PROJECT TITLE: STEAM PRESSURE CONTROLS ISSUES @ HEAT PLANT 2 (RABON PLANT)

BUILDING NUMBER: 473

PROJECT NO: W.O. 1065564

DATE: June 20, 2008

PREPARED BY:
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FINAL REPORT CENF Project No. 08009
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GENERAL

Recently the turbine in the University of Florida's power house (Rabon Heat Plant) #2 tripped (offline). At the time of the trip, steam was being provided by the boilers rather than the Progress Energy cogeneration facility. The turbine trip apparently caused the boilers to trip, resulting in a campus wide steam pressure loss. This loss of pressure also affected The Shands Medical facility.

The goal here is to investigate this occurrence and determine the mode of the failure and suggest ways to prevent its reoccurrence.

The turbine trip would have had minimal effect on the campus steam system if the steam was being provided by the Progress Energy cogeneration facility. The steam provided to the University of Florida by Progress Energy is produced at a higher pressure and temperature than required by the campus steam. Before delivery to the plant, the steam is pressure reduced and desuperheated. The pressure reducing valves would react to a sudden reduction in flow with little effect on the system. However, when operating on the back-up boilers, this is not the case.

We will first discuss how the steam pressure is controlled at the turbine, followed by boiler safeties information and information regarding the overpressure switch. Finally, we will offer options to prevent future occurrences of this nature.
TURBINE-GENERATOR PRESSURE CONTROL

The turbine is controlled by the pressure of the steam exhausting the unit, and operates as a pressure reducing valve. The governor valve opens to admit more steam as the pressure in the exhaust line falls, thus re-establishing the desired pressure. Conversely, as the steam pressure in the exhaust line rises, the governor valve closes, reducing the exhaust steam pressure. The desired pressure is set in the Woodward 505 turbine governor, the industry standard for governors. From all reports, this system is operating very well. We have heard no reports of variations in the steam pressures or failure of the control system.

The Elliott turbine has two inlet valves that feed an arc of steam nozzles directing the steam onto the blades attached to the turbine rotor. The two valve system improves the turn down of the turbine and helps to maintain higher low load efficiency. This device is driven by oil from the lubricating system which rotates a cam operating the valves. The number of nozzles in each arc may vary from design to design. We do not have records to indicate the amount of steam controlled by either of the two valves.

Pressure drops in the steam line to the Shands Medical Facility occur when the steam requirement exceeds the capacity of the turbine. The pressure drop in the line signals the two Copes Vulcan pressure control valves to open and make up the shortfall. The pressure reducing valves are set for a lower pressure than the turbine exhaust and thus stay closed when the turbine is satisfying the load, but open when the pressure falls. For example if the turbine pressure is set for 70 psig these valves would be set for approximately 65 psig. Thus when the capacity of the turbine is exceeded on a cold winter day the exhaust pressure in the steam line will fall by about 5 psig. The steam flow to Shands is maintained and the generator operates at full load.

The Copes Vulcan PRV valves (see Appendices A and C) are pneumatically controlled with air pressure to open and springs to close. The pressure in the line is fed to a pneumatic controller that in turn sends air pressure to the diaphragm on the top of the valve forcing it open. On the attached steam diagram (Appendix B) these valves are shown as PRV #2 and PRV #3. A page from a Copes Vulcan bulletin is also attached showing a cutaway of this type of valve. It should be noted that PRV-1 has not operated for over 20 years and it should be replaced. (It was reported that this PRV is scheduled for replacement in 2009.) Also, the PRV #2 air regulator and receiver controller have been recently replaced and PRV-2 is working properly. It was also reported by Mr. Rob Munsel at HP-2 that PRV-3 requires testing and maintenance in the next year.

The conditions are different in the case of a turbine trip. A turbine trip valve closes instantaneously. However, as the pressure reducing valves are not designed to operate instantaneously this results in a sudden reduction in steam flow and an inherent increase in pressure. The pressure reducing valves are called upon to meet the total steam need and require time to react. The pressure reducing valves are properly sized to meet the steam demand. This type of pressure reducing valve are standard in the industry and do an excellent job. However, as they are not quick opening valves it may take several seconds for the signal to reach the controller and for the proper pressure to be re-established in the line. The pressure spike caused by the sudden closing of the turbine trip valve is exacerbated by the reaction time of the pressure reducing valves.

The reaction to a turbine trip is a pressure spike in the steam system upstream and a momentary loss of pressure downstream. The momentary drop in steam pressure in the exhaust line is minor and quickly corrected by the volume of the system and the reaction of the pressure reducing valves.
The spike in the high pressure system is not so benign, and we attribute the boiler trip and the subsequent problems campus wide to this pressure spike.
PRESSURE RELIEF VALVES

To meet code all boilers must have safety relief valves. These valves are normally set ten (10%) percent above the boiler working pressure. The lowest pressure safety valve would be set for 250 psig plus 25 psig or a minimum pressure of 275 psig. If the boiler is equipped with a superheater, the superheater safety valve is set at this pressure. The superheater safety valve must be set at the lowest setting to insure that it opens first, thus maintaining steam flow in the superheater to protecting it from thermal damage. The steam is the coolant.

