RASCAL4

TUTORIAL

NUCLEAR POWER PLANT - PWR

LOSS-OF-COOLANT ACCIDENT (LOCA)

Prerequisites

Basic working familiarity with the RASCAL STDose model, from either the online RASCAL Fundamentals course or from previous practical RASCAL experience.

Disclaimer

This RASCAL tutorial was developed by the U.S. Nuclear Regulatory Commission to support training for its Incident Response Program and the Radiation Protection Computer Code Analysis and Maintenance Program (RAMP). The situations presented may not be realistic or likely and are for training purposes only.

Introduction

The Loss-of-Coolant Accident (LOCA) source term option in RASCAL implements the core damage and release timing sequences established in NUREG-1465, "Accident Source Terms for Light-Water Nuclear Power Plants." The basic scenario for this accident is initiated by a loss of reactor coolant significant enough to uncover fuel. In this accident sequence, uncovered fuel can heat up to release gap activity and eventually melt.

Additional Information

- If a LOCA takes place but is not significant enough to lead to uncovered fuel (and there is no fuel damage) use the Coolant Release Accident source term option instead.
- Both the LOCA and LTSBO source terms model fuel damage. The onset of damage occurs more rapidly in LOCAs (LTSBO slowly boils water off, then melts fuel) and the timelines once damage starts are slightly different.
- This source term will not properly model an ATWAS (failure to shutdown/insert rods).

Walkthrough

Scenario

Note: this PWR LOCA scenario repeats the example problem used in the RASCAL Fundamentals course. If you have recently taken that course, this walkthrough may serve as a beneficial review.

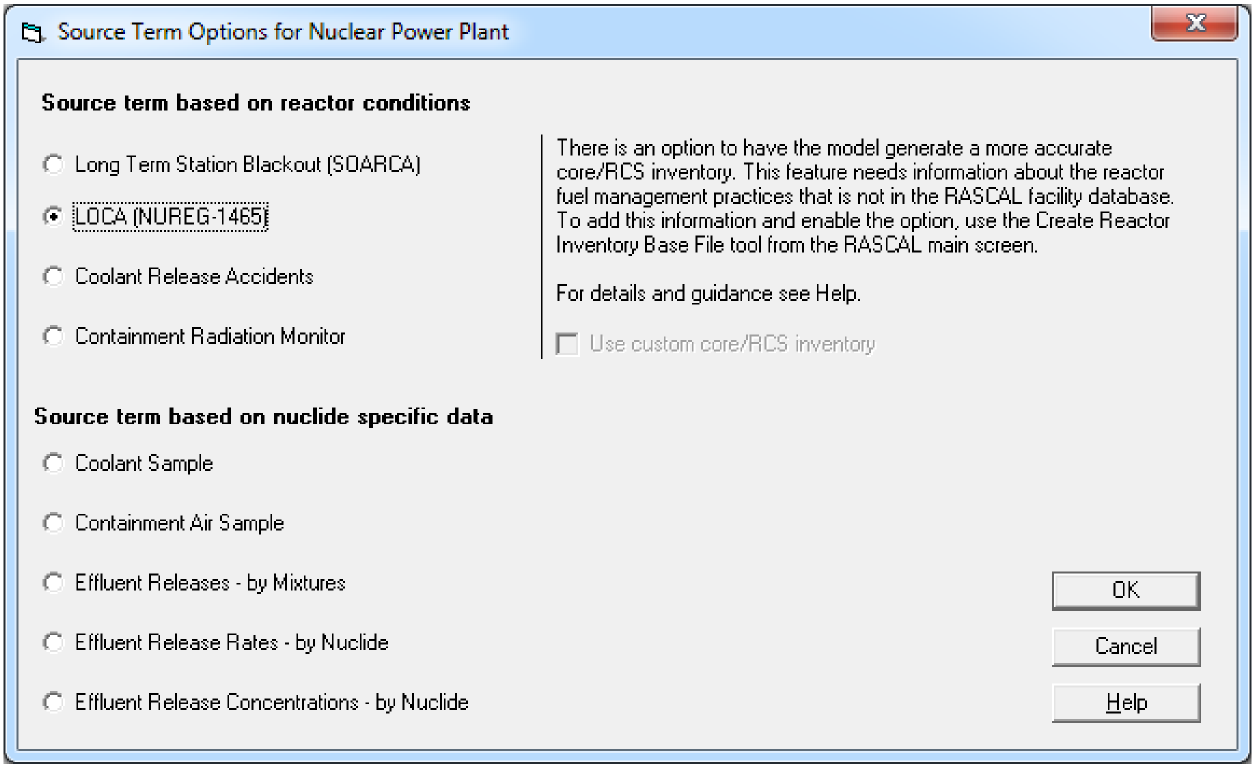
Braidwood, Unit 1 had been operating at full power. At 10:00 local time a major rupture in the primary coolant system (loss-of-coolant accident [LOCA]) caused the reactor to trip. Coolant loss was significant enough that the core was uncovered at 11:00. At 17:00, operators were able to recover the core.

