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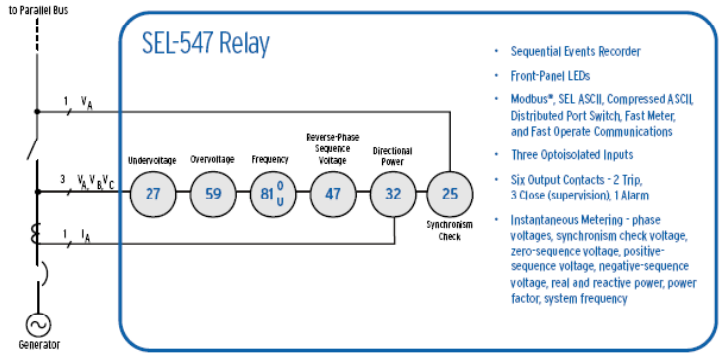
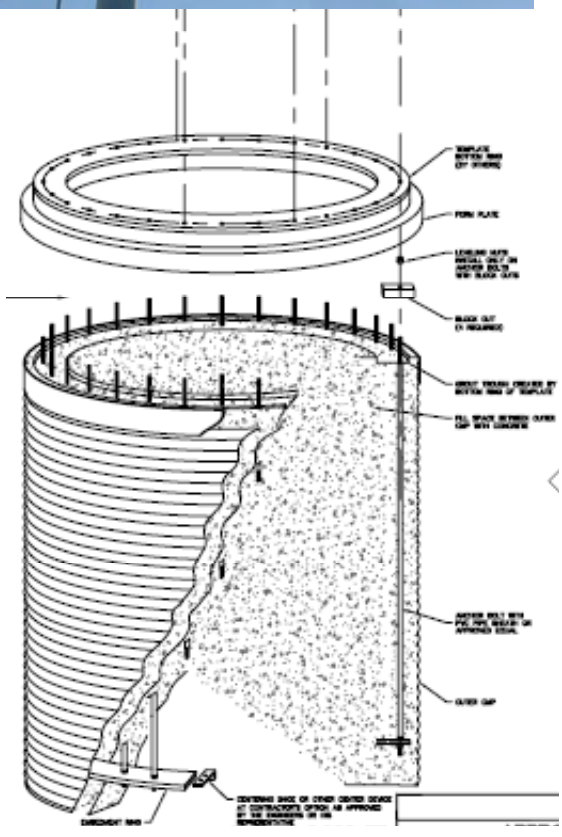
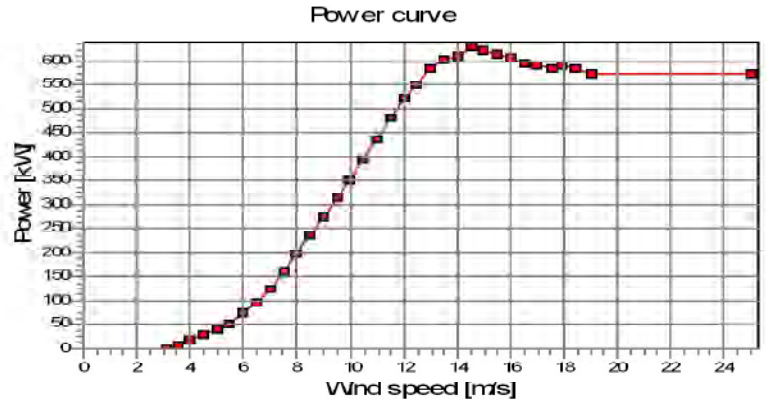
Project Report on Engineering Services for the Wind Turbine Project at the Cuyahoga County Fair

