

FILED

MAY 18, 2021

Missouri Public  
Service Commission

# Exhibit No. 303

Commission – Exhibit 303  
1990 Study  
File No. WC-2021-0129

## 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 regearred 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.

---

<sup>1</sup>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

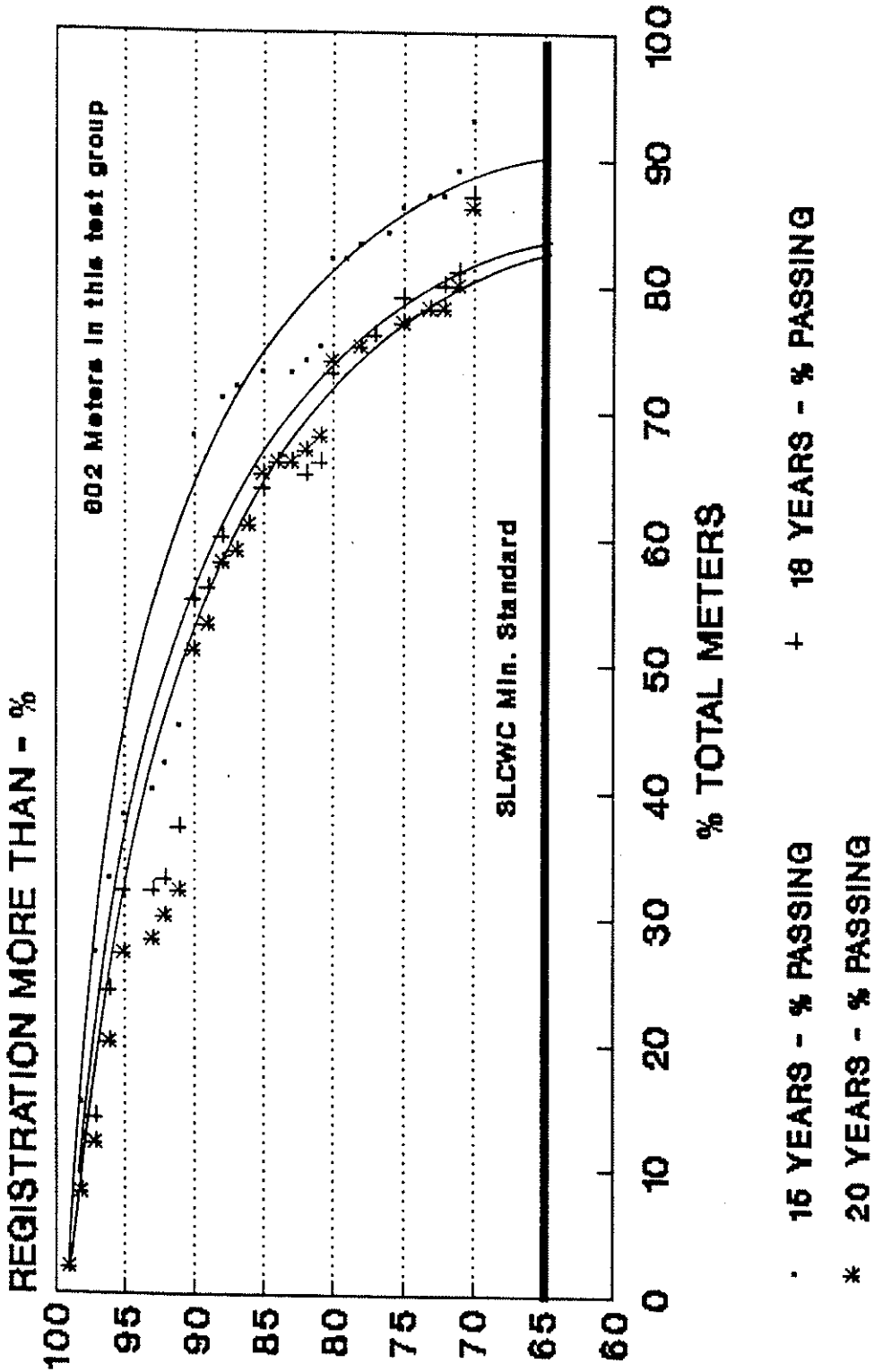


CHART 1 - NOVEMBER 1990

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

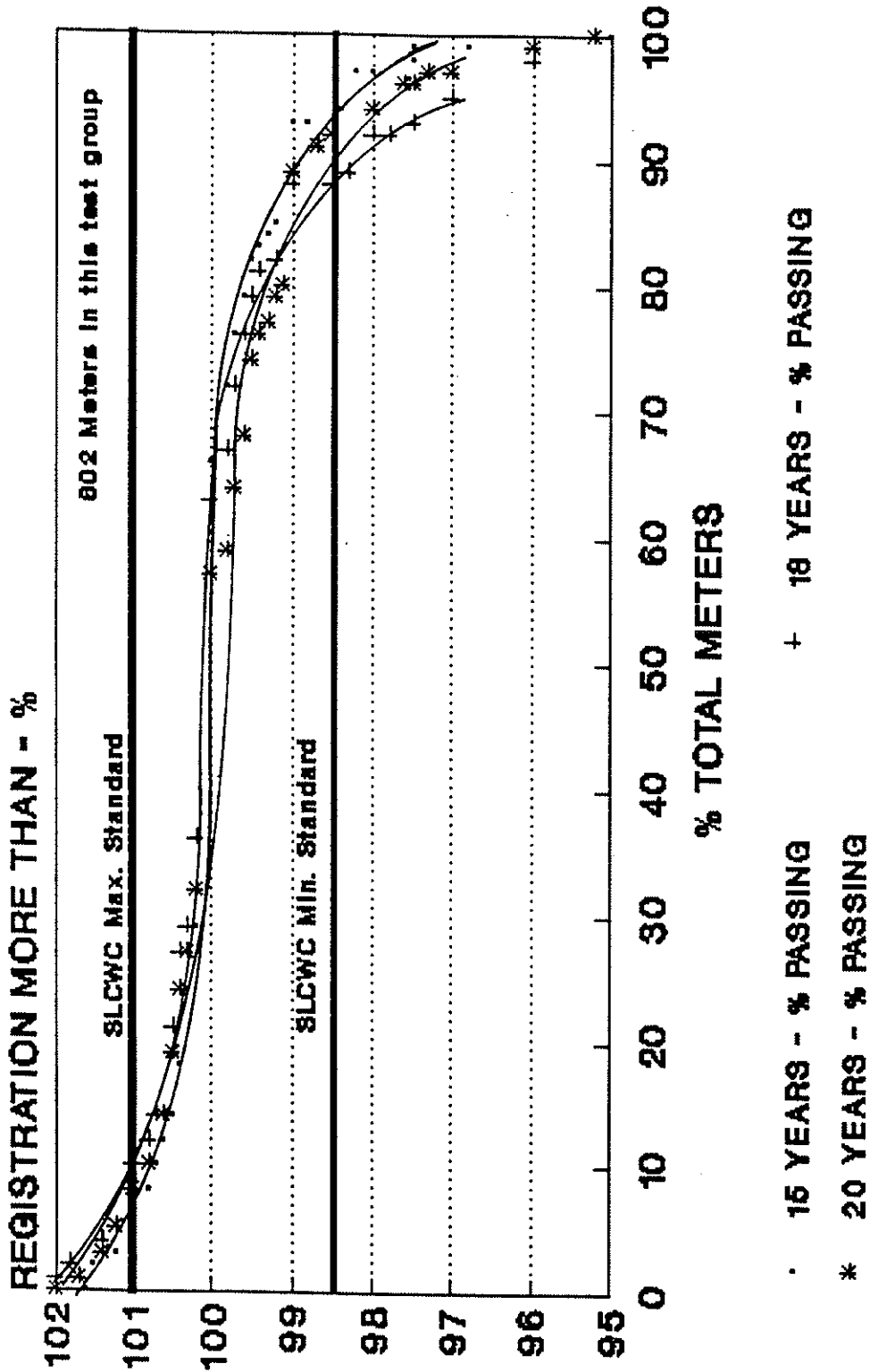
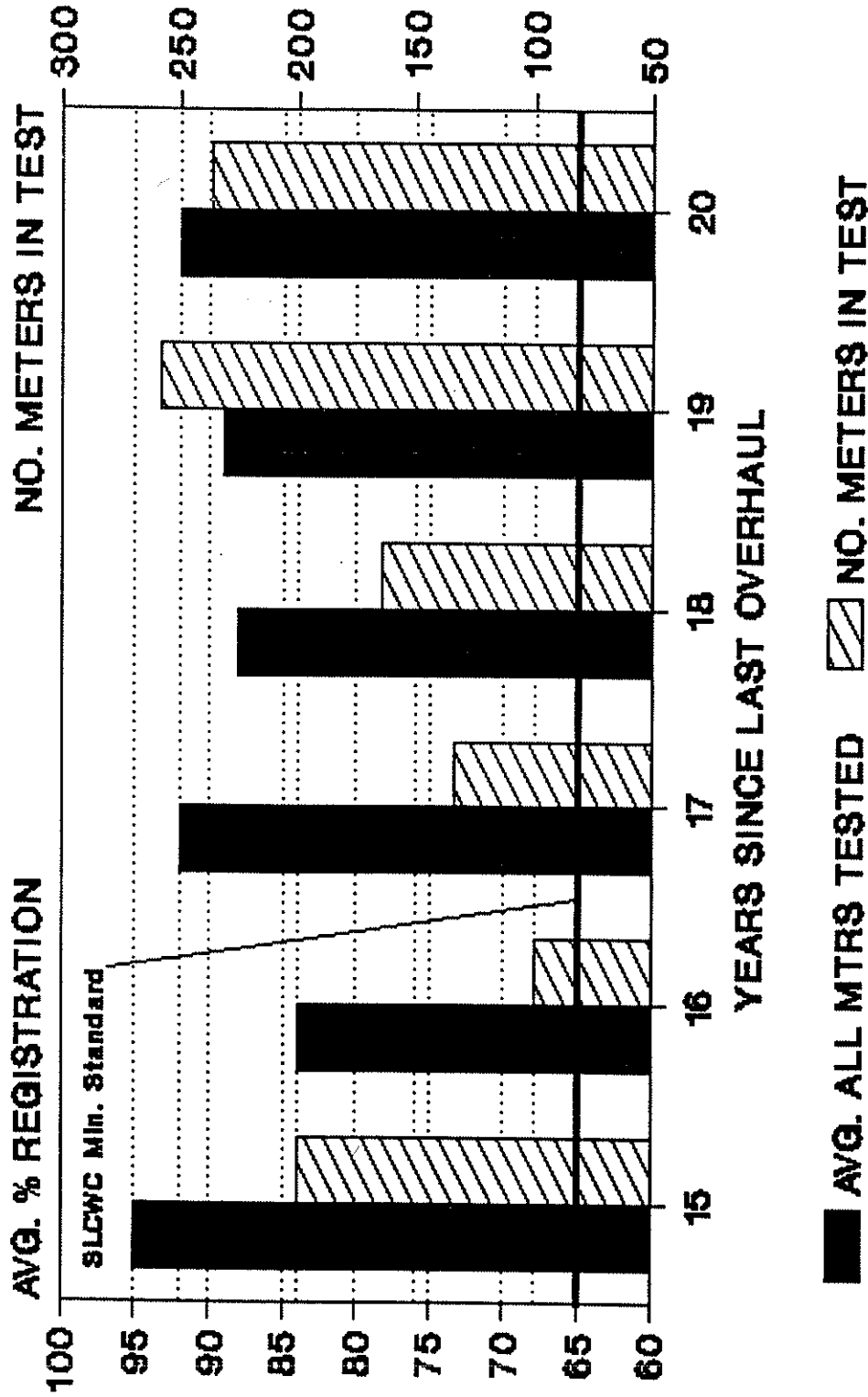


