PNC TN960 83-05

日米プラント経験ワーキンググループ実行委員会会議
および
プラント・最適化合同タスクグループ会議

報 告 書

1983年9月26日～9月30日

於 HEDL, Richland
Washington, U.S.A

動力炉・核燃料開発事業団
大洗工学センター

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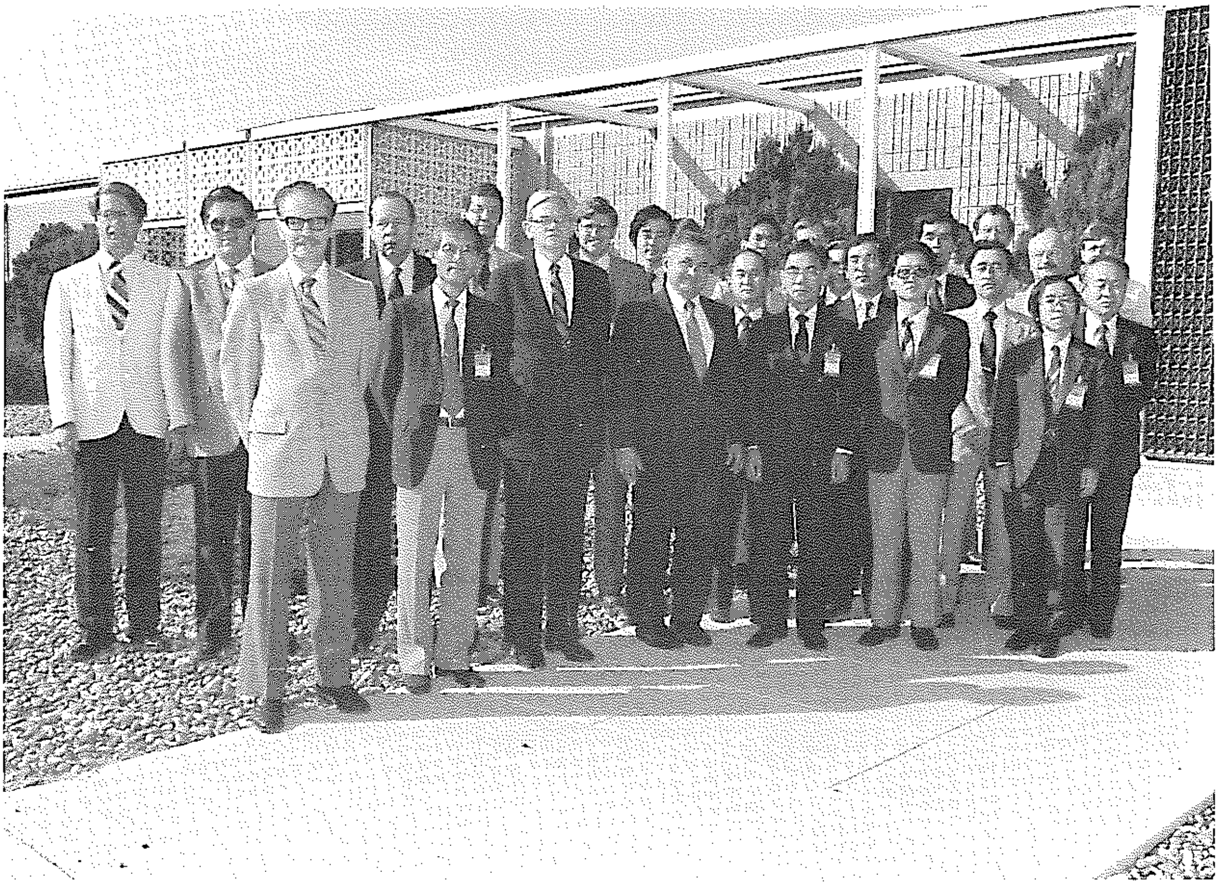

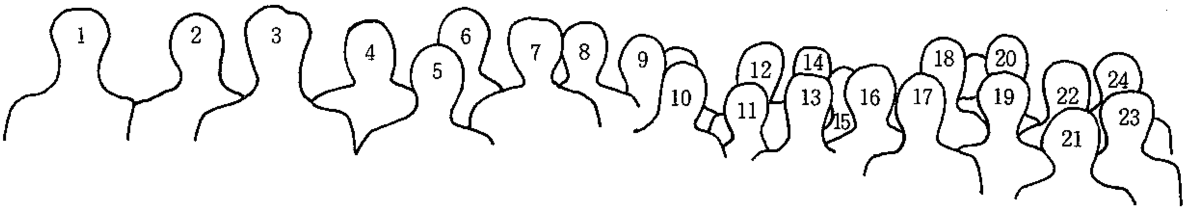

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ま え が き

本会議は，本年4月の第5回 PNC / DOE 合同プラント経験ワーキンググループで定めた方針のもとに，大型 FBR プラントの最適化に関する共同研究の可能性について，来春までの予定で進められている検討作業の中間検討を行なったものである。

本年6月以来，日米双方の各5つのタスクグループがそれぞれ相互に連絡をとりながらも，ほぼ独立に進めて来た共同研究の計画案を，本会議に持ち寄り，まず全体会議で確認した仕法によって，各テーマ毎の日米合同クスクグループ会議が2日及至2日半の熱心な討論を行ない，日米共同の推せん案を作成した。

その推せん案を全体会議で検討し，一部修正を行なった上，本会議としてのまとめを行なった。

本会議の結果は，今後の日米各タスクグループの作業の方向づけとなるものであり,来春のPNC /DOE 合同プラント経験ワーキンググループが来秋の日米 JCC（合同調整委員会）のために作成する答申案の基礎になり得るものと考えられる。

この会議は米側代表のリゾー氏の最終日の発言にあったように「日米双方の考え方を卒直に出し合い，真剣に討論し，その結果，非常に有益かつ希望的な方向づけを得ることができた」と思う。

この場を借りて，参加された電力，メーカーの方々および動燃のメンバーおよび国内のプラント経験ワーキンググループと各タスクグループの責任者，メンバー，事務局の方々に心から感謝の意を表します。

昭和58年9月30日

奈 良 義 彦

第　1　章

会　議　の　概　要

1. 会議の概要

1.1 会議の目的

本会議の目的は

① 第5回 DOE−PNC プラント経験合同ワーキンググループ（Joint PEWG）で合意された高速炉プラント最適化の5項目の技術分野(注1)での日米協力の実現性の是否について次の事項を考慮しながら検討し結論を得ること。

——プラント建設費の削減

——プラント性能の向上（効率，安全）

——相互の施設あるいは能力を利用し合うことによる R&D の経費削減

② 相互協力の実現性が見出された場合には1984年春（3月または4月）に予定されている DOE−PNC PEWG 実行委員会に正式な提案書を提出するための準備作業計画について合意すること。

である。

1.2 会議の日程

9/26（月） 全体会議

前回のプラント最適化に関する会議のレビュー

本会議の目的の確認

会議進行についての検討

DOE−PNC の各タスクグループから各項目の国内検討結果について説明

9/27（木）
9/28（金） } 各タスクグループ別の会議

各項目に於ける日米の背景ならびに今後の協力の可能性について討論し，PEWG 実行委員会に対する共同提案を作成した。

（注1）高速炉プラント最適化の5項目とは次のことを云う。

1. LMFBR 用配管ベローズの開発
2. DRACS（直接補助炉心冷却系）の実証
3. 一般耐震設計基準
4. ナトリウム機器・系統に対する熱および機械的荷重の繰返し負荷基準
5. 2次系削除を狙った SG の開発計画

9 / 29 （木）
9 / 30 （金）午前 } 全体会議

PEWG 実行委員会（リゾー，奈良委員の2名のみ）に対し，日米共同提案の説明が各タスクグループより行われた。

9 / 30 （金）午後　PEWG 実行委員会

各タスクグループの共同提案書を基に審議し，議事録および合意書の最終確認を行なった上で調印した。

1.3 開催場所

ハンフォード工学開発研究所（HEDL）
Richland, Washington

1.4 日本側出席者

PNC	奈良義彦	（本部　開発調整室付）
	青木忠雄	（大洗　構造物強度試験室長）
	加納茂機	（本部　構造材料グループリーダー）
	久保田淳	（米国 ETEC 駐在）
原電	林喬雄	（技術開発部　次長）
FBEC	山口友久	（プロジェクト部　主任）
三菱重工	和田宏	（神船　設計部　主任）
日立	阿部興司	（日立工場　原子力開発部　主任）
東芝	飯田式彦	（動力炉開発部　主任）
富士	井上隆	（川崎工場　設計部　主任）
川重	小畑清和	（原子力　技術部　課長）

第 2 章

DOE-PNC PEWG実行委員会としての決定事項

2. DOE-PNC PEWG実行委員会としての決定事項

本会議の最終日に開かれたDOE/PNC PEWG実行委員会で最終的に合意された事項は以下のように集約される。

なお，詳細については次章に載せた原文を参照されたい。

2.1 LMFBR用配管ベローズの開発

◉範　囲

ASMEコードN－290で「解析による設計」が認められるよう適切な修正を施すことに主眼を置いて，ベローズ設計ならびに製作基準を改善し，最終的にはASMEコードあるいはそれに類するコードに取り入れるようにする。

◉共同提案

(1) 「解析による設計」を許す設計基準を共同で開発する。

―― DOEはPNCに対しBASE TECHNOLOGY PROGRAMの成果を与える。（承認後1ケ月後に実施）

―― PNCはDOEに対し59年度中期から約3ケ年にわたる初期の開発成果を与える。この中には，クリープ疲労，熱過渡，ラチェット，座屈の試験が含まれる。

―― DOEはPNCの初期の試験データの評価を行い「解析による設計」を許すようなN－290に対する修正を推奨する。

(2) PNCとDOEは今後の試験計画ならびにプラント設計の状況にも依るが，ベローズに関する評価について協力する。

―― PNCはDOEに対し，次の試験が実施されればそのデータを提供する。振動（耐震），流力振動，耐衝撃圧（水ハンマー）

◉次のPEWG実行委員会までの準備作業

(1) DOEはBASE TECHNOLOGY PROGRAMのレポートのタイトルリスト，要旨，目次を送る。PNCは初期の試験（クリープ疲労，熱過渡，ラチェット，座屈）の概要を送る。（12 / 1 / 83）。

(2) 相互に送付された情報に関し不明な点を明らかにする。（12 / 15 / 83）

(3) 今回の共同提案の妥当性（バランス等）を検討する。（2 / 1 / 84）

(4) 必要ならば再協議する。（2 / 15 / 84）

(5) PEWG実行委員会に共同提案を提出する。（3 / 15 / 84）

2.2 DRACSの実証

◎範　囲

a. 以下の手段によって解析方法を開発する。但しコード自体の交換あるいは現有コードの他の要素交換は行わない。

(1) 入力条件や運転パラメータのコードの予測の感度に関する情報交換
(例　メッシュサイズ，時間ステップ)

(2) PNCは計算時間の速い簡易一次元フローネットワークモデルの開発と実証を行う。

(3) DOEはCOMMIXコードの検証結果を提供する。

b. 上記aが終了後，試験データ及び解析の交換ならびにDOE/PNCのDRACS実証試験についての計画について検討する。

◎共同提案

(1) 解析コード

——以下の項目に対する解析結果の感度について情報交換を行う。

コードの入力条件	日本：MIMIR，THAUPR，SCORT，THERVIS
計算セルの数	COMMIX，COBRA-IV
時間ステップ	米国：DASHR，COMTRAN，COMMIX，COBRA-IV，-WC
その他	CORTRAN，SASSYS，SSC

——1次元フローネットワークモデルの開発と実証を行なって結果を提供する。(日本)

——3次元COMMIXの検証結果を提供する。(米国)

(2) 部分試験

——既存の試験データと詳細内容の交換

日本：ピンバンドル試験
炉内流動分布試験
配管ストラティフィケーション水中試験
SGTFに於ける自然循環試験
常陽自然循環試験

米国：SSTFに於ける簡易ナトリウム中試験
SIMONEでの水中試験
FFTF自然循環試験
THORS-SHRS管束試験

——既存ならびに将来の試験データの解析結果の交換

(将来の試験)

日本：DRACSの小規模水中試験
Na-Na又はNa-NaKの低流量熱伝達試験

米国：SSTF に於ける炉内熱交換器試験

改良後の SIMONE 試験

Na 沸騰を含む THORS−SHRS 試験

――上記のデータでコンピュータの“BRUSH−UP”手直しの結果の情報交換

――将来試験の共同計画ならびにデータ交換

(3) 大型部分試験

――次の試験に関するデータ，解析の情報交換ならびに試験計画に参加する。

日本：常陽炉内自然循環試験

もんじゅ　NDHX 試験

システスの熱容量 / 放熱試験（可能ならば）

米国：EBR−Ⅱ自然循環試験

CRBRP NDHX 試験

FSF 冷却システム試験

システムの熱容量 / 放熱試験（可能ならば）

(4) 大型 DRACS プロトタイプ試験

――計画が具体化するまで（2～3年後）決定を延ばす。

◉次の PEWG 実行委員会までの準備

(1) 共同提案の背景となる情報交換を行う前に幾つかの例を相互が出し合って内容の範囲を明確にする。（11 / 15 / 83）

(2) 相互で決定したフォーマットに従って共同提案の背景となる情報交換を行う。（12 / 31 / 83）

(3) 双方から提案を出す。（1 / 31 / 84）

(4) 共同提案書（案）を用意し双方で検討する。このために必要ならば会議を持つ。（2 / 15 / 84）

(5) PEWG 実行委員会に共同提案書を提出する。（3 / 15 / 84）

2.3 一般耐震設計基準

◉範　囲

以下の3つの項目について共同作業を実施するが，いずれも早期着手が可能となるよう次の JCC に推奨する。

a. より大きなナトリウム配管減衰定数を確立する。

b. 配管の塑性変形によるエネルギーの吸収ならびにギャップによる非線形挙動を考慮したナトリウム配管の設計手法と基準を確立する。

c. 炉心アッセンブリダクトの振動挙動のモデル化ならびに設計上の制限を確立する。

◉ 共同提案

(1) ナトリウム配管の減衰定数

LMFBR の配管設計に於ける減衰定数については，現行の基準で使っている値より大きなものにすることが望ましい。

従って以下のような共同作業を通じてこの目的を達成する。

——現在ある減衰試験データを集め評価する。

——必要なデータを明らかにした上で追試験を行う。

——より大きな減衰定数を使うことの妥当性，対外的な認知ならびに実際の使用に関して有効な報告書を準備する。

(2) 配管の塑性挙動と非線形挙動

ギャップによる非線形挙動ならびに塑性変形によるエネルギー吸収を考慮したナトリウム配管用の設計手法と設計基準を確立するために以下の共同作業を行う。

——適切なデータと手法を検討し必要な試験ならびに手法の開発を明らかにする。

——ナトリウム配管への適用と，小口径配管用の DESIGN BY RULE を確立するために必要な試験と解析手法の開発の共同計画を立案する。

——試験を実施し，手法を開発して報告書を作成する。

——報告書を検討し，コメントを配慮し最終報告書を作成して設計に使用する。

(3) 炉心アッセンブリダクト衝撃モデルと強度限界

PNC が衝撃モデルを，DOE が強度限界を夫々開発しデータを交換し，共同計画の下に追試験を実施し炉心ダクトの耐震制限を確立する。

——関連の炉心ダクト耐震試験ならびにデータを検討する。

——今後必要なデータ，解析，手法を明らかにする。

——共同試験，開発，研究の合意事項を用意する。

——試験を実施し，成果報告書を作成する。

◉ 次の PEWG 実行委員会までの準備作業

(1) 背景となる情報交換（12 / 1 / 83）

(2) 双方で用意した提案書（案）の交換（12 / 15 / 83）

(3) 最初の共同提案書の作成（1 / 15 / 84）

(4) 最終共同提案書の作成（2 / 15 / 84）

(5) PEWG 実行委員会に共同提案書を提出する。（3 / 15 / 84）

2.4 ナトリウム機器・系統に対する熱及び機械的荷重の繰返し負荷基準

◉ 範　囲

a. サーマルストライピング設計手法の開発

b. 非弾性解析手法の開発

上記 a, b については早期着手が可能となるよう次の JCC に推奨する。

● 共同提案

a. サーマルストライピング

(1) 水とナトリウムの相関関係

——PNC は DOE に対し「もんじゅ」7本集合体の水中及びナトリウム中試験のデータを提供する。

(2) 非定常熱伝達係数の情報交換

——DOE は PNC に対し WH 社（現在実施中）ならびに RI 社（3/84）のナトリウム中試験のデータを提供する。

——PNC は DOE に対し「もんじゅ」7本集合体ナトリウム中試験のデータを提供する。

(3) サーマルストライピングの材料強度に及ぼす影響

——DOE は PNC に対し WH 社のナトリウム中試験（316 SS, 718 INCONEL, 他の材料は後日）ならびに RI 社のナトリウム中試験（316 SS については 6/84, 718 INCONEL, 9 Cr−/Mo については後日）のデータを提供する用意がある。

——DOE は PNC に対し WH 社ならびに RI 社の詳細試験計画を 12/31/83 までに送る。

——PNC は DOE の試験装置を検討し，DOE に国産材料を送って依頼することを考える。

DOEはこのための適切なスケジュールを PNC に送る。

(4) サーマルストライピングの設計手法の確立

—— 1985 年の夏か秋に専門家会議を開く。

b. 非弾性解析手法の開発

DOE と PNC は共同で FBR コンポーネントの非弾性解析による設計の基準，指針及び方法の開発を行う。

● 次の PEWG 実行委員会までの準備作業

a. サーマルストライピング

(1) 3/15/84 までに共同提案書を作成し，PEWG 実行委員会に提出する。

b. 非弾性解析手法の開発

(1) 非弾性設計手法の要素のうち最も改良が必要とされるもの（例　荷重の負荷順序，構成方程式）について優先度をつけたリストを交換する。（12/15/83）

(2) (1)で明らかにされた要素の開発計画を交換する。（1/15/84）

(3) これまでに行われた構造物の検証試験の要旨を交換する。（1/15/84）

(4) 以下の項目について共同提案（案）を作成し，双方で検討する。（2/15/84）

——試験データの交換

——解析結果の交換

——設計手法の改善について協力する。（専門家訪問を含む）

——検証試験に関する協力

——人の交換

(5) PEWG 実行委員会に共同提案書を提出する。（3/15/84）

2.5 2次系削除を狙った SG 開発計画

◉範　囲

概念設計評価

◉共同提案

概念設計研究を2年間で実施する。

(1) 研究計画

——目標の明確化

——作業内容と基本的な考え方の策定

——作業の配分

——作業工程の作成

(2) コスト削減に対する予備評価

——1次系 SG プラントと2次系 SG プラントの予備設計の比較

——コスト削減の面からの評価

——今後の作業に対する推奨

(3) 主要事項の詳細評価

——主要事項の明確化（安全性，コンポーネント，他）

——各主要事項の評価

——実現可能性と利益の再評価

(4) 必要な R&D の摘出

(5) 最終報告書の作成

◉次の PEWG 実行委員会までの準備作業

(1) 研究計画素案（基本的な作業の策定，作業の配分，作業工程，必要経費の算出）の交換（12/31/83）

(2) 共同提案書の作成と双方での検討（1/31/84）

(3) PEWG 実行委員会に共同提案を提出する。

第　3　章

DOE-PNC　PEWG実行委員会の正式議事録および合意書

RECORD OF MEETING

DOE-PNC Plant Experience Working Group
Executive Committee Meeting

Richland, Washington
Hanford Engineering Development Laboratory
September 26-30, 1983

In accordance with Agreement B.3 of the Fifth Meeting of the Joint DOE-PNC Working Group on Plant Experience, April 25-28, 1983, a meeting of the DOE-PNC Plant Experience Working Group Executive Committee was held at the Hanford Engineering Development Laboratory, Richland, Washington, on September 26-30, 1983. The sole purpose of this Executive Committee meeting was to review Task Group recommendations on proposed DOE-PNC collaboration on large LMFBR plant optimization. The express objectives of the meeting, as agreed upon by DOE and PNC, appear as Appendix I to this meeting record. The Executive Committee reviewed the Task Group recommendations on the five topics selected at the April, 1983 Plant Experience Working Group meeting and determined the feasibility of future DOE-PNC collaborative efforts in these areas. The findings of the Executive Committee are included in the attached Appendix II.

The agenda for the Executive Committee meeting is included as Appendix III to this record. A list of meeting participants is presented in Appendix IV. Illustrations used in the presentation of the final joint task group recommendations are included as Appendices V-IX.

The two delegations note that the stated objective of the meeting was successfully attained, reflecting the commitment of both parties to maintaining the positive and productive nature of this exchange. The Executive Committee expresses its gratitude to those persons who contributed to the preparation of the task group recommendations.

The contents of this record are mutually agreed upon by the two delegations.

For the United States Department of Energy

Alfred J. Rizzo
September 30, 1983

For the Power Reactor and Nuclear Fuel Development Corporation

Yoshihiko Nara
September 30, 1983

APPENDIX I

OBJECTIVES OF DOE-PNC PEWG EXECUTIVE COMMITTEE MEETING

September 26-30, 1983

OBJECTIVES OF MEETING

- REACH AGREEMENT ON THE FEASIBILITY OF COLLABORATIVE EFFORTS IN THE REACTOR TECHNOLOGY AREAS DEFINED IN THE FIVE LMFBR PLANT OPTIMIZATION TOPICS AGREED UPON AT THE FIFTH MEETING OF THE DOE-PNC JOINT WORKING GROUP ON PLANT EXPERIENCE, TAKING INTO CONSIDERATION
  - -- REDUCTION OF PLANT CAPITAL COSTS
  - -- IMPROVEMENT OF PLANT PERFORMANCE (EFFICIENCY, SAFETY)
  - -- REDUCTION OF R&D PROGRAM COSTS THROUGH JOINT UTILIZATION OF FACILITIES AND CAPABILITIES

- REACH AGREEMENT ON A PLAN FOR THE ACTIVITIES NECESSARY TO PRODUCE FORMAL PROPOSAL(S) FOR COLLABORATION, IN THE CASE OF THOSE COLLABORATIVE EFFORTS DEEMED FEASIBLE, WHICH WILL BE REPORTED TO THE DOE-PNC PEWG EXECUTIVE COMMITTEE IN MARCH-APRIL, 1984

Appendix II

FINDINGS OF EXECUTIVE COMMITTEE

The Joint DOE-PNC PEWG Executive Committee reviewed the Task Group recommendations and determined the feasibility of collaboration as described in the following sections.

1. Development of Piping Bellows for LMFBR Service

The Executive Committee affirms the potential for gaining significant reduction in plant capital cost through incorporation of bellows in primary or intermediate heat transport systems and in direct reactor auxiliary cooling systems (DRACS). Collaborative DOE-PNC efforts on bellows development can also lead to reduced bellows cost and enhanced licensability of designs utilizing bellows. It can also facilitate decisions to incorporate bellows in future designs, as for example in the design of DRACS.

The Executive Committee concurs with the joint DOE-PNC task group recommendation for collaborative bellows development and finds that collaboration is feasible to the following extent:

a. Development of improved bellows design and fabrication standards for eventual adoption by ASME and other approriate code organizations, with the principal emphasis to be placed on appropriate modifications to ASME Code N-290 to permit "design by analysis."

The Executive Committee hereby directs the joint DOE-PNC Task Group on Development of Piping Bellows for LMFBR Service to proceed with the development of a detailed proposal for collaboration. The proposal shall be limited to the scope described in the preceding paragraph and shall include full details on work activities, schedules and resource requirements. Preparation of the proposal shall proceed according to the schedule recommended by the Task Group, with the exchange of background information limited to that stated in Appendix V. Said exchange will take place by direct transmittal between the co-chairmen of the Executive Committee. The proposal shall be submitted to the PEWG co-chairmen (S. Nomoto, PNC; A. J. Rizzo, DOE-RL) not later than March 15, 1984.

2. Verification of DRACS

The Executive Committee recognizes the likelihood that future LMFBR plants will incorporate DRACS, with the attendant necessity to provide an optimized, licensable DRACS design. Collaborative work by DOE and PNC to develop improved analytical methods and design methodology for DRACS design is considered to be feasible.

The Executive Committee concurs in part with the recommendations of the joint DOE-PNC task group, and determines the following collaborative work scope to be feasible:

a. Development of analytical methods, to include (1) exchange of information on sensitivity of code predictions to input assumptions and operational parameters (e.g., mesh size, time steps), (2) development and verification of a fast-running simplified one-dimensional flow network model, and (3) providing of validation results for the COMMIX code. There shall be no exchange of codes, code models or other elements of the existing codes.

b. Planning for exchange of test data and analyses and for DOE/PNC DRACS verification testing upon completion of (a) above.

The Executive Committee hereby directs the joint DOE-PNC task group on Verification of DRACS to proceed with the development of a detailed proposal for collaboration. The proposal shall be limited to the scope described in the previous paragraph and shall include full details on work activities, schedules and resource requirements. Preparation of the proposal shall proceed according to the schedule recommended by the Task Group, with the exchange of background information limited to that stated on pages 12-13, Appendix VI. Said exchange of information shall take place by direct transmittal between the co-chairmen of the Executive Committee. The detailed proposal shall be submitted to the PEWG co-chairmen not later than March 15, 1984.

3. General Seismic Design Criteria

It is agreed that the development of an internationally-recognized set of general seismic design criteria can lead to substnatial reductions in design costs and plant capital costs, as well as acceleration of the licensing process. Collaboration between DOE and PNC in development of such criteria is considered by the Executive Committee to be feasible in certain limited areas.

The Executive Committee concurs in part with the recommendations of the joint DOE-PNC task group and finds the following collaborative activities to be feasible:

a. Establishment of higher sodium piping damping values (Topic A.1)

b. Establishment of sodium piping design procedures and criteria to account for energy absorption due to piping plastic deformation and non-linear behavior dur to the presence of gaps (Topic A.2)

c. Establishment of models and design limits for core assembly duct seismic performance (Topic C).

The Executive Committee recommends that early JCC approval be sought for implementation of collaborative activities in these areas. It is determined that Task Group Topics B.1, B.2, B.3, D and E should be deferred for future consideration.

The Executive Committee hereby directs the joint DOE-PNC Task Group on General Seismic Design Criteria to proceed with the development of a detailed proposal for collaboration. The proposal shall be limited to activities identified by the Task Group as Topics A.1, A.2 and C. The proposal shall include full details on specific work activities, schedules and resource requirements. Preparation of the proposal shall proceed according to the schedule recommended by the Task Group in Appendix VIII, with the exception that there shall be no initial exchange of background information, such exchange being regarded as unnecessary by the Executive Committee. The detailed proposal shall be submitted to the PEWG co-chairmen not later than March 15, 1984.

4. Thermal and Load Cycling Criteria for Sodium Components and Systems

The Executive Committee finds that various aspects of this broad topic can have substantial beneficial impact on plant capital costs and plant performance. In particular, design features to mitigate effects of thermal striping can be highly cost-effective, as can the utilization of inelastic design methodology. The collaborative development of said designs and design methods can provide benefits of common design and enhanced licensability.

The Executive Committee concurs in part with the joint DEO-PNC task group recommendation for collaborative work on thermal and load-cycling criteria, and finds that collaboration is feasible as follows:

a. Development of thermal striping design methodology.

b. Development of FBR component inelastic design criteria, guidelines and procedures.

The Executive Committee recommends that early JCC approval be sought for implementation of collaborative activities in the area of thermal striping design methodology.

The Executive Committee hereby directs the joint DOE-PNC Task Group on Thermal and Load Cycling Criteria for Sodium Components and Systems to proceed with the development of a detailed proposal for collaboration. The proposal shall be limited to the scope defined in Appendix VII and shall include full details on work activities, schedules and resource requirements. Preparation of the proposal shall proceed according to the schedule recommended by the Task Group, with the exchange of background information limited to that stated in Appendix VII. Said exchange on information shall take place by direct transmittal between the co-chairmen of the Executive Committee. The detailed proposal shall be submitted to the PEWG co-chairmen not later than March 15, 1984.

5. Definition of Steam Generator Development Program with Intent of Eliminating the Intermediate System

The Executive Committee regards the development of a Primary Steam Generator as providing a potential for highly significant reductions in plant capital cost. Even if the realization of a primary unit should prove to be difficult for various reasons, work directed toward this end would be beneficial in development of a steam generator design with greatly improved reliability and serviceability. The Task Group recommendation for a joint conceptual design evaluation of a primary steam generator is considered to be the appropriate scope for near-term collaborative efforts.

The Executive Committee concurs with the recommendations of the joint DOE-PNC TaskGroup on Definition of a Steam Generator Development Program, as defined in Appendix IX. The joint DOE-PNC Task Group is hereby directed to proceed with development of a detailed proposal for collaboration. The proposal shall be limited to the scope set forth in Appendix IX and shall include full details on work activities, schedules and resource requirements. Preparation of the proposal shall proceed according to the schedule recommended by the Task Group. The detailed proposal shall be submitted to the PEWG co-chairmen not later than March 15, 1984.

DISCUSSION OF PLANT PERFORMANCE

Extensive and very successful discussions were held concerning the question of plant performance. It was noted that the original instructions from the Joint Coordinating Committee (JCC) were to assess the feasibility of collaborative efforts on LMFBR plant optimization having the dual objectives of (1) improved plant performance and (2) reduced plant cost. This direction also included the provision that the collaborative work not be specific to a particular plant design. In response to the JCC direction, the Plant Experience Working Group (PEWG) initially considered a large number of potential topics for feasibility assessment. Some of these topics were rejected as design-specific, including plant parametric studies (e.g., power level, outlet temperature, steam conditions, number of loops, loop vs. pool, etc.).

For the purposes of the PEWG feasibility assessments, plant cost has been defined as plant capital cost, including interest; plant performance has been defined in terms of operating costs or power generation costs, and is thus related to efficiency of operation, reliability and safety. The five topics selected by the Joint DOE-PNC PEWG for initial feasibility assessment represented activities which were considered to be of significant mutual benefit, amenable to collaboration, and likely to succeed. These topics have, to certain varying degrees, aspects related both to improved plant performance and reduced plant cost. Other topics which are more strictly associated with plant performance are already under active collaboration or negotiation within the various DOE-PNC working group infrastructures.

The DOE and PNC representatives participating in these discussions affirmed their intentions to proceed as agreed at the September, 1982 PEWG Executive Committee meeting: "... During the period between April, 1983 and April, 1984, emphasis will be placed on a few selected high-priority topics; once the feasibility evaluation is successfully completed for these few topics, additional topics can be evaluated. This approach will keep the resource requirements for the study itself within reasonable limits." It is anticipated that the April, 1984 PEWG meeting will result in a recommendation to proceed with the further evaluation of topics for possible DOE-PNC collaboration on large LMFBR plant optimization. If interim guidance is received from the JCC to place increased emphasis on plant performance issues or to forego the constraint on design specificity, the PEWG will proceed accordingly.

APPENDIX III

A G E N D A

DOE-PNC PEWG EXECUTIVE COMMITTEE MEETING

September 26-30, 1983

AGENDA

DOE-PNC PEWG EXECUTIVE COMMITTEE MEETING ON LMFBR PLANT OPTIMIZATION STUDY FEASIBILITY ASSESSMENT

MONDAY, SEPTEMBER 26, 1983: PLENARY SESSION

9:00 - 9:15	INTRODUCTORY REMARKS
9:15 - 9:45	REVIEW OF PREVIOUS MEETINGS ON LMFBR PLANT OPTIMIZATION STUDY
9:45 - 10:00	DISCUSSION OF MEETING OBJECTIVES
10:00 - 10:30	DISCUSSION OF PROCEDURES
10:30 - 10:45	OVERVIEW OF TOPICS FOR FEASIBILITY ASSESSMENT
10:45 - 11:45	SUMMARY PRESENTATIONS OF DOE AND PNC ASSESSMENTS ON (1) DEVELOPMENT OF PIPING BELLOWS FOR LMFBR SERVICE
11:45 - 1:30	LUNCH
1:30 - 5:30	SUMMARY PRESENTATIONS (CONTINUED) (2) VERIFICATION OF DRACS (3) THERMAL AND LOAD CYCLING CRITERIA FOR SODIUM COMPONENTS AND SYSTEMS (4) GENERAL SEISMIC DESIGN CRITERIA (5) DEFINITION OF STEAM GENERATOR DEVELOPMENT PROGRAM WITH INTENT OF ELIMINATING THE INTERMEDIATE SYSTEM
5:30 - 6:00	DISCUSSION OF PLANT PERFORMANCE
6:00	ADJOURN

AGENDA - CONTINUED

TUESDAY, SEPTEMBER 27, 1983: SEPARATE TASK GROUP SESSIONS

8:30 - 11:30	DEVELOPMENT OF JOINT TASK GROUP RECOMMENDATIONS
11:30 - 1:15	LUNCH AT CONVENIENCE OF TASK GROUP
1:15 - 5:00	DEVELOPMENT OF JOINT TASK GROUP RECOMMENDATIONS
5:00	ADJOURN

WEDNESDAY MORNING, SEPTEMBER 28, 1983: SEPARATE TASK GROUP SESSIONS

8:30 - 11:00	PREPARATION OF PRESENTATIONS ON JOINT TASK GROUP RECOMMENDATIONS
11:30 - 1:15	LUNCH AT CONVENIENCE OF TASK GROUP

WEDNESDAY AFTERNOON, SEPTEMBER 28, 1983: PLENARY SESSION

1:15 - 5:00	PRESENTATIONS OF JOINT RECOMMENDATIONS BY EACH TASK GROUP (1½ HOURS EACH) (1) PIPING BELLOWS (2) DRACS (3) THERMAL AND LOAD CYCLING CRITERIA
5:00	ADJOURN

THURSDAY, SEPTEMBER 29, 1983: PLENARY SESSION

8:30 - 11:30	PRESENTATIONS OF JOINT RECOMMENDATIONS BY EACH TASK GROUP (CONT'D) (4) SEISMIC DESIGN CRITERIA (5) STEAM GENERATOR DEVELOPMENT

THURSDAY, SEPTEMBER 29, 1983: PLENARY SESSION (CONT'D)

11:30 - 1:30	LUNCH
1:30 - 5:00	DISCUSSION OF FEASIBILITY OF TASK GROUP RECOMMENDATIONS
5:00	ADJOURN

FRIDAY, SEPTEMBER 30, 1983: EXECUTIVE SESSION

8:30 - 11:30	ASSESSMENT OF FEASIBILITY OF COLLABORATION ACCORDING TO TASK GROUP RECOMMENDATIONS
11:30 - 1:30	LUNCH
1:30 - 5:00	PREPARATION OF MEETING RECORD AND AGREEMENTS
5:00	ADJOURN

OPTIONAL TOUR OF FFTF FOR DOE-PNC TASK GROUP REPRESENTATIVES:

8:30	DEPART FROM HANFORD HOUSE
9:00 - 10:00	BRIEFING AND TOUR OF MODEL AREA, FFTF VISITOR CENTER
10:00 - 12:00	TOUR FFTF
12:00	DEPART FOR RICHLAND
12:30	ARRIVE HANFORD HOUSE

Appendix IV

MEETING PARTICIPATION

DOE-PNC PEWG EXECUTIVE COMMITTEE MEETING

September 26-30, 1983

MEETING PARTICIPATION

DOE-PNC PEWG Executive Committee

Y. Nara, PNC
S. Kano, PNC
T. Aoki, PNC
A. J. Rizzo, DOE-RL
E. C. Norman, DOE-RL
J. J. Laidler, WHC-HEDL

DOE-PNC PEWG Task Group Members/Observers

W. J. McShane, WHC-HEDL
R. A. Johnson, COMO
R. I. Jetter, RI-ESG
G. Bieberbach, W-NCD
A. Dalcher, GE-ARSD
T. G. Davies, DOE-RL
A. R. DeGrazia, DOE-RL
R. W. Barr, DOE-RL
A. J. Rapacz, DOE-RL
L. D. Romine, DOE-RL
W. G. DeBear, RI-ESG
R. L. Stover, WHC-HEDL
L. K. Severud, WHC-HEDL
S. Rose, GE-ARSD
J. Kubota, PNC
T. Hayashi, Japan Atomic Power Company
T. Yamaguchi, FBEC
T. Inoue, Fuji Electric Company
N. Handa, Toshiba
K. Abe, Hitachi
K. Kobatake, Kawasaki Heavy Industries
H. Wada, Mitsubishi Heavy Industries

TASK GROUP PARTICIPATION

Development of Piping Bellows for LMFBR Service

T. Aoki, PNC (Co-Chairman)
R. I. Jetter, RI-ESG (Co-Chairman)
K. Kobatake, Kawasaki Heavy Industries
H. Wada, Mitsubishi Heavy Industries
T. Hayashi, Japan Atomic Power Company
L. D. Romine, DOE-RL

Thermal and Load Cycling Criteria for Sodium Components

T. Aoki, PNC (Co-Chairman)
W. J. McShane, WHC-HEDL (Co-Chairman)
K. Kobatake, Kawasaki Heavy Industries
H. Wada, Mitsubishi Heavy Industries
T. Hayashi, Japan Atomic Power Company
L. K. Severud, WHC-HEDL
T. G. Davies, DOE-RL

Verification of DRACS

J. Kubota, PNC (Co-Chairman)
R. A. Johnson, COMO (Co-Chairman)
N. Handa, Toshiba
R. L. Stover, WHC-HEDL
S. Rose, GE-ARSD
A. J. Rapacz, DOE-RL

General Seismic Design Criteria

S. Kano, PNC (Co-Chairman)
A. Dalcher, GE-ARSD (Co-Chairman)
T. Yamaguchi, FBEC
T. Inoue, Fuji Electric Company
L. K. Severud, WHC-HEDL
R. W. Barr, DOE-RL

TASK GROUP PARTICIPATION (Continued)

Definition of Steam Generator Development Program with Intent of Eliminating the Intermediate System

Y. Nara, PNC (Co-Chairman)

G. Bieberbach, W-NCD (Co-Chairman)

K. Abe, Hitachi

W. G. DeBear, RI-ESG

A. R. DeGrazia, DOE-RL

Appendix V

JOINT RECOMMENDATION FOR COLLABORATIVE LMFBR PLANT OPTIMIZATION EFFORTS

JOINT DOE-PNC TASK GROUP ON DEVELOPMENT OF PIPING BELLOWS FOR LMFBR SERVICE

September 30, 1983

FEASIBILITY ASSESSMENT TASK DEFINITION
"DEVELOPMENT OF PIPING BELLOWS FOR LMFBR SERVICE"

- ORIGINAL TASK DEFINITION (4/83)
  - 12 MO STUDY ADDRESSING
    - ADVANTAGES, LIMITATIONS, SPECIAL REQUIREMENTS DESIGN APPROACHES, R&D NEEDS, COST SAVINGS
    - ESTABLISH AND OR CONSOLIDATE CODES AND STANDARDS FOR DESIGN, FABRICATION AND INSPECTION
  - CONCLUSION OF 12 MONTH STUDY IS "...AGREEMENT ON FRAMEWORK AND SCHEME OF COLLABORATIVE PROGRAM"
- REVISED METHODOLOGY FOR FEASIBILITY ASSESSMENT (7/83)
    - PNC AND DOE SEPARATELY ASSESS BENEFITS, CAPABILITIES RESOURCE REQUIREMENTS, EQUITABLE PARTICIPATION, ALTERNATE APPROACHES AND RECOMMEND POTENTIAL AREAS OF COLLABORATION (7/83 TO 9/83)
    - PNC AND DOE TO REACH CONSENSUS POSITION AND PREPARE JOINT RECOMMENDATION (9/83)
      - INFORMATION EXCHANGE
      - JOINT DESIGN/ANALYSIS
      - JOINT TESTING

SUMMARY OF PNC AND DOE ASSESSMENTS

	PNC	DOE
BENEFITS:	. SUBSTANTIAL PLANT SAVINGS THROUGH USE OF BELLOWS IN PRIMARY SYSTEM	. MODERATE PLANT SAVINGS THROUGH USE OF BELLOWS IN DRACS AND IHTS (POTENTIALLY)
	. SAVINGS IN BELLOWS PROCUREMENT THROUGH DESIGN BY ANALYSIS . AVOIDS COSTLY TESTING REQUIRED BY ASME CODE	. DRACS NATURAL CIRCULATION ENHANCED THROUGH USE OF BELLOWS (LOWER PRESSURE LOSS)
	. FEASIBILITY OF BELLOWS PROCUREMENT ENHANCED BY MODIFICATION OF FABRICATION TOLERANCES	. MODERATE SAVINGS IN BELLOWS PROCUREMENT THROUGH DESIGN BY ANALYSIS
	. LICENSING ENHANCED THROUGH CONCENSUS STANDARDS	. DECISION TO USE BELLOWS IN DRACS ETC. ENHANCED BY ELEVATED TEMPERATURE TEST DATA.
CAPABILITIES:	. PNC INITIATING SUBSTANTIAL ELEVATED TEMP. BELLOWS TESTING PROGRAM.	. MODERATE INVESTMENT IN BELLOWS TEST FACILITY

SUMMARY OF PNC AND DOE ASSESSMENTS (CONT'D)

	PNC	DOE
RESOURCE REQUIREMENTS:	. SUBSTANTIAL FOR COMPLETE TEST PROGRAM	. $~ 500K FOR SINGLE COMPONENT TEST SERIES
EQUITABLE PARTICIPATION:	. PNC WOULD BENEFIT FROM DOE BASE TECHNOLOGY DATA TO AVOID DUPLICATION OF REPORT	. DOE WOULD BENEFIT FROM AVAILABILITY HIGH TEMP. CYCLIC DATA
	. BOTH PNC AND DOE BENEFIT FROM "DESIGN-BY-ANALYSIS"	. BOTH PNC AND DOE BENEFIT FROM "DESIGN-BY-ANALYSIS"
ALTERNATE APPROACHES		. DOE ACHIEVES CONTAINMENT BUILDING COST REDUCTION WITHOUT BELLOWS THROUGH USE OF SIPHON BREAKERS VERTICAL PIPE LOOPS
PROPOSED AREAS FOR COLLABORATION	. SYSTEM DESIGN . FABRICATION . DESIGN STANDARD	. INFORMATION EXCHANGE

RECOMMENDED COLLABORATIVE PROGRAM

- COLLABORATION ON DEVELOPMENT OF DESIGN STANDARD WHICH WOULD PERMIT "DESIGN-BY-ANALYSIS"
- SPECIFIC STEPS IN COLLABORATION TO DEVELOP IMPROVED STANDARD
  - DOE TO PROVIDE RESULTS OF BASE TECHNOLOGY PROGRAM TO PNC
    - ONE MONTH AFTER APPROVAL OF COLLABORATIVE PROGRAM
  - PNC TO PROVIDE RESULTS OF INITIAL PHASE OF TEST PROGRAM TO DOE
    - PNC PROGRAMS START IN MID '84
    - WILL LAST ABOUT 3 YEARS
    - REPORTS WILL BE AVAILABLE
      - CREEP-FATIGUE
      - THERMAL TRANSIENT
      - RACHETING
      - BUCKLING

RECOMMENDED COLLABORATIVE PROGRAM (CONTINUED)

- DOE TO PERFORM ANALYTIC ASSESSMENT OF INITIAL PHASE OF PNC TEST DATA AND RECOMMEND MODIFICATION TO N-290 TO PERMIT "DESIGN-BY-ANALYSIS"
  - PNC AND DOE TO JOINTLY ASSESS AND AGREE ON INITIATION OF ANALYTIC ASSESSMENT AND FURTHER COLLABORATION BASED ON
    - ELEVATED TEMPERATURE TEST RESULTS ('86-'87)
    - STATUS OF IMPLEMENTATION OF BELLOWS IN PLANT DESIGN
- PNC TO PROVIDE DOE RESULTS OF FURTHER TESTING IF CONDUCTED
  - SEISMIC
  - FLOW VIBRATION
  - WATER HAMMER

BENEFITS OF RECOMMENDED COLLABORATIVE PROGRAM ON PIPING BELLOWS FOR LMFBR SERVICE

PNC

- IMPROVED BELLOWS RELIABILITY THROUGH IMPROVED FABRICATION INSPECTION AND ANALYSIS
- REDUCED COST OF BELLOWS PROCUREMENT THROUGH "DESIGN-BY-ANALYSIS" INSTEAD OF COSTLY TESTING OF INDIVIDUAL BELLOWS DESIGNS AND APPLICATIONS CURRENTLY REQUIRED BY ASME CODE

DOE

- SUPPORTS DECISION TO USE BELLOWS IN DRACS
  - COST SAVINGS
  - PERFORMANCE IMPROVEMENT
- REDUCED COST OF BELLOWS PROCUREMENT

BELLOWS COLLABORATION PLANNING

. TRANSMIT BACKGROUND INFORMATION	12/1/83
. DOE TO PROVIDE ANNOTATED LISTING * OF BASE TECHNOLOGY PROGRAM REPORTS	
. PNC TO PROVIDE DESCRIPTIONS OF INITIAL TEST PHASE	
. RESOLVE QUESTIONS REGARDING BACKGROUND INFORMATION	12/15/83
. REVIEW AND APPROVE JOINT PROPOSAL IN EACH COUNTRY	2/1/84
. RENEGOTIATE (IF NECESSARY)	2/15/84
. SUBMIT JOINT PROPOSAL TO PEWG EXECUTIVE COMMITTEE	3/15/84

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* Report titles, summaries, tables of contents

Appendix VI

JOINT RECOMMENDATION FOR COLLABORATIVE LMFBR PLANT OPTIMIZATION EFFORTS

JOINT DOE-PNC TASK GROUP ON VERIFICATION OF DRACS

September 30, 1983

DRACS VERIFICATION TASK GROUP

JOINT RECOMMENDATION ON DOE/PNC COLLABORATION

RICHLAND, WASHINGTON
SEPTEMBER 26-30, 1983

CONTRIBUTORS

JAPAN - N. HANDA
- J. KUBOTA

U.S. - R. A. JOHNSON
- S. C. ROSE
- A. J. RAPACZ
- R. L. STOVER

DRACS VERIFICATION PROGRAM

PROGRAM BASE

- SEVERAL STUDIES HAVE BEEN PERFORMED BY THE COUNTRIES WORKING ON LARGE LMFBR DESIGNS AND ALL CONCLUDE THAT A NATURAL CIRCULATION DRACS COULD BE INCORPORATED AS A COST-OPTIMIZATION FEATURE. THIS HAS BEEN VERIFIED FOR SAFETY CRITERIA RANGING FROM VERY CONSERVATIVE TO VERY AGGRESSIVE.

