TABLE OF CONTENTS

Presentation:

Purpose
Study 2
Parameters
Conclusion
Presentation
Summary ..... Page 1 - 7

METER PERFORMANCE STUDY (YEARS)

Range of Meter Accuracies for Years 15, 18, 20
Comparison of Accuracy Curves
1/8 GPM & 2 GPM Charts 1 & 2 ..... Page 8 - 9

Overall Accuracies by Year @ 1/8 GPM & 2 GPM
Chart 3 & 4 ..... Page 10 - 11

Comparison % Acceptable Meters 1972 versus 1990
1/8 GPM & 2 GPM Charts 5 & 6 ..... Page 12 - 13

Comparison % Unacceptable Meters 1972 versus 1990
1/8 GPM & 2 GPM Charts 7 - 9 ..... Page 14 - 15

Meter Study Groups and Supporting Data - Individual Years Groups
1/8 GPM & 2 GPM Charts 10 - 21 ..... Page 16 - 39

METER PERFORMANCE STUDY (USAGE)

Usage Study Group (Comparison) 400,000 - 500,000 - 600,000
Cu. Ft. 1/8 GPM & 2 GPM Charts 22 - 23 .... Page 40 - 41

Usage Compared to Average % Accuracy. All Groups.
1/8 GPM & 2 GPM Chart 24 & 25 ..... Page 42 - 43

Usage Compared to Average % Accuracy. Meters Not Acceptable
@ 1/8 GPM Test Chart 26 ..... Page 44

Usage Compared to Average % Accuracy. Meters Not Acceptable
@ 2 GPM Test Chart 27 ..... Page 45

Usage Study Groups 100,000 Cu. Ft. Thru 700,000 Cu. Ft. and
Supporting Data Charts 28 - 41 ..... Page 46 - 73

Appendix A
Collection of Data - 1990 Study ..... Page 74 - 75

Appendix B
Historical Record
System Growth versus Meter Changes ..... Page 76

1990 METER STUDY

Purpose:

The purpose of this study was to see if our current 15 year meter change program for 5/8" meters was still appropriate, or if there was a need to revise either the years between changes, or to increase or decrease the mileage between changes.

Study Parameters:

This study, like the 5/8" meter studies made in 1968 and 1972, includes meters having service periods from 15 through 20 years. It is significant to recognize that a different style of meter was being tested in the 1990 study than was tested in 1972. In 1990, meters with plastic chambers were also in this group being tested while in 1972 the meters being tested all had bronze chambers.

An important difference between the two groups of data is that the 1990 data are a tabulation of meters that were last overhauled 15 through 20 years ago respectively. The 1972 data are a tabulation of meters that were last set 15 through 20 years ago respectively, without regard to the earlier last overhaul date. A further study of accuracy versus age since last set date is currently underway.

The total number of meters tested in this study was 1096 for age and 1934 for usage.

Conclusion:

From the data it can be concluded that our present service period of 15 years should continue to be used for 5/8" meters. It does appear that our overhaul period could be modified to allow meters to reach 500,000 cu. ft. of registration prior to replacement instead of our present 400,000 cu. ft. of registration (see chart 22 and 23). Note that the 400,000 cu. ft. curve and the 500,000 cu. ft. curve intersect the minimum standard line at nearly the same point.

Presentation of Data:

The method of presenting data using tables and graphs parallels the previous studies. The test standards of 98.5% to 101% at 2 GPM and 65% at 1/8 GPM are the same as the standards in 1972, and are more strict than AWWA new meter standards. The meters that do not test to these minimum accuracies are rebuilt. Meters that test between 65% and 70% accuracy at 1/8 GPM, or that test between 98.5 and 99.5% at 2 GPM are regeared but not rebuilt. No meter is returned to service unless they are accurate to 70% and 99.5% at the respective flows.

Charts 1 and 2 are a plotting of the duration curves for 15, 18, and 20 years of service. The curves were plotted for each rate so that any point of the curve may be read "X% of total meters did register more than Y%."

Charts 3 and 4 show average percentage registration for all meters in each of the years studied at each flow rate. Also it shows the amount of meters in each group.

Charts 5 thru 9 are charts which compare data from the 1972 study to 1990 data. These charts show the percent of meters at each flow rate (1/8 and 2 GPM) that registered within an acceptable range, and those that registered more than the SLCWC maximum standard, and those that registered below the SLCWC minimum standard.

Charts 10 thru 21 are the 15, 16, 17, 18, 19, and 20 year curves for each of the two flow rates. Following each set of charts is a tabulation of information for those charts.

Charts 22 and 23 are a plotting of the range of meter accuracies for meters with usage of 400,000 cu. ft., 500,000 cu. ft., and 600,000 cu. ft.

Charts 24 and 25 show the overall average accuracy of each group of meters with usage of 100,000 thru 700,000 cu. ft. Also included in the charts are the amount of meters in each group.

Charts 26 and 27 show the percent of meters that registered under the minimum standard. Charts include the number of meters in each group.

Charts 28 thru 41 are a plotting of the duration curves for usage from 100,000 cu. ft. thru 700,000 cu. ft. and the tabulated data for each usage group studied.

Summary of Data Presented:

1. Charts 1 and 2 are a plotting of the duration curves for meters with 15 years, 18 years, and 20 years service without regard of registration. These curves indicate that meters in the field beyond 15 years show a marked drop in accuracy.

2. Charts 3 and 4 are bar graphs illustrating the average percent of registration (accuracy) and the total number of meters in each age group in the 1990 test group only. In the sensitivity test (1/8 GPM), the average age group registration (accuracy) ranged from 84.0% to 95%. All year groups show average accuracies in the acceptable range.

   In the 2 GPM test, the average percent registration shows a drop from the 15 year group to the 18 year group, then the percent registration climbs. The reason is probably due to the fact that the older meters are more predominantly taken from residences with ARB readers, hence the difficulty of getting to them (age). These ARB meters tend to show lower than average mileage for their age. We speculate that buildings with ARB devices are occupied for a smaller percentage of the day, resulting in lower daily water use.

This chart also shows that accuracy remains above the minimum standard thru 17 years. After 17 years, accuracy is below the minimum acceptable level. This duplicates the results of earlier studies.

3. Charts 5 thru 9 are a comparison of the 1972 Meter Accuracy Study to 1990 data. The sensitivity tests (or 1/8 GPM test results) indicate that 1990 meter group 15 years through 20 years maintain approximately the same accuracy (see chart 5), while the 1972 meter group drops in accuracy with age. The reason that 1/8 GPM test accuracy tends to be greater in 1990 is that (1) these meters are newer (see footnote 1), (2) these meters generally have plastic chambers which are designed such that they can be fit at a tighter tolerance, and (3) these meters generally contain a graphite-impregnated ball and chamber that reduce friction, especially at low flows.

At the standard rate of 2 GPM, the average accuracy of the 1990 meter group shows a drop in each of the years through 19 years and then climbs in year 20 (see chart 6). The 1972 meter group shows no drop in accuracy versus age. We speculate that in the 1990 study, a 15 year (actual age) meter with high mileage experiences greater wear on the plastic chamber and parts than does the older brass chamber. This greater wear allows for greater slippage and thus less accuracy at higher flow.

4. Charts 10 through 21 show the predictable drop in accuracies as age increases. Charts 22 and 23 summarize the effect of mileage on accuracies.

5. Charts 24 and 25 are bar graphs of meter groups whose usage registration varies from 100,000 cu. ft. to 700,000 cu. ft. In the sensitivity test (1/8 GPM, chart 24) registration continues to improve through 400,000 cu. ft. and then declines through 700,000 cu. ft. The average accuracy for the 1/8 GPM test ranged from 78.7% to 85.6%. The 2 GPM test chart (chart 25) indicates the average accuracy ranged from 98.8% to 99.8%. In both cases fluctuation of accuracy is minimal and within our standards.

In studying charts 24 and 25, the effect of raising the "change-out" mileage to 500,000 cu. ft. will make almost no difference in the number of meters that would have failed SLCWC standards. Note that both the 400,000 and the 500,000 cu. ft. curves cross the 65% line (chart 22) and the 98.5% line (chart 23) at almost the same point. For this reason, the "change-out" mileage could be changed from 400,000 cu. ft. to 500,000 cu. ft. with no detrimental effect on metering accuracy among SLCWC's 5/8" meters.

The decision to increase the allowable mileage to 500,000 cu. ft. will affect the frequency with which meters are called in from the field, and it will also affect certain Meter Shop

procedures. Currently, a meter that might otherwise pass the short-use test will automatically go to "tear-down" if its mileage is greater than 400,000. The recommendation of this report is to raise that "trigger" to 500,000.

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[1]An important difference between 1972 and 1990 data is that the age of the meter in the 1990 study was defined as "years since last overhaul," while the age in the 1972 study was defined as "years since last set." The age defined as "years since last set" means that in most cases the actual in-service age of the meter was older than indicated. A study is continuing to look at accuracy data versus age using the "years since last set" definition. This continuing study is evaluating meters with both plastic and brass chambers, which are different than those meters studied in 1972 which had all brass chambers. When completed, we will be able to compare accuracy data on the same style of meters for both age definitions.

RANGE OF METER ACCURACIES AT
15,18 AND 20 YEARS - 1/8 G.P.M. TEST

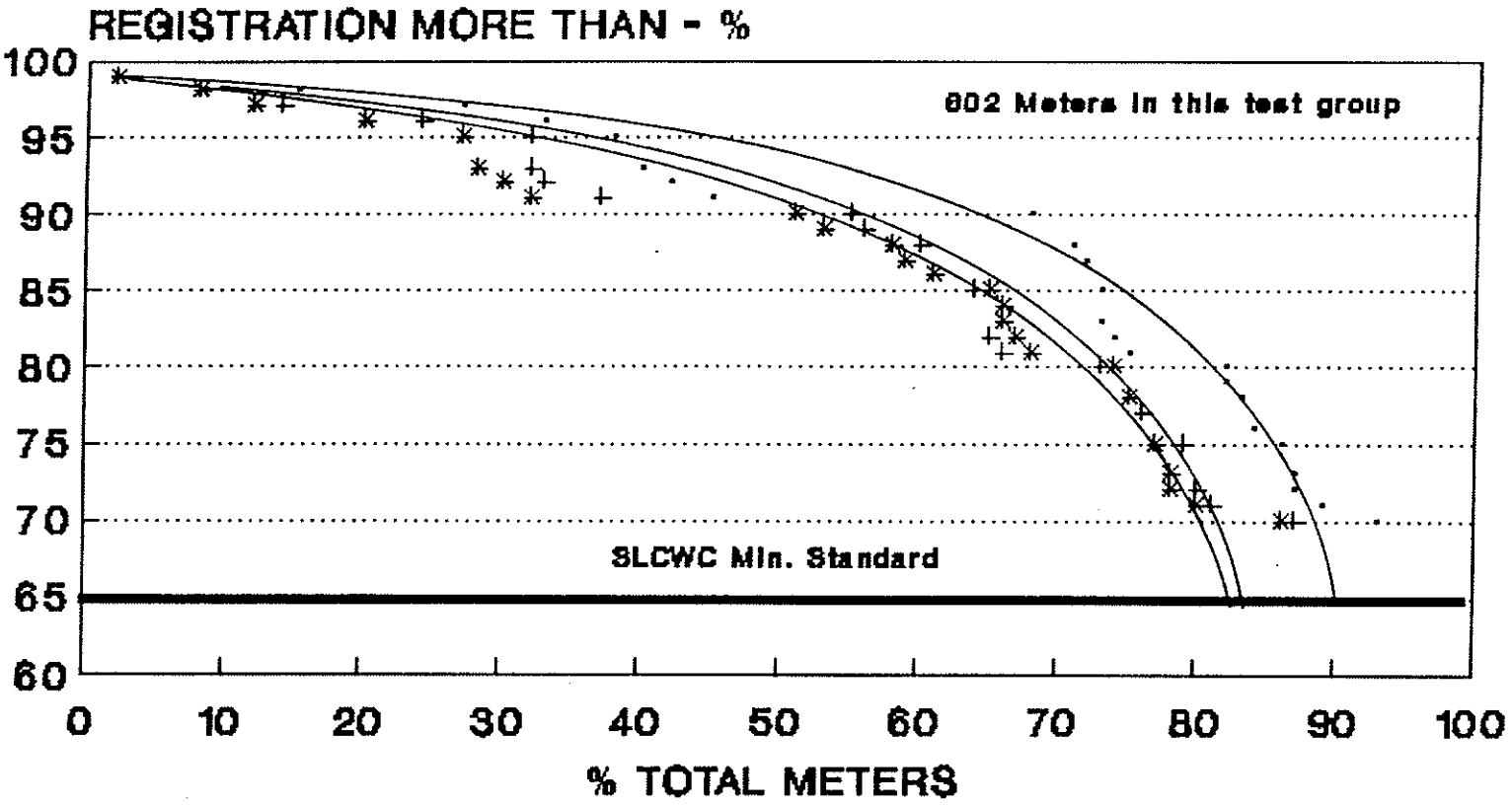


CHART 1 - NOVEMBER 1990

RANGE OF METER ACCURACIES AT
15,18 AND 20 YEARS - 2 G.P.M. TEST

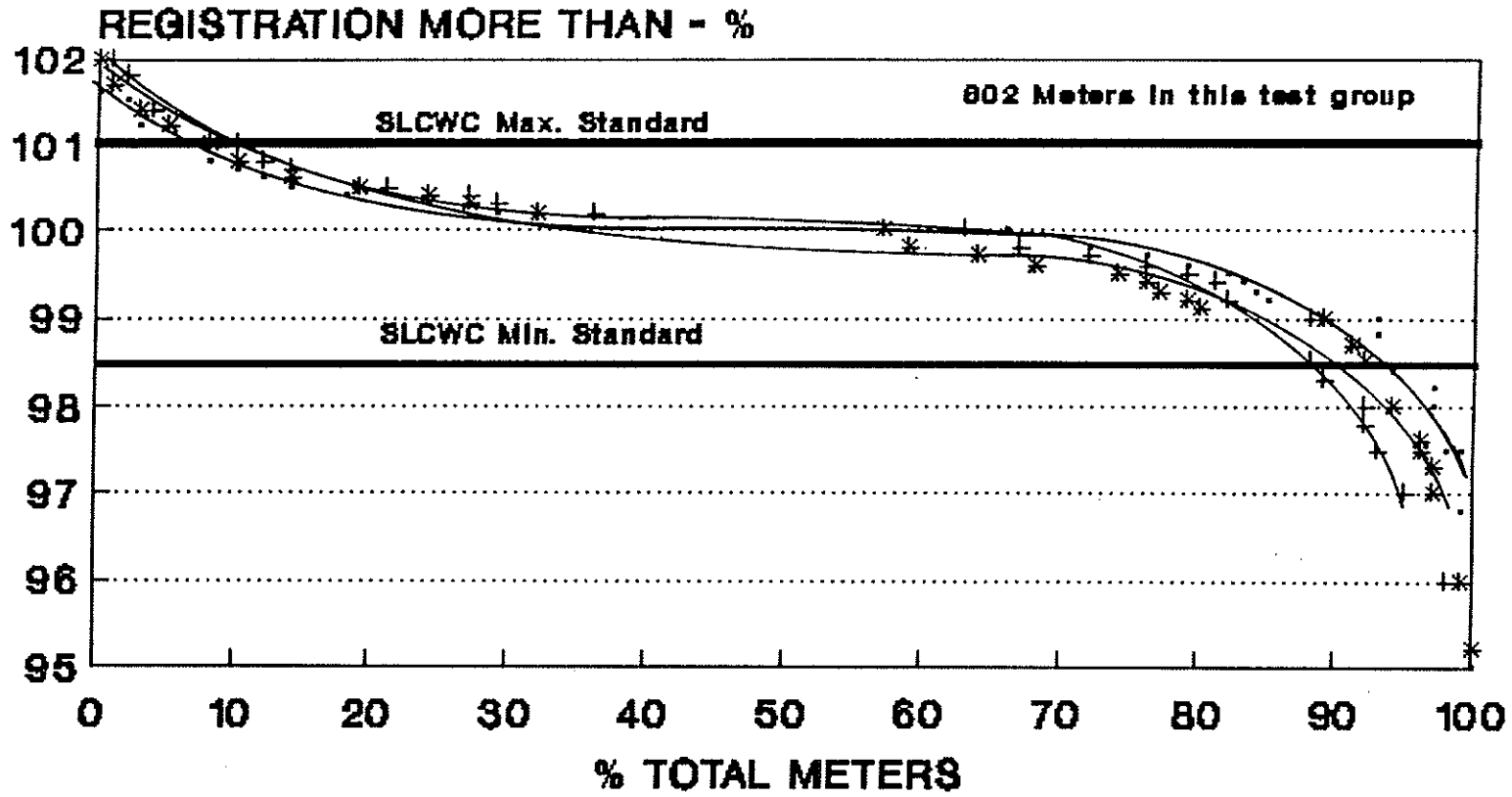
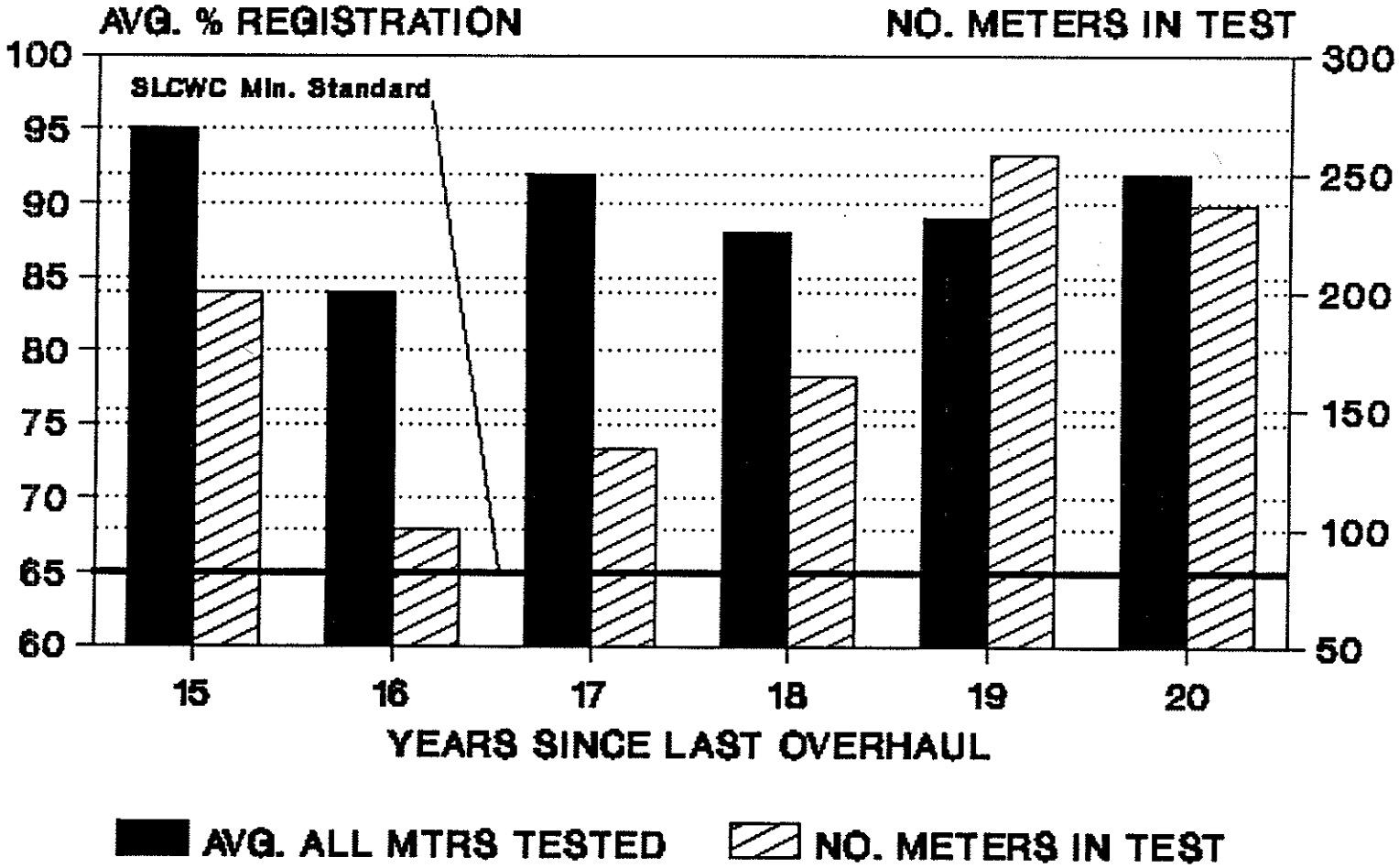


CHART 2 - NOVEMBER 1990

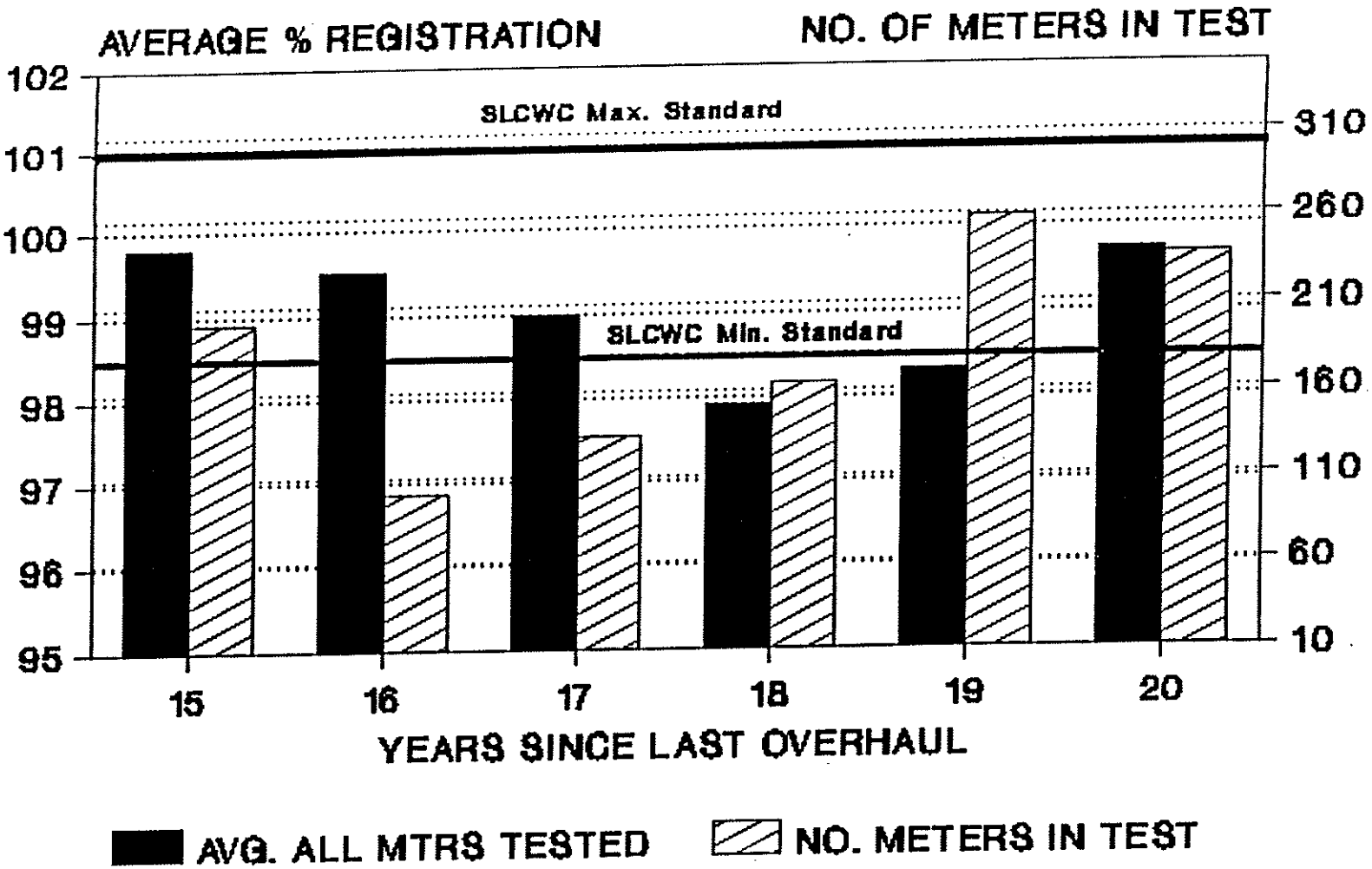
OVERALL ACCURACY BY YEAR
AVG % ACCURACY FOR GROUP 1/8 G.P.M.



