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Software Requirements of SNAP for Editing MELCOR 2.2 Models

Chun Fu, Christopher Faucett, and Jesse Phillips

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Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

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Chun Fu, Christopher Faucett, and Jesse Phillips
Nuclear Energy Safety Technologies
Sandia National Laboratories
P. O. Box 5800
Albuquerque, New Mexico 87185-MS0744

Abstract

Applications of the severe accident analysis code MELCOR, developed for the U.S. Nuclear Regulatory Commission (NRC) by Sandia National Laboratories (SNL), have been supported by the graphical user-interface and post-processing suite Symbolic Nuclear Analysis Package (SNAP), developed for the NRC by Applied Programming Technology (APT). With the release of MELCOR 2.2, new user functionality and models have been introduced and an update to the SNAP MELCOR plugin user interface is necessary to access these new features. This document relates all new features introduced into MELCOR to the development team at APT as well as the NRC.

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1. Introduction

The Symbolic Nuclear Analysis Package (SNAP) is a suite of integrated applications designed to simplify the process of performing engineering analysis. Developed by Applied Programming Technologies (APT), SNAP provides a Graphical User Interface (GUI) for a variety of analytical codes developed for the U.S. Nuclear Regulatory Commission (NRC) including MELCOR. SNAP can specifically assist users in developing input models, submitting jobs, and visualizing output results.

Each nuclear analysis code supported by SNAP has a corresponding plugin. The SNAP MELCOR plugin processes user input options to create user input files comprised of code specific input records which are interpreted by the MELCOR code for analysis. At the time of this document's development, the SNAP MELCOR plugin supported MELCOR version 2.1 input records, with some exceptions. This document communicates the modeling features recently added to MELCOR during the code update to version 2.2.9541 to the APT development team. Additionally, any known discrepancies identified between the MELCOR code input records and those permitted within the SNAP MELCOR plugin are presented.

A list of recommendations regarding the SNAP GUI and MELCOR plugin are provided at the end of the document. These listed items are viewed as areas where potential improvements to the functionality and capabilities could be made to improve user experience.

2. New User Input

This section lists all currently known input discrepancies between the SNAP MELCOR plugin and the previously released MELCOR code version 2.2.9541. MELCOR can be divided into several packages which represent unique sets of physical phenomena. Each package processes unique sets of user input. The input can be separated into three main catagories: user input records, control function arguments, and sensitivity coefficient. The known input discrepancies are presented below within tables for each user input within a given MELCOR package. The following sections are presented in a similar order as found in the MELCOR Users' Guide [1].

The records were identified by parsing the MELCOR source code for all permissible records. Once identified and given documentation is provided by the MELCOR Users' Guide, the SNAP MELCOR plugin GUI was tested to determine whether the input card was producible. All input documented in the MELCOR Users' Guide and similarly not found to be presently available within the SNAP MELCOR plugin has been listed. Only those packages requiring new input records or modifications to existing inputs are presented below.

2.1. MELCOR Packages

The following package list is reproduced from the MELCOR Users' Guide. Complete documentation and description of each package can be found within the users' guide and is not presented here.

2.1.1. ACC Package

Record	Notes on Perceived Discrepancies
ACC_ID	A simple accumulator model was added to MELCOR
ACC_SLP	
ACC_PAR	
ACC_LAG	

Control Function Arguments	Notes on Perceived Discrepancies
ESF-ACC-RAT	
ESF-ACC-MAS	
ESF-ACC-PRS	
ESF-ACC-REM	
ESF-ACC-ENG	

2.1.2. BUR Package

Record	Notes on Perceived Discrepancies
BUR_CF	
BUR_BRT	
BUR_CC	
BUR_FS	

2.1.3. CAV Package

Record	Notes on Perceived Discrepancies
CAV_L3	
CAV_L4	
CAV_L5	
CAV_L6	
CAV_L7	
CAV_L8	
CAV_L9	
CAV_DELETE	

Control Function Arguments	Notes on Perceived Discrepancies
CAV-VISLAY	
CAV-RADT	
CAV-TLCNTZ	
CAV-TLCNTR	

Sensitivity Coefficients
2302
2303
2312
2315

2.1.4. CF Package

Record	Notes on Perceived Discrepancies
CF_RANGE	
CF_VCF	
CONSTRUCT	
REMOVE	
CF_DELETE	

Control Function Arguments	Notes on Perceived Discrepancies
CF-CONST	
CF-LCONST	

2.1.5. CND Package

Record	Notes on Perceived Discrepancies
CND_PCCS_ID	
CND_ICS_ID	

Control Function Arguments	Notes on Perceived Discrepancies
ESF-ICS-TOTENG	
ESF-ICS-POW	
ESF-ICS-STM	
ESF-ICS-COND	

2.1.6. COR Package

Record	Notes on Perceived Discrepancies
COR_RFM	Reflector input
COR_TKE	
COR_DIFF	
COR_XPRT	
COR_DIFT	
COR_OX	
COR_HRM	
COR_ROD2	
COR_RODP	
COR_CR2	
COR_DX	Global core input
COR_NS	Global core input
COR_SS	Global core input
COR_PC	Global core input
COR_PR	Global core input
COR_CDM	
COR_BFA	
COR_NOX	
COR_TIN	
COR_BK	Global core input
COR_RFA	Reflector input
COR_QHS	
COR_RFG	Reflector input
COR_RFD	Reflector input
COR_KRF	Reflector input
COR_FCEL	

Record	Notes on Perceived Discrepancies
COR_PLOTS	
COR_ROD_VF	
COR_CR_VF	
COR_HRA	
COR_HRD	
COR_KHR	

