Mr. Oliver D. Kingsl[illegible]Jr.
President, TVA Nucle[illegible]nd
Chief Nuclear Officer
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, Tennessee 37402-2801

July 19, 1995

SUBJECT: WATTS BAR UNIT 1 - SEISMIC MODELING AUDIT (TAC M90549)

Dear Mr. Kingsley:

The staff conducted an on-site audit of the Watts Bar Unit 1 seismic modeling methodology on June 20, 1995. The main purpose of the audit was to discuss and resolve the issue regarding the modeling of the coupled internal concrete structures-nuclear steam supply system (ICS-NSSS) raised by the staff in its review of Chapter 3 of the Watts Bar Final Safety Analysis Report (FSAR), Amendment No. 79.

The audit included a presentation by TVA staff and its consultant, Westinghouse. In addition, an NRC staff member inspected the relevant NSSS supports in a plant walkdown and audited Westinghouse calculations of record.

The staff concluded that the methodology employed by TVA and Westinghouse to obtain the seismic response of the coupled ICS-NSSS by a linearized analysis is in conformance with common industry practice. The staff further found that sufficient cases of linear analysis were considered to adequately and conservatively bound the behavior of the coupled ICS-NSSS. Based on the audit, the staff considers this issue to be closed.

The detailed audit report is enclosed. The staff expects to publish its safety evaluation on FSAR Chapter 3, reflecting conclusions of this audit, in Supplement 16 of the Watts Bar Safety Evaluation Report (NUREG-0847).

Sincerely,

Original signed by

Peter S. Tam, Senior Project Manager
Project Directorate II-3
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Docket No. 50-390

Enclosure w/enclosure: Audit Summary

cc: See next page

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OFFICE OF NUCLEAR REACTOR REGULATION

SUMMARY OF SEISMIC MODELING AUDIT AT WATTS BAR UNIT 1

JUNE 20, 1995

(TAC M90549)

1.0 INTRODUCTION

The staff of the Civil Engineering and Geosciences Branch (ECGB) of the Office of Nuclear Reactor Regulation met with the staff of the Tennessee Valley Authority (TVA) and its consultants from Westinghouse to conduct an audit of the structural seismic modeling and analysis of coupled internal concrete structures-nuclear steam supply system (ICS-NSSS) on June 20, 1995.

The main purpose of the audit was to discuss and resolve an issue raised in two requests for additional information (RAI), dated May 3, 1994 (Reference 1) and October 11, 1994 (Reference 3). The staff audited the NSSS model development calculation, including the modeling of nonlinear NSSS supports in linear analyses, to verify that the criteria documented in the Final Safety Analysis Report (FSAR) is properly implemented in the analysis so that a safety determination can be made by the staff in a safety evaluation of the open issues in Chapter 3 of the FSAR. In addition, the staff conducted a walkdown of Watts Bar Unit 1 to ensure that the representative NSSS supports observed during the walkdown conform to the configuration modeled in the seismic analysis.

At the end of this audit report is the list of attendees, the agenda for the meeting, and handouts provided by TVA.

2.0 AUDIT SUMMARY

The audit consisted of three parts. A summary of the agenda is as follows:

1. Review of open issue by the staff; TVA presentation of the configuration of reactor coolant loop (RCL) components and supports, 4 Loop model schematic, review of construction drawings, 4 Loop computer model, active supports tables; questions and discussions.

