Certification & Compliance Division

EPA HD In-Use Testing Team:

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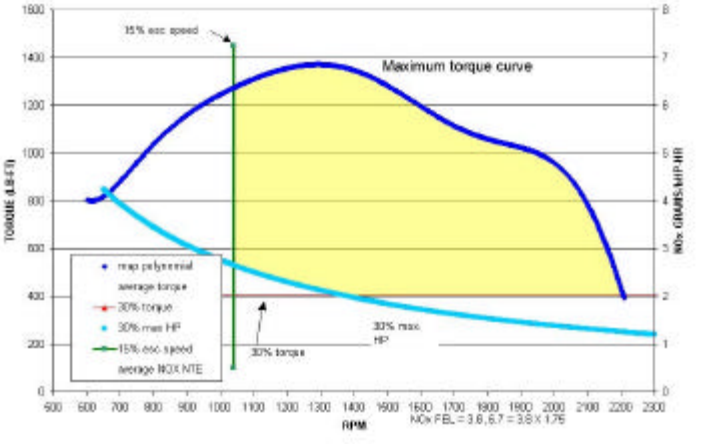
Not To Exceed (NTE) Emissions During EPA Marathon Testing

GRPE Off-Cycle Informal Working Group

Tuesday, September 13, 2005

EPAs HD In-Use Compliance Program Background

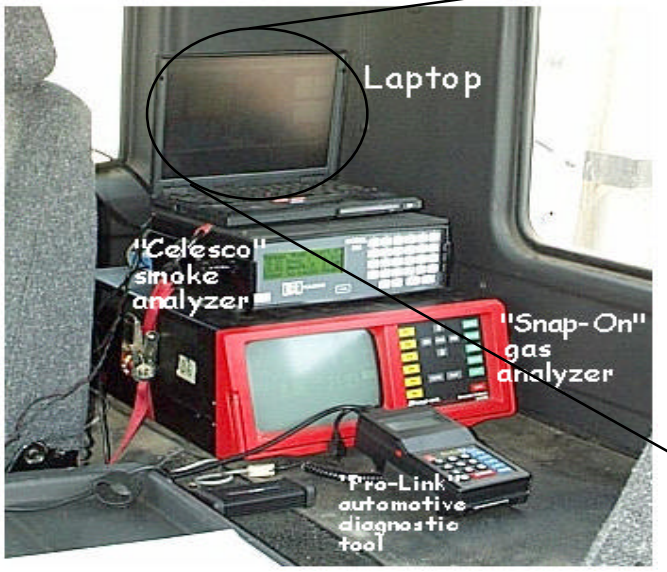
- First ever Federal program to measure emissions while trucks in actual real world operation
- Program started in 2001
- Portable testing equipment
  - ROVER system developed by EPA

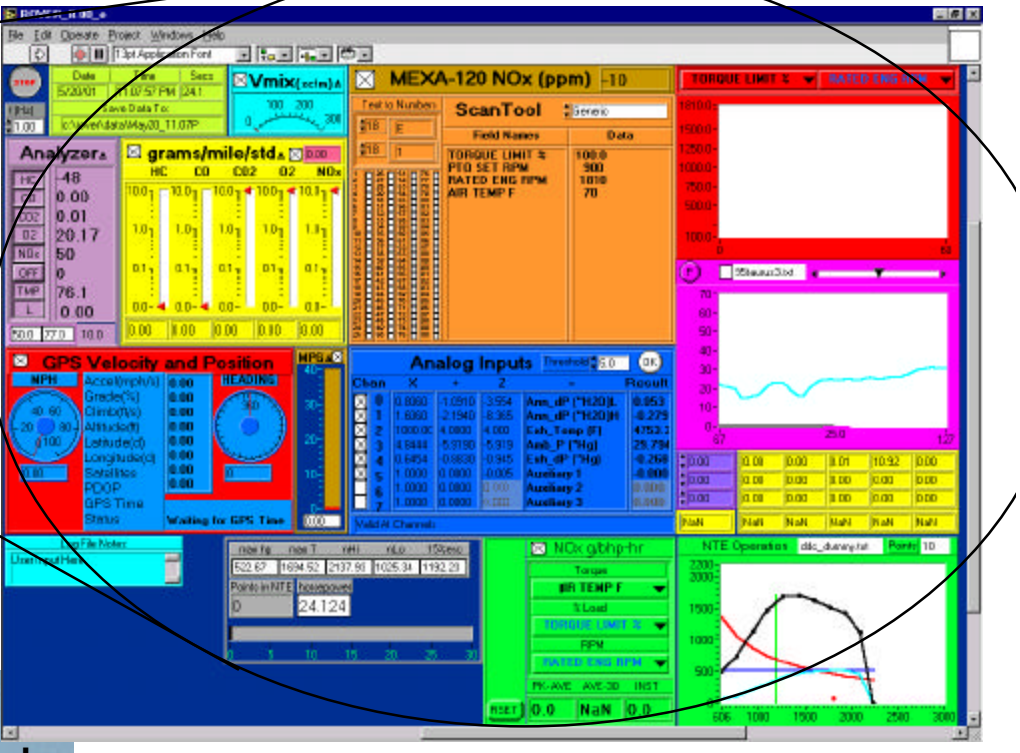


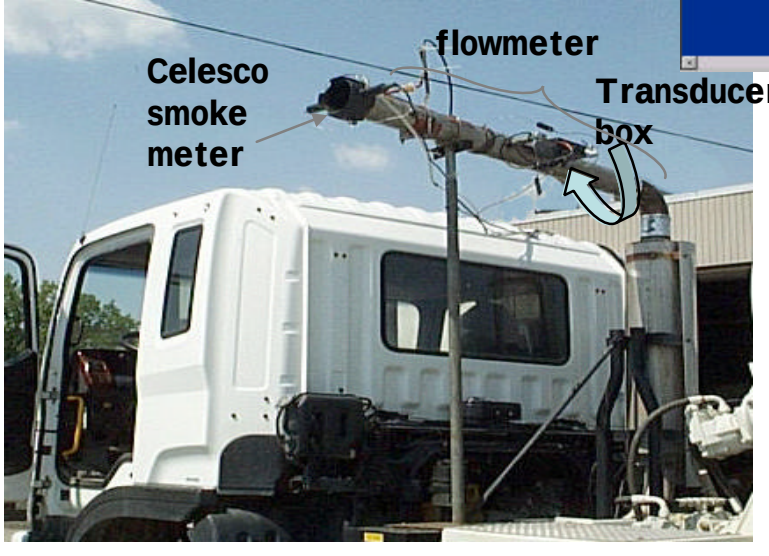
- Not-To-Exceed (NTE) test procedure
  - Covers broad range of real world operating conditions
  - Enables engine to be tested in trucks on the road
  - Required by consent decrees, 2007 regulations

Test Trucks

- Trucks are outfitted with ROVER, then tested during actual in-use service or other driving typical of normal operation
- Trucks limited to engines with Engine Control Modules that broadcast speed & torque (in percent load or lb-ft) data
- Source of trucks: Private companies, government agencies, truck rental companies, and private individuals.
- NOx results compared to NTE limits
- U. S. Army's Aberdeen Test Center (ATC) sets up ROVER and conducts testing through an Interagency Agreement with EPA





