

**Further Improvements in Portability and Cost
Reduction in the Through the Probe (TTP) Audit
Laboratory Through Design and Implementation of an
Even More Compact Alternative**

**Avraham Teitz, Mustafa Mustafa, and Mark Winter
U.S. EPA, Region 2, Edison, NJ 08837**

**Mark Shanis
US EPA, OAQPS, Research Triangle Park, NC 27711**

TTP Version 1.0

■ Trailer based

■ O₃

- audit gas generated by GPT device
- audit concentration determined by O₃ analyzer

■ NO_x, SO₂, and CO

- Audit gas generated by GPT dilution of multi-blend cylinder
- TTP CO analyzer calibrated w/ independent undiluted span/zero standards on day of audit @ audit site
- Audit concentration of CO determined by regression adjustment of CO analyzer response to pre/post audit span and precision checks
- NO_x, SO₂ audit concentration determined by:

*Adjusted CO analyzer response * [NO_x in cylinder, SO₂ in cylinder / CO in cylinder]*

TTP Version 1.0 Truck and Trailer



TTP Version 1.0 Rack and Manifold



TTP Version 1.0 Manifold Close-up



TTP Version 1.0 Disadvantages

■ Safety

Hitch-Up/Release
In Traffic/In Transit

■ Access to Sites

Terrain
Metro Traffic/Bridge and Tunnels
Homeland Security Issues

■ Operational Overhead

Trailer Maintenance
Generator Maintenance
HVAC system
Fuel
Aging of Instruments

Essentials for Compact System

■ Maintain identical capabilities

- Audit identical parameters
- Flow Rates (15 LPM minimum)
- Day of audit verification of system operation

■ Smaller Vehicle/Simpler Vehicle

■ Cheaper

TTP Version 2.0

Identical instrumentation in a
compact form factor

TTP Version 2.0

- Equipment in Rolling Racks
- Teflon/Stainless “tee” manifolds
- Box truck w/ inverter for transport
- Shorter presentation line
- Demonstrated equivalency March 2006

TTP Version 2.0 in Rolling Racks



TTP Version 2.0 Teflon/SS Manifolds



TTP Version 1.0 and 2.0 Vehicle Comparison



TTP Version 2.0 Vehicle Interior



TTP Version 2.0 Load-in



TTP Version 2.0 During Audit



TTP Version 3.0

- Identical O₃ instrumentation to earlier TTP versions
- Identical Multi-blend gas generation as earlier TTP versions
- ***Audit Concentrations of NO_x, SO₂, and CO determined by calibration of mass flow controllers in GPT device***

TTP Version 3.0 Advantages

- MFC calibration of GPT device for Multi-blend gas audits
 - Eliminates need for CO analyzer
 - Eliminates need for 3 cylinders to calibrate CO device
 - Eliminates need for 3.5 hour CO analyzer warmup
 - Eliminates need for 2nd rack
 - Eliminates need for a big truck – cargo van is suitable

TTP Version 3.0 Disadvantages

- Requires rigorous flow calibration
- Requires confirmation of flow calibration via comparisons against an undiluted gas (CO) standard
- Requires flow verification on day of audit @ audit site

