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# Specification of TRACY Benchmark I

## -Introduction

For the evaluation of the criticality accident of fissile solution, a number of numerical codes have been developed in several countries. The calculated values of the number of fission, power, temperature, are main measures of the accident and those on which the discussion on criticality accident or the international exchange of its information is based. However, there is a few experimental data that is available for the evaluation of the code itself.

The TRACY benchmark problem was made so that we can make out the feature of criticality accident analysis code. The analysis of the benchmark is beneficial to the improvement of the numerical code and gives the basis of the common knowledge for the international exchange of the information of criticality accident and its analysis.

The feature of the TRACY benchmark problem is as follows;

- Low enriched uranyl nitrate solution,
- Co-axial double cylinders tank,
- Three methods of reactivity insertion.

In this benchmark, the experiments of the pulse insertion of reactivity are provided, that is the simplest method of reactivity insertion for TRACY experiments.

## -Inserted reactivity and initial state.

In each experiment, the reactivity is inserted by pulse withdrawal of the transient rod, and there was no external neutron source.

Table 1: Selected experiments and their initial states.

| Run NO. | Inserted Reactivity($) | Initial state | | | |
|---|---|---|---|---|---|
| | | Criticality (Power) | Sol. Level(mm) | Fuel Temp. (°C) | Tr-rod position (mm) |
| 100 | 0.30 | Cri. (1W) | 508.52 | 26.2 | 471.7 |
| 143 | 0.70 | Sub | 551.83 | 24.8 | 0.0 |
| 72 | 1.10 | Sub | 537.05 | 26.2 | 0.0 |
| 196 | 2.00 | Sub | 582.50 | 25.9 | 0.0 |
| 203 | 2.97 | Cri. (1W) | 623.76 | 26.1 | 0.0 |

**- Fuel conditions**

The fuel solution is uranyl nitrate solution, which consists of uranyl nitrate [$UO_2(NO_3)_2$], free nitric acid [$HNO_3$], and water [$H_2O$]. The enrichment of $^{235}U$ is 9.98 wt.%.

Table 2: Solution fuel conditions at 25°C.

| Run NO. | I.R.($) | U Conc.(gU/L) | Acidity(N) |
|---|---|---|---|
| 100 | 0.30 | 392.9 | 0.66 |
| 143 | 0.70 | 375.9 | 0.64 |
| 72 | 1.10 | 393.5 | 0.74 |
| 196 | 2.00 | 385.5 | 0.58 |
| 203 | 2.97 | 388.2 | 0.58 |

**- Start time and Shutdown time**

Table 3 shows the duration time of the experiment.

Table 3: Duration time.

| Run NO. | I.R.($) | Duration Time(sec) |
|---|---|---|
| 100 | 0.30 | 554.8 |
| 143 | 0.70 | 73.4 |
| 72 | 1.10 | 137.7 |
| 196 | 2.00 | 18.6 |
| 203 | 2.97 | 7.6 |

**- Geometry data**

The core tank has an annular shape with 52cm outer and 7.6cm inner diameter. The effective cross section area for solution fuel is 1918 $cm^2$. For more information, see fig.1, 2 and 3. In fig.3, the position 0.0mm of the Tr-rod means that the bottom of $B_4C$ inside the Tr-rod is 90mm below of the bottom of the fuel solution. Figure 4 shows the positions of thermocouples.

**- Kinetic parameters**

The parameters necessary for each simulation should be calculated in the evaluation process by the evaluator. Tables 4 through 9 give standard values, which may be used for those who dose not have any calculation tool.

Table 4: Fuel conditions and kinetic parameters at 25.5°C.

| | |
|---|---|
| U-235 enrichment (%) | 9.98 |
| Uranium concentration (gU/L) | 390 |
| Acid morality (mol/L) | 0.77 |
| Solution height (cm) | 50.88 |
| Neutron multiplication factor[$k_{eff}$] | 1.0111 |
| Effective delayed neutron fraction[$\beta_{eff}$] | $7.5 \times 10^{-3}$ |
| Prompt neutron life time [$\Lambda$](sec) | $4.6 \times 10^{-5}$ |

Table 5: Atom number density of the fuel solution with the concentration of 390 gU/L at 25.5°C.

