



DATE: May 13, 1996
 TO: S. Hull/311
 FROM: K. Sahu/300.1 KS
 SUBJECT: Radiation Report on: A1280A
 Project: HST
 Control #: 14642 (HST/FLEX/HSR-SSR) (Group 1)
 14642A (HST/SSR) (Group 2)
 Job #: EE61884, EE61885 (HST/FLEX/HSR-SSR) (Group 1)
 EE61900 (HST/SSR) (Group 2)
 Project part #: A1280ACQ172C (5962-9215601MYA) (HST/FLEX/HSR/SSR) (Group 1)
 A1280ACQ172B (5962-9215601MYC) (HST/SSR) (Group 2)

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A radiation evaluation was performed on A1280A (Field Programmable Gate Array) to determine the total dose tolerance of these parts. A brief summary of the test results is provided below. For detailed information, refer to Tables I through IV and Figure 1.

The total dose testing was performed using a Co⁶⁰ gamma ray source. During the radiation testing, three parts from Group 1 (S/N 6, 7 and 8) and four parts from Group 2 (S/N 2, 3, 4 and 5) were irradiated under bias (see Figure 1 for bias configuration). One part in each group was used as a control sample. The total dose radiation levels were 3, 4, 5, 6 and 7 krad*. The dose rate was 0.059 krad/hour (see Table II for radiation schedule). After each radiation exposure and annealing step, parts were electrically tested according to the test conditions and the specification limits** listed in Table III. The electrical measurements included three functional tests at 1.0 MHz: one with Vcc = 4.5 V, Vil = 0.0 V and Vih = 4.5 V, one with Vcc = 5.0 V, Vil = 0.0 V and Vih = 5.0 V, and one with Vcc = 5.5 V, Vil = 0.0 V and Vih = 5.5 V.

All parts in both groups passed all electrical parametric and functional tests initially (before irradiation). After the 3, 4 and 5 krad irradiation, significant increases were seen in both ICCL and ICCH, although all irradiated parts continued to remain within specification limits (see Figs. 2-5 for ICCL and ICCH vs. total dose and annealing). Values for other electrical parameters in all irradiated parts remained approximately constant throughout all subsequent irradiation and annealing steps and all irradiated parts passed all functional tests throughout all irradiation and annealing steps.

After the 6 krad irradiation, S/N 7 (Group 1) exceeded the maximum specification limits of 20.00 mA for both ICCL and ICCH, with readings of 21.44 and 20.90 mA, respectively, and all four irradiated parts in Group 2 exceeded the maximum specification limits for ICCL and ICCH, with readings ranging from 28.05 to 31.36 mA for ICCL and from 27.22 to 30.26 mA for ICCH. All other irradiated parts continued to pass all functional and parametric tests, although increasing degradation was observed in both ICCL and ICCH in these parts (See Figures 2-5).

* The term rads, as used in this document, means rads(silicon). All consecutive annealing times at the same temperature and all radiation levels cited are cumulative.

** These are manufacturer's pre-irradiation data specification limits. No post-irradiation limits were provided by the manufacturer at the time these tests were performed.

After the 7 krad irradiation, all irradiated parts in both groups exceeded the maximum specification limits for ICCL and ICCH, with readings ranging from 23.65 to 32.45 mA in Group 1 and from 40.44 to 50.07 mA in Group 2.

After annealing for 72 hours at 25°C, all irradiated parts showed some recovery in ICCL and ICCH. One part (S/N 6, Group 1) recovered to within specification limits for ICCL and ICCH. All irradiated parts in Group 2 continued to exceed specification limits for ICCL and ICCH.

During annealing from 96 to 240 hours at 25°C, all irradiated parts continued to show increasing recovery in ICCL and ICCH.

After final annealing (648 hours) at 25°C, all irradiated parts in Group 1 had recovered at least marginally to within specification limits for ICCL and ICCH, while in Group 2, S/N 5 had recovered to within specification limits for ICCH and S/N 3 had recovered to within specification limits for both ICCL and ICCH.

Figures 2-5 provide graphs of the values of ICCL and ICCH for both groups throughout all irradiation and annealing steps.

Tables Iva (Group 1) and Ivb (Group 2) provide a summary of the functional test results and the mean and standard deviation values for each parameter after each irradiation exposure and annealing step.

Any further details about this evaluation can be obtained upon request. If you have any questions, please call me at (301) 731-8954.