ACCEPTABLE RANGE: ABOVE 65%

CHART 3 - NOVEMBER 1990

OVERALL ACCURACY BY YEAR
AVERAGE % ACCURACY FOR GROUP 2 G.P.M.

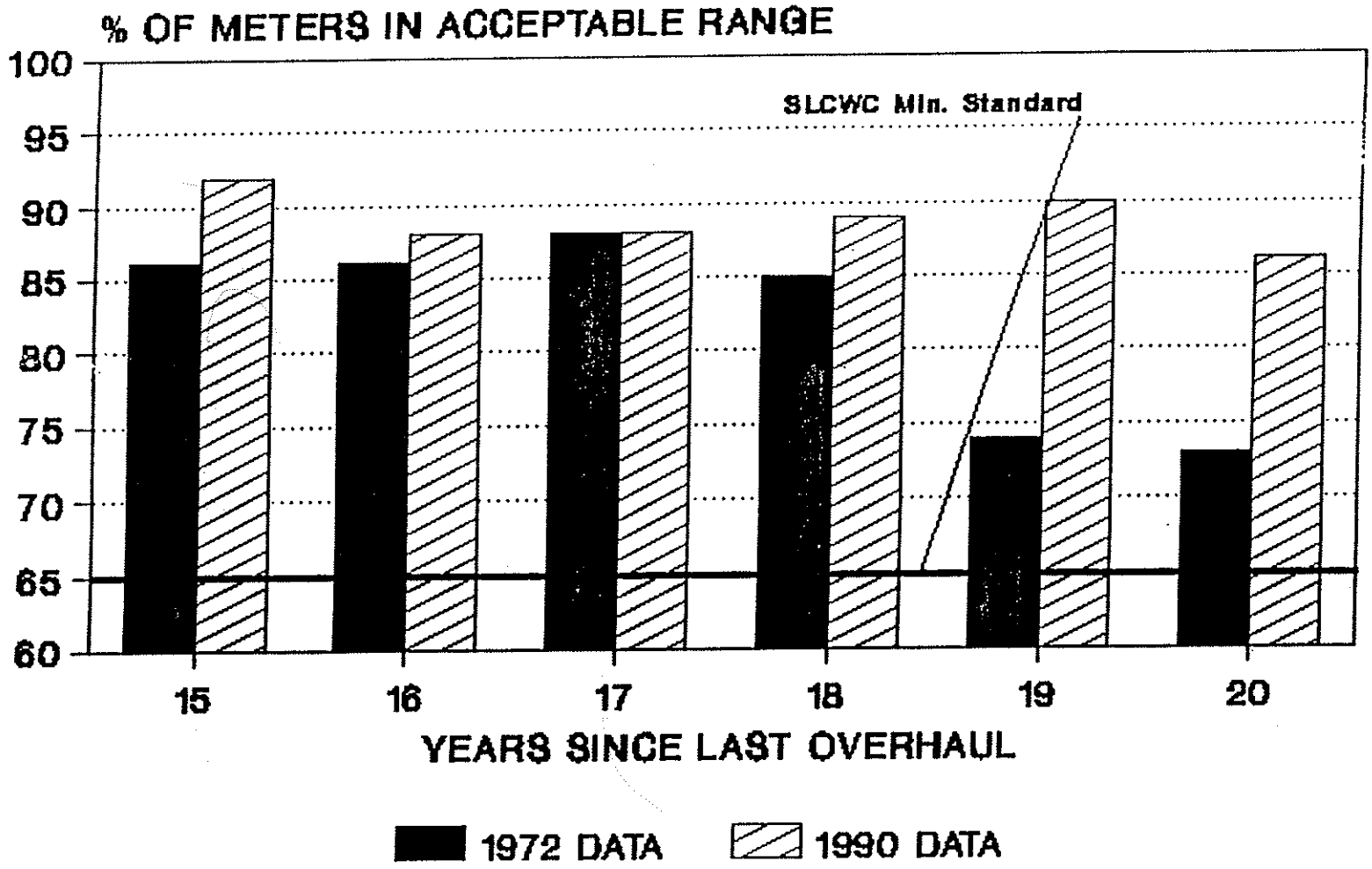


ACCEPTABLE RANGE: 98.5% - 101%

CHART 4 - NOVEMBER 1990

METER COMPARISON 1972 VERSUS 1990

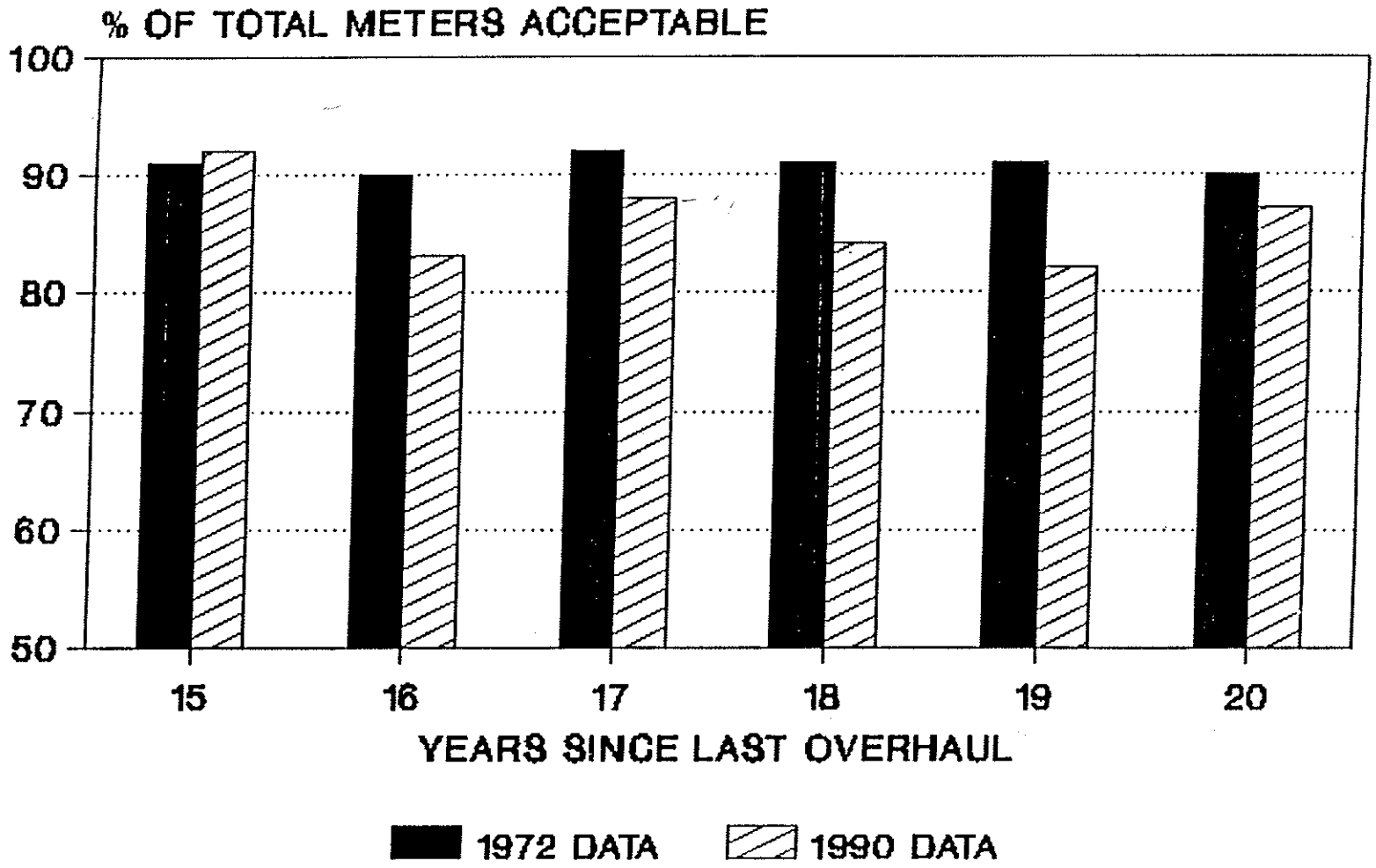
1/8 G.P.M. TEST



ACCEPTABLE RANGE: ABOVE 65%

CHART 5 - NOVEMBER 1990

METER COMPARISON 1972 VERSUS 1990
2 G.P.M. TEST

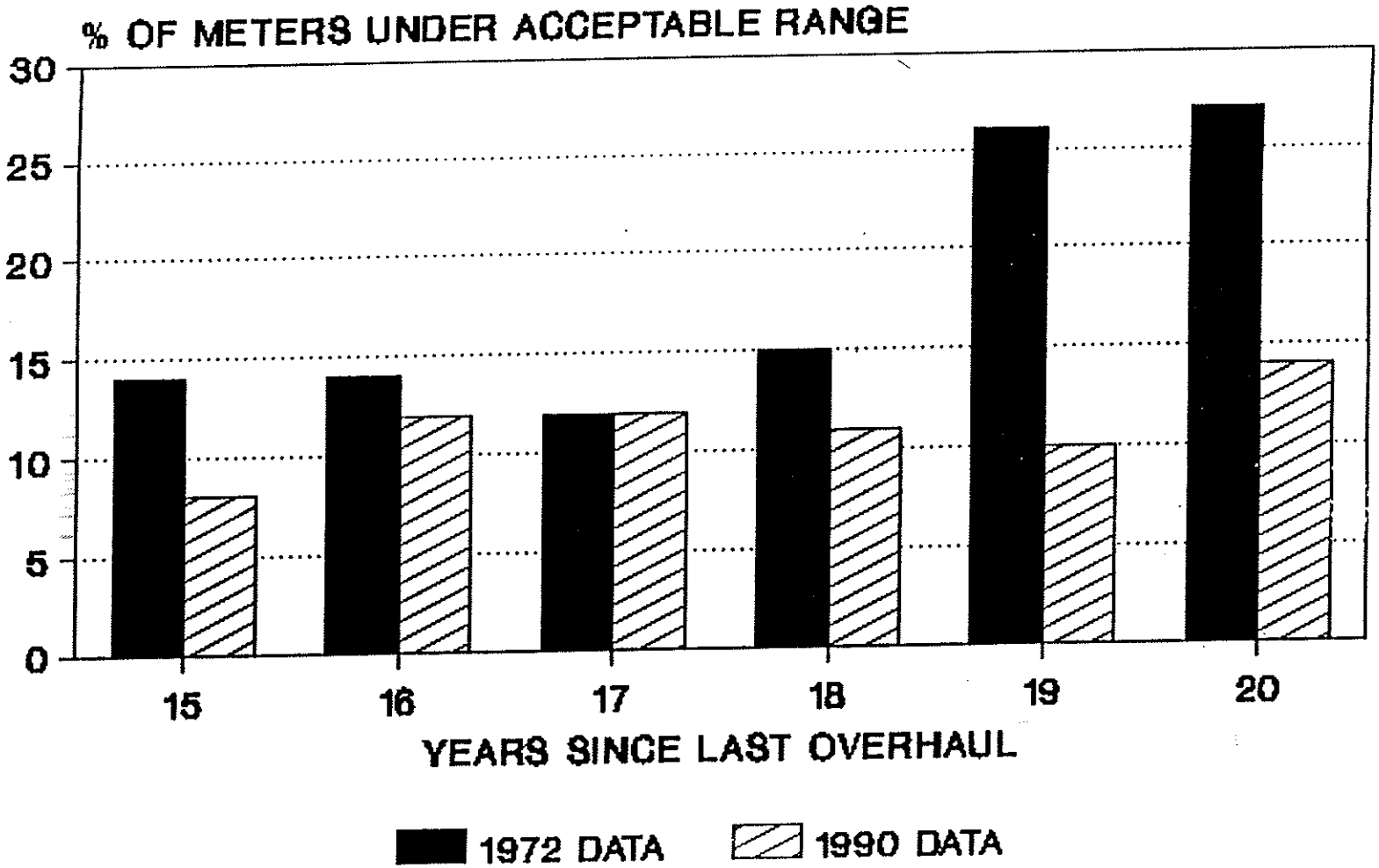


ACCEPTABLE RANGE: 98.5% - 101%

CHART 6 - NOVEMBER 1990

METER COMPARISON 1972 VERSUS 1990

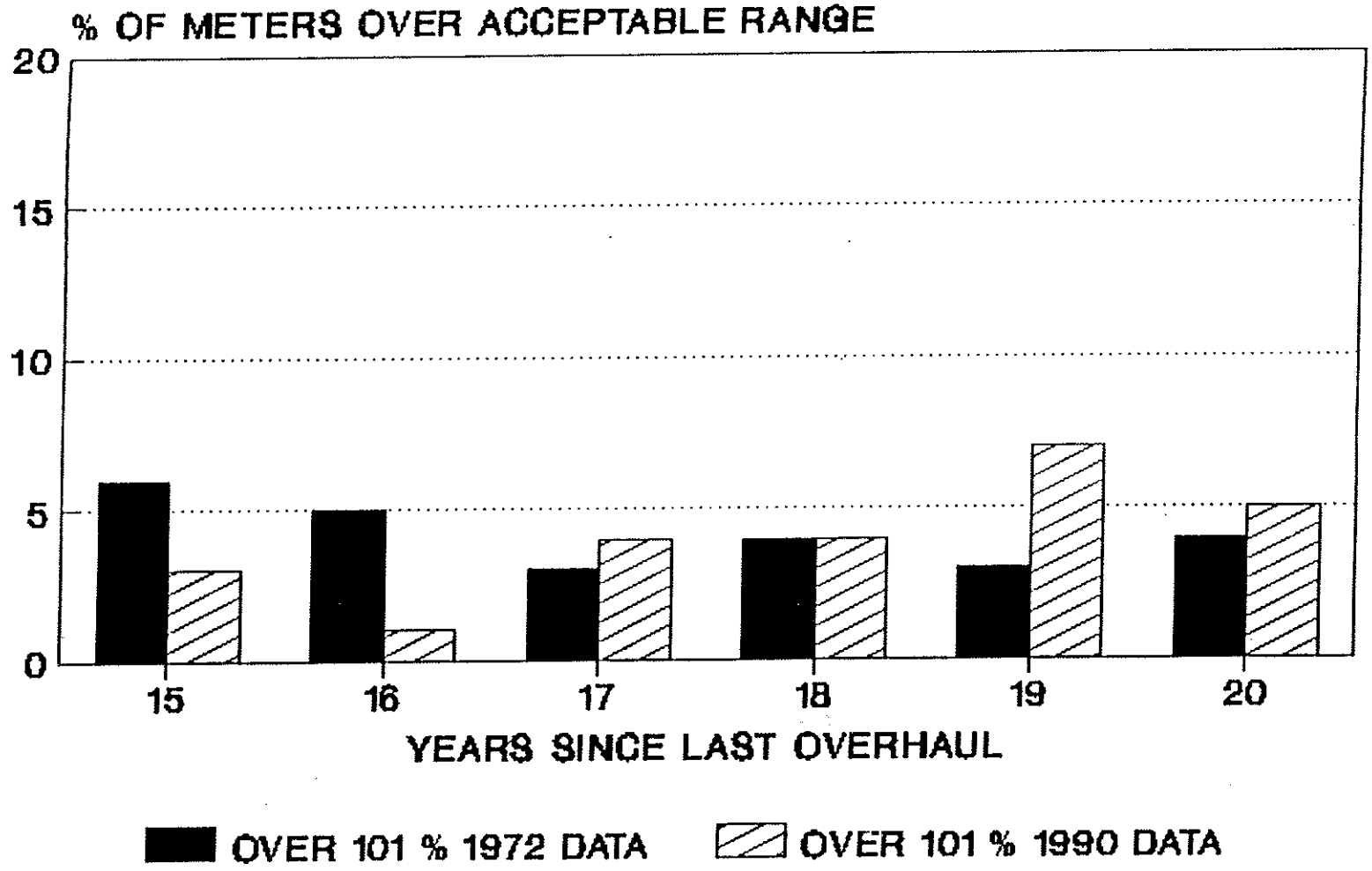
1/8 G.P.M. TEST



ACCEPTABLE RANGE: ABOVE 65%

CHART 7 - NOVEMBER 1990

METER COMPARISON 1972 VERSUS 1990
2 G.P.M. TEST



ACCEPTABLE RANGE: 101%

CHART 8 - NOVEMBER 1990

15 YEARS METER STUDY GROUP
1/8 G.P.M. TEST

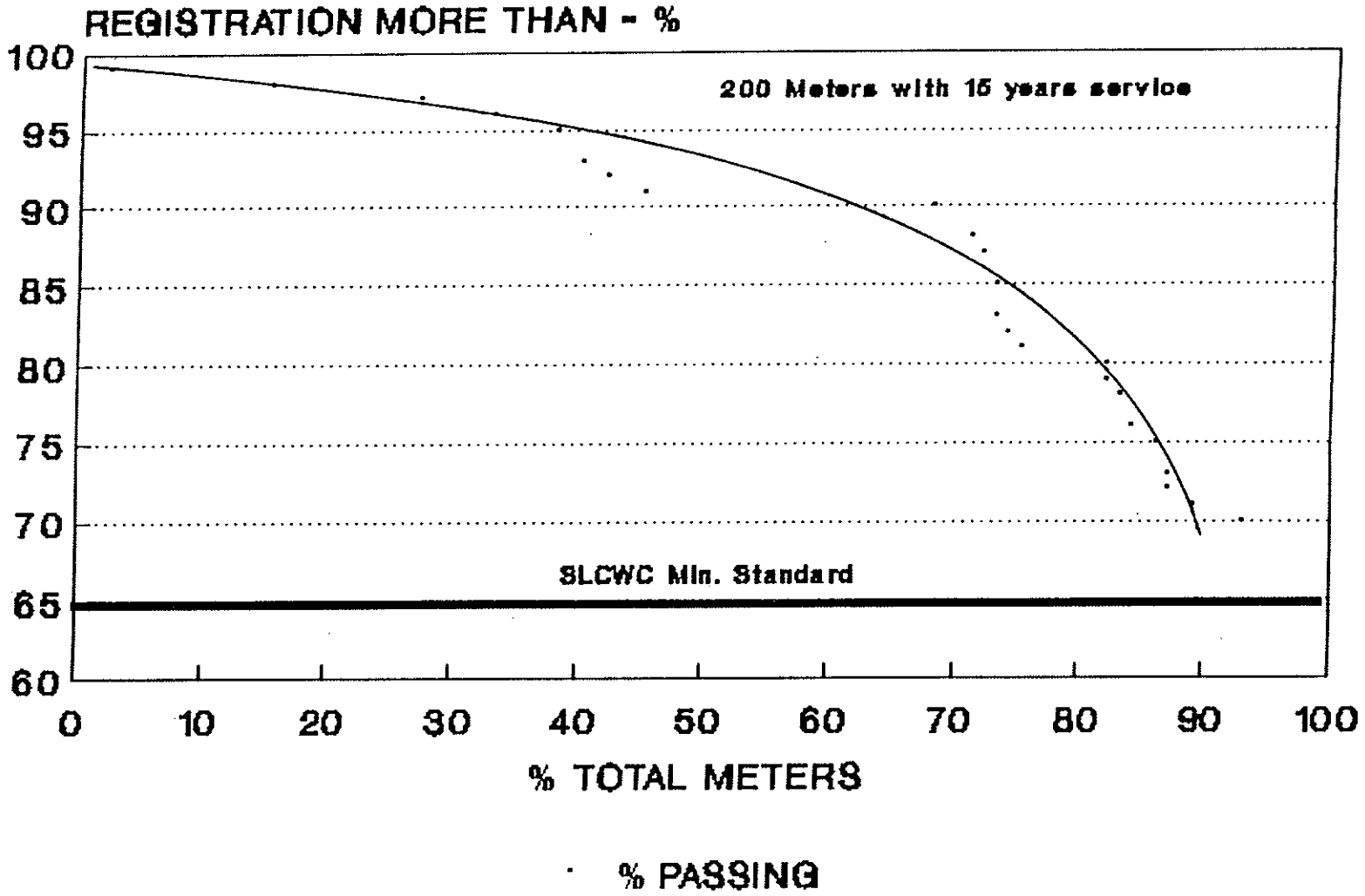


CHART 10 - NOVEMBER 1990

15 YEARS METER STUDY GROUP
2 G.P.M. TEST

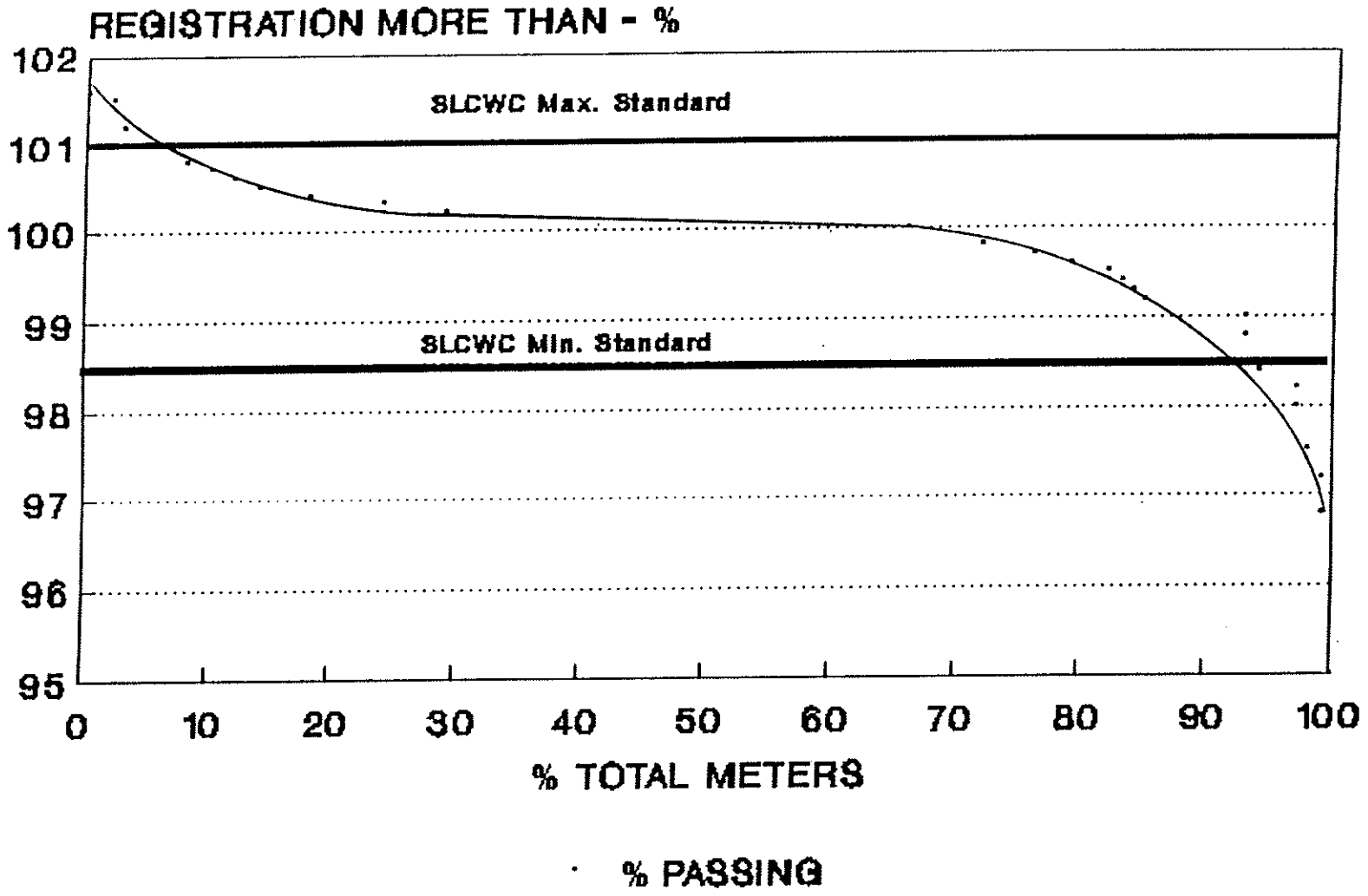


CHART 11 - NOVEMBER 1990

15 YEAR STUDY GROUP - 1990
1/8 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
15	200	100	*
8	185	93	70
3	177	89	71
1	174	87	72
1	173	87	73
5	172	86	75
1	167	84	76
2	166	83	78
1	164	82	79
14	163	82	80
2	149	75	81
1	147	74	82
1	146	73	83
2	145	73	85
1	143	72	87
6	142	71	88
46	136	68	90
6	90	45	91
5	84	42	92
3	79	40	93
11	76	38	95
12	65	33	96
24	53	27	97
25	29	15	98
4	4	2	99

* 8 Meters dead.

