Final Technical Report
Kotzebue Wind Power Project
Volume II – Appendices

Grant Identification Number

DE-FG36-97GO10199

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Prepared for:

U.S. Department of Energy
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Thompson Engineering

Acknowledgements

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Abstract

The Kotzebue Wind Power Project is a joint undertaking of the U.S. Department of Energy (DOE); Kotzebue Electric Association (KEA); and the Alaska Energy Authority (AEA). The goal of the project is to develop, construct, and operate a wind power plant interconnected to a small isolated utility grid in an arctic climate in Northwest Alaska.

The primary objective of KEA's wind energy program is to bring more affordable electricity and jobs to remote Alaskan communities. DOE funding has allowed KEA to develop a multi-faceted approach to meet these objectives that includes wind project planning and development, technology transfer, and community outreach.

The first wind turbines were installed in the summer of 1997 and the newest turbines were installed in the spring of 2007. The total installed capacity of the KEA wind power project is 1.16 MW with a total of 17 turbines rated between 65 kW and 100 kW. The operation of the wind power plant has resulted in a wind penetration on the utility system in excess of 35% during periods of low loads.

This document and referenced attachments are presented as the final technical report for the U.S. Department of Energy (DOE) grant agreement DE-FG36-97GO10199. Interim deliverables previously submitted are also referenced within this document and where reasonable to do so, specific sections are incorporated in the report or attached as appendices.

Appendix A

SOW Task Modification Request

Kotzebue Electric Association
DOE Grant DE-FG36-97GO10199, A004
November 6, 2001

Statement of Work (SOW) Modification Request

The objectives of this project are as follows: (1) to test and verify wind generation technology applications in wind/diesel hybrid systems and to provide system performance/cost data, (2) to maximize the reduction in consumption of diesel fuel by KEA through the use of wind power generation, (3) to develop a cold-weather wind turbine test site which will be available to DOE and the U.S. wind industry to develop advanced turbine designs, (4) to provide educational outreach activities for the general public in Alaska and for operators who will be trained to operate the hybrid wind/diesel power plants, and (5) to provide a basis for the evaluation of wind power system applications in the numerous power plants serving remote, non-grid-connected Alaska villages.

Task modification requests are described below including changes in fund allocation, task description changes and justification, and changes in deliverables. Please refer to the original Statement of Work for the full description of the tasks and related deliverables. The original budget, actual expenditures to date, requested adjustments, and balance of funds are summarized by task in Attachment 1.

Task 1: Project Management

Budget reduction of $20,000. A significant portion of the budget for this task was associated with project reporting that is being satisfied through KEA's participation in the DOE-Turbine Verification Program (TVP). KEA is not requesting changes to the SOW or deliverables.

Task 2: Meteorological Characterization

Budget reduction of $40,000. The majority of this task was performed under a DCRA grant and through KEA's participation in the TVP. KEA is not requesting changes to the SOW or deliverables.

Task 3: System Design

Budget increase of $150,000. KEA has performed system design work on the Wales, Alaska, High-Penetration Wind Project in order to gain knowledge and experience that directly facilitates the continuing expansion of the KEA Wind Project. The system design costs associated with the Wales project and allocated to this task are $284,000. Benefits gained from the Wales work include experience with grid stability, power quality and incorporation of dump loads in a high-penetration wind system. Understanding these issues are critical to the ongoing expansion of the KEA Wind Project and consistent with the stated project objectives.
The deliverables for this task (as-built drawings) are currently being prepared for delivery to DOE.

Task 4: Turbine Procurement

Budget reduction of $505,000. Equipment purchased under this task includes nine AOC 15/50s and one Northwind 100 (Polar 100). This represents a reduction of two AOC turbines from the original SOW. The original SOW also designated installation of an AWT turbine, which is no longer available. While KEA fully intends further expansion of the wind project, the rate of expansion initially envisioned has not been feasible. Project expansion scheduling has been affected by turbine manufacturing delays. For example, two AOC turbines that were to be installed earlier this year arrived too late and won't be installed until spring 2002. The Northwind 100 was also just recently delivered and will be installed in the spring. In addition, the system has experienced wind-penetration levels of up to 35% and KEA must balance the wind expansion with other system upgrades to ensure power quality and grid stability. Two additional AOCs will be ordered shortly with installation expected in 2002-2003.

Task 5: Balance of System Procurement

Budget reduction of $360,000. The majority of this reduction is attributed to the reduction in the number of installed turbines. The costs for this task, which included installation of a SCADA system, was further reduced by KEA's participation in the TVP, which provided the Second Wind SCADA system to KEA. KEA is not requesting changes to the SOW except as it relates to the number of turbines.

Task 6: Turbine Installation

Budget increase of $145,000. Turbine installation costs have been higher than expected due to the harsh remote environment. These higher costs have now been incorporated into the budget to ensure there are adequate funds to cover the remaining installation costs of the five turbines not yet installed. KEA is not requesting changes to the SOW except as it relates to the number of turbines.

Task 7: Balance of System Installation

Budget increase of $650,000. The majority of the increase on this task ($450,000) is attributed to the extension of the site road to gain year road access along the turbine rows. The remaining increase is for higher than expected costs related to the harsh remote environment. These higher costs have now been incorporated into the budget to ensure there are adequate funds to cover the remaining installation costs of the five turbines not yet installed. KEA is not requesting changes to the SOW except as it relates to the number of turbines.

Task 8: System Commissioning

Budget reduction of $45,000. Budgeted costs for this task were either over estimated or activities that could be allocated to this task were included in Task 7 activities. KEA is not requesting changes to the SOW except as it relates to the number of turbines.

Task 9: System Operation

KEA is not requesting any changes to this task.

Task 10: Turbine Test File Operations

KEA is not requesting any changes to this task.

Task 11: Educational Outreach

Budget increase of $25,000. Under this task KEA has accomplished a significant amount of educational and community outreach through the development of high-quality brochures and pamphlets. KEA has also added a wind-energy component to their website that provides information to the public. Site tours have been provided to local school groups, the news media, public policy officials, and utility and technical groups with specific need for information about the project. KEA held a well-attended project dedication ceremony involving local and state dignitaries in August 1999.

The original task included the development of a curriculum for training power plant operator in wind plant operation. Although preliminary work has been done with the University of Alaska and the Alaska Technical Center, the necessary components for developing this program are not in place. In spite of their commitment, KEA anticipates that the development of this program will ultimately be driven by need as wind projects are installed in other villages in northwest Alaska. KEA would like to include this work in a later program budget.

Task 12: TVP Integration

KEA is not requesting any changes to this task. However, DOE deliverables have not yet been defined.

Based on the amended budget, adequate funds are available to complete all tasks.

Appendix B

Meteorological Characterization Report

GLOBAL ENERGY CONCEPTS, LLC
ENGINEERING & TECHNOLOGY CONSULTING

June 12, 2002

Mr. Doug Hooker
U.S. Department of Energy
Golden Field Office
1617 Cole Boulevard, Building 17
Golden, CO 80401

Dear Mr. Hooker:

Attached is Global Energy Concepts' report, *Kotzebue Electric Association Wind Power Project Wind Resource Report – July 1997 to June 2001*. This report and the enclosed data CD are transmitted on behalf of Kotzebue Electric Association in satisfaction of Task 2 of the Statement of Work for Subcontract DE-FC36-97GO10199.

Sincerely,

Rana Vilhauer
Sr. Project Analyst

Attachments

cc: Brad Reeve, Kotzebue Electric Association

5729 Lakeview Dr. NE, Suite 100, Kirkland, Washington 98033 USA Phone: (425) 822-9008
email: gec@globalenergyconcepts.com Fax: (425) 822-9022

Kotzebue Electric Association Wind Power Project Wind Resource Report July 1997 to June 2001

June 2002

Prepared for:

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U.S. Department of Energy
Golden Field Office
1617 Cole Boulevard, Building 17
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under Cooperative Agreement
DE-FC36-97GO10199, Task 2 – Meteorological Characterization

Prepared by:

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Introduction

Kotzebue Electric Association (KEA) has collected wind resource data for seven years from numerous locations in the Kotzebue area. The purpose of the initial installation of monitoring equipment was to establish the general wind characteristics of the area. More sophisticated monitoring equipment was installed as KEA progressed towards the development of its wind project. The wind resource data are currently being collected from a hub-height meteorological (met) tower through the Supervisory Control and Data Acquisition (SCADA) system installed in 1999. The following summarizes KEA's wind monitoring program and the on-site wind resource from July 1997 through June 2001.

Data Collection

In the summer of 1995, KEA installed a 33-m (110-ft) met tower on site and began data collection in August 1995 at heights of 19.5 m (65 ft) and 33 m (110 ft). This data collection effort suffered from marginal data recovery during its first few years. Accordingly, this study focuses on the data collected after July 1997, when the recovery rates increased to a satisfactory level.

In August 1998, the met tower was relocated to a site approximately one rotor diameter upwind of the first row of turbines so that it could be used for performance evaluation purposes. Additional sensors were added to the tower and data were collected at 10 m, 20 m, and 30 m (33 ft, 66 ft, and 98 ft). However, when the next seven AOC turbines were installed upwind of the first three turbines, they created wake impacts and the met tower data were no longer representative of the wind conditions at the site.

In the summer of 1999, a second met tower was installed upwind of the ten-turbine project layout. This met tower is approximately two rotor diameters upwind of Turbine 8 and serves as the source of wind data for the period June 1999 to July 2001.

Table 1 shows the data recovery rates for the four-year collection period. Data were collected using the SCADA system, which averages data into ten-minute records. Where the data recovery rate was low, replacement data were used. For periods less than an hour, replaced data were computed based on an average of the wind speeds before and after the time period. For periods longer than an hour, when the 26.5-m anemometer was frozen but the lower sensors were not, a shear exponent of 0.2 and the lower-height wind speed were used to calculate the upper-level wind speed. When none of the sensors on the met tower were available, the turbine tower mounted anemometers were used to replace missing data.

Table 1. Data Recovery Rates – July 1997 to June 2001

	Year				
Month	**97-98**	**98-99**	**99-00**	**00-01**	**All Years**
July	99.7%	100.0%	80.0%	65.8%	86.4%
August	99.5%	100.0%	100.0%	88.5%	97.0%
September	99.3%	97.7%	100.0%	100.0%	99.3%
October	68.5%	99.9%	100.0%	100.0%	92.1%
November	100.0%	99.7%	100.0%	100.0%	99.9%
December	99.6%	98.1%	99.0%	82.3%	94.8%
January	100.0%	100.0%	100.0%	100.0%	100.0%
February	96.2%	100.0%	100.0%	100.0%	99.1%
March	97.7%	100.0%	100.0%	100.0%	99.4%
April	100.0%	100.0%	100.0%	99.9%	100.0%
May	100.0%	100.0%	100.0%	96.9%	99.2%
June	100.0%	100.0%	88.0%	96.3%	96.1%
Annual Average	96.7%	99.6%	97.3%	94.1%	96.9%

Wind Speed

Table 2 compares the monthly and annual 26.5-m wind speeds from July 1997 through June 2001 to the estimated long-term site wind speed at 26.5 m. The long-term site average is based on 15 years of Kotzebue airport wind data correlated to the project site. The average wind speed at the site was below the long-term average from 1997 through 2000. The lowest wind year was 1999-2000, with an average wind speed of 5.1 m/s, 16% lower than the long-term average of 6.1 m/s. The average wind speed for 2000-2001 was the highest, at 6.6 m/s, 8% above the long-term average. The average wind speed for the period 1997-2001 is 5.6 m/s, which differs from the long-term average of 6.1 m/s by 0.5 m/s, roughly the width of a power class.

Table 2. Mean Monthly 26.5-m Wind Speeds

	Year				
Month	**97-98**	**98-99**	**99-00**	**00-01**	**Long term**
July	5.5	4.1	5.5	5.7	5.8
August	5.2	5.3	5.3	6.8	6.5
September	5.5	5.5	5.1	5.8	6.4
October	5.7	6.7	4.8	5.6	6.6
November	8.4	6.1	4.5	7.3	7.1
December	5.4	5.1	4.2	9.7	6.2
January	5.8	5.4	5.3	7.1	6.3
February	4.3	6.2	7.2	9.4	6.7
March	6.5	4.7	6.5	5.3	5.5
April	6.4	6.6	4.9	7.3	5.3
May	4.9	4.0	4.4	4.0	5.3
June	4.3	5.0	3.7	4.6	6.0
Annual Average	**5.7**	**5.4**	**5.1**	**6.6**	**6.1**

The variation between the high wind year (00-01) and the low wind year (99-00) is over 22%. This significant variation is due mostly to variation in the winter storm cycles. One or two extra storm events per month during the winter season can account for this 20% increase in average wind speed. As shown in Figure 1, the inter-annual variation in wind speed is minimal during the spring and summer months. Comparing average monthly wind speeds from different years reveals differences no greater than 2.4 m/s for the March to September period. From October through February, the differences in monthly average wind speed are as high as 5.1 m/s.

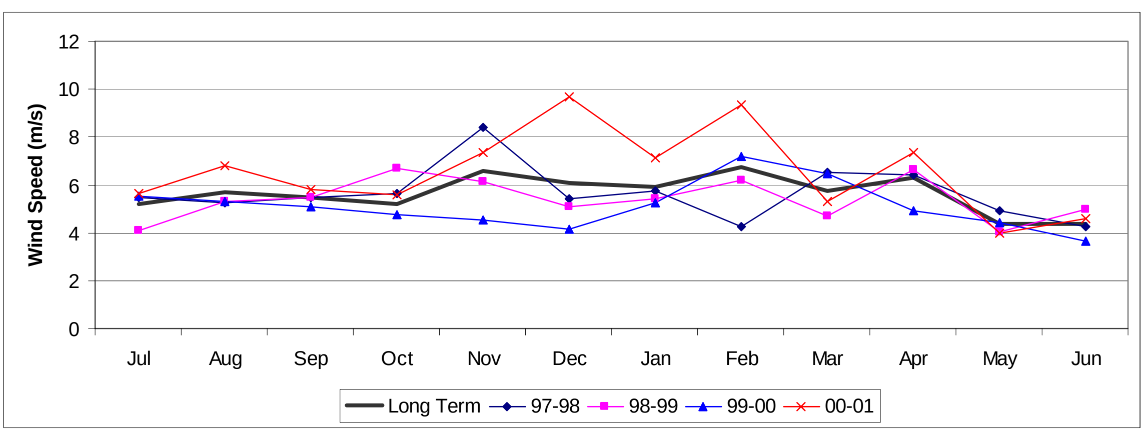


Figure 1. Monthly Wind Speed at 26.5 m

Figure 2 illustrates the average diurnal wind speed during the four-year period. The wind speed peaks around 3:00 p.m. and is at minimum around 8:00 a.m. The total variation is relatively small, averaging only 0.25 m/s over the period July 1997 through June 2001.

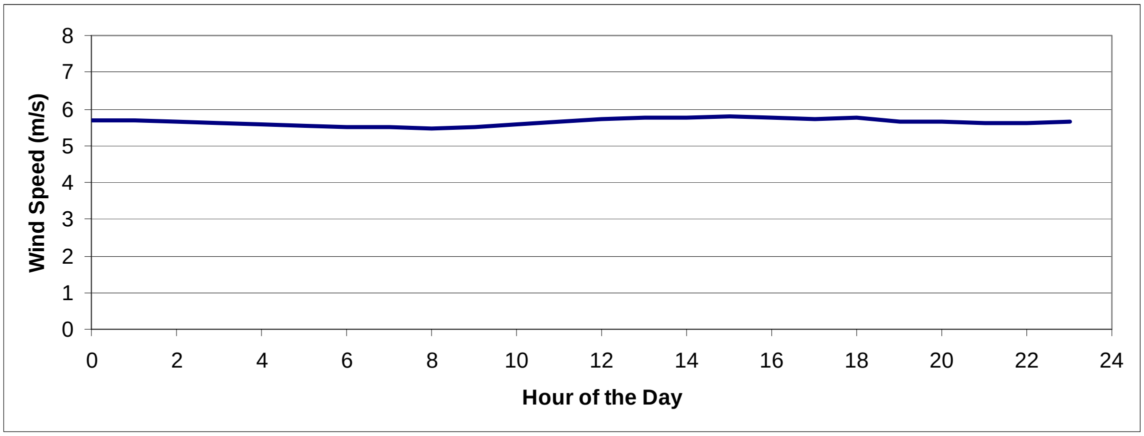


Figure 2. Diurnal Wind Speed at 26.5 m – July 1997 to June 2001

Figure 3 and Table 3 present the wind speed frequency distribution at Kotzebue in graphical and tabular form. Figure 3 shows the measured wind speed frequency distribution together with the Rayleigh distribution, which is often used to provide a simple estimate of the wind speed distribution. The Rayleigh distribution, based on the average wind speed, matches the actual wind speed distribution fairly closely in winds above 5 m/s. The Rayleigh distribution also provides a relatively accurate estimation of energy generation of the four-year period from 1997 to 2001, underestimating the actual energy production by 5%.

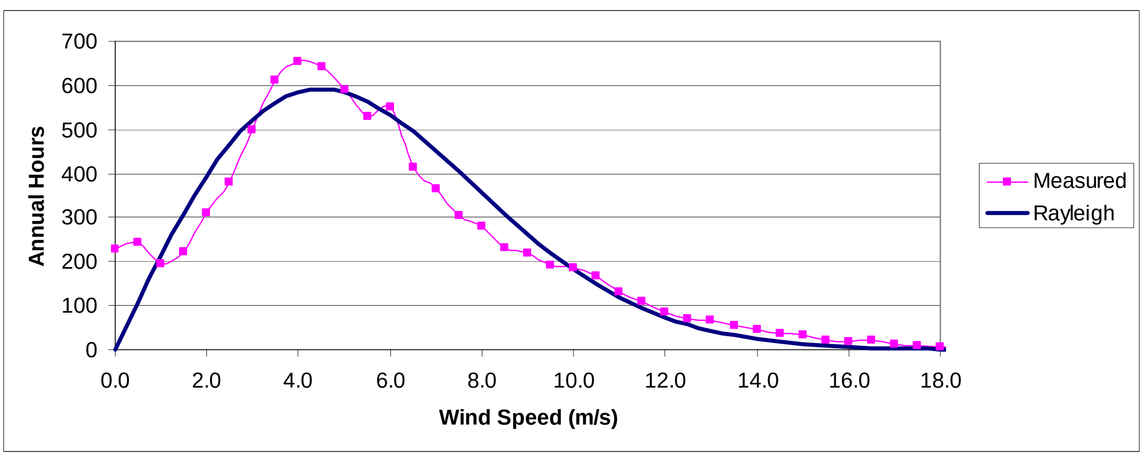


Figure 3. KEA Wind Speed Distribution Compared to a Rayleigh Distribution – July 1997 to June 2001

Table 3. Normalized 26.5-m Wind Speed Distribution – July 1997 to June 2001

Bin (m/s)	Measured Hours	Bin (m/s)	Measured Hours
0.0	227	11.5	111
0.5	242	12.0	85
1.0	195	12.5	71
1.5	223	13.0	66
2.0	312	13.5	55
2.5	381	14.0	46
3.0	498	14.5	35
3.5	612	15.0	33
4.0	655	15.5	20
4.5	643	16.0	19
5.0	591	16.5	22
5.5	528	17.0	13
6.0	552	17.5	10
6.5	415	18.0	8
7.0	365	18.5	7
7.5	305	19.0	4
8.0	279	19.5	1
8.5	232	20.0	1
9.0	219	20.5	1
9.5	192	21.0	1
10.0	186	21.5	0
10.5	166	22.0	1
11.0	129	Total	8,760

Wind Shear and Turbulence Intensity

A wind shear value between 10 m and 26.5 m was estimated to be 0.19 over the four-year reporting period. The shear was calculated based on the power law formula using wind speed data above 4.0 m/s from all directions. The wind shear values obtained for July and May of the 2000-2001 reporting period are uncharacteristically low. This anomaly is due to several occurrences of negative wind shear caused by local ground winds during these months. These ground winds are relatively common at the KEA wind project, particularly during the summer when the low westerly winds occur.

Tables 4 and 5 summarize the monthly wind shear and turbulence intensity during the period July 1999 to June 2001. Turbulence intensity is a relative indicator of the turbulence characteristics of the wind. Over the four-year period, the average turbulence intensity was 0.10 at wind speeds above 4 m/s (8.9 mph). This turbulence intensity is considered fairly low and unlikely to contribute to any operational problems.

Table 4. Monthly Wind Shear – 10 m to 26.5 m

	Wind Shear		
Month	**1999-2000**	**2000-2001**	**Average**
July	N/A	0.09	0.09
August	N/A	0.20	0.20
September	0.13	0.19	0.16
October	0.19	0.22	0.20
November	0.26	0.25	0.25
December	0.22	0.26	0.24
January	0.14	0.26	0.20
February	0.20	0.22	0.21
March	0.23	0.23	0.23
April	0.23	0.16	0.20
May	0.17	0.05	0.11
June	0.20	0.13	0.16
Average	**0.20**	**0.19**	**0.19**

Table 5. Turbulence Intensity

	Turbulence Intensity		
Month	**1999-2000**	**2000-2001**	**Average**
July	N/A	0.14	0.14
August	N/A	0.11	0.11
September	0.11	0.11	0.11
October	0.10	0.10	0.10
November	0.09	0.09	0.09
December	0.09	0.08	0.09
January	0.10	0.08	0.09
February	0.07	0.07	0.07
March	0.07	0.09	0.08
April	0.08	0.08	0.08
May	0.09	0.10	0.10
June	0.13	0.11	0.12
Average	**0.09**	**0.10**	**0.10**

Wind Direction

Kotzebue experiences a strong seasonal wind direction pattern. The winter months, October through February, exhibit strong easterly winds. The summer months, from May to July, are characterized by westerly winds. The wind roses in Figures 4 through 6 illustrate this seasonal variation for the year June 1998 to July 1999. The directional data recovery for this year was 82.5%. A wind rose for the entire four-year period (Figure 7) shows that although the wind has a strong tendency towards easterly and westerly, significantly more power is produced by the easterly winds since those are composed mainly of high-wind storms.

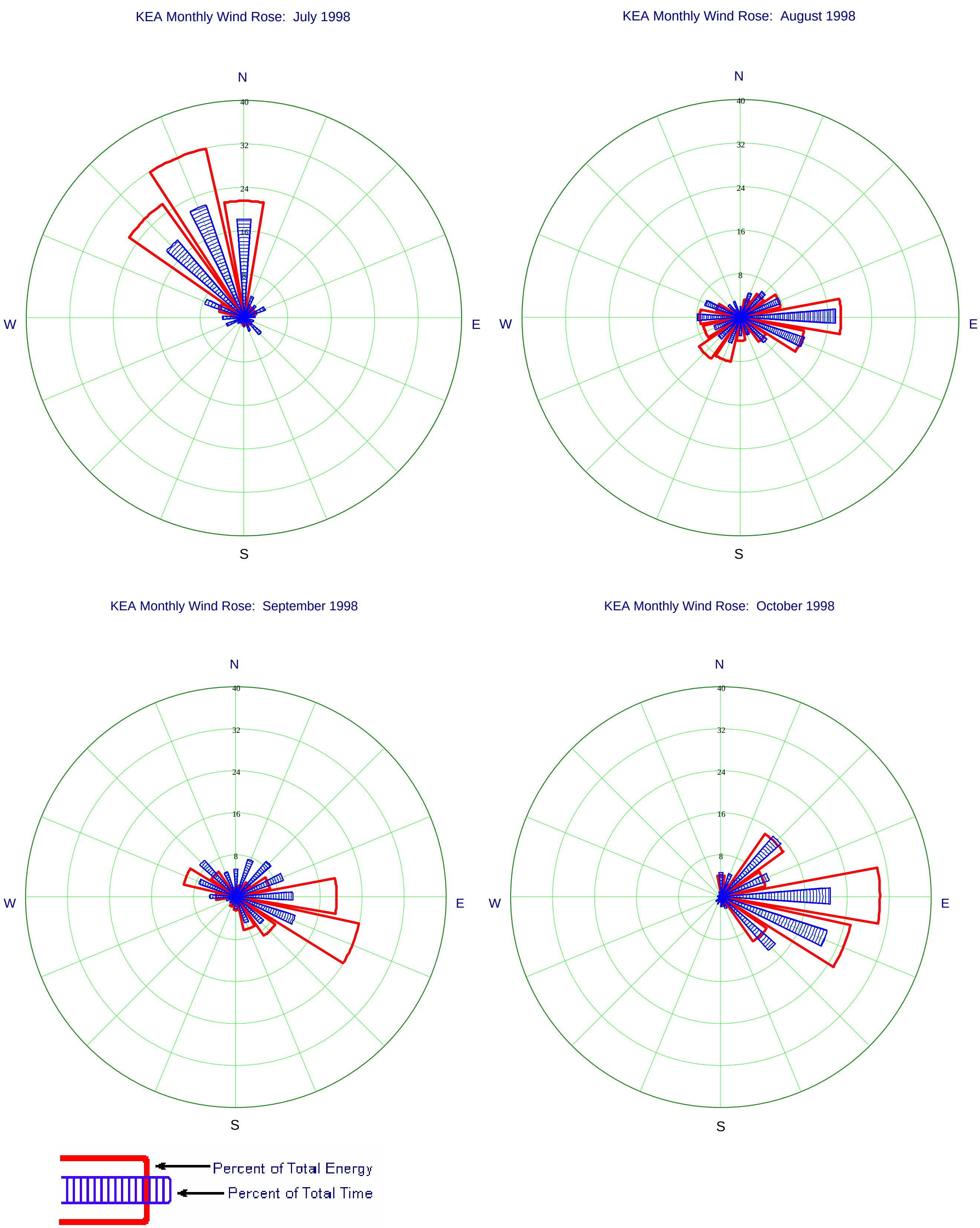


Figure 4. Monthly Wind Roses, July 1998 – October 1998

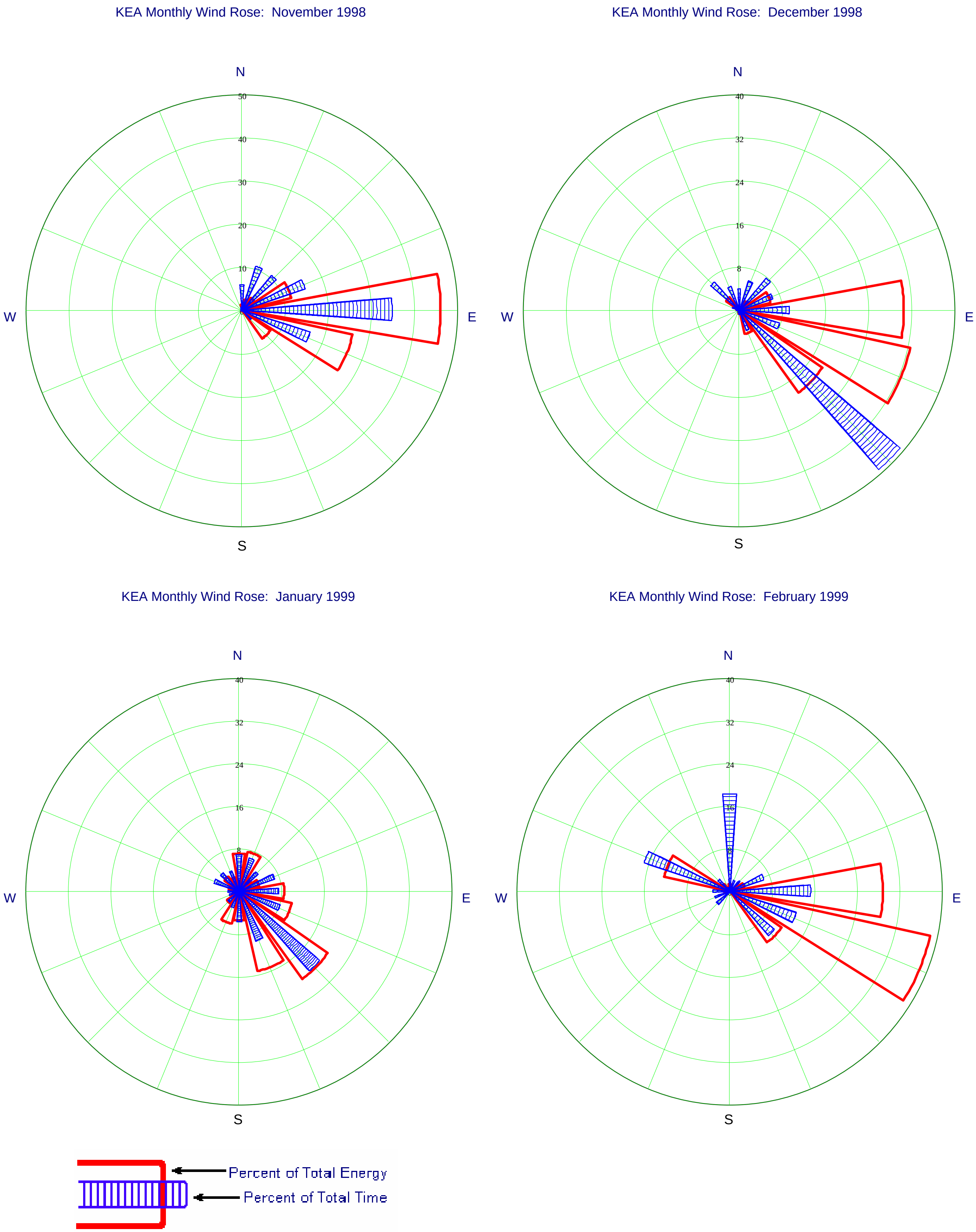


Figure 5. Monthly Wind Roses, November 1998 – February 1999

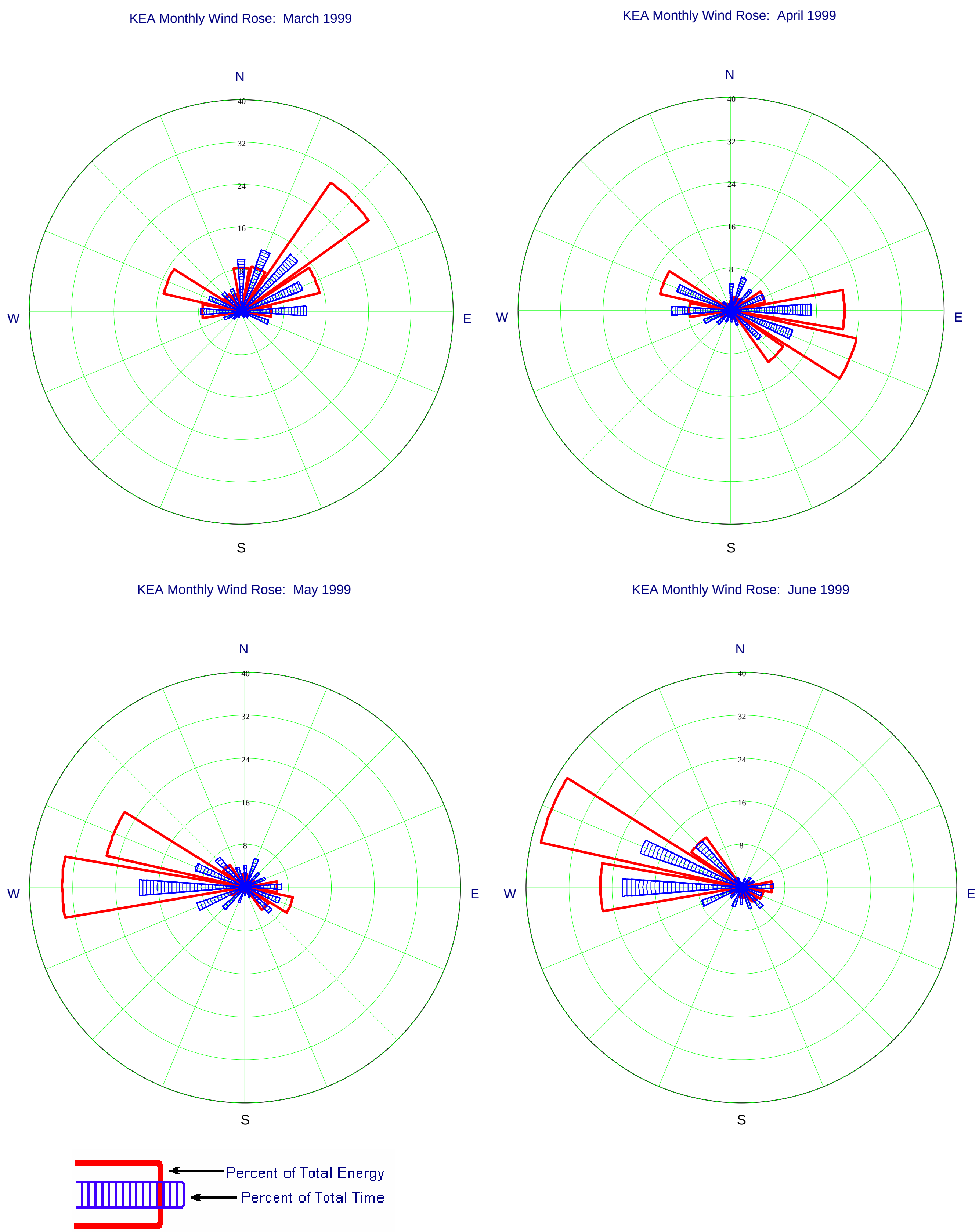


Figure 6. Monthly Wind Roses, March 1999 – June 1999

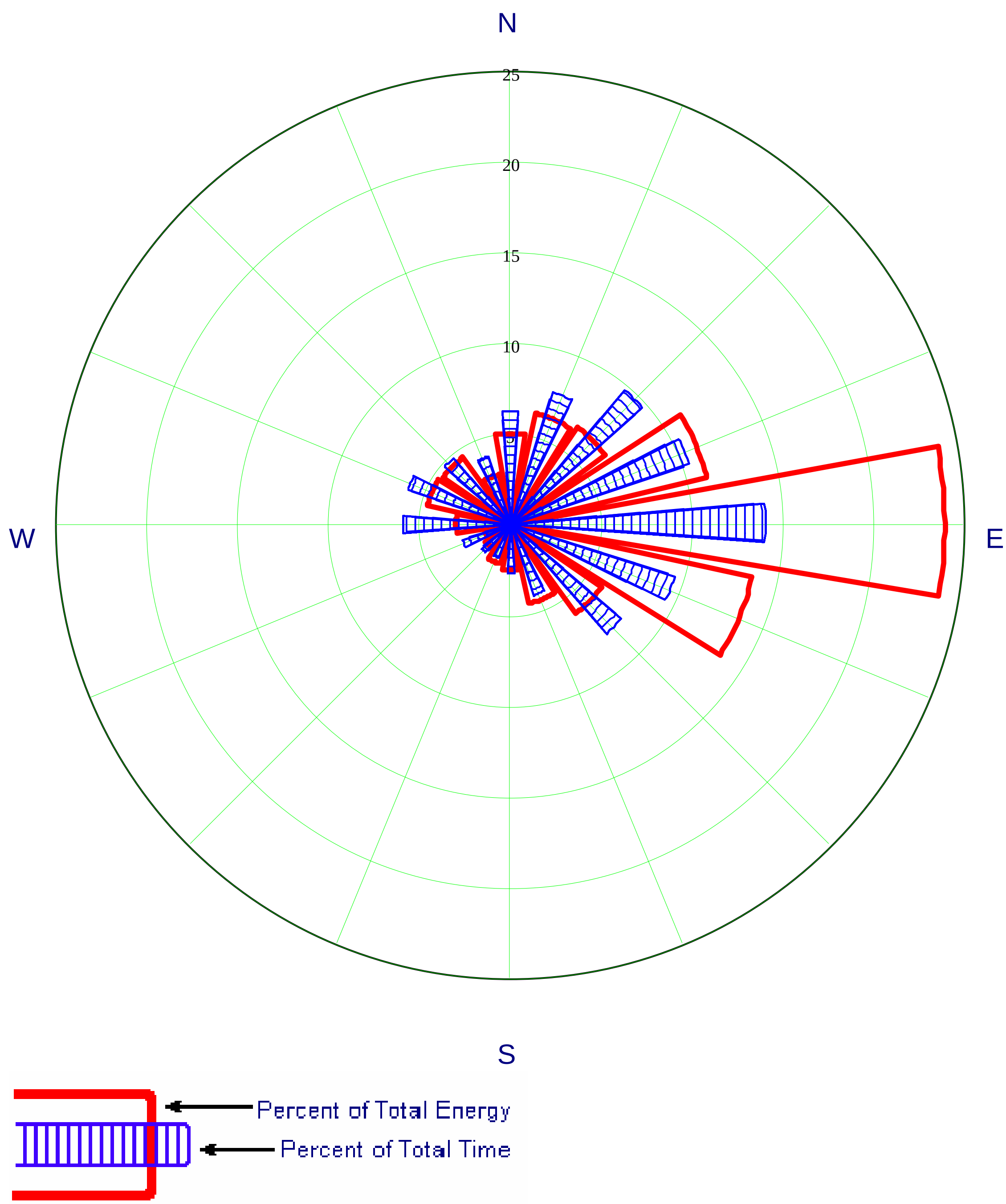
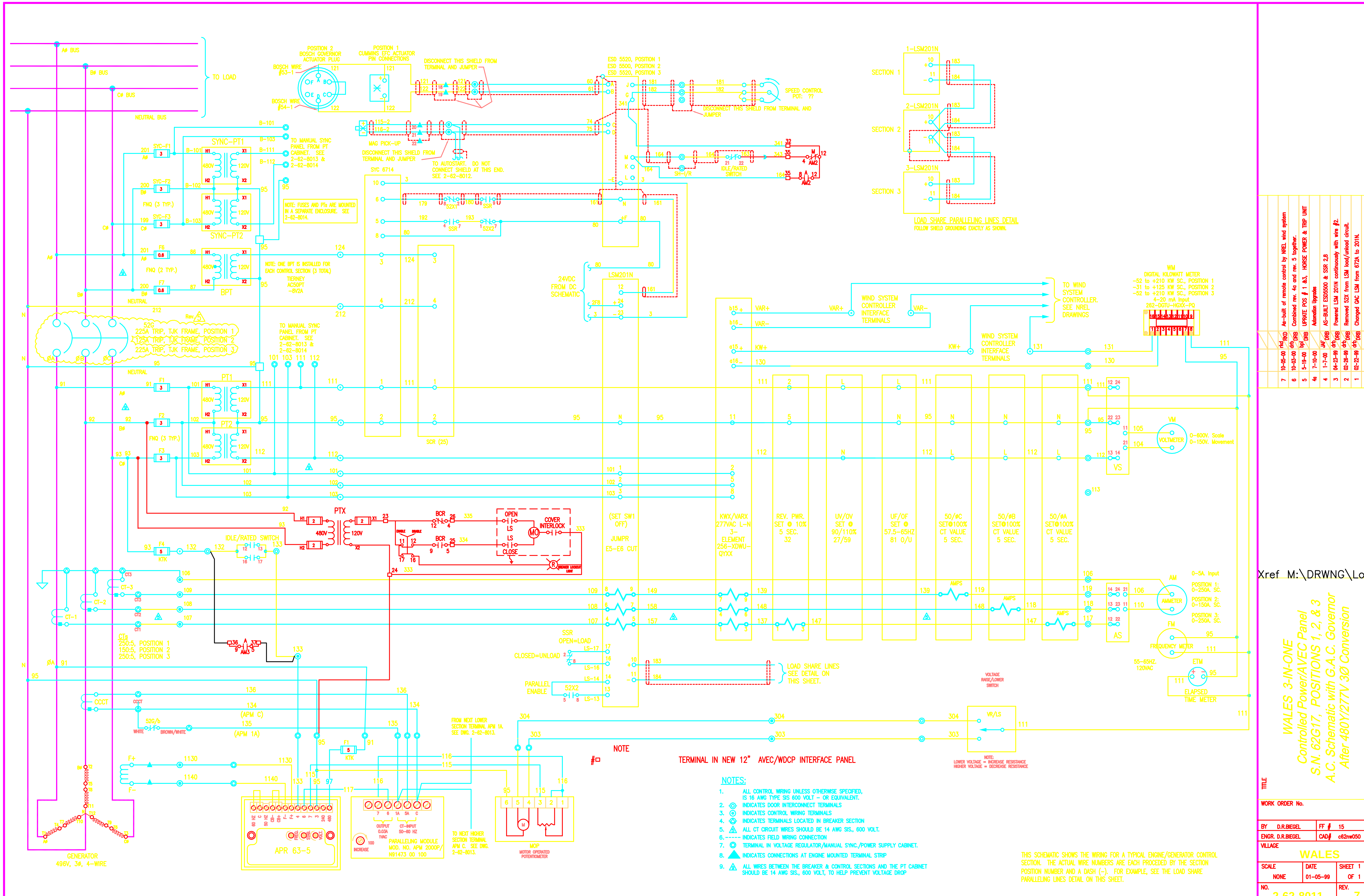


Figure 7. KEA Wind Rose, July 1997 – June 2001

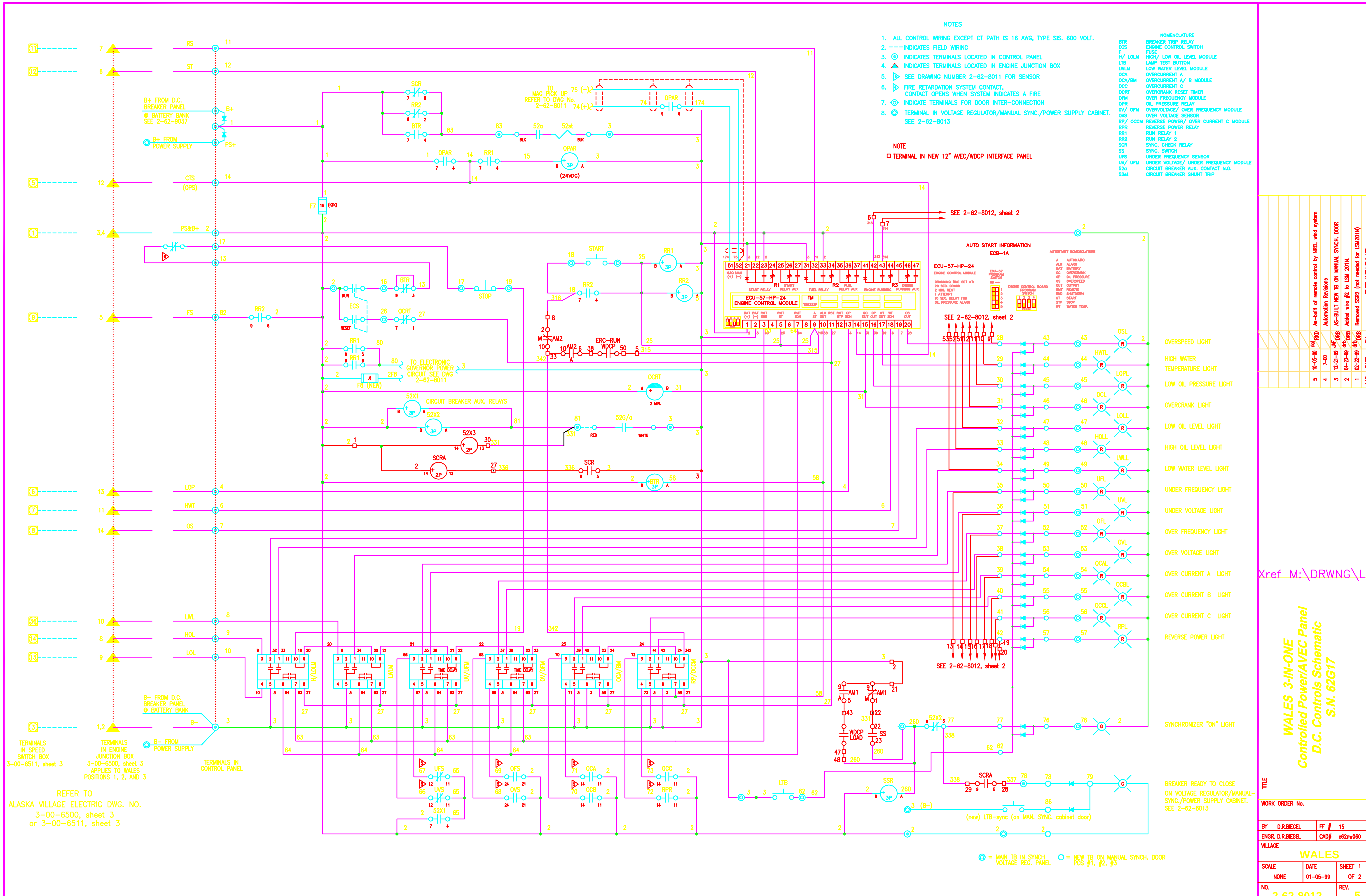
Appendix C

As-Built Drawings

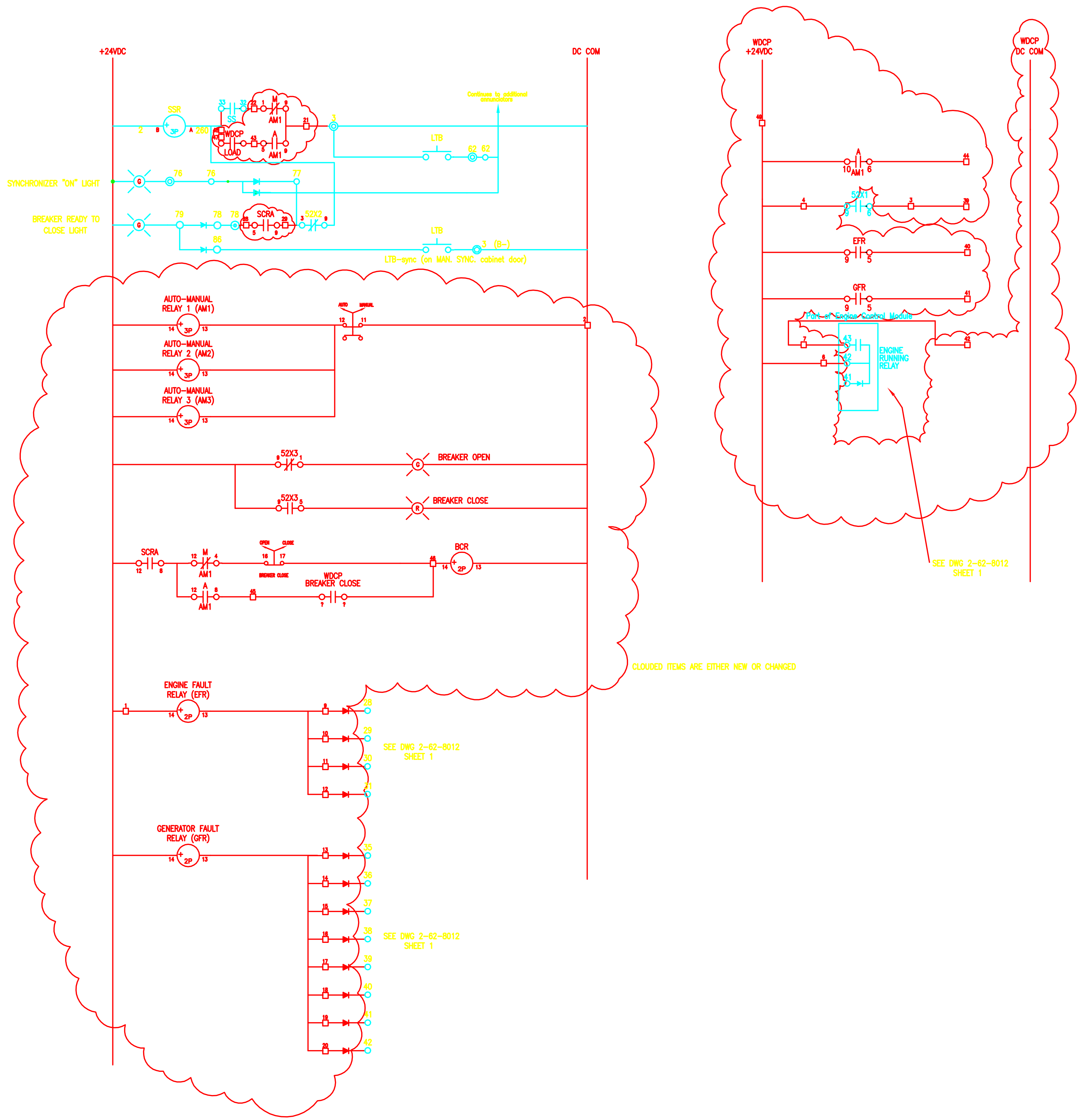
Wales Wind Power Plant



TO LOAD
A# BUS
B# BUS
C# BUS
NEUTRAL BUS
SYNC-PT1
SYNC-PT2
BPT
PT1
PT2
PTX
SECTION 1
SECTION 2
SECTION 3
LOAD SHARE PARALLELING LINES DETAIL
SPEED CONTROL POT.
24VDC FROM DC SCHEMATIC
TO WIND SYSTEM CONTROLLER. SEE NREL DRAWINGS
WIND SYSTEM CONTROLLER INTERFACE TERMINALS
DIGITAL KILOWATT METER
VOLTMETER
AMMETER
FREQUENCY METER
ELAPSED TIME METER
LOAD SHARE LINES SEE DETAIL ON THIS SHEET.
GENERATOR 480V, 3Ø, 4-WIRE
APR 63-5
PARALLELING MODULE
MOP MOTOR OPERATED POTENTIOMETER
NOTE
TERMINAL IN NEW 12" AVEC/WDCP INTERFACE PANEL
NOTES:
1. ALL CONTROL WIRING UNLESS OTHERWISE SPECIFIED, IS 16 AWG TYPE SIS 600 VOLT – OR EQUIVALENT.
2. INDICATES DOOR INTERCONNECT TERMINALS
3. INDICATES CONTROL WIRING TERMINALS
4. INDICATES TERMINALS LOCATED IN BREAKER SECTION
5. ALL CT CIRCUIT WIRES SHOULD BE 14 AWG SIS., 600 VOLT.
6. ----- INDICATES FIELD WIRING CONNECTION
7. TERMINAL IN VOLTAGE REGULATOR/MANUAL SYNC./POWER SUPPLY CABINET.
8. INDICATES CONNECTIONS AT ENGINE MOUNTED TERMINAL STRIP
9. ALL WIRES BETWEEN THE BREAKER & CONTROL SECTIONS AND THE PT CABINET SHOULD BE 14 AWG SIS., 600 VOLT, TO HELP PREVENT VOLTAGE DROP
REVISIONS
Xref M:\DRWNG\Logo-3.dwg
TITLE
WALES 3-IN-ONE
Controlled Power/AVEC Panel
S.N. 62G17, POSITIONS 1, 2, & 3
A.C. Schematic with G.A.C. Governor
After 480Y/277V 3Ø Conversion
WORK ORDER No.
BY D.R.BIEGEL
FF # 15
ENGR. D.R.BIEGEL
CAD# c62nw050
VILLAGE
WALES
SCALE NONE
DATE 01-05-99
SHEET 1 OF 1
NO. 2-62-8011
REV. 7



NOTES
1. ALL CONTROL WIRING EXCEPT CT PATH IS 16 AWG, TYPE SIS. 600 VOLT.
2. ---INDICATES FIELD WIRING
3. INDICATES TERMINALS LOCATED IN CONTROL PANEL
4. INDICATES TERMINALS LOCATED IN ENGINE JUNCTION BOX
5. SEE DRAWING NUMBER 2-62-8011 FOR SENSOR
6. FIRE RETARDATION SYSTEM CONTACT, CONTACT OPENS WHEN SYSTEM INDICATES A FIRE
7. INDICATE TERMINALS FOR DOOR INTER-CONNECTION
8. TERMINAL IN VOLTAGE REGULATOR/MANUAL SYNC./POWER SUPPLY CABINET. SEE 2-62-8013
NOTE
TERMINAL IN NEW 12" AVEC/WDCP INTERFACE PANEL
NOMENCLATURE
BTR BREAKER TRIP RELAY
ECS ENGINE CONTROL SWITCH
F FUSE
H/ LOLM HIGH/ LOW OIL LEVEL MODULE
LTB LAMP TEST BUTTON
LWLM LOW WATER LEVEL MODULE
OCA OVERCURRENT A
OCA/BM OVERCURRENT A/ B MODULE
OCC OVERCURRENT C
OCRT OVERCRANK RESET TIMER
OFM OVER FREQUENCY MODULE
OPR OIL PRESSURE RELAY
OV/ OFM OVERVOLTAGE/ OVER FREQUENCY MODULE
OVS OVER VOLTAGE SENSOR
RP/ OCCM REVERSE POWER/ OVER CURRENT C MODULE
RPR REVERSE POWER RELAY
RR1 RUN RELAY 1
RR2 RUN RELAY 2
SCR SYNC. CHECK RELAY
SS SYNC. SWITCH
UFS UNDER FREQUENCY SENSOR
UV/ UFM UNDER VOLTAGE/ UNDER FREQUENCY MODULE
52a CIRCUIT BREAKER AUX. CONTACT N.O.
52st CIRCUIT BREAKER SHUNT TRIP
SEE 2-62-8012, sheet 2
AUTO START INFORMATION
ECB-1A
ECU-57-HP-24
ENGINE CONTROL MODULE
B+ FROM D.C. BREAKER PANEL @ BATTERY BANK SEE 2-62-8037
B+ FROM POWER SUPPLY
MAG PICK UP REFER TO DWG No. 2-62-8011
TO ELECTRONIC GOVERNOR POWER CIRCUIT SEE DWG 2-62-8011
CIRCUIT BREAKER AUX. RELAYS
ERC-RUN
OVERSPEED LIGHT
HIGH WATER TEMPERATURE LIGHT
LOW OIL PRESSURE LIGHT
OVERCRANK LIGHT
LOW OIL LEVEL LIGHT
HIGH OIL LEVEL LIGHT
LOW WATER LEVEL LIGHT
UNDER FREQUENCY LIGHT
UNDER VOLTAGE LIGHT
OVER FREQUENCY LIGHT
OVER VOLTAGE LIGHT
OVER CURRENT A LIGHT
OVER CURRENT B LIGHT
OVER CURRENT C LIGHT
REVERSE POWER LIGHT
SYNCHRONIZER "ON" LIGHT
BREAKER READY TO CLOSE ON VOLTAGE REGULATOR/MANUAL-SYNC./POWER SUPPLY CABINET. SEE 2-62-8013
(new) LTB-sync (on MAN. SYNC. cabinet door)
= MAIN TB IN SYNCH VOLTAGE REG. PANEL
= NEW TB ON MANUAL SYNCH. DOOR POS #1, #2, #3
B- FROM D.C. BREAKER PANEL @ BATTERY BANK
B- FROM POWER SUPPLY
TERMINALS IN SPEED SWITCH BOX 3-00-6511, sheet 3
TERMINALS IN ENGINE JUNCTION BOX 3-00-6500, sheet 3 APPLIES TO WALES POSITIONS 1, 2, AND 3
TERMINALS IN CONTROL PANEL
REFER TO ALASKA VILLAGE ELECTRIC DWG. NO. 3-00-6500, sheet 3 or 3-00-6511, sheet 3
Xref M:\DRWNG\Logo-3.dwg
REVISIONS
NO. DATE BY
5 10-05-00 rkd RKD As-built of remote control by NREL wind system
4 7-00 Automation Revisions
3 12-21-99 JAF DRB AS-BUILT NEW TB ON MANUAL SYNCH. DOOR
2 04-23-99 drb DRB Added wire #2 to LSM 201N.
1 02-22-99 drb DRB Removed SSR2 (not needed for LSM201N)
TITLE
WALES 3-IN-ONE
Controlled Power/AVEC Panel
D.C. Controls Schematic
S.N. 62G17
WORK ORDER No.
BY D.R.BIEGEL
FF # 15
ENGR. D.R.BIEGEL
CAD# c62nw060
VILLAGE WALES
SCALE NONE
DATE 01-05-99
SHEET 1 OF 2
NO. 2-62-8012
REV. 5



CLOUDED ITEMS ARE EITHER NEW OR CHANGED

NOTES

1. ALL CONTROL WIRING EXCEPT CT PATH IS 16 AWG, TYPE SIS. 600 VOLT.
2. ---INDICATES FIELD WIRING
3. ◎ INDICATES TERMINALS LOCATED IN CONTROL PANEL
4. △ INDICATES TERMINALS LOCATED IN ENGINE JUNCTION BOX
5. ▷ SEE DRAWING NUMBER 2-62-8011 FOR SENSOR
6. ▷ FIRE RETARDATION SYSTEM CONTACT, CONTACT OPENS WHEN SYSTEM INDICATES A FIRE
7. ◎ INDICATE TERMINALS FOR DOOR INTER-CONNECTION
8. ◎ TERMINAL IN VOLTAGE REGULATOR/MANUAL SYNC./POWER SUPPLY CABINET. SEE 2-62-8013

NOTE
#☐ TERMINAL IN NEW 12" PANEL AVEC/WDCP INTERFACE PANEL

NOMENCLATURE

BTR	BREAKER TRIP RELAY
ECS	ENGINE CONTROL SWITCH
F	FUSE
H/ LOLM	HIGH/ LOW OIL LEVEL MODULE
LTB	LAMP TEST BUTTON
LWLM	LOW WATER LEVEL MODULE
OCA	OVERCURRENT A
OCA/BM	OVERCURRENT A/ B MODULE
OCC	OVERCURRENT C
OCRT	OVERCRANK RESET TIMER
OFM	OVER FREQUENCY MODULE
OPR	OIL PRESSURE RELAY
OV/ OFM	OVERVOLTAGE/ OVER FREQUENCY MODULE
OVS	OVER VOLTAGE SENSOR
RP/ OCCM	REVERSE POWER/ OVER CURRENT C MODULE
RPR	REVERSE POWER RELAY
RR1	RUN RELAY 1
RR2	RUN RELAY 2
SCR	SYNC. CHECK RELAY
SS	SYNC. SWITCH
UFS	UNDER FREQUENCY SENSOR
UV/ UFM	UNDER VOLTAGE/ UNDER FREQUENCY MODULE
52a	CIRCUIT BREAKER AUX. CONTACT N.O.
52st	CIRCUIT BREAKER SHUNT TRIP

REVISIONS

NO.	DATE	BY	
1	08-2000	CJT	ADD TERM AND CONTACT #S

Xref M:\DRWNG\Logo-3.dwg

TITLE
WALES 3-IN-ONE
Controlled Power/AVEC Panel
S.N. 62G17, D.C. Controls Schematic
Automation Additions
by Thompson Engineering

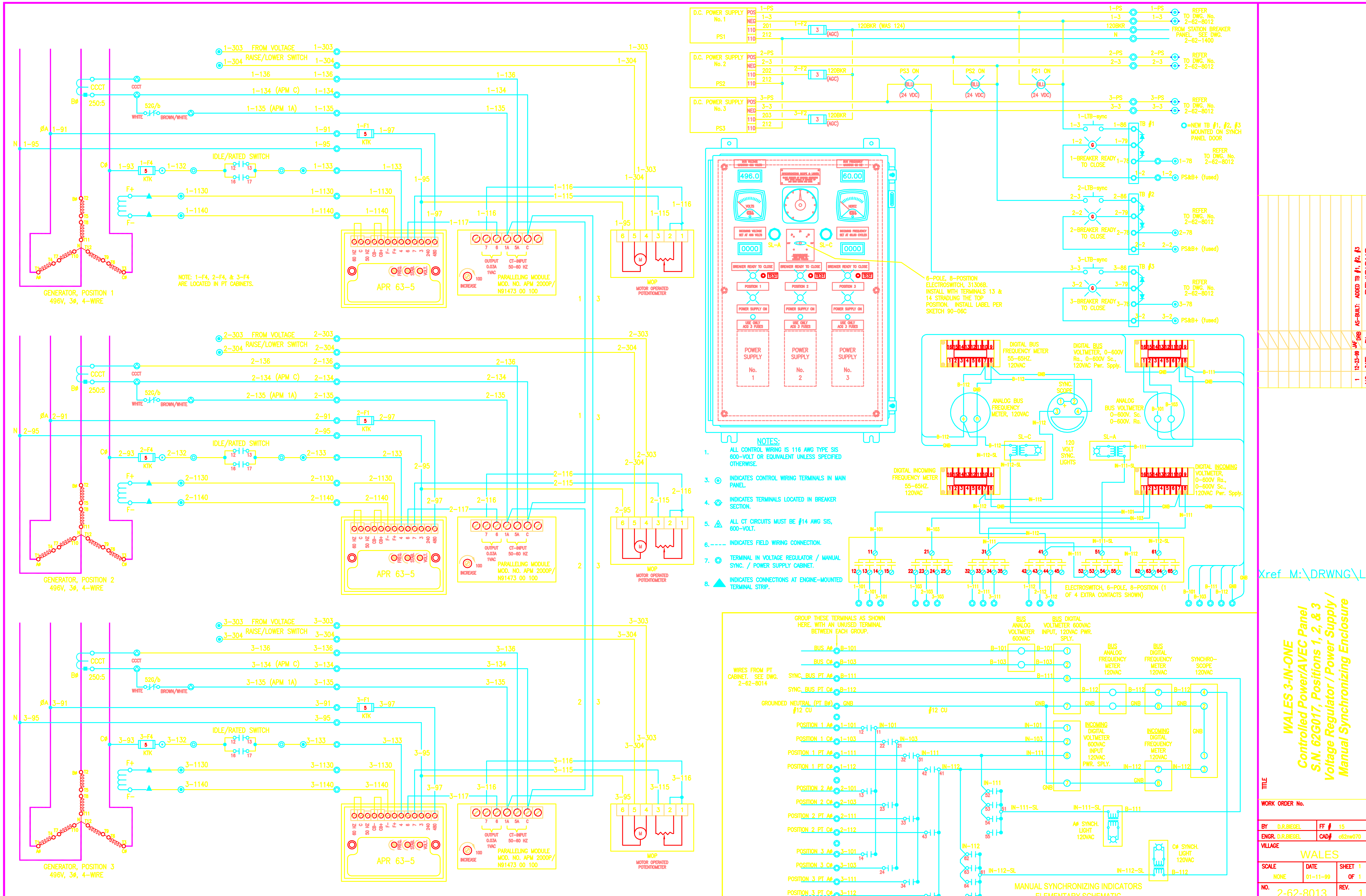
WORK ORDER No.

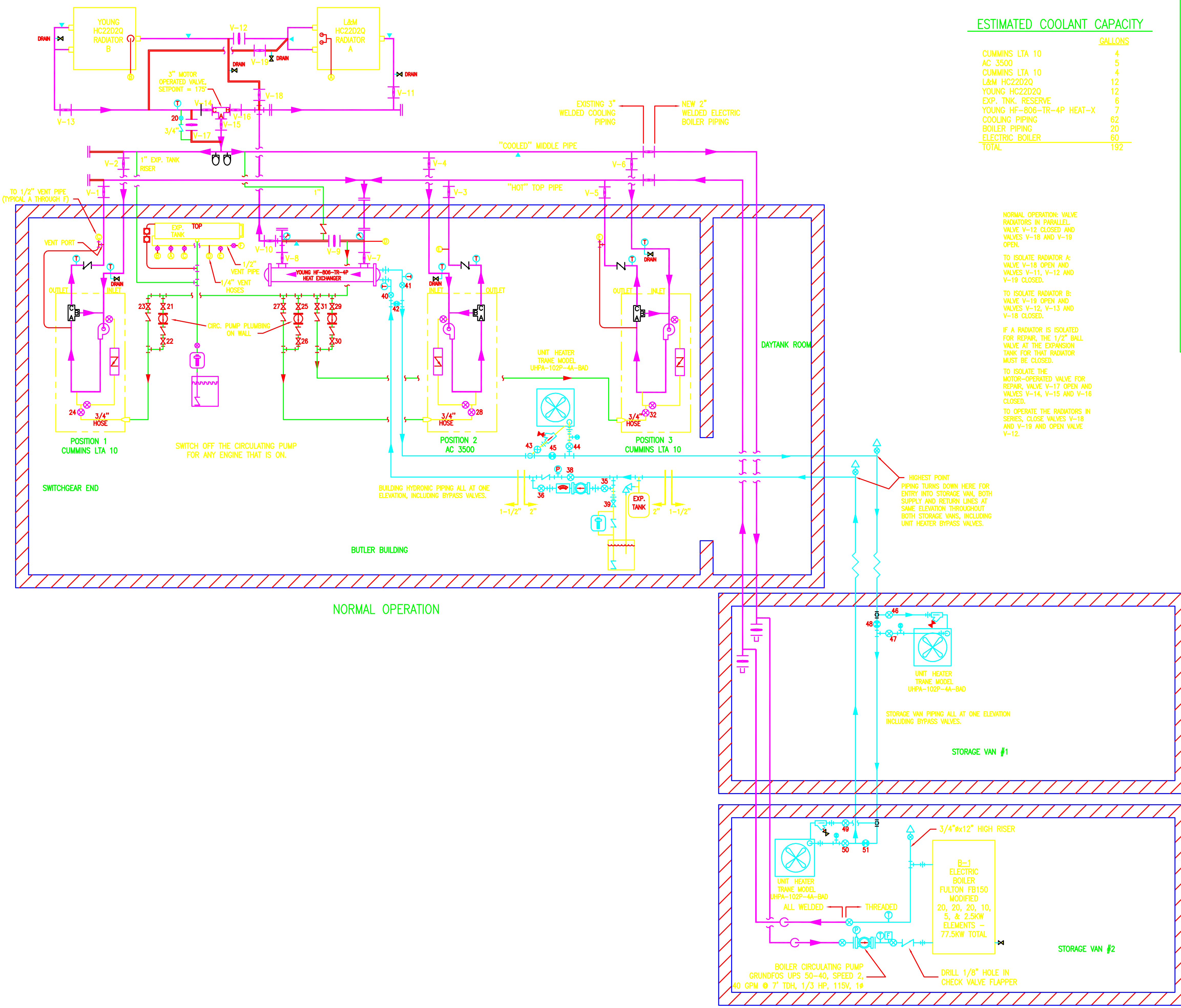
BY CJT	FF #
ENGR. CJT	CAD# c62nw060

VILLAGE WALES

SCALE	DATE	SHEET 2
NONE	08-14-2000	OF 2

NO. 2-62-8012 REV. 1


GENERATOR, POSITION 1
496V, 3Ø, 4-WIRE
GENERATOR, POSITION 2
496V, 3Ø, 4-WIRE
GENERATOR, POSITION 3
496V, 3Ø, 4-WIRE
FROM VOLTAGE RAISE/LOWER SWITCH
IDLE/RATED SWITCH
NOTE: 1-F4, 2-F4, & 3-F4 ARE LOCATED IN PT CABINETS.
APR 63-5
PARALLELING MODULE MOD. NO. APM 2000P/ N91473 00 100
MOP MOTOR OPERATED POTENTIOMETER
D.C. POWER SUPPLY No. 1
D.C. POWER SUPPLY No. 2
D.C. POWER SUPPLY No. 3
POWER SUPPLY No. 1
POWER SUPPLY No. 2
POWER SUPPLY No. 3
6-POLE, 6-POSITION ELECTROSWITCH, 31306B. INSTALL WITH TERMINALS 13 & 14 STRADDLING THE TOP POSITION. INSTALL LABEL PER SWITCH 90-08C
NOTES:
1. ALL CONTROL WIRING IS 116 AWG TYPE SIS 600-VOLT OR EQUIVALENT UNLESS SPECIFIED OTHERWISE.
3. INDICATES CONTROL WIRING TERMINALS IN MAIN PANEL.
4. INDICATES TERMINALS LOCATED IN BREAKER SECTION.
5. ALL CT CIRCUITS MUST BE #14 AWG SIS, 600-VOLT.
6. ---- INDICATES FIELD WIRING CONNECTION.
7. TERMINAL IN VOLTAGE REGULATOR / MANUAL SYNC. / POWER SUPPLY CABINET.
8. INDICATES CONNECTIONS AT ENGINE-MOUNTED TERMINAL STRIP.
GROUP THESE TERMINALS AS SHOWN HERE. WITH AN UNUSED TERMINAL BETWEEN EACH GROUP.
WIRES FROM PT CABINET. SEE DWG. 2-62-8014.
MANUAL SYNCHRONIZING INDICATORS
ELEMENTARY SCHEMATIC
Xref M:\DRWNG\Logo-3.dwg
REVISIONS
TITLE
WALES 3-IN-ONE
Controlled Power/AVEC Panel
S.N. 62G017, Positions 1, 2, & 3
Voltage Regulator / Power Supply /
Manual Synchronizing Enclosure
WORK ORDER No.
BY D.R.BIEGEL
FF # 15
ENGR. D.R.BIEGEL
CAD# c62nw070
VILLAGE WALES
SCALE NONE
DATE 01-11-99
SHEET 1 OF 1
NO. 2-62-8013
REV. 1



NORMAL OPERATION

ESTIMATED COOLANT CAPACITY

	GALLONS
CUMMINS LTA 10	4
AC 3500	5
CUMMINS LTA 10	4
L&M HC22D2Q	12
YOUNG HC22D2Q	12
EXP. TNK. RESERVE	6
YOUNG HF-806-TR-4P HEAT-X	7
COOLING PIPING	62
BOILER PIPING	20
ELECTRIC BOILER	60
TOTAL	192

NORMAL OPERATION: VALVE RADIATORS IN PARALLEL. VALVE V-12 CLOSED AND VALVES V-18 AND V-19 OPEN.

TO ISOLATE RADIATOR A: VALVE V-18 OPEN AND VALVES V-11, V-12 AND V-19 CLOSED.

TO ISOLATE RADIATOR B: VALVE V-19 OPEN AND VALVES V-12, V-13 AND V-18 CLOSED.

IF A RADIATOR IS ISOLATED FOR REPAIR, THE 1/2" BALL VALVE AT THE EXPANSION TANK FOR THAT RADIATOR MUST BE CLOSED.

TO ISOLATE THE MOTOR-OPERATED VALVE FOR REPAIR, VALVE V-17 OPEN AND VALVES V-14, V-15 AND V-16 CLOSED.

TO OPERATE THE RADIATORS IN SERIES, CLOSE VALVES V-18 AND V-19 AND OPEN VALVE V-12.

LEGEND

- OPEN BUTTERFLY VALVE
- CLOSED BUTTERFLY VALVE
- OPEN GATE VALVE
- CLOSED GATE VALVE
- OPEN BALL VALVE
- CLOSED BALL VALVE
- CHECK VALVE WITH FLOW DIRECTION INDICATED
- MAIN-LINE CIRCULATING PUMP
- GRUNFOS UPS-15-42-F CIRCULATING PUMP
- AMOT THERMOSTATIC VALVE
- STRAINER
- HYDRONIC SYSTEM FLOW METER UNIVERSAL FLOW MONITORS OK40G-12-32S-ONL
- or HAND FILL PUMP
- ENGINE THERMOSTAT
- ENGINE WATER PUMP
- ENGINE ELECTRIC BLOCK HEATER
- THERMOMETER
- THERMOCOUPLE SENSOR FOR RADIATOR MOTOR CONTROL PANEL (VOLKMAN VSD)
- INDICATES UNUSED, PLUGGED PORT FOR PRESSURE, TEMPERATURE, OR FLOW DIAGNOSTICS.
- CAPPED FLANGE FOR FUTURE SYSTEM ADDITIONS
- PRESSURE GAUGE
- PRESSURE RELIEF VALVE
- AIR ELIMINATOR W/ 3/4" BALL VALVE
- BUCKET W/LID
- STRAINER FOOT VALVE

BOILER PIPING

EXTERIOR PIPING – ALL WELDED ASTM A106B BLACK STEEL PIPE, WELD END FITTINGS, 150# RF WELD NECK FLANGES.

INTERIOR PIPING – ALL THREADED ASTM A106B BLACK STEEL PIPE, THREADED 3000# FORGED STEEL FITTINGS.

BALL VALVE – THREADED BRONZE BALL VALVE, NIBCO T-580

CHECK VALVE – THREADED BRONZE SWING CHECK VALVE WITH 1/8" HOLE DRILLED IN FLAPPER, NIBCO T-413

PIPE INSULATION – 2" FIBERGLASS PIPE INSULATION, INTERIOR & EXTERIOR

INSULATION JACKETING – CORRUGATED ALUMINUM JACKET, INTERIOR & EXTERIOR

PRESSURE GUAGES – 3-1/2" DIAL SIZE, RANGE AS INDICATED, TRERICE NO. 600C OR EQUAL

THERMOMETERS – 3" DIAL SIZE BIMETAL TYPE, DUAL SCALE F & C, 20F TO 240F RANGE. TRERICE NO. B83600.

DIFFERENTIAL PRESSURE GAUGES – 6" DIAMETER UNI-DIRECTIONAL DIAL, ALUMINUM BODY, COPPER ALLOY INTERNALS, BUNA-N SEALS, PLASTIC CASE, ACRYLIC LENS, 1/4" FPT CONNECTIONS. PROVIDE WITH OPTIONAL 115VAC SPDT SWITCH. MID-WEST INSTRUMENT 109-CE-00-0A, NO SUBSTITUTES.

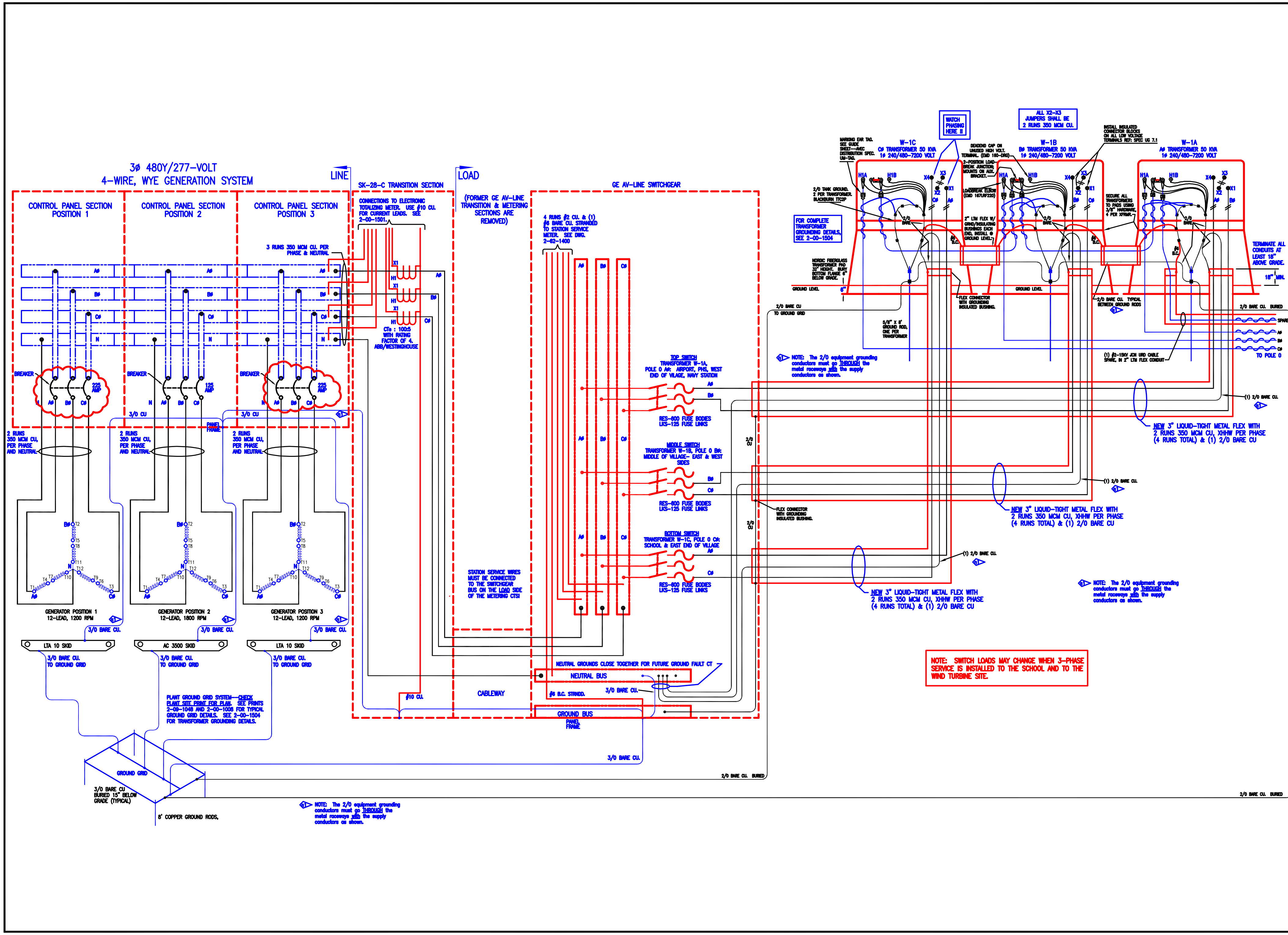
FLOW SWITCH – VANE OPERATED PROOF OF FLOW INDICATION SWITCH. SEALED BRASS BODY, STAINLESS STEEL VANE AND TRIM, MAGNETIC LINK, SNAP SWITCH 10A RATED AT 125VAC, 1-1/2" NPT CONNECTION, U.L. LISTED. FLOTECT 4V-2-U, NO SUBSTITUTES.

NO.	DATE	BY	REVISIONS
5	1-16-02	AAC / AAC	Rad. flow to parallel, added valve notes
4	8/17/01	AAC / MET	Changed AMOT to Motor Operated Valve
4			Moved thermocouples to outlet of M.O.V.
3	7/28/99	bcg / BCG	Add Electric Boiler.
2	05/24/93	DRB	ADDED S.V. #2, MODIFIED S.V. UHTR. PPNG.
1	10/14/92	DRB	MODIFIED HYDRONIC PUMP AREA

ALASKA VILLAGE ELECTRIC CO-OP

WALES COOLING & HEATING SCHEMATIC

BY D.R.BIEGEL / ENGR. DRB	DATE 01-06-92	SCALE NONE	WORK ORDER
FF# 15 / CAD# W62HQ000	SHEET 1 OF 1	NO. 4-62-7400	REV. 5

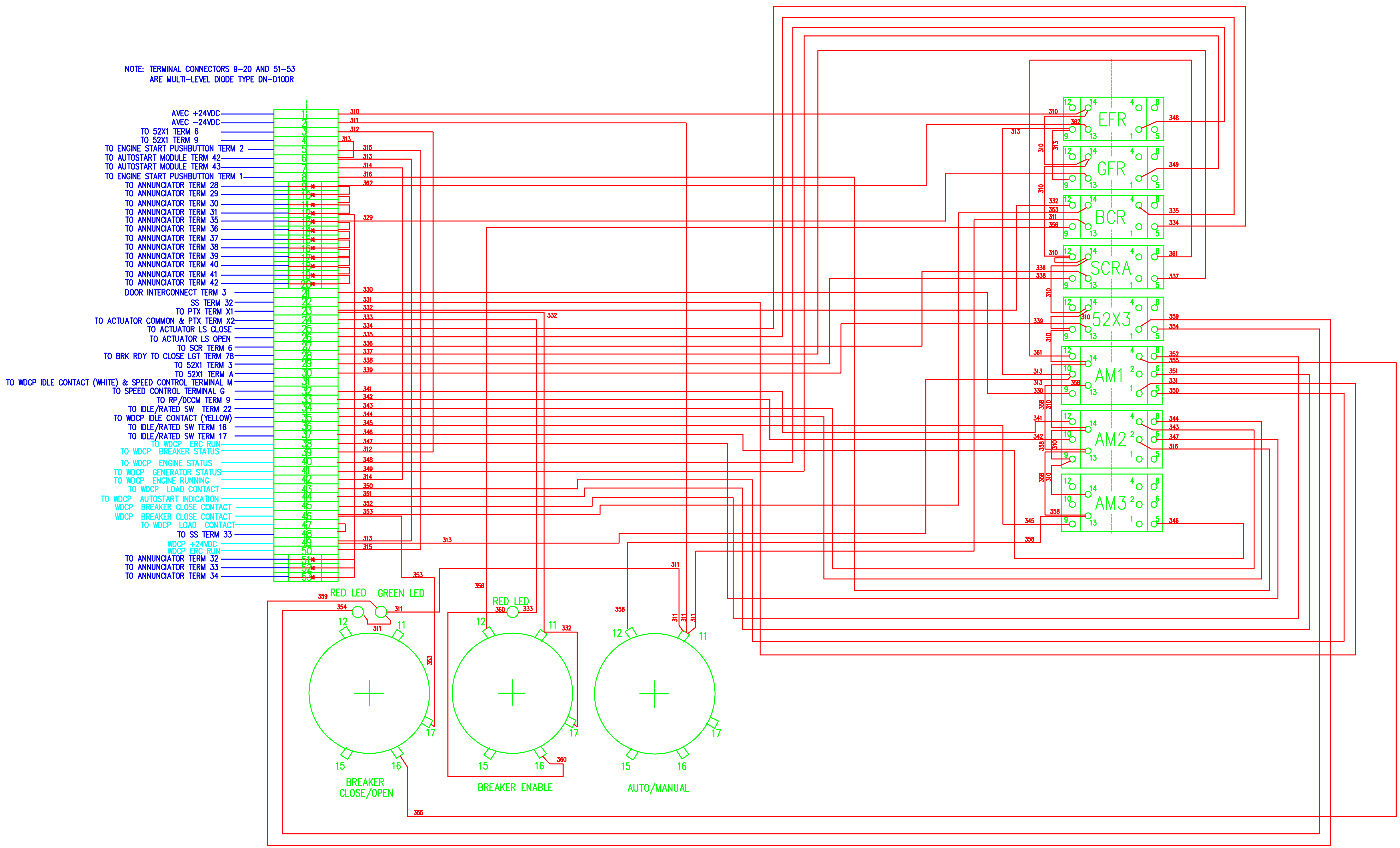


NO.	DATE	BY	REVISIONS
1	12-20-99	JAF/DRB	AS-BUILT NEW 350MCM TO XFMRS

AVEC
ALASKA VILLAGE ELECTRIC COOPERATIVE
4831 Eagle Street
Anchorage, Alaska 99503

TITLE
WALES
SECTIONALIZING & GROUNDING

WORK ORDER No.
BY d.r.biegel | FF # 15
ENGR. D.R.BIEGEL | CAD# j62dw000
VILLAGE WALES
SCALE NONE | DATE 12-28-98 | SHEET 1 OF 1
NO. 2-62-1500 | REV. 1



NO.	DATE	REVISIONS	BY	CHK	APPR'D
1	12/18/00	AS INSTALLED	SMD	SMD	SMD

THOMPSON ENGINEERING CO.

721 SESAME ST SUITE 2B, ANCHORAGE, AK 99503, PHONE (907) 562-1552

DESIGN: CJT | DRAWN: CJT | CHECKED: CJT | APPROVED: CJT

DATE: 8/14/2000 | FILENAME: DRAWINGS\WALES\AVEC\NEWPANELWIRING-WALES

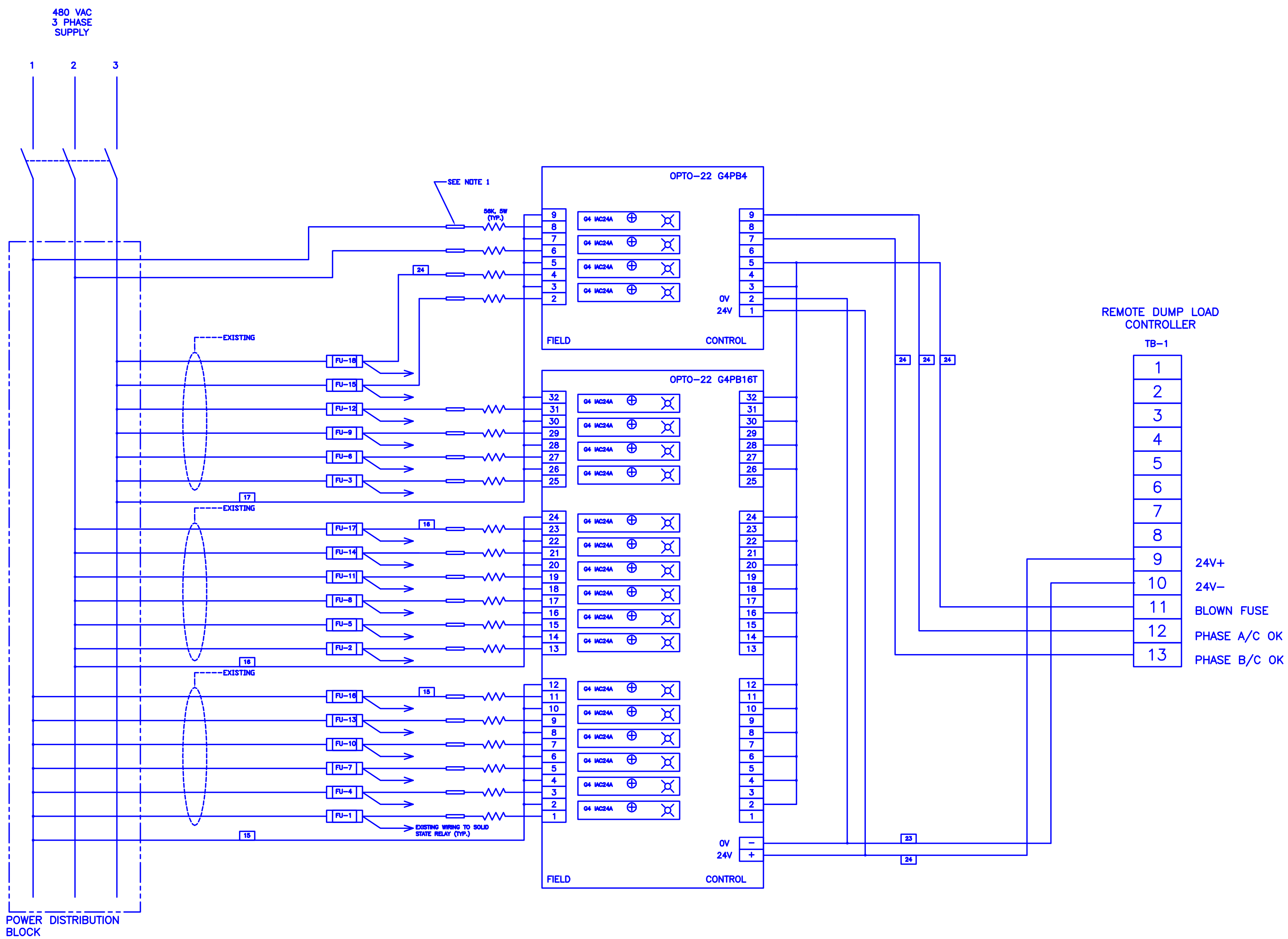
AVEC WALES PLANT

DIESEL CONTROLS INTERFACE PANEL
WIRING DIAGRAM

DRAWING NO. E-1

SHEET 1 OF 1 | REV. 1

CONTRACT NO. X



WIRING KEY

#	CONDUCTOR - COLOR CODING	480V AC	240V DC	120V AC	24V AC	24 DC
1	(2) EA. 350 MCM CU MTW - RED POSITIVE		X			
2	(2) EA. 350 MCM CU MTW - BLACK NEGATIVE		X			
3	#4/0 CU MTW - BROWN Cø 600V RATED	X				
4	#4/0 CU MTW - ORANGE Bø 600V RATED	X				
5	#4/0 CU MTW - YELLOW Aø 600V RATED	X				
6	#4/0 CU MTW - GREY NEUTRAL	X				
7	#4/0 CU MTW - GREEN GROUND	X	X			
8	#8 CU MTW - BLACK NEGATIVE		X			
9	#8 CU MTW - RED POSITIVE		X			
10	# 10 CU MTW - BROWN Cø 600V RATED	X				
11	# 10 CU MTW - ORANGE Bø 600V RATED	X				
12	# 10 CU MTW - YELLOW Aø 600V RATED	X				
13	# 10 CU MTW - WHITE NEUTRAL	X		X		
14	# 10 CU MTW - GREEN GROUND	X	X	X		
15	# 14 CU MTW - BROWN 600V	X				
16	# 14 CU MTW - ORANGE 600V	X				
17	# 14 CU MTW - YELLOW 600V	X				
18	# 14 CU MTW - GREY 600V NEUTRAL	X				
19	#14 CU MTW - BLACK 600V RATED		X	X		
20	# 14 CU MTW - RED 600V RATED		X		X	
21	# 14 CU MTW - WHITE 600V RATED			X	X	
22	#14 CU MTW GREEN - GROUND			X		
23	# 14 CU MTW - BLUE W/WHITE					X
24	# 14 CU MTW - BLUE					X
25	#8 CU MTW - BROWN, 600V RATED	X				
26	#8 CU MTW - ORANGE, 600V RATED	X				
27	#8 CU MTW - YELLOW, 600V RATED	X				
28	#6 CU MTW - BROWN, 600V RATED	X				
29	#6 CU MTW - ORANGE, 600V RATED	X				
30	#6 CU MTW - YELLOW, 600V RATED	X				
31	#12 CU MTW - BROWN, 600V RATED	X				
32	#12 CU MTW - ORANGE, 600V RATED	X				
33	#12 CU MTW - YELLOW, 600V RATED	X				

[X] WIRING TYPE REFERENCE WIRING KEY THIS SHEET.

NOTES:

1. JOIN RESISTOR TO WIRE END USING CRIMP SPLICE. ENCAPSULATE RESISTOR AND ITS LEADS IN HEAT SHRINK TUBING TO PROVIDE ELECTRICAL INSULATION AND STRAIN RELIEF.

2. LABEL ALL WIRES AT BOTH ENDS, INDICATING ORIGIN AND DESTINATION.

No.	Date	Description	By
2	9/5/00	REVISED INTERFACE TO DL CONTROL	SD
1	5/15/00	ADDED PHASE DETECTION RELAYS	SD

Revisions

Drawn By S. DROUILHET — Date 1/22/00
Engineer
Checked By S. DROUILHET
Approved By

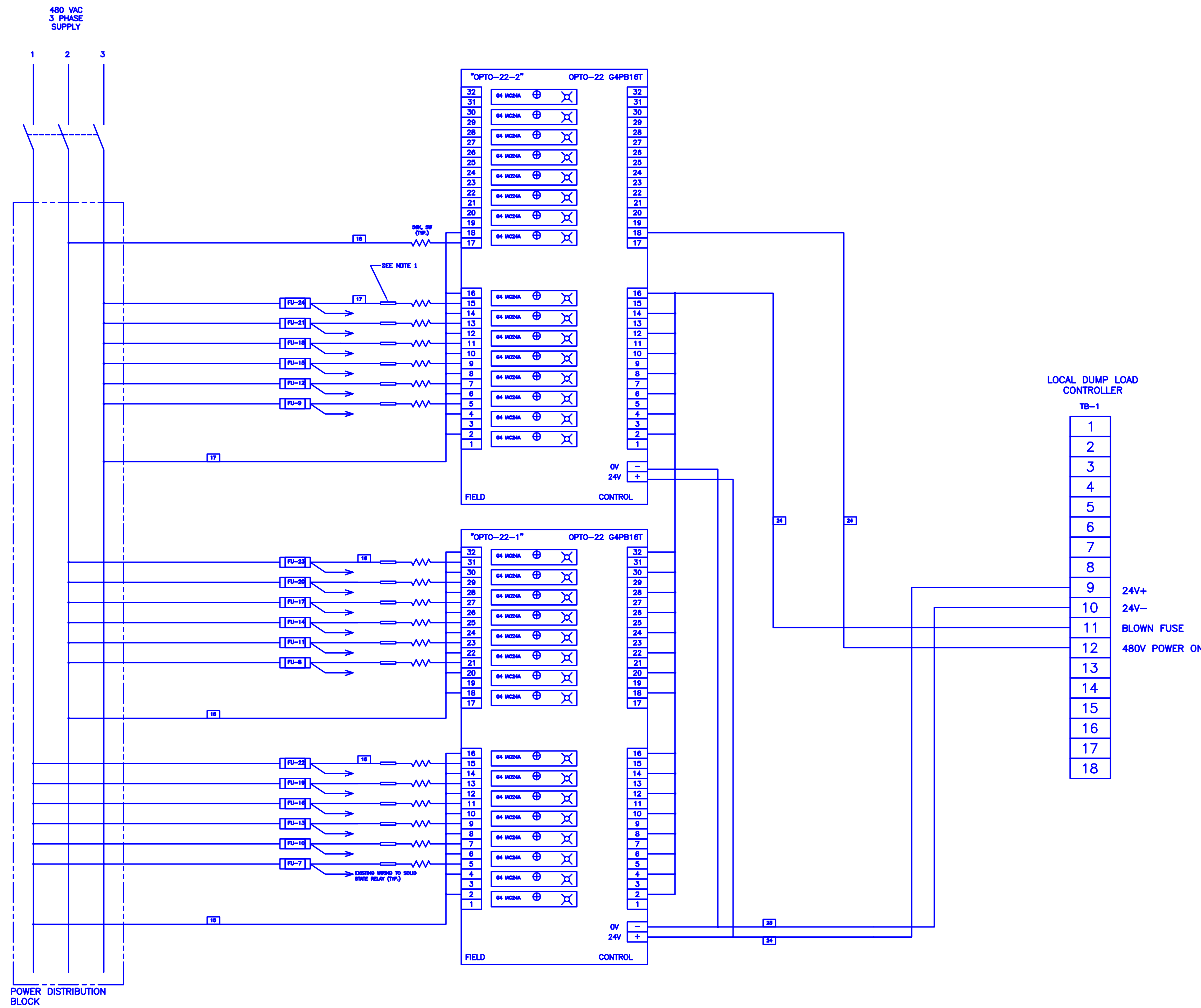
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401
Operated for the
U.S. Department of Energy
by Midwest Research Institute

Sheet Title
WIND-DIESEL POWER SYSTEM
REMOTE DUMP LOAD CONTROLLER
BLOWN FUSE DETECTION CIRCUIT

Work Request Number
Drawing Number NWTC-SD-0010
Sheet Number 1 OF 1
Sequence Number REV. 2

FORM: ZBD2234D.DWG-0

PLOT SCALE: STATION:
PLOT INFO: TIME:
FILE NAME: AUTOCAD VERSION: DATE: INITIALS:



WIRING KEY

#	CONDUCTOR - COLOR CODING	480V AC	240V DC	120V AC	24V AC	24 DC
1	(2) EA. 350 MCM CU MTW – RED POSITIVE		X			
2	(2) EA. 350 MCM CU MTW – BLACK NEGATIVE		X			
3	#4/0 CU MTW – BROWN CØ 600V RATED	X				
4	#4/0 CU MTW – ORANGE BØ 600V RATED	X				
5	#4/0 CU MTW – YELLOW AØ 600V RATED	X				
6	#4/0 CU MTW – GREY NEUTRAL	X				
7	#4/0 CU MTW – GREEN GROUND	X	X			
8	#8 CU MTW – BLACK NEGATIVE		X			
9	#8 CU MTW – RED POSITIVE		X			
10	# 10 CU MTW – BROWN CØ 600V RATED	X				
11	# 10 CU MTW – ORANGE BØ 600V RATED	X				
12	# 10 CU MTW – YELLOW AØ 600V RATED	X				
13	# 10 CU MTW – WHITE NEUTRAL	X		X		
14	# 10 CU MTW – GREEN GROUND	X	X	X		
15	# 14 CU MTW – BROWN 600V	X				
16	# 14 CU MTW – ORANGE 600V	X				
17	# 14 CU MTW – YELLOW 600V	X				
18	# 14 CU MTW – GREY 600V NEUTRAL	X				
19	#14 CU MTW – BLACK 600V RATED		X	X		
20	# 14 CU MTW – RED 600V RATED		X		X	
21	# 14 CU MTW – WHITE 600V RATED			X	X	
22	#14 CU MTW GREEN – GROUND			X		
23	# 14 CU MTW – BLUE W/WHITE					X
24	# 14 CU MTW – BLUE					X
25	#8 CU MTW – BROWN, 600V RATED	X				
26	#8 CU MTW – ORANGE, 600V RATED	X				
27	#8 CU MTW – YELLOW, 600V RATED	X				
28	#6 CU MTW – BROWN, 600V RATED	X				
29	#6 CU MTW – ORANGE, 600V RATED	X				
30	#6 CU MTW – YELLOW, 600V RATED	X				
31	#12 CU MTW – BROWN, 600V RATED	X				
32	#12 CU MTW – ORANGE, 600V RATED	X				
33	#12 CU MTW – YELLOW, 600V RATED	X				

[X] WIRING TYPE REFERENCE WIRING KEY THIS SHEET.

NOTES:

1. JOIN RESISTOR TO WIRE END USING CRIMP SPLICE. ENCAPSULATE RESISTOR AND ITS LEADS IN HEAT SHRINK TUBING TO PROVIDE ELECTRICAL INSULATION AND STRAIN RELIEF.

2. LABEL ALL WIRES AT BOTH ENDS, INDICATING ORIGIN AND DESTINATION.

No.	Date	Description	By
2	2/2/01	DELETED FUSES 1-6	SD
1	1/10/01	REVISED TERMINAL NUMBERS TO AGREE WITH LOCAL DL REDESIGN	SD

Revisions

Drawn By: S. DROUILHET — Date: 9/1/00
Engineer
Checked By: S. DROUILHET
Approved By

National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401
Operated for the
U.S. Department of Energy
by Midwest Research Institute

Sheet Title

WIND-DIESEL POWER SYSTEM

WALES LOCAL DUMP LOAD CONTROLLER
BLOWN FUSE DETECTION CIRCUIT

Work Request Number

Drawing Number: NWTC-SD-0012

Sheet Number: 1 OF 1 — Sequence Number: REV. 2

FORM: ZBD2234D.DWG-0

FILE NAME:
AUTOCAD VERSION:
INITIALS:
DATE:
PLOT INFO
TIME:
PLOT SCALE:
STATION:

WIRING KEY

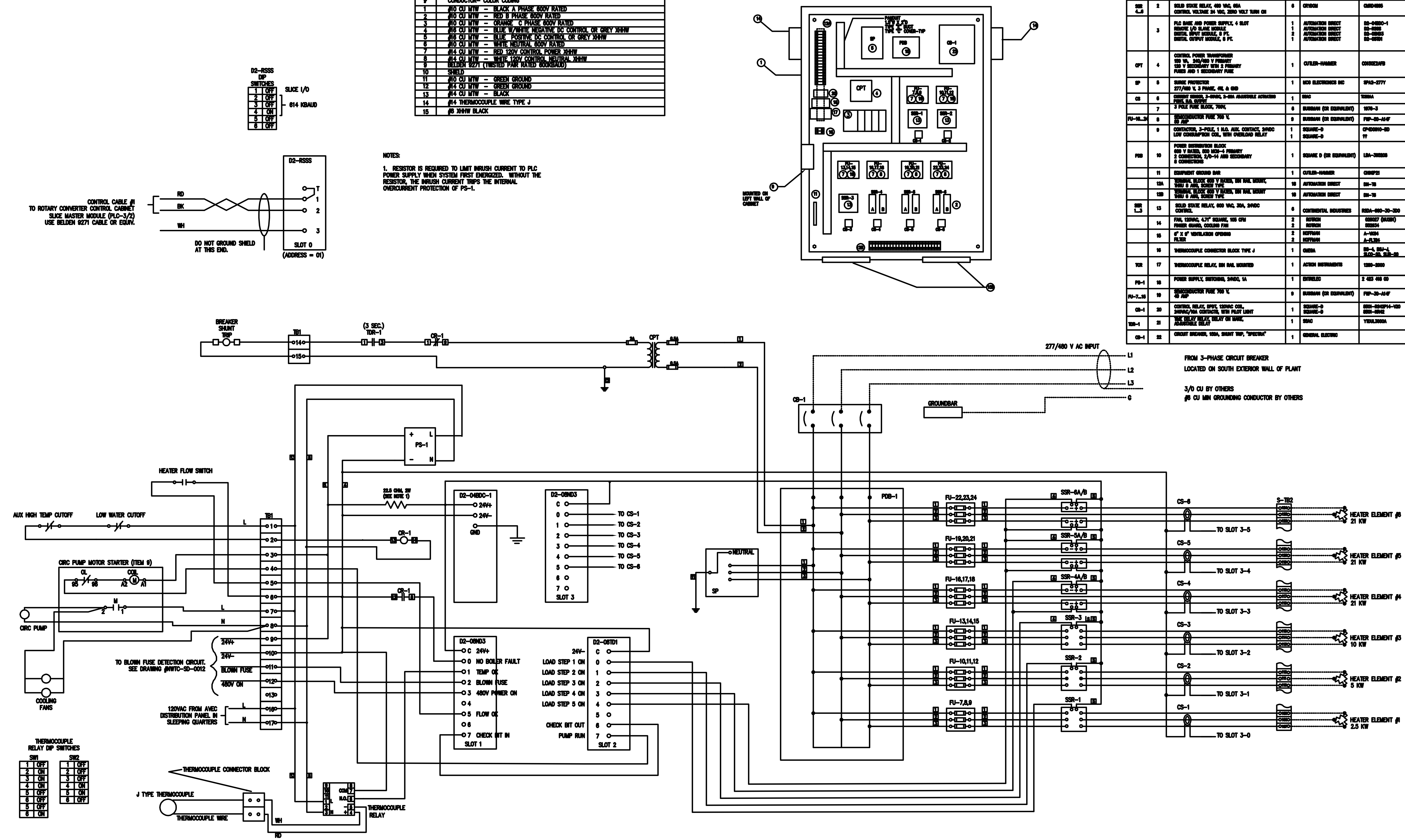
#	CONDUCTOR- COLOR CODING
1	#10 CU MTW – BLACK A PHASE 600V RATED
2	#10 CU MTW – RED B PHASE 600V RATED
3	#10 CU MTW – ORANGE C PHASE 600V RATED
4	#16 CU MTW – BLUE W/WHITE NEGATIVE DC CONTROL OR GREY XHHW
5	#16 CU MTW – BLUE POSITIVE DC CONTROL OR GREY XHHW
6	#10 CU MTW – WHITE NEUTRAL 600V RATED
7	#14 CU MTW – RED 120V CONTROL POWER XHHW
8	#14 CU MTW – WHITE 120V CONTROL NEUTRAL XHHW
9	BELDEN 9271 (TWISTED PAIR RATED 600KBAUD)
10	SHIELD
11	#10 CU MTW – GREEN GROUND
12	#14 CU MTW – GREEN GROUND
13	#14 CU MTW – BLACK
14	#14 THERMOCOUPLE WIRE TYPE J
15	#8 XHHW BLACK

NOTES:

1. RESISTOR IS REQUIRED TO LIMIT INRUSH CURRENT TO PLC POWER SUPPLY WHEN SYSTEM FIRST ENERGIZED. WITHOUT THE RESISTOR, THE INRUSH CURRENT TRIPS THE INTERNAL OVERCURRENT PROTECTION OF PS-1.

MATERIALS LIST FOR 480V SECONDARY LOAD CONTROL PANEL

KEY	ITEM NUMBER	ITEM DESCRIPTION	QTY	MANUFACTURER	CATALOG NO.
	1	ENCLOSURE	1	HOFFMAN (OR EQUIV)	A-48H36GLP
SSR 4...6	2	SOLID STATE RELAY, 480 VAC, 65A CONTROL VOLTAGE 24 VDC, ZERO VOLT TURN ON	6	CRYDOM	CMRD4865
	3	PLC BASE AND POWER SUPPLY, 4 SLOT REMOTE I/O SLAVE MODULE DIGITAL INPUT MODULE, 8 PT. DIGITAL OUTPUT MODULE, 8 PT.	1 1 2 1	AUTOMATION DIRECT AUTOMATION DIRECT AUTOMATION DIRECT AUTOMATION DIRECT	D2-04BDC-1 D2-RSSS D2-08ND3 D2-08TD1
CPT	4	CONTROL POWER TRANSFORMER 150 VA, 240/480 V PRIMARY 120 V SECONDARY WITH 2 PRIMARY FUSES AND 1 SECONDARY FUSE	1	CUTLER-HAMMER	C0150E2AFB
SP	5	SURGE PROTECTOR 277/480 V, 3 PHASE, 4W, & GND	1	MCG ELECTRONICS INC	SPA2-277Y
CS	6	CURRENT SENSOR, 3-50VDC, 2-20A ADJUSTABLE ACTUATING POINT, N.O. OUTPUT	1	SSAC	TCSOAA
	7	3 POLE FUSE BLOCK, 700V,	6	BUSSMAN (OR EQUIVALENT)	1976-3
FU-16...24	8	SEMICONDUCTOR FUSE 700 V, 50 AMP	9	BUSSMAN (OR EQUIVALENT)	FWP-50-A14F
	9	CONTACTOR, 3-POLE, 1 N.O. AUX. CONTACT, 24VDC LOW CONSUMPTION COIL, WITH OVERLOAD RELAY	1 1	SQUARE-D SQUARE-D	CP4D0810-BD ??
PDB	10	POWER DISTRIBUTION BLOCK 600 V RATED, 500 MCM-4 PRIMARY 2 CONNECTION, 2/0-14 AWG SECONDARY 8 CONNECTIONS	1	SQUARE D (OR EQUIVALENT)	LBA-365208
	11	EQUIPMENT GROUND BAR	1	CUTLER-HAMMER	CH6GP21
	12A	TERMINAL BLOCK 600 V RATED, DIN RAIL MOUNT, THRU 8 AWG, SCREW TYPE	18	AUTOMATION DIRECT	DN-T8
	12B	TERMINAL BLOCK 600 V RATED, DIN RAIL MOUNT THRU 6 AWG, SCREW TYPE	18	AUTOMATION DIRECT	DN-T6
SSR 1...3	13	SOLID STATE RELAY, 600 VAC, 30A, 24VDC CONTROL	6	CONTINENTAL INDUSTRIES	RSDA-600-30-3D0
	14	FAN, 120VAC, 4.71" SQUARE, 105 CFM FINGER GUARD, COOLING FAN	2 2	ROTRON ROTRON	028027 (MU2B1) 552934
	15	6" X 6" VENTILATION OPENING FILTER	2 2	HOFFMAN HOFFMAN	A-VK84 A-FLT84
	16	THERMOCOUPLE CONNECTOR BLOCK TYPE J	1	OMEGA	BS-4, BSJ-J, SLCO-20, SUR-20
TCR	17	THERMOCOUPLE RELAY, DIN RAIL MOUNTED	1	ACTION INSTRUMENTS	1280-2000
PS-1	18	POWER SUPPLY, SWITCHING, 24VDC, 1A	1	ENTRELEC	2 423 418 00
FU-7...15	19	SEMICONDUCTOR FUSE 700 V, 40 AMP	9	BUSSMAN (OR EQUIVALENT)	FWP-30-A14F
CR-1	20	CONTROL RELAY, DPDT, 120VAC COIL, 240VAC/10A CONTACTS, WITH PILOT LIGHT	1	SQUARE-D SQUARE-D	8501-RS42P14-V20 8501-NR42
TDR-1	21	TIME DELAY RELAY, DELAY ON MAKE, ADJUSTABLE DELAY	1	SSAC	YTDUL3000A
CB-1	22	CIRCUIT BREAKER, 150A, SHUNT TRIP, "SPECTRA"	1	GENERAL ELECTRIC	



NOT TO SCALE

NO.	DATE	REVISIONS	BY	CHK	APPR'D
7	8/15/01	AS INSTALLED, MARCH 2001	SD	SD	SD
6	3/7/01	REVISED LOAD STEP 5 CONTROL WIRING	SD	SD	SD
5	2/2/01	CORRECTED ITEM NUMBERING	SD	SD	SD
4	1/12/01	REDESIGNED WITH PLC I/O, NEW SSRs AND CURRENT SENSORS	SD	SD	SD

THOMPSON ENGINEERING CO.
721 SESAME ST SUITE 2B, ANCHORAGE, AK 99503, PHONE (907) 562-1552

DESIGN: CJT | DRAWN: CJT | CHECKED: CJT | APPROVED: CJT

DATE: MARCH 11, 1998 | FILENAME: DRAWINGS/KOTZ/WALES HEAT CONTROL

KOTZEBUE ELECTRIC ASSOCIATION
KOTZEBUE, ALASKA

WALES POWER PLANT
LOCAL DUMP LOAD CONTROLLER

DRAWING NO. E-1
SHEET 1 OF 1 REV. 7
CONTRACT NO. X

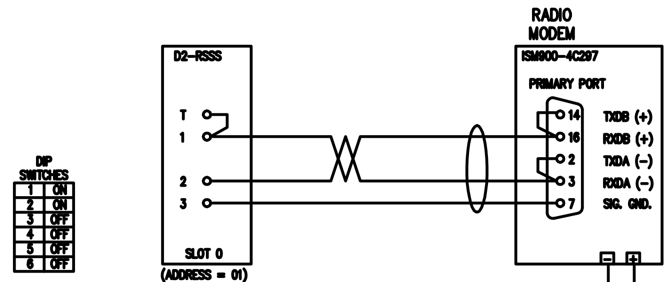
WIRING KEY

#	CONDUCTOR- COLOR CODING
1	#10 CU MTW – BLACK A PHASE 600V RATED
2	#10 CU MTW – RED B PHASE 600V RATED
3	#10 CU MTW – ORANGE C PHASE 600V RATED
4	#16 CU MTW – BLUE W/WHITE NEGATIVE DC CONTROL
5	#16 CU MTW – BLUE POSITIVE DC CONTROL
6	#10 CU MTW – WHITE NEUTRAL 600V RATED
7	#14 CU MTW – RED 120V CONTROL POWER
8	#14 CU MTW – WHITE 120V CONTROL NEUTRAL
9	BELDEN 9271 (TWISTED PAIR RATED 600KBAUD)
10	SHIELD
11	#10 CU MTW – GREEN GROUND
12	#14 CU MTW – GREEN GROUND
13	#14 CU MTW – BLACK JUMPER
14	#14 THERMOCOUPLE WIRE TYPE J

MATERIALS LIST FOR 480V SECONDARY LOAD CONTROL PANEL

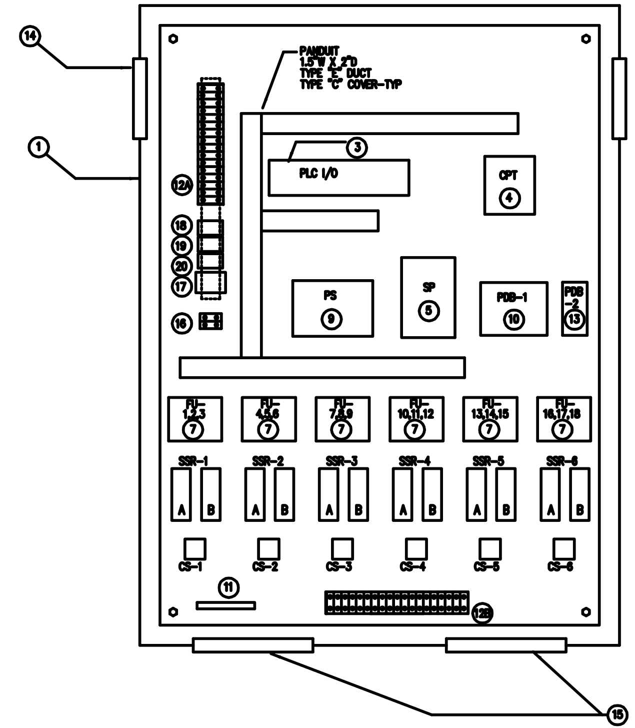
KEY	ITEM NUMBER	ITEM DESCRIPTION	QTY	MANUFACTURER	CATALOG NO.
	1	ENCLOSURE	1	HOFFMAN (OR EQUIV)	A-48H36DLP
SSR	2	SOLID STATE RELAY, 480 VAC, 65A CONTROL VOLTAGE 24 VDC, ZERO VOLT TURN ON	12	CRYDOM	CWD4865
	3	PLC BASE AND POWER SUPPLY, 4 SLOT REMOTE I/O SLAVE MODULE DIGITAL INPUT MODULE, 8 PT. DIGITAL OUTPUT MODULE, 8 PT.	1 1 2 1	AUTOMATION DIRECT AUTOMATION DIRECT AUTOMATION DIRECT AUTOMATION DIRECT	D2-04BDC-1 D2-RSSS D2-08ND3 D2-08TD1
CPT	4	CONTROL POWER TRANSFORMER 1000 VA, 240/480 V PRIMARY 120 V SECONDARY WITH 2 PRIMARY FUSES AND 1 SECONDARY FUSE	1		
SP	5	SURGE PROTECTOR 277/480 V, 3 PHASE, 4W, & GND	1	MCG ELECTRONICS INC	SPA2-277Y
CS	6	CURRENT SENSOR, 3-80VDC, 2-20A ADJUSTABLE ACTUATING POINT, N.O. OUTPUT	6	SSAC	TCS0AA
	7	3 POLE FUSE BLOCK, 700V,	6	BUSSMAN (OR EQUIVALENT)	1976-3
	7	SEMICONDUCTOR FUSE 700 V, 50 AMP	18	BUSSMAN (OR EQUIVALENT)	FWP-50-A14F
MDM	8	RADIO MODEM, SPREAD SPECTRUM, 900 MHZ	1	U.C. WIRELESS	ISM900-4C297
PS-1	9	LINEAR POWER SUPPLY, 120 V PRIMARY 24 VDC SECONDARY , 1.2 AMPS	1	MCG	
PDB	10	POWER DISTRIBUTION BLOCK 600 V RATED, 500 MCM-4 PRIMARY 2 CONNECTION, 2/0-14 AWG SECONDARY 8 CONNECTIONS	1	SQUARE D (OR EQUIVALENT)	LBA-385208
	11	EQUIPMENT GROUND BAR	1	C. HAMMER	CHGGP21
	12A	TERMINAL BLOCK 600 V RATED, DIN RAIL MOUNT, THRU 8 AWG, SCREW TYPE	16	AUTOMATION DIRECT	DN-T8
	12B	TERMINAL BLOCK 600 V RATED, DIN RAIL MOUNT THRU 6 AWG, SCREW TYPE	18	AUTOMATION DIRECT	DN-T6
	13	SPLICER REDUCER	1	ILSCO (OR EQUIVALENT)	PDB-11-2/0-1
	14	FAN, 120VAC, 4.71" SQUARE, 105 CFM FINGER GUARD, COOLING FAN	2 2	ROTRON ROTRON	028027 (MU2B1) 552934
	15	6" X 9" VENTILATION OPENING FILTER	2 2	HOFFMAN HOFFMAN	A-VK04 A-FLT04
	16	THERMOCOUPLE CONNECTOR BLOCK TYPE J	1	OMEGA	BS-4, BSJ-J, SLCO-20, SUR-20
TCR	17	THERMOCOUPLE RELAY	1	ACTION PAK	1280-2000 DIN RAIL MOUNTED
PS-2	18	POWER SUPPLY, SWITCHING, 12VDC, 2A	1	ENTRELEC	2.423.418.10
TDR	19	TIME DELAY RELAY, DELAY ON MAKE, 120VAC, ADJUSTABLE DELAY	1	SSAC	YTDUL3000A
CR-1	20	CONTROL RELAY, DPDT, 120VAC COIL, 240VAC/10A CONTACTS	1	SQUARE-D SQUARE-D	8501-RS42P14-V20 8501-NR42

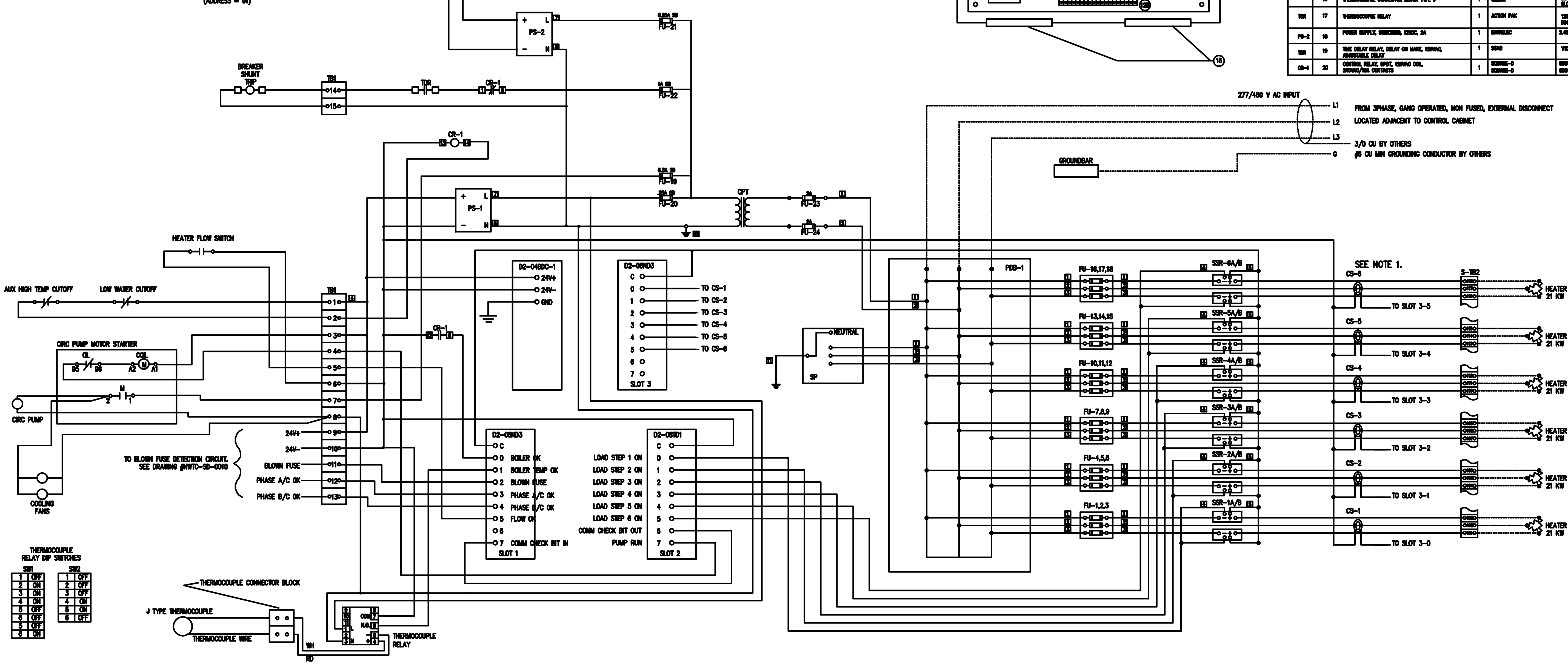
DETAIL OF COMMUNICATION CABLE BETWEEN REMOTE I/O SLAVE MODULE AND RADIO MODEM.



NOTES:

1. ADJUST TRIP POINT ON ALL CURRENT SENSORS TO 14A.





SCALE: 1" = 6"

NO.	DATE	REVISIONS	BY	CHK	APPR'D
8	10/15/01	CORRECTED TERMINAL 1 ON TC RELAY	SD	SD	SD
7	8/15/01	AS INSTALLED, MARCH 2001	SD	SD	SD
6	3/12/01	REVISED DIN RAIL DETAIL	SD	SD	SD
5	2/2/01	PARTS LIST CORRECTIONS	SD	SD	SD
4	12/4/00	NEW SSRs AND CURRENT SENSORS	SD	SD	SD

THOMPSON ENGINEERING CO.
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DESIGN: CJT DRAWN: CJT CHECKED: CJT APPROVED: CJT
DATE: MARCH 11, 1998 FILENAME: DRAWINGS/KOTZ/WALES HEAT CONTROL

KOTZEBUE ELECTRIC ASSOCIATION
KOTZEBUE, ALASKA

WALES SCHOOL
REMOTE DUMP LOAD CONTROLLER

DRAWING NO. E-1
SHEET 1 OF 1 REV. 8
CONTRACT NO. X

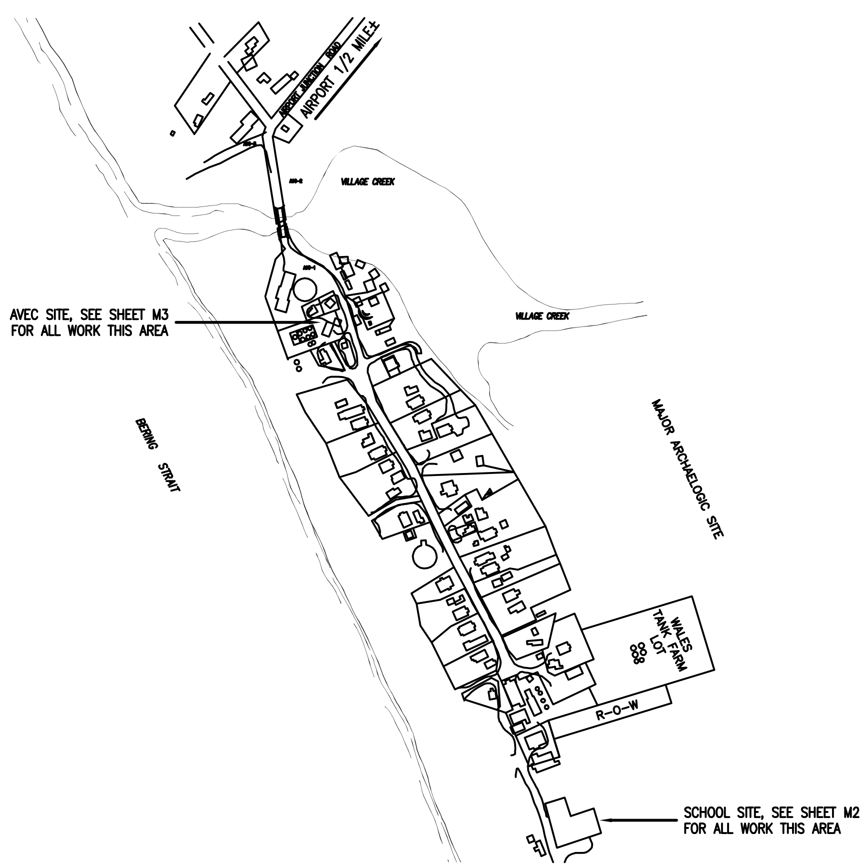
GENERAL NOTES:

THE PURPOSE OF THIS PROJECT IS TO INSTALL NEW ELECTRIC BOILERS IN THE AVEC WALES POWER GENERATION FACILITY AND NORTHWEST BERING STRAITS SCHOOL DISTRICT WALES SCHOOL. THIS PROJECT IS IN CONJUNCTION WITH THE INSTALLATION OF A WIND POWERED ELECTRICAL GENERATION FACILITY IN WALES BY THE KOTZEBUE ELECTRIC ASSOCIATION. THE SCOPE OF WORK INCLUDES THE FOLLOWING:

- INSTALLATION OF NEW ELECTRIC BOILERS AT THE AVEC AND SCHOOL SITES.
- INSTALLATION OF EXTERIOR WELDED AND INTERIOR THREADED STEEL PIPING AT THE AVEC FACILITY TO TIE THE NEW ELECTRIC BOILER INTO THE EXISTING COOLING MANIFOLD.
- INSTALLATION OF PIPE INSULATION AND METAL JACKETING ON NEW AND EXISTING PIPING AT THE AVEC SITE.
- INSTALLATION OF INTERIOR COPPER PIPING AT THE SCHOOL FACILITY TO TIE THE EXISTING HYDRONIC HEATING SYSTEM INTO THE NEW ELECTRIC BOILER.

SCHEDULE OF DRAWINGS

M1 SITE PLAN, NOTES, SCHEDULES, SPECIFICATIONS, ABBREVIATIONS, & LEGEND
M2 SCHOOL BOILER PLAN, DETAILS, & PIPING DIAGRAM
M3 AVEC POWER PLANT BOILER PLAN, DETAILS, & PIPING DIAGRAM



1 / M1 SITE PLAN
1"=250'

MECHANICAL SPECIFICATIONS

GENERAL CONDITIONS

THE CONTRACTING AGENCY FOR THIS PROJECT IS KOTZEBUE ELECTRIC ASSOCIATION. THE ENGINEER IS ALASKA ENERGY AND ENGINEERING. THE FACILITY OWNERS ARE THE ALASKA VILLAGE ELECTRIC COOPERATIVE (AVEC) AND THE BERING STRAITS SCHOOL DISTRICT (SCHOOL).

THE SCOPE OF WORK INCLUDES ALL MECHANICAL INSTALLATION INDICATED ON DRAWINGS M1 THROUGH M4. ALL ELECTRICAL POWER SERVICE AND CONTROLS FOR THIS PROJECT WILL BE PROVIDED BY OTHERS.

THE DRAWINGS ARE DIAGRAMMATIC AND DO NOT NECESSARILY SHOW ALL FEATURES OF THE REQUIRED WORK OR EXISTING CONDITIONS. PROVIDE ALL EQUIPMENT AND MATERIALS REQUIRED FOR A COMPLETE SYSTEM. MAKE MINOR RELOCATIONS WHERE NECESSARY TO RESOLVE CONFLICTS OR PRESENT A UNIFORM APPEARANCE. THE DRAWINGS SHOW EXACT LOCATION ONLY WHERE SPECIFICALLY DIMENSIONED. VERIFY EXISTING FIELD CONDITIONS PRIOR TO STARTING CONSTRUCTION. IMMEDIATELY CONTACT THE ENGINEER FOR CLARIFICATION OF QUESTIONABLE ITEMS OR APPARENT CONFLICTS.

ALL EQUIPMENT, PIPING, AND MATERIALS SHOWN ARE NEW UNLESS SPECIFICALLY INDICATED AS EXISTING AND WILL BE FURNISHED ON-SITE BY THE OWNER. WHERE ADDITIONAL OR REPLACEMENT ITEMS ARE REQUIRED, PROVIDE LIKE ITEMS BY THE SAME MANUFACTURER TO THE MAXIMUM EXTENT PRACTICAL. INSTALL ALL MATERIALS IN ACCORDANCE WITH MANUFACTURERS RECOMMENDATIONS AND INSTRUCTIONS, UNLESS INDICATED OTHERWISE.

PROTECT ALL MATERIALS AND EQUIPMENT DURING THE ENTIRE DURATION OF CONSTRUCTION WORK AGAINST CONTAMINATION OR DAMAGE. REPLACE OR REPAIR TO ORIGINAL MANUFACTURED CONDITION ANY ITEMS DAMAGED DURING CONSTRUCTION. IMMEDIATELY REPORT TO THE ENGINEER ANY ITEMS FOUND DAMAGED PRIOR TO COMMENCING CONSTRUCTION.

PERFORM ALL WORK IN ACCORDANCE WITH THE 1997 EDITIONS OF THE UNIFORM BUILDING CODE AND UNIFORM MECHANICAL CODE INCLUDING STATE OF ALASKA AMENDMENTS. COMPLY WITH ALL APPLICABLE STATE AND FEDERAL REGULATIONS.

PERFORM WORK WITH SKILLED CRAFTSMEN SPECIALIZING IN SAID WORK. INSTALL ALL MATERIALS IN A NEAT, ORDERLY, AND SECURE FASHION, AS REQUIRED BY THESE SPECIFICATIONS AND COMMONLY RECOGNIZED STANDARDS OF GOOD WORKMANSHIP.

DO NOT CUT, DRILL, OR NOTCH STRUCTURAL MEMBERS UNLESS SPECIFICALLY APPROVED BY THE ENGINEER.

MINIMIZE PENETRATIONS AND DISRUPTION OF EXISTING BUILDING FEATURES. WHERE PREVIOUSLY COMPLETED BUILDING SURFACES OR OTHER FEATURES MUST BE CUT, PENETRATED, OR OTHERWISE ALTERED, SUCH WORK SHALL BE CAREFULLY LAID OUT AND PERFORMED, AND PATCHED TO ORIGINAL CONDITION. SEAL ALL EXTERIOR FLOOR AND WALL PENETRATIONS AS INDICATED.

LEAVE ALL WORK SITES IN AN ORDERLY CONDITION CONSISTENT WITH THAT UPON ARRRIVAL.

PROVIDE ONE SET OF DRAWINGS CLEARLY MARKED UP WITH ALL AS-BUILT INFORMATION TO THE ENGINEER WITHIN TWO WEEKS OF COMPLETION.

CONTACT THE ENGINEER ONE WEEK PRIOR TO COMPLETION OF ALL WORK TO SCHEDULE A SUBSTANTIAL COMPLETION INSPECTION. THE ENGINEER WILL GENERATE A PUNCH LIST OF CORRECTIVE ACTION ITEMS DURING THE INSPECTION. WORK WILL NOT BE CONSIDERED COMPLETE UNTIL ALL CORRECTIVE ACTION ITEMS IN THE ENGINEERS PUNCH LIST HAVE BEEN SATISFACTORILY COMPLETED AND PHOTOGRAPHIC OR OTHER POSITIVE DOCUMENTATION HAS BEEN PROVIDED TO THE ENGINEER.

AVEC SITE SPECIAL CONDITIONS

ENSURE THAT APPROPRIATE SAFETY MEASURES ARE IMPLEMENTED AND THAT ALL WORKERS ARE AWARE OF THE POTENTIAL HAZARDS FROM ELECTRICAL SHOCK, BURN, ROTATING FANS, PULLEYS, BELTS, HOT MANIFOLDS, NOISE, ETC. ASSOCIATED WITH WORKING NEAR POWER GENERATION AND CONTROL EQUIPMENT.

COORDINATE WITH THE AVEC ENGINEERING OFFICE AND THE AVEC OPERATIONS AND MAINTENANCE DEPARTMENT REGARDING PROJECT SCHEDULE A MINIMUM OF ONE WEEK PRIOR TO STARTING CONSTRUCTION AND IMMEDIATELY UPON COMPLETION OF THE WORK.

USE OF AVEC FUEL FOR CONSTRUCTION PURPOSES IS PROHIBITED.

THE CONTRACTOR IS RESPONSIBLE FOR ANY AND ALL DAMAGE TO THE AVEC ENGINE SETS, BUILDINGS, AND EQUIPMENT CAUSED BY THE CONTRACTOR OR ITS AGENTS DURING THE COURSE OF CONSTRUCTION.

CONNECTION TO THE EXISTING COOLING MANIFOLD WILL REQUIRE SHUT DOWN OF THE POWER GENERATION SYSTEM TO DRAIN COOLING PIPING. SCHEDULE WORK TO MINIMIZE DISRUPTION TO POWER PLANT OPERATIONS. COORDINATE ALL WORK WITH THE LOCAL AVEC PLANT OPERATOR INCLUDING SHUT DOWN AND RE-START OF ENGINES. THE CONTRACTOR IS NOT ALLOWED TO SHUT DOWN OR START ENGINES.

HAVE AVEC OPERATOR SHUT DOWN ENGINES. ISOLATE EXISTING COOLING MANIFOLD PIPING WITH EXISTING VALVES. DRAIN GLYCOL SOLUTION INTO CLEAN CONTAINERS AND COVER TO PREVENT CONTAMINATION. REMOVE EXISTING BLIND FLANGES AT END OF COOLING MANIFOLDS AND INSTALL NEW BUTTERFLY VALVES. RECHARGE SYSTEM WITH SALVAGED GLYCOL SOLUTION. ASSIST THE AVEC OPERATOR IN RESTARTING PLANT AND VENTING AIR FROM THE PIPING SYSTEM. CHECK NEW CONNECTIONS FOR LEAKS. LOCK NEW BUTTERFLY VALVE HANDLES CLOSED AND TEMPORARILY INSTALL BLIND FLANGES UNTIL PERMANENT PIPING HAS BEEN CONNECTED AND TESTED.

SCHOOL SITE SPECIAL CONDITIONS

THE SCHOOL MAY BE OCCUPIED DURING THE PROJECT. COORDINATE AND SCHEDULE ALL WORK AT THE SCHOOL SITE WITH THE SCHOOL PRINCIPAL AND MAINTENANCE TECHNICIAN TO MINIMIZE DISRUPTION OF CLASS ROOM AREAS AND STUDENT ACTIVITIES. VIRTUALLY ALL WORK WILL OCCUR IN THE MECHANICAL ROOM WHICH IS SEPARATE FROM STUDENT AREAS. PROVIDE BARRICADES AS REQUIRED TO RESTRICT STUDENT ACCESS TO ALL WORK AREAS.

THE CONTRACTOR IS RESPONSIBLE FOR ANY AND ALL DAMAGE TO THE SCHOOL HEATING SYSTEM, BUILDING, AND EQUIPMENT CAUSED BY THE CONTRACTOR OR ITS AGENTS DURING THE COURSE OF CONSTRUCTION.

CONNECTION TO THE EXISTING HEATING PIPING WILL REQUIRE SHUT DOWN OF THE HEATING SYSTEM TO DRAIN A PORTION OF THE EXISTING PIPING. SCHEDULE WORK TO MINIMIZE DOWN TIME AND DISRUPTION OF SCHOOL OPERATIONS. COORDINATE SYSTEM SHUT DOWN WITH THE SCHOOL MAINTENANCE TECHNICIAN.

SHUT DOWN BOILERS AND ALL PUMPS. ISOLATE THE SECTION OF EXISTING PIPING TO BE MODIFIED UTILIZING EXISTING VALVES. DRAIN GLYCOL SOLUTION INTO CLEAN CONTAINERS AND COVER TO PREVENT CONTAMINATION. CUT IN NEW TEES AND RUN NEW PIPING TO NEW ISOLATION VALVES. PRESSURE TEST ALL NEW PIPING JOINTS AND CONNECTIONS TO EXISTING PIPING. RECHARGE SYSTEM WITH SALVAGED GLYCOL SOLUTION. RESTART BOILERS AND PUMPS, VENT AIR FROM PIPING, AND ENSURE PROPER SYSTEM OPERATION PRIOR TO LEAVING THE WORK AREA.

MISCELLANEOUS MATERIALS

FASTENERS - ALL NAILS, BOLTS, NUTS, WASHERS, AND LAGS GALVANIZED.

STRUT - COLD FORMED MILD STEEL CHANNEL STRUT. 12 GAUGE, 1-5/8" x 1-5/8" POWER-STRUT PS 200 H OR EQUAL, GALVANIZED FINISH. ALL FITTINGS, BRACKETS, BOLTS, NUTS, AND ACCESSORIES GALVANIZED STEEL DESIGNED SPECIFICALLY FOR USE WITH SPECIFIED CHANNEL STRUT.

PIPE CLAMPS, STRAPS AND HANGERS - GALVANIZED CARBON STEEL FOR STEEL PIPE, COPPER PLATED FOR COPPER TUBING. GRINNELL/POWER-STRUT OR EQUAL.
ELECTRICAL INSTALLATION.

INTERIOR PIPING

SCHOOL SITE - TYPE L HARD DRAWN COPPER TUBE WITH WROUGHT COPPER FITTINGS. ALL JOINTS SOLDERED WITH 95/5 TIN/ANTIMONY SOLDER OR SILVER SOLDER. REAM ALL CUT ENDS AND THOROUGHLY CLEAN PIPE ENDS AND FITTINGS PRIOR TO SOLDERING.

AVEC SITE - ASTM A106B SCHEDULE 40 SEAMLESS CARBON STEEL PIPE WITH THREADED ENDS. ASTM A-105 CLASS 3,000# FORGED STEEL THREADED FITTINGS. THOROUGHLY COAT MALE PIPE END WITH GLYCOL COMPATIBLE ARCTIC GRADE TEFLON BASED PIPE JOINT COMPOUND PRIOR TO ASSEMBLY.

EXTERIOR PIPING

AVEC SITE - ASTM A106B SCHEDULE 40 SEAMLESS CARBON STEEL PIPE WITH PLAIN BEVEL ENDS. ASTM A-234 SEAMLESS DOMESTIC CARBON STEEL WELD FITTINGS. ASTM A-105 FORGED STEEL ANSI 150# RAISED FACE FLANGES.

GENERAL PIPING

HYDROSTATICALLY TEST ALL NEW PIPING AT 100 PSIG MINIMUM FOR ONE HOUR WITH NO NOTICEABLE WATER LEAKS OR PRESSURE DROP EXCEPT AS CAUSED BY TEMPERATURE CHANGE. ISOLATE THE ENGINES FROM ANY PORTION OF THE AVEC SYSTEM BEING PRESSURE TESTED.

FLUSH ALL NEW PIPING WITH CLEAN WATER PRIOR TO FINAL CONNECTION TO EXISTING PIPING SYSTEMS.

SUPPORT PIPING AND EQUIPMENT AS SHOWN ON PLANS. IF NOT DETAILED ON PLANS, SUPPORT FROM BUILDING FRAMING MEMBERS WITH PIPE HANGERS, BRACKETS, OR PIPE STRAPS SPECIFICALLY INTENDED FOR THE APPLICATION. DO NOT SUPPORT PIPING FROM CONNECTIONS TO EQUIPMENT. INDEPENDENTLY SUPPORT PUMPS AND EQUIPMENT FROM BUILDING FRAMING MEMBERS.

INSTALL PERMENANT FLOW DIRECTION ARROWS INDICATING THE NORMAL DIRECTION OF FLOW ON ALL NEW PIPING.

PIPE INSULATION

SCHOOL SITE - INSULATE ALL NEW INTERIOR PIPING WITH 1" PRE-FORMED FIBERGLASS PIPE INSULATION, MAXIMUM CONDUCTIVITY 0.28 BTU-IN/HR-SQ.FT.-F AT 100F MEAN TEMPERATURE. JOHNS-MANVILLE MICRO-LOK OR EQUAL. PROVIDE WITH ALL SERVICE JACKET, JOHNS-MANVILLE AP-T-2000 OR EQUAL. PROVIDE PRE-FORMED PVC COVERS FOR ALL FITTINGS.

AVEC SITE - INSULATE ALL NEW PIPING AND EXISTING EXTERIOR PIPING INDICATED ON DRAWINGS WITH 2" PRE-FORMED RIGID FIBERGLASS PIPE INSULATION, MAXIMUM CONDUCTIVITY .28 BTU-IN/HR-SQ.FT.-F AT 100F MEAN TEMPERATURE. JOHNS-MANVILLE MICRO-LOK OR EQUAL. PROVIDE EXTERIOR GRADE CORRUGATED 0.016" THICK ALUMINUM JACKETING. CHILDERS CLEAR COATED ALUMINUM JACKETING OR EQUAL. PROVIDE PRE-FORMED ALUMINUM COVERS FOR ALL FITTINGS. ON EXISTING 3" PIPING, RUN ALUMINUM JACKETING CONTINUOUS WITHOUT INSULATION OVER EXISTING FLANGES AND BUTTERFLY VALVES.

VALVES

SOLDER BALL VALVE - BRONZE BODY, SOLDER ENDS, MINIMUM 400 PSIG WOG RATING, BRONZE BALL, TFE SEATS AND SEALS,. NIBCO S-580 OR EQUAL.

THREADED BALL VALVE - BRONZE BODY, THREADED ENDS, MINIMUM 400 PSIG WOG RATING, BRONZE BALL, TFE SEATS AND SEALS, - NIBCO T-580, NO SUBSTITUTES

THREADED CHECK VALVE - BRONZE BODY, THREADED ENDS, SWING CHECK STYLE, 200 PSIG MIN WORKING PRESSURE. NIBCO T-413, NO SUBSTITUTES

BUTTERFLY VALVE - LUG STYLE DUCTILE IRON BODY, ANSI 150# FLANGED ENDS, STAINLESS STEEL STEM WITH BRONZE BUSHING, BRONZE DISC, EPDM SEATS, LOCKING HANDLE. GRINNELL MODEL LD-8281-3, NO SUBSTITUTES

DRAIN VALVE - 3/4" THREADED BRONZE BALL VALVE WITH 3/4" MALE HOSE THREAD ADAPTER.

PIPING SPECIALTIES

AUTOMATIC AIR VENTS - BRASS BODY, SELF-CLOSING FLOAT OPERATED VALVE, SCREW ON CAP, 3/4" MPT x 1/2 FPT CONNECTION. HOFFMAN #79, NO SUBSTITUTES. PROVIDE WITH BALL VALVE ISOLATION.

PRESSURE GAUGES - 3-1/2" DIAL SIZE, CAST ALUMINUM CASE, PHOSPHOR BRONZE TUBE, BRASS MOVEMENT, BLACK POINTER ON WHITE DIAL FACE WITH BLACK GRADUATIONS, RANGE AS INDICATED. TRERICE NO. 600C OR EQUAL. PROVIDE WITH BALL VALVE ISOLATION.

THERMOMETERS - 3" DIAL SIZE BIMETAL TYPE, STAINLESS STEEL CASE AND STEM, BLACK POINTER ON WHITE DIAL FACE WITH BLACK AND BLUE GRADUATIONS, DUAL SCALE F AND C, 20F TO 240F RANGE, ADJUSTABLE ANGLE, 1% OF FULL SCALE ACCURACY. TRERICE NO. B83600 OR EQUAL. PROVIDE WITH THERMAL WELL.

SYSTEM STARTUP

SCHOOL SITE - AFTER FLUSHING AND PRESSURE TESTING OF NEW PIPING, FILL BOILER AND NEW PIPING WITH A SOLUTION OF DOWFROST PROPYLENE GLYCOL, NO SUBSTITUTES, PRE-MIXED TO A RATIO OF 50% PROPYLENE GLYCOL AND 50% WATER. COMPLETELY FILL NEW PIPING AND VENT OFF AIR. OPEN ISOLATION VALVES SLOWLY AND ALLOW NEW PIPING TO COME UP TO SYSTEM PRESSURE. INSTRUCT SCHOOL MAINTENANCE TECHNICIAN IN LOCATION OF ALL NEW EQUIPMENT AND VALVES.

AVEC SITE - AFTER FLUSHING AND PRESSURE TESTING OF NEW PIPING, FILL BOILER AND NEW PIPING WITH A SOLUTION OF "FLEETGUARD COMPLETE" ETHYLENE GLYCOL, NO SUBSTITUTES, PREMIXED TO A RATIO OF 60% ETHYLENE GLYCOL TO 40% WATER. COMPLETELY FILL NEW PIPING AND VENT OFF AIR. OPEN ISOLATION VALVES SLOWLY AND ALLOW NEW PIPING TO COME UP TO SYSTEM PRESSURE. INSTRUCT AVEC PLANT OPERATOR IN LOCATION OF ALL NEW EQUIPMENT AND VALVES.

MONITOR NEW PIPING AND EQUIPMENT FOR A MINIMUM OF 24 HOURS BEFORE LEAVING SITE.

STARTUP AND FUNCTIONAL TEST OF BOILERS, PUMPS, AND CONTROLS WILL BE PERFORMED BY OTHERS UPON COMPLETION OF THE ELECTRICAL INSTALLATION.

MECHANICAL EQUIPMENT SCHEDULE

B-1	AVEC ELECTRIC BOILER	ELECTRIC HOT WATER BOILER WITH PORTS FOR 6 INDIVIDUAL ELEMENTS. PROVIDE WITH TWO COMPLETE SETS OF ELEMENTS AS FOLLOWS: 3 EA. 20KW NOMINAL ELEMENTS, 1 EA. 10KW NOMINAL ELEMENT, 1 EA. 5KW NOMINAL ELEMENT, & 1 EA. 2.5KW NOMINAL ELEMENT FOR A TOTAL CAPACITY OF 77.5KW. ELEMENTS SHALL BE 480V, 3 PHASE AND 3" SHORTER THAN STANDARD LENGTH TO REDUCE FLOOR TO CEILING CLEARANCE TO 92" OVERALL FOR ELEMENT REMOVAL. PROVIDE COMPLETE WITH 50 PSIG ASME RATED PRESSURE RELIEF VALVE, COMBINATION PRESSURE/TEMPERATURE GAUGES, TYPE "J" THERMOCOUPLE, AUXILIARY HIGH LIMIT CUTOFF, & LOW WATER CUTOFF. BOILERS MANUFACTURED IN ACCORDANCE TO ASME SECTION VI AND PROVIDED WITH ASME LABEL FOR MINIMUM 100 PSIG WORKING PRESSURE. THE ENTIRE ASSEMBLY SHALL BE UL LABELED. FULTON BOILER WORKS FB-150 MODIFIED OR EQUAL
B-4	SCHOOL ELECTRIC BOILER	ELECTRIC HOT WATER BOILER WITH PORTS FOR 6 INDIVIDUAL ELEMENTS. PROVIDE WITH 6 EA. 20KW NOMINAL ELEMENTS FOR A TOTAL CAPACITY OF 120KW. ELEMENTS SHALL BE 480V, 3 PHASE AND SHALL BE STANDARD LENGTH. PROVIDE COMPLETE WITH 50 PSIG ASME RATED PRESSURE RELIEF VALVE, COMBINATION PRESSURE/TEMPERATURE GAUGES, TYPE "J" THERMOCOUPLE, AUXILIARY HIGH LIMIT CUTOFF, & LOW WATER CUTOFF. BOILERS MANUFACTURED IN ACCORDANCE TO ASME SECTION VI AND PROVIDED WITH ASME LABEL FOR MINIMUM 100 PSIG WORKING PRESSURE. THE ENTIRE ASSEMBLY SHALL BE UL LABELED. FULTON BOILER WORKS FB-150 MODIFIED OR EQUAL.
P-A1	AVEC HEATING PUMP	SYSTEM LUBRICATED CIRCULATING PUMP, 40 GPM AT 7' TDH, 1/3HP, 115V, 1ø, FLANGED ENDS. GRUNDFOS UPS 50-40, SPEED 2 OR EQUAL.
P-S1	SCHOOL HEATING PUMP	SYSTEM LUBRICATED CIRCULATING PUMP, 40 GPM AT 4' TDH, 1/5HP, 115V, 1ø, FLANGED ENDS. GRUNDFOS UPS 50-75F, OR EQUAL.

ABBREVIATIONS

ø	DIAMETER	MBH	THOUSAND BTU PER HOUR
AFF	ABOVE FINISHED FLOOR	MIN	MINIMUM
BTU	BRITISH THERMAL UNIT	OD	OUTSIDE DIAMETER
EWT	ENTERING WATER TEMPERATURE	PH	PHASE
EXIST	EXISTING	PRV	PRESSURE RELIEF VALVE
GA	GAUGE	PSI	POUNDS/PER SQUARE INCH
GALV	GALVANIZED	PSIG	POUNDS/PER SQ INCH GAUGE
GPM	GALLONS PER MINUTE	SCH	SCHEDULE
ID	INSIDE DIAMETER	TDH	TOTAL DEVELOPED HEAD
KW	KILOWATT	TYP	TYPICAL
LWT	LEAVING WATER TEMPERATURE	WG	WATER GAUGE
MAX	MAXIMUM	WPD	WATER PRESSURE DROP

LEGEND

GHS GLYCOL HEATING SUPPLY
GHR GLYCOL HEATING RETURN
DIRECTION OF FLOW

BALL VALVE
CHECK VALVE
BALANCING COCK
BUTTERFLY VALVE
DRAIN VALVE
AUTOMATIC AIR VENT
UNION
FLANGED JOINT
ELBOW TURNED UP
ELBOW TURNED DOWN
PIPING CONNECTION (TEE)
CHANGE OF PIPE SIZE (REDUCER)
P PRESSURE GAUGE
T THERMOMETER

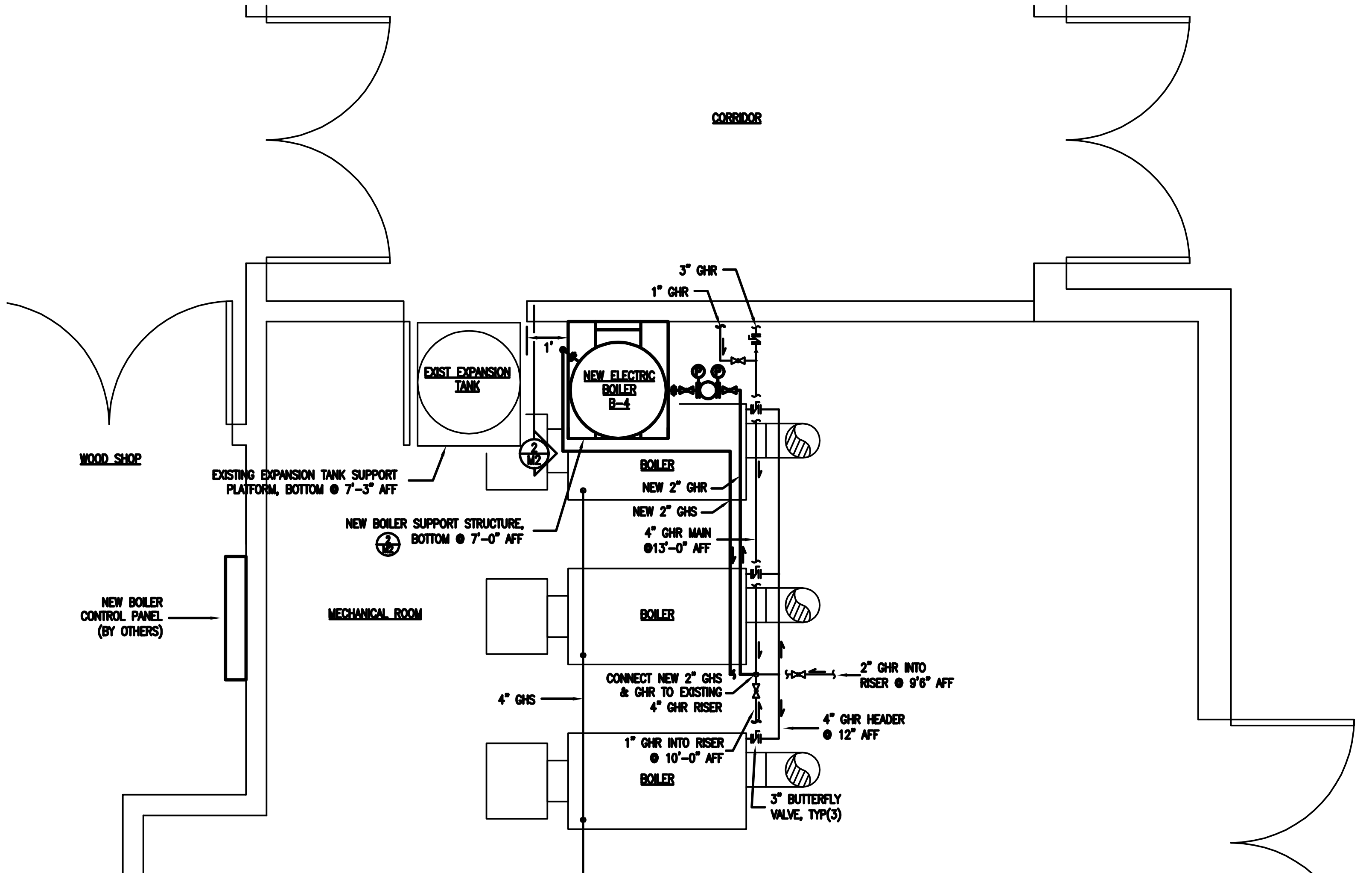
REDUCED PLOT - 1/2 SCALE
PRELIMINARY - NOT FOR CONSTRUCTION

PROJECT: WALES WIND GENERATION ELECTRIC BOILER INSTALLATION

TITLE: SITE PLAN, NOTES, SCHEDULES, SPECIFICATIONS, ABBREVIATIONS, & LEGEND

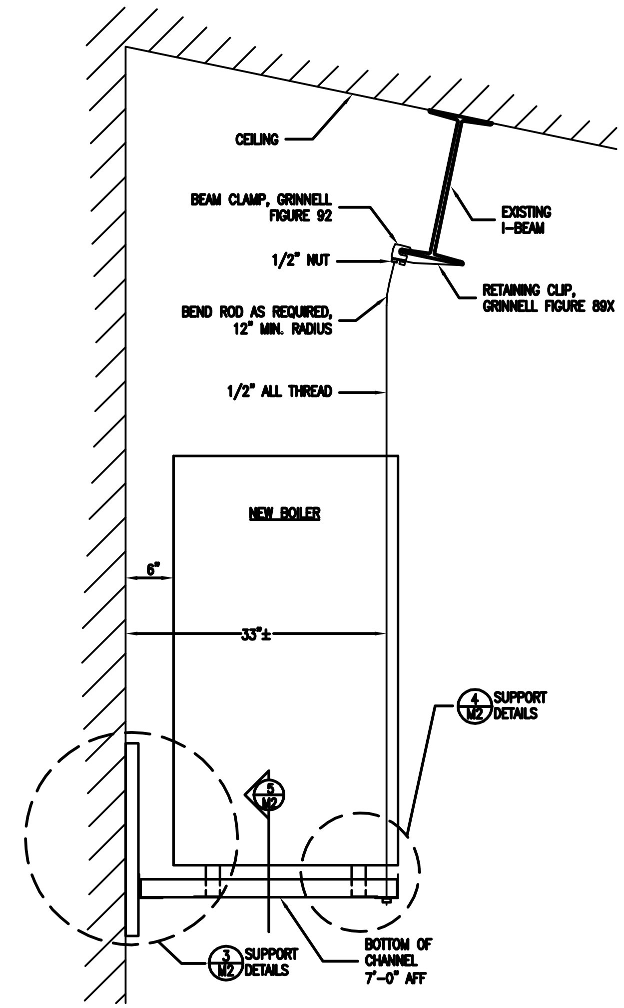
ALASKA ENERGY AND ENGINEERING, INC
P.O. BOX 111405 ANCHORAGE, ALASKA 99511-1405 PHONE (907) 349-0100

DRAWN BY: JTD	SCALE: AS NOTED	FILE NAME WalesHTM1	SHEET M1 of 3
DESIGNED BY: BCG	DATE: 6/28/99	PROJECT NUMBER 99-01-9783	

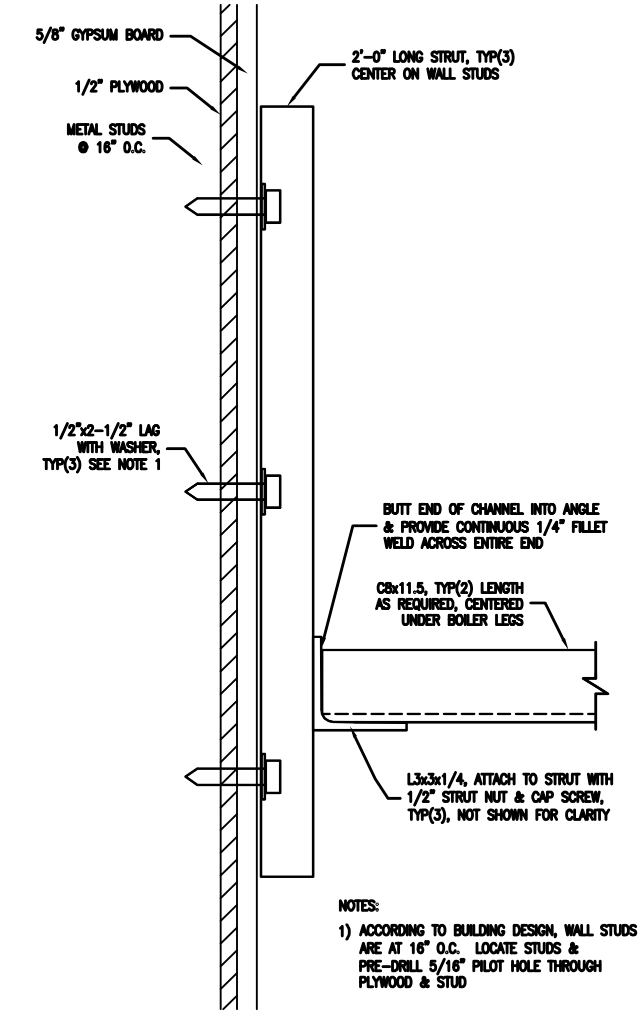


NOTES:
1) MECHANICAL ROOM PIPING & EQUIPMENT ONLY PARTIALLY SHOWN FOR CLARITY. FIELD VERIFY & LOCATE AS REQUIRED.
2) ALL PIPING EXISTING EXCEPT NEW 2" BRANCH PIPING FROM EXISTING 4" GHR RISER TO NEW ELECTRIC BOILER.

1 M2 PARTIAL FIRST FLOOR MECHANICAL PLAN
1/2"=1'-0"

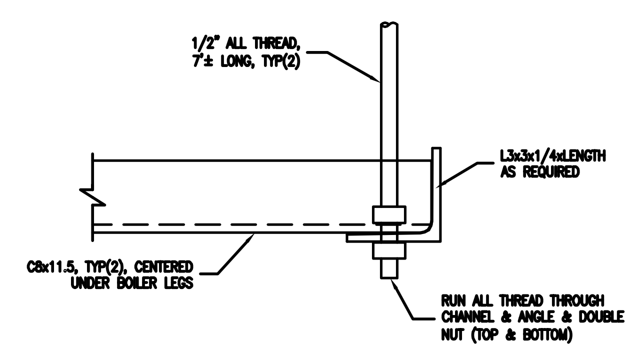


2 M2 NEW BOILER SUPPORT STRUCTURE
1"=1'-0"

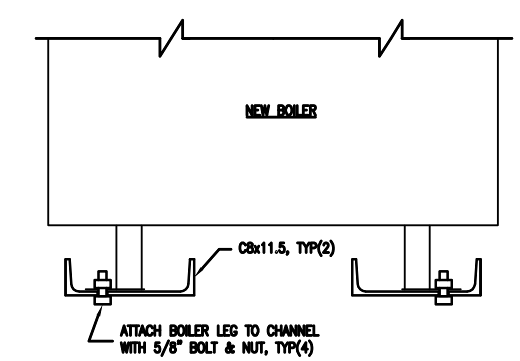


NOTES:
1) ACCORDING TO BUILDING DESIGN, WALL STUDS ARE AT 16" O.C. LOCATE STUDS & PRE-DRILL 5/16" PILOT HOLE THROUGH PLYWOOD & STUD

3 M2 BOILER WALL SUPPORT DETAILS
NO SCALE

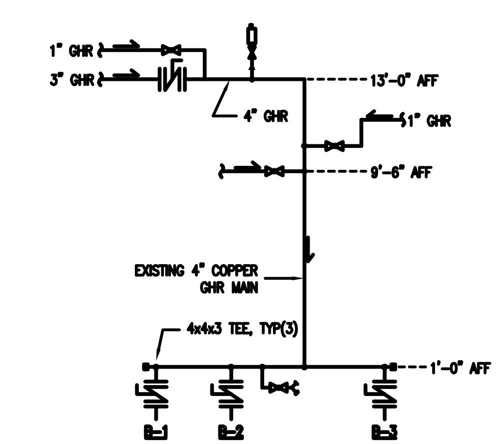


4 M2 BOILER OUTSIDE SUPPORT DETAILS
NO SCALE



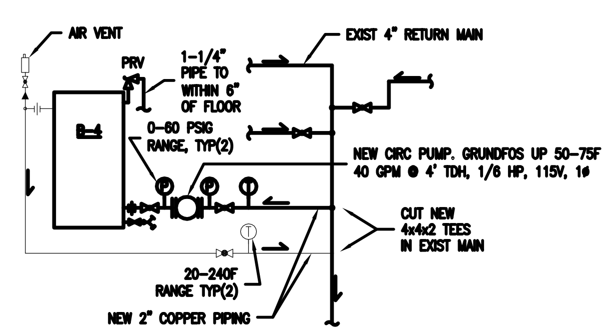
5 M2 BOILER BOLT DOWN DETAIL
NO SCALE

REDUCED PLOT – 1/2 SCALE
PRELIMINARY – NOT FOR CONSTRUCTION



NOTE: ALL EXISTING PIPING COPPER TUBE WITH SOLDER JOINTS.