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Figure 1. Radiation Bias Circuit for A1280A

Signal	Location	Burn-In Board	NOTES:
PRA	C9	VCC	1. VCC = 5.0 V, +/- 0.5 V
PRB	D7	VCC	
MODE	C3	GND	
SDI	B14	VCC	
SDO	P13	VCC	
DCLK	B3	GND	2. VCC/2 = 2.5 V +/- 0.25 V
ILINO	J15	VCC	
ILIN1	L1	GND	3. All outputs through 2.2 kohm +/- 10% 1/4 W resistors to VCC/2
ILIN2	B6	VCC	
ILIN3	H1	GND	
ILIN4	R6	VCC	
ILIN5	R3	GND	
ILIN6	M14	VCC	
ILIN7	B2	GND	
ILIN8	M1	VCC	
ILIN9	F15	GND	
ILIN10	C1	VCC	
ILIN11	J3	GND	4. Inputs connected to VCC through 2.2 kohm resistor
ILIN12	H15	VCC	
ILIN13	N2	GND	5. Inputs connected to GND do not require resistors
ILIN14	P9	VCC	
ILIN15	N14	GND	
ILIN16	C4	VCC	
ILIN17	M13	GND	
ILIN18	N15	VCC	
ILIN19	G3	GND	
ILOUT0	L15	VCC/2	
ILOUT1	K3	VCC/2	
ILOUT2	A6	VCC/2	
ILOUT3	J1	VCC/2	
ILOUT4	P7	VCC/2	
ILOUT5	P3	VCC/2	
ILOUT6	P14	VCC/2	
ILOUT7	D1	VCC/2	
ILOUT8	N1	VCC/2	
ILOUT9	G14	VCC/2	
ILOUT10	D3	VCC/2	
ILOUT11	K1	VCC/2	
ILOUT12	G13	VCC/2	
ILOUT13	P1	VCC/2	
ILOUT14	R10	VCC/2	
ILOUT15	L12	VCC/2	
ILOUT16	A3	VCC/2	
ILOUT17	P15	VCC/2	
ILOUT18	R15	VCC/2	
ILOUT19	G2	VCC/2	

VCC: F4, H3, J4, M5, N8, M11, H13, G12, D11, D8, D5, J14, H2, H14 (NO RESISTOR)

GND: D4, E4, G4, H4, K4, L4, M4, M6, M8, M10, M12, K12, J12, H12, F12, E12, D12, D10, C8, D6, J13

Table V. Radiation Bias Circuit for 1280A (cont.)

Signal	Location	Burn-In Board	NOTES:
OLIN0	B4	VCC	1. VCC = 5.0 V, +/- 0.5 V
OLIN1	K15	GND	
OLIN2	C7	VCC	
OLIN3	E14	GND	
OLIN4	C10	VCC	
OLIN5	C11	GND	2. VCC/2 = 2.5 V +/- 0.25 V
OLIN6	M9	VCC	
OLIN7	A10	GND	3. All outputs through 2.2 kohm +/- 10% 1/4 W resistors to VCC/2
OLIN8	A11	VCC	
OLIN9	D2	GND	
OLIN10	L14	VCC	4. Inputs connected to VCC through 2.2 kohm resistor
OLIN11	P8	GND	
OLIN12	N11	VCC	5. Inputs connected to GND do not require resistors
OLIN13	M3	GND	
OLIN14	C5	VCC	
OLIN15	F3	GND	
OLIN16	C12	VCC	
OLIN17	P6	GND	
OLIN18	E3	VCC	
OLIN19	P11	GND	
OLOUT0	A4	VCC/2	
OLOUT1	G15	VCC/2	
OLOUT2	B7	VCC/2	
OLOUT3	E2	VCC/2	
OLOUT4	B11	VCC/2	
OLOUT5	A12	VCC/2	
OLOUT6	N9	VCC/2	
OLOUT7	D9	VCC/2	
OLOUT8	B10	VCC/2	
OLOUT9	A1	VCC/2	
OLOUT10	L13	VCC/2	
OLOUT11	R7	VCC/2	
OLOUT12	R12	VCC/2	
OLOUT13	M2	VCC/2	
OLOUT14	B5	VCC/2	
OLOUT15	F2	VCC/2	
OLOUT16	B12	VCC/2	
OLOUT17	R5	VCC/2	
OLOUT18	B1	VCC/2	
OLOUT19	R11	VCC/2	
IOGATE	B80	GND	
SERIALIN	A7	VCC	
SERIALOUT	F1	VCC/2	
INX1	R2	VCC	
INX2	N5	VCC	
IN1A	M15	GND	

VCC: F4, H3, J4, M5, N8, M11, H13, G12, D11, D8, D5, J14, H2, H14 (NO RESISTOR)

GND: D4, E4, G4, H4, K4, L4, M4, M6, M8, M10, M12, K12, J12, H12, F12, E12, D12, D10, C8, D6, J13

Table V. Radiation Bias Circuit for I280A (cont.)

