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EVALUATION OF EPRI NUCLEAR POWER DIVISION RESEARCH TOPICS
SUPPORTIVE OF HTGR TECHNOLOGY

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SUBMITTED BY
GAS COOLED REACTOR ASSOCIATES
OCTOBER 6, 1978

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EVALUATION OF EPRI NUCLEAR POWER DIVISION RESEARCH TOPICS
SUPPORTIVE OF HTGR TECHNOLOGY

BACKGROUND

Prior to 1976, most of the U.S. HTGR program support came from private industry with government support mainly in the areas of basic technology. During 1976 and 1977, major reassessments of HTGR commercialization were conducted by private industry and the federal government.

In response to the recommendations of these commercialization studies, a group of utilities expressed interest in HTGR commercialization to DOE and initiated efforts to establish an organization of utilities which would manage government and utility funds toward establishing the HTGR as a viable commercial option.

An organization of utilities (now numbering 12) called the Gas-Cooled Reactor Associates (GCRA) was formed in March, 1978, by Arizona Public Service Company, Public Service Company of Colorado, Northeast Utilities, Philadelphia Electric Company, and San Diego Gas and Electric Company. Under the overall program management of GCRA, the HTGR design program is expected to produce an engineering package of documents necessary to fix total plant requirements, parameters, and major features to form a reference plant design, including the fuel and core design in sufficient detail to permit preparation and submittal of a PSAR by March, 1980.

In order for GCRA to be successful in accomplishing its objectives, it is critical that the broadest possible utility technical input is used. EPRI has the technical expertise to provide this input and the EPRI organizational objectives are consistent with the GCRA Program Plan. Since both the GCRA and EPRI organizations are funded by utilities whose interests are best served by ensuring that every R&D dollar spent has maximum benefits, an LWR/HTGR Technology Transfer Program can best serve the needs of both utilities and the nuclear power industry.

LWR/HTGR TECHNOLOGY TRANSFER

The LWR/HTGR Technology Transfer is based upon a review of ongoing and planned EPRI programs to determine those with technical goals and objectives similar to those of the HTGR generic program. Although the majority of the EPRI programs were predicated on meeting the requirements of LWRs, a brief review of project summaries indicates that many are devoted to broad-based technology development programs which have the potential for satisfying the needs of both the HTGR and LWR activities.

REVIEW APPROACH

The review of the EPRI 1979 Nuclear Power Division (NPD) projects was conducted on a detailed basis as supported by the information available. The initial stages of the review were devoted to the identification of candidate programs for LWR/HTGR Technology Transfer. The sources of information for this review of 1979 NPD projects were a published list of EPRI 1978 project summaries, a list of 1979 anticipated NPD projects, and a number of descriptions of Requests for Project Authorization (RPA) and Requests for Project Change (RPC) prepared by the EPRI NPD staff.

Once the programs amenable to LWR/HTGR Technology Transfer were identified, discussions were held which resulted in descriptions of planned and ongoing development efforts, accomplishments to date, and overall program objectives useful in defining the areas of specific applicability of the EPRI programs. Through these discussions, it was possible to evaluate the EPRI programs as to:

- applicability to specific HTGR task areas
- impact of unique HTGR needs
- modification to EPRI program
- estimate program impact cost (relative)
- value to HTGR program

The evaluating areas mentioned in the above paragraph were applied to each of the selected 1979 NPD projects in a systematic procedure. The evaluation represents an appraisal of the relative merits of each EPRI program as applied to the HTGR generic activities. The Summary Evaluation was done by categorizing suggested modifications to the EPRI programs as to their relative impact on the overall EPRI project cost and the value, in terms of technology advancement, to the HTGR program. The following is a definition of terms used in evaluation of cost impact and value to the HTGR program; the first three describe EPRI cost impact, the remaining three describe value to the HTGR program:

NONE - generically applicable program with no modifications necessary to benefit the HTGR program. In this case, the primary objective is EPRI acceptance of the applicability to the HTGR program.

MINOR - minor modifications, i.e., slightly increased scope or additional data base, will be priority ranked based on benefit to the HTGR program.

SIGNIFICANT - cost impact based on available information is believed to be beyond the range of a reasonable cost modification to an existing program. It is anticipated that this work will be performed as part of a separate program.

GENERIC - implies that the program is equally applicable to HTGR as well as LWR power plants.

TECHNOLOGY EXTENSION - will add to the current data base and complement ongoing or planned HTGR development programs.

COMPLETE TECHNOLOGY DEVELOPMENT - will finalize a particular program area or satisfy a program milestone, represents a significant addition to HTGR technology program.

1979 EPRI NPD PROJECTS REVIEW RESULTS

Initially, an approximate total of 208 NPD 1979 projects were screened in order to identify those which were technically compatible with the needs of the HTGR technology development program. Of this initial group, 26 project areas presented the highest probability for technology transfer. These final candidates for technology transfer were reviewed in as much detail as the available information allowed. Reviews were held between both cognizant GCRA technical staff and interested technical section personnel from General Atomic Company. The information gathered in the reviews was then assimilated and an evaluation of their impact both on EPRI and the HTGR technology development included on their respective "Summary Evaluation" sheets which are attached to each project evaluation.

Table A-1 entitled, "Summary Table - EPRI/HTGR Technology Transfer Projects," includes the EPRI proposal number, project title, and the possible program cost impact categories for each of the 26 candidate projects. The discussion and evaluation phases of this task clearly indicated that each of these projects would provide substantial input to the HTGR technology in their present state. For this reason, all 26 projects are indicated to be of substantial technical benefit to the HTGR program even without the benefit of minor modifications to include possible specific HTGR parameters, etc. However, a number of these project areas could provide a direct HTGR technology input of substantial value for what was evaluated to be only a minor cost impact. Therefore, a number of the 26 projects have also indicated in the table that a minor program cost impact would broaden their direct technical applicability into the HTGR technology field. The third category indicated in Table A-1 states that a given project could be modified to such an extent in the development of HTGR technology that its cost impact on the present EPRI project would be significant. As discussed previously, these significant cost impact project modifications are anticipated to be capable of being topics for separate programs.

Table A-2 entitled, "EPRI/HTGR Technology Transfer Projects -- Priority Ranking of Those Projects Capable of Minor Modifications," was developed to indicate the order in which these "minor modification possibility" projects might be considered for additional funding, should such means become available. The priority for these six (6) projects is based on their impact to the present HTGR technology development program. For example, RP 892, The Development of Inspection and Surveillance Methods for Primary System Piping and Pressure Vessels, was given first priority due to its immediate need by three important task areas in the completion of top and bottom head PCRV closure designs.

In summarizing the results on the review of 1979 NPD anticipated projects, the following points can be made:

1. At no cost impact to the selected EPRI projects evaluated in Appendix A, all 26 can have recognizable technical benefit to the HTGR technology program.
2. If funding to support direct HTGR technology is available, then the six (6) projects, which can accept minor modifications (see Table A-2), are the prime candidates.
3. A number of projects have also had modifications suggested that were evaluated to be significant in terms of cost impact to the present program. These modifications may be capable of being topics for separate programs.

It should be noted that the evaluation of EPRI project cost impact has been made on the basis of limited EPRI data. Clarification of indicated modifications with inputs of detailed EPRI project data may change the indicated cost impact determinations.

Table A-1 SUMMARY TABLE
EPRI/HTGR TECHNOLOGY TRANSFER PROJECTS

EPRI No.	Project Title	Possible Program Cost Impact Categories		
		None	Minor	Significant
E	Alternate Containment State-of-the-Art Review	X	X	
G	Nuclear Power Plant Fire Hazard Modeling	X		
I	On-Line Monitoring & Diagnostics for Turbine and System Machinery	X		X
NP 4826	In-Plant Instrumentation for Corrosive Conditions	X		
NP 4896	Power Plant Availability Engineering Program	X		
RP 307	Mechanics Code for LWR Transient Analysis	X		
RP 399	Full Scale Tornado and Turbine Missile Impact Test	X		
RP 502	Program to Increase the Reliability of Steam Turbine Rotors	X		
RP 504	Evaluation of Ultrasonic Tomography for Mapping Stress Fields in Thick Metal Sections	X		X
RP 603	Fundamental Study of Crack Initiation and Propagation	X	X	X
RP 609	Acoustic Techniques for Measuring Elastic Properties	X	X	
RP 700	Failure Analysis and Failure Prevention in Electric Power Systems	X	X	X
RP 810	Soil Structure Interaction	X		
RP 890	Assessment of Class 1E Equipment - Aging Qualification Tech.	X		
RP 891	On-Line Analysis of Power Plant Alarms and Disturbances	X		

