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AUTH.NAME AUTHOR AFFILIATION
HAMPTON,J.W. Duke Power Co.
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SUBJECT: Forwards response to NRC questions re effects of emergency power overfrequency on Units 1,2 & 3.

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Duke Power Company
Oconee Nuclear Site
P.O. Box 1439
Seneca, SC 29679

J. W. HAMPTON
Vice President
(803)885-3499 Office
(803)885-3564 Fax

DUKE POWER

January 4, 1995

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

Subject: Oconee Nuclear Station
Docket Nos. 50-269, -270, -287
Response to NRC questions on Technical Specification 4.6 Revision

In a letter dated December 19, 1994, the NRC requested additional information regarding the effects of emergency power overfrequency on Oconee Units 1, 2, and 3. This request is part of the review of a proposed modification which will address potential overfrequency scenarios. The modification is being reviewed by the staff as part of the review of the Technical Specification Section 4.6 amendment submitted on February 24, 1994. The written response to the NRC's questions is attached to this letter. If you have any additional questions, please contact Michael Bailey at (803) 885-4390.

Very truly yours,

J. W. Hampton

cc: Mr. S. D. Ebneter, Regional Administrator
U. S. Nuclear Regulatory Commission, Region II

Mr. L. A. Wiens, Project Manager
Office of Nuclear Reactor Regulation

Mr. P. E. Harmon
Senior Resident Inspector
Oconee Nuclear Site

A001

REQUEST FOR INFORMATION
OCONEE NUCLEAR STATION - UNITS 1, 2, AND 3
KEOWEE OVERSPEED CONDITION FOLLOWING A LOAD REJECTION

Question - Please provide a detailed discussion of the effect of frequency and voltage of the electrical power supplied by Keowee to safety-related motors (e.g., ECCS motors) and protective relays during an overspeed/overfrequency scenario as described in LER 268/93-01, Revision 1. The discussion should describe the exact sequence of events during a postulated overspeed/overfrequency scenario and discuss acceptable voltage and frequency ranges for the power supplied by the Keowee units which ensure ESF systems will function as intended. In your response, please discuss any administrative controls or limits regarding the normal mode operation of the Keowee units needed to ensure the time requirements contained in applicable accident analyses are met. This discussion of a postulated overspeed/overfrequency scenario should include and make reference to any pertinent calculation, analyses, and/or evaluations performed to support your assumptions and conclusions.

Please provide frequency and voltage plots vs. time for the power supplied by the Keowee units during a postulated overspeed/overfrequency scenario and any sensitivity studies conducted to show how frequency and voltage change with different lake levels or different power output levels of the Keowee units. Also, please provide any calculations performed to determine maximum and minimum lake levels for Keowee normal mode operations and the maximum Keowee power output levels permitted at these lake levels to ensure the time requirements contained in applicable accident analyses are met.

Response - The attached response provides the requested information. In the cases where a calculation is referenced, pertinent pages of the calculation have been furnished for your review. If the entire calculation is needed to complete the staff's review, then a complete copy will be furnished upon your request.

The effects of frequency and voltage on the safety related motors can best be described through describing the sequence of events. The events during a postulated load rejection scenario mentioned in LER 269/93-01, Revision 1 are described below.

If generating to the system grid at the time of an Oconee design basis event, the Keowee Hydro units will load reject and experience a speed transient. The Unit's excitation system and controls are such that each machine remains excited and voltage is kept relatively constant at its rated output level during this speed transient. When considering induction motor characteristics, torque (starting and maximum running) is proportional to the inverse of frequency squared ($T = 1/(f)^2$).

The scenario assumes that both Keowee Hydro (KH) units are generating to the system grid (above 75MW) when a design basis event occurs with a loss of offsite power (LOOP). Upon receipt of the emergency start (ES) signal, both KH units will separate themselves from the system grid thus rejecting their load and consequently overspeeding. The present KH control scheme allows the overhead path to be re-energized (following switchyard isolate) by the KH unit connected to the overhead path following a time delay (6.5 seconds for the KH unit 1 or 4.0 seconds for KH unit 2). At the end of this time delay, the KH units will still be overspeeding which results in above normal frequency output. The effect of above normal frequency is that the start-up source undervoltage relays (Westinghouse, CV-7 induction disc type) will not reset (ie. rotate) prior to the emergency power switching logic (EPSL) seeking the underground path as the source for an Oconee Loss of Coolant Accident (LOCA) unit (t=11 seconds) [Reference 1].

The KH unit connected to the underground path experiences the same speed transient (load rejection) as the KH unit connected to the overhead path. When loaded, the frequency output of the underground unit yields a lower starting torque ($T = 1/(f)^2$) to the 4kV safety related motors. Therefore, certain 4kV safety related loads would require a longer time to accelerate and could trip on overcurrent [Reference 2].

Secondly, if the initial power level of the KH units exceeded 75MW, with a low delta head, and the underground path is assumed to fail, conditions exist such that the time allowed to energize the Oconee main feeder buses could not be met [Reference 1]. The sequence of events for this scenario is as follows.

Upon receipt of the emergency start (ES) signal, both KH units will separate themselves from the system grid thus rejecting their load and consequently overspeeding. The present KH control scheme allows the overhead path to be re-energized (following switchyard isolated) by the KH unit connected to the overhead path following a time delay. At the end of this time delay, the KH units will still be overspeeding which results in above normal frequency output. As described above, the effect of above normal frequency is that the start-up source undervoltage relays will not reset prior to the EPSL seeking the underground path as the source for an Oconee LOCA unit (t=11 seconds). Assuming the underground path has failed and is unavailable, the EPSL will re-transfer the Oconee LOCA unit back to the startup transformer to receive power via the Keowee overhead path. The re-transfer time delay actuation begins once voltage is established on the startup transformer (ie. start-up source undervoltage relays reset). For the scenario of 90MW generation with 113' delta head, the time to reset the undervoltage relays is 24.2 seconds [Reference 3]. Therefore, 24.2 seconds along with the re-transfer to startup time delay of ten (10) seconds would have the Oconee LOCA loads being energized after thirty-three (33) seconds. After including the 15 second valve stroke time, the committed time of forty-eight (48) seconds to obtain ECCS injection would be slightly exceeded.

