TEST – allows the parking brake release, rotor jog and dynamic brake test switches to become active.
Parking Brake Release	Maintained	Releases the parking brake and allows the rotor to turn freely.
Rotor Jog	Maintained	Releases all brakes and connects the turbine to the grid.
Dynamic Brake Test	Maintained	Used with the rotor jog function to delay the operation of the tip and parking brakes in order to assess the performance of the dynamic brake.
Condensation Heater On/Off	Maintained	Energizes condensation heater.

Table 9.1-1 Operator input switches

The operation of these switches is described in detail in the following sections.

9.1.1 Turbine TEST/OFF/ON

Turbine OFF:

This is the normal OFF mode. All brakes are deployed with the brake relays de-energized. The main contactor is de-energized, disconnecting the turbine from the grid. The PLC disregards all other sensors while the switch is set to OFF. The brake light should be ON. The high wind, brake cooling cycle or other fault lights may also be ON, subject to conditions.

Turbine ON:

This is the normal ON mode. The PLC continuously monitors the system parameters for wind turbine readiness and for fault conditions.

In the absence of faults, the wind turbine is in the ready mode and the ready light will be ON. At low wind speeds the brake light will be ON indicating that the wind turbine is parked. When the wind speed average is above 4.9 m/s (11 mph) the PLC will release the brakes allowing the turbine to freewheel up to speed and come on line as follows:

- The brake relays are energized.
- The tip brake magnets are energized and hold the tip brake plates closed.
- The dynamic brake relay is energized, disconnecting the dynamic brake resistors and capacitors from the generator output.
- The parking brake solenoid is energized, releasing the high-speed shaft, thereby allowing it to rotate freely.
- In sufficiently strong winds the wind turbine freewheels up to speed and is monitored by the controller.
- When the high-speed shaft reaches 1500 rpm (50 Hz wind turbine) or 1800 rpm (60 Hz wind turbine), the PLC energizes the main contactor connecting the generator to the grid and turns the online light ON.

If the wind speed average drops below 3.6 m/s (8 mph), the wind turbine will go through a normal shutdown procedure as follows:

- The main contactor disconnects from the grid.
- The tip brake and dynamic brake relays deploy.
- The brake light lights up.
- The parking brake relay deploys after 4 seconds.
- The brake cooling cycle light lights up; the cooling cycle typically runs for 15 minutes.

The brake cooling cycle allows the dynamic brake resistors and parking brake to cool to ambient temperatures. During this period, the PLC overrides the wind speed sensor, thereby preventing the wind turbine from reconnecting to the grid. At the end of the cooling cycle, the PLC reverts to the normal control mode with the wind turbine ready light ON.

The PLC monitors the system parameters continuously as shown in Table 9.1-2. When a system parameter is out of range or a fault has been registered, the PLC takes appropriate action by disconnecting and either parking or freewheeling the wind turbine. Following this, it will continue to monitor the parameters and faults, resetting the system once they have cleared. Rotor over-speed faults and parking brake undercurrent faults require to be reset manually. The turbine TEST/OFF/ON switch must be switched to OFF first and then back to ON; it is the change from OFF to ON that resets the faults. All other faults reset automatically once the cause of the fault has cleared. An optional low power fault is included in some controllers to shut down the wind turbine, should the output drop significantly below the values expected at a given wind speed. This fault resets automatically, unless it has occurred three times within 75 minutes, in which case a manual reset is required.

During any fault related shutdown, the tip and dynamic brakes activate immediately, with the dynamic brake providing a large portion of the braking torque. Application of the parking brake is normally delayed until the rotor has slowed down sufficiently using the tip and the dynamic brakes. During a loss of utility power to the controller, all brakes are applied simultaneously. Thirty three percent of the dynamic brake capacitance is disabled to allow an immediate torque contribution by the parking brake, keeping the overall braking torque within safe limits.

Turbine TEST:

When set to TEST the parking brake, dynamic brake and rotor jog switches can be energized.

9.1.2 Heater ON

The generator winding and the parking brake heaters prevent condensation from collecting on the windings and the parking brake, respectively. They can be activated manually at the operator's discretion when the dew point is high but only when the wind turbine is disconnected from the grid. When the main contactor is closed, the PLC automatically de-energizes the heater circuit. An optional transmission heater can be provided for severe cold weather sites.

9.1.3 Parking Brake Release

The parking brake release switch allows the operator to release the parking brake when the wind turbine is in test mode and no grid faults, over-speed or high winds have been registered. It is not necessary to release the brake manually during normal operation.

	Instrumentation	60hz	50hz	action	reset when cleared	status lights
Grid parameters	grid monitor					
over voltage:		400-540V	350-450V	disconnect and park	automatic	grid monitor light
under voltage:		380-460V	300-400V	disconnect and park	automatic	grid monitor light
(response time)		adj 1-10secs	adj 1-10secs			
phase loss				disconnect and park	automatic	grid monitor light
phase reversal				disconnect and park	automatic	grid monitor light
Rotor Speed	2 speed sensors on					
	high speed shaft					
Rotor nominal:		1800rpm	1500rpm	if no faults connect to grid		turbine on line
Rotor full load:		1840rpm	1535rpm			
Rotor overpower:		1860rpm	1550rpm	disconnect and park	automatic	rotor overpower
Rotor over-speed		1875rpm	1560rpm	disconnect and park	manual	rotor overspeed
Rotor under-speed:		1760rpm	1460rpm	disconnect and park	automatic	
(freewheel option)		1800rpm	1500rpm	disconnect and freewheel	automatic	
(coast up option)		< 50rpm after 1 min?	< 50rpm after 1 min?	disconnect and park	automatic	rotor overspeed flashing
Wind Speed	2 anemometers					
wind in range		11mph - 50mph	11mph - 50mph	if no faults release brake		
low wind		8mph	8mph	disconnect and park or freewheel	automatic	
high wind		50 mph	50 mph	disconnect and park	automatic	high wind speed
Power output	watts transducer					
low power		% < set points	% < set points	disconnect and park	automatic	
		from power curve	from power curve			
Brake status						
brakes applied	plc signal			disconnect and park	automatic	brakes applied
parking brake fault	current sensor			disconnect and park	manual	brakes applied flashing
Generator Temperature	3 NC thermostats					
over temperature		145 deg C	145 deg C	disconnect and park	automatic	generator thermal alarm

Table 9.1-2 PLC control system monitoring

9.1.4 Rotor Jog

With the wind turbine in test mode the rotor jog switch will allow the operator to release the brakes and energize the main contactor, provided no high winds or fault conditions have been registered. It is not necessary to use the parking brake release switch with the rotor jog, as the rotor jog switch automatically releases all brakes before energizing the main contactor

9.1.5 Dynamic Brake

With the wind turbine in test mode, the dynamic brake switch allows the operator to test the dynamic brake. When the switch is set to ON, only the dynamic brake is used for braking, allowing its braking power to be observed. The dynamic brake test should be carried out only during periods of low wind and be limited to a maximum of 10 seconds. The dynamic brake resistors should be allowed to cool to ambient temperatures before repeating the test.

9.1.6 Operator Interface Indicating Lights

LED indicators are provided to indicate various wind turbine states (see Table 9.1-3). Unless a manual reset is stated, the turbine will automatically reset once a fault has cleared. Meters displaying wind speed, power output and wind turbine run time are available as options.

9.1.7 PLC Description

The PLC controls the AOC 15/50. The primary parameters measured for determining wind turbine performance and control are wind speed and generator rotor speed. Each wind speed signal is converted to an analog voltage and read by the PLC through analog input channels. The wind turbine output power is determined by measuring the generator rpm and calculating the power level based on rotor slip. The generator rotor speed is measured using two proximity switches, each with its own frequency to voltage (F/V) converter, and a timing gear. Optionally, a power transducer signal may be measured by the PLC. Other system parameters, such as utility network status, are relay type signals from external devices and are read through the PLC digital input channels. The PLC also has a serial communications port, which can be interfaced to some SCADA systems.

Figure 9-2 shows the inside of a typical turbine controller, Figure 9-3 the capacitor box and Figure 9-4 the PLC.

Table 9.1-3 AOC 15/50 System indicating lights

Function	**Color**	**Description**
Turbine Ready	Green	ON: Turbine can be connected to the utility network.
Turbine On Line	Green	ON: Turbine is connected to the utility network.
Brakes Applied	Red	ON: Any of the brakes are deployed. OFF: When parking brake is released during parking brake release test.
Brake Cooling Cycle	Red	ON: Turbine is waiting for brakes to cool (typically 15 minutes). FLASHING: Parking brake undercurrent fault. **Must be reset manually.**
Grid Fault	Red	ON: Monitor detected over/under voltage, phase reversal, loss of phase. Stays on for duration of brake cooling cycle.
Generator Thermal Alarm	Red	ON: Generator internal thermal switch indicates an elevated temperature. Must be reset manually. FLASHING: Softstart thermal switch indicates an elevated temperature**. Must be reset manually.**
Rotor Overspeed	Red	ON: Maximum rotor speed exceeded (1875 rpm for 60 Hz). **Must be reset manually.** FLASHING: Difference of over 20 rpm between the two speed sensors. This does not shut down the turbine.
Rotor Overpower	Red	ON: Generator maximum power rating exceeded (1550 rpm for 50 Hz and 1860 rpm for 60 Hz).
High Wind Speed	Red	ON: Wind speed has exceeded program limit (typically 22.3 m/s or 50 mph). Stays on for duration of brake cooling cycle.
Spare	Red	ON: Low power shut down. Turbine power output is low for giving wind speed. FLASHING: Three low power shut downs have occurred within 75 minutes. **Must be reset manually**.

- TURBINE READY
- TURBINE ON LINE
- BRAKES APPLIED
- BRAKE COOLING CYCLE
- HIGH WIND SPEED
- ROTOR OVERSPEED
- GRID FAULT
- ROTOR OVERPOWER
- GENERATOR THERMAL ALARM
- SPARE (low power option)

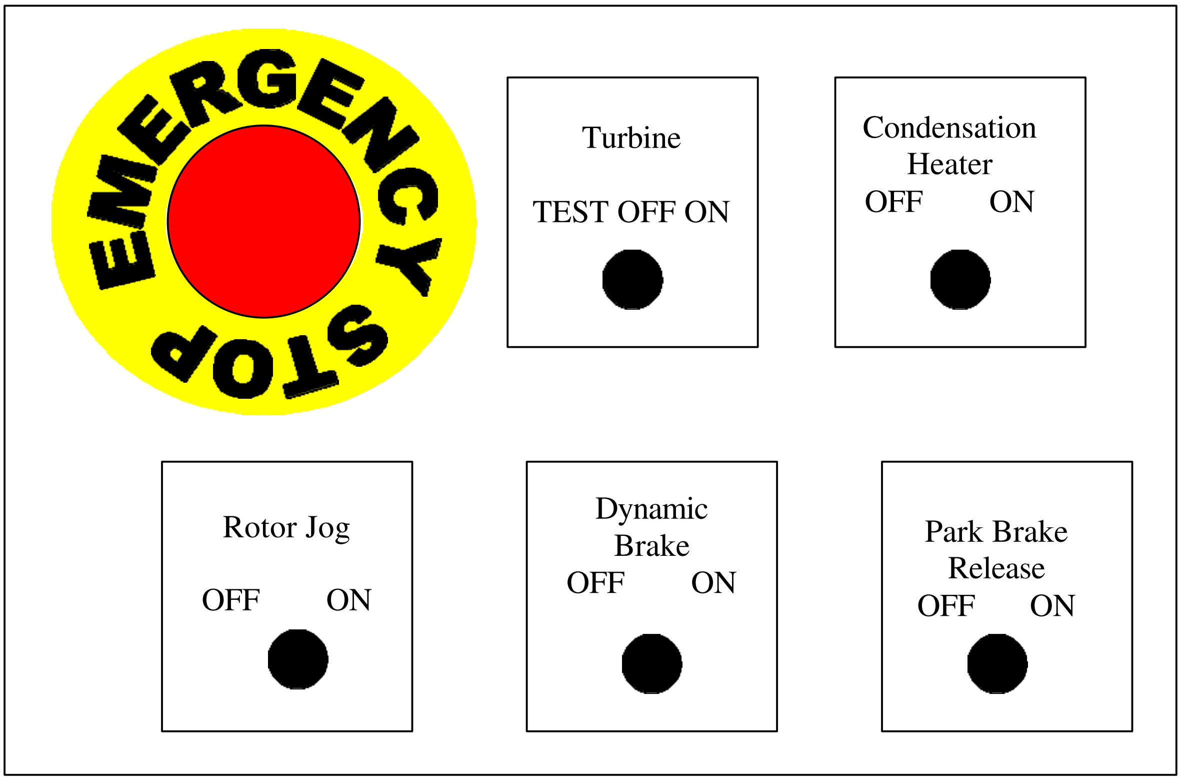


Figure 9-1 - Diagram of the system indicating lights and switches

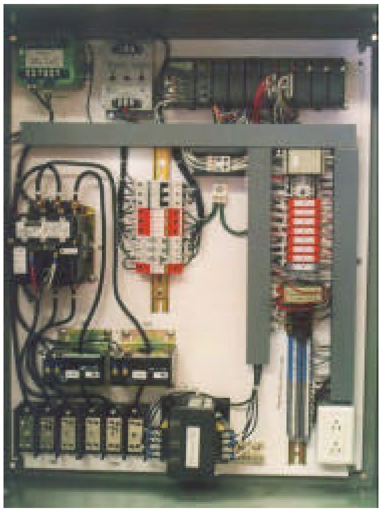
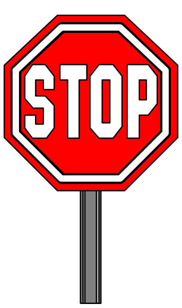


Figure 9-2 Inside of a typical turbine controller

Figure 9-3 Capacitor box

Figure 9-4 PLC



WARNING

THE SOFTWARE THAT OPERATES THE PLC IS DESIGNED BY AOC FOR EACH SPECIFIC APPLICATION, TO PROVIDE SAFE AND EFFICIENT WIND TURBINE CONTROL. MODIFICATIONS TO THE SOFTWARE, NOT AUTHORIZED BY AOC, COULD RESULT IN WIND TURBINE MALFUNCTION, DAMAGE TO IT AND/OR PERFORMANCE HAZARDS. AOC IS NOT RESPONSIBLE FOR ANY DIRECT OR CONSEQUENTIAL DAMAGES OR ANY INCIDENTAL EXPENSE, INCLUDING THE

LOSS OF POWER GENERATION, RESULTING FROM ANY SUCH MODIFICATIONS.

9.1.7.1 PLC Inputs

The following tables list and describe the input signals to the PLC controlling the AOC 15/50.

Function	Description
Anemometer #1	0-5 VDC analog signal corresponds to 0-45 m/s (0-100 mph).
Anemometer #2	0-5 VDC analog signal corresponds to 0-45 m/s (0-100 mph).
Generator speed proximity switches #1 and #2	Pulse input to F/V converter. 1-5 VDC signal corresponds to 0 to 2,000 rpm.
Watts Transducer Control	0-5 VDC analog signal corresponds to 0-8 kW.

Table 9.1-6 PLC low level analog inputs

Function	Description
Generator thermal switch	3 series connected switches within the generator.
Grid Voltage monitor	Relay contact indicating loss of phase, phase reversal and under or over voltage.
Grid Frequency monitor (optional)	Relay contact indicating over or under frequency.
Master control relay	Used to determine whether or not the turbine has been reset.
Turbine OFF/TEST/ON	Maintained switch parks or starts the turbine. In test position it allows special test functions to become active.
Rotor jog switch	Maintained switch releases the brakes and connects the turbine to the grid. Available in test mode.
Parking brake release switch	Maintained switch releases the parking brake. Available in test mode.
Dynamic brake test switch	Maintained switch used in combination with the rotor jog switch to delay operation of the tip and parking brakes to verify the effectiveness of the dynamic brake. Available in test mode.
Remote start (optional)	Allows a turbine to be started by another turbine's controller; its own anemometers (if equipped) are ignored.
Remote line start (optional)	Causes an across the line start if remote start is true.

Table 9.1-6 PLC AC inputs

9.1.7.2 PLC Outputs

The following tables describe the PLC outputs needed to control the AOC 15/50. AC outputs are used to control interposing relays and contactors for the various wind turbine functions. DC outputs are used for driving the LED indicators.

Function	Description
Dynamic brake contactor	Normally closed contacts are used to apply brake on loss of power.
Parking brake relay	Normally open contacts are used to apply brake on loss of power.
Tip brake relay	Normally open contacts are used to apply brake on loss of power.
Generator contactor	Connects generator to utility network.
Condensation heater relay	Provides 150 W of heating to the generator and 50 W to the parking brake to expel condensation.
Transmission heater relay	Provides 75 W of heating to the transmission.
Remote start output relay (optional)	Closure of N.O. contacts causes downstream turbine to start.
Oil heater (optional)	Provides power to gearbox oil heater.
Softstart relay (optional)	Closure of N.O. contacts bypasses softstart resistor

Table 9.1-7 PLC AC outputs

9.1.8 Control Systems Options

- Soft-start options – resistor or electronic softstart.
- Enclosure heater (typically 200 Watt).
- Drip-proof NEMA 3 and weatherproof enclosures NEMA 4.
- Tropical, marine (stainless steel) and arctic conditioned enclosures (heater and insulation).
- Enhanced display functions and diagnostics.
  - Over/under frequency.
  - G59 compatible grid monitor for UK sites.
  - PLC LCD display.
  - Wind turbine run time meter.
- Remote communications and data acquisition via RS 422 port.

9.2 Emergency Operation

In case of any emergency, an emergency cutoff switch is provided externally on the control box. See Section 3.8 for emergency procedures.

Emergency Stop Pushed In:

The emergency stop switch overrides all other switches. With the emergency stop pushed in, the wind turbine should come to a complete stop and de-energize immediately. All brakes deploy, the relays de-energize and the main contactor opens. In this mode, there is no power to the PLC output cards and the relays can not be energized. The wind turbine disconnects from the grid and remains so until the emergency stop is reset manually (pulled out).

Emergency Stop Pulled Out:

With the emergency stop switch pulled out, all the other switches can be operated.

9.3 Test Operation

The following sections show the procedures used when testing the wind turbine functions after installation and/or after any maintenance has been performed.

Before placing the wind turbine into service for the first time and after any maintenance and/or repair work, the following tests must be carried out and the commissioning/checkout test sheet (see Appendix G) must be completed.

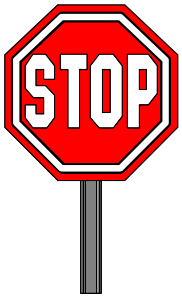
9.3.1 Power Up

1. Set all control switches to OFF.
2. Open the three 15 Amp circuit breakers on the 120 V side of the control transformer (1CB, 2CB, 3CB).
3. Open the three-pole, 3 Amp breakers on the 480 V bus which reads the control transformer and the grid monitor (4CB, 5CB, 6CB).
4. Energize the 480 V bus from the utility network.
5. Close the three pole, 3 Amp breakers to energize the control transformer (4CB, 5CB, 6CB).
6. Check for 120 VAC output on the control transformer.
7. Close the three 15 Amp circuit breakers on 120 V side of the control transformer (1CB, 2CB, 3CB).
8. Observe the panel lights, which should run through a flash sequence after which the turbine ready light should light up and remain on.

9.3.2 Parking Brake Release Test

1. Set the turbine test switch to TEST.
2. Set the parking brake release switch to ON.
3. Observe the rotor movement.

4. Reset the turbine test switch to OFF.
5. Observe the wind turbine; the parking brake should engage and the rotor should stop.



WARNING
THIS TEST SHOULD ONLY BE CARRIED OUT IN LOW WIND CONDITIONS.

9.3.3 Rotor Jog Test

1. Set the turbine test switch to TEST.
2. Turn the rotor jog switch to ON, connecting the wind turbine to the grid.
3. The rotor should turn counterclockwise when viewed looking upwind.
4. If the sense of the rotation is not correct shut down the system and swap any two of the 480 V leads to the generator to reverse the phase rotation.
5. Reset the rotor jog switch to OFF.
6. Reset the turbine test switch to OFF.

9.3.4 Dynamic Brake Test

1. Set the turbine test switch to TEST.
2. Set the dynamic brake switch to ON, disabling the parking brake and tip brakes.
3. Set the rotor jog switch to ON, connecting the wind turbine to the grid.
4. Allow several seconds for the wind turbine to come up to speed (64 rpm).
5. Turn the rotor jog switch to OFF.
6. Observe the wind turbine for any noticeable speed loss.
7. After 10 seconds maximum, switch the dynamic brake switch to OFF to apply the tip brakes and the parking brake.

9.3.5 Anemometer Signal Test

1. With some measurable amount of wind (> 4.5 m/s (10 mph)), determine the voltage (DC) across the terminals 5 (-) and 6 (+) with a multimeter on each NRG cube simultaneously.
2. The voltage should read between 0 and 5 VDC corresponding to a wind speed of 0 - 44.7 m/s (0 - 100 mph). Both anemometers should read approximately the same values. See Appendix H for voltage to wind speed conversion.

9.3.6 Speed Sensor Signal Test

1. Perform a rotor jog.
2. Measure the output voltage from the frequency to voltage converter. It should be approximately 3.75 VDC (50 Hz) or 4.5 VDC (60 Hz).

9.3.7 Normal Start-up/Shut-down Test

1. In 5.4 - 9 m/s (12 - 20 mph) winds, turn the turbine switch to ON.
2. The rotor should accelerate and the main contactor should close.
3. Turn the turbine switch to OFF.
4. When the tip brakes release, the turbine should come to a complete stop and de-energize.

9.3.8 Emergency Shut down Test

1. In 5.4 - 9 m/s (12 - 20 mph) winds, turn the turbine switch to ON.
2. The rotor should accelerate and the main contactor should close.
3. Depress the emergency stop button.
4. When the tip brakes release, the turbine should come to a complete stop and de-energize.

9.3.9 Low Wind Shut Down Test

1. In 5.4 - 9 m/s (12 - 20 mph) winds, turn the turbine switch to ON.
2. The rotor should accelerate and the main contactor should close.
3. Observe shut down when wind speeds fall below 5.4 m/s (12 mph). If necessary, an AOC representative can simulate low wind speed electronically.
4. The tip brakes should release and the wind turbine should come to a complete stop and de-energize.

9.4 Environmental Considerations

The following sections identify environmental considerations associated with the operation and maintenance of the AOC 15/50.

9.4.1 Corrosion

The primary source of corrosion is salt air, which is prevalent in marine environments and is particularly critical when combined with warm temperatures. A secondary source of corrosion, with more subtle symptoms, consists of airborne pollution, such as acid rain and industrial pollutants.

During routine inspections in aggressive environments, particular attention should be directed at locating oxidation and blistered paint. If any such surface degradation is found, corrective action should be taken immediately; the corroded layer should be removed and either paint or a corrosion-inhibiting film, such as Soft Seal, should be applied. The edges of holes (knockouts) drilled through electrical boxes for conduit installation must also be coated to prevent corrosion.

9.4.2 Lightning

The wind turbine and tower are protected against voltage surges. However, protection from direct lightning strikes cannot be guaranteed. If the system fails after an electrical storm all electrical components should be checked. Note that many components can be damaged due to lightning and the following items have been know to fail due to lightning strikes: anemometers, shaft speed sensors, generator, 120 VAC and 480 VAC surge suppressors and relays. After a lightning strike, the entire system, including the interconnect wiring, should be checked. If possible, power to the system should be turned off prior to an electrical storm and not be reconnected until the storm has passed. The most common cause of damage to electrical devices is voltage surges due to lightning strikes to the utility line.

9.4.3 Ice and Snow

Ice or snow will not normally affect wind turbine operation unless it builds up on the blades and/or tip brakes. If such build-up is uneven, it can cause rotor imbalance, which may lead to system vibration, if the rotor is allowed to rotate. During periods of potential icing the wind turbine should, therefore, be switched off.

CAUTION

IN EXTREME CASES ICE BUILD-UP MAY CAUSE DAMAGE TO THE SYSTEM. THEREFORE, IT IS NOT RECOMMENDED THAT THE WIND TURBINE BE OPERATED WITH SIGNIFICANT ICE BUILD-UP.

Wet snow may affect tip brake operation, possibly causing premature deployment or, in severe cases, damage due to the additional weight on the tip brake plate. Severe icing may also inhibit the tip brake from deploying correctly.

Ice build-up on the anemometers can prevent a wind turbine from starting up. If it is already running, the anemometers may ice up before the blades, indicating conditions in which the wind turbine should be shut down.

Normally, the ice will melt in a reasonable amount of time. In certain cases, it can be removed by gently tapping it off the anemometers, the tip brakes and the blades. To do this the machine must be switched OFF. If there is only a thin layer of ice on the blades, jogging the machine very briefly may remove it. The anemometers, blades and tip brakes must be free of ice before switching the turbine ON/OFF/TEST switch to ON. Prior to starting up a wind turbine, which has ice adhering to the blades, make sure that personnel are protected from any ice that might fly off them.

9.4.4 Temperature and Elevation

Although calculable, elevation and temperature extremes do not adversely affect a wind turbine's operation. The design temperature range is -40°C to +64°C (-40°F to +147°F) with no altitude constraints.

The power generated by a wind turbine is a function of wind speed and air density. Higher wind speeds produce more power. Variations in temperature and relative humidity, at any given altitude, have a more subtle effect. As temperature increases, air density decreases, reducing energy output. Conversely, at lower temperatures, energy output will increase, proportionally to the increase in air density. The formula below allows energy output to be corrected, taking altitude and temperature into consideration.

$$Corrected\ Output = P_s * C_t * C_a$$

Where P_s is power output at sea level at 15°C (59°F) and C_t and C_a are correction factors for temperature and altitude. They are defined as follows:

$$C_a = .966^{A/1000}$$

$$C_t = \frac{519}{T + 460}$$

Where T is temperature in °F and A is altitude in feet.

The example below illustrates the above formula:

If a 50 kW wind turbine generates 50 kW at 13.4 m/s (30 mph) wind speed under standard conditions, what would the output be at an altitude of 1,980 m (6,500 feet) and 30°C (86°F)?

Solution:

Corrected Output = Standard Output $*C_t *C_a$

$$P_s = 50 \text{ kW}$$

$$C_t = \frac{519}{86 + 460} = .951$$

$$C_a = .966^{6500/1000} = .799$$

Corrected Output = (50kW) (.951) (.799) = 38.0 kW

This approach can also be used, albeit with less accuracy, to correct annual energy (kWh) output predictions.

9.4.5 Acoustics

The AOC 15/50 has been designed as a low-noise wind turbine. The most significant sources of noise are the drive train and the turbulence caused by the blades as they pass the tower. An audible increase in noise may indicate a problem and appropriate measures to diagnose it should be taken immediately, to prevent damage to the wind turbine. Please note the sounds associated with a normally operating wind turbine when the machine is first installed; these will provide an acoustic baseline for future comparisons.

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10.0 System Monitoring

Photo Courtesy of KEA

KOTZEBUE ELECTRIC ASSOCIATION WIND FARM

The following sections discuss the various monitoring systems of the AOC 15/50.

10.1 Kilowatt-Hour Meter Applications

Some utilities may require the use of detented, unidirectional kilowatt-hour (kWh) meters: one to read the energy supplied by the utility and another to read the energy absorbed by it. This enables the utility to pay the avoided cost rate for the energy it buys and to charge the standard rate for the energy it consumes. A detented kWh meter can be used to monitor power production. The most useful information for evaluating system performance is obtained by comparing the kilowatt-hours generated with the average wind speed over the same period. The relevant parameters can be measured using a dedicated kWh meter (energy production) and an anemometer (wind speed).

Net billing refers to the installations where a single kWh meter is allowed to run forwards or backwards depending upon whether the system is consuming or producing energy. The kWh meter indicates the net energy flow and energy is valued at the same rate for consumption and production.

10.2 Anemometers

The AOC 15/50 has two anemometers which are boom-mounted across two tower legs, approximately 10 m (32 feet) below the tower top casting. The PLC samples the wind speed measured by each anemometer every second and calculates 8 second and 128 second averages from the sampled data.

10.3 Output Analysis

One of the best methods for evaluating a wind system's performance is to monitor energy production. Unless there is an obvious mechanical or electrical fault, wind speed and kilowatt-hour production should be recorded for at least one month after the wind turbine has started running and ideally afterwards also, either continuously or at regular intervals, so that any drastic changes in performance can be noted and investigated. Note that a number of factors can affect output, including wind velocity, wind turbine maintenance, temperature, humidity, etc. Recording these parameters will help evaluate system performance, as well as understand system operation.

10.4 Output Analysis Worksheet

The system monitoring checklist (see Appendix G) will assist in evaluating system performance, by providing the information necessary to reach an informed conclusion. It can be used for routine system monitoring, as well as to observe and understand normal system function. Energy production depends on a site's actual wind resources and conditions, and varies with wind turbine condition, altitude, temperature, topography and the proximity of other structures. It should be noted that most sites experience seasonal variations in wind resources and, therefore, in energy production.

10.5 Wind Energy Data Sheet

The wind energy data sheet (see Appendix G) can assist evaluating AOC wind systems. It can be used whenever both a dedicated non-ratcheted kWh meter and a recording anemometer have been installed.

NOTE: AOC bases all published output projections on monthly averages. Data should be sampled at small, regular intervals throughout the month, preferably at the same time each day, e.g. every 48 hours at 8:00 a.m. For best results, sample intervals should not exceed four days; daily sampling provides greater accuracy. For comparison with monthly data projections, readings should be taken on the same day each month. Energy output varies with air density and tends to be lower at high temperatures and high altitudes than at low temperatures and low altitudes. Monthly projections are based on 15ºC (59ºF) at sea level using a Rayleigh distribution. If the average wind speed is made up of a combination of strong and weak winds, the energy output will typically be greater than if the average is composed entirely of moderate winds. This is due to the relationship of wind speed to energy production.

11.0 Maintenance

Photo Courtesy of KEA

MAINTENANCE AT KOTZEBUE ELECTRIC ASSOCIATION

The following sections contain the maintenance routines for the AOC 15/50. Note that not all of the maintenance listed has to be carried out at every scheduled check. See Appendix H for the maintenance schedule and record sheets. The maintenance record sheet should be copied and filled out for all maintenance and repairs carried out. See Appendix J for the fastener torque requirements. Torques should be confirmed to 90% of the target value to ensure that bolts were not loosened during inspection.

11.1 Rotor Assembly

Blades:

Blades should be cleaned thoroughly at intervals determined by local conditions (dust, salt, insect loads, etc.) and after cases of severe contamination. The leading edge of each blade should be inspected for surface and tape damage (i.e. cracks, dents, etc.) and the blade root for cracking. The inspection and cleaning intervals can be adjusted to take environmental conditions and variations in power production into account.

Tip Brakes:

Their deployment mechanism should be inspected and any faulty components should be repaired or replaced as necessary. A pull test should be performed on each tip brake by attaching a spring scale to the trailing edge of the tip brake plate and pulling on the scale at right angels to the plate. The force at which the tip brake opens should be approximately 27 kg (60 lbs). The torque of the lock nuts holding the tip brakes to the blades should be checked, as should that of the fasteners holding the clevises, hinge eyes and catch plate in place; these fasteners must be snug tight and have Loctite 242 (Blue) applied. The magnet and the catch plate should be cleaned if necessary. The spring/damper mechanism should be inspected for smooth, even damping. The damper should also be checked for oil leaks, which would indicate a defective damper, and that the spring is fully threaded onto the spring retainer.

Hub:

All blade fasteners should be checked for proper torque (See Appendix J) and that their washers are seated completely in the slot counter bores. If a washer is misaligned or turns during the torque check, its bolt must be removed and replaced along with the washer. Take care to seat the washer correctly.

Rotary Transformer:

The connections on both the rotating and the fixed transformer halves should be checked for damage, such as corrosion, burn marks, melted insulation or breakage. The low speed shaft and hub bore should be checked for score marks which would indicate slippage. This can occur between the hub and the locking ring, as well as the locking ring and the shaft. The casting should be checked for discoloration and the rotary transformer for dirt or debris. The spacing (air gap) between the rotating and fixed transformer halves should be 0.5 - 1 mm (0.020" - 0.040") and should be corrected if needed.

11.2 Tower Assembly

Tower:

The tower fasteners and members should be checked visually for damage. A random check of bolt torques should be carried out on flanges and braces (see Appendix J). All pal nuts should be in place and the anchor bolt nuts and hinge nuts should be seated snugly.

Tower Top:

All nuts and bolts on the tower top casting should be checked for proper torque (see Appendix M). The yaw lock should be checked for proper operation.

Twist Cable:

The cable connections should be checked at both ends for any damage, such as bare copper, melted insulation or loose strain relieves. The cable should be inspected for wear, abrasion, cracking or discoloration. If the cable is excessively twisted it should be disconnected at the tower junction box and untwisted.

11.3 Drive Train Assembly

Gearbox:

The oil level should be checked and the seals inspected. The torque on all fasteners should be checked, where accessible (see Appendix M).

Generator:

The generator should be inspected for defects such as discoloration due to heat, signs of burning, etc. The torque on the mounting bolts to the gearbox should also be checked (see Appendix M).

Yaw Bearing:

The two bolt groups securing the yaw bearing to the transmission and tower top casting should be checked for proper torque (see Appendix J). If any bolts turn during the torque check, they must be removed and replaced using Loctite (see Appendix J). The bolts connecting the yaw bearing to the tower top casting should not have Loctite applied to them, if they are replaced. The yaw bearing should be greased periodically using a standard grease gun (usually five pumps per grease nipple). The seal should be inspected for cracks and other damage, and be repaired or replaced as necessary. For repairs it is recommended to use 3M Fast Track Adhesive. The yaw lock should be greased heavily.

Parking Brake:

The friction disks should be inspected for wear, checked to see whether it operates correctly and replaced if necessary.

Oil Filter:

The oil system should be checked for leaks and if it is equipped with a filter this should be replaced every year.

11.4 Power Distribution System/Controls

Main Control Enclosure:

- The panel should be inspected annually for burns, cracks and discoloration.
- The relays should be inspected annually for burned out coils and contacts.
- The calibration of the speed sensor circuit should be checked annually using a laptop computer and a programming cable to read the speed value into the PLC memory and by executing a rotor jog. The speed sensor signal frequency should be close to 1500 (50Hz) or 1800 (60Hz). Acceptable speed sensor signal frequency range lies between 1490 and 1510 (50 Hz) or 1790 and 1810 (60 Hz). If the signal frequency lies outside of this range see Appendix H for the calibration procedure.
- Similarly, the anemometers and their circuits should be checked for faults.
- Tripped circuit breakers should be checked for and if found AOC should be notified before resetting.

Dynamic Brake Capacitor Box:

- The panel should be checked monthly for burns, cracks or discoloration, especially the heavy gauge wiring and the capacitors.
- The fuses and indicating lights on the front panel of the power factor correction capacitor box should be checked. If any fuses have tripped, AOC should be notified before replacing them and restarting the machine.

Dynamic Brake Resistor Box:

- The panel should be checked monthly for burns, cracks or discoloration.
- The resistor coils should be checked for excessive oxidation.
- The wiring should be checked for insulation damage.

For a large-scale installation, regularly needed maintenance items can be identified from an analysis of the maintenance records. A 5% sample of wind turbines can serve as a base to identify frequently needed items and determine their life expectancies. The analysis can include (but is not limited to):

- Annual energy production figures for the sampled machines.
- Resistance across each generator winding (minimum value 1.48 M-ohms (see IEEE Std 43-1974)).
- Gearbox oil analysis for water and particulate contamination (metallic or other suspended abrasives).
- Periodic inspection of main shaft, gears, bearings and other gearbox components, as well as generator rotor and bearings.

11.5 Maintenance Schedule

The AOC 15/50 has been designed to reduce its maintenance requirements. However, to insure proper operation and peak performance, regular maintenance is recommended. Basic maintenance should be carried out once a year. Long-term maintenance requirements will vary from system to system. Certain items, such as the blade cleaning frequency, depend on the season and site conditions. Blades should be cleaned periodically to ensure peak energy capture. See Appendix I for a breakdown of the maintenance requirements.

12.0 Troubleshooting

Photo Courtesy of KEA

TIP BRAKE TESTING AT KOTZEBUE ELECTRIC ASSOCIATION

NOTICE: Use of the material contained in this document is subject to the warning on page Iv and the disclaimer on page v of this document.

This section contains a brief discussion of each major wind turbine component and the control system. See Section 12.7 for a summary of troubleshooting guidelines and recommendations.

When troubleshooting it can generally be assumed that only one fault exists. A failure can be due to a malfunctioning component, one that still works but with reduced capacity, a broken connection (mechanical or electrical), a set point which has drifted from its original calibration, a loose or poor electrical connection, an improperly grounded cable shield or an intermittent problem, i.e. one that can fall into any one of the previous categories after a certain period of time.

Multiple failures can occur but are not typical and normally it will not be clear from the outset whether a failure has single or multiple causes. The best course of action is to assume a single failure and proceed to correct the obvious symptoms first. As troubleshooting progresses, additional causes or failures can come to light.

12.1 Braking System

The braking system comprises three independent subsystems: the dynamic brake, the parking brake and the tip brakes. The dynamic brake employs a resistive capacitive circuit to slow rotation by dissipating rotational energy in the resistive network while maintaining some excitation. During normal shutdowns the parking brake is delayed to prevent excessive loading of the wind turbine transmission system. During emergency shutdowns the parking brake is applied immediately and to prevent overloading of the turbine the dynamic brake is detuned by switching out part of the capacitor circuit. The capacitor network consists of two distinct, relay controlled stages and for a shutdown due to power loss, one stage of the capacitors will not be active. See Figures 12.1-1 to 12.1-4 for depictions of the brake systems.

The tip brakes are electro-magnetically controlled. The tip brake magnets receive their power from the rotary transformer through a bridge rectifier located in each tip brake. Should the rotor over-speed, power to the magnets is cut and the tip brake plates swing away from the blade end due to centrifugal force, slowing the rotor down. Should a power loss occur in the grid, all three braking systems (dynamic, tip, and parking brakes) deploy simultaneously.

Should all tip brakes deploy prematurely, their electric circuits should be checked, as well as the rotary transformer, which could have developed a fault. If only one tip brake deploys prematurely, its magnet's setting should be checked, in addition to its electrical circuit. The surfaces of both the magnet and catch plate should be checked for nicks, corrosion and debris. Both must be smooth and flat for optimal operation. The vertical position of the magnet with respect to the hinge block should also be checked. It can be adjusted using the threaded rod attached to the magnet.

A deployed tip brake can also indicate a failure of a drive train component or of the dynamic brake. Deformation of the tip brake plate could be caused by an excessive holding force, due to a faulty magnet or corrosion, combined with rotor over-speed, heavy hailstone impact or by ice being shed from the blades.

The rotor is brought to a complete stop by the parking brake, which is engaged after a delay of several seconds. Should the dynamic brake fail, the rotor can over-speed during the time delay period, in which case, the tip brakes may deploy centrifugally to prevent over-speed.

Should any of the tip brakes deploy, other than for normal shutdowns and for reasons not related to a fault in their electrical circuits, the dynamic and parking brakes should be checked. A fault in the dynamic brake could be due to any of its electrical components. The resistors, capacitors and contactors should, therefore, be checked to if a problem with the dynamic brake occurs.

The parking brake is located on the upwind end of the generator. It is an electrically operated dry-disc brake, engaged to the high-speed shaft via a splined coupling. When energized, a solenoid releases the spring pressure on the disc, allowing the drive train to rotate freely. De-energizing the solenoid brings the stationary and friction discs back in to contact again, causing the rotor to stop and be held by a torque of 314 Nm (230 ft-lbs).

If the parking brake does not release, its solenoid may be faulty. This can be verified by manually releasing the brake by pulling on its brake release handle. Furthermore, the friction discs can become stuck in the brake housing, preventing the brake from releasing. The condition of the solenoid can be checked with an ohmmeter. The correct resistance across the leads is approximately 1.5 ohms.

If the parking brake does not engage, the pressure spring could be defective or the friction disc could be stuck or damaged.

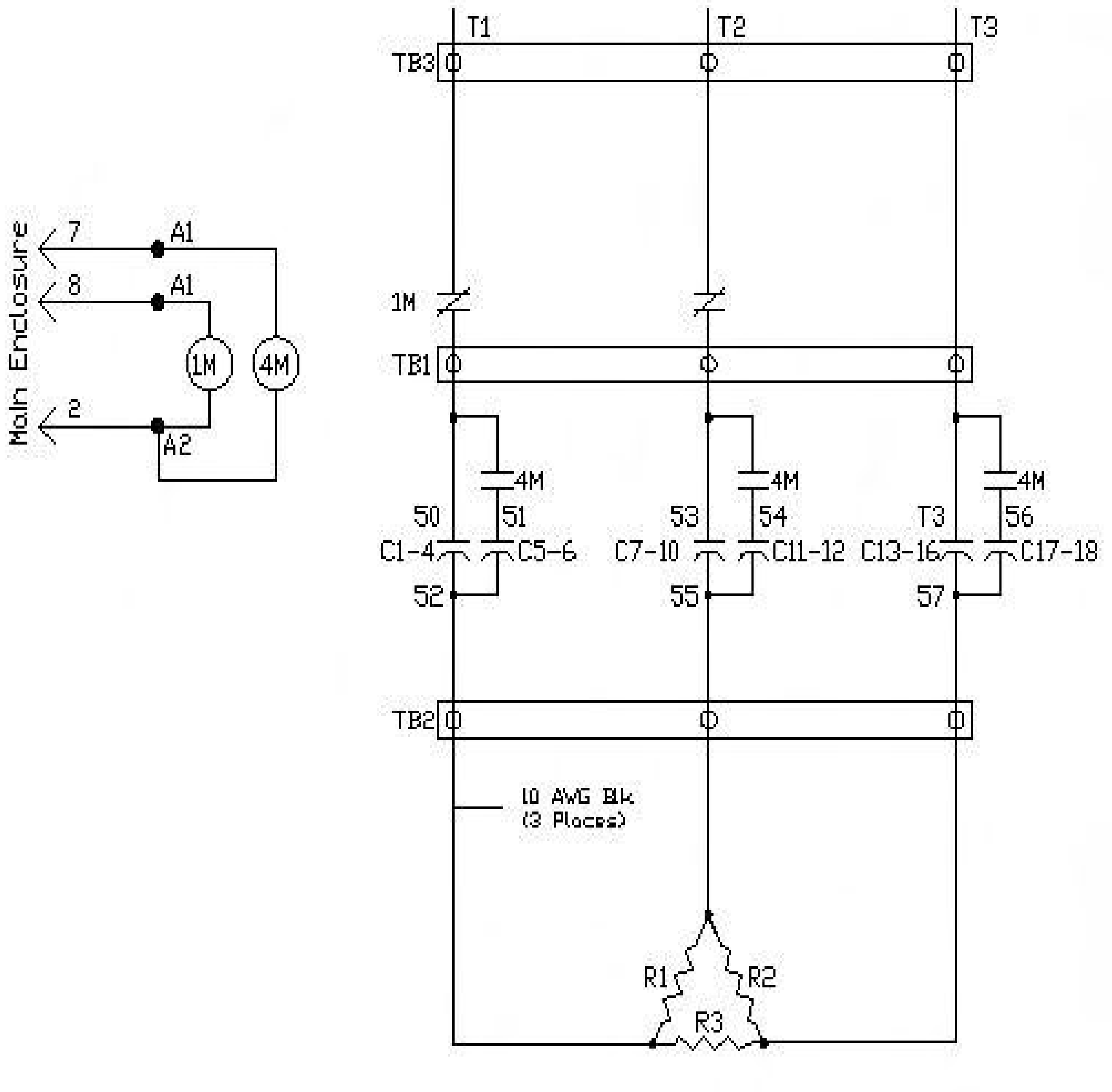

Figure 12.1-1 Dynamic brake schematic

Figure 12.1-2 Dynamic brake capacitor enclosure and power factor correction

Figure 12.1-3 Dynamic brake resistors

Figure 12.1-4 Stearns parking brake with speed pickup and temperature sensor

12.2 Generator

The generator is a 66 kW, 3-phase induction type generator. It is connected to the grid as follows once the PLC controller signals that the relevant conditions have been met: the brakes are released, the rotor freewheels (coasts) up to synchronization speed and the main contactor closes.

