B-737 GBI Testing

Measurement of Oxygen Concentration in a Boeing 737 Center Wing Fuel Tank During Ground and Flight Testing

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B-737 GBI Testing

Outline

- Background
- System Description
- Other Instrumentation
- Test Data
- Summary

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Background

- FAA is Seeking to Improve Upon Existing Fuel Tank Safety in Fleet in the wake of TWA800 Air Disaster
- 1998 ARAC FTHWG Stated GBI is a Potentially Cost-Effective Method of Providing Fuel Tank Protection
  - Report Also States CWTs More Susceptible to Mishaps
- Focus of the testing is to determine if the Existing Fleet Vented Fuel Tanks Will Maintain NEA Benefit for a Significant Amount of Time
  - Some CWTs in Fleet are Cross Vented
- Also Attempted to Gage Practicality

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Equipment Description

- Two 4 Channel Continuous Flow Sampling Systems
- Ability to Sample From the Tank or Calibration Gas
- Absolute Pressure Controllers (Inlet and Return)
  Maintain Constant Atmosphere On O2 Sensor Membrane
- Galvanic Fuel Cell type Oxygen Sensor - Oxygen Diffuses into the Sensor and Reacts Chemically at the Sensing Electrode to Produce an Electrical Current Output Proportional to the Oxygen Concentration in the Gas.
- Explosion-Proof Diaphragm Pumps - Two in Series

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Theory of Operation

- Sample Gas Enters Through Flash Arrestors
- Regulated to a Value Lower Than Anticipated Pressure Altitude - Approximately 3 psia
- Two Stages of Pumping
- Condensation Trap - With Draining Capabilities
- Needle Valve and Flow Meter - (Set to 2 SCFH)
- Flow Through Oxygen Sensors Remote From Analyzer
- Sample Gas Returns to the Tank Through the Outlet Pressure Controller - Approximately 16 psia
- Analyzer Output Wired to Boeing DAS

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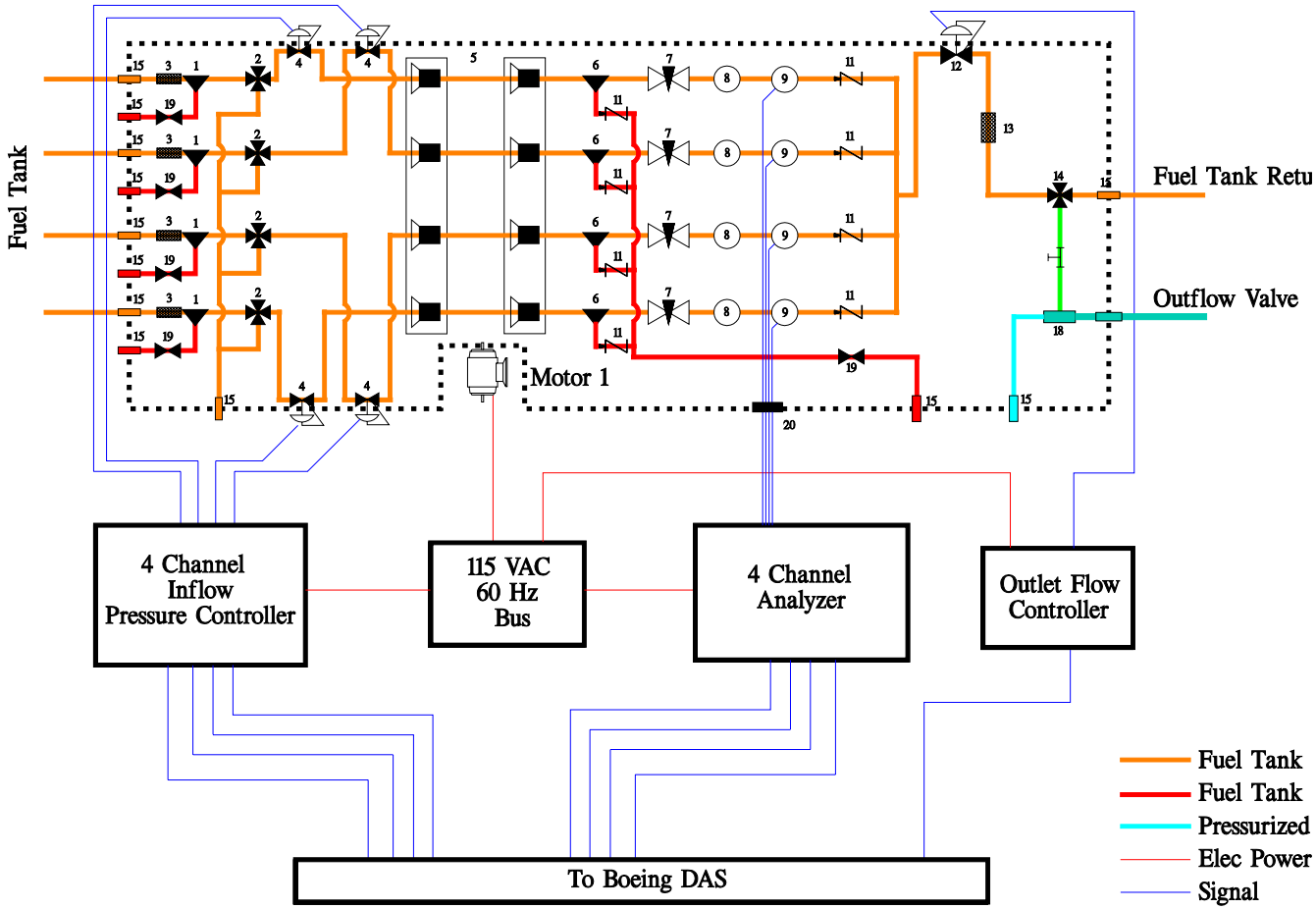
System Block Diagram



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Safety Features

- Redundant Float Valves - With Positive Shut Off Features
- Redundant Flash Arrestors - Sample Inlet as well as Return
- Ability to Secure Each Sample Port Independently
- Explosion Proof Diaphragm Pumps
- Explosion Proof Electrical Motor
- Upgraded Stainless Steel Oxygen Sensor Housing
- Shrouded Box With Continuous Purging - Ejector on Ground, Delta P In Flight
- Shrouded Sample Lines - Clear tubing for inspection
- FMECA/Fault Tree Analysis Performed By FAA

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Calibration and Operation

- 1 hour warm up time
- Select 16.0% Oxygen Calibration Gas
- Divert Sample Return Port Overboard
- Each Analyzer Set to Display the 16.0% Oxygen Value
- Return Sample Train to the Original Configuration

- Hands Free Operation - Monitor All Channels

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Additional Instrumentation

- Weather Conditions
- All Flight Parameter Information From the Aircraft Data Bus such as:
  - Fuel Quantity
  - Airspeed
  - Altitude
  - Pitch / Roll
  - Heading
- Ullage Temperatures With In the Fuel Tank