The above described concerns are resolved by preventing the KH units from energizing their respective paths until frequency approaches its nominal level. This ensures that the effects of frequency will not prevent the safety loads from performing their intended safety functions. Modification ON-52966 adds the controls necessary to prohibit the Keowee generator breakers from closing until frequency has decreased below 110%.

Attachments 1 and 2 further explain and support the above information. Attachment 1 shows the expected reactor building spray motor starting curve during the over frequency period and the over current device actuation [Reference 2]. Attachment 2 shows frequency and voltage plots vs. time for a Keowee unit during a load rejection scenario [Reference 4].

Administrative controls for power operation to the Duke system grid are required for the operation of Keowee. These administrative restrictions, currently found in the Keowee Modes of Operation procedure, are designed to ensure that Keowee will be at an acceptable frequency range following the initiation of an ES signal. An acceptable frequency which was evaluated in Calculation OSC-5701 Oconee-Keowee Overhead Path Analysis was found to be 110% overspeed. Following a load rejection from the Duke grid caused by an Oconee ES signal, the Keowee units will experience an overspeed until the governors can return the units to rated speed (128.6 RPM). Modifications at Keowee were designed to return the units to an acceptable frequency range within 22 seconds. The reaction of Keowee to these types of load rejections was evaluated in Calculation KC UNIT 1-2-0106, Keowee Power Operating Restrictions for NSM 52966.

The severity of load rejections at Keowee are dependent on three main variables:

* The initial power level has the greatest influence on load rejection overspeed. The greater the initial power level, the greater the wicket gate opening. This means that the

gates have further to travel and takes more time to reach the new position required for the emergency loads. Thus, the magnitude and duration of the overspeed is directly related to the initial power level.

* Headwater and tailwater elevations affect the operation of the unit by changing the head on the machine. The greater the head, the greater the energy content of the water. This requires less wicket gate opening to achieve the same power output. The lower the gate opening the less severe the overspeed. Therefore, the higher the head the faster the unit is returned to control.

* The third variable is the number of Keowee units in operation at the initiation of the event. Since both Keowee units share a portion of their penstocks, the friction losses for this portion of the penstock is increased for two unit operation. In addition, the pressure transient effects in the penstock are different for two unit operation. The net effect is that the magnitude and duration of the overspeed is greater for two unit operation.

These variables were evaluated in KC UNIT 1-2-0106. This calculation evaluates these variables through a bench-marked computer model developed by Voith Hydro Inc. Model runs were made for single and double unit operation and for various initial power levels. Gross head (headwater elev. minus tailwater elev.) was varied until a point was found where the unit speeds were at or below 110% speed at 22 seconds. Attachment 3 shows the load rejection curve for a single unit 88 MW load rejection for a gross head of 125.6 feet. The calculation adds a 2 second penalty to these curves. From Attachment 3 it can be seen that the unit speed is at 141.5 RPM (110% speed)and decreasing at 22 seconds.

If a plot of tailwater elevation versus headwater elevation is made, a line of constant gross head (125.6 feet) can be drawn (Attachment 4). If the unit is operated with a gross head greater than 125.6 feet (below the line), then the unit will respond with a less severe load rejection and will be below 110% speed in less than 22 seconds. If the unit is operated with a smaller gross head, then the load rejection will be more severe. Therefore, the region below and to the right of the line is identified as the acceptable operating region.

Curves like Attachment 4 were generated for each anticipated power and operating unit combination by calculation KC UNIT 1-2-0106. The Operating Restrictions enclosure in the Keowee Modes of Operation procedure will be revised to include this information.

References:

1. OSC-5701 Case 1H, 1L, 2H, 2L, & Appendix I.
2. OSC-5701 Case 3L.
3. OSC-5701 Case 1H.
4. OSC-5701 Case 6L, 7L.

ATTACHMENT 1

Reactor Building Spray Pump Motor

Starting Current vs Time Plot

The following plot (Figure J2) originated from OSC-5701, "OCONEE/KEOWEE OVERHEAD PATH ANALYSIS", Case 3L. This case was simulated for the scenario where the LOCA unit would be to the underground path 11 seconds following the event. The overhead path circuit was used to simulate this case because the underground circuit was not yet created (in the CYME model) and the results from the overhead circuit should be a good indicator as how the underground Unit would perform. At 11 seconds following a 75MW load rejection with a net head of 113', the frequency of the underground unit would be the same as the overhead unit. As a result some of the safety motors are expected to trip on overcurrent. The following plot (figure J2 in Appendix J) shows the starting current and time for the RBS pump motor, 5.08 pu for 370 cy. Based on the overcurrent relay setting also provided, this motor is expected to trip. Therefore, this case is not acceptable.