6 M2 EXISTING GLYCOL HEATING RETURN RISER DIAGRAM
NOT TO SCALE



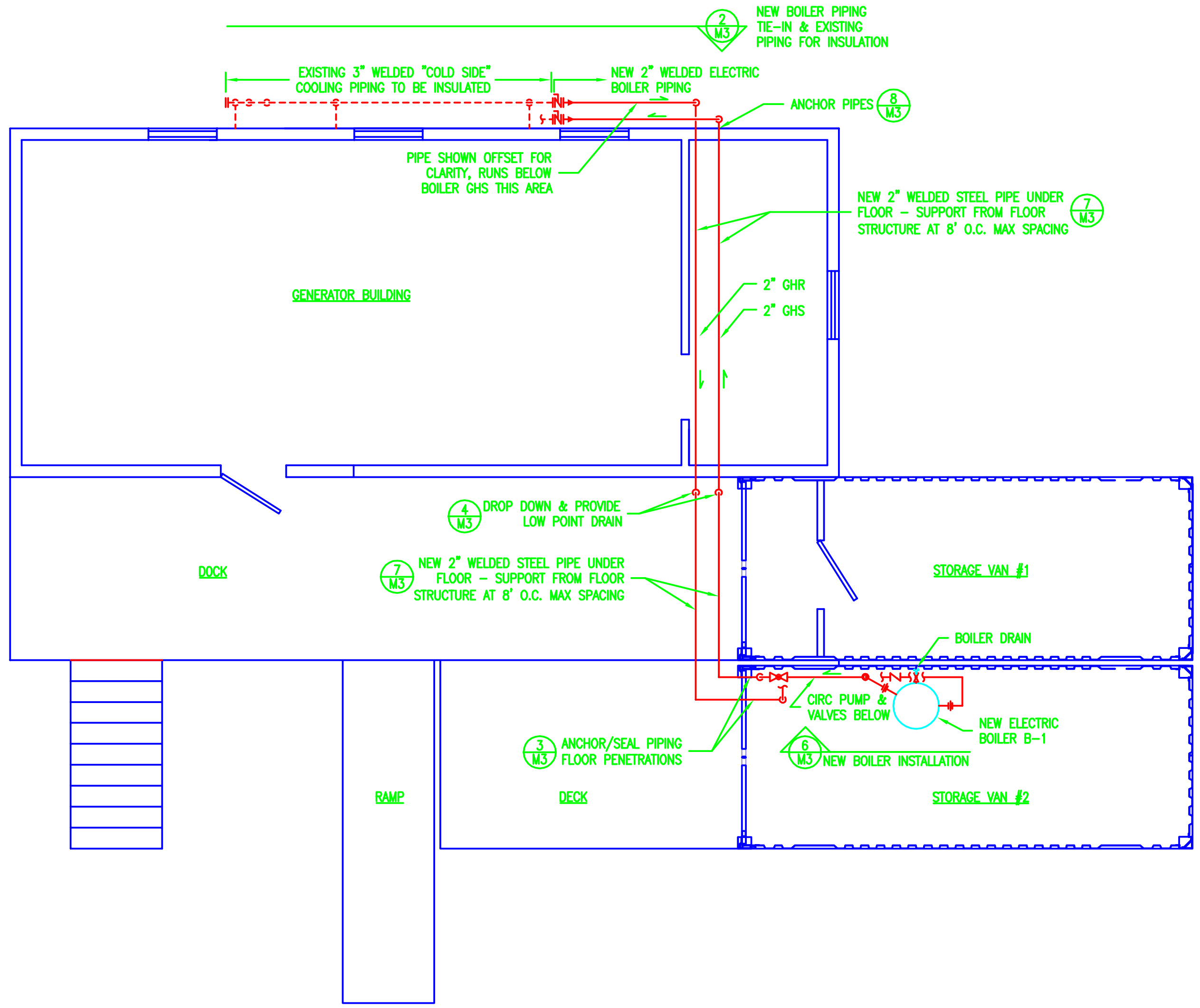
NOTES:
1) BOTTOM OF NEW BOILER & PIPING 7' MIN. ABOVE FLOOR
2) SUPPORT NEW PIPING FROM STRUCTURE ABOVE WITH STRUT, ALL THREAD, & BEAM CLAMPS.
3) NEW ELECTRIC BOILER B-4 FULTON FB-150 MODIFIED WITH 6 EA. 20 KW ELEMENTS, 120 KW TOTAL CAPACITY.

7 M2 NEW ELECTRIC BOILER PIPING DIAGRAM
NOT TO SCALE

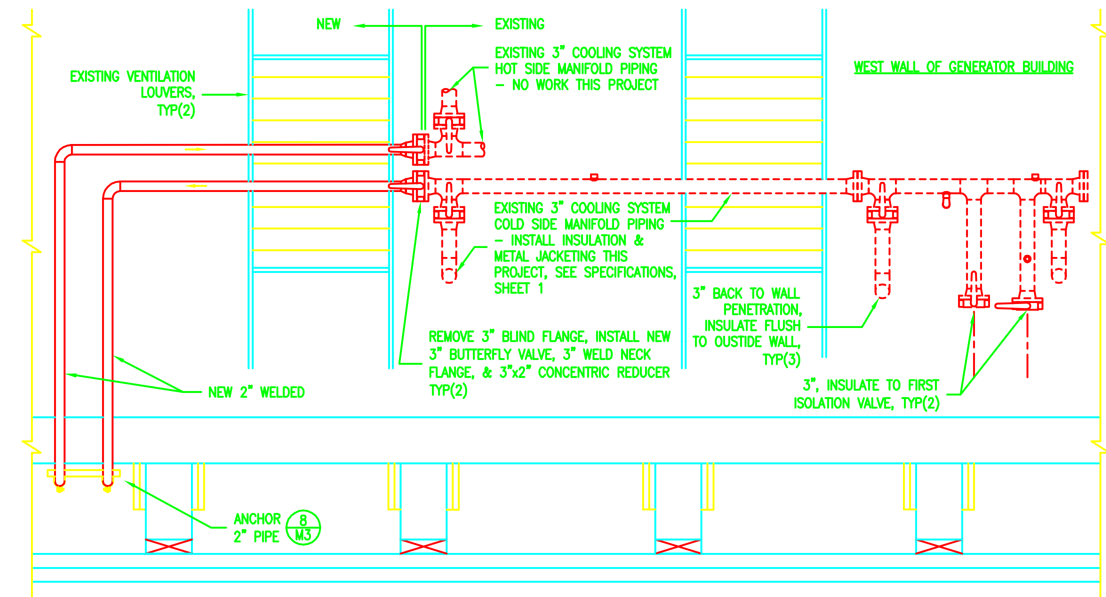
PROJECT:	WALES WIND GENERATION ELECTRIC BOILER INSTALLATION
TITLE:	SCHOOL BOILER PLAN, DETAILS, & PIPING DIAGRAM

ALASKA ENERGY AND ENGINEERING, INC
P.O. BOX 111405 ANCHORAGE, ALASKA 99511-1405 PHONE (907) 349-0100

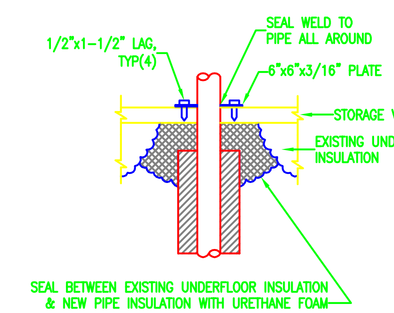
DRAWN BY: JTD	SCALE: AS NOTED	FILE NAME WalesHTM2	SHEET M2 of 3
DESIGNED BY: BCG	DATE: 6/28/99	PROJECT NUMBER 99-01-9783	



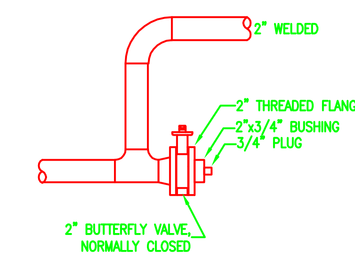
1 M3 PIPING PLAN
1/4" = 1'



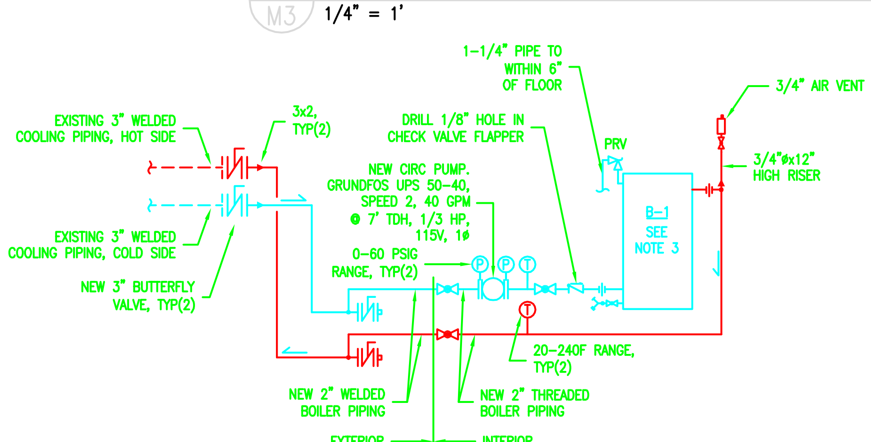
2 M3 NEW ELECTRIC BOILER PIPING TIE-IN DETAIL
1/2" = 1'



3 M3 FLOOR PENETRATION SEAL/ANCHOR DETAIL
NO SCALE



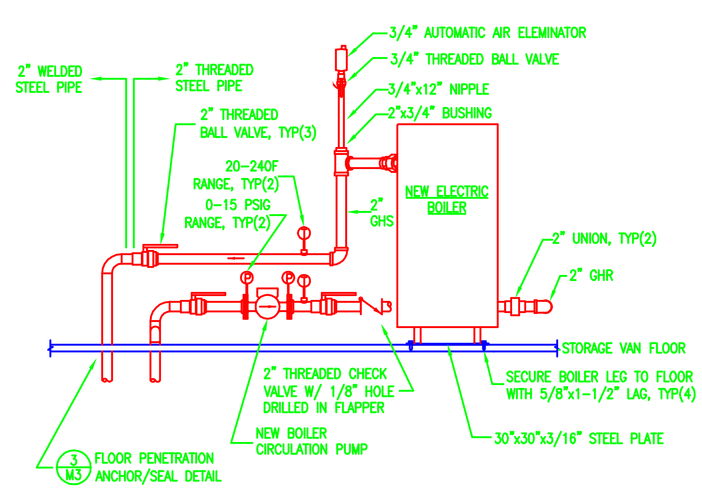
4 M3 2" PIPE LOW POINT DRAIN DETAIL
NO SCALE



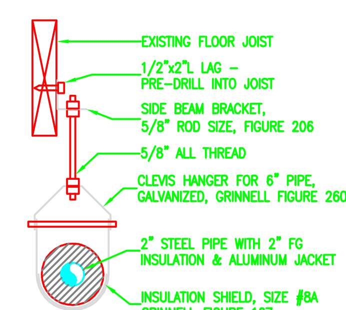
NOTES:

1) INSULATE ALL NEW PIPING AND EXISTING COLD SIDE COOLING SYSTEM PIPING WITH 2" FIBERGLASS PIPE INSULATION & COVER WITH METAL JACKETING PER SPECIFICATIONS, SEE SHEET 1 AND DETAIL 2/M3.
2) SUPPORT NEW PIPING FROM STORAGE VAN FLOOR OR WALL WITH STRUT.
3) NEW ELECTRIC BOILER B-1 FULTON FB-150 MODIFIED WITH 3 EA. 20KW, 1 EA. 10KW, 1 EA. 5KW, & 1 EA. 2.5KW ELEMENTS, 77.5KW TOTAL CAPACITY.

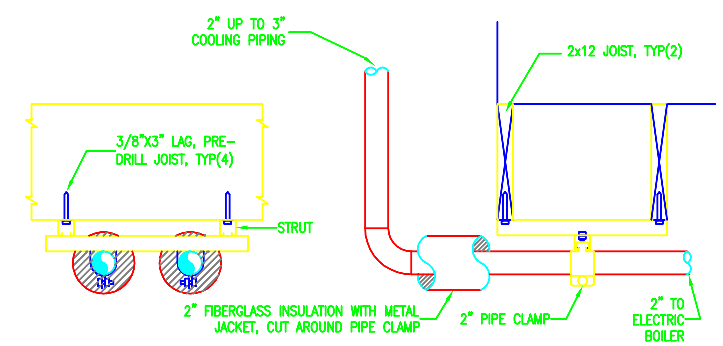
5 M3 NEW ELECTRIC BOILER PIPING DIAGRAM
NO SCALE



6 M3 NEW ELECTRIC BOILER INSTALLATION DETAIL
1/2" = 1'



7 M3 2" PIPE CLEVIS HANGER DETAIL
NOT TO SCALE



8 M3 2" PIPE ANCHOR DETAIL
NOT TO SCALE

REDUCED PLOT - 1/2 SCALE
PRELIMINARY - NOT FOR CONSTRUCTION

PROJECT:	WALES WIND GENERATION ELECTRIC BOILER INSTALLATION
TITLE:	AVEC POWER PLANT BOILER PLAN, DETAILS, & PIPING DIAGRAM

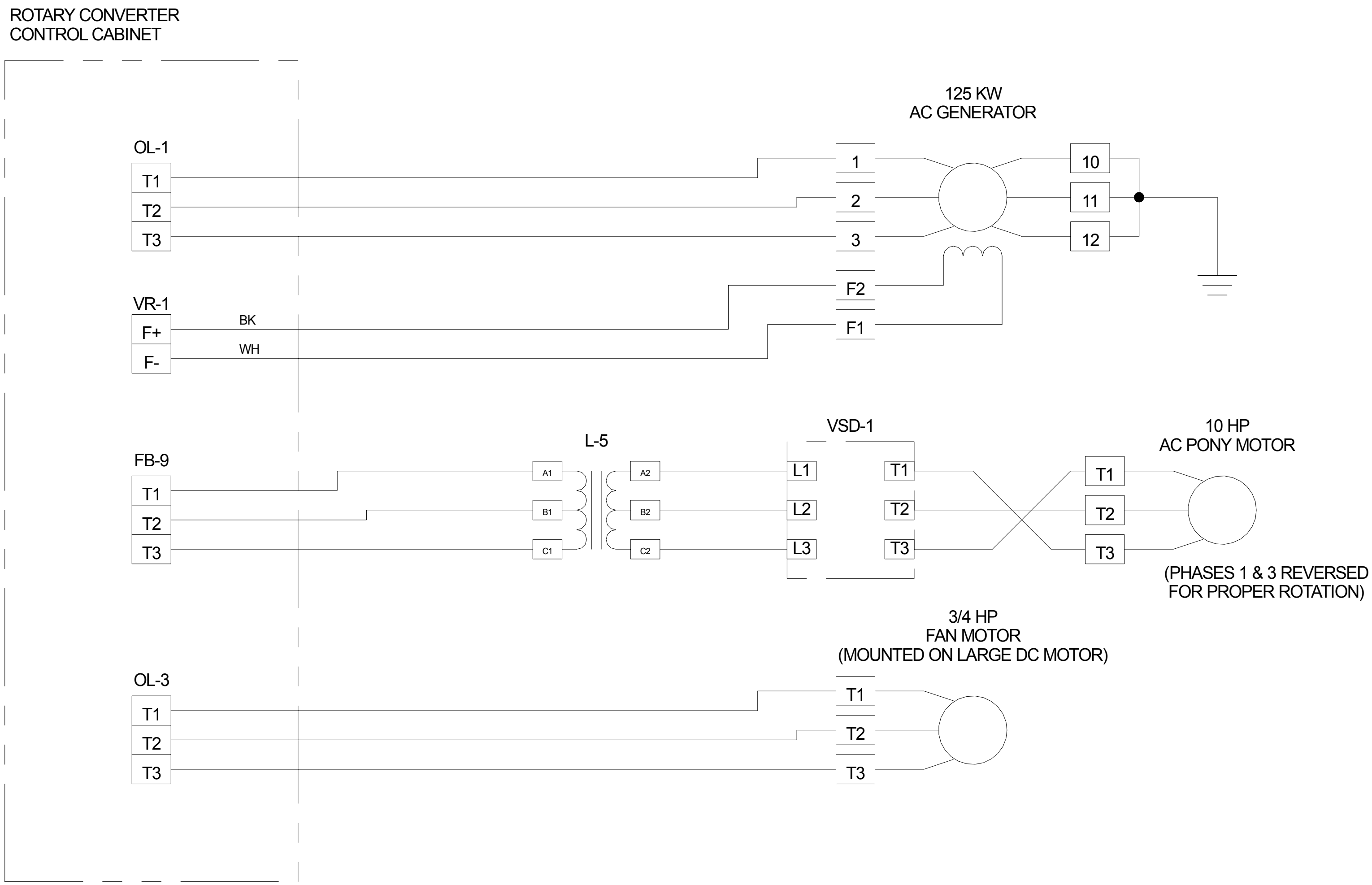
ALASKA ENERGY AND ENGINEERING, INC
P.O. BOX 111405 ANCHORAGE, ALASKA 99511-1405 PHONE (907) 349-0100

DRAWN BY: JTD	SCALE: AS NOTED	FILE NAME WalesHTM3	SHEET M3 of 3
DESIGNED BY: BCG	DATE: 6/28/99	PROJECT NUMBER 99-01-9783	

AC MOTOR/GENERATOR CONNECTIONS

S. DROUILHET

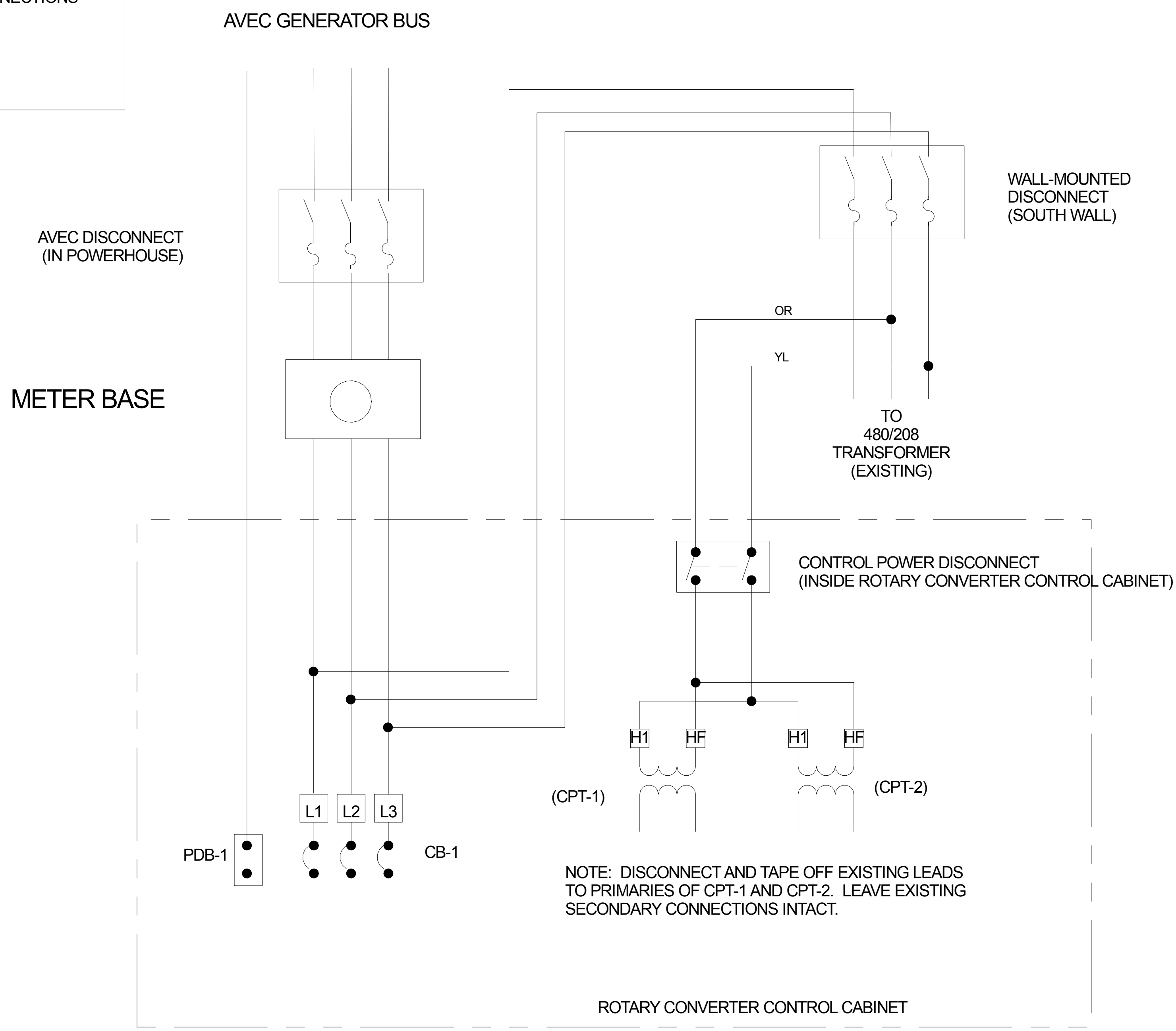
5/26/99 REV. 5

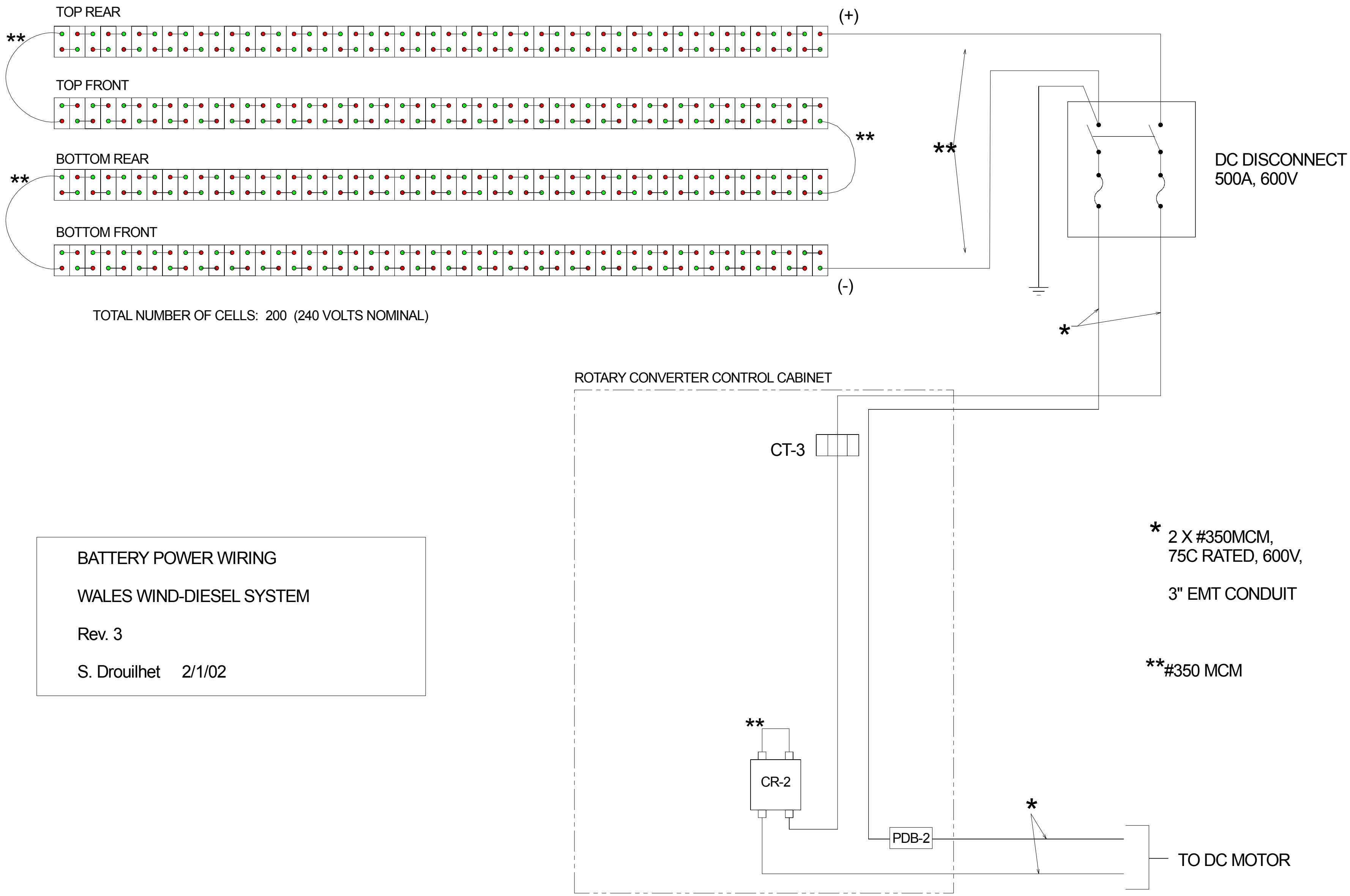


AC POWER CONNECTIONS

S DROUILHET

9/12/00 REV. 4

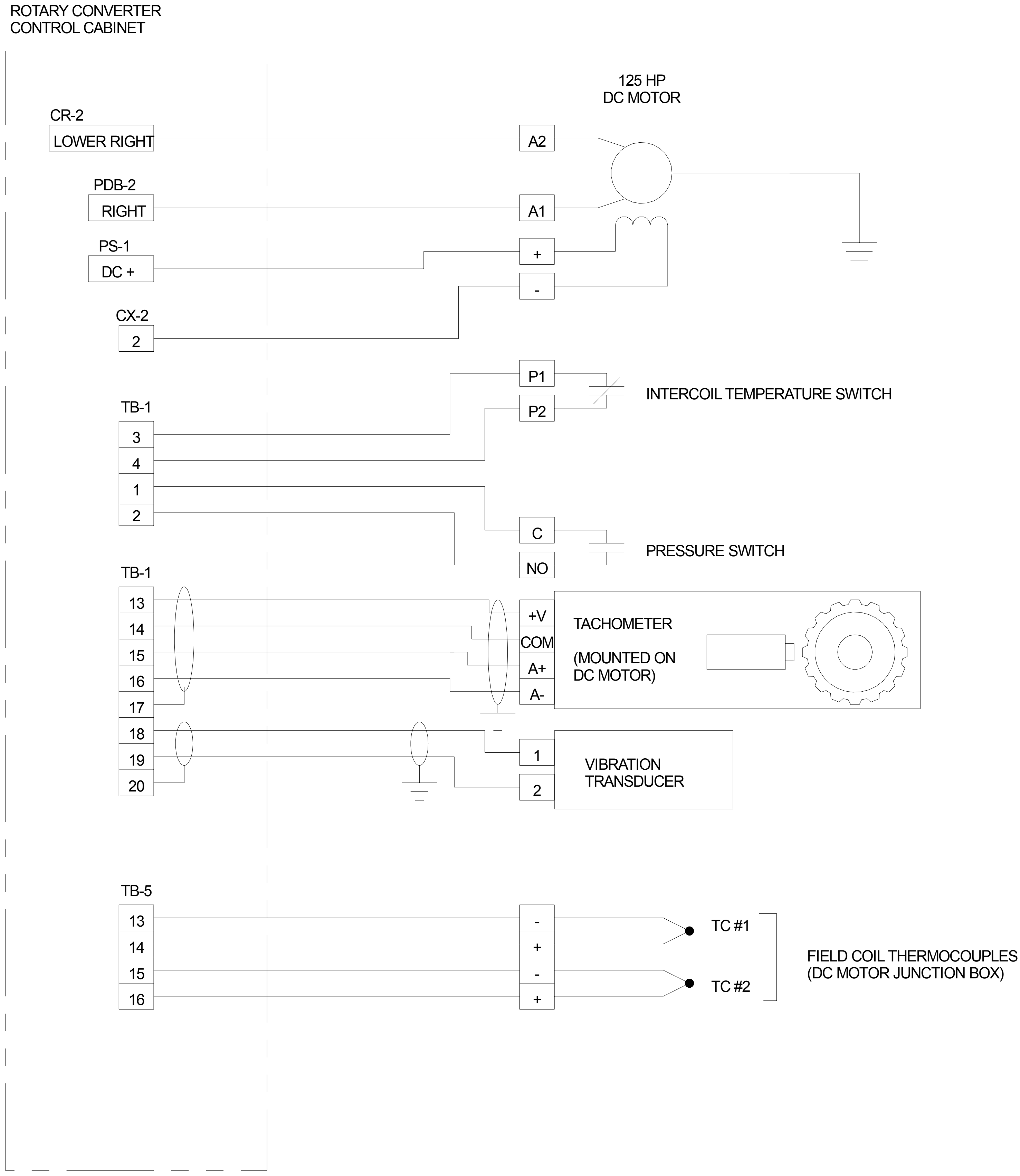



TOP REAR
(+)
**
TOP FRONT
**
BOTTOM REAR
**
**
BOTTOM FRONT
(-)
DC DISCONNECT
500A, 600V
TOTAL NUMBER OF CELLS: 200 (240 VOLTS NOMINAL)
*
ROTARY CONVERTER CONTROL CABINET
CT-3
BATTERY POWER WIRING
WALES WIND-DIESEL SYSTEM
Rev. 3
S. Drouilhet 2/1/02
* 2 X #350MCM,
75C RATED, 600V,
3" EMT CONDUIT
**#350 MCM
**
CR-2
*
PDB-2
TO DC MOTOR

DC MOTOR CONNECTIONS

S. DROUILHET

5/26/99 REV. 3

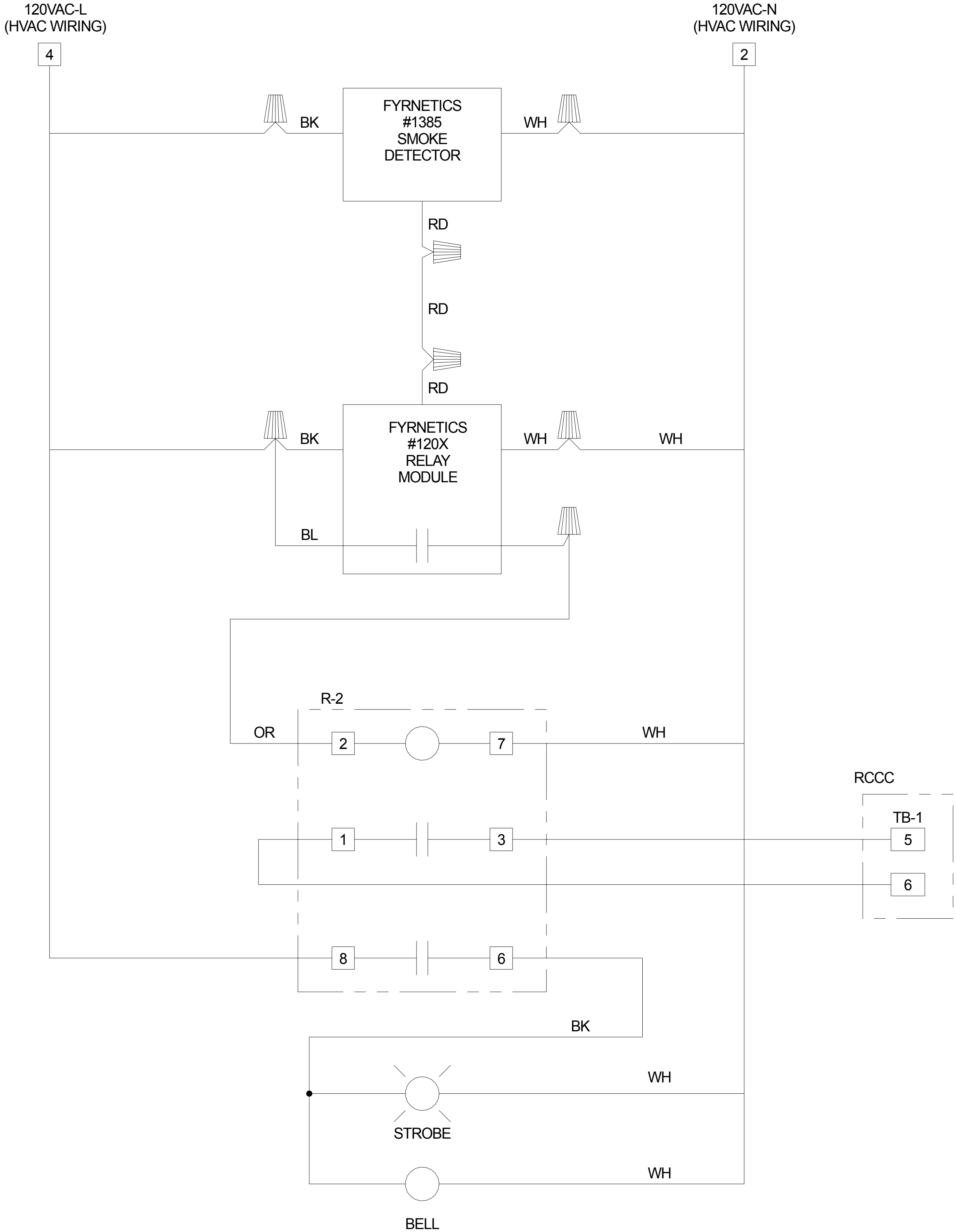


FIRE ALARM SYSTEM
ENERGY STORAGE SUBSYSTEM
WALES WIND-DIESEL SYSTEM

REV. 1

S. DROUILHET 5/26/99

NOTE: RELAYS FOR FIRE ALARM SYSTEM ARE INSTALLED IN THE HVAC CABINET.

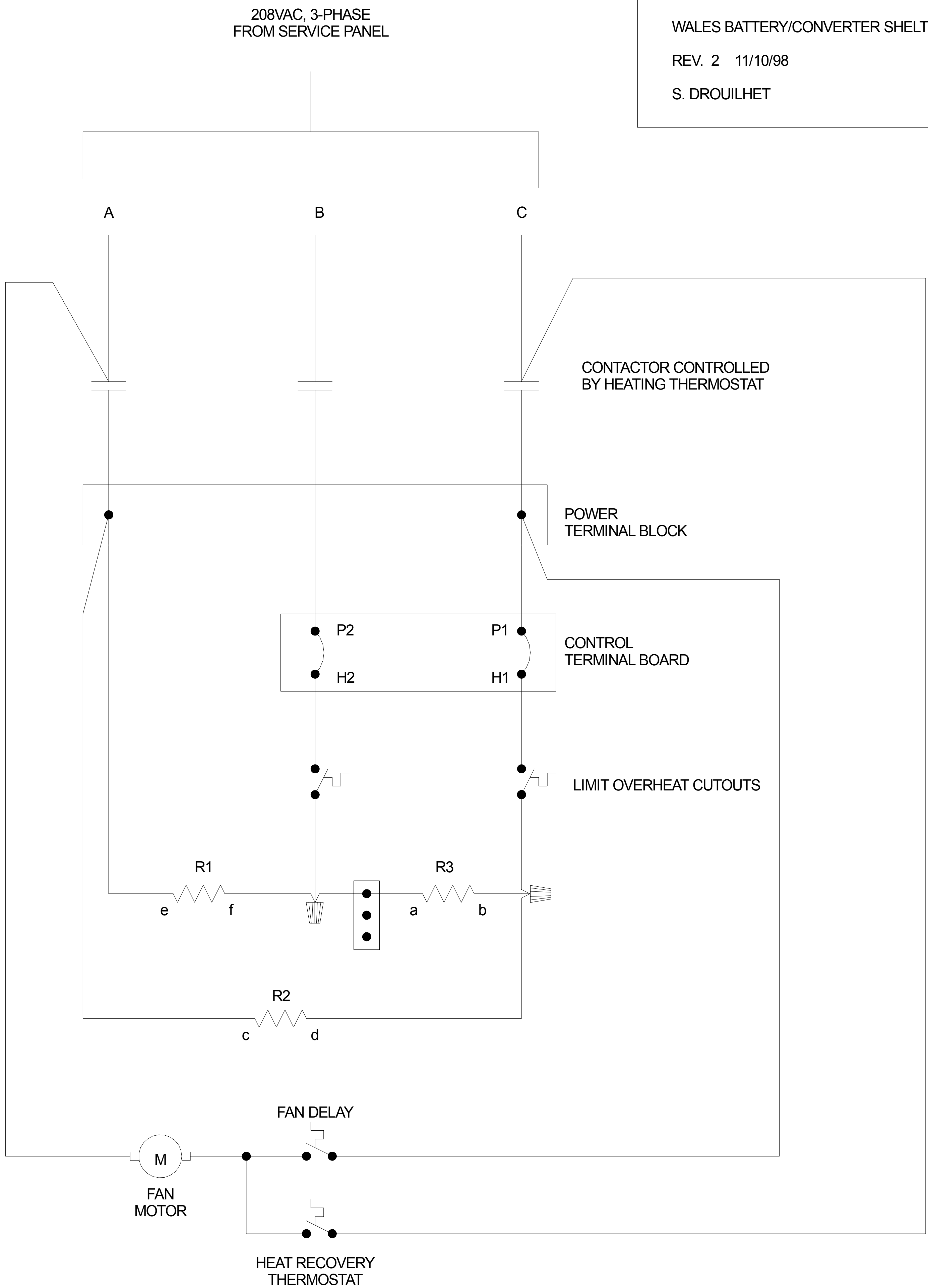


DAYTON HEATER WIRING

WALES BATTERY/CONVERTER SHELTER

REV. 2 11/10/98

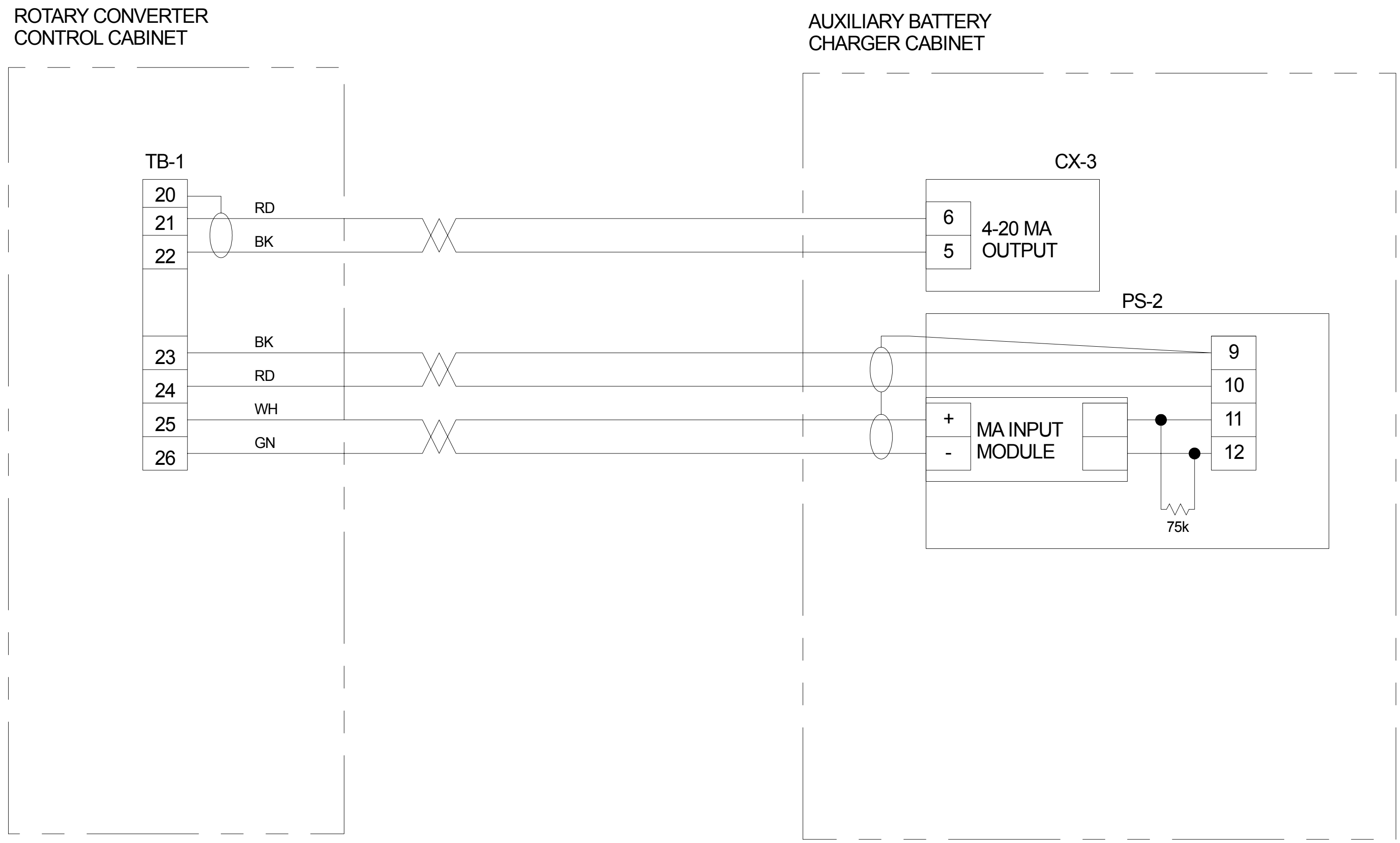
S. DROUILHET



RCCC TO BATTERY CHARGER CONNECTIONS

S. DROUILHET

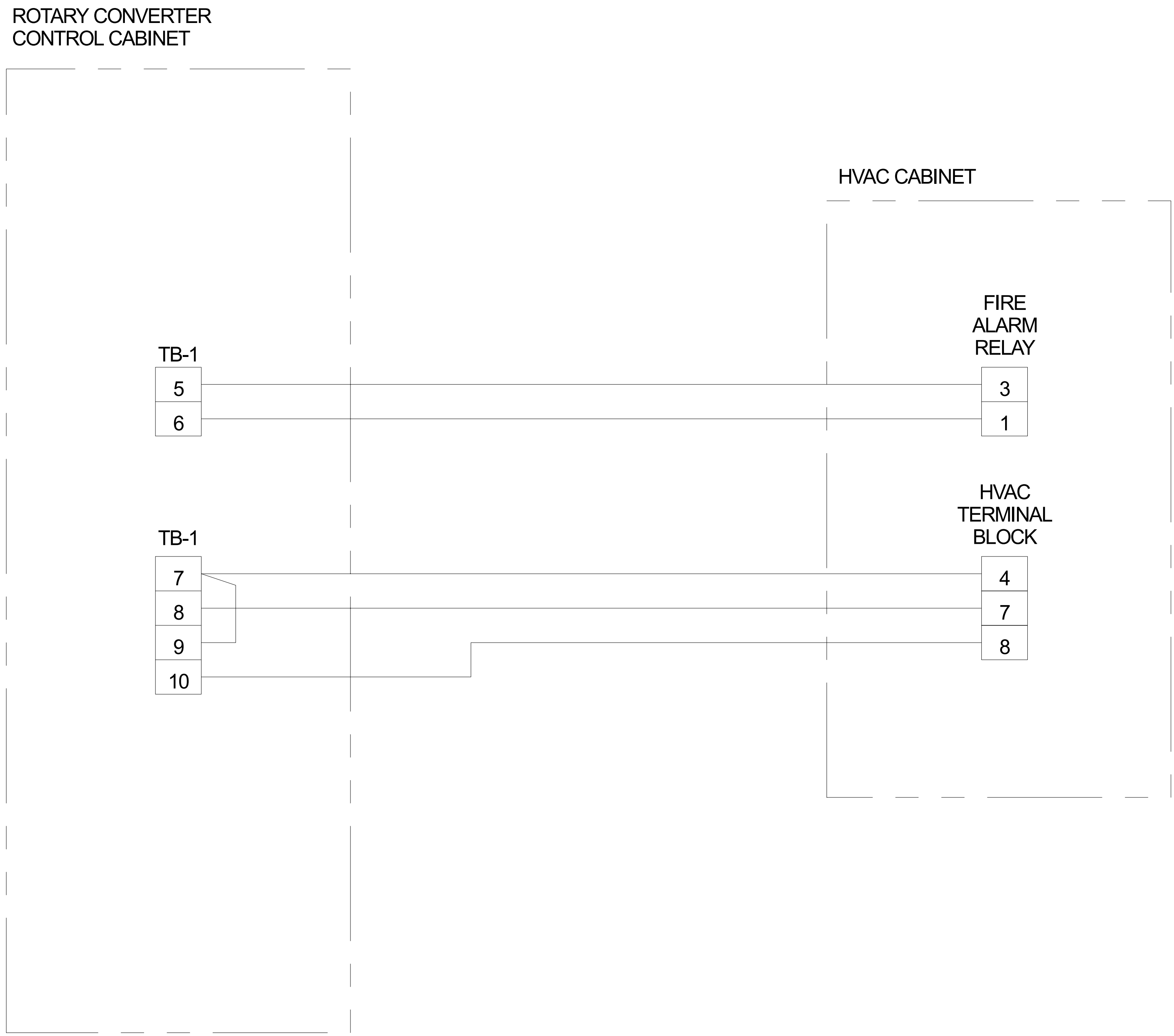
5/26/99 REV. 3



RCCC TO HVAC CONNECTIONS

S. DROUILHET

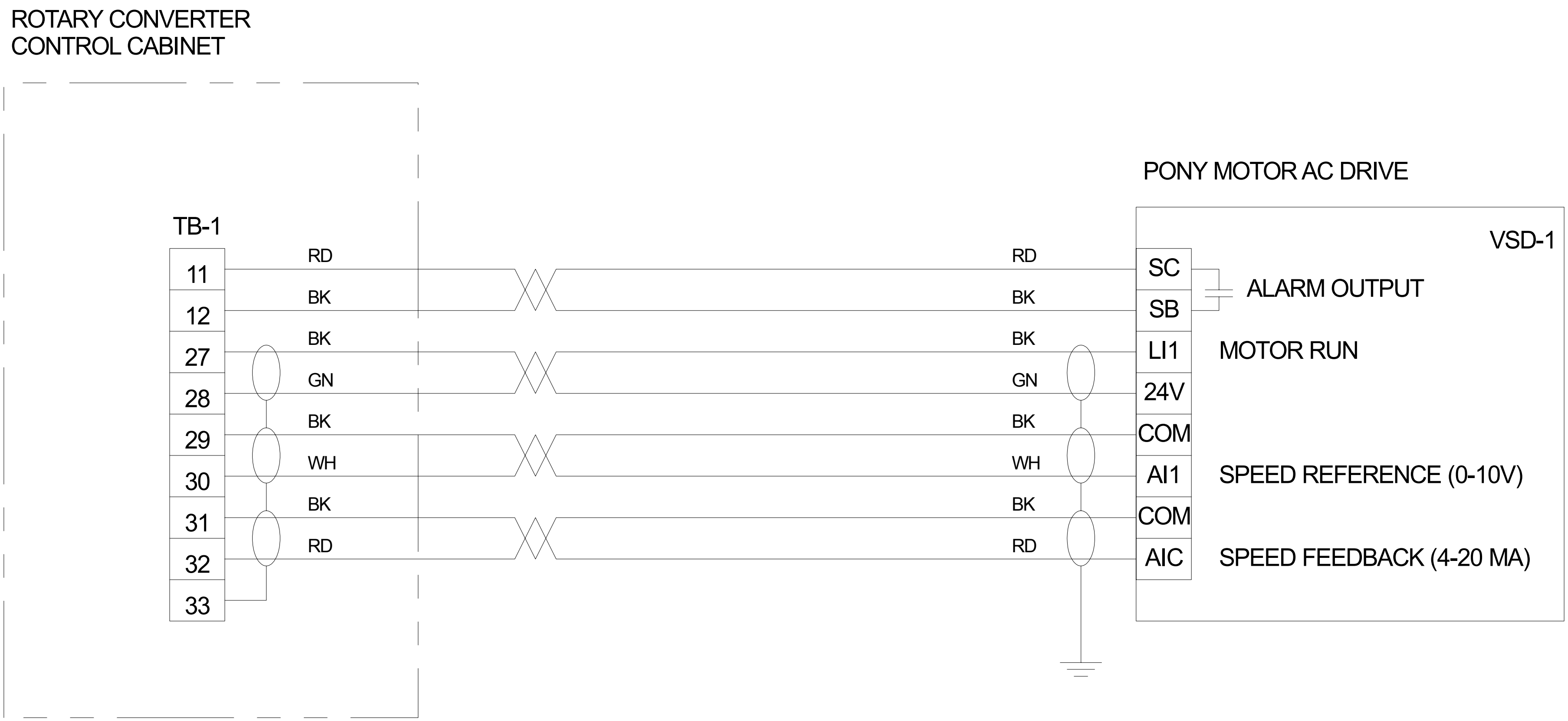
11/9/98 REV. 0



RCCC TO PONY MOTOR DRIVE CONNECTIONS

S. DROUILHET

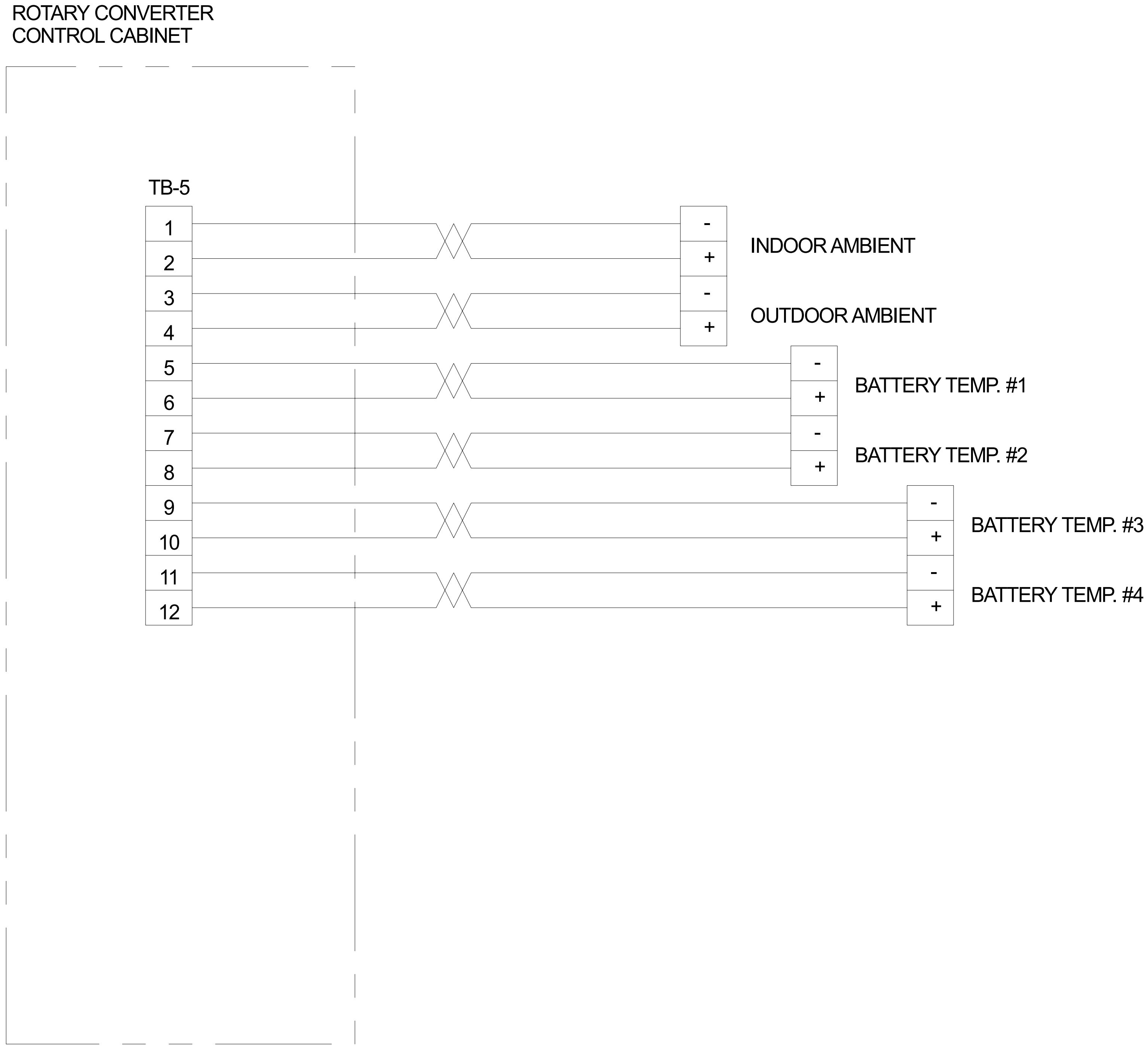
3/4/99 REV. 1



RCCC TO THERMOCOUPLE CONNECTIONS

S. DROUILHET

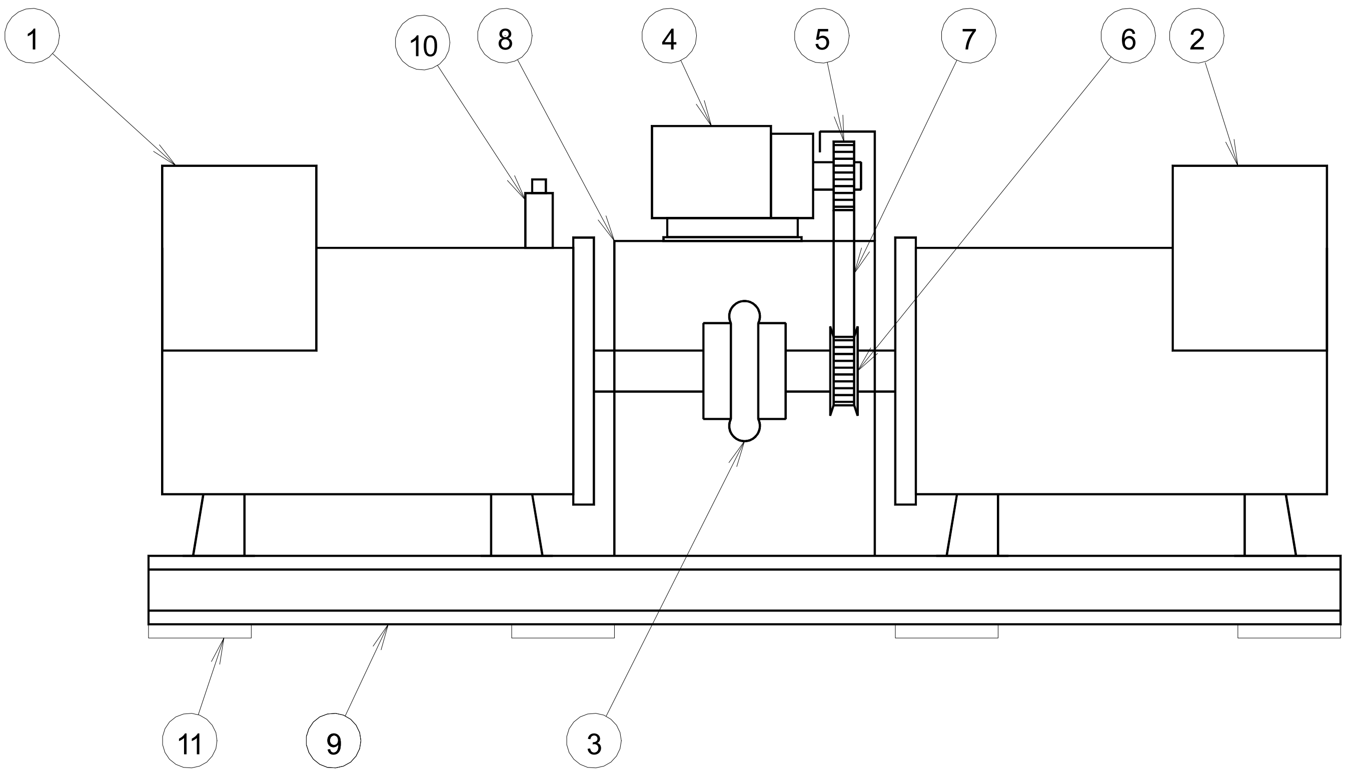
11/9/98 REV. 0



Rotary Converter Assembly
Wind-Diesel Hybrid System

Rev. 5 11/24/98

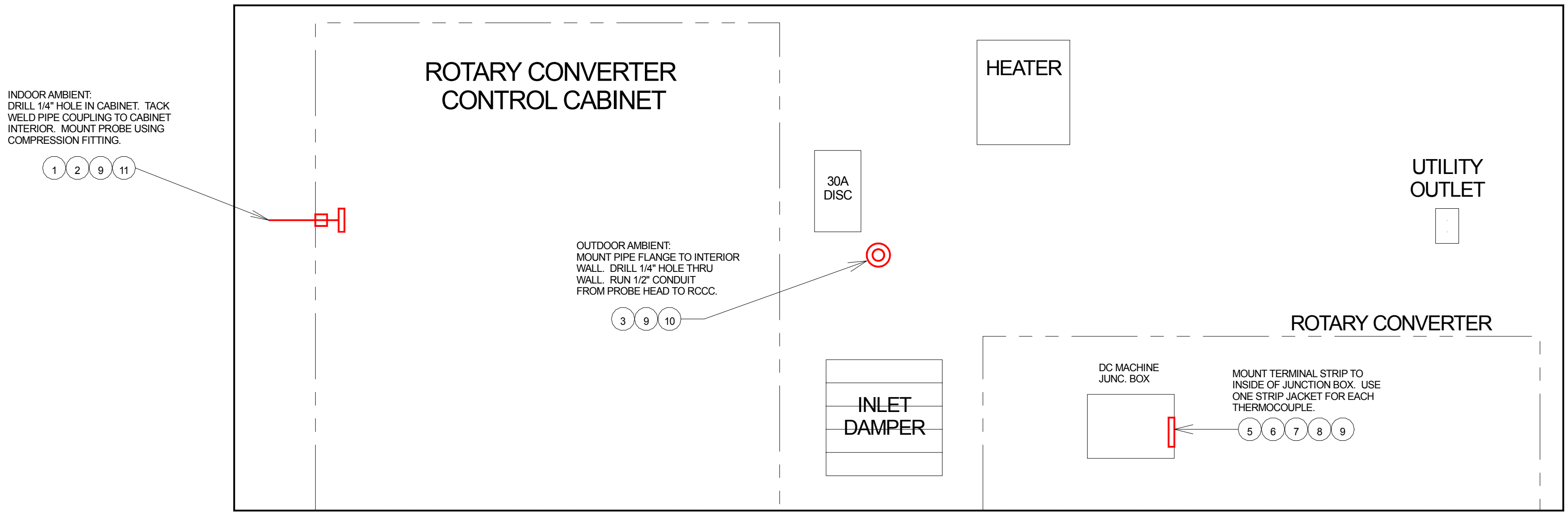
Steve Drouilhet
National Renewable Energy Laboratory



WALES WIND-DIESEL SYSTEM
ROTARY CONVERTER

PARTS LIST
(REV. 4)
11/23/98

ITEM NO.	DESCRIPTION	MANUFACTURER	MFR. PART NUMBER	ESTIMATED COST
1	DC MOTOR, RELIANCE ELECTRIC RPM III, DPG-FV ENCLOSURE, 125 HP CONTINUOUS DUTY, 1750 RPM BASE SPEED, 240V ARMATURE, 240V FIELD, STRAIGHT SHUNT FIELD WINDING, FRAME SIZE LC3212ATZ, WITH FOLLOWING MODIFICATIONS: 50 RD-120 PULSE GENERATOR (SINGLE DIRECTION) 32 AIR PRESSURE SWITCH WITH STANDARD ENCL. 10 HIGH LIMIT THERMOSTAT ON INTERCOIL (PER QUOTATION #721-A-6279 BY RELIANCE ELECTRIC DENVER SALES OFFICE)	RELIANCE ELECTRIC		$19,236
2	AC SYNCHRONOUS GENERATOR, KAMAG 18, CODE 04P02-1168, 125 KW @ 0.8 P.F., 80C TEMPERATURE RISE, 480V, 3 PHASE, WITH BASLER MODEL SSR63-12 VOLTAGE REGULATOR (PER QUOTATION #DM-2009-A)	KATO ENGINEERING	04P02-1168	$7,512
3	FLEXIBLE DISC SHAFT COUPLING, THOMAS SERIES 52, TOMALOY DISCS, 5" SPACER LENGTH, COUPLING SIZE 262, HUBS WITH FINISHED BORES: 2.750" AND 2.625"	REXNORD		$1,792
4	AC INDUCTION MOTOR, DESIGN C, 10 HP, 480V, 3 PHASE, FRAME SIZE 215T, BASE-MOUNTED, TEFC ENCLOSURE	RELIANCE ELECTRIC	P21G319	$512
5	DRIVER GEARBELT PULLEY, 7/8" PITCH, 2" WIDE, 30 TEETH, WITH SIZE E QD BUSHING, 1.375" BORE	BROWNING	30XH200E	$229
6	DRIVEN GEARBELT PULLEY, 7/8" PITCH, 2" WIDE, 29 TEETH, WITH SIZE E QD BUSHING, 2.75" BORE	BROWNING	29XH200E	$229
7	GEARBELT, 2" WIDE, 7/8" PITCH, 50.7" LONG	BROWNING	507XH200	$146
8	MOTOR MOUNT & COUPLING GUARD (DESIGNED BY ROTARY CONVERTER VENDOR)	RELIANCE SERVICE CENTER		NC
9	BASE FRAME	RELIANCE SERVICE CENTER		$6,500
10	VIBRATION TRANSMITTER	PMC/BETA	162VTR-A-1	$590
11	(8) VIBRATION ISOLATOR PADS, 6"X4", NEOPRENE-BACKED STEEL	GRAINGER	4C974	$170
	ROTARY CONVERTER ASSEMBLY	RELIANCE SERVICE CENTER		$2,332
			ESTIMATED TOTAL COST	$39,248.00



THERMOCOUPLE MOUNTING INSTRUCTIONS

INTERIOR VIEW OF SOUTH WALL

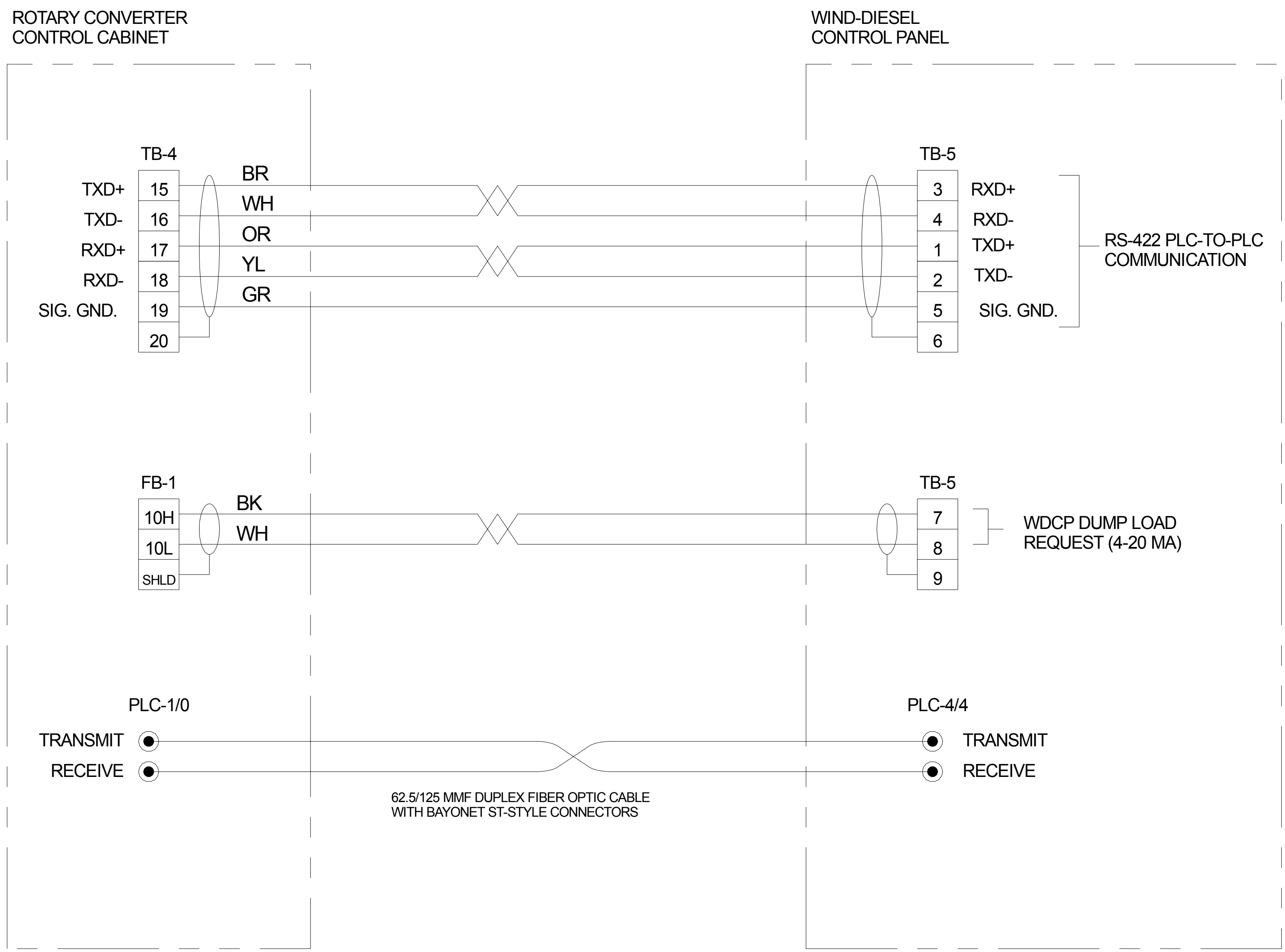
REV. 2 2/1/02

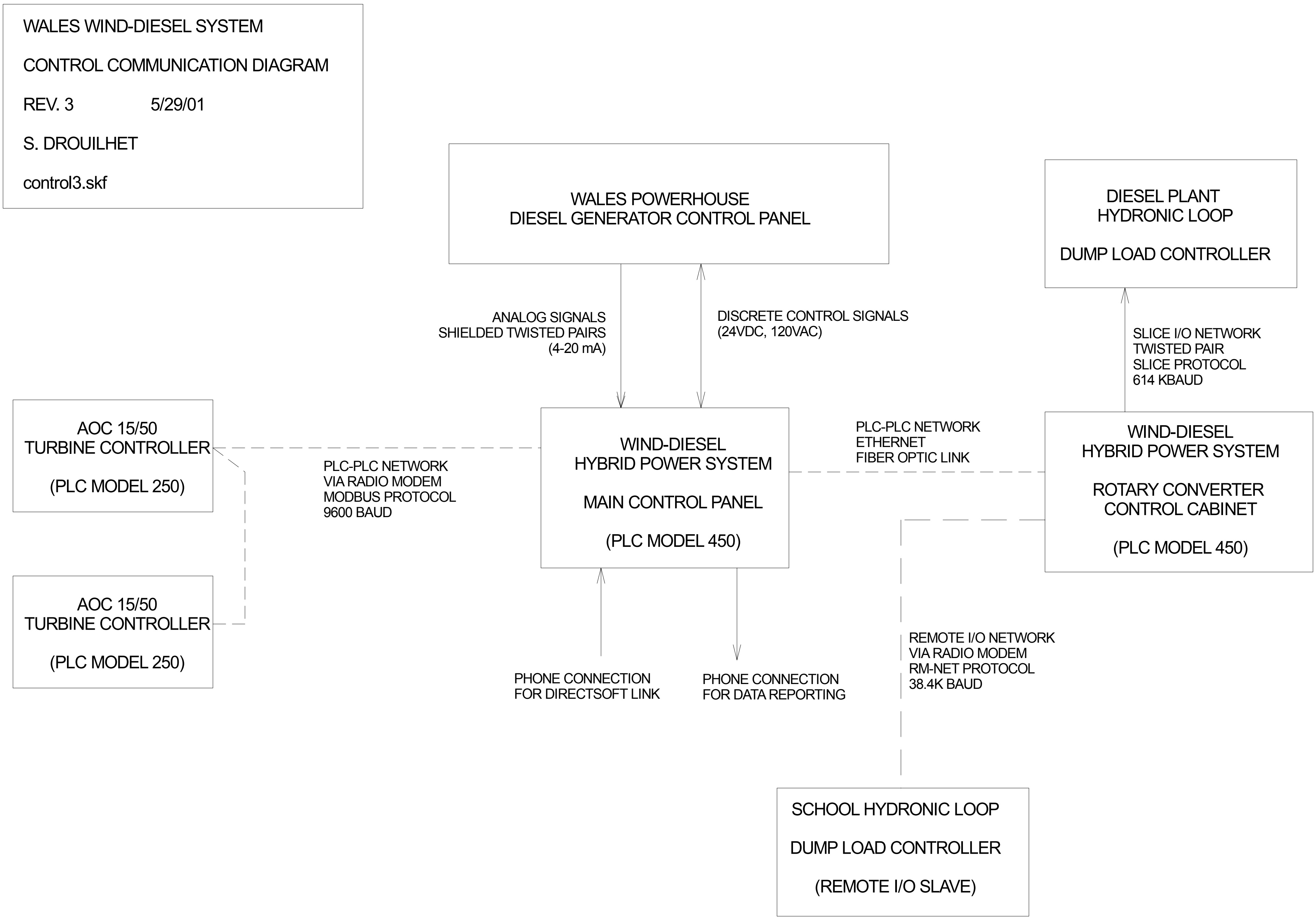
ITEM NUMBER	DESCRIPTION	OMEGA PART NUMBER
1	TERMINAL BLOCK TC PROBE	TB-ICSS-14E-12
2	COMPRESSION FITTING	BRLK-14-14
3	TC PROBE WITH PROTECTION HEAD	NB3-ICSS-14E-12
4	ADHESIVE THERMOCOUPLES	SA1-J
5	BARRIER TERMINAL STRIPS	BS4
6	BARRER STRIP JACKET - J TYPE	BSJ-J
7	SPADE LUGS, IRON	SLIR-20
8	SPADE LUGS, CONSTANTAN	SLCO-20
9	TC WIRE, SHIELDED, J TYPE	EXPP-J-16S-TWSH
10	FLOOR FLANGE, 1/2" NPT	
11	HALF PIPE COUPLING, 1/4" NPT	

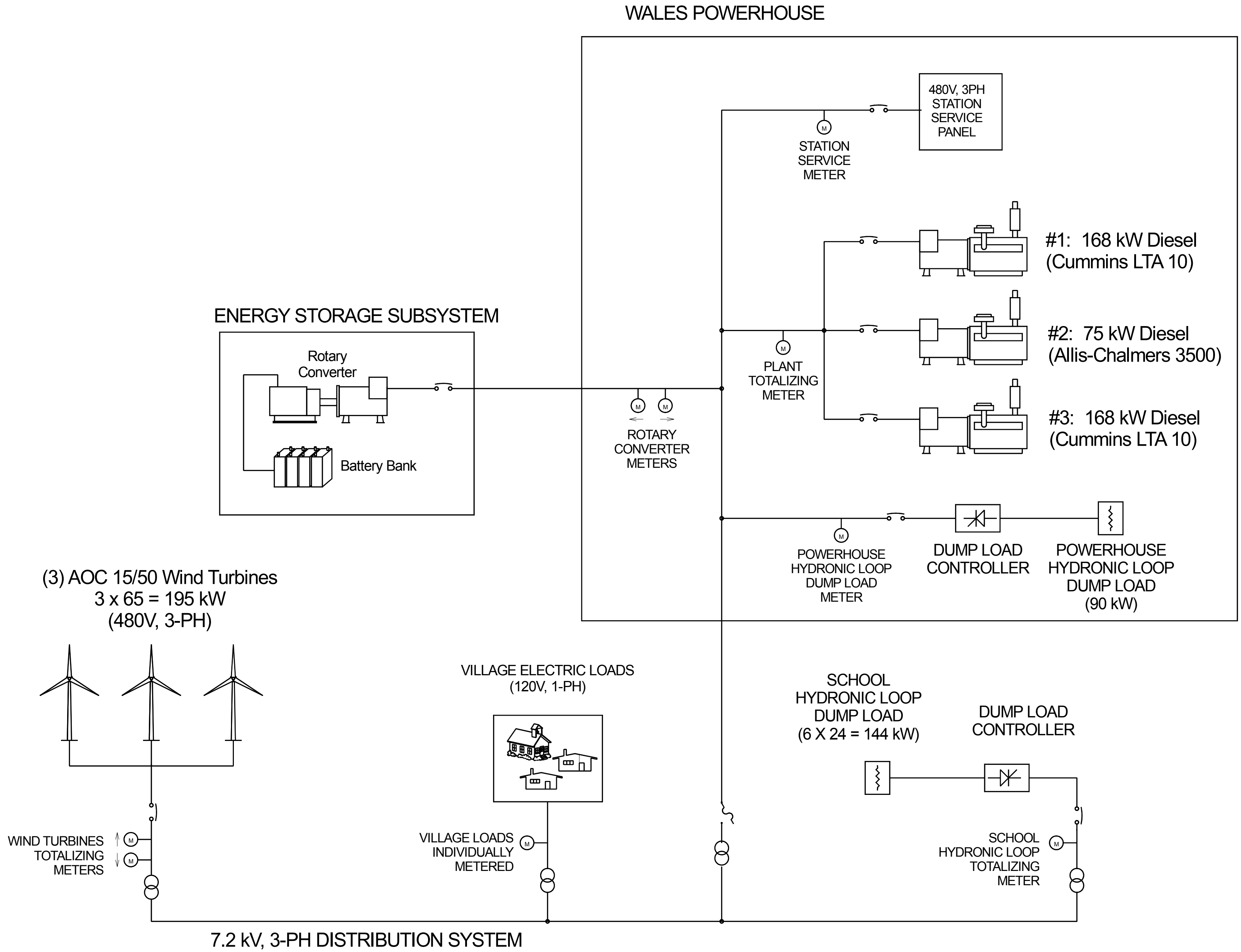
WDCP TO RCCC CONNECTIONS

S. DROUILHET

3/19/01 REV. 2




WALES WIND-DIESEL SYSTEM
CONTROL COMMUNICATION DIAGRAM
REV. 3 5/29/01
S. DROUILHET
control3.skf
WALES POWERHOUSE
DIESEL GENERATOR CONTROL PANEL
DIESEL PLANT
HYDRONIC LOOP
DUMP LOAD CONTROLLER
ANALOG SIGNALS
SHIELDED TWISTED PAIRS
(4-20 mA)
DISCRETE CONTROL SIGNALS
(24VDC, 120VAC)
SLICE I/O NETWORK
TWISTED PAIR
SLICE PROTOCOL
614 KBAUD
AOC 15/50
TURBINE CONTROLLER
(PLC MODEL 250)
PLC-PLC NETWORK
VIA RADIO MODEM
MODBUS PROTOCOL
9600 BAUD
WIND-DIESEL
HYBRID POWER SYSTEM
MAIN CONTROL PANEL
(PLC MODEL 450)
PLC-PLC NETWORK
ETHERNET
FIBER OPTIC LINK
WIND-DIESEL
HYBRID POWER SYSTEM
ROTARY CONVERTER
CONTROL CABINET
(PLC MODEL 450)
AOC 15/50
TURBINE CONTROLLER
(PLC MODEL 250)
PHONE CONNECTION
FOR DIRECTSOFT LINK
PHONE CONNECTION
FOR DATA REPORTING
REMOTE I/O NETWORK
VIA RADIO MODEM
RM-NET PROTOCOL
38.4K BAUD
SCHOOL HYDRONIC LOOP
DUMP LOAD CONTROLLER
(REMOTE I/O SLAVE)



WALES POWERHOUSE
480V, 3PH STATION SERVICE PANEL
STATION SERVICE METER
#1: 168 kW Diesel (Cummins LTA 10)
#2: 75 kW Diesel (Allis-Chalmers 3500)
#3: 168 kW Diesel (Cummins LTA 10)
PLANT TOTALIZING METER
ENERGY STORAGE SUBSYSTEM
Rotary Converter
Battery Bank
ROTARY CONVERTER METERS
POWERHOUSE HYDRONIC LOOP DUMP LOAD METER
DUMP LOAD CONTROLLER
POWERHOUSE HYDRONIC LOOP DUMP LOAD (90 kW)
(3) AOC 15/50 Wind Turbines
3 x 65 = 195 kW
(480V, 3-PH)
VILLAGE ELECTRIC LOADS
(120V, 1-PH)
SCHOOL HYDRONIC LOOP DUMP LOAD
(6 X 24 = 144 kW)
DUMP LOAD CONTROLLER
WIND TURBINES TOTALIZING METERS
VILLAGE LOADS INDIVIDUALLY METERED
SCHOOL HYDRONIC LOOP TOTALIZING METER
7.2 kV, 3-PH DISTRIBUTION SYSTEM

PARTS LIST FOR ROTARY CONVERTER CONTROL CABINET (DWG. #NWTC-SD-0001)					REV. 19 10/25/01	
ITEM NUMBER	KEY	ITEM DESCRIPTION	QTY	MANUFACTURER	CATALOG NO.	REVISED SINCE LAST REVISION
1	SW-1	EMERGENCY STOP BUTTON, THREE N.C. CONTACTS, WITH GUARD	1	ALLEN BRADLEY	800T-FXT6D4 AND 800T-N310 (GUARD)	
2	VSD-1	VARIABLE SPEED MOTOR DRIVE, "ALTIVAR 18", 460VAC 3-PHASE SUPPLY POWER, 20 HP RATING	1	SQUARE D	ATV18D23N4U	
3	GPR-1	GENERATOR PROTECTIVE RELAY, PARALLELED, 3PH OVERCURRENT, PHASE BALANCE,REACTIVE CURRENT, SYNC-CHECK	1	BASLER ELECTRIC	BE3-GPR-P-1-B-V-S	
4	PS-3	POWER SUPPLY, 24 VDC,2.4A, REGULATED OUTPUT, 120VAC INPUT	1	INTERNATIONAL POWER	IHC24-2.4	
5	VR-1	VOLTAGE REGULATOR, WITH SPIKE SUPPRESSION MODULE	1	BASLER ELECTRIC	SSR63-12	
6	WRN-1	SONALERT SIGNAL, 2900 HZ., 120VAC, PANEL MOUNT	1	MALLORY	SC110	
7	FU-3	FUSE, 600 V, 1 AMP, FAST ACTING, 13/32" X 1.5"	11	BUSSMAN	KTK-1	
8		ELECTRICAL ENCLOSURE, HEAVY DUTY, MULTI-DOOR, WITH BACKPANEL, 82H X 80W X 18D (NON-STANDARD HEIGHT)	1	CONTROL ENGINEERING CO	12MHDRH-082-080-018-DDUF	
9		LOUVER KIT, 8" X 8"	6	CONTROL ENGINEERING CO	35336	
10	FB-2,3	FUSE HOLDER TERMINAL BLOCK,	34	ENTRELEC	M4/8.SF-115 657.25	
11	FB-4,5,6,7,8	FUSE HOLDER TERMINAL BLOCK, 13/32" X 1.5"	22	ENTRELEC	MB 10/22.SF - 116.302.23	
12	SA-2	RS-485 SURGE PROTECTOR	1	ENTRELEC	PU4-200	
13	TB-1,2,3,4	TERMINAL BLOCK, 600 V RATED, #22-#8 AWG RANGE	118	ENTRELEC	M6/8 #115 118.11	
14	TB-5	TERMINAL BLOCK, THERMOCOUPLE	16	ENTRELEC	MTC6 #115 206.22	
15		DIN RAIL, 35 X 7.5 X1, TYPE PR30	1	ENTRELEC	173 220.05	
16		END STOPS, TERMINAL BLOCK	A/R	ENTRELEC	114 588.10	
17		END SECTIONS, TERMINAL BLOCK	A/R	ENTRELEC	118 368.16	
18		CIRCUIT SEPARATORS,TERMINAL	A/R	ENTRELEC	114.825.05	
19		JUMPER BARS, TERMINAL BLOCK	A/R	ENTRELEC	A/N	
20		TOP MARKER STRIPS, TERMINAL BLOCK	A/R	ENTRELEC	A/N	
21	FU-4	FUSE, 250 V, 1/4 AMP, SLO-BLO, 5X20MM	6	LITTELFUSE BUSS	239.250 GMD-250MA	
22	FU-6	FUSE, 250 V, 1/2 AMP, SLO-BLO, 5X20MM, 250V	4	LITTELFUSE BUSS	239.500 GMD-500MA	
23	FU-16	FUSE, 1.5A, TIME DELAY, 250V, 13/32" X 1.5"	1	BUSSMAN	FNM-1.5	
24	FU-8	FUSE, 1A, SLO-BLO, 5X20MM	4	LITTELFUSE BUSS	239.001 GMD-1A	
25	FU-9	FUSE, 40MA, FAST-ACTING, 5X20 MM, 250V	10	LITTELFUSE BUSS	217.040 GDB-40MA	
26	SA-1	SURGE PROTECTOR-480V,3 PH, 4 W	1	MCG SURGE PROTECTION	SPA-277Y	
27	L-1	LINE REACTOR, 8 A, 5 mH	1	MTE CORPORATION	RL-00803	
28	L-2	DC LINK CHOKE, 32A, 2.7 mH	1	MTE CORPORATION	32RB003	
29	L-3	LINE REACTOR, 55 A, 0.05 mH, NEMA 1 ENCLOSURE	1	MTE CORPORATION	RL-05512	
30	CT-1,2	CURRENT TRANSFORMER, METERING CLASS, 250:5	2	OHIO SEMITRONICS	12976	
31	CT-3	HALL EFFECT CURRENT SENSOR	1	OHIO SEMITRONICS	CTF-500TT	
32	CT-4	CURRENT TRANSFORMER, 250:5	2	OHIO SEMITRONICS	12271	
33	CX-1	CURRENT SIGNAL CONDITIONER, CALIBRATED WITH CTF-500TT, 4MA=-500 ADC,20MA=+500ADC	1	OHIO SEMITRONICS	CTA800-E-Y-03	
34	VT-1	VOLTAGE TRANSDUCER, 0-400VDC, 4-20MA OUTPUT	1	OHIO SEMITRONICS	VT7-008E	
35	VT-2	VOLTAGE TRANSDUCER, 0-600VAC, 4-20MA OUTPUT	1	OHIO SEMITRONICS	VT-3940E	

ITEM NUMBER	KEY	ITEM DESCRIPTION	QTY	MANUFACTURER	CATALOG NO.	REVISED SINCE LAST REVISION
36	WT-1	WATT/VAR TRANSDUCER, 0-600V, 3-PHASE, 4-WIRE, 4-12-20 MA OUTPUT, CALIBRATED WITH 250:5 CURRENT TRANSFORMERS: 4MA = -200 KW/KVAR, 12MA = 0 KW/KVAR, 20MA = +200 KW/KVAR	1	OHIO SEMITRONICS	GWV5-006E-Y	
37		PLASTIC WIRING DUCT, 2"W X 4"H	A/R	PANDUIT	E2X4LG6	
38	PS-1	DC OUTPUT POWER SUPPLY, 3-PHASE, 480 VAC INPUT, 0-520 VDC OUTPUT, 10 AMP, VOLTAGE LIMIT, 1-5 VDC CONTROL INPUT	1	PAYNE ENGINEERING	MODEL 36E-4-10-9-11F	
39	PS-2	DC OUTPUT POWER SUPPLY, 3-PHASE, 480 VAC INPUT, 0-520 VDC OUTPUT, 30 AMP, CURRENT LIMIT, 2-10 VDC OPTO-ISOLATED CONTROL INPUT	1	PAYNE ENGINEERING	MODEL 36E-4-30-12-20G	
40	PLC-3	PLC CPU	1	PLC DIRECT	D4-450	
41	PLC-4	PLC EXPANSION UNIT	1	PLC DIRECT	D4-EX	
42		PLC I/0 BASE, 8-SLOT	2	PLC DIRECT	D4-08B-1	
43		ANALOG INPUT MODULE	1	PLC DIRECT	F4-08AD	**X**
44		ANALOG OUTPUT MODULE	1	PLC DIRECT	F4-04DA	
45		DIGITAL INPUT MODULE, 12-14 VAC/DC	1	PLC DIRECT	D4-16NE3	
46		RELAY OUTPUT MODULE, 8 PT.	3	PLC DIRECT	F4-08TRS-2	
47		ETHERNET MODULE, FIBER OPTIC	1	PLC DIRECT	H4-ECOM-F	
48		THERMOCOUPLE INPUT MODULE, J-	1	PLC DIRECT	F4-08THM-J	
49		SLICE I/O MASTER MODULE	1	PLC DIRECT	D4-SM	
50	CB-1	MAGNETIC BREAKER, 250A, 600VAC, 1250-2500A TRIP RANGE, 1A/1B AUXILIARY CONTACTS, 1B ALARM CONTACTS	1	SQUARE D	KAL3625032M-1212-2103	
51	CPT-1	CONTROL POWER TRANSFORMER, 250 VA, 240/480 V PRIMARY, 120 VOLT SECONDARY	1	SQUARE D	9070-TF250D1	
52	CPT-2	CONTROL POWER TRANSFORMER, 100 VA, 240/480 V PRIMARY, 24 VOLT SECONDARY	1	SQUARE D	9070-TF100D2	
53	CPT-3	CONTROL POWER TRANSFORMER, 150 VA, 240/480 V PRIMARY, 120 VOLT SECONDARY	1	SQUARE D	9070-TF150D1	
54	CR-5	CONTROL RELAY, 3-POLE, 3 NO CONTACTS, 120VAC COIL	1	SQUARE D	8501-XO30-V02	
55		UNIVERSAL HANDLE AND OPERATING MECHANISM	1	SQUARE D	9422-ARP11	
56	GB-1	EQUIPMENT GROUND BAR	1	SQUARE D OR EQUIVALENT	PK18GTA	
57	CR-1	CONTACTOR, 250A, 480VAC, 3PH, IEC STYLE, 120VAC COIL	1	TELEMECANIQUE (SQUARE D)	LC1F265-G7	
58	CR-2	CONTACTOR, 500A, 480VDC RATED, 2P, IEC STYLE, 120VAC COIL	1	TELEMECANIQUE (SQUARE D)	LC1F5002-F7	
59	CR-3	CONTROL RELAY, 4 NO CONTACTS, 120VAC COIL	1	TELEMECANIQUE (SQUARE D)	CA2KN40F7	
60	CR-4	25A, 480VDC RATED, 3P, IEC STYLE CONTACTOR, 120 VAC COIL	1	TELEMECANIQUE (SQUARE D)	LC1D2510-G6	
61	OL-2	OVERLOAD RELAY	1	TELEMECANIQUE (SQUARE D)	LR2D13	
62		AUXILIARY CONTACT BLOCK FOR LC1F CONTACTOR, 2 N.O.	1	TELEMECANIQUE (SQUARE D)	LA1DN20	
63	OL-1	OVERLOAD RELAY, SOLID STATE, 132-220A, CLASS 10	1	TELEMECANIQUE (SQUARE D)	LR9F5371	
64		LUG KIT	1	TELEMECANIQUE (SQUARE D)	DZ2FH6	
65		OVERLOAD RELAY MOUNTING PLATE	1	TELEMECANIQUE (SQUARE D)	LA7F901	
66	OI-1	TOUCHSCREEN OPERATOR INTERFACE, 6" SCREEN, 24VDC, STN COLOR	1	TOTAL CONTROL PRODUCTS	ABK-2D100-S2P/SER	

ITEM NUMBER	KEY	ITEM DESCRIPTION	QTY	MANUFACTURER	CATALOG NO.	REVISED SINCE LAST REVISION
67	SC-1	701A DIGITAL SPEED CONTROL, HIGH VOLTAGE POWER SUPPLY	1	WOODWARD GOVERNOR	8280-182	
68	FB-1	FUSE HOLDER TERMINAL BLOCK, 5X20MM, DOUBLE DECK	16	ENTRELEC	M4/8.D2.SF-115.604.21	
69	PDB-1	POWER DISTRIBUTION BLOCK, (1) #6-350MCM MAIN, (1) #6-350MCM SECONDARY, ONE POLE	1	SQUARE D	LBA163101	
70	PDB-2	POWER DISTRIBUTION BLOCK, (2) #4-350MCM MAIN, (2) #4-350MCM SECONDARY, ONE POLE	1	SQUARE D	LBA165202	
71		SHIELDING CONNECTOR FOR ITEM 68	16	ENTRELEC	CBD2S - 178 408.14	
72	CR-6	CONTROL RELAY, PLUG-IN, MINIATURE, 3PDT, 24VAC COIL, 10A CONTACT RATING	1	SQUARE D	8501-RS43-V14	
73	CR-7,8	CONTROL RELAY, PLUG-IN, MINIATURE, 2PDT, 120VAC COIL, 10A CONTACT RATING	2	SQUARE D	8501-RS42-V20	
74		INTERFACE CABLE	1	TOTAL CONTROL PRODUCTS	HMI-CAB-C86	
75		EXPANSION CABLE, PLC	1	PLC DIRECT	D4-EXCBL-2	
76	CX-2	DC CURRENT TRANSDUCER, 0-10 A INPUT, 4-20 MA OUTPUT	1	OHIO SEMITRONICS	CT7-015E	
77	CR-9	CONTACTOR, 6A, 480VAC, 3PH, IEC STYLE, 120VAC COIL	1	SQUARE D	LC1K060F7	
78	FU-1	FUSE, 1.6A, 500V, TIME DELAY, 13/32"X1.5"	4	BUSSMAN	FNQ-1.6	
79	PDB-3	POWER DISTRIBUTION BLOCK, (1) #14-2/0 MAIN, (8) #14-6 SECONDARY, THREE POLE	1	GOULD	67093	
80		BASE EXPANSION CABLE	1	PLC DIRECT	D4-EXCBL-2	
81	R-1	POWER RESISTOR, 75 OHM, 100 WATT	1	OHMITE	L100J75R	
82	FU-10	FUSE, 0.25A, FAST-ACTING, 250V,5X20MM	15	BUSSMAN LITTELFUSE	GMA-250MA 235.25	
83	FU-11	FUSE, 12A, TIME DELAY, 500V, 13/32" X 1.5"	3	BUSSMAN	FNQ-12	
84	OL-3	OVERLOAD RELAY, 0.8-1.2A, CLASS 10	1	SQUARE D	LR2K0306	
85	FU-12	FUSE, 0.25A, TIME DELAY, 600V, 13/32" X 1.5"	1	BUSSMAN	FNQ-R-1/4	
86	FU-13	FUSE, 4A, TIME DELAY, 250V	1	BUSSMAN	FNM-4	
87	FU-14	FUSE, 0.5A, TIME DELAY, 500V, 13/32" X 1.5", REJECTION BASE	6	BUSSMAN	FNQ-R-1/2	
88	FU-15	FUSE, 2A, TIME DELAY, 250V, 13/32" X 1.5"	1	BUSSMAN	FNM-2	
89	FB-9,10	FUSE BLOCK, 3-POLE, J-TYPE	2	BUSSMAN	J60060-3CR	
90	FB-11	FUSE BLOCK, 2-POLE, H-TYPE	1	BUSSMAN	H60060-2CR	
91	L-4	LINE REACTOR, 25 A, 2.0 mH	1	MTE CORPORATION	RL-02503	
92	L-5	LINE REACTOR, 25 A, 2.0 mH, NEMA1 ENCLOSURE	1	MTE CORPORATION	RL-02513	
93	CT-5	HALL EFFECT CURRENT SENSOR	1	OHIO SEMITRONICS	CTL-50T	
94	CX-3	CURRENT SIGNAL CONDITIONER, 120VAC SUPPLY POWER, CALIBRATED WITH CTL-50T, 4MA=0 ADC,20MA=+50ADC	1	OHIO SEMITRONICS	CTA-215	
95	FU-2	FUSE, 40A, TIME DELAY, 500V	6	BUSSMAN	LPJ-40SP	
96	FU-5	FUSE, 35A, TIME DELAY, 500V, CURRENT-LIMITING	2	BUSSMAN	LPS-RK35SP	
97	AR-4	GROUND FAULT MONITOR, FOR AC GROUNDED SYSTEMS, INTEGRAL CURRENT TRANSFORMER, 1 SPDT ALARM RELAY, 120 VAC SUPPLY POWER	1	BENDER	RCM465-13	

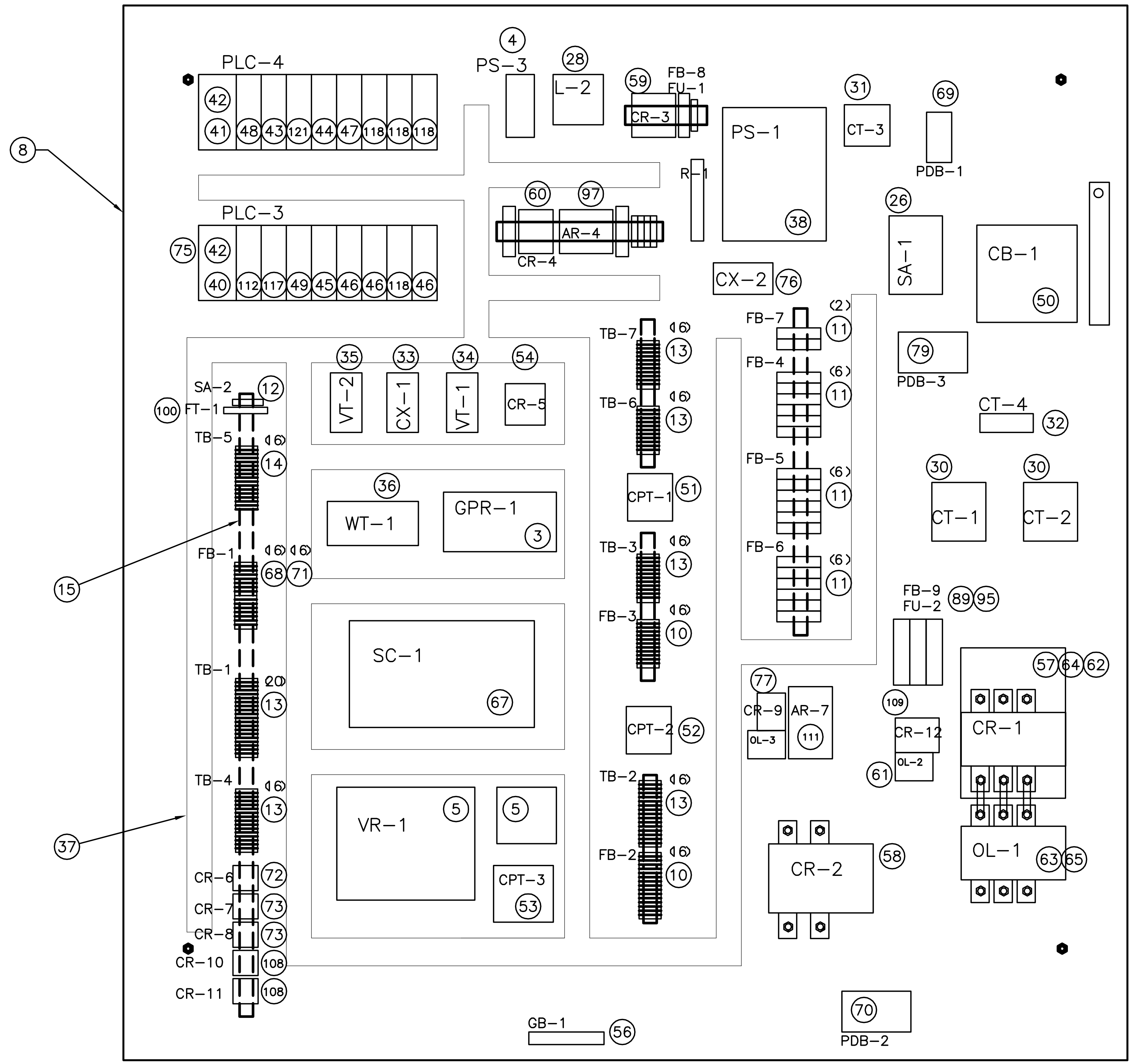
ITEM NUMBER	KEY	ITEM DESCRIPTION	QTY	MANUFACTURER	CATALOG NO.	REVISED SINCE LAST REVISION
98	AR-5	GROUND FAULT MONITOR, FOR AC OR DC UNGROUNDED SYSTEMS, 2 SPDT ALARM RELAYS, 120 VAC SUPPLY	1	BENDER	IR475LY-413	
99	AR-1,2,3,6	ALARM RELAY, CURRENT/VOLTAGE INPUT, 2 SPDT RELAY OUTPUTS, 24 VDC SUPPLY POWER	4	ACTION INSTRUMENTS	G108-0001	
100	FT-1,2	INPUT, 0-20 MA OUTPUT, 24 VDC SUPPLY POWER	2	ACTION INSTRUMENTS	G478-0001	
101	IL-1	INDICATOR LAMP BASE, 1" MOUNTING HOLE, FOR S-6 SCREW BASE BULB	1	NEWARK ELECTRONICS	45F606	
102		AMBER LENS, INDICATOR LAMP	1	NEWARK ELECTRONICS	50F6060	
103		LAMP, 6W, 120VAC, INCANDESCENT, S-6 SCREW BASE	1	NEWARK ELECTRONICS	96F5796	
104		RESISTOR MOUNTING BRACKET	2	NEWARK ELECTRONICS	13F099	
105	DVM-1	DIGITAL DISPLAY, +/- 300 VDC INPUT, 120VAC SUPPLY POWER	1	RED LION CONTROLS	APLVD400	
106	SW-2	TOGGLE SWITCH, SEALED, 2 POLE, 3 POSITION, (ON)-ON-(ON), MOMENTARY ACTION, SCREW TERMINALS	1	HONEYWELL	2TL1-70	
107	FU-17	FUSE, 2A, FAST ACTING, 250V, 5 X 20 MM	1	BUSSMAN	GMA-2	
108	CR-10,11	CONTROL RELAY, PLUG-IN, MINIATURE, 3PDT, 120VAC COIL, 10A CONTACT RATING	2	SQUARE D	8501-RS43-V20	
109	CR-12	32A, 480VDC RATED, 3P, IEC STYLE CONTACTOR, 120 VAC COIL	1	TELEMECANIQUE (SQUARE D)	LC1D3210-G6	
110	OL-4	OVERLOAD RELAY, 17-25A, CLASS 10	1	SQUARE D	LR2D1322	
111	AR-7	ALARM RELAY, VOLTAGE INPUT, 2 SPDT RELAY OUTPUTS, 120 VAC SUPPLY POWER	1	ACTION INSTRUMENTS	AP1090	
112		ANALOG OUTPUT MODULE, 16 CHANNEL	1	PLC DIRECT	F4-16DA-2	
113	PS-4	POWER SUPPLY, SWITCHING, 12VDC/2A OUTPUT, 120VAC INPUT	1	ENTRELEC	2.423.418.10	
114	DAQ-1	DATA ACQUISITION INTERFACE FOR PC PARALLEL PORT	1	NATIONAL INSTRUMENTS	DAQPAD-M1O-16XE-50 DAQPAD-TB-52	
115	MDM-1	RADIO MODEM	1	UC WIRELESS	ISM900-4C297	
116		SURGE ARRESTOR, ANTENNA	1	POLYPHASER	IS-50NX-C2	
117		REMOTE I/O MASTER MODULE	1	PLC DIRECT	D4-RM	
118		PLC FILLER MODULE	4	PLC DIRECT	D4-FILL	
119	R-2	RESISTOR, POWER, 2.5KOHM, 5W	1			
120	C-1	CAPACITOR, MOTOR RUN, 1.0 uF, 600 VAC	1			
121		ANALOG INPUT MODULE, 4 CHANNEL, ISOLATED	1	PLC DIRECT	F4-04ADS	**X**
122						
123						
124						

NOTES:

1. ITEMS 113, 114, 115, 119, AND 120 ARE MOUNTED ON THE LEFT WALL OF THE CABINET, NOT ON THE BACK PANEL.

2. ITEM 98 MOUNTED ON BACK OF RIGHT DOOR.

2. FOR PART DESCRIPTIONS, SEE SEPARATE PARTS LIST.



No.	Date	Description	By
5	10/25/01	CHANGED PLC-4/2.	SD
4	8/15/01	REVISED PLC MODULE DETAILS	SMD
3	11/18/98	ADDED CR-6,7,8,9 AND PDB-3	SMD
2	4/10/98	CHANGED QUANTITY OF ITEM 46 TO (3).	SMD
1	3/11/98	ADDED CX-2 (ITEM 75)	SMD

Revisions

Drawn By S. DROUILHET
Date
Engineer
Checked By S.DROUILHET
Approved By

National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401
Operated for the U.S. Department of Energy by Midwest Research Institute

Sheet Title

WIND DIESEL POWER SYSTEM
ROTARY CONVERTER CONTROL CABINET
BACK PANEL LAYOUT

Work Request Number

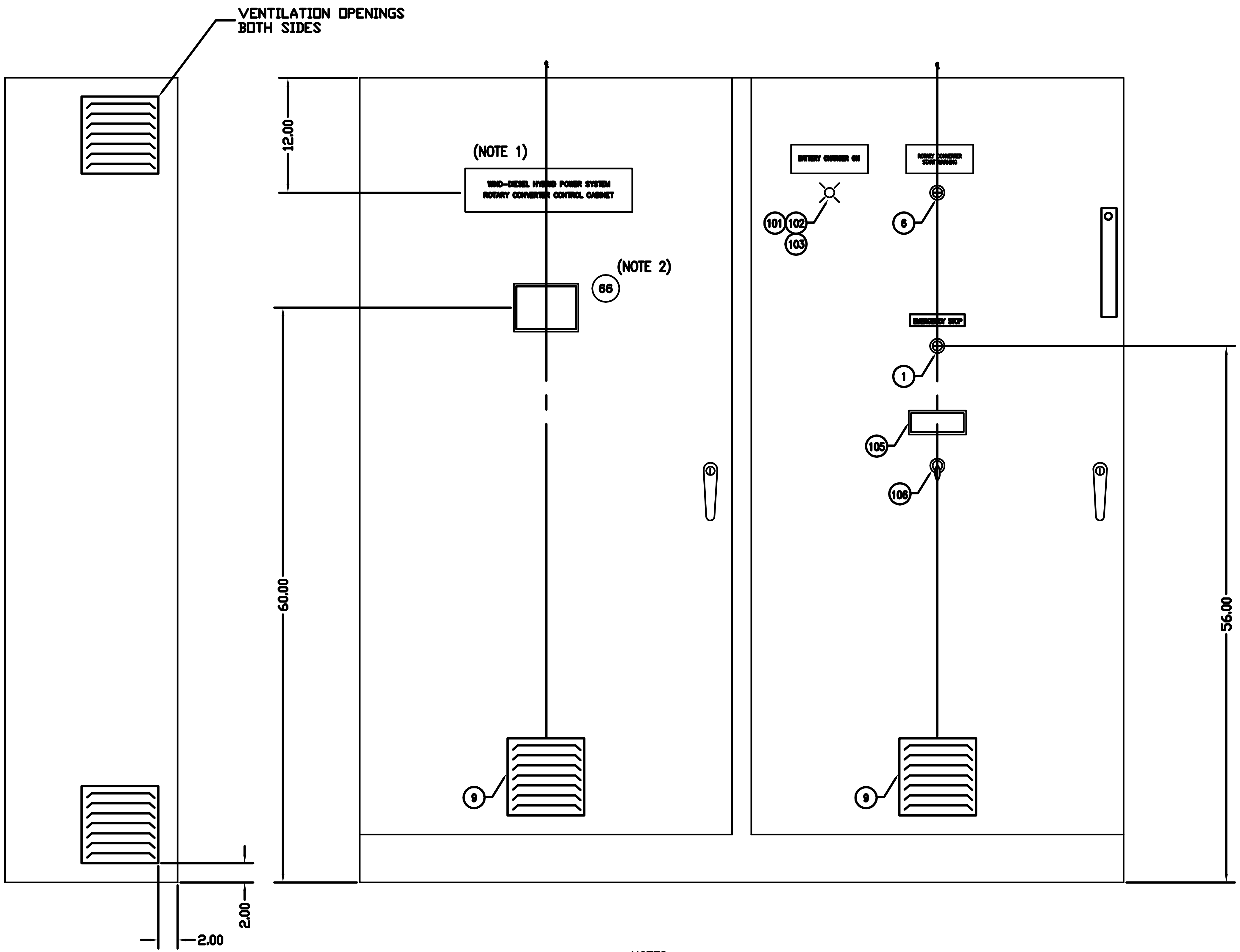
Drawing Number NWTC-SD-0001

Sheet Number 2 OF 2

Sequence Number REV. 5

FORM: ZBD2234D.DWG-0

PLOT SCALE: 1=1 STATION:
PLOT INFO: TIME:
FILE NAME: AUTOCAD VERSION: DATE: INITIALS:



NOTES:

1. FURNISH AND INSTALL PHENOLIC NAMEPLATE WITH TEXT AS SHOWN. MINIMUM TEXT HEIGHT 1/2"

2. FOR PART DESCRIPTIONS, SEE SEPARATE PARTS LIST.

No.	Date	Description	By
3	8/13/01	ADDED ITEMS 103, 105, AND 106	SD
2	5/16/00	ADDED INDICATOR LAMP	SD
1	3/11/98	CHANGED NOTE 2.	SMD

Revisions

Drawn By S. DROUILHET
Date
Engineer
Checked By S.DROUILHET 2/4/98
Approved By

National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401
Operated for the
U.S. Department of Energy
by Midwest Research Institute

Sheet Title

WIND-DIESEL POWER SYSTEM
ROTARY CONVERTER CONTROL CABINET
FRONT PANEL LAYOUT

Work Request Number

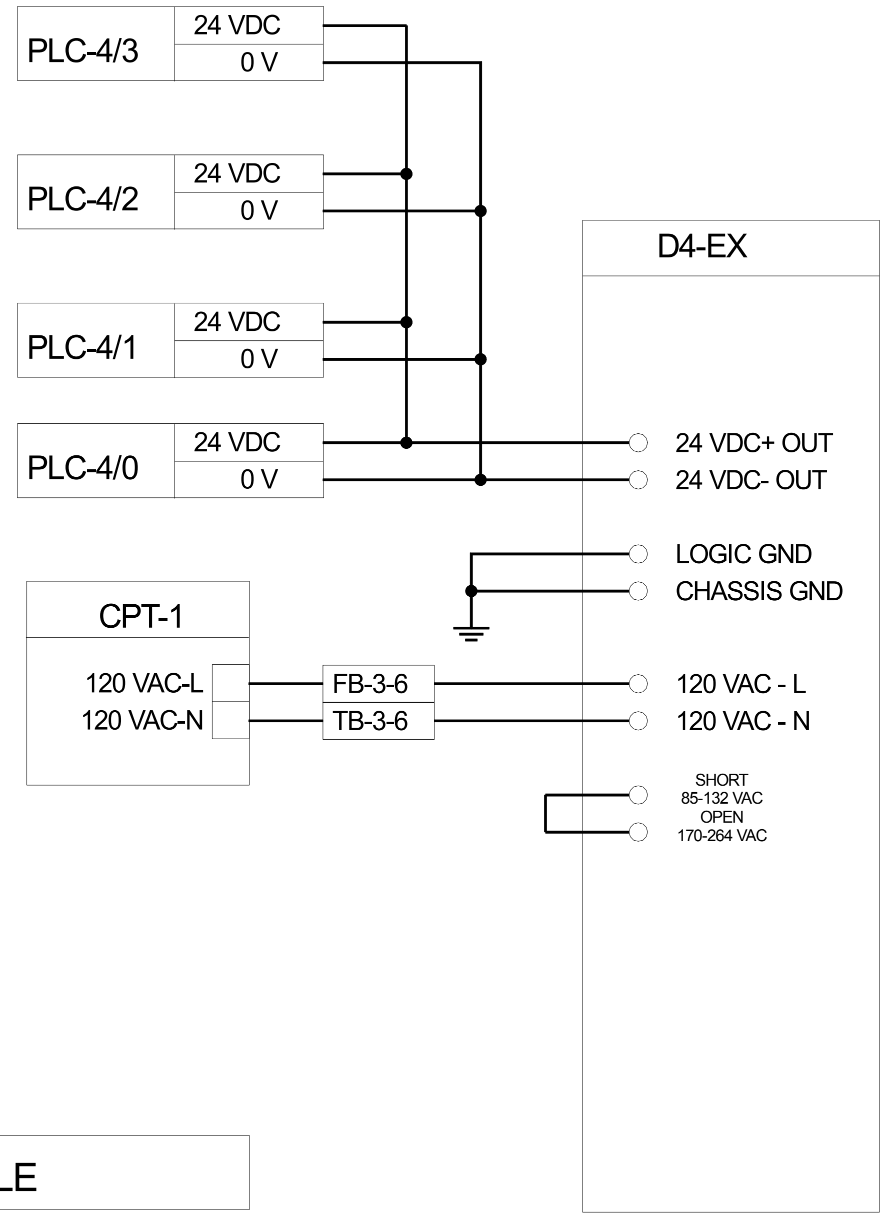
Drawing Number NWTC-SD-0001

Sheet Number 1 OF 2

Sequence Number REV. 3

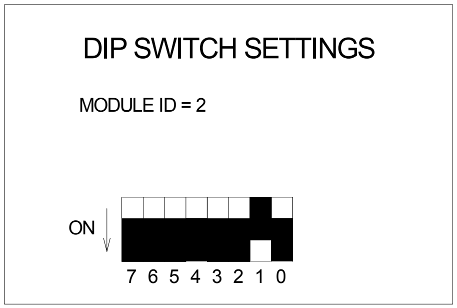
FORM: ZBD2234D.DWG-0

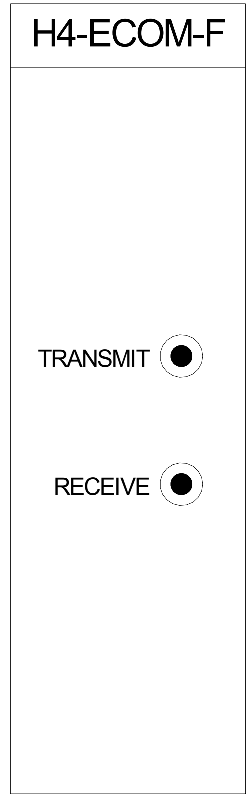
PLOT SCALE: 1=1
STATION: .
PLOT INFO TIME: .
FILE NAME:
AUTOCAD VERSION: DATE: .
INITIALS:



PLC-4/CPU	EXPANSION MODULE

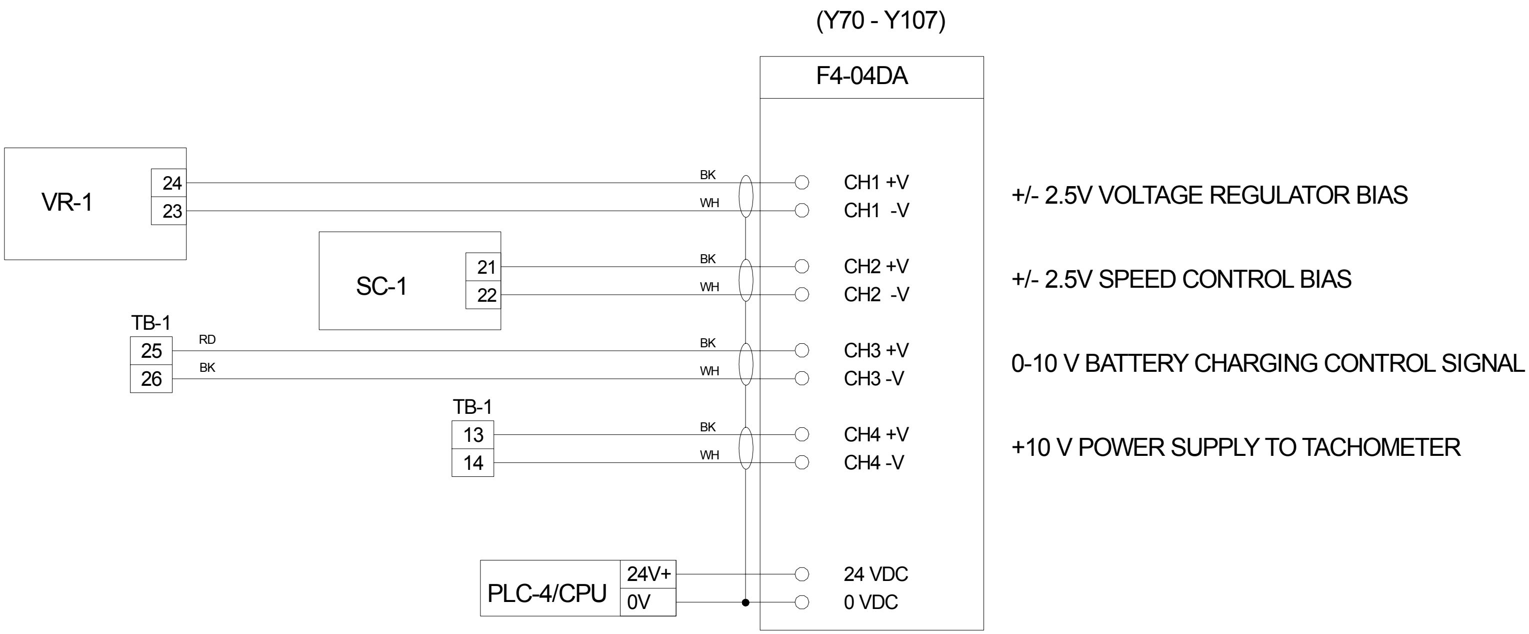
REV. 3 5/25/99



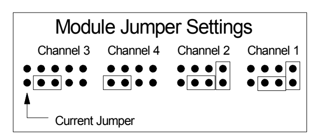


PLC-4/4	ETHERNET MODULE (RCCC TO WDCP LINK)

REV. 0 2/17/00

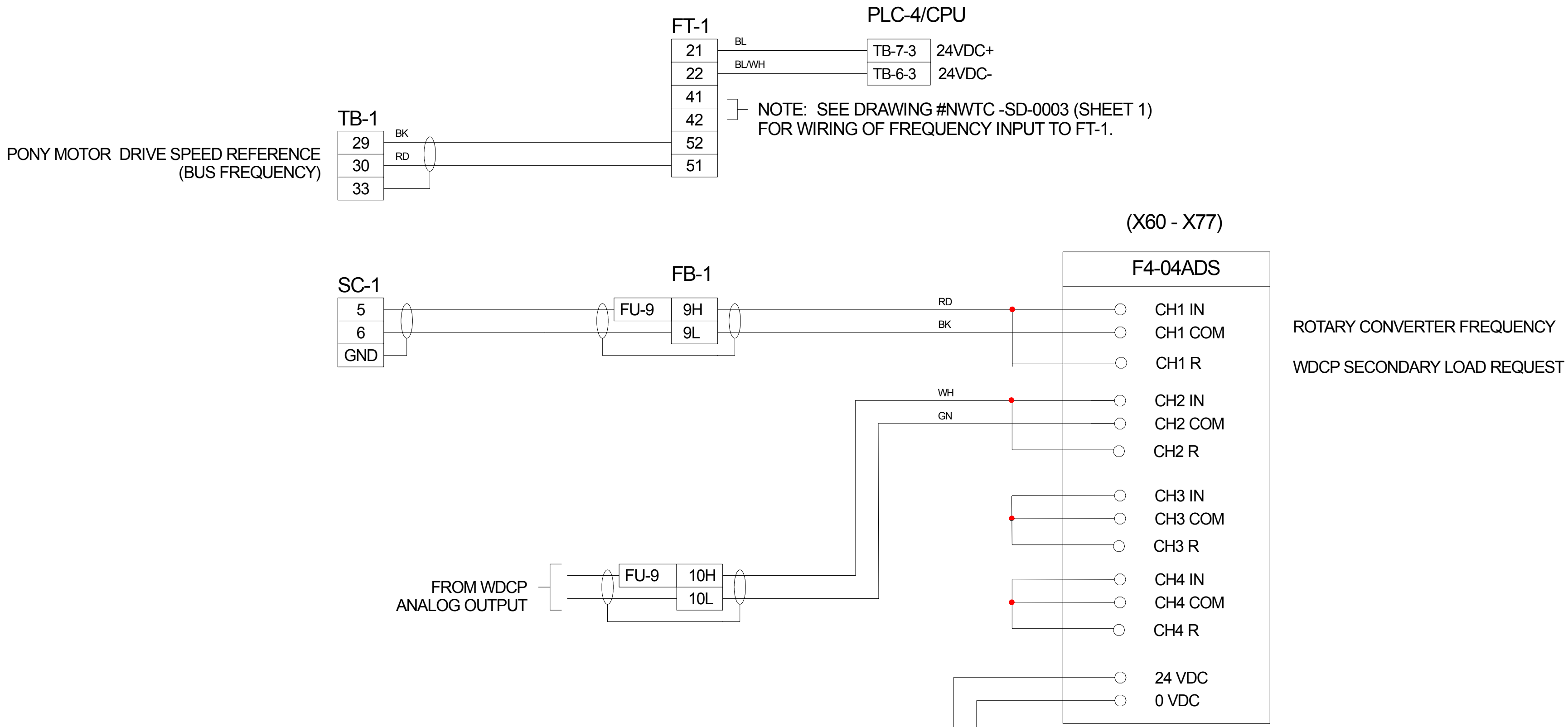


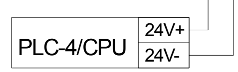
NOTES
1. Connect shields to the 0 V of the module or the 0 V of the power supply
2. Unused voltage and current inputs should remain open (no connections)



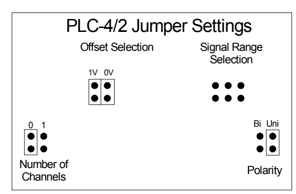
PLC-4/3	ANALOG OUTPUTS

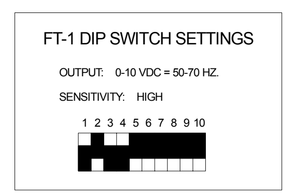
REV. 4 3/19/01





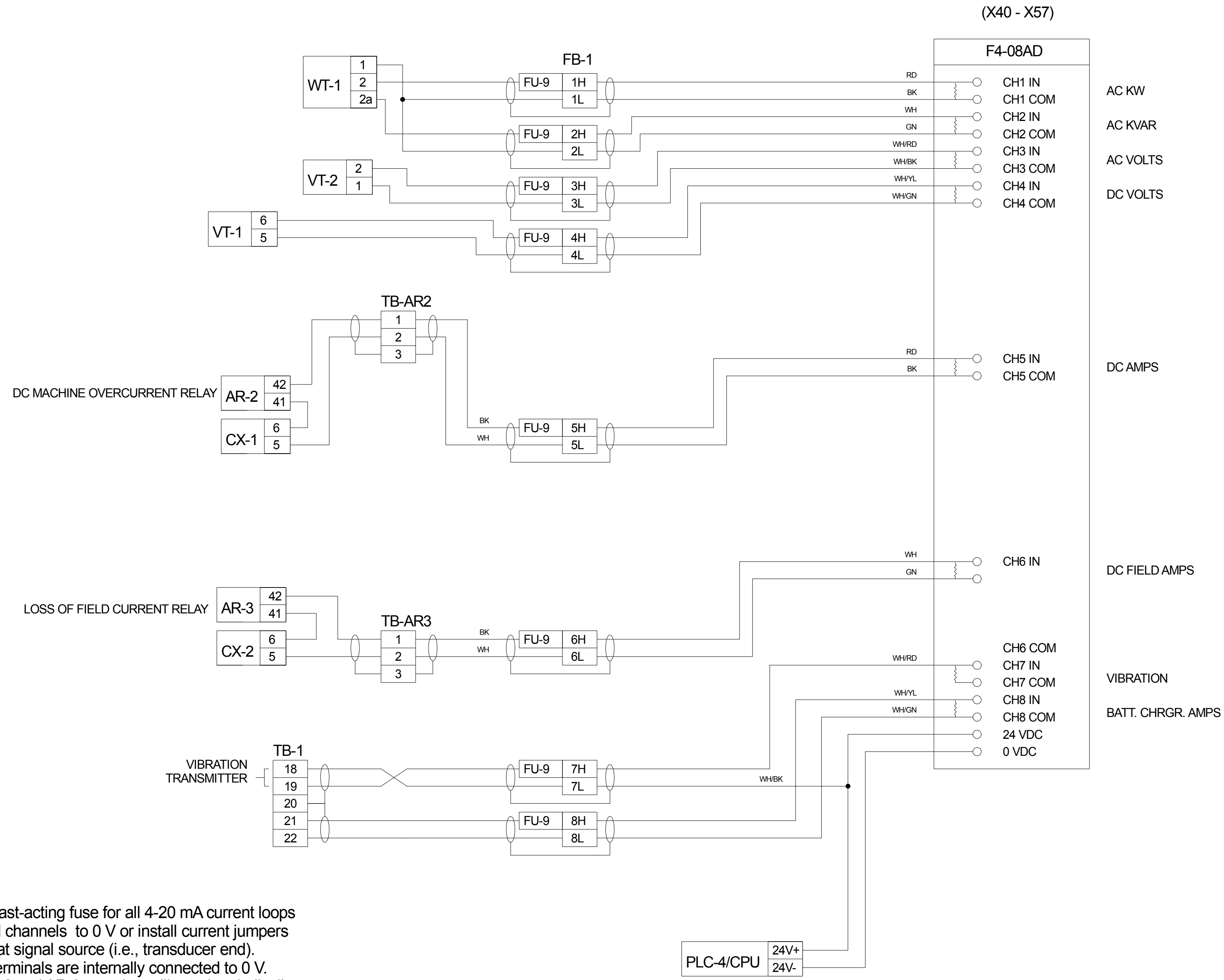
NOTES
1. Use a 0.040 A, fast-acting fuse for all 4-20 mA current loops
2. Jumper +V to COM on unused channels.
3. Ground shields at signal source (i.e., transducer end).
4. Frequency transducer FT-1 must be calibrated periodically (and after replacement) using a precision frequency generator. Adjust sensitivity per manufacturer's instructions.
6. All analog modules in PLC-4 derive 24 VDC supply power from PLC-4/CPU.





PLC-4/2	ANALOG INPUTS

REV. 7 10/25/01

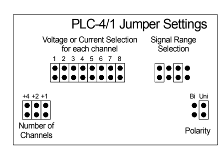


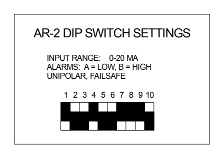
NOTES

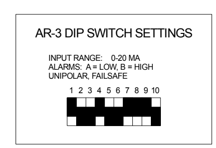
1. Use a 0.040 A, fast-acting fuse for all 4-20 mA current loops
2. Connect unused channels to 0 V or install current jumpers
3. Ground shields at signal source (i.e., transducer end).
4. All COMMON terminals are internally connected to 0 V.
5. Alarm relays AR-2 and AR-3 must be calibrated periodically (and after replacement) using a precision milli-amp source.

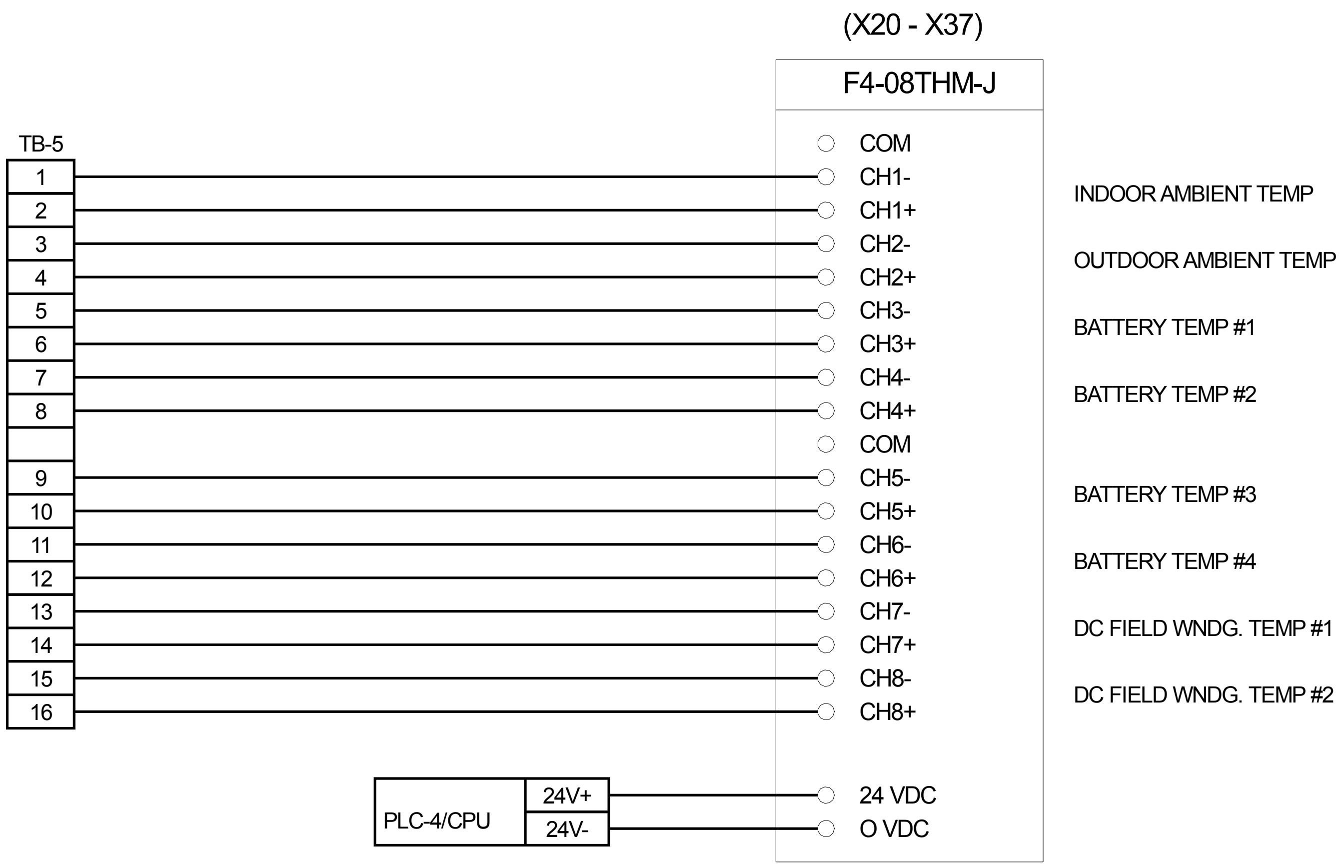
PLC-4/1	ANALOG INPUTS

REV. 9 3/19/01

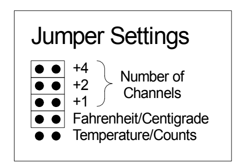






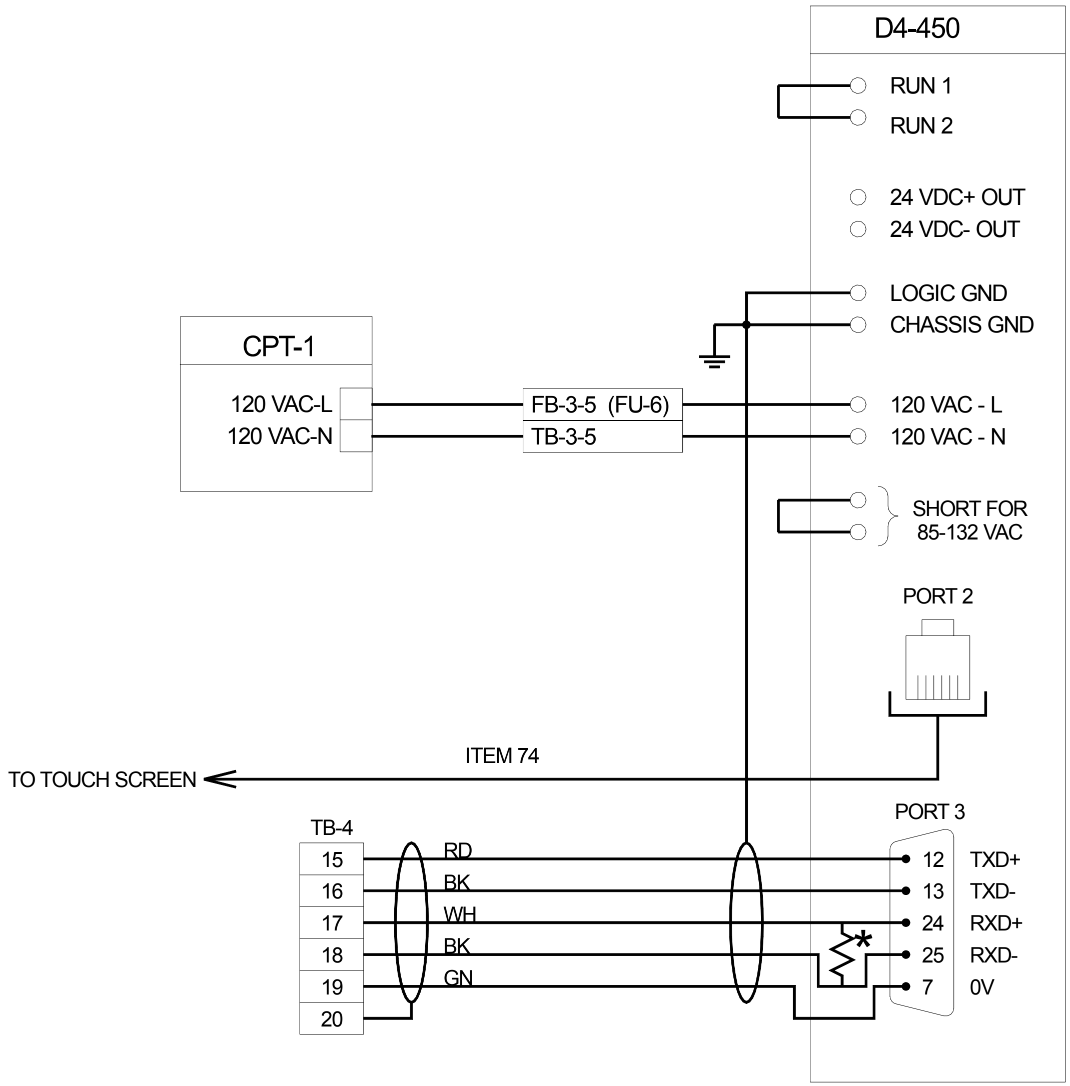


NOTES
1. Terminate shields at the respective signal source
2. Leave unused channels open (no connection)



PLC-4/0	THERMOCOUPLE INPUTS

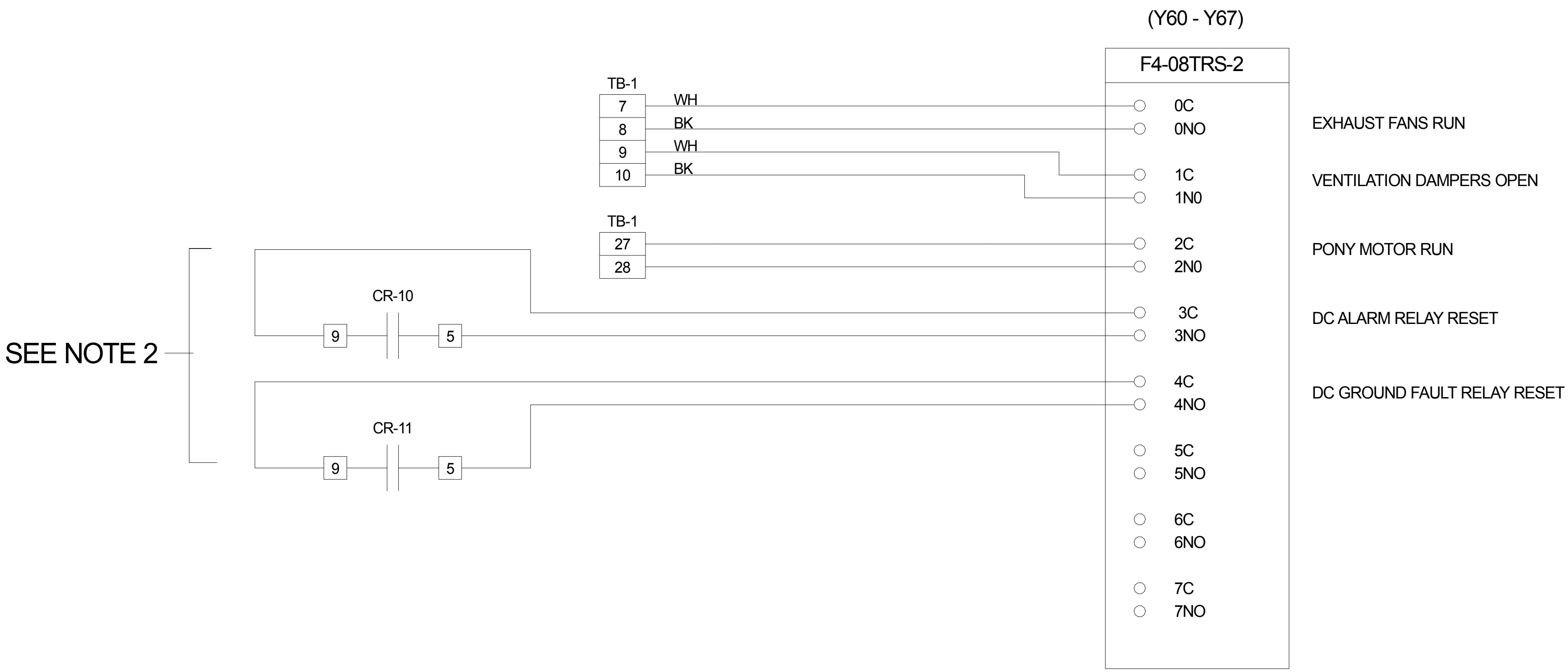
REV. 5 3/19/01



PLC-3/CPU	CPU MODULE

*120 ohm, 1/4W

REV. 6 3/2/00



NOTES

1. Module includes one replaceable fuse per common. Wickman # 19379-K-10A

2. See RCCC Power Wiring Schematic for details of CR-10 and CR-11 coil circuits.

PLC-3/7	DIGITAL OUTPUTS

REV. 9 3/19/01

D4-FILL

PLC-3/6	EMPTY

REV. 10 3/19/01

PLC-3/5	DIGITAL OUTPUTS

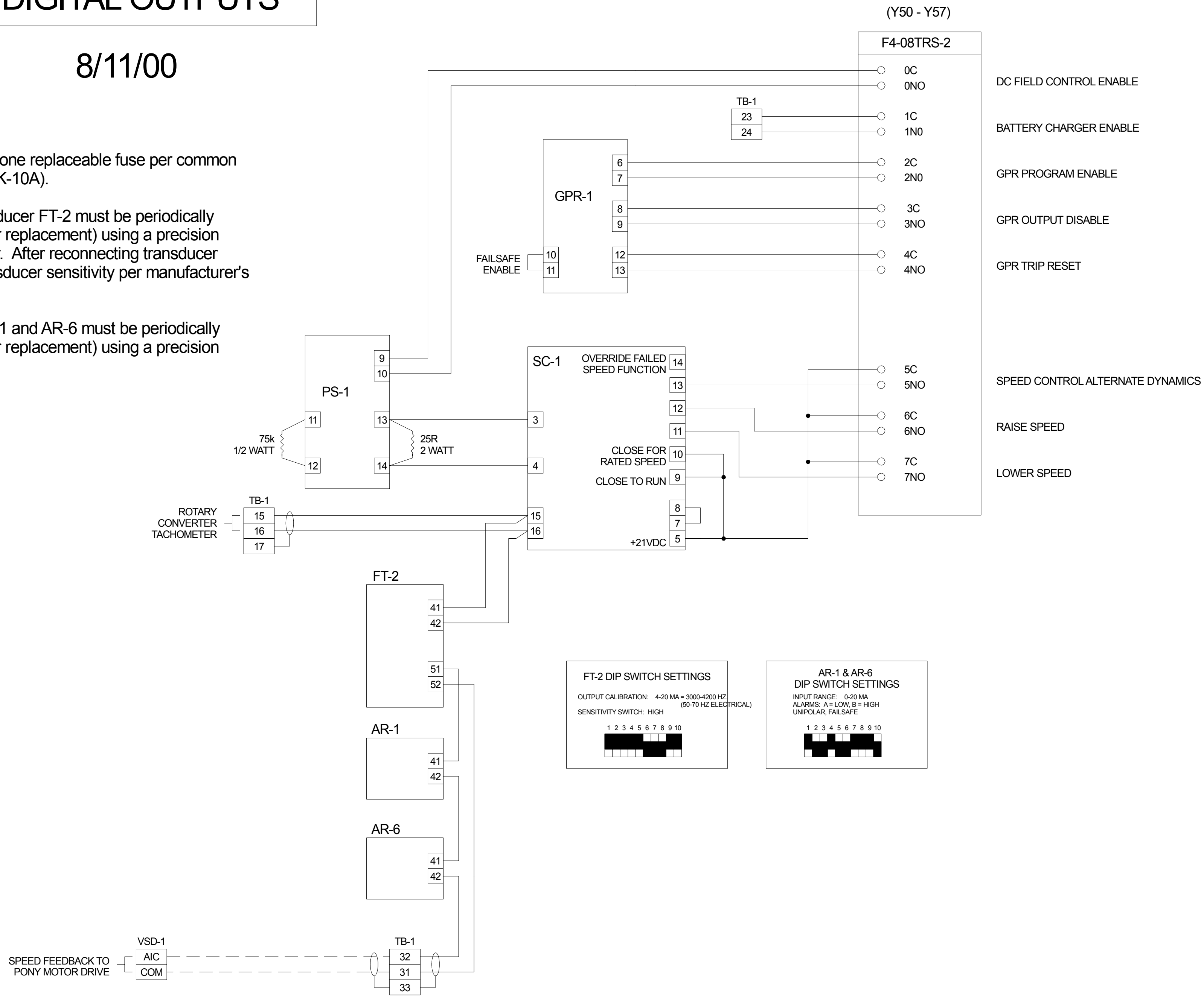
REV. 8 8/11/00

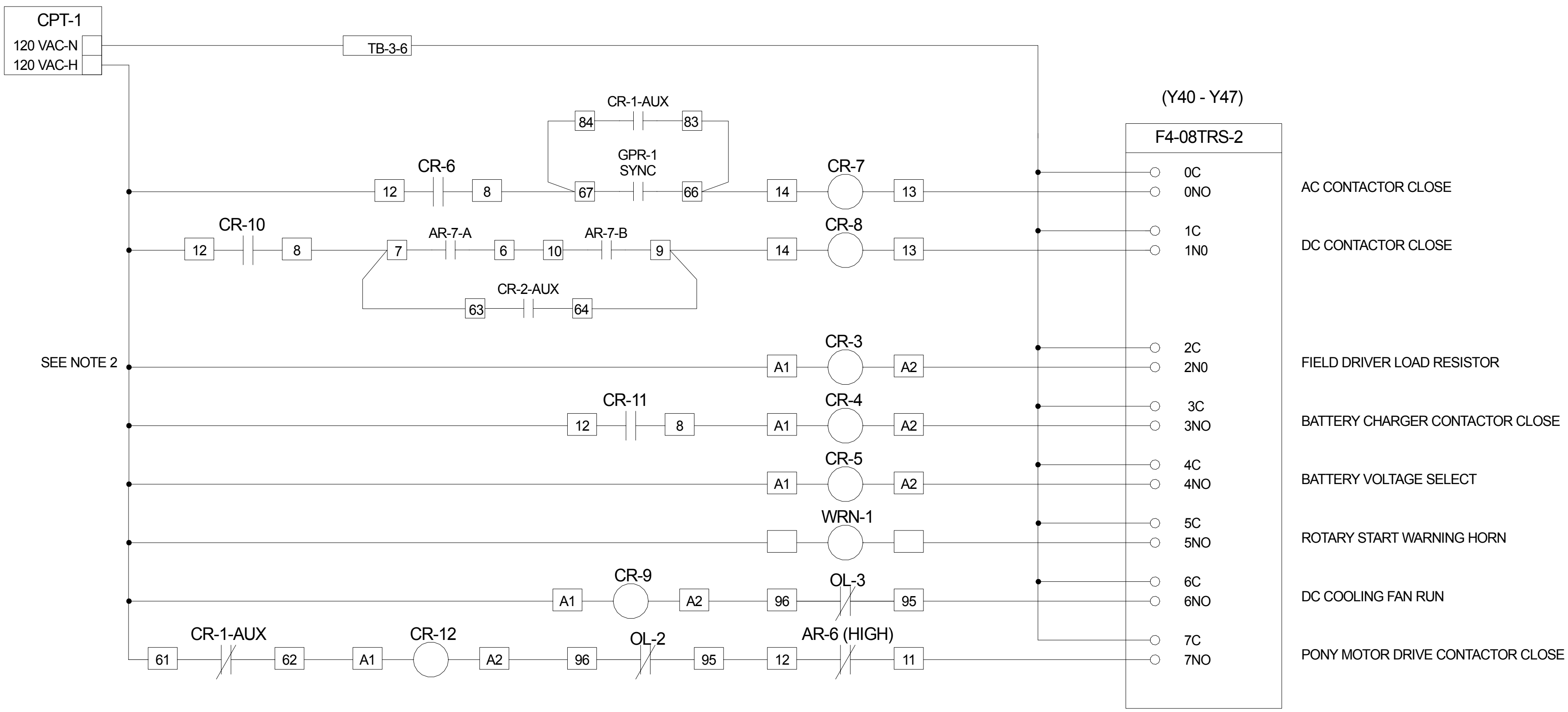
NOTES:

1. Module includes one replaceable fuse per common (Wickman # 19379-K-10A).

2. Frequency transducer FT-2 must be periodically recalibrated (or after replacement) using a precision frequency generator. After reconnecting transducer input, re-adjust transducer sensitivity per manufacturer's instructions.

3. Alarm relays AR-1 and AR-6 must be periodically recalibrated (or after replacement) using a precision milli-amp source.

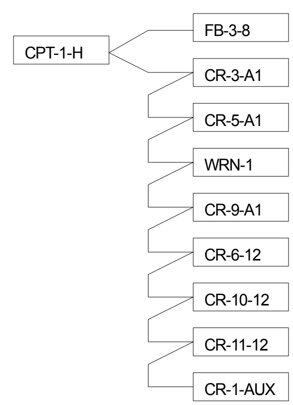




NOTES:

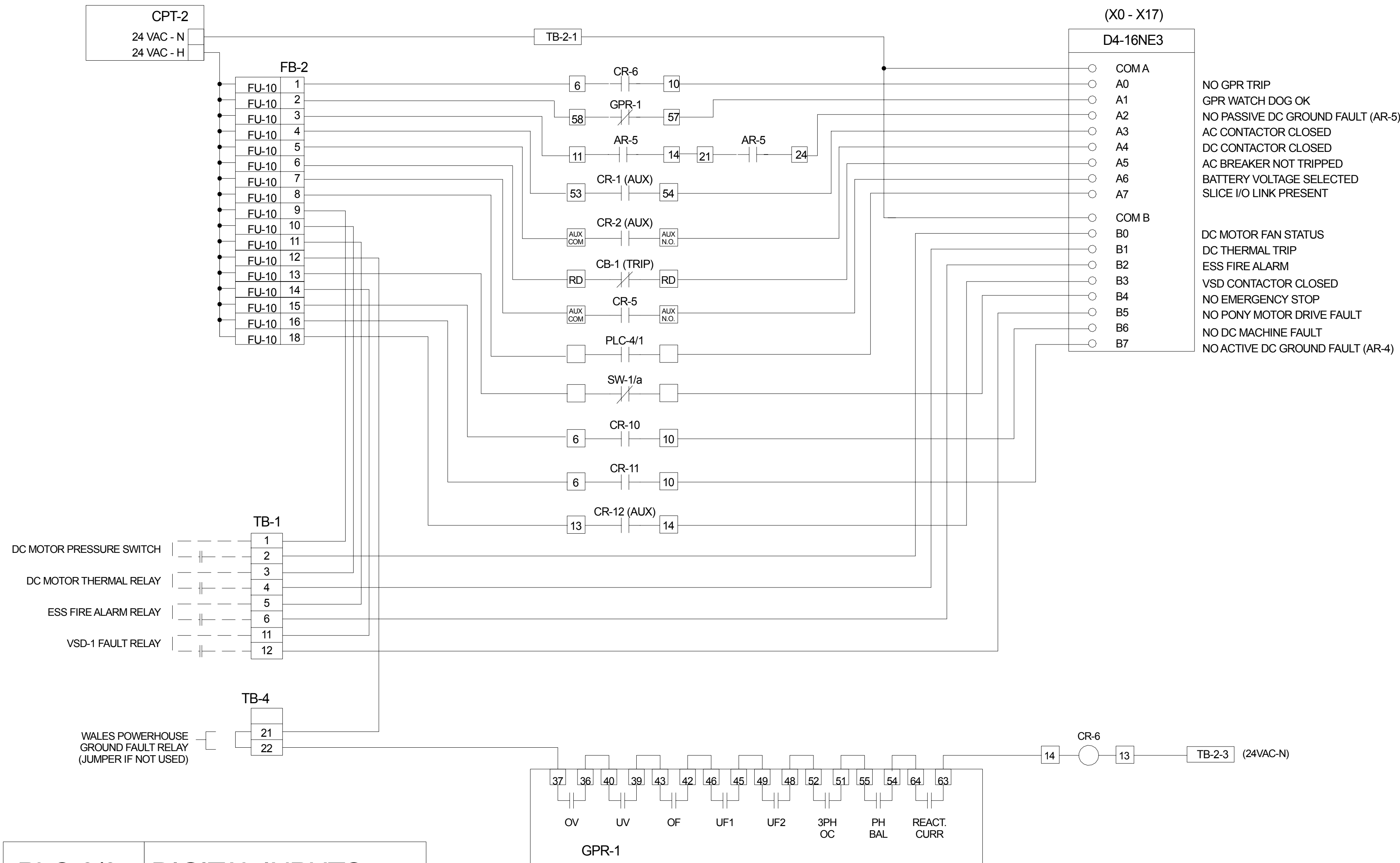
1. Module includes one replaceable fuse per common. Wickman # 19379-K-10A

2. Physical connection of 120 VAC-H wiring shown at right.



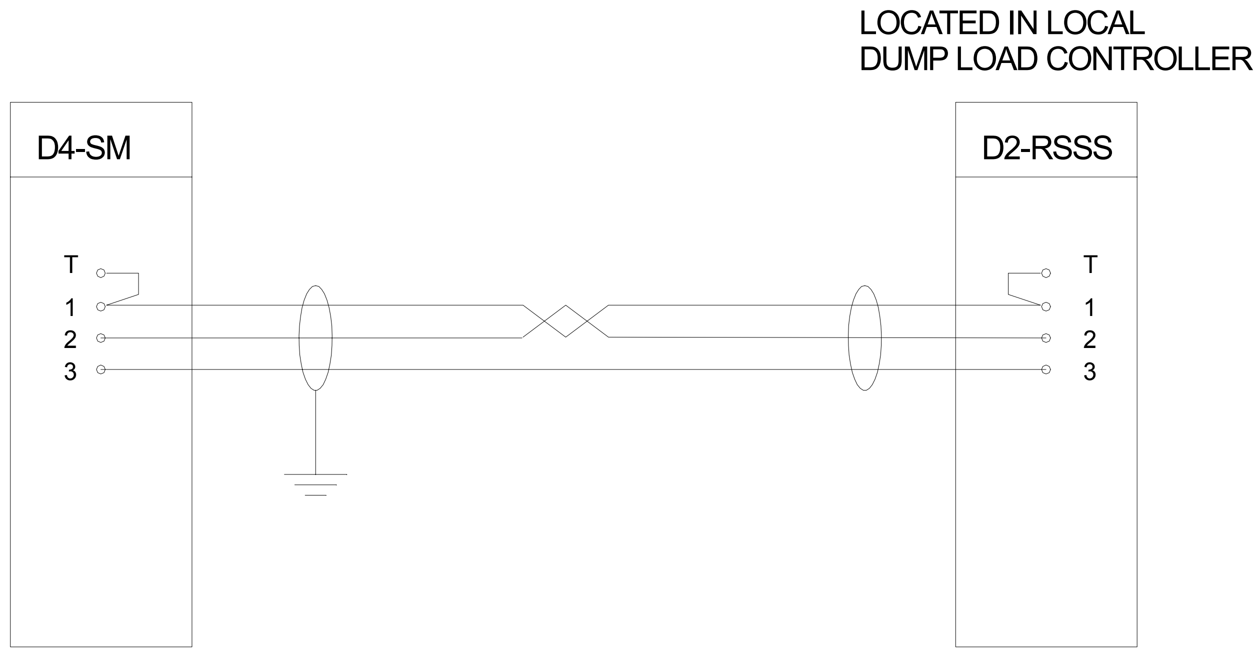
PLC-3/4	DIGITAL OUTPUTS

REV. 16   8/11/00



PLC-3/3	DIGITAL INPUTS

REV. 19 3/19/01



DIP SWITCH SETTINGS

1	ON
2	ON
3	OFF
4	OFF

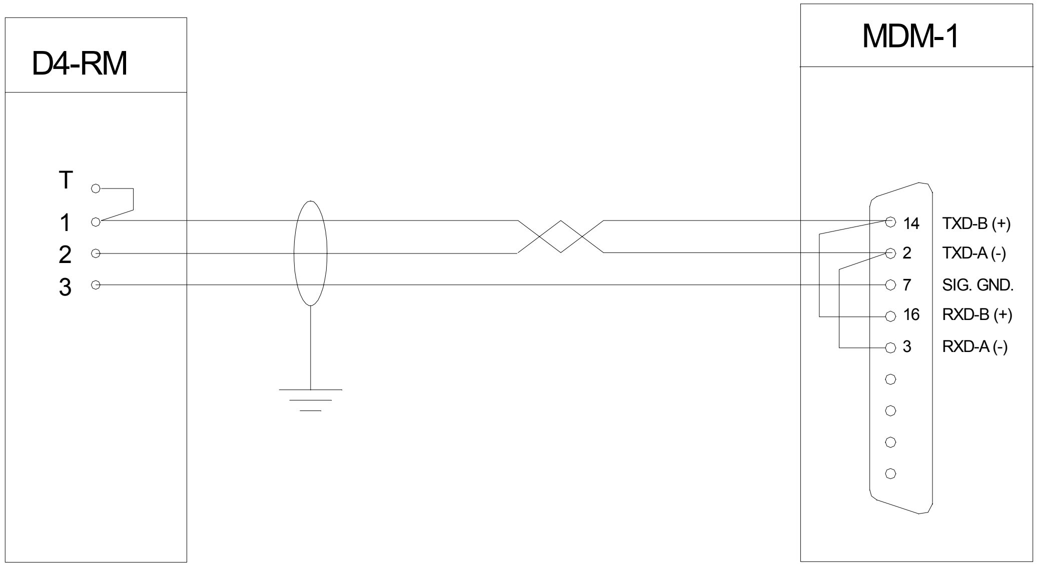
BAUD RATE = 614K

UNIT ADDRESS = 00

NOTE: PLC TO MODEM CONNECTION REQUIRES CUSTOM CABLE

PLC-3/2	SLICE MASTER MODULE: LOCAL DUMP LOAD INTERFACE

REV. 13 3/19/01



DIP SWITCH SETTINGS

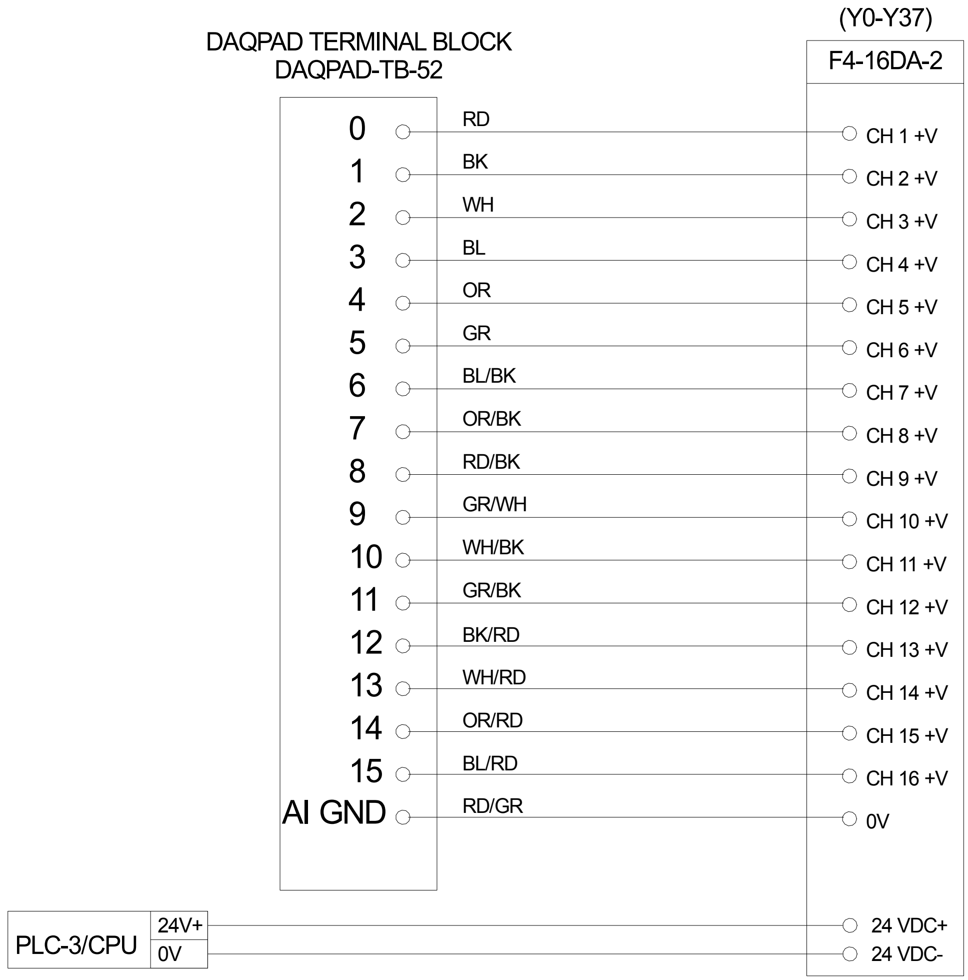
1	ON	MASTER
2	ON	BAUD RATE = 38.4K
3	OFF	
4	OFF	

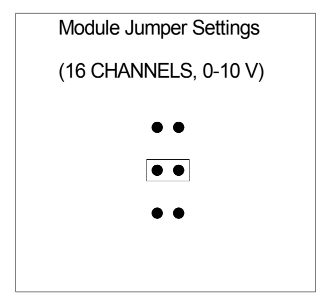
UNIT ADDRESS = 0

NOTE: PLC TO MODEM CONNECTION REQUIRES CUSTOM CABLE

PLC-3/1	REMOTE MASTER MODULE: RADIO MODEM INTERFACE

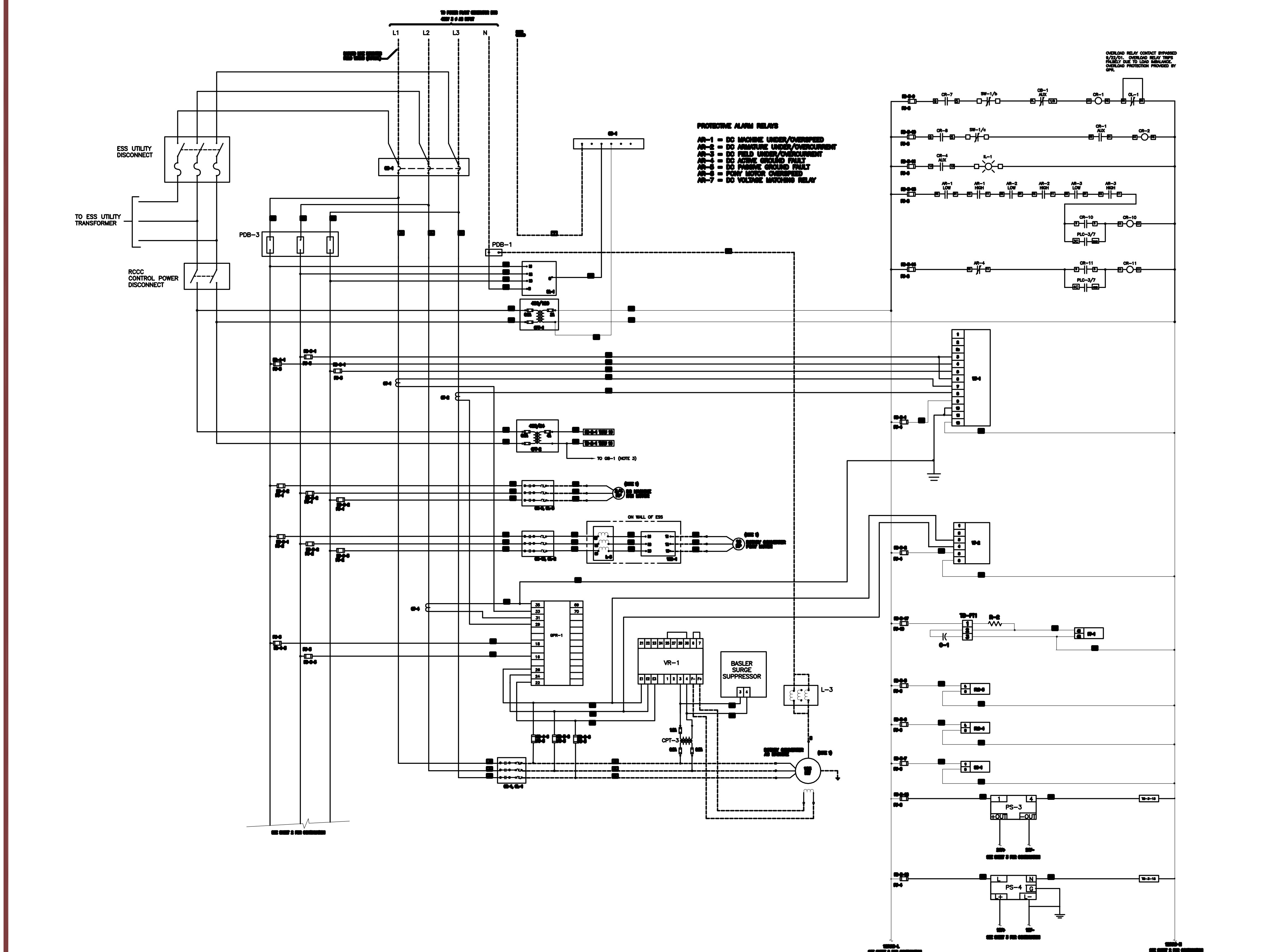
REV. 3 9/6/00





PLC-3/0	ANALOG OUTPUT MODULE

REV. 1 8/11/00



WIRING KEY

#	CONDUCTOR – COLOR CODING	480V AC	240V DC	120V AC	24V AC
1	(2) EA. 350 MCM CU MTW – RED POSITIVE		X		
2	(2) EA. 350 MCM CU MTW – BLACK NEGATIVE		X		
3	#4/0 CU MTW – BROWN CØ 600V RATED	X			
4	#4/0 CU MTW – ORANGE BØ 600V RATED	X			
5	#4/0 CU MTW – YELLOW AØ 600V RATED	X			
6	#4/0 CU MTW – GREY NEUTRAL	X			
7	#4/0 CU MTW – GREEN GROUND	X	X		
8	#8 CU MTW – BLACK NEGATIVE		X		
9	#8 CU MTW – RED POSITIVE		X		
10	# 10 CU MTW – BROWN CØ 600V RATED	X			
11	# 10 CU MTW – ORANGE BØ 600V RATED	X			
12	# 10 CU MTW – YELLOW AØ 600V RATED	X			
13	# 10 CU MTW – WHITE NEUTRAL	X		X	
14	# 10 CU MTW – GREEN GROUND	X	X	X	
15	# 14 CU MTW – BROWN 600V	X			
16	# 14 CU MTW – ORANGE 600V	X			
17	# 14 CU MTW – YELLOW 600V	X			
18	# 14 CU MTW – GREY 600V NEUTRAL	X			
19	#14 CU MTW – BLACK 600V RATED		X	X	
20	# 14 CU MTW – RED 600V RATED		X		X
21	# 14 CU MTW – WHITE 600V RATED			X	X
22	#14 CU MTW GREEN – GROUND			X	
23	# 14 CU MTW – BLUE W/WHITE NEGATIVE DC CONTROL				
24	# 14 CU MTW – BLUE POSITIVE DC CONTROL				
25	#8 CU MTW – BROWN, 600V RATED	X			
26	#8 CU MTW – ORANGE, 600V RATED	X			
27	#8 CU MTW – YELLOW, 600V RATED	X			
28	#6 CU MTW – BROWN, 600V RATED	X			
29	#6 CU MTW – ORANGE, 600V RATED	X			
30	#6 CU MTW – YELLOW, 600V RATED	X			
31	#12 CU MTW – BROWN, 600V RATED	X			
32	#12 CU MTW – ORANGE, 600V RATED	X			
33	#12 CU MTW – YELLOW, 600V RATED	X			

[X] WIRING TYPE REFERENCE WIRING KEY THIS SHEET.