Various components can affect generator operation, which need to be checked if a generator problem is suspected. They include the wiring between the control box and the generator, the parking brake solenoid, the main contactor and the dynamic brake.

12.3 Gearbox

The gearbox is a speed increaser converting the low speed blade rotation to approximately 1500 rpm (50Hz) or 1800 rpm (60Hz). The gearbox is a two-stage planetary gear type and runs with Texaco Pinnacle 150 synthetic oil (normal conditions) or Texaco Pinnacle 68 Synthetic Oil (cold environments).

When investigating gearbox noise, all fasteners on the machine should first be checked for tightness. Noises due the fasteners vibrating have been interpreted as gearbox noise in the past. The oil level in the sight glass should be checked and any oil leaks should be looked for.

Total seizure of the gears causes either the control system to sense a fault or the circuit breakers to open; the blades then no longer move. A failing parking brake exhibits the same symptoms. Conversely, an internal failure can cause the blades to freewheel independently of the drive train.

12.4 Blades

The three wood/epoxy laminate or fiberglass composite blades transmit wind energy to the drive train. The blades are attached to the hub, which is held in place on the low speed shaft by a locking ring. The end of each blade is fitted with a tip brake that can be deployed to slow down the rotor, should the parking and dynamic braking systems fail to do so, due to a fault with the gearbox or the dynamic brake capacitors. Minor blade damage can be repaired by epoxying, sanding and painting.

12.5 Twist Cable

The twist cable connects the wind turbine to its power and control cables, located at the base of the tower. It consists of a power cable and a control cable and eliminates any problems with the slip ring assembly as there are no moving parts. If the cable becomes physically twisted, i.e. more than ten complete turns, it must be disconnected, untwisted and re-connected. Depending on site conditions, this might have to be done every six months. Rotating connectors can be purchased from AOC as an option.

The only failures possible in the twist cable are broken connections at either end or a physically severed cable. The twist cables are suspended from the bottom of the gearbox by the bracket shown in Figure 12.5-1.

Figure 12-5-1 Bottom of gearbox showing oil valve and twist cable bracket

12.6 Yaw Bearing

The yaw bearing allows the wind turbine to align itself with the wind. When the blades turn, the turbine should yaw into the proper position with the rotor facing downwind from the rest of the machine. If the wind turbine does not yaw correctly with respect to the wind, the yaw bearing should be greased and visually inspected. It should also be checked to see whether it is level; any necessary adjustments should be made via the anchor bolts at the tower base.

12.7 Troubleshooting Summary

The operator interface, illustrated in Figure 12.7-1, is located on the control enclosure. The indicating lights assist the operator in determining system status, as well as major fault indicators.

Symptom	Potential Cause	Resolution
Turbine does not start	1. Not switched on 2. No wind or wind speeds too high 3. Parking brake applied 4. Anemometers not operational 5. Control fault 6. Dynamic brake cooling 7. Transmission failure 8. Grid monitor not set for site specifics	1. Switch on 2. Wait for proper wind 3. Release brake, check power 4. Check wiring and for icing 5. Clear fault 6. Allow brake to cool (20 min.) 7. Inspect transmission, oil level 8. Open grid monitor settings and work back to establish set points
Turbine does not connect to grid	1. Not enough wind speed 2. Speed sensor fault/set points 3. Too cold (oil viscous)	1. Wait for wind 2. Check wiring, sensor condition and adjust set points 3. Need across-the-line start
Premature tip brake deployment	1. Magnet and/or electrical connection faulty 2. Misadjusted magnet and/or catch-plate 3. Rotary transformer fault	1. Check wiring, leads. Test magnet using 12v battery. 2. Check spacing between magnet and catch-plate 3. Inspect, test transformer
Tip brake(s) does not deploy	1. Iced or corroded	1. Clear debris
Parking brake does not engage, hold rotor stopped	1. Corroded or pressure spring faulty 2. Pads worn	1. Try to apply manually. Disassemble brake and check springs and clean off corrosion 2. Check pads and replace if

		necessary
Parking brake does not release	1. Control fault 2. Loss of power 3. Wiring faulty 4. Solenoid faulty	1. Clear fault 2. Check grid connection 3. Check leads, connectors 4. Disassemble and check solenoid
Dynamic brake does not engage	1. Electrical component failure	1. Check dynamic brake panel, connections, capacitors and contractors and fuses
Generator not turning (with rotor rotating)	1. Transmission failure	1. Disassemble and overhaul transmission
Generator not producing power	1. Electrical connections faulty 2. Insulation problem	1. Inspect and test connections 2. Meg generator
Gearbox noise	1. Loose machine fasteners 2. Low oil level	1. Check and tighten all fasteners 2. Check level, add oil, determine cause of leak and call AOC
Excessive blade noise	1. Insect or ice build-up 2. Cuts or scratches in blades 3. Loose tip brake parts	1. Wash blades 2. Repair cuts 3. Check tip brakes
Excessive twist in twist cable	1. Too many machine revs.	1. Disconnect cable, untwist
Turbine does not yaw	1. Yaw lock engaged 2. Yaw bearing needs grease 3. Yaw bearing failure 4. Machine not level (yaw axis not vertical)	1. Disengage yaw lock 2. Inspect, grease bearing 3. Inspect bearing and attempt manual yaw 4. Adjust level at tower feet

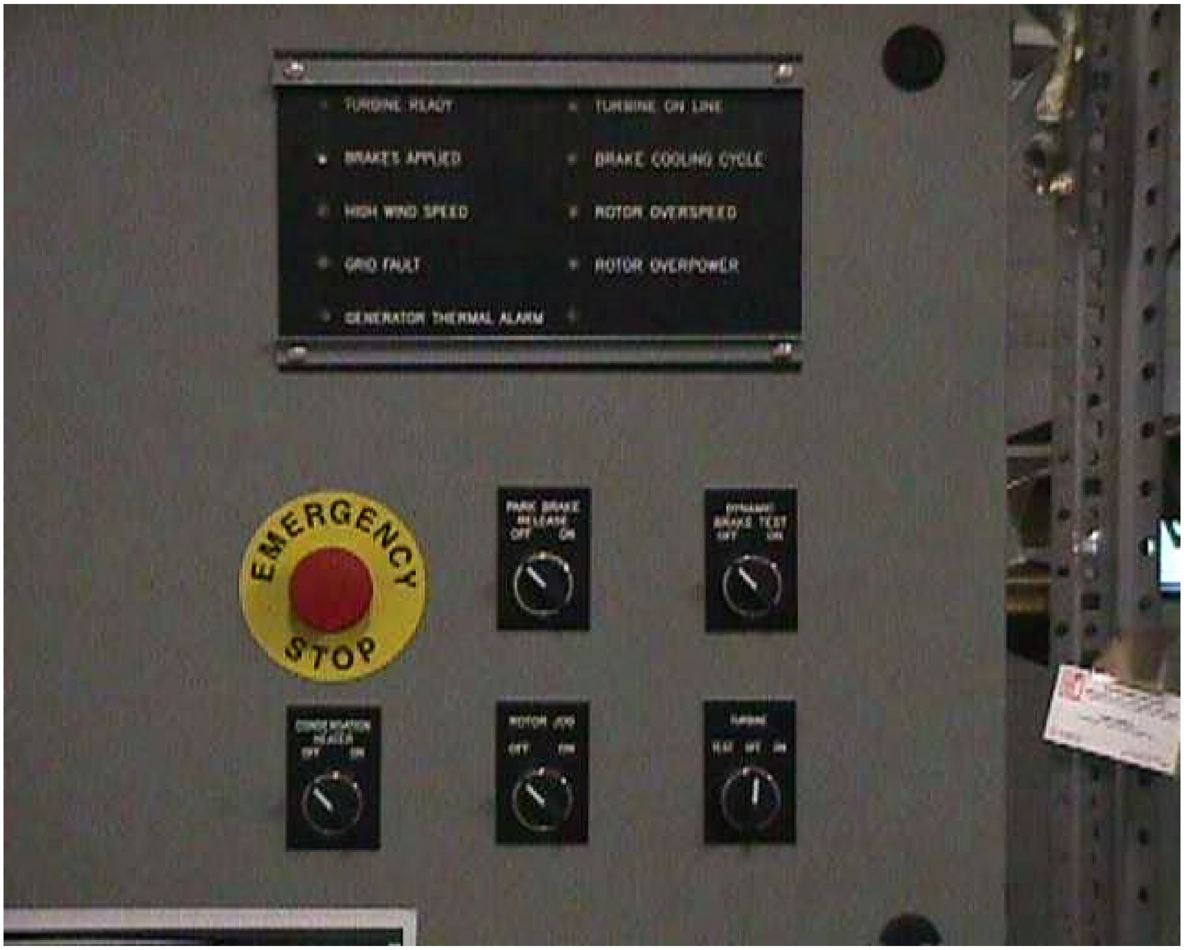

Figure 12.7-1 Indicating Lights and Control Switch

13.0 Spare Parts

TIP BRAKE ASSEMBLIES

13.1 Spare Parts Requirements

The spare parts in the standard spare parts kits range from common to long-lead items. However, since site requirements vary, the kits should be understood as a base from which to build up a stock of spares specific to an installation. Spare parts actually stocked depend on the number of machines installed, the environmental conditions and site accessibility. Remote or poorly accessible sites may need to stock a wider range of spare parts due to the longer lead times involved, even for otherwise common mechanical hardware or electrical components.

AOC supplies spare parts kits for single turbine installations, single turbine installations in remote areas, multi-turbine installations and multi-turbine installations in remote areas.

Appendix A: Specifications

AOC 15/50 50 Hz WTG Design Specifications

SYSTEM

Type	Grid Connected
Configuration	Horizontal Axis
Rotor Diameter	15 m (49.2 ft)
Centerline Hub Height	25 m (82 ft)

PERFORMANCE PARAMETERS

Rated Electrical Power	50 kW @12.0 m/s (26.8 mph)
Wind Speed	@hub height 25 m (82 ft)
cut-in	4.6 m/s (10.2 mph)
shut-down (high wind)	22.4 m/s (50 mph)
peak (survival)	59.5 m/s (133 mph)
Calculated Annual Output	
@ 100 % availability	5.4 m/s (12 mph) 85,000 kWh
	6.7 m/s (15 mph) 145,000 kWh
	8.0 m/s (18 mph) 199,000 kWh

ROTOR

Type of Hub	Fixed Pitch
Rotor Diameter	15 m (49.2 ft)
Swept Area	177 m ²(1902 ft²)
Number of Blades	3
Rotor Solidity	0.077
Rotor Speed @ rated wind speed	62 rpm
Location Relative to Tower	Downwind
Cone Angle	6º
Tilt Angle	0º
Rotor Tip Speed	48.6 m/s (109 mph) @ 50 Hz
Design Tip Speed	6.1

BLADE

Length	7.2 m (23.7 ft)
Material	Wood/epoxy laminate or Epoxy/glass fibre
Airfoil (type)	NREL, Thick Series, modified
Twist	7° outer blade
Root Chord	457 mm (18 in) @ 4% 279 mm (11in)
Max Chord	749 mm (29.5 in) @ 39% 2925 mm (115 in)
Tip Chord	406 mm (16 in) @ 100 % 7500 mm (295 in)
Chord Taper Ratio	± 2:1
Overspeed Device	Electro-magnetic tip brake
Hub Attachment	Embedded female bolt receptors
Blade Weight	150 kg (330 lbs) approximate

GENERATOR

Type	3 phase/4 pole asynchronous
Rated Temperature	-25°c
Frequency (Hz)	50 Hz
Voltage (V)	400, 3 phase @ 50 Hz (380V,415V also avail)
kW @ Rated Wind Speed	50 kW
kW @ Peak Continuous	55 kW
Speed RPM (nominal)	1500 @ 50 Hz
Winding Configuration	Ungrounded WYE
Insulation	Class F
Enclosure	Totally Enclosed Air Over (TEAO)
Frame Size	365 TC
Mounting	Direct mount to transmission
Options	Arctic low temp. shafting (-40°c)

TRANSMISSION

Type	Planetary
Housing	Ductile iron-integrated casting
Ratio (rotor to gen. speed)	1 to 24.57 (50 Hz)
Rating, output horse power	88
Lubrication	Synthetic gear oil/non toxic
Heater (option)	Arctic version, electric

YAW SYSTEM

Normal	Free, rotates 360 degrees
Optional	Yaw damping-required when known conditions frequently exceed 50° yaw rate per second.

DRIVE TRAIN TOWER INTERFACE

Structural	Yaw bearing mounted on tower top casting
Electrical	Twist Cable

TOWER

Type	Galvanized 3 legged, bolted lattice , self-supporting
Tower Height	24.4 m (80 ft)
Options	30.5 m (100 ft),
	Tilt down 24.4 m (80 ft)

FOUNDATION

Type	Concrete or special
Anchor Bolts	Certified ASTMA-A-193-Grade B7

CONTROL SYSTEM

Type	PLC based
Control Inputs	Wind speed, generator shaft speed
Control Outputs	Line interconnection, brake deployment
Communications	Serial link to central computer for energy monitor and maintenance dispatch (optional
Enclosures	NEMA 1, NEMA 4 (optional)
Soft Start	Optional

ROTOR SPEED CONTROL

Production	Blade stall increases with increased wind velocity
Normal Start up	Aerodynamic, electrical boost if necessary
Shut-down	Control system simultaneously applies dynamic brake and deploys tip brakes. Parking brake brings rotor to standstill.

Back-up Overspeed Control: Centrifugally activated tip brakes deploy

BRAKE SYSTEM CONTROL

Fail-safe brakes automatically deploy when grid failure occurs.

APPROXIMATE SYSTEM DESIGN WEIGHTS

Tower	3,210 kgs	(7,080 lbs)
Rotor & Drivetrain	2,420 kgs	(5,340 lbs)
Weight on Foundation	5,630 kgs	(12,420 lbs)

DESIGN LIFE: 30 Years

DESIGN STANDARDS: Applicable Standards, AWEA, EIA and IEC

DOCUMENTATION:
Installation Guide and Operation & Maintenance Manual

SCHEDULED MAINTENANCE: Semi-annual or after severe events.

NOTE 1: Atlantic Orient Corporation and its affiliates are constantly working to improve their products, therefore, product specifications are subject to change without notice.

NOTE 2: Power curves show typical power available at the controller based on a combination of measured and calculated data. Annual energy is calculated using power curves and a Rayleigh wind speed distribution. Energy production may be greater or lesser dependent upon actual wind resources and site conditions, and will vary with wind turbine maintenance, altitude, temperature, topography and the proximity to other structures including wind turbines.

NOTE 3: For design options to accommodate severe climates or unusual circumstances please contact the corporate office in Norwich, Vermont USA

NOTE 4: For integration into high penetration wind-diesel systems and village electrification schemes contact the corporate office in Norwich, VT USA for technical support and systems design.

REV. September 19th, 2000

AOC 15/50 60 Hz WTG Design Specifications

SYSTEM

Type	Grid Connected
Configuration	Horizontal Axis
Rotor Diameter	15 m (49.2 ft)
Centerline Hub Height	25 m (82 ft)

PERFORMANCE PARAMETERS

Rated Electrical Power	50 kW @11.3 m/s (25.3 mph)
Wind Speed	@hub height 25 m (82 ft)
cut-in	4.6 m/s (10.2 mph)
shut-down (high wind)	22.4 m/s (50 mph)
peak (survival)	59.5 m/s (133 mph)
Calculated Annual Output	
@ 100 % availability	5.4 m/s (12 mph) 87,000 kWh
	6.7 m/s (15 mph) 153,000 kWh
	8.0 m/s (18 mph) 215,000 kWh

ROTOR

Type of Hub	Fixed Pitch
Rotor Diameter	15 m (49.2 ft)
Swept Area	177 m ^{2}(1902 ft^2)
Number of Blades	3
Rotor Solidity	0.077
Rotor Speed @ rated wind speed	65 rpm
Location Relative to Tower	Downwind
Cone Angle	6º
Tilt Angle	0º
Rotor Tip Speed	51 m/s (114 mph) @ 60 Hz
Design Tip Speed	6.1

BLADE

Length	7.2 m (23.7 ft)
Material	Wood/epoxy laminate or Epoxy /glass fibre
Airfoil (type)	NREL, Thick Series, modified
Twist	7° outer blade
Root Chord	457 mm (18 in) @ 4% 279 mm (11in)
Max Chord	749 mm (29.5 in) @ 39% 2925 mm (115 in)
Tip Chord	406 mm (16 in) @ 100 % 7500 mm (295 in)
Chord Taper Ratio	± 2:1
Overspeed Device	Electro-magnetic tip brake
Hub Attachment	Embedded female bolt receptors
Blade Weight	150 kg (330 lbs) approximate

GENERATOR

Type	3 phase/4 pole asynchronous
Rated Temperature	-25°c
Frequency (Hz)	60 Hz
Voltage (V)	480, 3 phase @ 60 Hz
kW @ Rated Wind Speed	50 kW
kW @ Peak Continuous	66 kW
Speed RPM (nominal)	1800 @ 60 Hz
Winding Configuration	Ungrounded WYE
Insulation	Class F
Enclosure	Totally Enclosed Air Over (TEAO)
Frame Size	365 TC
Mounting	Direct mount to transmission
Options	Arctic low temp. shafting (-40°c)

TRANSMISSION

Type	Planetary
Housing	Ductile iron-integrated casting
Ratio (rotor to gen. speed)	1 to 28.25 (60 Hz)
Rating, output horse power	88
Lubrication	Synthetic gear oil/non toxic
Heater (option)	Arctic version, electric

YAW SYSTEM

Normal	Free, rotates 360 degrees
Optional	Yaw damping-required when known conditions frequently exceed 50° yaw rate per second.

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Structural	Yaw bearing mounted on tower top casting
Electrical	Twist Cable

TOWER

Type	Galvanized 3 legged, bolted lattice , self-supporting
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Options	30.5 m (100 ft),
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Anchor Bolts	Certified ASTMA-A-193-Grade B7

CONTROL SYSTEM

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Control Inputs	Wind speed, generator shaft speed
Control Outputs	Line interconnection, brake deployment
Communications	Serial link to central computer for energy monitor and maintenance dispatch (optional
Enclosures	NEMA 1, NEMA 4 (optional)
Soft Start	Optional

ROTOR SPEED CONTROL

Production	Blade stall increases with increased wind velocity
Normal Start up	Aerodynamic, electrical boost if necessary
Shut-down	Control system simultaneously applies dynamic brake and deploys tip brakes. Parking brake brings rotor to standstill.

Back-up Overspeed Control: Centrifugally activated tip brakes deploy

BRAKE SYSTEM CONTROL

Fail-safe brakes automatically deploy when grid failure occurs.

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Weight on Foundation	5,630 kgs	(12,420 lbs)

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DESIGN STANDARDS: Applicable Standards, AWEA, EIA and IEC

DOCUMENTATION:
Installation Guide and Operation & Maintenance Manual

SCHEDULED MAINTENANCE: Semi-annual or after severe events.

NOTE 1: Atlantic Orient Corporation and its affiliates are constantly working to improve their products, therefore, product specifications are subject to change without notice.

NOTE 2: Power curves show typical power available at the controller based on a combination of measured and calculated data. Annual energy is calculated using power curves and a Rayleigh wind speed distribution. Energy production may be greater or lesser dependent upon actual wind resources and site conditions, and will vary with wind turbine maintenance, altitude, temperature, topography and the proximity to other structures including wind turbines.

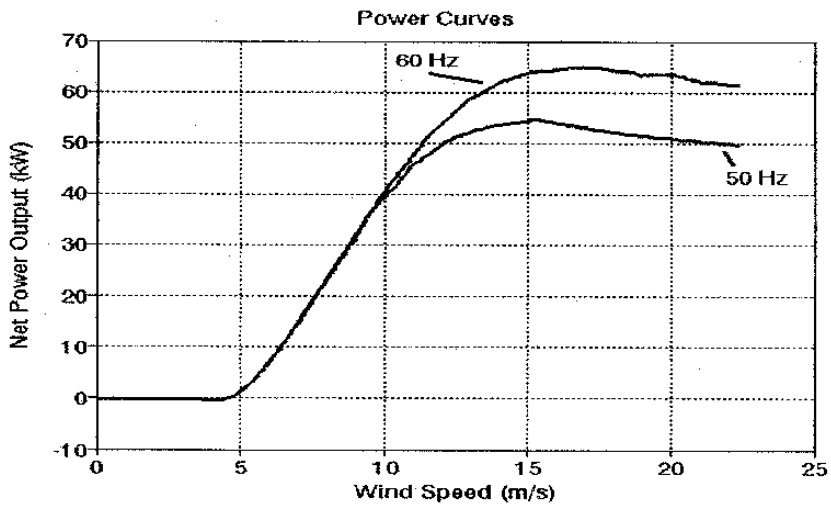
NOTE 3: For design options to accommodate severe climates or unusual circumstances please contact the corporate office in Norwich, Vermont USA

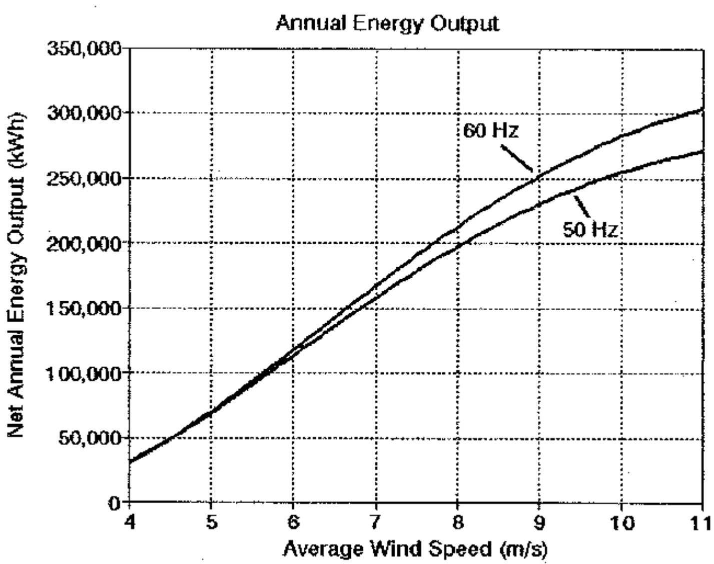
NOTE 4: For integration into high penetration wind-diesel systems and village electrification schemes contact the corporate office in Norwich, VT USA for technical support and systems design.

REV. September 2000

NOTICE: Use of the material contained in this document is subject to the warning on page Iv and the disclaimer on page v of this document.

Performance Characteristics
AOC 15/50 Wind Turbine





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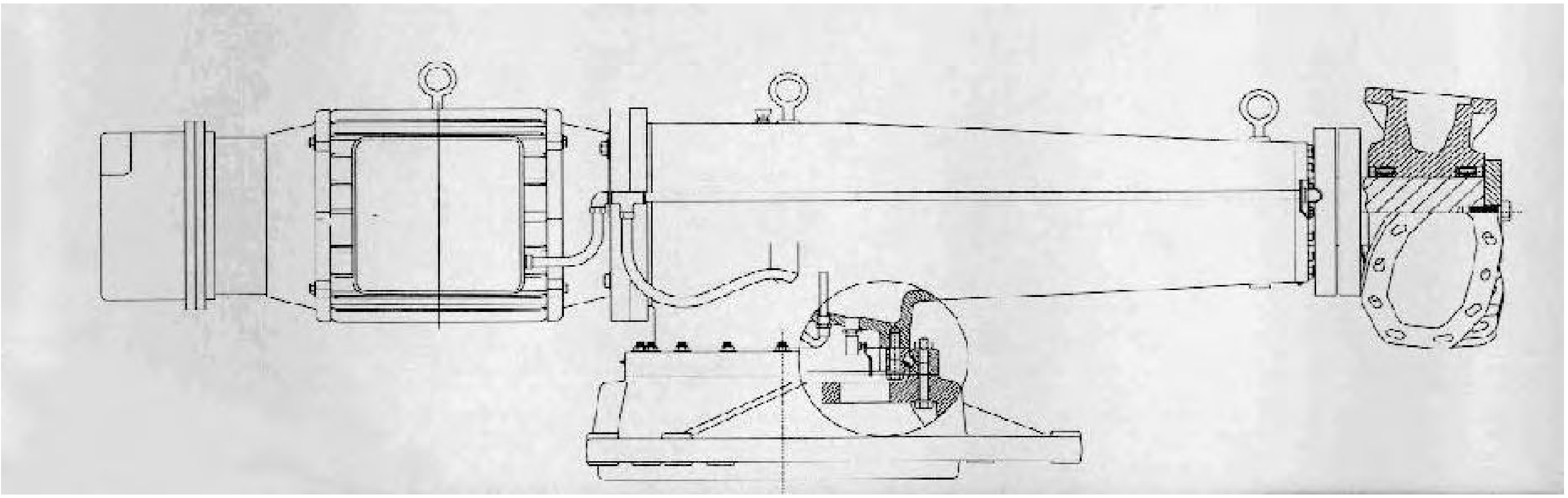
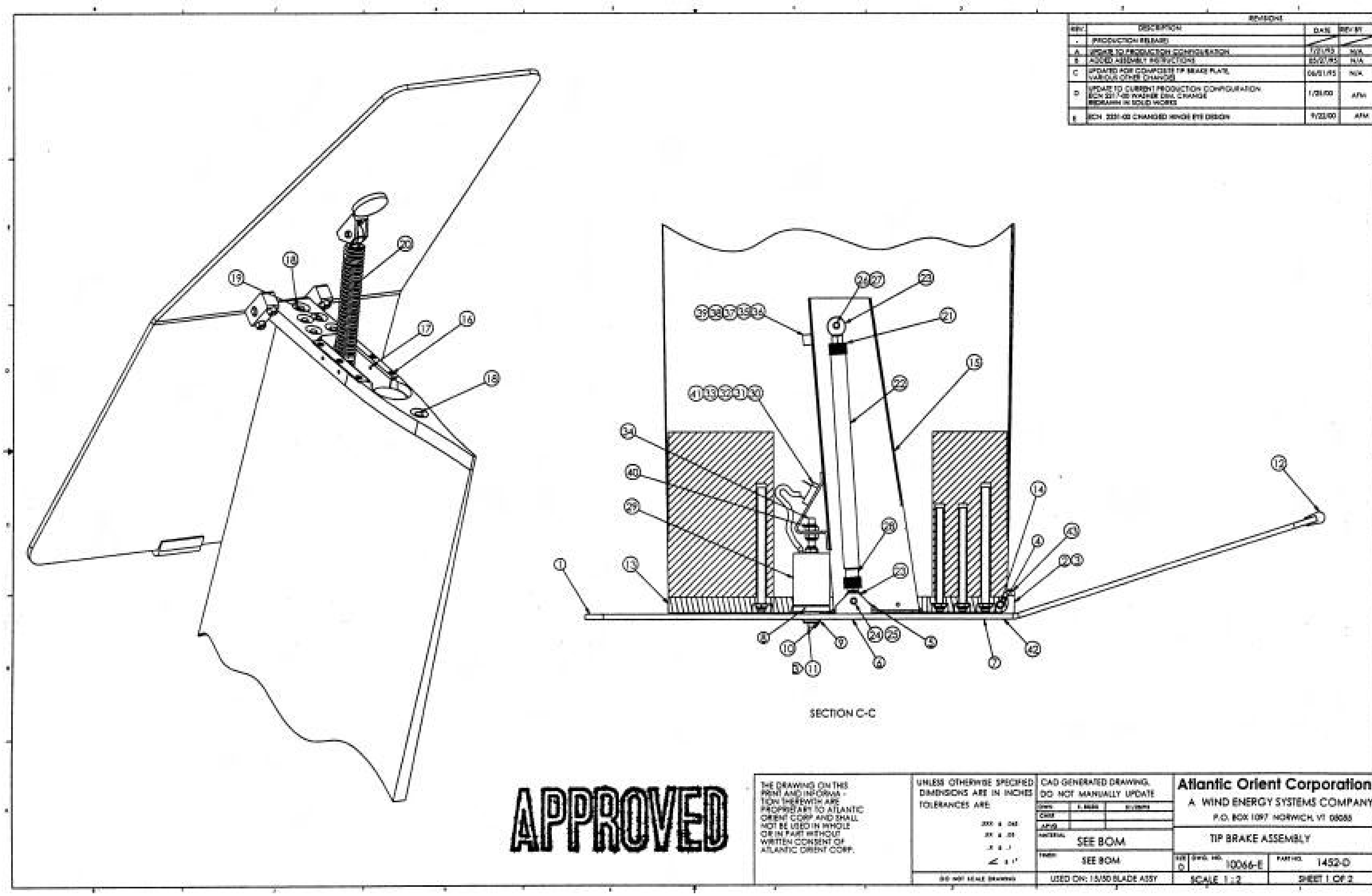
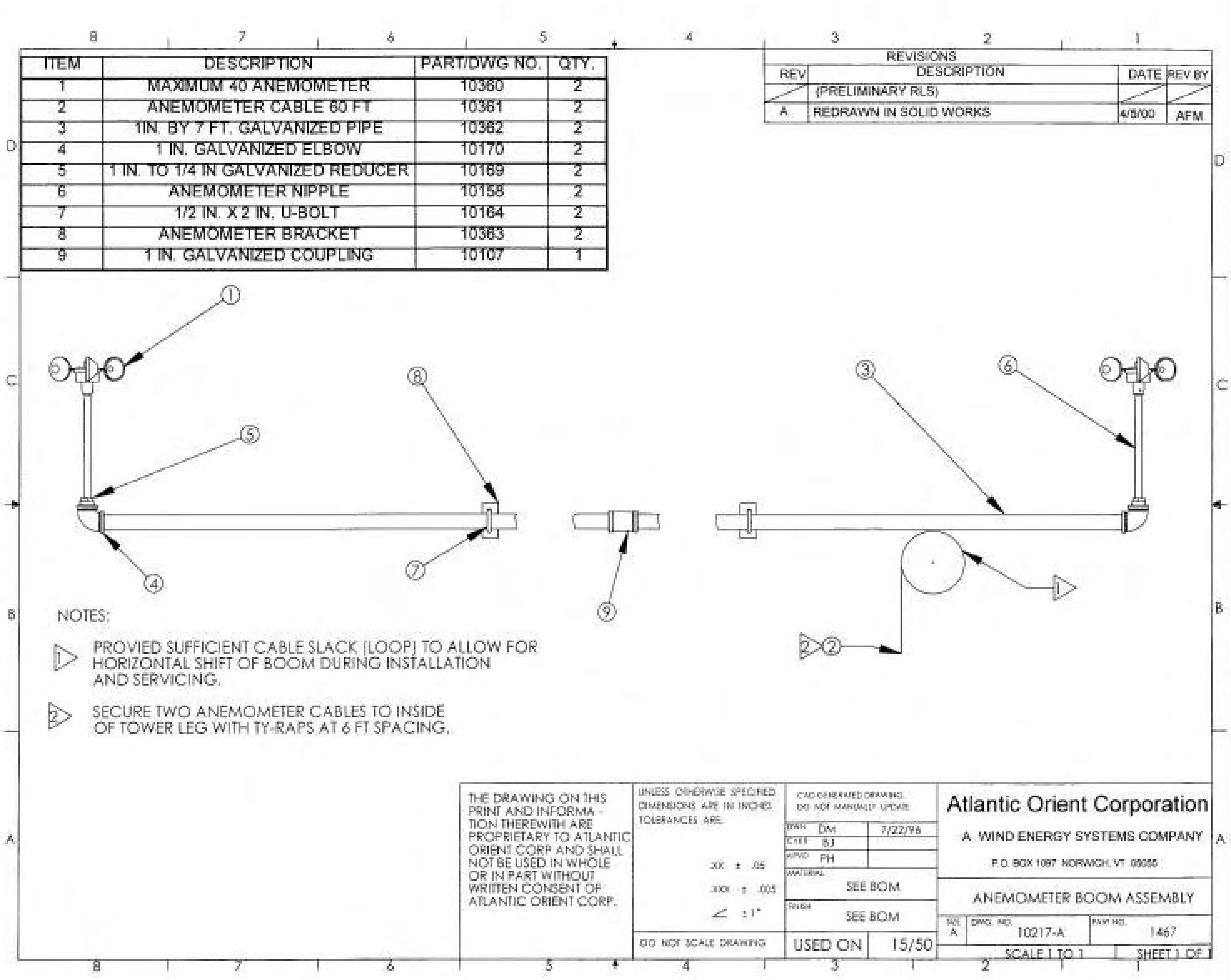
Appendix B: Turbine Assembly Drawings





NOTICE: Use of the material contained in this document is subject to the warning on page Iv and the disclaimer on page v of this document.



ITEM	DESCRIPTION	PART/DWG NO.	QTY.
1	MAXIMUM 40 ANEMOMETER	10360	2
2	ANEMOMETER CABLE 60 FT	10361	2
3	1IN. BY 7 FT. GALVANIZED PIPE	10362	2
4	1 IN. GALVANIZED ELBOW	10170	2
5	1 IN. TO 1/4 IN GALVANIZED REDUCER	10169	2
6	ANEMOMETER NIPPLE	10158	2
7	1/2 IN. X 2 IN. U-BOLT	10164	2
8	ANEMOMETER BRACKET	10363	2
9	1 IN. GALVANIZED COUPLING	10107	1

REVISIONS

REV	DESCRIPTION	DATE	REV BY
	(PRELIMINARY RLS)		
A	REDRAWN IN SOLID WORKS	4/5/00	AFM

NOTES:

1. PROVIED SUFFICIENT CABLE SLACK (LOOP) TO ALLOW FOR HORIZONTAL SHIFT OF BOOM DURING INSTALLATION AND SERVICING.
2. SECURE TWO ANEMOMETER CABLES TO INSIDE OF TOWER LEG WITH TY-RAPS AT 6 FT SPACING.

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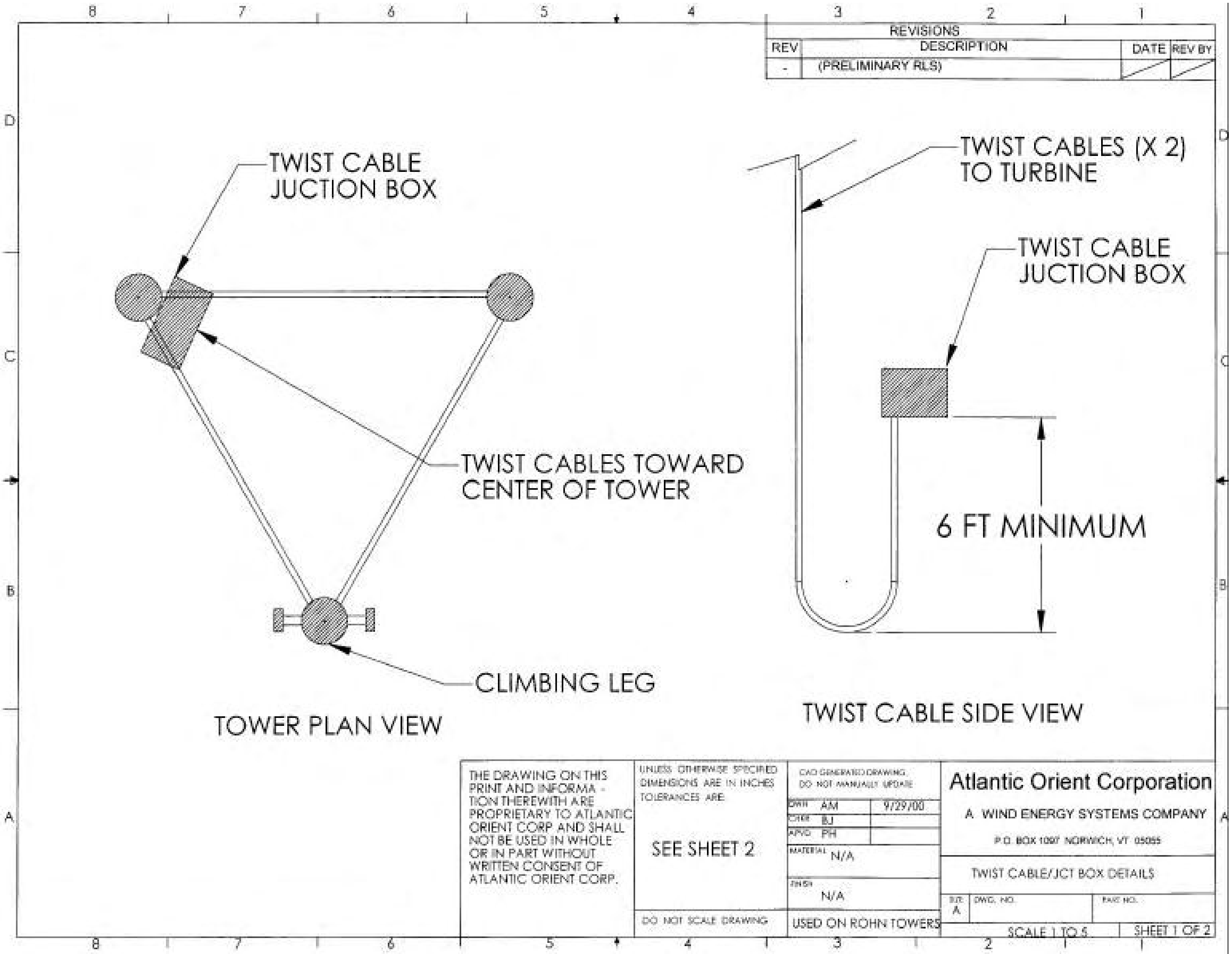
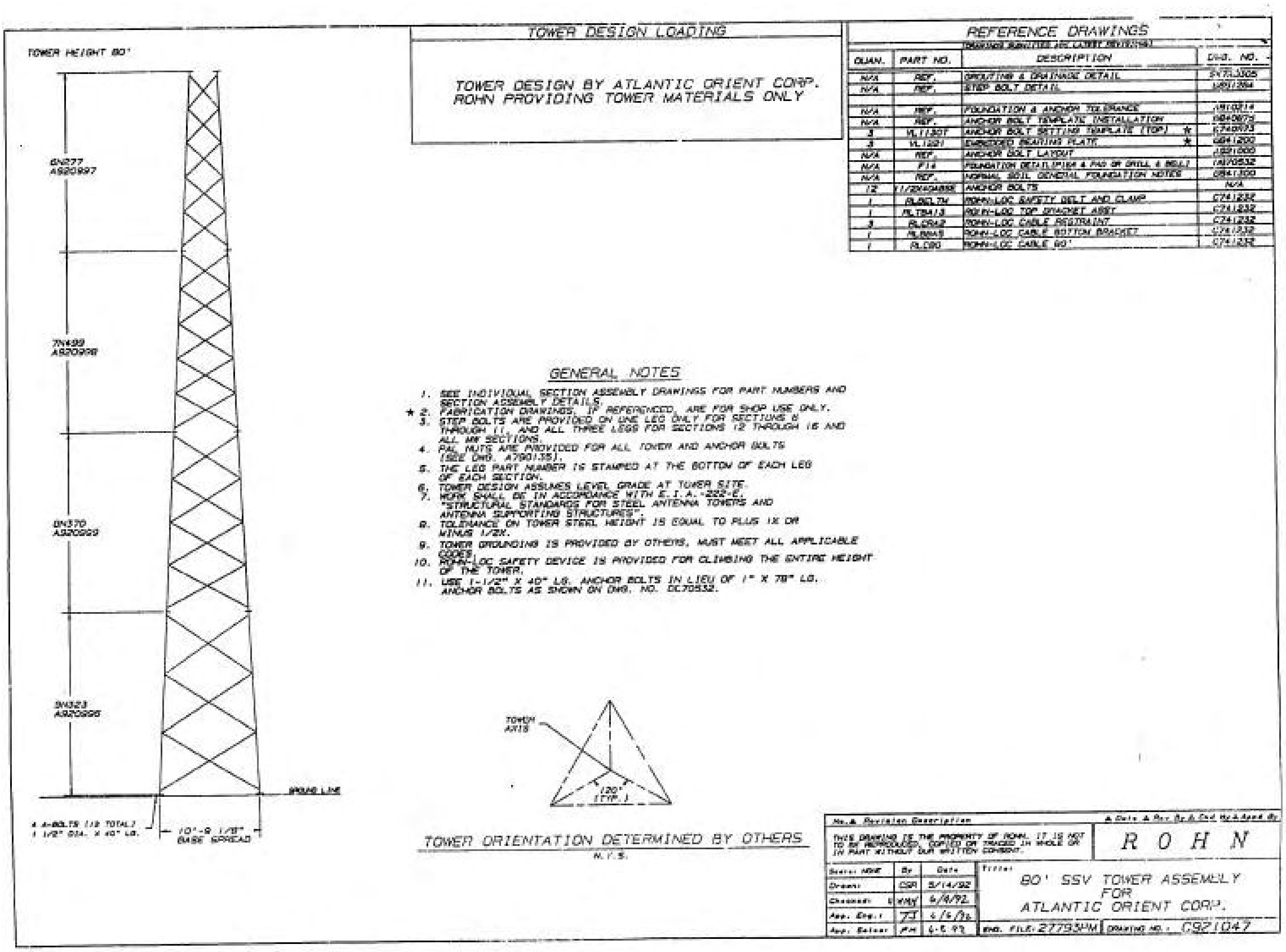
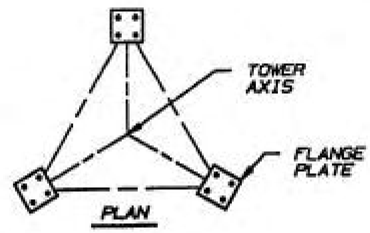


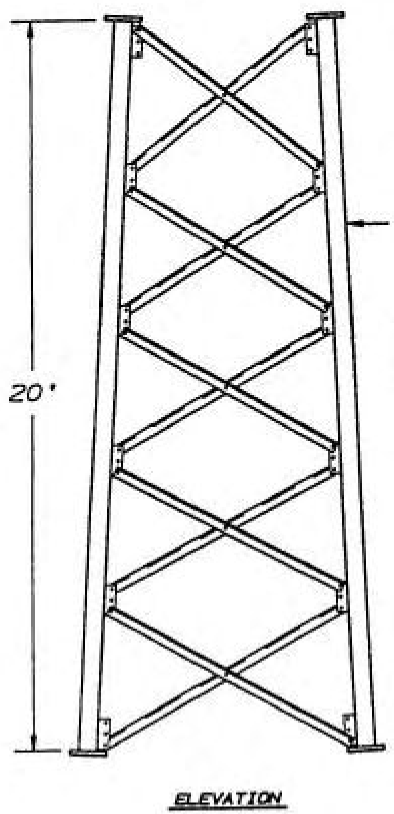
NOTICE: Use of the material contained in this document is subject to the warning on page Iv and the disclaimer on page v of this document.

Appendix C: Assembly Drawings for 24.4 m (80 ft) Tower



NOTICE: Use of the material contained in this document is subject to the warning on page Iv and the disclaimer on page v of this document.





NOTE:
BRACES ARE PLACED IN TOP TO BOTTOM ORDER GIVEN IN BILL OF MATERIAL.

BILL OF MATERIAL

ITEM	QUAN.	PART NO.	DESCRIPTION	DWG. NO.
1	2	VG566	LEG PIPE 4 E.H	B920989
2	1	VG566S	STEP LEG PIPE 4 E.H	B920989
3	6	VB1122	DIAG. BRACE (L 2X2X3/16)	B920998
4	6	VB1123	DIAG. BRACE (L 2X2X3/16)	B920998
5	6	VB1124	DIAG. BRACE (L 2X2X3/16)	B920998
6	6	VB1125	DIAG. BRACE (L 2X2X3/16)	B920998
7	6	VB1126	DIAG. BRACE (L 2X2X3/16)	B920998
8	75	210029GA	5/8" X 1 1/2" BOLT ASSY (BRACES)	C770404
♦ 9	12	210069GA	1" X 4 1/4" BOLT ASSY (FLANGES)	C770404

MISCELLANEOUS INFORMATION

FLANGE PLATE						SPREAD	
OFFSET	BEVEL	TOP		BOTTOM		TOP	BOTTOM
		SIZE	P/N	SIZE	P/N		
3/16 REV.	3 1/3 REV.	9.5" SQ. X 1-1/4"	VG565	9.5" SQ. X 1-1/4"	95A	2'-9 1/8"	4'-9 1/8"

GENERAL NOTES

1. LEG P/N IS STAMPED AT BOTTOM OF EACH LEG OF EACH SECTION.
2. PAL NUTS ARE PROVIDED FOR ALL TOWER BOLTS.
3. STEP BOLTS ARE PROVIDED ON ONE LEG ONLY.
4. FLANGE BOLTS (♦) GIVEN IN BILL OF MATERIAL ARE FOR FLANGE PLATES AT BOTTOM OF SECTION. IF THE SECTION IS USED AS A BASE SECTION SEE THE TOWER ASSEMBLY DRAWING OR ANCHOR BOLT LAYOUT FOR CORRECT SIZE AND QUANTITY OF ANCHOR BOLTS.
5. BEVEL FOR FLANGE PLATES IS FOR BOTTOM FLANGE PLATES ONLY UNLESS OTHERWISE NOTED.