Control Function Arguments	Notes on Perceived Discrepancies
COR-HTC	
COR-VOL-FLU	COR-FLU in SNAP
COR-VOL-FLUB	COR-FLUB in SNAP
COR-VOL-FLUC	COR-FLUC in SNAP
COR-VOLF	COR-CellVoidFrac in SNAP
COR-CELLFCELR	
COR-CELLFCELA	
COR-OXTH	
COR-H2	
COR-H2C	
COR-REL	
COR-RELB	
COR-RELD	

Sensitivity Coefficients
1018
1105
1291
1406

2.1.7. CVH Package

Record	Notes on Perceived Discrepancies
CV_DFT	Follow UG nomenclature and use CV_DFT rather than CVH_DFT (though both are functional)

Record	Notes on Perceived Discrepancies
CV_DIF	Included in SNAP-MELCOR Plugin as CVH_DIF
CV_TENDINI	
CV_DELETE	
CVH_ALLOWCOLDATM	Should be present in the MELCOR model editor, although it is presently in the MELGEN editor.
CVH MELCOR INPUT	The input should maintain MELGEN versus MELCOR input records separately. MELGEN CVH cards such as CVH_ALLOWCOLDATM appear in the MELCOR input cards

Control Function Arguments	Notes on Perceived Discrepancies
CVH-CPUE	Coded as "CVH-CCPUE" in SNAP

Sensitivity Coefficients
4416
4417
4418
4419
4421
4422
4500

2.1.8. DCH Package

Record	Notes on Perceived Discrepancies
DCH_OPT	
DCH_NFA	
DCH_ACT	
DCH_SUR	

2.1.9. EXEC Package

Record	Notes on Perceived Discrepancies
EXEC_DTTIME	
EXEC_TSTART	

Record	Notes on Perceived Discrepancies
EXEC_TITLE	
EXEC_JOBID	
EXEC_PLOT	
EXEC_PLOTLENGTH	
EXEC_UNDEF	
EXEC_GLOBAL_DFT	
EXEC_SS	
EXEC_WRT	

2.1.10. FCL Package

Record	Notes on Perceived Discrepancies
FCL_HT	

2.1.11. FDI Package

Record	Notes on Perceived Discrepancies
FDI_SC	

Sensitivity Coefficients
4602
4603
4604
4605
4606
4607
4608
4609
4610
4620

2.1.12. FL Package

Record	Notes on Perceived Discrepancies
FL_MACCS_SFP1	

Record	Notes on Perceived Discrepancies
FL_MACCS_SFP2	
FL_MACCS_SFP3	
FL_FLSH	
FL_VLV	
FL_CCF	
FL_RPD	
FL_SPH	
FL_SPT	
FL_TPH	
FL_TPT	
FL_PFR	
FL_PIN	
FL_SMT	
FL_PNT	
FL_DELETE	

Control Function Arguments	Notes on Perceived Discrepancies
FL-PMP-HEAD	
FL-PMP-THYD	
FL-PMP-SPD	
FL-PMP-TFR	
FL-PMP-PIN	
FL-PMP-DISS	
FL-PMP-EFF	
FL-PMP-TMOT	
FL-PMP-DELPOW	
FL-PMP-DHDQ	
FL-CHOKED	

2.1.13. HS Package

Record	Notes on Perceived Discrepancies
HS_FTDRN	
HS_RAD	

Record	Notes on Perceived Discrepancies
HS_LBR	
HS_LBAR	
HS_LBT	
HS_RBR	
HS_RBAR	
HS_RBT	
HS_FTLBF	
HS_FTLBM	
HS_FTLBE	
HS_FTRBF	
HS_FTRBM	
HS_FTRBE	
HS_DGICE	
HS_ZUKL	
HS_ZUKR	
HS_DELETE	

Control Function Arguments	Notes on Perceived Discrepancies
HS-Q-ATMS	
HS-Q-POOL	
HS-Q-BCFIX	
HS-Q-DECAY	
HS-Q-RADG	
HS-Q-TOTAL	
HS-Q-RAD	

Sensitivity Coefficients
4185
4186

2.1.14. LHC Package

Record	Notes on Perceived Discrepancies
LHC_ID	
LHC_PLATEZ	
LHC_PLATER	
LHC_DH	
LHC_GEOM	
LHC_SP	
LHC_TPO	
LHC_TPI	
LHC_NOX	
LHC_MLT	
LHC_U	
LHC_SC	
LHC_DELETE	
LHC_CPF	

Sensitivity Coefficients
2602
2603

2.1.15. MP Package

Record	Notes on Perceived Discrepancies
MP_SS	
MP_PVE	
MP_DELETE	

2.1.16. NCG Package

Sensitivity Coefficients
2090

2.1.17. RN Package

Record	Notes on Perceived Discrepancies
RN1_DIFMAP	
RN1_ADFG	
RN1_FP00	
RN1_GREL	
RN1_DIFF	
RN1_AS01	
RN1_TURB	
RN1_TDS	
RN1_DHVS	
RN1_DHSS	
RN1_TRN04	RN1_TRN04 is generated but shows as RN_RCT04 in SNAP

Control Function Arguments	Notes on Perceived Discrepancies
RN1-ERR	
RN1-ERR-REL	
RN1-RESUSPND	
RN1-DEPHS	
RN1-DEPHS-DIST	
RN1-TOTRES	
RN1-TURB-VEL	

Sensitivity Coefficients
7145
7146

2.1.18. SPR Package

Record	Notes on Perceived Discrepancies
SPR_JUN	
SPR_SUMP	
SPR_CV	
SPR_RN2_CLS	

Record	Notes on Perceived Discrepancies
SPR_RN2_HPART	
SPR_DELETE	

2.2. Control Function Arguments

Database variables of Control System provide control function arguments for user to choose when constructing new control functions. This database needs to be updated to include all control function arguments available in MELCOR 2.2. Figure 1 shows an input example from SNAP.

