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ORNL — PWR-BDHT Analysis Procedure A Preliminary Overview

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A PRELIMINARY OVERVIEW

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NOTICE This document contains information of preliminary nature. It is subject to revision or correction and therefore does not represent a final report.

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UNION CARBIDE CORPORATION, NUCLEAR DIVISION
operating the
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Oak Ridge Y-12 Plant . Paducah Gaseous Diffusion Plant
for the
DEPARTMENT OF ENERGY

CONTENTS

AUTHOR'S FOREWORD

This document is the last in a series of 10 documents relating to the author's involvement with the computer analysis section of the ORNL-PWR Blowdown Heat Transfer Separate-Effects Program. It is written on the eve of the author's transfer from the Computer Sciences Division's support for this analysis effort and, as such, represents the author's understanding of the analysis procedure from the computer science point of view. The engineering point of view is represented only as required to describe the computer science view of the project.

Further, this document is primarily the author's record of those concepts, suggestions, and occasional insights relating to the project as gained during the last 18 months. No commitment of either the Computer Sciences Division or of the analysis group is expressed, implied, or intended.

Steven B. Cliff

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R. A. Hedrick is responsible for defining the goals of this analysis procedure and many of its parts. He provided guidance throughout the project.

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ABSTRACT

The computer programs currently used in the analysis of the ORNL-PWR Blowdown Heat Transfer Separate-Effects Program are overviewed. The current linkages and relationships among the programs are given along with general comments about the future directions of some of these programs. The overview is strictly from the computer science point of view with only minimal information concerning the engineering aspects of the analysis procedure.

INTRODUCTION

The ORNL-PWR Blowdown Heat Transfer Separate-Effects Program [1] utilizes many computer programs in the analysis of data gathered by the Computer Controlled Data Acquisition System (CCDAS) [1] on the Thermal Hydraulic Test Facility (THTF). This document will give an overview of these programs and their interrelationships as they currently exist and as they may appear in the future. Hopefully, guidance will be given to the outside observer concerning the structure of the analysis procedure, while enabling the insider to better extend, change, and streamline this analysis procedure.

For the purposes of this discussion, data from the THTF-CCDAS is of two types, the steady-state information and the transient information [2], [3]. Starting from these two experimental data inputs, analysis proceeds to output of computer-generated prints and plots in a variety of forms produced by several programs. The cornerstone programs currently are COBRA [4], ORINC [5], ORTCAL [6], PINSIM [7], and various versions of RELAP [8], [9], [10]. Supportive programs include the plotters REDPLOT [11], ORCPLT [12], BDHTPLOT [13]; the interfaces OXREPT [14], OTOCI [15]; and the utilities RINPUT [16], RLPCPY [17], and EUCOPE [18]. While a summary of each of these programs and their interrelations follows, the reader needs a knowledge of the individual documents for a full understanding of this overview.

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CORNERSTONES

COBRA

Thermal-hydraulic analysis of rod bundles is provided by COBRA [4]. As originally developed, COBRA used empirical relationships for the determination of surface heat fluxes and surface temperatures. However, a local version [19] enables the external specification of these quantities, and it produces a plot tape suitable for REDPLOT. Figure 1 depicts the data paths involving COBRA. Surface heat fluxes and surface temperatures are determined by ORINC, and transformed by OTOCI into a form acceptable to COBRA, which then feeds REDPLOT plotting information. COBRA, like all the programs in this document, requires card input and produces printed output which are not described here.

ORINC

The Oak Ridge Inverse Conduction Code, ORINC [5], solves the inverse heat transfer problem in the electric pins of THTF. Given transient internal temperatures from the THTF-CCDAS, physical properties of rod materials from ORTCAL, and bulk fluid conditions near the rod from RLPORINC, ORINC determines a transient "surface heat flux," "heat transfer coefficient," and a "surface temperature." Output from ORINC is in two forms: an ORINC plot tape, read by ORCPLT, REDPLOT, BDHTPLOT, and OTOCI; and an interface tape read by OXREPT.