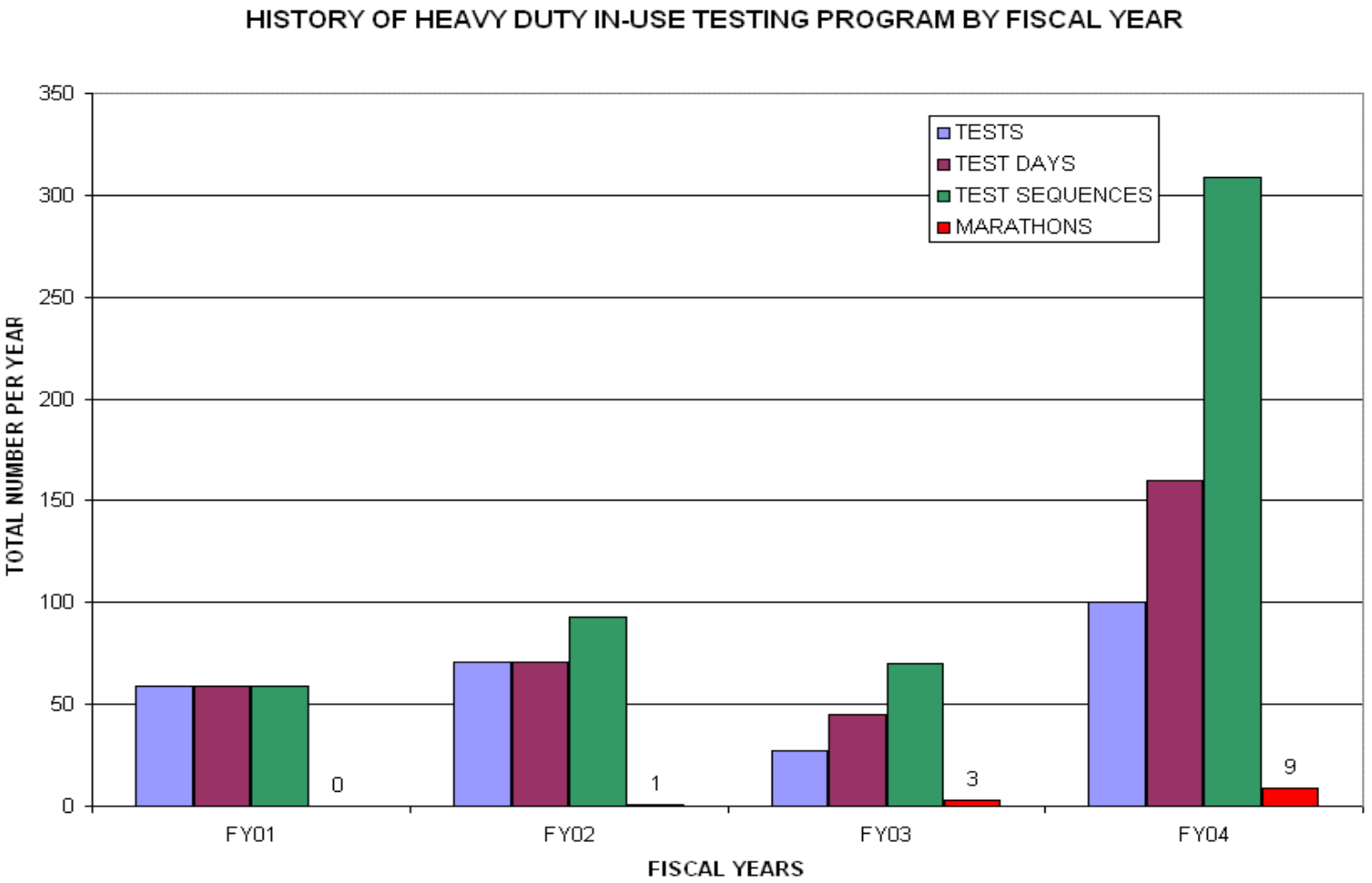


ROVER

U.S. Environmental Protection Agency's
Real-time On-road Vehicle Emissions Reporter

History of the EPA In-Use Test Program

- In 2001, one truck per engine family was tested to canvass the fleet
- Since then, program has expanded to included repeat testing of same family and longer term testing during marathon runs from Aberdeen, MD to/from Denver, CO
- Chart shows growth of program over time
- Limited pilot tests performed on NR equipment each year.


HISTORY OF HEAVY DUTY IN-USE TESTING PROGRAM BY FISCAL YEAR
TOTAL NUMBER PER YEAR
350
300
250
200
150
100
50
0
TESTS
TEST DAYS
TEST SEQUENCES
MARATHONS
0
1
3
9
FY01
FY02
FY03
FY04
FISCAL YEARS

Today's Presentation

- Today will present test results from a loop near Aberdeen, MD and same truck on a Marathon test run
- Will look at variety of issues to show why Agency likes this type of testing and feels it is a powerful tool
  - Background information/pictures (typical)
  - NTE NOx results in variety of formats
  - General NOx results, BSFC, MPG, others

Marathon Testing

- Used ROVER system – gaseous pollutant concentrations, exhaust flow, & engine ECM give mass emissions, GPM, & G/bhp-hr, NOx NTE
- Manufacturer-supplied torque map & ECM-out % torque used to estimate torque
- NOx from Horiba Mexa model 120
- Data analyzed and recorded once per second
- No PM measured

Marathon Analysis

- Sampling periods include engine idling
- Some data deleted due to analyzer sample line freeze-ups
- NOx NTE values based on standard 30 second rolling average periods, with no carve-outs or deficiencies applied
- The following parameters calculated based on totals of one-second in-zone operation periods:
  - NTE zone grams
  - grams/mile
  - grams/bhp-hr
  - % time in/out NTE

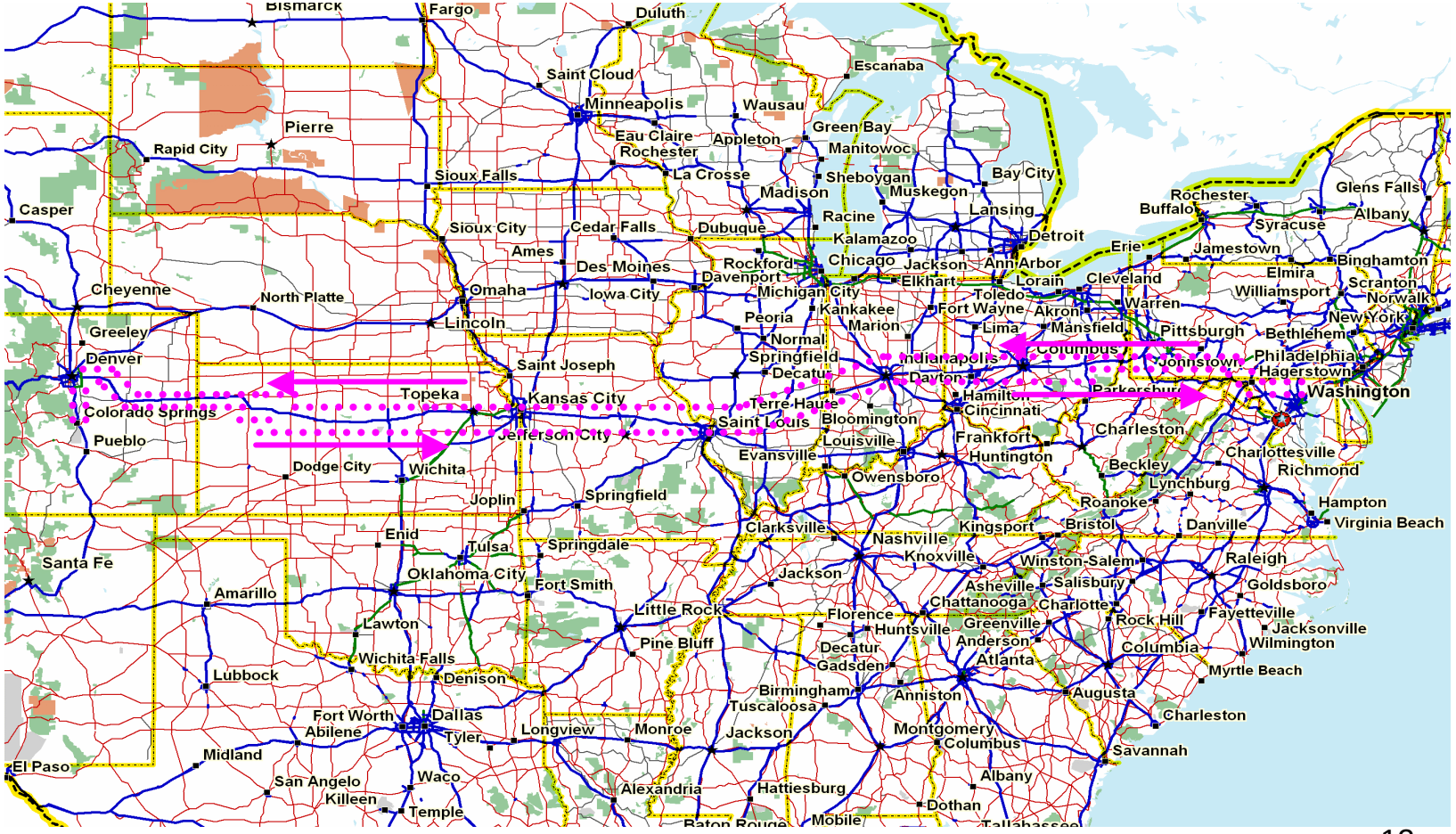
Marathon, Test Truck and Trailer Description

- MY 04 diesel engine, approximately 12 liter displacement
- Class 8, tandem axle, 80,000 lb. GVWR
- Total tractor + trailer weight = 60,000 lbs.
- 10 speed manual transmission
- 5 inch diameter single exhaust pipe
- Starting odometer 877 miles

