Attachment #5
page 1 of 8

Form 01077 (R7-89)

FORM 101.1	REVISION 13

CERTIFICATION OF ENGINEERING CALCULATION

STATION AND UNIT NUMBER OCONEE UNITS 1, 2 and 3 (KEOWEE)

TITLE OF CALCULATION ELECTRICAL CALCULATION FOR PIRs 0-92-0455 and 0-92-0490 (OPERABILITY EVALUATION)

CALCULATION NUMBER OSC-4995

ORIGINALLY CONSISTING OF: INFORMATION ONLY

PAGES 1 THROUGH 2

TOTAL ATTACHMENTS ONE TOTAL MICROFICHE ATTACHMENTS NONE

TOTAL VOLUMES 1 TYPE I CALCULATION/ANALYSIS YES ☐ NO ☒

TYPE I REVIEW FREQUENCY NA

THESE ENGINEERING CALCULATIONS COVER QA CONDITION 1 ITEMS. IN ACCORDANCE WITH ESTABLISHED PROCEDURES, THE QUALITY HAS BEEN ASSURED AND I CERTIFY THAT THE ABOVE CALCULATION HAS BEEN ORIGINATED, CHECKED OR APPROVED AS NOTED BELOW:

ORIGINATED BY T. E. Donaldson DATE 01/18/93

CHECKED BY INFORMATION ONLY DATE 1-25-93

APPROVED BY [signature] DATE 1-28-93

ISSUED TO TECHNICAL SERVICES DIVISION _____ DATE _____

RECEIVED BY TECHNICAL SERVICES DIVISION _____ DATE _____

MICROFICHE ATTACHMENT LIST: ☐ Yes ☒ No SEE FORM 101.4

REV. NO.	CALCULATION PAGES (VOL)			ATTACHMENTS (VOL)			VOLUMES		ORIG	CHKD	APPR	ISSUE DATE
	REVISED	DELETED	ADDED	REVISED	DELETED	ADDED	DELETED	ADDED	DATE	DATE	DATE	REC'D DATE

9511270228 951117
PDR ADOCK 05000269
P PDR

Attachment #5
page 2 of 8

Form 101.2 Revision 1
26164 (R9-89)

File/Calculation No. OSC-4995

REVISION DOCUMENTATION SHEET

Revision Number	Review Frequency Changed Yes/No	Revision Description

CALCULATION/ANALYSIS INFORMATION SHEET
(SHEET 1 OF 2)

CALCULATION/ANALYSIS NO. OSC-4995
ORIGINATOR: [illegible] DATE 1/20/93
CHECKER: HH DATE 1-25-93

A. PROBLEM: These PIRs address problems relating to circuitry failures which could result in failures to the Keowee generators voltage regulator systems. The failures described affect both the automatic and manual portions of the voltage regulators.

B. RELATION TO QA CONDITION: QA-1

C. DESIGN METHODS: Reviewed applicable drawings and instruction books and consulted with Westinghouse personnel. (Westinghouse is the equipment manufacturer).

CALCULATION/ANALYSIS INFORMATION SHEET
(SHEET 2 OF 2)

CALCULATION/ANALYSIS NO. OSC-4995
ORIGINATOR: [signature] DATE 01/20/93
CHECKER: MJM DATE 1-25-93

D. APPLICABLE CODES AND STANDARDS (NAME, NUMBER, DATE, REVISION): N/A

E. OTHER DESIGN CRITERIA: KEOWEE DBD
OSS-0254.00-00-2005

F. RELATED SAR CRITERIA (PSAR OR FSAR, PAGE, AMENDMENT):
FSAR CHAPTER 8
TECHNICAL SPECIFICATIONS 3.7.1 and 3.7.2

G. CALCULATIONS: - - - - - - - - - - - - - - - - PAGE NO. ATTACHMENT 1

H. ASSUMPTIONS: - - - - - - - - - - - - - - - - PAGE NO. N/A

I. REFERENCES: - - - - - - - - - - - - - - - - - PAGE NO. ATTACHMENT 1

J. CONCLUSION: - - - - - - - - - - - - - - - - - PAGE NO. ATTACHMENT 1

DESIGN ENGINEERING DEPARTMENT
OPERABILITY EVALUATION

OSC-4995
ATTACHMENT 1
PAGE 1 of 4

Station: Oconee Unit: 1, 2, & 3 PIR Number: 0-092-455 & 490

Structure, system, or component (SSC) in question: Emergency Power System

Keowee Hydro Unit 2

Design basis references applicable: OSS-0254.00-00-2005

Technical Specification sections applicable: 3.7.1

The SSC in question is recommended to be:

☐ OPERABLE ☐ CONDITIONALLY OPERABLE
Operability Evaluation expiration date: _____

~~☐~~ DNW ☒ INOPERABLE
This inoperability applies only to the Keowee unit affected during period of regulator inoperability. DNW

FSAR change required ☐ Yes ☒ No

10 CFR 50.59 Evaluation required ☐ Yes ☒ No

Summary/Comments:

This evaluation addresses past operability of Keowee Unit 2 with failed circuitry in its voltage regulator system.

This evaluation applies to the circuit failure associated with PIR 0-92-455 where relay 90X1C failed to pick up and activate the automatic regulator.

It also applies to PIR 0-92-490 where a failure of a switch prevented the manual regulator for Keowee Unit 2 from performing its function.

Our review of system drawings, calcs, design basis documents, and discussion with equipment manufacturers concludes that both (manual and automatic) features of the Keowee unit regulator are required to be operable for that Keowee unit to be considered operable.

It should be noted that either feature (manual or automatic) is fully capable of performing the safety function of the regulator during a Design Basis Event requiring the the Keowee units. However, certain failure modes within the manual regulator while the auto regulator is out or within the auto regulator while the manual regulator is out could have adverse impact on the Oconee Emergency Power System. Therefore, both the manual and automatic features of the regulator are required to be operable to account for single failure consideration.

