SSTC NRS | State Scientific and Technical Center for Nuclear and Radiation Safety

Conversion of MELCOR 1.8.5 model to MELCOR 2.1 for WWER-1000/V 320 reactor and containment system. Problems identified during conversion. Comparative SA calculations with different MELCOR versions

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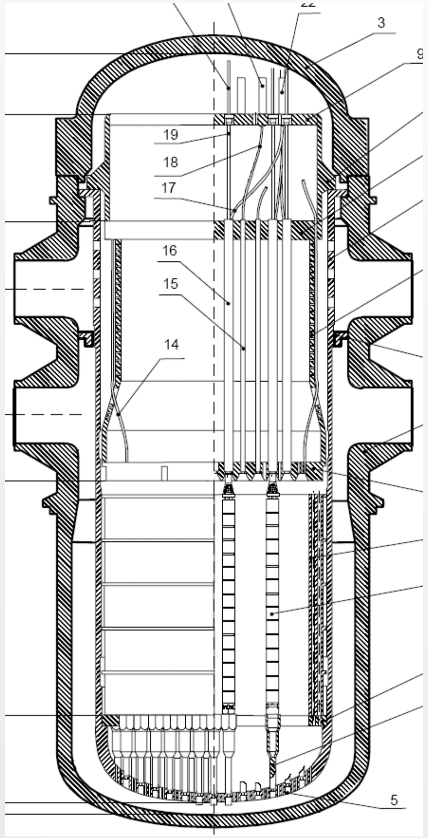
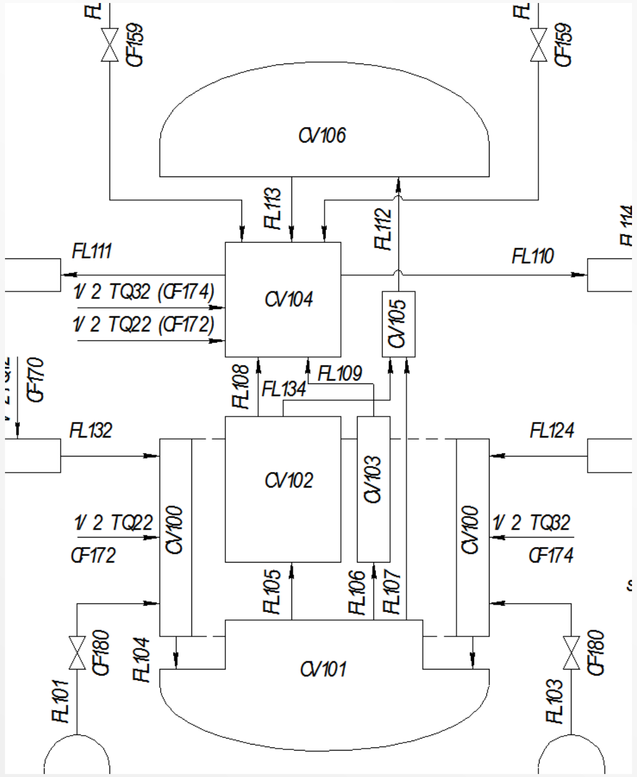
Contents

01 | Short description of MELCOR WWER-1000/V 320 model

Hydraulic model of reactor

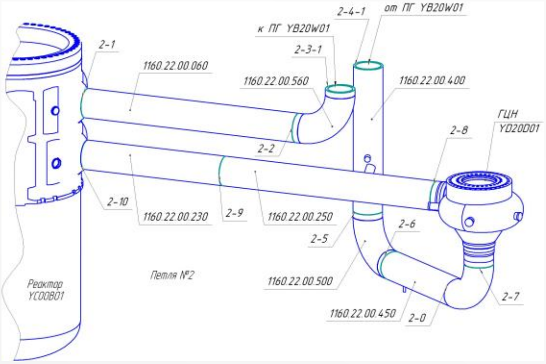


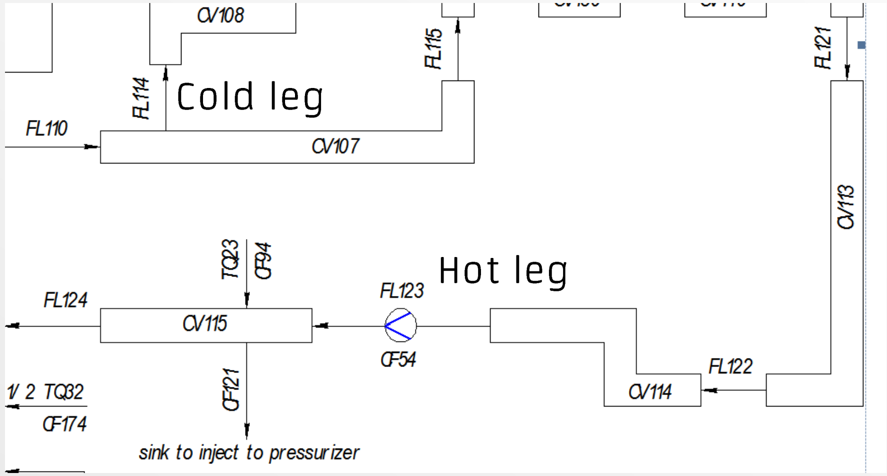


- 7 control volumes for reactor model
- 9 flow paths for reactor model
- 4 flow paths for hydroaccumulators

01 | Short description of MELCOR WWER-1000/V 320 model

Primary circuit model



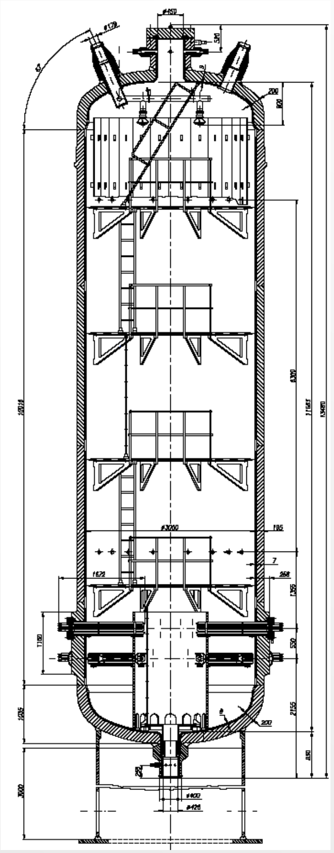


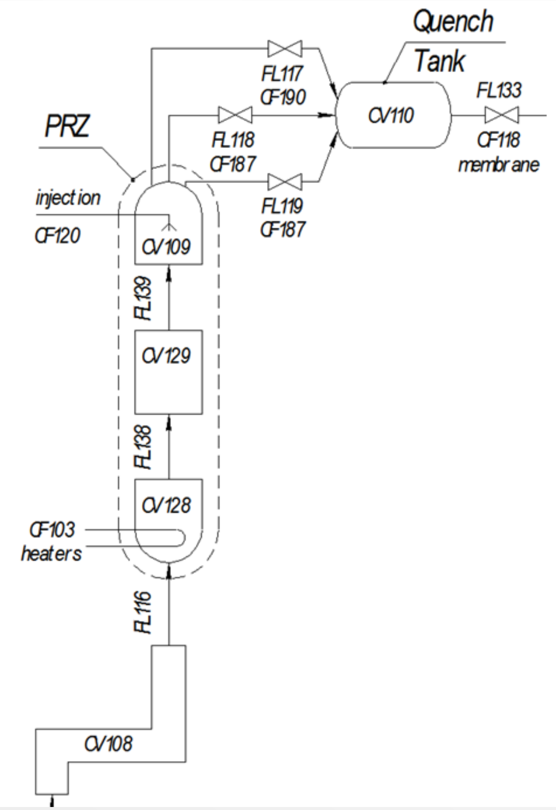
Single/triple loops:

- 4 control volumes each
- 6 flow paths

01 | Short description of MELCOR WWER-1000/V 320 model

Hydraulic model of pressurizer

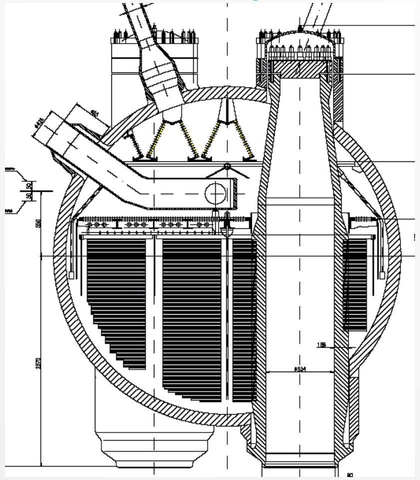


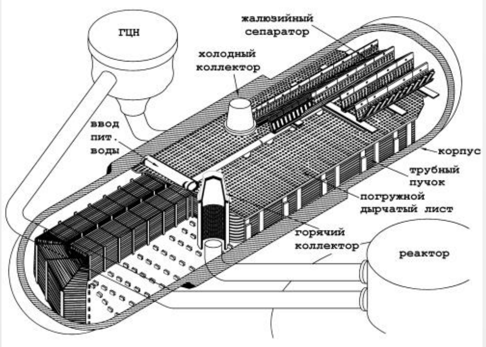


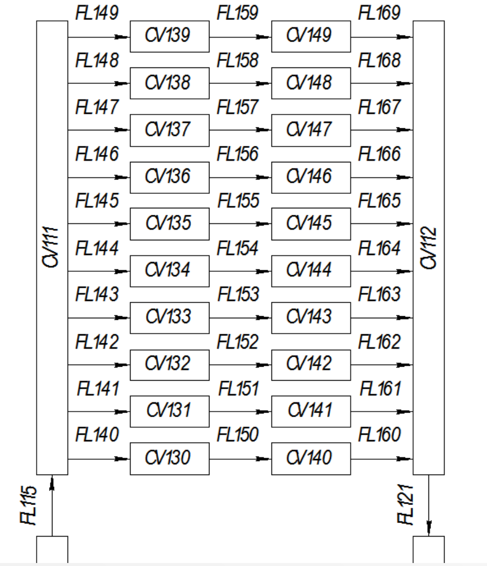
- 1 control volume for the surge line connecting PRZ with single hot leg;
- 3 control volumes for pressurizer;
- 1 control volume for bubbler tank;
- 4 flow paths for pressurizer and surge line;
- 3 flow paths for PRZ pilot operating relief valves;
- 1 flow paths for rupture disk between bubbler tank and containment;

01 | Short description of MELCOR WWER-1000/V 320 model

Hydraulic model of SG (primary circuit)





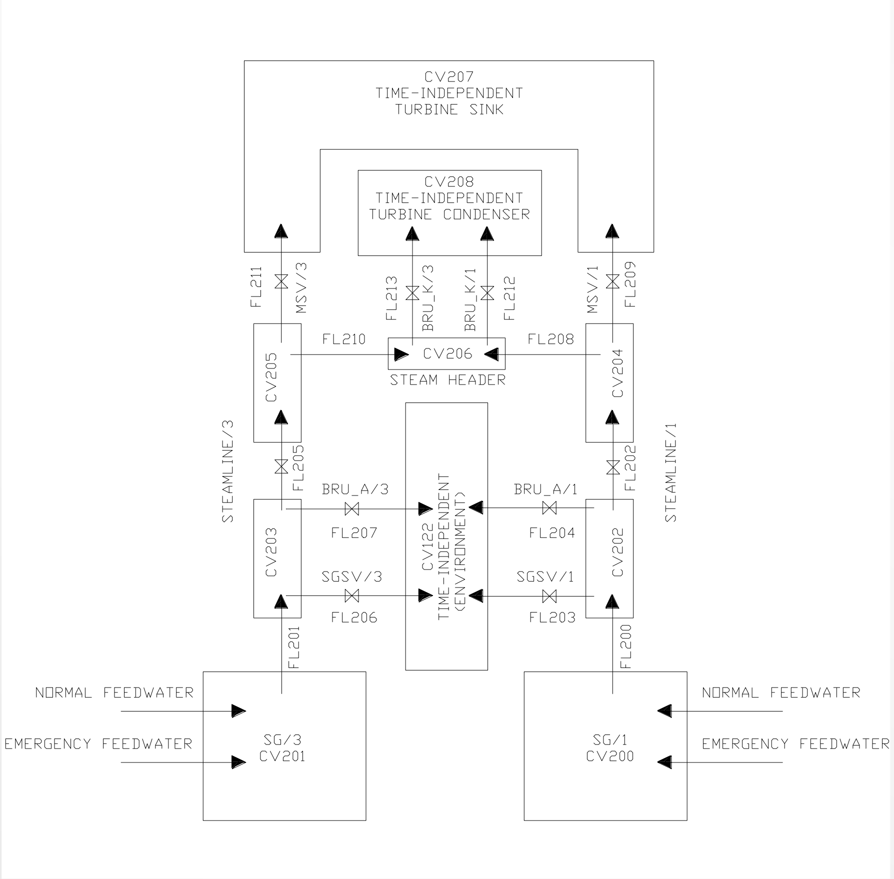


Single/triple SG model:

- 22 control volumes
- 30 flow paths

01 | Short description of MELCOR WWER-1000/V 320 model

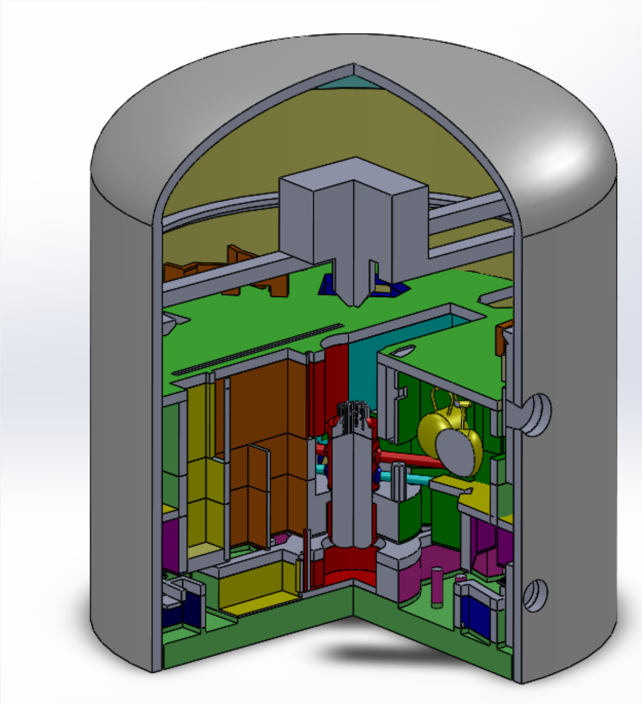
Secondary circuit model

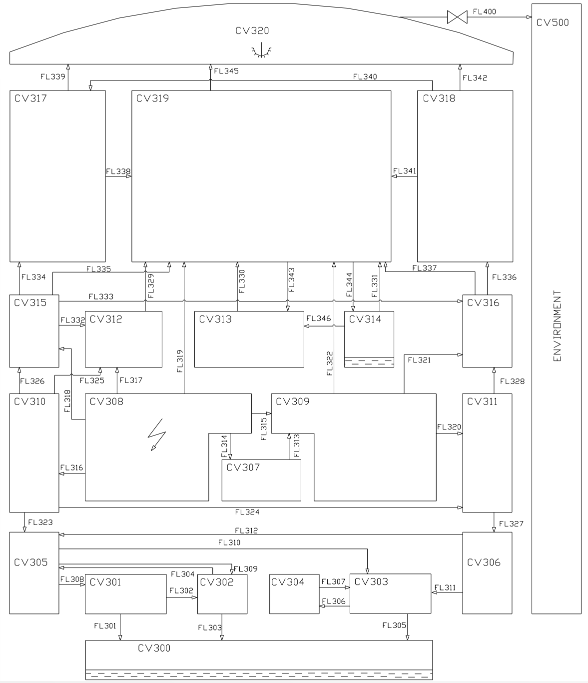


- 10 control volumes (include single/triple SG)
- 14 flow paths

01 | Short description of MELCOR WWER-1000/V 320 model

Hydraulic model of Containment

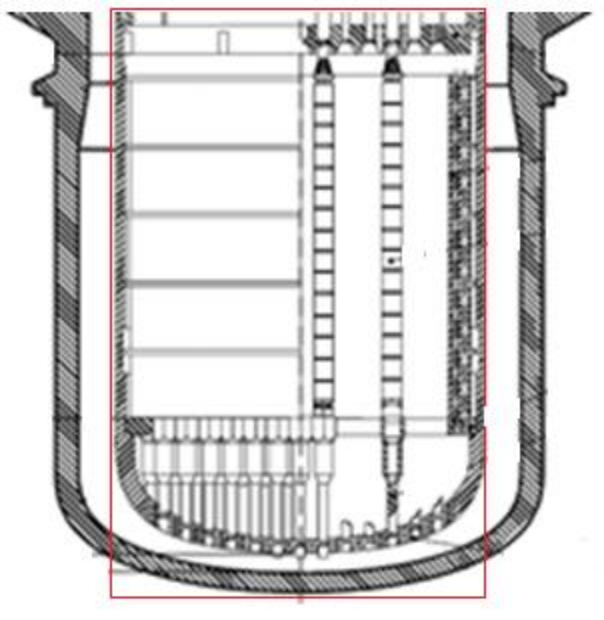




- 21 control volume
- 51 flow paths

01 | Short description of MELCOR WWER-1000/V 320 model

Reactor core model



HS10201	HS10203	HS10205		
117	217	317	HS10224	Upper unheated part of the reactor core
116	216	316	HS10222	Fuel part of the reactor core
115	215	315	HS10220	
114	214	314	HS10218	
113	213	313	HS10216	
112	212	312	HS10214	
111	211	311	HS10212	
110	210	310	HS10210	
109	209	309	HS10208	
108	208	308	HS10206	
107	207	307	HS10204	
106	206	306	HS10202	Bottom unheated part of the reactor core above support structures
105	205	305	HS10108	Elements of reactor barrel bottom and support structures
104	204	304	-	
103	203	303	-	
102	202	302	-	
101	201	301	-	
1	2 Reactor bottom	3		

3 radial rings

17 axial sections

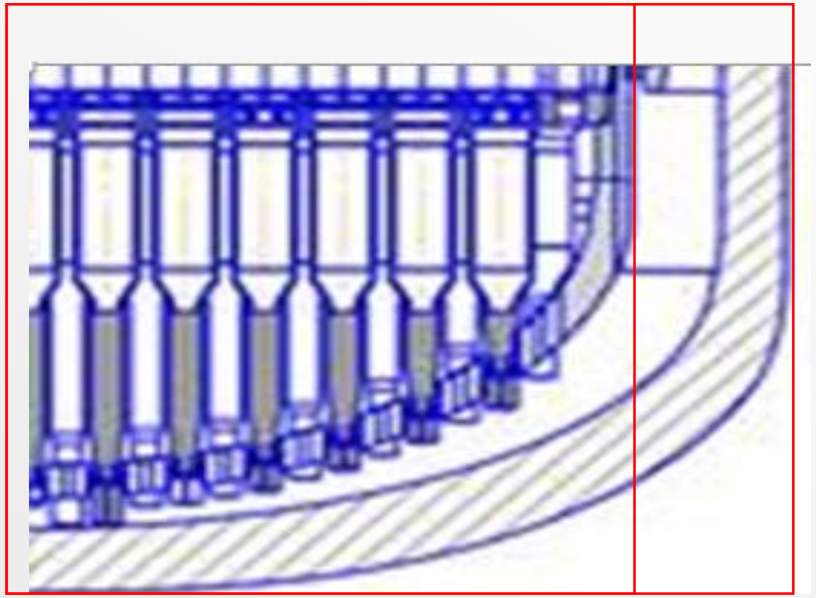
02 | Conversion procedure and models main changes

Converting Melcor 1.8.5 model for Melcor 1.8.6:

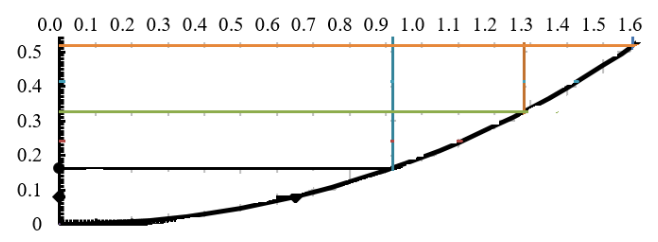
- Detailed Lower head Model
- *Core nodalization changes* (re-noding *axial segments for detailed LH model, add radial rings for cylindrical part of LH)*
- *RN, HS changes connected with changes in number of LH segments*

02 | Conversion procedure and models main changes

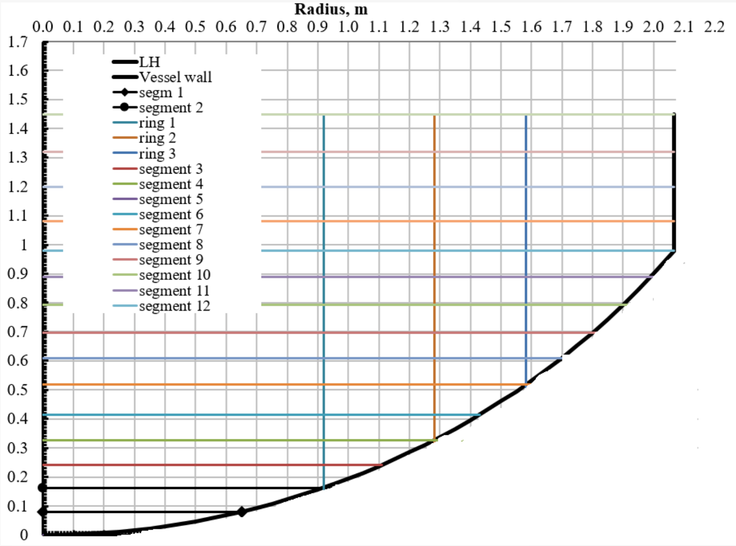
Lower head Model changes



VVER 1000 lower head



LH MELCOR 1.8.5 nodalization



LH MELCOR 1.8.6, 2.1 nodalization

02 | Conversion procedure and models main changes

CORE Model changes

Bottom elevation, m	Top elevation, m	Section height, m	HS10201	HS10203	HS10205		
22,301	23,018	0,717	117	217	317	HS10224	Upper unheated part of the reactor core
21,946	22,301	0,355	116	216	316	HS10222	Fuel part of the reactor core
21,591	21,946	0,355	115	215	315	HS10220	
21,236	21,591	0,355	114	214	314	HS10218	
20,881	21,236	0,355	113	213	313	HS10216	
20,526	20,881	0,355	112	212	312	HS10214	
20,171	20,526	0,355	111	211	311	HS10212	
19,816	20,171	0,355	110	210	310	HS10210	
19,461	19,816	0,355	109	209	309	HS10208	
19,106	19,461	0,355	108	208	308	HS10206	
18,751	19,106	0,355	107	207	307	HS10204	
18,525	18,751	0,226	106	206	306	HS10202	Bottom unheated part of the reactor core above support structures
18,348	18,525	0,177	105	205	305	HS10108	Elements of reactor barrel bottom and support structures
17,878	18,348	0,470	104	204	304		
17,119	17,878	0,759	103	203	303		
16,999	17,119	0,120	102	202	302		
16,899	16,999	0,1	101	201	301		
			1	2 Reactor bottom	3		

