NASA Force Balance Cryogenic Calibration Procedure
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Purpose
To ensure the proper Cryogenic Calibration of a Force Balance to generate the Thermal Gradient Correction Factors (TGCF) and Unloaded Zeroes for NTF Tunnel use.

Scope
This work instruction applies to the Cryogenic Calibration of Force Balances.

Responsibilities
The balance engineer and calibration technician are responsible for implementing the steps in this procedure. The NASA balance engineer is responsible for defining any additional requirements not included in this procedure.

Safety
All participating personnel shall be cognizant of and follow all cryogenic safety procedures during all phases of work to be completed as part of this procedure.

Work Instructions

1. Review with MM&T engineer all cryogenic calibration requirements including loads, wiring, voltage, etc. NASA shall provide a maximum temperature differential prior to the start of the balance room/cryogenic calibration, and the Contractor is responsible for ensuring that this differential is not exceeded at anytime during the loading processes.

2. Prepare necessary forms (MM&T form No.'s) from the following list to document required loads

    1. SGAG Calibration Work Sheet (Form No. M0308)
    2. Bridge Resistance Checks (Form No. M0307)
    3. Strain Gage Balance Loadings (Form No. M0310)

3. Assemble all hardware necessary to perform the cryogenic calibration including:

    a. Cryogenic capable calibration stand
    b. Aluminum heater jacket
    c. Resistance heaters
    d. Cryogenic instrument console, which includes:
        i. Oscilloscope
        ii. Heater control circuits
        iii. Resistance heater control circuitry
        iv. Temperature readouts

v. Electronic cryogenic level heater control circuitry
vi. Room temperature monitor & readout

e. Cryogenic calibration fixture
f. Cryogenic stump adapter
g. Hardware required to secure cryogenic stump in calibration stand (threaded pipe, washer(s) and nut)
h. Stainless steel LN2 hoses (4)
i. Cryogenic fittings required to connect LN2 hoses to the cryogenic fixture and stump
j. Cryogenic pitch/yaw, roll yoke
k. Pitch & roll arms
l. NF, AF, SF, PM, RM hangers & knife edges
m. Room temperature round one-inch bubble level
n. Electronic cryogenic level w/brass shims
o. Data acquisition system (DAS)
p. Gaseous nitrogen bottle (approximately 2500 psi) & flow regulator
q. Tubing to make required connections between gas bottle and balance
r. Calibrated weights

4. Verify that all weights, levels, and data system have current calibrations.

5. Installation of balance in cryogenic calibration fixture is to be done by MM&T machine shop personnel.

6. Mount cryogenic stump in 20K capacity calibration stand.

7. Install aluminum heater jacket around calibration stand stump.

8. Connect the 4 stainless steel hoses in the following configuration: 2 to the inlet and 2 to the outlet of the LN2 manifold in the calibration stand.

9. Mount regulator with hose on gaseous nitrogen bottle. Use full bottle only (approximately 2500 psi).

10. Connect PRT wires from calibration stand stump into the back of the cryogenic Instrument console into the Minco Model: CT137 temperature controllers.

11. Check resistance and resistance to ground of balance bridges and record values on the “Bridge Resistance Checks” form.

12. Mount the balance in the calibration stand (usually this is done in the +NF position to correspond with the position for final, "after calibration", electrical zeros taken at the end of the calibration) and connect the balance cable to the data acquisition system. Set the proper voltage before turning on power to the balance. Verify that the voltage indicated on the meter corresponds with voltage displayed in the calibration data system software.

13. Level the balance with bubble level located in its proper position and record the initial, "before calibration", electrical zeros of all bridges.

14. Install all calibration hardware including: Pitch/Roll/Normal force cryogenic yoke, NF hanger with knife edges, pitch and roll arms with hangers and knife edges, and connect all stainless steel cryogenic hoses.

15. Re-level fixture with bubble level, then remove level.

16. Install electronic cryogenic level with brass shims, turn on all instruments in instrument console and adjust/zero electronic level readout and record balance electric zeros.

17. Perform required room temperature loads (+NF, ±PM, and ±RM) recording all data and printing hard copies of each load.

18. Open new "Apparent Strain/Temp" file on the DAS and record data for at least five minutes at room temperature, before step 19. Leave record ON until current cryogenic calibration is completed.

19. Open outside LN2 tank main valve (key required to access tank).

20. Open inside LN2 valve 75% to 100% to begin balance cool down.

21. Balance engineer shall monitor the balance PRTs during the initial cool down period. If the balance temperature differentials exceed a certain limit (limit to be defined by the NASA balance engineer before start of calibration – limit dependent on balance type and size), the cryogenic flow rate must be adjusted. To adjust the flow rate of LN2, use the inside LN2 valve and if conditions continue to warrant, the LN2 tank main valve to maintain the balance temperature differentials indicated by the balance PRTs, soaking the balance PRTs to equalize. Multiple adjustments might be necessary in order to remain under the maximum temperature differential across the balance.

22. Uniform cryogenic temperature will occur approximately 30 minutes after all balance PRTs have leveled out based on the DAS readings. When uniform cryogenic temperatures are achieved, load +NF, ±PM, and ±RM at cryogenic temperature.

23. After the cryogenic loads are completed, SAVE the cool down data file. Close the inside LN2 valve and then close the main valve on the outside LN2 tank (access key required). Open a new "Apparent Strain/Temp" file on the DAS to record the balance temperatures during warm up. Balance warm up occurs overnight, using ambient room temperature. SAVE the warm up file the next morning.

24. Locate drip pan(s) under all frost covered calibration hardware.

25. Open valve on gaseous nitrogen bottle, set purge flow at 18psi.

26. Remove electronic cryogenic level from on top of the balance. Brush off the frost from balance, hoses, etc.

27. Allow balance to return to room temperature overnight.

28. The following morning, level balance with bubble level and record electrical zeros. Remember to SAVE the warm up file.

29. The balance engineer shall acquire and analyze the recorded cryogenic/room Strain/Temp data, as well as, the LOAD data. The balance engineer shall APPROVE the Data before changing the balance to the next load position. Remove all calibration hardware (hangers, arms, and Pitch/Roll yoke, etc.). Re-level bare balance fixture and record electrical zeros.

30. Rotate balance to the next loading position (usually -NF, +SF, -SF or +AF) in calibration stand.

31. Repeat steps (9) thru (30) above. Repeat until all seventeen primary room temperature and cryogenic loads are completed.

32. Balance engineer will process calibration data and determine if reloads are required. Additional loads, if necessary, shall be completed. If none are required, proceed to step (33).

33. Install balance in calibration stand in the same position that was used when recording the "before calibration" electric zeros and record the "after calibration" electrical zeros. Document electrical zero data.

34. After calibration data is finalized, and approved by the NASA balance engineer, remove the balance from calibration stand and deliver it to MM&T machine shop personnel for fixture removal.

35. At the completion of the loadings the balance engineer shall provide the NASA balance engineer with all data files (raw data files, processed data files, cool down and warm up temperature data files, etc) for review and storage in the NASA files.