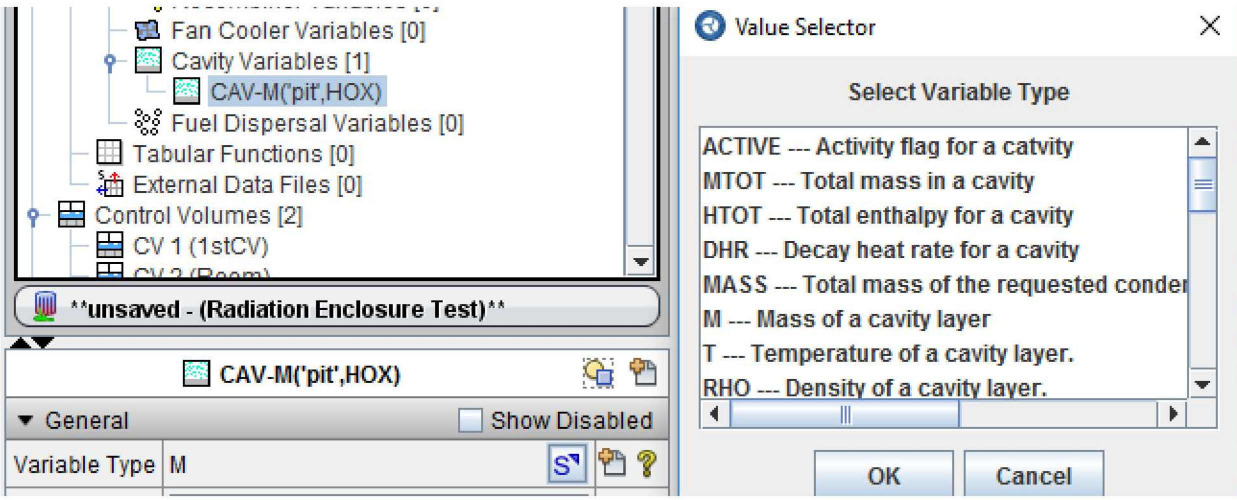

Figure 1 Database for Control Function Arguments

The user can only choose arguments from the supplied list of control function arguments. It would be more flexible if a user could directly type in a new control function argument. This is useful when new control function arguments are added in MELCOR but the SNAP list has not been updated. The complete list of control function arguments is presented in Table 1.

Table 1. Control Function Arguments

FDI-FMREL	FDI-FMRELT	FDI-ETRAN	FDI-ETRANT	FDI-STGEN
FDI-STGENT	FDI-OXRAT	FDI-OXTOT	FDI-ATM-POWR	FDI-ATM-HEAT
FDI-DEBRIS-T	FDI-OX-ENRGY	FDI-MASS-ADD	FDI-ENTH-ADD	FDI-ATM
FDI-SXRAT	FDI-SXTOT	FDI-SRF-POWR	FDI-SRF-HEAT	FDI-TBD-SURF
FDI-SX-ENRGY	FDI-MASS-SET	FDI-ENTH-SET	FDI-SRF	CAV-ACTIVE
CAV-MTOT	CAV-HTOT	CAV-DHR	CAV-MASS	CAV-M
CAV-T	CAV-RHO	CAV-THICK	CAV-VOL	CAV-VF
CAV-MAXRAD	CAV-MINALT	CAV-TMEX	CAV-MEX	CAV-QREA
CAV-QCNCT	CAV-QSURF	CAV-TGASMOL	CAV-R	CAV-Z
CAV-ASURF	CAV-CRUSTB	CAV-VISLAY	CAV-RADT	CAV-TLCNTZ
CAV-TLCNTR	CAV-CRUSTT	CAV-TSURF	CAV-MASSERR	CAV-ENERGYERR
CAV-CPUT	CAV-CPUC	CF-VALU	CF-CONST	CF-LCONST
BUR-CPUC	BUR-CPUE	BUR-CPUR	BUR-CPUT	BUR-N-SE
BUR-LOG	BUR-RAT	BUR-TOT	BUR-POWER	BUR-ENERGY
BUR-FTOT	BUR-FENERGY	ESF-PCCS-VNTFL	ESF-PCCS-TOTENG	ESF-PCCS-TOTSTM
ESF-ICS-VNTFL	ESF-ICS-TOTENG	ESF-ICS-TOTSTM	ESF-QFC-RAT	ESF-QFC-TOT
ESF-MFC-RAT	ESF-ICS-POW	ESF-ICS-STM	ESF-ICS-COND	ESF-MFC-TOT
ESF-PAR-DMH2	ESF-PAR-IMH2	ESF-PAR-DVOL	ESF-PAR-IVOL	ESF-PAR-TOUT
ESF-PAR-FMOL	ESF-ACC-RAT	ESF-ACC-MAS	ESF-ACC-PRS	ESF-ACC-REM
ESF-ACC-ENG	COR-ZQ	COR-TQ	COR-TUQ	COR-CELLMASS
COR-TOTMASS	COR-CELLMASSSS	COR-CELLMASSNS	COR-CELLMASSSH	COR-CELLMASSSHI
COR-CELLMASSSHO	COR-CELLMASSFM	COR-DC	COR-EMISS	COR-HTC
COR-PB	COR-PD	COR-M	COR-CELLMASSFU	COR-CELLMASSCL
COR-CELLMASSCN	COR-CELLMASSMP	COR-CELLMASSCNI	COR-CELLMASSCNO	COR-CELLMASSCBI
COR-CELLMASSCBO	COR-CELLMASSDB	COR-AFLMIN	COR-VOL-FLU	COR-VOL-FLUB
COR-VOL-FLUC	COR-CELLVOLFRAC	COR-VOLF	COR_VOLFRRAC	COR-CELL-Q
COR-CELLTEMP	COR-MLTFR	COR-ENERGY-TOT	COR-EFPD-TOT	COR-EMWR-TOT
COR-EB4C-TOT	COR-ECNV-TOT	COR-EBND-TOT	COR-EFPD-RAT	COR-EMWR-RAT
COR-EB4C-RAT	COR-ECNV-RAT	COR-EBND-RAT	COR-QCNV	COR-RADHEATRATEHS
COR-AXLHEATRATEHS	COR-HTCLH	COR-HTCLH-AVE	COR-QFLXLH	COR-QFLXLH-AVE
COR-QTOTLH	COR-QTOTLH-TOT	COR-SS-LOAD	COR-SS-STRESS	COR-SS-DAMAGE
COR-SS-TLEFT	COR-ROD-DAM	COR-DAM-FLAG	ROD-DAM-FLAG	COR-H2MASSPROD
COR-ZROX-TLEFT	COR-ZROX-LIFE	COR-ZROX-LIFE2	COR-DMCO-TOT	COR-DMCO2-TOT
COR-DMCH4-TOT	COR-TPN	COR-TLH	COR-VSTRAIN	COR-VSTRESS
COR-ABRCH	COR-MEJEC-TOT	COR-T-LP	COR-T-UP	COR-M-LP