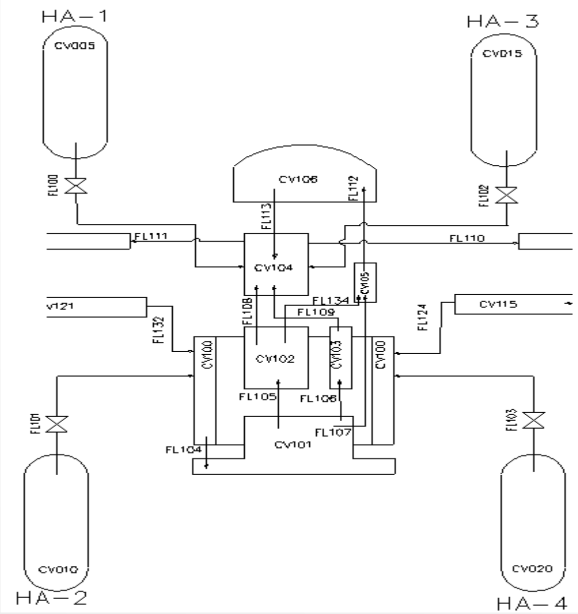
MELCOR 1.8.5 CORE nodalization

Bottom elevation, m	Top elevation, m	Section height, m	HS10201	HS10203	HS10205	HS10205		
22.301	23.018	0.717	125	225	325	425	HS10224	Upper unheated part of the reactor core
21.946	22.301	0.355	124	224	324	424	HS10222	Fuel part of the reactor core
21.591	21.946	0.355	123	223	323	423	HS10220	
21.236	21.591	0.355	122	222	322	422	HS10218	
20.881	21.236	0.355	121	221	321	421	HS10216	
20.526	20.881	0.355	120	220	320	420	HS10214	
20.171	20.526	0.355	119	219	319	419	HS10212	
19.816	20.171	0.355	118	218	318	418	HS10210	
19.461	19.816	0.355	117	217	317	417	HS10208	
19.106	19.461	0.355	116	216	316	416	HS10206	
18.751	19.106	0.355	115	215	315	415	HS10204	
18.525	18.751	0.226	114	214	314	414	HS10202	Bottom unheated part of the reactor core above support structures
18.348	18.525	0.177	113	213	313	413	HS10108	Elements of reactor barrel bottom and support structures
18.219	18.348	0.129	112	212	312	412	-	
18.099	18.219	0.120	111	211	311	411	-	
17.979	18.099	0.120	110	210	310	410	-	
17.878	17.979	0.101000	109	209	309	409	-	
17.787053	17.878	0.090947	108	208	308	408	-	
17.691573	17.78705	0.095480	107	207	307	407	-	
17.595671	17.69157	0.095902	106	206	306	406	-	
17.509051	17.59567	0.086620	105	205	305	405	-	
17.417259	17.50905	0.091792	104	204	304	404	-	
17.226125	17.41726	0.191134	103	203	303	403	-	
17.061902	17.22612	0.164222	102	202	302	402	-	
16.899	17.0619	0.162902	101	201	301	401	-	
			1	2 Reactor bottom	3	4		

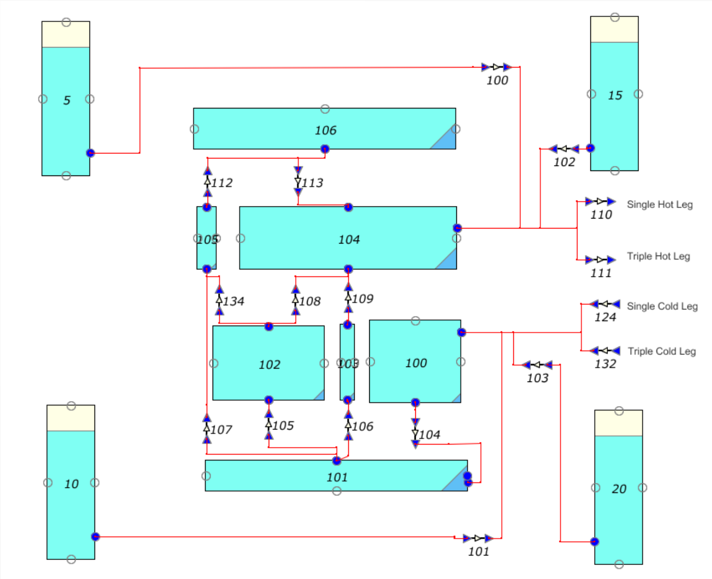
MELCOR 1.8.6, 2.1 CORE nodalization

02 | Conversion procedure and models main changes

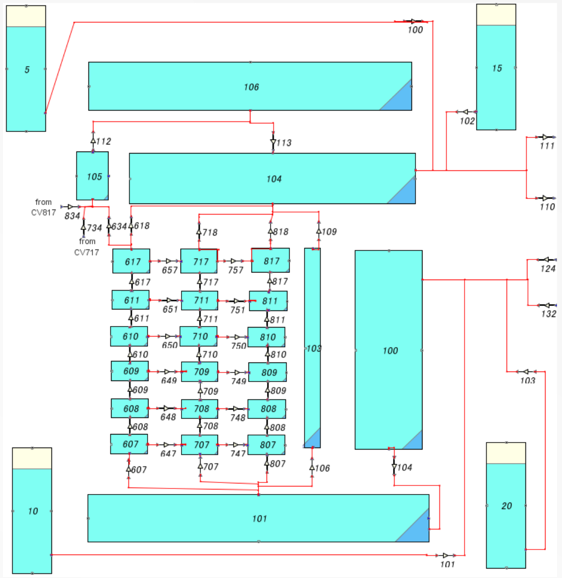
CORE hydraulics model changes



MELCOR 1.8.5 reactor nodalization with one core CV



MELCOR 1.8.6/2.1 reactor nodalization with one core CV



MELCOR 1.8.6/2.1 reactor nodalization with 18 core CVs

02 | Conversion procedure and models main changes

Conversion of MELCOR 1.8.6 model to MELCOR 2.1

- Conversion to MELCOR 2.1 code version using SNAP software
- *Change of incorrectly converted parts of the model* MELCOR 1.8.6
- *Verification of MELCOR 2.1 model*

03 | Problems identified during conversion

MELCOR 2.1 requires two arguments for MULTIPLY function

```
CF23600 'FW_ENTS' MULTIPLY  1   1.676E+05      0.0
CF23610 1.0   0.0  CFVALU.230
```

```
!               cfname          icfnum          cftype
CF_ID      'FW_ENTS_2'             236        MULTIPLY
!               cfscal          cfadcn
CF_SAI         1.676E5             0.0
!               icflim
CF_ULB         DEFAULT             0.0             0.0
!        size
CF_ARG     1 !n                  cfarg          arscal          aradcn
              1 CF-VALU('TX20_RATE_4')             1.0
```

```
!               cfname          icfnum          cftype
CF_ID      'FW_ENTS-2'             236        MULTIPLY
!               cfscal          cfadcn
CF_SAI         1.676E5             0.0
!               icflim
CF_ULB         DEFAULT             0.0             0.0
!        size
CF_ARG     2 !n                  cfarg          arscal          aradcn
              1 CF-VALU('TX20_RATE-4')             1.0
              2              EXEC-TIME             0.0             1.0
```

03 | Problems identified during conversion

The CV names with double quotes need to be replaced with single quotes

```
CV00500    "HA-1" 2 2 1
CV00501    0 0
```

```
!                   cvname        icvnum
CV_ID               "HA-1"             5
```

```
!                   cvname        icvnum
CV_ID               'HA-1'             5
```

03 | Problems identified during conversion

User material names 'ALUM', "ALUM“ before conversion need to be replaced with 'ALUMINIUM'

```
HS30201201      PAINT 1
HS30201202      ALUM  2
HS30201203      Bst3ps5  6
```

```
HS30201201          'PAINT'          1
HS30201202        'Bst3ps5'          6
```

```
HS30301201          'PAINT'          1
HS30301202      'ALUMINIUM'          2
HS30301203        'Bst3ps5'          6
```

```
HS_ND     31 ! n  n       xi tempin       matnam
             1  1      0.0      -      'PAINT'
             2  2   1.9E-4      -  'ALUMINIUM'
             3  3   4.4E-4      -    'Bst3ps5'
             4  4   8.4E-4      -    'Bst3ps5'
             5  5 1.56E-3      -    'Bst3ps5'
             6  6 2.93E-3      -    'Bst3ps5'
```

03 | Problems identified during conversion

Parameters for variables "RNVL", "RNAL", "RNVG", "RNAG" need to be changed manually since no automatic conversion possible

```
RNVG435 109 1. 9.84E-07 0. 0. 6.84E-08 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
RNAG436 109 2 1. 5.58E-06 0.  0.  0.  0.
RNAG437 109 3 1. 6.02E-11 0.  0.  0.  0.
RNAG438 109 4 1. 6.16E-07 0.  0.  0.  0.
RNAG439 109 6 1. 3.58E-12 0.  0.  0.  0.
RNAG440 109 8 1. 1.38E-11 0.  0.  0.  0.
RNAG441 109 9 1. 4.16E-09 0.  0.  0.  0.
```

```
*        ivol iclss rfrac   xmass1 xmass2 xmass3 xmass4 xmass5
RNAG000   109     2   1.0  5.58E-6    0.0    0.0    0.0    0.0
RNAG001   109     3   1.0 6.02E-11    0.0    0.0    0.0    0.0
RNAG002   109     4   1.0  6.16E-7    0.0    0.0    0.0    0.0
RNAG003   109     6   1.0 3.58E-12    0.0    0.0    0.0    0.0
RNAG004   109     8   1.0 1.38E-11    0.0    0.0    0.0    0.0
RNAG005   109     9   1.0  4.16E-9    0.0    0.0    0.0    0.0
```

```
RN1_VG 2 ! NSTR IVOL ICLSS RFRAC XMASS
           1 'PRZ_TOP' XE 1.0 9.84E-07
           2 'PRZ_TOP' I2 1.0 6.84E-08
!
RN1_AG 6 ! NSTR IVOL ICLSS RFRAC XMASS
           1 'PRZ_TOP' CS 1.0 5.58E-06
           2 'PRZ_TOP' BA 1.0 6.02E-11
           3 'PRZ_TOP' I2 1.0 6.16E-07
           4 'PRZ_TOP' RU 1.0 3.58E-12
           5 'PRZ_TOP' CE 1.0 1.38E-11
           6 'PRZ_TOP' LA 1.0 4.16E-09
```

03 | Problems identified during conversion

Number format "3E-11" shall be changed to "3.E-11" (with decimal point)

RNAL038 105 3 3E-11

RNAL001 0 0 Unknown Unknown

66 'GT_BYPASS' BA 1.0 3.E-11

03 | Problems identified during conversion

In MELCOR 2.1 the argument "AE“ in steam part of Pressurizer could not be read. This argument was replaced with "PE"

```
CV109C1    MASS.2 1091 3
CV109C2    AE 1141 3
```

```
CV_SOU     2 !n ctyp interp iessrc       srcname idmat
             1 MASS    RATE      CF 'ON/OFF_SPR' 'FOG'
             2  AE     RATE      CF      'SPR_IN'
```

```
CV_SOU     2 !n ctyp interp iessrc       srcname idmat
             1 MASS    RATE      CF 'ON/OFF_SPR' 'FOG'
             2  PE     RATE      CF      'SPR_IN'
```

03 | Problems identified during conversion

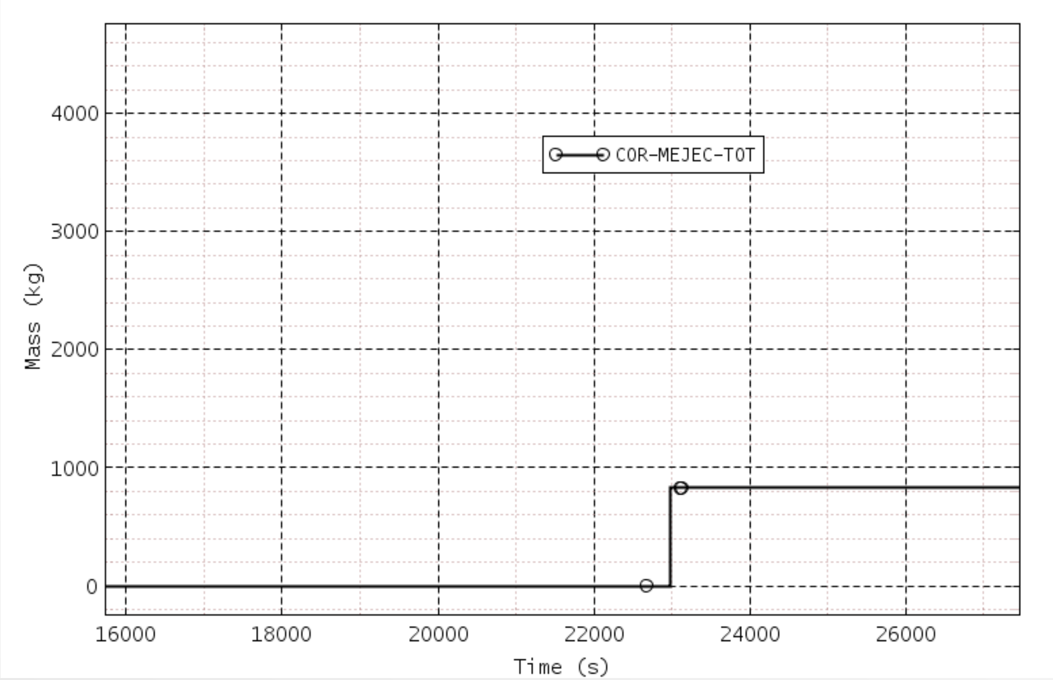
Verification MELCOR 2.1 model

- Line-by-line review of input data of the MELCOR version 2.1 model and comparison with input data for the MELCOR version 1.8.5 model;
- Additional verification of the MELCOR version 2.1 model in the process of creating nodalization diagram of operation systems using the software SNAP and comparing with nodalization schemes of MELCOR version 1.8.5 model;
- Verification of the MELCOR version 2.1 model in the process of test calculation (verify masses of core materials, systems operation logic etc.)

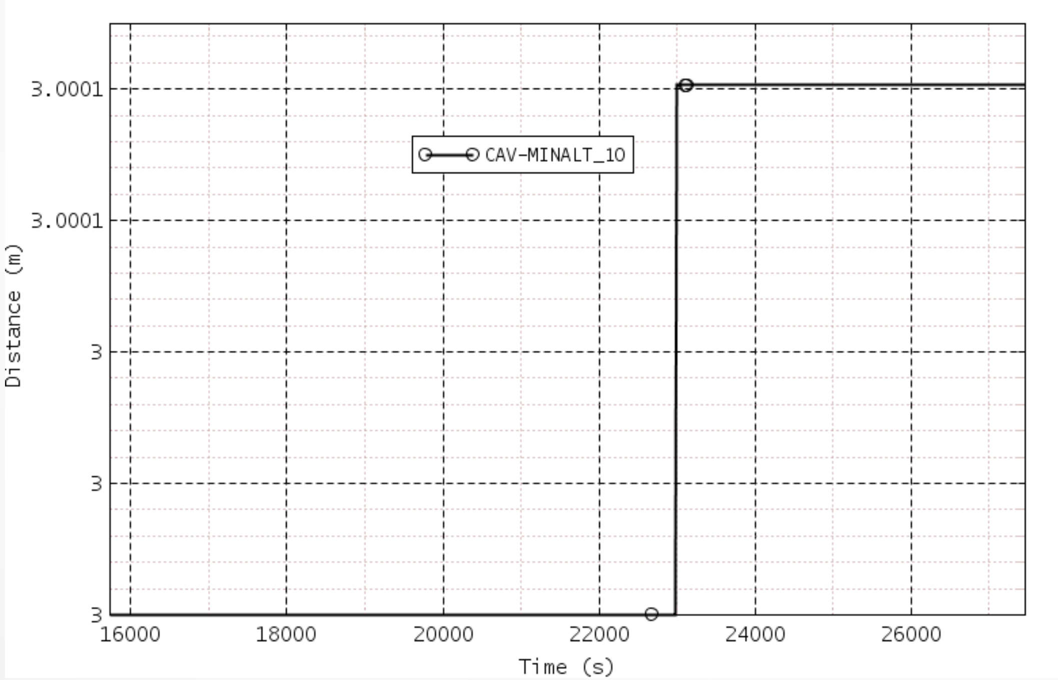
03 | Problems identified during conversion

Additional changes based on the results of calculation SA

Low mass of ejected debris after LH failure



Total debris mass ejected through vessel breach

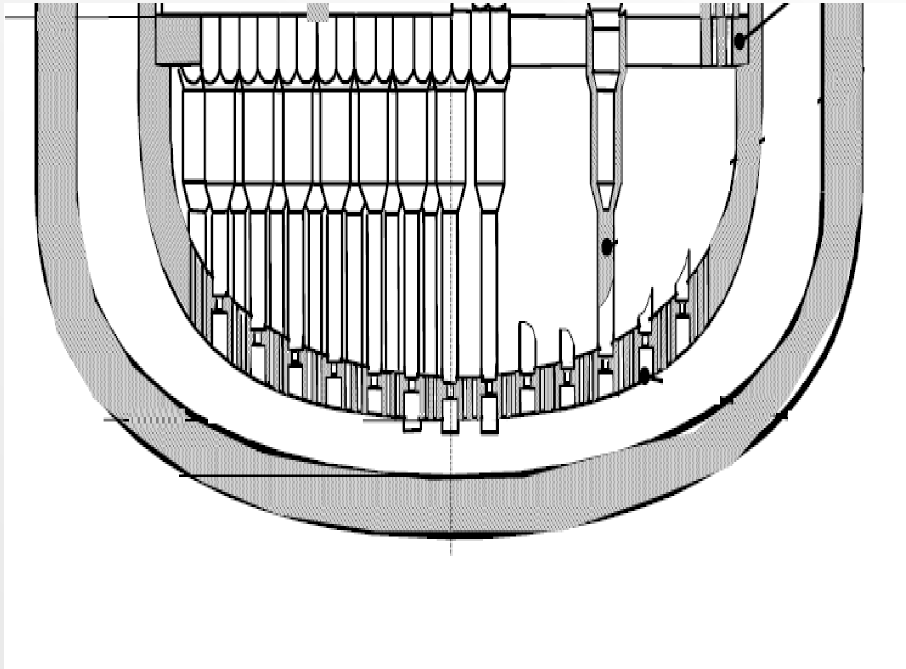


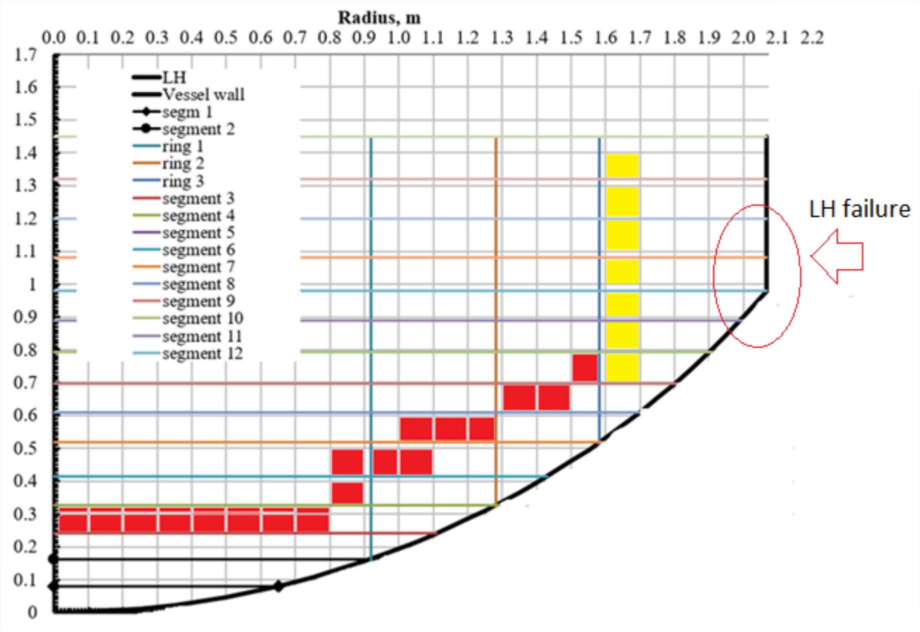
CAVITY ablation elevation

03 | Problems identified during conversion

Additional changes based on the results of calculation SA

Adding support structures to the fourth ring





04 | Comparative SA calculations

Scope of analysis:

- Analysis with Melcor 1.8.5 and 2.1 version
- Analysis with different Melcor 2.1 Release version
- Analysis with different time step

Analysis was made for SA scenarios:

- Blackout
- LB LOCA with Blackout

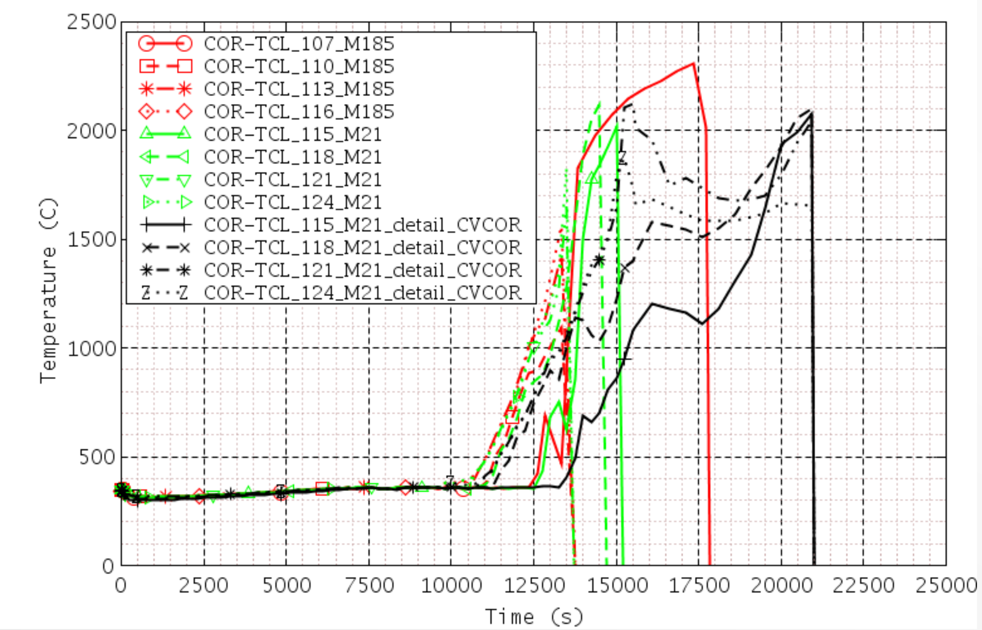
05 | Comparative SA calculations with MELCOR 1.8.5 and MELCOR 2.1