NOTES:

1. DC MOTOR, AC GENERATOR, AND AC MOTOR BELONG TO THE ROTARY CONVERTER ASSEMBLY. THE FRAMES OF ALL MOTORS AND GENERATORS SHOULD BE CONNECTED TO EARTH GROUND.

2. ON TB-2, FB-2, TB-3, & FB-3, USE COMB TYPE JUMBER BARS ON POWER INPUT SIDE. ON FB-4,5,6, USE JUMPERS ONLY TO CONNECT TERMINALS #1-5. TERMINAL 6 IS ON THE GENERATOR SIDE OF CR-1 AND THUS BELONGS TO A SEPARATE CIRCUIT.

3. TIE THE NEUTRAL LEG OF THE SECONDARY OF ALL CONTROL POWER TRANSFORMERS (CPT) TO THE GROUND BAR.

4. LABEL ALL WIRES AT BOTH ENDS, INDICATING ORIGIN AND DESTINATION. FOR EXAMPLE, LABEL THIS WIRE "FB-5-1 TO WT-1-3" AND THE OTHER END "WT-1-3 TO FB-5-1".

No.	Date	Description	By
17	10/25/01	BYPASSED OL-1 CONTACT.	SD
16	8/2/01	ADDED C-1 AND R-2 DESIGNATIONS	SD
15	1/26/01	ADDED CONTROL PWR DISCONNECT	SD
14	11/29/00	REVISED L-3 WIRING. PS-4 FUSE DETAIL	SD
13	8/16/00	ADDED PS-4	SD

Revisions

Drawn By: S. DROUILHET
Date:
Engineer:
Checked By: S. DROUILHET 2/12/98
Approved By:

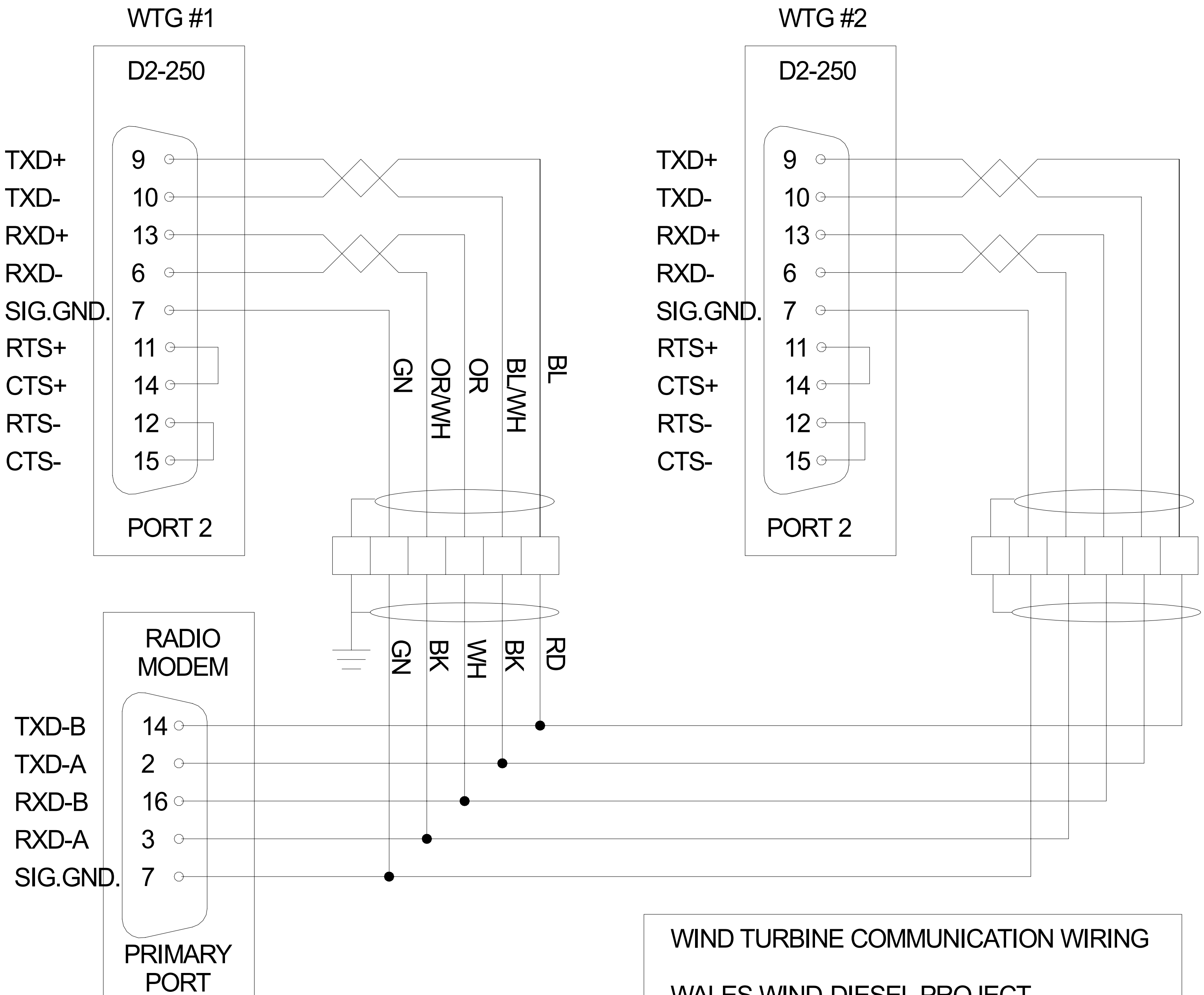
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401
Operated for the
U.S. Department of Energy
by Midwest Research Institute

Sheet Title
WIND-DIESEL POWER SYSTEM
ROTARY CONVERTER CONTROL CABINET
ELECTRICAL SCHEMATIC DIAGRAM
POWER WIRING

Work Request Number:
Drawing Number: NWTC-SD-0003
Sheet Number: 1 OF 3
Sequence Number: REV. 17

FORM: ZBD2234D.DWG-0

PLOT SCALE:
STATION:
PLOT INFO
TIME:
FILE NAME:
AUTOCAD VERSION:
DATE:
INITIALS:



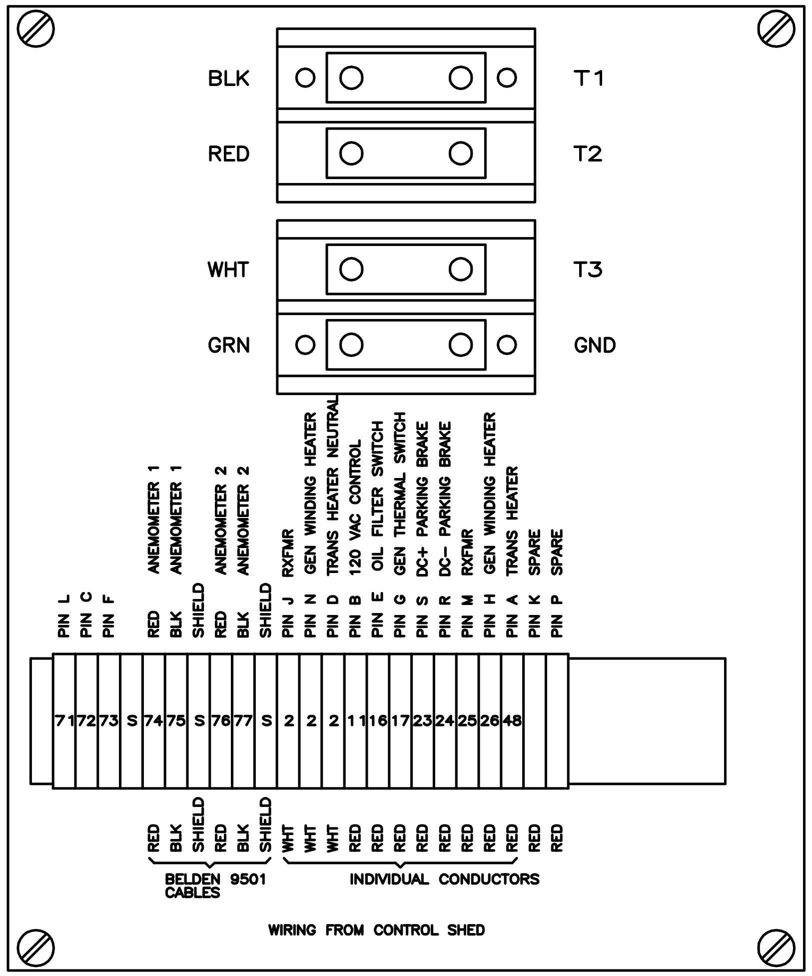
WIND TURBINE COMMUNICATION WIRING

WALES WIND-DIESEL PROJECT

S. DROUILHET REV. 1 8/15/01

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED

TWIST CABLE JUNCTION BOX



ITEM	QTY	DESCRIPTION	MFG	CAT NO.
1	1	ENCLOSURE 12" x 10" x 5"	HOFFMAN	A-1210CHNF
2	1	PANEL 10.75" X 8.88"	HOFFMAN	A-12P10
3	8	CRIMP LUG 2 AWG	T B	54107
4	2	TERMINAL BLOCK	MARATHON	1422122-CU
5	23	TERMINAL BLOCK, DIN RAIL	SQ D	9080GM6
6	1	END BLOCK	SQ D	9080GM6B
7	2	END CLAMP	SQ D	9080GH11
8	1	CORD GRIP 1-1/2"	HUBBELL	VHC-1059
9	1	LOCK NUT 1-1/2"	HUBBELL	003-22-005
10	1	O-RING 1-1/2"	HUBBELL	205-09-005
11	1	CORD GRIP 1"	HUBBELL	VHC-1042
12	1	LOCK NUT 1"	HUBBELL	003-22-003
13	1	O-RING 1"	HUBBELL	205-09-003
14	2	CORD GRIP 1/4"	HUBBELL	SHC-1002-CR
15	2	LOCK NUT 1/4" NYLON	HUBBELL	316-22-001
16	AR	35 MM DIN RAIL	SQ D	9080MH320
17	2	SUPERSTRUT PIPE CLAMP 5"	AMERICAN ELECTRIC	702-5(HDG)
18	AR	SUPERSTRUT CHANNEL	AMERICAN ELECTRIC	C1200
19	4	SPRINGLESS NUT 1/4-20	AMERICAN ELECTRIC	AC-100-1/4
20	1	CONNECTOR - RECEPTACLE	VARIOUS	MS3101F24-5S
21	1	CONNECTOR - PLUG	VARIOUS	MS3106F24-5P
22	AR	CONTROL CABLE 16/14 SOW-A	ROYAL	W4466
23	AR	POWER CABLE 2/4 SEOW-A	COLEMAN	22423
24				

CONTROL CABLE CONNECTOR CROSS REFERENCE			
WIRE #	PIN #	TWIST CABLE WIRE COLOR	FUNCTION
2	J	BLK	RXFMR NEUTRAL
2	N	RED/BLK	GEN WINDING HEATER NEUTRAL
2	D	RED/WHT	TRANSMISSION HEATER NEUTRAL
11	B	BLU/BLK	120 VAC CONTROL
16	E	ORN/BLK	OIL FILTER SWITCH
17	G	RED	GEN THERMAL SWITCH
23	S	BLU	DC+ PARKING BRAKE
24	R	WHT/BLK	DC– PARKING BRAKE
25	M	GRN	RXFMR
26	H	GRN/BLK	GEN WINDING HEATER
48	A	BLK/WHT	TRANSMISSION HEATER
71	L	ORN	+12VDC PROX SWITCH
72	C	WHT	SIGNAL PROX SWITCH
73	F	GRN/WHT	COMMON PROX SWITCH
	K		
	P		

UNLESS OTHERWISE SPECIFIED
.XX ±
.XXX ±
∠ ±

DWG INTERPRETATION ANSI Y14.5
DIMENSIONS IN INCHES (MM) AND APPLY AFTER PROCESSING

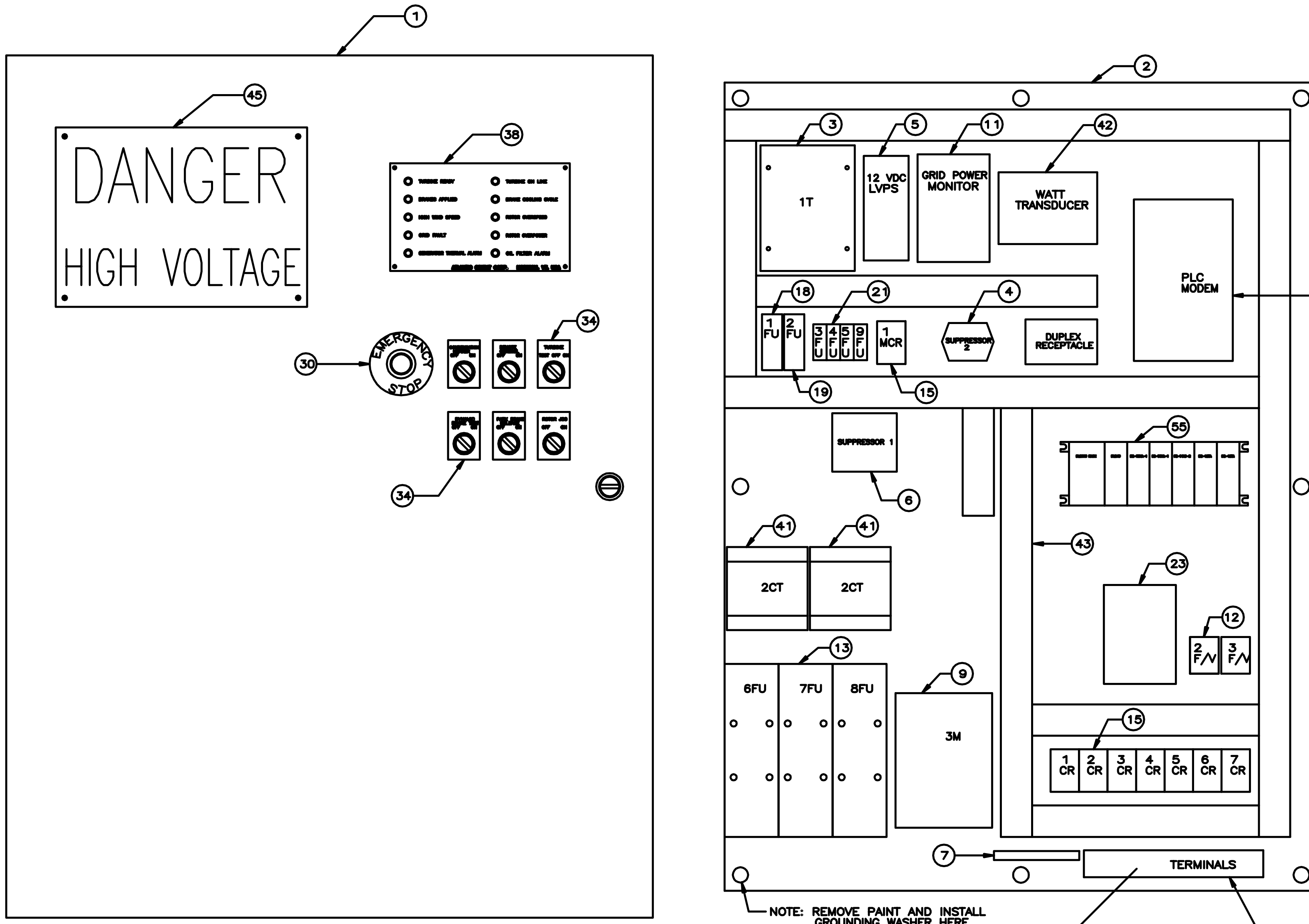
DWN DPB	8/21/95
CHKR	
APVD	
XX/XX-XX	XX/XX-XX
XX/XX-XX	XX/XX-XX
XX/XX-XX	XX/XX-XX
XX/XX-XX	XX/XX-XX
USED ON	

ATLANTIC ORIENT CORPORATION
A WIND ENERGY SYSTEMS COMPANY
P.O. BOX 1097 NORWICH, VT 05055

ELECTRICAL SCHEMATIC
KOTZEBUE 80KW TURBINE

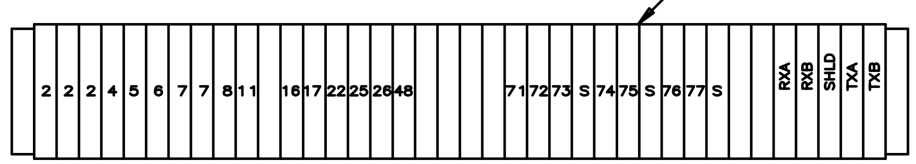
SIZE D | DWG NO. 10196
SCALE | WT | SHEET 9 OF 10

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED



ITEM	QTY	DESCRIPTION	MFG	CAT NO.
1	1	ENCLOSURE 48" x 36" x 9.25"	HOFFMAN	A48N3609
2	1	PANEL 45" x 33"	HOFFMAN	A48P36
3	1	CONTROL XFMR 1KVA, 480/120	SQ D	9070 K1000D31
4	1	SUPPRESSOR	PROTEK	587B051
5	1	12 VDC SUPPLY, REGULATED	SOLA	SLS-12-017
6	1	SUPPRESSOR	SQ D	SP3650
7	1	GROUND STRIP	GE	TGL2
8	2	GROUND STRIP ADAPTOR	GE	TGL20
9	1	CONTACTOR	SQ D	8910 DPA123
10	6	CRIMP LUG X 5/16"	BURNDY	YA4CL3BOX
11	1	GRID MONITOR	TIMEMARK	EX269
12	2	ANEMOMETER F/V	NRG	SI5100
13	3	FUSE, TIME DELAY 125A	BUSS	FRS-R125
14	3	FUSE BLOCK, 200A	BUSS	H60200-1CR
15	8	RELAY	POTTER BRMFLD	KRPA11AG120
16	8	DIN RELAY BASE	POTTER BRMFLD	27E891
17	1	SHORT HAUL MODEM	BLACK BOX	LD485A-MP
18	1	FUSE 5A	BUSS	FRN-R5
19	1	FUSE 10A	BUSS	FRN-R10
20	2	FUSE BLOCK	BUSS	H25030-1CR
21	4	FUSE 5A	BUSS	KTK 5
22	4	600 V FUSED TERMINAL	SQ D	9080 GF6
23	1	PANEL HEATER 200W	HOFFMAN	D-AH2001A
24	1	FUSE BLOCK END BARRIER	SQ D	9080 GF6B
25	38	TERMINAL BLOCK	SQ D	9080 GM6
26	1	TERMINAL BLOCK END BARRIER	SQ D	9080 GM6B
27	4	SLIP IN END CLAMP	SQ D	9080 GH11
28	AR	6 POLE JUMPER	SQ D	9080 GH710
29	AR	35 MM DIN RAIL	TELEMECHANIQUE	AM1DP200
30	1	E STOP SWITCH PUSH/PULL	TELEMECHANIQUE	ZB2BT2
31	1	E-STOP LEGEND	TELEMECHANIQUE	ZB2BY8330
32	1	SWITCH BASE / 1NC	TELEMECHANIQUE	ZB2BZ102
33	1	BRACKET	AOC	10201
34	6	SWITCH BASE / 1NO	TELEMECHANIQUE	ZB2BZ101
35	1	3 POS SEL SW OPERATOR	TELEMECHANIQUE	ZB2BD3
36	5	2 POS SEL SW OPERATOR	TELEMECHANIQUE	ZB2BD2
37	6	LEGEND, ENGRAVED	TELEMECHANIQUE	ZB2BY5101
38	1	ENGRAVED STATUS PANEL	AOC	10199
39	1	6 POLE JUMPER	SQ D	9080 GH710
40				
41	2	CURRENT TRANSFORMER 100:5	OHIO SEMITRONICS	12973
42	1	WATT TRANSDUCER	OHIO SEMITRONICS	GW5-006-CX5
43	AR	WIRE CHANNEL	PANDUIT	E1.5 X 2 LG6
44	AR	CHANNEL COVER	PANDUIT	C1.5 LG6
45	1	"HIGH VOLTAGE" SIGN	BRADY	47005
46	10	LAMP HOLDER	DIALIGHT	508-8738-504
47	8	LED CARTRIDGE RED	DIALIGHT	507-4759-3331-500
48	2	LED CARTRIDGE GREEN	DIALIGHT	507-4859-3332-500
49				
50				
51				
52				
53				
54				
55	1	PLC - SEE SHT 7	KOYO	
56				
57				
58				

NOTE: DOOR MUST BE BONDED TO PANEL GROUND



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.XXX ±
∠ ±

DWG INTERPRETATION ANSI Y14.5 DIMENSIONS IN INCHES (MM) AND APPLY AFTER PROCESSING

DWN DPB	8/21/95
CHKR	
APVD	
XX/XX-XX	XX/XX-XX
XX/XX-XX	XX/XX-XX
XX/XX-XX	XX/XX-XX
XX/XX-XX	XX/XX-XX
USED ON	

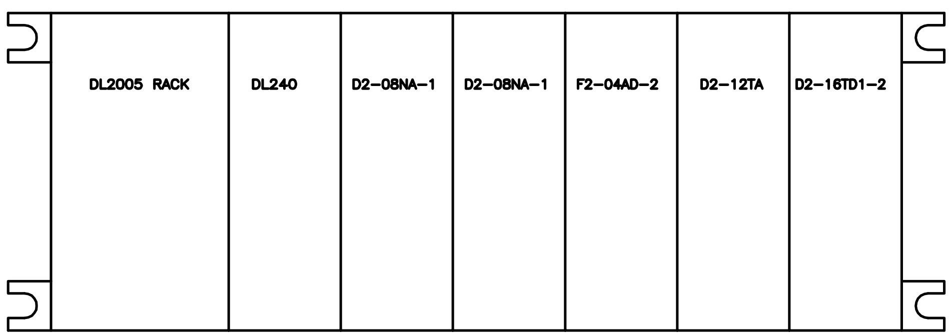
ATLANTIC ORIENT CORPORATION
A WIND ENERGY SYSTEMS COMPANY
P.O. BOX 1097 NORWICH, VT 05055

ELECTRICAL SCHEMATIC
KOTZEBUE 80KW TURBINE

SIZE D | DWG NO. 10196
SCALE 1/4 | WT | SHEET 8 OF 10

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED

PLC



ITEM	QTY	DESCRIPTION	MFG	CAT NO.
1	1	PLC RACK 6 POS.	KOYO	D2-06B
2	1	CPU	KOYO	D2-240
3	2	120 VAC INPUT MODULE	KOYO	D2-08NA-1
4	1	120 VAC OUTPUT MODULE	KOYO	D2-12TA
5	1	ANALOG INPUT MODULE	KOYO	F2-04AD-2
6	1	DC OUTPUT MODULE	KOYO	D2-16TD1-2
7	1	BATTERY FOR CPU	KOYO	D2-BAT

UNLESS OTHERWISE SPECIFIED
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DWG INTERPRETATION ANSI Y14.5 DIMENSIONS IN INCHES (MM) AND APPLY AFTER PROCESSING

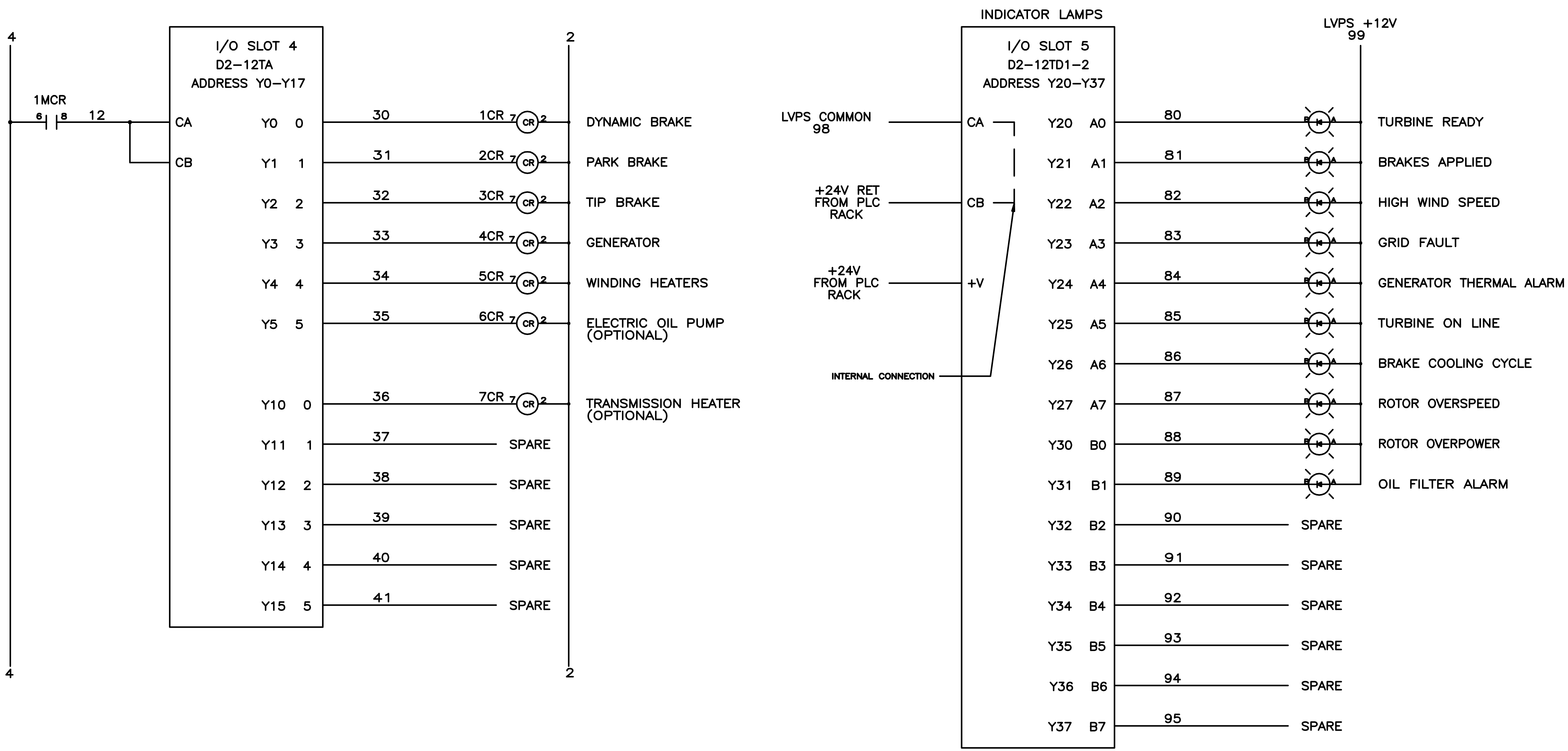
DWN DPB	8/21/95
CHKR	
APVD	
XX/XX-XX	XX/XX-XX
XX/XX-XX	XX/XX-XX
XX/XX-XX	XX/XX-XX
XX/XX-XX	XX/XX-XX
USED ON	

ATLANTIC ORIENT CORPORATION
A WIND ENERGY SYSTEMS COMPANY
P.O. BOX 1097 NORWICH, VT 05055

ELECTRICAL SCHEMATIC
KOTZEBUE 80KW TURBINE

SIZE D | DWG NO. 10196

SCALE | WT | SHEET 7 OF 10



REVISIONS			
REV	DESCRIPTION	DATE	APPROVED

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DWG INTERPRETATION ANSI Y14.5
DIMENSIONS IN INCHES (MM) AND APPLY AFTER PROCESSING

DWN	DPB	8/21/95
CHKR		
APVD		
XX/XX-XX	XX/XX-XX	
XX/XX-XX	XX/XX-XX	
XX/XX-XX	XX/XX-XX	
XX/XX-XX	XX/XX-XX	
USED ON		

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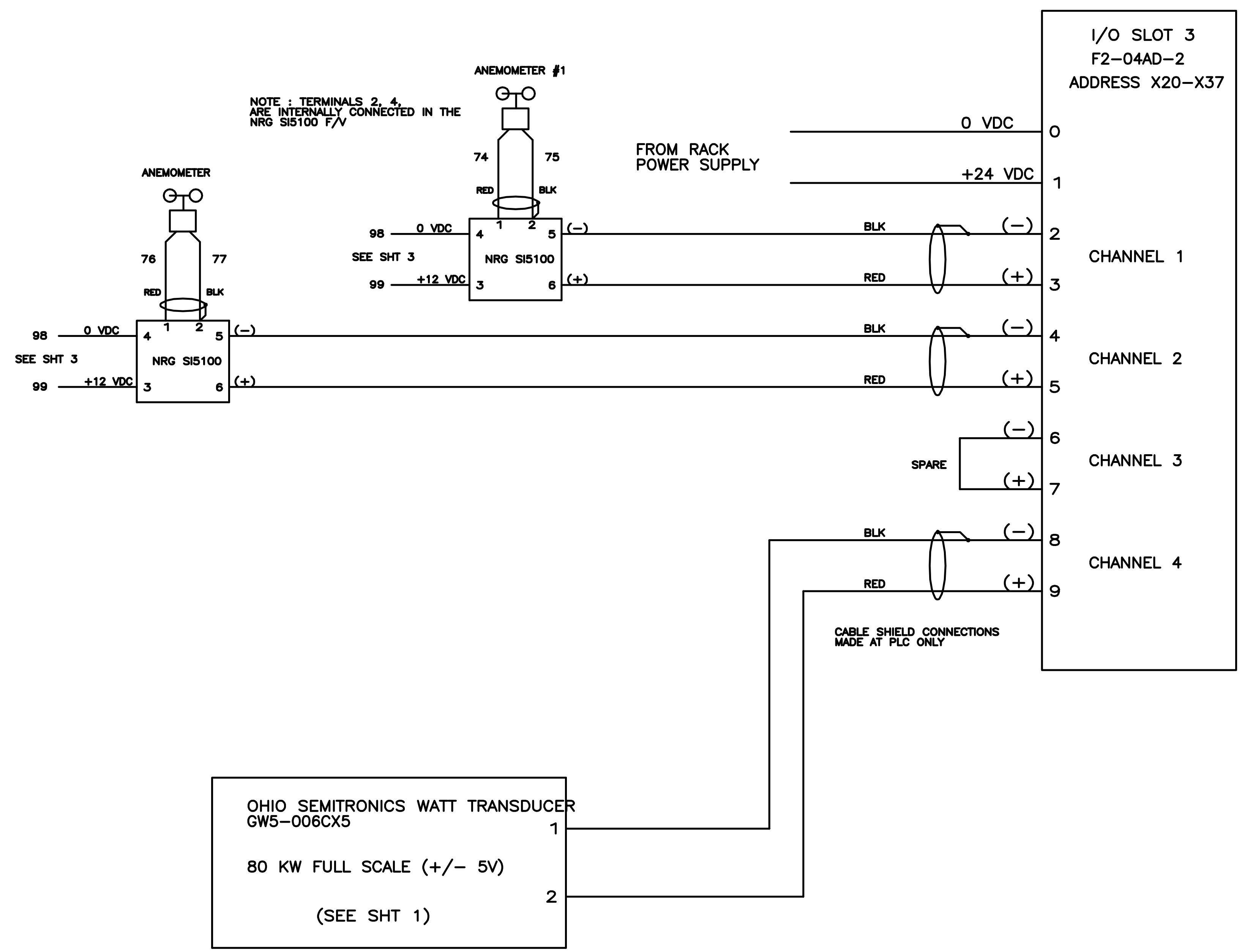
P.O. BOX 1097 NORWICH, VT 05055

ELECTRICAL SCHEMATIC
KOTZEBUE 80KW TURBINE

SIZE D | DWG NO. 10196
SCALE | WT | SHEET 6 OF 10



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.XXX ±
∠ ±

DWG INTERPRETATION
ANSI Y14.5
DIMENSIONS
IN INCHES (MM) AND
APPLY AFTER PROCESSING

DWN DPB	8/21/95
CHKR	
APVD	
XX/XX−XX	XX/XX−XX
XX/XX−XX	XX/XX−XX
XX/XX−XX	XX/XX−XX
XX/XX−XX	XX/XX−XX
USED ON	

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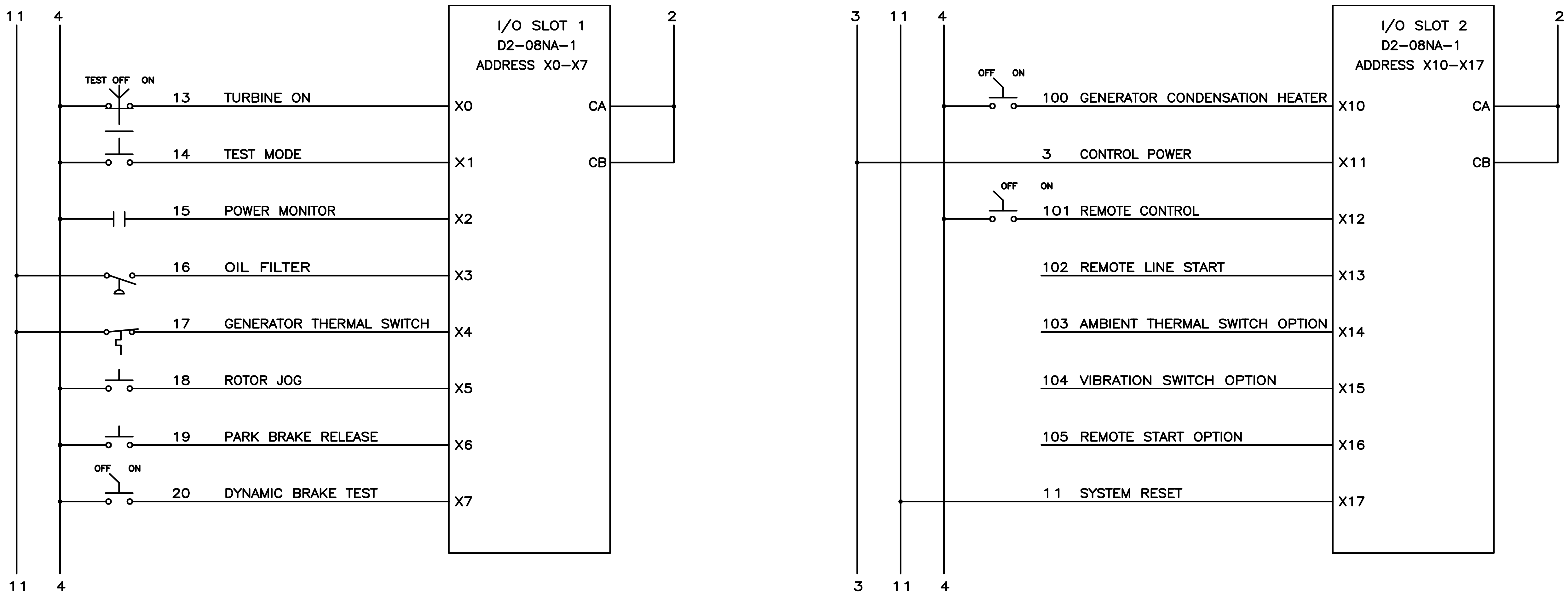
ELECTRICAL SCHEMATIC

KOTZEBUE 80KW TURBINE

SIZE D | DWG NO. 10196

SCALE | WT | SHEET 5 OF 10

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED



UNLESS OTHERWISE SPECIFIED
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DWG INTERPRETATION ANSI Y14.5
DIMENSIONS IN INCHES (MM) AND APPLY AFTER PROCESSING

DWN DPB		8/21/95
CHKR		
APVD		
XX/XX-XX	XX/XX-XX	
XX/XX-XX	XX/XX-XX	
XX/XX-XX	XX/XX-XX	
XX/XX-XX	XX/XX-XX	
USED ON		

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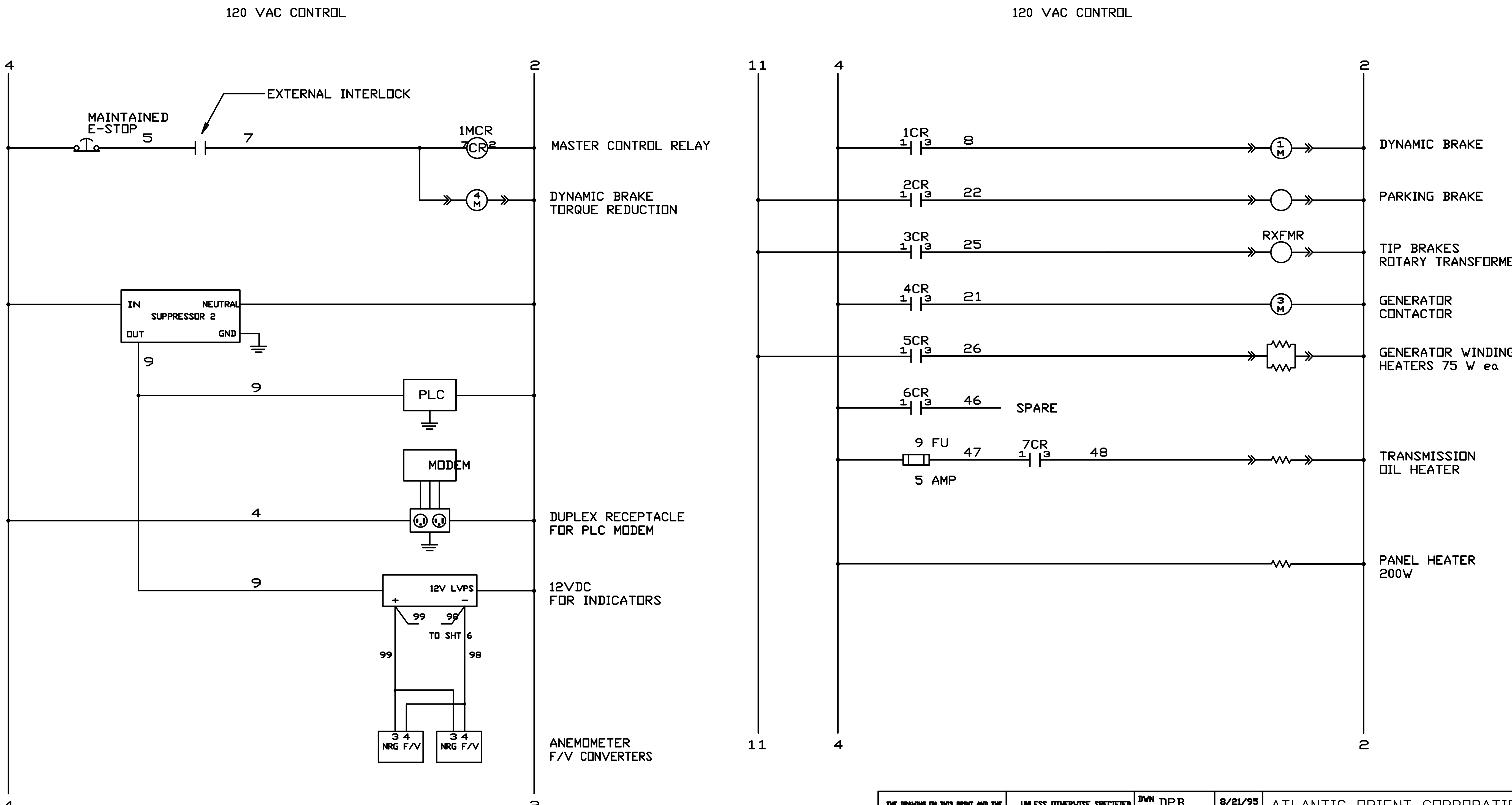
P.O. BOX 1097 NORWICH, VT 05055

ELECTRICAL SCHEMATIC
KOTZEBUE 80KW TURBINE

SIZE	DWG NO.		
D	10196		
SCALE	WT	SHEET 4	OF 10

REV	DESCRIPTION	DATE	APPROVED



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.XXX @
∠ @

DWG INTERPRETATION ANSI Y14.5 DIMENSIONS IN INCHES (MM) AND APPLY AFTER PROCESSING

DWN DPB	8/21/95
CHKR	
APVD	
XX/XX-XX	XX/XX-XX
XX/XX-XX	XX/XX-XX
XX/XX-XX	XX/XX-XX
XX/XX-XX	XX/XX-XX
USED ON	

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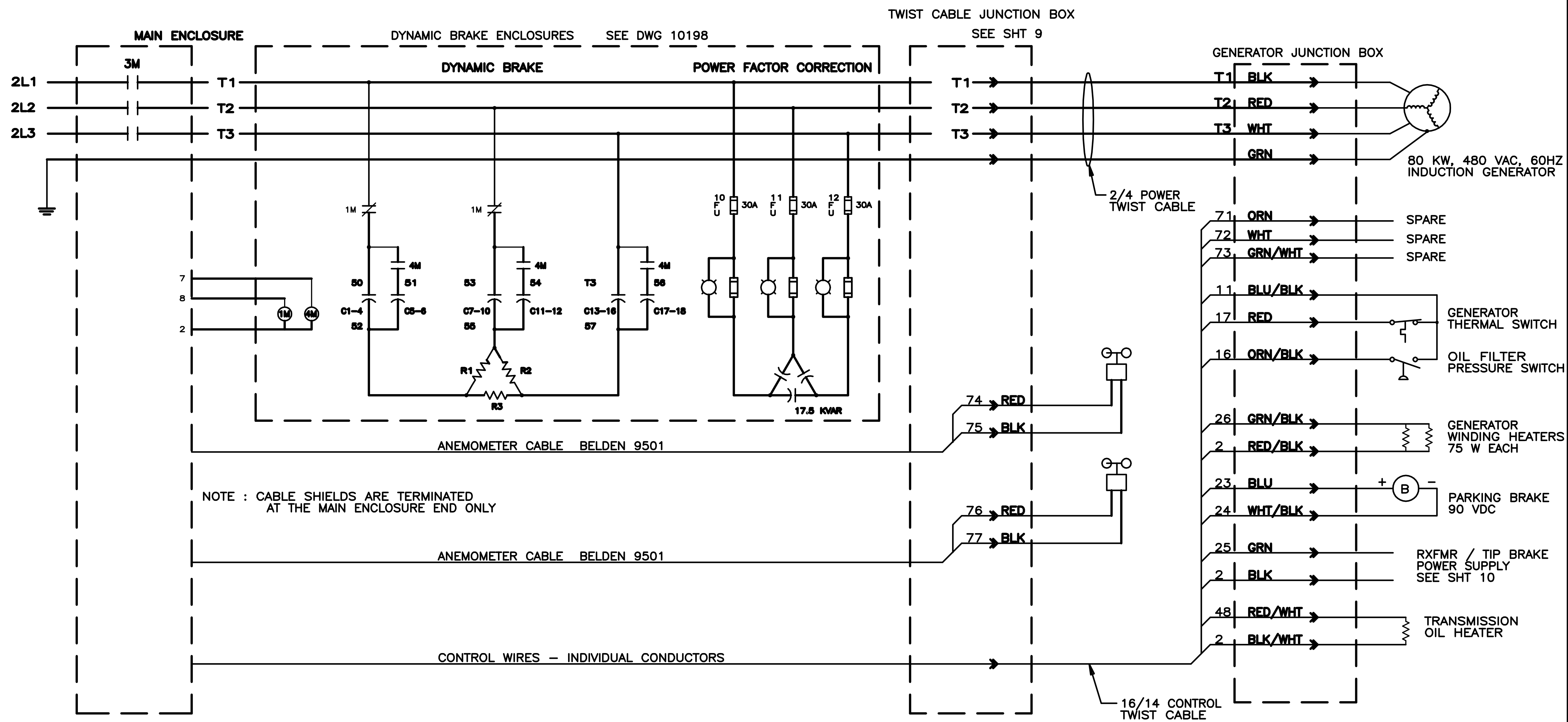
P.O. BOX 1097 NORWICH, VT 05055

ELECTRICAL SCHEMATIC
KOTZEBUE 80KW TURBINE

SIZE D | DWG NO. 10196
SCALE | WT | SHEET 3 OF 10



REVISIONS			
REV	DESCRIPTION	DATE	APPROVED

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.XXX ±
∠ ±

DWG INTERPRETATION ANSI Y14.5
DIMENSIONS IN INCHES (MM) AND APPLY AFTER PROCESSING

DWN DPB 8/21/95
CHKR
APVD

XX/XX-XX	XX/XX-XX
XX/XX-XX	XX/XX-XX
XX/XX-XX	XX/XX-XX
XX/XX-XX	XX/XX-XX

USED ON

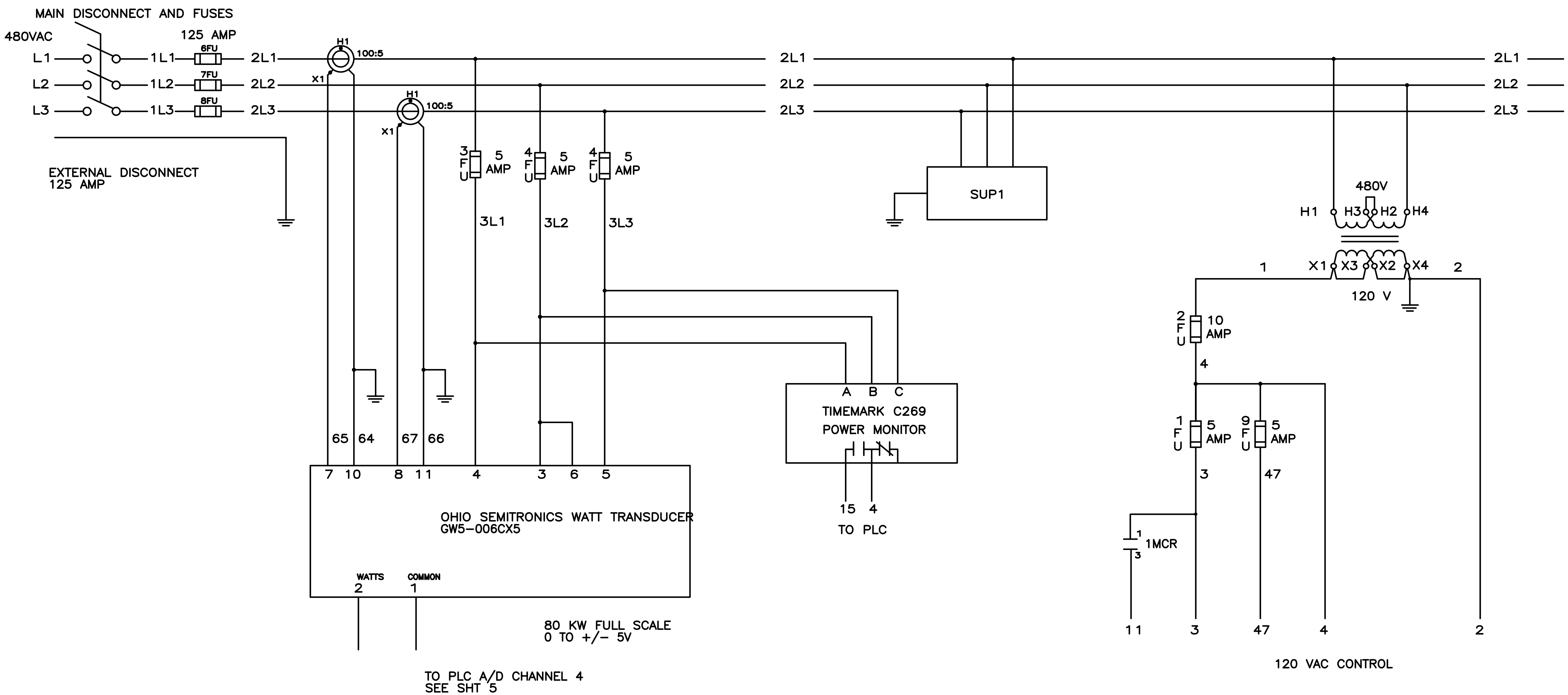
ATLANTIC ORIENT CORPORATION
A WIND ENERGY SYSTEMS COMPANY
P.O. BOX 1097 NORWICH, VT 05055

ELECTRICAL SCHEMATIC
KOTZEBUE 80KW TURBINE

SIZE D DWG NO. 10196

SCALE WT SHEET 2 OF 10

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED



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.XX ±
.XXX ±
∠ ±

DWG INTERPRETATION
ANSI Y14.5
DIMENSIONS
IN INCHES (MM) AND
APPLY AFTER PROCESSING

DWN DPB		8/21/95
CHKR		
APVD		
XX/XX-XX		XX/XX-XX
XX/XX-XX		XX/XX-XX
XX/XX-XX		XX/XX-XX
XX/XX-XX		XX/XX-XX
USED ON		

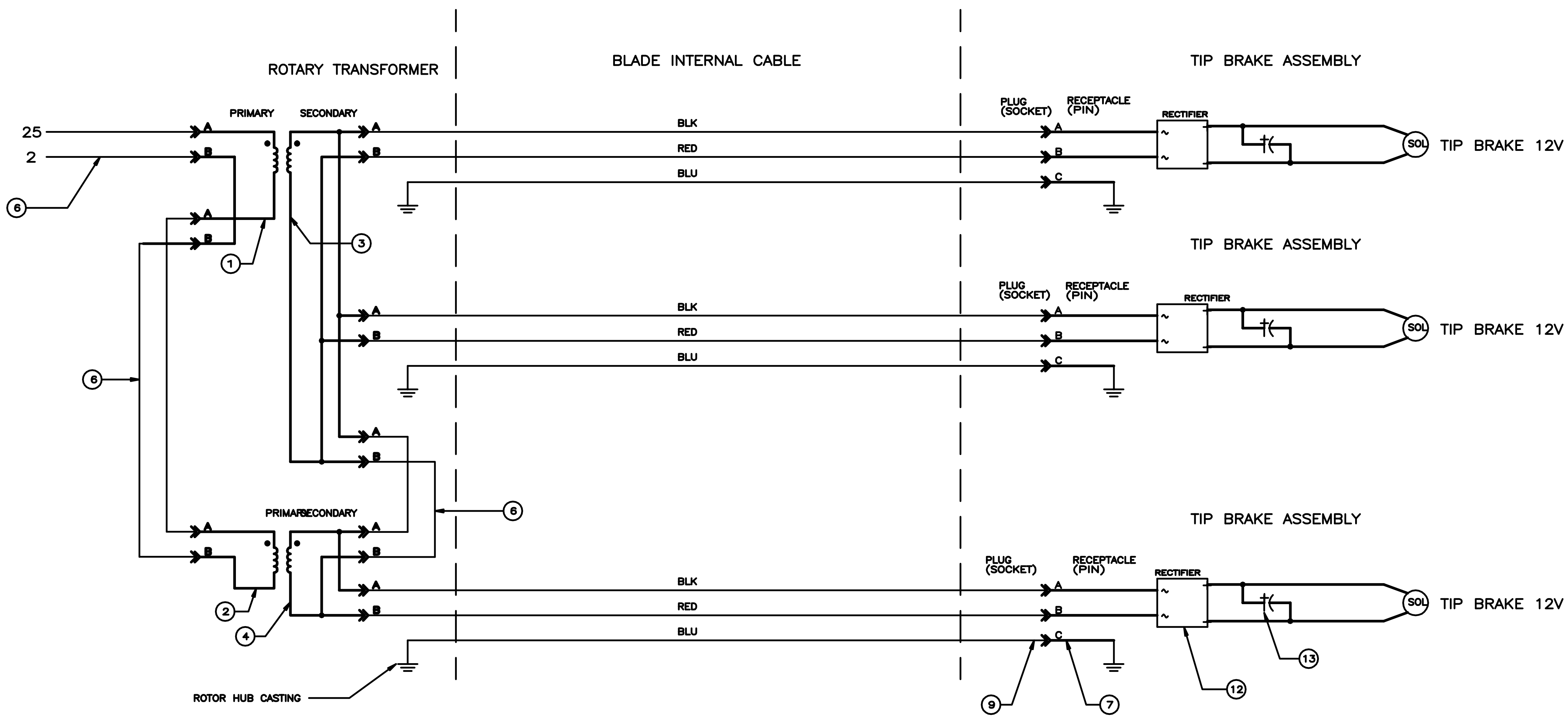
ATLANTIC ORIENT CORPORATION
A WIND ENERGY SYSTEMS COMPANY
P.O. BOX 1097 NORWICH, VT 05055

ELECTRICAL SCHEMATIC
KOTZEBUE 80KW TURBINE

SIZE D | DWG NO. 10196

SCALE | WT | SHEET 1 OF 10

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED



NOTE: EACH TIP BRAKE ASSEMBLY
MUST BE GROUNDED TO ROTOR HUB

ITEM	QTY	DESCRIPTION	MFG	CAT NO.
1	1	RXFMR PRIMARY	AOC	10052–1
2	1	RXFMR PRIMARY	AOC	10052–2
3	1	RXFMR SECONDARY	AOC	10052–3
4	1	RXFMR SECONDARY	AOC	10052–4
5	8	RXFMR CONNECTOR RECPTACLE	CONXALL	CXS3102A10SL4P300
6	8	RXFMR CONNECTOR PLUG	CONXALL	CXS3102A10SL4S300
7	3	TIP BRAKE RECEPTACLE	AMPHENOL	44–104–10003–02
8	9	RECEPTACLE PINS	AMPHENOL	44–100–1414P
9	3	TIP BRAKE PLUG	AMPHENOL	44–103–10003
10	9	PLUG SOCKETS	AMPHENOL	44–102–1414S
11	AR	SDN CONTROL CABLE 16/2	ROYAL	W1742
12	3	RECTIFIER 10A, 800V	FAGOR	FB1008
13	3	CAPACITOR 6800UF, 25V	CORNELL DUBILIER	FAS6800–25–AA

UNLESS OTHERWISE SPECIFIED
.XX ±
.XXX ±
∠ ±

DWG INTERPRETATION
ANSI Y14.5
DIMENSIONS
IN INCHES (MM) AND
APPLY AFTER PROCESSING

DWN DPB	8/21/95	
CHKR		
APVD		
XX/XX–XX	XX/XX–XX	
XX/XX–XX	XX/XX–XX	
XX/XX–XX	XX/XX–XX	
XX/XX–XX	XX/XX–XX	
USED ON		

ATLANTIC ORIENT CORPORATION
A WIND ENERGY SYSTEMS COMPANY
P.O. BOX 1097 NORWICH, VT 05055

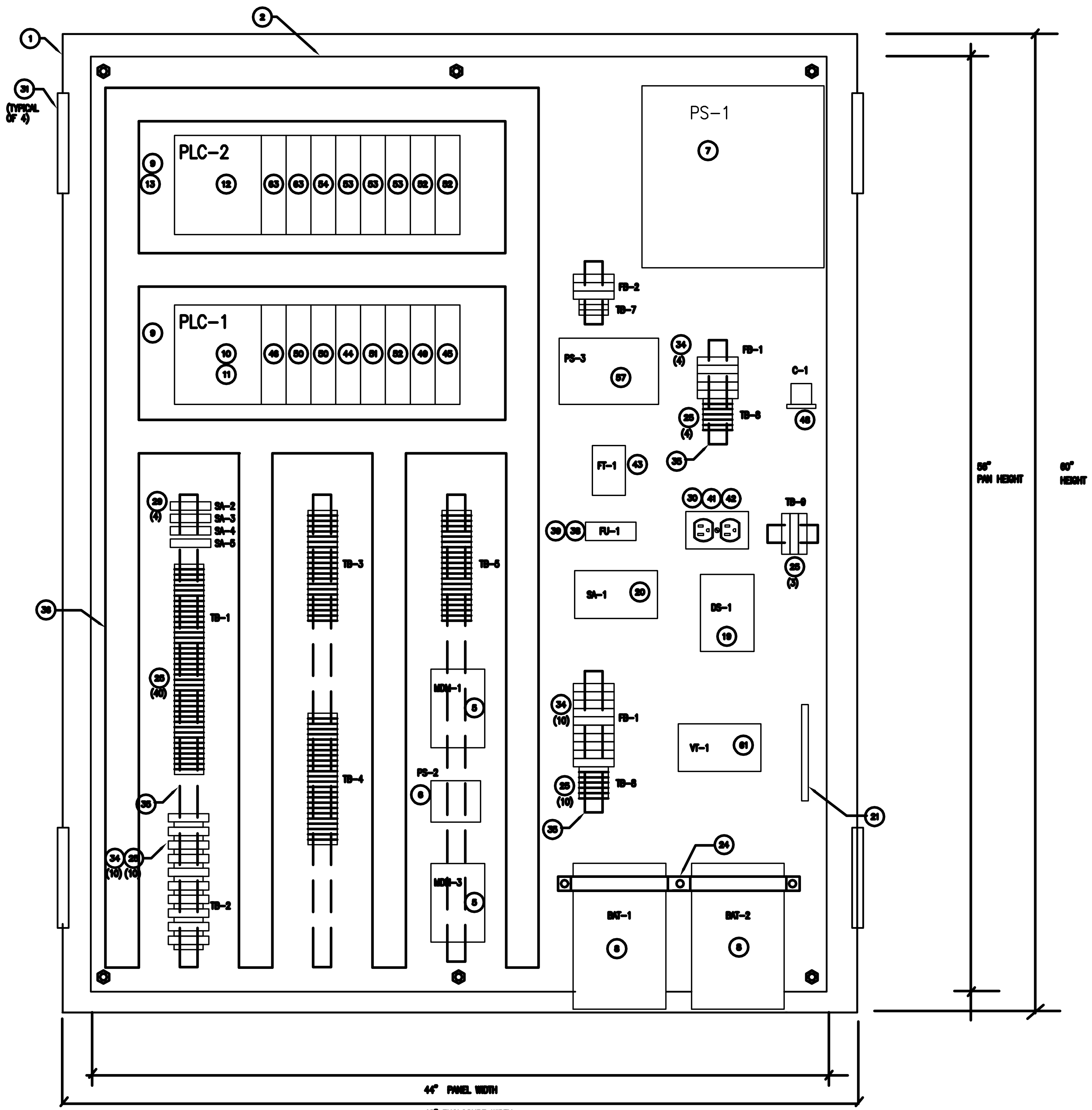
ELECTRICAL SCHEMATIC
KOTZEBUE 80KW TURBINE

SIZE D | DWG NO. 10196

SCALE | WT | SHEET 10 OF 10

PARTS LIST FOR WALES WIND-DIESEL HYBRID SYSTEM CONTROL PANEL					REV. 13 9/5/01
DRAWING NUMBER NWTC-SD-0008					
ITEM	KEY	DESCRIPTION	QTY.	MANUFACTURER	PART NUMBER
1		ENCLOSURE, TYPE 12, TWO DOOR	1	HOFFMAN (OR EQUIV.)	A-604812LP
2		BACK PANEL	1	HOFFMAN (OR EQUIV.)	A-60P48
3		KEYLOCK HANDLE	1	HOFFMAN (OR EQUIV)	PROVIDED W/ENCLOSURE
4	IL-1	LED INDICATOR LAMP, RED, 24 VDC	1	DIALIGHT	557-1505-203
5	MDM-1,3	MODEM, INDUSTRIAL, 33.6 KBAUD	2	SIXNET	VT-MODEM-1US
6	PS-2	POWER SUPPLY, SWITCHING, 120VAC INPUT, 12VDC/2A OUTPUT,	1	ENTRELEC	2.423.418.10
7	PS-1	BATTERY CHARGER, 120VAC INPUT, 24VDC OUTPUT, TWO ALARM OUTPUTS, U.L LISTED	1	STORED ENERGY SYSTEMS	FCA24-6-2211U
8	BAT-1,2	BATTERY, DYNASTY, SEALED, HIGH RATE, 12V, 50AH, FLAG TERMINAL	2	JOHNSON CONTROLS	UPS12-170FR
9		PLC BASE, 8 SLOT	2	PLC DIRECT	D4-08B-1
10	PLC-1	CPU, PROGRAMMABLE LOGIC CONTROLLER, 110 VAC POWER SUPPLY	1	PLC DIRECT	D4-450
11		PLC PROGRAMMING CABLE	1	PLC DIRECT	D2-DSCBL
12	PLC-2	PLC EXPANSION UNIT, 24VDC	1	PLC DIRECT	D4-EXDC
13		BASE EXPANSION CABLE, 0.5m	1	PLC DIRECT	D4-EXCBL-2
14	OI-1	TOUCHSCREEN OPERATOR INTERFACE, 10.5", COLOR TFT, 120VAC	1	TOTAL CONTROL PRODUCTS	ABI-21100-C2P/SER
15		INTERFACE CABLE, TOUCHSCREEN	1	TOTAL CONTROL PRODUCTS	HMI-CAB-C53
16	0I-2	LAMP ANNUNCIATOR PANEL, 24 LAMPS, (RED, GREEN, AND YELLOW)	1	PLC DIRECT	OP-1124-1
17		INTERFACE CABLE, ANNUNCIATOR PANEL	1	PLC DIRECT	OP-4CBL-1
18	FU-6	FUSE, 0.040A, FAST-ACTING, 5X20 MM	16	LITTELFUSE BUSS	217.040 GDB-40MA
19	DS-1	AC MANUAL MOTOR CONTROLLER, 30 AMP, 600V, DOUBLE POLE, WITH METAL TYPE 1 ENCLOSURE	1	HUBBELL (OR EQUIV.)	1372
20	SA-1	SURGE ARRESTOR, 120VAC, 5A	1	MCG ELECTRONICS	407
21		EQUIPMENT GROUND BAR	1	SQUARE D (OR EQUIV.)	PK18GTA
22	SW-1	KEY SWITCH	1	ALLEN BRADLEY	194L-E25-1751 194L-HCDG-001
23	SW-2	EMERGENCY STOP BUTTON, WITH GUARD	1	ALLEN BRADLEY	800T-FXT6D4 800T-N310 (GUARD)
24		BATTERY BRACKET	1	(BY VENDOR)	
25	TB-1,3,4,9	TERMINAL BLOCK, 600V RATED, #22-#8 AWG, .315" SPACING	100	ENTRELEC (OR PHOENIX)	M6/8 115 118.11
26		END STOPS, TERMINAL BLOCK	A/R	ENTRELEC	114 588.10
27		END SECTIONS	A/R	ENTRELEC	118 368.16
28		CIRCUIT SEPARATORS	A/R	ENTRELEC	114 825.05
29	SA-2	SURGE ARRESTOR, RADIO ANTENNA	1	POLYPHASER	IS-50NX-C2
30	RECPT	UTILITY POWER OUTLET, 120VAC RECEPTACLE	1	HUBBELL	5362
31		6"x6" VENTILATION OPENING WITH 16 GA FLATTENED EXPANDED METAL MESH WITH 3/4"X1/4" OPENINGS WITH FILTER. SECURELY FASTEN TO ENCLOSURE.	4	(BY VENDOR)	
32	FU-2	FUSE, 1A, TYPE T, SLO-BLO, (250V), 5x20MM	4	LITTELFUSE BUSS	239001 GMC-1A
33	FU-3	FUSE, 3A, TYPE T, SLO-BLO, (250V) 5x20MM	1	LITTELFUSE BUSS	239003 GMC-3A
34	FB-1,2	FUSE HOLDERS, RAIL MOUNTED, 5X20 MM	26	ENTRELEC	M4/8.SF 115 131.06

35		DIN RAIL	A/R	ENTRELEC (OR EQUIV.)	PR30 173 220.05
36		SLOTTED WALL DUCT, 2"W X 3"H, TYPE E WITH TYPE C COVER	A/R	PANDUIT (OR EQUIV.)	E2x3LG6W/C2LG6
37		ETCHED NAMEPLATE, NREL LOGO	1		
38	FU-1	FUSE, 6A, CLASS RK1, FAST ACTING, 250V	1	BUSS	KTN-R-6
39		FUSEHOLDER	1	BUSS	FR25030-1
40	TB-5	TERMINAL BLOCK, 600V RATED, #12 AWG	3	ENTRELEC	M618#11S 118.11
41		DEVICE BOX FOR RECEPTACLE	1	APPLETON OR EQ.	660
42		METAL DUPLEX RECEPTACLE COVER	1	APPLETON OR EQ.	FSK-1DR
43	FT-1	FREQUENCY TRANSDUCER, FIELD CONFIGURABLE SIGNAL CONDITIONER	1	ACTION INSTRUMENTS	AP7380
44		FILLER MODULE	1	PLC DIRECT	D4-FILL
45		BASIC CO-PROCESSOR MODULE	1	PLC DIRECT	F4-CP512-1
46		ETHERNET MODULE, FIBER OPTIC	1	PLC DIRECT	H4-ECOM-F
47	R-1	RESISTOR, POWER, 2500 OHM, 5W	1		
48	C-1	CAPACITOR, MOTOR RUN, 1.0 uF, 250 VAC	1		
49		16 CHANNEL ANALOG OUTPUT MODULE	1	PLC DIRECT	F4-16DA-2
50		DATA COMMUNICATION MODULE	2	PLC DIRECT	D4-DCM
51		4 CHANNEL ANALOG OUTPUT	1	PLC DIRECT	F4-04DA
52		8 PT. 12-30VDC OR 12-250 VAC RELAY OUTPUT MODULE	3	PLC DIRECT	F4-08TRS-2
53		16 PT. 12-24 VAC/DC INPUT MODULE	3	PLC DIRECT	D4-16NE3
54		8-CHANNEL ANALOG INPUT MODULE	1	PLC DIRECT	F4-08AD
55	FU-4	FUSE, 1A, FAST-ACTING, 250V, 5x20MM	8	LITTELFUSE BUSS	235001 GMA-1A
56	FU-5	FUSE, 10A, FAST-ACTING, 125V, 5x20MM	1	LITTELFUSE BUSS	217010 GMA-10A
57	PS-3	INVERTER, 24VDC INPUT, 115VAC/60HZ OUTPUT, 250 WATT	1	STATPOWER TECHNOLGIES CORPORATION	PROWATT 250/24
58	TB-2	FUSE BLOCK, DOUBLE DECK, 5X20 MM FUSE	16	ENTRELEC	M 4/8.D2.SF 115 604.21
59		SHIELDING CONNECTOR, FUSE BLOCK	16	ENTRELEC	CBD2S 178 408.14
60	MDM-2	RADIO MODEM, SPREAD SPECTRUM, 900 MHZ, CSMA PROTOCOL	1	UC WIRELESS	ISM900-4C297
61	VT-1	VOLTAGE TRANSDUCER, AC, 0-150 VAC INPUT, 4-20MA OUTPUT, 120VAC POWER SUPPLY	1	OHIO SEMITRONICS	VT-120E
62	FU-7	FUSE, 250 MA, TIME DELAY, 250V, 5x20MM	1	LITTELFUSE BUSS	239.250 GMD-250MA
63		4-CHANNEL ANALOG INPUT MODULE, ISOLATED	2	PLC DIRECT	F4-04ADS
64	IL-2,3,4	INDICATOR LAMP, AMBER, 24VDC	3	DIALIGHT	556-1304-304
65	WRN-1	SONALERT SIGNAL, 90 DB, 24 VDC, PANEL MOUNT	1	MALLORY	SC628AN



VIEW OF BACK PANEL WITHIN ENCLOSURE

NOTES:

1. RADIO MODEM (ITEM 60) MOUNTED ON LEFT INTE

No.	Date	Description	By
2	8/15/01	ADDED VT-1, MDM-3, PS-2, FB-3, TB-10	SD
		REVISED PLC MODULE NUMBERING	
1	8/31/99	AS BUILT CONFIGURATION	SD

Revisions

Drawn By: S. DROUILHET — Date: 7/27/98
Engineer
Checked By
Approved By

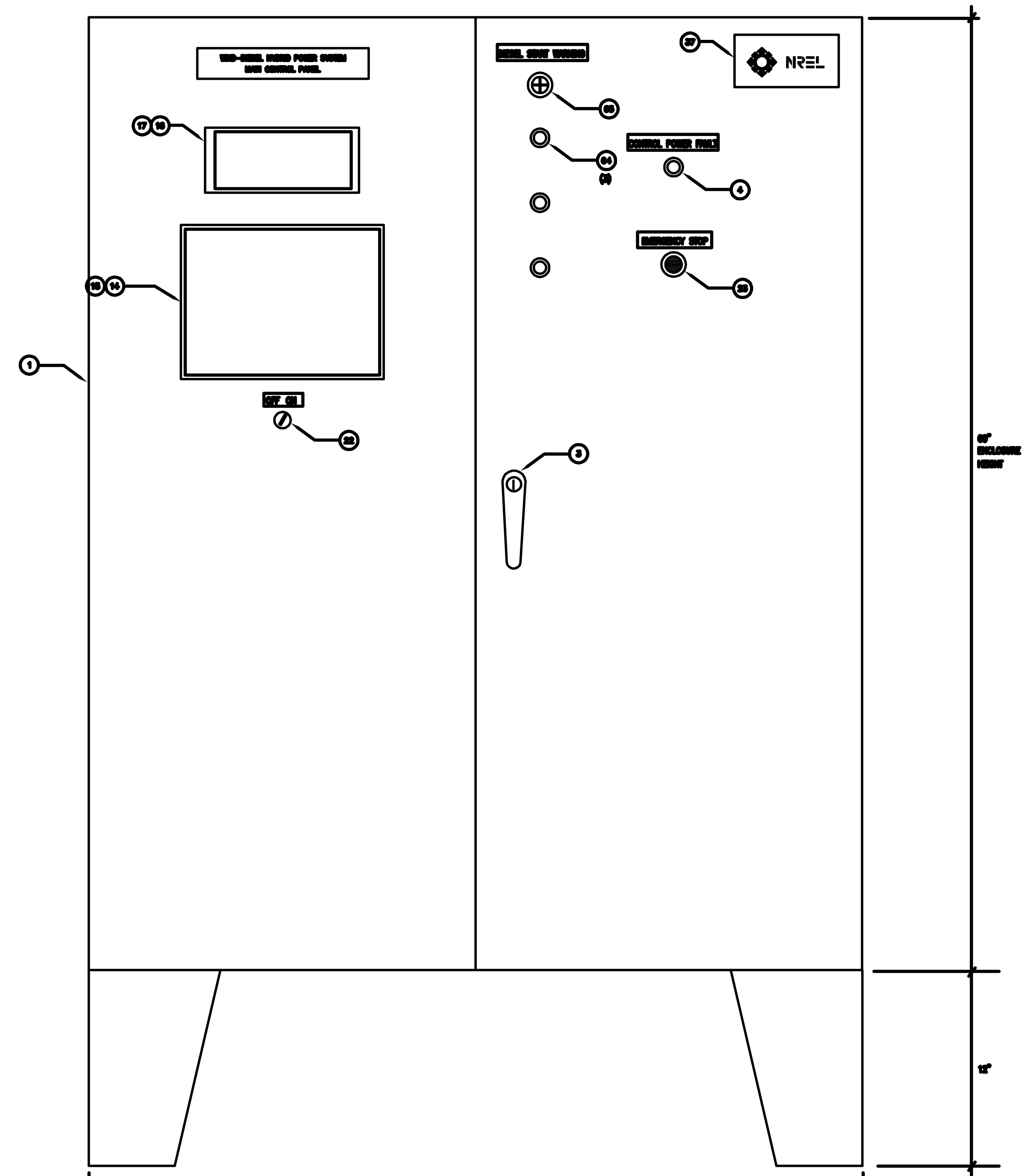
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401
Operated for the
U.S. Department of Energy
by Midwest Research Institute

Sheet Title
WALES WIND-DIESEL SYSTEM
WIND-DIESEL CONTROL PANEL
PANEL ASSEMBLY

Work Request Number
Drawing Number: NWTC-SD-0008
Sheet Number: 2 OF 2
Sequence Number: REV. 2

FORM: ZBD2234D.DWG-0

FILE NAME:
AUTOCAD VERSION:
INITIALS:
DATE:
PLOT INFO
TIME:
PLOT SCALE:
STATION:



FRONT VIEW OF PANEL EXTERIOR

NOTES:

1. REFER TO SEPARATE PARTS LIST NWTC-SD-0008-PL.

No.	Date	Description	By
3	8/28/01	ADDED ITEMS 64 AND 65	SD
2	9/3/98	REVISED WORDING OF ITEM 4 LABEL.	SD
1	8/3/98	ADDED ITEM 4	SD

Revisions

Drawn By S. DROUILHET Date 7/24/98
Engineer
Checked By
Approved By

National Renewable Energy Laboratory
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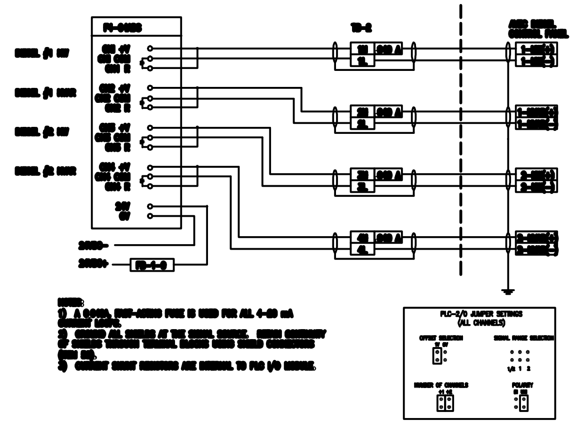
Operated for the
U.S. Department of Energy
by Midwest Research Institute

Sheet Title
WALES WIND-DIESEL SYSTEM
WIND-DIESEL CONTROL PANEL
PANEL ASSEMBLY

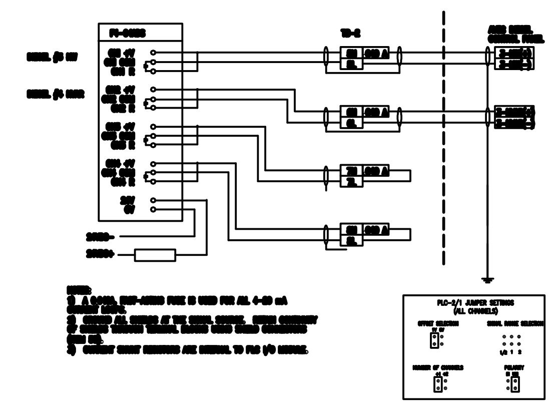
Work Request Number
Drawing Number NWTC-SD-0008
Sheet Number 1 OF 2
Sequence Number REV. 3

FORM: ZBD2234D.DWG-0

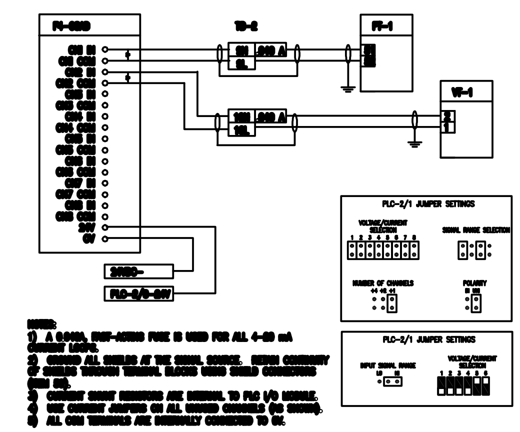
FILE NAME:
AUTOCAD VERSION:
INITIALS: DATE:
PLOT INFO: TIME:
PLOT SCALE: STATION:



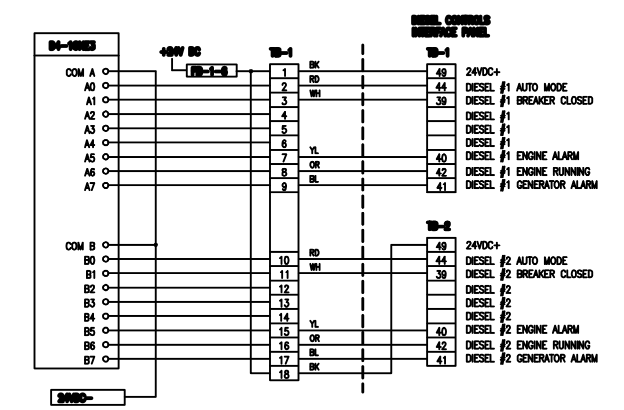
PLC-2/0 ISOLATED ANALOG INPUTS
(X0-X17)



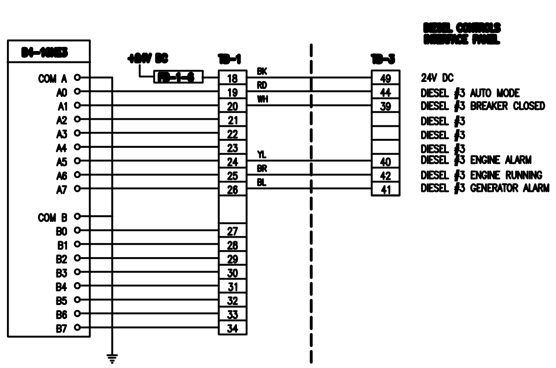
PLC-2/1 ISOLATED ANALOG INPUTS
(X20-X37)



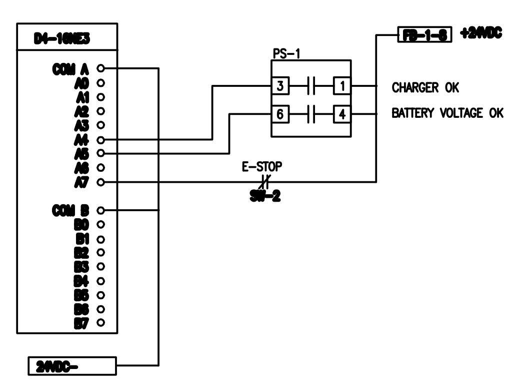
PLC-2/2 ANALOG INPUTS
(X40-X57)



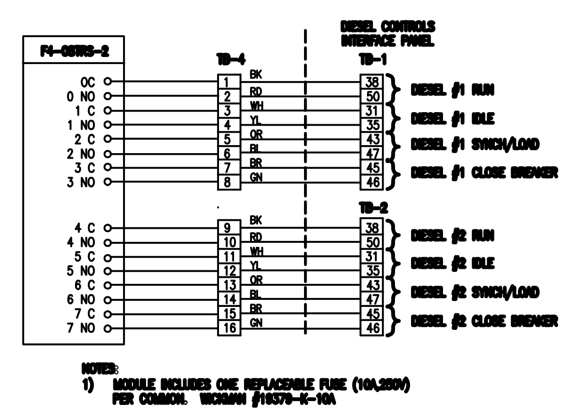
PLC-2/3 DIESEL DIGITAL INPUTS
(X60-X77)



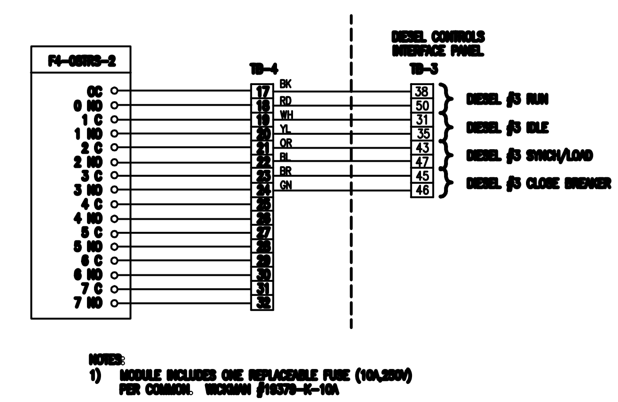
PLC-2/4 DIESEL DIGITAL INPUTS
(X100-X117)



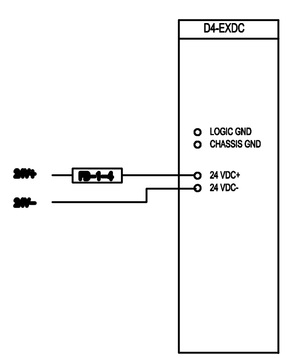
PLC-2/5 DIGITAL INPUTS
(X120-X137)



PLC-2/6 DIGITAL OUTPUTS
(Y70-Y77)



PLC-2/7 DIGITAL OUTPUTS
(Y100-Y107)



PLC-2/CPU PLC EXPANSION UNIT

No.	Date	Description	By
8	10/25/01	REVISED ANALOG INPUT NOTES.	SD
7	3/21/01	ISOLATED INPUTS IN 2/0 & 2/1. MOVED F4-08AD TO 2/2. REVISED DIESEL OUTS.	SD
6	8/24/01	ADDED DIESEL INTERFACE DETAILS. DELETED LOCAL DL WIRING ON 2/5.	SD

Revisions

S. DROUILHET — Drawn By
5/18/98 — Date
Engineer
Checked By
Approved By

National Renewable Energy Laboratory
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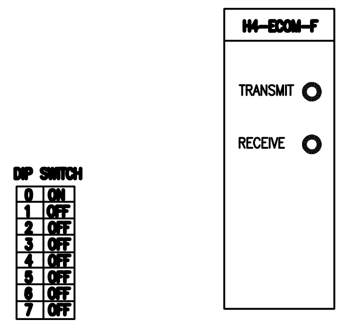
Golden, Colorado 80401
Operated for the
U.S. Department of Energy
by Midwest Research Institute

Sheet Title
WALES WIND-DIESEL SYSTEM
WIND-DIESEL CONTROL PANEL
CONTROL WIRING DIAGRAM

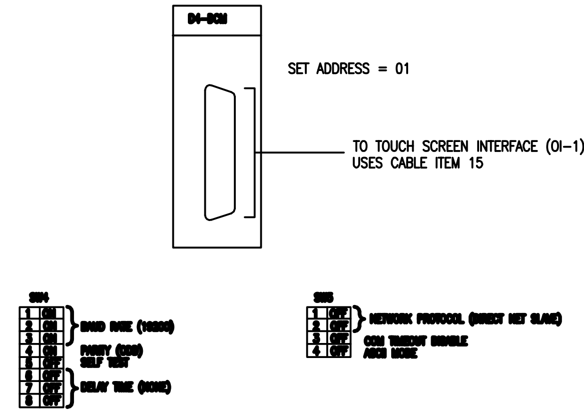
Work Request Number
Drawing Number: NWTC-SD-0007
Sheet Number: 2 OF 2
Sequence Number: REV. 8

FORM: ZBD2234D.DWG-0

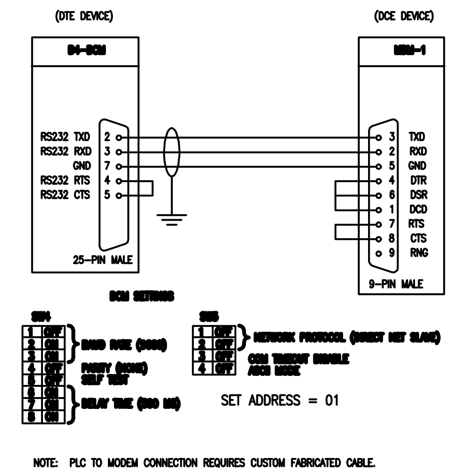
FILE NAME:
AUTOCAD VERSION:
INITIALS:
DATE:
PLOT INFO
TIME:
PLOT SCALE:
STATION:



PLC-1/0 ETHERNET MODULE
(WDCP-TO-RCCC COMMUNICATIONS)

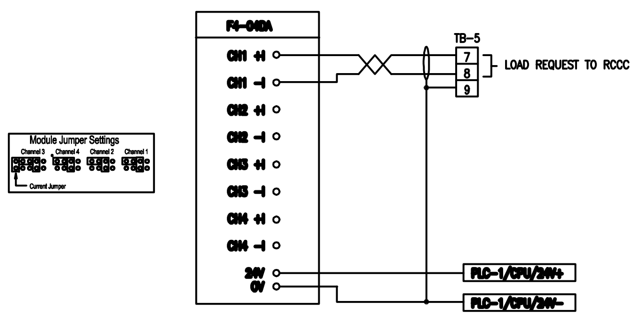


PLC-1/1 INTERFACE TO TOUCH SCREEN OPERATOR INTERFACE
(DATA COMMUNICATIONS MODULE)



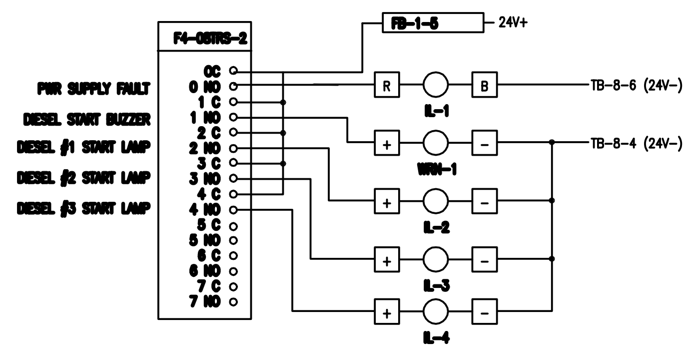
PLC-1/2 REMOTE PC MODEM INTERFACE
(DATA COMMUNICATIONS MODULE)

PLC-1/3 FILLER MODULE



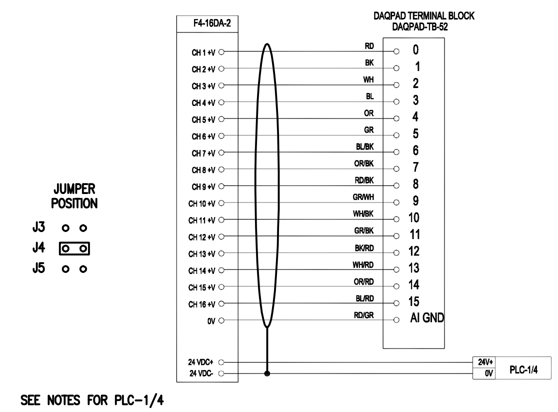
1) SHIELDS SHOULD BE CONNECTED TO 0V TERMINAL OF THE MODULE.
2) UNUSED OUTPUT CHANNELS SHOULD REMAIN OPEN.
3) ALL -V TERMINALS INTERNALLY CONNECTED TO 0V.
4) ALL +I TERMINALS INTERNALLY CONNECTED TO 24V.

PLC-1/4 ANALOG OUTPUTS
(Y0-Y17)

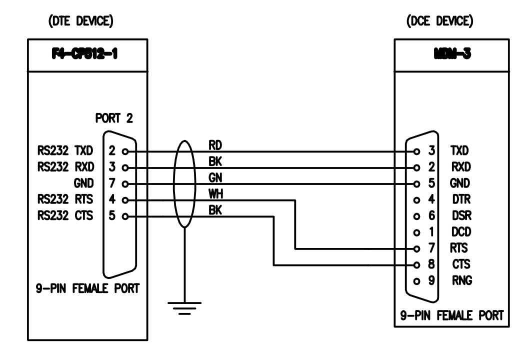


NOTES:
1) MODULE INCLUDES ONE REPLACEABLE FUSE (10A,250V) PER COMMON. WICKMAN #19379-K-10A

PLC-1/5 DIGITAL OUTPUTS
(Y20-Y27)

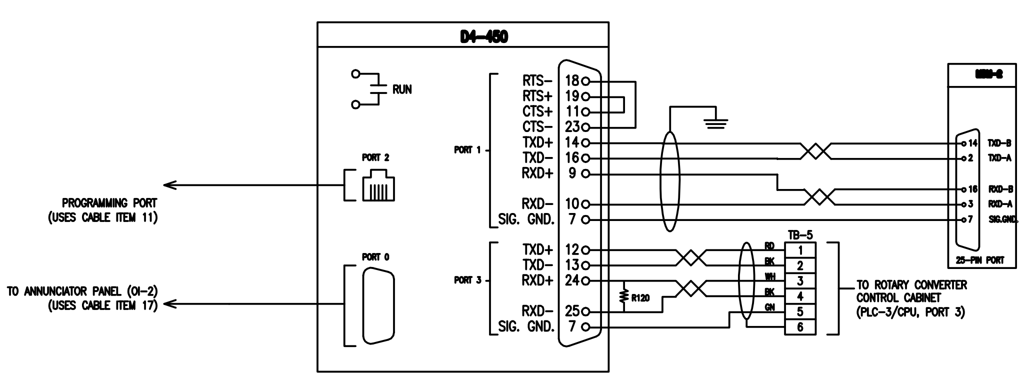


PLC-1/6 ANALOG OUTPUTS
(USED FOR DIAGNOSTICS ONLY)
(Y30-Y67)



NOTES:
1) JUMPER BOTH PORT 1 (J9) AND PORT 2 (J8) FOR RS-232.
2) REMOVE "CLEAR ALL" JUMPER (J10).

PLC-1/7 DATALOGGING TELEPHONE COMMUNICATION
(BASIC CO-PROCESSOR MODULE)



PLC-1/CPU CPU MODULE

NOTES:

1. ALL CONTROL WIRING TO BE 16 AWG UNLESS SPECIFIED OTHERWISE.

2. ALL WIRING FROM PLC MODULES IS WIRED TO RIGHT HAND SIDE OF TERMINAL OR FUSE BLOCKS. ALL SIGNALS TO OR FROM EXTERIOR OF CABINET ARE WIRED TO LEFT SIDE OF TERMINAL OR FUSE BLOCKS.

3. ALL WIRES TO BE LABELED AT BOTH ENDS WITH SOURCE AND DESTINATION DESIGNATIONS. FOR EXAMPLE, THE END OF THE WIRE CONNECTED TO TERMINAL #1 OF PLC-1/4 IS TO BE LABELED "PLC-1/4-1 TO SA-4-C".

4. THE PORT 3 RS-485 LINK TO THE ROTARY CONVERTER CONTROL CABINET IS PROVIDED AS A BACKUP IN CASE OF FAILURE OF THE ETHERNET LINK (PLC-1/0). IT IS NOT USED IN NORMAL OPERATION.

No.	Date	Description	By
12	10/25/01	REVISED MODULE NOTES, 1/5 WIRING.	
11	9/5/01	CHANGED PLC-1/7 DETAIL	SD
10	8/28/01	ADDED DIESEL START WARNINGS	SD
9	?	?	SD
8	9/7/00	ADDED CABLING DETAIL FOR MDM-2	SD
7	8/11/00	REVISED 1/2 WIRING. DELETED SLICE.	SD
6	5/12/00	ADDED MODULES 1/0 AND 1/6.	SD

Revisions

Drawn By: S. DROUILHET Date: 6/9/98
Engineer
Checked By
Approved By

National Renewable Energy Laboratory
1617 Cole Boulevard
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Operated for the
U.S. Department of Energy
by Midwest Research Institute

Sheet Title
WALES WIND-DIESEL SYSTEM
WIND-DIESEL CONTROL PANEL
CONTROL WIRING DIAGRAM

Work Request Number
Drawing Number: NWTC-SD-0007
Sheet Number: 1 OF 2
Sequence Number: REV. 12

FORM: ZBD2234D.DWG-0

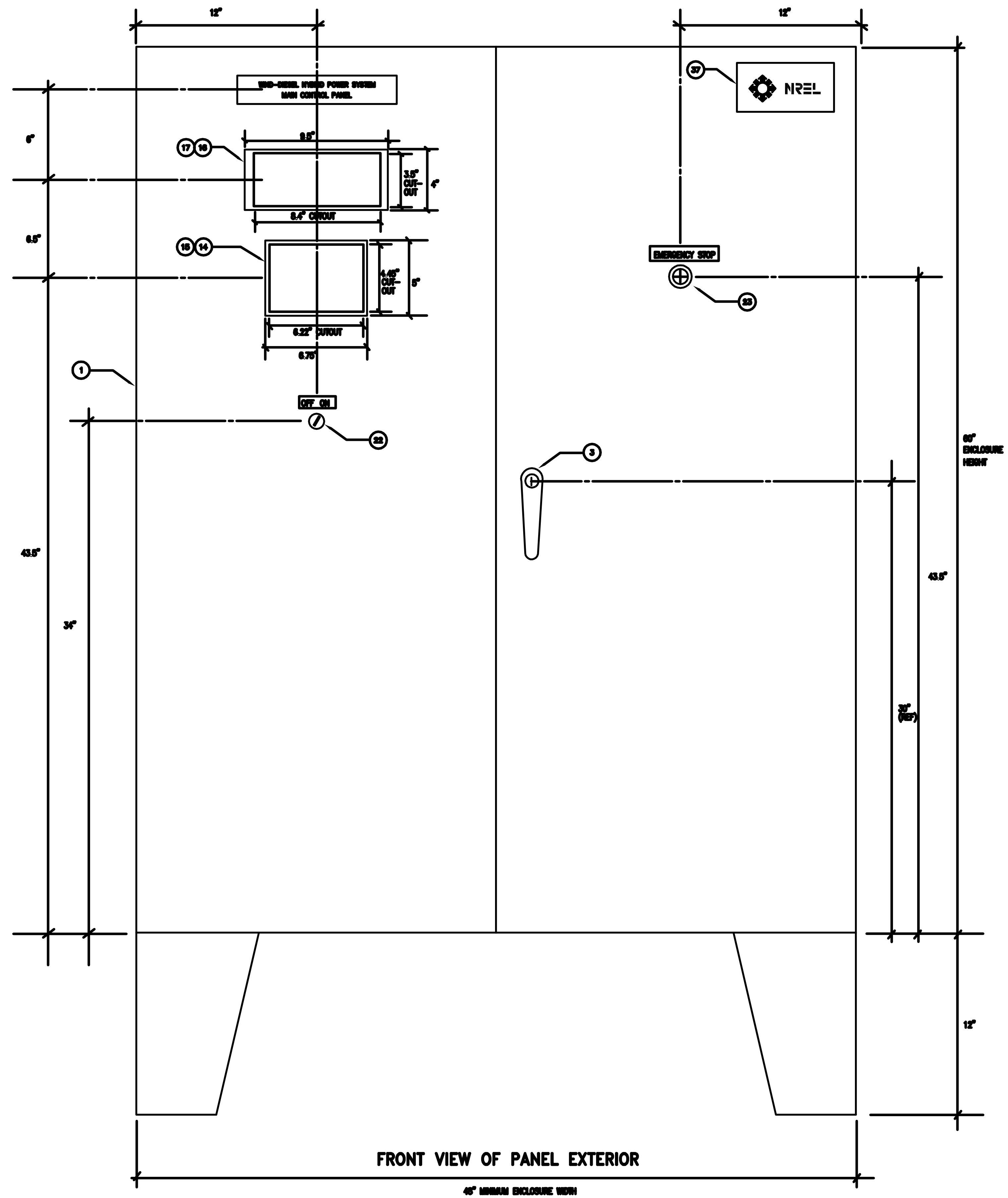
PLOT SCALE:
PLOT INFO:
FILE NAME:
AUTOCAD VERSION:

MATERIALS LIST FOR WIND-DIESEL HYBRID SYSTEM CONTROL PANEL

ITEM	KEY	DESCRIPTION	QTY.	MANUFACTURER	PART NUMBER
1		ENCLOSURE, TYPE 12, TWO DOOR	1	HOFFMAN (OR EQUIV.)	A-604812LP
2		BACK PANEL	1	HOFFMAN (OR EQUIV.)	A-60P48
3		KEYLOCK HANDLE	1	HOFFMAN (OR EQUIV)	PROVIDED W/ENCLOSURE
4	PS-2	DC/DC CONVERTER, 200W, 300VDC INPUT, 28 VDC OUTPUT	1	VICOR	VI-L6L-CU
5					
6		THERMAL GASKET, GRAFOIL, STANDARD	1	VICOR	01777
7	PS-1	POWER SUPPLY,115V AC INPUT, 300VDC OUTPUT, 250W	1	VICOR	VI-FKE6-CUX
8	BAT-1,2	BATTERY, DYNASTY, SEALED, HIGH RATE, 12V, 50AH, FLAG TERMINAL	2	JOHNSON CONTROLS	UPS12-170FR
9		PLC BASE, 8 SLOT	2	PLC DIRECT	D4-08B
10	PLC-1	CPU, PROGRAMMABLE LOGIC CONTROLLER	1	PLC DIRECT	D4-440DC-1
11		MEMORY CARTRIDGE, EPROM, 15.5K	1	PLC DIRECT	D4-EE2
12	PLC-2	PLC EXPANSION UNIT, 24VDC	1	PLC DIRECT	D4-EXDC
13		BASE EXPANSION CABLE, 0.5m	1	PLC DIRECT	D4-EXCBL-2
14	OI-1	TOUCHSCREEN OPERATOR INTERFACE, 5", COLOR, 24VDC	1	TOTAL CONTROL PRODUCTS	QSJ-2D100-S2P
15		INTERFACE CABLE, TOUCHSCREEN	1	TOTAL CONTROL PRODUCTS	HMI-CAB-C53
16	OI-2	LAMP ANNUNCIATOR PANEL, 24 LAMPS, (RED, GREEN, AND YELLOW)	1	PLC DIRECT	OP-1124-1
17		INTERFACE CABLE, ANNUNCIATOR PANEL	1	PLC DIRECT	OP-4CBL-1
18		FUSE, 0.032A, SERIES 217, FAST-ACTING, 5X20 MM	16	LITTELFUSE	217.032
19	DS-1	AC MANUAL MOTOR CONTROLLER, 30 AMP, 600V, DOUBLE POLE, WITH METAL TYPE 1 ENCLOSURE	1	HUBBELL (OR EQUIV.)	1372
20	SA-1	SURGE ARRESTOR, 120VAC, 5A	1	MCG ELECTRONICS	407
21		EQUIPMENT GROUND BAR	1	SQUARE D (OR EQUIV.)	PK18GTA
22	SW-1	KEY SWITCH	1	ENTRELEC	ECC 622/455
23	SW-2	EMERGENCY STOP BUTTON, WITH GUARD	1	ALLEN BRADLEY	800T-FXT6D4 AND 800T-N310 (GUARD)
24		BATTERY BRACKET	1	(BY VENDOR)	
25	TB-1,2,3 4,5	TERMINAL BLOCK, 600V RATED, #22-#8 AWG, .315" SPACING	103	ENTRELEC (OR PHOENIX)	M6/8 #115 118.11
26		END STOPS, TERMINAL BLOCK	A/R	ENTRELEC	114 598.10
27		END SECTIONS	A/R	ENTRELEC	118 368.16
28		CIRCUIT SEPARATORS	A/R	ENTRELEC	114 825.05
29		SURGE ARRESTOR, DATA PU5-200, 5 VOLT	4	ENTRELEC	008 029.04
30	RECPT	UTILITY POWER OUTLET, 120VAC RECEPTACLE	1	HUBBELL	5362
31		6"x6" VENTILATION OPENING WITH 16 GA FLATTENED EXPANDED METAL MESH WITH 3/4"X1/4" OPENINGS WITH FILTER. SECURELY FASTEN TO ENCLOSURE.	4	(BY VENDOR)	
32		FUSE, 1A, TYPE T, SLO-BLO, (250V), 5x20MM	6	LITTELFUSE	239001
33		FUSE, 3A, TYPE T, SLO-BLO, (250V) 5x20MM	2	LITTELFUSE	239003
34	FB-1 TB-2	FUSE HOLDERS, RAIL MOUNTED, 5X20 MM	24	ENTRELEC	M4/8.SF-115 131.06
35		DIN RAIL	A/R	ENTRELEC (OR EQUIV.)	PR30-173 220.05
36		SLOTTED WALL DUCT, 2"W X 3"H, TYPE E WITH TYPE C COVER	A/R	PANDUIT (OR EQUIV.)	E2x3LG6W/C2LG6
37		ETCHED NAMEPLATE, NREL LOGO	1	FURN BY NREL.	
38	FU-1	FUSE, 5A	1	BUSS	FRN-R-5
39		FUSEHOLDER	1	BUSS	FR25030-1
40					
41		DEVICE BOX FOR RECEPTACLE	1	APPLETON OR EQ.	680
42		METAL DUPLEX RECEPTACLE COVER	1	APPLETON OR EQ.	FSK-1DR
43	FT-1	FREQUENCY TRANSDUCER, 55-65 HZ, 4-20 MA OUTPUT	1	OHIO SEMITRONICS	FT-080E
44		INTERRUPT INPUT MODULE	1	PLC DIRECT	D4-INT
45		BASIC CO-PROCESSOR MODULE	1	PLC DIRECT	F4-CP123-T
46		SLICE I/O MASTER MODULE	1	PLC DIRECT	D4-SM
47		REMOTE I/O MASTER	1	PLC DIRECT	D4-RM
48		PID COPROCESSOR MODULE	1	PLC DIRECT	D4-16PID
49		HIGH SPEED COUNTER MODULE	1	PLC DIRECT	D4-HSC
50		DATA COMMUNICATION MODULE	2	PLC DIRECT	D4-DCM
51		4 CHANNEL ANALOG OUTPUT	1	PLC DIRECT	F4-04DA
52		8 PT. 12-30VDC OR 12-250 VAC RELAY OUTPUT MODULE	1	PLC DIRECT	F4-08TRS-2
53		16 PT. 12-24 VAC/DC INPUT MODULE	3	PLC DIRECT	D4-16NE3
54		8-CHANNEL ANALOG INPUT MODULE	2	PLC DIRECT	D4-08AD
55	J-1	D-SUB CONNECTOR, RECEPTACLE, SOLDER TYPE, 9-PIN	1	WPI (OR EQ.)	17-10090
56		D-SUB CABLE CLAMP ASSEMBLY, SHELL SIZE E/9	1	WPI (OR EQ.)	17-310-01
57		END STOPS, TERMINAL BLOCK	2	ENTRELEC (OR PHOENIX)	BAM 103 002.26
58		END SECTIONS	2	ENTRELEC (OR PHOENIX)	FEM6S-118 624.27
59		END STOPS, TERMINAL BLOCK	2	ENTRELEC (OR PHOENIX)	FEM6S-118 624.128

NOTES:

1 EQUIPMENT CUT-OUTS ARE APPROXIMATE DIMENSIONS. MANUFACTURER TO VERIFY EXACT DIMENSIONS OF EQUIPMENT BEING PURCHASED.
2 INSTALL BATTERIES WITH TERMINALS UPWARD.
3 ON TB-2, ALTERNATE ITEMS 25 AND 34, I.E. INTERSPERSE FUSE BLOCKS AND ORDINARY TERMINALS.
4 ON EACH TERMINAL BLOCK, NUMBER EACH TERMINAL CONSECUTIVELY, STARTING WITH #1 AT THE TOP.



FRONT VIEW OF PANEL EXTERIOR

48" MINIMUM ENCLOSURE WIDTH

No.	Date	Description	By

Revisions

Drawn By: TCK — Date: 1/10/97
Engineer: TCK — 1/10/97
Checked By: S.DROUILHET — 1/10/97
Approved By: S.DROUILHET — 1/10/97

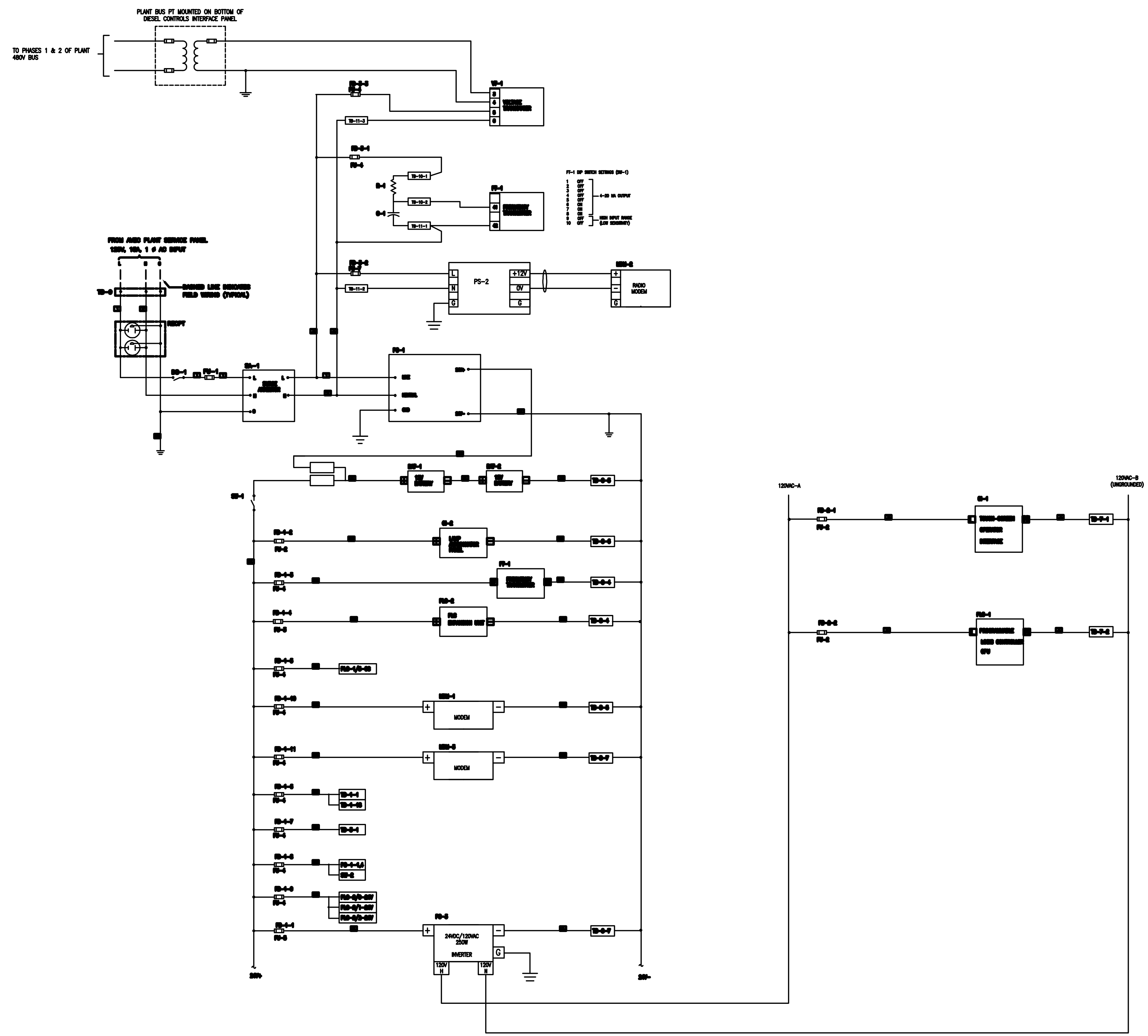
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401
Operated for the
U.S. Department of Energy
by Midwest Research Institute

Sheet Title
WIND DIESEL
HYBRID CONTROL PANEL
FRONT LAYOUT

Work Request Number: W41798
Drawing Number: E-PN-200-09
Sheet Number: 2 OF 2
Sequence Number: 6

FORM: ZBD2234D.DWG-0

FILE NAME: G:\NWTC\WINDCNTL2\EPN2009.DWG
AUTOCAD VERSION: V13 PLOT INFO: ELMOND.CEP PLOT SCALE: 1=1
INITIALS: TCK DATE: 1/7/97 TIME: . STATION: .



WIRING KEY

#	CONDUCTOR - COLOR CODING
1	#12 CU MTW BLACK – 120VAC HOT
2	#12 CU MTW WHITE – 120VAC NEUTRAL
3	#14 CU MTW BLACK – 120VAC HOT
4	#14 CU MTW WHITE – 120VAC NEUTRAL
5	#12 CU MTW, BLUE/WHITE (24VDC–)
6	#12 CU MTW, BLUE (24VDC+)
7	INTERFACE CABLE, ANNUNCIATOR PANEL
8	INTERFACE CABLE, TOUCHSCREEN
9	PLC BASE EXPANSION CABLE
10	#12 CU MTW GREEN – GROUND
11	#16 CU MTW, BLUE/WHITE (24VDC–)
12	#16 CU MTW, BLUE (24VDC+)

[X] WIRING TYPE REFERENCE WIRING KEY THIS SHEET.

No.	Date	Description	By
11	1/30/02	CORRECTED LABELING OF FT-1	SD
10	10/25/01	ADDED 24V- TERMINAL BLOCK NOS.	SD
9	9/4/01	ADDED MDM-3	SD
8	3/12/01	ADDED PLANT BUS P.T.	SD
7	3/12/01	AS INSTALLED	SD
6	8/15/00	ADDED VT-1. REVISED FUSE LABELING.	SD
5	5/12/00	ADDED PS-2 AND MDM-2 ADDED RC FILTER FOR FT-1	SD

Revisions

S. DROUILHET — Drawn By — Date: 6/8/98

Engineer

Checked By

Approved By

National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401

Operated for the
U.S. Department of Energy
by Midwest Research Institute

Sheet Title
WALES WIND-DIESEL SYSTEM
WIND-DIESEL CONTROL PANEL
POWER WIRING DIAGRAM

Work Request Number

Drawing Number: NWTC-SD-0009

Sheet Number

Sequence Number: REV. 11

FORM: ZBD2234D.DWG-0

PLOT SCALE:
STATION:
PLOT INFO:
TIME:
FILE NAME:
AUTOCAD VERSION:
DATE:
INITIALS:

Appendix D

Wind Energy Workbook

Elementary School Curriculum

Wind Power

A Resource Booklet for
Middle and High School Teachers

Teacher's Guide to Using
The Wind Power Resource Materials

Introduction

This binder contains basic student readings on the history of wind energy and the math and science used in designing wind turbines. It also contains exercises, model plans and some other reference materials you may find useful in identifying appropriate additional readings or activities for students.

The core materials in this binder, "Wind Power: A Brief History," "Wind Power: Math, Science and Technology," and the model plans were originally created by Rollin Tait for Green Mountain Power in Vermont. Green Mountain Power gave Kotzebue Electric Association permission to adapt the materials for use in Alaska. The first KEA draft of these materials, produced in 2000, was slightly updated in 2007.

Before using these materials, you may find it useful to have students review some of the standard curriculum materials available regarding electricity and magnetism. Such a review may help students understand the material presented here, which does not go into how electricity is produced, focusing instead on how wind energy is captured. While each section may be used as a stand-alone piece, students will likely find it motivating to read the history section first before tackling the formulas in the math and science section.

Please consider this binder a start, and a place to organize additional information you may want to gather or develop for teaching about wind power.

Summary of Binder Contents

A short summary of what is behind each tab in this binder is listed below, as is a review of which State of Alaska curriculum standards may be met through using these materials.

Section A: Wind Power: A Brief History. This section contains reading material that can be copied as a stand-alone section for a student handout. It reviews the uses people have made of wind power since ancient times and how technology for harnessing wind energy has changed and developed. It ends with a focus on the status of wind power generation in Alaska. It is followed by a tab behind which you can store exercises you may develop for this section.

Section B: Wind Power: Math, Science and Technology. This section contains reading material that can be copied as a stand-alone section for a student handout. It reviews how winds are created, how geographic features and obstacles affect wind power, the relationship between wind power and wind speed, how to calculate the amount of power in the wind, and some of the basic features and calculations that go into designing rotors which are used to capture wind power.

Glossary: Definitions of some wind power terms.

Model Plans: Model plans compiled by Rollin Tait for the original Green Mountain Power version of this curriculum material. Students can use these plans to create different types of rotors.

Wind at Work Activities. Copies of few of the exercises and activities included in Gretchen Woelfe's excellent book "The Wind at Work." You may wish to purchase a copy of this book.

Web and Other Resources: There are tremendous educational resources available through the Internet. A number of websites have basic background information about wind power. Government, industry association and turbine manufacturer sites provide a great deal more detail about the matters covered in the readings that are included in this binder. Information is available about energy economics, marketing and other matters not covered here. Behind this tab, find:

- A listing of some of the major Web sites with information about wind power
- The bibliography for the original Green Mountain Power materials

Alaska Education Standards

In 2000, a former teacher and developer of middle school science curriculum materials reviewed the materials in this binder and suggested they had, at that time, the potential to address the following Alaska Education Standards:

Math A2: Select and use appropriate systems, units, and tools of measurement, including estimation.

Math A4: Represent, analyze and use mathematical patterns, relations, and functions using methods such as tables, equations, and graphs.

Math B1: Use computational methods and appropriate technology as problem-solving tools.

Math B2: Use problem solving to investigate and understand mathematical content.

Math C1: Express and represent mathematical ideas using oral and written presentations, physical materials, pictures, graphs, charts, and algebraic expressions.

Math C2: Relate mathematical terms to everyday language.

Math E1: Explore problems and describe results using graphical, numerical, physical, algebraic, and verbal mathematical models or representations.

Math E3: Use mathematics in other curriculum areas.

Science A5: Understand the strength and effects of forces of nature, including gravity and electromagnetic radiation (Forces of Nature).

Section A6: Understand that forces of nature cause different types of motion and describe the relationship between these forces and motion (Motion).

Science A15: Use science to understand and describe the local environment (Local Knowledge).

Science SB2: Design and conduct scientific investigations using appropriate instruments.

Science C3: Understand that society, culture, history, and environment affect the development of scientific knowledge.

Science D3: Recommend solutions to everyday problems by applying scientific knowledge and skills.

Geography E1: Understand how resources have been developed and used.

History D6: Create new approaches to issues by incorporating history with other disciplines, including economics, geography, literature, the arts, science and technology.

Wind Power:
A Brief History

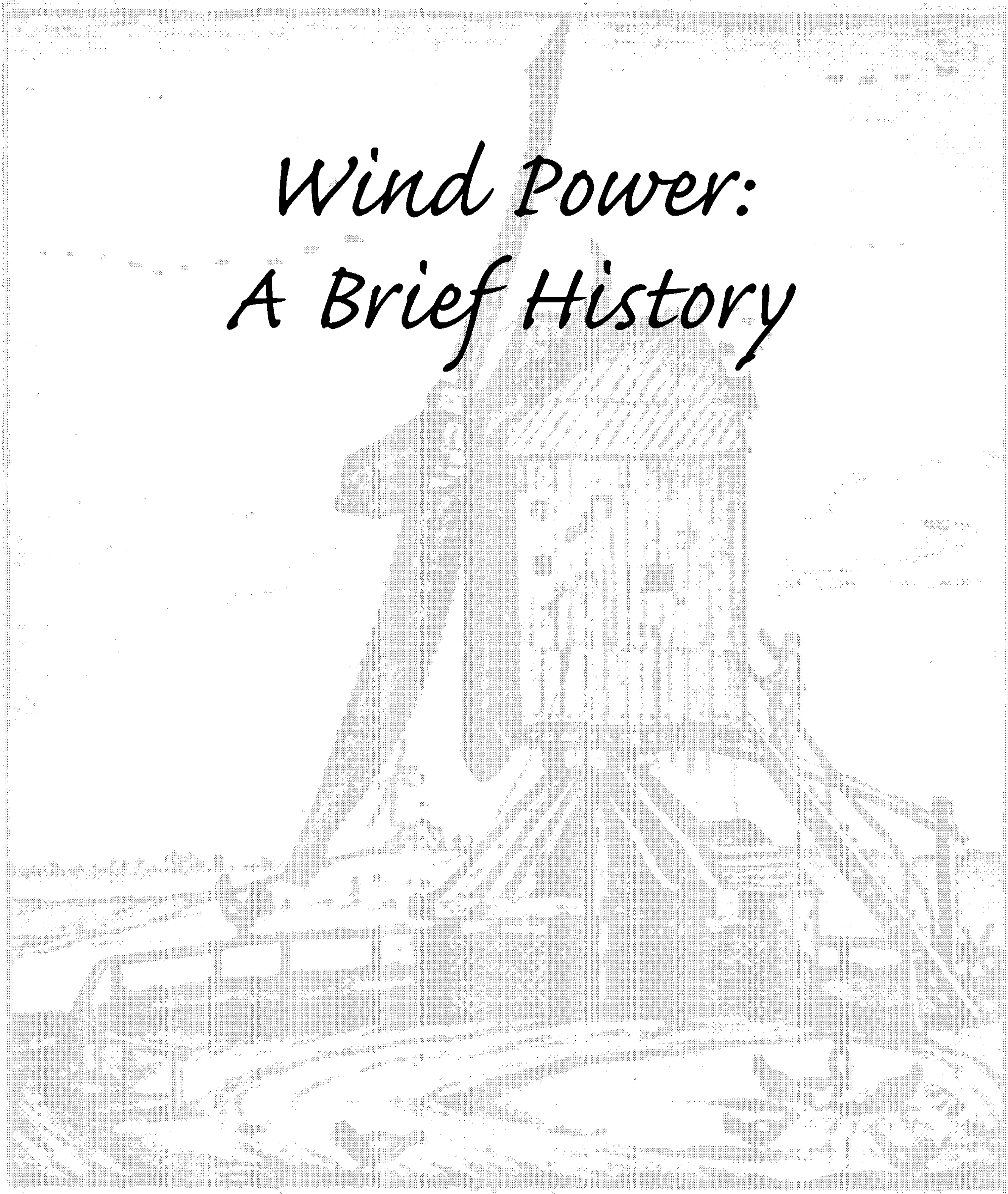


TABLE OF CONTENTS

TABLE OF CONTENTS – continued

WIND POWER HISTORY TIMELINE

Year	Event
Pre 2000 BC	Sails and kites are in common use throughout Eurasia.
2000 BC	The Persian windmill is developed in the Middle East. The Chinese Clapper windmill is developed in Asia.
500 AD	The Persian windmill is brought to Europe. The Cretan windmill is developed in the Middle East.
1000 AD	The Cretan windmill design spreads across Europe.
1200 AD	The low-land European countries developed the Post and Cap windmills to do a wide variety of work.
1600 AD	Shuttered wooden blades replace cloth on windmills.
1750's	Englishman John Smeaton conducted the first scientific research on wind power and windmill design.
1750 - 1850	The Industrial Revolution transforms everyday life. Coal-fired steam power becomes the dominant power Source. Windmill use and research stagnates.
1870 - 1900	Electric generators, motors and lights are perfected. The internal combustion engine is invented. The first hydroelectric dam is built.
1865 - 1950's	Mechanical, modern-design wind powered water-pumps are widely used in the American west.

WIND POWER HISTORY TIMELINE

Year	Event
1890's	Dane P. La Cour researches modern windmill design.
1910 - 1945	The first generation of large-scale wind turbine generators are built in numerous countries. Small-scale stand-alone wind turbine generators were widely used in rural USA, especially the west.
1910's	The Danes build the first large-scale wind turbines.
1920's	The Savonius and Darrieus rotors are invented.
1937	The Rural Electrification Act establishes national Electricity grids eliminating the market for small wind turbines.
1941 - 1945	Grandpa's Knob turbine operates at Rutland, VT, USA.
1973 and 1980	Oil shortage crises stimulate development of alternative energy sources: solar, wind, hydro, biomass.
1980 - 1990	The second generation of large-scale wind turbine generators are built in the USA and western Europe.
1980's	Experimental stand-alone turbines are installed separate from utility systems in Alaska. Most fail quickly.
1990's	New legislation, government subsidies, improved designs and rising oil prices make wind-generated electric power cost competitive with traditional energy sources. The third generation of large-scale wind turbine generators are built in increasing numbers.

WIND POWER HISTORY TIMELINE – continued

Year	Event
1997	Kotzebue Electric Association (KEA) installs three Entegrity Wind Systems 15/50 turbines at Alaska's first utility-run wind energy farm.
1998	225 kW turbine installed on St. Paul island to serve Tanadgusix Corporation commercial complex.
1999	KEA installs seven additional Entegrity 15/50 turbines bringing its wind farm to 10 turbines and installed capacity of 660 kW.
2000	Wordwide installed wind energy generation capacity reaches 17,300 megawatts.
	KEA installs two Entegrity 15/50 turbines at Wales, Alaska with a total capacity of 132 kW.
2002	KEA installs one Northern Power Systems 100 kW Northwind 100 turbine.
2003	Alaska Village Electric Cooperative (AVEC) installs four Entegrity 15/50 turbines in Selawik, Alaska with a total capacity of 264 kW.
2005	KEA installs two additional Entegrity 15/50 turbines.
2006	KEA installs two additional Entegrity 15/50 turbines and one Vestas E-15 turbine at Kotzebue.
	Alaska Village Electric Cooperative (AVEC) installs three Northern Power Systems Northwind 100 turbines at Toksook Bay with a total capacity of 300 kW.
2007	KEA installs one additional Entegrity 15/50 turbine at Kotzebue for a total of 17 turbines and 1155 kW capacity, the first Alaska wind farm over one megawatt.

Chapter 1–Ancient History (up to 1200 AD)

People all over the world have been harnessing the power of the wind for a very long time – 4 millennium at least (since about 2000 BC). Many machines have been created to make use of the power of the wind. Some of these devices are for work, others are just for fun. This booklet will introduce you to some of these wind machines and to the people who made them.

Key Ideas in this Chapter

- ***The power in the wind can be harnessed to do work.***
- ***Early uses included transportation, pumping and grinding.***

Sails: When people think of capturing the power of the wind most people think of sails and sailboats. Early sails were of the 'parachute' or 'drag' type, designed merely to be pushed along by the wind *(figure 1)*. Later, sails of the 'wing' or 'lift' type were able to make better use of the wind *(figure 2)*. These improvements in sail design foreshadowed windmill and airplane developments later on in history.

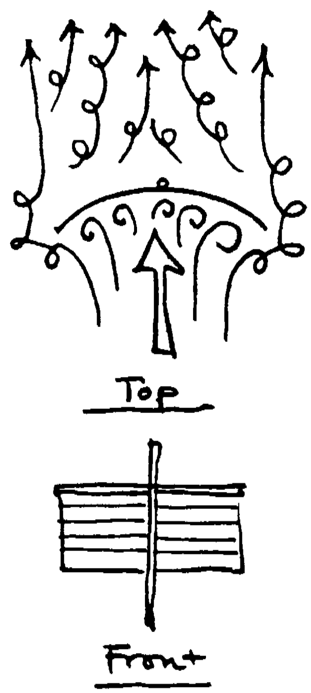


figure 1

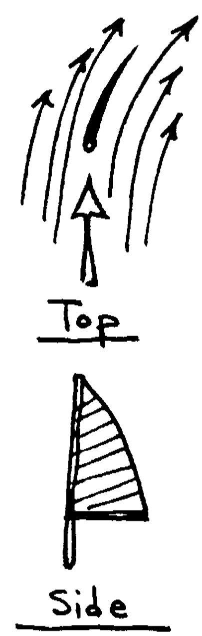


figure 2

Kites: The kite is another ancient device which makes use of the power of the wind. It has a long history in the Far East (China, Japan, etc.) and in the Pacific (Indonesia, Polynesia, Hawaii, etc.). While seen today as a

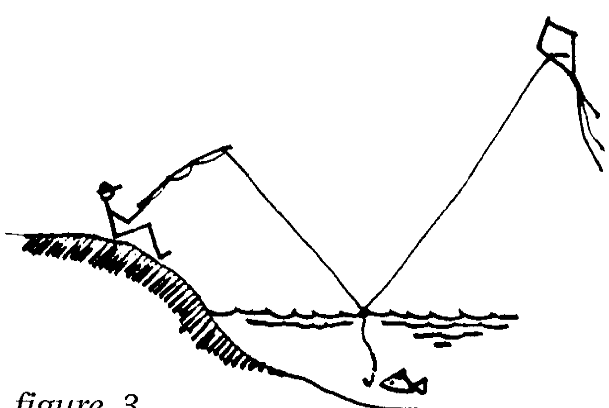


figure 3

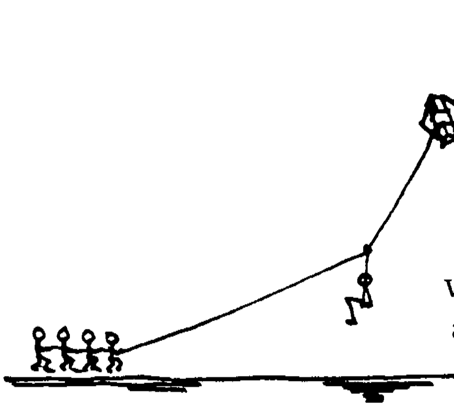


figure 4

plaything, kites had strong cultural and religious significance. They were thought to be able to contact the Gods and were seen as divine instruments, controlled by the Gods themselves. Kites have been used both for work as well as playthings. They have been used as aerial fishing rods, *(figure 3)*, for observation in wartime *(figure 4)*, to pull vehicles *(figure 5)*, and they have been instrumental in the development of the airplane *(figure 6)*.

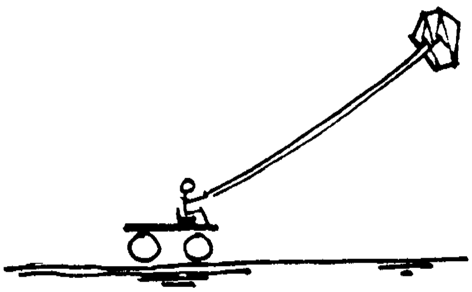


figure 5

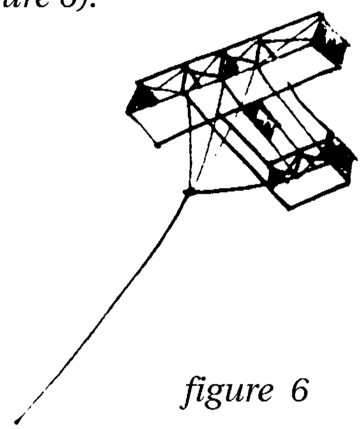


figure 6

Animal powered machines: Wind machines able to do work such as grinding or pumping water were developed from animal and water-powered machines in the 2000 years before Christ. Animal (or human) powered machines appear to have developed first. One of these early devices was the **Horizontal beam mill** *(figure 7)*. The animal pulled the beam which turned the axle with its attached grind stone which ground the grain.

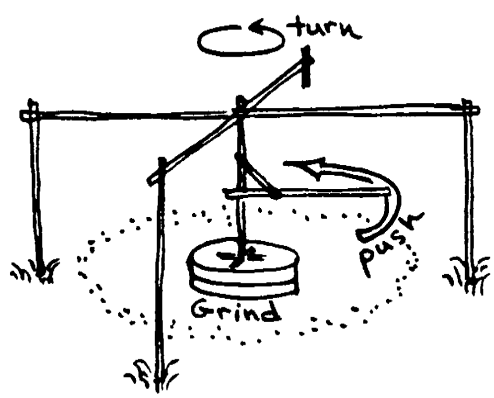


figure 7

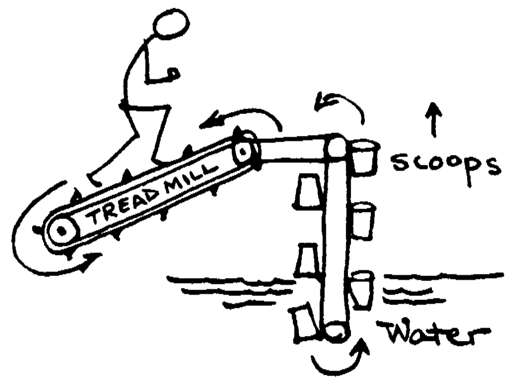


figure 8

The **Treadmill** was another useful machine *(figure 8).* Here, pushing on the treadmill paddles (or track) turned the axle with its attached water scoops which lifted (pumped) water.

Both of these devices were simple, robust and low-tech.

Water-powered machines: It seems probable that water-powered machines were in use before wind-powered ones. There were a couple of reasons for this. First, water was easier to harness than wind because it flows in a well defined location and direction. Wind is less predictable. Second, water is denser than wind and so has more power in its flow. Wind doesn't push as hard.

The most common water-powered machines in the ancient world were developments of the treadmill design idea. The two basic types were the **Undershot** and the **Overshot waterwheels** *(figures 9 and 10).*

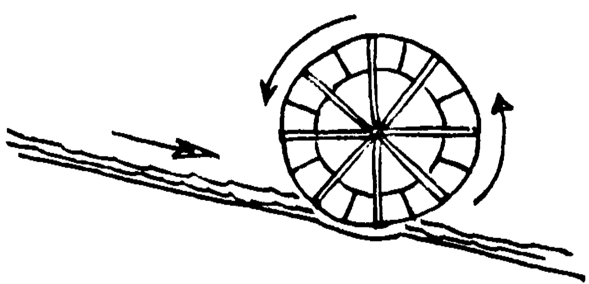


figure 9

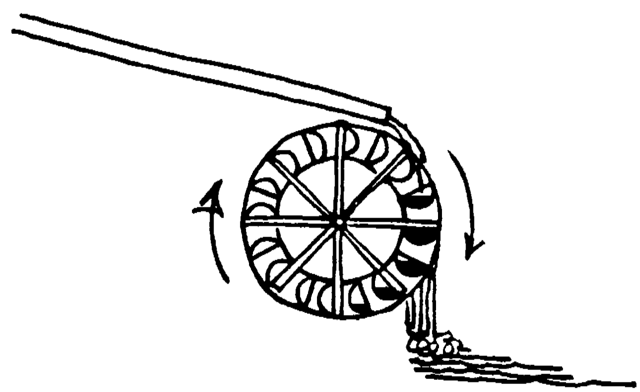


figure 10

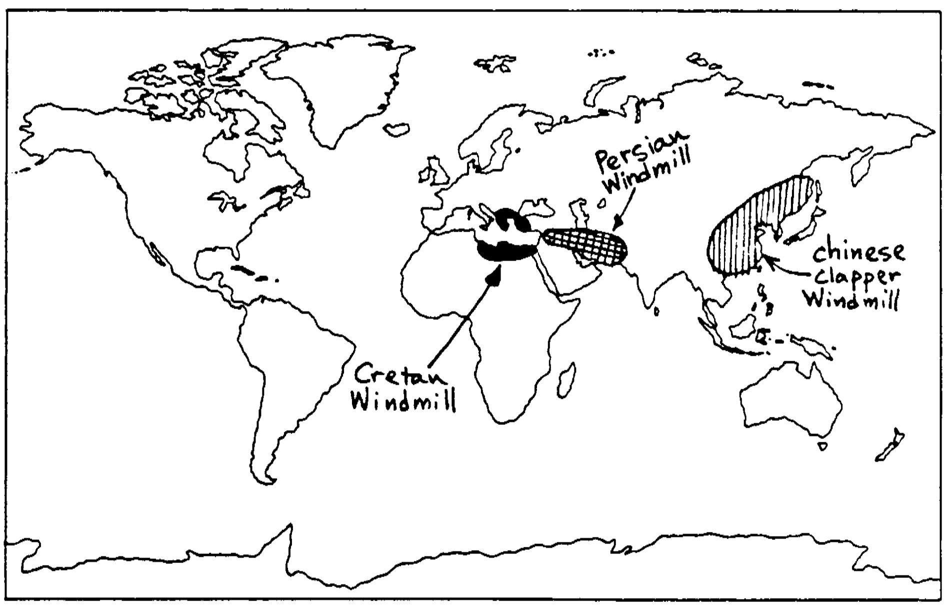
Water-power would appear to be the power source of choice. However, there are situations where wind-power is best. Areas which are flat, like open farmland, often did have enough running water for water-powered machines. In fact, getting water to these areas (or out of them) so crops can be grown was often what the machine is needed for in the first place. If there are steady, strong winds then wind power was the solution. Of course, any area with lots of wind had potential to be a good site for wind-powered machines.

Wind powered machines: The earliest wind-powered machines were developments of existing animal and water-powered models. Two families (types) of wind-machine emerged, each with its own design features and each from different areas of the world.

From the Mid-East came the Persian Windmill and from the Far East came the Chinese "Clapper" Windmill. Both of these designs were developments of the Horizontal Beam Machine and, in the end, developed into modern Vertical Axis Wind Turbines (VAWT) such as the Savonius and Darrieus rotor turbines.

From the Mediterranean region came the Cretan (or Greek) windmill, a development that combined the treadmill machine design a sail-rotor for motive power. This design evolved into the modern Horizontal Axis Wind Turbines (HAWT) which are the current standard design.

The map below shows the origins of the windmills of the Middle and Far East. *(figure 11).*



The World

figure 11

Vertical axis windmills: The **Persian windmill** was developed in Persia (modern day Iran) and the Middle East around 2000 BC *(figure 12).* In this design an axle-sail assembly, like an up-ended paddle wheel, was placed inside a tower with windows in it that allowed the wind to hit the sails on only one side of the axle. The axle, connected to a grind stone, turned and grain was ground. The tower was built to face the prevailing wind. If the wind came from a different direction then the windmill wouldn't work. This problem was solved by replacing the tower with a movable screen to block the wind *(figure 13)*. These Persian windmills spread throughout the Middle East and were brought to Europe through Africa and Spain around 500 BC.

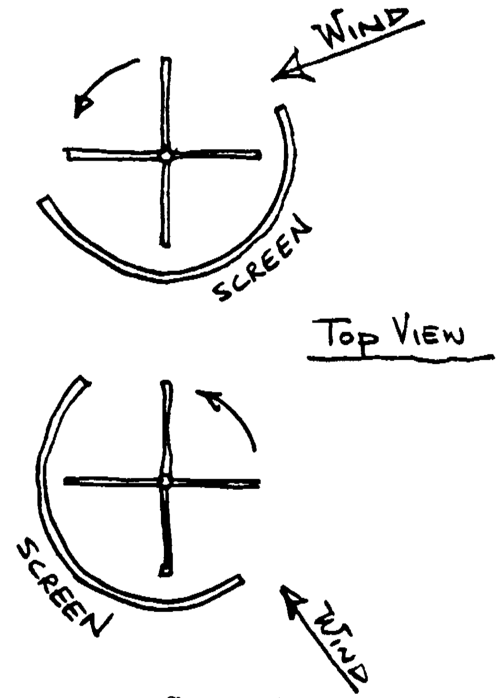


figure 13

The **Chinese "Clapper" Windmill** *(figure 14)* needed no tower or shield because the sails 'feathered' or turned 'edge-on' to the wind for the return half of their cycle. To do this the sails had special pivot axles and stop-pins. The noise made by the sails hitting their retaining pins gave this windmill its name. A major advantage of this type of mill was that it worked no matter where the wind came from.

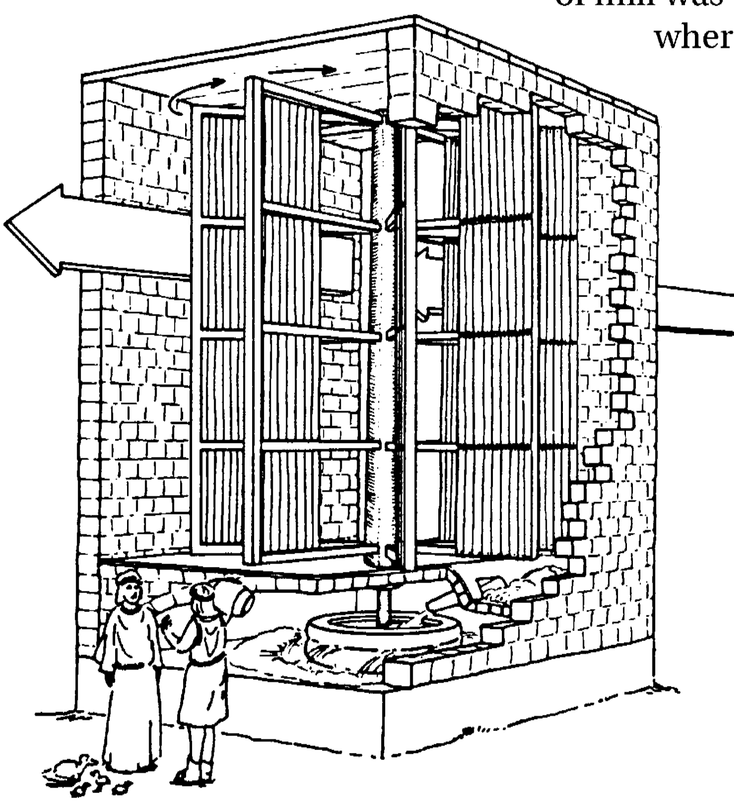


figure 12

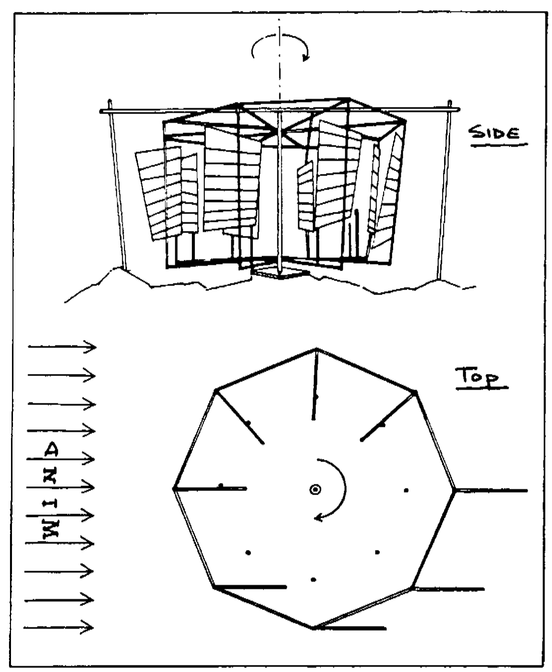


figure 14

Horizontal axis windmills: The Cretan (or Greek) windmill, developed on the island of Crete (part of Greece) and in Egypt, around 500 BC. *(figure 15)* This windmill was the forerunner of the modern propeller-style wind turbine. It had a rotor with 8 to 10 sail-blades mounted on top of a tower. The rotor and tower were positioned so they faced into the prevailing wind. At some point in its development, the windmill became able to be rotated on its base (or tower), which allowed it to make use of winds from any direction.

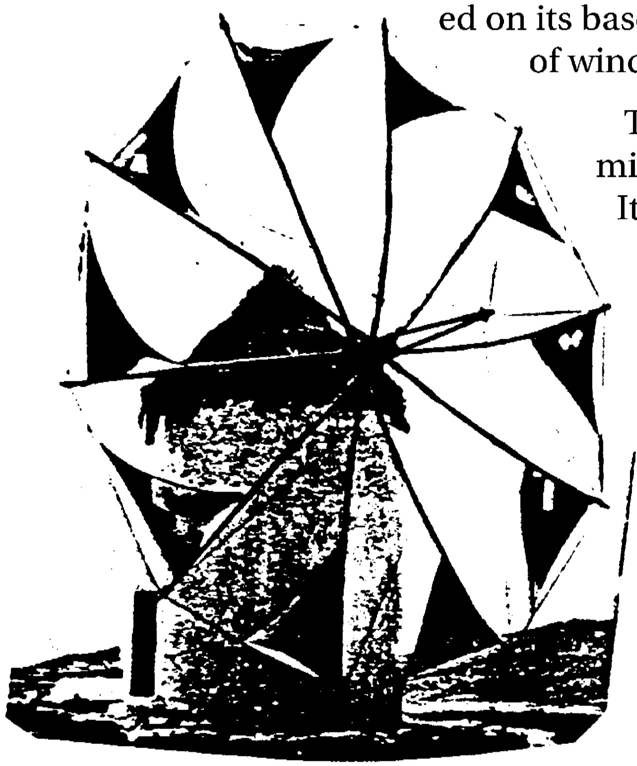


figure 15

The Cretan windmill was not a direct-drive mill like the Persian and Chinese windmills. It had to have a power-transfer linkage to get the power of the turning rotor down to the ground where it could be used. This was done through a crank arm, belts, or gears, etc. *(figure 15).*

By the 11th century windmills were common in the Middle and Far-East. They were used for all types of work. It is thought that windmill technology moved to Western Europe with traders and the returning Crusaders (in the 12th and 13th centuries).

ASK YOURSELF THIS…

- ***How has the wind been used in this area?***

- ***How do you use the wind?***

CHAPTER 2 – MIDDLE HISTORY (1200 TO 1850 AD)

KEY IDEAS IN THIS CHAPTER

- ***Refinements were made to windmill designs to solve operational problems.***
- ***The intermittent availability of wind made it less attractive than water-powered machines and the internal combustion engine***

By the 13th c. windmills were common throughout lowland Europe: Holland, Germany, France, England, etc. The Dutch took the lead in improving windmill design and used them extensively to drain marshes to reclaim land for farming.

Postmill: The predominant type was based on the Cretan windmill. The Dutch developed two main models. In the Post Windmill, the whole body of the windmill was mounted on a huge pivot-post. The windmill could be turned into the wind by pushing a pole stuck out the back. *(figure 16).*

Capmill: In the Cap Windmill, the tower body of the windmill was fixed on the ground and the 'cap' (top) of the mill could be turned into the wind on its own. This was easier to build and allowed the tower base to be used for storage *(figure 17).*

Rotor blade improvements: The Dutch also improved the design of the rotor blades. By the 16th century cloth sails-blades were replaced by more efficient and controllable shuttered wooden blades. *(figure 18).*

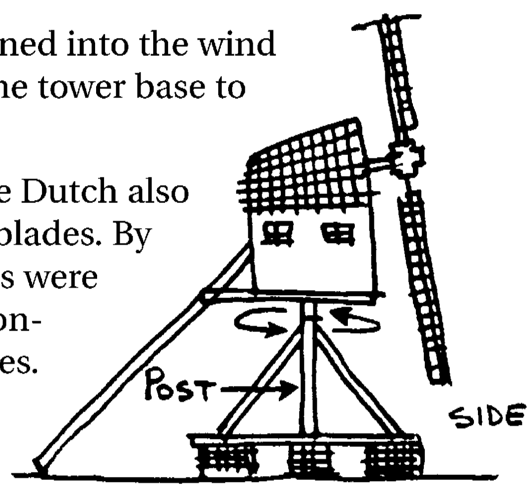


figure 16

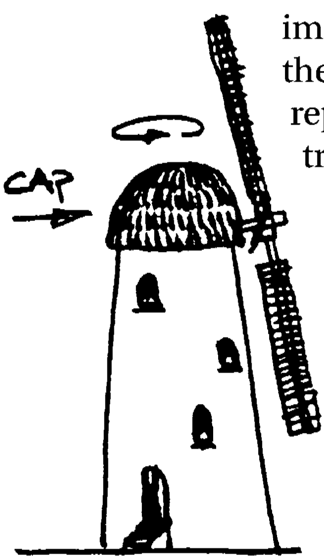


figure 17

Fantail: In 1745 an Englishman, **Edmund Lee,** patented a device that automatically kept the windmill facing into the wind. This was the Fantail, a small rotor set perpendicular to the main rotor. When the windmill was head-on to the wind, the fantail didn't turn

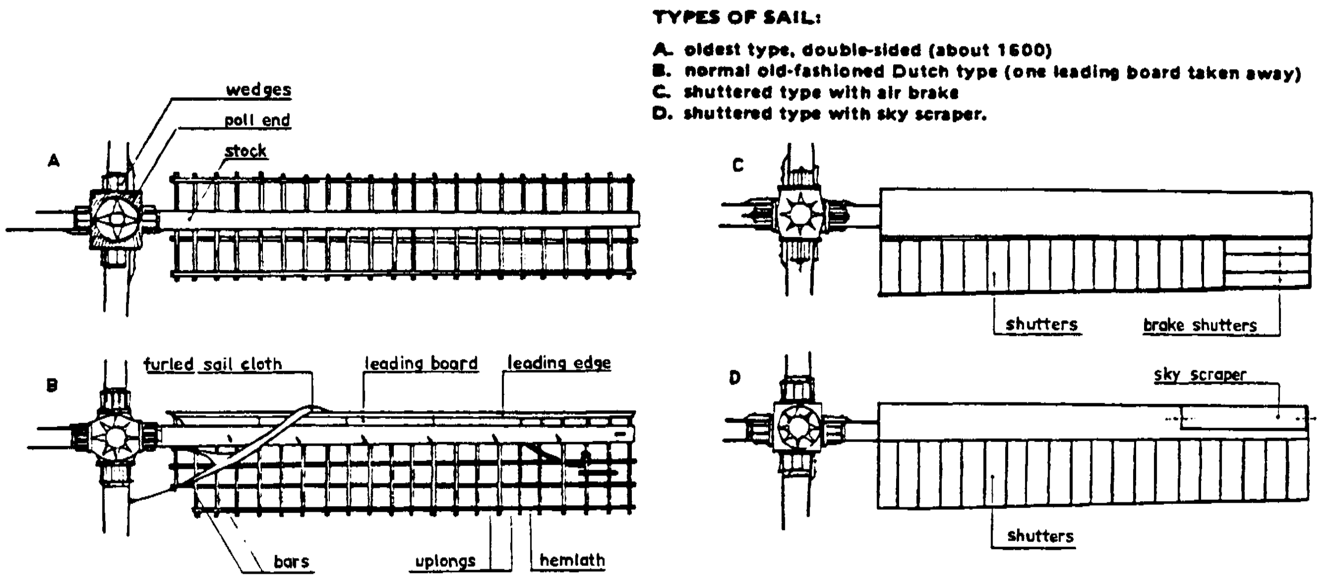


figure 18

because it was edge-on to the wind. When the wind shifted to the side, the fantail would then be turned by the wind. Through a series of gears, the fantail would turn the main rotor to face the wind again *(figure 19)*.

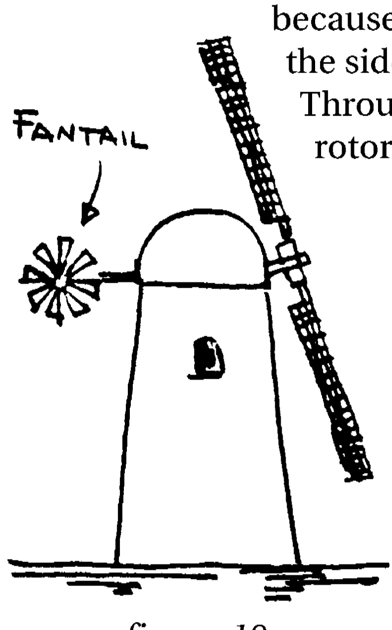


figure 19

In the 1750's **John Smeaton,** another Englishman, was the first to scientifically investigate windmill design and performance. He discovered some of the basics 'laws' of rotor and blade design. His propeller testing machine is shown *(figure 20)*.

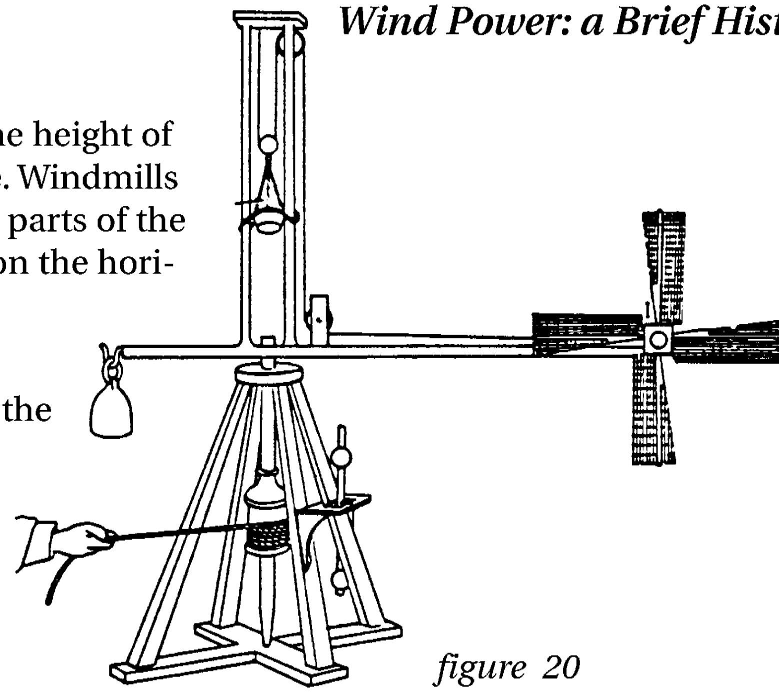


figure 20

These designs represented the height of windmill technology at the time. Windmills were built in America and other parts of the world. But, radical change was on the horizon …

The **Industrial Revolution** (roughly 1750 to 1900) changed the developed world. Attention was focused on new technologies (steam power, mass production of goods) and new ways of life (people moved from agricultural to factory work). The late 1800's saw the arrival of electric power, the internal combustion engine, and many other laborsaving devices.

Wind-powered machines could not compete head-to-head with steam and water powered ones and so the development of wind-powered machines stagnated.

Do You Remember?

- ***What were some of the innovations made to make it easier to use windmills in shifting winds?***

- ***Why were water-powered and internal combustion machines chosen over wind-powered machines?***

CHAPTER 3–MODERN HISTORY (1850 TO 1950)

KEY IDEAS IN THIS CHAPTER

- ***Electricity use became widespread because it provided power in a form that can be used to do a lot of different kinds of work.***
- ***Wind machines were developed to produce electricity.***
- ***Aircraft propeller technology developed during World War I spurred a boom in wind energy development for farms and other remote areas.***

Up to this point in history, windmills were used to produce local, mechanical power. A new type of windmill was being born … the wind turbine electric generator. This type of windmill could produce power in one place to be used in another. Electric power generation was the wave of the future.

First generation wind turbines: Many countries worked on developing the first generation of large-scale wind turbine generators, most notably Denmark, Russia, England, France, Germany, and the USA.

In **Denmark, Professor P. La Cour** set up a research wind turbine in 1891 *(figure 21).* His work laid the foundation for modern wind turbine science. By 1910 several hundred large-scale wind turbines were in service. These turbines had 80-foot towers supporting 75-foot diameter 4-bladed shuttered wood rotors driving 25 kW generators. *(figure 22).* The tower was a steel-lattice design. The generator was at the bottom of the tower, driven by a shaft coming down from the rotor.

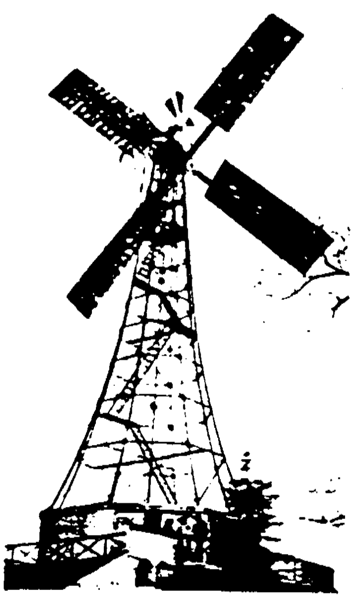


figure 21

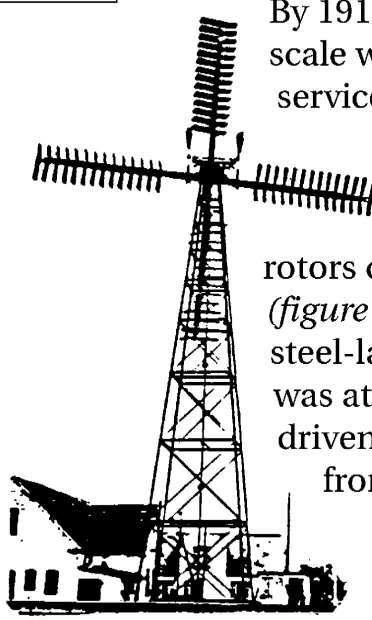


figure 22

In 1931, **Russia** built a large wind turbine near Yalta on the Black Sea. It had an advanced aviation-style rotor. The generator was now moved to the top of the 100 foot tall tower. The turbine produced 100 kW. Development was halted by the Second World War *(figure 23)*.

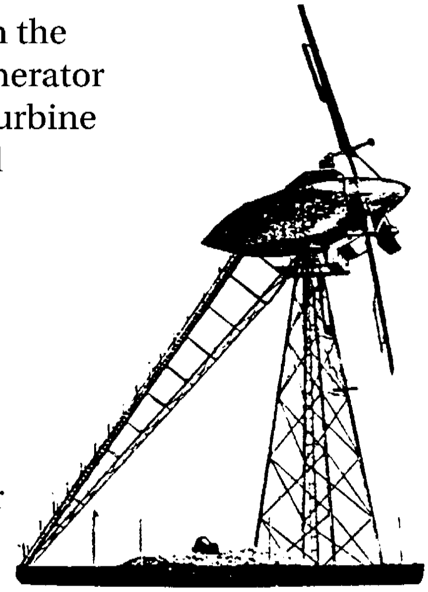


figure 23

In the 1940's and 50's **English** wind-power pioneers **E. Golding and A. Stoddard** did research on wind and wind turbines. In 1950 a 100 kW turbine was built on the Orkney Islands *(figure 24)*.

Also during the 40's and 50's the **Germans,** under the direction of **Professor Ulrich Hutter** introduced a number of improvements in turbine design. They introduced lightweight, simplified components: rotors built with fiberglass or plastic blades, towers made of a single tubes supported by guy wires, and direct-drive generators. They also continued the now-standard use of an aviation-style, variable-pitch, constant-speed, 3-bladed rotors. These are common features of the modern wind turbine, *(figure 25)* though not all wind turbines share these features.

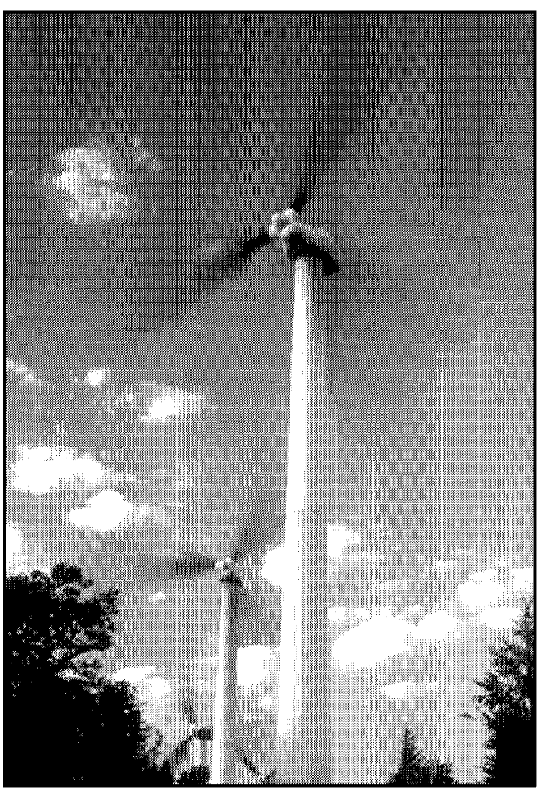


figure 25

Despite these advances, engineers found that the cost of large-scale wind-generated power was high compared with that produced by conventional fossil-fuel power plants. Therefore, further development of wind power was sporadic and slow.

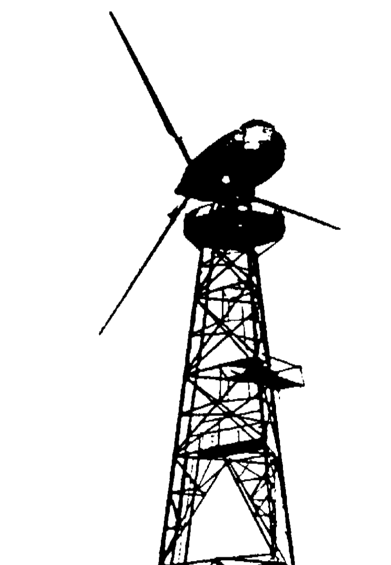


figure 24

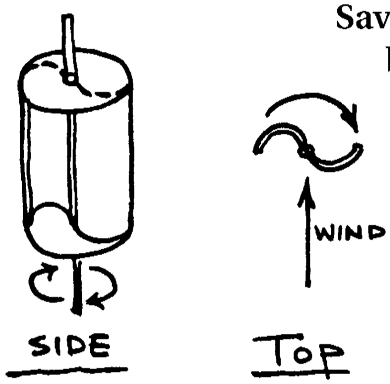


figure 26

Savonius and Darrieus Rotors: The Savonius Rotor was invented by S.J. Savonius of Finland, in the late 1920's. *(figure 26).* It operates like a cup anemometer, being dragged around by the wind. It does produce some lift though and it can be made into a kite quite easily *(figure 27).* This turbine has applications for mechanical operations (like pumping water) but is not efficient enough for electrical generation.

The **Darrieus Rotor** was invented by Frenchman **G.J.M. Darrieus** in 1929 *(figure 28).* It was also re-invented by two Canadians, **Raj Rangi** and **Peter South** in 1964. The Canadian team only found out it had already been invented when they applied for a patent on it! It looks like a huge, up-ended eggbeater, with rapidly spinning D-shaped blades mounted on a vertical axle. The Canadian government did a lot of research on these rotors but they have not been used in commercial-scale power production.

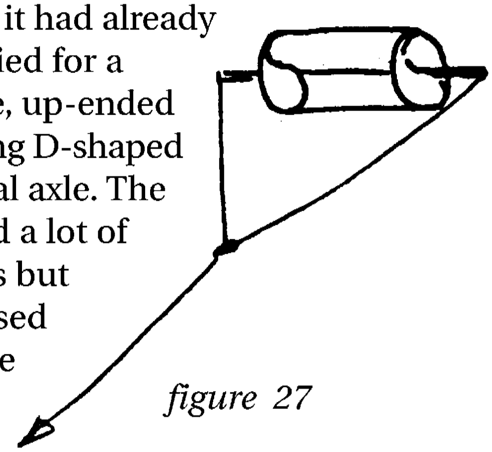


figure 27

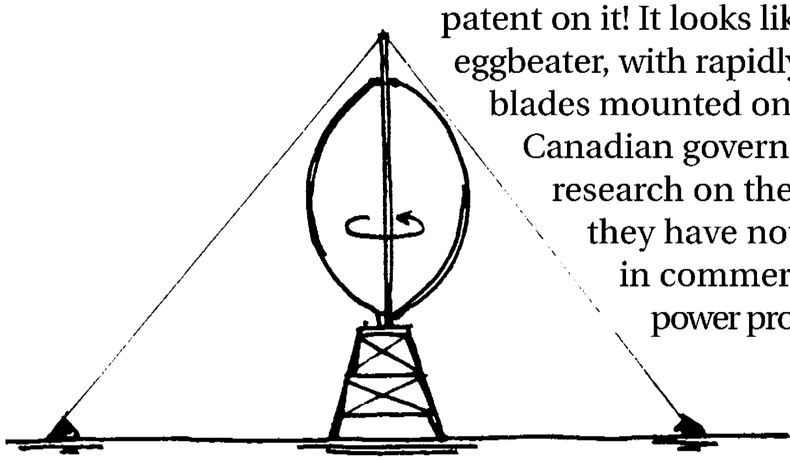


figure 28

Check Your Knowledge...