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Sample Port Location Diagram

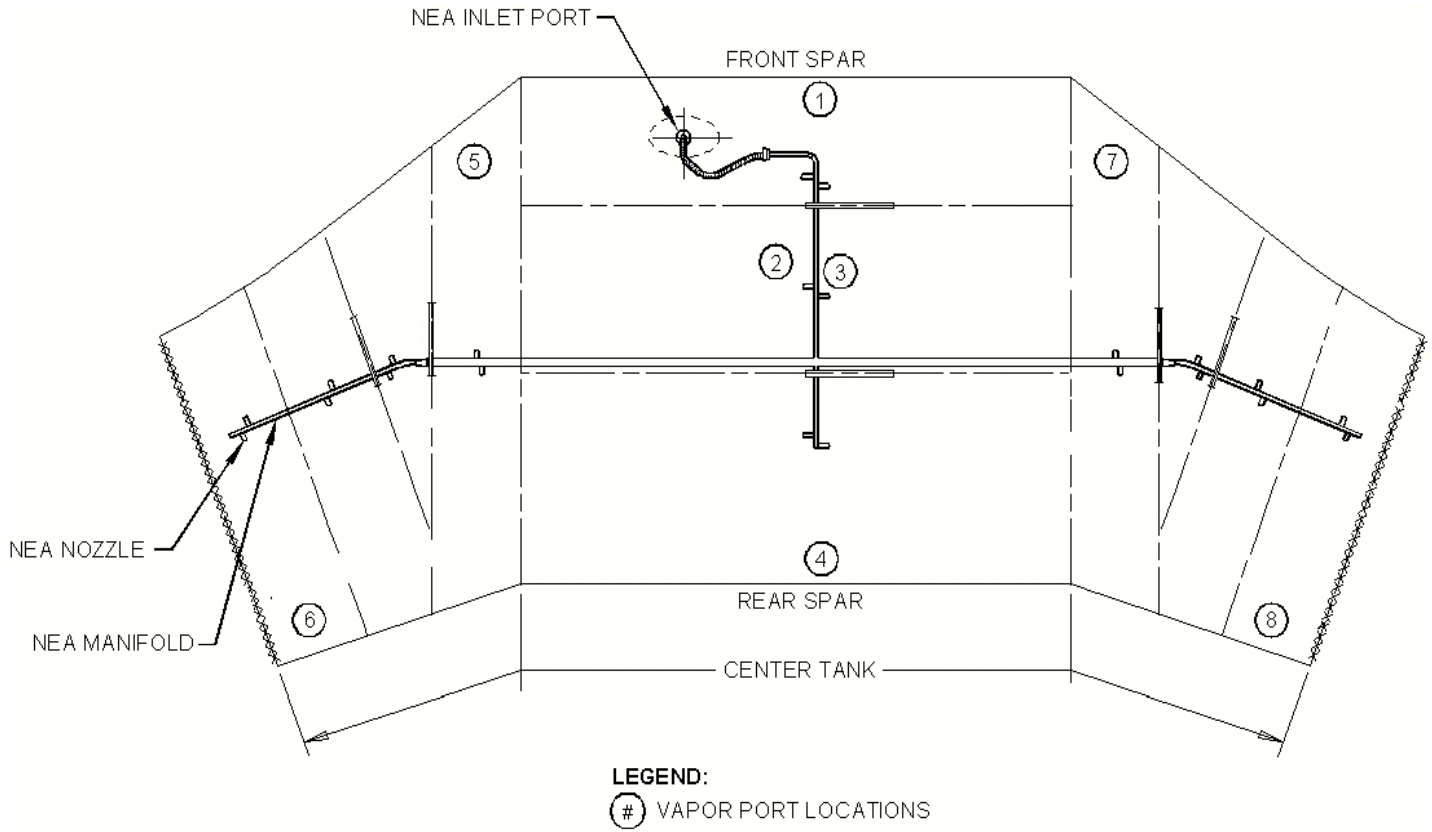

Figure 1 Nitrogen Distribution Manifold and Fuel Vapor Ports in Center Tank

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Test Data

- Calculated Average Oxygen Concentration in the Three Primary Areas in CWT:
  - Center Section
  - Left Cheek
  - Right Cheek
- Marked Some Critical Events
- Data Plotted:

  1/Second for Inerting

  1/Minute for Ground and Flight Tests

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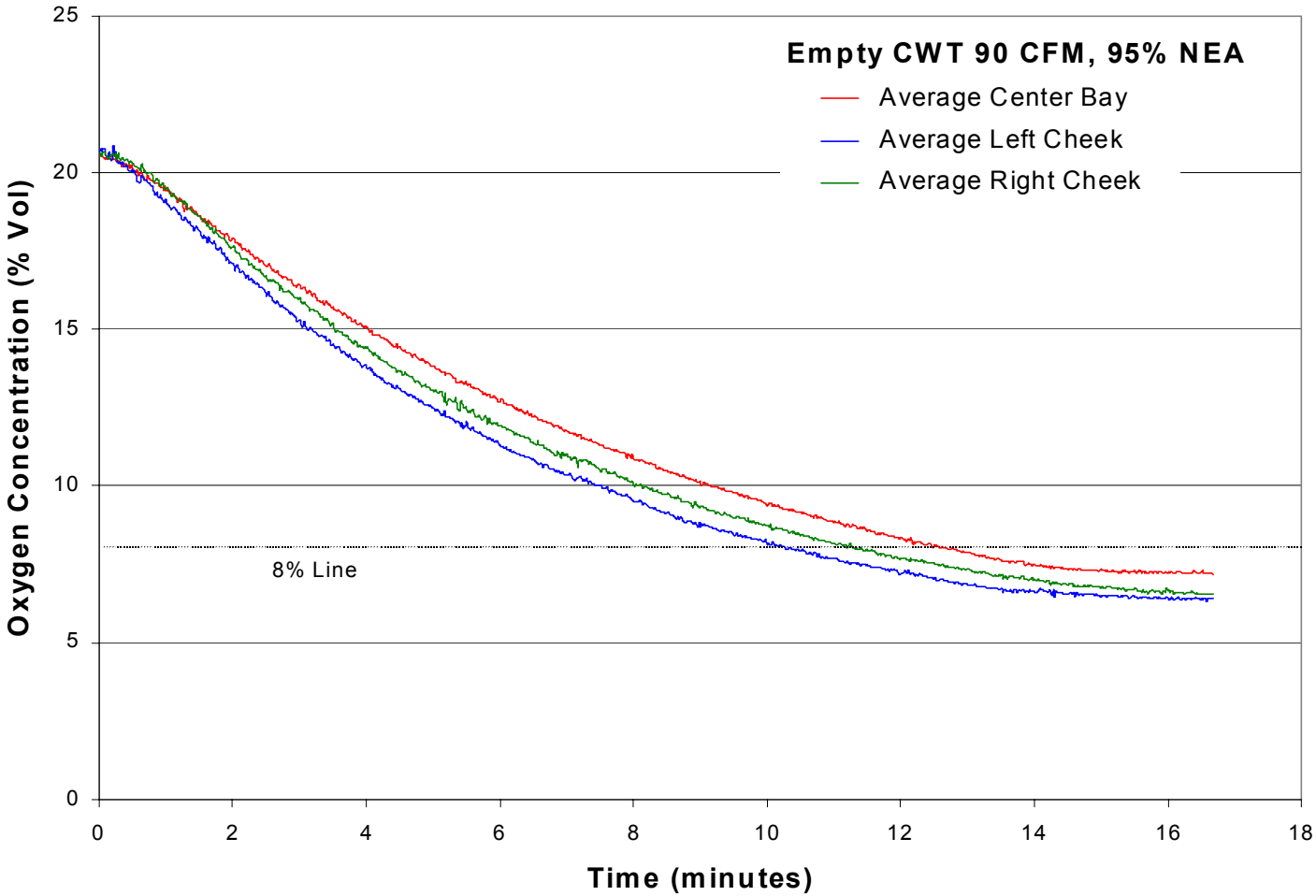
Fuel Tank Inerting Data



