Final Test Results of HEBT Quadrupoles (12Q45)

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AP Video Meeting

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Acknowledgement:

Ted Hunter (Team Leader)

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33 HEBT Quadrupoles

- LAMS: 11 quads, G*L=2.1 T @ 1 GeV
- Acromat: (8 ring quads 21Q40)
- ARMS: 15 quads, G*L: 0.96 T to 3.9 T (0.85 GeV to 1.3 GeV)
- Linac Dump: 6 quads, G*L: 1.25 T to 1.75 T ? @ 1 GeV

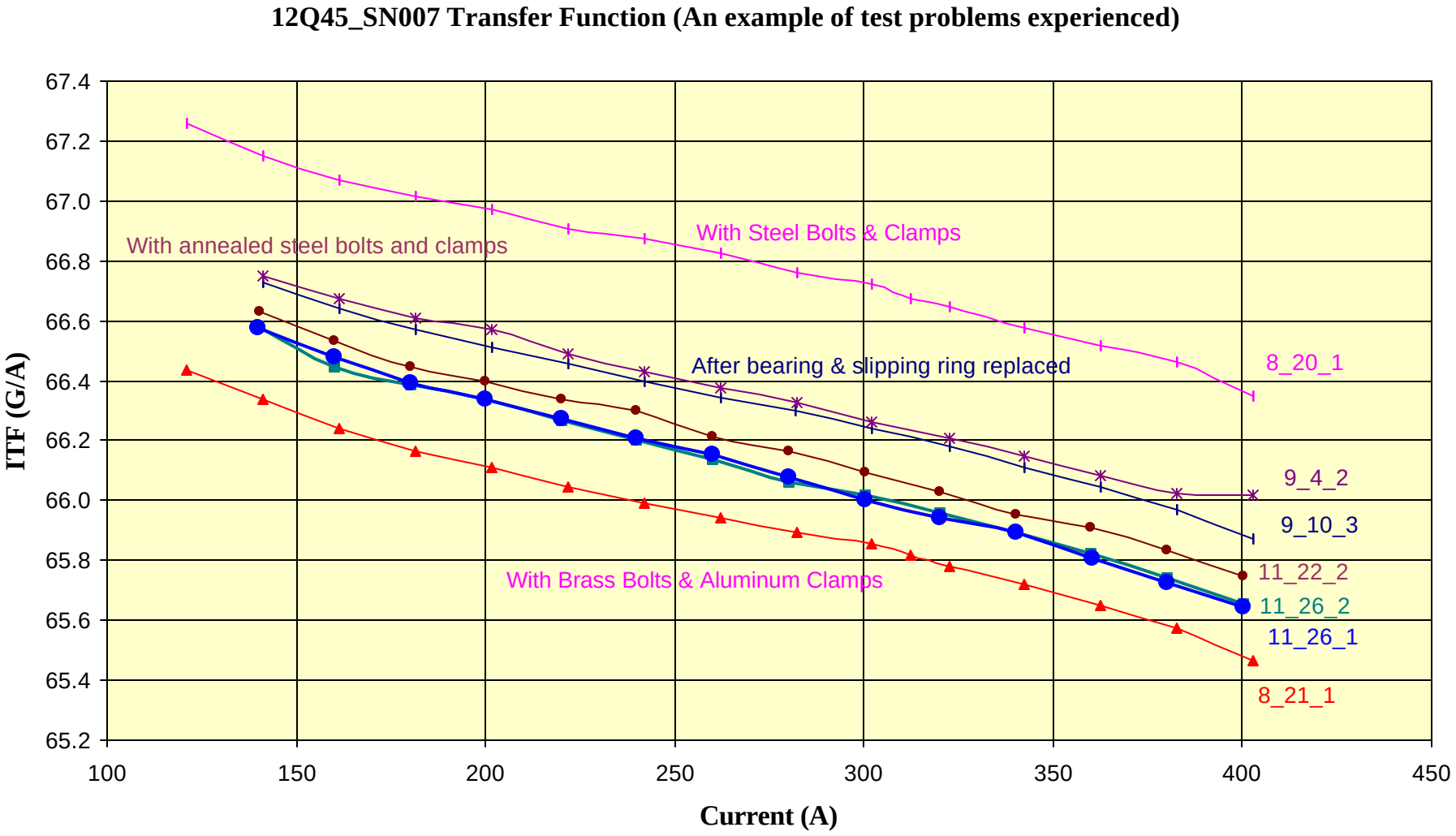
- HEBT quadtrupoles were designed by BNL, manufactured by Danfysik, and tested at ORNL.

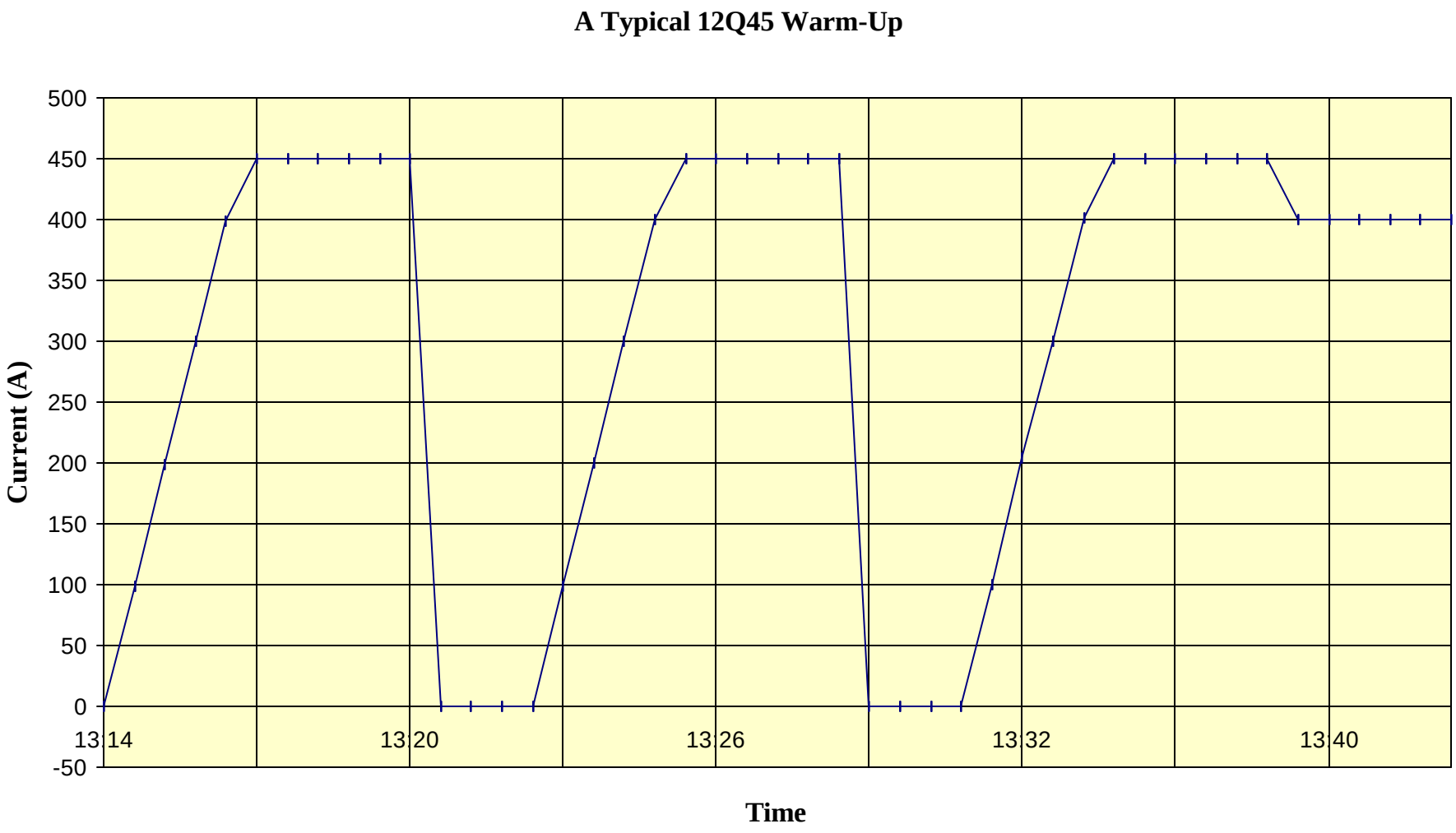
- HEBT Quads Test Parameters:
  - Integrated Transfer Function (ITF)
  - Integrated Gradient (G*L)
  - Variation of ITF or G*L among 12Q45s
  - Harmonics contents
  - Trim coefficients
  - …