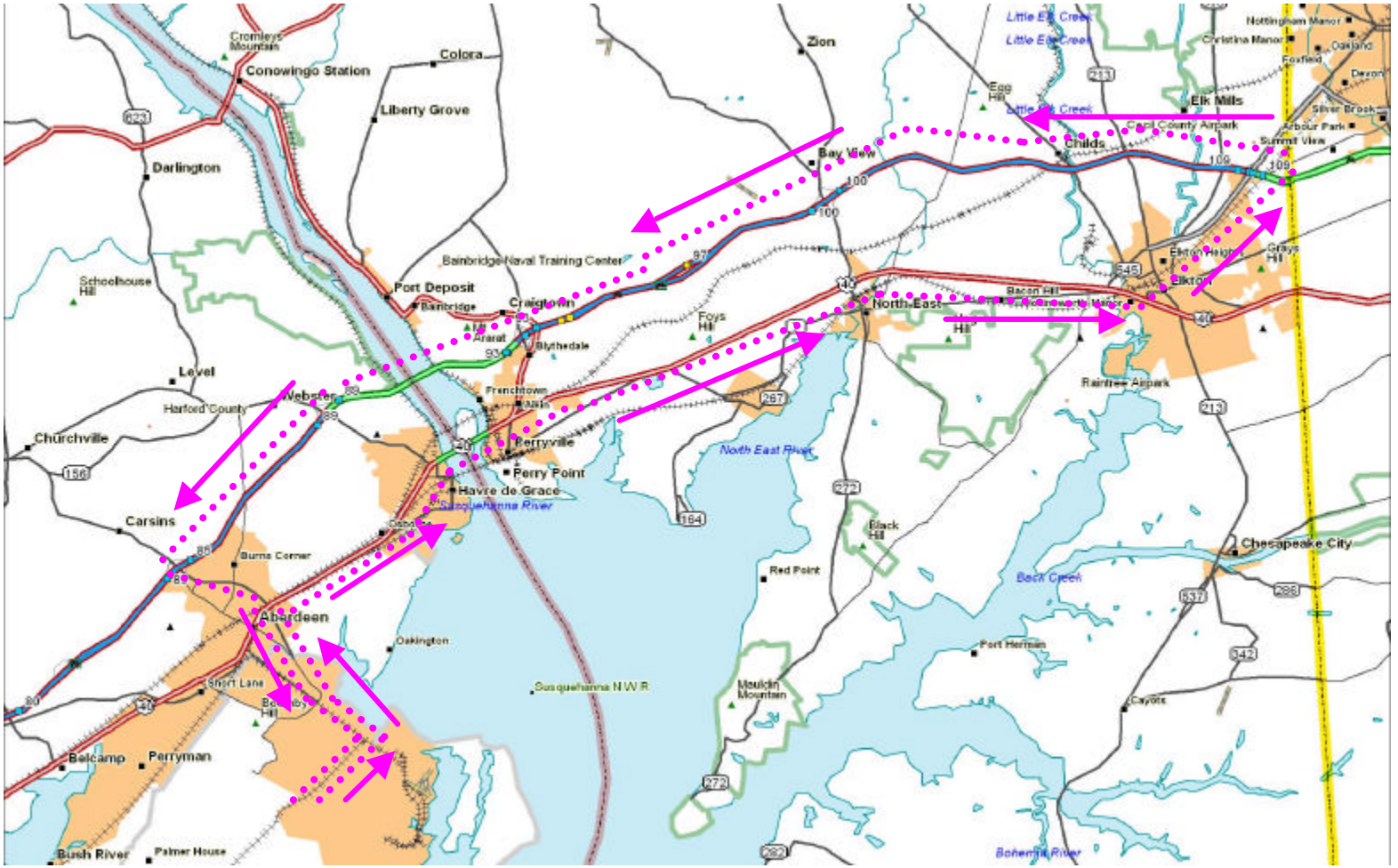
Description of Heavy Duty In-use Test Routes

	APG Loop	Marathon Route
Type of route	Maryland - Local	Aberdeen, MD to Denver, CO area and return
Traffic conditions	Mixed city & expressway	Mostly expressway
Roundtrip distance & time	68 miles, 2.5 hours	3500 miles, 67 hours
Average speed	31 miles per hour	54 miles per hour
Dates	Jan 23, 2004 & Feb 2, 2004	Jan 26 – Jan 31, 2004

