# TOTAL DOSE RADIATION TEST REPORT

# INTEL 16 MB FLASH MEMORY DA28F016SV-70

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## Introduction

The Intel DA28F016SV is a high-performance, 16-Mbit block erasable, non-volatile synchronous random access memory, organized as either 1Mbit X 16 (32 blocks of 32K-word) or 2Mbit X 8 (32 blocks of 64K-byte). Intel's SmartVoltage technology allows users to select Vcc at either 3.3V or 5V and to program Vpp at 5V or 12V. By using the programming voltage Vpp at 5V with the operation voltage Vcc at 3.3V, external circuitry is minimized in space critical designs and power usage is minimal in battery-powered applications. Using the 12V Vpp option shortens write/erase execution time. There are four different combinations:

Mode A: Vcc=3.3V , Vpp=5V

Mode B: Vcc=3.3V , Vpp=12V

Mode C: Vcc=5.0V , Vpp=5V

Mode D: Vcc=5.0V , Vpp=12V

The device's built-in Internal Algorithm Automation feature allows *block erase operations* and *byte/word writes* to be executed using a Two-Write command sequence. All operations are started by a sequence of Write commands to the device. The 28F016SV contains a Status Register and a Ready/Busy output to monitor the progress of the requested operation. The Intel devices under TID tests have *plastic* packages and are graded as commercial parts (specifications at 0 degree C and 70 degree C, Vcc1 range of 3.0V to 3.6V, Vcc2 range of 4.75V and 5.25V).

After irradiation, positive oxide-trapped charge causes a decrease in threshold voltage. The threshold voltage level may shift downward and may cause the transistors move from

an enhancement mode into a depletion mode. The Intel flash memory can be electrically erased only by a block of memory cells each time since it does not have individual series gate transistors in each cell. The transistors must remain in the enhancement mode during the programmed and erase states. The radiation induced threshold shift is different for different bias voltage condition.

There are four different configurations of biasing voltage:

1. Vcc=5.0V and Vpp=5.0V as shown in figure 1
2. Vcc=5.0V and Vpp=12V as shown in figure 2
3. Vcc=3.3V and Vpp=5.0V
4. Vcc=3.3V and Vpp=12V

Table 1 below categorized different bias voltages, and pre-conditions of tested parts.

| S/N | BIAS VOLTAGE | PRE-CONDITION |
|---|---|---|
| 8069 | Configuration 1 (Vcc=5V, Vpp=5V) | Normal 25C |
| 8070 | Configuration 1 (Vcc=5V, Vpp=5V) | Normal 25C |
| 8061 | Configuration 2 (Vcc=5V, Vpp=12V) | Normal 25C |
| 8059 | Configuration 3 (Vcc=3.6V, Vpp=5.5V) | Normal 25C |
| 3 | Configuration 4 (Vcc=3.6V, Vpp=12V) | Normal 25C |
| 8069 | Vcc=5V, Vpp=5V | Normal 25C |
| 8071 | Vcc=5V, Vpp=5V | Standard (no pre-condition) |
| 2 | Vcc=5V, Vpp=5V | 85C/85%RH for 190 hours |
| 8072 | Vcc=5V, Vpp=5V | 100C for 44 hours |
| 8073 | Vcc=5V, Vpp=5V | 100C for 44 hours |

| | | |
|---|---|---|
| 8069 | Vcc=5V, Vpp=5V | Standard (no pre-condition) |
| 8052 | Vcc=5V, Vpp=5V | Burn-in at 125C |
| 8057 | Vcc=5V, Vpp=5V | Burn-in at 125C |
| 8065 | Vcc=5V, Vpp=5V | Test at 125C before TID |
| 8080 | Vcc=5V, Vpp=5V | Test at 125C before TID |
| 8074 | Vcc=5V, Vpp=5V | Pre-test at 125C & -55C |
| 8075 | Vcc=5V, Vpp=5V | Pre-test at –55C |
| 8077 | Vcc=5V, Vpp=5V | Pre-test at –55C |

The electrical measurements include the following tests, and results

- Input leakage IIH at Vcc=5.5V
- Input leakage IIL at Vcc=3.6V
- Read Checkerboard at Vcc=3.3V
- Input Threshold High at Vcc=3.3V
- Input Threshold Low at Vcc=3.3V
- Output Current IOL at Vcc=4.75V (Force 0.45V)
- Output Current IOL at Vcc=3.00V (Force 0.40V)
- Output Current IOH at Vcc=3.00V (Force 2.40V)
- Output Current IOH at Vcc=4.75V (Force 4.037V)
- CE to Output Delay at Vcc=3.30V
- Address to Output Delay at Vcc=3.30V
- OE to Output Delay at Vcc=3.30V
- Static Currents at both Vcc=3.60V and Vcc=5.50V *failed @10krads(Si)*
- Dynamic Currents at both Vcc=5.50V and Vcc=3.60V
- All Block Erase at all modes *failed @ 10krads(Si)*
- Write/Read Checkerboard, Diagonal at all modes
- Write/Read Inverse Checkerboard and Inverse Diagonal at all modes
- Currents of All Block Erase and Write/Read at all modes

## TEST RESULTS of 4 DIFFERENT BIAS VOLTAGE CONDITIONS

**Biasing Configuration 1 : Vcc=5.0V, Vpp=5.0V**

Serial number 8069 was irradiated at 25rads(Si) per second with the following doses: 0.5K, 1K, 1.5K, 2K, 3K, 4K, 6K, 8K, 10K, 12K, 16K, 18K, 20K, 22K, 24K, 26K.

The *All Block Erase* time of S/N 8069 at Vcc=3.3V and Vpp=5.0V (mode A) increased with increasing levels of radiation, prolonging to *373 seconds at 16Krads(Si)* versus the typical 35 seconds before irradiation. The Power Supply Stand-by Current ICCS at both Vcc=3.3V and Vcc=5.0V went up with increasing doses.

Serial number 8070 was tested with the same dose of S/N 8069. It was changed to biasing configuration 2 (see bias configuration 2 below) at 18Krads(Si) and above in order to observe radiation effects on the part's performance at Vcc=5.0V and Vpp=12V (Mode D). There was no significant change of All Block Erase at mode D. But the All Block Erase time was *366 seconds at 16Krads(Si)*, at mode A. Both devices, 8069 and 8070, failed All Block Erase functional tests at 26Krads(Si).

**Biasing Configuration 2: Vcc=5.0V and Vpp=12V**

Serial number 8061 was tested after irradiating at the following doses: 1K, 2K, 4K, 8K, 12K, 16K, and 26Krads(Si). Three parameters varied with increasing doses. The 32-Block Erase time of Mode A went up to *160 seconds to clear at 16Krads(Si)*. Stand-by current ICCS also moved upward. However, serial number 8061 was still functioning at 26Krads(Si).

**Biasing Configuration 3: Vcc=3.6V and Vpp=5.5V**

Serial number 8059 was exposed at 3Krads(Si), 9Krads(Si), 11Krads(Si), 13Krads(Si), 14Krads(Si), 15Krads(Si), 20Krads(Si), and 25Krads(Si). The device failed to erase all 32 blocks (Mode A) at 25Krads(Si). The part's All Block Erase time was *39 seconds at 15Krads(Si)*. ICCS values increased at higher doses.

**Biasing Configuration 4: Vcc=3.6V and Vpp=12V**

Serial number 3 failed the functional test, Block Erase Mode A, at 25Krads(Si). The time to erase was *43 seconds at 15Krads(Si)*. ICCS changed with increasing doses. This part was tested at 5K, 10K, 15K, 19K, 21K, 23K, and 25Krads(Si).

**Considering the worst-case results of four biasing conditions, Vcc=5.0V and Vpp=5.0V were used to bias the devices during irradiation for the subsequent tests. Chart 1 showed the data points of five parts. Figure 3 exhibited the raw data of chart 1.**

**TEST RESULTS of BAKED PARTS with BIAS VOLTAGE Vcc=5V and Vpp=5V**

Serial numbers 8072 and 8073 were baked in the oven for 44 hours at 100 degree C. The parts then were exposed to the following doses: 4K, 8K, 10K, 12K, 16K, 18K, 20K, 22K, 24K, 26K, 28K, 30K, and 32Krads(Si). The parameter ICCS of both units was out-of-specifications at 18Krads(Si). Their All Block Erase time also were over 60 seconds at 20Krads(Si). However, both still were functioning at 32Krads(Si).