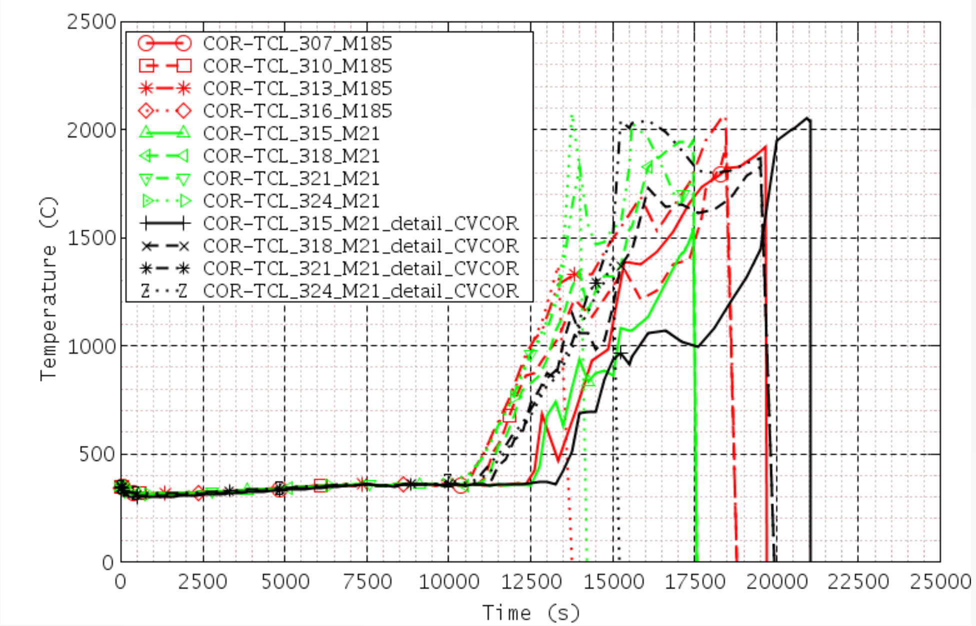
Type of calculation

- Melcor 1.8.5 model with 1 core CV
- Melcor 2.1 (revision 6342) model with 1 core CV
- Melcor 2.1 (revision 6342) model with 18 core CVs

05 Comparative SA calculations with MELCOR 1.8.5 and MELCOR 2.1

Blackout

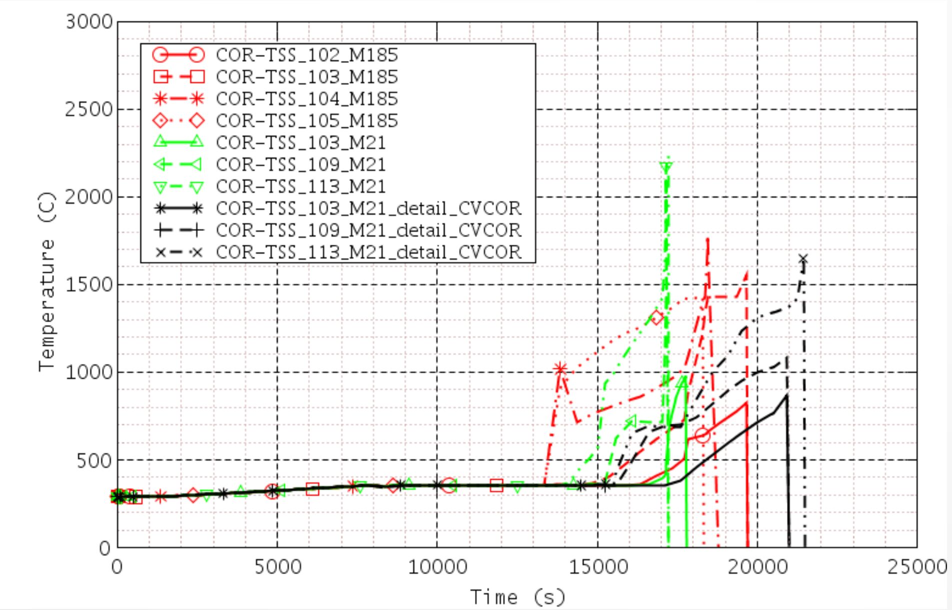


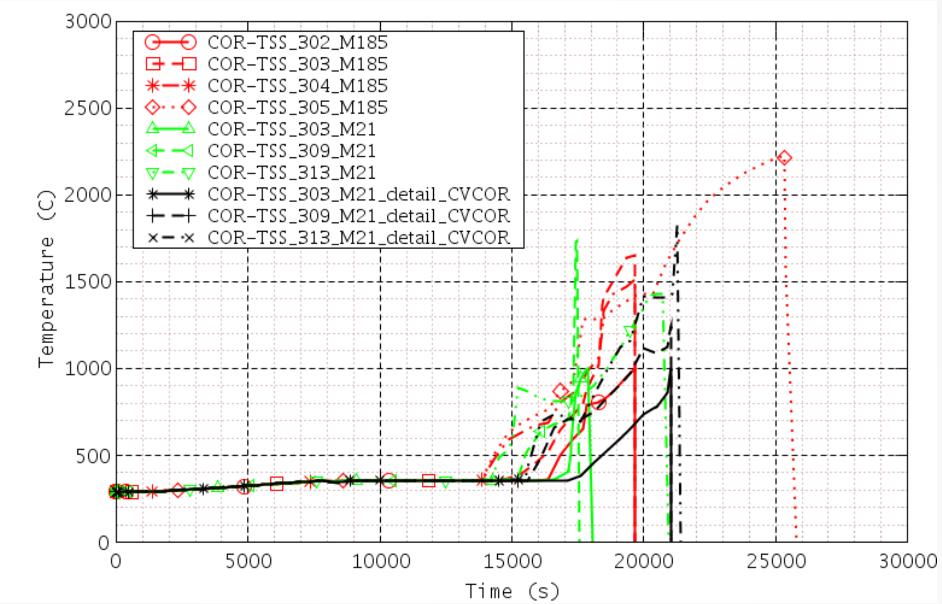


Cladding temperature

05 | Comparative SA calculations with MELCOR 1.8.5 and MELCOR 2.1

Blackout

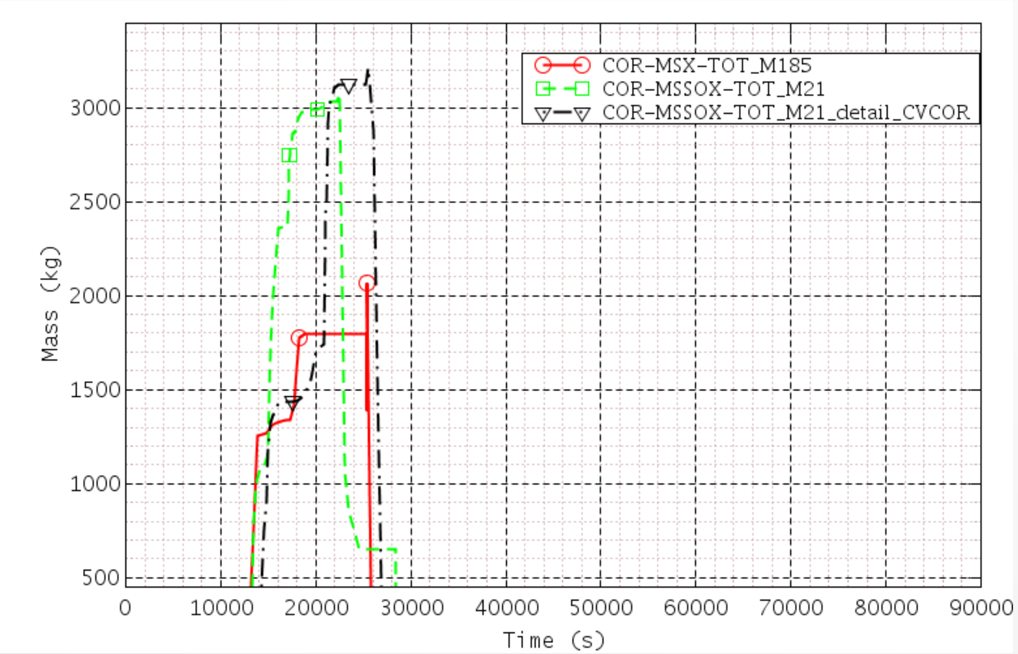




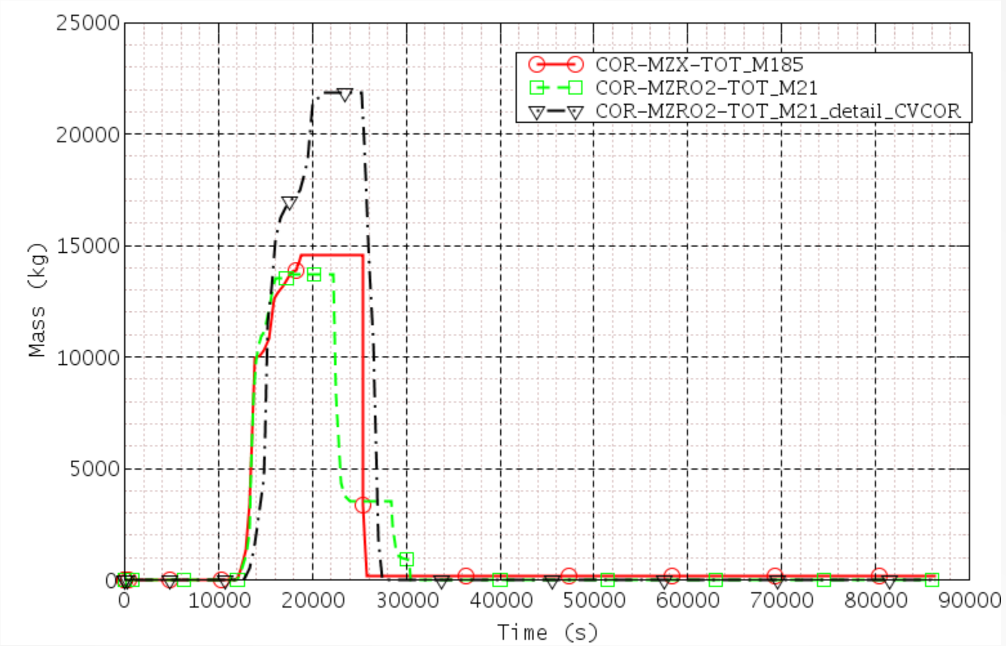
Base plate support structure temperature

05 | Comparative SA calculations with MELCOR 1.8.5 and MELCOR 2.1

Blackout



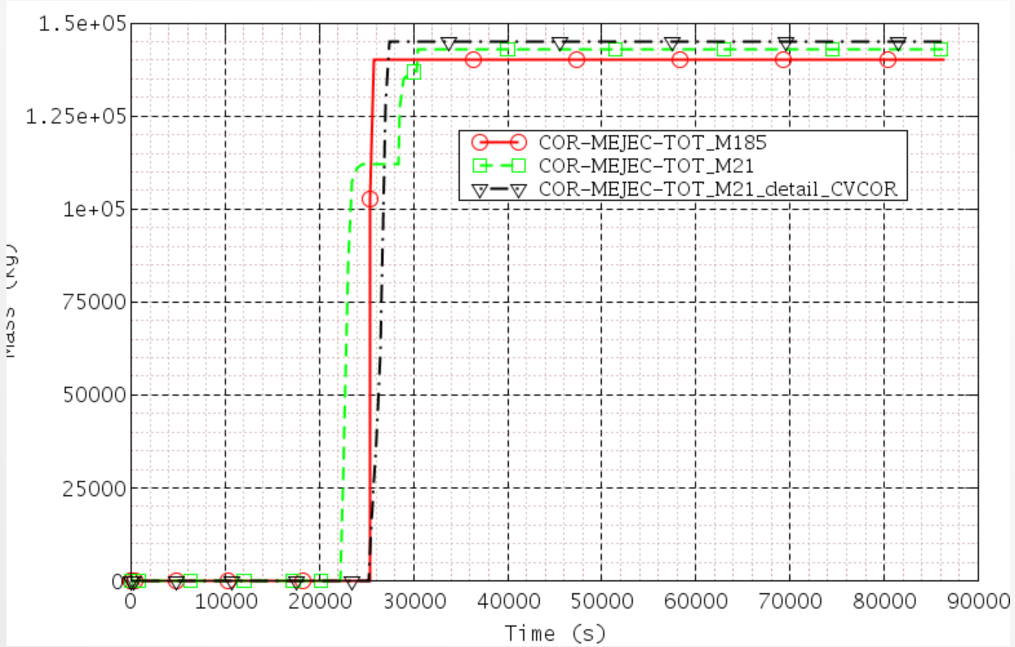
Mass change of steel oxide



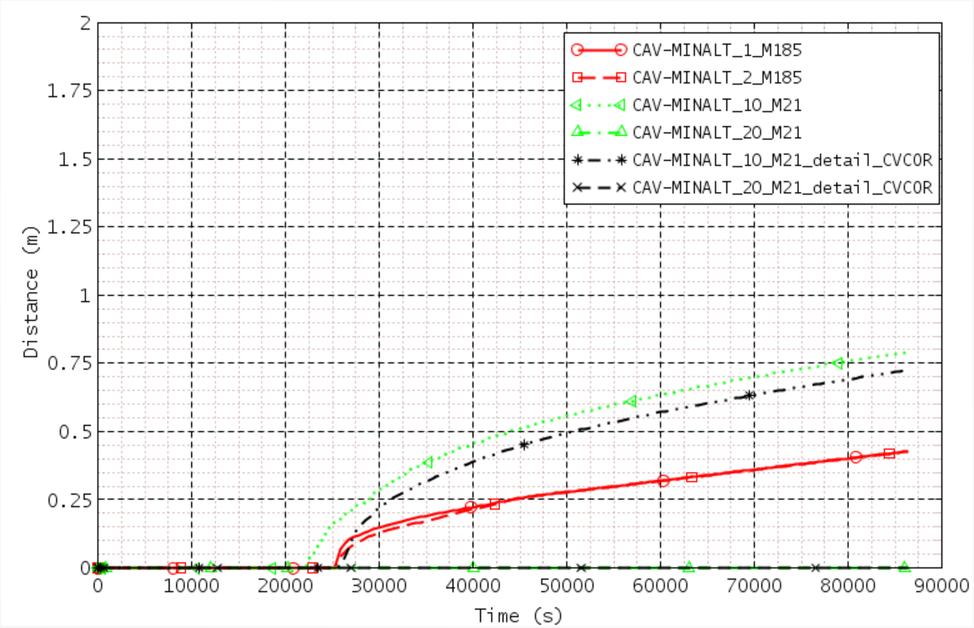
Mass change of zircaloy oxide

05 Comparative SA calculations with MELCOR 1.8.5 and MELCOR 2.1

Blackout



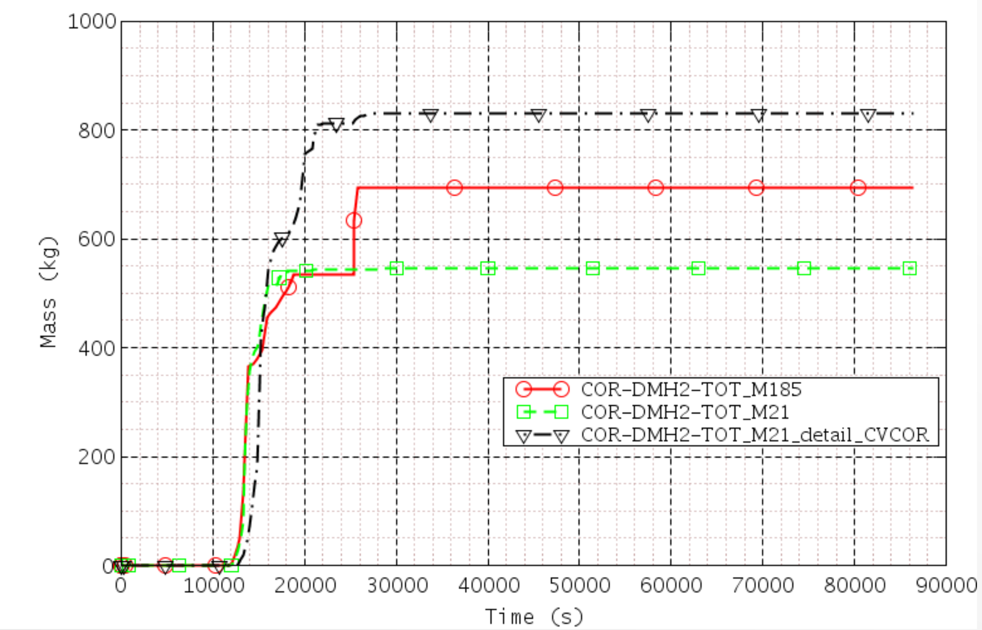
Total debris mass ejected through vessel breach