Table A-1 SUMMARY TABLE (Continued)
EPRI/HTGR TECHNOLOGY TRANSFER PROJECTS

EPRI No.	Project Title	Possible Program Cost Impact Categories		
		None	Minor	Significant
RP 892	Development of Inspection and Surveillance Methods for Primary Piping and Pressure Vessels	X	X	X
RP 893	Evaluation and Test of Improved Fire-Resistant Fluid Lubricants for Water Reactor Coolant Pump Motors	X		X
RP 961	Validation of Real Time Software in Nuclear Plant Safety Applications	X		
RP 964	Seismic Testing and Analysis Program	X		
RP 969	Transport of Corrosive Salt in Dry Steam	X		
RP 1068	Deposition of Salts from Steam	X		X
RP 1125	Application of Non-Linear Signal Processing to Pipe and Nozzle Inspection	X		X
RP 1126	Human Factors Review of Power Plant Maintainability	X		
RP 1166	Corrosion Programs to Support Reliability of Nuclear LWR System	X	X	X
RP 1237	Simplified Prediction of Elastic Plastic Fractures	X		X
RP 1242	Practical Methods for Inelastic Analysis of Nuclear Power Plant Components	X		X

Table A-2. EPRI/HTGR TECHNOLOGY TRANSFER PROJECTS
PRIORITY RANKING OF THOSE PROJECTS CAPABLE OF MINOR MODIFICATION

EPRI No.	Project Title	Minor Modification	HTGR Priority for Available Funding
E	Alternate Containment - State-of-the-Art Review	Include HTGR Accident Sequence in DBDA	5th
RP 603	Fundamental Study of Crack Initiation and Propagation	Include Forgings and 2½ Cr, Alloy 800 H, Austenitic Stainless, SA-537 Cl 1&2 2½-4" Thick	4th
RP 609	Acoustic Techniques for Measuring Elastic Properties	Include HTGR Material - Alloy 800 H, 2½ Cr-1Mo	6th
RP 700	Failure Analysis and Failure Prevention in Electric Power Systems	Add Material 2½ Cr - 1 Mo & 800 H	2nd
RP 892	Development of Inspection and Surveillance Methods for Primary System Piping and Pressure Vessels	Add Material 2½ Cr - 1 Mo, Alloy 800, 800 H and HTGR Restrictive Access Areas	1st
RP 1166	Corrosion Programs to Support Reliability of Nuclear LWR Systems	Add Material 2½ Cr - 1 Mo & 800 H	3rd

----- EPRI PROGRAM INFORMATION -----

TITLE: Alternate Containment State-of-the-Art Review
DIVISION: Nuclear Power
PROGRAM AREA: Water Reactor System Technology
SUBPROGRAM: Structural Integrity

DESCRIPTION AND STATUS:

Recent interest has focused on alternate containment systems which may have a high potential for mitigating the consequences of postulated severe accidents. The objective of the program is to perform a state-of-the-art review of alternate containment concepts in order to establish practical requirements that include feasibility, performance and design criteria, and to identify those concepts which should be pursued in greater detail.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Safety

Date: 9/30/78	Rev. 0
EPRI No. E	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Safety

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

General Atomic has published a report, "HTGR Containment Design Options: An Application of Probabilistic Risk Assessment" which investigates the merits of several containment alternatives for the HTGR from the viewpoints of economics, licensability, and risk. This study has continued as part of the Accident Initiation and Progression Analysis (AIPA) study.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

The EPRI program should complement the work previously done for HTGR containments. Inclusion of containment concepts and improvements to the options previously studied will improve the data base for selecting the optimum containment for an HTGR.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The present program appears to be equally applicable to both HTGRs and LWRs; however, differences in postulated accident sequences, i.e., LOCA vs. DBDA and the inherent safety of the HTGR should be considered.

Date: 9/30/78

Rev. 0

EPRI No.

Page

E

2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Safety	1) None 2) Include HTGR accident sequences in DBDA	1) None 2) Minor	1) Generic 2) Tech. Extension

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

The suggested program modifications for the inclusion of HTGR specific accident sequences were evaluated on the information available as minor changes to the present program at EPRI. The incorporation of these additional features into the project will provide for significant technology extension. Within a total of 6 projects with recommended minor modifications, these changes suggested here would rank 5th for available funding.

Date: 9/30/78

Rev. 0

EPRI No.

Page

E

3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Nuclear Power Plant Fire Hazard Modeling
DIVISION: Nuclear Power
PROGRAM AREA: Water Reactor System Technology
SUBPROGRAM: Probabilistic Safety Analysis

DESCRIPTION AND STATUS:

Because of the complexity of the fire growth process, different materials environmental conditions, ventilation conditions and locations, different mathematical models will be needed to characterize the fire hazards and their effects on nuclear system safety. Project is intended to develop a credible methodology to quantify the effects of fire on the safety of nuclear power plant operation and to reduce the plant productivity loss due to plant fires by improving the fire protection and design.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Safety & Reliability

Date: 9/30/78	Rev. 0
EPRI No. G	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Safety & Reliability

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

Presently involved in a program to determine the safety consequences of fires from a total risk assessment approach. The study is focused on safety fires, i.e., those with core heatup potential.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

The EPRI program, because of the testing involved, would provide input to the risk assessment approach taken by General Atomic. Such parameters as heat release and smoke damage will be quantified and the sensitivity of the fire growth process to flame spread, fuel surface, ventilation, etc., can be used to quantify the risks involved in various types of fires.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The present program, due to the generic nature of the study, should provide valuable input to both HTGR and LWR safety studies.

Date: 9/30/78	Rev. 0
EPRI No. G	Page 2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Safety & Reliability	None	None	Generic

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.

G

Page

3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: On-Line Monitoring & Diagnostics for Turbines
and Primary System Machinery
DIVISION: Nuclear Power Engineering and Operations Department
PROGRAM AREA: Reliability, Availability, and Economics
SUBPROGRAM: Instrumentation and Control Engineering

DESCRIPTION AND STATUS:

Project is to determine what advances in instrumentation are required to provide early detection of flaws or failures in turbine blades and rotors, primary coolant pump seals, and coolant charging pumps.

Information on equipment abnormalities shall be compiled by a survey of all available sources, including electric utilities, machinery manufacturers, insurance companies, and other EPRI projects. To gather more data on normal and abnormal characteristics, the project is to use existing full-scale test facilities for turbines and primary coolant pumps. The project term is from 1/79 to 7/80.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Mechanical Engineering - Rotating Machinery
Control and Auxiliaries Engineering

Date: 9/30/78	Rev. 0
EPRI No. I	Page 1 of 4

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Mechanical Engineering - Rotating Machinery

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

The Rotating Machinery has utilized GA facilities for testing the main circulators and the auxiliary circulators. Their responsibility includes determination of the method of monitoring such circulator parameters as shaft speed, vibration, and performance of the seal water system. At present, they are evaluating the instrumentation philosophy used on Fort St. Vrain for applicability to the new circulator designs. The performance characteristics and method of monitoring for both the main and auxiliary circulators has not been finalized.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

Although the HTGR main turbine characteristics, i.e., operating speed and blade size, differ from those in LWR plants, any advances in instrumentation produced by this EPRI project to enable early detection of flaws in turbine blades and rotors would be of direct benefit to the HTGR program. In addition, such instrumentation would be applicable to the high pressure bearing water system of the main circulators whose seal design is analogous to the LWR coolant pump seal.

The instrumentation required for adequate monitoring of bearings on HTGR circulators is considerably different than that found in LWR primary pump areas. The auxiliary circulator has ball bearings which are exposed to a hot helium (3500° F) environment. The main circulator uses a high pressure bearing water system at the circulator itself and tilting pad radial and thrust bearings in the external electric drives. The speed for the main circulators is also slightly above that used in LWR primary coolant pumps (2200 vs. 1800 RPM).

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

This EPRI project is directly applicable to the HTGR in the area pertaining to the design of instrumented bearings and rotors required to detect flaws in the main turbine blading and rotors. In the area of the reactor coolant pump's seal system, a substantial amount of pertinent information on instrumented seals design can be transferred to the HTGR. The EPRI project could be modified for greater HTGR effect in this task area by including the design of instrumented ball bearings in a 3500° F helium environment and tilting pad radial bearings in 2200 RPM main circulator motors.