**TEST RESULTS of 85C/85% R.H. PART, BIAS VOLTAGE Vcc=5V, Vpp=5V**

Serial number 2 was steamed in the humidity chamber for 190 hours before being irradiated with the very same doses. Two parameters: the Block Erase time, and ICCS increased with increasing doses. At 32 Krads(Si), the 32-Block Erase time was 874 seconds. Figure 4 and chart 2 showed the measured data and corresponding curves of five parts under three different conditions.

## All Block Erase Time

The length of time that need to erase all 32 segments is one of the criteria to assure the operation of all parts after irradiation. Intel's ETOX (EEPROM Tunnel Oxide) flash memory cell is basically EEPROM cell with a thinner gate oxide. A flash memory cell consists of a source, a drain, a select gate and a floating gate. The Intel 28F016SV programs a cell by grounding the source and applying positive voltage to the select gate and drain to accumulate enough electrons on the floating gate to change state. It erases each block by floating the drain, grounding the select gate, and applying the positive voltage to the source to pull electrons off the floating gate. Electrons repeatedly travel through the thin oxide during erasing. Due to positive charge build up in the gate oxide after irradiation, the threshold voltage may shift down to depletion mode. Electrons may be trapped in the tunnel oxide. Consequently, the build up of permanent negative charge in the tunnel oxide reduces the electric field for the sample applied voltage. This effect slows down the time to erase all 32 blocks at mode A and mode C ( or Vcc=3.3V,5V and Vpp=5V). There are no significant delay of Block Erase time at mode B and D (Vpp=12V and Vcc=3.3V , 5V). This implies that the program voltage of 12 volts can

create a higher electric field across the thin oxide between the floating gate and the source than the 5-volts Vpp to remove electrons from the floating gate.

From pre-irradiation to 10Krads(Si), there was no significant difference of erase time among baked parts (S/Ns 8072 and 8073), steamed part (S/N 2) and normal part (S/N 8071). The steamed part started slowing down to erase after 10Krads(Si). At 30Krads(Si), the baked parts could erase the whole 32 blocks in 250 seconds while the steamed part needed 620 seconds to accomplish the task. The normal part ended up in the middle with 406 seconds.

## Stand-By Current

The measured values of baked and steamed parts were over the limits at 18Krads(Si). There were almost 300 micro-amps difference in ICCS between the steamed part and baked parts at 30Krads(Si). This corresponds to the surge in erase time of steamed part at the same level of irradiation.

## TID on flash memory plastic packaging devices

All three charts 2,3 and 4 showed that the measured parameters of the steamed part degraded more than those of baked parts at high dose range. However, there were no significant variance in the lower range in order to clearly determine the effect of bake and steam process on the plastic package. After 480 hours of annealing, the steamed part's block erase time improves slightly from 874 seconds down to 843 seconds. The baked part (S/N 8073) also speeds up its erase time from 390 to 370 seconds. There was no significant change for both serial numbers 8072 (baked part) and 8071.

## Baked parts with pre-conditions:

The following serial numbers 8074, 8075, and 8077 were used to further study the effect of bake process on plastic package of Intel flash memory device. All three parts were baked for 44 hours. Since the decision was made late in the process, therefore the above three selected parts were already tested at different temperatures.

Serial number 8074 had been tested at 125C and –55C before subjected to radiation. Both 8075 and 8077 previously went under –55C test. Data of erase time (Vcc=3.3V and Vpp=5V) showed baked parts with –55C pre-condition passed at 8 Krads(Si). At 8 Krads(Si), the time to erase all blocks at Vcc=3.3V and Vpp=5.0V were 40 seconds and 39 seconds for 8075 and 8077 respectively. It took 58 seconds for 8074 to perform the similar task. The specification limit is 45 seconds. At 16 Krads(Si), S/N 8074 had to wait 588 seconds to finish erasing all blocks, while S/N 8075 did for 199 seconds and S/N 8077 for 168 seconds.

Baked parts with no initial pre-condition, S/N 8072 and 8073, were still within specifications at 16 Krads(Si), 44 seconds and 43 seconds, respectively. At 32 Krads(Si), the two parts would take more than 300 seconds to erase all memory blocks.

## Summary

Plastic parts of Intel DA28F016SV were found to have a wide range of sensitive reaction to radiation even though all came from the same lot. The devices passed DC, AC and functional tests up to 10 krads(Si).

The Block Erase time were out of specifications at radiation levels of 8krads(Si) to 32krads(Si) with Vcc=3.3V and Vpp=5V . The baked parts were slightly better than the steamed device. Since we had only two parts with no pre-condition to investigate the effect of bake at 100C on plastic package, we need more new samples for further TID tests to draw the conclusion. Charts 3,4, 8 and 9 showed no significant change of leakage current in the 0 – 8 krads(Si) range. Moisture also had no effect on devices irradiated at 0 to 8 krads(Si).

Applications using the 12V Vpp will not have any problem in erase all 32 blocks. Note however that any low 5V Vpp application should be concerned if the erase function of 32 blocks is used frequently at radiation level of 8 krads(Si) and up (refer to chart 6 and figure 8 for raw data).

