Impact calculations of 1 g of Tritium (HT or HTO) on ITER site

Comparison between CERES and UFOTRI codes results

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General scenario

1 g of accident Tritium released to the atmosphere

Location: ITER site parameters

No accident tritium liquid releases at ITER

Several scenarios considered

Tritium: HT or HTO (but ITER considers tritium releases only as HTO form)

2 releases heights: 10 m (ground) or stack level (around 58 m)

Building wake effects: yes or no, for 58 m

Weather conditions: Doury dispersion parameters: Low diffusion 2 m/s (DF2) or normal diffusion 5 m/s (DN5)

Rainy conditions, applied or not for DN5

Calculations for 1 year child, 10 years child, adults

Acronym	Dispersion parameter	Release height (m)	Weather conditions	Rain	Comment
DF2_60	Doury	60	E, 2 m/s	No	Building wake
DF2_10	Doury	10	E, 2 m/s	No	No building wake
DN5_60	Doury	60	D, 5 m/s	No	Building wake
DN5_10	Doury	10	D, 5 m/s	No	No building wake
DN5P_60	Doury	60	D, 5 m/s	10 mm/h	Building wake
DN5P_10	Doury	10	D, 5 m/s	10 mm/h	No building wake

Use of CERES and UFOTRI codes

Use of the 2 following documents

- *UFOTRI: EFDA/06-1489 – FU06-CT-2006-00400 – TW6-TSS-SEP 2 - Calculations for unit releases of Tritium (HTO and HT) (...) from the European ITER site Cadarache to support licensing in 2007. W. Raskob - I. Hasemann*

- *CERES (Gazaxi 2002): ENV SURCI RBC DET 08000086 A - Radiological impact from accidental ITER tritium release. L. PATRYL*

Use of new version of CERES code (MITHRA)

Use of CERES and UFOTRI codes

Use of the same conditions for ITER site

- Impact locations
  - several distances considered,
  - all exposure pathways considered according to their locations : inhalation, ingestion, plume exposure at big distances, no ingestion at the fence

-Use (apparently) of the same dose conversion factors and the same human biokinetics models (ICRP)

Results

All the results, whatever the scenarios and the codes, leads to low doses

Highest result of CERES (Gazaxi 2002) code: 1.40 mSv

Highest result of UFOTRI code: 1.40 mSv

Highest results of CERES (Mithra): 4.46 mSv

Results similar between old CERES and UFOTRI.

Results completely different with new CERES

Comparison between (old) CERES and UFOTRI

Maximum result for CERES:
1.4 mSv with HTO for an adult at the fence for poor diffusion, a wind speed of 2 m/s (DF2), with a release height at ground level;
Exposure= inhalation and skin transfer

Maximum result for UFOTRI:
1.4 mSv with HTO for an adult at the fence for normal diffusion, a wind speed of 5 m/s (DN5), with a release height at ground level, same results with or whitout rain;
Exposure= inhalation and skin transfer

Both codes consider that adult are the most impacted, at short distances, when releases are at the ground level, through inhalation and skin transfer (note: skin transfer is considered in CERES at 40% of inhalation dose, UFOTRI? At ITER, use of 50% coefficient for skin transfer)

First difference between old CERES and UFOTRI: dispersion coefficients for poor and normal diffusion

Comparison between old CERES and new CERES

Maximum result for old CERES:

1.4 mSv with HTO for an adult at the fence for poor diffusion, a wind speed of 2 m/s (DF2), with a release height at ground level;
Exposure= inhalation and skin transfer

Maximum result for new CERES:

4.46 mSv with HTO for an adult at the fence for poor diffusion, a wind speed of 2 m/s (DF2), with a release height at ground level;
Exposure= inhalation and skin transfer
At DN5 without rain, 1.85 mSv; with rain, 1.83 mSv, still higher than UFOTRI

- Probable difference between old CERES and new CERES: rule of maximum dispersion for distance lower than the bounding distance ; this appears to be a very important element for small distances and releases at ground level
- Comparison can only be made between new CERES and other codes at big distances, greater than the bounding dispersion distance
- Other difficulty for a comparison: new CERES has been applied for actual assumptions around ITER site (e.g. no harvest and crops in the first 3 .5 km)
- Overestimation but envelope