Date: 9/30/78	Rev. 0
EPRI No. I	Page 2 of 4

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Control and Auxiliaries Engineering

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

The Control and Auxiliaries Engineering Group has been working with the Rotating Machinery Group in the various phases of testing the auxiliary and main circulators. Their responsibility has been to design the various auxiliary system, i.e., the oil extraction and injection system, and to develop their associated instrumentation and control loops. In addition, they have worked to develop probes for use within the auxiliary circulator motor cavity which must withstand a 350° F cavity temperature.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

This EPRI project is applicable to the HTGR in the areas of advancing instrumentation systems for the detection of flaws or failures in the main turbine and other rotating machinery. With regard to reactor coolant pumps and their seal systems, the overall instrumentation concepts would be of direct benefit to the HTGR program. The auxiliary circulator requires unique instrumentation to withstand the elevated cavity temperatures and to monitor operation of its ball bearings.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

Instrumentation technology developed in this EPRI project for use on the main turbine is directly applicable to the HTGR program. Benefit can also be derived from that portion of the project dealing with the reactor coolant pumps and their seal systems. Viable auxiliary and main circulator instrumentation data can be obtained through implementation of modifications to the present project by the inclusion of ball bearings in high temperature environments, etc.

Date: 9/30/78	Rev. 0
EPRI No. I	Page 3 of 4

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Mechanical Engineering - Rotating Machinery	1) None	1) None	1) Generic
	2) Add auxiliary circ. ball bearings - 350°F	2) Significant	2) Tech. Extension
	3) Add main circulator bearing system	3) Significant	3) Tech. Extension
Controls & Auxiliaries Engineering	1) None	1) None	1) Generic
	2) Instr. for Aux. Circ. Ball Bearings	2) Significant	2) Tech. Extension
	3) Instr. for Main Circ.	3) Significant	3) Tech. Extension

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.

I

Page

4 of 4

----- EPRI PROGRAM INFORMATION -----

TITLE: In-Plant Instrumentation for Corrosive Conditions

DIVISION: Nuclear Power

PROGRAM AREA: Reliability, Availability, and Economics

SUBPROGRAM: Plant Chemistry and Corrosion

DESCRIPTION AND STATUS:

This project is to improve well-established measuring instrumentation methods from their existing laboratory or test loop stage to the level of operability and reliability necessary for use in operating plants. Methods for measuring pH, dissolved hydrogen, oxidation-reduction potential, chloride, and a general method for measuring all nonhydrolyzing ions to parts-per-billion (sodium, potassium, ammonium, chloride, fluoride, sulphate, carbonate, phosphate) are included. The term of this project is from 1/79 to 12/82.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Control and Auxiliaries Engineering

Date: 9/30/78	Rev. 0
EPRI No. NP 4826	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Control and Auxiliaries Engineering

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

The Control and Auxiliaries Engineering Group has not been specifically engaged in the development of improved measuring instrumentation methods. To date, existing instrumentation for on-line continuous monitoring has been considered adequate for measuring plant water chemistry.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

The subject EPRI project is directly applicable to the HTGR program. Since the feedwater chemistry requirements for this type of plant are comparable to those for a PWR, the development of improved measuring instruments would be equally beneficial to both reactor programs. In addition, the HTGR could utilize these new instruments on the PCRV liner cooling system whose water chemistry is also closely monitored.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The EPRI project in its present format is directly applicable to the HTGR. No unique modifications or additions are required.

Date: 9/30/78	Rev. 0
EPRI No. NP 4826	Page 2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Control and Auxiliaries	None	None	Generic

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.

NP 4826

Page

3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Power Plant Availability Engineering Program
DIVISION: Nuclear Power
PROGRAM AREA: Reliability, Availability, and Economics
SUBPROGRAM: Plant Operations and Engineering
DESCRIPTION AND STATUS:

Recently, the concept of implementing a comprehensive availability engineering program throughout the life cycle of the plant has become a desirable goal for many utilities. The objective of this project is to bring together in a single-source document current experience and developments in reliability technology having application to power plant availability engineering and provide a model for implementing availability engineering into the design, construction, and operation activities of power plants. The basic model developed in this project can then be tailored by utilities to meet their specific needs.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Safety & Reliability

Date: 9/30/78	Rev. 0
EPRI No. NP 4896	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Safety & Reliability

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

General Atomic had performed a similar analysis on the Fort St. Vrain helium circulators as a pilot program to assess the methodology of availability engineering.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

The utility interest in plant performance and reliability cannot be understated; thus, all efforts resulting in reduced outages are of primary importance to suppliers. The EPRI program will complement the work performed by General Atomic and lead to increased performance of power plant systems and components.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The program, as stated, appears to be directed toward developing a methodology for power plant availability engineering that can be modified by individual utilities to meet their specific needs. In this case, the program is equally applicable to both HTGR and LWR power plants.

Date: 9/30/78	Rev. 0
EPRI No. NP 4896	Page 2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Safety & Reliability	None	None	Generic

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.
NP 4896Page
3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Continuum Mechanics Codes for LWR Transient Analysis

DIVISION: Nuclear Power

PROGRAM AREA: Water Reactor System Technology

SUBPROGRAM: Structural Integrity

DESCRIPTION AND STATUS:

Provide for a user-oriented, high frequency, finite difference, transient stress analysis code STEALTH. Applications of the code include soil structure interaction, fluid structure interaction, waterhammer and waste deposits. Short versions of the code for "special applications" will be developed following the successful documentation of the general purpose code.

The two-dimensional version of the code has been distributed. Distribution of the three-dimensional version will begin following the completion of additional example calculations.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Structural Mechanics

Date: 9/30/78	Rev. 0
EPRI No. RP 307	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Structural Mechanics

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

General Atomic is continuously investigating new analytical techniques due to the high technology areas involved in all phases of design and analysis of nuclear power plant systems and components.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

STEALTH can augment the various analytical methods available in the structural mechanics area with direct applicability to two rather difficult problems:

1. fuel storage well analysis - fluid structure interaction during accident (seismic) conditions.
2. soil structure interaction.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The current EPRI program can be applied directly to the HTGR program with no modifications.

Date: 9/30/78	Rev. 0
EPRI No. RP 307	Page 2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Structural Mechanics	None	None	Generic

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.
RP 307Page
3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Full-Scale Tornado & Turbine Missile Impact Tests
DIVISION: Nuclear Power
PROGRAM AREA: Water Reactor System Technology
SUBPROGRAM: Structural Integrity
DESCRIPTION AND STATUS:

Full-scale tests of tornado and turbine missiles impacting nuclear power plant structures. Tornado missile tests involved impacts of reinforced concrete panels by missiles such as utility poles and pipes. Turbine missile testing first consists of impacts of full-scale simulated turbine casings to determine the exit conditions of fragments from failed, shrunk-on discs in plants with a non-peninsular turbine arrangement. These tests will be supplemented with subscale versions to assess the feasibility of scale modeling as an alternative to full-scale testing. The second phase consists of impacts of full-scale reinforced concrete structures representing nuclear plant walls.

Completed:

Full-scale tornado missile tests
Full-scale turbine casing exit tests

Remaining:

Design of target walls and backup structures for turbine missile impact tests of full size structures.
Analytical simulations of the full-scale casing exit tests. Results of different approaches to be compared with test data.
Increased scope of full-scale concrete structures tests to improve quality of impact load measurements and different targets such as prestressed concrete.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Structural Mechanics

Date: 9/30/78	Rev. 0
EPRI No. RP 399	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Structural Mechanics

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

General Atomic has no experimental data in this area; however, they do draw upon current industry-wide programs for applicable data useful in the design and analysis of power plant structures and equipment.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

The current program will provide valuable information applicable to the design and analysis of virtually all power plant structures. Potential benefits arise from the reduction in design margins and simplified procedures for tornado and turbine missile protection. Results may also benefit the pipe whip analysis effort.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

This program is equally applicable to all nuclear power plants with, perhaps, more interest in the HTGR due to the high speed of the turbine and a potentially higher energy missile.

Date: 9/30/78	Rev. 0
EPRI No. RP 399	Page 2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Structural Mechanics	None	None	Generic

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.
RP 399Page
3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: A Program to Increase the Reliability of Steam Turbine Boilers

DIVISION: Nuclear Power

PROGRAM AREA: Reliability, Availability, and Economics

SUBPROGRAM: Plant Materials and Processes

DESCRIPTION AND STATUS:

The objective of this program is to ensure the integrity of the forged turbine rotor spindle by advancing inservice nondestructive evaluation techniques and interpreting the significance of their results in an analytical lifetime prediction system. A thermoelastic stress computer program and a fracture mechanics analysis model have been completed for two types of rotors. These program-inspected rotors are to be cut apart for various material test specimens and certain defects evaluated and compared to the bore-sonic-indicated imperfections.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

HTGR Systems Engineering - BOP

Date: 9/30/78	Rev. 0
EPRI No. RP 502	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: HTGR Systems Engineering - BOP

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

The Balance of Plant is not actively engaged in the development of advanced inservice non-destructive evaluation techniques. Such test methods are generally developed and perfected by turbine manufacturers and inspection agencies.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

The subject EPRI Program is directly applicable to the HTGR main turbine rotor inspection program. Although the HTGR machines operate at 3600 rpm and possess smaller LP section blading, the techniques of this program could still be used on these rotors to detect and evaluate flaws and to predict the future performance and reliability of the machine.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

This EPRI Program establishes a system for determining the integrity and reliability of turbine rotors in large steam generating plants. In its present format, this program is directly applicable to both LWR and HTGR plants. No further additions or modifications are required.