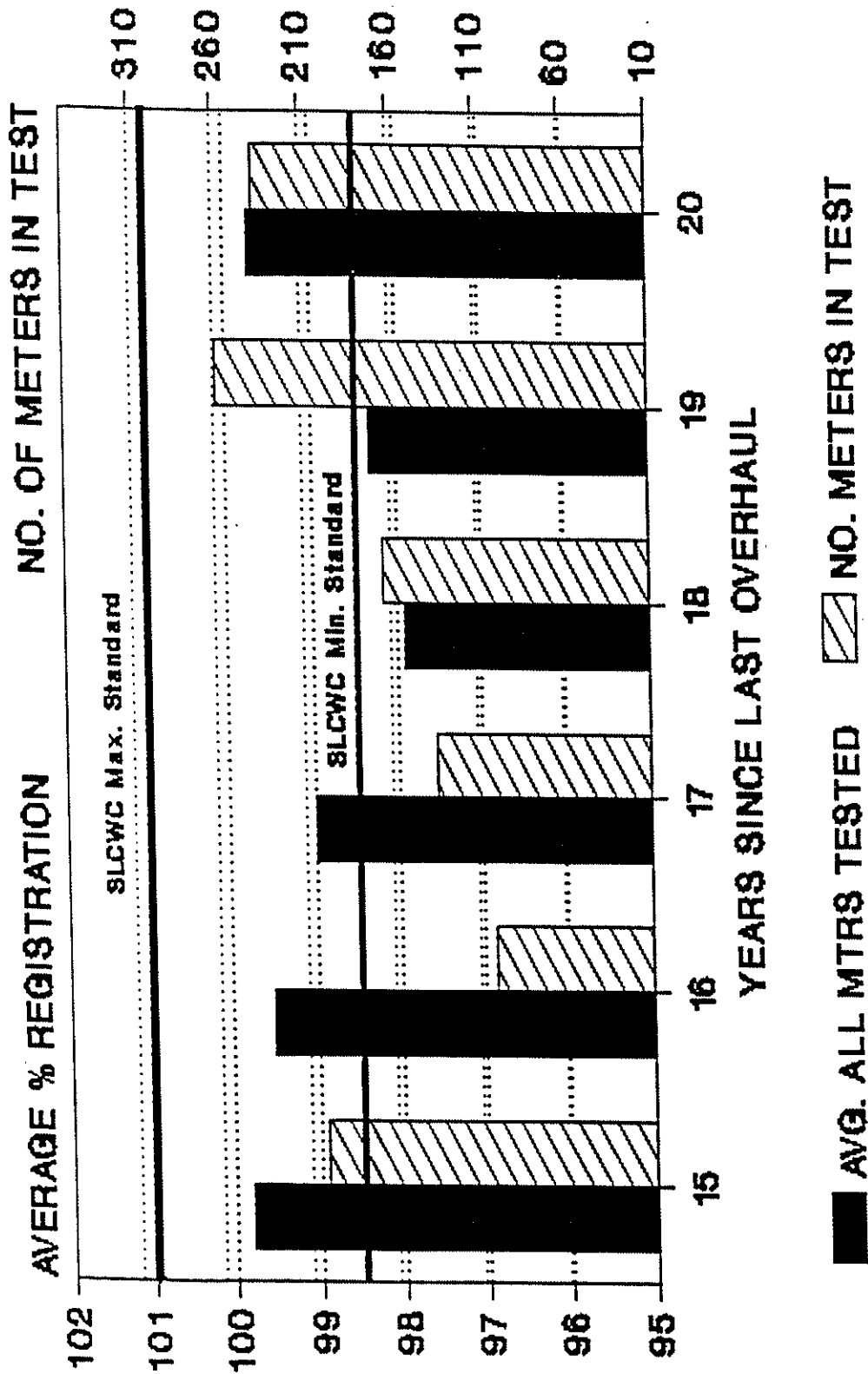
CHART 2 - NOVEMBER 1990

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



**ACCEPTABLE RANGE: ABOVE 