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THE LOS ALAMOS NUCLEAR PLANT ANALYZER: AN INTERACTIVE POWER-PLANT SIMULATION PROGRAM*

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ABSTRACT

The Nuclear Plant Analyzer (NPA) is a computer-software interface for executing the TRAC or RELAP5 power-plant systems codes. The NPA is designed to use advanced supercomputers, long-distance data communications, and a remote workstation terminal with interactive computer graphics to analyze power-plant thermal-hydraulic behavior. The NPA interface simplifies the running of these codes through automated procedures and dialog interaction. User understanding of simulated-plant behavior is enhanced through graphics displays of calculational results. These results are displayed concurrently with the calculation. The user has the capability to override the plant's modeled control system with hardware-adjustment commands. This gives the NPA the utility of a simulator, and at the same time, the accuracy of an advanced, best-estimate, power-plant systems code for plant operation and safety analysis.

INTRODUCTION

The Nuclear Plant Analyzer (NPA), a US Nuclear Regulatory Commission (NRC) sponsored project, provides a more powerful and convenient user interface for executing the major power-plant systems codes: the Transient Reactor Analysis Code (TRAC) (Ref. 1) and the Reactor Leak and Power Safety Excursion Code (RELAP5) (Ref. 2). Los Alamos National Laboratory and Idaho National Engineering Laboratory (INEL) jointly are developing the NPA. Technology Development of California (TDC) Inc. is developing the Nuclear Plant Data Bank (NPDB) to be used by the NPA for TRAC or RELAP5 input data preparation.

TRAC and RELAP5 are advanced, best-estimate, thermal-hydraulic systems codes used to analyze the operation and safety of nuclear, as well as conventional, power plants. Weeks to months of human effort are required to prepare and quality-assure input data, to execute TRAC or RELAP5 utilizing that data, and to interpret the results of the calculation. The NPA is designed to automate most of this procedure. In addition, the NPA provides interactive capability to the user during the calculation. Calculational results are

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presented in graphics displays as the calculation proceeds. Control of the plant, as defined by the input data, can be overridden at any time during the calculation by hardware-adjustment commands issued by the NPA user. The NPA handles all interaction with the computing environment. This allows the user's attention to be devoted fully to the transient event being analyzed.

The NPA provides TRAC and RELAP5 users with an analysis tool that can reduce significantly the time and effort required to analyze power-plant transients. Opportunities for introducing human error into the analysis are reduced greatly through automating most of the data manipulation. No experience is needed to run these complex computer codes with the NPA. Reading and understanding a sizable user's manual are no longer prerequisites. Now, analysts need only the expertise to understand the complex thermal-hydraulic phenomena occurring in power-plant transients.

The NPA has been under development for two years. Several more years will be required to develop its full capability. Thus far, an NPA to drive TRAC has been developed at Los Alamos, and a separate NPA to drive RELAP5 has been developed at INEL using common guidelines. This was done to facilitate the programming and testing of NPA interactive coupling to each code. With this now completed, the next step will be to combine these two NPA versions utilizing the best features of each and to incorporate software to access and utilize the NPDB. In this paper, the current TRAC-based NPA developed at Los Alamos will be described.

HARDWARE

The Tektronix 4115B, intelligent, high-resolution color-graphics terminal has been selected as the NPA workstation. In addition, it has data storage configured as two hard-disk drive units and two floppy-disk drive units, a color hard-copy unit, and a 4800/9600-baud modem to communicate with the mainframe computers at Los Alamos or INEL. The TRAC/RELAP5 thermal-hydraulic calculation is executed on a Cray-1 or a Control Data Corporation 7600/Cyber 176 mainframe computer.

Currently, the NPA software and graphics-data manipulation are executed on the mainframe computer as well. In this form, the NPA can be run on a Tektronix 4105, 4107, or 4109 nonintelligent, color-graphics terminal. Eventually, when the two NPA versions are combined, these functions will be downloaded to execute on the 4115B intelligent workstation. The capability for executing everything on the mainframe computer, however, will be maintained so that a less expensive, nonintelligent workstation can be used as well.

SOFTWARE STRUCTURE

A block diagram of the Los Alamos NPA software structure is shown in Fig. 1. Computer programs are shown as boxes, and data files are shown as ellipses. There are three programs that execute on the same computer using different execution suffixes in a time-shared computing environment. The NPA executive program executes on suffix A; it generates the terminal's graphics display and communicates with the NPA user, TRAC, and the Common File System (CFS) for accessing and permanently storing files. The IOGRF program executes on suffix D; it reads data from the TRAC graphics-data output file TRCGRF1 and writes a selected portion of that data to the NPA executive graphics-data