Figure 2 depicts the ORINC paths. RLPORINC must have a core model to determine the fluid conditions for ORINC. A version of RELAP, RLPORINC, must have hydraulic conditions specified at the inlet and outlet of the core. These specifications could come from RELAP4 using a loop

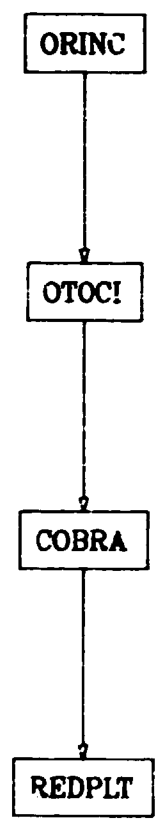
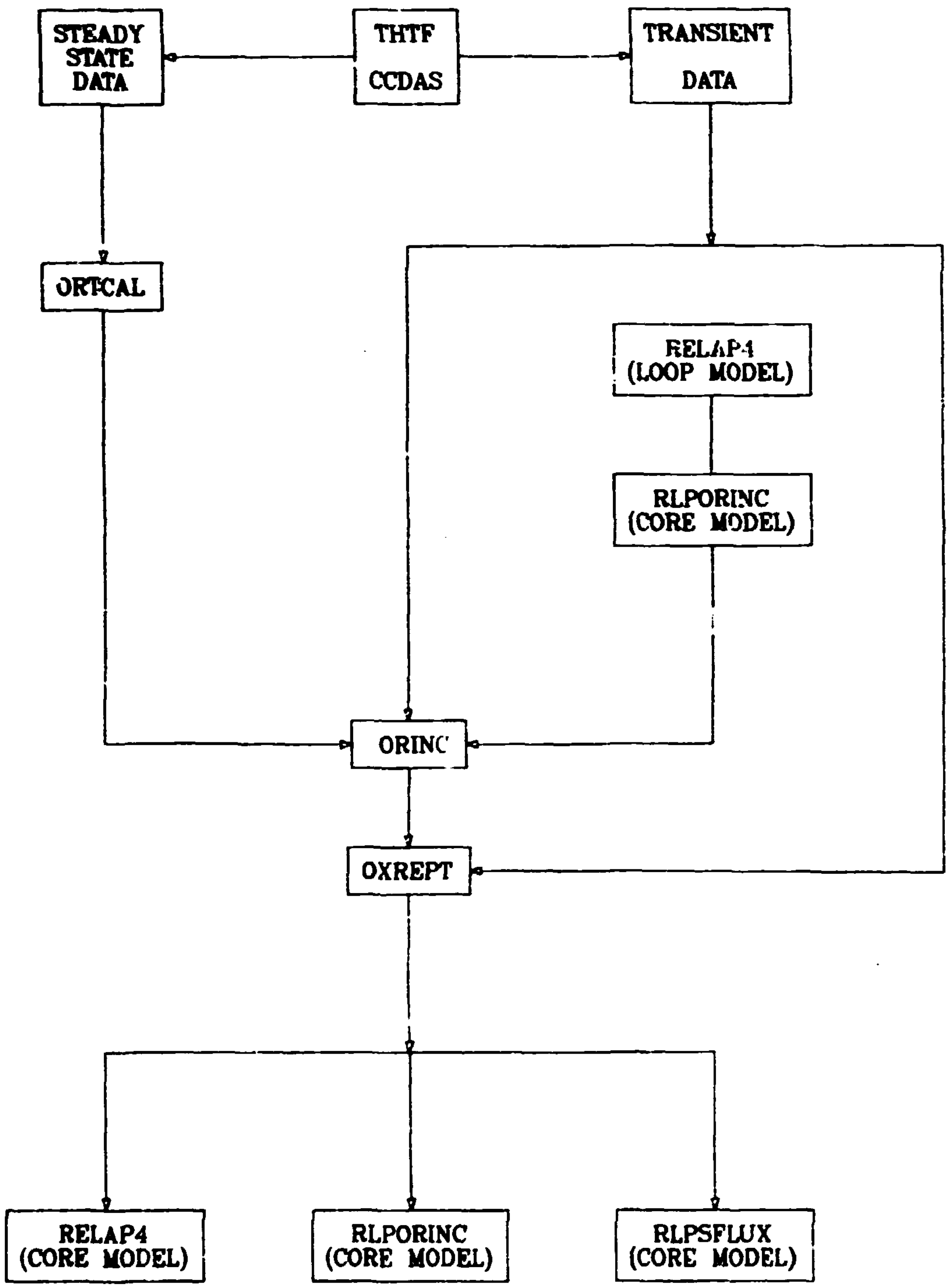