Signal	Location	Burn-In Board
IN2A	K14	GND
IN_AND3	P12	VCC
IN_AND4	P13	GND
IN_OR3	N6	VCC
IN_OR4	N10	GND
IN_NAND4	M7	VCC
IN_NOR4	N13	GND
DA	L3	VCC
RESET	P2	GND
ENCNTR	C13	VCC
CNTRLD	E13	GND
RESETCENTR	D14	GND
CLOCK	A9	GND
OUTX1	N3	VCC/2
OUTX2	R4	VCC/2
OUTA	K13	VCC/2
O_AND3	R13	VCC/2
O_AND4	N12	VCC/2
O_OR3	P5	VCC/2
O_OR4	P10	VCC/2
O_NAND4	N7	VCC/2
O_NOR4	R14	VCC/2
QA0	L2	VCC/2
QA1	K2	VCC/2
YO11	B13	VCC/2
YO10	F14	VCC/2
YO9	A13	VCC/2
YO8	A15	VCC/2
YO7	D15	VCC/2
YO6	A14	VCC/2
YO5	D13	VCC/2
YO4	C14	VCC/2
YO3	E15	VCC/2
YO2	B15	VCC/2
YO1	C15	VCC/2
YO0	F13	VCC/2

NOTES:

1. VCC = 5.0 V, +/- 0.5 V
2. VCC/2 = 2.5 V +/- 0.25 V
3. All outputs through 2.2 kohm +/- 10% 1/4 W resistors to VCC/2
4. Inputs connected to VCC through 2.2 kohm resistor
5. Inputs connected to GND do not require resistors

VCC: F4, H3, J4, M5, N8, M11, H13, G12, D11, D8, D5, J14, H2, H14 (NO RESISTOR)

GND: D4, E4, G4, H4, K4, L4, M4, M6, M8, M10, M12, K12, J12, H12, F12, E12, D12, D10, C8, D6, J13

TABLE I. Part Information (Group 1)

Generic Part Number:	A1280A*
Project Part Number	A1280ACQ172C (5962-9215601MYA) (IIST/FLEX/IISR/SSR)
Control Number:	14642 (IIST/FLEX/IISR-SSR)
Charge Number:	EE61884, EE61885 (IIST/FLEX/IISR-SSR)
Manufacturer:	Actel
Lot Date Code (LDC):	9607
Quantity Tested:	4
Serial Number of Control Samples:	1
Serial Numbers of Radiation Samples:	6, 7, 8
Part Function:	Field Programmable Gate Array
Part Technology:	CMOS
Package Style:	172-pin Quad Flatpack
Test Equipment:	S-50
Engineer:	A. Duvalsaint

* No radiation tolerance/hardness was guaranteed by the manufacturer for this part.

TABLE I. Part Information (Group 2)

Generic Part Number:	A1280A*
Project Part Number	A1280ACQ172B (5962-9215601MYC) (HST/SSR)
Control Number:	14642A (HST/SSR)
Charge Number:	EE61900 (HST/SSR)
Manufacturer:	Actel
Lot Date Code (LDC):	9541
Quantity Tested:	5
Serial Number of Control Samples:	1
Serial Numbers of Radiation Samples:	2, 3, 4, 5
Part Function:	Field Programmable Gate Array
Part Technology:	CMOS
Package Style:	172-pin Quad Flatpack
Test Equipment:	S-50
Engineer:	A. Duvalsaint

* No radiation tolerance/hardness was guaranteed by the manufacturer for this part.