- RATIONAL SAFETY CRITERIA FOR LMFBRs HAS EVOLVED AND IS BEING APPLIED IN CURRENT DESIGN ACTIVITIES. THESE ALLOW A NUMBER OF DIFFERENT SPECIFIC DESIGN SOLUTIONS, E.G., ADDING DECAY HEAT REMOVAL RELIABILITY TO REDUCE CONTAINMENT REQUIREMENTS, AND AN OPTIMIZED SOLUTION CAN ONLY BE ESTABLISHED FOR A SPECIFIC OVERALL DESIGN. THE GENERIC REQUIREMENTS FOR A SINGLE DRACS SYSTEM ARE WELL ESTABLISHED HOWEVER.

- THE DRACS EFFORT REQUIRED THEN, IS TO PROVIDE THE TECHNOLOGY AND DESIGN METHODOLOGY NEEDED TO ENABLE THE PLANT DESIGNER TO PROVIDE OPTIMIZED LICENSABLE DESIGNS THAT CAN BE INCORPORATED SINGLY OR IN MULTIPLES IN AN LMFBR.

<u>WHERE WE ARE</u>:

- COST REDUCTION OF DRACS CONCEPT CONFIRMED
- REQUIREMENTS FOR DRACS CONCEPT ESTABLISHED
- REQUIREMENTS FOR A SPECIFIC DRACS DESIGN DEPENDENT ON:
  - -- OVERALL PLANT SAFETY REQUIREMENTS (BEING ADDRESSED BY OTHER JAPANESE AND U.S. GROUPS - DOE, PNC, COMO, FPO)
  - -- TRADEOFFS OF OVERALL SAFETY REQUIREMENTS ON A SPECIFIC PLANT
  - -- PLANT DESIGN DETAILS
- TECHNOLOGY AND DESIGN METHODOLOGY NOT YET VALIDATED

<u>FURTHER STEPS REQUIRED</u>:

- COMPLETE COMPUTER CODES DEVELOPMENT
- * DEVELOP ANALYSIS METHODS FOR THERMAL HYDRAULIC DESIGN
- * CONDUCT TESTS TO PROVIDE DESIGN VERIFICATION DATA
- VALIDATE CODES WITH TEST DATA
- * IF NECESSARY, PERFORM A DRACS PROTOTYPE TEST

<u>GOAL</u>:

- VERIFIED DESIGN METHODS AS BASIS FOR:
  - -- LICENSING
  - -- DESIGNER CONFIDENCE
  - -- REDUCED COSTS THROUGH REDUCED UNCERTAINTIES/MARGINS

* COLLABORATION TO REDUCE R&D COSTS AND BROADEN EXPERIENCE BASE

REASONS FOR COLLABORATION ON NATURAL CIRCULATION DRACS VERIFICATION

- DRACS IS A NECESSITY FOR OPTIMIZED PLANTS, IMPROVING INHERENT SAFETY AND SIGNIFICANTLY REDUCING COST BY SHRINKAGE OF THE SAFETY-GRADE ENVELOPE

- JAPAN AND THE U.S. ARE NOW PURSUING PARALLEL PATHS FOR DRACS DEVELOPMENT

- NEAR-TERM COLLABORATION CAN:
  - BROADEN EXPERIENCE BASE AND 1) AID LICENSING, 2) REDUCE COSTS THROUGH REDUCTION OF UNCERTAINTIES AND MARGINS, AND 3) REDUCE POSSIBILITY OF UNEXPECTED PROBLEMS
  - ESTABLISH BASIS FOR LATER COLLABORATION

- LONG-TERM COLLABORATION CAN SIGNIFICANTLY REDUCE R&D COST

SAFETY CRITERIA PROPOSED BY JAPAN

. SHOULD BE COVERED WITHIN BROADER SCOPE

. WILL BE COVERED BY OTHER ACTIVITIES

THEREFORE, JAPAN/US AGREE TO DELETE FROM DRACS VERIFICATION, ALTHOUGH BOTH COUNTRIES AGREE ON IMPORTANCE

DRACS VERIFICATION

AREAS FOR FURTHER EVALUATION OF COLLABORATION

PHASE I: (TO ~1988)
- ANALYTICAL EXPERIENCE
- SPECIAL PURPOSE TESTS
- LARGE RELATED TESTS

PHASE II: (AFTER ~1988)
- LARGE-SCALE PROTOTYPE DRACS TEST

DRACS VERIFICATION PROGRAM

ANALYTICAL EXPERIENCE

JAPAN

- DESIGN METHODOLOGY USING THERMAL-HYDRAULIC CODES SUCH AS:
  - -- MIMIR
  - -- THAUPR
  - -- SCORT
  - -- THERVIS
  - -- COMMIX
  - -- COBRA-IV
  - -- ETC.

U.S.

- DESIGN METHODOLOGY USING THERMAL-HYDRAULIC CODES SUCH AS:
  - -- DASHR
  - -- COMTRAN
  - -- COMMIX
  - -- COBRA-IV AND -WC
  - -- CORTRAN
  - -- SASSYS
  - -- SSC

TYPES OF COLLABORATION:

- EXCHANGE INFORMATION ON SENSITIVITY OF ANALYTICAL RESULTS TO:
  - -- CODE INPUT ASSUMPTIONS
  - -- NUMBER OF COMPUTATIONAL CELLS
  - -- TIME STEPS
  - -- ETC.
- DEVELOP AND VERIFY AN ADEQUATE 1-D FLOW NETWORK MODEL (JAPAN)
- PROVIDE COMMIX 3-D VALIDATION RESULTS (U.S.)

SPECIAL PURPOSE TESTS

BASIS FOR COLLABORATION:

JAPAN

- EXISTING DATA FROM:
  - PIN BUNDLE TESTS
  - IN-VESSEL FLOW DISTRIBUTION TESTS
  - PIPING STRATIFICATION TEST WITH WATER
  - NATURAL CIRCULATION TEST IN SGTF
  - JOYO NATURAL CIRCULATION TEST
- PLANNED/POSSIBLE FUTURE DATA FROM:
  - SMALL SCALE H_2O TEST OF DRACS
  - Na-Na OR NaK HEAT TRANSFER AT LOW FLOW

U.S.

- EXISTING DATA FROM:
  - SSTF SIMPLE Na TESTS
  - SIMONE WATER TESTS
  - FFTF NATURAL CIRCULATION TEST
  - THORS-SHRS TUBE BUNDLE TESTS
- PLANNED/POSSIBLE FUTURE DATA FROM:
  - SSTF TESTS WITH IN-VESSEL HX
  - ADVANCED SIMONE TESTS
  - EXPANDED THORS-SHRS TESTS INTO Na BOILING

TYPES OF COLLABORATION:

- EXCHANGE EXISTING TEST DATA WITH DETAILS
- EXCHANGE ANALYSES OF EXISTING AND FUTURE TEST DATA
- EXCHANGE RESULTS OF COMPUTER "BRUSH UP" CHANGES WITH THIS DATA
- JOINTLY PLAN FUTURE TESTS AND EXCHANGE DATA

LARGE RELATED TESTS

BASIS FOR COLLABORATION:

JAPAN

- IN-VESSEL NATURAL CIRCULATION TEST IN JOYO
  - ISOLATED PHTS (LOWERED Na LEVEL)
  - FLOW PASSAGES THROUGH REFLECTOR REGION
  - EXTERNALLY COOLED VESSEL
- MONJU NDHX TEST
- SYSTEM HEAT CAPACITY/HEAT LOSS TEST IF FEASIBLE

U.S.

- EBR-II NATURAL CIRCULATION TESTS
  - PROTECTED AND UNPROTECTED LOSS OF PUMPING POWER
  - EXTENSIVE CORE SUBASSEMBLY AND PLANT INSTRUMENTATION
- CRBRP NDHX TEST
- FSF COOLING SYSTEM TEST
- SYSTEM HEAT CAPACITY/HEAT LOSS TEST IF FEASIBLE

TYPES OF COLLABORATION:

- EXCHANGE TEST DATA WITH DETAILS
- EXCHANGE ANALYSES OF TEST DATA
- JOINTLY PLAN TESTS

LARGE-SCALE PROTOTYPE DRACS TEST

- DECISION ON TEST DEFERRED FOR 2-3 YEARS
  - JAPAN - TEST ANTICIPATED BUT DESIGN SELECTION NOT SCHEDULED UNTIL ~1987
  - U.S. - NECESSITY OF TEST TO BE DECIDED IN ~1986 AFTER COMPLETION OF ADDITIONAL WORK
- COLLABORATION DECISION ALSO DEFERRED BUT COULD INCLUDE:
  - JOINT PLANNING AND FUNDING OF A LARGE TEST
  - EXCHANGE OF DATA FROM NATIONAL TESTS
  - MODERATE U.S. INVOLVEMENT IN JAPANESE TEST
  - ETC.

DRACS VERIFICATION PROGRAM

DRACS VERIFICATION COLLABORATION PLANNING

• TRANSMIT EXAMPLES OF BACKGROUND INFORMATION	11/15/83
• TRANSMIT BACKGROUND INFORMATION	12/31/83
• TRANSMIT SUGGESTED PROPOSALS	1/31/84
• MEET TO NEGOTIATE AND DRAFT A JOINT PROPOSAL, AS REQUIRED	2/15/84
• REVIEW AND APPROVE JOINT PROPOSAL IN EACH COUNTRY	
• RENEGOTIATE (IF NECESSARY)	
• SUBMIT JOINT PROPOSAL TO PEWG EXECUTIVE COMMITTEE	3/15/84

ANALYTICAL EXPERIENCE BACKGROUND INFORMATION

- ON EACH COMPUTER CODE, SUMMARIZE:
  - DESCRIPTION, CAPABILITIES, FEATURES & LIMITATIONS
  - CURRENT STATUS OF CODE DEVELOPMENT/VALIDATION
  - COMPUTER COMPATIBILITY
  - AMOUNT OF ANALYSIS DONE (WHEN, BY WHOM, ETC.)
  - PROBLEMS SOLVED (MODELS, TIME COVERED, ETC.)
  - FUTURE PLANS
- DEVELOPMENT OF 1D FLOW NETWORK (JAPAN)
  - PLANS & APPROACH CONSIDERED
  - DESCRIPTION OF VERIFICATION PLANS
- DESCRIPTION OF PLANS FOR COMMIX-3D VALIDATION (U.S.)

BACKGROUND INFORMATION ON TESTS

FOR EACH SET OF EXISTING DATA, SUMMARIZE (~2 PAGES TEXT)

- TEST DESCRIPTION
  - PURPOSE
  - DIAGRAMS, SCHEMATICS, DIMENSIONS
  - PARAMETERS
  - FACILITY
  - TEST PROGRAM
  - DATES PERFORMED OR SCHEDULED
- INSTRUMENTATION (QUANTITY, TYPE, LOCATION, ACCURACY)
- FORM OF DATA (RAW, REDUCED, ANALYZED)
- ACTUAL OR EXPECTED FINDINGS AND THEIR SIGNIFICANCE
- CODE VALIDATION ANALYSES PERFORMED

Appendix VII

JOINT RECOMMENDATION FOR COLLABORATIVE LMFBR PLANT OPTIMIZATION EFFORTS

JOINT DOE-PNC TASK GROUP ON THERMAL AND LOAD CYCLING CRITERIA FOR SODIUM COMPONENTS AND SYSTEMS

A. Thermal Striping Design

B. Inelastic Design Methodology

September 30, 1983

STUDY OF THE FEASIBILITY OF COLLABORATIVE PNC/DOE EFFORT ON THERMAL STRIPING DESIGN

OBJECTIVE OF STUDY

DETERMINE FEASIBILITY OF A COOPERATIVE EFFORT TO DEVELOP A THERMAL STRIPING DESIGN METHODOLOGY.

BENEFITS

- REDUCTION OF PLANT CAPITAL COST
  - LESS EXPENSIVE MATERIALS (E.G. SS 316 VS INCONEL 718) IN UPPER INTERNAL STRUCTURE
  - LESS EXPENSIVE FABRICATION METHOD (WELDED VERSUS BOLTED, NO CLADDING)
- LICENSABILITY
  - IMPROVED BASIS FOR PLANT LICENSING ACCEPTANCE
- IMPROVEMENT OF PLANT PERFORMANCE
  - IMPROVED CORE COMPONENT LIFE
  - MORE FLEXIBILITY IN CORE DESIGN
  - PLANT CAPACITY FACTOR IMPROVEMENT
- REDUCTION OF R&D PROGRAM COSTS
  - ACCESSIBILITY OF INFORMATION, INCLUDING TEST DATA TO DOE AND PNC OF PAST & FUTURE R&D
  - AVAILABILITY OF ADDITIONAL FACILITIES TO EACH COUNTRY FOR VALIDATION TESTING OF COMPONENTS

STUDY ON THERMAL STRIPING DESIGN (CONTD)

BACKGROUND

. THE DESIGN DATA ARE NOW AVAILABLE FOR THE MONJU UPPER PLENUM FROM WATER TESTS PERFORMED WITH PLANT SIZE 1/3 SECTOR MODEL AND 19 ASSEMBLY MODEL.

. AT PNC A COMPARATIVE TEST IN WATER AND IN SODIUM WILL START IN THE SUMMER OF 1984 USING A 7 ASSEMBLY FULL SCALE MODEL.

. WAESD IS CONDUCTING TESTS TO DETERMINE DYNAMIC FILM COEFFICIENTS AND THE AFFECTS OF THERMAL STRIPING ON MATERIAL STRENGTH.

. RI IS CONDUCTING TESTS ON FILM COEFFICIENTS AND AFFECTS ON MATERIAL UNDER MORE VARIETIES OF CONDITIONS.

. THE CRBRP FULL SIZE 7 ASSEMBLY WATER TEST DATA AT WHC IS AVAILABLE.

CONCLUSION

IT IS RECOMMENDED THAT COLLABORATION PROCEED IN THE DEVELOPMENT OF THERMAL STRIPING DESIGN METHODOLOGY. THE SPECIFIC AREAS IN WHICH THIS COLLABORATION IS MOST NEEDED ARE:

CORRELATION OF WATER AND SODIUM TEST DATA

DYNAMIC FILM COEFFICIENT INFORMATION

EFFECTS OF THERMAL STRIPING ON MATERIAL STRENGTH

ESTABLISHMENT OF A DESIGN METHOD

THERMAL STRIPING

RECOMMENDATIONS

1. WATER SODIUM CORRELATION

PNC FURNISH THE DATA FROM THE MONJU WATER AND SODIUM SEVEN ASSEMBLY TESTS.

. COMPLETE SPRING 1985

. PROGRAM PLAN BY END OF 1983

2. DYNAMIC FILM COEFFICIENT EXCHANGE

WAESD NA TESTS - CURRENTLY IN PROGRESS

RI NA TESTS - MARCH 1984

PNC MONJU SEVEN ASSEMBLY NA TEST - MARCH 1985

THERMAL STRIPING RECOMMENDATIONS (CONT'D)

3. EFFECTS OF THERMAL STRIPING ON MATERIAL STRENGTH
   EXCHANGE
   WAESD NA TEST DATA - 316 SS & 718 INCONEL AVAILABLE, OTHER MATERIAL LATER
   RI SODIUM TEST DATA
   JUNE 1984 FOR 316 SS
   OTHER MATERIALS LATER 718, 9 CR - 1 MO
   DETAILED PROGRAM PLANS FOR BOTH FACILITIES (THIS SHOULD BE PROVIDED BY END OF 1983).
   PNC WILL REVIEW AND CONSIDER SENDING TEST SPECIMEN TO US.
   US TO INFORM PNC OF SCHEDULE.

4. ESTABLISH THERMAL STRIPING DESIGN METHOD.
   THERE SHOULD BE A MEETING ON THIS SUBJECT IN THE FALL OR SUMMER OF 1985.

5. THIS ACTIVITY SHOULD BE CARRIED OUT UNDER THE SYSTEMS AND COMPONENT WORKING GROUP.

HIGH TEMPERATURE STRUCTURAL DESIGN SUBTOPIC:
FEASIBILITY STUDY OF PNC/DOE COLLABORATION ON INELASTIC DESIGN METHODOLOGY

OBJECTIVE: TO DETERMINE IF A COLLABORATIVE EFFORT BY PNC AND DOE TO DEVELOP CRITERIA, GUIDELINES AND PROCEDURES FOR FBR COMPONENT INELASTIC DESIGN IS FEASIBLE AND BENEFICIAL TO EACH SIDE.

POTENTIAL BENEFITS:

. REDUCTION OF PLANT CAPITAL COST
  LESS EXPENSIVE MATERIALS
  WIDER FABRICATION TOLERANCES
  LESS COMPLEX STRUCTURES (E.G. THERMAL BAFFLES) TO MITIGATE THERMAL TRANSIENTS IMPACT

. IMPROVEMENT OF PLANT PERFORMANCE
  IMPROVED PLANT STARTUP AND SHUTDOWN RATES
  PERMITS LARGER PLANT OPERATING ENVELOP TO ACCOMMODATE NORMAL, UPSET AND EMERGENCY CONDITIONS
  LESS COMPLEX OPERATING PROCEDURES

. LICENSABILITY
  IMPROVED BASIS FOR PLANT LICENSING ACCEPTANCE

HIGH TEMPERATURE STRUCTURAL DESIGN SUBTOPIC: (CONT'D)

BACKGROUND

. ASME BOILER AND PRESSURE VESSEL CODE C.C. N-47 PROVIDES DESIGN RULE BASED ON ELASTIC ANALYSES AS WELL AS INELASTIC ANALYSES

. DESIGN RULE BASED ON ELASTIC ANALYSES GIVE UNDULY CONSERVATIVE RESULTS IN SOME CASES

. U.S. HAS PROVIDED RATHER DETAILED GUIDELINE FOR DESIGN BASED ON INELASTIC ANALYSES

- PNC PROVIDED "STRUCTURAL DESIGN GUIDE FOR CLASS 1 COMPONENTS OF PROTOTYPE FAST BREEDER REACTOR FOR ELEVATED TEMPERATURE SERVICE"
- DESIGN RULE IN "PNC DESIGN GUIDE" USING ELASTIC ANALYSES CONSIDERS INELASTIC RESPONSE OF STRUCTURES IN SIMPLIFIED WAY
- PNC IS PREPARING GUIDELINE FOR DESIGN BY INELASTIC ANALYSES
- CURRENTLY AVAILABLE PROCEDURES FOR DESIGN BASED ON INELASTIC ANALYSES HAVE MANY ASPECTS FOR IMPROVEMENT (E.G. LOAD ORDERING, CONSTITUTIVE EQUATION, HARDENING RULES), MORE REASONABLE DESIGN PROCEDURES SHOULD BE ESTABLISHED BY EXTENSIVE MATERIAL TESTS, ANALYTICAL WORK, AND COMPONENT VALIDATION TESTS.
- REDUCTION OF R&D PROGRAM COSTS

  ACCESSIBILITY OF INFORMATION, INCLUDING TEST DATA TO DOE AND PNC OF PAST AND FUTURE R&D.

  AVAILABILITY OF AN ADDITIONAL FACILITIES TO EACH COUNTRY FOR VALIDATION TESTING OF COMPONENTS.

CONCLUSION

DOE AND PNC RECOMMENDS THAT COLLABORATION PROCEED IN THE DEVELOPMENT OF CRITERIA, GUIDELINES AND PROCEDURES FOR FBR COMPONENT INELASTIC DESIGN.

INELASTIC DESIGN COLLABORATION PLANNING

. TRANSMIT PRIORITIZED LIST OF ELEMENTS OF INELASTIC DESIGN METHODOLOGY WHICH ARE MOST IN NEED OF IMPROVMENT (E.G. LOAD ORDERING, CONSTITUTIVE EQUATIONS)	12/15/83 PNC & DOE
. TRANSMIT DEVELOPMENT PLANS FOR ELEMENTS OF INELASTIC DESIGN IDENTIFIED ABOVE	1/15/84 PNC & DOE
. TRANSMIT SUMMARIES OF COMPONENT VALIDATION TESTING	1/15/84 PNC & DOE
. MEET TO NEGOTIATE AND DRAFT A JOINT PROPOSAL FOR: . EXCHANGE OF TEST DATA . EXCHANGE OF ANALYSIS . COLLABORATIVE EFFORT ON METHODOLOGY IMPROVEMENTS (E.G. SPECIALIST VISITS) . COLLABORATIVE EFFORT ON VALIDATION TESTS . EXCHANGE OF PERSONNEL	2/15/84
. REVIEW AND APPROVE JOINT PROPOSAL IN EACH COUNTRY	
. SUBMIT JOINT PROPOSAL TO PEWG EXECUTIVE COMMITTEE	3/15/84

Appendix VIII

JOINT RECOMMENDATION FOR COLLABORATIVE LMFBR PLANT OPTIMIZATION EFFORTS

JOINT DOE-PNC TASK GROUP ON GENERAL SEISMIC DESIGN CRITERIA

September 30, 1983

DOE/PNC JOINT PLANT EXPERIENCE WORKING GROUP MEETING
HANFORD ENGINEERING DEVELOPMENT LABORATORY
RICHLAND, WASHINGTON
SEPTEMBER 26-30, 1983

Summary of Meeting Proceedings on LMFBR General Seismic Design Criteria Topics

Eight topics in five categories were identified and recommended by the joint DOE/PNC Seismic Design Task Group for collaborative activity during the next one to five years (see Figure 1). All of these topics are judged to be potentially important contributors to optimization and cost reduction for large LMFBR plants.

LMFBR GENERAL SEISMIC DESIGN CRITERIA

TOPICS IDENTIFIED FOR COLLABORATION

A. PIPING SYSTEM

1. SODIUM PIPING DAMPING VALUES
2. PIPING PLASTICITY AND NON-LINEAR BEHAVIOR

B. FUNCTIONAL QUALIFICATION OF ACTIVE COMPONENTS

1. CONTROL ROD DRIVE SYSTEM SEISMIC TESTING
2. PUMP HYDROSTATIC BEARING LOADS AND COASTDOWN TIME
3. SODIUM VALVE SEISMIC DESIGN METHODOLOGY

C. CORE DUCT ASSEMBLY IMPACT MODELS AND STRENGTH LIMITS

D. SEISMIC ISOLATION

E. FLUID-STRUCTURE INTERACTION ANALYSIS METHODS

Figure 1.

From evaluations of the status of current programs and the applicability to near-term studies, it was agreed that three of these topics should be recommended for immediate action (Items A1, A2, and C; Figures 2, 3, and 7), for data exchange, cooperative testing, and design methods development; one recommended for near-term collaboration on concept feasibility studies (Item D; Figure 8); three recommended for collaboration which include information exchange and planning for joint testing at a later date (Items B1, B2, and B3; Figures 4, 5 and 6); and one item (Item E; Figure 9) which is pending further negotiation.

LMFBR GENERAL SEISMIC DESIGN CRITERIA

TOPIC A.1 - SODIUM PIPING DAMPING VALUES

OBJECTIVE: ESTABLISH DAMPING VALUES FOR LMFBR DESIGN WHICH ARE HIGHER THAN THOSE USED IN CURRENT STANDARD PRACTICE

BENEFITS: REDUCED PLANT COSTS

PROBABILITY FOR TECHNICAL SUCCESS: HIGH

STATUS: SOME DATA EXIST; FURTHER TESTING NEEDED

PROPOSED TASKS:

1) ASSEMBLE AND EVALUATE AVAILABLE DAMPING TEST DATA

2) IDENTIFY AND PERFORM ADDITIONAL NECESSARY DAMPING TESTS

3) PREPARE REFERENCE REPORT WHICH CAN BE USED FOR JUSTIFICATION, ACCEPTANCE, AND IMPLEMENTATION OF HIGHER DAMPING VALUES

COMMENT: DAMPING VALUES FOR OTHER REACTOR EQUIPMENT MAY BE CONSIDERED FOR COLLABORATION IN THE FUTURE.

Figure 2.

TOPIC A.2 - PIPING PLASTICITY AND NON-LINEAR BEHAVIOR

OBJECTIVE: ESTABLISH DESIGN PROCEDURES AND CRITERIA FOR SODIUM PIPING WHICH RECOGNIZES NON-LINEAR BEHAVIOR BY GAPS AND ENERGY ABSORBTION PROVIDED BY PLASTIC DEFORMATION

BENEFITS: POTENTIAL COST REDUCTIONS IN COSTS OF PIPING, PIPING SUPPORT STRUCTURE, AND DESIGN ENGINEERING

PROBABILITY FOR TECHNICAL SUCCESS: MEDIUM

STATUS: SOME STUDIES AND TESTS HAVE BEEN PERFORMED; DESIGN APPROACH HAS BEEN PROPOSED IN U.S.

PROPOSED TASKS:

1) REVIEW PERTINENT DATA AND METHODS, AND IDENTIFY ADDITIONAL NEEDED TESTS AND METHODS DEVELOPMENT

2) PREPARE PLANS FOR COOPERATIVE TESTING AND ANALYSIS METHODS DEVELOPMENT FOR APPLICATION TO SODIUM PIPING, AND FOR DESIGN BY RULES FOR SMALL BORE PIPING

3) PERFORM TESTS, DEVELOP METHODS, AND PREPARE ASSOCIATED REPORTS

4) REVIEW REPORTS, RECONCILE COMMENTS, PREPARE AND ISSUE FINAL REPORTS FOR DESIGN USE

Figure 3.

TOPIC B.1 - CONTROL ROD DRIVE SYSTEM SEISMIC TESTING

OBJECTIVE: EXCHANGE CONTROL ROD DRIVE SYSTEM SEISMIC TEST DATA

BENEFITS: OBTAIN CLEARER UNDERSTANDING OF SEISMIC BEHAVIOR FOR APPLICATION TO MORE EFFICIENT AND ECONOMICAL DESIGNS

PROBABILITY OF TECHNICAL SUCCESS: HIGH

STATUS: U.S. AND JAPANESE DATA EXIST

PROPOSED TASKS:

1) IDENTIFY SEISMIC TESTS WHICH HAVE BEEN PERFORMED

2) DOCUMENT TEST DETAILS

3) EXCHANGE AND EVALUATE DATA WITH RESPECT TO ANALYTICAL METHODS

COMMENT: IN THE FUTURE, US/PNC WILL CONSIDER COOPERATION ON JOINT DEVELOPMENT OF EVALUATION METHODS FOR CRD.

Figure 4.

TOPIC B.2 - PUMP HYDROSTATIC BEARING LOADS AND COASTDOWN TIME

OBJECTIVE: DEVELOP AND VERIFY GUIDELINES FOR PREDICTING HYDROSTATIC BEARING LOADS AND FAILURE MARGINS

BENEFITS: OBTAIN VERIFIED DESIGN GUIDELINES FOR DESIGN OF HYDROSTATIC BEARINGS AT MINIMUM COST

PROBABILITY OF TECHNICAL SUCCESS: HIGH

STATUS: ANALYTICAL METHODS EXIST. CONFIRMATION IS NEEDED. PNC IS PERFORMING TESTS IN NA AT FULL PLUS REDUCED SPEED UNDER SIMULATED EARTHQUAKE CONDITION. U.S. IS DOING TESTS ON FRICTION AND WEAR.

PROPOSED TASKS:

1) EXCHANGE AND REVIEW CURRENT (UP TO TIME OF EXCHANGE) DESIGN METHODS AND DATA, AND IDENTIFY TECHNOLOGY NEEDS FOR LARGE PLANTS

2) IF APPROPRIATE, PREPARE PLANS FOR COOPERATIVE TESTS, DEVELOPMENT, AND STUDY AGREEMENTS

COMMENTS:

- U.S. IS FOCUSSED ON DATA RELATING TO PUMP COASTDOWN TIME DURING EARTHQUAKE AS WELL AS REDUCED SPEED PERFORMANCE WITHOUT LOSS OF ELECTRIC POWER, AND TOLERANCE OF BEARING TO IMPACT LOADS.
- PERFORMANCE OF TESTING, METHODS DEVELOPMENT, AND STUDIES WILL BE CONSIDERED FOR A FUTURE COLLABORATIVE AGREEMENT.

Figure 5.

TOPIC B.3 - SODIUM VALVE SEISMIC DESIGN METHODOLOGY

OBJECTIVE: DEVELOP AND VERIFY GUIDELINES FOR PREDICTING SODIUM VALVE INTEGRITY AND FAILURE MARGINS

BENEFITS: OBTAIN VERIFIED DESIGN GUIDELINES FOR DESIGN OF SODIUM VALVES AT MINIMUM COST

PROBABILITY OF TECHNICAL SUCCESS: HIGH

STATUS: ANALYTICAL METHODS EXIST. CONFIRMATION IS NEEDED. PNC IS PERFORMING TESTS UNDER SIMULATED EARTHQUAKE CONDITIONS

PROPOSED TASKS:

1) EXCHANGE AND REVIEW CURRENT (UP TO TIME OF EXCHANGE) DESIGN METHODS AND DATA, AND IDENTIFY TECHNOLOGY NEEDS FOR LARGE PLANTS

2) IF APPROPRIATE, PREPARE PLANS FOR COOPERATIVE TESTS, DEVELOPMENT, AND STUDY AGREEMENTS

Figure 6.

TOPIC C - CORE DUCT ASSEMBLY IMPACT MODELS AND STRENGTH LIMITS

OBJECTIVE: DEVELOP IMPACT MODELS (PNC) AND STRENGTH LIMITS (DOE), EXCHANGE DATA, AND PERFORM ADDITIONAL TESTING THROUGH JOINT PROGRAM, FOR ESTABLISHMENT OF CORE DUCT SEISMIC LIMITS

BENEFITS: POTENTIAL COST REDUCTIONS IN REACTOR AND REACTOR SUPPORTING STRUCTURES BY SHOWING THAT CORE DUCTS HAVE HIGH TOLERANCE TO SEISMIC LOADING

PROBABILITY OF TECHNICAL SUCCESS: HIGH

STATUS: SOME TEST DATA EXIST AND SOME PNC/DOE EXCHANGE HAS TAKEN PLACE; ADDITIONAL TESTING PLANNED

PROPOSED TASKS:

1) REVIEW RELEVANT CORE DUCT SEISMIC TESTS AND EXISTING DATA

2) IDENTIFY NEEDED ADDITIONAL DATA, ANALYSIS AND METHODS

3) PREPARE COOPERATIVE TEST, DEVELOPMENT AND STUDY AGREEMENTS

4) PERFORM TESTS AND PREPARE ASSOCIATED REPORTS

Figure 7.

TOPIC D - SEISMIC ISOLATION

OBJECTIVE: DEVELOP AND EVALUATE REACTOR PLANT SEISMIC ISOLATION SYSTEMS

BENEFITS: POTENTIAL REDUCTION OF PLANT ENGINEERING AND CONSTRUCTION COSTS. IMPROVED PLANT RELIABILITY AND SAFETY

PROBABILITY OF TECHNICAL SUCCESS: MEDIUM

STATUS: ISOLATION SYSTEMS HAVE BEEN APPLIED TO LWR's AND CONVENTIONAL STRUCTURES. PERFORMANCE AND COST EFFECTIVENESS DATA NEEDED

PROPOSED TASKS:

1) PERFORM FEASIBILITY STUDIES, AND EXCHANGE INFORMATION AND DESIGN/ANALYSIS METHODOLOGIES

COMMENT: FURTHER COOPERATIVE ACTIVITIES WILL BE EXPLORED IN THE FUTURE AND WILL DEPEND ON ASSESSMENT OF RESULTS OF FEASIBILITY STUDIES.

Figure 8.

LMFBR GENERAL SEISMIC DESIGN CRITERIA

TOPIC E - FLUID-STRUCTURE INTERACTION ANALYSIS METHODS
(PENDING: PNC WILL ARRANGE WITH JAPANESE INDUSTRIES)

OBJECTIVE: DEVELOPMENT OF FLUID-STRUCTURE INTERACTION DATA FOR VALIDATION OF REACTOR SYSTEM ANALYTICAL MODELS

BENEFITS: POTENTIAL REDUCTION OF PLANT COSTS THROUGH AVOIDANCE OF OVERLY CONSERVATIVE DESIGN

PROBABILITY OF TECHNICAL SUCCESS: MEDIUM

STATUS: DOE SPONSORED EXPERIMENTAL PROGRAM TO BE INITIATED IN 1984. INDUSTRY TESTS BEING PERFORMED IN JAPAN

PROPOSED TASKS (U.S. ONLY):

1) PERFORM INITIAL SLOSHING TESTS AND HEAD-MOUNTED COMPONENT TESTS

2) PERFORM TESTING ON INTERNAL COMPONENTS AND COMPLEX MODELS

3) PREPARE RECOMMENDED ANALYSIS METHODS BASED ON RESULTS OF TESTS

4) ISSUE FINAL REPORT

Figure 9.

In order to prepare for the detailed proposal for submittal to the Executive Committee, PNC and DOE will jointly exchange specific background information relative to the content, scope, and nature of the proposed collaboration topics (see Figure 10).

NEAR-TERM SEISMIC COLLABORATION ACTIVITIES

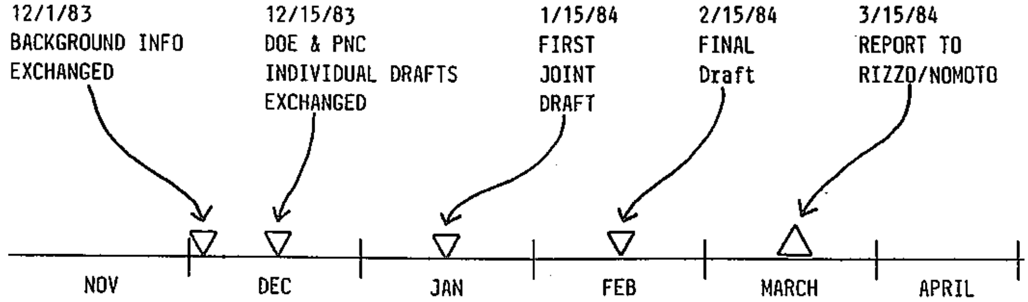


Figure 10.