COR-M-UP	COR-V-UP	COR-V-LP	COR-RA-UP	COR-RA-LP
COR-MPR-UP	COR-MPR-LP	COR-DT	COR-NCYCLE	COR-CPU
COR-MASSERR	COR-ENERGYERR	COR-REL-ENGY-ERR	COR-REL-ENGY-ERM	COR-MASS-DISCARD
COR-ENGY-DISCARD	COR-CELLFCELR	COR-CELLFCELR	COR-OX	COR-HTR-Q
COR-OXTH	COR-H2	COR-H2C	COR-REL	COR-RELB
COR-RELD	COR-LH-CNV-IN	COR-LH-CNV-OUT	COR-RE-POOL	COR-RE-ATMS
COR-RE-FILM	COR-PR-POOL	COR-PR-ATMS	COR-PR-FILM	COR-GR-POOL
COR-GR-ATMS	COR-GR-FILM	COR-RA-POOL	COR-RA-ATMS	COR-RA-FILM
COR-NUFRAC-POOLQ	COR-NUFRAC-POOLU	COR-NUFRAC-ATMS	COR-NUNFRAC-POOLQ	COR-NUNFRAC-POOLU
COR-NUNFRAC-ATMS	EDF	RN1-VCND	RN1-CPUC	RN1-CPUE
RN1-CPUR	RN1-CPUT	RN1-ATMG	RN1-ARMG	RN1-VTMG
RN1-VRMG	RN1-ATML	RN1-ARML	RN1-VTML	RN1-VRML
RN1-XMRLSE	RN1-XMRLSET	RN1-XMRLSER	RN1-TOTMAS	RN1-TYCLAIR
RN1-AMG	RN1-VMG	RN1-AML	RN1-VML	RN1-ADEP
RN1-VDEP	RN1-ATMT	RN1-ATMR	RN1-VTMT	RN1-VTMR
RN1-TMT	RN1-TMR	RN1-MDT	RN1-TMDTT	RN1-TMDTR
RN1-DHTOT	RN1-DHCOR	RN1-DHCAV	RN1-DHDEP	RN1-DHATM
RN1-DHPOL	RN1-AMGT	RN1-CVCLT	RN1-TYCLT	RN1-CVTOT
RN1-TYTOT	RN1-MMDW	RN1-GSDW	RN1-MMDD	RN1-GSDD
RN1-PH	RN1-IOP	RN1-IOT	RN1-IOD	RN1-CAT
RN1-CAD	RN1-TMCAT	RN1-ERR	RN1-ERR-REL	RN1-TMCAR
RN1-MCA	RN1-MMDC	RN1-GSDC	RN1-RESUSPND	RN2-CPUC
RN2-CPUE	RN2-CPUR	RN2-CPUT	RN2-AMFLT	RN2-RAFLT
RN2-VMFLT	RN2-RVFLT	RN2-AMFLTS	RN2-VMFLTS	RN2-FLT-QTOT
RN2-FLT-QLOS	RN2-VFLT-TMP	RN2-VFLT-RAD	RN2-VFLT-THR	RN2-VFLT-BUR
RN2-DFBUB-W	RN2-DFBUB-A	RN2-DFBUB-V	RN2-DFBBT-W	RN2-DFBBT-V
RN2-DFBBT-A	RN1-DEPHS	RN1-DEPHS-DIST	RN1-TOTRES	RN1-TURB-VEL
FL-EFLOW	FL-EFLOW-TR	FL-FRUNBLK	FL-I-EFLOW	FL-I-EFLOW-TR
FL-I-MFLOW	FL-I-MFLOW-TR	FL-MFLOW	FL-MFLOW-TR	FL-V-N-OC
FL-VEL	FL-VOID	FL-MCH-DELTA_P	FL-MCH-EFFIC	FL-MCH-SPEED
FL-MCH-TORQUE	FL-MCH-POWER	FL-IHX-FL1-TIN	FL-IHX-FL1-TOUT	FL-IHX-FL2-TIN
FL-IHX-FL2-TOUT	FL-IHX-HTCOEFF	FL-IHX-Q12	FL-PMP-HEAD	FL-PMP-THYD
FL-PMP-SPD	FL-PMP-TFR	FL-PMP-PIN	FL-PMP-DISS	FL-PMP-DISSPOL
FL-PMP-DISSATM	FL-PMP-EFF	FL-PMP-TMOT	FL-PMP-DELPOW	FL-PMP-DHDQ
FL-CHOKED	FL-VISC	H2C-CHX-TIN	H2C-CHX-TOUT	H2C-CHX-TRIN
H2C-CHX-TROUT	H2C-CHX-HTCOEFF	H2C-CHX-QHX	H2C-RC-SP-1	H2C-RC-SP-2
H2C-RC-SP-3	H2C-RC-SP-4	H2C-RC-SP-5	H2C-RC-OF-1	H2C-RC-OF-2
H2C-RC-OF-3	H2C-RC-OF-4	H2C-RC-OF-5	H2C-RC-OF-6	H2C-RC-OF-7
H2C-RC-OF-8	H2C-RC-SR-1	H2C-RC-SR-2	H2C-RC-SR-3	H2C-RC-SR-4
H2C-RC-OINV-1	H2C-RC-OINV-2	H2C-RC-OINV-3	H2C-RC-OINV-4	H2C-RC-OINV-5
H2C-RC-OINV-6	H2C-RC-OINV-7	H2C-RC-OINV-8	H2C-RC-SINV-1	H2C-RC-SINV-2

