

RELAP5-3D Unit Conversion Work

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Outline

- Introduction
- Procedure
- Coding Modifications
- Results
- Conclusions

Introduction

- RELAP5-3D was created by various developers over the course of many years. This has led to inconsistencies in the conversion factors for converting between British and SI units.
- Individual subroutines have their own conversion factors.
- The conversion factors are the same across subroutines but having them set in many locations can lead to errors/inconsistency.
- Internal code calculations are performed in SI units.
- The code allows users to enter their input in either units. If entered in British units, the code uses conversion factors to transform the entries into SI units.
- Users can also elect to receive output in either SI or British units. If the output is requested to be in British units, the code converts the SI (internal) calculation values into British units before printing the output.

Introduction, cont.

- The National Institute of Standards and Technology (NIST) releases standardized conversion factors between the units.
- The conversion factors in RELAP5-3D were compared against the NIST documentation (Reference 1), and some slight discrepancies were found (typically in precision).
- To standardize the conversion factors, a new module was created. Each of the conversion factors were assigned a unique variable name that are used by the separate routines.
- These unit conversion factors are referenceable values, defined by NIST.
- The existing unit conversion factors used throughout the code have been replaced with the values stored in the new module: unitmod.F.

Procedure

- The unit conversions are primarily performed in either the read-level routines (where input is read in from an input deck) or in routines that process code output.
- Subroutine irequest.F is used to generate output for plots and minor edits. This routine also stores various hard-coded unit conversion factors.
- The unit conversion factors found in irequest.F were used to identify factors needing to be addressed. These factors were compared against the NIST documentation, then set in accordance with the documentation.

Coding Modifications

- Module unitmod.F
- The unit conversion factors found throughout the code are stored in the new module unitmod.F.
- Conversion factors were added to the module one at a time.
- As new conversion factors were added to the module, a search and replace (with the proper variable) was performed in the code so that only the conversion factors stored in unitmod.F are used.
- The unit conversion for temperature is handled with an equation. In the case of temperature, only the additive constant is added to unitmod.F.

Coding Modifications, cont.

Unit conversion	British to SI ^a	SI to British
ft to m	0.3048	3.280839895
ft ² to m ²	0.09290304	10.76391042
ft ³ to m ³	0.02831685	35.31466672
BTU to J	1055.056	0.000947817
BTU/lbm to J/kg	2326.0	0.000429923
BTU/lbm-F to J/kg-K	4186.8	0.000238846
lbf-ft to N-m	1.355818	0.737562121
lbf/ft to N/m	14.5939	0.06852178
lbf-s ² /ft ⁵ to N-s ² /m ⁵	1690.875424 ^b	0.00059141
lbm to kg	0.4535924	2.204622476
lbm/ft to kg/m	1.488164	0.67196895
lbm/ft ² to kg/m ²	4.882428	0.204816128
lbm-ft ² to kg-m ²	0.04214011	23.73036046
lbm/ft ³ to kg/m ³	16.01846	0.062427974
lbm-s ² /ft ⁵ to kg-s ² /m ⁵	172.4212685 ^c	0.005799749

psi to Pa	6894.757	0.000145038
psi/ft ³ to Pa/m ³	243486.0456 ^d	4.10701E-06
BTU/s-ft ² to W/m ²	11356.53	8.80551E-05
BTU/s-ft ³ to W/m ³	37258.95	2.68392E-05
BTU/s-ft-F to W/m-K	6230.646 ^e	0.000160497
BTU/s-ft ² -F to W/m ² -K	20441.75	4.89195E-05
BTU/s-ft ³ -F to W/m ³ -K	67066.10892 ^f	1.49107E-05
revolutions/min to radians/s	0.1047198	9.549292493
degrees to radians	0.01745329251994 ^g	57.29577951
F/psi to K/Pa	8.05765E-05 ^h	12410.5626
s ² /ft ² to s ² /m ²	10.76391042	0.09290304
F/ft ² to K/m ²	5.979950232 ⁱ	0.167225472
gal/min to m ³ /s	6.30902E-05	15850.32224
F to K	N/A	-255.372222
C to K	N/A	273.15

Coding Modifications, cont.

- Example conversion factors found in rpipe.F.
- ft – 0.3048
- ft2 – 9.290304e-2
- ft3 – 2.831685e-2
- eng – 2.326e3
- psia – 6.894757e3
- degf2 – 255.3722222222
- xlbsec – .45359237

Codeing Modifications, cont.

- 49 subroutines were modified.
- This includes all component “read” routines and all output specific routines.

Results

- The code changes were tested using the verification test set [2].
- This test set was constructed to extensively test the RELAP5-3D code to identify the effect of the code changes.
- The verification test set consisted of 59 cases.
- All cases involving British units for input values were expected to differ from the unmodified version, due to changes in the conversion factors.
- Cases with SI input are minorly affected by the conversion factors prior to being run (i.e., conversion from degrees to radians).

Results

- After running the test cases, differences were observed in all the cases involving British unit inputs (18 cases total).
- Differences were also observed in three other cases: l2-5-emA, pitch, and valve.
- The differences were evaluated by adding subroutine changes one at a time to determine the source of the differences.
- The differences seen in case “l2-5-emA” were caused by the changes to the conversion factors used in subroutine chfapk.F (which used limited precision previously).
- The differences in cases “pitch” and “valve” are due to the additional precision added in converting between radians and degrees.

Conclusions

- The RELAP5 code was modified to use a centralized module to store conversion factors.
- These factors replaced the factors used in individual subroutines.
- The changes were tested using the verification test set to determine how the results were affected.
- All cases involving British input were found to have changed, as expected.
- Cases I2-5-emA, pitch, and valve were found to have changed due to changes in the precision of the conversion factors.

References

- [1] Thompson, A. and Taylor, B. N., “Guide for the Use of the International System of Units (SI),” *NIST Special Publication 811*, 2008.
- [2] Mesina, G. L., “RELAP5-3D Backup and Restart Verification Testing,” INL/EXT-13-29568, Idaho National Laboratory, Idaho Falls, ID, 2013.