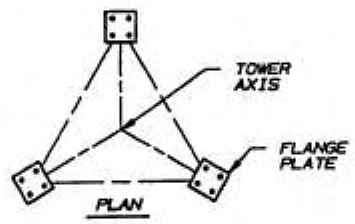
No. ▲ Revision Description	▲ Date	▲ Rev By	▲ Ckd By	▲ Appd By

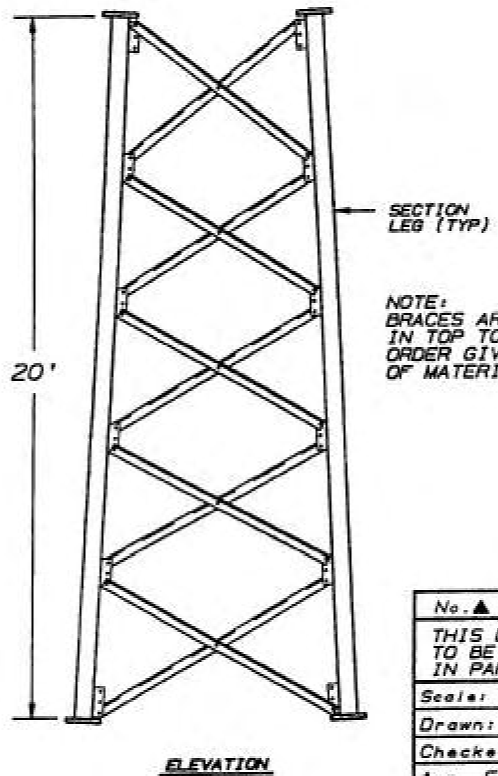
ROHN

Scale: None	By	Date
Drawn:	CSR	5/14/92
Checked:	U WMN	6/4/92
App. Eng.:	TS	6/6/92
App. Sales:	[illegible]	[illegible]

Title: ASSEMBLY DETAILS FOR SSV SECTION 6N277

DRAWING NO.: A920997





NOTE:
BRACES ARE PLACED IN TOP TO BOTTOM ORDER GIVEN IN BILL OF MATERIAL.

BILL OF MATERIAL

ITEM	QUAN.	PART NO.	DESCRIPTION	DWG. NO.
1	2	VG567	LEG PIPE 4 E.H	B920995
2	1	VG567S	STEP LEG PIPE 4 E.H	B920995
3	6	X71	DIAG.BRACE (L1-3/4 X 3/16")	SK720320
4	6	X72	DIAG.BRACE (L1-3/4 X 3/16)	SK720320
5	6	X73	DIAG.BRACE (L1-3/4 X 3/16)	SK720320
6	6	X74	DIAG.BRACE (L1-3/4 X 3/16)	SK720320
7	6	X75	DIAG.BRACE (L1-3/4 X 3/16)	SK720320
8	75	210029GA	5/8" X 1 1/2" BOLT ASSY (BRACES)	C770404
♦ 9	12	210069GA	1" X 4 1/4" BOLT ASSY (FLANGES)	C770404

MISCELLANEOUS INFORMATION

FLANGE PLATE						SPREAD	
OFFSET	BEVEL	TOP SIZE	TOP P/N	BOTTOM SIZE	BOTTOM P/N	TOP	BOTTOM
---	---	9.5" SQ. X 1-1/4"	95A	9.5" SQ. X 1-1/4"	95A	4'-9 1/8"	6'-9 1/8"

GENERAL NOTES

1. LEG P/N IS STAMPED AT BOTTOM OF EACH LEG OF EACH SECTION.
2. PAL NUTS ARE PROVIDED FOR ALL TOWER BOLTS.
3. STEP BOLTS ARE PROVIDED ON ONE LEG ONLY.
4. FLANGE BOLTS (♦) GIVEN IN BILL OF MATERIAL ARE FOR FLANGE PLATES AT BOTTOM OF SECTION. IF THE SECTION IS USED AS A BASE SECTION SEE THE TOWER ASSEMBLY DRAWING OR ANCHOR BOLT LAYOUT FOR CORRECT SIZE AND QUANTITY OF ANCHOR BOLTS.
5. BEVEL FOR FLANGE PLATES IS FOR BOTTOM FLANGE PLATES ONLY UNLESS OTHERWISE NOTED.

No. ▲	Revision Description	▲ Date	▲ Rev By	▲ Ckd By	▲ Appd By

ROHN

Scale: None	By	Date
Drawn:	CSR	5/14/92
Checked:	UWMN	6/4/92
App. Eng.:	TJ	6/6/92
App. Sales:	[illegible]	[illegible]

Title: ASSEMBLY DETAILS FOR SSV SECTION 7N499

DRAWING NO.: A920998

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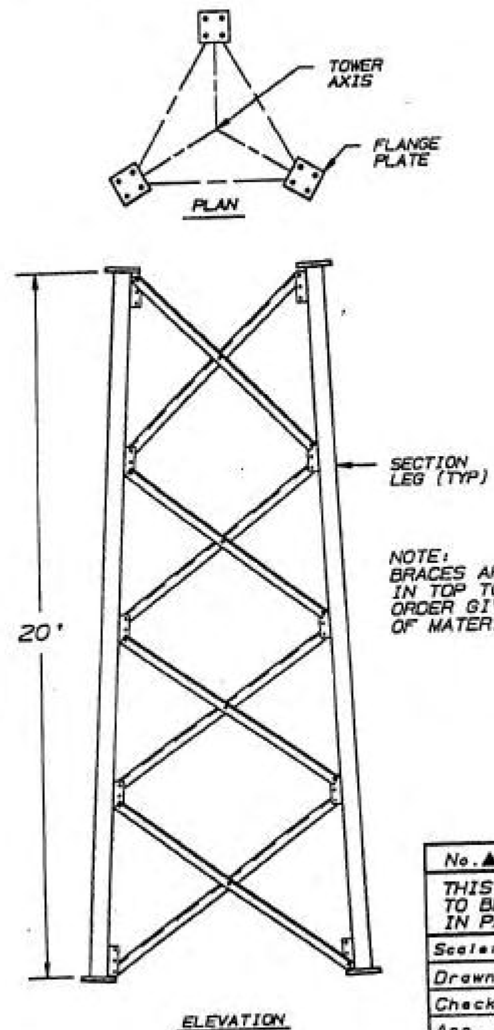

NOTE:
BRACES ARE PLACED IN TOP TO BOTTOM ORDER GIVEN IN BILL OF MATERIAL.

BILL OF MATERIAL

ITEM	QUAN.	PART NO.	DESCRIPTION	DWG. NO.
1	2	VG584	LEG (4 EH PIPE)	B921261
2	1	VG584S	STEP LEG (4 EH PIPE)	B921261
3	6	XB1	DIAG. BRACE (L 1-3/4 X 3/16)	SK720320
4	6	XB2	DIAG. BRACE (L 1-3/4 X 3/16)	SK720320
5	6	XB3	DIAG. BRACE (L 1-3/4 X 3/16)	SK720320
6	6	XB4	DIAG. BRACE (L 1-3/4 X 3/16)	SK720320
7	60	210029GA	5/8 X 1-1/2 BOLT ASSY	C770404
8	12	210069GA	1 X 4-1/2 BOLT ASSY	C770404

MISCELLANEOUS INFORMATION

FLANGE PLATE						SPREAD	
		TOP		BOTTOM			
OFFSET	BEVEL	SIZE	P/N	SIZE	P/N	TOP	BOTTOM
1/2"	N/A	9.5X9.5 X1.25	95A	9.5X9.5 X1.25	95B	6' 9-1/8"	8'-10"

GENERAL NOTES

1. LEG P/N IS STAMPED AT BOTTOM OF EACH LEG OF EACH SECTION.
2. PAL NUTS ARE PROVIDED FOR ALL TOWER BOLTS.
3. STEP BOLTS ARE PROVIDED ON ONE LEG ONLY.
4. FLANGE BOLTS (+) GIVEN IN BILL OF MATERIAL ARE FOR FLANGE PLATES AT BOTTOM OF SECTION. IF THE SECTION IS USED AS A BASE SECTION SEE THE TOWER ASSEMBLY DRAWING OR ANCHOR BOLT LAYOUT FOR CORRECT SIZE AND QUANTITY OF ANCHOR BOLTS.
5. BEVEL FOR FLANGE PLATES IS FOR BOTTOM FLANGE PLATES ONLY UNLESS OTHERWISE NOTED.

No.	Revision Description	Date	Rev By	Ckd By	Appd By

R O H N

Scale: None	By	Date
Drawn:	JDM	10-27-92
Checked:	WPL	10-28-92
App. Eng.:	TS	10-28-92
App. Sales:	PM	10-25-92

Title: ASSEMBLY DETAILS FOR SSV SECTION 8N377

DRAWING NO.: A921513

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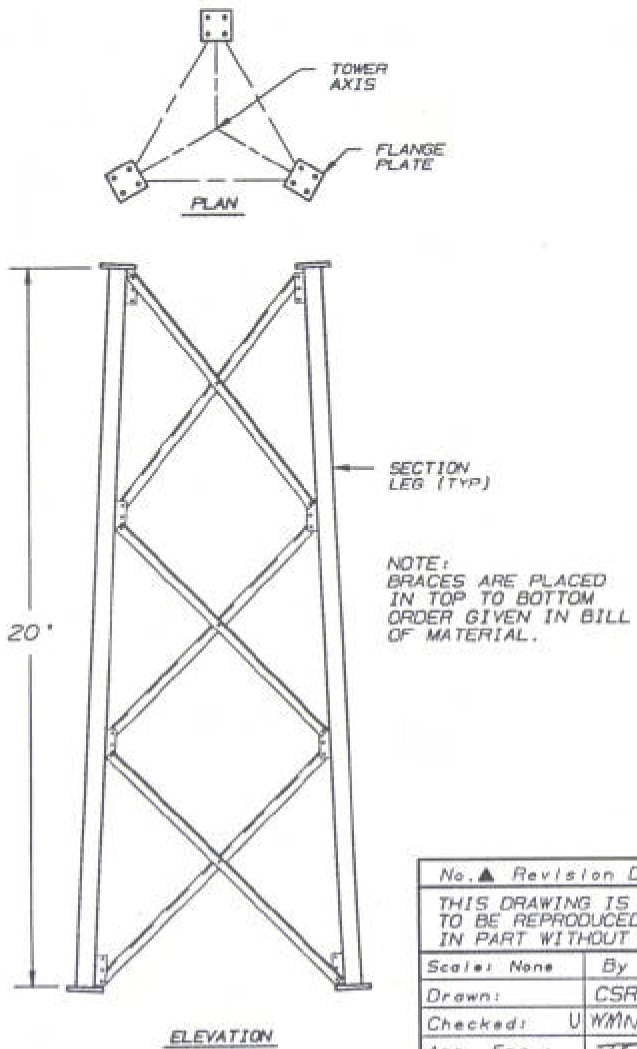

BILL OF MATERIAL

ITEM	QUAN.	PART NO.	DESCRIPTION	DWG. NO.
1	2	VG564	LEG (4 E.H. PIPE)	B920987
2	1	VG564S	STEP LEG (4 E.H. PIPE)	B920987
3	6	X91	DIAGONAL BRACE (L2 X 2 X 3/16)	SK720320
4	6	X92	DIAGONAL BRACE (L2 X 2 X 3/16)	SK720320
5	6	X93	DIAGONAL BRACE (L 2 X 2 X 3/16)	SK720320
6	45	210029GA	5/8" X 1-1/2" BOLT ASSY (BRACES)	C770404

MISCELLANEOUS INFORMATION

FLANGE PLATE						SPREAD	
OFFSET	BEVEL	TOP		BOTTOM		TOP	BOTTOM
		SIZE	P/N	SIZE	P/N		
---	3 1/3 STD.	9 1/2"SQ. X 1-1/4	95A	12" SQ. X 1-1/2"	VG563	8'-9 1/8"	10'-9 1/8"

GENERAL NOTES

1. LEG P/N IS STAMPED AT BOTTOM OF EACH LEG OF EACH SECTION.
2. PAL NUTS ARE PROVIDED FOR ALL TOWER BOLTS.
3. STEP BOLTS ARE PROVIDED ON ONE LEG ONLY.
4. BEVEL FOR FLANGE PLATES IS FOR BOTTOM FLANGE PLATES ONLY UNLESS OTHERWISE NOTED.

No. ▲ Revision Description	▲ Date	▲ Rev By	▲ Ckd By	▲ Appd By

ROHN

Scale: None	By	Date
Drawn:	CSR	5/14/92
Checked: U	WMN	6/4/92
App. Eng.:	TS	6/6/92
App. Sales:	[illegible]	[illegible]

Title: ASSEMBLY DETAILS FOR SSV SECTION 9N323 BASE

DRAWING NO.: A920996

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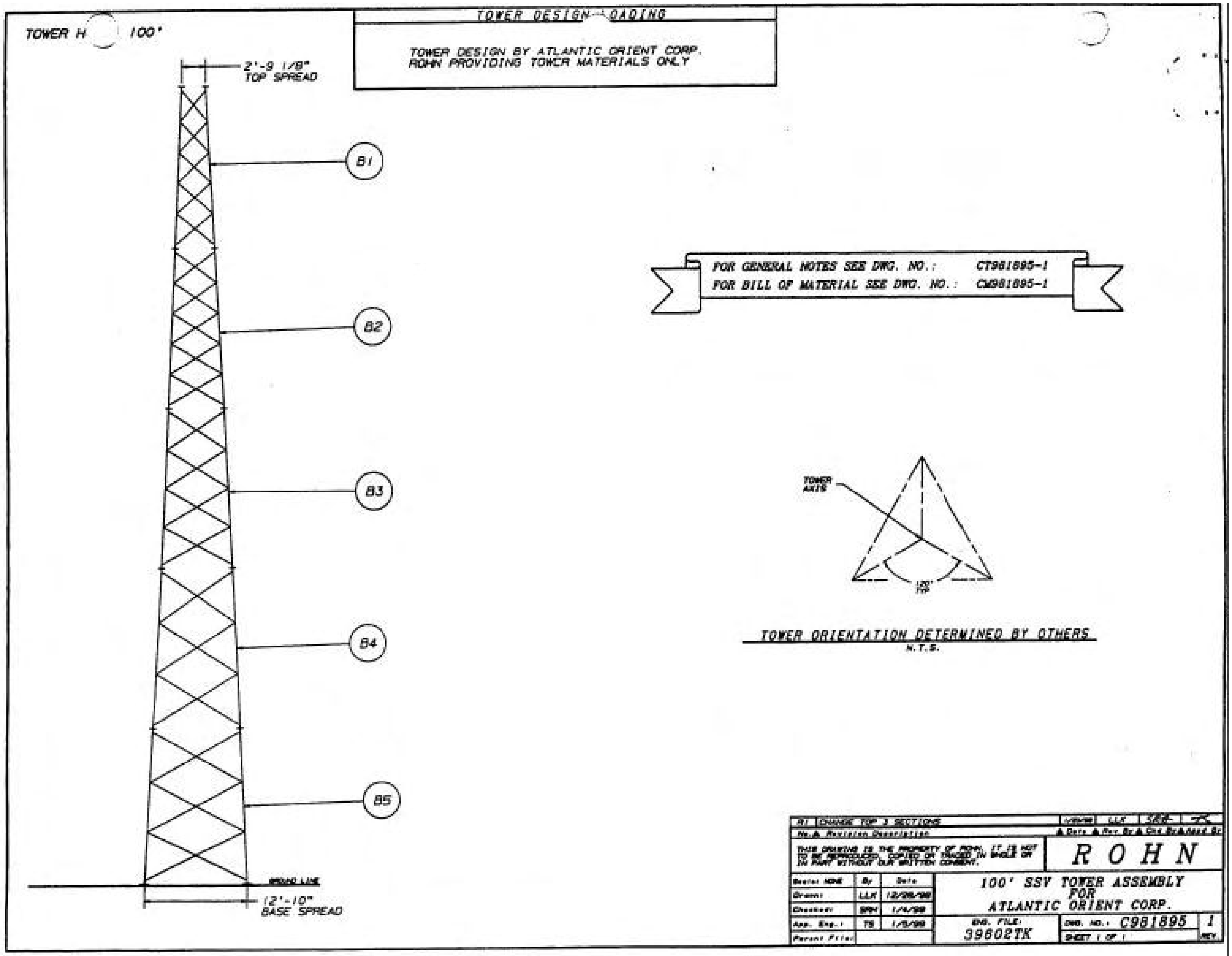
Appendix D: Assembly Drawings for 30.5 m (100 ft) Tower



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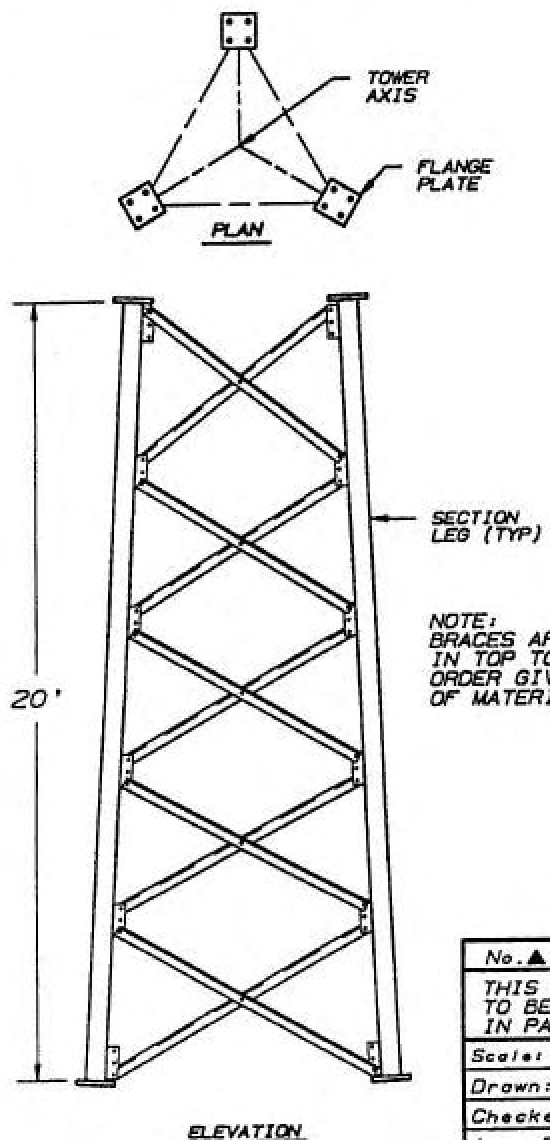


NOTE:
BRACES ARE PLACED IN TOP TO BOTTOM ORDER GIVEN IN BILL OF MATERIAL.

BILL OF MATERIAL

ITEM	QUAN.	PART NO.	DESCRIPTION	DWG. NO.
1	2	VG566	LEG PIPE 4 E.H	B920989
2	1	VG566S	STEP LEG PIPE 4 E.H	B920989
3	6	VB1122	DIAG. BRACE (L 2X2X3/16)	B920998
4	6	VB1123	DIAG. BRACE (L 2X2X3/16)	B920998
5	6	VB1124	DIAG. BRACE (L 2X2X3/16)	B920998
6	6	VB1125	DIAG. BRACE (L 2X2X3/16)	B920998
7	6	VB1126	DIAG. BRACE (L 2X2X3/16)	B920998
8	75	210029GA	5/8" X 1 1/2" BOLT ASSY (BRACES)	C770404
* 9	12	210069GA	1" X 4 1/4" BOLT ASSY (FLANGES)	C770404

MISCELLANEOUS INFORMATION

FLANGE PLATE						SPREAD	
		TOP		BOTTOM			
OFFSET	BEVEL	SIZE	P/N	SIZE	P/N	TOP	BOTTOM
3/16 REV.	3 1/3 REV.	9.5" SQ. X 1-1/4"	VG565	9.5" SQ. X 1-1/4"	95A	2'-9 1/8"	4'-9 1/8"

GENERAL NOTES

1. LEG P/N IS STAMPED AT BOTTOM OF EACH LEG OF EACH SECTION.
2. PAL NUTS ARE PROVIDED FOR ALL TOWER BOLTS.
3. STEP BOLTS ARE PROVIDED ON ONE LEG ONLY.
4. FLANGE BOLTS (*) GIVEN IN BILL OF MATERIAL ARE FOR FLANGE PLATES AT BOTTOM OF SECTION. IF THE SECTION IS USED AS A BASE SECTION SEE THE TOWER ASSEMBLY DRAWING OR ANCHOR BOLT LAYOUT FOR CORRECT SIZE AND QUANTITY OF ANCHOR BOLTS.
5. BEVEL FOR FLANGE PLATES IS FOR BOTTOM FLANGE PLATES ONLY UNLESS OTHERWISE NOTED.

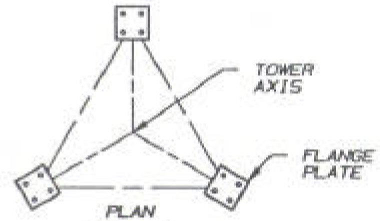
No. ▲	Revision Description	▲ Date	▲ Rev By	▲ Ckd By	▲ Appd By

ROHN

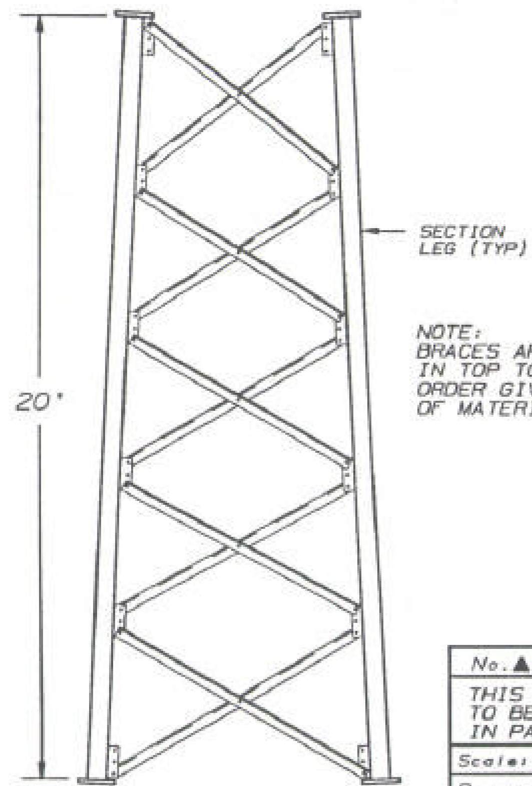
Scale: None	By	Date
Drawn:	CSR	5/14/92
Checked:	WMN	6/4/92
App. Eng.:	TS	6/6/92
App. Sales:	PA	6-5-92

Title: ASSEMBLY DETAILS FOR SSV SECTION 6N277

DRAWING NO.: A920997



PLAN



ELEVATION

NOTE:
BRACES ARE PLACED IN TOP TO BOTTOM ORDER GIVEN IN BILL OF MATERIAL.

BILL OF MATERIAL

ITEM	QUAN.	PART NO.	DESCRIPTION	DWG. NO.
1	2	VG567	LEG PIPE 4 E.H	B920995
2	1	VG567S	STEP LEG PIPE 4 E.H	B920995
3	6	X71	DIAG. BRACE (L1-3/4 X 3/16")	SK720320
4	6	X72	DIAG. BRACE (L1-3/4 X 3/16)	SK720320
5	6	X73	DIAG. BRACE (L1-3/4 X 3/16)	SK720320
6	6	X74	DIAG. BRACE (L1-3/4 X 3/16)	SK720320
7	6	X75	DIAG. BRACE (L1-3/4 X 3/16)	SK720320
8	75	210029GA	5/8" X 1 1/2" BOLT ASSY (BRACES)	C770404
* 9	12	210069GA	1" X 4 1/4" BOLT ASSY (FLANGES)	C770404

MISCELLANEOUS INFORMATION

FLANGE PLATE						SPREAD	
OFFSET	BEVEL	TOP SIZE	TOP P/N	BOTTOM SIZE	BOTTOM P/N	TOP	BOTTOM
---	---	9.5" SQ. X 1-1/4"	95A	9.5" SQ. X 1-1/4"	95A	4'-9 1/8"	6'-9 1/8"

GENERAL NOTES

1. LEG P/N IS STAMPED AT BOTTOM OF EACH LEG OF EACH SECTION.
2. PAL NUTS ARE PROVIDED FOR ALL TOWER BOLTS.
3. STEP BOLTS ARE PROVIDED ON ONE LEG ONLY.
4. FLANGE BOLTS (*) GIVEN IN BILL OF MATERIAL ARE FOR FLANGE PLATES AT BOTTOM OF SECTION. IF THE SECTION IS USED AS A BASE SECTION SEE THE TOWER ASSEMBLY DRAWING OR ANCHOR BOLT LAYOUT FOR CORRECT SIZE AND QUANTITY OF ANCHOR BOLTS.
5. BEVEL FOR FLANGE PLATES IS FOR BOTTOM FLANGE PLATES ONLY UNLESS OTHERWISE NOTED.

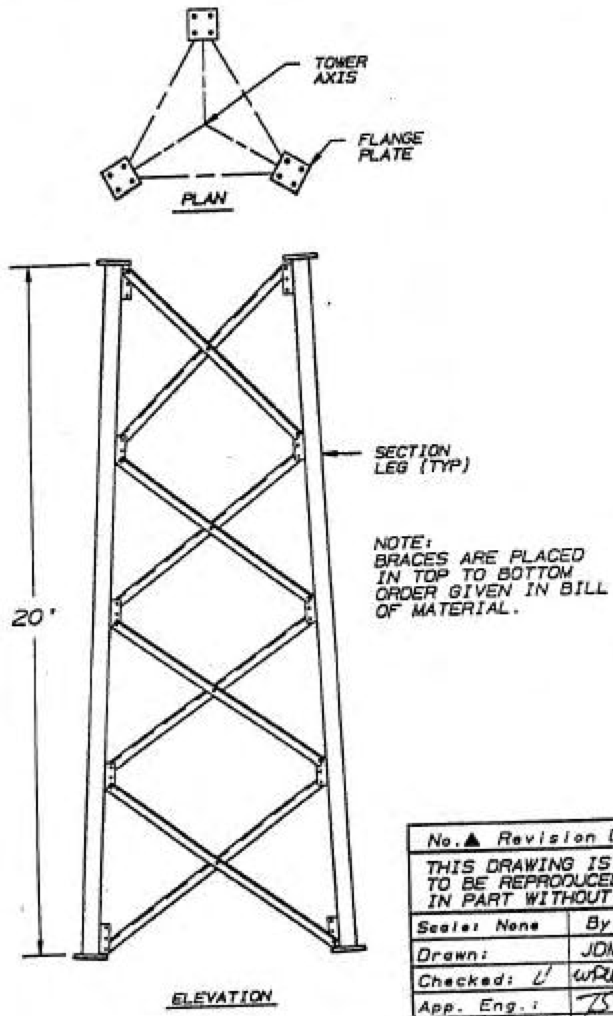
No. ▲	Revision Description	▲ Date	▲ Rev By	▲ Ckd By	▲ Appd By

ROHN

Scale: None	By	Date
Drawn:	CSR	5/14/92
Checked:	WMN	6/4/92
App. Eng.:	TJ	6/6/92
App. Sales:	PM	6-4-92

Title: ASSEMBLY DETAILS FOR SSV SECTION 7N499

DRAWING NO.: A920998



BILL OF MATERIAL

ITEM	QUAN.	PART NO.	DESCRIPTION	DWG. NO.
1	2	VG584	LEG (4 EH PIPE)	B921261
2	1	VG584S	STEP LEG (4 EH PIPE)	B921261
3	6	XB1	DIAG. BRACE (L 1-3/4 X 3/16)	SK720320
4	6	XB2	DIAG. BRACE (L 1-3/4 X 3/16)	SK720320
5	6	XB3	DIAG. BRACE (L 1-3/4 X 3/16)	SK720320
6	6	XB4	DIAG. BRACE (L 1-3/4 X 3/16)	SK720320
7	60	210029GA	5/8 X 1-1/2 BOLT ASSY	C770404
8	12	210069GA	1 X 4-1/2 BOLT ASSY	C770404

MISCELLANEOUS INFORMATION

FLANGE PLATE						SPREAD	
		TOP		BOTTOM			
OFFSET	BEVEL	SIZE	P/N	SIZE	P/N	TOP	BOTTOM
1/2"	N/A	9.5X9.5 X1.25	95A	9.5X9.5 X1.25	95B	6' 9-1/8"	8'-10"

GENERAL NOTES

1. LEG P/N IS STAMPED AT BOTTOM OF EACH LEG OF EACH SECTION.
2. PAL NUTS ARE PROVIDED FOR ALL TOWER BOLTS.
3. STEP BOLTS ARE PROVIDED ON ONE LEG ONLY.
4. FLANGE BOLTS (*) GIVEN IN BILL OF MATERIAL ARE FOR FLANGE PLATES AT BOTTOM OF SECTION. IF THE SECTION IS USED AS A BASE SECTION SEE THE TOWER ASSEMBLY DRAWING OR ANCHOR BOLT LAYOUT FOR CORRECT SIZE AND QUANTITY OF ANCHOR BOLTS.
5. BEVEL FOR FLANGE PLATES IS FOR BOTTOM FLANGE PLATES ONLY UNLESS OTHERWISE NOTED.

No. ▲	Revision Description	▲ Date	▲ Rev By	▲ Ckd By	▲ Appd By

ROHN

Scale: None	By	Date
Drawn:	JDM	10-27-92
Checked:	WRU	10-28-92
App. Eng.:	TS	10-28-92
App. Sales:	PM	10-28-92

Title: ASSEMBLY DETAILS FOR SSV SECTION 8N377

DRAWING NO.: A921513

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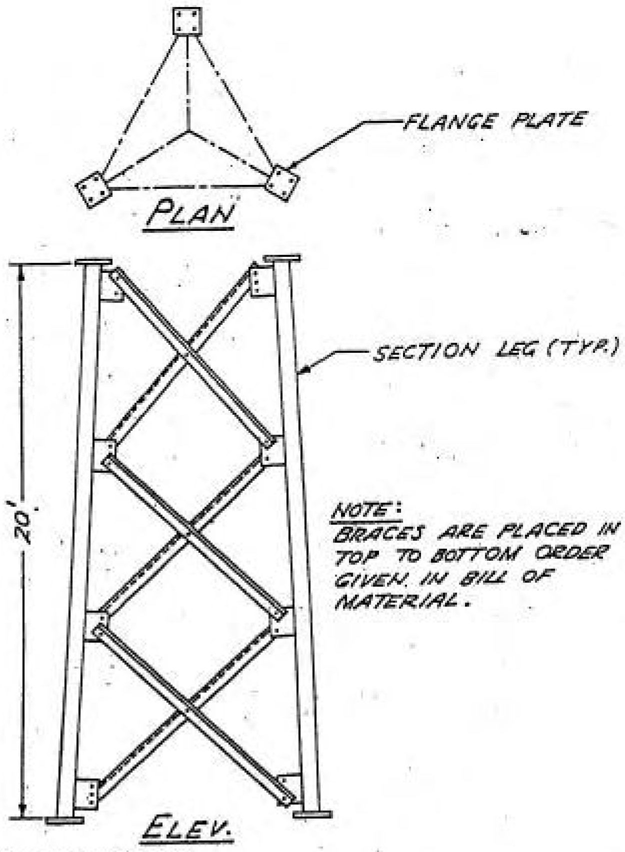

BILL OF MATERIAL

ITEM	QUAN.	PART No.	DESCRIPTION	DWG. No.
1	2	VL595	LEG (PIPE 5X-STR)	B790030
2	1	VL595C	STEP LEG (")	"
3	6	VB34	BRACE (2½x2½x[illegible])	[illegible]
4	[illegible]	VB35	" (")	"
5	[illegible]	VB37	" (")	"
6	45	[illegible]	⅝x1½ BOLT ASSY	C770404
7	12	[illegible]	1x4¼ " "	"

MISC. INFO.

FLANGE PLATE						SPREAD	
OFFSET	BEVEL	SIZE (TOP)	P/N	SIZE (BOTTOM)	P/N	TOP	BOTTOM
—	—	9.5x7.5x[illegible]	[illegible]	9.5x7.5x1.25	[illegible]	[illegible]	[illegible]

GENERAL NOTES:

1. LEG P/N IS STAMPED AT BOTTOM OF EACH LEG OF EACH SECTION.
2. PAL NUTS ARE PROVIDED FOR ALL TOWER BOLTS.
3. STEP BOLTS ARE PROVIDED ON ONE LEG ONLY.
4. FLANGE BOLTS (*) GIVEN IN BILL OF MATERIAL ARE FOR FLANGE PLATES AT BOTTOM OF SECTION. IF THE SECTION IS USED AS A BASE SECTION SEE THE TOWER ASSEMBLY DWG. OR ANCHOR BOLT LAYOUT FOR CORRECT SIZE AND QUANTITY OF ANCHOR BOLTS.
5. BEVEL FOR FLANGE PLATES IS FOR BOTTOM FLANGE PLATES ONLY UNLESS OTHERWISE NOTED.

No. ▲	Revision Description	▲ Date	▲ By

Unarco-Rohn
Division of Unarco Industries, Inc.

Scale: NONE
Drawn by: WRF Date: 12-28-84
Checked by: [illegible] Date: 1-2-85
Approved: TS Date: 1-3-85
Approved: JC Date: 1-3-85

Title: ASSEMBLY DETAILS FOR SSV SECTION 9N201

Drawing Number: A840517

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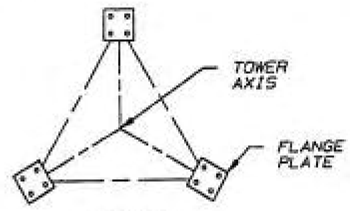
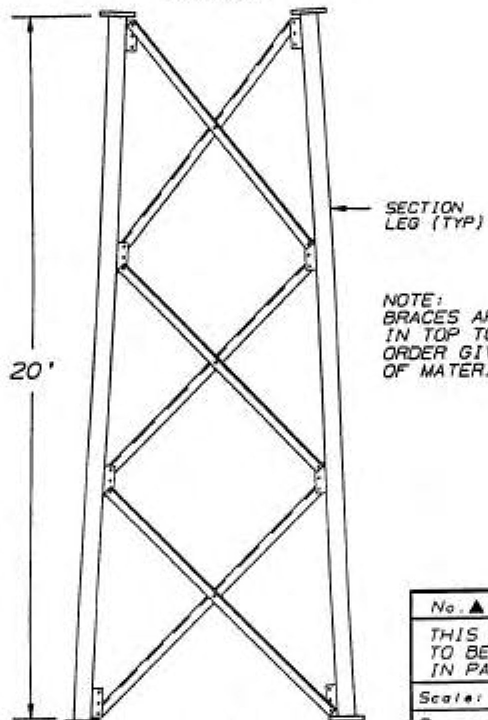


PLAN



ELEVATION

NOTE:
BRACES ARE PLACED IN TOP TO BOTTOM ORDER GIVEN IN BILL OF MATERIAL.

BILL OF MATERIAL

ITEM	QUAN.	PART NO.	DESCRIPTION	DWG. NO.
1	2	VG666	BASE LEG (P 5 EH)	B982667
2	1	VG666S	STEP BASE LEG (P 5 EH)	B982667
3	6	VB122	DIAG. BRACE (L2.50 X .19")	SK7310228
4	6	VB123	DIAG. BRACE (L2.50 X .19")	SK7310228
5	6	VB124	DIAG. BRACE (L2.50 X .19")	SK7310228
6	45	210029GA	BRACE BOLT ASS'Y (.63 X 1.50")	C770404
7	12	250031	LOCK WASHER (1-1/2")	N/A
8	16	5/8STEP	STEP BOLTS	B651264
9				
10				

MISCELLANEOUS INFORMATION

FLANGE PLATE						SPREAD	
OFFSET	BEVEL	TOP SIZE	TOP P/N	BOTTOM SIZE	BOTTOM P/N	TOP	BOTTOM
-----	3.3° STD	9.5X9.5 X1.25	95C	1" SQUARE X 1.5"	VG665	10'-10"	12'-10"

GENERAL NOTES

1. LEG P/N IS STAMPED AT BOTTOM OF EACH LEG OF EACH SECTION.
2. PAL NUTS ARE PROVIDED FOR ALL TOWER BOLTS.
3. STEP BOLTS ARE PROVIDED ON ONE LEG ONLY.
4. FLANGE BOLTS (+) GIVEN IN BILL OF MATERIAL ARE FOR FLANGE PLATES AT BOTTOM OF SECTION. IF THE SECTION IS USED AS A BASE SECTION SEE THE TOWER ASSEMBLY DRAWING OR ANCHOR BOLT LAYOUT FOR CORRECT SIZE AND QUANTITY OF ANCHOR BOLTS.
5. BEVEL FOR FLANGE PLATES IS FOR BOTTOM FLANGE PLATES ONLY UNLESS OTHERWISE NOTED.

No. ▲ Revision Description	▲ Date	▲ Rev By	▲ Ckd By	▲ Appd By

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ROHN

Scale: NONE	By	Date
Drawn:	LLK	12/28/98
Checked:	SRH	01/04/99
App. Eng.:	TJ	1/5/99
Parent File:		

10N322
SSV SECTION ASSEMBLY

DWG. NO.: A983119
SHEET 1 OF 1
REV.