65%**  
**CHART 3 - NOVEMBER 1990**

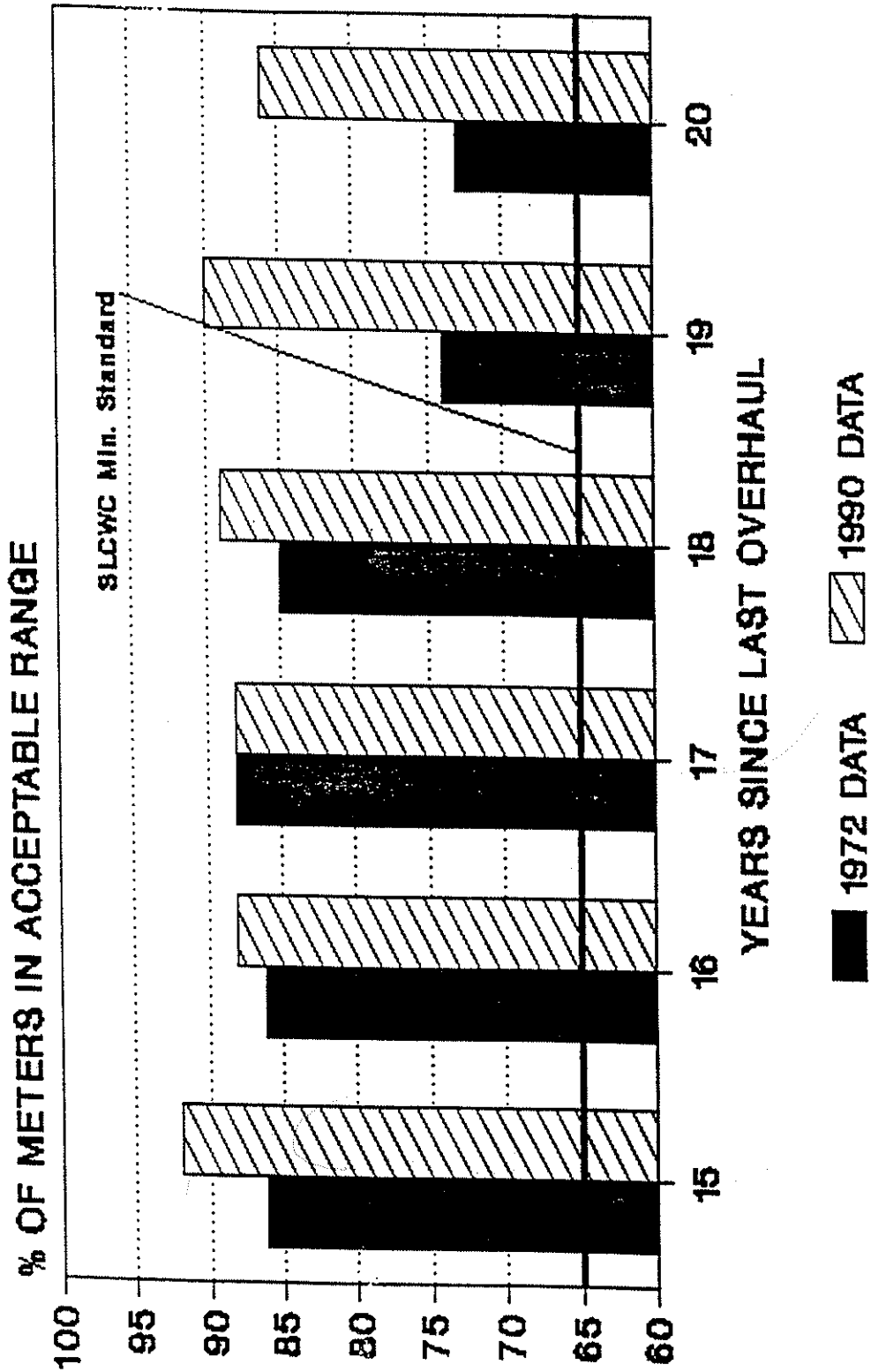
**OVERALL ACCURACY BY YEAR**  
**AVERAGE % ACCURACY FOR GROUP 2 G.P.M.**