- ***What design features from the 1940's and 1950's have become the standard for rotors today?***

CHAPTER 4–USA HISTORY (1850 TO 1990)

Small wind turbine pumps: In the USA small wind turbine pumps were developed after the Civil War (1865) to supply water in the new territories of the west. Two companies, **Halladay** and **Eclipse,** manufactured turbines which could be moved and built more readily than traditional types *(figure 29)*. Note that these windmills were built of metal. By the turn of the century hundreds of thousands of windmills were in use across the country.

After World War I wind-electric generation really took off due to advances in aircraft propeller technology. These new propeller blade designs made wind turbines more efficient. At the same time people in rural areas like the Mid-West wanted to have electricity like people in urban areas. If rural folks wanted electric power, they had to produce it themselves.

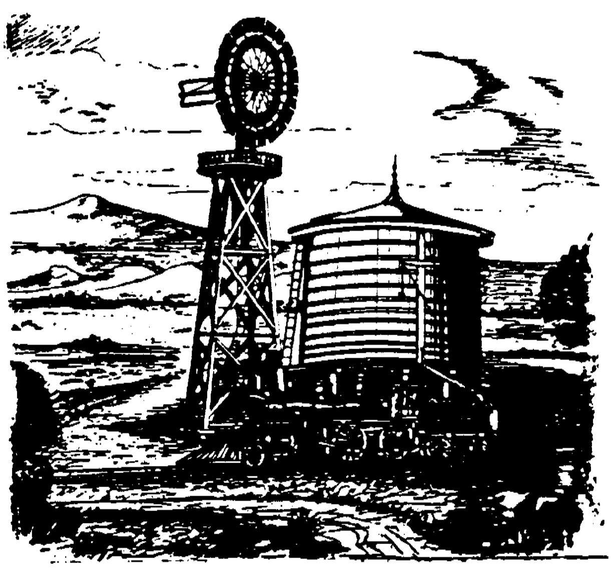


figure 29

KEY IDEAS IN THIS CHAPTER

- ***Wind turbines were used broadly for pumping water in agricultural areas.***
- ***Wind energy development declined when most of the country became interconnected in a large electricity grid and could tap efficient large-scale fossil-fuel and hydroelectric plants.***
- ***The energy crises of 1973 and the early 1980s spurred Congress to encourage wind energy development.***
- ***The "California Wind Rush" and other wind energy developments in the 1980s made the U.S. a leader for awhile.***

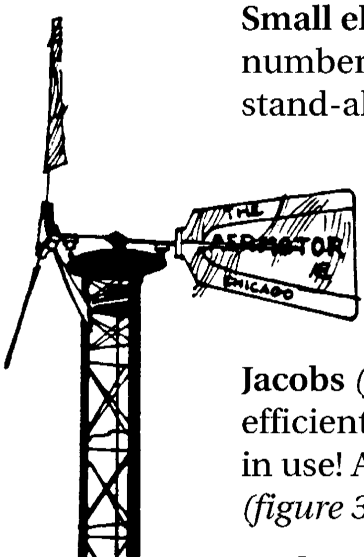


figure 30

Small electric wind generators: Beginning in the early 1920's a number of companies produced small electric wind generators for stand-alone operation on rural farms and homesteads. These generators produced DC electricity and could charge up batteries for storage.

One of the first of these turbine generators was the **Aeroelectric** *(figure 30).* Another pioneer turbine was the **Jacobs Wind Electric** designed and built by **Marcellus Jacobs** *(figure 31).* This was the Cadillac of turbines, simple and yet efficient. There are 60 year-old Jacobs turbines still in use! Another DC generator was the **Wincharger** *(figure 32).*

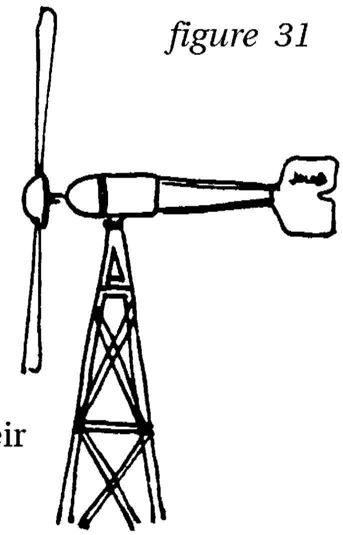


figure 31

Over the 30 year period from 1920 to 1950 over a million wind generators were installed in rural locations across the USA. This proliferation of wind power was to be cut short by **The 1937 Rural Electrification Act.** This act made low-cost, centrally distributed electric power available to rural areas. People didn't need their wind generators anymore – the government brought electricity to their homes and farms on poles and wires.

Grandpa's Knob wind turbine: In 1941 the USA joined European countries in developing a first-generation, large-scale wind turbine generator. The Smith-Putnam wind turbine was built on Grandpa's Knob near Rutland, Vermont *(figure 33).* This was the world's largest wind turbine of the time. It produced 1250 kW (1.25 MW) of power. It operated off an on until 1945 when one of its 85-foot blades broke off and it was shut down.

As in Europe, it was found that the cost of large-scale wind-generated power was high compared with that produced by conventional fossil-fuel power plants. Despite

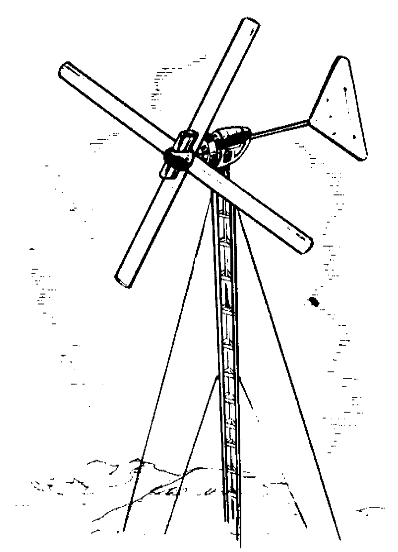


figure 32

technological advancements, wind-power simply couldn't compete with inexpensive, often government-subsidized fossil-fuel and nuclear power plants. Use of wind-power to generate electricity went into decline.

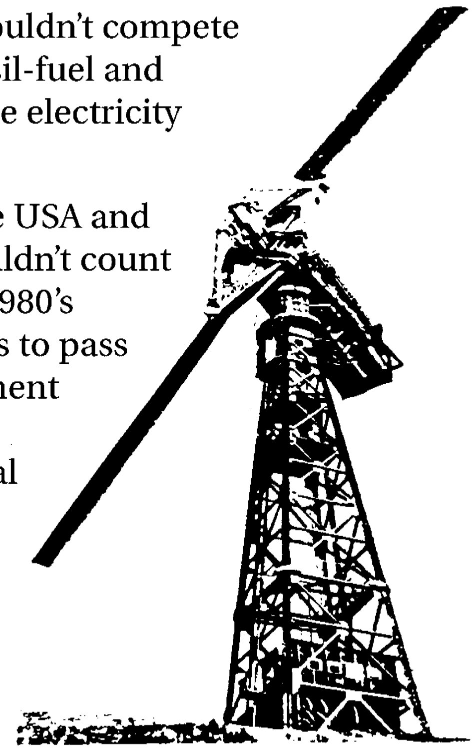


figure 33

Energy Crisis: In 1973, the first Oil Crisis hit. The USA and the rest of the industrialized world realized they couldn't count on cheap, readily available fossil fuels. In the early 1980's there was another oil crisis. This prompted Congress to pass legislation providing federal funding to the Department of Energy (DOE) for research and development of commercial-scale wind-power systems. The National Renewable Energy Lab (NREL) was established and its wind-power section, The National Wind Technology Center (NWTC), carried out research on a wide variety of turbines. At the same time, California instituted state-level tax credits to stimulate development and use of alternative energy sources. In addition to funding for R & D, the legislation forced utility companies to buy the new wind-generated electricity even if it was more expensive than traditionally produced electricity. The stage was set for The California Wind Rush. Investors couldn't resist – first, get a subsidy to develop the product and then, have a guaranteed market for it.

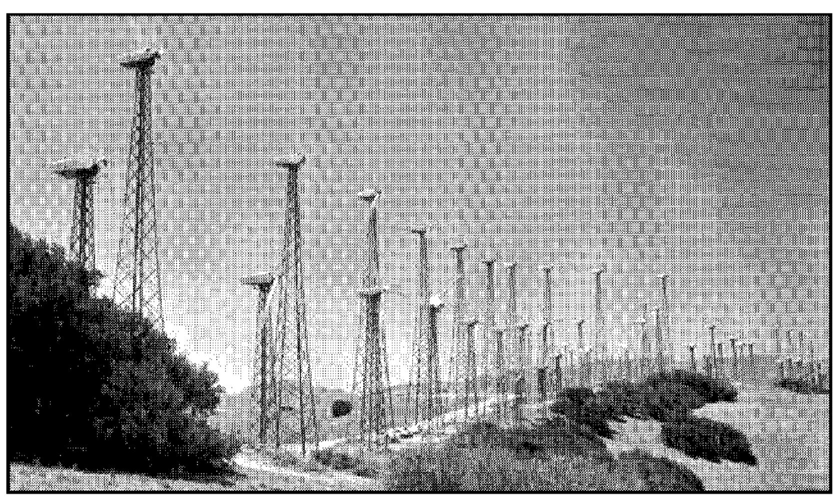


figure 34

Second generation wind turbines: First generation commercial wind turbines were large (500 kW to 1.5 MW). In the 40's and 50's engineers learned that despite the theoretical advantages of large size, the big machines were not the way of the future at that time. They couldn't be made as efficient in practice as they were in theory. They had a bothersome number of mechanical problems. They required a large, unobstructed site and were somewhat intrusive. It was found that smaller machines could do the job better. They were as efficient as the large machines. They were easier to build and repair. They lasted longer in service because of modern, light-weight materials and new, better construction techniques.

The California Wind Rush: Smaller, advanced-design turbines were built in the thousands, mostly in California because of the tax incentive and market-guarantee program there. By 1986 there were over 17,000 turbines in California producing 90% of the world's wind-generated electricity. Most of these were located in densely laid-out wind farms around San Francisco: Tehachapee *(figure 34)*, Altamont Pass, and near Palm Springs. The US Windpower company's model 56-100 was typical of these second generation wind turbines. It had a 56 foot rotor diameter and developed 100 kW of power. It was the "Jeep" of the California Wind Rush.

The USA was dominant in the field of wind-power. However, in the next ten years the USA would lose its preeminent place in wind power. Government tax credits and other incentives dried up as the energy crisis eased. At the same time European governments stepped up their investment in wind power. By 1996, the US share of world wind-generated electricity had dropped to 30% (from 90% in 1986).

Consider This…

- ***Why was wind energy popular with farmers in the United States? What changed?***

- ***How is the situation in Alaska similar and different than in other areas of the United States?***

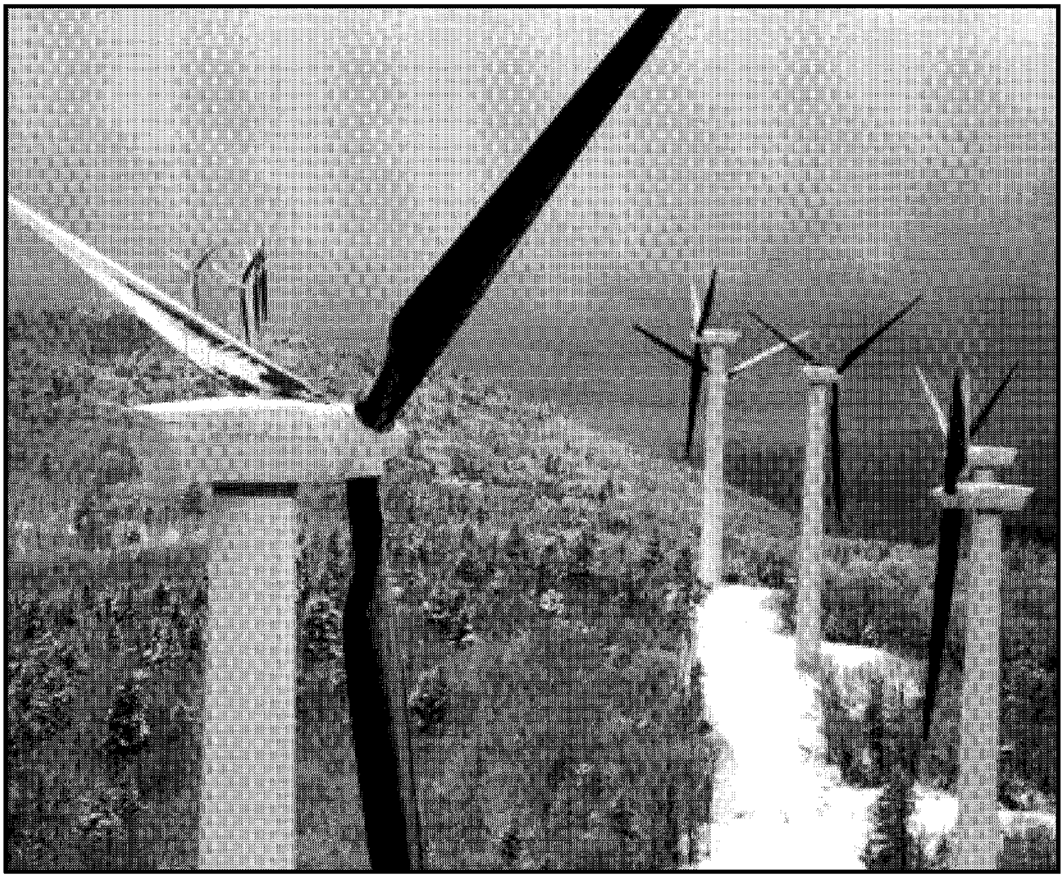
Chapter 5–The Future of Wind Power

> **Key Ideas in this Chapter**
>
> - ***Wind energy has come of age as a cost-competitive source of supplementary electricity.***
> - ***Environmental concerns are helping to push wind power development.***
> - ***Different types and sizes of wind turbines work better in different environments. Innovation is underway to identify the best types for different places.***

Wind turbine technology continues to advance, with various designs being developed for specific wind profiles, environmental characteristics and applications. Wind turbines come with power ratings ranging from 500 watts to 5 megawatts. Very small turbines are used to charge batteries for remote applications. Home-sized wind machines, often 10 kilowatts, have rotors between eight and 25 feet in diameter and reach 30 feet tall or more. There is strong growth in the use of wind turbines ranging from 1.5 megawatts to 3 megawatts to feed power grids that utilities use to deliver electricity to consumers. A large turbine may have blades that span more than the length of a football field and it may stand 20 stories high. A turbine of that size can produce enough electricity to power 1,400 homes.

Wind power has come of age. The cost of fossil fuels continues to rise and, at the same time, wind-turbine technology continues to improve and get less expensive. These two factors have made wind power cost-competitive with traditional sources of energy. It will only get more so. The industrialized world has taken note and is installing new wind turbines at record rates, mostly in Western Europe (Spain, the Netherlands and Britain). There is also a huge market for wind turbines in the developing world. They are being installed in India and parts of Latin America.

Wind energy development in the United States was given a boost when Congress passed the **National Energy Policy Act** in 1992, which gives a tax credit for production of electricity from alternative energy sources. Some utility companies will respond to this incentive and build "green" power plants.



Green Mountain Power's wind farm in Searsburg, Vermont. *figure 35*

Today many states have mandated "Renewable Portfolio Standards" that requires utilities to have a percentage of their power come from new renewable sources. State renewable portfolio standards, mandates, and renewable energy goals are all relatively new. It has been estimated that these new requirements for new renewable energy capacity in 15 States resulted in an estimated 2,335 megawatts of renewable energy by 2003. Most of the new energy comes from wind power, with smaller amounts of landfill gas, hydroelectricity, biomass, and solar photovoltaic technologies.

Wind energy is the world's fastest-growing energy source. Total worldwide capacity in 2007 reached 73.9 gigawatts. Installed capacity in the US reached 11,600 megawatts in 2007. The **World Wind Energy Association** (WWEA) predicts that by 2010, 160 gigawatts will be installed worldwide. The **American Wind Energy Association** identified the leading states in terms of installed wind capacity in 2007 as Texas (2,768 megawatts (MW), California (2,361 MW), Iowa (936 MW), Minnesota (895 MW) and Washington (818 MW).

Still the wind energy being tapped in the U.S. and worldwide is a small fraction of the potential, and in the United States is a sliver of the pie of total generation. According to the American Wind Energy Association, wind power capacity increased by 27% in 2006 and is expected to increase by an additional 26% in 2007. More than half of the nation's electricity was produced using coal. Nuclear power, natural gas, and hydroelectric power, in that order, provided the next highest contributions to generation.

Wind power is part of the future of the world energy market. How much it will dominate the market remains to be seen.

Discussion

- ***Why is wind power development increasing?***
- ***How much of the nation's electricity is produced using wind?***
- ***How can the use of wind power help address environmental concerns?***

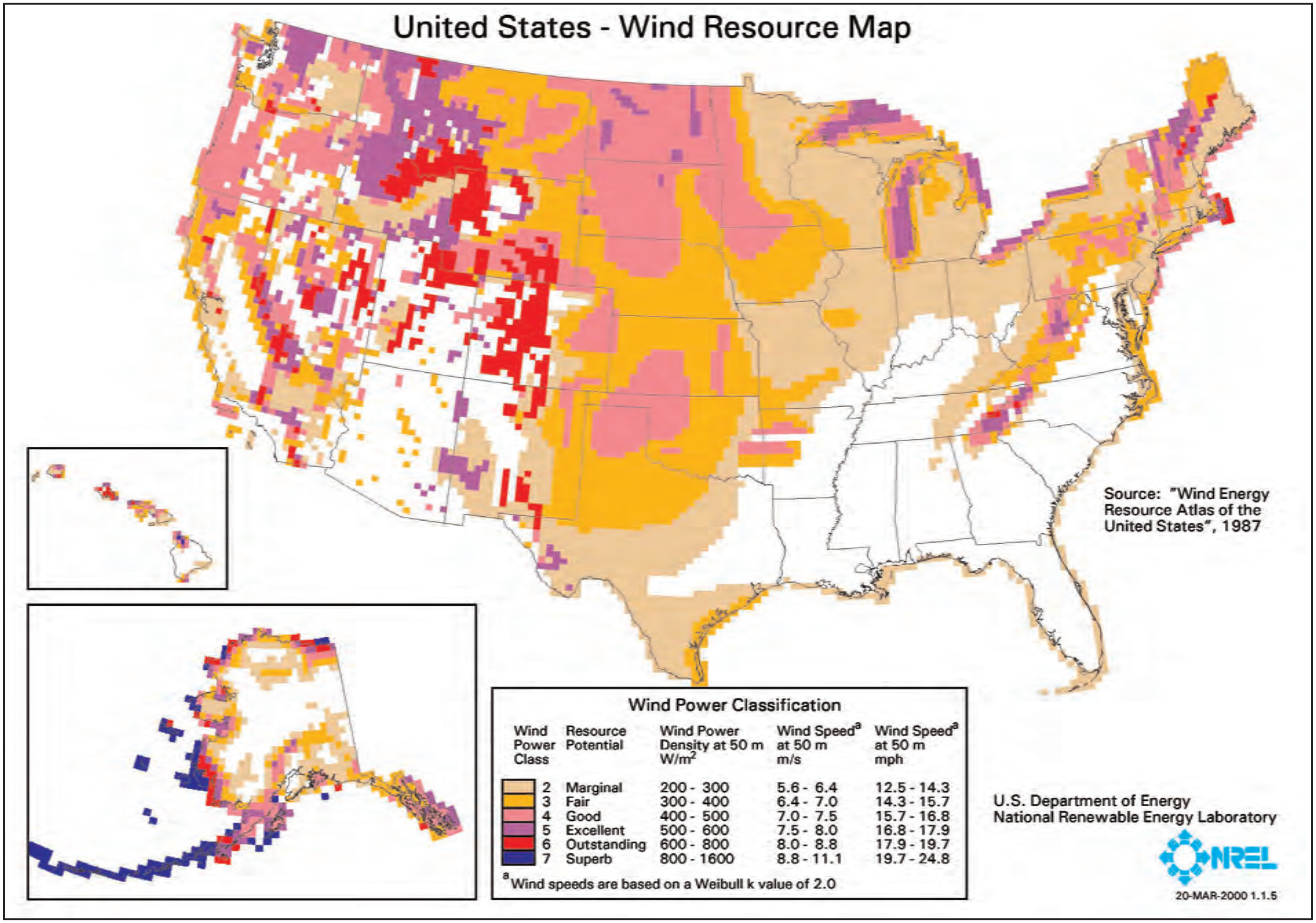

United States - Wind Resource Map
Source: "Wind Energy Resource Atlas of the United States", 1987
Wind Power Classification
Wind Power Class | Resource Potential | Wind Power Density at 50 m W/m2 | Wind Speed[a] at 50 m m/s | Wind Speed[a] at 50 m mph
2 Marginal 200 - 300 5.6 - 6.4 12.5 - 14.3
3 Fair 300 - 400 6.4 - 7.0 14.3 - 15.7
4 Good 400 - 500 7.0 - 7.5 15.7 - 16.8
5 Excellent 500 - 600 7.5 - 8.0 16.8 - 17.9
6 Outstanding 600 - 800 8.0 - 8.8 17.9 - 19.7
7 Superb 800 - 1600 8.8 - 11.1 19.7 - 24.8
[a] Wind speeds are based on a Weibull k value of 2.0
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
20-MAR-2000 1.1.5

figure 36

CHAPTER 6—WIND POWER IN ALASKA

KEY IDEAS IN THIS CHAPTER

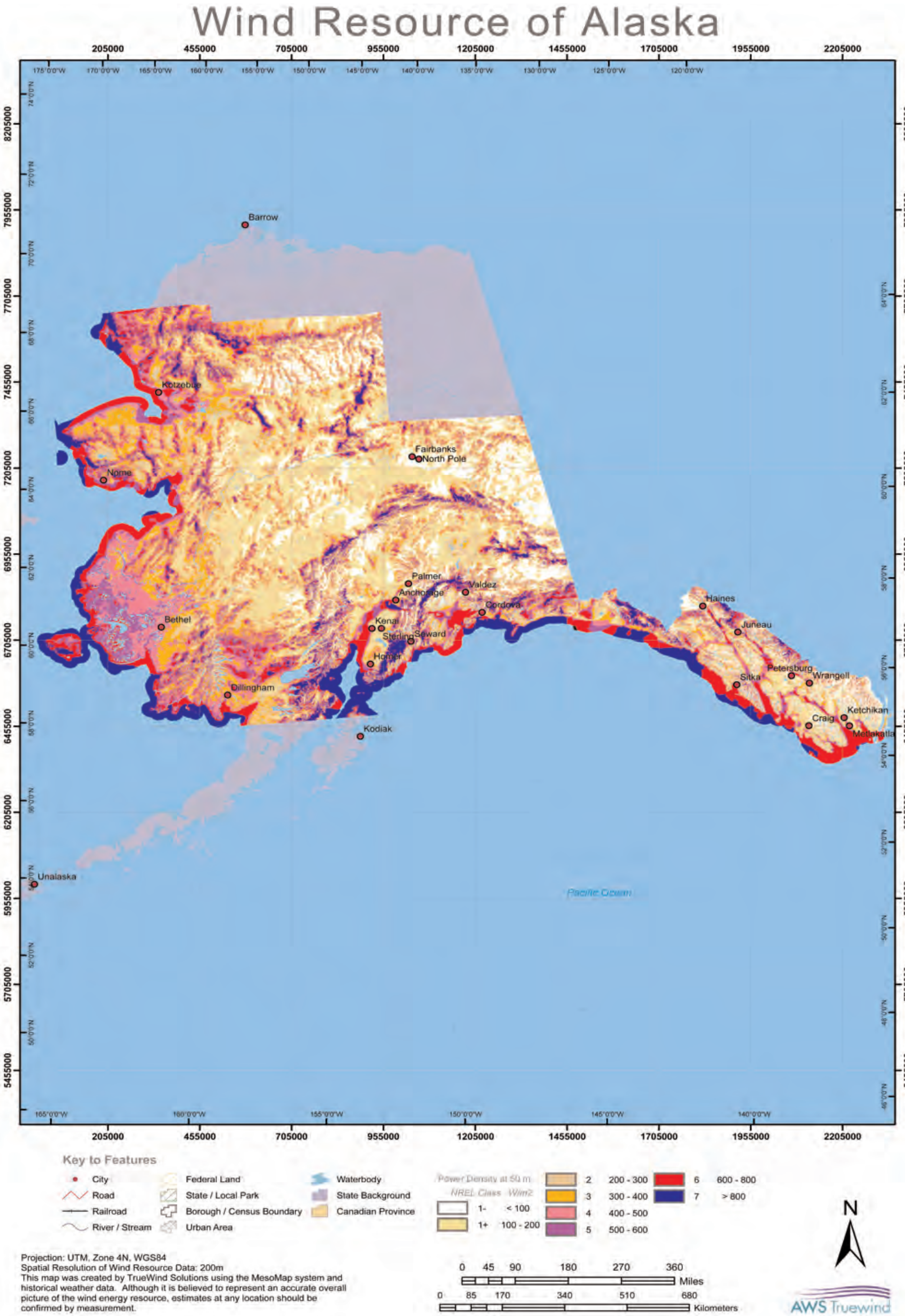
- ***Alaska has abundant wind energy resources, and a need for new sources of energy.***
- ***Early Alaska wind energy development failed in part due to inadequate design for cold-weather conditions and lack of maintenance.***
- ***Demonstration projects in Alaska are helping to develop viable wind energy systems for remote communities.***

Alaska has abundant wind energy resources and a growing need for electricity. These are good reasons to develop wind power generation. There are two other pressing concerns, the need to lower the cost of energy, and the need to reduce pollution. Utilities are also exploring wind power generation as a way to meet consumer interest in purchasing “green” power, and to reduce the cost of energy.

Wind resources in Alaska. Alaska has among the best wind resources for power generation in the world. Winds are often strong and steady in coastal areas, and Alaska has 33,904 miles of shoreline, twice the amount of the continental U.S. The Alaska Division of Energy once estimated that 70-90 communities in Alaska have strong enough wind resources to benefit from wind power generation.

Specific local conditions are extremely important in identifying possible sites for wind turbines. In recent years, the Alaska Energy Authority and many utilities in Alaska, both large and small, have invested in extensive wind monitoring to further assess wind energy options. These efforts are yielding good data that provide the foundation for successful wind energy development.

Need to lower the cost of energy. Many of the communities with the strongest wind resources are the same ones with a critical need to reduce their cost of power. Rural Alaskans typically pay more than four or five times the electricity rates paid by consumers in urban areas of the state and other areas of the country.



Wind Resource of Alaska
Barrow
Kotzebue
Nome
Fairbanks
North Pole
Palmer
Anchorage
Valdez
Cordova
Bethel
Kenai
Sterling
Seward
Homer
Dillingham
Kodiak
Haines
Juneau
Sitka
Petersburg
Wrangell
Craig
Ketchikan
Metlakatla
Unalaska
Pacific Ocean
Key to Features
City
Road
Railroad
River / Stream
Federal Land
State / Local Park
Borough / Census Boundary
Urban Area
Waterbody
State Background
Canadian Province
Power Density at 50 m
NREL Class W/m2
1- < 100
1+ 100 - 200
2 200 - 300
3 300 - 400
4 400 - 500
5 500 - 600
6 600 - 800
7 > 800
Projection: UTM, Zone 4N, WGS84
Spatial Resolution of Wind Resource Data: 200m
This map was created by TrueWind Solutions using the MesoMap system and historical weather data. Although it is believed to represent an accurate overall picture of the wind energy resource, estimates at any location should be confirmed by measurement.
Miles
Kilometers
N
AWS Truewind

figure 37

Wind Power Class	Average annual wind speed (miles per hour at 10 meters)
1	9.8
2	11.1
3	12.2
4	13.4
5	14.0
6	15.6
7	21.2

Kotzebue winds are class 5, and St. Paul has winds rated class 7. *figure 38*

These isolated communities cannot tap into distant large power projects that provide relatively low-cost electricity. It would be too expensive in most cases to run the sort of long transmission lines that allow residents of Fairbanks to use power produced from Cook Inlet gas at the state's largest hydroelectric project at Bradley Lake, which is more than 500 miles to the south.

Most small communities, ranging in size from less than 100 people to several thousand in a few larger rural centers, rely primarily on local diesel generators. Fuel represents about one-third to one-half of the cost of producing power. Fuel, equipment and other items must be transported hundreds, even thousands of miles. Larger diesel generators are usually more efficient, producing more electricity for each gallon of fuel used. But small populations in villages often do not use enough electricity to be able to benefit from larger generators.

Current wind energy projects in Alaska are helping to identify the costs and benefits of wind energy for these communities.

Wind energy is a supplementary power source. Winds do not blow all the time or at the same force consistently. Also, there is currently no effective way to store the energy produced by wind turbines for long periods of time. Short-term battery storage is common and is used in some areas for feeding consistent energy amounts through electrical systems as the wind fluctuates.

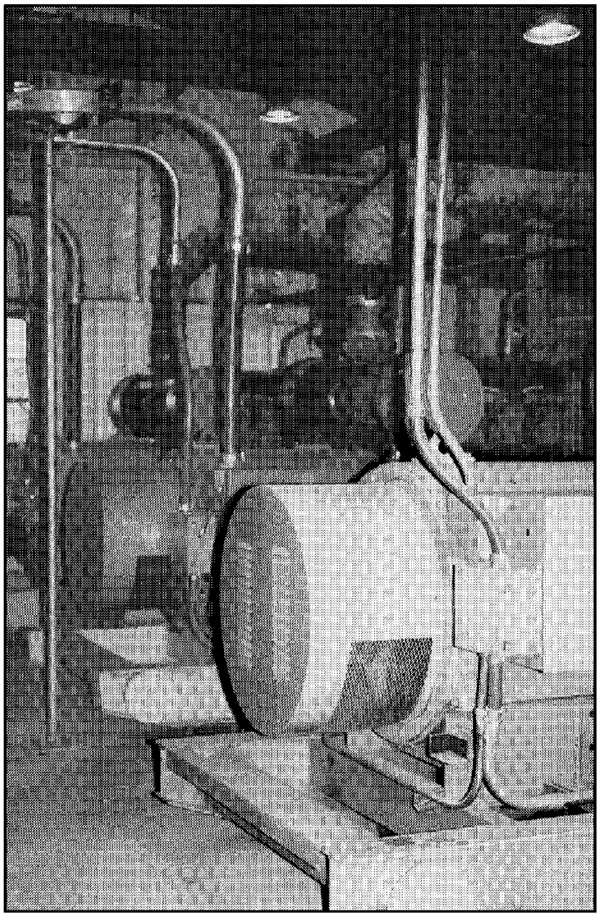
Electricity Generation in Alaska

Wind energy is just beginning to be used to produce electricity for Alaska's communities. There are many other fuels currently in use.

Combustion turbines fueled by natural gas produce most of the electricity in the populous Railbelt region, encompassing Fairbanks, Anchorage, and the Kenai Peninsula. About 10 percent of the power for that area is produced with water flowing through hydroelectric plants; some electricity comes from burning coal.

Kodiak and some of the communities in Prince William Sound and Southeast Alaska (including the state's capitol, Juneau) rely primarily on hydropower.

Most of the rest of the state, particularly small communities in rural areas, currently have no cost-effective alternative to diesel generation. They bring in and store fuel to produce the electricity that lights and powers homes and businesses.



Diesel generators are the only or main source of power in about 200 small Alaska communities. Photo courtesy AVEC. *figure 39*

Because it is intermittent, wind energy will not fully replace diesel generation. But by providing supplementary power and replacing expensive imported diesel fuel with free local fuel, wind power might lower costs. In some communities, wind generation might be able to serve as the main source of power, with diesel generators kicking in only when there is not enough electricity generated by wind to serve community needs.

Wind energy reduces pollution. Diesel generation creates many pollution dangers. Because the rivers and ocean freeze in many areas of Alaska, fuel must be barged in during the summer and stored for winter use. For instance—the 1.5 million gallons of fuel used in Kotzebue each year is transported over a thousand miles.

In addition to the danger of spills during the transportation and storage of fuel, diesel generation produces air pollutants. As rural communities grow and their electricity use grows, continued reliance on diesel could cause air pollution problems.

Urban utilities that use other types of generation are interested in wind power for similar reasons—lowering costs, reducing pollution, and providing consumers with clean "green" power. These interconnected urban systems face similar if somewhat different challenges in integrating wind power.

History of wind energy in Alaska

Wind energy has been used in many ways in Alaska, the most prominent use, perhaps, was for sailing. In rural areas, hunters use the signs of the wind on the land and snow to help guide them in finding animals. Travelers have used the dominant patterns on the snow created by prevailing winds to find their way home.

Amid the California Wind Rush of the 1980s, when incentive programs spurred growth of the industry, the State of Alaska encouraged Alaskans to try wind energy. The turbines available at that time were those constructed for use at individual homes and buildings in warmer climates, such as California. About 140 wind turbines were set up by government agencies at city offices, schools and other buildings around Alaska, including a few in Kotzebue. There was usually no involvement in the projects by local electric utilities.

Capturing Wind Energy for Heat

Using wind-generated electricity for heat has two benefits in rural Alaska communities that are interested in developing wind power. It can help maintain power quality and perhaps reduce heating costs.

Maintaining Power Quality

In the normal electric utility system, the power being produced and sent into the system is matched to the amount consumers use on the other end. This steady matching of output and input helps to maintain constant voltages as electricity flows within the system. Flickering lights, television sets, and damage to computers are among the problems that can come from fluctuating voltage, because appliances are designed to run on the standard voltage provided through the electric system.

In diesel generation systems, when there is a drop in the need for electricity, utilities can adjust the power output by burning less fuel. With modern systems and electronics, this can occur almost instantaneously. But utilities cannot speed up or slow down the wind, which is the fuel source for wind energy systems. So, other adjustments must be made.

Using electricity to heat water that can then be used for space heating provides one outlet for this excess energy and a way to capture energy that might otherwise have to be wasted. This use of wind energy for heating is part of the wind energy projects in Wales and on St. Paul Island.

Lowering Heating Costs

Electric heating currently does not exist in most of Alaska's rural communities because it would be inefficient. Most of the electricity used in these communities is produced by burning diesel fuel. It makes more sense to burn heating oil directly to create heat rather than burning it to create electricity and then heating with electricity.

The fuel for wind systems is free. So, where the cost of heating oil is high and where extra wind energy is available beyond what is needed for other electricity needs, utilities may be able to provide cost-effective supplementary wind-powered electric heating for consumers who now rely on heating oil. These systems will likely take the form of using electricity to heat water which is then circulated to heat buildings.

Most turbines failed quickly, because they weren't built to withstand cold weather, or needed maintenance that was not available. The mostly small 4-10 kilowatt turbines produced direct current (DC) electricity instead of the alternating current (AC) used by utility systems.

The Entegrity 15/50 (formerly AOC) wind turbines installed at the Kotzebue Electric Association wind farm are modern-design Horizontal Axis Wind Turbines (HAWT) with a trailing rotor that has three blades. The turbines are set on 80 -foot towers. Each can produce up to 66 kilowatts of power. Photo courtesy KEA.

figure 40

The failure of many of these installations dampened interest in wind energy, though there is recent renewed interest. Some small individual systems are being operated in remote areas, and some companies are using small, low-power wind systems to charge batteries for remote electronics.

The first utility wind farm in Alaska

New efforts by utilities to integrate wind as a part of the mix of generation sources is bringing greater harvesting of this resource in Alaska than ever before.

In 1992, Kotzebue Electric Association (KEA), with assistance from the Alaska Division of Energy, began investigating local wind energy resources. Anemometers were installed to test wind-speed at various places and at varying heights above the ground. Over several years, tests and analyses were conducted to detail wind speeds, direction, power and other factors necessary to determining how much energy could be captured for electricity production.

Tests confirmed good wind energy potential, with Kotzebue being ranked as a Class 5 wind site. At that time KEA entered into project partnerships with federal and state agencies to begin the Kotzebue Wind Energy Demonstration Project. The purpose of the project is to test and develop turbines for use in remote, northern communities.

At first, it was difficult to find an appropriate U.S.-manufactured turbine built to withstand arctic conditions. However, more turbines are being built and as the project proceeds a number of different types of turbines will be tested in Kotzebue.

The first utility wind farm in Alaska was begun as KEA installed three Entegrity 15/50 (formerly AOC) turbines in 1997. By January 2000, ten of these turbines were operating at the cooperative's wind farm, about five miles south of Kotzebue. Each of these turbines can produce up to 66 kilowatts of power, and enough electricity each year to meet the needs of 20 homes.

The turbines are HAWTs with three-blade trailing rotors. They have special features for use in arctic conditions, such as cold-weather metallurgy and heaters. Special braking mechanisms help stop the turbines and prevent damage in high winds.

KEA has also installed two other types of turbines and plans to continue to develop its wind farm.

Ultimately, the utility plans to install 2- to 3-megawatts of wind energy capacity, enough that it could, at times of good wind, meet the entire electricity needs of the community by harvesting wind energy. It hopes to eventually reduce use of diesel fuel by 300,000 gallons a year.

In addition, the cooperative is planning to provide options for heating using wind-generated electricity. That could reduce the need for purchase and storage of heating fuel used in the community.

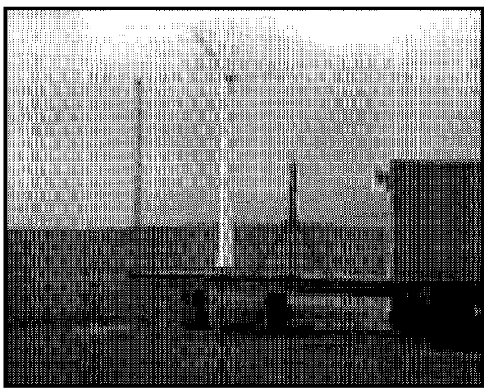


figure 41 Wind turbine on St. Paul Island in Alaska where winds are excellent for power development. Photo courtesy TDX Power.

Wind Energy Development in Alaska

Since KEA's installation of the first utility wind farm in Alaska, interest in wind energy has been growing in the state. Utilities and other companies have been exploring projects both large and small.

Alaska Village Electric Cooperative is developing wind power. In 1998 KEA, working with the Alaska Village Electric Cooperative (AVEC), initiated a **high penetration** project in Wales, Alaska. The main goal of the Wales project was to demonstrate that is possible to effectively incorporate a large proportion of wind energy into an isolated electrical system. The **Wales High Penetration Wind System** utilizes a system controller, wind turbines and short-term energy storage to displace diesel fuel used to produce electricity. This project was the prototype for numerous installations throughout Alaska.

This project is important in that an electric system can only accept a certain proportion of wind energy before it becomes unstable, unless certain steps are taken to avoid problems.

The proportion of wind power on a system is referred to as the **penetration level.**

The Wales project wind system was commissioned in July 2001. The wind portion of the project was primarily financed and maintained by Kotzebue Electric Association and the energy was sold under agreement to the Alaska Village Electric Cooperative.

Penetration Levels

Low Penetration – Diesel generators are always on.

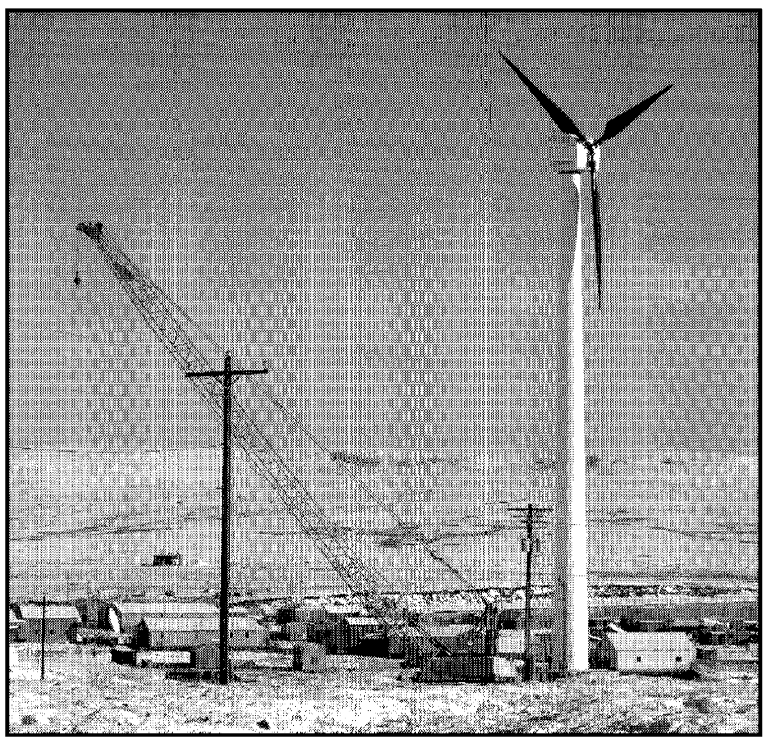
Medium Penetration – Diesel generators are always on, but electronics keep the system stable with a higher proportion of wind power.

High Penetration – Little or no diesel power needed – thermal energy, battery storage and electronics keep the system stable with a high proportion of wind power.

High penetration wind-diesel technology is important for rural Alaska because of the large number of villages which are located on the coast and could benefit from this technology.

AVEC has since installed wind turbines in several of the other villages it serves. In 2006 it had systems operating in Selawik, Kasigluk and Toksook Bay and was looking at putting up systems in Savoonga and Gambell, Chevak, Hooper Bay and possibly Mekoryuk.

Kotzebue Electric Association was the field project manager for the wind system in Selawik. Four of the same sort of turbines originally installed in Kotzebue (the Entegrity 15/50, formerly AOC) were set up in 2003.



A Northwind 100 turbine at Toksook Bay, Alaska. Photo courtesy AVEC. *figure 42*

In 2006 three 100 kW Northwind 100 turbines were installed in Kasigluk to supplement a diesel power system that serves Kasigluk, Old Kasigluk and Nunapitchuck. This system was expected to displace 52,000 gallons of fuel each year. The new system includes upgrades to the diesel system as well, and a system for using excess heat to warm a community building and the power plant.

AVEC also installed three 100 kW Northwind 100 turbines in Toksook Bay in 2006. The wind-diesel system in Toksook also provides power to Tununak and Nightmute.

St. Paul Island Commercial Complex. In 1999, Tanadgusix Corporation installed the largest turbine ever placed in Alaska, a 225 kW Vestas wind turbine on St. Paul Island, which has among the best wind energy resources in Alaska. The island has a documented average annual wind resource in excess of 18 mph.

Tanadgusix (TDX) is a shareholder-owned Aleut village corporation with primary offices in Saint Paul and Anchorage.

The turbine works in conjunction with two diesel generators to provide electricity needed by the company's commercial building complex. The hybrid system incorporates a full waste-heat hot water system to handle excess electricity generated by the wind turbine. This is expected to reduce the corporation's annual purchase of 30,000 gallons of diesel heating fuel. TDX Power plans to expand this system and is working on projects for other communities as well.

Kodiak has good wind resources. In 2006, Kodiak Electric Association was planning a 3- to 5 megawatt wind farm on Pillar Mountain behind the city of Kodiak. The utility produces electricity using diesel generation and also gets power from a hydroelectric plant at Terror Lake. The utility was expecting that wind generation would save diesel fuel, reduce polluting emissions, lower generation costs, stabilize fuel costs, and allow efficient use of the hydroelectric plant, which could serve as a sort of battery to help maintain voltage amid shifting winds. Kodiak was exploring the use of up to eight 600 kW turbines.

Urban utilities explore larger wind projects. Golden Valley Electric Association, based in Fairbanks, has pledged to use renewable energy for 20 percent of its peak generation by 2014. In 2006 it was evaluating the possibility of a major wind project near Healy, Alaska and had begun a program called SNAP (Sustainable Natural Alternative Power). SNAP links local people who want to produce renewable power, such as wind or solar, with members of the cooperative who want to buy renewable power.

Chugach Electric Association, Alaska's largest producer of electric power, is exploring the possibility of a large wind farm on Fire Island, perhaps as large as 50 to 100 megawatts.

These projects across the state represent just part of the explosion of interest in wind power generation in Alaska.

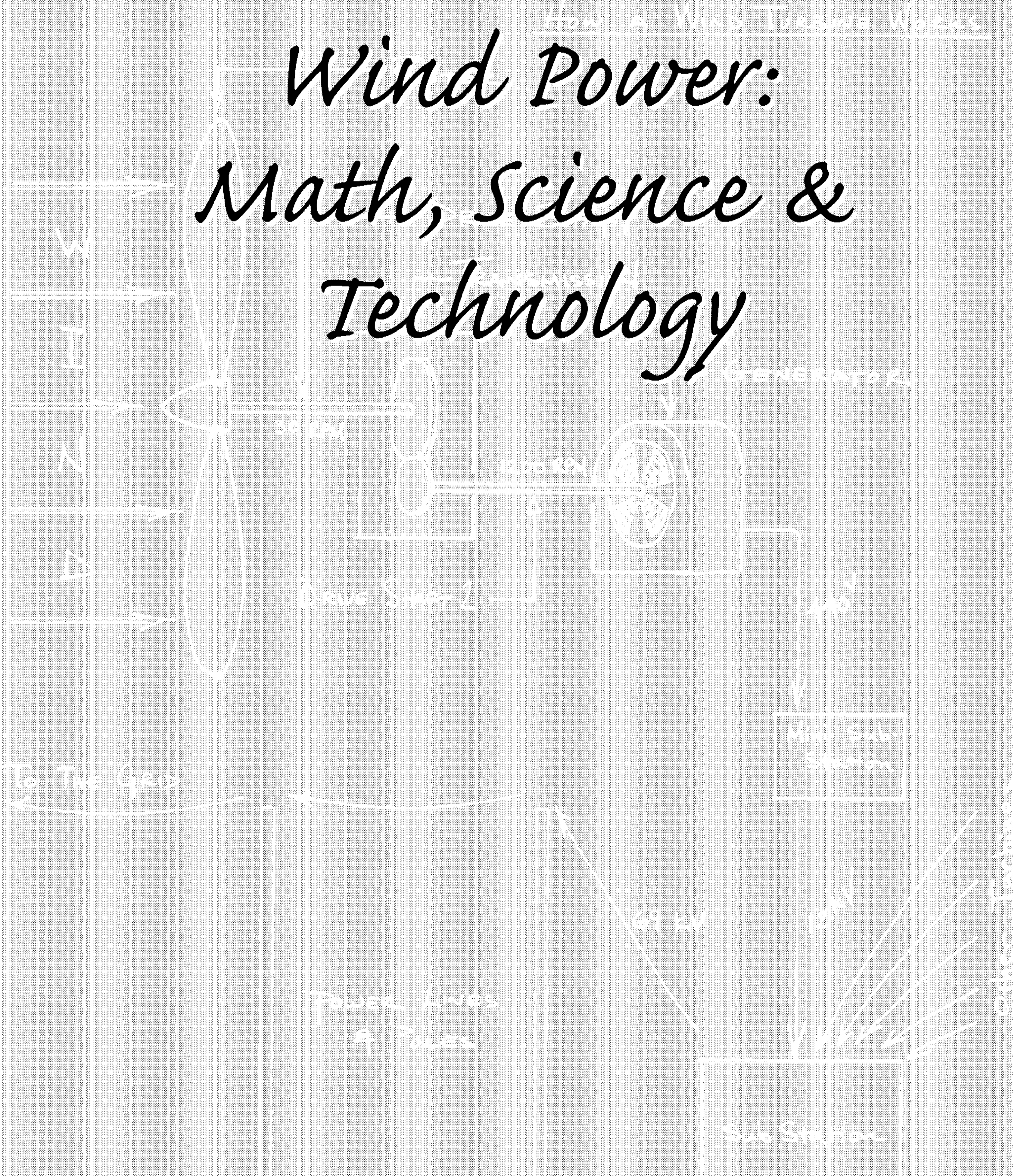
For each of these and other project to begin operation, utilities and other companies must carefully assess wind resources, find the appropriate generation, plan for integration and operation with existing systems, evaluate potential environmental impacts, find ways to pay for the equipment, find skilled employees to operate wind systems, and deal with many other issues.

The math section of this curriculum provides a better understanding of some of the technical factors that wind energy developers must consider.

WHAT DO YOU THINK?

- ***Where are the best wind energy resources in Alaska?***
- ***What is the average wind speed for a Class 5 rating?***
- ***What are some of the challenges of developing wind power in Alaska***

Wind Power: Math, Science & Technology



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CHAPTER 1–THE NATURE OF WIND

KEY IDEAS IN THIS CHAPTER

- *Wind is a form of solar energy.*
- *Geography affects wind patterns.*
- *Wind speed increases with height above the ground.*

Early wind machines were simple devices. (see the "Wind Power: History" booklet). Modern wind turbines, in contrast, are highly refined, complex machines. This booklet will introduce the basic concepts and mathematics involved in designing wind turbines.

The Wind is solar-powered: Wind energy is a form of solar energy. Without the Sun, there would be no wind. When the Sun strikes the Earth it heats it and the atmosphere around it. Because of the Earth's round shape, uneven surface, elliptical orbit, and clouds in the atmosphere, this solar heating is uneven. Some areas get warmer than others. These areas of warmer air become less dense and therefore rise. Cooler air fills in from the sides. So, wind is merely air moving around in an attempt to equalize the temperature and pressure differences caused by this uneven solar heating *(figure 1).*

World wind patterns: Although the solar heating of the Earth is uneven, predictable global wind patterns have developed *(figure 2).* These 'prevailing' or 'trade' wind routes have long been taken advantage of by sailors. The more regular and powerful the wind is, the better it will be for wind turbines.

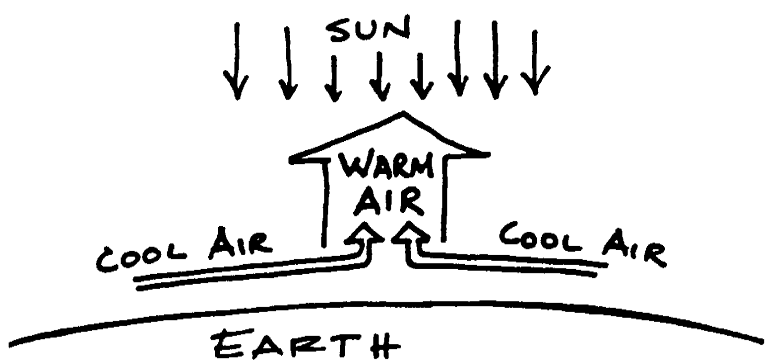


figure 1

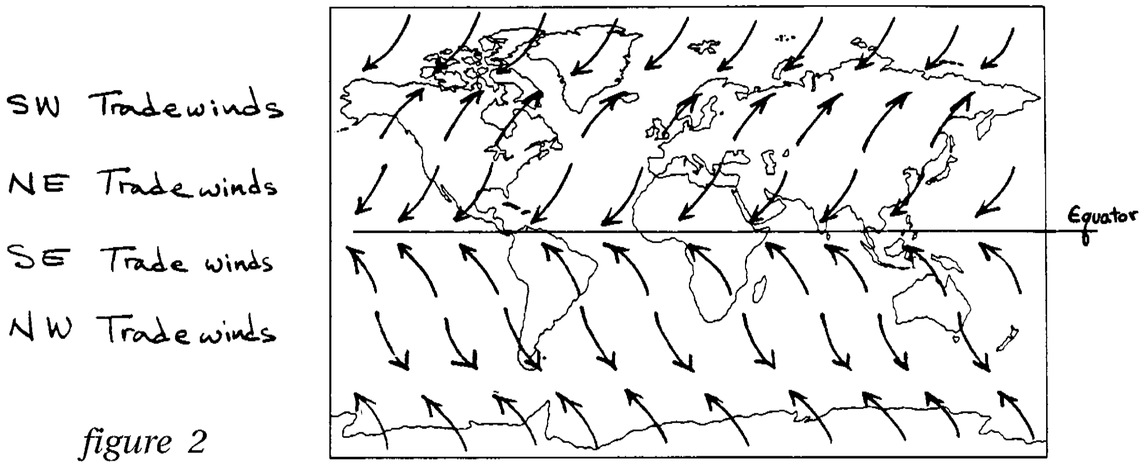


figure 2

Local wind patterns: Local areas often have predictable daily wind patterns caused by solar heating of uneven geography like coastlines, hills and valleys *(figure 3)*.

Wind speed and ground friction: There is friction between the wind and the ground. It causes wind near the ground to slow. So, the higher you go, the stronger the wind is. *(figure 4)*.

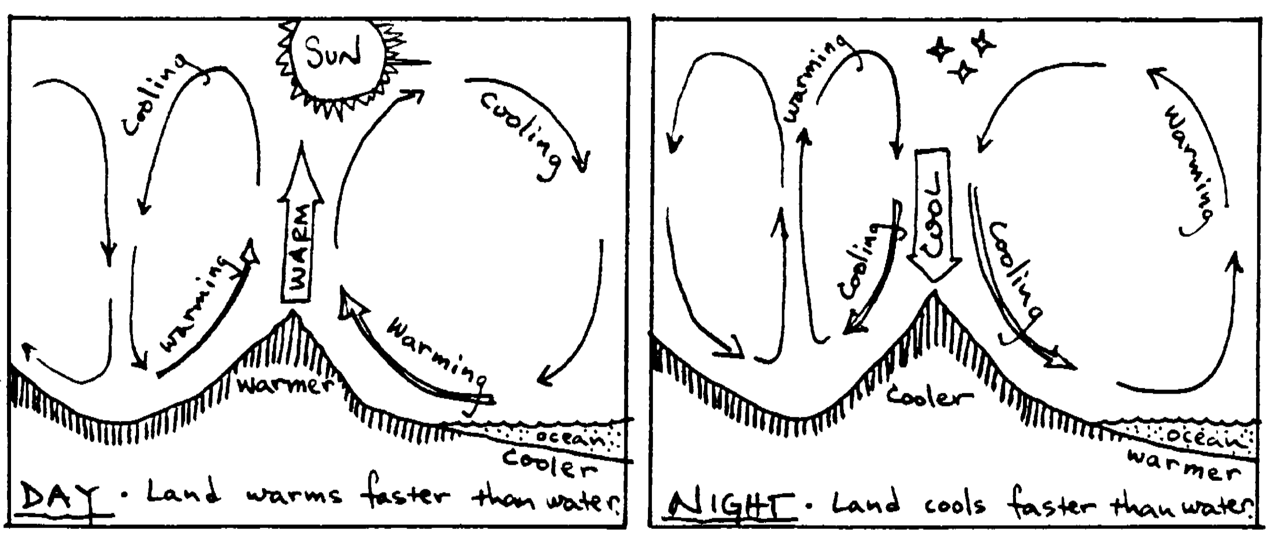


figure 3

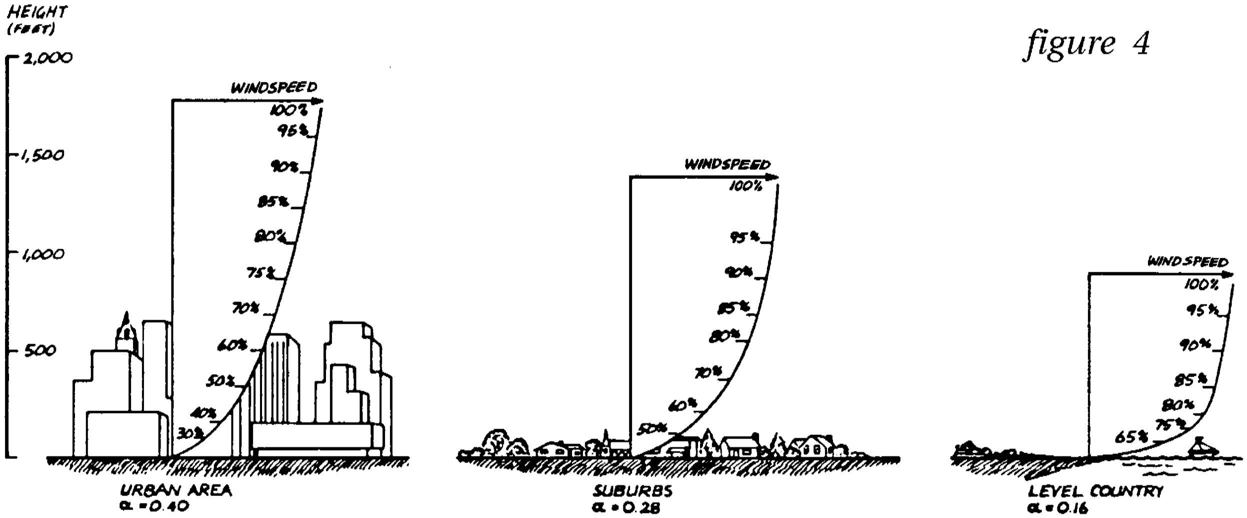


figure 4

The Wind Speed – Ground Friction Rule gives the speed of the wind at any chosen altitude. To use it you need to know the wind speed at another known height:

$$V = V_o \times (H / H_o)^F$$

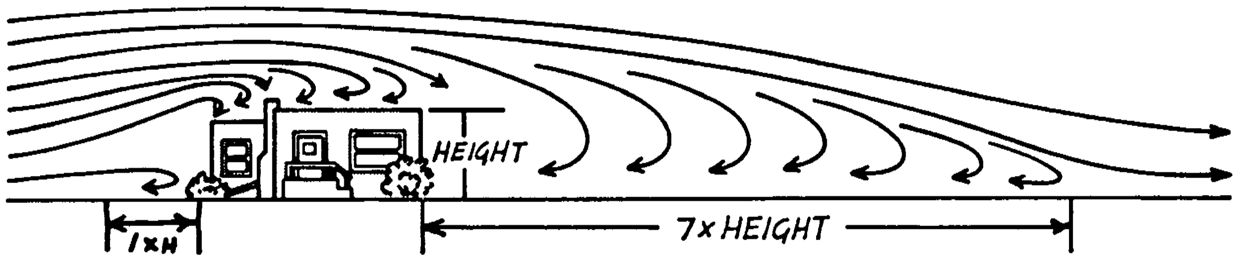
Where:	H	=	height at which wind speed is wanted
	H_o	=	height at which wind speed is known
	V	=	wind speed you want to know (at H)
	V_o	=	wind speed at Ho (which is known)
	F	=	Friction Coefficient of the ground …
		=	.10 for smooth, hard ground or water
		=	.15 for foot high grasses
		=	.20 for high crops, hedges, few trees
		=	.30 for wooded country and towns
		=	.40 for cities with tall buildings

Example:

if $V_o = 10$ mph at $H_o = 10$ ft & $F = .20$

then $V = 10 \times \left(\frac{50}{10}\right)^{.20} = 13.8$ mph.

(at H = 50 ft)



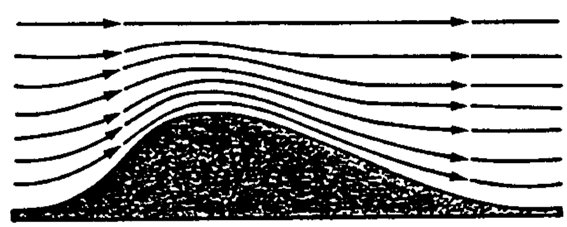
Substantial turbulence occurs on the downwind side of buildings. The turbulence is greater for buildings with sharp edges. If the building is 100 feet tall, the air turbulence downwind extends about 700 feet and the turbulence upwind extends about 100 feet.

figure 5

Wind flow and obstacles: Wind turbines need smooth wind flow to operate efficiently. Any obstacle in the path of the wind will disturb its smooth flow. Obstacles create turbulence both up and down wind. One rule of thumb states that for an obstacle of height H, the wind will be turbulent 1 x H upwind and 7x H downwind *(figure 5).*

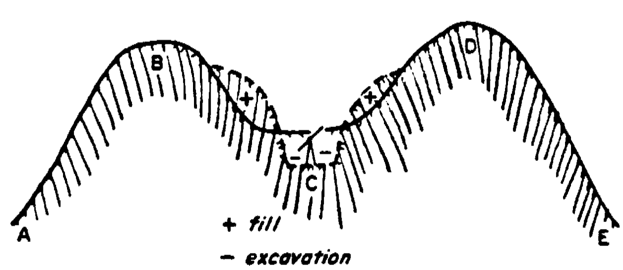
If the building is 100 feet tall, the air turbulence downwind extends about 700 feet and the turbulence upwind extends about 100 feet.

Wind-enhancing geographic features: Certain land formations will actually increase the speed of the wind. One formation that does this is a gradual, smooth hill *(figure 6).* Another is a narrow valley with a smooth, gradual entrance and exit *(figure 7).* The phenomenon which causes these speed-increasing effects is called the Bernoulli Effect, the same effect that gives wings their lifting properties.



Acceleration of Wind Over Hill

figure 6



Proposed Type of Terrain Modification for the Purpose of Augmenting Average Wind Speeds

figure 7

Summary: Wind turbine siting:

So, here are some guidelines for siting a wind turbine to take advantage of the best winds:

- Choose a high wind speed region (check a wind map).
- Choose high altitude and mount the turbine on a tower.
- Choose open sites with few obstacles.
- Choose a site with wind-enhancing geographic features.
- Above all, take wind speed and direction measurements over a substantial period of time to ensure your site is in fact a good one for a wind turbine.

Consider your Community

- ***From what direction do the winds usually blow in your community? Does the direction change depending upon the time of day or time of year?***
- ***What local geographic features affect wind patterns in your community?***
- ***What obstacles exist to wind flow in your community that create friction or turbulence?***
- ***Where do you think the best place might be to try to harness the wind in your community? Why?***

Chapter 2 – The Physics of Wind Turbines

Key Ideas in this Chapter

- ***Energy = Power x Time***
- ***The energy in the wind increases dramatically as wind speed increases.***
- ***Only part of the energy of the wind can be captured.***
- ***Wind energy is harnessed with drag or lift devices.***

Energy, work and power: Energy is the capacity to do work. Work is done when a force moves an object. Power is the rate at which energy is used (or made) or work is done.

Here is an example: The gasoline in a car's fuel tank has a certain amount of energy in it (ability to do work). When I drive fast, the car uses more power (works harder) and empties the tank more quickly than if I drive more slowly, using less power. Energy is what you have, work is using it, power is how fast you use it (or make it). Expressed as a formula:

Energy = Power x Time E = P x T (kilowatt hours = kWh)

or

Power = Energy / Time P = E /T (kilowatts = kW)

Power in the Wind

The power in the wind is essentially the force its moving mass exerts on objects it hits. In other words, wind has power to move things it hits. It is this inertial force we can capture and use. The power of moving air is given by the Formula:

$$\text{Power} = \frac{1}{2} \times p \times V^3 \times A \quad \text{(watts)}$$

Where:
- p = density of air (about 0.0023 slugs / ft3) (1 slug = 32.2 lb @ sea level)
- V = speed of the wind (mph)
- A = area of wind captured (ft^2)

$\frac{\pi d^2}{4}$ = area of a circle where
d = diameter of the rotor

Wind power is proportional to the cube of the wind speed. For example: if wind speed goes up 2x, then wind power goes up 8x ($2^3 = 2 \times 2 \times 2$)

Wind power is proportional to the area of wind captured. This means a bigger turbine catches lots more energy. For example: if you double the rotor diameter of a HAWT, then wind power quadruples.

Since: $$\frac{\pi d^2}{4} = A$$

Thus: $$\frac{\pi (2d)^2}{4} = \frac{\pi (2^2)(d^2)}{4} = 4A$$

Wind power is proportional to the density of the air running past the blades. Air density (**p**) is directly related to air pressure and temperature by the following equation.

$$p = \frac{P}{R_U T}$$

Where:	P	=	air pressure
	T	=	air temperature
	R_U	=	universal gas constant

From the wind power equation $\textbf{Power} = \frac{1}{2} \times p \times V^3 \times A$ we see that power will increase if the air density increases. From the air density equation we see that **p** will increase if air pressure increases or temperature decreases. Therefore, wind turbines will produce more power in the winter than in the summer.

Capturing the power in the wind: Of course, wind turbines are not 100% efficient. The designs vary widely but, as a rule, they lose between 50 and 90% of the wind's power before it can be used. So, here's the adjusted formula:

Useful Power = $\frac{1}{2} \times p \times V^3 \times A \times E$ **(watts)**

Where: E = efficiency of power extraction (.10 to .50)

E = .10 to .20 for a Savonius rotor

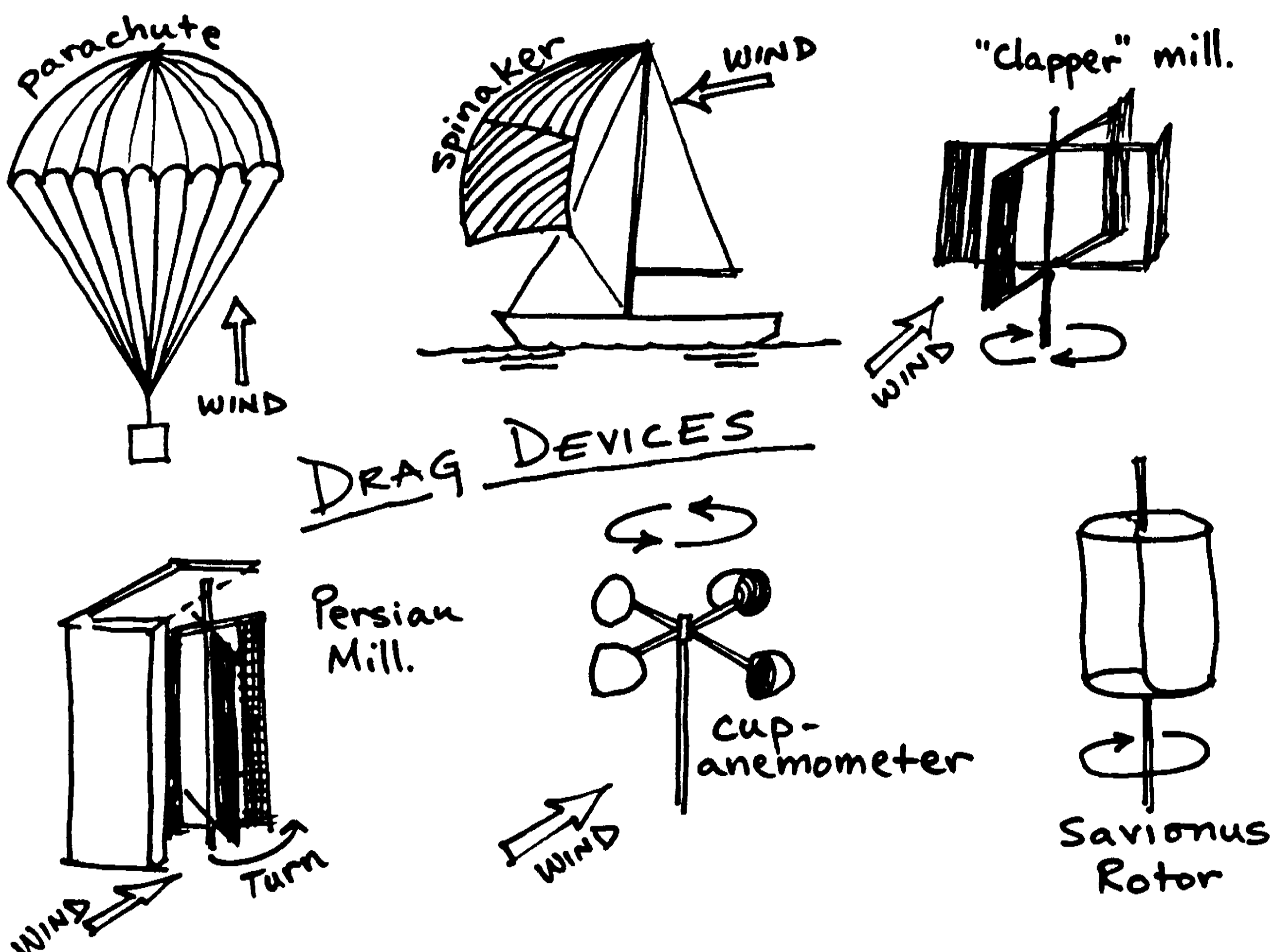
E = .15 to .30 for a Darrieus rotor

E = .20 to .45 for a HAWT (Horizontal Axis Wind Turbine)

Two Types of Wind Devices: Draggers and Lifters

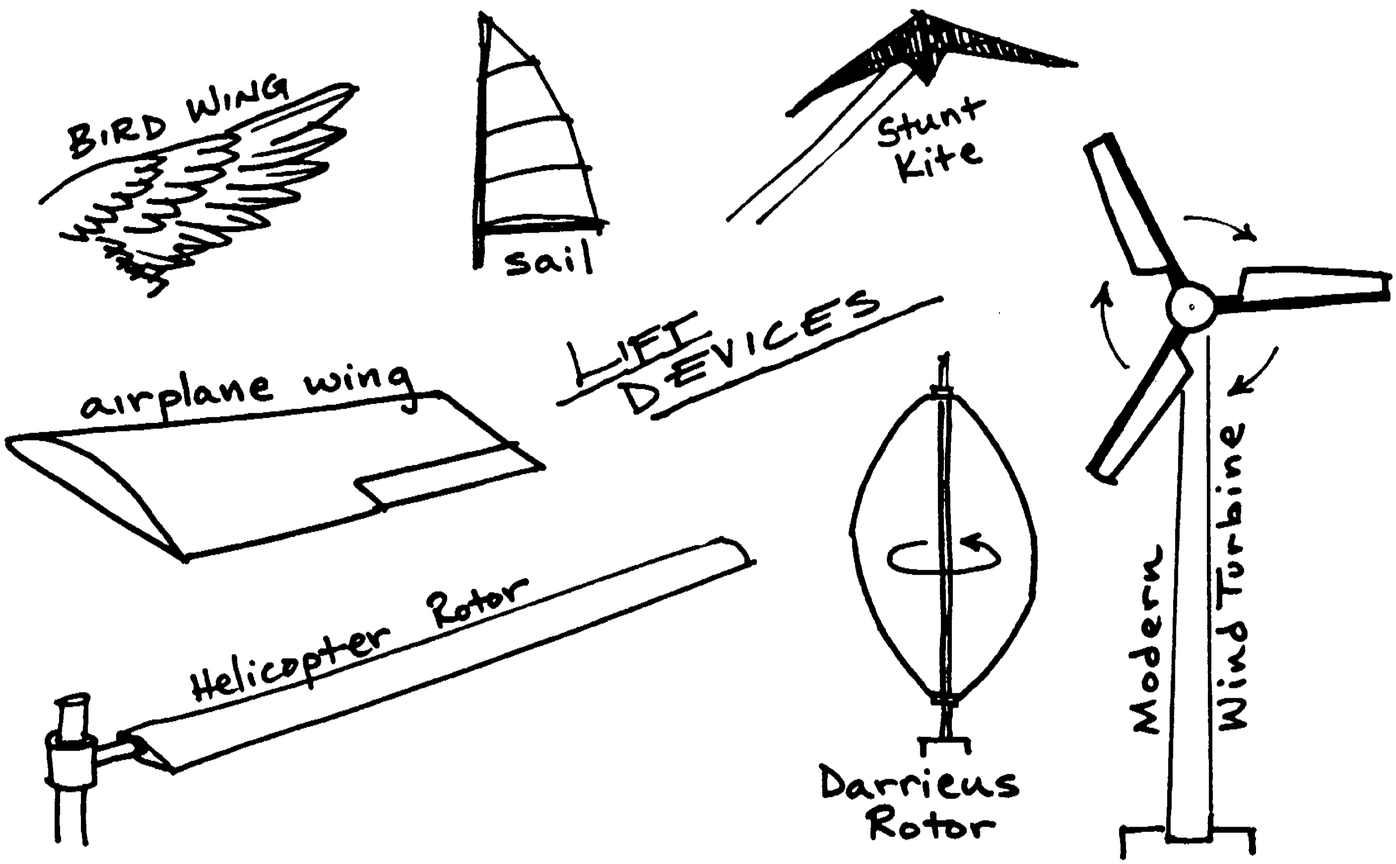
Drag devices use the direct ‘pushing’ power of the wind. Their efficiency is low, about 10 to 20%. Examples of drag devices are parachutes, spinnaker sails, cup-anemometers, Persian windmills, Chinese ‘clapper’ windmills, and Savonius rotors *(figure 8)*.

figure 8



Lift devices make use of aerodynamic lift and capture much more of the wind's power than drag devices of the same area. Their efficiency is about 30 to 50%. Examples of lift devices are: bird wings, modern sails, kites, airplane wings, helicopter rotors, Darrieus rotors and modern windmills.

figure 9



How lift devices work: Here is how 'Lift' devices capture more of the wind's power than 'drag' devices. 'Drag' devices like parachutes lose most of their power to turbulence (which takes power to make) *(figure 10).*

'Lifting' devices like wings allow the wind to maintain its laminar (smooth) flow, so little power is lost to turbulence. Also, because the wind has to travel farther on the 'top' of the wing than the 'bottom' (and therefore gets less dense or thinner) the wing gets 'lifted' along by the lower pressure there *(figure 11).*

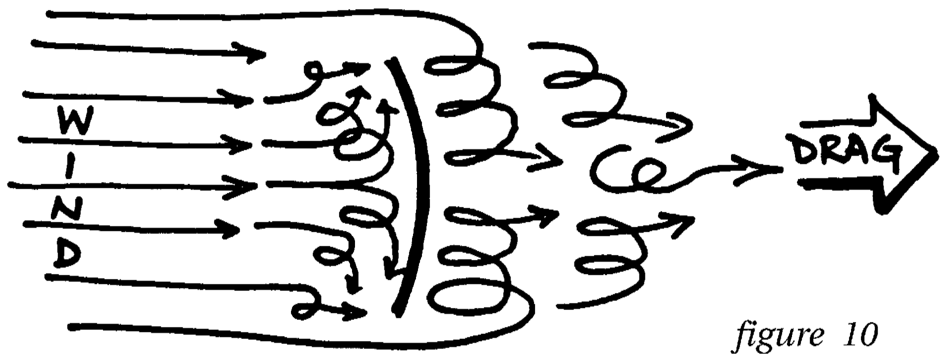
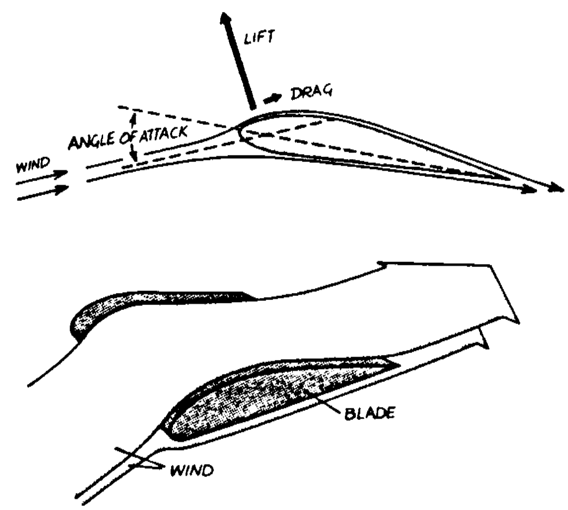


figure 10

Summary: Wind turbine physics:

Let's look at what we know:

- **Wind energy is proportional to the cube of wind speed.** For example: if wind speed goes up 2x, then wind energy goes up 8x ($2^3 = 2 \times 2 \times 2$)
- **Wind energy is proportional to the area of wind captured.** This means…a bigger turbine catches lots more energy. For example: if a HAWT rotor diameter goes up 2x, Then wind energy goes up 4x ($2^2 = 2 \times 2$)
- These two facts would lead us to believe that the **bigger the turbine, the better.** This is exactly what designers thought in the 30's and 40's. The Smith-Putnam turbine on Grandpa's Knob near Rutland, Vermont was an example of this thinking. (See "Wind Power, A Brief History" booklet)
- However,other factors, such as which turbine is most productive with a particular wind profile and whether the equipment needed to install large turbines is available may also need to be considered. So the size of turbine to be used must be evaluated for each site to determine what is best.



The flow of wind about a wind turbine blade. Lift forces act perpendicular to the local wind direction, while drag forces act parallel to it. The rotor blades of KEA's Entegrity turbines are designed to make use of the lift forces.

figure 11

REVIEW

- ***What is the difference between energy and power?***
- ***If wind speed doubles, how much greater is the energy in the wind? Why?***
- ***How does air density affect wind power?***
- ***Name a drag type wind device; now name a lift type.***
- ***How much of the power in the wind can be captured by modern wind turbines?***
- ***Why is the area a rotor sweeps important to the amount of power that can be captured?***
- ***Why would you want to put a turbine high in the air if you are trying to harness the wind?***

CHAPTER 3 – DESIGNING MODERN WIND TURBINES

Selecting and Designing Modern Wind Turbines

The key thing to remember in either choosing or designing a wind turbine for electric power generation is that it must be matched to the wind profile and operating realities where it will be installed. So, in other words, know your wind, and know your electric system!

The first step in deciding on a turbine is to do detailed wind energy assessments to identify average wind speeds, duration, fluctuations and other characteristics. These help identify the actual wind energy potential. Additionally, wind assessments will help in choosing or designing a turbine. For instance, different types of turbines are able to begin producing power at different wind speeds, and produce their maximum power at different wind speeds. You want to find the best fit for specific circumstances.

Because the wind does not blow at the same force all the time, wind energy is an intermittent energy source and so must be coupled with batteries or other types of generation in order to assure a constant source of power. Understanding in what way a wind turbine will be used and contribute to the overall need for power is important to choosing a design.

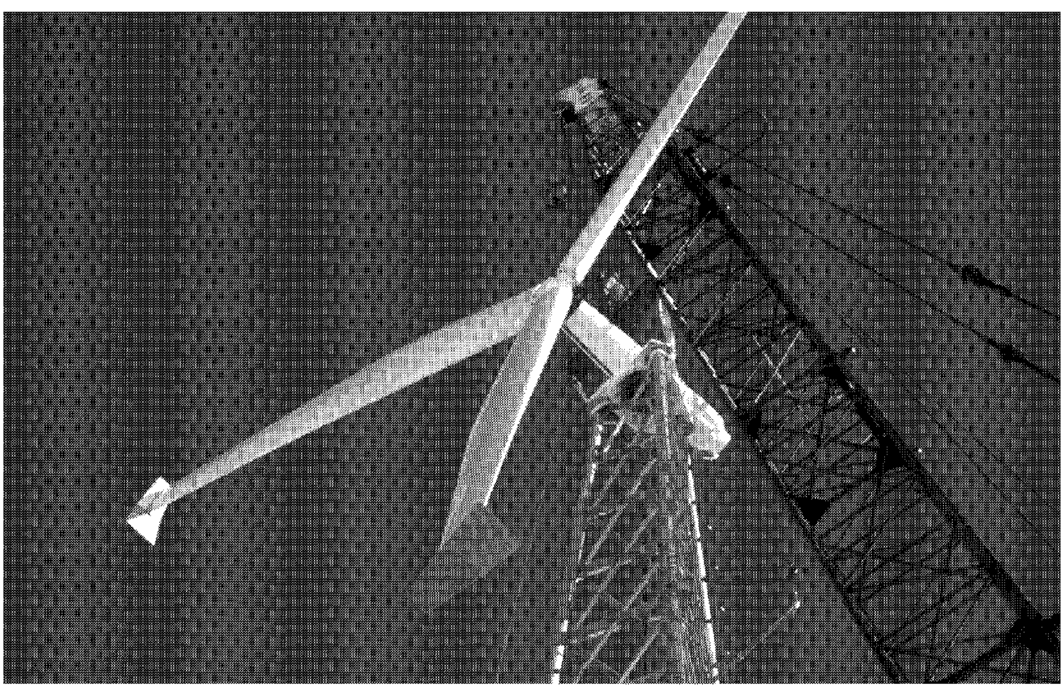
KEY IDEAS IN THIS CHAPTER

- ***Turbine design must match specific use.***
- ***Design elements balance issues of cost, ease of use, efficiency, conditions within which the turbine will operate, and other considerations.***
- ***Design elements:***
  - ***Horizontal or vertical axis***
  - ***Leading or trailing rotor***
  - ***Rotor area and diameter***
  - ***Tip-speed ratio and rotor solidity***
  - ***Blade pitch***
  - ***Overspeed and high wind protection***

Will it be used to charge batteries that feed electricity to a home? Will it be used as one of many generators feeding a large utility grid where most of the power comes from other sources? Will it occasionally be used as the main power source for a small hybrid system using diesel or other generators? Within integrated systems, what is the ideal goal for how much of the total energy produced will come from wind power? What is the most cost-effective mix of generation options? All of these questions are important.

It is also important to understand the conditions under which the turbine will operate. Is the weather very hot, or very cold? Is the equipment needed for installation available? These and many other factors must be considered.

Modern wind turbines are being designed to combine a variety of technical features that will make turbines effective in specific circumstances. The rotor of a wind turbine is what is used to capture the energy of the passing winds, and therefore is of great importance. In the rest of this section, we'll learn about some of the major technical choices regarding rotors that face a wind turbine designer.



Entegrity 15/50 rotor.

Wind turbine design flow chart: Below is a generic planning flow chart for the design of wind turbine systems.

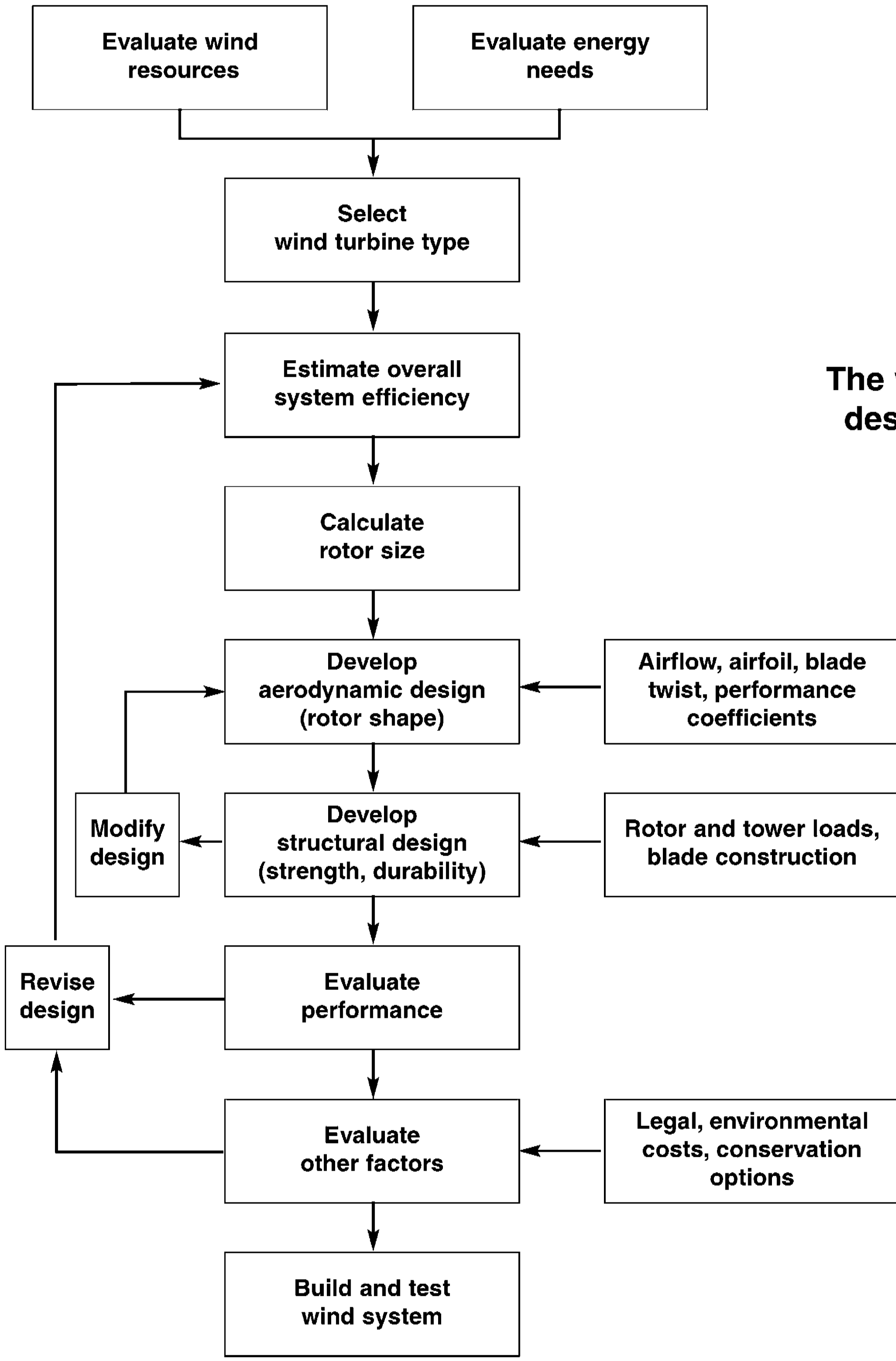
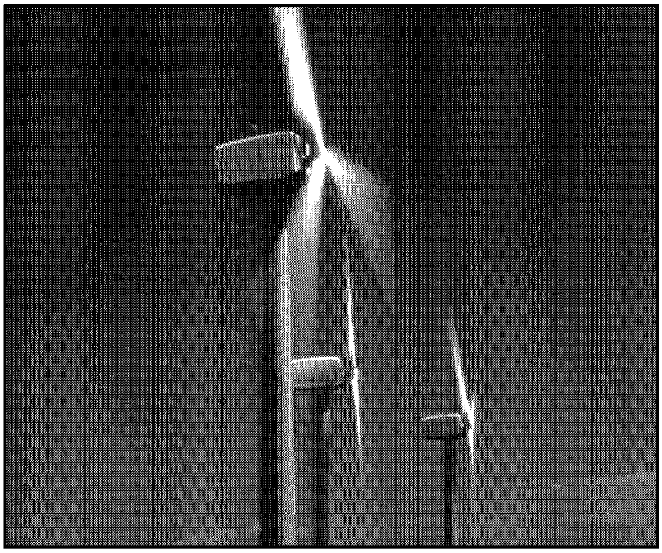


figure 12

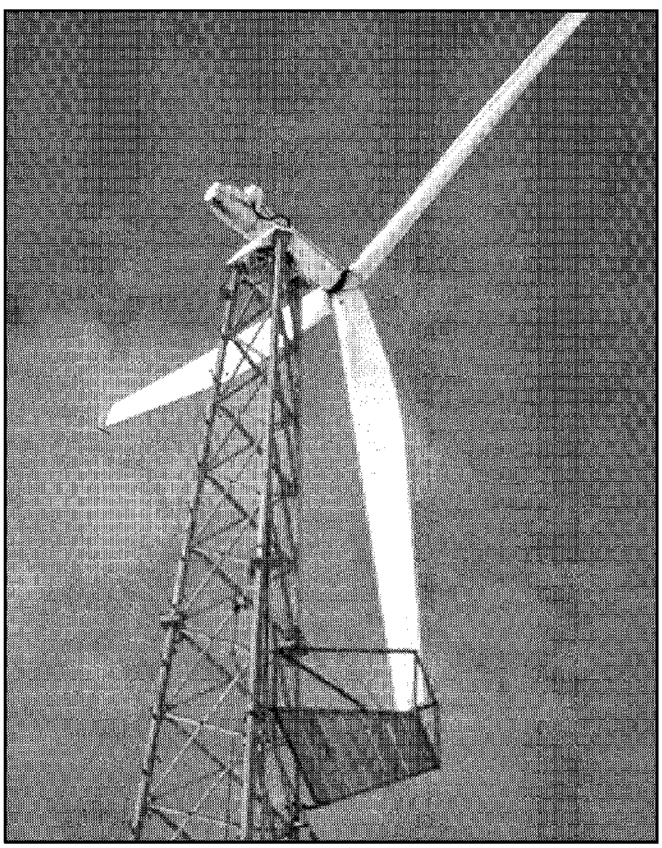
The wind machine design process.

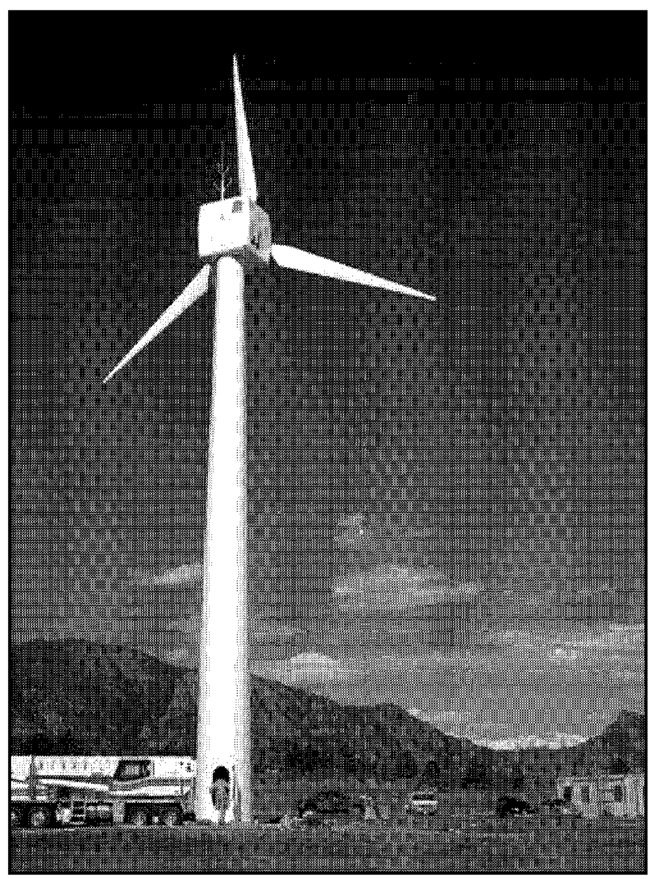
The big question: HAWT or VAWT ?: The biggest decision facing a designer is the type of rotor. There are two main groups of turbine rotors. They are defined by the orientation of their rotor axles: horizontal and vertical.



Horizontal Axis Wind Turbines (HAWT): HAWTs are the most common type of wind turbine. They are the most efficient type (up to 45%) and can operate at high speeds. This makes them good for lots of applications, especially generating electricity. They do require a mounting tower which can make installation and maintenance more challenging than VAWTs. Some modern HAWTs are shown below *(figure13).*

figure 13





Leading vs Trailing Rotor: HAWTs are designed with either leading or trailing rotors.

Leading rotors are positioned in front of the nacelle (and tower) to catch the cleanest wind *(figure 14)*. Because the wind wants to push the rotor around behind the tower, they require mechanical yaw (side-to-side) control which adds cost and complexity to the design.

Trailing rotors have their rotors behind the nacelle and tower *(figure 15)*. Because of this they don't need yaw control. However, the air hitting the blades is disturbed by the nacelle and tower. This is simpler and cheaper but it lowers efficiency. The Entegrity 15/50 turbine used in Kotzebue has a trailing rotor.

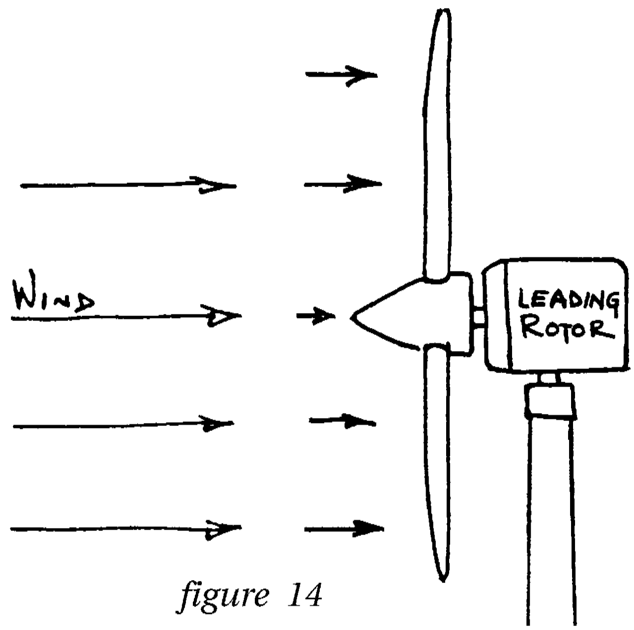


figure 14

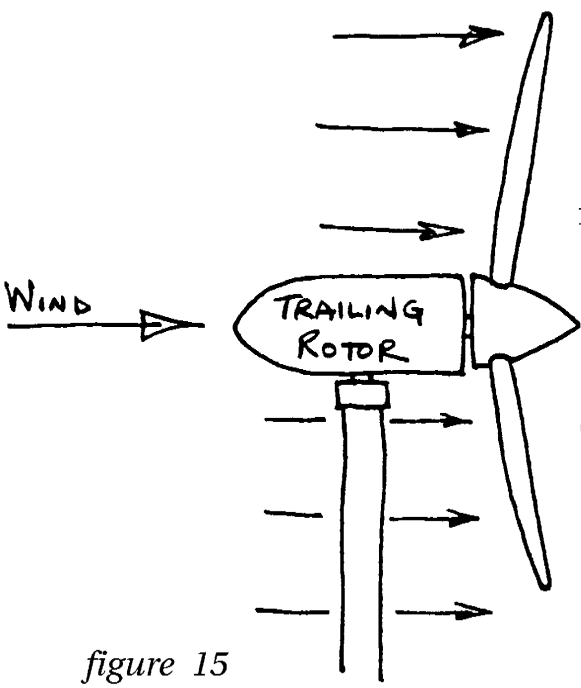


figure 15

Yaw control: HAWTs with leading rotors need yaw control. A number of mechanisms have been designed to do this job. The **tail-fin** *(figure 16)* is the ultimate in simplicity. It drags in the wind, keeping the rotor (which has less drag) forward.

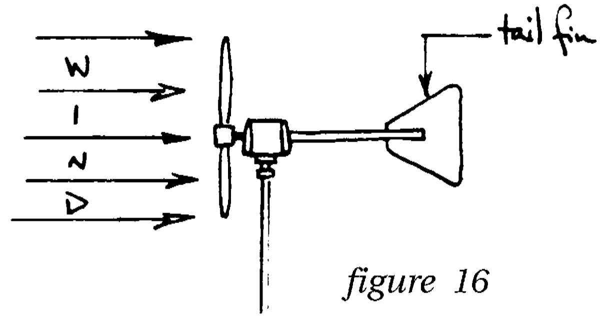


figure 16

The **fantail** *(figure 17)* was an early (1745) mechanical solution. The **fantail** was a small rotor set perpendicular to the main rotor. When the windmill was head-on to the wind, the fantail didn't turn because it was edge-on to the wind. When the wind shifted to the side, the fantail would then be turned by the wind and, through a series of gears, it would turn the main rotor to face the wind again.

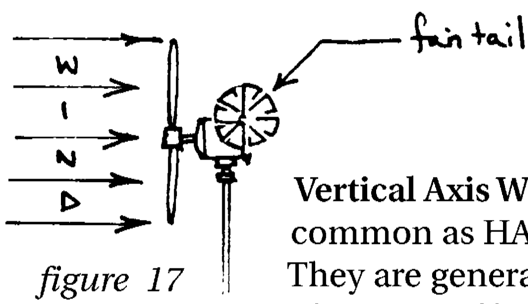
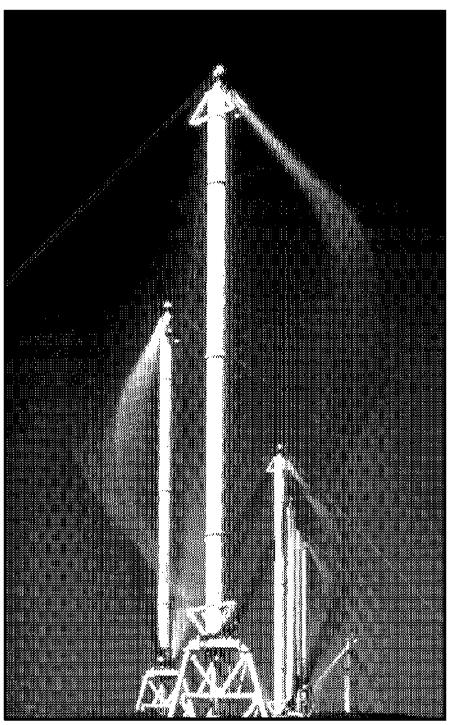
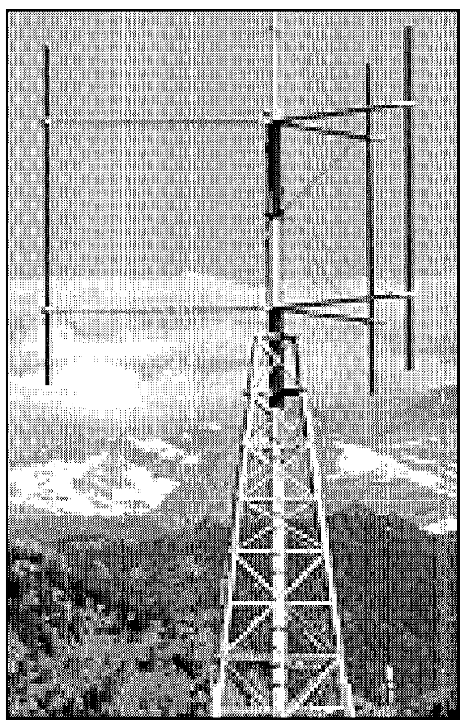


figure 17

Most modern HAWTs use hydraulics controlled by computers which monitor the wind.

Vertical Axis Wind Turbines (VAWT): VAWTs, while not as common as HAWTs, are being built in substantial numbers. They are generally less efficient than HAWTs but have the advantage of being simpler to build and maintain. The tower can be short and the generator is on the ground. Examples of modern VAWTs are shown below *(figure 19)*.


Darrieus Rotor


A straight-bladed Darrieus Rotor

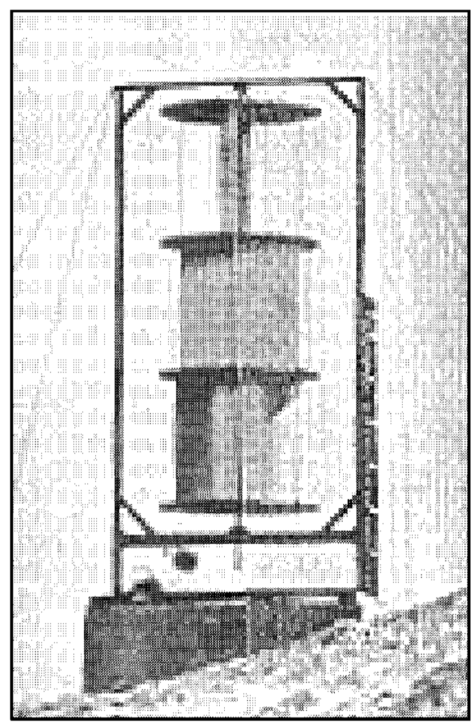

Savonius Rotor

figure 19

Savonius (S-rotor) : It operates like a cup anemometer, being dragged around by the wind. The basic design is shown below with some variations *(figure 20).* It has high starting torque but low operating efficiency (10 to 20%). This turbine has applications for mechanical operations (like grinding grain and pumping eater) but is not efficient enough for electrical generation. (see plan 16 for a model windmill to build).

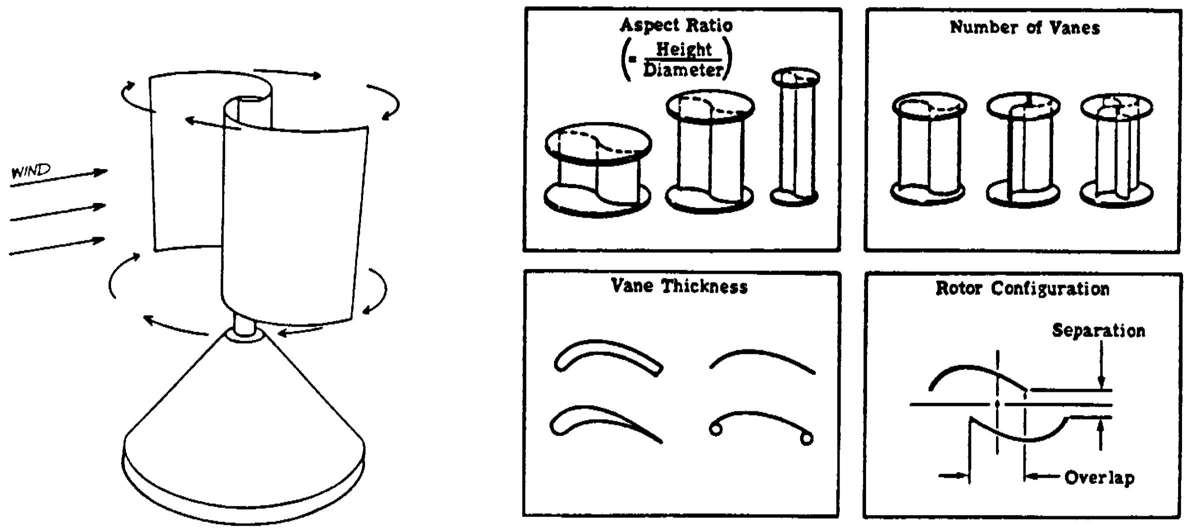


figure 20

Although it is primarily a drag device, it does produce some lift and it can be made into a kite quite easily *(figure 21).*

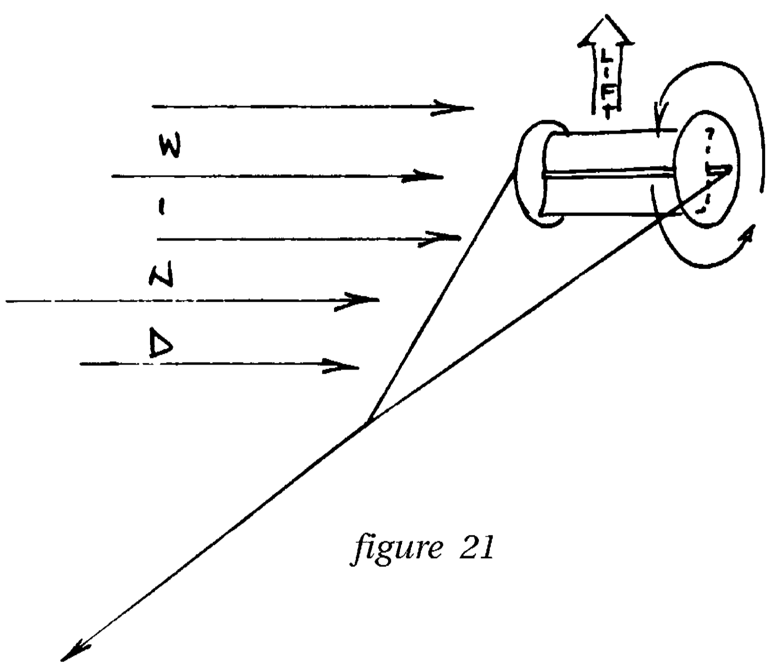


figure 21

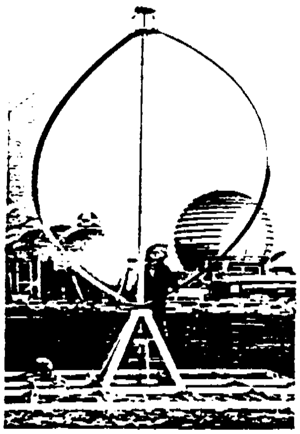


figure 22

Darrieus (D-rotor): The Darrieus rotor is a lift device and is much more efficient (15 to 30%) than the Savonius rotor and comes close to the efficiency of the HAWT rotors. It has very low starting torque and early models were not self-starting. Modern designs are good for generating electricity and are competitive with HAWTs. The basic design is shown below *(figure 22).* (see plans 17a, b, c, for models you can build)

Darrieus rotors work like other airfoils, on the principle of lift. It appears more complex than other types because of the circular path of the blades. Darrieus rotors depend on high speed operation for their efficiency. Because of the high speed of the blades, the relative wind, while constantly changing, stays in front of the blade, allowing it to produce lift *(figure 23).*

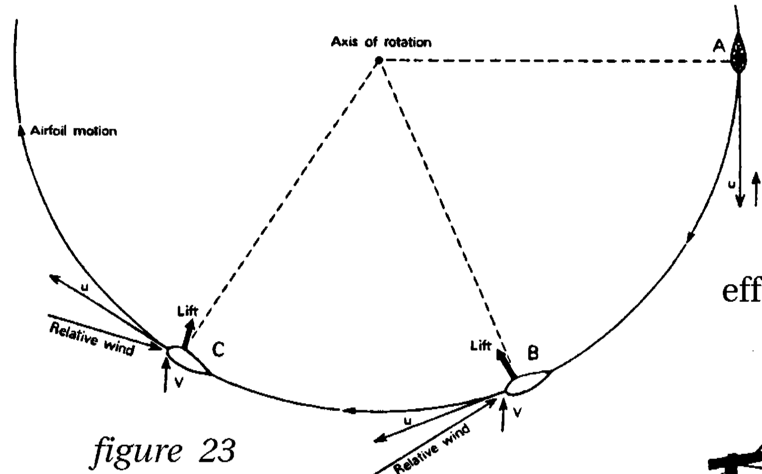


figure 23

Hybrids (H-rotor): Hybrid rotors are modifications of Savonius and Darrieus rotor designs. In combination, they can produce good starting torque and good high speed efficiency *(figure 24).*

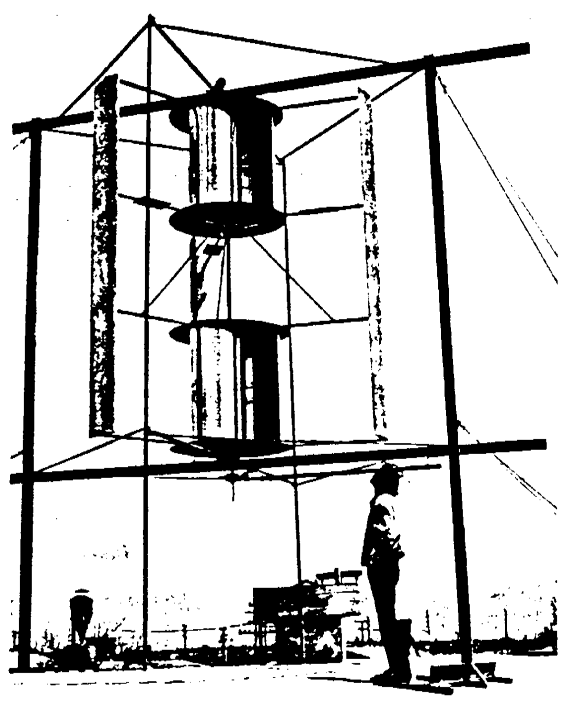


figure 24

This can also be accomplished with variable pitch blades.

Rotor and blade design issues: An important part of any wind turbine project is the design of the rotor and its blades. There are many issues to consider. The major steps involved in the design of a turbine are:

1. Know the facts.
2. Choose the rotor design to suit its use.
3. Calculate rotor area and diameter.
4. Choose appropriate tip-speed ratio and rotor solidity.
5. Calculate blade area and proportions.
6. Calculate blade pitch.

1. Know the facts: The first thing to do is to know what the turbine will be used for, how powerful it needs to be, and what kind of winds it will operate in. Most turbines are used for either mechanical or electrical power generation. Different types of turbines are better suited to each application. You also need to know what the average wind speed and direction will be at you site. To learn this you will need to take measurements over a substantial period of time.

2. Choose the rotor design to suit the use: Here are some basic rules of thumb for finding a rotor design to suit you intended use. An HAWT design is assumed:

Mechanical Applications
pumping, milling
needs high torque
speed less important

"Fan" Rotor Design
lower wind speed required
Low tip-speed ratio
High rotor solidity
High blade pitch

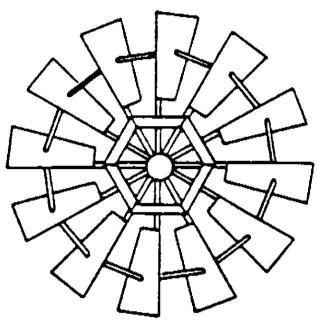


figure 25

Electricity Generation
turning an electric generator
needs high speed
torque less important

"Propeller" Rotor Design
requires higher wind speed
high tip-speed ratio
low rotor solidity
low blade pitch

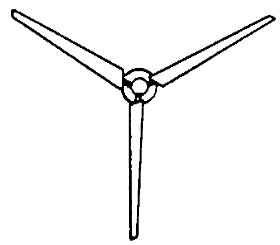


figure 26

3. Rotor Area: The first design element to tackle is the area of the rotor. In other words, "How big should it be?" I n order to size the rotor you need to know:

E = the efficiency of the rotor *(see figure 27)*

V = speed of the wind

F = the power factor *(see figure 28)*

The formula is:

Rotor area = A = P / (E x F)

(P= power)

Model wind turbine example: Let's calculate the rotor area for a model wind turbine. It will have four blades, operate in 10 mph winds, turn a 3 Watt bicycle electricity generator and have an efficiency of 20%. So ...

Rapid Efficiency Estimator		
Wind System	Efficiency, %	
	Simple Construction	Optimum Design
Multibladed farm water pumper	10	30
Sailwing water pumper	10	25
Darrieus water pumper	15	30
Savonius windcharger	10	20
Small prop-type windcharger (up to 2 kW)	20	30
Medium prop-type windcharger (2 to 10 kW)	20	30
Large prop-type wind generator (over 10 kW)	—	30 to 45
Darrieus wind generator	15	35

figure 27

$$A = 10 / (20\% \times 17.3) = \frac{10}{0.2 \times 17.3} = 2.89 \text{ ft}^2 \approx \underline{\underline{3 \text{ ft}^2}}$$

Power Factor F	
V	F
6	1.07
7	1.76
8	2.62
9	3.74
10	5.13
11	6.82
12	8.86
13	11.26
14	14.07
15	17.30
16	21.00
17	25.19
18	29.90
19	35.17
20	41.02
21	47.48
22	54.59
23	62.38
24	70.88
25	80.11
26	90.12
27	100.92
28	112.55
29	125.05
30	138.43

figure 28

To calculate the diameter of the rotor:

$$D = 2 \times \sqrt{\frac{A}{\pi}} = 2 \times \sqrt{\frac{2.89}{3.1415}} = 1.92 \text{ ft} = 23 \text{ in.} \approx \underline{\underline{24''}}$$

$$R = \frac{D}{2} = \frac{24''}{2} = \underline{\underline{12''}}$$

$$\pi = 3.1415$$

↑ Radius

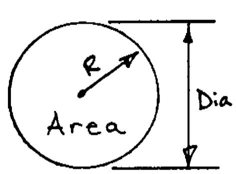
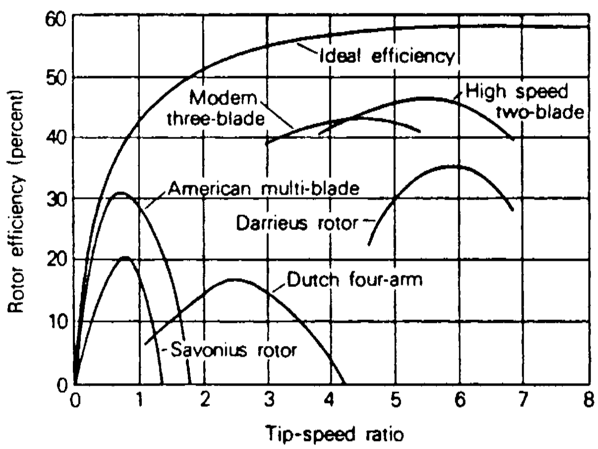


figure 29

BLADE NUMBER VS. TSR	
Tip-Speed Ratio	**Number of Blades**
1	6-20
2	4-12
3	3-8
4	3-5
5-8	2-4
8-15	1-2



Typical performance curves for several wind machines. Rotor efficiency is the percent of available wind power extracted by the rotor

Tip-speed ratio: In order to be efficient the blades of a turbine rotor need to spin at a certain speed. The best speed is different for each type of rotor. Wind turbine operating speed are defined in terms of tip-speed ratios instead of simple RPM. This allows designers to compare turbines of different sizes.

$$\text{Tip-speed ratio} = \text{TSR} = \frac{\text{blade tip-speed}}{\text{wind speed}}$$

Look at the graph at left *(figure 29)*. A modern three-blade HAWT, for example, is most efficient at a TSR of between 3 and 5.

Expressed as a formula, Tip-speed ratio (TSR) is:

$$\textbf{TSR} = \frac{\textbf{blade tip-speed}}{\textbf{wind speed}} \quad \textbf{or}$$

$$\textbf{TSR} = \frac{2 \times pi \times R \times RPM}{60 \times k \times V} \quad \textbf{or, solving for R:}$$

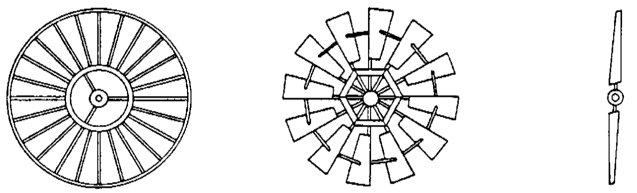
$$\textbf{R} = \frac{TSR \times 60 \times k \times V}{2 \times \pi \times RPM} \quad \textbf{or, solving for RPM:}$$

$$\textbf{RPM} = \frac{TSR \times 60 \times k \times V}{2 \times \pi \times R}$$

Where:
- π = 3.1415
- R = rotor radius (ft)
- RPM = rpm of rotor
- V = wind speed (mph)
- k = 1.47 for V in mph

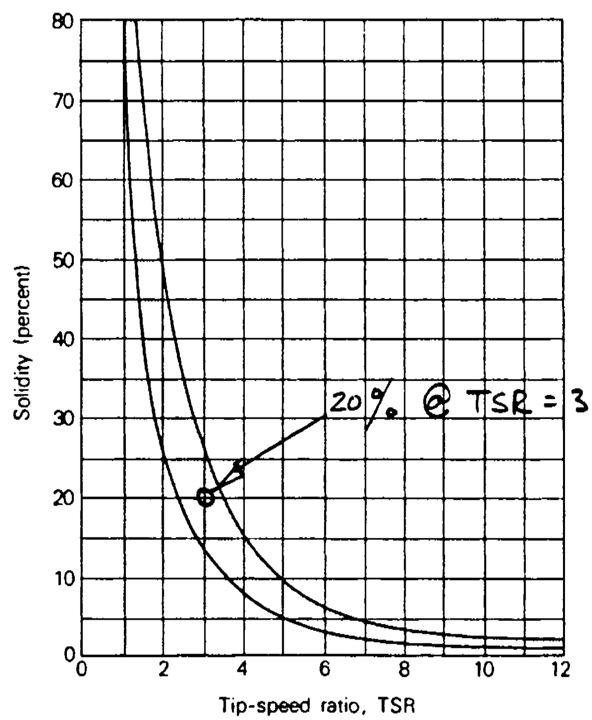
Rotor solidity and Blade Area: Rotor solidity tells of how much of the rotor-swept-area is occupied by the blades. *(figure 30 shows high, medium and low solidity rotors)*

figure 30



Rotor solidity needs to match the rotor's intended tip-speed ratio. The graph below correlates the two *(figure 31)*. For example, our four-blade rotor with a TSR of 3 should have a rotor solidity of about 20%.

figure 31



Typical performance curves for several wind machines. **Rotor efficiency is the percent of available wind power extracted by the rotor**

Blade Area and Proportions: Once you know your rotor solidity you can then calculate the total blade area of the rotor and the area of each blade. Here's the formula:

Total blade area = **solidity x swept-rotor-area**
= **solidity x π x R^2**

Single blade area = $\dfrac{\textbf{total blade area}}{\textbf{Number of blades}}$

Where:

swept-rotor-area = π x R^2 for a HAWT
= H x W for a Savonius rotor
= 1.33 x R x H for a Darrieus rotor

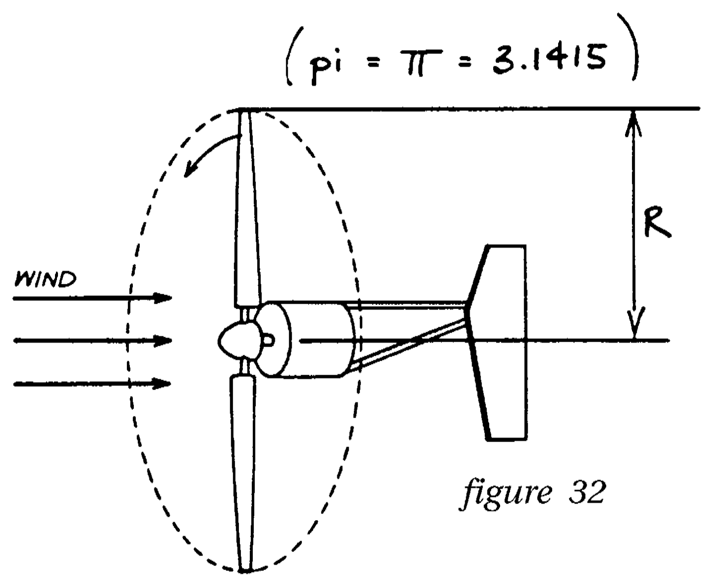


figure 32

For our four-blade rotor example, it's rotor solidity would be about 20% so,

Total blade Area = $.20 \times 3.1415 \times 1^2 = 0.62\ ft^2$
$= 90.5\ in^2$

Single blade area = $\frac{0.62\ ft^2}{4} = 0.155\ ft^2 = 22.6\ in^2$
$\approx 24\ in^2$

Blade Proportions = $24\ in^2 = 8'' \times 3''$

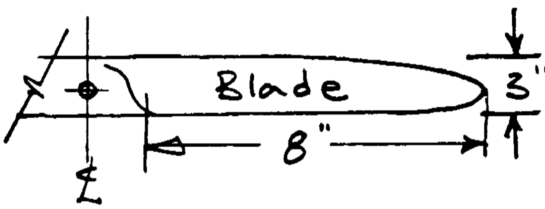


figure 33

Blade pitch: The pitch of a blade is the angle it makes with rotor's plane of rotation. A blade with 0 degrees of pitch is in-line with the plane of rotation. A blade with 90 degrees pitch is perpendicular to the plane of rotation. Most blades have a pitch of between 5 and 20 degrees *(figure 34).*

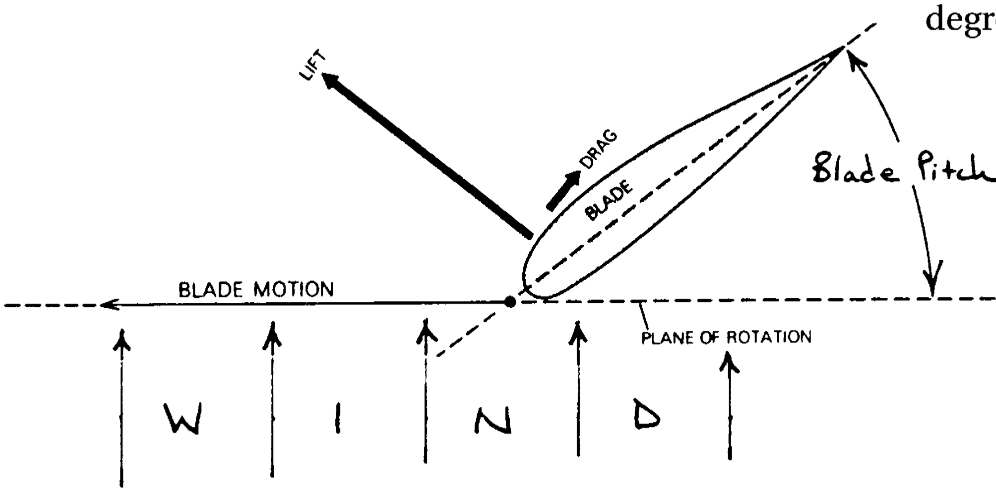


figure 34

Blade pitch allows the wind to spin the rotor in the same way a screw spins its way into a piece of wood. Ancient wind mills had a fixed pitch for the whole length of the blade. (in other words, the pitch near the hub was the same as that at the tip) Modern turbines vary the pitch along the length of the blade to compensate for the differences in speed. This is called blade-twist. Near the hub the pitch is high (20 degrees), at the tip it is low (5 degrees). *(figure 35).*

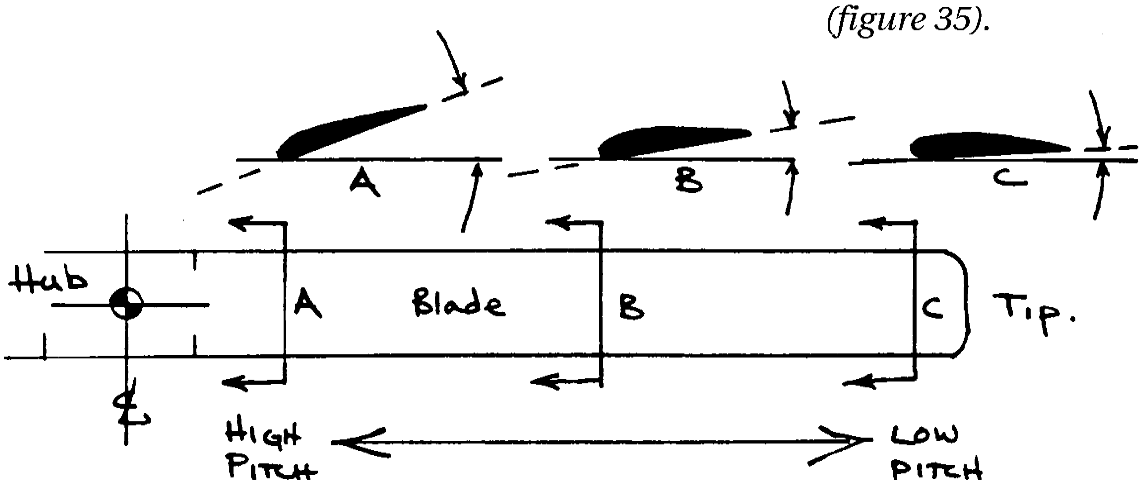


figure 35

Most modern HAWT can also vary the pitch of their blades by rotating the blade at the hub. In this way, they can adjust to different wind speeds in order to maximize their efficiency. *(figure 36).*

Calculating the correct pitch and twist for a turbine blade is very complicated. For our purposes t he following angles will suffice (these are from Professor P. La Cour) :

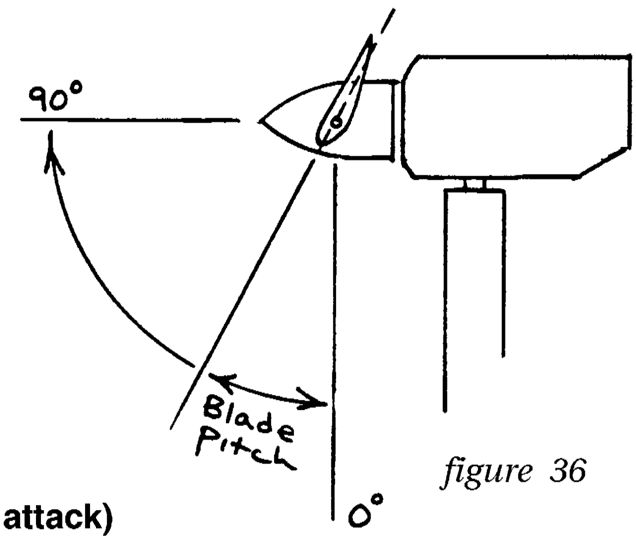
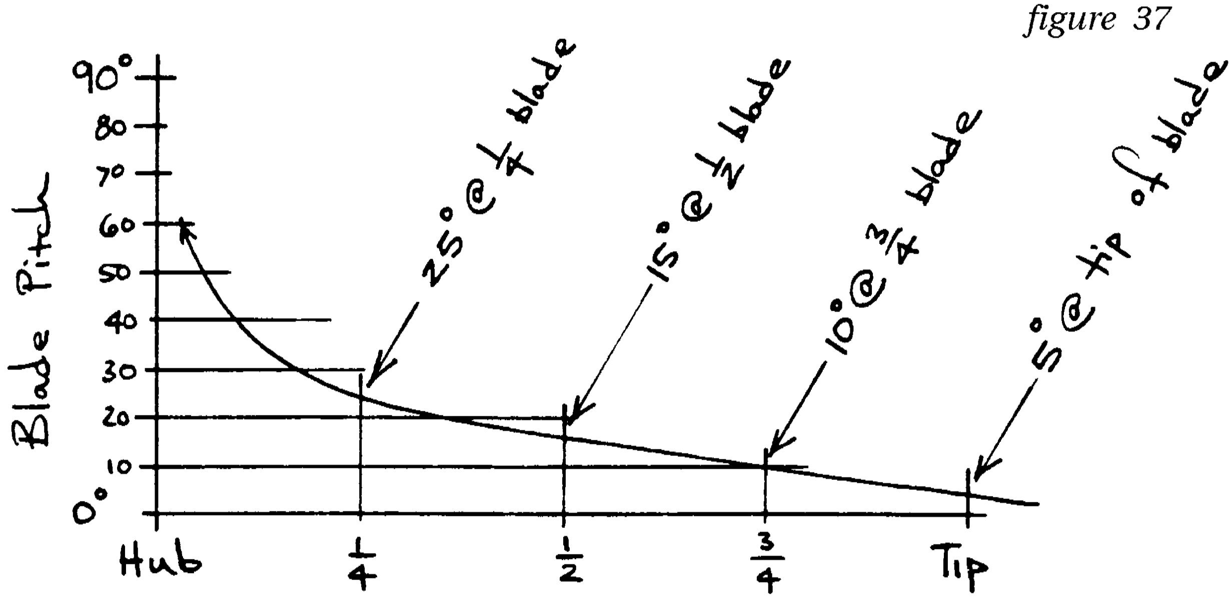


figure 36

Position on blade	pitch (angle of attack)
1/3 to tip	20°
2/3 to tip	15°
at the tip	10°

see the graph below:

figure 37



Over speed and high wind protection: Turbines have to be designed to protect themselves from self-destruction by spinning too fast when wind speed rises above their designed operating speed. There are a number of methods used to accomplish this function.

One simple method is to have a spring in the turbine which turns the rotor out of the wind *(figure 38)*. Another is to 'feather' the blades of the rotor *(figure 39)*.

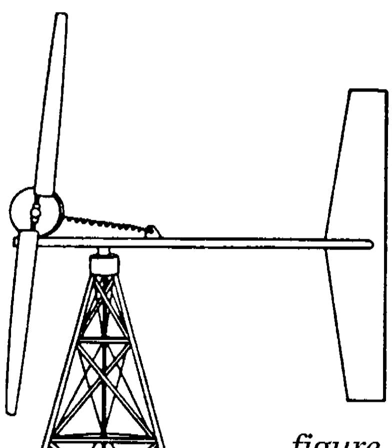


figure 38

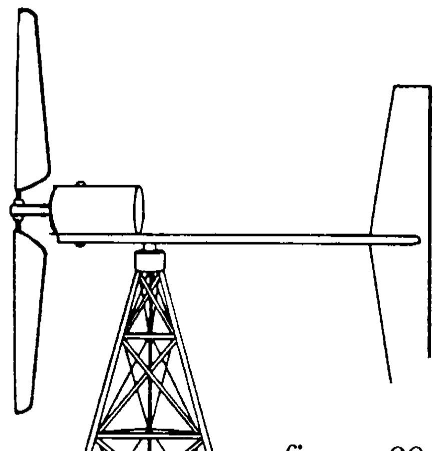


figure 39

Some machines use air brakes to slow the rotation of the blades *(figure 40)*. Turbines may also use mechanical friction brakes on the axle to slow the rotor down.

Wind Turbine Generates Electricity

It is not within the scope of this booklet to explain how an electric generator works. Suffice it to say that they do. There are however a some important factors that relate to generator operation that affect the design of a wind turbine.

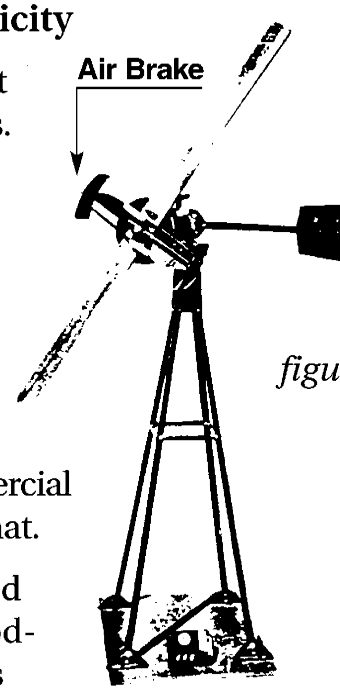


figure 40

Electricity produced for commercial use is 60 Hz AC (alternating current) electricity. Wind turbines that are intended to pump electricity into the commercial grid must match the standard 60 Hz AC format.

Constant vs variable speed rotors: Fixed speed rotors turn at a fixed RPM. Most modern turbines are fixed-speed turbines. This allows them to match their electricity with the 60 Hz frequency of the grid. To do this requires brakes or blade feathering or other methods to control the rotor RPM. This adds cost and complexity, limits operation in light winds, and adds stress to parts.Variable speed turbines rotate at wind-dictated RPM. They are free to spin fast or slow. This reduces cost, complexity and stress on parts but it requires converting the electricity produced (which is of variable frequency) to the standard 60 HZ. This adds cost.

Direct drive vs transmission: Direct drive turbines are simpler and mechanically more efficient but require specially designed low-speed generators which are generally less efficient. Turbines with transmissions to step-up the rotor RPM are mechanically more complicated but they can use higher efficiency high-speed generators. Most modern turbines use a transmission.

Summary: How a Wind Turbine Works:

Here is a quick run down on the power-train in a modern wind turbine. The Zond Z-40 turbine will be used as an example. This system is drawn in (*figure 41).*

Wind: The wind blows, its moving mass pushes against the turbine rotor. (8 mph will turn the turbine, 27 mph is ideal, 65 mph will shut unit down, 150 mph is max survival speed)

Rotor: The force of the wind pushing against the rotor causes it to spin. The rotor in turn spins a drive shaft. (the Zond unit has a fixed RPM of 29)

Drive Shaft 1: The drive shaft turns the transmission (gear box). (at 29 RPM)

Transmission: The transmission raises the RPM speed of the drive shaft to a level appropriate for the generator. (1200 RPM)

Drive Shaft 2: This drive shaft turns the generator. (1200 RPM)

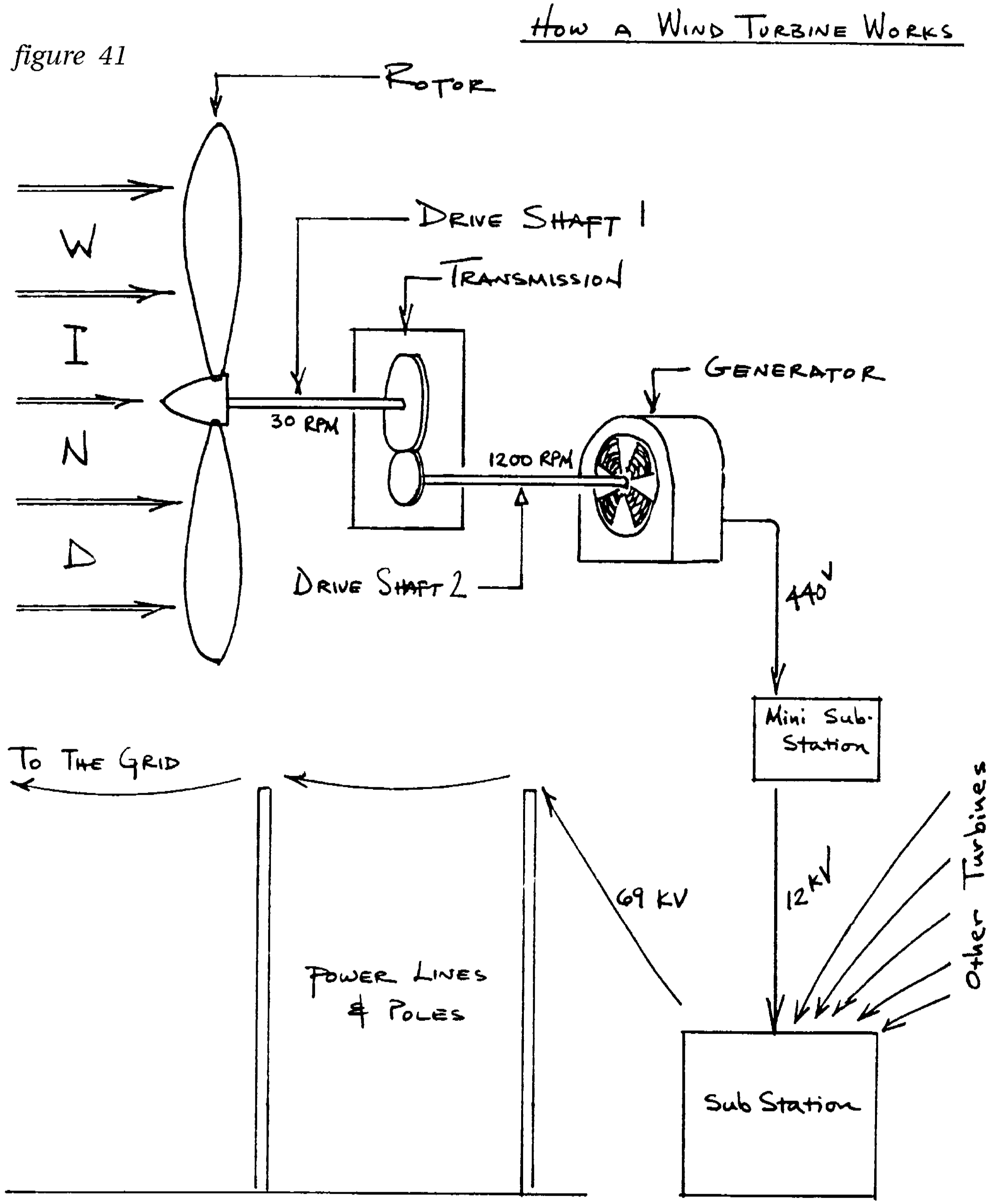
Generator: The generator produces electricity. (550 kW at 440 V)

Plant Electricity: This is usually lower voltage power. (12 kV)

Sub Station: The voltage is raised to grid level. (69 kV)

Power Grid Electricity: The electricity enters the regional electricity grid and goes out to customers on demand.

figure 41


How a Wind Turbine Works
Rotor
W
I
N
D
Drive Shaft 1
Transmission
30 RPM
1200 RPM
Generator
Drive Shaft 2
440V
Mini Sub-Station
To The Grid
69 KV
12KV
Other Turbines
Power Lines & Poles
Sub Station

CHECK YOUR KNOWLEDGE...

- ***What are some things you should know before choosing a wind turbine design?***
- ***Explain the difference between HAWT and VAWT rotors. Give an example of each.***
- ***What are the advantages and disadvantages of leading and trailing rotors?***
- ***The tip speed ratio defines what about a wind turbine?***
- ***Where is blade pitch greatest on modern rotors, at the hub or the tip? Why?***

Glossary

(Term definitions and explanations from the U.S. Department of Energy)

Anemometer: Measures the wind speed and transmits wind speed data to the controller.

Blades: Most turbines have either two or three blades. Wind blowing over the blades causes the blades to "lift" and rotate.

Brake: A disc brake which can be applied mechanically, electrically, or hydraulically to stop the rotor in emergencies.

Controller: The controller starts up the machine at wind speeds of about 8 to 16 miles per hour (mph) and shuts off the machine at about 65 mph. Turbines cannot operate at wind speeds above about 65 mph because their generators could overheat.

Gear box: Gears connect the low-speed shaft to the high-speed shaft and increase the rotational speeds from about 30 to 60 rotations per minute (rpm) to about 1200 to 1500 rpm, the rotational speed required by most generators to produce electricity. The gear box is a costly (and heavy) part of the wind turbine and engineers are exploring "direct-drive" generators that operate at lower rotational speeds and don't need gear boxes.

Generator: Usually an off-the-shelf induction generator that produces 60-cycle AC electricity.

High-speed shaft: Drives the generator.

Low-speed shaft: The rotor turns the low-speed shaft at about 30 to 60 rotations per minute.

Nacelle: The rotor attaches to the nacelle, which sits atop the tower and includes the gear box, low- and high-speed shafts, generator, controller, and brake. A cover protects the components inside the nacelle. Some nacelles are large enough for a technician to stand inside while working.

Pitch: Blades are turned, or pitched, out of the wind to keep the rotor from turning in winds that are too high or too low to produce electricity.

Rotor: The blades and the hub together are called the rotor.

Tower: Towers are made from tubular steel (shown here) or steel lattice. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity.

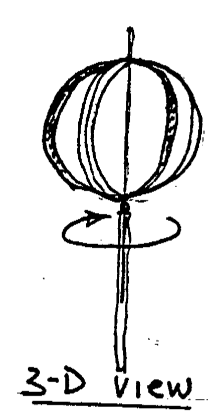
Wind direction: This is an "upwind" turbine, so-called because it operates facing into the wind. Other turbines are designed to run "downwind", facing away from the wind.

Wind vane: Measures wind direction and communicates with the yaw drive to orient the turbine properly with respect to the wind.

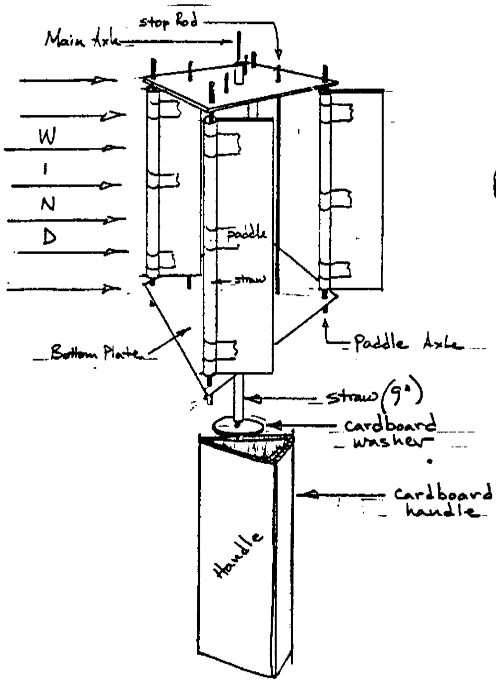
Yaw drive: Upwind turbines face into the wind; the yaw drive is used to keep the rotor facing into the wind as the wind direction changes. Downwind turbines don't require a yaw drive, the wind blows the rotor downwind.

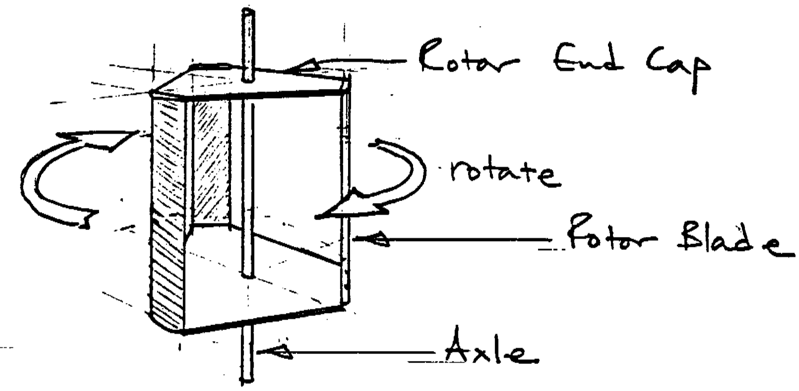
Yaw motor: Powers the yaw drive.

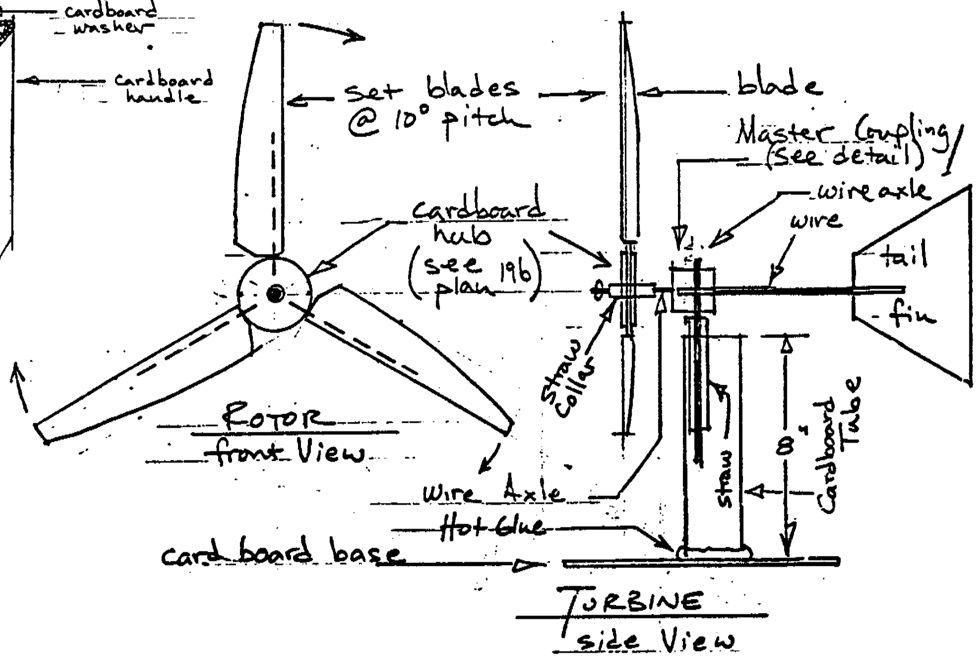
Wind Power



Paper Model Plan Book



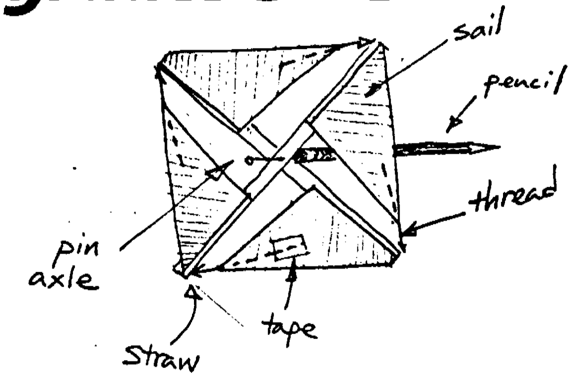




A Resource Booklet for Grades 5 - 8

by

Rollin Tait



Acknowledgements

This unit was developed as part of a school-business internship during the summer of 1997 with Green Mountain Power Company of Montpelier, Vermont.

During the year I teach 5^{th} and 6^{th} grade at East Montpelier Elementary School in East Montpelier, Vermont.

I am grateful to GMP for sponsoring me and providing resources and support for this project. Special thanks go to Cynthia Russell, my supervisor at GMP.

Introduction

The plans presented in this booklet are designed to be built by students with a minimum of tools and skills. Most are designed to be duplicated on a photocopier and worked on directly. Others are scale drawings to be used as building plans.

Here is a list of tools you will need to have a successful experience: pencil, ball-point pen, markers, scissors, exacto-knife, board to cut on,ruler, compass, photocopier, hot glue gun (and glue), wire cutters, pliers, saw.

Materials: paper, oak tag, heavy card stock, cardboard, white glue, tape (scotch, masking and duct), pins, paper clips, paper fasteners, coat hanger wire, bendy wire, straws, tongue depressors, popsicle sticks, trash bag plastic, toilet paper and paper towel roll tubes, wood dowels.

Note Well: not all models require all or even most of these things - look at the models you intend to build and take it from there.

Each model has been built and works. However, as these designs were done and tested, improvements may have been made which are not shown on the designs. So, be prepared to tinker if things don't work perfectly. I am confident that it will all work - so be patient!

Good luck and have a great time building and 'flying' your creations,

Rolli

Rollin 7/20/98

Wind Power

Paper Model Plan Book

Table of Contents

Enjoy!

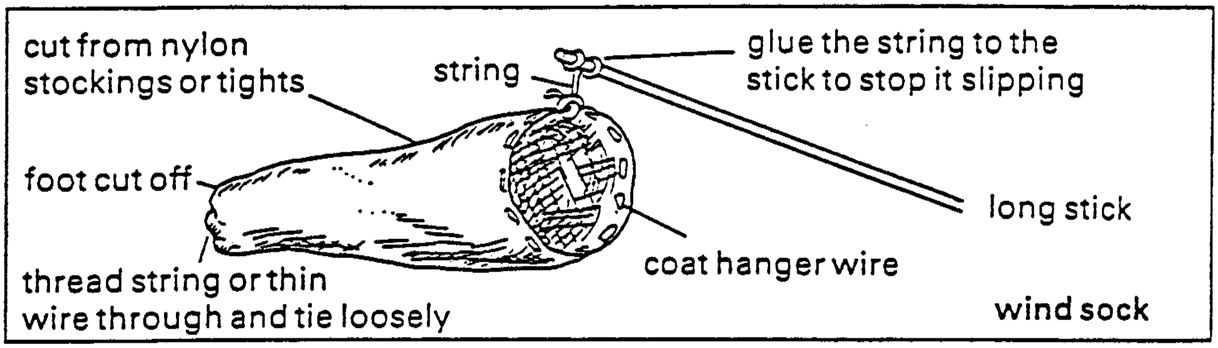
Tt: Wind Power & the Beaufort Scale | Dt: 7-22-97
#: 1
By: Rollin Tait | Sx: ~

Beaufort Wind Scale

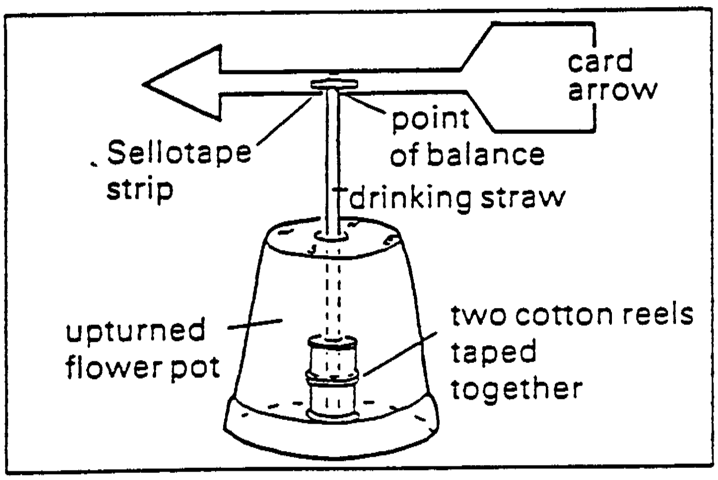
wind strength (for home-made anemometers)	Beaufort number	wind speed (m.p.h)	description	effects that can be seen on land
	0	Below 1	calm	smoke rises vertically
light winds	1	1–3	light air	wind direction shown by smoke, but vanes do not move
	2	4–7	light breeze	leaves rustle, wind felt on face, vanes move
	3	8–12	gentle breeze	leaves and small twigs move, light flags extended
moderate winds	4	13–18	moderate breeze	dust raised, small branches sway, flags flap
	5	19–24	fresh breeze	small trees sway
strong winds	6	25–31	strong breeze	umbrellas difficult to use, large branches sway
high winds	7	32–38	near gale	trees sway, hard to walk against wind
gales	8	39–46	gale	twigs broken off trees, very hard to walk into wind
	9	47–54	strong gale	slight damage to houses
	10	55–63	storm	trees uprooted, serious damage to houses
	11	64–72	violent storm	widespread damage
	12	above 72	hurricane	disaster, terrible damage

TH	WIND MEASUREMENT DEVICES (DIRECTION)	Dt	1·19·98
		#	2
by	ROLLIN TAIT	Sx	——

A.



B.



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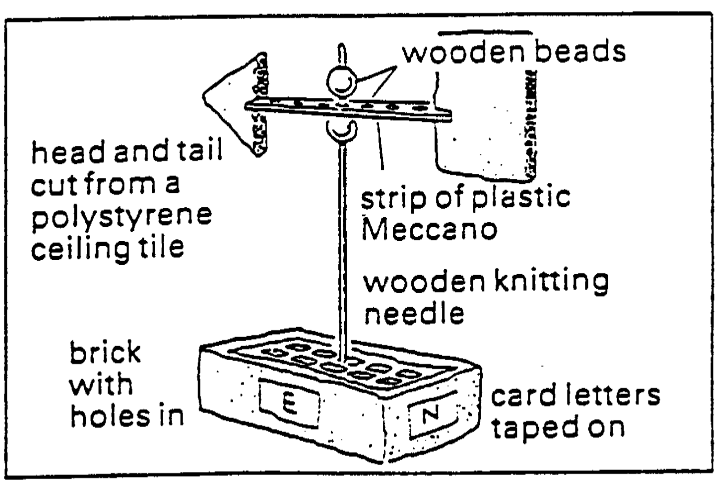
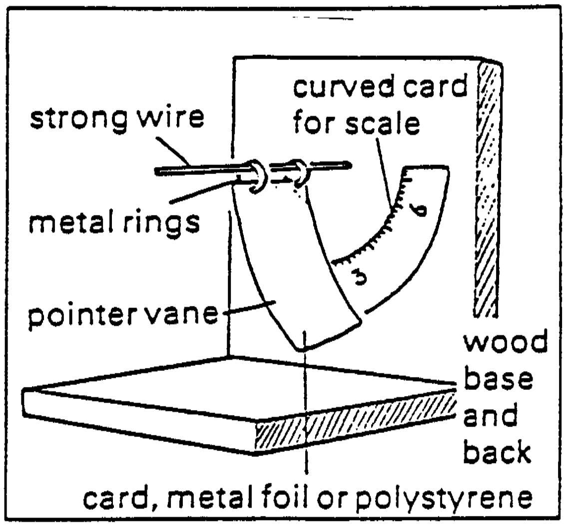


T+I	WIND MEASUREMENT DEVICES	Dt	1/19/98
	(Speed)	#	3
by	ROLLIN TAIT	Sk|	—

A.



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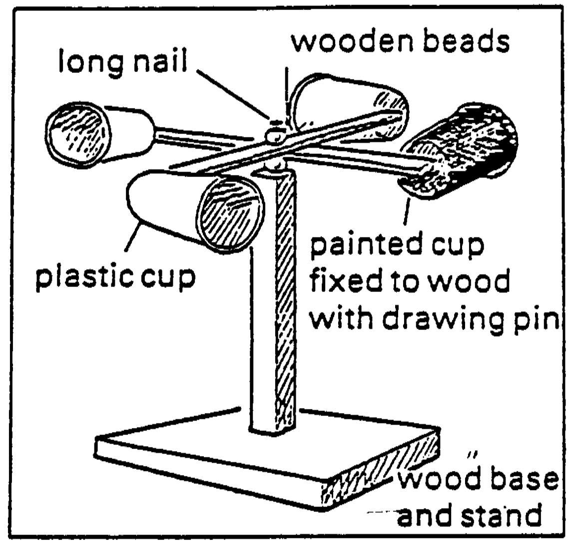

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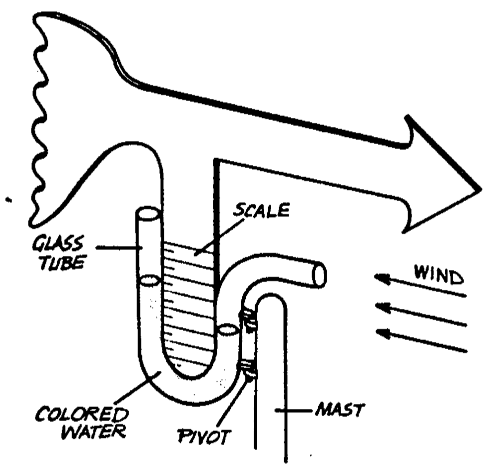
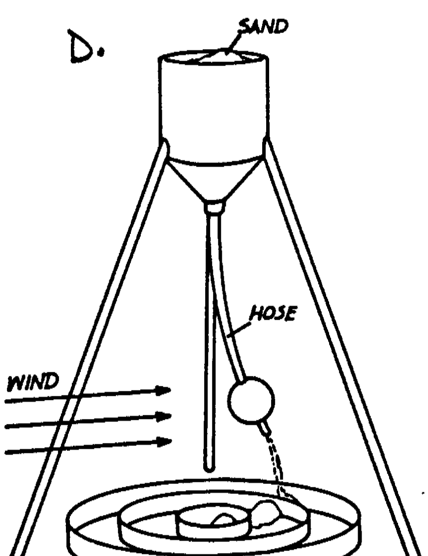


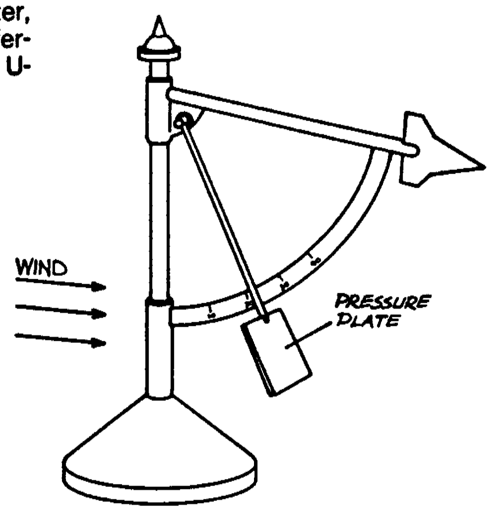
In an early pressure-tube anemometer, wind pressure induces a height difference between the fluid levels in a U-shaped tube.

D.



A "sandpile" anemometer, first used in the 1830's. This simple but crude method of recording windspeed provided only qualitative estimates.

E.



A pressure-plate anemometer. Wind pressure forces the plate to swing up along a graduated scale, providing a rough measure of the windspeed.

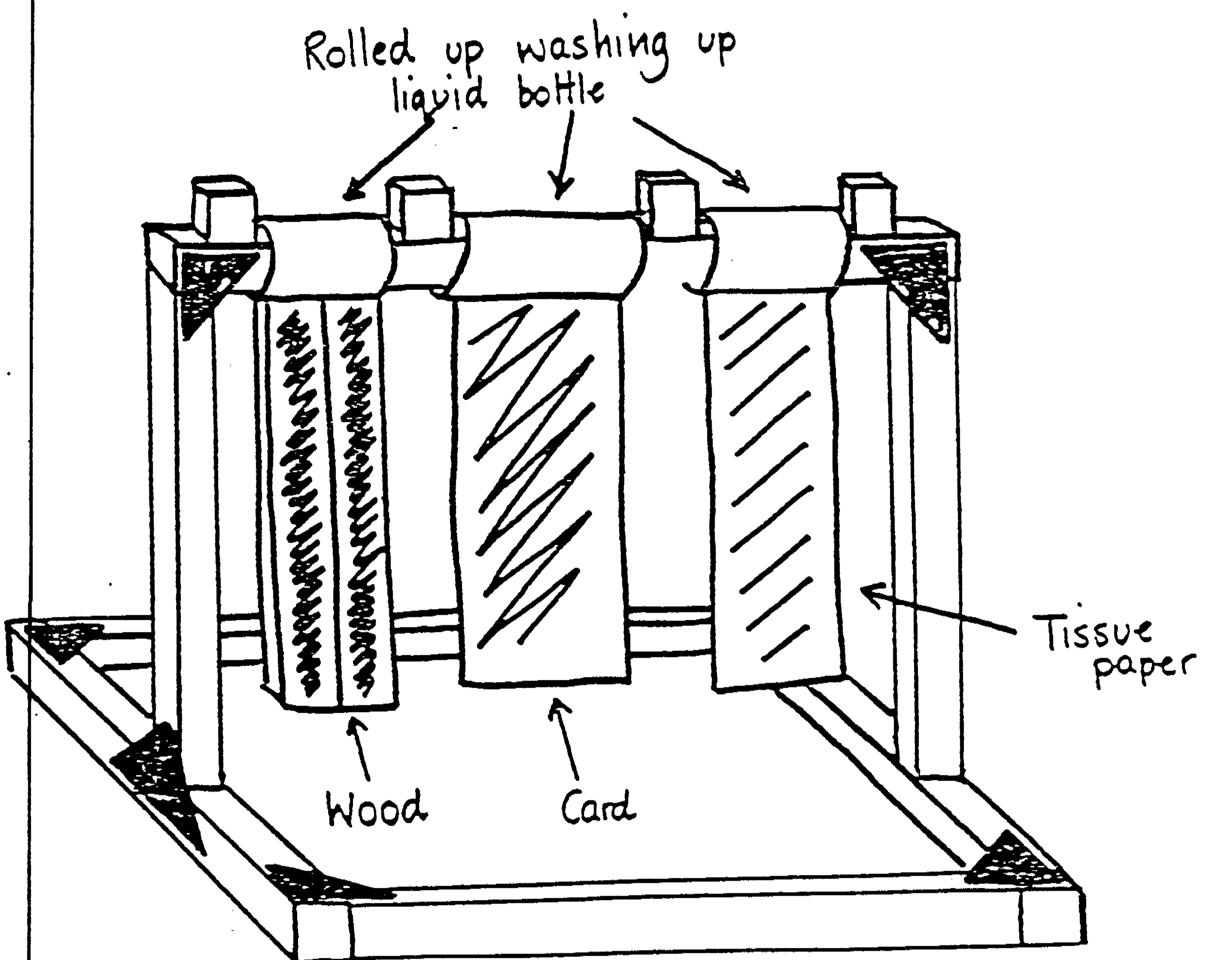
WIND MEASUREMENT DEVICES 1·20·98

(speed) # 4

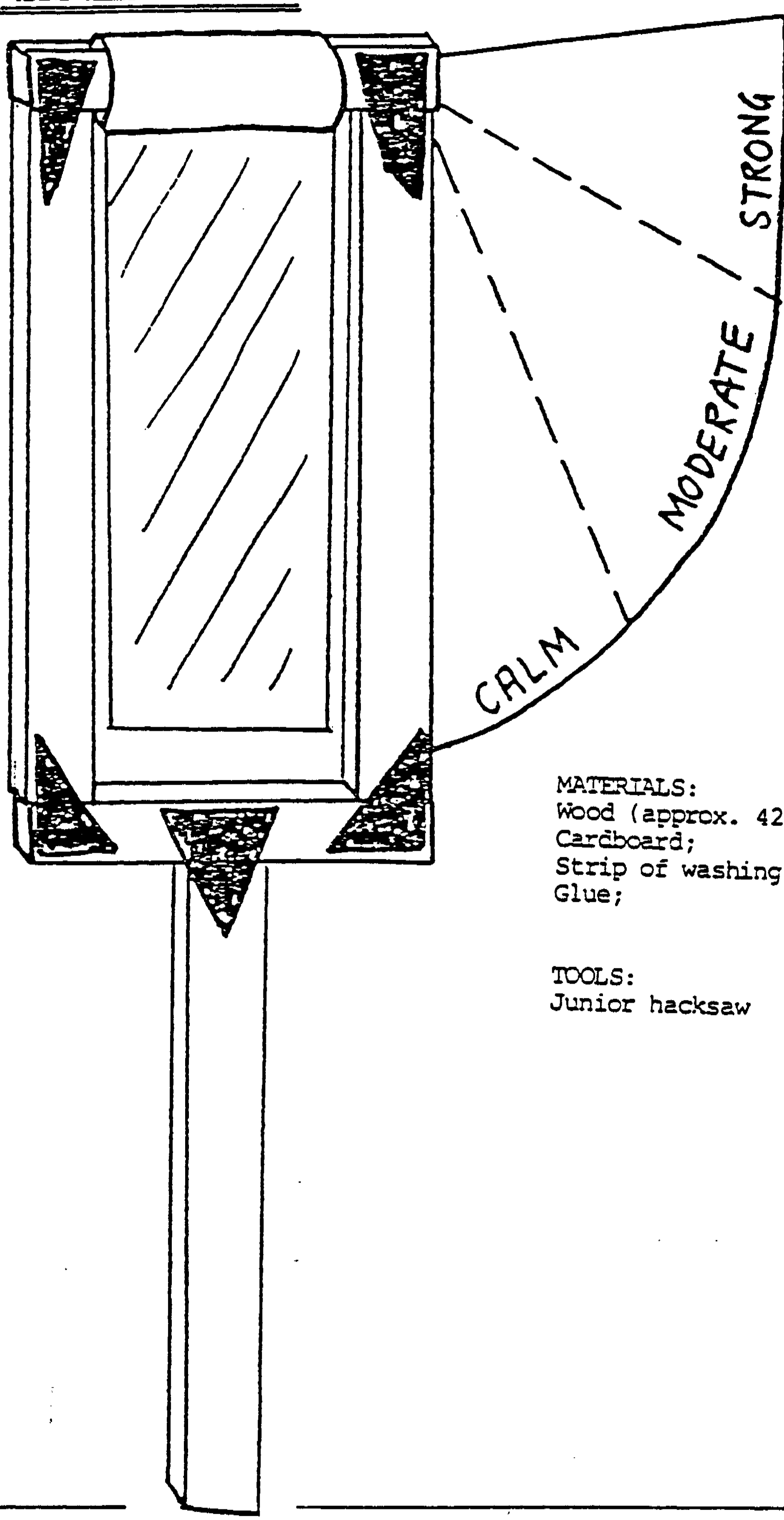
WIND SPEED INDICATOR

MATERIALS:
Wood (approx. one metre);
Cardboard;
Strips of washing-up liquid bottle;
Glue;
Sticky tape;
Tissue paper.