Functional Overview







Wind Turbine Engineering Services

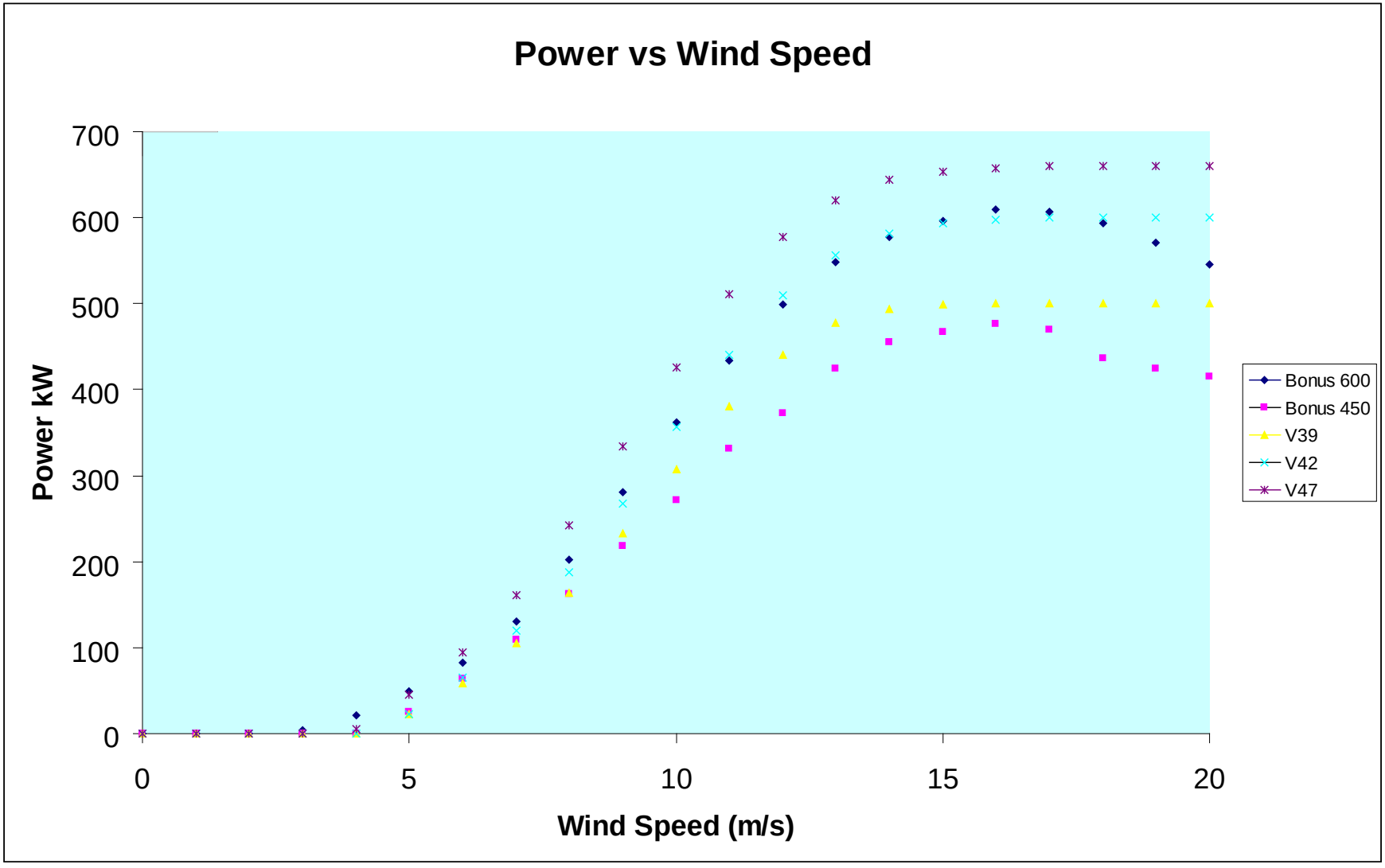
The Cuyahoga County Fair (Fair) has expressed an interest in a 600kW Wind Turbine Generator (WTG) that would be installed at the fairgrounds in Berea, Ohio. As the project manager for the Vestas V27 WTG at the Great Lakes Science Center (GLSC), **Phillips Group** is uniquely qualified to assist the Fair in this project. A summary of the scope of work and results to date are included here.

1. We are determining the electrical connection requirements from the turbine to the connection point, developing engineering drawings suitable for bidding, and developing the utility interconnection schematic. . The deliverables will be as follows:

   - A minimum of three pages of electrical drawings suitable for bidding – including an electrical 1Line, 3Line, Schematic, Wiring, Conduit, and Detail Drawings.
   - Specifications/Scope of Work for bidding purposes.
   - Grounding for the Wind Turbine.
   - Updated Cuyahoga Fair electrical drawings with the generator addition.
   - Utility interconnection drawings and settings for the Multilin relay.
   - Calculation of the available short circuit for the system.
   - Selection of the correct breaker/disconnect and settings for the 2.4kV connection point.
   - A list of qualified bidders for installing the electrical system.
   - Cost estimate for the electrical scope of work
   - Project timeline for the electrical scope of work.