TABLE II. Radiation Schedule for A1280A (Groups 1 and 2)

EVENT.....	DATE
1) INITIAL ELECTRICAL MEASUREMENTS.....	04/04/96
2) 3 KRAD IRRADIATION (0.05 KRADS/HOUR).....	04/05/96
POST-3 KRAD ELECTRICAL MEASUREMENT.....	04/08/96
3) 4 KRAD IRRADIATION (0.06 KRADS/HOUR).....	04/08/96
POST-4 KRAD ELECTRICAL MEASUREMENT.....	04/09/96
4) 5 KRAD IRRADIATION (0.06 KRADS/HOUR).....	04/09/96
POST-5 KRAD ELECTRICAL MEASUREMENT.....	04/10/96
5) 6 KRAD IRRADIATION (0.06 KRADS/HOUR).....	04/10/96
POST-6 KRAD ELECTRICAL MEASUREMENT.....	04/11/96
6) 7 KRAD IRRADIATION (0.06 KRADS/HOUR).....	04/11/96
POST-7 KRAD ELECTRICAL MEASUREMENT.....	04/12/96
7) 72-HOUR ANNEALING @25°C.....	03/12/96
POST-72 HOUR ANNEAL ELECTRICAL MEASUREMENT.....	04/15/96
8) 96-HOUR ANNEALING @25°C.....	04/15/96
POST-96-HOUR ANNEAL ELECTRICAL MEASUREMENT.....	04/16/96
9) 144-HOUR ANNEALING @25°C.....	04/16/96
POST-144-HOUR ANNEAL ELECTRICAL MEASUREMENT.....	04/19/96
10) 240-HOUR ANNEALING @25°C.....	04/19/96
POST-216-HOUR ANNEAL ELECTRICAL MEASUREMENT.....	04/22/96
11) 648-HOUR ANNEALING @25°C.....	04/22/96
POST-648-HOUR ANNEAL ELECTRICAL MEASUREMENT.....	05/09/96

PARTS WERE IRRADIATED AND ANNEALED UNDER BIAS; SEE FIGURE 1.

Table III. Electrical Characteristics of A1280A

FUNCTIONAL TESTS PERFORMED						
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS AT +25C ONLY
FUNCT 1	4.5V	0.0V	4.5V	FREQ=1.000MHZ	ALL I/O	VOL<2.25V ; VOH>2.25V
FUNCT 2	5.0V	0.0V	5.0V	FREQ=1.000MHZ	ALL I/O	VOL<2.50V ; VOH>2.50V
FUNCT 3	5.5V	0.0V	5.5V	FREQ=1.000MHZ	ALL I/O	VOL<2.75V ; VOH>2.75V
DC PARAMETRIC TESTS PERFORMED						
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS @ -55C,+25C,+125C
VOH1	4.5V	0.00V	4.50V	LOAD=-4.0MA	OUTS	>+3.70V ; <+4.50V
VOL1	4.5V	0.00V	4.50V	LOAD=+6.0MA	OUTS	>+0.0V ; <+0.40V
I _{IH}	5.5V	0.00V	5.5V	V _{IN} = 5.5V	INS	>-10UA ; <+10UA
I _{IL}	5.5V	0.00V	5.5V	V _{IN} = 0.0V	INS	>-10UA ; <+10UA
I _{OSN}	5.5V	0.0V	5.5V	V _{OUT} = GND	VCC	>-100MA ; <+100MA
I _{CCH}	5.5V	0.0V	5.5V	V _{OUT} = 5.5V	VCC	>+0.0UA ; <+25MA
I _{CCL}	5.5V	0.0V	5.5V	V _{OUT} = 0.0V	VCC	>+0.0UA ; <+25MA
AC PARAMETRIC TESTS PERFORMED						
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS @ -55C,+25C,+125C
TPLH	4.5V	0.00V	3.00V	V _{TEST} =2.0V	OUTS	>+0.0NS ; <+100NS
TPHL	4.5V	0.00V	3.00V	V _{TEST} =2.0V	OUTS	>+0.0NS ; <+100NS

Table IVa: Total Dose Exposures and Annealing for A1280ACQ172C (5962-9215601MYA) (Group 1) /1