TOOLS:
Junior hacksaw



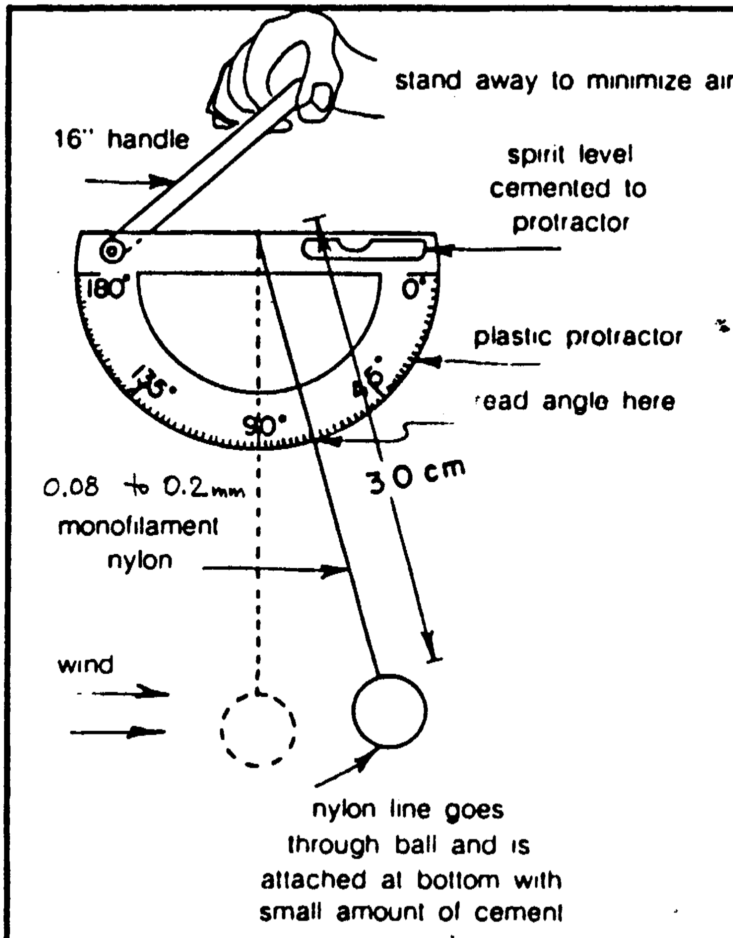
HAND HELD WIND GAUGE



MATERIALS:
Wood (approx. 42 cm.);
Cardboard;
Strip of washing-up liquid bottle;
Glue;

TOOLS:
Junior hacksaw

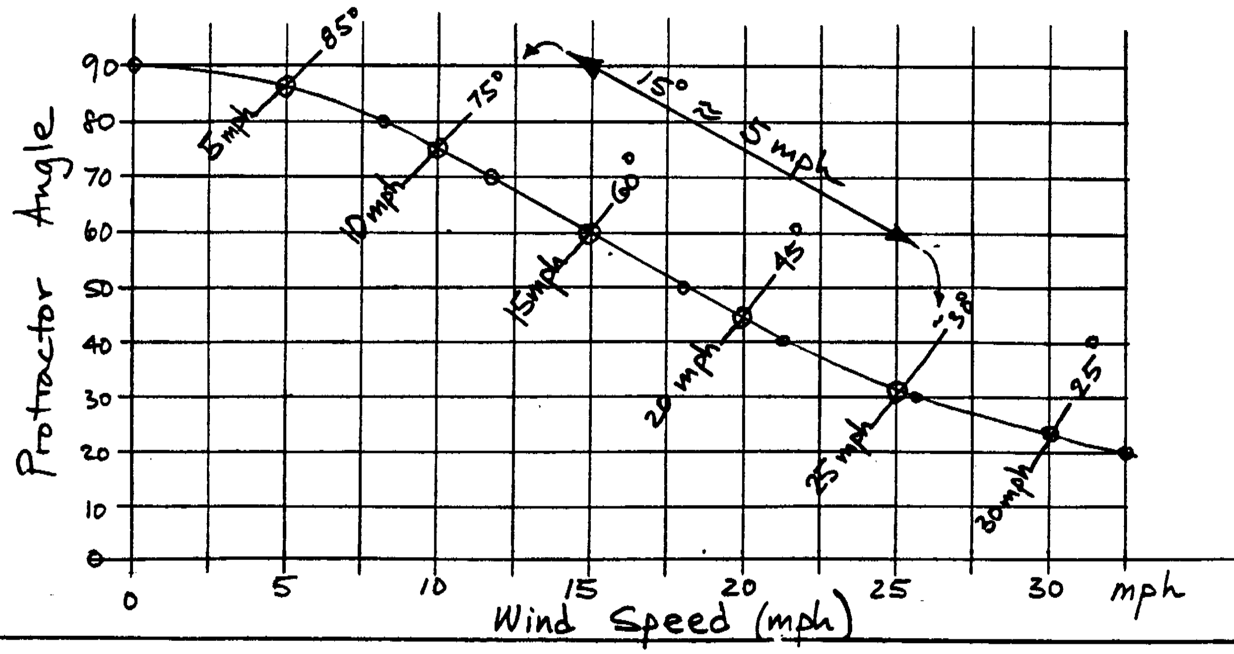
T+l	HAND HELD WIND GUAGE (speed)	Dt	7·21·97
		#	6
by	ROLLIN TAIT	Sxl	~



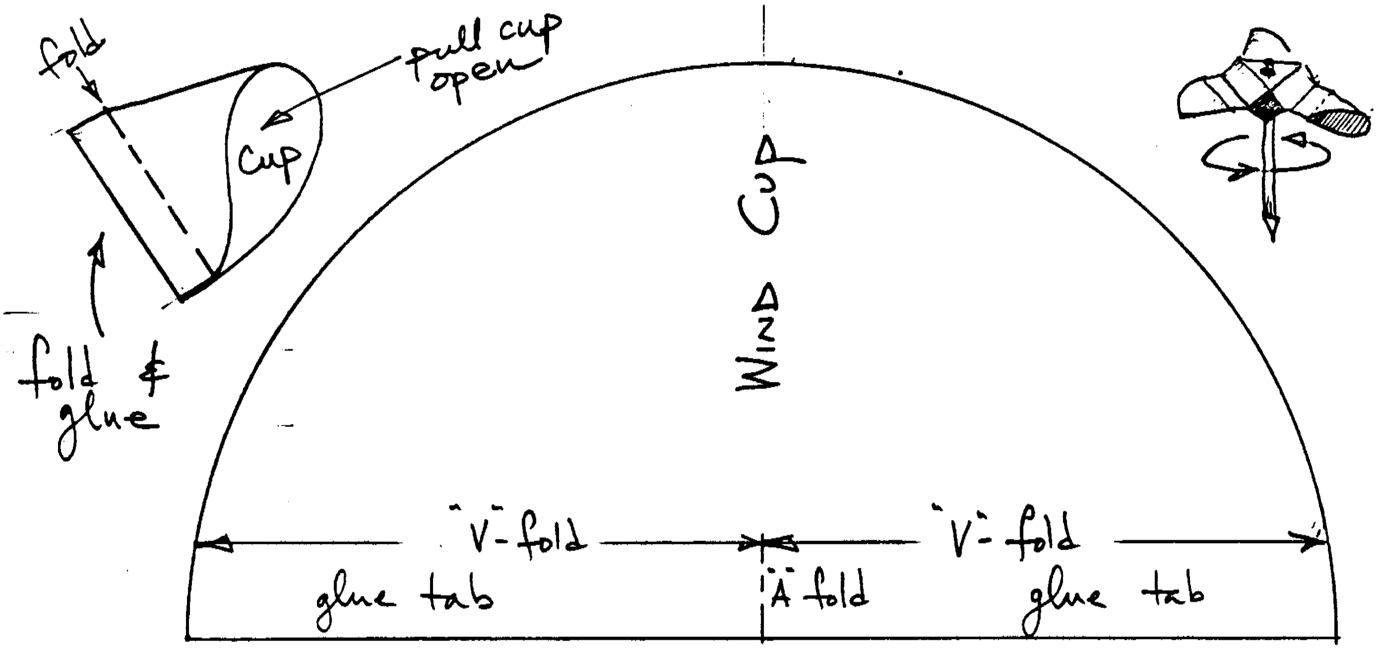
calibration data

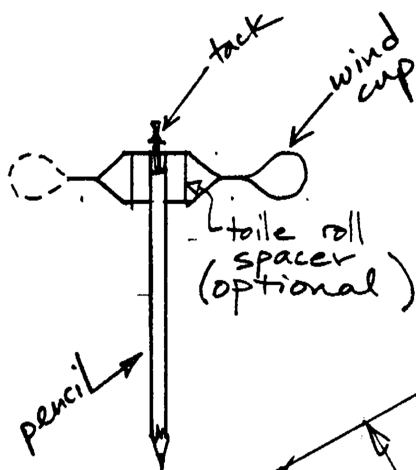
angle	mph
90	0
85	5.8
80	8.2
75	10.1
70	11.8
65	13.4
60	14.9
55	16.4
50	18.0
45	19.6
40	21.4
35	23.4
30	25.8
25	28.7
20	32.5

A do-it-yourself, hand-held wind gauge with calibration data (based on C.L. Strong, *Scientific American*, October 1971).

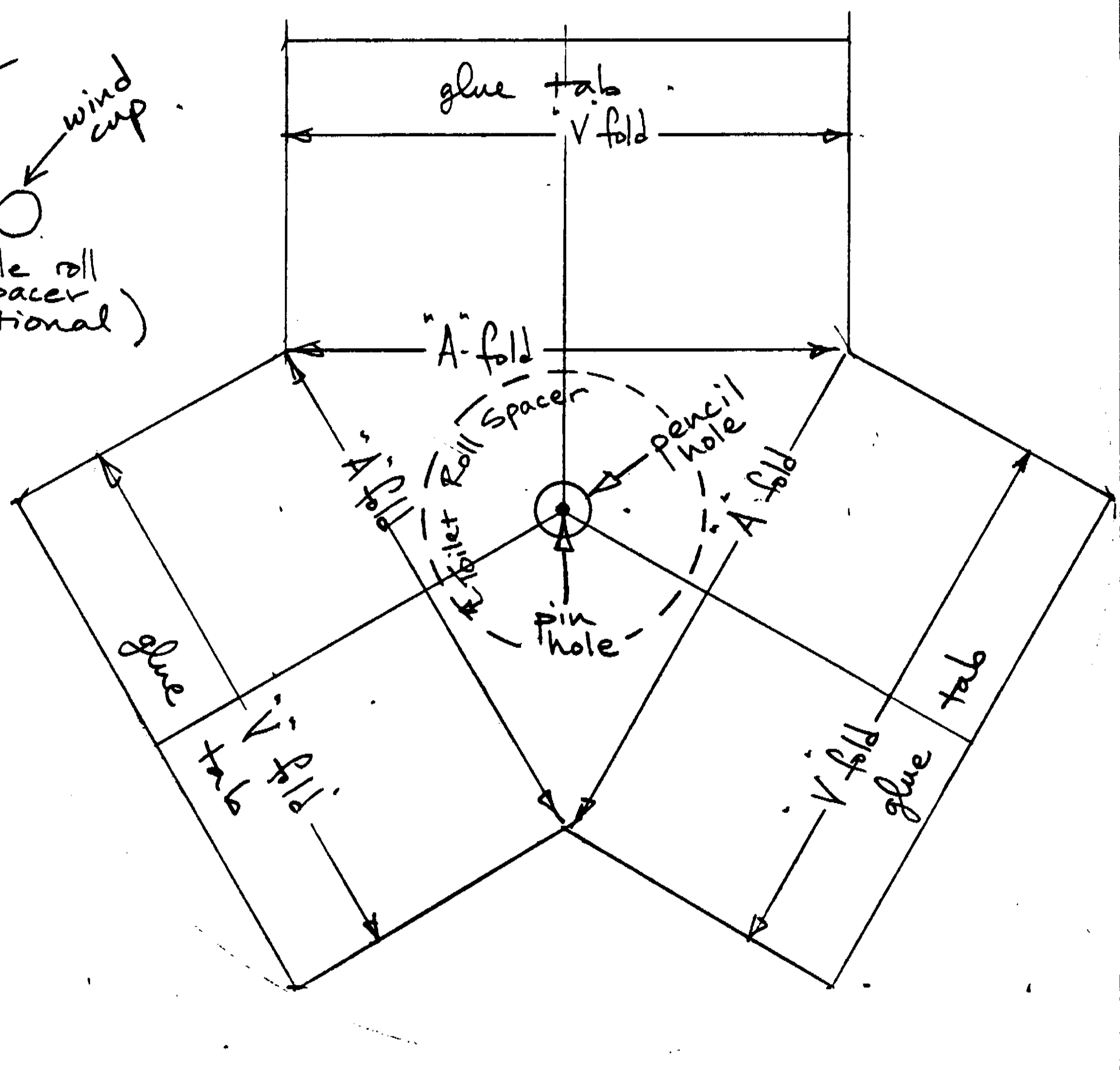


Tt	ANEMOMETER ("Cup" Rotor)	Dt	7.18.97
	HORIZONTAL AXIS WIND TURBINE	#	7
by	ROLLIN TAIT	Sc	HALF SIZE

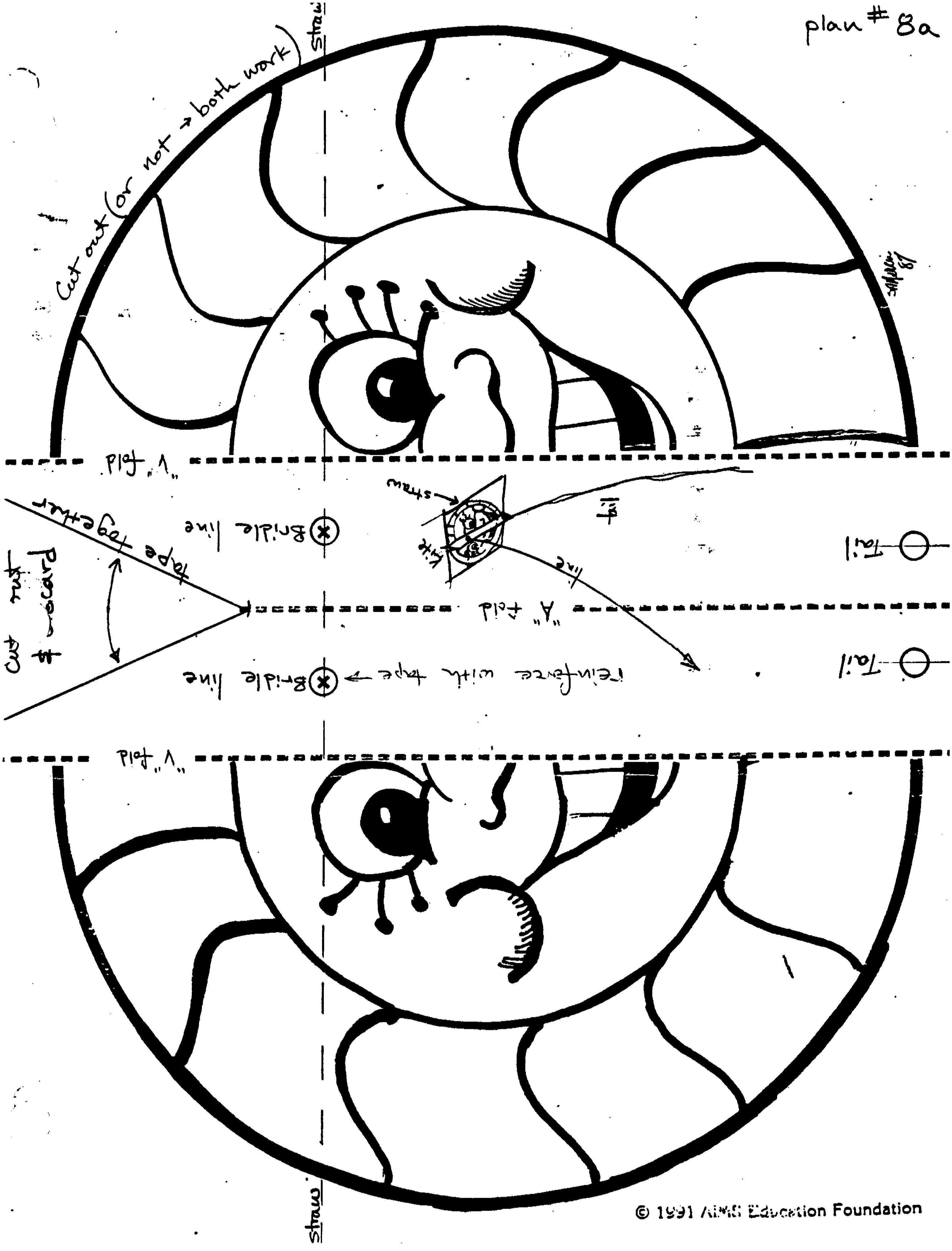




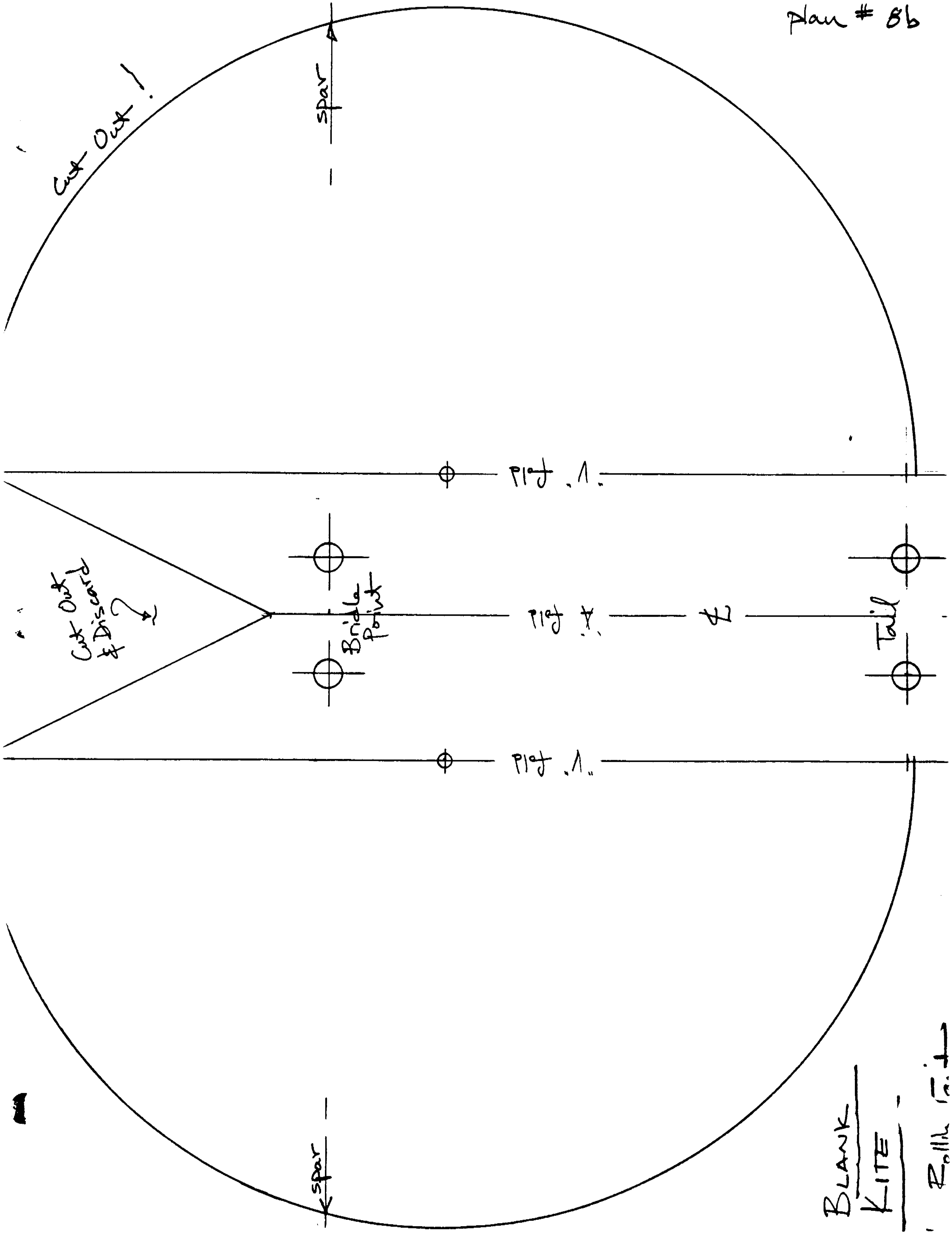
Side View



plan # 8a

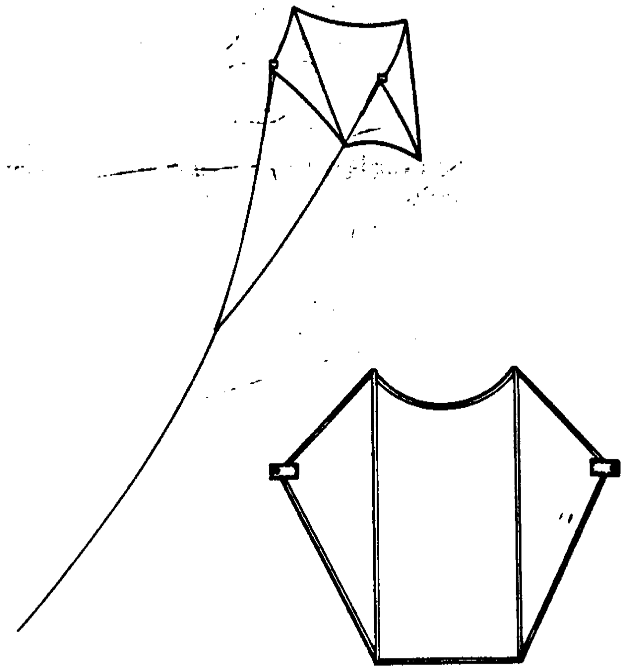

straw
Cut out (or not → both work)
fold "A"
Bridle line
Tail
tape together
Cut out & card
"A" fold
reinforce with tape
Bridle line
Tail
fold "A"
straw
kite
line
straw

plan # 8b



Cut Out!
spar
Cut Out & Discard
Bridle Point
Tail
spar
BLANK KITE

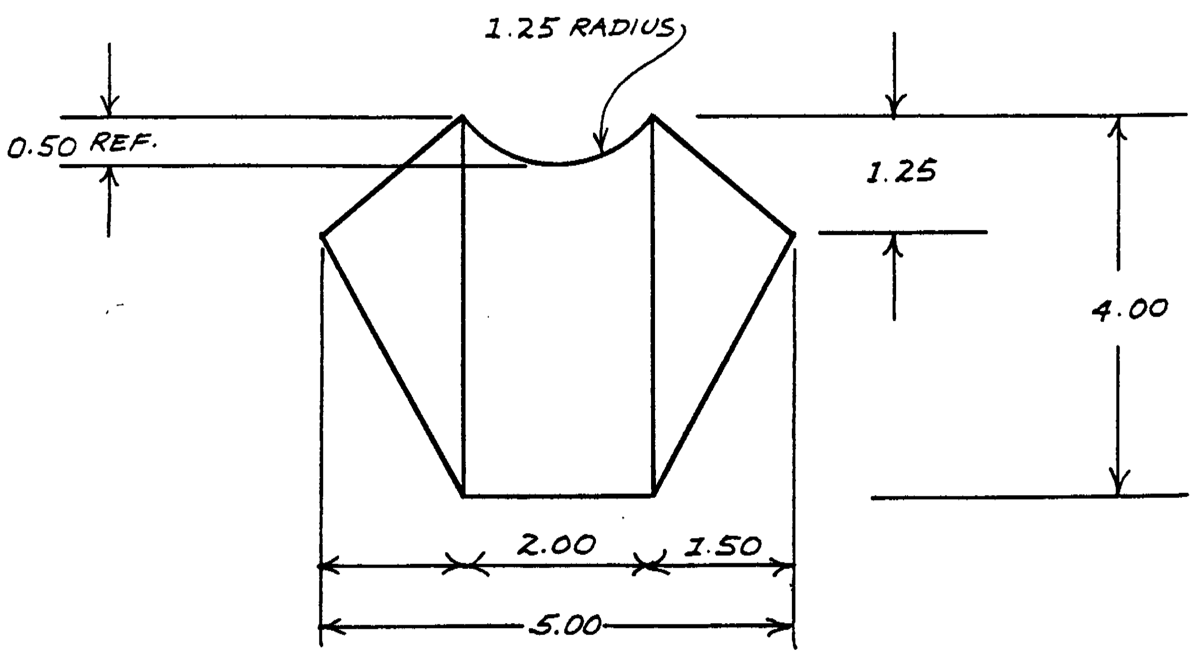
T+l	A SLED KITE	D+	1·20·98
		#	9a
by		Sk l	~

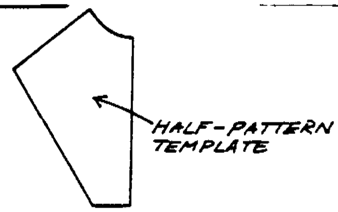


Illus. 162. *The Hornbean Sled Kite Mark I.*

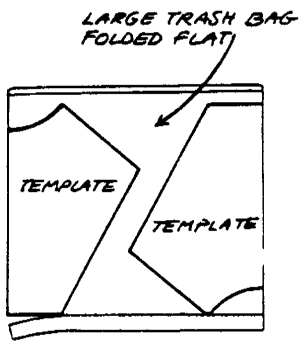
Construction

1. First, scale the kite based on the design shown in Illus. 163. Establish your module unit by dividing the height by 4. For a 36″ kite: 36 ÷ 4 = 9; multiply each module by 9 for a 36″ version of the kite. For a 16″ kite, multiply modules by 4. A kite with 16″ or 24″ longerons makes efficient use of both standard 48″ dowels (a ⅛″ dowel for 24″ and smaller) and large-size trash bags.
2. Make the kite half-pattern template (Illus. 164).
3. Two 24″ kites may be cut from an unopened trash bag. Trim the sealed bottom end and the top as required to lay the trash bag completely flat. Align the straight sides of the templates along the bag's fold lines (Illus. 165).
4. Cut out a half-pattern for a complete kite (Illus. 166).

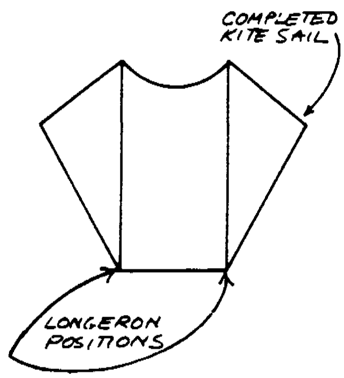




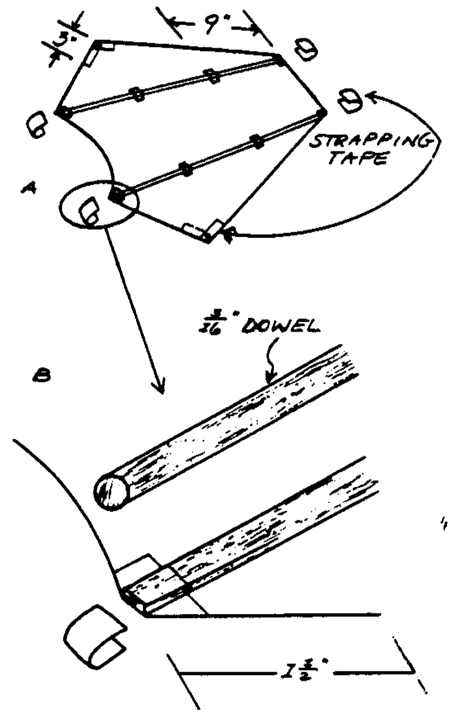
Illus. 164. Step 2.



Illus. 165. Step 3.



Illus. 166. Step 4.



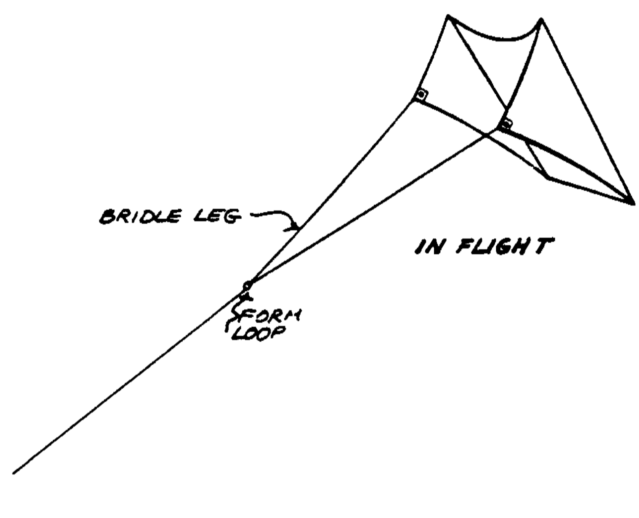
Illus. 167. Step 5.

5. Use 3″ strips of Scotch transparent tape to secure the longerons in position as shown in A of Illus. 167. Two strips of tape, fore and aft, are sufficient for 16″ kites that can be flown from heavy carpet thread for buttons. Larger kites need additional tape to keep the longerons in position.

The kite shown here illustrates taping (9′ apart) a 36″ kite with ¼″ dowels for longerons. Reinforce the bridle connect points with an overlapping section of strapping tape; punch holes in the keel tips for the bridle.

Optional detail: (See B of Illus. 167.) The tape will hold the longeron tips more securely if the dowel ends are sanded flat as shown. Add strapping tape to prevent the dowel from poking through the transparent tape.

6. The bridle should be three times the height of the kite. For a 36″ version, tie the ends of 18′ of 30 lb.-test line to the keel tips. Form a loop at the middle of the bridle and attach the flying line. (See Illus. 168.) Note: Adding crepe paper streamers to the aft tips of kites 24″ and under makes the kites more stable in higher winds.



Illus. 168. Step 6.

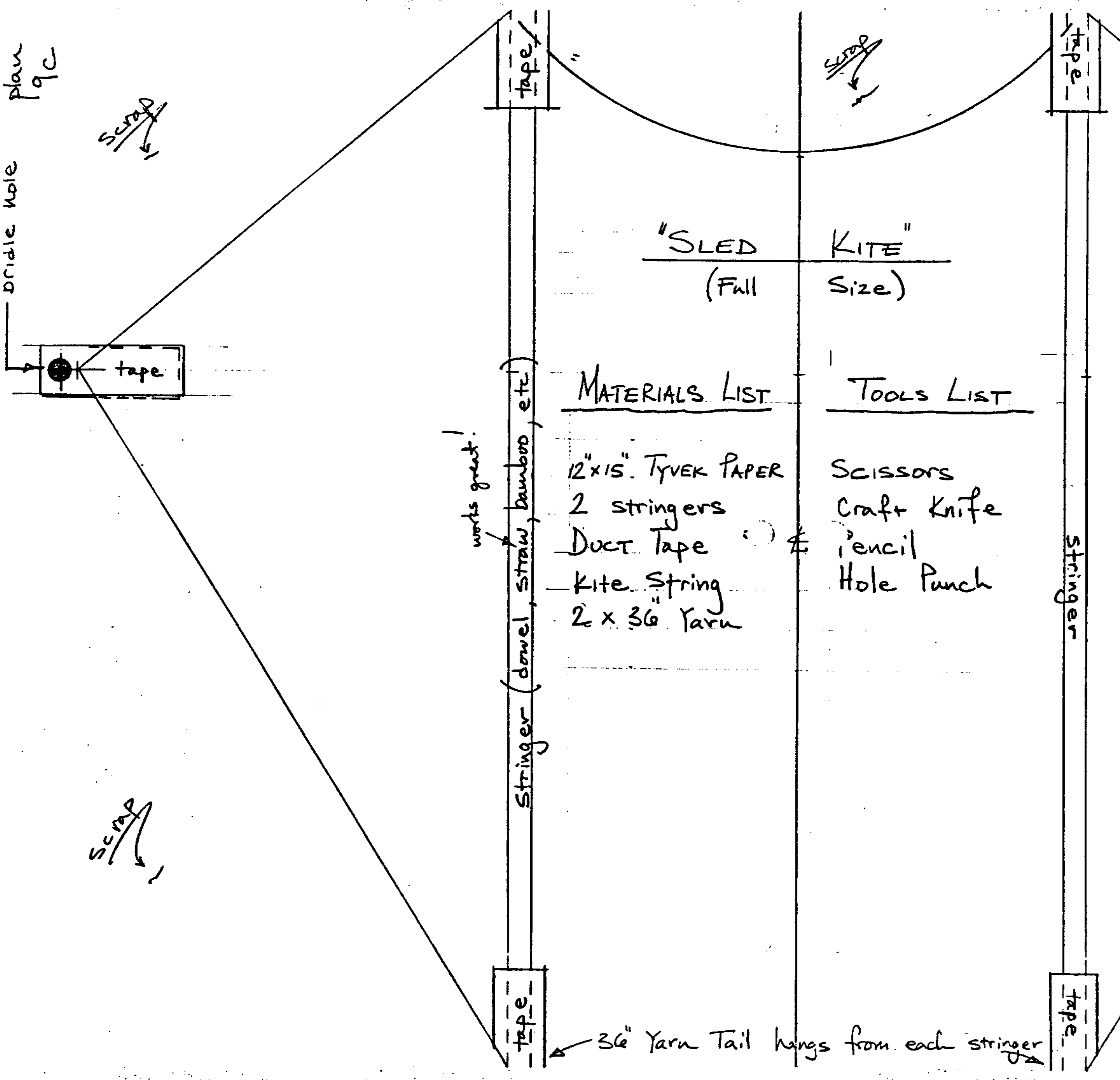
7. Keel tip option: (See the steps in Illus. 169.) Use strapping tape to secure a ¾″ × ⅛″ dowel in place to absorb the stress of the bridle. Punch a ⅛″ hole for the bridle line.

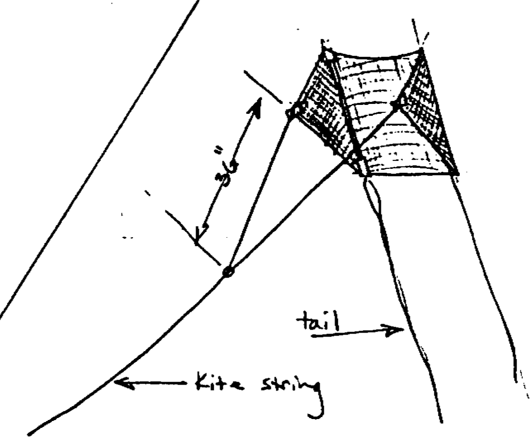
"SLED" KITE PLAN 9c
ROLLIN TAIT
7·16·97
★NB· Enlarge to 11"x 17" paper to use★

plan 9c

"SLED KITE"
(Full Size)

MATERIALS LIST	TOOLS LIST
12"x15" TYVEK PAPER	Scissors
2 stringers	Craft Knife
DUCT Tape	Pencil
Kite String	Hole Punch
2 x 36" Yarn	





plan 10a

43
A Rotor Kite

Design: Courtesy of W. D. (Red) Braswell

Rotating Lift from the Wind

The rotor, shown in Illus. 303, is one of the eight generic kite forms. This kinetic kite manifests lift through an autorotating action induced by the motion of the surrounding air currents. With its dynamic surfaces blinking ever faster at the sun, the rotor must be in constant motion to stay aloft. While passive rotors, like windmills and kites, rely solely on available wind for their power, other rotation-lifting surfaces, like airplane and helicopter propellers, are motorized.

The lift principle occurring in a spinning body moving through a fluid or air, as in this case, is known as the *Magnus effect*, after G. Magnus, a mid-nineteenth-century physicist, who observed and recorded the phenomenon. However, nature's use of the Magnus effect predates Magnus's discovery by countless millions of years. Many of us have observed maple seedlings, for example, twirling and gliding earthwards—often catching the winds to travel great distances.

On the official side, while patents for rotor and related gyration-lifting airfoils date back to 1911, interest in rotor kites remains esoteric—though a spinning rotor continues to amaze us.

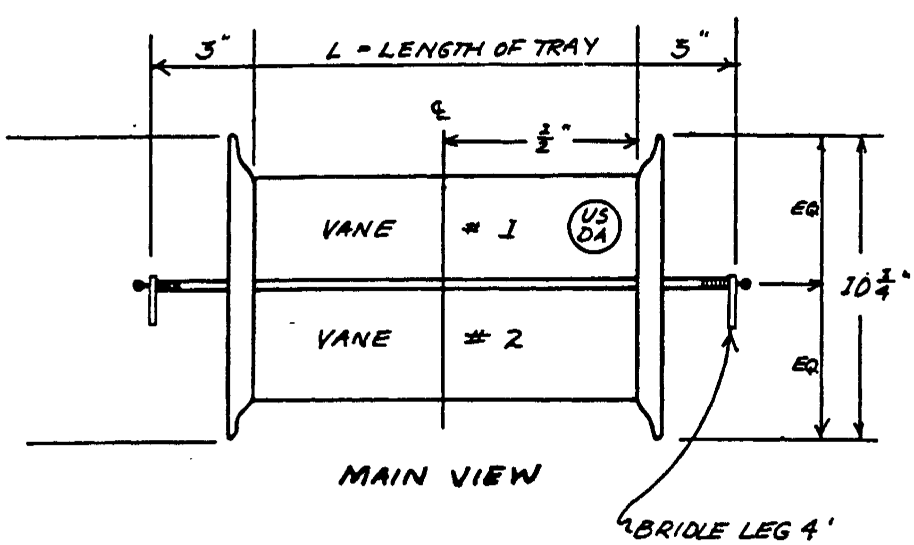
Materials

To make this kite you need:

- a ±3⁄16″ × 8″ × 12″ expanded polystyrene (foam) meat tray,
- two ±10¼″ foam picnic plates,
- one 3⁄16″ × 48″ dowel—cut to the length of the rotor plus 6″,
- two round head pins,
- a plastic lid from a yogurt cup, coffee can, or margarine tub—for bridle connectors,
- Elmer's Glue-All (white glue),
- 20 lb.-test line—for bridle,
- a hobby knife,
- sandpaper or an emery board,
- wax paper,
- nylon thread,
- super glue like Elmer's Wonderbond Plus, and
- (optional) a Dremel Moto-tool and router.

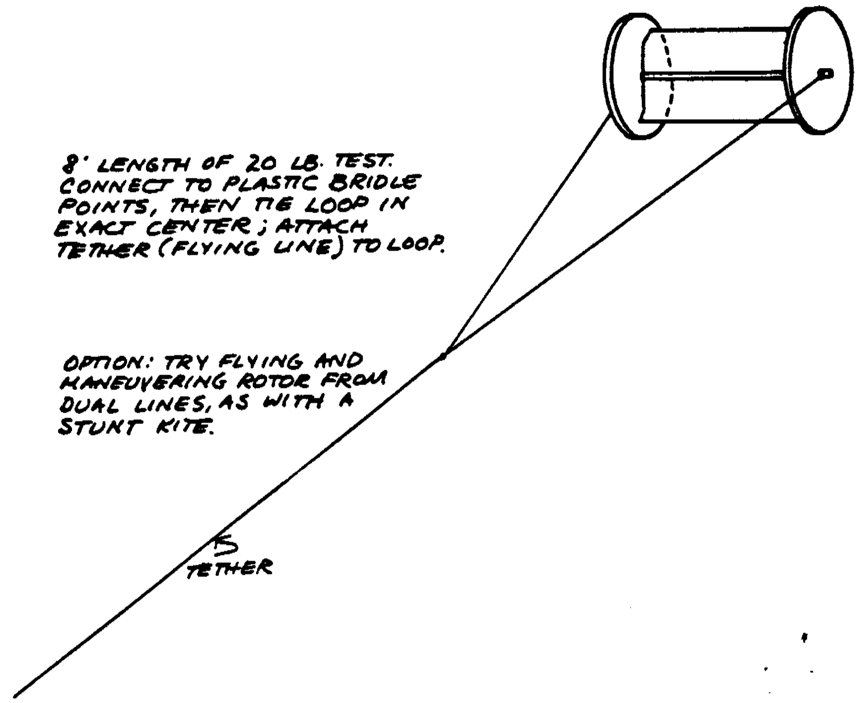
Details

- (Detail 1 in Illus. 302.) Main view.
- (Detail 2 in Illus. 303.) In flight. 8′ length of 20 lb. test: Connect to plastic bridle points, tie the loop in the exact center, and then attach the tether (flying line) to the loop. (Option: Try flying and maneuvering the rotor from dual lines as with a stunt kite.)



Illus. 302. Detail 1.

plan 10k



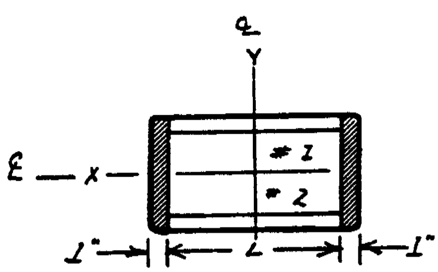
Illus. 303. Detail 2—in flight.

Flight Data: Wind range: 8–20 mph
Line: 20 lb. test
AE: ±55°

Construction

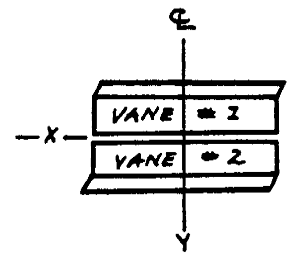
Cutting:

1. Use a sharp hobby knife to cut the expanded polystyrene (foam) meat tray. Smooth the rough edges with light sandpaper or an emery board. Trim the edges of the meat tray as shown in Illus. 304. Mark the horizontal centerline *X* and the vertical centerline *Y*. Tip: Use a flexible straightedge, like a business envelope, as guide in marking lines over the tray's curved edges.



Illus. 304. Step 1.

2. Cut the tray along centerline *X* to form vanes #1 and #2. Reverse the position of vane #2 as shown in Illus. 305.



Illus. 305. Step 2.

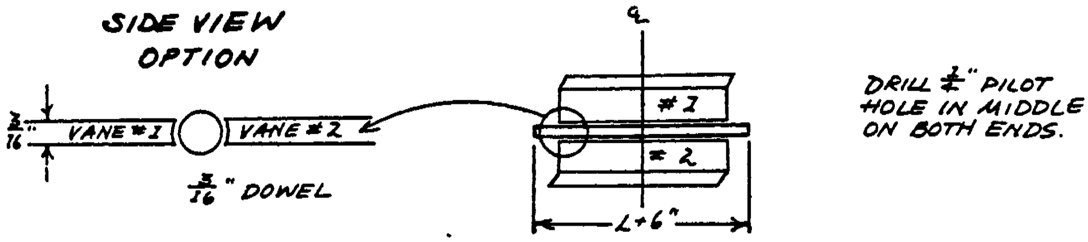
Gluing:

3. See Illus. 306. Cut 3/16" dowel to the length of the vane (L) plus 6" and mark the middle. Drill a 1/4" pilot hole (pin diameter) in the middle of both ends. Wrap the ends with nylon thread and glue them to prevent splitting.

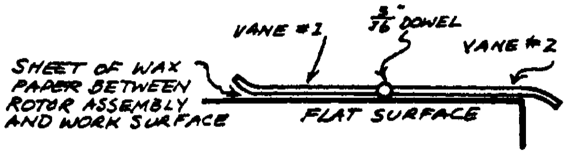
   Align the centerline of vane #1 with the middle of the dowel and glue in position. Align vane #2 (facing the opposite direction) with vane #1 and glue to form a rotor assembly.

   Option: For a precision join, use a Dremel Mototool with a router attachment to uniformly rout the edges of vanes #1 and #2 that meet at the dowel.
4. See Illus. 307. Place a sheet of wax paper between the rotor assembly and a flat surface to prevent glue from sticking to your work area; make sure the rotors are aligned and flat. Allow to dry overnight.
5. See Illus. 308. Locate the middle of both plates and drill a 3/16" hole in each.
6. See Illus. 309. Sandwich the rotor assembly be-

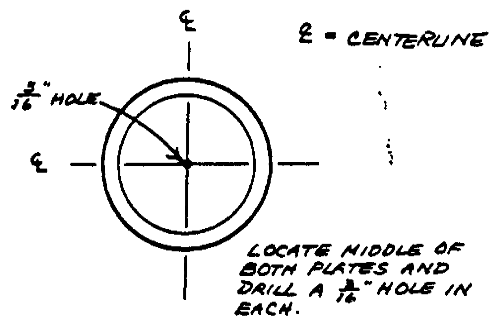
plan 10c



Illus. 306. Step 3.



Illus. 307. Step 4.

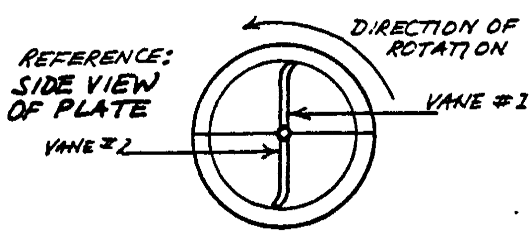


Illus. 308. Step 5.

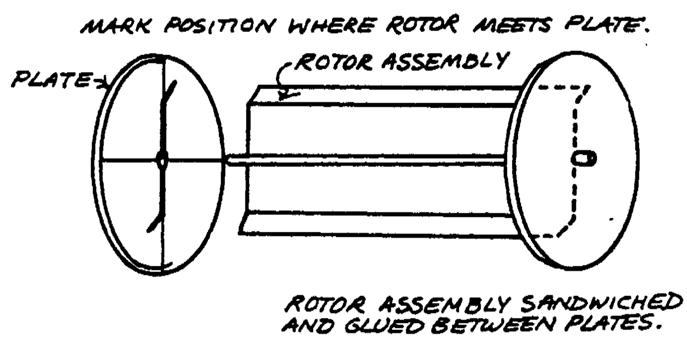
tween the two plates; mark the positions where the rotor meets the plate. Check for gaps and trim the rotor ends for a flush fit. Remove the plates and lightly sand the area where the rotor will be glued.

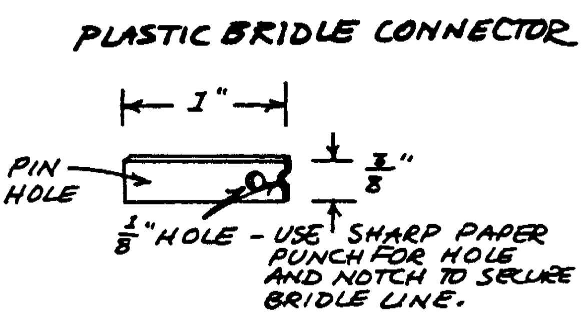
Glue and sandwich the rotor assembly between the plates. Let it dry overnight.

7. See Illus. 310. Cut two plastic bridle connectors to size (1" × 3/8"). Use a darning needle or other thin, strong, sharp point to make a pin hole. Use a sharp paper punch for both a 1/8" hole and a notch at the tip.
8. See Illus. 311. Take two round head pins and cut both to 1/2" lengths. Make pin holes large enough to allow free movement of the bridle connector. Place a dab of glue in the holes on the dowel ends. Insert the pins through the bridle-connector pin holes and 3/8" into the dowel ends.
9. To make the bridle knot, fix the bridle line to the connector as shown in Illus. 312.

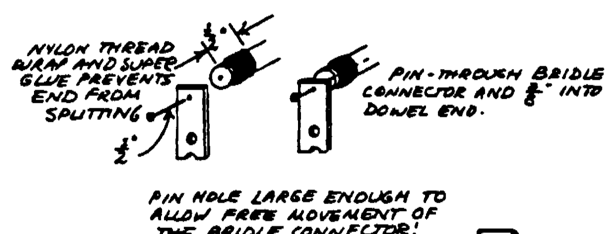


Illus. 309. Step 6.

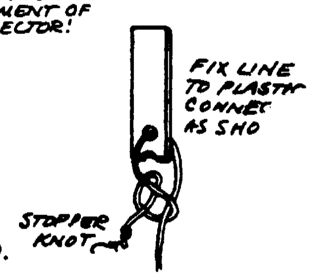




Illus 310. step 7



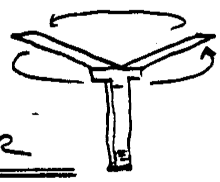
Illus. 311. Step 8.



Illus. 312. Step 9.

plan # 11

Paper Helicopter



Key:

←Cut→ means cut

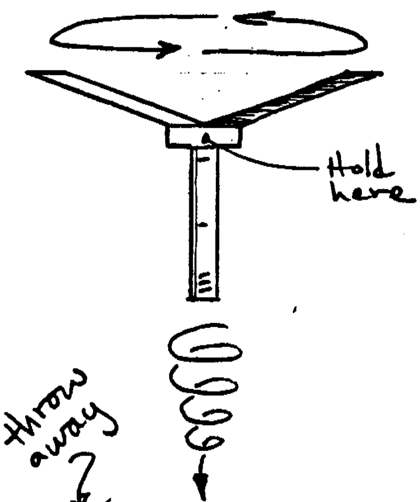
←Up→ means Fold up

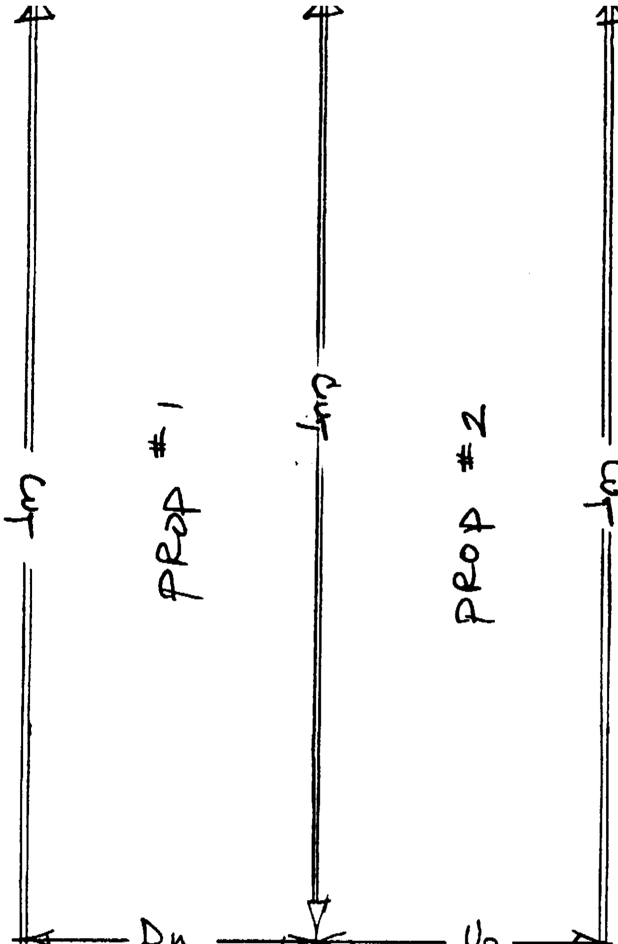
←Dn→ meas Fold down

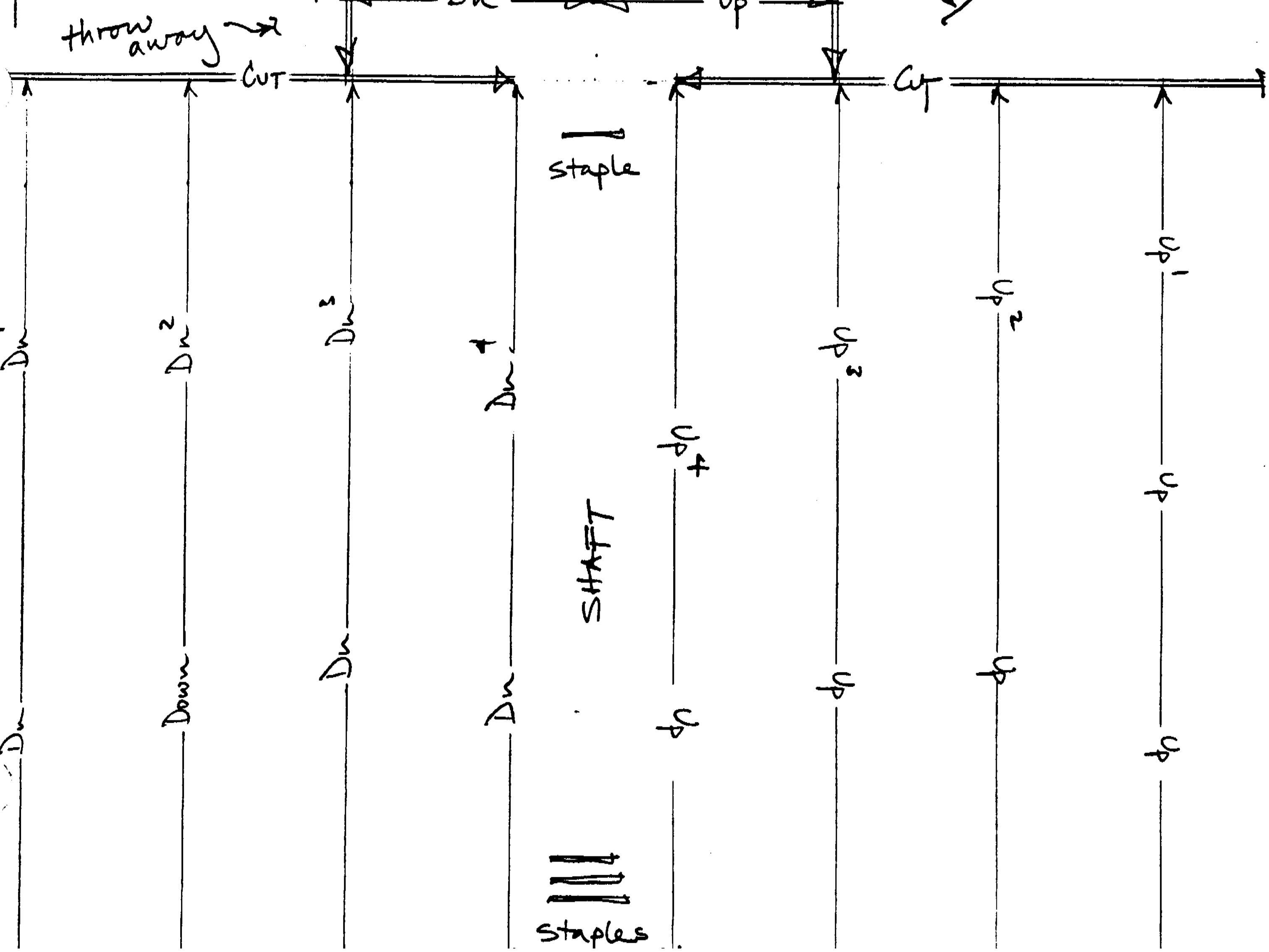
▬ staple means staple here

Flight Notes

to fly, hold just below props & drop. The helicopter will spin as it falls.

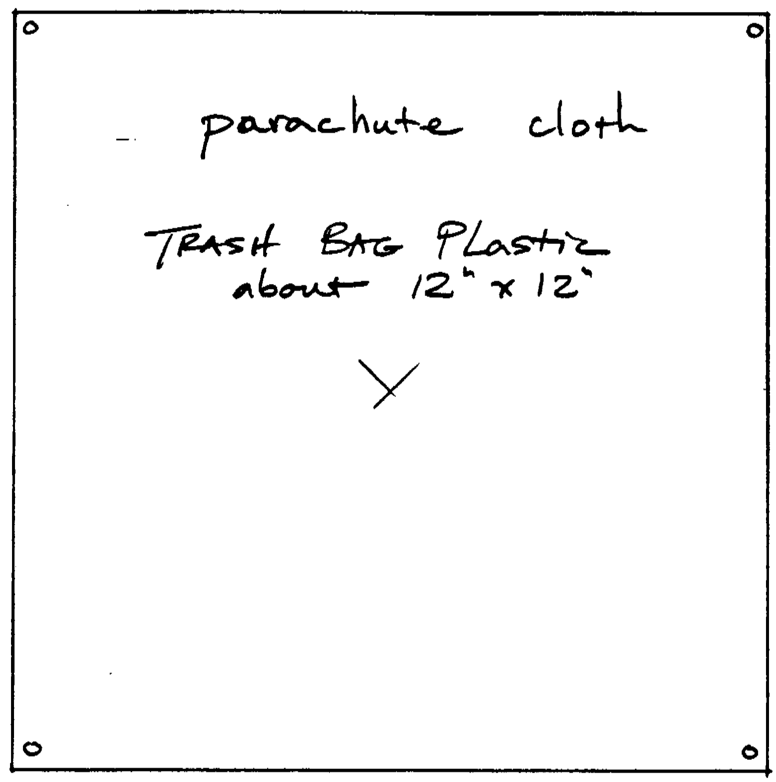


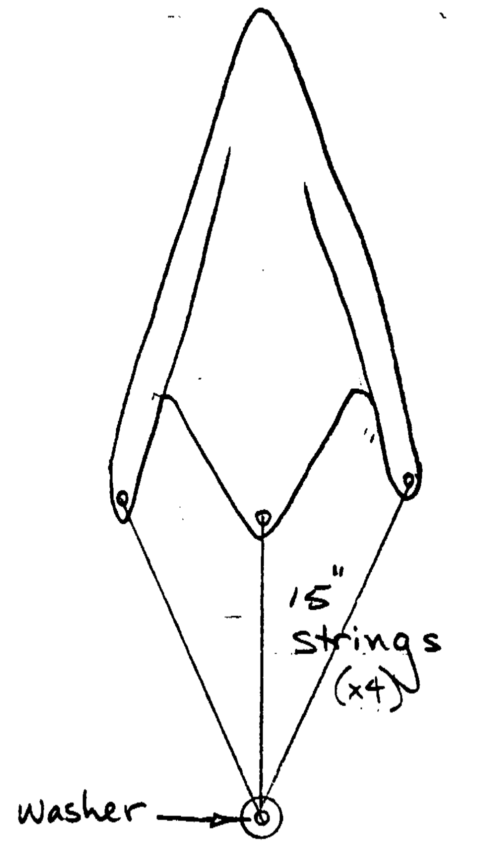




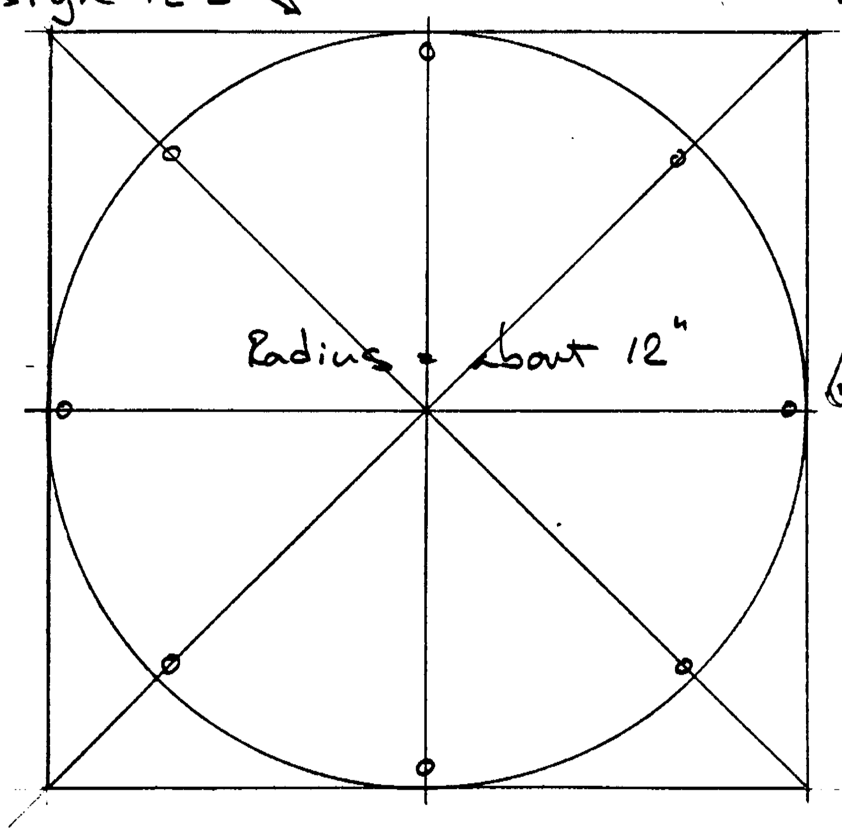
T+l	PARACHUTE	Dt	1.20.98
		#	12
by	ROLLIN TAIT	Sxl	—

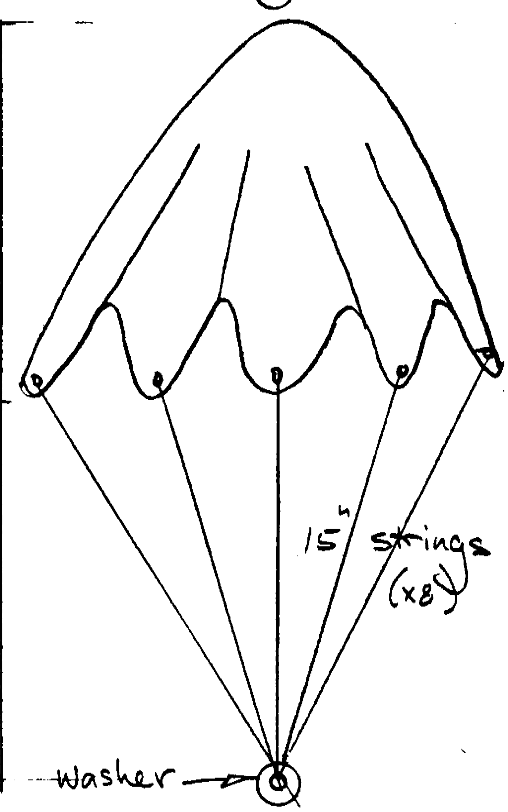
Design 12A



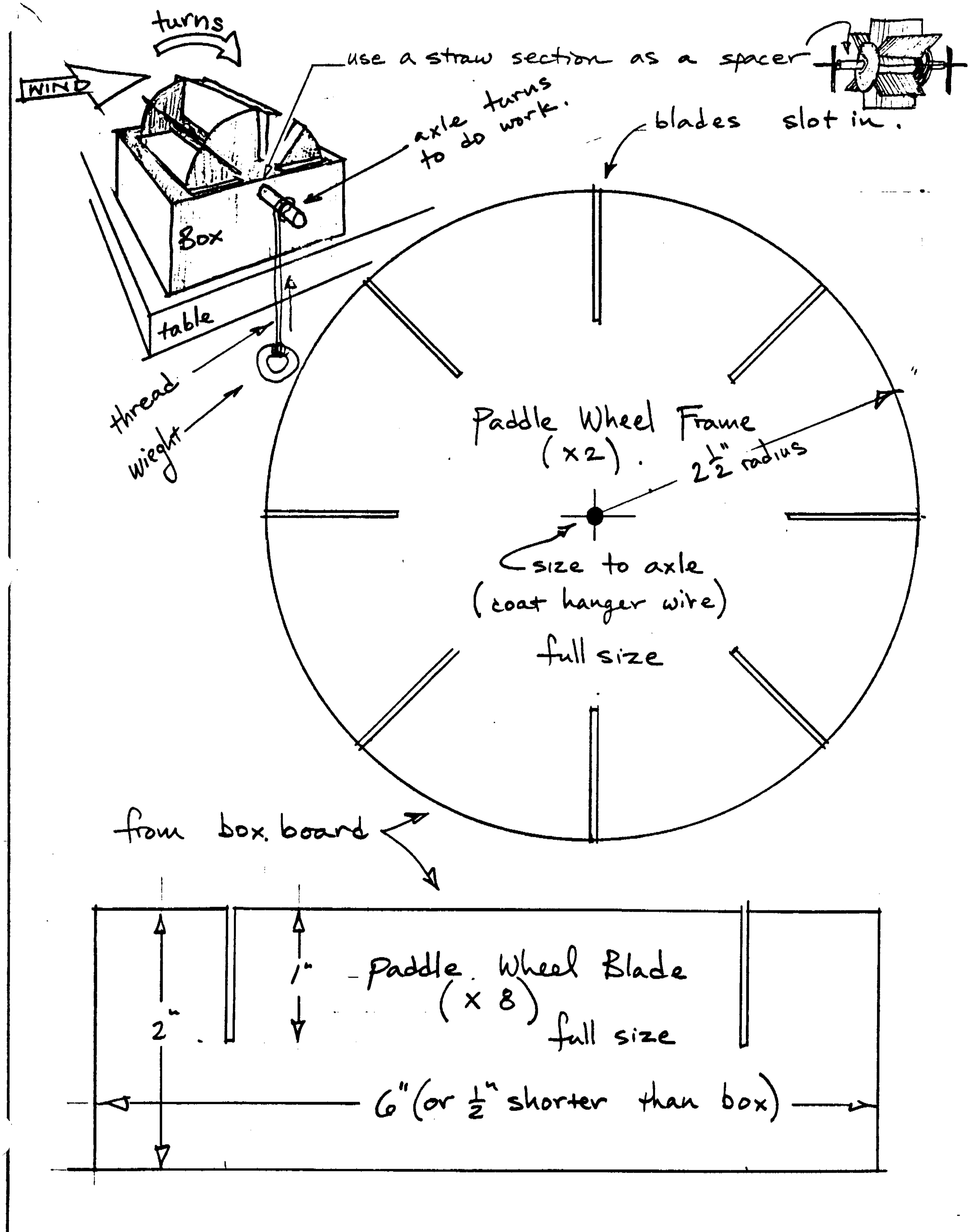


Design 12B





Tt	PERSIAN WIND MILL	Dt	7·11·97
		#	13 a
by	ROLLIN TAIT	Sxl	FULL SIZE



plan # 136

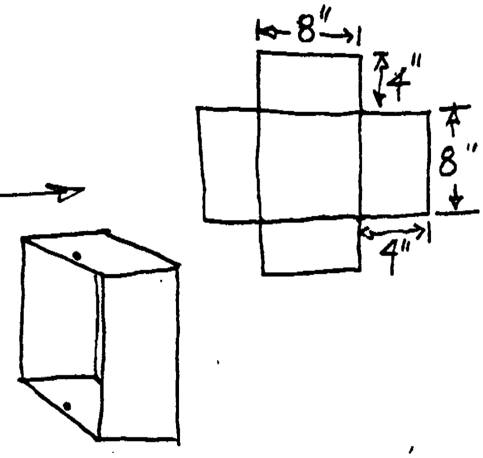
How to build the "Persian" Windmill

Materials: cardboard
coathanger wire
tape
hot glue

Study the sample model before you start to build !!

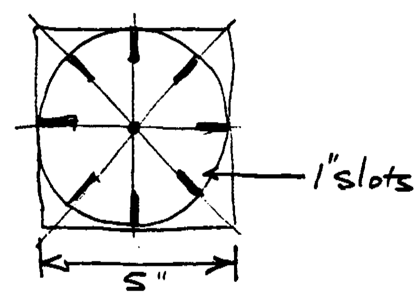
The box - tower

- cut out a piece of cardboard to the design shown.
- fold into a box and staple / glue together.
- poke holes at each side of the open end of the box (with a piece of wire) to accept the axle.



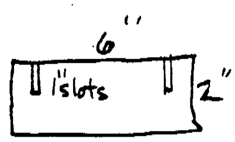
The top and bottom plates

- cut 2 squares of cardboard (5" x 5") to form the top and bottom plates of the rotor.
- draw diagonals and mark the center.
- poke a hole in the center (with a pencil) big enough for a straw to 'just' fit snugly.
- poke a hole in each corner (with a piece of wire) about 1/4" in from the edge.
- draw two more lines so that the cardboard looks like it has 8 equal pieces.
- draw a " diameter circle on the cardboard.
- cut out the cardboard to the circle.
- cut narrow slots (1" long) into the cardboard along each radiating line. (these slots should be just big enough for a piece of cardboard to fit into them snugly)



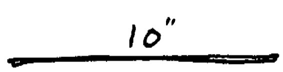
The paddles

- cut 8 pieces of cardboard (6" x 2")

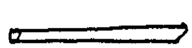


The axle

- cut a piece of wire 10" long



- cut a straw 7" long

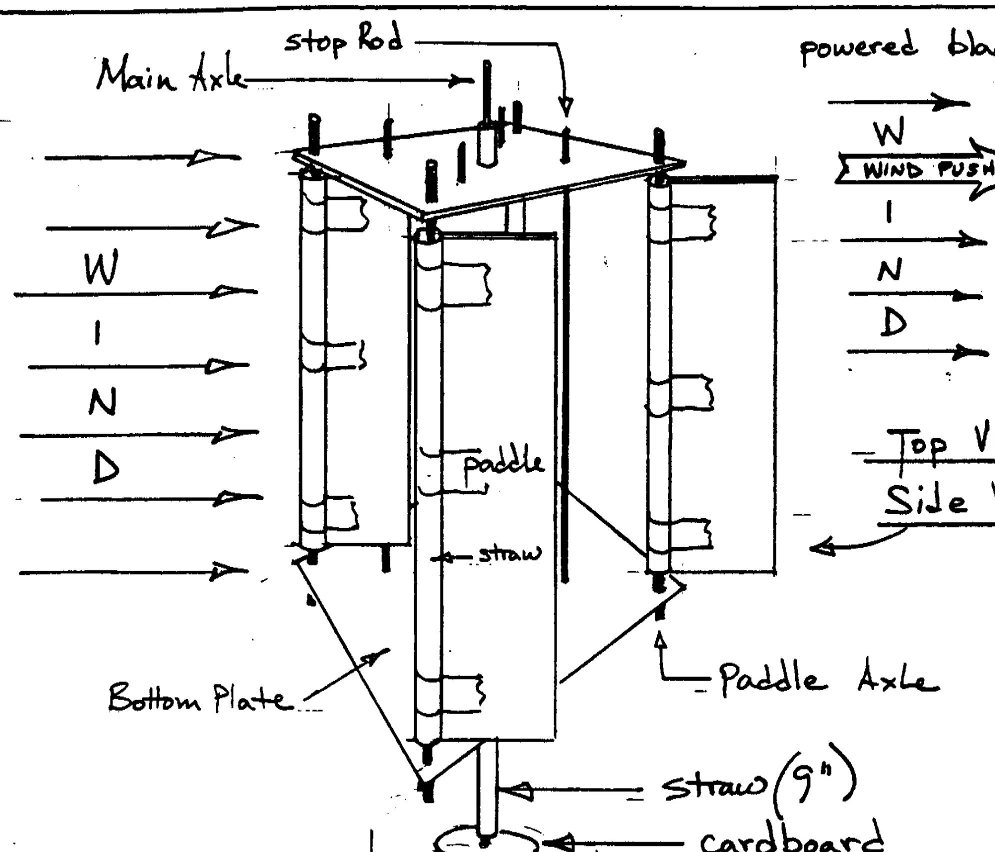


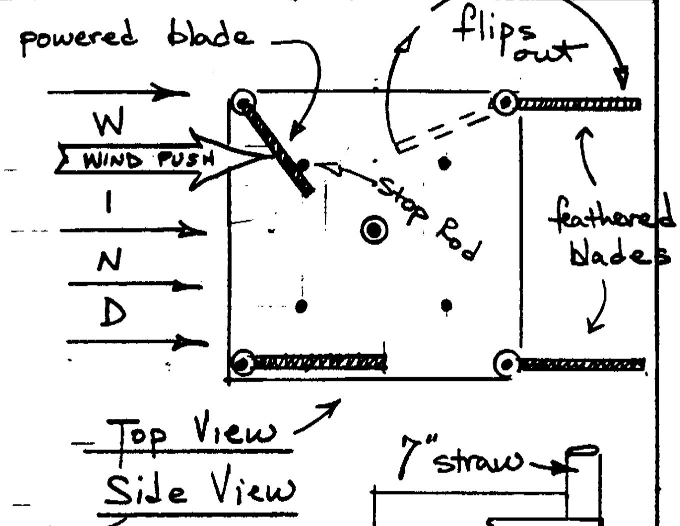
Assemble it

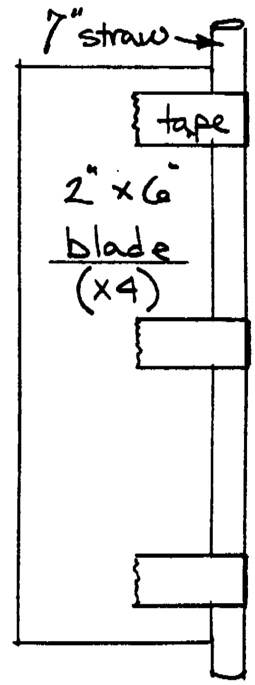
- glue the paddles into the slots you cut in the top and bottom plates.

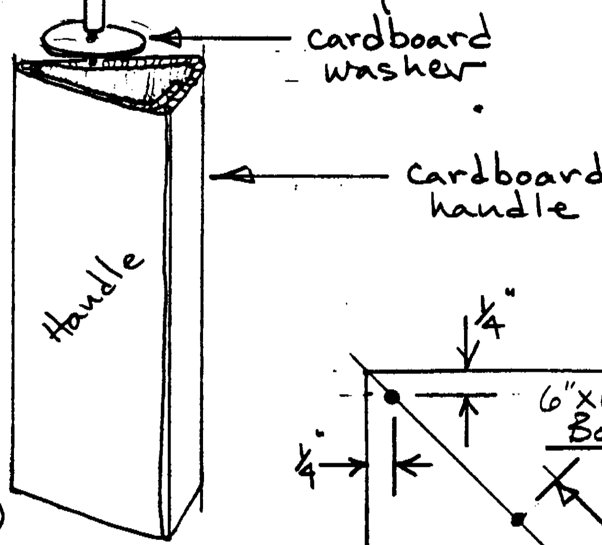
- insert the straw into the center holes of the top and bottom plates so that it sticks out about 1". Glue in place.
- Pu the rotor and the tower together and feed the wire axle through it all.
- Bend the wire over at top and bottom so it stays.

Ttl	CHINESE "CLAPPER" WINDMILL	Dt	1·18·98
		#	14 a
by	Rollin Tait	Scl	½" = 1"



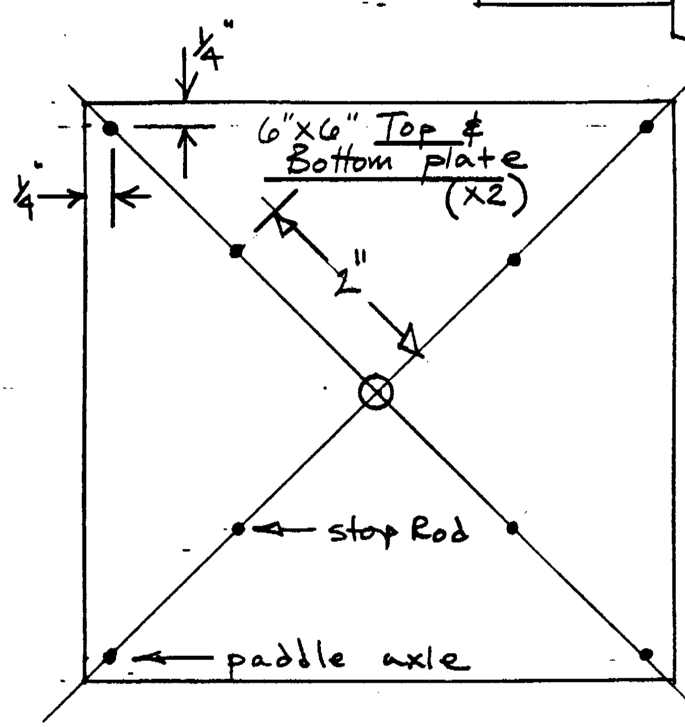






Straw Pieces

Item	Size	Qty
Main Axle	9"	x1
paddle Axle	7"	x4



Wire Pieces
(Coat Hanger wire)

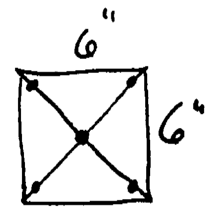
Item	length	Qty
Main Axle	12"	x1
Paddle Axle	8"	x4
Stop Rod	8"	x4

plan # 14b

How to build the "Chinese Clapper" windmill

Materials: cardboard
coathanger wire
tape
glue

Study the sample model before you build it !

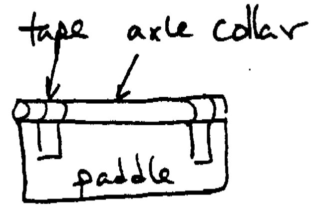


The top and bottom plates

- cut 2 squares of cardboard (6" x 6") to form the top and bottom plates of the rotor.
- draw diagonals and mark the center.
- poke a hole in the center (with a pencil) big enough for a straw to fit snuggly.
- poke a hole in each corner (with a piece of wire) about 1/4" in from the edges.
- poke a hole in each diagonal about half way out from the center towards the corner.

The paddles

- cut 4 pieces of cardboard 6" x 6".
- cut 4 straws 7" long for the paddle axle-collars.
- tape the paddles onto the axle collars like this ---------->

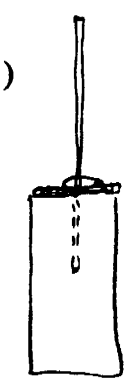


The axles and rods

- cut one piece of wire 12" long for the central axle.
- cut one piece of straw 9" long for the central axle-collar.
- cut 4 pieces of wire 8" long for the paddle axles.
- cut 4 ~~straws~~ wires 8" long for the paddle stop-rods.

Assemle it

- *don't glue anything until it is all put together together !!!!!!!!* ← see the sample model!
- insert the 9" straw axle-collar into the center hole in the top and bottom plates
  (it should stick out about 1/2" at each end)
- insert the 8" ~~straw~~ stop-rods into the holes in the diagonals of the top and bottom plates
  (they should stick out about 1/2" at each end)
- feed the 8" wire paddle-axles *through the paddle axle-collars* (on the paddles) and
  insert them into the holes in the corners of the top and bottom plates.
  (they should stick out about 1/2" at each end)
- square everything up and glue it with hot glue (be sure the paddles are free to rotate!)



The handle

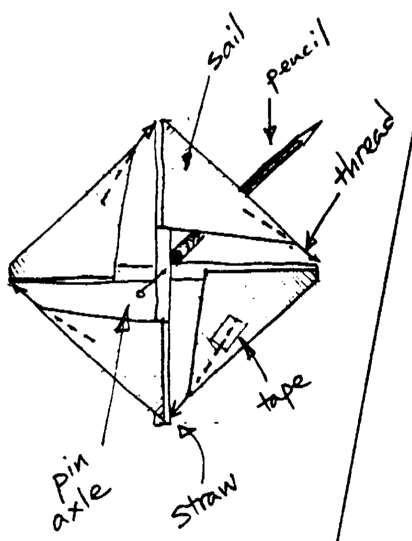
- cut a piece of cardboard 6" x 3" (with the corrogations running the 6" way).
- insert the 12" wire axle into the corrogations of the handle about 3" and hot glue.
- cut a small washer of cardboard and put it on the axle just above the handle.

Final assembly

- put the windmill on the handle

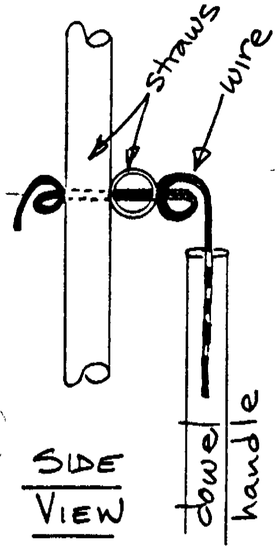
You are done !

Ttl	CRETAN WIND MILL	Dt	7·23·97
	HORIZONTAL AXIS WIND TURBINE	#	15
by	by ROLLIN TAIT	Scl	FULL SIZE

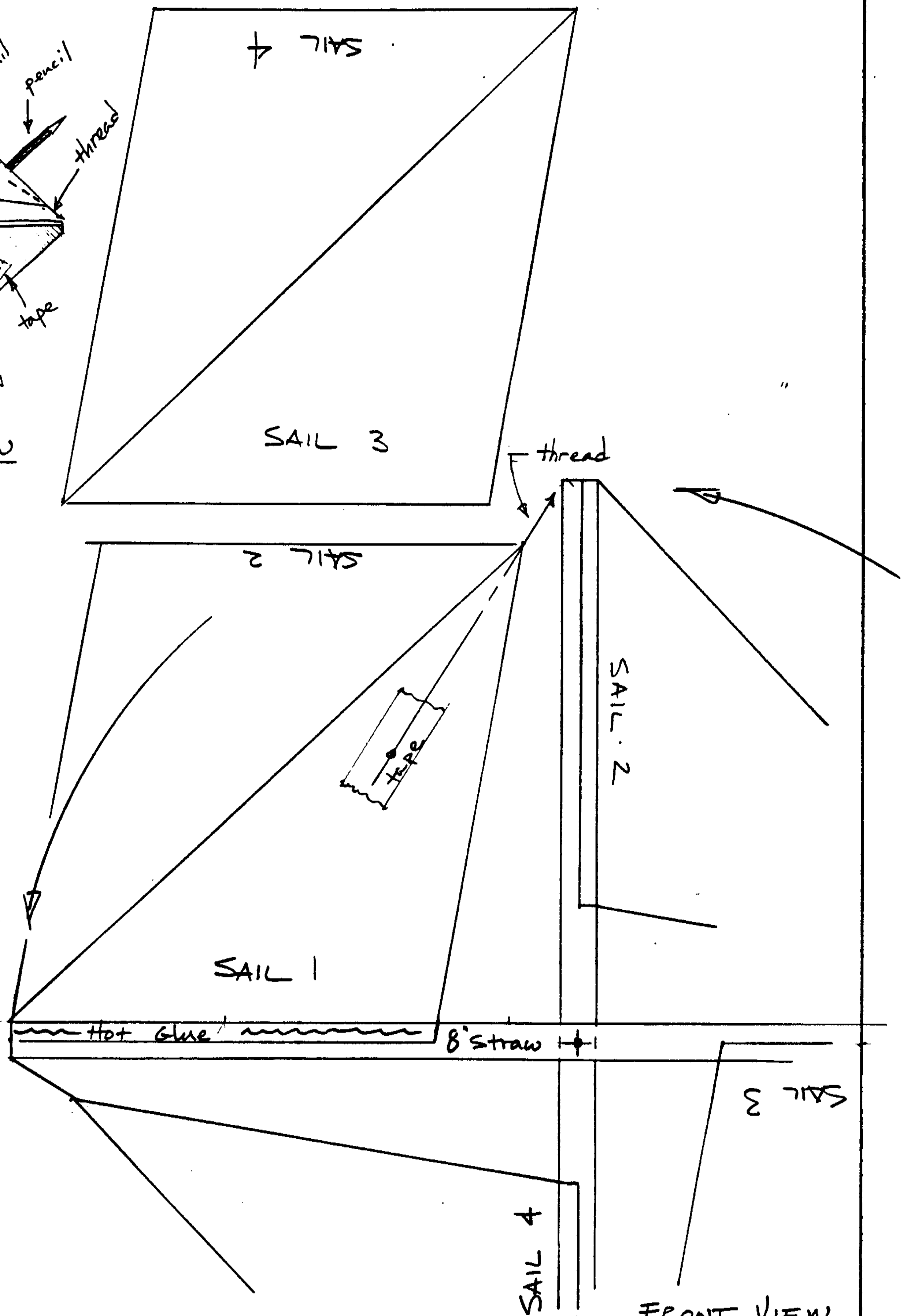


FULL VIEW

two different axle systems are shown

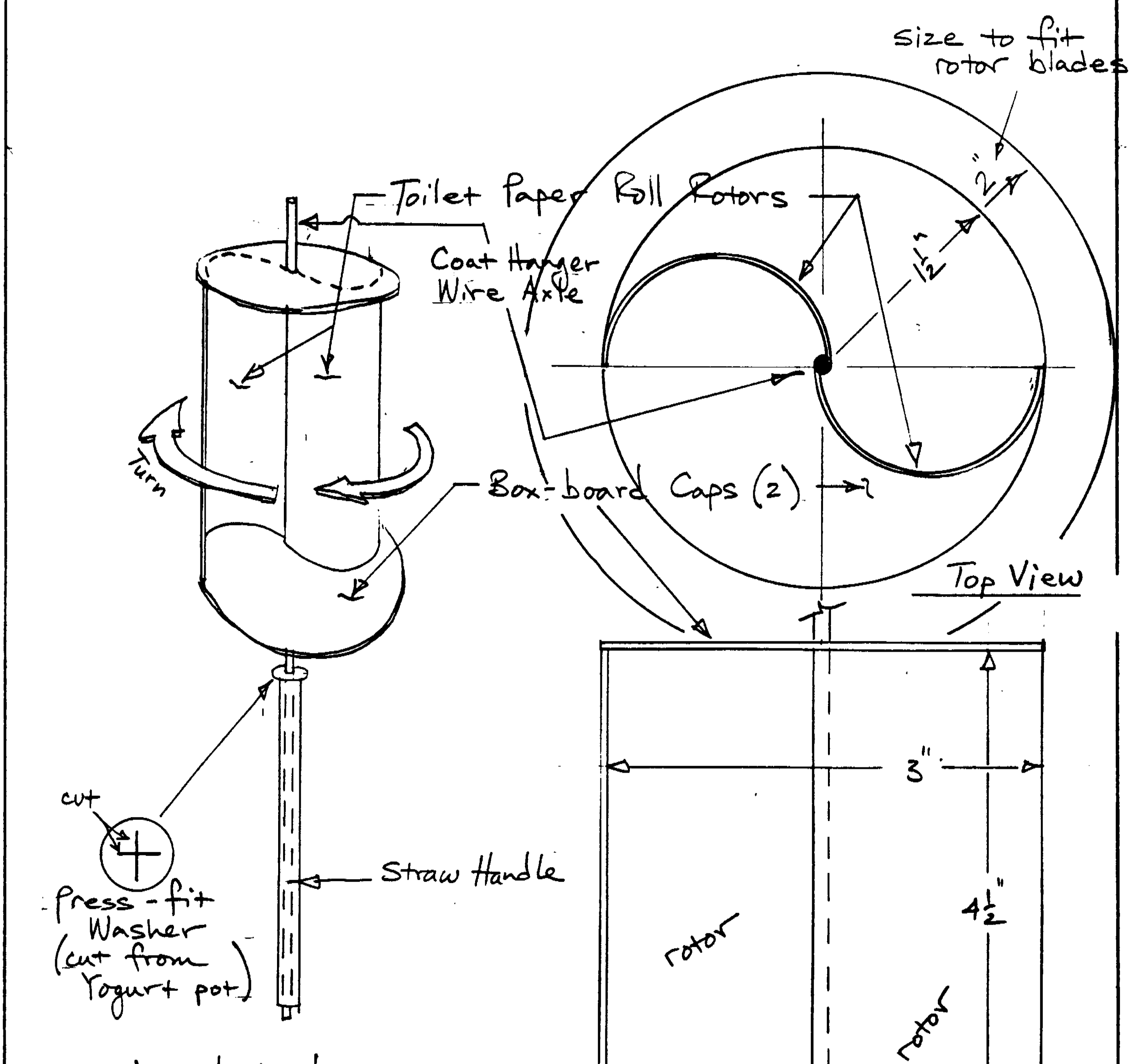


SIDE VIEW



FRONT VIEW

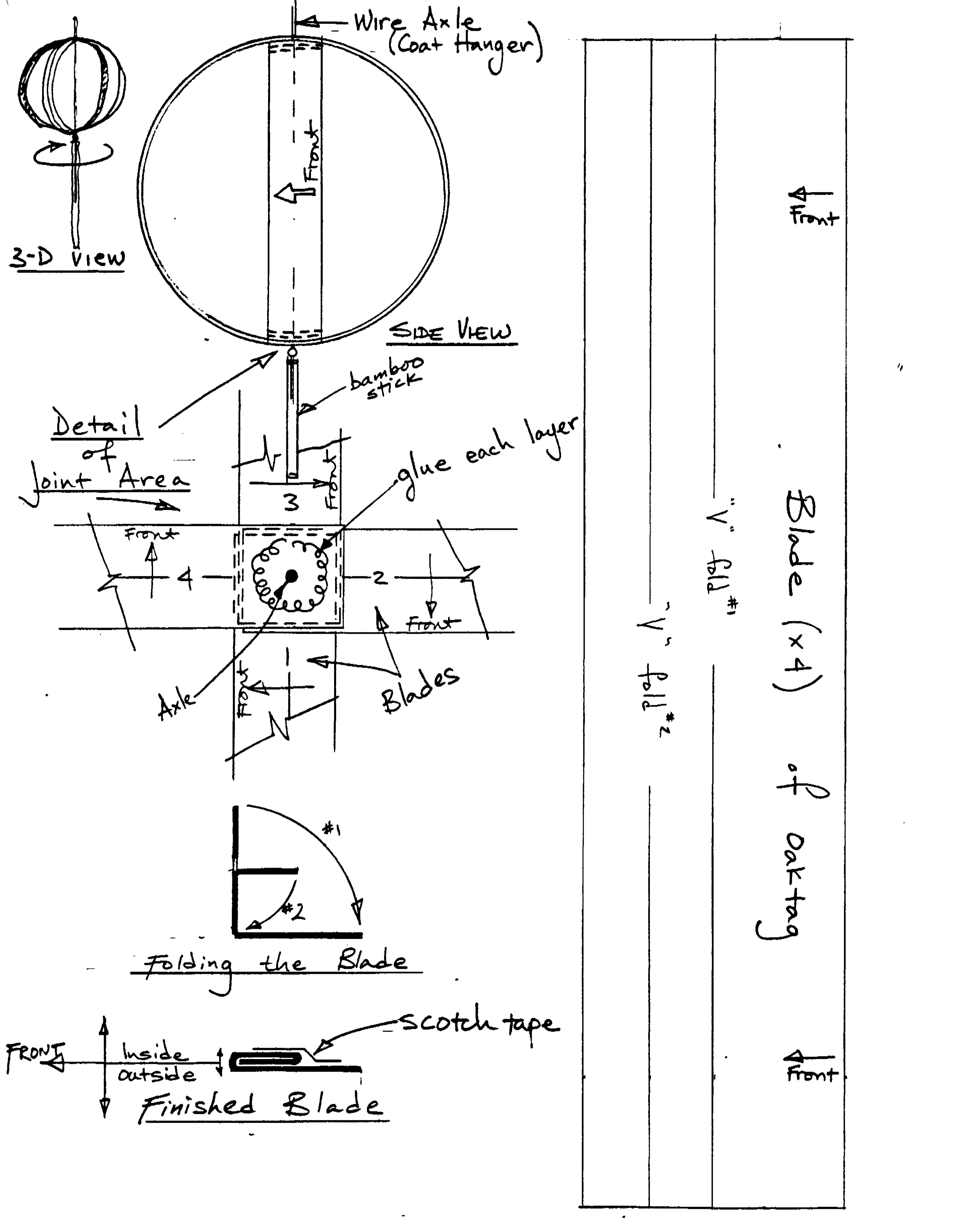
Tl	SAVONIUS ROTOR ("S"- Rotor)	Dt	7.16.97
	VERTICAL AXIS WIND TURBINE	#	16
by	ROLLIN TAIT	Sc	FULL SIZE



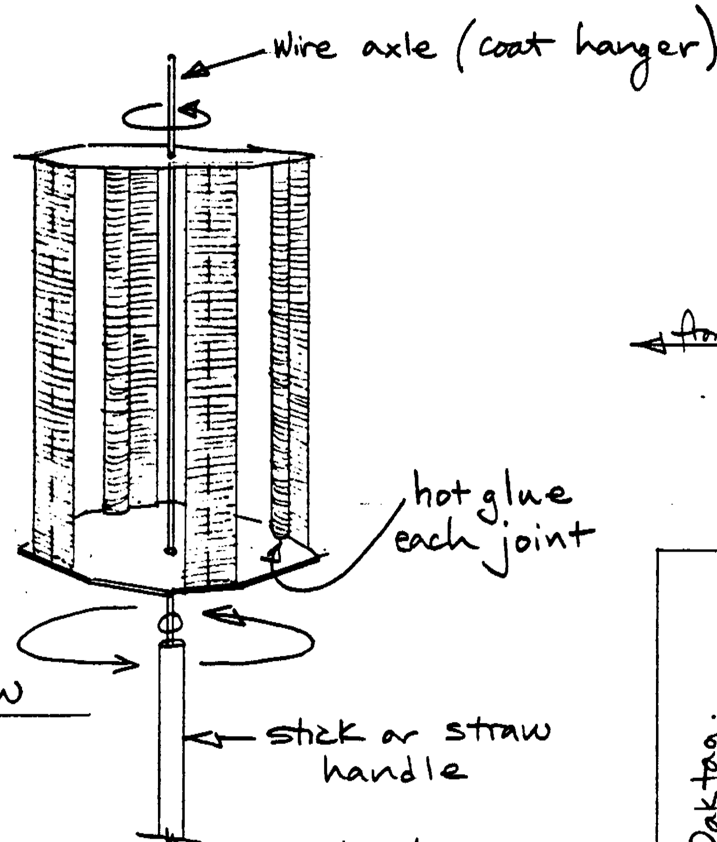
Use hot glue to assemble axle, rotor blades and end caps.

Note: you could also use a hollow straw axle

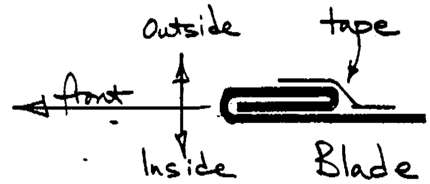
Ttl	DARIOUS ROTOR ("D" Rotor)	Dt	7·18·97
	VERTICAL AXIS WIND TURBINE	#	17.a
by	ROLLIN TAIT	Scl	FULL SIZE

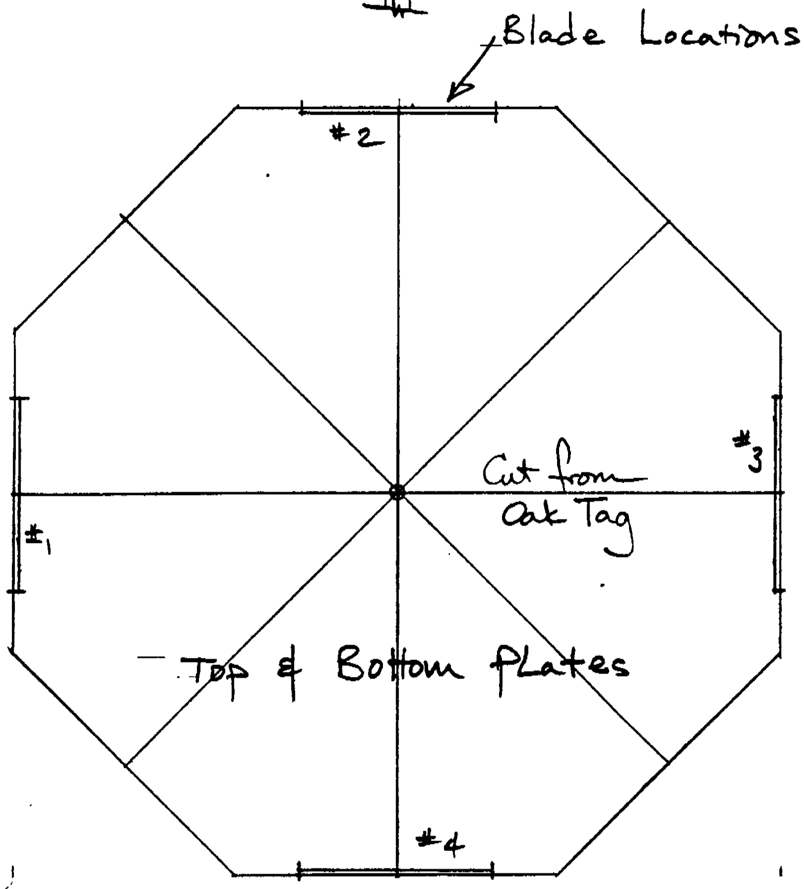


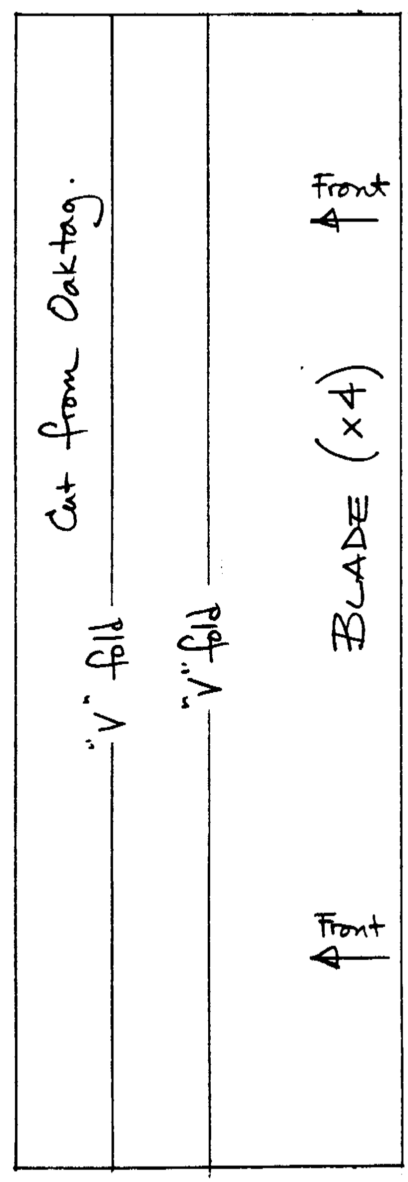
Ttl	"H" - Rotor	Dt	7-23-97
	VAWT - Vertical Axis Wind Turbine	#	176
by	Rollin Tait	Scl	FULL SIZE



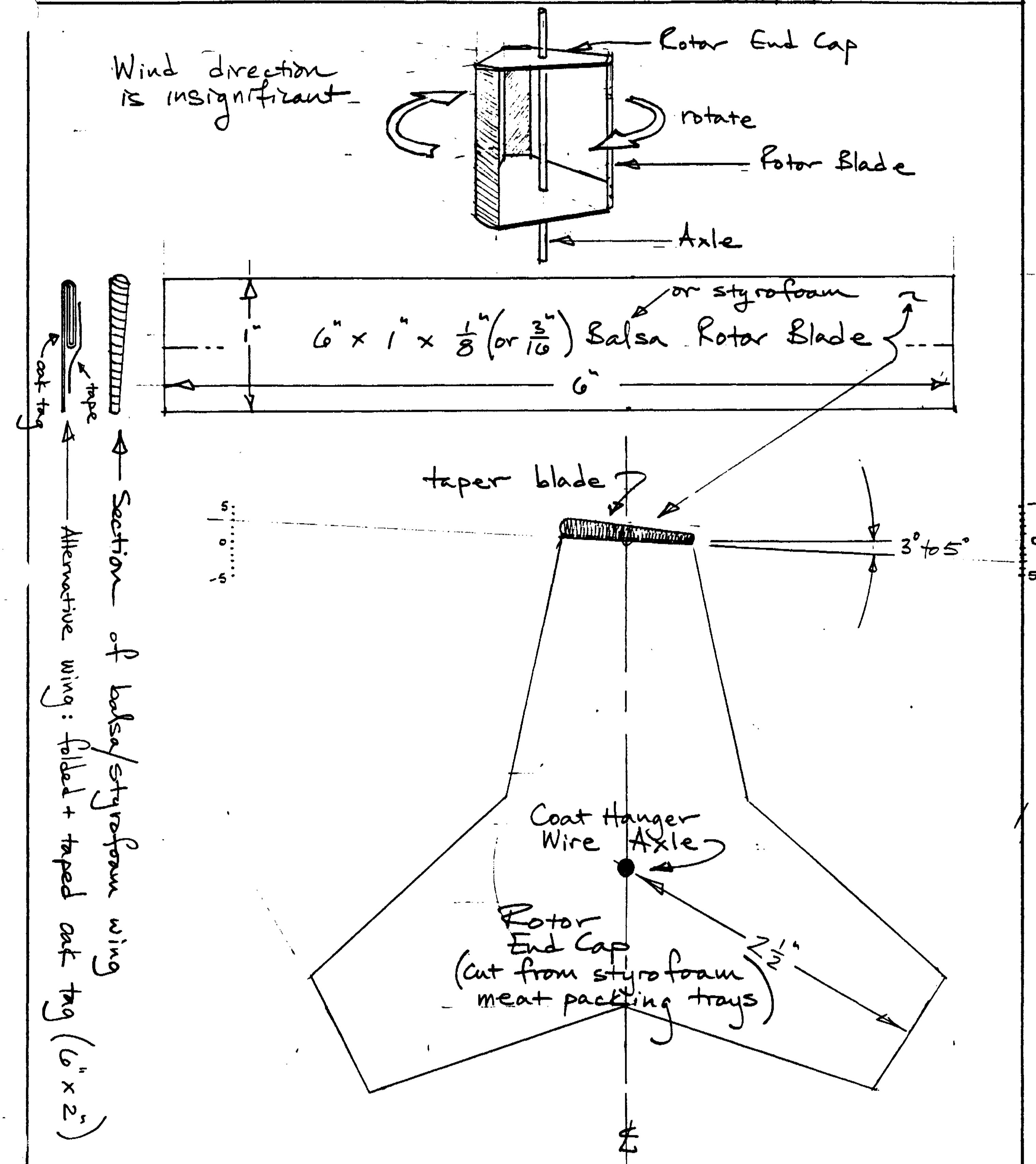
3-D View



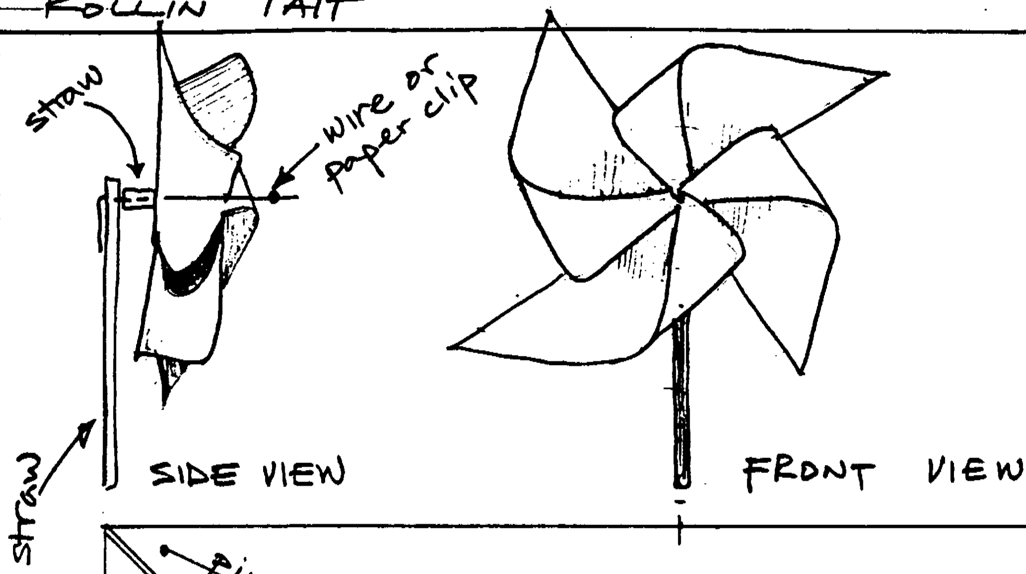


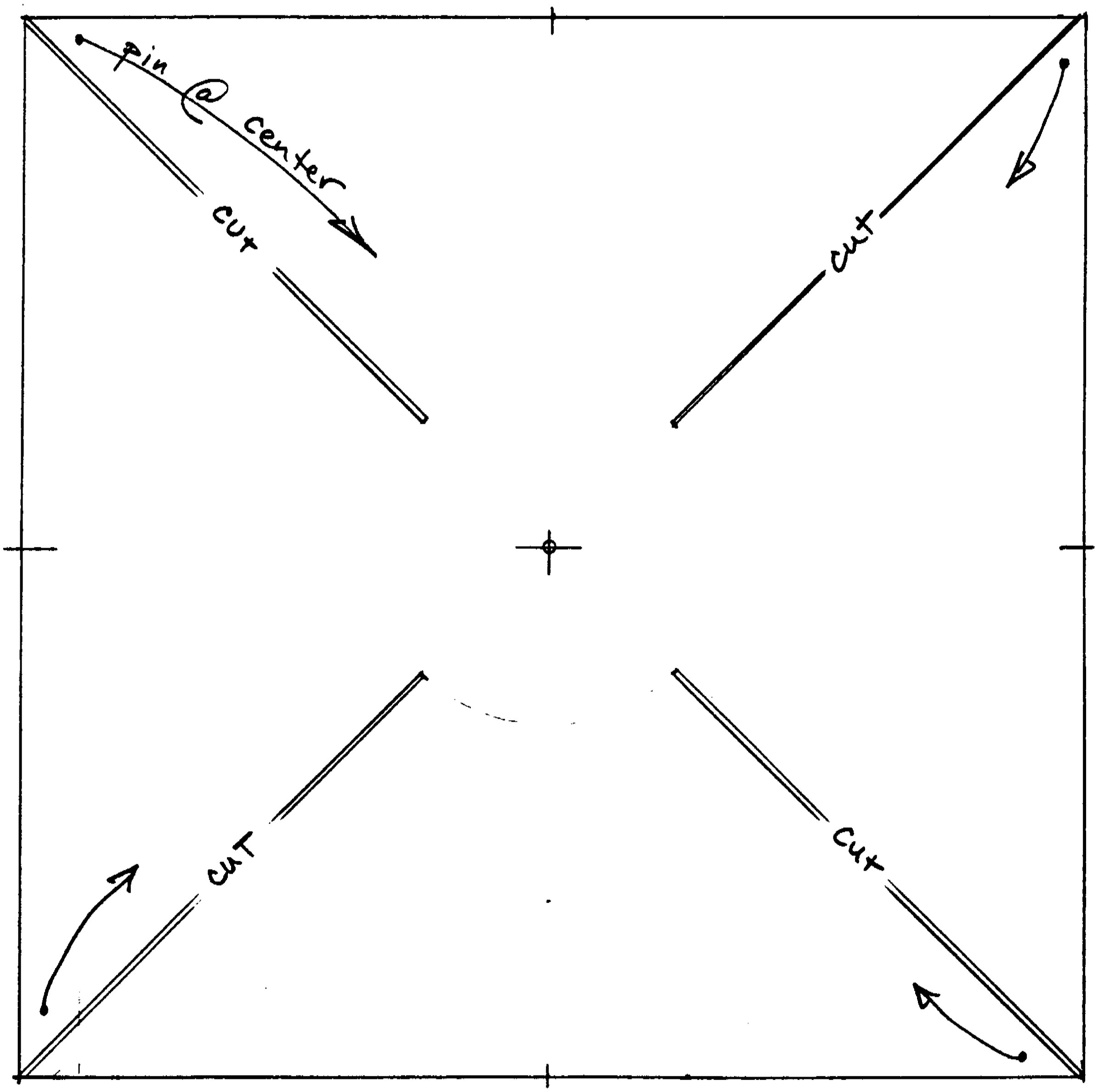


TH	"H" = ROTOR	DT	7·18·97
	VERTICAL AXIS TURBINE	#	17 C
BY	ROLLIN TAIT	SK	FULL SIZE

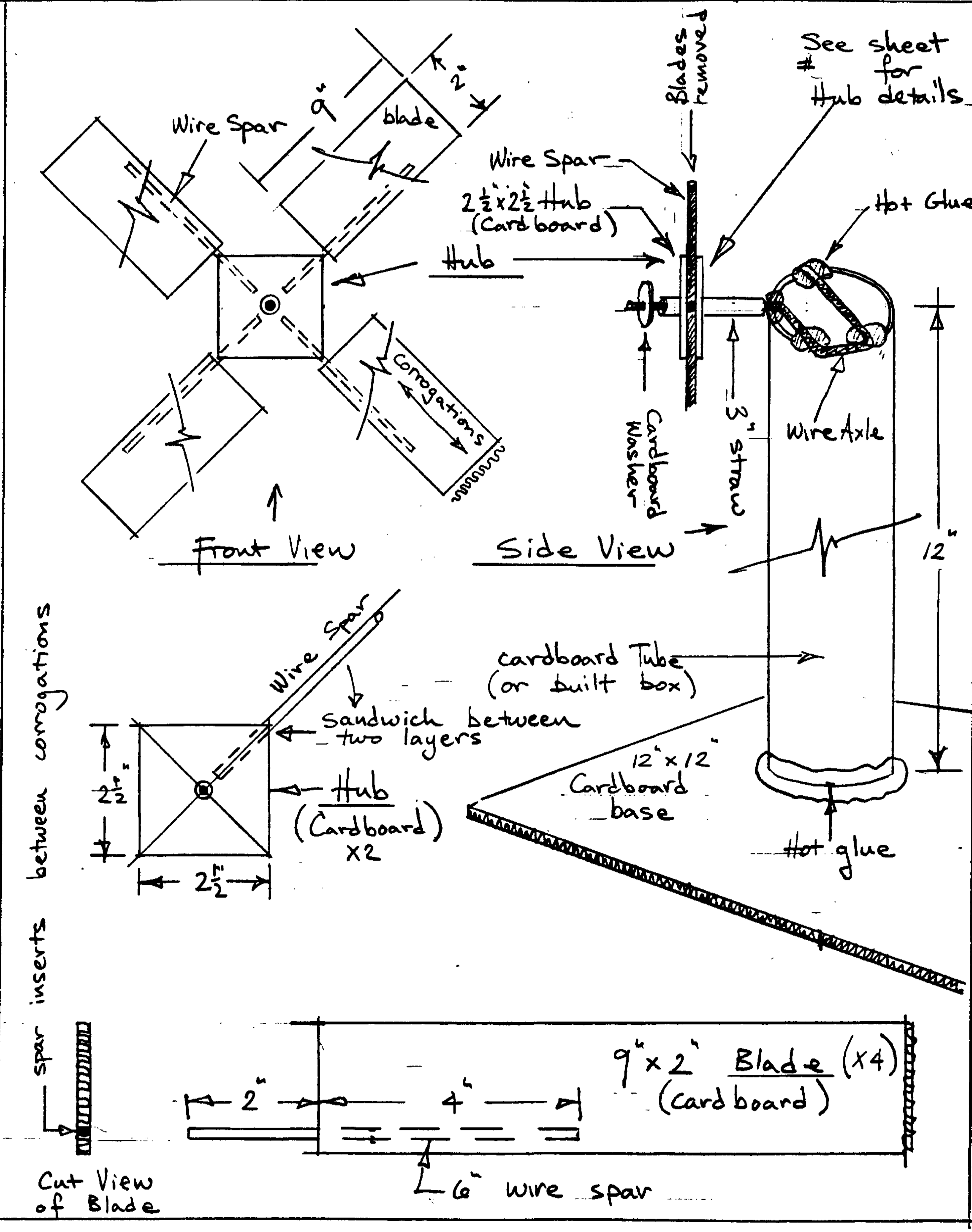


Ttl	CLASSIC PINWHEEL TURBINE	Dt	7·23·97
	HAWT = HORIZONTAL AXIS WIND TURBINE	#	18
by	ROLLIN TAIT	Scl	FULL SIZE





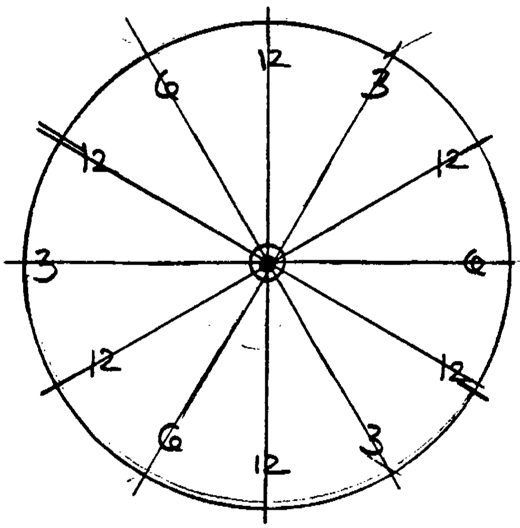
TH	DUTCH 4-BLADE WINDMILL	Dt	1.18.98
		#	19a
	ROLLIN TAIT	SKL	½" = 1"



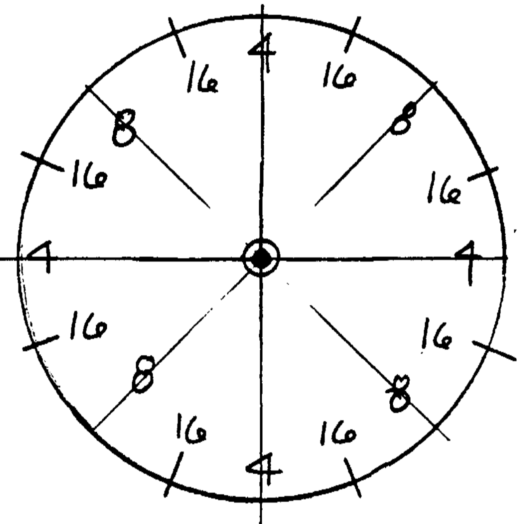
WINDMILL HUBS (Model)

(you need 2)

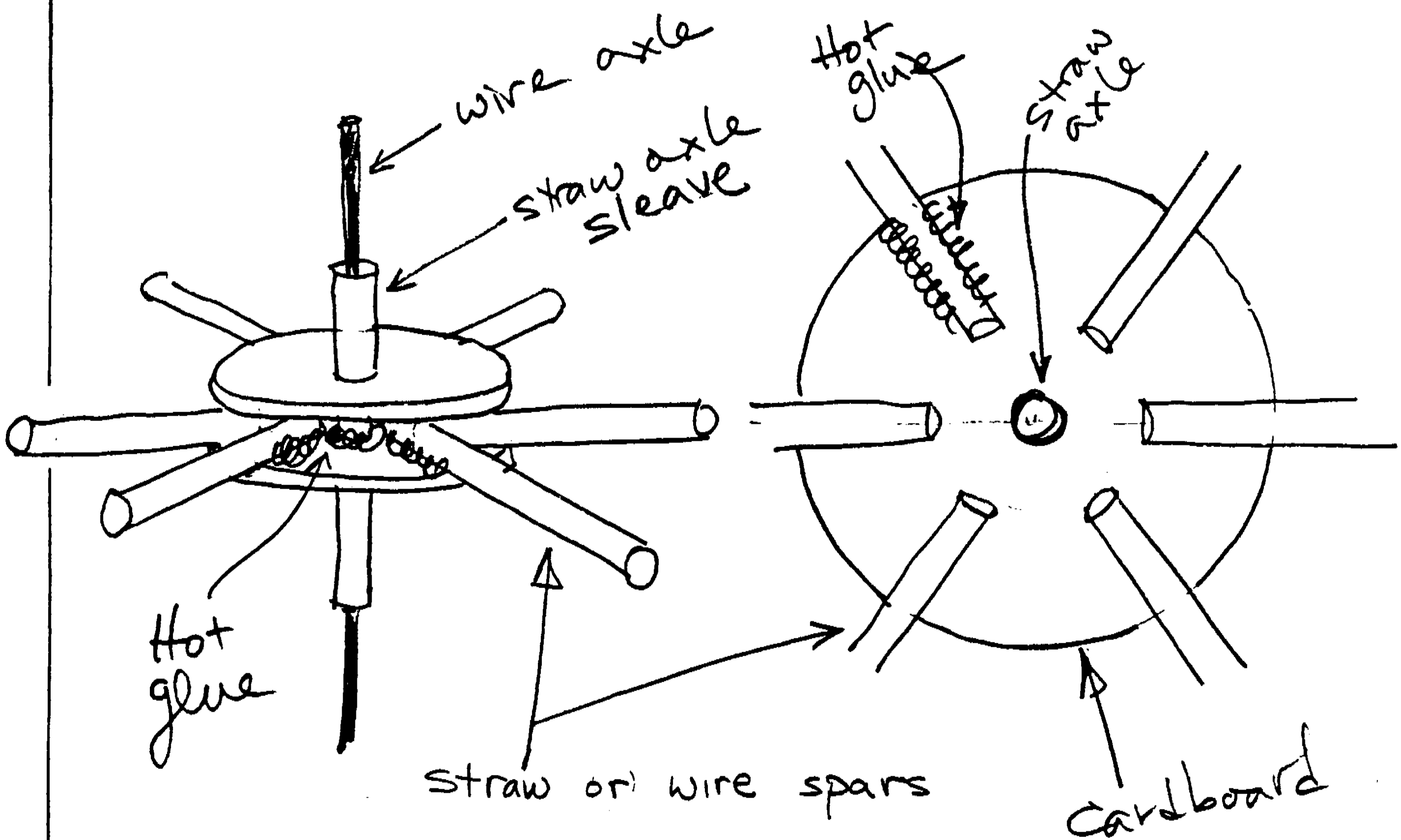
(2½" diameter)



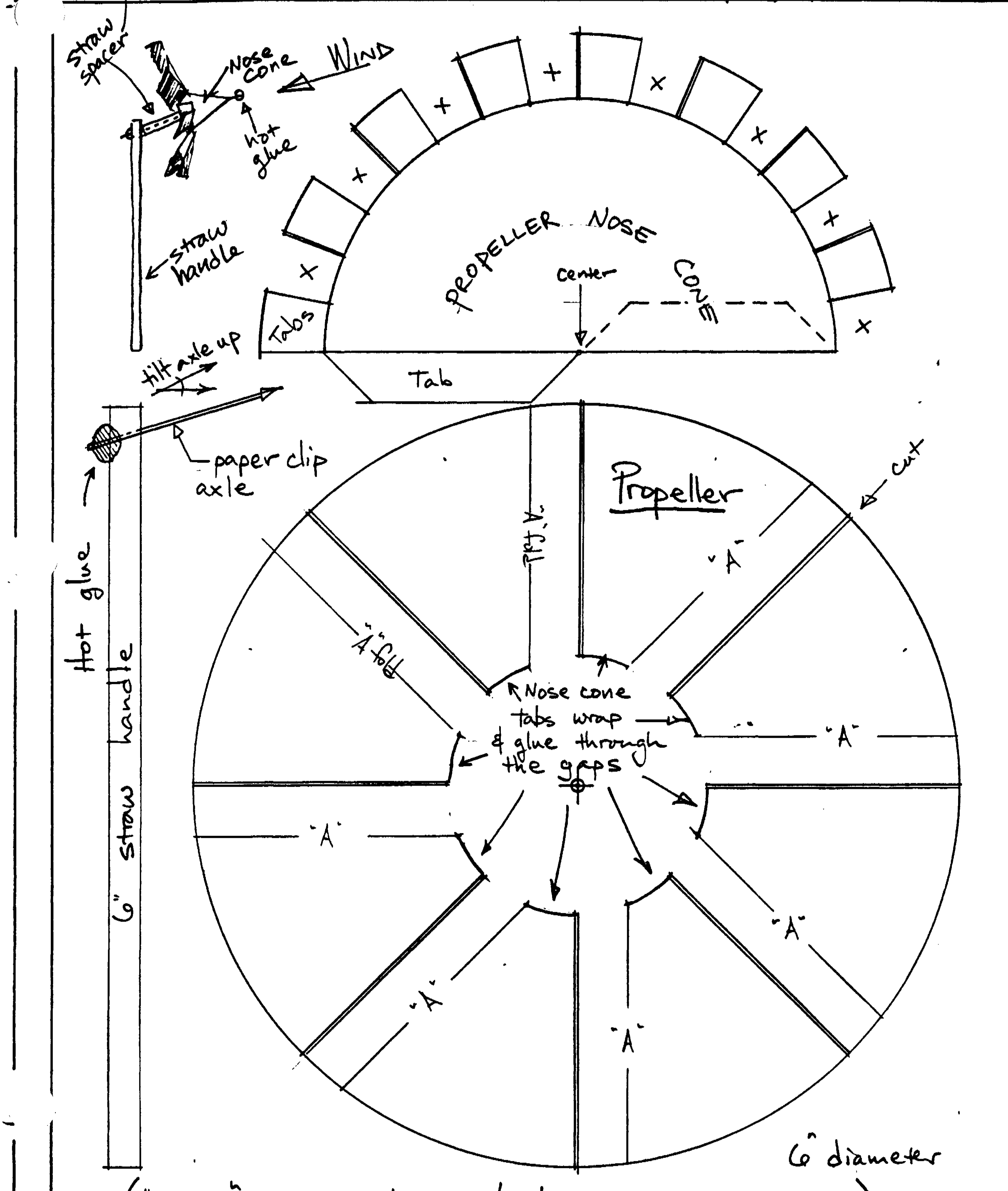
3, 6 & 12 Blade Hub



4, 8, 16 Blade Hu

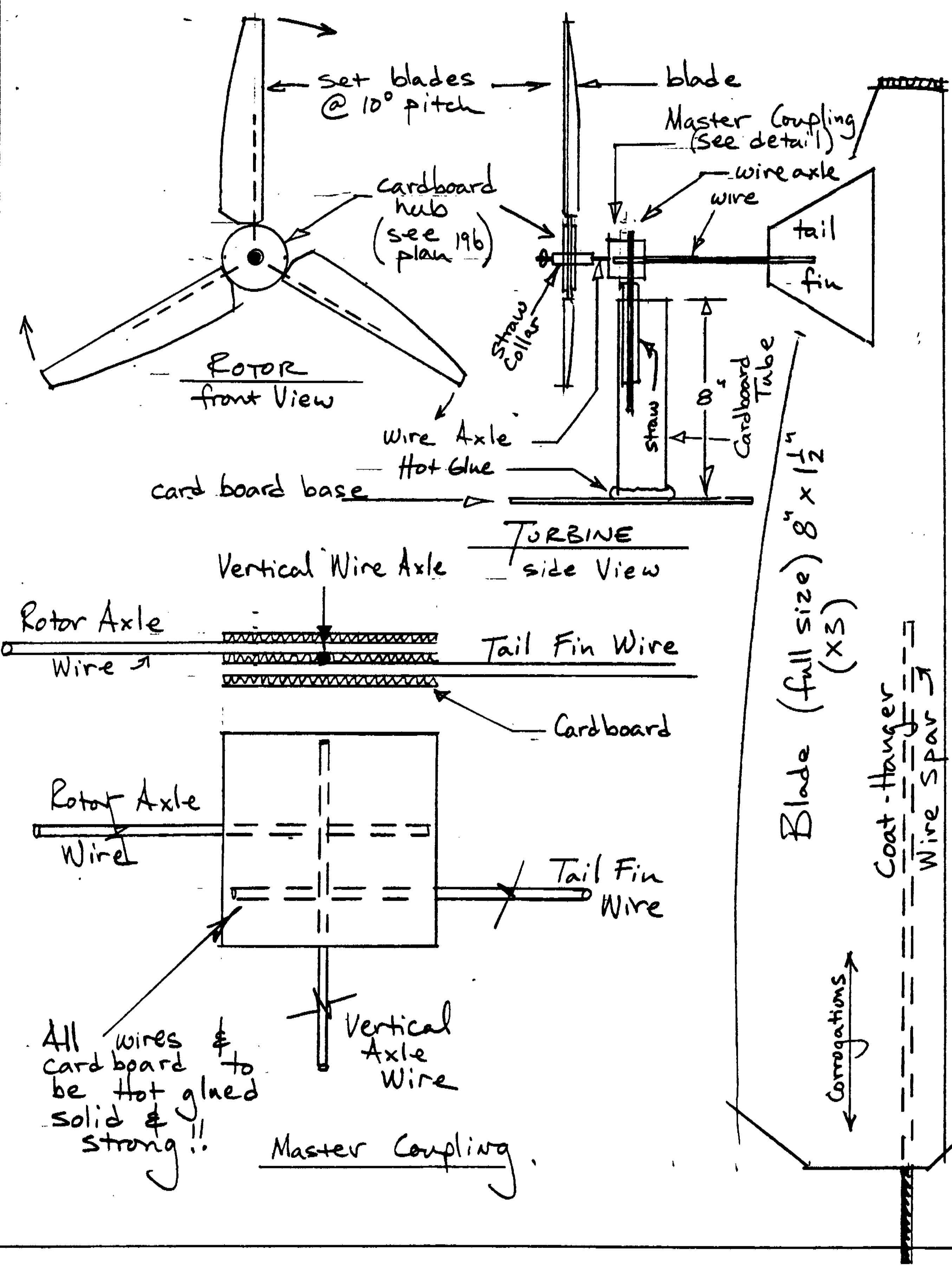


TH	EIGHT-BLADED WIND TURBINE	Dt	7-23-97
	HORIZONTAL AXIS WIND TURBINE	#	20
by	By ROLLIN TAIT	Scl	FULL SIZE



("SOLID" Rotors have high starting torque)

T+l	Up-Wind Rotor HAWT (Horizontal Axis Wind Turbine)	Dt	1.18.98
		#	21
by	R. Tait	Sxl	



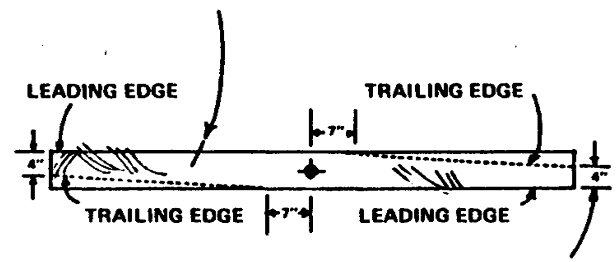
Ttl	HOME MADE WOODEN PROPELLER	Dt	7·22·97
	FOR WIND TURBINE	#	22a
by	ROLLIN TAIT (from Mother Earth News)	Sxl	~

GENERAL CONSTRUCTION TIPS

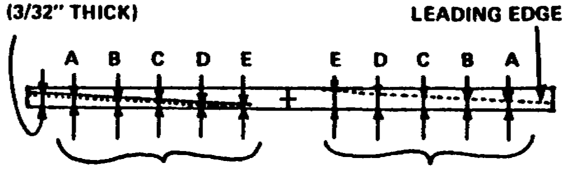
Start at tips bringing wood down on airfoil side of prop with drawknife (or rasp when it starts getting close) until template for station A will fit on prop in the right place (7" from tip)—then go to template B until it fits (7" from A)—and so on toward the center. The flat side made in Step 3 is your reference for positioning the templates.

Sand well, varnish (several coats), and balance both horizontally and vertically. Balancing can easily be accomplished by adding small weights to the edge (vert. balance) and front (horiz. balance).

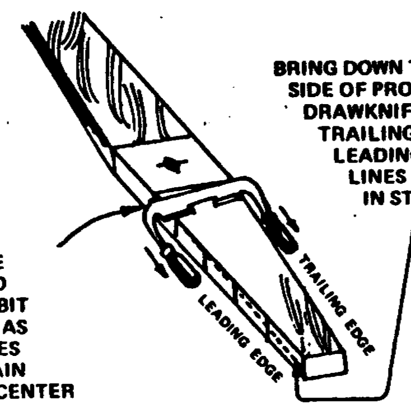
NOTE: This prop can be made 10 feet long by extending the distance between stations from 7" to 10", making the 3" x 4" sections both 5". All other dimensions, the same.



STEP 1

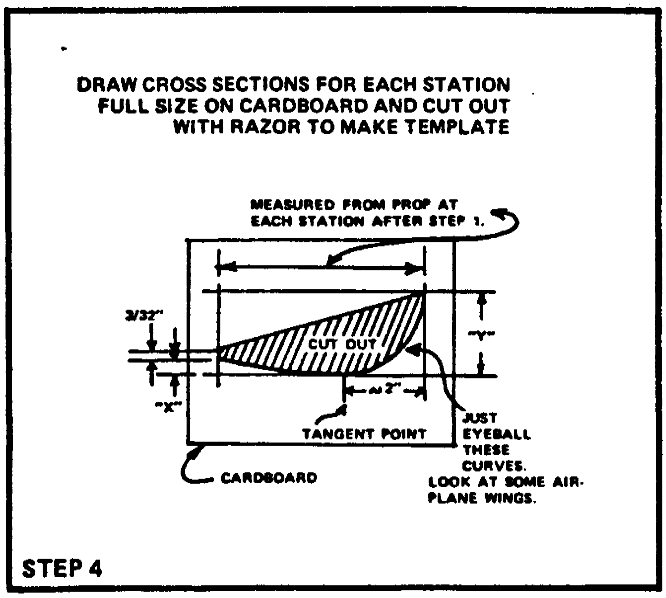


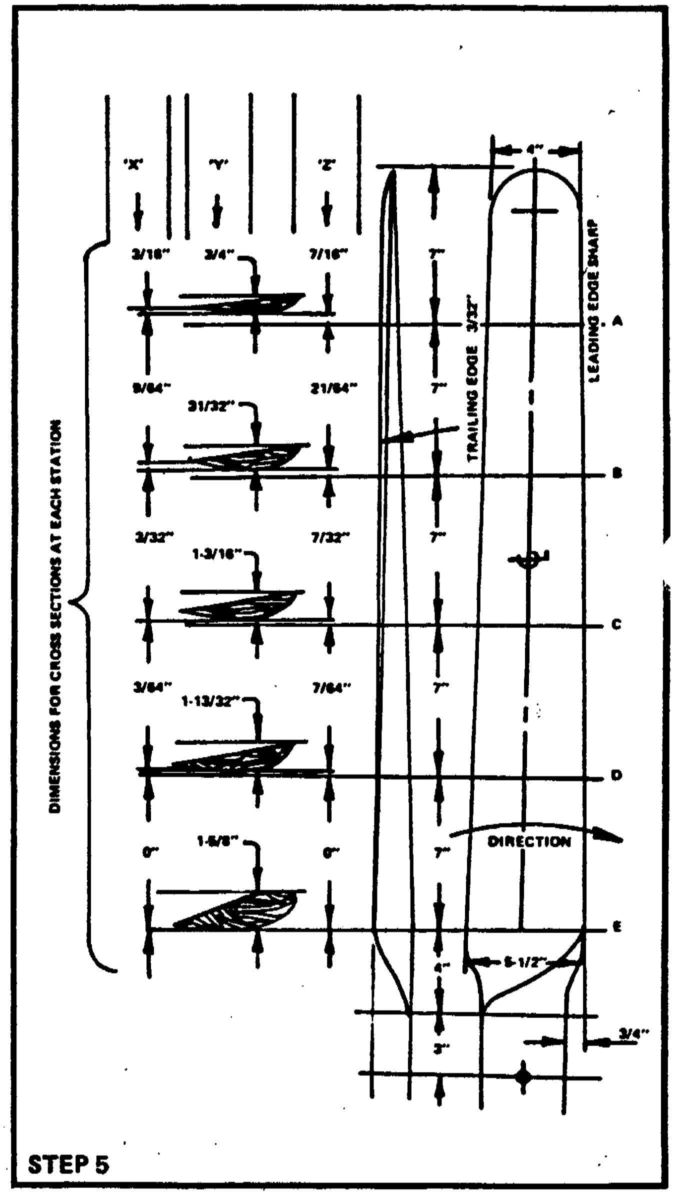
STEP 2



STEP 3

Ttl	HOME MADE WOODEN PROP	Dt	7-22-97
		#	226
by	ROLLIN TAIT	Sxl	~





The Wind at Work

COMPARE ELEMENT TEMPERATURES

Goal *Understand temperature patterns that affect the wind.*

Materials

2 plastic buckets of the same size
Water
Earth
3 outdoor thermometers
Notebook
Pencil
1 piece of graph paper
3 different color markers
Ruler

Directions

Fill one bucket with earth and the other bucket with water. Place a thermometer in each bucket. Place the buckets side by side. Place the third thermometer on the ground nearby to measure the air temperature. Make sure you place the buckets and thermometers someplace where the sun can shine on them for part of each day.

Use the notebook to record your observations three times a day. For each observation, record the day of the week, time of day, the name of the element (water, earth, or air), the temperature reading on the thermometer, and the weather conditions at the time of your observation. Record your observations for three days.

Day	Time	Element	Temperature	Condition
Monday	morning	Water	76 degrees	sunny but cloudy
Monday	morning	Earth	78	same
Monday	morning	Air	77	same
Monday	afternoon	Water	82	sunny
and so on . . .				

At the end of your three days of observation, create a chart like the one shown above. Write in a temperature range on the vertical axis and the days of observation on the horizontal axis leaving enough room to record your three daily observations. Use a different color marker to record your observations for each element. Place a dot in the spot where the day of the week and time intersect with the recorded temperature. Once you've recorded all your observations, use a ruler to connect these dots.

Results

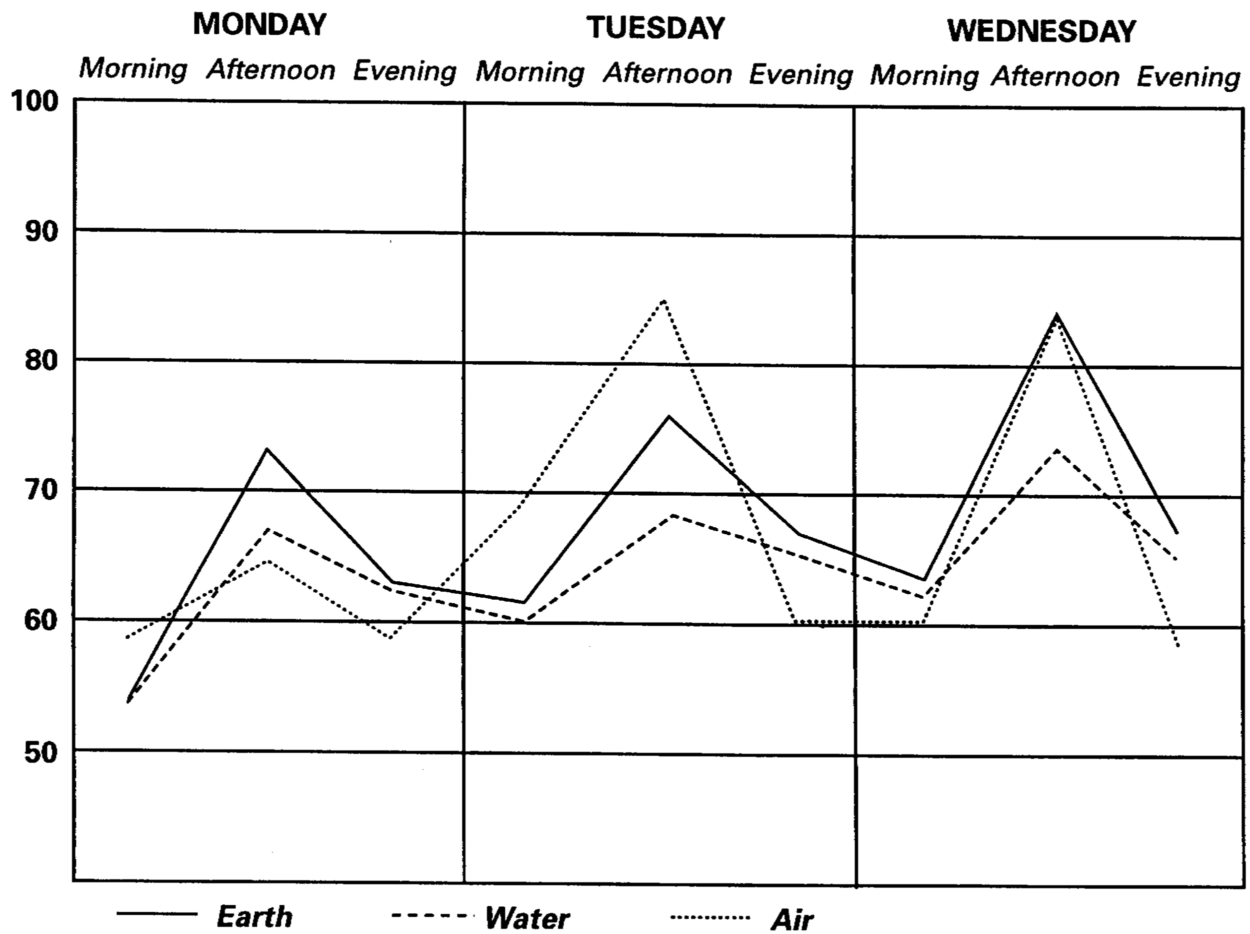
What element has the highest temperature—water, earth, or air—in the morning? Afternoon? Evening?

Which element heats up the most during the day?

Which element cools down the most at night?

Which element shows the least temperature change during the day?

What does this tell you about the relative temperature of the oceans, earth, and atmosphere? How might these temperature differences affect wind patterns?

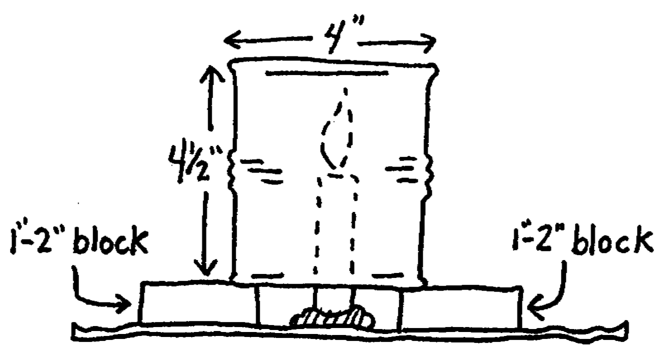


LEARN HOW TEMPERATURE AFFECTS WIND

Goal *Observe the flow of air in a warm and cool environment.*

Materials

1 2-foot piece aluminum foil
1 small piece molding clay
1 thick candle, 4 inches tall
Matchbook
2 small wooden blocks, 1 or 2 inches thick
1 empty soup can, label and both ends removed
1 sharp knife
1 piece heavy cotton string, 3 inches long (Don't use nylon string!)

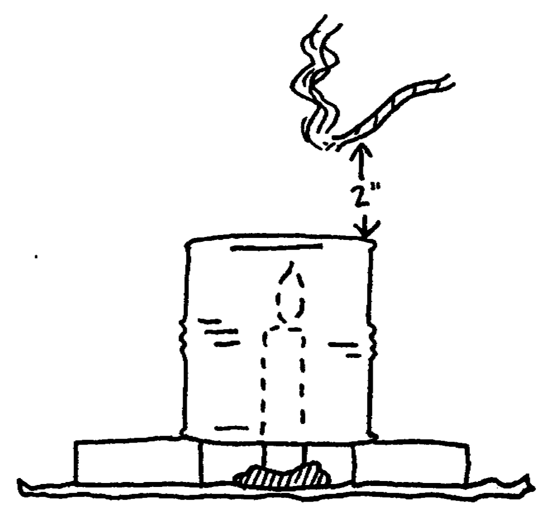


Directions

(Adult help suggested.)

Spread the aluminum foil on top of a table. Secure the candle to the tabletop with clay. Light the candle. Place 2 wooden blocks on opposite sides of the candle. Carefully place the can over the candle and resting on top of the 2 blocks. The candle flame should not show above the can. (If the candle is too tall, blow it out and cut it at the bottom so it will fit inside the can.)

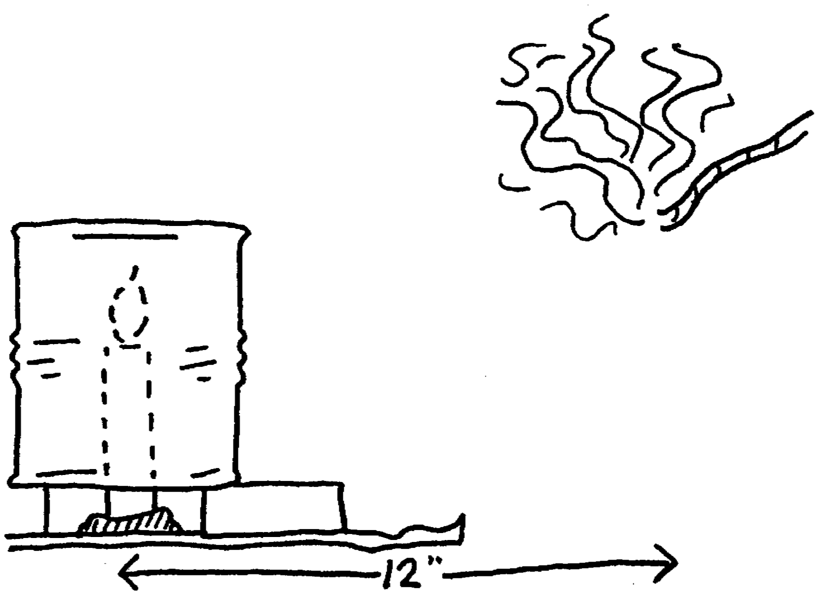
Light the end of the string over the sink, then quickly blow out the flame. The string should smoke. Hold the smoking string 2 inches above the candle flame. Notice the temperature above the candle. What happens to the smoke?

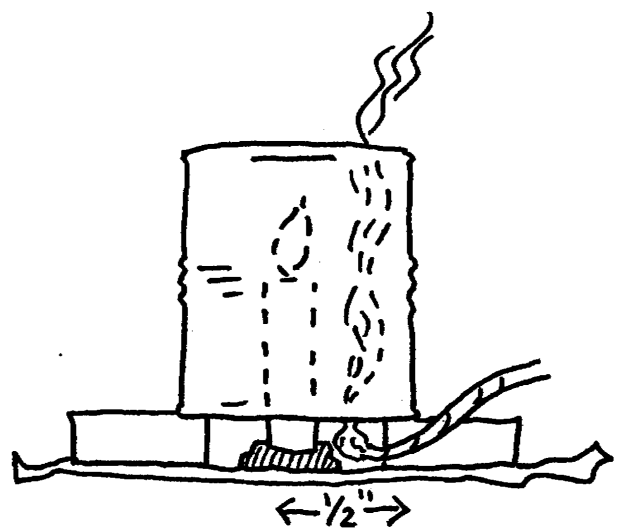


While the string continues to smoke, hold it beside the candle, about a foot away. Notice the temperature now. What happens to the smoke? Finally, hold the string near the table top, about ½ inch from the edge of the can. What happens to the smoke? How can you explain this?

Results

If our atmosphere were all the same temperature, air wouldn't move. However, sunlight warms our atmosphere just like a candle warms the air around it. The warm air rises, and the cooler air moves in to take its place. So, when you hold the string directly above the candle, the smoke rises. When you hold the string a foot away from the heat source, the smoke drifts because the air surrounding the string is not as warm. Finally, when you hold the string close to the bottom of the tin can, the smoke is drawn up under the can and rises because the smoke moves in the direction of the warmer air.





MAKE A WIND SOCK AND WIND VANE

Wind socks are used in airports to show which direction the wind is blowing.

Goal *Make a wind sock and wind vane and learn how they work.*

Materials

1 nylon knee sock or 1 knee-high hosiery 15-18 inches long
1 12 ounce Styrofoam cup
1 3⁄16 inch wooden dowel, 3 feet long
2 straight plastic straws, 8 inches long (not the flexible kind)
1 1⁄4 inch washer
1 push pin
1 sheet construction paper

Tools

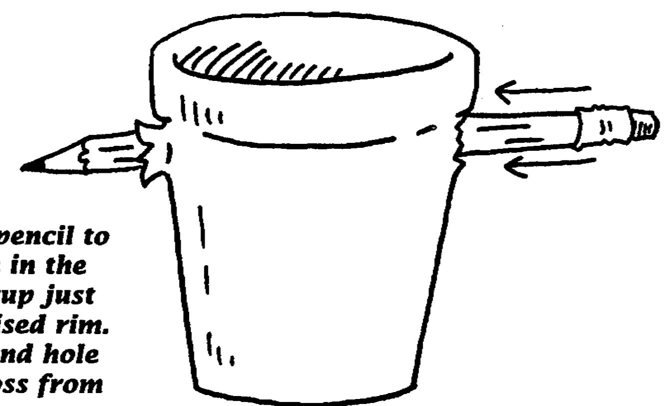
Scissors
Pencil
Masking tape
White glue
Ruler
Compass

Directions

WIND SOCK

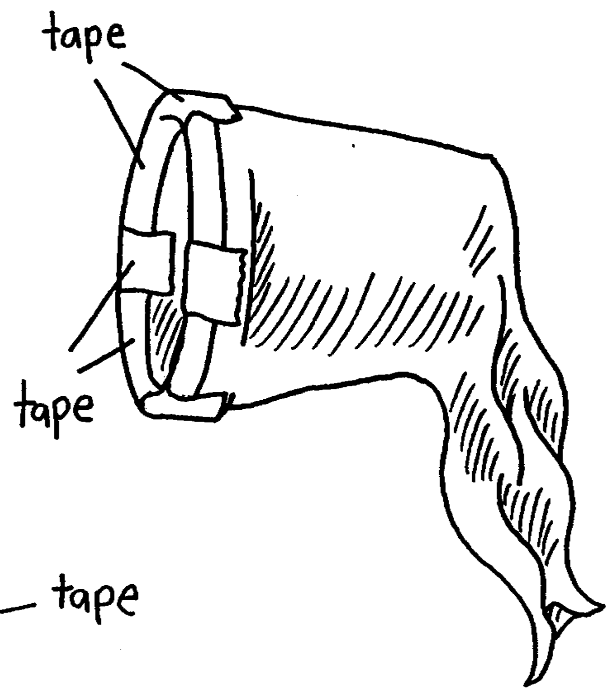
(Adult help suggested.)

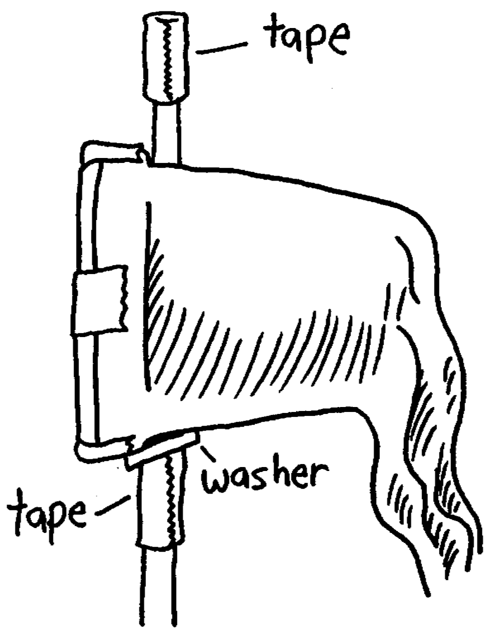
1. Use the scissors to cut off the toe of the sock or the knee-high hose, so that it is open at each end.
2. Cut out the bottom of the Styrofoam cup. Using a sharp pencil, bore a hole in the cup, just below the raised rim. This hole should be big enough for the 1 3⁄16 inch dowel to fit through. Bore another hole directly opposite the first one.



Use a sharp pencil to bore a hole in the Styrofoam cup just below the raised rim. Make a second hole directly across from the first one.

Pull sock or hose over the cup, from the bottom/narrower end up, and secure with tape. This is your wind sock. Use scissors to rip holes in the sock or hose where the cup holes are located.





Slide the wind sock onto the dowel through the 2 holes. Place the washer directly below the cup. Wrap tape around the pole directly above the cup and just below the washer to secure.

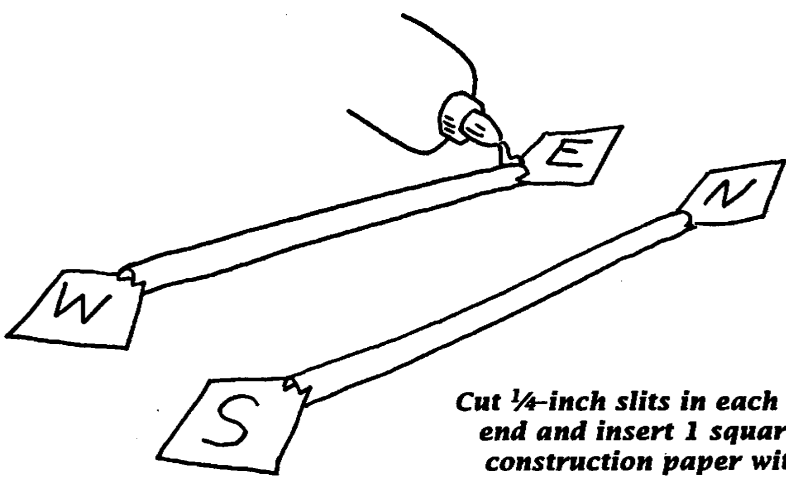
3. Stretch the wide (knee-end) of the sock or hose over the bottom of the cup up to the raised rim. Tape the sock or hose onto the rim by securing it with 1 long piece of tape. Reinforce it with 4 small pieces of tape around the rim.
4. Use scissors to snip holes in the sock or hose where the cup holes are located.

WIND SOCK POLE

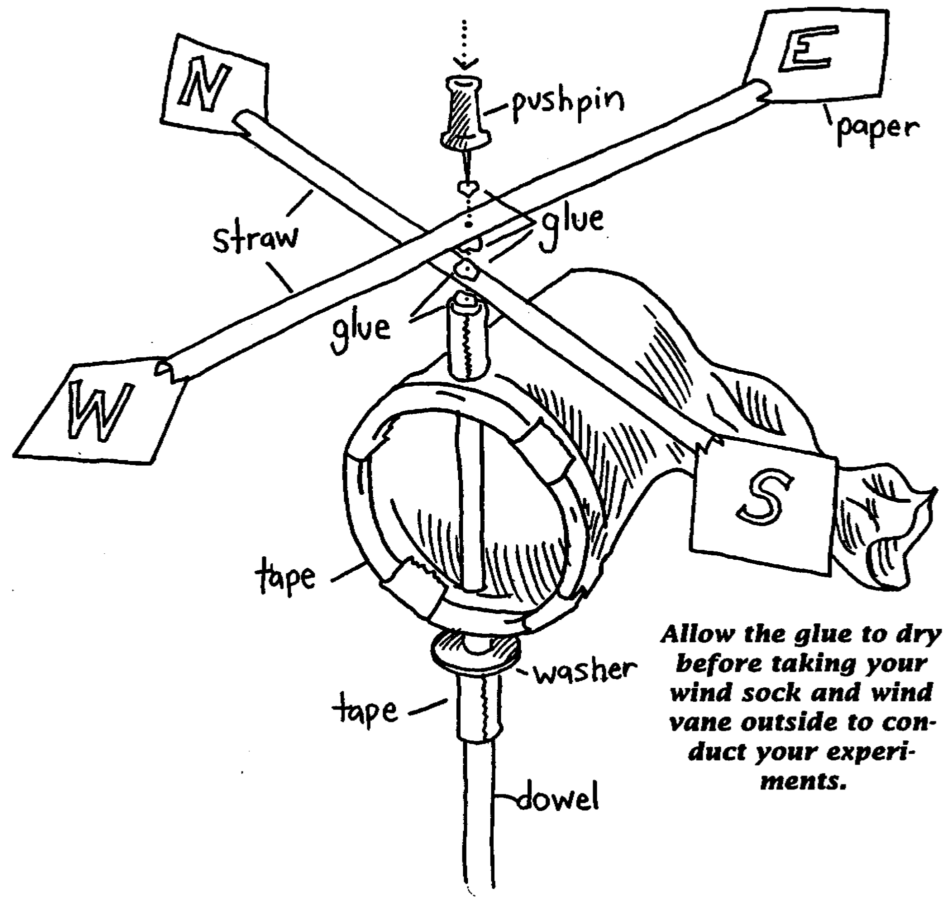
1. Push the pushpin through the top end of the dowel, as far as it will go. Then twist and remove the pushpin. (This hole will be needed for the next stage when you make your wind vane.)
2. Slide the wind sock onto the dowel through the 2 holes, leaving 1 inch free at the top.
3. Place the ¼ inch washer on the bottom of the dowel and push it up the pole until it rests just below the Styrofoam cup. Wrap a piece of tape around the pole several times, just underneath the washer, until it is thick enough to hold the washer in place. The washer will prevent the wind sock from sliding down the pole.
4. Wrap another strip of tape around the top end of the dowel, just above the wind sock, to keep it from sliding off the top of the pole.

WIND VANE

1. Carefully cut ¼-inch slits in each end of the straws. Cut 4 small 1 by 1-inch squares of construction paper. Mark each square of construction paper with a compass direction N, S, E, or W. Dab a drop of white glue on each side of the paper and slip one piece between each pair of slits on all 4 ends of the 2 straws. Place N and S on the 2 ends of 1 straw; E and W on the other, just like the compass points. Be sure that the paper is horizontal. Dab more glue on the spots where the paper meets the straw to secure. Allow this to dry.



Cut ¼-inch slits in each straw end and insert 1 square of construction paper with a compass direction between each pair of slits.



Allow the glue to dry before taking your wind sock and wind vane outside to conduct your experiments.

2. Measure the straws and find the middle of each. Pierce the middle of each straw with the pushpin. Then dab the following surfaces with white glue: the top of the dowel with the pushpin hole, the middle of each straw, and point of the pushpin.

3. Insert the pushpin through both straws and into the top of the dowel, loosely secured with the pushpin. Be certain the straws form a cross, with each arm 90° apart. Wipe off excess glue. Allow glue to dry before trying the experiments.

Experiments

1. Take your wind sock outside and watch it fill with wind. Wind speed increases with altitude, so use the highest (safe) location you can find to test your wind sock. Walk to the top of a nearby hill or climb to the top of the slide in a playground. If you can't find any place higher than the level ground, hold the wind sock above your head. Try to stay clear of trees and buildings. These will block the wind.
2. Use a compass to find North. Point your N straw vane in that direction. Your wind sock will turn until it faces into the wind. The wind vane will show you the direction of the wind.

In the next activity, you can use your wind sock to determine how fast the wind is blowing.

MEASURE THE WIND WITH ADMIRAL BEAUFORT

Young Francis Beaufort joined the British Royal Navy and went to sea when he was twelve years old. For more than twenty years he learned the ways of the wind. In 1805 he devised a scale to determine the wind speed by looking at things around him—trees, flags, smoke. In later years he became Admiral Sir Francis Beaufort. Today, sailors, meteorologists, and others continue to rely on the Beaufort scale. You can find the wind speeds in your neighborhood by using your wind sock and wind vane from the previous activity and by following the Beaufort scale.

Goal *Observe and measure wind patterns at different times of the day. Calibrate (adjust) your wind sock and wind vane to the Beaufort scale.*

Materials

Beaufort scale (see pg. 19)
Notebook
Pencil
Wind sock and wind vane (see *Make a Wind Sock and Wind Vane* activity above)
Compass

Experiment

Take your wind sock to your backyard, school yard, or a nearby park. Find an open area, away from trees and buildings. Observe the wind in

BEAUFORT SCALE

Beaufort Number	Name of Wind	Signs/Description	Wind Speed/mph
0	calm	calm; smoke rises vertically	<1
1	light air	smoke drifts, indicating wind direction	1–3
2	light breeze	wind felt on face; leaves rustle; flags stir	4–7
3	gentle breeze	leaves and small twigs in constant motion	8–12
4	moderate breeze	small branches move; wind raises dust and loose paper	13–18
5	fresh breeze	small-leaved trees begin to sway; crested wavelets form on inland water	19–24
6	strong breeze	overhead wires whistle; umbrellas difficult to control; large branches move	25–31
7	moderate gale or near gale	whole trees sway; walking against wind is difficult	32–38
8	fresh gale or gale	twigs break off trees; moving cars veer	39–46
9	strong gale	slight structural damage occurs such as signs and antennas blown down	47–54
10	whole gale or storm	trees uprooted; considerable structural damage occurs	55–63
11	storm or violent storm	widespread damage occurs	64–74*
12	hurricane	widespread damage occurs	74+*

**The United States uses 74 mph as speed criterion for a hurricane.*

the same place in the morning, afternoon, and evening for five days. Watch how the wind moves different things: the tops of trees, a tall flagpole, your wind sock. Using the Beaufort scale, estimate the wind speed and record in your notebook.

Recopy the Beaufort scale in your notebook but leave room to record your own observations under the description column. Observe how your wind sock reacts to different wind speeds. Add this information to the description column on your Beaufort scale.

Find North using your compass. Point the N arm of your wind vane North. Find the wind direction using your wind sock and record in your notebook.

Results

You will probably memorize the Beaufort scale after a few days and then you'll always know how hard the wind is blowing! How could this be useful to you?

When does the wind blow strongest in your neighborhood? When is it weakest? Do you notice any wind speed pattern?