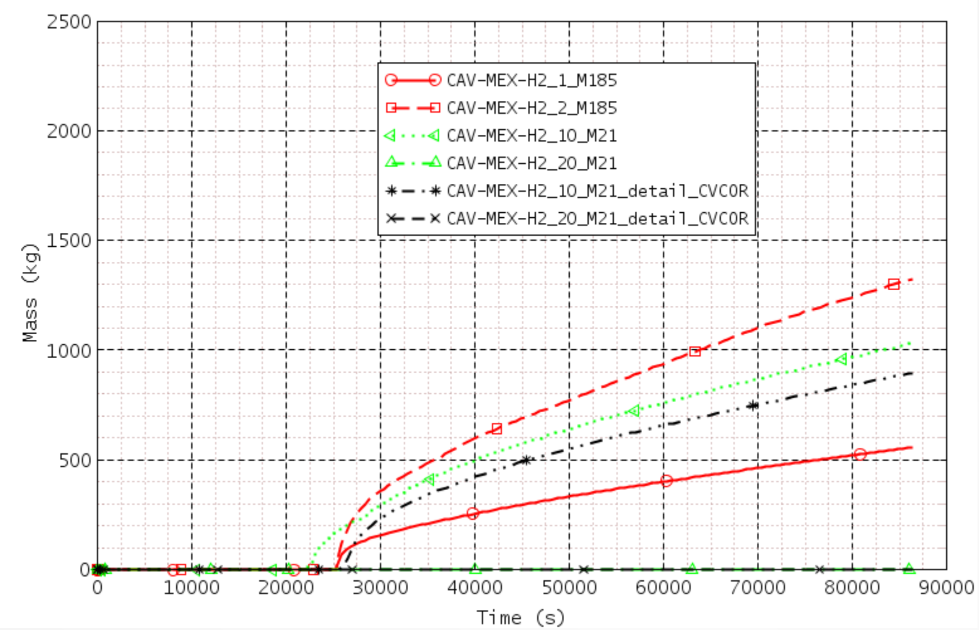


CAVITY ablation elevation

05 | Comparative SA calculations with MELCOR 1.8.5 and MELCOR 2.1

Blackout

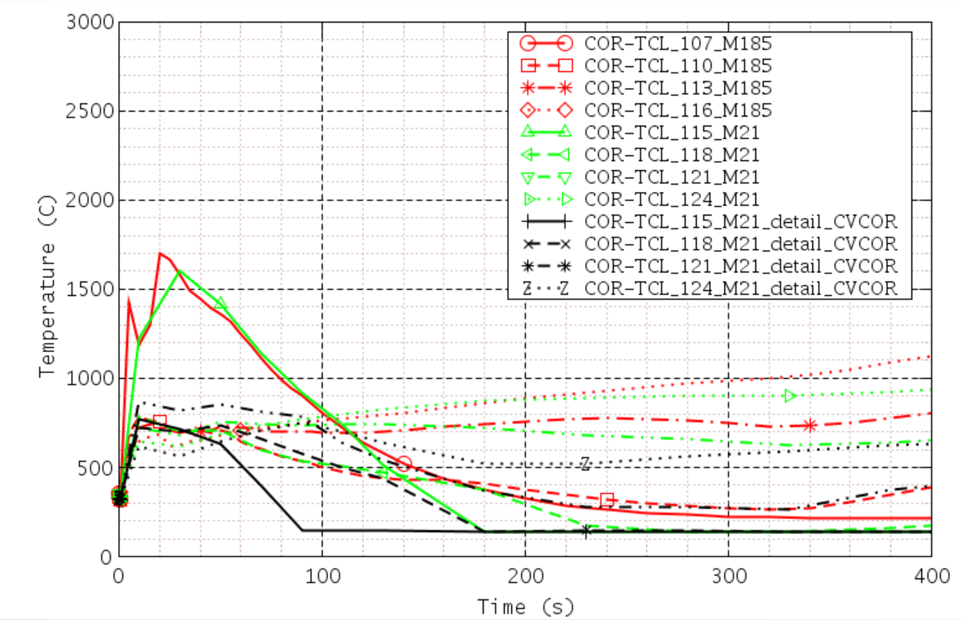


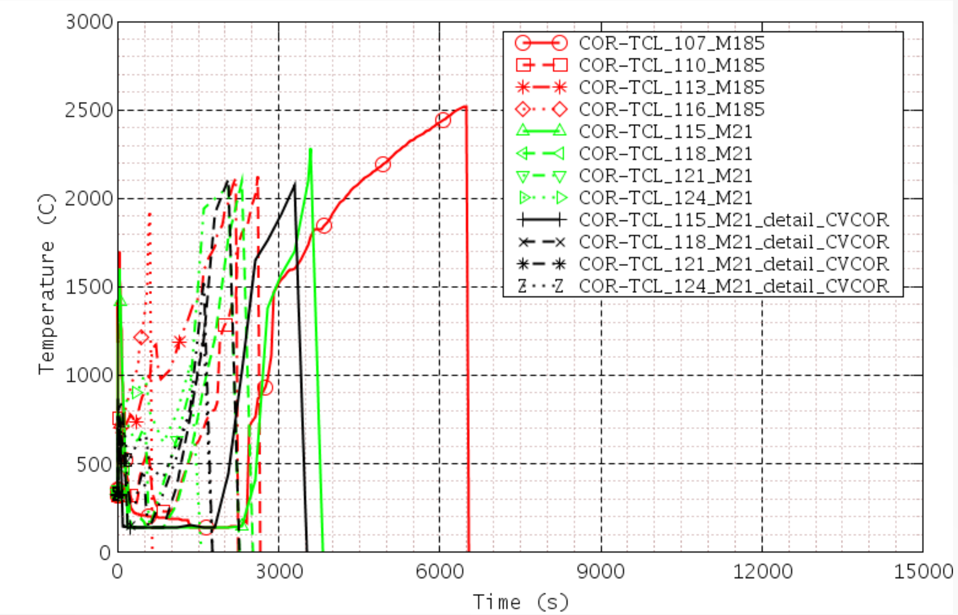


Hydrogen generations

05 | Comparative SA calculations with MELCOR 1.8.5 and MELCOR 2.1

LB LOCA

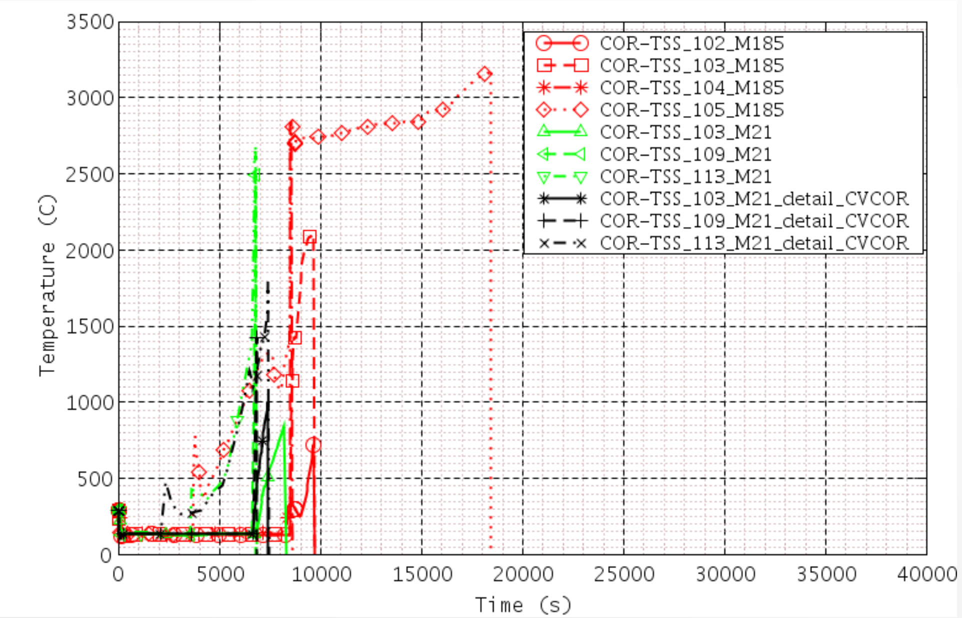


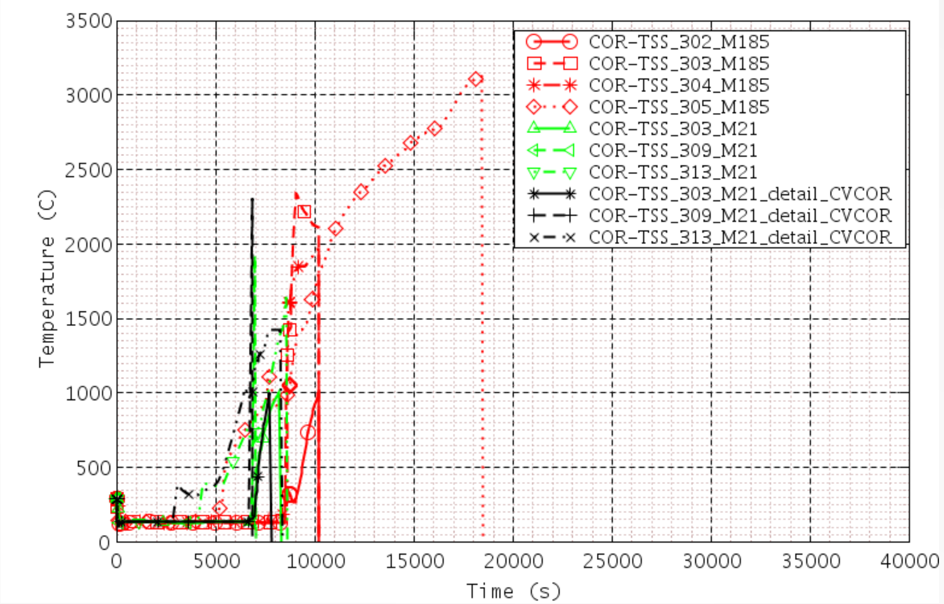


Cladding temperature

05 | Comparative SA calculations with MELCOR 1.8.5 and MELCOR 2.1

LB LOCA

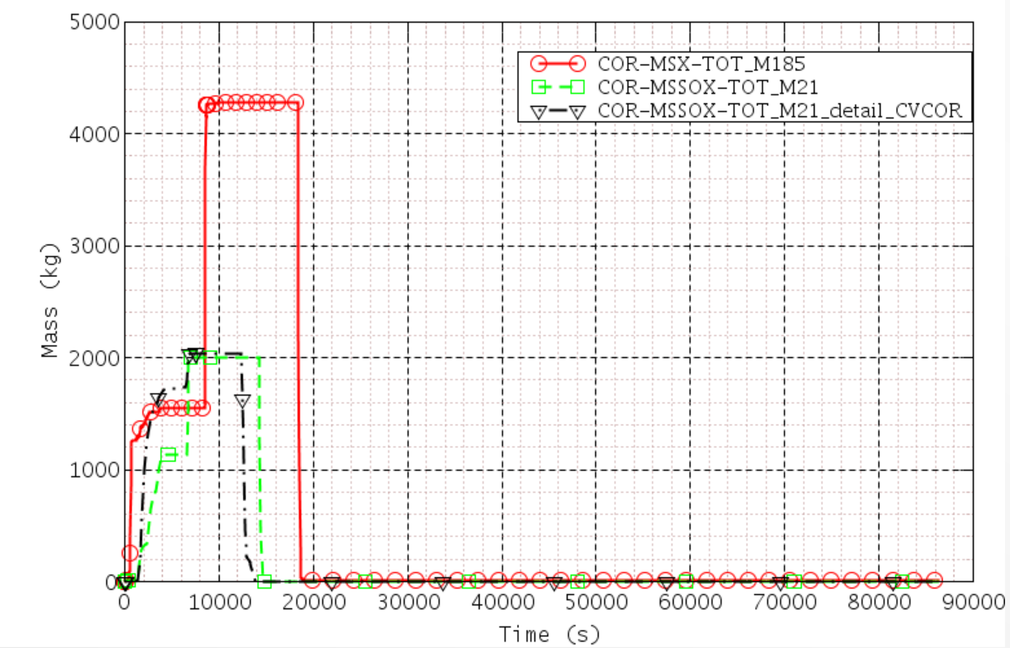




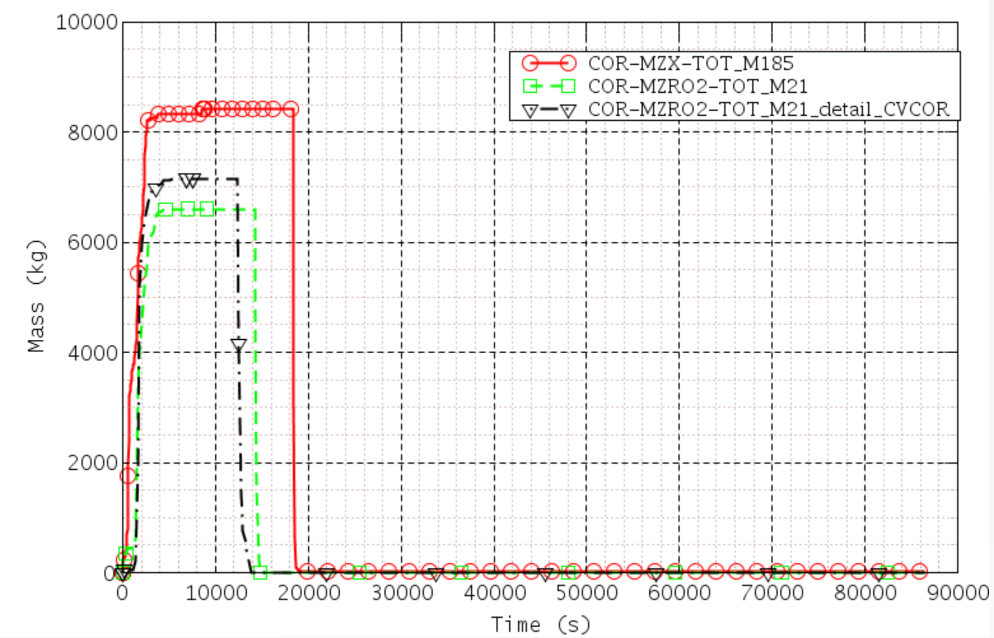
Support structure temperature

05 | Comparative SA calculations with MELCOR 1.8.5 and MELCOR 2.1

LB LOCA



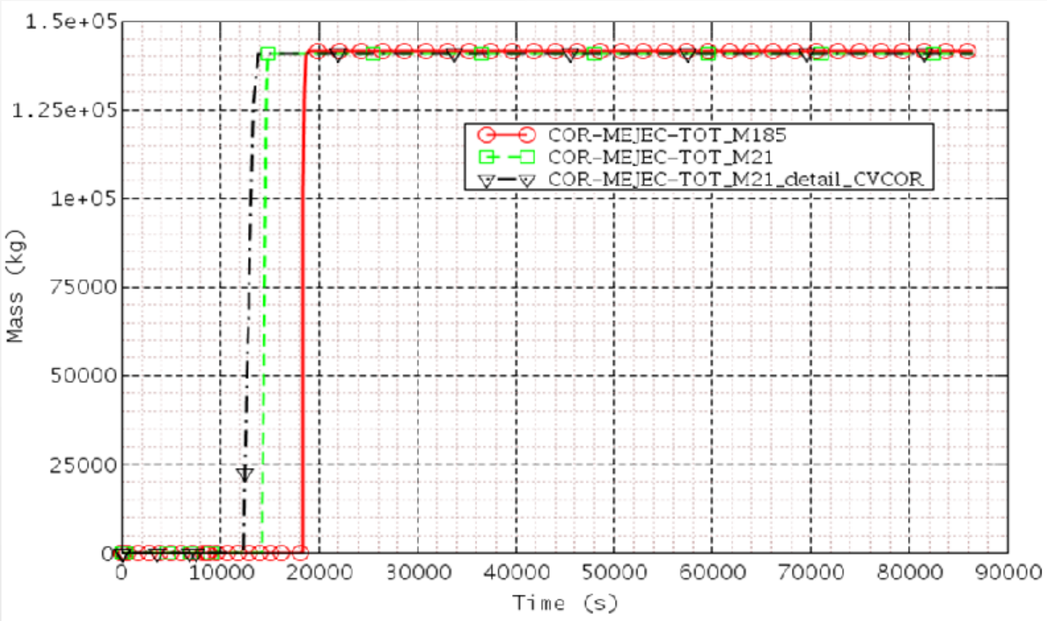
Mass change of steel oxide



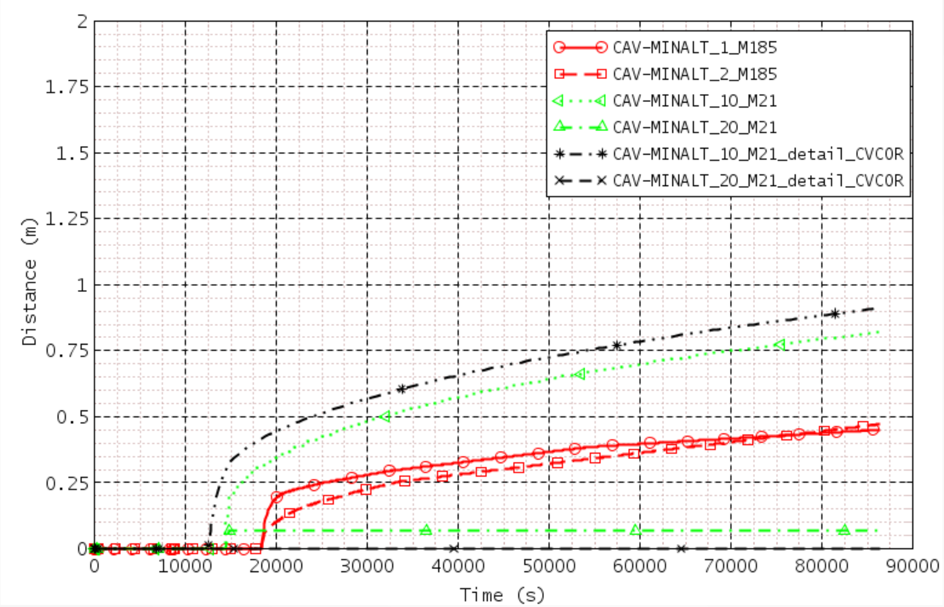
Mass change of zircaloy oxide

05 Comparative SA calculations with MELCOR 1.8.5 and MELCOR 2.1

LB LOCA



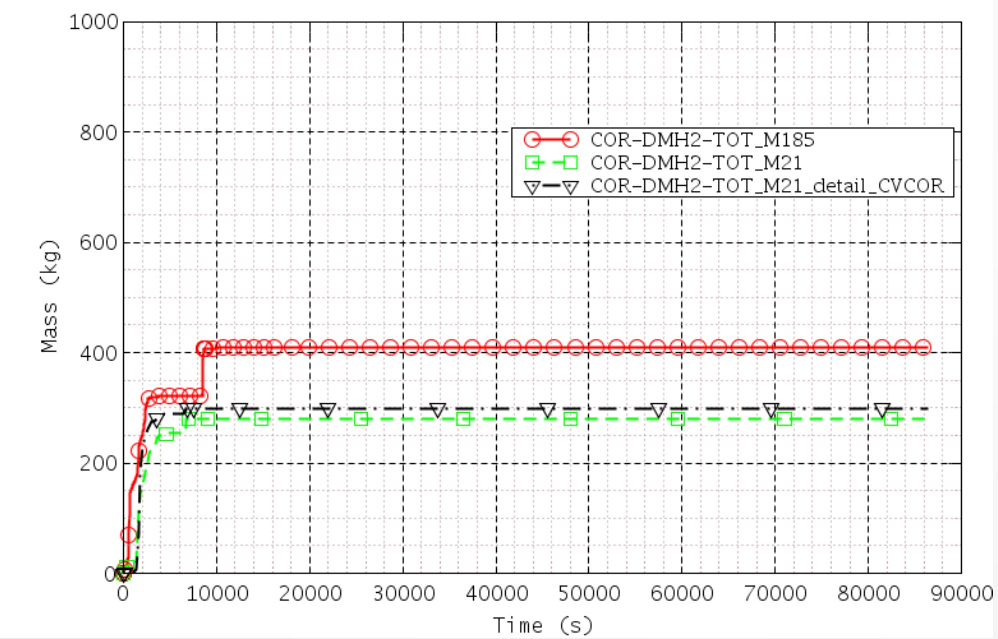
Total debris mass ejected through vessel breach

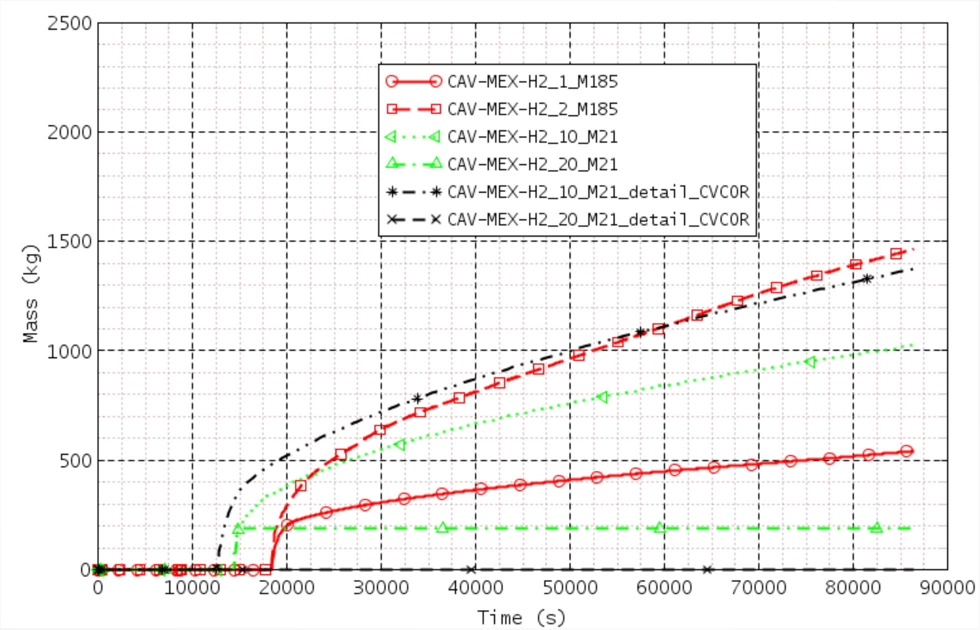


CAVITY ablation elevation

05 | Comparative SA calculations with MELCOR 1.8.5 and MELCOR 2.1

LB LOCA





Hydrogen generations

05 | Comparative SA calculations with MELCOR 1.8.5 and MELCOR 2.1

Calculation results

Blackout:

- Melcor 2.1 model with detailed core shows increased oxidation of the zirconium structural elements and mass of hydrogen for In-Vessel phase;
- Melcor 2.1 model with detailed lower part of the core (LH, Support structures) shows increase the oxidation of the support steel structural elements;
- SA Ex-Vessel phase for Melcor 1.8.5 and Melcor 2.1 models are different for melt spreading and core-concrete interaction between cavity models.

LB LOCA:

- Melcor models with one core CV shows at the start of SA increase the cladding temperature by the reason of fast pool drain and delayed refloodding;
- Melcor 2.1 models show faster failure of core structures and earlier LH failure;
- SA Ex-Vessel phase for Melcor 1.8.5 and Melcor 2.1 models are different for melt spreading and core-concrete interaction between cavity models.

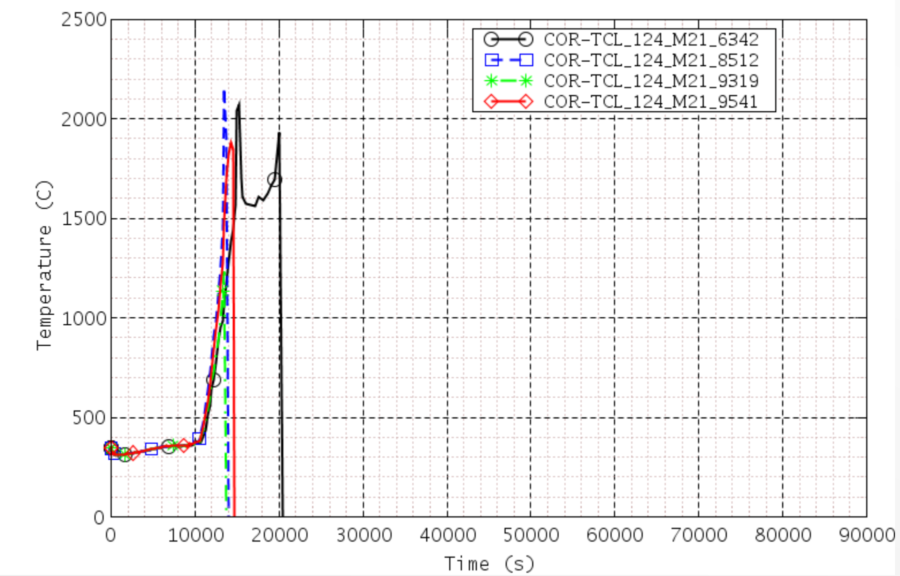
06 | Comparative SA calculations with different MELCOR 2.1 Release version

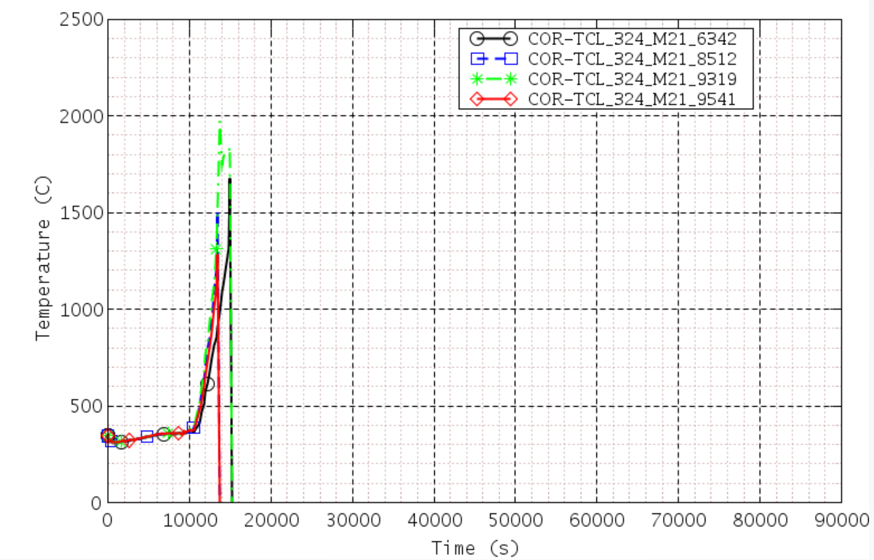
Scope of calculation

- Melcor 2.1.6342 for model with 18 CVs for fuel part of core
- Melcor 2.1.8512 for model with 18 CVs for fuel part of core
- Melcor 2.1.9319 for model with 18 CVs for fuel part of core
- Melcor 2.1.9541 for model with 18 CVs for fuel part of core

