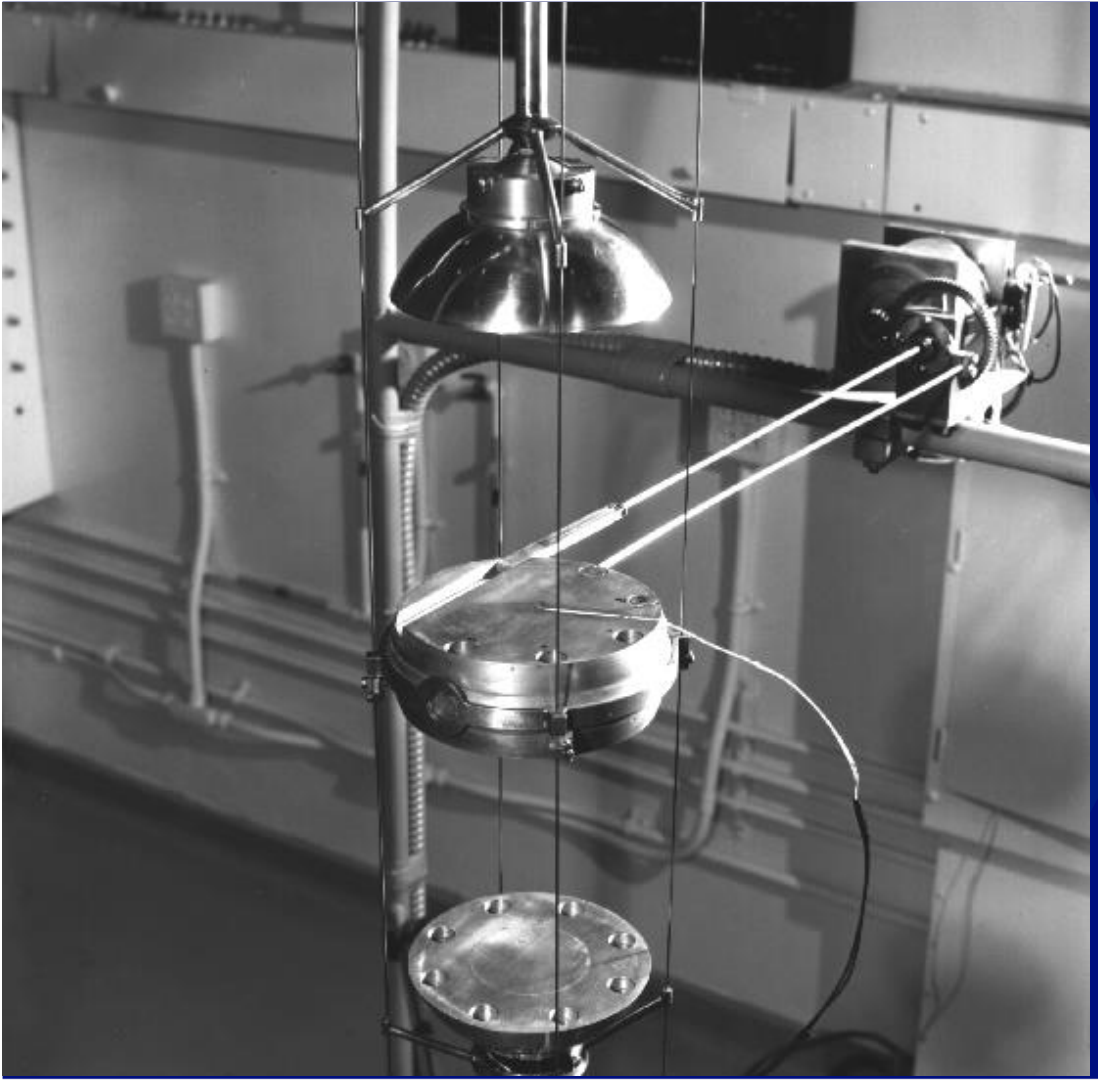


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NCSD Benchmarking Tutorial: Section 1

