# DESCRIPTION OF DATA FILES FOR AIAA PAW6 - NOZZLE/JET CASE: (Updated April 15, 2024 for NASA TMR)

This folder contains experimental data, with non-dimensionalization as explained below, for the 5 test cases used in the 6th AIAA Propulsion Aerodynamics Workshop (PAW6) – nozzle/jet case. The files are provided in tecplot-compatible format; but hopefully if someone is using a different plotting package, the variable names show what each column's data represents.

NOTE FOR THE NASA TURBULENCE MODELING RESOURCE:

- The **TEMPERATURE MATCHED MACH 1.63 ROUND JET** is Case 5.
- The **HEATED MACH 1.63 ROUND JET** is Case 2.
- The **OFF-DESIGN MACH 1.63 NOZZLE** is Case 4.

Questions may be directed to Nick Georgiadis (Georgiadis@nasa.gov)

There are 8 files for each case, as shown below; with the exception that there is no temperature data provided for Case 5, the temperature matched case. However, there were temperatures measured for this case and are available in the raw data set available with the NASA TM (https://ntrs.nasa.gov/citations/20205007269). The original PAW nozzle case description (PAW6_nozzle_July_1_2022.pdf) is also included in this package.

EXAMPLE OF FILES FOR CASE 1:

**Case1_ucl.dat** = centerline (r/D =0) velocity and related velocity turbulent statistics (9 columns)
**Case1_ull.dat** = lipline (r/D = 0.5) velocity and related velocity turbulent statistics (9 columns)
**Case1_u_radial.dat** = velocity and related velocity turbulent statistics at 6 axial stations (x/D = 0.2, 2, 4, 8, 12,16), starting at the centerline and moving out radially (9 columns).
**Case1_tcl.dat** = centerline (r/D =0) mean static temperature (T) and RMS of temperature (T') (3 columns)
**Case1_tll.dat** = lipline (r/D = 0.5) mean static temperature (T) and RMS of temperature (T') (3 columns)
**Case1_temp_rad.dat** = mean static temperature (T) and RMS of temperature (T') at 5 axial stations (x/D = 2, 4, 8, 12,16), starting at the centerline and moving out radially (5 columns), ; last 2 columns are x/D repeated.
**Case1_ucl_filt.dat** = centerline (r/D =0) velocity and related velocity turbulent statistics (9 columns) – where turbulent statistics are filtered axially over -0.15 < x/D < +0.15. Mean velocity is not filtered.

**Case1_ull_filt.dat** = lipline (r/D = 0.5) velocity and related velocity turbulent statistics (9 columns) – where turbulent statistics are filtered axially over $-0.15 < x/D < +0.15$. Mean velocity is not filtered.

The first two files (Case1_ucl_.dat, Case1_ull.dat) and last two files (Case1_ucl_filt.dat, Case1_ull_filt.dat) are very similar, respectively, except for a short range filtering of the turbulent statistics.

The "**Case1_u_radial.dat" file (and same for all 5 cases) is different than supplied just before the 2023 AIAA PAW. The current data uses the "underside" of streamwise PIV plane to avoid the turbulent stress noise at the top of the profiles that is evident for some of the profiles for the "topside" of the streamwise plane. Data in the jet mixing layer is very nearly the same for both topside and underside profiles, so if the "noise" away from the jet in the previously supplied files doesn't bother you, you can use the older data sets.**

The jet velocities, and related turbulent statistics are normalized by each case's ideal exit velocity (Uj); note that these are different for the measured experimental data in comparison to the computations, which is primarily due to local ambient conditions varying during the course of the tests. The ideal jet velocity for the computations should be based on the suggested NPR, total temperature, and reference ambient conditions in the table provided in the workshop document, which is also in this folder.

For the streamwise PIV that was used to construct these data files, the w-component of velocity was not measured. For purposes of computing turbulent kinetic energy (k) we have made the assumption that ww = 3/2 vv. This is based on examination of other compressible mixing layer data sets, most recently that of Kim, et al. (AIAA J., Vol. 58, No. 1, 2019, p. 133 ).

Temperatures are normalized by the difference in temperature between the jet's exit and ambient static temperature. Again, this varied from day to day during individual runs. For the computations, this was suggested to be a constant value equal to 233 K.

If someone wishes to "dimensionalize" the experimental/or computational data (based on conditions provided in the case document), the table below shows the fully expanded jet velocities for each case – please read the note below for the special situation of Case 4.

| | Experimental U-jet (m/s) | Computational U-jet (m/s) |
|---|---|---|
| Case 1 | 600.0 | 622.9 |
| Case 2 | 745.0 | 746.6 |
| Case 3 | 930.0 | 916.0 |

| | | |
|---|---|---|
| Case 4 | 580.0* | 594.0* |
| Case 5 | 543.5 | 555.2 |

*For Case 4, the NPR and Tt would yield a perfectly expanded jet velocity of 622.9 m/s, equal to that of Case 1. However, computations indicate a normal shock (from the centerline outward a small radial distance) early in the jet exhaust which reduces the jet total pressure, and results in a modified "perfectly expanded velocity" of 594.0 m/s for expected computations. This number is used by workshop organizers to normalize computational velocities for Case 4 so that the velocity oscillations are centered about a "u/Ujet =1" line using this jet velocity. The measurements used a modified post-shock reference jet velocity of 580.0 m/s.

While this normal shock effect would also occur for temperatures, for purposes of the workshop and these data sets, we did not make an equivalent adjustment to temperature data, such that temperatures are still normalized using "(T – Tamb)/(Delta_T)" where Tamb, T, and Delta_T all use values consistent with pre-shock values. Very simply, if someone wishes to dimensionalize the experimental data to be comparable to dimensional computational temperatures, please use Delta_T = 233 K for all 5 cases, including Case 4.

If you'd like to see more discussion of this and more details of the experimental findings, please see the following reports. Let me know if you do not have access to them, and I can email them to you.


1. Georgiadis, N.J., Wernet, M. P., Locke, R. J., and Eck, D. G., "Mach Number and Heating Effects on Turbulent Supersonic Jets," ***AIAA Journal***, Vol. 62, No. 1, Jan. 2024, pp. 31-51.
2. Wernet, M. P., Georgiadis, N. J., and Locke, R. J., "Velocity, Temperature, and Density Measurements in Supersonic Jets," AIAA 2021-0596 and NASA TM 20205007269, Jan. 2021.
3. Wernet, M. P., Georgiadis, N. J., and Locke, R. J., "Raman Temperature and Density Measurements in Supersonic Jets," ***Experiments In Fluids***, Vol. 62, No. 3, 2021, pp. 1-21.