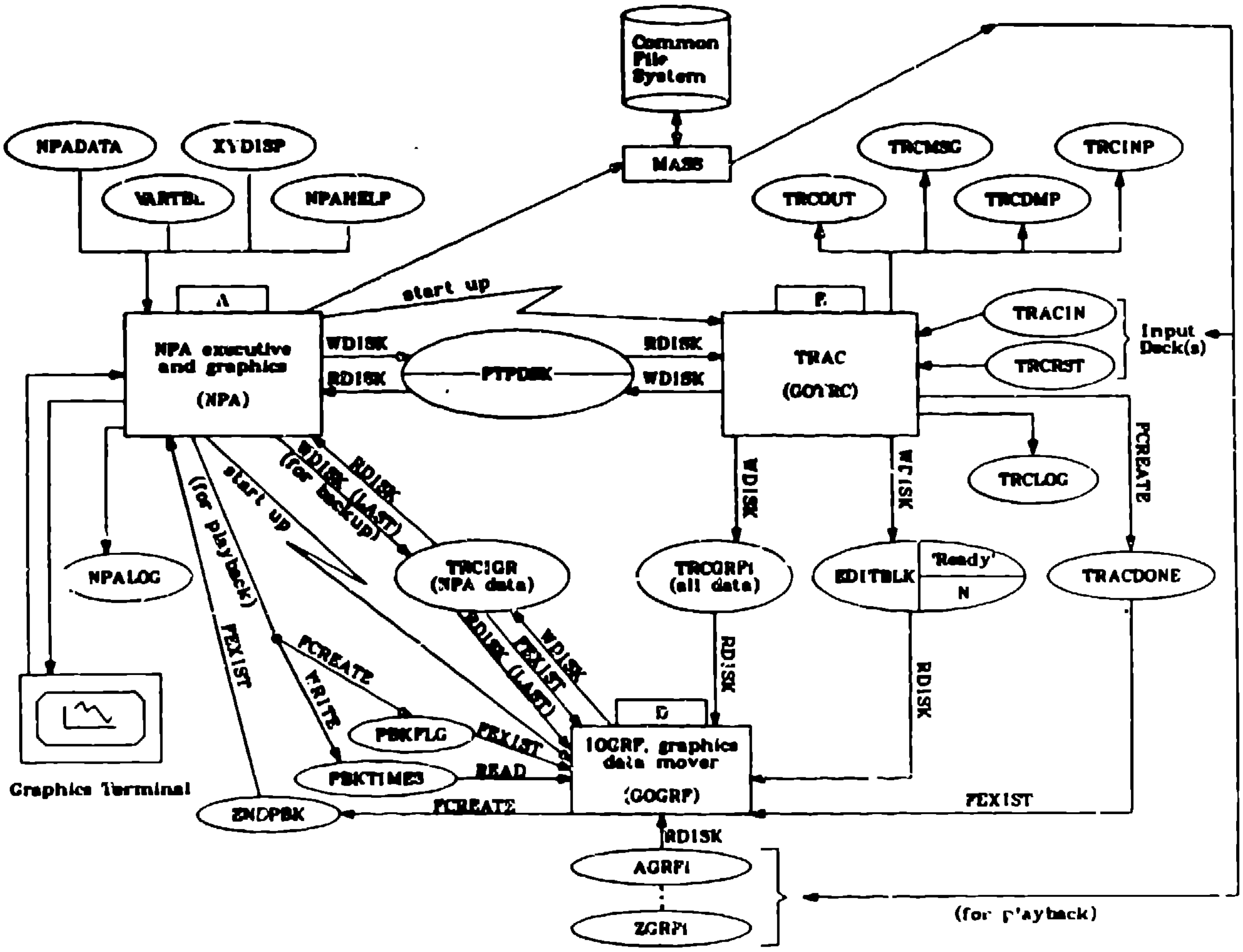

Fig. 1.
A block diagram of the NPA software structure.

input file TRCIGR. The TRAC program executes on suffix E; it performs the power-plant, thermal-hydraulic calculation.

The data files reside on a local storage disk and perform three functions: to communicate data and information between programs, to provide input data to a program, and to store output data from a program. The files TRCGRF1, TRCIGR, EDITBLK, TRACDONE, PTPDSK, PBKTIMES, PBKFLG, and ENDPBK communicate between programs. Files NPADATA, VARTBL, XYDISP, NPAHELP, TRACIN, and TRCRST provide input data to the NPA and TRAC programs. Files NPALOG, TRCLOG, TRCGRF1, TRCOUT, TRCMSG, TRCDMP, and TRCINP store output data from the NPA and TRAC programs.

Files TRCGRF1 and TRCIGR, as described earlier, are used to transfer graphics data from the TRAC program to the NPA executive program using the IOGRF program. The NPA executive program also uses file TRCIGR to send to program IOGRF the number of time edits of graphics data (LAST) to be retained in file TRCIGR for a backup/branch calculation. File EDITBLK sends to program IOGRF the message 'Ready' and the number of time edits already written by TRAC on file TRCGFR1. File TRACDONE is created by TRAC just before terminating a TRAC run. Its presence serves as a flag to program IOGRF to terminate execution as well because no further data will be written to the TRCGRF1 file by TRAC.

File PTPDSK communicates information between the TRAC and NPA executive programs. The NPA sends user commands affecting TRAC and NPA messages to the TRAC program; TRAC sends its status data and TRAC messages to the NPA executive program. At present, PTPDSK is a disk file. Communications with it, however, have been designed to allow it to be replaced eventually with a direct process-to-process (PTP) protocol communication path between the TRAC and NPA executive programs. A direct PTP path would eliminate much of the time delay experienced with disk read/write operations and with written data being buffered in blocks for efficiency.

Files PBKTIMES, PBKFLG, and ENDPBK communicate the problem time intervals that graphics data in previously generated TRCGRF1 files (renamed AGRF1, BGRF1, ..., ZGRF1) are to be played back through file TRCIGR to the NPA executive program. In this NPA operating mode, the TRAC program is not executed. The creation of file PBKFLG flags the IOGRF program to read the problem time intervals from file PBKTIMES; to read the desired graphics data from TRCGRF1 files AGRF1, BGRF1, ..., ZGRF1; and to write it to file TRCIGR. Program IOGRF signals completion of this task to the NPA executive program by creating file ENDPBK.