When the release started, the containment spray system was active. Containment release rate to the atmosphere was 3% per day. Containment remained at high pressure (which kept the release ongoing) and pressure wasn't reduced until 21:00 (at which point the release stopped, or is at 0%).

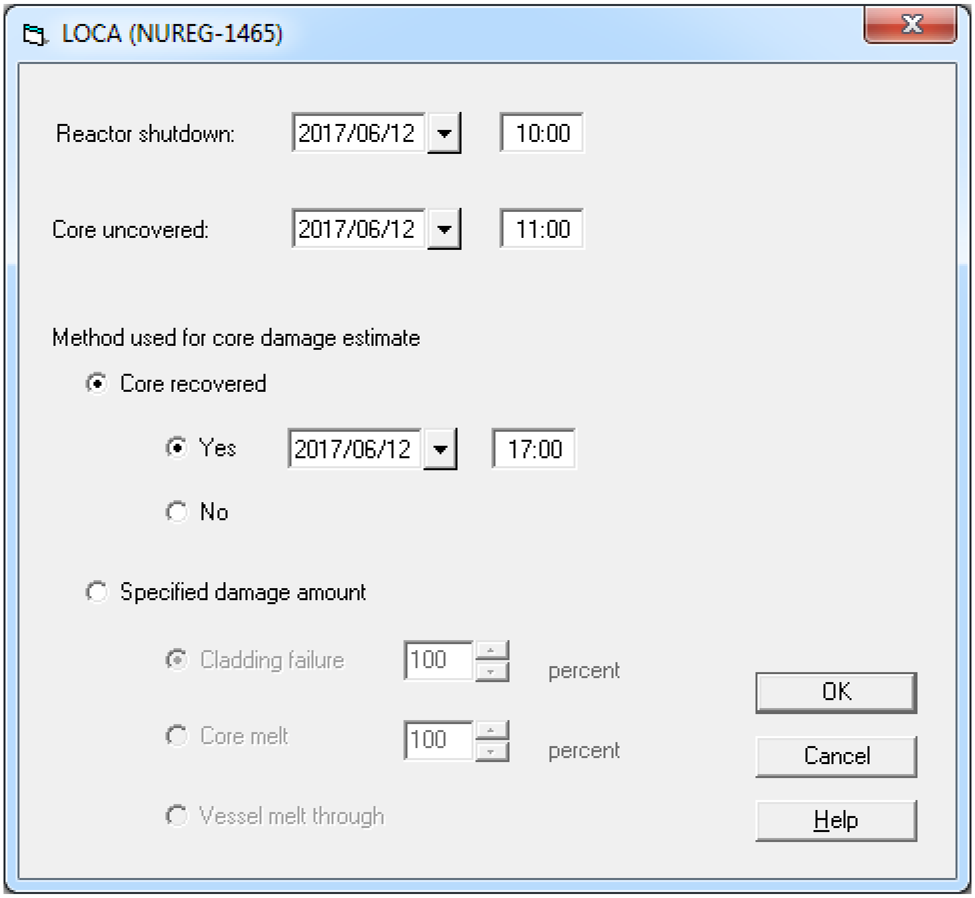
Use Standard Meteorology.