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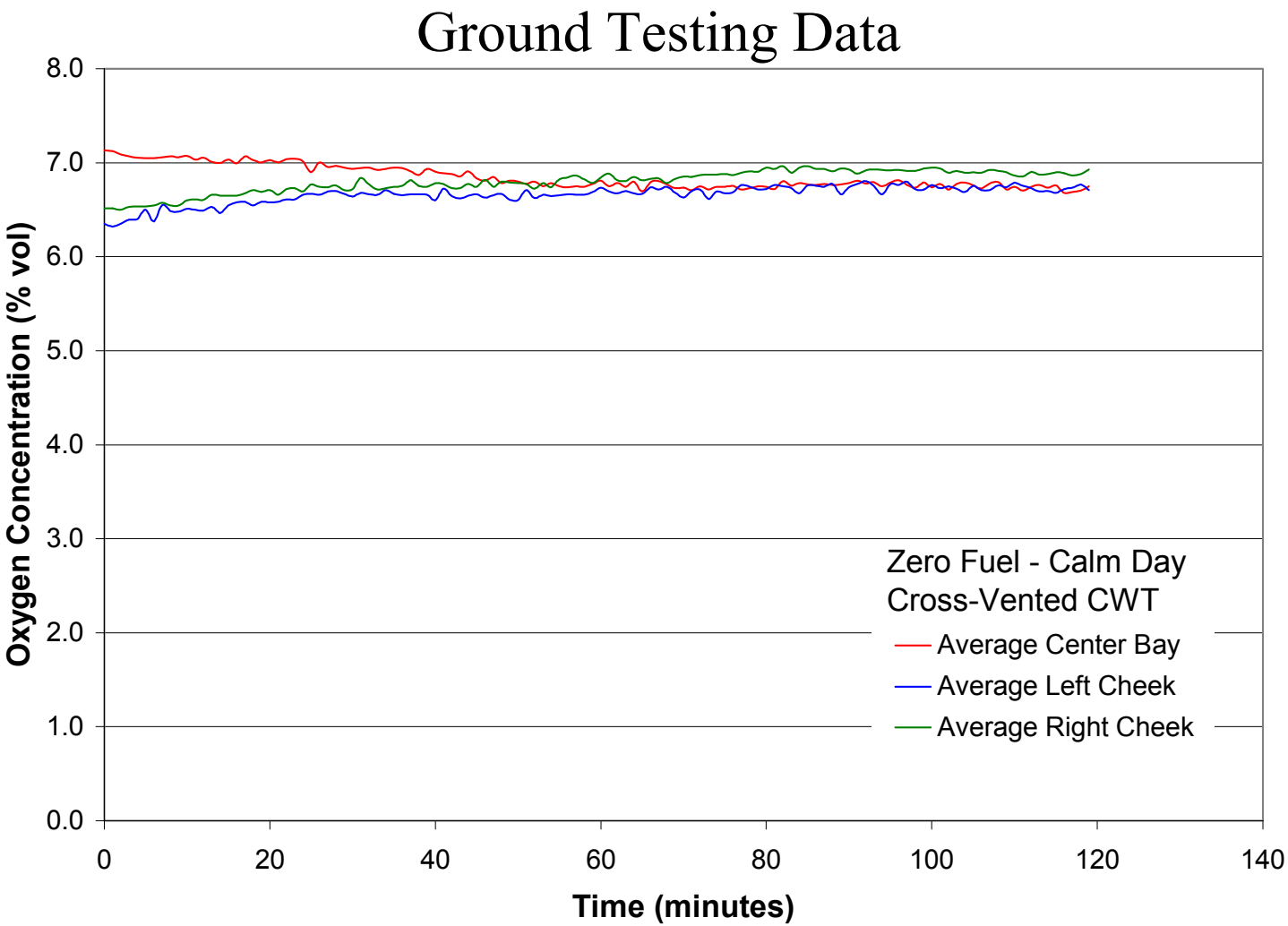