Test /2	Spec. Lim./3	Initial		Total Dose Exposure (krads)														Annealing									
				25°C		3		4		5		6		7		72 hrs @ 25°C		96 hrs @ 25°C		144 hrs @ 25°C		240 hrs @ 25°C		648 hrs @ 25°C			
# Parameters	Units	min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd		
1	FUNC1, VCC=4.5V, VIL=0.0V, VIH=4.5V, 1MHz			P		P		P		P		P		P		P		P		P		P		P			
2	FUNC2, VCC=5.0V, VIL=0.0V, VIH=5.0V, 1MHz			P		P		P		P		P		P		P		P		P		P		P			
3	FUNC3, VCC=5.5V, VIL=0.0V, VIH=5.5V, 1MHz			P		P		P		P		P		P		P		P		P		P		P			
4	VOHI	V	3.7	4.5	4.21	.01	4.21	.01	4.21	.01	4.21	.01	4.22	.01	4.22	5.8	4.22	.01	4.22	.01	4.22	.01	4.22	.01	4.22	.01	
5	VOLI	mV	0	400	127	5.2	126	5.4	125	5.6	126	5.6	129	4.7	129	4.5	129	4.2	130	4.6	130	6.2	130	3.8	130	4.1	
6	I IH	uA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	I IL	uA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
9	I OSN	mA	-100	-10	-31.08	.74	-31.06	.72	-31.21	.70	-31.21	.73	-31.32	.69	-31.28	.67	-31.31	.67	-31.26	.67	-31.20	.68	-31.10	.69	-31.32	.68	
9	I CCL	mA	0	20	2.09	.26	2.92	.14	5.39	.47	9.79	1.5	17.96	2.7	27.59	3.7	21.91	3.5	21.54	3.4	20.00	3.6	18.63	3.7	14.68	3.5	
10	I CCH	mA	0	20	2.09	.26	3.10	.34	5.21	.67	9.88	1.5	17.32	2.8	26.49	3.4	21.54	3.3	20.44	3.5	19.09	3.5	17.99	3.9	13.67	3.6	
11	T PLH	ns	0	100	35.45	3.0	35.34	3.0	35.19	2.9	35.16	2.9	35.28	2.9	35.04	3.5	35.27	2.9	35.02	3.5	35.51	4.2	35.55	4.2	35.80	3.3	
12	T PHL	ns	0	100	34.65	4.3	34.53	4.2	34.36	4.1	34.39	4.1	34.46	4.1	34.54	4.1	34.50	4.1	34.54	4.1	35.18	4.4	35.25	4.4	35.59	3.6	

Notes:

- 1/ The mean and standard deviation values were calculated over the three parts irradiated in this testing. The control sample remained constant throughout the testing and is not included in this table.
- 2/ In the functional tests, "P" means that all parts passed this test at this irradiation or annealing level, "F" means that all parts failed this test at this irradiation or annealing level and "nPmF" means that n parts passed at this level and m parts failed at this level.
- 3/ These are manufacturer's pre-irradiation data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed.

Table IVb: Total Dose Exposures and Annealing for A1280ACQ172B (5962-9215601MYC) (Group 2) /1

Test /2	# Parameters	Units	Spec. Lim./3		Initial		Total Dose Exposure (krads)										Annealing											
					25°C		3		4		5		6		7		72 hrs @ 25°C		96 hrs @ 25°C		144 hrs @ 25°C		240 hrs @ 25°C		648 hrs @ 25°C			
					mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
1	FUNCL VCC=4.5V, VIL=0.0V, VIH=4.5V, 1MHz					P		P		P		P		P		P		P		P		P		P		P		
2	FUNCL VCC=5.0V, VIL=0.0V, VIH=5.0V, 1MHz					P		P		P		P		P		P		P		P		P		P		P		
3	FUNCL VCC=5.5V, VIL=0.0V, VIH=5.5V, 1MHz					P		P		P		P		P		P		P		P		P		P		P		
4	VOHI	V	3.7	4.5	4.20	.01	4.19	.01	4.19	.01	4.19	9.9	4.20	.01	4.20	.01	4.20	.01	4.20	.01	4.20	.01	4.20	.01	4.20	.01	4.20	.01
5	VOLI	mV	0	400	137	4.7	137	4.9	138	4.3	137	4.9	140	2.7	140	2.6	140	2.7	140	2.2	140	2.3	140	2.1	140	2.2	140	2.2
6	I _{IH}	uA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	I _{IL}	uA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	I _{OSN}	mA	-100	-10	-28.33	.55	-28.34	.55	-28.21	.56	-28.30	.56	-28.42	.54	-28.30	.56	-28.28	.55	-28.38	.55	-28.39	.56	-28.24	.56	-28.39	.55	-28.39	.55
9	ICCL	mA	0	20	1.70	.12	1.93	.27	1.99	.92	18.70	.85	29.91	1.3	46.22	3.2	30.60	3.6	29.50	3.7	28.14	4.4	26.77	4.8	21.74	5.2	21.74	5.2
10	ICCH	mA	0	20	1.84	.12	4.66	.44	8.37	.88	17.94	.53	28.95	1.1	44.64	2.9	29.02	2.9	27.98	3.4	26.49	3.9	25.05	4.4	20.09	5.3	20.09	5.3
11	TPLH	ns	0	100	36.16	5.2	35.98	5.3	36.05	5.5	35.95	5.5	35.99	5.6	36.05	5.8	36.09	5.7	35.97	5.7	36.58	5.9	36.70	5.9	36.76	5.6	36.76	5.6
12	TPHL	ns	0	100	36.44	4.9	36.32	4.8	36.50	4.8	36.4	4.8	36.47	4.8	36.62	4.8	36.61	4.8	36.51	4.7	37.06	5.0	37.18	5.0	37.56	4.4	37.56	4.4