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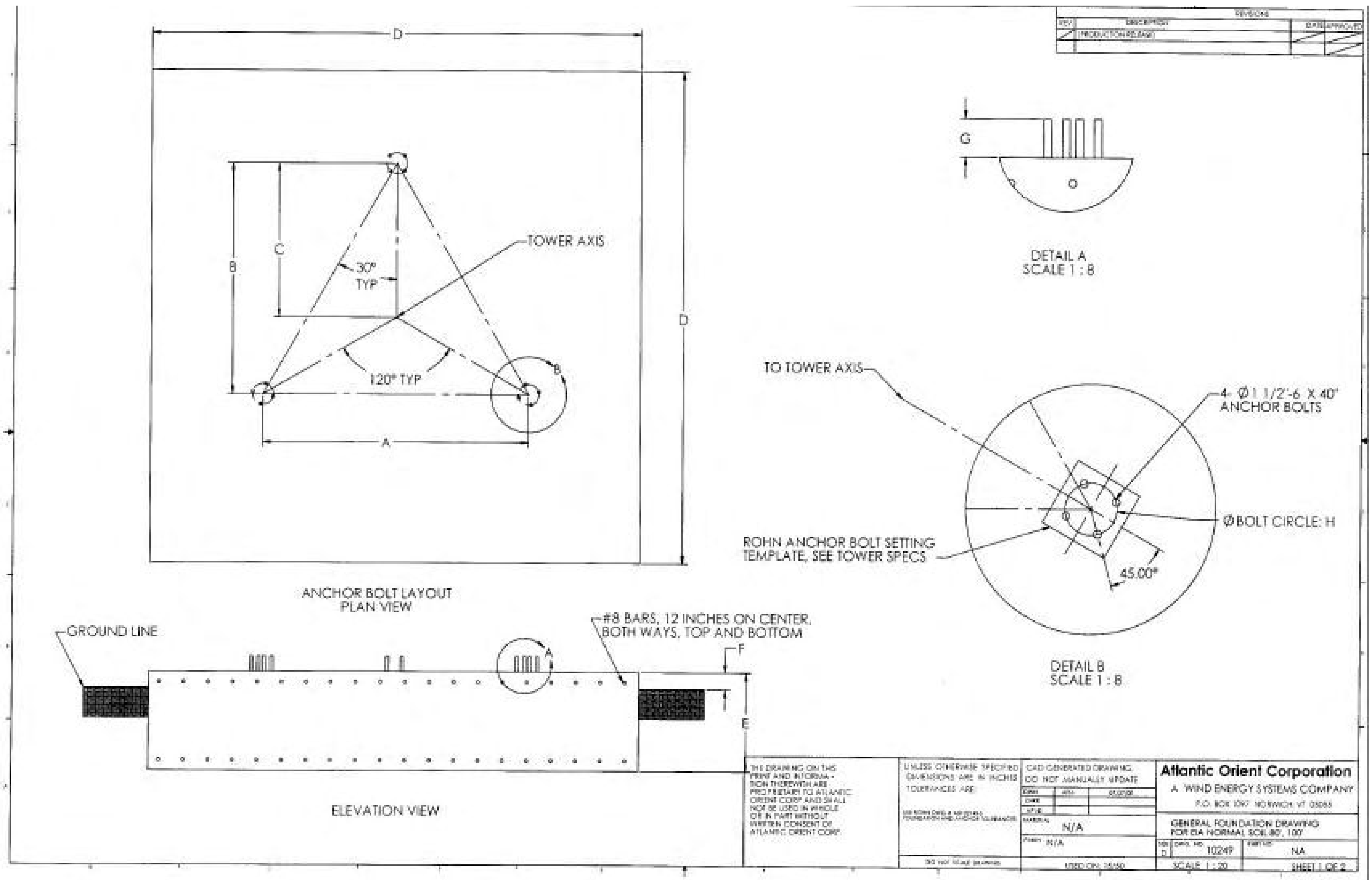
Appendix E: Crate Dimensions and Weights

Description	Crated	Crated	Weight	Weight
	Dimensions (ft)	Dimensions (m)	(lbs)	(kg)
Drivetrain	9 x 4 x 4	2.7 x 1.2 x 1.2	5,500	2495
Blades	25 x 3.3 x 6.5	7.5 x 1 x 2	1843	836
Control Boxes	4 x 4 x 4	1.2 x 1.2 x 1.2	600	272
Tower	21 x 3 x 3	6.5 x 1.2 x 1	2000 / section	900 / section

Appendix F: Foundation Loads and Details

FOUNDATION INFORMATION						
	Tower Base Loads (lbsf)			Single Leg Loads (lbsf)		
	Vertical Loads (weight)	Horizontal Loads (thrust)	Overturning Moment (ft-lbs)	Horizontal	Vertical	
					Tension	Compression
80 ft. SSV (4" bottom sec.)	12,400	21,200	1,360,000	12,700	141,000	150,000
100 ft. SSV	15,300	24,400	1,810,000	14,600	158,000	168,000

Note: Loads calculated by spreadsheet at survival wind speed of 59.5 m/s (133 mph)



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TOWER	DIMENSION							
	A	B	C	D	E	F	G	H
80 FT	10' - 9 1/8"	9' - 3 13/16"	6'-2 9/16"	19' - 3"	4' - 0"	0' - 6"	7 1/2"	10 1/4"
100 FT	12' 10"	11' - 1 5/16"	7'-4 7/8"	21' - 0"	6' - 0"	0' - 8"	7 1/2"	10 1/4"

NOTES:

1. ALL CONCRETE SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH OF 3000 PSI AT 28 DAYS.
2. ALL REINFORCING STEEL SHALL BE DEFORMED BARS MEETING THE REQUIREMENTS OF ASTM A615, GRADE 60.
3. MINIMUM CONCRETE COVER ON REINFORCEMENT SHALL BE 3 INCHES.
4. FOR ANCHOR BOLT LOCATIONS AND INSTALLATION INSTRUCTIONS, SEE SPECIFICATIONS FOR TOWER BEING USED.
5. FOR FOUNDATIONS AND ANCHOR BOLT TOLERANCES AND FOUNDATION NOTES, SEE SPECIFICATIONS FOR TOWER BEING USED.
6. SPLICES IN REINFORCEMENT SHALL NOT BE ALLOWED. WELDING OF REINFORCING STEEL OR ANCHOR BOLTS IS NOT ALLOWED.
7. ALL CONSTRUCTION SHALL CONFORM TO LOCAL CODES AND TO THE LATEST VERSION OF ACI-318, "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE.
8. THE BASE OF THE FOUNDATION SHALL BE PLACED ON NATURAL UNDISTURBED SOIL.
9. IN THE PLAN VIEW THE AXIS OF THE TOWER SHALL BE LOCATED AT THE CENTER OF THE FOUNDATION.
10. THE CONTRACTOR SHALL CONFIRM THAT THE SOIL CONDITIONS AT THE SITE ARE AT LEAST THE EQUIVALENT OF E.I.A. "NORMAL" SOIL (4000 PSF ALLOWABLE BEARING PRESSURE) AND THAT THE DEPTH OF THE FOUNDATION IS ADEQUATE FOR MAXIMUM FROST DEPTHS AT THE SITE.
11. CONTACT AOC BEFORE FOUNDATION CONSTRUCTION FOR LATEST REV DRAWINGS AND SPECIFICATIONS

CAD GENERATED DRAWING, DO NOT MANUALLY UPDATE

Atlantic Orient Corporation
A WIND ENERGY SYSTEMS COMPANY

GENERAL FOUNDATION DRAWING FOR EIA NORMAL SOIL 80', 100'

N/A

10249

SCALE 1:30

SHEET 2 OF 2

DO NOT SCALE DRAWING

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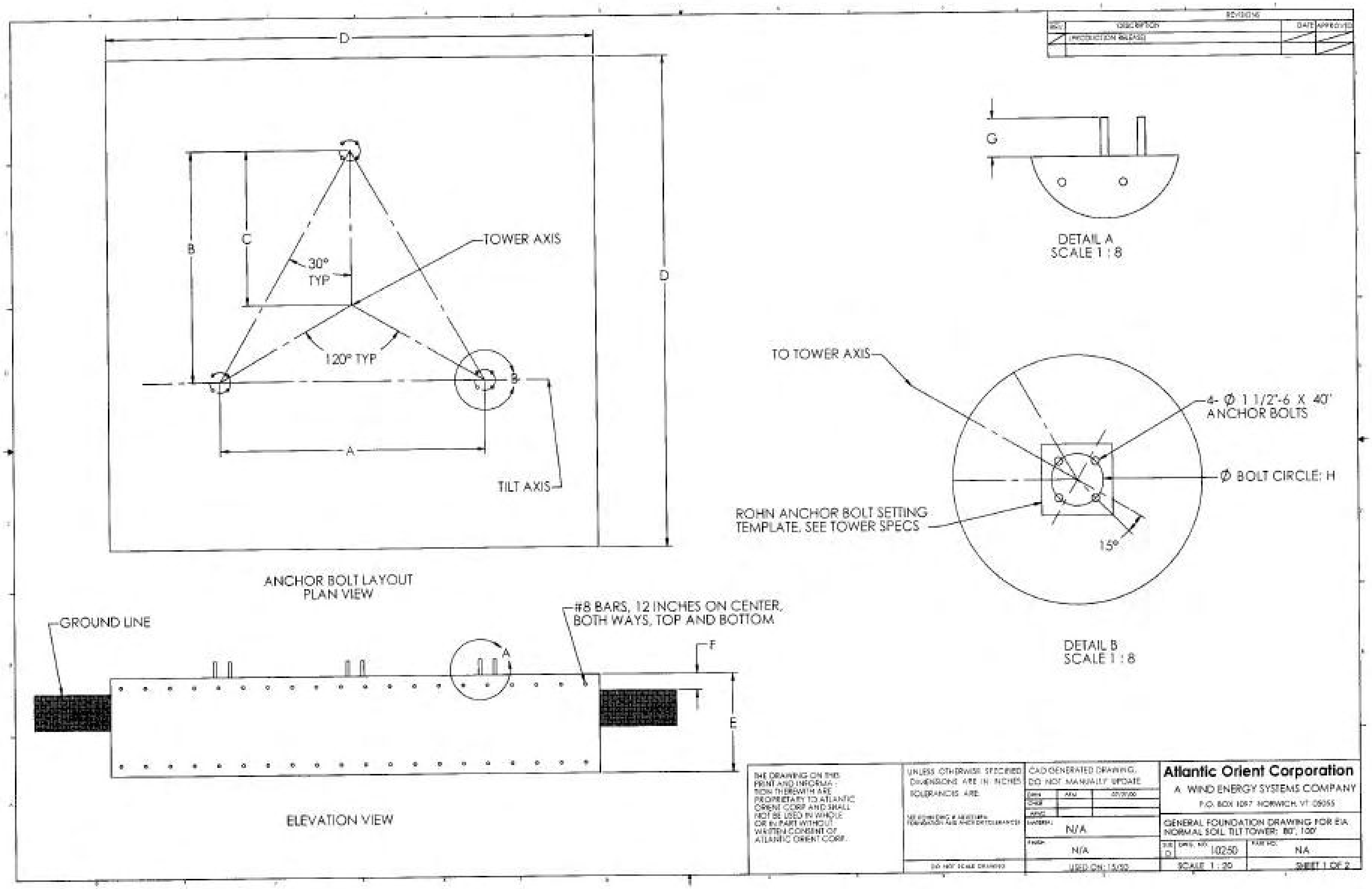

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TOWER	DIMENSION							
	A	B	C	D	E	F	G	H
80 FT	10' - 9 1/8"	9' - 3 13/16"	6'-2 9/16"	19' - 3"	4' - 0"	0' - 6"	7 1/2"	10 1/4"
100 FT	12' 10"	11' - 1 5/16"	7'-4 7/8"	21' - 0"	6' - 0"	0' - 8"	7 1/2"	10 1/4"

NOTES:

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2. ALL REINFORCING STEEL SHALL BE DEFORMED BARS MEETING THE REQUIREMENTS OF ASTM A615. GRADE 60.
3. MINIMUM CONCRETE COVER ON REINFORCEMENT SHALL BE 3 INCHES.
4. FOR ANCHOR BOLT LOCATIONS AND INSTALLATION INSTRUCTIONS, SEE SPECIFICATIONS FOR TOWER BEING USED.
5. FOR FOUNDATIONS AND ANCHOR BOLT TOLERANCES AND FOUNDATION NOTES, SEE SPECIFICATIONS FOR TOWER BEING USED.
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8. THE BASE OF THE FOUNDATION SHALL BE PLACED ON NATURAL UNDISTURBED SOIL.
9. IN THE PLAN VIEW THE AXIS OF THE TOWER SHALL BE LOCATED AT THE CENTER OF THE FOUNDATION.
10. THE CONTRACTOR SHALL CONFIRM THAT THE SOIL CONDITIONS AT THE SITE ARE AT LEAST THE EQUIVALENT OF E.I.A. "NORMAL" SOIL (4000 PSF ALLOWABLE BEARING PRESSURE) AND THAT THE DEPTH OF THE FOUNDATION IS ADEQUATE FOR MAXIMUM FROST DEPTHS AT THE SITE.
11. CONTACT AOC BEFORE FOUNDATION CONSTRUCTION FOR LATEST REV DRAWINGS AND SPECIFICATIONS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:

DO NOT SCALE DRAWING

CAD GENERATED DRAWING. DO NOT MANUALLY UPDATE

MATERIAL N/A

FINISH N/A

USED ON: 15/50

Atlantic Orient Corporation

A WIND ENERGY SYSTEMS COMPANY

P.O. BOX 1097 NORWICH, VT 05055

GENERAL FOUNDATION DRAWING FOR EIA NORMAL SOIL 80', 100'

SIZE D | DWG NO. 10249 | PART NO. N/A

SCALE 1 : 30 | SHEET 2 OF 2

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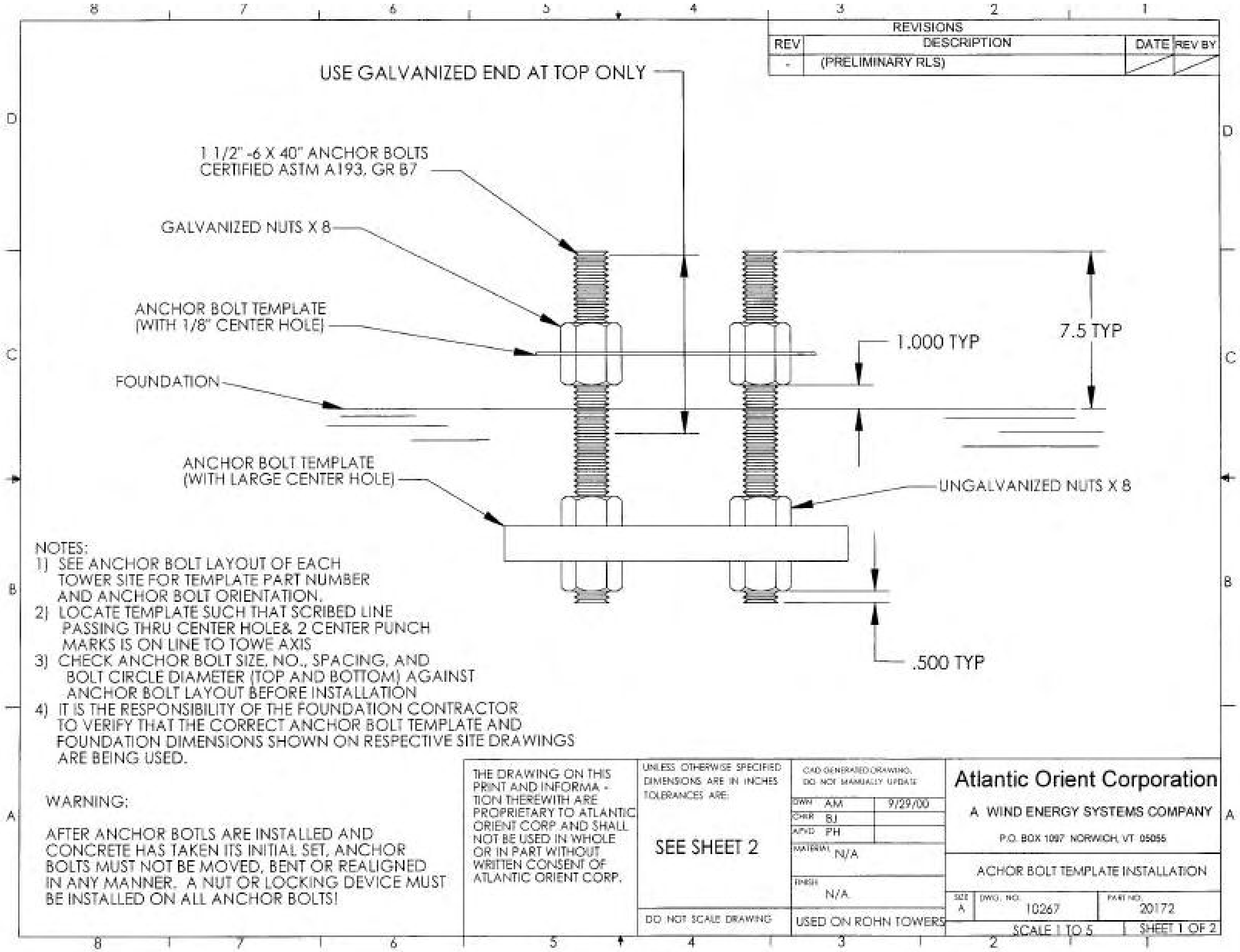

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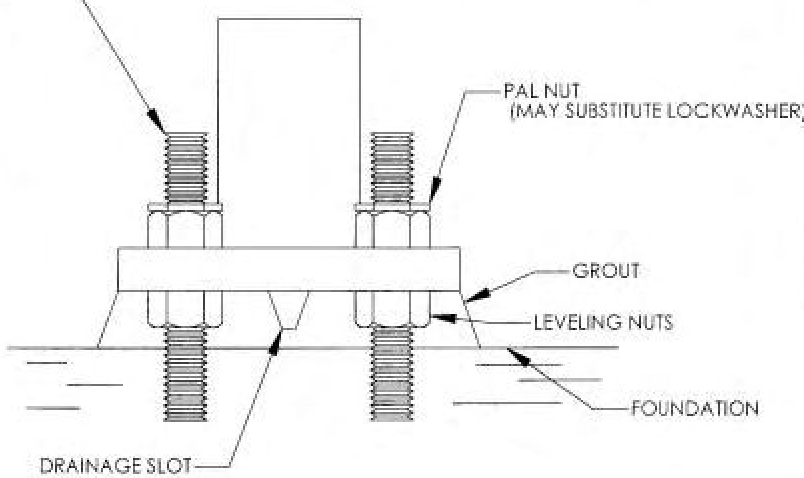
REVISIONS			
REV	DESCRIPTION	DATE	REV BY
-	(PRELIMINARY RLS)		



TOWER FOUNDATION
GROUT DETAIL

FOUNDATION AND ANCHOR TOLERANCES:		
FOUNDATIONS		
1)	CONCRETE DIMENSIONS	± 1"
2)	DEPTH OF FOUNDATION	+3 / -0
3)	DRILLED FOUNDATIONS OUT OF PLUM	1.0 DEG
4)	REINFORCING STEEL PLACEMENT	PER A.C.I. 301
5)	PROJECTION OF EMBEDMENT	± 1/8"
6)	VERTICAL EMBEDMENT OUT OF PLUM	1/2 DEG
ANCHOR BOLTS		
7)	MAXIMUM DISTANCE FROM CENTERLINE OF ANCHOR BOLTS TO CENTERLINE OF FOUNDATION	1/24 OF PIER DIAMETER UP TO A MAX OF 2"
8)	ANCHOR BOLT SPACING	1/16"
9)	ANCHOR BOLT CIRCLE ORIENTATION	1/4 DEG
10)	ANCHOR BOLT CIRCLE DIAMETER	± 1/16"
SELF SUPPORTING TOWER		
11)	FACE SPREAD DIMENSION CENTER TO CENTER OF ANCHOR BOLT CIRCLES	± 1/16" OR 1/16" PER 20 FT OF FACE SPREAD
12)	MAXIMUM DIFFERENCE BETWEEN ANY TWO FOUNDATION ELEVATIONS	1/2"

THE DRAWING ON THIS PRINT AND INFORMATION THEREWITH ARE PROPRIETARY TO ATLANTIC ORIENT CORP AND SHALL NOT BE USED IN WHOLE OR IN PART WITHOUT WRITTEN CONSENT OF ATLANTIC ORIENT CORP.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE:

SEE SHEET 2

DO NOT SCALE DRAWING

CAD GENERATED DRAWING. DO NOT MANUALLY UPDATE

DWN	AM	9/29/00
CHK	BJ	
APVD	PH	
MATERIAL	N/A	
FINISH	N/A	

USED ON ROHN TOWERS

Atlantic Orient Corporation
A WIND ENERGY SYSTEMS COMPANY
P.O. BOX 1097 NORWICH, VT 05055

ACHOR BOLT TEMPLATE INSTALLATION

SIZE	DWG. NO.	PART NO.
A	10267	20172

SCALE 1 TO 5 SHEET 2 OF 2

Appendix G: Installation Records

Installation Records

Installation Data:

Customer: ______________________________ Company ____________________

Location: ______________________________

Date: ______________________________

Turbine Data:

Model: ______________________________

Make: ______________________________

Serial No.: ______________________________

Installations Personnel:

Foundation:

Representative(s) ____ Company ____________________

Electrical:

Representative(s) ____ Company ____________________

Utility Connection:

Representative(s) ____ Company ____________________

Tower Assembly:

Representative(s) ____ Company ____________________

Tower/Turbine Erection:

Representative(s) ____ Company ____________________
Representative(s) ______________________________(crane)__ Company ____________________

Turbine Commission:

Representative(s) ____ Company ____________________

Turbine Number___________
Customer____________

Inspection of Shipped Components

	Check
Inspect blades for damage	
Inspect turbine assembly for damage	
Check sight glass to verify transmission oil level	
Inspect electrical components and cables for damage	
Inspect tower components for damage	

Q.A.	Date

Tower Assembly and Tower Erection

	Check
Braces installed with bolt heads inboard, locking nuts outboard	
1" flange bolts torqued to 250 ft/lbs	
5/8" brace nuts torqued to 150 ft/lbs	
Pal nuts installed on bolts indicating fully torqued	
Confirm anchor bolts undamaged	
Tighten anchor bolts snug tight, with locking washers installed	
Verify tower base is level	
Tower is grounded on each leg	
Tower base flange grouted with drain	

Assy by	Q.A.	Date

Blade Mounting

	Check
Clean blade root inserts with Loctite cleaner	
Ensure correct blade pitch angle	
Remove all paint and rust from hub blade bolt counterbores	
Blade washers aligned and seated properly and in counter bore	
Apply primer and Loctite 271 to all blade bolts	
Torque blade bolts to 180 ft/lbs	

Assy by	Q.A.	Date

Tip Brake Installation

	Check
Ensure tip brake slides into blade end without obstruction	
Tip brake cables properly attached to connector points	
Ensure installation of low-profile washers	
Torque 5/16 mounting nuts to 11 ft/lbs	
Torque 3/8" studs to 18 ft/lbs	
Perform tip brake pull test	

Assy by	Q.A.	Date

Installing Turbine

	Check
Tower top bolts torqued to 600 ft/lbs	
Confirm free yaw with yaw lock disengaged	
Install twist cables into twist cable junction box	
Install anemometer assembly at proscribed location on tower	

Assy by	Q.A.	Date

QA approval signature ______________________

Date ______________________

AOC 15/50 Commissioning Test QA Checklist

Turbine Number ____________________
Customer ____________________

Control Box Check

	QA Check	Date
Inspect cabling to control boxes		

Emergency Stop

	QA Check	Date
Confirm function of Emergency Stop switch (MCR disabled)		

Parking Brake release

	QA Check	Date
Confirm electrical release of Parking Brake		

(Rotor should turn if wind present)
NOTE: Parking brake release should produce an audible click

Anemometer Signal Check

	QA Check	Date
With computer interface, check for signal from both units		

(0-5V=0-100mph)

Conduct Rotor Jog

Confirm Directional Rotation
Confirm RPM (50Hz 1495-1530 and 60Hz 1790-1830)
Confirm tip brakes do not deploy

QA Check	Date

Dynamic Brake Test

Check connection of 1M and 4M wires (control wires)
Observe sufficient drop in RPM
(33-50% drop without tip brakes or parking brake deployed)

QA Check	Date

CAUTION: DO NOT RUN DYNAMIC BRAKE FOR LONGER THAN TEN (10) SECONDS. ALLOW RESISTORS TO COOL TO ROOM TEMPERATURE BEFORE REPEATING TEST

Placing Turbine On Line

	QA Check	Date
Observe turbine coming on line		

Manual Shutdown

Confirm turbine coming off line
Turn turbine power switch to "OFF"

QA Check	Date

Low Wind Shutdown

	QA Check	Date
Observe low-wind shutdown.		

(If conditions do not permit, simulate electrically)

QA Approval Signature ____________________
Date ____________________

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Atlantic Orient Corporation
Wind Energy Systems for the World

Appendix H: Maintenance Records

Maintenance Item	Date Due	Date Performed	Completed By	Comments

Maintenance Record

AOC 15/50 Maintenance Record

TURBINE #:
OWNER:___________________ LOCATION:
DATE INSTALLED:_________OPERATING HOURS:
SHUTDOWN HOURS:_______ENERGY PRODUCED:

Scheduled Routine Maintenance for the AOC 15/50

Monthly (ground level inspection):

- Visually inspect the wind turbine and site for obvious problems.
- Record the meter and run time readings.
- Inspect the dynamic brake components for discoloration or failure.

Six months after turbine installation:

- Visually inspect the tower fasteners and carry out a random torque check.
- Check and clean the electrical connections.
- Check the blade bolt washer alignment and all accessible fasteners, especially the tower top bolts, blade bolts and yaw bearing bolts.
- Inspect the yaw bearing and yaw lock.
- Inspect the tip brakes.
- Check the torque of the hinge block nuts and the tip brake plate fasteners.
- Inspect the generator.
- Inspect the gearbox for leaks and vent clogging.
- Check the oil level in the site glass.
- Inspect the main shaft for cracking.
- Inspect the rotary transformer.

Annually

- Check oil level in the site glass.
- Grease the yaw bearing and yaw lock.
- Clean the blades.

Every two years (or after severe events):

- As for the inspection carried out after the first six months of operation
- Clean the blades.
- Re-calibrate the control system if necessary.
- Inspect and replace the anemometers if necessary.
- Inspect all exposed cables

Every five years:

- As for the inspection carried out every two years.
- Overhaul the wind turbine generator if the oil samples and/or inspection records indicate this to be necessary.

NRG #40 cups, per NRG on 11-10-99			
Frequency (Hz)	Wind Speed (mph)	(m/s)	Output SI5100 (Vdc)
0.00	0.78	0.35	0.0000
1.00	2.49	1.11	0.0880
2.00	4.20	1.88	0.1760
3.00	5.91	2.64	0.2640
4.00	7.62	3.41	0.3520
5.00	9.34	4.17	0.4400
5.39	10.00	4.47	0.4743
5.51	10.21	4.56	0.4849
6.00	11.05	4.94	0.5280
7.00	12.76	5.70	0.6160
8.00	14.47	6.47	0.7040
9.00	16.18	7.23	0.7920
10.00	17.89	8.00	0.8800
11.00	19.60	8.76	0.9680
12.00	21.31	9.53	1.0560
13.00	23.02	10.29	1.1440
14.00	24.73	11.06	1.2320
15.00	26.45	11.82	1.3200
16.00	28.16	12.59	1.4080
17.00	29.87	13.35	1.4960
18.00	31.58	14.12	1.5840
19.00	33.29	14.88	1.6720
20.00	35.00	15.65	1.7600
21.00	36.71	16.41	1.8480
22.00	38.42	17.17	1.9360
23.00	40.13	17.94	2.0240
24.00	41.84	18.70	2.1120
25.00	43.56	19.47	2.2000
26.00	45.27	20.23	2.2880
27.00	46.98	21.00	2.3760
28.00	48.69	21.76	2.4640
28.77	50.01	22.35	2.5318
29.00	50.40	22.53	2.5520
30.00	52.11	23.29	2.6400
31.00	53.82	24.06	2.7280
32.00	55.53	24.82	2.8160
33.00	57.24	25.59	2.9040

34.00	58.95	26.35	2.9920	
35.00	60.67	27.12	3.0800	
36.00	62.38	27.88	3.1680	
37.00	64.09	28.65	3.2560	
38.00	65.80	29.41	3.3440	
39.00	67.51	30.18	3.4320	
40.00	69.22	30.94	3.5200	
41.00	70.93	31.71	3.6080	
42.00	72.64	32.47	3.6960	
43.00	74.35	33.24	3.7840	
44.00	76.06	34.00	3.8720	
45.00	77.78	34.77	3.9600	
46.00	79.49	35.53	4.0480	
47.00	81.20	36.30	4.1360	
48.00	82.91	37.06	4.2240	
49.00	84.62	37.82	4.3120	
50.00	86.33	38.59	4.4000	
51.00	88.04	39.35	4.4880	
52.00	89.75	40.12	4.5760	
53.00	91.46	40.88	4.6640	
54.00	93.17	41.65	4.7520	
55.00	94.89	42.41	4.8400	
56.00	96.60	43.18	4.9280	
57.00	98.31	43.94	5.0160	
57.99	100.00	44.70	5.1031	Freq= given
58.00	100.02	44.71	5.1040	MPH=(HZ*1.711)+.78
59.00	101.73	45.47	5.1920	M/S=MPH*.447
60.00	103.44	46.24	5.2800	SI5100 output=.088*Freq

Appendix I: Tools and Equipment

Tools Required For Installation			
Check	**Qty**	**Item**	**USED ON**
		All Maintenance Tools	
	1	Installation Manual	general
	1	Electrical drawings	wiring
	1	Computer and program	PLC control
	1	Tower Directions	tower assembly
	1	Template	tower assembly
	1	Aqua-gel cable lubricant	tip brake cables
	1	15/16 combination wrench	5/8” blade bolts
	2	15/16 socket	5/8” blade bolts
	2	½ drive socket wrench	5/8” blade bolts
	1	250 in-lb torque wrench, ½ drive	5/8” blade bolts (120, 180 in-lb step)
	6	1” Non-locking nuts	temporary tower fastener
	1	Crow bar	tower top aligning
	1	36" drift pin	tower top aligning
	2	1" Drift Pin	tower top aligning
	1	1 ½ socket, 3/4 drive	1’’ tower top bolts
	1	1 ½ combination wrench	1’’ tower top bolts
	1	1 7/16 socket	1’’ tower top bolts
	1	600 lb torque wrench, ¾ drive	1” tower top bolts (600 ft-lbs)
	1	1/2 to 3/4 drive adaptor	general
	1	¾ drive socket wrench	1” tower top bolts
	1	Level	leveling tower
	1	2 3/8 open ended wrench	1 1/2 tower base bolts
	1	1 1/16 socket, 3/4" drive	5/8” brace bolts
	1	1 1/16 socket, 1/2" drive	5/8” brace bolts
	1	1 1/16 combination wrench	5/8” brace bolts
	1	15/16 combination wrench	5/8” brace pal nuts
	1	1 5/8 socket	1” flange bolt
	1	1 5/8 combination wrench	1” flange pal nuts
	2 +	Lifting straps	tower assembly, blade assembly
	2	Ropes, 100 ft.	maneuver turbine when raising
	1	Loctite 271	blade bolts
	1	7/8" socket, 1/2" drive	safety cable big u-bolt
	1	3/4" socket, 1/2" drive	safety cable small u-bolt
	1	13/16" combination	safety cable pal nut
	1	5/16 Allen wrench	generator jct box ground lug
	1	3/16 Allen wrench	generator jct box connector lug
	1	Rotating File	removing blade epoxy
	1	Grinder bit and extension	removing blade epoxy
	1	wire clippers	anemometer zip ties
	1	9/16" combination wrench	anemometer bolt
	1	Rubber insulation tape	general
	1	Wire Cutters (large wire)	power wiring

Tools Required For Field Service Maintenance			
Check	**Qty**	**Item**	**USED ON**
	1	Spring Scale	tip brake pull test
	1	Quick-link	tip brake pull test
	2	½ “combination wrench	anemometer u-bolt
	1	¼” combination wrench	anemometer
	2	½ inch socket, 3/8" drive	tip brake nuts
	2	9/16 inch socket, 3/8" drive	tip brake nuts
	2	3/8" drive socket wrench	tip brake nuts, general
	1	250 in-lb torque wrench	tip brake nuts
	2	5/32 Allen wrench	hinge eye fastener
	2	3/32 Allen wrench	catch plate fastener (old)
	1	5/16" Allen wrench	Stearns brake cover fasteners
	1	10 mm Allen wrench	Ringfeder
	1	Loctite 242	tip brake fasteners
	1	Rounded Course File	removing blade epoxy
	1	Flat Steel Brush	rust removal
	2	Small round steel brush	rust removal (approx. 5/8 diameter)
	1	7/16" deepsocket, 1/2" drive	
	1	Marine Epoxy	blade repair
	1	Fine sandpaper for metal	general, rust
	1	Big adjustable wrench	general
	1	Small adjustable wrench	general
	1	Rubber Mallet	general
	1	Small sledge hammer	general
	1	Needle nose pliers	general
	2	Flat-head screwdriver	general
	2	Phillips-head screwdriver	general
	2 +	Harnesses	climbing
	2 +	Climbing hardware	climbing
	1	Rope	hauling
	1	Wire crimpers	general
	1	Wire strippers/cutter	general
	1	Electrical Tape	general
	1	Rust inhibitor	general
	1	Vise grips	general
	1	Small Pliers	general
	1	Channel Locks	general
	2	Small Screwdriver	terminal strip
	1	extractor tool	general, blade cable
	3	1.5 ft. bungee cords	tip brake plate restraint
	1	English allen set on keyring	general
	1	razor knife	general

Atlantic Orient Corporation
Wind Energy Systems for the World

Appendix J: Wire, Cable and Bolt Specifications

AOC SUPPLIED CABLE

Description	Type
Power Twist Cable	4 - # 4 Cu
Control Twist Cable	14 - # 16 Cu
Anemometer Cables (2)	Belden 9501

CUSTOMER SUPPLIED CABLE

Description		Distance from controller to tower		
		<50m	50m –200m	200-300m*
power cable	4 wire	#2 Cu THHW	#1 Cu THHW	1/0 THHW
control cable	14 wire	#14 Cu THHW	#10 Cu THHW	#8 Cu THHW
signal cable	2 shielded twisted pair	Belden 9501		
	2 shielded twisted triple	Belden 8771		

***For distances greater than 300m consult AOC.**

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The table below shows the AOC torque specification for the critical fasteners on the 15/50. These should be referred to whenever a fastener is required to be torqued 'to specification' by the assembly procedure. For detailed procedures refer to AOC Assembly Manual DOC010Rxxx.

Fastener Type	AOC p/n	Used On	AOC Torque Specification (ft-lbs)	Loctite
05/16-18	10001	Thrust ring	35	Yes
05/16-18	10056	Rotary Transformer to seal carrier	19	Yes
1/2-13	10008	Endcover	126	Yes
1/2-13	10009	Seal Carrier	96	Yes
5/8-11	10031	Parking Brake to Generator	125	Yes
5/8-11	10029	Generator to Endcover	159	Yes
5/8-18	10157	Blade to Hub	180	Yes
3/4-10	10040	Yaw Bearing to Gearbox	254	Yes
3/4-10	10041, 10042 & 10639	Yaw Bearing to Tower Top	282	No
1-8	10037	Tower Top to Tower	600	No
1-8	10267	Retaining Washer	600	Yes

Note: Refer to Turbine Installation QA Checklist, Appendix G-2, for tower flange bolt , tower brace nut and tip brake torques.

Procedure for Bolt Replacement Requiring Loctite

The Loctite Specification Sheets should be read and followed precisely. If it is not feasible to follow specification sheet exactly, it is imperative that the vendor be contacted and asked the consequences of such action (1-800-LOCTITE).

(1) It is very important to remove and replace only one bolt at a time when reinstalling any bolts so that preload is distributed evenly between all bolts.

(2) The surfaces of both the inserts and bolts must be **CLEAN** and **DRY**. A cleaning solvent must be used to remove all 242/271 residues and any grease, rust or dirt. A wire brush is usually necessary. Permatex Brake and Parts Cleaner or Loctite 22355 Cleaner & Degreaser (formerly Loctite 7070) is the recommended product.

(3) All AOC parts used in conjunction with Loctite are considered Inactive Metals (see Loctite specs). **Therefore, the surfaces for all AOC applications must be primed before Loctite is applied!** The threads should all be sprayed with Permatex Klean'N Prime or Loctite 7649 Primer-N.

(4) After surfaces have been prepared and have **completely** dried, apply Loctite to threads of the bolt. (An few air blasts may be helpful in blowing excess cleaner and primer from the inserts if applicable. This will also improve drying time.) A thin layer covering all threads on the bottom three-quarters of the bolt will be sufficient. (Be careful on blade bolts not to over apply Loctite, as excess Loctite will allow the washer to slip when applying torque, causing misalignment.) **Do not apply Loctite to wet surfaces, as the bonding properties will be affected.**

(5) Torque bolt to recommended value . **For blade bolts, it is extremely important that blade washers be aligned properly and are well seated in the counterbore. If washers are misaligned, remove torque realign and apply specified torque once again.** Loctite will fixture within 5 to 20 minutes after which blades and yaw bearing may be moved around. However, the Loctite must be allowed to cure 24 hours before any dynamics are initiated into the system (i.e. running the machine).

NOTE: The specification sheets show a procedure for applying Loctite to blind holes. In our blade/hub assembly procedure, this is not practical as there is a fairly large reservoir in the bottom of the insert. In this case, it is acceptable to apply the Loctite on bottom half of the bolt, as pressure will push the Loctite towards the top. In addition some may be applied to the insert also.

Appendix K: Planning

PROCUREMENT RESPONSIBILITY		
GENERAL DESCRIPTION	**AOC PROVIDES**	**CUSTOMER PROVIDES**
Wind Turbine Drivetrain	X	
Gearbox	X	
Generator	X	
Parking Brake	X	
Assembly Hardware	X	
Blades (unassembled)	X	
Tip Brakes	X	
Tip Brake Cables	X	
Assembly Hardware	X	
Standard 80 ft Tower	X	
Tower Safety Climbing Cable and harness	X	
Foundation (engineering, materials, labor)		X
Anchor Bolts, Nuts and Template (standard foundation)	X	
Weatherproof Controls Structure (If using non-NEMA 4 Enclosures)		X
Controls, Power Electronics and Enclosure (non-NEMA 4)(NEMA 4/tropical optional)	X	
Power Factor Correction	X	
Grid Monitor	X	
Surge Protector	X	
PLC/Controls and Enclosure	X	
Dynamic Brake Capacitors and Enclosure	X	
Dynamic Brake Resistors and Enclosure	X	
Generator Resistor Contactor Soft Start (optional)	X	
Throw Switch		X
125 A, 3 Phase Circuit Breaker		X
75 KVA Transformer		X
Watts Transducer and Current Transformer (optional)	X	
Parking Brake Heater	X	
Transmission Heater	X	
KWH Metering Device		X
Tower Base Pull Box (optional)		X
Twist Cable Jct Box	X	
Control Cable (b/w generator jct box and twist cable jct box)	X	
Power Cable (b/w generator jct box and twist cable jct box)	X	
Anemometer Cable (b/w generator jct box and twist cable jct box)	X	
Anemometer Cable (b/w twist cable jct box and controls and utility)		X
Control Cable (b/w twist cable jct box and controls and utility)		X
Power Cable (b/w twist cable jct box and controls and utility)		X
All Protective Conduit (b/w twist cable jct box and controls and utility)		X
Spare Parts	X	
NOTE: This procurement checklist is a tool for planning purposes only and is by no means a substitute for contractual agreements. Some items may or may not have been purchased by the customer.		

Required Customer Power Grid Information

Transformer Data

Primary Voltage ☐ 13.8kV ☐ 12.5kV ☐ 4160V ☐ 2400V ☐ Other__________

Secondary Voltage ☐ 400V ☐ 415V ☐ 480V ☐ Other__________

Frequency ☐ 50Hz ☐ 60Hz

Taps Number Plus__________ Number Minus__________ Step %__________

Mounting Type ☐ Pole ☐ Pad ☐ Other

Rated kVa ____________

Winding Configuration Primary ☐ Wye ☐ Delta ☐ Other__________

Winding Configuration Secondary ☐ Wye ☐ Delta ☐ Other__________

Impedance__________ Per Unit

Surge / Lightning Protection____________________________________

Measured Secondary Voltage

Normal Load ____________

Min Load ____________

Max Load ____________

Distance from Transformer to Wind Turbine (in Meters) ________________

Additional Loads

Size ____________ kW

Type ☐ ☐

☐ ☐

Peak Rating__________ Inrush Current __________ Amps

(For multiple loads detail on separate sheet)

Power Factor Correction ☐ Yes ☐ No

kVAR__________

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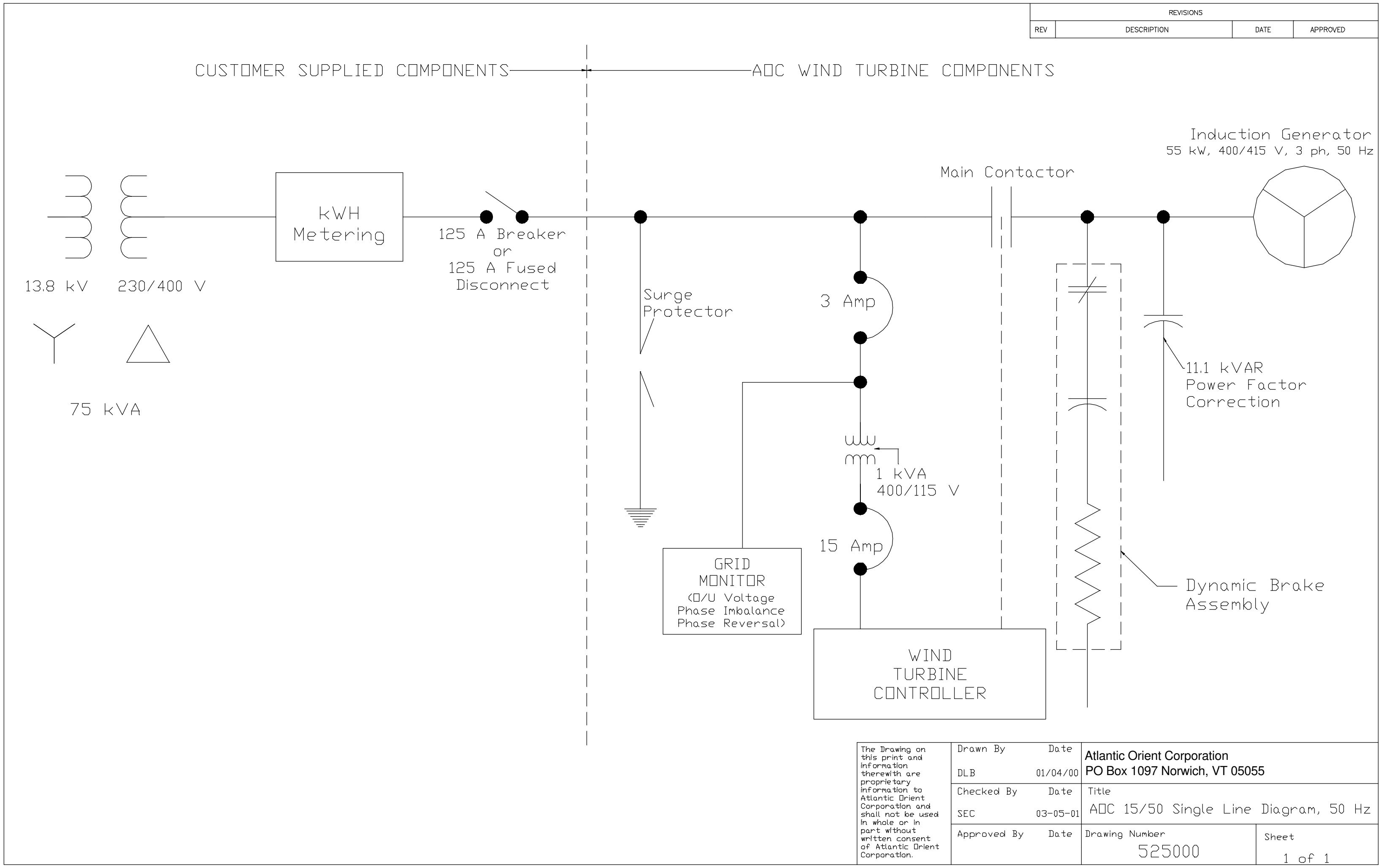
Appendix L: 50Hz Electrical Schematics

IMPORTANT

Schematics are site specific. The schematics in this appendix are provided for general planning information only. Please refer to as built schematics for accurate site specfic information.