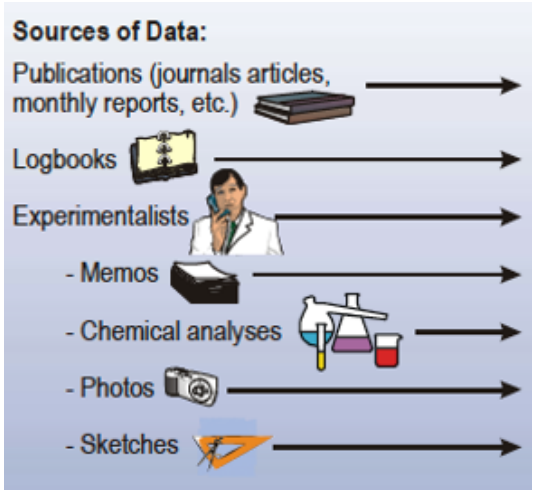
Jesson Hutchinson, Theresa Cutler

Purpose of Section 1

- The purpose of Section 1 is to fully describe the experiment.
- If you were to give only Section 1 to someone, they should have full understanding of
  - What quantity was measured (and what the measured results and uncertainties were)
  - Dimensions of all components used in the experiment
  - Material information of all components used in the experiment

Section 1 is a compilation of information from many sources

- The information can come from any of the sources of data given at the right.
- It should be clear which source a particular datum is coming from.
  - And ideally it is from the original source (units not converted, etc.).
- After the benchmark is published, it should become the primary source document for the experiment.
  - A user/reader should never have to go find those documents.



From crit guide: It is recommended that only experimental data that are taken directly from the references be included in Section 1. However, values derived from experimental data, such as density derived from masses and dimensions, or compositions normalized to 100 wt.%, may be included if clearly noted as derived with the method of derivation given.

Section 1 is NOT an evaluation

- From the crit guide: “In order to clarify the description of the experiment and to not prejudge the evaluation, there should be no mention of
  - models,
  - calculated results,
  - or evaluative statements”

- Given this, all evaluative statements should be saved for Section 2 (see David’s talk next).

Actual experiments versus idealized experiments

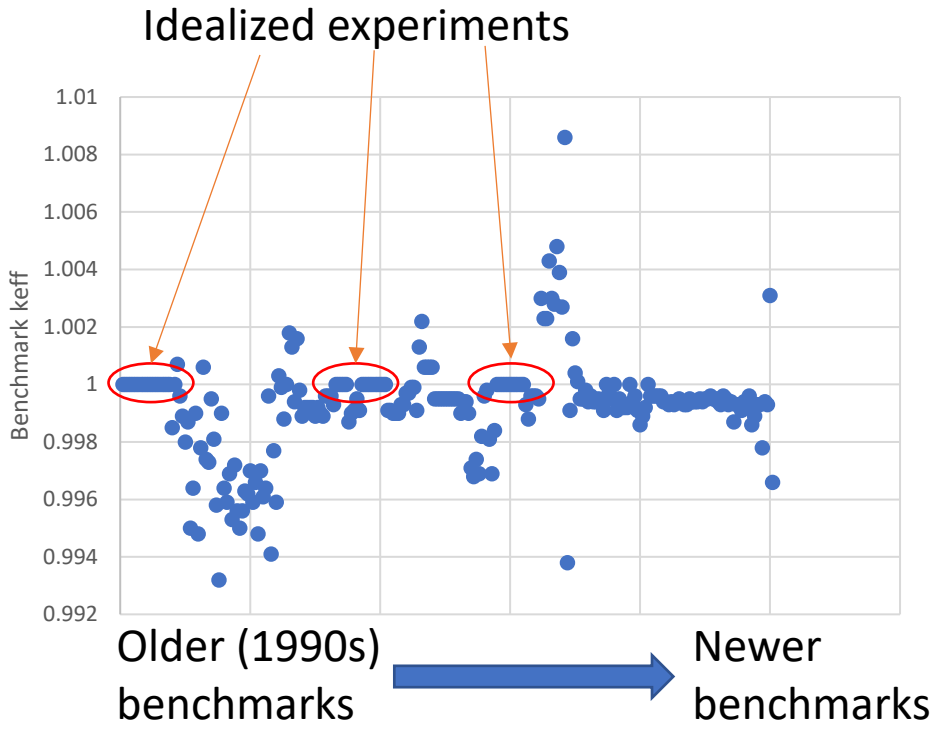
- From the crit guide:

> However, if the exact experimental configuration is unknown (e.g., perhaps it was not reported because it was thought to be too complicated to describe in detail) and an idealization was provided by the experimenters, then the idealized experiment may be described here. Evaluation (Sections 2 and 3.1) of an idealized experiment includes an explanation of the assumptions used in going from the real experimental configuration to the idealization.

- Over time, the judgement of “too complicated to describe in detail” has changed.
- In the early 1990s, most benchmark used idealized experiments.
- Today it is more common to not use idealized experiments.



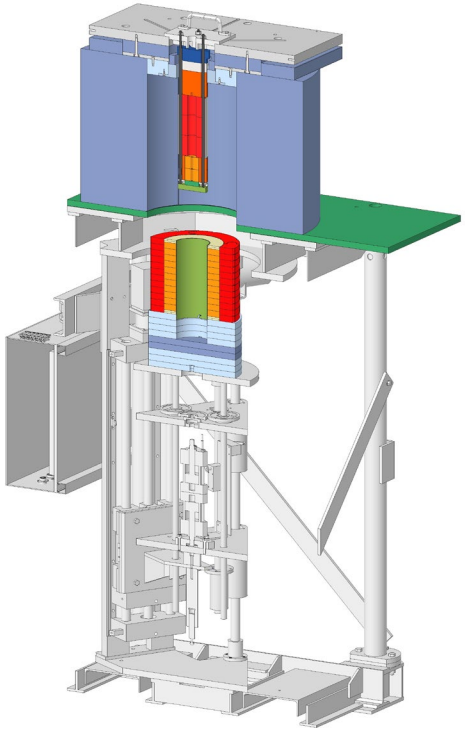
Actual experiments versus idealized experiments



Data from Whisper benchmark suite.

Examples

- If not specified, the example in this (Section 1) presentation is KRUSTY (Kilowatt Reactor Using Stirling TechnologY).
  - HEU-MET-FAST-101.
  - Accepted at the 2020 ICSBEP meeting.
- Other examples mentioned include
  - HMF001, HMF003



Section 1.1

Section 1.1 not only sets the stage for the entire evaluation, but it also documents key information for future preservation.

- Section 1.1 is a general overview of the experiment.
- Things to include:
  - Overview of experiment and experiment objectives
  - **Specific** dates: one bad example from HMF001 → at Los Alamos in the 1950's
  - Names of experimenters: this is important if things are unclear and the evaluators are unavailable to answer questions.
  - Critical assembly machine name and facility.

KRUSTY

1.1 Overview of Experiment

From November 16, 2017 to January 23, 2018, sixty configurations were measured with an HEU(93.1 wt.%)-Mo annulus reflected by beryllium oxide (BeO) on the Comet vertical lift critical assembly machine. These experiments took place at the Nevada National Security Site's (NNSS's) National Criticality Experiments Research Center (NCERC) inside the Device Assembly Facility (DAF). Rene Sanchez, Travis Grove, Jesson Hutchinson, John Bounds, Joetta Goda, Theresa Cutler, George McKenzie, Jessie Walker, David Hayes, and Kenny Valdez of Los Alamos National Laboratory (LANL) performed these measurements during the component critical experiments phase of the Kilopower Reactor Using Stirling Technology (KRUSTY) demonstration.

Section 1.2

- In this section, figures are extremely helpful:
  - Photographs of the experiment, CAD images showing the assembled experiment, configuration figures, detailed drawings, etc.
- Any measurements should list the type of instrument used to make the measurement.
  - Using X model caliper, Y model scale, etc.
  - It is a good practice to include certificates of these instruments in an appendix.
- This section should include ALL necessary dimensions to make a detailed model.
- It should also include all uncertainty information associated with dimensions and position that will be evaluated in Section 2.