Date: 9/30/78	Rev. 0
EPRI No. RP 502	Page 2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
HTGR Systems Engineering, BOP	None	None	Generic

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.
RP 502Page
3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Evaluation of Ultrasonic Tomography for Mapping of Stress Fields in Thick Metal Sections

DIVISION: Nuclear Power

PROGRAM AREA: Water Reactor System Technology

SUBPROGRAM: Primary and Secondary Pressure Boundary

DESCRIPTION AND STATUS:

In the past, designers, structural analysts, and regulators have been forced to make very conservative assumptions concerning residual stresses. These conservative assumptions could lead to extended outages for repair of flaws which, if actual residual stresses were known, could be shown to be safe. Residual stress is also an important factor in the initiation and propagation of stress corrosion cracks in stainless steel piping. The objective of this project is to develop a device to measure residual stresses in thick ferritic pressure vessel steel and austenitic stainless steel piping.

Completed:

Laboratory test have demonstrated an accuracy of 1 ksi out of 120 ksi on heavy ferritic pressure vessel plate.

Work proceeding to develop field capabilities.

Remaining:

Develop acoustic stress velocity data for stainless steel.

Modify stress reconstruction software for piping geometry.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Heat Exchangers, Applied Mechanics

Date: 9/30/78	Rev. 0
EPRI No. RP 504	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Heat Exchangers, Applied Mechanics

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

Tests have been conducted on steam generator thru diameter tube bends to measure residual stress and strain. X-ray diffraction, chip removal, and stress corrosion techniques were employed for residual stress measurement and microhardness and hole drilling for residual strain.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

Directly applicable to the main steam piping and could be of great value in evaluating residual stresses in forgings and small diameter tubes (i.e., steam generator, core auxiliary heat exchanger).

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The inclusion of thick-walled forgings would provide considerable information to analysts concerning stress distributions to both the HTGR and LWR industry. Extension of the program to include small diameter tubing and various materials (2½ Cr; Alloy 800 H) would aid in reducing design margins in the heat exchangers.

Date: 9/30/78	Rev. 0
EPRI No. RP 504	Page 2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Heat Exchangers Applied Mechanics	1) None 2) Include small dia- meter tubes in HTGR Materials (Alloy 800 H & 2½ Cr) 3) Include thick- walled forgings in HTGR materials	1) None 2) Significant 3) Significant	1) Generic 2) Tech. Extension 3) Tech. Extension

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.
RP 504Page
3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Fundamental Study of Crack Initiation and Propagation

DIVISION: Nuclear Power

PROGRAM AREA: Water Reactor Systems Technology

SUBPROGRAM: Primary and Secondary Pressure Boundary

DESCRIPTION AND STATUS:

Establish basic predictive capability requirements for potential failure of the pressure vessel in the presence of material flaws. A coupled calculational and experimental approach will be used to predict crack initiation and propagation. Will lead to simplified design methods in fracture problems.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Structural Materials

Date: 9/30/78	Rev. 0
EPRI No. RP 603	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Structural Materials

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

General Atomic maintains an effort to remain aware of the state-of-the-art in fracture mechanics and crack initiation and propagation.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

Assuming the current program is directed toward the light water reactor industry, the primary effort is concerned with relatively low temperatures and LWR materials. Although any approach which can simplify design methods in fracture problems is generically applicable, an ideal program in this area would include the following topics:

1. forgings
2. elevated temperature ($>1000^{\circ}$ F) crack propagation in HTGR materials ($2\frac{1}{2}$ Cr, Alloy 800 H, Austenitic Stainless Steel)
3. SA537 Class 1 & 2 $2\frac{1}{2}$ - 4" thick.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The program, as currently stated, will provide considerable guidance for design methods in fracture problems; however, the high temperature environment common to HTGR's places additional stress on structural materials, forcing the use of more temperature-resistant alloys.

Date: 9/30/78	Rev. 0
EPRI No. RP 603	Page 2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Structural Materials	1) None	1) None	1) Generic
	2) Include forgings and HTGR materials (2½ Cr, Alloy 800H, austinitic stain- less steel, SA 537 Class 1 & 2 2½ - 4" thick)	2) Minor	2) Tech. Extension
	3) Include high temperatures (> 1000° F) and HTGR materials	3) Significant	3) Tech. Extension

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

The suggested program modifications for new materials and shapes (forgings) unique to the HTGR were evaluated on the information available as minor changes to the present program at EPRI. The incorporation of these additional features into the project will provide for significant technology extension. Within a total of 6 projects with recommended minor modifications these changes suggested here would rank 4th for available funding.

Date: 9/30/78

Rev. 0

EPRI No.

Page

RP 603

3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Acoustic Techniques for Measuring Elastic Properties

DIVISION: Nuclear Power

PROGRAM AREA: Reliability, Availability, and Economics

SUBPROGRAM: Diagnostics and Evaluation

DESCRIPTION AND STATUS:

The project is to evaluate three acoustic approaches for measurement of material elastic properties:

1. acoustic wave phase contrast monitoring
2. measurement of the plane of polarization rotation of shear acoustic waves
3. measurements based on material nonlinear acoustic wave propagation characteristics.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Structural Materials

Date: 9/30/78	Rev. 0
EPRI No. RP 609	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Structural Materials

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

No programs currently exist specifically in this area; however, the early identification of premature mechanical failure through material parameters is recognized as a potentially valuable technique that could lead to significant economic savings.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

The EPRI program can be used to augment the current HTGR inservice inspection program as a means of identifying potentially dangerous situations; i.e., locate areas with deteriorating material properties that could develop cracks more readily.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The program appears to be equally beneficial to both HTGRs and LWRs provided a sufficiently wide range of materials is investigated.

Date: 9/30/78

Rev. 0

EPRI No.

Page

RP 609

2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Structural Materials	1) None 2) Include HTGR materials (Alloy 800 H, 2½ Cr)	1) None 2) Minor	1) Generic 2) Tech. Extension

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

The suggested program modifications for new materials common in HTGR power plants were evaluated on the information available as minor changes to the present programs at EPRI. The incorporation of these additional features into this project will provide for significant technology extension. Within a total of 6 projects with recommended minor modifications, these changes suggested here would rank 6th for available funding.

Date: 9/30/78	Rev. 0
EPRI No. RP 609	Page 3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Failure Analysis and Failure Prevention in Electric Power Systems
DIVISION: Nuclear Power
PROGRAM AREA: Reliability, Availability, and Economics
SUBPROGRAM: Diagnostics and Evaluation

DESCRIPTION AND STATUS:

This continuing project includes: (1) root-cause failure diagnostics; (2) development of improved probabilistic failure prediction methods; (3) specific application of Task (2) failure prediction methods to pressure vessel reliability, condenser, and feedwater systems malfunction analysis. Conventional and new influence functions have been incorporated into a single computer program (BIGIF) for fracture mechanics analysis of cracks in numerous complex structures, and the ASME Code Section XI (Evaluation of In-surface NDI Indications) has been computerized. A new eddy current system used to measure dented/ovalized steam generator tubes will be evaluated for use with inner diameter surface inspections on Zircaloy fuel rod tubes.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Heat Exchangers, Applied Mechanics

Date: 9/30/78	Rev. 0
EPRI No. RP 700	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Heat Exchangers, Applied Mechanics

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

General Atomic has expressed concern for investigations of the safety aspects of high temperature pressure boundaries such as in the steam generator tubesheet and penetration area.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

The primary interest in this program lies in the methodology utilized in failure analysis and prediction and their adaptability to a high temperature environment.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

It is assumed that this project scope is very general and applies to all types of nuclear plants including the HTGR. More pertinent data to the HTGR can be generated by including the temperatures (1000° F) and materials (2½ Cr. Alloy 800 H) used in the high temperature pressure boundaries.