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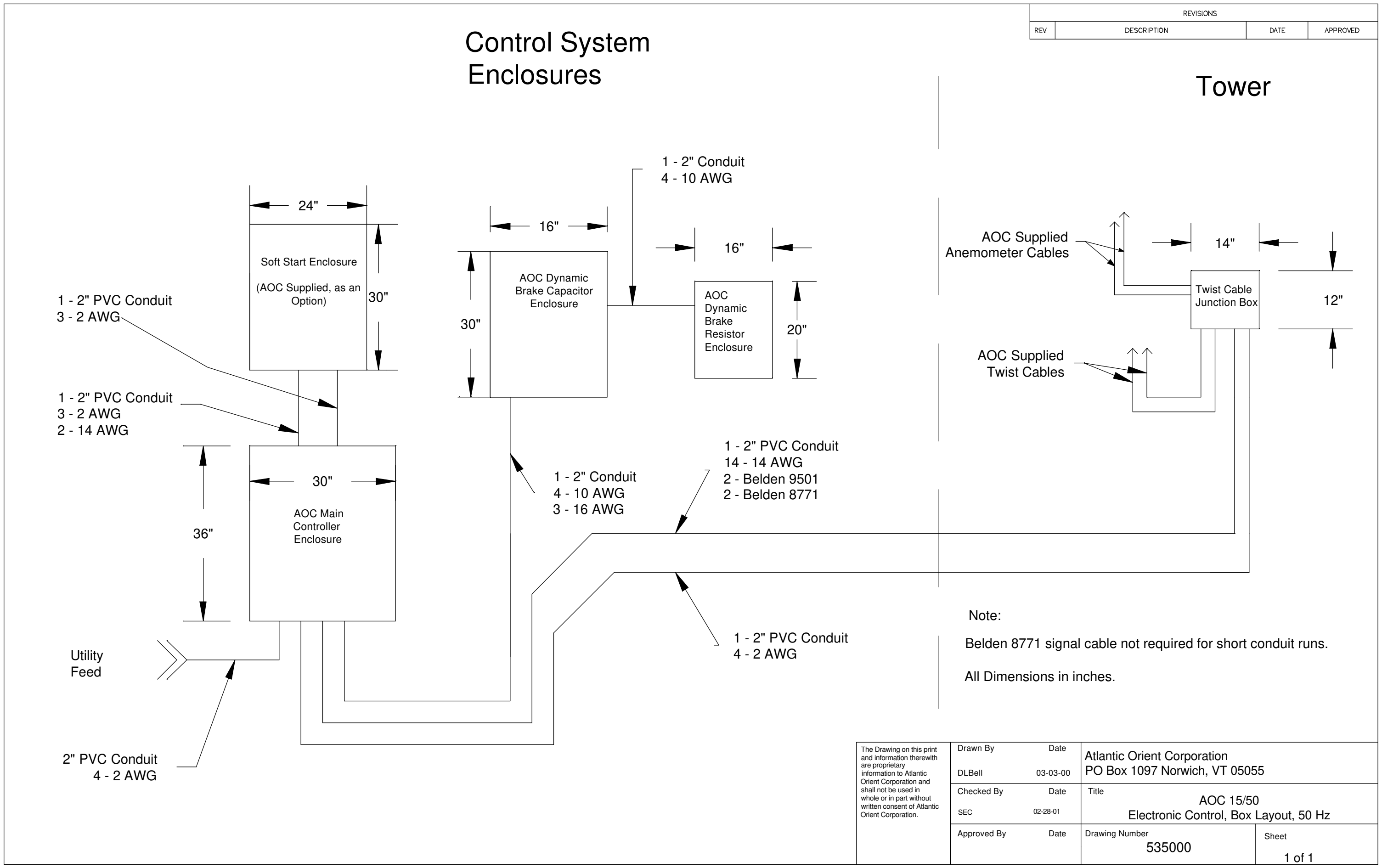

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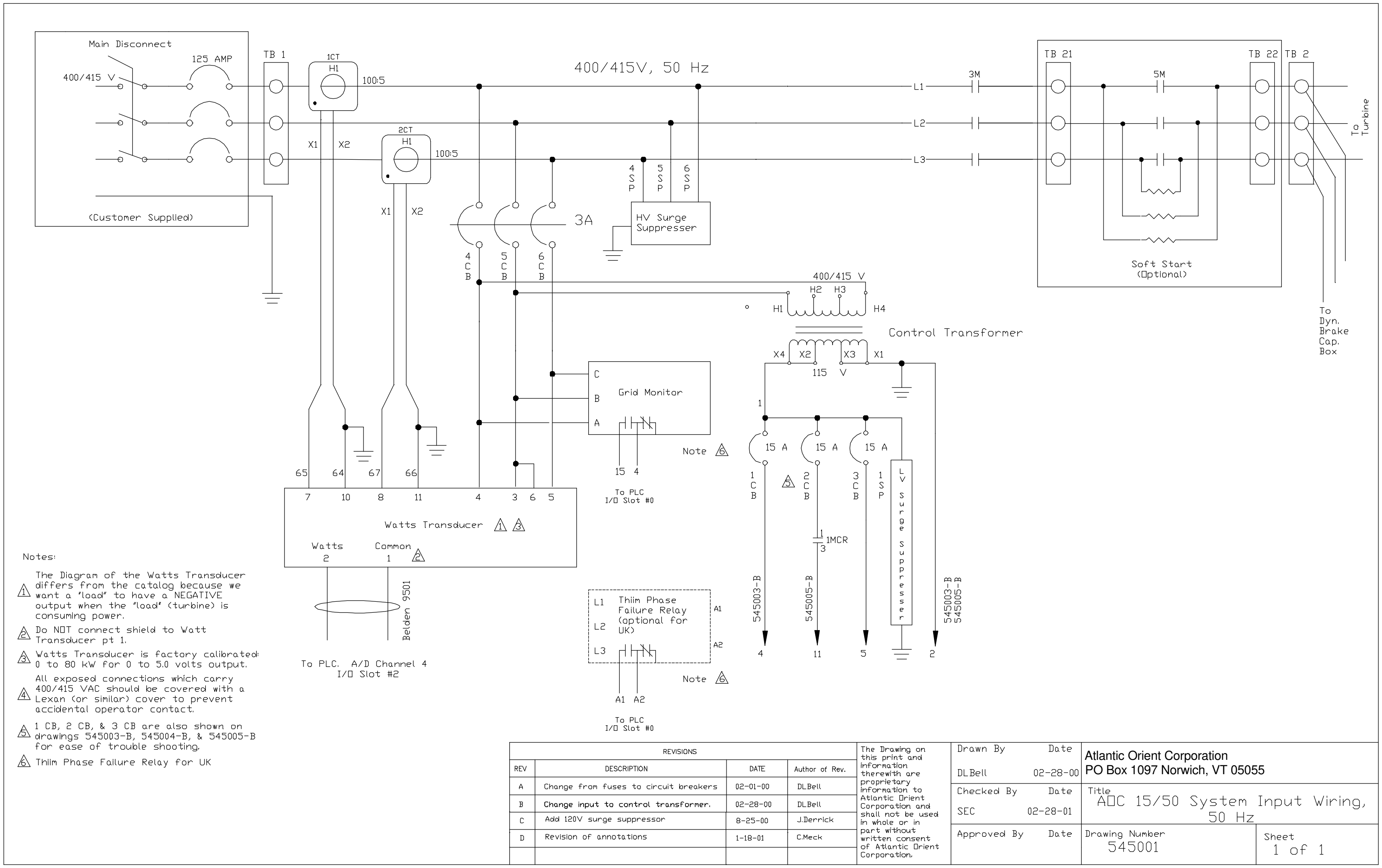

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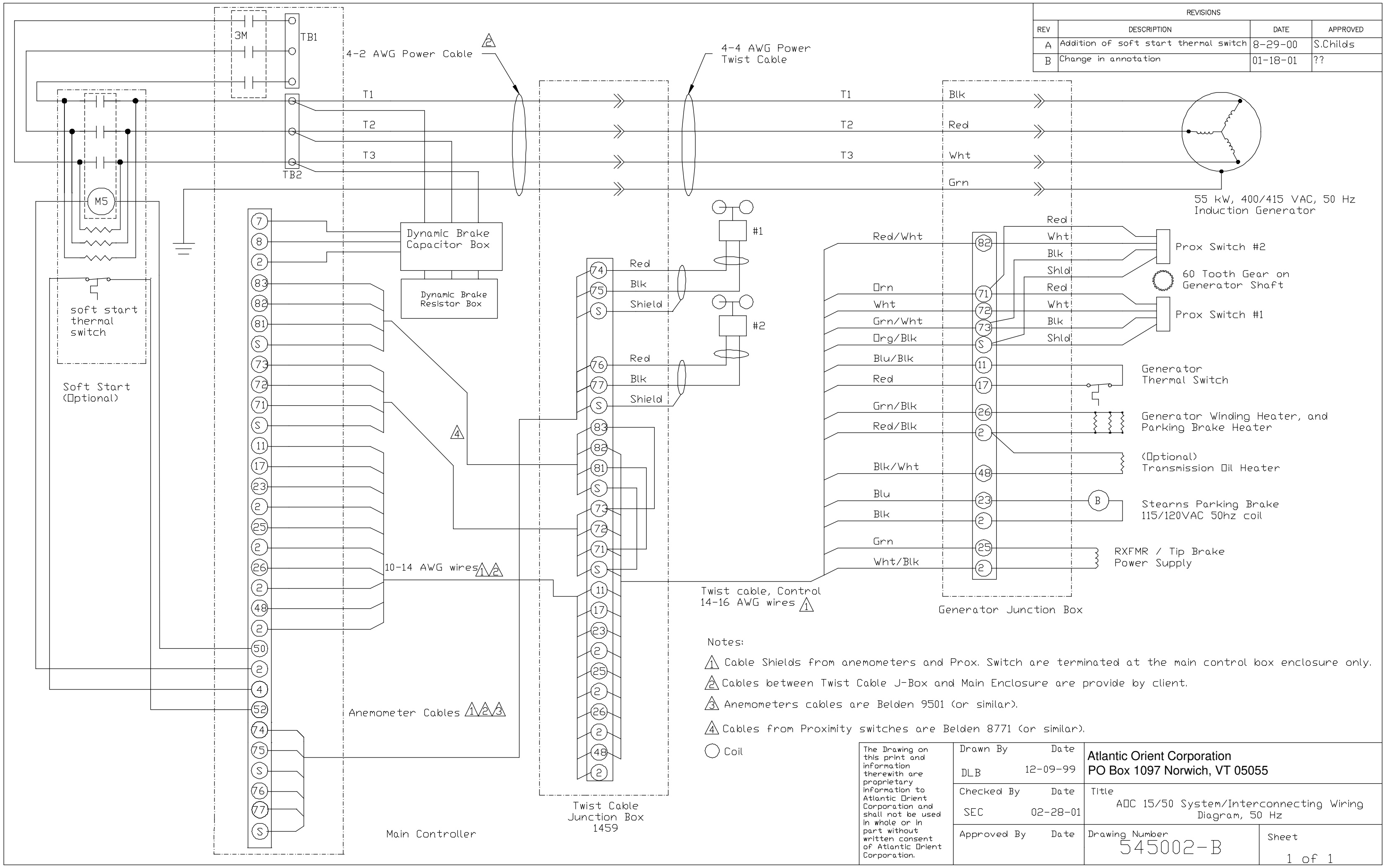

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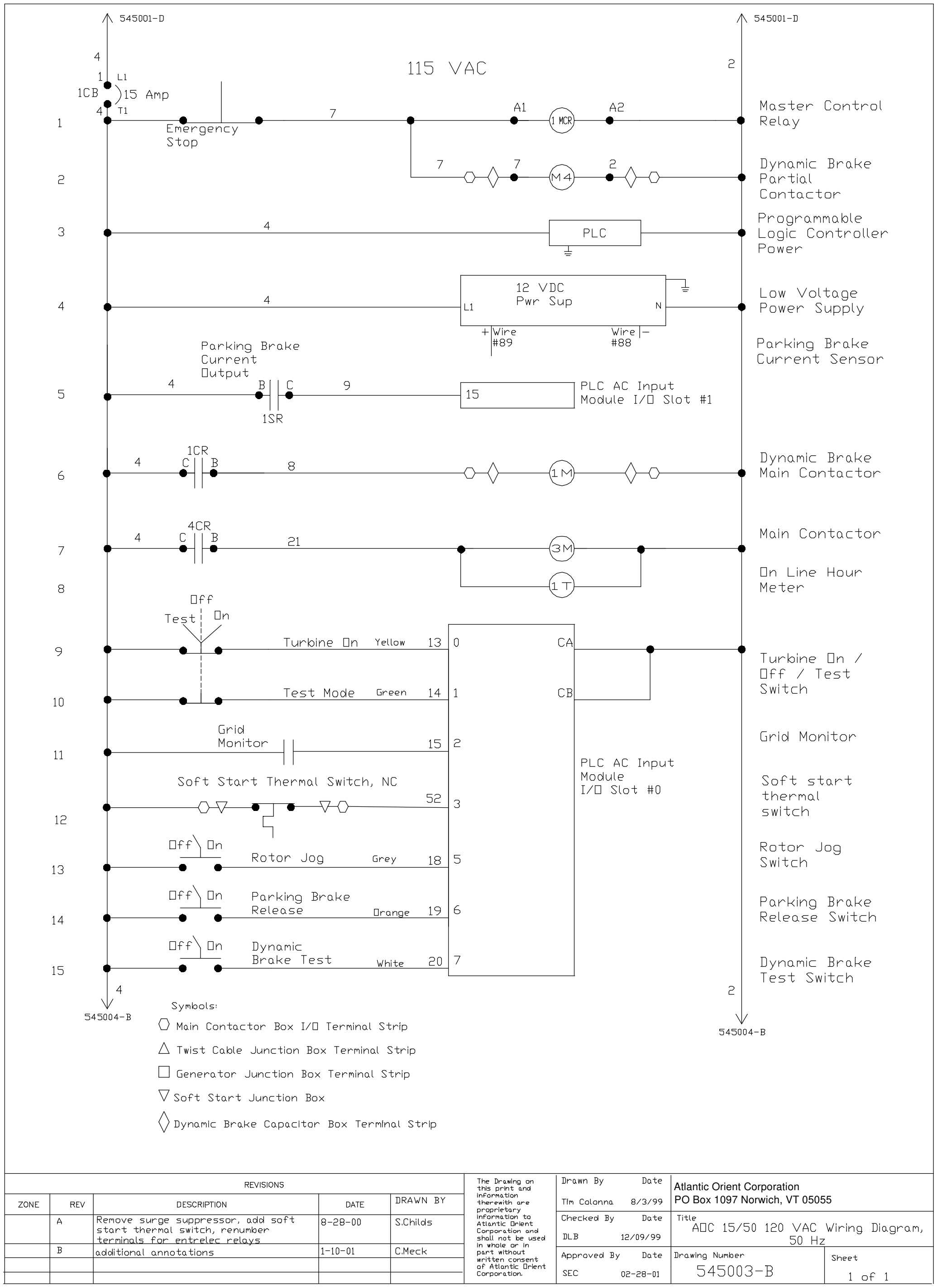

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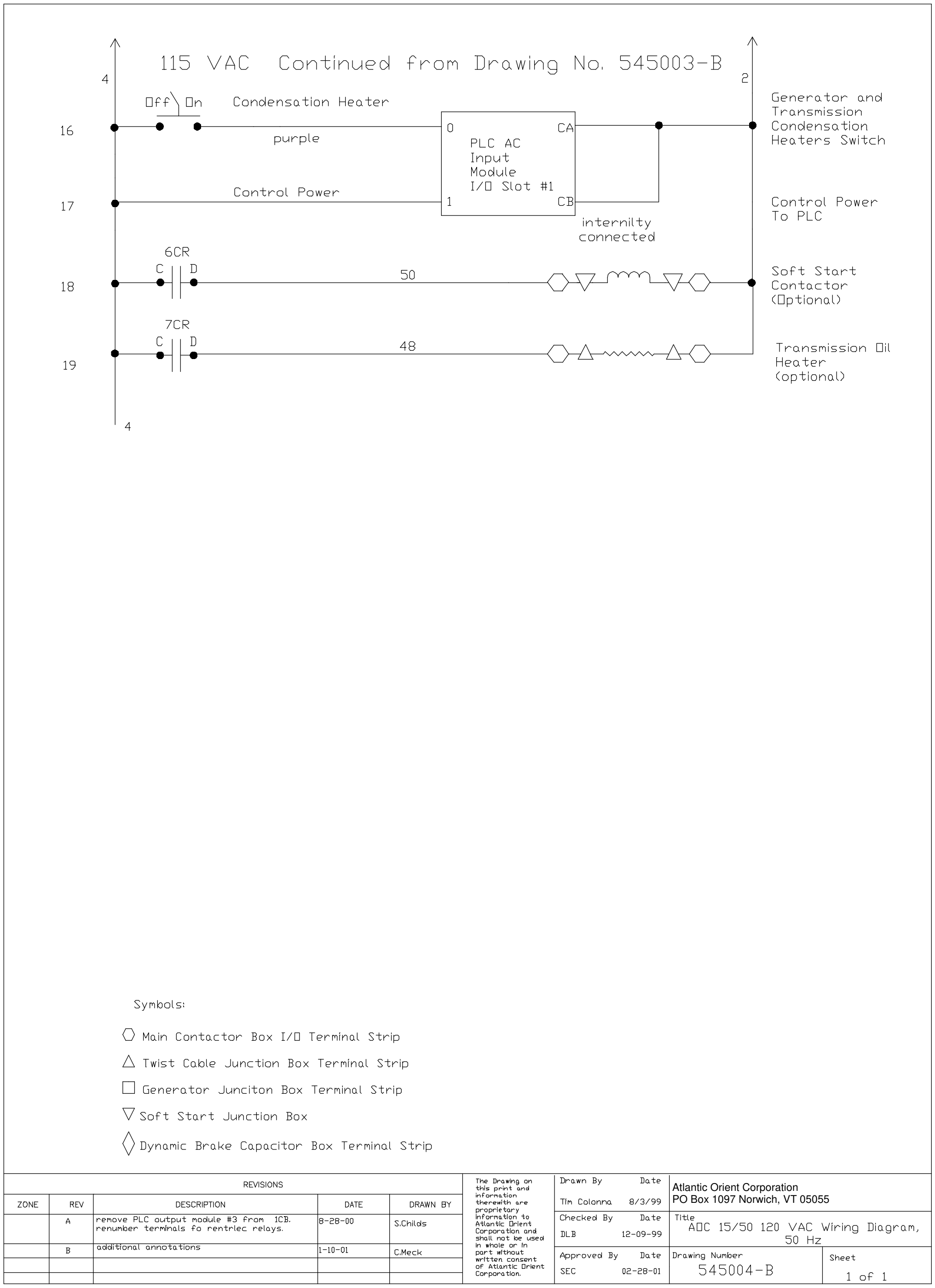

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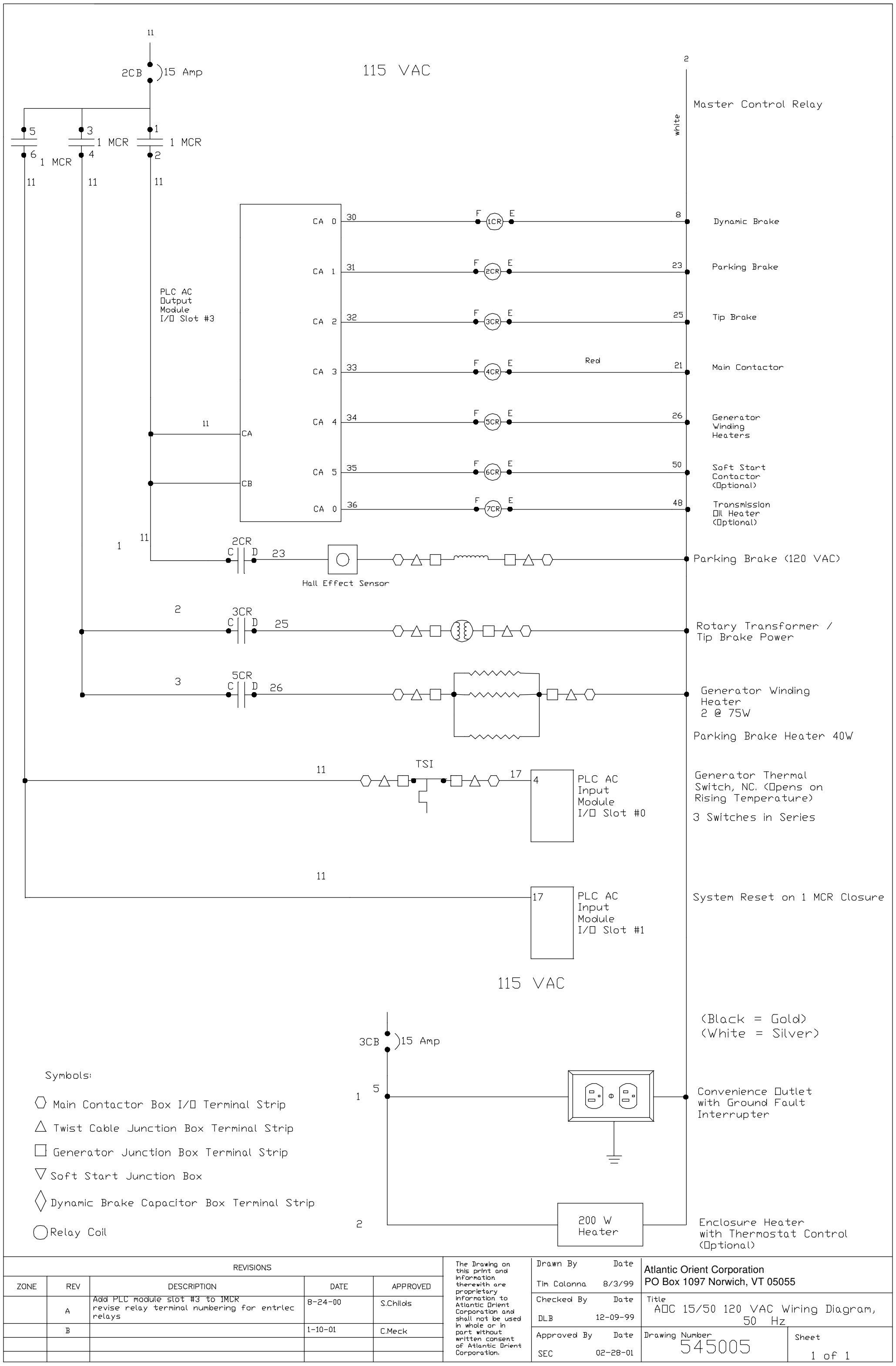

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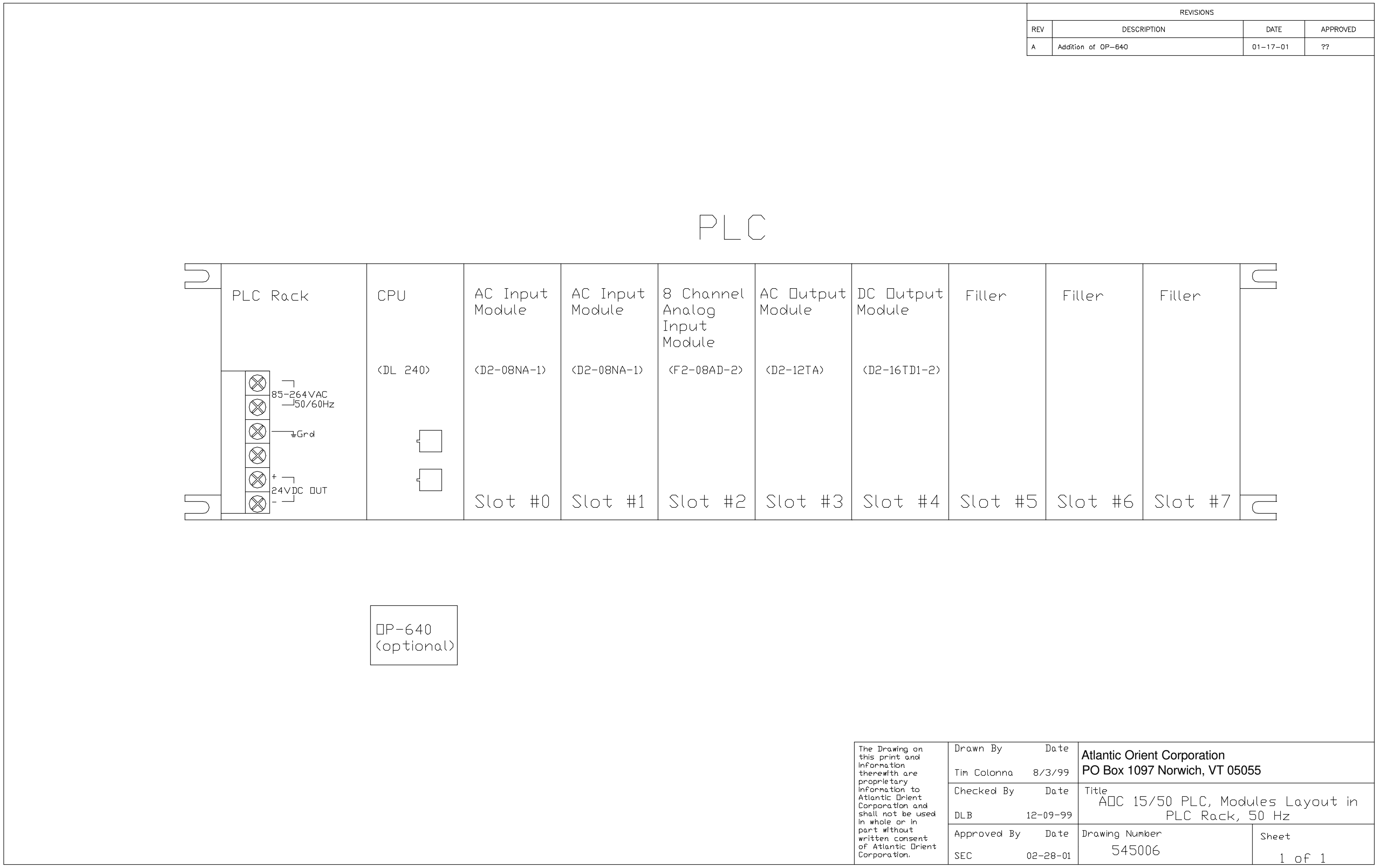

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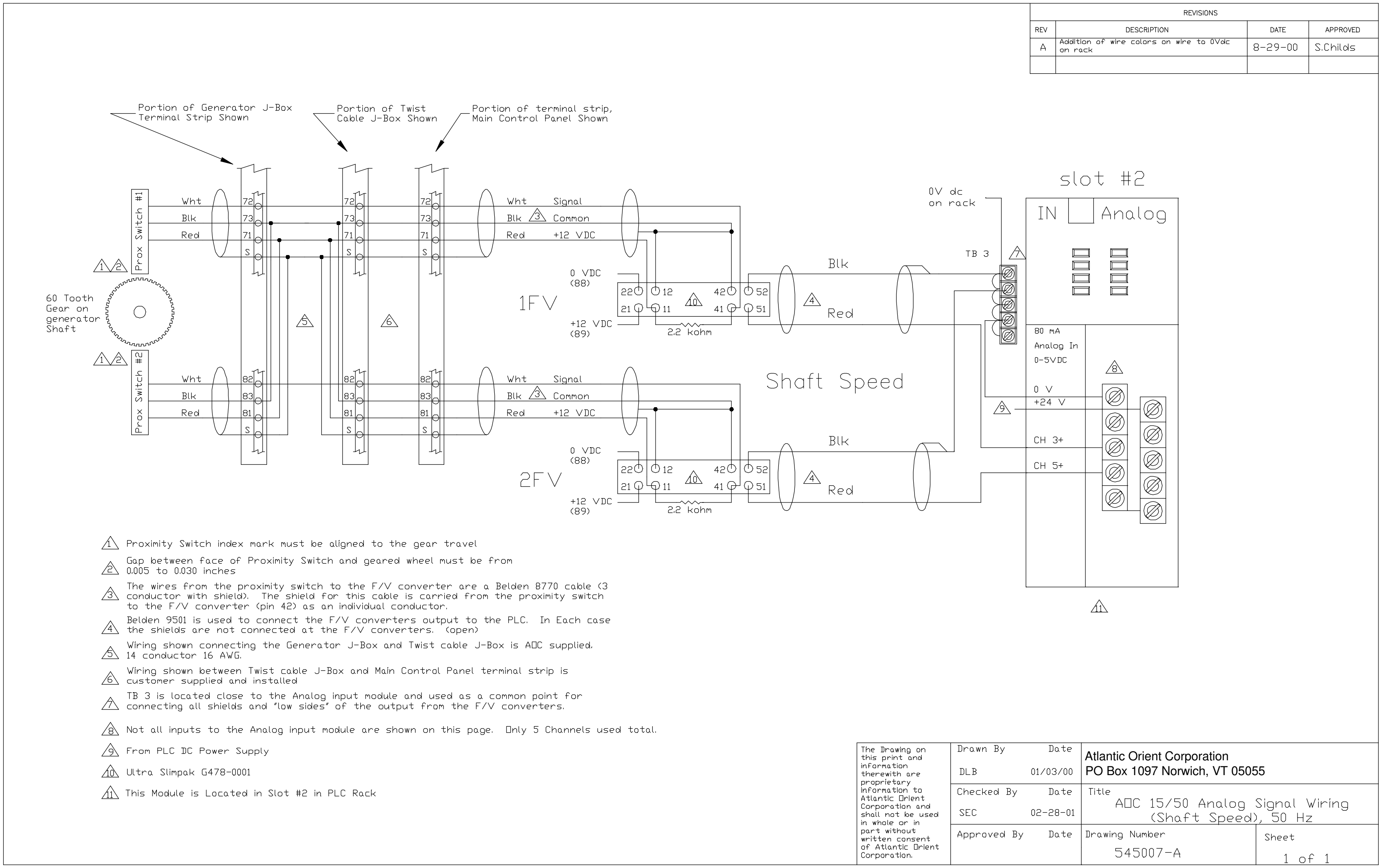

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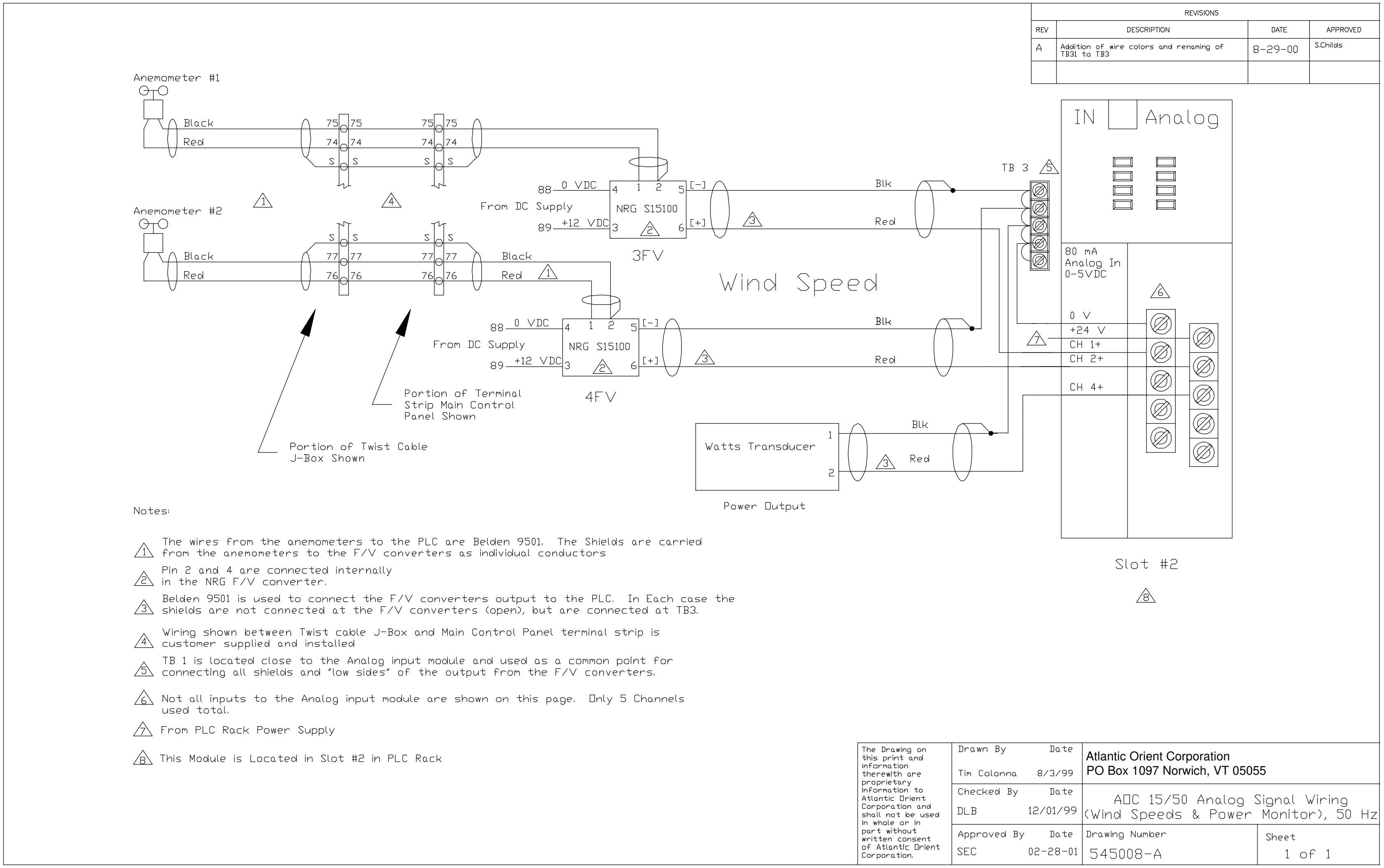

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REVISIONS			
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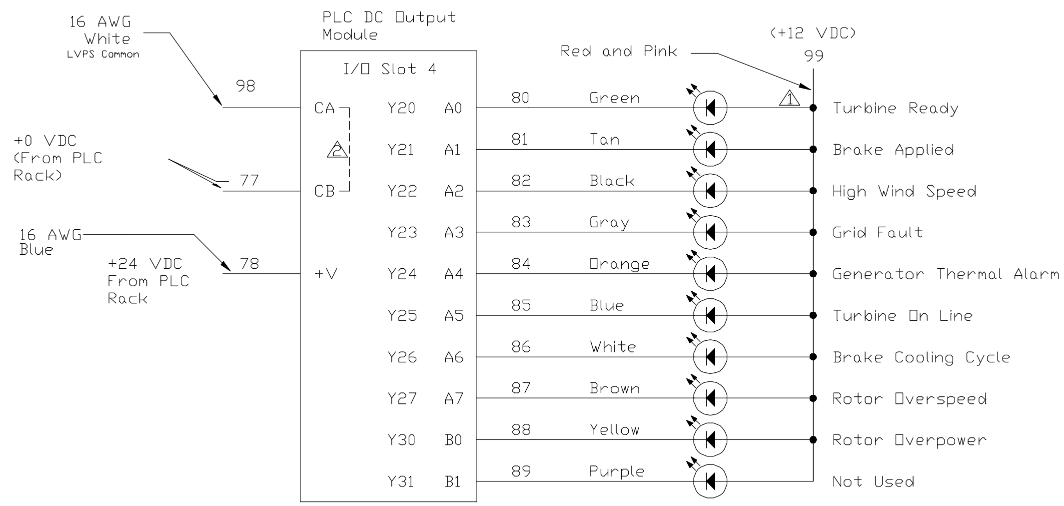
A	Relabelling of wire 77	8-29-00	S.Childs



Notes:

1. All Wires to the LED light panel are run in the Belden 8457 cable bundle.
2. Pins "CA" and "CB" are shorted internally in the Module.

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	Checked By: SEC Date: 02-28-01	Title: AOC 15/50 PLC DC Output Module Wiring, 50 Hz	
	Approved By: Date:	Drawing Number: 545009-A	Sheet: 1 of 1

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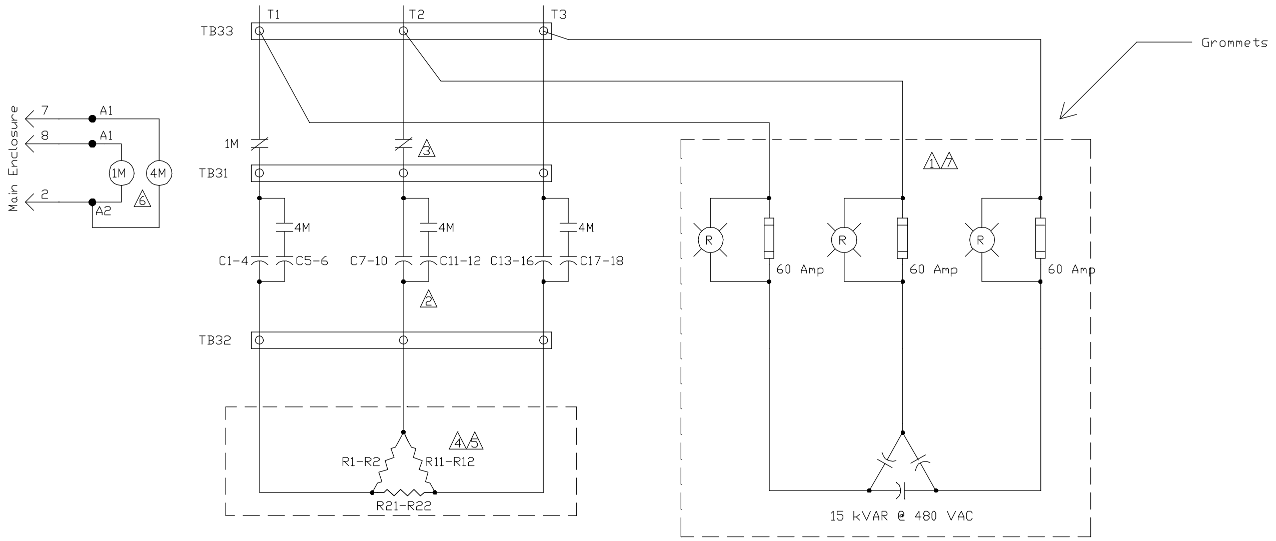
REVISIONS			
REV	DESCRIPTION	DATE	APPROVED
A	Relabelling TB1, TB2, TB3 to TB31, TB32, TB33	8-30-00	S.Childs



Notes:

1. Wires from the PFC to TB3 are 8 AWG. Black.
2. Wires from all capacitors to TB1 and to TB2 are 14 AWG. Black.
3. Wires from 1M contactor to TB3 are 10 AWG. Black.
4. Dynamic brake resistor network (R1, R2, R3) is located inside a separate enclosure.
5. Dynamic brake resistors: R1-R2 = R11-R12 = R21-22 = 9.0 ohms, 820 watts.
6. 4M is P/N D0910. 1M is P/N D12008. 4M is closed when grid power is applied.
7. The PFC Module has a nameplate rating of 22.5 kVAR @ 600 VAC. In the 480 VAC circuit, it provides 14.4 kVAR of Power Factor Correction.

(M) Coil

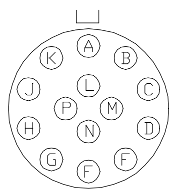
(R) Light

Drawn By	Date	Atlantic Orient Corporation PO Box 1097 Norwich, VT 05055	
Tim Colonna	8/2/99		
Checked By	Date	Title	
DLB	12-09-99	AOC 15/50 Dynamic Brake, Capacitor Box, 50 Hz	
Approved By	Date	Drawing Number	Sheet
SEC	02-28-01	545010-A	1 of 1

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED

Model #

Wiring to "Quick Disconnect" connector (Twist Cable Junction Box-Control Cable)

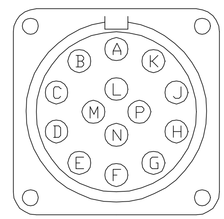


Solder tail view of cable connector

Rear View

MS3106R22-19S

A	48	Black/White
B	82	Red/White
C	73	Green/White
D	71	Orange
E	23	Blue
F	2	White/Black
G	2	Red/Black
H	26	Green/Black
J	S	Orange/Black
K	11	Blue/Black
L	72	White
M	17	Red
N	25	Green
P	2	Black



Solder tail view of box connector

Front View

Cannon

MS3100R27-19S

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	Checked By SEC Date 03-01-01	Title AOC 15/50 Control Cable (Twist Cable) Connector Wiring, 50 Hz	
	Approved By Date	Drawing Number 545011	Sheet 1 of 1

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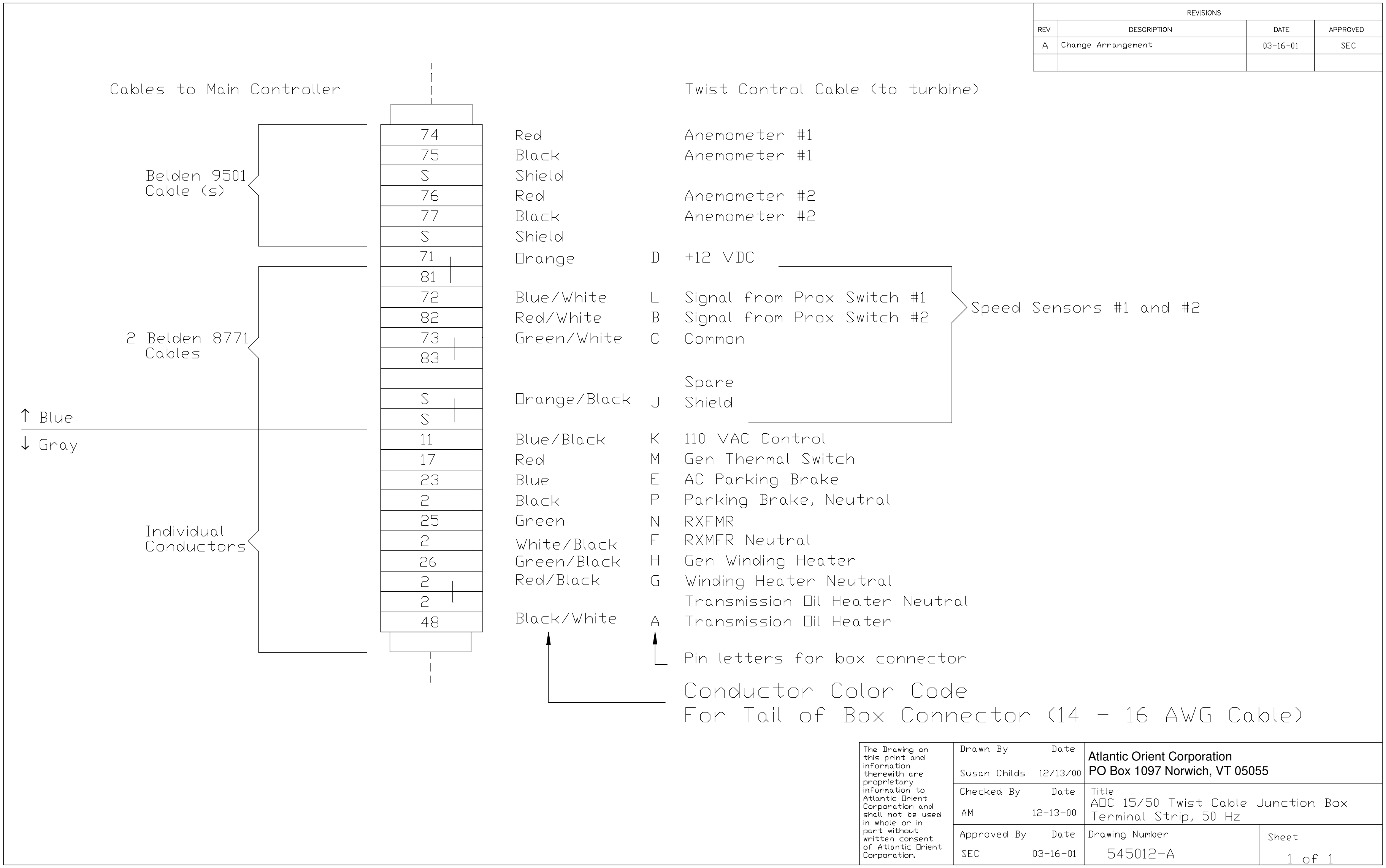
REVISIONS
REV | DESCRIPTION | DATE | APPROVED
A | Change Arrangement | 03-16-01 | SEC
Cables to Main Controller
Twist Control Cable (to turbine)
Belden 9501 Cable (s)
2 Belden 8771 Cables
Individual Conductors
↑ Blue
↓ Gray
74 Red Anemometer #1
75 Black Anemometer #1
S Shield
76 Red Anemometer #2
77 Black Anemometer #2
S Shield
71 Orange D +12 VDC
81
72 Blue/White L Signal from Prox Switch #1
82 Red/White B Signal from Prox Switch #2
73 Green/White C Common
83
Speed Sensors #1 and #2
Spare
S Orange/Black J Shield
S
11 Blue/Black K 110 VAC Control
17 Red M Gen Thermal Switch
23 Blue E AC Parking Brake
2 Black P Parking Brake, Neutral
25 Green N RXFMR
2 White/Black F RXMFR Neutral
26 Green/Black H Gen Winding Heater
2 Red/Black G Winding Heater Neutral
2 Transmission Oil Heater Neutral
48 Black/White A Transmission Oil Heater
Pin letters for box connector
Conductor Color Code
For Tail of Box Connector (14 - 16 AWG Cable)
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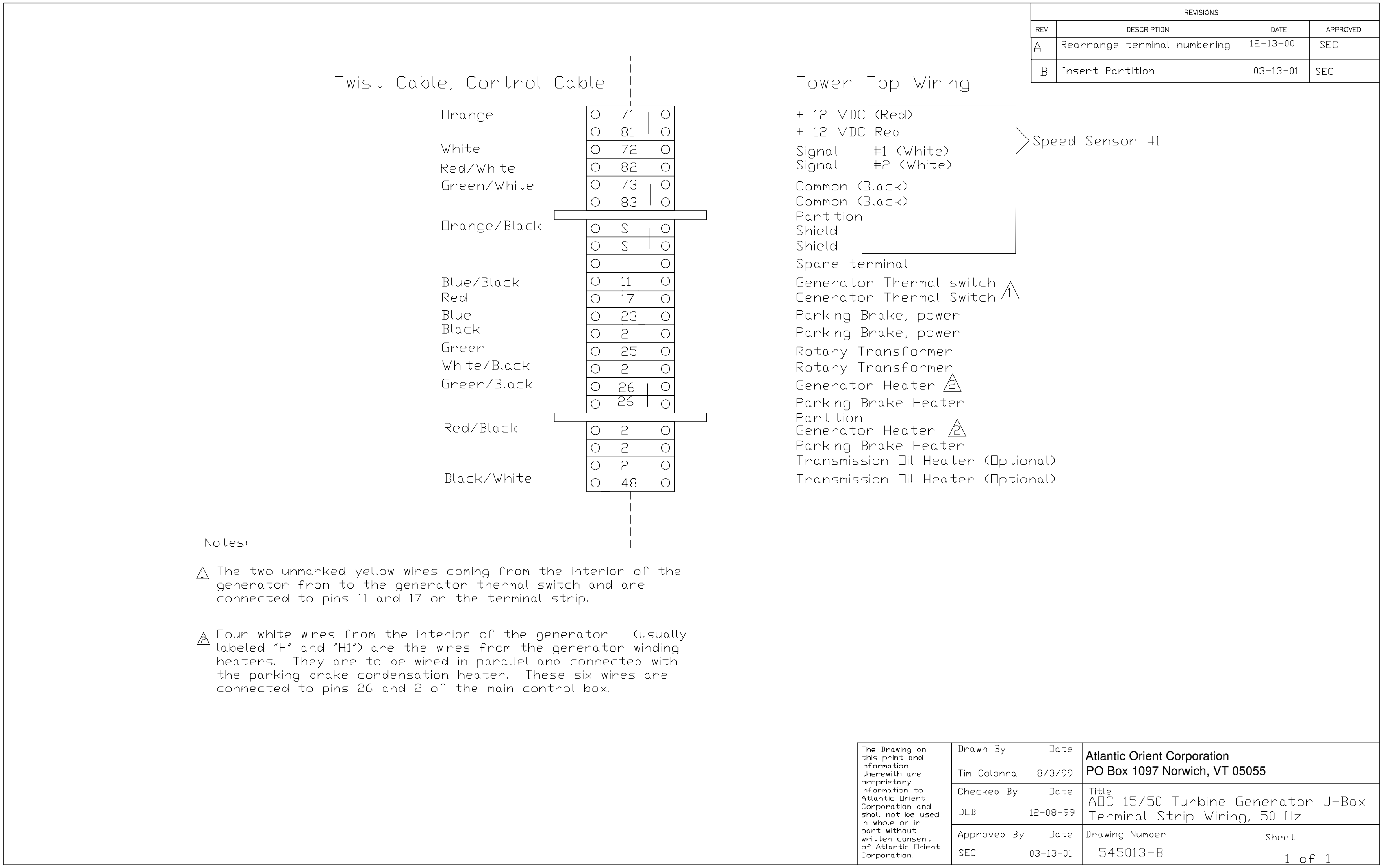
Drawn By Date
Susan Childs 12/13/00
Atlantic Orient Corporation
PO Box 1097 Norwich, VT 05055
Checked By Date
AM 12-13-00
Title
AOC 15/50 Twist Cable Junction Box Terminal Strip, 50 Hz
Approved By Date
SEC 03-16-01
Drawing Number
545012-A
Sheet
1 of 1