Marathon #8 Route

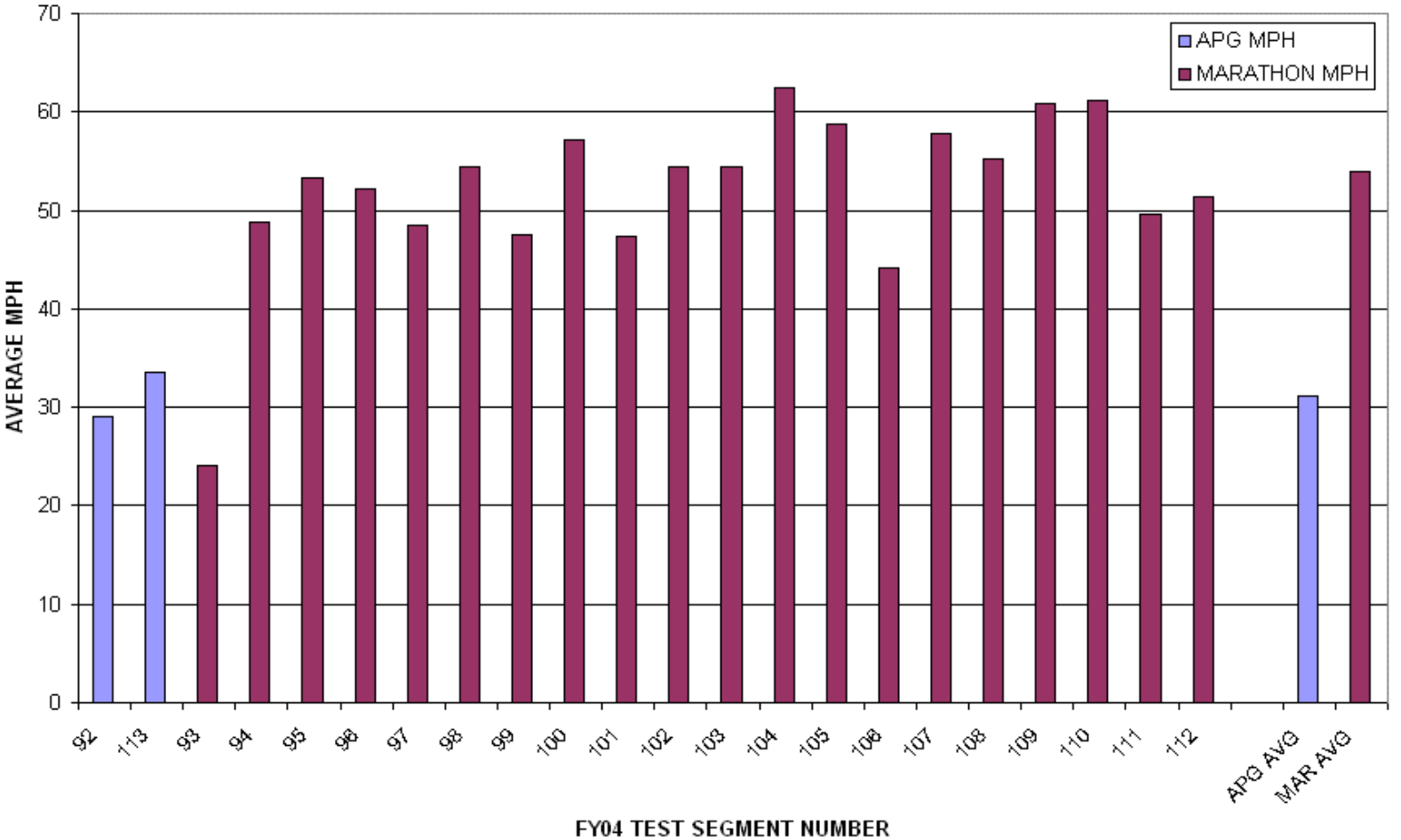


APG Loop

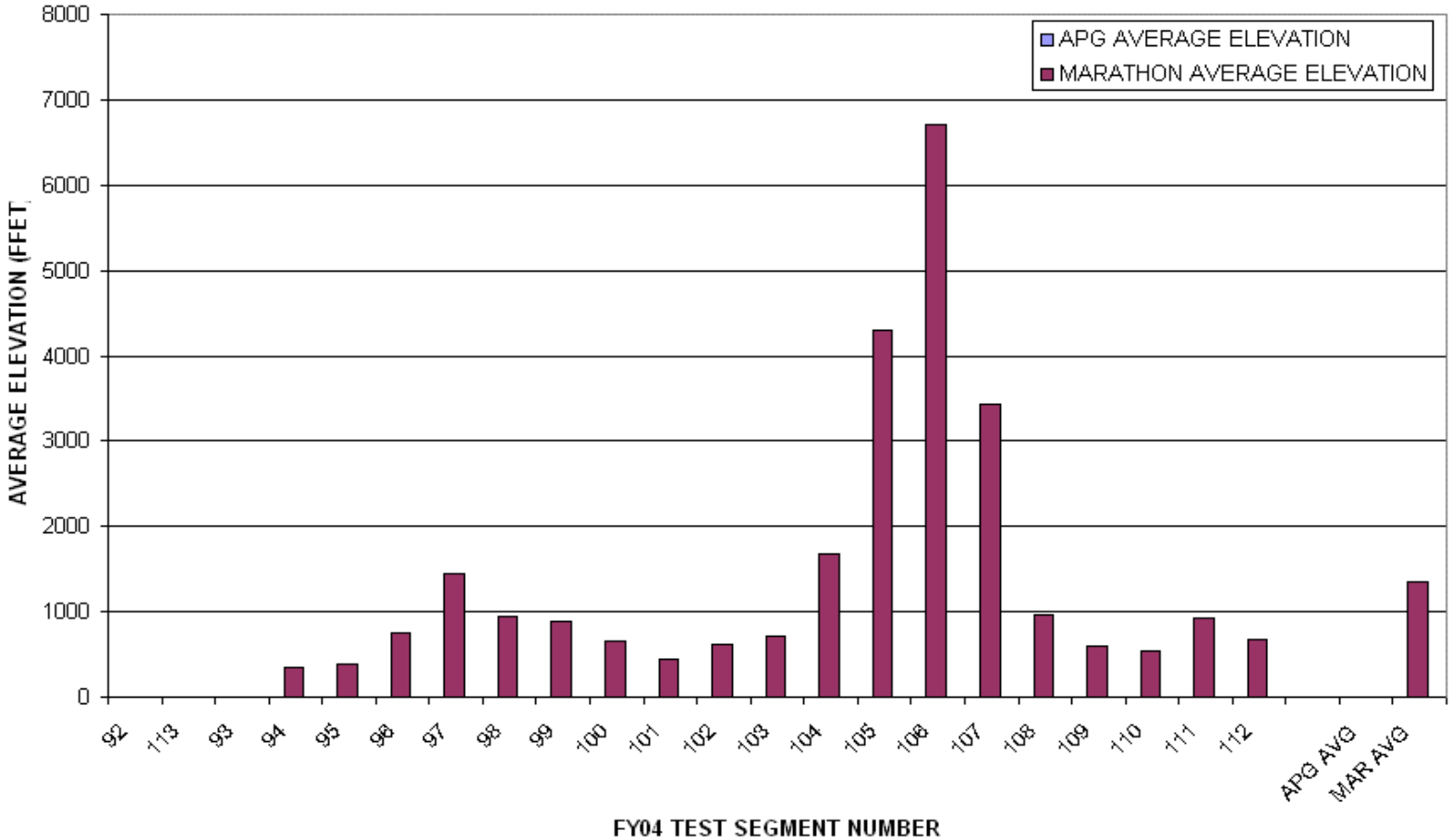

Cromleys Mountain
Conowingo Station
Colora
Liberty Grove
Darlington
Zion
Little Elk Creek
Nottingham Manor
Christina Manor
Oakland
Foxfield
Devon
Egg Hill
Elk Mills
Silver Brook
Cecil County Airpark
Arbour Park
Childs
Bay View
Summit View
Bainbridge Naval Training Center
Schoolhouse Hill
Port Deposit
Bainbridge
Craigtown
Ararat
Blythedale
Foys Hill
North East
Bacon Hill
Elkton Heights
Grays Hill
Elkton
Level
Webster
Harford County
Frenchtown
Rainbow Acres
Churchville
Perryville
North East River
Perry Point
Havre de Grace
Susquehanna River
Carsins
Burns Corner
Aberdeen
Oakington
Short Lane
Susquehanna N.W.R.
Red Point
Black Hill
Chesapeake City
Back Creek
Port Herman
Maulkin Mountain
Cayots
Belcamp
Perryman
Bush River
Palmer House
Bohemia River


EMERGENCY
STOPPING
ONLY
5 7:57 AM

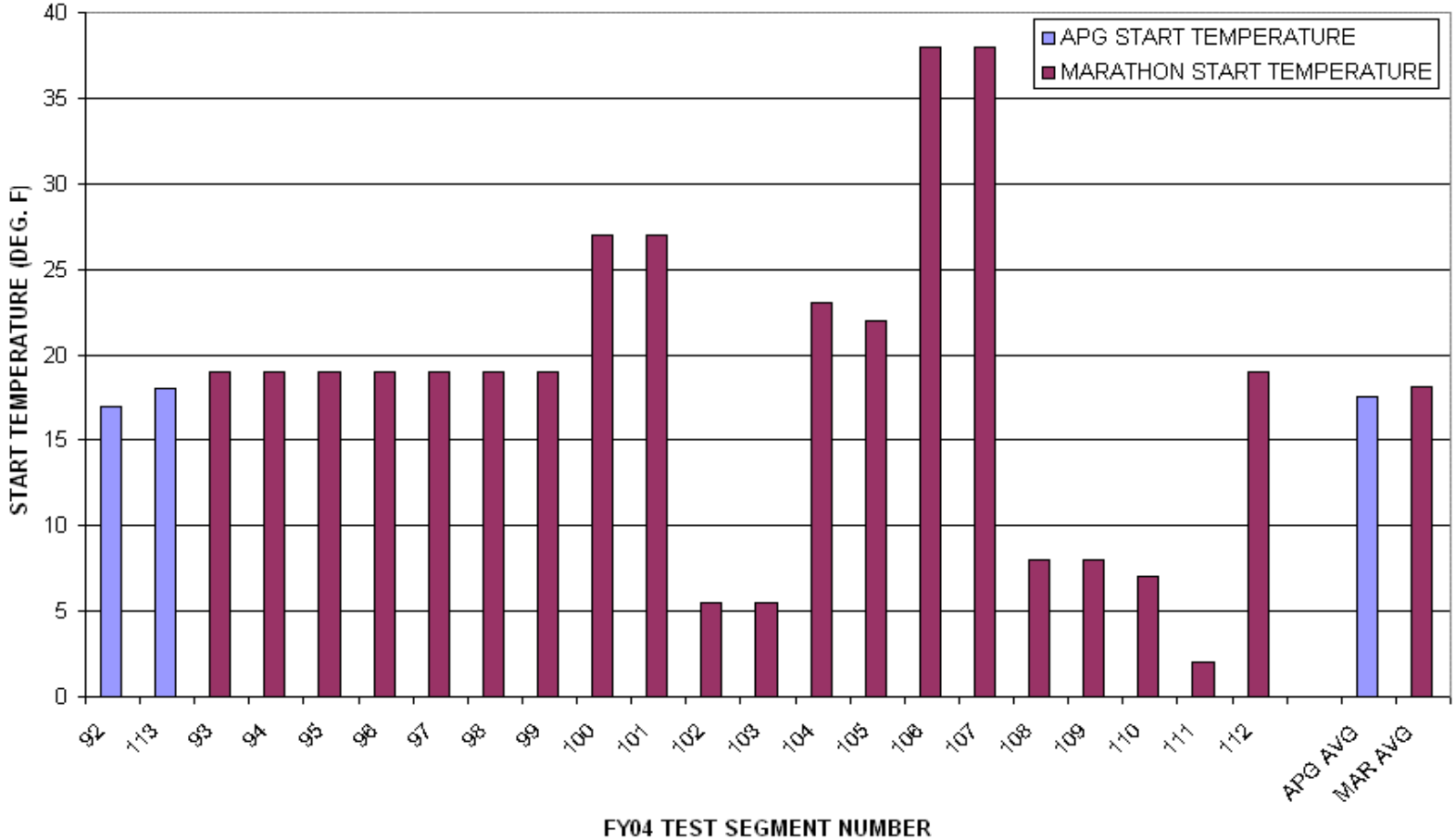
APG LOOP AND MARATHON - TEST SEGMENT AVERAGE MILES PER HOUR (MPH)



APG LOOP AND MARATHON - TEST SEGMENT AVERAGE ELEVATION (FEET)