2. A comparison of wind turbines suitable for the site has been compiled utilizing the available wind data.

	Wind Turbine Comparison					
Turbine >	Vestas V39	Vestas V42	Vestas V47 660	Vestas V47 660/200	Bonus 450	Bonus 600
Tower	40 m - 55 m	40 m - 55 m	40 m - 55 m	40 m - 65 m	35 m - 50 m	40 m - 60 m
Blade Diameter	39 m	42 m	47 m	47 m	37 m	44 m
Technology	Gearbox	Gearbox	Gearbox	Gearbox	Gearbox	Gearbox
Power Output - kW	500	600	660	660	450	600
Rotor Speed	30 rpm	30 rpm	28.5 rpm	26 rpm	30 rpm	27 rpm
Cut-in Wind Speed	4 m/s	3.5 m/s	4 m/s	3.5 m/s	3.5 m/s	3.5 m/s
Full Power Wind Speed	15 m/s	13 m/s	15 m/s	16 m/s	15 m/s	15 m/s
Cut-Out Wind Speed	25 m/s	25 m/s	25 m/s	25 m/s	25 m/s	25 m/s
Control Technology	Standard	Standard	Standard	Standard	Standard	Standard
Maintenance Issues	Gearbox	Gearbox	Gearbox	Gearbox	Gearbox	Gearbox
Output Voltage	690 V	690 V	690 V	690 V	690 V	690 V
Capacity Factor - 40 m	11.9%	11.2%	12.9%	13.6%	12.9%	13.5%
Capacity Factor - 60 m	13.9%	13.1%	14.6%	15.7%	14.9%	15.4%
Turbine Cost	$610,000	$660,000	$800,000	$820,000	$490,000	$600,000
$/kW	1220	1100	1212	1242	1089	1000
$/kWh	$1.00	$0.96	$0.95	$0.90	$0.83	$0.74


Power vs Wind Speed
Power kW
700
600
500
400
300
200
100
0
0
5
10
15
20
Wind Speed (m/s)
Bonus 600
Bonus 450
V39
V42
V47