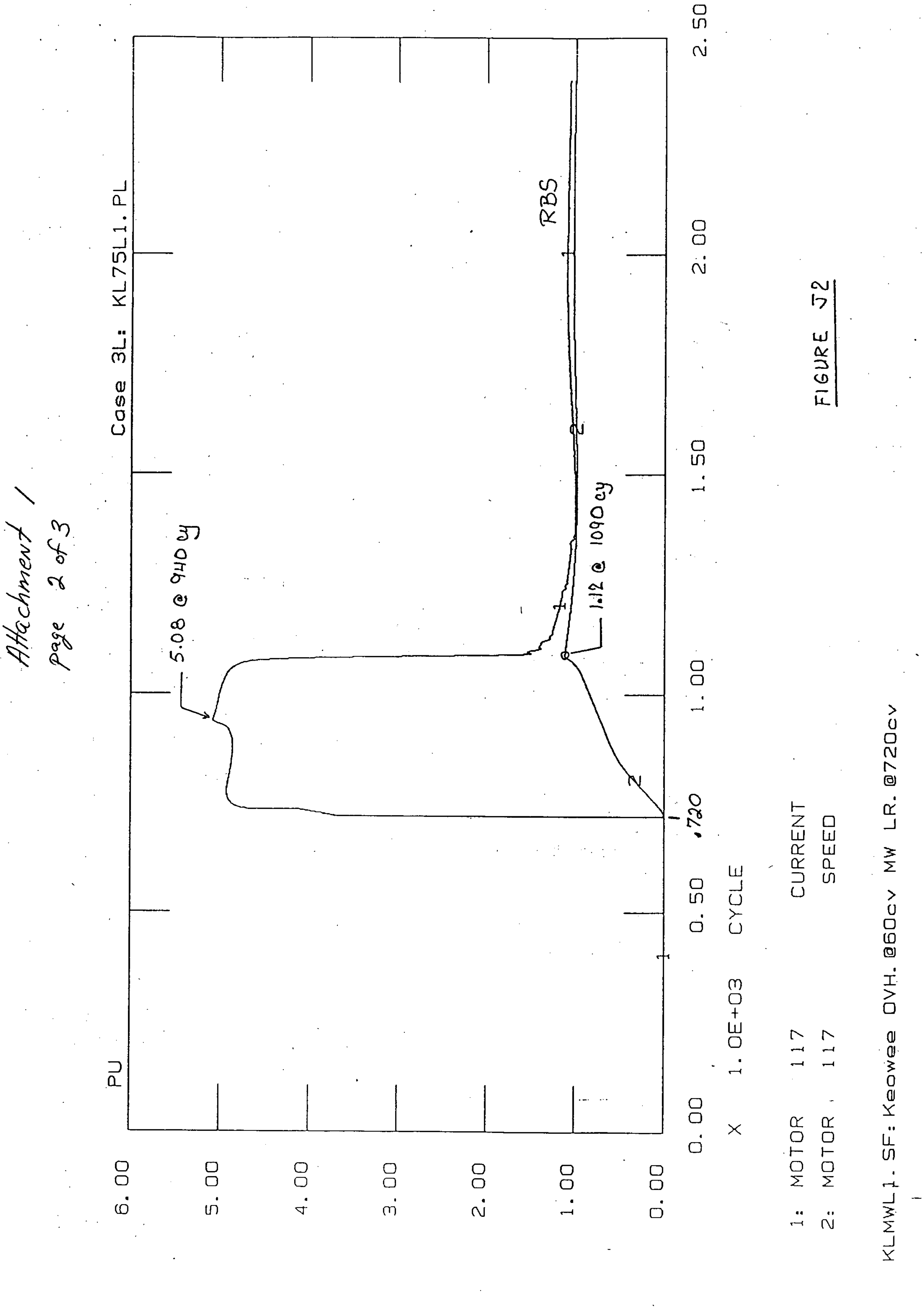

Attachment 1
page 2 of 3
Case 3L: KL75L1.PL
PU
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
0.50
1.00
1.50
2.00
2.50
X 1.0E+03 CYCLE
5.08 @ 940 cy
1.12 @ 1090 cy
.720
RBS
1: MOTOR 117 CURRENT
2: MOTOR 117 SPEED
KLMWL1.SF: Keowee OVH. @60cv MW LR. @720cv