Benchmark	# of figures in Section 1
HMF001	2
HMF003	2
HMF009	3
HMF010	2
HMF017	2
HMF101	63

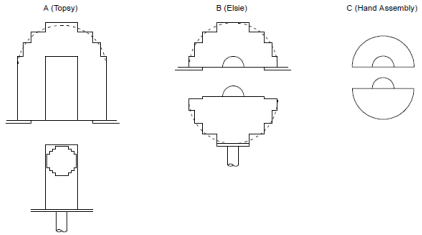


Figure 1. Types of Reflector Assemblies Used in Critical Mass Studies.

Example of a figure that is not detailed enough (from HMF003)

Section 1.2

- This section should also clearly state what was measured (and how it was measured).
  - Approach-to-critical
  - Reactor period
  - Other
- From the crit guide: “The method of determining the critical condition and, if applicable, the method of determining the measured reactivity are stated.”

- This section should also make it very clear what is different between multiple configurations (if applicable).

Section 1.3

- Should include compositional information on all components present in the experiment.
- Masses of each component along with scale used should be given.
- Elemental (and isotopic where applicable) information should be given for each component.
  - Type of analysis used to get this information should be provided.
  - Ideal to also give the Minimum Detectable Amount (MDA) for each element.
  - For components that are less central to the experiment (support components, etc.), whatever information that is known should still be provided (material certs, etc.).
  - Note that most earlier benchmarks didn't even acknowledge the materials of the supporting materials which were clearly present.

	HMF001	HMF101 (fuel only)	HMF101 (all)
# Pages	2	10	20
# Tables	2	13	31

Section 1.4 + 1.5

- Section 1.4 contains temperature information.
  - This should include the type of instrument used for the measurement, the measured values, and information on the uncertainty (which will be used in Section 2).
- Section 1.5 can contain supplemental experiment information. This is optional, so won't be focused on here.

KRUSTY

1.4 Temperature Data

The core temperatures of each configuration are reported in Table 56 along with the uncertainty. The reported temperature measurements are those of a Resistance Temperature Detector (RTD) in contact with the HEU. The temperature data was acquired and recorded using an Allen Bradley Temperature Module 1771-IR. The RTD used had a resolution of 0.1 °C with an uncertainty of ± 3.0 °C. The standard deviation in the temperature while these configurations were assembled was much less than this uncertainty (on the order of 0.1 °C).

Where to find information when writing new benchmarks?

- This depends somewhat if this is a new experiment or a historical experiment, so we will explore both of these.



New experiments

- For new experiments, it should (in theory) be much easier to find all of the needed information for the evaluation.
- And it is even easier if you are planning everything ahead of time for the evaluation (for NCSP experiments, the CED-2, CED-3a, and CED-3b reports should help).
- During experiment design, thought should be placed on experiment uncertainties and documentation.

New experiments

- Drawings will be important for generating the model but also for dimensional uncertainties in Section 2.
  - During the design phase, the sizes of tolerances should be considered, especially for components in which the uncertainty could result in a large uncertainty in keff. Ideally, dimensional measurements can be performed on precision instruments to further reduce dimensional uncertainties.
- For material composition, level of detail will likely depend on component type/location:
  - Fuel will need isotopic and impurities.
  - Reflectors and moderators will need impurities.
  - Structural may or may not need more than provided by material certs from the manufacturer.

New experiments

- During the experiment, the exact configuration should be detailed at all times.

		Core Loading	
Top	Sleeve	Outer	Inner
		B4C: B4C Flange 1	
		SS: SS-2	
		BeO: Top Axial 1	
	Al Sleeve	U: KRUSTY-1 D7XP	
		U: KRUSTY-2 DDND	
		U: KRUSTY-3 DAR2	
Bottom		BeO: Bottom Axial 1	BeO: P1
			BeO: P2

