HVAB Data Use Recommendations

Version History

9/28/23	Initial Release
11/6/23	Changed document title. Described kulite location errors in HVAB blade TM.
9/24/24	v2: Update Table 1 to include PIV data and correct typos. Update recommended data assumptions.

This document provides recommended combinations of data points from the HVAB hover test to use during analysis validation, as well as identifying other items to consider when performing the comparisons.

Recommended Data for Analysis Validation

As described in the general information readme file ("HVAB General Information Readme_v2.pdf"), and shown in Table 1, the HVAB test acquired research-quality hover performance data for two configurations: standard blades with natural transition (Runs 44, 46, 48, 50, 52, 54, 92, 95) and standard blades with forced transition (Runs 59, 61, 63, 65).

Table 1. Test Configurations and Conditions

Performance (P), Photogrammetry (PG), Thermography (TG), Shadowgraphy (SG), Airloads (A), PIV (PIV)

Configuration	M_{tip} or RPM	Run Numbers	Collective	Key Measurements	Primary Objective
Standard blades, natural transition	1160 RPM	36	4, 6, 8, 10, 12	P, PG	Blade deformation
	1250 RPM	30, 36	4, 6, 8, 10, 12, 13, 14		
	1310 RPM	34	4, 6, 8, 10, 12, 14		
	0.600	46	4 to 15, 1 deg incr	P, TG	Performance and transition
	0.650	44	4 to 15, 1 deg incr		
	0.675	48	4 to 14, 1 deg incr		
	0.600	54	8, 10, 12, 14	P, TG, SG	Performance, transition, and wake geometry
	0.650	50	8, 10, 12, 14		
	0.675	52	8, 10, 12, 14		
	0.650	92, 95	8, 10, 12, 14	P, PIV	Performance and PIV
Standard blades, forced transition	0.600	61	4 to 15, 1 deg incr	P, TG	Performance and transition - fully tripped
	0.650	59	4 to 15, 1 deg incr		
	0.675	63	4 to 14, 1 deg incr		
	0.600	65	10, 12, 14	P, TG	Performance and transition – tripped lower surface only
	0.650	65	4, 6, 8, 10, 12, 14		
	0.675	65	10, 12, 14		

Pressure blade	0.600	72	4 to 12, 1 deg incr	P, TG, A	Blade Airloads
	0.650	77	4, 6, 8, 10, 11, 12, 13		

Although performance data were also acquired during the photogrammetry (Runs 30, 34, 36) and pressure blade runs (Runs 72, 77), the rotor torque measurements for these runs were somewhat compromised and are not recommended for analysis validation. (Photogrammetry runs had a large number of retroreflective targets on the lower surface; pressure blade runs showed some flow interactions with the pressure transducers as well as other effects.) The resultant torque/drag differences are assumed to have minimal effects on the blade deformation or blade pressures/airloads, however, and thus these data should be combinable with research-quality performance and transition data from the other runs.

As shown in Table 1, there were no runs/data points for which all key research data were acquired simultaneously (runs 50-54 had the most simultaneous data). To help with analysis validation, the experimental team has identified combinations of data/data points which are most consistent with the research-quality performance data described above. These recommendations are provided in the file “Data Recommendations_v2.xlsx”.

The following assumptions were made when developing these recommendations:

1) Blade deformations and pressures were not significantly affected by the extra drag/torque associated with retroreflective targets, pressure transducers, or blade contamination.
2) The differences in atmospheric conditions between runs did not significantly affect the key measurements provided. In particular, it was assumed that blade deformations, pressures, wake geometry, and tip vortex properties were minimally affected by small variations in test condition.

Other Items to Consider

Other items to consider when performing comparisons with the provided data:

1) The thermography data show differences between blades, especially on the lower surface at lower collectives. In particular, there are turbulent wedges seen at different locations on each blade (possibly due to leading edge contaminants). Care should be taken when comparing with these results.
2) The thermography data for the forced transition runs clearly show fully tripped flow on all blade surfaces for all conditions. It should be noted, however, that the measured transition locations were somewhat downstream of the trip dot locations (x/c=0.10 vs x/c=0.05).
3) The blade lag measurements are inconsistent at lower collective settings. This is possibly due to the high lag damping.
4) The collective values were set using the rotor control console (based on a linear calibration of a single blade). These settings were nominally correct but can differ from the average blade pitch measurements (average of all 4 blades) by up to 0.3 deg (the blade pitch readings are lower). (Differences between individual blades are larger; this

was expected since the pitch links were adjusted during blade tracking). This may (or may not) affect how analysts ultimately compare with the data.

5) The individual blades are identified by their serial numbers in the thermography and photogrammetry data results but are identified by their blade number for other results (i.e. root pitch, etc.). The relationships for most of the data runs are as follows: Blade 1 (SN005), Blade 2 (SN002), Blade 3 (SN003), Blade 4 (SN001).
6) There are a few errors in the NASA TM describing the HVAB blades (Overmeyer, A. D., Copp, P. A., and Schaeffler, N. W., "Hover Validation and Acoustic Baseline Blade Set Definition," NASA TM-2020-5002153, May 2020.)
    a. In Section 4, the shear center, center of gravity, and tension center are reported relative to the blade coordinate system and NOT relative to the local airfoil coordinate system.
    b. The units of chord inertia on page iv and in Tables 20, 21, 23 and 24 are lbf s^2, not lbf s^2 in^2 or lbf s^2 in.
    c. Tables 4-14 have incorrect values for the as-designed kulite locations, both for the global and local coordinate system. Updated/corrected location information can be found in the Blade Pressure readme file located in the Pressure and Airloads Data portion of this website.