Further details of this evaluation are documented in Calculation #OSC-4995.

Originated by: D A Davidson for DNW Date: 10/13/92

Reviewed by: [signature] Date: 10/13/92

Approved by: [signature] Date: 10/13/92

EVALUATION

KEOWEE VOLTAGE REGULATOR AND POSTULATED VOLTAGE PROBLEMS

As a result of the failure of relay 90XIC to automatically pick up (and place the KEOWEE #2 GENERATOR voltage regulator in AUTO) an analysis was performed to determine specific failure modes of the KEOWEE voltage regulators and static excitation systems.

BASIC SYSTEM DESCRIPTION

The voltage regulator and excitation system, which is installed on each of the Keowee generators, is the Westinghouse type WTA solid state regulator and TRINISTAT static excitation system.

This type of system precludes the inherent problems associated with exciter generators and rotary amplifiers by utilizing a portion of the generator output (for main field excitation) via an excitation transformer and silicon control rectifiers (thyristers) and by the application of solid state components for the regulator.

The main field rectifiers (trinistat power units) consist of eight individual sections six of which are required to supply full load excitation at rated power factor. Further, the firing (control) system to the trinistat power units are comprised of two separate (redundant) circuits.

The operation of the system is such that a manually operated base adjuster is pre-set to establish an excitation level which corresponds to generator no load voltage. Once actuated the AUTO voltage regulator functions to oppose or aid (BUCK/BOOST) the base value to automatically maintain the generator output voltage at the value selected by the auto voltage regulator.

A "BASE FOLLOWING" feature automatically adjusts the BASE ADJUSTER rheostats when the regulator is in the AUTO MODE such that if the auto regulator is lost (or removed from service) a "bumpless" transition to the manual regulator (BASE ADJUST) occurs.

Also, the ranges of operation are such that the generator output voltage will be automatically maintained (from no load to full load values) if the base adjust output goes to zero during automatic regulator operation. However, for the base adjust output to completely fail, in this manner, both of the redundant firing circuits must go to zero.

Other features of the WTA regulator enhance overall reliability further by providing limiting, compensating and protective functions which act to protect both the Keowee generators and connected devices from the potential damaging effects of postulated regulator/excitation system malfunctions.

These features include:

1. Maximum excitation limiter.
2. Minimum excitation limiter.
3. Volts per Hertz limiter and protection
4. Reactive droop compensation.

5. Reactive line drop compensation.
6. Resistive line drop compensation.
7. Field overcurrent protection.
8. AC overvoltage protection.
9. Loss of potential protection.

POSTULATED PROBLEMS

1. UNDERVOLTAGE

Various regulator malfunctions were considered which could result in Keowee generator output voltage decreasing to unacceptable values during emergency operation.

As noted, in the previous section, the built-in redundance of the field rectifiers (trinistats) and the firing circuits auctioneering feature greatly reduces the likelihood that a single component failure will result in less than acceptable generator output voltage.

Also, there exists adequate undervoltage protection in the Oconee Emergency Power Switching logic systems which is independent of the Keowee voltage regulator/excitation systems.

However, because of the nature of the particular relay failure (90XIC) which resulted in the regulator not shifting into AUTO (on a normal Keowee startup), this scenario was postulated to occur during a Keowee emergency start and subsequent automatic loading.

During this analysis the KEOWEE no load saturation curve (obtained from the generator manufacturer's instruction book) was utilized to determine generator voltage under various design basis loading conditions. These values were then input into the ASDOP program which resulted in verifying adequate voltage under conditions where the Keowee unit was loaded with the base adjuster at the pre-set position and the auto regulator failed to engage.

2. OVERVOLTAGE

Because of the limiters and protective devices provided with the Keowee voltage regulator/excitation system malfunctions which result in high generator output voltage are very unlikely.

However, because the field overcurrent protective feature, which trips the applicable Keowee unit during normal operation, is bypassed during emergency operation this particular scenario was considered.

Postulated malfunctions analyzed were ones that would result in the trinistat firing circuits in the regulator output going high while assuming that the excitation limiters and auto regulator had no effect on limiting the voltage to acceptable values.

No malfunctions were identified that could occur as the result of any one single failure..

Mr. Don Kimmel and Mr. Richard Mummert of the Westinghouse Facility in Asheville, North Carolina were consulted in an attempt to determine resultant voltage levels, under the conditions described, and their knowledge or credibility of such malfunctions actually occurring.

Mr. Don Kimmel (704-687-3320) performed an in-depth analysis utilizing the generator no load saturation curve, field resistances at various temperatures, excitation transformer saturation data and information concerning the potentially damaging overheating effects of prolonged over excitation to the generator field and stator.

Mr. Kimmel's conclusion was that, if the conditions postulated could credibly occur, generator voltage would rise to higher than normal values. He also noted that he considered this to be a hypothetical situation which he had not seen (or been aware of occurring) in his experience with the Westinghouse WTA regulator. Mr. Kimmel's experience with Westinghouse voltage regulator/excitation equipment includes research and development as well as field and manufacturing work.

Mr. Mummert agreed with Mr. Kimmel's assessment and also noted that no one single failure could result in regulator responses as postulated.

CONCLUSIONS

The Westinghouse WTA voltage regulator and trinistat excitation systems are highly reliable with between three and four hundred units in operation dating to the mid 1960's.

Because of the utilization of the KEOWEE generators as system peaking units and as the emergency on-site sources of auxiliary power to the Oconee Nuclear Station certain protective features are defeated (bypassed) during emergency operation of the units.

This is accomplished to increase reliability when the units are called upon as emergency sources to Oconee.