- HEBT Quads Test Method:
  - Rotational Coil Mapper

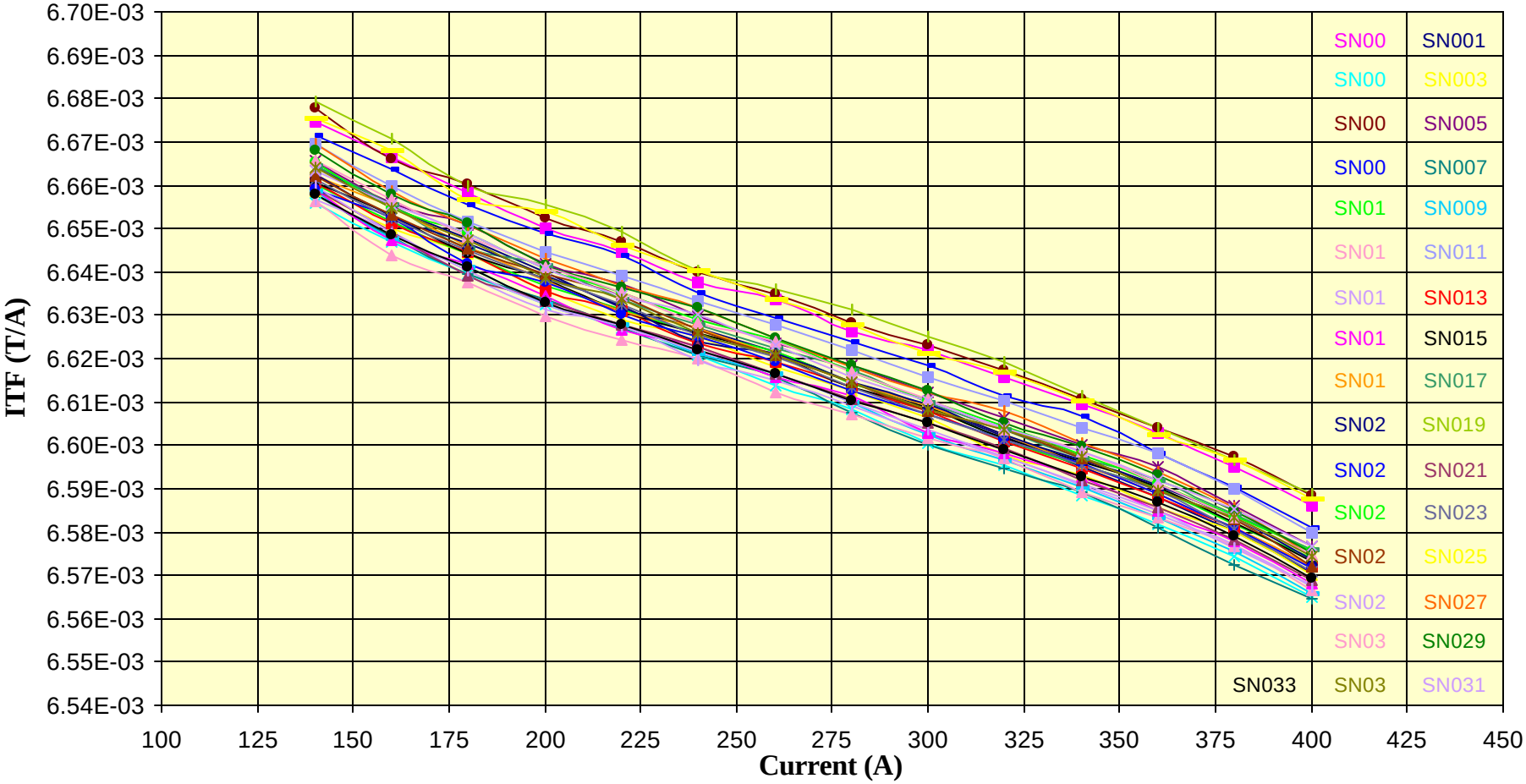
Problems Experienced in Tests

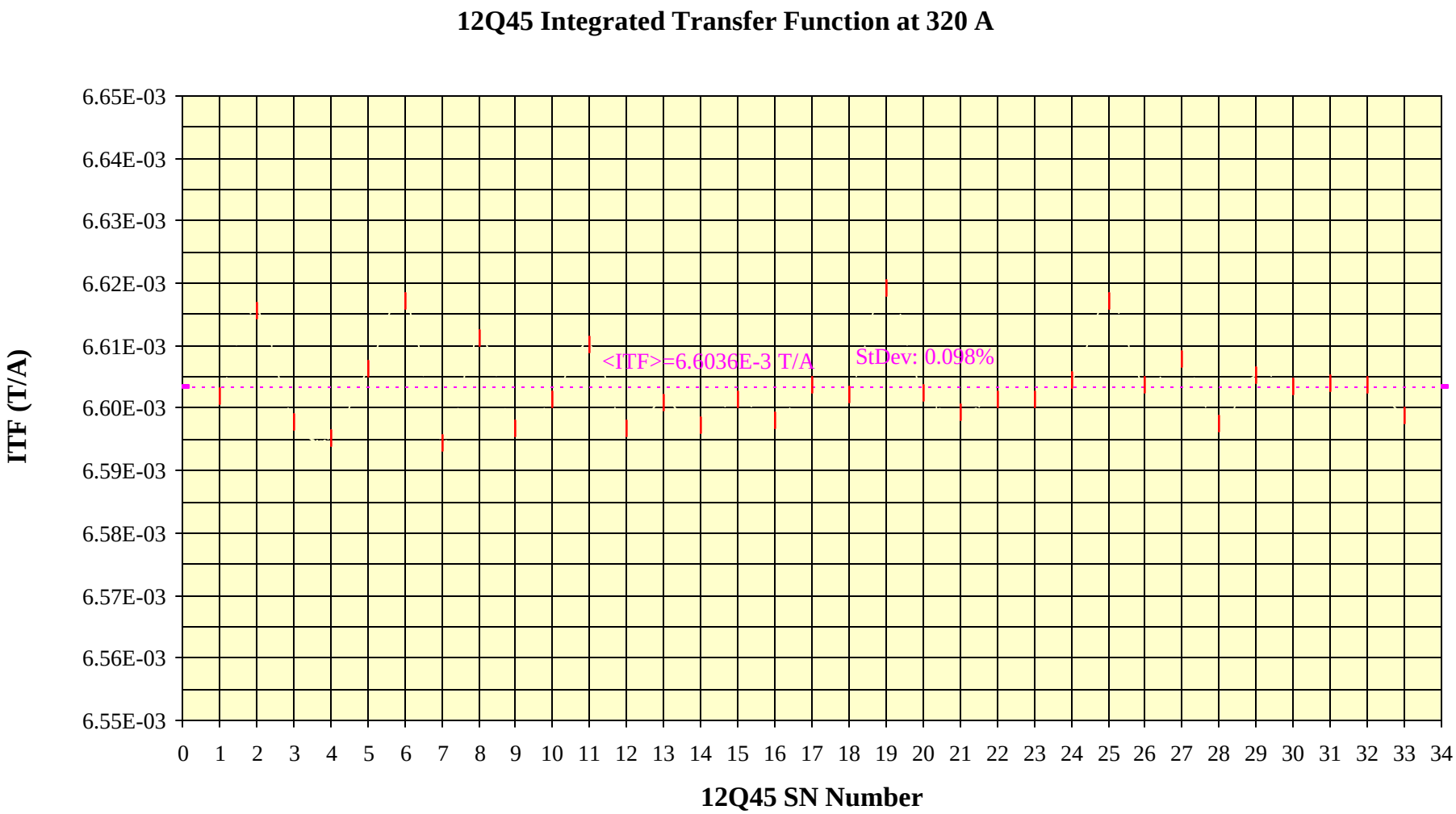
- Manufacture:
  - Water leak;
  - Winding shortening;
  - Magnetic bolts and clamps;
  - …
- Test system:
  - Bearing and slipping ring
  - Rotating coil;
  - Power supply & Electronics;
  - …

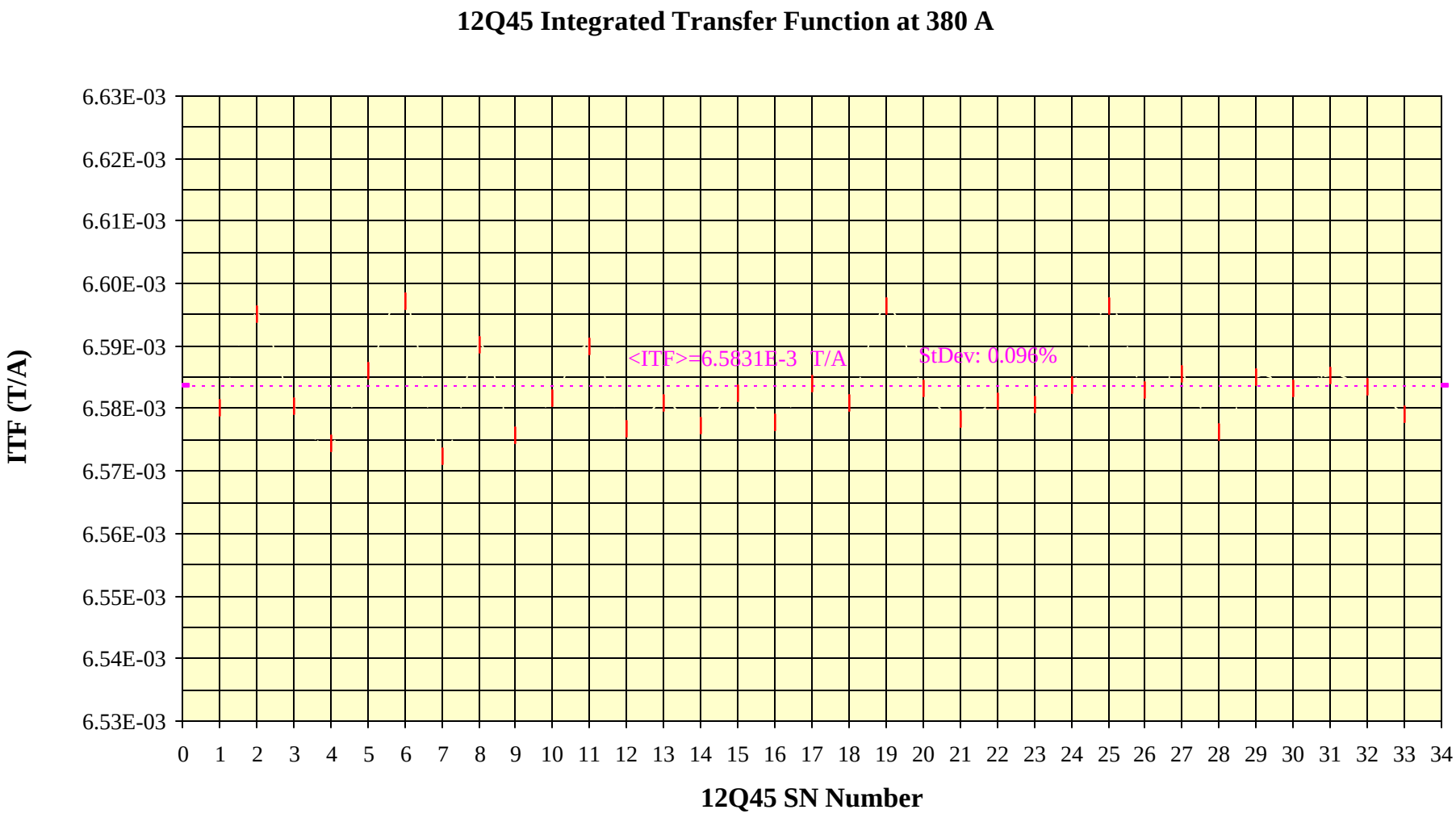

12Q45_SN007 Transfer Function (An example of test problems experienced)
ITF (G/A)
Current (A)
67.4
67.2
67.0
66.8
66.6
66.4
66.2
66.0
65.8
65.6
65.4
65.2
100
150
200
250
300
350
400
450
With annealed steel bolts and clamps
With Steel Bolts & Clamps
After bearing & slipping ring replaced
With Brass Bolts & Aluminum Clamps
8_20_1
9_4_2
9_10_3
11_22_2
11_26_2
11_26_1
8_21_1