Date: 9/30/78	Rev. 0
EPRI No. RP 700	Page 2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Heat Exchangers - Applied Mechanics	1) None 2) Add 2¼ CR-1Mo and Alloy 800 H 3) Use High Temp (10000° F) and 2¼ Cr-1Mo, and Alloy 800 H	1) None 2) Minor 3) Significant	1) Generic 2) Technology Extension 3) Technology Extension

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

The suggested program modifications for new materials (2¼ Cr and Alloy 800 H) were evaluated on the information available as minor changes to the present program at EPRI. The incorporation of these additional features into the project will provide for a definite technology extension. Within a total of 6 projects, with possible minor cost impact modifications, the changes suggested here would rank 2nd for available funding.

Date: 9/30/78

Rev. 0

EPRI No.

Page

RP 700

3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Soil Structure Interaction
DIVISION: Nuclear Power
PROGRAM AREA: Water Reactor System Technology
SUBPROGRAM: Structural Integrity

DESCRIPTION AND STATUS:

An integrated soil structure interaction program including soil models development, in situ testing techniques, system analysis, and experimental data base from explosive tests. Will provide alternative methods for nonlinear analysis and a data base for comparison by all techniques.

Completed:

Two explosive tests completed. Significant reduction in the fundamental rocking frequency from the critical prediction observed.

Several system analysis compared with measured data.

Optional system analysis method treating the event as a general wave propagation phenomenon for response due to large strain, high intensity events.

Development of three-dimensional nonlinear endochronic constitutive soil models.

Evaluation of in situ testing methods for high amplitude, dynamic soil property determination.

Remaining:

Modify three-dimensional, endochronic, constitutive soil model to a user-oriented format for wider applications.

Additional site soil tests necessary to provide a better data base.

Explosive tests with scaled structures on bedrock being considered.

Placement of scaled structures in active seismic regions under consideration.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Structural Mechanics

Date: 9/30/78

Rev. 0

EPRI No.
RP 810Page
1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Structural Mechanics

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

General Atomic has developed a computer code (finite element) for soil structure interaction analysis (FLUSH) and generally utilizes site specific data available as a result of the site selection investigations.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

All data acquired on soil properties would be useful, particularly that which is related to strain rate (dynamic) effects and damping. Correlations of soil property and strain level, especially at large levels of strain, are also applicable.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

EPRI Program is directly applicable to the HTGR program without modification.

Date: 9/30/78

Rev. 0

EPRI No.

Page

RP 810

2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Structural Mechanics	None	None	Generic

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.
RP 810Page
3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Assessment of Class 1E Equipment Aging and
Qualification Technologies
DIVISION: Nuclear Power
PROGRAM AREA: Water Reactor System Technology
SUBPROGRAM: Light Water Reactor System Behavior and Control
DESCRIPTION AND STATUS:

The work comprises (1) a state-of-the-art survey to gather together the known material aging to wear models which may be useful in meeting aging requirements, (2) development of individual state-of-the-art aging procedures for a select cross section of class 1E equipment, and (3) a technical critique of developed procedures to determine the extent to which present aging requirements can be realistically met.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Control and Auxiliaries Engineering

Date: 9/30/78	Rev. 0
EPRI No. RP 890	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Control and Auxiliaries Engineering

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

General Atomic has been involved in equipment aging programs from a modeling standpoint, evaluating various methods and their applicability to the IEEE qualification procedures.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

The HTGR presents generally the same type problems as an LWR as far as aging qualification of equipment is concerned. The only unique situation can be the auxiliary circulator motors which are located in a helium environment, the consequences of which remain to be determined.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The program is aimed at an evaluation of aging technology and aging requirements, problems common to all nuclear power plants and, as such, can be applied directly to the HTGR program.

Date: 9/30/78

Rev. 0

EPRI No.
RP 890

Page
2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Control and Auxiliaries	None	None	Generic

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.
RP 890Page
3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: On-Line Analysis of Power Plant Alarms & Disturbances
DIVISION: Nuclear Power
PROGRAM AREA: Water Reactor System Technology
SUBPROGRAM: LWR System Behavior
DESCRIPTION AND STATUS:

On-Line Analysis of Power Plant Alarms and Disturbances: The purpose of this two (2) year project is to develop and demonstrate the feasibility of a methodology for on-line analysis of power plant alarms and disturbances. The detailed functional objectives and a representative subset of possible plant disturbances will be identified for consideration. The process of sorting out relevant information and integrating it in a timely and understandable fashion has become more complex. The potential benefits from the project are great if it can help to avert or mitigate the consequences of off-normal plant conditions.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Control and Auxiliaries Engineering

Date: 9/30/78	Rev. 0
EPRI No. RP 891	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Control & Auxiliaries Engineering

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

The work performed by the Control and Auxiliaries Group has consisted not of linking plant alarms and disturbance to a computer for analysis, but connecting certain trip alarms to a task number which relates to a text where explanations and corrective measures are presented.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

This project involves determining the feasibility of a methodology for on-line analysis of plant alarms utilizing a representative subset of plant disturbances. This methodology could be directly applied to the HTGR program to analyze plant disturbances which are either common to the LWR or unique to the HTGR.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The methodology for on-line analysis under development in this EPRI project is general in nature and is of direct benefit to either LWRs or HTGRs. Although the inputted plant disturbances are LWR related, the feasibility of this methodology to mitigate the consequences of these disturbances is the applicable segment to the HTGR program. Therefore, the EPRI project is supportive of the HTGR and requires no modification.

Date: 9/30/78	Rev. 0
EPRI No. RP 891	Page 2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Control & Auxiliaries	1) None	1) None	1) Generic

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.
RP 891Page
3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Development of Inspection and Surveillance Methods
for Primary System Piping and Pressure Vessels
DIVISION: Nuclear Power
PROGRAM AREA: Reliability, Availability, and Economics
SUBPROGRAM: Diagnostics and Evaluation
DESCRIPTION AND STATUS:

The objective of this project is to substantially increase the ability to find and characterize flaws in pressure vessels and piping by improved discrimination, calibration, and reproducibility of ASME code-approved inservice ultrasonic inspection techniques and procedures. This three-year project is expected to be completed in 1980.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Structural Mechanics
HTGR Systems Engineering - BOP/ISI
Heat Exchangers

Date: 9/30/78	Rev. 0
EPRI No. RP 892	Page 1 of 5

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Structural Materials

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

The Structural Materials Group has been actively utilizing current ultrasonic inspection procedures on various materials as part of a QA program in the manufacturing of equipment. In addition, they have been studying different techniques in order to determine an optimum method of examining unique HTGR materials.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

This EPRI program involving the improved ability to find and characterize flaws in various materials is of direct benefit not only to LWRs but also to HTGRs. Some items covered in this program which are common to both types of reactors include examination of clad and unclad vessel nozzles, stainless steels, and of bimetallic and trimetallic welds. Further applicability of this program to the HTGR can be achieved by including unique materials such as Alloy 800, Alloy 800H, and 2½CR-1Mo in the list of materials considered.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The subject EPRI program is considered to be directly applicable to both LWRs and HTGRs due to the similarity of most materials used in these types of plants. Development of preferred ASME code approved ultrasonic inspection techniques would serve to standardize inspections methods used both in the manufacture of nuclear components and for the inservice inspection of such components in LWRs and HTGR. Further support of the HTGR program can be achieved by expanding the scope of the EPRI project to include the unique HTGR materials and inspection situations.

Date: 9/30/78	Rev. 0
EPRI No. RP 892	Page 2 of 5

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: HTGR Systems Engineering - BOP/ISI

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

The ISI Group has prepared an ASME Code Publication on HTGR Inservice Inspection which has been in circulation for industry review for one year. This document contains all the subsections of the comparable LWR subsection to the ASME Code Section XI plus additional subsections on Concrete Reactor System and Compressors. An additional subsection on Surveillance on Elevated Temperature Metals has been scheduled for submittal to the ASME subcommittee on 9/78. This document deals with specific components as the steam generator, CAHE, control rods, and core restraints. Another subsection on non-metallics dealing with the reactor internals is still in draft form. The ISI Group has also worked in conjunction with an outside inspection agency on the development of a transport ultrasonic probe to be used for inspecting the steam generator and CAHE tube

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA bundles.

This EPRI project of developing improved ultrasonic inspection techniques and procedures is directly beneficial to the ISI Group in their area of revising the ASME Code and establishing procedures for their special pieces of equipment, i.e., the reactor core, CAHE, and the steam generators.