3. The available data for the Bonus 600 is as follows:

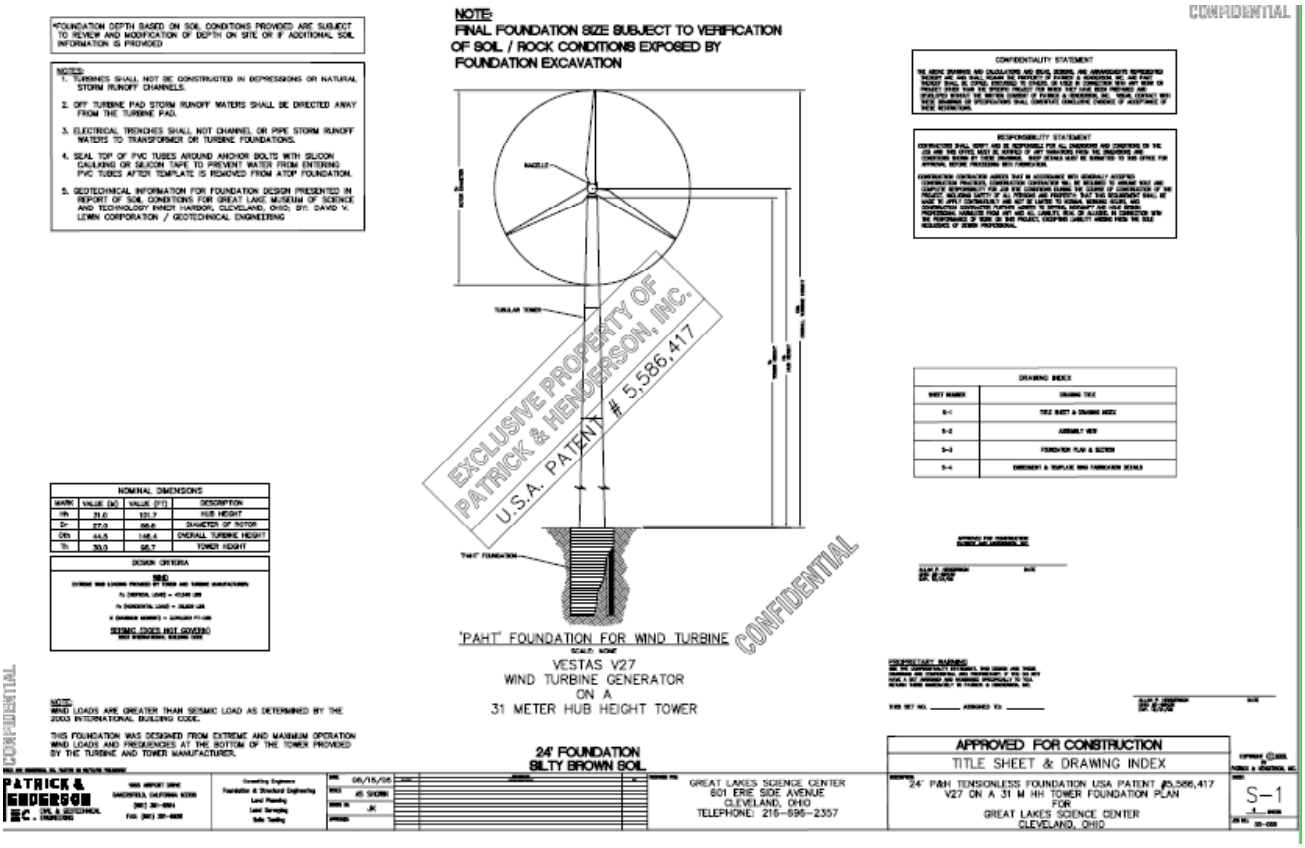
Bonus 600 Mk IV

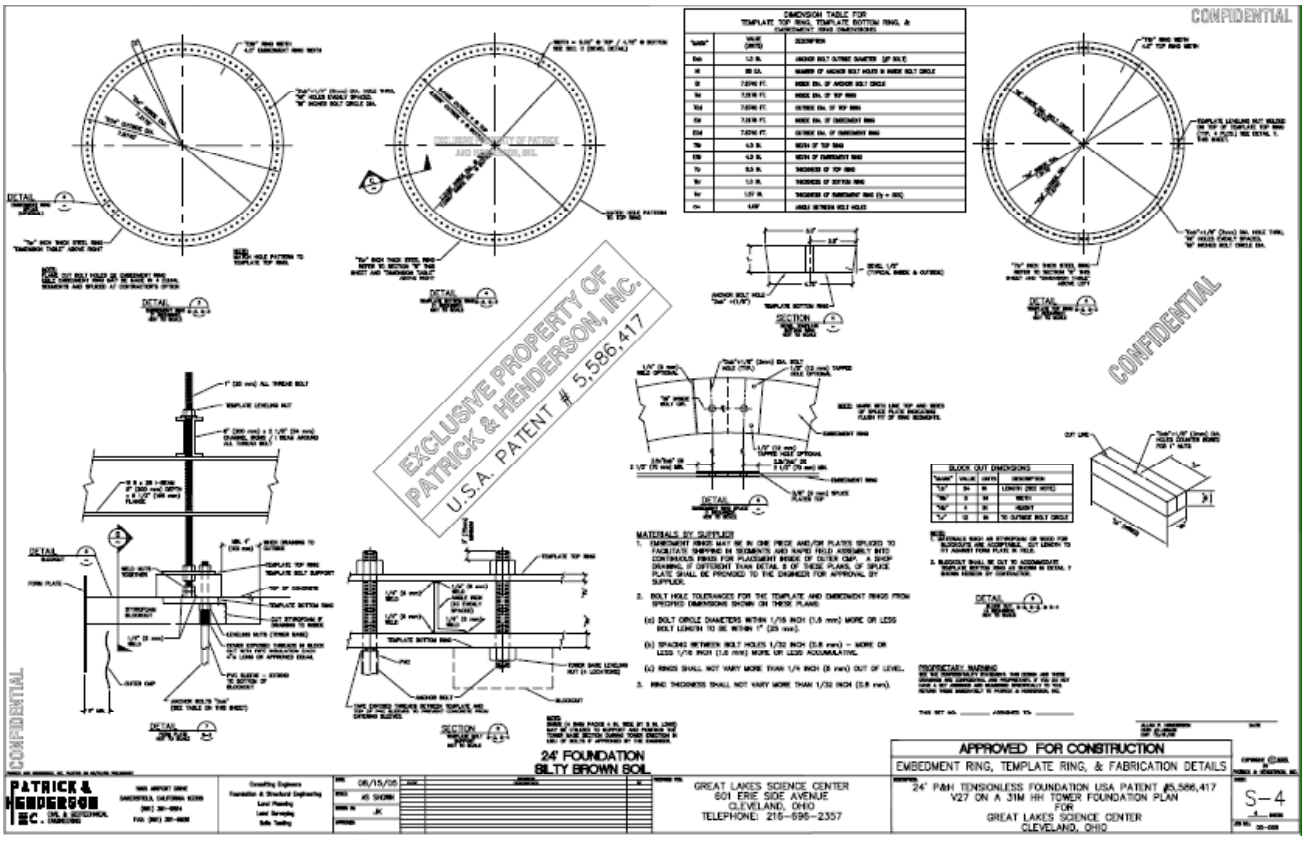
Generator Type	Asynchronous	**Gearbox Mfg.**	Flender
Generator Output	120/600 kW	**Gearbox Type**	3-Stage Planetary
Generator Speed	1200/1800 rpm	**Gearbox Ratio**	1 to 66.67
Generator Voltage	690 V	**Gearbox Cooling**	Oil Cooler
Generator Cooling	Air	**Brake System 1**	Aerodynamic
		Brake System 2	Dual Disc
Rotor Diameter	44 m		
Rotor Swept Area	1520 m2	**Cut/in Speed**	3 m/s
Rotor Speed	18/27 rpm	**Full Power**	15 m/s
Blade Length	19 m	**Cut/out Speed**	25 m/s
Regulation	Stall	**Withstand Speed**	57 m/s
Lightning Protection	Blade Tips		
Blade Design	NACA 63	**Tower Height**	40, 50, 58 m
		Hub Height	42 - 60 m
Controller	Mita-Teknik		
Remote Data	Windows		
Turbine Control	Base & Nacelle		
Diagnostics	Hand Held		