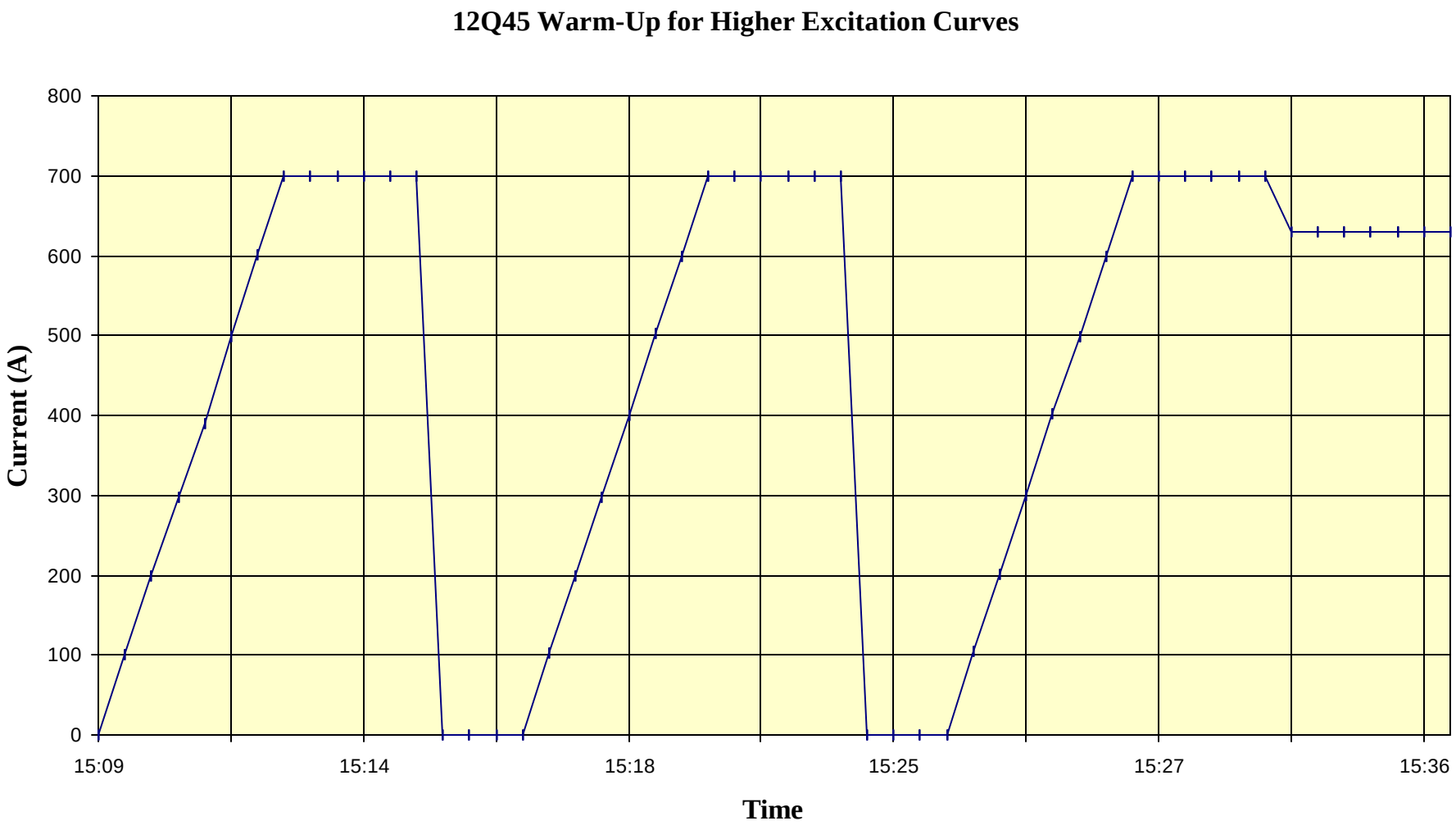

A Typical 12Q45 Warm-Up
Current (A)
500
450
400
350
300
250
200
150
100
50
0
-50
13:14
13:20
13:26
13:32
13:40
Time