Try this experiment during different seasons. Do you see the same wind patterns in summer and winter? In the rainy season and the dry season?

What sort of geographical area do you live in—plains, valley, mountains, desert, seaside, or lakeside? How does this help to explain the wind patterns you find?

WRITE ABOUT THE WIND

You can do these writing exercises alone or, with a group of people, with everyone contributing words and ideas. If you work in a group, try writing your story, legend, or journal as a play with different people acting out each role.

Goal *Use your imagination to experience the wind from different points of view and express this experience in words.*

Materials

Pen or pencil

Paper

Directions

EXERCISE 1: IMAGINE A COOL WIND ON A HOT DAY

Use your eyes and think about riding a bicycle, skateboard, or roller skating on a hot, sunny day. What does the wind feel like blowing on your face? Think of words to describe this physical feeling. Open your eyes and write down your words.

Close your eyes again and get back on your imaginary bicycle, skateboard, or skates. Think of words to describe the sound of the wind. Open your eyes and write down your words. Repeat this process for seeing, tasting, and smelling the wind.

After you have compiled these lists of words describing the wind through your five senses, look at your list of words. Now write a paragraph or a poem using some of these words to describe exactly how you experienced the wind while on your bike, skateboard, or skates. (Hint: If you write a poem, try writing one that does not rhyme. You can choose from a greater variety of words this way.)

Read your paragraph or poem to someone else. Ask them if they could feel the sensations about which you wrote.

EXERCISE 2: IMAGINE A COLD WIND IN A RAINSTORM

Repeat Exercise 1 while you imagine walking against a strong wind on a cold, rainy afternoon. Close your eyes and imagine each of the following senses, one at a time: sound, touch, sight, taste, and smell. Write down your descriptive words for each sense. Choose the words that best describe walking through the cold, windy rainstorm, and write a paragraph or poem about it. (Hint: Again, if you write a poem, try writing one that does not rhyme so that you can choose from a greater variety of words.)

Read your paragraph or poem to someone else. Ask them if they could feel the sensations about which you wrote.

EXERCISE 3: WRITE A STORY ABOUT THE WIND

Think of a friendly sort of wind that flies kites, pushes sailboats and windsurfers, makes waves on the water, pollinates plants, moves clouds across the sky, turns windmill sails, or makes the trees sway. Close your eyes and pretend you are a bird, a kite, a windmiller, a sailor, or a child lying on your back on the grass. A gentle wind is moving some of the things that surround you.

After a few minutes, open your eyes and begin writing a story by describing who you are, what you are doing, and what you see, hear, smell, taste, and touch. Remember that you are inventing a story, not just writing a list of words.

Now imagine that the wind is growing stronger and stronger until it turns into a storm, a hurricane, or a tornado. Perhaps it starts raining, or snowing, or a raging wind sweeps a fire toward you. Think about what you might see, hear, smell, taste, or touch. (Remember, you are still a bird, sailor, child, or whatever you originally imagined.)

Write about what is happening around you now. You might use parts of a true experience or you might make up the whole story.

Now imagine that the wind finally dies down. What has happened to you? What has happened to the world around you? Write a conclusion to your story.

Read your story to another person. Ask them if they could feel some of the same things that you wrote about in your story.

EXERCISE 4: WRITE A LEGEND ABOUT HOW THE WIND CAME TO BE

Many cultures have legends about how the earth was made or how the first people were created. Think up a legend about how the wind came to be. Perhaps it resulted from an argument between the moon and the sun or the earth and the ocean. Perhaps the wind was the child of an unusual mother and father. Use your imagination and make your legend as fantastic as you like. Begin your story this way: *A long time ago, before there were any books or storytellers, or any humans at all, there was no wind. Then one day . . .*

Read your legend to someone else and use different voices and movements to tell your story like a traditional storyteller would do.

EXERCISE 5: RECORD A DAY IN THE LIFE OF THE WIND

Pretend *you* are the wind. Write a journal about a day in your life. You might make it funny or serious or both. Begin writing about this day as if it is an hour before sunrise. Where are you? Are you asleep or have you been traveling in disguise all night?

Write down your activities all through the day. Where do you go? What and who do you see? What do you do? Still pretending to be the wind, allow yourself to talk to the trees, the mountains, the ocean, or the people you meet. Record these encounters. Do you ever take a rest? Do you become angry, sad, or happy? What happens if you do?

Continue your journal into the evening of your day and through the night, finally ending 24 hours after you started.

Read your journal to someone else using sound effects, different voices, and body movements to make your story dramatic.

Take your imagination with you next time you're outside on a windy day. See how you can experience the day from a different point of view.

MAKE AN ELECTRIC INVENTORY OF YOUR HOUSE

One hundred years ago most people didn't have electricity in their home. When their houses were finally wired, they installed electric lights. Other inventions came later. Today we depend on electricity for dozens of activities.

Goal *Discover all the ways you use electricity by making an electrical survey of your home.*

Materials

Notebook
Pencil

Directions

Make a chart in your notebook like the one shown below.

Room	Electrical Equipment	How often used	Importance
Kitchen	Refrigerator	24 hours/day	necessity
	Garbage disposal	as needed	convenience
	____ light bulbs	as needed	more important at night
	Ventilator fan . . .		

Walk through each room of your house and write down everything that uses electricity. Look carefully—some items may be stored in cupboards and closets. Remember to include battery-operated watches, toys, and so on. (Be sure to ask permission to inspect other people's rooms first.) Don't forget the garage and the basement. What about heating and cooling systems for your house? Are they electric, do they use electric fans, or starter motors? Ask your family to help estimate how much time they use each electrical item. Some are used every day, all the time (such as a refrigerator) and others may be used only once a month (such as a crock pot). Mark down their answers next to each item.

During a day at home, record on another sheet of paper each time you use something electrical. Mark down each item and how many times you use it. This includes looking at an electrical watch or a clock, answering the telephone, and counting all the light bulbs that are on in the rooms you enter.

At the end of the day, review the electrical equipment you used. Rewrite this list in your notebook, putting the items in three categories: necessity, convenience, or luxury. (Be certain to leave room for one more column for the next activity.) Now add all the electrical equipment from your first list.

How often do you use the items in this list? Could you live without many of your electrical items? In the next activity you'll have a chance to try.

LEARN WHAT LIFE WAS LIKE BEFORE ELECTRICITY

Some electrical inventions have been around for a long time such as lights and radios. Others were not invented when your parents were children such as computers. Perhaps they heard stories from *their* parents and grandparents about how people lived without the electrical equipment we have today.

Goal *Research the past and discover old ways of doing things.*

Materials

Notebook

Chart from "Recording Household Electricity Usage"

Pencil

Directions

Add an "alternate" category to your final list from the "Make an Electric Inventory of Your House" activity. Show the list to your parents, grandparents, and other adults. Ask them how people did things without the electrical equipment you found in your house. Write their responses in this column. Try to discover a non-electrical alternative for everything on your list. You might remember books you've read or movies you've seen about life long ago.

Discuss all your alternatives with your family or classmates. Did you find alternatives for everything? How did the alternatives make people's lives different from yours? Was life better in any way? Was it worse? Which electrical inventions would you miss most? Which would you not miss very much?

SPEND A DAY WITHOUT ELECTRIC POWER

Plan this activity when you don't have school so you can spend the whole day without electricity. Talk to your family about doing this activity together so that you'll experience the full impact of using no electricity around the house. Even if they don't all agree to do it, do your best to stay away from those watts! (Note: Leave your electric refrigerator or freezer running, or the food will begin to spoil. But try to eat food that needs no refrigeration.)

Goal *Experience what life was like before electricity.*

Materials

Notebook

Pencil

Directions

Unplug your electric clock the night before and take off your battery watch. (Remember, battery-powered items use electricity, even though they're not plugged into a wall socket.) Use a wind-up clock or watch, or try to tell time by the sun. Pay attention to everything you do. Don't turn on the lights and don't cook toast in the toaster. Try not to eat food from the refrigerator. (Discuss this with your parents first.)

Keep a diary during the day. Write about everything you do. Was it fun or hard work? Did it take longer to accomplish tasks without electricity? Which ones? Choose some non-electrical activities for part of the day—playing sports, riding your bike, reading by daylight. See how many non-electrical alternatives you can use (see "Learning What Life Was Like Before Electricity"). Bake cookies (if you have a gas oven) using a hand beater. Wash the dishes by hand. Try some hand sewing. (See the activities in chapter 5). Do some household chores without electricity. Wash your clothes by hand and hang them out to dry or clean your room without a vacuum cleaner.

What can you do after dark without electricity? Will you go to bed at sunset or light candles? (Check with your parents about using candles safely.) Make your own music or tell your own stories instead of listening to a radio or watching television. Play non-electronic games such as checkers or chess.

On the following day, discuss how the day went with other members of your family who participated in this activity. Write down everyone's answers to the following questions. Was it hard to live without electricity for a day? What parts were the most fun? Most difficult? Could you live comfortably without electricity for very long? How would your life change if you did? What things would be better or worse?

In the next chapter, you'll learn to measure the electricity your family uses, and find ways to conserve or use less electricity.

LEARN HOW MUCH ELECTRICITY YOU USE

Goal *Read your electric bill and meter to understand how much energy you use.*

Metropolitan Electric Company

***The meter number** on your bill will match the number on your electric meter.*

Customer and Service Address
Jane Consumer
1153 Palm Road
Sun Valley, CA 91234

Account #
410-66823-01153-0008

***Billing period** or **service dates** refer to the time that you were charged for electric power. Each bill may cover one or two months.*

Dates of Service 8/1/97-8/31/97

Current Electricity Rate

Service charge	.60
Energy used 553 kWh x $0.07288	40.30
City tax 10%	4.03
State tax 553 kWh x $0.00020	.11
Total	$45.04

***Energy used** or **energy charged** will tell you how many kilowatt-hours (kWh) you used during this time period, the basic charge per kilowatt-hour, and the total cost of your electricity.*

***City and state taxes** and other charges may be added to your bill.*

Meter Usage Information

Meter Number	Current Reading	Previous	Usage
6-8953125	21230	20677	553

Usage Comparison

Usage		Daily Average		Seasonal Average	
This year	Last year	This year	Last year	Summer	Winter
553 kWh	699 kWh	9 kWh	12kWh	10.4 kWh	19.6 kWh

***The usage comparison** section tells you how many kilowatt-hours your family used this year and last year during the same months. Also, it will give the average daily use and the seasonal average for both years.*

Materials

Electric bills during the past year, one for each season
Notebook
Pencil
Calculator
Stool
Flashlight (optional)

Directions

Look at your family's electricity bills from the previous year. (If necessary, you can probably order duplicate copies from your electric company.) The categories on your bill may not have the same names as those illustrated above, but you should find the same information.

How much electricity—in kilowatt-hours—does your family use each year? Find out a daily average by taking the total monthly reading and dividing it by the number of days in that month.

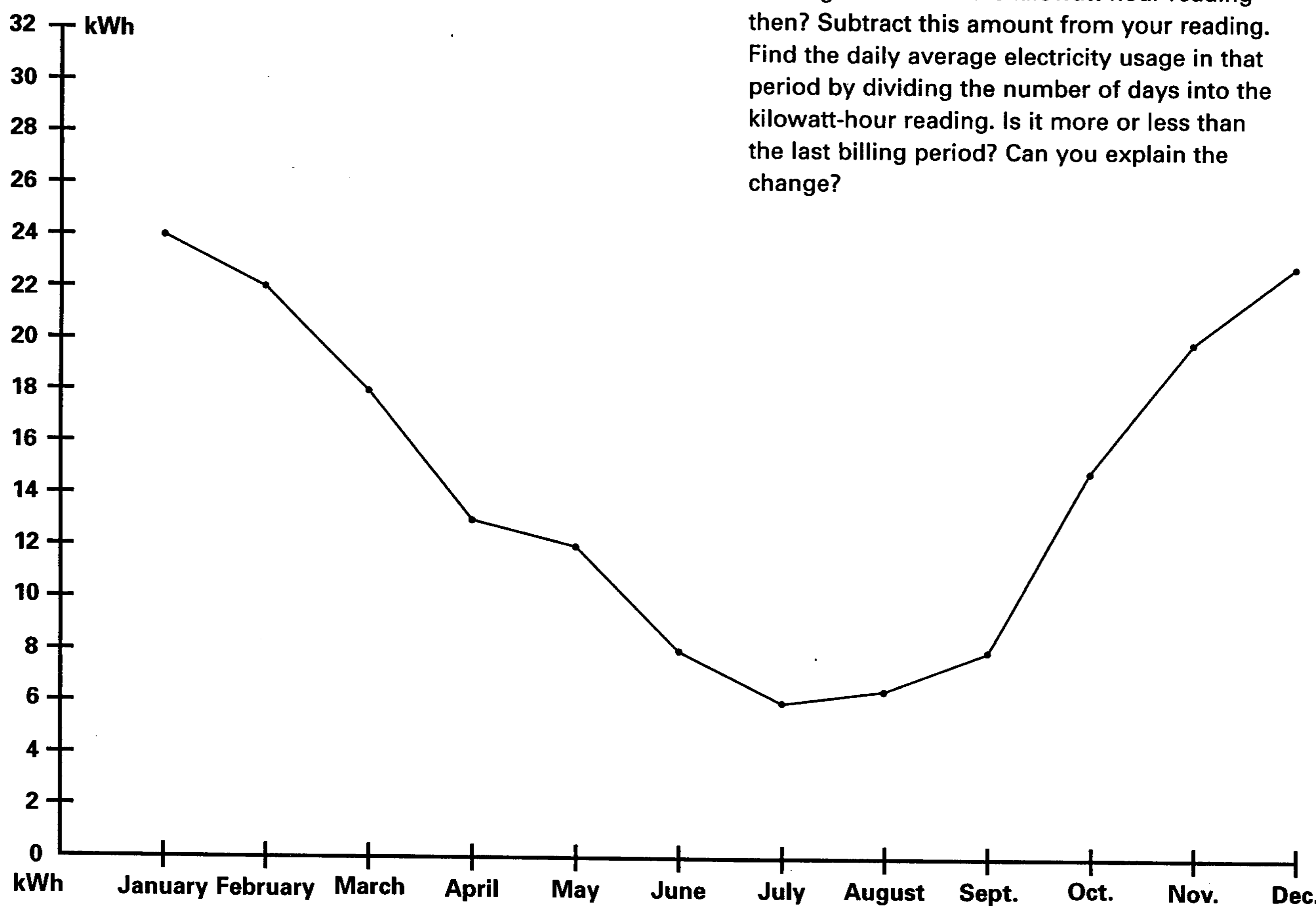
Draw a graph in your notebook, like the one shown here, to record your family's use of kilowatt-hours. Mark a range of kilowatt-hours on the vertical axis and the names of the months on the horizontal axis. Do you use more electricity in different seasons? Why? Look at your list of electrical equipment in the activity called "Make an Electric Inventory of Your House" in the previous chapter to see what might make the difference.

Find your electric meter. It may be outside, in the basement, or in a hallway. You may need a stool or a flashlight to see the meter. If you live in an apartment building, there may be many meters, one for each unit. Check the number on the meter to see that it matches the meter number on your electric bill.

An electric meter has a wheel in the center. The faster the wheel rotates, the more electricity you are using at that moment. Watch how fast the meter turns. Walk through your house and see how many electrical items are on (lights, television, and so on). Turn off anything that is not needed. Look at your meter again and see if the wheel spins more slowly.

The five dials on the meter turn at different speeds and show the number of kilowatt-hours used. Create a chart like the one below. Read your meter then write down the numbers on the dials from *left to right* (counter clockwise). Look at the one on the extreme left. Is the dial pointing directly to a number? Write down that number. If the pointer is between two numbers, write down the *lower* number. Read the dial to the right in the same way, and record it to the right of the first number. Continue reading the dials and writing the numbers.

Look at your latest electricity bill. How many days have passed since the last official meter reading? What was the kilowatt-hour reading then? Subtract this amount from your reading. Find the daily average electricity usage in that period by dividing the number of days into the kilowatt-hour reading. Is it more or less than the last billing period? Can you explain the change?



SAVE ENERGY AT HOME

Goal *Monitor your electricity use and change your energy habits to conserve electricity.*

Materials

Notebook
Pencil

Directions

Make a chart like the one below. Read your electric meter each day for a week. Try and determine why you used more or less electricity during different days of the week.

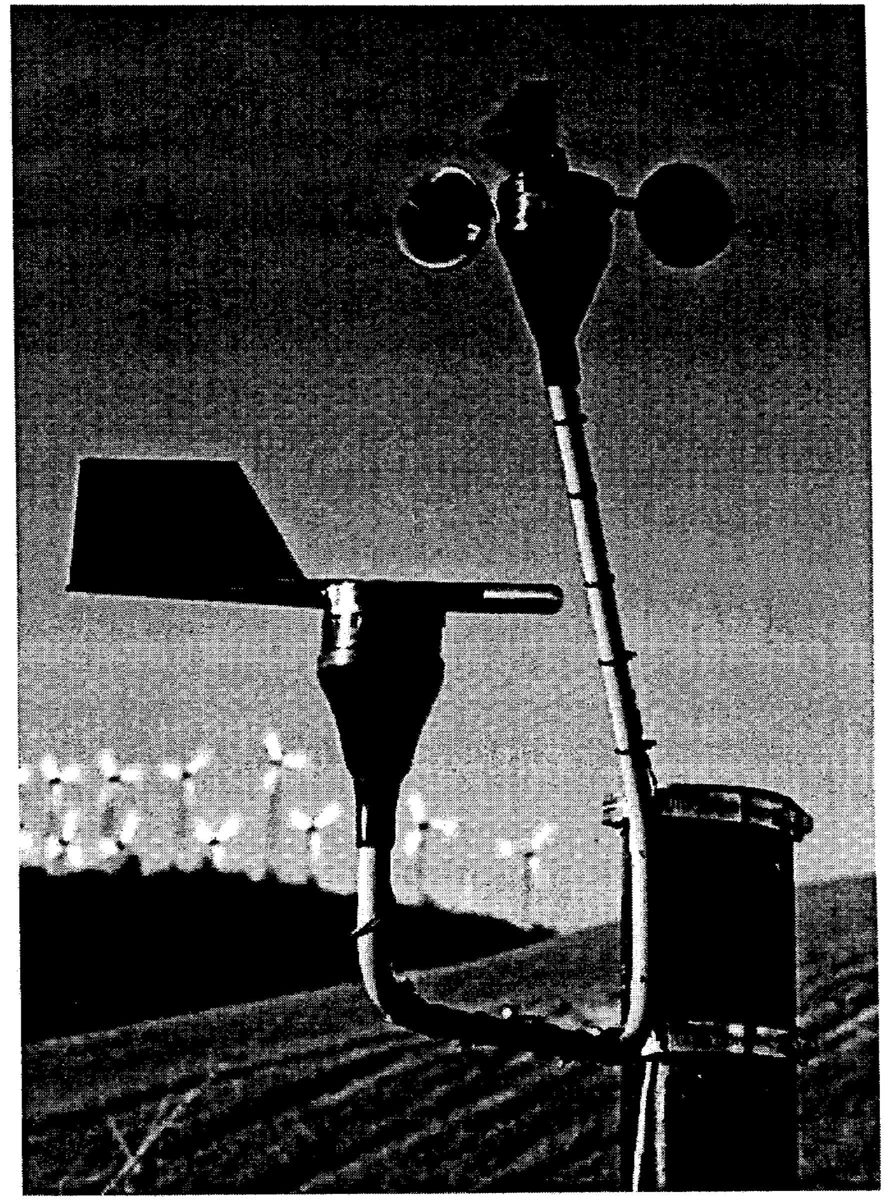
Call a family meeting and talk to members of your family about using less electricity. Ask your electric company for information about energy conservation programs. Their phone number should be on your bill. Share these conservation ideas with your family. Create a plan for your family to modify their electricity use, such as turning off lights when leaving a room, turning off the television, and more. You may save a few dollars a month on your electricity bill. Each family's energy habits *do* make a difference.

After putting this energy-saving plan into action, read the electric meter each day for a week and record the results. Call another family meeting and review your findings. Are you using less electricity? Does everyone agree that you are as energy-efficient as you can be? If the answer to both questions is yes, congratulate yourselves. If you think you can be more energy-efficient, review your conservation plan and keep trying. The following ideas may help.

Date	Current meter reading	Previous meter reading	kilowatt-hours used	Special Activities
11/4	16698	16685	13	
11/5	16723	16698	25	portable heater on 8 hours
11/6	16739	16723	16	lights and TV on all day
11/7	16747	16739	8	away all day
11/8				
11/9				
11/10				

HINTS FOR CONSERVING ENERGY

- In the winter, lower your thermostat a few degrees to save heat and put on a sweater instead. If you use air conditioning in the summer, keep your house a few degrees warmer than usual to save energy. Do you need to heat or cool every room in the house all day long? Is it possible to close some air vents in rooms you aren't using?
- Insulate your home (walls, windows, doorways) and your hot water heater to save on heating and cooling costs. (Your power company may pay part or all of the costs of these conservation measures.)
- Turn your refrigerator dial to a warmer setting to save energy.
- Turn lights and electronic equipment off when no one is in the room.
- Don't use the heated drying setting on your dishwasher. This doubles the amount of energy it takes to do the dishes.
- Many new models of electrical equipment—including that energy hog, the refrigerator—use much less electricity than older models. When it's time to buy a new appliance or piece of electronic equipment, compare the energy use of different models. (Some appliances offer energy cost/savings charts affixed to their exterior.)
- Try compact fluorescent light bulbs. They cost more to buy, but they use *much less* electricity and last ten- to twenty-times longer than ordinary incandescent light bulbs. In the long run, they are much cheaper and more energy-efficient. Also, your electricity company may give special rebates for compact fluorescent bulbs.



Anemometers, or wind-measuring instruments, measure wind patterns for a year or more before wind turbines are installed on a site. Computer programs can also predict the wind, but are not as accurate as measuring the wind directly. *Zond Systems, Inc.*

Web Resources for Wind Power Education

There are many good websites with information about wind power. A good place to start is the U.S. Departments of Energy's wind energy site, http://www1.eere.energy.gov/windandhydro/, Two other must-see sites include the American Wind Energy Association (AWEA) website, www.awea.org, and the wind research website for the National Renewable Energy Laboratory, http://www.nrel.gov/wind/.

AWEA offers a Wind Web Tutorial at http://www.awea.org/faq

NREL has an education site at http://www.nrel.gov/education

The Franklin Institute Museum of Science has wind energy materials and a "hotlist" linking to other sites with that information at http://www.fi.edu/tfi/hotlist/wind.html

The Danish Wind Turbine Manufacturers Association offers a "Wind with Miller" curriculum online at http://www.windpower.org/en/kids/index.htm

The Alaska Energy Authority provides a listing of wind projects in Alaska at http://www.akenergyauthority.org/programwind.html

Utilities actively involved in wind energy development activities in Alaska include

Kotzebue Electric Association, http://kea.coop/home/

Alaska Village Electric Cooperative, www.avec.org

Chugach Electric Association, www.chugachelectric.com

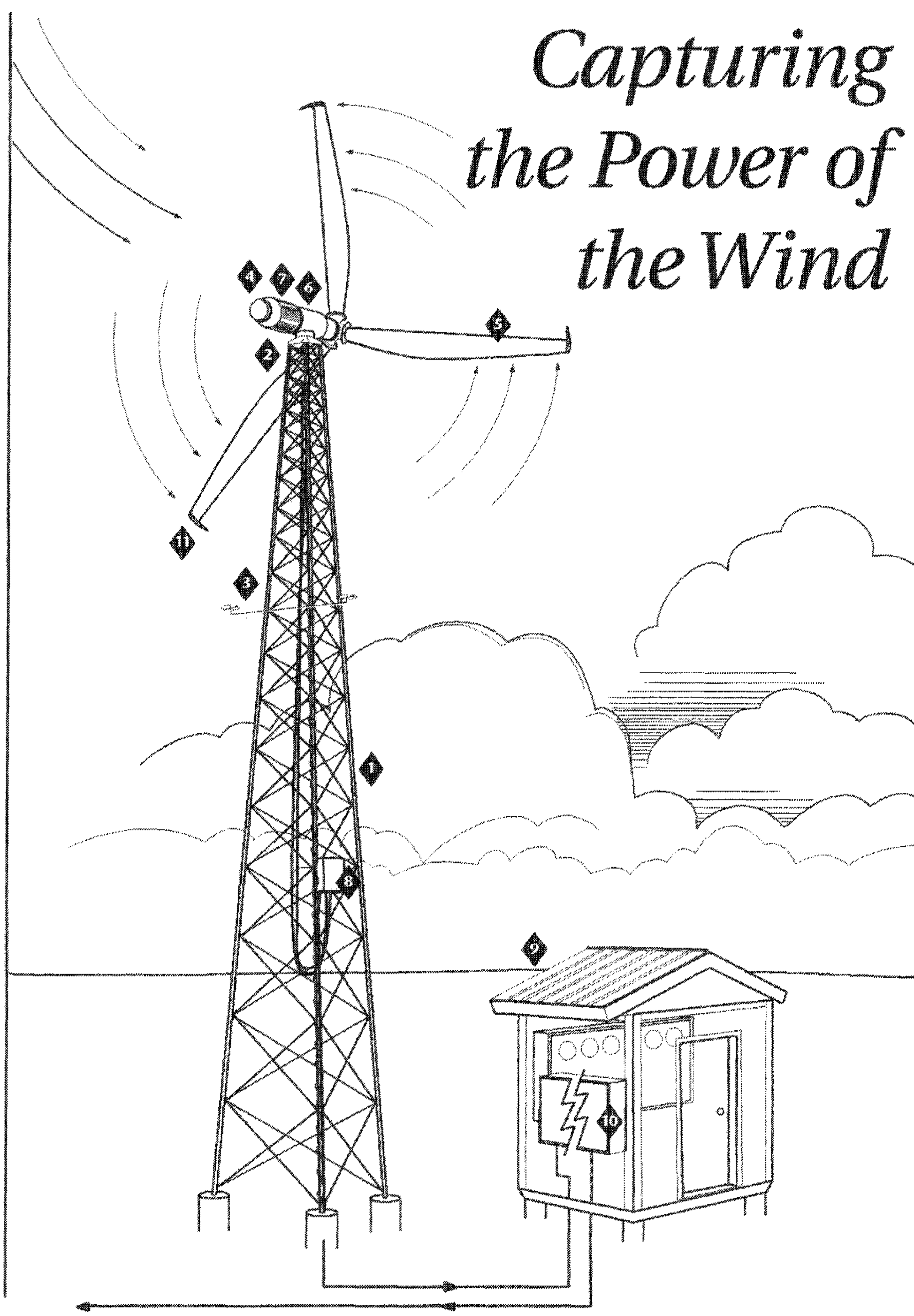
Golden Valley Electric Association, www.gvea.com

Kodiak Electric Association, www.kodiakelectric.com

Alaska Power Association, www.alaskapower.org

NEWS, NOTES &

Capturing the Power of the Wind



INFORMATION

KOTZEBUE ELECTRIC ASSOCIATION

Wind turbines have different characteristics. Here is a look at how the AOC 15/50 turbine produces electricity to light homes and power businesses in Kotzebue.

1. The **80-foot Tower** raises the rotor into stronger, more consistent winds.

2. The turbine assembly rotates on the **Yaw Bearing** like a weather vane, orienting the rotor so that it faces downwind.

3. **Anemometers** measure the wind speed.

4. At 11 miles per hour, electronic controls automatically release the **Parking Brake.**

5. The **Rotor** begins to spin. Each of the blades on the rotor measures 23.7 feet. The wind's force is transferred to the rotor as it sweeps an area of about 1900 square feet.

6. When the rotor reaches 64 revolutions per minute, a **Gearbox** increases the turning speed of a generator shaft.

7. The **Generator** shaft begins to turn at 28.3 times the rotor speed.

8. When the generator speed reaches 1800 revolutions per minute (or the equivalent of 60 Hz frequency) a signal is sent through the **Tower Junction Box**.

9. At the **Control House,** a computer program relays commands that automatically control system operations.

10. A **Main Connector Switch** is activated, sending electrical power into the main power grid.

11. At 50 mph, when the wind is strong enough to blow down signs and antennas and cause other damage, the automatic controller deploys **brakes** to stop the rotor in order to protect the turbine and generator from damage.

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Wind Power Curriculum

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Appendix E

Special Provisions for EPC
Kotzebue SCADA System

High Penetration Wind SCADA System
Engineer, Procure, & Construct (EPC) Project

SPECIAL PROVISIONS

August, 24, 2005

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1. Intent

The Special Provisions are intended to provide project background data and requirements for implementation of the SCADA system. Individual subcomponents of the SCADA system are described in detail, and other bid documents are referenced when they pertain to the specific system.

2. General Project Description

Kotzebue Electric Association, Inc. (KEA) is the sole power provider for Kotzebue Alaska. Generation includes diesel generators and wind turbines. In order to increase efficiency in diesel and wind-powered electrical generation, KEA is requesting proposals to implement a High Penetration Wind Supervisory Control and Data Acquisition (SCADA) System, including replacement switchgear design. As the KEA system is a standalone power generation and distribution grid, the SCADA System installed must be highly reliable with adequate fail safes to provide plant availability at its current level or better.

3. General Background

3.1. Kotzebue, Alaska; Location and People

The City of Kotzebue, Alaska is located about 550 air miles northwest of Anchorage and 26 miles above the Arctic Circle. The major portion of the city encompasses about a square mile.

Kotzebue is incorporated as a 2nd Class City and is the seat of government and education for the Northwest Arctic Borough and Northwest Arctic School District. Kotzebue is the commercial center for all villages in the Borough as Kotzebue offers transportation, medical services, and retail business.

Kotzebue's approximately 3,082 residents are primarily Inupiat Eskimo and White. This mix reflects a culture that combines the traditional subsistence Inupiat way of life with modern Alaskan urban living. Languages include English and to a lesser extent Inupiaq.

3.2. Climate

Kotzebue Sound is ice-free from early July until early October. Summers are short and cool. The average high during July is 58 deg F. The highest temperature on record is 85 deg F. From December through March, sub-zero temperatures are normal. The average low temperature during January is –12 deg F. The lowest temperature on record is –58 deg F. The number of heating degree-days is 16,039 per year.

Annual precipitation averages about nine inches of rain and four feet of snow. There is a prevailing easterly wind for nine months and westerly in the summer with winds averaging 13.5 mph. Blowing winter winds and extended cold periods often result in snowdrifts that hamper pedestrian and vehicular travel.

3.3. Transportation

Kotzebue is accessible by air or sea. Air is the primary means of transportation year-round and there is daily jet service to Anchorage. Kotzebue's airport has a 5,900-foot main paved runway. Water is the secondary means of transportation. Kotzebue is the transfer point between ocean and inland shipping for Northwest Alaska. The shipping season lasts approximately one hundred days, from early July to early October, when Kotzebue Sound is ice-free. Kotzebue's harbor is shallow so deep-draft vessels must anchor fifteen miles out and lighter their cargo to shore. Freight costs are high whether by air or sea.

Although there are twenty-six miles of local roads, there are no roads connecting to any other town or village.

3.4. Kotzebue Electric Association, Inc.

Kotzebue Electric Association, Inc. (KEA) is an electrical utility serving the residents of Kotzebue, Alaska. Most of KEA's approximately 1,237 customers are located within a five-mile radius of KEA's Power Plant. In recent years, KEA has generated approximately 22 million kWh of electricity per year. Kotzebue is not connected to any other power system or grid. KEA's main components include a Power Plant, diesel fuel tank farm and fuel delivery system, Wind Site, power distribution system, and offices.

4. KEA System Description

4.1. Power Plant

KEA's Power Plant is separated into two power generation bays, termed the Old Plant and the New Plant. The Old Plant houses three Caterpillar (CAT) diesel-powered generators, engine day tanks for each unit, and a Sound Proof Room. The New Plant houses three Electro-Motive Diesel (EMD) diesel-powered generators and an engine day tank for each unit. A Plenum Area separates the Old Plant and the New Plant. The Plenum serves as a work area and houses some engine day tanks and a couple of mufflers. Refer to the Reference Drawings, Figure 01- KEA Plant Overview for a layout of the Power Plant.

4.2. Diesel Generation

KEA currently generates approximately 95% of its electrical output using its six diesel-fueled reciprocating engine generators, that is, three CAT units and three EMD units. EMD Unit # 15, Model 16-710 has recently replaced Unit #9. Refer to Table 1 – KEA Diesel Unit Summary on the following page, for a description of each unit.

Table 1- KEA Diesel Unit Summary

	UNIT # 07	UNIT # 11	UNIT # 12	UNIT # 10	UNIT # 14	UNIT # 15
Unit Location	Old Plant	Old Plant	Old Plant	New Plant	New Plant	New Plant
Year Installed	1987	1992	1992	1992	1994	2004
Engine Data:						
Make	CAT	CAT	CAT	GM EMD	GM EMD	GM EMD
Model	3516	3512	3512	20-710-G4A	L16-710-G4B	L16-710
Cylinders	16	12	12	20	16	16
Serial No.	73Z00217	24Z01526	24Z01524	86-H1-1033	94-F1-1001	
Starting System	Air	Air	Air	Air	Air	air
Injectors						
Rated Speed (RPM)	1,200	1,800	1,800	900	900	900
Cooling System:						
Radiator	*Radiators in common loop. See Thompson Engineering Co. radiator drawings for details.*					
Heat Exchanger	APV 259271	Shell & Tube American Std 1-10251-01-01	APV 259272 *Not Connected*	Alfa-Laval AK20-FG, 30101-65733	Alfa-Laval AK20-FG 30101-98772	
Unit or Remote Mounted	Remote	Remote	Remote	Unit	Unit	
Generator Data:						
Make	KATO	KATO	KATO	Baylor	Baylor	
Model	A242710000	A204420000	A204420000	G855RNV-379	G855RNV-415	
Serial No.	94801	93436-01	93436-02	EN-65961-01-B	FP-60RNV154-1-B	
KW Rating	1,135	1,000	1,016	3,080	2,865	
KVA Rating	1,415	1,250	1,270	3,850	3,581	
Power Factor (PF)	0.8	0.8	0.8	0.8	0.8	
Full Load Current (Amps)		174	174	535	497	
Frequency (Hertz)	60	60	60	60	60	
Phase	3PH	3PH	3PH	3PH	3PH	
Wire	6	6	6	12	12	
Leads	4	4	4	4	4	
Voltage	2,400/4,160 VAC	2,400/4,160 VAC	2,400/4,160 VAC	2,400/4,160 VAC	2,400/4,160 VAC	2,400/4,160 VAC
PMG Voltage	240V	120V	120V			
Control Panel and Engine Control Data:						
Mechanical Panel:						
Make				Electric Power Controls (EPC)	Electric Power Controls (EPC)	
Model						
Unit or Remote Mounted				Remote	Remote	
Voltage Regulator:						
Make	*KEA currently changing out voltage regulators.*				Basler	
Model					SR8A	
Metering:						
Hourmeter					Yes	
Voltmeter						
Ammeter						
Freqmeter						
KW Meter						
Other						
Engine Actuator:						
Actuator Make	Woodward	Woodward	Woodward	Woodward	Woodward	
Model	EG-3P	EG-3P	EG-3P	UA-12	UA-10	
Engine Controller (Governor):						
Make	Woodward	Woodward	Woodward	Woodward	Woodward	
Model	2301A	2301A	2301A	2301A	2301A	
Engine Control Voltage:	24 VDC	125-24	125-24	125 VDC	125 VDC	
Circuit Breaker:						
Make	AC	FPE	FPE			
Frame Size						
Trip Rating						

4.3. Power Plant Buss

All of the diesel generators feed a common plant buss that can be sectionalized to provide a separate buss for the three EMD diesel-powered generators and for the three CAT diesel-powered generators. Portions of the current buss system are rated at 600 amps and this bus is commonly operating at 500 amps, including the bus tie between the New Plant and the Old Plant. Refer to the Reference Drawings, Figure 03 – Plant One Line Diagram.

The switchgear in both the Old and New Plant is dated. As of the release of this bid, KEA currently has the funding to replace both Plants' switchgear. Part of the SCADA system contractor's scope is to design and provide bid documents for new switchgear. The Contractor will be responsible for installation of the switchgear after KEA procurement. The successful bidder of the SCADA system shall work with KEA during the switchgear procurement to review submittals and ensure adequate space for SCADA system components. Further details of the Contractor's requirements are provided in Section 16 of the Special Provisions.

4.4. Station Service

KEA's Station Service system is designed with redundancy to be powered from the main generation buss from either the Old Plant or from the New Plant. Refer to the Reference Drawings, Figure 04 – Station One Line Diagram.

4.5. Diesel Fuel System

Number 2 diesel fuel is delivered to KEA's storage tanks once per year by barge. The fuel is pumped through a buried pipeline from the dock to KEA. KEA's bulk diesel fuel storage capacity consists of three tanks, all of which have secondary containment. Two of the tanks have a capacity of one million gallons each and the third tank has a capacity of 150,000 gallons. One of the large tanks has a heating system so that diesel fuel can be utilized at all times by the Power Plant. One of the large tanks has electronically monitored under-floor leak detection.

The plant's fuel delivery system provides fuel heating, fuel filtering, fuel circulation, fuel transfer from the bulk fuel tanks to engine day tanks in the Power Plant. Each diesel engine generator set has a day tank that supplies the engine with fuel and provides a location for the excess fuel return. The return fuel from the CAT diesel-powered generators is routed through a return fuel cooler prior to returning to the day tank.

4.6. Power Plant Fire Protection

The Power Plant does not currently have a fixed fire detection or suppression system. The current system consists of large cart-mounted and smaller handheld fire extinguishers and reliance on the municipal fire station response. A fixed water mist fire suppression system will be installed in the near future. The new fire protection system will not provide general plant coverage but will provide protection for the portions of the diesel engine-generator skids and fuel delivery system that have either the potential for fuel leakage or ignition. Refer to the Reference Drawings, Figure 02 – Plant Fire Protection Plan.

4.7. Substation

The primary Substation for the KEA power system is located on Fifth Avenue next to the Power Plant. It consists of 2 step-up transformers, and switchgear with 4 feeders.

4.8. Wind Generation

KEA generates approximately 5% of its electrical output using wind turbine generators. The wind turbines are located at KEA's Wind Site, which is approximately 4.5 miles south of town. It is connected to KEA's distribution system via feeder #4. Eleven wind turbines are installed on the grid, and two additional wind turbines have been recently installed. The two new wind turbines are Wind Turbine Generator (WTG) Unit #11 and WTG Unit #12, both Atlantic Orient Corporation (AOC) Model 15/50's. The latest installation brings the total to twelve AOC 15/50 units and one Northwind 100. Each wind turbine is controlled by an Automation Direct (Koyo) PLC. Refer to the Reference Drawings, Figure 05 – Windsite One-Line Diagram.

KEA currently controls the Wind Site by a Second Wind SCADA System. The front-end of the system consists of one Communicating Turbine Monitor (CTM) per wind turbine. The CTM combines a smart RTU and datalogger and allows the operator to stop and start the turbine, clear turbine faults, enter and exit maintenance mode, and reset the CTM. The Second Wind SCADA System also includes the Supervisor which is the central supervisory computer and software. The Supervisor consists of a digitized image of the Wind Site, displays and stores data, supervises towers, provides for single and group turbine control, and provides for remote access. The Second Wind SCADA System is accessible from KEA's Office by phone line using Laplink software.

During the preliminary engineering phase it was determined that the SCADA system will interface directly with the individual Koyo PLC's. The new SCADA system will provide the same functionality as the Second Wind SCADA system. The main SCADA system shall control the wind turbines, display operating data, and be able to store the data.

Table 2 – KEA Wind Turbines

Unit Name	Power Source	Location	Manufacturer	Model	Install Year	Hub Height	TVP Rating (kW)
WTG Unit # 01	wind	KEA wind farm	AOC	15/50	1997	26.5 m	66
WTG Unit # 02	wind	KEA wind farm	AOC	15/50	1997	26.5 m	66
WTG Unit # 03	wind	KEA wind farm	AOC	15/50	1997	26.5 m	66
WTG Unit # 04	wind	KEA wind farm	AOC	15/50	1999	26.5 m	66
WTG Unit # 05	wind	KEA wind farm	AOC	15/50	1999	26.5 m	66
WTG Unit # 06	wind	KEA wind farm	AOC	15/50	1999	26.5 m	66
WTG Unit # 07	wind	KEA wind farm	AOC	15/50	1999	26.5 m	66
WTG Unit # 08	wind	KEA wind farm	AOC	15/50	1999	26.5 m	66
WTG Unit # 09	wind	KEA wind farm	AOC	15/50	1999	26.5 m	66
WTG Unit # 10	wind	KEA wind farm	AOC	15/50	1999	26.5 m	66
WTG Unit # 11	wind	KEA wind farm	AOC	15/50	2004	26.5 m	66
WTG Unit # 12	wind	KEA wind farm	AOC	15/50	2004	26.5 m	66
WTG Unit # 14	wind	KEA wind farm	Northwind	100	2002	~ 85 ft	100
						Total TVP Rating (kW)	892

4.9. Demand and Operating Philosophy

KEA's current operating philosophy requires that KEA be able to meet demand for power while operating without the two largest diesel units. This requirement is in place to assure that power will be maintained in the event that the largest diesel unit is down for routine maintenance and a second large diesel unit fails. This level of backup is necessary as KEA is the only power supplier for the area. KEA's current capacity when operating without the two largest units is approximately 5,000 kW.

KEA's easily handles its largest electrical demands within current capacity. KEA's peak load in 2003 was 3,730 kW. KEA's largest power loads are listed in the following table.

Table 3 – KEA Large Power Loads

	Peak kW			
Load Name	1999	2000	2001	2002
Pioneer Home	91	91	91	125
Technical Center	77	77	77	81
Hospital	352	384	352	384
FAA	63	74	74	74
Mar Site	88	144	162	156

In the near future, KEA anticipates that the hospital load will increase but no other significant loads will increase or be added. However, over the next decade, KEA expects to gradually increase its power generation to accommodate Kotzebue's increasing population as well as increasing electrical consumption per capita. Besides the current installations of EMD Unit #15, WTG Unit #11, and WTG Unit #12, KEA plans to increase its power generation capacity by installing more wind turbines at its Wind Site. These future wind turbine installations are currently unscheduled.

KEA's typical mode of operation is to base load with a single EMD unit, utilize wind to the extent possible, and compensate for load with a single CAT unit. It is anticipated that KEA will operate in this same manner after the SCADA System is installed. See Table 4 on the following page for a sample load profile showing a day's worth of produced kW averaged every 15 minutes for all six diesel units and the Wind Site. (Additional electronic kW data can be made available to the Bidder upon request.)

Table – 4 Sample Daily Load Profile page 1

Line No	Date	Time	EMD Unit # 14 (kW)	EMD Unit # 9 (kW)	EMD Unit # 10 (kW)	CAT Unit # 7 (kW)	CAT Unit # 11 (kW)	CAT Unit # 12 (kW)	Total Wind Site (kW)	Total Diesel (kW)	Total Plant (kW)
1	4/22/2004	24:00:00	2163.2	0.0	0.0	0.0	0.0	0.0	56.7	2163.2	2219.9
2	4/23/2004	0:15	2169.6	0.0	0.0	0.0	0.0	0.0	94.5	2169.6	2264.1
3	4/23/2004	0:30	2131.2	0.0	0.0	0.0	0.0	0.0	94.5	2131.2	2225.7
4	4/23/2004	0:45	2048.0	0.0	0.0	0.0	0.0	0.0	76.1	2048.0	2124.1
5	4/23/2004	1:00	2041.6	0.0	0.0	0.0	0.0	0.0	14.0	2041.6	2055.6
6	4/23/2004	1:15	2054.4	0.0	0.0	0.0	0.0	0.0	5.4	2054.4	2059.8
7	4/23/2004	1:30	2048.0	0.0	0.0	0.0	0.0	0.0	14.6	2048.0	2062.6
8	4/23/2004	1:45	2016.0	0.0	0.0	0.0	0.0	0.0	62.1	2016.0	2078.1
9	4/23/2004	2:00	1996.8	0.0	0.0	0.0	0.0	0.0	24.8	1996.8	2021.6
10	4/23/2004	2:15	1990.4	0.0	0.0	0.0	0.0	0.0	3.8	1990.4	1994.2
11	4/23/2004	2:30	1996.8	0.0	0.0	0.0	0.0	0.0	1.1	1996.8	1997.9
12	4/23/2004	2:45	1990.4	0.0	0.0	0.0	0.0	0.0	0.0	1990.4	1990.4
13	4/23/2004	3:00	1977.6	0.0	0.0	0.0	0.0	0.0	0.0	1977.6	1977.6
14	4/23/2004	3:15	1984.0	0.0	0.0	0.0	0.0	0.0	0.0	1984.0	1984.0
15	4/23/2004	3:30	1958.4	0.0	0.0	0.0	0.0	0.0	0.5	1958.4	1958.9
16	4/23/2004	3:45	1945.6	0.0	0.0	0.0	0.0	0.0	8.1	1945.6	1953.7
17	4/23/2004	4:00	1945.6	0.0	0.0	0.0	0.0	0.0	20.0	1945.6	1965.6
18	4/23/2004	4:15	1920.0	0.0	0.0	0.0	0.0	0.0	23.2	1920.0	1943.2
19	4/23/2004	4:30	1926.4	0.0	0.0	0.0	0.0	0.0	23.8	1926.4	1950.2
20	4/23/2004	4:45	1926.4	0.0	0.0	0.0	0.0	0.0	27.5	1926.4	1953.9
21	4/23/2004	5:00	1913.6	0.0	0.0	0.0	0.0	0.0	15.1	1913.6	1928.7
22	4/23/2004	5:15	1913.6	0.0	0.0	0.0	0.0	0.0	9.2	1913.6	1922.8
23	4/23/2004	5:30	1939.2	0.0	0.0	0.0	0.0	0.0	0.5	1939.2	1939.7
24	4/23/2004	5:45	1958.4	0.0	0.0	0.0	0.0	0.0	0.0	1958.4	1958.4
25	4/23/2004	6:00	2048.0	0.0	0.0	0.0	0.0	0.0	0.0	2048.0	2048.0
26	4/23/2004	6:15	2048.0	0.0	0.0	0.0	0.0	0.0	1.6	2048.0	2049.6
27	4/23/2004	6:30	2080.0	0.0	0.0	0.0	0.0	0.0	1.1	2080.0	2081.1
28	4/23/2004	6:45	2144.0	0.0	0.0	0.0	0.0	0.0	0.5	2144.0	2144.5
29	4/23/2004	7:00	2176.0	0.0	0.0	0.0	0.0	0.0	0.0	2176.0	2176.0
30	4/23/2004	7:15	2291.2	0.0	0.0	0.0	0.0	0.0	0.0	2291.2	2291.2
31	4/23/2004	7:30	2387.2	0.0	0.0	0.0	0.0	0.0	0.0	2387.2	2387.2
32	4/23/2004	7:45	2508.8	0.0	0.0	0.0	0.0	0.0	0.0	2508.8	2508.8
33	4/23/2004	8:00	2515.2	0.0	0.0	0.0	0.0	0.0	0.0	2515.2	2515.2
34	4/23/2004	8:15	2604.8	0.0	0.0	0.0	0.0	0.0	0.0	2604.8	2604.8
35	4/23/2004	8:30	2636.8	0.0	0.0	0.0	0.0	0.0	0.0	2636.8	2636.8
36	4/23/2004	8:45	2624.0	0.0	0.0	0.0	0.0	0.0	0.0	2624.0	2624.0
37	4/23/2004	9:00	2662.4	0.0	0.0	0.0	0.0	0.0	0.0	2662.4	2662.4
38	4/23/2004	9:15	2713.6	0.0	0.0	0.0	0.0	0.0	0.0	2713.6	2713.6
39	4/23/2004	9:30	2688.0	0.0	0.0	0.0	57.6	0.0	0.0	2745.6	2745.6
40	4/23/2004	9:45	2457.6	0.0	0.0	0.0	283.2	0.0	0.0	2740.8	2740.8
41	4/23/2004	10:00	2489.6	0.0	0.0	0.0	288.0	0.0	0.0	2777.6	2777.6
42	4/23/2004	10:15	2489.6	0.0	0.0	0.0	288.0	0.0	0.5	2777.6	2778.1
43	4/23/2004	10:30	2547.2	0.0	0.0	0.0	288.0	0.0	1.6	2835.2	2836.8
44	4/23/2004	10:45	2566.4	0.0	0.0	0.0	288.0	0.0	1.1	2854.4	2855.5
45	4/23/2004	11:00	2528.0	0.0	0.0	0.0	288.0	0.0	0.5	2816.0	2816.5
46	4/23/2004	11:15	2534.4	0.0	0.0	0.0	288.0	0.0	4.9	2822.4	2827.3
47	4/23/2004	11:30	2566.4	0.0	0.0	0.0	288.0	0.0	4.3	2854.4	2858.7
48	4/23/2004	11:45	2579.2	0.0	0.0	0.0	288.0	0.0	1.1	2867.2	2868.3
49	4/23/2004	12:00	2636.8	0.0	0.0	0.0	292.8	0.0	0.0	2929.6	2929.6

Table – 4 Sample Daily Load Profile page 2

Line No	Date	Time	EMD Unit # 14 (kW)	EMD Unit # 9 (kW)	EMD Unit # 10 (kW)	CAT Unit # 7 (kW)	CAT Unit # 11 (kW)	CAT Unit # 12 (kW)	Total Wind Site (kW)	Total Diesel (kW)	Total Plant (kW)
50	4/23/2004	12:15	2604.8	0.0	0.0	0.0	288.0	0.0	0.5	2892.8	2893.3
51	4/23/2004	12:30	2579.2	0.0	0.0	0.0	288.0	0.0	2.7	2867.2	2869.9
52	4/23/2004	12:45	2585.6	0.0	0.0	0.0	288.0	0.0	7.0	2873.6	2880.6
53	4/23/2004	13:00	2553.6	0.0	0.0	0.0	292.8	0.0	11.3	2846.4	2857.7
54	4/23/2004	13:15	2521.6	0.0	0.0	0.0	288.0	0.0	9.7	2809.6	2819.3
55	4/23/2004	13:30	2540.8	0.0	0.0	0.0	292.8	0.0	15.7	2833.6	2849.3
56	4/23/2004	13:45	2534.4	0.0	0.0	0.0	288.0	0.0	14.0	2822.4	2836.4
57	4/23/2004	14:00	2515.2	0.0	0.0	0.0	288.0	0.0	11.3	2803.2	2814.5
58	4/23/2004	14:15	2553.6	0.0	0.0	0.0	288.0	0.0	11.9	2841.6	2853.5
59	4/23/2004	14:30	2566.4	0.0	0.0	0.0	288.0	0.0	17.3	2854.4	2871.7
60	4/23/2004	14:45	2585.6	0.0	0.0	0.0	288.0	0.0	14.0	2873.6	2887.6
61	4/23/2004	15:00	2617.6	0.0	0.0	0.0	288.0	0.0	22.1	2905.6	2927.7
62	4/23/2004	15:15	2585.6	0.0	0.0	0.0	288.0	0.0	28.1	2873.6	2901.7
63	4/23/2004	15:30	2579.2	0.0	0.0	0.0	288.0	0.0	52.9	2867.2	2920.1
64	4/23/2004	15:45	2553.6	0.0	0.0	0.0	292.8	0.0	95.0	2846.4	2941.4
65	4/23/2004	16:00	2457.6	0.0	0.0	0.0	288.0	0.0	110.2	2745.6	2855.8
66	4/23/2004	16:15	2457.6	0.0	0.0	0.0	288.0	0.0	122.0	2745.6	2867.6
67	4/23/2004	16:30	2489.6	0.0	0.0	0.0	288.0	0.0	132.8	2777.6	2910.4
68	4/23/2004	16:45	2457.6	0.0	0.0	0.0	288.0	0.0	141.5	2745.6	2887.1
69	4/23/2004	17:00	2361.6	0.0	0.0	0.0	288.0	0.0	152.3	2649.6	2801.9
70	4/23/2004	17:15	2291.2	0.0	0.0	0.0	288.0	0.0	135.5	2579.2	2714.7
71	4/23/2004	17:30	2246.4	0.0	0.0	0.0	292.8	0.0	126.9	2539.2	2666.1
72	4/23/2004	17:45	2297.6	0.0	0.0	0.0	292.8	0.0	138.2	2590.4	2728.6
73	4/23/2004	18:00	2304.0	0.0	0.0	0.0	292.8	0.0	123.1	2596.8	2719.9
74	4/23/2004	18:15	2297.6	0.0	0.0	0.0	292.8	0.0	82.1	2590.4	2672.5
75	4/23/2004	18:30	2342.4	0.0	0.0	0.0	292.8	0.0	109.1	2635.2	2744.3
76	4/23/2004	18:45	2361.6	0.0	0.0	0.0	288.0	0.0	152.3	2649.6	2801.9
77	4/23/2004	19:00	2208.0	0.0	0.0	0.0	292.8	0.0	149.0	2500.8	2649.8
78	4/23/2004	19:15	2316.8	0.0	0.0	0.0	148.8	0.0	164.7	2465.6	2630.3
79	4/23/2004	19:30	2425.6	0.0	0.0	0.0	0.0	0.0	173.9	2425.6	2599.5
80	4/23/2004	19:45	2323.2	0.0	0.0	0.0	0.0	0.0	190.1	2323.2	2513.3
81	4/23/2004	20:00	2284.8	0.0	0.0	0.0	0.0	0.0	187.4	2284.8	2472.2
82	4/23/2004	20:15	2259.2	0.0	0.0	0.0	0.0	0.0	194.4	2259.2	2453.6
83	4/23/2004	20:30	2252.8	0.0	0.0	0.0	0.0	0.0	226.3	2252.8	2479.1
84	4/23/2004	20:45	2195.2	0.0	0.0	0.0	0.0	0.0	194.9	2195.2	2390.1
85	4/23/2004	21:00	2182.4	0.0	0.0	0.0	0.0	0.0	178.2	2182.4	2360.6
86	4/23/2004	21:15	2124.8	0.0	0.0	0.0	0.0	0.0	155.0	2124.8	2279.8
87	4/23/2004	21:30	2233.6	0.0	0.0	0.0	0.0	0.0	142.6	2233.6	2376.2
88	4/23/2004	21:45	2214.4	0.0	0.0	0.0	0.0	0.0	144.2	2214.4	2358.6
89	4/23/2004	22:00	2252.8	0.0	0.0	0.0	0.0	0.0	117.2	2252.8	2370.0
90	4/23/2004	22:15	2240.0	0.0	0.0	0.0	0.0	0.0	134.5	2240.0	2374.5
91	4/23/2004	22:30	2188.8	0.0	0.0	0.0	0.0	0.0	156.6	2188.8	2345.4
92	4/23/2004	22:45	2156.8	0.0	0.0	0.0	0.0	0.0	189.5	2156.8	2346.3
93	4/23/2004	23:00	2144.0	0.0	0.0	0.0	0.0	0.0	212.2	2144.0	2356.2
94	4/23/2004	23:15	2124.8	0.0	0.0	0.0	0.0	0.0	177.7	2124.8	2302.5
95	4/23/2004	23:30	2124.8	0.0	0.0	0.0	0.0	0.0	170.6	2124.8	2295.4
96	4/23/2004	23:45	2176.0	0.0	0.0	0.0	0.0	0.0	182.5	2176.0	2358.5
97	4/23/2004	24:00:00	2144.0	0.0	0.0	0.0	0.0	0.0	185.2	2144.0	2329.2

4.10. Distribution System

KEA's distribution system totals about 15 miles of line and consists of four feeders, Feeder #1 through Feeder #4. The majority of the distribution system covers the city, an area of about a square mile. The distribution system extends out from the city to KEA's Wind Site through Feeder #4. All four feeders are energized at 7.2/12.5 kV and are located aboveground with the exception of portions of Feeder #3 and Feeder #4. The feeders may be run as a loop system but are presently operated as radial feeders. Sectionalizing can be performed to mitigate planned or unplanned outages. Refer to Reference Drawings, Figures 20 and 21 - KEA Distribution One Line, Sheet 1 and 2. These are one-line drawings showing the distribution system covering the majority of the City of Kotzebue.

Feeder #4 has the smallest load than any of the other feeders, which consists of customers as well as minimal operation of KEA's Wind Site. Feeder #4 generally operates bi-directionally; that is, Feeder #4 supplies power from the Power Plant diesel generators out through Feeder #4 and it also receives power from the Wind Site in through Feeder #4. The other three feeders utilize this power from the Wind Site. Feeder #1, Feeder #2, and Feeder #3 operate in one direction supplying power to the city from the Power Plant diesel generators as well as power from the Wind Site.

5. SCADA System Operation

5.1. Local Unit Control

The entire KEA Power System must have the ability to operate in manual mode. In the event the SCADA system fails, the operator shall be able to start, synchronize, load, unload, and stop units at their respective control panels. At the local level, units need the ability to be operated for maintenance and testing, independent of the SCADA system. All necessary information for unit operation shall be provided real time at the local controls as well as unit alarms and shutdowns.

At a minimum, Local Unit Controls include:

- Local control of diesel generation sets
- Local control of wind turbines
- Local control of feeders

The local unit controls must be capable of operating from a black start condition. In the event of a complete power loss, local unit control must be able to be reestablished quickly with the personnel and equipment on site. Manual operation shall be available at the local level without any other portion of the SCADA system available providing the following functions:

- Unit start
- Unit synchronization
- Unit breaker operation
- Unit load control
- Unit stop
- Black start capability
- Single or parallel unit operation
- Selection of isoc or droop response
- Feeder operation

5.2. Automatic Control (Control Room)

At this level the SCADA system will oversee and automatically control the diesel generators, wind turbines, and feeders. The SCADA system operation will be monitored by operators via an HMI. Ancillary systems shall be monitored and displayed. Automatic control shall be designed so that an operator can monitor the operation of the total plant, dispatch units, and respond to alarm conditions from the power plant or KEA office HMI. At a minimum, the SCADA system shall automatically control the following items.

- Generator unit start
- Generator unit synchronization
- Generator unit breaker operation
- Generator load control
- Generator stop
- Multiple unit operation
- Load sharing
- Operator selection of isoc or droop response
- Wind turbine unit start/stop
- Feeder breaker operation

5.3. Remote Control

There are two types of remote control required for the KEA SCADA system, one being remote control by KEA personnel, and the other being remote control by the Contractor or another third party. The SCADA system shall have the ability to allow offsite KEA personnel to control the system remotely via internet connection. For service and on-line support, the Contractor and authorized third parties shall also be able to connect to the system remotely. The remote connection needs to provide the same amount of control and data display as the automatic local system HMI's provide. The connection should be secure, so that only authorized KEA employees and outside sources can access the system.

5.4. Data Collection

The SCADA system shall store data to a server or PC for use by KEA personnel. The data collection system shall have redundancy in the case of a PC failure. A variety of methods are acceptable, such as utilizing an HMI, a second PC, or backup hard drive. The data shall have remote access by KEA personnel. The individual control system details described further on in the Special Provisions list the minimum points KEA requires the SCADA system to log. As a minimum, the SCADA system must store two years worth of data.

6. Scope of Work & System Requirements

Contractor shall be responsible for the detailed design, equipment procurement, factory acceptance testing, installation, site acceptance testing, commissioning, training, service, and documentation of the new SCADA System. The Contractor shall also be responsible for the design and implementation of bid documents for replacement switchgear, along with engineering assistance during the procurement phase.

The SCADA system must monitor the efficiency of the diesel generation units and the level of power being generated by the wind turbines. The SCADA system shall then dispatch generation equipment to optimize the overall plant efficiency, based on the current demand.

The SCADA System installation must minimize any interruption to service as it will be installed in a functioning power plant. In addition, the system must be designed and implemented to support the training of O&M personnel in plant operation via SCADA controls.

Besides monitoring and storing operational data, the SCADA System shall have the capability to manually or automatically dispatch both diesel and wind generators depending upon electrical demand and wind conditions.

The SCADA system shall meet the operational and business requirements of KEA, listed below:

- Provide the least cost for an operational system that meets KEA's current and future requirements.
- Provide the least cost for future upgrades of software and hardware.
- Provide a full range of functionality from load dispatch to power load shed recovery, and black plant start.
- Monitor and control diesel and wind generation automatically while maintaining power and frequency stability.
- Provide non-critical and critical alarms.
- Automatically swap and shut down units with critical alarm conditions.
- Provide trending and operating reports.
- Provide 99.9% system availability.
- Provide assurance that the Power Plant will be operational with a failed SCADA System, allowing for complete manual operation of the diesel units. The wind generators shall continue to operate at the last operating conditions before the SCADA system failure.
- Provide for automatic control, remote operator control, and local control at the unit panel.
- Automatically start, synchronize, connect, and load the generation units based on demand. The SCADA system must also unload, disconnect, and shutdown units when they are not needed.
- Monitor and control the power feeders, including automatic load shedding, load recovery, and trending of real time and historical power flow.
- Monitor and control ancillary power plant systems.

- Provide a simple, clear, and easy to understand operator interface.
- Provide local training and documentation for operation and maintenance personnel.
- Provide for system diagnostics remotely via internet.
- Provide readily available expert resources, offsite, 24/7
- Provide modular replacement of components.
- Provide readily available repair parts and service personnel.
- Allow for the potential of higher wind penetration, which requires automated controls to dispatch engine-generator sets, wind turbines, and possibly other load control devices such as resistance heat loads or static VAR compensation.
- Compensate for KEA's Construction Work Plan (CWP) and ongoing upgrades.
- Allow for future monitoring of diesel unit fire protection system.
- Industry standard communication protocols, to the extent practicable

The following sections of the Special Provisions break down each subsystem, and their respective requirements.

7. Diesel Engine Generator Controls

7.1. Controller

The existing control panels for both the EMD and Caterpillar Diesel Units have no automation or remote display of data at the present time. The existing control panels shall be replaced with either a PLC or Industrial PC based programmable electronic controller for each generator unit. For the engine-generator sets, these controllers shall perform all of the functions that are currently provided through the existing mechanical generator control and monitoring systems.

The unit controllers shall allow the individual unit to be operated manually from the unit controller for short-term maintenance and troubleshooting as well as for long-term operation. The unit controllers shall also allow for remote operation from the SCADA system. When the unit controller is operating in the manual or automatic mode, the engine and generator performance data and alarm conditions shall be available at the unit control HMI. The unit controllers shall provide the control functions necessary for complete protection of the engine, generator, and unit switchgear.

In both manual and remote modes, the unit controller shall control the operation of the engine generator set. The unit controller shall have the functionality to: start, warm-up, bring the unit to speed, synchronize and connect to the buss, and load the engine generator set to its optimal operating conditions of voltage, frequency, and power factor to meet the demand. The unit controller shall sense the condition of the power system to determine if it is starting and loading against a dead buss or a live buss. The unit controller shall have the functionality to: unload, disconnect from the buss, bring the unit to an idle, cool-down, stop the unit, operate the post lube functions and configure the warm-up circulation system.

Provide performance and alarm data at the local HMI from the unit controller, and provide that data to the SCADA system. Also, provide non-critical alarm data to the SCADA system so that other units can be operator dispatched prior to shutdown of the unit with the non-critical alarm. The unit controller shall provide critical alarm data to the SCADA system and automatically perform a shutdown of the engine-generator set.

The unit controller shall be designed to accept external commands separate from the SCADA system and perform the necessary functions based on those commands. These would include a manually initiated emergency shutdown and emergency shutdown due to a unit shutdown alarm such as a fire signal.

The unit controllers shall be designed so that the operator procedures are the same for common operations of the different engine generator sets. To the extent practicable, the HMI displays shall have the same design, layout, and utilize the same symbols. Unique functions and alarms are acceptable where the functions and alarms are not common between the engine generator sets.

The controller shall be designed to allow for ease of removal utilizing plug type connectors that are wired to a terminal strip or panel.

7.2. Protective Relay

The existing protective relays for the generator are outdated electromechanical units. During the SCADA system installation, the Contractor shall upgrade the generator protective relays to a commercially available solid state relay. The relay needs to communicate with the SCADA system, preferably using either Modbus or DNP 3.0 protocol. The relay is required to meet IEEE Standard C37.90, be UL listed, and meet the KEA temperature operating range listed in the Division 1 Technical Specifications. As part of the SCADA project, the Contractor is responsible for setting the relays. The relay shall have the following generator protection capabilities:

- Overexcitation
- Undervoltage
- Overvoltage
- Underfrequency
- Overfrequency
- Loss of Excitation
- Phase overcurrent
- Negative Sequence overcurrent
- Current differential (EMD units only)
- Synchronization Check

7.3. Generator load/voltage controllers

For load sharing and speed control, a Woodward model 2301D unit shall be used on both the Caterpillar and EMD units. Proprietary systems that provide load sharing and speed control are acceptable substitutes, provided they have similar functionality as the Woodward 2301D unit.

The EMD units have been recently upgraded with Basler DECS-200 voltage regulators. The Caterpillar units have not yet been upgraded. The SCADA system Contractor shall provide, install, and commission new Basler DECS-200 units for the Caterpillar generators. No substitutes are allowed.

7.4. Control Panels

The unit controllers shall be designed to be mounted in the engine-generator room, and they must have the ability to operate in such an environment. As stated previously, KEA is performing a switchgear upgrade in the Old and New Plants. Since the SCADA Contractor is responsible for design of the replacement switchgear, the Contractor shall incorporate space requirements in the switchgear for any necessary SCADA controls. It would be an advantage to the SCADA Contractor to provide the hardware and mounting locations to the switchgear vendor, limiting field installation time.

There are a variety of possibilities of where equipment could be located, mostly depending on the system type being installed. For example, if the switchgear is the location where the Contractor wants to locate the generator controller, the Contractor must find a way to get I/O data between the generator and the switchgear. If the control equipment is located entirely in the switchgear, there would no longer be a need for a control panel.

In general, the Contractor shall utilize a “best fit” layout that corresponds to the SCADA system design. A “best fit” means the optimum equipment locations are chosen to minimize wiring, maximize communication speed, simplify troubleshooting, and provide easy access to operator controls. The hardware layout shall be approved by the Engineer before installation.

7.5. Generator Sensor SCADA Integration

The list below provides the analog sensors required to be installed by the Contractor for each generator type. The list does not include protective relays or start/stop SCADA inputs. Refer to Special Provision section 7.6 for the table showing a complete listing of the existing sensor types and functions required. Also, the project Equipment list provides recommended manufacturers of new sensors. The Contract Drawings detail the integration of the sensors into the SCADA system.

Note: On generator unit #10, new thermocouples are installed for the engine cylinder temperatures. However, the thermocouples are not wired back to the engine control panel like the other generator units. The contractor shall provide and install wiring from the thermocouples to the SCADA generator analog input location.

7.5.1. Units 7, 11, and 12 required sensors:

- Intake air pressure differential
- Intake air pressure
- Intake air temperature
- Fuel filter differential pressure
- Fuel inlet pressure
- Jacket water pressure
- Jacket water temperature in
- Jacket water temperature out
- Lube oil filter differential pressure
- Lube oil inlet pressure
- Lube oil temperature
- Engine air starting pressure
- Six generator stator rtd's

7.5.2. Units 10, 14, and 15 required sensors:

- Fuel inlet pressure
- Lube oil filter differential pressure
- Lube oil outlet temperature

7.6. Spreadsheet of functions/data logging

The following spreadsheet provides an overview of the current engine management, and gives details on what the SCADA system shall input, output, alarm, and data store. Wherever relays are used currently, the generator controller shall implement with internal logic if possible.

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Kotzebue Electric Association, Inc.
Table 5 - SCADA Data and Functions
Caterpillar Diesel Units

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Unit Controller	Local Display Real Time Data
1.0	N/A	N/A	Timestamp	data	N/A	time	system monitoring	Date and time	N/A	N/A			record	date time		
2.0	N/A	Unit #	Diesel Unit Name	data	engine	id	system monitoring	Name of Caterpillar diesel unit Allowed values: Diesel Unit # 7, Diesel Unit # 11, Diesel Unit # 12	N/A	N/A			record	name		
3.0	N/A	unknown	Diesel Unit Equipment	data	engine	eng/gen	system monitoring	Caterpillar diesel unit equipment Allowed values: Caterpillar 3516, Caterpillar 3512	N/A	N/A				fixed equipment		
4.0	N/A	unknown	Diesel Unit Status	data	engine	eng/gen	system monitoring	Unit status Allowed values: Ready, Operating, Off, etc.	N/A	N/A	startup may be initiated from SCADA		record	sequence status	startup may be initiated locally	status
5.0	7DC, 11/12DC	ESS (Part 1)	Electronic Speed Switch - Crank Termination	control	electrical panel	speed	arming	Speed Specs: — Unit # 7 — Unit #11 & #12 Crank Termination — 400 rpm — 400 rpm Idle — 600 rpm — 900 rpm Oil Step — 800 rpm — 1,200 rpm Rated — 1,200 rpm — 1,800 rpm Over Speed — 1,416 rpm — 2,124 rpm This part of the switch terminates engine cranking when engine speed reaches crank termination speed (and arms set of lower speed condition switches). Details: This is an adjustable engine speed setting that signals the starter motor that the engine is firing and cranking must be terminated. When the speed setting is reached, a switch will open to stop current flow to the starter motor circuit. The starter motor pinion gear will now disengage from the engine flywheel ring gear. Note: Crank motor air valve closes two seconds after crank termination speed is reached.	CAT 7W2743	400 rpm			record	sequence status	part of startup	
6.0	7DC, 11/12DC, 11/12BKR	TD	Time Delay Relay	control	electrical panel	time	arming	Delay period for arming of shutdown circuits after Crank Termination speed is achieved to allow time for engine to startup and avoid instantaneous shutdown. Details: Terminals 1 and 3 trigger delay period. After delay period is up: --- Contacts 6 and 7 close on Unit # 7 to arm SR1 (Slave Relay 1) --- Contacts 4 and 5 close on Units # 11 & # 12 to arm ESDR (Engine Shut Down Relay)	ECU-PMTN Time Delay Relay	approx 30 seconds			record	sequence status	part of startup	
7.0	7DC, 11/12DC	ESS (Part 2)	Electronic Speed Switch - Oil Step	control	electrical panel	speed	arming	Arms set of higher speed condition switches when engine speed reaches oil step speed	CAT 7W2743	Unit #7 = 800 rpm Unit #11 & #12 = 1,200 rpm			record	sequence status	part of startup	
8.0	7DC, 11/12DC	ESS (Part 3)	Electronic Speed Switch - Over Speed	control	electrical panel	speed	shut down	Engine shutdown if engine speed exceeds the overspeed limit of 118% of rated speed Unit # 7 = 1,200 + 216 = 1,416 rpm Unit # 11 & # 12 = 1,800 + 324 = 2,124 rpm Details: This is an adjustable engine speed setting that prevents engine from running at a speed that could damage the engine. This condition will cause a switch to close that shuts off both the inlet air and the fuel to the engine.	CAT 7W2743	Unit #7: 1,416 rpm Units #11 & #12: 2,124 rpm		alarm	record	alarm and set point	shut down	status and alarm
9.0	7DC, 11/12DC	FPS1	(Low) Fuel Pressure Switch State 1	control	engine	fuel	alarm	Low engine fuel pressure alarm	AMOT 2340 Model Q21ROAA99W	45 psi		alarm	record	alarm and set point		status and alarm

Kotzebue Electric Association, Inc.
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10.0	7DC, 11/12DC	FPS2	(Low) Fuel Pressure Switch State 2	control	engine	fuel	shut down	Low engine fuel pressure shutdown	AMOT 2340 Model Q21ROAA99W	35 psi		alarm	record	alarm and set point	shut down	status and alarm
11.0	7DC, 11/12DC	JWP1	(Low) Jacket Water Pressure Switch State 1	control	engine	jacket water	alarm	Low engine jacket water pressure alarm	AMOT 8256A12AK Serial C871	Unknown psi (Craig/CAT to verify setting)		alarm	record	alarm and set point		status and alarm
12.0	7DC, 11/12DC	JWP2	(Low) Jacket Water Pressure Switch State 2	control	engine	jacket water	shut down	Low engine jacket water pressure shutdown	AMOT 8256A12AK Serial C871	5 psi (Craig/CAT to verify setting)		alarm	record	alarm and set point	shut down	status and alarm
13.0	7DC, 11/12DC	HWT	High (Jacket) Water Temperature (Switch)	control	engine	jacket water	alarm	High engine jacket water temperature alarm	CAT 9Y0327	203 degF (95 degC)		alarm	record	alarm and set point		status and alarm
14.0	7DC, 11/12DC	WTS	(High Jacket) Water Temperature Switch	control	engine	jacket water	shut down	High engine jacket water temperature shutdown	CAT 9Y0914	215 degF (102 degC)		alarm	record	alarm and set point	shut down	status and alarm
15.0	7DC, 11/12DC	OLS1	(Low) Oil Level Switch State 1	control	engine	lube oil	alarm	Low engine lube oil level alarm	Murphy Switch (KEA to verify part #)	Unknown level (KEA to verify setting)		alarm	record	alarm and set point		status and alarm
16.0	7DC, 11/12DC	OLS2	(Low) Oil Level Switch State 2	control	engine	lube oil	shut down	Low engine lube oil level shutdown	Murphy Switch (KEA to verify part #)	Unknown level (KEA to verify setting)		alarm	record	alarm and set point	shut down	status and alarm
17.0	7DC, 11/12DC	LOPAS1	Low Oil Pressure Auxiliary Switch 1	control	engine	lube oil	alarm	Low engine lube oil pressure alarm set for idle speed	CAT 6T6651	Actuation 35 psi. Deactuation 30 psi.		alarm	record	alarm and set point		status and alarm
18.0	7DC, 11/12DC	OPS1	(Low) Oil Pressure Switch State 1	control	engine	lube oil	shut down	Low engine lube oil pressure shutdown set for idle speed	CAT 6T6652	Actuation 23 psi. Deactuation 18 psi.		alarm	record	alarm and set point	shut down	status and alarm
19.0	7DC, 11/12DC	LOPAS2	Low Oil Pressure Auxiliary Switch 2	control	engine	lube oil	alarm	Low engine lube oil pressure alarm set for rated speed	CAT 6T6653	Actuation 45 psi. Deactuation 40 psi.		alarm	record	alarm and set point		status and alarm
20.0	7DC, 11/12DC	OPS2	(Low) Oil Pressure Switch State 2	control	engine	lube oil	shut down	Low engine lube oil pressure shutdown set for rated speed	CAT 6T6651	Actuation 35 psi. Deactuation 30 psi.		alarm	record	alarm and set point	shut down	status and alarm
21.0	7DC, 11/12DC	OTS1	(High) Oil Temperature Switch State 1	control	engine	lube oil	alarm	High engine lube oil temperature alarm	AMOT 2340 Model EOIR7AA00W Serial 871	234 degF		alarm	record	alarm and set point		status and alarm
22.0	7DC, 11/12DC	OTS2	(High) Oil Temperature Switch State 2	control	engine	lube oil	shut down	High engine lube oil temperature shutdown	AMOT 2340 Model EOIR7AA00W Serial 871	240 degF		alarm	record	alarm and set point	shut down	status and alarm
23.0	7DC	VR	(High) Vibration Relay	control	engine	vibration	shut down	High vibration shutdown Note: Not installed on Units #11&#12 and the one on Unit #7 might be disconnected.	AMOT Vibro-Guard Switch Model 4109B	Unknown level (KEA to verify setting)		alarm	record	alarm and set point	shut down	status and alarm
24.0	11/12AC, 11/12BKR	BE1-32	Reverse Power Relay	control	electrical panel	power	alarm, electrical connection, shut down	Disconnects generator from buss system if power reverses direction - 15% of full rated power (instantaneous) Units #7, #11 & #12 = 1,000 x 0.15 = 150 kW	Basler BE1-32, Catalogue No. A2E-AIP-AONIF, Trans CT 400:5	150 kW		alarm	record	alarm and set point	disconnect and shut down	status and alarm
25.0	11/12AC, 11/12BKR	BE1-25	Synchronizing Check Relay	control	electrical panel	voltage & phase angle sync	electrical connection	Does not allow generator to connect to buss system if out of sync on phases or frequency is detected. Note: Black start function will override sync check relay.	Basler BE1-25, Catalogue No. MIH-A6P-A4R6F, Trans PT 20:1	Unknown (KEA to verify setting)				sequence status	prevents out of sync connection	

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Caterpillar Diesel Units

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Unit Controller	Local Display Real Time Data
26.0	unknown	COV-9	Voltage Restrained Overcurrent Relay (Unit #7)	control	Unit #7 electrical panel	current	alarm and electrical connection	Disconnects generator from buss system if current is exceeded. Does not shut down unit.	Westinghouse COV-9 (KEA to verify part #)	Time Dial 03, Inst Setting 40, Tap 5		alarm	record	alarm	disconnect	status and alarm
27.0	11/12AC, 11/12BKR	BE1-51/27	Voltage Restrained Overcurrent Relay (Units #11 & #12)	control	Units #11 & #12 electrical panel	current	alarm and electrical connection	Disconnects generator from buss system if current is exceeded. (inverse) Does not shut down unit.	Basler BE1-51/27, Catalogue No. PIE-B5P-AICIF, Trans CT 400:5	Unknown (KEA to verify setting)		alarm	record	alarm	disconnect	status and alarm
28.0	7DC	AUX RELAY	Auxiliary (Engine Shut Down) Relay (Unit #7)	control	Unit #7 electrical panel	eng/gen	alarm, electrical connection, shut down	Prevents engine start with any existing mechanical or electrical faults. Auxiliary relay to SR1 (Slave Relay 1) which is controlled by contacts from any mechanical or electrical relay designated to trip the unit breaker.	Unknown (KEA to verify part #)	N/A		alarm	record	alarm	disconnect and shut down	status and alarm
29.0	11/12AC, 11/12BKR	ESDRX	Auxiliary Engine Shut Down Relay (Units #11 & #12)	control	Units #11 & #12 electrical panel	eng/gen	alarm and electrical connection	Prevents engine start with any existing mechanical or electrical faults. Auxiliary relay to ESDR (Engine Shut Down Relay) which is controlled by contacts from any mechanical or electrical relay designated to trip the unit breaker.	Unknown (KEA to verify part #)	N/A		alarm	record	alarm	disconnect	status and alarm
30.0	7DC, 11/12DC	ES	Emergency Stop	control	engine (*red button)*	eng/gen	shut down	Manual emergency engine shutdown which bypasses time delay relay for instantaneous shut down	N/A	N/A		alarm	record	alarm	shut down	status and alarm
31.0	7DC, 11/12DC	N/A	Engine Shutdown	control	engine	eng/gen	shut down	Current manual procedure to be automated in SCADA: Reduce power load via governor. When 0 kW is achieved, open Main Unit Breaker to disconnect from Plant Buss. Turn speed switch from RATED to IDLE: --- The governor automatically reduces speed. --- When oil step speed is achieved, the set of higher speed condition switches disarms and the set of lower speed condition switches arms. --- When idle speed is achieved, the engine cools down. When engine is cool, turn RUN/STOP switch to OFF: --- The governor automatically reduces speed. --- When crank termination speed is achieved, the set of lower speed condition switches disarms and the Starting Air Valve (SAV on Unit #7) or Starting Air Interposing Relay (SAIR on Units #11&#12) arms (for restart if desired). --- The governer reduces speed to 0 rpm.	Woodward 2301A Governor	N/A	shut down may be initiated from SCADA		record	sequence status	shut down may be initiated locally	status
32.0	unknown	unknown	Engine Intake Air Pressure Differential	data	engine	air	system monitoring	Engine intake air pressure differential measured across air filter	Unknown (KEA to verify part #)	psi Note: Convert inHg to psi			record	psi		psi
33.0	unknown	unknown	Engine Intake Air Pressure	data	engine	air	system monitoring	Engine intake air pressure (downstream of turbos)	requires instrumentation/ transducer installation	psi			record	psi		psi
34.0	unknown	unknown	Engine Intake Air Temperature	data	engine	air	system monitoring	Engine intake air temperature (downstream of turbocharger and aftercoolers)	requires instrumentation/ transducer installation	degF			record	degF		degF
35.0	unknown	N/A	Cylinder Exhaust Temperature Differential	data	cylinder	cylinder exhaust	system monitoring	Largest differential in exhaust temperature between any two unit cylinders (calculated) Note: See individual Cylinder Exhaust Temperatures in Unit Cylinder Table	N/A	degF			record	degF		degF

Kotzebue Electric Association, Inc.
Table 5 - SCADA Data and Functions
Caterpillar Diesel Units

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Unit Controller	Local Display Real Time Data
36.0	unknown	N/A	Cylinder Exhaust Temperature Differential Alarm	control	cylinder	cylinder exhaust	alarm	High differential cylinder exhaust temperature alarm Note: See individual Cylinder Exhaust Temperatures in Unit Cylinder Table	N/A	unknown differential degF	SCADA program	alarm	record	alarm and setpoint		alarm
37.0	unknown	unknown	Engine Fuel Pressure Differential	data	engine	fuel	system monitoring	Engine fuel pressure differential measured across fuel filter	requires instrumentation/ transducer installation	psi			record	psi		psi
38.0	unknown	unknown	Engine Fuel Pressure In	data	engine	fuel	system monitoring	Engine fuel pressure going into the engine (downstream of fuel filter)	requires instrumentation/ transducer installation	psi			record	psi		psi
39.0	unknown	unknown	Engine Jacket Water Pressure	data	engine	jacket water	system monitoring	Engine jacket water pressure (downstream of water pumps)	requires instrumentation/ transducer installation	psi			record	psi		psi
40.0	unknown	unknown	Engine Jacket Water Temperature In	data	engine	jacket water	system monitoring	Engine jacket water temperature going into the engine from the radiator	requires instrumentation/ transducer installation	degF			record	degF		degF
41.0	unknown	unknown	Engine Jacket Water Temperature Out	data	engine	jacket water	system monitoring	Engine jacket water temperature coming out of the engine	requires instrumentation/ transducer installation	degF			record	degF		degF
42.0	unknown	unknown	Engine Lube Oil Pressure Differential	data	engine	lube oil	system monitoring	Engine lube oil pressure differential measured across oil filter	requires instrumentation/ transducer installation	psi			record	psi		psi
43.0	unknown	unknown	Engine Lube Oil Pressure In	data	engine	lube oil	system monitoring	Engine lube oil pressure going into the engine (downstream of oil filter)	requires instrumentation/ transducer installation	psi			record	psi		psi
44.0	unknown	unknown	Engine Lube Oil Temperature	data	engine	lube oil	system monitoring	Engine lube oil temperature	requires instrumentation/ transducer installation	degF			record	degF		degF
45.0	unknown	unknown	Engine Speed	data	engine	speed	system monitoring	Engine speed	engine tachometer	rpm			record	rpm		rpm
46.0	unknown	unknown	Accumulated Engine Hours Operated	data	engine	time	system monitoring	Total amount of time engine has been running since unit installation (accumulated hours) Notes: Accumulator should not be automatically reset but and should be manually set initially. SCADA must store last known value so operators can reset accumulator.	Hobbs Run Time Meter (RTM)	hours (accumulated)			record	hours (accumulated)		hours (accumulated)
47.0	unknown	unknown	Diesel Generator Frequency	data	electrical panel	frequency	system monitoring	Generator frequency	frequency meter	Hz			record	Hz		Hz
48.0	unknown	unknown	Diesel Generator Voltage on Phase A	data	electrical panel	voltage	system monitoring	Generator voltage on Phase A	voltmeter	Volts			record	volts		volts
49.0	unknown	unknown	Diesel Generator Voltage on Phase B	data	electrical panel	voltage	system monitoring	Generator voltage on Phase B	voltmeter	Volts			record	volts		volts
50.0	unknown	unknown	Diesel Generator Voltage on Phase C	data	electrical panel	voltage	system monitoring	Generator voltage on Phase C	voltmeter	Volts			record	volts		volts
51.0	unknown	unknown	Diesel Generator Current on Phase A	data	electrical panel	current	system monitoring	Generator current on Phase A	ammeter	Amps			record	Amps		Amps

Kotzebue Electric Association, Inc.
Table 5 - SCADA Data and Functions
Caterpillar Diesel Units

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Unit Controller	Local Display Real Time Data
52.0	unknown	unknown	Diesel Generator Current on Phase B	data	electrical panel	current	system monitoring	Generator current on Phase B	ammeter	Amps			record	Amps		Amps
53.0	unknown	unknown	Diesel Generator Current on Phase C	data	electrical panel	current	system monitoring	Generator current on Phase C	ammeter	Amps			record	Amps		Amps
54.0	unknown	unknown	Diesel Generator Power Generated	data	electrical panel	power	system monitoring	Amount of power being generated by generator	power meter	kW			record	kW		kW
55.0	unknown	unknown	Diesel Generator Power Factor	data	electrical panel	power	system monitoring	Generator power factor - the ratio of real power to apparent power, related to the phase angle between voltage and current (calculated)	power factor meter	unitless			record	unitless		unitless
56.0	unknown	unknown	Future Engine Fire Alarm	control	N/A	fire	alarm	Future engine/generator fire alarm	N/A	unknown		alarm	record	alarm	shut down	alarm

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Kotzebue Electric Association, Inc.
Table 6 - SCADA Data and Functions
Electro-Motive Diesel Units

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Unit Controller	Local Display Real Time Data
1.0	N/A	N/A	Timestamp	data	N/A	time	system monitoring	Date and time	N/A	N/A			record	date time		
2.0	N/A	Unit #	Diesel Unit Name	data	engine	id	system monitoring	Name of Electro-Motive diesel unit Allowed values: Diesel Unit # 10, Diesel Unit # 14, Diesel Unit # 15	N/A	N/A			record	name		
3.0	N/A	unknown	Diesel Unit Equipment	data	engine	eng/gen	system monitoring	Electro-Motive diesel unit equipment Allowed values: EMD 20-710-G4A, EMD L16-710-G4B	N/A	N/A				fixed equipment		
4.0	N/A	unknown	Diesel Unit Status	data	engine	eng/gen	system monitoring	Unit status Allowed values: Ready, Operating, Maintenance, etc.	N/A	N/A			record	sequence status	startup may be initiated only locally	status
5.0	10DC, 14DC1	LCOPDR	Low Circulating Oil Pressure Delay Relay	control	mech panel	lube oil	timing	Activates with Master Switch, time delay to allow lube oil to pressure-up during startup and arms LCOPS (Low Circulating Oil Pressure Switch)	SAAC Time Delay On Make Relay, Part TDM110DL	Unknown time (KEA to verify setting)			record	sequence status	part of startup	
6.0	10DC, 14DC1	LCOPS	Low Circulating Oil Pressure Switch	control	engine	lube oil	alarm	Low oil pressure alarm at startup and low speed.	Sq D Class 9012, Series C	10 psi		alarm	record	alarm and set point	part of startup	status and alarm
7.0	10G	SS (1) *(also listed as DSS)*	(Dual) Speed Switch - Crank Terminate Delay Relay	control	mech panel	speed	arming	Speed Specs: Unit #10 & #14 (Unit #15 not installed yet) Crank Termination 200 rpm? Idle 600 rpm? Oil Step 850 rpm Rated 900 rpm Over Speed 975 rpm Note: Units #10 and #14 arm slightly differently (see drawings). This part of the switch terminates engine cranking when engine speed reaches crank termination speed and activates CDR, CDRX, and CDRXX relays (and arms set of lower speed condition switches). Details: This is an adjustable engine speed setting that signals the starter motor that the engine is firing and cranking must be terminated. When the speed setting is reached, a switch will open to stop air flow to the starter motor. The starter motor pinion gear will now disengage from the engine flywheel ring gear.	ECU-SS40	200 rpm			record	sequence status	part of startup	
8.0	10DC, 14DC1	CDR	Crank Disconnect Relay	control	mech panel	eng/gen	electrical connection	Upon crank termination, closes the ASV (Air Start Valve)	IDEC RH2B	N/A			record	sequence status	part of startup	
9.0	10DC, 14DC1	CDRX	Auxiliary 1 Crank Disconnect Relay	control	mech panel	eng/gen	electrical connection	Upon crank termination, activates ODR (Oil Delay Relay), ODRX (Auxiliary Oil Delay Relay), PLTD (Pre-Lube Time Delay Relay), and SBTD (Soak-Back Time Delay Relay)	IDEC RH2B	N/A			record	sequence status	part of startup	
10.0	10DC, 14DC1	ODR	Oil Delay Relay	control	mech panel	lube oil	timing	Delay to allow lube oil to pressure-up at low speed and arms LOPWS (Low Oil Pressure Warning Switch) and LOPS (Low Oil Pressure Switch)	SAAC Time Delay On Make Relay, Part TDM110DL	Unknown time (KEA to verify setting)			record	sequence status	part of startup	
11.0	10DC, 14DC1	LOPWS	Low Oil Pressure Warning Switch	control	engine	lube oil	alarm	Low engine lube oil pressure alarm	Sq D Class 9012, Series C	35 psi		alarm	record	alarm and set point		status and alarm
12.0	10DC, 14DC1	LOPS	Low Oil Pressure Switch	control	engine	lube oil	shut down	Low engine lube oil pressure shutdown	Sq D Class 9012, Series C	20 psi		alarm	record	alarm and set point	shutdown	status and alarm
13.0	10DC, 14DC1	LOPR	Low Oil Pressure Relay	control	mech panel	lube oil	electrical connection	Relay activated by the LOPS (Low Oil Pressure Switch) which activates the EFR (Engine Failure Relay)	IDEC RH2B	N/A			record	sequence status	part of shut down	status

Kotzebue Electric Association, Inc.
Table 6 - SCADA Data and Functions
Electro-Motive Diesel Units

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Unit Controller	Local Display Real Time Data
14.0	10DC, 14DC1	ODRX	Auxiliary Oil Delay Relay	control	mech panel	lube oil	timing	Time delay prior to arming: LWPWS (Low Jacket Water Pressure Warning Switch), HCCPS (High Crank Case Pressure Switch), LWPS (Low Jacket Water Pressure Switch) Note: HCCPS and LWPS also require second step of DSS (Dual Speed Switch) to arm	SAAC Time Delay On Make Relay, Part TDM110DL	Unknown time (KEA to verify setting)			record	sequence status	part of startup	
15.0	10G	SS (2) *(also listed as DSS)*	(Dual) Speed Switch - Second Step	control	mech panel	speed	arming	Completes arming of HCCPS (High Crank CasePressure Switch) and the LWPS (Low Jacket Water Pressure Switch) when the engine reaches second step speed.	ECU-SS40	850 rpm			record	sequence status	part of startup	
16.0	10DC, 14DC1	HCPS *(also listed as HCCPS)*	High Crank Case Pressure Switch	control	engine	crank case	shut down	High crank case pressure shutdown Note: This switch shuts down engine if there is high crank case pressure at rated speed.	EMD 8362040	0.8 to 2.5 inches of water pressure		alarm	record	alarm and set point	shut down	status and alarm
17.0	10DC, 14DC1	LWPWS	Low (Jacket) Water Pressure Warning Switch	control	engine	jacket water	alarm	Low engine jacket water pressure alarm	Sq D Class 9012, Series C	35 psi		alarm	record	alarm and set point		status and alarm
18.0	10DC, 14DC1	LWPS	Low (Jacket) Water Pressure Switch	control	engine	jacket water	shut down	Low engine jacket water pressure shutdown	Sq D Class 9012, Series C	20 psi		alarm	record	alarm and set point	shut down	status and alarm
19.0	10DC, 14DC1	LWPR	Low (Jacket) Water Pressure Relay	control	mech panel	jacket water	electrical connection	Relay which activates EFR (Engine Failure Relay) when LWPS (Low Jacket Water Pressure Switch) or HCCPS (High Crank Case Oil Pressure Switch) are initiated in order to shut down the engine and open the generator breaker.	IDEC RH2B	N/A			record	sequence status	part of shut down	
20.0	10DC, 14DC1	PLTD	Pre-Lube Time Delay Relay	control	mech panel	lube oil	timing	Time delay period during startup to allow time for engine to lube completely prior to engine cranking. Activates LPMS (Lube Pump Master Switch); With Unit off, PLTD closed and allows prelube pump to run in REMOTE or LOCAL With Unit start at DSS1 speed, the CDR(X) activates PLTD thereby turns off the prelube pump With Unit stopping, LOPS1 (Low Oil Pressure Switch 1) closes the SBTD (Soak-Back Time Delay Relay) and allows prelube pump to run for a timed period.	SAAC Time Delay On Make Relay, Part TDM110DL	Unknown time (KEA to verify setting)			record	sequence status	part of startup	
21.0	10DC	LOPS1	Low Oil Pressure Switch 1	control	engine	lube oil	electrical connection	Shuts off the prelube pump when engine oil pressure opens the LOPS1 switch. Upon engine shutdown, activates SBTD (Soak Back Time Delay) to allow pre-lube pump to run after unit is shut down.	Unknown (KEA to verify part #)	Unknown psi (KEA to verify setting)			record	sequence status	part of startup & shut down	
22.0	10DC, 14DC1	SBTD	Soak-Back Time Delay Relay	control	mech panel	lube oil	timing	Time delay period to allow for continued oil circulation after the engine shuts down.	SAAC Time Delay On Break Relay, Part TDBH110VDCL	Unknown time (KEA to verify setting)			record	sequence status	part of shut down	
23.0	10DC, 14DC1	CDRXX	Auxiliary 2 Crank Disconnect Relay	control	mech panel	eng/gen	electrical connection	Upon crank termination, disarms the LCOPDR (Low Circulating Oil Pressure Delay Relay)	IDEC RH2B	N/A			record	sequence status	part of startup	
24.0	10DC, 14DC1	OSS	Over Speed (Limit) Switch	control	engine	speed	shut down	Engine shutdown if engine speed exceeds the overspeed limit	EMD 8422449, Sq D Class 9007, Type TUB1-53 (made by Sq D proprietary to EMD)	975 rpm		alarm	record	alarm and set point	shut down	status and alarm
25.0	10DC, 14DC1	OSR	Over Speed Relay	control	mech panel	speed	electrical connection	Relay activated by the OSS (Over Speed Switch) which activates the EFR (Engine Failure Relay)	IDEC RH2B	N/A			record	sequence status	part of shut down	
26.0	10DC, 14DC1	HFDPS	High Fuel Differential Pressure Switch	control	engine	fuel	alarm	High engine fuel differential pressure alarm	Sq D Type 9012 Series C	30 psid		alarm	record	alarm and set point		status and alarm
27.0	10DC, 14DC1, 14C	LFLS	Low Fuel Level Switch	control	fuel tank	fuel	alarm	Low engine fuel level alarm	ACE Tank Magnetrol # B10-1K3A-ALK-1 Low Level Switch, catalog pg 242	Unknown level (KEA to verify setting)		alarm	record	alarm		status and alarm

Kotzebue Electric Association, Inc.
Table 6 - SCADA Data and Functions
Electro-Motive Diesel Units

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Unit Controller	Local Display Real Time Data
28.0	10DC, 14DC1, 14C	HFLS	High Fuel Level Switch	control	fuel tank	fuel	alarm	High engine fuel level alarm	ACE Tank Magnetrol # B10-1K3A-ALK-1 High Level Switch, catalog pg 242	Unknown level (KEA to verify setting)		alarm	record	alarm		status and alarm
29.0	10DC, 14DC1	HWTWS	High (Jacket) Water Temperature Warning Switch	control	engine	jacket water	alarm	High engine jacket water temperature alarm	EMD 40040504, Sq D Class 9025, Series C, Type GZW23-S109	208 degF		alarm	record	alarm and set point		status and alarm
30.0	10DC, 14DC1	HWTS	High (Jacket) Water Temperature Switch	control	engine	jacket water	shut down	High engine jacket water temperature shutdown	EMD 40040507, Sq D Class 9025, Series C, Type GZW23-S113	215 degF		alarm	record	alarm and set point	shut down	status and alarm
31.0	10DC, 14DC1	HWTR	High (Jacket) Water Temperature Relay	control	mech panel	jacket water	electrical connection	Relay activated by the HWTS (High Water Temperature Switch) which activates the EFR (Engine Failure Relay)	IDEC RH2B	N/A			record	sequence status	part of shut down	
32.0	10DC, 14DC1	HOTWS	High Oil Temperature Warning Switch	control	engine	lube oil	alarm	High engine lube oil temperature alarm	EMD 40040508, Sq D Class 9025, Series C, Type GZW23-S143	230 degF (KEA to verify setting)		alarm	record	alarm and set point		status and alarm
33.0	10DC, 14DC1	LOTWS	Low Oil Temperature Warning Switch	control	engine	lube oil	alarm	Low engine lube oil temperature alarm	EMD 40040500, Sq D Class 9025, Series C, Type GZW1-S124 (KEA to verify part #)	140 degF (KEA to verify setting)		alarm	record	alarm and set point		status and alarm
34.0	10DC, 14DC1	HVS	High Vibration Switch	control	engine	vibration	shut down	High vibration shutdown Note: Installed on Unit #10 and might be disconnected on Unit #14.	AMOT Vibro-Guard Switch Model 4128 (Explosion Proof)	N/A		alarm	record	alarm and set point	shut down	status and alarm
35.0	10DC, 14DC1	HVR	High Vibration Relay	control	mech panel	vibration	electrical connection	Relay activated by the HVS (High Vibration Switch) which activates the EFR (Engine Failure Relay)	IDEC RH2B	N/A			record	sequence status	part of shut down	
36.0	10DC, 14DC1	GFRS	Generator Failure Relay Switch	control	electrical panel	eng/gen	shut down	Generator failure shutdown	Unknown (KEA to verify part #)	Unknown		alarm	record	alarm	shut down	status and alarm
37.0	10DC, 14DC1	GFR	Generator Failure Relay	control	mech panel	eng/gen	electrical connection	Relay activated by the GFRS (Generator Failure Relay Switch) which activates the EFR (Engine Failure Relay)	IDEC RH2B	N/A			record	sequence status	part of shut down	
38.0	10DC, 14DC1	EFR	Engine Failure Relay	control	mech panel	eng/gen	alarm and electrical connection	Common relay for engine shut down	Unknown (KEA to verify part #)	N/A		alarm	record	sequence status	shut down	status and alarm
39.0	10DC, 14DC1	EFRX	Auxiliary 1 Engine Failure Relay	control	mech panel	eng/gen	alarm and electrical connection	Common relay for engine shut down. Latches shut down until reset.	Unknown (KEA to verify part #)	N/A		alarm	record	sequence status	shut down	status and alarm
40.0	10DC, 14DC1	EFRXX	Auxiliary 2 Engine Failure Relay	control	mech panel	eng/gen	alarm and electrical connection	Common relay for engine shut down	Unknown (KEA to verify part #)	N/A		alarm	record	sequence status	shut down	status and alarm
41.0	unknown	BE1-32	Reverse Power Relay	control	electrical panel	power	alarm, electrical connecion, shut down	Disconnects generator from buss system if power reverses direction - 15% of full rated power (instantaneous) Unit #10 = 3,080 x 0.15 = 462 kW Unit #14 = 2,865 x 0.15 = 430 kW	Basler BE1-32, Catalogue No. A2E-AIP-AONIF, Trans CT 400:5	Unit #10 = 462 kW Unit #14 = 430 kW		alarm	record	alarm and set point	disconnect and shut down	status and alarm
42.0	unknown	BE1-25	Synchronizing Check Relay	control	electrical panel	voltage & phase angle sync	electrical connection	Does not allow generator to connect to buss system if out of sync on phases or frequency is detected. Note: Black start function will override sync check relay.	Basler BE1-25, Catalogue No. MIH-A6P-A4R6F, Trans PT 20:1	Unit #10: Unknown (KEA to verify setting) Unit #14: Time Delay 0.01 sec, Phase Angle 15 deg, Delta Voltage 10 V < 0 deg and 0 V < 5 deg				sequence status	prevents out of sync connection	

Kotzebue Electric Association, Inc.
Table 6 - SCADA Data and Functions
Electro-Motive Diesel Units

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Unit Controller	Local Display Real Time Data
43.0	10AC	BE1-51/27	Voltage Restrained Overcurrent Relay (Unit #10)	control	Unit 10 electrical panel	current	alarm and electrical connection	Disconnects generator from buss system if current is exceeded. Does not shut down unit.	Basler BE1-51/27, Catalogue No. PIE-B5P-AICIF, Trans CT 400:5	Time Dial 03, Low Range Tap J		alarm	record	alarm	disconnect	status and alarm
44.0	14DC2	ITE 51I	Voltage Restrained Overcurrent Relay (Overcurrent Relay Part) (Unit #14)	control	Unit 14 electrical panel	current	alarm and electrical connection	Disconnects generator from buss system if current is exceeded. Coordinates with voltage relay. Breaker is held closed unless voltage is decaying along with current. Does not shut down unit.	BBC - ITE 51I, Catalouge No. 423T1341, SS No. 37862, Trans CT 400:5 (KEA to verify part #)	Time Dial 01, Inst Setting 16, Tap 5 (KEA to verify setting)		alarm	record	alarm	disconnect	status and alarm
45.0	unknown	ITE 51I	Voltage Restrained Overcurrent Relay (Voltage Relay Part) (Unit #14)	control	Unit 14 electrical panel	voltage	alarm and electrical connection	Disconnects generator from buss system if current is exceeded. Coordinates with current relay. Breaker is held closed unless voltage is decaying along with current. Does not shut down unit.	BBC - ITE 51I, Catalouge No. 411N0171, Trans CT 400:5 (KEA to verify part #)	Unknown (KEA to verify setting)		alarm	record	alarm	disconnect	status and alarm
46.0	unknown	BE1-87G	Differential Protective Generator Relay	control	electrical panel	current	alarm, electrical connecion, shut down	Disconnects generator from buss system if generator differential is exceeded	Basler BE1-87G, Catalogue No. GIE-AIJ-BONOF, Trans CT 400:5	Tap F (0.8)		alarm	record	alarm	disconnect and shut down	status and alarm
47.0	10G	APD	Engine Intake Air Pressure Differential	data	mech panel	air	system monitoring	Engine intake air pressure differential measured across air filter (Air Pressure Differential)	Unknown (KEA to verify part #)	psi			record	psi		psi
48.0	10G	EAP	Engine Intake Air Pressure	data	mech panel	air	system monitoring	Engine intake air pressure (downstream of turbo) (Engine Airbox Pressure)	Unknown (KEA to verify part #)	psi			record	psi		psi
49.0	10G	EAT	Engine Intake Air Temperature	data	mech panel	air	system monitoring	Engine intake air temperature (downstream of turbocharger and aftercoolers) (Engine Air Temperature)	Unknown (KEA to verify part #)	degF			record	degF		degF
50.0	unknown	N/A	Cylinder Exhaust Temperature Differential	data	cylinder	cylinder exhaust	system monitoring	Largest differential in exhaust temperature between any two unit cylinders (calculated) Note: See individual Cylinder Exhaust Temperatures in Unit Cylinder Table	N/A	degF			record	degF		degF
51.0	unknown	N/A	Cylinder Exhaust Temperature Differential Alarm	control	cylinder	cylinder exhaust	alarm	High differential cylinder exhaust temperature alarm Note: See individual Cylinder Exhaust Temperatures in Unit Cylinder Table	N/A	unknown differential degF	SCADA program	alarm	record	alarm and setpoint		alarm
52.0	10G	FDP	Engine Fuel Pressure Differential	data	mech panel	fuel	system monitoring	Engine fuel pressure differential measured across fuel filter (Fuel Differential Pressure)	Unknown (KEA to verify part #)	psi			record	psi		psi
53.0	unknown	unknown	Engine Fuel Pressure In	data	engine	fuel	system monitoring	Engine fuel pressure going into the engine (downstream of fuel filter)	requires instrumentation/ transducer installation	psi			record	psi		psi
54.0	10G	EWP	Engine Jacket Water Pressure	data	mech panel	jacket water	system monitoring	Engine jacket water pressure (downstream of water pumps) (Engine Water Pressure)	Unknown (KEA to verify part #)	psi			record	psi		psi
55.0	10G	EWTI	Engine Jacket Water Temperature In	data	mech panel	jacket water	system monitoring	Engine jacket water temperature going into the engine from the radiator (Engine Water Temperature In)	Unknown (KEA to verify part #)	degF			record	degF		degF
56.0	10G	EWTO	Engine Jacket Water Temperature Out	data	mech panel	jacket water	system monitoring	Engine jacket water temperature coming out of the engine (Engine Water Temperature Out)	Unknown (KEA to verify part #)	degF			record	degF		degF
57.0	unknown	unknown	Engine Lube Oil Pressure Differential	data	engine	lube oil	system monitoring	Engine lube oil pressure differential measured across oil filter	requires instrumentation/ transducer installation	psi			record	psi		psi
58.0	10G	EOP	Engine Lube Oil Pressure In	data	mech panel	lube oil	system monitoring	Engine lube oil pressure going into the engine (downstream of oil filter) (Engine Oil Pressure)	Unknown (KEA to verify part #)	psi			record	psi		psi
59.0	unknown	unknown	Engine Lube Oil Temperature In	data	engine	lube oil	system monitoring	Engine lube oil temperature going into the engine (downstream of oil cooler)	Unknown (KEA to verify part #)	degF			record	degF		degF

Last Modified 08/16/05

Kotzebue Electric Association, Inc.
Table 6 - SCADA Data and Functions
Electro-Motive Diesel Units

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Unit Controller	Local Display Real Time Data
60.0	10G	EOT	Engine Lube Oil Temperature Out	data	mech panel	lube oil	system monitoring	Engine lube oil temperature coming out of the engine (upstream of oil cooler) (Engine Oil Temperature)	requires instrumentation/ transducer installation	degF			record	degF		degF
61.0	10G	EST	Generator Stator Temperature	data	mech panel	wiring	system monitoring	Stator temperature (temperature of wiring through which generated power passes) Note: This data may produce multiple temperatures for different parts of the stator and may require its own data table.	may require instrumentation/ transducer installation	degF			record	degF		degF
62.0	unknown	unknown	Engine Speed	data	engine	speed	system monitoring	Engine speed	engine tachometer	rpm			record	rpm		rpm
63.0	unknown	unknown	Accumulated Engine Hours Operated	data	mech panel	time	system monitoring	Total amount of time engine has been running since unit installation (accumulated hours) Notes: Accumulator should not be automatically reset but manually set initially. SCADA must store last known value so operators can reset accumulator.	Run Time Meter (RTM) - timer set to keep accumulated time	hours (accumulated)			record	hours (accumulated)		hours (accumulated)
64.0	unknown	unknown	Diesel Generator Frequency	data	electrical panel	frequency	system monitoring	Generator frequency	frequency meter	Hz			record	Hz		Hz
65.0	unknown	unknown	Diesel Generator Voltage on Phase A	data	electrical panel	voltage	system monitoring	Generator voltage on Phase A	voltmeter	Volts			record	volts		volts
66.0	unknown	unknown	Diesel Generator Voltage on Phase B	data	electrical panel	voltage	system monitoring	Generator voltage on Phase B	voltmeter	Volts			record	volts		volts
67.0	unknown	unknown	Diesel Generator Voltage on Phase C	data	electrical panel	voltage	system monitoring	Generator voltage on Phase C	voltmeter	Volts			record	volts		volts
68.0	unknown	unknown	Diesel Generator Current on Phase A	data	electrical panel	current	system monitoring	Generator current on Phase A	ammeter	Amps			record	Amps		Amps
69.0	unknown	unknown	Diesel Generator Current on Phase B	data	electrical panel	current	system monitoring	Generator current on Phase B	ammeter	Amps			record	Amps		Amps
70.0	unknown	unknown	Diesel Generator Current on Phase C	data	electrical panel	current	system monitoring	Generator current on Phase C	ammeter	Amps			record	Amps		Amps
71.0	unknown	unknown	Diesel Generator Power Generated	data	electrical panel	power	system monitoring	Amount of power being generated by generator	power meter	kW			record	kW		kW
72.0	unknown	unknown	Diesel Generator Power Factor	data	electrical panel	power	system monitoring	Generator power factor - the ratio of real power to apparent power, related to the phase angle between voltage and current (calculated)	power factor meter	unitless			record	unitless		unitless
73.0	unknown	unknown	Future Engine Fire Alarm	control	N/A	fire	alarm	Future engine/generator fire alarm	N/A	unknown		alarm	record	alarm	shut down	alarm

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Kotzebue Electric Association, Inc.
Table 7 - SCADA Data and Functions
Diesel Unit Cylinders

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Local Display Real Time Data
1.0	N/A	N/A	Timestamp	data	N/A	time	system monitoring	Date and time	N/A	N/A			record	date time	
2.0	N/A	Unit #	Diesel Unit Name	data	engine	id	system monitoring	Name of Unit Allowed values: Diesel Unit # 7, Diesel Unit # 11, Diesel Unit # 12, Diesel Unit # 10, Diesel Unit # 14, Diesel Unit # 15	N/A	N/A			record	name	
3.0	unknown	Cylinder #	Clylinder Number	data	cylinder	id	system monitoring	Unit cylinder number Allowed values: 1, 2, 3, … 20	N/A	N/A			record	name	name
4.0	10G	EST	Cylinder Exhaust Temperature	data	cylinder	cylinder exhaust	system monitoring	Cylinder exhaust temperature	Thermocouples (KEA to verify part #)	degF			record	degF	degF

8. Wind Turbine Generator Controls

8.1. Wind Farm Control System

Currently, an Automation Direct (Koyo) PLC controls each of the wind turbines, which is monitored and controlled by a “Second Wind” SCADA system. To improve bandwidth and have greater real time accuracy, the Contractor shall set up a fiber optic communication network as shown schematically on the Contract Drawings. The fiber optic network shall connect to an Ethernet switch near each controlling PLC, and replace the existing RS485 copper network. Make the Ethernet connection from the Ethernet switch to each PLC via an Automation Direct ECOM card. The Equipment List calls out the part numbers for the components required to communicate with each PLC, as described below:

- Turbines 1, 2, and 3 – The current 6 slot PLC rack is full. The Contractor shall provide and install a 9 slot rack to replace the 6 slot rack, and an Ethernet communications card for each turbine PLC.

- Turbines 4, 5, 6, 7, 8, 9, 10, 11, and 12 – There is room in the current PLC rack. The Contractor shall provide and install an Ethernet communications card for each turbine PLC.

- Turbine 14 – The current PLC rack is full. The following components are required to add a second rack: 110 VAC power supply, 6 slot expansion rack, expansion cable, and Ethernet communications card. Turbine 14 has a 405 series Koyo PLC, which differs from the 205 series used in the other units. Currently, the 405 series Ethernet card does not have Modbus TCP capability like the 205 series. Automation Direct has stated it will release a new 405 series ECOM card capable of Modbus TCP in September of 2005. If Automation Direct has not made the 405 series capable of Modbus TCP before final design of the SCADA system, the Contractor should consider converting the unit to a 205 series Koyo PLC. Having the ability to communicate in one protocol will simplify the HMI polling process.

Utilize the existing communications network raceways for the fiber network, after removing the existing network copper conductors. At a minimum, provide 2 spare fibers in the fiber cable. The fiber line shall terminate at the wind farm control building, where it shall interface with a Contractor provided Ethernet radio. The radio link provides a communication link back to the power plant for integration into the SCADA system. The radio link will most likely require a repeater between the wind farm and the power plant. The Owner will provide mounting structures and install the antenna and cable for the radio link. The Contractor shall provide all hardware for a complete radio communication system. The radio system shall have a minimum capability of 10 Mbps transfer speed for data, voice, and video transfer.

The wind farm data shall be displayed at all HMI’s, along with the ability to control the wind turbines. Also, performance data from the wind turbines shall be collected and stored through the SCADA system such that periodic performance reports can be automatically generated. **The new SCADA system must provide the same or greater functionality as the Second Wind SCADA system.** The Second Wind SCADA system shall be decommissioned by the Contractor during installation and commissioning of the fiber optic network. Consult with the Owner before beginning Work and agree on a path forward that minimizes the down time of the wind farm SCADA system.

8.2. Programming

Installation of the PLC Ethernet communication cards will require programming changes in the Koyo PLC's. The Owner shall provide a current copy of the programming software and turbine controller logic files for the Contractor to modify. The Contractor shall complete the logic edits and return the final logic files and software back to the Owner during project closeout. Provide comments in the logic as required to describe changes made.

8.3. Spreadsheet of functions/data logging

The following spreadsheet provides an overview of the current wind farm SCADA system, and gives details on what the new SCADA system shall input, output, alarm, and data store.

Last Modified 08/16/05

Kotzebue Electric Association, Inc.
Table 8 - SCADA Data and Functions
Wind Turbine Units

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Unit Controller	Local Display Real Time Data
1.0	N/A	N/A	Timestamp	data	N/A	time	system monitoring	Date and time	N/A	N/A			record	date time		
2.0	N/A	Unit #	Wind Turbine Name	data	wind turbine	id	system monitoring	Name of wind turbine Allowed values: WTG Unit # 01, WTG Unit # 02,...WTG Unit # 14	N/A	N/A			record	name		
3.0	N/A	unknown	Wind Turbine Equipment	data	wind turbine	turbine/gen	system monitoring	Wind turbine equipment Allowed values: AOC 15/50, Northwind 100	N/A	N/A				fixed equipment		
4.0	N/A	unknown	Wind Turbine Status	data	Wind Site Second Wind SCADA System	turbine/gen	system monitoring	Unit status Allowed values: Ready, Operating, Maintenance, etc.	N/A	N/A			record	sequence status		status
5.0	unknown	unknown	Wind Generator Power Generated	data	Wind Site Second Wind SCADA System	power	system monitoring	Amount of power being generated by generator	power meter	kW			record	kW		data
6.0	unknown	unknown	Turbine Wind Speed	data	Wind Site Second Wind SCADA System	wind	system monitoring	Wind speed measured from individual wind turbine anemometers	anemometer	mph Note: Convert meters/sec to mph			record	mph		data
7.0	N/A	unknown	Wind Turbine Startup	control	Wind Site Second Wind SCADA System	turbine/gen	startup	Makes wind turbine available to generate power	N/A	N/A	SCADA program		record	sequence status	startup may be initiated locally	status
8.0	N/A	unknown	Wind Turbine Shut Down	control	Wind Site Second Wind SCADA System	turbine/gen	shut down	Makes wind turbine unavailable to generate power	N/A	N/A	SCADA program		record	sequence status	shut down or maint lockout may be initiated locally	status
9.0	unknown	unknown	Wind Turbine Failure Alarm	control	Wind Site Second Wind SCADA System	turbine/gen	alarm	General wind turbine alarm	Wind Site Second Wind SCADA System	N/A	SCADA program	alarm	record	alarm		alarm
10.0	unknown	unknown	Wind Turbine Generator RPM Alarm	data	Wind Site Second Wind SCADA System	turbine/gen	alarm	Generator RPM Alarm	Wind Site Second Wind SCADA System			alarm		alarm		alarm
11.0	unknown	unknown	Wind Turbine Parking Brake Fault	data	Wind Site Second Wind SCADA System	turbine/gen	alarm	Parking Brake Failure Alarm	Wind Site Second Wind SCADA System			alarm		alarm		alarm
12.0	unknown	unknown	Wind Turbine Overspeed Fault	data	Wind Site Second Wind SCADA System	turbine/gen	alarm	Overspeed Fault Alarm	Wind Site Second Wind SCADA System			alarm		alarm		alarm
13.0	unknown	unknown	Wind Turbine Overpower Fault	data	Wind Site Second Wind SCADA System	turbine/gen	alarm	Overpower Fault Alarm	Wind Site Second Wind SCADA System			alarm		alarm		alarm

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Kotzebue Electric Association, Inc.
Table 8 - SCADA Data and Functions
Wind Turbine Units

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Unit Controller	Local Display Real Time Data
14.0	unknown	unknown	Wind Turbine Grid Fault	data	Wind Site Second Wind SCADA System	turbine/gen	alarm	Grid Fault Alarm	Wind Site Second Wind SCADA System			alarm		alarm		alarm
15.0	unknown	unknown	Wind Turbine Estop Fault	data	Wind Site Second Wind SCADA System	turbine/gen	alarm	Emergency Stop Fault Alarm	Wind Site Second Wind SCADA System			alarm		alarm		alarm

9. Power Feeder Controls

9.1. Power Feeder Control System

All four feeders are connected to a under frequency time delayed load shed system that is designed to operate in the event of the loss of an engine generator. If the KEA system drops frequency, the load shed system is designed to shed the largest feeder loads first in an attempt to reduce the overall system load to a level where system frequency is manageable by the remaining generation.

The existing power feeder breakers shall be provided with a feeder controller(s) that is PLC or Industrial PC based programmable electronic controller. These controller(s) shall perform all of the functions that are currently provided manually, including:

- Open or close the breaker
- Open/Closed breaker position indication
- Status of protective relays
- Three-phase measurement of the RMS value of phase-to-neutral and phase-to-phase voltages
- Three-phase measurement of the rms value of current
- Three-phase measurement of the rms value of active power
- Three-phase measurement of reactive power
- KWh per hr/month distributed by feeder
    - Peak
    - Average

The feeder controller(s) shall allow the individual feeder to be operated manually from the feeder switchgear for short-term maintenance and troubleshooting as well as for long-term operation. The feeder controller(s) shall also allow for remote operation from the SCADA system. When the feeder controller is operating in the manual mode or from the SCADA system, the feeder performance data and alarm conditions shall be available at the HMI's. In addition, when the feeder is being operated in the manual mode from the feeder control panel, the feeder performance data shall still be provided to the SCADA system for storage and trending. The feeder controller on feeder number four must be capable of bidirectional measurement of performance data, as it also receives power from the wind farm.

Feeder controller(s) shall be designed to accept external commands separate from the SCADA system and perform the necessary functions based on those commands. These would include a manually initiated emergency shutdown and emergency shutdown due to a plant fire signal.

Feeder controller(s) shall be designed to allow for ease of removal utilizing plug type connectors that are wired to a terminal strip or panel. Upon failure of a feeder controller, an alarm shall be annunciated and the power feeder shall continue to operate as if it were in manual operation.

9.2. Protective Relay

The existing protective relays for the feeders are electromechanical. During the SCADA system installation the Contractor shall upgrade the feeder protective relays to a commercially available solid state relay. The relay needs to communicate with the SCADA system, preferably using either Modbus or DNP 3.0 protocol. It also is required to meet IEEE Standard C37.90, be UL listed, and meet the KEA temperature operating range listed in the Division 1 Technical Specifications. As part of the SCADA project, the Contractor is responsible for setting the relays. The relay shall have the following feeder protection capabilities:

- Undervoltage
- Overvoltage
- Underfrequency – Provide load shedding similar to pre-SCADA operations. Refer to Table-9 for feeder priority listing.
- Overfrequency
- Phase current faults
- Negative Sequence overcurrent
- Neutral Overcurrent
- Auto reclosing option

9.3. Spreadsheet of functions/data logging

The following spreadsheet provides an overview of the current power feeder protection, and gives details on what the new SCADA system shall input, output, alarm, and data store.

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Kotzebue Electric Association, Inc.
Table 9 - SCADA Data and Functions
Power Feeders

Line No	**Dwg Ref**	**Code**	**Name**	**Data or Control Device**	**Current Location**	**Com-ponent**	**General Function**	**Description**	**Current Make & Model**	**Current Setting & Meas Units**	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Feeder Controller	Local Display Real Time Data
1.0	N/A	N/A	Timestamp	data	N/A	time	system monitoring	Date and time	N/A	N/A			record	date time		
2.0	N/A	Unit #	Feeder Name	data	Substation	id	system monitoring	Name of power feeder Allowed values: Feeder # 1, Feeder # 2, Feeder # 3, Feeder # 4	N/A	N/A			record	name		
3.0	N/A	N/A	Feeder Status	data	N/A	feeder	system monitoring	Feeder status Allowed values: open or closed	N/A	N/A			record	status		status
4.0	unknown	N/A	Feeder Load Shed Priority	data	N/A	power	system monitoring	Priority level to shed feeder load Note: Current load shed sequence is Feeder # 1, Feeder # 3, Feeder # 2, Feeder # 4	N/A	priority			record	fixed priority		
5.0	unknown	N/A	Feeder Current Direction	data	Substation	power	system monitoring	Direction of current Allowed values: "Positive" for Feeders # 1, # 2, and # 3. "Positive" or "Negative" for Feeder # 4.	Unknown (KEA to verify part #)	N/A			record	pos or neg		
6.0	unknown	N/A	Feeder Voltage on Phase A	data	Substation	voltage	system monitoring	Feeder voltage on Phase A	feeder voltmeter	volts			record	volts		volts
7.0	unknown	N/A	Feeder Voltage on Phase B	data	Substation	voltage	system monitoring	Feeder voltage on Phase B	feeder voltmeter	volts			record	volts		volts
8.0	unknown	N/A	Feeder Voltage on Phase C	data	Substation	voltage	system monitoring	Feeder voltage on Phase C	feeder voltmeter	volts			record	volts		volts
9.0	unknown	N/A	Feeder Current on Phase A	data	Substation	current	system monitoring	Feeder current on Phase A	YEW AC ammeter, Catalogue No. 103131LSxx	Amps			record	Amps		Amps
10.0	unknown	N/A	Feeder Current on Phase B	data	Substation	current	system monitoring	Feeder current on Phase B	YEW AC ammeter, Catalogue No. 103131LSxx	Amps			record	Amps		Amps
11.0	unknown	N/A	Feeder Current on Phase C	data	Substation	current	system monitoring	Feeder current on Phase C	YEW AC ammeter, Catalogue No. 103131LSxx	Amps			record	Amps		Amps
12.0	unknown	N/A	Feeder VARs	data	Substation	voltage & current	system monitoring	Amount of volt-amp-reactants (vars) on feeder	YEW 3-ph 4-wire varmeter, Catalogue No. 103	vars			record	vars		vars
13.0	SUBST	WHD	Feeder Power Demand	data	Substation	power	system monitoring	Amount of power being demanded by feeder	YEW AC watthour demand meter, Catalogue No. 103251Cxxx	kW			record	kW		kW
14.0	FIBKR	BBC - ITE 51Y	Feeder Overcurrent Relay - 3 Phase	control	Substation	current	alarm and electrical connection	Disconnects feeder from buss system if current on three phases is exceeded (very inverse)	BBC - ITE 51Y, Catalogue No. 443T2241	Time Dial 01, Inst Setting 5.5, Feeder #1: Tap 2.5, CT 200:5; Feeder #2: Tap 2, CT 100:5; Feeder #3: Tap 2.5, CT 100:5; Feeder #4: Tap 3, CT 50:5;		alarm	record	alarm and set point	disconnnect feeder	status and alarm
15.0	FIBKR	unknown	Feeder Overcurrent Relay - Neutral	control	Substation	current	alarm and electrical connection	Disconnects feeder from buss system if current on neutral is exceeded (very inverse)	BBC - ?, Catalogue No. 443S2241	Unknown (KEA to verify setting)		alarm	record	alarm and set point	disconnnect feeder	status and alarm

Kotzebue Electric Association, Inc.
Table 9 - SCADA Data and Functions
Power Feeders

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com- ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Feeder Controller	Local Display Real Time Data
16.0	unknown	unknown	Feeder Under Frequency Timing Relay	control	Old Plant Bus	time	alarm and electrical connection	Delay period (adjustable) after an Under Frequency Relay trips to: allow time for a disconnection of a feeder from the buss system (timing relay delay set according to load shed priority); determine whether or not the system requires additional feeders to be disconnected; and disconnect the additional feeders if required. Note: See Under Frequency Load Shed Relay in Load Shed Table	Potter Brumfield	Unknown time (KEA to verify setting)		alarm	record	alarm and set point	part of disconnnect feeder	status and alarm
17.0	unknown	unknown	Feeder Disconnect	control	Substation	feeder	electrical connection	Feeder breaker is opened manually to disconnect the feeder from the buss system. This action may only be initiated manually by an operator via the SCADA Master controller or by an operator opening the feeder breaker.	Unknown (KEA to verify part #)	N/A	disconnect feeder may be initiated from SCADA manually		record	status	disconnnect feeder may be initiated locally	
18.0	unknown	unknown	Feeder Connect	control	Substation	feeder	electrical connection	Feeder breaker is closed manually to reconnect the feeder to the buss system. This action may only be initiated manually by an operator via the SCADA Master controller or by an operator closing the feeder breaker.	Unknown (KEA to verify part #)	N/A	connect feeder may be initiated from SCADA manually		record	status	connnect feeder may be initiated locally	
Load Shed Relay Data Below																
19.0	N/A	N/A	Timestamp	data	N/A	time	system monitoring	Date and time	N/A	N/A			record	date time		
20.0	N/A	Unit #	Load Shed Relay Name	data	relay	id	system monitoring	Name of under frequency load shed relay Allowed values: Feeders # 1&# 4, Feeders# 2&# 3	N/A	N/A			record	name		
21.0	unknown	unknown	Under Frequency Load Shed Relay	control	Old Plant Bus	frequency	alarm, electrical connection	Disconnects feeders from buss system if frequency is too low Note: Each frequency load shed relay can disconnect up to two feeders	Basler BE1-81, Catalogue No. TIE-EIC-AONIF	Trip Frequency 2 cycles/sec under 60 cycles/sec, Built-In Time Delay 10 cycles/sec		alarm	record	alarm	disconnect feeder	status and alarm
22.0	unknown	unknown	Load Shed Recovery	control	Old Plant Bus	frequency	electrical connection	After the Under Frequency Load Shed Relay disconnects one or more feeders from the buss system, the feeder breakers are reclosed manually to reconnect the feeders to the buss system. This action may only be initiated manually by an operator via the SCADA Master controller or by an operator closing the feeder breaker.	Unknown (KEA to verify part #)	N/A	connect feeder may be initiated from SCADA manually		record	sequence status	connnect feeder may be initiated locally	

10. Ancillary Systems Monitoring

Due to the variety of controllers and methods to monitor ancillary systems, no preliminary engineering connection drawings are included in the Contract. The Special Provisions discuss the individual inputs the Contractor must integrate into the system. The Contractor shall design detailed drawings during the design phase.

10.1. Jacket Water/Radiator System

The engine jacket water and radiator loop is currently controlled and monitored by an Automation Direct Koyo PLC. Refer to the Contract design drawings for a P & ID of the system, and the project reference drawings which shows the connections to the PLC. The SCADA system shall poll the data from the Koyo PLC to display and store at an HMI. The PLC rack has an H2-ECOM card in slot 7, which the SCADA system shall interface with. Consult with Automation Direct on the complete listing of available communication protocols available. An Ethernet based protocol should be the preferred method. It is recommended that the H2-ECOM card be replaced with an H2-ECOM-100 card to communicate via Modbus TCP. Refer to the project reference drawing E-1 for a detail of the PLC architecture and I/O. Request the PLC program from the Owner to determine the registers to poll data from.

The spreadsheet on the following pages details the information that requires display and data storage.

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Kotzebue Electric Association, Inc.
Table 10 - SCADA Data and Functions
Radiator Systems

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Local Display Real Time Data
1.0	N/A	N/A	Timestamp	data	N/A	time	system monitoring	Date and time	N/A	N/A			record	date time	
2.0	N/A	Unit #	Radiator Name	data	N/A	id	system monitoring	Name of radiator Allowed values: Radiador Closest to Old Office, Radiator Farthest from Old Office	N/A	N/A			record	name	
3.0	N/A	unknown	Radiator Status	data	radiator	radiator	system monitoring	Radiator status Allowed values: Ready, Operating, Maintenance, etc.	N/A	N/A			record	status	
4.0	N/A	unknown	Radiator Water Temperature In	data	radiator	radiator water	system monitoring	Temperature of water going into the radiator	Unknown (KEA to verify part #)	degF			record	degF	?
5.0	N/A	unknown	Radiator Water Temperature Out	data	radiator	radiator water	system monitoring	Temperature of water coming out of the radiator	Unknown (KEA to verify part #)	degF			record	degF	?
6.0	N/A	unknown	Accumulated Radiator Run Time	data	radiator	time	system monitoring	Total amount of time radiator has been running since installation (accumulated hours)	N/A	hours (accumulated)			record	hours (accumulated)	?
7.0	unknown	unknown	Radiator Water Low Temperature Alarm	control	N/A	heating water	alarm	Radiator water low temperature alarm	N/A	unknown degF	SCADA program	alarm	record	alarm and set point	?
8.0	unknown	unknown	Radiator Water High Temperature Alarm	control	N/A	heating water	alarm	Radiator water high temperature alarm	N/A	unknown degF	SCADA program	alarm	record	alarm and set point	?
9.0	unknown	unknown	VFD Frequency	data	radiator	radiator	system monitoring	Radiator Fan VFD Frequency	N/A	Hz			record	Hz	?

10.2. Air Pressure

The power plant has one air system for the Old Plant and another air system for the New Plant. Generally, the systems are connected and operate together, but they also have the capability to operate independently. If possible, the generator controller shall monitor the starting air pressure of each unit. Otherwise, the SCADA master controller shall provide monitoring of each generator units starting air pressure. The EMD units have air pressure sensors currently installed on the generator units. Contractor shall provide and install air pressure sensors for the three Caterpillar units, as they do not have sensors currently. A recommended sensor manufacturer is listed in the project Equipment List. Refer to Table 11 on the following page for the spreadsheet listing data and storage requirements.

On rare occasions, the air compressors receive power from the motor starters, but fail to run. The Contractor shall provide SCADA system inputs for monitoring the compressor starter contactors, located in the plant MCC. The SCADA system shall display whether or not an air compressor is running. If the air compressor contact is allowing the compressor to run and the generator air pressure falls below a set point, the SCADA system shall provide a compressor failed to run alarm. Discuss with KEA the alarm pressure set point values.

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Kotzebue Electric Association, Inc.
Table 11 - SCADA Data and Functions
Power Plant

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Local Display Real Time Data
1.0	N/A	N/A	Timestamp	data	N/A	time	system monitoring	Date and time	N/A	N/A			record	date time	
2.0	N/A	N/A	Plant Name	data	plant	id	system monitoring	Name of power plant Allowed value: KEA Power Plant	N/A	N/A			record	name	
3.0	unknown	N/A	Power Plant Power Generated	data	N/A	power	system monitoring	Amount of power being generated by Power Plant (a summation of: Total Diesel Generator Power Generated and Total Wind Generator Power Generated)	N/A	kW (totaled)			record	kW (totaled)	
4.0	unknown	N/A	Total Diesel Generator Power Generated	data	N/A	power	system monitoring	Amount of power being generated by diesel generators (a summation of Diesel Generator Power Generated)	N/A	kW (totaled)			record	kW (totaled)	
5.0	unknown	N/A	Total Wind Generator Power Generated	data	N/A	power	system monitoring	Amount of power being generated by wind generators (a summation of Wind Generator Power Generated)	N/A	kW (totaled)			record	kW (totaled)	
6.0	10G	SAP	Starting Air Pressure New Plant	data	N/A	air	system monitoring	Air pressure of air going into the starting motors on the EMD diesel generation units.	requires instrumentation/ transducer installation	psi			record	psi	
7.0	unknown	N/A	Starting Air Pressure Old Plant	data	N/A	air	system monitoring	Air pressure of air going into the starting motors on the CAT diesel generation units	requires instrumentation/ transducer installation	psi			record	psi	
8.0	unknown	N/A	Main Heat Loop Temperature to Heat Loads	data	N/A	heating water	system monitoring	Main heating water loop temperature entering heating loads.	requires instrumentation/ transducer installation	degF			record	degF	
9.0	unknown	N/A	Main Heat Loop Temperature from Heat Loads	data	N/A	heating water	system monitoring	Main heating water loop temperature leaving heating loads	requires instrumentation/ transducer installation	degF			record	degF	
9.0	unknown	unknown	Low Starting Air Pressure Alarm New Plant	control	N/A	air	alarm	Low air pressure alarm for air going into the starting motors on the EMD diesel generation units.	N/A	unknown psi	SCADA program	alarm	record	alarm and set point	
10.0	unknown	unknown	Low Starting Air Pressure Alarm Old Plant	control	N/A	air	alarm	Low air pressure alarm for air going into the starting motors on the CAT diesel generation units.	N/A	unknown psi	SCADA program	alarm	record	alarm and set point	
11.0	unknown	unknown	Main Heat Loop Low Temperature Alarm	control	N/A	heating water	alarm	Main heating loop low temperature alarm	N/A	unknown degF	SCADA program	alarm	record	alarm and set point	
12.0	unknown	unknown	Main Heat Loop High Temperature Alarm	control	N/A	heating water	alarm	Main heating loop high temperature alarm	N/A	unknown degF	SCADA program	alarm	record	alarm and set point	

10.3. Battery System

KEA has three independent 125 VDC sealed cell, control voltage battery systems. An individual system is located at the Old Plant, New Plant, and in the substation. Not included in the Table 12 spreadsheet, but also requiring monitoring is a 24 VDC black start battery for generator #7. The actual battery voltage and charging system voltage shall be monitored by the SCADA system. If values exceed alarm set points provided by the Owner, the SCADA system shall provide alarms. Currently there are only manual gauges on these systems. Provide and install 2 transducers for each battery system to monitor the battery voltage and the charging system voltage. Refer to the Equipment List for a recommended manufacturer of battery system transducers. Table 12 shown on the following page lists the battery system SCADA requirements.

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Kotzebue Electric Association, Inc.
Table 12 - SCADA Data and Functions
Battery Systems

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Local Display Real Time Data
1.0	N/A	N/A	Timestamp	data	N/A	time	system monitoring	Date and time	N/A	N/A			record	date time	
2.0	unknown	N/A	Battery Control System Name	data	N/A	id	system monitoring	KEA-assigned battery system name Allowed values: Old Plant Battery System, New Plant Battery System, Substation Battery System	N/A	N/A			record	name	
3.0	unknown	N/A	Battery Control System Voltage	data	various	system voltage	system monitoring	125VDC control system voltage	N/A	volts			record	volts	volts
4.0	unknown	N/A	Battery Charger Voltage	data	various	charger voltage	system monitoring	Battery charger voltage	N/A	volts			record	volts	volts
5.0	unknown	unknown	Battery Control System Low Voltage Alarm	control	N/A	system voltage	alarm	125VDC control system low voltage alarm	unknown	unknown voltage		alarm	record	alarm and set point	status and alarm
6.0	unknown	unknown	Battery Charger Low Voltage Alarm	control	N/A	charger voltage	alarm	Battery charger low voltage alarm	unknown	unknown voltage		alarm	record	alarm and set point	status and alarm
7.0	unknown	unknown	Battery Charger High Voltage Alarm	control	N/A	charger voltage	alarm	Battery charger high voltage alarm	unknown	unknown voltage		alarm	record	alarm and set point	status and alarm

10.4. Aftercooler/Emissions System

The generator aftercooler and emission system for units 10, 14, and 15 is currently controlled with an Automation Direct Koyo PLC. There is no emission system control for units 7, 11, and 12. The engine manufacturer has found that by reducing the temperature of the air going into the engine cylinders, output emissions are reduced. Cylinder input air temperature is reduced by operating the turbo charger after coolers on these engines with a cooling system separate from the jacket water cooling system.

The PLC system detects the system glycol temperature and provides an output signal to a variable speed drive controlling the radiator fan motor. The fan speed is controlled to return the input glycol back from the aftercooler at a user adjustable range from 90-100° F.

The SCADA system is only required to monitor and store the aftercooler and emissions system data, as the Koyo PLC will continue to control it. Similar to the radiator system, the PLC rack has an existing H2-ECOM communications card in slot 7. The Contractor shall connect the SCADA communication network to the card in slot 7 and poll the emissions system data as requested in Table 13 below. It is recommended that the installed H2-ECOM card be replaced with an H2-ECOM-100 card to communicate via Modbus TCP. The data shall be displayed on the SCADA system HMI’s and recorded. Refer to Reference Drawing E-2 for a wiring schematic of the system.

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Kotzebue Electric Association, Inc.
Table 13 - SCADA Data and Functions
Emissions System

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Local Display Real Time Data
1.0	N/A	N/A	Timestamp	data	N/A	time	system monitoring	Date and time	N/A	N/A			record	date time	
2.0	N/A	N/A	Pump Name	data	plant	id	system monitoring	Name of pump Allowed value: KEA Waste Heat Pump	N/A	N/A			record	name	
3.0	N/A	unknown	Pump Status	data	plant	pump	system monitoring	Pump status Allowed values: Ready, Operating, Maintenance, etc.	N/A	N/A			record	status	
4.0	N/A	unknown	Unit 10 glycol temp in	data	plant	glycol	system monitoring	Temperature of glycol entering generator unit 10	N/A	N/A			record	status	
5.0	N/A	unknown	Unit 10 glycol temp out	data	plant	glycol	system monitoring	Temperature of glycol exiting generator unit 10	N/A	N/A			record	status	
6.0	N/A	unknown	Unit 14 glycol temp in	data	plant	glycol	system monitoring	Temperature of glycol entering generator unit 14	N/A	N/A			record	status	
7.0	N/A	unknown	Unit 14 glycol temp out	data	plant	glycol	system monitoring	Temperature of glycol exiting generator unit 14	N/A	N/A			record	status	
8.0	N/A	unknown	Unit 15 glycol temp in	data	plant	glycol	system monitoring	Temperature of glycol entering generator unit 15	N/A	N/A			record	status	
9.0	N/A	unknown	Unit 15 glycol temp out	data	plant	glycol	system monitoring	Temperature of glycol exiting generator unit 15	N/A	N/A			record	status	
10.0	N/A	unknown	Radiator glycol temp in	data	plant	glycol	system monitoring	Temperature of glycol entering radiator	N/A	N/A			record	status	
11.0	N/A	unknown	Radiator glycol temp out	data	plant	glycol	system monitoring	Temperature of glycol exiting radiator	N/A	N/A			record	status	
12.0	N/A	unknown	VFD trip	data	plant	VFD	alarm	VFD trip alarm	N/A	N/A		alarm			
13.0	N/A	unknown	VFD Frequency	data	plant	VFD	system monitoring	VFD Frequency	N/A	N/A			record	status	
14.0	N/A	unknown	Expansion tank hi limit	data	plant	level switch	alarm	Expansion tank hi limit switch	N/A	N/A		alarm			
15.0	N/A	unknown	Expansion tank low limit	data	plant	level switch	alarm	Expansion tank low limit switch	N/A	N/A		alarm			

10.5. City Water Waste Heat

A city water waste heat system has been installed at KEA. The city water enters the building power plant from the street main and is routed through an existing heat exchanger. The jacket water radiator system has been tapped to provide heated glycol to the heat exchanger. Table 14 - City Water Heating System details the SCADA monitoring and data logging requirements, and drawing KSS-ME-2004 sheet 1 shows a P & ID of the city waste heat system. There are several points that KEA requires the SCADA system to monitor, as listed in Table 13. A Koyo 250 Series PLC is currently installed to monitor and control the waste heat system. The SCADA system shall poll data from this PLC via an Automation Direct H2-ECOM card, which is already installed. However, it is recommended that the existing H2-ECOM card be replaced with an H2-ECOM-100 card to communicate via Modbus TCP.

The city water waste heat system has an Onicon BTU meter installed, which the Automation Direct PLC gathers data from. The SCADA system shall poll the BTU meter information from the Automation Direct PLC.

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Kotzebue Electric Association, Inc.
Table 14 - SCADA Data and Functions
City Water Heating System

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Local Display Real Time Data
1.0	N/A	N/A	KEA Glycol Loop Temperature In	data	N/A	glycol	system monitoring	Temperature of KEA glycol going into heat exchanger	N/A	degF			record	degF	?
2.0	N/A	N/A	KEA Glycol Loop Temperature Out	data	N/A	glycol	system monitoring	Temperature of KEA glycol coming out of heat exchanger	N/A	degF			record	degF	?
3.0	N/A	N/A	City Water Flowrate	data	N/A	water	system monitoring	City's water flowrate	N/A	gpm			record	gpm	?
4.0	N/A	N/A	City Water Temperature In	data	N/A	water	system monitoring	Temperature of City water going into heat exchanger	N/A	degF			record	degF	?
5.0	N/A	N/A	City Water Temperature Out	data	N/A	water	system monitoring	Temperature of City water coming out of heat exchanger	N/A	degF			record	degF	?
6.0	N/A	N/A	Transferred Heat	data	N/A	heat	system monitoring	Amount of heat currently being transferred from KEA to City	N/A	btus/hour			record	btus/hour	?
7.0	N/A	N/A	Accumulated Transferred Heat	data	N/A	heat	system monitoring	Amount of accumulated heat transferred from KEA to City	N/A	btus (accumulated)			record	btus (accumulated)	
8.0	N/A	N/A	Glycol Loop Pump Frequency	data	N/A	Hz	system monitoring/alarm	Frequency from the glycol loop pump VFD.	N/A	Hz		alarm	record	Hz	

10.6. Fuel System

KEA has three bulk fuel diesel storage tanks. Two of the tanks are rated for 1 million gallon storage and one is rated for 150,000 gallon storage. All three tanks have Varec figure 2500 automatic tank gauges, model 8512. Included with the tank gauge are 4-20 mA current output transmitters, model 77-8200. These units are powered by 120 VAC with an internal power supply. Data from the transmitters shall be monitored and logged in the SCADA System, as requested in Table 14 on the following page.

Temperature of the (2) one million gallon diesel storage tanks shall also be monitored and logged. Currently no temperature probes exist in any of the tanks. The easiest installation option is to mount a temperature sensor device into the tank from the top, such as a Varec model 9909 average temperature sensor. The Varec 9909 is the preferred device, as it averages the fuel temperature throughout the tank. However, KEA is open to other options that the Contractor may submit for approval.

KEA has leak detection systems on each of the bulk fuel tanks. One of the million gallon tanks and the 150,000 gallon tank have passive systems installed under the tanks with detection tubes. The other 1 million gallon tank has an active system with petroleum sensors installed under the tank. This system has a logger and alarm arrangement located in the KEA plant control room. The unit is an FCI Environmental CMS 5000, with (3) DHP-100 probes. FCI Environmental dials into this system weekly via modem to download the unit's data. Unfortunately, the CMS 5000 does not have any features to allow a SCADA system to poll the gas particulate values. In the future KEA may replace the unit with a CMS 4000 which has analog outputs for SCADA system monitoring.

For now the Contractor shall monitor alarms only, via a Conxall 9 pin plug on the CMS-5000. The unit requires 12 VDC for monitoring. The pinout below lists all outputs.

Pin 1 – Audio alarm
Pin 2 – Flashing Lamp
Pin 3 – Green LED, logging lamp
Pin 4 – Red LED, low battery
Pin 5 – Blinking LED, equipment failure
Pin 6 – Spare
Pin 7 – Input, alarm acknowledge
Pin 8 – Ground
Pin 9 - +12 VDC

Inside the plant, KEA requires additional fuel system monitoring before fuel gets to the generator day tanks. The Contractor shall provide and install two pressure sensors for the incoming fuel lines from the tank farm. The pressure sensors shall be located inside the plant after the fuel lines enter the building. Secondly, the Contractor shall provide and install a temperature sensor for one of the two incoming lines before the fuel lines reach the day tank pumps. The three day tank pumps shall be monitored for an off/running status via their respective starter contact, and also by a Contractor provided flow switch downstream of each pump.

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Kotzebue Electric Association, Inc.
Table 15 - SCADA Data and Functions
Bulk Fuel Storage and Leak Detection Systems

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Local Display Real Time Data
1.0	N/A	N/A	Timestamp	data	N/A	time	system monitoring	Date and time	N/A	N/A			record	date time	
2.0	N/A	Unit #	Fuel Tank Name	data	various tanks	id	system monitoring	Name of bulk fuel tank Allowed values: New Million, Old Million, 150,000 Gallon	N/A	N/A			record	name	
3.0	N/A	unknown	Fuel Temperature	data	various tanks	fuel	system monitoring	Fuel temperature	N/A	degF			record	degF	?
4.0	N/A	unknown	Bulk Fuel Tank Level	data	various tanks	fuel	system monitoring	Fuel tank level	Varec figure 2500 automatic tank gauge Model 8512	ft-in			record	ft-in	?
5.0	N/A	unknown	Day Tank Level	data	Day Tanks	fuel	system monitoring	Fuel tank level	N/A	requires transducer			record	inches	?
6.0	N/A	unknown	Day Tank Low Fuel Level Alarm	control	Day Tanks	fuel	alarm	Low fuel tank level alarm. Receive signal from fuel level transmitter and set low alarm point in SCADA system.	N/A	requires transducer			record	alarm and set point	status and alarm
7.0	N/A	unknown	Day Tank High Fuel Level Alarm	control	Day Tanks	fuel	alarm	High fuel tank level alarm. Receive signal from fuel level transmitter and set high alarm point in SCADA system.	N/A	requires transducer		alarm	record	alarm and set point	status and alarm
8.0	N/A	unknown	Fuel Leak Detection Alarm	control	New Million	fuel	alarm	Hydrocarbon sniffer alarm for New Million Tank	Unknown (KEA to verify part #)	Unknown (KEA to verify setting)		alarm	record	alarm and set point	status and alarm
9.0	N/A	unknown	Plant Fuel Temperature	data	Plant Entrance	fuel	system monitoring	Incoming Fuel Temperature measured inside Power Plant	requires sensor	degF			record	degF	
10.0	N/A	unknown	Day Tank Pump Contactor Status	data	MCC	fuel	system monitoring	Day Tank Pumps Off/Run status via starter contactor.	Unknown (KEA to verify part #)	N/A				on/off	
11.0	N/A	unknown	Day Tank Pump Flow Status	data	After Day Tank Pumps	fuel	system monitoring and alarm	Day Tank Pumps flow status.	requires sensor	N/A		alarm		on/off	

10.7. Plant Heating System

The plant heating system utilizes the waste heat from the generators to heat the power plant. Each generator has an individual heat exchanger which transfers heat to the plant waste heat loop. The heated glycol is sent to multiple water to air heat exchanger locations in the plant, office buildings, fuel system, and line warehouse. Refer to drawing KSS-ME-2005 for a P & ID detail of the plant waste heat system. KEA requires the SCADA system to monitor the plant waste heat system temperatures before and after the various heating loops. Contractor shall install (2) Weld-o-let NPT fittings and RTD transducers to remotely monitor and log the plant waste heat temperature. In addition, (1) NPT and pressure transducer shall also be installed in the system. Coordinate draining of glycol in the pipe with the Owner before installation. Drawing KSS-ME-2005 sheet 1 shows the locations where the RTD's and pressure transducer shall be installed.

Wire the RTD's back to the master PLC/controller or to the nearest I/O module for incorporation into the SCADA system. Refer to Table 11 shown previously for the requirements of plant waste heat SCADA monitoring and logging.

10.8. Power Meters

During the implementation of the SCADA system, the Contractor is responsible for procurement and installation of multiple power metering devices capable of data collection. Wind farm metering shall consist of a single meter to replace the existing Landis and Gyr unit, which does not have a communications option. Refer to Table 15 – Energy Meters and Table 9 – Power Feeders for data collection information. The individual components below shall be responsible for providing power flow information for the KEA system. All meters measuring data on feeder four shall have the capability to measure bi-directionally. The meters shall have an accuracy of greater than within 0.2 percent.

Currently the meters at KEA provide kWh values updated every fifteen minutes. The SCADA system shall provide yearly, monthly, daily, and hourly kWh totals from each meter and display on the HMI's. The SCADA system shall update these values at a minimum of fifteen minute intervals.

- **Feeder Relays**
  - Three phase RMS phase-to-neutral and phase-to-phase voltages
  - Three phase RMS value of current
  - Three phase RMS value of active power
  - Three-phase measurement of reactive power
  - KWh per hr/month distributed by feeder (calculated by SCADA)
    - Peak
    - Average

- **Diesel Generator Unit Meters**
  - Three phase RMS phase-to-neutral and phase-to-phase voltages
  - Three phase RMS value of current
  - Three phase RMS value of active power
  - Three-phase measurement of reactive power

- KWh per hr/month for each generator
  - Peak
  - Average

- **Diesel Generator Protective Relays**
  - Similar information as Diesel Generator Unit Meters

- **Wind Farm Unit Meter**
  - Three phase RMS phase-to-neutral and phase-to-phase voltages
  - Three phase RMS value of current
  - Three phase RMS value of active power
  - Three-phase measurement of reactive power
  - KWh per hr/month for wind farm
    - Peak
    - Average

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Kotzebue Electric Association, Inc.
Table 16 - SCADA Data and Functions
Energy Meters

Line No	Dwg Ref	Code	Name	Data or Control Device	Current Location	Com-ponent	General Function	Description	Current Make & Model	Current Setting & Meas Units	SCADA Perform Control Function	SCADA Alarm	SCADA Record Data into Data Historian	SCADA Display Real Time Data	Local Display Real Time Data
1.0	N/A	N/A	Timestamp	data	N/A	time	system monitoring	Date and time	N/A	N/A			record	date time	
2.0	unknown	N/A	Energy Meter Name	data	N/A	id	system monitoring	KEA-assigned meter name Examples: Windsite Prime Meter; Feeder # 4; etc.	N/A	N/A			record	name	
3.0	unknown	N/A	Accumulated Metered Energy	data	various energy meters	energy	system monitoring	Amount of accumulated metered energy	N/A	kWh (accumulated)			record	kWh (accumulated)	kWh (accumulated)

Note: If SCADA kW and timestamp are accurate enough for billing purposes, kWh data may be calculated in SCADA rather than taken from the kWh meters.

10.9. Fire Alarm System

KEA plans on installation of a fine water mist fire suppression system in the future. This system would protect the generators in the event of a building fire. The SCADA system master controller shall have available free memory and the capability to monitor a smoke alarm input signal, and shut down the generators in the event of a fire. No implementation shall be involved in the SCADA system Contract.

10.10. Station Service and Jack Buss

Besides the generator and feeder breakers, there are five other 5 kV circuit breakers that require monitoring by the SCADA system. The five circuit breakers consist of two station service breakers, two bus main breakers, and one jack buss breaker that ties the old and new plant switchgear together. The SCADA system shall monitor the open/closed condition of the circuit breakers and display the status at the HMI's. The SCADA system shall also record and timestamp when these breakers open and close.

11. SCADA Master Controller

The SCADA master controller shall be an industrial PC based or PLC based processor that has the capability to collect data from and send commands to the engine-generator controllers, the feeder controllers, and the wind turbine controllers. In addition, the SCADA master controller shall collect data from ancillary systems such as, but not limited to fuel tank levels, fuel temperatures, fuel meters, power meters, and radiator cooling system operation. The SCADA master and the SCADA system in general shall be designed in a modular fashion so that replacement of a unit is a simple process. The master controller shall have a minimum 30 percent spare memory capacity for future additions to the SCADA system.

In addition, the SCADA master controller shall have the capacity to monitor load conditions and operate the power plant automatically. The SCADA master controller shall provide for prioritization of alarms from any of the inputs and provide alarm displays and acknowledgment controls. The SCADA master shall provide for sequence of event recording of alarms for event analysis. The SCADA master controller shall have the ability to function with some units in manual and others in automatic mode.

The SCADA Master controller should be located in the power plant's sound proof room. The Contractor may request approval of an alternative installation location from the Owner.

12. Communications

12.1. Communication hardware

The communications network is schematically detailed on the Contract Drawings, and recommended parts are listed in the Equipment list. The general philosophy behind the communications hardware is to utilize fiber optic cable for longer distances and to reduce noise interference, while utilizing an Ethernet system for shorter distances. The hardware shall be designed for industrial use. Protocol converters shall be used wherever necessary to allow an individual device to talk with the SCADA system network.

As discussed in Section 8 of the Special Provisions, wind farm communication will consist of a wireless Ethernet radio link, provided by the contractor.

12.2. Communication protocol

There are two primary communication types with regards to devices in the power industry, which are Modbus and DNP 3.0. In general, devices installed at the KEA site should communicate in at least one of these two protocols. As some proprietary systems are based around a single protocol which is not Modbus or DNP 3.0, other protocols are allowed to be utilized, upon final approval by the Engineer. However, if devices with multiple protocol types are available, the Contractor shall submit the device available with Modbus or DNP 3.0.

13. Human Machine Interface (HMI)

13.1. HMI requirements

The HMI units shall either consist of a PC or touch screen capable of surviving for many years in an industrial environment.

13.2. HMI locations

The SCADA system Contractor shall provide HMI's for the following locations:

Old Plant Switchgear – A single HMI shall be located at the old plant switchgear to monitor and control the Caterpillar Diesel units. If the HMI cannot be easily viewed from the manual generator controls or the manual generator controls are mounted at a location other than the switchgear, an individual HMI shall be used for each individual generator. At a minimum, the Old Plant Switchgear HMI needs to display the complete operational data of the Caterpillar generators, such as power output, alarms, generator status, etc.

New Plant Switchgear – A single HMI shall be located at the new plant switchgear to monitor and control the EMD Diesel units. If the HMI cannot be easily viewed from the manual generator controls or the manual generator controls are mounted at a location other than the switchgear, an individual HMI shall be used for each individual generator. At a minimum the New Plant Switchgear HMI needs to display the complete operational data of the EMD generators, such as power output, alarms, generator status, etc.

Plant Operations – An HMI which can monitor and control the complete SCADA system shall be provided and installed in the power plant's sound proof room. The Plant Operations HMI must provide the capability to control and monitor the diesel generators, wind turbines, feeders, and ancillary systems. The HMI shall also allow the user to trend real time and up to 6 months worth of operating data.

Wind Farm Site – An HMI shall be located at the wind farm to monitor and control the wind turbines when an operator or technician is at the wind farm. The site shall display and control the wind farm turbines at a minimum.

KEA Office – An HMI shall be located at the main office as directed by KEA. Setup the HMI to have the same characteristics as the Plant Operations HMI, allowing full system operations and trending. The HMI unit shall be password controlled to limit access to authorized users only.

KEA requires the system to be accessible remotely via DSL/Cable router. Provide secure access to the KEA Office HMI for KEA or third party observation and maintenance. The KEA office is wired with an Ethernet network with internet access. Consult with KEA for a location to connect into the network.

14. Data Historian

The Data Historian shall collect and store data from the SCADA System on a time-stamped basis to allow for trending of operational parameters, and the generation of periodic reports. KEA will manually print the reports, but the data historian shall organize the data as listed below:

- Daily Engine Log
- Daily Feeder Log
- Month-End Plant Report
- Monthly Diesel/Wind Comparison

Samples of current reports can be obtained from KEA upon request. The successful bidder shall work with KEA on the format of the reports generated and what data is required.

The SCADA system shall store the following data, which is refined in the individual system descriptions shown previously:

- Power meters
- Generator operating data
- Generator alarms
- Wind turbine status and alarms
- Feeder status and alarms
- Plant heat loop temperature and provide low and high temperature alarm capabilities
- Diesel unit starting air pressure
- Station batteries and chargers
- Bulk fuel tank levels and fuel temperatures in the bulk fuel tanks and provide low and high level alarm capabilities
- Bulk fuel tank leak detection system
- Radiator cooling system
  - Display fan operating condition (on/off)
  - Provide fan run times
  - Radiator inlet and outlet temperatures and provide low and high temperature alarm capabilities

15. Hardware and Software Manufacturers

15.1. Hardware Component Manufacturers

The hardware section below lists component manufacturers that are recommended for the KEA SCADA system. Each component section lists several acceptable manufacturers, and the primary manufacturer used in the Equipment List. The listing below is only for major components. The Contractor is required to provide submittals for the items chosen from the below manufacture and the other components used not listed here. Refer to the Technical Specifications for submittal procedures.

Note the list below does not include proprietary system components. A successful proprietary system bidder shall provide submittals as required in the Technical Specifications, disregarding PLC components listed below.

1. PLC Components

- Allen-Bradley
- GE Fanuc
- Schneider Electric (Modicon)
- Siemens
- Automation Direct

Manufacturer used in Equipment List: GE Fanuc

2. HMI Hardware

The list below covers both PCs and touch screens. It should be considered more of a recommendation list, as there are a vast number of companies that provide PCs and touch screens. The HMI hardware submitted should be from a reputable manufacturer that has been in the business for at least 5 years.

- Wonderware
- Maple Systems
- Xycom
- Dell
- Gateway

Manufacturer used in Equipment List: Wonderware

3. HMI Software

- Wonderware

- Rockwell Automation
- GE Fanuc

Manufacturer used in Equipment List: Intouch by Wonderware

4. Generator voltage controllers

- Basler DECS-200 is the only unit permitted for generator voltage control

5. Generator governors

- Woodward 2301D is the only governor allowed, unless the SCADA system uses proprietary controls.

6. Protective Relays

- Schweitzer Engineering Labs Inc.
- General Electric
- Basler

Manufacturer used in Equipment List: Schweitzer Engineering Labs

7. Communication Hardware

The list below contains a variety of recommended communication manufacturers for Ethernet, fiber optic communications, and protocol conversion. Other manufacturers besides the list below are permitted, provided they are designed for industrial use and meet the requirements in the Technical Specifications.

- Moxa
- Lantronix
- Sixnet
- Hirschmann
- Linksys (office area location)
- Netgear (office area location)

Manufacturer used in Equipment List: Moxa

16. Switchgear Design and Installation

The Contractor shall provide a switchgear design package and bid documents as a part of this Contract under bid line Item "Power Plant Switchgear Design". The switchgear shall be configured to accommodate the new SCADA devices, protection and control, generator control, as well as modern metalclad indoor equipment. Circuit breakers shall be vacuum type. All relays shall be microprocessor-based solid state relays, utilizing the same manufacturer as the relays chosen for the SCADA system. All relay current, voltage, and contact input/outputs shall be installed through a test switch, ABB FT-1 or approved equivalent. Bus configuration shall be equivalent to the existing configuration as shown on drawing KSS-EL-0400.

The existing bus is rated for 600 and 800 amps; however, the new bus for both the old and new plants shall be rated for 1200A continuous. Base the switchgear fault current ratings on the assumption that a 2.8 MW generator is present at each of the six generator set locations and two units are at full load at each plant. The bus tie breakers and generator breakers are the only units requiring protective relays. Station service breakers shall provide overcurrent protection for the downstream transformer and conductors. Provide power metering for both of the station service feeds.

The switchgear design package shall contain, at a minimum, the following items: one line drawings, three line drawings, DC schematics, elevation drawings, and specifications. The documents shall indicate a specific design by the Contractor, and shall not be a "performance-based" design or specification. The design shall be utilized for procurement by KEA, so the design must be performed by or under the direction of an electrical engineer registered in the State of Alaska. The Contractor shall be responsible for coordinating three KEA reviews of the switchgear bid documents at 60%, 90%, and final milestones. The Contractor shall also provide engineering support to KEA in evaluating submittals and answering questions from vendors during the bid process. Any additional work that KEA may deem appropriate to be done, that is deemed by KEA, and at KEA's sole discretion, to be out of the scope of this project shall be billed at the hourly Direct Labor Rates the Contractor has provided as part of the Bid.

After KEA has procured the switchgear and shipped it to the site, the Contractor shall install the switchgear. The Contractor shall coordinate switchgear replacement with KEA to minimize downtime and outages. Installation shall be done by a licensed electrical contractor in the state of Alaska.