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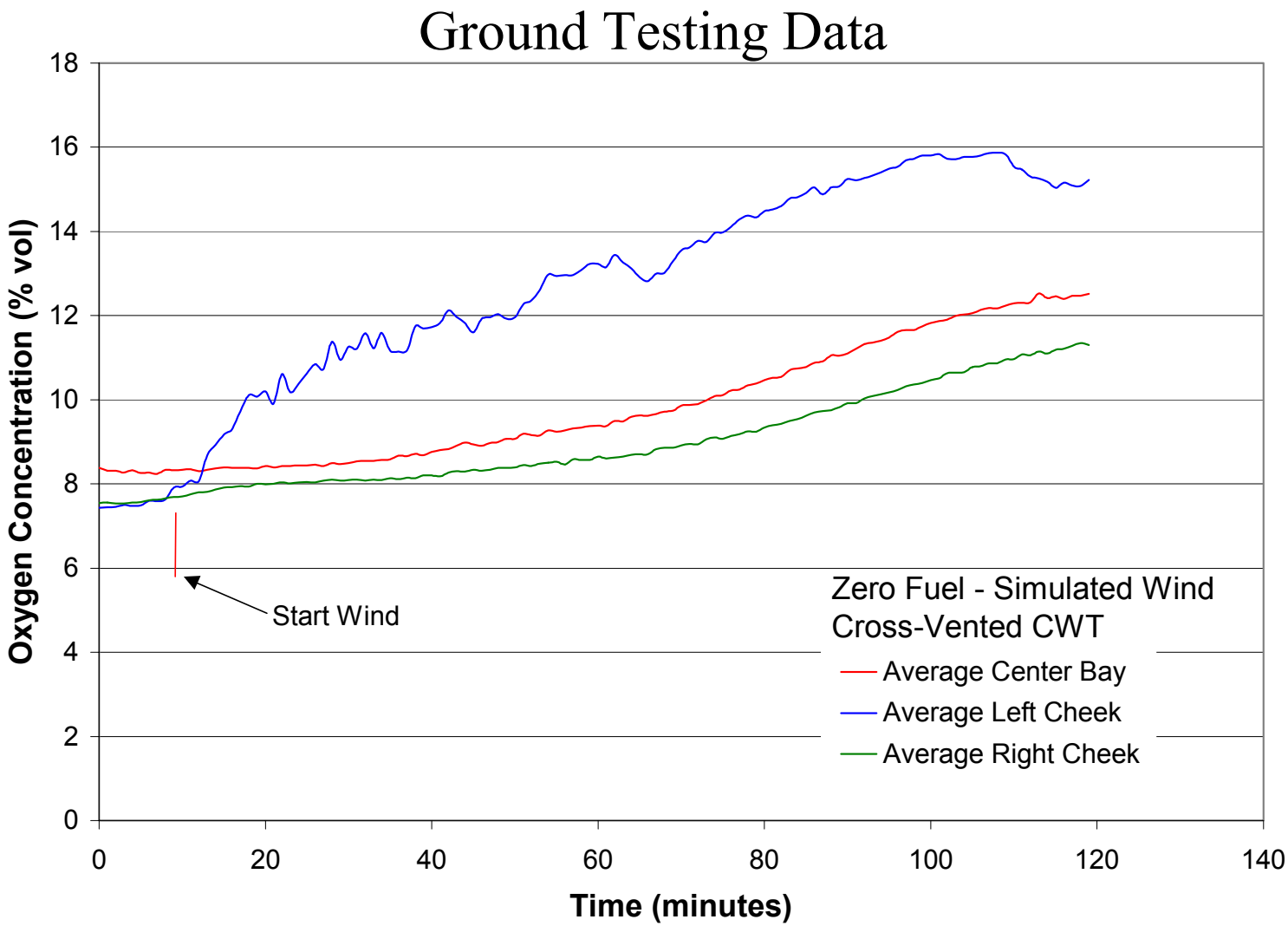

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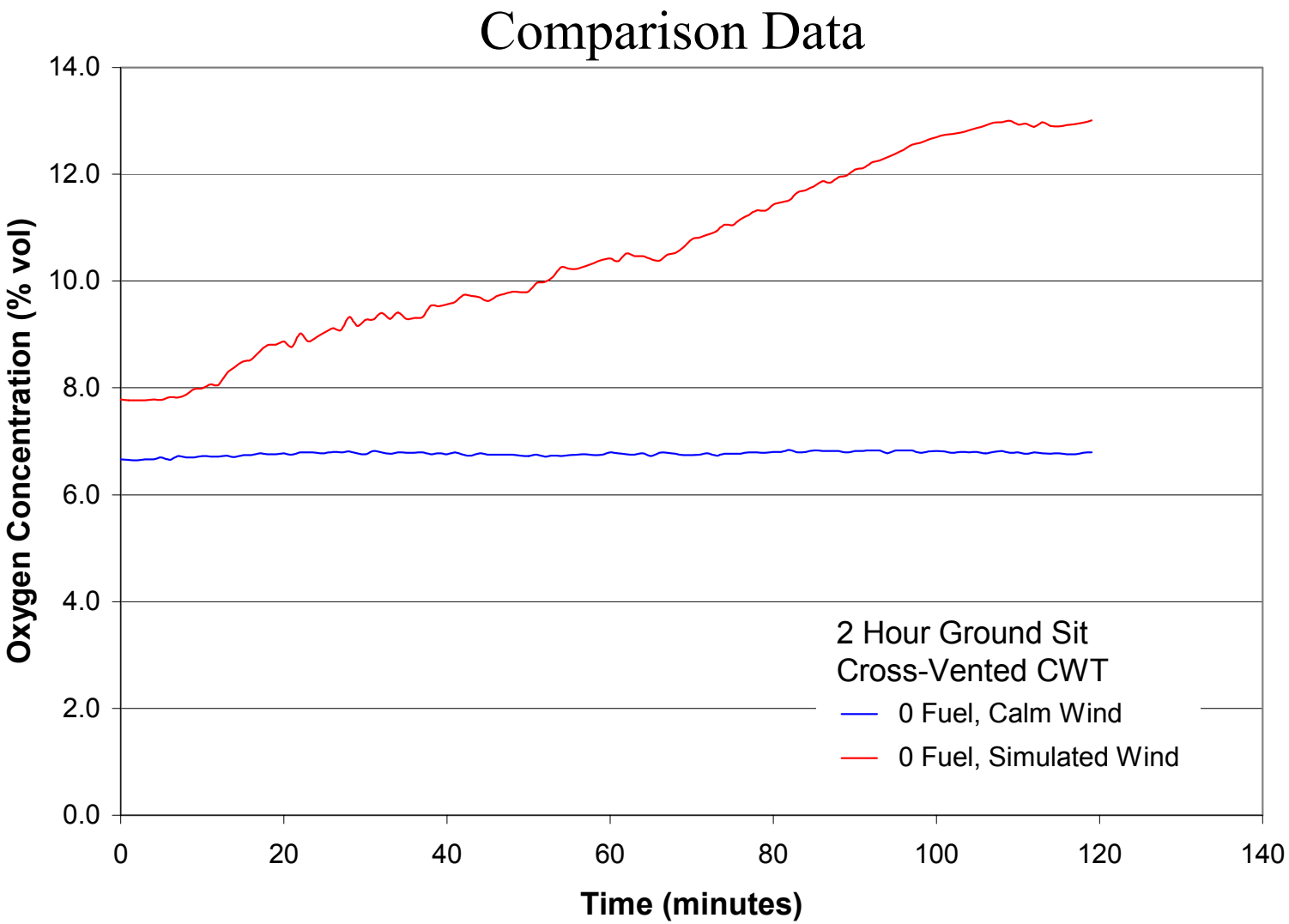

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Flight Testing Data

- Due to Profound Effect of Ground Winds and some Flight Conditions, Vent System was Modified to Prevent Cross Flow After First Flight Test
  - Effect of Cross-Flow Very Profound Over a Two Hour Flight
- Flight Profile: 30 min Ground Operations, Normal Take Off & Climb to 35K feet, 1 hour Level Flight, 30 minutes mis-trimmed 1 degree nose left, 30 minutes mis-trimmed 1degree nose Right
- Plotted Altitude with Average Bay Oxygen Concentrations to Illustrate Effect of Flight
- With Cross-Flow Eliminated The CWT Retained the Oxygen Concentration Fairly Well.