~~H2C-RC-SINV-3~~	~~H2C-RC-SINV-4~~	HS-CPUC	HS-CPUE	HS-CPUR
HS-DEGAS-ENERGY	HS-DEGAS-MASS	HS-DEGAS-RATE	HS-DEGAS-STEELM	HS-DEGAS-CSTEELM
HS-DELE-ATMS	HS-DELE-POOL	HS-DELE-SURF	HS-DELM-DROP	HS-DELM-POOL
HS-DELM-STEAM	HS-MASS-FLUX	HS-ENERGY-FLUX	HS-ENERGY-INPUT	HS-ENERGY-STORED
HS-FILM-ENTH	HS-FILM-MASS	HS-FILM-TEMP	HS-FILM-THICK	HS-HTC-ATMS
HS-HTC-POOL	HS-ITER-FREQ	HS-RE-POOL	HS-RE-ATMS	HS-RE-FILM
HS-NU-POOL	HS-NU-ATMS	HS-NU-FILM	HS-PR-POOL	HS-PR-ATMS
HS-PR-FILM	HS-PRS-POOL	HS-PRS-ATMS	HS-GR-POOL	HS-GR-ATMS
HS-RA-POOL	HS-RA-ATMS	HS-RA-FILM	HS-SC	HS-SH
HS-MTC	HS-POOL-FRAC	HS-QFLUX-ATMS	HS-QFLUX-POOL	HS-QFLUX-TOTAL
HS-QTOTAL-ATMS	HS-Q-ATMS	HS-Q-POOL	HS-QTOT-SURF	HS-Q-BCFIX
HS-Q-DECAY	HS-Q-RADG	HS-Q-TOTAL	HS-QTOTAL-POOL	HS-RAD-FLUX
HS-Q-RAD	HS-TEMP	HS-DELE-FILMCNV	SPR-TP	SPR-FL
SPR-HTTRAN	SPR-MSTRAN	SPR-SUMPHT	SPR-SUMPMS	DCH-COREPOW
DCH-CLSPOW	DCH-TOTCLSPOW	CVH-ATM-FR	CVH-CVOLLIQ	CVH-VELLIQCV
CVH-VELVAPCV	CVH-CLIQLEV	CVH-CPUT	CVH-CPUE	CVH-CPUC
CVH-CPUR	CVH-E	CVH-ECV	CVH-H	CVH-LIQLEV
CVH-MASS	CVH-P	CVH-PPART	CVH-PSAT	CVH-QUALITY
CVH-RHO	CVH-TLIQ	CVH-TOT-E	CVH-TOT-M	CVH-TSAT
CVH-TVAP	CVH-VEL	CVH-VIRVOL	CVH-VOID	CVH-VOLFOG
CVH-VOLLIQ	CVH-VOLVAP	CVH-X	CVH-THCP	CVH-THCA
CVH-VISCP	CVH-VISCA	CVH-CVP	CVH-CPP	CVH-CVA
CVH-CPA	CVH-BETATP	CVH-BETATA	CVH-SP	CVH-SA
CVH-ALPHAA	CVH-ALPHAP	CVH-SC-ATMS	CVH-PR-ATMS	CVH-PR-POOL
CVH-GR-POOL	CVH-GR-ATMS	MACCS-PLTEMP	MACCS-PLHEAT	MACCS-PLMFLO
MACCS-PLMWT	MACCS-M-RE	MACCS-RHONOM	EXEC-TIME	EXEC-DT
EXEC-CYCLE	EXEC-CPU	EXEC-WARP	EXEC-LOCALWARP	LHC-QPLTOPTOT
LHC-QPLBOTTOT	LHC-QPLTOPHYD	LHC-QPLBOTHYD		

3. New Features and Associate Input

3.1. Introduction

New code capabilities and models, while enacted through new user input records, have been separated into this section to provide further context for the SNAP development team. While the input presented in the prior section can be easily implemented into the SNAP MELCOR plugin, these features may be more difficult to integrate and have been segregated based on perceived difficulties in their implementation.

3.2. Core Components, Surfaces, and Materials

The control function arguments within the core package allow users to specify the core cell, component, surface, and materials for various arguments. The following is a list of accepted inputs for the components, surfaces, and materials. These listings have been incomplete in recent MELCOR documentation but are provided here to the SNAP developers to allow for permissible input to be determined.