17. SCADA System Automatic Dispatching of Units

One of the major goals behind the implementation of a new KEA SCADA system is to burn as few gallons of diesel fuel possible, while running the diesel generators at their greatest efficiency. The primary method to reduce fuel usage is to utilize as much wind power available, which should be the primary thought while designing the automation system. The secondary goal is to operate the generator units at their highest efficiency to maximize power produced per gallon of diesel fuel.

KEA plans on reaching higher penetration rates from the wind farm in the future, which means diesel unit dispatching may change. The SCADA system shall have the flexibility for modification of the dispatch configuration, to obtain the greatest power system efficiency now and in the future. Ideally, the system should be configured to allow KEA and the operator the ability to adjust operating set points based on seasonal changes, load characteristics, and wind farm production. For the initial system installation, the SCADA system should provide automation as described in the following guideline sections below. However, the guidelines are not exact. The Contractor shall meet with KEA during the programming process to determine the exact operating characteristics of the SCADA system. During the commissioning process, the Contractor shall fine tune the system for optimum operation.

17.1. Primary system operation

For greatest efficiency based on highest kWH per gallon of fuel consumed, the EMD generator units should run between 75 to 100% of the unit's rated kW. The Caterpillar generator units have a broader range of recommended efficiency from 50 to 100% of rated kW. Fuel consumption versus output is fairly linear throughout this range.

A typical average load on the KEA system is approximately 2500 kW. The highest peak load seen in the year 2003 was 3730 kW. Nighttime and early morning loads fall between 1600-2000 kW.

When comparing the data above and the current generation equipment, it is apparent only one operating structure is the best fit for generating efficiency. The bulleted items below describe how the new SCADA system shall control KEA's generator system. The set point references provided are intended to provide an approximate value for estimation purposes. During implementation, exact set points shall be discussed and agreed upon with KEA.

1. A majority of the time, a single EMD unit shall provide the base load power for the system, which is the current methodology at KEA.

2. When the system load is greater than 75% of the EMD rated kW, the SCADA system shall utilize all power available from the wind farm.

3. If the system load increases to greater than 95% of the EMD rated kW, the SCADA system shall automatically start one Caterpillar unit. To maximize efficiency under this condition, the Caterpillar unit shall baseload between 40 to 50% of its rated kW, with the wind farm also providing the most power available. The EMD will vary its output to compensate for load and wind farm variations. This transition typically occurs during the mid-morning hours.

4. When the load decreases to less than 85% of the EMD rated kW, the SCADA system shall transfer load from the Caterpillar online unit to the EMD. Shut down the Caterpillar unit after unloading. The EMD and the wind farm will provide system power until a Caterpillar unit is required again. This transition typically occurs during the evening hours.

5. If one EMD and the wind farm are the only units running, the wind farm should still provide its maximum available power to the system. Even though the EMD will be less efficient running below 75% of rated, KEA will still get a greater benefit from utilizing wind power versus running a generator at the greatest efficiency. Running below 75% of the EMD rated kW typically only occurs during the late evening and early morning hours. In the future when the system load is less than 75% of the EMD rated kW, the SCADA system shall have the capability to control load dumps to bring the load up to 75% of the EMD rated kW. There are currently no load dumps installed, but KEA has future plans to install them.

6. At no time should a generator be loaded less than 30% of its rated kW for extended periods. Running at a greater load than 30% of the unit's kW prevents wet stacking or carbonizing. If a generator is running below 30% its load shall be transferred to another generator if possible, or wind turbines should be shut down.

17.2. EMD Automatic Dispatch

Currently, one EMD can meet a majority of the KEA load, supplemented at peak loads by a Caterpillar unit. Under most cases, a Caterpillar unit should be the first unit to automatically dispatch for an increase in load. Currently, there are two reasons which require the automatic dispatch of an EMD unit. The first reason is to transfer units when one unit has a critical alarm. The SCADA system shall bring a second EMD online when the running unit sends a critical alarm and transfer load. The second reason is when an EMD unit has run for a set period of continuous time, it shall transfer load to another unit to cycle the units. The SCADA system shall have an operator adjustable set point where after so many hours the SCADA system transfers load to the next available EMD. In the transfer process, the SCADA system shall incrementally transfer the load at a slow ramp up/down rate to softly load and unload each respective unit.

17.3. Manual dispatch option

During the midnight hours there is the possibility that the wind farm and two Caterpillar units could meet the system demand until mid morning. Operating in this fashion would be at the discretion of the KEA operator, but it is an option which could provide a higher kW/gallon of fuel ratio than running one EMD at lower efficiency. This option could be useful when the wind farm is producing a significant amount of power, and the system is lightly loaded. To operate in this condition, the load must be below the combined rated kW of the two online Caterpillar units. Upon successful award of the bid, discuss this option with KEA, and implement if requested.

18. Programming/Configuration

In general, each controller shall be responsible for the individual units I/O, and independently control the unit or system it is pertaining to. The individual controllers shall provide a block of memory for data transfer between the master SCADA controller and the individual unit controller. The SCADA system logic shall be well commented, so that a third party can follow the logic. Refer to the Technical Specifications Division 17 for more requirements regarding SCADA system programming.

19. Project Schedule and Generator Schedule of Outages

In order to minimize the impact to KEA’s operation, it is expected that site testing, and commissioning will be performed in a sequence that allows for installation of system components without effecting the power system operations. Each generator controller must be installed and commissioned one at a time to allow the available operation of the other units. A suggested sequence of installation is shown below. Confirm sequence of events with KEA before and during installation and commissioning.

Start

- Master SCADA Controller
- Power Plant and Office HMI’s
- Power Plant communications network
- Wind turbine communications network (depending on weather conditions)

- Wind turbine HMI
- Feeder relays and control
- Commission wind system, radio link to master controller operational
- Feeder relays and controller
- Generator Unit #7
- Generator Unit #11
- Generator Unit #12
- Generator Unit #10
- Generator Unit #14
- Generator Unit #15
- Ancillary Systems Integration

Finish

To facilitate upgrades the Contractor shall be allowed to take generators off line for installation and testing. The contractor shall provide an estimated schedule of outages with his work schedule. Outages shall be constrained by the following:

- Only one generator shall be out of service at a time
- Contractor shall provide one week notice for scheduled generator outages.
- Contractor shall be allowed two weeks for generation outages.
- KEA & Contractor will then have one week additional week for testing of modified generators. Upon satisfactory acceptance testing, Contractor will then be allowed to take the next generator off-line.

20. System Operations

The following sections describe to the Contractor how individual items in the plant are currently operating, and how the Contractor integrates these items into the SCADA system

20.1. Diesel Units 10, 14 and 15 - Pre and Post Lube

Before SCADA system implementation

When the unit master switch is in the off position no pre lube operation is taking place.

When the unit master switch is either in the Local or Remote position and the unit is off, a pre lube time delay (PLTD) relay controls the pre lube operation. The PLTD insures the pre lube pump remains on until the unit is running. Once the engine is running an oil pressure switch opens, turning the pre lube pump off. If the unit has just been turned off, a soak back time delay (SBTD) relay insures the pre lube pump continues to circulate oil for a fixed amount of time even if the master switch is turned off. In general the master switch is left in the local position so that even if the unit is not running it is always being pre lubed and kept warm.

The pre lube operation starts an electric pump that delivers oil from the engine sump to the oil filter housing where it is routed through the oil cooler and therefore heated by the engine preheat system. From the oil cooler the oil is then routed to the turbo charger. In addition, if a manual valve is opened, oil is also circulated to the engine top deck which helps keep the entire engine warm.

After SCADA system implementation

Units 10, 14 and 15 will be automatically SCADA dispatched engines. After a unit has gone through the daily blowdown procedure, the plant operator shall place the unit mode switch in the automatic position and the existing pre and post lube operations will be accomplished by the generator controller I/O.

The SCADA System shall include status indications confirming that the pump motor has been turned on and is operating in remote or manual. The automatic engine start shall be conditional upon successful operation of the pre and post lube system.

20.2. Diesel Units 7, 11 and 12 - Pre and Post Lube

Before SCADA system implementation

Engine generators 7, 11 and 12 are pre lubed now as follows. When the engine is to be started the operator depresses the start button and an air driven pre lube pump starts. Once the oil pressure reaches 30 the starting air valve operates and actuates the flow of air to the starter. When the operator stops depressing the start pushbutton the pre lube pump stops.

After SCADA system implementation

Units 7, 11 and 12 will be automatically SCADA dispatched engine generators. Therefore, the pre lube process they currently undergo will need to be automated by the following steps:

When the unit mode switch is in the automatic position, and the determination has been made by the SCADA load control system or the plant operator to start the unit, the pre lube process shall commence. The generator controller shall monitor the oil pressure, and when it reaches greater than 30 psi, it shall open the air start valve. As soon as the engine starts, the generator controller will shutdown the pre lube pump and close the air-starting valve.

20.3. Diesel Units 10, 14 and 15 – Pre-Heat System

Before SCADA system implementation

After an engine has been shut down and the water temperature has been allowed to cool down below 170°F, the engine three-way thermostatic control valve closes. After the engine continues to cool to below 120°F, three valves are manually operated on the engine, listed below:

- A valve in the 2” line located on the top of the engine connecting the unit to the expansion tank is closed.
- A valve in the 2” AMOT bypass line is opened.
- A valve in the 2” line from the heat loop to the pre heat pump is opened.

After the three valves are operated, the operator turns on the pre heat pump switch on the mechanical panel and starts the pre heat pump. The above procedure is reversed just prior to starting.

After SCADA system implementation

The when the unit mode switch is in the automatic position and the engine has cooled below 120° F, the SCADA system shall open the three valves that were manually operated before the SCADA system implementation. The Contractor shall provide and install the components to automate the valves. The motor operated valve shall be equipped with auxiliary position switches, which will be used to indicate in SCADA that the valve is either in the opened or closed position. The motor operated valve shall be equipped with limit switches that will stop the motor operation when the valve is fully open or fully closed.

After the valves have been opened, the SCADA system shall start the pre heat pump motor. The procedure is the opposite during starting. The three aforementioned valves will be closed and the engine started. Once the engine has started, the preheat pump shall be shut off by the controller.

Regardless of the generator being in automatic or manual, status of the pre heat pump motor shall be displayed by the SCADA system HMI.

20.4. Diesel Units 7, 11 and 12 – Pre-Heat System

Before SCADA system implementation

After a Caterpillar engine has been shut down and has time to cool sufficiently, the engine three-way thermostatic control valve automatically closes. A valve that allows bypass of the thermostatic control valve is manually opened to the main radiator circulating system. The water pressure from this line is sufficient to circulate water through the engine and keep it warm. This operation is reversed just prior to starting.

After SCADA system implementation

The Caterpillar units will be SCADA dispatched engine generators and therefore the pre-heat process they currently undergo will need to be updated to automatic operation as follows**:**

The existing pre-heat by-pass valve will need to be retrofitted with a motor operated valve, which will close as part of the standard start up dispatch process and will open as part of the normal temperature pre heat process. The motor operated valve shall be equipped with auxiliary position switches, which will be used to indicate in SCADA that the valve is either in the opened or closed position. The motor operated valve shall be equipped with limit switches that will stop the motor operation when the valve is fully open or fully closed. The valve will be opened and closed in the same time period before SCADA implementation.

20.5. Diesel Units 10, 14, and 15 Blow Down Procedure

Before SCADA system implementation

If one of units 10, 14 or 15 is to be started, an operator manually opens the blow down petcock on each cylinder. With the engine run switch in the off position, the operator then operates a manual air by pass valve which provides air pressure to the air starting motors and turns the engine over. Once the unit has turned over several times, the operator closes the air starter by pass valve and the engine stops turning over. The operator then proceeds to close each blow down petcock on each cylinder and can proceed with starting the engine. The purpose of this blow down procedure is to prevent a potential cylinder liquid lock, which could occur if liquids leak or condense in a cylinder and the engine is turned over rapidly.

After SCADA system implementation

Units 10, 14 and 15 are SCADA dispatched engines. However, the engines must go through a manual blow down procedure daily before starting. The Remote/Local/Off switches for the EMD units require a fourth setting called Blowdown. To start the blowdown process, the operator will go to the generator control panel and switch the unit into blowdown mode. The petcocks will be manually opened by the operator. For a period of 5 to 15 seconds, the operator will hold the start button to turn over the engine. When in blowdown mode, the generator controller must prevent the unit from actually starting.

After the blowdown procedure is complete, the operator will close the petcocks and turn the switch to automatic. The SCADA system can now automatically dispatch the unit for a period of 24 hours. After 24 hours, the generator must go through another blowdown cycle.

20.6. Units 10, 14, 15 Start/Stop Procedure

Before SCADA system implementation

When one of these engines is to be started:

- The blow down procedure is completed.
- The pre-heat system, which should have been in operation, is turned off.
- Prior to starting an engine, the determination needs to be made on what governor operating mode to run in and the Droop/Isoch switch on the mechanical panel is manually placed in the proper position.
- Pre-lube should have been in operation so the engine should be lubed and warm.
- The Idle/Rated switch on the mechanical panel is manually placed in Idle.
- The run switch on the mechanical panel is manually placed in the run mode. A contact on the run switch starts the fuel pump.
- The start pushbutton on the mechanical panel is depressed and held for several seconds. This actuates the air solenoid valve, which opens and delivers air to

the air starters. The engine starts and the governor brings the engine to idle speed.

- Protection against an inadvertent re-attempt of the start system when the unit is operating is provided by a crank delay relay contact (CDR).
- Protection against starting the engine with any existing mechanical or electrical faults is provided by an engine Fault Relay Contact (EFR).
- Once the engine has been run at idle speed for a sufficient time too fully warm up, the operator manually switches the Idle-Rated switch, located on the mechanical panel, to Rated. This does two things:
    - The governor brings the engine to rated speed (900 RPM)
    - A contact off the Idle-rated switch turns on the voltage regulator
- Once the engine and generator are operating at speed and voltage, the operator manually turns on the sync switch, located on the electrical panel, and manually operates the governor and or voltage raise-lower switch(s), located on the electrical panel, which operate motor operated potentiometers (MOPs). The MOP's are adjusted to match the unit speed and voltage to the system speed and voltage and the unit breaker is closed synchronizing the unit to the system.
- The Synch switch is then manually turned off and adjustments to the governor raise-lower switch are made to add load to the generator.
- Once the unit has around 300 kW load, small manual adjustments are made on the voltage raise-lower switch, which in turn adjusts the unit power factor.
- Initial unit load set points are determined by manual operation of the unit's governor raise-lower switches.
- A normal stop of a unit is a reversal of all the steps above. The load is removed from the unit, the unit breaker is opened, the idle rated switch is turned to idle, and the unit is run at idle speed until it cools down. After the unit cools down the run switch is turned to off and the pre heat and pre and post lube system are started.

After SCADA system implementation

Units 10, 14 and 15 will be SCADA dispatched engines. This means that all functions that are presently done manually will need to be converted to automatic operation. A brief descriptive example of what is expected in an after SCADA System is detailed below:

- After conversion to the SCADA System all units shall always have the fallback option of being manually controlled.
- Perform the blowdown procedure manually.
- Start the pre-heat system.
- Once the unit generator mode switch has been placed in the automatic position, the unit shall be available for SCADA dispatch. The SCADA controller shall perform similarly to the manual operation as described previously.
- If the unit fails to start in the time allotted, the SCADA system shall lock out the unit for operator reset, and initiate an operator warning alarm. The SCADA system shall then attempt to start the next unit in the priority list.

20.7. Units 7, 11, 12 Start/Stop Procedure

Before SCADA system implementation

When one of these units is to be started:

- The unit Pre-heat system is turned off.
- Prior to starting these units, operator will determine to run the unit governor in Isoch or Droop by setting the Droop/Isoch switch on the mechanical panel in the proper position.
- The Idle/Rated switch on the mechanical panel is manually placed in Idle.
- The run switch on the mechanical panel is manually placed in the run mode.
- The start button on the mechanical panel is depressed and held for several seconds. This actuates the air solenoid valve, which opens and delivers air to the pre-lube system. When the pre-lube system has brought the oil pressure to the desired level, air is diverted to the air starters.
- Protection against an inadvertent re-start when the unit is operating is provided by an “engine crank delay relay contact” (ESS).
- Protection against starting the engine with any existing mechanical or electrical faults is provided by an engine Fault Relay Contact (ESDRX).
- Once the engine has been run at idle speed for a sufficient time to fully warm up, the operator manually switches the Idle-Rated switch, located on the mechanical panel, to Rated. This does two things:
    - The governor brings the engine to rated speed (1,200 RPM on Unit 7 or 1,800 RPM on Units 11 or 12)
    - A contact off the Idle-rated switch turns on the voltage regulator.
- Once the engine and generator are operating at speed and voltage, the operator manually turns on the sync switch, located on the electrical panel. Secondly, the operator manually operates the governor and or voltage raise-lower switch(s), located on the electrical panel, which operate motor operated potentiometers (MOPs). The MOP’s are adjusted to match the unit speed and voltage to the system speed and voltage, and the unit breaker is closed synchronizing the unit to the system.
- The Synch switch is then manually turned off and adjustments to the governor Raise-Lower switch are made to add load to the generator.
- Once the unit has around 300 kW load, small manual adjustments are made on the voltage raise-lower switch, which in turn adjusts the unit power factor.
- Initial unit load set points are determined by manual operation of the unit’s governor raise-lower switches.
- A normal stop of a unit is a reversal of all the steps above. The load is removed from the unit, the unit breaker is opened, the idle rated switch is turned to idle, and the unit is run at idle speed until it cools down. After the unit cools down the run switch is turned to off and the pre heat and pre and post lube systems are started.

After SCADA system implementation

Units 7, 11 and 12 will be SCADA dispatched engines. This means that all functions that are presently done manually will need to be converted to automatic operation. A brief descriptive example of what is expected in an after SCADA System is detailed below:

- After conversion to the SCADA System all units shall always have the fallback option of being manually controlled.
- Start the pre-heat heat system.
- Start the pre-lube system.
- Once the unit generator mode switch has been placed in the automatic position, the unit shall be available for SCADA dispatch. The SCADA controller shall perform similarly to the manual operation as described previously.
- If the unit fails to start in the time allotted, the SCADA system shall lock out the unit for operator reset, and initiate an operator warning alarm. The SCADA system shall then attempt to start the next unit in the priority list.

20.8. All Units Governor Operations

Before SCADA system implementation

Units 7, 11, 12, 10 and 14 all have Woodward 2301A load sharing and speed control governors. Although these electronic governors have the ability to load share, this function has not been implemented and auto synchronizing is not installed.

A simplified jumper system between the load share connections on units 7, 11 and 12 has been installed that allows these units to all operate in isoch. This is used on rare occasions to recover from some black start conditions but lacks the sophistication to softly load and unload units and causes power flow shifts during isoch droop settings changes.

The standard operating procedure for the KEA plant is to run one of units 10, 14, 15 in isoch and one or more of units 7, 11, 12 in droop.

Unit 15 currently has a Woodward 2301D governor installed.

After SCADA system implementation

All engine generator sets, as a part of the SCADA upgrade project, shall be equipped with Woodward 2301D governors. Unit 15 is the only unit with a 2301D governor currently installed.

With a governor system/load control system installed, the SCADA system will in the automatic mode:

- Be governed in conjunction with the other units in the plant
- Incorporate an Idle/Rated speed operation in the start up/shut down sequence
- Perform or allow for load share or base loading

- Perform or allow for auto sync involving both speed control and voltage regulation.
- Be capable or soft ramp up and ramp down load functions of incoming and out going generators.
- Be capable of black start operation.
- Be capable of seamless fallback to manual unit operation in the event of loss of the SCADA System.

The new SCADA system shall recognize the status of all the units on the system and allow for proper manual operation of some units and automatic control of others, or full manual control of all units.

If a unit is in manual mode the governor needs to incorporate the following:

- Needs to be capable of operated in conjunction with the other units in the plant.
- Needs to incorporate an operator selectable Idle/rated speed operation.
- Needs to be capable of switch selectable manual or auto synchronizing incorporating manual or auto voltage raise/lower and manual unit speed raise lower operation
- Needs to allow for manual black start operation

20.9. All Units Voltage Regulator System

Before SCADA system implementation

The voltage regulators used on the existing KEA engine generators are Basler SR4 or SR8 voltage regulators. These analog units are either now on the Basler "special" list or will be shortly. This means Basler will continue to support the units for as long as their supplies last, but sometime in the near future they will be obsolete.

The existing voltage regulator system includes cross current compensation wiring between all units. Each unit is isolated, while off, from the cross current compensation loop by an auxiliary breaker contact that opens when the unit is placed on line.

Each unit's voltage when operated independently or not attached to the bus is now adjusted by either an adjustable potentiometer or an electronic adjustable potentiometer (Basler RA-70A).

When these units are tied in parallel the same adjustable potentiometers or RA-7A units are used to adjust Var loading on the units or the overall system voltage

All three of the EMD units have had their existing Basler voltage regulators replaced with Basler Digital regulators (DECS-200).

After SCADA system implementation

The voltage regulators on units 7, 11 and 12, as part of the SCADA System upgrade, need to be upgraded to new Basler DECS-200 voltage regulators

All voltage regulators will need to connect to a unit auto synchronizer (envisioned as part of the new generator supervisor control unit) which can bring the unit to both a matching bus speed and voltage. In all cases the auto synchronizer shall act as a sync check relay and shall allow black start operation.

The voltage regulator shall, in the manual unit control mode, be manually adjustable by a local operator.

20.10. Units 10, 14, and 15 Mechanical Protection

Before SCADA system implementation

Units 10, 14 and 15 are equipped with the following protective devices, which act in conjunction with either an annunciator or an annunciator like system to either alarm or alarm and shut down the unit.

Shutdown:

- *Generator Failure Relay (GFR)* - Acts as a master relay controlled by contacts from any mechanical or electrical relay designated to both, trip the unit breaker and shut the unit off.
- *Over Speed Switch (OSS)* - Engine mounted electrical switch actuated by engine mechanical over-speed device.
- *High Water Temperature Switch (HWTS)* - Engine mounted electrical switch actuated by engine water temperature exceeding 215°F.
- *Low Water Pressure Switch (LWPS)* - Engine mounted electrical switch actuated by engine water pressure less than 20 PSI.
- *High Crankcase Pressure Switch (HCPS)* - Engine mounted electrical switch actuated by crankcase pressures above .8 to 2.25 inches of water pressure.
- *Low Oil Pressure Switch (LOPS)* - Engine mounted electrical switch actuated by engine oil pressure below 20 PSI.
- *High Vibration Switch (HVS)* - Engine mounted electric switch actuated by engine vibrations.
- *Emergency Kill Button*

Alarm:

- *Low oil pressure warning switch (LOPWS)* - engine mounted electrical switch actuated by engine oil pressure below 35 PSI.
- *Low water pressure warning switch (LWPWS)* - Engine mounted electrical switch actuated by engine water pressure below 35 PSI.
- *High Water Temperature Warning Switch (HTWWS)* - Engine mounted electrical switch actuated by engine oil temperature above 208° F.
- *High Oil Temperature Warning Switch (HOTWS)* - Engine mounted electrical switch actuated by engine oil temperature above 230° F.
- *High Fuel Differential Pressure Switch (HFDPS)* - Engine mounted electrical switch that monitors pressure drop across the engine fuel filters and actuated by differential fuel pressure greater than 30 PSI.
- *Low Oil Temperature Warning Switch (LOTWS)* - Engine mounted electrical switch actuated by engine oil temperatures less than 140° F.
- *Low Circulation Oil Pressure Switch (LCOPS)* - Engine mounted electrical switch actuated by circulating oil pressures less than 10 PSI.

- *Low Fuel Level Switch (LFLS)* - Day tank mounted electrical switch when day tank fuel level is less than a certain amount.
- *High Fuel Level Switch (HFLS)* - Day tank mounted electrical switch when day tank level is greater than a certain amount.

Numerous additional displays are located on the engine mechanical panel including such items as control voltage, fuel pressure and fuel filter differential pressure, air filter differential pressure and engine time meter.

After SCADA system implementation

All of the same protections and displays as described in the "before SCADA system implementation" shall be required of the "after SCADA" system via the new generator controllers and HMI's.

20.11. Units 7, 11, and 12 Mechanical Protection

Before SCADA system implementation

Units 7, 11 and 12 are equipped with the following protective devices, which act in conjunction with either an annunciator or an annunciator like system to alarm only or alarm and shutdown.

Shutdown:

- *Engine shut down relay (ESDR)* - acts as a master relay controlled by contacts from any mechanical or electrical relay designated to trip the unit breaker.
- *Engine Over-speed (ESS)* - mechanical panel mounted unit operated off of Magnetic Pickup.
- *Oil pressure switches 1 & 2 (OPS1-18 PSI and OPS2-30 PSI)* – Engine mounted low oil pressure switches.
- *Oil level switch 2 (OLS2)* - Engine mounted oil level switch state 2.
- *Oil temperature switch (OTS2)* - Engine mounted oil temperature switch state 2 designed to trip at 240ºF
- *Jacket water pressure switch state 2 (JWP2)* – Engine mounted water pressure switch state 2.
- *Fuel pressure switch state 2 (FPS2)* - Engine mounted fuel pressure switch to shut down the unit at fuel pressure of 35 PSI and below.
- *Vibration relay (VR)* - Engine mounted vibration sensing relay.
- *Emergency kill button (ES)*
- *Water temp switch (WTS)* - Engine mounted electrical switch actuated by engine water temperature of 215ºF.

Alarm:

- *High water temperature (HWT)* - Engine mounted temperature switch actuated by engine water temperature of 205ºF

- *Oil Level switch 1 (OLS1)* - Engine mounted oil level switch set to indicate approach to low oil level condition.
- *High oil temperature switch (OTS1)* - Engine mounted oil temperature switch set to warn of approaching high oil temperature 234ºF.
- *Low oil pressure auxiliary switch (LOPAS1)* - Engine mounted oil pressure switch set to alarm oil pressures of 30 PSI and below.
- *Low oil pressure auxiliary switch 2 (LOPAS2)* - Engine mounted oil pressure switch set to alarm oil pressures of 40 PS1 and below.
- *Jacket water pressure switch (JWPS1)* - Set to alarm low jacket water pressures.
- *Fuel pressure switch 1 (FPS1)* - set to alarm fuel pressures of 45 PSI and below.

After SCADA system implementation

All of the same protections and displays as listed "Before SCADA system implementation" for units 7, 11 and 12 shall be required of the "after SCADA" system implementation via the generator controllers and HMI's.

20.12. Units 10, 14, and 15 Electrical Protection/Annunciation

Before SCADA system implementation

KEA - Units 10, 14 and 15 are attached to the New Plant 5KV buss through unit circuit breakers. Each unit has the following protective devices:

- Reverse power relay
- Voltage restrained over current relay
- Unit differential relay

If any of these protective relays operate, the unit is disconnected from the bus system by the unit breaker.

If the differential relay operates, it takes the unit offline and shuts down the engine.

In addition to the relays listed above, each unit is protected against out of synch closure of the unit breaker by a sync check relay.

After SCADA system implementation

After the SCADA upgrade, each of these units will have the same or greater level electrical protection they presently have. Refer to section 7.2 in the Special Provisions for the requirements of the SCADA system generator electrical protection.

20.13. Units 7, 11, and 12 Electrical Protection/Annunciation

Before SCADA system implementation

KEA Units 7, 11 & 12 are attached to the old plant 5 KV bus through unit circuit breakers. Each unit has the following protective device:

1. Reverse power relay
2. Voltage restrained over current relay

If either of the protective relays operates, the unit is disconnection from the bus system by the unit breaker.

In addition to the relays listed above, each unit is protected against out of sync closure of the unit breaker by a sync check relay.

After SCADA system implementation

After the SCADA upgrade, each of these units will have the same or greater level of electrical protection they presently have. Refer to section 7.2 in the Special Provisions for the requirements of the SCADA system generator electrical protection.

20.14. Station Service System

KEA does not envision major changes to the diesel power plant station service system, except the new overcurrent protection and metering involved with the new switchgear installation. The status of the station service switchgear shall be monitored as described in Special Provision section 10. The details below are a short background on the Station Service system, which might assist the Contractor in the installation process.

During the construction season of 1996, KEA rewired major portions of the generation plant to have the entire plant operational on a 277/480 volt grounded wye system. Previously the two plants were on separate voltages. Each plant now has its own separate transformer, capable of running either both sides of the plant separately or combined. This means that the Motor Control Center (MCC) is now capable of receiving power from either the Old Plant or the New Plant. Each plant has its own 300 kVA transformer located outside the north and south ends of the plant respectively. This was done to provide redundancy for the plant in the event of a major failure, fire, or transformer failure.

<u>Motor Control Center</u>

The primary Motor Control Center (MCC) for the KEA Generation plant is located in the south-east corner of the new plant near unit #14. The MCC controls the following equipment:

- Engine/generator #10 pre and post lube oil pump
- Engine/generator #14 pre and post lube oil pump
- Engine/generator #15 pre and post lube oil pump
- Engine/generator #10 fuel oil pump

- Engine/generator #14 fuel oil pump
- Engine/generator #15 fuel oil pump
- Fuel Transfer Pump for Units #10, #14, and #15
- Lube Oil Transfer Pump
- Radiator fan #1
- Radiator fan #2
- Radiator fan #3
- Radiator fan #4
- Radiator fan #5
- Radiator fan #6
- Main Heat Loop Pump
- Old Air Compressor
- Main Air Compressor
- Wall Fan New Plant

21. Welding Requirements

Due to the limited mechanical requirements of the project, a full mechanical division is not included in the Technical Specifications. However, several requirements for welding instrument NPT fittings and other miscellaneous items are listed below that the Contractor shall adhere to.

- Preparation, welding, and, repair work shall conform to the requirements of ASME B31, unless otherwise noted.

- The Contractor shall be responsible for the quality of all joint preparation, welding, and examination. All materials used in the welding operations shall be clearly identified and recorded. The inspection and testing defined in this specification are minimum requirements. Additional inspection and testing shall be the responsibility of the Contractor when the Owner deems it necessary to achieve the quality required.

- The welder is not required to be qualified per ASME B31. However, the welder shall have prior experience welding the materials required for performing the Contract Work.

- All filler metals, electrodes, fluxes, and other welding materials shall be delivered to the site in manufacturers' original packages and stored in a dry space until used. Packages shall be properly labeled and designed to give maximum protection from moisture and to insure safe handling.

- Welding shall not be done when the quality of the completed weld could be impaired by the prevailing working or weather conditions.

- Parts that are to be joined by welding shall be fitted, aligned, and retained in position during the welding operation by the use of bars, jacks, clamps, or other mechanical fixtures. Welded temporary attachments shall not be used except when it is impractical to use mechanical fixtures.

- Visual weld inspection shall be performed by the Contractor to detect surface and internal discontinuities in completed welds. All tack welds, weld passes, and completed welds shall be visually inspected. When inspection and testing indicates defects in a weld joint, the weld shall be repaired.

22. Extended Service, Future I/O, and Spare Parts

22.1. Service Contract

The SCADA system Contractor shall provide a one year service agreement with KEA upon closeout of the Project Work. The service agreement shall include:

- 24 hour, 7 days a week remote phone and internet connection support during system faults. The maximum remote service time for the first year shall be 120 hours. Additional remote service above 120 hours shall be billed to KEA at the Professional Engineer rate listed in the Contract Documents Direct Labor Schedule.

- A service technician or engineer shall be on site within 48 hours of a KEA repair request that cannot be fixed remotely. One (1) five day trip to the KEA site is required during the service agreement time frame. Additional on site service above the five day trip shall be billed to KEA at the Professional Engineer rate listed in the Contract Documents Direct Labor Schedule. Additional on site service travel shall also be billed to KEA, utilizing KEA approved travel methods.

- During the service contract time period, the Contractor shall be responsible to keep any SCADA software or firmware used at KEA up to date. The Contractor shall bear the cost of software upgrades. The Contractor shall install the software upgrades during the 5 day site service visit, or remotely if feasible.

- After the initial one year service contract, KEA may request additional SCADA system support in the form of a separate yearly contract from the Contractor.

22.2. Spare Parts

The Contractor shall provide one (1) spare part to KEA for each major system component used in the SCADA system, before the final inspection and closeout is completed. Since there are multiple HMI's in the system, a spare HMI does not need to be included. Spare parts shall include, but not limited to:

- Master control unit or PLC CPU, power supply, and backplane
- Generator unit controller
- One of each type of I/O module used
- Generator relay
- Feeder relay
- One of each type of protocol converter used
- One of each type of Ethernet or fiber optic switch used
- Power supplies

23. Transportation, Lodging, and Equipment

KEA has housing accommodations for a maximum of three persons, which are available for the Contractor or subcontractor to use while performing work under the Contract. KEA will also provide the use of one vehicle for the Contractor. Meals, additional lodging, and additional transportation shall be the responsibility of the Contractor.

The Contractor shall furnish all necessary construction tools and construction equipment.

END OF SPECIAL PROVISIONS

Appendix F

High Penetration Wind Scada EPC Project,

Bid Document

High Penetration Wind SCADA System

Engineer, Procure, & Construct (EPC) Project

Offered By:

Kotzebue Electric Association, Inc.

P.O. Box 44
Kotzebue, Alaska 99752
Phone: (907) 442-3491
Fax: (907) 442-2482
Email:b_reeve@kea.coop
Website: www.kea.coop

August 24, 2005

Prepared by

Electric Power Systems, Inc.
3305 Arctic Blvd., Suite 201
Anchorage, Alaska 99503
Phone: (907) 522-1953
Fax: (907) 522-1182
Email: drogers@epsinc.com

Bid Package Table Of Contents

KOTZEBUE ELECTRIC ASSOCIATION, INC.
High Penetration Wind SCADA System
Engineer, Procure, & Construct (EPC) Project

NOTICE AND INSTRUCTIONS TO BIDDERS

1. **Kotzebue Electric Association (KEA) is requesting sealed proposals** to execute the Engineer-Procure-Construct (EPC) project that implements a Supervisory Control and Data Acquisition (SCADA) system. The SCADA system project also includes scope to design and install new switchgear in the power plant. The SCADA architecture, preliminary engineering, and major components have been selected by KEA for implementation. This project will require the Contractor to finalize the preliminary design documents, procure all materials needed to construct the SCADA system, install the SCADA system, commission the SCADA system, service the SCADA system, and train KEA personnel to operate and maintain the SCADA system. The switchgear design portion of the project consists of producing bid documents and assisting KEA with submittal reviews of the switchgear. Proposals shall be submitted to KEA on or before **3:00** o'clock PM on **October 5, 2005** at KEA and a copy delivered to Thompson Engineering at which time and place the proposals will be privately opened. Electronic proposals appropriately signed may be submitted; however, signed hardcopy originals must be provided prior to award. Any proposal received after the time specified will not be considered. KEA, subsequent to the bid opening, may elect to conduct negotiations with Bidders to resolve any questions related to the substance of the Bidder's proposal and to arrive at a final price.

   Kotzebue Electric Association, Inc.
   Attn: Brad Reeve, General Manager
   P.O. Box 44
   Kotzebue, Alaska 99572
   Email: b_reeve@kea.coop
   Phone: (907) 442-3491
   Fax: (907) 442-2482

   Thompson Engineering Co., Inc.
   Attn: Craig Thompson P.E.
   721 Sesame Street, Suite 2B
   Anchorage, AK 99503
   Email: teco@gci.net
   Phone: (907) 562-1552
   Fax: (907) 562-1530

2. **Bidder Qualifications.** The Bidder shall provide data verifying a minimum of three years experience in the installation of engine-generator unit controls and power plant SCADA systems. A list of two successful installations with installation dates, description of installation, and a contact for each installation shall be submitted with the bid. In addition, the Bidder must identify the manufacturers of major equipment components used in their last two designs/installations.

   The Bidder shall also provide a list of switchgear projects similar to the KEA project completed within the last five years, and contact information for each project. For projects to be considered similar, they must include design utilizing indoor or outdoor metalclad switchgear, vacuum circuit breakers, and microprocessor-based relays.

The Bidder shall be a licensed Electrical Contractor in the state of Alaska. Subcontractors employed by the Bidder shall be licensed by the State of Alaska in the crafts which they are being employed. Engineers employed in the development of final design drawings shall be registered and licensed by the State of Alaska.

3. **Manner of Submitting Proposals.** Proposals and all supporting instruments must be delivered in a sealed envelope addressed to KEA. The name and address of the Bidder, Bidder's Alaskan Electrical Contractors license number and the date and hour of the opening of bids must appear on the envelope in which the Proposal is submitted. Proposals must be completed in ink or typewritten. No alterations or interlineations will be permitted, unless made before submission, and initialed and dated. The Bidder shall submit two copies of the Proposal. If by email, one shall go to KEA and one to Thompson Engineering Company, Inc. If by US Mail both copies shall go to Thompson Engineering Company, Inc.

4. **Due Diligence.** Prior to the submission of the Proposal, the Bidder shall make and shall be deemed to have made a careful examination of the site of the project and shall review the location and nature of the proposed work, the transportation facilities, and all other matters that may affect the cost and time of completion of the work. By submitting a bid the Contractor declares that it has carefully examined the Contract Documents, and that it has full knowledge and understanding thereof. Any failure by the Contractor to acquaint himself with the available information will not relieve the Contractor from responsibility for determining properly the difficulty or cost of successfully performing the Work. Bidder will be required to comply with all federal, state, and local laws, rules, and regulations applicable to its performance, including those pertaining to the licensing of contractors. Bidder questions shall be provided by email to KEA and Thompson Engineering Company, Inc. Questions and answers will be provided to all Bidders via email.

5. **Proposals** will be accepted only from those pre-qualified bidders invited by KEA to submit a proposal.

6. **Evaluation Factors.** In estimating the lowest cost to KEA as one of the factors in deciding the award of the Contract, KEA will consider, in addition to the price quoted in the Proposals, the following:

   - Schedule of hourly costs for the personnel anticipated to be utilized on the project.
   - Description of the Bidder including years in business, number of personnel employed, and capacity to perform this project.
   - Description of work performed by the Bidder that demonstrates experience and capability to perform this type of work including: experience with SCADA hardware and software manufacturers, engine-generator manufacturers, switchgear manufacturers, and wind turbine manufacturers.
   - Description of Subcontractors including description of work to be performed, years in business, number of personnel employed, and capacity to perform work.
   - References and contact numbers for projects completed or in progress identified above.
   - Resumes of personnel that would perform this work for KEA.
   - Organizational chart showing the functional reporting relationship of the project team including subcontractors and consultants.
   - Hardware and Software components anticipated to be utilized on the project.
   - Identification of the anticipated time that each person on the project team will be dedicated to this work.
   - Preliminary project schedule including start dates and durations for engineering, procurement, construction and closeout.

- KEA will select the Proposal that provides the best value and most closely matches their long range plans for the KEA Power System.

7. **Contract is Entire Agreement.** The Contract to be effected by the acceptance of the Proposal shall be deemed to include the entire agreement between the parties thereto, and the Bidder shall not claim any modifications thereof resulting from any representation or promise made at any time by any officer, agent or employee of KEA or by any other person.

8. **Minor Irregularities.** KEA reserves the right to waive minor irregularities or minor errors in any Proposal, if it appears to KEA that such irregularities or errors were made through inadvertence. Any such irregularities or errors so waived must be corrected on the Proposal in which they occur prior to the acceptance thereof by KEA.

9. **Bid Rejection.** KEA reserves the right to reject any or all Proposals.

10. KEA Represents:

a. If by provisions of the Proposal KEA shall have undertaken to furnish any materials for the project, such materials are on hand at locations specified or if such materials are not on hand they will be made available by KEA to the successful Bidder at the locations specified before the time such materials are required. KEA will provide drawings and data that are available to the successful Bidder. However, it will be the responsibility of the Bidder to validate that the information on the drawings and data supplied match the actual installations in KEA's Power Plant.

b. All funds necessary for prompt payment for the work will be available. If KEA shall fail to comply with any of the undertakings contained in the foregoing representation or if any of such representations shall be incorrect, the Bidder will be entitled to an extension of time of completion for a period equal to the delay, if any, caused by the failure of KEA to comply with such undertakings or by any such incorrect representation; provided the Bidder shall have promptly notified KEA in writing of its desire to extend the time of completion in accordance with the foregoing; provided, however, that such extension, if any, of the time of completion shall be the sole remedy of the Bidder for KEA's failure, because of conditions beyond the control and without the fault of KEA, to furnish materials in accordance with subparagraph a. above.

Kotzebue Electric Association, Inc.

Signed By: ____________________________________

Title: General Manager

Date:

BID PROPOSAL

TO: The Kotzebue Electric Association, Inc., herein called KEA:

Pursuant to and in compliance with your Notice to Contractors Inviting Bids, Information For Bidders, Agreement and the other Contract Documents relating thereto, the undersigned Bidder, being fully familiarized with all the terms of all the Contract Documents and with the project site and local conditions and costs affecting the performance as called for in the Contract Documents, hereby proposed and agrees to perform, within the time and in the manner stipulated, the Contract, including all of its component parts, and everything required to be performed, and to provide and furnish any and all of the work labor, materials, tools, supplies, and all transportation and other services necessary to perform the Contract in a skillful and timely manner, all in strict conformity with the Contract Documents, including addenda for the following project:

High Penetration Wind SCADA System
Engineer, Procure, & Construct (EPC) Contract

for an amount computed on the basis of the quantity of work actually performed at the prices set forth on the Bid Schedule herein contained consisting of one (1) sheets, which is incorporated and made a part of this Bid Proposal:

TOTAL BID SCHEDULE AMOUNT $____

1. **Award of Contract**: KEA shall have the right to reject this bid proposal, and such bid proposal shall remain open and may not be withdrawn for a period of **sixty (60)** days after the date prescribed for its opening.

2. **Execution of Contract and Performance Security**: It is understood and agreed that if written notice of the acceptance of this proposal and award of the Contract is mailed, E-mailed, telefaxed, or delivered to the undersigned Bidder within sixty (60) days after the opening of the proposal, or at any time thereafter before it is withdrawn in writing, the undersigned Bidder will execute and deliver the Agreement in the form set forth in the Contract Documents to KEA in accordance with the proposal as accepted, and will also furnish and deliver to KEA the Certificate of Insurance, Construction Bond, and policies of insurance and any other documents or bonds called for in the Contract Documents, all within ten (10) days after notice of acceptance and award of the Contract is given.

3. **Notice of acceptance and award of the Contract** or requests for additional information may be addressed to the undersigned Bidder at the business address set forth at the end of this proposal.

4. **Wherever in this proposal** an amount is stated in both words and figures, in case of discrepancy between words and figures, the words shall prevail; if all or any portion of the proposal is required to be given in unit prices and totals and a discrepancy exists between any such unit prices and totals so given, the unit prices shall prevail.

5. **Conformance to RFQ:** Select a) or b)

a) ____ This proposal is in complete conformance with the terms and conditions of the RFP and contract requirements.

b) ____ This proposal is in conformance with the terms and conditions of the RFP and contract requirements with the exceptions noted on a separate "Exceptions" attachment.

6. **Receipt of the following Addenda** to the Contract Documents is hereby acknowledged.

ADDENDUM NO.	DATE OF RECEIPT OF ADDENDUM	SIGNED ACKNOWLEDGMENT
1	____________________	____________________
2	____________________	____________________
3	____________________	____________________
4	____________________	____________________

(**Note**: Failure to acknowledge receipt of any addenda may be considered an irregularity in the proposal and grounds for rejection of the bid.)

BIDDER:

____
Company Name

By:____________________________________
Signature

(Title)

Alaska Contractor License No.____________________

Telephone:____

Business
Address:____

Location of Business, if different than address:
____

Date ______________________________, 2005.

NOTE: If Bidder is a corporation, the legal name of the corporation shall be set forth above together with the signatures of the officer or officers authorized to sign contracts on behalf of the corporation; if Bidder is co-partnership the true name of the firm shall be set forth above together with the signature of the partner or partners authorized to sign contracts in behalf of the co-partnership, and if Bidder is an individual, the appropriate signature shall be placed above.

Bid Schedule
&
Table of Compensation

15% Completion…………………………………………………………………….... $__________

Produce final SCADA system design based on Preliminary Engineering Documents
Adjudicate final design review comments from Owner

40% Completion……………………………………………………………………... $__________

Procure SCADA system materials
Write programs for unit and master controllers
Configure HMI's
Factory Acceptance Test

90% Completion……………………………………………………………………... $__________

Install SCADA system
Validate Functionality of SCADA system
Final Commissioning

100% Completion…………………………………………………………………… $__________

Provide O&M Manuals
Provide Warranty Documentation
Provide As-Builts
Train KEA Personnel

Power Plant Switchgear Design…………………………………………………. $__________

Provide switchgear design
Provide procurement bid documents
Adjudicate bid document review comments from KEA Engineer

Power Plant Switchgear Installation…………………………………………….. $__________

Install Switchgear after KEA Procurement

One Year Service Agreement……………………………………………………. $__________

Provide remote support via phone and internet
Provide limited on site repair and assistance

TOTAL BID SCHEDULE AMOUNT……………………………...………………… $__________

Bid Proposal Checklist

Each of the following items shall be supplied with the successful bid proposal:

Section 1: **Bid Proposal**

Section 2: **Bid Schedule**

Section 3: **Bid Bond**

Section 4: **Direct Labor Schedule**
(Include hourly rates for basis of change order and additional switchgear support compensation)

Section 5: **Description of Company**

Section 6: **Description of Work Experience**

Section 7: **Listing of Project References and Contacts**

Section 8: **Listing of Proposed Subcontractors and Description of Work to be Performed by Each.**

Section 9: **Resumes for Key Personnel Assigned to the Project**
(and percent of time anticipated to be working on this project)

Section 10: **Narrative of Project Execution Approach**
(Include whether system is PLC based or proprietary, and provide a proposed equipment list and manufacturer of the major system components, inlcuding: HMI, PLC or PC controller, protective relays, and major communication components.

Section 11: **Project implementation schedule**

Section 12: **Exceptions, explanations of bid conformance exceptions**
(Include any operating conditions that could not be met.)

KOTZEBUE ELECTRIC ASSOCIATION
HIGH PENETRATION WIND SCADA SYSTEM
ENGINEERING-PROCURE-CONSTRUCT (EPC) CONTRACT AGREEMENT

(to be executed, upon award, by the successful bidder)

This contract, made ____________________ , _______ , between Kotzebue Electric Association (hereinafter called the "Owner") and ____ of ____ (hereinafter called the "Contractor").

WHEREAS, the Owner desires to install a SCADA System that will allow for greater overall power plant efficiencies through the optimal use of wind energy in conjunction with diesel-engine driven power generation and requires that the Detailed Engineering, Procurement and Construction of the SCADA System including switchgear design (hereinafter called the "Project") be executed.

NOW, THEREFORE, in consideration of the mutual undertakings herein contained, the parties hereto agree as follows:

ARTICLE I
General Obligation of Contractor

The Contractor shall render, diligently and competently in accordance with the normal standards used in the profession, all engineering services, material procurement and installation labor which shall be necessary or advisable for the expeditious, economical, and sound design, construction, and satisfactory completion of the Project. The enumeration of specific duties and obligations to be performed by the Contractor hereunder shall not be construed to limit the general undertakings of the Contractor. The obligations of the Contractor hereunder run to, and are for the benefit of, only and shall not relieve the Contractor of its own responsibility under its agreement with the Owner.

ARTICLE II
Engineer-Procure-Construct (EPC)

Section 1.

(a) The Contractor shall:

(1) Employ a licensed engineer to finalize all SCADA preliminary design documents.
(2) Employ a licensed engineer to produce a switchgear design and bid documents.
(2) Procure all materials to build the complete SCADA system
(3) Install the KEA procured switchgear
(4) Install the SCADA system
(5) Commission the SCADA system
(6) Train KEA personnel to operate and maintain the SCADA system.

Any changes in the Preliminary Documents required as a condition of approval shall be promptly made by the Contractor.

Section 2. So far as it shall be necessary in the finalization of the design documents and in the construction of the Project, the Owner shall furnish the Contractor access to the drawings and specifications for the installed equipment that are held by the Owner and allow access to the plant and equipment as necessary to develop the final design documents and construct the project.

Section 3. If the Owner shall direct that the Project shall be constructed under more than one contract, the Contractor shall submit all necessary Construction Contract forms and shall also prepare and submit in connection with each such contract all of the information and documents that shall be required for construction of the Project.

Section 4. The Contractor shall furnish to the Owner all engineering information, data, and drawings required for procuring all necessary or desirable permits, licenses, franchises, and authorizations, and shall cooperate with the Owner's attorney in the procuring thereof.

ARTICLE III
Compensation

Section 1. The Owner shall pay the Contractor for all services performed hereunder, except as provided in Section 3 hereof, a sum of _______________. (The Owner and Contractor should agree upon the compensation schedule to be inserted in the Table below.)

TABLE NO. 1
EPC PROJECT TABLE OF COMPENSATION

15% Completion………………………………………………………………... $__________
Produce final design based on Preliminary Engineering Documents
Adjudicate final design review comments from Owner

40% Completion………………………………………………………………... $__________
Procure all materials
Write programs for unit and master controllers
Configure HMI's
Factory Acceptance Test

90% Completion………………………………………………………………... $__________
Install SCADA system
Validate functionality of SCADA system
Final Commissioning

100% Completion……………………………………………………………… $__________
Provide O&M Manuals
Provide Warranty Documentation
Provide As-Builts
Train KEA Personnel

Power Plant Switchgear Design………………………………….……………..…...$__________
Provide switchgear design
Provide procurement bid documents
Adjudicate bid document review comments from KEA Engineer

Power Plant Switchgear Installation……………………………………………...….$__________
Install Switchgear after KEA procurement.

One Year Service Agreement……………………………………………………$__________

Provide remote support via phone and internet

Provide limited on site repair and assistance

The balance, if any, of the compensation due under this Section 1 and all other provisions of this Agreement, shall be payable within thirty (30) days after Completion of the Project in accordance with the provisions of Section 2 of this Article III.

The term “Completion of the Project” shall mean full performance of all obligations under this Agreement and all amendments and revisions thereof.

Section 2. Prior to the time when any payment shall be made to the Contractor pursuant to this Agreement, the Contractor, if requested by the Owner, shall furnish to the Owner, as a condition precedent to such payment, a certificate to the effect that all salaries or wages earned by the employees of the Contractor in connection with the Project have been fully paid by the Contractor up to and including a date not more than fifteen (15) days prior to the date when such payment shall be due.

Upon completion of the project, but prior to final payment to the Contractor, the Contractor shall deliver to KEA a waiver and release of all liens and rights to claim any lien from all manufacturers, materialmen, and subcontractors furnishing services or materials for the project. A certificate by the Contractor shall be provided specifying that all labor used in or for the project has been paid, and that all such releases have been submitted to KEA prior to final payment. Should any liens on a project resulting from the Contractor’s actions or inaction not be discharged by the Contractor prior to or at project completion, KEA may elect to discharge the liens up to the amount of and from the funds as yet not paid to the Contractor. The Contractor shall indemnify KEA for any claim or payment due to a lien arising from the Contractor’s actions.

Section 3. If the Contractor shall, at the request of the Owner as indicated on an Owner signed and approved “Change Order”, perform any services not included in the Proposal, the Contractor shall be paid, in respect thereof, the sum approved on the Change Order document. Change Orders shall describe the scope of the work addition, the specific deliverables to be provided under the Change Order, the cost or estimated cost of the Change Order, and the affect of the change order on the schedule. The cost of the Change Order shall be of one of these forms: 1) Lump sum cost for the work; 2) Time and material not to exceed; or 3) Time and material. The Change order must be signed and dated by the Contractor and signed “Approved” by the Owner prior to the Change Order taking effect. If the Change Order is for “time and material” or “not to exceed”, the Contractor shall submit to the Owner a statement of the time and material costs and include signed timesheets and receipts for materials procured. The rates corresponding to “Direct Labor Schedule” set forth below shall apply:

Direct Labor Schedule:

Professional Engineer/Project Manager	$ 108.00/hour
Journeyman Electrician/Equipment Tech	$ 101.00/hour
Designer	$ 80.00/hour
Drafter	$ 60.00hour

Section 4. If this Agreement shall be terminated pursuant to the provisions of Section 1 or Section 2 of Article IV hereof, the compensation for services rendered prior to such termination shall be computed as follows:

(a) Compensation for the Percentage Complete for those items listed in the EPC Project Table of Compensation above. Plus time for those items worked but not completed. Time will be determined from signed timesheets and rates shall be determined from the “direct labor” schedule in Section 3.

(b) Compensation for the services referred to in Section 2 of Article III, which may be performed by the Contractor at the request of the Owner and for extra drafting and other services because of changes ordered by the Owner, shall be computed in accordance with the provisions of Section 3 of this Article III.

Section 5. Interest shall be paid by the Owner to the Contractor on all unpaid balances due the Contractor, commencing thirty (30) days after the due date, provided that the delay in payment beyond the due date shall not have been caused by any condition within the control of the Contractor. Such interest shall be at the rate of eighteen percent (18%) annually. [Percentage is not to exceed any applicable State usury laws.] Such compensation shall be paid ten (10) days after the amount of the interest has been determined by the Contractor and the Owner.

ARTICLE IV
Miscellaneous

Section 1. The Owner may at any time terminate this Agreement by giving notice to the Contractor in writing to that effect, delivered and mailed to the Contractor's last known address not less than ten (10) days prior to the effective date of termination specified in the notice. From and after the effective date of termination specified in such notice, this Agreement shall be terminated, provided, however, that the Contractor shall be entitled to receive compensation for services theretofore rendered pursuant to this Agreement, computed in accordance with the provisions of Article III, Section 4, hereof.

Section 2. The Contractor shall have the right, by giving to the Owner not less than thirty (30) days notice in writing, to terminate this Agreement if the Contractor shall have been prevented by conditions beyond the control and without the fault of the Contractor (a) from commencing performance of this Agreement for a period of twelve (12) months from the date of this Agreement, or (b) from proceeding with the completion of full performance of any remaining services required of the Contractor pursuant to this Agreement for a period of six (6) months from the date of last performance by the Contractor of other services required pursuant to this Agreement. From and after the effective date specified in such notice this Agreement shall be terminated, except that the Contractor shall be entitled to receive compensation for services performed hereunder, computed and payable in the same manner as set forth in Section 1 of this Article.

Section 3. Upon Completion of the Project or termination of this Agreement, the Contractor shall be obligated forthwith to deliver to the Owner all maps, tracings, and drawings of the Project and all letters, documents, and other material including all records pertaining thereto.

Section 4. Insurance. Contractor shall not commence work under this Contract until all of the insurance required under this section has been obtained and Contractor has filed the certificates of insurance and copies of insurance policies with the Owner as required by the Contract Documents, and the Owner has approved the same, nor shall Contractor allow any subcontractor to commence work on his subcontract until the insurance required has been so obtained.

The Contractor shall take out and maintain throughout the period of this Agreement insurance of the following types and minimum amounts:

(a) Workers' compensation and employers' liability insurance, as required by law, covering all of the Contractor’s employees who perform any of the obligations of the Contractor under the

Agreement. If any employer or employee is not subject to the workers' compensation laws of the governing State, then insurance shall be obtained voluntarily to extend to the employer and employee coverage to the same extent as though the employer or employee were subject to the workers' compensation laws.

(b) Public liability insurance covering all operations under the Agreement shall have limits for bodily injury or death of not less than $1 million each occurrence, limits for property damage of not less than $1 million each occurrence, and $1 million aggregate for accidents during the policy period. A single limit of $1 million of bodily injury and property damage is acceptable. This required insurance may be in a policy or policies of insurance, primary and excess including the umbrella or catastrophe form.

(c) Automobile liability insurance on all motor vehicles used in connection with the Agreement, whether owned, non-owned, or hired, shall have limits for bodily injury or death of not less than $1 million per person and $1 million per occurrence, and property damage limits of $1 million for each occurrence. This required insurance may be in a policy or policies of insurance, primary and excess including the umbrella or catastrophe form.

(d) Errors and Omissions (Professional Liability): Provide error and omissions insurance for engineering and design services on this project. Insurance in an amount at least as large as the maximum compensation specified in Article III, Section 1, but not less than $2 million.

The Owner shall have the right at any time to require public liability insurance and property damage liability insurance greater than those required in subsections "b" and "c" of this Section. In any such event, the additional premium or premiums payable solely as the result of such additional insurance shall be added to the total compensation to be paid under this Agreement.

The Owner shall be named as Additional Insured on all policies of insurance required in subsections "b" and "c" of this Section.

The policies of insurance shall be in such form and issued by such insurer as shall be satisfactory to the Owner. The Contractor shall furnish the Owner a certificate evidencing compliance with the foregoing requirements which shall provide not less than thirty (30) days prior written notice to the Owner of any cancellation or material change in the insurance.

Section 5: Bid Bond. The Contractor shall provide the Owner a Bid Bond with the proposed bid. The bid bond shall be in the amount of 10% of the total Bid amount. The bond shall be underwritten by a bonding company authorized to write bonds in the State of Alaska.

Section 6: Contractor Bond. Upon successful award of the Bid, the Contractor shall provide the Owner a Contractor Bond in the amount of 50% of the Contract amount. The Contractor shall not be allowed to proceed on the project unless the bond is received by KEA. The bond shall be underwritten by a bonding company authorized to write bonds in the State of Alaska.

Section 7: **Contract Documents**. The Contract, and the component parts of this Contract, entered into by the acceptance of the Contractor's Bid Proposal and the signing of this Agreement, consist of the following documents, all of which are component parts of said Contract and are as fully a part thereof as if herein set forth in full, and if not attached, as if attached hereto:

1. This Agreement
2. Notice to Contractors Inviting Bids
3. Information for Bidders
4. Notice of Award
5. Bid Proposal as accepted
6. Change Orders

7. Addendum No(s).
8. Notice to Proceed
9. Written amendments, including Change Orders, if any, to this Agreement signed by both parties entered into after execution of this Agreement
10. Certificate of Insurance
11. Contractors Labor Rate Schedule
12. General Conditions
13. Special Conditions
14. Technical Specifications
15. Contract Drawings.
16. Equipment List
17. Logic Diagrams

Section 8: Construction Time.

1. The Contractor agrees to complete all work and construction Contract Documents, to the satisfaction of the Owner within the below or, in the event the time for completion is extended by Change the additional days by which the time is so extended. All changes only by written Change Order to the Contract.
2. Time is of the essence on the project. Ninety percent completion on this contract shall be completed no later than **September 1, 2006**, provided the Notice to Proceed is issued by October 17, 2005. All work on this contract shall be completed no later than September 30, 2006, excluding the one year service agreement. The Contractor shall provide an estimated project schedule with the bid.

   If at any time the project falls behind schedule based on the Contractors provided schedule with the bid, the Contractor and KEA shall agree on a path forward to make up lost time, at the cost of the Contractor. However, the Contractor shall not be deemed responsible if the cause of delay is outside of his control.

Section 9. The obligations and duties to be performed by the Contractor under this Agreement shall be performed by persons qualified to perform such duties efficiently. The Contractor, if the Owner shall so direct, shall replace any person employed by the Contractor in connection with the Project.

For the information of the Owner, the Contractor shall, upon request, file with the Owner, statements of the qualifications, including specific experience, of each person assigned to the Project and the duties assigned to each, and certifications of insurance coverage.

Section 10. This Agreement shall be simultaneously executed and delivered in two counterparts, each of which when so executed and delivered shall be deemed to be an original, and all shall constitute but one and the same instrument.

Section 11. The obligations of the Contractor under this Agreement shall not be assigned without the approval in writing of the Owner.

Section 12. The Contractor shall comply with applicable statutes pertaining to the practice of the profession. It is hereby warranted that the Contractor possesses Alaska Electrical Administrators License number ________________ issued by the State of Alaskas on the ___________________ day of ______________________ , ______.

IN WITNESS WHEREOF, the parties hereto have caused this Agreement to be duly executed and their respective corporate seals to be affixed and attested by their duly authorized representatives all as of the date first above written.

____ Owner
By ______________________________________ President

ATTEST:
____ Secretary

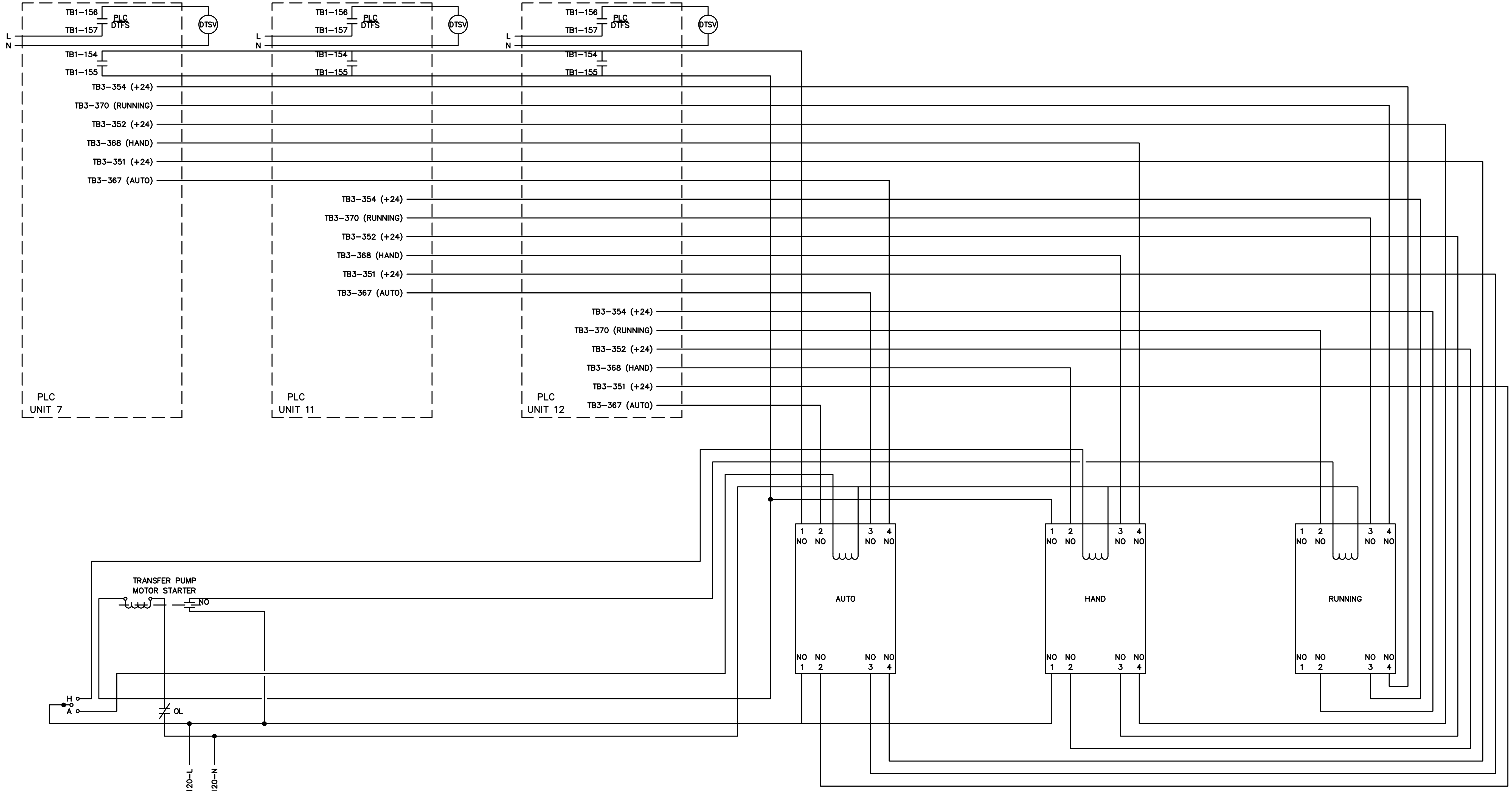
____ Contractor
____ Title

ATTEST:
____ Secretary

Appendix G

As-Built Drawings

Kotzebue Wind Power Plant



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. - SCADA EPC
DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW
W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-08-2006	RJM/12-08-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

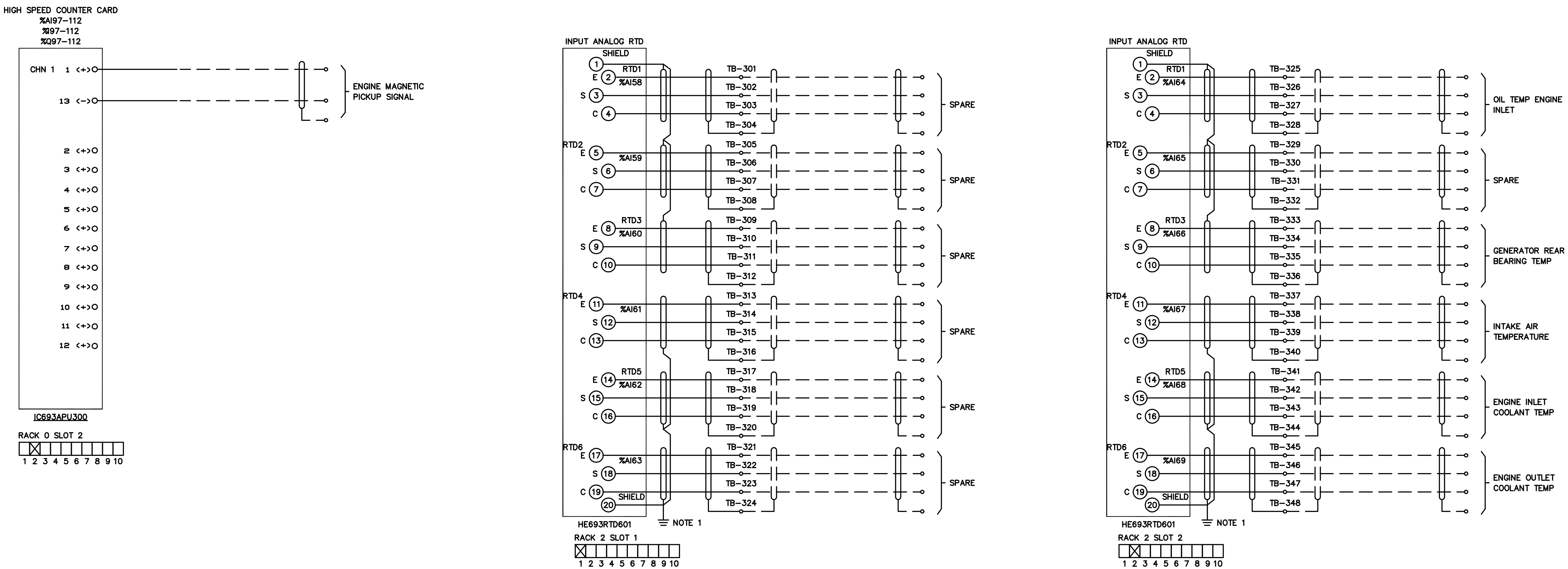
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
CATERPILLAR UNITS
FUEL TRANSFER SYSTEM

kss-el-2005_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2005

SHEET 1 OF 1



NOTES:

1. TIE RTD SHEILDS AND PIN 1 AND 20 OF THE ANALOG CARD TO AN EARTH GROUND.

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-05-2006	RJM/12-05-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

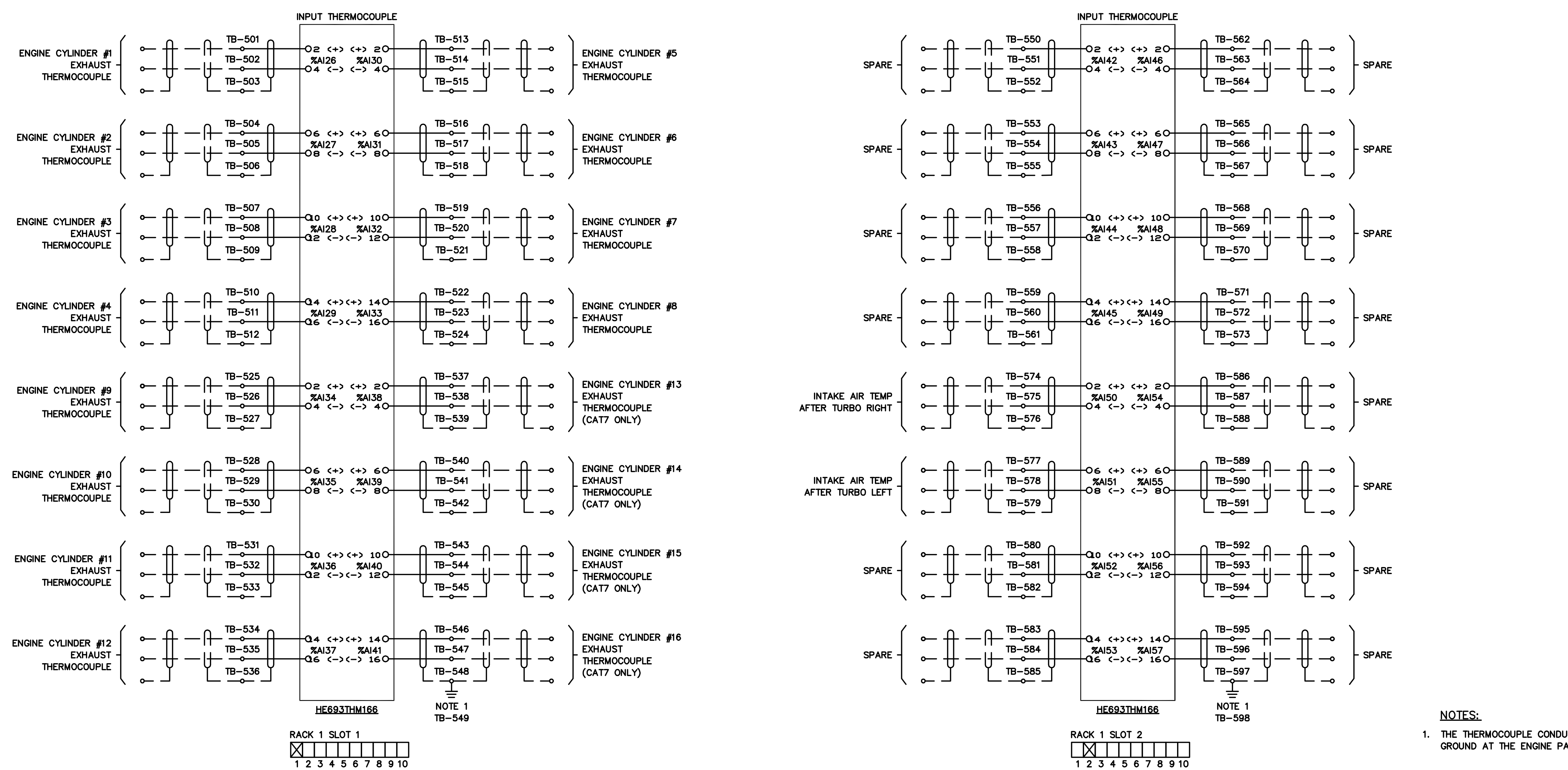
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
CATERPILLAR UNITS
ENGINE CONTROL PANEL
PLC ANALAOG INPUTS

kss-el-2004_3.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2004

SHEET 3 OF 3



NOTES:

1. THE THERMOCOUPLE CONDUCTOR SHIELD SHALL BE CONNECTED TO AN EARTH GROUND AT THE ENGINE PANEL TERMINALS, TYPICAL FOR EACH THERMOCOUPLE.

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. - SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-05-2006	RJM/12-05-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

DRAWING NAME:

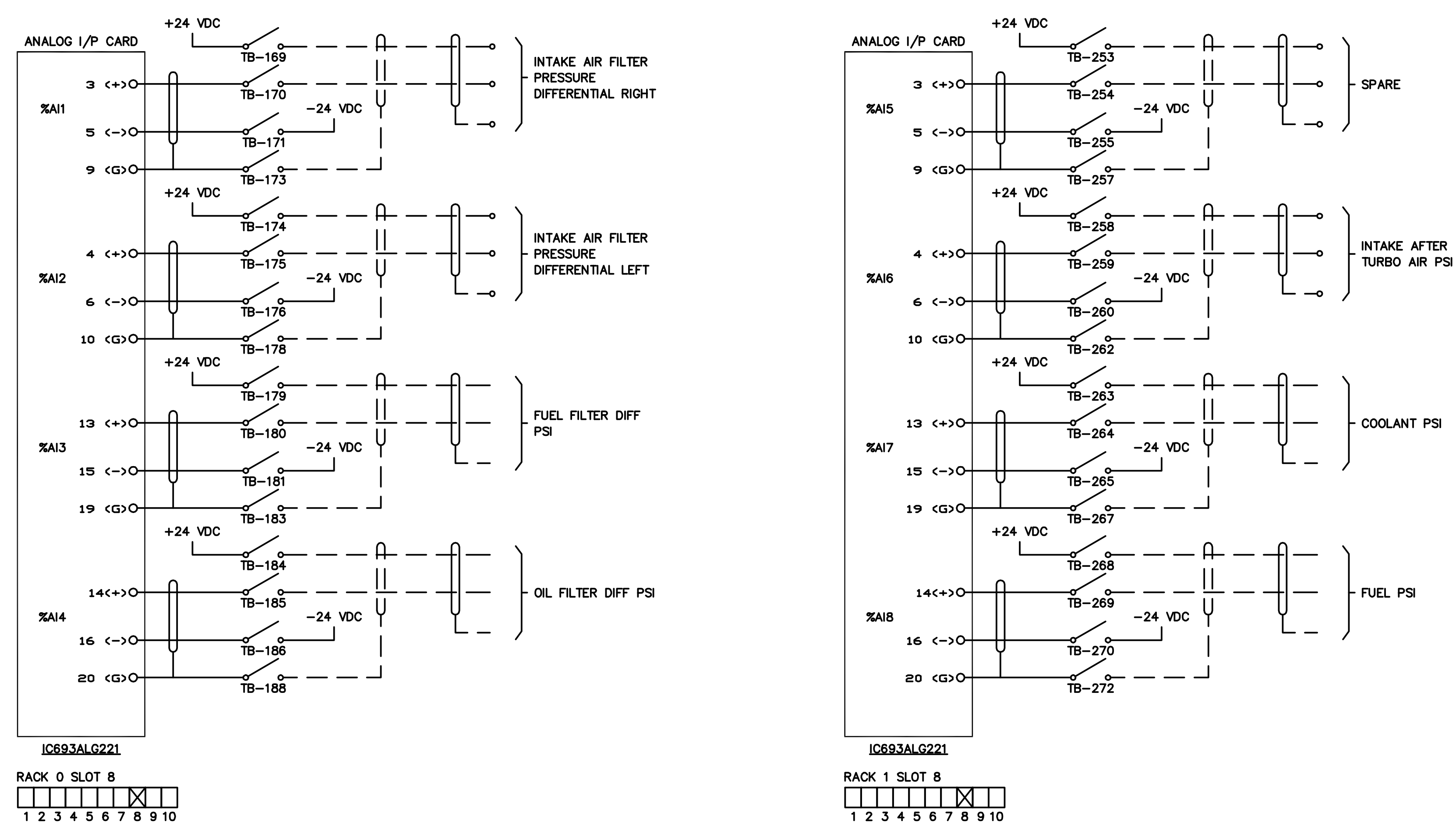
KOTZEBUE SCADA SYSTEM
CATERPILLAR UNITS
ENGINE CONTROL PANEL
PLC ANALOG INPUTS

kss-el-2004_2.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2004

SHEET 2 OF 3



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. # 05-0204

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DRAWING NAME:

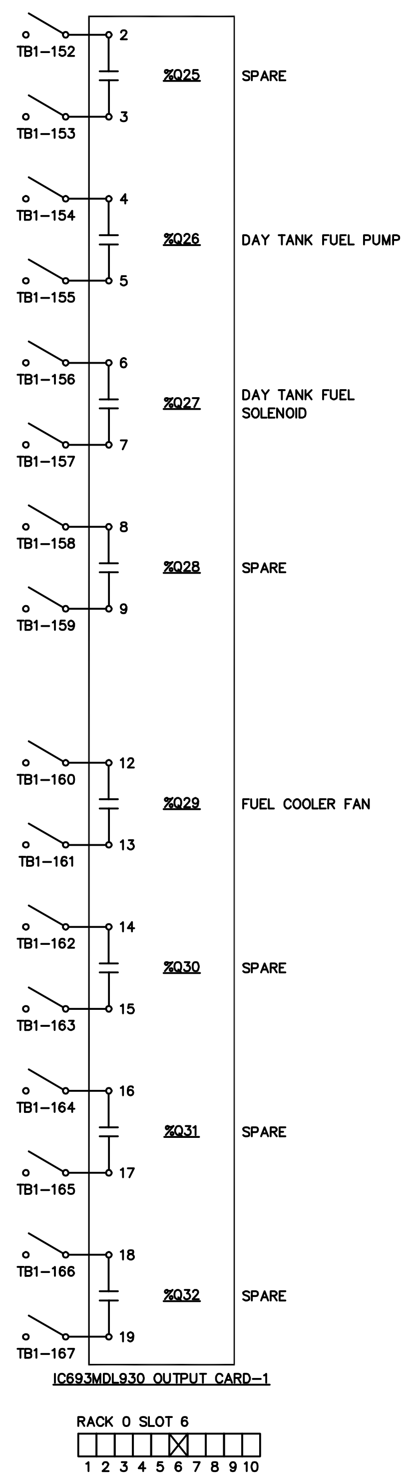
KOTZEBUE SCADA SYSTEM
CATERPILLAR UNITS
ENGINE CONTROL PANEL
PLC ANALOG INPUTS

kss-el-2004_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2004

SHEET 1 OF 3



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PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. - SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
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ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

DRAWING NAME:

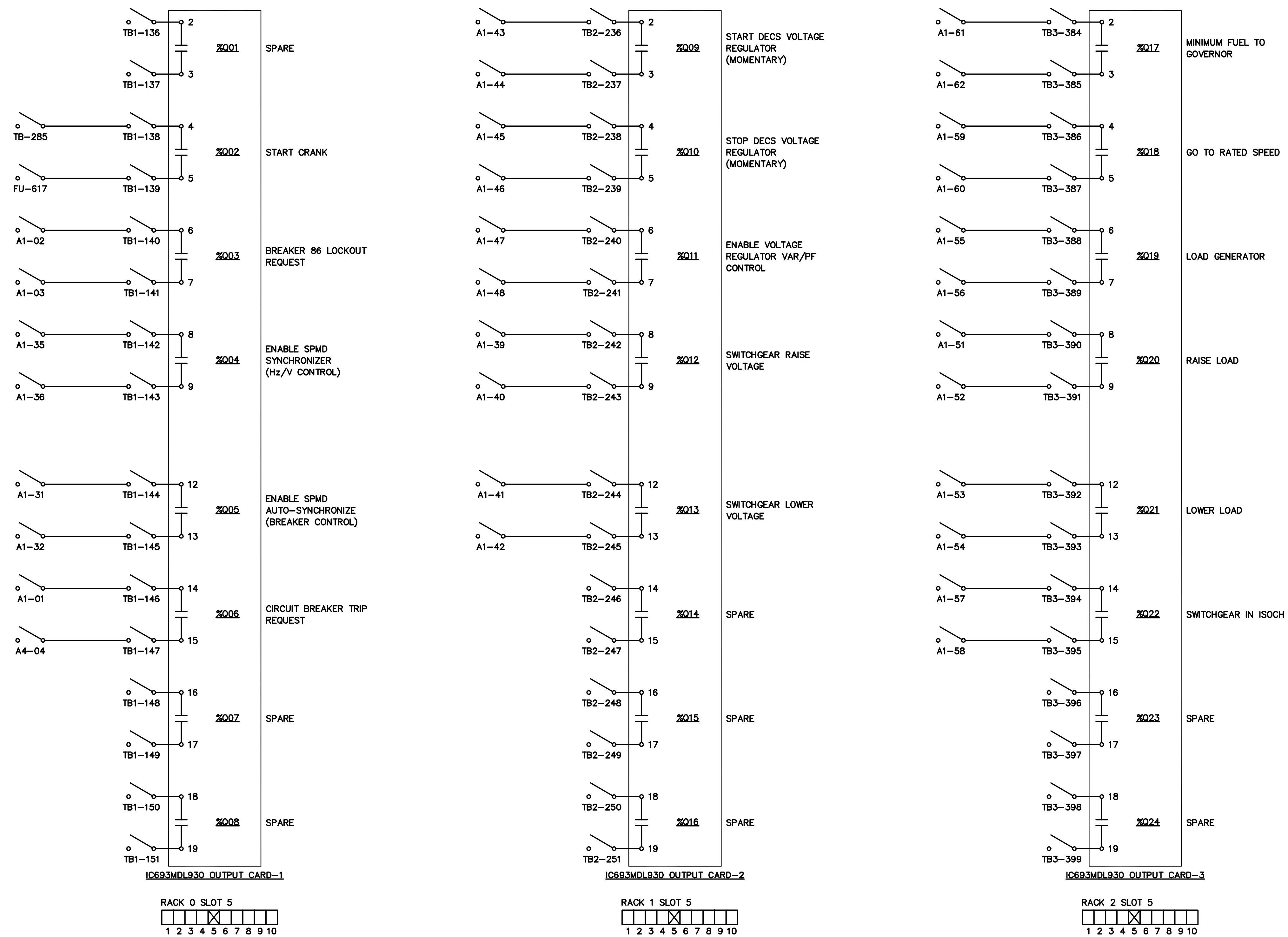
KOTZEBUE SCADA SYSTEM
CATERPILLAR UNITS
ENGINE CONTROL PANEL
PLC DISCRETE OUTPUTS

kss-el-2003_2.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2003

SHEET 2 OF 2



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW   W.O. #: 05-0204

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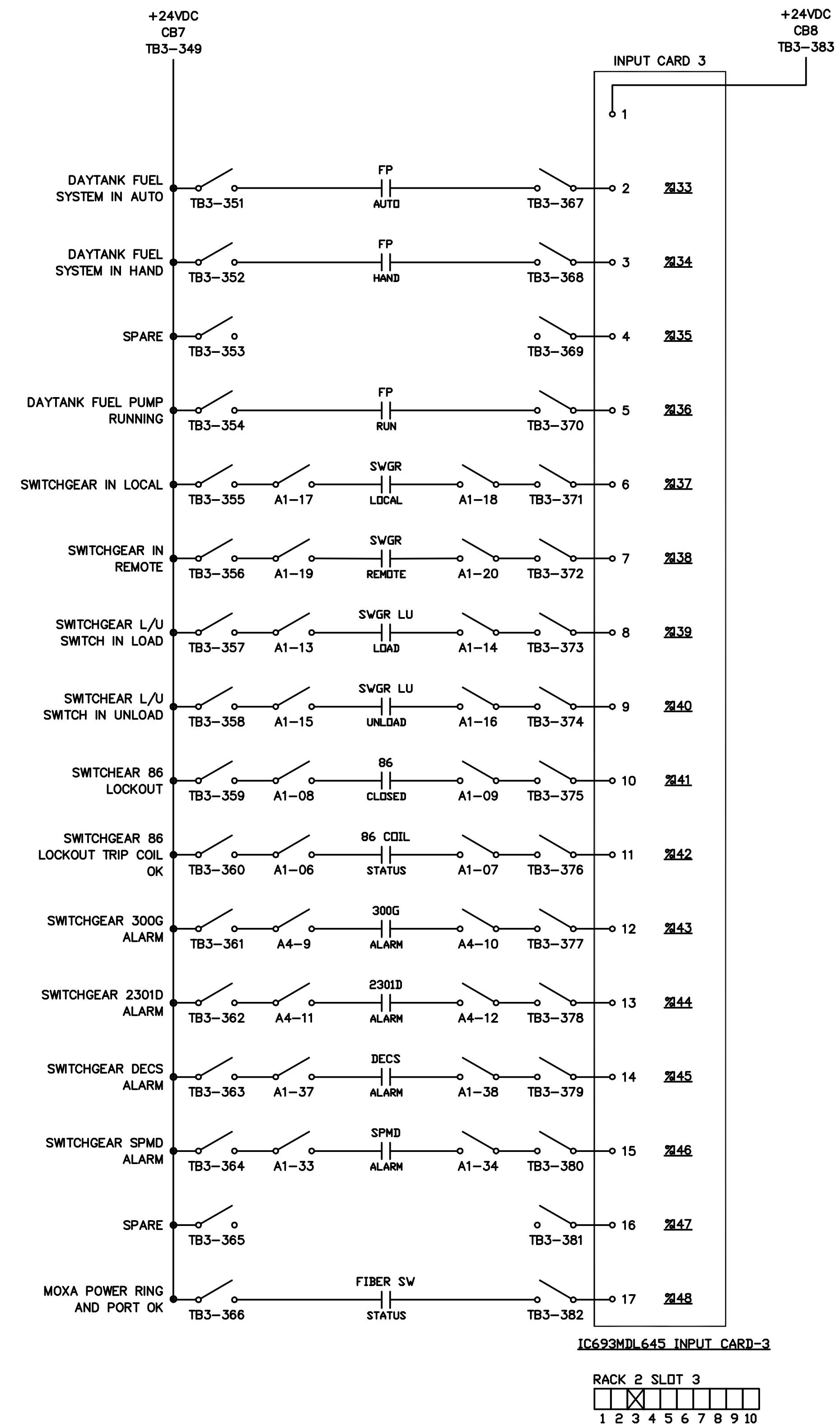
KOTZEBUE SCADA SYSTEM
CATERPILLAR UNITS
ENGINE CONTROL PANEL
PLC DISCRETE OUTPUTS

kss-el-2003_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2003

SHEET 1 OF 2



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PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. - SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. # 05-0204

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FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

DRAWING NAME:

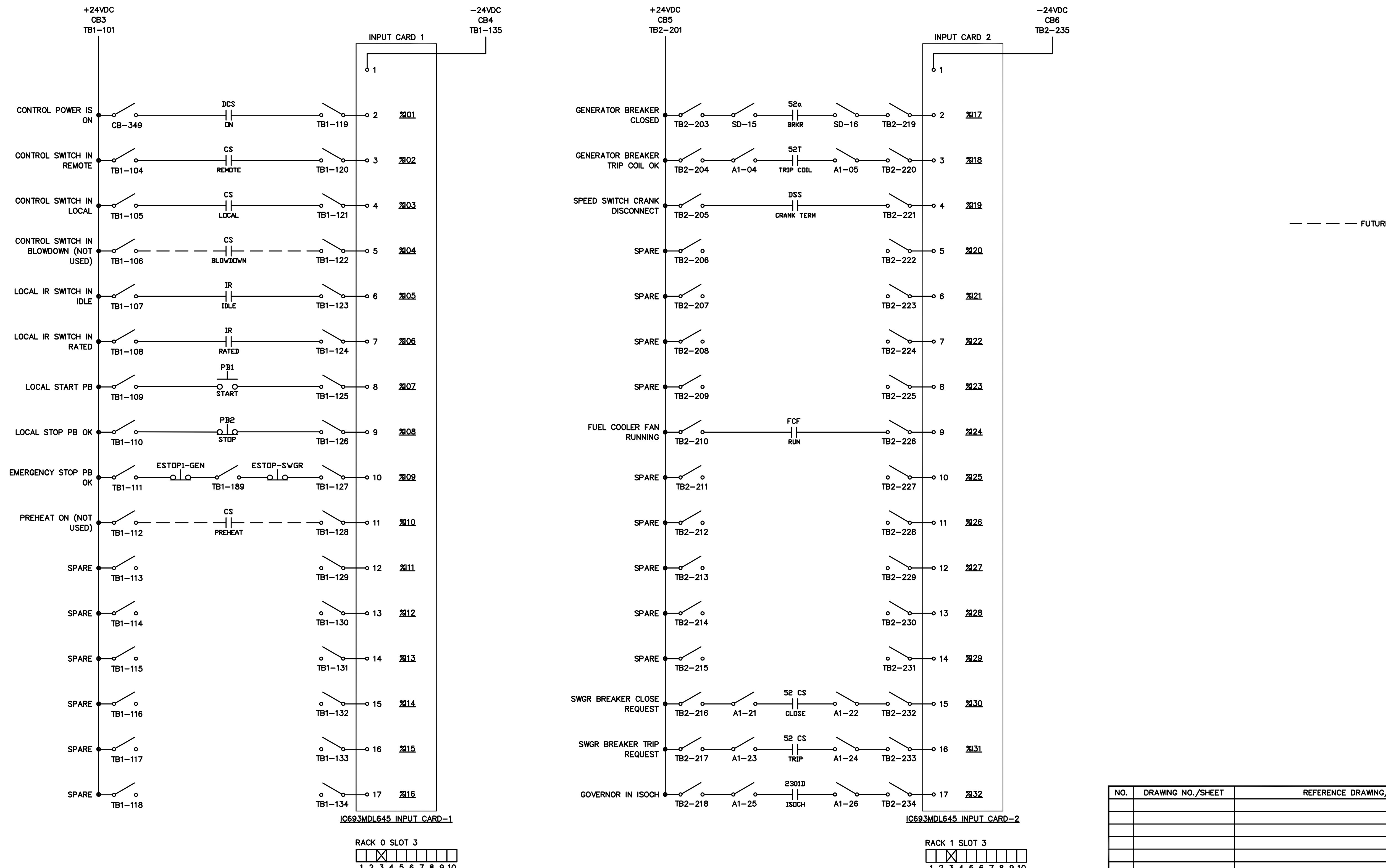
KOTZEBUE SCADA SYSTEM
CATERPILLAR UNITS
ENGINE CONTROL PANEL
PLC DISCRETE INPUTS

kss-el-2002_2.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2002

SHEET 2 OF 2



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. - SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. # 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
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WEB: WWW.EPSINC.COM

DRAWING NAME:

KOTZEBUE SCADA SYSTEM
CATERPILLAR UNITS
ENGINE CONTROL PANEL
PLC DISCRETE INPUTS

kss-el-2002_1.dwg

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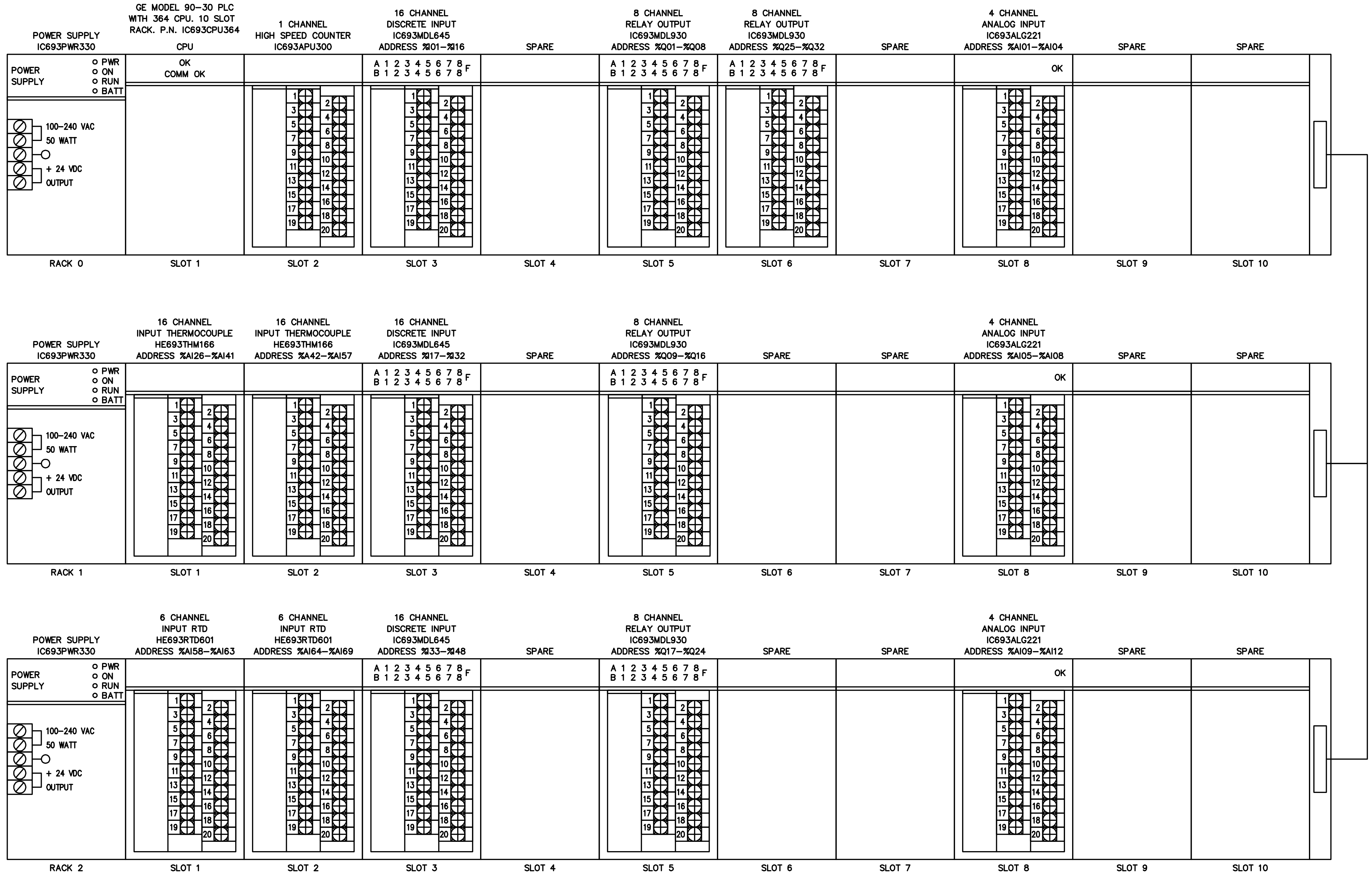
DRAWING NO.: KSS-EL-2002

SHEET 1 OF 2



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. # 05-0204

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0	AS BUILT	KER/12-05-2006	RJM/12-05-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

DRAWING NAME:
KOTZEBUE SCADA SYSTEM
CATERPILLAR UNITS
ENGINE CONTROL PANEL
PLC LAYOUT

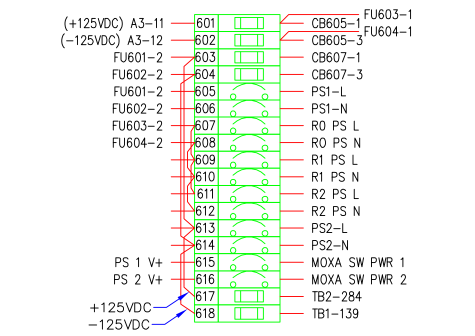
kss_el_2001_1.dwg

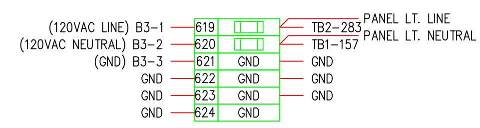
REF DWG(S):

DRAWING NO.: KSS-EL-2001

SHEET 1 OF 1

TB6





PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC
DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW
W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-05-2006	RJM/12-05-2006	

ENG. STAMP

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Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

DRAWING NAME:
KOTZEBUE SCADA SYSTEM
CATERPILLAR UNITS
ENGINE CONTROL PANEL
TERMINAL BLOCK LAYOUT

REF DWG(S):
kss-el-2000_7.dwg

DRAWING NO.: KSS-EL-2000

SHEET 7 OF 7

TB5
(UNIT 7)

CYL-1+	501	SHLD	R1S1-C2
CYL-1-	502	SHLD	R1S1-C4
	503	SHLD	SHIELD
CYL-2+	504	SHLD	R1S1-C6
CYL-2-	505	SHLD	R1S1-C8
GND	506	SHLD	SHIELD
CYL-3+	507	SHLD	R1S1-C10
CYL-3-	508	SHLD	R1S1-C12
GND	509	SHLD	SHIELD
CYL-4+	510	SHLD	R1S1-C14
CYL-4-	511	SHLD	R1S1-C16
GND	512	SHLD	SHIELD
CYL-5+	513	SHLD	R1S1-A2
CYL-5-	514	SHLD	R1S1-A4
GND	515	SHLD	SHIELD
CYL-6+	516	SHLD	R1S1-A6
CYL-6-	517	SHLD	R1S1-A8
GND	518	SHLD	SHIELD
CYL-7+	519	SHLD	R1S1-A10
CYL-7-	520	SHLD	R1S1-A12
GND	521	SHLD	SHIELD
CYL-8+	522	SHLD	R1S1-A14
CYL-8-	523	SHLD	R1S1-A16
GND	524	SHLD	SHIELD
CYL-9+	525	SHLD	R1S1-C18
CYL-9-	526	SHLD	R1S1-C20
GND	527	SHLD	SHIELD
CYL-10+	528	SHLD	R1S1-C22
CYL-10-	529	SHLD	R1S1-C24
GND	530	SHLD	SHIELD
CYL-11+	531	SHLD	R1S1-C26
CYL-11-	532	SHLD	R1S1-C28
GND	533	SHLD	SHIELD
CYL-12+	534	SHLD	R1S1-C30
CYL-12-	535	SHLD	R1S1-C32
	536	SHLD	SHIELD
	537	SHLD	R1S1-A18
	538	SHLD	R1S1-A20
	539	SHLD	SHIELD
	540	SHLD	R1S1-A22
	541	SHLD	R1S1-A24
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	545	SHLD	SHIELD
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	548	SHLD	SHIELD
	549	GND	GND
	550	SHLD	R1S2-C2
	551	SHLD	R1S2-C4
	552	SHLD	SHIELD
	553	SHLD	R1S2-C6
	554	SHLD	R1S2-C8
	555	SHLD	SHIELD
	556	SHLD	R1S2-C10
	557	SHLD	R1S2-C12
	558	SHLD	SHIELD
	559	SHLD	R1S2-C14
	560	SHLD	R1S2-C16
	561	SHLD	SHIELD
	562	SHLD	R1S2-A2
	563	SHLD	R1S2-A4
	564	SHLD	SHIELD
	565	SHLD	R1S2-A6
	566	SHLD	R1S2-A8
	567	SHLD	SHIELD
	568	SHLD	R1S2-A10
	569	SHLD	R1S2-A12
	570	SHLD	SHIELD
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	573	SHLD	SHIELD
TCR+	574	SHLD	R1S2-C18
TCR-	575	SHLD	R1S2-C20
GND	576	SHLD	SHIELD
TCL+	577	SHLD	R1S2-C22
TCL-	578	SHLD	R1S2-C24
GND	579	SHLD	SHIELD
	580	SHLD	R1S2-C26
	581	SHLD	R1S2-C28
	582	SHLD	SHIELD
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	589	SHLD	R1S2-A22
	590	SHLD	R1S2-A24
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	592	SHLD	R1S2-A26
	593	SHLD	R1S2-A28
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	595	SHLD	R1S2-A30
	596	SHLD	R1S2-A32
	597	SHLD	SHIELD
	598	GND	GND

TB5
(UNITS 11 & 12)

CYL-1+	501	SHLD	R1S1-C2
CYL-1-	502	SHLD	R1S1-C4
	503	SHLD	SHIELD
CYL-2+	504	SHLD	R1S1-C6
CYL-2-	505	SHLD	R1S1-C8
GND	506	SHLD	SHIELD
CYL-3+	507	SHLD	R1S1-C10
CYL-3-	508	SHLD	R1S1-C12
GND	509	SHLD	SHIELD
CYL-4+	510	SHLD	R1S1-C14
CYL-4-	511	SHLD	R1S1-C16
GND	512	SHLD	SHIELD
CYL-5+	513	SHLD	R1S1-A2
CYL-5-	514	SHLD	R1S1-A4
GND	515	SHLD	SHIELD
CYL-6+	516	SHLD	R1S1-A6
CYL-6-	517	SHLD	R1S1-A8
GND	518	SHLD	SHIELD
CYL-7+	519	SHLD	R1S1-A10
CYL-7-	520	SHLD	R1S1-A12
GND	521	SHLD	SHIELD
CYL-8+	522	SHLD	R1S1-A14
CYL-8-	523	SHLD	R1S1-A16
GND	524	SHLD	SHIELD
CYL-9+	525	SHLD	R1S1-C18
CYL-9-	526	SHLD	R1S1-C20
GND	527	SHLD	SHIELD
CYL-10+	528	SHLD	R1S1-C22
CYL-10-	529	SHLD	R1S1-C24
GND	530	SHLD	SHIELD
CYL-11+	531	SHLD	R1S1-C26
CYL-11-	532	SHLD	R1S1-C28
GND	533	SHLD	SHIELD
CYL-12+	534	SHLD	R1S1-C30
CYL-12-	535	SHLD	R1S1-C32
GND	536	SHLD	SHIELD
CYL-13+	537	SHLD	R1S1-A18
CYL-13-	538	SHLD	R1S1-A20
GND	539	SHLD	SHIELD
CYL-14+	540	SHLD	R1S1-A22
CYL-14-	541	SHLD	R1S1-A24
GND	542	SHLD	SHIELD
CYL-15+	543	SHLD	R1S1-A26
CYL-15-	544	SHLD	R1S1-A28
GND	545	SHLD	SHIELD
CYL-16+	546	SHLD	R1S1-A30
CYL-16-	547	SHLD	R1S1-A32
GND	548	SHLD	SHIELD
	549	GND	GND
	550	SHLD	R1S2-C2
	551	SHLD	R1S2-C4
	552	SHLD	SHIELD
	553	SHLD	R1S2-C6
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	558	SHLD	SHIELD
	559	SHLD	R1S2-C14
	560	SHLD	R1S2-C16
	561	SHLD	SHIELD
	562	SHLD	R1S2-A2
	563	SHLD	R1S2-A4
	564	SHLD	SHIELD
	565	SHLD	R1S2-A6
	566	SHLD	R1S2-A8
	567	SHLD	SHIELD
	568	SHLD	R1S2-A10
	569	SHLD	R1S2-A12
	570	SHLD	SHIELD
	571	SHLD	R1S2-A14
	572	SHLD	R1S2-A16
	573	SHLD	SHIELD
TCR+	574	SHLD	R1S2-C18
TCR-	575	SHLD	R1S2-C20
GND	576	SHLD	SHIELD
TCL+	577	SHLD	R1S2-C22
TCL-	578	SHLD	R1S2-C24
GND	579	SHLD	SHIELD
	580	SHLD	R1S2-C26
	581	SHLD	R1S2-C28
	582	SHLD	SHIELD
	583	SHLD	R1S2-C30
	584	SHLD	R1S2-C32
	585	SHLD	SHIELD
	586	SHLD	R1S2-A18
	587	SHLD	R1S2-A20
	588	SHLD	SHIELD
	589	SHLD	R1S2-A22
	590	SHLD	R1S2-A24
	591	SHLD	SHIELD
	592	SHLD	R1S2-A26
	593	SHLD	R1S2-A28
	594	SHLD	SHIELD
	595	SHLD	R1S2-A30
	596	SHLD	R1S2-A32
	597	SHLD	SHIELD
	598	GND	GND

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW

W.O. #: 05-0204

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0	AS BUILT	KER/12-05-2006	RJM/12-05-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

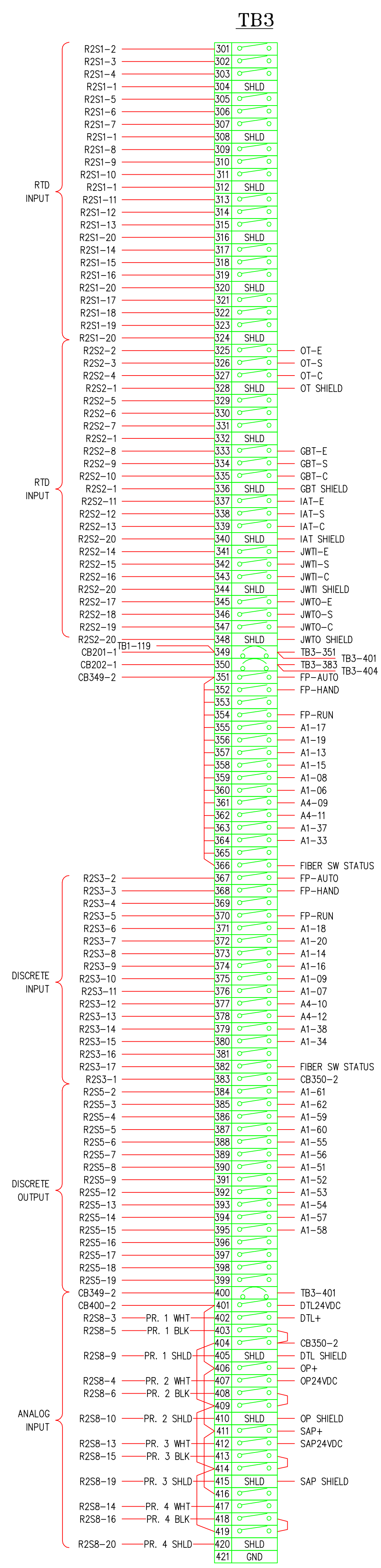
NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

DRAWING NAME: KOTZEBUE SCADA SYSTEM CATERPILLAR UNITS ENGINE CONTROL PANEL TERMINAL BLOCK LAYOUT

REF DWG(S): kss-el-2000_6.dwg

DRAWING NO.: KSS-EL-2000

SHEET 6 OF 7



PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC
DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW
W.O. #: 05-0204

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ELECTRIC POWER SYSTEMS EPS Inc.
Consulting Engineers
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FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

DRAWING NAME:
KOTZEBUE SCADA SYSTEM
CATERPILLAR UNITS
ENGINE CONTROL PANEL
TERMINAL BLOCK LAYOUT

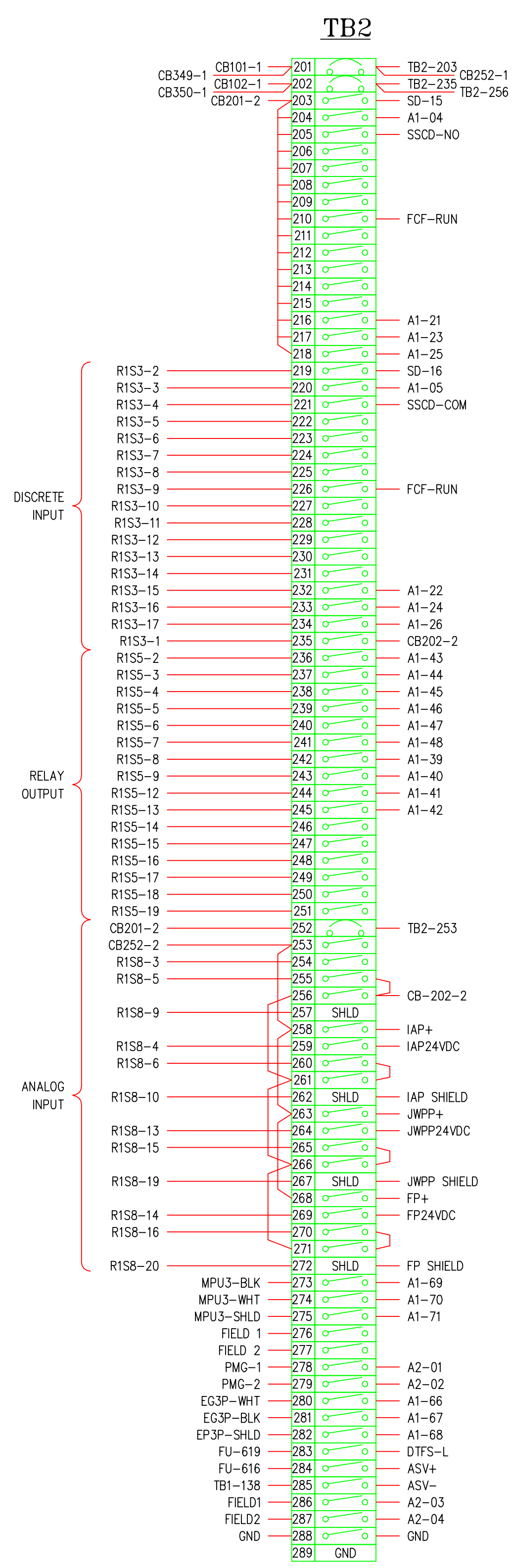
REF DWG(S):
kss-el-2000_5.dwg

DRAWING NO.: KSS-EL-2000

SHEET 5 OF 7

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

TB2



NOTE: FIELD 1, FIELD 2, A2-03, A2-04 TERMINATED IN 276, 277 IN GEN 11.

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. - SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW

W.O. #: 05-0204

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NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

DRAWING NAME: KOTZEBUE SCADA SYSTEM CATERPILLAR UNITS ENGINE CONTROL PANEL TERMINAL BLOCK LAYOUT

REF DWG(S): kss-el-2000 4.dwg

DRAWING NO.: KSS-EL-2000

SHEET 4 OF 7

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC
DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW
W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
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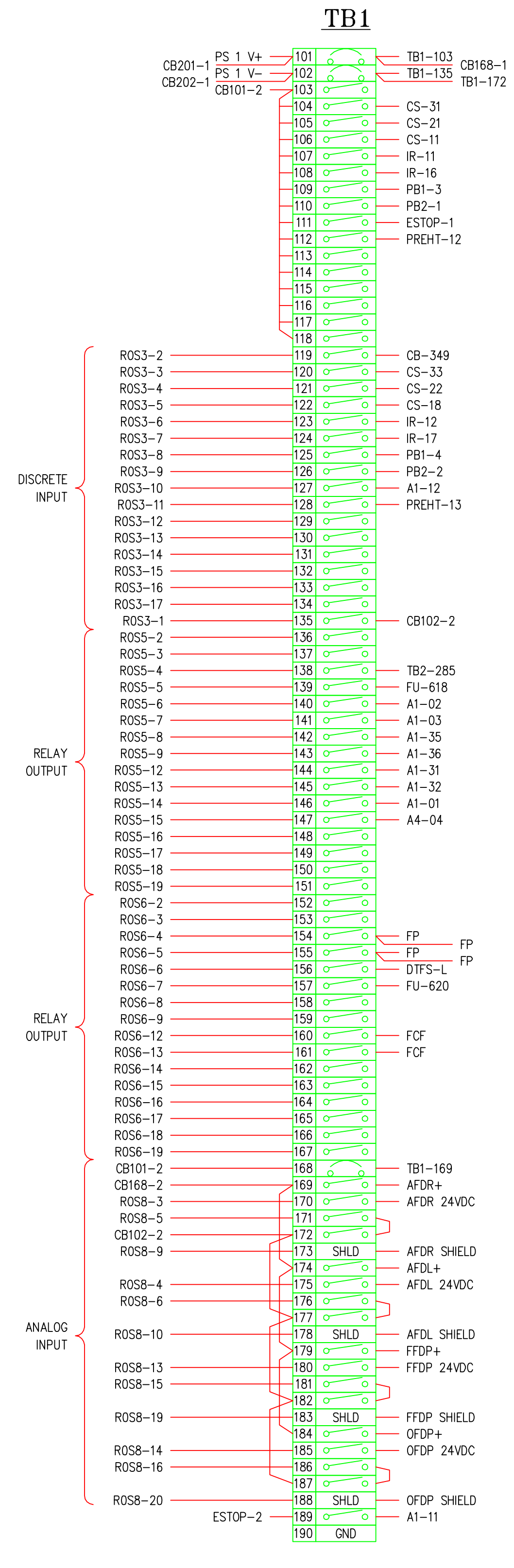
TB1



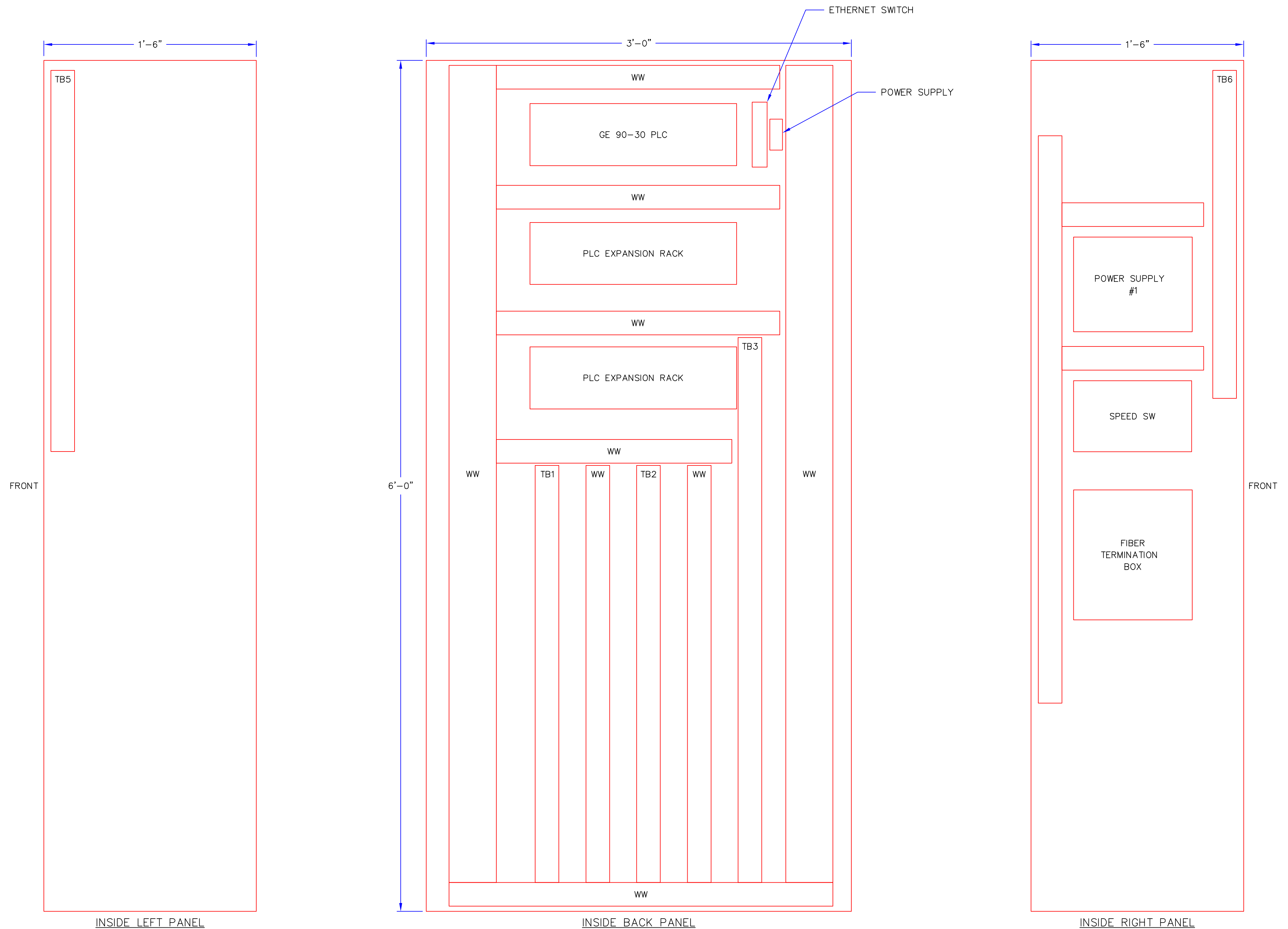
NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

DRAWING NAME: KOTZEBUE SCADA SYSTEM CATERPILLAR UNITS ENGINE CONTROL PANEL TERMINAL BLOCK LAYOUT

REF DWG(S): kss-el-2000_3.dwg

DRAWING NO.: KSS-EL-2000

SHEET 3 OF 7



DESCRIPTION	MANUFACTURER	PART NUMBER
WW (WIREWAY)	PANDUIT	VARIOUS
TBX (TERMINAL BLOCK)	ENTRELEC	VARIOUS
GE 90-30 PLC	GE	SEE KSS-EL-2001
ETHERNET SWITCH	MOXA	EDS-405-MM-SC
POWER SUPPLY #1	IDEC	PS5R-240
FIBER TERMINATION BOX	CORNING	WIC-012
SPEED SWITCH	CATERPILLAR	7W2743
POWER SUPPLY #2	IDEC	PS5R-SC24

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC
DESIGNER/PROJECT ENGINEER: STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
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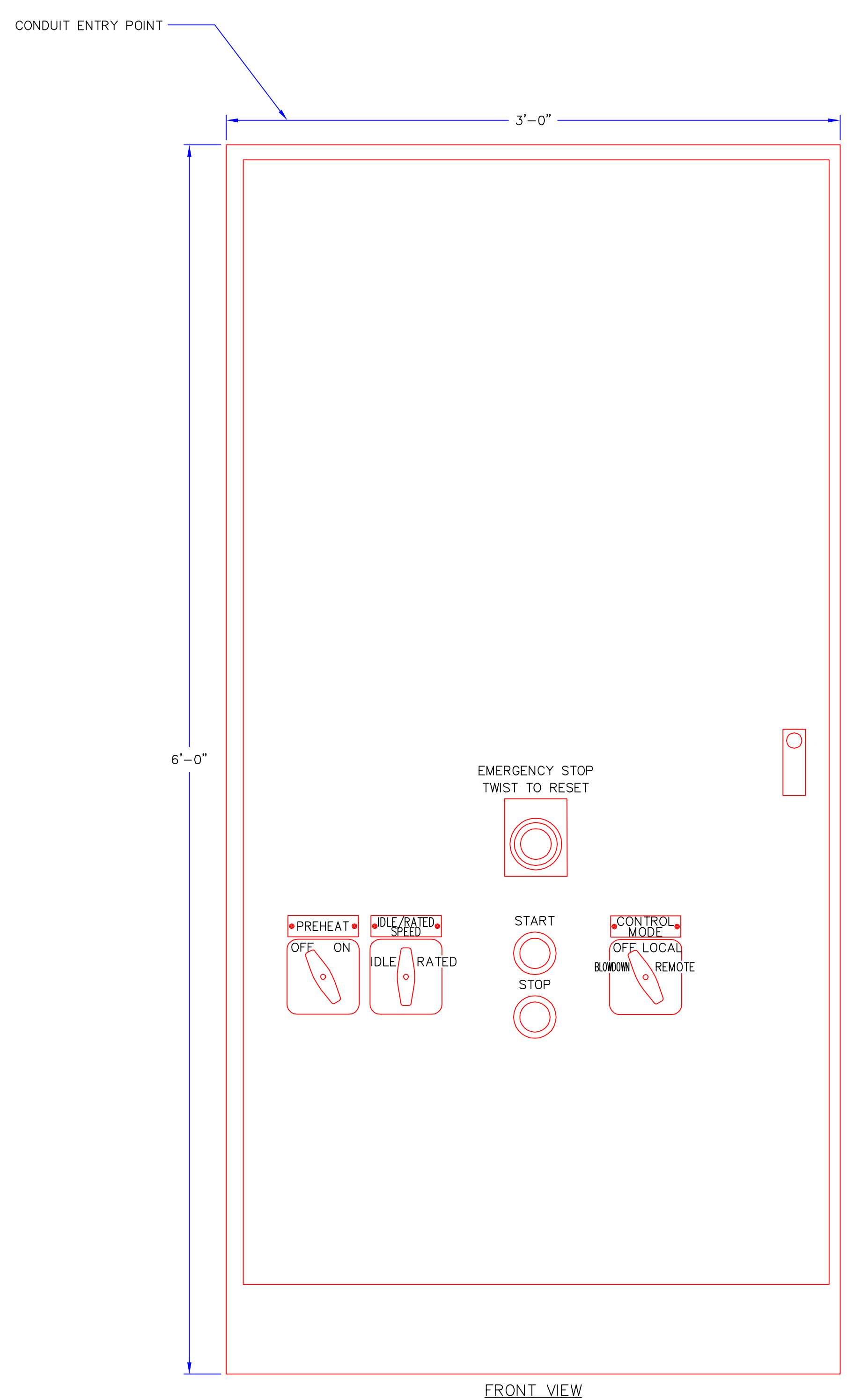
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
CATERPILLAR UNITS
ENGINE CONTROL PANEL
COMPONENT LAYOUT

kss-el-2000_2.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2000

SHEET 2 OF 7



DESCRIPTION	MANUFACTURER	PART NUMBER
EMERGENCY STOP	CUTLER HAMMER	10250ED1043-4, 10250TS13
START PUSH BUTTON	CUTLER HAMMER	10250T53, 10250T30G, 10250TS33
STOP PUSH BUTTON	CUTLER HAMMER	10250T51, 10250T30R, 10250TS34
PREHEAT SWITCH	ELECTROSWITCH	24201C
IDLE/RATED SWITCH	ELECTROSWITCH	24201C
CONTROL MODE SWITCH	ELECTROSWITCH	24303C
STEEL ENCLOSURE	HOFFMAN	A723618FS

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC
DESIGNER/PROJECT ENGINEER: STEVE DREW
W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
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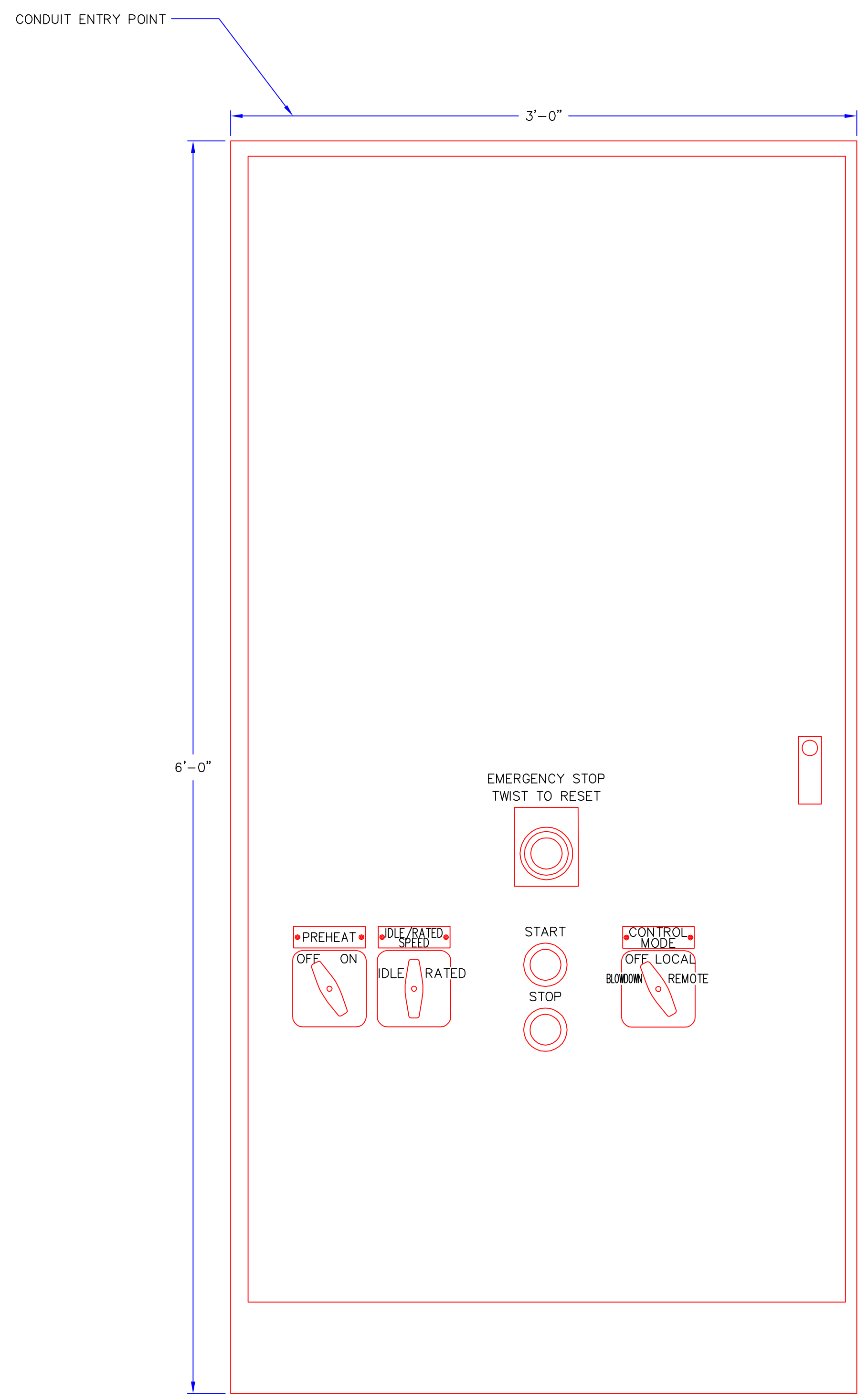
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
CATERPILLAR UNITS
ENGINE CONTROL PANEL
ELEVATION VIEW

kss-el-2000_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2000

SHEET 1 OF 7



FRONT VIEW

DESCRIPTION	MANUFACTURER	PART NUMBER
EMERGENCY STOP	CUTLER HAMMER	10250ED1043-4, 10250TS13
START PUSH BUTTON	CUTLER HAMMER	10250T53, 10250T30G, 10250TS33
STOP PUSH BUTTON	CUTLER HAMMER	10250T51, 10250T30R, 10250TS34
PREHEAT SWITCH	ELECTROSWITCH	24201C
IDLE/RATED SWITCH	ELECTROSWITCH	24201C
CONTROL MODE SWITCH	ELECTROSWITCH	24303C
STEEL ENCLOSURE	HOFFMAN	A723618FS

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. - SCADA EPC
DESIGNER/PROJECT ENGINEER: STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
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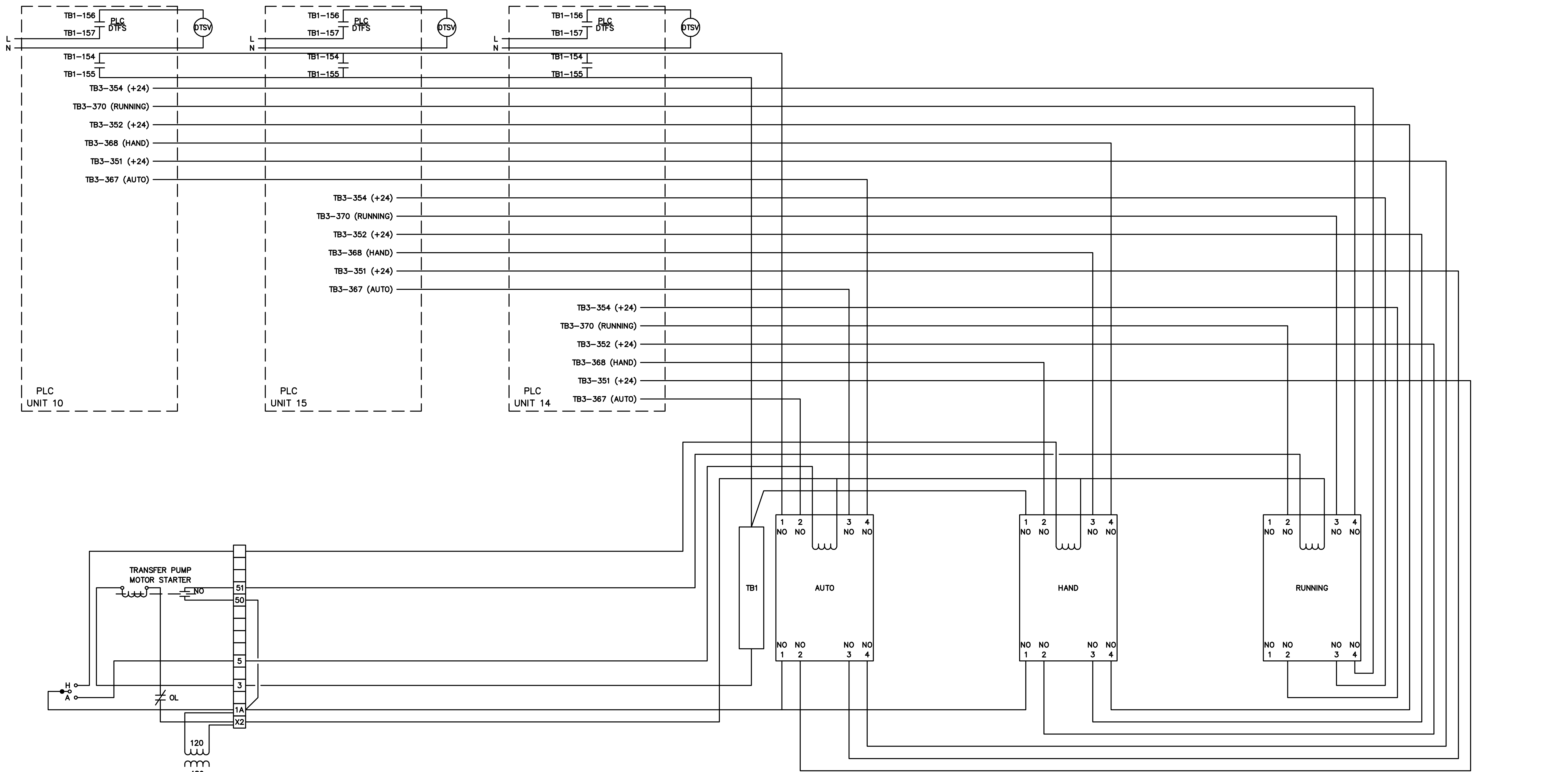
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
CATERPILLAR UNITS
ENGINE CONTROL PANEL
ELEVATION VIEW

kss-el-2000_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2000

SHEET 1 OF 7



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-08-2006	RJM/12-08-2006	

ENG. STAMP

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FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

DRAWING NAME:

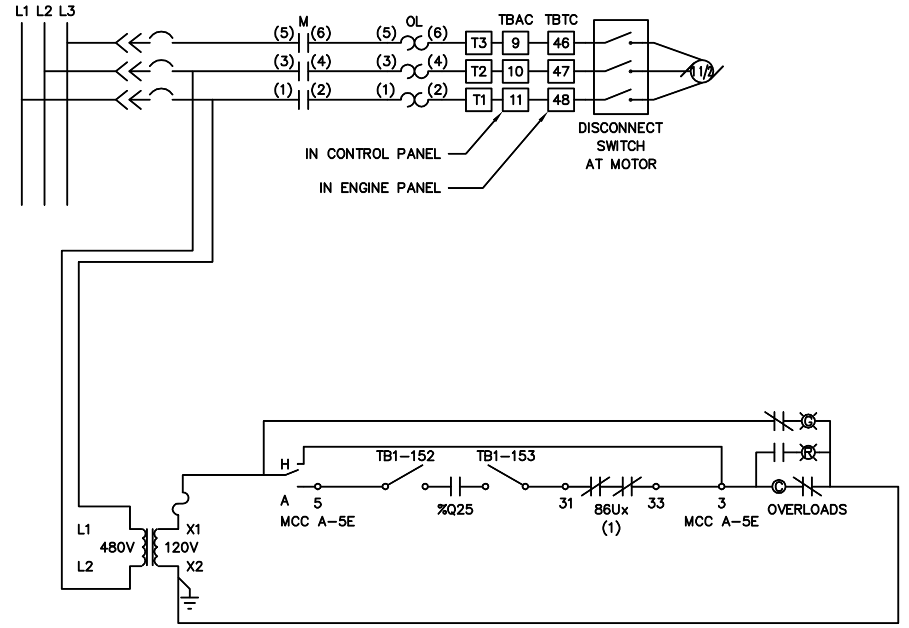
KOTZEBUE SCADA SYSTEM
EMD UNITS
FUEL TRANSFER SYSTEM

kss-el-2015_2.dwg

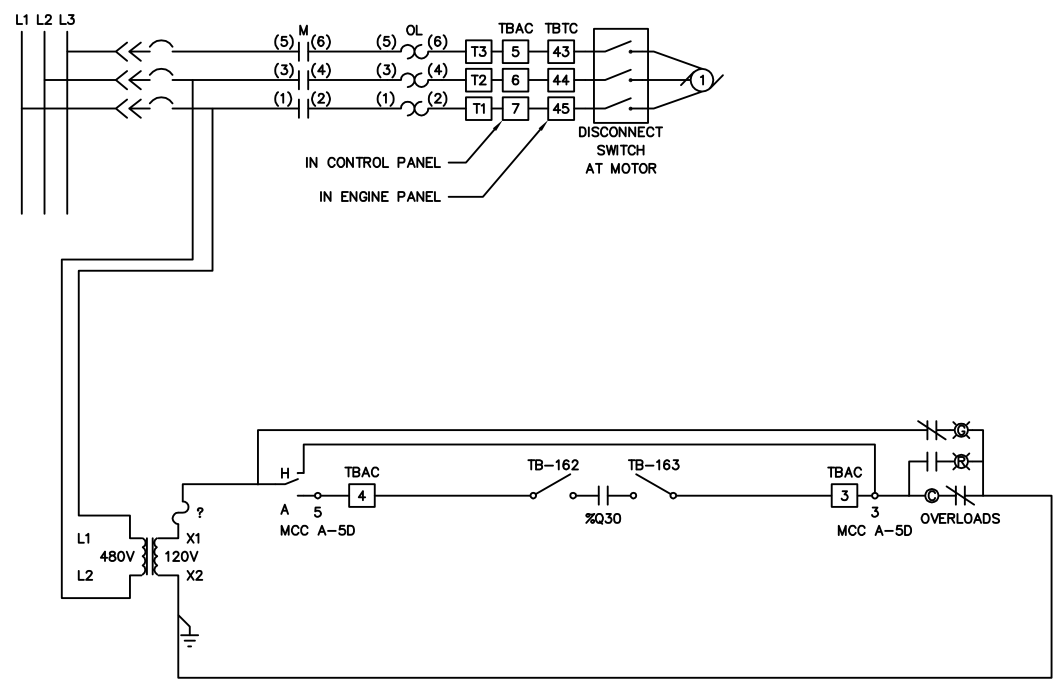
REF DWG(S):

DRAWING NO.: KSS-EL-2015

SHEET 2 OF 2



UNIT 10, 14, 15 FUEL PUMP CONTROLS



UNIT 10, 14, 15 PRELUBE PUMP CONTROLS

%Qn PLC OUTPUT
⬡ ENGINE TERMINAL BLOCK
□ ENGINE PANEL

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC
DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
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Consulting Engineers
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WEB: WWW.EPSINC.COM

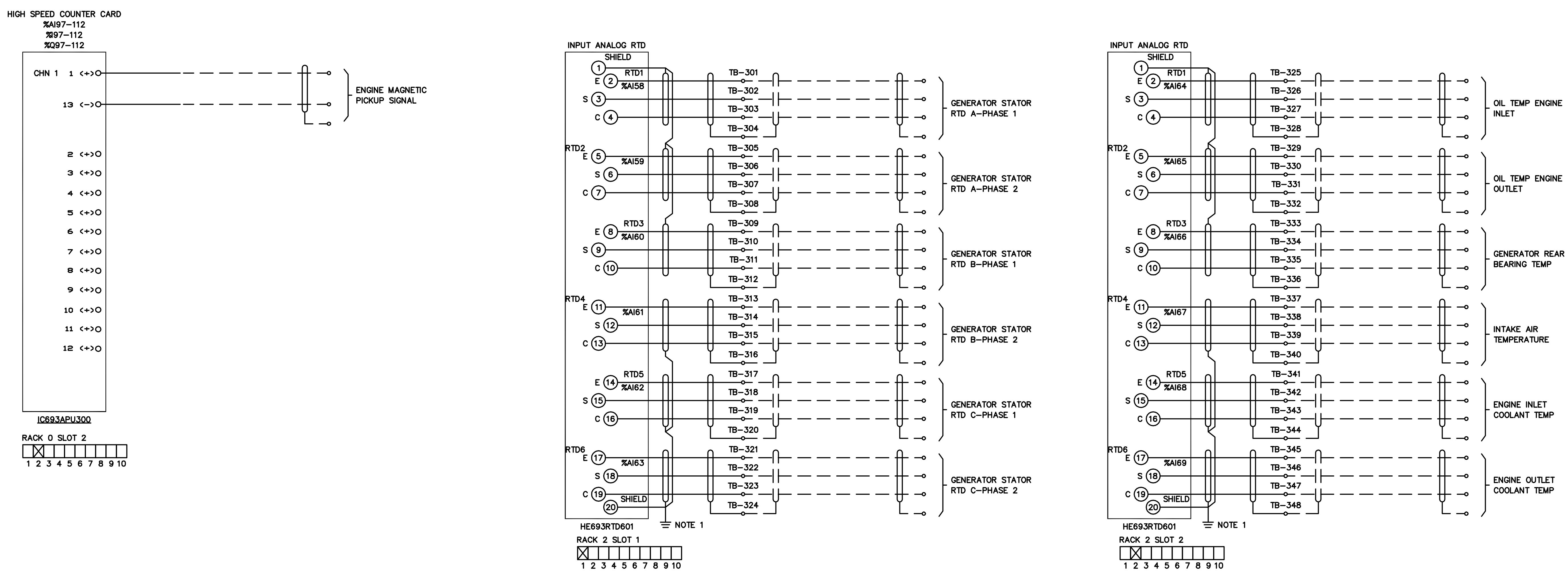
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
EMD UNITS
ANCILLARY CONTROLS
ENGINE CONTROL PANEL DC SCHEMATIC

kss-el-2015_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2015

SHEET 1 OF 2



NOTES:

1. TIE RTD SHEILDS AND PIN 1 AND 20 OF THE ANALOG CARD TO AN EARTH GROUND.

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC
DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05–0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
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ENG. STAMP

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Consulting Engineers
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FAX: (907) 522–1182
WEB: WWW.EPSINC.COM

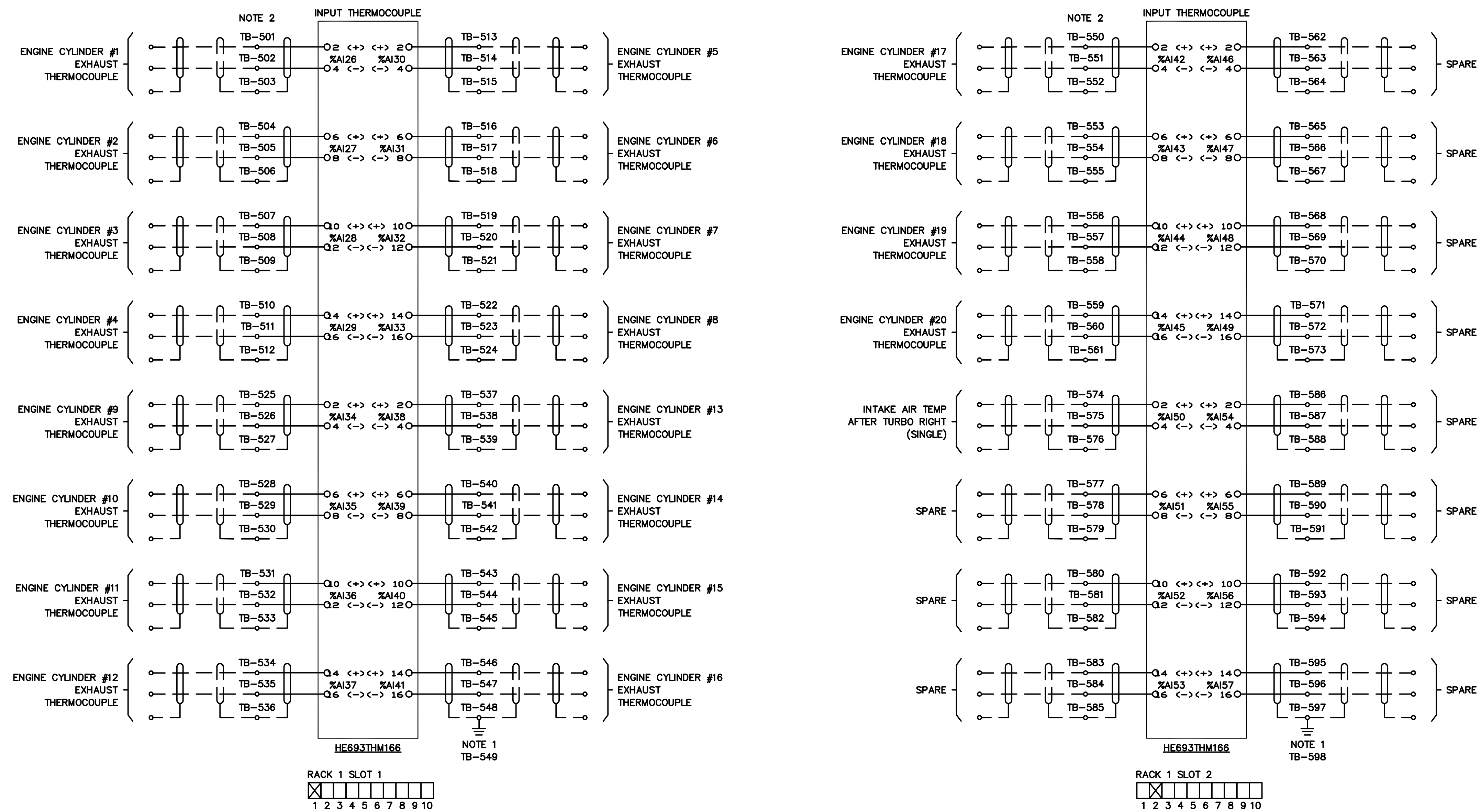
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
EMD UNITS
ENGINE CONTROL PANEL
PLC ANALAOG INPUTS

kss–el–2014_3.dwg

REF DWG(S):

DRAWING NO.: KSS–EL–2014

SHEET 3 OF 3



NOTES:

1. THE THERMOCOUPLE CONDUCTOR SHIELD SHALL BE CONNECTED TO AN EARTH GROUND AT THE ENGINE PANEL TERMINALS, TYPICAL FOR EACH THERMOCOUPLE.
2. GENERATOR UNIT 15 TERMINAL BLOCKS ARE DIFFERENT THAN SHOWN. R1S1 NUMBERING BEGINS AT TB-550 AND R1S2 NUMBERING BEGINS AT TB-501.