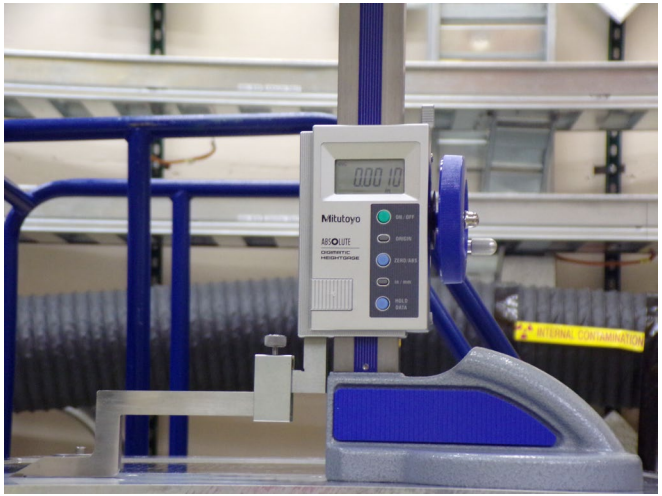
	Radial Reflector	
	Outer Rings	Inner Rings
Top	OSTA (1/8")	ISTA (1/8")
	OTE	ITH
	OTA	ITI
	OTD	ITB
	OTC	ITA
	OK	ITF
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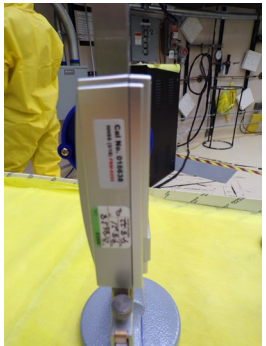
New experiments

- During the experiment, certain position measurements should be conducted.









New experiments

- Logbook should include needed information on the experiment (measured values, assumptions, etc.)
  - Try to make life easier for your future self (or whoever ends up working on the evaluation)
- Photos are very useful for filling in missing details that were not captured elsewhere.
  - Photos are often used to answer discrepancies that arise during the benchmark process. They really are priceless, so the more the better.

Historical experiments

- These generally include a lot more digging for information from original sources.
- Looking through logbooks, drawings, and previous reports.
- Talking to experimenters.
- NCSP Information Preservation has helped with this.



Historical experiments

- One issue of historical experiments is that there will be discrepant information.
  - And this generally gets harder the further back in time you go.
- Going to the source is always best.
  - Other reported values could be calculated using additional assumptions or rounded from initial values.
- But sometimes the source documents don't tell the full story.
  - And the evaluation needs to capture the things that were discovered later in time.

2.2.3 Modifications in Red - Some of the dimensions given in Section 1.2.2 were taken from a drawing[a] originally dated April 1952. The drawing has a change note, dated April 1953, saying "As shown on print (filed) in red." We found an undated full-scale drawing with red pencil mark-ups showing the remachined spherical radius of 2.489 inches (Section 1.2.2); this drawing also has the red-pencil notation "see modification C-6," evidently a reference to the drawing that shows the planned remachining.[b] This drawing, here dubbed "Red Mark-up #1," is almost certainly the one referenced in the April 1953 change note.

However, another undated full-scale drawing with red pencil mark-ups, here dubbed "Red Mark-up #2," was also found. Differences between the original drawing and Red Mark-up #2 are listed in Table 17 along with the dimensions from the as-built drawings[c] of October 1954.

Table 17. Comparison of Original Drawing, "Red Mark-up #2" Drawing, and As-Built Dimensions. (Dimensions in inches)

Feature	Original Drawing	Red Mark-up #2	As-Built Drawing
Spherical radius[(a)]	2.563	2.537	2.563[(b)]
Control rod length	3.715	3.645	Not given
Control rod channel width	0.395	0.400	0.396
M2 height (not including 1/8-inch conic section)	1.360	1.336	1.353/1.351[(c)]
M2 center to bottom plane	0.873	0.871	0.871/Not given[(c)]
Button height	0.245	0.240	Not given
Button hole diameter	0.510	0.515	0.510/0.511[(c)]
Glory hole diameter	0.510	0.515	0.510
Nickel plating thickness	0.004	0.005	Varies

(a) Radius before the remachining of November 1954.
(b) This is the radius given on the as-built drawings, which were made before the remachining of November 1954.
(c) Upper/Lower.

Example from PMF001

Acknowledgements

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