LMFBR GENERAL SEISMIC DESIGN CRITERIA

TOPICS IDENTIFIED FOR COLLABORATION

A. PIPING SYSTEM

1. SODIUM PIPING DAMPING VALUES
2. PIPING PLASTICITY AND NON-LINEAR BEHAVIOR

B. FUNCTIONAL QUALIFICATION OF ACTIVE COMPONENTS

1. CONTROL ROD DRIVE SYSTEM SEISMIC TESTING
2. PUMP HYDROSTATIC BEARING LOADS AND COASTDOWN TIME
3. SODIUM VALVE SEISMIC DESIGN METHODOLOGY

C. CORE DUCT ASSEMBLY IMPACT MODELS AND STRENGTH LIMITS

D. SEISMIC ISOLATION

E. FLUID-STRUCTURE INTERACTION ANALYSIS METHODS

Appendix IX

JOINT RECOMMENDATION FOR COLLABORATIVE LMFBR PLANT OPTIMIZATION EFFORTS

JOINT DOE-PNC TASK GROUP ON DEFINITION OF STEAM GENERATOR DEVELOPMENT PROGRAM WITH INTENTION OF ELIMINATING THE INTERMEDIATE SYSTEM

September 30, 1983

DEFINITION OF STEAM GENERATOR DEVELOPMENT PROGRAM WITH INTENT OF ELIMINATING THE INTERMEDIATE SYSTEM

PRESENTATION

I. OBJECTIVE OF MEETING

II. CONCLUSIONS

III. OBJECTIVE OF COLLABORATIVE EFFORT FOR CONCEPTUAL DESIGN STUDY

IV. POTENTIAL BENEFIT OF COLLABORATION FOR CONCEPTUAL DESIGN STUDY

V. APPROACH FOR CONCEPTUAL DESIGN STUDY

VI. SCHEDULE FOR CONCEPTUAL DESIGN STUDY

VII. RESOURCES FOR CONCEPTUAL DESIGN STUDY

I. OBJECTIVE OF MEETING

REACH AGREEMENT ON THE FEASIBILITY OF COLLABORATIVE EFFORTS INVOLVING A PRIMARY SYSTEM STEAM GENERATOR (PSSG)

II. CONCLUSIONS

- HIGH RELIABILITY AND SERVICEABILITY OF S/G's ARE REQUIRED FOR IMPROVED PLANT AVAILABILITY AND, IN PARTICULAR, AS A PREREQUISITE TO IHTS ELIMINATION
- ELIMINATION OF THE IHTS OFFERS THE POTENTIAL FOR SIGNIFICANT COST REDUCTION FOR FUTURE-GENERATION PLANTS
- COLLABORATION IS DESIRABLE AT PRESENT ONLY IN THE STUDY AREA
- INITIAL EFFORT IS RECOMMENDED FOR A CONCEPTUAL DESIGN EVALUATION
  -- DECISION ON FUTURE COLLABORATIVE EFFORT WILL BE REACHED AFTER REVIEW OF CONCEPTUAL DESIGN EVALUATION RESULTS

III. OBJECTIVE OF COLLABORATIVE EFFORT FOR CONCEPTUAL DESIGN STUDY

- CLARIFY THE POTENTIAL FOR PLANT COST REDUCTION AND THE FEASIBILITY OF A PRIMARY SYSTEM STEAM GENERATOR FBR PLANT
- DEFINE R & D REQUIREMENTS FOR A PRIMARY SYSTEM STEAM GENERATOR FOR APPLICATION IN FUTURE LMFBR PLANT

IV. POTENTIAL BENEFIT OF COLLABORATION FOR CONCEPTUAL DESIGN STUDY

- SHARING KNOWLEDGE, IDEAS AND EXPERIENCE DURING INITIAL CONCEPTUAL DESIGN EVALUATION
- FUTURE POTENTIAL FOR COST SHARING IN R & D PROGRAMS WHICH ADDRESS THE CRITICAL ISSUES

COLLABORATION PLANNING TO NEXT PEWG

- EXCHANGE OF EACH DRAFT PROPOSAL ON PRE-"STUDY PLAN"* 12/31/83

---

* PRE-"STUDY PLAN" WILL INCLUDE THE PRELIMINARY INFORMATION FOR FOLLOWING ITEMS:

(1) DESCRIPTION OF TASK ON GROUNDRULES (INCLUDING TASK CONCEPT)

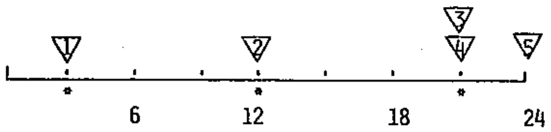
(2) ASSIGNMENT OF WORK

(3) WORK SCHEDULE

(4) EXPECTED RESOURCES

- DRAFT OF JOINT PROPOSAL 1/31/84
- REVIEW JOINT PROPOSAL IN EACH COUNTRY
- SUBMIT JOINT PROPOSAL TO PEWG EXECUTIVE COMMITTEE 3/15/84

VI. <u>SCHEDULE FOR CONCEPTUAL DESIGN STUDY</u>



1. COMPLETE STUDY PLAN
2. COMPLETE PRELIMINARY ASSESSMENT OF BENEFITS
3. COMPLETE DETAILED EVALUATION OF MAJOR CONCERNS
4. COMPLETE IDENTIFICATION OF R & D REQUIREMENTS
5. COMPLETE FINAL REPORT

V. <u>APPROACH FOR CONCEPTUAL DESIGN STUDY</u>

A. STUDY PLAN
   1. IDENTIFICATION OF GOALS AND OBJECTIVES
   2. DESCRIPTION OF TASKS AND GROUNDRULES
   3. ASSIGNMENT OF WORK
   4. DEVELOPMENT OF A WORK SCHEDULE

B. PRELIMINARY ASSESSMENT OF BENEFITS
   1. PRELIMINARY DESIGN OF A PSSG PLANT AND COMPARISON WITH IHTS PLANT
   2. EVALUATION OF THE BENEFIT
   3. RECOMMENDATION FOR FOLLOW-ON ACTIVITIES

C. DETAILED EVALUATION OF MAJOR CONCERNS
   1. IDENTIFICATION OF THE MAJOR CONCERNS:
      A. SAFETY
      B. COMPONENTS
      C. ETC.....
   2. EVALUATION OF EACH MAJOR ITEM
   3. REASSESSMENT OF FEASIBILITY AND BENEFIT

D. IDENTIFICATION OF R & D REQUIREMENTS

E. FINAL REPORT

VII. <u>RESOURCES FOR CONCEPTUAL DESIGN STUDY</u>

TO BE DETERMINED BY EACH SEPARATE COUNTRY

(50 MM TO 120 MM)

* RECOMMENDED INFORMATION EXCHANGE SESSIONS

第 4 章

討論内容および経緯

4. 討論内容および経緯

4.1 DOE/PNC タスクグループの提案

今回の会議に先立って，夫々の国内のタスクグループで検討してきた提案が示された。

(1) LMFBR 用配管ベローズの開発

DOE	PNC
1. 情報交換 • PNC および ISES 182 G の高温繰返し試験 • DOE の BASE TECHNOLOGY PROGRAM 基格規準 工学と設計 材 料 試 験 製 作 2. 設 計 • ベローズの共同仕様 設計要求 温 度 圧 力 移動量（作動） 他 3. コンポーネント試験 • 不活性雰囲気での設計裕度確認試験 高温での繰返し 耐 震 ASME クラス指針 4. システム試験 • 実際のナトリウム配管にベローズを設置して次の点を確認する。	1. システム設計 • ベローズを中心としたプラント配管系の最適化 • ベローズ型式の選択 • 日米共通の LBB の設計思想の確立 • ベローズの ISI. ISM 交換を考慮したシステム設計 2. 製 作 • 日米の配管ベローズの製作技術の調査 • 寸法公差の実態と N－290 の基準値の妥当性の調査 • 製作手順の統一化（基準化） 3. 設計基準 • N－290 の背景となる文献調査等を通してその改良すべき項目を明確にする。 • N－290 の "試験による設計" を "解析による設計" にする上での問題点を摘出する。 • クリープ疲労や座屈の合理的な評価法を確立するために必要な試験計画を作成する。

設　計 製作と検査 据　付 ISI 運　転 以上の4つの提案のうち，最初の情報交換を最優先とする。	

(2) DRACS の実証

DOE	PNC
1. 情報交換 ・設計解析者による計算コードの使用経験 ・コードの検証に使われた試験データ ・コード検証のための解析結果 2. 等価な共同計画の作成と実施 ・日本に提供できるもの 米国のコードの最新版 （例　COMMIX－1B） 重要な試験技術 （例　レーザ・ドップラー測定法） サポート試験のデータ （例　SSTF, SIMONE, THORS-SHRS) ・共同で計画，建設，試験する。 将来の特殊（部分）試験 SGTF, ETEC あるいは FFTF に於ける大規模 Na 中試験	1. 安全基準に関する情報交換（日米会議） ・必要とされる多重性と多様性 ・一般安全要求項目 ・BOP に対する設計基準 2. 実証のための試験データの交換 ・部分試験 プール型の試験（日本で実施） ループ型の試験（米国で実施） ・ナトリウム中での流動伝熱基礎試験 日米双方で実施 ・計算コードの検証 日米双方で実施

(3) 一般耐震設計基準

DOE	PNC
1. 原子炉機器の減衰定数 ・現在ある減衰試験データを集め評価する。 ・必要なデータを明らかにした上で追試験	1. 免　震 ・フィージビリティスタディ 免震システムの調査

を実施する。

- より大きな減衰定数を使うことの妥当性，対外的な認知ならびに実際の使用に関して有効な報告書を準備する。

2. 制御棒駆動機構の耐震試験
- 過去の試験の収集
- 詳細な試験記録の調査
- データの交換と相互評価

3. 炉心機器の限界試験と設計基準
- 炉心機器設計技術のレビュー
- 必要なデータ，解析手法の明確化
- 日米共同の試験，開発研究の合意書の作成
- 試験の実施と報告書の作成

4. 配管個有の塑性
- 関連の技術をレビューし，必要な試験ならびに手法の開発を明らかにする。
- 小口径配管に適用するための試験ならびに手法の開発を共同で実施する計画を立案する。
- 試験を実施し，手法を開発して報告書を作成する。
- 報告書をレビューし，コメントを配慮して，設計用としての最終報告書を作成する。

5. 流体と構造物の相互作用

解析手法
- 初期のスロッシング試験ならびに頂部を据付けた（HEAD-MOUNTED）コンポーネント試験を実施する。
- 内部機器ならびに複雑なモデルの試験を実施する。
- 試験結果を基に推奨する解析手法を用意

免震システムの FBR への適用性調査

実用化に当っての問題点の摘出

- 試　験

試験計画の立案

日米分担の計画立案

免震システムの振動解析手法の開発

実用化に当って必要な試験の実施

耐震設計の合理化と基準化

コスト削減

耐震設計基準合理化のための情報の提供

2. 配管系耐震解析手法の合理化
- 非線形挙動
- 配管伸縮継手
- 塑性振動挙動

これらについて以下の作業を行う。

情報調査

問題点の摘出

R & D 計画の立案

日米分担の計画立案

震度設計の裕度の確認と合理化

コスト削減

耐震設計基準合理化のための情報の提供

3. 流体と構造物の相互作用に対する解析手法の開発
- スロッシング
- 容器壁の変形
- 流体中の構造物の振動

これらについて 2.と同様の作業を行う。

4. 動的機器の機能維持
- CRD
- 機械式ポンプ軸受

する。

- 最終報告書を作成する。

6. ポンプの静圧軸受荷重とコーストダウン時間
   - 現在の設計手法およびデータをレビューし，大型プラントで必要とする技術を明確にする。
   - 適切であれば試験，開発ならびに研究に関する合意書を用意する。
   - 試験，開発，研究を実施する。
   - 設計指針書を作成する。
7. 構造物の具体的な減衰
   - 過去のデータのレビューと評価
   - 必要な追試験の実施
   - 減衰定数に対する推奨値を示す報告書の作成
8. 免　震
   - フィージビリティ・スタディを実施し，設計/解析手法を開発して試験計画を立案する。
   - 小規模試験を実施する。
   - コスト効果を評価し，大規模試験計画を立案する。
   - 大規模試験を実施する。
   - 設計用の報告書を作成する。
9. 地盤と構造物の相互作用（SSI）の解析
   - 過去のデータとSSI計算コードのレビュー
   - 検証するコードとデータの選択
   - コード検証と報告書の作成

- ナトリウム弁

(4) ナトリウム機器・系統に対する熱および機械的荷重の繰返し負荷基準

DOE	PNC
1. 高温構造設計基準 • 溶接物の設計手法 • 形状不連続部のクリープ疲労およびクリープ破断基準の改良 • 弾性解析による設計制限の改良 • 配管機器の検証試験 2. サーマルストライピング • 水とナトリウムの相互関係の確立 • 非定常熱伝達係数の開発 • 応力集中に与えるサーマルストライピングの影響 3. 大型機器の熱挙動試験 • コードによる予測が可能であるので，この計画は延期する。 4. ストラティフィケーション • DRACS の計画の中に折り込む。	1. 非弾性解析による設計 • 材料試験 基礎材料試験 複雑な荷重履歴下での変形試験 複雑な荷重履歴下での強度試験 • 構造要素試験 ビーム，管等を対象に機械，熱あるいはそれらの組合せ荷重を使って変形と強度試験を行う。 • 構造物試験 構造不連続部のある容器，ノズル，配管構造物を対象に構造要素と同様の試験を行う。 2. サーマルストライピング • 温度ゆらぎの基礎試験と解析コードの開発 • FBR 材料の高サイクル疲労に対する評価法の確立 3. ストラティフィケーション • PNC−DOE 双方の実験データによる流動伝熱解析コードの検証と改良 • 連行現象の基礎試験 • 大型モデルによる実証試験

(5) 2次系削除を狙った SG の開発計画

DOE	PNC
1. PHASE I • 参考として DWT（2重管）の概念を選定する。 • DWT の試験計画を立案する。	1. 水リークタイトの SG 概念で2次系削除の FBR プラントが可能であるかどうか検討し，このプラントの成立性に対する確率を評価する材料を提供する。

- PSG（1次系 SG）のシステム設計を計画する。
- PHASE Ⅱを立案する。

2. 2次系削除によるメリット，デメリットならびに建設費と運転費の削減について評価する。
3. 高信頼性，水リークタイトの SG ならびに認可され得る2次系無しのプラントシステムの確立に必要な R & D を摘出する。

4.2 合同タスクグループによる討論内容

(1) LMFBR 用配管ベローズの開発

〔出席者〕 米国側 R. Jetter (RI)
McShane (WE-HEDL)
L. K. Severud * (WE-HEDL)
Romine (DOE)
Bieberback (WE-HEDL)
日本側 青 木 (PNC)
小 畑 (KHI)
林 (JAPCO)
和 田 (MHI)

(＊印は部分出席)

〔配布資料〕

資料－1. Feasibility Assessment on Development of Piping Bellows for LMFBR Service (米側作成)

〃 －2. PNC/DOE PEWG Executive Committee Meeting on Plant Optimization Collaboration Feasibility (SA 013 DWG 83 － 02(1)) (日本側作成)

〃 －3. PNC Proposal for The Development of Piping Bellows for LMFBR Applications (日本側作成)

〃 －4. Recommended Area of Collaboration－LMFBR Piping Bellows (日米共同作成)

〃 －5. Feasibity Assessment Task Definition "Development of piping Bellows for LMFBR Service" (日米共同作成)

〃 －6. (AI から Mr. Jetter 宛のファクシミリ)

1. 打合せ経過概要

1.1) 9月26日 (月) 全体会議で日米双方の提案を
米国側：Jetter から資料－1により
日本側：青木から資料－2及び資料－3により
それぞれ報告があり，質疑応答がなされた。

1.2) 9月27日 (火)，28日 (水) の個別グループ会議 (ベローズの場合は，Eグループとシリーズに開催) において討議を行ない，共同提案によるリコメンデーション (資料－4) を作成した。

1.3) 9月29日 (木) 朝の全体会議で，リコメンデーション (資料－4) の報告を Jetter が行ない，青木から補足説明がなされた。

Rizzo（米側代表）より，今年4月開催の PEWG で選ばれた時の趣旨と今回のリコメンデーションとの対応が明らかとなるようにしてほしいと要望が出された。

1.4）9月29日（木）午後，個別グループ会議を行ない，再調整の上，改訂版（資料－5）を作成した。

1.5）9月30日（金），全体会議でリコメンデーションの改訂版を，青木から報告があり了承された。

2. 個別グループ内の打合せ詳細

2.1）9月26日の全体会議及び9月27日における日米双方の説明より，米国側は，配管ベローズの使用を補助冷却系（DRACS 等）の安全系配管（Sec. Ⅲ，Class 2）及び2次主冷却系の非安全系配管（B 31.1，EJMA）に対して考えており，又，Class 1用のベローズ高温設計製作基準 ASME C. C. N－290の基本骨子は完成したとの観点にあることが明らかとなった。

一方，日本側は主冷却系を主対象に考えていることから共同研究の提案に大幅な差があることを確認した。

2.2）米側は，これまでに N－290開発研究で行なったバックデータ及び，これから行なうことを計画中の若干の試験データでもって，PNC が実施計画中の多くの試験及び ISES-182の研究データと情報交換することを，この共同研究の主体とするように考えていることがわかり，日本側から N－290のバックデータに該当する文献リストを要求した。

その結果，資料－6が AI よりファクシミリで到来した。Jetter から，このリストの他に，ベローズ加工精度の文献があると補足説明があった。

2.3）米国側より，資料－2及び3に対して，ベローズにおける LBB の考え方，1次主冷却系で考えているベローズの型式，ラチエット考慮の有無，加工寸法精度の実績，サポートの方式，ISES−182Gの研究状況，ベローズハードの研究計画等についての質問があり，日本側より回答した。

又，ISES－182Gの試験データについては，米国側へ提供できる立場にないとの理由でことわった。

2.4）資料－6の文献リストを見て，日本側より N－290関連の研究状況を質問したところ，米国側より，1～2年前から研究はスローダウンさせられ，計画していた高温疲労試験はほとんど実施しておらず，日本側の研究に期待しているとの回答があった。

米国側が計画中の研究では，研究予算の見とおしは不詳にしても，DRACS 用2次配管（6～10^B，損傷状態で1,400°F）のベローズ試験があることがわかった。

2.5）共同研究のフィージビリティーを中心とした討議に移り，9月26日，27日の会議をふまえて，米国側から第1次案を作ってもらうことになった。（作成の間，E グループの打合せを実施。）

2.6）米国側から示された第1次案（9月27日夕方）は，

(1) PNC−DOE のベローズ研究の情報交換をする。

(2) 上記(1)が PEWG/DOE から拒否された場合の修正案。

(3) 加速クリープ試験と，その関連の非公式専門家会議を開催する。

(4) 設計基準の共同研究は，日本側の中間報告が出て来だす2年後に再検討する。

を対象としたものであったが，打合せ調整の結果，(1)及び(4)の組合せで，9月29日の全体会議へ報告することになった（資料−4）。

2.7）9月29日朝の全体会議で，リコメンデーション（資料−4）の報告を行なったところ，米国側代表の Rizzo より，今年4月開催の PEWG で選定された時の趣旨と，今回のリコメンデーションとの対応が明らかとなるようにしてほしいと要望が出された。

2.8）9月29日午後，個別グループ会議を行ない，要望にそって資料−4を全面的に書き換え（内容は資料−4に同じ），これを資料−5とした。

2.9）9月30日の全体会議で，リコメンデーションの改訂版を報告し，コメントされた表現修正を行なうこと以外にはコメントもなく，了承された。

以　上

(2) DRACSの実証

〔出席者〕 米国側 R. A. Johnson (COMO)
R. L. Stover (WHC-HEDL)
S. Rose (GE-ARSD)
A. J. Rapacz (DOE)
日本側 久保田 (PNC)
飯 田 (東芝)

会議では最初に日本側から Agenda を提案し，それに基ずいて進められた。経過を以下に示す。

前日に発表された米国側の提案に関して日本側から質問し，提案内容の詳細を明らかにした。ここで質問した主要なポイントは，

(1) DRACS VERIFICATION に対する米国の考え方
(2) 米国解析コードの特徴，開発の現状，今後の予定
(3) 米国側解析コードの信頼性等

であった。

米国は，自然循環除熱による DRACS を最重要視し，今回の目的が NON-SPECIFIC DESIGN を前提とした協力という主旨を充分に理解しており，試験ではなく，むしろ現象の理解あるいは解析方法についての協力を強く主調してきた。解析コードは，COMMIX-1B (乱流モデルを含む) を前提としている。COMMIX-1B の乱流モデルには，大変な期待がよせられているという印象であった。

米国が協力の土台とした試験は，現在までに実施した，あるいは今後2年間で実施する予定の自然循環除熱に関する試験をすべてリストアップしたものであった。

次に，日本側提案に対して米国側が質問し，日本側が返答した。米国側の質問の主要点は次の通りであった。

(1) 日本で既に実施した各種試験の詳細内容 (含データ交換の可能性)
(2) Joyo での IN-VESSEL N. C. 試験の詳細
(3) 日本側コードの特徴，開発の現状
(4) 実験計測装置 特にレーザ・ドップラーによる乱流場の測定

ここで，米国側は Joyo の IN VESSEL N. C. 試験について強い興味を示し，この試験から米国では得られないユニークなデータが期待できるとの評価を下していた。また，日本側コードの現状，特に一次元フローネットワークモデルについては関心を示し，多くの質問があった。これらの質疑応答を通じて，日本側としては，(1) 各種の多様な実験データを既に有していること，(2) MIMIR, THAUPR をはじめ3次元解析が可能な各種国産のコードを既に開発するなど，相当な努力をはらっており，(3) 日本としては COMMIX コードは

ONE of THEM と考えている，(4) 今後に計画している試験を含めて全体として米国と対等な規模，水準にあることを強調した。

米国側及び日本側ともに相手側の提案内容を充分に理解したうえで Joint Recomendation の検討に移った。Joint Recomendation は日本側提案通り，全体を Phase 1 （1988年まで）と Phase 2 （1988年以降）に分ける構成とした。また，両国から提案した各タスクはほとんどの部分について Feasible と認められ，これらを次の3ジャンルに分けた。

(1) Analytical Experience

(2) Special Purpose Tests

(3) Large Related Tests

(4) Large-Scale Prototype DRACS Test

日本から提案した Safety Criteria については，DRACS Verification であつかうには Scope が大きすぎること，及び安全に関する他の日米協力が進められており，そこでカバーされることから本項目からは削除することとなった。しかし，Satety Criteria を日米共同で確立することの重要性，またその Merit が極めて大きい事については全員が認めていた。

最後に1984年4月までのスケジュールについて検討した。その結果，両国とも1983年12月までにコードの概要を含む解析経験及び試験の各タスクについてバックグラウンド情報を交換し，その上で共同提案表を作成することとなった。

(3) 一般耐震設計基準

〔出席者〕 米国側 A. Dalcher (GE-ARSD)

L. Severud (WHC-HEDL)

R. Barr (DOE)

日本側 加 納 (PNC)

井 上 (富士電機)

山 口 (FBEC)

アメリカ側提案の順に各項目ごとに討議を進めた。

(1) Reactor Equipment Damping Values

○U. S の提案主旨は機器・配管等で通常解析に用いる減衰定数をもっと上げることを目的としたものである。

○機器系の試験は高くなるし，spec ific matter となるので対象を配管だけとし，標題を Sodium piping damping values とする 結論。

○Discussion 概要

＊ (U. S 側) 小口径＊配管に限定したい。

＜理由＞ 数値が多く削減効果が大きい。

試験費用が安い，負荷荷重が小さいので楽，減衰を大きくとれる可能性がある。

＊ 8^{B} 以下 (200 ϕmm 以下)

＊ (JAP. 側) 限定したくない。

＊配管サイズの限定をせず，テストデータの交換をして今後のテストを考える。

＊ (U. S) データベースは米の方がはるかに大きいはずだが，PNC の方のデータを見てから交換したい。

＊ (JAP) 了解

(2) Control Rod Drive System Seismic Testing

○これまでのテストデータを交換することで一致した。

(3) Core Components Limits Testing and Design Criteria

○ (JAP) すでに別の場 (Plant Systems and Component W/G) に提案し始まっているテーマだが POST に乗せたいのならかまわない。但し，Core Components は機器の範囲が広いので制限したい。

○ (U. S) 衝撃力による Failure (deformation, crack) に範囲を限りたい。

○ (JAP) Viollon コード及び日本でのテストについて概要を説明。

○ (U. S) 実験はパッドだけをとり出し，衝撃力により損傷する限界を調べるものである。実験条件は SCRAP コードで決める。(SCRAP コードの検証は Monju 用デ

ータで行なった)。

U. S ではインパクトロードの限界で原子炉を支持する建物が決まっている。従って，インパクトロードの限界がわかれば Building(Supporting Structures) の Cost Reduction につながる。

- (JAP) Building という表現は広い意味があるので誤解を紹くため Supporting Structures としたい。

(4) Piping Inherent Plasticity

- (U. S) (1) に記したのと同じ理由から小口径（8^B 以下）に限定している。現在，塑性領域については世界に 30 ～ 40 種類の文献** が出ており，それらを見てどうするか一緒に決めよう。

  ** 一部を U. S より受領

- (U. S) 日本の言うガタ系等の非線型系でのテストデータは 1981 年にやった 1^B でのデータ，WH でやった 8^B でのデータ等があり，もう充分であると考えている。ベローズの試験はやっていない。
  (関心はあるが，他にプライオリティの高いものがあるので何もしていない)。
  日本が塑性をやるなら，上述データと交換しょう。

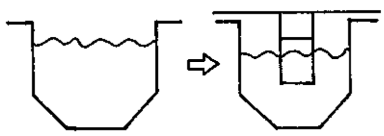
- (U. S) 2^B ～ 4^B 程度の小口径配管は Design by Rule で作れるようになると考えている。

(5) Fluid-Structure Interaction Analysis Methods

- (JAP) 日本国内で現在試験が行われているので，今後国内で調整するため現時点ではペンディングとしたい。

- (U. S) DOE がスポンサーで AI で行なうテストを説明
  2.5 年の計画，以下 R. JETTER が説明した。

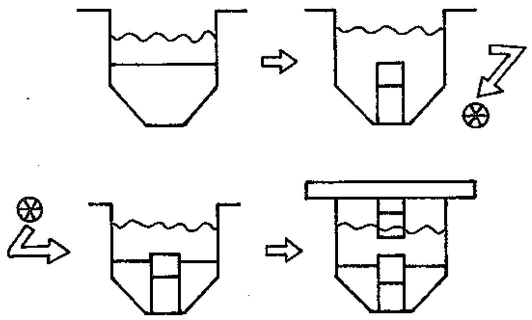
phase I (FY'84)
a. Determine Magnitude of Sloshing Forces
b. Investigate Forces on Vertically Suspended Components
c. Write Reports



タンク型～ 1／5 scale モデル

phase II (FY'85)
a. Test Vessel Mounted Components
b. Redans (Baffle Plate)

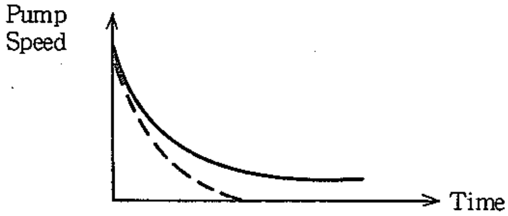
(FY'86) c. Compare Results to Analytical Prediction　With Report



(6) Pump Hydrostatic Bearing Loads and Coastdown Time

○ (JAP) 動燃委託（日立）のテストについて説明

○ (U. S) 軸受での抵抗が変化して，コーストダウン特性が変わると，Clad Temperature が高くなるのではないかということに関心がある。



解析手法は持っている。U. S は，Friction と wear のテストをしている。

○ (JAP) 日本でコーストダウンのテスト（振動中の）ができるか確認する。

(7) Concrete Damping in Structures

○ FBR specific でないので除外することで一致。

(8) Seismic Isolation

○ (U. S) Feasibility Study は各国でやって，その後のテストを一緒にやったらどうか？米では EPRI でやった Study 以外には，行なうつもりはない。

○ (JAP) Feasibility Study について情報交換したい。Seismic Isolationに対するJAPの今後の方針を説明した。

(9) Soil-Structure Interaction Analysis

○ FBR specific でないので除外することで一致。

(10) Sodium Valve Seismic Design Methodology

○ (JAP) バルブの動的機能維持のための必要なことを説明。

○ (U. S) 提案はしていないが，追加してもよい。

○ 本テーマは，JAP の提案により POST で取り上げることにした。

(4) ナトリウム機器・系統に対する熱および機械的荷重の繰返り負荷基準

〔出席者〕 米国側 McShane (WH-HEDL) 日本側 青 木 (PNC)
L. K. Severud (WH-HEDL) 和 田 (MHI)
R. Jetter (RI) 林 (JAPCO)
Romine (DOE) 小 畑 (KHI)
Bieberback (WH-HEDL)

I. 非弾性解析による設計

1. 米国側から「高温設計基準」として提案された内容は日本側の提案と似てはいるが，非弾性解析手法の検証の為のコンポーネント試験が中心であり，解析手法自体（検証用の試験を含む），及びその設計への適用方法を主体とした日本側提案とは内容的にかなりの差が認められた。
2. 日本側の提案は範囲が非常に広く，その中でテーマを絞ったものが米国側の提案になっているとの説明で，米国側の提案をそのまま取入れた纒め案（あらかじめ用意されたもの）が提案され，さらにベンチマーク問題に対する解析結果の検討を含めるとの話もでたが，解析手法は対象としないとの事で，合意できるものとはならなかった。
3. 日本側から双方の提案を合わせた形で次の3項目に纒めるとの提案を行った。
   i 非弾性解析による構造設計手法（溶接部の取扱い，及びクリープ疲労の基準の改善を含む)。
   ii 弾性解析による設計の制限値の改善
   iii 検証用のコンポーネント試験
4. この提案に対し問題はないが，1の設計手法は範囲が広すぎ境界が不明確になるとの意見がだされ，逆に米国側からコンポーネント試験及びその解析（手法を含む）を主体とした案が提示されたが，非弾性解析による設計の問題の内一部（荷重の負荷順序，物性値のバラツキの取扱等）が抜けてしまう為合意に到らなかった。
5. 大枠としては3の案をベースとし，細目については今後つめる事として，その為の作業手順の形で纒めるとの合意がなされ，i及びiiiについて必要な作業項目，及び84/1/15までに非弾性解析による設計に必要とされる検討項目のリスト，これまでの成果及び今後の計画，検証用コンポーネント試験の成果を交換し，84/2/15頃会議を行って，必要な検討項目及び協力の方法について合意を得るとの工程を纒めた形で全体会議への提案書が作成された。
6. 全体会議での意向をふまえ，プラント最適化の観点から予測される成果，背景，結論及び84/3までの実施内容と工程の形に提案書の書き直しを行った。内容的には大差はないが，3項目を纒めた形で「非弾性解析による設計手法」との名称が残り，「弾性解析による設計の制限値の改善」は隠れた形になった。又，工程が一部早められた。

Ⅱ. サーマルストライピング

1. 米国は現行のサーマルストライピング設計対応は安全裕度をとり過ぎており，このままではより強い材料を使うことによってコストが高くなるか，炉心機器の寿命が犠牲になるかどちらかになるとしており，サーマルストライピング現象を正確に把握することの重要性をあげている。
2. 米国はストライピング R&D プログラムとして(1)水/ナトリウムの相互関係を確立すること，(2)非定常の熱伝達係数を開発すること，(3)ストライピングが応力集中に与える影響を明確にすることを考えている。

   従って，サーマルストライピングに対する日米の考え方の違いは全くない。
3. 日本側からも用意していった OHP を使ってストライピングのこれまでの成果（1/1スケール1/3セクター水試験）来年度実施予定の「もんじゅ」7本集合体モデルによる水中およびナトリウム中試験とそれをベースとした水/ナトリウムの相互関係の把握，今後の課題としての構造材の機械的な高サイクル試験と熱荷重による試験について説明をし，日米相互の考え方の一致を確認した。
4. 米側は，「もんじゅ」7本集合体の水中及びナトリウム中試験（実寸大）に大きな興味を示した。これは LSPB の炉心上部機構が，CRBRP あるいは FFTF のチムニー型から構造変更して下方にバッフルを設けており，「もんじゅ」型に似てきたためと考えられる。また，ストライピングが炉心上部から上方に行くに従って緩和されていく様子（ストライピングのプレナム内の分布）が知りたいこともあったようだ。
5. 一方，非定常の熱伝達係数については RI 社が，また材料に及ぼす影響については WH 社がかなりユニークな試験装置を使ってそれぞれ実施していることを昨年10月の日米専門家会議から判っていたので，その後の経過について質問し以下の情報を得た。

   RI 社： 昨年の会議の段階では EPRI からの予算が切れて計画が中断していたが，現在は DOE から予算を貰って実施中。
   3/84までに非定常熱伝達係数についての結果は出る。
   6/84までに316 SS の材料試験結果が出る。
   その後，718 INCONEL，9 Cr－1 Mo のデータも出る予定（10/85頃）。

   WH 社：昨年度から材料試験は継続している。
   316 SS，718 INCONEL の結果は出ている。
   その他の材料試験結果も後日出る予定。
6. この時点で「もんじゅ」7本集合体の水中及びナトリウム中試験データと米側の RI 社と WH 社の非定常熱伝達係数ならびに材料試験データとの情報交換を行うこと。さらにより詳細な討論をするために1985年の夏か秋頃専門家会議を開くことを日本側から提案した。

専門家会議の時期は，「もんじゅ」7本集合体の試験と評価が完了することを想定して決めた。

7. 非定常熱伝達係数を定めるための供試体の計装については日米双方とも感心のある所で，「もんじゅ」7本集合体は大きなそして複雑な形状をした供試体であるためデータの精度が落ちる心配がある。

Jetter はこれに対して，PNC ができるだけ早く熱電対の取付け方法を連絡すれば，RI 社の試験体に PNC 方式を取入れ，RI 社のデータで比較校正し，PNC のデータの精度を高めることが可能となると提案して呉れた。

8. このようにストライピングについては共同研究することにより，相互補完的な成果が得られ，最終的な結果の精度をかなり高めることができ，POST の目的にかなった望ましいトピックスであることが確認された。

(5) 2次系削除を狙った SG の開発計画

〔出席者〕 米国側 Bieberbach* (WH)

Degraz (DOE)

DeBear (ETEC)

日本側 奈 良 (PNC)

阿 部 (日立)

*(replacement of Mr. Mangus)

9 / 27

A. Comparison of each position

(1) 9 / 26 に実施された日米の proposal から，本 Task-work に対する日米の対応の仕方（本 Task-work を考える上での Assumption。また，Approach の仕方）について比較して，その差異の有無について認識を図った。

(2) 米国側 proposal と日本側 proposal の差異として下記を認めた。

<米国側>

米国側	日本側
① phase I (study) +phase II (R&D実施) を規定	日本側は，phase II の要否については，phase I 結果によって考えることとして，phase II を想定しない。
② DWT SG を reference	日本側は，SG 型式は study の結果として決まるものとして，DWT を前提とはしない。
③ DWT SG の fabrication & Test を加速。その分規は，DOE/DWT Unit 供給 PNC/DWT Unit 試験	日本側としては，study だけの実施を考えており，DWT SG の Fabrication Test を加速することも，又 DOE/PNC 分担についても白紙。

B. Concensus of each position

(1) 前項での proposal 内容の差異に関して，「米国側提案はひとつの "Idea" であり，両国提案と consolidate する内で米国側提案を Eliminate することは可」と米国側譲歩。

(2) よって基本的 approach としては，日本側提案をベースとして Joint Recommendation をまとめることとした。

C. Work frame of Joint Task

(1) Joint Task の Work frame をどのようにするか，日本側の提案をベースに討議，TASK work のタイトル及び主要実施事項について合意。

I STUDY PLAN

Ⅱ　Preliminary Assesment of Benefits

Ⅲ　Detail Evaluation of Major Concerns

Ⅳ　Identification of R & D Requivement

Ⅴ　Final Report

(2) Task work の詳細は“Ⅰ. STUDY PLAN”にて決めることとする。

（詳細は，Joint Recommendation を参照）

(3) Ⅱ. Preliminary Assesment of Benefits において，PHTS−less plant の概念設計を行なうことの意議，また可能かどうか米国側より議論が出されたが，この作業は，「IHTS−less plant」がする cost reduction の Potential を把握する為に必要である旨主張。“Preliminary”と表現することで合意。

米国側（WH）は，2次系削除の効果について preliminary study をやっており，roughly 10％ or less の cost reduction 程度が期待されると結果を得ているようであり，米国側は2次系削除に関して plant 全体的な Benefit Assesment をやることを考えていなかったようではある。

(4) 本 TASK−work の進め方として，この「Ⅱ. preliminary Assesment of Benefits」で IHTS−Less plant の Benefit として Negative な結果が出た場合も考え，それ以降の詳細評価の進め方（TASK−work を継続するかも含めて）をその時点で検討，Recommend することを合意。

［Ⅱ. preliminary Assesment of Benefits の終了時点を Key milestone として follow−on activity を再確認する。］

D. 関連 Q & A

添付参照

Question	Answer
9/27 Separate Session Q (阿部) TELEX 内における Approach I : New Design SG }の通り Approach II : D. W. T. SG の提案から, 9/26発表においては, "DWT SG" を前提とする提案にかえった理由は何か？	A (Bieberbach) (イ) PSG として現実的な考え方としては, D. W. T におちつくものと考えた。 (ロ) 米国側での study* の結論としては D. W. T を選んでいる。 (* WH preliminary study)
Q (阿部) Institutional interface とは何か？	A (Bieberbach) Safety, Licensing, Enviromertal, Protection 等々に関すること。

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A. 米国側 presentation (9 / 26) に関する質問を実施。(Q & A 添付)

B. 前日に引続き, Joint Recommendation 作成を実施。基本的に日本側意見をベースに議事を進めた。

(1) Conculusion

前日の議事における基本的合意のもので, 日本側主張に沿った conculusion とし, 特に collaboration は "study" に限ること, 及び将来の collaboration も "study" の結果を review してから決めることを明確にした。

(2) Objective of study

plant cost reduction の potential と feasibility を "plant 的" に明確化することとしたが, Q & A requirement の define は "PSSG" に focus を続ることとした。

(3) Potential Benefit

日本の knowledge と経験を share することで "study" を効果/効率的にできること, また将来の開発費の share の可能性について記載。

(4) Approach for Conceptual Design Study

9 / 26 討議内容をそのまま Recommendation とすることとした。

(5) Schedule

- 米国側 20 ケ月, 日本側 24 ケ月が original の提案であるが, プラント概念設計を含めることもあり, 米国側も 24 ケ月することで合意。
- Preliminary Assesement[2]で "Go" との Recommendation が出れば詳細評価をすることとなるが, 日本側 original 提案では期間が短かすぎることから, Preliminary Assesement を少し前倒しに終了し, 詳細評価[3]期間を長くとることとした。(5 ケ月〜 9 ケ月化)
- 3 回/ 2 年の Information Exchange Session を設定。
- START は, Fall/ 1984 JCC Authorization とすることで合意。

(6) Resource

- 米国側よりは 120 man−month ($120^{\text{人・月}}$($5^{\text{人}}$ × 24ケ月) × $10^{\text{K\$}}/_{\text{人・月}}$($10\sim15^{\text{K\$}}/_{\text{人・月}}$) × $250^{\text{K¥}}/_{\text{K\$}} \approx 300^{\text{M¥}}$), 日本側よりは 50 man−month ($50^{\text{人・月}}$ × $1^{\text{M¥}}/_{\text{人・月}} \approx 50^{\text{M¥}}$) 程度かとの話がされたが, 日米とも概算状況であるので, 表現上は T. B. D (50〜$120^{\text{M・M}}$/ each) として 4 / 1984 の PEWG までに明確化することとした。

(7) Collaboration の仕方について

(a) 米国側より "study" について Guideline 等を決めておくことが必要とのコメントがあったが, 日本側から "study" の為の方針。Guideline 等も I . Study Plan 作成フェーズにて実施されるべきことと回答。

(b) 本 "Study" の preliminary assesment は日本各々にパラに実施することが想定されるが，このような形式で，"Collaboration" として適当かとの懸念が米国側から示されたが，Collaboration として情報交換フェーズのものからへ R & D 実施のものまで許容される（奈良氏説明）ので OK だろうと回答。

将来の collaboration への発展性も考えられるので，現時点では "Study" でも可とした。

C. 次回 PEWG までの Collaboration（9月29日 additional meeting），今回の Joint Recommendation だけでは，PEWG として判断できるだけの材料にまで到らないことから，次回 PEWG（4 / 1984）までの追加検討として Preliminary Study Plan を作成することで合意。（添付参照）

12 / 31 / 1983 までに日米の Draft Proposal を交換することとした。

〔米国側*は，この作業実施用の Fund が明確でないことから（* WH が米国側 Team Leader），この次回 PEWG までの追加作業をしぶっていたが，協議により上記に合意した。〕

(1/2)

Question	Answer
Q (阿部) 米国側 TASK-C メンバーはどのような構成か。(日本側メンバーと所属を説明)	A (Bieberbach) Team Leader : J. Mangus (WH) (WH: ピッツバーグ) G. Bieberbach (WH: ペンサコーラ) F. Tippet (GE) R. McCounell(EBR−II) H. Brandt (WH)
Q (阿部) WH の "2次系削除 study" は, いつ頃実施したか。 10% Cost Reduction とのことであるが Risk を考慮して, この10%は attractive か。	A (Bieberbach) o WH−ピッツバーグ (MangusG)にて実施した。最近終ったと思うが詳細不明。WH−private work. o "10%" Cost Reduction ということは, "大きい" Cost Reduction と考えている。
Q (阿部) 本 Study に関して, Major Concerns として, 日本側から具体的に例示しているが米国側のイメージはどんなものか。	A (Bieberbach) o "Safety" である。 oリストを持っていないので後で Mangus に聞く。
Q (阿部) 70 MW D. W. T SG の現状はどうか。	A (Bieberbach) o 詳細設計　50%完 o fabrication　40% o 材料購入　90% o ETEC への搬出 : 9月/1985 [現在 Pensacola* 工場にて製作中。Tampa 工場を閉鎖して, PWR−SG と供に Pensacola (フロリダ) に移っている。] A (Debear) ETEC の試験はヘリカルタイルの後となり,

Question	Answer
Q（阿部） D. W. T SG としては WH 型を前提にしているか。	～1986年頃か。（未定。） A（Bieberbach） D. W. T SG として，WH 型以外のものは現実に考えられない。（例えば，GEのものは単なる設計）

第 5 章

プラント・パフォーマンスに関する討論

5. プラントパフォーマンスに関する討論

日　時：83.9.27（火）p.m 5.30～6.30

場　所：リゾー氏の室（Federal Blg 2 F, DOE Office）

出席者：AL. Rizzo, J. Laidler, Kruper, Absher, Davies
　　　　奈良，林（原電），青木，加納，久保田（ETEC 駐在）

議事要旨：

奈良から議題の主旨及び背景を説明した上，討論を行ない下記の方針を確認した。

(1) 昨年（1982年）5月の JCC が PEWG に与えた指示にしたがい，Plant Performance と Plant Cost Reduction の両面のテーマ候補をリストアップした。

(2) 昨年9月の Joint PEWG Executive Mt'g で，テーマ選定の方針を確認した。
Plant Performance としてリストアップされたテーマは運転性，信頼性，保修性などに関するものであり，プラントの specific design に強く関係するので，Plant Cost Reduction に焦点を合せることにした。ただし，これのテーマも部分的には Performance 改善に寄与する。

(3) 今回の会議で検討する5テーマは，本年4月の Joint PEWG で，上記方針の下で，多くのテーマから選択されたものである。

(4) 今後必要あれば，JCC の示唆にしたがい別の項目についても検討していく。

付　　録

1. POST タスクグループ準備資料

1.1 米 国 側 資 料

1.2 日 本 側 資 料

2. 施 設 見 学

2.1 Hanford Science Center

2.2 FFTF

1.1 米国側資料

FEASIBILITY ASSESSMENT ON DEVELOPMENT OF PIPING BELLOWS FOR LMFBR SERVICE

- SUMMARY
- TECHNICAL BACKGROUND
- FEASIBILITY ASSESSMENT

SUMMARY

- USE OF BELLOWS IN U.S. LMFBR DESIGN
  - AUXILIARY HEAT REMOVAL SYSTEM
    - SAFETY RELATED (SECTION III, CLASS 2)
    - 6-10 IN.
    - 30-100 PSIG
    - 950-990°F DESIGN TEMPERATURE
FAULTED TRANSIENT TO 1400°F
  - INTERMEDIATE HEAT TRANSPORT SYSTEM
    - NONSAFETY RELATED (B31.1, EJMA)
    - 24-40 IN.
    - 300 PSIG
    - 820-960°F
- BASE TECHNOLOGY PROGRAM ON BELLOWS
  - DESIGN
  - FABRICATION
  - ROOM TEMPERATURE TESTING

SUMMARY (CON'TD)

- COLLABORATION IS FEASIBLE
  - INFORMATION EXCHANGE
    - DOE BASE TECHNOLOGY AND PNC/ISES PROGRAMS
  - DESIGN
    - COMMON BELLOWS DESIGN
  - COMPONENT TESTING
    - SMALL DIAMETER, SAFETY RELATED
  - SYSTEM TESTING
    - SMALL DIAMETER AND LARGE DIAMETER IN NA LOOPS
- INFORMATION EXCHANGE IS HIGHEST PRIORITY

TECHNICAL BACKGROUND

- SYSTEM DESIGN
  - APPLICATIONS
  - COST INCENTIVES
  - SAFETY AND LICENSING
  - ADVANTAGES/DISADVANTAGES
- STATUS
  - EXPERIENCE
  - DOE BASE TECHNOLOGY PROGRAM
  - CODES AND STANDARDS
  - TESTING OPTIONS