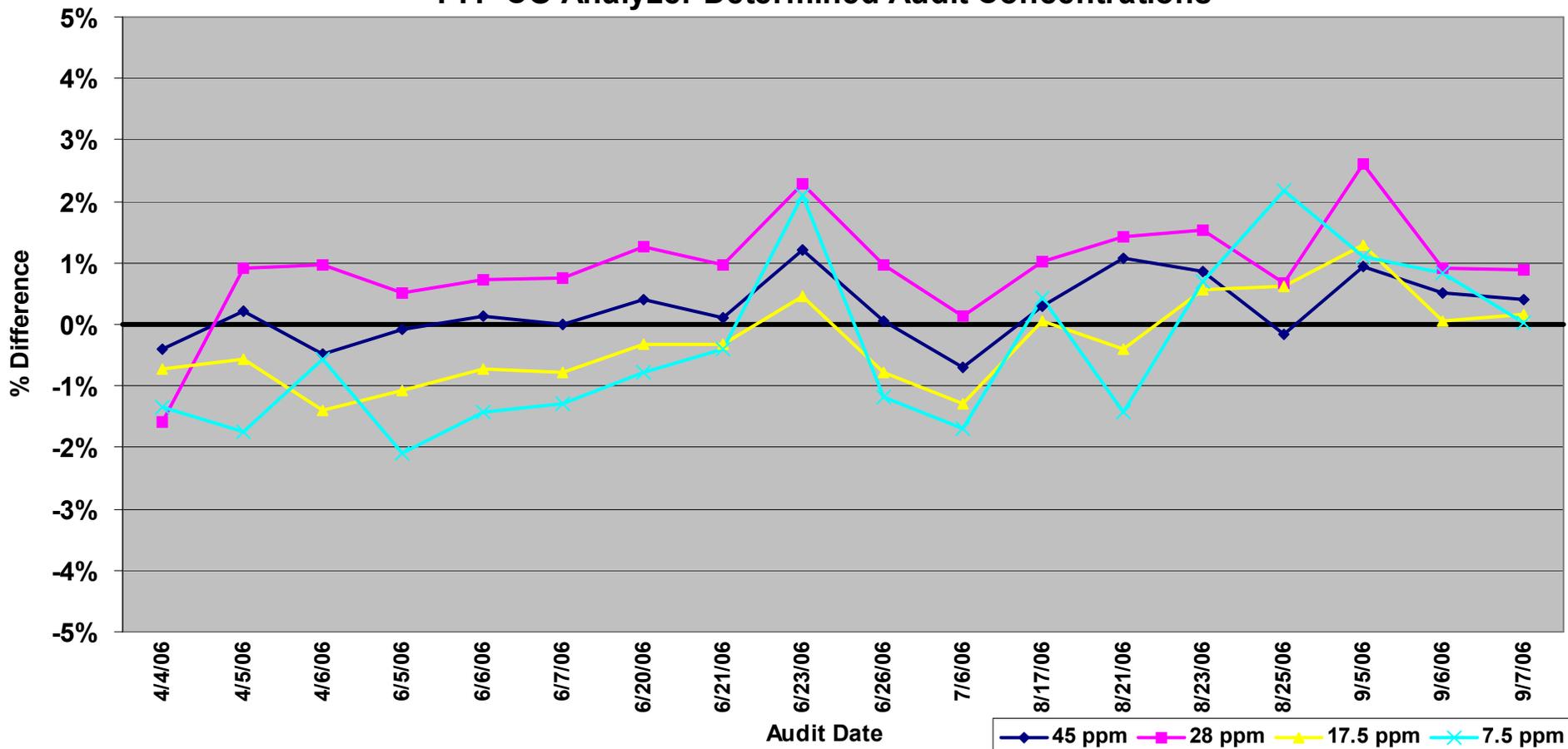
EPA Region 2 Flow Bench



How do audit concentrations predicted by MFC calibration compare to audit concentrations determined by the TTP CO analyzer ?

- Calibrate the MFCs of the GPT Device
- Run audits w/ TTP Version 2.0 per SOP
- Compare

**% Difference in MFC Predicted Audit Concentrations
vs.
TTP CO Analyzer Determined Audit Concentrations**



What is the accuracy of the TTP CO analyzer for the determination of official audit results?

■ 1) CO Instrument limitations:

Linearity = $\pm 1\%$ of full scale
Span drift (24 hour) = $\pm 1\%$ of full scale