7 Meters registered less than 65%. Average registration for this group was 46.28%

15 YEAR STUDY GROUP - 1990
2 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
2	200	100	
1	198	99	95
1	197	99	96.8
2	196	98	97.2
6	194	97	97.5
2	188	97	98
1	186	94	98.2
2	185	93	98.4
13	183	93	98.8
2	170	85	98
3	168	84	99.2
2	165	83	99.3
6	163	82	99.4
6	157	79	99.5
8	151	76	99.6
12	143	72	99.7
73	131	66	99.8
11	58	29	100
12	47	24	100.2
8	35	18	100.3
4	27	14	100.4
3	23	12	100.5
5	20	10	100.6
1	15	8	100.7
9	14	7	100.8
2	5	3	101
2	3	2	101.2
1	1	.5	101.5
			101.6

16 YEARS METER STUDY GROUP
1/8 G.P.M. TEST

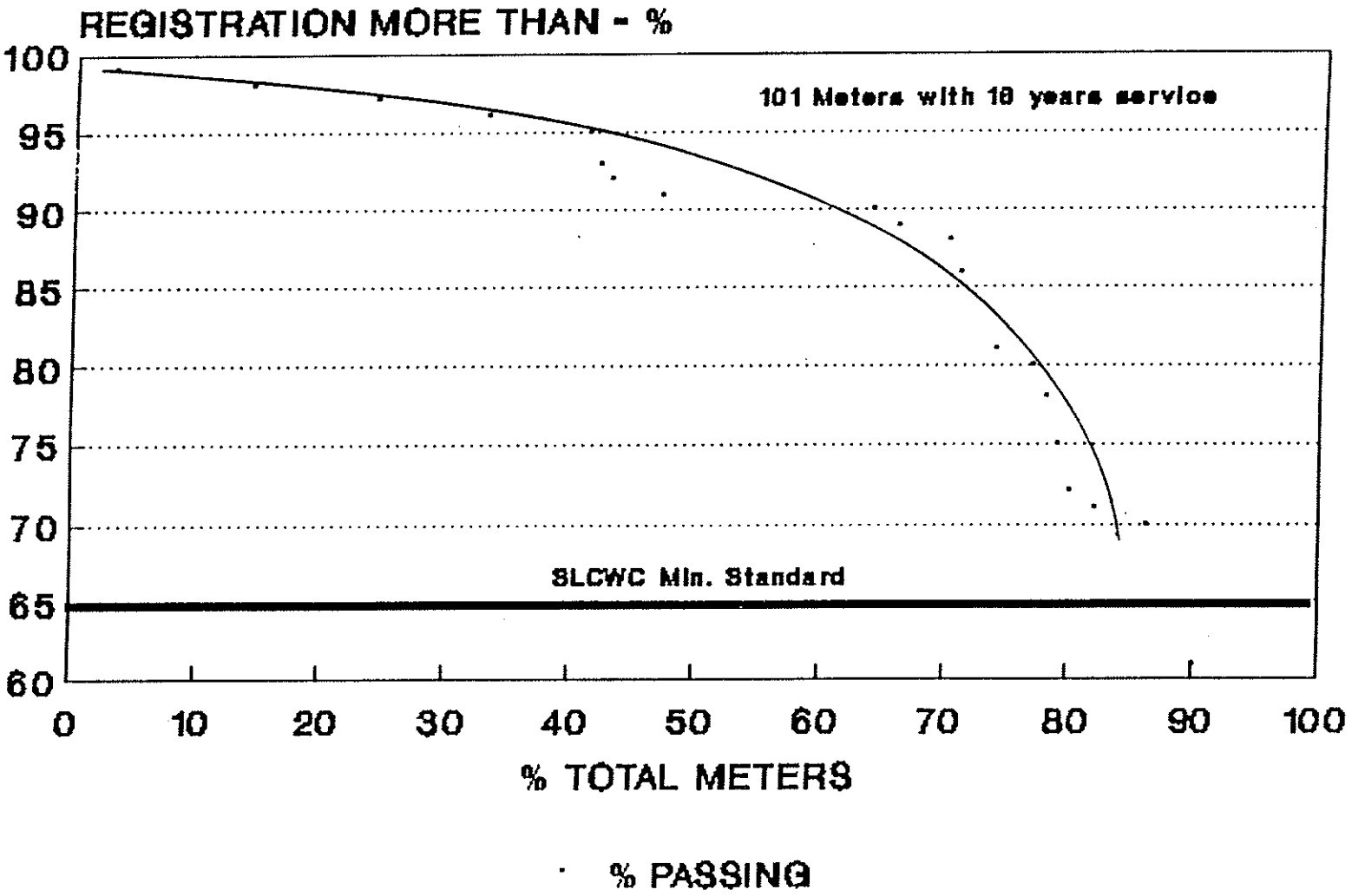


CHART 12 - NOVEMBER 1990

16 YEARS METER STUDY GROUP
2 G.P.M. TEST

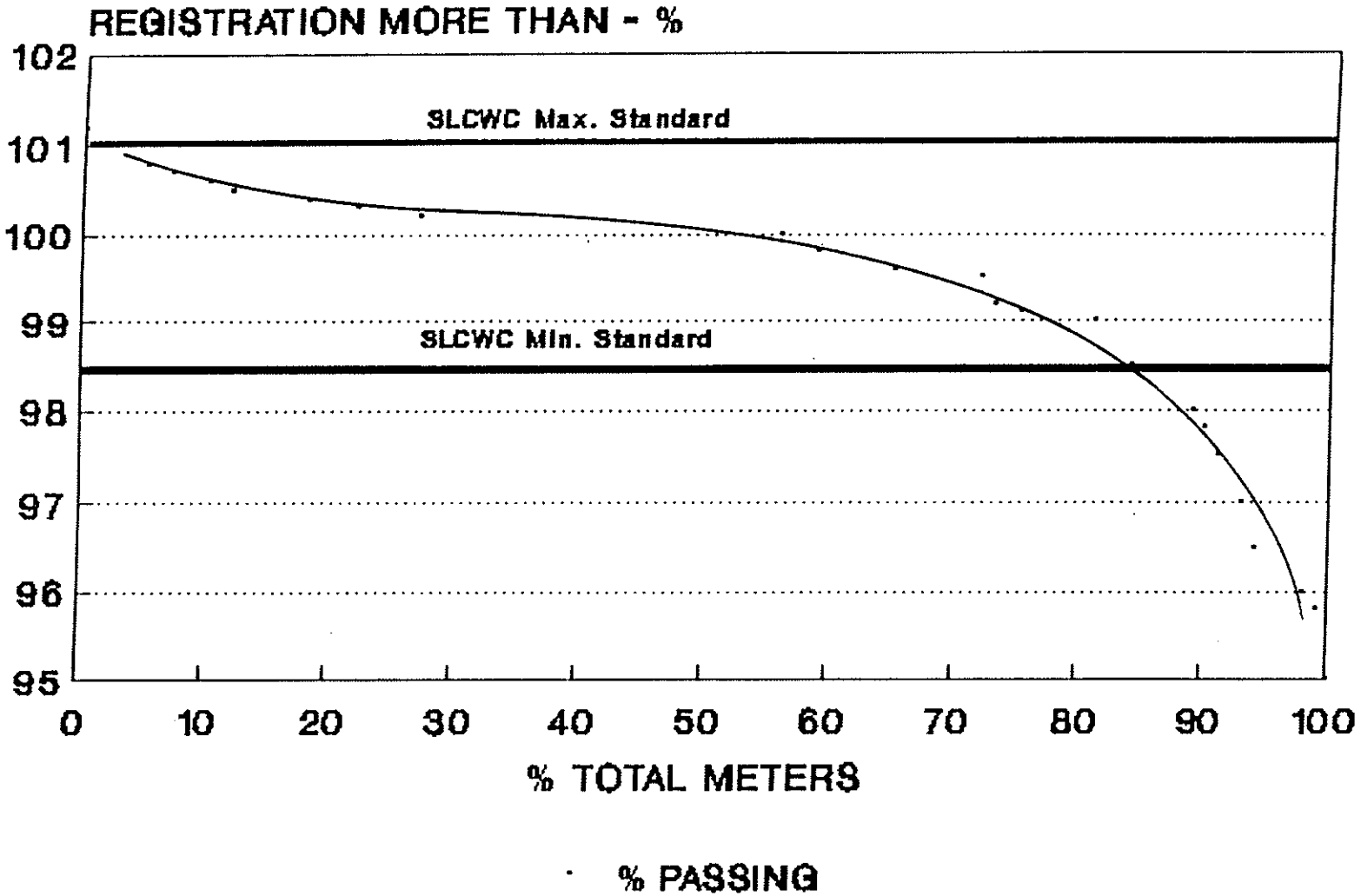


CHART 13 - NOVEMBER 1990

16 YEAR STUDY GROUP - 1990
1/8 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
10	101	100	*
4	91	90	61
4	87	86	70
2	83	82	71
1	81	80	72
1	80	79	75
1	79	78	78
3	78	77	80
3	75	74	81
1	72	71	86
4	71	70	88
2	67	66	89
18	65	64	90
4	47	47	91
1	43	43	92
1	42	42	93
8	41	41	95
9	33	33	96
10	24	24	97
11	14	14	98
3	3	3	99

* 3 Meters dead

11 Meters registered less than 65%. Average registration for this group was 50.27%

16 YEAR STUDY GROUP - 1990
2 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
1	101	100	95
1	100	99	95.8
4	99	98	96
1	95	94	96.5
2	94	93	97
1	92	91	97.5
1	91	90	97.8
5	90	89	98
3	85	84	98.5
6	82	81	99
2	76	75	99.1
1	74	73	99.2
7	73	72	99.5
6	66	65	99.6
3	60	59	99.8
30	57	56	100
5	27	27	100.2
4	22	22	100.3
6	18	18	100.4
2	12	12	100.5
3	10	10	100.6
2	7	7	100.7
1	5	5	100.8
3	4	4	101
1	1	1	101.2

17 YEARS METER STUDY GROUP
1/8 G.P.M. TEST

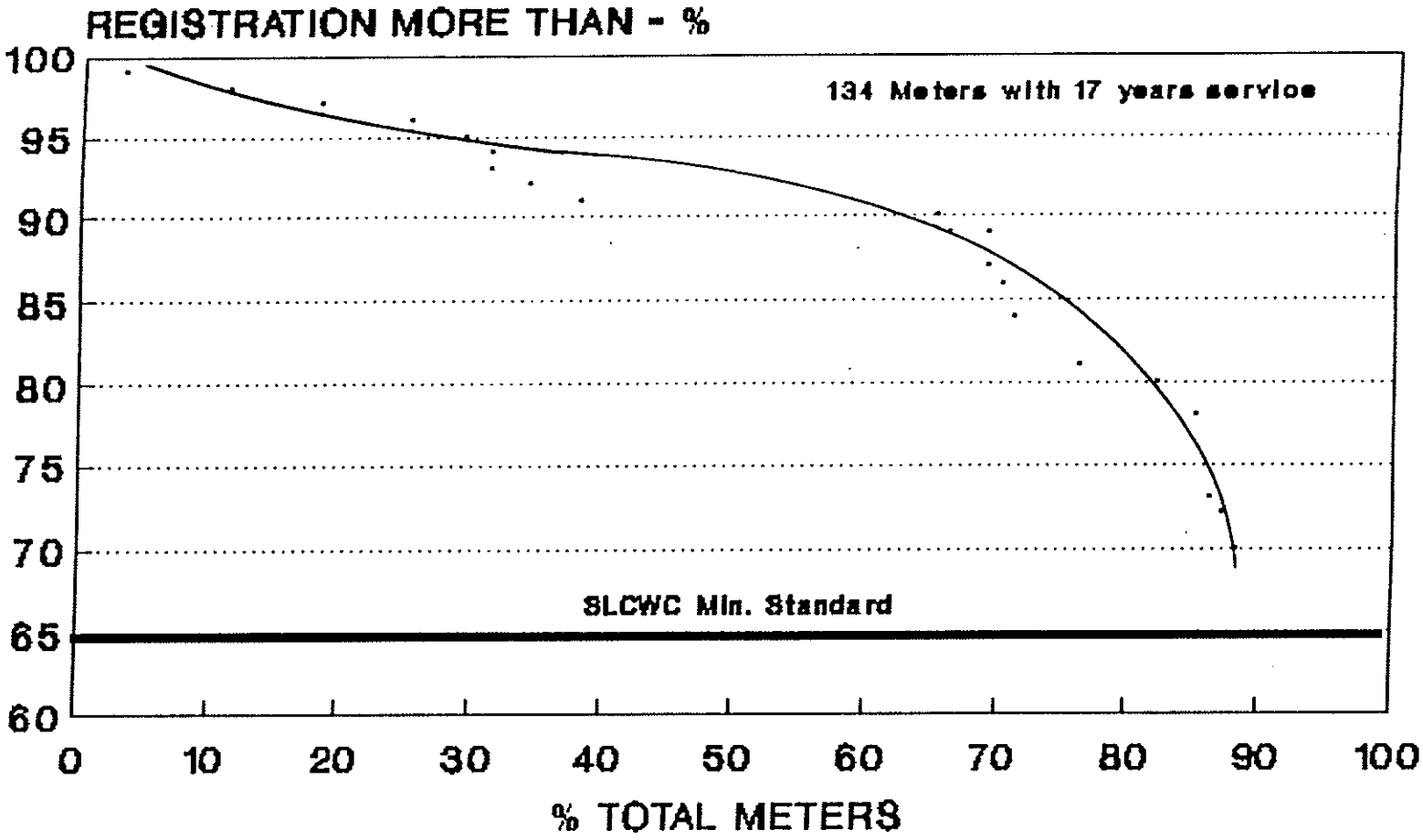


CHART 14 - NOVEMBER 1990

17 YEARS METER STUDY GROUP
2 G.P.M. TEST

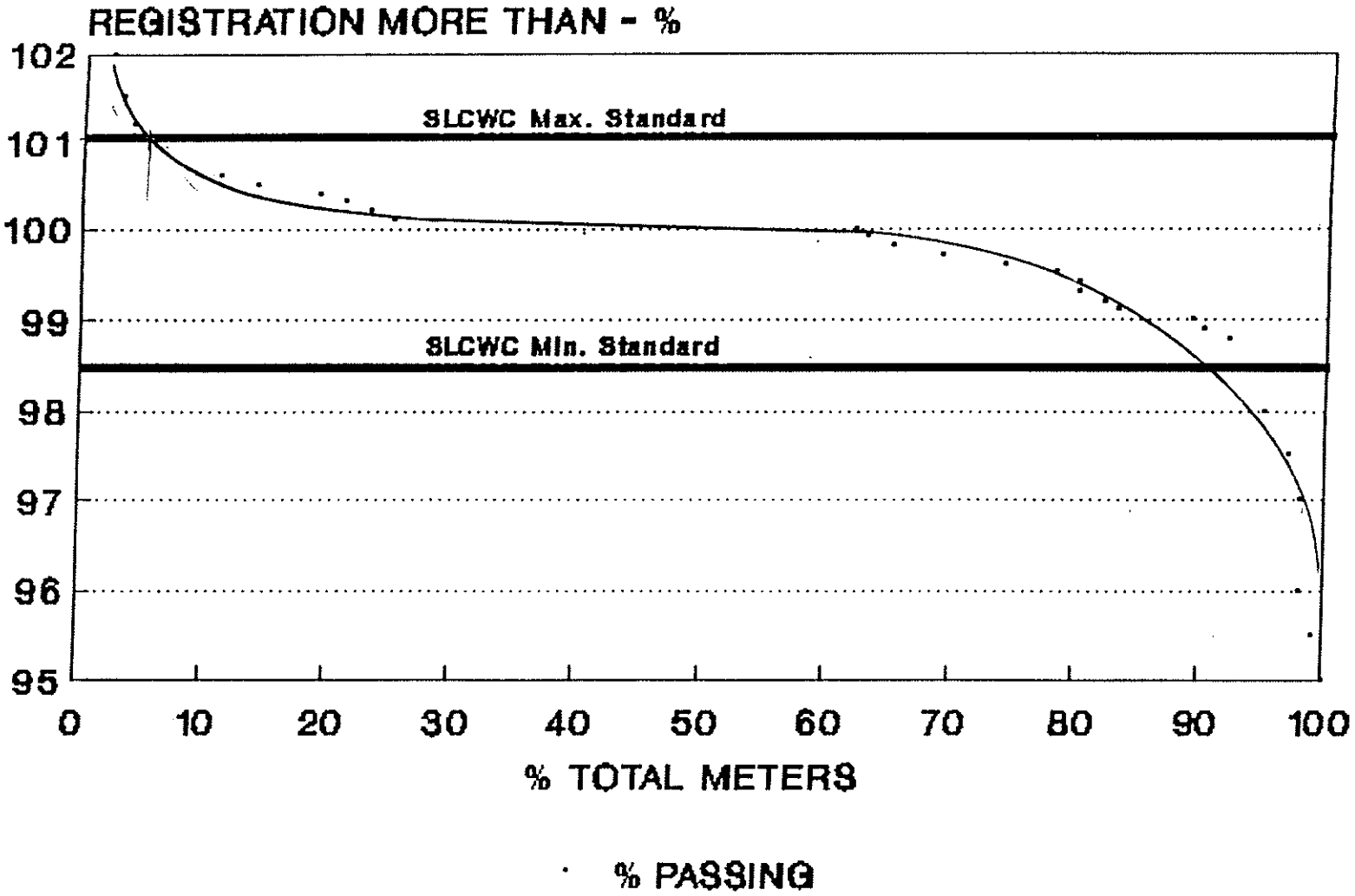


CHART 15 - NOVEMBER 1990

17 YEAR STUDY GROUP - 1990
1/8 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - ⅜	% Reg. More Than
16	134	100	*
2	118	88	70
1	116	87	72
1	115	86	73
4	114	85	78
8	110	82	80
7	102	76	81
1	95	71	84
1	94	70	86
1	93	69	87
3	92	69	88
2	89	66	89
36	87	65	90
6	51	38	91
3	45	34	92
1	42	31	93
2	41	31	94
5	39	29	95
10	34	25	96
9	24	18	97
11	15	11	98
4	4	3	99

* 10 Meters dead

6 Meters registered less than 65⅜. Average registration for this group was 44.5⅜

17 YEAR STUDY GROUP - 1990
2 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
1	134	100	*
2	132	99	95
1	131	98	96
1	130	97	97
3	129	96	97.5
4	126	94	98
2	122	91	98.8
1	120	90	98.9
8	119	89	99
2	111	83	99.1
2	109	81	99.2
1	107	80	99.3
2	106	79	99.4
6	104	78	99.5
6	98	73	99.6
5	92	69	99.7
3	87	65	99.8
2	84	63	99.9
49	82	61	100
3	33	25	100.1
2	30	22	100.2
3	28	21	100.3
7	25	19	100.4
3	18	13	100.5
4	15	11	100.6
2	11	8	100.7
4	9	7	101
2	5	4	101.2
1	3	2	101.5
2	2	1	102