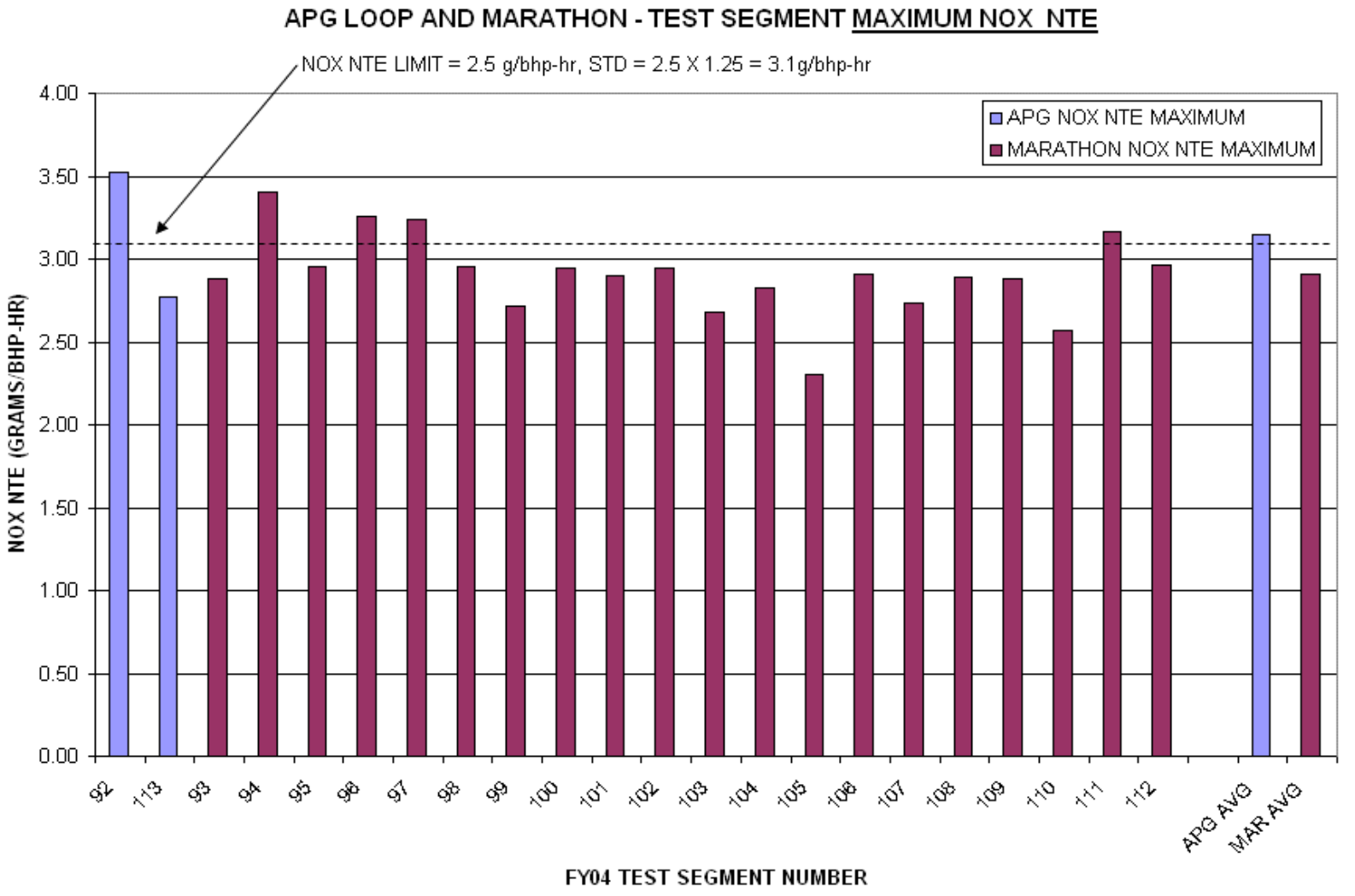


APG LOOP AND MARATHON - TEST SEGMENT START TEMPERATURE (DEG. F)