Given: 50 ppm instrument range

Then: Variability due to linearity error is ± 0.5 ppm

With a precision cylinder @ 7.86 ppm, this is $\pm 6.3\%$ difference

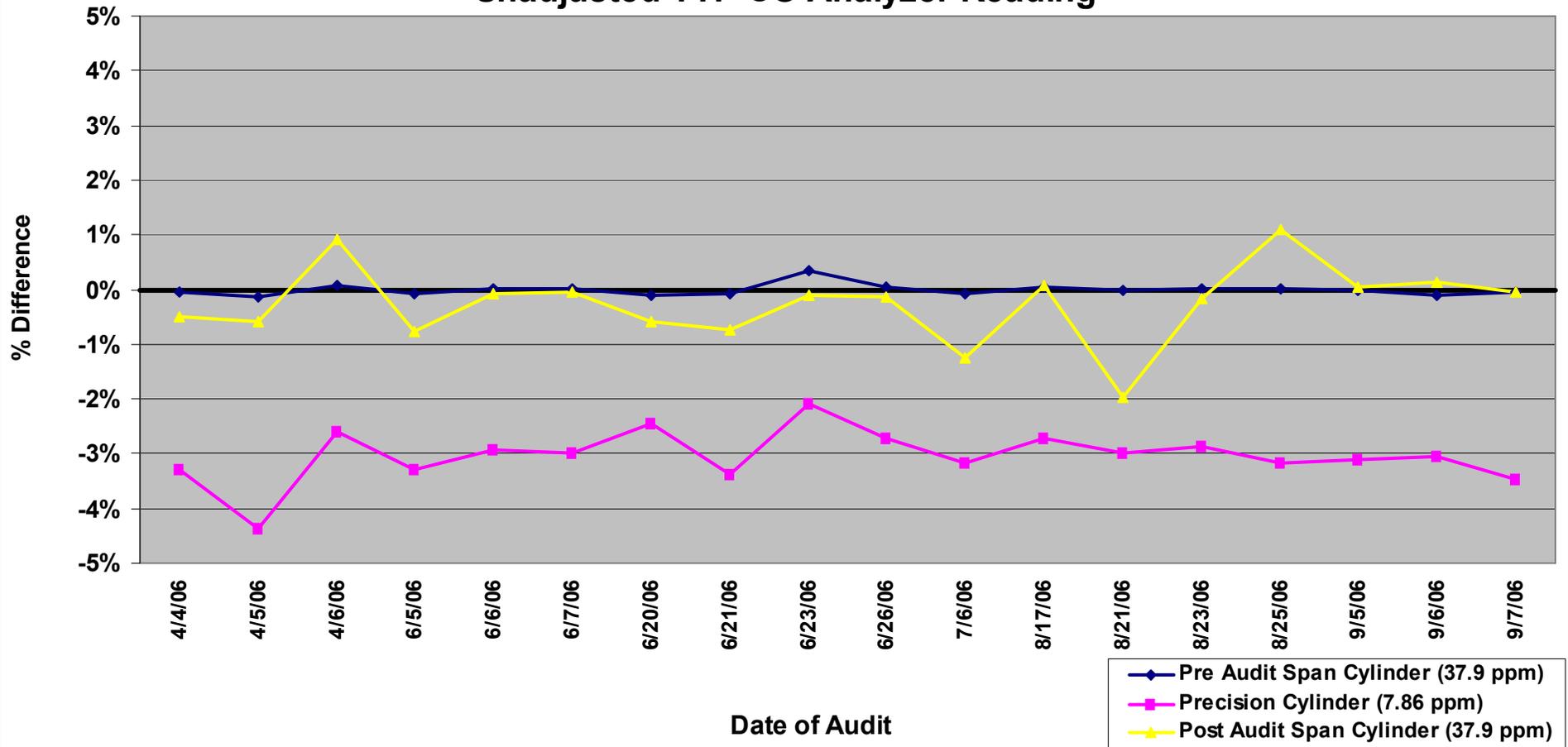
What is the accuracy of the TTP CO analyzer for the determination of official audit results?

- 2) Compare the CO analyzer readings obtained in the pre/post audit span and precision checks

vs.

Certified concentrations of the span and precision undiluted cylinder standards

% Difference of Span/Precision Cylinder Standards Certified Concentrations vs. Unadjusted TTP CO Analyzer Reading



