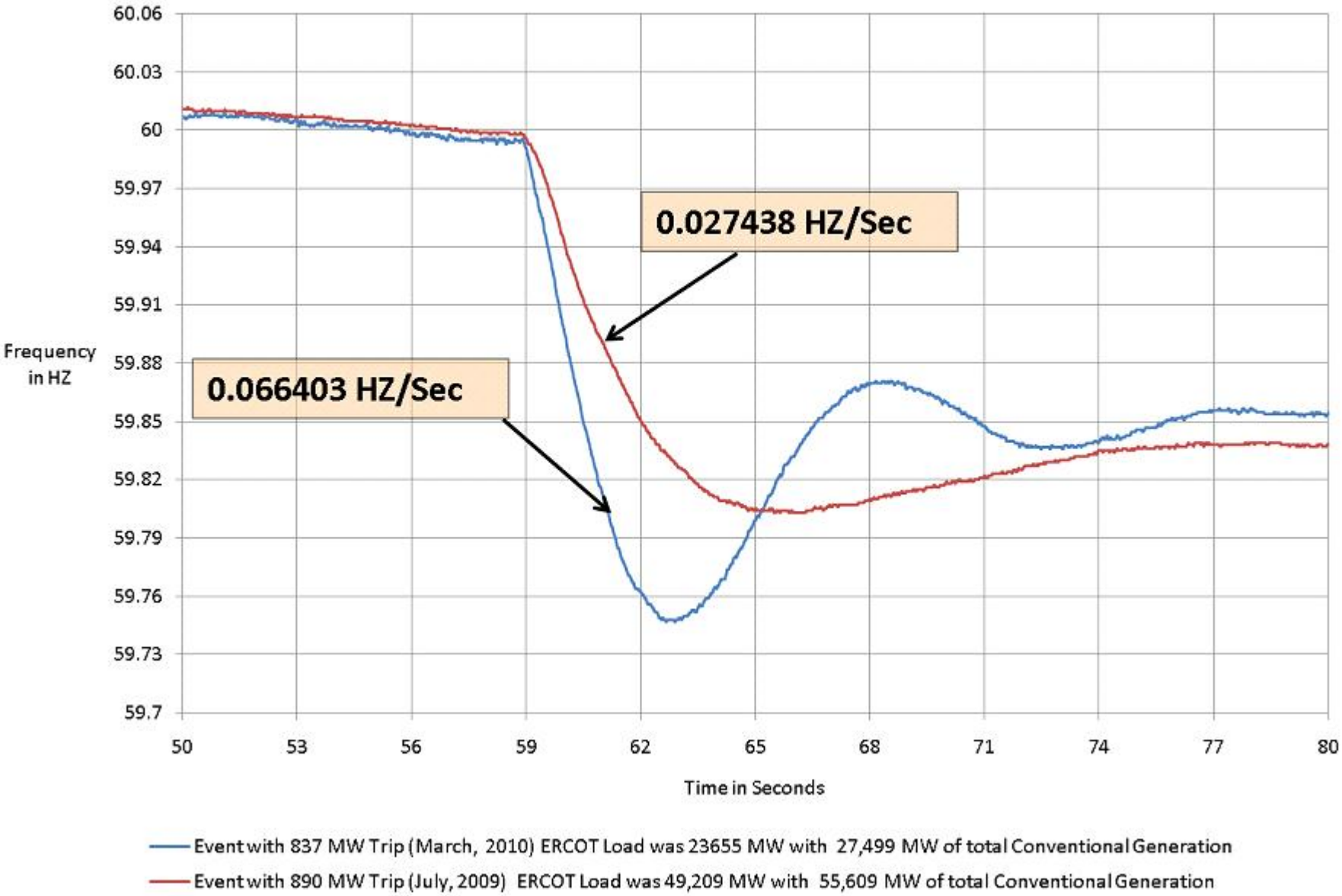
FERC Technical Conference Frequency Response September 23, 2010