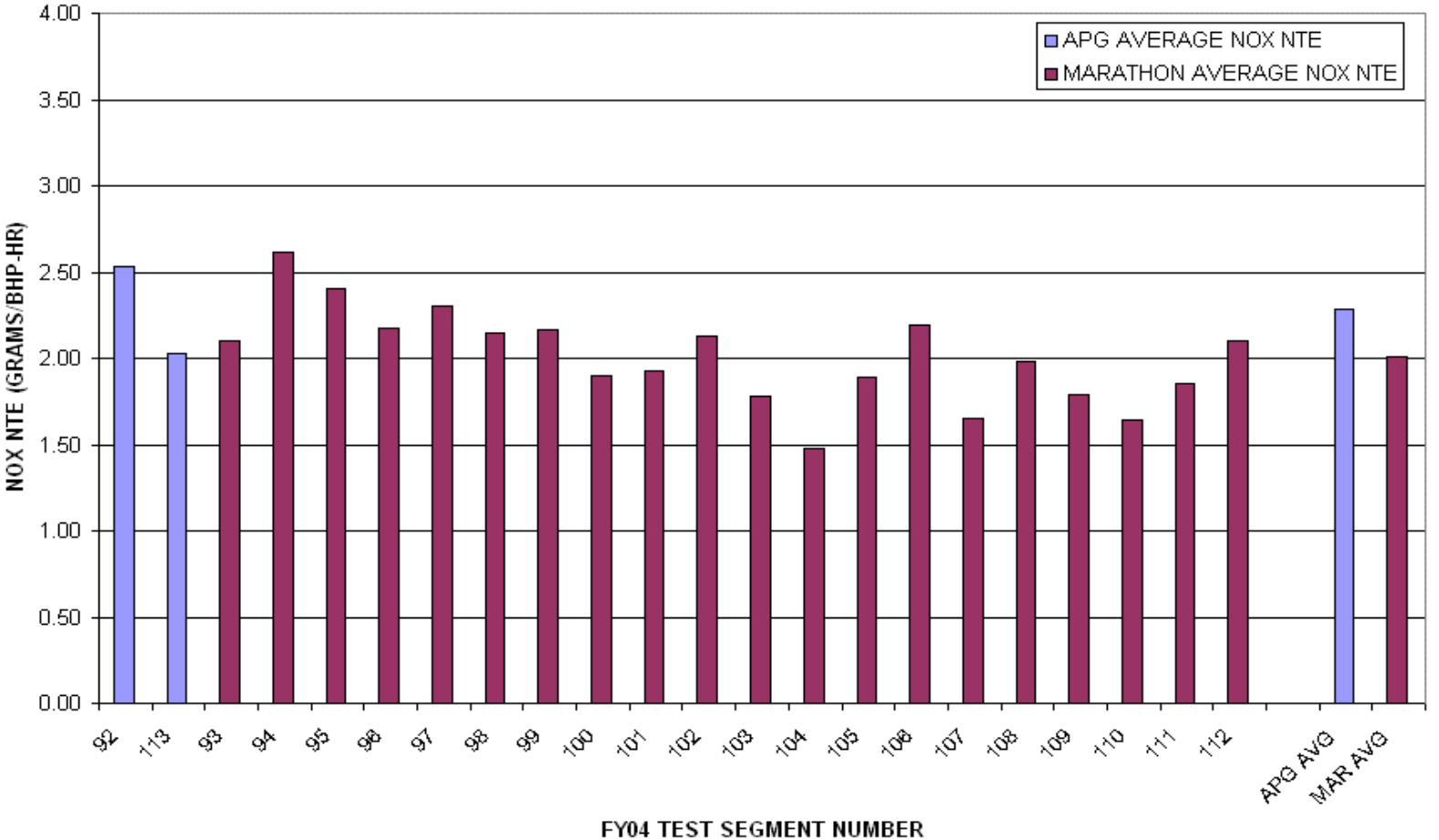


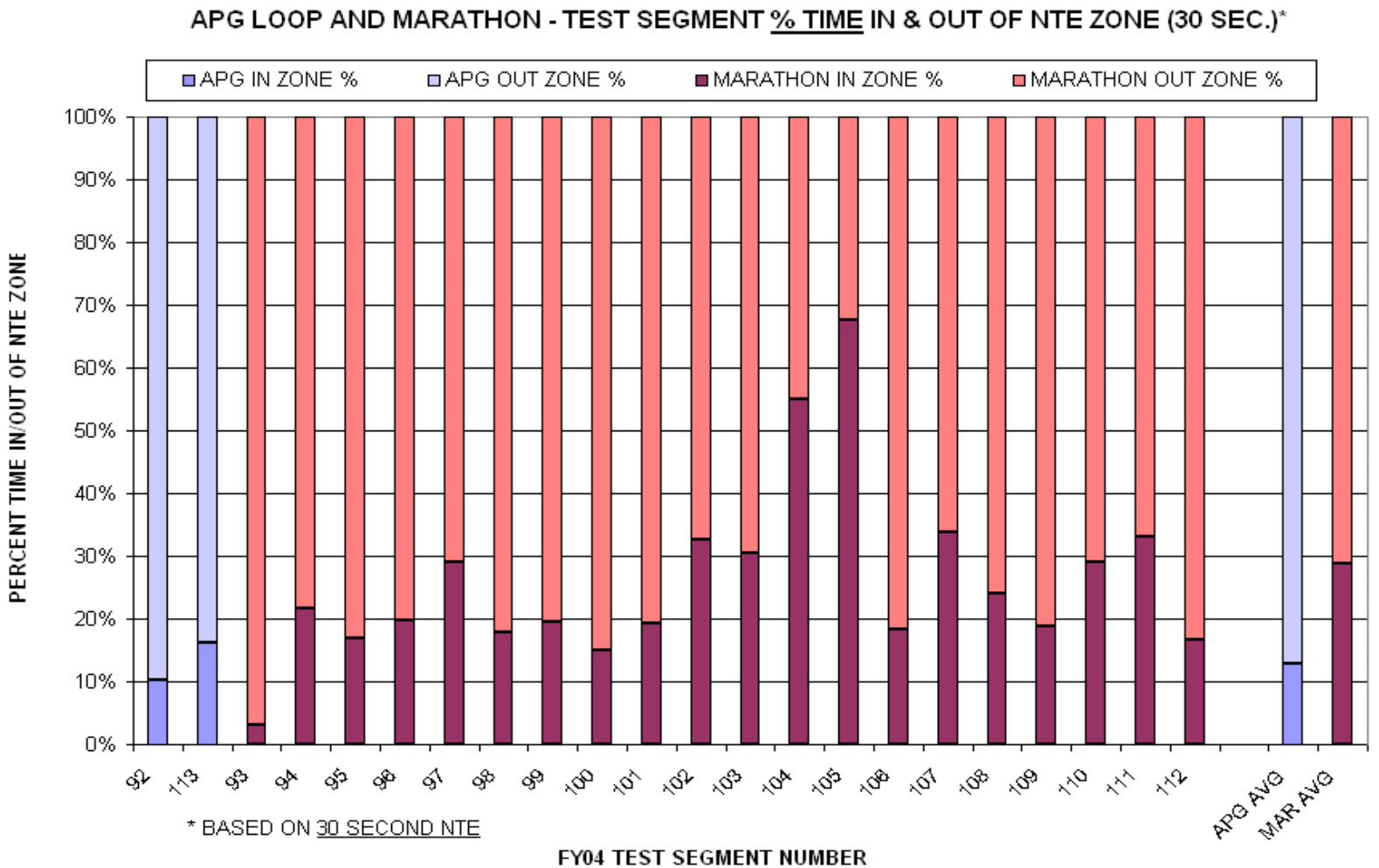
Start Location for Test Segment

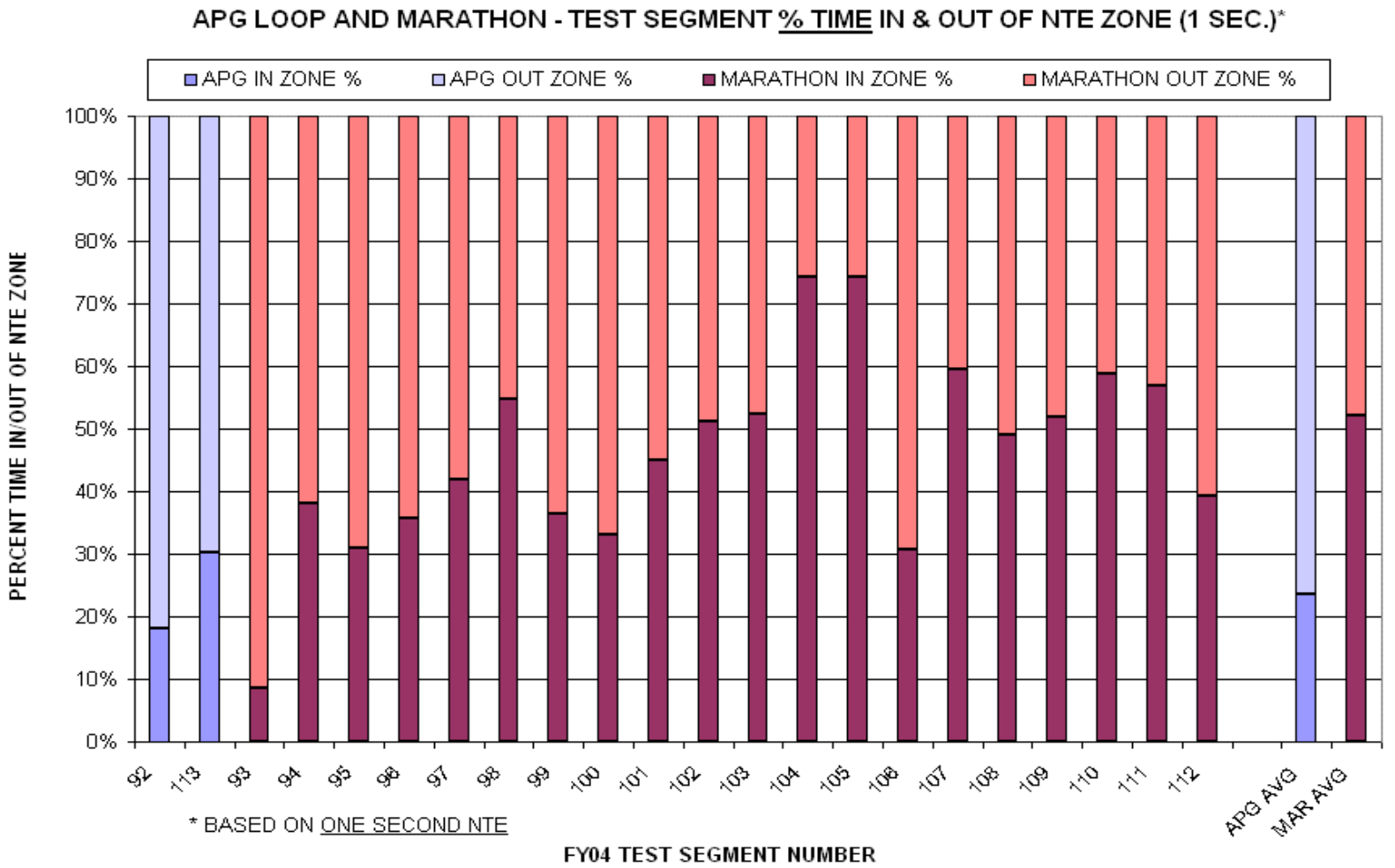
Sgmnt #	Start Location	# (cont.)	Start Location
92	APG, MD	102	St. Louis, MO
113	APG, MD	103	Fulton, MO
93	APG, MD	104	Lawrence, KN
94	Baltimore, MD	105	Colby, KN
95	Hagerstown, MD	106	Limon, CO
96	Big Springs, MD	107	CO. Springs, CO
97	Breezewood, PA	108	Abilene, KN
98	Yeager, PA	109	Blue Springs,MO
99	New Libson, OH	110	Greenville, IL
100	Indianapolis, IN	111	Indianapolis, IN
101	State Line IL/IN	112	Somerset, PA

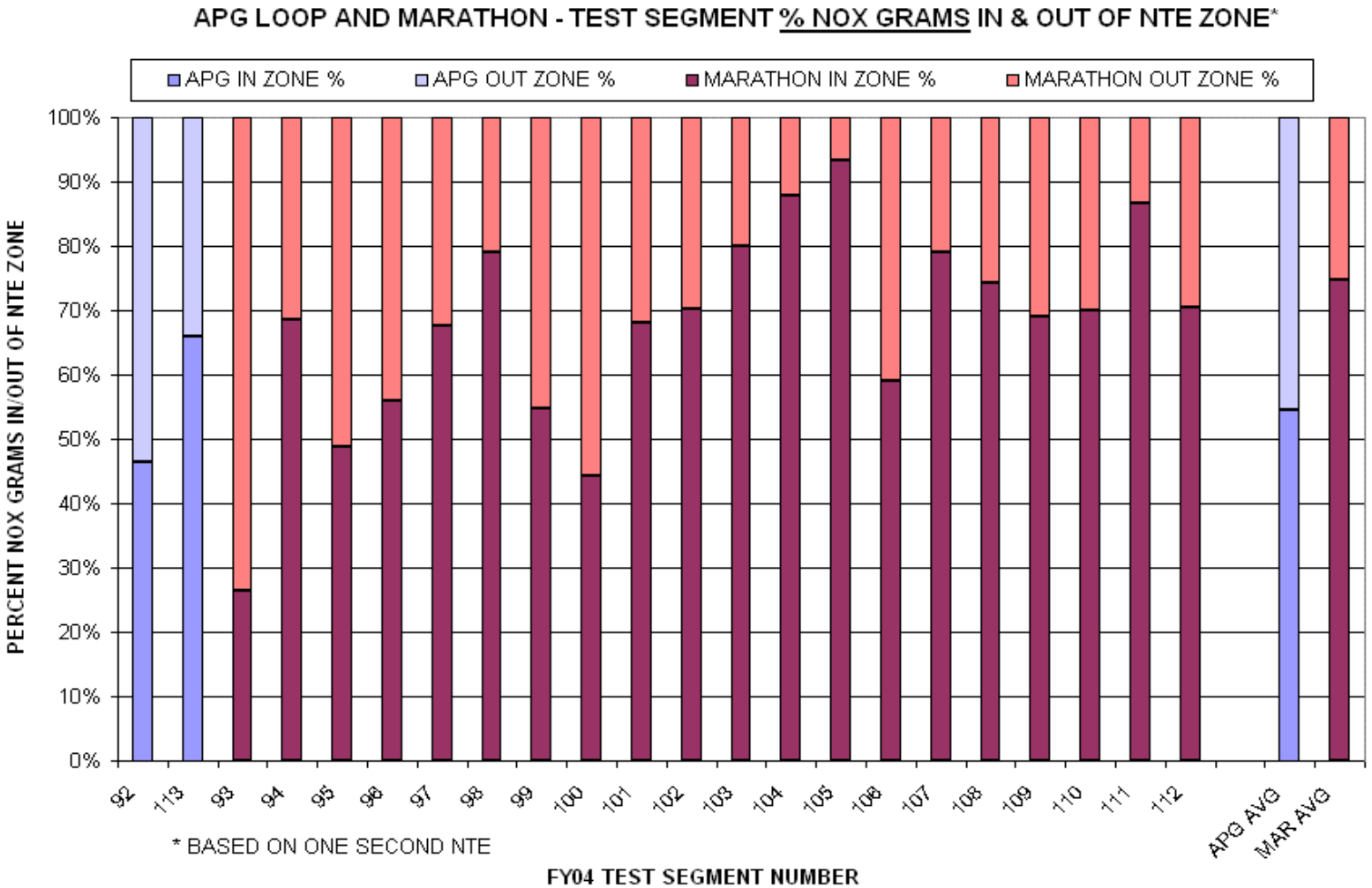

APG LOOP AND MARATHON - TEST SEGMENT MAXIMUM NOX NTE
NOX NTE LIMIT = 2.5 g/bhp-hr, STD = 2.5 X 1.25 = 3.1g/bhp-hr
APG NOX NTE MAXIMUM
MARATHON NOX NTE MAXIMUM
NOX NTE (GRAMS/BHP-HR)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
92
113
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
APG AVG
MAR AVG
FY04 TEST SEGMENT NUMBER