Step by step

Start the STDose tool; set Event Type as Nuclear Power Plant and Event Location as Braidwood Unit 1.

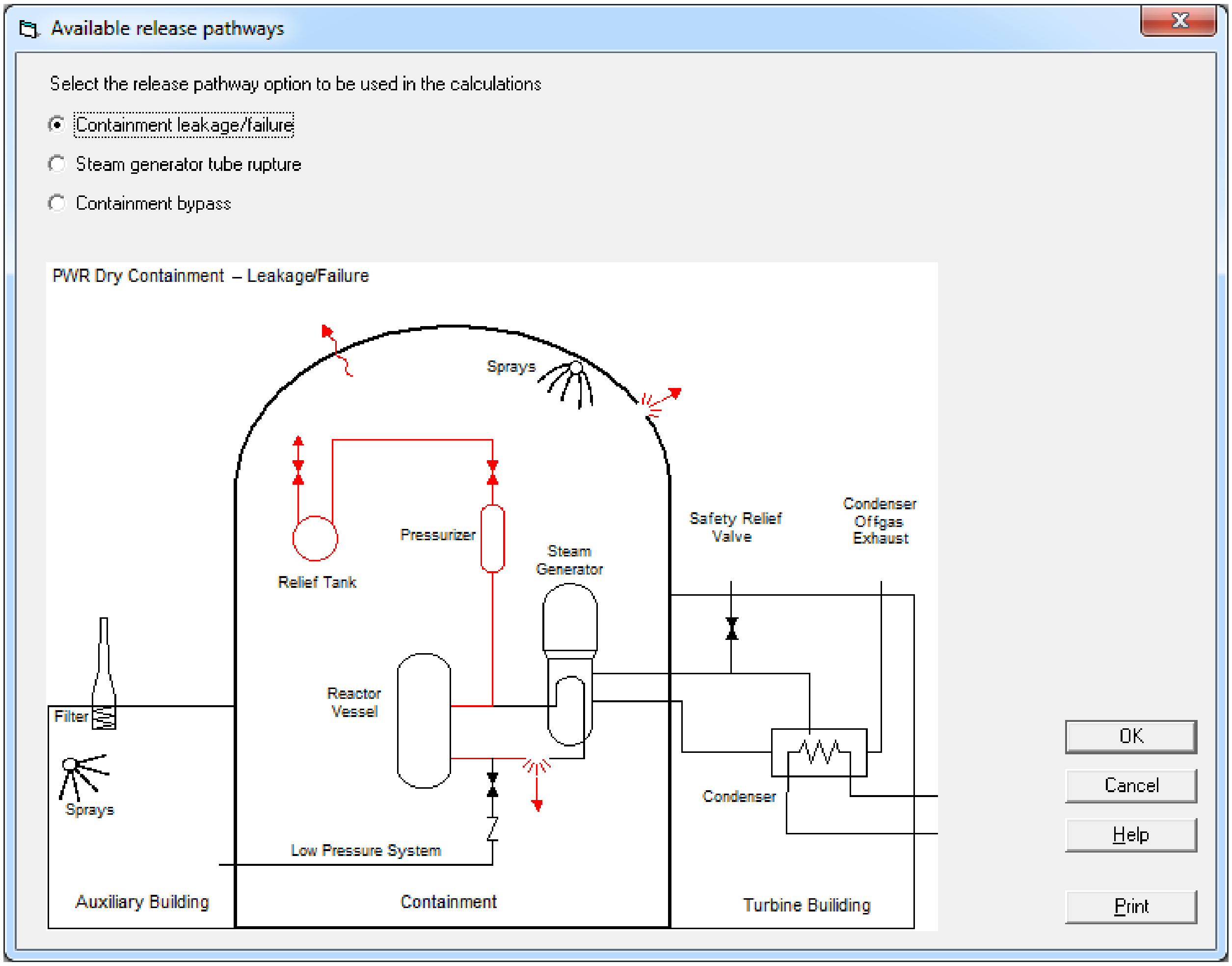


Click Source Term and then select the LOCA (NUREG-1465) option. Click OK.