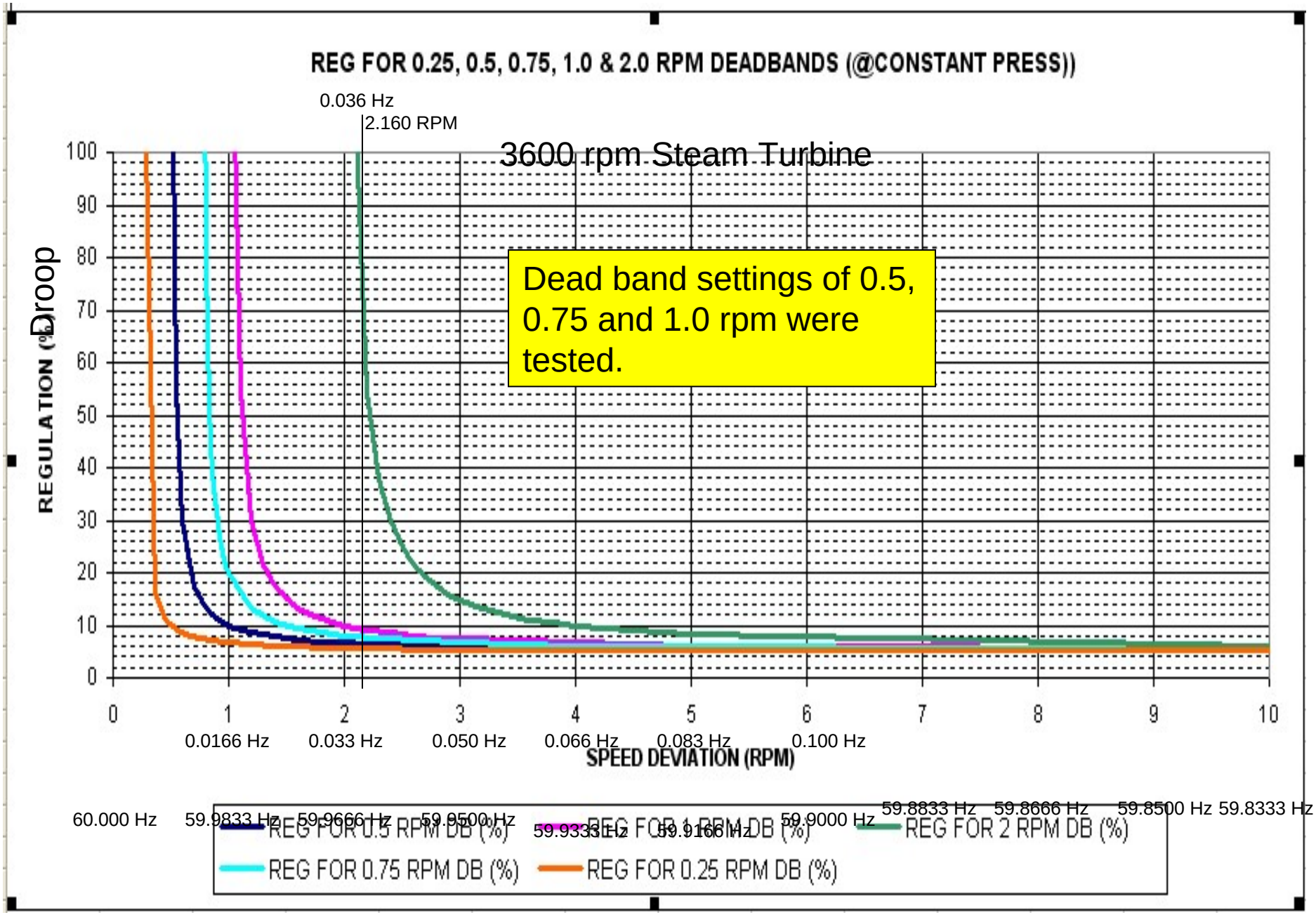
Submitted By:

Sydney L. Niemeyer – NRG Energy

Kenneth McIntyre - ERCOT

Depiction of Inertial Response





Dead band settings of 0.5, 0.75 and 1.0 rpm were tested.

Governor response is proportional at the dead-band reaching 5% at 3 Hz deviation

Frequency Deviation Hz	Grid Frequency Hz	Frequency Response MW	Droop %
-0.04000	59.96000	4.69287	8.52357%
-0.03900	59.96100	4.49175	8.68258%
-0.03800	59.96200	4.29064	8.85650%
-0.03700	59.96300	4.08952	9.04752%
-0.03600	59.96400	3.88840	9.25830%
-0.03500	59.96500	3.68728	9.49208%
-0.03400	59.96600	3.48617	9.75283%
-0.03300	59.96700	3.28505	10.04551%
-0.03200	59.96800	3.08393	10.37636%
-0.03100	59.96900	2.88281	10.75338%
-0.03000	59.97000	2.68170	11.18694%
-0.02900	59.97100	2.48058	11.69081%
-0.02800	59.97200	2.27946	12.28359%
-0.02700	59.97300	2.07835	12.99110%
-0.02600	59.97400	1.87723	13.85020%
-0.02500	59.97500	1.67611	14.91548%
-0.02400	59.97600	1.47499	16.27125%
-0.02300	59.97700	1.27388	18.05512%
-0.02200	59.97800	1.07276	20.50786%
-0.02100	59.97900	0.87164	24.09245%
-0.02000	59.98000	0.67052	29.82737%
-0.01900	59.98100	0.46941	40.47654%
-0.01800	59.98200	0.26829	67.09147%
-0.01700	59.98300	0.06717	100.00000%
-0.01600	59.98400	0.00000	100.00000%