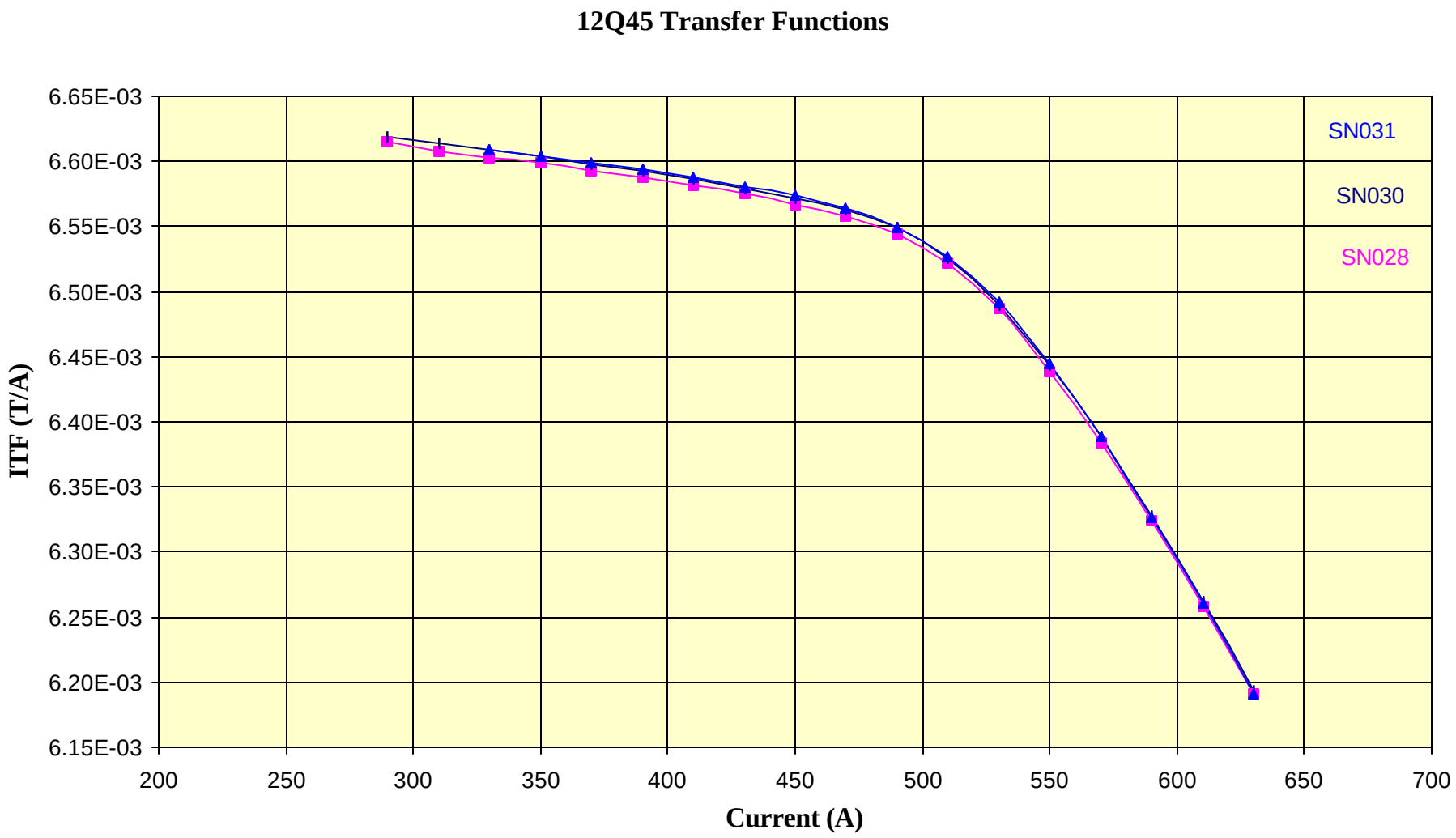
12Q45 Transfer Functions

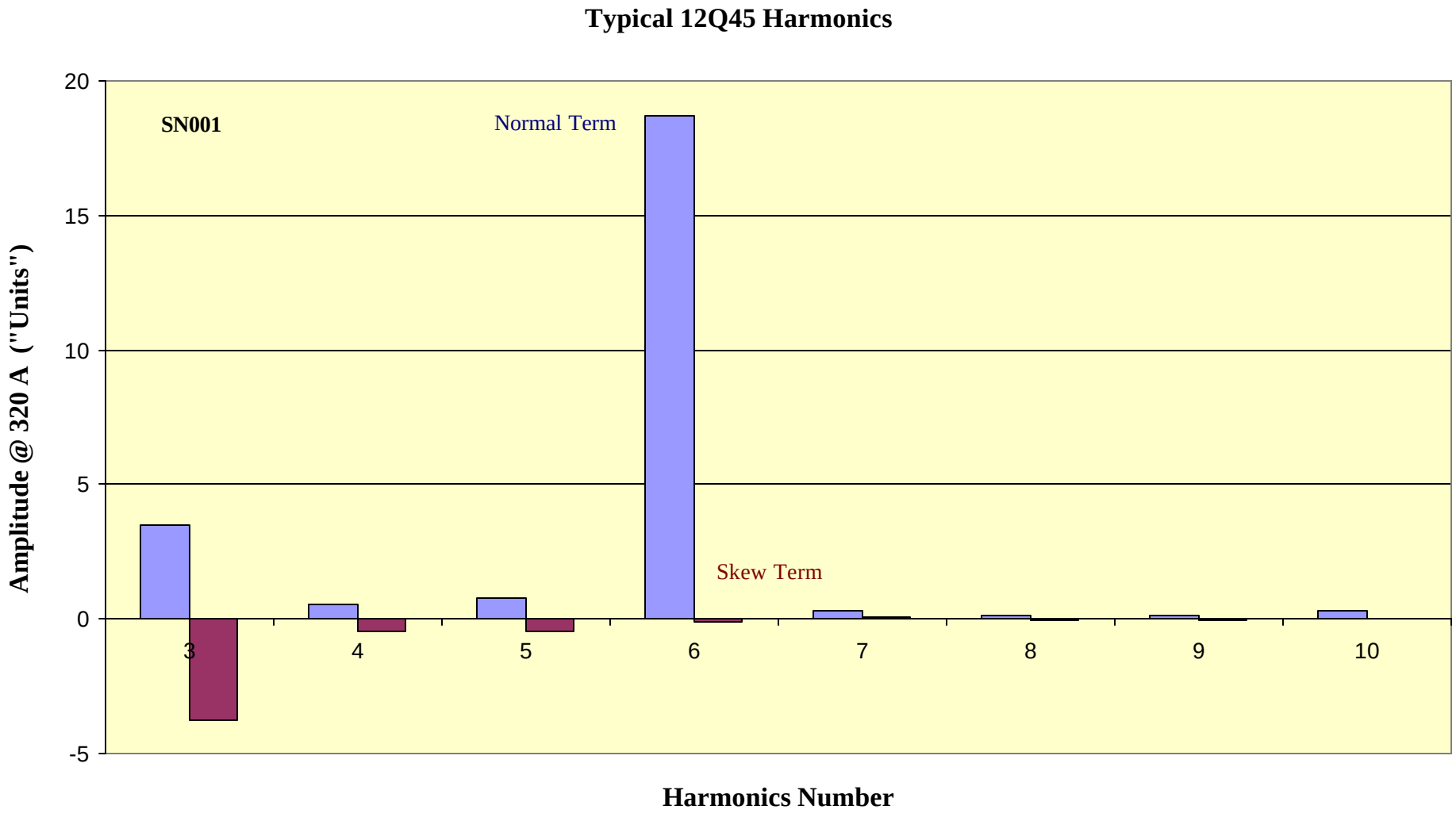


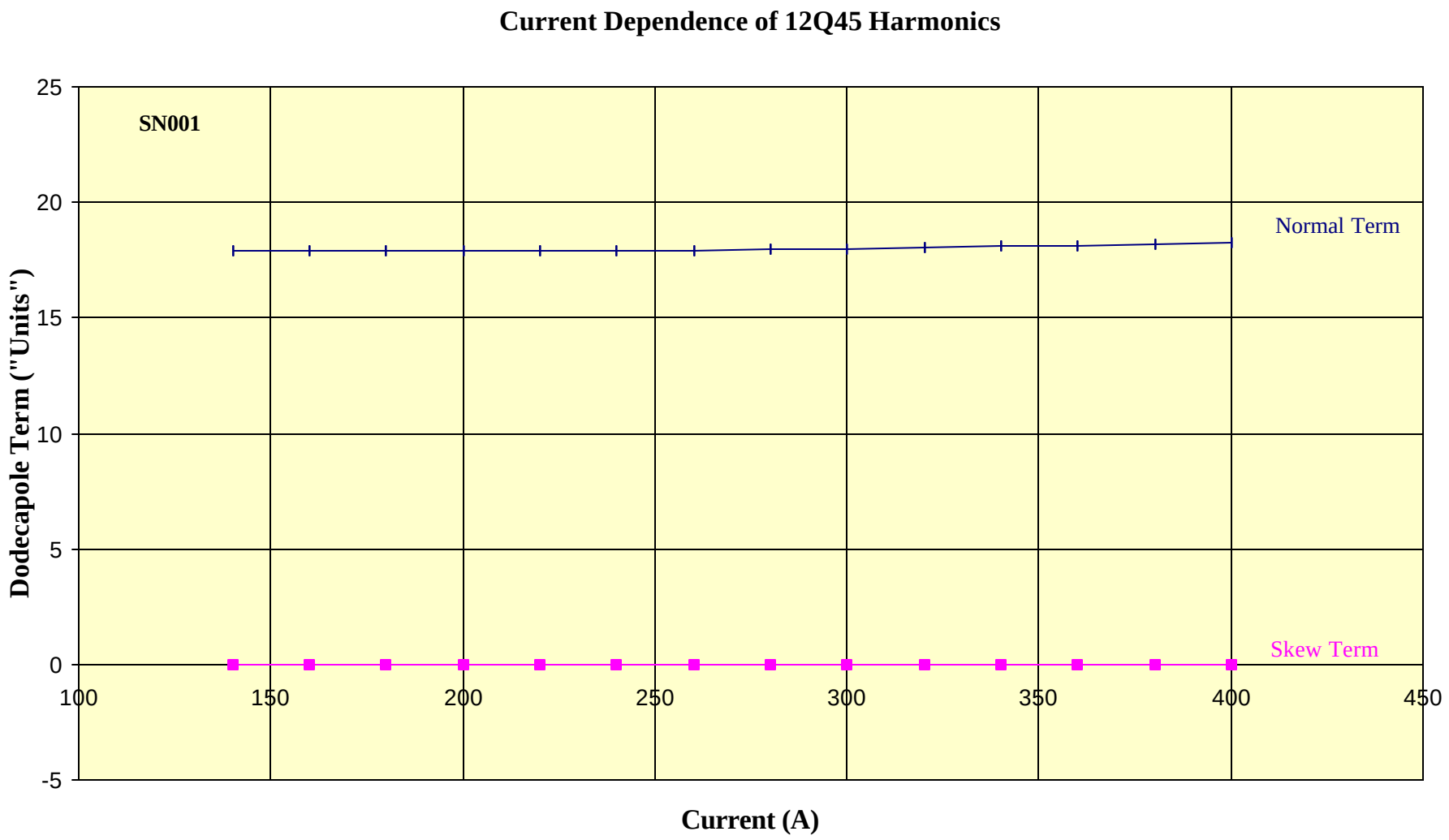

12Q45 Integrated Transfer Function at 320 A
ITF (T/A)
6.65E-03
6.64E-03
6.63E-03
6.62E-03
6.61E-03
6.60E-03
6.59E-03
6.58E-03
6.57E-03
6.56E-03
6.55E-03
<ITF>=6.6036E-3 T/A
StDev: 0.098%