In addition, the ISI Group could more directly benefit from this EPRI project if it is expanded to include unique HTGR inspection areas. These include inspection methods such as allowable access and probe design for weld and surface inspection on the various liner penetration transition pieces. Procedures for inspecting bimetallic welds, particularly on vessel connections and on the backing strips on the liner transition pieces, are also needed.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The subject EPRI project is directly beneficial to both LWRs & HTGRs from the standpoint of improving and developing inspection techniques capable of serving the common materials and components present in these plants. Further applicability to the HTGR can be achieved by increasing the scope of the EPRI project to include its unique access and material problems.

Date: 9/30/78	Rev. 0
EPRI No.	Page
RP 892	3 of 5

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Heat Exchangers

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

The Heat Exchanger Group has proceeded with the design of the primary coolant heat exchangers in accordance with an established program to confirm the feasibility of ISI on typical heat exchanger pressure boundary penetrations. This program consists of examining several task areas. These include:

1. Testing to determine the inspectability of bimetallic welds and welds made on safe ends for various materials and thickness parameters.
2. Testing to determine inspectability of welds made with backing strips for material, environment and thickness parameters.
3. Tests to determine minimum access required for manual and remote inspection.
4. Tests to determine the inspectability of various shapes and sizes.
5. Inspection of surfaces at temperatures between 240 & 360° F.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

This EPRI Program is directly applicable to the design work being performed by the Heat Exchanger Group. Several critical ISI areas in their equipment can utilize the improved ultrasonic inspection techniques under the scope of the EPRI program. These areas include the development of a transportation type probe for inspection of the steam generator tubing. This probe must be qualified to inspect helical and straight tubes of varying material, diameter, and thickness of down to 5/8" ID.

In addition, the HTGR core must be kept hot during shutdown conditions. This requires the development of ISI techniques and procedures compatible with inspection of material surfaces at 300° F.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

This EPRI program concerning the development of improved ISI techniques and procedures is directly applicable to both HTGRs and LWRs. Both types of reactor plants can readily use advanced methods of inspection and surveillance to assure both licensability and reliability of equipment. To further support the HTGR program, additional items could be included in the scope of this EPRI project. As mentioned above, unique steam generator tube inspection equipment is needed along with improved inspection techniques pertaining to elevated surface temperatures. Although these items are initially unique to the HTGR, development of such advanced equipment and procedures could serve to improve ISI programs on LWRs as well.

Date: 9/30/78

Rev. 0

EPRI No.

Page

RP 892

4 of 5

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Structural Materials	1) None 2) Add Alloy 800, 800 H, 2½ Cr-1 Mo	1) None 2) Minor	1) Generic 2) Tech. Extension
BOP/ISI	1) None 2) Add HTGR restrictive access areas for technique definition	1) None 2) Minor	1) Generic 2) Tech. Extension
Heat Exchanger	1) None 2) Elevated Temp.(300°F) 3) Varying tube geometry**	1) None 2) Significant 3) Significant	1) Generic 2) Tech. Extension 3) Tech. Extension

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

The suggested program modifications for new material and restrictive access areas unique to the HTGR were evaluated on the information available as minor changes to the present program at EPRI. The incorporation of these additional features into this project will provide for significant technology extension. Within a total of 6 projects with recommended minor modifications, these changes suggested here would rank 1st for available funding.

**General Atomic possesses a substantial background in the development of ultrasonic tube inspection techniques. Therefore, this development issue should be investigated in depth by EPRI and GCRA personnel to determine if the indicated evaluation correctly assesses this important area.

Date: 9/30/78	Rev. 0
EPRI No. RP 892	Page 5 of 5

----- EPRI PROGRAM INFORMATION -----

TITLE: Evaluation and Test of Improved Fire-Resistant Fluid Lubricants for Water Reactor Coolant Pump Motors
DIVISION: Nuclear Power
PROGRAM AREA: Water Reactor System Technology
SUBPROGRAM: Component Technology

DESCRIPTION AND STATUS:

Select and demonstrate a more fire-resistant lubricant as practical for application in a reactor coolant pump motor. Process involves evaluation, analysis, additive addition, selection, and testing of a fire resistant lubricant for pump motors with procurement and application documentation. If a more fire resistant lubricant can be developed and proven acceptable, it would reduce a fire hazard in a critical plant component. This two-year project is scheduled to be completed in 1980.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Mechanical Engineering - Rotating Machinery
Control and Auxiliaries Engineering

Date: 9/30/78	Rev. 0
EPRI No. RP 893	Page 1 of 4

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Mechanical Engineering - Rotating Machinery

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

The Rotating Machinery Group has been involved in various tests performed on both the main and auxiliary circulators. Recent full scale, full speed bearing tests were conducted on the auxiliary circulators. Results on the performance of the bearings were satisfactory, however, significant foaming of the lubricating oil was experienced. Following this test, concerns were expressed about the possible degassifying of the oil following a DBDA and increase of the auxiliary circulator to full speed.

Testing by the Rotating Machinery Group of commercial size main circulators was last performed as part of the manufacturing program for previously contracted HTGR customers. Limited irradiation tests have been conducted on various oils. No testing has been done on fire resistant oils.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

Technology developed in the subject EPRI program would be directly applicable to this GA task area, however, certain unique HTGR parameters should be examined. The bearing designs of the reactor coolant pumps considered in the EPRI program are typically journal/sleeve types. The auxiliary circulators and the main circulators have ball and tilting pad type bearings, respectively. The Rotating Machinery Group stated that a fire resistant lubricant is desirable for use in their equipment; however, its development program should include testing its performance on the HTGR equipment bearing designs.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

In general, a program to develop a fire resistant lubricant is applicable to HTGR equipment. The auxiliary and main circulators have oil lubrication systems similar in size and design to those associated with the LWR reactor coolant pumps considered in the subject EPRI program. However, the program should be expanded to include the examination of the effects of a developed fire resistant lubricant upon the performance of the various bearing systems mentioned above. This item is considered a minor change and would result in an EPRI program directly applicable to both LWRs & HTGRs.

Date: 9/30/78	Rev. 0
EPRI No. RP 893	Page 2 of 4

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Control and Auxiliaries Engineering

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

The Control and Auxiliaries Engineering Group has been involved with the Rotating Machinery Group in the performance of the various tests on the main and auxiliary circulators as described on page 2. The Control and Auxiliaries Group responsibility included design of the oil lubrication system auxiliaries such as the heat exchanger and oil reserve system, and development of the instrumentation and controls for that system.

This group has also interfaced with the motor manufacturer for the auxiliary and main circulators in the areas of the oil lubrication system, its operating conditions, size, and operating environment.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

Development of a fire resistant lubricant would directly benefit the HTGR program from the standpoint of reducing the fire hazard concerns within the containment building. The auxiliary circulator system contains an oil inventory of 7 gallons while each main circulator system has a capacity of 250 gallons. Located atop the PCRV, these systems pose a particularly critical fire hazard. A fire resistant lubricant for use in these applications could significantly reduce the potential for fire damage and the size and complexity of a fire suppression system.

The Control and Auxiliaries Group did state, however, that before a fire resistant lubricant can be accepted for use in these applications, tests should be performed to determine its compatibility with unique HTGR conditions. Such tests should include determination of specific heat, maximum operating temperature and, in the case of the auxiliary circulators, performance within a helium environment at an elevated temperature.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The subject EPRI program is directly applicable to the HTGR, particularly in the area of the auxiliary and main circulators whose oil lubrication systems are comparable to those on the reactor coolant pumps in LWRs. Fire resistant lubricants could be used on other HTGR rotating machinery also. Complete applicability to the HTGR cannot be realized, however, without expanding the EPRI program to include demonstrating compatibility of the new lubricant with the operating and environmental conditions unique to the HTGR equipment. With this minor modification, the subject EPRI program would be applicable to both LWRs and HTGRs and would serve to reduce fire hazard concerns and to improve licensability of these reactor systems.

Date: 9/30/78	Rev. 0
EPRI No. RP 893	Page 3 of 4

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Mech. Engineering Rotating Machinery	1) None 2) Include ball and tilted pad type bearing	1) None 2) Significant	1) Generic 2) Tech. Extension
Control and Auxiliaries	1) None 2) Helium environment 1770 C	1) None 2) Significant	1) Generic 2) Tech. Extension

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.