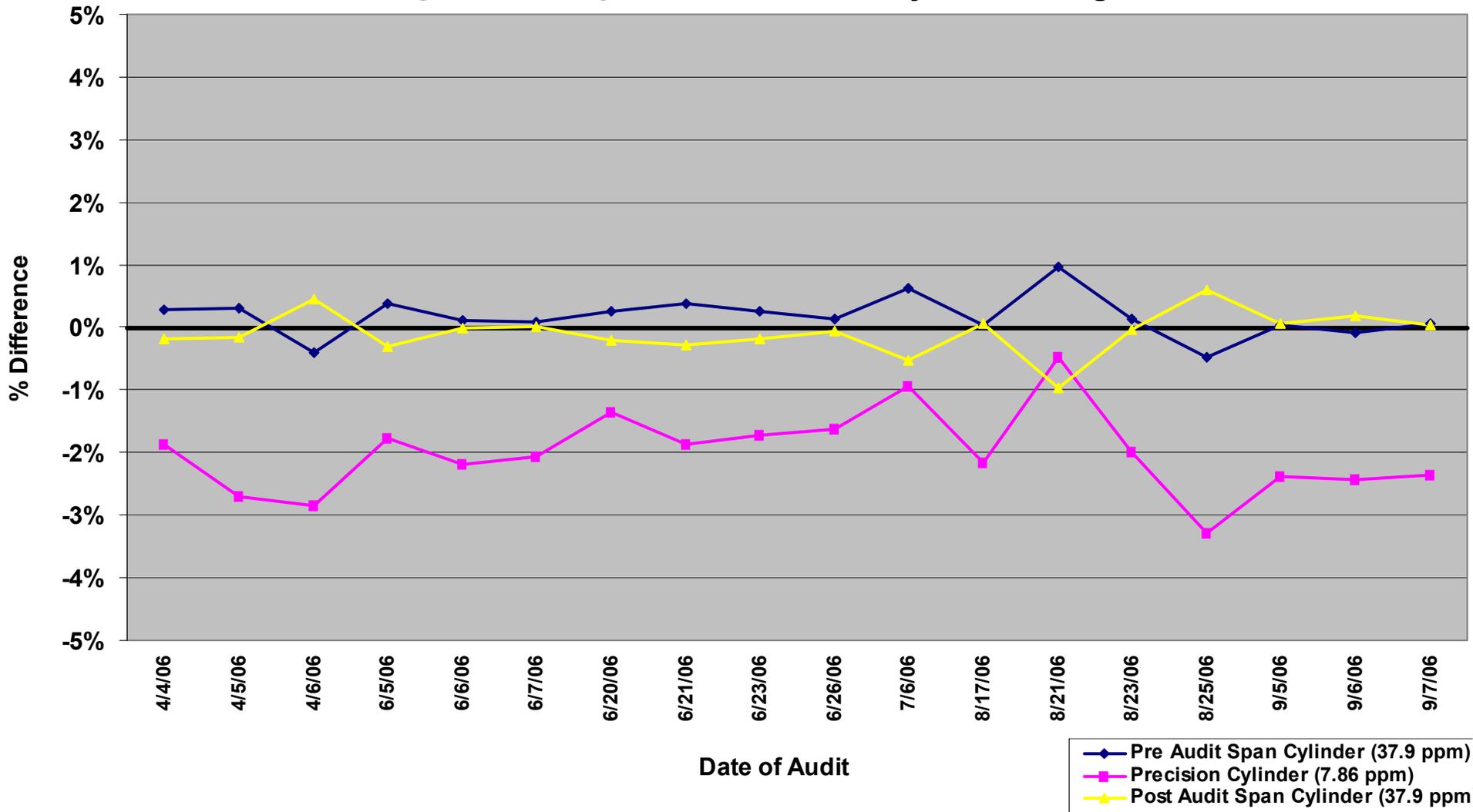
What is the accuracy of the TTP CO analyzer for the determination of official audit results?

- 3) Compare the *regression adjusted* CO analyzer readings obtained in the pre/post audit span and precision checks

vs.