* 1 Meter dead

18 YEARS METER STUDY GROUP
1/8 G.P.M. TEST

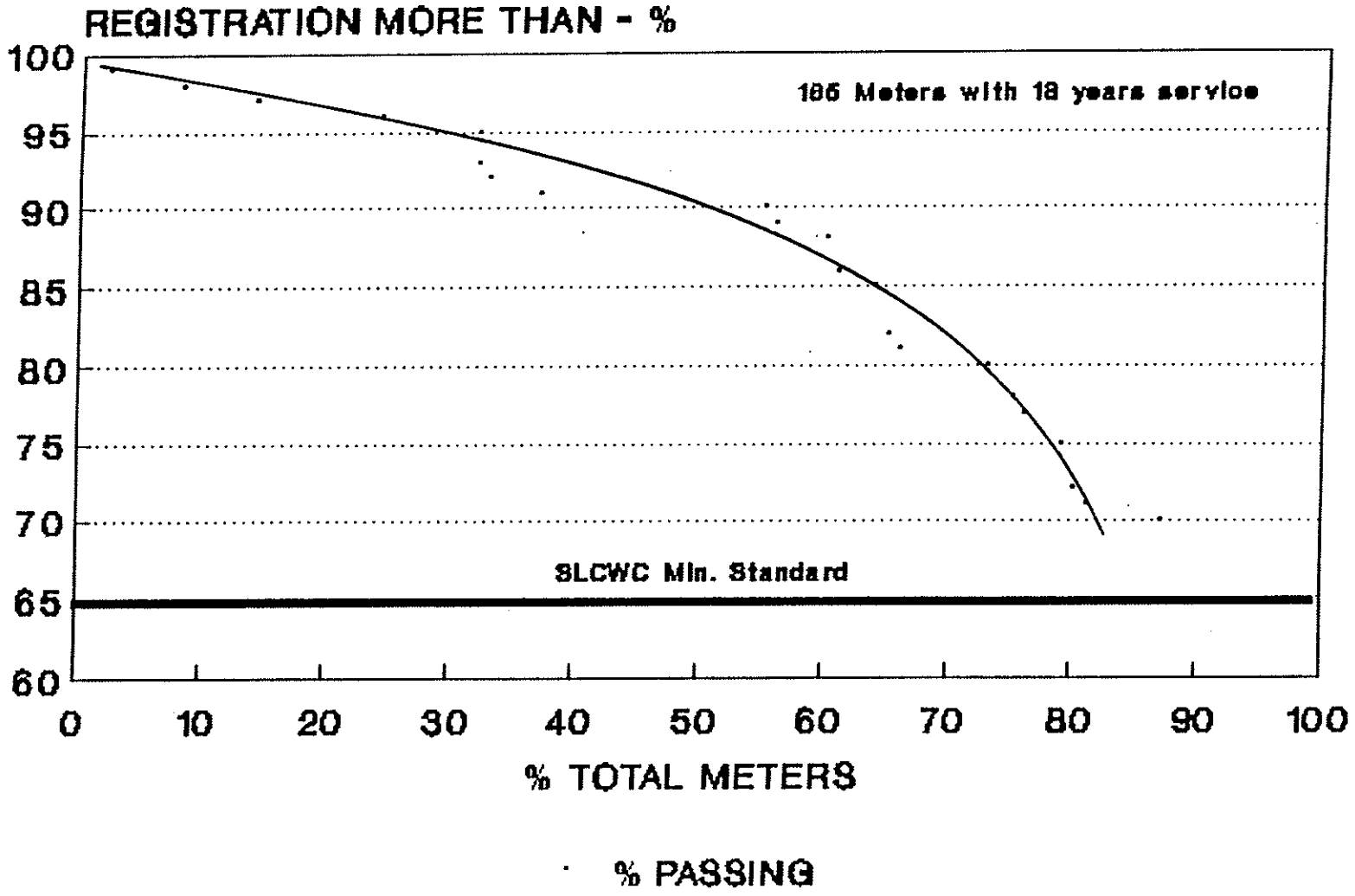


CHART 16 - NOVEMBER 1990

18 YEARS METER STUDY GROUP
2 G.P.M. TEST

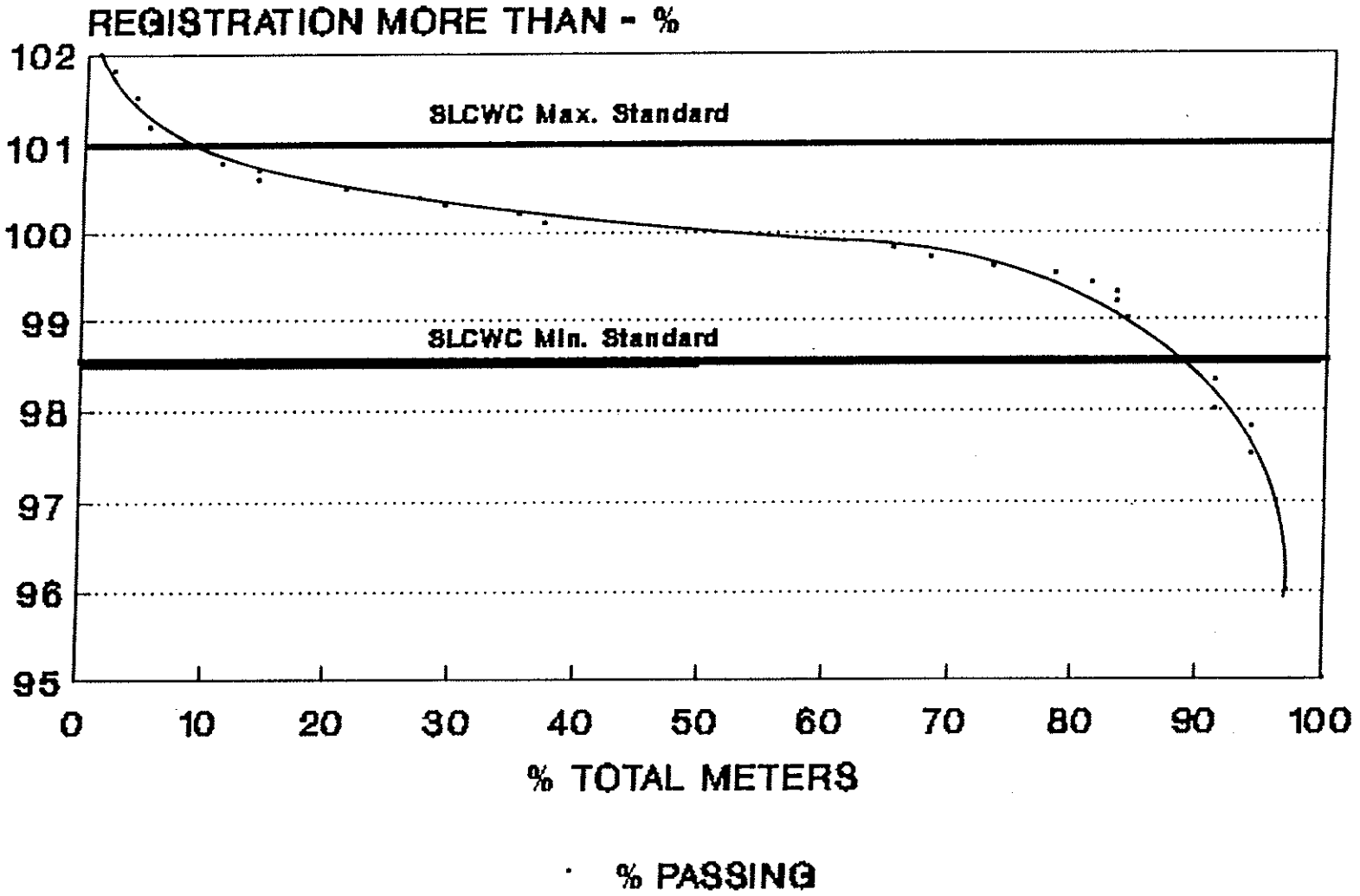


CHART 17 - NOVEMBER 1990

18 YEAR STUDY GROUP - 1990
1/8 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
21	165	100	*
11	144	87	70
2	133	81	71
1	131	80	72
5	130	79	75
1	125	76	77
3	124	75	78
12	121	73	80
2	109	66	81
2	107	65	82
5	105	64	85
1	100	61	86
6	99	60	88
2	93	56	89
30	91	55	90
7	61	37	91
1	54	33	92
1	53	32	93
13	52	32	95
16	39	24	96
10	23	14	97
10	13	8	98
3	3	2	99

* 12 Meters dead

9 Meters registered less than 65%. Average registration for this group was 39%

18 YEAR STUDY GROUP - 1990
2 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
4	165	100	*
5	161	98	96
2	156	95	97
2	154	93	97.5
1	152	92	97.8
4	151	92	98
1	147	89	98.3
1	146	88	98.5
9	145	88	99
3	136	82	99.2
3	133	81	99.4
5	130	79	99.5
7	125	76	99.6
8	118	72	99.7
6	110	67	99.8
45	104	63	100
12	59	36	100.2
3	47	28	100.3
10	44	27	100.4
11	34	21	100.5
5	23	14	100.7
2	18	11	100.8
8	16	10	101
2	8	5	101.2
2	6	4	101.4
2	4	2	101.8
2	2	1	102

* 3 Meters dead
1 Meter registered 84.5%

19 YEARS METER STUDY GROUP
1/8 G.P.M. TEST

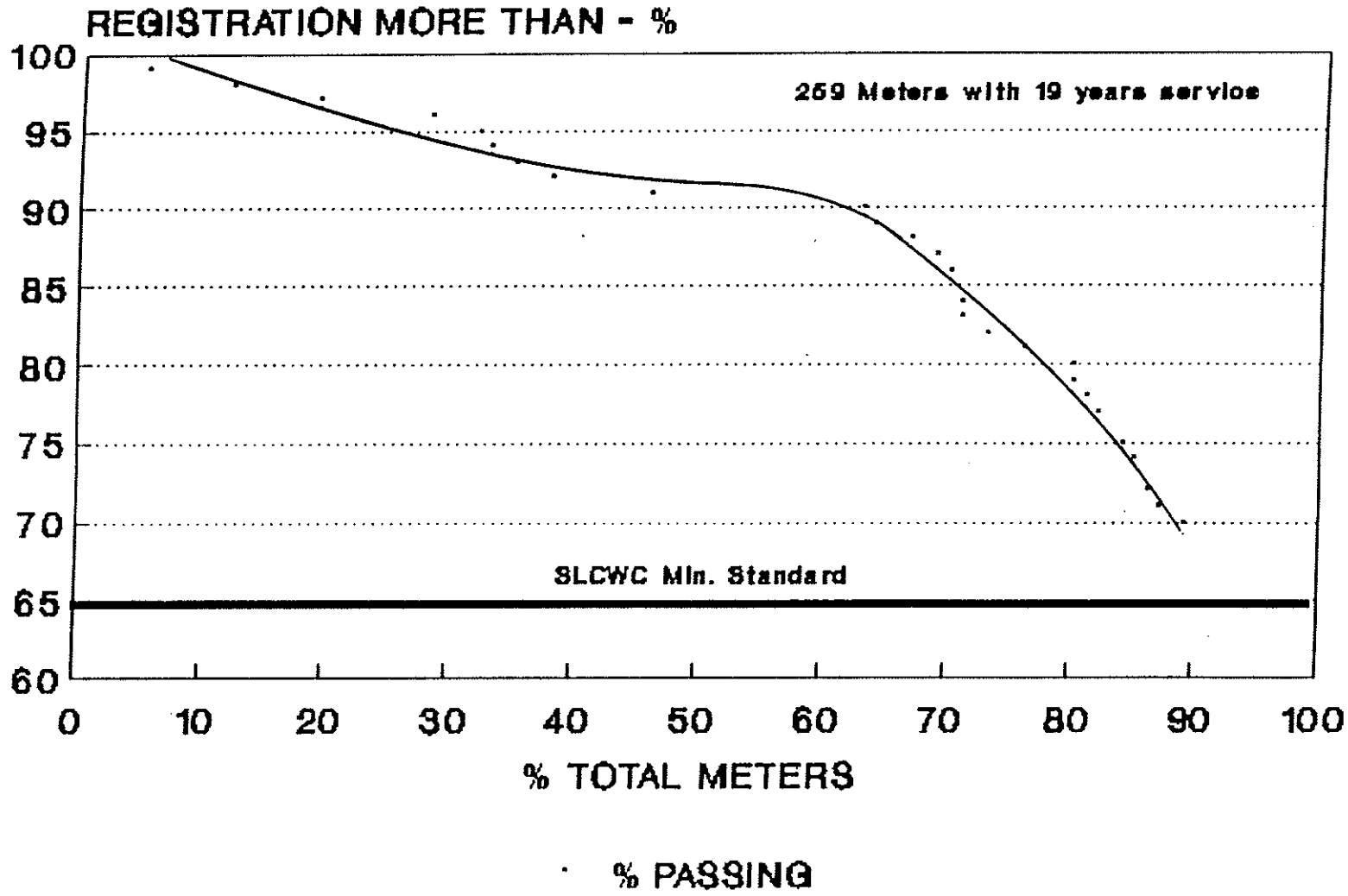


CHART 18 - NOVEMBER 1990

19 YEARS METER STUDY GROUP
2 G.P.M. TEST

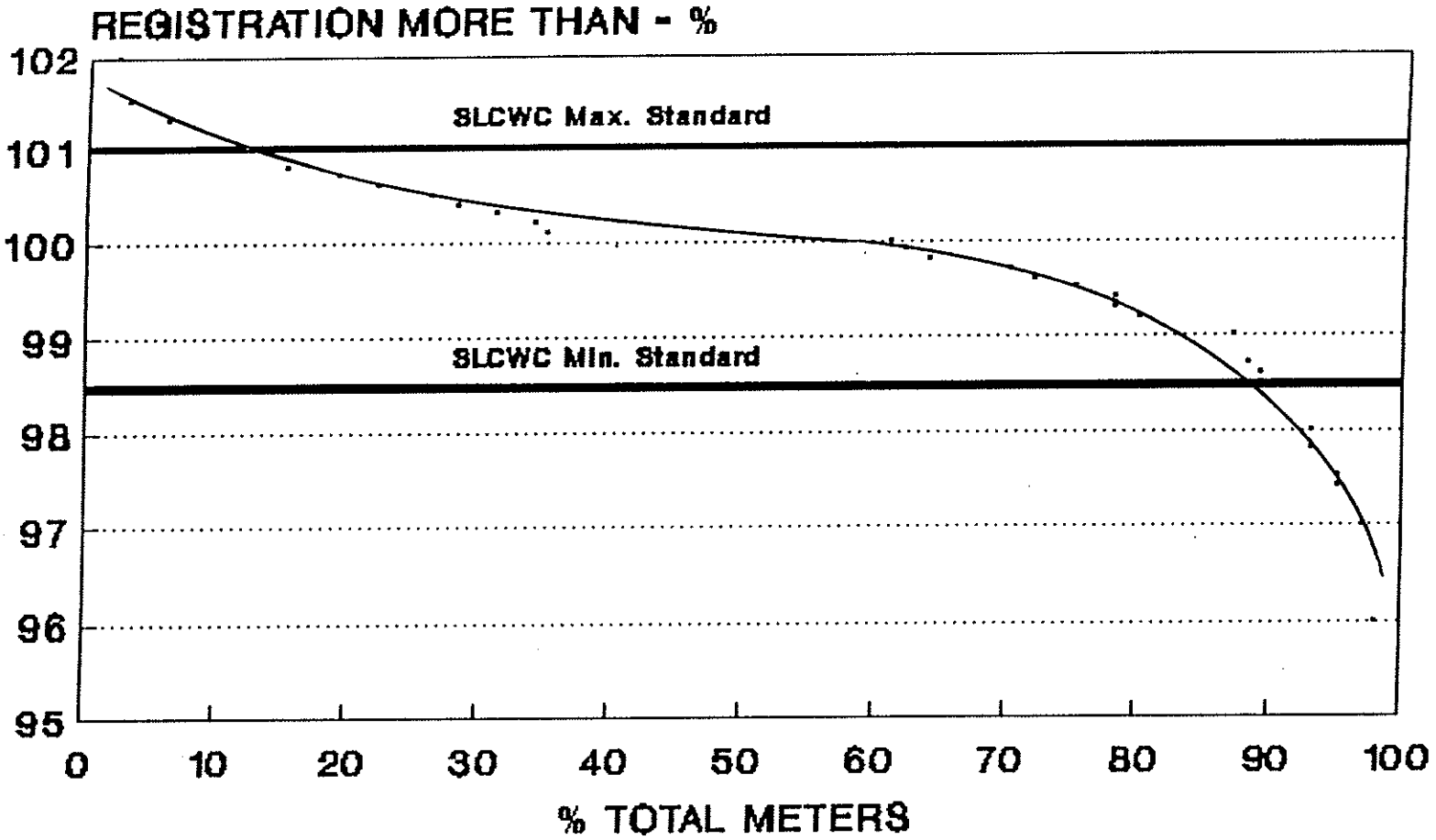


CHART 19 - NOVEMBER 1990

19 YEAR STUDY GROUP - 1990
1/8 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
29	259	100	*
5	230	89	70
2	225	87	71
3	223	86	72
2	220	85	74
5	218	84	75
2	213	82	77
4	211	81	78
1	207	80	79
10	206	80	80
8	196	76	81
3	188	73	82
2	185	71	83
2	183	71	84
2	181	70	86
3	179	69	87
9	173	67	88
4	167	64	89
44	163	63	90
20	119	46	91
9	99	38	92
5	90	35	93
1	85	33	94
12	84	32	95
22	72	28	96
18	50	19	97
19	32	12	98
13	13	5	99

* 14 Meters dead

15 Meters registered less than 65%. Average registration for this group was 45.73%

19 YEAR STUDY GROUP - 1990
2 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
4	259	100	*
5	255	98	96
4	250	97	97
1	246	95	97.4
3	245	95	97.5
2	242	93	97.8
8	240	93	98
2	232	90	98.5
2	230	89	98.6
3	228	88	98.7
19	225	87	99
3	206	80	99.2
2	203	78	99.3
6	201	78	99.4
9	195	75	99.5
5	186	72	99.6
15	181	70	99.7
6	166	64	99.8
3	160	62	99.9
66	157	61	100
4	91	35	100.1
7	87	34	100.2
7	80	31	100.3
6	73	28	100.4
10	67	26	100.5
8	57	22	100.6
10	49	19	100.7
5	39	15	100.8
18	34	13	101
7	16	6	101.3
5	9	3	101.5
4	4	2	102

* 4 Meters dead

20 YEARS METER STUDY GROUP
1/8 G.P.M. TEST

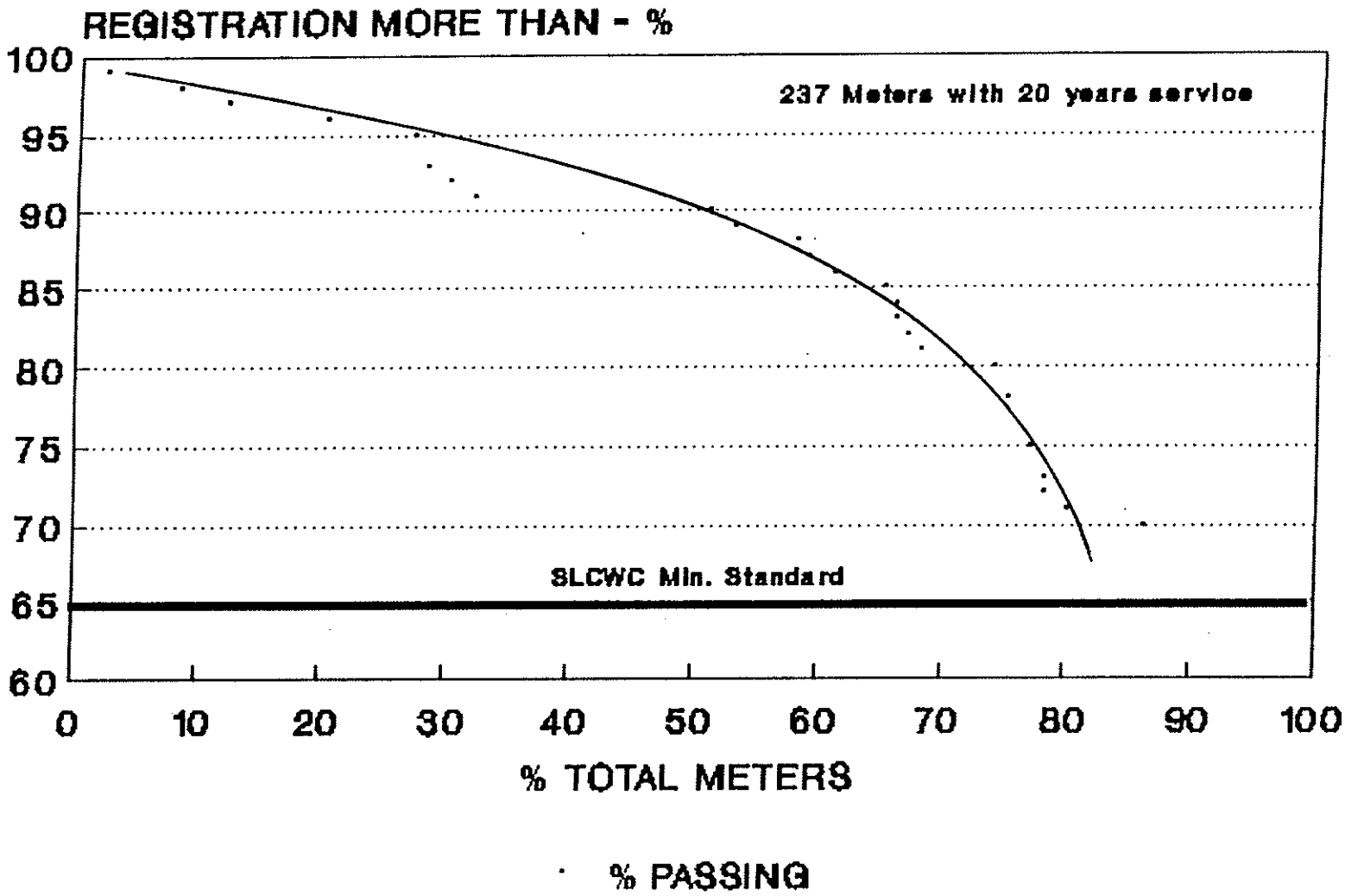


CHART 20 - NOVEMBER 1990

20 YEARS METER STUDY GROUP
2 G.P.M. TEST

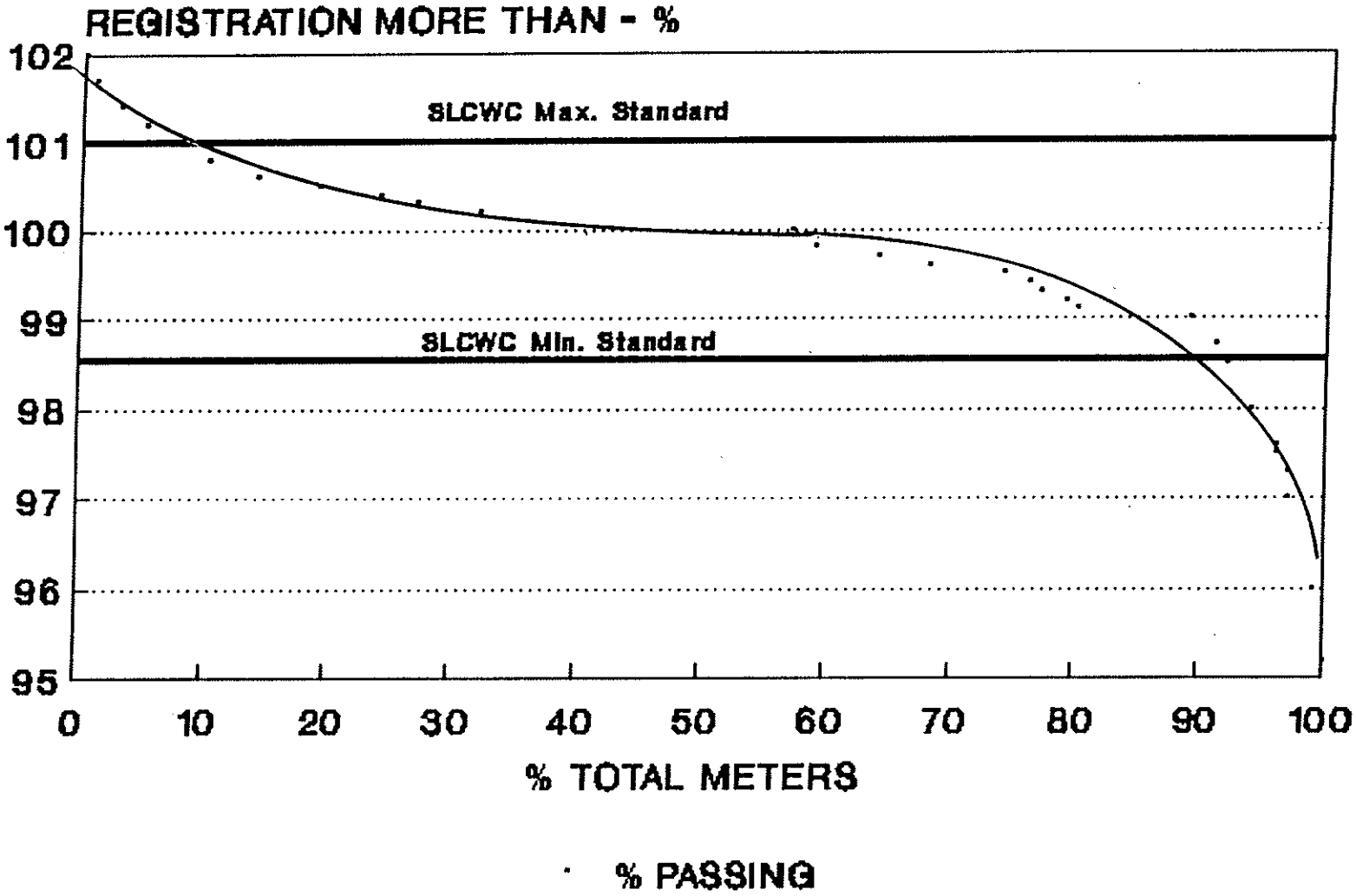


CHART 21 - NOVEMBER 1990

20 YEAR STUDY GROUP - 1990
1/8 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
34	237	100	*
13	203	86	70
4	190	80	71
2	186	78	72
2	184	78	73
5	182	77	75
1	177	75	78
15	176	74	80
3	161	68	81
1	158	67	82
1	157	66	83
1	156	66	84
11	155	65	85
4	144	61	86
3	140	59	87
11	137	58	88
4	126	53	89
47	122	51	90
5	75	32	91
4	70	30	92
2	66	28	93
17	64	27	95
18	47	20	96
10	29	12	97
14	19	8	98
5	5	2	99