FIGURE J2

000026

RBS

CT_R = 15
TAP = 4A
4.6s @ 200%
I_{inst} = 25
IRC = 175.31A _1.86s
I_L = 30.77a

30.81
$I_r \simeq$ 40A

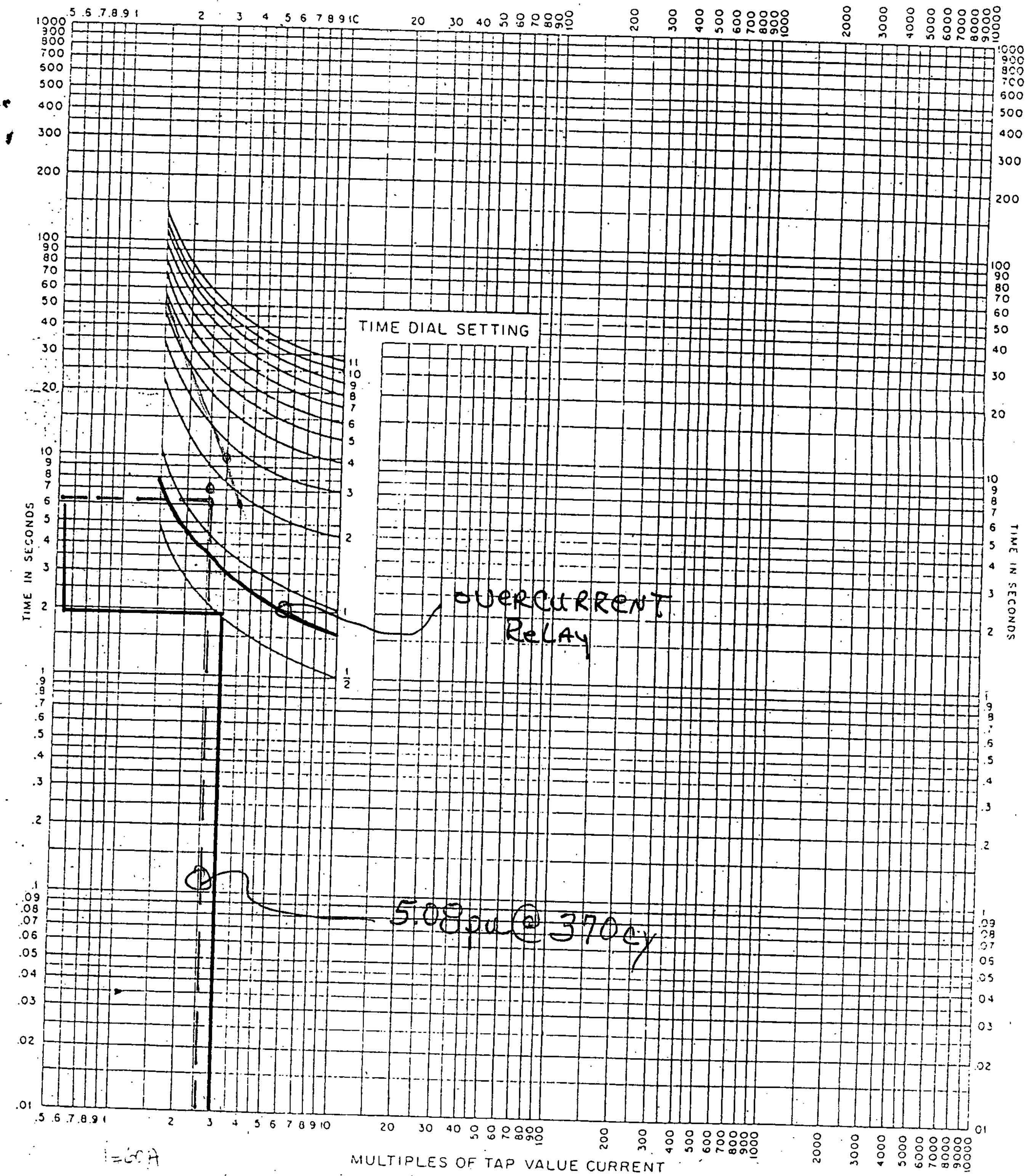
ATTACHMENT 1
PAGE 3 of 3

Att. 5 of OSC 5701
Sh 6 of 9

TYPE CO-5 LONG TIME OVERCURRENT RELAY
TYPICAL 50/60 CYCLE CURRENT TIME CURVES

WESTINGHOUSE ELECTRIC CORPORATION NEWARK, N.J., U.S.A.

CURVE # 471045



ATTACHMENT 2

Keowee Hydro Station

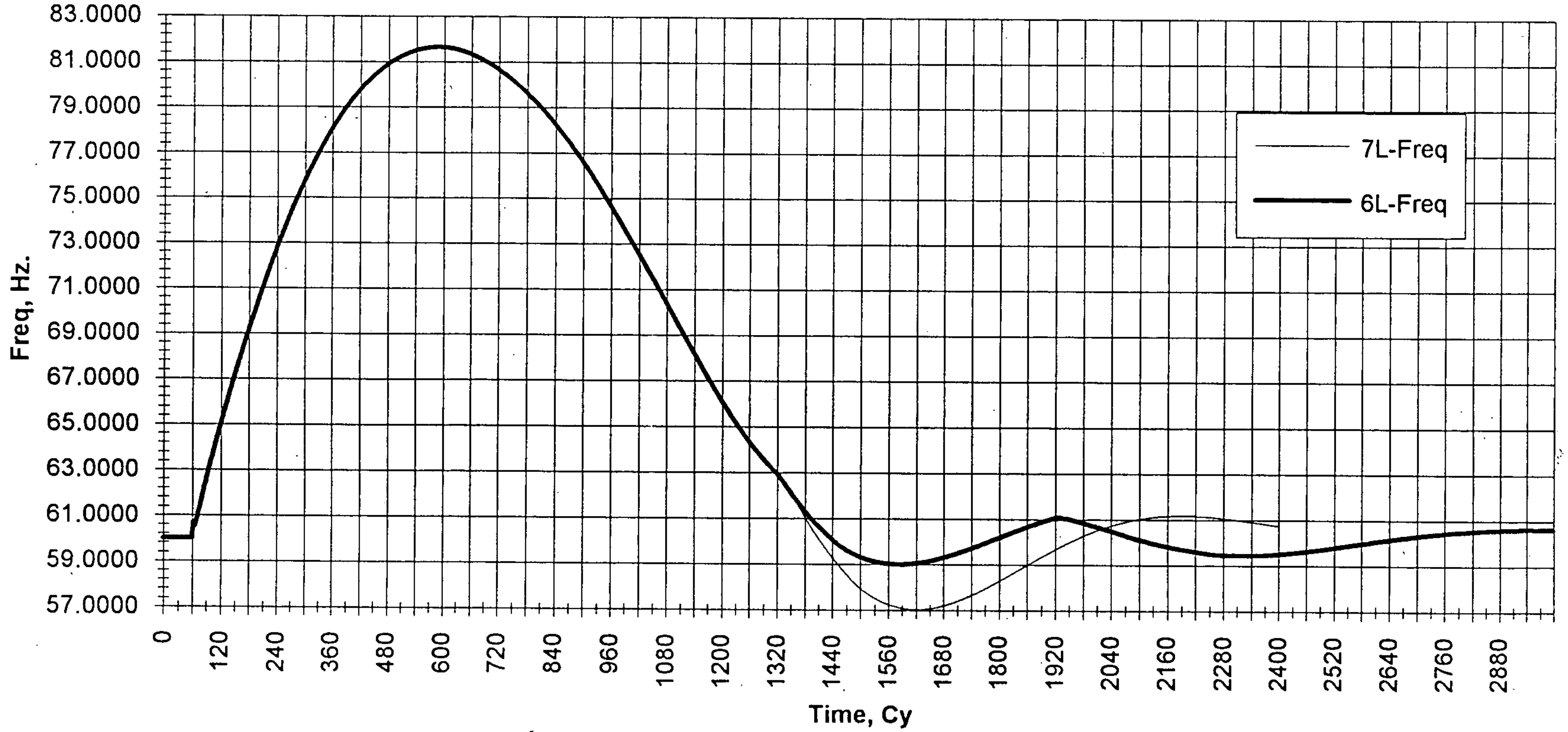
Voltage and Frequency vs. Time Plots

The following plots were originated from calculation OSC-5701, "OCONEE/KEOWEE OVERHEAD PATH ANALYSIS", Cases 6L and 7L.