RP 893

Page

4 of 4

----- EPRI PROGRAM INFORMATION -----

TITLE: Validation of Real-Time Software in Nuclear Plant
Safety Application

DIVISION: Nuclear Power - Safety and Analysis Department

PROGRAM AREA: Water Reactor System Technology

SUBPROGRAM: LWR System Behavior and Control

DESCRIPTION AND STATUS:

This project is an attempt to improve the reliability of the software programs governing the digital computers now in increased use in nuclear power plants for safety and control applications. The objectives are to establish guidelines for software development that will improve reliability and help ensure testability and to develop and demonstrate a procedure for validating the reliability of this safety-system software. The proposed completion date for this project is 9/79.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Control and Auxiliaries Engineering

Date: 9/30/78	Rev. 0
EPRI No. RP 961	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Control and Auxiliaries Engineering

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

The Control and Auxiliaries Engineering Group is presently hard wiring the systems within their responsibility. They are not utilizing the digital computers included in the EPRI project. Consideration is being given, however, to digitalizing the Plant Protection System.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

This EPRI project is concerned with development of guidelines for improving the reliability of software programs. It deals with this item in a general manner such that benefits can be derived by both LWRs and HTGRs. Although present HTGR systems are hard wired, development of this reliable software program could result in its utilization in HTGR systems yet to be finalized, i.e., Plant Protection System.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The subject EPRI project, in its present format, is directly applicable to the HTGR program. Since there are no unique HTGR requirements pertaining to this area, no additions or modification to the program are required.

Date: 9/30/78	Rev. 0
EPRI No. RP 961	Page 2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Control & Auxiliaries	1) None	1) None	1) Generic

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.

RP 961

Page

3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Seismic Testing and Analysis Program
DIVISION: Nuclear Power
PROGRAM AREA: Water Reactor System Technology
SUBPROGRAM: Structural Integrity

DESCRIPTION AND STATUS:

Broad based experimental and analysis program required to identify and quantify the conservatisms inherent in present seismic design procedures and criteria for reactor structures and components. Consolidated Edison Company has offered Indian Point 1 to provide a full scale test data base for components relating to current and future seismic designs. The project will provide data and analysis methods of sufficiently broad scope to allow for an increase of design damping values, more realistic guidelines for piping analysis, assessment of fluid/structure interaction phenomena and improved procedures for plant requalification.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Structural Mechanics
Heat Exchanger, Applied Mechanics

Date: 9/30/78	Rev. 0
EPRI No. RP 964	Page 1 of 4

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Structural Mechanics

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

Testing programs have been limited to HTGR specific problems such as the core seismic program, however, analytical techniques are being constantly upgraded.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

The EPRI program can be used to verify analytical techniques for seismic analysis of systems and components, establish new procedures for design and analysis, and reduce conservatisms that currently exist in the seismic area.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The program, as it stands, will provide a substantial input to the design and analysis efforts in all nuclear power plants.

Date: 9/30/78	Rev. 0
EPRI No.	Page
RP 964	2 of 4

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Heat Exchangers, Applied Mechanics

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

Primarily concerned with the damping values to be used in steam generator seismic analysis (because the NRC Regulatory Guide 1.61 value of 2% is considered excessively conservative for a helically coiled steam generator), tests are currently planned at Saclay, France, to measure steam generator damping.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

The EPRI program will complement the efforts of the Heat Exchanger Applied Mechanics department in reducing the conservatism in seismic analysis. The primary interest lies in the large scale seismic test programs and the acceptability of the test results to the NRC for justifying higher damping values.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The current program can be applied directly to the HTGR.

Date: 9/30/78

Rev. 0

EPRI No.

Page

RP 964

3 of 4

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Structural Mechanics	None	None	Generic
Heat Exchanger Applied Mechanics	None	None	Generic

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.

Page

RP 964

4 of 4

----- EPRI PROGRAM INFORMATION -----

TITLE: Transport of Corrosive Salts in Dry Steam
DIVISION: Nuclear Power
PROGRAM AREA: Water Reactor System Technology
SUBPROGRAM: Plant Chemistry and Corrosion

DESCRIPTION AND STATUS:

Obtain a reliable set of data for the solubility of pure and mixed steam generator corrosive salts in dry steam over the temperature range from 100 - 800° C and from 15-5000 psi. Data will allow the calculation of the rate of deposition of corrosive salts in the turbine for a given concentration of salts in the steam generator feedwater and may be used to set boiler and feedwater specifications for minimizing salt corrosion.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Structural Materials

Date: 9/30/78	Rev. 0
EPRI No. RP969	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Structural Materials

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

The Structural Materials Group has made use of existing industry data in this area of salt solubility in dry steam to establish the various water chemistry requirements.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

Available industry information on the solubility of salts covering full steam conditions experienced in turbines is quite limited. This EPRI project of establishing a reliable set of data for this situation would be directly beneficial to both the LWR and HTGR programs.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The scope of this EPRI project encompasses the steam conditions anticipated in the HTGR cycle and is, therefore, directly applicable to the HTGR without modification.

Date: 9/30/78	Rev. 0
EPRI No. RP 969	Page 2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Structural Materials	None	None	Generic

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.

Page

RP 969

3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Deposition of Salts from Steam
DIVISION: Nuclear Power
PROGRAM AREA: Reliability, Availability, and Economics
SUBPROGRAM: Plant Chemistry and Corrosion
DESCRIPTION AND STATUS:

This project is to determine which factors can and must be controlled to maintain corrosion safe environments for the steam turbine internals. This project will provide data on the range of corrosive conditions on turbine surfaces relative to different steam and feedwater conditions under both steady state and cycling loads in PWRs. This forty-two month project is scheduled to be completed in 1980.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:
Structural Materials

Date: 9/30/78	Rev. 0
EPRI No. RP 1068	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR-RELATED TASK AREA: Structural Materials

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

The HTGR utilizes a once-through steam generator design which requires that a minimum concentration of impurities exist in the feedwater. The Structural Materials Group has concentrated their design efforts in this area of establishing water chemistry requirements to prevent corrosion in the steam generators. Maintaining a corrosion-safe environment for the main turbine internals is a matter which is of generic interest to all steam cycle plants, including the HTGR.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

The HTGR design is mainly concerned with maintaining a corrosion-safe environment for their specific pieces of equipment, i.e., the steam generators. For this effort, the Structural Materials Group has established specific feedwater chemistry requirements. The requirements are comparable to those developed for the feedwater systems in PWRs. Therefore, this EPRI project, which provides data on the potential corrosion conditions on turbine surfaces relative to different feedwater and steam conditions, is applicable to the HTGR. Considerations should be given, however, to modify the project to include data based on the unique HTGR main steam conditions (1000° F, 2500 psig at HP inlet).

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

Control of plant parameters to maintain corrosion-safe environments for the main turbine internal is of major concern with all types of steam generation plants. This EPRI project, which deals exclusively with PWRs, is considered partly applicable to the HTGR program due to the similarity of the feedwater conditions between the two types of plants. A more complete benefit to the HTGR program can be achieved by expanding the scope of the project to include the effects of the superheated main steam conditions (1000° F, 2500 psig).

Date: 9/30/78	Rev. 0
EPRI No. RP 1068	Page 2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Structural Materials	1) None 2) Incorporate 1000° F. 2500 psig steam conditions	1) None 2) Significant	1) Generic 2) Complete Technology Development

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.

RP 1068

Page

3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Application of Nonlinear Signal Processing to
Pipe and Nozzle Inspection

DIVISION: Nuclear Power

PROGRAM AREA: Reliability, Availability, and Economics

SUBPROGRAM: Diagnostics and Evaluation

DESCRIPTION AND STATUS:

The objective of the project is to design, fabricate, and field evaluate an Adaptive Learning Network (ALN) signal processing system for inspection of austenitic pipe joints and nozzles in nuclear reactor piping systems. Laboratory demonstrations have shown that ALN can distinguish between different sources of ultrasonic signals such as geometric reflectors, fatigue cracks, etc. This capability would eliminate the time required to evaluate these signals.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Structural Materials

Date: 9/30/78	Rev. 0
EPRI No. RP 1125	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Structural Materials

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

The Structural Materials Group is aware of this and similar techniques utilizing a computer program to analyze ultrasonic signals during inspection of power plant components. To date, they have not made use of such techniques; however, several unique HTGR situations exist, as described below, which could readily be examined by such methods.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

The development of the inspection technique described in the subject EPRI program is directly applicable to both LWRs and HTGRs. Situations exist in both types of reactor plants in which inspection of components with unique configurations results in distorted signals and difficult evaluation of the component's integrity.

The HTGR can derive further applicability by having the program expanded to address such areas as examination of high alloy ferritics (9% Cr + 12% Cr), the steam generator nozzles and Alloy 800 H material, the PCRV liner and penetration transition pieces, and the influence of the concrete structure upon the ultrasonic signals.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

This EPRI program is directly applicable to the HTGR in the area of developing an advanced signal processing system for inspection of austenitic pipe joints and nozzles. It should be noted, however, that unique HTGR materials and components, as described above, warrant expansion of this program in order that it be completely applicable to the HTGR.