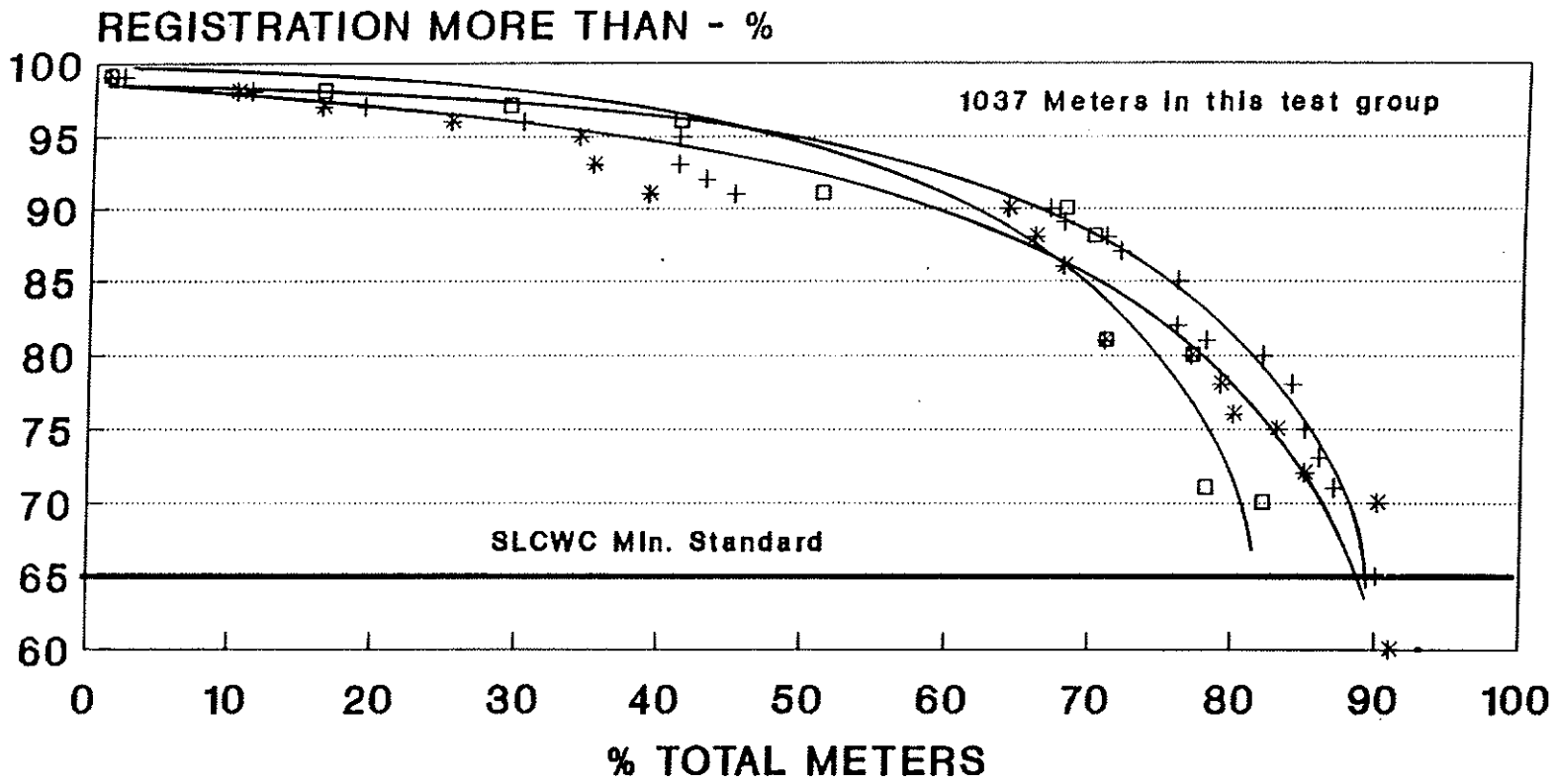
* 9 Meters dead

25 Meters registered less than 65%. Average registration for this group was 49.2%

20 YEAR STUDY GROUP - 1990
2 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
2	237	100	95.2
4	235	99	96
2	231	97	97
2	229	97	97.3
3	227	96	97.5
1	224	96	97.6
4	223	94	98
4	219	92	98.5
5	215	91	98.7
21	210	89	99
1	189	80	99.1
5	188	79	99.2
3	183	77	99.3
5	180	76	99.4
14	175	74	99.5
9	161	68	99.6
13	152	64	99.7
4	139	59	99.8
60	135	57	100
11	75	32	100.2
6	64	27	100.3
13	58	24	100.4
12	45	19	100.5
10	33	14	100.6
5	23	10	100.8
6	18	8	101
5	12	5	101.2
4	7	3	101.4
1	3	1	101.7
2	2	1	102

400/500/600,000 CU.FT. USAGE STUDY GROUP
1/8 G.P.M. TEST



\+ 400,000 CU.FT. GROUP

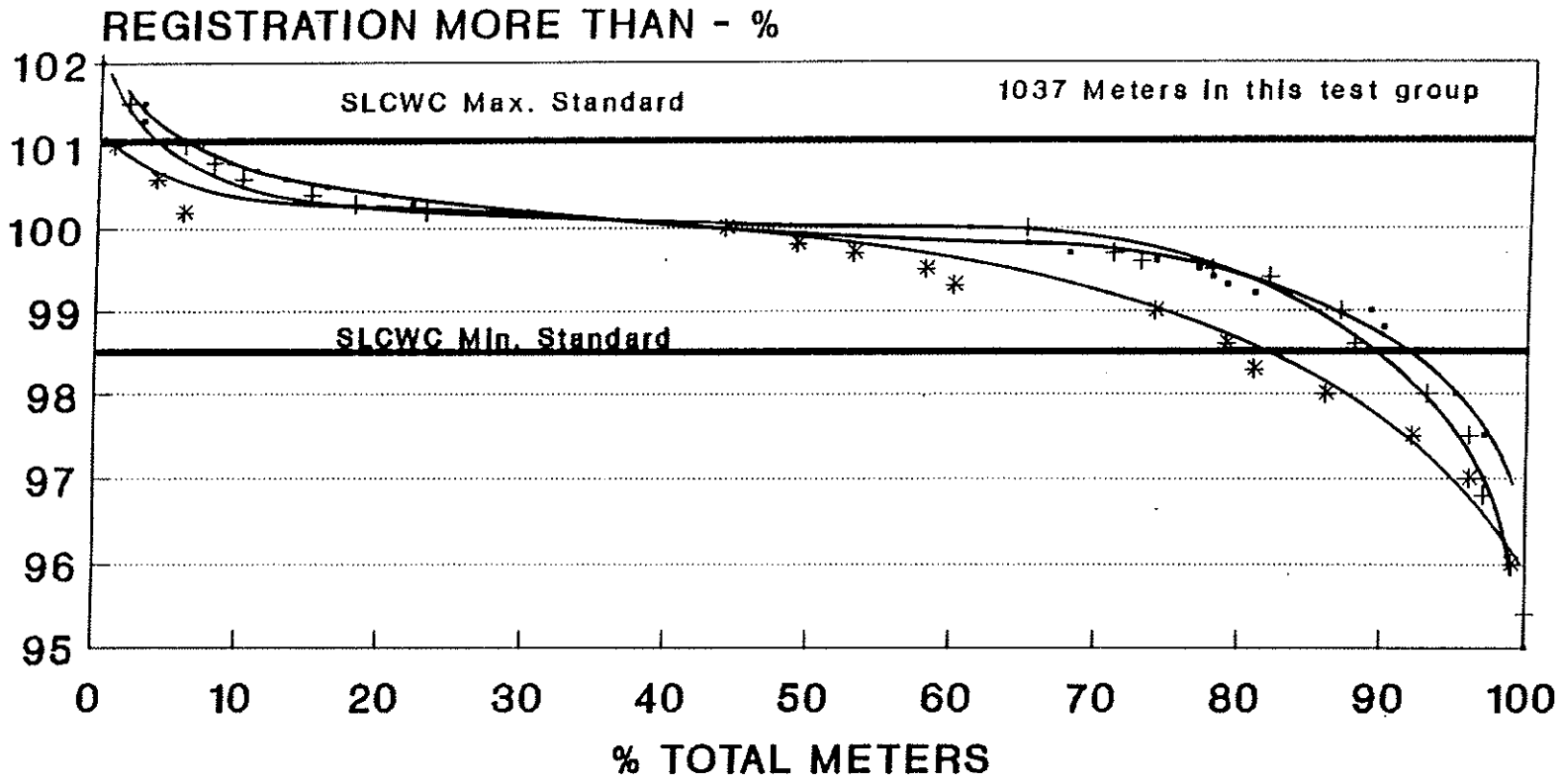
* 500,000 CU.FT. GROUP

□ 600,000 CU.FT. GROUP

ACCEPTABLE RANGE: OVER 65%

CHART 22 - NOVEMBER 1990

400/500/600,000 CU.FT. USAGE STUDY GROUP
2 G.P.M. TEST



· 400,000 CU.FT. GROUP

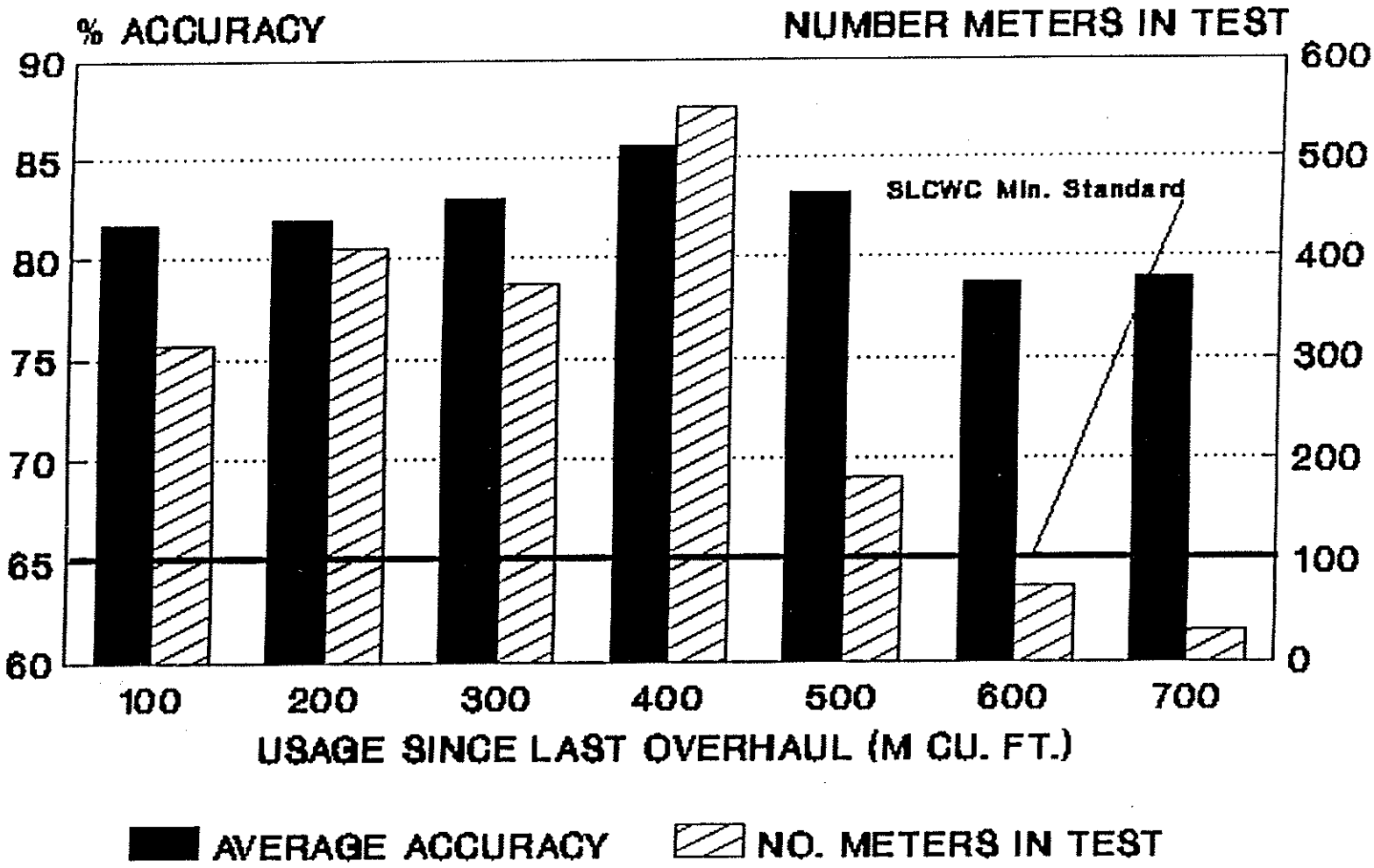
\+ 500,000 CU.FT. GROUP

* 600,000 CU.FT. GROUP

ACCEPTABLE RANGE: 98.5% - 101%

CHART 23 - NOVEMBER 1990

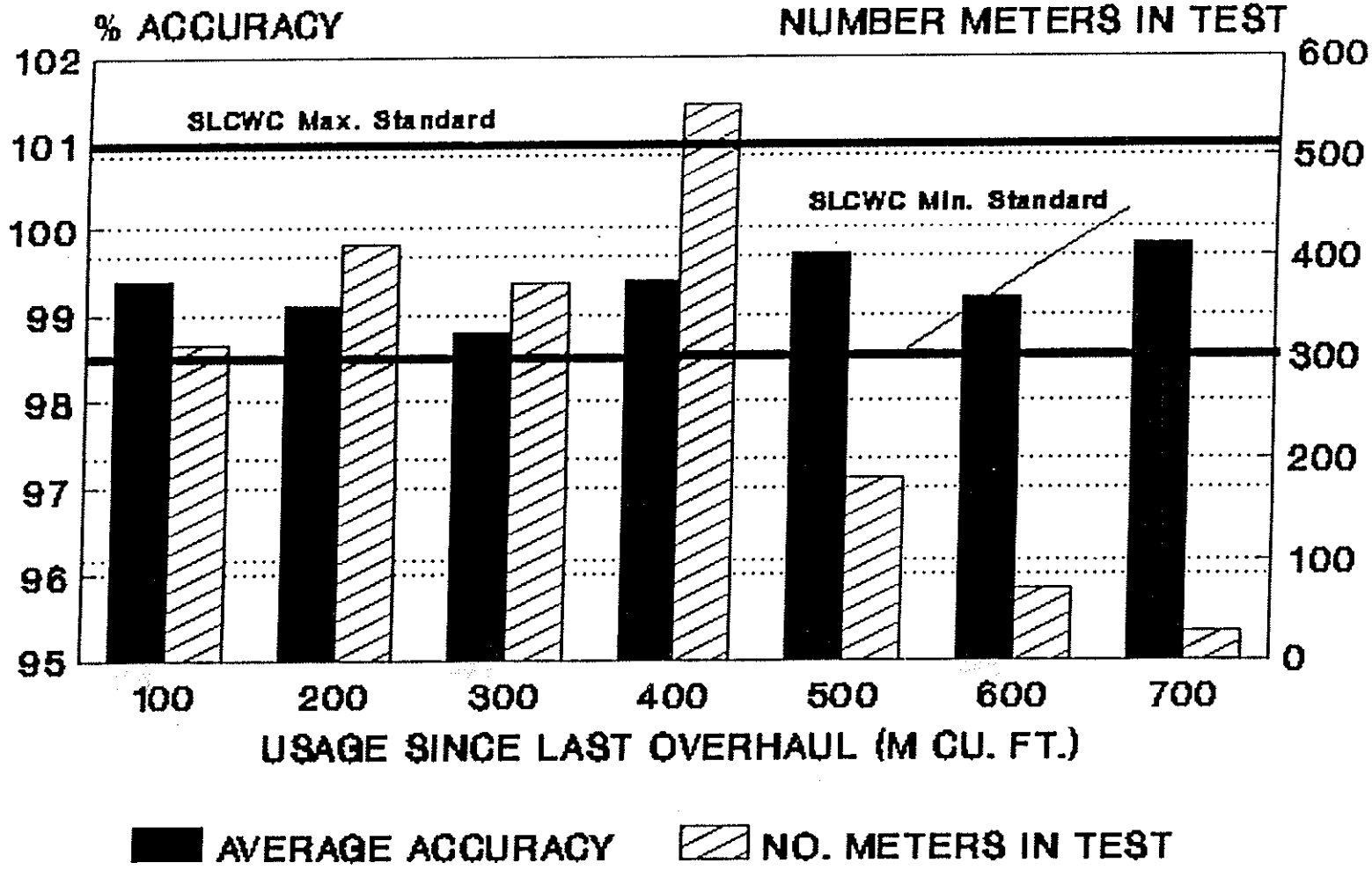
USAGE COMPARED TO AVG. % ACCURACY
1/8 G.P.M. TEST