If the boiler is not equipped with a superheater, the first safety on the boiler drum will be set for 275 psig. In all cases the safety valves must be set such that the pressure in the boiler does not exceed the design pressure. Most boilers are equipped with a high pressure switch to prevent the safeties from opening and to further prevent over pressuring the boiler. This switch will trip the boiler in the event of an overpressure incident.

It was reported that the turbine tripped for an unknown reason and that the resulting boiler trip is assumed to be a result of the turbine trip. This is probably a safe assumption, as no other equipment in the power house tripped at that time. However, both the boiler and the turbine are equipped with devices that are sensitive to trips in the event of very short interruptions such as switching on the line. The boiler has Maxon or equal valves on the fuel system and the turbine has the generator protection system. We will proceed with the assumption that the trip of the turbine caused the boiler trip.

We learned in the meeting that there is no first out feature on the boiler. A first out feature device records the actions of the burner management system and would have allowed visibility as to what first happened to trip the boiler. It is suggested that a first out feature be incorporated on the new boiler.

There are many reasons for a boiler to trip, including high or low gas pressure, flame failure or a momentary loss of power dropping out the Maxon valve. However, none of these would be caused by a turbine trip. The most likely cause is the overpressure trip. The spike in the steam system discussed earlier could have activated this trip. That spike in pressure is due to the slamming of the turbine governor valve combined with the necessary reaction time of the pressure reducing valves.
PREVENTING BOILER TRIPS WHEN THE TURBINE TRIPS

How can this trip be prevented while still keeping all the safety features of the boiler intact? There are several options.

- **Option 1: Pre-loading the PRV’s** –

  By placing solenoid valves in the air signal to the diaphragm of the control valve the valve can be made to operate off its controller manually as well as automatically. In manual operation the solenoid in the signal line is closed and the solenoid in the new air source is open. From the load on the turbine an approximate pressure for the new source of air to the diaphragm can be controlled to approximate the proper valve position. When the turbine trips the solenoid opens and the pressure reducing valve responds to this signal, opening the valve to that set point. After a few seconds the first solenoid closes and the second opens, returning the valve to its normal operating mode.
  
  Advantage – relatively low cost and faster valve response
  Disadvantage – relatively complex and not a 100% guaranteed solution

- **Option 2: Add a quick-opening valve** –

  In this case a new quick opening valve is added to the inlet of the pressure reducing valve. Again, two solenoid valves are added to the pneumatics of the pressure reducing valve. The difference is that the pressure reducing valve is opened to the estimated position during turbine operation. A turbine trip would operate the quick opening valve and the solenoid valves switch position to put the pressure control system in operation.
  
  Advantage – faster response
  Disadvantage - relatively complex and more costly

- **Option 3: Adjusting the pressure switch** –

  A simple solution would be to adjust the pressure switch to a higher setting that will not trip on the spike. The pressure should be set about 10 psig below the safety valve setting or 265 psig.
  
  Advantage – virtually no cost, the boiler is still protected by the safety valves
  Disadvantage – The pressure switch is still an instantaneous cut out and the boiler could still trip.

- **Option 4: Time delay in the pressure switch** –

  The preferred solution is to add approximately 10 seconds of time delay to the pressure switch. All safeties remain intact.
  
  Advantage – low cost and a guaranteed solution
  Disadvantage – Although doubtful, it is possible the safeties could lift in a condition where they might not have lifted without the time delay.
  
  We recommend that this option be utilized.
WHY DID THE TURBINE TRIP?

The key remaining question is why exactly did the turbine trip? It has been suggested that the speed indicator is in poor condition. However failure of this device would result in an indicated speed slower than the actual speed and not result in a shut down. Almost without exception every time the turbine has tripped we have found blown fuses or failed electrical devices. It would be very interesting and beneficial to install a recording power quality monitor over an extended period of time to determine the quality of the power in Heat Plant No. 2. This monitoring equipment has been reportedly recently installed and is apparently ready to record the electrical system parameters should another tripping event occur; however, it is our understanding that a programming error apparently prevented this data from being retained during the most recent tripping event.

It should also be noted that Steve Williams with S&C Electrical Co. has speculated that two different situations might contribute to changing the effective slip ratio of the induction electrical turbine generator such that it moved into an unstable region sufficiently to cause a shutdown. The first situation is during an undervoltage condition on the electric grid system into which the induction unit is supplying power. The second situation is when the steam system delivers steam that drops below more typical energy levels (wet steam) too rapidly.

However, it is not at all clear that either of these situations could cause a shutdown. If this were the cause of the shutdowns, it would be expected that this would be more likely to occur during times when the most power is being drawn from the generator; however, multiple shutdowns have occurred during times of relatively low to mid range power draw from the generator. At these times it would be expected that the effective slip ratio is not particularly close to one of the unstable regions.

If authorized, S&C Electric Co. could perform a computer simulation of these conditions and provide a possible answer to these questions. The cost of this computer simulation is $60,000 (not to exceed). See Appendix D for the S&C proposal.

In addition, it has been suggested that it might be easier to mitigate turbine stability problems if the unit utilized permanent magnets instead of self-excitation. This has been investigated and we have determined that a 1 megawatt permanent magnet motor does not exist.