Dead-band

0.01666 Hz Dead-Band

BAL-001-TRE-1 Implementation

Governor response "Steps" to the 5% droop curve at the dead-band

Frequency Deviation Hz	Grid Frequency Hz	Frequency Response MW	Droop %
-0.04000	59.96000	8.00000	5.00000%
-0.03900	59.96100	7.80000	5.00000%
-0.03800	59.96200	7.60000	5.00000%
-0.03700	59.96300	7.40000	5.00000%
-0.03600	59.96400	7.20000	5.00000%
-0.03500	59.96500	0.00000	100.00000%
-0.03400	59.96600	0.00000	100.00000%
-0.03300	59.96700	0.00000	100.00000%
-0.03200	59.96800	0.00000	100.00000%
-0.03100	59.96900	0.00000	100.00000%
-0.03000	59.97000	0.00000	100.00000%
-0.02900	59.97100	0.00000	100.00000%
-0.02800	59.97200	0.00000	100.00000%
-0.02700	59.97300	0.00000	100.00000%
-0.02600	59.97400	0.00000	100.00000%
-0.02500	59.97500	0.00000	100.00000%
-0.02400	59.97600	0.00000	100.00000%
-0.02300	59.97700	0.00000	100.00000%
-0.02200	59.97800	0.00000	100.00000%
-0.02100	59.97900	0.00000	100.00000%
-0.02000	59.98000	0.00000	100.00000%
-0.01900	59.98100	0.00000	100.00000%
-0.01800	59.98200	0.00000	100.00000%
-0.01700	59.98300	0.00000	100.00000%
-0.01600	59.98400	0.00000	100.00000%