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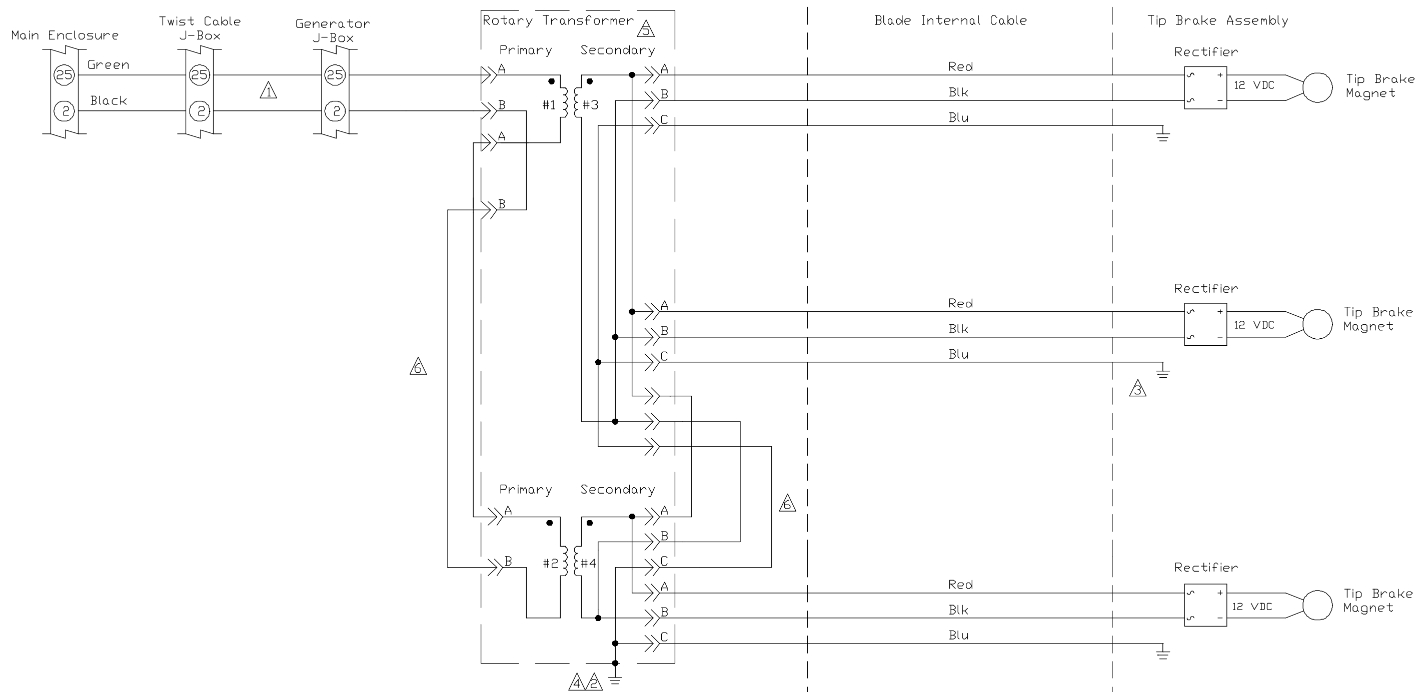

Notes:

1. Only a portion of the generator Junction box terminal strip, tower junction box strip terminal strip, and the main enclosure terminal strip are shown here.
2. Internal grounding to the rotary transformer secondary casting housing.
3. Grounding wire attached to the Damper Bracket on the Tip Brake Assembly.
4. External braided wire connects the casting to the hub.
5. With 120 VAC input to Rotary Transformer, expect 18 - 20 VAC output on each of the secondary plugs. This output is a function of the gap.
6. Temper Cable Assembly, 1'5'' with 3pm connectors AOC part # 10276

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	Checked By SEC — Date 03-01-01	Title AOC 15/50 Tip Brake Power Wiring, and Wiring to Rotary Transformer, 50 Hz		
	Approved By — Date	Drawing Number 545014	Sheet 1 of 1	

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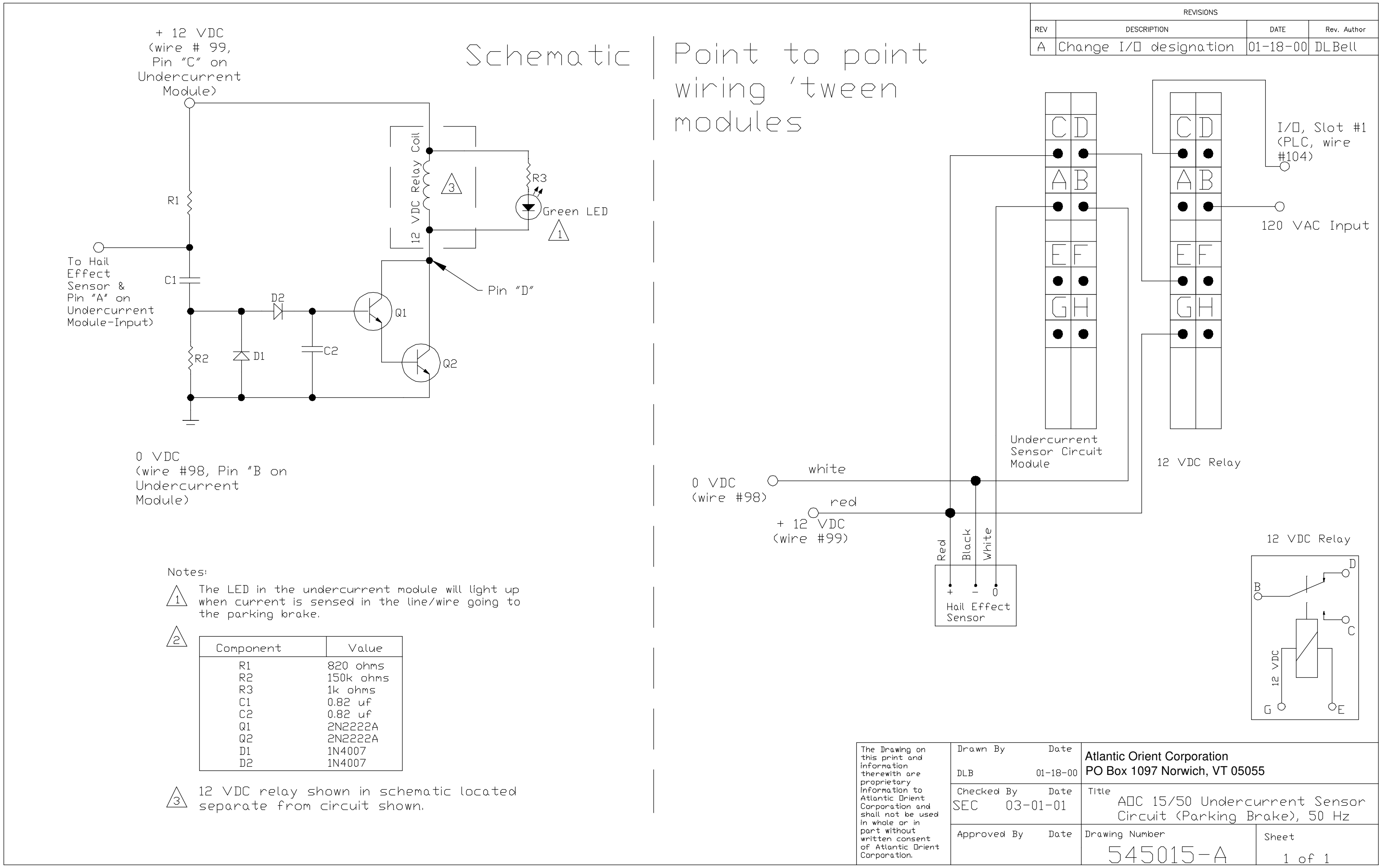

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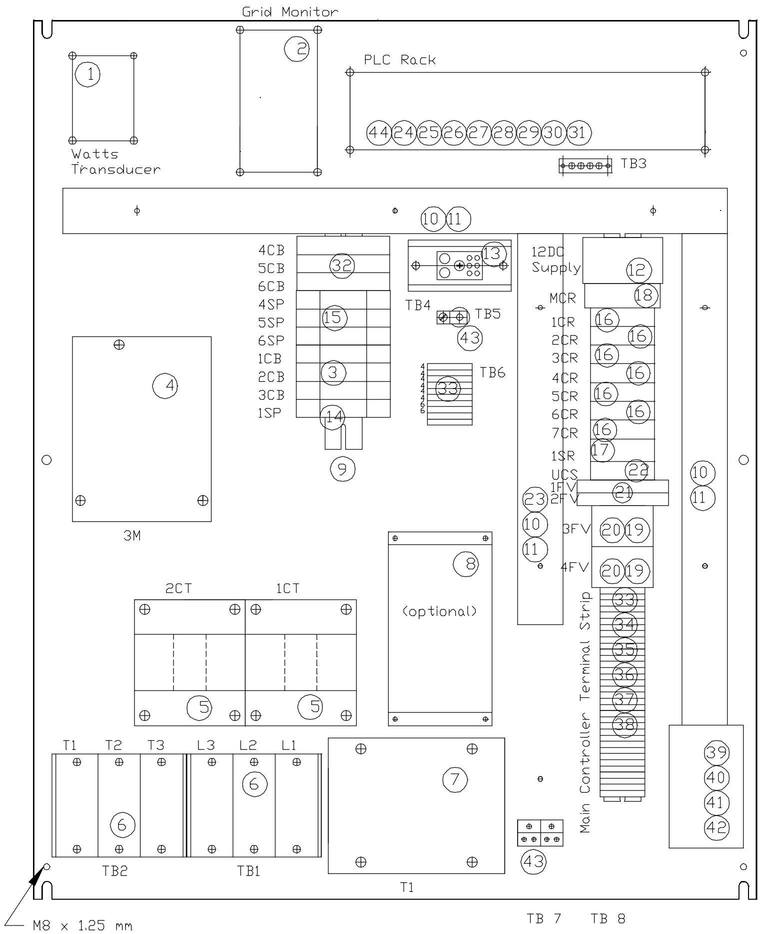
REVISIONS		
DESCRIPTION	DATE	APPROVED
RELABLED AND AMENDED DRAWING	01-03-01	??



Item	Qty.	Description	AOC Part No.
1	1	Power Monitor, Watts Transducer	10317
2	1	Grid Monitor	10318
3	3	Circuit Breaker, 15 amp, 1 pole, 250 volt	10382
4	1	Main Contactor	10313
5	2	Current Transformer(s), 100:5	10316
6	2	Power Terminal Blocks	10370
7	1	1 KVA Control Transformer, 60 Hz	10312
8	1	Enclosure Heater, 200 Watt (optional)	10314
9	1	35 mm Din Rail, 7.5 mm	10093
10	1	Pan Duit Wire Channel	10340
11	1	Pan Duit Wire Channel Covers	10341
12	1	12 VDC Power Supply	10406
13	1	Terminal Block	10379
14	1	Low Voltage Surge Suppresser	10403
15	3	High Voltage Surge Suppresser, 1 phase	10394
16	7	120 VAC SPDT Relay Module	10410
17	1	12 VDC SPDT Relay	10407
18	1	120 VAC DPDT, Master Control Relay	10408
19	2	Freq. to Volt. Converter (Wind Speed), W/B	10305
20	2	Octal Base	10308
21	2	Freq. to Volt. Converter (Shaft Speed)	10305
22	1	Undercurrent Sensor Module, 60 Hz	1477
23	1	Ferrite Core (Hall Effect Sensor)	10319
24	1	PLC Rack 9 Bay, W/Power Supply	10320
25	2	PLC, AC input module, 8 point	10321
26	1	PLC, AC output module, 12 point	10322
27	1	PLC, DC output module, 16 point	10323
28	1	PLC, CPU, DL 240 processor	10324
29	1	PLC, battery for CPU	10325
30	1	PLC, Analog input module, 8 channel	20326
31	3	PLC, filler module	10327
32	1	Circuit Breaker, 3 amp, 3 pole, 480 VAC	10399
33	20	Terminal Block, 1 pole (Grey)	20090
34	14	Terminal Block, 1 pole (Blue)	10187
35	2	Terminal Block, end barrier	20091
36	3	Terminal Block, Slip in partition	20092
37	1	Terminal Block,jumper	10185
38	34	Terminal Block, Markers	10186
39		Outlet Receptacle Enclosure	10149
40	1	Outlet receptacle, GFI, 20 amp	10369
41	1	Outlet Conduit Adapter	10150
42	1	Outlet Cover	N/C
43	3	Grounding Lug (set screw lug)	10089
44	1	Shielded Cable OP640 to RS232 (optional)	10670
45		last item	
46			
47			
48			
49			

Drawn By: DLB Date: 12-15-99

Checked By: SEC Date: 03-06-01

Approved By: Date:

Atlantic Orient Corporation
PO Box 1097 Norwich, VT 05055

Title: AOC 15/50, Main Control Box/Panel Assembly Drawing, 50 Hz

Drawing Number: 555005-A

Sheet: 1 of 1

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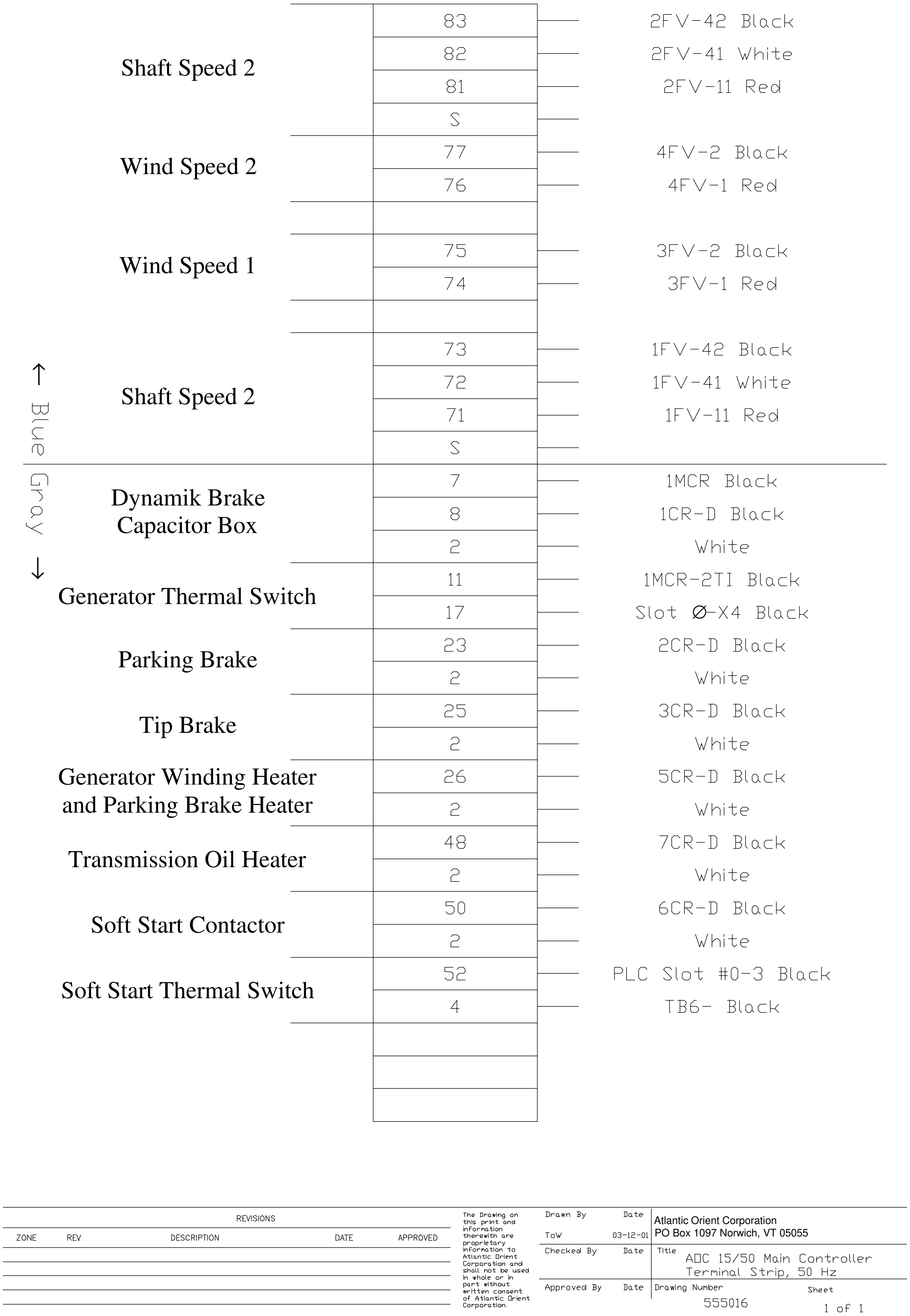

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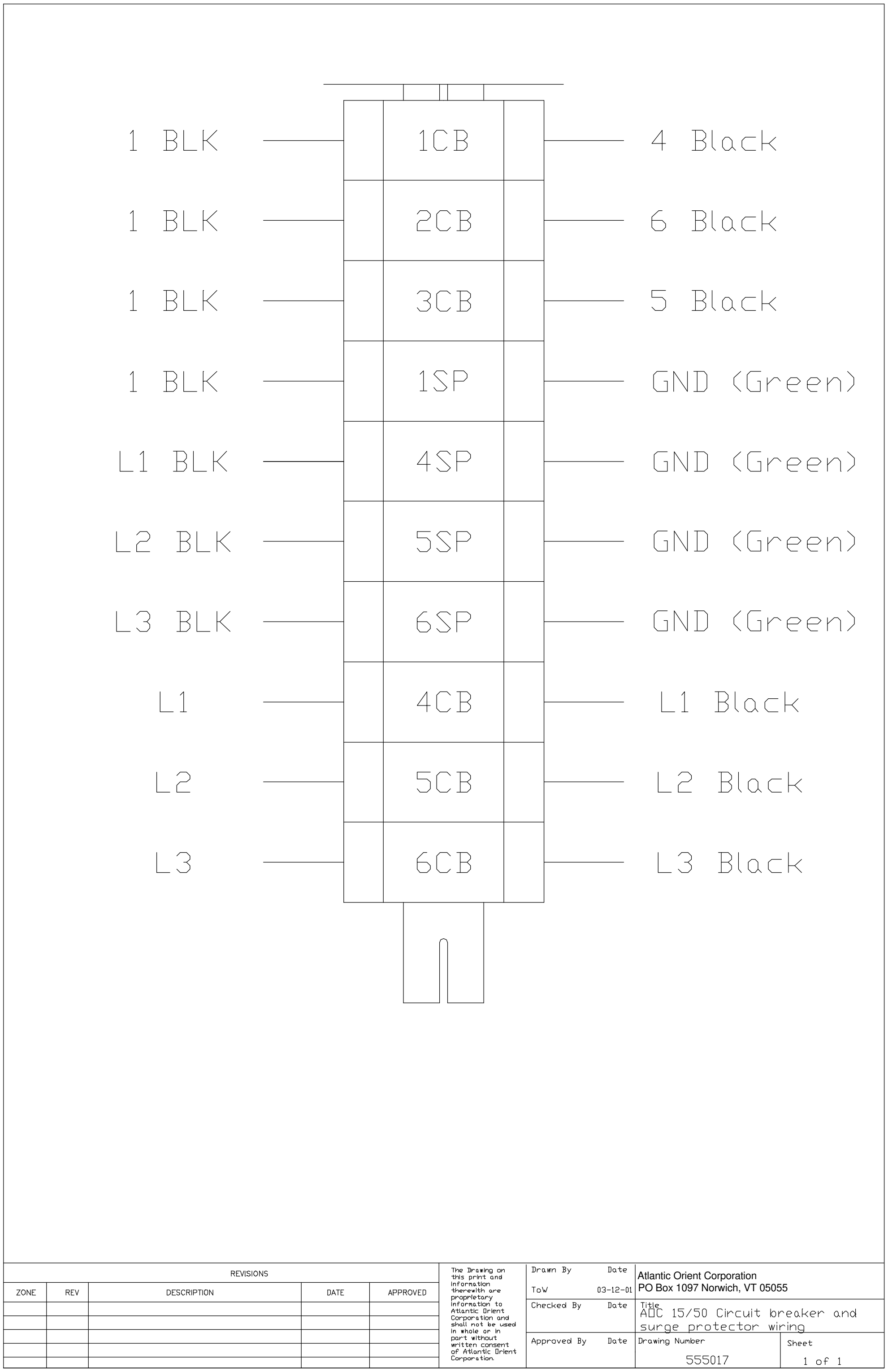

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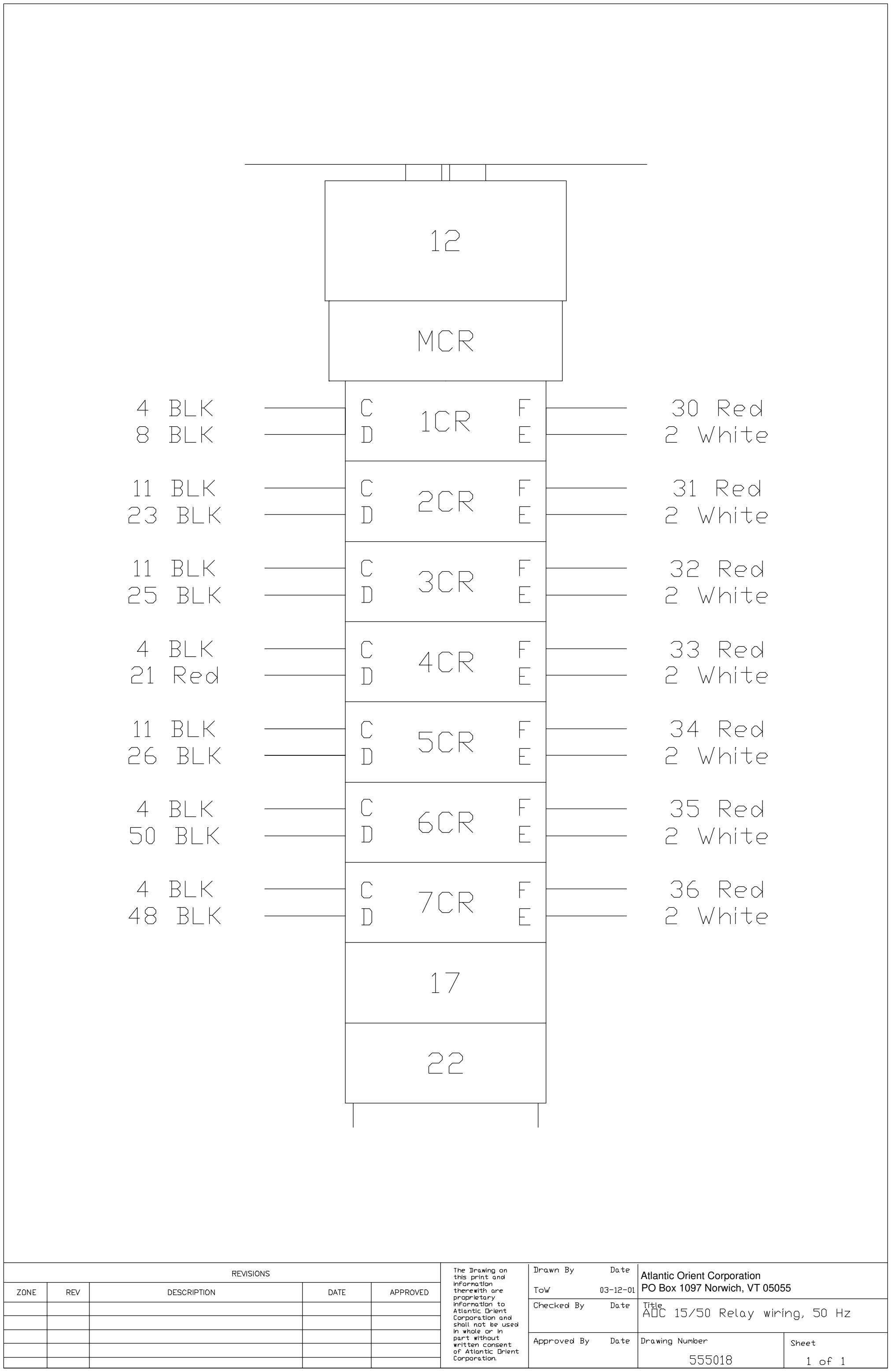

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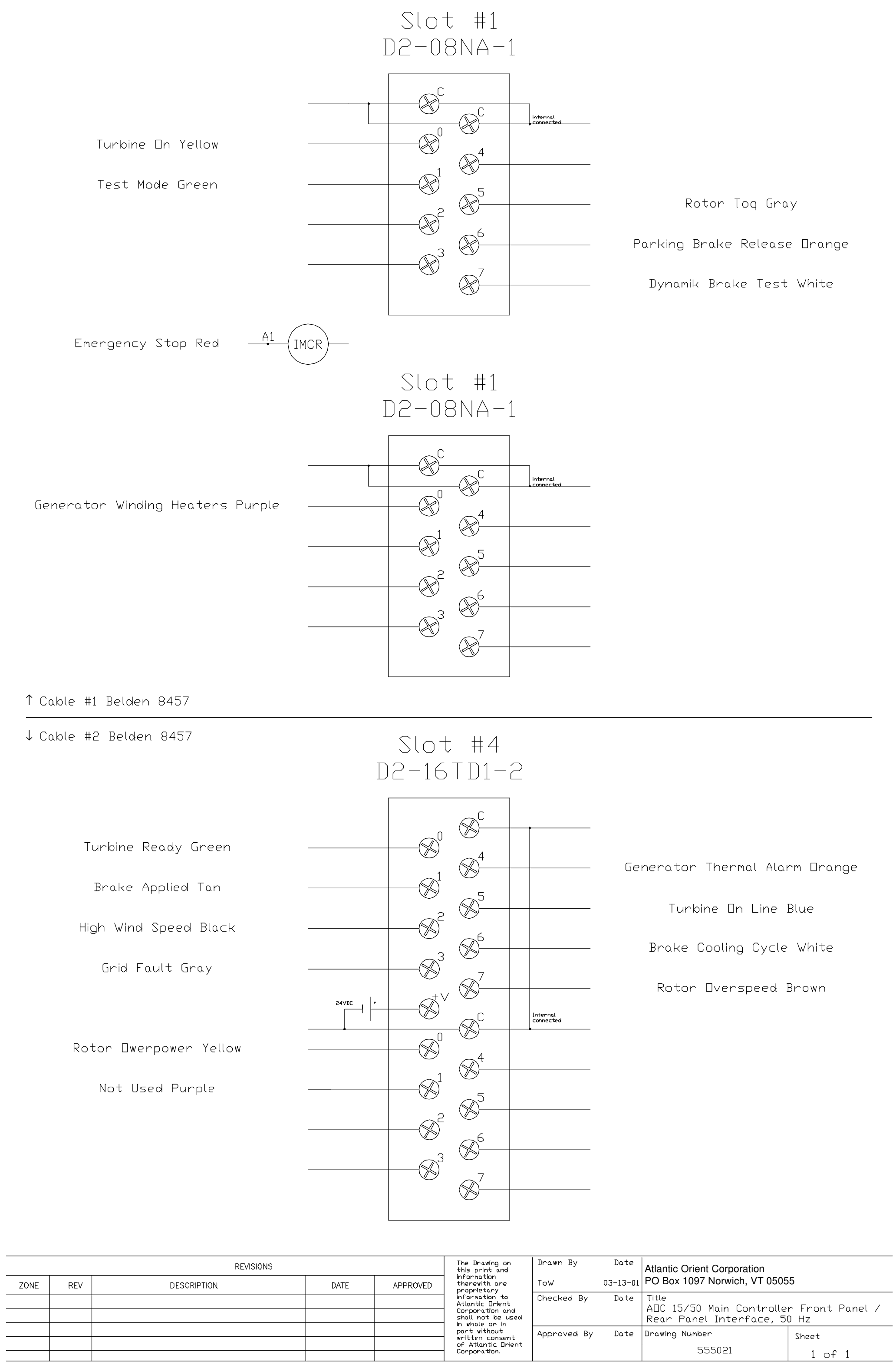

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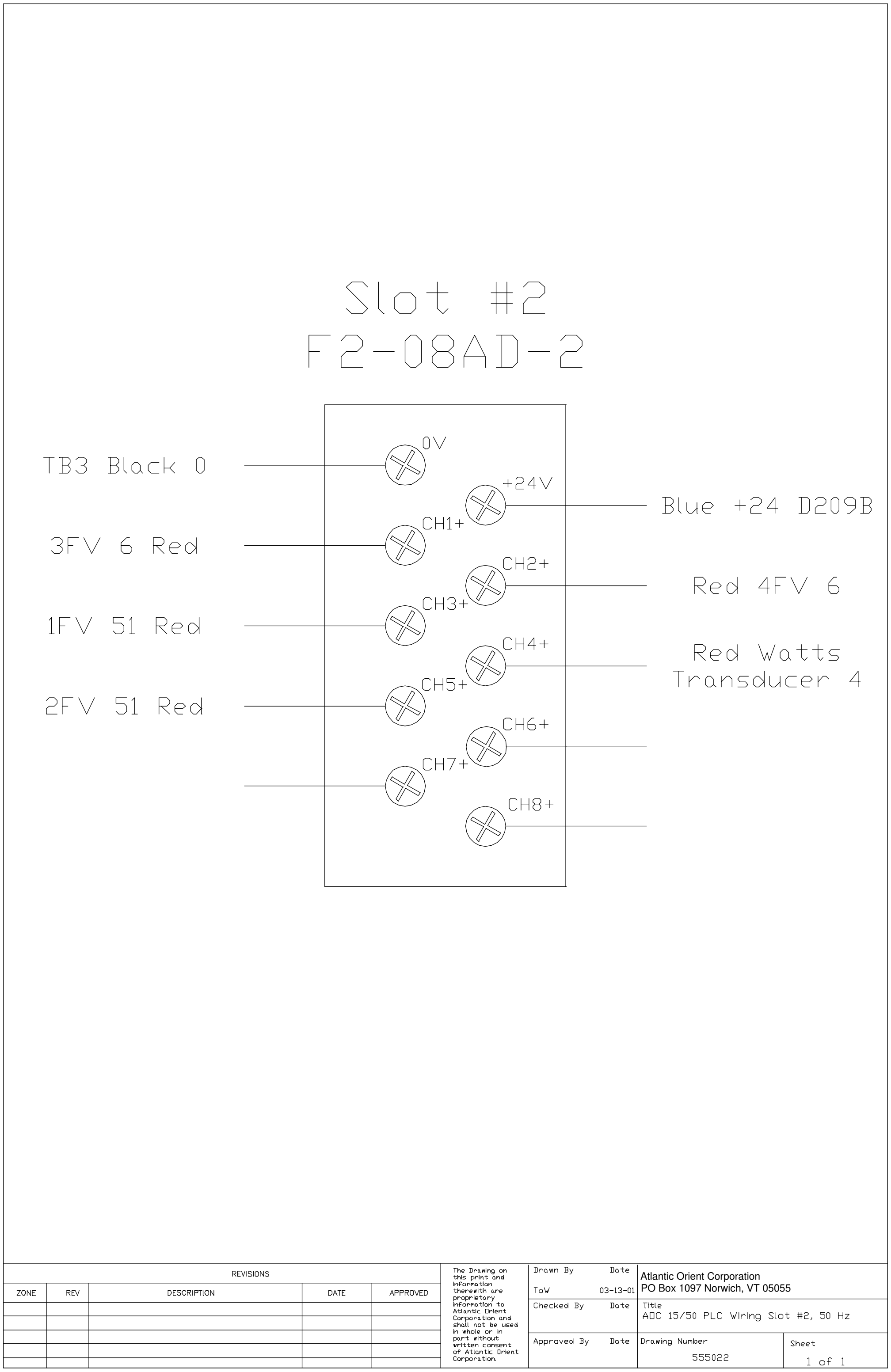

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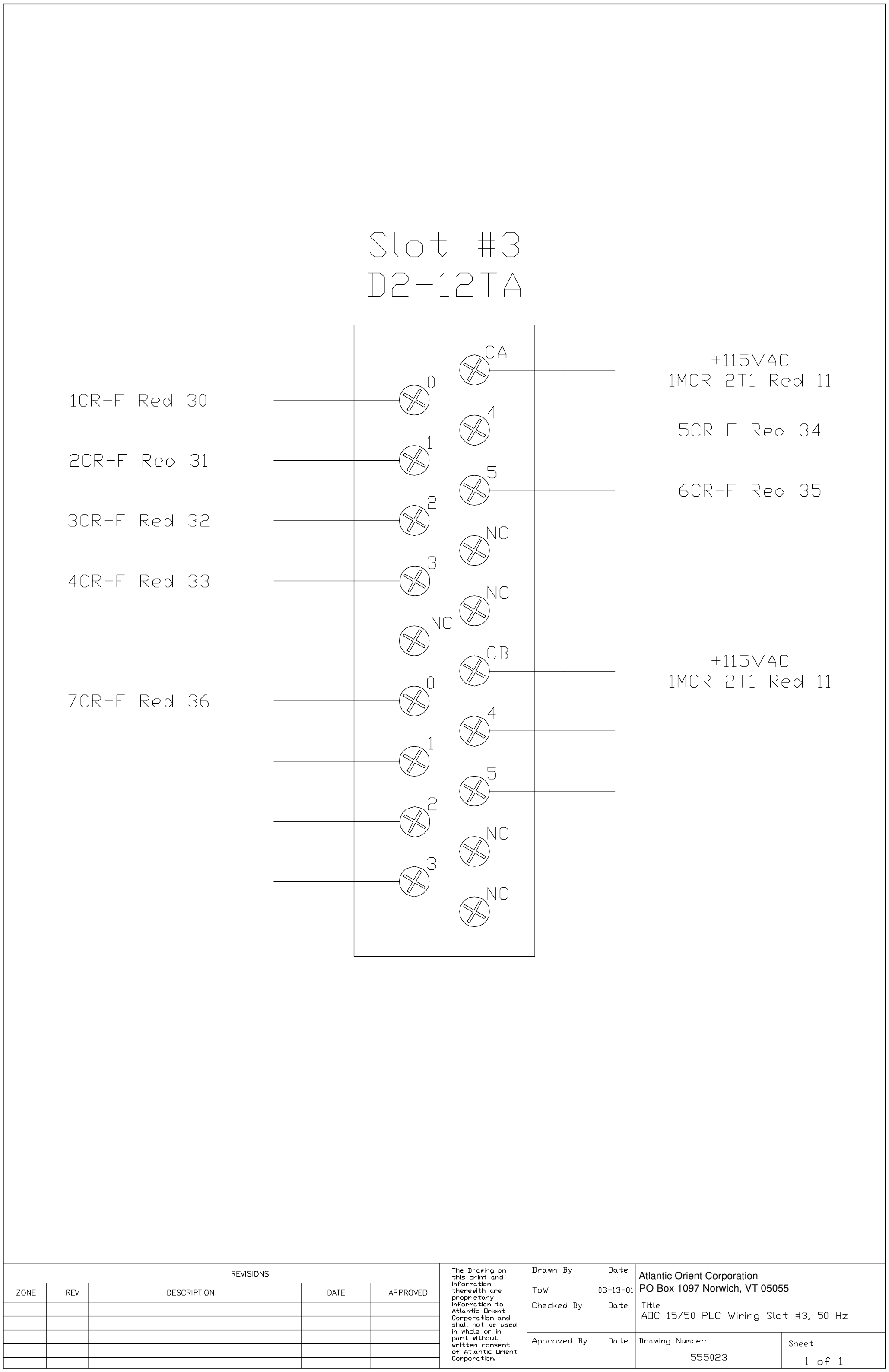

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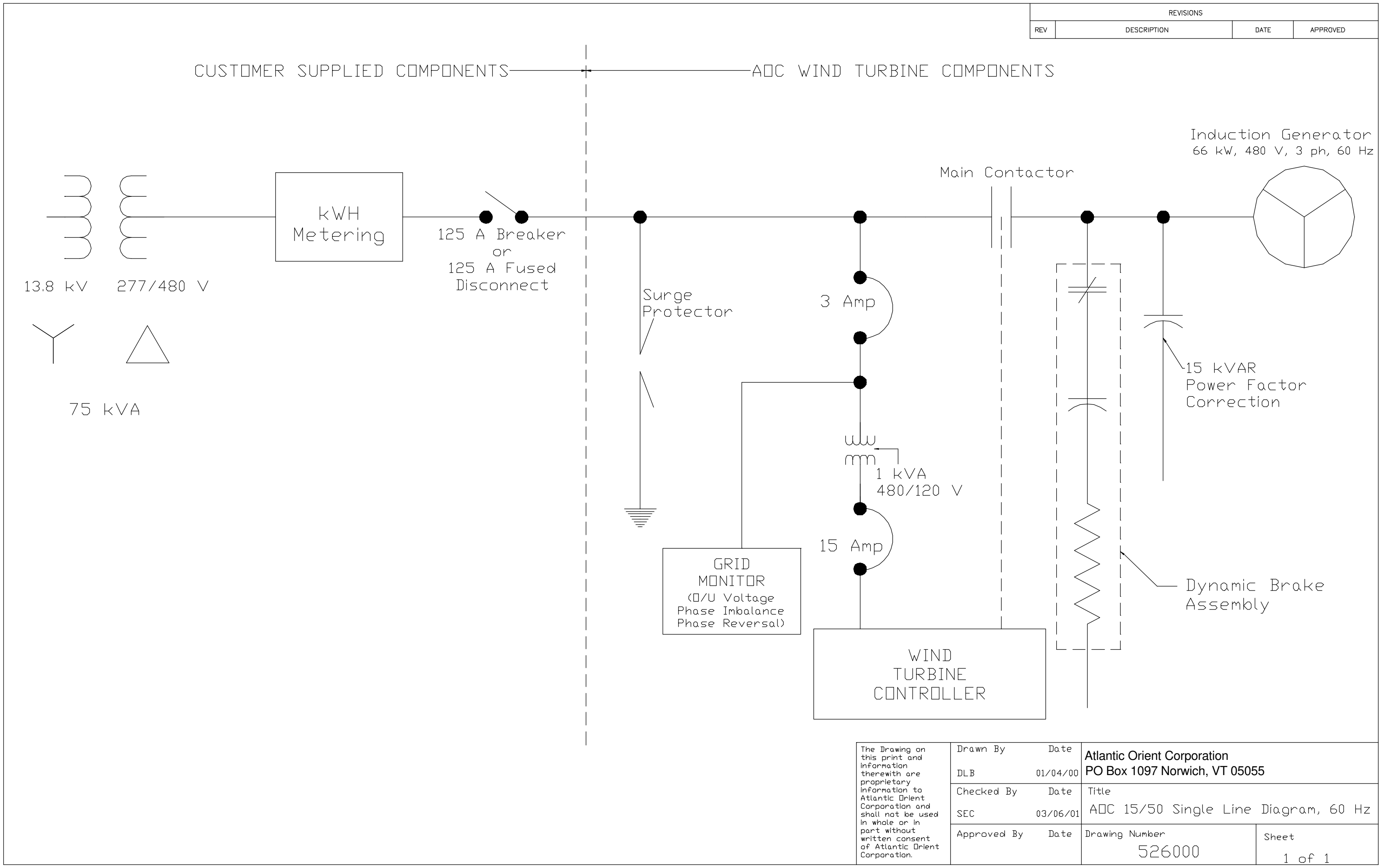
Appendix M: 60 Hz Electrical Schematics

IMPORTANT

Schematics are site specific. The schematics in this appendix are provided for general planning information only. Please refer to as built schematics for accurate site specfic information

Drawing Number	Latest Rev	Date	Title
526000		3/6/01	AOC 15/50 Single Line Diagram, 60 Hz
536000		3/6/01	AOC 15/50 Electronic Control, Box Layout, 60 Hz
546001	D	3/6/01	AOC 15/50 System Input Wiring, 60 Hz
546002	B	3/6/01	AOC 15/50 System/Interconnecting Wiring Diagram, 60 Hz
546003	B	3/6/01	AOC 15/50 120 VAC Wiring Diagram, 60 Hz
546004	B	3/6/01	AOC 15/50 120 VAC Wiring Diagram, 60 Hz
546005	B	3/6/01	AOC 15/50 120 VAC Wiring Diagram, 60 Hz
546006	A	3/6/01	AOC 15/50 PLC, Modules Layout in PLC Rack, 60 Hz
546007	A	3/6/01	AOC 15/50 Analog Signal Wiring (Shaft Speed), 60 Hz
546008	A	3/6/01	AOC 15/50 Analog Signal Wiring (Wind Speed & Power Monitoring), 60 Hz
546009	A	3/6/01	AOC 15/50 PLC DC Output Module Wiring, 60 Hz
546010	A	3/6/01	AOC 15/50 Dynamic Brake, Capacitor Box, 60 Hz
546011		3/6/01	AOC 15/50 Control Cable (Twist Cable) Connector Wiring, 60 Hz
546012	A	3/16/01	AOC 15/50 Twist Cable Junction Box Terminal Strip Wiring, 60 Hz
546013	A	3/6/01	AOC 15/50 Turbine Generator J-Box Terminal Strip Wiring, 60 Hz
546014		3/6/01	AOC 15/50 Tip Brake Power Wiring, and Wiring to Rotary Transformer, 60 Hz
546015	A	3/6/01	AOC 15/50 Undercurrent Sensor Circuit (Parking Brake), 60 Hz
556005	A	3/6/01	AOC 15/50 Main Control Box/Panel Assembly Drawing, 60 Hz
556016		3/12/01	AOC 15/50 Main Controller Terminal Strip
556017		3/12/01	AOC 15/50 Circuit breaker and surge protector wiring
556018		3/12/01	AOC 15/50 Relay wiring
556021		3/13/01	AOC 15/50 Main Controller Front Panel / Rear Panel Interface, 60 Hz
556022		3/13/01	AOC 15/50 PLC Wiring Slot #2, 60 Hz
556023		3/13/01	AOC 15/50 PLC Wiring Slot #3, 60 Hz



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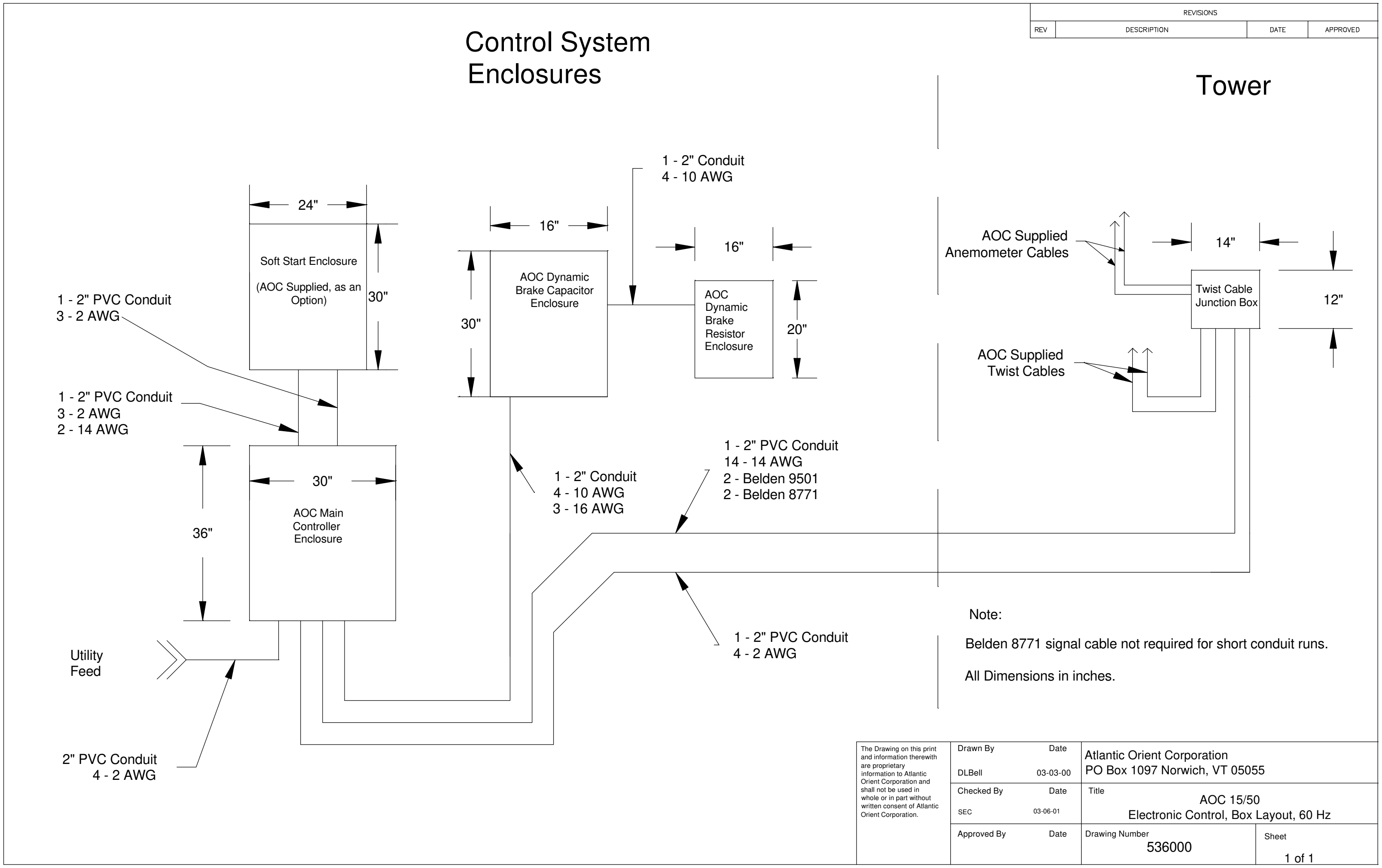