2. Plant walkdown to observe NSSS supports.

3. Audit of design calculations and exit meeting.

The first part consisted of a review and discussion of the issue and TVA's response for its resolution. In this part, the staff presented a brief summary of the issue identified in Reference 1. In Section 3.7 of the FSAR, a description has been provided for the seismic model of the ICS-NSSS for the purpose of the plant structure seismic response. TVA stated in the FSAR that the NSSS supports in the coupled model exhibit nonlinear behavior due to the presence of gaps and tension-only tie rods at the NSSS and ICS interfaces. In Question 4 of Reference 1, the staff requested that TVA provide the detailed methodology used in the development of the dynamic models of the NSSS supports which are used in the coupled seismic model. In its response (Reference 2), TVA stated that the integration of the NSSS and the ICS model was previously reviewed by the NRC and found to be acceptable. In addition, TVA provided the details of the references which documented the modeling of the NSSS and the ICS. However, the staff contended (Reference 3) that the applicant did not provide detailed information on conversion of a nonlinear structure to a linear model and the validity of the conversion and, therefore, the staff concluded that the applicant did not provide information as requested by the staff. The staff also reviewed the inspection reports cited in Reference 2 and concluded that the inspector did not review the approximation of the nonlinear NSSS model to an equivalent linear model and the associated boundary conditions. In Reference 3, the staff concluded that the applicant's response in Reference 2 is not sufficient and requested that the applicant provide further details of the combined ICS and NSSS models. In Reference 4, the applicant provided additional information concerning the structural model such as the geometry and the resulting forces and moments at the ICS-NSSS interface. In Question 4 of Reference 1, the staff requested a detailed description of the linearized NSSS support stiffnesses that were used for the ICS-NSSS analyses and a discussion of how these representations of the supports adequately modeled the nonlinear system evaluated. The applicant stated that a study had been performed by Westinghouse to investigate different NSSS analysis cases and to identify the supports or tie rods that will be activated under a specific loading condition. The applicant further stated that based on the study, an active support list table was developed by Westinghouse and used by TVA in performing the seismic analysis. The applicant concluded that since only a specific set of NSSS supports with their specified orientation are activated for each different loading condition, a linear support stiffness can be developed.

During the audit, TVA and Westinghouse presented the detailed construction configuration and modeling methodology for the NSSS supports. The NSSS components included in the coupled model for the ICS consist of the reactor pressure vessel (RPV), four loops of the primary reactor coolant loop (RCL) piping (hot legs, cold legs, and cross-over legs), the steam generator (SG), and the reactor coolant pump (RCP) associated with each loop. The NSSS models for four loops consist of masses and mass moments of inertia lumped at the nodal points of RPV, RCL piping, SG, and RCP, and interconnected with elastic elements. The stiffness properties of the elastic elements are represented by various 12 x 12 generalized stiffness matrices. For the purpose of linear response analyses, four linearized NSSS analyses, each with a unique set of linearized NSSS support stiffness, are used to bound the nonlinear support behavior under various dynamic loading conditions. For each NSSS analysis case, a specific set of NSSS supports with their specified orientation are activated for a particular loading condition and a set of linear support stiffnesses is provided to represent the active supports. The active supports for each of the four analysis cases are shown in Reference 3. A simplified diagram of the reactor coolant system is shown in Figure 1-2 of Attachment 3. Figures 5.5-6 through 5.5-10 of TVA's handout material show the support arrangement for RPV, SG, RCP, and crossover leg piping. An examination of the active support conditions specified in Attachment 2, Tables A-1 through A-4 of Reference 4, show that the active support conditions for NSSS analysis cases 1 and 3 are complimentary to each other and are for resisting horizontal seismic loads in the plant north-south (NS) directions; the active support conditions for the NSSS analysis cases 5 and 6 are complimentary and are primarily for resisting loads in the plant east-west (EW) direction. For the vertical response analysis, the NSSS analysis cases 5 and 6 are used. It may be noted that the RPV supports are active for all conditions and hence, are appropriately modeled as linear elastic supports.

The staff concludes that it is common industry practice that pipe supports are constructed with gaps and that the supports are active only if the gaps close during the earthquake motion. The staff recognizes that linear elastic modeling of the pipe supports is a common industry practice as long as the overall analysis adequately models various support conditions. The staff further notes that linear elastic modeling of pipe supports which are active only in tension due to gaps is a common industry practice as long as the analysis adequately represents the actual support conditions. Based on the presentation of the various cases considered to model the RVP supports, SG upper and lower supports, crossover leg restraints on the SG and RCP sides, RCP lower supports, and RCP tie rods, the staff concludes that the NSSS-ICS coupled model appropriately represents the actual configuration and the enveloping of the response conservatively represents the seismic response of the NSSS-ICS structural system.