Figure 1

COBRA Paths



NOTES. LINKS TO PLOTTING PACKAGES NOT SHOWN
ITERATIONS INVOLVING RELAP TO RELAP CONNECTIONS NOT SHOWN

Figure 2

ORINC Paths

model or from experimental conditions as transformed by OXREPT. Note that experimental bounding must come after a first iteration starting with ORINC, to OXREPT before RLPORINC (core model) with experimental hydraulic bounds can be executed.

ORCTAL

The Oak Ridge Thermocouple Calibration System, ORCTAL [6], is a series of four programs which determine physical properties from ORINC from THTF-CCDAS data. ORCTAL's output is an interface tape to ORINC.

PINSIM

The Nuclear Fuel Pin and Electric Pin Simulator Transient Analysis Program, PINSIM [7], currently does not directly accept data from other programs. It does produce a plot tape for REDPLT.

RELAP

There are three versions of the Reactor Linearized Analysis Program, RELAP, in use in this analysis procedure. The key version is RELAP4, MOD5, UPDATE2, as released by the Idaho National Engineering Laboratory [8]. Referred to as RELAP4 in this document, it is the root of the other two ORNL-generated versions, RLPORINC, RELAP with ORINC Interface [9], and RLPSFLUX, RELAP with Surface Flux Modifications [10]. RELAP is used with two types of models, loop and core. The loop models include modeling of the entire THTF, but only coarse modeling of the core section is possible. The core models provide a more accurate analysis of the core section while requiring the specification of hydraulic conditions at the inlet and outlet of the test section. The time-dependent volume option of RELAP is vital to this analysis technique whereby the hydraulic boundary conditions are obtained from a RELAP Plot/Restart tape. This tape can be produced by RELAP4 with a model giving theoretical conditions or by the OXREPT interface program giving experimental conditions. Thus hydraulic bounds for RELAP4, RLPORINC and RLPSFLUX can be either theoretical or experimental. Additionally, RLPSFLUX can be bounded thermally by processed experimental conditions from ORINC through OXREPT.

Among the input and output of each of these three versions of RELAP are RELAP Plot/Restart tapes. Additionally, RLPORINC specifies local fluid conditions for ORINC through its interface output. Of course, any of the Plot/Restart tapes can be plotted by REDPLT and BDHTPLOT. Figure 3 depicts the RELAP Data Flow Paths.