Notes:

- 1/ The mean and standard deviation values were calculated over the four parts irradiated in this testing. The control sample remained constant throughout the testing and is not included in this table.
- 2/ In the functional tests, "P" means that all parts passed this test at this irradiation or annealing level, "F" meant that all parts failed this test at this irradiation or annealing level and "nPrmF" means that n parts passed at this level and m parts failed at this level.
- 3/ These are manufacturer's pre-irradiation data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed.

Figure 2. ICCL (mA) A1280A 5962-9215601MYA (Group 1)

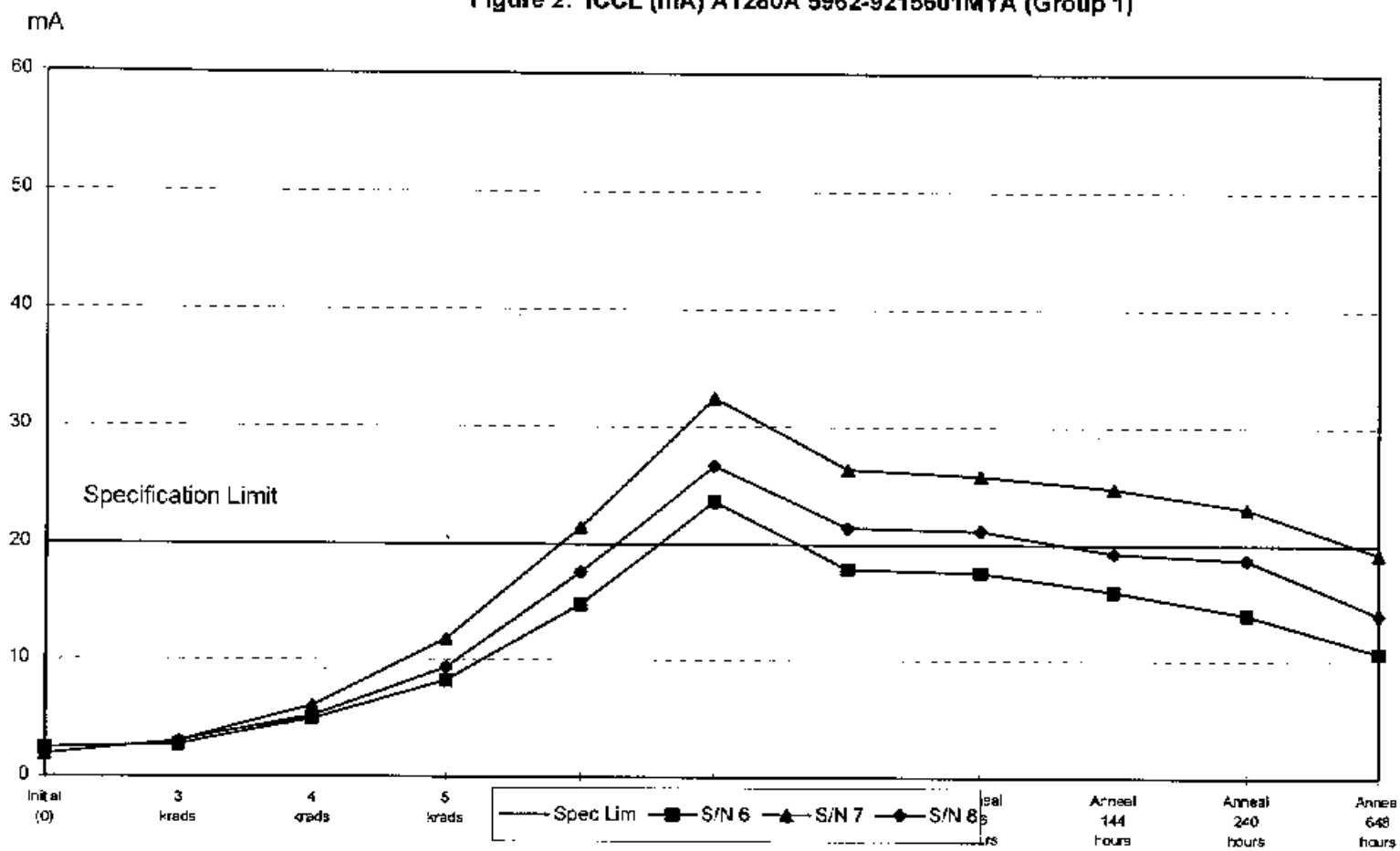


Figure 3. ICCH (mA) A1280A 5962-9215601MYA (Group 1)

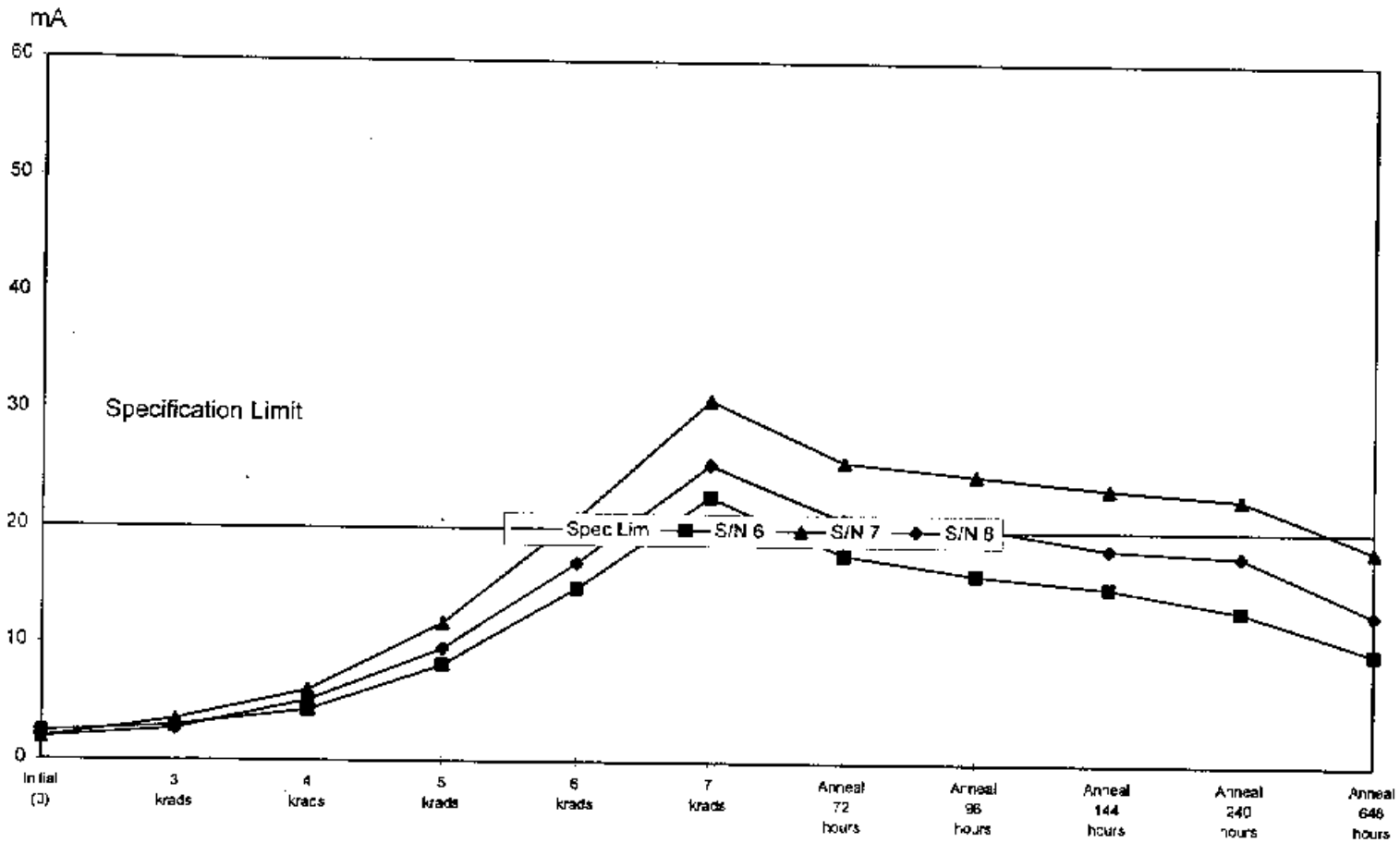


Figure 4. ICCL (mA) A1280A 5962-9215601MYC (Group 2)