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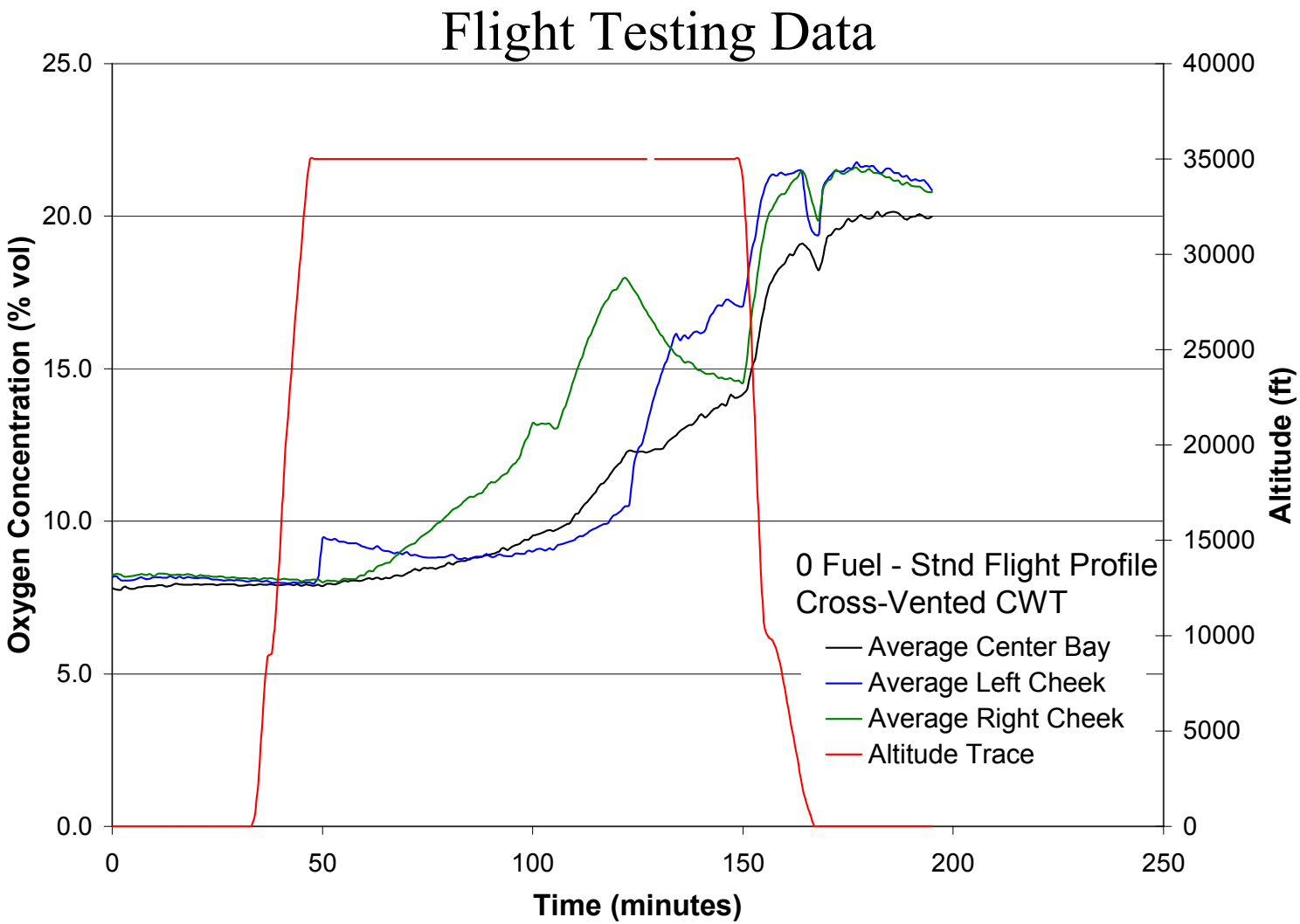

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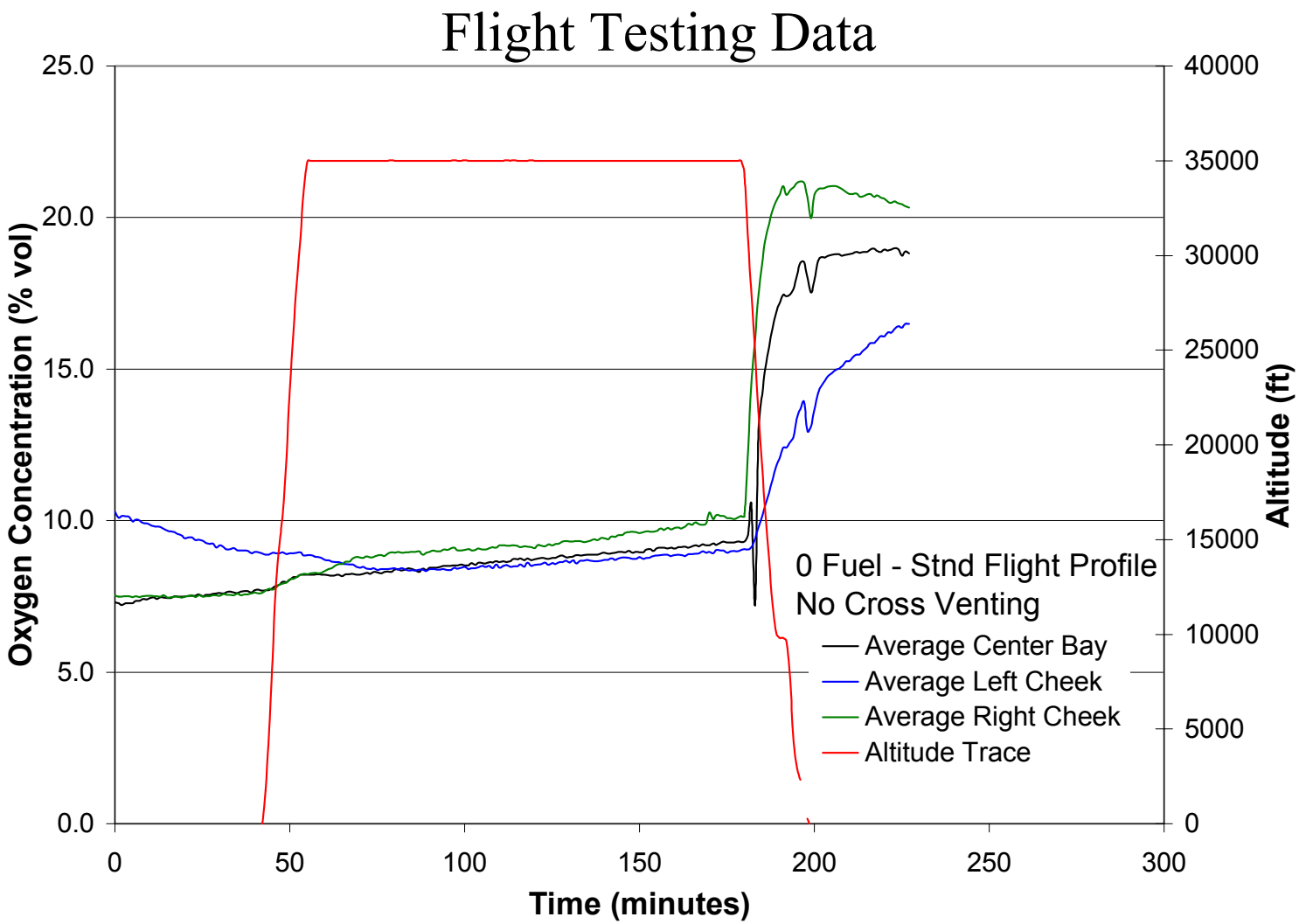