| Nucleus | Number density (atoms/barn.cm) |
|---|---|
| H | $5.7292 \times 10^{-2}$ |
| N | $2.4394 \times 10^{-3}$ |
| O | $3.7708 \times 10^{-2}$ |
| U235 | $9.9622 \times 10^{-5}$ |
| U238 | $8.8823 \times 10^{-4}$ |

Table 6: Atom number density of SUS304L at 25.5°C.

| Nucleus | Number density (atoms/barn.cm) |
|---|---|
| C | $1.1939 \times 10^{-4}$ |
| Si | $1.7004 \times 10^{-3}$ |
| Cr | $1.7450 \times 10^{-2}$ |
| Mn | $1.7385 \times 10^{-3}$ |
| Fe | $5.7180 \times 10^{-2}$ |
| Ni | $8.9482 \times 10^{-3}$ |
| Si | $4.4682 \times 10^{-5}$ |

Table 7: Atom number density of air at 25.5°C.

| Nucleus | Number density (atoms/barn.cm) |
|---|---|
| O16 | $1.8789 \times 10^{-6}$ |
| N14 | $5.7238 \times 10^{-6}$ |

Table 8: Reactivity temperature coefficient.

| Temperature (°C) | Reactivity Coef. (Δk/kk')/°C |
|---|---|
| 25.5 | 0.0 |
| 40 | $-4.7 \times 10^{-2}$ |
| 60 | $-4.8 \times 10^{-2}$ |
| 80 | $-4.9 \times 10^{-2}$ |

*Uranium concentration of solution is 390 gU/L.

Table 9: Reactivity void coefficient.

| Void (vol.%) | Reactivity Coef. (Δk/kk')/% |
|---|---|
| 0 | 0.0 |
| 5 | $-4.0 \times 10^{-3}$ |
| 10 | $-4.7 \times 10^{-3}$ |
| 20 | $-6.1 \times 10^{-3}$ |

*Uranium concentration of solution is 390 gU/L.

**- Items for Comparison**

Table 9 in the next page shows the summary format.

Table 9: Summary form

| xperiments | R100 | R143 | R72 | R196 | R203 |
|---|---|---|---|---|---|
| Iaximum inverse period ($sec^{-1}$) | | | | | |
| irst peak power (W) | | | | | |
| nergy to the first peak (J) | | | | | |
| nergy to the first minimum (J) | | | | | |
| otal Energy (J) | | | | | |
| inal Temperature (°C) | | | | | |
| eak Pressure (Pa) | | | | | |
| irst peak time (sec) | | | | | |
| irst minimum time (sec) | | | | | |
| ressure Peak time (sec) | | | | | |
| elayed neutron fraction | | | | | |
| rompt neutron life time (sec) | | | | | |
| emperature Reactivity Coef. (cent./°C) | | | | | |
| oid Reactivity Coefficient (cent./%) | | | | | |