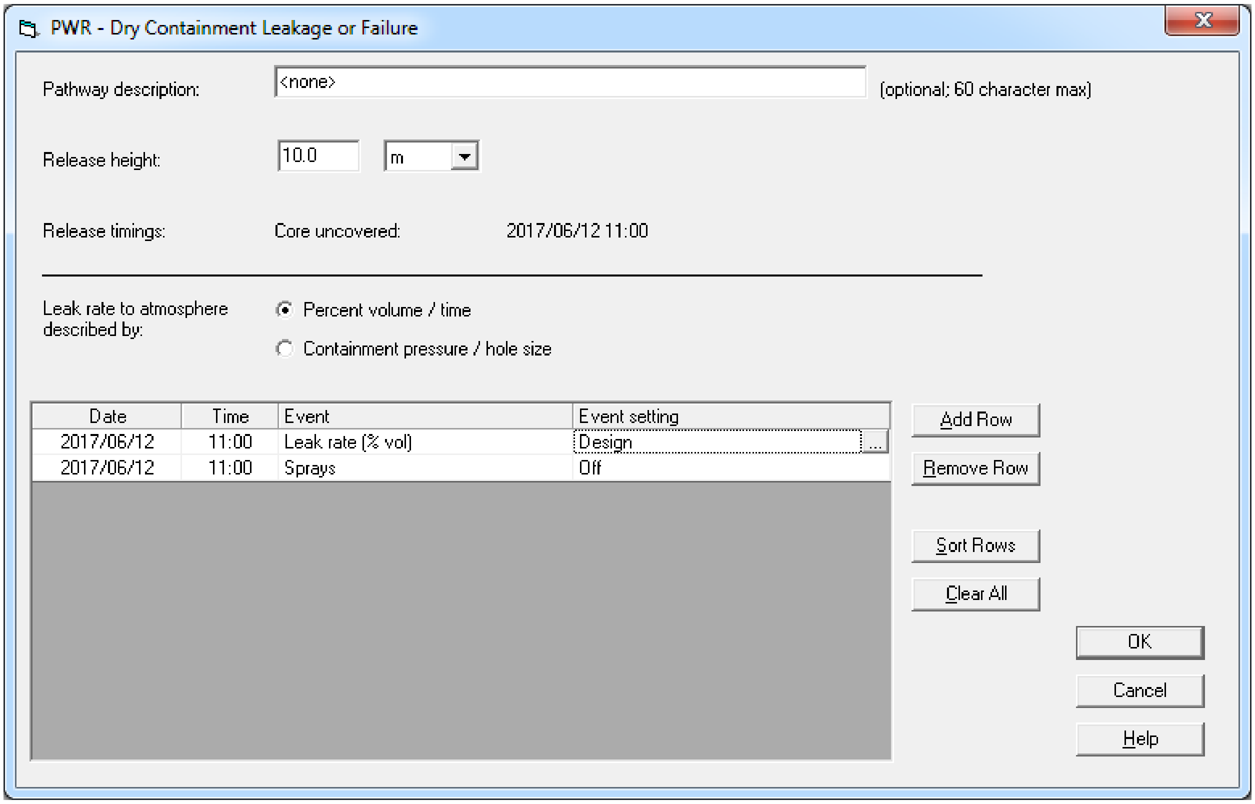


Now define the LOCA timeline parameters. Set the Reactor Shutdown time to 10:00, which starts the decay clock for the isotopes in the reactor. Set the Core Uncovered time to 11:00, which starts the NUREG-1465 timeline that describes the amount of core damage per time. Lastly, you need to specify the extent of core damage, which can be done in two ways. The Core Recovered option will follow the accident progression timeline for a given time duration. If yes, RASCAL will stop the generation of new source material at the specified time. If no (not recovered), RASCAL will continue fuel melt and generation of new source material until the end of calculations. In contrast, the Specified Damage Amount option defines a set endpoint and persists damage until that time. For this scenario, set the Core Recovered option to Yes and the time to 17:00. Click OK.