TABLE 1

APPLICATION OF PIPING BELLOWS IN ADVANCED LMFBR DESIGNS

Plant	System	Type	Diameter	Class Code	Bellows Material	Design Temp	Design Pressure	Remarks
Large Scale Prototype Breeder	Shutdown Heat Removal System	Gimbal	10 in	ASME III-2	800H	950°F[3]	30 psig	Slow Transients
	Cooling System for Ex-Vessel	Gimbal	8 in.	ASME III-2	800H	600°F	30 psig	Slow Transients
	Storage Tank Auxiliary Sodium Systems	Gimbal	3 in. to 6 in.	B31.1	SS	910°F	300 psig	
Modular Breeder Reactor	Intermediate Heat Transport System	Gimbal	24 in.	B31.1	SS	820°F	300 psig	Slow Transients
Large Pool Plant	Intermediate Heat Transport System	Gimbal	32 in.	B31.1	SS or 800H	960°F	300 psig	
	Shutdown Heat Removal System	Gimbal	6 in. & 10 in.	ASME III-2	800H	990°F[3]	30 psig & 100 psig	Slow Transients
Volkswagen Design	Primary Heat Transport System	Axial	Approx. 40 in.[1]	UNK	UNK	UNK	UNK	Note[2]
	Intermediate Heat Transport System	Axial	Approx. 40 in.[1]	UNK	UNK	UNK	UNK	Note[2]

[1]Estimated from sketch in published material

[2]Plant design described in Power Engineering September 1982 detailed information not available

[3]Additional end of life plant faulted condition, DRACS emergency condition temperature to 1400°F for up 100 hr

COST INCENTIVES

- PRIMARY HEAT TRANSPORT SYSTEM
  - MAJOR INCENTIVE IS REDUCTION OF CONTAINMENT BUILDING (98%)
  - REDUCTION CAN BE ACHIEVED BY ALTERNATE METHODS
    - SIPHON BREAKERS AND VERTICAL LOOPS
    - ALTERNATE MATERIALS (MOD. 9CR-1MO)
- INTERMEDIATE HEAT TRANSPORT SYSTEM
  - MAJOR INCENTIVE IS BUILDING REDUCTION
  - CURRENTLY IN 3 OUT OF 4 CONCEPTS
- DECAY HEAT REMOVAL SYSTEM
  - SPACE REQUIREMENTS
  - PIPING SUPPORT REDUCTION
  - SYSTEM PERFORMANCE (LOW HEAD LOSS)

SAFETY AND LICENSING

- BASED ON CONSEQUENCES OF LOSS OF FUNCTION
  - SYSTEM (E.G., COOLING CAPABILITY)
  - SPECIFIC BELLOWS (E.G., NA FIRES)
- CORRELATED WITH ASME CODE CLASSIFICATION/REQUIREMENTS
  - PRESSURE
  - CYCLIC FATIGUE
- LICENSING REQUIREMENTS DEPEND ON TIMING
  - DEVELOPMENT PROGRAM DEFINED FOR CONSTRUCTION PERMIT
  - DEVELOPMENT COMPLETED FOR OPERATING PERMIT

TECHNICAL ADVANTAGES/DISADVANTAGES

- ADVANTAGES
  - REDUCTION IN PIPE, FITTINGS AND SUPPORTS
  - REDUCED CELL SIZE
  - SMALLER SODIUM INVENTORY
  - REDUCED SUPPORT SYSTEM REQUIREMENTS
    - COOLING, HEAT TRACING
  - REDUCED NOZZLE LOADS
- DISADVANTAGES
  - DEMONSTRATED RELIABILITY
    - LEAK BEFORE BREAK
  - TRANSITION JOINTS
  - LEAK DETECTION REQUIREMENTS

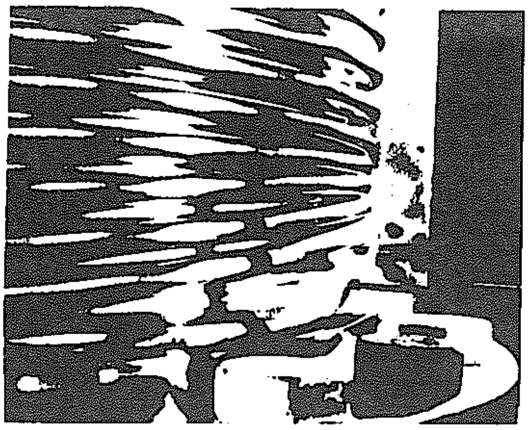
TECHNOLOGY STATUS/EXPERIENCE

- SODIUM SERVICE
  - SUCCESSFUL EXPERIENCE AT ETEC
- NUCLEAR POWER
  - WIDESPREAD IN COMMERCIAL NUCLEAR (PENETRATIONS, ETC.)
  - SOMEWHAT MIXED EXPERIENCE
- R&D PROGRAMS
  - DOE BASE TECHNOLOGY PROGRAM
- AEROSPACE
  - TECHNOLOGY DEVELOPED FOR RELIABLE, CONSISTENT PERFORMANCE
- PETRO-CHEMICAL
  - MANY APPLICATIONS IDENTIFIED

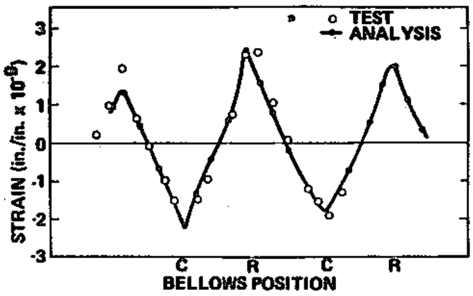
DOE BASE TECHNOLOGY EXPANSION JOINT PROGRAM

- CODE CASE SUPPORT
  - CODE CASE N290 PASSED FOR CLASS 1 BELLOWS
  - CODE CASE N253 MODIFIED FOR ELEVATED TEMPERATURE CLASS 2 AND 3 BELLOWS
- ENGINEERING AND DESIGN
  - PROTOTYPIC EXPANSION JOINT DESIGNS COMPLETED FOR PHTS AND IHTS
  - BELLOWS ANALYSIS TECHNIQUES CONFIRMED
- MATERIAL DEVELOPMENT
  - LUBRICANTS AND MATERIAL COUPLES INVESTIGATED FOR HINGE JOINTS
  - WELDING AND HEAT TREATMENT PROCESS CONTROL DEFINED FOR MANUFACTURING BELLOWS

FLEXIBLE JOINTS FOR LMFBR PIPING SYSTEMS



TEST RESULTS CONFIRM ANALYTICAL MODEL



PREDICTED FAILURE PRESSURE – 275 psig
ACTUAL FAILURE PRESSURE – 280 psig

DEVELOPMENT PROGRAM ACCOMPLISHMENTS

- **OBTAINED ASME III, CLASS I CODE CASE FOR SODIUM SYSTEMS**
- **ESTABLISHED FABRICATION, INSPECTION CRITERIA**
- **VALIDATED ELASTIC-PLASTIC ANALYSIS METHODS, FAILURE LIMITS**
- **IN FINAL APPROVAL STAGES OF CASES SIMPLIFYING III-1 RULES, EXTENDING III-2 and 3 TO HIGH TEMPERATURE**

Rockwell International
Energy Systems Group

81-F28-1-29A

DOE BASE TECHNOLOGY EXPANSION JOINT PROGRAM

(CONTINUED)

- TESTING
  - ROOM TEMPERATURE SUBSCALE TESTING COMPLETED TO VERIFY ANALYSIS TECHNIQUES
  - ACCELERATED (Creep) TESTING METHODOLOGY DEFINED
  - HIGH-TEMPERATURE STATIC TESTS VERIFY FABRICATION TOLERANCES
- MANUFACTURING AND DEVELOPMENT
  - TOTAL OF 41 BELLOWS, 18 IN. DIA. X 0.036 IN. WALL DELIVERED TO ASME CODE REQUIREMENTS
  - INSPECTION TECHNOLOGY DEFINED AND DEMONSTRATED
    - SURFACE AND VOLUMETRIC NDE
    - GEOMETRY CONTROL

CODES AND STANDARDS

- SAFETY RELATED
  - CC-N-290 FOR ASME CLASS 1
    - REDUNDANT BELLOWS
    - ACCELERATED CREEP TESTING
      - SAME HEAT
    - TIGHT FABRICATION TOLERANCES
  - CC-N-253 FOR ASME CLASS 2
    - NO REDUNDANT BELLOWS
    - ACCELERATED CREEP TEST -- NOT SAME LOT
    - TIGHT FABRICATION CONTROL
- NON-SAFETY RELATED
  - B31-1, EJMA
    - PRODUCT LINE TESTING

TESTING OPTIONS

- SAFETY-RELATED SMALL DIAMETER COMPONENT TEST
  - OVERTESTING TO DEMONSTRATE DESIGN MARGIN
  - CYCLIC LOADING AND SEISMIC
- SYSTEM TEST
  - INSTALLED IN SODIUM LOOPS
  - DEMONSTRATE SUCCESSFUL DESIGN, PROCUREMENT, INSTALLATION, OPERATION AND MAINTENANCE

FEASIBILITY ASSESSMENT

- BENEFITS
- CAPABILITIES
- RESOURCE REQUIREMENTS
- EQUITABLE PARTICIPATION
- ALTERNATE APPROACHES
- CONCLUSIONS

FEASIBILITY ASSESSMENT

- BENEFITS
  - PLANT USAGE
    - Direct Reactor Auxiliary Cooling Systems (DRACS)
    - IHTS
  - BELLOWS TESTING
    - Component Testing Required for Safety Related
    - System Tests to Demonstrate Feasibility
  - COLLABORATION
    - Conserve Money and Manpower
    - Enhance Licensing
- CAPABILITIES
  - COMPONENT TESTING
    - Base Technology Program
      - MTS System, Angulation Test Fixture, Data Acquisition, Instrumentation
  - SYSTEM TESTING
    - EBR-II
    - FFTF
    - ETEC
    - ANL
    - ORNL

TABLE 3
FACILITY CAPABILITIES

Sodium Facility	Design Conditions Temp. °F	Pressure psig	Flow gpm	Pipe Size	Status
EBR-II Secondary	875	41	5,800	12	Operating
EBR-II Recirculation	585	23	60	2	Operating
EBR-II Purification	585	23	20	2	Operating
FFTF Secondary	900	220	14,500	16 - 18	Operating
ETEC-SCTI	1100	150	9,000	14	Operating
ETEC-SPTF	1100	250	85,000	18 & 36	Being Modified
Cooler	1100	143	585	4 - 6	
ETEC-SCTL	1200	225	3,500	8 - 10	Operating
ETEC-Static Na System	1500	300	Static	--	Operational
ANL-CCTL	1200	110	800	4 & 5	Standby
ANL-SGTF	1200	85	56	4	Operational
ANL-HPTL	1200	180	1.5	2	Operating
ORNL-THORS	1300	150	600	6	Operating
ORNL-TTF	1100	700	100	6	Standby

RESOURCE REQUIREMENTS

- COMPONENT TESTING
  - $250 - $500 K + COST OF BELLOWS ASSEMBLIES
- SYSTEM TESTS
  - DESIGN AND FABRICATION (INC. BELLOWS) $ 600 K
  - INSTALL 150 K
  - INSTRUMENT 50 K
  - MONITOR, ETC. 200 K

$ 1,000 K

EQUITABLE PARTICIPATION

- U.S. DEVELOPMENT PROGRAM LACKS HIGH TEMPERATURE CYCLIC DATA
- PNC/ISES WOULD BENEFIT FROM DOE DEVELOPMENT PROGRAM
- COMMON DESIGN ENHANCES LICENSABILITY

ALTERNATE APPROACHES

- PHTS
  - SIPHON BREAKERS AND VERTICAL LOOPS ACHIEVE SAME BUILDING SIZE REDUCTION
- IHTS
  - USE OF BELLOWS NOT CONCEPT LIMITING
  - COST PENALTY UNDEFINED
    - ESTIMATE IN $10-30 M RANGE
- DRACS
  - TECHNICAL ADVANTAGES (LOW HEAD LOSS, ETC.)
  - TESTING TO GET CODE STAMP

CONCLUSIONS

- COLLABORATION IS FEASIBLE IN SEVERAL AREAS
- INFORMATION EXCHANGE IS HIGHEST PRIORITY FOR COLLABORATION

POTENTIAL ACTIVITIES FOR COLLABORATION

1. INFORMATION EXCHANGE
   - PNC AND ISES 1826 PROGRAMS
     - ELEVATED TEMPERATURE CYCLIC TESTS
   - DOE BASE TECHNOLOGY PROGRAM
     - CODES AND STANDARDS
     - ENGINEERING AND DESIGN
     - MATERIALS
     - TESTING
     - MANUFACTURING

2. DESIGN

- COMMON BELLOWS JOINT CONFIGURATION ENVELOPING
  - DESIGN REQUIREMENTS
  - TEMPERATURE
  - PRESSURE
  - MOVEMENT
  - ETC.

3. COMPONENT TESTING

- DESIGN MARGIN TESTING IN INERT ATMOSPHERE
  - ELEVATED TEMPERATURE CYCLING
  - SEISMIC
  - ASME CLASS 2 GUIDELINES

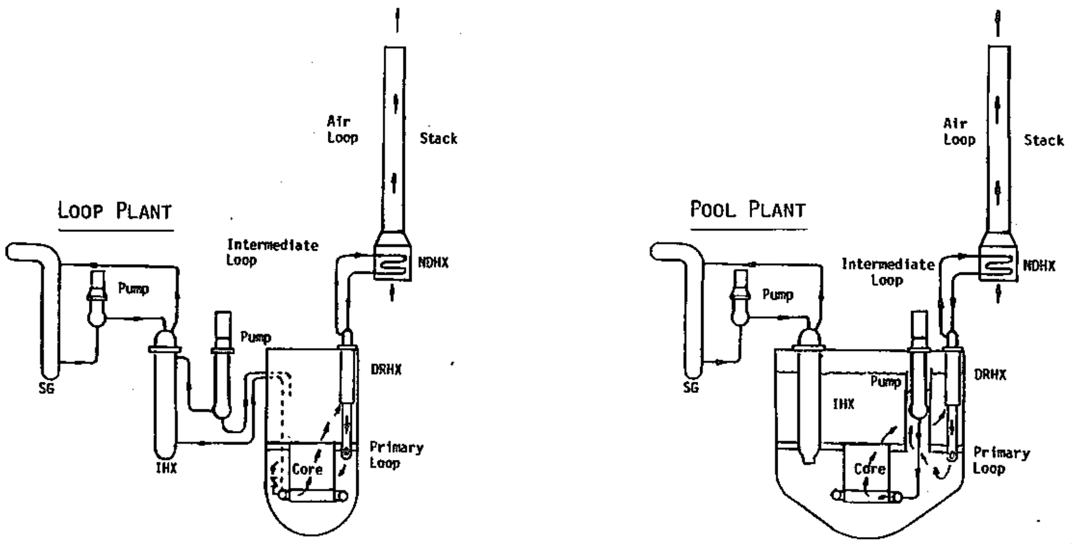
4. SYSTEM TESTING

- INSTALLED IN OPERATIONAL NA PIPELINE
  - DESIGN
  - FABRICATION AND INSPECTION
  - INSTALLATION
  - ISI
  - OPERATION

VERIFICATION OF DRACS

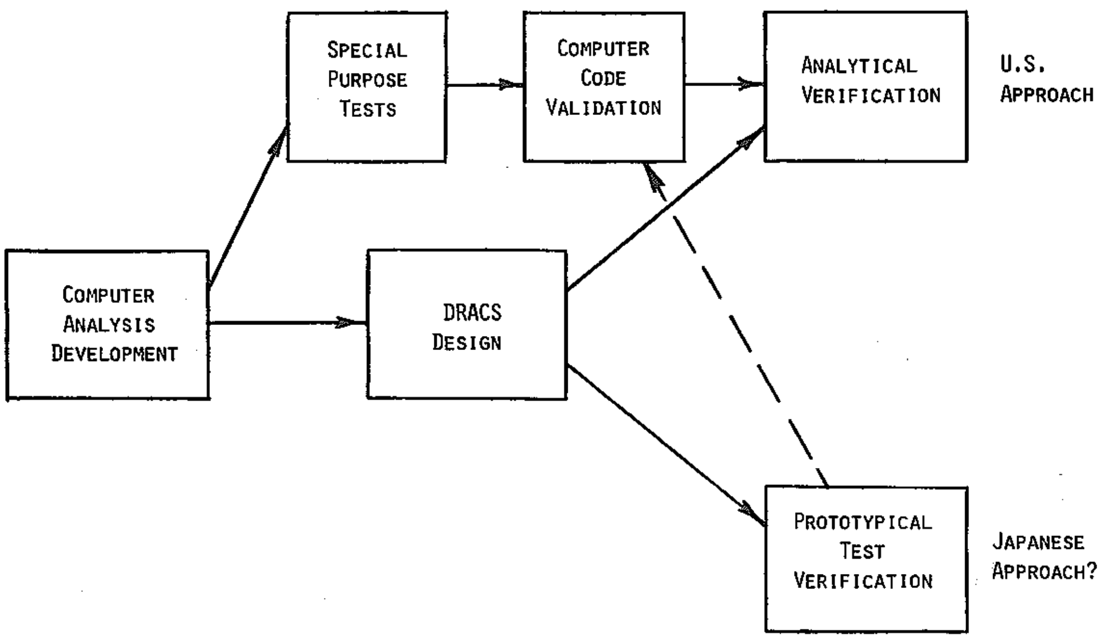
- **DEVELOPMENT OF A TECHNICAL UNDERSTANDING OF THE TRANSIENT THERMAL-HYDRAULIC BEHAVIOR ADEQUATE FOR CONFIDENCE IN DESIGN AND LICENSING.**

Definition of Problem



- In-vessel Flow and Heat Transfer
  - -- Three dimensional
  - -- Complicated by stratification
  - -- Dependent on sequence of conditions
- Overall System Performance
  - -- Generally one dimensional
  - -- Long duration transients
  - -- Dependent on Heat Transfer System status

Approaches to DRACS Verification



Steps in Verification

- Development of Computer Codes
  - -- Overall system analyses
  - -- In-vessel analyses
  - -- Hot channel analyses
- Verification Testing
  - -- Reduced-scale, special purpose tests
  - -- Tests in existing reactors
  - -- Large-scale sodium tests
- Validation of Computer Codes

Current U.S. Approach

● Code Development	
-- Overall system analyses	-- DASHR, ARIES, SASSYS and COMTRAN currently in use
-- In-vessel analyses	-- COMMIX-1A and TEMPEST in use with 500 node 2D and 4000 node 3D models. COMMIX-1B with numerical integration and 2-equation turbulence model due in late 1984.
-- Hot channel analyses	-- COBRA and CORTRAN available
● Verification Testing	
-- Special purpose tests	-- Static Sodium Test Facility (SSTF) operation into 1985 -- Water simulation of SSTF with above -- SIMONE water tests with laser--Doppler anemometry -- THORS-SHRS sodium boiling in tube bundle tests into 1985
-- Tests in existing reactors	-- Well instrumented natural circulation tests in EBR-II (mid-1984 to mid-1986) -- Limited tests in FFTF
-- Large-scale sodium tests	-- Not in program (desirable but not essential)
● Code Validation	-- Completion expected with successful calculation of above tests

CANDIDATE AREAS FOR U.S. - JAPANESE COLLABORATION

• CODE DEVELOPMENT -- OVERALL SYSTEM ANALYSES -- IN-VESSEL ANALYSES -- HOT CHANNEL ANALYSES	• TRADE FOR ADVANCED VERSIONS OF CODES • EXCHANGE EXPERIENCE IN THE USE OF CODES -- MODELLING APPROACHES -- NUMBER OF COMPUTATIONAL CELLS -- TIME STEP SIZE -- ETC.
• VERIFICATION TESTING -- SPECIAL PURPOSE TESTS	• EXCHANGE OR TRADE TEST DATA AND/OR MEASUREMENT TECHNIQUES
-- TESTS IN EXISTING REACTORS	• JOINTLY PLAN AND CONDUCT CURRENTLY PLANNED OR NEW TESTS
-- LARGE-SCALE SODIUM TESTS	• COLLABORATE ON TEST IN OEC 50 MWT SGTF OR AT ETEC • COLLABORATE ON DRACS TEST IN FFTF
• CODE VALIDATION	• EXCHANGE COMMIX VALIDATIONS AGAINST U.S. AND JAPANESE DATA SETS • EXCHANGE RESULTS OF ANALYSES BY EACH COUNTRY'S CODES ON THE SAME PROBLEM

CONCLUSIONS AND RECOMMENDATION

COLLABORATION ON DRACS VERIFICATION IS FEASIBLE

TWO LEVELS OF COLLABORATION SHOULD BE EVALUATED:

- EXCHANGE OF:
  - -- EXPERIENCE IN THE USE OF CODES BY DESIGN ANALYSTS
  - -- TEST DATA FOR USE IN CODE VALIDATION
  - -- RESULTS OF ANALYSES TO SUPPORT CODE VALIDATION
- A JOINT EQUITABLE PROGRAM BASED ON:
  - -- PROVIDING JAPAN WITH:
    - -- ADVANCED VERSIONS OF U. S. CODES (E.G., COMMIX-1B)
    - -- SIGNIFICANT TESTING TECHNIQUES (E.G., LASER-DOPPLER ANEMOMETRY)
    - -- RESULTS OF SPECIAL PURPOSE TESTS (E.G., SSTF, SIMONE, THORS-SHRS)
  - -- JOINTLY PLANNING, CONSTRUCTING AND CONDUCTING:
    - -- FUTURE SPECIAL PURPOSE TESTS
    - -- A LARGE-SCALE SODIUM TEST AT SGTF, ETEC OR FFTF

BENEFITS TO U.S.

- BROADER BASE OF EXPERIENCE
  - -- EASIER JUSTIFICATION OF CODE VALIDATION
  - -- FEWER PROBLEMS AND GREATER EFFICIENCY WHEN USING CODES

- INVOLVEMENT IN A LARGE-SCALE SODIUM TEST WITH REDUCED INVESTMENT
  - -- ADDED INSURANCE AGAINST PROBLEMS IN LICENSING OR OPERATIONS
  - -- POSSIBLE REDUCTION IN REQUIRED DESIGN MARGINS
  - -- POSSIBLE REDUCTION IN LICENSING EFFORT
  - -- ACCELERATION OF DRACS VERIFICATION, IF SUCH A TEST IS FOUND TO BE ESSENTIAL

LMFBR GENERAL SEISMIC DESIGN CRITERIA

TOPICS IDENTIFIED FOR DISCUSSION

1. REACTOR EQUIPMENT DAMPING VALUES
2. CONTROL ROD DRIVE SYSTEM SEISMIC TESTING
3. CORE COMPONENTS LIMITS TESTING AND DESIGN CRITERIA
4. PIPING INHERENT PLASTICITY
5. FLUID/STRUCTURE INTERACTION ANALYSIS METHODS
6. PUMP HYDROSTATIC BEARING LOADS AND COASTDOWN TIME
7. CONCRETE DAMPING IN STRUCTURES
8. SEISMIC ISOLATION
9. SOIL STRUCTURE INTERACTION ANALYSIS

TOPICS SELECTION BASIS

A) POTENTIAL REDUCTION OF PLANT COSTS

B) POTENTIAL IMPROVEMENT IN PLANT PERFORMANCE

C) LIKLIHOOD OF SUCCESS

D) REGULATORY RISK

AWD 830902

TOPIC 1. REACTOR EQUIPMENT DAMPING VALUES

OBJECTIVE: ESTABLISH DAMPING VALUES FOR LMFBR DESIGN WHICH ARE HIGHER THAN THOSE USED IN CURRENT STANDARD PRACTICE.

BENEFITS: REDUCED PLANT COSTS

PROBABILITY FOR SUCESS: HIGH

REGULATORY RISK: LOW

STATUS: SOME DATA EXIST; FURTHER TESTING NEEDED

PROPOSED TASKS:

A) ASSEMBLE AND EVALUATE AVAILABLE DAMPING TEST DATA

B) IDENTIFY AND PERFORM ADDITIONAL NECESSARY DAMPING TESTS

C) PREPARE REFERENCE REPORT WHICH CAN BE USED FOR JUSTIFICATION, ACCEPTANCE, AND IMPLEMENTATION OF HIGHER DAMPING VALUES

AWD 830903

TOPIC 2. CONTROL ROD DRIVE SYSTEM SEISMIC TESTING

OBJECTIVE: EXCHANGE CONTROL ROD DRIVE SYSTEM SEISMIC TEST DATA

BENEFITS: OBTAIN CLEARER UNDERSTANDING OF SEISMIC BEHAVIOR FOR APPLICATION TO MORE EFFICIENT AND ECONOMICAL DESIGNS

PROBABILITY OF SUCCESS: HIGH

REGULATORY RISK: LOW

STATUS: US AND JAPANESE DATA EXIST

PROPOSED TASKS:

A) IDENTIFY SEISMIC TESTS WHICH HAVE BEEN PERFORMED

B) DOCUMENT TEST DETAILS

C) EXCHANGE AND EVALUATE DATA

AWD 830904

TOPIC 3. CORE COMPONENTS LIMITS TESTING AND DESIGN CRITERIA

OBJECTIVE: EXCHANGE DATA, PERFORM ADDITIONAL TESTING THROUGH JOINT PROGRAM, FOR ESTABLISHMENT OF CORE COMPONENT SEISMIC LIMITS

BENEFITS: POTENTIAL COST REDUCTIONS IN REACTOR STRUCTURES AND BUILDINGS

PROBABILITY OF SUCCESS: HIGH

REGULATORY RISK: LOW

STATUS: SOME TEST DATA EXIST; ADDITIONAL TESTING PLANNED

PROPOSED TASKS:

A) REVIEW CORE COMPONENT SEISMIC DESIGN TECHNOLOGY

B) IDENTIFY NEEDED DATA, ANALYSIS AND METHODS

C) PREPARE COOPERATIVE TEST, DEVELOPMENT AND STUDY AGREEMENTS

D) PERFORM TESTS AND PREPARE ASSOCIATED REPORTS

AWD 830905

TOPIC 4. PIPING INHERENT PLASTICITY

OBJECTIVE: ESTABLISH DESIGN PROCEDURES AND CRITERIA FOR SMALL BORE PIPING WHICH RECOGNIZES ENERGY ABSORBTION PROVIDED BY PLASTIC DEFORMATION.

BENEFITS: POTENTIAL COST REDUCTIONS IN COSTS OF PIPING, PIPING SUPPORT STRUCTURE, AND DESIGN ENGINEERING

PROBABILITY OF SUCCESS: MEDIUM

REGULATORY RISK: LOW-MEDIUM

STATUS: SOME STUDIES AND TESTS HAVE BEEN PERFORMED; DESIGN APPROACH HAS BEEN PROPOSED.

PROPOSED TASKS:

A) REVIEW PERTINENT TECHNOLOGY AND IDENTIFY NEEDED TESTS AND METHODS DEVELOPMENT.

B) PREPARE PLANS FOR COOPERATIVE TESTING AND METHODS DEVELOPMENT FOR APPLICATION TO SMALL BORE PIPING.

C) PERFORM TESTS, DEVELOP METHODS, AND PREPARE ASSOCIATED REPORTS.

D) REVIEW REPORTS, RECONCILE COMMENTS, PREPARE AND ISSUE FINAL REPORTS FOR DESIGN USE.

AWD 830906

TOPIC 5. FLUID-STRUCTURE INTERACTION ANALYSIS METHODS

OBJECTIVE: DEVELOPMENT OF FLUID-STRUCTURE INTERACTION DATA FOR VALIDATION OF REACTOR SYSTEM ANALYTICAL MODELS

BENEFITS: POTENTIAL REDUCTION OF PLANT COSTS THROUGH AVOIDANCE OF OVERLY CONSERVATIVE DESIGN

PROBABILITY OF SUCCESS: MEDIUM

REGULATORY RISK: LOW

STATUS: DOE SPONSORED EXPERIMENTAL PROGRAM TO BE INITIATED IN 1984

PROPOSED TASKS:

A) PERFORM INITIAL SLOSHING TESTS AND HEAD-MOUNTED COMPONENT TESTS

B) PERFORM TESTING ON INTERNAL COMPONENTS AND COMPLEX MODELS

C) PREPARE RECOMMENDED ANALYSIS METHODS BASED ON RESULTS OF TESTS

D) ISSUE FINAL REPORT

AWD 830907

TOPIC 6. PUMP HYDROSTATIC BEARING LOADS AND COASTDOWN TIME

OBJECTIVE: DEVELOP AND VERIFY GUIDELINES FOR PREDICTING HYDROSTATIC BEARING LOADS AND FAILURE MARGINS

BENEFITS: OBTAIN VERIFIED DESIGN GUIDELINES FOR DESIGN OF HYDROSTATIC BEARINGS AT MINIMUM COST

PROBABILITY OF SUCCESS: HIGH

REGULATORY RISK: LOW

STATUS: ANALYTICAL METHODS EXIST. CONFIRMATION IS NEEDED

PROPOSED TASKS:

A) REVIEW CURRENT DESIGN METHODS AND DATA, AND IDENTIFY TECHNOLOGY NEEDS FOR LARGE PLANTS

B) IF APPROPRIATE, PREPARE COOPERATIVE TESTS, DEVELOPMENT, AND STUDY AGREEMENTS

C) PERFORM TESTING, DEVELOPMENT, AND STUDIES

D) PREPARE AND ISSUE DESIGN GUIDELINES DOCUMENT

AWD 830908

TOPIC 7. CONCRETE DAMPING IN STRUCTURES

OBJECTIVE: ESTABLISH CONCRETE DAMPING VALUES WHICH ARE HIGHER THAN THOSE USED IN CURRENT STANDARD PRACTICE

BENEFITS: REDUCED PLANT COSTS

PROBABILITY OF SUCCESS: HIGH

REGULATORY RISK: LOW

STATUS: SOME DATA EXIST; FURTHER TESTING NEEDED

PROPOSED TASKS:

A) REVIEW AND EVALUATE AVAILABLE DATA

B) DEFINE ADDITIONAL REQUIRED TESTING

C) PERFORM ADDITIONAL TESTS

D) PREPARE REPORT ON RECOMMENDATIONS FOR DAMPING VALUES

AWD 830909

TOPIC 8. SEISMIC ISOLATION

OBJECTIVE: DEVELOP AND EVALUATE REACTOR PLANT SEISMIC ISOLATION SYSTEMS

BENEFITS: POTENTIAL REDUCTION OF PLANT ENGINEERING AND CONSTRUCTION COSTS. IMPROVED PLANT RELIABILITY AND SAFETY

PROBABILITY OF SUCCESS: MEDIUM

REGULATORY RISK: MEDIUM

STATUS: ISOLATION SYSTEMS HAVE BEEN APPLIED TO LWR's AND CONVENTIONAL STRUCTURES. PERFORMANCE AND COST EFFECTIVENESS DATA NEEDED

PROPOSED TASKS:

A) PERFORM FEASIBILITY STUDIES, DEVELOP DESIGN/ANALYSIS METHODOLOGIES, AND PREPARE TEST PLANS

B) PERFORM SMALL-SCALE TESTS

C) EVALUATE COST EFFECTIVENESS & PLAN LARGE SCALE TESTS

D) PERFORM LARGE-SCALE TESTS

E) PREPARE REPORT FOR DESIGN USE

AWD 830910

TOPIC 9. SOIL-STRUCTURE INTERACTION ANALYSIS

OBJECTIVE: DEVELOP AND VERIFY SSI ANALYSIS METHODS WHICH ARE APPROPRIATELY CONSERVATIVE BUT LESS RESTRICTIVE THAN CURRENT PRACTICE

BENEFITS: REDUCED PLANT COSTS

PROBABILITY OF SUCCESS: MEDIUM-HIGH

REGULATORY RISK: MEDIUM

STATUS: ADVANCES IN COMPUTATIONAL TECHNIQUES HAVE BEEN MADE. ADDITIONAL TEST DATA AND VERIFICATION NEEDED

PROPOSED TASKS:

A) REVIEW AVAILABLE DATA AND SSI COMPUTER PROGRAMS

B) IDENTIFY PROGRAMS FOR VERIFICATION AND SELECT DATA

C) PERFORM PROGRAM VERIFICATION STUDIES & PREPARE REPORTS

AWD 830911

A. W. DALCHER
GE - ARSD
September, 1983

LMFBR SEISMIC DESIGN TOPICS

1 Reactor Equipment Damping Values

There is wide agreement that some data already exists to substantiate higher damping values in certain systems, although further testing is needed to make a solid case for all elements of reactor equipment. Benefits in equipment (and support) cost reduction could be substantial. The probability of a successful program is high, and in the US regulatory risk is low, as the regulations already allow for higher damping values when justified.

2 Control Rod System Seismic Testing

Data on this subject is known to be available in both countries, but has not yet been exchanged. The potential for control rod drive designs with improved seismic capability is high, as is the potential for cost reduction in future testing. Downside risk is low to non-existent, and program costs up to the time further testing is identified will be low.

3 Core Components Limits Testing and Design Criteria

As reactor cores grow larger, the potential for crushing loads on fuel elements increases, with the result that the reactor core imposes proportionately greater restraints on the reactor structures. There is reason to believe that the ducts can accommodate considerably larger impulsive loadings than present analysis techniques predict. Testing is already planned in the USA, and is believed to be proceeding in Japan. Facility requirements and program costs are low, regulatory risk is low and program success probability is high. Assuming program success, cost benefits are realized in reactor structures and buildings.

4 Piping Inherent Plasticity

There is wide agreement that design rules for small bore piping are urgently needed, with the potential for cost reduction both in design analysis and piping supports. There is less common agreement that large plant designers would wish to take on the regulatory risk of substantiating plastic piping deformation as a standard method for large piping design. This aspect of the program therefore runs the risk that, even if technologically successful, it will not translate into the expected plant cost reduction. In addition, large plant designers are exploring alternate approaches to large piping systems, in which safety functions are diminished and rigid piping restraints are utilized.

5 Fluid Structure Interactions

There is some disagreement as to whether present analytic techniques for modeling liquid masses and their connections to reactor structures are adequate, or are overly conservative. As reactor systems get larger, and particularly for pool plants, sodium masses become a larger proportion of total system mass, and conservatisms, if they exist, increase. Program costs would be low to medium, depending on the extent of testing required.

Regulatory risk is low, program success uncertain, as is the cost benefit.The extent to which Japanese designers would embrace the proposal approach needs to be explored. Regulatory risk is judged to be higher than for Tasks A1-A3, but probably acceptable.

6 Large Sodium Pump Hydrostatic Loads and Coastdown Time

There is the potential for pump hydrostatic bearings to malfunction under the dynamic loading of an earthquake, and thereby to damage the bearing or, more seriously, affect the reactor flow coastdown. The magnitude of this problem for large plants is uncertain. There is a high probability that such a program would be successful, the regulatory risk is low and the plant cost benefit is small to zero.

7 Concrete Damping in Structures

As for Task A1, some data exists and the probability of a successful program is high. However, the ability of a relatively small breeder program to change design rules for the whole civil structural arena must be questioned, and the regulatory risk is judged to be medium. It is acknowledged that the breeder system, because of its large components and thin structures, has a greater incentive for success than other fields of civil or nuclear design. Cost benefits could be substantial and program costs are expected to be modest. This task is therefore top priority in the B category.

8 Seismic Isolation

As the detailed evaluation points out, there has been a recent surge of international interest in seismic isolation systems, although their cost benefit in specific cases is uncertain. Regulatory risk of acceptance is judged to be medium to low, although the first project to employ the system in the USA would expect problems. Differences in seismic requirements in the USA and Japan are an impediment to common design, which seismic isolators have the potential for eliminating. This aspect needs further exploration with our Japanese colleagues. Program costs, up to the point of any large scale testing required, should be modest.

9 Soil Structure Interaction Analysis

There is general agreement that the approach taken by regulatory bodies to this topic is conservative, and that a combination of analysis and data can be assembled to prove the point. The probability of program success is therefore high and program costs are medium. As with other topics in this area, the extent of the breeder program to influence established LWR regulatory practice is uncertain, and in this particular case the regulatory risk is judged to be medium. This task should be discussed with the Japanese to elucidate their interest.

THERMAL AND LOAD CYCLING CRITERIA FOR SODIUM COMPONENT AND SYSTEMS

SUB-TOPICS

LARGE COMPONENT THERMAL TESTS

HIGH TEMPERATURE STRUCTURAL DESIGN CRITERIA

THERMAL STRIPING

STRATIFICATION

HIGH TEMPERATURE STRUCTURAL DESIGN CRITERIA

THE DEVELOPMENT OF IMPROVED HIGH TEMPERATURE DESIGN CRITERIA IS ESSENTIAL TO GUARD AGAINST TIME DEPENDENT FAILURE MODES

BENEFITS

THE U.S. HIGH TEMPERATURE STRUCTURAL DESIGN TECHNOLOGY PROGRAM IS ORGANIZED TO PROVIDE THE DESIGN LIMITS, GUIDELINES AND PROCEDURES REQUIRED TO CREATE STRUCTURES PROTECTED FROM FAILURE MODES ASSOCIATED WITH HIGH TEMPERATURE, TIME DEPENDENT MATERIAL BEHAVIOR -

CREEP RUPTURE
CREEP-FATIGUE INTERACTION
CREEP-ENHANCED RATCHETTING
CREEP BUCKLING

EVALUATION

THE U.S. TEAM WAS ASKED:

1. WHAT NEEDS REMAIN FOR FURTHER DEVELOPMENT?
2. WOULD A COOPERATIVE PROGRAM BE HELPFUL IN SATISFYING THESE NEEDS FOR BOTH DOE & PNC?

RESPONSE

1. THE NEEDS OF THE U.S. PROGRAM INCLUDE:

   - DESIGN METHODOLOGY FOR WELDMENTS
   - IMPROVED CREEP-FATIGUE AND CREEP-RUPTURE CRITERIA FOR GEOMETRIC NOTCHES
   - IMPROVED ELASTIC ANALYSIS DESIGN LIMITS
   - VALIDATION TESTING OF PIPING COMPONENTS
   - EXPAND MATERIALS DATA BASE

2. SINCE BOTH DOE AND PNC HAVE EXTENSIVE DEVELOPMENT PROGRAMS IN HIGH TEMPERATURE STRUCTURAL DESIGN TECHNOLOGY, A COOPERATIVE EFFORT TO SHARE TEST INFORMATION AND TO COORDINATE FUTURE TESTING WILL:

   - HELP REDUCE DEVELOPMENT COSTS
   - EXPAND THE DATA BASE AVAILABLE TO BOTH SIDES
   - MAKE DATA AVAILABLE SOONER

RECOMMENDATIONS

THE U.S. PROPOSES THAT A COOPERATIVE PROGRAM BE UNDERTAKEN BETWEEN DOE AND PNC ON:

- DESIGN METHODOLOGY FOR WELDMENTS
- IMPROVED CREEP-FATIGUE AND CREEP-RUPTURE CRITERIA FOR GEOMETRIC NOTCHES
- IMPROVED ELASTIC ANALYSIS DESIGN LIMITS
- VALIDATION TESTING OF PIPING COMPONENTS

FEASIBILITY STUDY REPORT FOR DOE/PNC COOPERATIVE PROGRAM ON THERMAL STRIPING

EXCESSIVE CONSERVATISM IN REACTOR STRIPING DESIGN MAY LEAD TO INCREASED COSTS FOR MORE RESISTANT MATERIALS OR A SACRIFICE OF CORE COMPONENT LIFETIME

BENEFITS

THE U.S. HIGH TEMPERATURE STRUCTURAL DESIGN TECHNOLOGY PROGRAM IS ORGANIZED TO PROVIDE THE DESIGN LIMITS, GUIDELINES AND PROCEDURES REQUIRED TO CREATE STRUCTURES PROTECTED FROM FAILURE MODES ASSOCIATED WITH HIGH TEMPERATURE, TIME DEPENDENT MATERIAL BEHAVIOR -

CREEP RUPTURE
CREEP-FATIGUE INTERACTION
CREEP-ENHANCED RATCHETTING
CREEP BUCKLING

EVALUATION

THE U.S. TASK TEAM CONSIDERED:

1. WHAT ARE THE NEEDS OF THE U.S. PROGRAM?
2. WOULD A COOPERATIVE EFFORT WITH PNC BE HELPFUL IN FULFILLING THE U.S. NEEDS IN AN EQUITABLE FASHION?

RESPONSES

1. THE THERMAL STRIPING PROGRAM MUST:
   - ESTABLISH A WATER-TO-SODIUM CORRELATION
   - DEVELOP DYNAMIC FILM COEFFICIENT INFORMATION
   - DETERMINE THE EFFECTS OF THERMAL STRIPING ON STRESS CONCENTRATIONS
2. DUE TO THE VERY HIGH COSTS ASSOCIATED WITH PERFORMING LARGE SCALE SODIUM THERMAL STRIPING TESTS, AN EQUITABLE PROGRAM UTILIZING DOE AND PNC FACILITIES SHOULD MAKE IT POSSIBLE TO SATISFY THE NEEDS OF BOTH COUNTRIES AT GREATLY REDUCED COST

RECOMMENDATION

SINCE A COOPERATIVE PROGRAM HAS THE POTENTIAL TO LEAD TO

REDUCED CAPITAL COSTS
IMPROVED OPERABILITY AND RELIABILITY
REDUCED DEVELOPMENT COSTS

THE U.S. PROPOSES THAT A PROGRAM BE UNDERTAKEN TO COORDINATE TESTING TO:

- ESTABLISH A WATER-TO-SODIUM CORRELATION
- DEVELOP DYNAMIC FILM COEFFICIENT INFORMATION
- DETERMINE THE EFFECTS OF THERMAL STRIPING ON STRESS CONCENTRATIONS

LARGE COMPONENT THERMAL TESTS

THE PURPOSE OF A LARGE COMPONENT THERMAL TEST IS TO EVALUATE COMPLEX SODIUM FLOW AND THE THERMAL BOUNDARY CONDITIONS WHICH EXIST IN A REACTOR VESSEL DURING THERMAL TRANSIENTS

BENEFITS

KNOWLEDGE OF THE SODIUM FLOW DISTRIBUTION AND THERMAL BOUNDARY CONDITIONS PERMITS THE DESIGNER TO DETERMINE THE TEMPERATURES AND STRESSES IN REACTOR VESSEL COMPONENTS DURING THERMAL TRANSIENTS

EVALUATION

THE U.S. TEAM WAS ASKED:

1. IS VERY MUCH MORE INFORMATION NEEDED FOR US TO PREDICT FLOW DISTRIBUTIONS AND THERMAL BOUNDARY CONDITIONS OF LARGE LMFBR'S?