Other significant results

2 types of calculations are presented in the next slides

- small distance with only inhalation+ skin transfer

- higher distance to consider also ingestion (no eatable products at short distances around ITER site)

Other significant results

For 1 g HTO tritium accident releases
DN5 58m rain with building wake effect

The maximum results are globally similar (around 15% difference)
BUT
Old CERES : 10 y old are the most exposed at 2.5 km due to ingestion;
UFOTRI: adult at 200 m are the most exposed due to inhalation

Old CERES is globally envelope at long distances with ingestion by a factor 7
UFOTRI is globally envelope at short distances with a factor 3
-Difference in models (or “hidden assumptions”) implemented for dispersion?
-Difference in models (or “hidden assumptions”) implemented for ingestion?

Other significant results

For 1 g HT tritium accident releases
DN5 58m rain with building wake effect

10 y old children at 2.5 km are the most exposed for both codes
BUT
Old CERES gives a maximum value 2 orders of magnitude higher than UFOTRI
Old CERES is globally envelope at long distances with ingestion by a factor 30
UFOTRI is globally envelope at short distances with a factor 6

But the doses are in the range of microSv or less.

-Difference in models (or "hidden assumptions") implemented for **dispersion**, as well for **ingestion**?

Other significant results

For 1 g HTO tritium accident releases
DF2 58m rain bldg wake effect

Adult are still the most exposed; With HTO, at stack release height, and DF2, UFOTRI is globally envelope with a factor 2

For 1 g HT tritium accident releases
DF2 58m rain bldg wake effect

10 y old are the most exposed at 2.5 km due to ingestion; 2 to 4 decades below HTO
At stack release height, for poor diffusion, UFOTRI is globally envelope with a factor between 3 and 100, but the doses are in the range of microSv or less.

Other significant results

For other scenarios

Differences are less impressive, but still some factors that could be > 2 between old CERES and UFOTRI

For bounding case with ingestion at 2.5 km (old CERES)

-inhalation: 17%
-Skin transfer : 7%
-Direct Ingestion (air pathway): 62% (28% animals, 34% plants)
-Indirect Ingestion (soil pathway): 14% (9% animals, 5% plants)

Summary

- 3 codes have been benchmarked: UFOTRI, old CERES (Gazaxi) and new CERES (Mithra)
- Scenarios involved 1g of tritium in an accident with different chemical forms, weather conditions, and releases height
- All the results are in the range of low doses
- New CERES is bounding at short distances; comparison is difficult at long distances between new CERES in one hand and the two other codes in the other hand (use of actual assumptions for new CERES/ use of theoretic assumptions for the two others)
- Old CERES and UFOTRI give exactly the same maximum values, but for different weather conditions :
  - Old CERES is envelope at long distances, considering ingestion
  - UFOTRI is envelope at short distances for the inhalation
  - In some scenarios, very important differences between the two codes (factors up to 100!)
- Differences may be attributed to the models or the hidden assumptions
- Choice of new CERES (Mithra) for ITER for bounding safety case
- But what is the truth?

Summary

- 3 codes have been benchmarked: UFOTRI, old CERES (Gazaxi) and new CERES (Mithra)
- Scenarios involved 1g of tritium in an accident with different chemical forms, weather conditions, and releases height
- All the results are in the range of low doses

⇒Accidents at ITER are not a concern

Limits of this "benchmark" work:

- only the direct results from the codes have been compared, not the models themselves,
- ITER is a code user, not a code developer
- comparison of figures inside reports for old CERES and UFOTRI, use of the code itself for new CERES; for the reports, some "hidden assumptions" may impact the results

Summary

- New CERES is bounding at short distances; comparison is difficult at long distances between new CERES and the two other codes (use of actual assumptions for new CERES/ use of theoretic assumptions for the two others)
- Old CERES and UFOTRI give exactly the same maximum values, but for different weather conditions :
  - Old CERES is envelope at long distances, considering ingestion
  - UFOTRI is envelope at short distances for the inhalation
  - In some scenarios, very important differences between the two codes (factors up to 100, hopefully for extremely low doses with HT, and it does not impact bounding results)
- Differences may be attributed to the models or the hidden assumptions
- Choice of new CERES (Mithra) for ITER for bounding safety case

But what is the truth?

Thanks for your attention

Now

Within
10 years