Westinghouse also presented the construction sketches (see handout material) and drawings for the RCL supports during the audit. Subsequent to the discussion, the staff performed a walkdown of the RCL supports and observed the configuration of the accessible SG, RCP, and crossover leg supports.

In part three of the audit, the staff audited Westinghouse calculation WCAP-10784. This calculation provides the justification for the various supports considered active in the NSSS-ICS seismic analysis and presents the computation of the support stiffness. The staff found that the calculation is prepared and reviewed adequately and provides an adequate basis for the NSSS model used in the coupled NSSS-ICS seismic model.

3.0 CONCLUSIONS

The ICS-NSSS structural model issue, identified in References 1 and 4, was discussed and resolved in this audit meeting. The staff noted that most of the pipe supports in nuclear power plants are constructed with gaps such that the supports are active only if the gaps close during an earthquake motion. The staff concluded that linear elastic modeling of pipe supports is a common industry practice as long as the overall analysis adequately models various support conditions. Based on the presentation of the various cases considered to model the RPV, SG, RCP, and crossover leg supports, the staff concluded that the model appropriately approximates the actual configuration, and the enveloping of the response conservatively represents the seismic response of the NSSS-ICS structural system. Based on the audit, the staff considers this issue to be closed.

Principal Contributor: Syed Ali

Dated: July 1995

4.0 REFERENCES

1. Letter from Peter S. Tam of NRC to Oliver D. Kingsley, Jr. of TVA, "Request for Additional Information Relating to FSAR Amendment 79," May 3, 1994.

2. Letter from Dwight E. Nunn of TVA to NRC Document Control Desk, "Response to the Staff RAI," August 18, 1994.

3. Letter from Peter S. Tam of NRC to Oliver D. Kingsley, Jr. of TVA, "Request for Additional Information on FSAR Chapter 3 as Revised by Amendment 79," October 11, 1994.

4. Letter from Dwight E. Nunn of TVA to NRC Document Control Desk, "Watts Bar Nuclear Plant - Request for Additional Information on FSAR Chapter 3 as Revised by Amendment 79," February 3, 1995.

Attachments:
1. List of Attendees
2. Agenda
3. Meeting Handout

LIST OF ATTENDEES

WATTS BAR UNIT 1 AUDIT

JUNE 20, 1995

NAME	ORGANIZATION
Syed A. Ali	NRC
James G. Adair	TVA
Rebecca N. Mays	TVA
C. R. Allen	TVA
R.D. Cutsinger	TVA
R. O. Enis	TVA
Phil Kotwicki	Westinghouse
K. R. Spates	Westinghouse

ATTACHMENT 1

AGENDA
WATTS BAR NUCLEAR PLANT - UNIT 1
REACTOR COOLANT LOOP SUPPORT MODELING
JUNE 20, 1995

8:30 AM TO 9:30 AM **TVA PRESENTATION**

<u>Opening Remarks and Introductions:</u> James G. Adair, WBN Lead Civil

<u>Background:</u> Charles R. Allen, WBN Engineering Mechanics Manager
- Brief Review of the Open Issue
- Reactor Coolant Loop (RCL) Components
- RCL Supports

<u>RCL 4-Loop Model:</u> Philip J. Kotwicki, Westinghouse
- 4-Loop Model - Schematic
- Construction Drawings
- Active Supports Example - North Movement
- 4-Loop Computer Model
- Active Support Tables