Certified concentrations of the span and precision undiluted cylinder standards

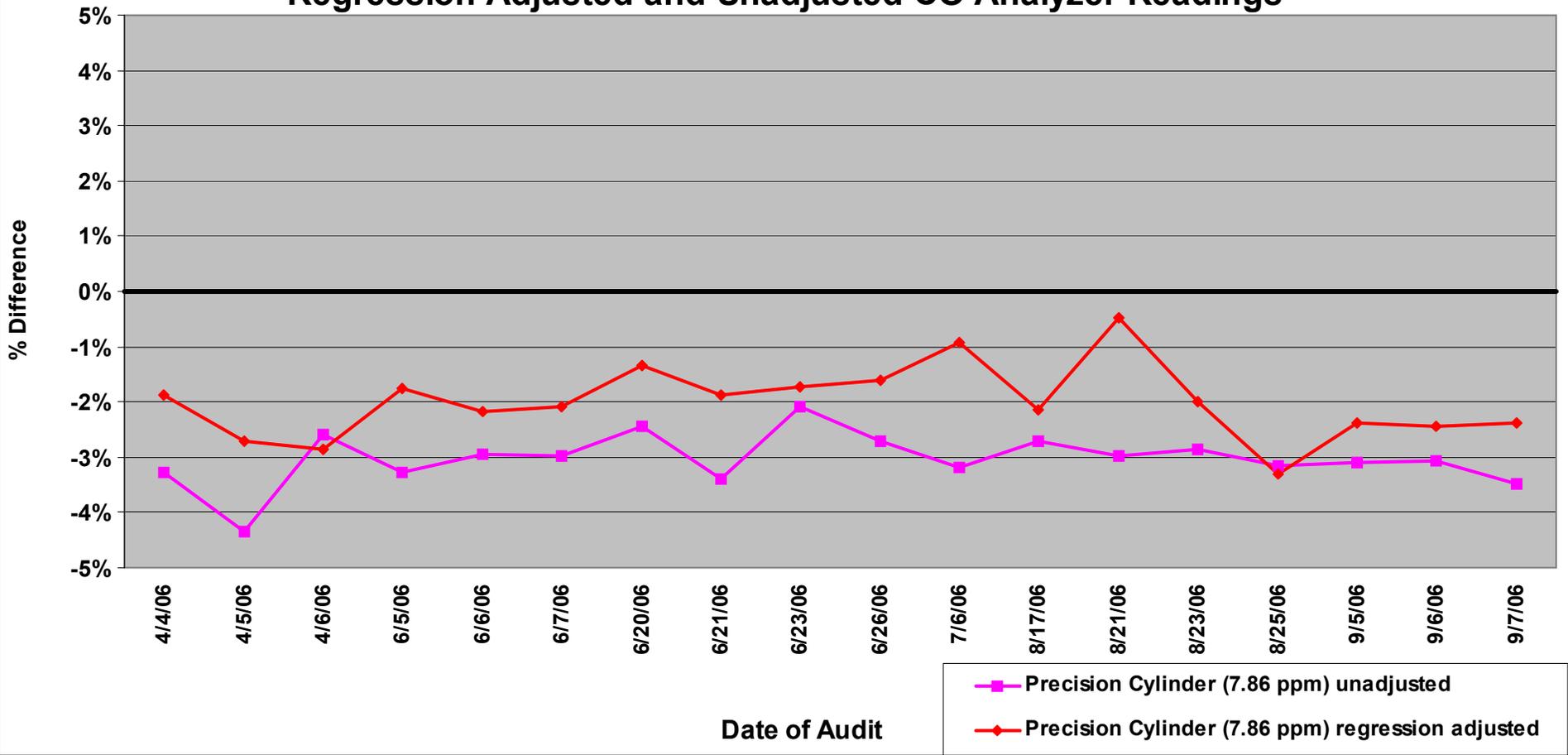
**% Difference of Span/Precision Cylinder Standards Certified Concentrations
vs.
Regression Adjusted TTP CO Analyzer Reading**



What is the accuracy of the TTP CO analyzer for the determination of official audit results?

- 4) Directly compare the effect of regression adjustment @ the lowest audit concentration

**% Difference of Precision Cylinder Certified Concentration
vs.
Regression Adjusted and Unadjusted CO Analyzer Readings**



