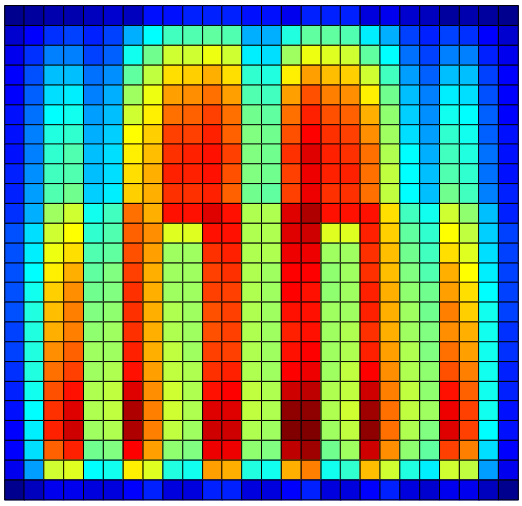
RESEARCH REPORT

VTT-R-02178-10



Update on changes in TRAB-3D programming in 2009

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Summary

The present report summarizes the changes made into VTT's three dimensional reactor dynamics code TRAB-3D during 2009 and the changes to be made to its User's Manual accordingly. The report is intended for the code users.

The work has been carried out in the TRICOT project of the SAFIR2010 Research programme, with the funding of VTT and VYR.

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1 Introduction

The present report summarizes the changes made into VTT's three dimensional reactor dynamics code TRAB-3D /1 / during 2009 and the changes to be made to its User's Manual /2/ accordingly. The report is intended for the code users.

The work has been carried out in the TRICOT project of the SAFIR2010 Research programme, with the funding of VTT and VYR.

2 Changes in the model of the code

1. A new model allowing to use cross section data acquired from the SIMULATE-3 code, hence referred to as S3 /2/, has been programmed. The preparation of data is reported in /4/, and its use in TRAB-3D in /5/. Changes in TRAB-3D were needed in reading and manipulating input data, in subroutines inih_crsect.f, inih_input.f, inih_rodpos.f, neut_difpar.f, neut_params.f, and COMMON BLOCKs COMM_PARAM and COMM_XSTAB.

2. A model earlier programmed for a separate benchmark version of TRAB-3D was taken into use, allowing reading of control rod positions from a radial map. Changes in the code in subroutines inih_input.f, inih_rodpos.f, inih_rods__.f and outp_output.f.

3. A new output option was added into TRAB-3D, allowing calculation of DNB/CHFR for selected fuel rods and their output in map form /6/. Changes in the code in auxi_genco_.f, hydr_crdata_.f, init_bdata_.f, init_dinit_.f, init_inpupr.f, init_restrt.f, init_vaddr_.f, hydr_addcr2.f, hydr_addcr4.f, hydr_corth_.f, hydr_crisis.f, hydr_scorth.f, outp_oinit_.f, outp_output.f, outp_outsel.f, COMM_ADDCRC, COMM_ARRIND, and COMM_HYDRA.

4. Other minor changes: inih_crsect.f, inih_indeks.f, outp_interr.f, COMM_MATER

3 Subroutines and COMMON BLOCKs with changes

Subroutines and COMMON BLOCKs of TRAB-3D with changes, in alphabetical order:

COMM_ADDCRC	added ADDCRC-COMMON, in similar form as in 1D-TRAB, including variables of relevant correlations
COMM_ARRIND	added a HEXBU-starting address for DNB/CHFR-table
COMMON_HYDRA	replaced obsolete DNBRC-COMMON with a new one, with 18 IDFR-dimensioned tables and 7 variables
COMM_MATER	added a dummy variable for testing purposes
COMM_PARAM	IDMAT increased, IDHT increased
COMM_XSTAB	parameter MAXTAB for tabulated cross sections set from 14688 to 1 to reduce needed memory space
auxi_genco_.f	included a COMMON BLOCK containing MCCPR values for time-d output
hydr_crdata.f	new block data subprogram for dry-out correlations
inih_crsect.f	deleted JMAT = 0
inih_indexs.f	added missing initial values for EPS1(IDMAT) and EPS2(IDMAT)
inih_input_.f	added selection of reading data from S3 modified: reading of control rod positions from a radial map added INCLUDE COMM_ARRIND
inih_rodpos.f	added omission of discontinuity factor manipulation if S3 data, modified: control rod positions from a radial map
inih_rods__.f	modified: control rod positions from a radial map
init_bdata_.f	added new keyword for radial map of dry-out correlations, DNBCOR
init_dinit_.f	deleted obsolete lines connected to 1D code's DNB/CHFR correlations
init_inpupr.f	added reading of input for radial map of MCCPR
init_restrt.f	updated correct COMMON BLOCK lengths for restart
init_vaddr_.f	added new parameter for radial map of MCCPR
hydr_addcr2.f	new subprogram: calculation of DNB/CHFR correlation
hydr_addcr4.f	new subprogram: calculation of DNB/CHRF correlation
hydr_corth_.f	added a call to subprogram CRISIS calculating MCCPRs
hydr_crisis.f	new: calculation of MCCPRs for one fuel at a time. Completely different from the corresponding subprogram in the 1D code
hydr_scorth.f	added a call to subprogram CRISIS calculating MCCPRs

neut_difpar.f	no changes, temporary output
neut_params.f	added alternative manipulation of cross section input data if from S3
outp_interr.f	added missing output for error stop (funtim)
outp_oinit_.f	deleted obsolete lines connected to 1D code's hot channel output
outp_outpu_.f	deleted obsolete lines connected to 1D code's hot channel output
outp_output.f	added radial map output for MCCPR and its minimum
outp_outsel.f	deleted obsolete lines connected to 1D code's hot channel output

4 Changes to the input manual

4.1 New input

Section 9.11.

/XSDATA / NXSDAT = -4 initiates reading of the neutronic data file derived from S3 calculation

Section 9.8

/RODPOS / NGR = 0 read radial positions of control rods from a radial map
/ positions in a radial map,
0 indicates no control rod
> 0 refers to a control rod group in the position

example for a full core layout (the numbers are meaningless):

```
/RODPOS/  0
                      0 0 0 0 0 0
                    0 0 0 0 0 0 0 0
                  0 0 0 0 0 0 7 7 0 0 0 0 0 0
                0 0 0 0 0 0 0 7 7 0 0 0 0 0 0 0
              0 0 8 8 5 5 0 0 3 3 8 8 4 4 0 0 0 0
            0 0 0 8 8 5 5 0 0 3 3 8 8 4 4 0 0 0 0 0
          0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 8 8 0 0
          0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 8 8 0 0
          0 0 4 4 0 0 1 1 0 0 2 2 0 0 1 1 0 0 5 5 0 0
        0 0 0 4 4 0 0 1 1 0 0 2 2 0 0 1 1 0 0 5 5 0 0 0
      8 8 0 0 7 7 0 0 0 0 6 6 7 7 6 6 0 0 0 0 7 7 0 0 0 0
      8 8 0 0 7 7 0 0 0 0 6 6 7 7 6 6 0 0 0 0 7 7 0 0 0 0
      0 0 0 0 3 3 8 8 2 2 0 0 1 1 8 8 2 2 0 0 3 3 8 8 0 0
      0 0 0 0 3 3 8 8 2 2 0 0 1 1 8 8 2 2 0 0 3 3 8 8 0 0
      0 0 0 0 0 0 0 0 0 0 6 6 0 0 6 6 0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 0 6 6 0 0 6 6 0 0 0 0 0 0 0 0 0 0
        0 0 0 5 5 0 0 1 1 0 0 2 2 0 0 1 1 0 0 4 4 0 0 0
          0 0 5 5 0 0 1 1 0 0 2 2 0 0 1 1 0 0 4 4 0 0
          0 0 7 7 0 0 8 8 0 0 7 7 0 0 0 0 0 0 7 7 0 0
          0 0 7 7 0 0 8 8 0 0 7 7 0 0 0 0 0 0 7 7 0 0
            0 0 0 0 0 0 4 4 0 0 3 3 8 8 5 5 0 0 0 0 0
              0 0 0 0 0 4 4 0 0 3 3 8 8 5 5 0 0 0 0
                0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
                  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
                      0 7 7 0 0 0 0 0
                        7 7 0 0 0 0
```