The remaining files provide input data to and store output results from the NPA executive and TRAC programs. Files NPADATA, VARTBI, and XYDISP contain problem-dependent information that the NPA executive program uses to create the graphics displays. Information for an on-line help package for the NPA user is contained in file NPAHELP. The two input files, TRACIN and TRCRST, are the standard TRAC input and restart data files, respectively. The NPALOG and TRCLOG files contain a record of all communications between the NPA user, the NPA executive program, and the TRAC program. This encompasses commands, messages, and responses (when the message is a question). Files TRCGRF1, TRCOUT, TRCMSG, TRCDMP, and TRCINP are the standard TRAC output files containing graphics data, thermal-hydraulic state edits, execution messages, data dumps, and TRAC input-format data, respectively.

PROBLEM STARTUP

The NPA is run by executing the NPA executive program. Input-data files NPADATA, VARTBL, XYDISP, and NPAHELP must be created or retrieved from CFS storage by the user before the run. Eventually, the NPA executive program will be automated to do this. A menu system is available to allow the user to select a desired power plant and to have the NPA executive program access the plant's TRAC input-data files TRACIN and TRCRST from CFS storage. At present, these files are available for only the Three Mile Island (TMI) Unit 2 and Calvert Cliffs power plants. An example sequence of four menu displays is shown in Fig. 2. Positioning the + cursor nearest to an item and hitting the space-bar key or typing the number of the item brings up its subdirectory menu on the video screen. The screen displays shown in Fig. 2 and in subsequent figures are black and white copies of actual screen displays made by the color hard-copy unit.

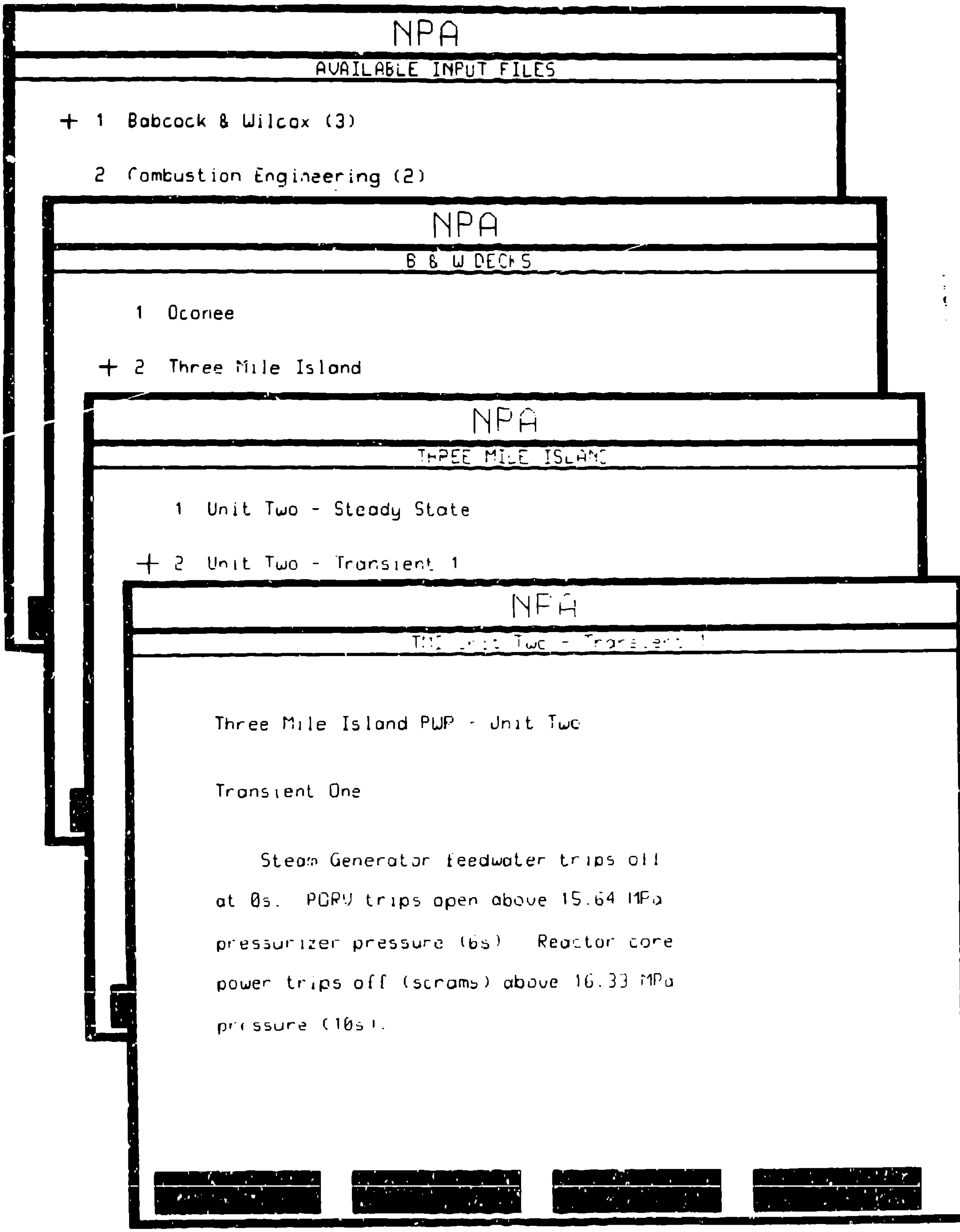

Fig. 2.
Four sequential screen displays selected by the + cursor from the hierarchical menu system.

For each power plant, steady-state and transient input-data files are available. There is only the TRACIN file for steady-state analysis, because it is an initial TRAC calculation. Transient analysis requires file TRCRST as well as TRACIN, because it is the restart of a previous TRAC run (the end of the steady-state calculation or the restart at some time during a transient calculation). Restart-data file TRCRST is the renamed data-dump file TRCDMP created by TRAC in a previous run. The menu system may be bypassed if files TRACIN and TRCRST were created or accessed from CFS storage by the user before the run. Eventually, the menu system will provide the user with the capability to create file TRACIN using the geometric and operational data from a desired power plant stored in the NPDB. Numerical modeling information, which also is required to create TRACIN, would be obtained through interactive dialog with the user.