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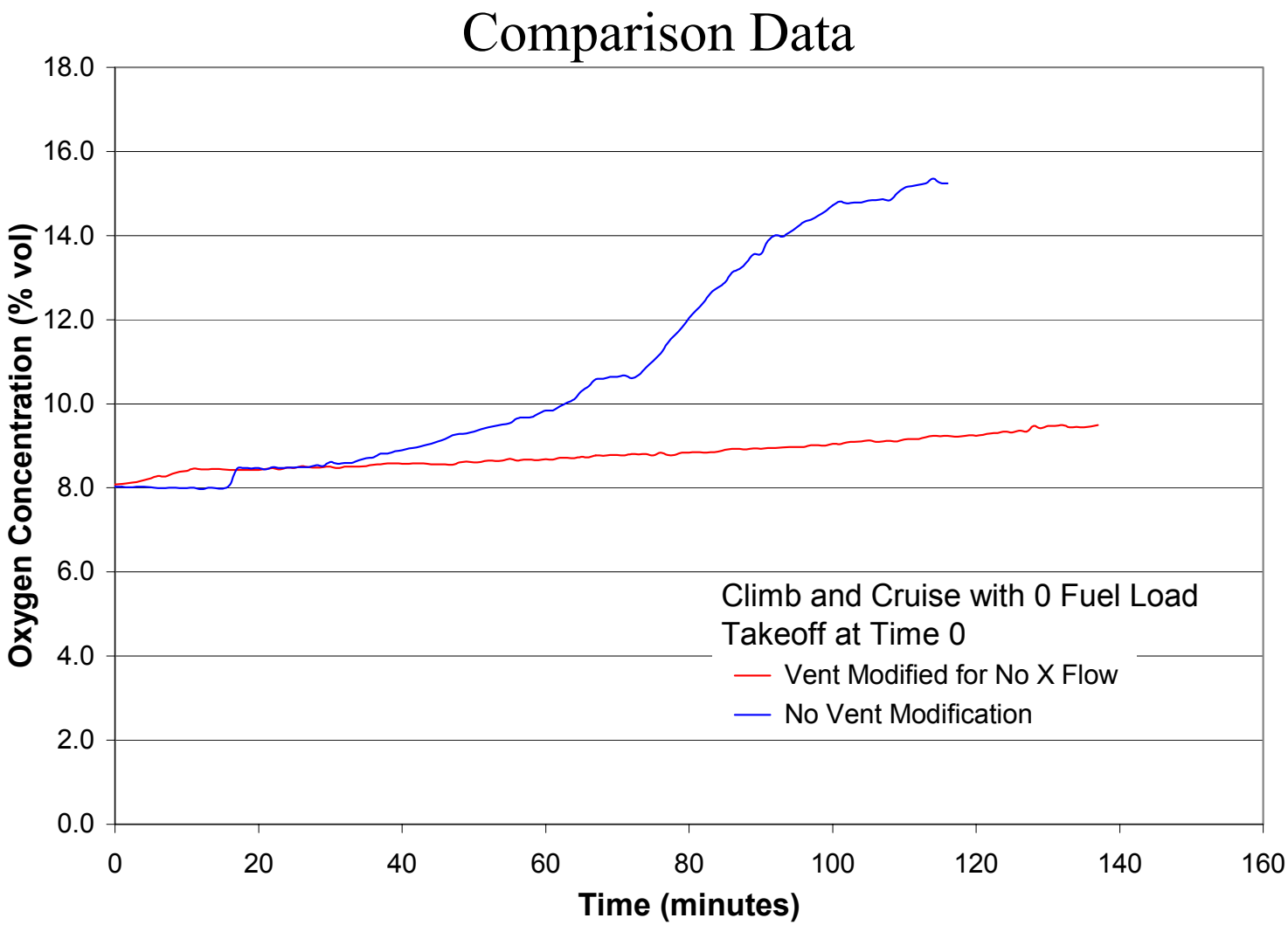

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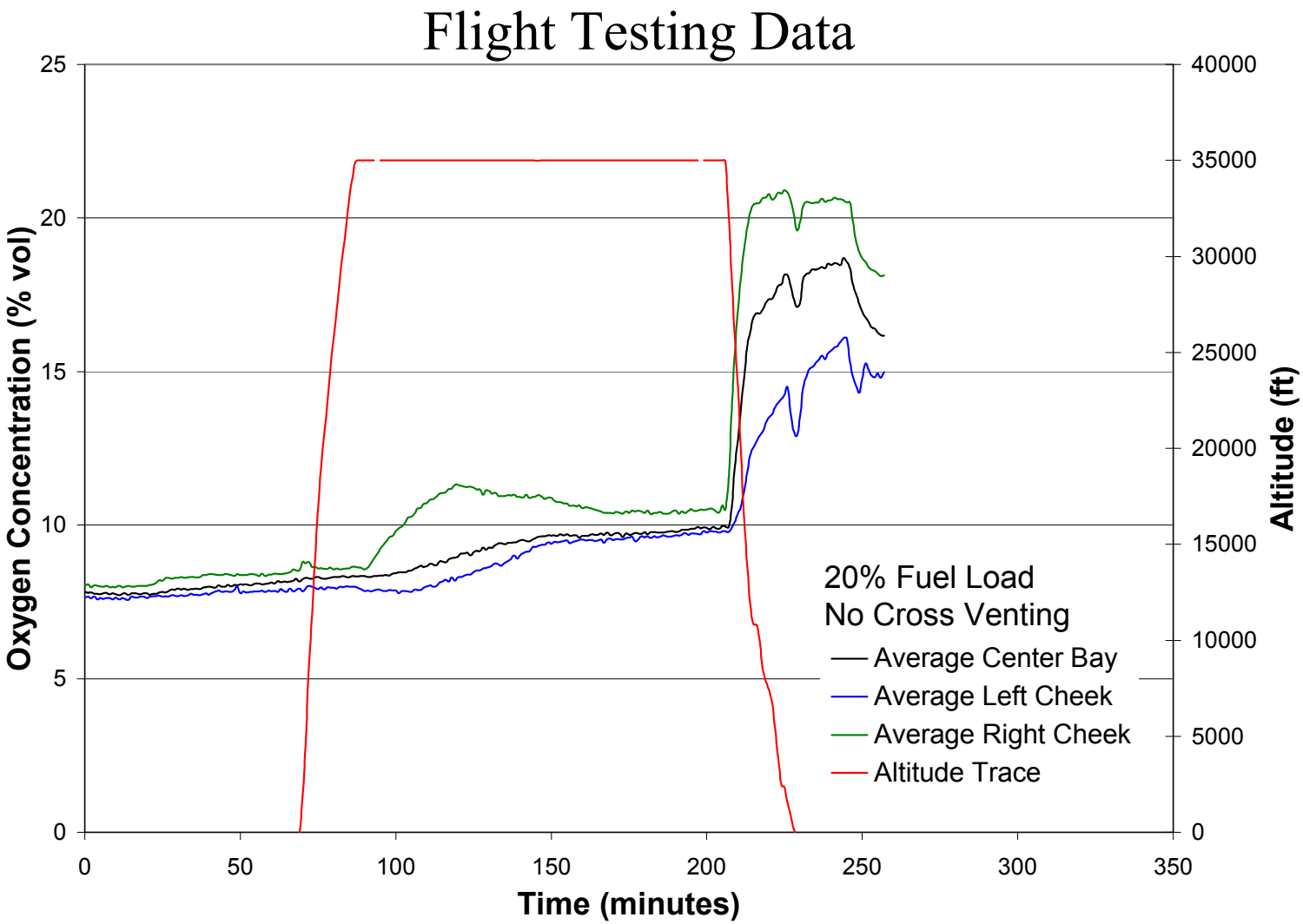