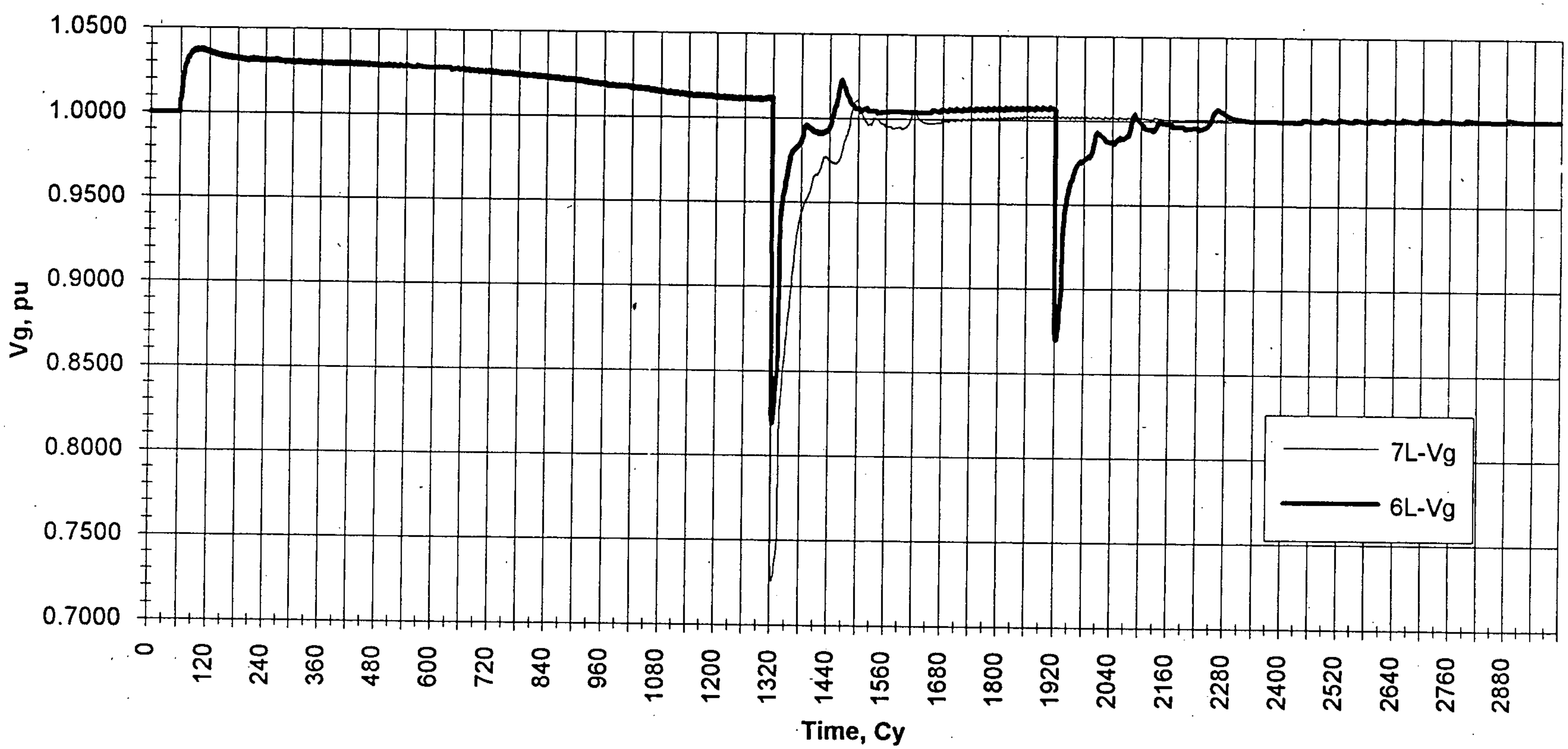
Case 6L simulates the Keowee overhead unit, with a net head of 113', rejecting 75MW of load at t=60 cy, and then accepting Oconee load in two steps. The first step at t=1320 cy, 21 seconds following load rejection, the startup bus is energized (see results of case 2L). At this time, the LOCA unit has already transferred to the Underground Unit, and only the LOOP units would be connected to the overhead path. Ten (10) seconds later, t=1920 cy, if the underground circuit failed for any reason, the LOCA unit would transfer back to the startup bus. This re-transfer constitutes the second step for Case 6L.

Case 7L simulates the Keowee overhead unit, with a net head of 113', rejecting 75MW of load at t=60 cy, and then accepting Oconee load at t=1320 cy when the startup bus in energized 21 seconds following load rejection (see results of case 2L). Oconee loads consist of Oconee unit 1 LOCA loads plus the largest unscheduled motor load and Oconee unit 2 & 3 LOOP loads.