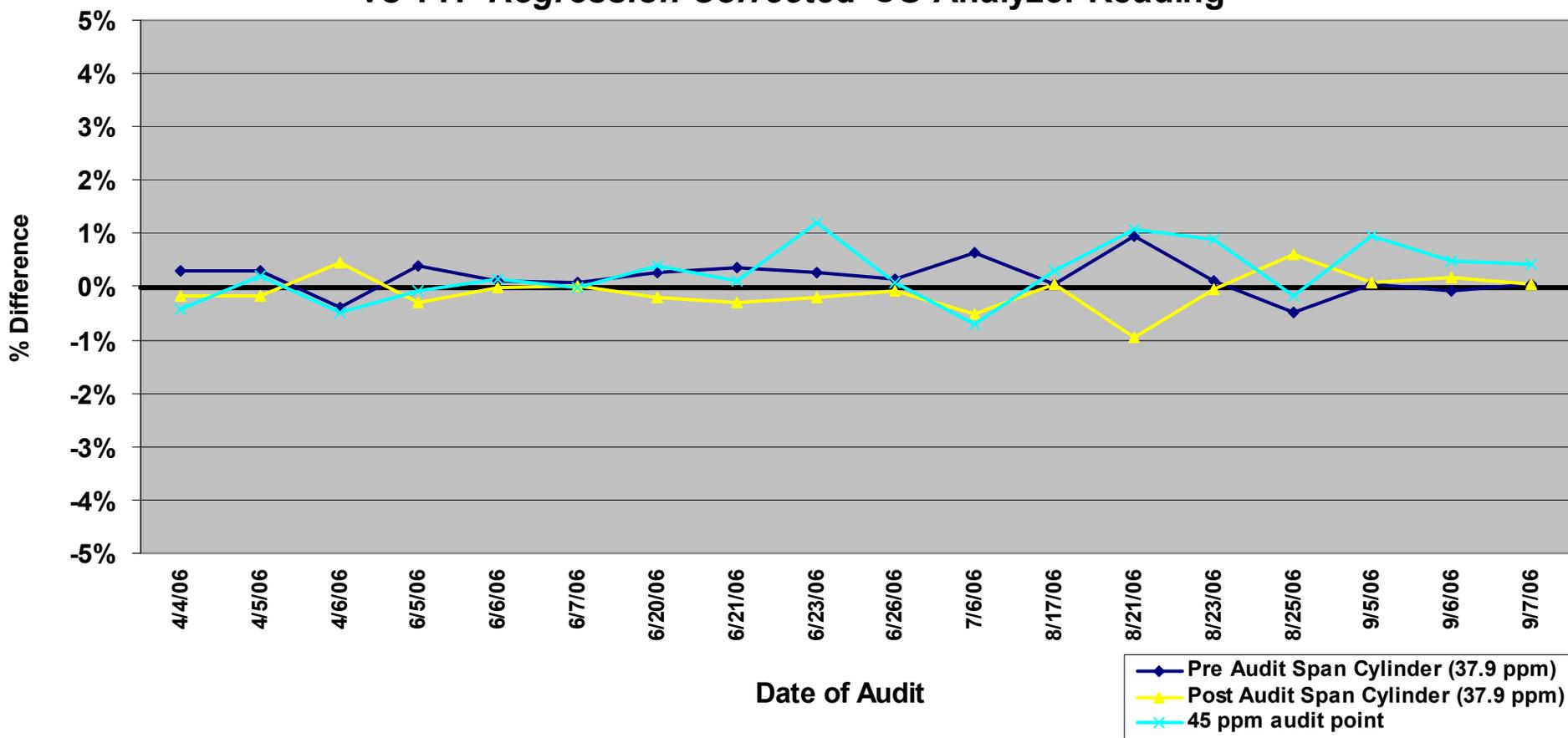
Putting MFC Prediction Results in the Context of Span Cylinder Pre/Post Audit Checks

Compare the official TTP CO analyzer results

vs.

- 1) MFC predicted concentration @ 45 ppm
audit point
- 2) Span cylinder standard certified concentration
(37.9 ppm) @ pre/post audit span check

Span Cylinder Standard Certified Concentration and MFC Predicted High CO Audit Point vs TTP Regression Corrected CO Analyzer Reading