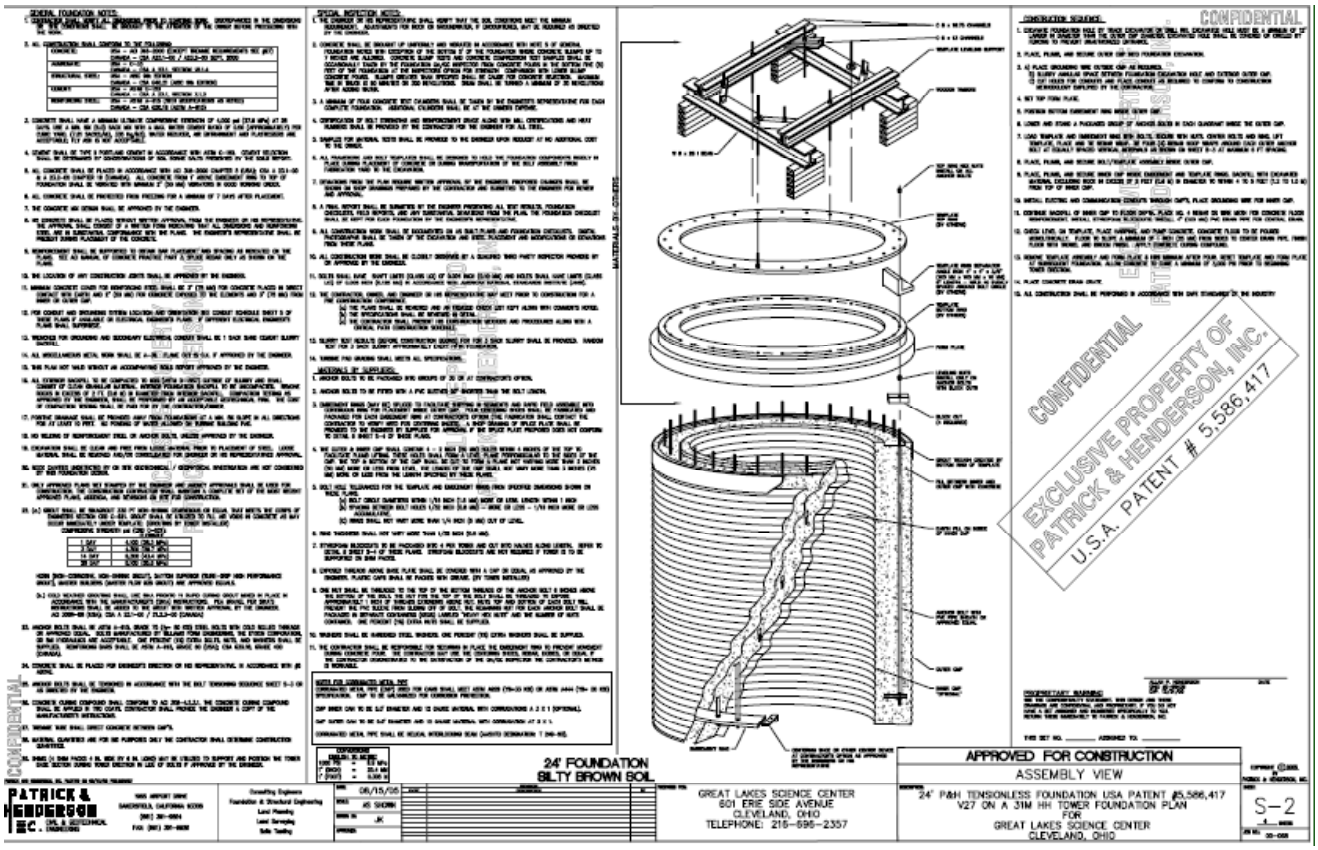
<u>Controller Parameters</u>

Wind direction	Wind speed
Generator overheating	The direction of yawing
Hydraulic pressure level	Low-speed shaft speed
Correct valve function	High-speed shaft speed
Vibration level	Voltage on all three phases
Twisting of the power cable	Current on all three phases
Emergency brake circuit	Frequency on one phase
Electric motors temp.	Temperature inside the nacelle
Brake-caliper adjustment	Generator temperature
Centrifugal-release active	Gear oil temperature
	Gear bearing temperature

4. Sample foundation design for tensionless foundation (caisson type)



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CLEVELAND, OHIO
TELEPHONE: 216-696-2357
24' P&H TENSIONLESS FOUNDATION USA PATENT #5,586,417
V27 ON A 31M HH TOWER FOUNDATION PLAN
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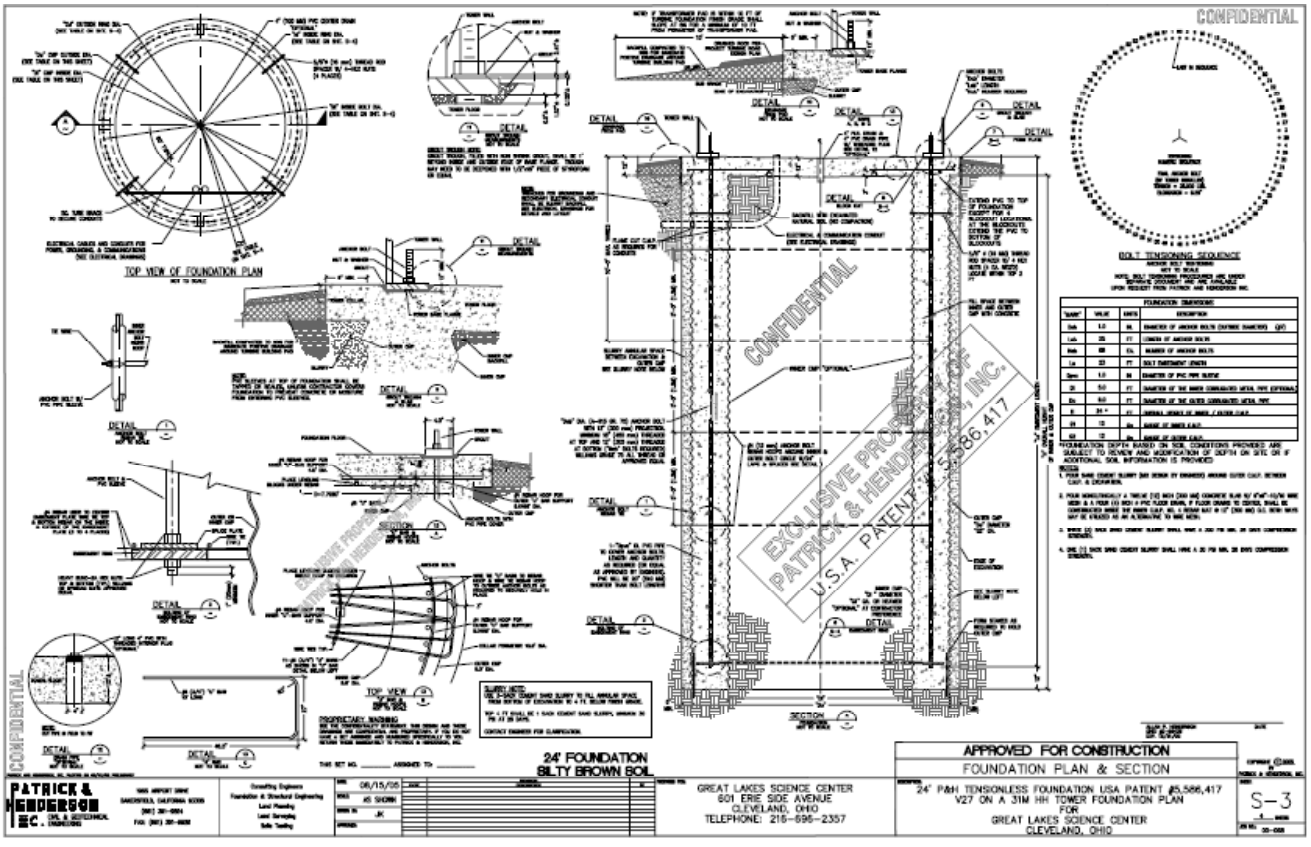
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5. Sample Foundation for a Spread Footer type