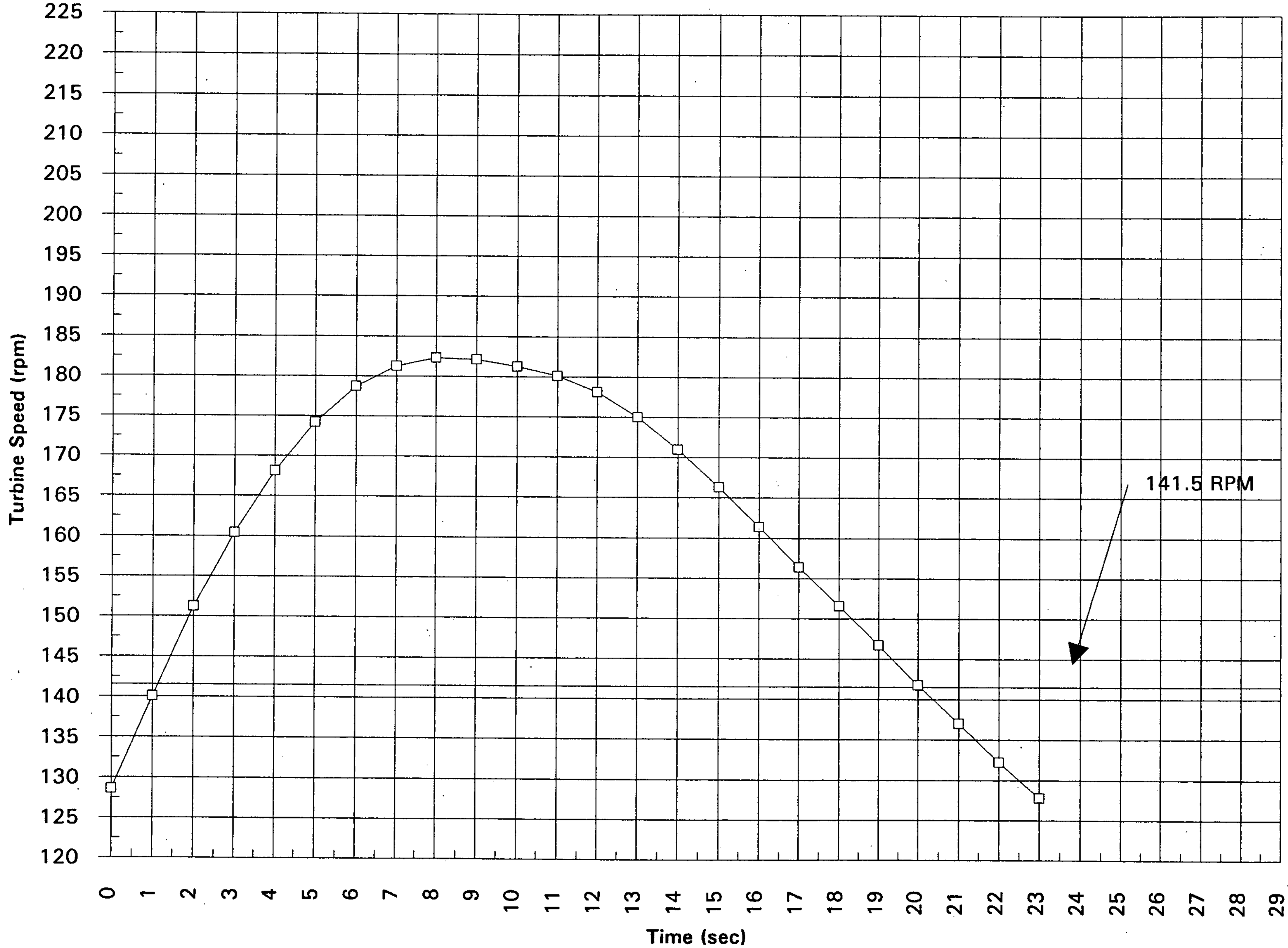
Case 6L & 7L: Freq



Case 6L & 7L: Vg

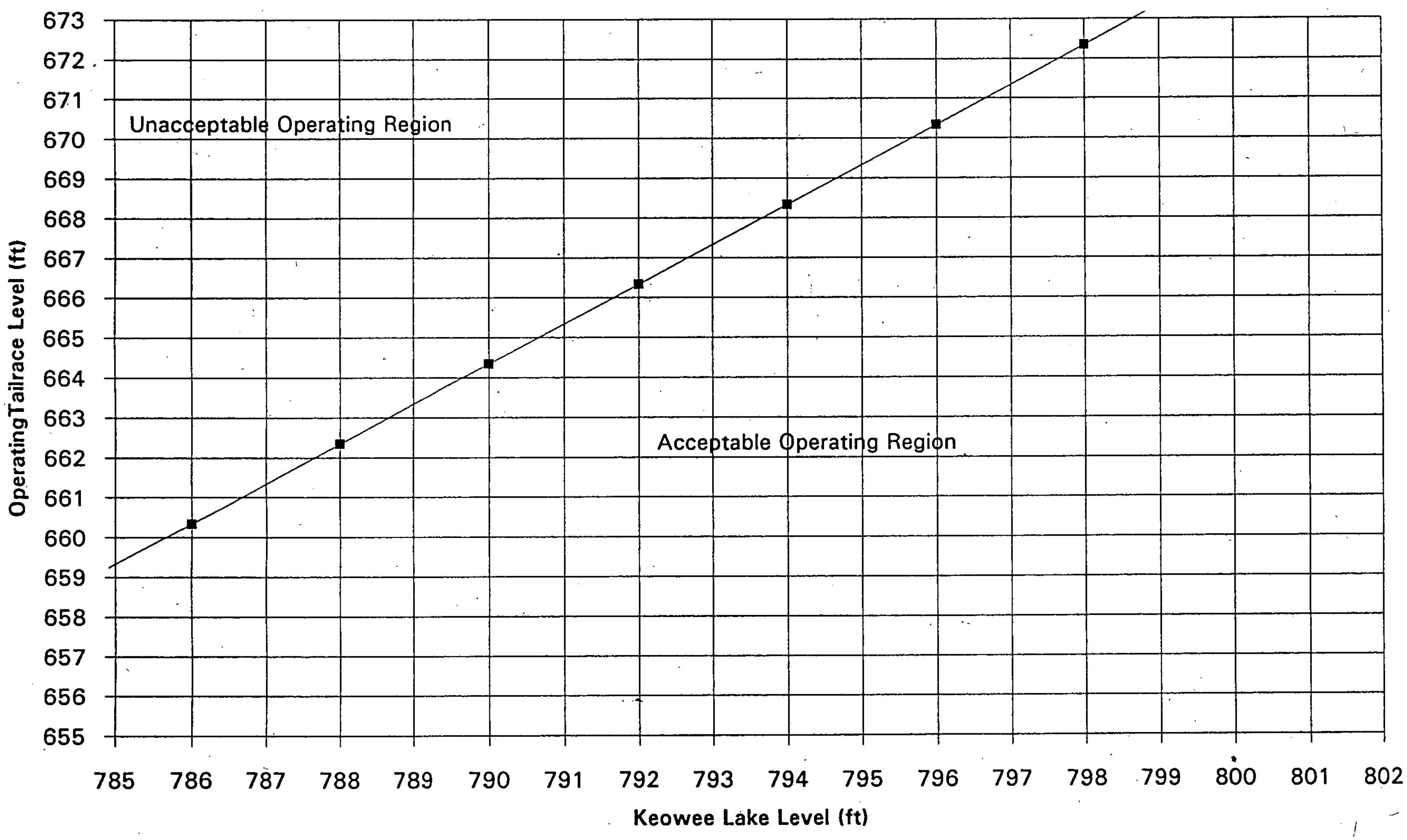

Vg, pu
1.0500
1.0000
0.9500
0.9000
0.8500
0.8000
0.7500
0.7000
0
120
240
360
480
600
720
840
960
1080
1200
1320
1440
1560
1680
1800
1920
2040
2160
2280
2400
2520
2640
2760
2880
Time, Cy
7L-Vg
6L-Vg

1 Unit 88 MW


Turbine Speed (rpm)
225
220
215
210
205
200
195
190
185
180
175
170
165
160
155
150
145
140
135
130
125
120
141.5 RPM
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
Time (sec)

1 Unit 88 Mw

Keowee Operating Chart



REQUEST FOR INFORMATION
OCONEE NUCLEAR STATION - UNITS 1, 2, AND 3
KEOWEE OVERSPEED CONDITION FOLLOWING A LOAD REJECTION

Question - Please provide any safety evaluation related to the proposed modification to the Oconee Nuclear Station intended to address the overfrequency concern.

Response - The attached response provides the safety evaluation related to the proposed modification.

DESCRIPTION

Oconee Nuclear Station Modification (NSM) 52966 will change Keowee logic to prevent certain postulated scenarios from adversely impacting the ability of the Keowee hydro units to supply emergency power to the Oconee nuclear units. The BL1 portion of this modification installs Keowee control logic to prevent possible adverse effects from overspeed conditions due to automatic load rejections and/or governor failures. For more information see Reference 4.

SAFETY EVALUATION

The purpose of the Keowee Emergency Power System is to supply a reliable source of emergency power to the Oconee Nuclear Station during a design basis event (DBE). The Keowee emergency start logic at Oconee is designed to send a signal to the start circuitry of both Keowee hydro units in the event the normal and startup power sources are not available and/or an Engineered Safeguards (ESG) signal is present. Both units are started automatically and simultaneously and run on standby under any of the following three conditions: (1) undervoltage signals from both main feeder busses, (2) the presence of an ESG signal, (3) a signal from the external grid trouble protection system. The Keowee units will start and accelerate from zero to rated speed and voltage within 23 seconds. If the Keowee units are already operating when an emergency start signal is received, they will separate from the network and run in standby until needed. [References 1, 3]

The BL1 portion of this modification installs Keowee control logic to prevent possible adverse effects from overspeed conditions due to automatic load rejections and/or governor failures. A Keowee generator may overspeed as a result of either of the following scenarios: (1) load rejection due to receipt of an emergency start signal while the unit is generating to the 230 KV system, or (2) failure of a turbine governor (runaway). The new control logic will function to automatically trip and block the Keowee generator breakers on both the overhead and underground pathways, whenever the possibility exists for safety loads to be tied to an overspeeding Keowee unit. For single failure purposes, an additional measure involves the installation of a new trip and reclosure block feature for both SK breakers during potential overfrequency conditions. This item prevents the Oconee main feeder busses from being energized by an overspeeding Keowee generator even if the underground path breaker fails to trip during the above described scenarios. [Reference 4]