2. ARE LARGE COMPONENT THERMAL TESTS WITH SODIUM THE MOST COST EFFECTIVE WAY TO GET THE NEEDED INFORMATION?

RESPONSE

1. THE U.S. HAS DEVELOPED CODES WHICH CAN PREDICT THE DETAILED FLUID AND METAL TEMPERATURE INFORMATION TO SUPPORT THE STRUCTURAL ANALYSIS OF LARGE REACTOR COMPONENTS.

   THESE CODES HAVE UNDERGONE SUFFICIENT VALIDATION IN PREDICTING LMFBR FORCED FLOW TEMPERATURE AND VELOCITY DISTRIBUTIONS.

2. THE U.S. HAS NOT IDENTIFIED A FIRM NEED FOR A LARGE SCALE TEST. ANY NEEDED VALIDATION CAN BE ACHIEVED WITH SMALL SCALE SODIUM AND WATER TESTS.

RECOMMENDATION

DOE RECOMMENDS THAT PLANS FOR A COLLABORATIVE EFFORT ON LARGE COMPONENT THERMAL TEST BE DEFERRED

STRATIFICATION

THERMAL STRATIFICATION IS OF IMPORTANCE TO LMFBR PLANTS IN THAT IT AFFECTS EMERGENCY CORE COOLING AND CAN DELAY RECOVERY FOLLOWING SCRAMS

BENEFITS

THE MAJOR BENEFIT OF STRATIFICATION STUDIES IS TO UNDERSTAND THE SODIUM TEMPERATURE AND FLOW BEHAVIOR IN PLENA DURING SEVERE TRANSIENTS FOLLOWED BY NATURAL CONVECTION FLOW.

RECOMMENDATION

THE U.S. RECOMMENDS THAT ANY COLLABORATIVE EFFORT ON STRATIFICATION BE CARRIED OUT AS PART OF THE EFFORT ON DRACS

DEFINITION OF STEAM GENERATOR DEVELOPMENT PROGRAM WITH INTENT OF ELIMINATING THE INTERMEDIATE SYSTEM

BENEFITS

- PLANT CAPITAL COST REDUCTION OF ABOUT 10%.
- SHARING THE COST OF DEVELOPMENT AND TESTING PROGRAMS.
- SHARING KNOWLEDGE.
- POSSIBLE BENEFITS IF COMPLETE GOAL NOT REACHED.
  - HIGHER AVAILABILITY.
  - SWRPRS ELIMINATION.

ASSUMPTIONS

- ALL PSG PLANT CONCEPTS NEED PROVEN RELIABLE SG.
- START IMMEDIATELY TO ACCELERATE DWT FABRICATION & TEST PROGRAM.
- DOE TO PROVIDE DWT UNIT.
- PNC TO PROVIDE TEST OF DWT.
- DOE/PNC SHARE IN DESIGN, FABRICATION AND PERFORMANCE KNOWLEDGE.
- IN PARALLEL, START DESIGN CONCEPTS FOR PLANT SYSTEMS.

DEFINITION OF STEAM GENERATOR DEVELOPMENT PROGRAM WITH INTENT OF ELIMINATING THE INTERMEDIATE SYSTEM

U. S. EXPERIENCE IN DOUBLE-WALLED TUBE SG's

- o SUBMARINE INTERMEDIATE REACTOR PROGRAM (SEVERAL MODELS)
- o SODIUM REACTOR EXPERIMENT (3 MODELS)
- o HALLAM NUCLEAR POWER FACILITY (6 MODELS)
- o YEARS OF SUCCESSFUL OPERATION IN EBR-II
- o SMALL STEAM GENERATOR MODEL - DWT TESTED.
- o FEW TUBE MODEL - DWT TESTED.
- o THIRD FLUID LEAK DETECTION SYSTEM TESTED.
- o 70 MW MODEL - DWT BEING FABRICATED FOR TEST.

PHASE I APPROACH

- o SELECT DWT CONCEPT AS REFERENCE.
- o DEFINE TEST PROGRAM FOR DWT.
- o DEFINE SYSTEM DESIGN FOR PSG.
- o DEFINE IMPLEMENTATION PLAN FOR PHASE II.

OBJECTIVES

PHASE IA -

- o DEVELOP DOUBLE WALL TUBE TESTING PROGRAM

PHASE IB -

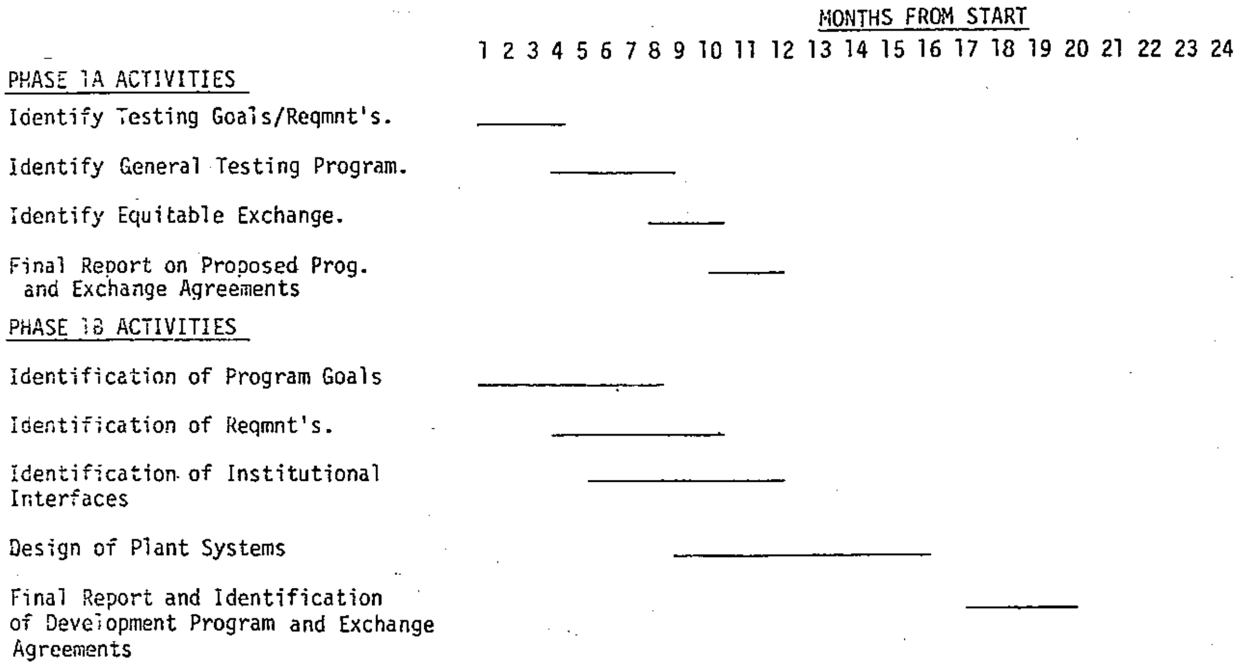
- o DEVELOP SYSTEM DESIGN FOR DWT/PSG
- o QUANTIFY SAVINGS POTENTIALLY AVAILABLE
- o IDENTIFY CHARACTERISTICS AND REQUIREMENTS
- o DEFINE COOPERATIVE R&D PROGRAMS

PHASE II -

- o IMPLEMENT COOPERATIVE R&D PROGRAMS

DEFINITION OF STEAM GENERATOR DEVELOPMENT PROGRAM WITH INTENT OF ELIMINATING THE INTERMEDIATE SYSTEM

SCHEDULE



EQUITABLE PARTICIPATION

PHASE I - EQUAL BENEFITS OBTAINED BY BOTH U. S. AND JAPAN.
- EQUAL RESOURCES EXPENDED BY BOTH U. S. AND JAPAN.

PHASE II- NOT DEFINED
- EXPECTED TO BE POSSIBLE TO DEFINE PROGRAM WITH EQUITABLE PARTICIPATION.

CONCLUSIONS

o RECOMMEND THAT PHASE I BE IMPLEMENTED AS A JOINT DOE/PNC COOPERATIVE PROGRAM.

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PNC PRESENTATION

PNC/DOE PEWG EXECUTIVE COMMITTEE MEETING

ON PLANT OPTIMIZATION COLLABORATION FEASIBILITY

RICHLAND, WASHINGTON

SEPTEMBER 26-30, 1983

POWER REACTOR AND NUCLEAR FUEL DEVELOPMENT CORPORATION

JAPAN

CONTENTS

DOE/PNC LARGE PLANT OPTIMIZATION STUDY
STUDY TOPIC FEASIBILITY EVALUATION

Study Topic

* LMFBR Seismic Tests Program : Development of Isolation System

Objectives of Study

* Investigation of the applicability of isolation system for FBR and clarification of the problems to be solved for practical use (Feasibility study)

* Development of isolation system considering the application for FBR and performance of R & D works needed for practical use.

Potential Benefits

* Reduction of an amount of materials for components and numbers of supports and hangers for pipings and components.

* Standardization of seismic design.

* Reduction of R & D cost each other.

* Authorization of the concept of isolation system by mutual recognition.

Background

* Both Japanese and US LMFBR designers are much interested in the development of isolation system, reduction of an amount of materials and standardization of seismic design.

* Long term R & D works and much money are necessary for practical use of isolation system.

* There exist many residual works to be conducted until license.

* Isolation system is potential technology to solve the problem of higher thermal stress at large scale reactor.

Schedule for Study

Month	(1)	(2)	(3)		(4)		(5)	(6)
	12	24		36		48		60

(1) Complete information investigation(I) (Japan & US)
(2) Complete information investigation(II) and preliminary analysis to decide the scale of test models and test conditions (Japan & US)
(3) Complete review of Japanese and US test proposal (Japan & US)
(4) Complete design and manufacturing of test models
  Japan: Isolation system model of reactor vessel
  US : Isolation system model of reactor building
(5) Complete vibration tests (Japan & US)
(6) Complete the evaluation of test results (Japan & US)

Resources

* Estimated direct labor required for study

Japan: 63 man-months
US : 63 man-months

* Estimated cost for study

Japan: ¥360M ($1.44M)
US : ¥360M ($1.44M)

* Personnel exchange

(1) and (2)	Japan and US mutually have specialist's visit once a year.
(3) (4) (5) and (6)	A Japanese stays at US for 6 months a year. An American stays at Japan for 6 months a year.

DOE/PNC LARGE PLANT OPTIMIZATION STUDY
STUDY TOPIC FEASIBILITY EVALUATION

Study Topic

* LMFBR Seismic Tests Program: Rationalization of Seismic Analysis Method for Piping System.

Objectives of Study

* Development of analysis method to evaluate non-linear vibration behavior of large scale piping system including gap.

* Development of vibration analysis method for large scale piping system including expansion joint.

* Test of vibration response of piping system in elastic-plastic region and, therefore, confirmation of design margin and rationalization of design.

Potential Benefits

* Ralionalization of seismic design, for example, increase of damping factor.

* Establishment of vibration analysis method.

* Reduction of numbers of supports and hangers for piping system.

* Reduction of R & D cost each other

Background

* Both Japanese and US LMFBR designers are much interested in the development of seismic analysis method for piping system and the rationalizaion of seismic design.

* There is no experience of vibration analysis for piping system including expansion joint.

Schedule for Study

Month	(1) (2)		(3)		(4)	(5)
	12	24		36		48

(1) Complete information investigation (Japan & US)
(2) Complete review of Japanese and US test proposal.
Japan: Test of piping system including gap.
Test of expansion joint
US : Test of piping system in elastic-plastic region.
(3) Complete design and manufacturing of test models
Japan: Test model of piping system including gap.
Test model of expansion joint
US : Test model of piping system in elastic-plastic region.
(4) Complete vibration tests (Japan & US)
(5) Complete the evaluation of test results (Japan & US)

Resources

* Estimated direct labor required for study

  Japan: 105 man-months
  US : 60 man-months

* Estimated cost for study

  Japan: ¥415M ($1.66M)
  US : ¥215M ($0.86M)

* Personnel exchange

(1)	Japan and US mutually have specialist's visit once a year.
(2) (3) (4) and (5)	A Japanese stays at US for 6 months a year. An American stays at Japan for 6 months a year.

DOE/PNC LARGE PLANT OPTIMIZATION STUDY
STUDY TOPIC FEASIBILITY EVALUATION

Study Topic

* LMFBR Seismic Tests Program : Development of Vibration Analysis Method for Fluid Structure Interation

Objectives of Study

* Development of analysis method to evaluate sloshing behavior
* Development of analysis method for vessel wall deformation by fluid impact
* Development of analysis method for component vibration in fluid

Potential Benefits

* Establishment of analysis method for fluid structure interaction at large scale reactor
* Clarification of vibration behavior relating to fluid structure interaction
* Rationalization of seismic design.
* Reduction of R & D cost each other.

Background

* Both Japan and US recognize that fluid structure interaction is severer and more important probelm by scale up of reactor.
* US developed FLUSTER code.
* Perto-chemical industry examined sloshing behavior of storage tank.

Schedule for Study

Month	(1)	(2)		(3)	(4)	(5)
	12		24	36		48

(1) Complete information investigation (Japan & US)
(2) Complete review of Japanese and US test proposal (Japan & US)
(3) Complete design and manufacturing of test models (Japan & US)
(4) Complete vibration tests (Japan & US)
(5) Complete the evaluation of test results and verification of analysis code (Japan & US)

Resources

* Estimated direct labor required for study

  Japan: 57 man-months
  US : 57 man-months

* Estimated cost for study

  Japan: ¥330M ($1.32M)
  US : ¥330M ($1.32M)

* Personnel exchange

(1) Japan and US mutually have specialist's visit once a year.

(2) (3) (4) and (5) A Japanese stays at US for 6 months a year. An American stays at Japan for 6 months a year.

DOE/PNC LARGE PLANT OPTIMIZATION STUDY
STUDY TOPIC FEASIBILITY EVALUATION

Study Topic

* LMFBR Seismic Tests Program: Functional Qualification of Active Components

Objectives of Study

* Information exchange of analysis and evaluation method for functional qualification of active components: integrity of hydrostatic bearing of mechanical pump, insertability of control rod and function of sodium valve at reactor scram.

* Development of analysis and evaluation method for functional qualification of active components used for large scale reactor.

* Mutual recognition of necessary R & D work for functional qualification of active components.

Potential Benefits

* Establishment of analysis and evaluation method for large scale reactor.

* Reduction of R & D cost each other.

Background

* Both Japan and US developed the analysis and evaluation method of active components for MONJU and CRBR, respectively.

* Both Japanese and US designers are much interested in the modification of analysis and evaluation method for active components used for large scale reactor.

* Functional qualification of active component is much important for the safety security at reactor scram.

Schedule for Study

month				
	(1)		(2)	(3)
	12	24		36

(1) Complete information exchange. (Japan & US)
(2) Complete establishment of analysis and evaluation method for large scale reactor. (Japan & US)
(3) Complete pointing out of R & D work necessary in future.

Resources

* Estimated direct labor required for study

Japan: 27 man-months
US : 27 man-months

* Estimated cost for study

Japan: ¥215M ($0.86M)
US : ¥215M ($0.86M)

* Personnel exchange

(1) Japan and US mutually have specialist's visit once a year.
(2) and (3) A Japanese stays at US for 6 months a year.
An American stays at Japan for 6 months a year.

DOE/PNC LARGE PLANT OPTIMIZATION STUDY
STUDY TOPIC FEASIBILITY EVALUATION

Study Topic

- Information exchange of safety concept.

Objective of Study

- Consolidation of concept for safety, licensing and design when the design such as shrinkage of safety system would be adopted.

Potential Benefits

- Possibly establish the common concept for criteria mentioned as above of a shutdown heat removal system between Japan and U.S..

Back ground

- Safety concept such as diversity give an impact on the plant design.
- It is important to collaborate such concepts between Japan and U.S. or among various countries.

Schedule for Study

FY 1984 1985

Information exchange

Resorces

- Estimated direct labor required for completion of study

Japan	37.5 man-months
U.S.	15.0 man-months

- Total estimated cost for study

Japan	$0.25 M
U.S.	$0.25 M

DOE/PNC LARGE PLANT OPTIMIZATION STUDY
STUDY TOPIC FEASIBILITY EVALUATION

Study Topic

- Basic test data for verification

Objective of Study

- Obtaining the data necessary to verify various types of DRACS and providing the data to validate computer codes.

Potential Benefits

- Saving the R & D cost when R & D for pool-type reactor would be performed in Japan and R & D for loop-type reactor would be done in U.S.

Back ground

- It is important to verify the non-symmetrical heat removal characteristic with interaction between in-vessel and primary system and to obtain basic heat transfer characteristic in DHX.

Schedule for Study

FY	1984	1985	1986
	Design, Fabrication & Installation		Operation & Testing

Resorces

- Estimated direct labor required for completion of study

  Japan 58.5 man-months
  U.S. 23.5 man-months

- Total estimated cost for study

  Japan $ 2.7 M
  U.S. $ 1.5 M

DOE/PNC LARGE PLANT OPTIMIZATION STUDY
STUDY TOPIC FEASIBILITY EVALUATION

Study Topic

- In-vessel natural circulation verification test in Joyo.

Objective of Study

- Verification of in-vessel natural circulation capability and providing the data necessary to validate the computer code.

Potential Benefits

- Obtaining the test data in a large scale experimental facility (JOYO).

Back ground

- JOYO is the only reactor to have capability of performing the in-vessel natural circulation test. In-pile data are always valuable especially for licensing.

Schedule for Study

FY	1984	1985	1986
	Prediction and Test planning		Natural circulation test

Resorces

- Estimated direct labor required for completion of study

Japan	35.0 man-months
U.S.	included in study topic "Validation of computer codes"

- Total estimated cost for study

Japan	$0.4 M
U.S.	included in study topic "Validation of computer codes"

DOE/PNC LARGE PLANT OPTIMIZATION STUDY
STUDY TOPIC FEASIBILITY EVALUATION

Study Topic

- Validation of computer codes.

Objective of Study

- Validation of computer codes and obtaining regulatory agency approval.

Potential Benefits

- Standardization of thermo-hydraulic behavior analysis code.

Back ground

- There are many problems to be solved in order to confirm the natural circulation based design.
  Analytical model and method with high potentiality are required.

Schedule for Study

FY	1984	1985	1986	1987

Development and verification of 1-D code
Verification of 3-D code

Resorces

- Estimated direct labor required for completion of study

  Japan 52 man-months
  U.S. 35 man-months

- Total estimated cost for study

  Japan $0.5 M
  U.S. $0.8 M

C

DOE/PNC LARGE PLANT OPTIMIZATION STUDY
STUDY TOPIC FEASIBILITY EVALUATION

Study Topic

Definition of Steam Generator Development Programwith Intent of eliminating the Intermediate System.

Subtheme

- o Conceptual Design Study of IHTS(Intermediate Heat Transport System)-less FBR Plant Using High Reliable SG (Steam Generator)

Objective of Study

- o Study the feasibility (especialy philosophical concept of safety) of IHTS-less FBR plant by establishing water leak-tight SG concepts and provide the material for evaluation of probability adopting this concept of plant.

- o Evaluate the merit and demerit and plant capital and operation cost reduction benefit by elimination of IHTS.

- o Study the requirement and define R&D programs for the establishment of high reliable water leak-tight SG and licensable IHTS-less plant system.

Potential Benefits

- o Combine both countries experience to evaluate the feasibility of an IHTS-less FBR plant.

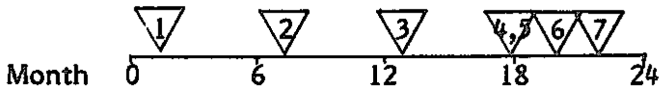
- o Understand the mutual current status and future programs for the development of SG and establish the basis for the further collabaratiove activities.

Background

- o High reliability and serviceability of SG's are required for improved plant availability and as a prerequisite for IHTS elimination.

- o Elimination of the IHTS offers a potential for major plant cost reduction but it should be recognized that such plant is not available to be adopted to the next stage FBR plant in near future. For that purpose accumulation of plant experience based on water leak-tight SG's are required.

Schedule for study



▽1 Identification of study goals, specification of the study in detail and sharing of the work.

▽2 Conceptual design to set up the specific IHTS-less plant concept show the outline of plant by drawing the piping system, arrangement of major components in building, especialy in reactor container.

▽3 Evaluation of expecting benefits and reducing plant capital and operating costs comparison of the cost with the existing plant cost.

▽4 Extraction of items to be studied further

* Requirements for SG to realize this plant such as water-leak probability evaluation, water-leak detection system, large scale water-leak proof system and so on.

* Same for safety and overall system such as establishment of safety scenario and event tree, analysis of structural safety of reactor due to pressure propagation by large scale water-leak, evaluation of the effect of reactor blockage by sodium-water reaction product, accident analysis of water-steam pipe rupture in reactor container and so on.

▽5 Discussion and evaluation in detail for extracted items. Show the conceptual design and drawing of SG configulation to satisfy the requirement to establish the IHTS-less plant.

▽6 Extraction of required R&D items and setting of development programs.

▽7 Completion of Report.

C

Resources

o Estimated cost for study

U.S. TBD

Japan TBD

Remarks: This work should be restricted to research and feasibility study. Further collaborative work should be discussed after completion of this work.

D

DOE/PNC LARGE PLANT OPTIMIZATION STUDY
STUDY TOPIC FEASIBILITY EVALUATION

Study Totic

- o Development of piping bellows for LMFBR service.

Objective of study

- o Establish the advantages, limitations, special requirements, design approaches, R&D needs, and cost savings associated with the use of bellows expansion sections in LMFBR piping systems.

- o Establish and/or consolidate codes and standards for design, fabrication and inspection for piping bellows in a cooperatiove effort between U.S. and Japan.

Potential Benefits

- o Bellows applications in main heat transport and auxiliary piping systems offer potential construction cost savings by(1) reduction in quantities of pipe and fittings, piping support hardware, building support locations, and piping construction welds (with associated post weld heat treatment, examination and ISL costs); (2) reduced cell sizes and containment structure sizes; (3) smaller sodium inventory; and (4) reduced support systems requirements, such as cell cooling, heat tracing, and leak monitoring. All these savings can be related to reduced piping lengths if bellows expansion sections provide the major flexibility for thermal growth.

- o Plant functional improvements also result from the reduced piping length. These include reduced pressure drops and heat losses, particularly important to natural circulation heat removal systems.

- o Increased plant reliability can be achieved by reduction in piping stress and equipment nozzle load contributor to early fatigue cracking. A reduction in the number of wilds and associated heat-affected operational problems, also increases reliability. Finally, support steel thermal movement due to excessive cell temperatures (sodium fires, loss of cell cooling) can be more readily accommodated without piping lines using expansion joints.

D

o Collaboration of U.S./Japan parties who share common interest and objecteves should not only save cost and man power but also produce workable codes and standards that are backed up with thoroughly reviewed experimental data which have achieved consensus from the expertise of both countries.

o Codes and standards as a product of cooperative effort between the two leading countries should be favorably accepted by licensing authorities.

Background

o U.S. has taken the initiative in consolidating codes and standards on piping bellows such as EJMA and ASME CC N-290 and is making a continuing effort in this area.

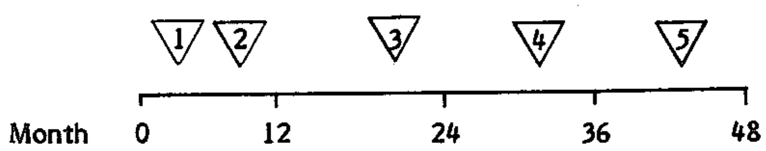
o Whereas in Japan, PNC is about to take a position of leap-frogging to complete a feasibility study on the use of bellows for an FBR piping system by the end of1986.

o PNC is accelerating its effort in the piping bellows development program by constructing several test units subjecting convolutions to various loadings up to and including failure. Tests include fatigue, creep-fatigue, mechanical ratchet, buckling, vibration, etc. Proof test on plant size expansion joints in sodium is also in line. Along with this testing, development of codes and standards on design, fabrication and inspection is another majhor task included in the program.

o Therefore, it is appropriate for the two countries to consider unifying their program plans to reach a common goal.

D

Schedule for study



1. Complete review of U.S. and Japan piping bellows R&D program
2. Agreement on the framework and scheme of collaboration program
3. 1st year review meeting
4. 2nd year review meeting
5. 3rd and last year of 1st phase review meeting.

Resources

- o Estimated direct labor required for completion of study:

  U.S. 200 man-months
  Japan 220 man-months

- o Utilize U.S. and Japan test units
- o Annual review meeting by specialists
- o Total estimated cost for study

  U.S. $5M
  Japan $7M

DOE/PNC LARGE PLANT OPTIMIZATION STUDY
STUDY TOPIC FEASIBILITY EVALUATION

Study Topics

- o Development of Procedures for Design of FBR Components using Inelastic Analyses

Objective of Study

- o Develop guidelines or procedures for design of FBR components using inelastic analyses validated by comprehensive R&D

Potential Benefits

- o Reduce construction cost by allowing to adopt more simplified structures, smaller dimensions and cheaper fabrication methods.

- o Reduce restraining factors for plant operation.

- o Contribute to establish more rational design procedures based on elastic analyses.

Background

- o ASME Boiler and Pressure Vessel Code C.C. N-47 provides design rule based on elastic analyses as well as inelastic analyses.

- o Design rule based on elastic analyses give unduly conservative results in some cases.

- o U.S. has provided rather detailed guideline for design based on inelastic analyses.

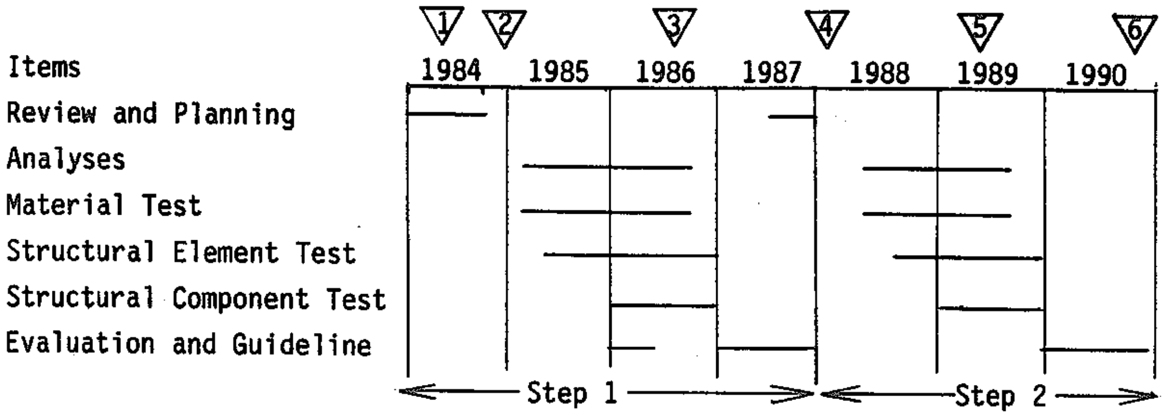
- o PNC provided 'Structural Design Guide for Class 1 Components of Prototype Fast Breeder Reactor for Elevated Temperature Service'.

- o Design rule in 'PNC Design Guide' using elastic analyses considers inelastic response of structures in simplified way.

o PNC is preparing guideline for design by inelastic analyses.

o Currently available procedures for design based on inelastic analyses have many aspects for improvement. More reasonable design procedures should be established by extensive material tests, structural tests and analytical works.

Schedule for Study



1 Review of available results and experiences; Basic planning (specialists visit,S.V.)

2 Detailed planning for collaborative study (S.V.)

3 Interim evaluation and report (S.V)

4 Evaluation and drawing up of guideline (S.V.)

5 Interime evaluation and report (S.V.)

6 Evaluation and drawing up of guideline (Rev. 1), (S.V.)

Remarks ;Both countries should contribute to each item equally in princeple.

Resources

o Estimated direct lavor required for completion of study.
U.S.
Japan 300 man-months

o Utilize U.S. and Japanese test facilities.

o Long term stay of each one engineer at counterpart's laboratory.

- o Specialists visit.

- o Total estimated cost for study
  (excluding personnel expenditure)

  U.S. $1.2M
  Japan $1.2M

Remarks; In the course of progress of this study, it will be possible to extend scope of this study to wider area, for example to establish more rational creep-fatigue evaluation criteria or to develop more improved high temperature design criteria.

DOE/PNC LARGE PLANT OPTIMIZATION STUDY
STUDY TOPIC FEASIBILITY EVALUATION

Study Topic

- Development of Analytical Codes for Thermal Stratification.

Objective of Study

- To clarify accuracy and problems of analytical code(s) through validation by existing data
- To improve analytical code(s) by desolving problems such as "carry-over" by using data obtained from basic tests
- To determine rational thermal boundary conditions upon studying the application of test data to design

Potential Benefits

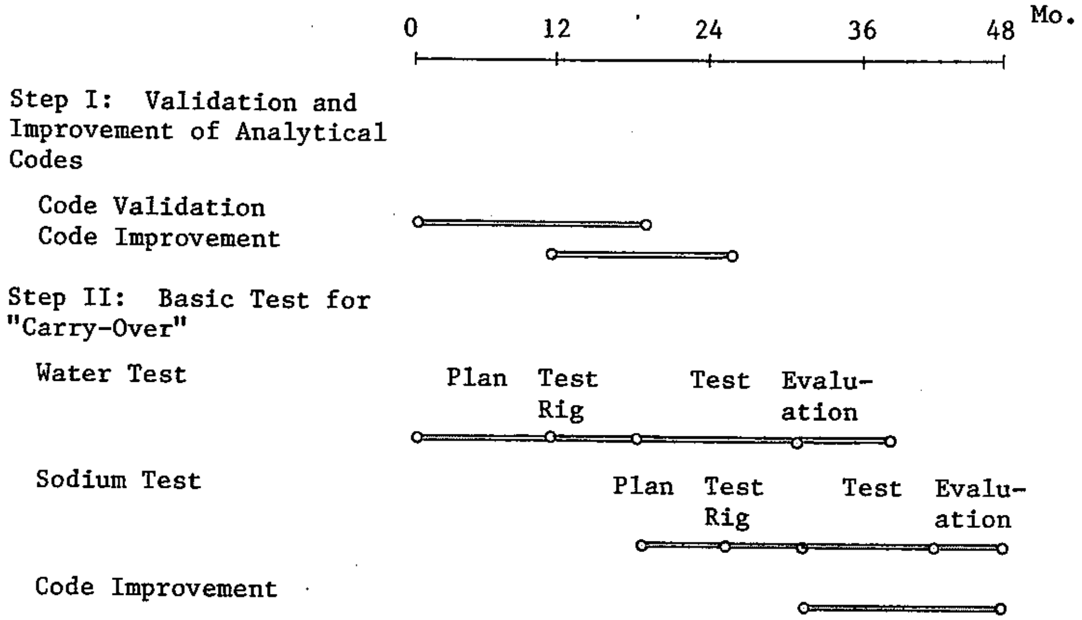
- The measure for thermal stratification mitigation can be rationalized, for example, to reduce the amount of materials and to simplify structure and fabrication procedure, resulting in the reduction of plant construction cost.
- The rational design thus achieved will mitigate the limitation otherwise set for the plant operation procedure.

Background

- Thermal stratification phenomenon has been thoroughly studied in the MONJU upper plenum test including its initiation, rising speed of density interface, resulting temperature distribution and dissipation.
- Analytical codes are available to simulate the phenomenon with sufficient accuracy.
- It was found from the test that the "carry-over" was an important mechanism to describe the rise of density interface.
- Further test is necessary to understand the mechanism of "carry-over" in order to improve existing analytical codes.
- Sodium data from a large scale model may be necessary in future before completing the development of analytical codes.

E-2

Schedule for Study



Remarks: Both countries should contribute to each item equally in principle.

Resources

- Estimated direct labor required for completion of study
  US :
  Japan: 120 Man-Months

- Utilizationon of U.S. and Japanese test facilities.

- Specialists visits

- Total estimated cost for study (excluding personnel expenditure)
  US : $1.0 M
  Japan: $1.0 M

DOE/PNC LARGE PLANT OPTIMIZATION STUDY
STUDY TOPIC FEASIBILITY EVALUATION

Study Topic

- Development of Design Method free from Thermal Striping Damage

Objective of Study

- To develop analytical code describing temperature fluctuation from the data obtained from basic tests
- To establish an appropriate evaluation method for high cycle thermal fatigue by performing high cycle thermal fatigue test on FBR material and comparing it with existing high cycle mechanical fatigue data
- To determine rational thermal boundary conditions so as to be applicable to design loading conditions

Potential Benefits

- The measure for thermal striping mitigation can be rationalized, for example, to reduce the amount of materials and to simplify structure and fabrication procedure, resulting in the reduction of plant construction cost.
- The rational design thus achieved will mitigate the limitation otherwise set for the core design.
- The improvement on accuracy in the LMFBR design can be achieved.

Background

- The design data are now available for the MONJU upper plenum from water tests performed with plant size 1/3 sector model and 19 assembly model.
- A comparative test in water and in soduim is planned in the summer of 1984 using a 7 assembly full scale model.
- The development of analytical code with K-ε model has begun to study the striping phenomenon.
- The urgent need exists to develop analytical code by performing basic tests on temperature fluctuation and by understanding its mechanism.
- Little data are available on high cycle thermal fatigue of FBR materials in sodium, which should be supplied at the earliest possible time.
- It is necessary to develop a simplified method such as a curve or a chart which enables one to assess the effect of thermal striping on the structural design.

Schedule for Study

	0	12	24	36	48 Mo.
Basic Test on Temperature Fluctuation	Plan	Test Rig	Test		Evaluation
Development of Analytical Code			Development		
High Cycle Thermal Fatigue Test on FBR Materials					
Sodium Test	Plan	Test Rig	Test		Evaluation
Mechanical Test at High Temperature	Plan	Test Rig	Test		Evaluation
Development of Evaluation Guide for High Cycle Thermal Fatigue			Development		

Remarks: Both countries should contribute to each item equally in principle.

Pesources

- Estimated direct labor required for completion of study
  US :
  Japan: 120 Man-Months
- Utilization of U.S. and Japanese test facilities
- Specialists visits
- Total estimated cost for study (excluding personnel expenditure)
  US : $1.0M
  Japan: $1.0M

CONTENTS

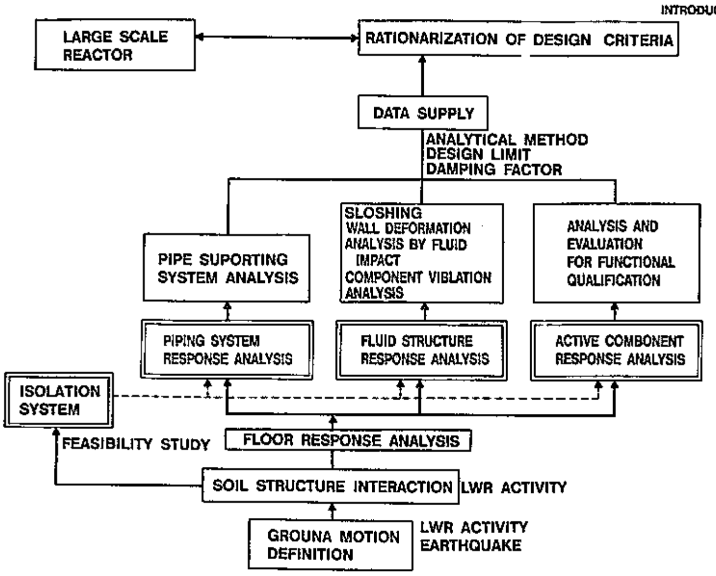
OPTIMIZATION STUDY FOR SEISMIC DESIGN AREA

OBJECTIVES

- REDUCTION OF PLANT CAPITAL COST AND OPERATION COST
- REDUCTION OF R & D'S COST
- RATIONALIZATION AND STANDARDIZATION OF SEISMIC DESIGN
- SUPPLY OF IMFORMATION TO RATIONALIZE SEISMIC DESIGN CRITERIA

PROPOSALS FOR PNC / DOE COLLABORATION STUDY

- DEVELOPMENT OF ISOLATION SYSTEM
  - FEASIBILITY STUDY
  - TEST
- RATIONALIZATION OF SEISMIC ANALYSIS METHOD FOR PIPING SYSTEM
  - NON-LINEAR VIBRATION BEHAVIOR
  - EXPANSION JOINT
  - PLASTIC VIBRATION BEHAVIOR
- DEVELOPMENT OF VIBRATION ANALYSIS METHOD FOR FLUID STRUCTURE INTERACTION
  - SLOSHING
  - VESSEL WALL DEFORMATION
  - IN-FLUID STRUCTURE VIBRATION
- FUNCTIONAL QUALIFICATION OF ACTIVE COMPONENTS
  - CONTROL ROD
  - MECHANICAL PUMP BEARING
  - SODIUM VALVE



BACKGROUND

ISOLATION SYSTEM

- BOTH JAPAN AND US ARE MUCH INTERESTED IN THE DEVELOPMENT OF ISOLATION SYSTEM, THOUGH THEY HAVE NO EXPERIENCE TO APPLY IT FOR NUCLEAR PLANT
- FRENCH PEOPLE APPLIED ISOLATION SYSTEM FOR PWR.
- SCALE UP OF REACTOR
  - INCREASE OF AN AMOUNT OF MATERIALES ←→ COST REDUCTION
  - THICKER WALL ←→ MITIGATION OF THERMAL STRESS ⇒ ISOLATION SYSTEM
  - MASSIVE STRUCTURE OF PLANT SYSTEM ←→ MITIGATION OF SEISMIC RESPONSE NEEDED
- ECONOMICS
  - DECREASE OF AN AMOUNT OF MATERIALS
  - DECREASE OF NUMBERS OF SEISMIC SUPPORTS
  - RATIONALIZATION OF SEISMIC DESIGN
  - STANDARDIZATION OF SEISMIC DESIGN

  → MITIGATION OF SEISMIC RESPONSE ⇒ ISOLATION SYSTEM NEEDED
- ISOLATION SYSTEM IS MORE IMPORTANT IN FBR THAN IN LWR BECAUSE OF THE REQUIREMENT OF THIN-WALLED STRUCTURE TO MITIGATE THERMAL STRESS IN FBR
- LONG TERM R & D WORKS AND MUCH MONEY ARE NECESSARY FOR PRACTICAL USE OF ISOLATION SYSTEM
- THERE EXIST MANY RESIDUAL WORKS TO BE PERFORMED UNTIL LICENSE

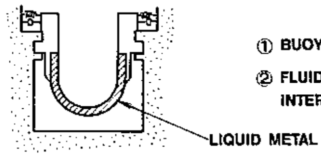
ISOLATION SYSTEM

STATUS OF TECHNOLOGY

- NEW CONCEPT
  - PERMISSION OF LICENSE SHOULD BE OBTAINED IN FUTURE.
- LACK OF PRACTICAL USE
  - ONLY FRANCE HAS EXPERIENCE TO APPLY ISOLATION SYSTEM FOR PWR.
  - NO PRACTICAL USE FOR LARGE SCALE REACTOR AND STRONG SEISMIC AREA LIKE JAPAN
- SUBJECTS TO BE SOLVED AND CONFIRMED
  - LONG TERM RELIABILITY
  - ENDURABILITY TO ENVIRONMENTAL EFFECT
  - MAINTENANCE AND EXCHANGEABILITY
  - CONSIDERATION OF RELATIVE DISPLACEMENT
  - RESPONSE CHARACTERISTICS TO LOW FREQUENCY SEISMIC WAVE
  - RESPONSE CHARACTERISTICS TO VERTICAL MOTION

  , ETC.