Date: 9/30/78	Rev. 0
EPRI No.	Page
RP 1125	2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Structural Materials	1) None 2) Include high alloy ferritics (9% & 12% Cr), Alloy 800 H, complex forgings	1) None 2) Significant	1) Generic 2) Tech. Extension

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.

Page

RP 1125

3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Human Factors Review of Power Plant Maintainability

DIVISION: Nuclear Power

PROGRAM AREA: Reliability, Availability, and Economics

SUBPROGRAM: Instrumentation & Control Engineering

DESCRIPTION AND STATUS:

Project shall identify and evaluate human factors problems associated with nuclear power plant maintenance and instrumentation and control activities. Suggestions are to be made for remedial actions to alleviate problems that degrade maintenance effectiveness and that increase the duration or cost of plant outages.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Controls & Auxiliaries Engineering

Date: 9/30/78	Rev. 0
EPRI No. RP 1126	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Controls & Auxiliaries Engineering

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

Ongoing work has consisted of utilizing available information from the Fort St. Vrain Plant regarding hazards and difficulties encountered by maintenance personnel in the performance of their duties.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

Any human factor problems associated with plant maintenance would be of direct benefit to the HTGR program. At the present state of the HTGR technology, no unique human factors problems have been identified.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The subject EPRI project is considered to be directly applicable to the HTGR program. No additions or modifications to the scope of the project are required.

Date: 9/30/78	Rev. 0
EPRI No. RP 1126	Page 2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Control & Auxiliaries	None	None	Generic

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.

RP 1126

Page

3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Corrosion Programs to Support Reliability of
Nuclear LWR Systems

DIVISION: Nuclear Power

PROGRAM AREA: Reliability, Availability, and Economics

SUBPROGRAM: Plant Chemistry & Corrosion

DESCRIPTION AND STATUS:

This project is to explore metallurgical and environmental factors that limit the lifetime of structural materials used in LWRs for piping, pressure vessels, steam generators, condenser tubes, turbine blades, and other components. Plant outages due to cracks or corrosion damage to these structures are costly and have a major impact on the economic and social acceptability of nuclear power generation. This basic program of corrosion science and technology is a continuing need as new alloys and water chemistry environments are developed in the power industry. This project is scheduled for completion in 1980.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Structural Materials

Date: 9/30/78	Rev. 0
EPRI No. RP 1166	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Structural Materials

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

The Structural Materials Group is not directly involved with the balance of plant equipment such as the main turbine and the condenser; however, they are actively engaged in the design of heat exchangers and equipment associated with the primary coolant system. For this activity, materials are selected and studied based on the anticipated equipment, environment, and service conditions. Unique alloy materials are given particular attention regarding corrosion resistance and behavior at elevated temperatures (1000 to 1350° F).

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

The subject EPRI project is directly applicable to the HTGR in the balance of plant area where service conditions and materials are similar to those existing in LWRs. For nuclear systems, development of corrosion science and technology regarding high chromium steels and Alloy 800 material would provide a more direct benefit to the HTGR program.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

This EPRI project is directly applicable to the HTGR in the areas where materials and service conditions are similar to those in LWRs. The project should be expanded, however, to encompass the unique HTGR high alloy materials in order to more fully benefit the HTGR program. Development of such advanced corrosion science technology could further benefit certain fossil fueled systems with similar steam conditions or provide more suitable material options for specific LWR systems.

Date: 9/30/78	Rev. 0
EPRI No. RP 1166	Page 2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Structural Materials	1) None 2) Incorporation of 2½ Cr and Incalloy 800 H 3) 10000 F to 13000 F & 2½ Cr and 800 H	1) None 2) Minor 3) Significant	1) Generic 2) Technology Extension 3) Complete Technology Development

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

The incorporation of two new materials (2½ Cr and Incalloy 800 H) into this project would present a minor cost impact as a trade-off for the broader applicability of the resulting data. The incorporation of these additional features into the project will provide for significant technology extension. Within a total of 6 projects with recommended minor modifications, the changes suggested here would rank 3rd for available funding.

Note:

The move to a higher temperature (approx. double LWR areas) was evaluated to be a significant cost increase due to the facility and instrumentation problems it would create.

Date: 9/30/78

Rev. 0

EPRI No.
RP 1166Page
3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Simplified Prediction of Elastic Plastic Fracture

DIVISION: Nuclear Power

PROGRAM AREA: Water Reactor System Technology

SUBPROGRAM: Primary and Secondary Pressure Boundary

DESCRIPTION AND STATUS:

Efforts are developing techniques for assessing design margins for pressure vessel components. Goal is to develop an engineering procedure for ductile fracture analysis of nuclear components intended to meet both design and regulatory needs, and reduce the attendant conservatisms associated with the present elastic flaw evaluation procedures. The principal objective of the project is to produce a simplified engineering tool in the form of a plastic fracture handbook and analytical procedure for the analysis of fracture in generalized structural components.

----- TECHNOLOGY TRANSFER DATA -----

HTGR RELATED TASK AREAS:

Heat Exchangers, Applied Mechanics

Date: 9/30/78	Rev. 0
EPRI No. RP 1237	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Heat Exchangers, Applied Mechanics

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

Current investigations in this area center upon stable and unstable crack propagation in both tubesheets and tubes.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

The primary objective of producing a plastic fracture handbook and analytical procedure for fracture analysis would provide a valuable tool in the conceptual and preliminary design phases. Reduction of design margins will continue to be of primary importance in both analysis and design of nuclear components.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The current program, while expanding the design and analysis methods available in the fracture mechanics area, can provide substantial support to the HTGR program by including materials such as Alloy 800 H and 2½ Cr and higher temperatures (>1000° F).

Date: 9/30/78	Rev. 0
EPRI No. RP 1237	Page 2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Heat Exchanger Applied Mechanics	1) None 2) Include HTGR materials (2½ Cr & Alloy 800H) and temperatures (> 1000°F)	1) None 2) Significant	1) Generic 2) Tech. Extension

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.

Page

RP 1237

3 of 3

----- EPRI PROGRAM INFORMATION -----

TITLE: Practical Methods for Inelastic Analysis of
Nuclear Power Plant Components

DIVISION: Nuclear Power

PROGRAM AREA: Water Reactor System Technology

SUBPROGRAM: Primary and Secondary Pressure Boundary

DESCRIPTION AND STATUS:

Materials testing program to develop the capability to take into account inelastic effects in deformation and fracture of reactor components. Address the problems of excessive computer costs, which currently impedes the analysis of ductile behavior of power plant components, and the question of the applicability of the analysis, when performed.

----- TECHNOLOGY TRANSFER DATA -----

HTGR-RELATED TASK AREAS:

Heat Exchangers, Applied Mechanics

Date: 9/30/78	Rev. 0
EPRI No. RP 1242	Page 1 of 3

----- HTGR PROGRAM INFORMATION -----

HTGR RELATED TASK AREA: Heat Exchangers, Applied Mechanics

STATUS OF THIS HTGR TASK AREA RELATED TO THE EPRI PROJECT

Several simplified analysis methods have been developed for use in the conceptual and preliminary design phases of high temperature heat exchangers with the intent of gaining some level of understanding of critical areas and interactions without resorting to complex finite element solutions.

TECHNICAL EVALUATION OF EPRI PROGRAM APPLICABILITY TO THIS TASK AREA

Assuming the program is directed toward light water reactors, the temperature range and materials are not directly applicable to the most critical HTGR components; however, increasing analytical capabilities in the area of inelastic and fracture analysis is an industry-wide concern.

EVALUATION OF THE IMPACT OF UNIQUE HTGR NEEDS ON EPRI PROJECTS

The current program will be useful in expanding the data base on inelastic analysis. Considerable progress can be realized in analytical methods for non-uniform temperature fields in inelastic analysis and by including high temperature ($>1000^{\circ}$ F) effects. Of particular interest is a method for simplified analysis of high temperature creep for use in the conceptual design stage.

Date: 9/30/78

Rev. 0

EPRI No.

Page

RP 1242

2 of 3

----- SUMMARY EVALUATION -----

TASK AREA	MODIFICATION TO EPRI PROGRAM	ESTIMATE PROGRAM IMPACT COST	VALUE TO HTGR PROGRAM
Heat Exchanger Applied Mechanics	1) None 2) Include high temp. ($>1000^{\circ}\text{F}$) and non- uniform temperature fields	1) None 2) Significant	1) Generic 2) Tech. Extension

PRIORITY DESCRIPTION FOR MINOR COST IMPACT AREAS

Date: 9/30/78

Rev. 0

EPRI No.
RP 1242Page
3 of 3