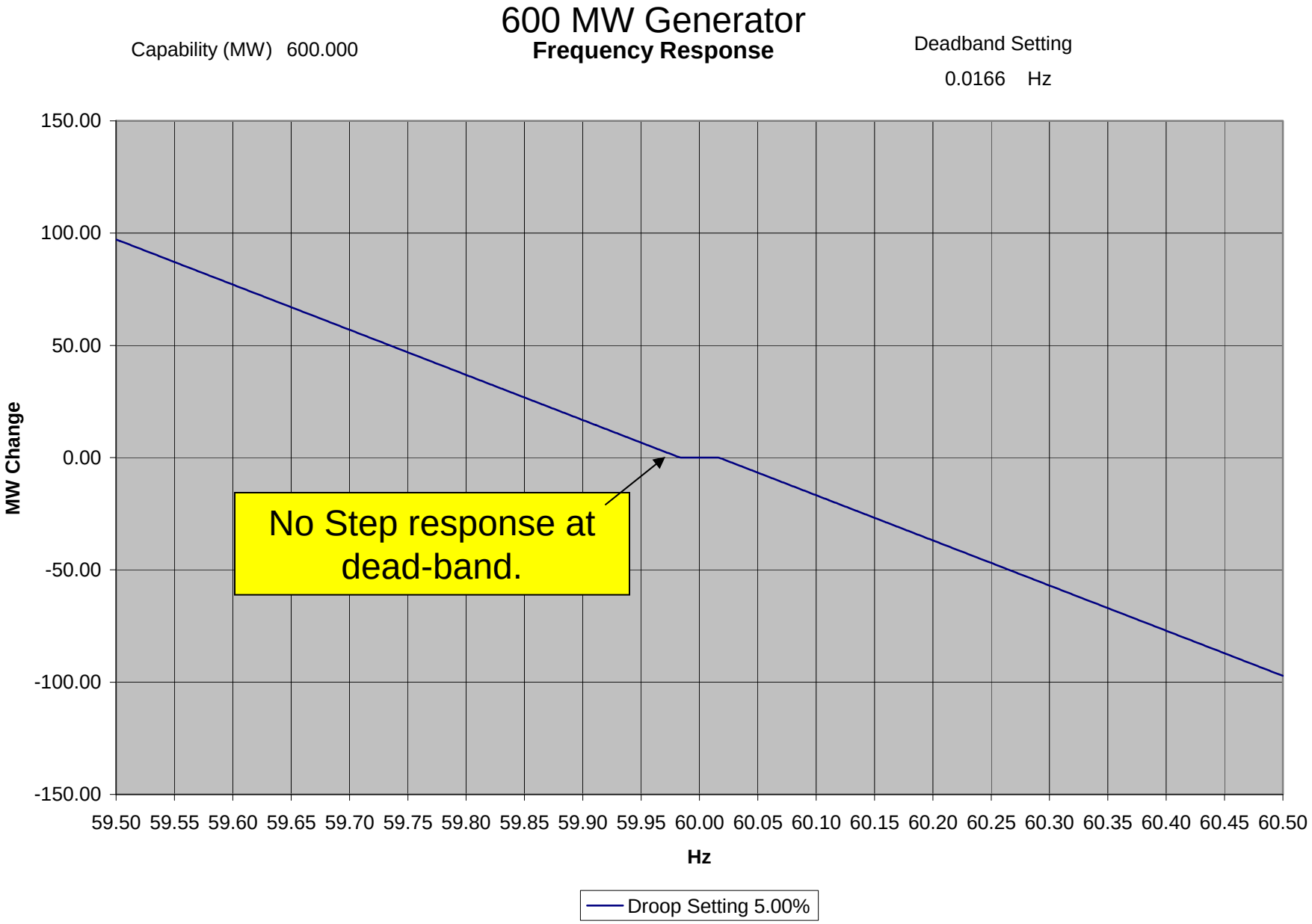
Dead-band

0.036 Hz Dead-Band

Common Industry Implementation

600 MW Steam Turbine 5% Droop Setting

Close up look at +/-0.0166 Hz Dead Band with No Step Implementation



Close up look at +/-0.036 Hz Dead Band with Step Implementation

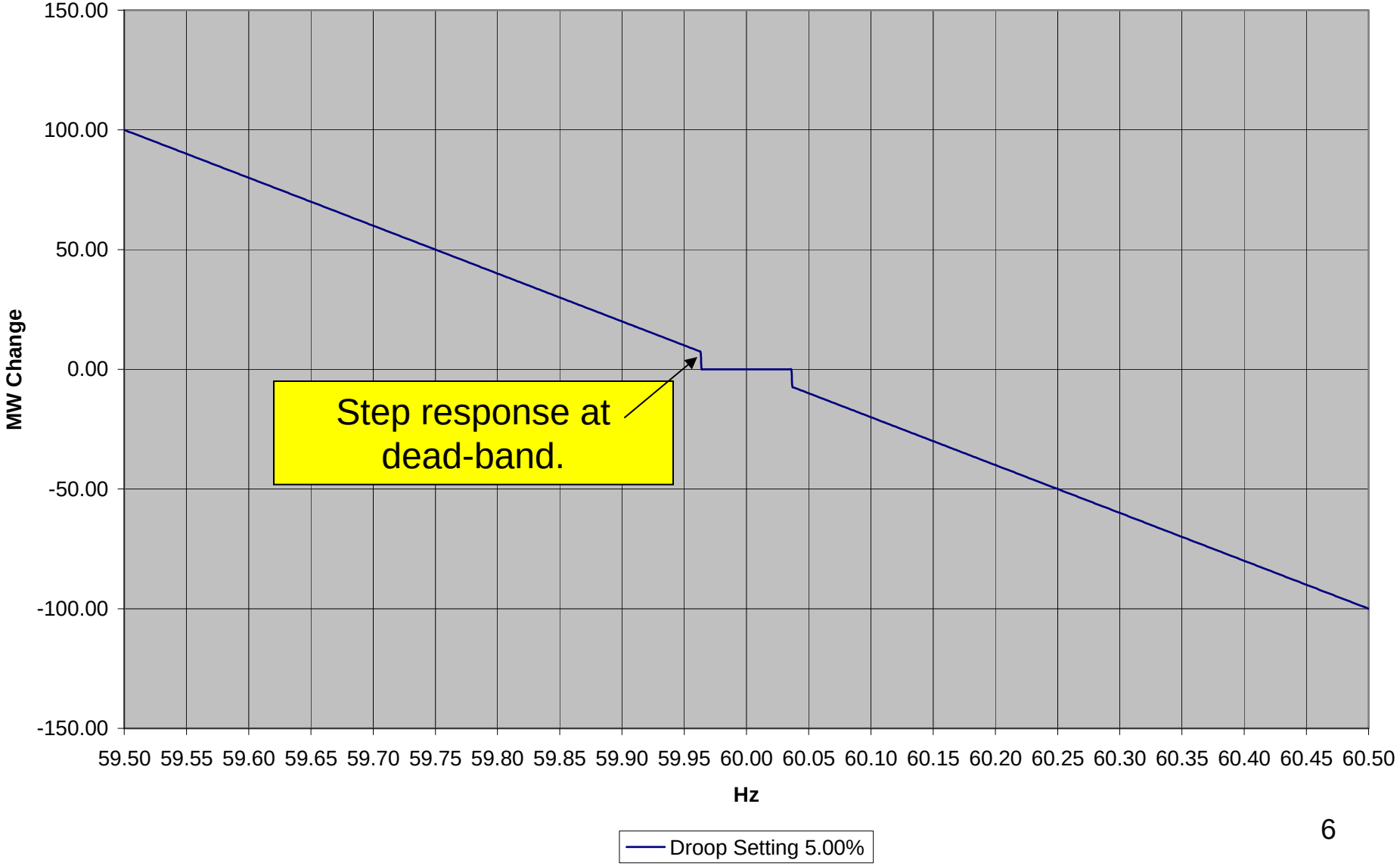
600 MW Generator

Capability (MW) 600.000

Frequency Response

Deadband Setting

0.036 Hz

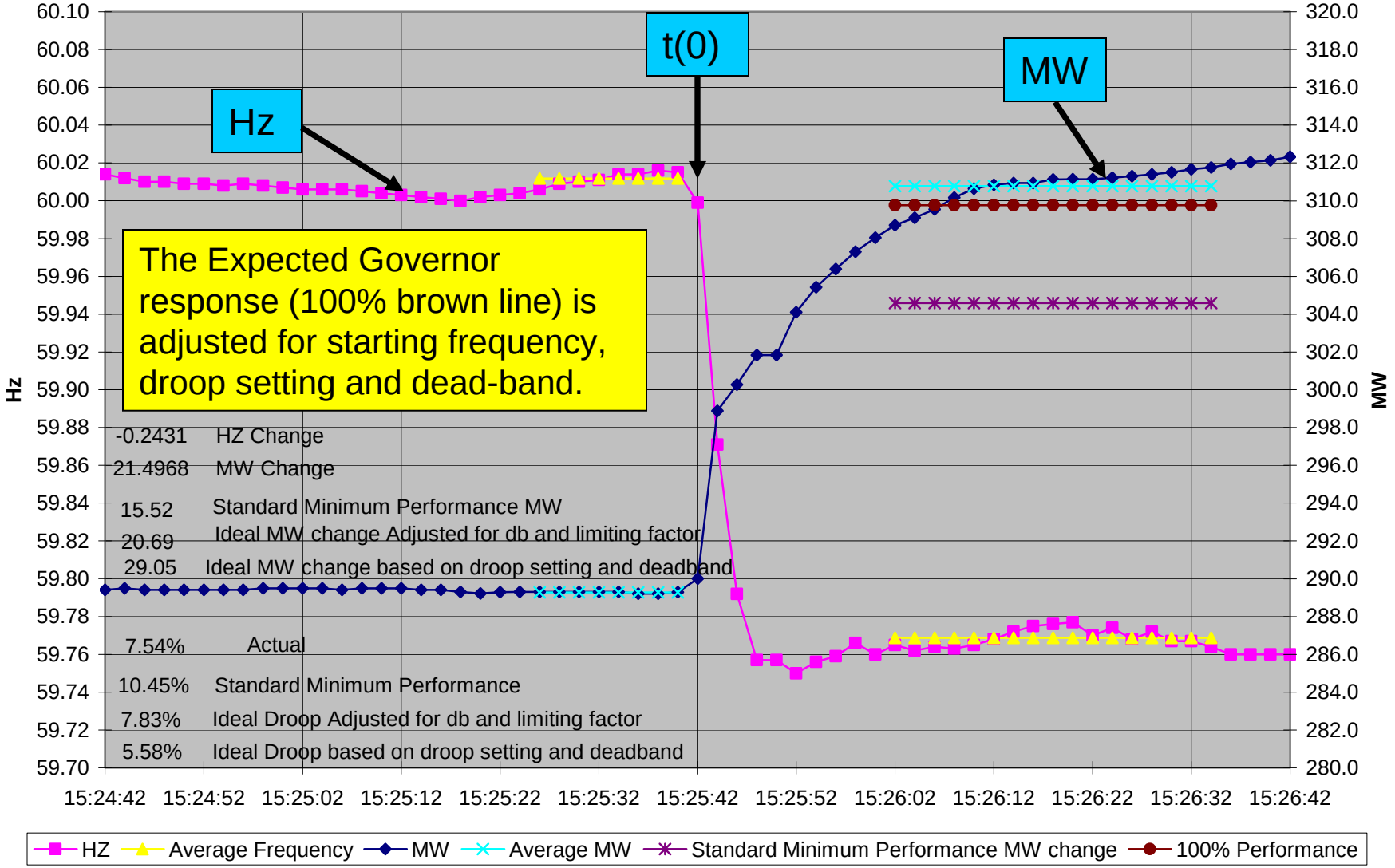


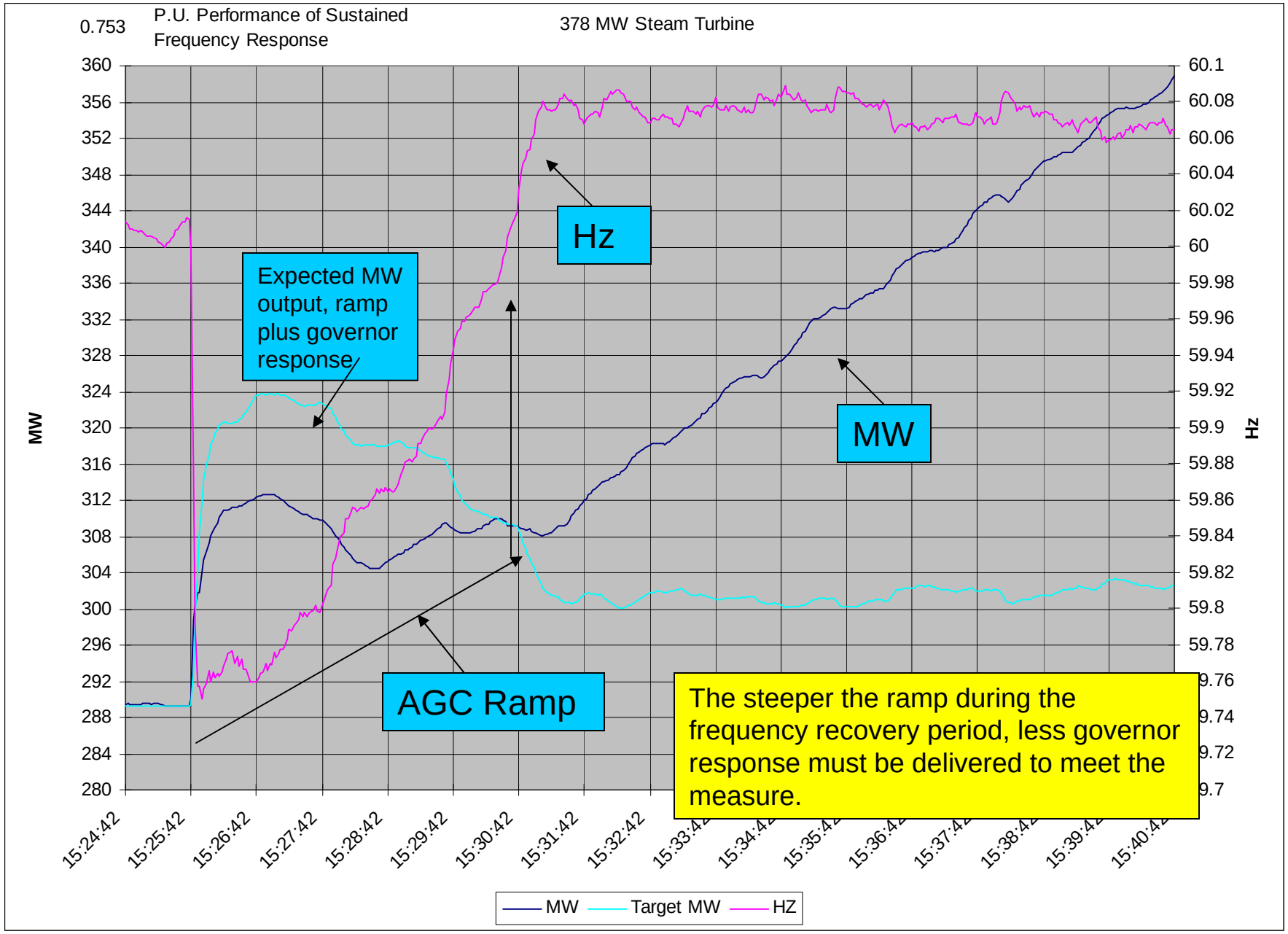