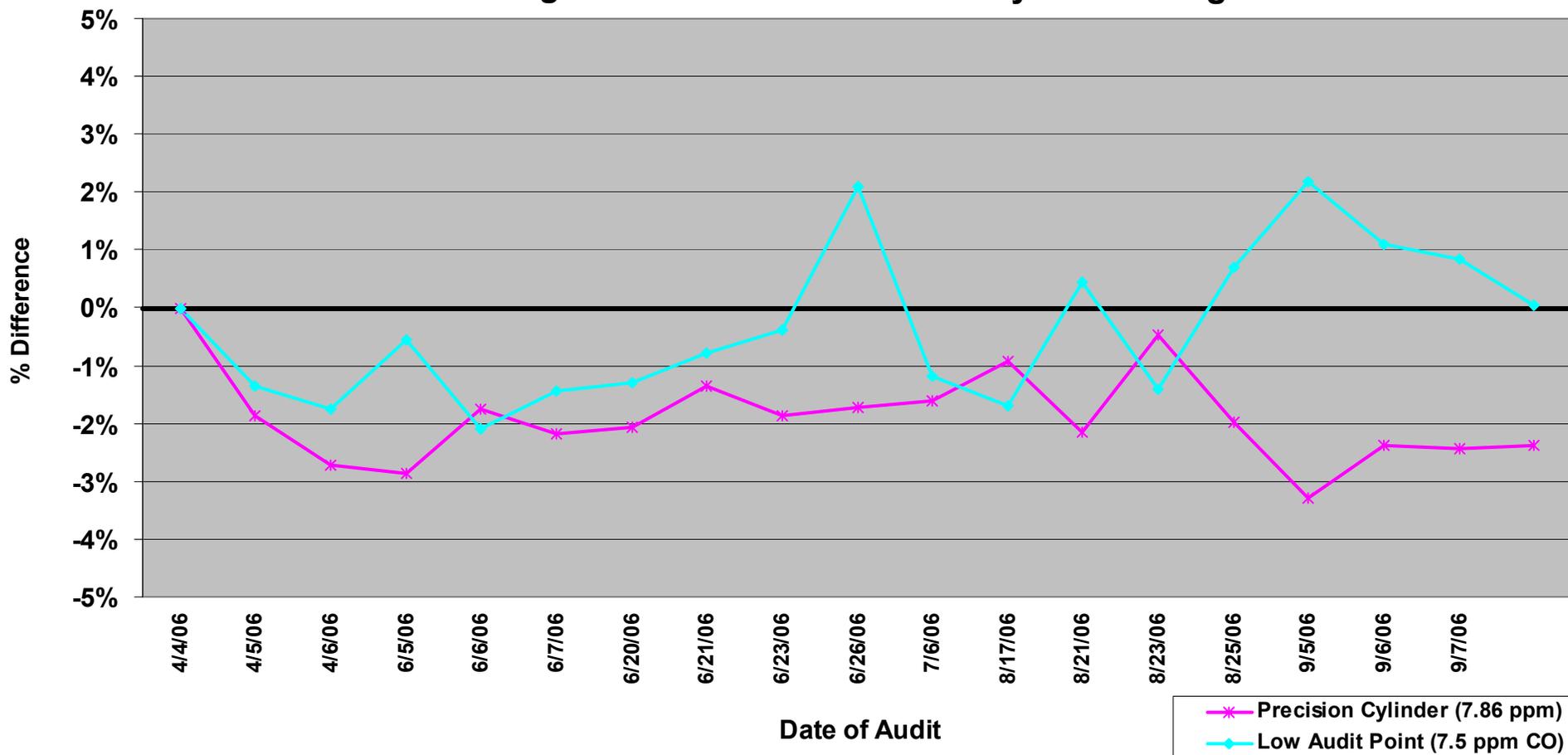
Putting MFC Prediction Results in the Context of Precision Cylinder Audit Checks

Compare the official TTP CO analyzer results

vs.

- 1) MFC predicted concentration @ 7.5 ppm
audit point
- 2) Precision cylinder standard certified
concentration (7.86 ppm) @ audit
precision check