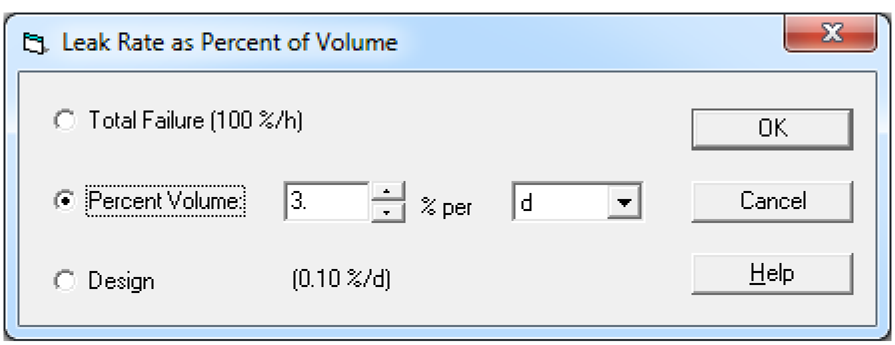
Click Release Path and determine which pathway best characterizes the release.



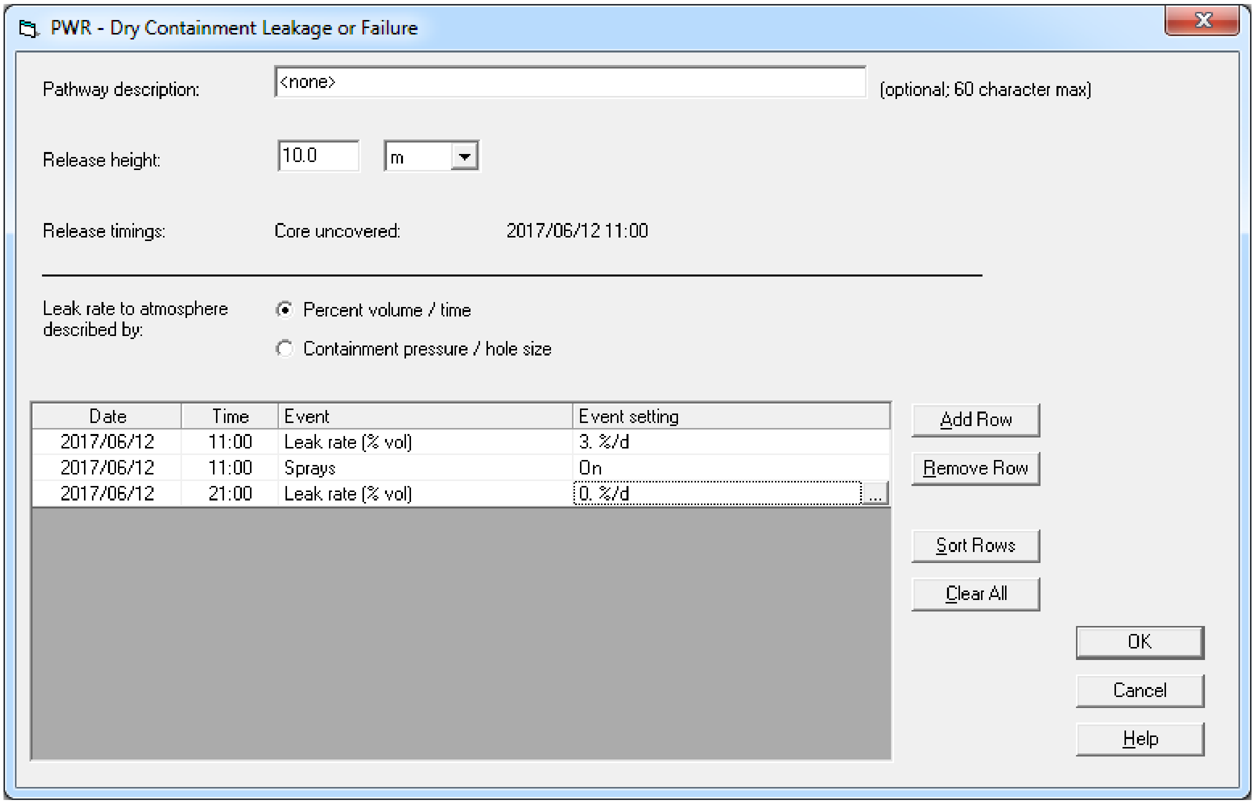
In this scenario, there's no indication of a leak in the steam generator or a system bypassing containment, so we can assume that material will directly enter containment. This will cause an increase in containment pressure which could damage containment, resulting in leakage to the atmosphere unless containment pressure is reduced. We can see by the line diagram the expected release pathway. Since this release pathway option is selected by default, just click OK.