It has also been noted that the HP switch or other sensors may receive their power for operation from the Heat Plant 2 South Vault or another source which is not adequately electrically isolated from the turbine generator. This could cause a possible undesirable electrical feedback loop between the generator and the HP switch or other sensor. This could theoretically cause problems with the turbine generator or associated steam systems to become exacerbated. We recommend identifying the power source for all such sensors and re-circuiting them as necessary from another source such as the Heat Plant 2 North Vault to increase this electrical isolation between sensors and generator.
SCOPE OF WORK SUMMARY

1. What are the causes of not being able to get the Electrical Generator back on line, and resolve in the field (if possible).

   The causes for not being able to get the Turbine Generator (TG) set back on-line after a trip have all been electrical in nature to our knowledge. Electrical failures on equipment serving, monitoring or protecting the TG set; i.e. fuses blown, PT’s burned, etc. have been found after the TG trips. Once the failed equipment was either repaired or replaced, the TG was able to be brought back on-line.

2. If necessary, redraw the Steam One-line, correcting any errors.

   See report Appendix B for One-line Steam Flow Diagram.

3. What timing interrelation exists between the Generator’s Overcurrent Protective Device settings and that of the Steam Pressure Control System. If problems are apparent, resolve in the field, or recommend solutions.

   The mechanical issues with the steam pressure control system are addressed in the report. Their timing relationship with the generator’s overcurrent protective device settings may only be established by the proposed S&C transient stability study.

4. What PRV capacities should be in place for the present 140,000 lb/hr. steam system?

   Existing PRV capacities (mass steam flow) for the 140,000 lb/hr steam system are adequate. The problems being experienced relate to the reaction or response time of the PRV and steam system bypass around the TG set as well as the trip settings on the steam generating equipment. See report for further discussion and recommended solutions.

5. What PRV capacities should be in place for the planned 250,000 lb/hr steam system?

   The PRV needs to be specified for the steam line size required for the appropriate steam flow and the pressure reduction desired. The PRV’s response time, or how quickly it can open to bypass the steam in the event of a trip is the critical aspect to prevent boiler trips as described in item 4 above. See report for further discussion and recommended solutions.

6. Are Items #4&5 compatible? Can they be made compatible, without removing the entire PRV?

   PRV’s are specified by the steam need of the process or processes they serve, not the supply available. A steam flow distribution diagram for the planned 250,000 lb/hr steam system identifying expected steam flows is needed to determine if the existing PRV’s are compatible with the planned system.

7. What PRV set points are recommended for the steam system, present and future?

   See report for PRV and steam bypass recommended solutions.
8. When the Turbine/Generator is offline, is the present system configured to properly process excess steam on the system?

   Yes.

9. Is the Steam Operator’s Manual proper?

   The steam turbine manuals contain the appropriate turbine information. They should be updated to include the information in this report.
APPENDIX A

Copes Vulcan Valve
Description and Principle of Operation

GS-700 Valve assemblies feature a straight-through globe style body design with streamlined precision cast bodies to provide smooth contours and transition areas. The result is minimized flow restriction and maximized capacity. Computer calculated cross sections and wall thicknesses assure high structural integrity while maintaining a very favorable strength-to-weight ratio. The GS-700 Valves are available in .75–8” (20–200mm) sizes as standard, ANSI pressure classes of 125–600, and most standard castable material choices, with either flanged, welded or threaded end connections.

GS-700 Valves can be equipped with an extensive array of standardized trims to meet virtually any general service requirement. A number of high performance trims, such as Raven, HUSH, Tandem, and GAD are also available and can be used to control occurrences of cavitation, flashing or noise. All trims are quick change to assure ease of maintenance. All trims are fully interchangeable between like sizes to ensure maximum flexibility and reduced inventory requirements.

A complete range of 700 series pneumatic diaphragm actuators that can handle supply air pressure as high as 80 psig (550 kPag) provides performance usually associated with much more expensive actuation systems. Copes-Vulcan pneumatic actuators are known worldwide for high performance and reliability.

The design is in accordance with ANSI B16.1, B16.5, B16.11, B16.25, B16.34. Copes-Vulcan also holds the following certifications that can be applied to the GS-Style Globe valve: ASME Section I, ASME Section III ‘N’ & ‘NPT’, 97/23/EC-PED-CE and is also ISO-9001 certified.
APPENDIX B

Steam Flow Diagram
Steam supply (250#) will either be from Progress Energy (primary) or boilers from Rabon Plant (back-up).

70 psig steam to Shands

Rabon Boiler #5
Rabon Boiler #4
PRV #1 (not in use)

70#
250#
250#

PRV #2 (located by generator)

Steann Generator

250 psig Steam Header

250#
250#

PRV #3 (located by operating room)

MDV (motorized operated valve)

Progress Energy

70#
70#
250#
250#

MDV (motorized operated valve)

70#
70#
250#

70#
70#

70#

to campus

University of Florida
Steam Flow Diagram

Drawn by
D. Latulippe
4/17/08

Rem Engineering, Inc.
P.O. Box 1955, Roswell, GA 30077
770/594-9393 Fax: 770/594-9393
APPENDIX C

PRV Control Diagram
APPENDIX D

S&C Proposal
Proposal
to
Campbell Engineering
of
North Florida, Inc.