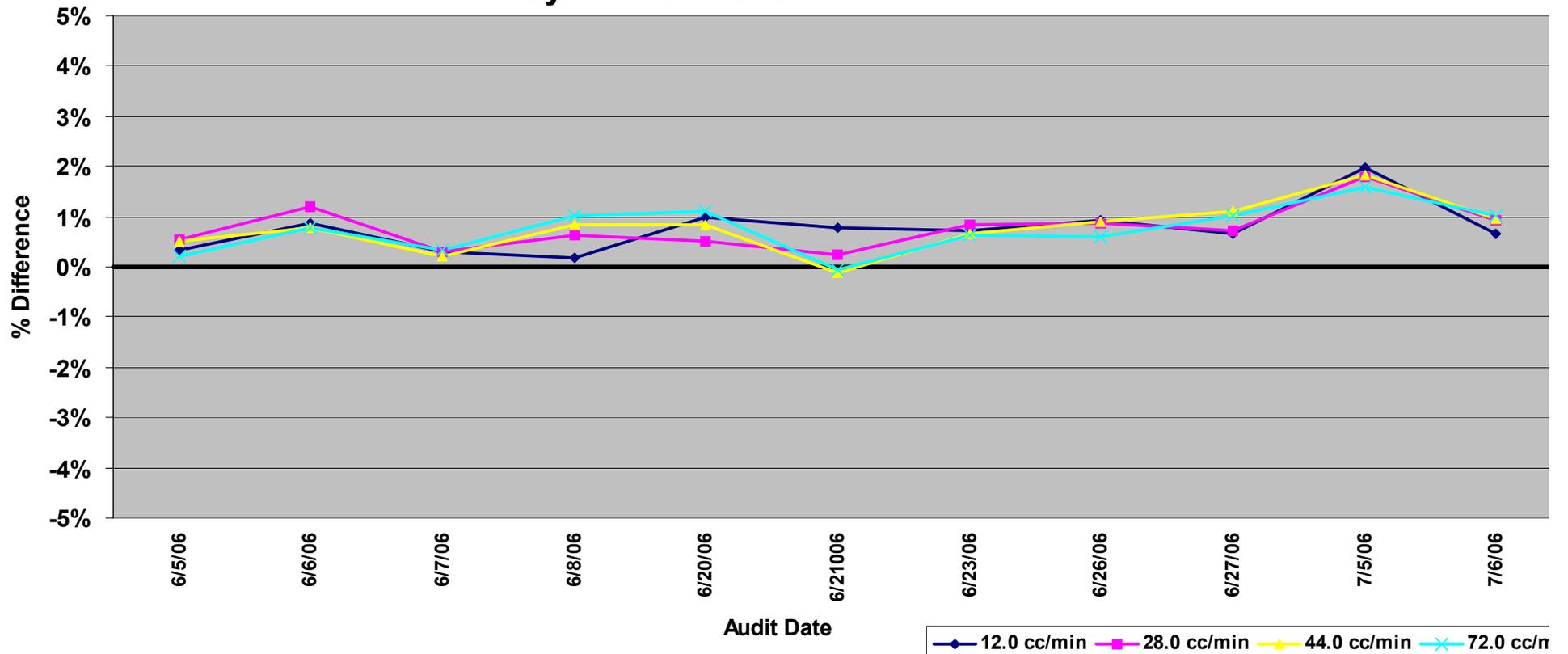
Precision Cylinder Standard Certified Concentration and MFC Predicted Low Audit Point vs TTP Regression Corrected CO Analyzer Reading



TTP Version 3.0 Flow Verification

- MFC zero and pollutant flows calibrated by Bios ML-800 @ each audit point
- MFC zero and pollutant flows determined by Bios DryCal Lite @ each audit point at same time as ML-800 calibration
- Dilution ratio for DryCal Lite results computed @ each audit point
- On day of audit @ site, MFC zero and pollutant flows determined by DryCal Lite
- Dilution Ratio determined by DryCal Lite on day of audit compared to dilution ratio determined on day of calibration

% Difference in MFC Dilution Ratio Determined by DryCal Lite @ Each Audit point: Day of Audit vs. 5/31-6/1 Calibration



TTP Version 3.0 – Smaller Transport Vehicle



TTP Version 3.0 - Loading The Van



TTP Version 3.0 – Loading The Van (continued)



TTP Version 3.0 – Pelican Case #1



TTP Version 3.0 – Pelican 1660 Case #2



TTP Version 3.0 on site



TTP Version 3.0 – Whiteface Base Station Site 4 Wheel Drive Required



TTP Version 3.0 – Whiteface Summit Station



TTP Version 3.0 – Whiteface Mountain Summit



TTP Version 3.0 – Summit Tunnel



TTP Version 3.0 – Whiteface Summit Elevator



TTP Version 3.0 – The Lug From the Top of the Elevator to the Station



TTP Version 3.0 – Whiteface Summit @ the Silo



TTP Version 3.0 – Whiteface Summit 2 Story Spiral Staircase



TTP Version 3.0 – Whiteface Summit Monitoring Station, Analyzer Reads 625 mm Hg atm Pressure



TTP Version 3.0 – Whiteface Summit Ladder #1



TTP Version 3.0 – Whiteface Summit Ladder #2



TTP Version 3.0 – Whiteface Summit Door to the Roof



TTP Version 3.0 – Whiteface Summit @ the Top



Conclusions

- MFC based calibration for TTP audits provides accuracy equivalent to CO analyzer based systems
- MFC Based calibration systems require rigorous flow calibration and verification
- MFC based calibration systems provide easier and safer transport, and require less equipment and maintenance
- Turnkey system can be purchased for less than \$40,000 – even less if you already have CO and Ozone analyzers