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
12Q45 SN Number

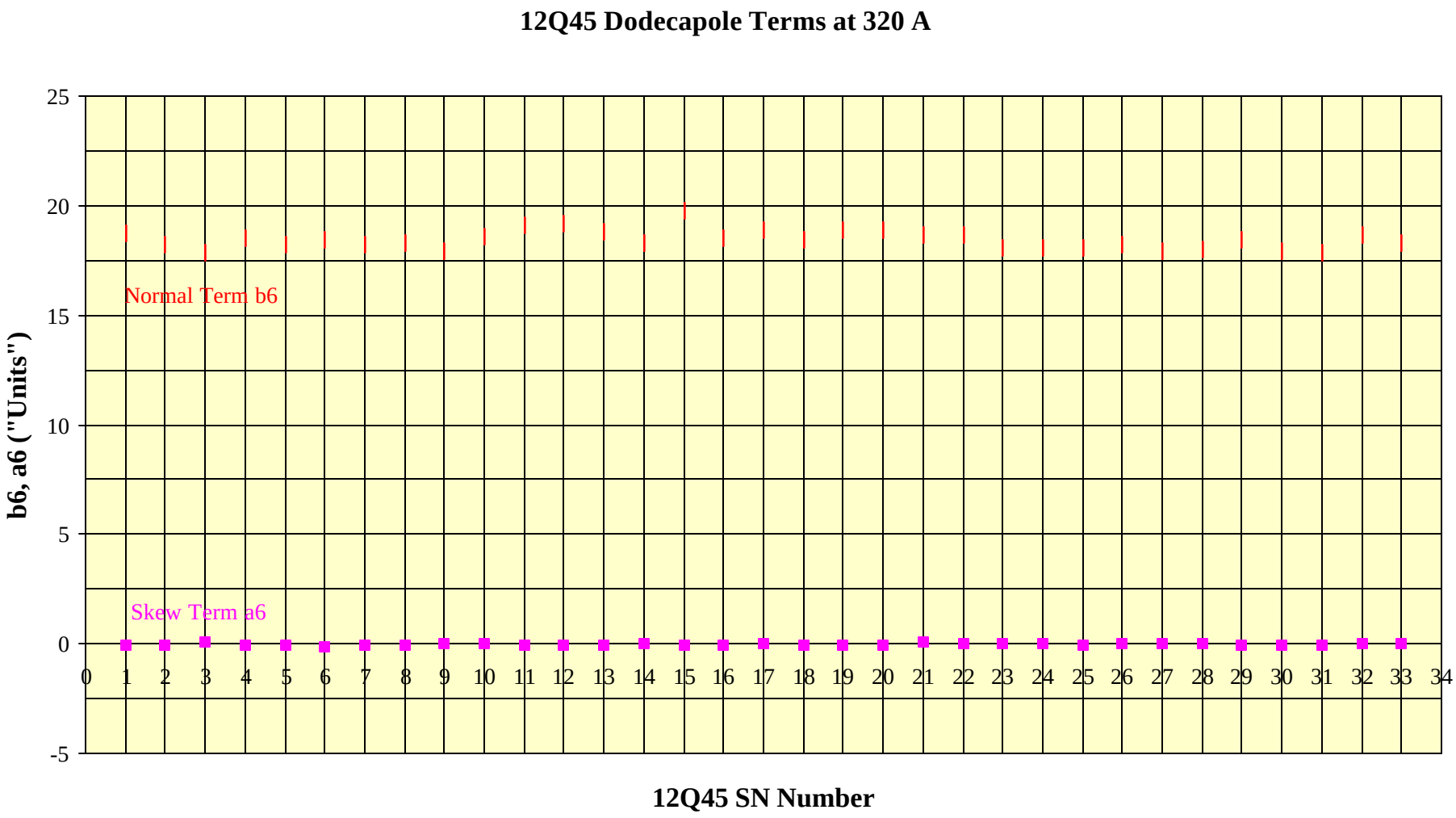

12Q45 Integrated Transfer Function at 380 A
ITF (T/A)
6.63E-03
6.62E-03
6.61E-03
6.60E-03
6.59E-03
6.58E-03
6.57E-03
6.56E-03
6.55E-03
6.54E-03
6.53E-03
<ITF>=6.5831E-3 T/A
StDev: 0.096%
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
12Q45 SN Number