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

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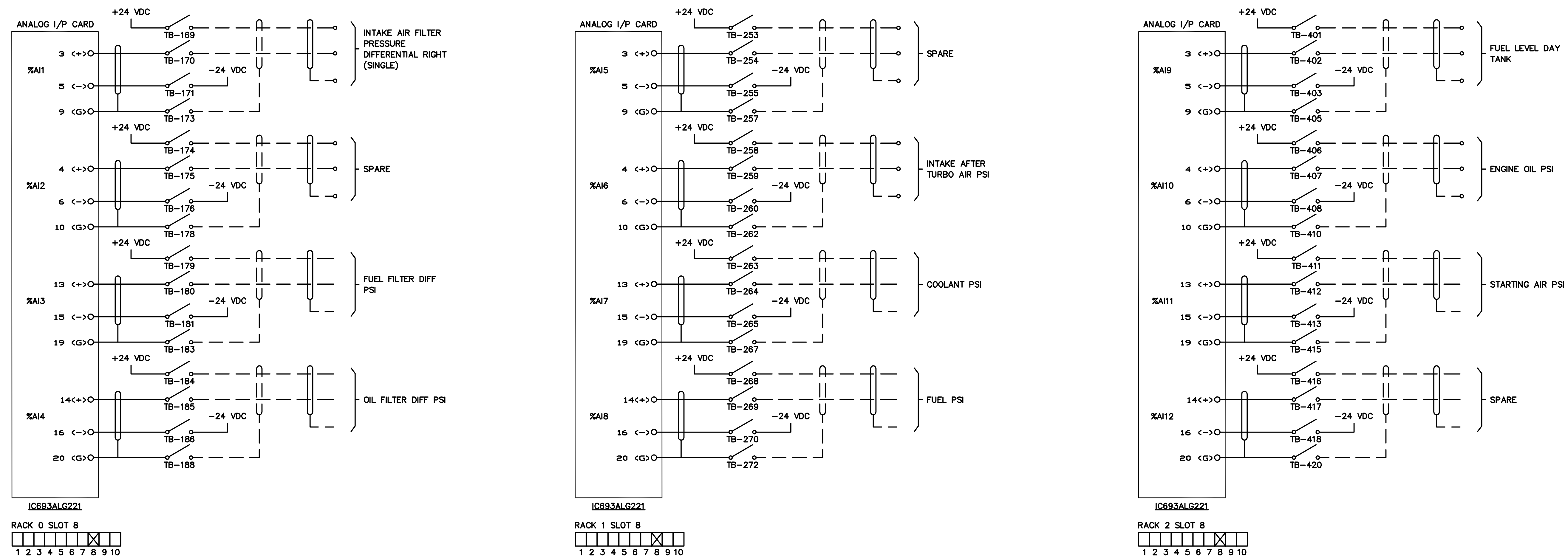
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
EMD UNITS
ENGINE CONTROL PANEL
PLC ANALOG INPUTS

kss-el-2014_2.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2014

SHEET 2 OF 3



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. - SCADA EPC
DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

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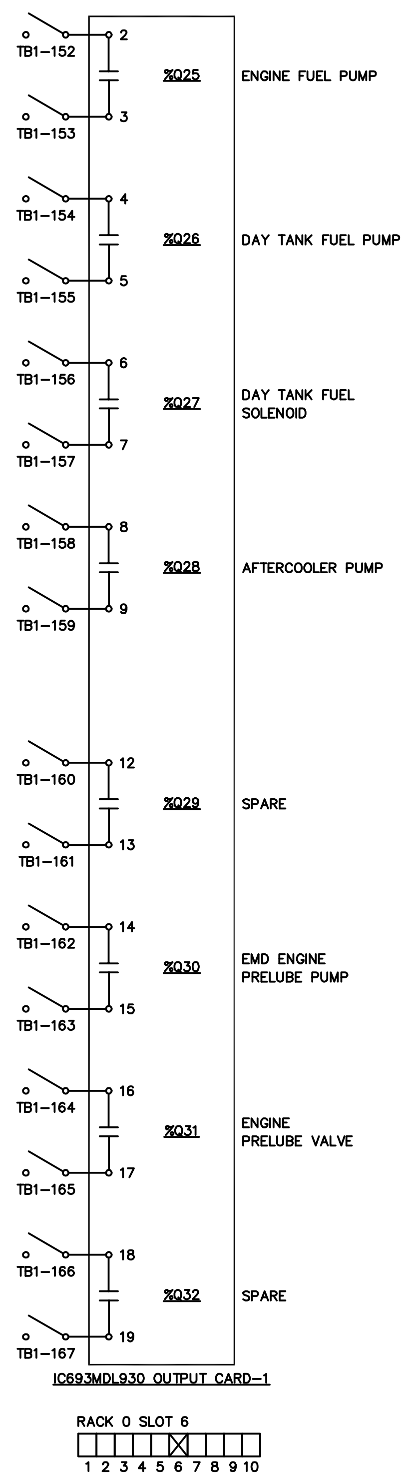
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
EMD UNITS
ENGINE CONTROL PANEL
PLC ANALOG INPUTS

kss-el-2014_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2014

SHEET 1 OF 3



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DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

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WEB: WWW.EPSINC.COM

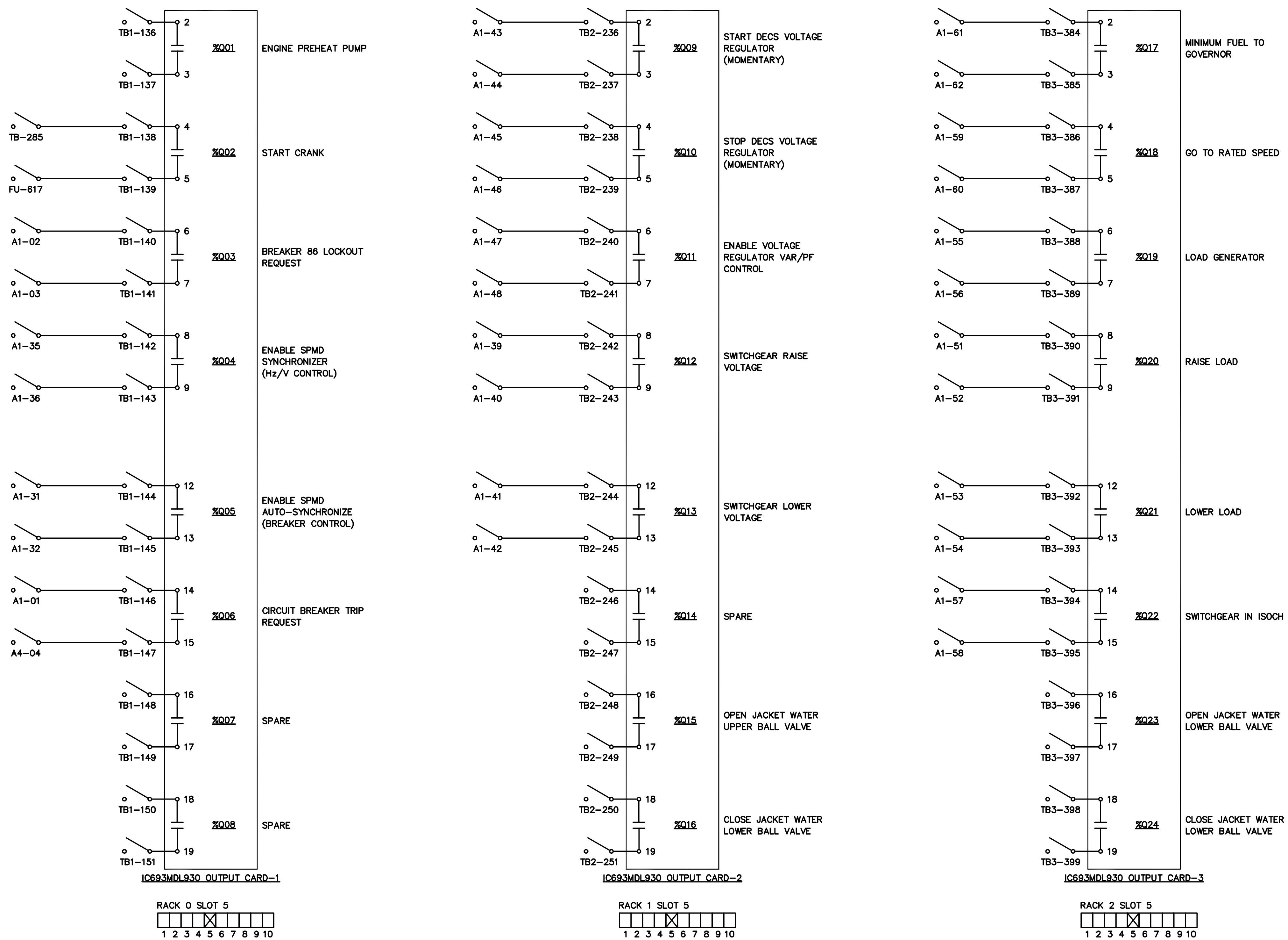
DRAWING NAME: KOTZEBUE SCADA SYSTEM
EMD UNITS
ENGINE CONTROL PANEL
PLC DISCRETE OUTPUTS

kss-el-2013_2.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2013

SHEET 2 OF 2



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

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DRAWING NAME:

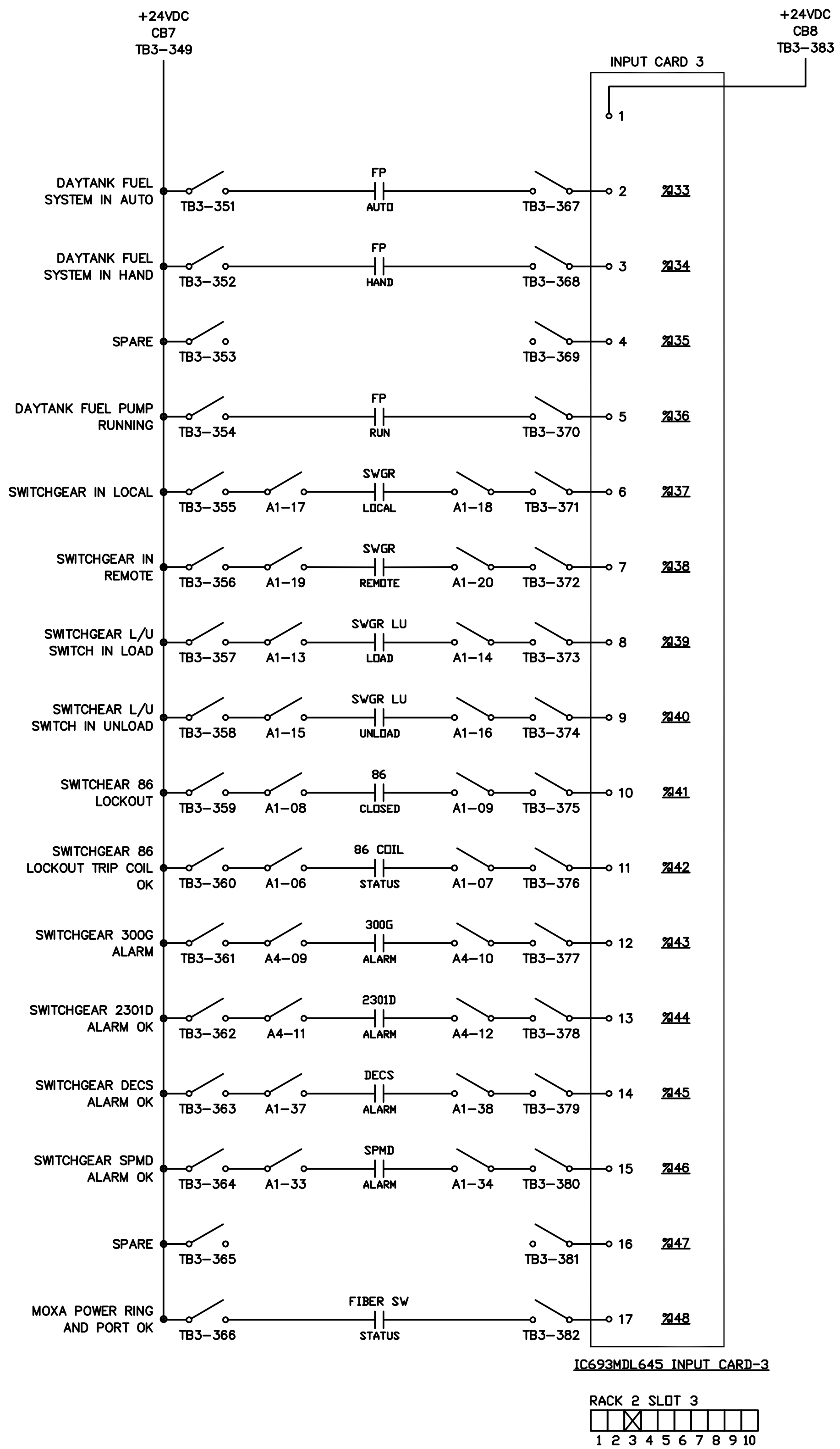
KOTZEBUE SCADA SYSTEM
EMD UNITS
ENGINE CONTROL PANEL
PLC DISCRETE OUTPUTS

kss-el-2013_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2013

SHEET 1 OF 2



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WEB: WWW.EPSINC.COM

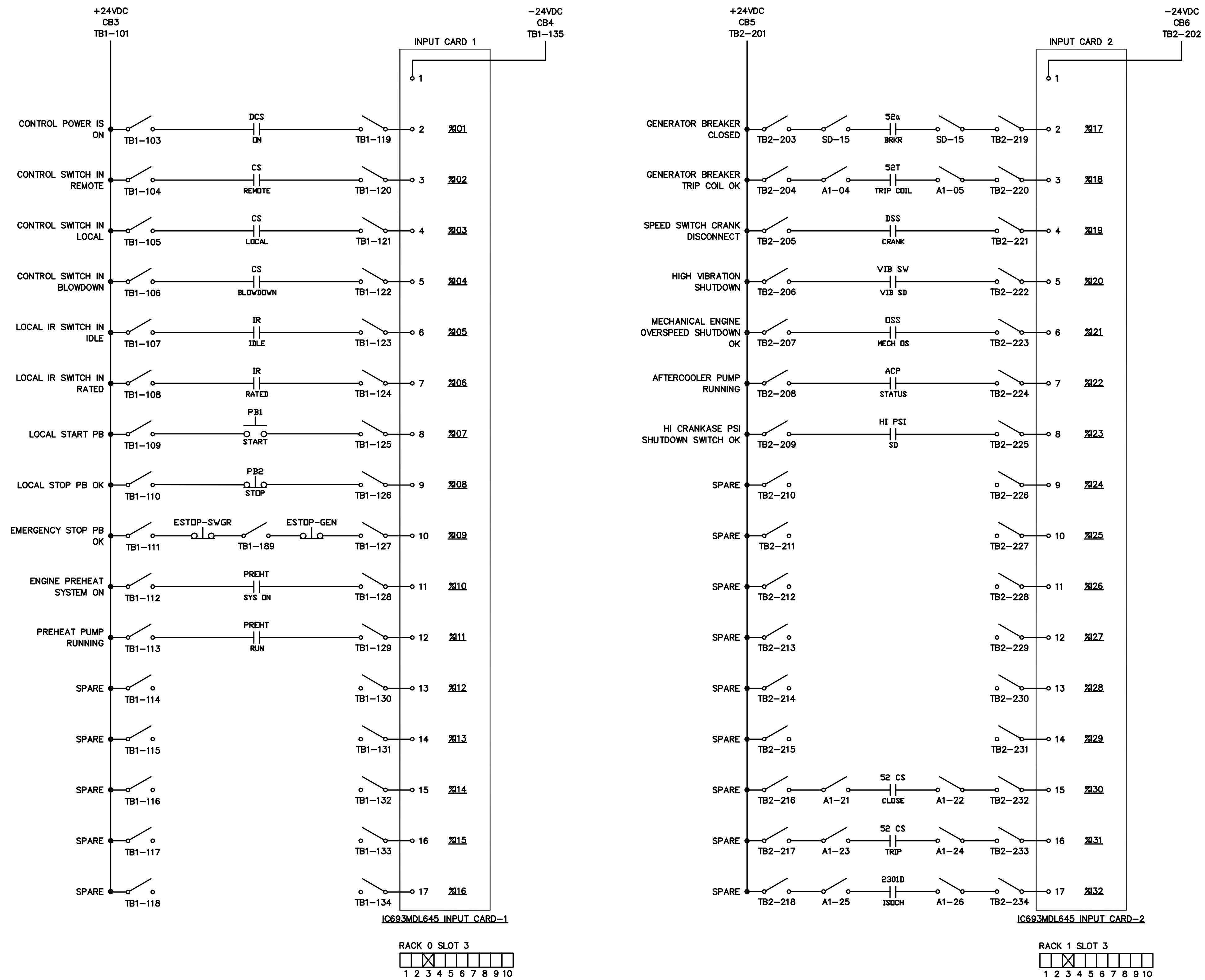
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
EMD UNITS
ENGINE CONTROL PANEL
PLC DISCRETE INPUTS

kss-el-2012_2.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2012

SHEET 2 OF 2



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

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DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

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DRAWING NAME:
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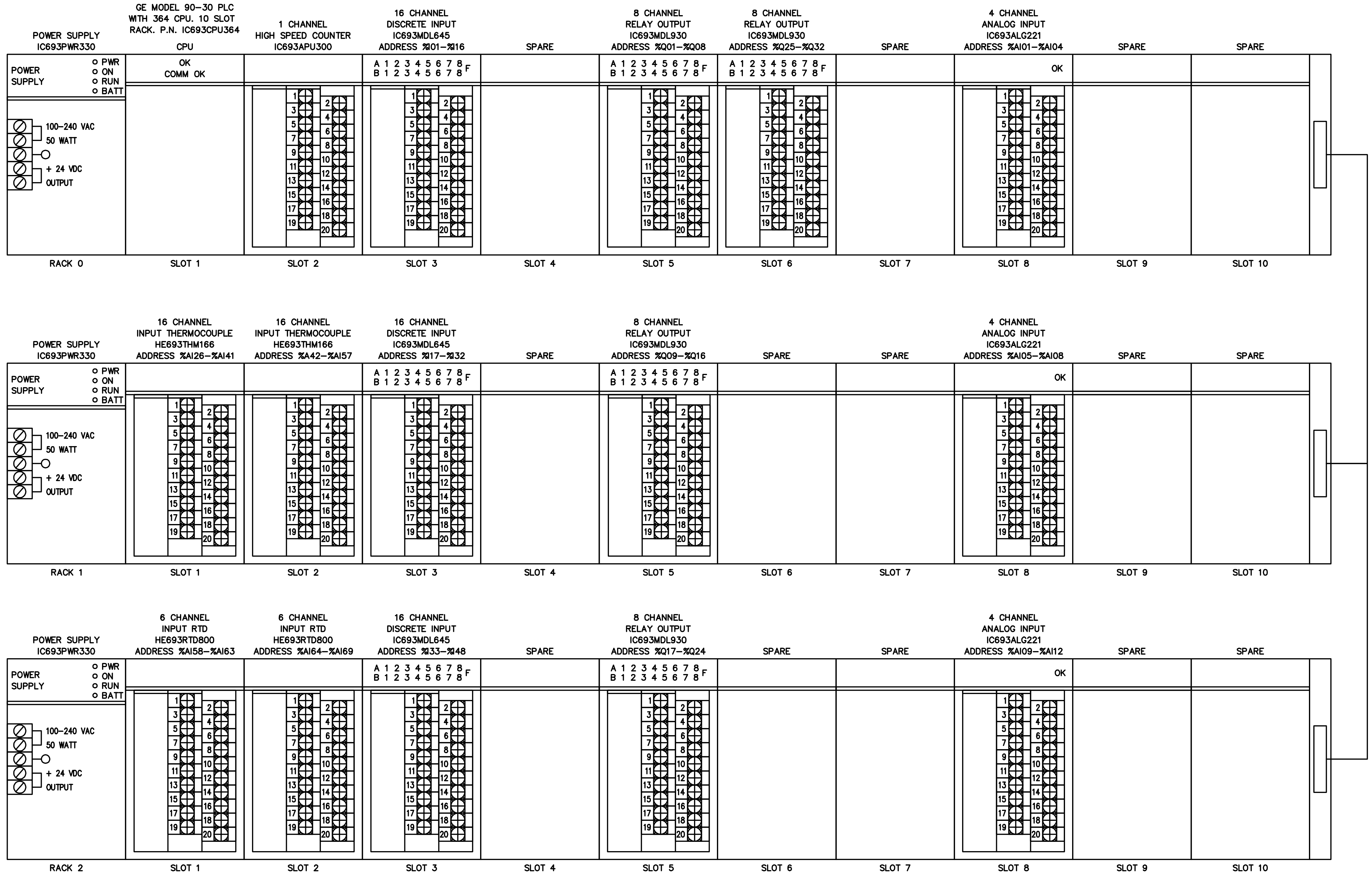
EMD UNITS
ENGINE CONTROL PANEL
PLC DISCRETE INPUTS

kss-el-2012_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2012

SHEET 1 OF 2



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DRAWING NAME:

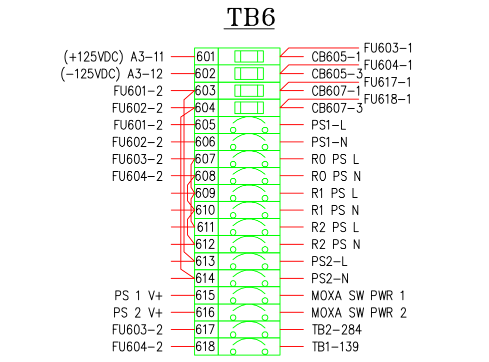
KOTZEBUE SCADA SYSTEM
EMD UNITS
ENGINE CONTROL PANEL
PLC LAYOUT

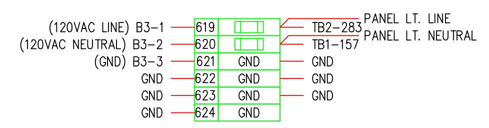
kss_el_2011_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2011

SHEET 1 OF 1





PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW

W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-05-2006	RJM/12-05-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

DRAWING NAME:
KOTZEBUE SCADA SYSTEM
EMD UNITS
ENGINE CONTROL PANEL
TERMINAL BLOCK LAYOUT

REF DWG(S):
kss-el-2010_7.dwg

DRAWING NO.: KSS-EL-2010

SHEET 7 OF 7

TB5
(UNITS 10 & 14)

CYL-1+	501	SHLD	R1S1-C2
CYL-1-	502	SHLD	R1S1-C4
GND	503	SHLD	SHIELD
CYL-2+	504	SHLD	R1S1-C6
CYL-2-	505	SHLD	R1S1-C8
GND	506	SHLD	SHIELD
CYL-3+	507	SHLD	R1S1-C10
CYL-3-	508	SHLD	R1S1-C12
GND	509	SHLD	SHIELD
CYL-4+	510	SHLD	R1S1-C14
CYL-4-	511	SHLD	R1S1-C16
GND	512	SHLD	SHIELD
CYL-5+	513	SHLD	R1S1-A2
CYL-5-	514	SHLD	R1S1-A4
GND	515	SHLD	SHIELD
CYL-6+	516	SHLD	R1S1-A6
CYL-6-	517	SHLD	R1S1-A8
GND	518	SHLD	SHIELD
CYL-7+	519	SHLD	R1S1-A10
CYL-7-	520	SHLD	R1S1-A12
GND	521	SHLD	SHIELD
CYL-8+	522	SHLD	R1S1-A14
CYL-8-	523	SHLD	R1S1-A16
GND	524	SHLD	SHIELD
CYL-9+	525	SHLD	R1S1-C18
CYL-9-	526	SHLD	R1S1-C20
GND	527	SHLD	SHIELD
CYL-10+	528	SHLD	R1S1-C22
CYL-10-	529	SHLD	R1S1-C24
GND	530	SHLD	SHIELD
CYL-11+	531	SHLD	R1S1-C26
CYL-11-	532	SHLD	R1S1-C28
GND	533	SHLD	SHIELD
CYL-12+	534	SHLD	R1S1-C30
CYL-12-	535	SHLD	R1S1-C32
GND	536	SHLD	SHIELD
CYL-13+	537	SHLD	R1S1-A18
CYL-13-	538	SHLD	R1S1-A20
GND	539	SHLD	SHIELD
CYL-14+	540	SHLD	R1S1-A22
CYL-14-	541	SHLD	R1S1-A24
GND	542	SHLD	SHIELD
CYL-15+	543	SHLD	R1S1-A26
CYL-15-	544	SHLD	R1S1-A28
GND	545	SHLD	SHIELD
CYL-16+	546	SHLD	R1S1-A30
CYL-16-	547	SHLD	R1S1-A32
GND	548	SHLD	SHIELD
	549	GND	GND
	550	SHLD	R1S2-C2
	551	SHLD	R1S2-C4
	552	SHLD	SHIELD
	553	SHLD	R1S2-C6
	554	SHLD	R1S2-C8
	555	SHLD	SHIELD
	556	SHLD	R1S2-C10
	557	SHLD	R1S2-C12
	558	SHLD	SHIELD
	559	SHLD	R1S2-C14
	560	SHLD	R1S2-C16
	561	SHLD	SHIELD
	562	SHLD	R1S2-A2
	563	SHLD	R1S2-A4
	564	SHLD	SHIELD
	565	SHLD	R1S2-A6
	566	SHLD	R1S2-A8
	567	SHLD	SHIELD
	568	SHLD	R1S2-A10
	569	SHLD	R1S2-A12
	570	SHLD	SHIELD
	571	SHLD	R1S2-A14
	572	SHLD	R1S2-A16
	573	SHLD	SHIELD
TCR+	574	SHLD	R1S2-C18
TCR-	575	SHLD	R1S2-C20
	576	SHLD	SHIELD
	577	SHLD	R1S2-C22
	578	SHLD	R1S2-C24
	579	SHLD	SHIELD
	580	SHLD	R1S2-C26
	581	SHLD	R1S2-C28
	582	SHLD	SHIELD
	583	SHLD	R1S2-C30
	584	SHLD	R1S2-C32
	585	SHLD	SHIELD
	586	SHLD	R1S2-A18
	587	SHLD	R1S2-A20
	588	SHLD	SHIELD
	589	SHLD	R1S2-A22
	590	SHLD	R1S2-A24
	591	SHLD	SHIELD
	592	SHLD	R1S2-A26
	593	SHLD	R1S2-A28
	594	SHLD	SHIELD
	595	SHLD	R1S2-A30
	596	SHLD	R1S2-A32
	597	SHLD	SHIELD
	598	GND	GND

TB5
(UNIT 15)

	501	SHLD	R1S2-C2
	502	SHLD	R1S2-C4
	503	SHLD	SHIELD
	504	SHLD	R1S2-C6
	505	SHLD	R1S2-C8
	506	SHLD	SHIELD
	507	SHLD	R1S2-C10
	508	SHLD	R1S2-C12
	509	SHLD	SHIELD
	510	SHLD	R1S2-C14
	511	SHLD	R1S2-C16
	512	SHLD	SHIELD
	513	SHLD	R1S2-A2
	514	SHLD	R1S2-A4
	515	SHLD	SHIELD
	516	SHLD	R1S2-A6
	517	SHLD	R1S2-A8
	518	SHLD	SHIELD
	519	SHLD	R1S2-A10
	520	SHLD	R1S2-A12
	521	SHLD	SHIELD
	522	SHLD	R1S2-A14
	523	SHLD	R1S2-A16
	524	SHLD	SHIELD
TCR+	525	SHLD	R1S2-C18
TCR-	526	SHLD	R1S2-C20
	527	SHLD	SHIELD
	528	SHLD	R1S2-C22
	529	SHLD	R1S2-C24
	530	SHLD	SHIELD
	531	SHLD	R1S2-C26
	532	SHLD	R1S2-C28
	533	SHLD	SHIELD
	534	SHLD	R1S2-C30
	535	SHLD	R1S2-C32
	536	SHLD	SHIELD
	537	SHLD	R1S2-A18
	538	SHLD	R1S2-A20
	539	SHLD	SHIELD
	540	SHLD	R1S2-A22
	541	SHLD	R1S2-A24
	542	SHLD	SHIELD
	543	SHLD	R1S2-A26
	544	SHLD	R1S2-A28
	545	SHLD	SHIELD
	546	SHLD	R1S2-A30
	547	SHLD	R1S2-A32
	548	SHLD	SHIELD
	549	GND	GND
CYL-1+	550	SHLD	R1S1-C2
CYL-1-	551	SHLD	R1S1-C4
GND	552	SHLD	SHIELD
CYL-2+	553	SHLD	R1S1-C6
CYL-2-	554	SHLD	R1S1-C8
GND	555	SHLD	SHIELD
CYL-3+	556	SHLD	R1S1-C10
CYL-3-	557	SHLD	R1S1-C12
GND	558	SHLD	SHIELD
CYL-4+	559	SHLD	R1S1-C14
CYL-4-	560	SHLD	R1S1-C16
GND	561	SHLD	SHIELD
CYL-5+	562	SHLD	R1S1-A2
CYL-5-	563	SHLD	R1S1-A4
GND	564	SHLD	SHIELD
CYL-6+	565	SHLD	R1S1-A6
CYL-6-	566	SHLD	R1S1-A8
GND	567	SHLD	SHIELD
CYL-7+	568	SHLD	R1S1-A10
CYL-7-	569	SHLD	R1S1-A12
GND	570	SHLD	SHIELD
CYL-8+	571	SHLD	R1S1-A14
CYL-8-	572	SHLD	R1S1-A16
GND	573	SHLD	SHIELD
CYL-9+	574	SHLD	R1S1-C18
CYL-9-	575	SHLD	R1S1-C20
GND	576	SHLD	SHIELD
CYL-10+	577	SHLD	R1S1-C22
CYL-10-	578	SHLD	R1S1-C24
GND	579	SHLD	SHIELD
CYL-11+	580	SHLD	R1S1-C26
CYL-11-	581	SHLD	R1S1-C28
GND	582	SHLD	SHIELD
CYL-12+	583	SHLD	R1S1-C30
CYL-12-	584	SHLD	R1S1-C32
GND	585	SHLD	SHIELD
CYL-13+	586	SHLD	R1S1-A18
CYL-13-	587	SHLD	R1S1-A20
GND	588	SHLD	SHIELD
CYL-14+	589	SHLD	R1S1-A22
CYL-14-	590	SHLD	R1S1-A24
GND	591	SHLD	SHIELD
CYL-15+	592	SHLD	R1S1-A26
CYL-15-	593	SHLD	R1S1-A28
GND	594	SHLD	SHIELD
CYL-16+	595	SHLD	R1S1-A30
CYL-16-	596	SHLD	R1S1-A32
GND	597	SHLD	SHIELD
	598	GND	GND

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC
DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW
W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-05-2006	RJM/12-05-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

DRAWING NAME: KOTZEBUE SCADA SYSTEM
EMD UNITS
ENGINE CONTROL PANEL
TERMINAL BLOCK LAYOUT

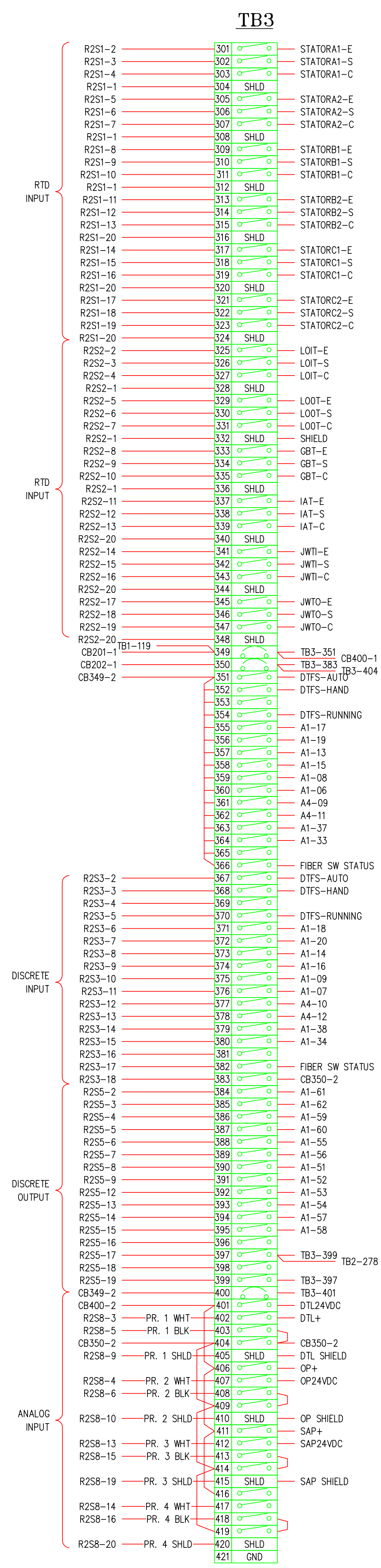
REF DWG(S):

kss-el-2010_6.dwg

DRAWING NO.: KSS-EL-2010

SHEET 6 OF 7

TB3



PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC
DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW
W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-05-2006	RJM/12-05-2006	

ENG. STAMP

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Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

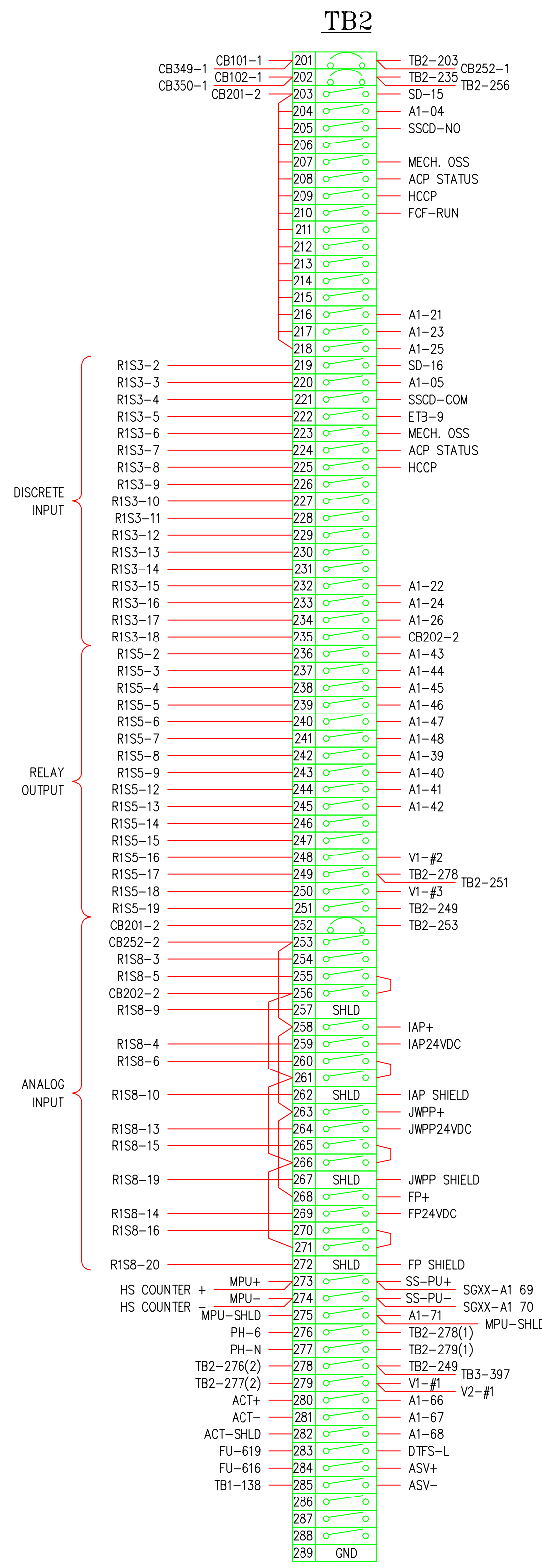
NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

DRAWING NAME:
KOTZEBUE SCADA SYSTEM
EMD UNITS
ENGINE CONTROL PANEL
TERMINAL BLOCK LAYOUT

REF DWG(S):
kss-el-2010_5.dwg

DRAWING NO.: KSS-EL-2010

SHEET 5 OF 7



PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW

W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
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ENG. STAMP

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WEB: WWW.EPSINC.COM

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

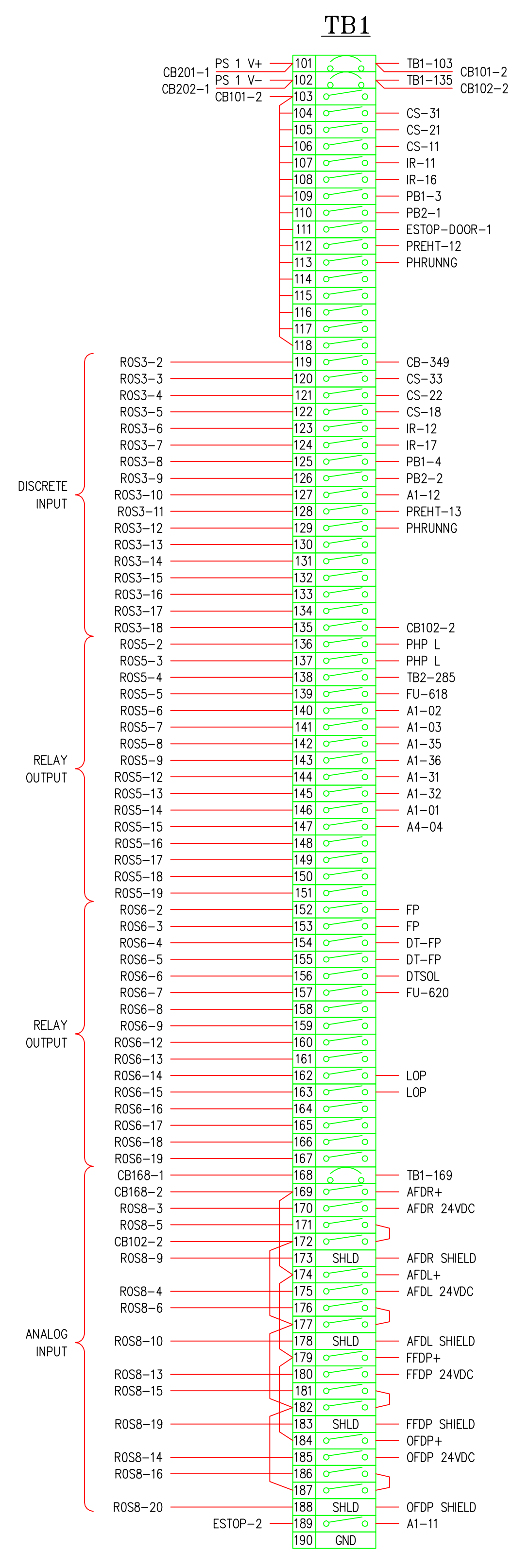
DRAWING NAME: KOTZEBUE SCADA SYSTEM
EMD UNITS
ENGINE CONTROL PANEL
TERMINAL BLOCK LAYOUT

REF DWG(S):

kss-el-2010_4.dwg

DRAWING NO.: KSS-EL-2010

SHEET 4 OF 7



PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW

W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-05-2006	RJM/12-05-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

DRAWING NAME: KOTZEBUE SCADA SYSTEM
EMD UNITS
ENGINE CONTROL PANEL
TERMINAL BLOCK LAYOUT

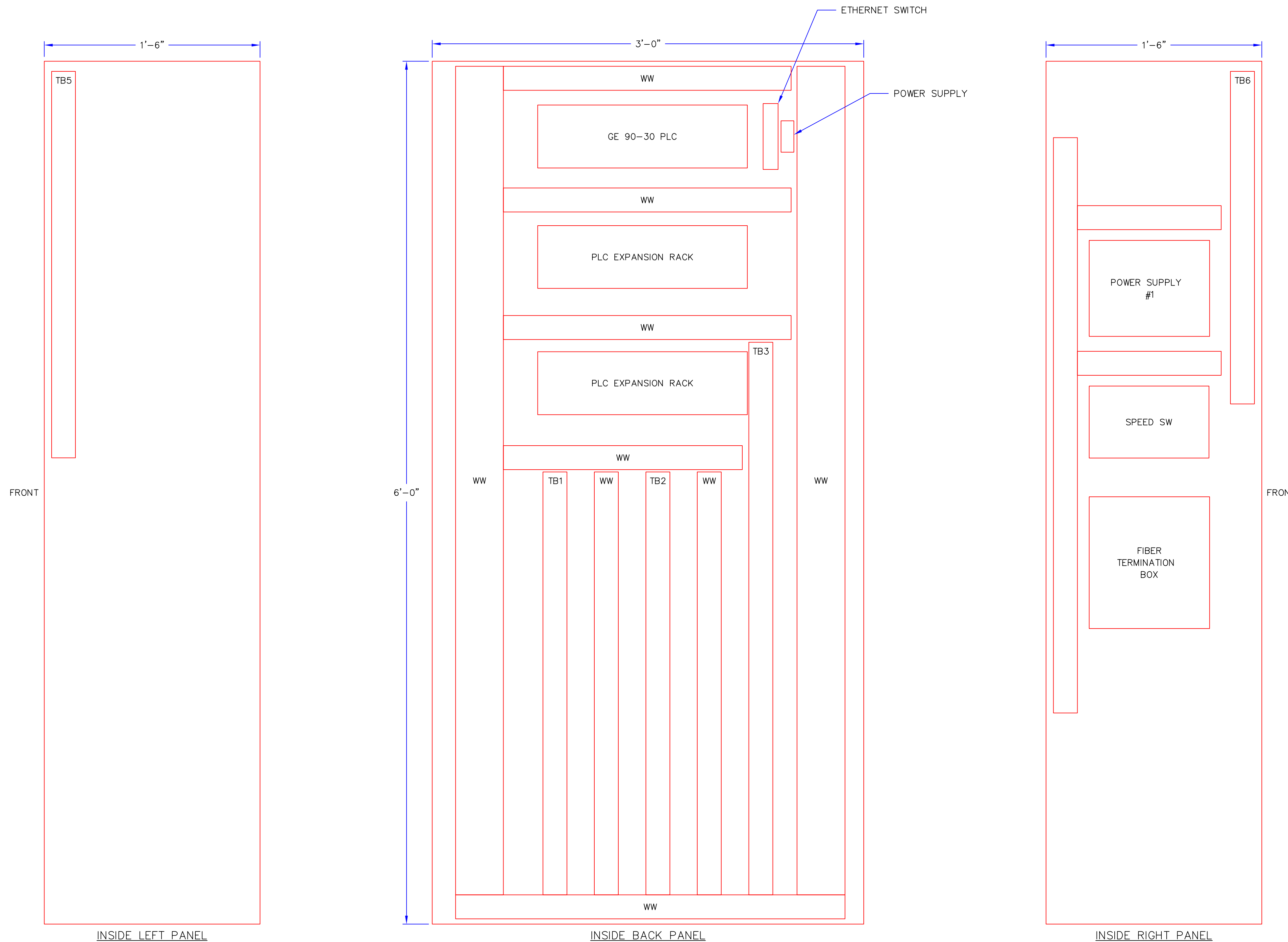
REF DWG(S):

kss-el-2010_3.dwg

DRAWING NO.: KSS-EL-2010

SHEET 3 OF 7

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION



DESCRIPTION	MANUFACTURER	PART NUMBER
WW (WIREWAY)	PANDUIT	VARIOUS
TBX (TERMINAL BLOCK)	ENTRELEC	VARIOUS
GE 90-30 PLC	GE	SEE KSS-EL-2001
ETHERNET SWITCH	MOXA	EDS-405-MM-SC
POWER SUPPLY #1	IDEC	PS5R-240
FIBER TERMINATION BOX	CORNING	WIC-012
SPEED SWITCH	CATERPILLAR	7W2743
POWER SUPPLY #2	IDEC	PS5R-SC24

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC
DESIGNER/PROJECT ENGINEER: STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-05-2006	RJM/12-05-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

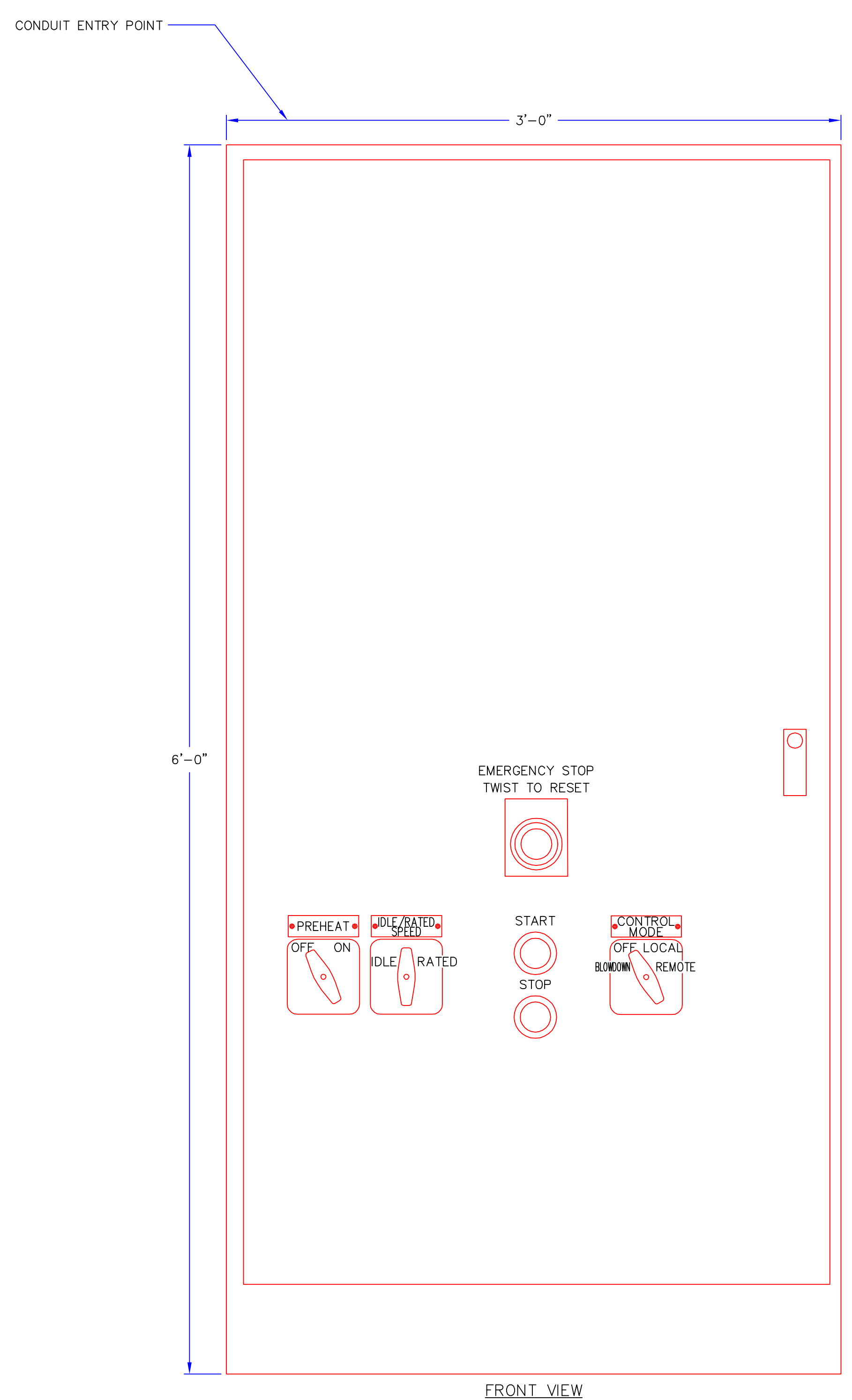
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
EMD UNITS
ENGINE CONTROL PANEL
COMPONENT LAYOUT

kss-el-2010_2.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2010

SHEET 2 OF 7



DESCRIPTION	MANUFACTURER	PART NUMBER
EMERGENCY STOP	CUTLER HAMMER	10250ED1043-4, 10250TS13
START PUSH BUTTON	CUTLER HAMMER	10250T53, 10250T30G, 10250TS33
STOP PUSH BUTTON	CUTLER HAMMER	10250T51, 10250T30R, 10250TS34
PREHEAT SWITCH	ELECTROSWITCH	24201C
IDLE/RATED SWITCH	ELECTROSWITCH	24201C
CONTROL MODE SWITCH	ELECTROSWITCH	24303C
STEEL ENCLOSURE	HOFFMAN	A723618FS

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC
DESIGNER/PROJECT ENGINEER: STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-05-2006	RJM/12-05-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

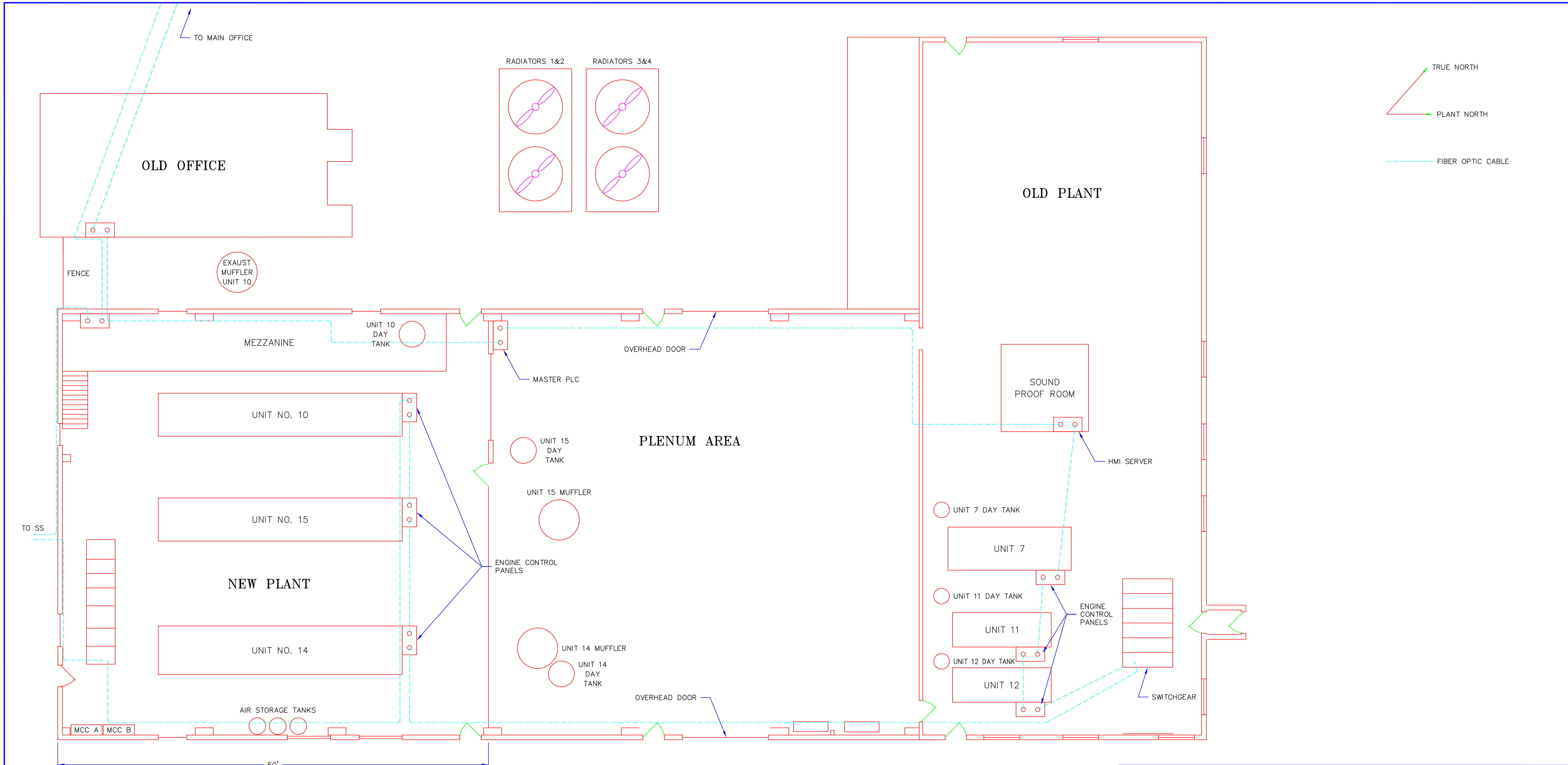
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
EMD UNITS
ENGINE CONTROL PANEL
ELEVATION VIEW

kss-el-2010_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2010

SHEET 1 OF 7



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA ASSESSMENT

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 04-0234

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-05-2006	RJM/12-11-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

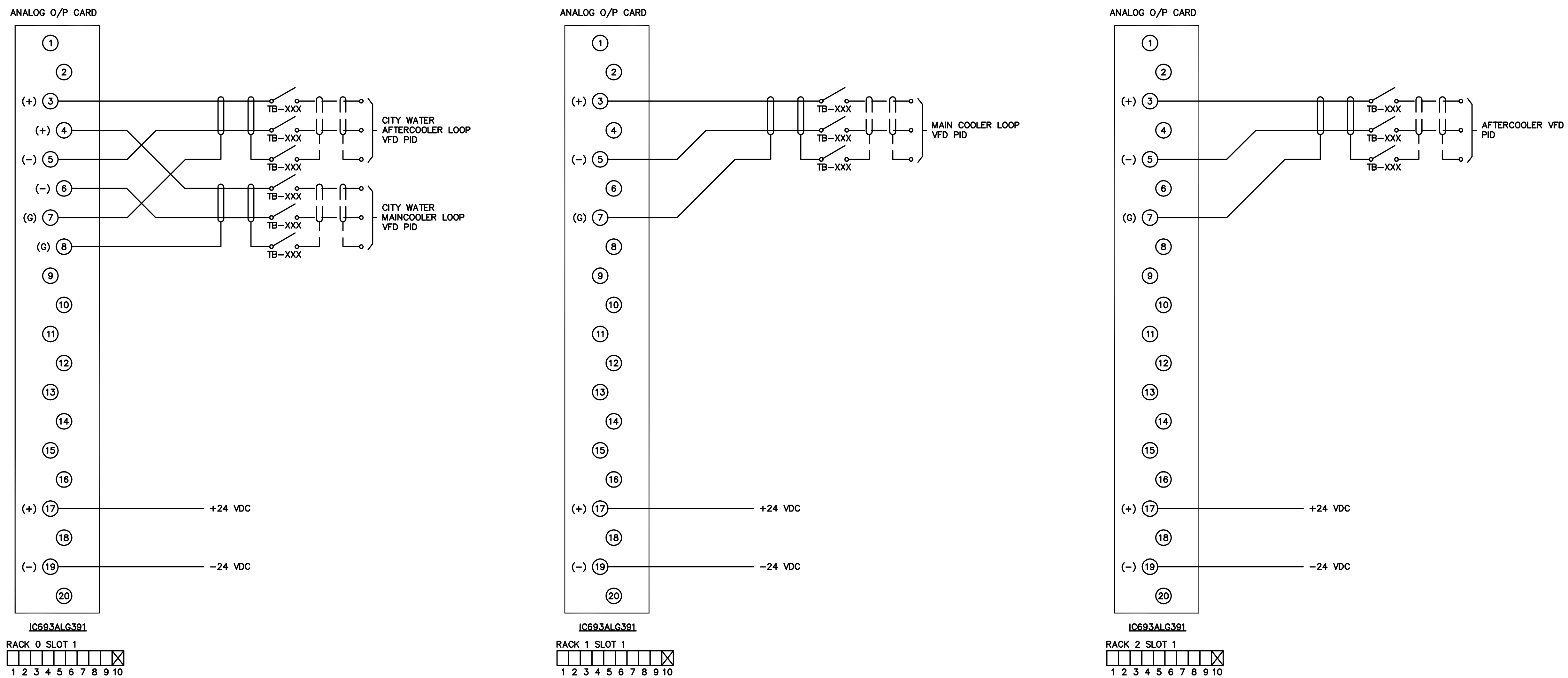
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
POWER PLANT FLOOR PLAN
NETWORK AND EQUIPMENT LAYOUT

kss-el-4000_1.dwg

REF DWG(S): fig_02_plant_fire_plan.dwg, REV 0 – 1/16/03

DRAWING NO.: KSS-EL-4000

SHEET 1 OF 1



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC
DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	ASBUILT	RA/10-17-2006		

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

DRAWING NAME:

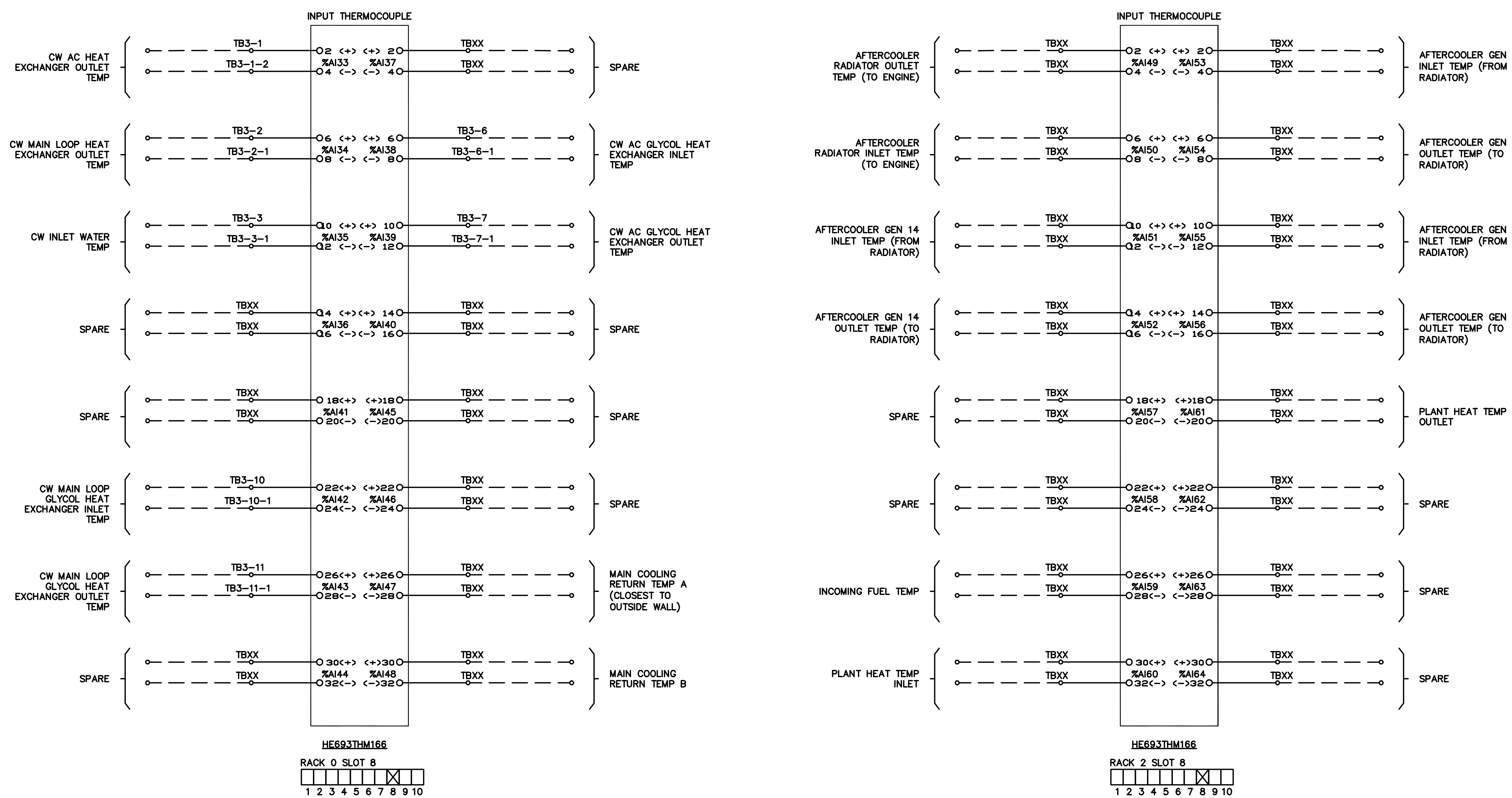
KOTZEBUE SCADA SYSTEM MASTER/DEMAND CONTROL PLC ANALOG OUTPUTS

kss-el-2057_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2057

SHEET 1 OF 1



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. - SCADA EPC
DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	60% FINAL DESIGN	RJM/10-14-2006		

ENG. STAMP

Electric Power Systems Inc.
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TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

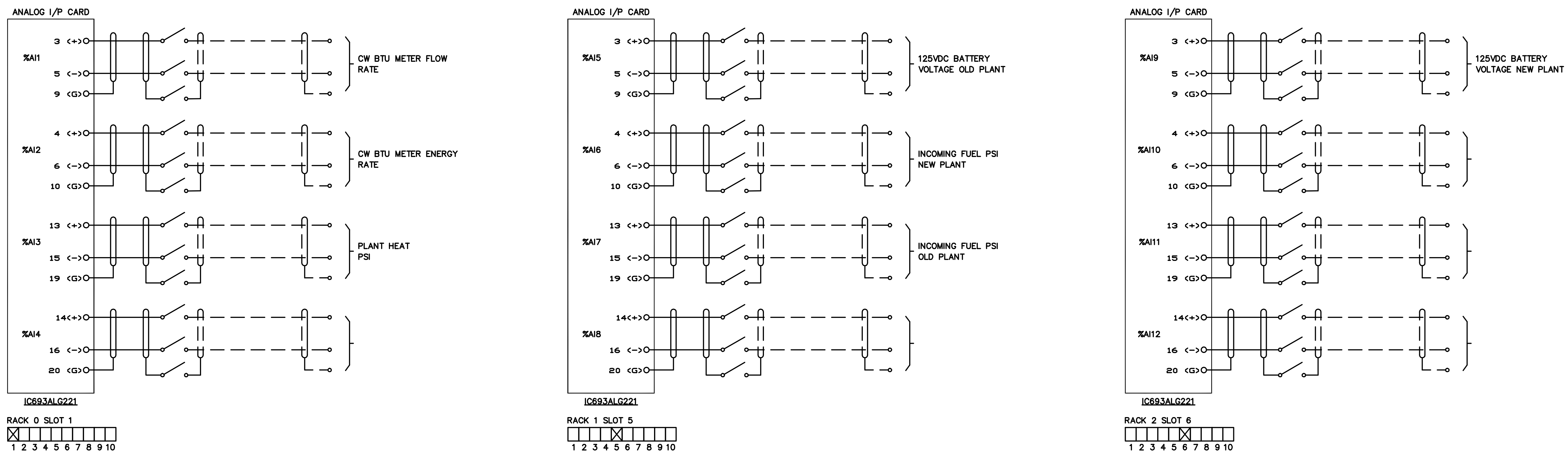
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
MASTER/DEMAND CONTROL
PLC ANALOG INPUTS

kss-el-2056_2.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2056

SHEET 2 OF 2



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. # 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
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ENG. STAMP

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Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

DRAWING NAME:

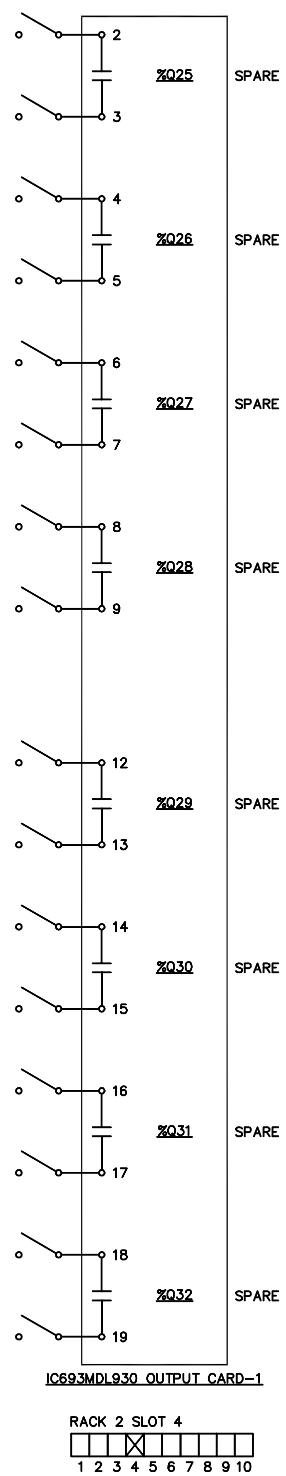
KOTZEBUE SCADA SYSTEM MASTER/DEMAND CONTROL PLC ANALOG INPUTS

kss-el-2056_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2056

SHEET 1 OF 2



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. - SCADA EPC
DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

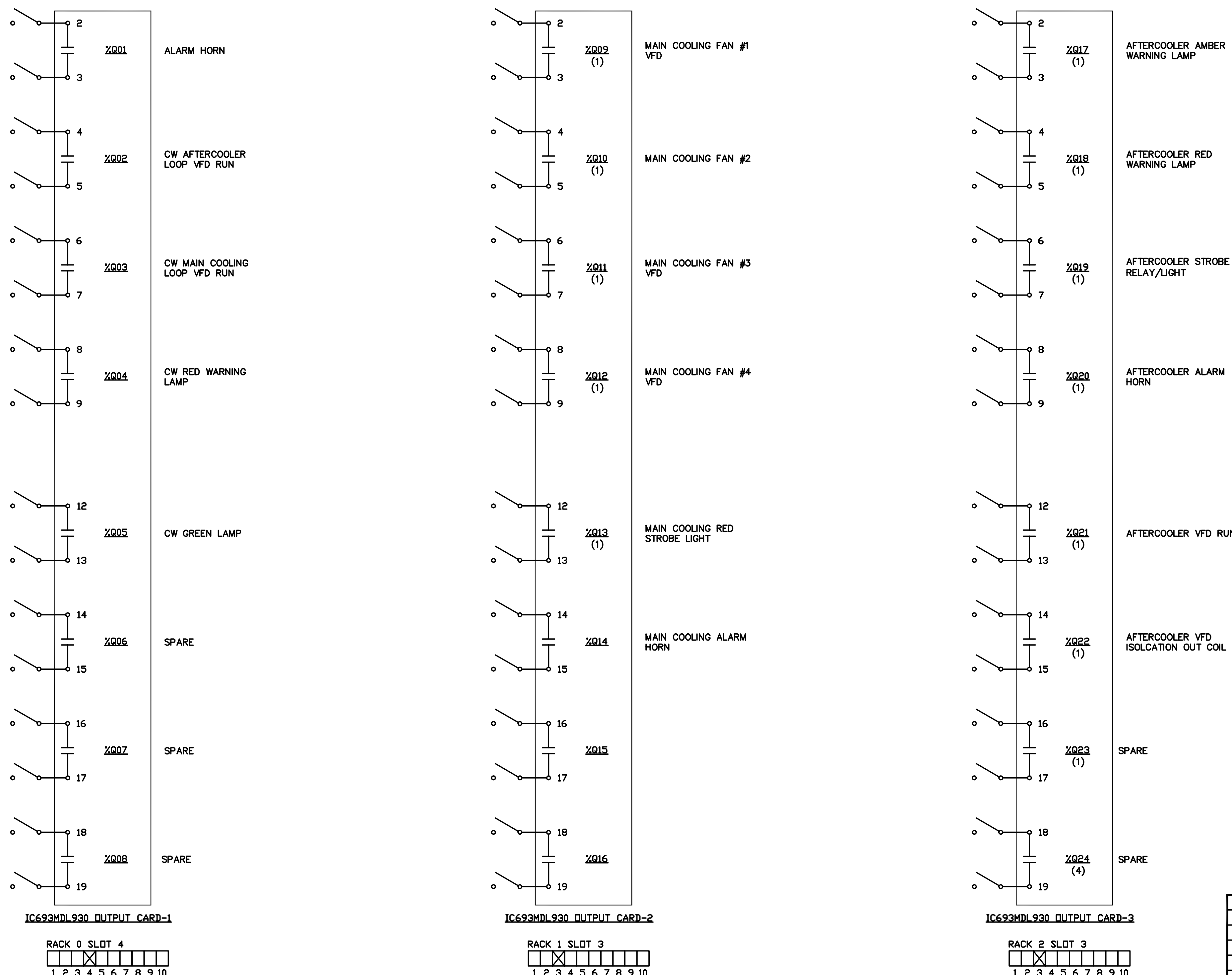
NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-07-2006	RJM/12-07-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

DRAWING NAME:
KOTZEBUE SCADA SYSTEM
MASTER/DEMAND CONTROL
PLC DISCRETE OUTPUTS

kss-el-2055_2.dwg
REF DWG(S):
DRAWING NO.: KSS-EL-2055
SHEET 2 OF 2



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	FINAL DESIGN	RJM/10-14-2006		

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

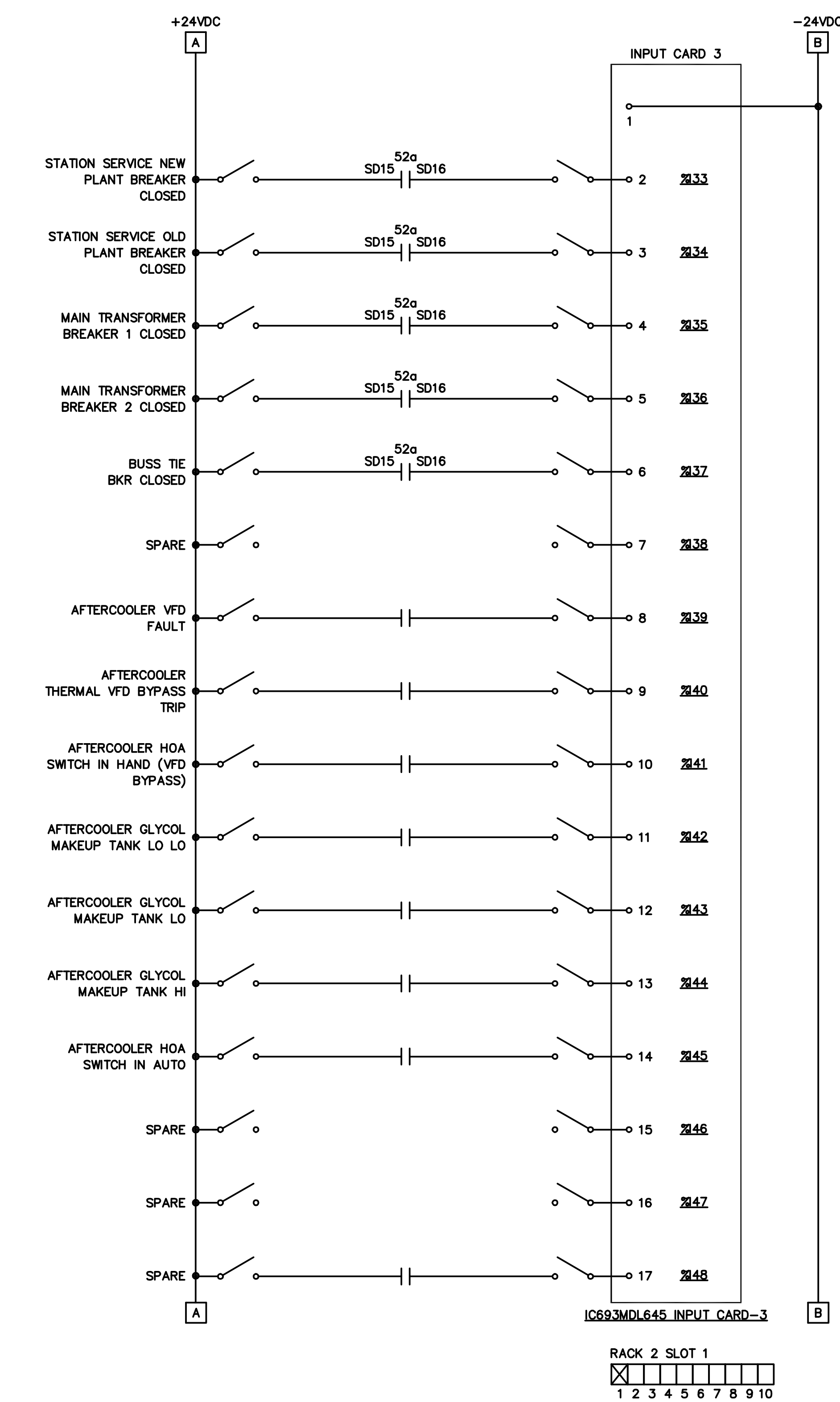
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
MASTER/DEMAND CONTROL
PLC DISCRETE OUTPUTS

kss-el-2055_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2055

SHEET 1 OF 2



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-07-2006	RJM/12-07-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

DRAWING NAME:

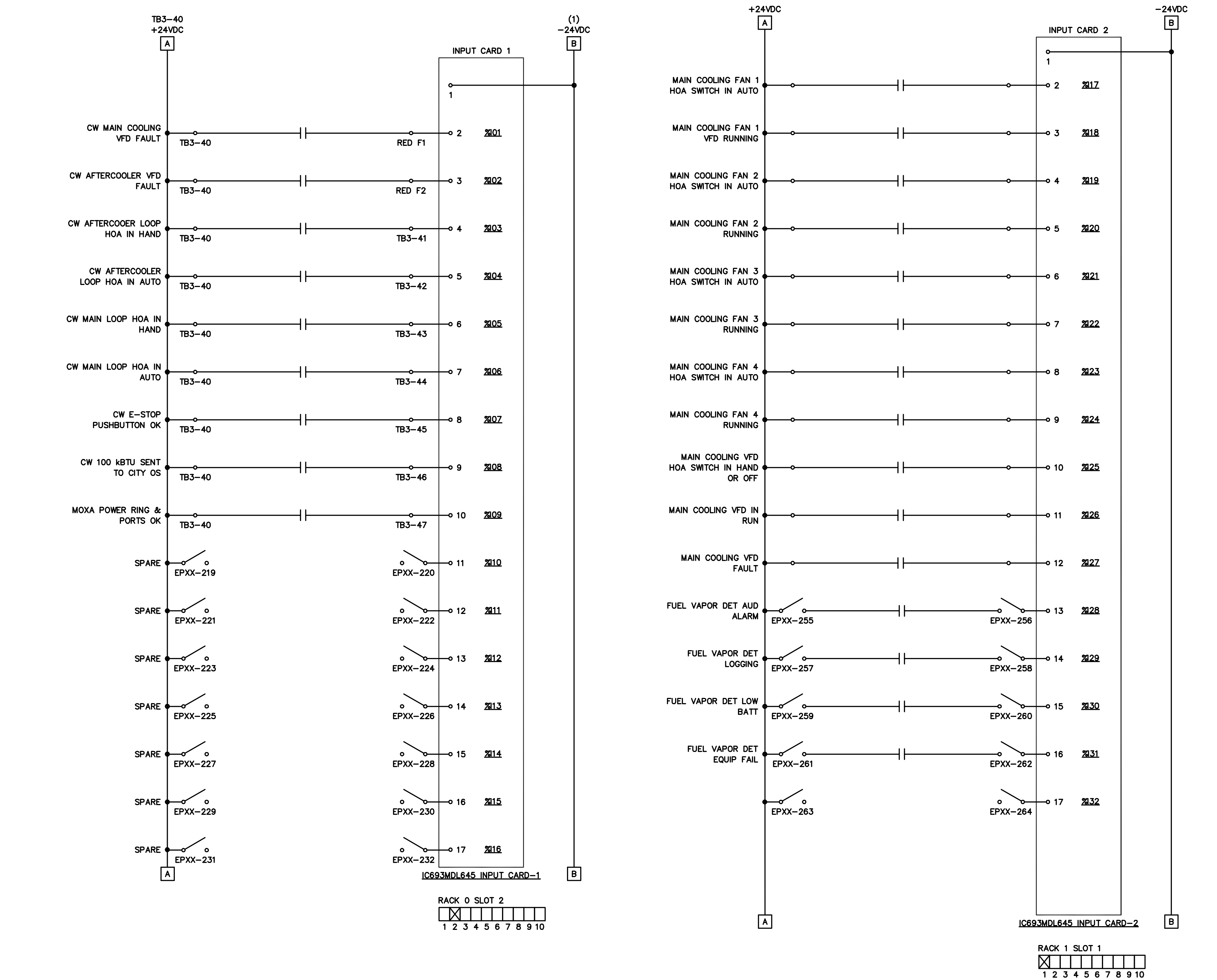
KOTZEBUE SCADA SYSTEM
MASTER/DEMAND CONTROL
PLC DISCRETE INPUTS

kss-el-2054_2.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2054

SHEET 2 OF 2



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05–0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	FINAL DESIGN	RA/10–15–2006		

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522–1953
FAX: (907) 522–1182
WEB: WWW.EPSINC.COM

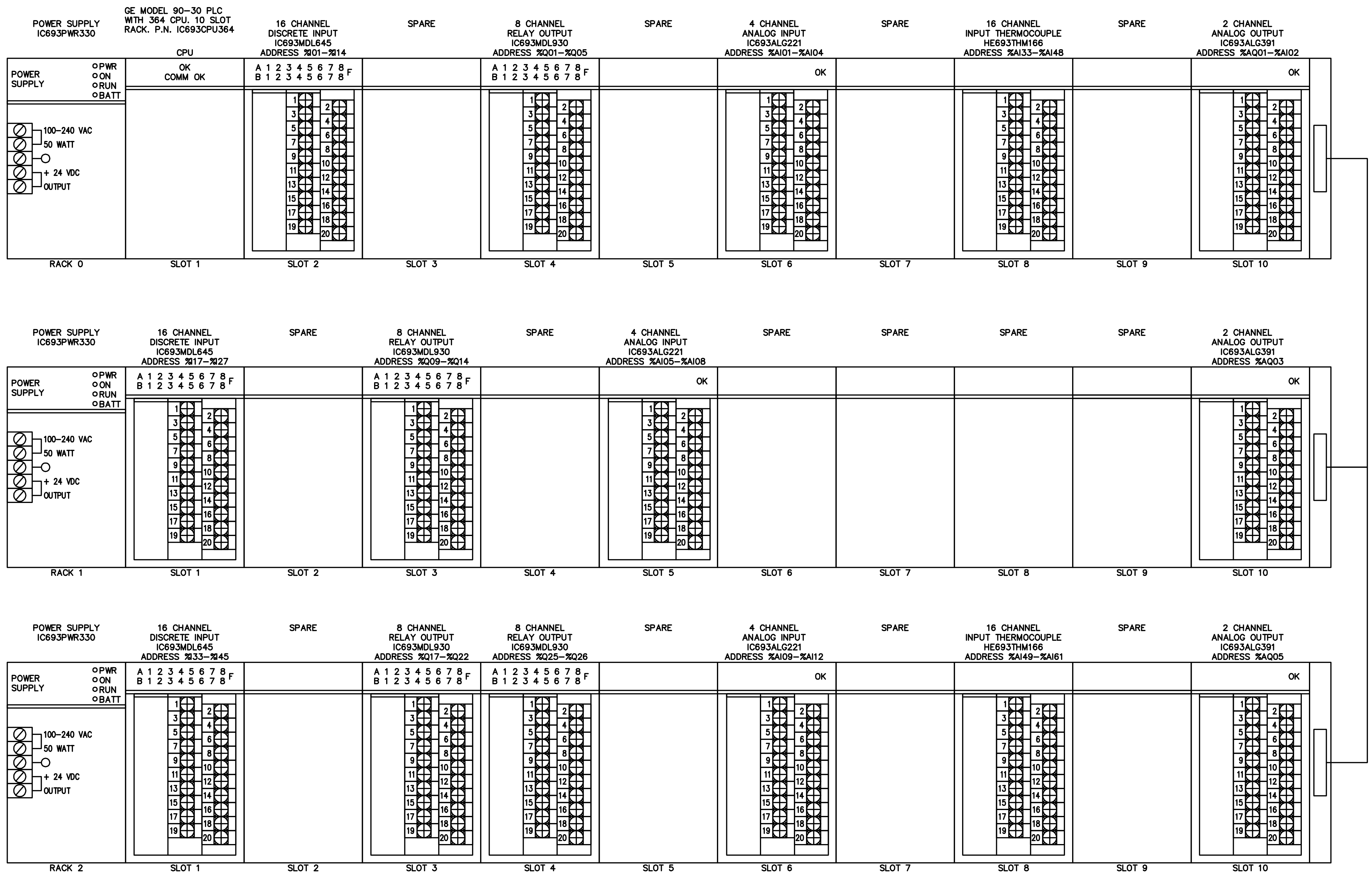
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
MASTER/DEMAND CONTROL
PLC DISCRETE INPUTS

kss–el–2054_1.dwg

REF DWG(S):

DRAWING NO.: KSS–EL–2054

SHEET 1 OF 2



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. - SCADA EPC
DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW
W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS-BUILT	RA/09-21-2006		

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

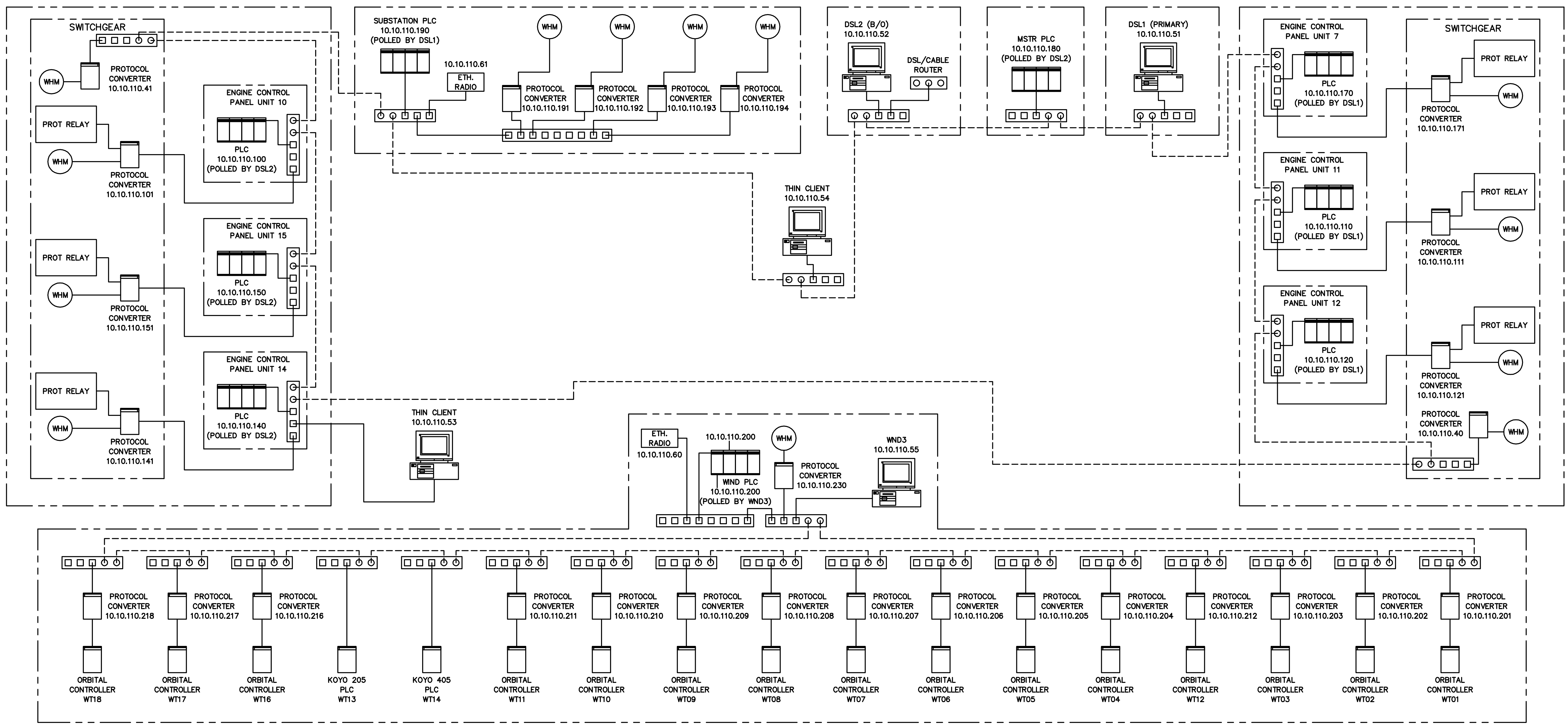
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
MASTER/DEMAND CONTROL
PLC LAYOUT
COOLING/AFTERCOOLER/WASTE HEAT

kss_el_2053_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2053

SHEET 1 OF 1



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

NOTE:

1. DRAWING SHOWS SCHEMATIC CONNECTIONS ONLY. ACTUAL CONDUCTOR ROUTING SHALL BE VERIFIED IN THE FIELD.

LEGEND:

- - - - - FIBER OPTIC
——— ETHERNET CAT 5/6 COPPER

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA ASSESSMENT
DESIGNER/PROJECT ENGINEER: TREVER KUDRNA/DAN ROGERS W.O. # 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	RJM/01-25-2007	RJM/01-25-2007	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

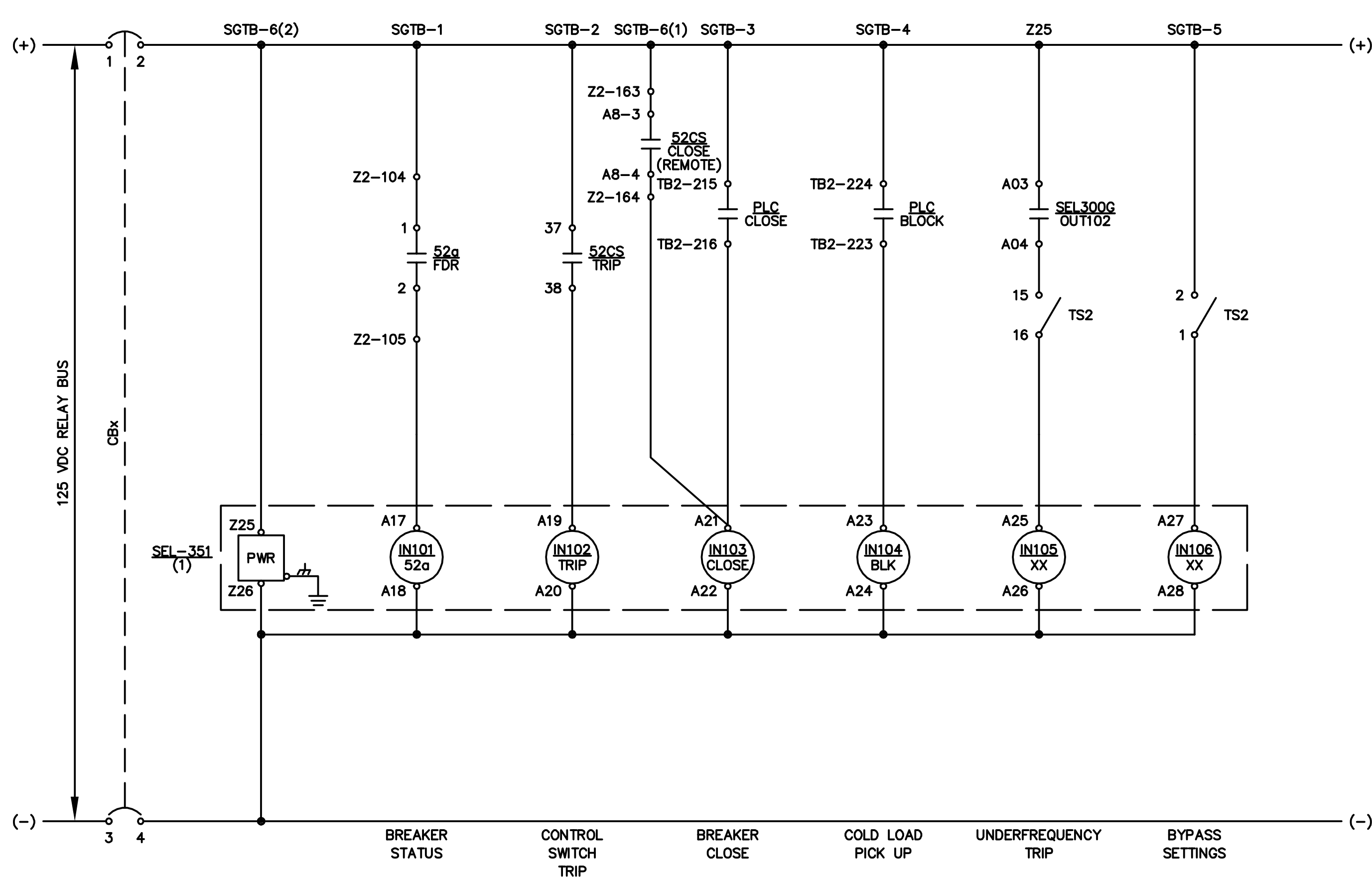
DRAWING NAME: KOTZEBUE SCADA SYSTEM NETWORK COMMUNICATIONS SYSTEM OVERVIEW

kss-el-0010_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-0010

SHEET 1 OF 1



300G-Ux	FUNCTIONS	REF. DWG.
A01 OUT101 A02 1 2 TS2	FEEDER CIRCUIT BREAKER TRIP	
A03 OUT102 A04 5 6 TS2	FEEDER CIRCUIT BREAKER TRIP UNDERFREQUENCY	
A05 OUT103 A06 7 8 TS2	FEEDER CIRCUIT BREAKER CLOSE	
A07 OUT104 A08		
A09 OUT105 A10		
A11 OUT106 A12		
A13 OUT107 A14		
A15 OUT108 A16	SELF TEST	

NOTES:

VARIOUS DESIGNATIONS:
TERMINAL BLOCKS – xxAxx
- TERMINAL NO. (PANEL BUILDER)
- MOUNTING LOCATION–A=LEFT, B=BACK, C=RIGHT
- CUBICLE NO.

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA ASSESSMENT
DESIGNER/PROJECT ENGINEER: DAVID BUSS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-07-2006	DMB/12-07-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

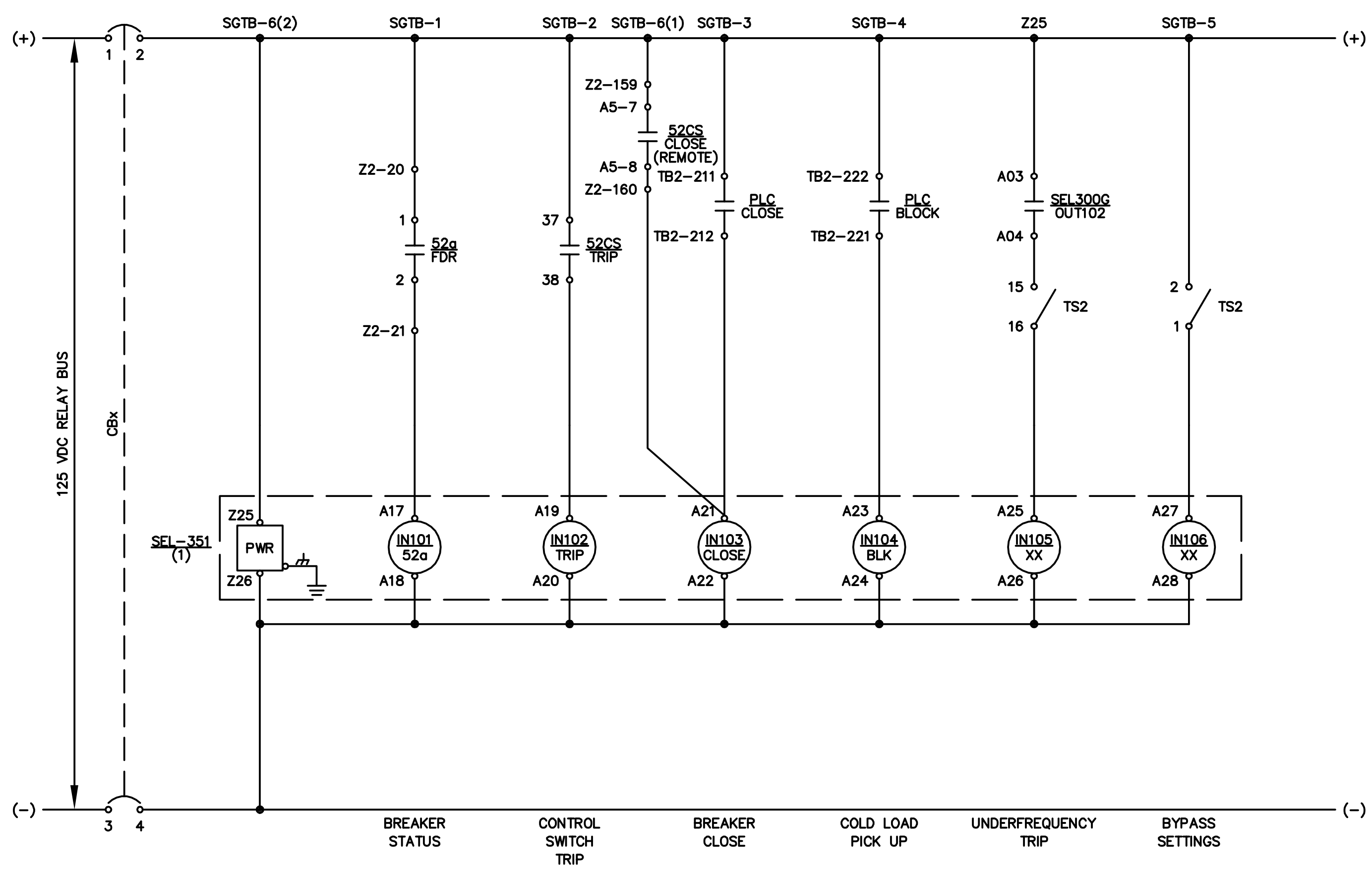
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
FEEDER 4
PROTECTION RELAY
TYPICAL FEEDER PROTECTION I/O

kss-el-2042_4.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2042

SHEET 4 OF 4



300G-Ux	FUNCTIONS	REF. DWG.
A01 OUT101 A02 1 2 TS2	FEEDER CIRCUIT BREAKER TRIP	
A03 OUT102 A04 5 6 TS2	FEEDER CIRCUIT BREAKER TRIP UNDERFREQUENCY	
A05 OUT103 A06 7 8 TS2	FEEDER CIRCUIT BREAKER CLOSE	
A07 OUT104 A08		
A09 OUT105 A10		
A11 OUT106 A12		
A13 OUT107 A14		
A15 OUT108 A16	SELF TEST	

NOTES:

VARIOUS DESIGNATIONS:
TERMINAL BLOCKS – xxAxx
- TERMINAL NO. (PANEL BUILDER)
- MOUNTING LOCATION–A=LEFT, B=BACK, C=RIGHT
- CUBICLE NO.

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA ASSESSMENT
DESIGNER/PROJECT ENGINEER: DAVID BUSS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-07-2006	DMB/12-07-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

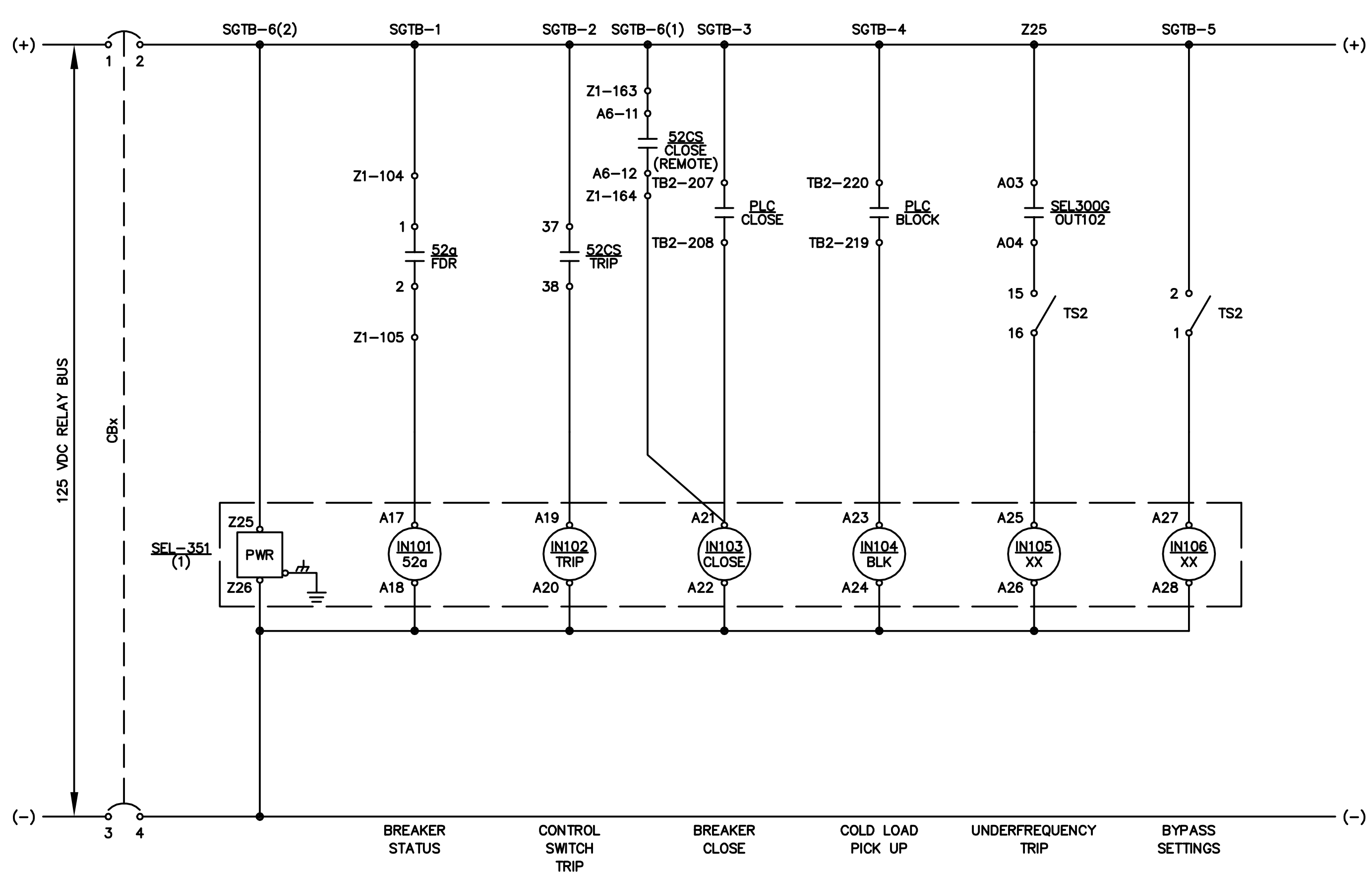
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
FEEDER 2
PROTECTION RELAY
TYPICAL FEEDER PROTECTION I/O

kss-el-2042_3.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2042

SHEET 3 OF 4



300G-Ux	FUNCTIONS	REF. DWG.
A01 OUT101 A02 1 2 TS2	FEEDER CIRCUIT BREAKER TRIP	
A03 OUT102 A04 5 6 TS2	FEEDER CIRCUIT BREAKER TRIP UNDERFREQUENCY	
A05 OUT103 A06 7 8 TS2	FEEDER CIRCUIT BREAKER CLOSE	
A07 OUT104 A08		
A09 OUT105 A10		
A11 OUT106 A12		
A13 OUT107 A14		
A15 OUT108 A16	SELF TEST	

NOTES:

VARIOUS DESIGNATIONS:
TERMINAL BLOCKS – xxAxx
- TERMINAL NO. (PANEL BUILDER)
- MOUNTING LOCATION–A=LEFT, B=BACK, C=RIGHT
- CUBICLE NO.

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA ASSESSMENT
DESIGNER/PROJECT ENGINEER: DAVID BUSS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-07-2006	DMB/12-07-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

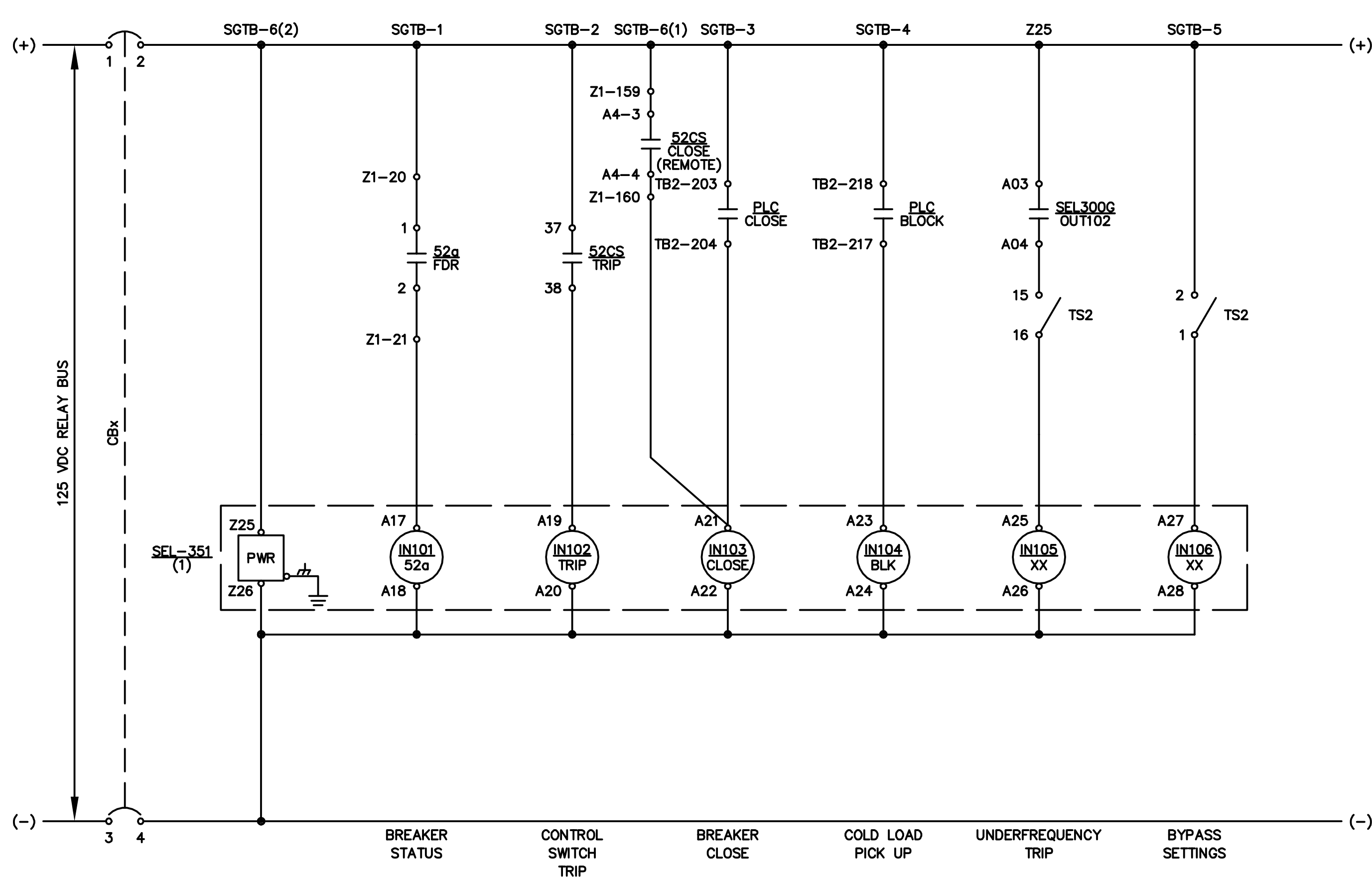
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
FEEDER 3
PROTECTION RELAY
TYPICAL FEEDER PROTECTION I/O

kss-el-2042_2.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2042

SHEET 2 OF 4



300G-Ux	FUNCTIONS	REF. DWG.
A01 OUT101 A02 — TS2 1 2	FEEDER CIRCUIT BREAKER TRIP	
A03 OUT102 A04 — TS2 5 6	FEEDER CIRCUIT BREAKER TRIP UNDERFREQUENCY	
A05 OUT103 A06 — TS2 7 8	FEEDER CIRCUIT BREAKER CLOSE	
A07 OUT104 A08		
A09 OUT105 A10		
A11 OUT106 A12		
A13 OUT107 A14		
A15 OUT108 A16	SELF TEST	

NOTES:

VARIOUS DESIGNATIONS:
TERMINAL BLOCKS – xxAxx
- TERMINAL NO. (PANEL BUILDER)
- MOUNTING LOCATION–A=LEFT, B=BACK, C=RIGHT
- CUBICLE NO.

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA ASSESSMENT
DESIGNER/PROJECT ENGINEER: DAVID BUSS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-07-2006	DMB/12-07-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

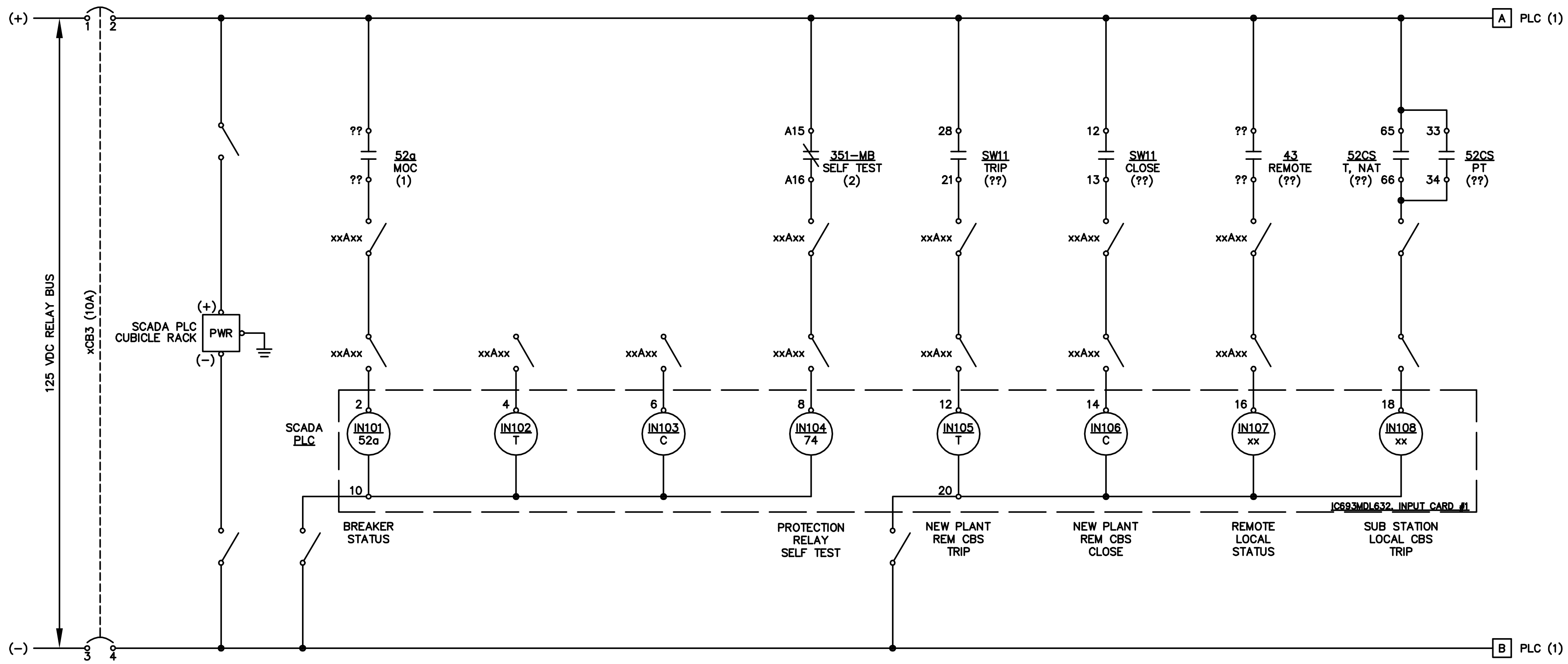
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
FEEDER 1
PROTECTION RELAY
TYPICAL FEEDER PROTECTION I/O

kss-el-2042_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2042

SHEET 1 OF 4



IC693MDL930 OUTPUT CARD #1	FUNCTIONS	REF. DWG.
OUT 01 — 2, 3, xxAxx	52FB TRIP	1
OUT 02 — 4, 5, xxAxx	52FB CLOSE	1
OUT 03 — 6, 7, xxAxx	RECLOSE BLOCK	2
OUT 04 — 8, 9, xxAxx	SPARE	–
OUT 05 — 12, 13, xxAxx	SPARE	–
OUT 06 — 14, 15, xxAxx	SPARE	–
OUT 07 — 16, 17, xxAxx	SPARE	–
OUT 08 — 18, 19, xxAxx	SPARE	–

NOTES:

VARIOUS DESIGNATIONS:
TERMINAL BLOCKS – xxAxx
- TERMINAL NO. (PANEL BUILDER)
- MOUNTING LOCATION–A=LEFT, B=BACK, C=RIGHT
- CUBICLE NO. (U7, U11, U12)

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION
1	KSS-EL-2040/1	FEEDER BREAKER CONTROL, TYPICAL PLC DC SCHEMATIC
2	KSS-EL-2042/1	FEEDERS, PROTECTION RELAY, TYPICAL PLC DC SCHEMATIC

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA ASSESSMENT
DESIGNER/PROJECT ENGINEER: WILLIAM J. BRIMSTEIN/DANIEL C. ROGERS W.O. # 04-0234

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	PRELIMINARY DESIGN, ISSUED FOR BID	WJB/08-19-2005	DCR/08-19-2005	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

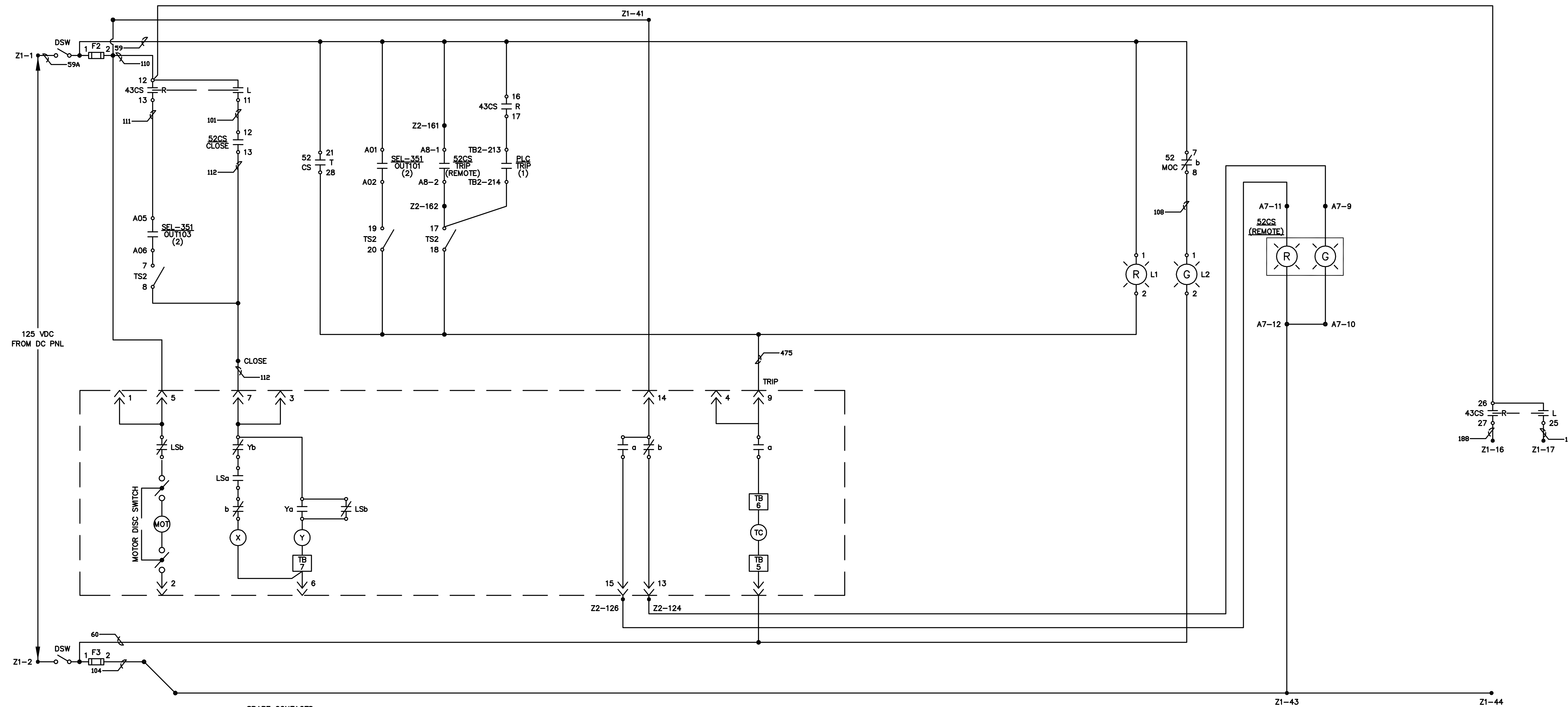
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
FEEDERS
PLC I/O
TYPICAL PLC SCHEMATIC

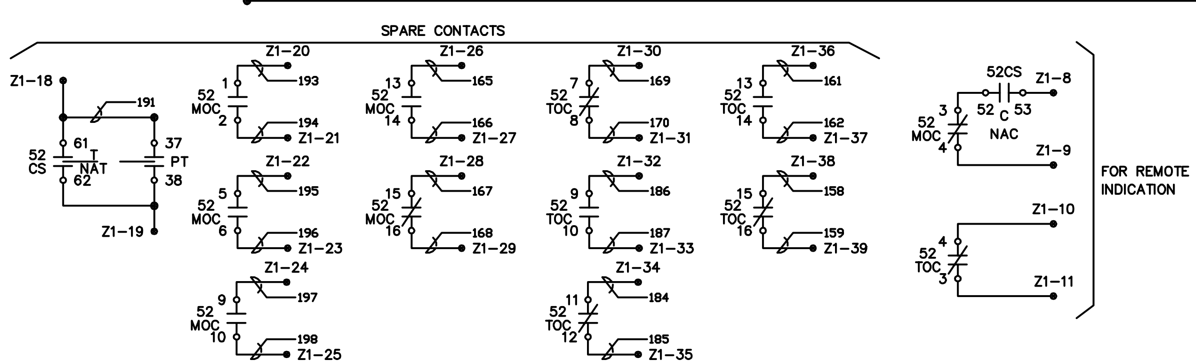
kss-el-2041_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2041

SHEET 1 OF 1





LEGEND:

F2,3–FUSES
L1–CIRCUIT BREAKER CLOSED IND. LIGHT
L2–CIRCUIT BREAKER OPEN IND. LIGHT
43CS–LOCAL–REMOTE CONTROL SWITCH
50/51–INSTANTANEOUS TIME OVERCURRENT RELAY
50/51N–INSTANTANEOUS TIME OVERCURRENT RELAY (NEUTRAL)
52–FEEDER CIRCUIT BREAKER
52CS–CIRCUIT BREAKER CONTROL SWITCH
52TOC–TRUNK OPERATED CONTACT
79–RECLOSING RELAY
• CUSTOMER CONNECTION TERM. BLOCK

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION
1	KSS–EL–2041/1	FEEDERS, PLC I/O, TYPICAL PLC SCHEMATIC
2	KSS–EL–2042/1	FEEDERS, PROTECTION RELAY, TYPICAL PLC DC SCHEMATIC

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA ASSESSMENT
DESIGNER/PROJECT ENGINEER: DAVID BUSS/STEVE DREW W.O. #: 05–0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12–07–2006	DMB/12–07–2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522–1953
FAX: (907) 522–1182
WEB: WWW.EPSINC.COM

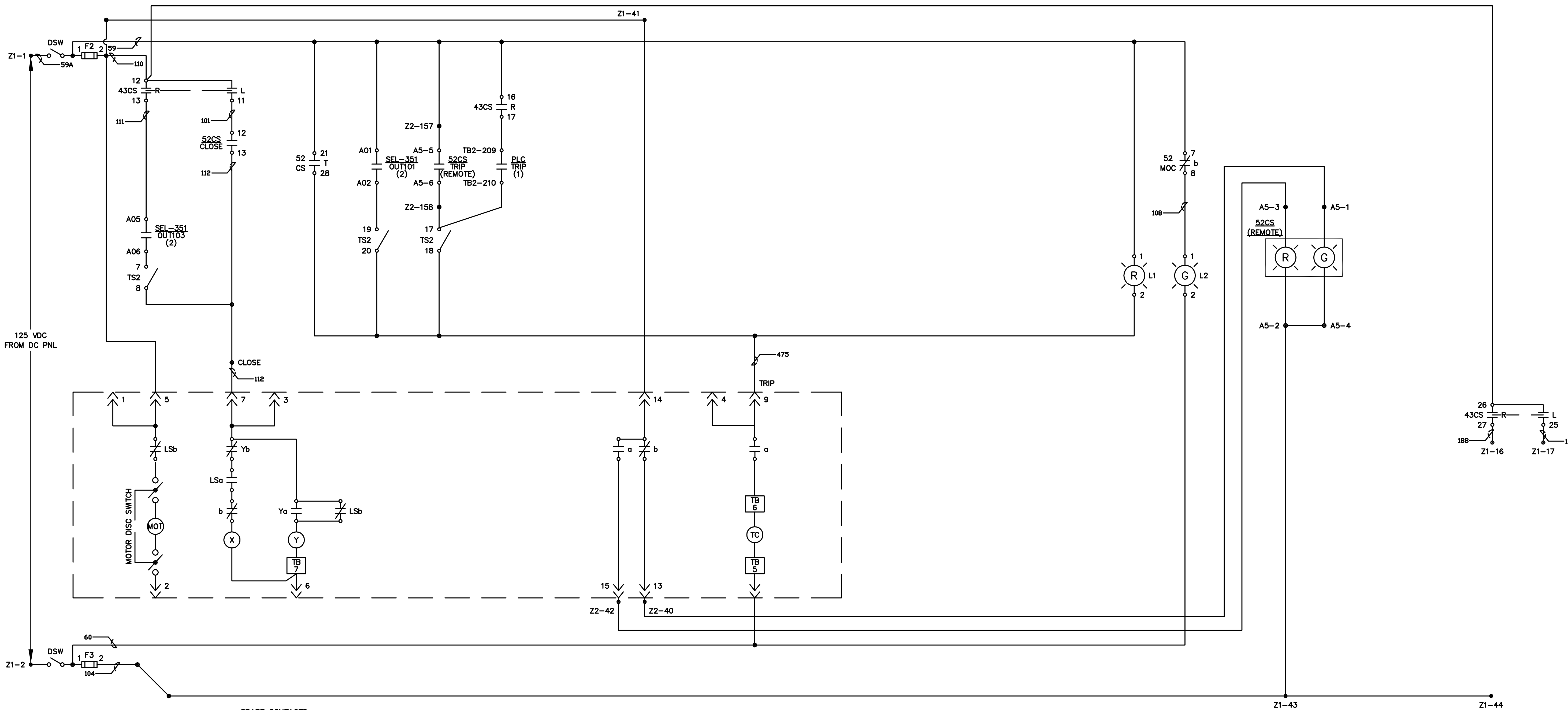
DRAWING NAME:
KOTZEBUE SCADA SYSTEM FEEDER 4 BREAKER CONTROL DC SCHEMATIC

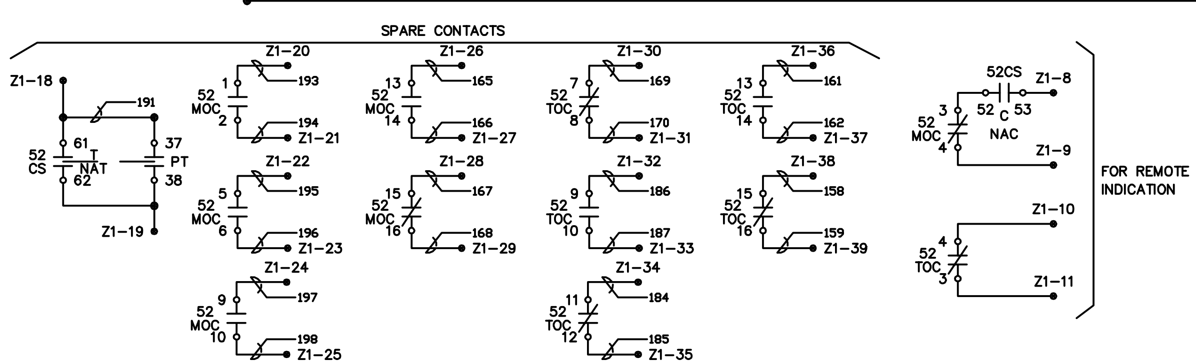
kss–el–2040_4.dwg

REF DWG(S):

DRAWING NO.: KSS–EL–2040

SHEET 4 OF 4





LEGEND:

F2,3–FUSES
L1–CIRCUIT BREAKER CLOSED IND. LIGHT
L2–CIRCUIT BREAKER OPEN IND. LIGHT
43CS–LOCAL–REMOTE CONTROL SWITCH
50/51–INSTANTANEOUS TIME OVERCURRENT RELAY
50/51N–INSTANTANEOUS TIME OVERCURRENT RELAY
(NEUTRAL)
52–FEEDER CIRCUIT BREAKER
52CS–CIRCUIT BREAKER CONTROL SWITCH
52TOC–TRUNK OPERATED CONTACT
79–RECLOSING RELAY
• CUSTOMER CONNECTION TERM. BLOCK

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION
1	KSS-EL-2041/1	FEEDERS, PLC I/O, TYPICAL PLC SCHEMATIC
2	KSS-EL-2042/1	FEEDERS, PROTECTION RELAY, TYPICAL PLC DC SCHEMATIC

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA ASSESSMENT
DESIGNER/PROJECT ENGINEER: DAVID BUSS/STEVE DREW
W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-07-2006	DMB/12-07-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

DRAWING NAME:

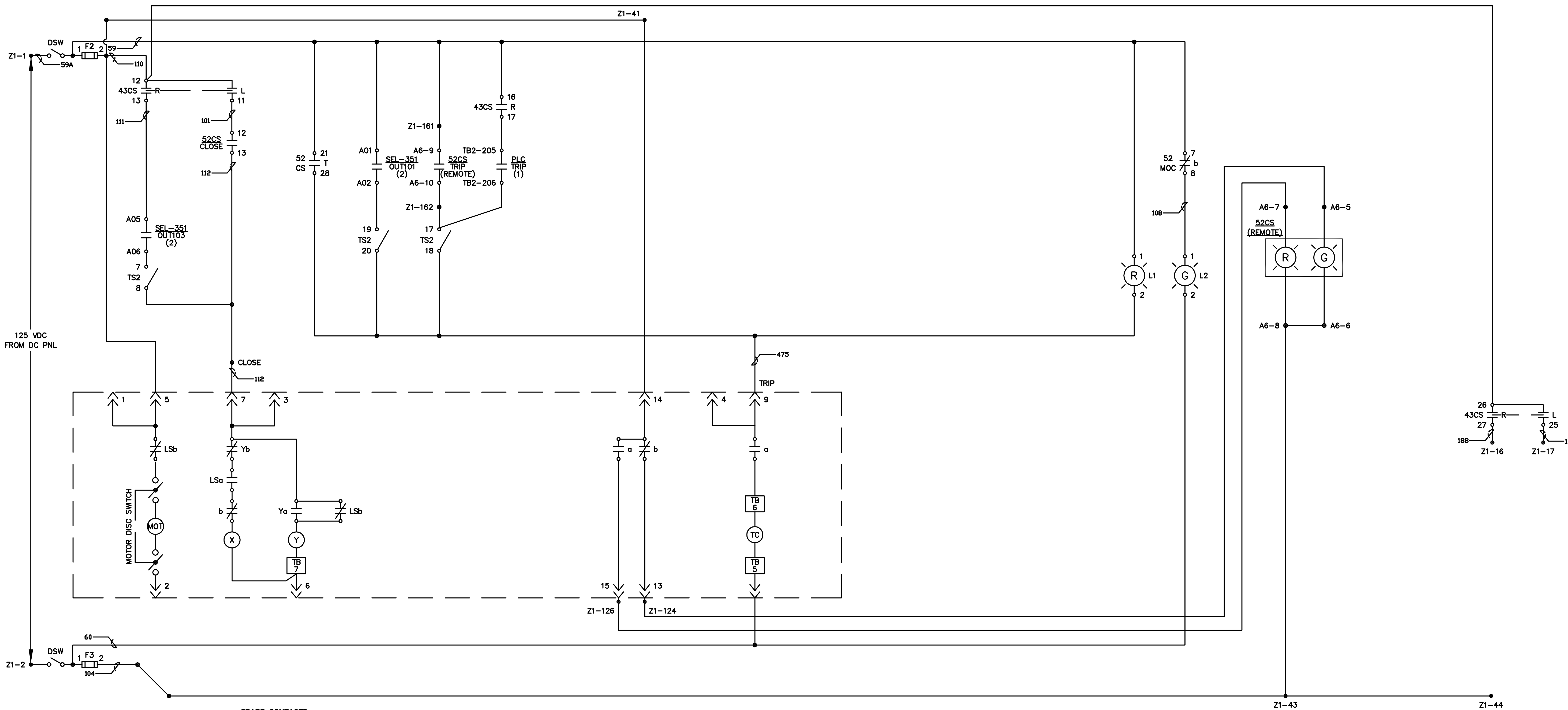
KOTZEBUE SCADA SYSTEM
FEEDER 2
BREAKER CONTROL
DC SCHEMATIC

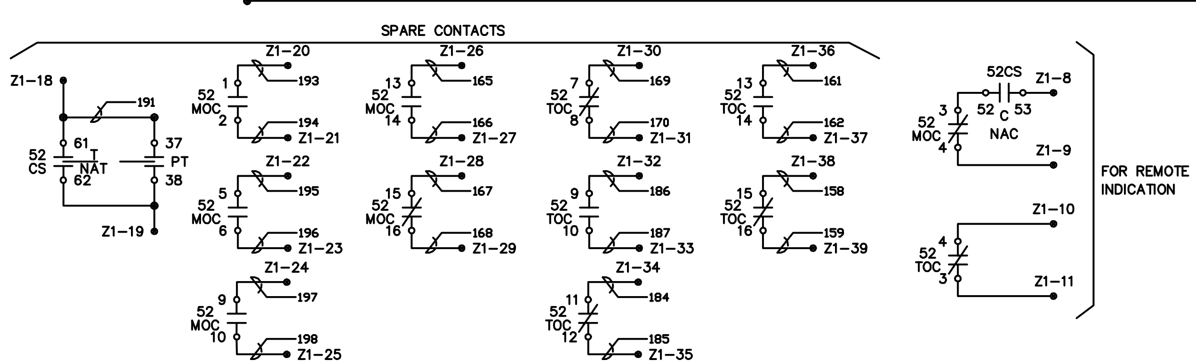
kss-el-2040_3.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2040

SHEET 3 OF 4





LEGEND:

F2,3–FUSES
L1–CIRCUIT BREAKER CLOSED IND. LIGHT
L2–CIRCUIT BREAKER OPEN IND. LIGHT
43CS–LOCAL-REMOTE CONTROL SWITCH
50/51–INSTANTANEOUS TIME OVERCURRENT RELAY
50/51N–INSTANTANEOUS TIME OVERCURRENT RELAY (NEUTRAL)
52–FEEDER CIRCUIT BREAKER
52CS–CIRCUIT BREAKER CONTROL SWITCH
52TOC–TRUNK OPERATED CONTACT
79–RECLOSING RELAY
• CUSTOMER CONNECTION TERM. BLOCK

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION
1	KSS-EL-2041/1	FEEDERS, PLC I/O, TYPICAL PLC SCHEMATIC
2	KSS-EL-2042/1	FEEDERS, PROTECTION RELAY, TYPICAL PLC DC SCHEMATIC

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA ASSESSMENT
DESIGNER/PROJECT ENGINEER: DAVID BUSS/STEVE DREW   W.O. # 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-07-2006	DMB/12-07-2006	

ENG. STAMP

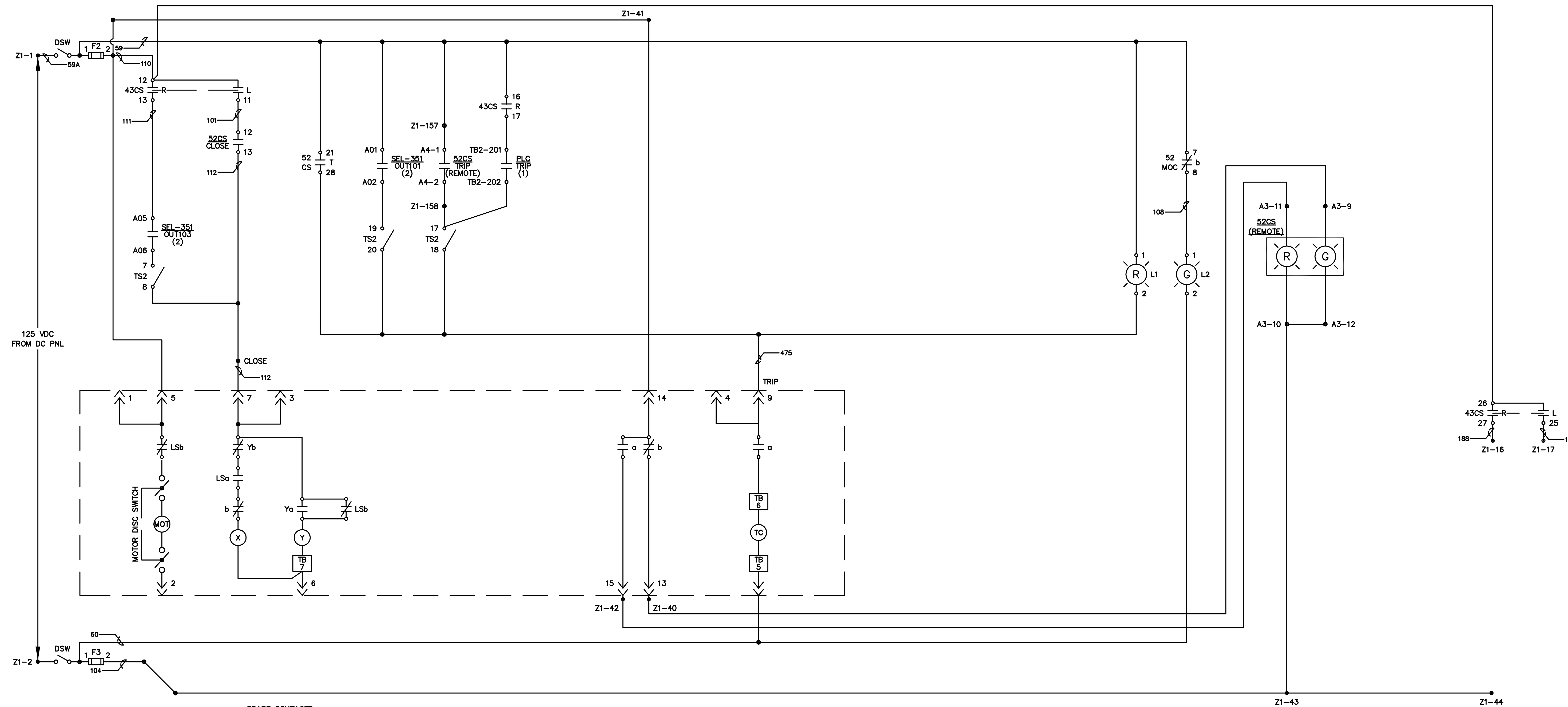
Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

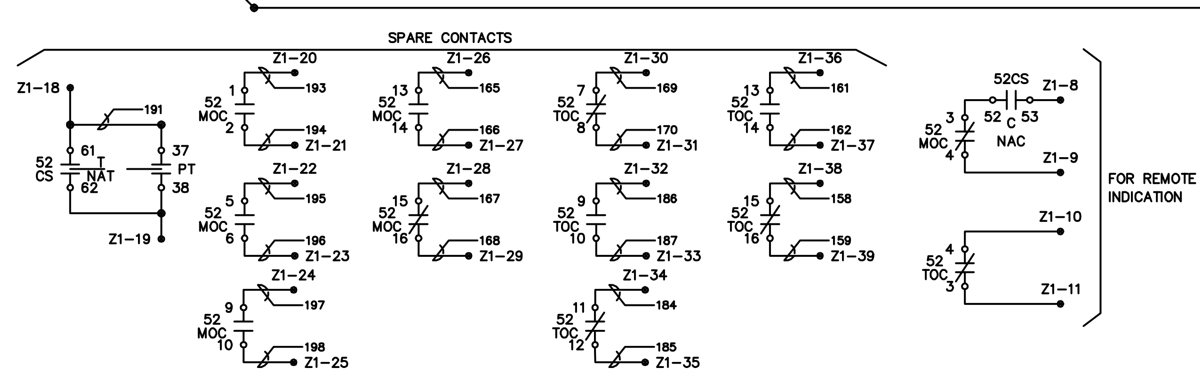
DRAWING NAME:
KOTZEBUE SCADA SYSTEM FEEDER 3 BREAKER CONTROL DC SCHEMATIC

kss-el-2040_2.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2040





LEGEND:

F2,3–FUSES
L1–CIRCUIT BREAKER CLOSED IND. LIGHT
L2–CIRCUIT BREAKER OPEN IND. LIGHT
43CS–LOCAL-REMOTE CONTROL SWITCH
50/51–INSTANTANEOUS TIME OVERCURRENT RELAY
50/51N–INSTANTANEOUS TIME OVERCURRENT RELAY (NEUTRAL)
52–FEEDER CIRCUIT BREAKER
52CS–CIRCUIT BREAKER CONTROL SWITCH
52TOC–TRUNK OPERATED CONTACT
79–RECLOSING RELAY
• CUSTOMER CONNECTION TERM. BLOCK

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION
1	KSS-EL-2041/1	FEEDERS, PLC I/O, TYPICAL PLC SCHEMATIC
2	KSS-EL-2042/1	FEEDERS, PROTECTION RELAY, TYPICAL PLC DC SCHEMATIC

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA ASSESSMENT
DESIGNER/PROJECT ENGINEER: DAVID BUSS/STEVE DREW   W.O. # 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-07-2006	DMB/12-07-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

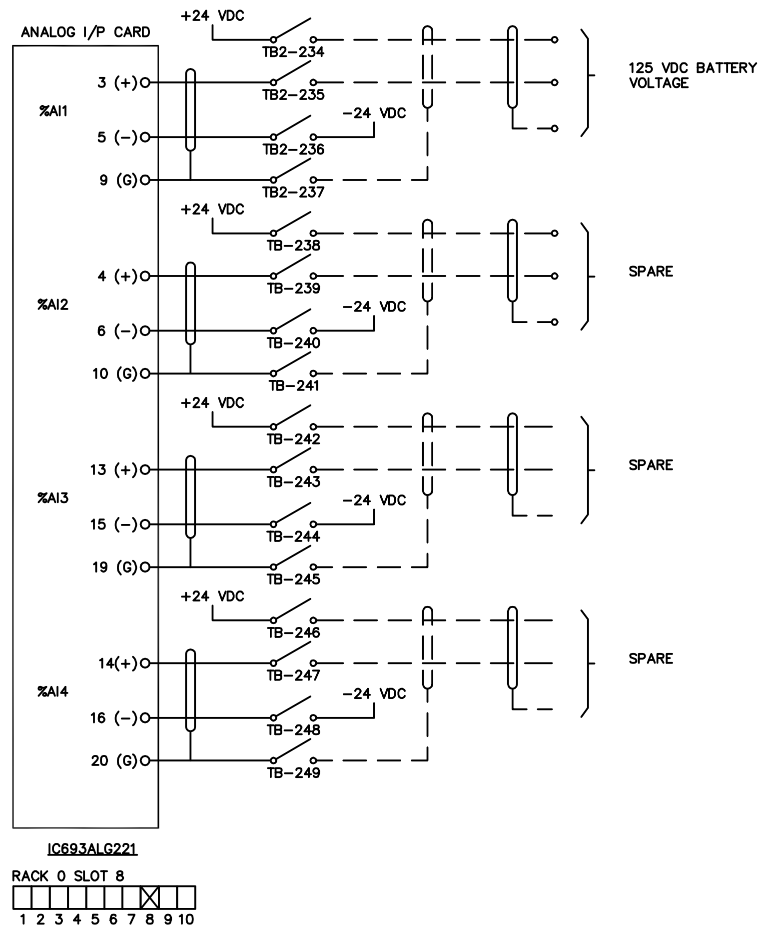
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
FEEDER 1
BREAKER CONTROL
DC SCHEMATIC

kss-el-2040_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2040

SHEET 1 OF 4



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. − SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05−0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	RJM/09−22−2006		

ENG. STAMP

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TEL: (907) 522−1953
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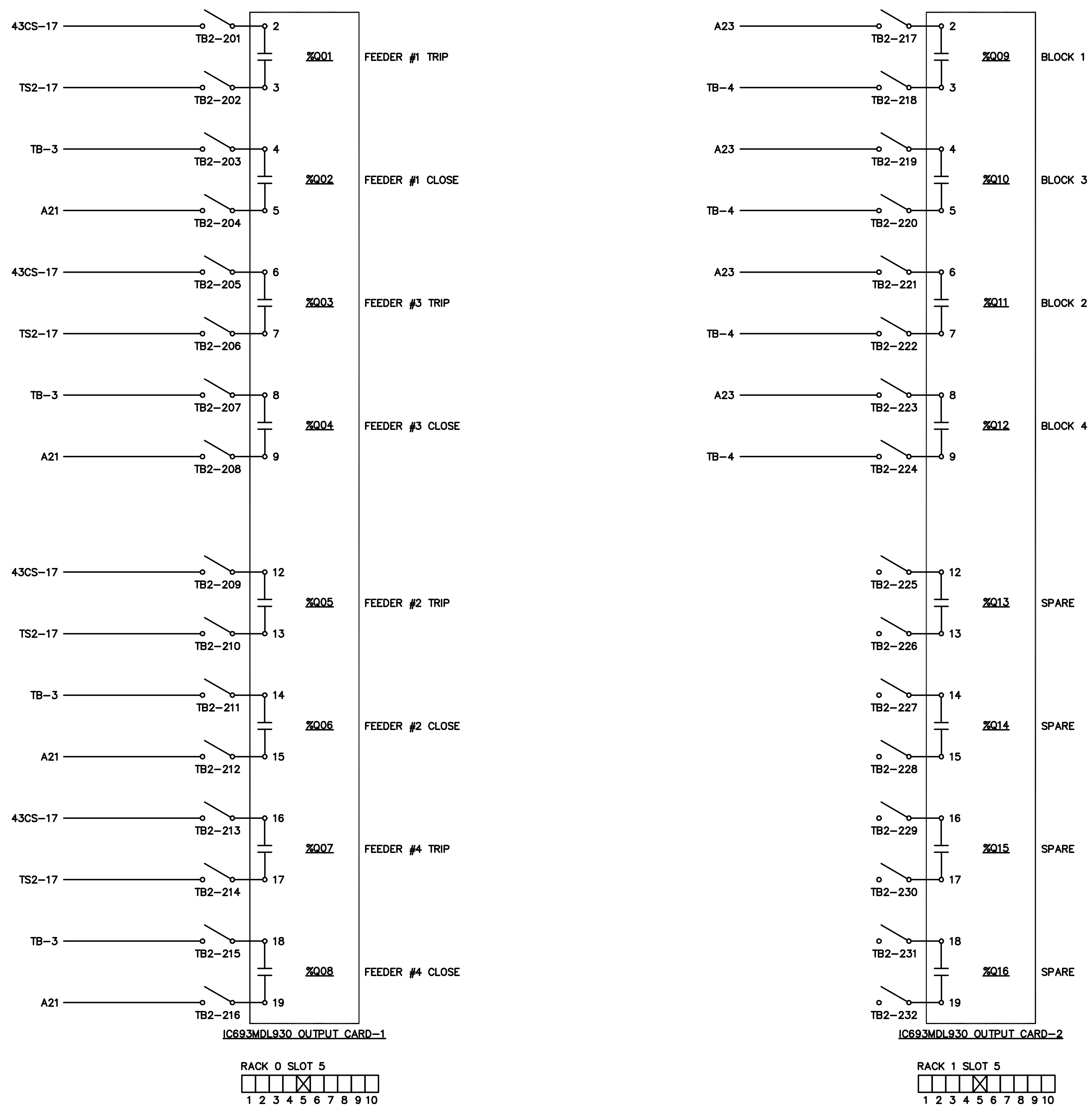
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
SUBSTATION PLC PANEL
PLC ANALOG INPUTS

kss−el−2024_1.dwg

REF DWG(S):

DRAWING NO.: KSS−EL−2024

SHEET 1 OF 1



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
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ENG. STAMP

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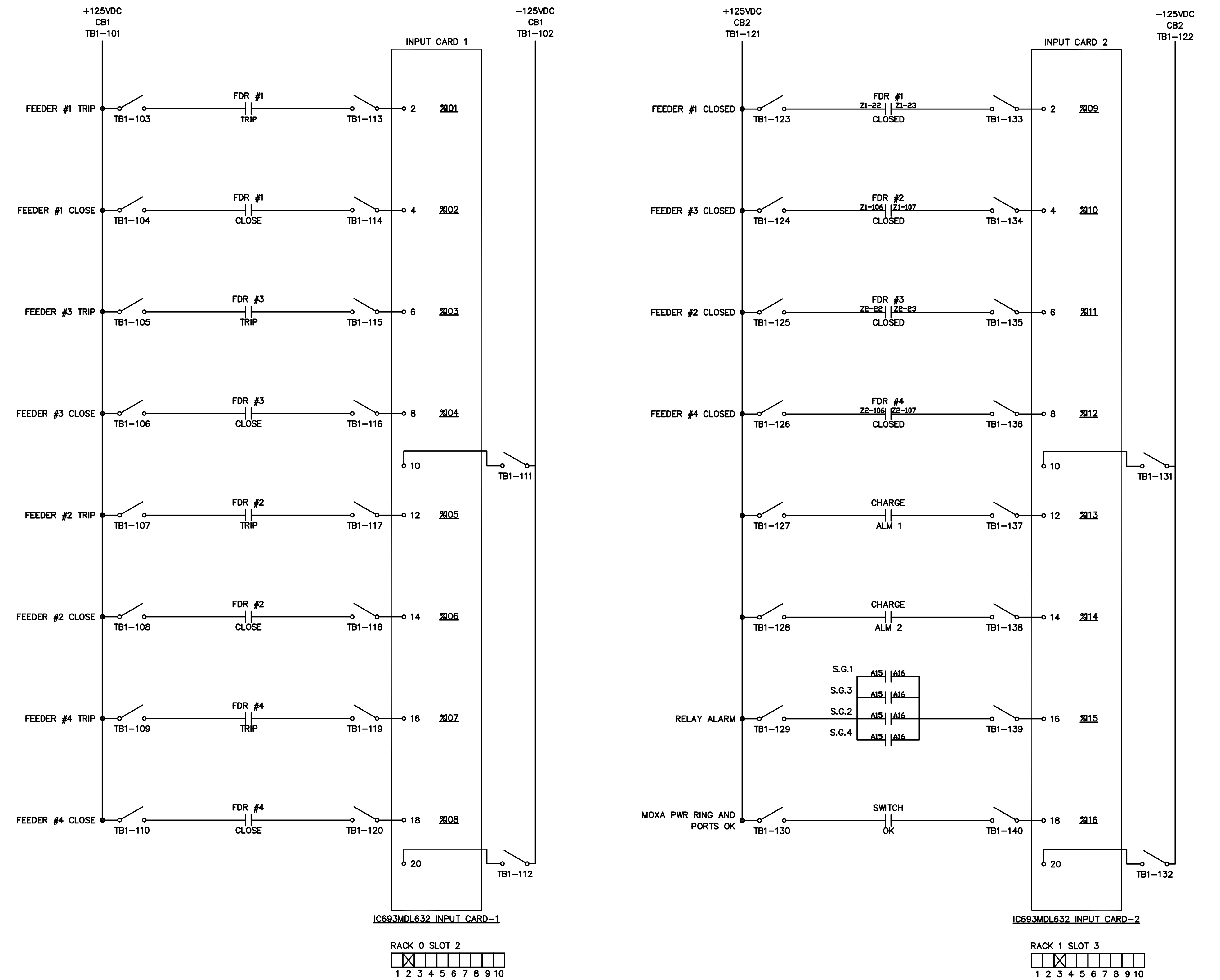
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
SUBSTATION PLC PANEL
PLC DISCRETE OUTPUTS

kss-el-2023_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2023

SHEET 1 OF 1



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. - SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
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ENG. STAMP

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DRAWING NAME:

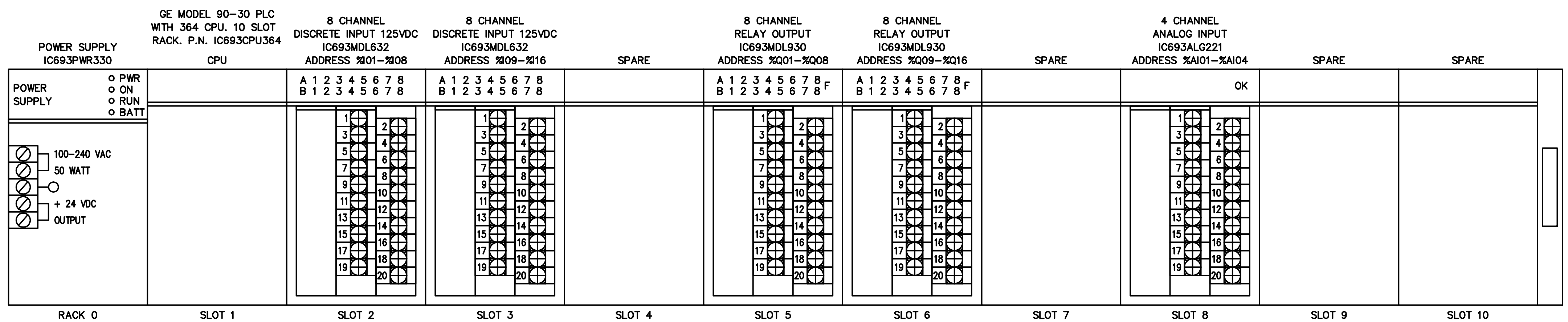
KOTZEBUE SCADA SYSTEM
SUBSTATION PLC PANEL
PLC DISCRETE INPUTS

kss-el-2022_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2022

SHEET 1 OF 1



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. - SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
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ENG. STAMP

Electric Power Systems Inc.
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TEL: (907) 522-1953
FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

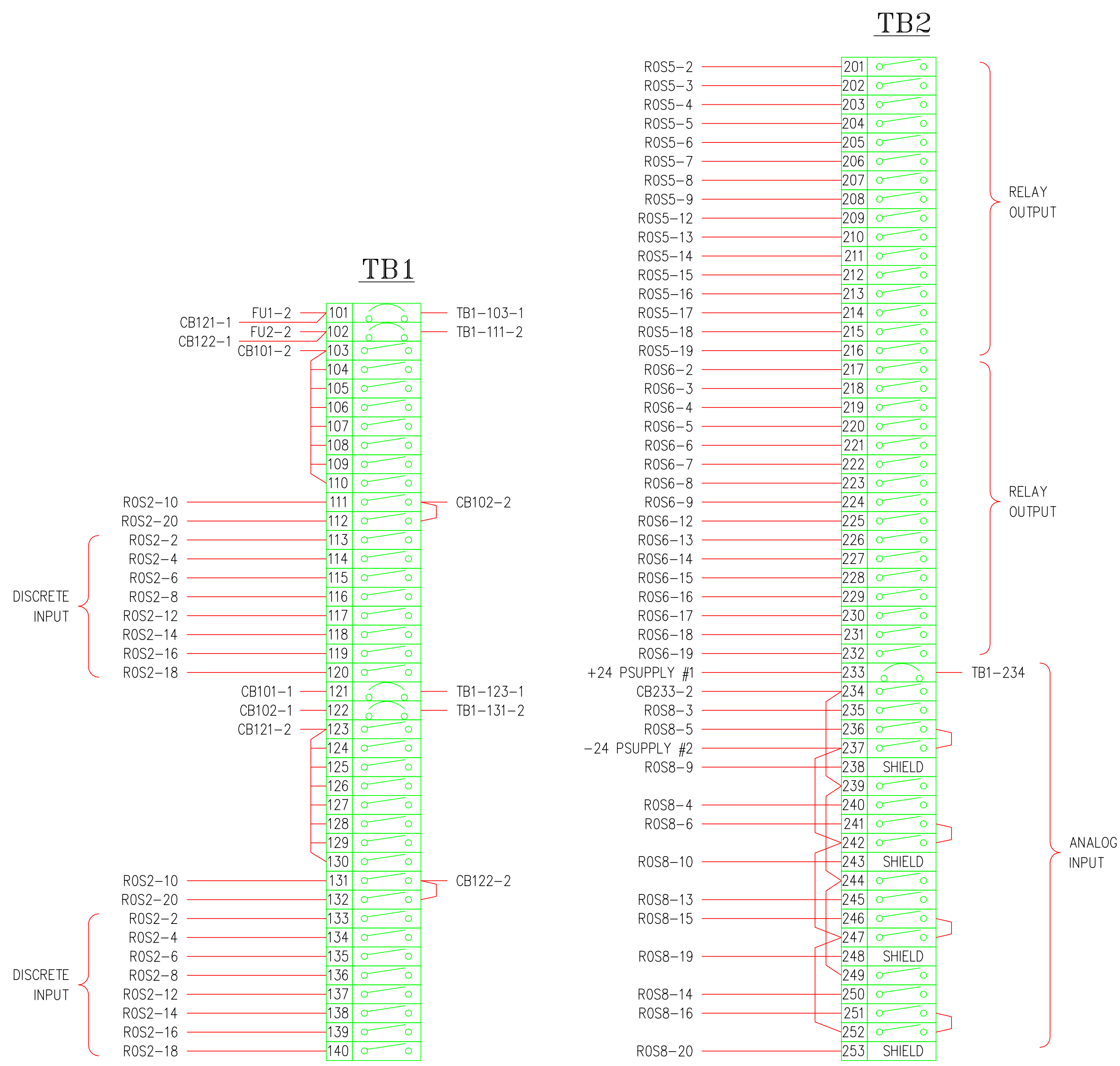
DRAWING NAME: KOTZEBUE SCADA SYSTEM
SUBSTATION PLC PANEL
PLC LAYOUT

kss_el_2021_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2021

SHEET 1 OF 1



PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. - SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW

W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
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ENG. STAMP

Electric Power Systems Inc.
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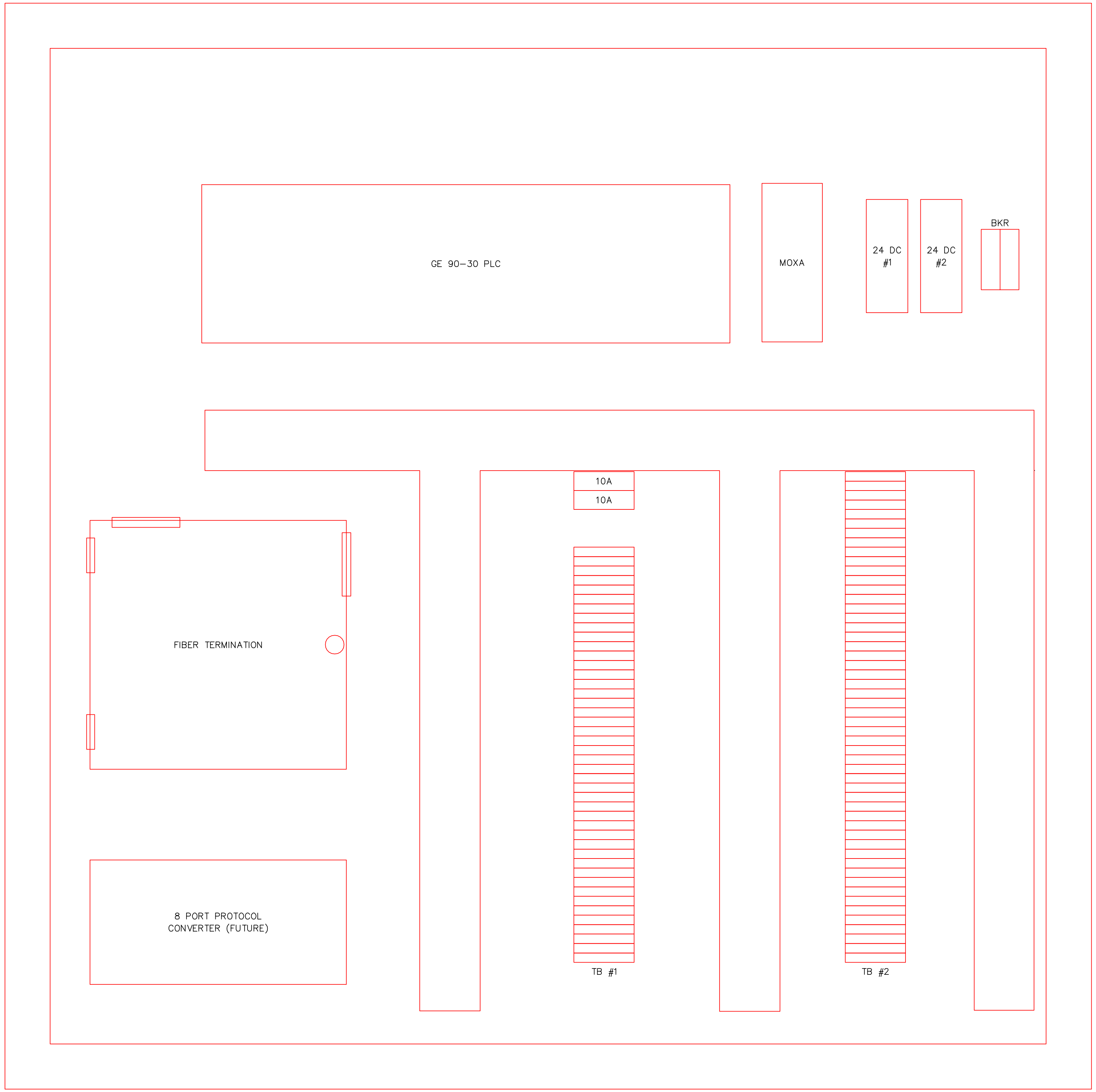
NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

DRAWING NAME:
KOTZEBUE SCADA SYSTEM
SUBSTATION PLC PANEL
TERMINAL BLOCK LAYOUT

REF DWG(S):
kss-el-2020_2.dwg

DRAWING NO.: KSS-EL-2020

SHEET 2 OF 2



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA ASSESSMENT

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #:

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-07-2006	RJM/12-07-2006	

ENG. STAMP

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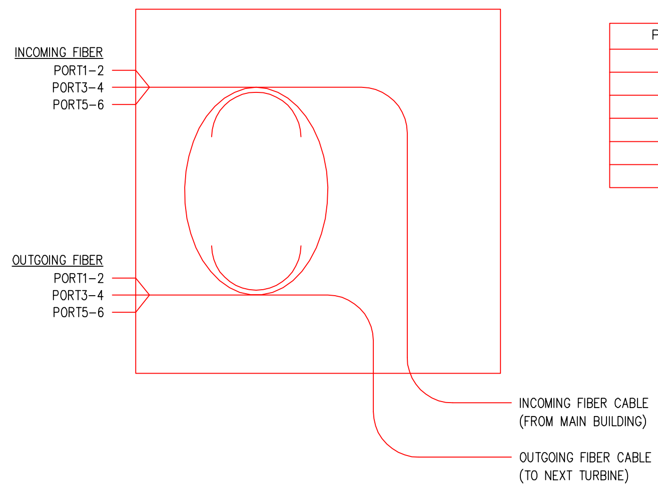
DRAWING NAME:
KOTZEBUE SCADA SYSTEM
SUBSTATION PLC PANEL
COMPONENT LAYOUT

kss-el-2020_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2020

SHEET 1 OF 2



TYPICAL FIBER TERMINATION PANEL
(NOTE 1)
(NOTE 2)

PORT #	FIBER COLOR
1	GREY
2	BLUE
3	WHITE
4	GREEN
5	ORANGE
6	BROWN

JUMPER TABLE
FOR TURBINES 4, 5, 6, 9, 14, 15, 16, AND 17

FIBER SWITCH	FIBER PANEL
5TX	1U
5RX	2U
4RX	1L
4TX	2L
FIBER PANEL	FIBER PANEL
3L	3U
4L	4U

JUMPER TABLE
FOR TURBINES 7, 10, 11, 12, 18

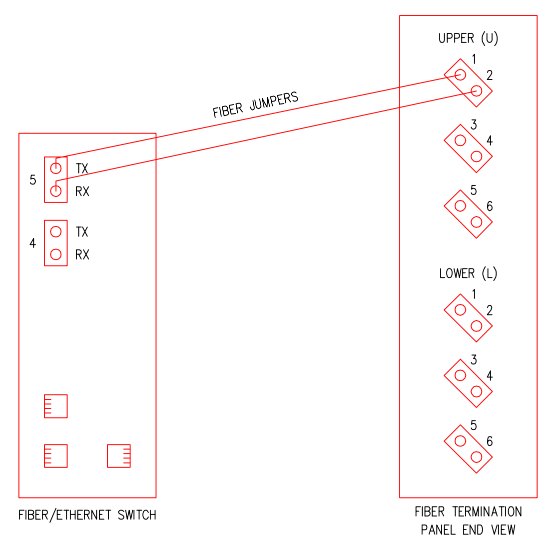
FIBER SWITCH	FIBER PANEL
5TX	1U
5RX	2U
4TX	3U
4RX	4U

JUMPER TABLE
FOR TURBINES 8 (NOTE 3)

FIBER SWITCH	FIBER PANEL
5TX	1U
5RX	2U
4RX	1L
4TX	2L
FIBER PANEL	FIBER PANEL
S2U	3L
S1U	4L
S3U	3U
S4U	4U

JUMPER TABLE
FOR MAIN BUILDING (NOTE 3)

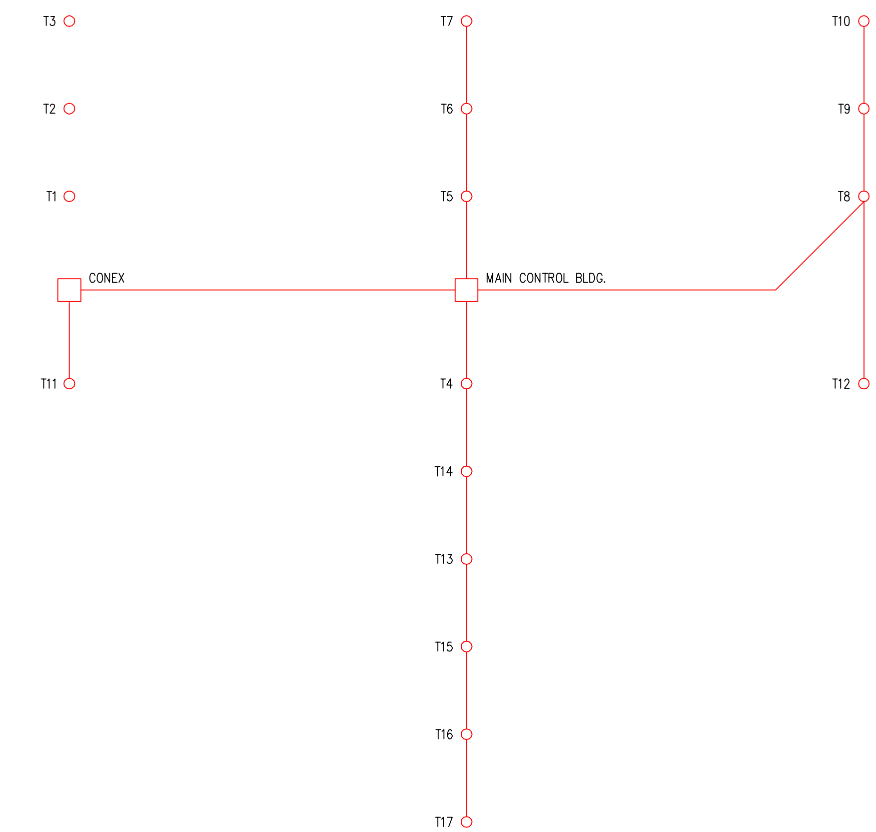
FIBER SWITCH	FIBER PANEL
5TX	1U
5RX	2U
4TX	S4L
4RX	S3L
FIBER PANEL	FIBER PANEL
3U	2L
4U	1L
3L	S2U
4L	S1U
S3U	S2L
S4U	S1L



FIBER JUMPER DETAIL

JUMPER TABLE
FOR CONEX

FIBER SWITCH	FIBER PANEL
SW#2 5TX	1U
SW#2 5RX	2U
SW#1 5RX	1L
SW#1 5TX	2L
FIBER SWITCH	FIBER SWITCH
SW#1 4TX	SW#2 4RX
SW#1 4RX	SW#2 4TX
FIBER PANEL	FIBER PANEL
3L	3U
4L	4U



FIBER CONNECTION DIAGRAM

NOTES:

1. THE MAIN CONTROL BUILDING HAS 2 FIBER TERMINATION BOXES. THE PRIMARY BOX INCOMING FIBER CONNECTS TO THE CONEX, AND THE OUTGOING FIBER CONNECTS TO TURBINE 4. THE SECONDARY BOX INCOMING FIBER CONNECTS TO TURBINE 5 AND THE OUTGOING FIBER CONNECTS TO TURBINE 8.
2. TURBINE 8 CONTROL BUILDING HAS 2 FIBER TERMINATION BOXES. THE PRIMARY BOX INCOMING FIBER CONNECTS TO THE MAIN CONTROL BUILDING, AND THE OUTGOING FIBER CONNECTS TO TURBINE 9. THE SECONDARY BOX INCOMING FIBER CONNECTS TO TURBINE 12.
3. (S) PREFIX STANDS FOR SECONDARY PANEL.

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC
DESIGNER/PROJECT ENGINEER: RYAN MILLS W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-06-2006	RJM/12-06-2006	

ENG. STAMP

Electric Power Systems Inc.
Consulting Engineers
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WEB: WWW.EPSINC.COM

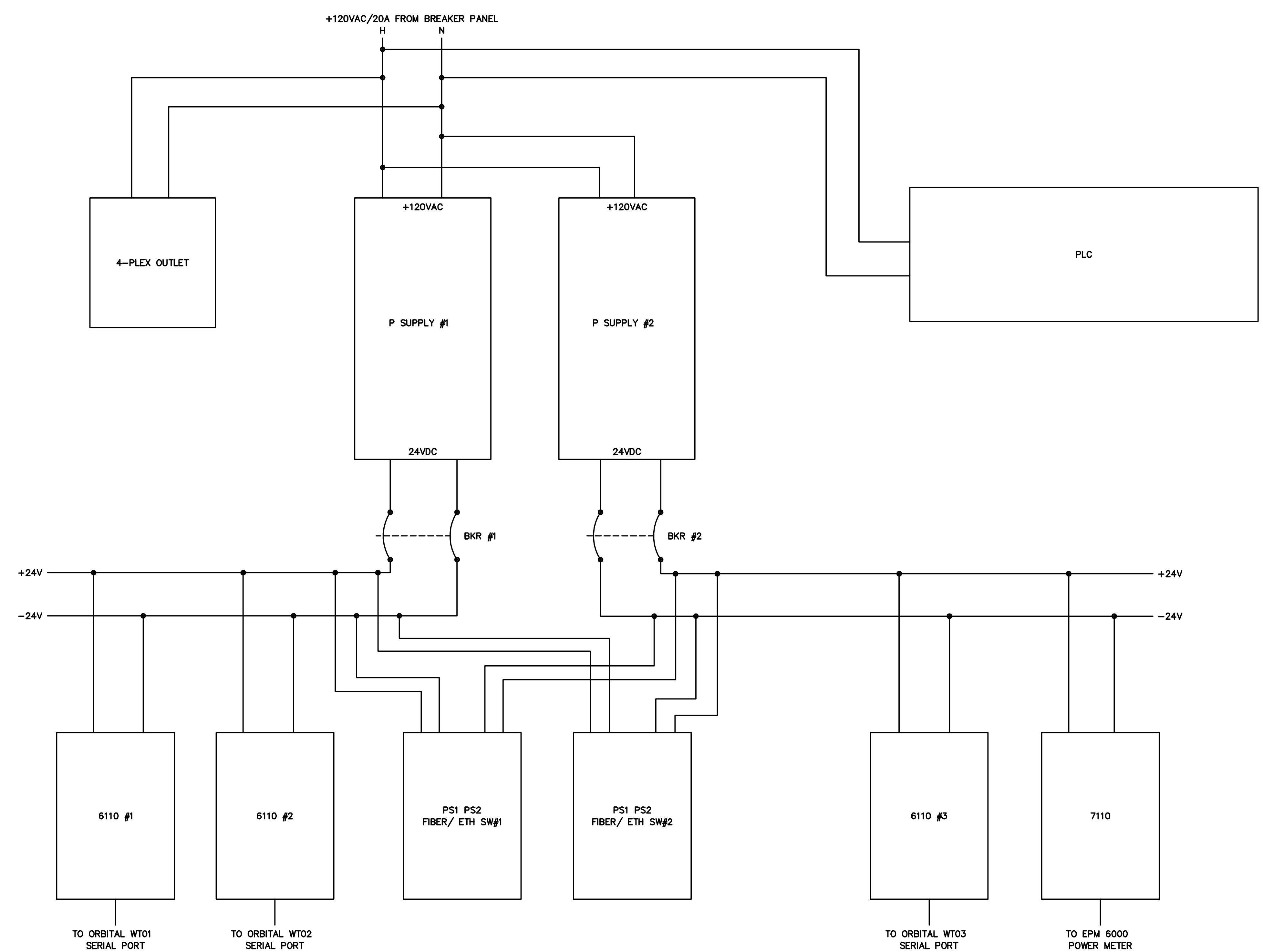
DRAWING NAME: KOTZEBUE SCADA SYSTEM
WIND FARM
FIBER TERMINATIONS

kss-el-2101_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2101

SHEET 1 OF 1



NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. - SCADA EPC

DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	RJM/09-20-2006		

ENG. STAMP

Electric Power Systems Inc.
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TEL: (907) 522-1953
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WEB: WWW.EPSINC.COM

DRAWING NAME:

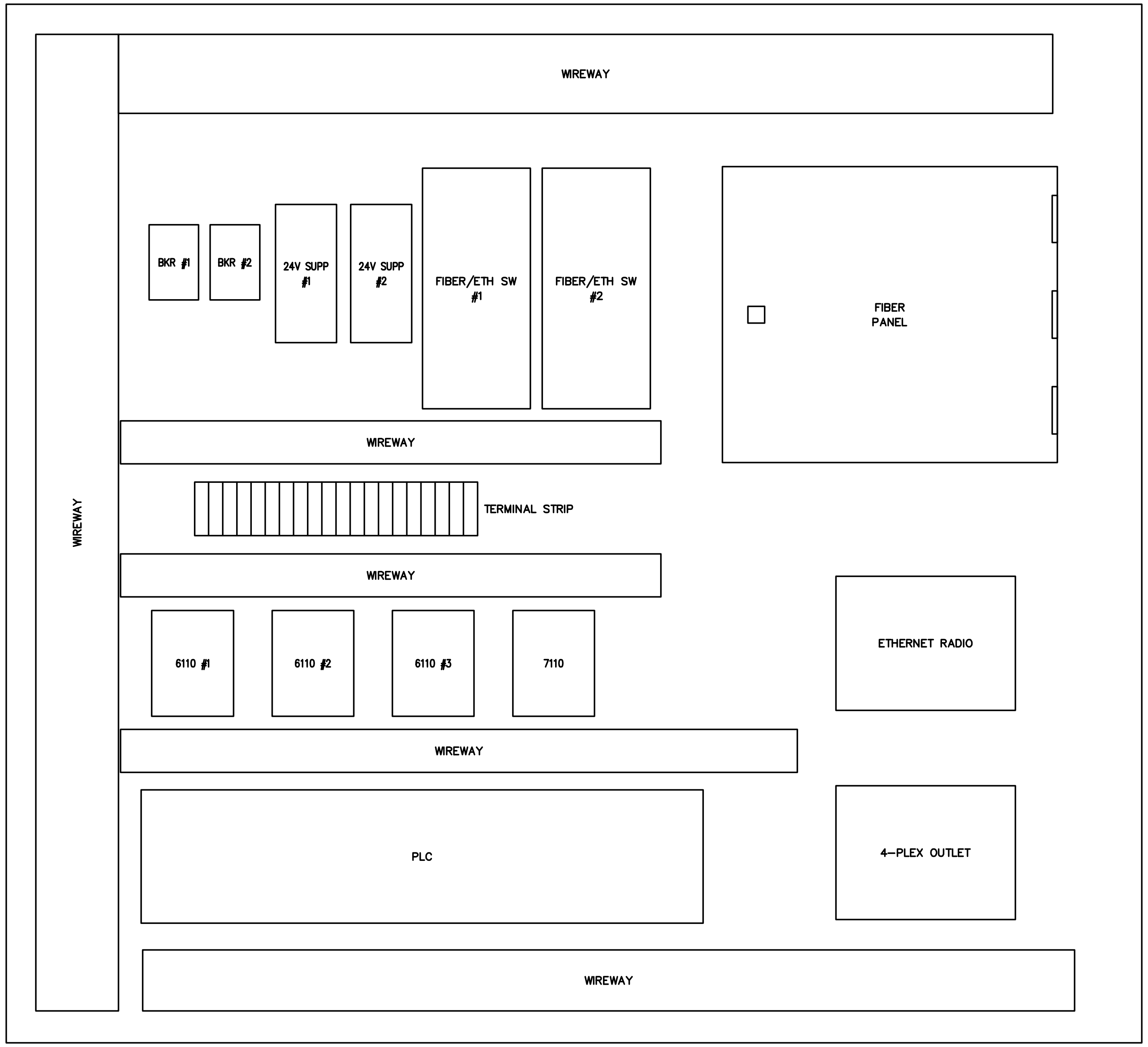
KOTZEBUE SCADA SYSTEM
WIND FARM
CONEX COMMUNICATIONS PANEL SCHEMATIC

kss_el_2100_3.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2100

SHEET 3 OF 3



CONEX COMM CABINET LAYOUT

DESCRIPTION	MANUFACTURER	PART NUMBER
FIBER PANEL	CORNING	WIC-012
FIBER/ETH SWITCH	MOXA	EDS-405-MM-SC
6110	MOXA	UC-6110
24V POWER SUPPLY	IDEC	PS5R-SC24
2 POLE 2A BREAKER	CUTLER HAMMER	WMS2D02
7110	MOXA	UC-7110
ETHERNET RADIO	RADIOLINX	RLX-IH
PLC BACKPLANE	GE	IC693CHS391
PLC CPU	GE	IC693CPU364
PLC POWER SUPPLY	GE	IC693PWR330

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. – SCADA EPC
DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
0	AS BUILT	KER/12-06-2006	RJM/12-06-2006	

ENG. STAMP

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WEB: WWW.EPSINC.COM

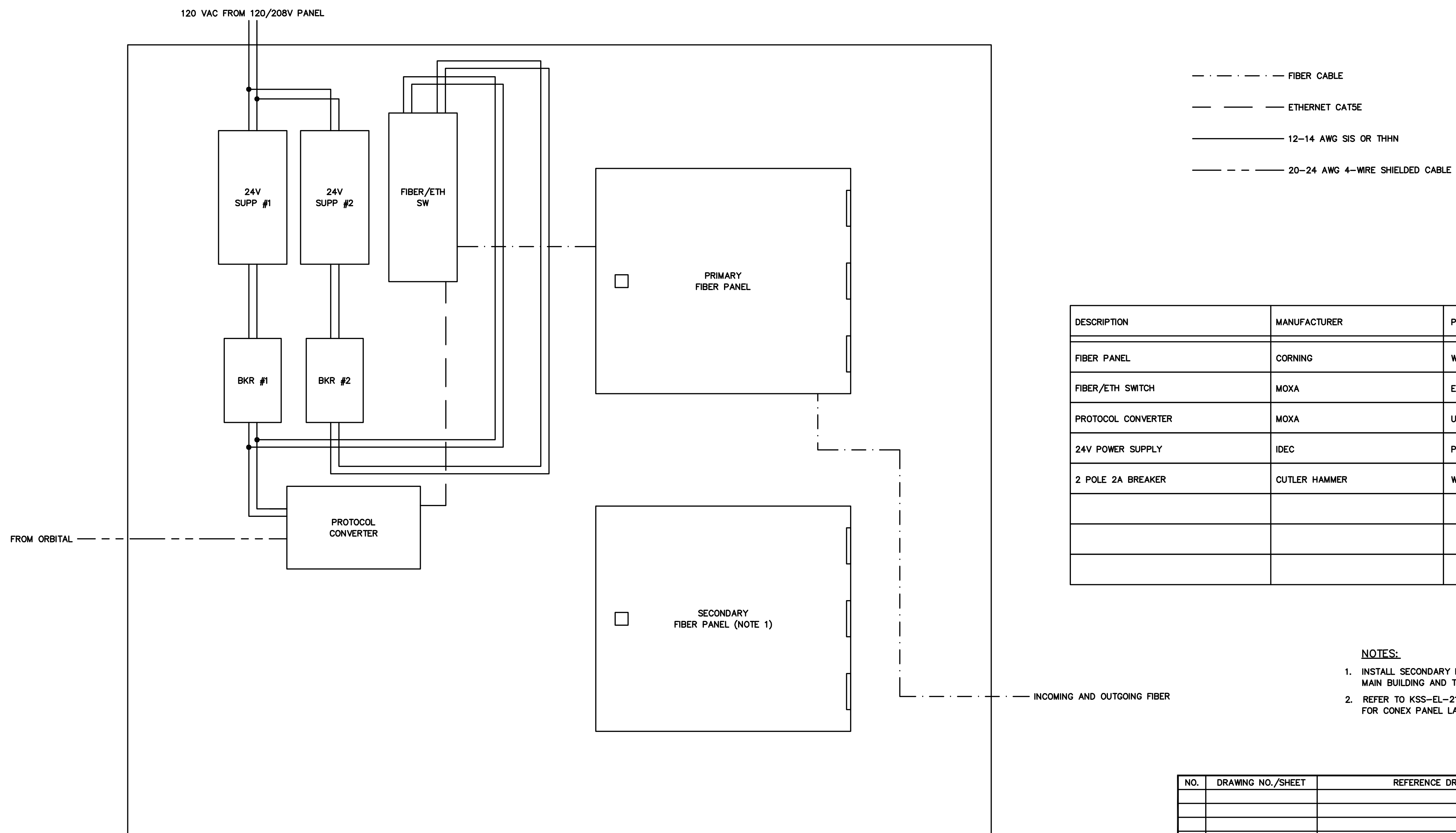
DRAWING NAME: KOTZEBUE SCADA SYSTEM
WIND FARM
CONEX COMMUNICATIONS PANEL LAYOUT

kss_el_2100_2.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2100

SHEET 2 OF 3



TYPICAL COMM CABINET LAYOUT
(NOTE 2)

DESCRIPTION	MANUFACTURER	PART NUMBER
FIBER PANEL	CORNING	WIC-012
FIBER/ETH SWITCH	MOXA	EDS-405-MM-SC
PROTOCOL CONVERTER	MOXA	UC-6110
24V POWER SUPPLY	IDEC	PS5R-SC24
2 POLE 2A BREAKER	CUTLER HAMMER	WMS2D02

NOTES:

1. INSTALL SECONDARY FIBER PANELS IN THE MAIN BUILDING AND TURBINE 8 ONLY.
2. REFER TO KSS-EL-2100 SHEETS 2 AND 3 FOR CONEX PANEL LAYOUT AND SCHEMATIC.

NO.	DRAWING NO./SHEET	REFERENCE DRAWING/DETAIL/PLAN/SECTION DESCRIPTION

PROJECT: KOTZEBUE ELECTRIC ASSOCIATION, INC. - SCADA EPC
DESIGNER/PROJECT ENGINEER: RYAN MILLS/STEVE DREW W.O. #: 05-0204

NO.	DESIGN/CONSTRUCTION/ASBUILT REVISION	DWN BY/DATE	REVIEWED (MGR/SUPV)/DATE	APPROVED (DIRECTOR)/DATE
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ENG. STAMP

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Consulting Engineers
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FAX: (907) 522-1182
WEB: WWW.EPSINC.COM

DRAWING NAME: KOTZEBUE SCADA SYSTEM
WIND FARM
TYPICAL COMMUNICATIONS PANEL LAYOUT
AND SCHEMATIC

kss_el_2100_1.dwg

REF DWG(S):

DRAWING NO.: KSS-EL-2100

SHEET 1 OF 3