Institutionalize Card 1 Option 3

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Introduction

- *RELAP5-3D Card 1 Option 3 makes junction sound speed calculation method when noncondensables are present consistent with volume sound speed calculation method when noncondensables are present.*

- *Purpose of task to institutionalize Card 1 Option 3 was to make this option the default, to carry out verification, and to document the code changes in the code manuals.*

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Background

- *RELAP5-3D and RELAP5/MOD3.2 simulations of AP600 SBLOCAs showed there were code problems/failures past accumulator emptying where noncondensables entered the primary system.*

- *Analysis indicated a contributing factor to the failures was that sound speed calculation between volumes and junctions was inconsistent when noncondensables were present.*

Background (continued)

- *Thus, coding was developed in 2000 to make junction sound speed calculation for standard choked flow model (Ransom-Trapp) in presence of noncondensables be consistent with volume sound speed calculation in presence of noncondensables.*

- *This was put in the code as Card 1, Option 3.*

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Base Code

- *Without Card 1 Option 3, junction sound speed with noncondensables present in RELAP5-3D is based on the incomplete nonequilibrium-nonhomogeneous two-phase model in volumes for RELAP5/MOD1.*

- *The incomplete model uses a combined (vapor/gas and liquid) mixture internal energy equation, and thus it requires an additional assumption to complete the specification of the state of the two phase mixture.*

- *The additional assumption used is that the least massive phase is assumed to exist at the saturation state corresponding to the local pressure.*

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Base Code (continued)

- *With Card 1 Option 3, junction sound speed with noncondensables present in RELAP5-3D is based on the complete nonequilibrium-nonhomogeneous two-phase model in volumes for RELAP5/MOD2, RELAP5/MOD3, RELAP5/MOD3.2, and RELAP5-3D.*

- *The complete model uses a uses a separate vapor/gas internal energy equation and a liquid internal energy equation.*

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Code Modifications

- *Necessary coding changes were made to make Card 1 Option 3 the default; original coding was preserved as Card 1 Option 3.*

- *Changes were made to subroutines RCHNG, ISTATE, TSTATE, STATEP, and JCHOKE.*

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Verification

- **Tested the simple two-volume problem on the most recent code version 2.9.1 (has the changes to make Card 1 Option 3 the default).**

- **Problem used 11 different void fractions, 4 different velocities, and 9 different noncondensable qualities.**

- **Tested the problem with Card 1 Option 3 and without Card 1 Option 3.**

- **Code ran successfully and gave similar results to calculations run previously in January 2000 with meaning of Card 1 Option 3 now switched.**

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Verification (continued)

- *Tested the pipe problem (noncondensable choking) on the most recent code version 2.9.1 (has the changes to make Card 1 Option 3 the default).*

- *Tested the problem with Card 1 Option 3 and without Card 1 Option 3.*

- *Code ran successfully and gave similar results to calculations run previously in January 2000 with meaning of Card 1 Option 3 now switched.*

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Verification (continued)

- *Tested the AP600 problem (past accumulator emptying and noncondensable entering primary) on the most recent code version 2.9.1 (has the changes to make Card 1 Option 3 the default).*

- *Tested the problem with Card 1 Option 3 and without Card 1 Option 3.*

- *Code gave expected results.*

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Verification (continued)

- *With Card 1 Option 3: AP600 calculation ran slow (dt = 3.81 e-8 s) at 560 s, noncondensable had entered system from accumulator 885 after it emptied, noncondensable was present in nearby volumes, choking with noncondensable occurred in nearby junctions, time step cuts occurred in nearby volumes, calculation was terminated at this point.*

- *Without Card 1 Option 3: AP600 calculation ran past 560 s and continued out past 2,000 s.*

Conclusions

- *Default RELAP5-3D code now has junction sound speed calculation method with noncondensables present consistent with volume sound speed calculation method with noncondensables present.*

- *Verification of this feature indicates the code behaves as expected.*

- *Old calculation method is now Card 1 Option 3 in RELAP5-3D code.*

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