ACCEPTABLE RANGE: OVER 65%

CHART 24 - NOVEMBER 1990

USAGE COMPARED TO AVG. % ACCURACY
2 G.P.M. TEST

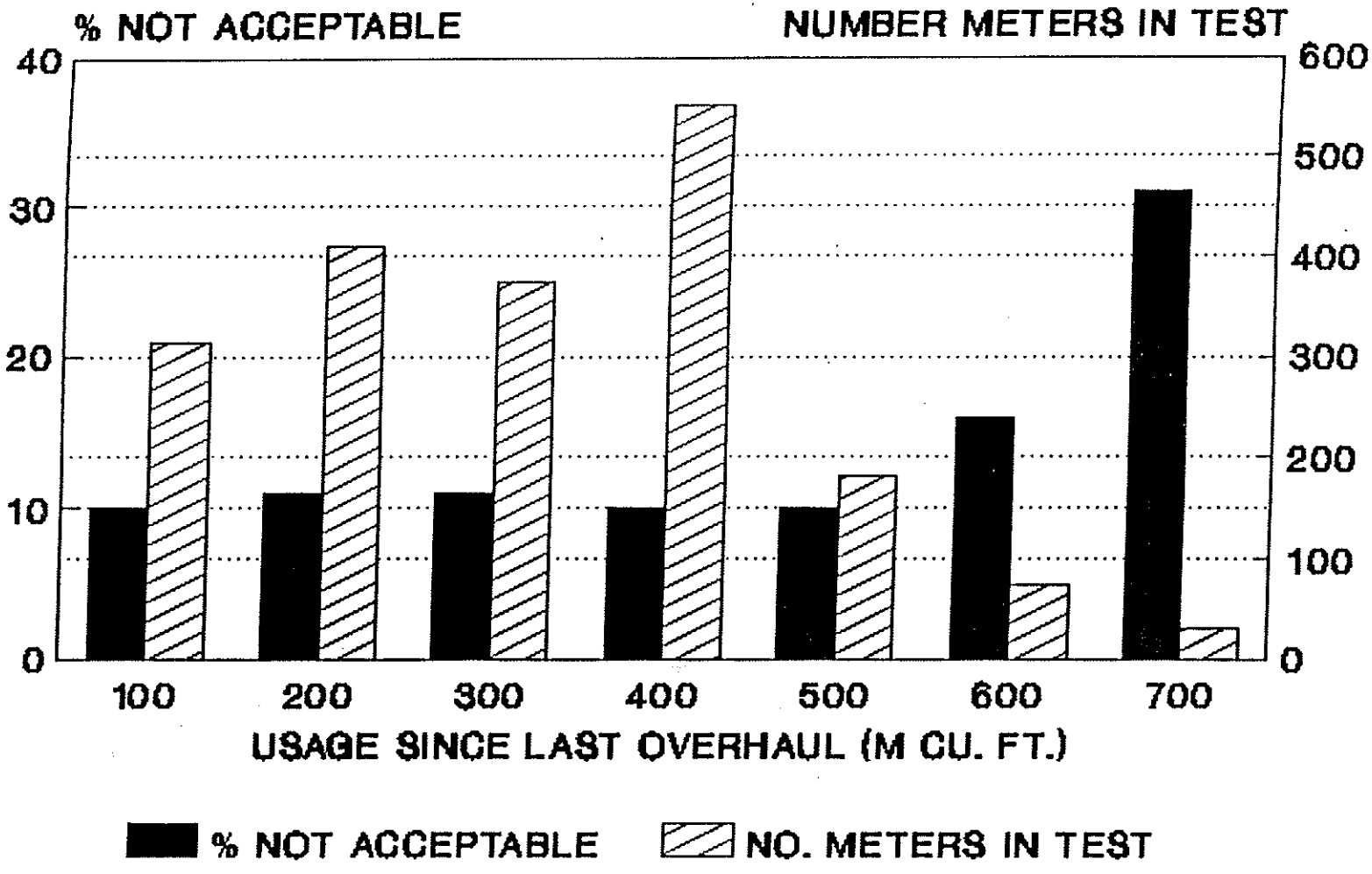


ACCEPTABLE RANGE: 98.5% - 101%

CHART 25 - NOVEMBER 1990

USAGE COMPARED TO AVG. % ACCURACY

1/8 G.P.M. TEST

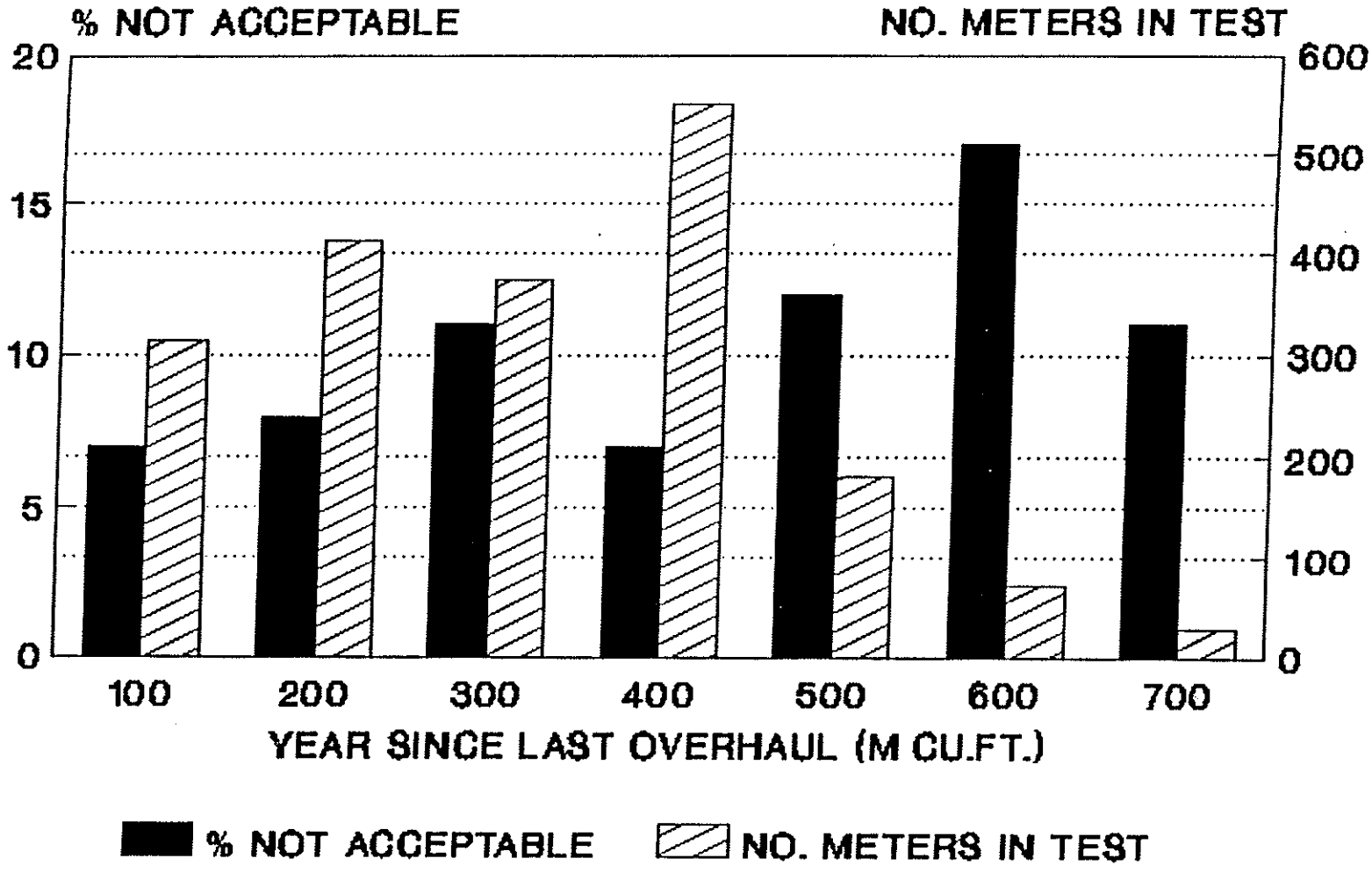


METERS UNDER 65%

CHART 26 - NOVEMBER 1990

USAGE COMPARED TO AVERAGE % ACCURACY

2 G.P.M. TEST

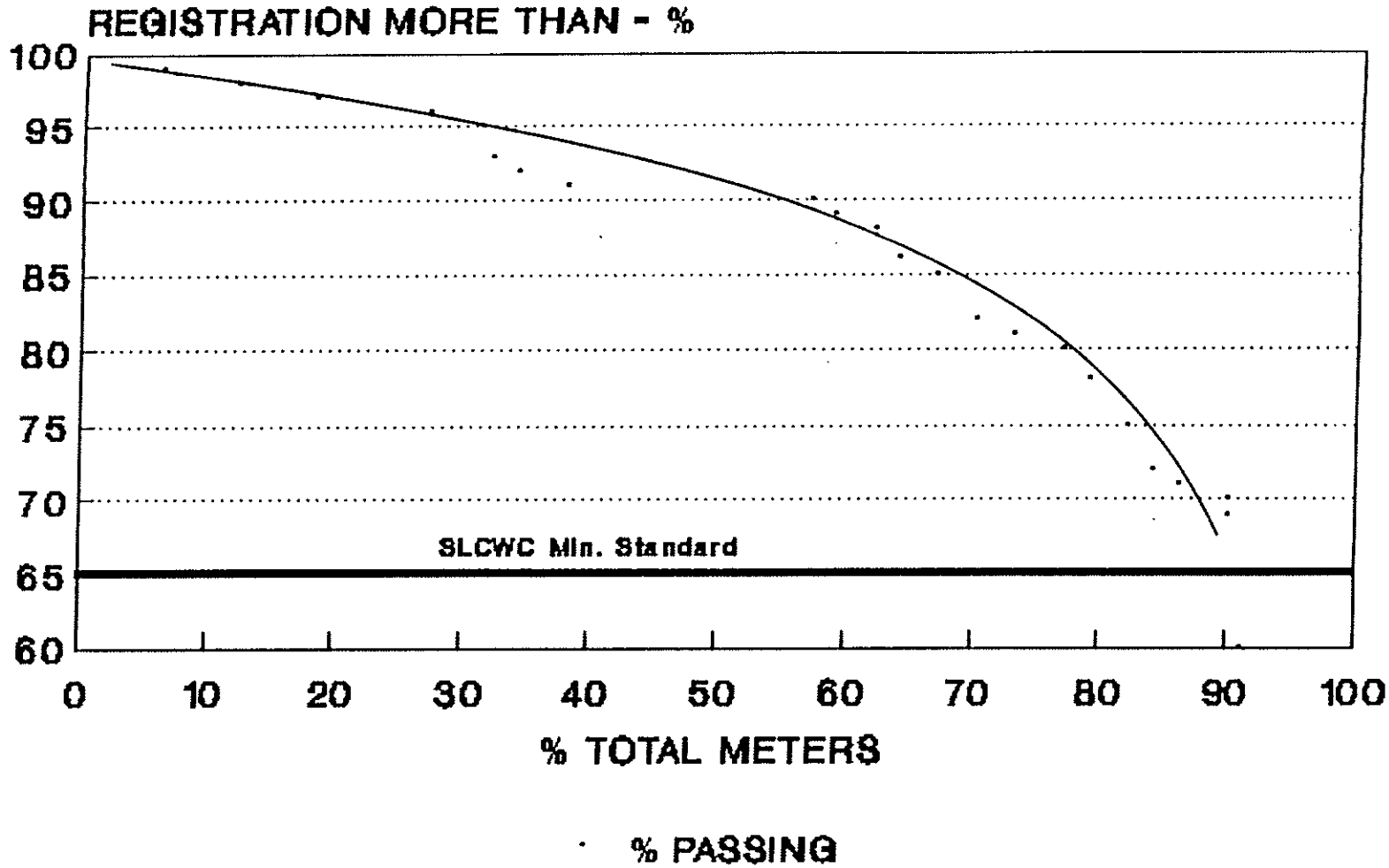


ACCEPTABLE RANGE: 98.5% - 101%

CHART 27 - NOVEMBER 1990

100,000 CU. FT. USAGE STUDY GROUP

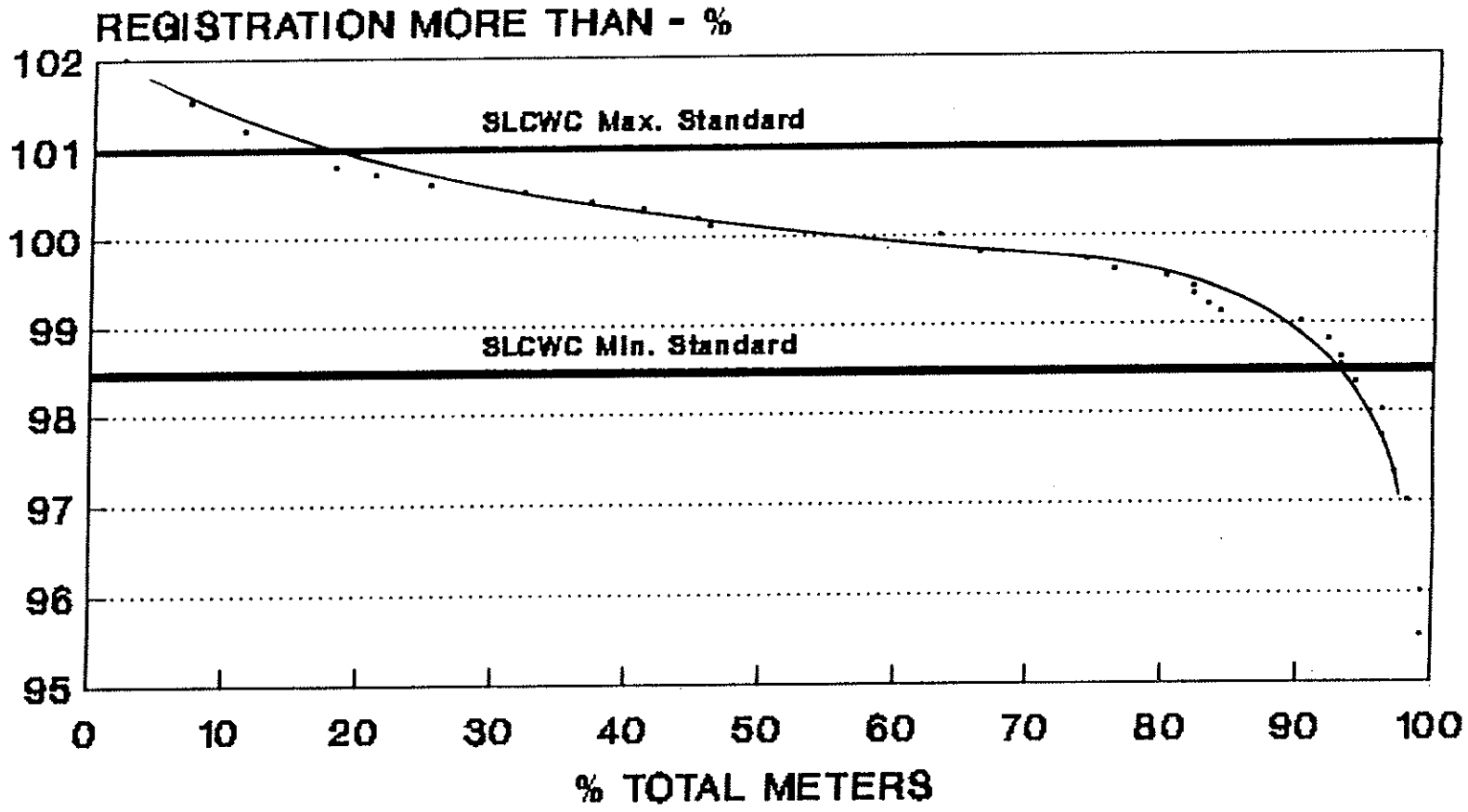
1/8 G.P.M. TEST



ACCEPTABLE RANGE: OVER 65%

CHART 28 - NOVEMBER 1990

100,000 CU. FT. USAGE STUDY GROUP
2 G.P.M. TEST



ACCEPTABLE RANGE: 98.5% - 101%

CHART 29 - NOVEMBER 1990

100,000 CU. FT. USAGE STUDY GROUP - 1990
1/8 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
28	313	100	*
3	285	91	60
1	282	90	69
13	281	90	70
5	268	86	71
6	263	84	72
9	257	82	75
7	248	79	78
14	241	77	80
9	227	73	81
7	218	70	82
10	211	67	85
7	201	64	86
9	194	62	88
7	185	59	89
60	178	57	90
11	118	38	91
6	107	34	92
5	101	32	93
13	96	31	95
28	83	27	96
17	55	18	97
20	38	12	98
18	18	6	99

* 18 Meters dead

10 Meters registered less than 65%. Average registration for this group was 44.8%

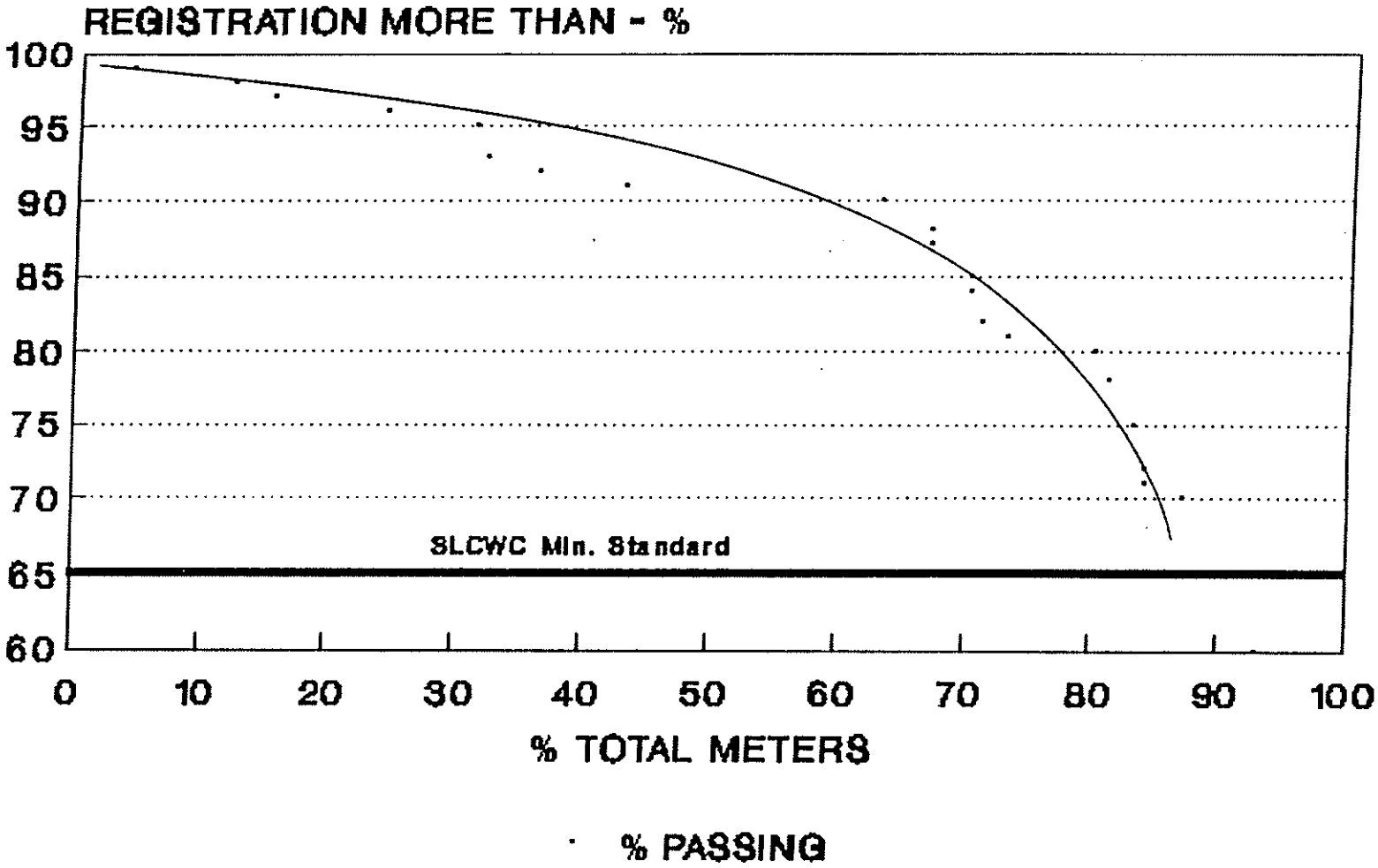
100,000 CU. FT. USAGE STUDY GROUP - 1990
2 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
2	313	100	*
1	311	99	95.5
2	310	99	96
4	308	98	97
2	304	97	97.3
2	302	96	97.7
7	300	96	98
2	293	94	98.3
2	291	93	98.5
2	289	93	98.6
4	287	92	98.8
21	283	90	99
2	262	84	99.1
2	260	83	99.2
2	258	82	99.3
5	256	82	99.4
12	251	80	99.5
8	239	76	99.6
24	231	74	99.7
9	207	66	99.8
54	198	63	100
3	144	46	100.1
14	141	45	100.2
11	127	41	100.3
15	116	37	100.4
22	101	32	100.5
13	79	25	100.6
11	66	21	100.7
2	55	18	100.8
19	53	17	101
13	34	11	101.2
14	21	7	101.5
7	7	2	102

* 2 Meters dead

21 Meters registered less than 98.5%. Average registration for this group was 97.45%

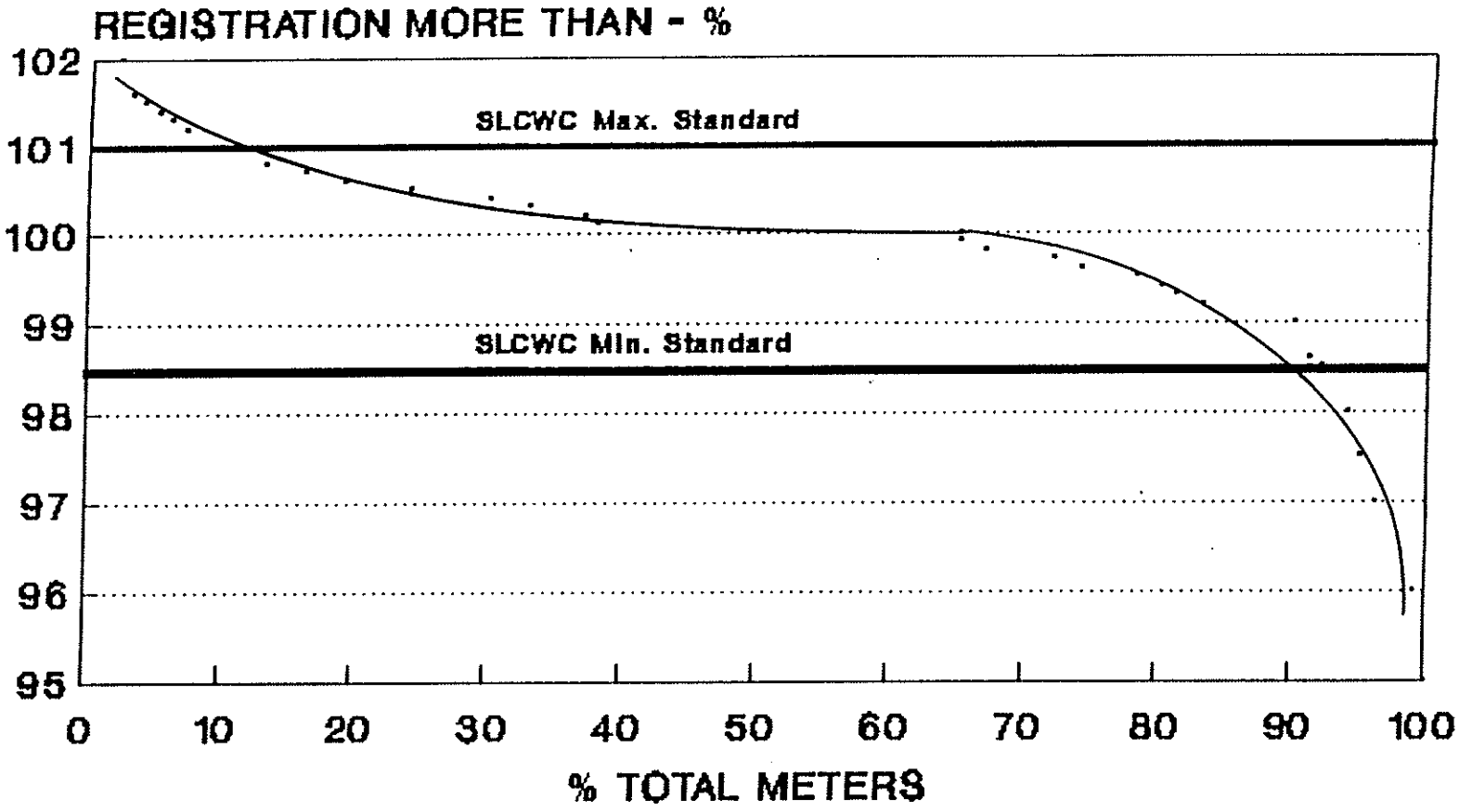
200,000 CU. FT. USAGE STUDY GROUP
1/8 G.P.M. TEST



ACCEPTABLE RANGE: OVER 65%

CHART 30 - NOVEMBER 1990

200,000 CU. FT. USAGE STUDY GROUP
2 G.P.M. TEST



ACCEPTABLE RANGE: 98.5% - 101%

CHART 31 - NOVEMBER 1990

200,000 CU. FT. USAGE STUDY GROUP - 1990
1/8 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
46	412	100	*
5	386	93	60
12	360	87	70
3	348	84	71
3	345	84	72
7	342	83	75
5	335	81	78
30	330	80	80
7	300	73	81
4	293	71	82
2	289	70	84
8	287	70	85
5	279	67	87
15	274	67	88
84	259	63	90
28	176	43	91
18	148	36	92
4	130	32	93
28	126	31	95
35	98	24	96
12	63	15	97
33	51	12	98
18	18	4	99