<u>Conclusion:</u> Mr. Allen

<u>Questions / Discussion:</u> Mr. Ali, USNRC

9:30 AM TO 11:00 AM **PLANT TOUR - RCL SUPPORTS**

11:00 AM TO 11:30 AM **FOLLOW-UP DISCUSSIONS**

11:30 AM TO 12:30 PM **LUNCH**

12:30 PM TO ? **TO BE DETERMINED**

ATTACHMENT 2

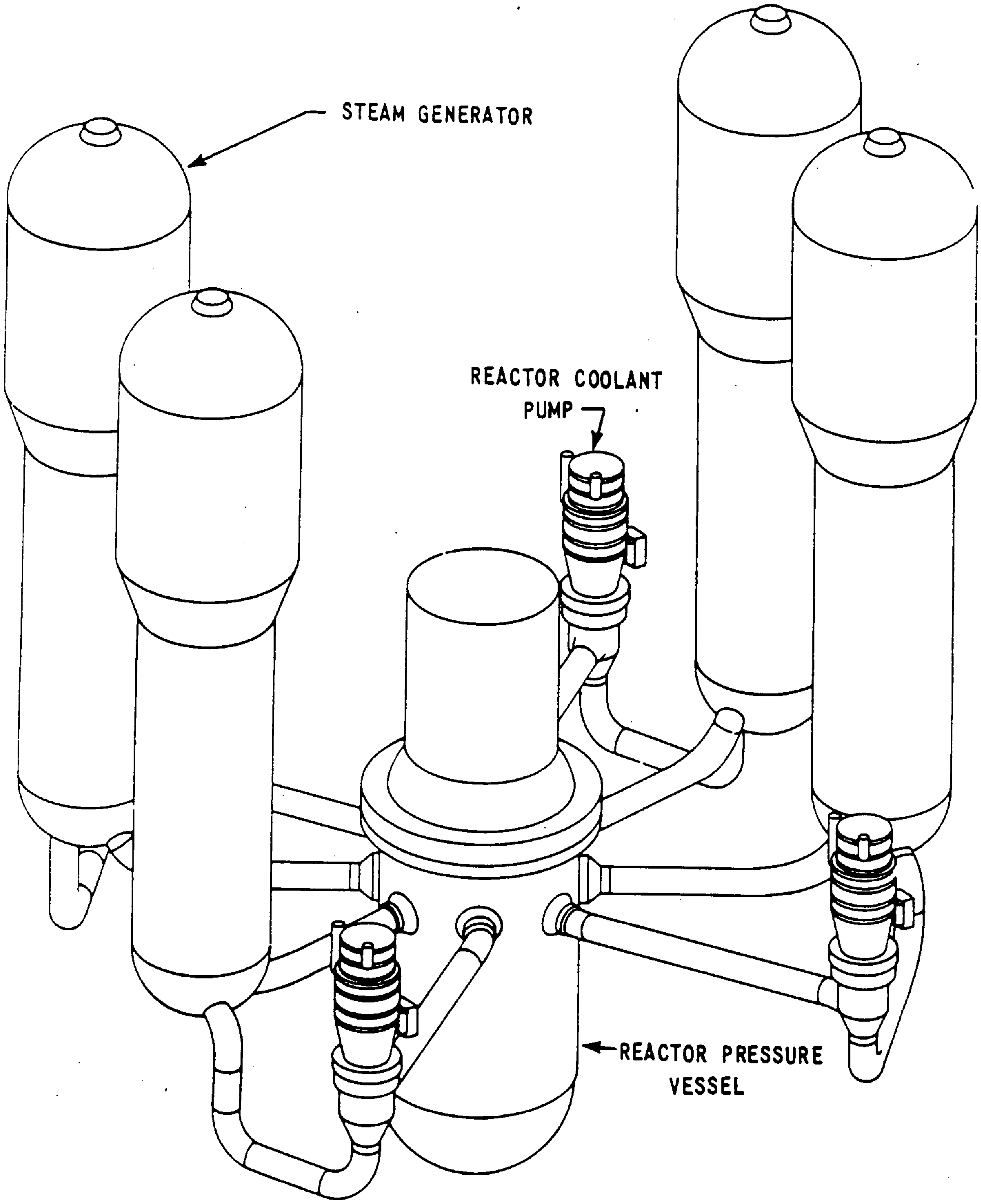