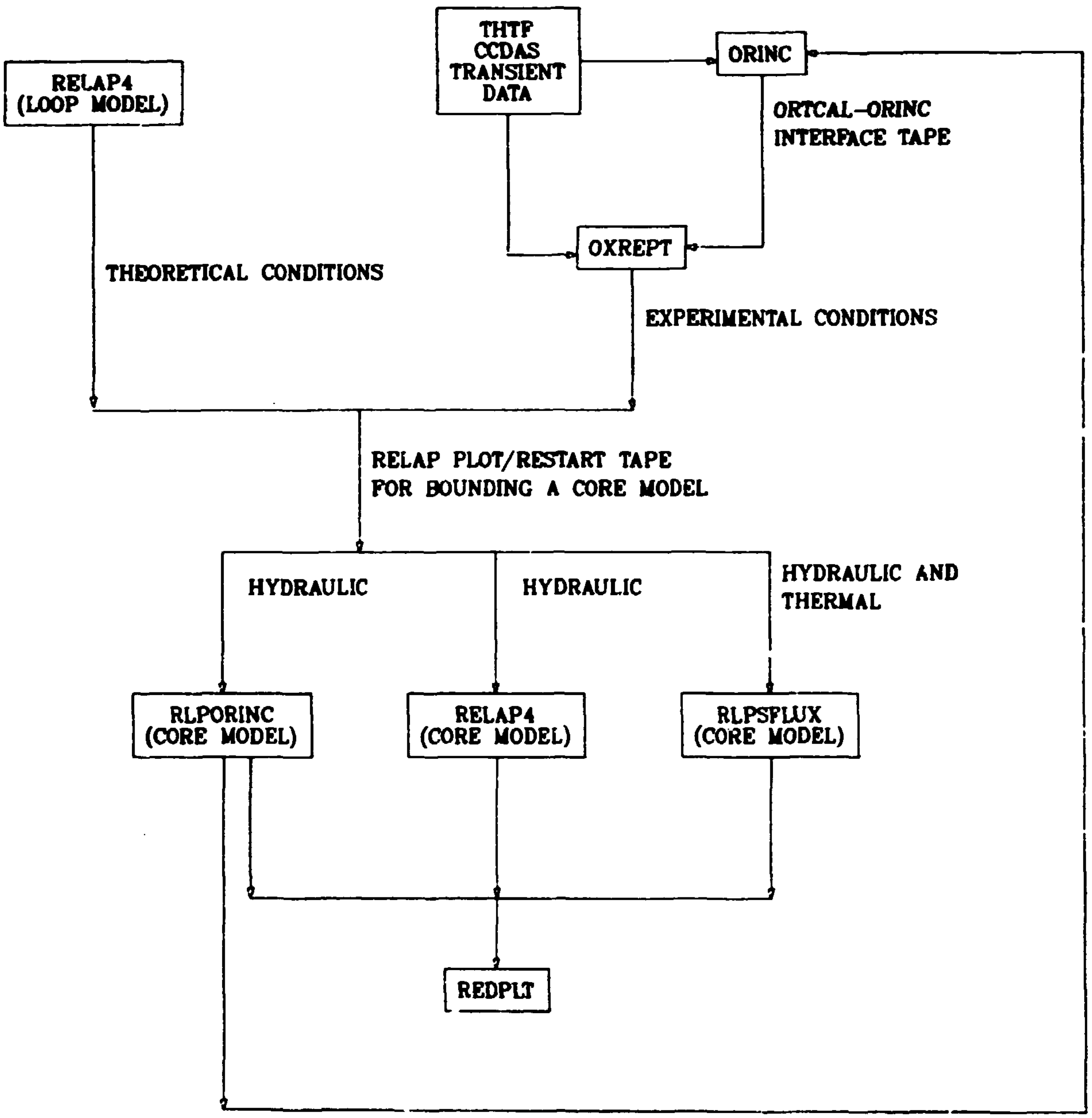


Figure 3

RELAP Paths

PLOTTERS

REDPLT

The RELAP and Experimental Data Plotter, REDPLT [11], not only can plot RELAP and transient experimental data from THTF-CCDAS, but also ORINC, COBRA and PINSIM plot tapes. REDPLT's primary product is history plots, although it is capable of listing or punching any of the information it can read.

ORCPLT

The ORINC plotter, ORCPLT [12], produces radial distributions and history plots of ORINC data.

BDHTPLOT

Plots of variables along a rod or any set of volumes or slabs at a specific time are produced by BHDTPLOT [13]. RELAP plot tapes, ORINC plot tapes and experimental data tapes are used by BDHTPLOT.

INTERFACES

OXREPT

The ORINC and experimental data to RELAP plot tape interface, OXREPT, combines ORINC plot tapes and experimental data into RELAP plot tapes. Heat transfer information is obtained from the ORINC data while fluid conditions at the spool pieces are obtained from the experimental data. After appropriate calculations and transformations, the RELAP plot tape produced will have slabs and volumes whose conditions have origins in experimental data. This plot tape may then be used with any of the RELAP versions to bound fluid conditions experimentally. Additionally, RLPSFLUX can use the information to experimentally bound the heat transfer package of RELAP.