* 25 Meters dead

26 Meters registered less than 65%. Average registration for this group was 44.9%

200,000 CU. FT. USAGE STUDY GROUP - 1990
2 GPM FLOW

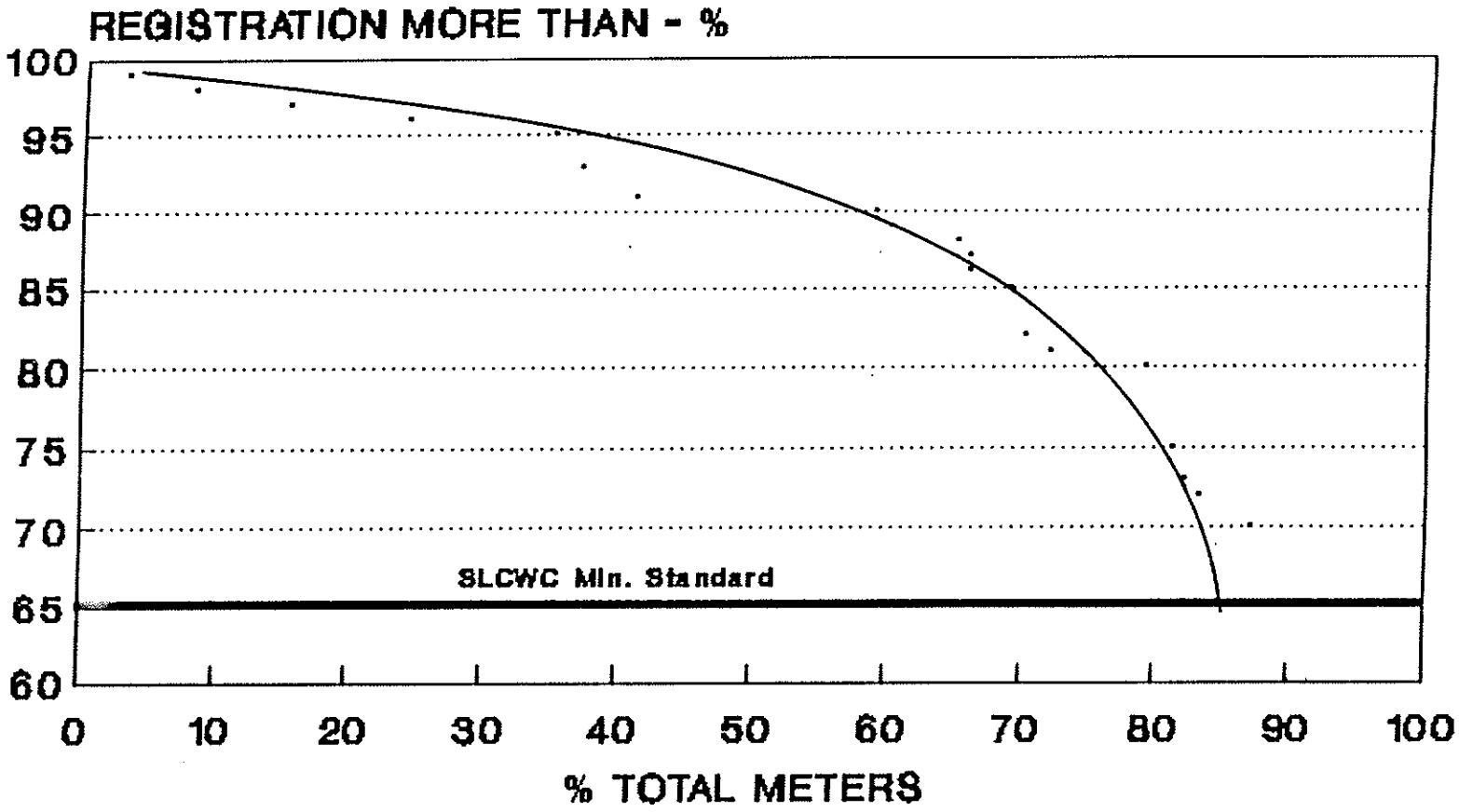
Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
2	412	100	*
4	410	100	95
9	406	99	96
6	397	96	97
3	391	95	97.5
10	388	94	98
4	378	92	98.5
2	374	91	98.6
28	372	90	99
10	344	83	99.2
3	334	81	99.3
9	331	80	99.4
17	322	78	99.5
9	305	74	99.6
18	296	72	99.7
9	278	67	99.8
3	269	65	99.9
111	266	65	100
4	155	38	100.1
17	151	37	100.2
11	134	33	100.3
23	123	30	100.4
22	100	24	100.5
14	78	19	100.6
9	64	16	100.7
8	55	13	100.8
18	47	11	101
4	29	7	101.2
4	25	6	101.3
4	21	5	101.4
3	17	4	101.5
7	14	3	101.6
7	7	2	102

* 2 Meters dead

32 Meters registered less than 98.5%. Average registration for this group was 96.88%

300,000 CU. FT. USAGE STUDY GROUP

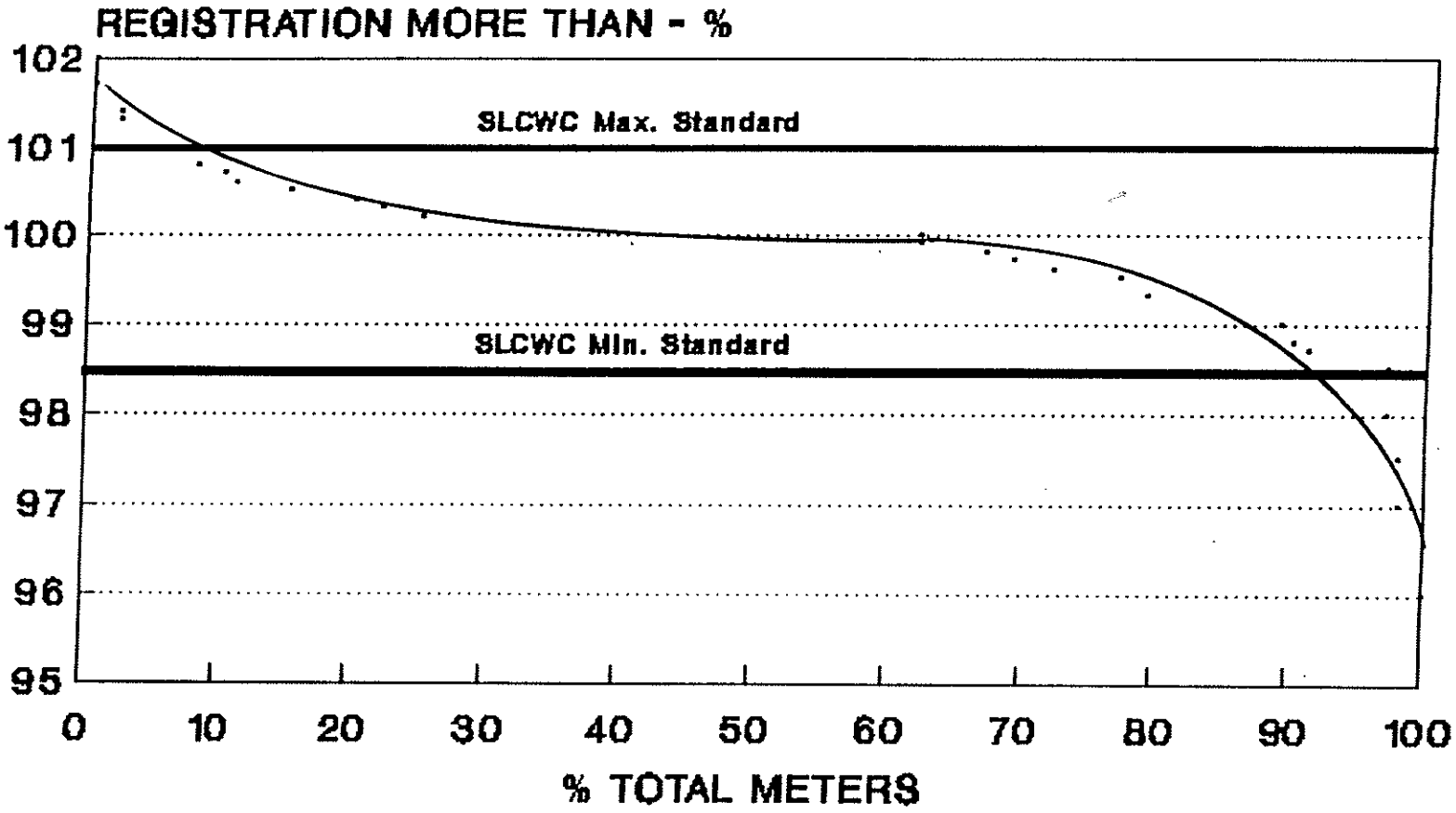
1/8 G.P.M. TEST



ACCEPTABLE RANGE: OVER 65%

CHART 32 - NOVEMBER 1990

300,000 CU. FT. USAGE STUDY GROUP
2 G.P.M. TEST



ACCEPTABLE RANGE: 98.5% - 101%

CHART 33 - NOVEMBER 1990

300,000 CU. FT. USAGE STUDY GROUP - 1990
1/8 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
37	374	100	*
6	337	90	60
5	331	89	65
16	326	87	70
5	310	83	72
3	305	82	73
5	302	81	75
27	297	79	80
7	270	72	81
4	263	70	82
11	259	69	85
2	248	66	86
4	246	66	87
17	242	65	88
3	225	60	89
70	222	59	90
15	152	41	91
6	137	37	93
40	131	35	95
91	24	24	96
25	56	15	97
21	31	8	98
10	10	3	99

* 10 Meters dead

27 Meters registered less than 65%. Average registration for this group was 45.52%

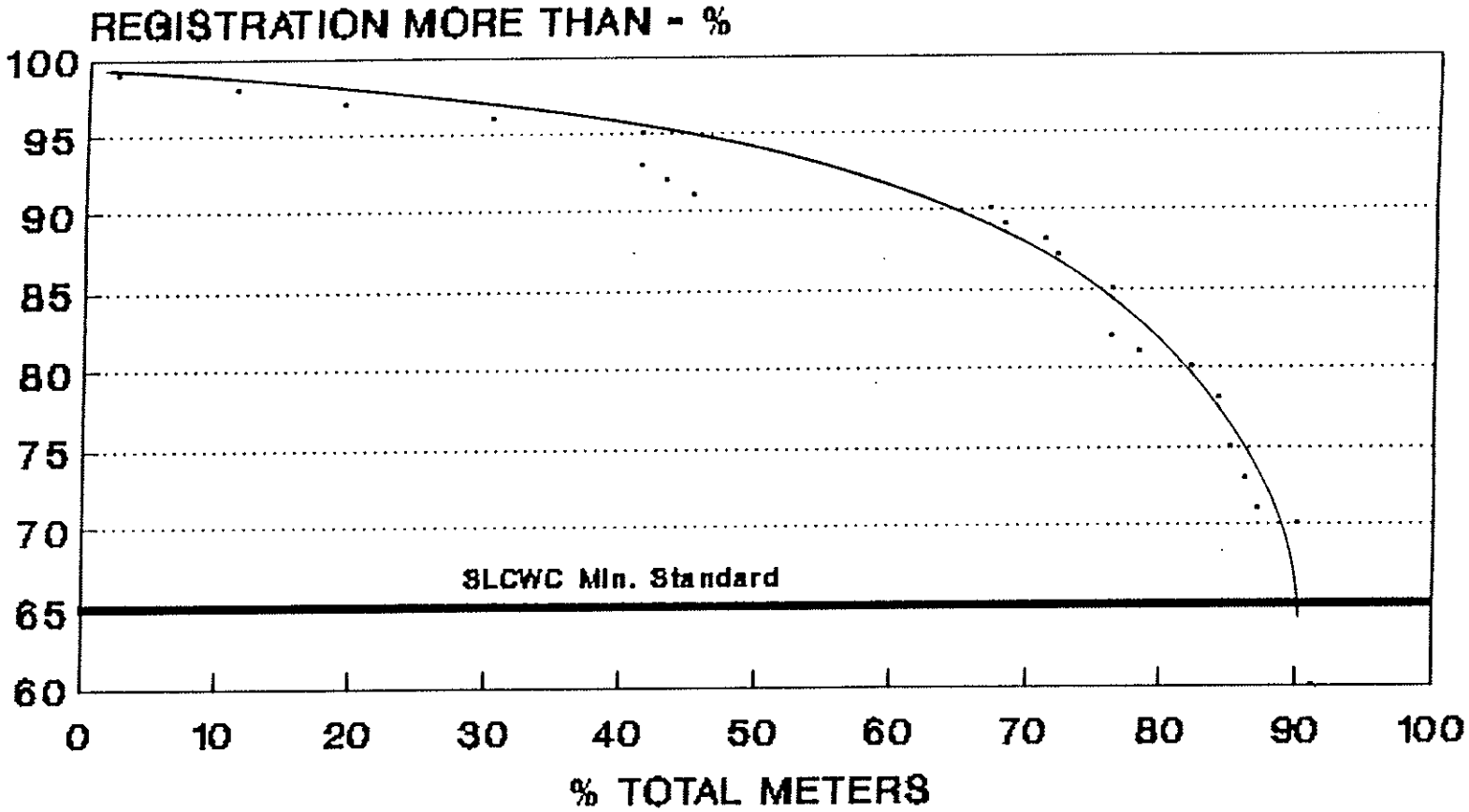
300,000 CU. FT. USAGE STUDY GROUP - 1990
2 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
1	374	100	*
7	373	100	96
1	366	98	97
4	365	98	97.5
16	361	97	98
6	345	97	98.5
3	339	91	98.7
4	336	90	98.8
38	332	89	99
5	294	79	99.3
19	289	77	99.5
12	270	72	99.6
9	258	69	99.7
16	249	67	99.8
3	233	62	99.9
135	230	62	100
12	95	25	100.2
8	83	22	100.3
20	75	20	100.4
14	55	15	100.5
3	41	11	100.6
7	38	10	100.7
4	31	8	100.8
19	27	7	101
2	8	2	101.3
3	6	2	101.4
1	3	.8	101.7
2	2	.5	102

* 1 Meter dead

28 Meters registered less than 98.5%. Average registration for this group was 97.36%

400,000 CU. FT. USAGE STUDY GROUP
1/8 G.P.M. TEST

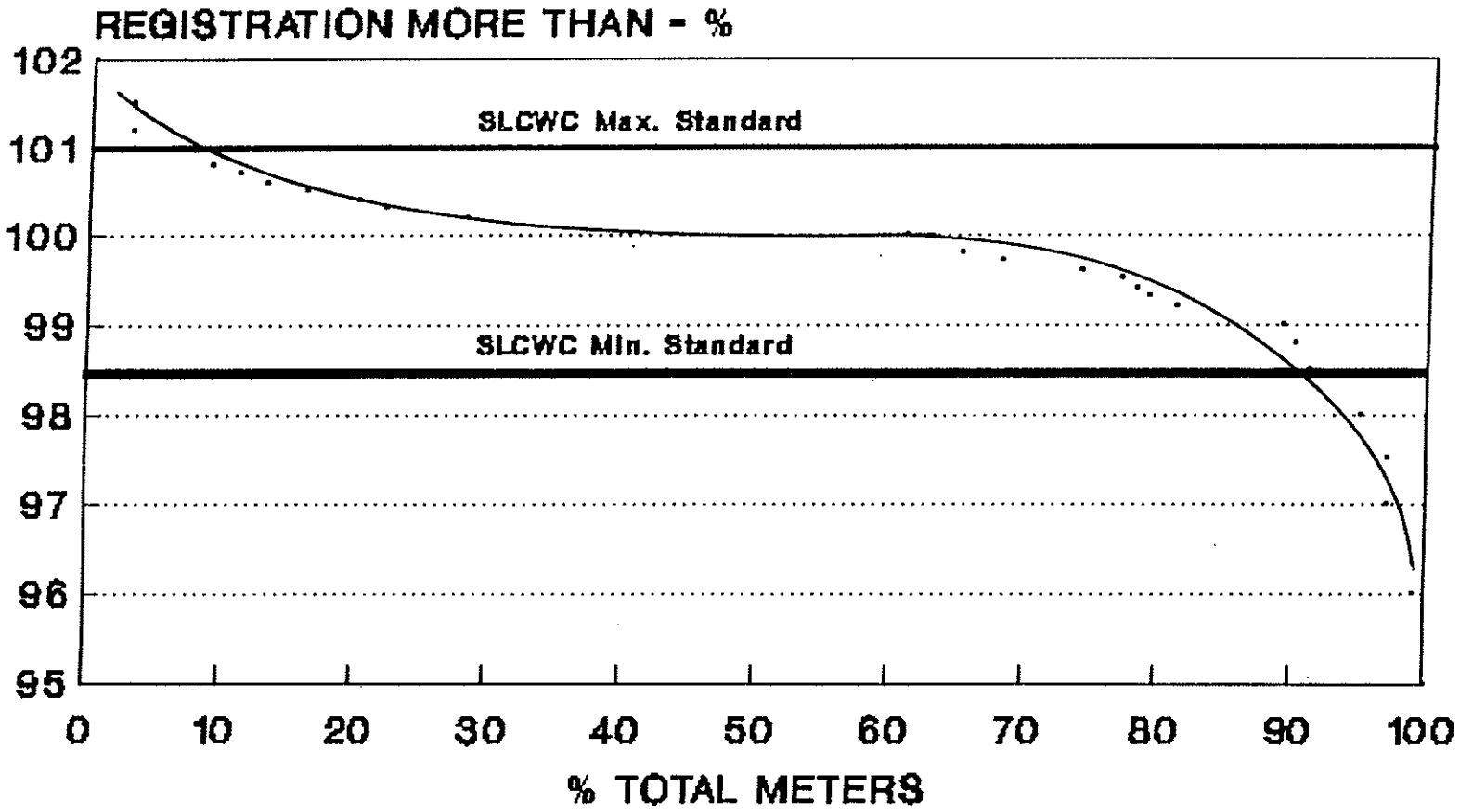


% PASSING

ACCEPTABLE RANGE: OVER 65%

CHART 34 - NOVEMBER 1990

400,000 CU. FT. USAGE STUDY GROUP
2 G.P.M. TEST



ACCEPTABLE RANGE: 98.5% - 101%

CHART 35 - NOVEMBER 1990

400,000 CU. FT. USAGE STUDY GROUP - 1990
1/8 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
47	552	100	*
6	505	91	60
3	499	90	65
16	496	90	70
8	480	87	71
4	472	86	73
7	468	85	75
6	461	84	78
27	455	82	80
7	428	78	81
3	421	76	82
19	418	76	85
5	399	72	87
19	394	71	88
4	375	68	89
12	371	67	90
15	251	45	91
7	236	43	92
5	229	41	93
60	224	41	95
57	164	30	96
48	107	19	97
48	59	11	98
11	11	2	99

* 7 Meters dead

46 Meters registered less than 65%. Average registration for this group was 45.82%

400,000 CU. FT. USAGE STUDY GROUP - 1990
2 GPM FLOW

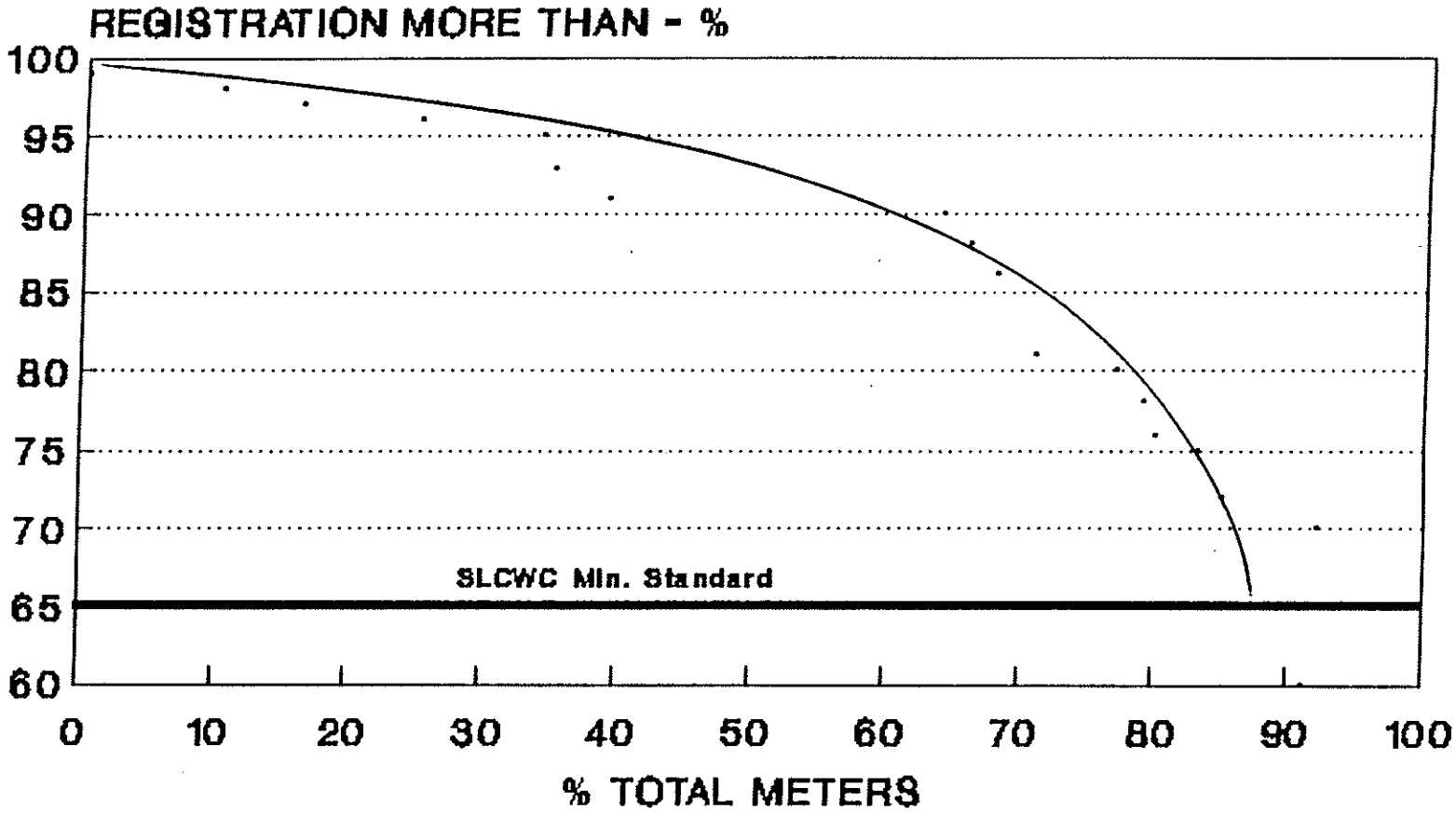
Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
1	552	100	*
3	551	100	95
10	548	99	96
3	538	97	97
9	535	97	97.5
22	526	95	98
5	504	91	98.5
5	499	90	98.8
47	494	89	99
9	447	81	99.2
8	438	79	99.3
5	430	78	99.4
19	425	77	99.5
31	406	74	99.6
17	375	68	99.7
23	358	65	99.8
180	335	61	100
34	155	28	100.2
9	121	22	100.3
25	112	20	100.4
14	87	16	100.5
10	73	13	100.6
15	63	11	100.7
7	48	9	100.8
23	41	7	101
4	18	3	101.2
9	14	3	101.5
5	5	.9	102