Initial P.U. Performance 1.04

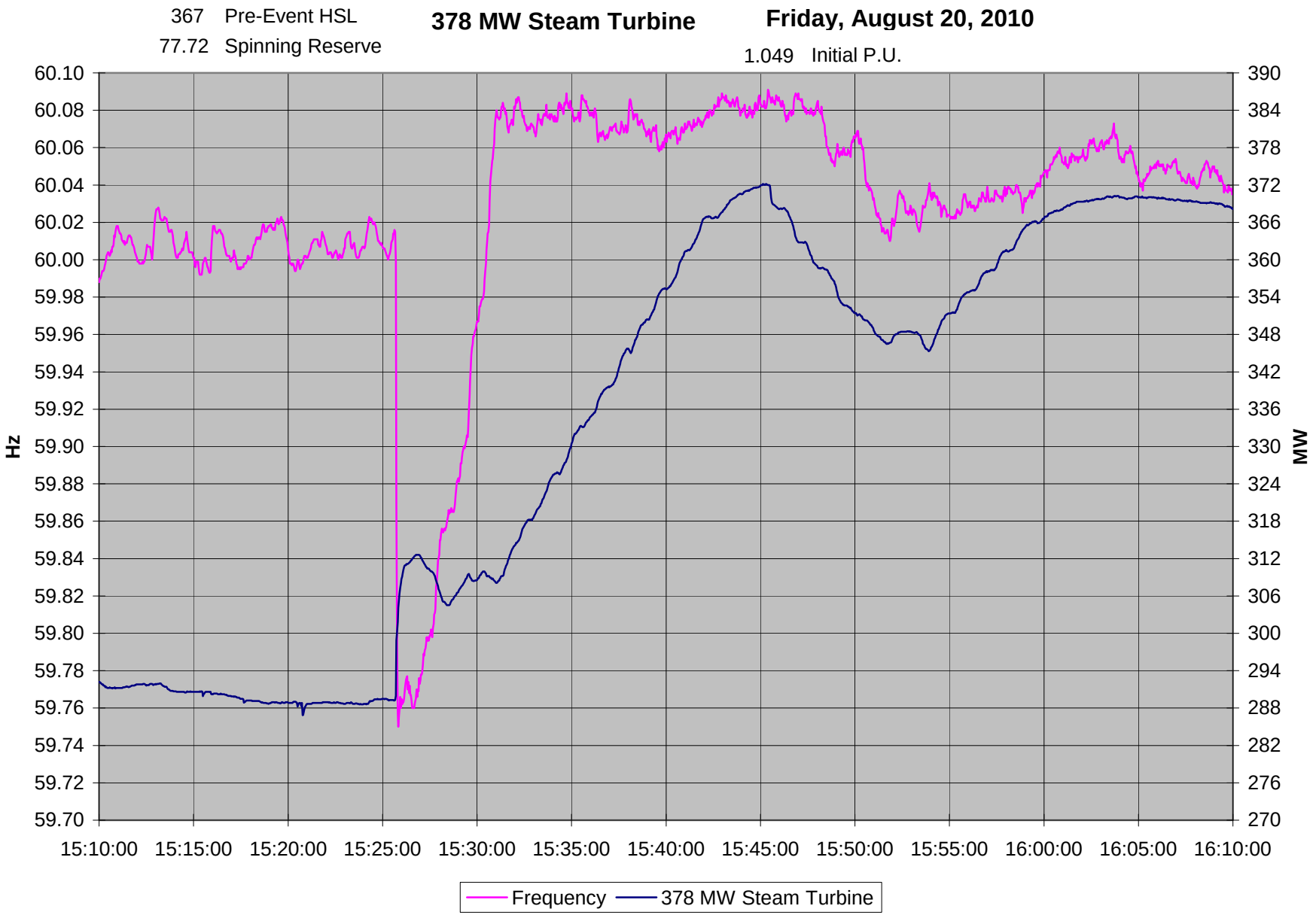
Spinning Reserve 77.72

378 MW Steam Turbine Performance

Friday, August 20, 2010

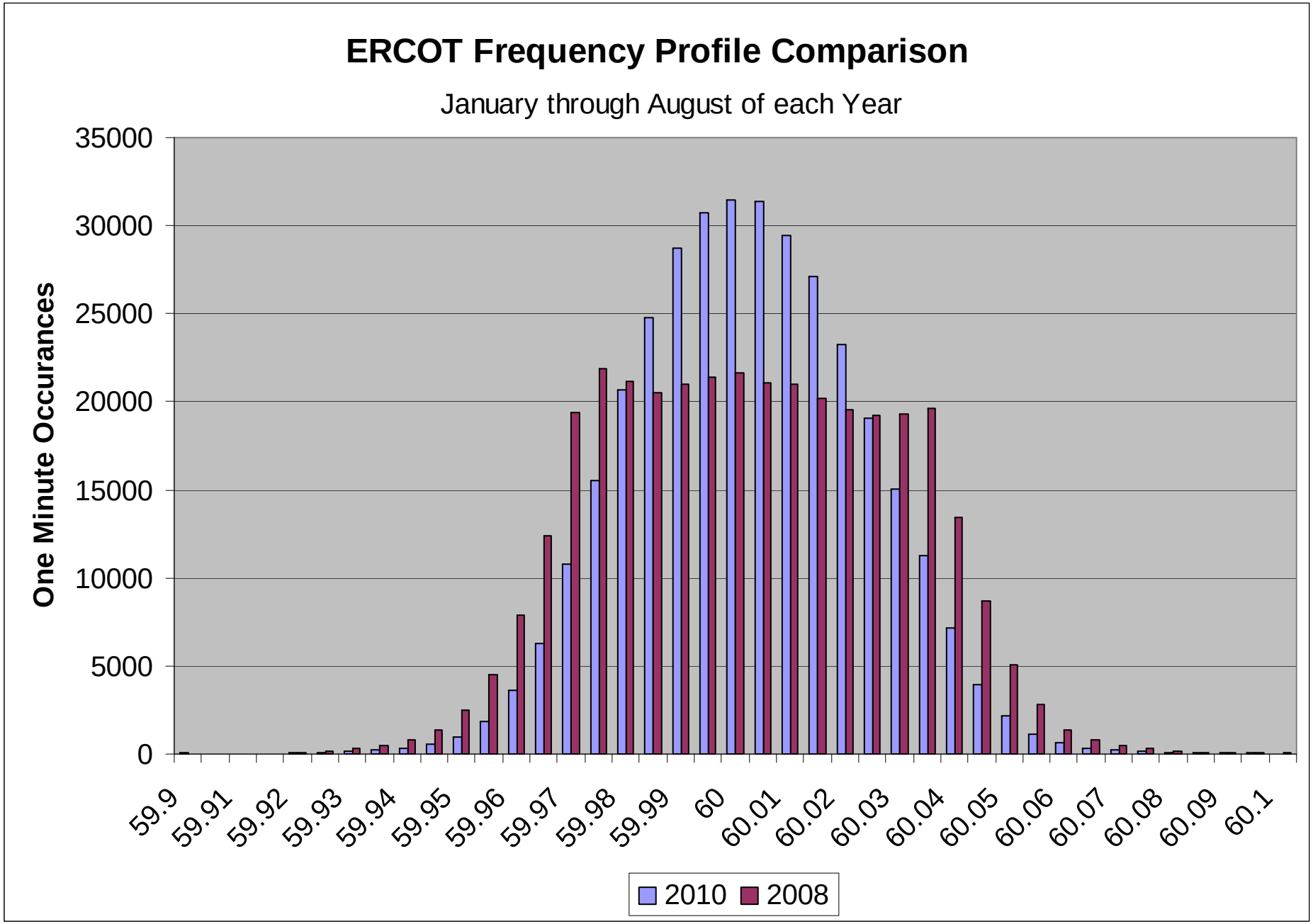


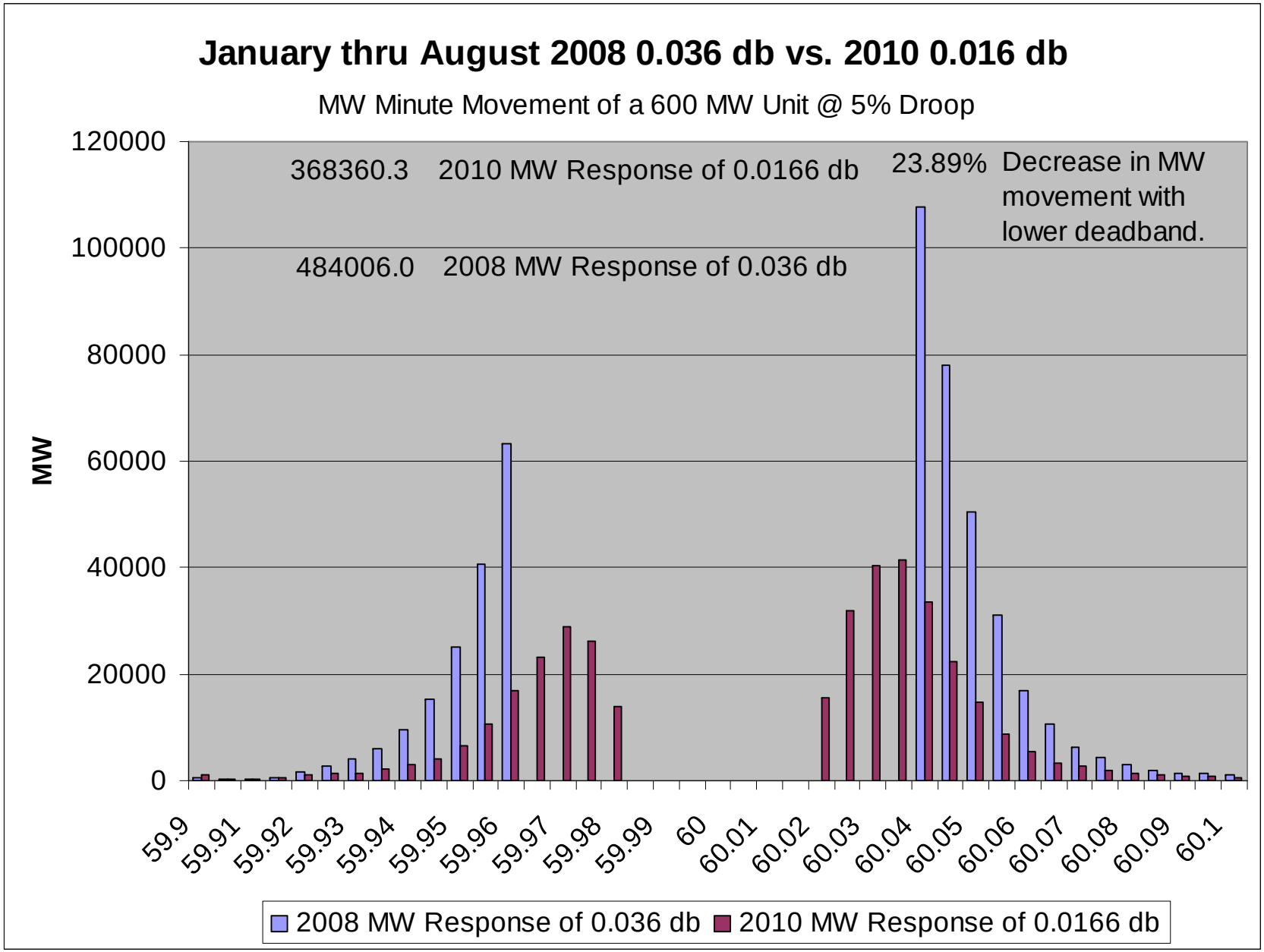

0.753
P.U. Performance of Sustained Frequency Response
378 MW Steam Turbine
MW
Hz
Hz
MW
Expected MW output, ramp plus governor response
AGC Ramp
The steeper the ramp during the frequency recovery period, less governor response must be delivered to meet the measure.