06 | Comparative SA calculations with different MELCOR 2.1 Release version

Blackout

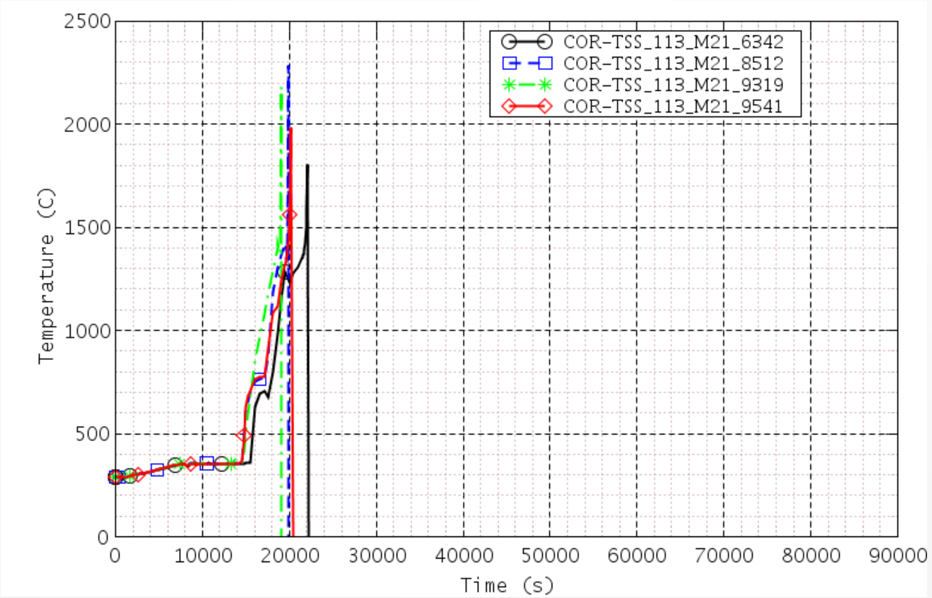


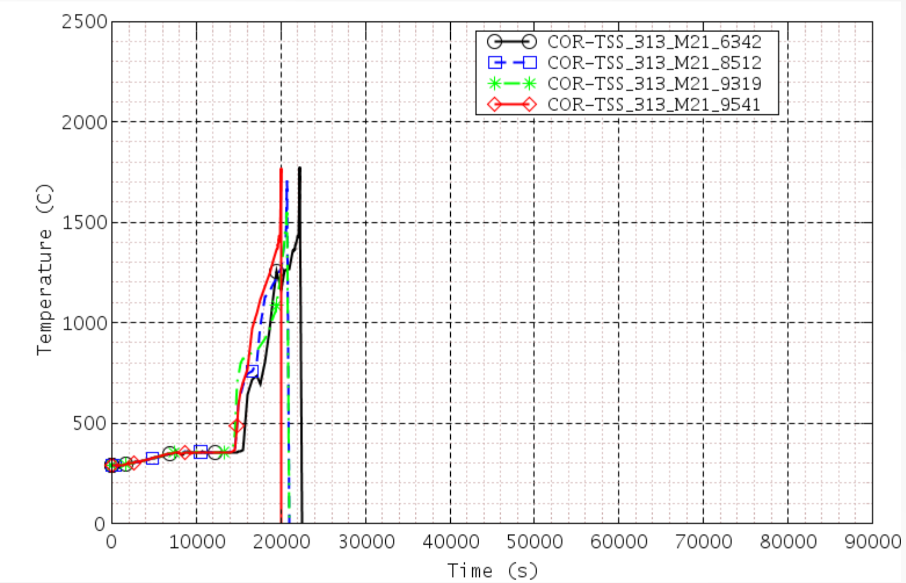


Cladding temperature in top segments

06 | Comparative SA calculations with different MELCOR 2.1 Release version

Blackout

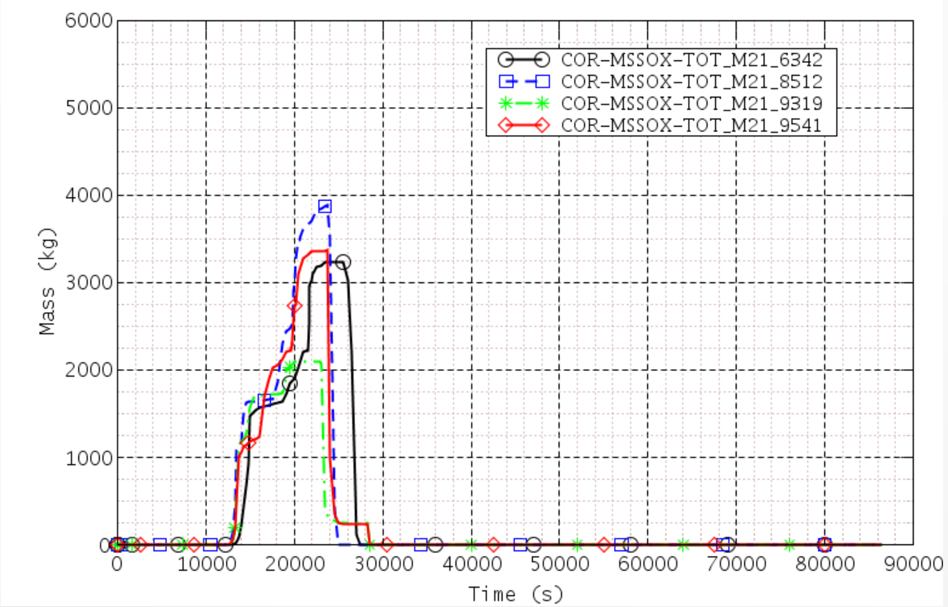




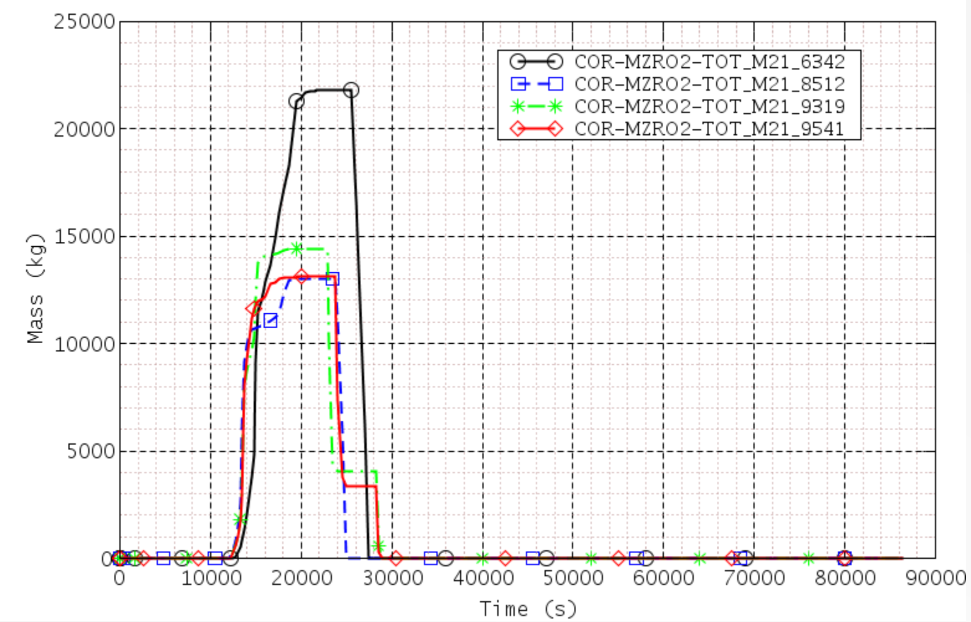
Base plate support structure temperature

06 | Comparative SA calculations with different MELCOR 2.1 Release version

Blackout



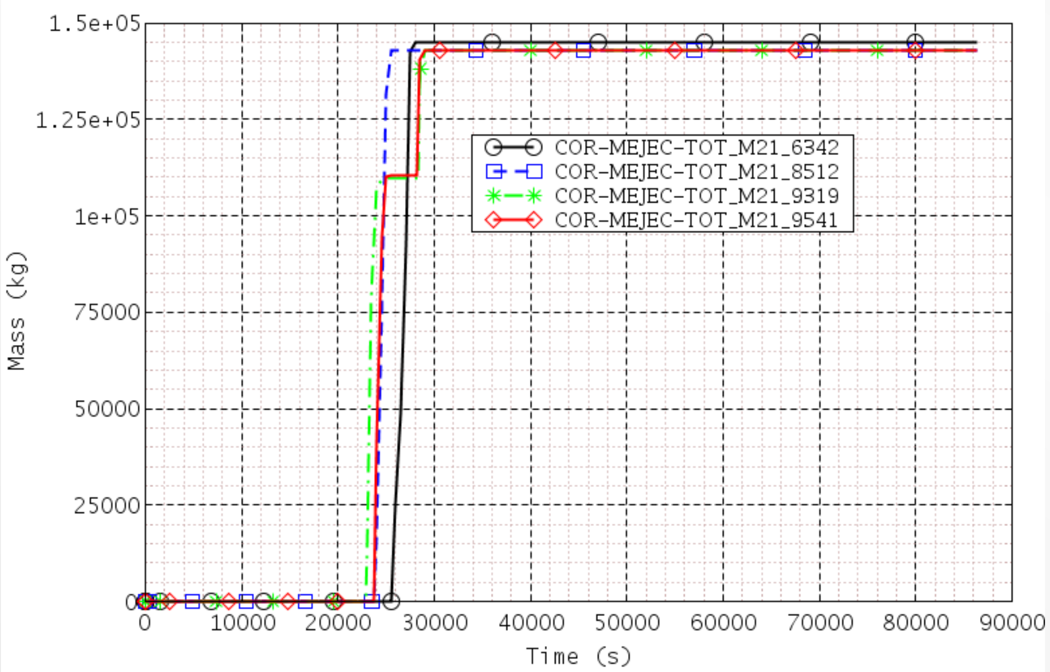
Mass change of steel oxide



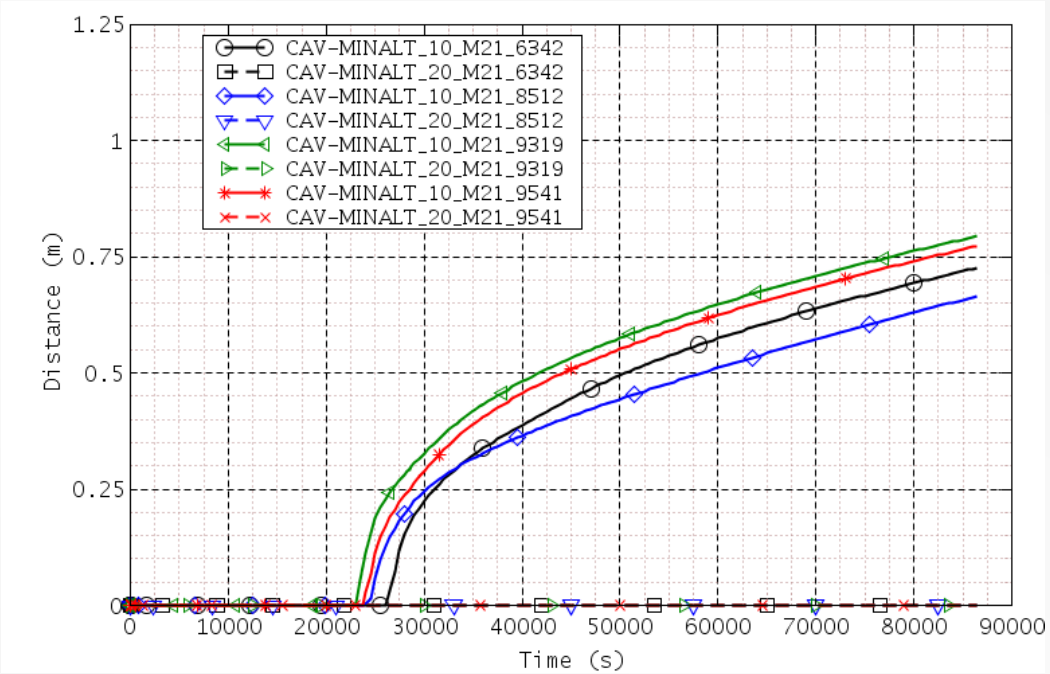
Mass change of zircaloy oxide

06 Comparative SA calculations with different MELCOR 2.1 Release version

Blackout



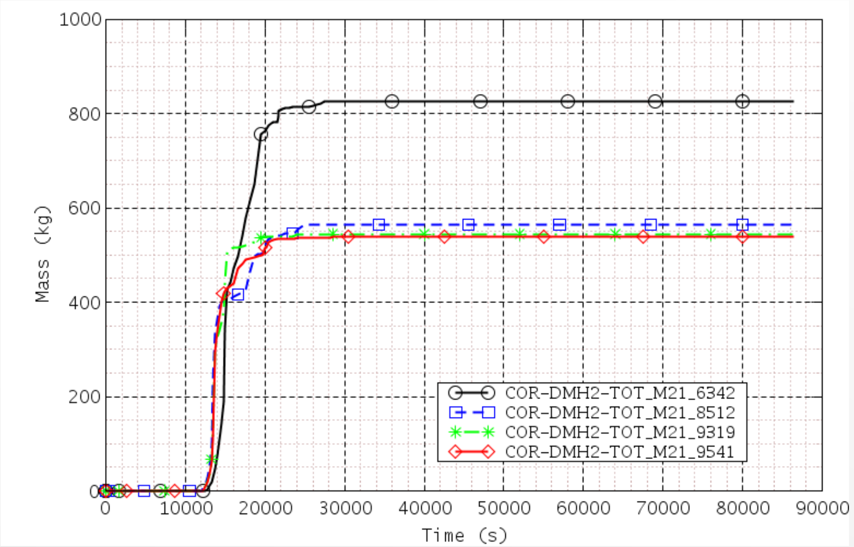
Total debris mass ejected through vessel breach