Components	Reactors Types	Description
FU	All	Fuel
CL	All	Clad
CN	BWR,SBWR,SFP-BWR	BWR Canister component facing away from the blade.
CB	BWR,SBWR,SFP-BWR	BWR Canister component facing the blade.
SH	PWR,PWRX	PWR Shroud
FM	PWR,PWRX	PWR Former
RK	SFP-BWR, SFP-PWR	Spent fuel pond rack.
RF	PBR, PMR	PBR and PMR reflector
PD	All	Particulate Debris in the channel
HR	PWR-HR	PWR heavy reflector
SS	All	Supporting Structure
NS	All	Non-supporting Structure
PB	All	Particulate Debris in the bypass
MP1	All	Molten Pool, metallic and in the channel
MP2	All	Molten Pool, oxidic and in the channel
MB1	All	Molten Pool, metallic and in the bypass
MB2	All	Molten Pool, oxidic and in the bypass

Components	Possible Materials
FU	UO2, †, *
CL	ZR, ZR02, INC
CN	ZR, ZRO2
CB	ZR, ZRO2

SH	SS, SSOX
FM	ZR, ZRO2, SS, SSOX
RK	ZR, ZRO2, CRP, SS, SSOX
RF	GRP ¥
PD	UO2, ZR, ZRO2, CRP, SS, SSOX
SS	ZR, ZRO2, GRP ¥, SS, SSOX
NS	ZR, ZRO2, CRP, SS, SSOX
PB	UO2, ZR, ZRO2, CRP, SS, SSOX
MP1	ZR, ZRO2, CRP, SS, SSOX
MP2	ZR, ZRO2, CRP, SS, SSOX
MB1	ZR, ZRO2, CRP, SS, SSOX
MB2	ZR, ZRO2, CRP, SS, SSOX

(*) Represents materials defined through the COR-FUM or COR_ELMAT cards.

(†) Represents materials defined through the COR_ELMAT card only.

(¥) Graphite is also additionally found in particulate debris and molten pool components if the modeled reactor type permits its use.

Material Short Name	Description
ZR	Zircaloy
CRP	Control poison
INC	Inconel
SS	Stainless-steel
SSOX	Stainless-steel oxide
UO2	Uranium dioxide
ZRO2	Zirconium dioxide
GRP	Graphite

Surface	Reactor Types	Description
FU	All	Fuel
CL	All	Cladding
SS	All	Supporting structure
NS	All	Nonsupporting structure
PD	All	Particulate debris in channel
PB	All	Particulate debris in bypass
MP1	All	Molten metallic pool 1
MB1	All	Molten metallic pool 1 in bypass
MP2	All	Molten oxidic pool 2

Surface	Reactor Types	Description
MB2	All	Molten oxidic pool 2 in bypass
FM	PWR, PWRX	PWR core former
SHI	PWR, PWRX	PWR core shroud adjacent to channel
SHO	PWR, PWRX	PWR core shroud adjacent to bypass
CBI	BWR,SBWR, SFP-BWR	BWR canister (adjacent to control blade) facing channel
CBO	BWR,SBWR, SFP-BWR	BWR canister (adjacent to control blade) facing bypass
CNI	BWR,SBWR, SFP-BWR	BWR canister (nonadjacent to control blade) facing channel
CNO	BWR,SBWR, SFP-BWR	BWR canister (nonadjacent to control blade) facing bypass
RK	SFP-BWR, SFP-PWR	Spent fuel pool rack
HRI	PWR-HR	Heavy reflector facing channel
HRO	PWR-HR	Heavy reflector facing bypass
RFI	PBR, PMR	Reflector facing channel
RFO	PBR, PMR	Reflector facing bypass
CTI	ACR-700	Caland tube facing channel
CTO	ACR-700	Caland tube facing bypass

3.3. Vector Control Functions and Ranges

Control function ranges and vector control functions have been implemented to avoid creating numerous similar control function blocks. Control function ranges permit users to create an ordered list of MELCOR objects, i.e., a vector, which can be comprised either control volumes, heat structures, control functions, core cells, core components, or core materials. Once defined, a control function range is identified within a control function argument by a preceding '#' character, similar to the following

```
CF_ARG   1
         1 COR-CELLMASS(#UPPERCORE,'ZR')   1.0   0.0
```

A control function may operate upon a control function range in one of two manners. If the control function by default returns a scalar value, then the control function will supply a summation of the control function operation results for each object within the control function range. However, if the control function is defined as a vector, using CF_VCF, the vector control function will store a vector of the resulting control function operation for each object within the defined control function range.

If desired, the value of an individual element of a vector control function can be accessed by appending a square bracketed index number '[#]' to the vector control function, where # represents the desired vector index. For example, the following control function argument would interrogate the vector control function "VXeRelease" for the value of the second vector index element.

```
CF_ARG   1
         1 CF-VALU(VXeRelease)[2]   1.0   0.0
```

The MELCOR Users' Guide provides further information on the new records: CF_RANGE, CONSTRUCT, REMOVE, and CF_VCF.

3.4. Defining a Constant Control Function Argument

A new method for defining constant values for control function operations may be performed by using either the keyword 'CF-CONST' or 'CF-LCONST' as the control function argument for either a constant real or constant logical value, respectively. Unlike all other control function arguments, only one input field is permitted following either constant control function argument to define the constant value, see examples below.

```
CF_ARG   1
         1 CF-CONST   2.2
```

```
CF_ARG   1
         1 CF-LCONST   true
```

3.5. Optional Comment Block

The comment blocks provide a new capability for users to enable or disable segments of user input. Encasing input within triple parenthesis '(((' and ')))' creates a comment block demarking the enclosed records as optional input for processing. By default, the encased records are treated as comments and are ignored; however, should the user provide a name for the commented block and enable the comment block on the COMMENTBLOCK record, the comment block will be processed as input. Section 3.2 of the EXEC package in the MELCOR Users' Guide provides further information.

3.6. Heat Structure Radiation Enclosure Network

A new net enclosure model has been added to calculate the net radiative heat transfer between a set of heat structures. The radiation enclosure model consists of two or more surfaces that envelope a region of space for which radiation transfer occurs among those surfaces. The space between these surfaces may or may not be filled with a participating medium, for which the gas may absorb, emit, and scatter radiation emitted by the surfaces. Each surface is assumed to be isothermal, opaque, diffuse, and gray, and are characterized by uniform radiosity.

Input data for the radiation enclosure model are supplied on the HS_RAD record. It is necessary for the user to specify the heat structure surfaces in the network (right or left surface), emissivities for the surfaces, and view factors between the surfaces. Section 2.1.4 of the HS package in the MELCOR Users' Guide provides further information.