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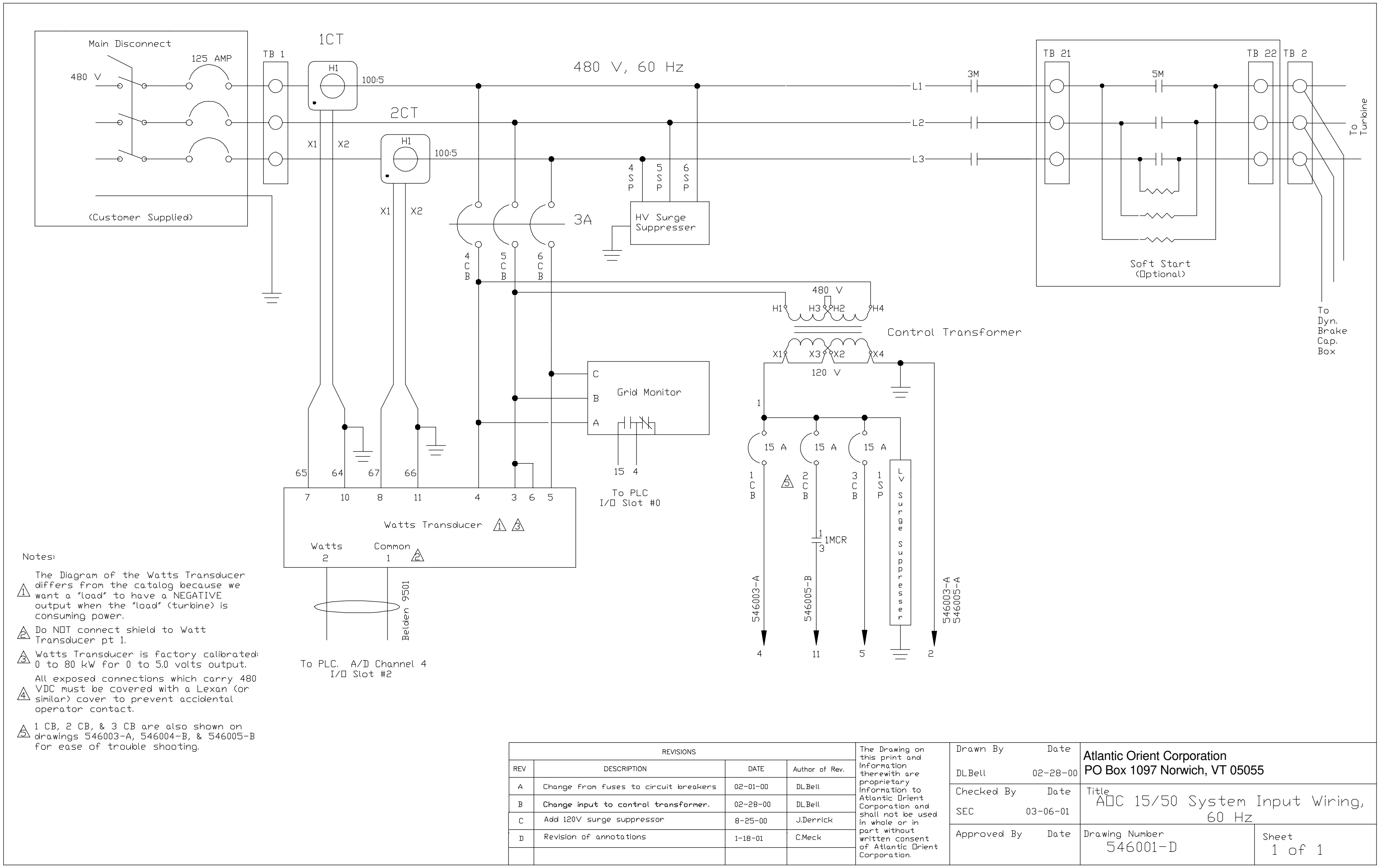

REVISIONS

REV	DESCRIPTION	DATE	Author of Rev.
A	Change from fuses to circuit breakers	02-01-00	DLBell
B	Change input to control transformer.	02-28-00	DLBell
C	Add 120V surge suppressor	8-25-00	J.Derrick
D	Revision of annotations	1-18-01	C.Meck

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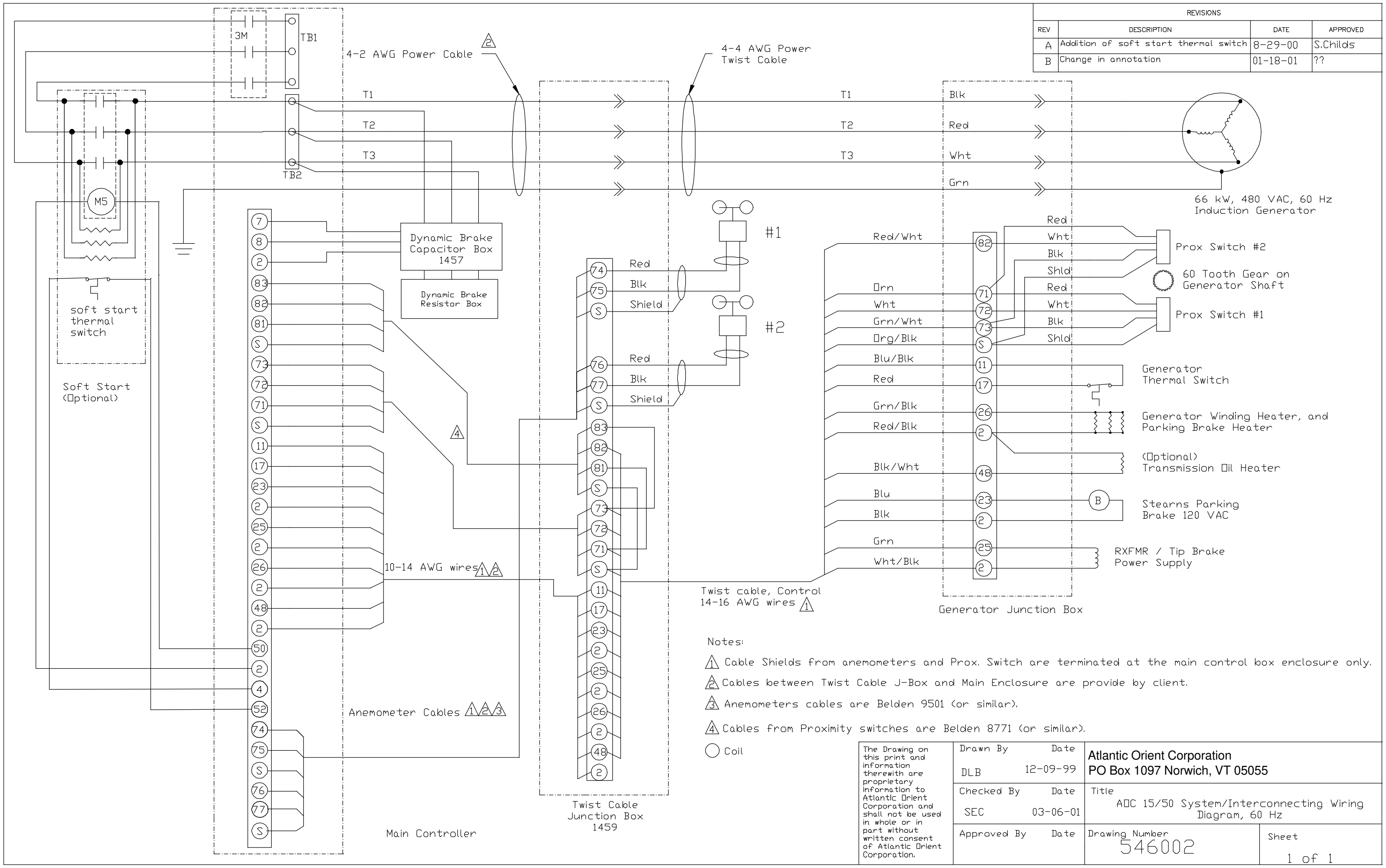

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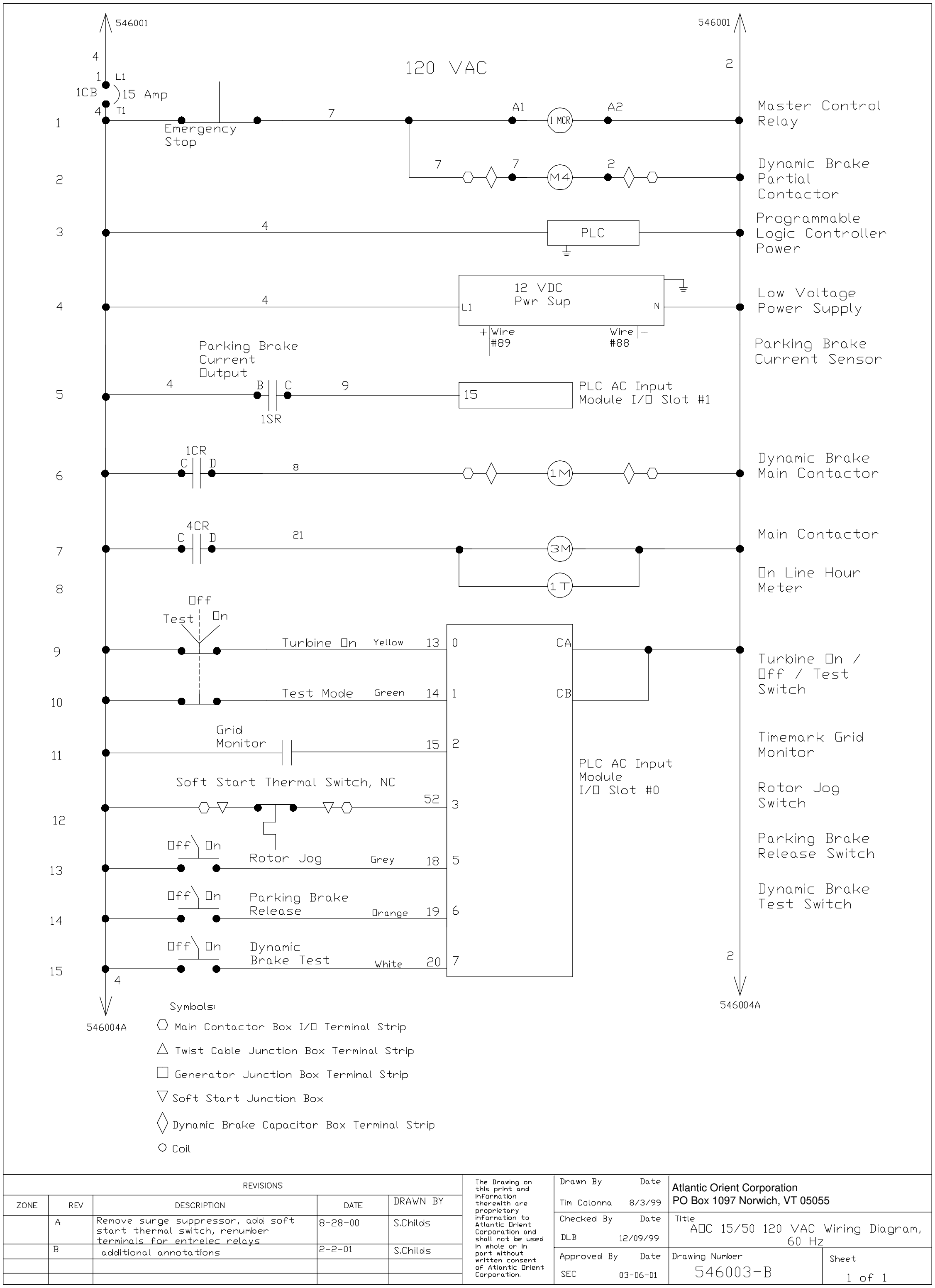

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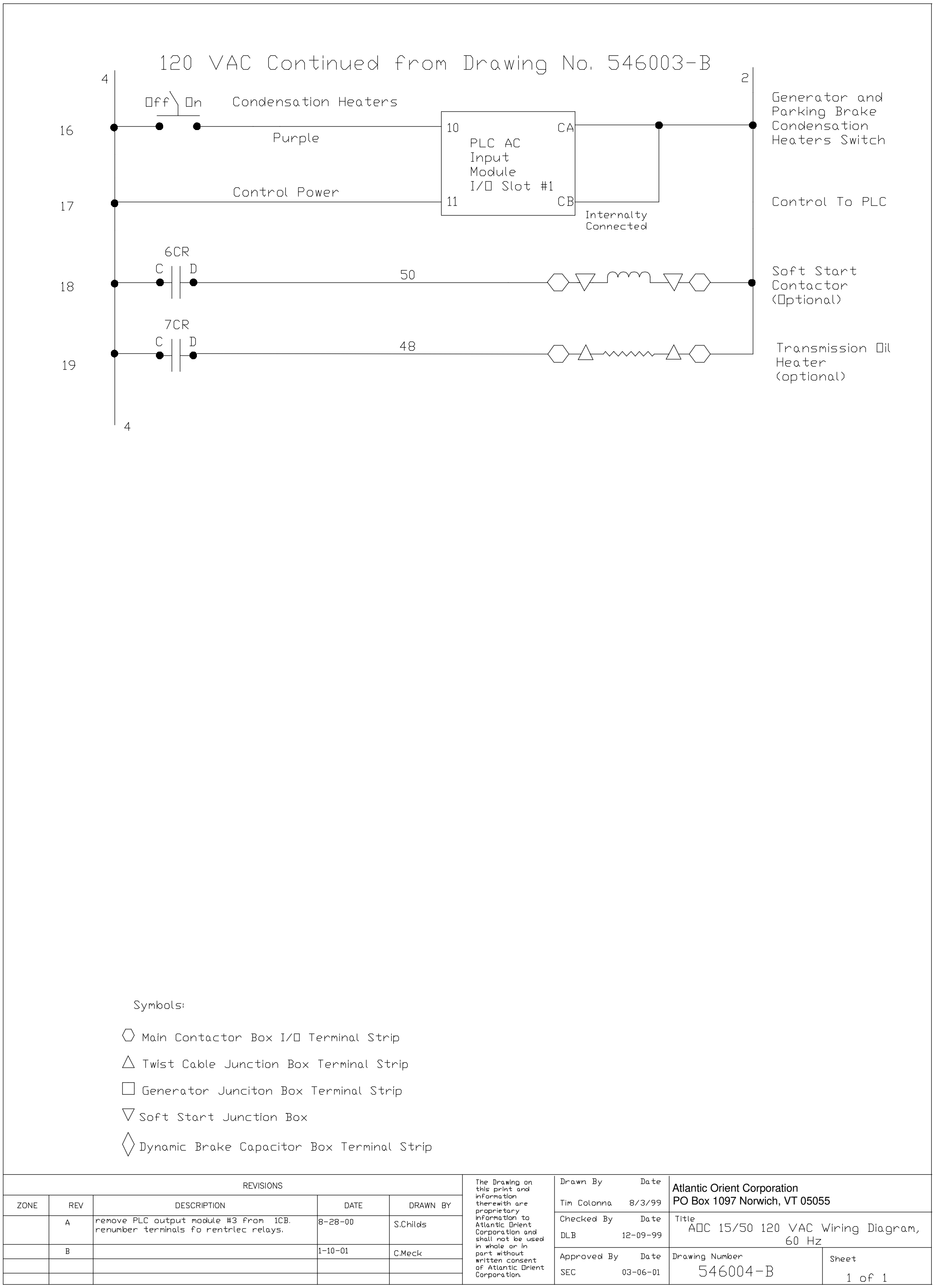

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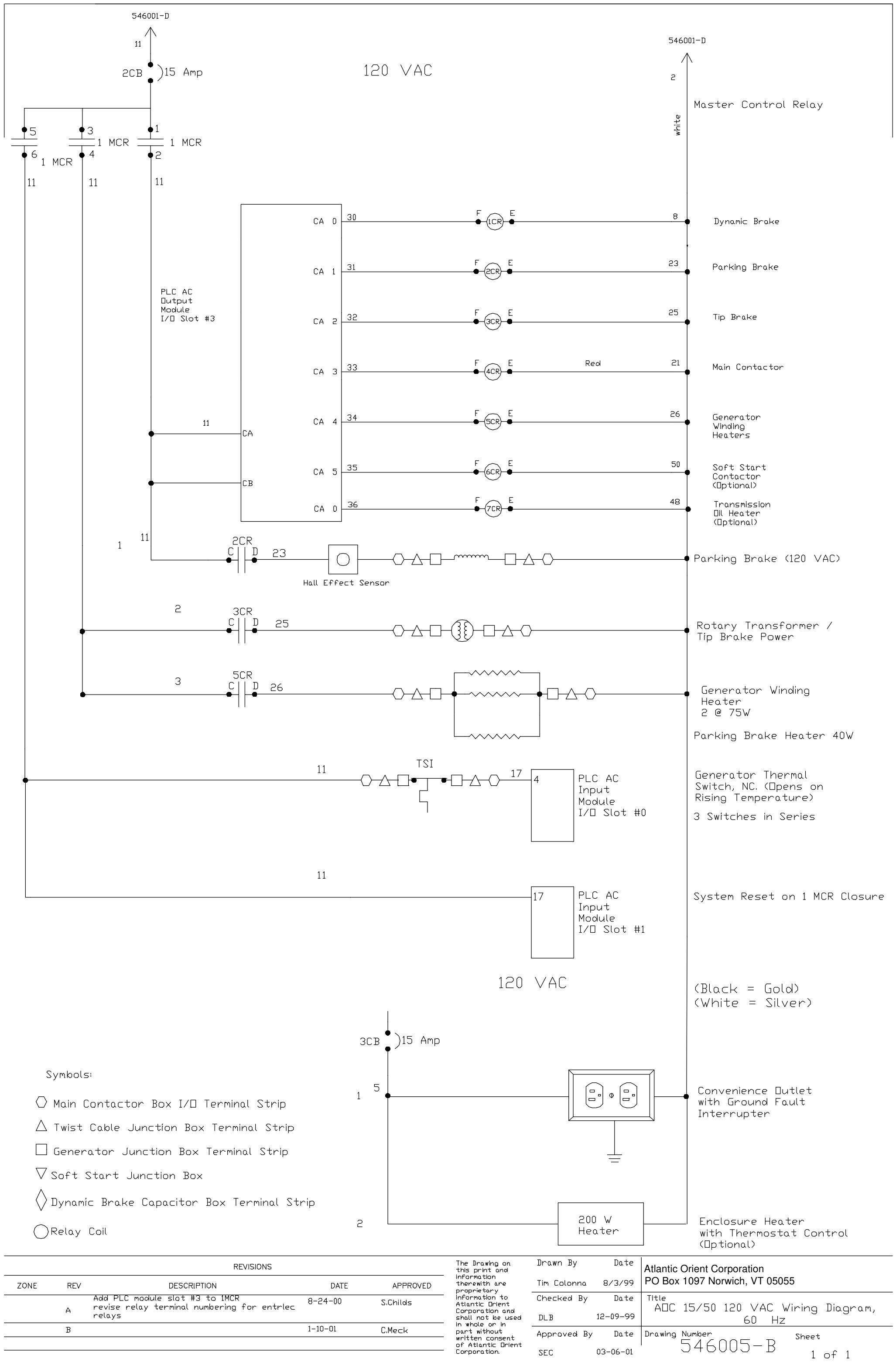

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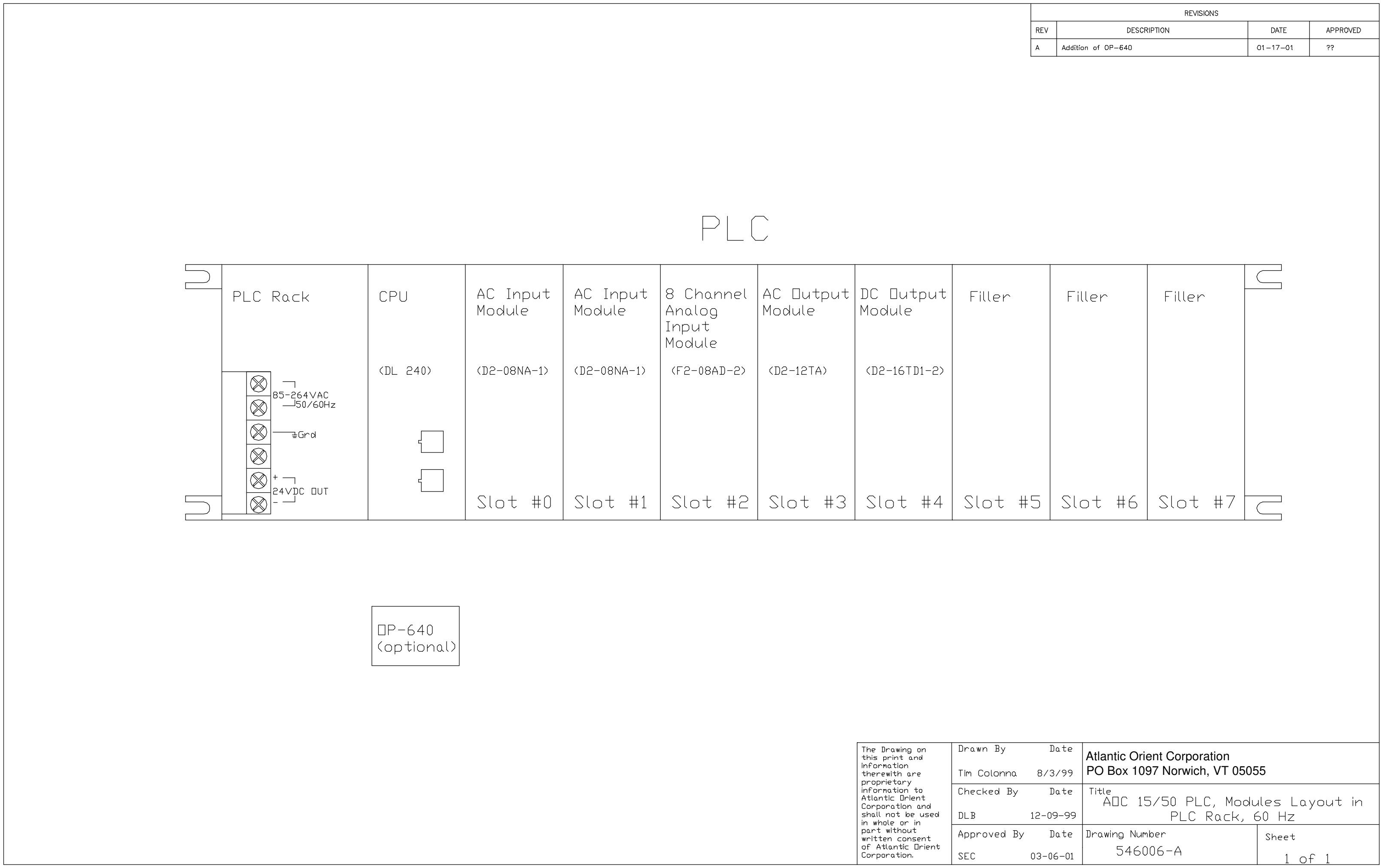

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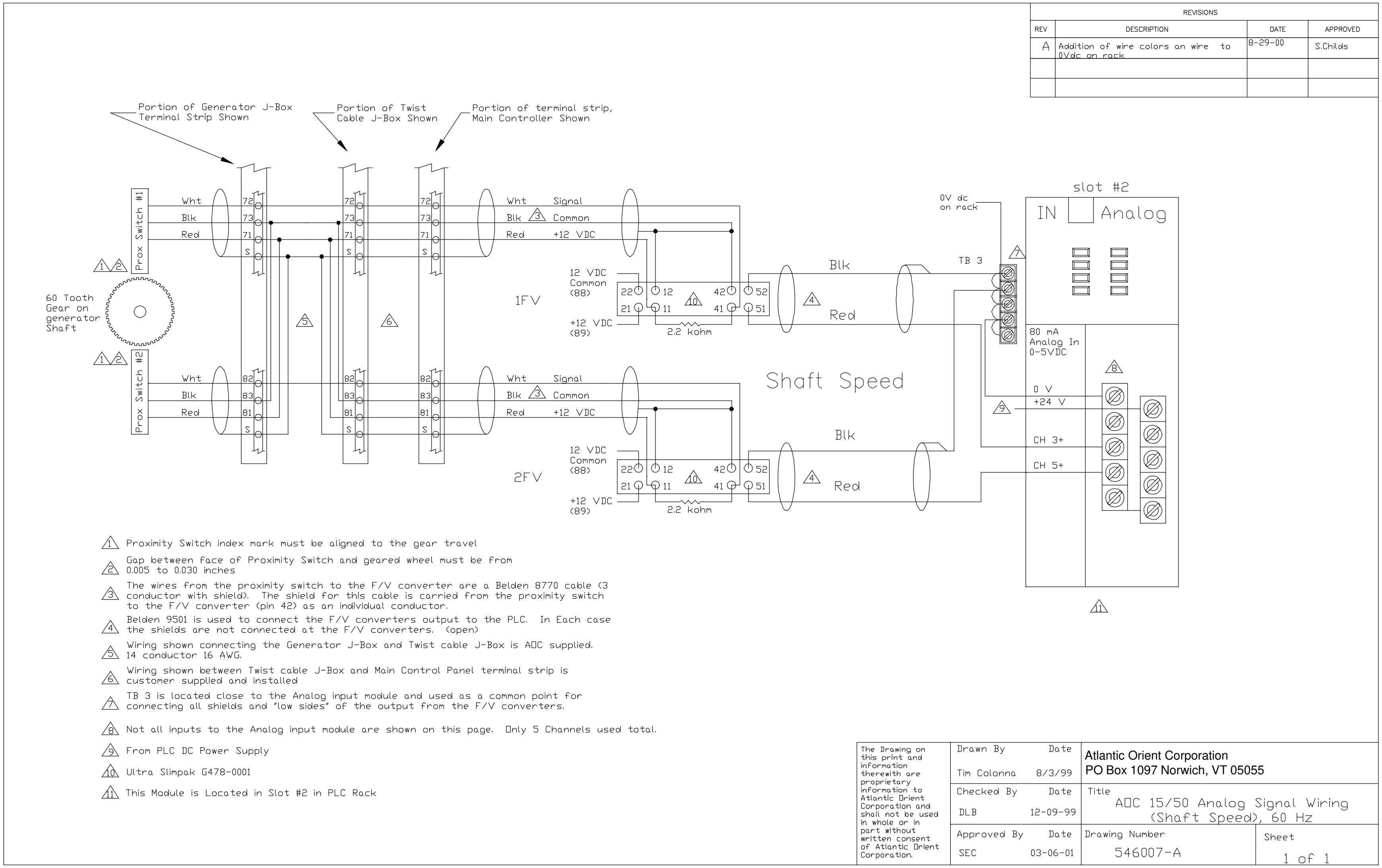
REVISIONS
REV
DESCRIPTION
DATE
APPROVED
A
Addition of wire colors on wire to 0Vdc on rack
8-29-00
S.Childs
Portion of Generator J-Box Terminal Strip Shown
Portion of Twist Cable J-Box Shown
Portion of terminal strip, Main Controller Shown
Prox Switch #1
Prox Switch #2
60 Tooth Gear on generator Shaft
Wht
Blk
Red
Signal
Common
+12 VDC
12 VDC Common (88)
+12 VDC (89)
1FV
2FV
2.2 kohm
Blk
Red
0V dc on rack
TB 3
slot #2
IN
Analog
80 mA Analog In 0-5VDC
0 V
+24 V
CH 3+
CH 5+
Shaft Speed
1 Proximity Switch index mark must be aligned to the gear travel
2 Gap between face of Proximity Switch and geared wheel must be from 0.005 to 0.030 inches
3 The wires from the proximity switch to the F/V converter are a Belden 8770 cable (3 conductor with shield). The shield for this cable is carried from the proximity switch to the F/V converter (pin 42) as an individual conductor.
4 Belden 9501 is used to connect the F/V converters output to the PLC. In Each case the shields are not connected at the F/V converters. (open)
5 Wiring shown connecting the Generator J-Box and Twist cable J-Box is AOC supplied. 14 conductor 16 AWG.
6 Wiring shown between Twist cable J-Box and Main Control Panel terminal strip is customer supplied and installed
7 TB 3 is located close to the Analog input module and used as a common point for connecting all shields and "low sides" of the output from the F/V converters.
8 Not all inputs to the Analog input module are shown on this page. Only 5 Channels used total.
9 From PLC DC Power Supply
10 Ultra Slimpak G478-0001
11 This Module is Located in Slot #2 in PLC Rack
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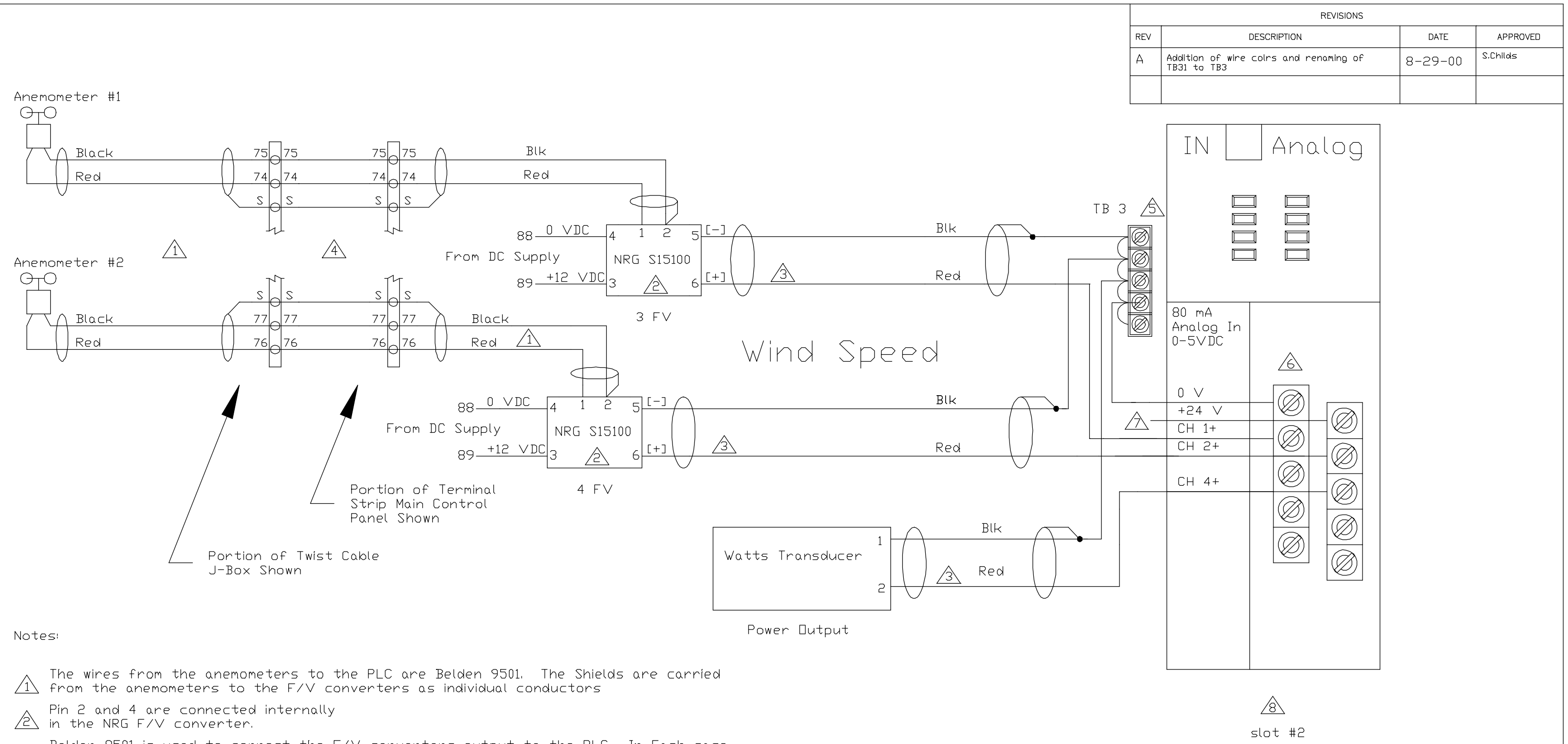
Drawn By
Date
Tim Colonna
8/3/99
Checked By
Date
DLB
12-09-99
Approved By
Date
SEC
03-06-01
Atlantic Orient Corporation
PO Box 1097 Norwich, VT 05055
Title
AOC 15/50 Analog Signal Wiring (Shaft Speed), 60 Hz
Drawing Number
546007-A
Sheet
1 of 1



Notes:

1. The wires from the anemometers to the PLC are Belden 9501. The Shields are carried from the anemometers to the F/V converters as individual conductors
2. Pin 2 and 4 are connected internally in the NRG F/V converter.
3. Belden 9501 is used to connect the F/V converters output to the PLC. In Each case the shields are not connected at the F/V converters (open), but are connected at TB3.
4. Wiring shown between Twist cable J-Box and Main Control Panel terminal strip is customer supplied and installed
5. TB 3 is located close to the Analog input module and used as a common point for connecting all shields and "low sides" of the output from the F/V converters.
6. Not all inputs to the Analog input module are shown on this page. Only 5 Channels used total.
7. From PLC Rack Power Supply
8. This Module is Located in Slot #2 in PLC Rack

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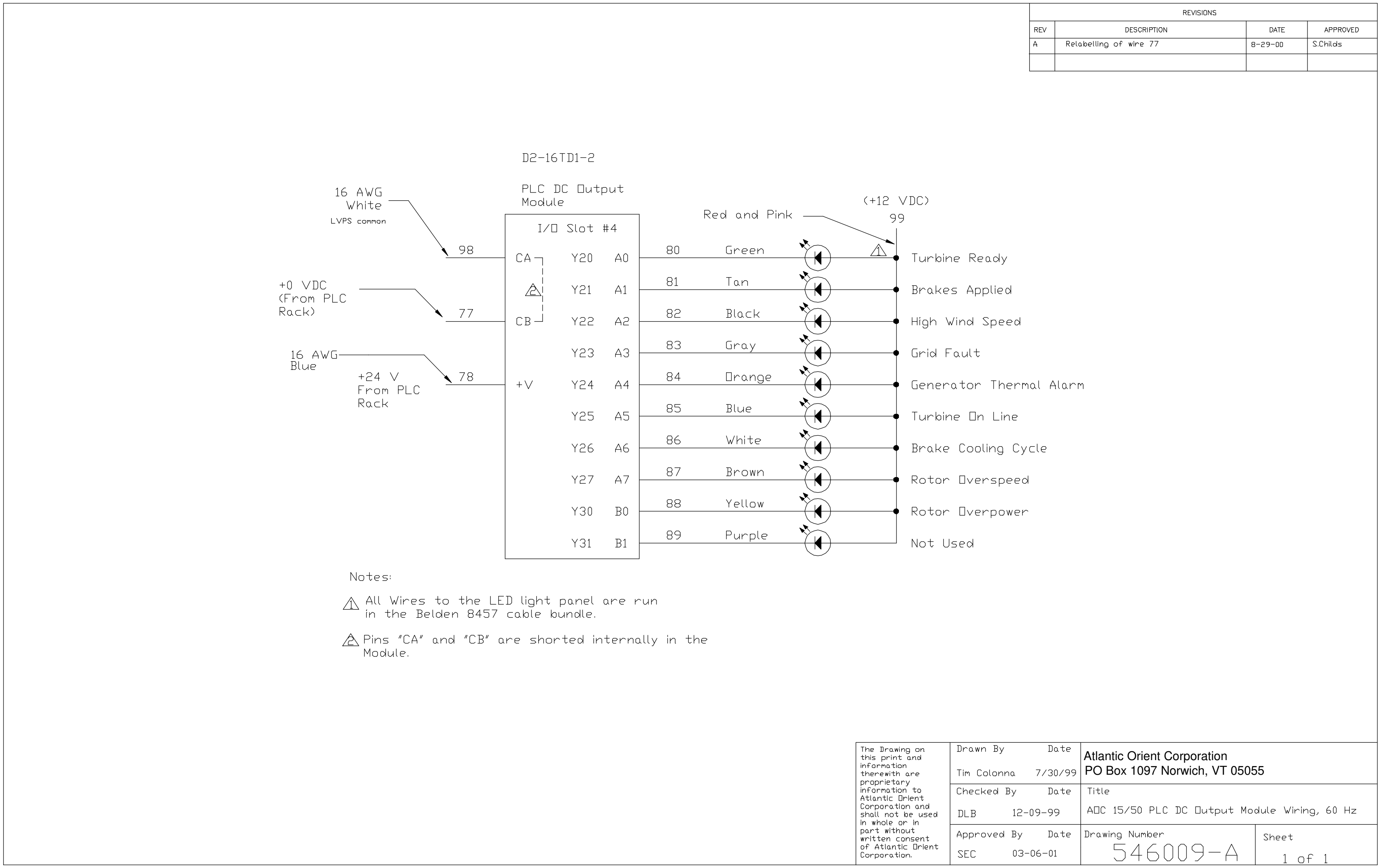
	Checked By: DLB — Date: 12/01/99	AOC 15/50 Analog Signal Wiring (Wind Speeds & Power Monitor), 60 Hz	
	Approved By: SEC — Date: 03-06-01	Drawing Number: 546008-A	Sheet: 1 of 1


REVISIONS
REV | DESCRIPTION | DATE | APPROVED
A | Relabelling of wire 77 | 8-29-00 | S.Childs
D2-16TD1-2
PLC DC Output Module
I/O Slot #4
16 AWG White
LVPS common
+0 VDC (From PLC Rack)
16 AWG Blue
+24 V From PLC Rack
98
77
78
CA
CB
+V
Y20 A0 80 Green
Y21 A1 81 Tan
Y22 A2 82 Black
Y23 A3 83 Gray
Y24 A4 84 Orange
Y25 A5 85 Blue
Y26 A6 86 White
Y27 A7 87 Brown
Y30 B0 88 Yellow
Y31 B1 89 Purple
Red and Pink
(+12 VDC)
99
Turbine Ready
Brakes Applied
High Wind Speed
Grid Fault
Generator Thermal Alarm
Turbine On Line
Brake Cooling Cycle
Rotor Overspeed
Rotor Overpower
Not Used
Notes:
All Wires to the LED light panel are run in the Belden 8457 cable bundle.
Pins "CA" and "CB" are shorted internally in the Module.
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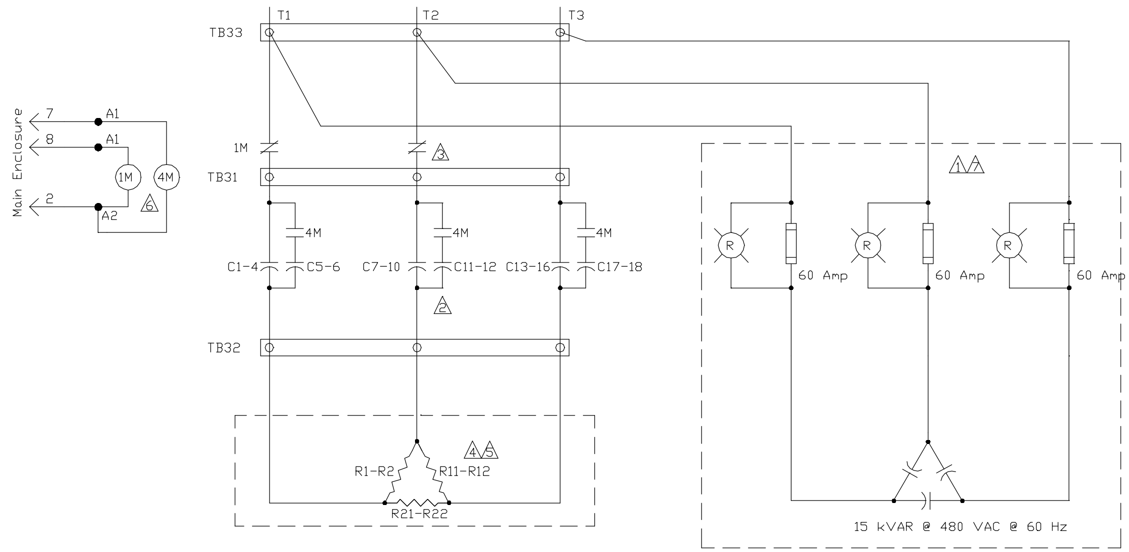
Drawn By Date
Tim Colonna 7/30/99
Checked By Date
DLB 12-09-99
Approved By Date
SEC 03-06-01
Atlantic Orient Corporation
PO Box 1097 Norwich, VT 05055
Title
AOC 15/50 PLC DC Output Module Wiring, 60 Hz
Drawing Number
546009-A
Sheet
1 of 1

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED
A	Relabelling TB1, TB2, TB3 to TB31, TB32, TB33	8-30-00	S.Childs



Notes:

1. Wires from the PFC to TB3 are 8 AWG. Black.
2. Wires from all capacitors to TB1 and to TB2 are 14 AWG. Black.
3. Wires from 1M contactor to TB3 are 10 AWG. Black.
4. Dynamic brake resistor network (R1, R2, R3) is located inside a separate enclosure.
5. Dynamic brake resistors: R1 - R2 = R11 - R12 = R21 - R22 = 9.0 ohms, 820 watts.
6. 4M is P/N D0910. 1M is P/N D12008. 4M is closed when grid power is applied.
7. The PFC Module has a nameplate rating of 22.5 kVAR @ 600 VAC. In the 480 VAC circuit, it provides 14.4 kVAR of Power Factor Correction.