With TRACIN and TRCRST as local files, the NPA executive program starts the IOGRF and TRAC programs on execution suffixes D and E, respectively. It then pauses execution until TRAC and IOGRF execute far enough to create and write graphics data to the TRCGRF1 and TRCIGR files, respectively. At this point, TRAC and IOGRF pause execution as well. The NPA executive program then initializes the graphics display and the TRAC status as being "paused" on the video screen. The problem setup and calculation startup are now complete. An NPA-user command is needed now to continue with the interactive TRAC calculation.

SCREEN DISPLAYS

The video-screen display is subdivided into two areas: the upper 84% of the screen is for the graphics display and the lower 16% is for five lines of data communications with the NPA user. Three different types of graphics displays currently are available: time-history plots, a power-plant display of generic data, and a TRAC-noding display of detailed data. The five communication lines consist of two lines for TRAC-status information, one line for messages or questions to the NPA user, and two scrolling dialog lines for entering NPA-user commands and responses.

An example display of six time-history (x-y) plots is shown in Fig. 3. This display can have from one to six time-history plots with one to three function curves (in green, yellow, and white) on each plot. The number of such displays and the form of each is defined by file XYDISP. The NPA user is given the capability to define or modify the form of these displays interactively at the terminal.

Examples of a TMI Unit 2 power-plant display of generic data and a TRAC-noding display of detailed data are shown in Figs. 4 and 5, respectively. Generic and detailed data, defined by files NPADATA and VARTBL and written to file TRCIGR by program IOGRF, are shown in Table I. The form and content of these schematic displays are programmed currently in the NPA executive program. Eventually, they will be generated internally by the NPA executive program from the geometric and numerical-modeling information in the TRACIN and TRCRST files and from the NPA user's interactively selected parameters. In these displays, the numerical values of generic data are shown and vary as TRAC problem time advances. The detailed-data parameter's value (void fraction of water in Fig. 5) is represented by color with a spectrum of colors spanning the parameter's value range. If Fig. 5 was shown in color as it is on the video-screen display, it would be easy to locate where steam and liquid

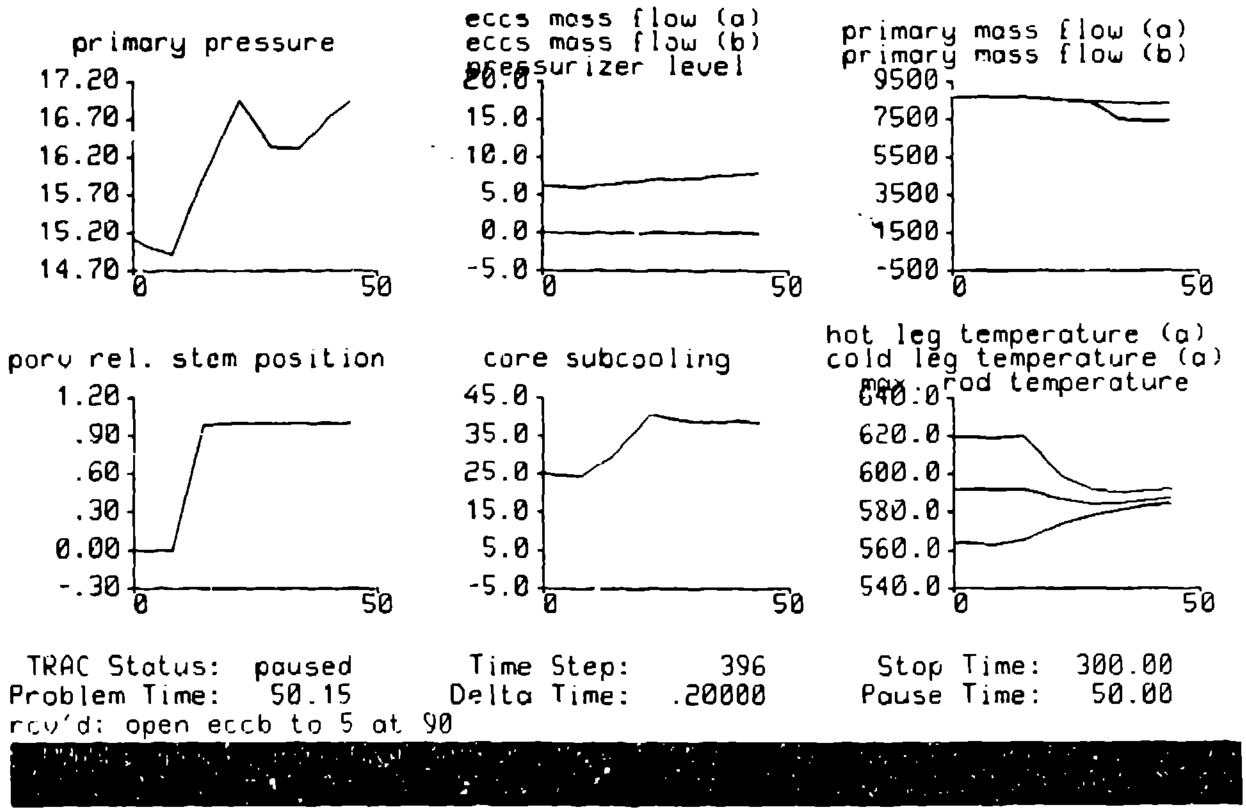

Fig. 3.
Time-history (x-y) plot display.

water reside and where change of void fraction is occurring (when viewed over time).