OTOCI

The ORINC to COBRA interface, OTOCI, converts heat transfer data from an ORINC plot tape into a specialized input tape to a local version of COBRA, thereby bounding it experimentally.

UTILITIES

RINPUT

The RELAP input deck modifier, RINPUT [16], takes RELAP data decks and modifies the steady-state conditions as required to begin a RELAP run.

RLPCPY

The RELAP Plot/Restart Tape Copy-Edit Program, RLPCPY [17], copies RELAP Plot/Restart tapes while doing minor editing as requested by the user.

EUCOPE

The Engineering Units Tape Copy-Edit Program, EUCOPE [18], copies and edits the transient data from the THTF-CCDAS.

SUMMARY

The 15 programs described thus far form a part of the analysis procedure for the ORNL — PWR-BDHT Program as it currently exists. Figure 4 is an overview of all the paths the data in these programs takes.

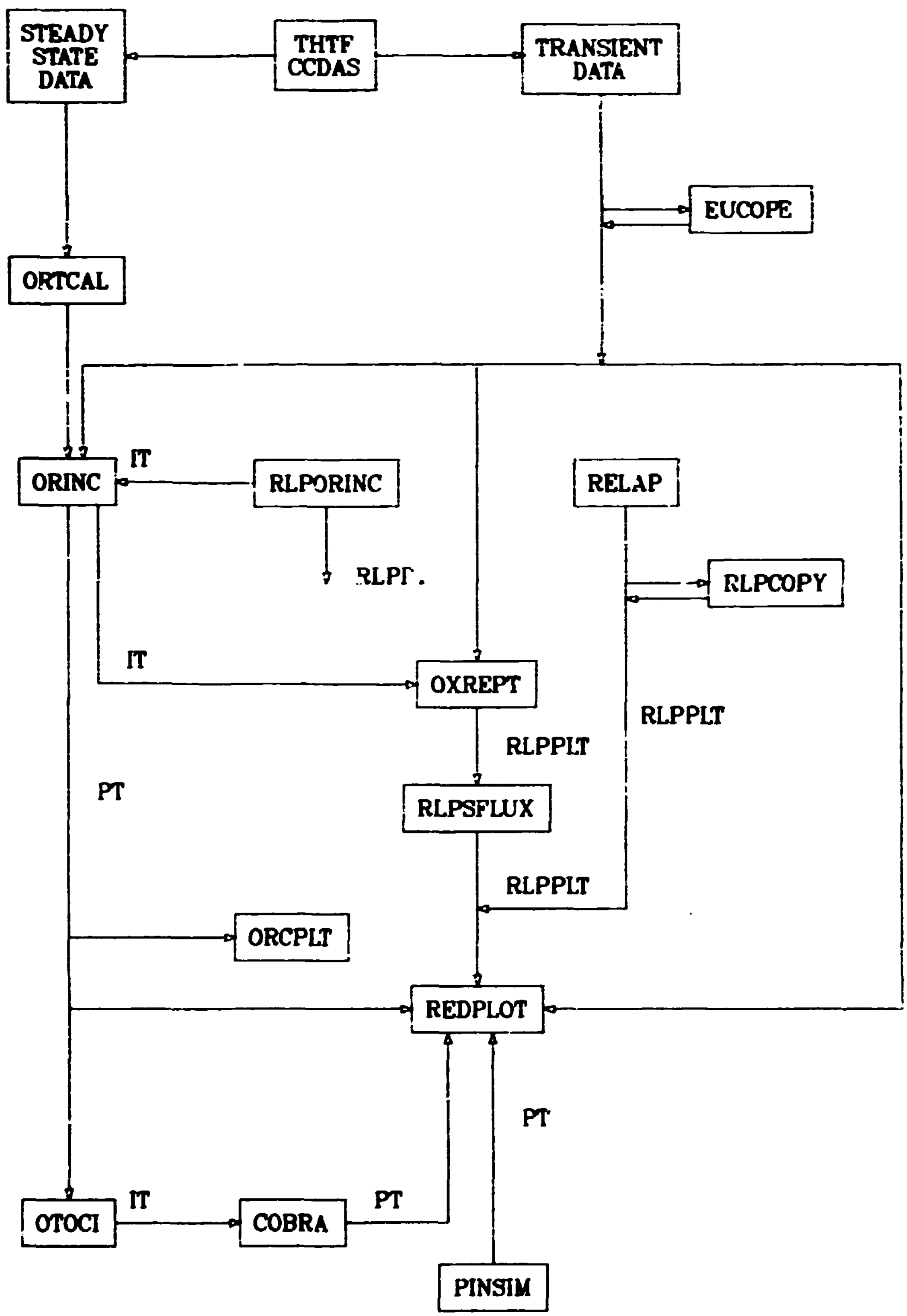


Figure 4

Program Connection Path

SUGGESTIONS FOR FUTURE DEVELOPMENT

INTRODUCTION

Several suggestions on the future of some of these programs are given. Based upon the author's own understanding, they do not represent commitments of the project and are primarily intended to aid those who will continue the author's work.

The technique, first implemented by RELAP4, of using the Plot or Plot/Restart file as both input and output to a program should be extended where appropriate. RLPSFLUX has already used it for thermal information. (RLPORINC did not use it since ORINC required information not kept on the RELAP Plot Tape.) COBRA should be modified to follow this technique (although this could be implemented in the next version of COBRA).

Any future versions of ORINC should also utilize this technique, requiring the writing of a new interface which will take the data from THTF-CCDAS, ORTCAL and RLPORINC and transform it into a redefined ORINC plot tape which would then be read by the calculation portion of ORINC. Considerable discussions with those involved with ORINC has made apparent their receptiveness to this rearrangement of ORINC. ORINC's inversion technique, while accurate, may not be the optimum available. It, and the input/output algorithms, should be reviewed in any future versions.

PINSIM, should it ever need interface inputs, should accept these from its Plot/Restart tape.