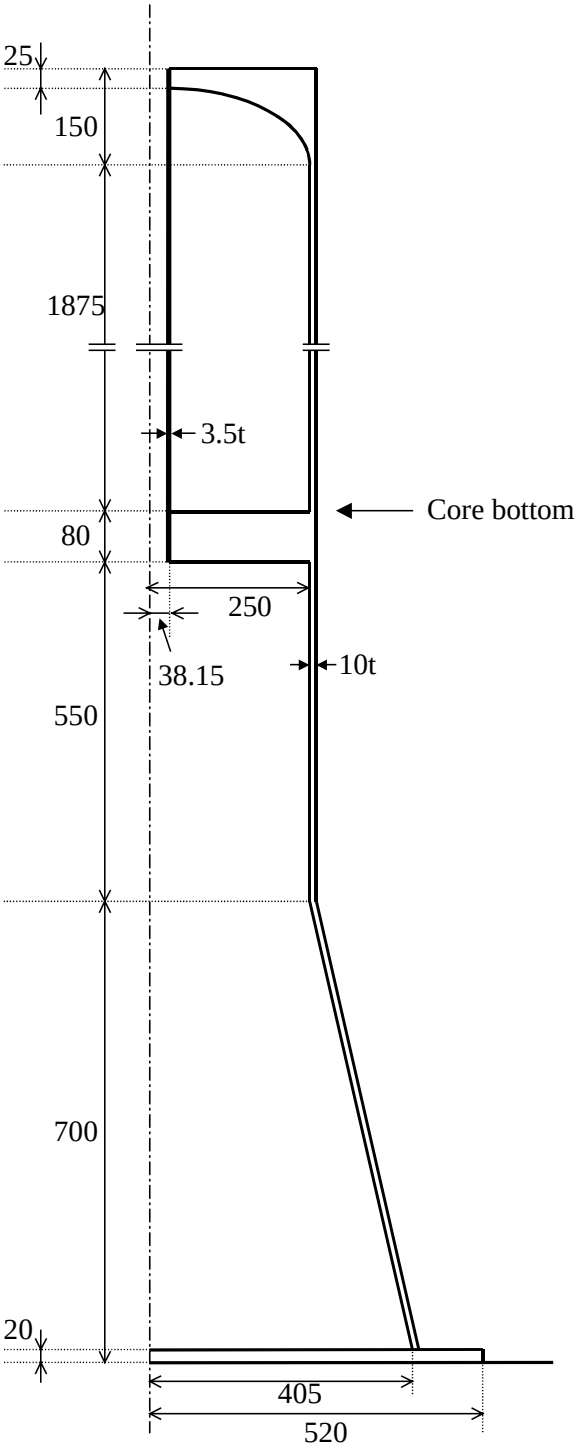


Figure 1: Schematic view of TRACY core tank.