Chart 1

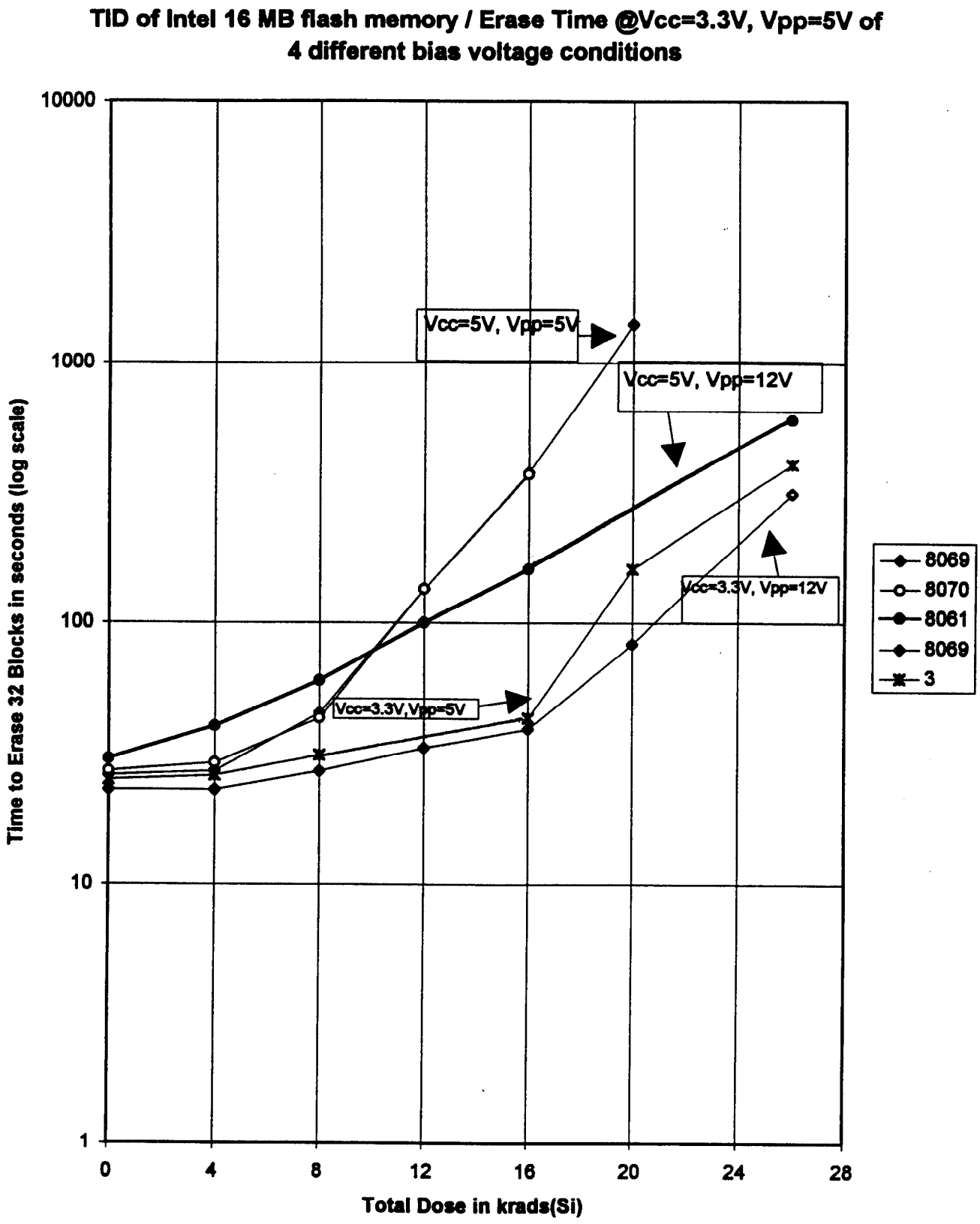
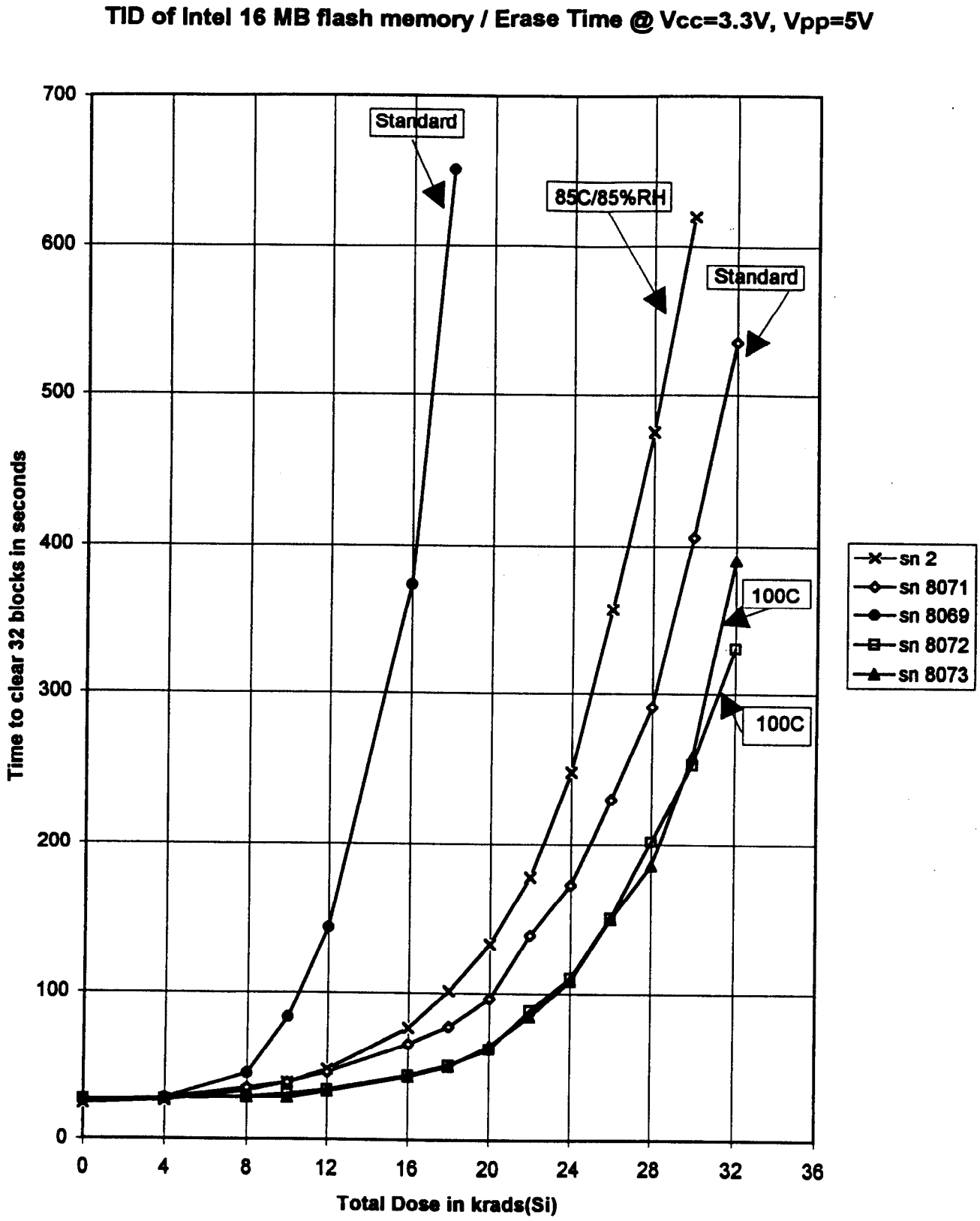

TID of Intel 16 MB flash memory / Erase Time @Vcc=3.3V, Vpp=5V of 4 different bias voltage conditions
10000
1000
100
10
1
0
4
8
12
16
20
24
28
Time to Erase 32 Blocks in seconds (log scale)
Total Dose in krads(Si)
Vcc=5V, Vpp=5V
Vcc=5V, Vpp=12V
Vcc=3.3V, Vpp=12V
Vcc=3.3V,Vpp=5V
8069
8070
8061
8069
3