ACCEPTABLE RANGE: 98.5% - 101%

CHART 4 - NOVEMBER 1990

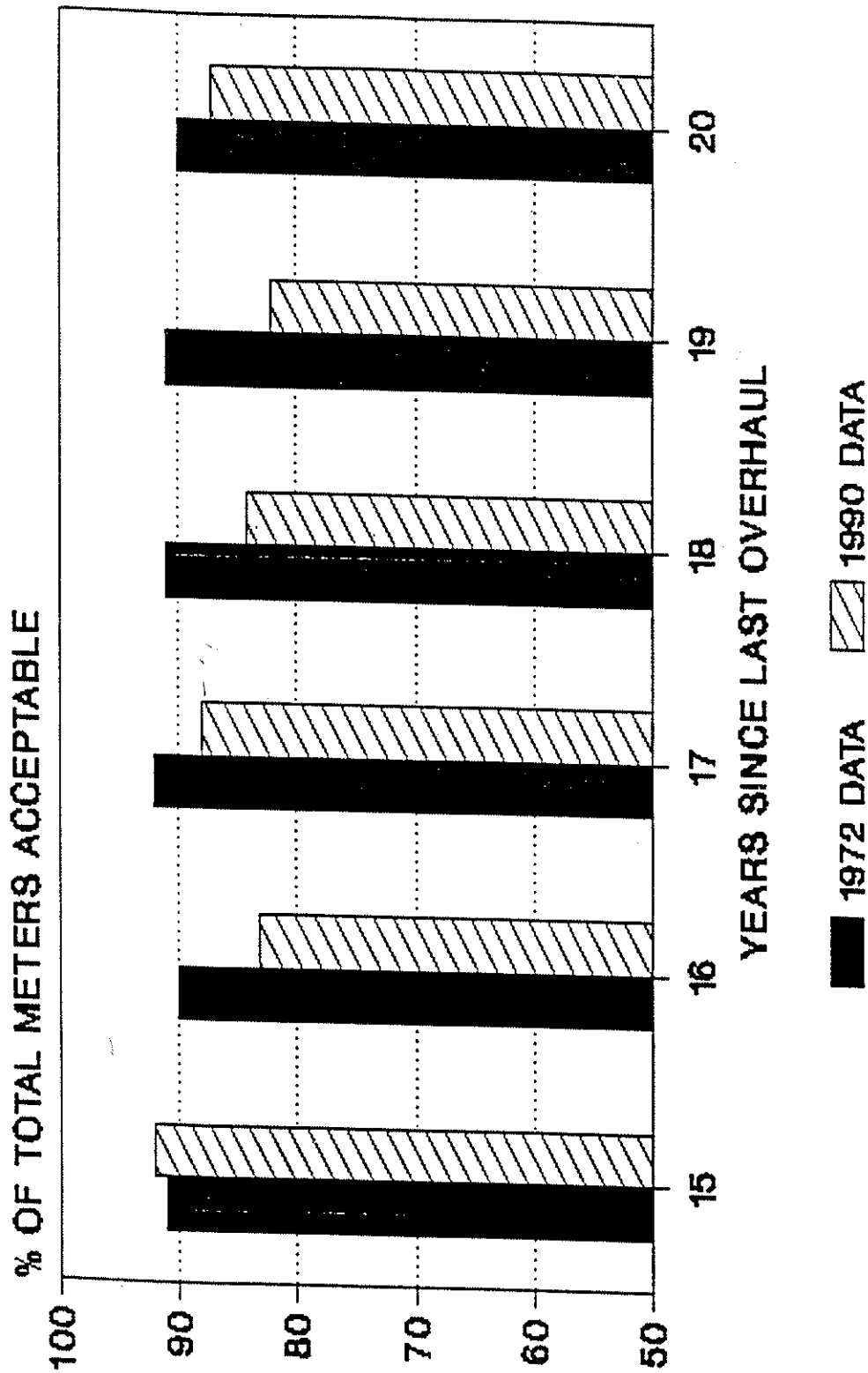
# METER COMPARISON 1972 VERSUS 1990 1/8 G.P.M. TEST