Now define additional release parameters. Let's start with release height. Remember that RASCAL won't take input values any lower than 10 meters. For ground releases or building releases without a specific release location, just use 10 meters. Since this is already the default, move down to the leak rate options below. Start by changing the first leak rate from design to what is in the scenario. Click on the Design entry, then click the dotted button on the right.

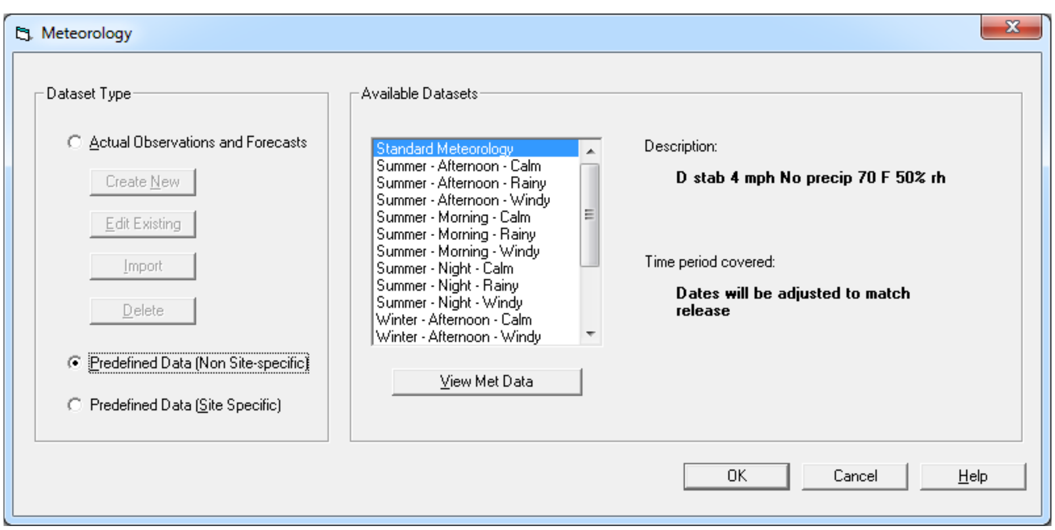


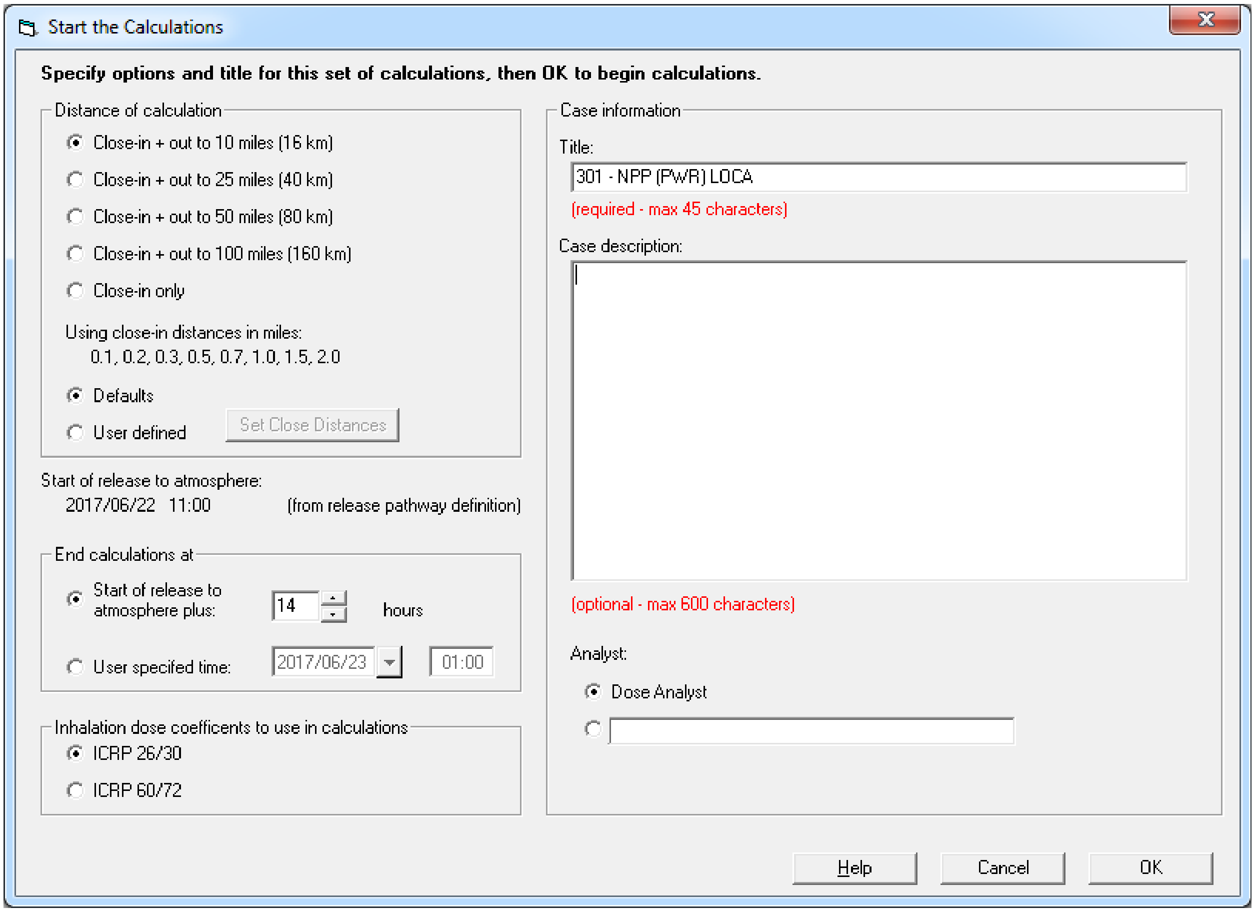
Select the Percent Volume option. Enter 3 in the % box and d in the dropdown. Click OK.



In the scenario, the containment spray system was active, so change the Sprays value to On. We'll also need to account for the fact that the operators were able to reduce containment pressure (stopping the leak). Click the Add Row button on the right. Set the time in this row to 21:00. In the Event column, select Leak Rate. For the Event Setting, click the dotted button, select the Percent Volume option, and set to 0%. Click OK and then click OK again to return to the main STDose screen.

Click Meteorology; select the Predefined Data (Non-Site Specific) option and select Standard Meteorology.

