



Reactivating Air Stations at the 14-by 22-Foot Subsonic Tunnel

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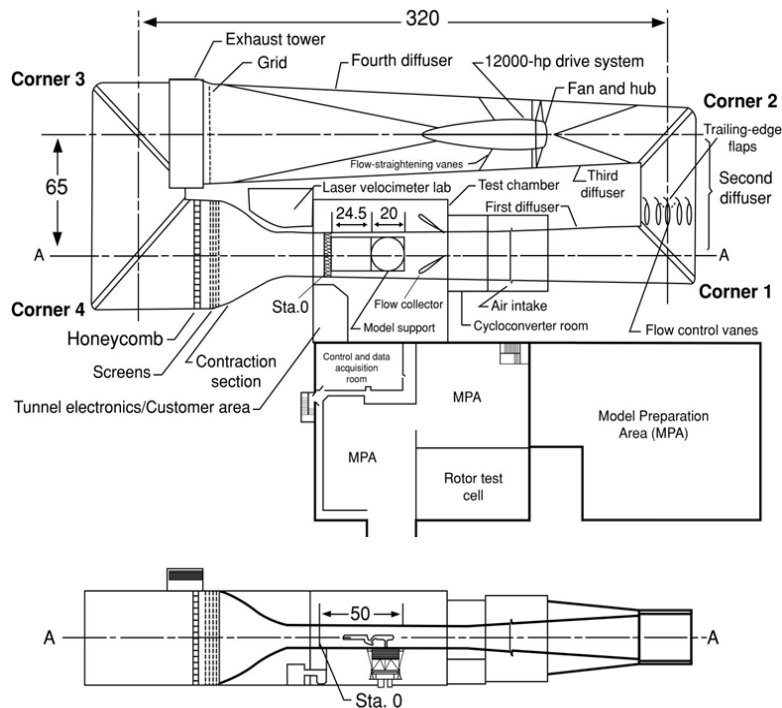
**Subject Category: Research and Support Facilities, Wind Tunnels
Key Words: Air Station**

Agenda

- **14x22 Description**
- **Overview of HPA Capabilities**
- **Timeline of Events**
- **Challenges of Reactivation**
- **Future Work**
- **Key Takeaways**

14x22 Description

Test Section	14.5 x 21.75 x 50 Feet (4.4 x 6.6 x 15.2 meters)	
	Closed Jet	Open Jet
Speed	348 ft/sec (106 m/sec)	275 ft/sec (84 m/sec)
Reynolds No. Max	2.2×10^6 / ft (7.2×10^6 / m)	1.7×10^6 / ft (5.6×10^6 / m)



Schematic of 14-by 22-Foot Tunnel (dimensions in feet)



14-by 22-Foot Subsonic Tunnel

Overview of HPA Capabilities

- **14x22 Capabilities**
 - 7 Air Stations at facility
 - Provide low and high pressure air supply up to 5000 psi (3.45×10^7 Pa)
- **Potential 14x22 Uses**
 - Propulsion simulation
 - Tethered free flight
 - Augmented lifting simulation

Tethered Free
Flight using HPA



Propulsion
Simulation

Overview of HPA Capabilities

- **High Pressure Air (HPA) Supply**
 - Supplied from a centralized compressor station
 - Provides up to 5000 psi (3.45×10^7 Pa) supply air
 - Stored in bottle fields on center
 - Center can store up to 1.6×10^6 lbs (7.1×10^6 N) of HPA
 - Processed through dryer to remove oil and moisture
 - Nominal dew point is -80°F (211 K)
 - Distributed to facilities through miles of piping



Center Bottle field

Overview of HPA Capabilities

- **Air Station #1**
 - Provides air to test section
 - Designed for propulsion simulation
 - High Flow Leg
 - Flow Rate: 12 lbs/sec (5.44 kg/sec) to 30 lbs/sec (13.61 kg/sec)
 - 1800 psig (1.24×10^7 Pa) to 5000 psig (3.45×10^7 Pa)
 - Low Flow Leg
 - Flow Rate: 0 lbs/sec (0 kg/sec) to 12 lbs/sec (5.44 kg/sec)
 - 100 psig (6.89×10^5 Pa) to 1800 psig (1.24×10^7 Pa)
 - 5 Micron Filter
 - Steam heaters provide up to 200°F (366 K) air
 - Automated Control System in LabView
 - Previously used in 2007, but reactivated in 2018