APG LOOP AND MARATHON - TEST SEGMENT AVERAGE NOX NTE

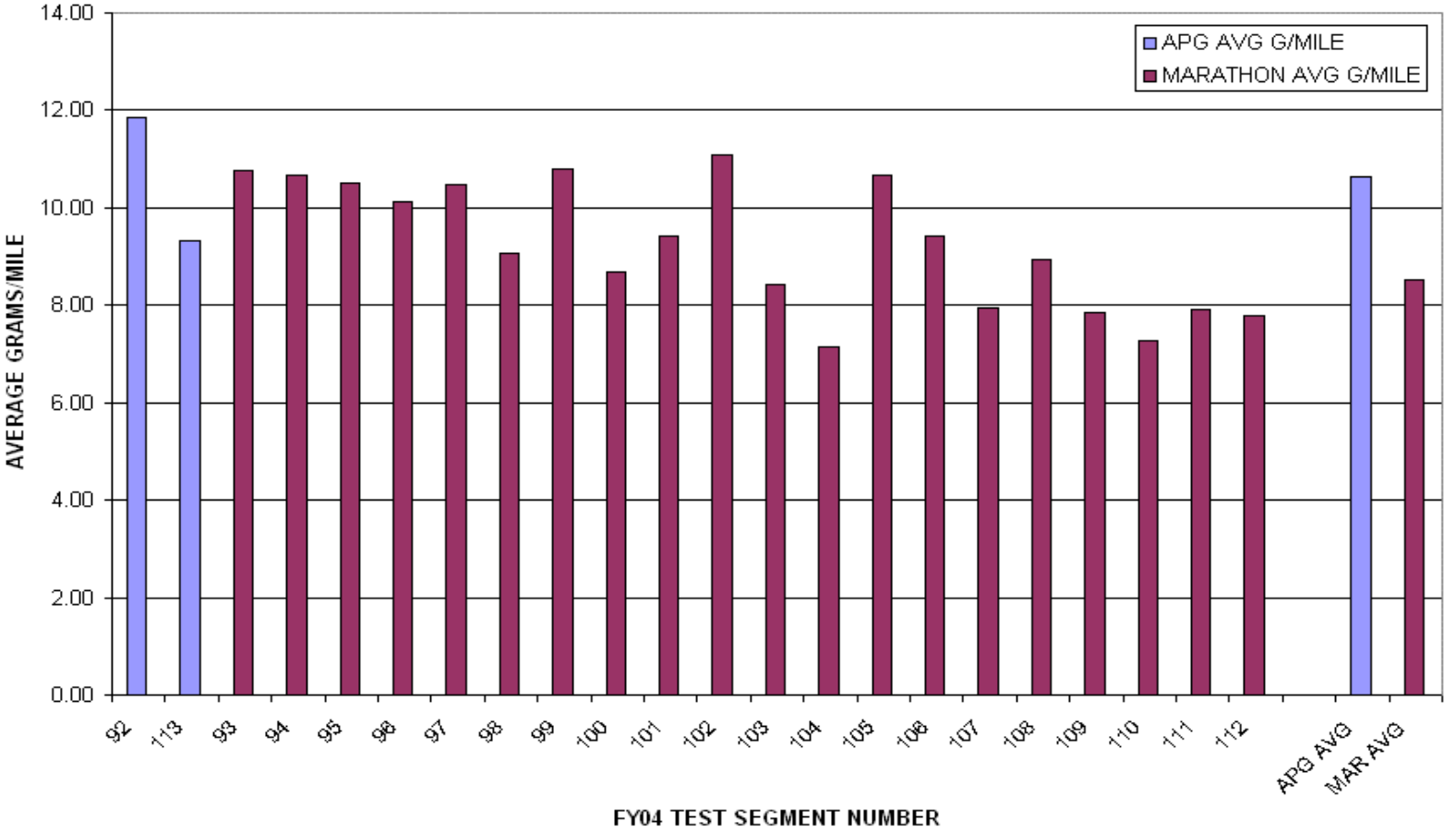


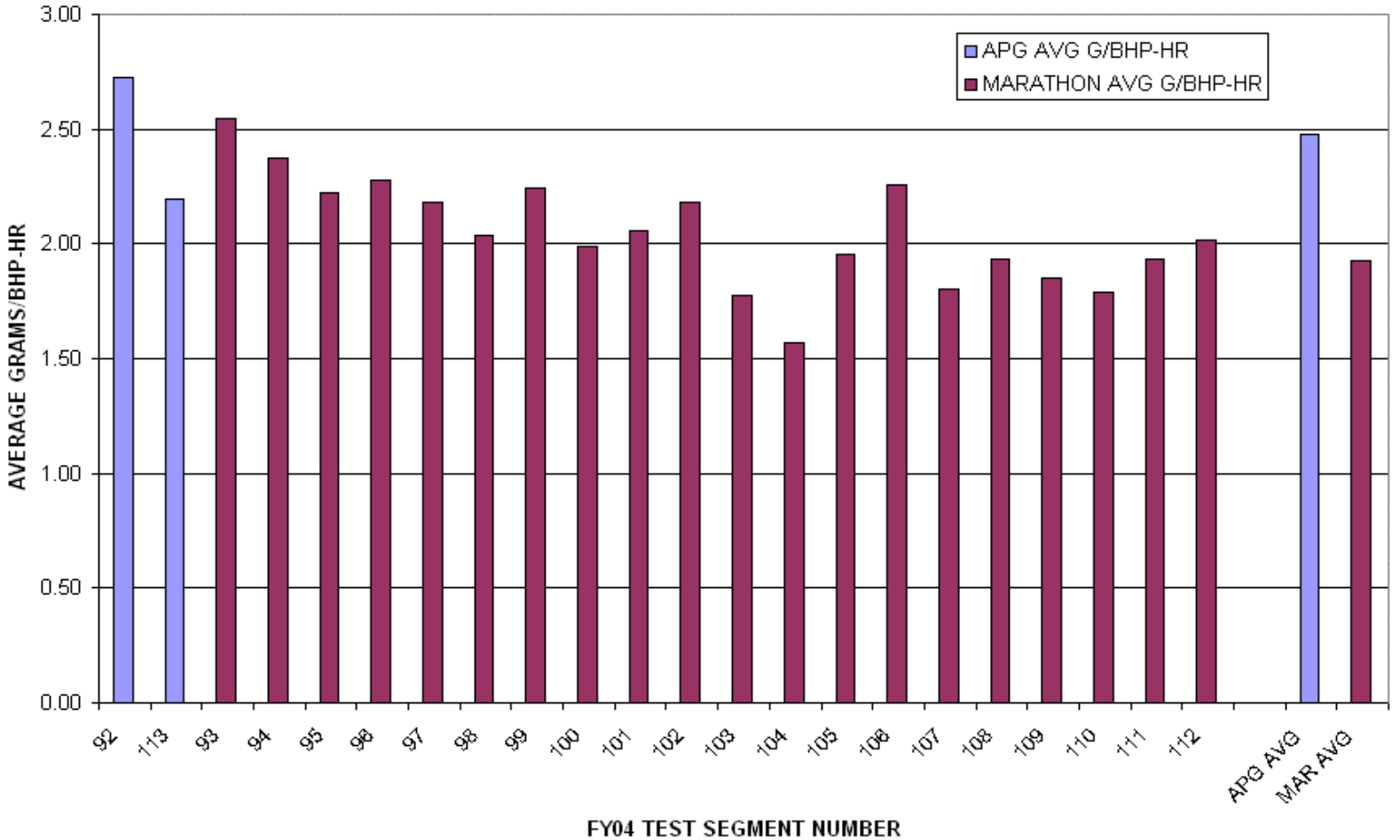

APG LOOP AND MARATHON - TEST SEGMENT % TIME IN & OUT OF NTE ZONE (30 SEC.)*
APG IN ZONE %
APG OUT ZONE %
MARATHON IN ZONE %
MARATHON OUT ZONE %
PERCENT TIME IN/OUT OF NTE ZONE
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
92
113
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
APG AVG
MAR AVG
* BASED ON 30 SECOND NTE
FY04 TEST SEGMENT NUMBER