3.7. Homologous Pump Model

The new MELCOR homologous pump model has been included within the MELCOR code, similar to the model in RELAP (RELAP5-3D, RELAP4) but with some distinguishing features. Several new MELGEN input records have been added that, in general, allow the user to fully specify 1) rated pump conditions, 2) single/two-phase pump performance via homologous curve input, 3) pump friction torque as a polynomial, 4) pump inertia as a polynomial, 5) pump speed and motor torque controls, and 6) pump trips. Additionally, pump data from the Semiscale and Loft experiments are available as a "built-in" option and a "universal correlation".

The new homologous pump model is enabled through the FL_PMP record. The new permissible input records related to the homologous pump are identified among the missing records in the FL package section.

3.8. Aerosol Resuspension Model

A new resuspension model was incorporated into MELCOR. The model is used for resuspending deposited aerosol from heat structures given local gas velocities. The deposited particle size distribution is now tracked as a function of time in MELCOR. Deposited particles larger than a critical diameter are resuspended within a few seconds, once the geometric mean diameter of particle in a section is above the critical diameter. HS_LBAR and HS_RBAR activate this model and are discussed further within the MELCOR Users' Guide.

3.9. Zukauskas Heat Transfer Coefficient

The Zukauskas correlation for external cross-flow across a tube bundle has been added as an option for the HS boundary surface data records. This empirical correlation has been developed for both staggered and aligned tube arrays relative to the fluid velocity vector and has been applied to a helical coil steam generator design. The model is enabled on the HS_LB and HS_RB records. Furthermore, the HS_ZUKL and HS_ZUKR input (though missing from the Users' Guide but is applied similar to HS_ZUKL) becomes permissible and are discussed within the MELCOR Users' Guide.

3.10. Reflector Models

Modeling reflectors is now available. The heavy reflector (HR) is a new component available for PWR-HR reactor type and the reflector is an overwrite of the CB component PBR/PMR reactor types (see COR_RT for all new available reactor types). Several records have been modified to permit reflector related input: COR_RT, COR_TAVG, and COR_QHS as well as the following new records: COR_KRF, COR_KHR, COR_RFD, COR_HRD, COR_RFG, COR_RFA, COR_HRA, COR_RFM, COR_HRM. Several core control function variables will also permit the HR and RF component identification (see COR-T for one example) as well as Graph as a material (see COR-M for one example).

3.11. Core Catcher

A new Lower Head and Containment package (LHC) has been added to MELCOR to model a "second lower head" or a "core-catcher" structure around/about the COR lower head. This new model calculates the thermal response of a new LHC structure and debris supported by this structure. The user specifies the LHC plate geometry, material, nodalization, etc. using the new records provided within the LHC package section of this report. The structure represented by the LHC package also identifies surrounding control volumes which interact with the structure. Additionally, similar to the core and cavity package interfaces that transport core material and radionuclides using the Transfer Process package (TP), transfer processes must be defined to perform similar transfers to and from the LHC package.

3.12. Multiple Fuel Rod Types in a COR Cell

In modeling the Sandia PWR spent fuel pool experiment it became apparent to capture the steep temperature gradient at the rack boundary it was necessary to represent the bundle with multiple rod types with independent temperatures. This temperature gradient was essential in predicting the timing of propagation of ignition from one fuel rod to the next. The multi-rod model permits the user to specify sets of rods (referred to as rod groups) within a core radial level (commonly referred to as a core ring but in spent fuel pool applications “rings” is not an appropriate descriptor). Each rod group will have a unique temperature for associated components (FU, CL, and NS) to enhance fidelity within a given radial level. If multi-rods are defined, the rod groups will have corresponding component identifiers of FUn, CLn, and NSn, augmenting the available components for control function arguments shown in Section 3.2.

Each rod group has a fraction of the fuel rod mass and surface area associated with those rods and the user-specified radiation view factors for radiation heat transfer. The new records COR_ROD2 and COR_ROD_VF allow for the rod group mass fractions and surface area fractions to be defined as well as the view factors between rod groups, respectively. Additionally, the power associated with each group can be defined on COR_RODP.

Similar to fuel elements and cladding, control elements which are modeled as NS can be defined with rod groups using COR_CR2 and COR_CR_VF to assign mass and surface area fractions as well as view factors between control element groups and nearby radial levels.

For the control function arguments, the multi-rod model extends FL, CL, and NS to ‘n’ user defined rod groups. When multi-rod model is used the user may specify which rod group is desired by supplying the component as <COMP>n, i.e., FU1, CL5, etc. If the rod group is not specified, the last radial level value will be supplied if rod groups exist. A mass-average value will be returned if ‘0’ is provided as the rod group.

3.13. Generalized Fission Product Release Model

A generalized fission product release model has been added to MELCOR consisting of two components, a burst fission product release term and a cumulative diffusive fission product release term. The associated records include a modified RN1_FP00 record and the addition of the RN1_GREL and RN1_DIFF. Other inclusions associated with the control function argument list and sensitivity coefficients are provided in the RN and COR package tables above.

3.14. New Debris Cooling Models added to CAV Package

Recent MELCOR code development has focused on improvements to the ex-vessel core-melt cooling models available to MELCOR code users. In particular, a water ingression model, a melt eruption model, and a melt spreading model were added to MELCOR. These models though available have not been completed and therefore are not recommend for user applications at this time.

3.15. Spreading Model Implemented into CAV Package

The spreading model implemented in MELCOR is based on a balance between gravitational and viscous forces. The new Ramacciotti model for calculating debris viscosity for two-phase (solid/liquid) flow has been implemented. This model was adopted from the MELTSPREAD [2] code and was assessed against the Vulcano VE-U7 test. Prior to this model, melt would spread across the cavity in a single time step by default, or would spread at a parametric rate specified by the user through a control function, see CAV_SP in the MELCOR Users’ Guide for details on the new model input.