MW
Target MW
HZ


367 Pre-Event HSL
77.72 Spinning Reserve
378 MW Steam Turbine
Friday, August 20, 2010
1.049 Initial P.U.
Hz
MW
60.10
60.08
60.06
60.04
60.02
60.00
59.98
59.96
59.94
59.92
59.90
59.88
59.86
59.84
59.82
59.80
59.78
59.76
59.74
59.72
59.70
390
384
378
372
366
360
354
348
342
336
330
324
318
312
306
300
294
288
282
276
270
15:10:00
15:15:00
15:20:00
15:25:00
15:30:00
15:35:00
15:40:00
15:45:00
15:50:00
15:55:00
16:00:00
16:05:00
16:10:00
Frequency
378 MW Steam Turbine

Generation with Governor Settings per Draft Regional Standard

- Digital and Electronic Governors set with a Dead-band less than or equal to +/-0.01666 Hz and droop curve with no step function.
- Mechanical Governors with a maximum +/-0.034 Hz Dead-band
- 14,258 MW Total Capacity Identified.
    - 1690 MW Steam Turbine – Lignite fired
    - 5534 MW Steam Turbine – Coal fired
    - 3780 MW Combustion Turbine Combined Cycle
    - 1519 MW Combustion Turbine Simple Cycle
    - 1224 MW Steam Turbine – natural gas fired
    - 240 MW Hydro
    - 271 MW Wind Generators


ERCOT Frequency Profile Comparison
January through August of each Year
One Minute Occurances
35000
30000
25000
20000
15000
10000
5000
0
59.9
59.91
59.92
59.93
59.94
59.95
59.96
59.97
59.98
59.99
60
60.01
60.02
60.03
60.04
60.05
60.06
60.07
60.08
60.09
60.1
2010
2008



Same 600 MW unit - MW movement due to frequency each year.