Figure 1-2. Simplified Diagram of the Reactor Coolant System

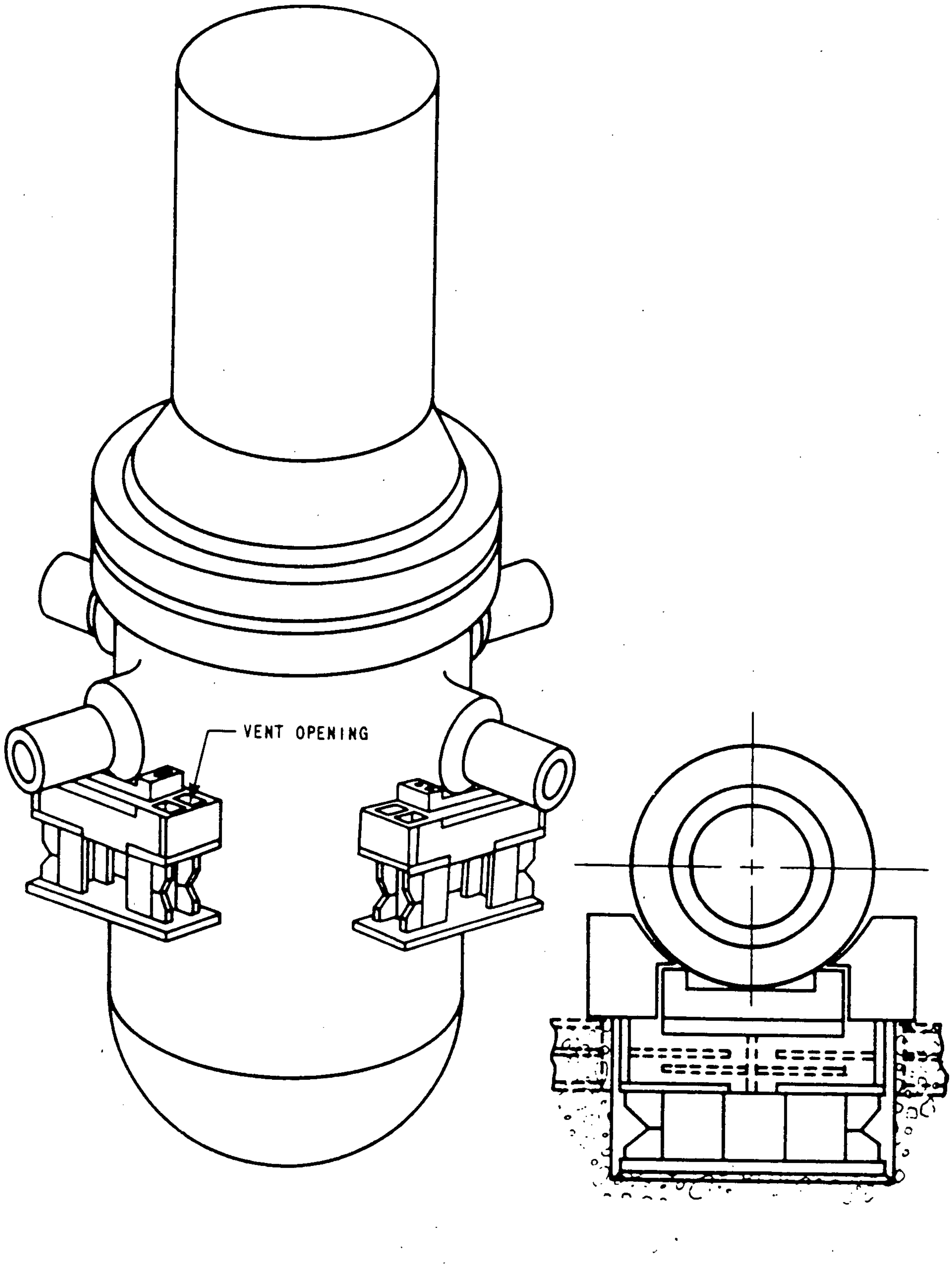

Figure 5.5-6 Reactor Vessel Supports

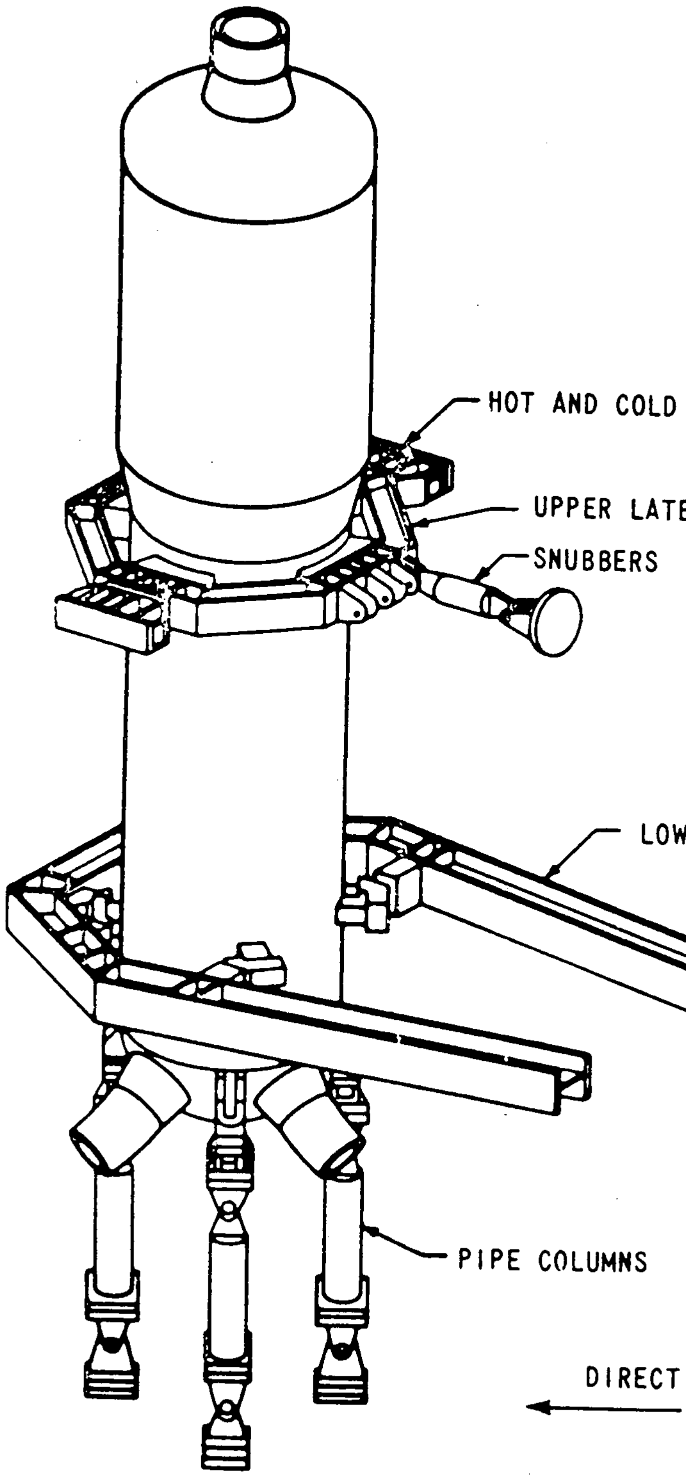