ISOLATION SYSTEM

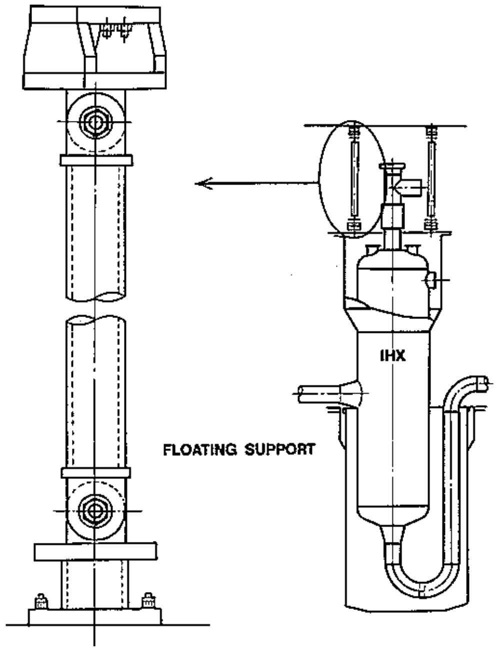


① BUOYANCY

② FLUID STRUCTURE INTERACTION

METHOD BY FLUID

ISOLATION OF COMPONENT



ISOLATION OF COMPONENT

SCHEDULE FOR COLLABORATIVE STUDY

ACTIVITY	(1)	(2)	(3)	(4)		(5)	(6)
MONTH	12	24	36		48		60

ACTIVITY

(1) COMPLETE INFORMATION INVESTIGATION(I)(JAPAN & US)
(2) COMPLATE INFORMATION INVESTIGATION(II) AND PRELIMINARY ANALYSIS TO DECIDE THE SCALE OF TEST MODELS AND TEST CONDITIONS(JAPAN & US)
(3) COMPLETE REVIEW OF JAPANESE AND US TEST PROPOSAL(JAPAN & US)
(4) COMPLETE DESIGN AND MANUFACTURING OF TEST MODELS
JAPAN : ISOLATION SYSTEM MODEL OF REACTOR VESSEL
US : ISOLATION SYSTEM MODEL OF REACTOR BUILDING (VICE VERSA)
(5) COMPLETE VIBRATION TESTS(JAPAN & US)
(6) COMPLETE THE EVALUATION OF TEST RESULTS(JAPAN & US)

BACKGROUND

- BOTH JAPAN AND US ARE MUCH INTERESTED IN THE DEVELOPMENT OF SEISMIC ANALYSIS METHOD FOR PIPING SYSTEM AND THE RATIONALIZATION OF SEISMIC DESIGN
- NON-LINEAR VIBRATION CHARACTERISTICS HAVE BEEN OBTAINED ABOUT PIPING SUPPORT SYSTEMS FOR PROTOTYPE REACTOR
- SEISMIC ANALYSIS IS MAINLY CARRIED OUT ONLY AT ELASTIC REGION, THOUGH SEISMIC DESIGN CRITERIA OF S_2 EARTHQUAKE PERMITS PLASTIC DEFORMATION WITHOUT COOLANT LEAKAGE
- SCALE UP OF REACTOR AND ECONOMICS
  - MODIFICATION OF NON-LINEAR VIBRATION ANALYSIS METHOD FOR LARGE SCALE REACTOR
  - COST REDUCTION ⟶ REDUCTION OF CONTAINMENT VESSEL SIZE → USE OF EXPANSION JOINT ⟶ APPLICATION OF EXPANSION JOINT TO PIPING SYSTEM ⟶ VIBRATION ANALYSIS METHOD NEEDED
  - RATIONALIZATION OF SEISMIC DESIGN ⟶ INCREASE OF DAMPING FACTOR AND CONFIRMATION OF DESIGN MARGIN ⟶ VIBRATION TEST AT ELASTIC-PLASTIC REGION ESTABLISHMENT OF VIBRATION ANALYSIS METHOD AT PLASTIC REGION

STATUS OF TECHNOLOGY

- BEING DEVELOPED NON-LINEAR VIBRATION ANALYSIS METHOD FOR PIPING SYSTEM OF PROTOTYPE REACTOR
- NO VIBRATION ANALYSIS FOR PIPING SYSTEM INCLUDING EXPANSION JOINT
- FEW EXPERIENCES OF VIBRATION TEST IN PLASTIC REGION FOR PIPING SYSTEM
- SUBJECTS TO BE SOLVED AND CONFIRMED
  - ESTABLISHMENT OF NON-LINEAR VIBRATION ANALYSIS METHOD FOR LARGE SCALE REACTOR
  - COFIRMATION OF VIBRATION BEHAVIOR AND ESTABILISHMENT OF SUPPORTING METHOD FOR EXPANSION JOINT
  - CONFIRMATION OF VIBRATION BEHAVIOR IN PLASTIC REGION

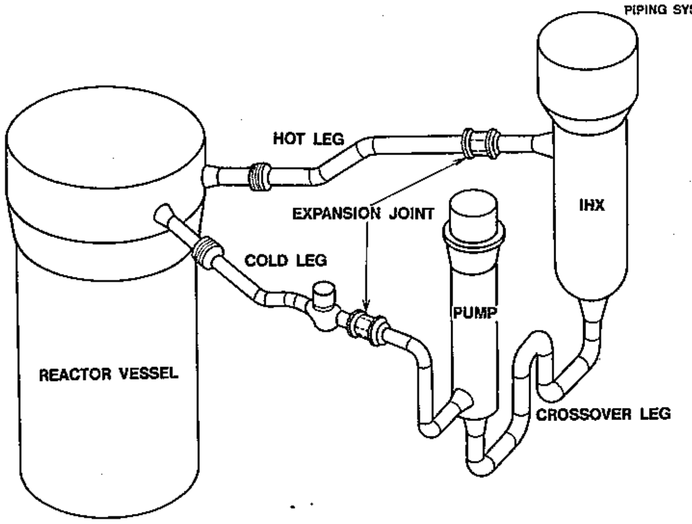
OBJECTIVES OF COLLABORATIVE STUDY

- INFORMATION SURVEY
- CLARIFICATION OF THE PROBLEMS TO BE SOLVED
- PLANNING OF R & D WORKS REQUIRED
- ALLOTMENT OF R & D WORKS BETWEEN JAPAN AND US
- DEVELOPMENT AND VERIFICATION OF NON-LINEAR VIBRATION ANALYSIS METHOD FOR LARGE SCALE REACTOR
- VIBRATION TEST OF EXPANSION JOINT AND DEVELOPMENT OF VIBRATION ANALYSIS METHOD
- VIBRATION TEST OF PIPING SYSTEM IN PLASTIC REGION AND DEVELOPMENT OF VIBRATION ANALYSIS METHOD
- CONFIRMATION OF DESIGN MARGIN AND RATIONALIZATION OF SEISMIC DESIGN
- COST REDUCTION
- SUPPLY OF INFORMATION TO RATIONALIZE SEISMIC DESIGN CRITERIA (EX. INCREASE OF DAMPING FACTOR)

POTENTIAL BENEFITS BY COLLABOLATION

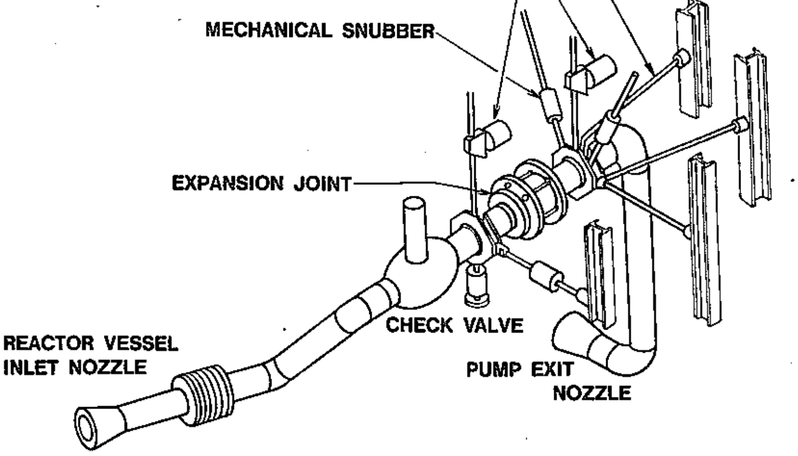
- REDUCTION OF PLANT COST
  - DECREASE OF AMOUNT OF MATERIALS
  - REDUCTION OF SUPPORTS AND HANGERS
- ESTABLISHMENT OF VIBRATION ANALYSIS METHOD FOR LARGE SCALE REACTOR
- RATIONALIZATION OF SEISMIC DESIGN
- REDUCTION OF R & D COST

PIPING SYSTEM



PRIMARY SYSTEM INCLUDING EXPANSION JOINT

PIPING SYSTEM



SUPPORTING SYSTEM OF EXPANTION JOINT

PIPING SYSTEM

SCHEDULE FOR COLLABORATIVE STUDY

ACTIVITY		(1)	(2)		(3)	(4)	(5)
MONTH	0	12		24	36		48

ACTIVITY

(1) COMPLETE INFORMATION INVESTIGATION(JAPAN & US)

(2) COMPLETE REVIEW OF JAPANESE AND US TEST PROPOSAL.
JAPAN : TEST OF PIPING SYSTEM INCLUDING GAP.
TEST OF EXPANSION JOINT
US : TEST OF PIPING SYSTEM IN ELASTIC-PLASTIC REGION.

(3) COMPLETE DESIGN AND MANUFACTURING OF TEST MODELS
JAPAN : TEST MODEL OF PIPING SYSTEM INCLUDING GAP
TEST MODEL OF EXPANSION JOINT
US : TEST MODEL OF PIPING SYSTEM IN ELASTIC-PLASTIC REGION.

(4) COMPLETE VIBRATION TESTS(JAPAN & US)

(5) COMPLETE EVALUATION OF TEST RESULTS(JAPAN & US)

OBJECTIVES OF COLLABORATIVE STUDY

FEASIBILITY STUDY

- INFORMATION SURVEY OF ISOLATION SYSTEM
- INVESTIGATION OF THE APPLICABILITY OF ISOLATION SYSTEM FOR FBR
- CLARIFICATION OF THE PROBLEMS TO BE SOLVED FOR PRACTICAL USE

R & D TESTS

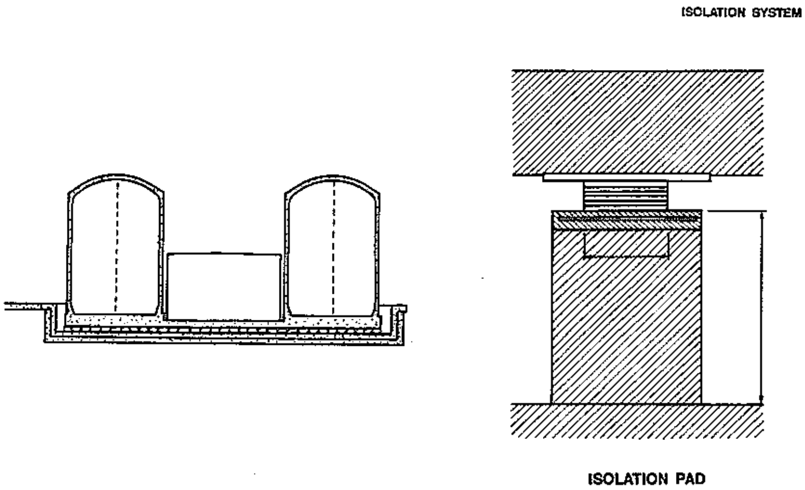
- PLANNING OF R & D WORKS REQUIRED
- ALLOTMENT OF R & D WORKS BETWEEN JAPAN AND US
- DEVELOPMENT OF VIBRATION ANALYSIS METHOD FOR ISOLATION SYSTEM
- PERFORMANCE OF R & D TEST NEEDED FOR PRACTICAL USE
- RATIONALIZATION AND STANDARDIZATION OF SEISMIC DESIGN
- COST REDUCTION
- SUPPLY OF INFORMATION TO RATIONALIZE SEISMIC DESIGN CRITERIA

POTENTIAL BENEFITS BY COLLABORATION

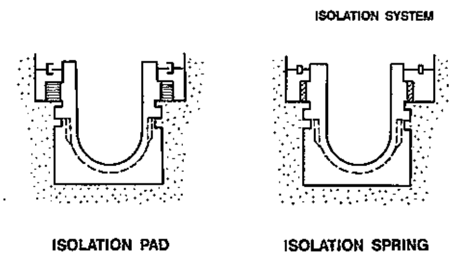
- REDUCTION OF PLANT COST
  - DECREASE OF AN AMOUNT OF MATERIALS
  - REDUCTION OF NUMBERS OF SUPPORTS AND HANGERS
- RATIONALIZATION AND STANDARDIZATION OF SEISMIC DESIGN
- AUTHORIZATION OF THE CONCEPT OF ISOLATION SYSTEM BY INTERNATIONAL RECOGNITION
- REDUCTION OF R & D COST

METHOD OF ISOLATION FOR NUCLEAR PLANT

- ISOLATION OF BUILDING STRUCTURE
  - BULK ISOLATION OF BUILDING STRUCTURE : ISOLATION PAD SAME TO FRANCE METHOD
  - PARTIAL ISOLATION OF BUILDING FLOOR
- ISOLATION OF COMPONENT (ESPECIALLY REACTOR VESSEL)
  - ISOLATION PAD
  - ISOLATION SPRING
  - FLOATING SUPPORT
  - METHOD BY FLUID



BULK ISOLATION OF BUILDING STRUCTURE



ISOLATION OF COMPONENT

FSI

BACKGROUND

- IMPORTANT REACTOR COMPONENTS IMMERSED IN SODIUM ARE AFFECTED BY THE FLUID MOTION DURING EARTHQUAKE
- CURRENTY AVAILABLE SIMPLIFIED APPROACHES SHOW CONSERVATIVE DESIGN VALUES AND MAKE PLANT COST EXPESIVE
- THEREFORE, APPROPRIATE MODELLING OF FLUID BEHAVIOR NEEDED
- US DEVELOPED FLUSTER CODE
- SCALE UP OF REACTOR AND ECONOMICS
  - FLUID STRUCTURE INTERACTION INCLUDING SLOSHING IS SEVERER AND MORE IMPORTANT PROBLEM
  - CONFIRMATION OF THE RESISTANCE TO BUCKING FOR THIN-WALLED VESSEL
  - ESPECIALLY IMPORTANT FOR TANK TYPE REACTOR
- TEST IS PERFORMED FOR REACTOR VESSEL IN JAPAN

FSI

STATUS OF TECHNOLOGY

- NO SUFFICIENT ANALYSIS METHOD FOR FLUID STRUCTURE INTERACTION
- NO BUCKLING TESTS FOR IMPORTANT VESSELS
- CURRENTLY AVAILABLE APPROACHES SHOW CONSERVATIVE DESIGN VALUES AND MAKE PLANT COST EXPENSIVE
- SUBJECTS TO BE SOLVED AND CONFIRMED
  - APPROPRIATE MODELLING OF FLUID STRUCTURE INTERACTION
  - DEVELOPMENT OF ANALYSIS METHOD
  - CONFIRMATION OF RESISTANCE TO DEFORMATION BY FLUID IMPACT

FSI

OBJECTIVES OF COLLABOLATIVE STUDY

- INFORMATION SURVEY
- CLARIFICATION OF THE PROBLEMS TO BE SOLVED
- PLANNING OF R & D WORKS REQUIRED
- ALLOTMENT OF R & D WORKS BETWEEN JAPAN AND US
- DEVELOPMENT AND VERIFICATION OF ANALISIS METHOD TO EVALUATE SLOSHING BEHAIOR
- TEST RELATINGTO VESSEL WALL DEFORMATION BY FLUID IMPACT AND DEVELOPMENT OF ANALYSIS METHOD
- IN-FLUID VIBRATION TEST OF IMPORTANT COMPONENTS INSIDE VESSEL AND DEVELOPMENT OF ANALYSIS METHOD
- CONFIRMATION OF DESIGN MARGIN AND RATIONALIZATION OF SEISMIC DESIGN
- COST REDUCTION
- SUPPLY OF IMFORMATION TO RATIONALIZE SEISMIC DESIGN CRITERIA

FSI

POTENTIAL BENEFITS BY COLLABORATION

- REDUCTION OF PLANT COST
- ESTABLISHMENT OF ANALYSIS METHOD FOR FLUID STRUCTURE INTERACTION AT LARGE SCALE REACTOR
- CLARIFICATION OF VIBRATION BEHAVIOR
- RATIONALIZATION OF SEISMIC DESIGN
- REDUCTION OF R & D COST

FSI

SCHEDULE FOR COLLABORATIVE STUDY

ACTIVITY (1) (2) (3) (4) (5)

MONTH 12 24 36 48

ACTIVITY

(1) COMPLETE INFORMATION INVESTIGATION (JAPAN & US)

(2) COMPLETE REVIEW OF JAPANESE AND US TEST PROPOSAL (JAPAN & US)

(3) COMPLETE DESIGN AND MANUFACTURING OF TEST MODELS (JAPAN & US)

(4) COMPLETE VIBRATION TESTS(JAPAN & US)

(5) COMPLETE THE EVALUATION OF TEST RESULTS AND VERIFICATION OF ANALYSIS CODE(JAPAN & US)

BACKGROUND

- BOTH JAPANESE AND U.S. DESIGNERS ARE MUCH INTERESTED IN THE MODIFICATION OF ANALYSIS METHOD FOR ACTIVE COMPONENTS USED FOR LARGE SCALE REACTOR
  - JAPANESE SEISMIC DESIGN STANDARD (DRAFT) REQUIRES FUNCTIONAL QUALIFICATION FOR ACTIVE COMPONENTS IN NUCLEOR PLANT
  - FIRM EVALUATION METHOD AND ALLOWANCE LIMITS DO NOT EXIST FOR FUNCTIONAL QUALIFICATION OF ACTIVE COMPONENTS UNDER SEISMIC LOAD
  - DEVELOPMENT OF THE ANALYSIS PROGRAM FOR ACTIVE COMPONENTS

    SODIUM PUMP → IMPACT FORCE AT THE HYDROSTATIC BEARING
    CRD → INSERT TIME
    VALVE → OPEN OR CLOSURE TIME

STATUS OF TECHNOLOGY

- INTEGRITY OF COOLANT BOUNDARY
  - ASME CODE
  - MITI 501
  - MONJU DESIGN STANDARD
- PROGRAM DEVELOPMENT
  - CONTROL ROD INSERT TIME ANALYSIS PROGRAM FOR "MONJU"
- ALLOWABLE LIMIT
  - RUBBING ENDURANCE OF HARDFACING MATERIALS FOR "MONJU" MECHANICAL PUMP HYDROSTATIC BEARING
- TESTING
  - HYDRO-STATIC BEARING
  - CRD
  - SODIUM VALVE

OBJECTIVES OF STUDY

- INFORMATION EXCHAGE OF ANALYSIS AND EVALUATION METHOD FOR FUNCTIONAL QUALIFICATION
  - SEISMIC DESIGN PHYLOSOPHY
  - FUNCTIONAL QUALIFICATION EVALUATION LOGIC
  - SEISMIC TESTING
- DEVELOPMENT OF ANALYSIS AND EVALUATION METHOD FOR FUNCTIONAL QUALIFICATION OF ACTIVE COMPONENTS USED LARGE SCALE REACTOR
  - PUMP { IMPACT LOAD, DAMPING AT HYDRO-STATIC BEARING; GYRATE EFFECT OF SHAFT }
  - CRD { INTERACTION BETWEEN CONTROL ROD AND GUIDE TUBE; HYDRAULIC RESISTANCE EFFECT }
  - VALVE { EVALUATION LOGIC; SIMPLIFIED VALVE SEISMIC ANALYSIS MODEL IN PIPING SYSTEM }

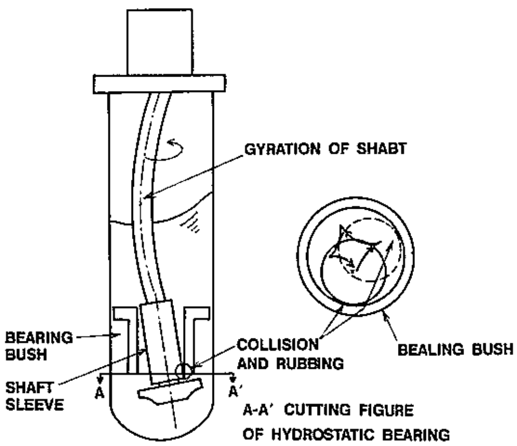
— CONTINNED —

OBJECTIVES OF STUDY

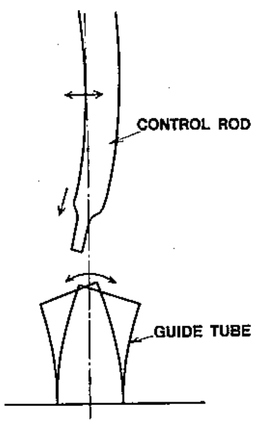
- MUTUAL RECOGNITION OF NECESSARY R & D WORK FOR FUNCTIONAL QUALIFICATION OF ACTIVE COMPONENTS
  - ANALYTICAL COMPUTER PROGRAM DEVELOPMENT
  - TESTING FOR PROGRAM VERIFICATION

POTENTIAL BENEFIT

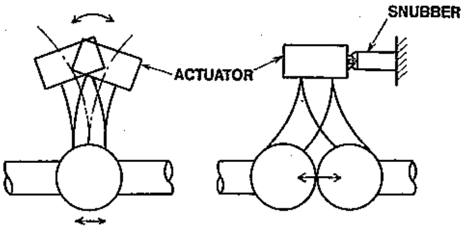
- ESTABLISHMENT OF ANALYSIS AND EVALUATION METHOD FOR LARGE SCALE REACTOR
  - EFFECTIVE USE OF R & D RESULTS OF BOTH JAPAN (MONJU) AND U.S (CRBRP) FOR LARGE SCALE FBR
- REDUCTION OF R & D COST EACH OTHER
  - DIVIDE TOTAL AMOUNT OF COST INTO HALF FOR EACH COUNTRY
  - EFFECTIVE USE OF EXISTING TEST RIGS



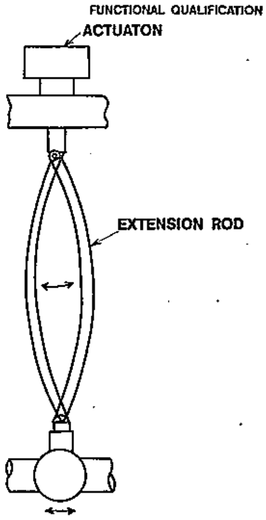
VIBRATION CHARACTERISTICS OF MECHANICAL PUMP



VIBRATION CHARACTERISTICS OF CONTROL ROD AND GUIDE TUBE



TWO DEFORMATION MODES OF SODIUM VALVE DURING EARTHQUAKE



VIBRATION CHARACTERISTICS OF SODIUM VALVE WITH EXTENSION ROD

FUNCTIONAL QUALIFIEATIM

SCHEDULE FOR STUDY

ACTIVITY	(1)	(2)	(3)
MONTH	12	24	36

ACTIVITY

(1) COMPLETE INFORMATION EXCHANGE.(JAPAN & US)

(2) COMPLETE ESTABLISHMENT OF ANALYSIS AND EVALUATION METHOD FOR LARGE SCALE REACTOR.(JAPAN & US)

(3) COMPLETE POINTING OUT OF R & D WORK NECESSARY IN FUTURE.

VERIFICATION OF DRACS

- NATURAL CIRCULATION HEAT REMOVAL SUPPORT ACTIVITIES IN JAPAN
- INTRODUCTION
- DISCUSSIONS TO IDENTIFY R&D ITEMS
- CONCLUSION

1983 9/26 - 30

NATURAL CIRCULATION HEAT REMOVAL SUPPORT ACTIVITIES

○ EXPERIMENT

	STATUS
● IN SUBASSEMBLY	
• ELECTRICALLY HEATED 91 - PIN BUNDLE TEST USING WATER 1)	COMPLETED
• ELECTRICALLY HEATED 37 - PIN BUNDLE TEST USING SODIUM	COMPLETED
● IN VESSEL	
• TWO-DIMENSIONAL INTER FLOW REDISTRIBUTION AND INTER HEAT TRANSFER TEST	COMPLETED
• THREE-DIMENSIONAL SMALL SCALED TEST IN VESSEL 2)	COMPLETED
• IN-VESSEL TEST UNDER HEAT TRANSFER CONDITION BETWEEN VESSEL WALL AND ATOMOSPHERE	IN PROGRESS
● IN PIPING	
• STRATIFICATION TEST IN PIPING USING WATER	COMPLETED

	STATUS
● IN IHX	
• STEADY STATE HEAT TRANSFER TEST IN LOW P_e REGION IN JOYO	COMPLETED
• NATURAL CIRCULATION TEST IN 50 MW SG FACILITY	COMPLETED
● IN AIR COOLER	
• NATURAL CIRCULATION TEST IN 50 MW SG FACILITY	COMPLETED
● IN PLANT	
• THREE TYPES OF NATURAL CIRCULATION TESTS IN JOYO 3) 1) TEST FROM ISOTHERMAL CONDITION 2) TEST FROM PARTIAL POWER CONDITION 3) TEST FROM FULL POWER CONDITION	COMPLETED FOR MARK - I CORE
● OTHER ACTIVITIES	
• UTILITIE'S EFFORTS [4]	IN PROGRESS

○ ANALYSIS

- DEVELOPMENT OF ONE-DIMENSIONAL PLANT SIMULATION CODE
  - MIMIR - N2 5), 6)
    - VERY GOOD AGREEMENT BETWEEN PREDICTED TEMPERATURE/FLOW BEHAVIOR AND MEASURED ONE IN JOYO NATURAL CIRCULATION TEST
    - THE CODE WAS BRUSHED UP BY POST ANALYSIS OF TESTS

- DEVELOPMENT OF THREE - DIMENSIONAL ANALYSIS CODE
  - THAUPR 7)
    - 「THAUPR」 CODE FULLY EXPLAINS THE INTERACTION PHENOMENA BETWEEN UPPER PLENUM FLOW PATTEN AND CORE EXIT FLOW IN JOYO NATURAL CIRCULATION TEST
  - OTHER THREE-DIMENSIONAL CODES HAVE BEEN DEVELOPED AND SUCCESSFULLY APPLIED

OBSERVATIONS

- IN THE GENERAL NATURAL CIRCULATION HEAT REMOVAL R&D AREA, BOTH U.S. AND JAPAN HAS POTENTIAL ENOUGH TO REACH THE CONCLUSIONS TO CONFIRM "NATURAL CIRCULATION BASED DESIGN", SEPARATELY.

- THEREFORE, POTENTIAL BENEFITS OF COLLABOLATION ARE LITTLE IN THIS FIELD.

- HOWEVER, THERE ARE MANY ITEMS TO COLLABOLATE IN R&D AREA OF DRACS.

REFERENCES

1) "NATURAL CIRCULATION DECAY HEAT REMOVAL EXPERIMENTS AND ANALYSIS IN AN LMFBR FUEL ASSEMBLY" International Topical Meeting on Liquid Metal Fast Breeder Reactor Safety and Related Design and Operational Aspects, LYON (1982)

2) "EXPERIMENTAL STUDY FOR IN-VESSEL THERMAL HYDRAULICS IN A LOOP-TYPE LMFBR DURING NATURAL CIRCULATION DECAY HEAT REMOVAL" Trans. ANS (1983) 44

3) "NATURAL CIRCULATION TESTS IN THE EXPERIMENTAL FAST REACTOR JOYO" IAHR Specialist Meeting, Sunnyvale (1983)

4) PUBLISHED IN IAHR Specialist Meeting (1983)
PREPARED FOR ASME 1983 Winter Annual Meeting (1983)

5) VERIFICATION OF THE PLANT SIMULATION CODE BY THE JOYO POWER ASCENTION TEST DATA" LYON (1982)

6) "NATURAL CIRCULATION PHENOMENA IN THE UPPER PLENUM OF JOYO" IAHR Specialist Meeting (1983)

7) "COMPUTER CODE DEVELOPMENT FOR THREE-DIMENSIONAL THERMO-HYDRAULIC ANALYSIS OF COOLANT BEHAVIOR IN AN LMFBR" ANS/ASME/NRC International Topical Meeting (1980)

INTRODUCTION

INTRODUCTION

- ROLE OF DRACS IN PLANT DESIGN
  - REDUCTION OF PLANT CAPITAL COST
  - REDUCTION OF POTENTIAL RISK

- ITEMS TO BE DISCUSSED
  - BASIC SAFETY REQUIREMENTS WHEN SAFETY SYSTEM WOULD BE SHRINKED
  - APPLICABILIIY OF DESIGN CODE TO NON-SAFETY GRADED BOP
  - REQUIRED R&D FOR DRACS IN LOOP
  - REQUIRED R&D FOR DRACS IN POOL

DISCUSSIONS TO IDENTIFY R&D ITEMS

BASIC SAFETY REQUIREMENTS

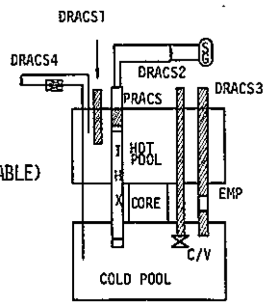
- BASIC REQUIREMENTS

	SINGLE FAILURE	REDUNDANCY	DIVERSITY
JAPAN	O	O	NOT MANDATORY BUT DISCUSSED
U. S.	O	O	O

- OTHER CONSIDERATIONS
  - LICENSABILITY/RELIABILITY
  - ABILITY TO PERFORM AS PREDICTED - CONFIDENCE IN DESIGN
  - MAINTAINABILITY AND INSPECTABILITY
  - TESTABILITY
  - OPERABILITY
  - AVOIDANCE OF THERMAL TRANSIENTS
  - INTEGRATION WITH PLANT FEATURES

CONSIDERATIONS OF DIVERSITY

- IRACS F/C N/C (IRACS IS RECOGNIZED AS DRACS FOR POOL)
- ◉ DRACS2 DRACS4 (FOR LOOP)
- ◉ DRACS2 DRACS3
- ◉ DRACS2 DRACS1
- ◉ DRACS2 PRACS (FOR POOL)
- ◉ DRACS1 DRACS4
- ◉ DRACS1 DRACS3
- DRACS1 F/C (SECONDARY) N/C
- DRACS2 F/C (SECONDARY) N/C (PRIMARY F/C MAY BE AVAILABLE)
- DRACS3 F/C (PRIMARY/SECONDARY) N/C
- PRACS F/C (PRIMARY/SECONDARY) N/C (FOR POOL)
- ◉ IRACS DRACS1
- ◉ IRACS DRACS2



◉ SYSTEMS WITH HIGHER DIVERSITY

APPLICABILITY OF DESIGN CODE

- DESIGN CODE
  - JAPAN MITI 501
  - U.S. ASME SEC. III ASME SEC. VIII B31.1
- SGB STRUCTURE/IHTS & SG SYSTEMS DESIGN PHILOSOPHY
  - SEISMIC DESIGN
  - STRUCTURAL DESIGN
  - ISOLATION BETWEEN SAFETY GRADE SYSTEM AND NON-SAFETY GRADE SYSTEM
- SAFETY CONCERNS
  - EFFECT OF LARGE SODIUM SPILL ON
    - SHUTDOWN HEAT REMOVAL SYSTEM
    - STURCTURES/SYSTEMS/COMPONENTS IMPORTANT TO SAFETY
    - SITE-RELATED CONSIDERATIONS

REQUIRED R&D FOR LOOP

DRACS OPTION	PROBLEMS TO BE SOLVED	REQUIRED R&D
DRACS1	• HEAT REMOVAL CAPABILITY • HOT SODIUM ENTRANCE INTO VESSEL INLET	• FLOW DIODE • THERMAL HYDRAULIC BEHAVIOR IN HOT POOL • FLOW DISTRIBUTION BETWEEN IN-VESSEL AND PRIMARY SYSTEM OR CHECK VALVE WITH POWER
DRACS2	• HOT SODIUM ENTRANCE INTO VESSEL INLET • CORE BYPASS FLOW	• FLOW DISTRIBUTION BETWEEN IN-VESSEL AND PRIMARY SYSTEM • FLOW DIODE/CHECK VALVE
DRACS3	• CORE BYPASS FLOW • FEASIBILITY OF EMP IN SODIUM	• FLOW DIODE/CHECK VALVE • EMP IN SODIUM

DRACS4	• RELIABILITY	• MIXING CAPABILITY

R&D COMMON TO ALL TYPES OF DRACS

1) FLOW DISTRIBUTION BETWEEN IN-VESSEL AND PRIMARY SYSTEM
2) NON-SYMMETRICAL NATURAL CIRCULATION CHARACTERISTICS
3) DHX HEAT TRANSFER

REQUIRED R&D FOR POOL

DRACS OPTION	PROBLEMS TO BE SOLVED	REQUIRED R&D
IRACS	• LOW SODIUM LEVEL AT VESSEL LEAKAGE	• CONTROL OF SODIUM LEVEL BY COVER GAS SYSTEM
PRACS	• LOW SODIUM LEVEL • COMPLICATED IHX DESIGN	• CONTROL OF SODIUM LEVEL BY COVER GAS SYSTEM
DRACS1	• LOW SODIUM LEVEL • HOT SODIUM ENTRANCE INTO VESSEL INLET	• THERMAL HYDRAULIC BEHAVIOR IN HOT POOL
DRACS2	• HOT SODIUM ENTRANCE INTO VESSEL INLET • CORE BYPASS FLOW	• THERMAL HYDRAULIC BEHAVIOUR IN HOT POOL • SHUT-OFF VALVE OF IHX WINDOW • SHUT-OFF VALVE OF DHX WINDOW
DRACS3	• CORE BYPASS FLOW • FEASIBILITY OF EMP IN SODIUM	• SHUT-OFF VALVE OF DRACS • EMP IN SODIUM

R&D COMMON TO ALL TYPES OF DRACS

1) FLOW DISTRIBUTION BETWEEN DHX AND PRIMARY SYSTEM FOR DRACS
2) NON-SYMMETRICAL NATURAL CIRCULATION CHARACTERISTICS
3) DHX HEAT TRANSFER EXCEPT IRACS

IDENTIFIED R&D ITEMS

R&D ITEMS	SYSTEM	LOOP	POOL
• NON-SYMMETRICAL NATURAL CIRCULATION CHARACTERISTICS	ALL TYPES	○	○
• DHX HEAT TRANSFER	ALL TYPES EXCEPT IRACS	○	○
• FLOW DISTRIBUTION BETWEEN DRACS AND PRIMARY SYSTEM	DRACS 1～4	○	○
• FLOW DIODE	DRACS 1,2,3 (LOOP)	○	△ (FOR PUMP BYPASS)
• CHECK VALVE	DRACS 2,3 (LOOP)	○	×
• EMP IN SODIUM	DRACS 3	○	○
• SHUT-OFF VALVE OF IHX WINDOW	DRACS 2 (POOL)	×	○
• SHUT-OFF VALVE OF DHX WINDOW	DRACS 2,3 (POOL)	×	○
• THERMAL HYDRAULIC BEHAVIOR IN HOT POOL	DRACS 1	○	○
• CONTROL OF SODIUM LEVEL BY COVER GAS SYSTEM	IRACS, PRACS	×	○

SUMMARY

- R&D ITEMS COMMON TO ALMOST ALL TYPES OF DRACS
  - (A) IN-VESSEL NON-SYMMETRICAL NATURAL CIRCULATION
  - (B) DHX HEAT TRANSFER
  - (C) FLOW DISTRIBUTION BETWEEN DHX AND PRIMARY SYSTEM
    - APPROACH
      - (i) SCALED MODEL EXPERIMENT
      - (ii) IN-VESSEL EXPERIMENT
      - (iii) COMPUTER CODE
  - (D) CRITERIA FOR SAFETY, DESIGN
- PLANT SPECIFIC R&D ITEMS
  - (A) FLOW DIODE / CHECK VALVE
  - (B) EMP IN SODIUM
  - (C) SHUT-OFF VALVE OF IHX WINDOW
  - (D) SHUT-OFF VALVE OF DHX WINDOW
  - (E) CONTROL OF SODIUM LEVEL BY COVER GAS SYSTEM

SCHEDULE

PHASE 1 R&D FOR DESIGN

PHASE 2 R&D FOR CONSTRUCTION

- BASIC R&D ITEMS ARE PREFERED FOR PHASE 1
- PROTOTYPIC R&D ITEMS ARE PREFERED FOR PHASE 2

CONCLUSION

VERIFICATION OF DRACS

- OBJECTIVE
  - VERIFICATION OF POSSIBLE DRACS
  - CONFIRMATION OF NATURAL CIRCULATION BASED DESIGN
- POTENTIAL BENEFITS OF COLLABOLATION
  - SAVE REQUIRED R&D COST
  - EXTENSIVE INFORMATION EXCHANGE
- RESTRICTION AT THIS STAGE
  - PLANT DESIGN CONCEPT IS NOT SPECIFIED
  - TIME PERIOD OF PHASE 1 COLLABOLATION IS LIMITED
- REDUCTION OF COLLABOLATION CONCEPT

DUE TO THE RESTRICTION, PROTO TYPIC R&D ITEMS SHALL NOT BE IDENTIFIED ➡

1) INFORMATION EXCHANGE ON SAFETY CRITERIA
2) BASIC TEST DATA FOR VERIFICATION
3) IN-VESSEL NATURAL CIRCULATION VERIFICATION TEST IN JOYO
4) VALIDATION OF COMPUTER CODES

INFORMATION EXCHANGE ON SAFETY CRITERIA

- OBJECTIVE
  - CONSOLIDATION OF CRITERIA FOR SAFETY, LICENSING AND DESIGN
- APPROACH
  - INFORMATION EXCHANGE ON THE FOLLOWING TOPICS
    - REQUIRED REDUNDANCY AND DIVERSITY
    - GENERAL SAFETY REQUIREMENTS
    - DESIGN CRITERIA FOR BOP
- POSSIBLE COLLABORATION
  - INFORMATION EXCHANGE MTG. BETWEEN JAPAN AND U. S.

TEST DATA FOR VERIFICATION

- OBJECTIVE
  - OBTAINING THE DATA NECESSARY TO VERIFY VARIOUS TYPES OF DRACS AND PROVIDING THE DATA TO VALIDATE COMPUTER CODES
- APPROACH
  - TWO TYPES OF TESTING
    - SMALL SCALED TESTING USING WATER
      FOR POOL TYPE REACTOR
      FOR LOOP TYPE REACTOR
    - BASIC HEAT TRANSFER TESTING IN SODIUM

● POSSIBLE COLLABORATION

- JAPAN
  - SMALL SCALED TESTING FOR POOL TYPE REACTOR (FIG. 1)
  - BASIC HEAT TRANSFER TESTING IN SODIUM
  - VERIFICATION OF COMPUTER CODES
- U. S.
  - THE SAME ITEMS (POOL TYPE IS REPLACED BY LOOP TYPE)

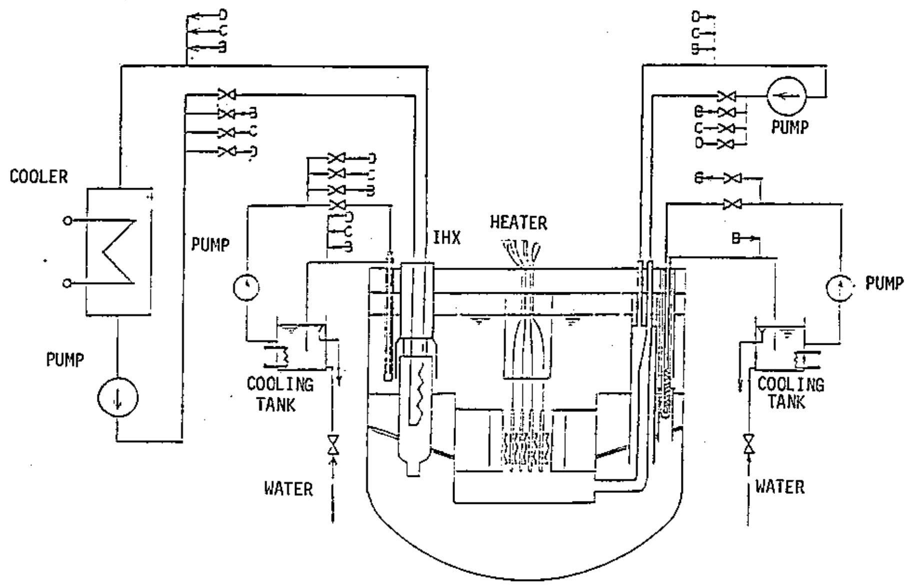


FIG. 1 SCHEMATIC OF TEST FACILITY FOR DRACS

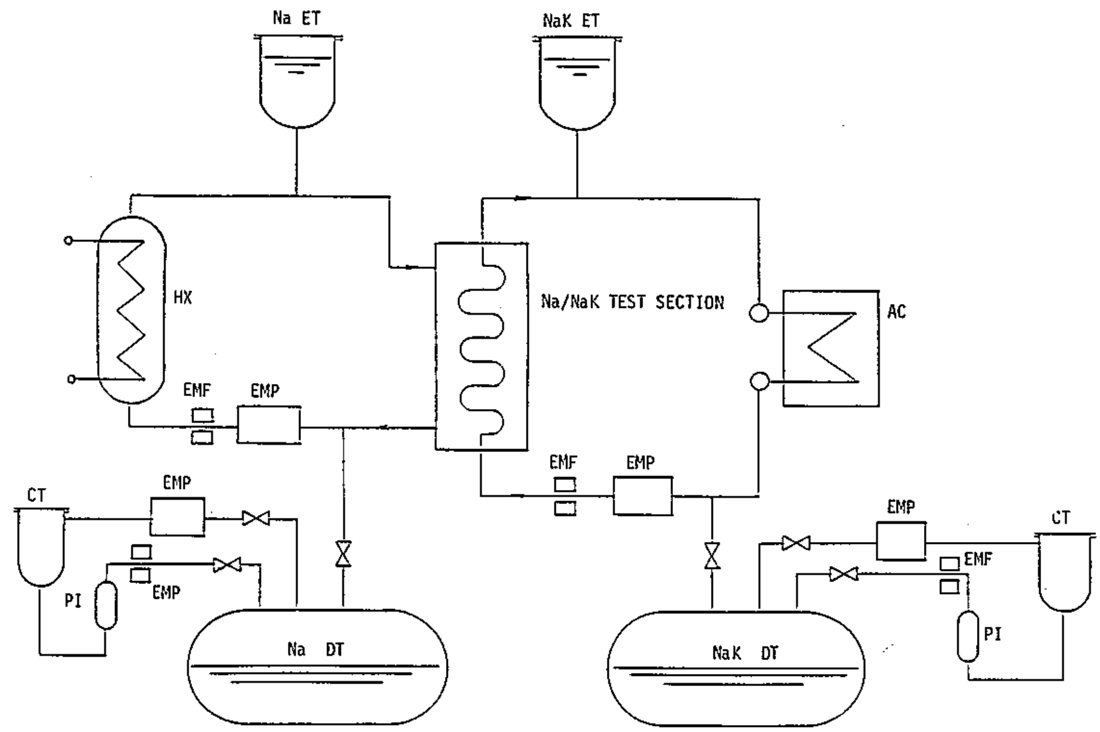


FIG. 1B BASIC HEAT TRANSFER TEST

IN-VESSEL NATURAL CIRCULATION VERIFICATION TEST

- OBJECTIVE
  - VERIFICATION OF IN-VESSEL NATURAL CIRCULATION CAPABILITY AND PROVIDING THE DATA NECESSARY TO VALIDATE THE COMPUTER CODES
- APPROACH
  - IN-VESSEL NATURAL CIRCULATION TEST IN JOYO (FIG. 2)
- POSSIBLE COLLABORATION
  - JAPAN
    - IN-VESSEL NATURAL CIRCULATION TEST
    - VERIFICATION OF COMPUTER CODE
  - U. S.
    - VERIFICATION OF COMPUTER CODE

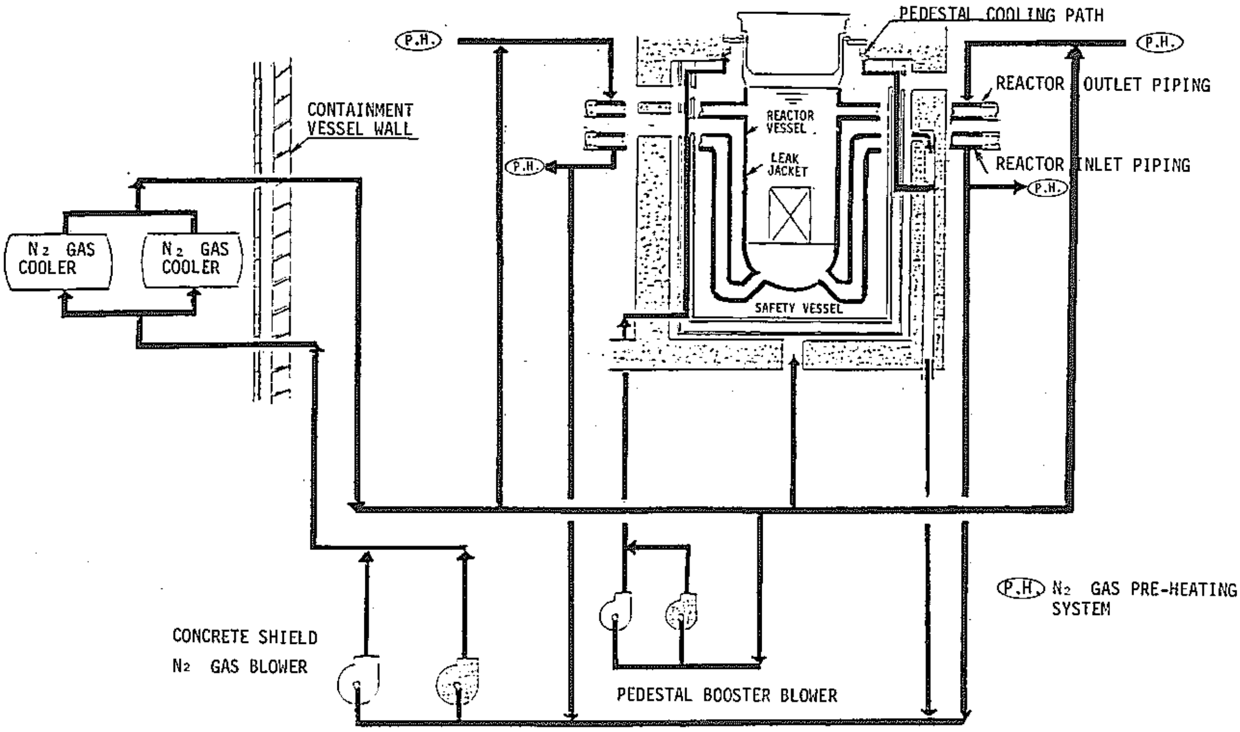


FIG. 2 SCHEMATIC OF IN-VESSEL COOLING SYSTEM OF JOYO

VALIDATION OF COMPUTER CODES

- OBJECTIVE
  - VALIDATION OF COMPUTER CODES
- APPROACH
  - DEVELOPMENT OF ONE DIMENSIONAL FLOW NETWORK MODEL
  - VERIFICATION OF THE MODEL (FIG. 3)
  - VERIFICATION OF THREE DIMENSIONAL CODES
- POSSIBLE COLLABOLATION
  - JAPAN
    - DEVELOPMENT OF 1-D FLOW NETWORK MODEL
    - VERIFICATION OF THE MODEL
  - U. S.
    - VERIFICATION OF 3-D CODES

SPECIFIC ITEMS

- IN - VESSEL AND SYSTEM NATURAL CIRCULATION
- INTERACTION BETWEEN DHX AND PRIMARY CIRCUIT
- NON - SYMMETRICAL FEATURE IN VESSEL

FIG. 3 VERIFICATION SCOPE OF THE MODEL

DOE/PNC LARGE PLANT OPTIMIZATION STUDY

STUDY TOPIC
- DEFINITION OF STEAM GENERATOR DEVELOPMENT PROGRAM WITH INTENT OF ELIMINATING THE INTERMEDIATE SYSTEM

US | I. IDENTIFICATION OF STUDY | J
- IDENTIFICATION OF STUDY GOALS
- SPECIFICATION FOR EACH STUDY ITEM
- ASSIGNMENT OF WORK
- PROCEDURE OF WORK
- WORK SCHEDULE

II. CONCEPTUAL CONSIDERATION OF IHTS-LESS FBR PLANT | J.
- (TENTATIVE) SAFETY DESIGN SPECIFICATION ON IHTS-LESS FBR PLANT
- (TENTATIVE) PRINCIPAL SYSTEM SPECIFICATION ON IHTS-LESS FBR PLANT
- PLANT LAYOUT OF MAJOR COMPONENTS (DRAWING OF PRELIMINARY PLANT LAYOUT)
- OUTLINE OF MAJOR COMPONENT (STRUCTURE / DIMENSION)

US | III. EVALUATION OF BENEFITS
- EVALUATION OF MERIT AND DEMERIT GENERALLY DUE TO ELIMINATION OF IHTS
- EVALUATION OF IHTS-LESS FBR PLANT CAPITAL COST AND OPERATION COST
- COMPARISON OF IHTS-LESS FBR PLANT COST TO FBR PLANT COST WITH IHTS.