3.16. Tabular Functions using Control Functions as Arguments

The TF package was modified to allow the user to specify a control function for the Y value for each X-Y data pair, see TF_TAB in the MELCOR Users' Guide.

3.17. Turbulent Deposition Modeling

The input has been restructured since the original implementation and now utilizes optional string input to provide a more readable input deck. In addition, the user can specify a flow path for determining the flow velocity. In the previous release, the flow velocity was obtained from the CV velocity but additional options are now available. The associated records are the RN1_TURB and RN1_TDS.

3.18. Temporal Relaxation Models

Many physical processes in MELCOR are modeled by correlations based on relationships developed from steady-state experiments. These models do not represent the time it takes for these processes to respond if conditions change. As a result, temporal "rate-of-change" aspects of MELCOR simulations are not expected to be highly accurate and numerical instabilities can be magnified when sudden changes occur. Temporal relaxation is a simple way to introduce a user-imposed time-scale based model that limits how quickly processes being modeled can change in time. A new LAG control function has been added, see section 2.1.4 of the MELCOR Users' Guide for an example of the new input. On CF_ID, CFTYPE can now be defined as type 'LAG'. The CF_MSC record has an input requirement for two constants for LAG control functions, but this is missing from the control function table listing miscellaneous number requirements in MELCOR Users' Guide.

4. SNAP Improvements

4.1. SNAP Menu

- There should be a menu option for converting between input formats between MELCOR versions. Currently this has been a two-step process, first choosing code version at "Code Flavor" under "Model Options" in the SNAP navigator, and second using menu item "Export" under menu "File". A straightforward process under menu is expected for version conversion. For example, a menu item "Convert Code Versions" can be added under menu "File".

4.2. SNAP Navigator

- Each input group in the SNAP interface should be marked with the corresponding MELCOR input identification, if it exists. For example, RN1_GAP as well as Cladding Inventory in the RN1 package section. Having the corresponding record name will assist knowledgeable users identify which SNAP field modifies the desired record.
- As an alternative approach, add a search functionality for users to quickly find the input group or field related to a given MELCOR record.
- It should be made clear for users that if a new control function (under Control Functions in Control System) uses control function arguments, control function arguments need to be selected as a database variable before adding new control

functions. Or as an alternate approach, “Database Variables” should be renamed as “Control Function Arguments”, making users realize that each argument is constructed from an element in the database of Control Function Arguments.

- External file: Adding external files should be easy. A user may need to add an External File for a given package. A “Select from External Data Files” window pops up. But there is not any available component in the window before any external data file is added, and it is difficult to figure out how an external file is added. External files can be added through “External Data Files” under “Control Systems” in the SNAP navigator. This should be pointed out at the “Select from External Data Files” window.
- Using default values of input from MELCOR Users’ Guide if the default value is available, is subjective. The default may change resulting in a disconnect between documented default values and the values presented within the GUI as defaults. Perhaps not populating default values is warranted.
- It is not clear what function “Control Time Limit” under Model Options performs.
- “Display Units” under Model Options can be used to convert units when editing the input. But it should be clarified that MELCOR 2.2 uses mostly SI units for input.
- Condenser package need be marked with MELCOR abbreviation CND. Each input need be marked with MELCOR variable name, for example, “VLPCSL” for input Volume PCCS Source. This also applies to other packages.
- Core package: Region Geometry input does not work.
- Core package: Cell Properties always shows “Invalid values” even if the input looks fine.
- Core package: Axial levels and radial rings are initialized when turning Enable Core to True for the first time, and cannot be changed thereafter. These should be able to be changed. Or it should allow the user to start it over with the Core package by initializing core dimensions again.
- Core package: LHF input should be situated with the other Lower Head input
- Core package: The whole package need to be organized consistently with MELCOR Users’ Guide.
- Radionuclide package: Input groups RNCFDS and RNCFPT are not MELCOR input.
- Radionuclide package: RN2 input such as Pool Scrubbing and Filters, should be labeled as “RN2_”.

4.3. SNAP Miscellaneous

- The copy and paste feature allows elements to be moved from an input model to an animation model. It would be greatly improved if it copied control volumes as polygons rather than the hydraulic bean, deprecated(?). The polygon drawing element is perhaps the most versatile drawing elements and more applicable for control volume depictions. Also, the amount of information necessary to populate the two-fields, water level data, and axial heights could be brought over in the process, reducing user input error and improving rapid animation model development.

- When running UQ with the DAKOTA plugin, if you encounter a situation where one of the realizations fails, no report is generated, there is no attempt to account for statistics with the missing runs, and there is no indication to the user that jobs failed and for this reason, no report is generated.
- There is currently no way to add command line arguments to a MELCOR or MELGEN run. Attempting to add one via the SNAP Configuration (below) leads to an error in the run where SNAP fails to find the input deck
- Perhaps the most important recommendation: because SNAP development occurs after features are added to MELCOR, it is essential that SNAP permits users the capability to directly provide text-based input. Users who develop models within SNAP may need to conclude work outside of the program to utilize new features available in MELCOR.

5. Conclusions

The presented material gives an account of new model capabilities found in MELCOR 2.2 which at the time of this document had yet to be implemented into the SNAP MELCOR plugin. Additionally, recommendations to enhance SNAP users' experience have been provided.

References

[1] L. L. Humphries and et. al., "MELCOR Computer Code Manuals Vol. 1: Primer and Users' Guide Version 2.2.9541," Sandia National Laboratories, 2017.

[2] M. T. Farmer, "The MELTSPREAD Code for Modeling of Ex-Vessel Core Debris Spreading Behavior Code Manual - Version3-beta," Nuclear Engineering Division, Argonne National Laboratory, 2017.

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