(M) Coil

(R) Light

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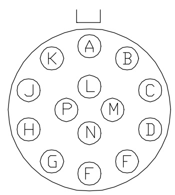
	Checked By: DLB, Date: 12-09-99	Title: AOC 15/50 Dynamic Brake, Capacitor Box, 60 Hz	
	Approved By: SEC, Date: 03-06-01	Drawing Number: 546010-A	Sheet: 1 of 1

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED

Model #

Wiring to "Quick Disconnect" connector (Twist Cable Junction Box-Control Cable)

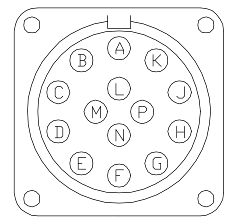


Solder tail view of cable connector

Rear View

MS3106R22-19S

A	48	Black/White
B	82	Red/White
C	73	Green/White
D	71	Orange
E	23	Blue
F	2	White/Black
G	2	Red/Black
H	26	Green/Black
J	S	Orange/Black
K	11	Blue/Black
L	72	White
M	17	Red
N	25	Green
P	2	Black



Solder tail view of box connector

Front View

Cannon
MS3100R27-19S

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	Checked By DLB — Date 12-08-99	Title AOC 15/50 Control Cable (Twist Cable) Connector Wiring, 60 Hz	
	Approved By SEC — Date 03-06-01	Drawing Number 546011	Sheet 1 of 1

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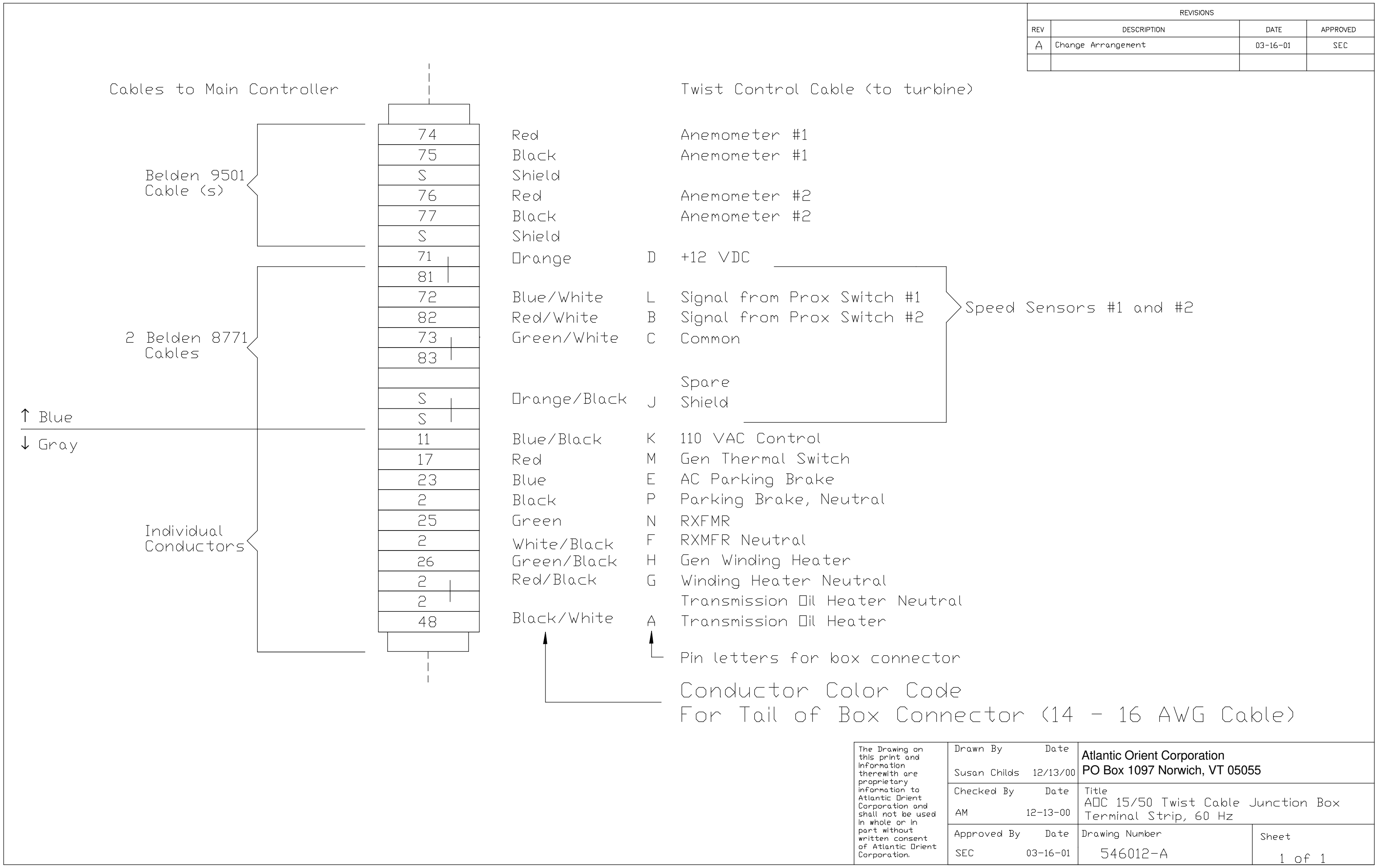

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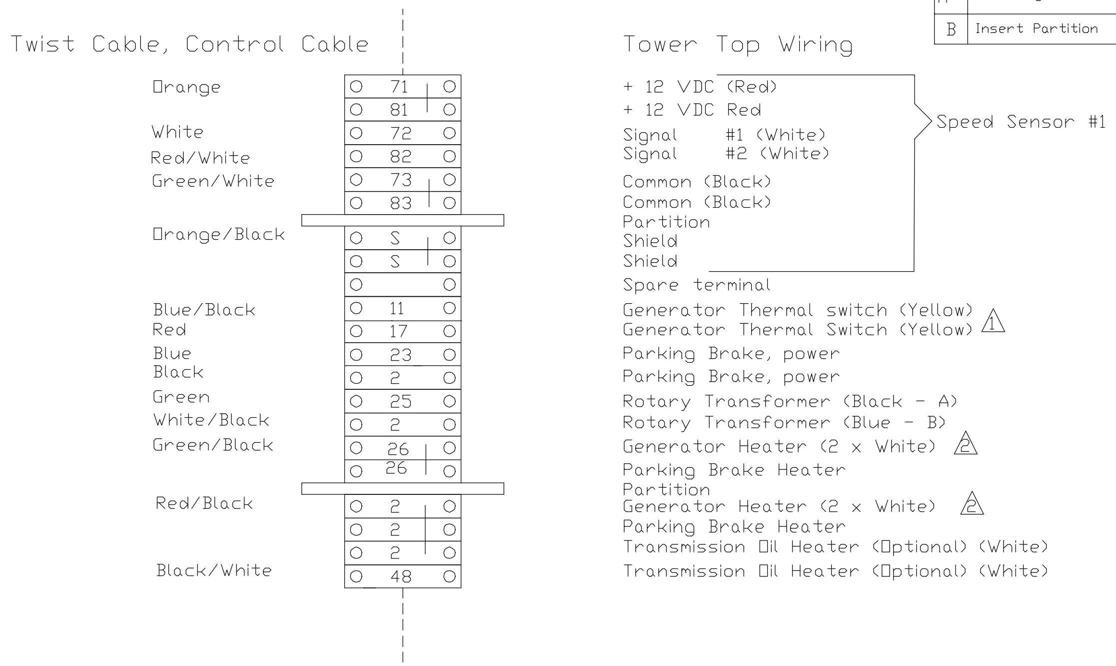
REVISIONS

REV	DESCRIPTION	DATE	APPROVED
A	Rearrange terminal numbering	12-13-00	SEC
B	Insert Partition	03-13-01	SEC



Notes:

1. The two unmarked yellow wires coming from the interior of the generator from to the generator thermal switch and are connected to pins 11 and 17 on the terminal strip.

2. Four white wires from the interior of the generator (usually labeled "H" and "H1") are the wires from the generator winding heaters. They are to be wired in parallel (MagneTek: H and H1 each together) and connected with the parking brake condensation heater. These six wires are connected to pins 26 and 2 of the main control box.

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	Checked By: DLB, Date: 12-08-99	Title: AOC 15/50 Turbine Generator J-Box Terminal Strip Wiring, 60 Hz	
	Approved By: SEC, Date: 03-13-01	Drawing Number: 546013-B	Sheet: 1 of 1

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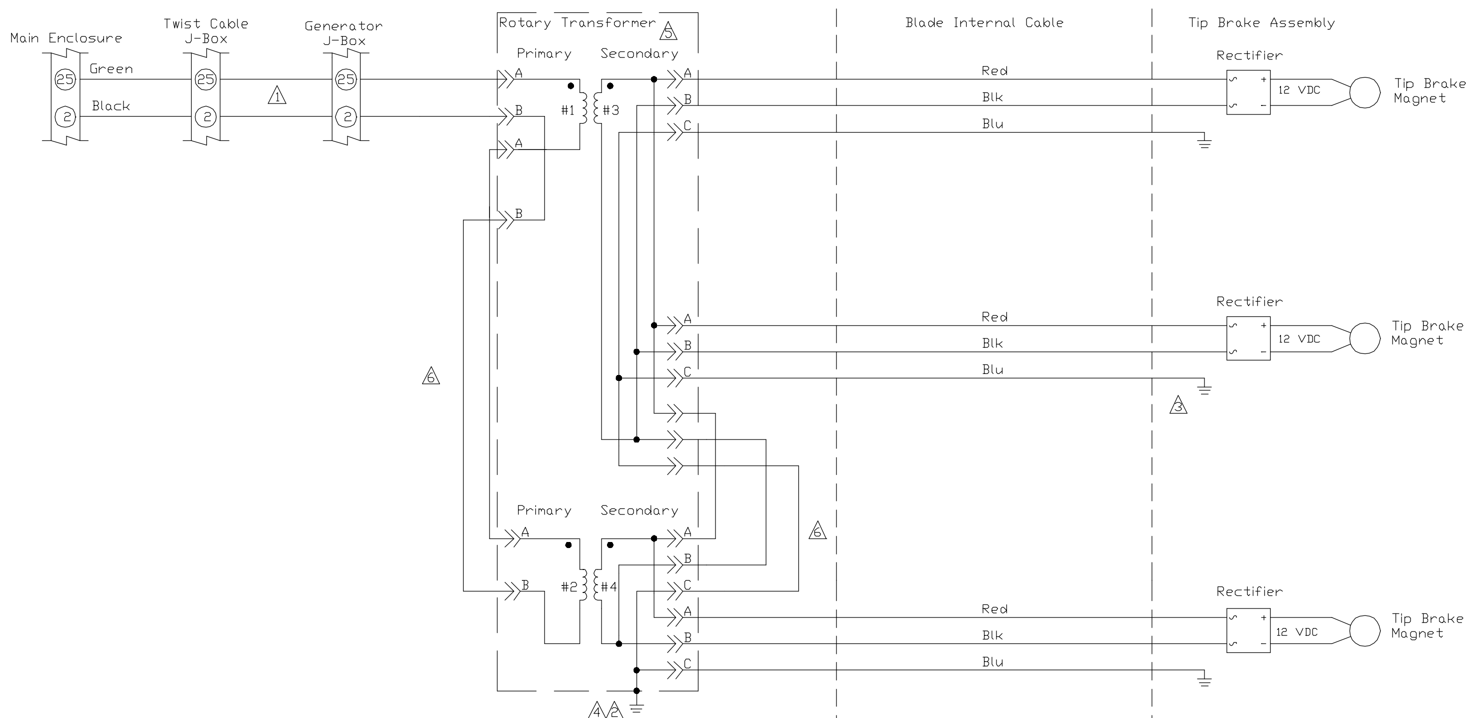
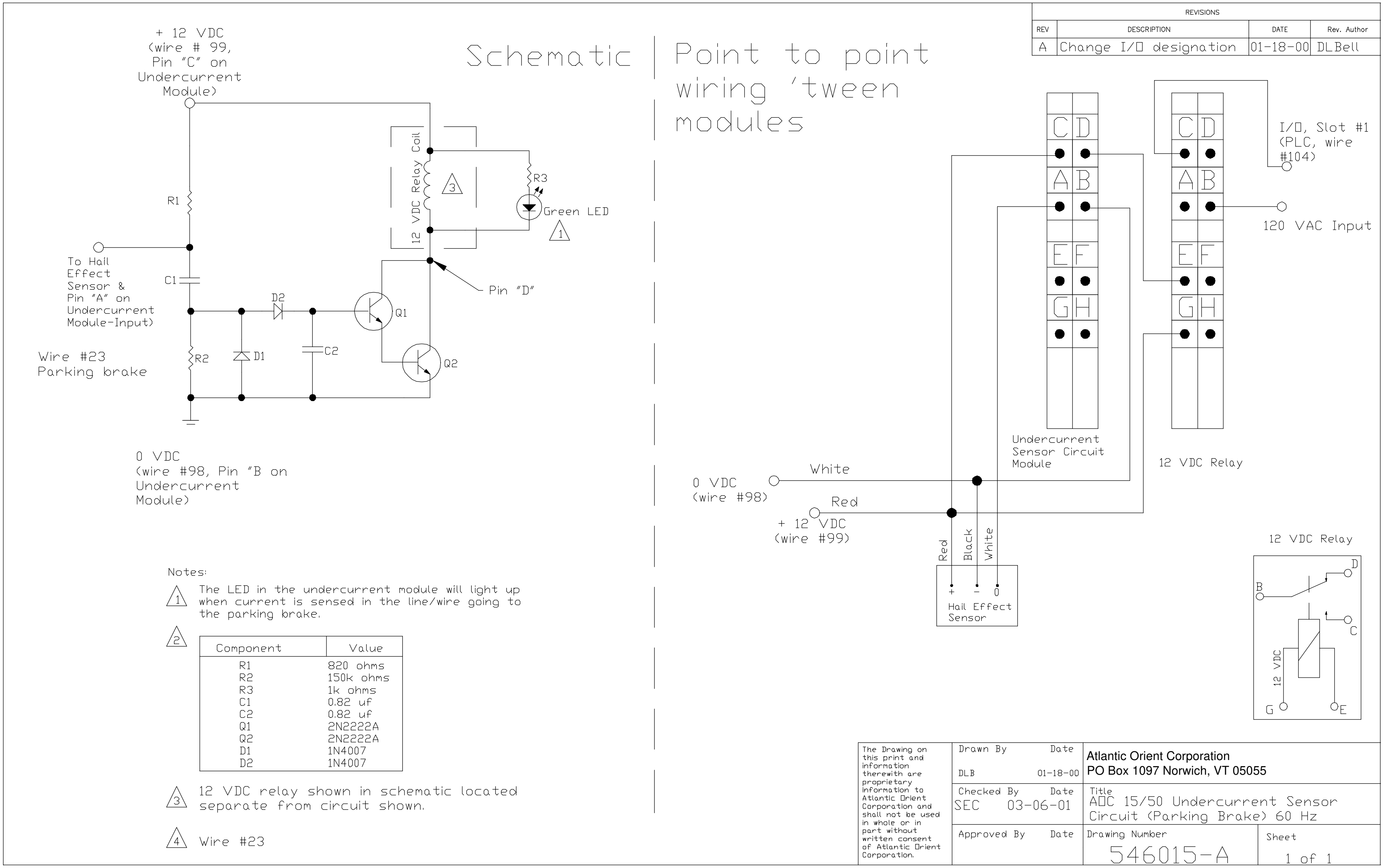
REVISIONS			
REV	DESCRIPTION	DATE	APPROVED



Notes:

1. Only a portion of the generator Junction box terminal strip, tower junction box strip terminal strip, and the main enclosure terminal strip are shown here.
2. Internal grounding to the rotary transformer secondary casting housing.
3. Grounding wire attached to the Damper Bracket on the Tip Brake Assembly.
4. External braided wire connects the casting to the hub.
5. With 120 VAC input to Rotary Transformer, expect 18 - 20 VAC output on each of the secondary plugs. This output is a function of the gap.
6. Temper Cable Assembly, 1'5'' with 3pm connectors AOC part # 10276

The Drawing on this print and information therewith are proprietary information to Atlantic Orient Corporation and shall not be used in whole or in part without written consent of Atlantic Orient Corporation.	Drawn By: Tim Colonna	Date: 8/3/99	Atlantic Orient Corporation PO Box 1097 Norwich, VT 05055	
	Checked By: DLB	Date: 12-07-99	Title: AOC 15/50 Tip Brake Power Wiring, and Wiring to Rotary Transformer, 60 Hz	
	Approved By: SEC	Date: 03-06-01	Drawing Number: 546014	Sheet: 1 of 1



Component	Value
R1	820 ohms
R2	150k ohms
R3	1k ohms
C1	0.82 uf
C2	0.82 uf
Q1	2N2222A
Q2	2N2222A
D1	1N4007
D2	1N4007

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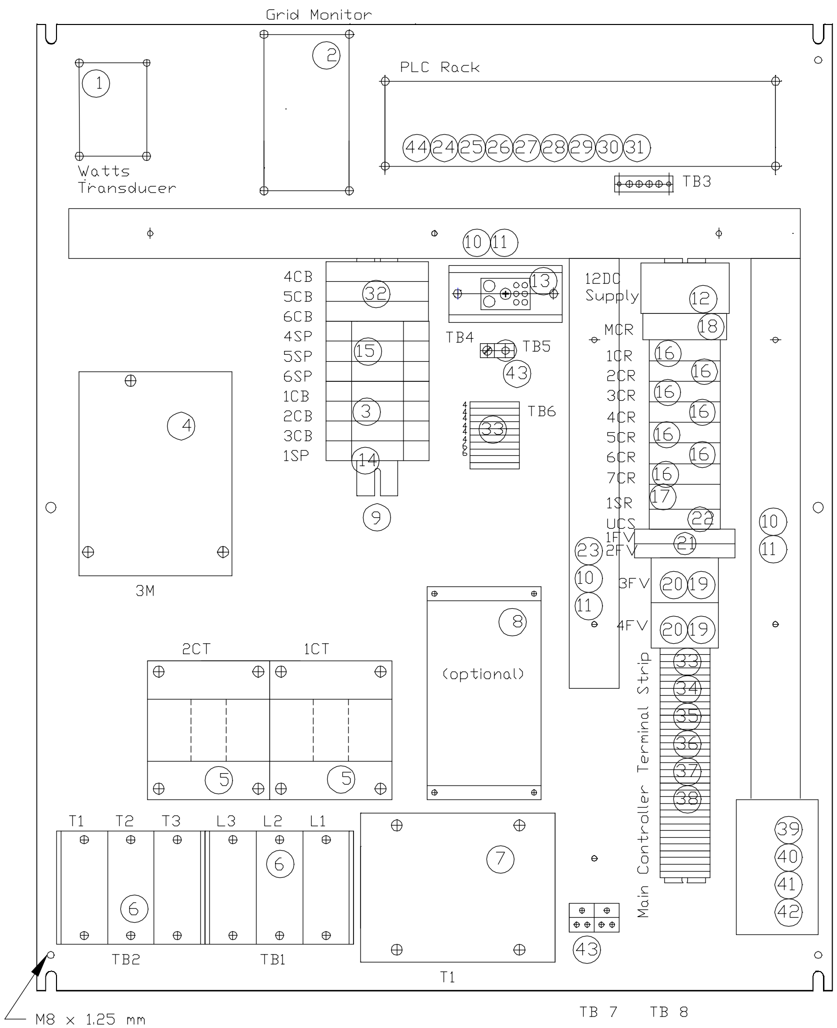
REVISIONS		
DESCRIPTION	DATE	APPROVED
RELABLED AND AMENDED DRAWING	01-03-01	??



Item	Qty.	Description	AOC Part No.
1	1	Power Monitor, Watts Transducer	10317
2	1	Grid Monitor, 60 Hz	10318
3	3	Circuit Breaker, 15 amp, 1 pole, 250 volt	10382
4	1	Main Contactor	10313
5	2	Current Transformer(s), 100:5	10316
6	2	Power Terminal Blocks	10370
7	1	1 KVA Control Transformer, 60 Hz	10312
8	1	Enclosure Heater, 200 Watt (optional)	10314
9	1	35 mm Din Rail, 7.5 mm	10093
10	1	Pan Duit Wire Channel	10340
11	1	Pan Duit Wire Channel Covers	10341
12	1	12 VDC Power Supply	10406
13	1	Terminal Block	10379
14	1	Low Voltage Surge Suppresser	10403
15	3	High Voltage Surge Suppresser, 1 phase	10394
16	7	120 VAC SPDT Relay Module	10410
17	1	12 VDC SPDT Relay	10407
18	1	120 VAC DPDT, Master Control Relay	10408
19	2	Freq. to Volt. Converter (Wind Speed), W/B	10305
20	2	Octal Base	10308
21	2	Freq. to Volt. Converter (Shaft Speed)	10305
22	1	Undercurrent Sensor Module, 60 Hz	1477
23	1	Ferrite Core (Hall Effect Sensor)	10319
24	1	PLC Rack 9 Bay, W/Power Supply	10320
25	2	PLC, AC input module, 8 point	10321
26	1	PLC, AC output module, 12 point	10322
27	1	PLC, DC output module, 16 point	10323
28	1	PLC, CPU, DL 240 processor	10324
29	1	PLC, battery for CPU	10325
30	1	PLC, Analog input module, 8 channel	20326
31	3	PLC, filler module	10327
32	1	Circuit Breaker, 3 amp, 3 pole, 480 VAC	10399
33	20	Terminal Block, 1 pole (Grey)	20090
34	14	Terminal Block, 1 pole (Blue)	10187
35	2	Terminal Block, end barrier	20091
36	3	Terminal Block, Slip in partition	20092
37	1	Terminal Block,jumper	10185
38	34	Terminal Block, Markers	10186
39		Outlet Receptacle Enclosure	10149
40	1	Outlet receptacle, GFI, 20 amp	10369
41	1	Outlet Conduit Adapter	10150
42	1	Outlet Cover	N/C
43	3	Grounding Lug (set screw lug)	10089
44	1	Shielded Cable OP640 to RS232 (optional)	10670
45		last item	
46			
47			
48			
49			

Drawn By DLB	Date 12-15-99	Atlantic Orient Corporation PO Box 1097 Norwich, VT 05055
Checked By SEC	Date 03-06-01	Title AOC 15/50, Main Control Box/Panel Assembly Drawing, 60 Hz
Approved By	Date	Drawing Number 556005-A — Sheet 1 of 1

NOTICE: Use of the material contained in this document is subject to the warning on page Iv and the disclaimer on page v of this document.

Device	Terminal	Connection
Shaft Speed 2	83	2FV-42 Black
	82	2FV-41 White
	81	2FV-11 Red
	S	
Wind Speed 2	77	4FV-2 Black
	76	4FV-1 Red
Wind Speed 1	75	3FV-2 Black
	74	3FV-1 Red
Shaft Speed 2	73	1FV-42 Black
	72	1FV-41 White
	71	1FV-11 Red
	S	
Dynamik Brake Capacitor Box	7	1MCR Black
	8	1CR-D Black
	2	White
Generator Thermal Switch	11	1MCR-2TI Black
	17	Slot Ø-X4 Black
Parking Brake	23	2CR-D Black
	2	White
Tip Brake	25	3CR-D Black
	2	White
Generator Winding Heater and Parking Brake Heater	26	5CR-D Black
	2	White
Transmission Oil Heater	48	7CR-D Black
	2	White
Soft Start Contactor	50	6CR-D Black
	2	White
Soft Start Thermal Switch	52	PLC Slot #0-3 Black
	4	TB6- Black

↑ Blue

Gray ↓

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED

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Drawn By: ToW	Date: 03-12-01	Atlantic Orient Corporation PO Box 1097 Norwich, VT 05055	
Checked By	Date	Title: AOC 15/50 Main Controller Terminal Strip, 60 Hz	
Approved By	Date	Drawing Number: 556016	Sheet: 1 of 1

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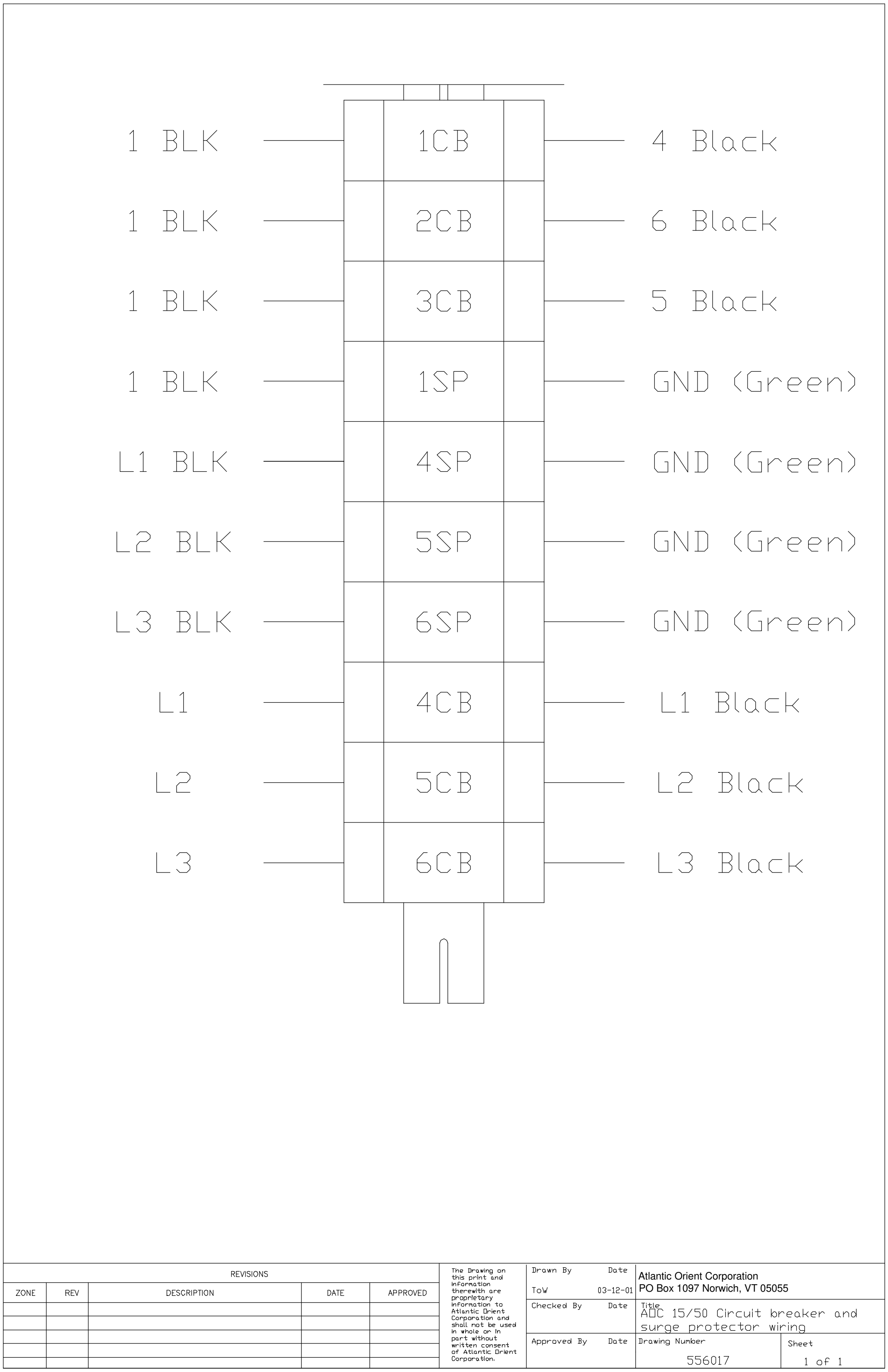

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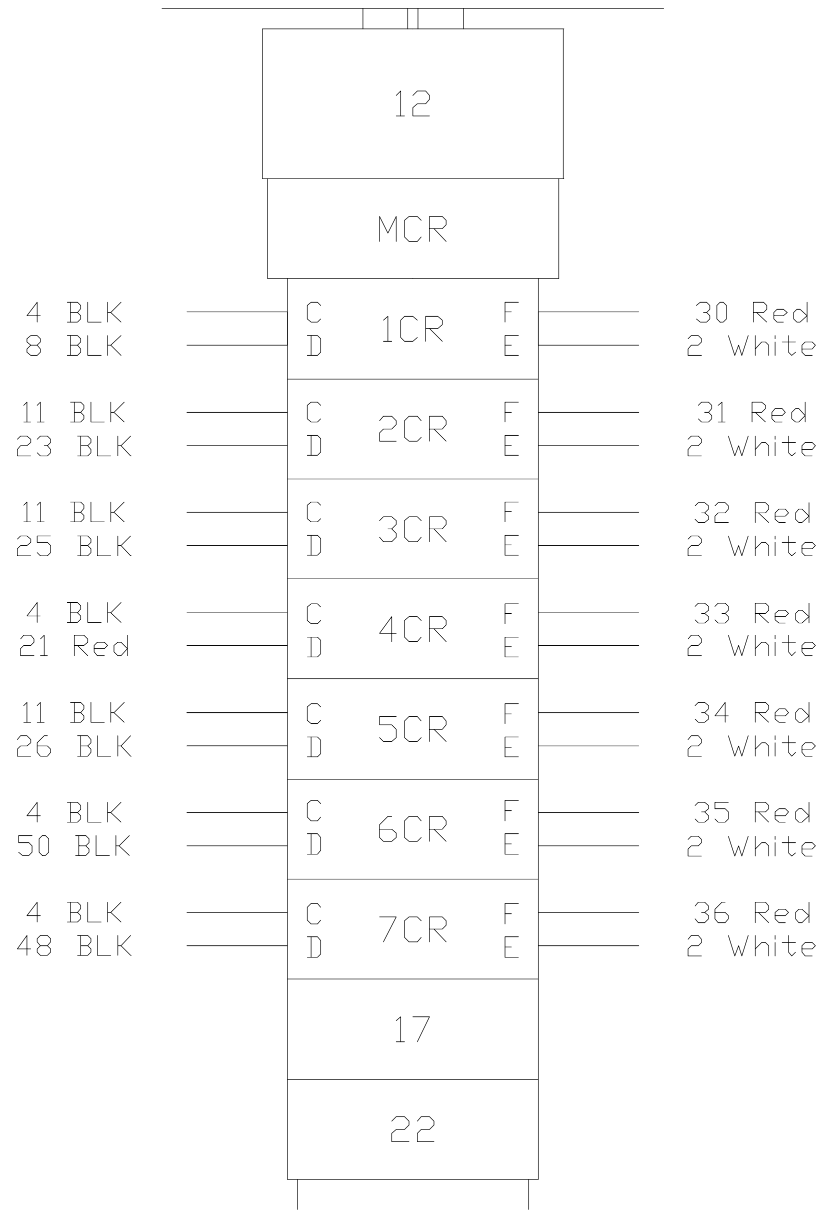

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Checked By / Date
Approved By / Date

Atlantic Orient Corporation
PO Box 1097 Norwich, VT 05055

Title: AOC 15/50 Relay wiring, 60 Hz

Drawing Number: 556018
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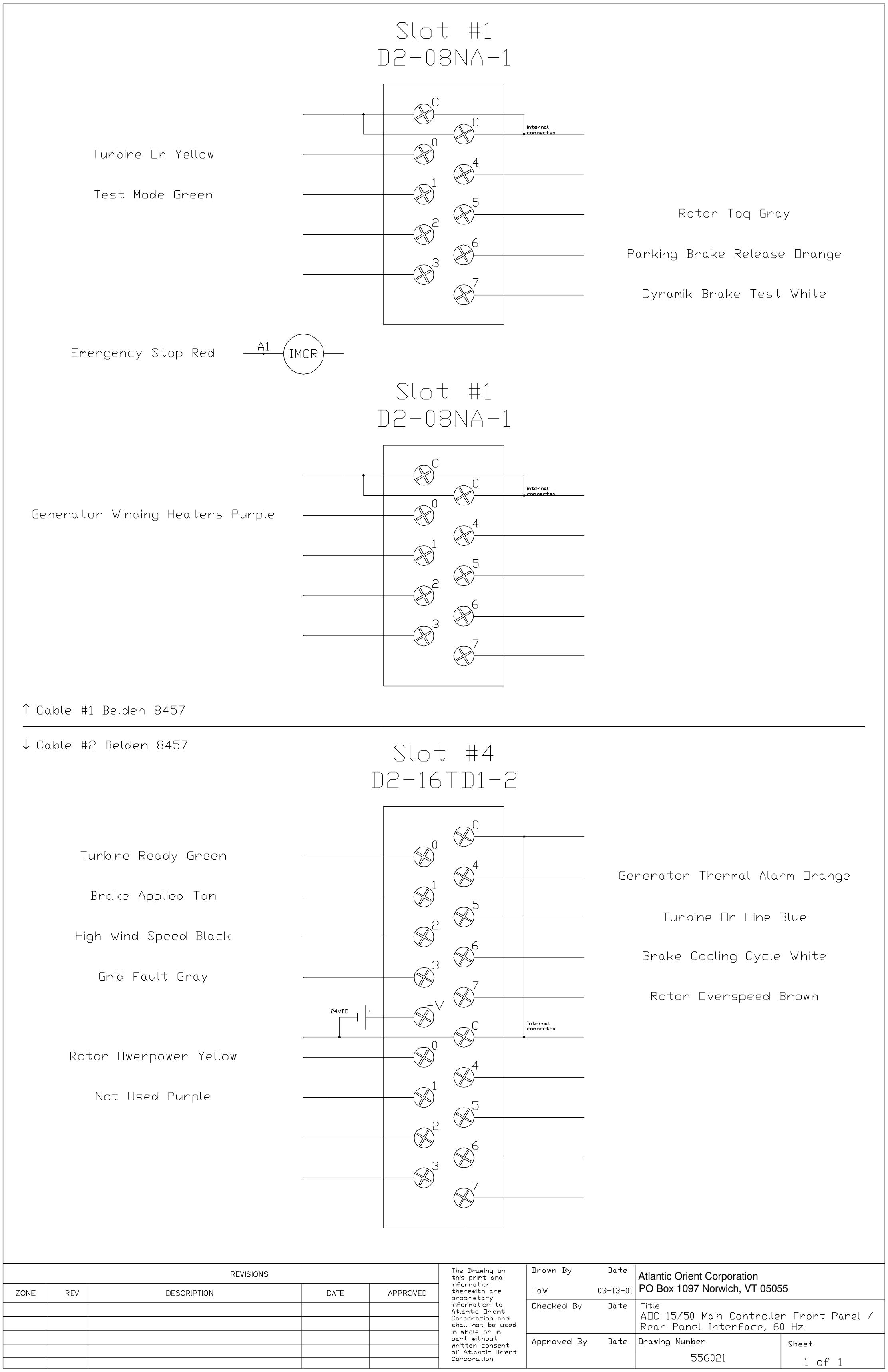

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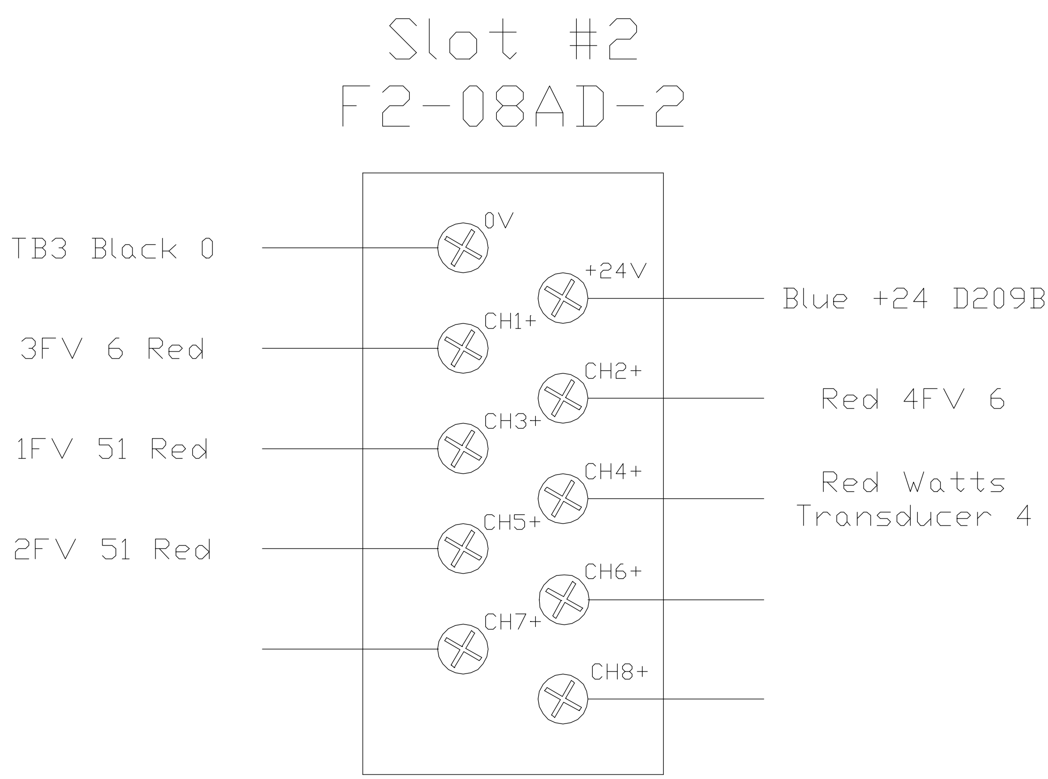

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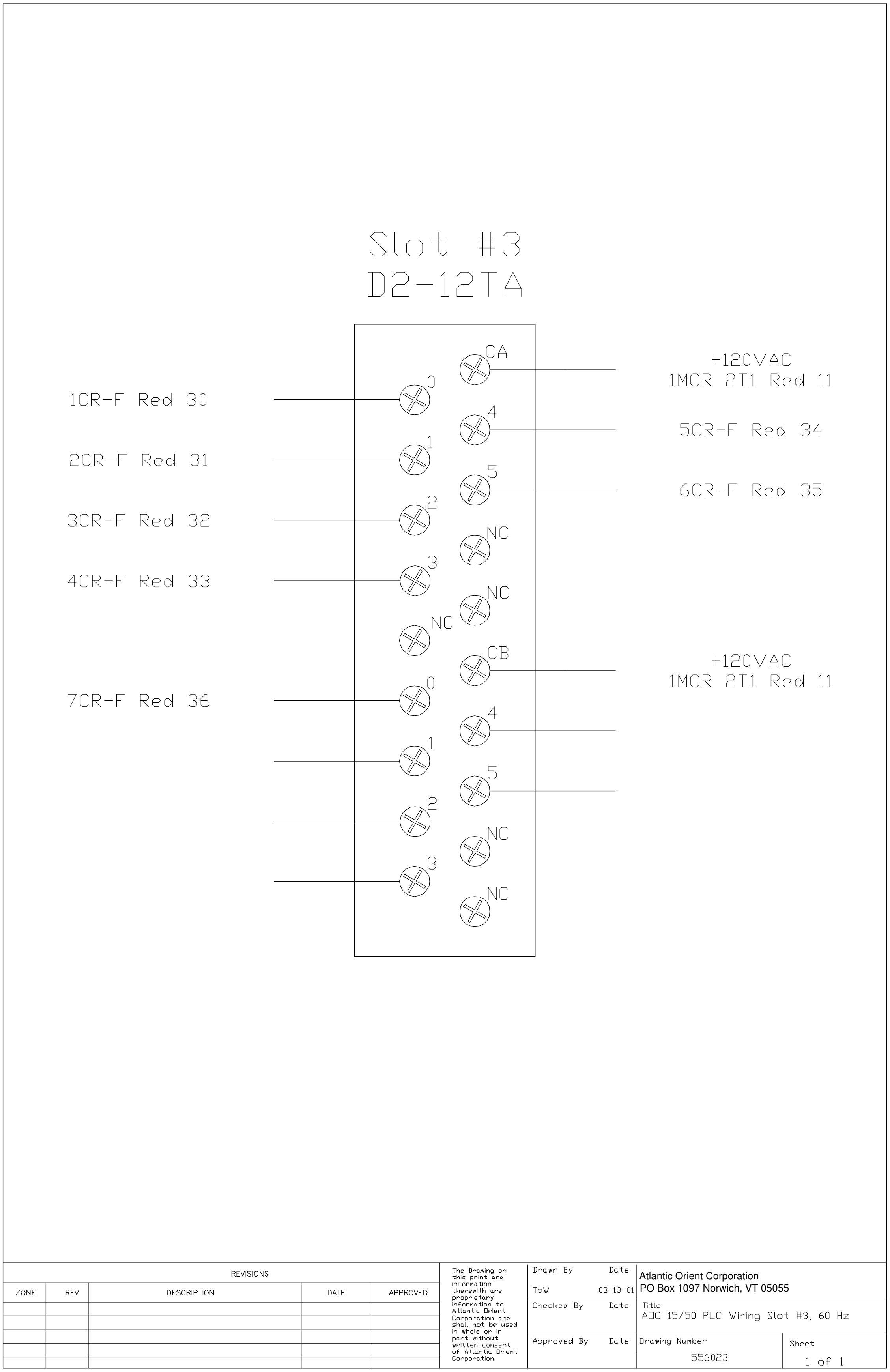
Drawn By	Date	
ToW	03-13-01	Atlantic Orient Corporation PO Box 1097 Norwich, VT 05055
Checked By	Date	Title AOC 15/50 PLC Wiring Slot #2, 60 Hz
Approved By	Date	Drawing Number: 556022 — Sheet: 1 of 1



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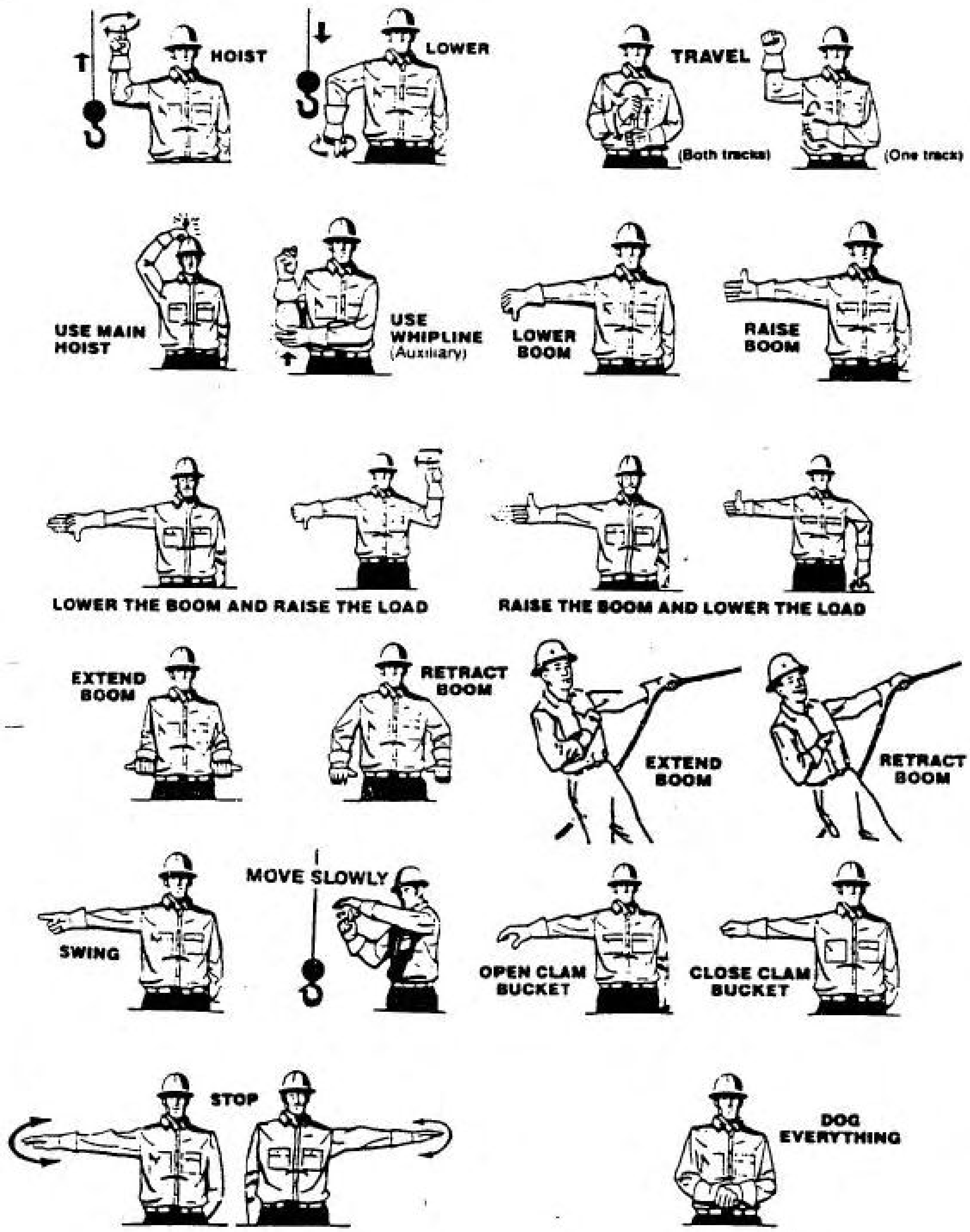
Appendix N: Hand Signals for Crane Operators



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