Figure 5.5-7 Ice Condenser Steam Generator Supports

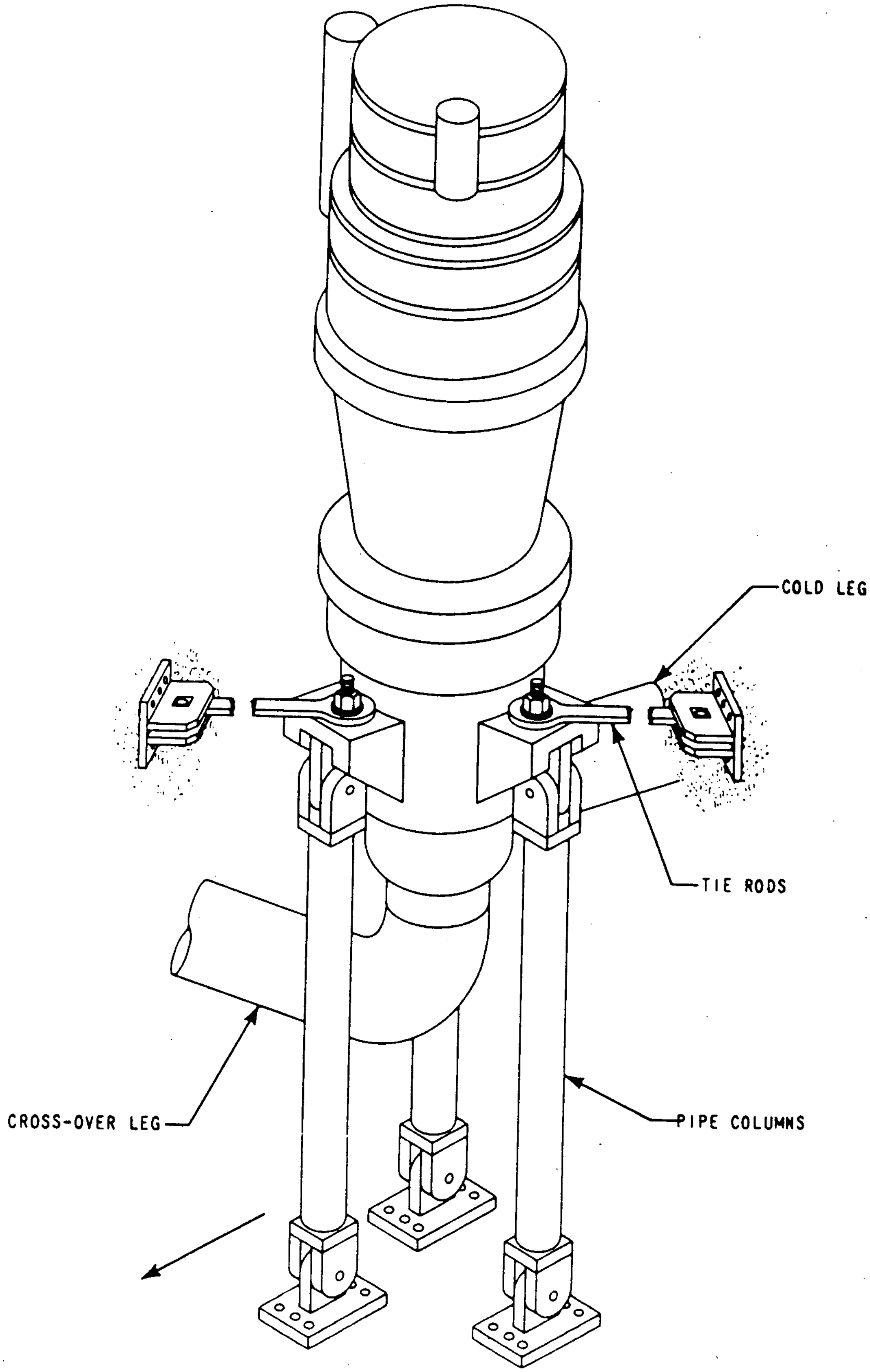

Figure 5.5-8. Reactor Coolant Pump Supports.