University of Florida Substation 2,
Heat Plant 2 Induction Generator

Transient Stability Study

S&C Proposal No: BD-2266

April 29, 2008
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## APPENDICES

**SINGLE LINE DIAGRAM**

A

**S&C PRICE SHEET 181**

B
1. **Scope of Work**

S&C Electric is pleased to present this proposal for consulting and analytical services to Campbell Electric for work to be performed for the University of Florida in Gainesville, FL.

S&C Electric will perform a transient stability study to include the University of Florida Steam Plant 2 Induction Generator.

The electrical boundaries of this study are limited to the generator at heat plant 2 to the Progress Energy 33.6 MVA 69/23-kV Transformer No. 2. This electrical boundary is identified on the single line diagram of Appendix A.

**A. General**

Since this is part of an investigative effort to determine the cause of the numerous trip events experienced by the generator, the scope of work is not rigidly defined. It is expected that the following activities will comprise the study scope of work:

1. Gather the equipment details necessary to develop a transient stability model of the steam turbine induction generator, its associated controls, and the nearby electrical system equipment that may be deemed to have an operational impact on the subject generator.

2. Develop the electromechanical system model in the time-based simulation software EMTDC/PSCAD and verify the system model against existing event recordings, if those recordings exist.

3. Using the verified system model, evaluate the performance of the system for electrical plant and steam plant disturbances.

4. If the disturbance response indicates a lack of adequate transient stability margin, identify corrective measures that may be appropriate for the steam generator system. Evaluate these corrective measures using the transient stability system model.

**B. Technical Considerations Supporting the Study**

Typically, transient stability studies are associated with large generators on the interconnected electric grid. It is less common for a small generator, especially an induction machine, to require such analysis when connected to a much larger system. However, there are several facets to the
behavior of this particular machine in operation on this particular system that support the need for a detailed transient stability analysis. Among these are:

1. The machine can be operated in a smooth, stable fashion for an extended period, but upsets in the system – steam and/or electrical – result in turbine tripping on over speed. Turbine tripping due to over speed is a serious event since it points to a lack of control responsiveness. As such, this event always merits investigation.

2. An induction machine introduces an interaction between real and reactive electric power that is not characteristic of a synchronous machine. Upon replacing the original synchronous machine with a newer induction machine, the dynamics of the nearby electrical system must be evaluated for stable operation.

3. Also associated with the induction machine retrofit, the mechanical inertia of the turbine generator system has been altered, which will have a corresponding impact on its transient stability.

C. Site-Visits

A site visit will be conducted to collect the necessary data for the analysis and to examine the generator electrical system.

D. Report

S&C will provide to Campbell Engineering one bound copy of the written report and one CD having the findings and recommendations of this study.

2. Data Requirements

Campbell Engineering shall provide any additional equipment data, generator data transformer nameplate, breaker, fuse, feeder information, etc. not previously supplied by the University of Florida.

3. Professional Engineer License

The proposed engineering study will be reviewed by a professional engineer licensed in the State of Florida.
4. **Pricing**

The Transient Stability Analysis will be billed on a Time and Material basis at a rate of $195 per hour, not to exceed $60,000.00.

Travel expenses will be billed at cost plus 10%. Travel time and time on site will be billed at normal time rates.

5. **Schedule**

The system studies can be completed within ten (10) weeks of receiving your official order and all additional information required to perform the studies. Any delays in receipt of required information will impact the schedule for completion of the work.

6. **Terms of Payment**

S&C Electric Company will invoice 100% at the end of the project. Net 30 days after receipt of the invoice.

7. **Terms and Conditions**

This proposal is firm and valid for 90 days, and in accordance with S&C general terms and conditions of sales (S&C Price Sheet 181).

Customer agrees that it shall not solicit for employment with Customer (or with any other party) any S&C employee with whom Customer has had contact in connection with this Agreement, both during the term of this Agreement and for twelve (12) months following termination of this Agreement.
8. **Purchase Order Information**

Please include the S&C reference number of this proposal, BD-2266 on your purchase order. A purchase order may be sent to:

S&C Electric Company  
6601 N. Ridge Blvd.  
Chicago, Illinois 60626-3904  
Attn: Al Stevens  
astevens@sandc.com

With an additional copy sent to Robert Morrison at:  
rmorrison@sandc.com

9. **Qualifications**

The electrical system protective device studies and analysis work will be performed by qualified Engineers in the Power Systems Services Division at S&C Electric Company's offices in Chicago, Illinois. S&C Electric Company has worked together with Power User customers throughout the world on various projects associated with utility, industrial, and commercial electrical power distribution systems. The extensive knowledge gained by S&C through these projects uniquely positions S&C to provide detailed electrical equipment recommendations and system analysis. Further, S&C has over the course of 90 years, provided a solid level of innovation in the design, manufacture, and application of electrical equipment for utility, industrial, and commercial electrical power distribution systems. This experience also provides S&C with an intimate understanding of the needs of power users. S&C’s products are recognized industry-wide for exceptional quality and unsurpassed technical support. The extensive knowledge possessed by S&C’s engineers in this highly specialized field allows unparalleled expertise in dealing with the nuances associated with such issues as transformer protection, cable protection, power fuse application factors; short-circuit interruption, protective device coordination in addition to arc-flash studies. Engineers that perform our studies have extensive experience in the design and applications of arc-flash resistant gear in addition to standard product offerings.