US
- EXTRACTION OF REQUIREMENTS ON SG SYSTEM OF IHTS-LESS FBR PLANT
  - ITEMS
  - REQUIREMENTS
  - BACKGROUND OF REQUIREMENTS

J.
- EXTRACTION OF REQUIREMENTS ON SAFETY AND SYSTEM SPECIFICATION
  - ESTABLISHMENT OF SAFETY SCENARIO
    - IN THE CASE THAT LARGE WATER LEAK IS EXCLUDED FROM "DBA" EVENTS.
    - IN THE CASE THAT LARGE WATER LEAK IN INCLUDED IN "DBA" EVENTS.
    - REQUIREMENTS TO EXCLUDE. LARGE WATER LEAK FROM "DBA" EVENTS.

IV. STUDY OF MAJOR CONCERNS ON IHTS-LESS FBR PLANT

US | V. DISCUSSION / EVALUATION | J.
- CONCEPTUAL DESIGN OF SG
- COMPARISON OF PRIMARY SG QUANTITY (OR COST) TO SECODARY SG QUANTITY (OR COST)
- PROBABILITY OF WATER LEAK TO SODIUM. IN STEAM GENERATOR
- WATER LEAK DETECTION SYSTEM AND DETECTABILITY
- EVALUATION OF IMPACTS OF PRESSURE WAVE PROPAGATION DUE TO LARGE WATER LEAK TO SODIUM.
- EVALUATION OF IMPACTS OF WATER/STEAM LINE BREAK ACCIDENT TO CONTAINMENT VESSEL STRUCTURE
- EVALUATION OF HYDROGEN TRANSFER TO/FROM PRIMARY SYSTEM FROM/TO WATER-STEAM SYSTEM.
- RE-EVALUATION OF SYSTEM SPECIFICATION WITH REFLECTION OF THESE STUDIES SUCH AS SAFETY SCENARIO, ACCIDENT ANALYSIS, ABOVE EVALUATIONS ETC.

US. | VI. EXTRACTION OF REQUIRED R & D ITEMS | J.

US. | VII COMPLETION OF REPORT | J.
(INCLUDING RE-EVALUATION OF BENENITS OF IHTS-LESS FBR PLANT)

DOE/PNC LARGE PLANT OPTIMIZATION STUDY

STUDY TOPIC FEASIBILITY EVALUATION

STUDY TOPIC

- DEFINITION OF STEAM GENERATOR DEVELOPMENT PROGRAM WITH INTENT OF ELIMINATING THE INTERMEDIATE SYSTEM

SUB-THEMA

- CONCEPTUAL DESIGN STUDY OF IHTS (INTERMEDIATE HEAT TRANSPORT SYSTEM)-LESS FBR PLANT USING HISH RELIABLE SG (STEAM GENERATOR)

OBJECTIVES

- STUDY THE FEASIBILITY (ESPECIALY PHILOSOPHICAL CONCEPT OF SAFETY) OF IHTS-LESS FBR PLANT BY ESTABLISHING WATER LEAK-TIGHT SG CONCEPTS AND PROVIDE THE MATERIAL FOR EVALUATION OF PROBABILITY BY ADOPTING THIS CONCEPT OF PLANT

- EVALUATE THE MERIT AND DEMERIT AND PLANT CAPITAL AND OPERATING COST REDUCTION BENIFIT BY ELIMINATING IHTS.

- STUDY THE REQUIREMENT AND DEFINE R & D PROGRAMS FOR THE ESTABLISHMENT OF HIGH RELIABLE WATER LEAK-TIGHT SG AND LICENSABLE IHTS-LESS PLANT SYSTEM

BACKGROUND

- HIGH RELIABILITY AND SERVICEABILITY OF SG'S ARE REQUIRED FOR IMPROVED PLANT AVAILABILITY AND AS A PREREQUISITE FOR IHTS ELIMINATION

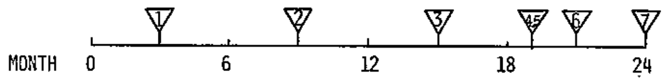
- ELIMINATION OF THE IHTS OFFERS A POTENTIAL FOR MAJOR PLANT COST REDUCTION, BUT IT SHOULD BE RECOGNIZED THAT SUCH PLANT IS NOT AVAILABLE TO BE ADOPTED TO THE NEXT STAGE FBR PLANT IN NEAR FUTURE. FOR THAT PURPOSE ACCUMULATION OF PLANT EXPERIENCE BASED ON WATER LEAK-TIGHT SG'S ARE REQUIRED

POTENTIAL BENEFITS

- COMBINE BOTH COUNTRIES EXPERIENCE TO EVALUATE THE FEASIBILITY OF AN IHTS-LESS FBR PLANT

- UNDERSTAND THE MUTUAL CURRENT STATUS AND FUTURE PROGRAMS FOR THE DEVELOPMENT OF SG AND ESTABLISH THE BASIS FOR THE FURTHER COLLABORATIVE ACTIVITIES

SCHEDULE



(1): IDENTIFICATION OF STUDY

(2): CONCEPTUAL CONSIDERATION

(3): EVALUATION OF BENENITS

(4): STUDY OF MAJOR CONCERNS

(5): DISCUSSION/EVALUATION

(6): EXTRACTION REQUIRED R & D

(7): COMPLETION OF REPORT

I. IDENTIFICATION OF STUDY

- OBJECTIVE

  TO IDENTIFY THE CONTENTS OF STUDY TO BE PERFORMED IN THE POST TASK-C COLLABORATION.

- WORK SCOPE US, J.
  - IDENTIFICATION OF STUDY GOALS
  - SPECIFICATION FOR EACH STUDY ITEM
  - ASSIGNMENT OF WORK
  - PROCEDURE OF WORK
  - WORK SCHEDULE

- SCHEDULE
  - PRELIMINARY DISCUSSION. (SEP. 1983)
  - MUTUAL ADJUSTMENT & RECOMMENDATION. (BY MAR. 1984)
  - ESTABLISHMENT OF WORK PLAN AFTER AUTHORIZATION BY JCC. AUTUMN 1984. (BY WINTER 1985)

II. CONCEPTUAL CONSIDERATION OF IHTS-LESS FBR PLANT

- OBJECTIVE

  TO SET-UP THE SPECIFIC IHTS-LESS FBR PLANT AS THE PRELIMINARY PLANT IMAGE FOR THE FOLLOWING CONSIDERATION.

- WORK SCOPE
  - (TENTATIVE) SAFETY DESIGN SPECIFICATION ON IHTS-LESS FBR PLANT — J
  - (TENTATIVE) PRINCIPAL SYSTEM SPECIFICATION ON IHTS-LESS FBR PLANT — J
    - HEAT TRASPORT SYSTEM
    - DECAY HEAT REMOVAL SYSTEM.
    - WATER LEAK DETECTION SYSTEM.
    - SODIUM WATER REACTION RELIEF SYSTEM.
  - PLANT LAYOUT OF MAJOR COMPONENTS (DRAWING OF PRELIMINARY PLANT LAYOUT) — J
  - OUTLINE OF MAJOR COMPONENT (STRUCTURE / DIMENSION) — J

III. EVALUATION OF BENEFITS

- OBJECTIVE

  TO CLARIFY THE BENEFITS DUE TO ELIMINATION OF IHTS.

- WORK SCOPE
  - EVALUATION OF MERIT AND DEMERIT GENERALLY DUE TO ELIMINATION OF IHTS FROM THE VIEW POINT OF: — US

    (1) ECONOMICS
       - INCLUDING THE EVALUATION OF DIFFERENCE OF COMP. & SYSTEM SPECIFICATION.

    (2) OPERABILITY

    (3) SAFETY

    (4) LICENSABILITY

    (5) RESEARCH & DEVELOPMENT
  - EVALUATION OF IHTS-LESS FBR PLANT CAPITAL COST AND OPERATION COST — US
  - COMPARISON OF IHTS-LESS FBR PLANT COST TO FBR PLANT COST WITH IHTS. — US

IV. STUDY OF MAJOR CONCERNS ON IHTS-LESS FBR PLANT

- OBJECTIVE

  TO CLARIFY THE ITEMS AND REQUIREMENTS TO BE DISCUSSED FOR IHTS-LESS FBR PLANT

- WORK SCOPE
  - EXTRACTION OF REQUIREMENTS ON SG SYSTEM OF IHTS-LESS FBR PLANT — US
    - ITEMS
    - REQUIREMENTS
    - BACKGROUND OF REQUIREMENTS
  - EXTRACTION OF REQUIREMENTS ON SAFETY AND SYSTEM SPECIFICATION — J
    - ESTABLISHMENT OF SAFETY SCENARIO
      - IN THE CASE THAT LARGE WATER LEAK IS EXCLUDED FROM "DBA" EVENTS.
      - IN THE CASE THAT LARGE WATER LEAK IN INCLUDED IN "DBA" EVENTS.
      - REQUIREMENTS TO EXCLUDE. LARGE WATER LEAK FROM "DBA" EVENTS.
    - ACCIDENT ANALYSIS / EVALUATION
    - ANALYSIS ON STRUCTURAL SAFETY BY LARGE SCALE WATER LEAK EVENT.

V. DISCUSSION / EVALUATION

- OBJECTIVE

  TO DISCUSS AND EVALUATE THE CONCERNS AND REQUIREMENTS EXTRACTED FOR IHTS-LESS FBR PLANT.

- WORK SCOPE
  - CONCEPTUAL DESIGN OF SG — US. J.
    - SELECTION OF SG TYPE AND STRUCTURE TO MEET THE REQUIREMENTS.
    - SIZING AND DESIGNING SG STRUCTURE. CONCEPTUAL DRAWING OF SELECTED SG.
    - ESTIMATION OF THE QUANTITY ON SG STRUCTURE. (WEIGHT ETC.)
    - CONSIDERATION ON THE FABRICABILITY INSPECTABILITY, MAINTENABILITY.
  - COMPARISON OF PRIMARY SG QUANTITY (OR COST) TO SECODARY SG QUANTITY (OR COST) — US. J.
  - ITEMS TO BE CONSIDERED/EVALUATED. — US. J.
    - PROBABILITY OF WATER LEAK TO SODIUM. IN STEAM GENERATOR
    - WATER LEAK DETECTION SYSTEM AND DETECTABILITY
    - EVALUATION OF IMPACTS OF PRESSURE WAVE PROPAGATION DUE TO LARGE WATER LEAK TO SODIUM.
      - TO REACTOR COOLANT BOUNDARY
      - TO REACTOR SHUTDOWN FUNCTION
      - TO DECAYHEAT REMOVABLE SYSTEM.
    - EVALUATION OF IMPACTS OF SODIUM-WATER REACTION PRODUCTS DUE TO WATER LEAK TO SODIUM.
      - TO REACTOR COOLANT BOUNDARY
      - TO REACTOR SHUTDOWN FUNCTION
      - TO DECAY HEAT REMOVABLE SYSTEM

- EVALUATION OF IMPACTS OF WATER/STEAM LINE BREAK ACCIDENT TO CONTAINMENT VESSEL STRUCTURE
- EVALUATION OF HYDROGEN THANSFER TO/FROM PRIMARY SYSTEM FROM/TO WATER-STEAM SYSTEM.
  - IMPACT TO PURIFYING SYSTEM OF PRIMARY COOLANT.
  - REDIOACTIVITY TRANSFER TO WATER-STEAM SYSTEM.
- RE-EVALUATION OF SYSTEM SPECIFICATION WITH REFLECTION OF THESE STUDIES SUCH AS SAFETY SCENARIO, ACCIDENT ANALYSIS, ABOVE EVALUATIONS ETC.
  - HEAT TRANSPORT SYSTEM
  - DECAY HEAT REMOVABLE SYSTEM
  - WATER LEAK DETECTION SYSTEM
  - SODIUM WATER REACTION RELIEF SYSTEM

VI. EXTRACTION OF REQUIRED R & D ITEMS

- OBJECTIVE

  TO CONSIDER THE REQUIRED R & D AND DEVELOPMENT COST FOR THE IHTS-LESS FBR PLANT

- WORK SCOPE
  - EXTRACTION OF REQUIRED R & D — US, J.
    - FOR IHTS-LESS FBR PLANT
    - FOR STEAM GENERATOR
  - CONSIDERATION ON R & D PROGRAM — US, J.

JAPANESE ACTIVITIES ON IHTS-LESS FBR PLANT

- INFORMATION INVESTIGATION OF HIGH RELIABILITY SG.
- CONCEPTUAL DESIGN STUDY OF HIGH RELIABILITY SG
- INVESTIGATION OF D.W.T. FABLICABILITY
- PRELIMINARY CONCEPTUAL DESIGN STUDY OF IHTS-LESS FBR PLANT

(D.W.T : DOUBLE WALL TUBE)

OUTLINE OF PRELIMINARY DESIGN STUDY PLAN OF IHTS-LESS FBR PLANT

- TERM OF STUDY : SEP. 1983 ～ JUN. 1984
- OBJECTIVES AND CONTENTS OF STUDY :

① SUPPLY THE MATERIALS TO SHOW THE POSSIBILITY OF IHTS-LESS PLANT

② SHOW THE POTENTIAL BENIFITS OF THIS PLANT, PARTICULARY EVALUATE PLANT CAPITAL AND OPERATING COST REDUCTION BY ADOPTING THIS PLANT

③ EXTRACT THE TOPICAL ITEMS TO BE STUDIED FURTHER

④ SHOW THE OVERALL IMAGE OF THE PLANT

⑤ EXTRACT AND EVALUATE THE R & D ITEMS

MAJOR PLANT CONDITIONS FOR THE STUDY :
APPLY CORRESPONDINGLY THE CONDITIONS OF PNC DEMO. FBR PLANT DESIGN STUDY

JAPANESE CURRENT STATUS FOR DOUBLE-WALL-TUBE SG

(1) WE HAVE NO DECISION OR CONCLUSION FOR D.W.T SG, JUST STARTED INFORMATION INVESTIGATION

(2) IHTS-LESS PLANT IS THOUGHT TO HAVE A CAPABILITY FOR PLANT COST REDUCTION. FOR REALIZATION OF THIS PLANT, HIGH RELIABILITY SG NEED TO BE USED. SO, IF THERE IS LARGE POSSIBILITY OF IHTS-LESS PLANT, HIGH RELIABILITY SG DEVELOPMENT SHOULD BE CONSIDERED.

(3) SOME SPECIAL REASONS ARE NECESSALY FOR D.W.T. SG TO BE SELECTED FOR DEMO. PLANT AND START DEVELOPMENT, SUCH AS RELATIVE LOW COST AND HIGH RELIABILITY

PNC FACILITY FOR SG TEST

(1) 1MW SG TF

(2) 50 MW SG TF

(3) SWAT-1

(4) SWAT-2

(5) SWAT-3

(6) SWAT-4

(7) HYDRODYNAMIC T.F

PNC PROPOSAL FOR THE DEVELOPMENT OF PIPING BELLOWS FOR LMFBR APPLICATIONS

I. AREAS TO BE COVERED

1. SYSTEM DESIGN

OBJECTIVE: TO ESTABLISH THE OPTIMAL DESIGN METHOD FOR THE LOOP TYPE FBR PLANT WITH THE INTRODUCTION OF BELLOWS EXPANSION JOINTS INTO THE MAIN COOLANT SYSTEM.

STUDY ITEMS:

- TO CLARIFY THE PLANT DESIGN TO FIT IN WELL WITH B. E. J.
- TO SELECT THE MOST SUITABLE TYPE OF BELLOWS
- TO ESTABLISH THE DESIGN PHILOSOPHY ON THE LEAK BEFORE BREAK (LBB) WHICH CAN ACHIEVE THE CONSENSUS OF MUTUAL OPINION.
- TO STUDY THE SYSTEM DESIGN FROM THE POINT OF ISI, ISM OR REPAIR INCLUDING THE RE-INSTALLMENT OF FAILED BELLOWS.

2. FABRICATION

OBJECTIVE: TO STUDY THE STATE OF THE ART AND IDENTIFY THE AREA FOR IMPROVEMENT ON THE FABRICATION TECHNOLOGY OF FBR BELLOWS, AND TO BRING FORTH THE STANDARDIZATION ON ACCOUNT OF ITS QUALITY CONTROL

STUDY ITEMS:

- TO SURVEY THE CURRENT PRACTICE OF PIPING BELLOWS FABRICATION IN JAPAN AND IN THE U. S.
- TO SURVEY THE FACT OF DIMENSIONAL STABILITY AND TO CLARIFY THE APPROPRIATENESS OF THE FABRICATION TOLERANCE RULED BY ASME C. C. N-290 .
- TO REVIEW CLOSELY THE EXAMINATION AND QUALITY CONTROL IN EACH STEP OF FABRICATION PROCESS WITH INTENT TO STANDARDIZE IT AS MUCH AS POSSIBLE.

3. DESIGN STANDARD

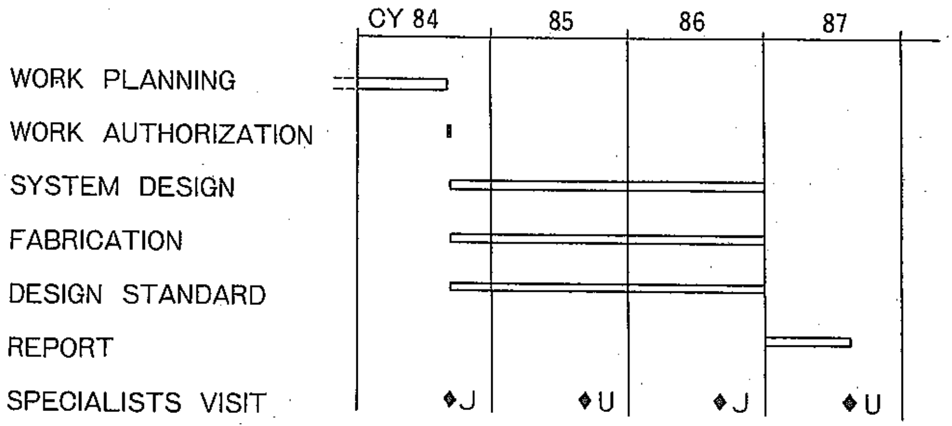
OBJECTIVE: TO DEVELOP MORE RATIONAL DESIGN STANDARD BY MAKING REFERENCE TO EXISTING ONES SUCH AS EJMA AND C. C. N-290

STUDY ITEMS:

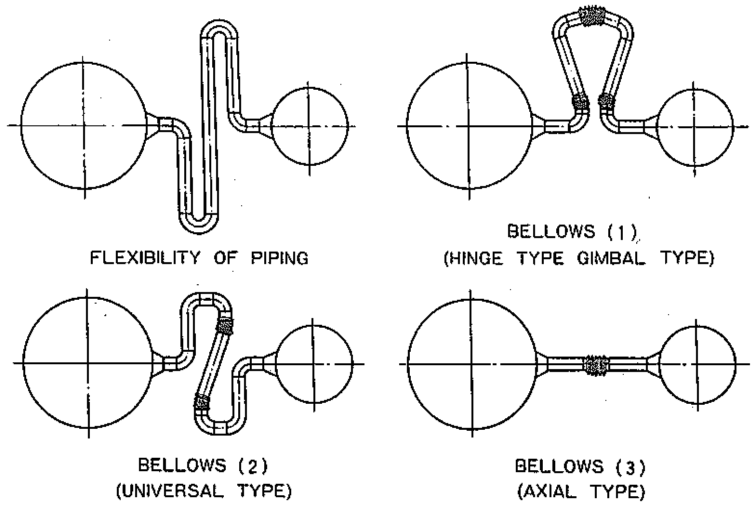
- TO LOOK FOR THE POSSIBLE AREA FOR IMPROVEMENT IN C.C.N-290 FROM, E.G., THOROUGH SURVEY OF ITS BACKGROUND DOCUMENTS.
- TO IDENTIFY THE PROBLEMS TO BE SOLVED IN ORDER TO REPLACE THE C.C.N-290 REQUIREMENTS OF DESIGN BY TESTING WITH DESIGN BY ANALYSIS.

- TO ESTABLISH A RATIONAL EVALUATION METHOD FOR CREEP-FATIGUE AND BUCKLING WHICH ARE PARTICULARLY IMPORTANT IN THE DESIGN BY ANALYSIS, BASED ON THE WELL-DESIGN TEST PROGRAM.

Ⅱ SCHEDULE

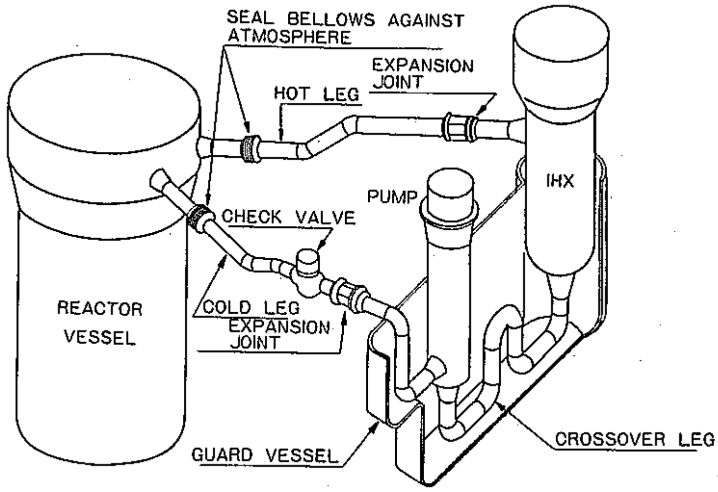


APPLICATION OF BELLOWS TO LMFBR

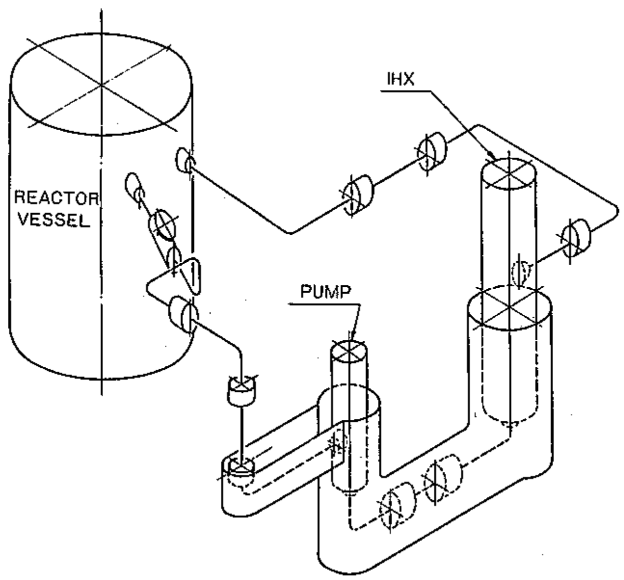


ABSORBER OF THERMAL EXPANSION

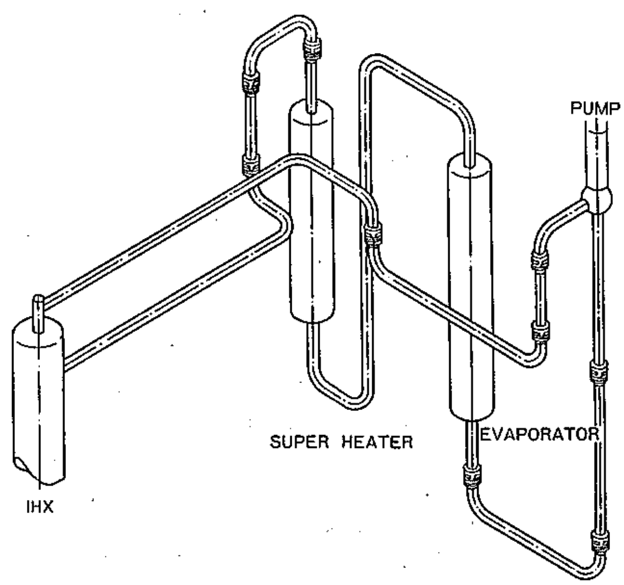
1 . APPLICATION IN MAIN COOLANT SYSTEM
(PRIMARY PIPING)



ARRANGEMENT OF PRIMARY COOLANT SYSTEM (A)



ARRANGEMENT OF PRIMARY COOLANT SYSTEM (B)



ARRANGEMENT OF SECONDARY COOLANT SYSTEM

2. DESIGN CONDITION OF PRIMARY COOLANT SYSTEM

A. DESIGN TARGET

- C/V DIAMETER SMALLER THAN 50 (M)
- SIMPLE LAYOUT OF PIPING SYSTEM
- MAINTENABILITY AND INSPECTABILITY
- G/V FREE FROM SUPPORTS

B. THE BASIC PHILOSOPHY OF BELLOWS DESIGN

- MITIGATION OF FLOW INDUCED VIBRATION AND THERMAL SHOCK
  →EXTERNAL PRESSURE TYPE TO AVOID DIRECT CONTACT OF MAIN FLOW
- PREVENTION OF EXCESSIVE DEFORMATION
  →USE OF TIE RODS OR PIN JOINTS
- BACK-UP FOR BOUNDARY BELLOWS FAILURE
  →BACK-UP BELLOWS
- LEAK DETECTION
  →ON LINE MONITORING OF GAS IN THE SPACE BETWEEN BOUNDARY BELLOWS AND BACK-UP BELLOWS
- REPAIRBILITY
  →G/V TO BE FREE FROM BELLOWS
- DRAINABILITY
  →EXTERNAL PRESSURE TYPE FOR HORIZONTAL BELLOWS

C. DESIGN SPECIFICATIONS

	HOT LEG	CROSS OVER LEG	COLD LEG
GRADE	CLASS I	CLASS I	CLASS I
MATERIALS PIPING BELLOWS	 SUS 304 SUS 304	 SUS 304	 SUS 304 SUS 304
TEMPERATURE DESIGN SERVICE	 550 ℃ 530 ℃	 405 ℃ 385	 405 ℃ 385
PRESSURE DESIGN SERVICE	 2.0kg/cm² 1.5	 2.0 kg / cm² 1.5	 12.0kg/cm² 9.5
NOM. PIPING DIA.	42 IN	42 IN	38 IN

3. COST EFFECTIVE

PIPING	W/O BELLOWS	W/ BELLOWS (A)	W / BELLOWS (B)
C/V DIAMETER (m)	64	50	50
PIPING LENGTH (m)	390	160	210
NO. OF ELBOW	60	33	30
NO. OF SUPPORT	170	36	222
NO. OF BELLOWS	0	6	21
TYPE OF BELLOWS		AXIAL	GIMBAL & UNIVERSAL
DESIGN BASED ON		EJMA	C.C.N-290 BDS

TECHNOLOGY STATUS/EXPERIENCE FOR BELLOWS APPLICATIONS

1. SODIUM SERVICE

		JOYO IHX	JOYO AUX. IHX			JOYO R/V	JOYO	JOYO PRIMARY (OUTER) PIPING	
		BELLOWS	UPPER-INNER B.	UPPER OUTER B.	LEAK JACKET	LEAK JACKET	S/V	HOT LEG	COLD LEG
DIAMETER (mm)		402.5	162.2	359.5	581.5	3857	6492	670	603
NO. OF CONVOLUTION		4	5	3	2	3	8	3～5	4～5
DESIGN TEMP. (℃)		550	550	550	550	550	450	550	450
DESIGN PRESS. (Atg)		1	1	1	1	1	0.5	1	1
BELLOWS TYPE		AXIAL / U-SHAPED							
MATERIAL		SUS 304							
FLUID IN CONTACT	INNER	Na	Na	N_2+(Na)					
	OUTER	N_2+(AIR)	N_2+(AIR)	N_2+(AIR)					

NOTE: N_2+(Na) MEANS NORMALLY N_2; Na, ONLY WHEN SODIUM LEAKING

N_2+(AIR) MEANS NORMALLY N_2; AIR, ONLY WHEN MAINTENANCE TAKING PLACE

TECHNOLOGY STATUS/EXPERIENCE

2. RESEARCH AND DEVELOPMENT PROGRAMS

		MONJU IHX BELLOWS TEST		SPTF BELLOWS TEST	LMFBR PIPING BELLOWS		
		TYPE A (W/O RING)	TYPE B (W/ RING)		A	B	C
DIAMETER (mm)		720		305	700	1100	300
NO. OF CONVOLUTION		7		3 5	5	7	
DESIGN TEMP. (℃)		400		500	500	550	550
DESIGN PRESS. (Atg)		2		10	2	1.5	5~9.5
BELLOWS TYPE		AXIAL / U-SHAPED / 2-PLY			AXIAL/U 2-PLY	AXIAL/U 1-PLY	AXIAL/U 1-PLY
MATERIAL		SUS 316					
FLUID IN CONTACT	INNER	Na					
	OUTER	N_2					

3. OTHER THAN LMFBR APPLICATIONS

SCOPE OF RESEARCH FOR BELLOWS APPLICATIONS OTHER THAN LMFBR

(1) NOMINAL DIAMETERS GREATER THAN 300 mm

(2) DESIGN OR MAXIMUM WORKING TEMPERATURE HIGHER THAN 400 ℃

(3) ALSO INCLUDED IN THE PRESENT RESEARCH ARE :

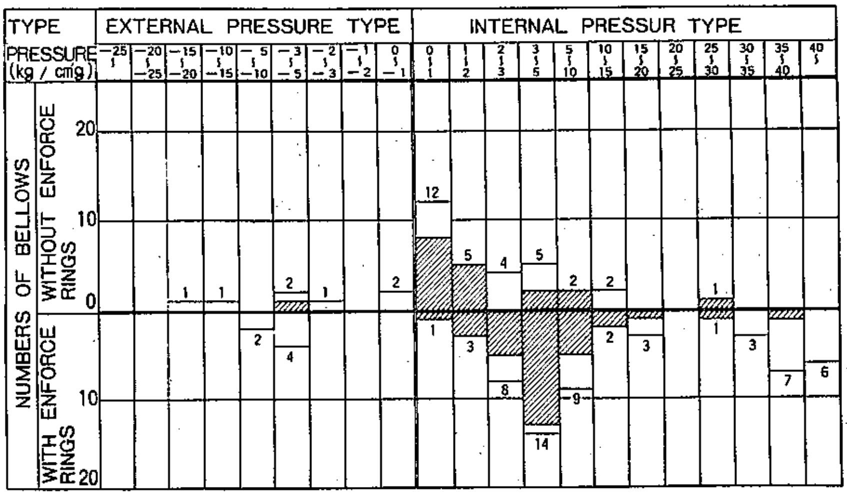
- BELLOWS CONTAINING SODIUM
- BELLOWS LOADED HIGH PRESSURE (HIGHER THAN 30 kg/cm²)
- BELLOWS EXPOSED TO THE SIGNIFICANTLY CORROSIVE ENVIRONMENT
- EXTERNAL PRESSURE TYPE BELLOWS

(4) FOUR JAPANESE BELLOWS FABRICATORS WITH 10 TO 15 YEARS EXPERIENCES ARE SURVEYED.

A. APPLIED TEMPERATURE AND ITS FIELDS

TEMPERATURE (℃) / FIELDS	0 ~	0 ~ 100	100 ~ 200	200 ~ 300	300 ~ 400	400 ~ 425	425 ~ 450	450 ~ 500	500 ~ 550	550 ~ 600	600 ~ 650	650 ~ 700	700 ~ 750	750 ~ 800	800 ~
CHEMICAL PLANT		1	3	3	2	3	2		4	1	6	3	4		
STEEL WORKS			4		1	1	1	2							3
CEMENT PLANT											1			1	
PETROCHEMISTRY		1	11	2	2	2	4	2	4		5	3	2	1	3
FOSSIL POWER STATION			1			2									
GEOTHERMAL POWER STATION				2											
NUCLEAR POWER STATION		1	1												
JET ENGINE & GUS TURBINE					1					1		1			
OTHERS	2		1		2	1			1.	1	1	1			

D. MAXIMUM WORKING RRESSURE VS WITH/WITHOUT ENFORCEMENT RINGS



NOTE : OBLIQUE LINED PORTION SHOWS SERVICE TEMP. OVER 425℃ (797° F)

B. USED MATERIALS AND APPLIED FIELDS

FIELDS \ MATERIALS	SUS 304	SUS 304L	SUS 316	SUS 316L	SUS 321	SUS 310	SUS 347	INCOLOY 800	INCOLOY 825	INCONNEL 600	NICKEL	MONEL	B424	B409	B429
CHEMICAL PLANT	4		7	1	10		2	2		1	1	1		1	1
STEEL WORKS	4		4		4										
CEMENT PLANT	2														
PETRO CHEMISTRY	9	3	4	1	17	1	3	3	1	1		1			
FOSSIL POWER STATION			2	1											
GEOTHERMAL POWER STATION						1							2		
NUCLEAR POWER STATION		2													
JET ENGINE & GAS TURBINE	1				2										
OTHERS	2	2	4		2										

CODES/STANDARDS OF BELLOWS EXPANSION JOINTS

1. EVALUATION OF CONVOLUTION DESIGN BY EJMA AND C.C.N-290-1

STRENGTH EVALUATION	EJMA (1980)	ASME. C.C.N-290-1
STRESS EQ.	◎	—
PRIMARY STSESS LIMIT	○	◎
STRAIN LIMIT	—	△
FATIGUE	△	○ EXP.
CREEP-FATIGUE	—	○ EXP.
BUCKLING	○	○ EXP.
TORSION	○	—
VIBRATION	△	—

◎ SATISFACTORY METHOD AVAILABLE

○ METHOD AVAILABLE

○EXP. EVALUATION BY EXPERIMENT

△ METHOD AVAILABLE BUT UNSATISFACTORY

— METHOD NOT AVAILABLE

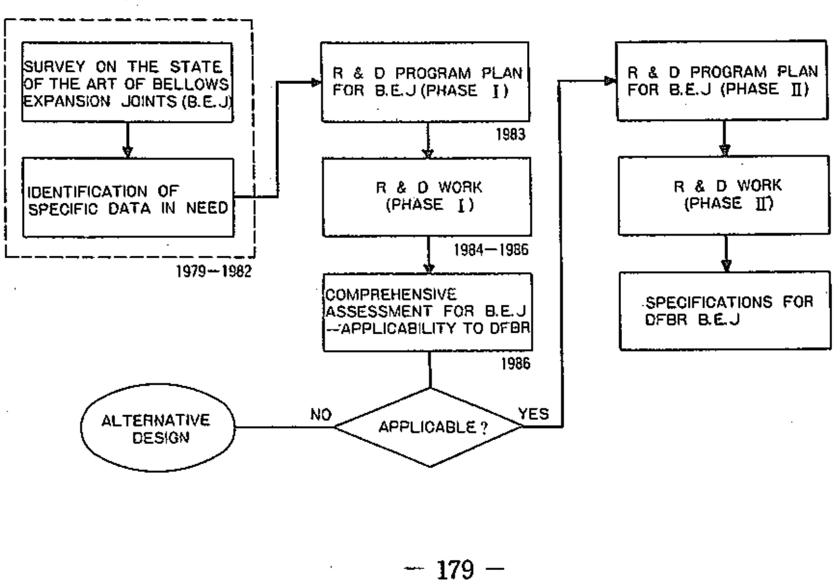
2 . AREAS FOR IMPROVEMENT

- EVALUATION OF LOCAL BUCKLING (IN-PLANE INSTABILITY) BY EJMA IS NOT SATISFACTORY. $\left(P = \frac{3\pi}{N^2 q} \times 1.7 \times \frac{d_p E_p t_p^3 n}{W^3 C_f} \right)$
- RESONANT FREQUENCY OF LATERAL VIBRATION EVALUATED BY EJMA IS OVER-CONSERVATIVE. $\left(f = C \times \frac{d_p}{L} \sqrt{\frac{K_{SR}}{W}} \right)$
- EJMA'S DESIGN FATIGUE CURVE PREDICTS THE FATIGUE LIFE EXPECTANCY ON UN-SAFE SIDE.
- WITH DIMENSIONAL TOLERANCES RULED BY ASME C.C.N-290, STRESSES EVALUATED BY EJMA GIVE SOMETIME SMALLER VALUES THAN THOSE OBTAINED BY ELASTIC FEM.
- DIMENSIONAL TOLERANCE RULED BY C.C.N-290 IS A LITTLE TOO SEVERE FROM CURRENT LEVEL OF FABRICATION TECHNOLOGY.
- IN THE STRAIN LIMIT RULE OF C.C.N-290, THE EVALUATION OF X-PARAMETER BY CONVENTIONAL O-P METHOD YIELDS OVER-CONSERVATIVE VALUE DUE TO THE DOUBLE COUNTING OF STRAIN BY BENDING
- IN ORDER TO ESTABLISH "DESIGN BY ANALYSIS" FOR CREEP-FATIGUE DAMAGE IN C.C.N-290, FOLLOWING ITEMS MUST BE INCLUDED FOR DISCUSSION :

- FATIGUE DAMAGE
  - CALCULATION OF STRAIN RANGE
    - STRAIN CONCENTRATION FACTOR
    - ELASTIC FOLLOW-UP FACTOR
    - INITIAL DEFORMATION FACTOR
  - FATIGUE DAMAGE CURVE ——— MODIFICATION FACTOR FOR THIN MATERIAL
- CREEP DAMAGE
  - MODIFICATION FACTOR FOR CREEP RUPTURE CURVE
  - PREPARATION OF STRESS RELAXATION PROCESS
- PREPARATION OF SAFETY MARGIN FOR TOTAL DAMAGE

GUIDE LINE FOR THE DEVELOPMENT OF BELLOWS EXPANSION JOINTS AT PNC

1 . R & D FLOW



2 . SCOPE

R & D WORK (PHASE I)

- PREPARATION OF R & D PROGRAM PLAN (PHASE I)
- ASSESSMENT OF THE STATE OF THE ART OF B.E.J.
- DESIGN, FABRICATION AND INSPECTION PRACTICE WITH B.E.J MODELS
- TRIAL USE OF B.E.J IN SODIUM TEST LOOPS
- STRUCTURAL STRENGTH TESTS ON BELLOWS CONVOLUTIONS
- ASSESSMENT OF B.E.J IN CONNECTION WITH DFBR SYSTEM DESIGN STUDY.
- PREPARATION OF DESIGN CRITERIA (DRAFT)
- PREPARATION OF FABRICATION STANDARD (DRAF)
- COMPREHENSIVE ASSESSMENT ON THE APPLICABILITY OF B.E.J TO DFBR
- PREPARATION OF R & D PROGRAM PLAN (PHASE II)
- R & WORK (PHASE II)
- SPECIFICATIONS FOR DFBR B.E.J

PROPOSED SCOPE OF THE CURRENT POST-D ACTIVITY

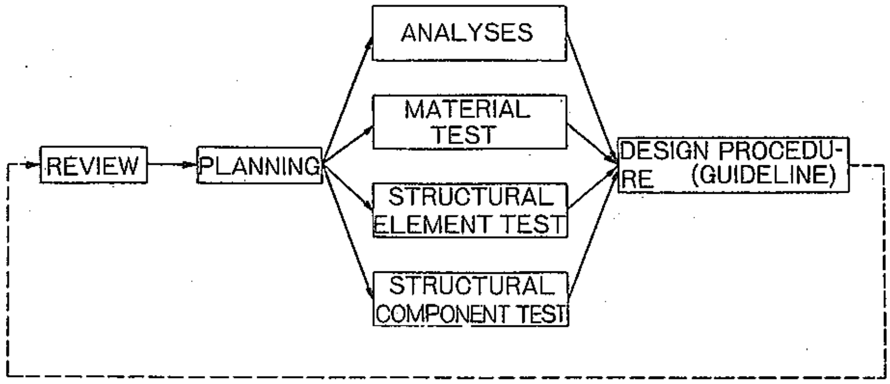
- R & D PROGRAM PLAN FOR B.E.J (PHASE I)
- R & D WORK (PHASE I)
- COMPREHENSIVE ASSESSMENT FOR B.E.J— APPLICABILITY TO DFBR

STRUCTURAL STRENGTH TEST PROGRAM AT PNC

No.	TYPE OF TESTS	TEST MODEL	DIA. (mm)	NO. OF MODELS	TEST CONDITIONS
1	CREEP-FATIGUE	CONVOLUTION	1100	20	IN-AIR : 600℃, 650℃
2	CREEP-FATIGUE	CONVOLUTION	500	10	IN-AIR : RT. 600℃, 650℃
3	THERMAL TRANSIENT	BELLOWS EXP. JOINT	1100	2	IN-Na : 250⇄650℃
4	RATCHET	CONVOLUTION	1100	6	IN-AIR : RT. 500℃, 550℃, 600℃
5	BUCKLING	CONVOLUTION	500 ~1100	18	IN-AIR : RT. ~650℃ 30kg / cm² MAX
6	FLOW VIBRATION	GIMBAL	500	1	IN-WATER : ~5m/S
7	VIBRATION OF BELLOW PIPING	GIMBAL	500	1	IN-AIR
8	SHOCK	HINGE, GIMBAL AND UNIVERSAL	250 ~500	3	WATER HAMMER

REFERENCE	FATIGUE	CONVOLUTION	1100	15	IN-AIR : RT. 400℃, 550℃
			700	6	IN-AIR : RT. 500℃
			300	27	IN-AIR : RT. 400℃, 500℃, 550℃

INELASTIC DESIGN METHOD



FLOW OF STUDY

DESIGN BY INELASTIC ANALYSES (PNC PROPOSAL)

MATERIAL TEST

(1) BASIC MATERIAL TEST
(DEFORMATION, STRENGTH)

(2) DEFORMATION TEST UNDER COMPLICATED LOAD HISTORY.