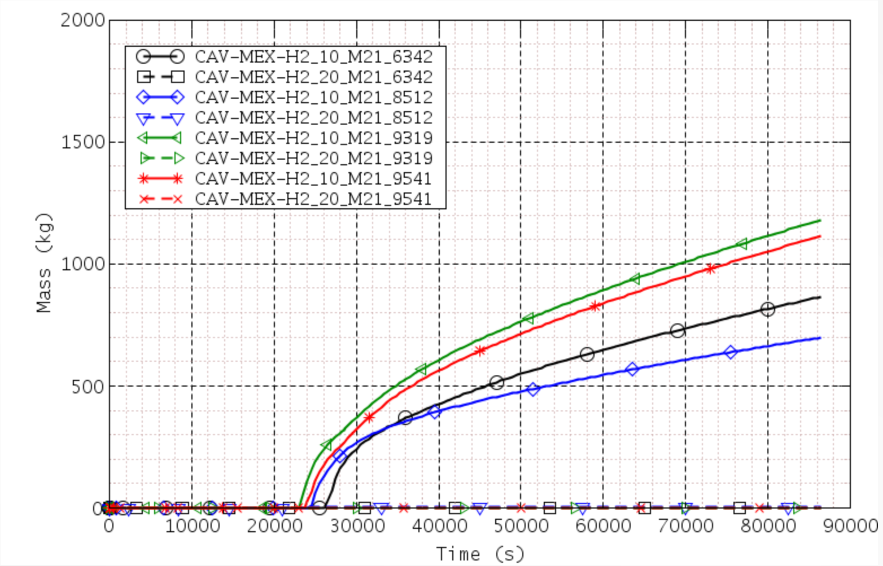


CAVITY ablation elevation

06 | Comparative SA calculations with different MELCOR 2.1 Release version

Blackout

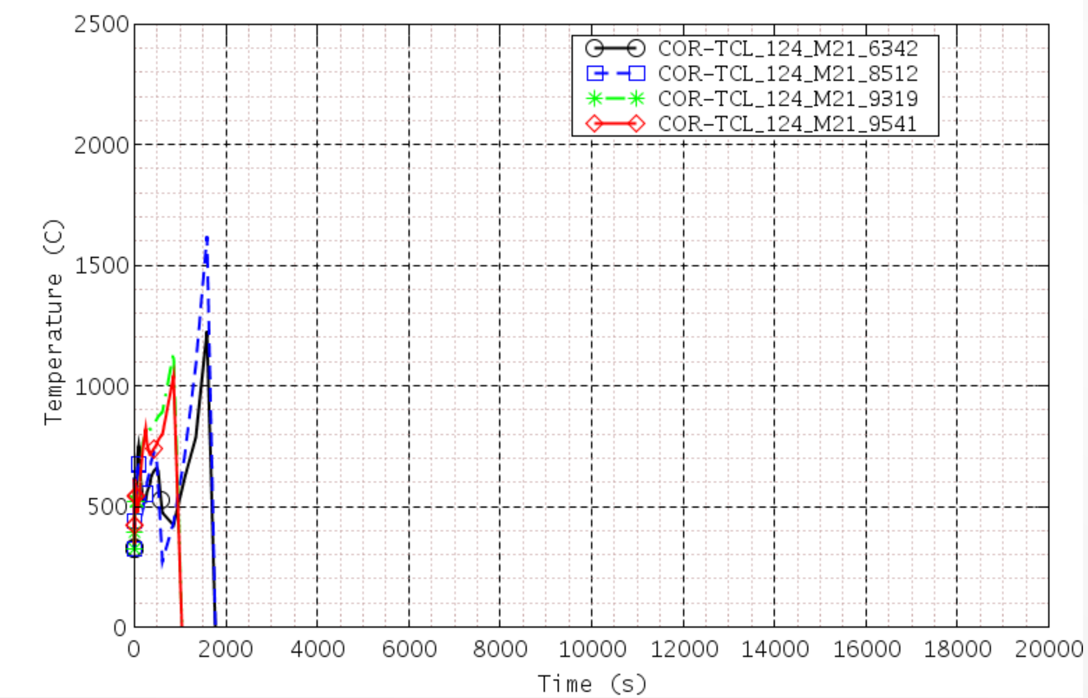


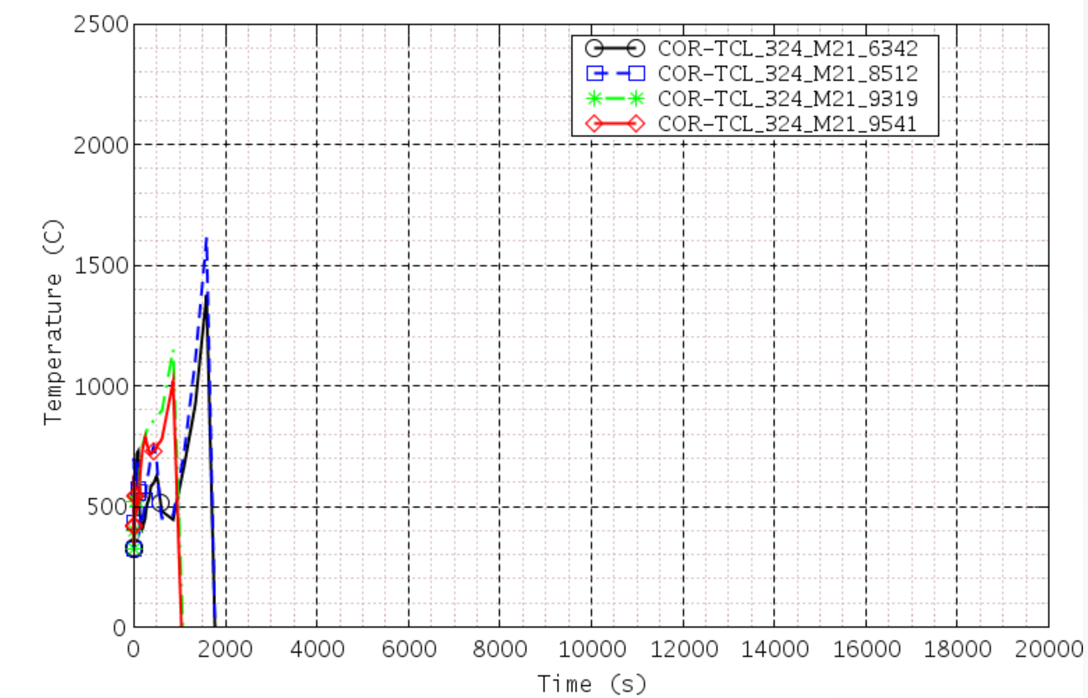


Hydrogen generations

06 | Comparative SA calculations with different MELCOR 2.1 Release version

LB LOCA

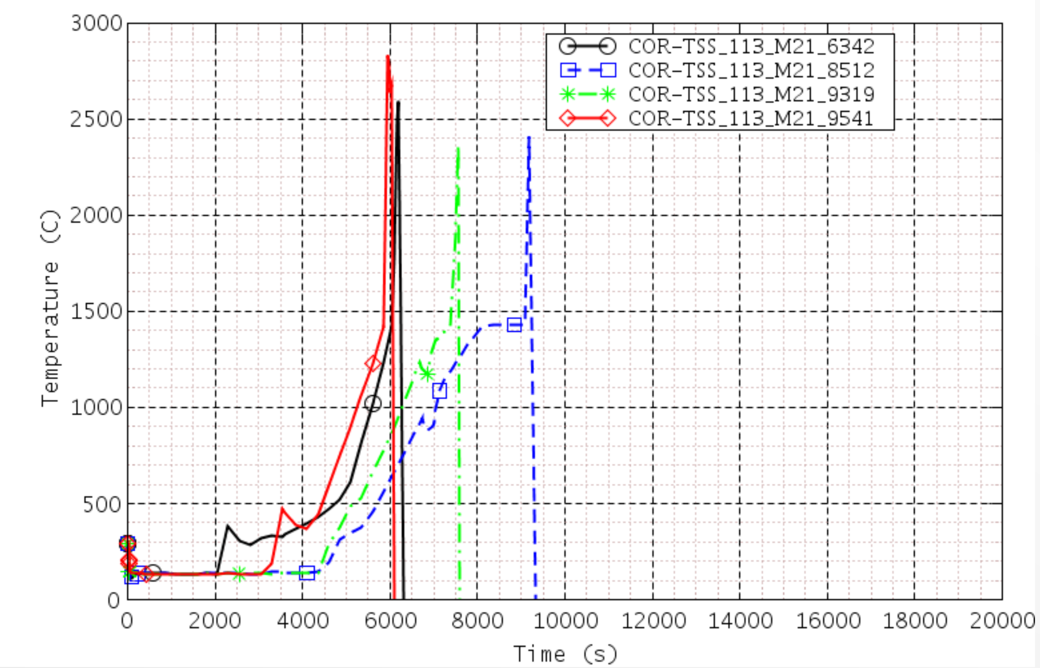


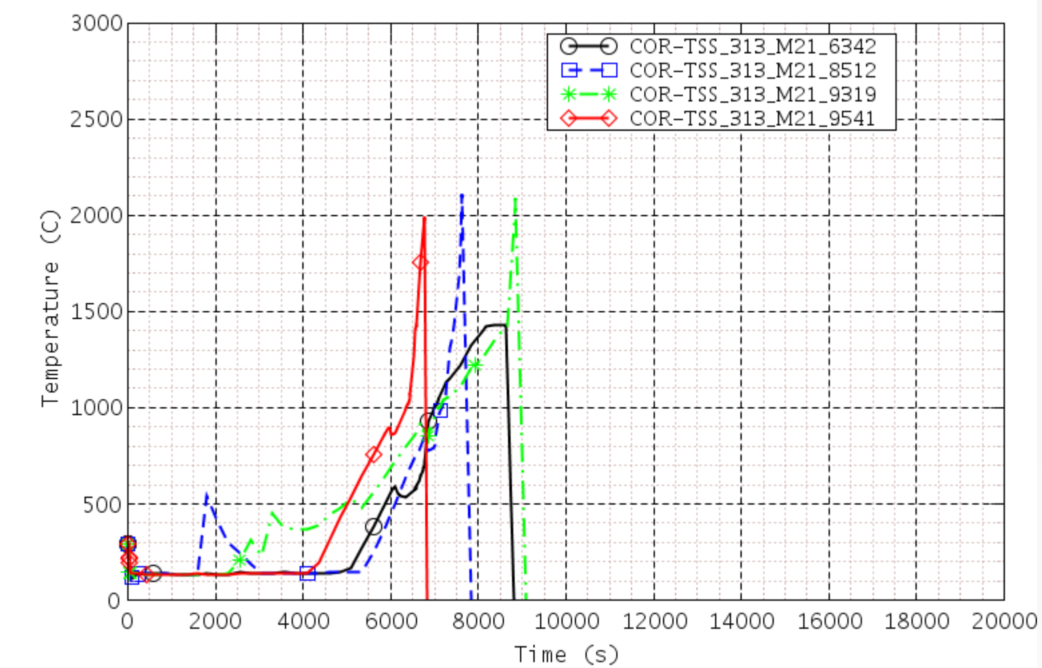


Cladding temperature in top segments

06 | Comparative SA calculations with different MELCOR 2.1 Release version

LB LOCA

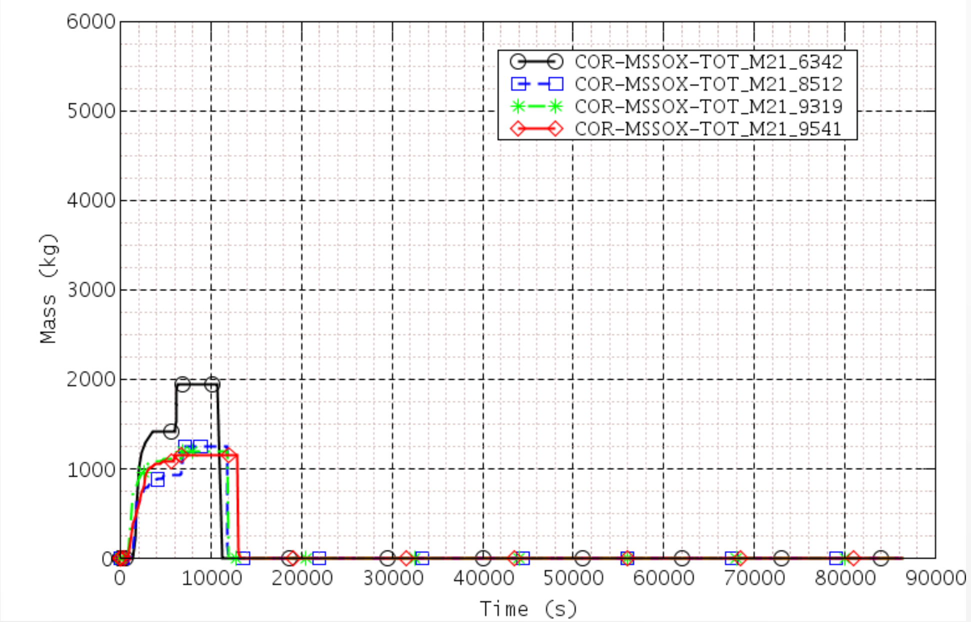




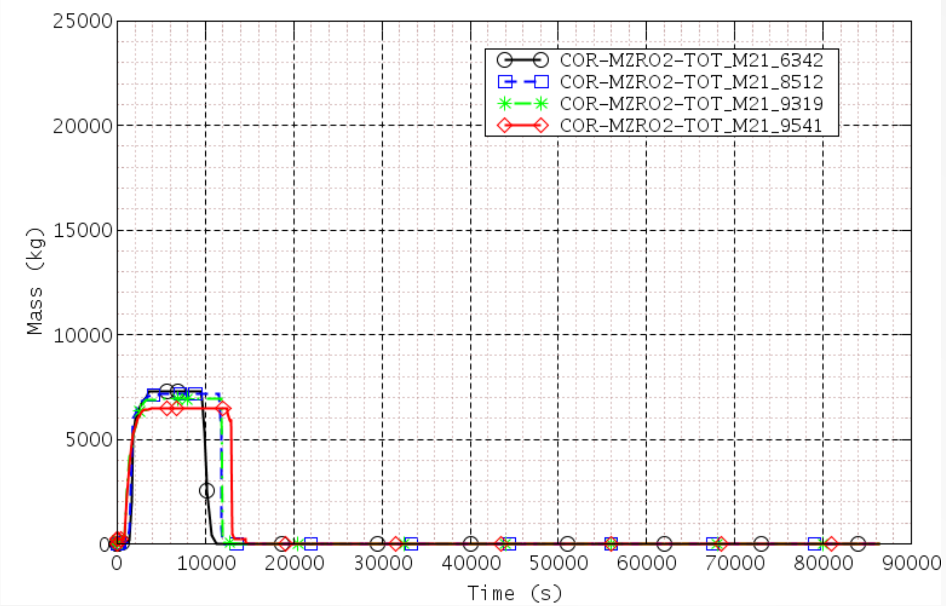
Base plate support structure temperature

06 Comparative SA calculations with different MELCOR 2.1 Release version

LB LOCA



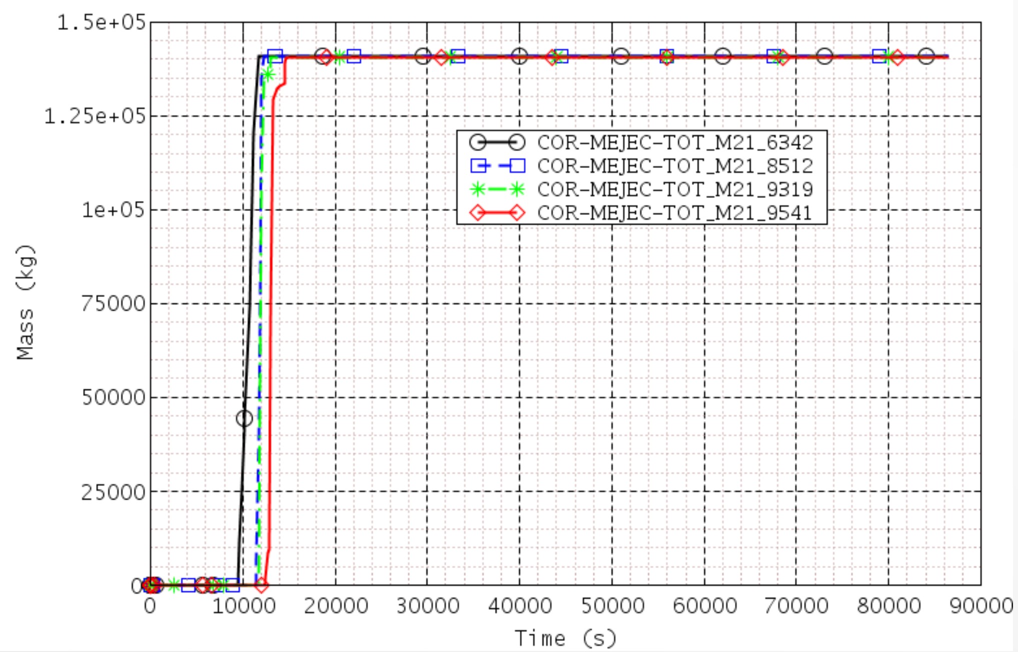
Mass change of steel oxide

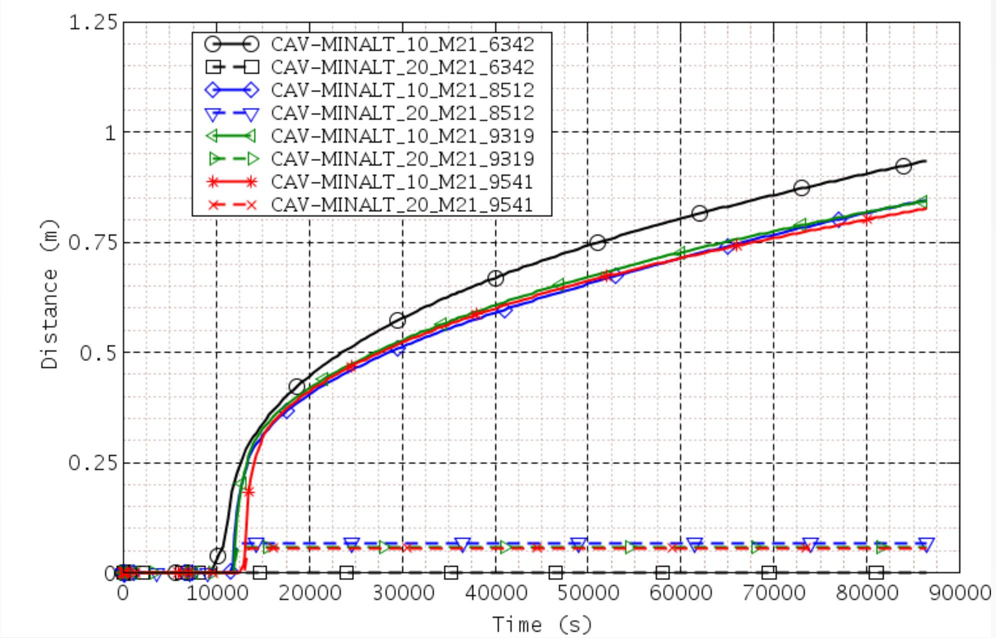


Mass change of zircaloy oxide

06 | Comparative SA calculations with different MELCOR 2.1 Release version

LB LOCA



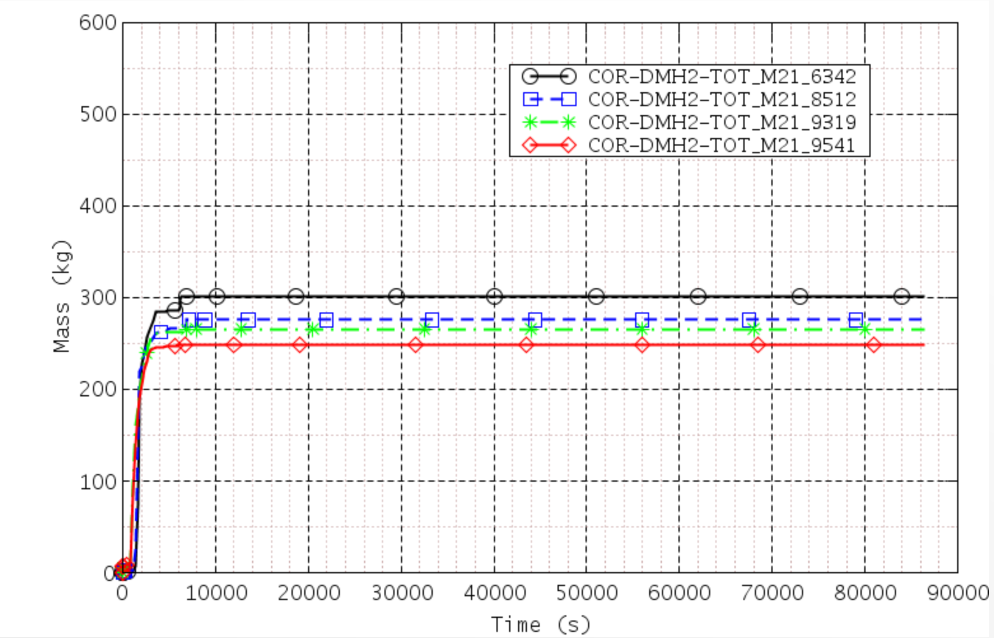


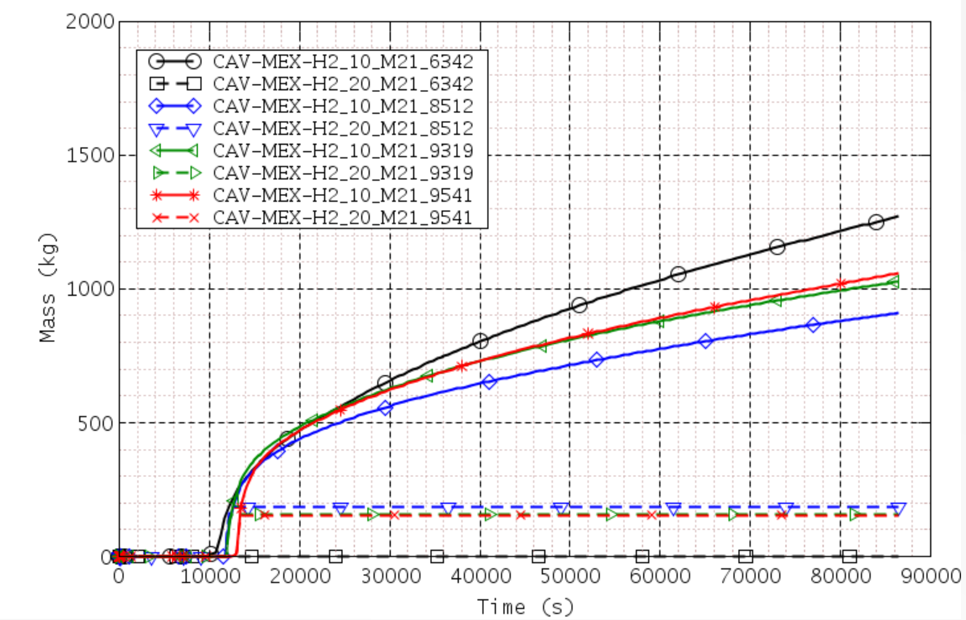
Total debris mass ejected through vessel breach

CAVITY ablation elevation

06 | Comparative SA calculations with different MELCOR 2.1 Release version

LB LOCA





Hydrogen generations

Calculation results

Blackout:

- Melcor 2.1.6342 calculations compared with other M2.1 version for In-Vessel phase show the later failure of core claddings structures which cause the increase the zirconium structural elements oxidation and gives greater mass of hydrogen for In-Vessel phase;
- Melcor 2.1.9319 and Melcor 2.1.9541 show the faster failure of LH and start core-concrete interaction which cause hydrogen mass generation increase compared to Melcor 2.1.6342 and Melcor 2.1.8512;
- SA Ex-Vessel phase for various Melcor 2.1 versions are different for melt spreading and core-concrete interaction between cavity models (differences between the Melcor 2.1.9319 and Melcor 2.1.9541 are not quite significant).

LB LOCA:

- The heating and cladding failure are almost identical between versions MELCOR 2.1.9319 and 2.1.9541. This SA phase have similar behavior for Melcor versions 2.1.6342 and 2.1.8512;
- Melcor 2.1.6342 calculations compared with other M2.1 versions for In-Vessel phase show greater mass of hydrogen for In-Vessel phase;
- SA Ex-Vessel phase for various Melcor 2.1 version is different for melt spreading and core-concrete interaction between cavity models (differences between the Melcor 2.1.9319 and Melcor 2.1.9541 are not quite significant).

07 | Comparative SA calculations with different time step

Scope of calculation

Blackout:

- Melcor 2.1.6342 and time step 0.01
- Melcor 2.1.6342 and time step 0.05
- Melcor 2.1.6342 and time step 0.116
- Melcor 2.1.6342 and time step 0.5
- Melcor 2.1.6342 and time step 1.

LB LOCA:

- Melcor 2.1.6342 and time step 0.05
- Melcor 2.1.6342 and time step 0.116
- Melcor 2.1.6342 and time step 0.5

07 | Comparative SA calculations with different time step

Calculation results

Blackout:

- Cladding failure time is almost identical for all calculations. But for time step 0.116 cladding failure started in other core rings compared to other time steps;
- Increasing the time steps causes the earlier time of support base plate and LH failure ;
- Calculations with the time step 0.01 and 0.05 show the maximum mass of steel oxides. Also after the LH failure for these time steps less molten fragments masses are left in reactor;
- The greatest total mass of hydrogen for In-Vessel phase was generated for time step 0.01, 0.05 and 1.0. The lowest mass of hydrogen for In-Vessel phase was obtained for time step 0.5;
- Calculation with the time step 0.116 shows the greatest mass of hydrogen for Ex-Vessel phase;
- SA Ex-Vessel phase for various time steps behaves differenly in cavity melt spreading and core-concrete interaction.

07 | Comparative SA calculations with different time step

Calculation results

LB LOCA:

- Increasing the time steps caused the increasing the time of claddings failure;
- Time support plate failure was earlier for time step 0.116. For different time step support plate failure started in different rings.
- Calculation with the time step 0.5 shows the maximum mass of steel oxides (for blackout scenario it was for steps 0.05 and 1.0);
- Calculation with the time step 0.116 show the maximum mass of zirconium oxide;
- The greatest total mass of hydrogen for In-Vessel phase was generated for time step 0.116 and 0.5 (for blackout scenario it was for steps 0.01, 0.05 and 1.0).
- Calculation with the time step 0.116 shows the faster LH failure
- Increasing the time steps caused the decreasing the hydrogen generation for Ex-Vessel phase.
- SA Ex-Vessel phase for various time steps behaves differenly in cavity melt spreading and core-concrete interaction.

08 | Conclusions

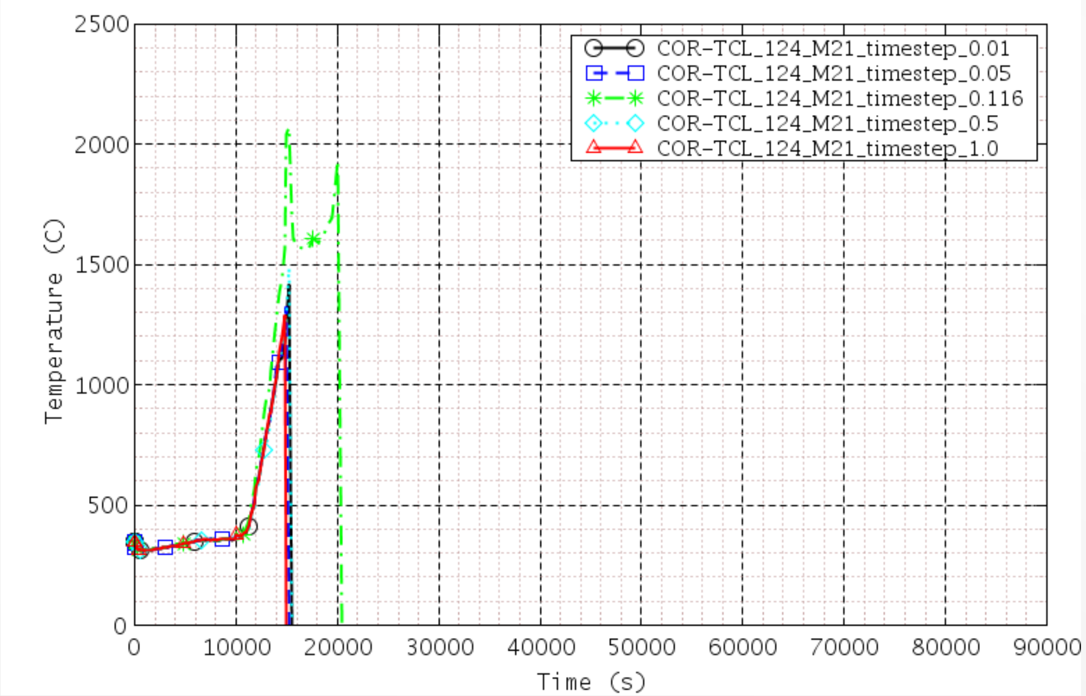
- During the conversion of the Melcor model 1.8.5/1.8.6 to version 2.1, it is necessary to perform its detailed verification.
- The propagation of molten fragments into the LH and LH failure needs further detailed modeling with different approaches for LH and support structures modeling for WWER type reactor.
- It is needed to perform sensitivity and uncertainty analysis in relation to MELCOR code version and timestep for specific SA analysis;
- Uncertainty in Ex-Vessel melt spreading for cavities models and core-concrete interaction depends heavily on MELCOR code version/revision and timestep. This issue can be refined by using separate CAVITY models with initial conditions for melt, and also by use of special melt spreading codes (for example, LAVA).