Air Station #1

Overview of HPA Capabilities

- **Air Reducing Station**
 - Provides air to test section
 - Reduce from 5000 psig (3.45×10^7 Pa) to 500 psig (3.45×10^6 Pa)
 - Up to 3.5 lbs/sec (1.59 kg/sec)
- **Air Station #2**
 - Provides air to Model Preparation Area (MPA) for model buildup and checkout
 - Up to 1800 psig (1.24×10^7 Pa) and 10 lbs/sec (4.54 kg/sec)
 - Reactivated in 2018 in preparation for Common Research Model (CRM) buildup, but not used
- **Other Air Stations (4, 5, 6, and 7)**
 - Provide air for flight dynamics models, including tethered free-flight



Air Reducing Station



Air Station #2 (Model Preparation Area)

Timeline of Events

- **Air Station #1 Inspection in 2016**
 - During a routine inspection, numerous items were identified as unacceptable
 - 4 unacceptable welds
 - Deteriorating insulation, broken pressure transducers, etc.
 - Air Station #1 placed in a decommissioned status
 - As of 2016, no planned use in the near future and no funding for repairs
- **Air Station #2 Reactivation**
 - Planned use of Air Station #2 in MPA
 - Planned buildup in MPA in June 2018 for CRM model
 - Months of effort to reactivate Air Station #2
 - Due to CRM model fabrication delays, model buildup began in August 2017 in the test section
 - Air Station #2 not used for CRM model checkout
 - Switched efforts to complete checkout of Air Reducing Station for air supply in the test section for CRM test

Timeline of Events

- **Air Reducing Station Preparations**
 - Due to model complexities of the CRM, buildup in the test section lasted three months beginning August 2018
 - Wind-on testing began late October 2018
 - Flow rates from reducing station not as high as anticipated
 - An investigation led to a discovery that what was believed to be a 2-inch (50.8-mm) valve was actually a 1-inch (25.4-mm) valve
 - Valve appeared to be 2 inches (50.8 mm) and documentation insufficient to prove otherwise
 - Options to achieve desired flow rate
 - Valve replacement at a significant cost
 - Reactivate Air Station #1

Timeline of Events

- **Air Station #1 Reactivation**
 - Customer and facility agreed that a higher flow rate was needed
 - Began repairs to air station
 - Repaired 4 rejected welds
 - Replaced broken pressure transducers
 - Installed additional supports, etc.
 - Completed a blow down and functional checkout
 - Performed all tasks in 2 weeks!
 - Due to quick response, customers were able to complete CRM test objectives

Challenges

- **Incomplete Documentation**
 - Air reducing station drawings not detailed
 - Maximum flow rate unknown prior to buildup
- **Air Outage**
 - Double block and bleed isolation required to safely perform maintenance
 - Due to shared piping across the center, the air outage to repair welds impacted other facilities
- **Specialized Welders Required**
 - Welders were on center performing another task
 - Able to pause task to repair welds on the 14x22 air station
 - Due to overwhelming support from center and quick response from the welders, the repairs were made and inspected less than a week after the request was made
- **Spare Parts**
 - Parts for air station #1 were scavenged from across the field

Lessons Learned

- **Maintain air stations if possible**
- **Provide a better standby state**
 - Option 1: Install check valves to prevent moisture and debris in the system
 - Option 2: Slightly pressurize system with inert gas to prevent contamination and internal corrosion
- **Cycle valves quarterly**
 - Slows aging process of the system
 - Enables operators to remain familiar with system

Future Work

- **Currently preparing to complete Return-to-Service tasks for Air Station #2**
- **Updating documentation on air reduction station**
- **Design and build an air station cart to supply controlled low-flow and heated air to test section**
- **Reviewing tasks to improve functionality of Air Station #1**
 - Upgrade transducers and transmitters
 - Upgrade software to improve tuning of regulators
- **Provide shelter for air stations to prevent weathering**

Key Takeaways

- **Verify drawings when new equipment arrives**
- **If possible, provide shelter for air stations to protect from weather**
- **Ensure air stations receive proper maintenance**
- **Cycle valves periodically**
 - Keeps seals lubricated to prevent cracking
 - Maintains operators' familiarity with system
- **If left in an idle state, slightly pressurize system with inert gas**
 - Prevents debris and moisture from contaminating system
- **Purchase spare critical parts**