10. **Additional Work**

Any additional work required to be performed and which is not included in the proposed scope of work, will require definitions and submittal of a proposal by S&C Electric Company of all known costs for approval.
Appendix A

SINGLE LINE DIAGRAM
Simplified One-Line – UF Generator near Heat Plant 2 South Vault and upstream devices
June 8, 2007 -- “Normal” Configuration according to UF One-Line “e” drawings

Drawing Not to Scale

PE XFRMR 2
33.6 MVA
69/23 kV

PE Brkr # 1232

A-956_UF5

A-957_UF4

MH-300 (MH-3C4-1)

MH-250

MH-305

SUB_2_TX_1
6175 kVA
23/4.16 kV

SUB_2_TX_2
6175 kVA
23/4.16 kV

MAIN 1
($801421)

MAIN 2
($672955)

TIE 1
(346739)

TIE Switch
OPEN

Brkr_S2-F7

Brkr_S2-F1

S2_SWITCH-HOUSE_SW3

(916829)
Way 1

(388731)
Way 2

(663379)
Way 3

Oil Fuse Cutout 4
($798131)

Oil Fuse Cutout 5
($535540)

G
Crompton Relay

South Vault Xfmr # 1
(0473_HEAT_PLT2_S_XFMRAT)

South Vault Xfmr # 2
(0473_HEAT_PLT2_S_XFMRB)

UF4 Tripped

Point of Fault

(151770)
SW_HSE(494)_T1_FDR7

(674421)
SW_HSE(494)_SW#2
BUS1_FDR1
APPENDIX B

S&C PRICE SHEET 181
1. PURPOSE AND SCOPE: These S&C Electric Company ("S&C") standard terms and conditions together with S&C's Acknowledgment or Agreement and any supplements or modifications confirmed in writing by an S&C Authorized Executive (S&C's chairman of the board, president, vice president of any rank, or any other executive expressly designated by S&C) shall constitute a service order ("Service Order") and shall constitute the complete and exclusive statement of S&C's terms and conditions applicable to all services by S&C for the customer ("Customer").

2. DESIGNATED SERVICES: The services to be performed by S&C (the "Designated Services") are set forth in S&C's Service Order, as modified or supplemented from time to time by Customer and S&C in accordance with paragraph 9.

3. WORKING CONDITIONS:
   a. Customer shall designate at least one authorized person ("Customer's Representative") who shall represent Customer in all matters related to Designated Services. For performance of services at Customer's jobsite, Customer's Representative shall be present at the jobsite at all times when Designated Services are being performed and shall observe the performance of Designated Services. In performing Designated Services, S&C personnel may rely on decisions made by Customer's Representative regarding the Designated Services and on any change orders, additions, deletions, or other modifications or supplements to the Designated Services approved by Customer's Representative. In addition, S&C personnel may follow the instructions or recommendations of Customer's Representative, and to the fullest extent permitted by applicable law, Customer shall indemnify, defend, and hold harmless S&C and its personnel from all liability and damages whatsoever suffered or incurred as a result of following such instructions or recommendations (other than liability and damages which result from the sole negligence of S&C or its personnel).
   b. Customer shall provide S&C with safe, unrestricted access to the jobsite as necessary or appropriate for the performance of the Designated Services, free of material interference, hazard, and debris. S&C personnel shall have no obligation to perform services under conditions which they determine create material risk of personal injury or property damage. Customer shall make available to S&C all records, drawings, maps, and other documents in its possession or to which it has access regarding the equipment, machinery, and other facilities on or in connection with which the Designated Services are to be performed (the "Subject Facilities"). At Customer's expense, Customer shall obtain and cause to be provided all necessary or appropriate utility outages, voltage testing, tagging, lockout, application of grounds, and other jobsite preparation to secure the jobsite and shall provide all necessary or appropriate jobsite lighting and power. If S&C personnel believe that Customer has not adequately prepared the jobsite as required for the performance of the Designated Services, or if requested by Customer, S&C personnel may, at their option, undertake and perform all necessary or appropriate jobsite preparation incidental to the performance of Designated Services, and Customer shall pay additional charges for such work in accordance with S&C's applicable rates.

4. CUSTOMER'S RULES AND PROCEDURES: S&C personnel shall use reasonable efforts to comply with Customer's applicable rules and procedures relating to the performance of the Designated Services, provided that such rules and procedures have been approved in advance by an S&C Authorized Executive. S&C shall have no liability for delays resulting from any such rules or procedures (including without limitation labor policies), and Customer shall pay additional charges in regard to such rules and procedures in accordance with S&C's applicable rates.