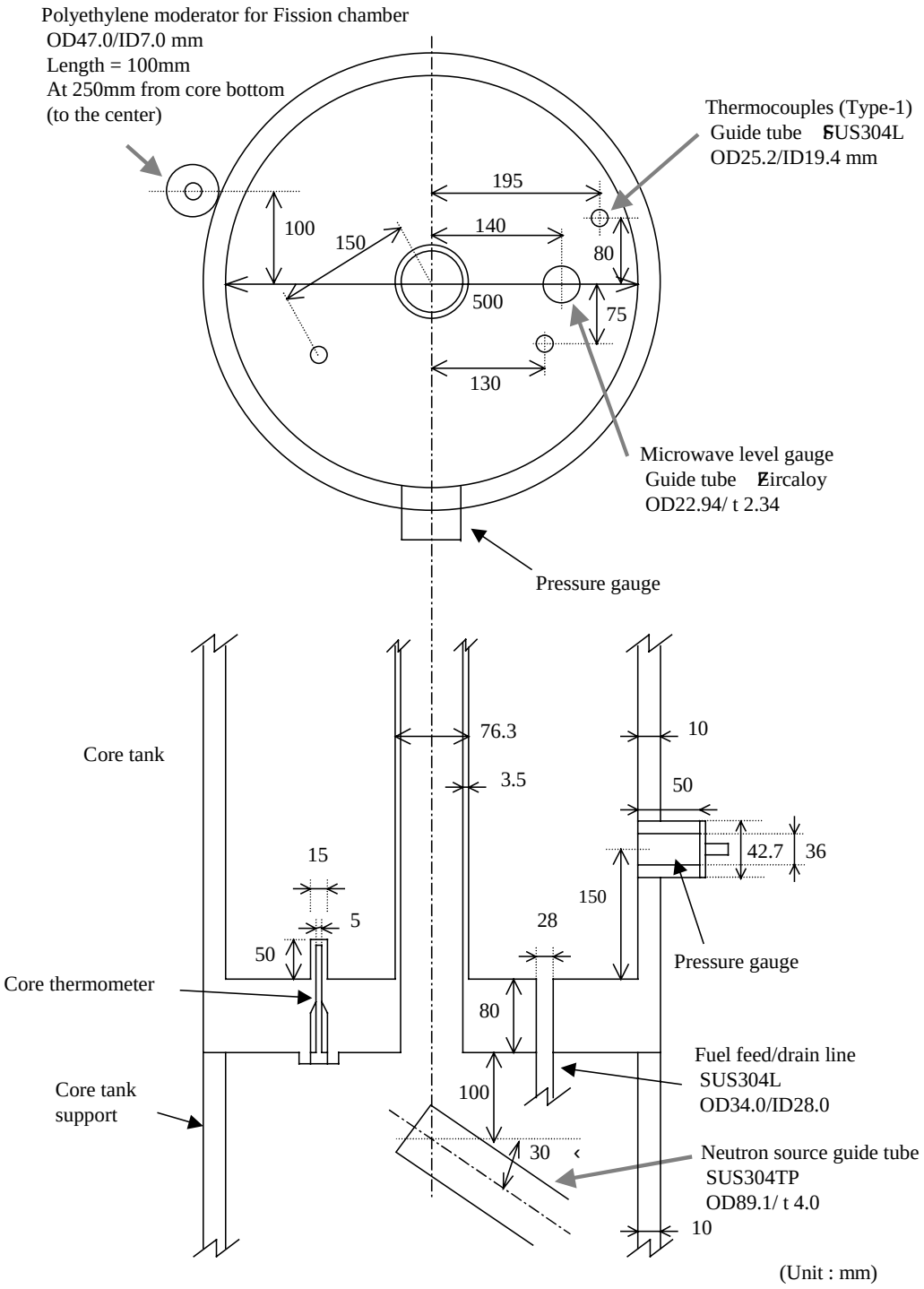


Figure 2: Schematic view of TRACY core tank cross section (detail).

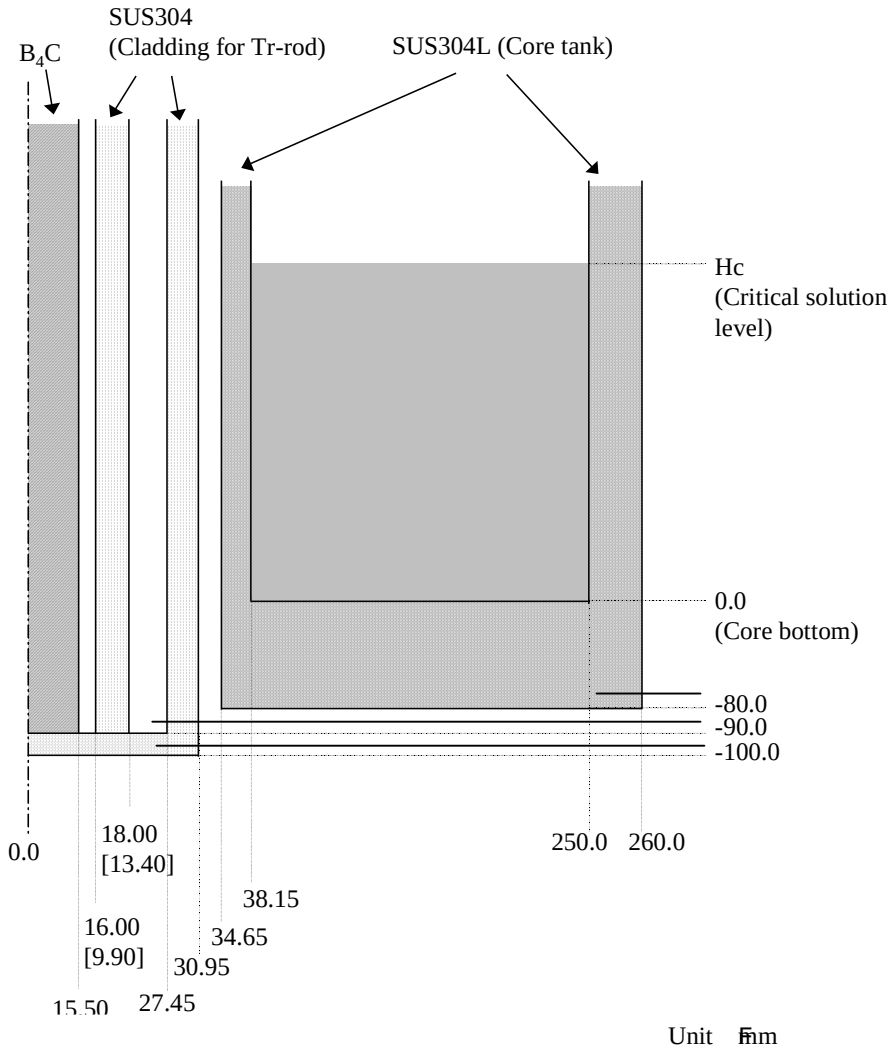


Figure 3: Schematic view of cross section of TRACY core tank and Tr-rod.