The new control logic arrangement is comprised of auxiliary, time delay, and overfrequency relays which act together to recognize each Keowee unit's status immediately prior to receipt of an emergency start signal. Simply put, the new circuitry can detect if the units are operating to the grid and whether or not they are selected to the overhead or to the underground paths. The new logic then functions to trip and block reclosure of the Keowee generator breakers (and the SK breakers) until the Keowee unit(s) speed decreases below the point where overfrequency problems may be encountered. To maintain the margin accounting for relay, breaker, etc. operating times and Keowee generator coastdown, the Emergency Power Switching Logic (EPSL) re-transfer to startup timers setpoint will be decreased from 10 to 5 seconds. The setpoints for the existing reclose timers associated with PCB-9 will be changed for compatibility with the newly installed timers. The adequacy of the new timer setpoints is detailed below. [Reference 4]

The Oconee Unit 1 SER states in part that if there is a loss of normal power sources, the engineered safeguards functions will be powered by a Keowee hydro unit that will start up and accelerate to full speed within 23 seconds. Furthermore, the pumps and valves of the emergency injection systems (HPI & LPI) will be energized at less than 100% voltage and frequency. This statement means that as the Keowee hydro units come up to rated speed, injection system valves start stroking and pumps begin operating before rated voltage and 60 Hertz frequency are achieved. Currently, the most limiting case is a large break LOCA (LBLOCA) concurrent with a failure of the underground emergency power path. In this scenario, the time required to provide the design injection flow rate includes 23 seconds for Keowee hydro to start and achieve rated speed and voltage, plus 10 seconds re-transfer to startup, plus 15 seconds for the affected ECCS valves to stroke open, for a total of 48 seconds. A LBLOCA is the most limiting FSAR accident with respect to ECCS injection times. B&W Engineering evaluated the Oconee LBLOCA accident analyses for 48 seconds to full injection flow and determined that peak clad temperatures were acceptable for all core elevations. Technical Specification 4.6.2.a addresses periodic testing of the Keowee hydro units to verify their ability to start and attain rated speed within 25 seconds. This Technical Specification does not require the ECCS to be supplying design flow rate in 25 seconds. [References 1, 2, 6, 7]