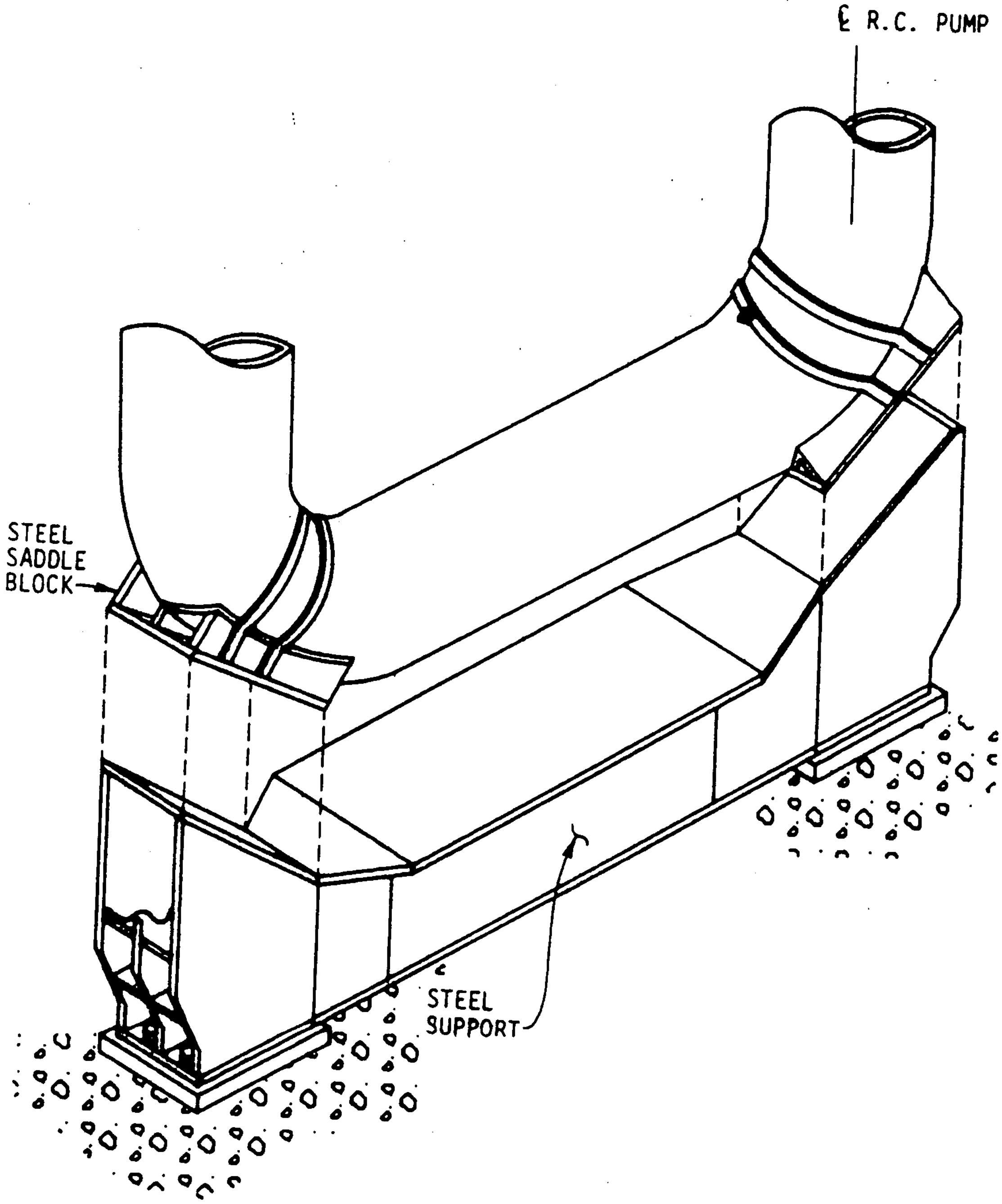

FIGURE 5.5-10

CROSSOVER LEG RESTRAINTS

Revised by Amendment 52

Mr. Oliver D. Kingsley, Jr.
Tennessee Valley Authority

WATTS BAR NUCLEAR PLANT

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