6. Rebuilding Specifications

a. Blades

1) Disassemble, test and inspect all blade components
2) Repair structural and/or cosmetic damage to blades
3) Replace seal between blade root and blade (where applicable)
4) Replace hub-to-nacelle and blade-to-hub fasteners
5) Surface prep, re-coat surface and polish blades

b. Gearbox

1) Disassemble, test and inspect complete gear unit
2) Inspect all gears for wear, pitting, and abrasion
3) Furnish and install new gears where required
4) Recondition/kiss grind gears where required
5) Furnish and install new bearings
6) Recondition/replace shafts where necessary
7) Furnish and install new gaskets
8) Furnish and install new filters
9) Furnish and install new gear oil
10) No load run test complete unit
11) Document all components with pictures and serial numbers

c. Brake system

1) Replace safety pressure sensor
2) Replace working pressure sensor

3) Re-condition or replace brake solenoid
4) Re-condition calipers
5) Re-condition brake fluid reservoir
6) Re-condition Brake pump motor
7) Pressure test and re-charge brake accumulators
8) Flush, re-charge with new fluid and bleed brake system
9) Recondition/replace hoses, fittings, and wiring as needed.

d. Generator

1) Disassemble, test and inspect complete generator
2) Steam clean all parts
3) Dip and bake stator in Class 200 Epoxy
4) Dynamically balance rotor (G2.5)
5) Furnish and install new bearings
6) Recondition/replace leads if necessary
7) Assemble, test and paint
8) No-load test complete unit

e. All Other Electric Motors

1) Disassemble, test and inspect
2) Steam clean all parts
3) Dip and bake stator in Class 200 Epoxy
4) Dynamically balance rotor (G2.5)
5) Furnish and install new bearings

6) Recondition/replace leads if necessary

7) Assemble, test and paint

8) No-load test complete unit

f. Other Electrical / Mechanical Components

1) Disassemble, test and inspect all junction boxes/terminal enclosures

2) Air clean all components

3) Repair/replace as required

4) Repair/replace connections/lugs as required

5) Inspect and recondition cable twist as necessary

6) Inspect and replace yaw gears as necessary

7) Replace hydraulic lines as required

g. Nacelle Components

1) Steam entire nacelle inside and out

2) Replace nacelle struts as required

3) Replace gaskets as required

4) Repair/replace fiberglass components as necessary

5) Paint/coat components as required

6) Re-align nacelle cover & nose cone as required

h. Bolts, Nuts & Fasteners

1) Replace all components with equal or better class items