5. INSURANCE: In providing services hereunder, S&C is an independent contractor and not the employee or agent of the Customer. S&C shall maintain Workers' Compensation Insurance as required by law and Employer's Liability Insurance of at least $1,000,000. In addition, S&C will maintain Automobile Liability and Comprehensive General Liability (including contractual liability) Insurance in an amount not less than $10,000,000 subject to such deductibles or retentions as S&C may, from time to time, consider appropriate. It shall be Customer's responsibility to maintain appropriate property, casualty, liability, and workers' compensation insurance in such amounts as may be reasonable and customary in the industry. Notwithstanding any other provision of these standard terms and conditions, S&C shall bear no risk for failure of Customer to do so.

6. PERFORMANCE STANDARDS:
   a. In performing the Designated Services, S&C and its employees shall in all material respects act in accordance with and exercise the degree of skill and care required by customarily accepted industry practices and procedures (the "Performance Standards").
   b. In performing the Designated Services, S&C may rely without independent verification on information supplied by Customer, Customer's Representative, or Customer's consultants or other contractors and on information available from generally accepted reputable sources.
   c. All parts or materials furnished by S&C in connection with the Designated Services shall be considered to have been sold under the terms and conditions of S&C Standard Conditions of Sale—Domestic (Price Sheet 150) and shall be subject in all respects thereto.

7. WARRANTY AND EXTENT OF LIABILITY:
   a. For a period of one year after performance of the Designated Services, S&C shall, if promptly notified in writing by Customer, reperform the Designated Services (or relevant portion thereof) to the extent that S&C did not meet the Performance Standards or otherwise misperformed or failed to perform any of the Designated Services. This remedy shall constitute Customer's exclusive remedy, and S&C's reperformance of such Designated Services shall fulfill S&C's entire liability. In no event shall S&C's liability exceed the cost of reperforming the Designated Services. These provisions shall apply without regard to fault or negligence, and in all respects, to the fullest extent permitted by law.
   b. S&C and its personnel shall not be liable, in contract, tort, or otherwise (including for negligence, breach of warranty, indemnity, and strict liability) for any special, indirect, or consequential damages, whether for personal injury or property damage, including specifically but without limitation, loss of profits or revenue, loss of full or partial use of any equipment or facility, down-time costs, business interruption, any claim arising out of loss of electrical power, cost of capital, loss of goodwill, claims of third parties, costs associated with the removal of equipment from service or reinstallation or disassembly or reassembly, or similar damages, arising out of or resulting from this Service Order or the performance or nonperformance or misperformance of the Designated Services.

These Standard Terms and Conditions apply to all services performed for delivery in the U.S.A. For services performed for, or delivered to, customers outside the U.S.A., International Rider (See Price Sheet 182) is applicable and supplements these Standard Terms and Conditions.
8. BILLING AND TERMS OF PAYMENT: S&C shall be compensated for Designated Services in accordance with S&C’s applicable rates. S&C’s invoices shall be rendered as services are performed and are due and payable upon receipt. S&C shall have and be entitled to all mechanic’s, materialmen’s, and other liens available to it under applicable law (including, for purposes of this provision, the law of the jurisdiction where the Designated Services are to be performed) as security for the payment of all amounts due hereunder. If in the judgment of S&C, the credit status of Customer at any time does not justify the continuation of services on the terms previously agreed upon, S&C may require revision of payment terms to its satisfaction and shall be entitled to cancel or defer any orders or scheduled service dates then outstanding, without obligation by S&C with respect to unperformed or uncompleted services. Any sales, use, service, or other similar taxes which S&C is authorized or required to collect in respect of the Designated Services shall be added to the invoice as a separate item.

9. MODIFICATION OR CANCELLATION: Designated Services and scheduled service dates may be modified or cancelled only by agreement of Customer’s Representative and S&C’s designated representative.

10. SCHEDULED DATES AND FORCE MAJEURE: S&C shall make all reasonable effort to meet scheduled service dates. However, scheduled service dates and completion of work are based upon prompt receipt of all necessary information and approvals from Customer, and access (as required) to Customer’s jobsite and the Subject Facilities. S&C is not liable for failure to perform or for delay in performance due to causes beyond its reasonable control such as, but not limited to: acts of God, acts of Customer, acts of civil or military authority, priorities, fires, strikes, labor issues or difficulties, floods, earthquakes, weather, epidemics, quarantine restrictions, war, riot, delays in transportation, government restrictions or embargoes, compliance with Customer’s rules and procedures, failure of Customer to obtain any necessary permits, difficulties in obtaining necessary materials or services from usual sources, or lack of access to Customer’s jobsite or to the Subject Facilities. In the event of delay in performance due to any such causes, the date for the provision or completion of services shall be extended by a period of time reasonably necessary to overcome the effect of such delay, and S&C’s compensation hereunder shall be adjusted in accordance with S&C’s applicable rate schedules.

11. NUCLEAR APPLICATION: In the event that this Service Order relates to services performed or to be performed on or in connection with any nuclear installation or activity, neither S&C nor its personnel shall have any liability for any business interruption claims or for nuclear damage, injury or contamination to any person or property whether located at the site or elsewhere, and to the fullest extent permitted by law, Customer hereby agrees to indemnify, defend, and hold harmless S&C and its personnel against any such liability (whether or not arising from their own negligence).