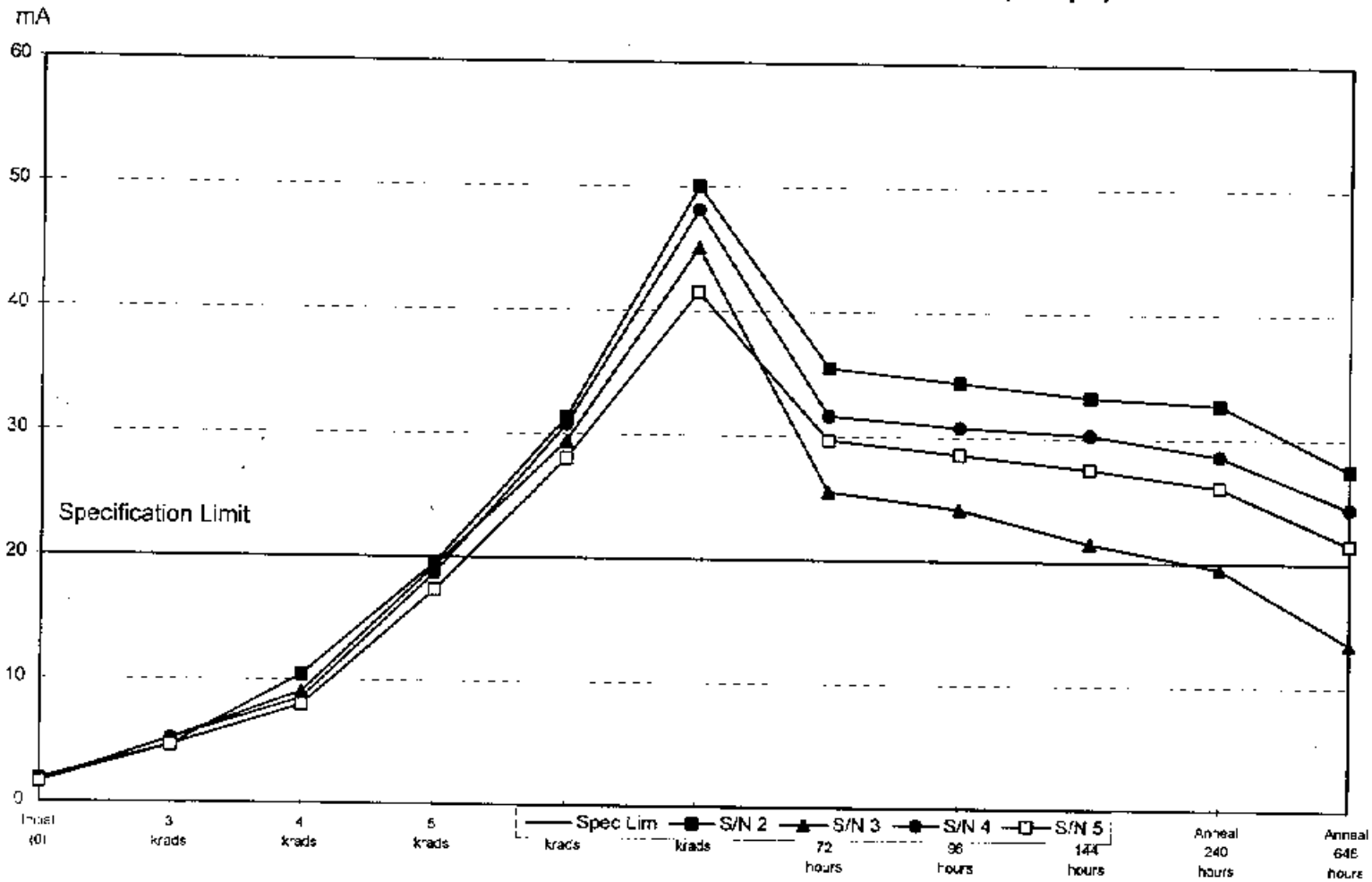


Figure 5. ICCH (mA) A1280A 5962-9215601MYC (Group 2)