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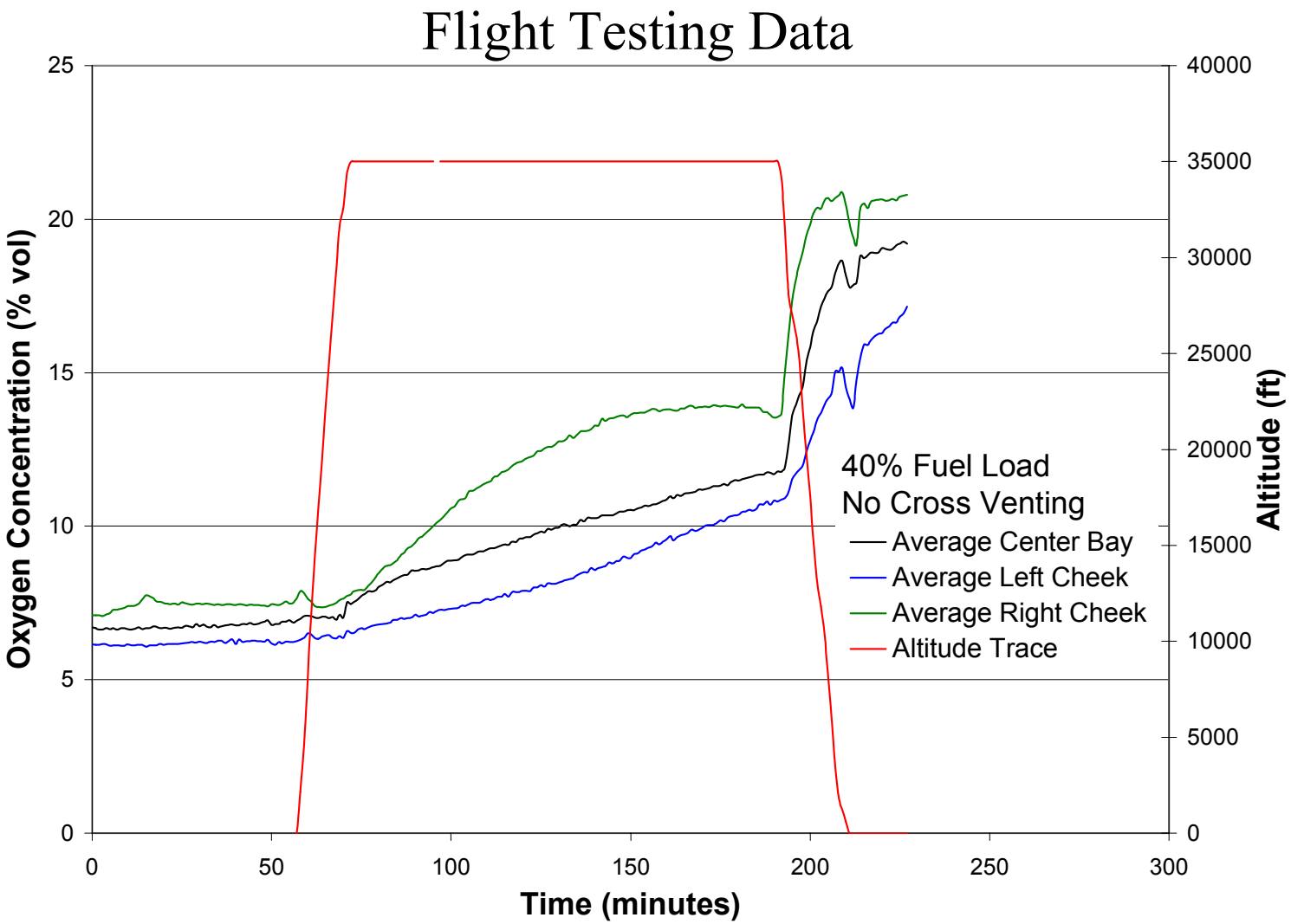