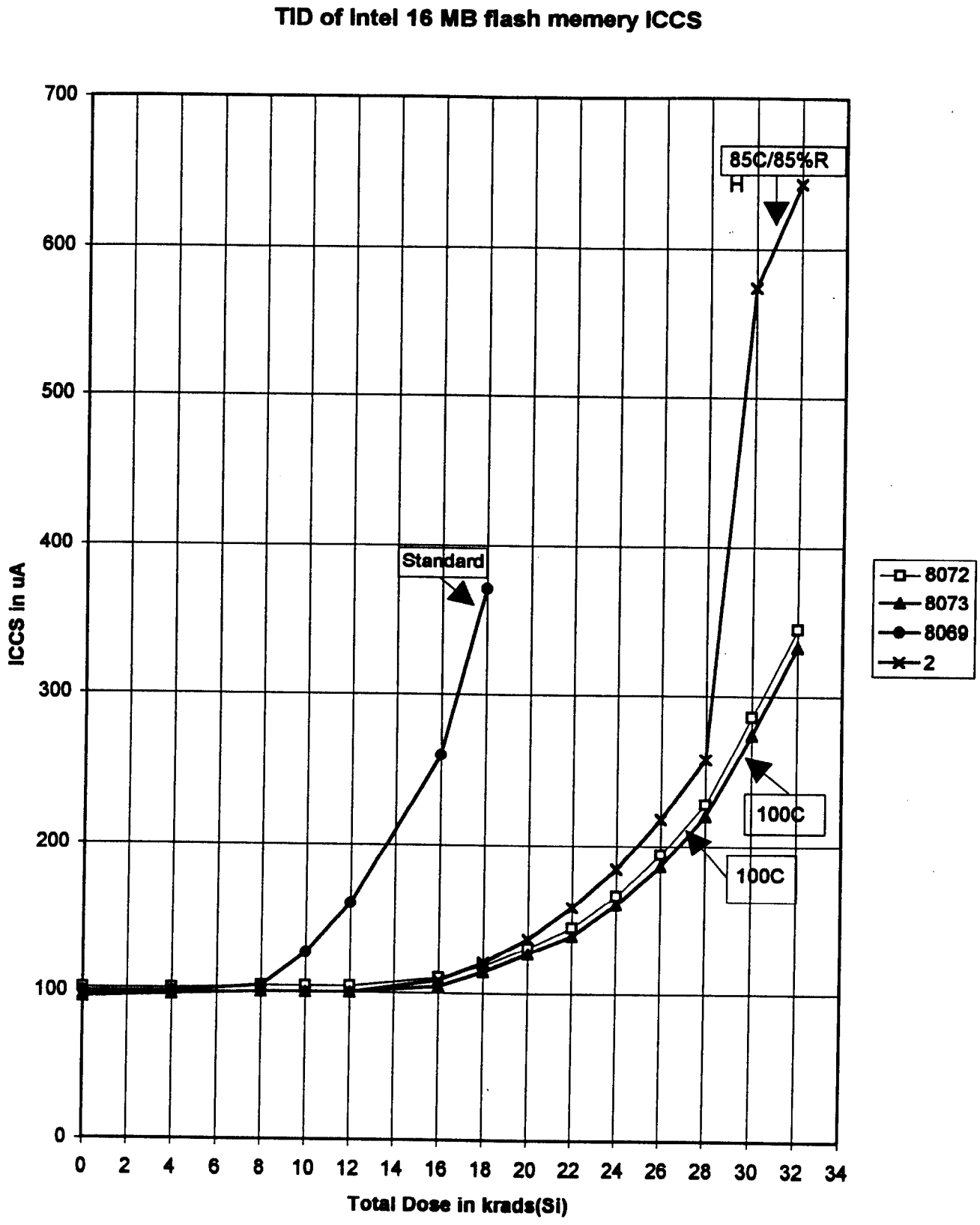
Chart2




sn 2: 85C/ 85%RH for 190hrs

sn 8072-73: baked for 44 hrs

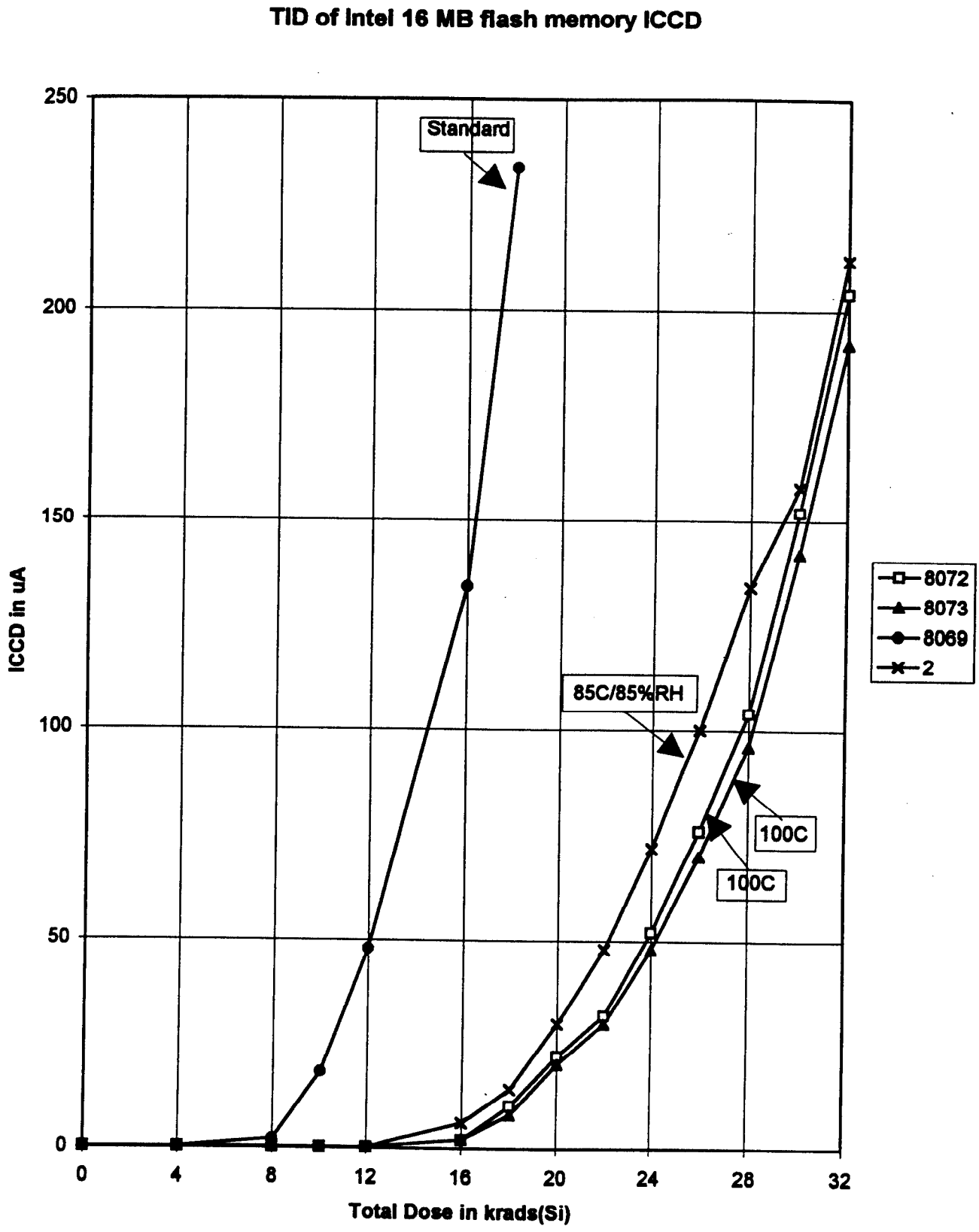
Chart3




sn 2: 85C/ 85%RH for 190hrs

sn 8072-73: baked for 44 hrs

Chart4




sn 2: 85C/ 85%RH for 190hrs

sn 8072-73: baked for 44 hrs

Chart5

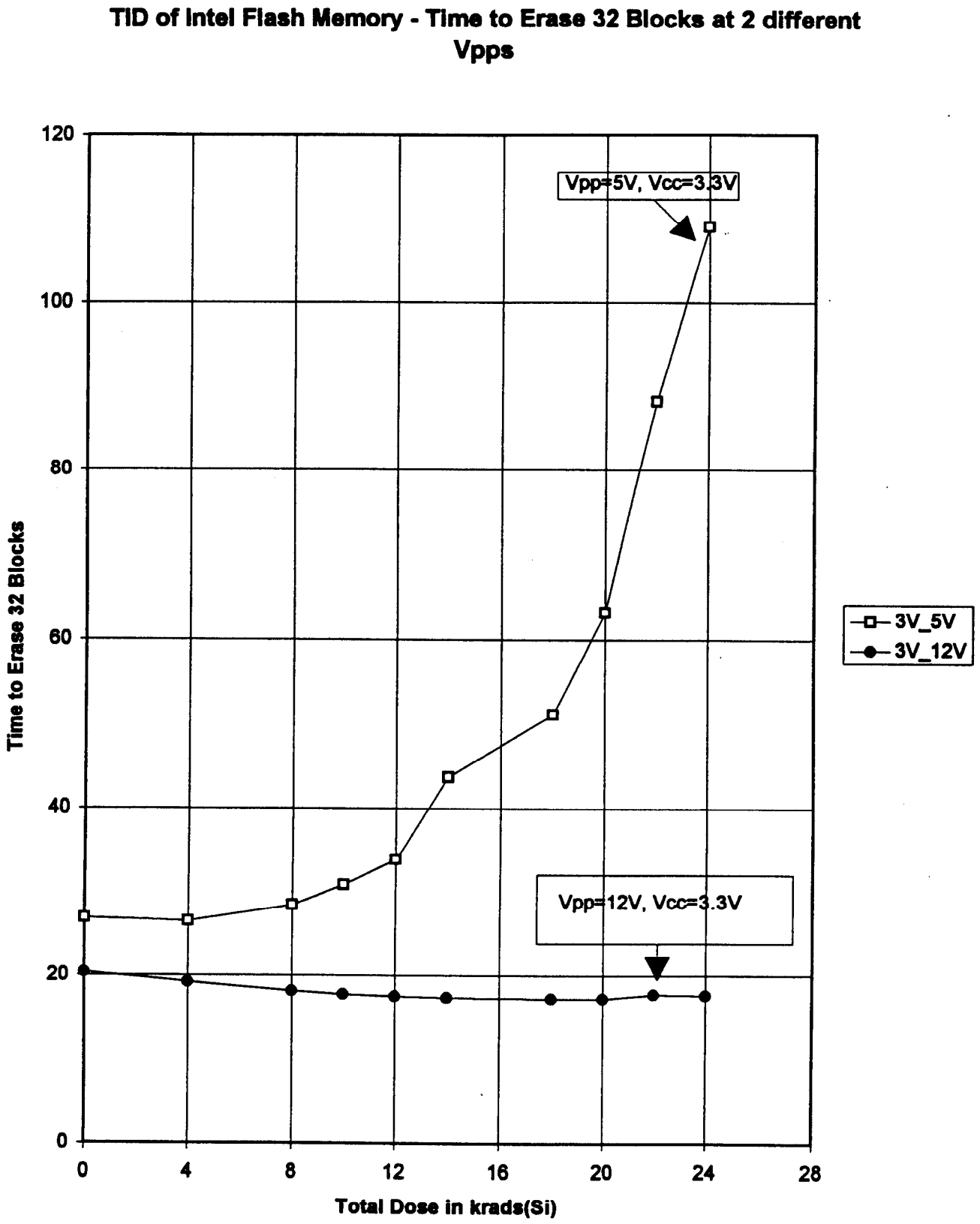

TID of Intel Flash Memory - Time to Erase 32 Blocks at 2 different Vpps
Vpp=5V, Vcc=3.3V
Vpp=12V, Vcc=3.3V
3V_5V
3V_12V
Time to Erase 32 Blocks
Total Dose in krads(Si)
0
20
40
60
80
100
120
0
4
8
12
16
20
24
28

Chart 6