After installation of this modification, the Keowee units will function as described below if both hydro units are generating to the Duke grid and an ES signal (requiring emergency power) is received. The Keowee generator breakers that are closed will trip (open) resulting in load rejection. When the Keowee units speed decreases to 110% of rated ($\leq$ 20 $\pm$ 2 seconds), the appropriate overhead and underground path breakers will close to allow the hydro units to supply power to Oconee. Assuming a failure of the underground path, the EPSL re-transfer timer will time out in 5 seconds. The ECCS valve stroke times remain 15 seconds. Thus, the total time to deliver design ECCS injection flow will be approximately 40 seconds, leaving some additional margin for physical operation of breakers, timers, etc. [References 4, 8]

If a Keowee unit is shutdown when an emergency start signal is received, there is no load rejection, and both Keowee and Oconee emergency power systems will respond in a fashion similar to the existing (pre-modification) logic. In the event of a runaway governor concurrent with an emergency start of a shutdown unit, enhanced overspeed protection will now be provided by new magnetic speed switches and associated relays. The new control and interlocking logic detects a runaway unit by sensing the speed of the affected unit's governor fly-ball motor, and then acts to trip the applicable unit's generator breakers. This prevents a failed unit from supplying unstable power to Oconee. The trip logic of the magnetic speed switches is only functional during emergency start conditions. The unit overspeed switches have multiple contacts. The existing overspeed switch contact in the emergency start part of the shutdown solenoid circuit is no longer necessary and will be deleted. However, as an additional measure, the overspeed switch logic in the unit lockout circuit will be retained, and can shut the failed Keowee unit down after a 30 second time delay when operating in emergency mode. [Reference 4]

Another relatively minor part of BL1 removes a new contact and relay that was installed by Part AL1. Subsequent to installation of ES contacts and 62-3C/4C timers in Part AL1, it was discovered that an already existing circuit (52-1TD/2TD) contained enough spare contacts to perform the necessary function. These circuits are all QA-1 and there is no difference in voltage or amps associated with the contact. [Reference 4]

The Keowee Hydro units provide the main source of emergency power for the Oconee Nuclear units, but they are not accident initiators. The FSAR Loss of Electric Power accident assumes two types of events: (1) Loss of load (unit trip) and (2) Loss of all system and station power. These changes to the control logic do not increase the likelihood of either. The loss of all station power accident analysis assumptions are still valid. This modification will not adversely affect the ability to mitigate LOOP, LOCA, and LOCA/LOOP accidents as described in the FSAR. This modification has no adverse impact on the ability of the Keowee Units to satisfy their design requirements of achieving rated speed and voltage within 23 seconds of receipt of an emergency start signal. All replacement equipment will be QA Condition 1 and seismically mounted. [References 1, 4]

The changes to the Keowee operating logic per this modification will not adversely affect the ability to mitigate any SAR described accidents or increase the radiological consequences of any such accidents. The Keowee Units will still satisfy their design requirements (of achieving rated speed and voltage within 23 seconds of receipt of an emergency start signal) for providing emergency onsite power to the Oconee units. In addition, a B&W analysis has concluded that a delay in ECCS design injection flow of up to 48 seconds results in no significant change to peak clad temperatures and is acceptable for all core elevations for the LBLOCA. Because SBLOCA transients are slower developing, they are less affected by injection times than the LBLOCA. There is no adverse impact on containment integrity, radiological release pathways, fuel design, filtration systems, main steam relief valve setpoints, or radwaste systems. Both Appendix R and seismic reviews of this modification have been initiated. [References 1, 4, 6]

This modification to the Keowee control logic removes the possibility of certain postulated events causing a loss of emergency power to the Oconee nuclear units. Upon installation, the Keowee emergency power system will remain operable and available to mitigate accidents. No new failure modes or credible accident scenarios are postulated. No function of any safety related emergency power system/component will be degraded as a result of this modification. This modification will require addition of Cutler Hammer type M relays, type M relay contact blocks, and solid state timing modules. ABB frequency relays and Dynalco magnetic pickup speed sensing switches will also be installed. These new devices will be QA Condition 1 safety related components. The need for additional cabling is expected to be minimal. The new devices will be seismically mounted and located within the mild Keowee environment. No safety or design limits are adversely affected. There is no adverse impact to the nuclear fuel, cladding, RCS, or containment systems. Therefore, the margins of safety as defined in the bases to any Technical Specifications are not reduced as a result of this modification. [References 1-5]

CONCLUSION

Based on the preceding discussion, Part BL1 of NSM-52966 involves no safety concerns. No Technical specification changes are necessary for implementation. FSAR section 8.3 and the DBD [Reference 3] will need to be revised to address the new logic.

REFERENCES

[1] Oconee Final Safety Analysis Report, Sections 6.3.3.3, 6.3.3.4, 7.1.2.2, 8.1, 8.2, 8.3, 8.4, 15.8, 15.14, Table 8-3, Figure 8-6, 1993 Update

[2] Oconee Technical Specifications, Sections 3.7, 4.6, as amended 10-31-94

[3] Keowee Emergency Power Design Basis Document, Rev 2, dated 12-8-93

[4] NSM-ON-52966, Project Description

[5] Selected Licensee Commitments, section 16.8.2, as amended 11-16-94

[6] B&W Co. Engineering Calculation 86-1178201-01 "177FA-LL 48 Second ECCS Delay Time" dated 10-13-89

[7] Oconee Unit 1 SER, Supplement 1, Section 2.0

[8] Duke Power Engineering Calculation KC-UNIT 1-2-0106, "Keowee Power Operations Restrictions" for NSM-52966