12. GENERAL: S&C reserves the right to correct clerical errors or omissions in quotations, acknowledgments, invoices, or other documents. All drawings, plans, specifications, computer data, and other similar materials generated by S&C in performing the Designated Services shall remain the property of S&C. If any term, condition, or provision of this Service Order is declared void or unenforceable, or limited in its application or effect, such term or provision shall be deemed stricken and the remaining provisions of this Service Order shall remain in full force and effect. This Service Order contains the entire agreement between the parties as to the Designated Services and the obligations and liabilities of S&C and Customer with respect thereto. This Service Order may not be assigned by Customer without the prior written consent of S&C. All previous or contemporaneous agreements, representations, warranties, promises, and conditions relating to the subject matter of this Service Order are superseded by this Service Order. This Service Order, whether or not based upon specific quotations, is subject to acceptance by S&C at its general offices in Chicago, Illinois.

13. GOVERNING LAW: The law of Illinois shall govern.

① These Standard Terms and Conditions apply to all services performed for delivery in the U.S.A. For services performed for, or delivered to, customers outside the U.S.A., International Rider (See Price Sheet 182) is applicable and supplements these Standard Terms and Conditions.
APPENDIX E

95% Review Comments & Responses
# DESIGN PROGRESS REVIEW & RESPONSE

by

University of Florida
Physical Plant Division
Architecture/Engineering Department

<table>
<thead>
<tr>
<th>Project Number:</th>
<th>1065564</th>
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<tbody>
<tr>
<td>Project Title:</td>
<td>HP# 2/Rabon Plant; Steam Pressure Controls Issues</td>
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<tr>
<td>Review Purpose:</td>
<td>95%</td>
</tr>
<tr>
<td>Date:</td>
<td>May 19, 2008</td>
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<tr>
<td>Project Consultant:</td>
<td>Campbell Engineering</td>
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<tr>
<td>Response by A/E Due:</td>
<td>May 29, 2008</td>
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**PPD Comments**

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<td><strong>Page 6</strong> Acknowledged</td>
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**Progress Energy**

(W. Hicks/J. Peet)

Option 3: The pressure switch settings are already set at the highest settings possible to meet boiler protection requirements. So, no further adjustments can be made.

| Option 4: No time delays are allowed for NFPA required interlocks for safety shutdown. This option cannot be done. | Page 6 **Not familiar with NFPA requirement referenced. Recommend checking with FM (Factory Mutual) or Hartford requirements as to conflict.** Acknowledged – as recommended in the report. |

The control and mechanical elements in the loop must be fast acting and anticipatory on sensing the steam turbine trip, and not wait for resulting pressure rise on the header to act. The steam controls should incorporate:

- Fast acting (2 sec stroke or less) steam pressure reducing valves.
- “Valve Prepositioning” control logic (usually 3-5 sec pulse directly initiated from the steam turbine trip signal that drives the steam PRV to a preset open amount, before release back to pressure control).
- A controller header “sky vent” (second line of defense) that opens before the boilers trip or safeties lift to limit the header pressure should the primary PRV control loop not function quickly enough during the
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<td>The turbine trip issues were not adequately addressed. There was no resolution for electrical issues leading to the trips. Thorough root cause analysis should be done by a contractor independent from the induction motor design contractor.</td>
<td>Page 8</td>
<td>Acknowledged. Electrical system evaluation was not included in the scope of this project. The proposed S&amp;C study would add insight to these questions.</td>
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## DESIGN PROGRESS REVIEW & RESPONSE

by

University of Florida  
Physical Plant Division  
Architecture/Engineering Department