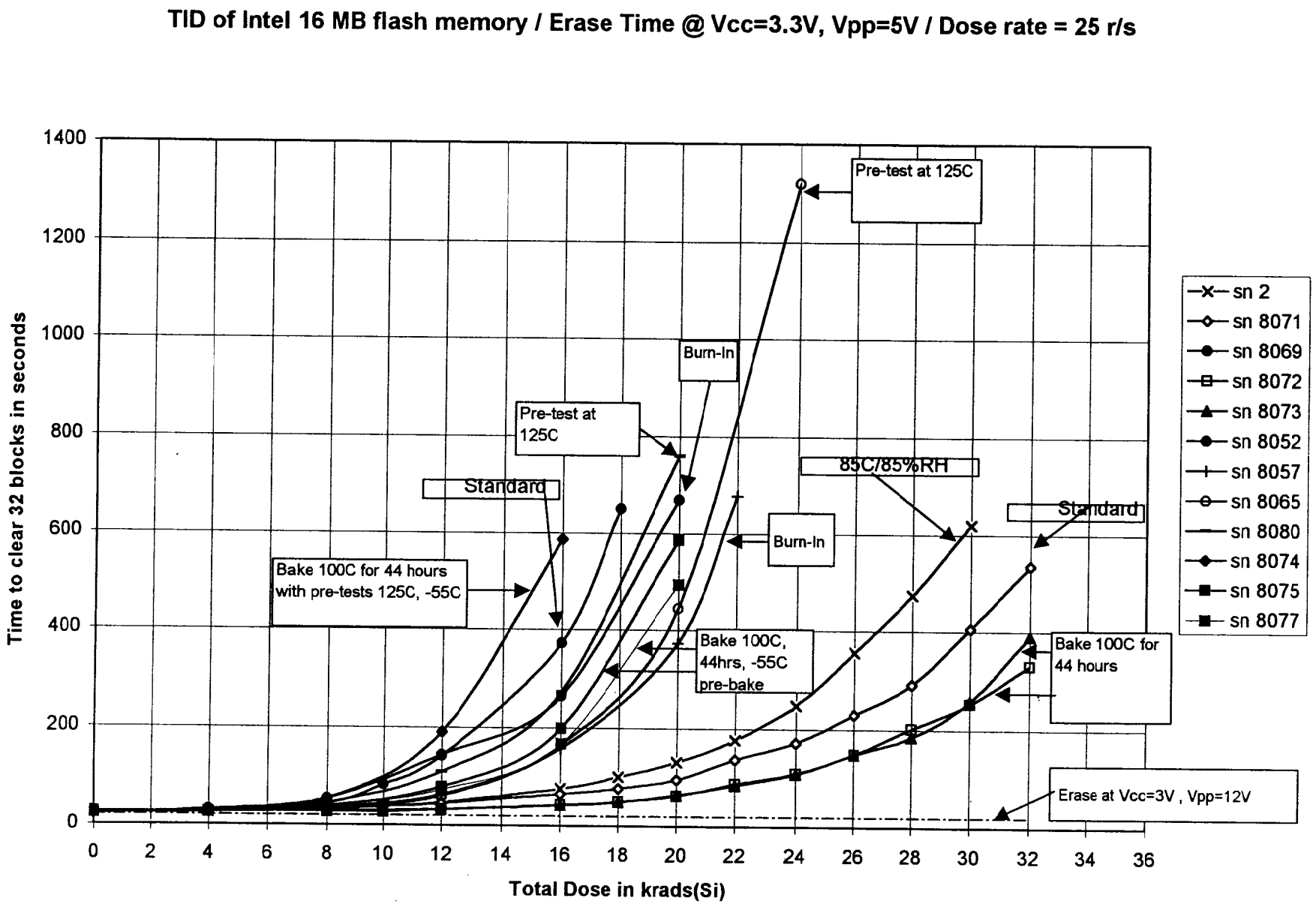

TID of Intel 16 MB flash memory / Erase Time @ Vcc=3.3V, Vpp=5V / Dose rate = 25 r/s
Time to clear 32 blocks in seconds
Total Dose in krads(Si)
0
200
400
600
800
1000
1200
1400
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
Pre-test at 125C
Burn-In
Pre-test at 125C
Standard
85C/85%RH
Standard
Burn-In
Bake 100C for 44 hours with pre-tests 125C, -55C
Bake 100C, 44hrs, -55C pre-bake
Bake 100C for 44 hours
Erase at Vcc=3V , Vpp=12V
sn 2
sn 8071
sn 8069
sn 8072
sn 8073
sn 8052
sn 8057
sn 8065
sn 8080
sn 8074
sn 8075
sn 8077