The TRAC-status information shown in the first two communication lines of the display is transferred from TRAC to the NPA executive program by file PTPDSK. This information consists of the execution state of TRAC (running, paused, end exit, or err exit), current TRAC problem time, current time-step number, size of the last time step, the NPA user-defined TRAC stop time, and the next pending TRAC pause time. While TRAC problem time also is shown in the graphics displays, the TRAC-status time is more current with the TRAC calculation. Eventually, when the PTPDSK file is replaced by a PTP protocol communication path between the TRAC and NPA executive programs, the time delay between the TRAC calculation and its status display will be reduced to only a few time steps. Having current TRAC-status information can be very important when issuing commands to TRAC "on the fly" (when TRAC is running).

The message/question line and the two dialog lines for NPA-user commands/responses provide the window for communication between the NPA executive program and the NPA user. Commands available to the NPA user are discussed in the next section. When the NPA executive program processes a command, the command in the form that it was received is displayed on the message line (see Figs. 3 and 4). Many possible messages and questions may appear on this line. Figure 5 provides an example of a backup question. When

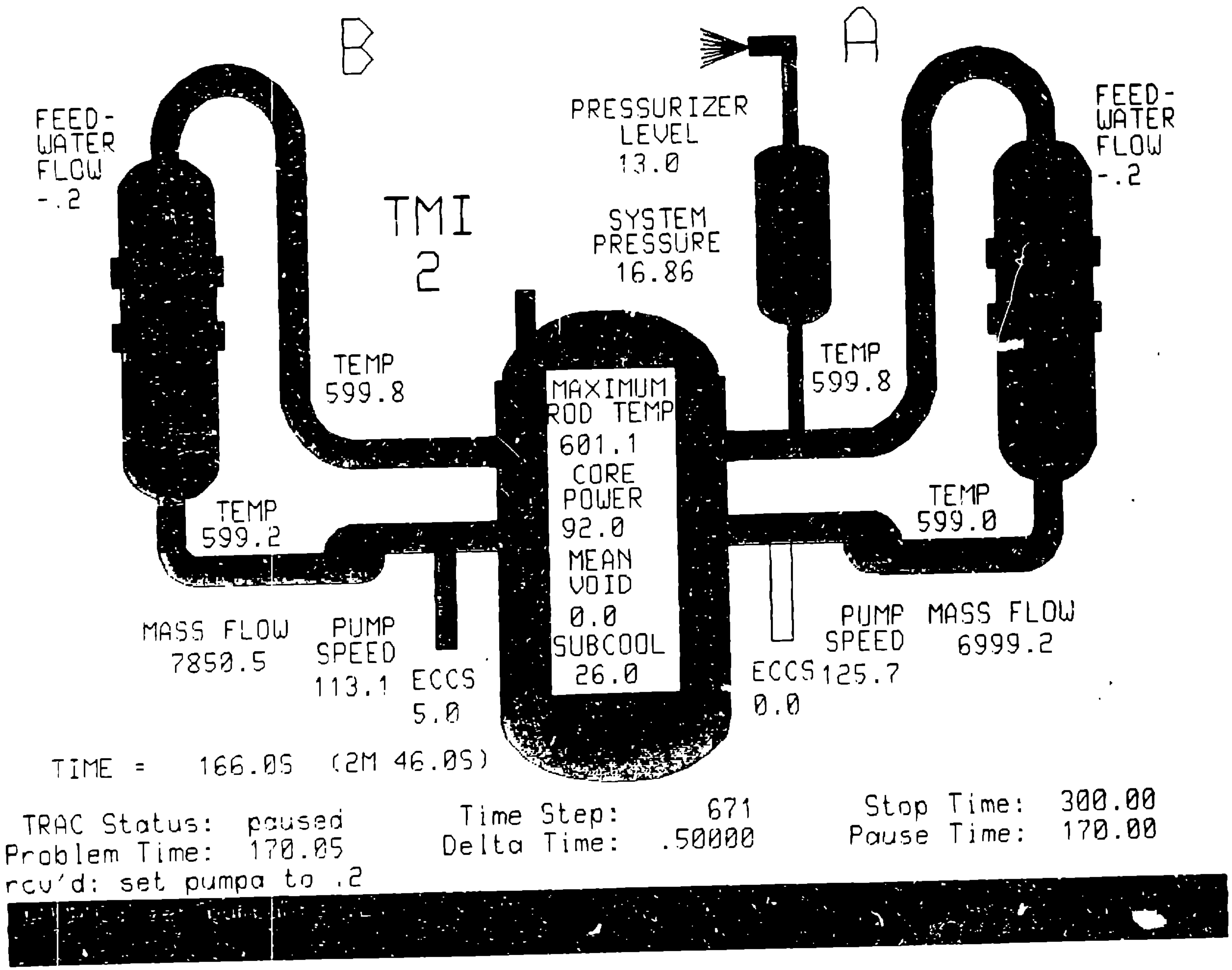

Fig. 4.
Power-plant display of generic data.