OXREPT should be broken into two parts, an ORINC to RELAP plot tape interface and an experimental data to RELAP plot tape interface. Then, a program which already exists could be used to merge these outputs into the one tape needed for RLPSFLUX. The RELAP Plot Tape Merging

Program, REPMEP [20], provides this capability. REPMEP reads up to three RELAP Plot/Restart plot tapes, merging them into one such tape. (The analysis group has shown a desire to combine RELAP4 loop model data with THT -CCDAS data and ORINC data in bounding a RELAP core model.) Any future interfaces to RELAP should be made through its Plot/Restart input, if possible. In particular, a time-dependent junction version of RELAP has already been discussed. Further, if any other links to RELAP through its plot tape are to be made, the links should each have a single input, and REPMEP should be used to merge multiple inputs to RELAP. The suggested breaking of OXREPT illustrates this idea.

REPMEP itself could be extended to allow various calculations involving the plot data; for example, averaging of data may be desirable under certain circumstances. Further, REPMEP's modularity will make it a good base for writing an ORINC or PINSIM plot tape merge program, if ever needed.

As mentioned earlier, the time-dependent junction version of RELAP should probably start with RLPSFLUX, since the plot tape handling routines have already been modified and the extensions to handle the time-dependent junction are fairly straightforward. The actual use of the junction data in the solution process of RELAP will probably be very similar to that used already for fill table values. Thus, the fill table routines should be carefully checked for help in implementing time-dependent junctions. When the time-dependent junctions feature has been implemented, the fill table renumbering may no longer be needed and possibly could be removed. Another reason that RLPSFLUX is the suggested start of this modification to RELAP stems from the desire of the analysis group to have thermal bounding available for use with the time-dependent junctions. It should not be necessary to implement time-dependent junctions in RELAP4, since RLPSFLUX will duplicate RELAP4 calculations if the thermal bounding is not specified in its input.

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