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<tr>
<td><strong>PPD Architectural/Engineering Department</strong> – (MR) Last sentence…<strong>this was not the case.</strong> “This” is a vague pronoun reference to a prior sentence. Please clarify. “Was not the case” or “is not the case”? The issue is important, please clarify. Was not the case implies something happened which was unexpected. Is not the case implies things worked as planned, something else may have happened.</td>
<td>95% Report, Sh. 2</td>
<td>Clarified in final report</td>
</tr>
<tr>
<td>Could a problem in the oiling system or the Cam itself cause other system problems which we are worried about? My discussions with the maintenance personnel have indicated occasional unusual noises.</td>
<td>Sh 3, para 2 – Oil/Cam</td>
<td>No – not in our opinion. The turbine steam inlet valves are controlled off of the oil system pressure. Water or condensate in the oil would not affect the system pressure.</td>
</tr>
<tr>
<td>Copes Vulcan Pressure Control Valves are pneumatically controlled. Are the pneumatics backed up by battery power, or receive power separate from the S Vault Substation? The S Vault can put out a poor power signature during Steam System disturbance.</td>
<td>Sh. 3, para 3 &amp; para 4</td>
<td>The pneumatics are not backed up by battery power to our knowledge. The valve only has pneumatic and mechanical (spring) control, no electrical. The only control signal to the valve is air pressure. The only way a poor power signature would be evident at the valve is if the air compressor that provided the pressurized air to the valve went off-line and enough pressure was not available for control.</td>
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<td>Sh. 3, para 5</td>
<td>Electrical system evaluation was not included in the scope of this project and therefore a more detailed analysis is not possible. If electrical system and/or generator data is available from the time of the boiler trip, a more detailed analysis may be able to be performed. The proposed S&amp;C study would add insight to these questions.</td>
</tr>
<tr>
<td>In this paragraph it may be appropriate to cite a more detailed analysis if possible correlating the electrical and mechanical timing interrelationships for a complete stability analysis. A caveat could also be mentioned here referencing the reader to Option 4, page 6 and para 2 and 3, page 7</td>
<td>Sh. 4, sentence</td>
<td>Acknowledged</td>
</tr>
<tr>
<td>Then the Consultant is saying in this last sentence that a spike in the high pressure system caused by the sudden closing of the turbine trip valve probably caused the boiler trip, with subsequent campus steam problems?</td>
<td></td>
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<td>Do we know if we have a superheater equipped boiler? Either way, the discussion is ok, but the Consultant should mention which type UF has.</td>
<td>Sh. 5, para 1&amp;2</td>
<td>No, we are not sure if the existing boiler has a superheater. The discussion was general to cover either case. Yes, the boiler is equipped with a working HP switch, which is electrical in nature. A brief discussion of these issues has been added to the report conclusions.</td>
</tr>
<tr>
<td>Mention is made that most boilers are equipped with a HP Switch to trip the boiler in the event of overpressure. Do we have one? Is it working? Is it electrical in nature? If electrical, is it fed out of the South Vault? If fed out of the South Vault, the vault and produce poor power during system disturbances, moments prior to trip out. What does the switch do or does not do if feed poor quality power? If nothing, ok. But if something does not work properly, then is the overall interaction between the electrical and mechanical systems a problem? Similarly, is the Boiler Management System on the S Vault?</td>
<td>Sh. 5, para 4 – First Out Feature</td>
<td>The First Out feature should be incorporated into the UF data acquisition and management system. We would not recommend a separate, stand alone system that would need to be integrated into your existing system. Please refer to UF for costs.</td>
</tr>
<tr>
<td>What is the cost for a suitable First Out feature for our 2 boilers?</td>
<td></td>
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<tr>
<td>What can we do to mitigate the spike or</td>
<td></td>
<td>Please see report, Sh. 6</td>
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### PPD Comments

**Reference Spec.**

**A/E Response**

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<td>minimize the reaction time? Are these questions addressed in the report?</td>
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<tr>
<td>What are the approximate costs for each option?</td>
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<tr>
<td>In the past I have seen the Governor Report - All Speed Probes Failed, when in reality there were very small particle iron filings on the magnetic pickups. I have always assumed the filings were from the Turbine, but couldn’t they be from anywhere in the turbine system, including the Cams or even the Speed Sensing mechanism itself, wobbling?</td>
</tr>
<tr>
<td>Further we installed such a recording meter during the installation of the generator, as a hindsight item. Unfortunately when the trip occurred, all memory was lost. That is not supposed to happen. We will need to discuss with Byram Labs the available time period settings for length of recording such information.</td>
</tr>
<tr>
<td>In the examples you might mention the speed sensing problems too….probes ok, but with iron filings on magnets, shorting them out to ground.</td>
</tr>
<tr>
<td>For all timing issues to be addressed (mechanical and electrical in nature, a full blown Stability study would be needed - $60k.) Your team appears to recommend minor fixes such as Option 4 time delay in the pressure switch and (not clearly stated) fixes to the electrical system for an equivalent amount of money with improved system total performance, first.</td>
</tr>
<tr>
<td>You would appear to be recommending that the Consultant performing the proposed Boiler Upgrade Project (RMF) address changes to the PRV Capacities as they change in future design projects BASED upon Future Load Flow. If correct, if changes do not occur in the load flow, no changes may be required just because there</td>
</tr>
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**Sh. 6, Options 1-4**  
Added to final report

**Sh. 7, para 1 – Speed Control**  
Acknowledged. In our opinion, the small amount of filings are not contributing to the cause of the turbine trip problems. As already recommended though, the speed sensor should be repaired or replaced.  
Acknowledged. Data recorded from any trip incident would greatly help in determining the trip causes.

**Sh 8, Item 1**  
Added in final report

**Sh. 8, Items 3 & 4**  
We only recommend the minor, less inexpensive fixes as a stop gap measure to prevent turbine and boiler trip conditions until a proper, full blown study can be completed.

**Sh. 8, Items 5 & 6**  
Correct.
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<td>Sh. 9, Item 9</td>
<td>Not to our knowledge. A manual has not been provided for our review.</td>
</tr>
<tr>
<td>Sh. 13, Steam One Line</td>
<td>No. The MOV operates on the 70 psig steam header from PE, not the 250 psig header serving the turbine generator.</td>
</tr>
<tr>
<td>Sh. 24, Electrical One Line</td>
<td>This one-line drawing was a part of S&amp;C’s proposal to study the electrical system and was not prepared by CENF. This electrical fault is believed to be associated with a previous trip.</td>
</tr>
</tbody>
</table>

**PPD Operations Engineering – No comment.**

**PPD Systems**

(RG/RM) Process with option #4 (page 6).

At this time, do not proceed with S&C Proposal No. BD-2266.

**PPD Energy – No comment.**

**PPD Facilities – No comment.**

**PPD Grounds – No comment.**

**PPD Building Services – No response.**

**PPD Operations Analysis – No response.**

**OIT Telecommunications – No comment.**