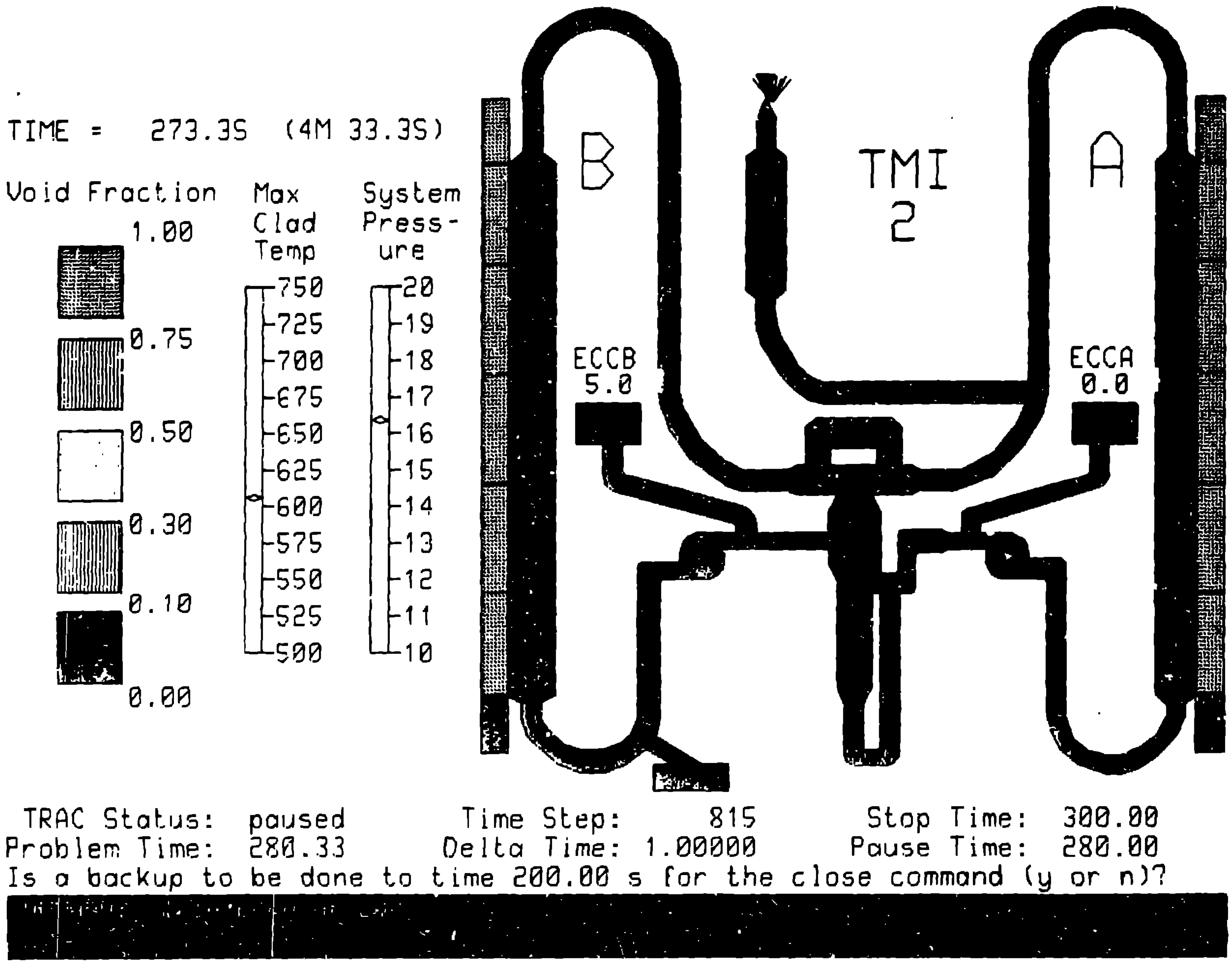

Fig. 5.
TRAC-noding display of detailed data.

TABLE I

NPA GRAPHICS-DATA PARAMETERS

Generic Data, Two-Loop (A and B) Plant

Name	Description	Name	Description
CLTA	Cold-leg temperature (A)	PRZRLV	Pressurizer level
CLTB	Cold-leg temperature (B)	PUMPSPA	Pump speed (A)
COREVOID	Core void fraction	PUMPSPB	Pump speed (B)
ECCSMFA	ECCS mass flow (A)	SECPA	Steam-generator secondary pressure (A)
ECCSMFB	ECCS mass flow (B)	SECPB	Steam-generator secondary pressure (B)
HLTA	Hot-leg temperature (A)	SGPRIMFA	Steam-generator primary mass flow (A)
HLTB	Hot-leg temperature (B)	SGPRIMFB	Steam-generator primary mass flow (B)
LDMFB	Let-down mass flow (B)	SGSECLVA	Steam-generator secondary level (A)
MAXRT	Maximum rod-cladding temperature	SGSECLVB	Steam-generator secondary level (B)
PORV	PORV relative stem position	SGSECMFA	Steam-generator secondary mass flow (A)
POWER	Reactor-core thermal power	SGSECMFB	Steam-generator secondary mass flow (B)
PRIMFA	Primary mass flow (A)	SUBCOOL	Reactor-core subcooling
PRIMFB	Primary mass flow (B)	SUPHEATV	Reactor-core vapor superheat
PRIP	Primary pressure		

Detailed Data

Name	Description	Name	Description
ALPHA	Void fractions in all mesh cells	TL	Liquid temperatures in all mesh cells
MFLOW	Mass flows at all mesh-cell interfaces		

a question is asked, the expected responses are shown within parentheses by the question mark. For a question with "(y or n)?", for example, the NPA user should respond with "y" for yes or "n" for no.

NPA-USER COMMANDS

After problem startup is completed, the TRAC and IOGRF programs are paused and the NPA executive program issues a "COMMAND:" prompt on the lower dialog line. Now, the NPA user controls execution of the NPA executive and TRAC programs with the commands shown in Table II. At some point, a RUN or STEP command must be entered to restart TRAC (and IOGRF) execution. The use of all other commands is optional. Commands can be entered at any time, even when TRAC is running. When TRAC is "running", the RETURN key must be hit first to get a "COMMAND:" prompt before entering a command. When TRAC is in a "paused", "end exit", or "err exit" state, the "COMMAND:" prompt appears automatically.