Chart 7

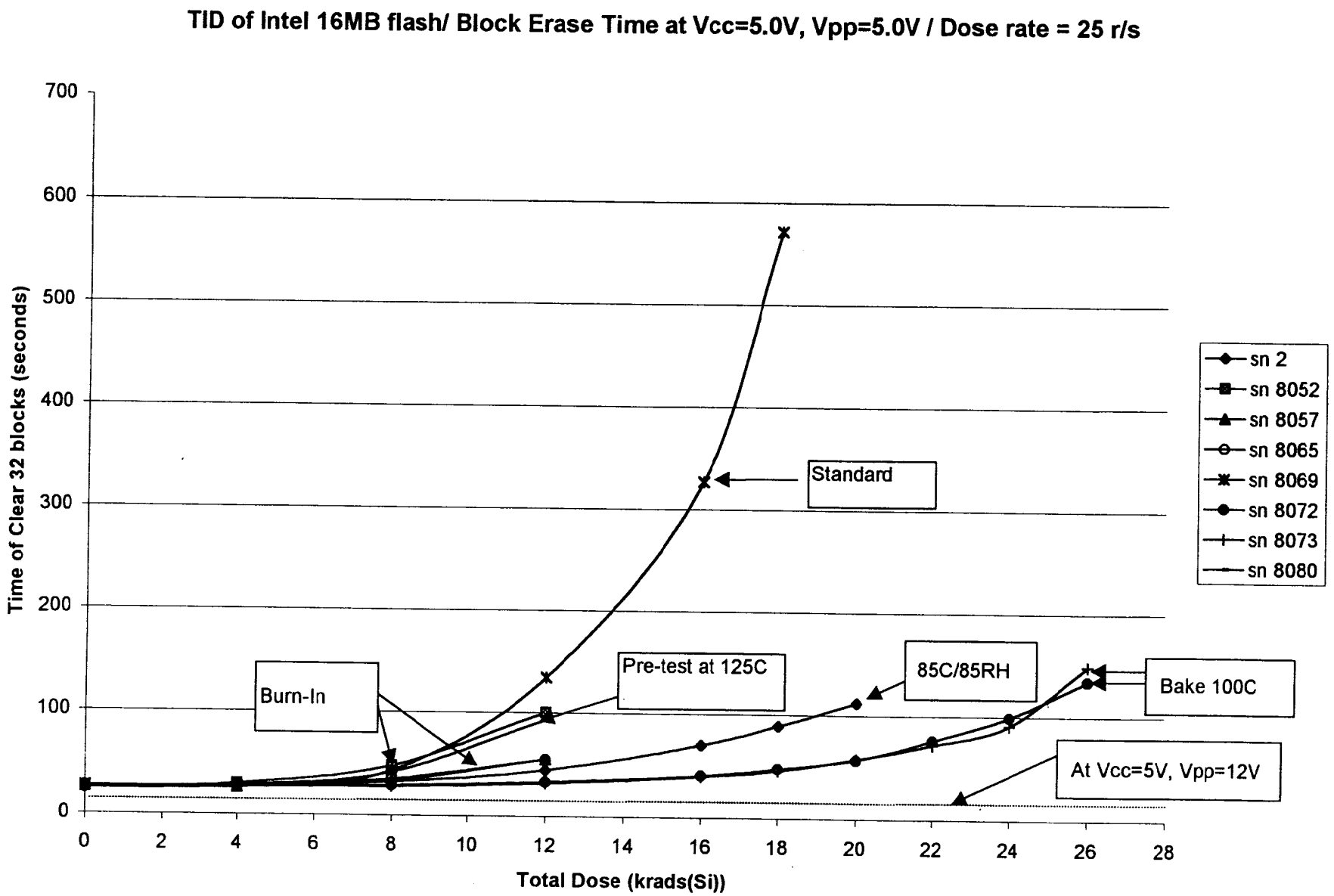

TID of Intel 16MB flash/ Block Erase Time at Vcc=5.0V, Vpp=5.0V / Dose rate = 25 r/s
Time of Clear 32 blocks (seconds)
700
600
500
400
300
200
100
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
Total Dose (krads(Si))
Standard
Burn-In
Pre-test at 125C
85C/85RH
Bake 100C
At Vcc=5V, Vpp=12V
sn 2
sn 8052
sn 8057
sn 8065
sn 8069
sn 8072
sn 8073
sn 8080

Chart 8

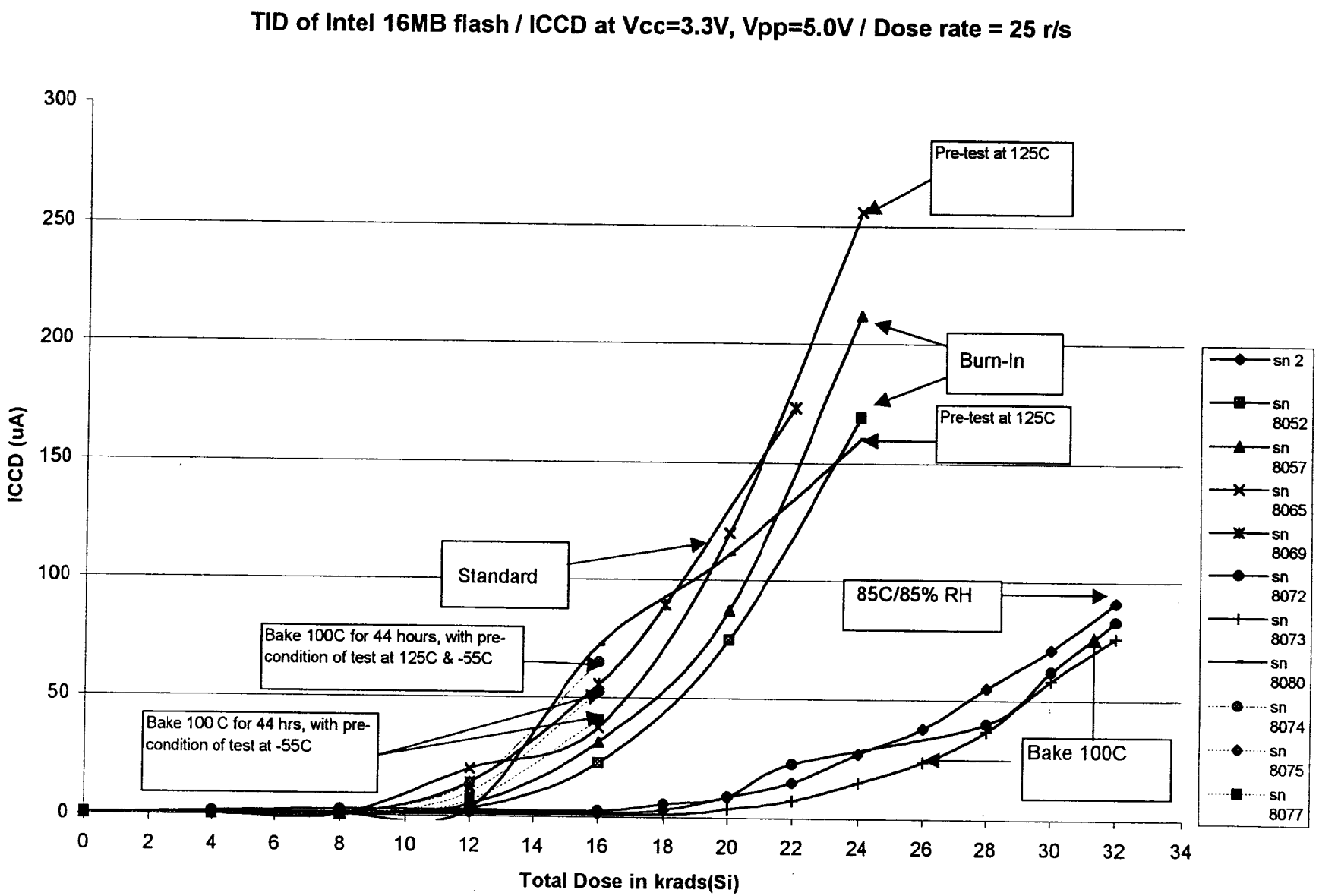

TID of Intel 16MB flash / ICCD at Vcc=3.3V, Vpp=5.0V / Dose rate = 25 r/s
ICCD (uA)
Total Dose in krads(Si)
300
250
200
150
100
50
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
Pre-test at 125C
Burn-In
Pre-test at 125C
Standard
85C/85% RH
Bake 100C for 44 hours, with pre-condition of test at 125C & -55C
Bake 100 C for 44 hrs, with pre-condition of test at -55C
Bake 100C
sn 2
sn 8052
sn 8057
sn 8065
sn 8069
sn 8072
sn 8073
sn 8080
sn 8074
sn 8075
sn 8077