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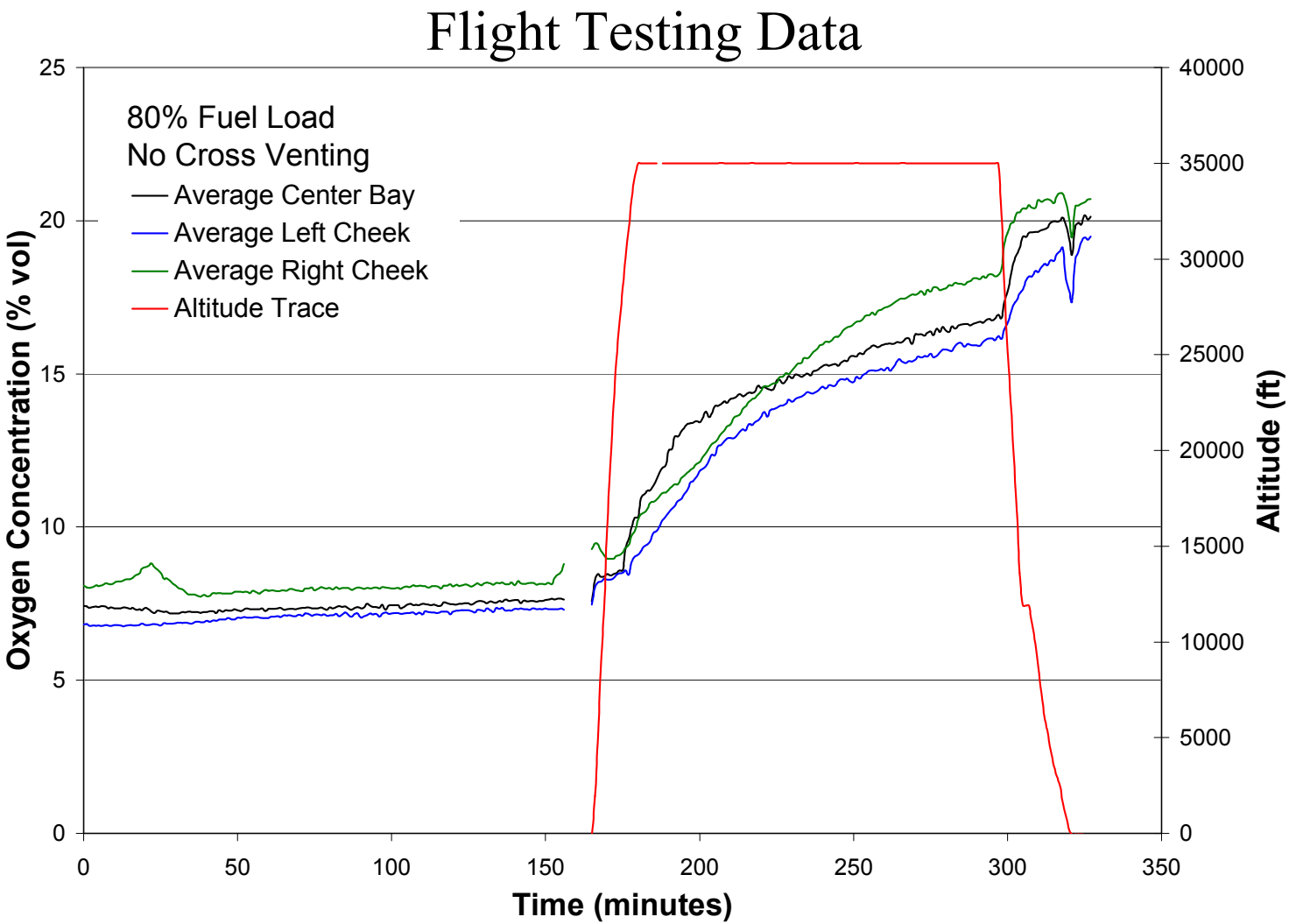

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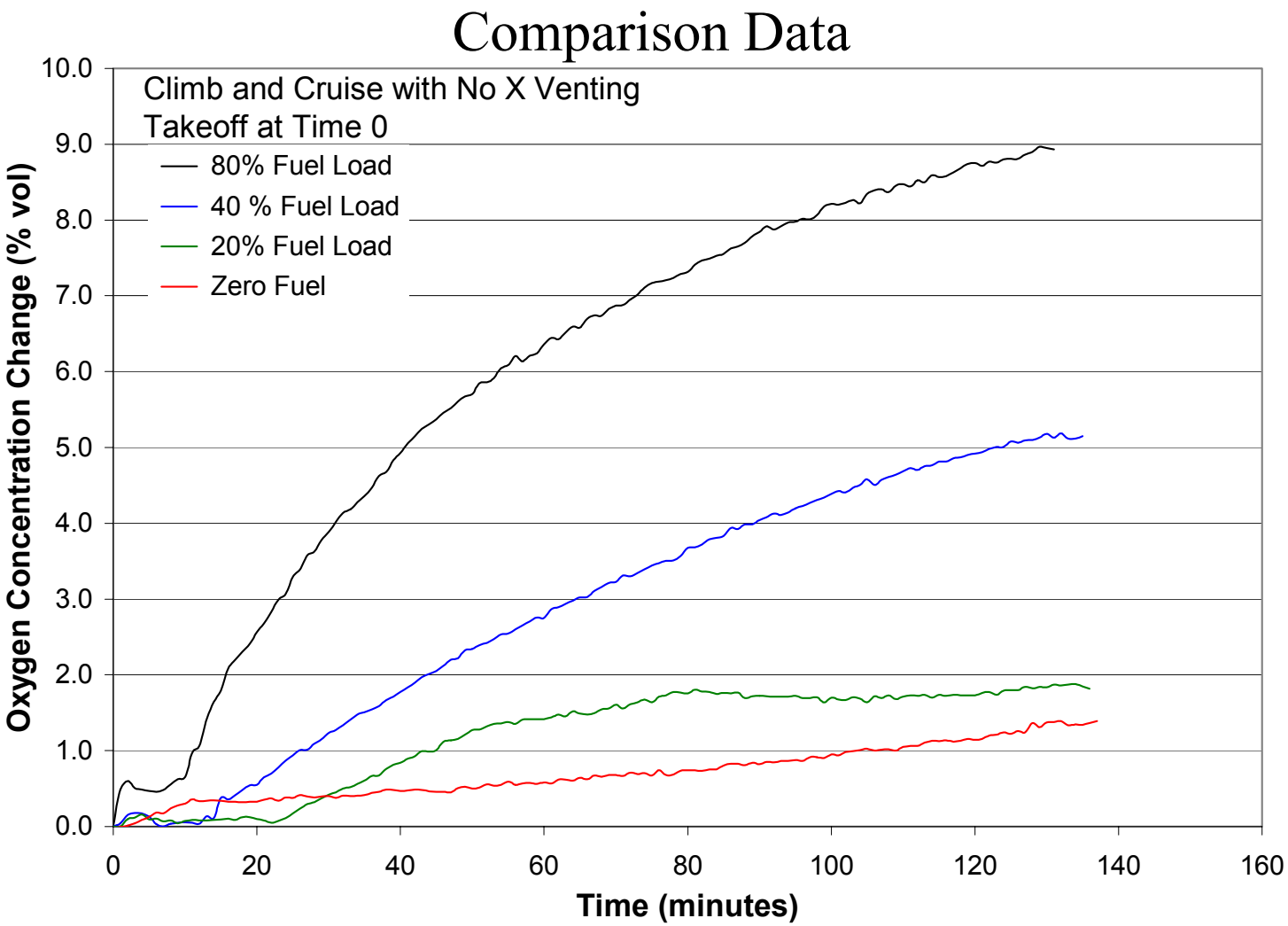

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Summary

- System Design Allowed For Hands Free Operation and Allowed for Successful Acquisition of Needed Data
- Large Volume of Sample Train Led to Increase in Lag time
- GBI Was Easily Accomplished and Provided Significant Protection Through Takeoff and Most of Cruise to a Vented CWT Even with Some Fuel Loads
  - Cross Venting Needed to be Eliminated
  - High Fuel Loads Caused Large Increases in Oxygen Concentration During Flight Tests