A command is implemented either by the NPA executive program or the TRAC program, as noted in Table II. The commands that the NPA executive program sends to TRAC through file PTPDSK are used to control hardware adjustment (currently valve closure, pump speed, reactor-core thermal power, and boundary-condition pressure and mass flow), TRAC output affecting the NPA, and TRAC execution. The quantities "value", "time", and "interval" in the commands are user-defined numbers (values). The quantity "command name" or "component name" is a word or letter string: "command name" is the first word of any command in Table II; "component name" is one of the letter-string names in Table III defining a hardware component or an adjustable action. Currently, the names in Table III are programmed in the NPA executive program

TABLE II

NPA-USER COMMANDS

To the NPA Executive Program

Command	Description
ADD value	Add a new x-y display numbered "value"
CANCEL (or C)	Cancel previous command entered
CHANGE (or CH) value	Change existing display numbered "value"
COPY	Make a color hard copy of the screen display
DISPLAY (or D) value	Bring up the screen display numbered "value"
END (or E)	End the NPA interactive run
HELP command name	Get help information on "command name"
RESET (or RESCALE or RS) keyword TO (or =) value/s	Rescale or redefine x-y plot coordinates or format
WCOPY	Make a color hard copy of the screen display with black and white reversed

To the TRAC Program

Command	Description
For Hardware-Adjustment Control	
CLOSE component name TO (or =) value AT time	Close a valve, pump, or fill to its "value" state
OPEN component name TO (or =) value AT time	Open a valve, pump, or fill to its "value" state
SCRAM AT time	Shut down the reactor-core thermal power
SET component name TO (or =) value AT time	Set the hardware-action state to "value"
TRIP component name AT time	Set the hardware-action state to its zero-value state
For TRAC-Output-Affecting-NPA Control	
DUMP AT time EACH interval	Redefine the TRAC data-dump time and interval
EDIT AT time EACH interval	Redefine the TRAC graphics-data edit time and interval
For TRAC-Execution Control	
BACKUP TO time	Perform a backup/branch procedure
PAUSE (or P) AT time	Pause the TRAC program
RUN (or R) TO (or FOR) time	Restart TRAC and set the TRAC-run end time
SPEED RATIO value	Limit TRAC to execute no faster than "value" times real time
STEP value	Restart TRAC and implement a PAUSE AT "present time plus value" command
STOP AT time	Set the TRAC-run end time

TABLE III

NPA "COMPONENT NAME" FOR HARDWARE COMPONENTS OR ADJUSTABLE ACTIONS

Name	Description	Name	Description
CONPA	Containment pressure at Loop A PORV	LDB	Letdown mass flow or velocity, Loop B
CORE	Reactor-core component	PORV	Pressure-operated relief-valve component
ECCA	ECC[a] mass flow or velocity, Loop A	PUMPA	Primary pump component, Loop A
ECCB	ECC[a] mass flow or velocity, Loop B	PUMPB	Primary pump component, Loop B
FWA	SGS[b] feedwater mass flow or velocity, Loop A	SGSECPA	SGS[b] pressure, Loop A
FWB	SGS[b] feedwater mass flow or velocity, Loop B	SGSECPB	SGS[b] pressure, Loop B

[a]ECC is emergency core coolant.

[b]SGS is steam-generator secondary side.

for a two-loop plant. Eventually, the user will be able to define these names and the hardware-adjustment actions they represent interactively.

For the TRAC commands, the "AT time", "TO (or =) value", and "EACH interval" are optional parts of the command. If "AT time" is not specified, the time for implementing the command's action defaults to the current TRAC problem time. If "TO (or =) value" is not specified, the default value is 0.0 for the CLOSE command and 1.0 for the OPEN command. An exception is the SET command that requires a "value" to be specified. The number "value" is either the physical value of the action (in SI units) or the fractional value (when between 0.0 and 1.0) of the 'fully deployed' operating state. If "EACH interval" is not specified, the default time interval is a very large number.

Commands received by TRAC are stored in a 'stack' arrangement. The commands are ordered first by type of command and then by implementation time. This allows the NPA user to enter any number of commands to TRAC with any number of the same type (PAUSE, for example) to be implemented at different future problem times. The user is able to 'stack' up commands for future implementation. While the NPA user adds commands to the stack, TRAC removes them from the stack after they have been implemented. The user can remove a command that has not been implemented from the stack by entering the same command again but with the four letters "AUTO" for its "value". This command also can be used, when there is not a similar command in the stack (same type and time), to return control of the hardware action to the hardware's AUTOmatic control procedure defined by TRAC's input data.

BACKUP/BRANCH AND PLAYBACK

During an NPA run, there are three occasions when TRAC is not executed on suffix E: problem setup, backup/branch, and playback. Problem setup was described earlier. Backup/branch and playback are user-convenient features of the NPA that will be described now. They greatly extend the analysis capability of the NPA for the user.

Backup/branch is a procedure implemented at any time during TRAC execution wherein the NPA user can stop the TRAC calculation and restart it at some earlier problem time. Restarting TRAC produces a separate identifiable run with its own TRAC input/output files; thus, it is a branch calculation. The NPA user initiates a backup/branch procedure by entering a "BACKUP TO time" command or one of the TRAC hardware-adjustment commands with an "AT time" that is before TRAC's current problem time. TRAC responds to the latter commands by sending a message to the NPA executive program asking if the user wishes to do a backup. The question is displayed to the NPA user (see Fig. 5). If answered "y" for yes, a backup procedure is initiated; if answered "n" for no, the "time" in the command is changed to the current problem time, the command is implemented, and TRAC continues its execution.