ACCEPTABLE RANGE: ABOVE 65%

CHART 5 - NOVEMBER 1990

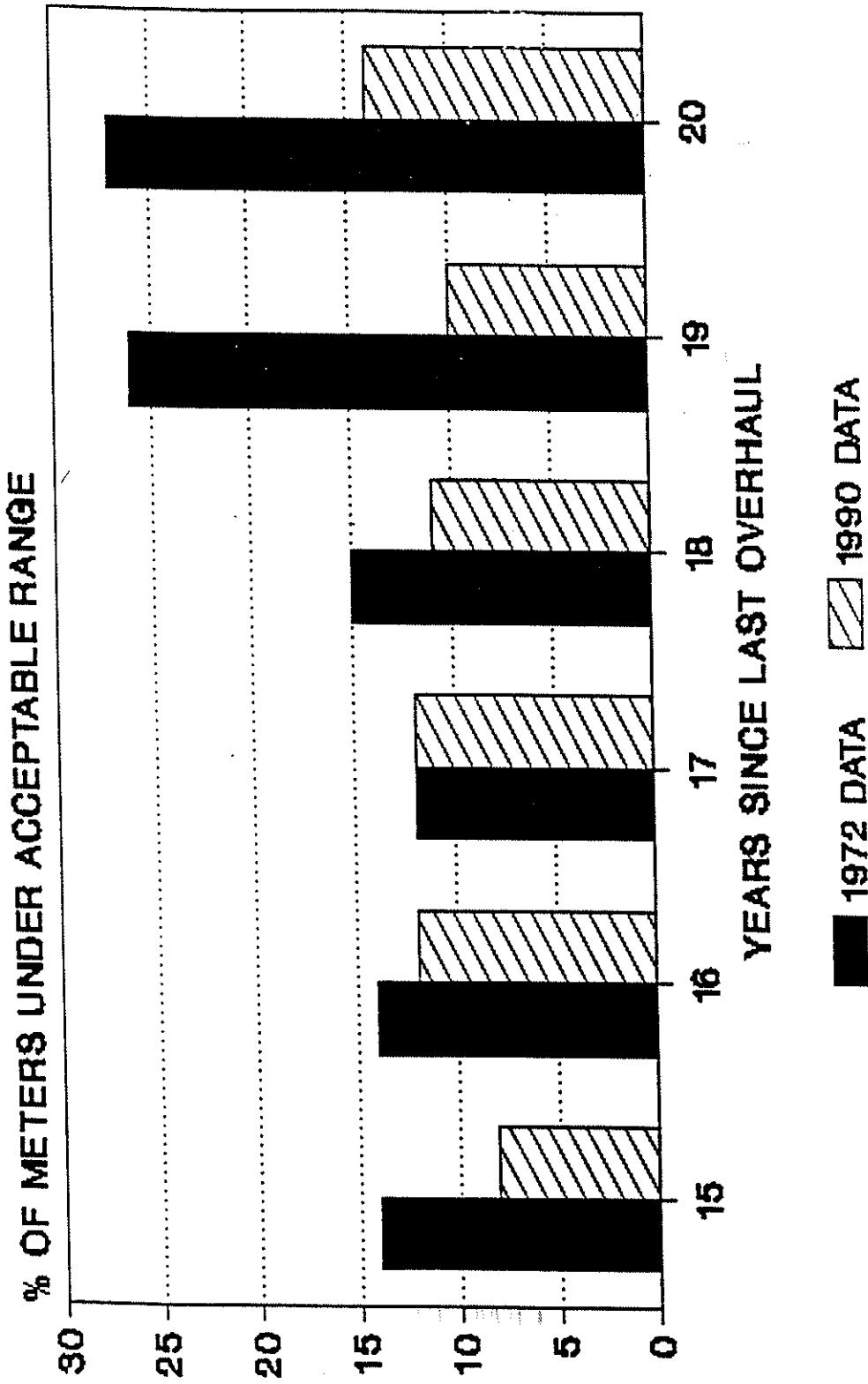
# METER COMPARISON 1972 VERSUS 1990 2 G.P.M. TEST