* 1 Meter dead

47 Meters registered less than 98.5%. Average registration for this group was 97.26%

500,000 CU. FT. USAGE STUDY GROUP

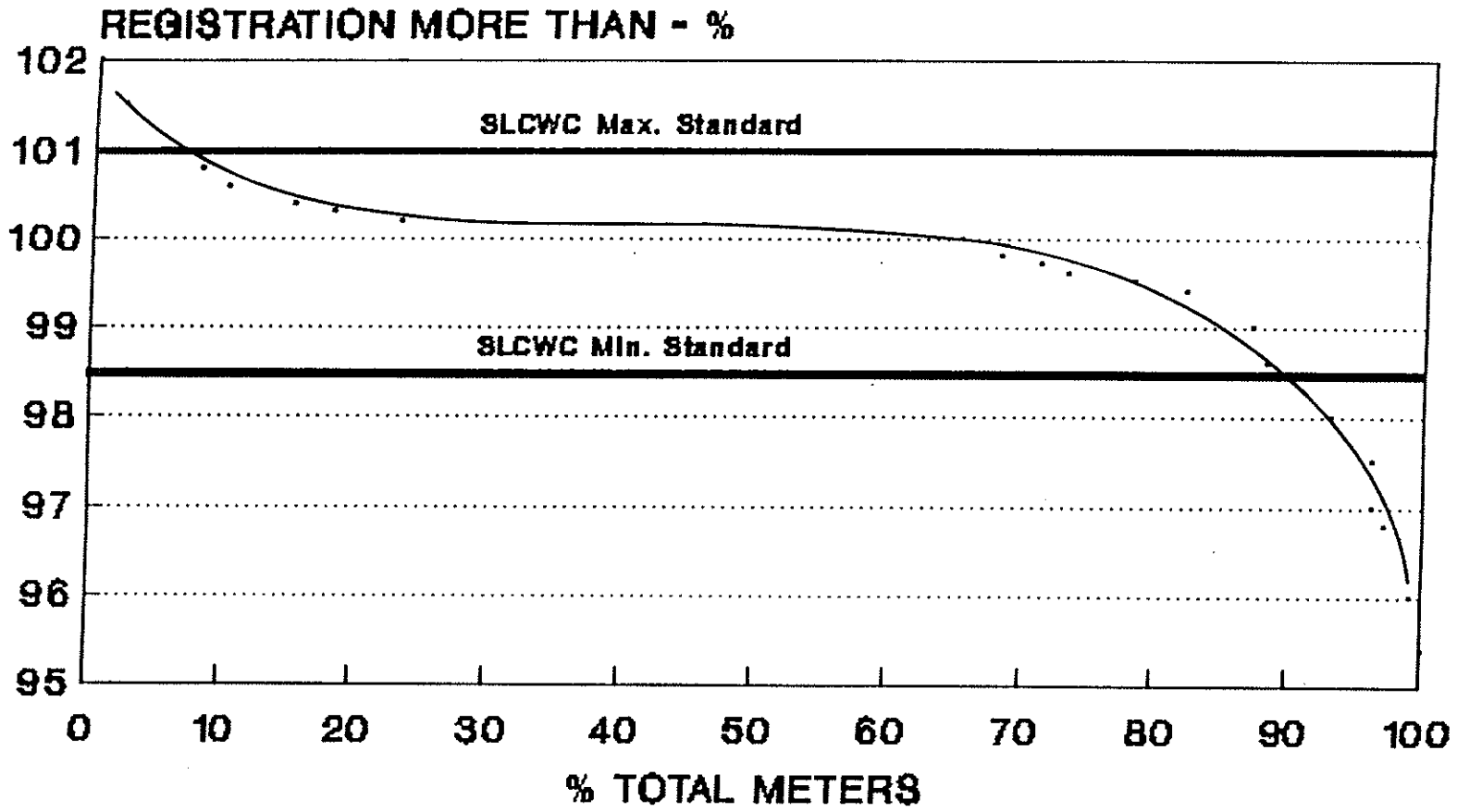
1/8 G.P.M. TEST



ACCEPTABLE RANGE: OVER 65%

CHART 36 - NOVEMBER 1990

500,000 CU. FT. USAGE STUDY GROUP
2 G.P.M. TEST



ACCEPTABLE RANGE: 98.5% - 101%

CHART 37 - NOVEMBER 1990

500,000 CU. FT. USAGE STUDY GROUP - 1990
1/8 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
16	181	100	*
2	165	91	60
9	163	90	70
3	154	85	72
6	151	83	75
2	145	80	76
3	143	79	78
12	140	77	80
5	128	71	81
4	123	68	86
4	119	66	88
45	115	64	90
6	70	39	91
3	64	35	93
15	61	34	95
17	46	25	96
10	29	16	97
18	19	10	98
1	1	.05	99

* 3 Meters dead

15 Meters registered less than 65%. Average registration for this group was 38.92%

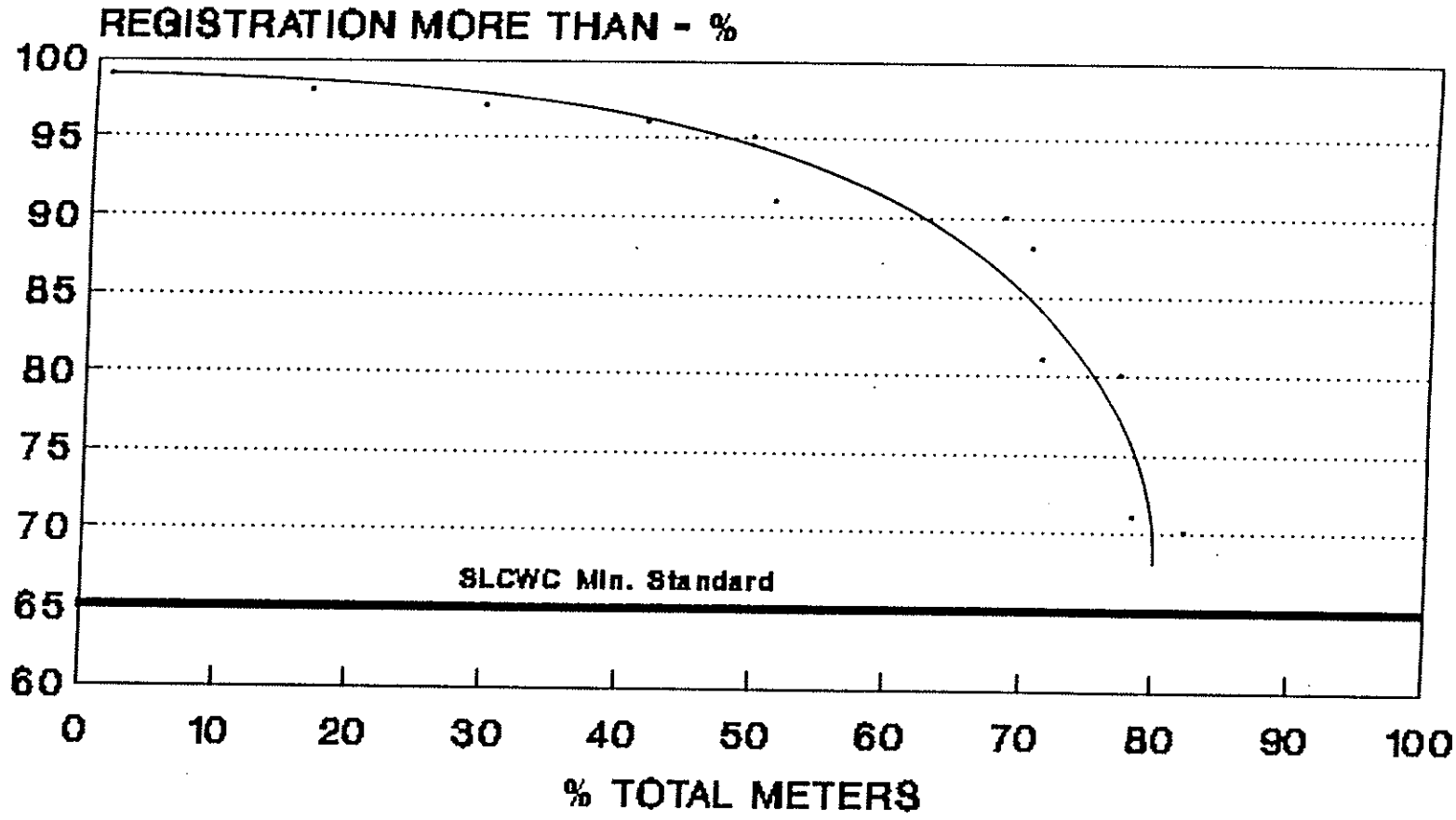
500,000 CU. FT. USAGE STUDY GROUP - 1990
2 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
1	181	100	95.4
4	180	99	96
2	176	97	96.8
1	174	96	97
5	173	96	97.5
8	168	93	98
2	160	88	98.6
10	158	87	99
6	148	82	99.4
10	142	78	99.5
3	132	73	99.6
6	129	71	99.7
5	123	68	99.8
76	118	65	100
10	42	23	100.2
4	32	18	100.3
9	28	15	100.4
5	19	10	100.6
3	14	8	100.8
7	11	6	101
3	4	2	101.5
1	1	.5	102

21 Meters registered less than 98.5%. Average registration for this group was 97.45%

600,000 CU. FT. USAGE STUDY GROUP

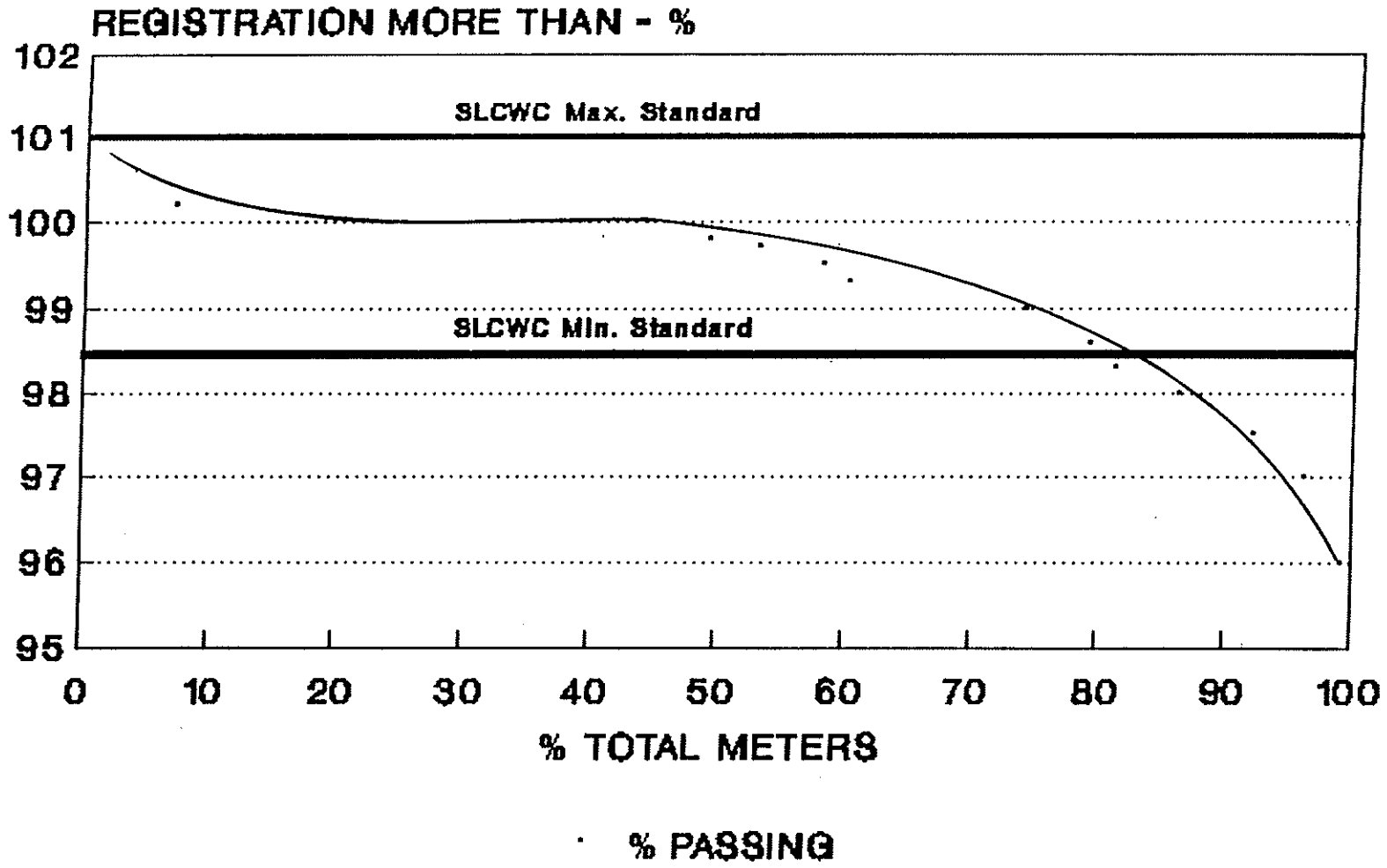
1/8 G.P.M. TEST



ACCEPTABLE RANGE: OVER 65%

CHART 38 - NOVEMBER 1990

600,000 CU. FT. USAGE STUDY GROUP
2 G.P.M. TEST



ACCEPTABLE RANGE: 98.5% - 101%

CHART 39 - NOVEMBER 1990

600,000 CU. FT. USAGE STUDY GROUP - 1990
1/8 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
13	73	100	*
3	60	82	70
1	57	78	71
4	56	77	80
1	52	71	81
1	51	70	88
13	50	68	90
1	37	51	91
6	36	49	95
9	30	41	96
9	21	29	97
11	12	16	98
1	1	1	99

* 7 Meters dead

5 Meters registered less than 65%. Average registration for this group was 46%

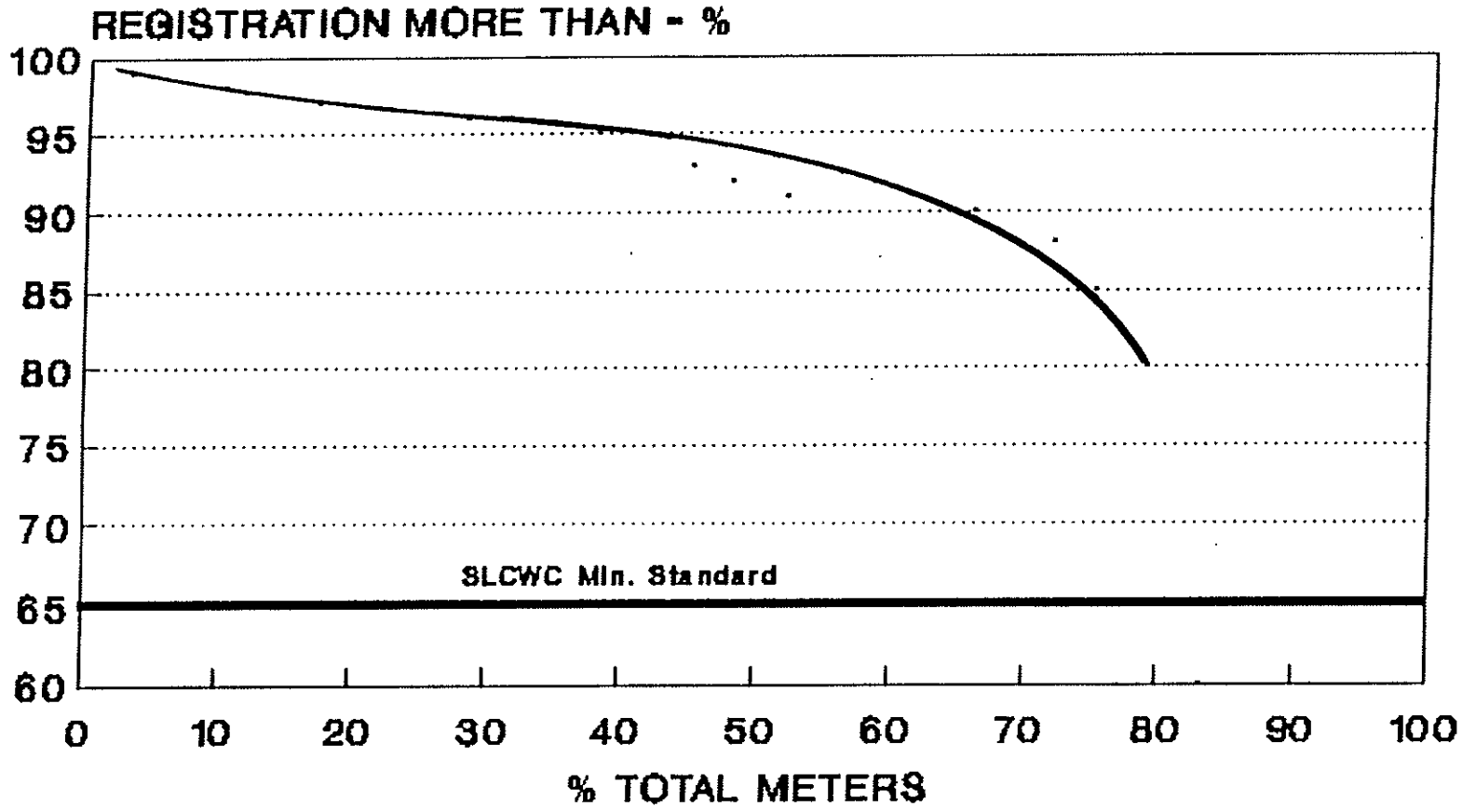
600,000 CU. FT. USAGE STUDY GROUP - 1990
2 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
1	100	100	*
2	99	99	96
3	96	96	97
4	92	92	97.5
4	86	86	98
1	81	81	98.3
4	79	79	98.6
10	74	74	99
2	60	60	99.3
3	58	58	99.5
3	53	53	99.7
4	49	49	99.8
27	44	44	100
2	7	7	100.2
2	4	4	100.6
1	1	1	101

* 1 Meter registered 84.5%

14 Meters registered less than 98.5%. Average registration for this group was 97.35%

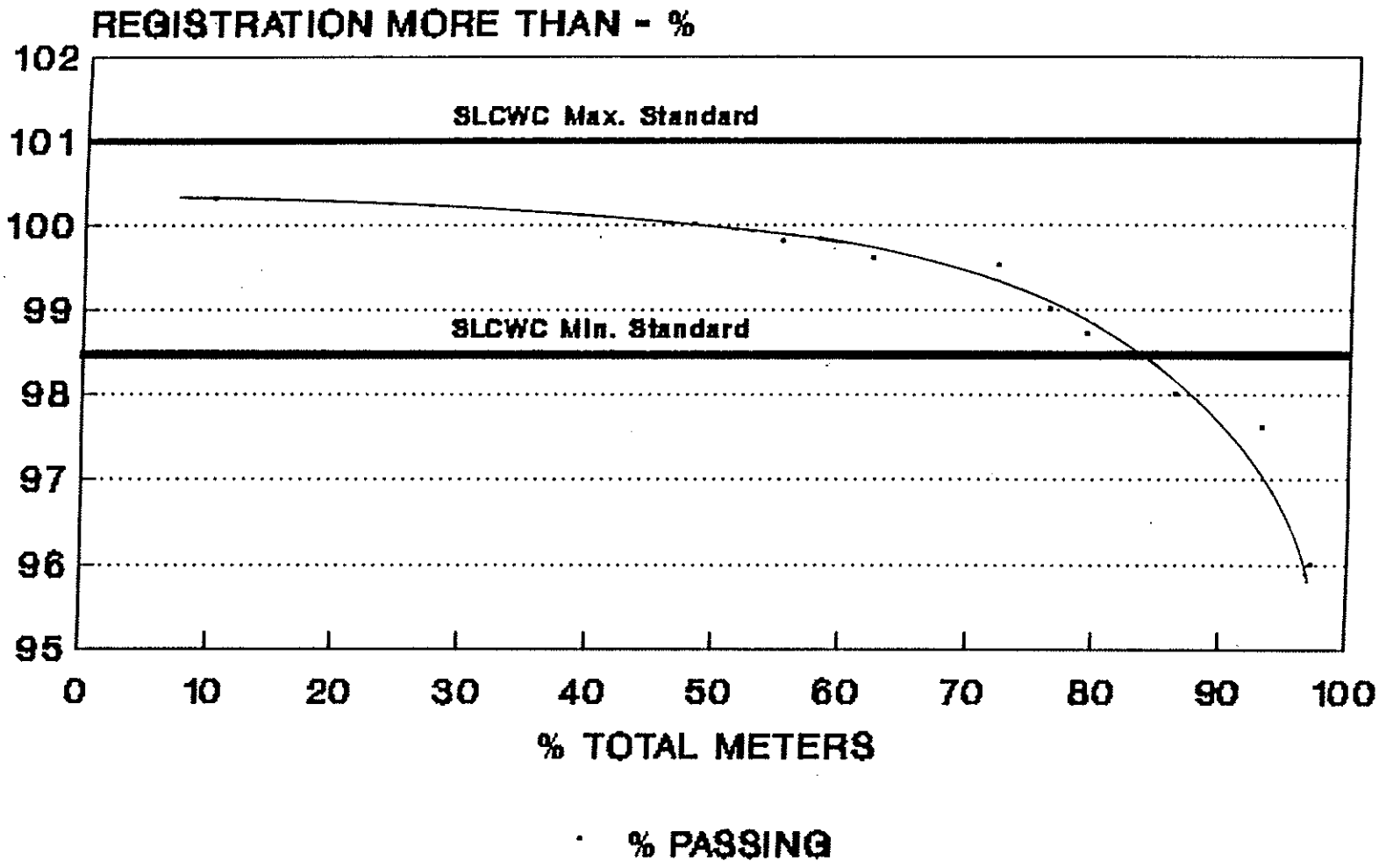
700,000 CU. FT. USAGE STUDY GROUP
1/8 G.P.M. TEST



ACCEPTABLE RANGE: OVER 65%

CHART 40 - NOVEMBER 1990

700,000 CU. FT. USAGE STUDY GROUP
2 G.P.M. TEST



ACCEPTABLE RANGE: 98.5% - 101%

CHART 41 - NOVEMBER 1990

700,000 CU. FT. USAGE STUDY GROUP - 1990
1/8 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
5	29	100	*
1	24	83	60
1	23	79	80
1	22	75	85
2	21	72	88
4	19	66	90
1	15	52	91
1	14	48	92
2	13	45	93
3	11	38	95
3	8	28	96
2	5	17	97
2	3	10	98
1	1	3	99

* 3 Meters dead

3 Meters registered less than 65%. Average registration for this group was 48%

700,000 CU. FT. USAGE STUDY GROUP - 1990
2 GPM FLOW

Number of Meters	Cumulative No. Meters	Summation of Total Tested - %	% Reg. More Than
1	29	100	*
1	28	97	96
2	27	93	97.6
2	25	86	98
1	23	79	98.7
1	22	76	99
3	21	72	99.5
2	18	62	99.6
2	19	55	99.8
11	14	48	100
2	3	10	100.3
1	1	3	101

* 1 Meter dead

5 Meters registered less than 98.5%. Average registration for this group was 97.44%

APPENDIX A

COLLECTION OF DATA:

The data for this study was collected from June through September 1990, each day ten to fifteen 5/8" meters would be pulled at random and the history of those meters investigated to find the last overhaul date. The data was recorded in the following way.

1. Meter Number
2. Year of Last Overhaul
3. Mileage on Meter
4. Test Performance at 1/8 GPM & 2 GPM

There was no effort made in any way to control the number of meters coming into the Meter Shop for any specified service plan. All meters were accepted as normal, routine, everyday operating procedures dictated.

At the time we made this study the Company was in the process of a major 15 year meter change program, this was a prime time to find out how well our meters were performing since many of the meters were in service for 20 to 25 years.

The sampling of the meters selected was random and unbiased.

Listed below is the number of meters used in this study, first by years in service, second by total mileage recorded on the meter.

Service Years	15	16	17	18	19	20		Total
No. of 5/8" Meters	200	101	134	165	259	237		1096
Mileage (M Cu. Ft.)	100	200	300	400	500	600	700	
No. of 5/8" Meters	313	412	374	552	181	73	29	1934

Test Standard:

St. Louis County Water Company uses the following standard to allow incoming meters to be returned to service:

Accuracy must be between 98.5% - 101% @ 2 GPM

Accuracy must be over 65% @ 1/8 GPM*

*Normal industry standard for sensitivity testing is 1/4 GPM.

There were 1934 meters in this study. Some of the meters in this study were under fifteen years of age, also many of the meters were over twenty years of age which put them out side of the study parameters. For this reason, there is a smaller number of meters in the "Years" study group than in the "Mileage" study group.

APPENDIX B

HISTORICAL RECORD

SYSTEM GROWTH - VERSUS METER CHANGES

(All Meter Sizes)

Year	No. Meters In Service As of Jan. 1	Meter Growth During Year	Changes Made During Year
1972	223,131	4,919	2,206
1973	228,052	4,589	4,286
1974	232,641	3,005	8,566
1975	235,646	2,906	7,913
1976	238,552	4,644	8,680
1977	243,196	4,778	6,617
1978	247,974	4,841	6,762
1979	252,815	4,149	9,567
1980	256,964	1,915	14,575
1981	258,879	1,772	16,099
1982	260,651	1,234	14,463
1983	261,885	2,569	11,184
1984	264,454	2,921	7,237
1985	267,375	3,115	5,651
1986	270,490	3,866	7,912
1987	274,356	4,431	6,617
1988	278,787	4,450	8,760
1989	283,237	2,506	11,680
1990	285,743	3,329	17,853