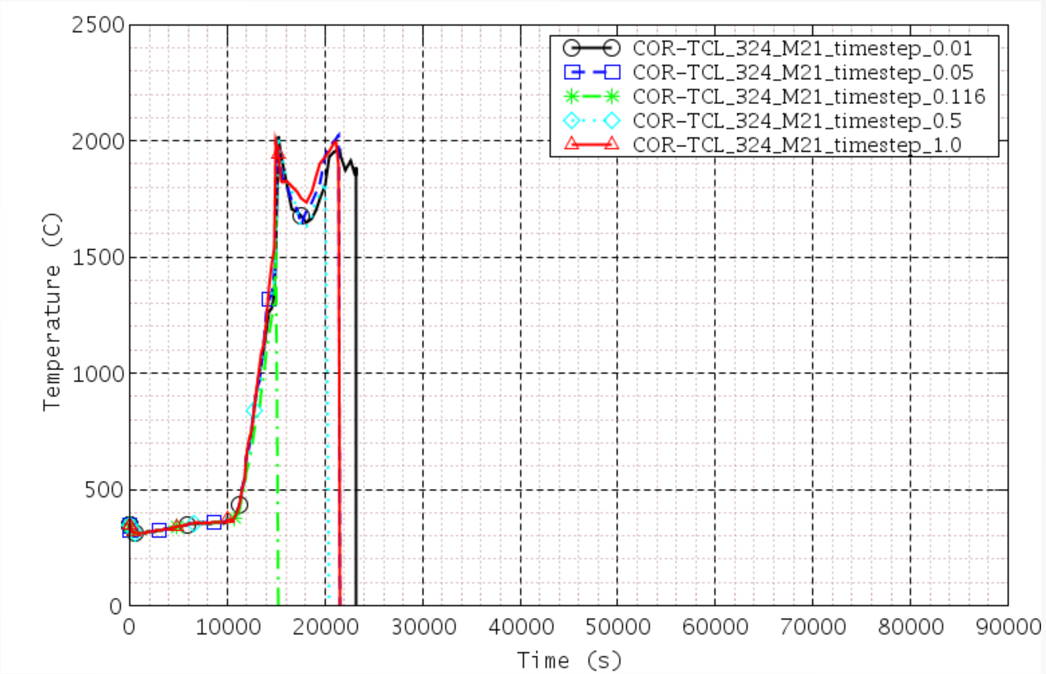
SSTC NRS | State Scientific and Technical Center for Nuclear and Radiation Safety

Thanks for your attention

07 | Comparative SA calculations with different time step

Blackout

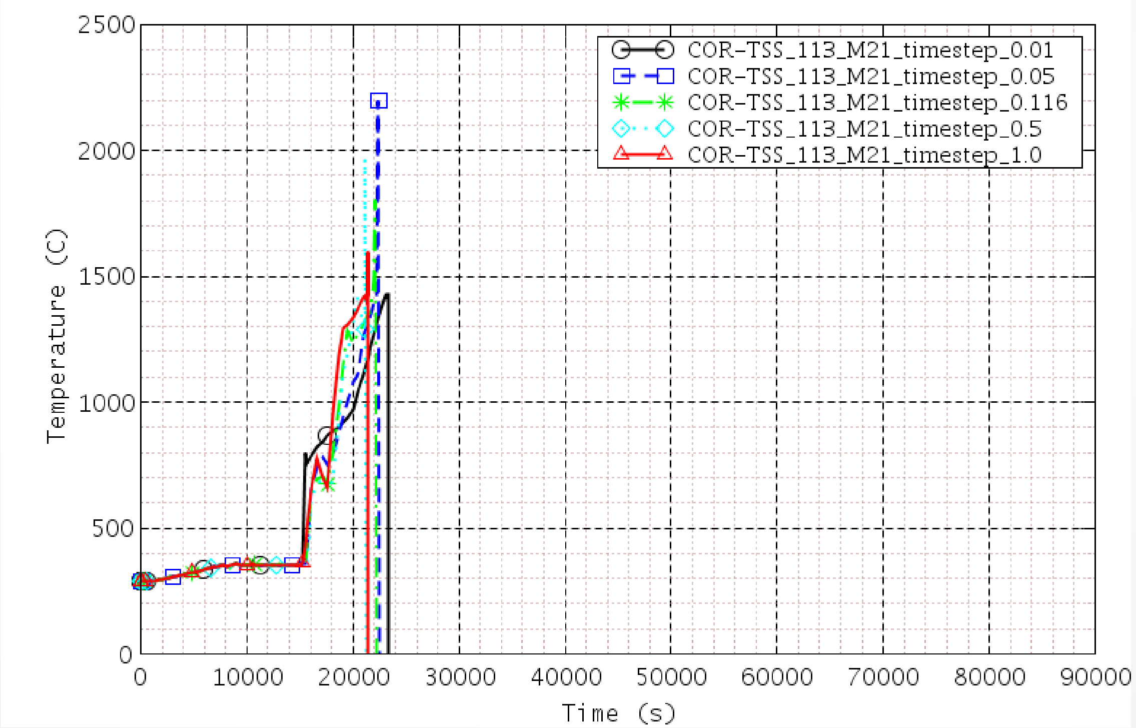


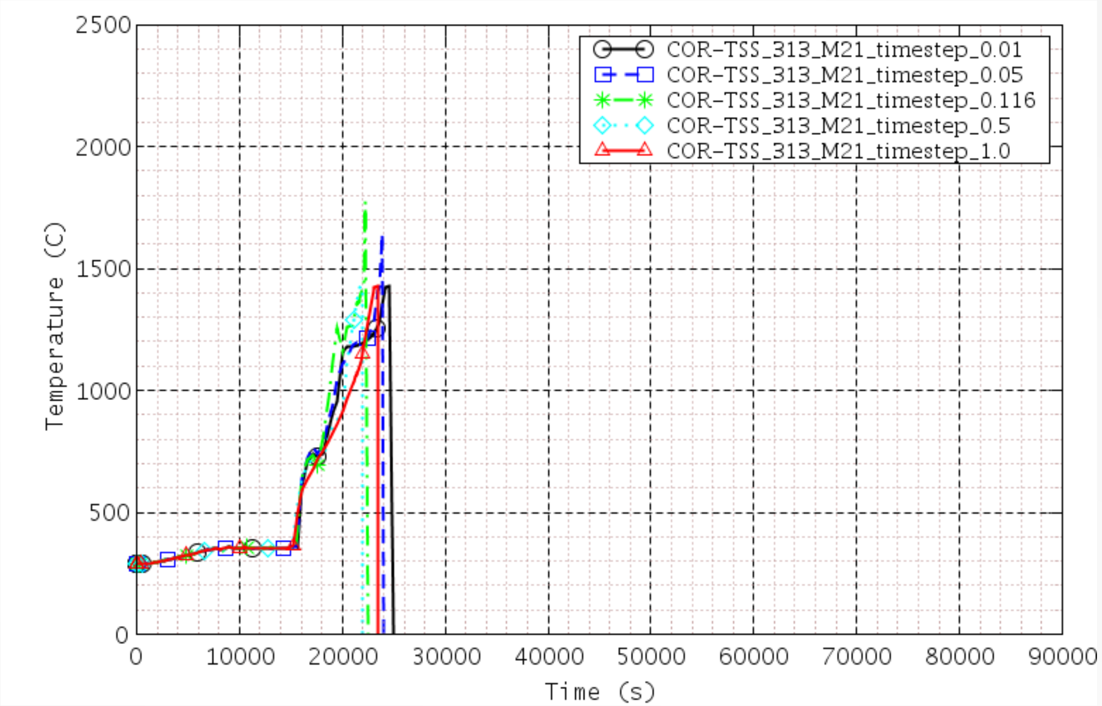


Cladding temperature in top segments

07 | Comparative SA calculations with different time step

Blackout

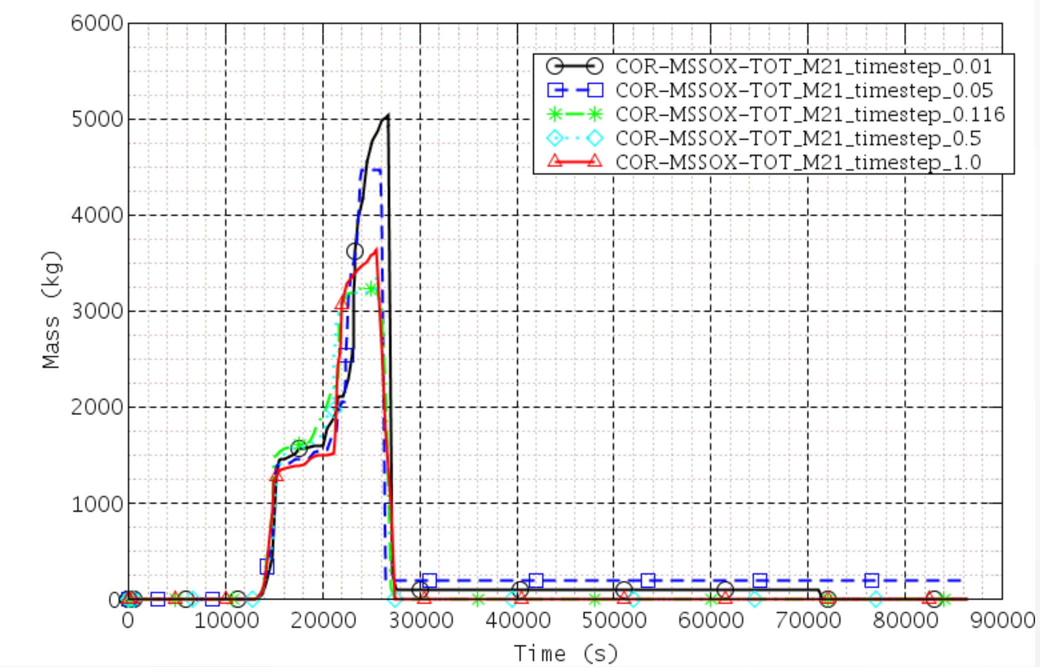




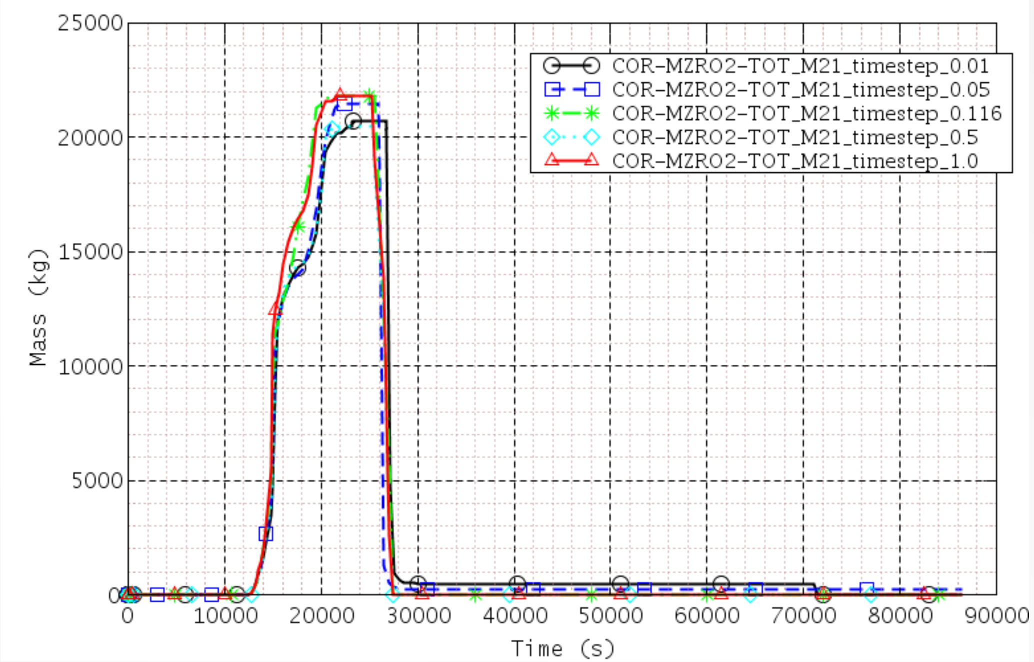
Base plate support structure temperature

07 | Comparative SA calculations with different time step

Blackout



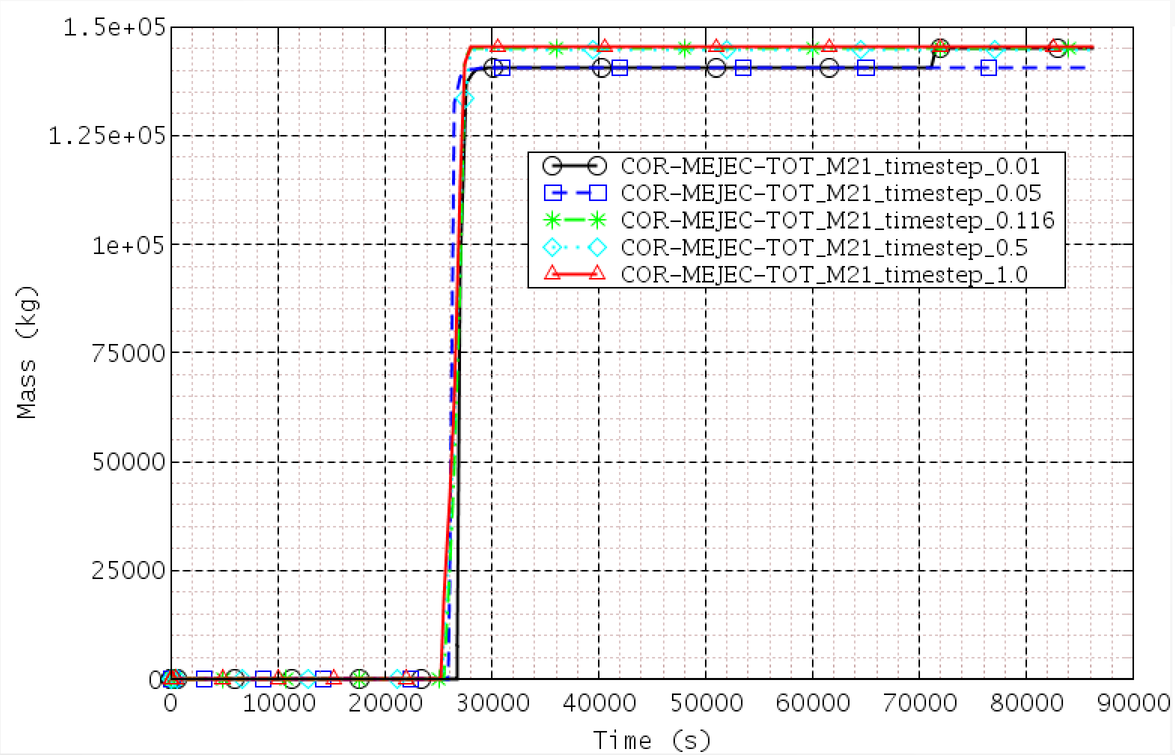
Mass change of steel oxide



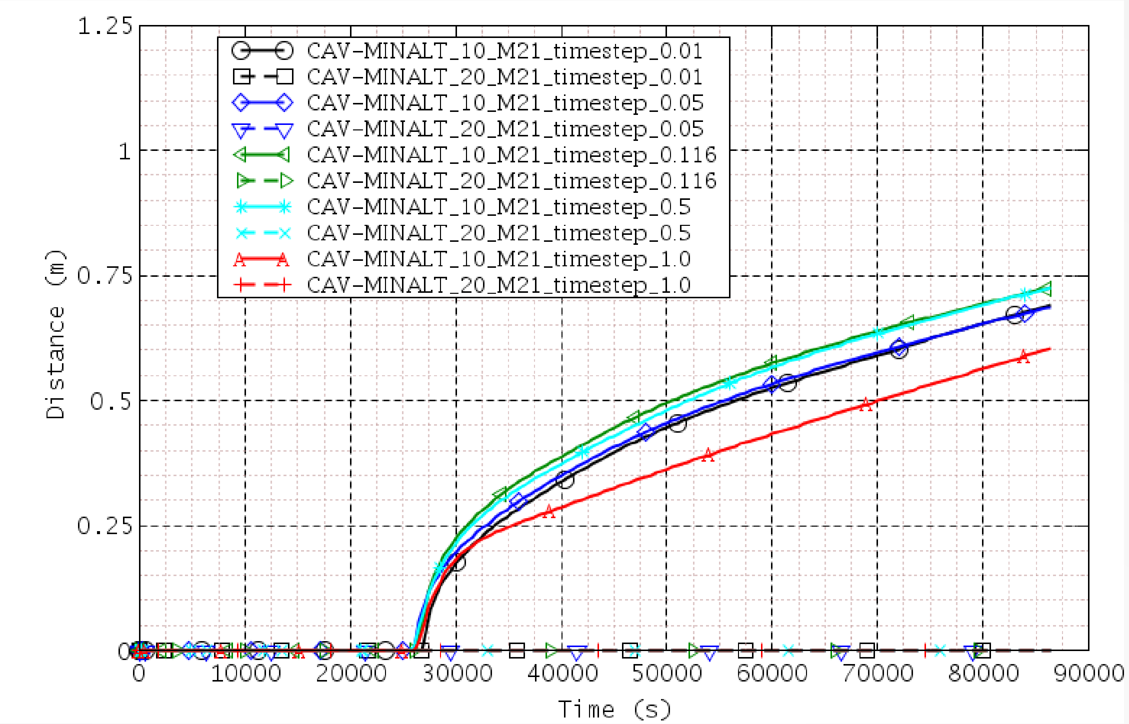
Mass change of zircaloy oxide

07 | Comparative SA calculations with different time step

Blackout



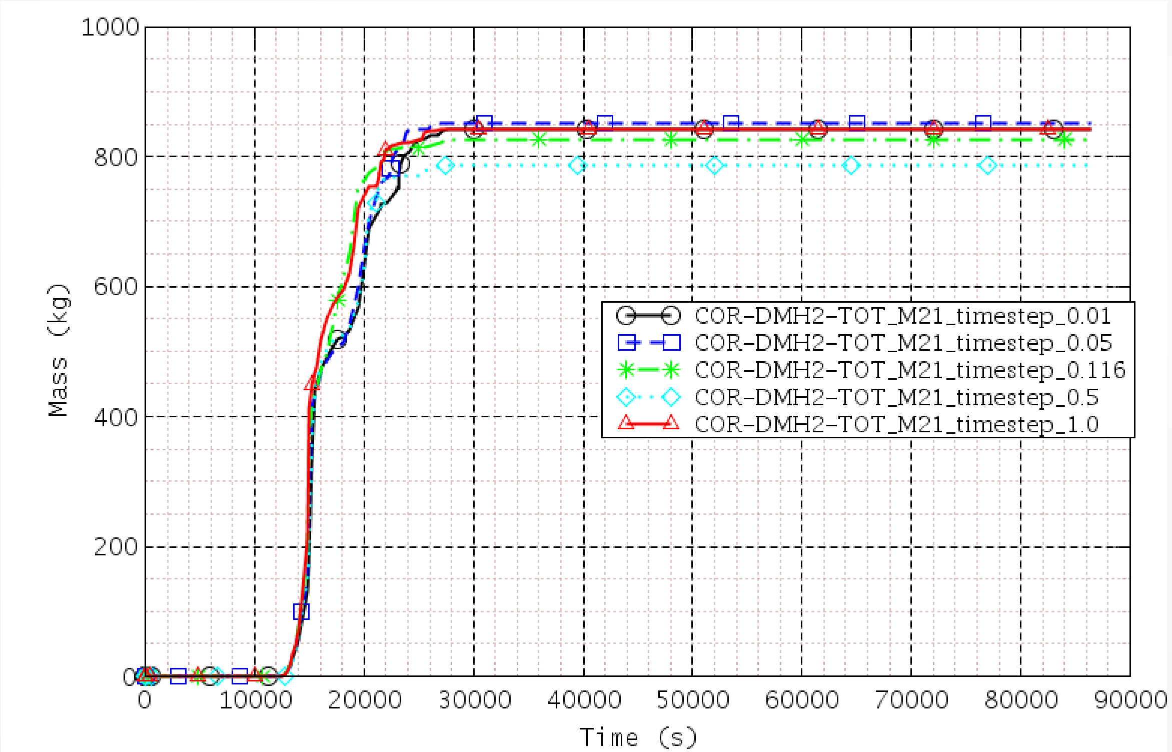
Total debris mass ejected through vessel breach