(3) STRENGTH TEST UNDER COMPLICATED LOAD HISTORY.

STRUCTURAL ELEMENT TEST

SPECIMEN

- BEAMS
- TUBES (WITH AND WITHOUT STRUCTURAL DISCONTINUITIES)

LOAD

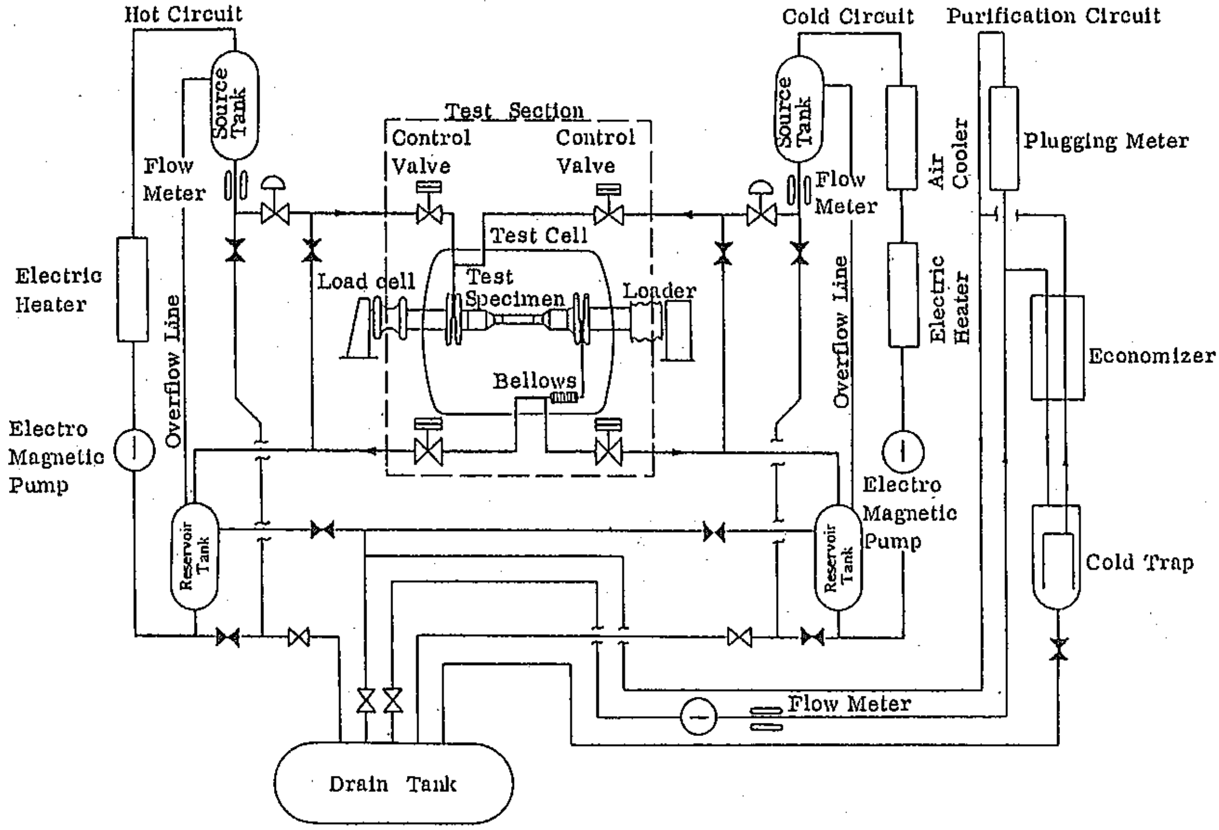
- MECHANICAL LOAD
- THERMAL LOAD
- COMBINED LOAD

TEST

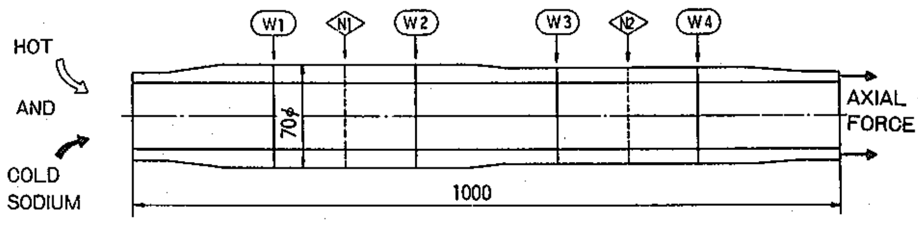
- DEFORMATION TEST
- STRENGTH TEST

TEST RIG

- SODIUM PIPING THERMAL TRANSIENT TEST LOOP (SPTL)
- SMALL THERMAL SHOCK TEST LOOP (STST)
- AIR-COOLED THERMAL TRANSIENT TEST FACILITY (ATTF)

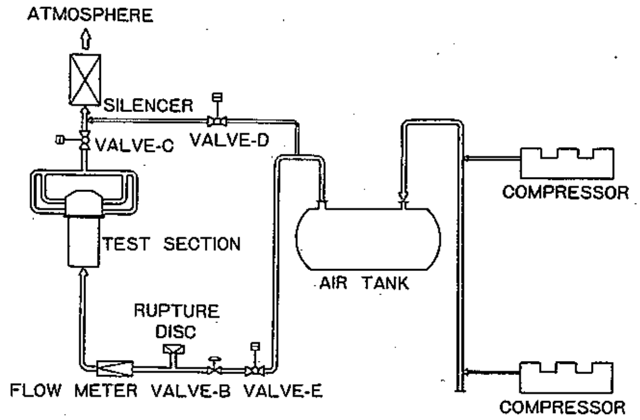


Schematic of Sodium Piping Thermal Transient Test Loop
for Structural Element Test



W : WELDED JOINT
N : CIRCUMFERENTIAL NOTCH

STRUCTURAL COMPONENT TEST (EXAMPLE 1)



FACILITY SPECIFICATIONS

TEST TEMPERATURE	550℃ MAX
TEST PRESSURE	8 kg / cm² MAX
MAIN PIPING SIZE	8 -IN
COMPRESSED AIR SUPPLY	35kg / cm²G
THERMAL TRANSIENT	550℃→150℃
(DOWN RAMP)	IN~ 4 MIN
MECHANICAL LOAD	TO BE CONSIDERED

FIG. AIR-COOLED THERMAL TRANSIENT FACILITY (ATTF)

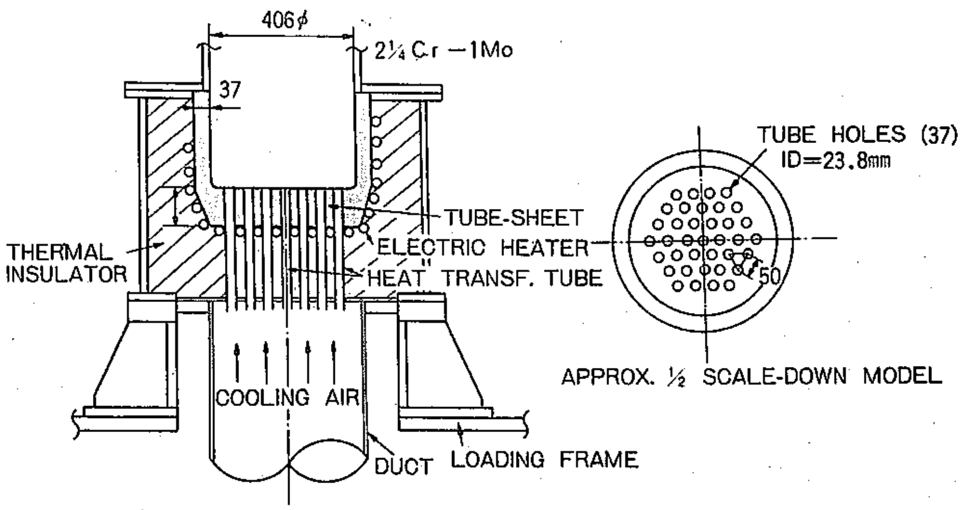


FIG. EVAPORATOR TUBE-SHEET STRUCTURE TO BE TESTED AT ATTF

DESIGN BY INELASTIC ANALYSES (PNC PROPOSAL)

STRUCTURAL COMPONENT TEST

SPECIMEN

- VESSELS WITH STRUCTURAL DISCONTINUITIES
- NOZZLES
- PIPING COMPONENTS

LOAD

- MECHANICAL LOAD
- THERMAL LOAD
- COMBINED LOAD

TEST

- DEFORMATION TEST
- STRENGTH TEST

TEST RIG.

- THERMAL TRANSIENT TEST RIG FOR STRUCTURES (TTS)

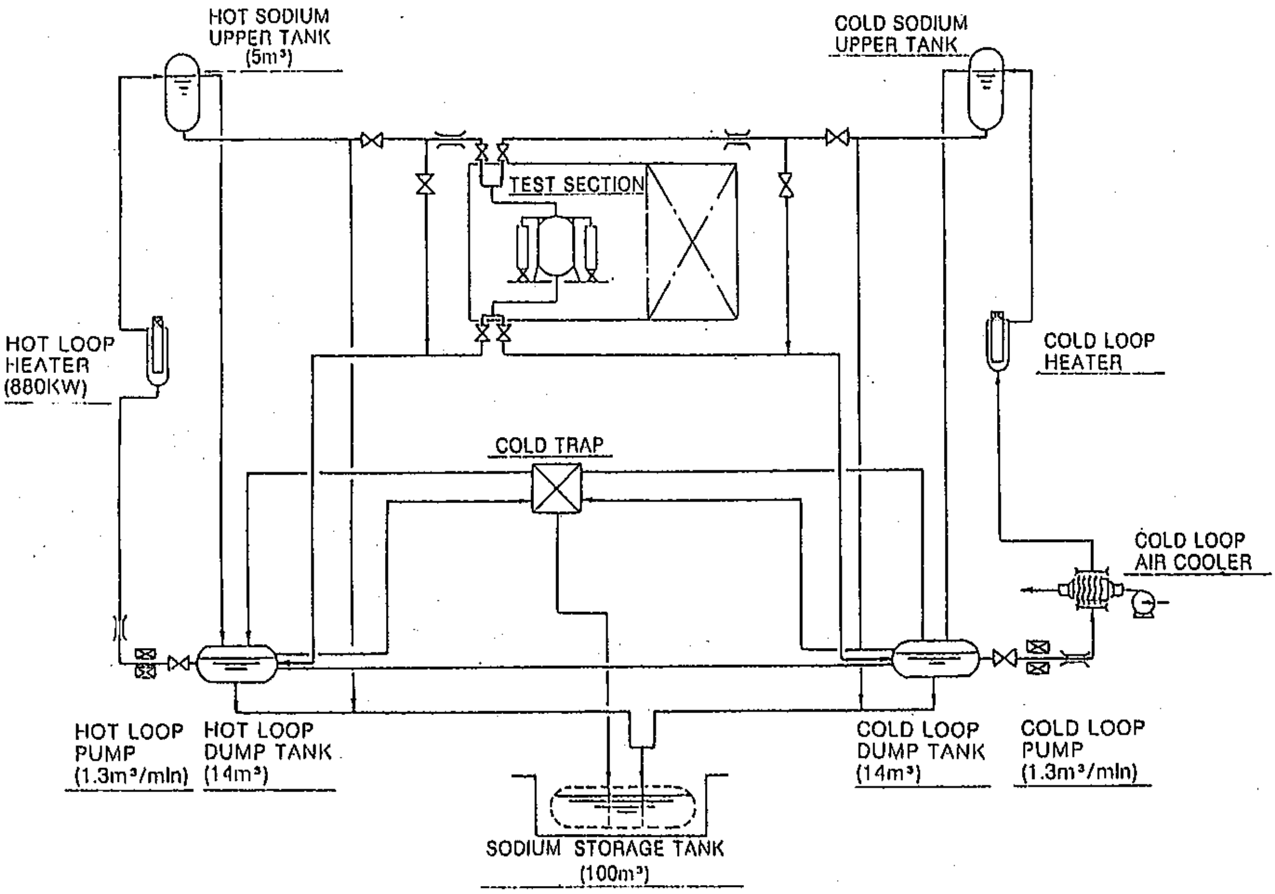
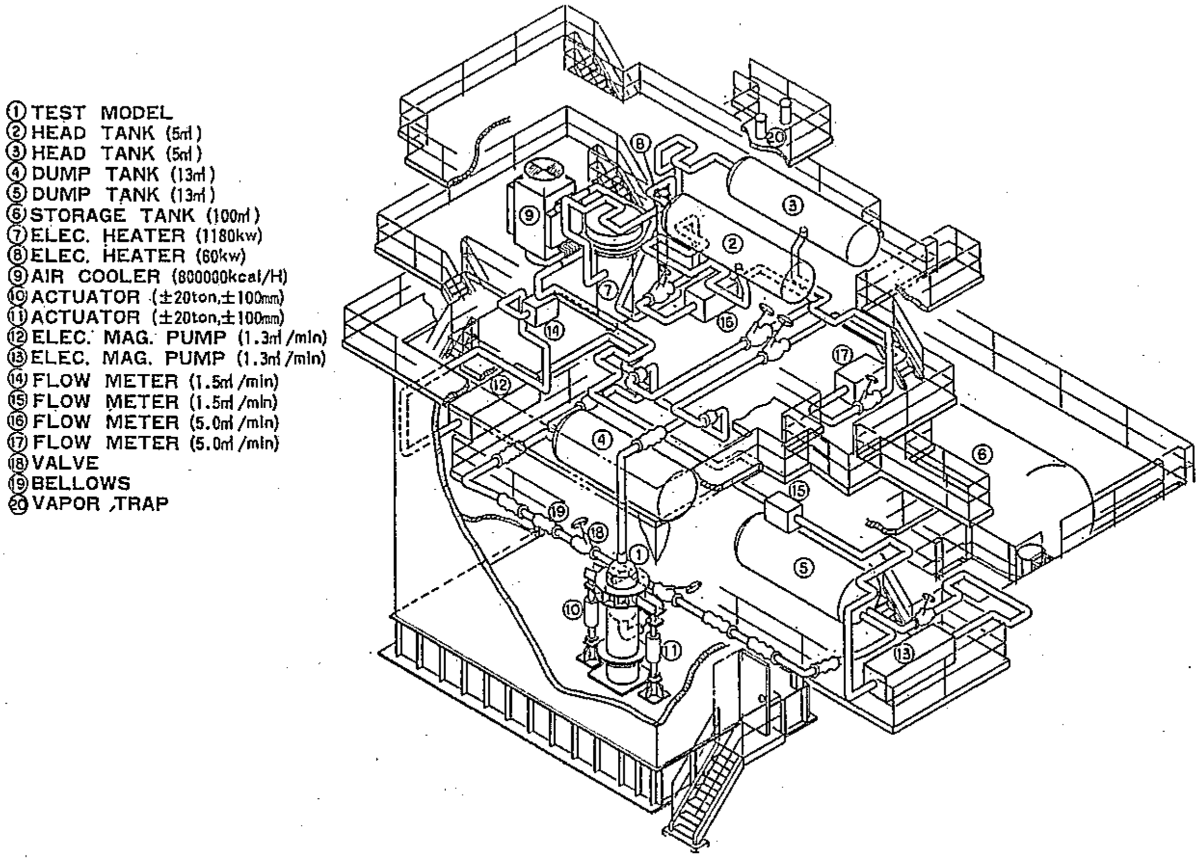
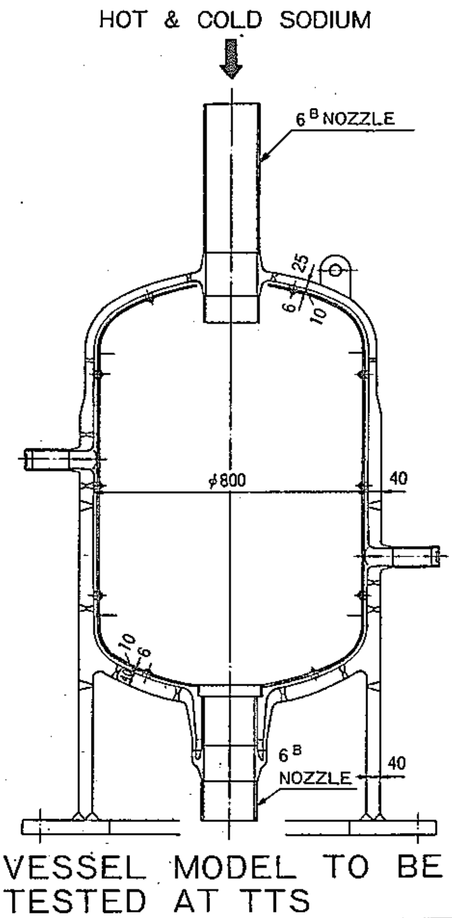


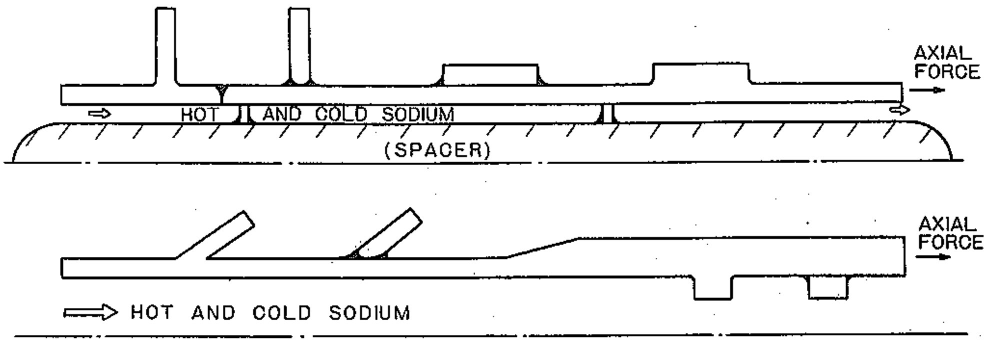
Fig. 1 FLOW DIAGRAM (PLAN) TTS FOR STRUCTURAL COMPONENT TEST



THERMAL TRANSIENT TEST RIG FOR STRUCTURES (TTS)



VESSEL MODEL TO BE TESTED AT TTS



STRUCTURAL ELEMENT TEST (EXAMPLE)

THERMAL STRACTIFICATION (PNC PROPOSAL)

STEP Ⅰ. VALIDATION AND IMPROVEMENT OF HEAT TRANSFER/FLOW ANALYSIS CODES BY EXPERIMENTAL DATA SUPPLIED BY BOTH PNC/DOE

- EXCHANGE OF EXPERIMENTAL DATA BETWEEN PNC AND DOE
- CODE VALIDATION USING EXCHANGED DATA
- STUDY ON THE ACCURACY AND PROBLEMS OF ANALYTICAL CODES
- PREPARATION OF R & D PROGRAM
- IMPROVEMENT OF ANALYTICAL CODES

STEP Ⅱ. BASIC TEST ON "CARRY-OVER" PHENOMENON

- PREPARATION OF TEST PROGRAM AND DESIGN OF TEST MODEL
- WATER TEST
- SODIUM TEST
- EVALUATION OF TEST RESULTS
- IMPROVEMENT OF ANALYTICAL CODE

STEP Ⅲ. PROOF TEST BY LARGE SCALE MODEL

- PREPARATION OF TEST PROGRAM AND DESIGN OF TEST MODEL
- SODIUM TEST
  LOOP TYPE : IN CONNECTION WITH DRACS
  TANK TYPE : IN CONNECTION WITH IHX AND DRACS
- EVALUATION OF TEST RESULTS
- VALIDATION OF ANALYTICAL CODE

(STEP Ⅲ WILL BE PROCEEDED AFTER THE PLANT TYPE OF DFBR BEING DECIDED)

THERMAL STRATIFICATION

TOPICS	NECESSARY DATA	CURRENT STATUS	IDENTIFIED PROBLEMS	FUTURE R & D
1) THERMAL STRATIFICATION • INITIATION • RISE OF DENSITY INTERFACE • DISSIPATION	• CONDITIONS FOR INITIATION • RISING SPEED OF INTERFACE • TEMP. DISTER. IN THE INTERFACE • DISSIPATION TIME	OBTAINABLE BY ANALYTICAL CODES (E.G. SKORT, THAUPR NAGARE, COMMIX)	• IMPROVEMENT ON ACCURACY-UNDER-STANDING OF "CARRY-OVER" AND ITS CODE SIMULATION • DETERMINATION OF DESIGN LOADING FROM TEST DATA	(1) CODE VERIFICATION BY EXISTING DATA (2) IDENTIFICATION OF PROBLEM (E.G. "CARRY-OVER") AND IMPROVEMENT ON ACCURACY (3) BASIC TEST (4) CODE IMPROVEMENT (5) PROOF TEST (6) APPLICATION OF TEST DATA TO DESIGN
2) THERMAL BEHAVIOR OF STRUCTURES	TEMPERATURE DISTRIBUTION IN STRUCTURES	DISTRIBUTION OBTAINABLE BY ANALYTICAL CODE		
3) LOADING CONDITIONS OF STRUCTURES	STRESS/STRAIN DISTRIBUTION IN STRUCTURES	OBTAINABLE BY STRUTURAL ANALYSIS CODE	INELASTIC BEHAVIOR OF STRUCTURES	IMPROVEMENT OF INELASTIC ANALYSIS CODE
4) CREEP-FATIGUE DAMAGE	MATERIAL STRENGTH DATA	LINEAR ACCUMULATION DAMAGE RULE (HTSD RULE)	TOO CONSERVATIVE DESIGN MARGIN	DEVELOPMENT OF CREEP-FATIGUE DAMAGE EVALUATION METHOD WITH REASONABLE DESIGN MARGIN

THERMAL STRIPING (PNC PROPOSAL)

(1) BASIC TEST ON TEMPERATURE FLUCTUATION AND DEVELOPMENT OF ANALYSIS CODE

- PREPARATION OF TEST PROGRAM AND DESIGN OF SIMPLIFIED BASIC TEST MODEL
- WATER TEST
- SODIUM TEST
- EVALUATION OF TEST RESULTS
- DEVELOPMENT OF ANALYTICAL CODE

(2) ESTABLISHMENT OF EVALUATION METHOD FOR HIGH CYCLE THERMAL FATIGUE OF FBR MATERIALS

- PREPARATION OF TEST PROGRAM AND DESIGN OF TEST-RIG/MODEL
- HIGH CYCLE THERMAL FATIGUE TEST IN SODIUM
- HIGH CYCLE MECHANICAL FATIGUE TEST IN HIGH TEMPERATURE ENVIRONMENT
- COMPARATIVE EVALUATION OF TEST RESULTS BY THERMAL LOADING AND BY MECHANICAL LOADING
- STUDY OF RATIONAL EVALUATION METHOD FOR HIGH CYCLE THERMAL FATIGUE

TOPICS	NECESSARY DATA	CURRENT STATUS	IDENTIFIED PROBLEMS	FUTURE R & D
1) TEMPERATURE FLUCTUATION	AMPLITUDE FREQUENCY REPRESENTATIVE WAVE PATTERN	WATER TEST DATA BY PLANT SIZE MODEL WATER/SODIUM CORRELATION DATA	• GEOMETRY DEPENDENCY→ANALYTICAL CODE • DETERMINATION OF DESIGN LOADING FROM TEST DATA	① BASIC TEST WITH SIMPLIFIED MODEL ② CODE DEVELOPMENT ③ PROOF TEST ④ CODE VALIDATION ⑤ APPLICATION OF TEST DATA TO DESIGN
2) TRANSIENT HEAT TRANSFER BETWEEN FLUID/ STRUCTURE	TRANSIENT HEAT TRANSFER	TEST DATA	LITTLE DATA AVAILABLE	AQUISITION OF DATA
3) THERMAL BEHAVIOR OF STRUCTURES	TRANSIENT TEMPERATURE DISTRIBUTION	OBTAINABLE BY STRUCTURAL ANALYSIS CODE	————	————
4) LOADING CONDITIONS OF STRUCTURES	STRESS/STRAIN DISTRIBUTION IN STRUCTURES	OBTAINABLE BY STRUCTURAL ANALYSIS CODE	INELASTIC BEHAVIOR OF STRUCTURES	IMPROVEMENT OF INELASTIC ANALYSIS CODE
5) HI-CYCLE THERMAL FATIGUE	HI-CYCLE THERMAL FATIGUE STRENGTH DATA	LINEAR ACCUMULATION DAMAGE RULE (HTSD RULE) APPLICABLE TO LOW/MEDIUM CYCLE FATIGUE REGION	• RELATION BETWEEN HI-CYCLE THERMAL/ HI-CYCLE FATIGUE STRENGTH BY MECH. LOAD NOT KNOWN • TOO CONSERVATIVE DESIGN MARGIN	① HI-CYCLE THERMAL FATIGUE TEST ② RELATION BETWEEN FRACTURE CRITERIA/HI-CYCLE FATIGUE STRENGTH BY MECH. LOAD ③ DESIGN CURVE FOR HI-CYCLE THERMAL FATIGUE

2. 施 設 見 学

施 設 見 学

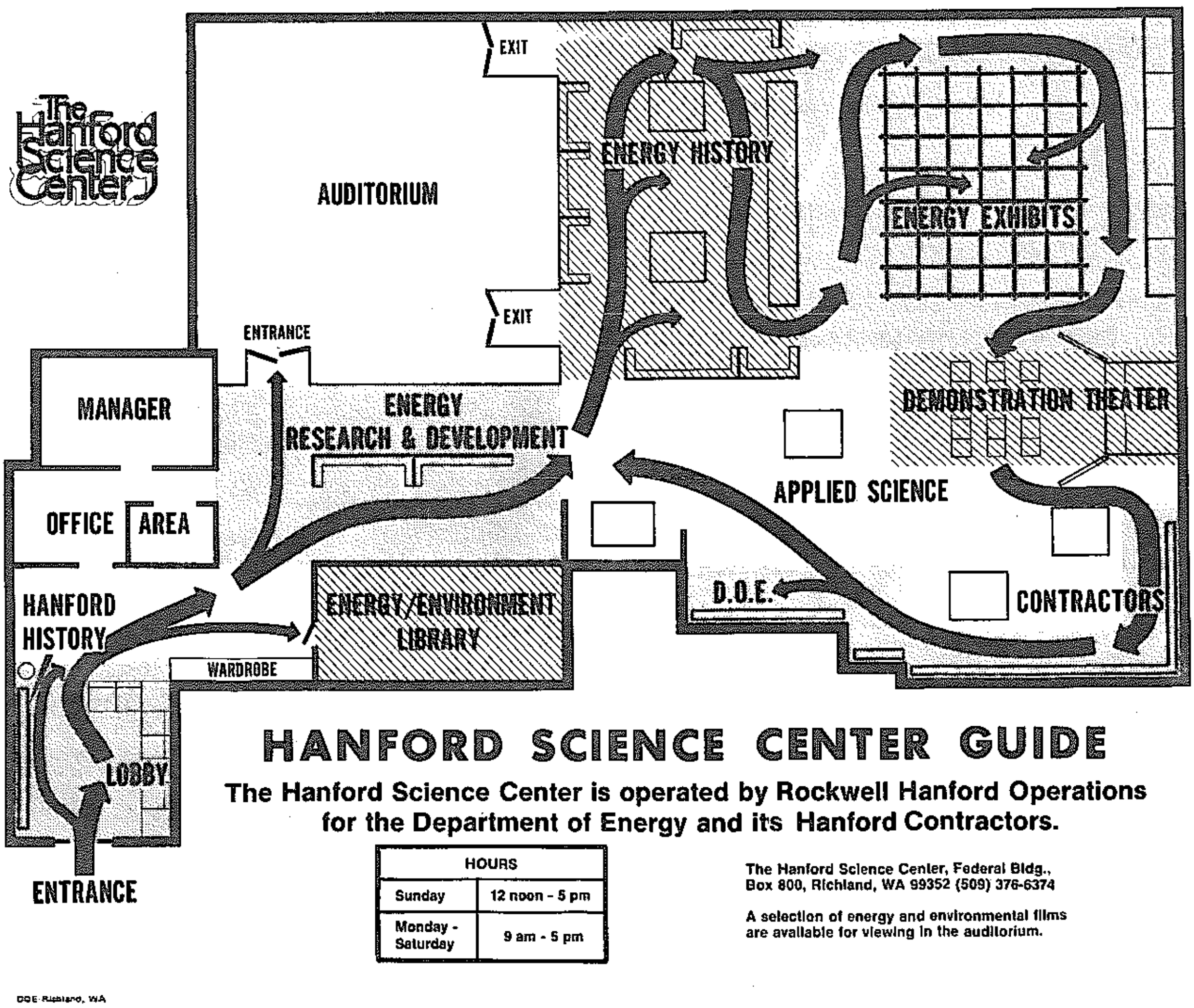
2.1 Hanford Science Center

1983年9月30日 10：30～11：30

見学者：林，山口，飯田，和田，阿部，小畑，井上

Hanford Science Center は Hanford の技術開発の概要を表わした展示場形式のセンターである。見学は DOE の4人の案内により行なった。入口を入った所に Hanford の歴史の流れが展示されていた。その中に日本に投下された原爆の当時の新聞記事があったのが印象的であった。

展示場には，動力をおこす種々のモデル，例えば光を利用するもの，水を利用するもの等があり，その中に原子力の基本的な説明（一般大衆に理解できる程度の簡単なもの）をしたビデオを利用したものがあった。又，FFTF の燃料集合体の実寸大モデルが展示されていた。



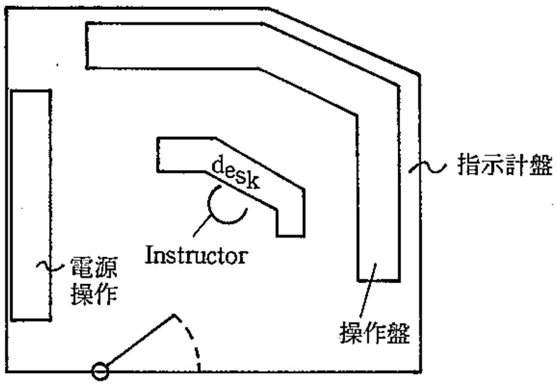
2.2 FFTF

1983年9月30日 14:00～15:30

見学者：小畑，飯田，和田，阿部，山口，井上

まずPRセンタで，全体の縮尺モデル，燃料集合体実物等の説明を受けた後，出入管理所を通って運転員訓練センタを見学した。この建物は，FFTFの建屋とは独立の専用建物となっており，制御盤等の訓練施設が実物と全く同じ配置で，しかも同じ向きに設置されている。見学時は，訓練が行なわれていなかったが，平均的に約3ケ月の訓練を当所で受けるそうで，当然のことであるがコンピュータによるシュミレーション運転が中心とのことである。ここでは，既に訓練を終った運転員も，2年に1回，この施設でテストを受けることになっているそうである。

次に，セキュリティーチェックの扉を経て，制御室を見学した。8m×8m位の広さであり，こじんまりとまとまっている。（図参照）75MWtの運転中で，運転は3名で行なわれていた。



二重扉を経て格納容器内へ案内されたが，放射線管理は予想外にゆるく，履物・衣服等も見学者が身に付けているもののままでよく，出て来た時にモニタチェックをされただけであった。

出力運転中であり1次系には入れず，運転床上を見学した。1次系ポンプの運転音が格納容器内に響きわたっていた。

格納容器内の運転床では，約10人が作業中であったが，ルーチンワークの作業を行なっているようであった。運転床の隣の燃料取扱いセルは，作業休止中であったが，内部にランプがついており，鉛ガラス窓より内部のマニュプレータ，燃料集合体の仮置き等を見学した。全長が20m以上の長いものを垂直方向のセル内で取扱われるのに対し，個々の鉛ガラス窓から見れる範囲は限られている為，操作は連携プレーで行なわれるものと思った。

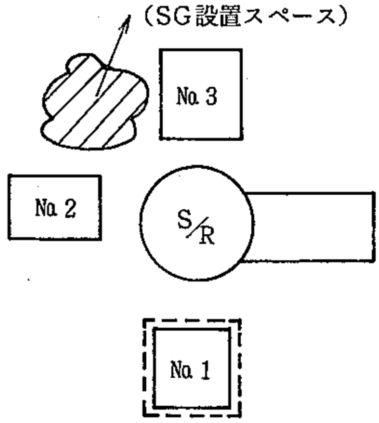
運転床より2段程下のレベルまで降り，冷却系，補助設備の一部を見学したが，通路は比較的に狭く，保守，保修もスペース的に容易ではないものと思った。2次系ゴールドトラップ及びポンプを見学したが，運転プラギング温度は280°F（～140℃）であった。

配管防震器は建設当初，トラブルを起し，別メーカ（パシフイック・サイアンティフィック社）

のメカニカルスナッバーに取換えられたと聞いていたが，実際に取り付けられている状況を見学した。当スナッバーの建屋側取付端には，セット後のチェックを示すベクテル社の確認マークがなされていた。

屋外の空気冷却器4基（約37 MWt/基）は，GL レベル内に据付けられ,比較的に高い排気ダクトであることが目についた燃焼ガス方式である。

空気冷却器の配置を図に示す。№1ループのみが安全上の対策として保護カバーがつけられている。予熱等はこの FFTF 施設を使って，崩壊熱除去の自然循環冷却テストが行なわれたと聞いたが，熱交との間に充分な落差がとってあるように見える。



建屋の出入口扉には，トルネド対策の為，扉を堅固なものとしてある旨記してあったが，設置場所の特異性によるものと思った。又，この FFTF の設置場所は,人里離れた砂膜の中に設けられ，一番近い施設（PWR 発電所）まででも5 km 以上離れており，このような場所への設置理由は， FFTF 個有のものでないことは明らかと思った。

以　上

Plutonium Production Reactors 2

Located along the Columbia River, eight of the nine production reactors at Hanford were shut down between 1965 and 1971 because of a reduced need for plutonium. In recent years extensive work has been carried out to dismantle nonradioactive facilities at some of these reactor sites. Plans are being developed to remove radioactive portions from these reactors during the 1980's as part of a program to further develop the capabilities to decommission outdated nuclear facilities.

PUREX 3

The PUREX (which stands for Plutonium Uranium Extraction) Plant is where Hanford's production reactor irradiated fuel is chemically dissolved and the plutonium and uranium removed and shipped to other Hanford facilities for further processing.

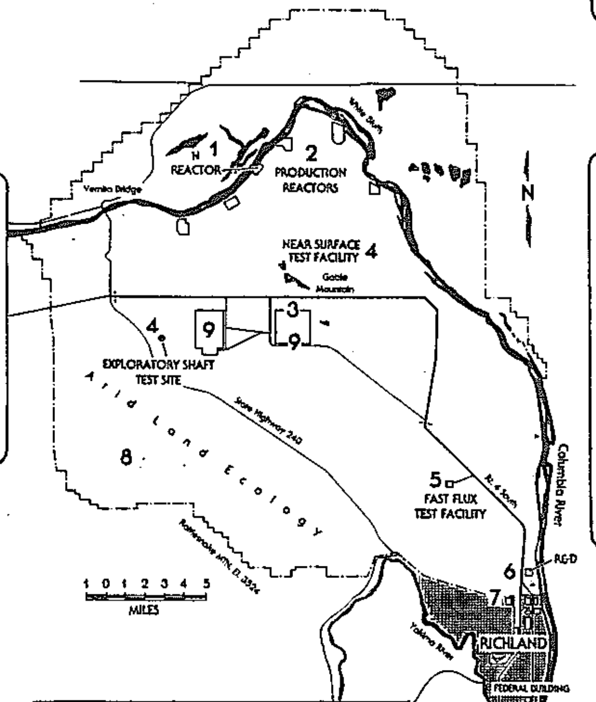
N Reactor-Hanford Generating Project 1

The N Reactor, Hanford's only remaining operating production reactor, produces plutonium for the nation's defense programs. The reactor also supplies steam to the adjacent Hanford Generating Project where the Washington Public Power Supply System generates 860 megawatts of electricity, enough to serve a city the size of Seattle. The two facilities produce approximately 4 billion kilowatt hours of electricity per year.

Basalt Waste Isolation Project 4

The Department of Energy is studying various geologic formations in the United States to locate suitable sites for underground repositories for nuclear waste. One geology being studied is the dense Columbia Basin Basalt flow that underlies the Hanford Site. As part of the Basalt Waste Isolation Project, a Near Surface Test Facility (NSTF) has been mined out of the side of a basalt outcropping in Gable Mountain in the center of the Hanford Site. Electric heaters have been implanted in the basalt to study the effects of heat on the rock.

The next phase of this program is the construction and operation of a 4,000' exploratory shaft test facility.



Defense Waste Management 9

Radioactive wastes generated in the production of defense materials at Hanford are stored and managed on a plateau near the center of the site. Older high-level liquids stored in tanks are being solidified into a salt form; improved tanks are being built to store remaining liquids; and technology is being developed and options evaluated for ultimate disposal of all defense wastes at Hanford.

Breeder Reactor Development 5

Hanford plays a prominent role in the development of Liquid Metal Fast Breeder Reactors, a new generation of nuclear plants which can extend fuel supplies for centuries. The focal point of this effort is the Fast Flux Test Facility (FFTF), the world's largest and most sophisticated reactor for testing breeder fuels, materials and components.

The FFTF is located in the 400 Area Fuels and Materials Development Complex which includes the Fuels and Materials Examination Facility; Fuels Storage Facility, and the Maintenance and Storage Facility.

HANFORD TODAY:
A Major Department of Energy Field Installation

- 570-square mile site
- Multiprogram multicontractor operation
- $800 million budget
- 12,000 Federally - funded employees
- Missions of national significance

Environmental Research 8

The 120-square mile area of the Hanford Site located west of Highway 240 is a dedicated site for the study of the ecology of the semi-arid, steppe-desert region. Known as Project ALE (Arid Lands Ecology) the preserve is used by Hanford scientists to study the interaction between plants, animals, insects, climate and natural phenomenon without the intrusion of man.

The entire Hanford Site was designated a National Environmental Research Park (NERP) in 1977, making it available to qualified offsite scientists for controlled environmental research.

Research and Development 6

Department of Energy contractors at Hanford are in the forefront of research and development in virtually all forms of energy. Research on fossil, solar, nuclear fission and fusion energy, is underway, primarily in the 300 Area just north of Richland. Extensive environmental, biomedical and materials research is also underway.

Work is also being conducted on converting liquid radioactive wastes into glass. This material, similar to pyrex, provides an excellent form for long-term storage in an underground formation. Currently nearly half of the Hanford budget is devoted to energy research and development.

Fusion Materials Research 7

The Fusion Materials Irradiation Test Facility (FMIT) proposed for the southeast corner of the Hanford Site will enable testing and development of alloys for potential use in advanced fusion reactor systems. The FMIT will be the first facility in the world offering irradiation test conditions similar to those anticipated in fusion power reactors.