Chart 9

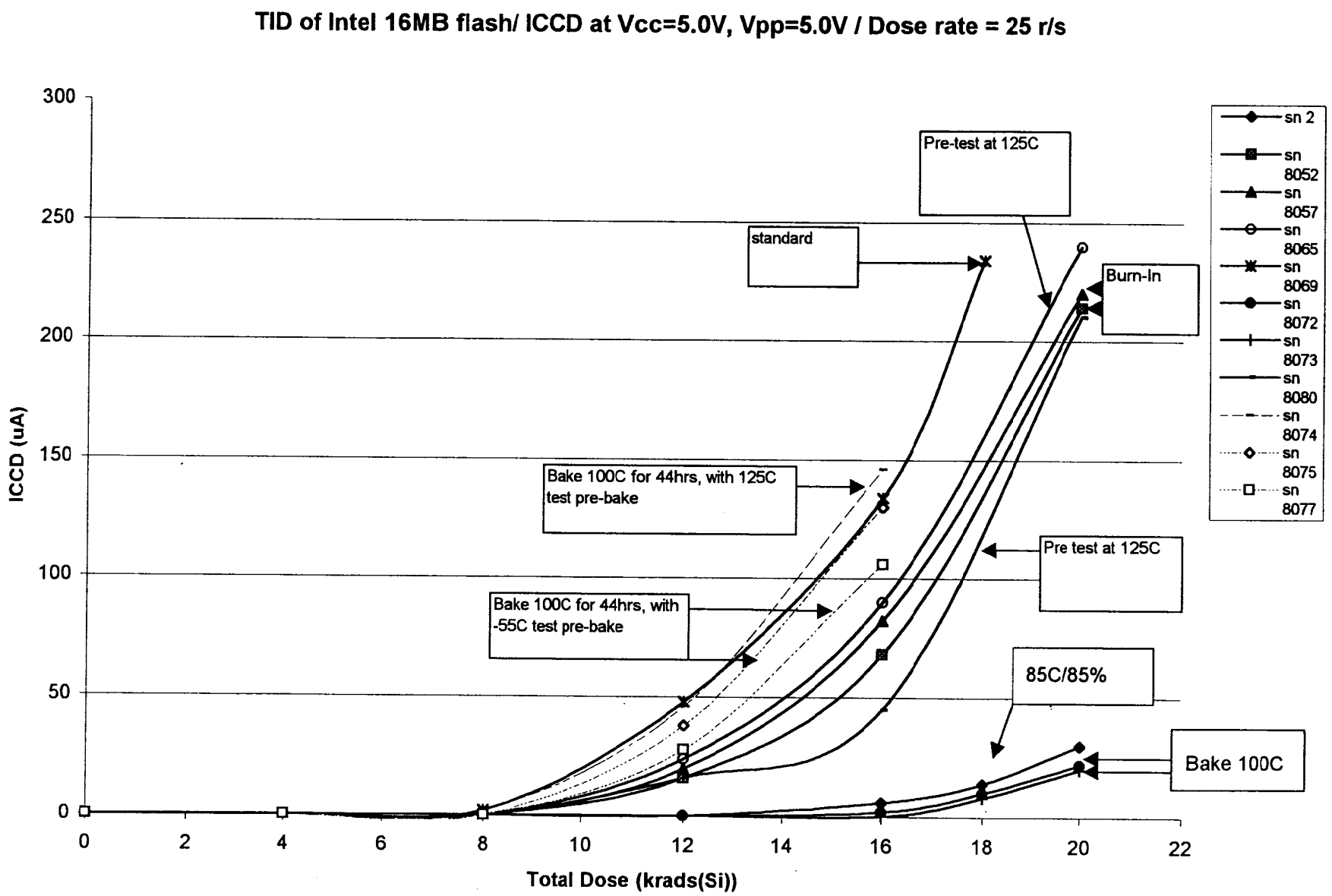

TID of Intel 16MB flash/ ICCD at Vcc=5.0V, Vpp=5.0V / Dose rate = 25 r/s
ICCD (uA)
Total Dose (krads(Si))
300
250
200
150
100
50
0
0
2
4
6
8
10
12
14
16
18
20
22
Pre-test at 125C
standard
Burn-In
Bake 100C for 44hrs, with 125C test pre-bake
Bake 100C for 44hrs, with -55C test pre-bake
Pre test at 125C
85C/85%
Bake 100C
sn 2
sn 8052
sn 8057
sn 8065
sn 8069
sn 8072
sn 8073
sn 8080
sn 8074
sn 8075
sn 8077

Figure 3

TID of Intel 16 MB flash memory

Functional Test: Time to Clear All 32 Blocks with Vcc=3.3V and Vpp=5V measured in seconds

| | 0 | 0.5 | 1 | 1.5 | 2 | 3 | 4 | 5 | 6 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8069 | 26 | 26 | 25 | 25 | 25 | 26 | 27 | | 35 | 45 | | 83 | | 143 | | | | 373 | 651 | | 1400 | | 3100 | | 4430 | | |
| 8070 | 27 | 27 | 26 | 26 | 26 | 27 | 29 | | 33 | 43 | | 70 | | 134 | | | | 366 | | | | | | | | | |
| 8061 | 30 | | 30 | | 40 | | 40 | | | 60 | | | | 100 | | | | 160 | | | | | | | | | 600 |
| 8059 | 23 | | | | | 23 | | | | | 27 | | 30 | | 33 | 36 | 39 | | | | 83 | | | | | 310 | |
| 3 | 25 | | | | | | | 26 | | | | 31 | | | | | 43 | | | 87 | | 160 | | 240 | | 400 | |

sn 8069 is biased at Vcc=5V and Vpp=5V

sn 8070 is biased at Vcc=5V and Vpp=5V from 0 krads(Si) to 16 krads(Si)

sn 8061 is biased at Vcc=5V and Vpp=12V

sn 8059 is biased at Vcc=3.6V and Vpp=5.5V

sn 3 is biased at Vcc=3.6V and Vpp=12V

sn 8061's Block Erase function still works at 26 krads(Si).

sn 8069 failed to erase at 24 krads(Si)

sn 3 and 8059 failed at 25 krads(Si).

Figure 4

TID of 16 MB flash memory

AC test: Time to Clear 32 blocks with Vcc=3.3V and Vpp=5V

| | 0 | 4 | 8 | 10 | 12 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| sn 2 | 24 | 26 | 33 | 39 | 48 | 76 | 101 | 132 | 177 | 248 | 356 | 475 | 620 | |
| sn 8071 | 26 | 28 | 35 | 39 | 46 | 65 | 77 | 96 | 138 | 172 | 230 | 291 | 406 | 536 |
| sn 8069 | 26 | 28 | 45 | 83 | 143 | 373 | 651 | | | | | | | |
| sn 8072 | 27 | 27 | 29 | 31 | 34 | 44 | 51 | 62 | 88 | 110 | 150 | 202 | 253 | 330 |
| sn 8073 | 27 | 27 | 28 | 28 | 33 | 43 | 50 | 64 | 84 | 108 | 149 | 185 | 258 | 390 |

Serial number 2 was steamed under 85C and 85% R.H. for 190 hours

Serial numbers 8072 and 8073 were baked for 44 hours at 100C

Serial number 8069 failed to erase at 24 krads(Si). It was exposed at 0.5k, 1k, 1.5k, 2k, 3k, 4k, 6k, 8k, 10k, 12k, 16k, 18k, 20k, 22k, 24krads(Si)

All five parts are biased at Vcc=5V and Vpp=5V

Figure 5

TID of 16 MB flash memory

ICCS at Vdd=5V

| | 0 | 4 | 8 | 10 | 12 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8072 | 102 | 102 | 104 | 104 | 104 | 110 | 118 | 130 | 144 | 166 | 194 | 228 | 286 | 344 |
| 8073 | 96 | 98 | 100 | 100 | 100 | 104 | 114 | 126 | 138 | 160 | 186 | 220 | 274 | 332 |
| 8069 | 100 | 100 | 104 | 126 | 160 | 260 | 370 | | | | | | | |
| 2 | 98 | 98 | 100 | 100 | 100 | 108 | 120 | 136 | 158 | 184 | 218 | 258 | 574 | 644 |

Serial number 2 was steamed under 85C and 85% R.H. for 190 hours

Serial numbers 8072 and 8073 were baked at 100C for 44 hours

Serial number 8069 was irradiated at 0.5k, 1k, 1.5k, 2k, 3k, 4k, 6k, 8k, 10k, 12k, 16k, 18k, 20k,22k,24k

The above parts were biased at Vcc=5V and Vpp=5V

Figure 6

TID of 16 MB flash memory

ICCD at Vcc=5V

| | 0 | 4 | 8 | 10 | 12 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8072 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 2 | 10 | 22 | 32 | 52 | 76 | 104 | 152 | 204 |
| 8073 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 2 | 8 | 20 | 30 | 48 | 70 | 96 | 142 | 192 |
| 8069 | 0.2 | 0.2 | 2 | 18 | 48 | 134 | 234 | | | | | | | |
| 2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 6 | 14 | 30 | 48 | 72 | 100 | 134 | 158 | 212 |