ACCEPTABLE RANGE: 98.5% - 101%

CHART 6 - NOVEMBER 1990

# METER COMPARISON 1972 VERSUS 1990 1/8 G.P.M. TEST

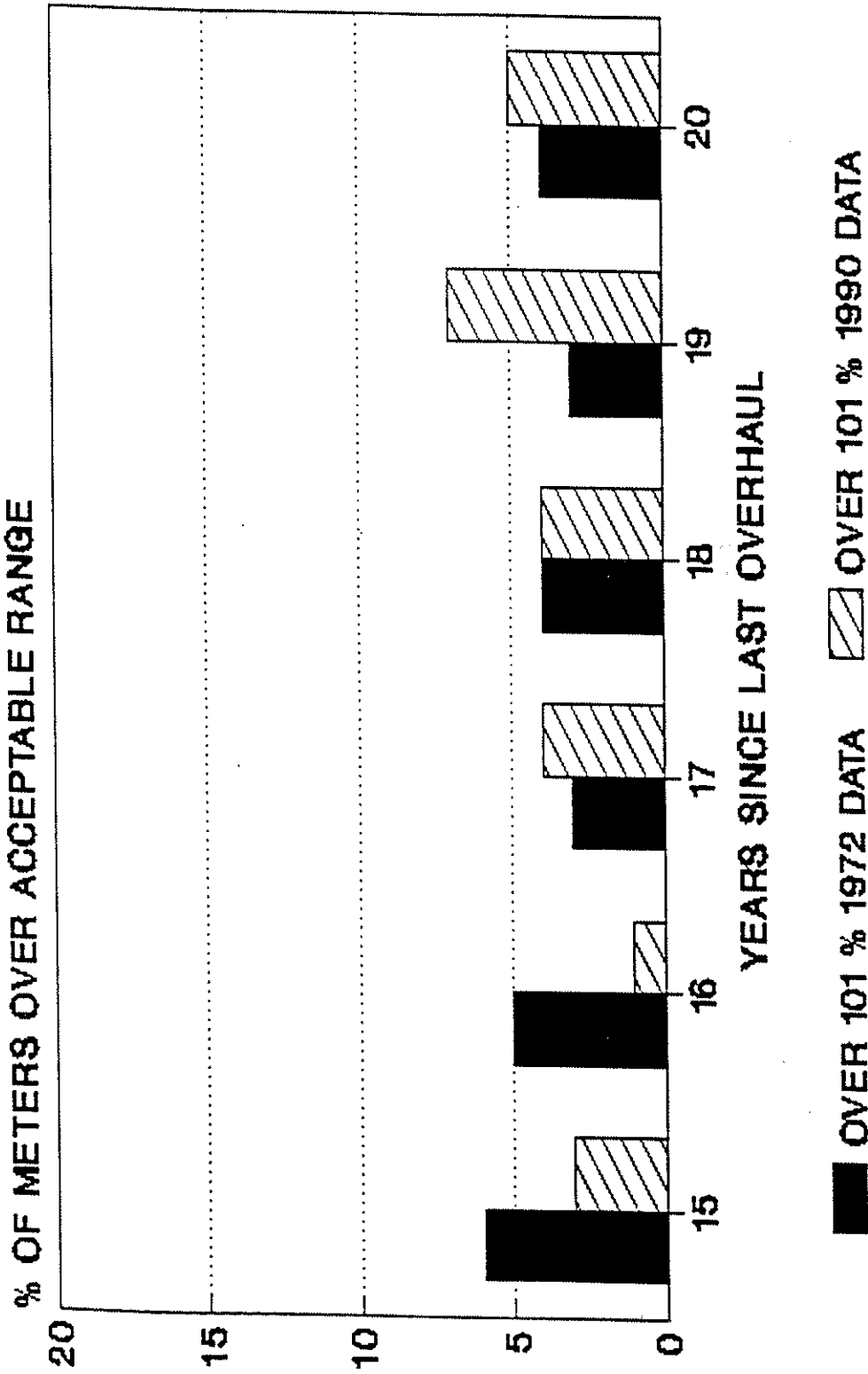


ACCEPTABLE RANGE: ABOVE 65%