The NPA executive program performs the backup/branch procedure under interactive-dialog control from the NPA user. The NPA executive program sends a STOP command to TRAC. TRAC terminates execution with an "end exit" status; IOGRF terminates as well. The NPA user is given the options of renaming the terminated TRAC-run output files and storing them on the CFS. The actual renaming and storing are done by the NPA executive program. Files TRACIN and TRCRST are renamed by adding the number of this backup/branch (1, 2, 3, ...) to the end of their names. Then, a new TRACIN file is generated for the branch calculation; file TRCDMP is copied and named TRCRST. Only the graphics data before the backup time are saved in file TRCIGR by redefining the total number of time points of graphics data in TRCIGR to this lesser number. The NPA executive program then starts up TRAC and IOGRF to begin the branch calculation. When reading the TRAC command-stack parameters from file TRCRST, all commands to be implemented at and after the backup time are discarded. The TRAC data dump just before the backup time is used. To complete the backup/branch procedure, the NPA executive program automatically sends a "PAUSE AT backup time" command and the hardware-adjustment command that caused the backup (if such is the case) to TRAC.

Playback is a procedure for interactively analyzing on NPA graphics displays all the graphics data in existing TRCGRF1 files (renamed AGRF1, BGRF1, ..., ZGRF1) from previous TRAC runs with the NPA. At present, only the generic and detailed data parameters in Table I can be accessed from the AGRF1, BGRF1, ..., ZGFR1 files by program IOGRF during a playback. Data from any time frame of the transient can be displayed. Data from successive branch calculations can be concatenated for display by renaming the TRCGRF1 files from the initial TRAC run and subsequent branch calculations with the names AGRF1, BGRF1, CGRF1, ... The time intervals for data to be extracted from each of these files and then combined are interactively specified by the user to the NPA executive program that then writes it to file PBKTIMES for program IOGRF.

In the future, when the NPA executive and IOGRF programs are downloaded to execute on the Tektronix 4115B intelligent workstation, the playback procedure would be executed entirely on the workstation. A telephone link to the mainframe computer would not be needed when operating the NPA in the playback mode. Analyzing the results of previous TRAC runs with this interactive graphics-display capability would be inexpensive and convenient. The TRCGRF1 files from such runs could be copied by the workstation onto a floppy disk and mailed to other NPA workstation sites for further analysis and evaluation.

FUTURE DEVELOPMENT

The basic capabilities of the NPA are programmed and operational on both the TRAC-based and RELAP5-based NPA versions. Many of the desired enhancements to this capability for the TRAC-based NPA version are mentioned throughout the text of this paper. A list of future developments for the NPA follows:

1. Combine the best features of the Los Alamos TRAC-based and INEL RELAP5-based NPA versions into one NPA for running either code.

2. Download most functions of the NPA executive and IOGRF programs for execution on the Tektronix 4115B intelligent workstation. While doing this, maintain as an option the current capability to execute the entire NPA on a mainframe computer so that a less expensive, nonintelligent color-graphics terminal can be used as well.

3. Implement a menu-driven data-base management system to provide convenient storage and retrieval of NPA files. Currently, only specific predetermined files can be accessed interactively.

4. Produce a special NPA thermal-hydraulic code with a three-dimensional two step numerics and vectorization for fast running.

5. Incorporate into the NPA the software being developed by TDC to create TRAC or RELAP5 input-data files using the NPDB and numerical-modeling information obtained interactively from the NPA user.

6. Provide interactive capability to renode a TRAC or RELAP5 input-data file. When coupled with the backup/branch procedure, this would allow, among other advantages, arbitrary placement of breaks for loss-of-coolant analysis (LOCA) studies.

7. Provide batch-execution capability for the NPA so that a more cost-effective TRAC/RELAP5 calculation can be performed when playback analysis of the results is sufficient.

8. Expand the graphics-display capabilities; for example, animation of flow information, three-dimensional displays, automatic generation of plant-noding displays, interactive definition of graphics displays, etc.

9. Give the NPA user the interactive capability to define or modify the names of generic data, detailed data, and adjustable-hardware components or actions.

10. Incorporate additional commands that would be useful to the user.

11. Create as many suitable input-data files as possible for other power plants.

12. Increase flexibility in all areas of NPA user/executive program interaction.

CONCLUSIONS

Recent advances in computer technology and numerical-solution methods have made it appropriate to develop the user-convenient features of the NPA described in this paper. The computational speed and high-resolution color graphics now available make it possible to evaluate and analyze interactively power-plant thermal-hydraulic behavior with best-estimate computer models. Sufficient computational speed is available when using current-generation mainframe computers to execute the TRAC code. This program uses the recently developed stability-enhancing two-step numerical method (Ref. 3) that allows very large time steps (thus, fewer time steps) to be employed for evaluating slow transients. With a reasonable numerical model of a power plant (several hundred nodes), operational transients can be evaluated by TRAC (PF1/MOD1 version) faster than real time. With such speed, the NPA running TRAC becomes a useful interactive analyzer. The high-resolution color-graphics terminals now available make it possible with graphics to analyze calculational results effectively. Presenting these graphics concurrently with the calculation gives the user the information needed to interact and control the calculation and its solution. While the NPA is a convenient power-plant analyzer, it also can be used as a highly accurate power-plant simulator.

TRAC is an extremely complex fluid-dynamics code for power-plant analysis. Preparing input data and executing TRAC on a computer require considerable expertise, experience, effort, and time. Much of this expertise and experience is being programmed into the NPA. Automating the process with the NPA eliminates most of the effort and the time requirement. Flexibility is maintained by interactive dialog with the user. With the NPA, TRAC is no longer the province of the expert; NPA provides an expert system that allows the user to be the analyst. Under NPA control, TRAC becomes a convenient and useful tool for power-plant operation and safety analysis.

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