Serial number 2 was steamed under 85C and 85% R.H. for 190 hours

Serial numbers 8072 and 8073 were baked at 100C for 44 hours

Serial number 8069 was irradiated at 0.5k, 1k, 1.5k, 2k, 3k, 4k, 6k, 8k, 10k, 12k, 16k, 20k, 22k, 24krads(Si)

All above parts were biased at Vcc=5V and Vpp=5V

Figure 7

| TID of Intel 16 MB flash memory | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| Time of 32 blocks erase in seconds with Vcc=3.3V, Vpp=5V and Vcc=3.3V, Vpp=12V | | | | | | | | | | |
| Serial number 8072 | | | | | | | | | | |
| | | | | | | | | | | |
| | ***0*** | ***4*** | ***8*** | ***10*** | ***12*** | ***14*** | ***18*** | ***20*** | ***22*** | ***24*** |
| 3V_5V | 27 | 26.6 | 28.6 | 31 | 34.1 | 43.6 | 51 | 63.3 | 88.3 | 109 |
| 3V_12V | 20.4 | 19.2 | 18.1 | 17.7 | 17.5 | 17.3 | 17.2 | 17.2 | 17.7 | 17.6 |

Figure 8

TID of 16 MB flash memory

AC test: Time to Clear 32 blocks with Vcc=3.3V and Vpp=5V

| | 0 | 4 | 8 | 10 | 12 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| sn 2 | 24 | 26 | 33 | 39 | 48 | 76 | 101 | 132 | 177 | 248 | 356 | 475 | 620 | |
| sn 8071 | 26 | 28 | 35 | 39 | 46 | 65 | 77 | 96 | 138 | 172 | 230 | 291 | 406 | 536 |
| sn 8069 | 26 | 28 | 45 | 83 | 143 | 373 | 651 | | | | | | | |
| sn 8072 | 27 | 27 | 29 | 31 | 34 | 44 | 51 | 62 | 88 | 110 | 150 | 202 | 253 | 330 |
| sn 8073 | 27 | 27 | 28 | 28 | 33 | 43 | 50 | 64 | 84 | 108 | 149 | 185 | 258 | 390 |
| sn 8052 | 25 | 32 | 54 | #N/A | 145 | 265 | #N/A | 670 | | | | | | |
| sn 8057 | 24 | 26 | 36 | #N/A | 63 | 159 | #N/A | 373 | 678 | | | | | |
| sn 8065 | 24 | 28 | 37 | #N/A | 60 | 165 | #N/A | 445 | #N/A | 1320 | | | | |
| sn 8080 | 24 | 29 | 46 | #N/A | 110 | 272 | #N/A | 760 | | | | | | |
| sn 8074 | 23 | 30 | 55 | #N/A | 191 | 588 | | | | | | | | |
| sn 8075 | 25 | 27 | 40 | #N/A | 79 | 199 | #N/A | 587 | | | | | | |
| sn 8077 | 25 | 26 | 38 | #N/A | 73 | 168 | #N/A | 494 | | | | | | |

Serial number 2 was steamed under 85C and 85% R.H. for 190 hours

Serial numbers 8072 and 8073 were baked for 44 hours at 100C

**Serial number 8069 failed to erase at 24 krads(Si). It was exposed at 0.5k, 1k, 1.5k, 2k, 3k, 4k, 6k, 8k, 10k, 12k, 16k, 18k, 20k, 22k, 24krads(Si)**

All five parts are biased at Vcc=5V and Vpp=5V

Figure 9

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TID of ICCD at Vcc=3.3 volts, Vpp=5.0V | | | | | | | | | | | | | |
| | 0 | 4 | 8 | 12 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 |
| sn 2 | 0.6 | 0.8 | 1.4 | 1.6 | 1.6 | 3 | 8.6 | 15 | 27.2 | 38 | 55 | 71 | 91 |
| sn 8052 | 0.8 | 0.8 | 0.8 | 3.2 | 22.8 | #N/A | 74.6 | #N/A | 169 | | | | |
| sn 8057 | 0.4 | 0.4 | 0.4 | 5 | 31.4 | #N/A | 87 | #N/A | 212 | | | | |
| sn 8065 | 0.4 | 0.4 | 0.4 | 20 | 37.6 | #N/A | 120 | #N/A | 256 | | | | |
| sn 8069 | 0.2 | 0.4 | 0.4 | 14.2 | 55.6 | 89.2 | #N/A | 173 | | | | | |
| sn 8072 | 0.4 | 1.6 | 2.6 | 2.6 | 2.6 | 5.6 | 8.8 | 23 | #N/A | #N/A | 40 | 62 | 83 |
| sn 8073 | 0.2 | 0.2 | 0.8 | #N/A | #N/A | 1.2 | 3.8 | 7.4 | 15 | 24 | 37 | 58 | 76 |
| sn 8080 | 0.4 | 0.4 | 0.4 | 3 | 72 | #N/A | 110.8 | #N/A | 160 | | | | |
| sn 8074 | 0.2 | 0.4 | 1.2 | 13.8 | 64.8 | | | | | | | | |
| sn 8075 | 0.4 | 0.4 | 0.4 | 10.2 | 52.2 | | | | | | | | |
| sn 8077 | 0.4 | 0.8 | 0.8 | 6.6 | 40.6 | | | | | | | | |
| | | | | | | | | | | | | | |
| TID of ICCD at Vcc=5.0 volts, Vpp=5.0V | | | | | | | | | | | | | |
| | 0 | 4 | 8 | 12 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 |
| sn 2 | 0.2 | 0.2 | 0.2 | 0.2 | 6 | 14 | 30 | 48 | 72 | 100 | 134 | 158 | 212 |
| sn 8052 | 0.2 | 0.2 | 0.2 | 16 | 68 | #N/A | 214 | #N/A | 900 | | | | |
| sn 8057 | 0.2 | 0.2 | 0.2 | 20 | 82 | #N/A | 220 | #N/A | 866 | | | | |
| sn 8065 | 0.2 | 0.2 | 0.2 | 24 | 90 | #N/A | 240 | #N/A | 844 | | | | |
| sn 8069 | 0.2 | 0.2 | 2 | 48 | 134 | 234 | #N/A | 972 | 2300 | | | | |
| sn 8072 | 0.2 | 0.2 | 0.2 | 0.2 | 2 | 10 | 22 | 32 | 52 | 76 | 104 | 152 | 204 |
| sn 8073 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 8 | 20 | 30 | 48 | 70 | 96 | 142 | 192 |
| sn 8080 | 0.2 | 0.2 | 0.2 | 16 | 44.8 | #N/A | 210 | #N/A | 852 | | | | |
| sn 8074 | 0.2 | 0.2 | 2 | 46 | 146 | | | | | | | | |
| sn 8075 | 0.2 | 0.2 | 0.2 | 38 | 130 | | | | | | | | |
| sn 8077 | 0.2 | 0.2 | 0.2 | 28 | 106 | | | | | | | | |
| TID of Time of Erase 32 blocks at Vcc=5.0V, Vpp=5.0V | | | | | | | | | | | | | |
| | 0 | 4 | 8 | 12 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 |
| sn 2 | 24.6 | 26 | 32.5 | 44.5 | 70.3 | 89 | 112 | | | | | | |
| sn 8052 | 25 | 30 | 48 | 100 | | | | | | | | | |
| sn 8057 | 26 | 26 | 33 | 55 | | | | | | | | | |
| sn 8065 | 25 | 28 | 35 | 55 | | | | | | | | | |
| sn 8069 | 27 | 27 | 43 | 134 | 327 | 572 | | | | | | | |
| sn 8072 | 27 | 27 | 29 | 33 | 41 | 48 | 57 | 76.4 | 99 | 134 | | | |
| sn 8073 | 27 | 27 | 28 | 32 | 40 | 46 | 58 | 72 | 91 | 148 | | | |
| sn 8080 | 25 | 28 | 42 | 93 | | | | | | | | | |