Section 6.17
Obsolete keyword /BOILIN replaced by

/DNBCOR / JDNBC (IDFR)	>0 calculate the correlation indicated by the number for fuel IDFR (radial map) =0 do not calculate for fuel IDFR
/ FRADXX(IDFR)	= radial peaking for fuel IDFR (radial map)
/ RXLXX(IDFR)	= parameter for the correlation for fuel IDFR (radial map)

Example for a half core layout (the numbers are meaningless):

```
/DNBCOR  /   JDNBC INDICATOR OF CORRELATION, IF ZERO, NOT CALCULATED
  ONE: CORR1
  TWO: CORR2
                        2 2 1 2 2 2
                      2 2 2 1 1 2 2 2
                  2 1 1 2 1 2 1 1 1 1 1 1 1 2
                2 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2
              2 2 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2
            2 2 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 2
          2 2 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2
          2 2 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 2 1
          1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2
        2 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2
      2 2 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 2 2 2
      2 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2
      2 2 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2

/                 FRADXX RADIAL PEAKING FACTOR FOR BUNDLE

                              1. 1. 1. 1. 1. 1.
                          1. 1. 1. 1. 1. 1. 1. 1.
                      1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
                    1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
                  1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
              1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
            1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
            1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
            1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
         1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
      1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
      1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
      1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.

/                  R-FACTOR FOR BUNDLE

                              1. 1. 1. 1. 1. 1.
                          1. 1. 1. 1. 1. 1. 1. 1.
                      1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
                    1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
                  1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
              1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
            1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
            1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
            1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
         1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
      1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
      1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
      1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
```

4.2 New output

Section 3.7
/TIME-D new output variables:
single variables (funtim)
AO = axial offset
(may also be used as a triggering quantity, /TRIGG (8.4) utilizing general functions)

TCCPRM = whole core minimum critical channel power ratio
ZZCPRM = axial position of TCCPRM from bottom of fuel
RNCPRM = node from bottom for TCCPRM
RLCPRM = location for TCCPRM
RFCPRM = fuel for TCCPRM
CHCPRM = channel for TCCPRM

Note: the node number output variables are not integers but real, because time-d output does not print out integer numbers.

table variables (DISLA)
CCPRM(IDFR) = minimum critical channel power ratio for IDFR

table variables (NODESL)
CCPR node values for time-dependent storing and plotting e.g. in horizontal or vertical planes, order of variable = 172

Section 3.9
/H-TABLE
CCPR3D added as TRAB3D node variable for printout, with LSDAT1 = 13.

4.3 Corrections or clarifications to the input manual

At the end of the XSDATA-keyword (9.11) there has to be an extra slash: normally the keyword is ended with the beginning slash of the next keyword, but without the extra slash the reading of cross section data is not initiated, and a hard to decipher error message follows.

Likewise the END4 (9.13) and END5 (11.4) keywords assume a slash to follow.

LPSD is given in keyword STEADY, but the present version of the code expects to reread it as the first value in file unit 25, and based on that decides whether or not to read the samarium concentration in addition to the xenon concentration. (To be corrected later.)

Section 6.7
/BY-PAS
A second record reading JHCBY1, indicator for coupled by-pass channels. The model is not active yet, but the structure is there already. An empty record should be given.

Section 8.1
/DISTUR
Clarification: if the disturbed variable is “insertion of control rod group” (XCRT), the meaning of the “special treatment” variable i_{sp} is 11 for the first group, 12 for the second group etc. The special treatment will set the order of the moving control rod group into the JXCR-table. Note: for control rod groups moving with hydraulic scram (7.1) the special treatment variable is not used.

Section 9.5, TRAB-3D
/LAYOUT
NLAY = 0 (initial value; usually BWR)
NLAY = 1 (usually PWR)
in the previous text the comments are erroneously given the other way round.

Section 9.9
/RODCON
Clarification: MROD1 and MROD2 are both increments to the material number of the unrodded material. The recommended increment for MROD2 should be 2, not 1.

Section 9.11.

/XSDATA / NXSDAT	≥0 reading of cross section data with logical unit 14 is obsolete in HEXTRAN and TRAB-3D, it is a HEXBU-3D feature
	-1 tabulated cross sections are read with logical unit 26 for both HEXTRAN and TRAB-3D (not 24 and 28, as previously indicated)
	-2 wide range cross sections are read from file hexbu.crsec.inp, only HEXTRAN (not with logical unit 700 as previously indicated)

Correction: initial values for EPS1 and EPS2 should be 1, not 0.