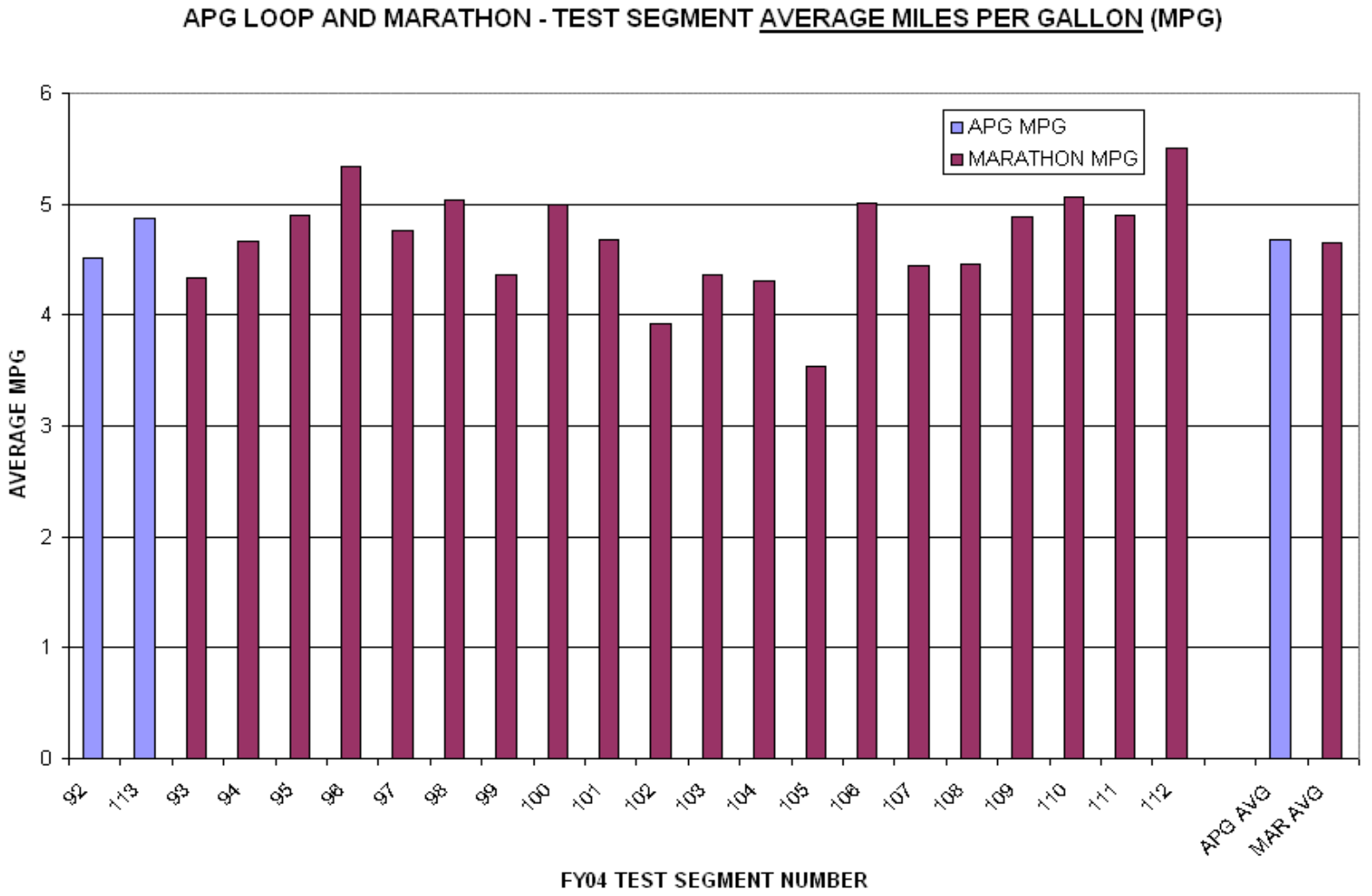

APG LOOP AND MARATHON - TEST SEGMENT % TIME IN & OUT OF NTE ZONE (1 SEC.)*
APG IN ZONE %
APG OUT ZONE %
MARATHON IN ZONE %
MARATHON OUT ZONE %
PERCENT TIME IN/OUT OF NTE ZONE
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
92
113
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
APG AVG
MAR AVG
* BASED ON ONE SECOND NTE
FY04 TEST SEGMENT NUMBER

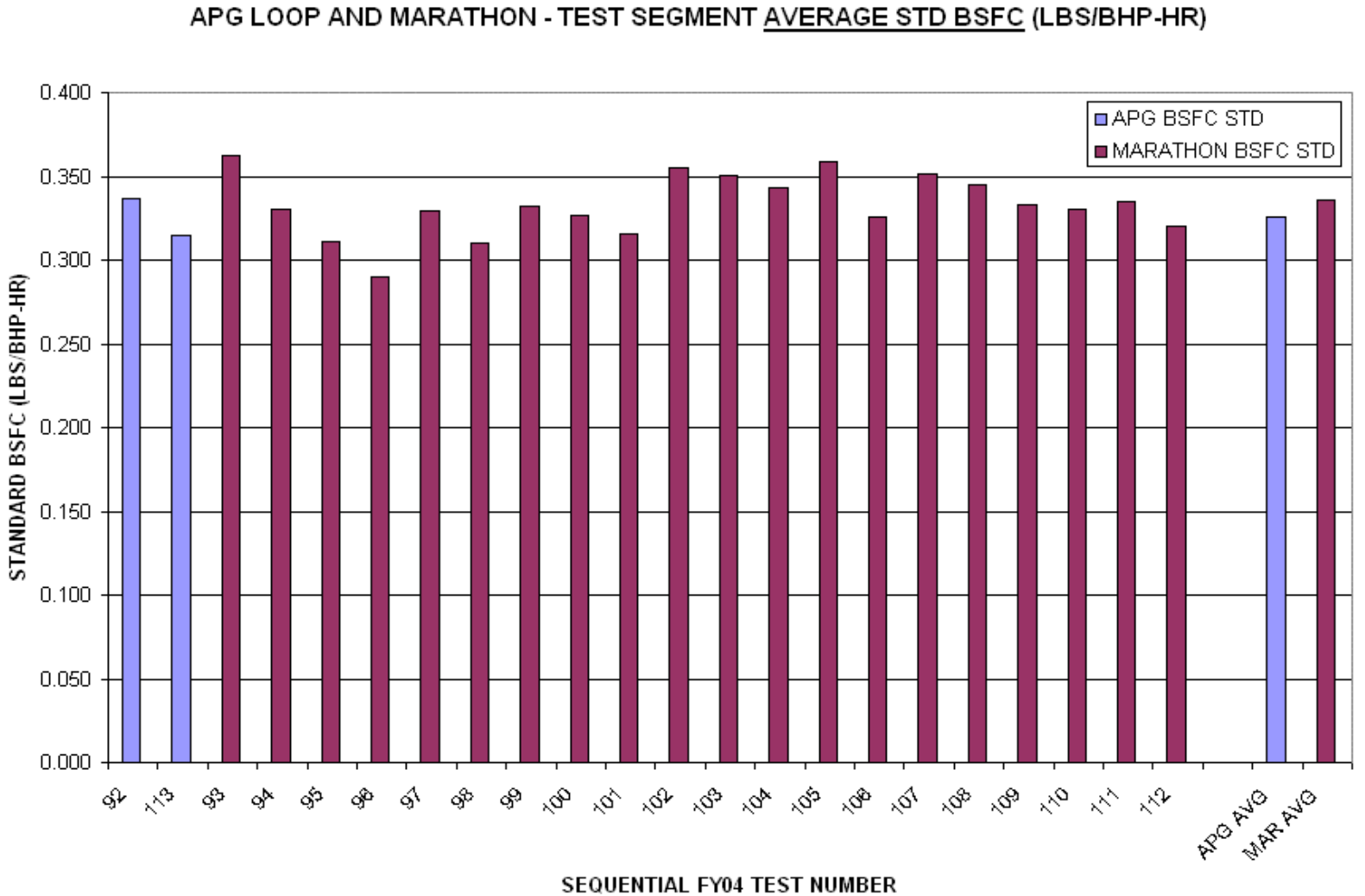

APG LOOP AND MARATHON - TEST SEGMENT % NOX GRAMS IN & OUT OF NTE ZONE*
APG IN ZONE %
APG OUT ZONE %
MARATHON IN ZONE %
MARATHON OUT ZONE %
PERCENT NOX GRAMS IN/OUT OF NTE ZONE
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
92
113
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
APG AVG
MAR AVG
* BASED ON ONE SECOND NTE
FY04 TEST SEGMENT NUMBER

APG LOOP AND MARATHON - TEST SEGMENT NOX AVERAGE GRAMS/MILE




APG LOOP AND MARATHON - TEST SEGMENT NOX AVERAGE GRAMS/BHP-HR
APG AVG G/BHP-HR
MARATHON AVG G/BHP-HR
AVERAGE GRAMS/BHP-HR
3.00
2.50
2.00
1.50
1.00
0.50
0.00
92
113
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
APG AVG
MAR AVG
FY04 TEST SEGMENT NUMBER


APG LOOP AND MARATHON - TEST SEGMENT AVERAGE MILES PER GALLON (MPG)
APG MPG
MARATHON MPG
AVERAGE MPG
0
1
2
3
4
5
6
92
113
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
APG AVG
MAR AVG
FY04 TEST SEGMENT NUMBER


APG LOOP AND MARATHON - TEST SEGMENT AVERAGE STD BSFC (LBS/BHP-HR)
APG BSFC STD
MARATHON BSFC STD
STANDARD BSFC (LBS/BHP-HR)
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
92
113
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
APG AVG
MAR AVG
SEQUENTIAL FY04 TEST NUMBER

Conclusions

- The NOx NTE, both on the APG loop and marathon, rarely exceeded the limit. (less than 9 minutes out of 63.4 hours or 0.2%) - Most segments of the marathon were below the NOx NTE limit.
- The emissions performance of the engine above 5,500 feet was quite good.
- The % of time the engine operated within the NTE zone varied greatly between test segments.
- The NOx grams/mile appeared to decrease over time which might have been due to the break-in of a new engine.
- Marathons provide a wider variations in test conditions: altitude, temperature, humidity, & terrain.

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