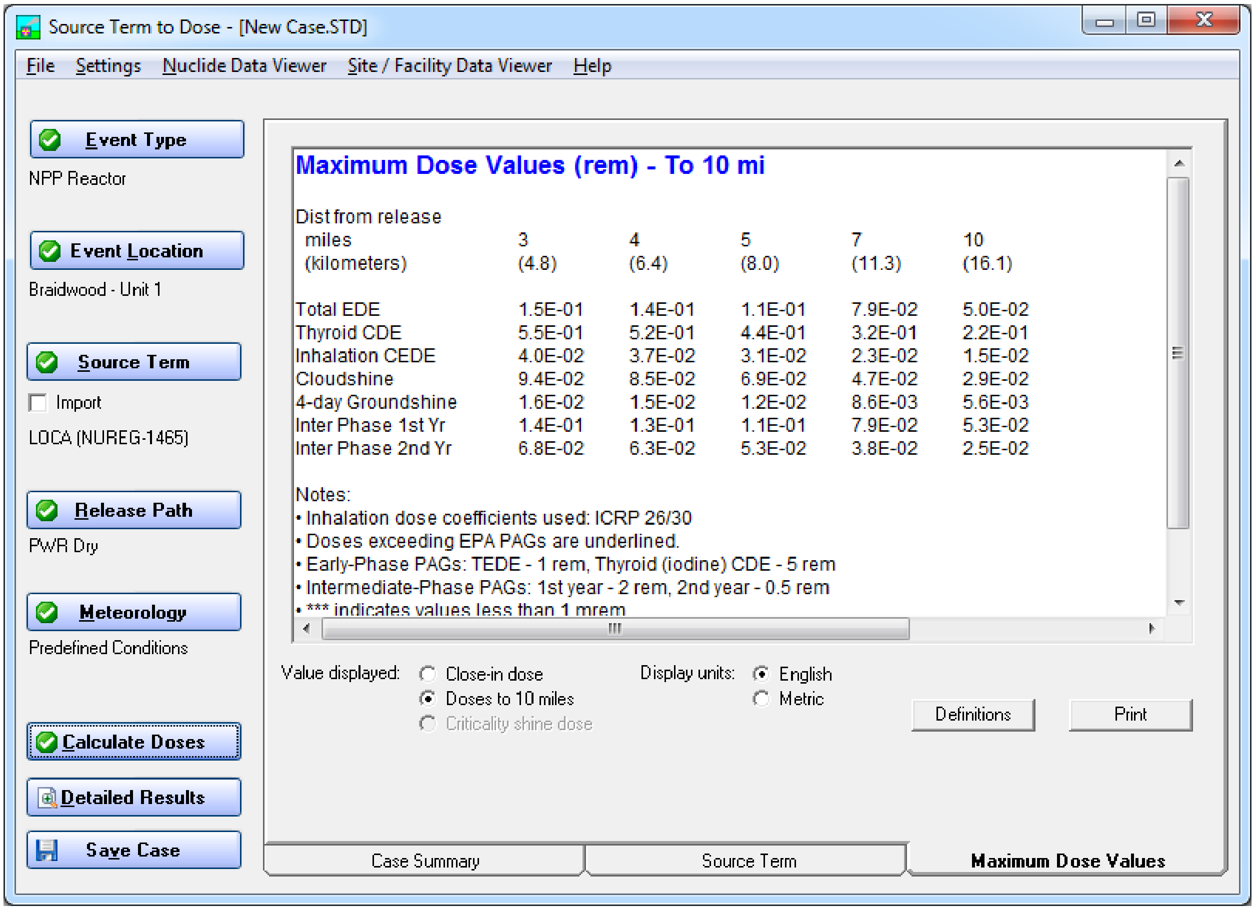




Click Calculate Doses.

Leave the Distance of Calculation set to 10 miles. For End Calculations use the Start of Release to Atmosphere plus option. For this release duration, we need to account for the release time and duration that the plume will take to get to 10 miles. We know the release lasted 10 hours (11:00 to 21:00) despite the fact that the core was recovered at 17:00 (this just means no new material is available for release, but material in containment can still be released). It takes the 4 mph wind (in Standard Met) 2.5 hours to transport material 10 miles. We'll add the two times, and add 10% for dispersion and uncertainty, resulting in 13.75. Rounding up a bit, input 14 hours. There's no need to change the inhalation dose coefficients option. Enter a case title and then click OK.

Compare your results to the screenshot below.



Conclusion

This problem steps through a LOCA that led to core damage and ultimately released to the atmosphere through containment. Just as a reminder, this model should be used only when assuming a LOCA will result in core damage/melt. If a LOCA takes place but is not significant enough to lead to uncovered fuel, and therefore no fuel damage, use the Coolant Release Accident source term instead. Additionally, if any information for release pathways was known (e.g., failed seals into aux building), then you would choose the appropriate pathway in the Release Path section instead of assuming containment failure.