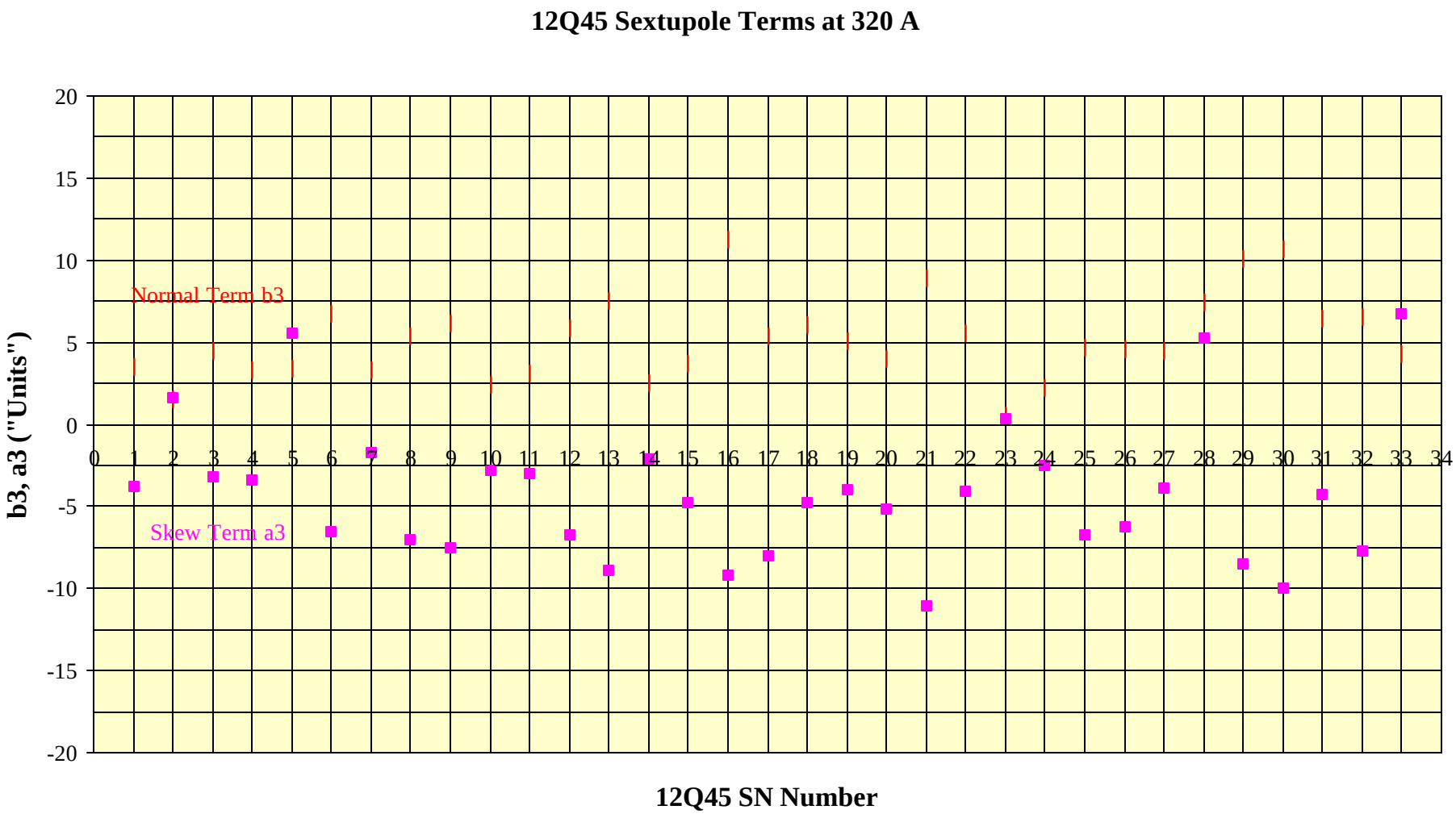

12Q45 Warm-Up for Higher Excitation Curves
Current (A)
800
700
600
500
400
300
200
100
0
15:09
15:14
15:18
15:25
15:27
15:36
Time