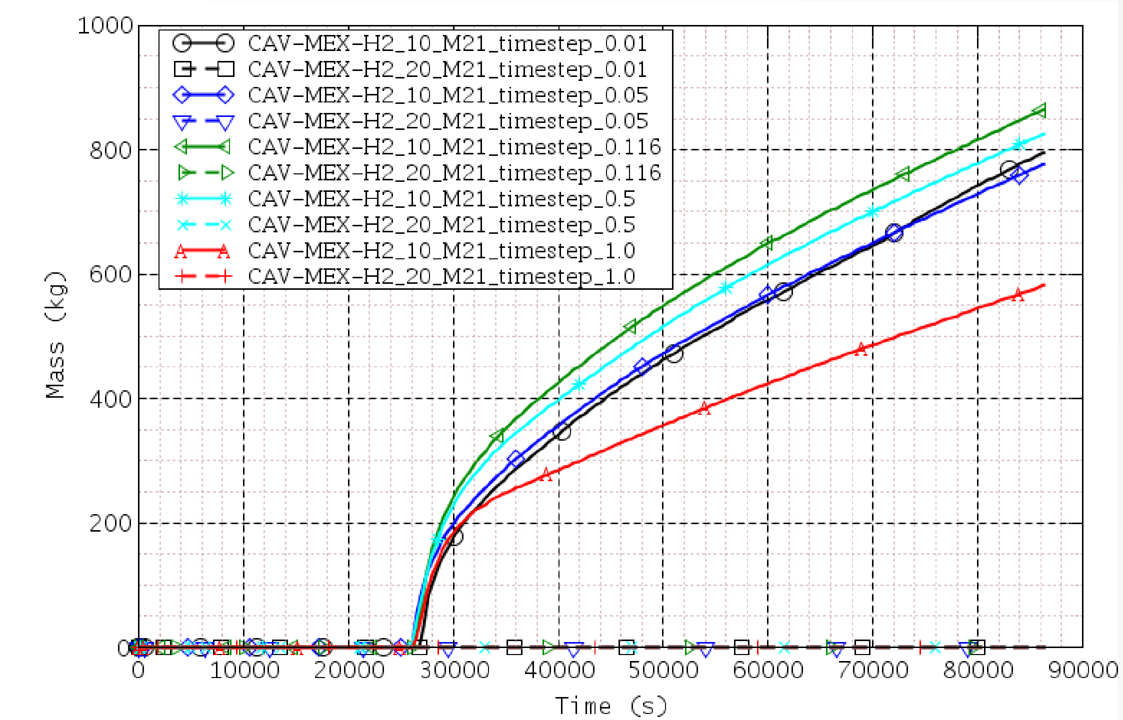


CAVITY ablation elevation

07 | Comparative SA calculations with different time step

Blackout

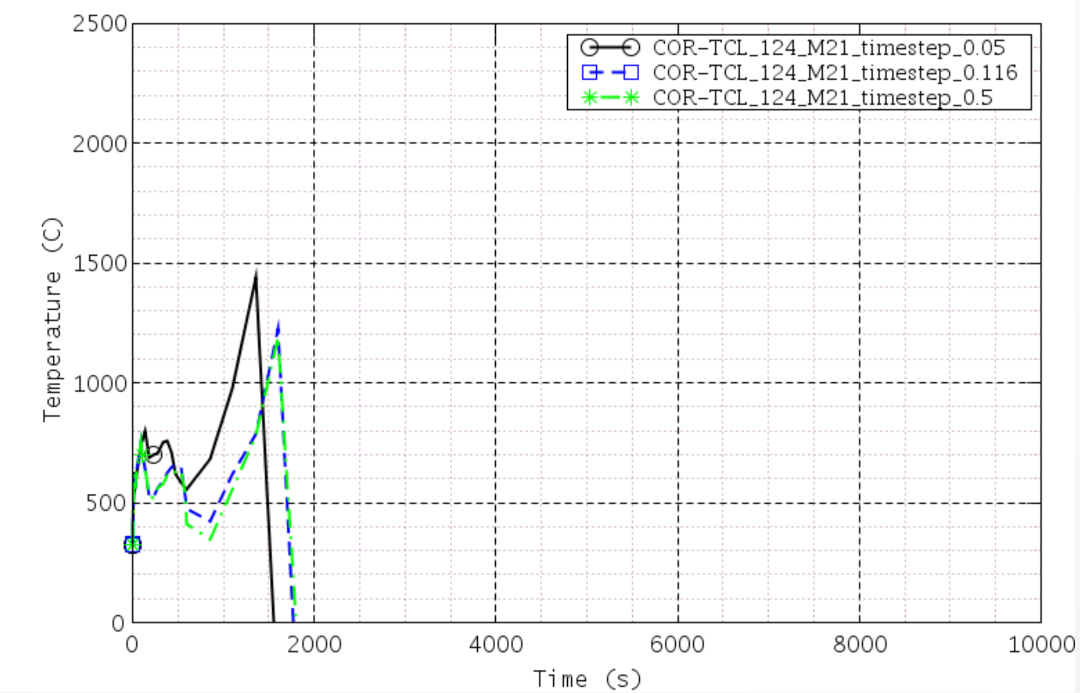


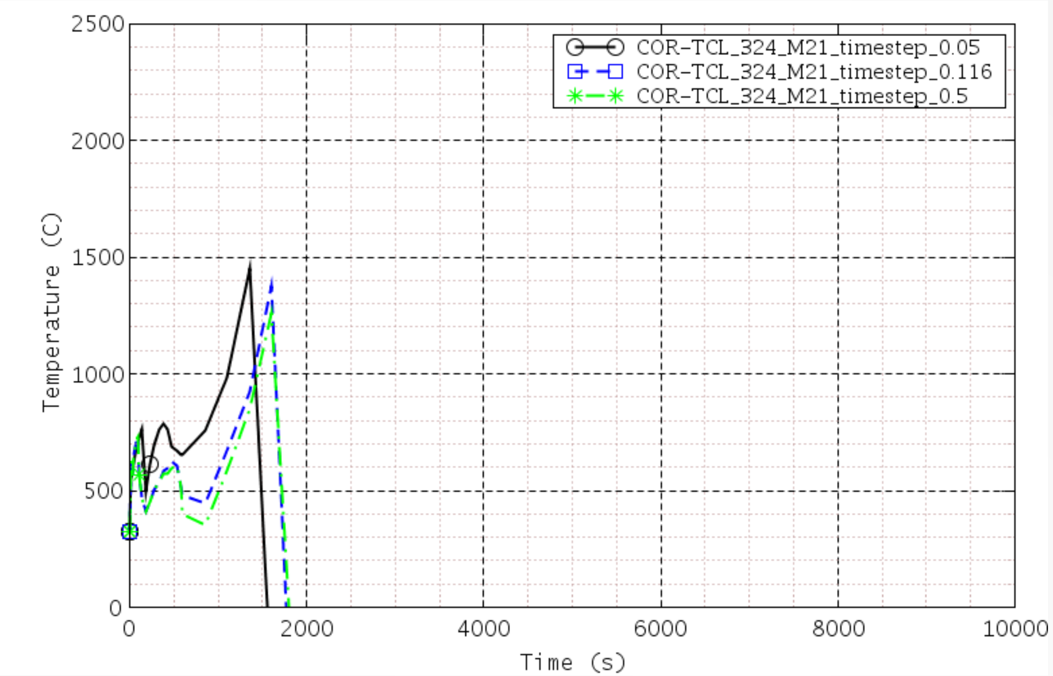


Hydrogen generations

07 | Comparative SA calculations with different time step

LB LOCA

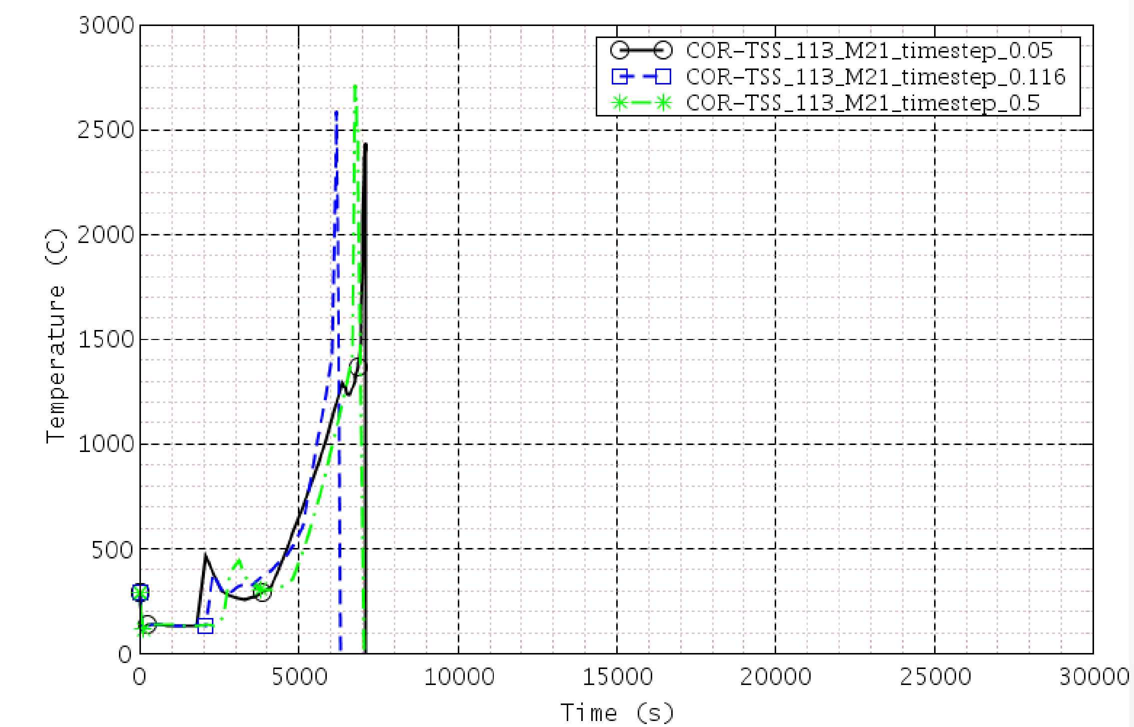


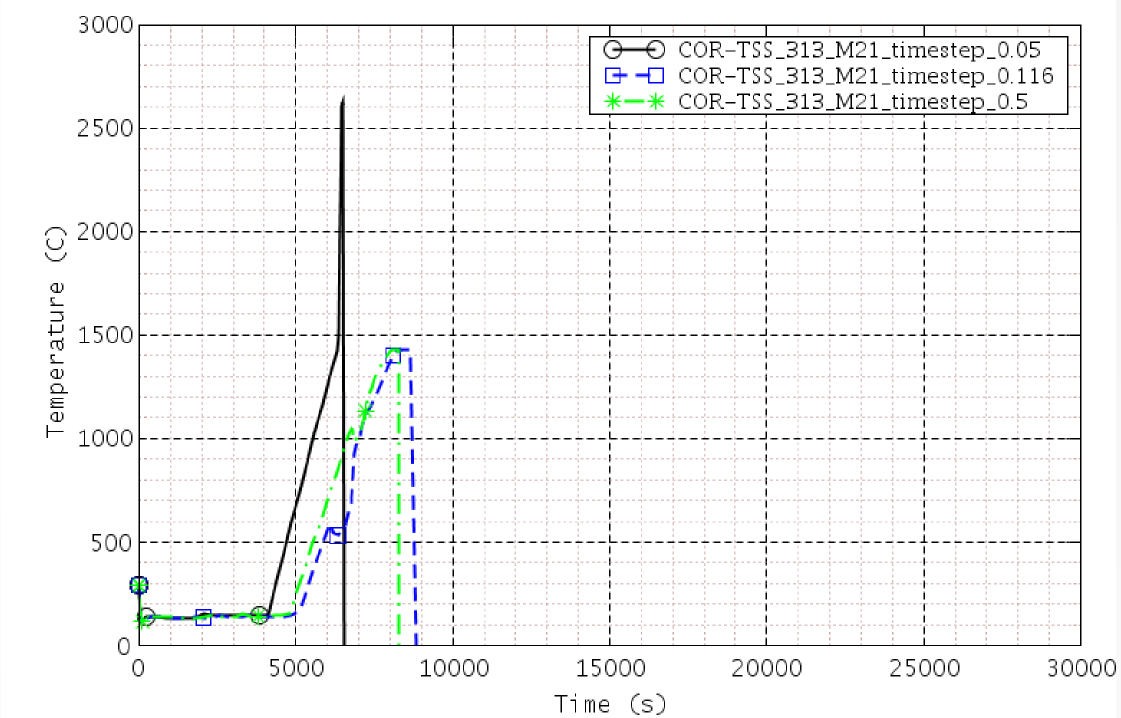


Cladding temperature in top segments

07 | Comparative SA calculations with different time step

LB LOCA

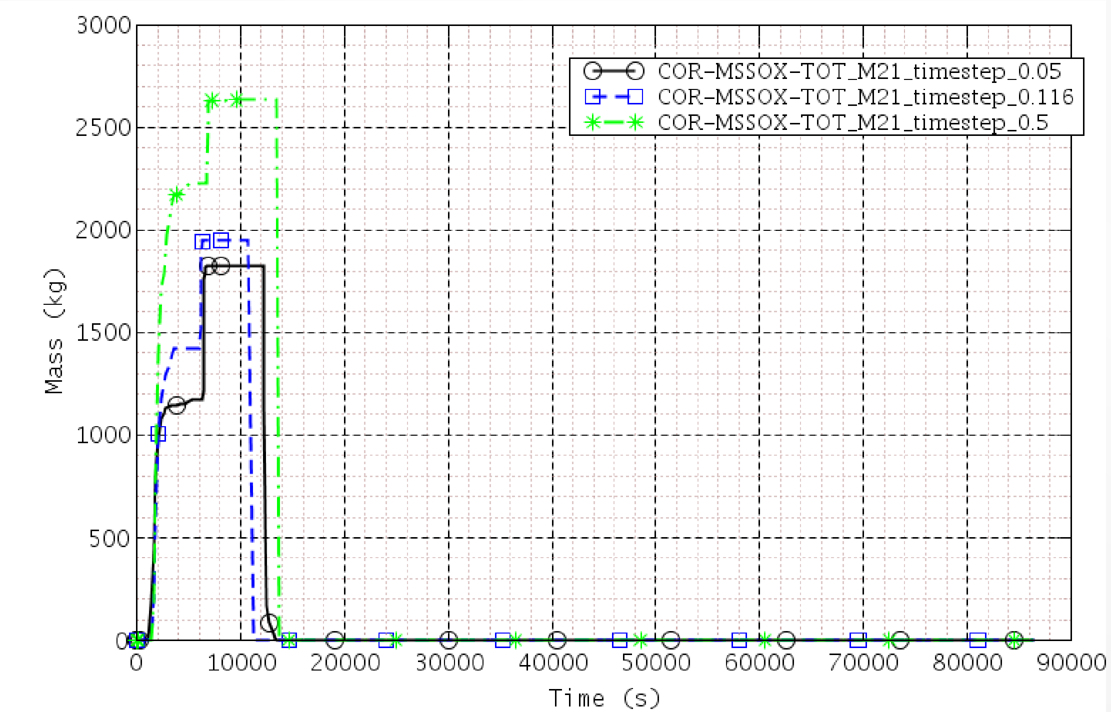




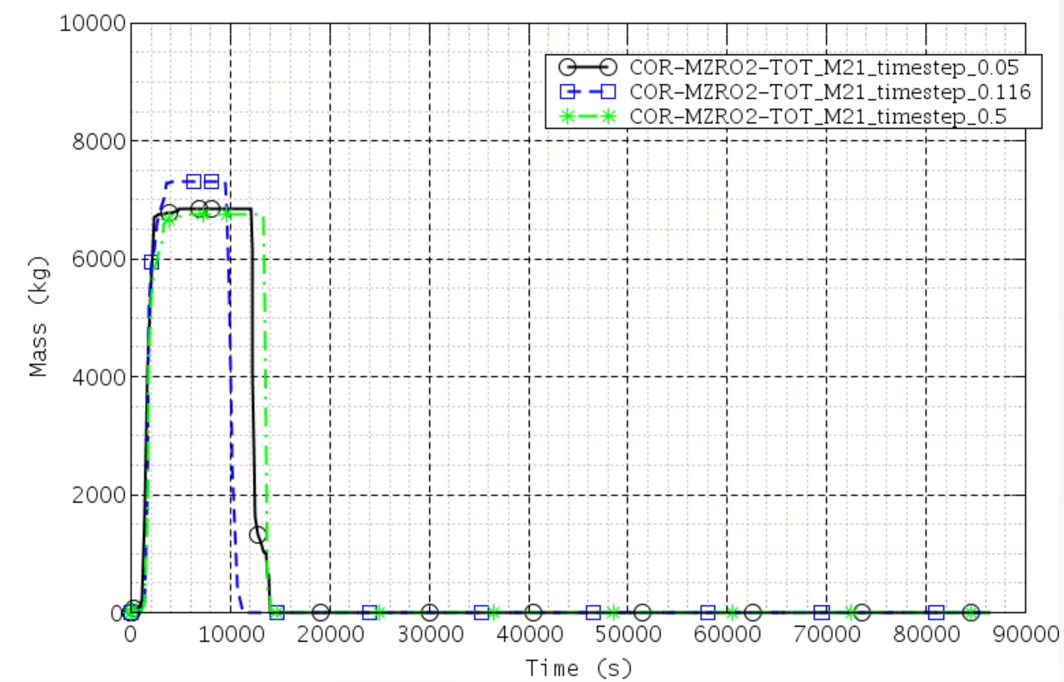
Base plate support structure temperature

07 | Comparative SA calculations with different time step

LB LOCA



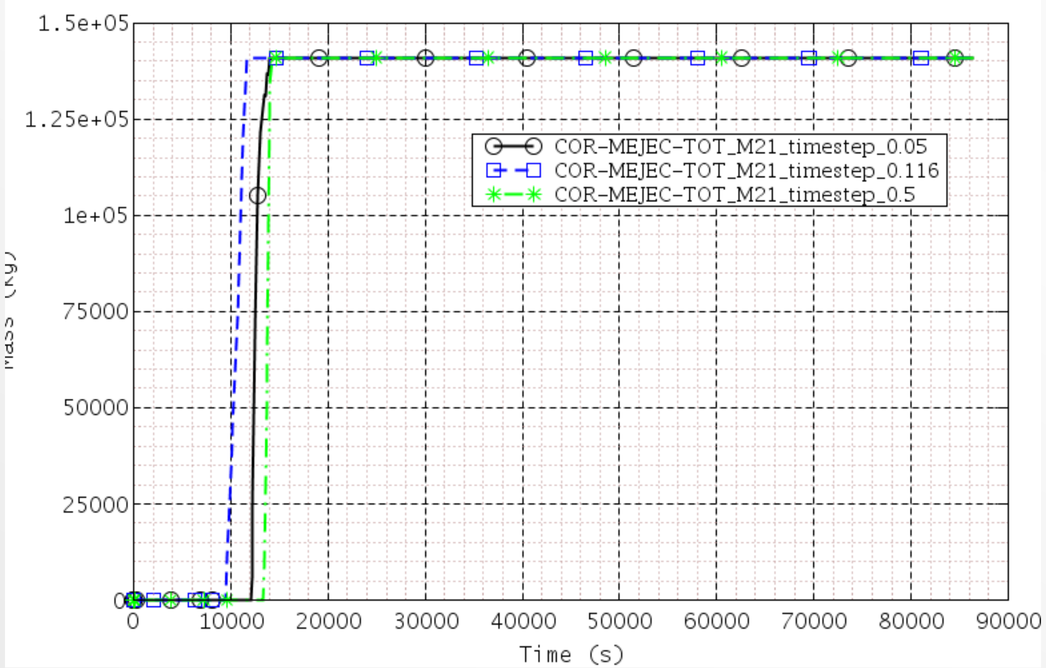
Mass change of steel oxide

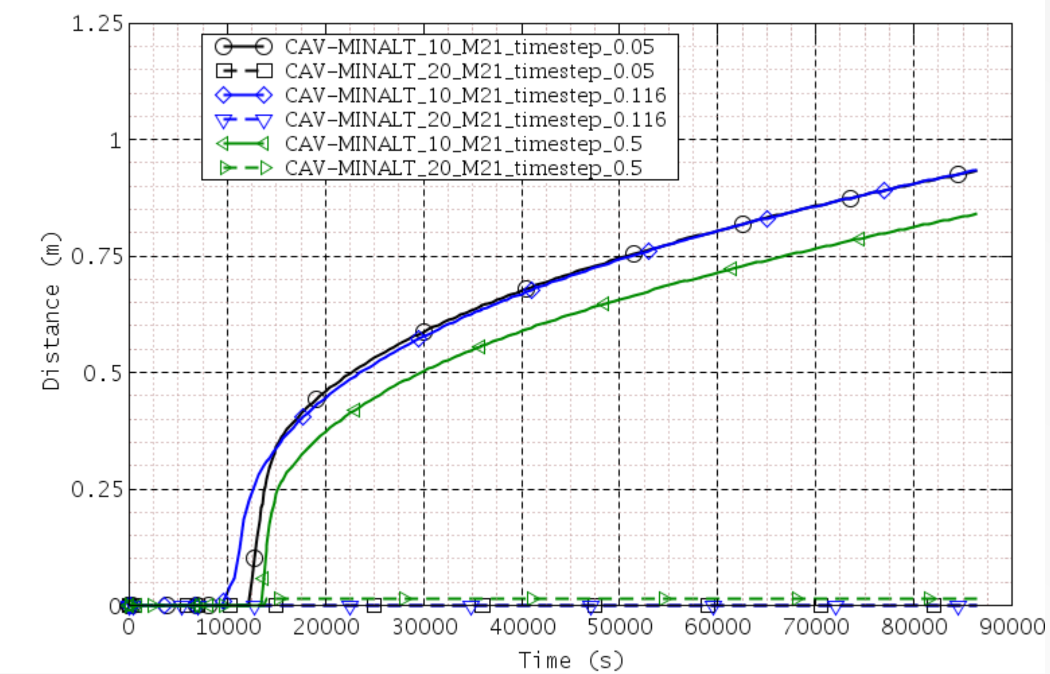


Mass change of zircaloy oxide

07 Comparative SA calculations with different time step

LB LOCA



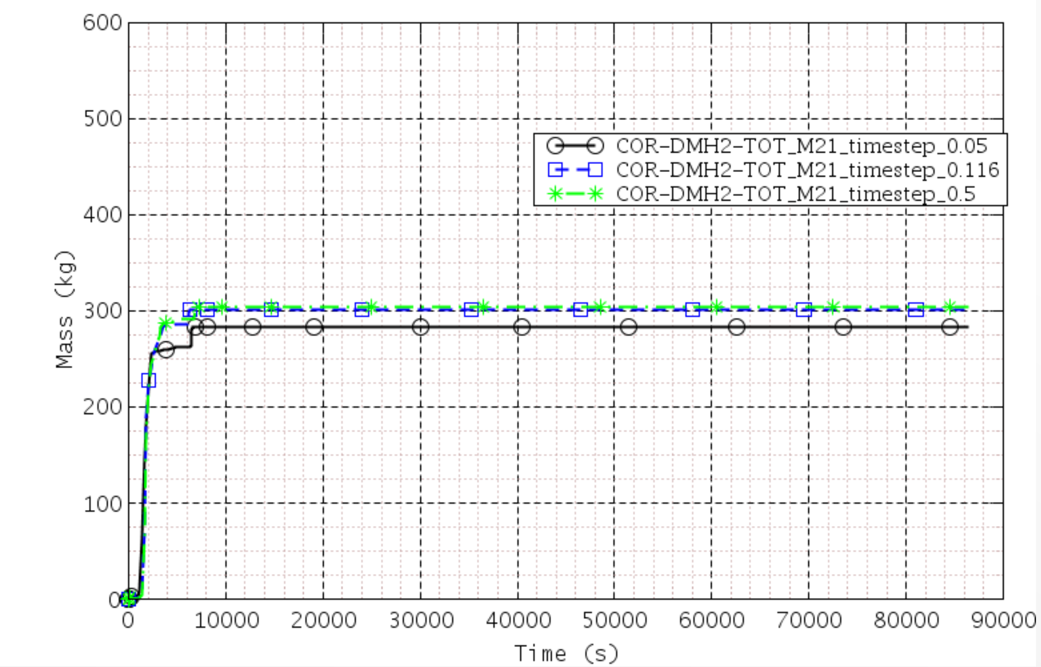


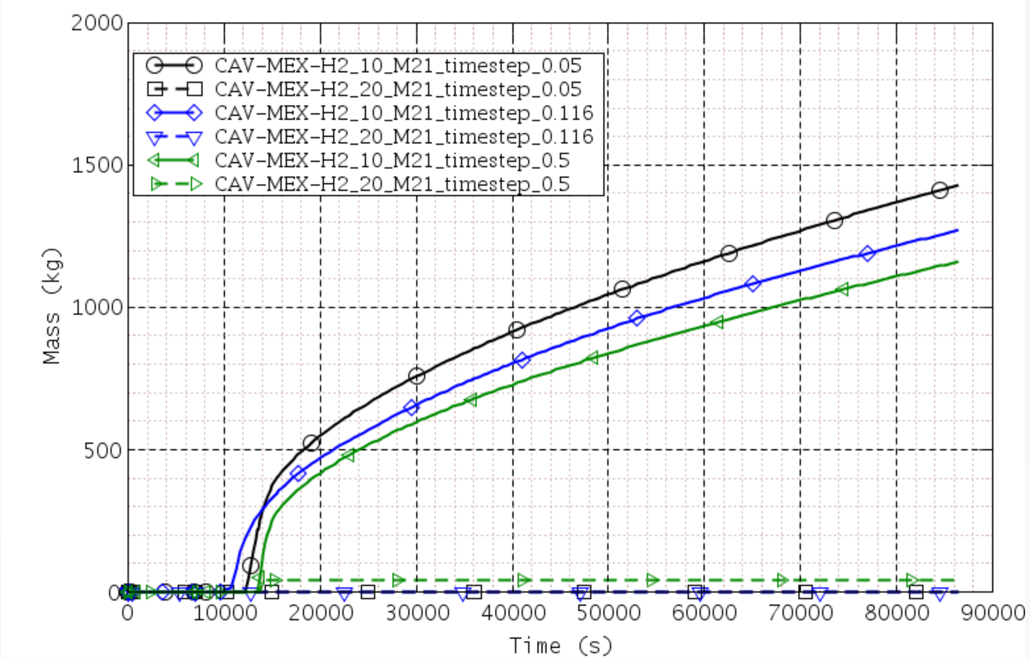
Total debris mass ejected through vessel breach

CAVITY ablation elevation

07 | Comparative SA calculations with different time step

LB LOCA





Hydrogen generations