

Multimodal Subcooled Pool Boiling Dataset

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Overview

This dataset contains four single-run subcooled pool-boiling histories acquired on a 10 mm by 10 mm upward-facing oxygen-free copper 101 surface. Each history includes thermal, pressure, DC electrical-power, hydrophone, and high-speed-video records. Acoustic-emission (AE) records are available only for the two higher-load histories. The dataset supports the analysis reported in the companion manuscript, *Coupled Thermal and Acoustic Signatures of Slow Modulation in Microbubble Emission Boiling*.

The experiments were conducted in water at measured mean pressures of 97.28-97.51 kPa. Four embedded T-type thermocouples were used to reconstruct an extrapolated wall temperature and an outward-positive temperature-gradient heat-flux proxy. Hydrophone data were reduced to spectrograms, 0-6 kHz band-integrated voltage-PSD power proxies, and characteristic-frequency metrics. The higher-load histories show sustained thermal oscillations and hydrophone-power modulation. The dataset is an exploratory case series with one operating history per condition, not a replicated parametric power sweep.

Cases and coverage

Dataset folder	Test ID	Nominal electrical load (W)	Mean liquid temperature (degC)	Subcooling (K)	Thermal, pressure, DC power, and hydrophone	AE waveform	High-speed video
A_150W	Boiling-412	150	58.83	40.01	available	not acquired	available
B_180W	Boiling-413	180	52.38	46.46	available	not acquired	available
C_230W	Boiling-416	230	57.27	41.62	available	available	available
D_250W	Boiling-417	250	57.60	41.30	available	available	available

The 150 and 180 W histories are lower-load reference records. The 230 and 250 W histories are the developed oscillatory microbubble-emission-boiling (MEB) histories discussed in the companion manuscript. These classifications are operational descriptions within this dataset. They do not establish a universal MEB threshold or a repeatability estimate.

Directory structure

```
<case>/
  Raw_data/
    Temperature.lvm      Original instrument exports
    Pressure.lvm         LabVIEW temperature record
    DC_power.lvm         LabVIEW pressure record
    Hydrophones.lvm     LabVIEW DC voltage, current, and power record
    AE_Hit.TXT           LabVIEW hydrophone voltage record
    AE_Time.TXT          EasyAE hit table (C and D only)
    *.DTA                EasyAE time table (C and D only)
    *.wfs                EasyAE configuration/export file (C and D only)
    EasyAE waveform file (C and D only)
  Processed_data/
    thermal_timeseries.csv Derived, analysis-ready data products
    critical_events.csv    Thermal reconstruction on the temperature time base
    hydrophone_*.csv       Operational thermal-event markers
    ae_*.csv               Hydrophone PSD-power and characteristic-frequency products
    meb_envelope_*.csv     AE products for C and D only; see AE limitation below
    hysteresis_*.csv/.xlsx Envelope-analysis products
    time_alignment.json    Active-heating and full-history boiling-curve products
    summary.json/.md       Relative alignment information and acquisition-clock metadata
    plots/                 Case-level analysis summary
    Boiling-*.mp4          Rendered diagnostic figures
                           High-speed video export for qualitative inspection
```

<case>/Processed_data/ is the authoritative derived-data location. The duplicate D_250W/Raw_data/Processed_data/ directory is not an additional raw-data source; users should use D_250W/Processed_data/.

Release-level files

The intended release includes `manifest.csv` (file inventory and SHA-256 checksums), `data_dictionary.json` (machine-readable schemas), `timing_reconciliation.csv` (time-base evidence), `event_definition.md`, `processing/`, `calibration/`, `LICENSE`, and `CITATION.cff`. The intended release scope excludes `D_250W/Raw_data/Processed_data/`, which is a duplicate derived-data tree, and interpreter-cache artifacts under `__pycache__/`. `manifest.csv` uses the explicit value `SELF_REFERENTIAL_NOT_APPLICABLE` for its own digest because a file cannot contain a stable hash of itself.

Experimental system and acquisition

The experiments used a pressure-controlled stainless-steel boiling chamber with optical access. The chamber was operated open to atmosphere with condenser controls off for these records. The 10 mm by 10 mm copper surface was heated by cartridge heaters. The liquid column above the surface was approximately 70 mm. Water was degassed by vigorous boiling for one hour before the subcooled test sequence.

Four 0.81 mm diameter T-type thermocouples were installed along the copper centerline. The reduction uses positions $x = [0, 2.54, 5.08, 7.62]$ mm measured from the deepest thermocouple toward the boiling surface and an extrapolated wall location of $x_w = 13.1826$ mm. Temperature was acquired at 3 Hz. The hydrophone was an HTI-96-MIN acquired through an NI-9230 module at approximately 12.8 kHz. AE records for the 230 and 250 W cases were acquired with a MISTRAS R3a sensor and EasyAE/AEWin. High-speed video was recorded with a Phantom VEO 710L camera.