Section 10.2
/NOMCON
Clarification. The discontinuity factors should be given starting from top right corner of an assembly, in the order west-south-east-north. Additionally, the code assumes the discontinuity factors to be calculated by CASMO, and manipulates the values given in input accordingly. For S3 data this feature is now behind the same input option as reading of neutronics data. Note that despite the reading of discontinuity factors their use can be prevented with input parameter NCORHX in keyword ITER (Section 9.3).

Note check the discontinuity factor calculation, if S3 is calculations are used to produce PWR data in future.

Section 10.3
/FITCO
J = 1 … 6, not 1 …5; the last feedback effect (moderator buckling) is missing.

Section 3.3, 3.5 and 6.11
/O-TABLE, /FIXED and /O-REGIONS
References to “Appendix 2” should refer to “Appendix 2 [7]”.

5 New or previously unlisted subroutines

New of previously unlisted subroutines in alphabetical order, to supplement the list given in the User’s Manual, Section 12:

ADDCR2	hydraulic subprograms (TRAB-3D only)
ADDCR3	hydraulic subprograms (TRAB-3D only)
AXOFF	output subprograms
CIRCIN	input and initialization subprograms
CORFU	input and initialization subprograms
CRSECT	input and initialization subprograms
CRDATA	hydraulic subprograms (TRAB-3D only)
DRIEPR	hydraulic subprograms (TRAB-3D only)
POLATE2	auxiliary subprograms
READXS	input and initialization subprograms
READGC	input and initialization subprograms
SLIEPR	hydraulic subprograms (TRAB-3D only)
SLIPRA	hydraulic subprograms
SLIPRB	hydraulic subprograms

New of previously unlisted subroutines and their function, or corrections:

Prefix for neutronic subprograms, erroneously given as neutr_, to be corrected to neut_.

Auxiliary subprograms
auxi_
POLATE2 interpolates tabulates nodewise data for gas gap conductivity

Input and initialization subprograms
init_
CIRCIN numerates the coolant circuit channel regions and initializes some variables
CORFU initializes fuel heights for core
READGC reads tabulated nodewise data for gas gap conductance

Input and initialization subprograms
inih_
CRSECT controls reading of material specifications (neutronic data file) for fitted cross sections.
READXS controls reading of material specifications (neutronic data file) for tabulated cross sections.

Hydraulic subprograms
hydr_
ADDCR2 evaluates dry-out margins according to one correlation (check source code for the correlation). (TRAB-3D only)
ADDCR3 evaluates dry-out margins according to one correlation(check source code for the correlation). (TRAB-3D only)
CRDATA block data subprogram; initial data for dry-out correlations. (TRAB-3D only)
DRIEPR evaluates the drift flux parameters according to the Chexal-Lellouche model (“EPRI model”) (TRAB-3D only)
SLIEPR evaluates parameters for slip between the phases at one mesh point according to the Chexal-Lellouche model (“EPRI model”) (TRAB-3D only)
SLIPRA evaluates parameters for slip between the phases at one mesh point (check source code for the correlation). (TRAB-3D only)
SLIPRB evaluates parameters for slip between the phases at one mesh point (check source code for the correlation). (TRAB-3D only)

Output subprograms
AXOFF evaluates axial offset.

6 Orders of COMMON BLOCKs

Orders of COMMON-blocks of TRAB-3D and HEXTRAN for additional input, disturbances and general functions, Table 3 in Section 2.3:

To be deleted as obsolete: FUNCT, KLO and SERROR.

Missing COMMON-blocks to be included:

Name of COMMON-block	order of COMMON-block (octal constant)
ALBEDO (HEXTRAN only)	
FUNTC	
FUNTC1 (TRAB-3D only)	34
FUNTC2	35
GCTAB	
MATER	45
XSTAB	

7 Summary

The changes made into VTT's three dimensional reactor dynamics code TRAB-3D during 2009 have been summarized. The necessary changes to be made to the code's User's manual have been listed. The updated code and its updated manual will be re-entered into VTT's Version Control system.

References

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