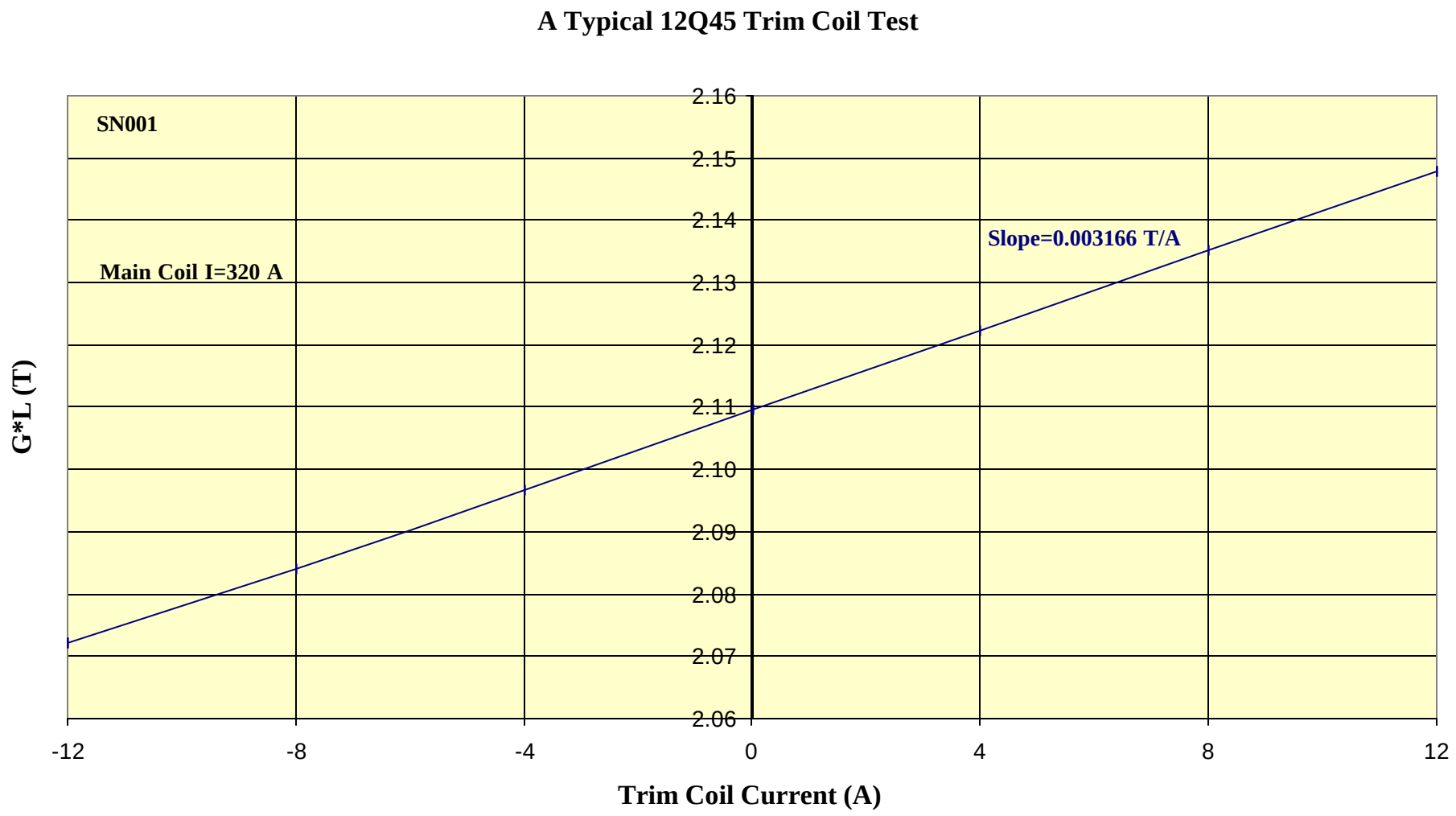

12Q45 Transfer Functions
ITF (T/A)
6.65E-03
6.60E-03
6.55E-03
6.50E-03
6.45E-03
6.40E-03
6.35E-03
6.30E-03
6.25E-03
6.20E-03
6.15E-03
200
250
300
350
400
450
500
550
600
650
700
Current (A)
SN031
SN030
SN028


Typical 12Q45 Harmonics
SN001
Normal Term
Skew Term
20
15
10
5
0
-5
3
4
5
6
7
8
9
10
Amplitude @ 320 A ("Units")
Harmonics Number

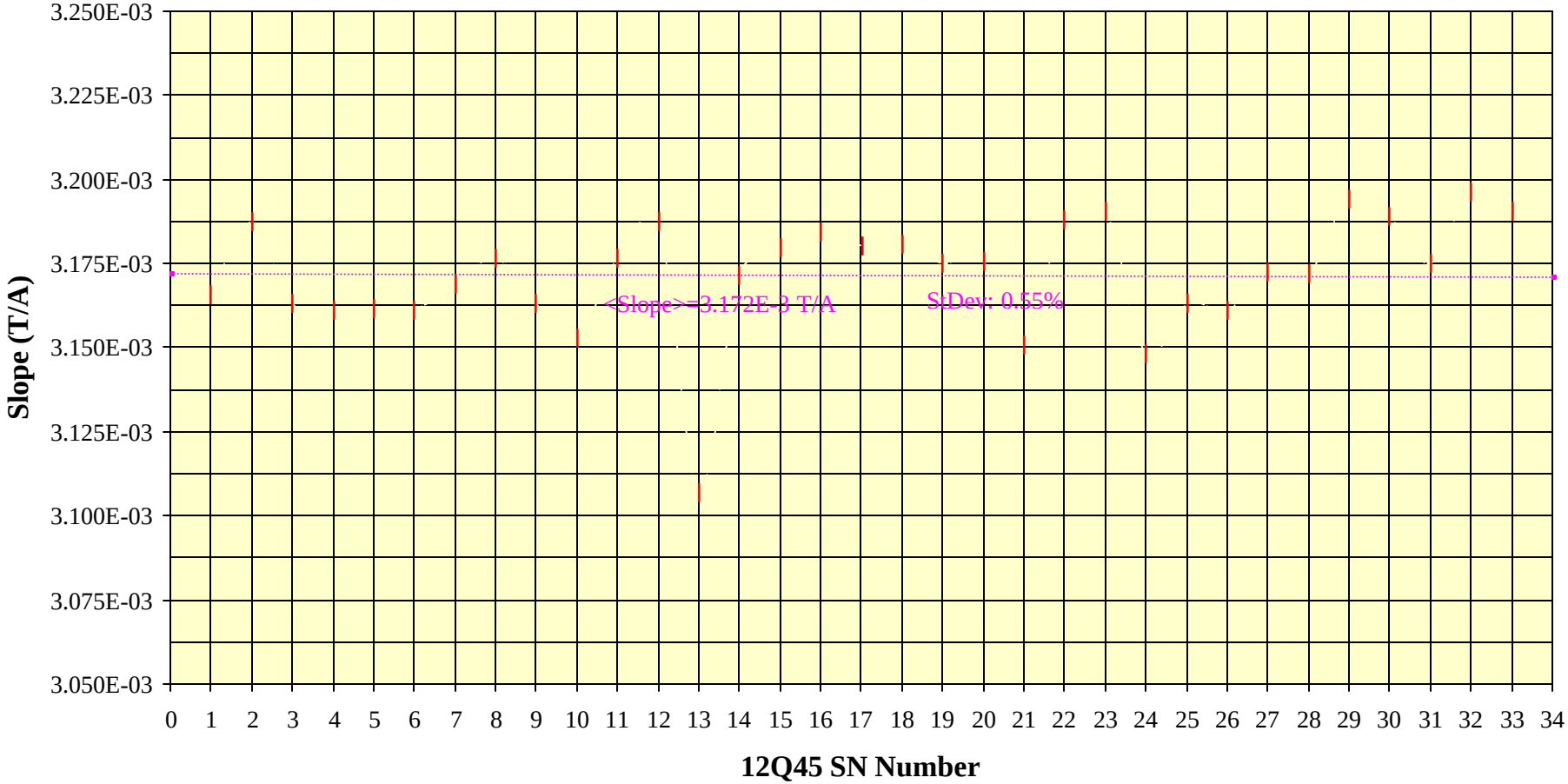

Current Dependence of 12Q45 Harmonics
SN001
Normal Term
Skew Term
Dodecapole Term ("Units")
Current (A)
25
20
15
10
5
0
-5
100
150
200
250
300
350
400
450


12Q45 Dodecapole Terms at 320 A
b6, a6 ("Units")
25
20
15
10
5
0
-5
Normal Term b6
Skew Term a6
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
12Q45 SN Number


12Q45 Sextupole Terms at 320 A
b3, a3 ("Units")
20
15
10
5
0
-5
-10
-15
-20
Normal Term b3
Skew Term a3
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
12Q45 SN Number


A Typical 12Q45 Trim Coil Test
SN001
Main Coil I=320 A
Slope=0.003166 T/A
G*L (T)
2.16
2.15
2.14
2.13
2.12
2.11
2.10
2.09
2.08
2.07
2.06
-12
-8
-4
0
4
8
12
Trim Coil Current (A)

12Q45 Trim Coil Transfer Coefficients at 320 A



Conclusions

- The acceptance tests (ITF, harmonics and trim) of 33 HEBT quads (12Q45) have been completed;
- The performances of these quads are, we believe, satisfactory to SNS HEBT operation;
- The test results have been reported to AP group for final review and approval;
- Each 12Q45 will be assigned to a HEBT lattice element according to the test results.
- Database files and chamber installation will follow.