Time bases and synchronization

The temperature record is the reference time base for processed thermal quantities. Each `time_alignment.json` file records relative offsets used during processing. Hydrophone and AE clocks were not independently synchronized to an absolute common clock. The processed files therefore support comparison of each signal history and their independently estimated slow-modulation frequencies. They do not support a claim of absolute thermal-hydrophone, thermal-AE, or video-acoustic phase lag. High-speed videos are supplied for qualitative regime inspection only; their transcoded-video clock was not independently verified against the acquisition clocks.

Processed-data definitions

Thermal reconstruction

`thermal_timeseries.csv` contains the four thermocouple temperatures, extrapolated wall temperature, pressure-interpolated saturation temperature, wall superheat, heat-flux proxy, fit coefficient of determination, and aligned DC power. At each retained time sample, a linear temperature profile is fit as

$$T(x) = a x + b, T_w = a x_w + b, \text{ and } q'' = -k_{Cu} a,$$

where $k_{Cu} = 392 \text{ W m}^{-1} \text{ K}^{-1}$. The sign convention gives positive q'' toward the liquid. This is a one-dimensional, instantaneous temperature-gradient reconstruction; it is not an independent direct wall-temperature or heat-flux measurement. Its limitations during fast transients are described in the companion manuscript.

`critical_events.csv` records operational markers, not universally validated physical transitions. In particular, `dnb_proxy` is the algorithmic sudden-drop marker, `surface_temperature_peak` is the maximum

wall temperature in the specified search window, and `chf_proxy` is a screening marker. A `chf_proxy` must not be interpreted as a confirmed critical heat flux.

Hydrophone products

Hydrophone spectrograms use voltage PSD. `hydrophone_band_integrated_power.csv` integrates the PSD from 0 to 6 kHz and reports a voltage-power proxy in V^2 and dB re V^2 . It is not calibrated acoustic power in watts. `hydrophone_characteristic_frequencies.csv` contains PSD-derived carrier metrics, including peak frequency, spectral centroid, and spectral bandwidth.

`hydrophone_band_power_oscillation_spectrum.csv` describes slow modulation of the band-integrated power.

AE products

Raw AE hit/time tables and WFS waveforms are available only for `c_230w` and `d_250w`. The current AE waveform products were generated using a sparse legacy 0-250 kHz reduction. They are retained as derived products, but the companion manuscript excludes them from the quantitative cross-case comparison because a band-consistent raw replay over the intended analysis band has not yet been completed. The AE plots found in `A_150W/Processed_data/plots/` and `B_180W/Processed_data/plots/` are not associated with available AE waveform data and should not be interpreted or cited.

Envelope and hysteresis products

`meb_envelope_analysis.csv` and `meb_envelope_metrics.csv` report signal envelopes and fitted descriptors. The envelope metrics depend on processing choices and are intended for sensitivity-aware comparison rather than as universal material parameters. `hysteresis_timeseries.csv`, `hysteresis_summary.csv`, `hysteresis_metadata.json`, and `hysteresis_analysis.xlsx` contain active-heating and full-history boiling-curve reductions. Heating samples are identified using positive aligned DC power; cooling samples follow power shutoff.

File formats

Extension	Description	Recommended reader
<code>.lvm</code>	Tab-delimited LabVIEW Measurement file with an instrument header	Text editor, Python, MATLAB, or LabVIEW
<code>.csv</code>	Comma-separated derived table; headers specify variable names and units where available	Spreadsheet software, Python, or MATLAB
<code>.json</code>	Case metadata and relative time-alignment record	Text editor, Python, or MATLAB
<code>.npz</code>	NumPy compressed thermal array	Python/NumPy
<code>.xlsx</code>	Spreadsheet summary and plots	Microsoft Excel or compatible reader
<code>.wfs</code> , <code>.DTA</code> , <code>.TXT</code>	EasyAE/AEWin waveform, configuration, and event exports	EasyAE/AEWin or a validated compatible parser
<code>.mp4</code>	High-speed-video export	Standard video player
<code>.png</code>	Rendered diagnostic plot	Standard image viewer

Companion code and manuscript

The companion analysis repository is <https://github.com/UARK-NED3/BoilingLab>. Cite this dataset using the DOI below. The exact historical code commit and software environment that generated the archived processed products are unavailable. `processing/README.md` pins an inspected BoilingLab source state for reprocessing, but regenerated outputs must be assessed against the released documentation and products rather than assumed identical.

Limitations and responsible use

1. Each load condition is represented by one history. Differences among cases cannot be isolated as power-load effects because liquid subcooling differs and no repeatability series is included.
2. The hydrophone band-integrated quantity is a voltage-PSD proxy, not an absolute acoustic-power calibration.
3. The thermocouple reconstruction assumes instantaneous one-dimensional conduction. It attenuates and delays rapid heat-flux fluctuations relative to a true wall boundary condition.
4. Relative alignment information is available, but the records are not absolutely synchronized across instruments. No phase, event-to-event lag, or causal statement across modalities should be inferred without additional clock registration.
5. The high-speed videos provide qualitative evidence only. They are not released as cycle-resolved, time-registered vapor-field measurements.
6. AE raw waveforms are available only for the 230 and 250 W cases. The current derived AE products are not band-consistent with the intended cross-case analysis.

Citation, license, and acknowledgment

Recommended dataset citation

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