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

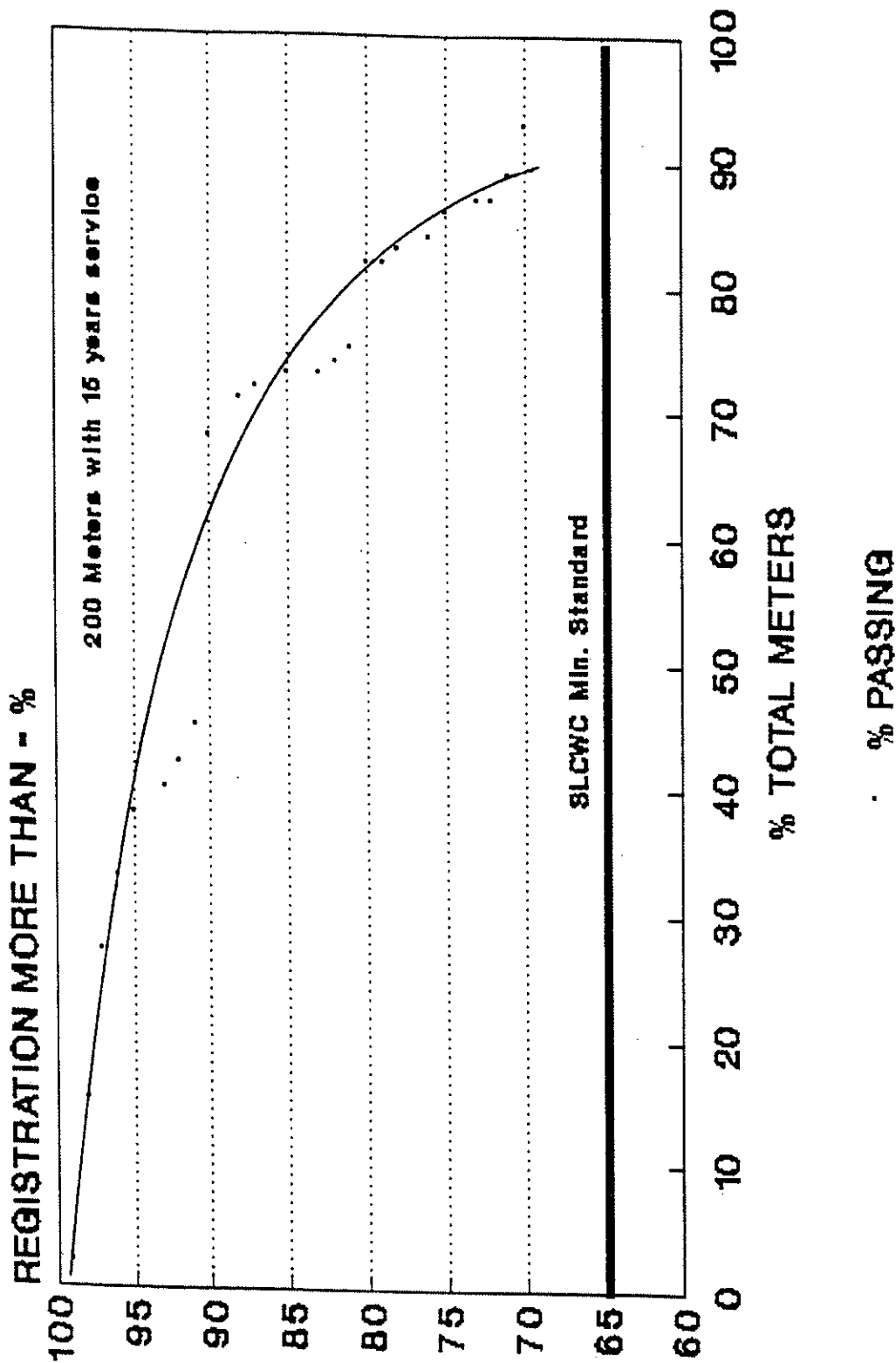


CHART 10 - NOVEMBER 1990

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

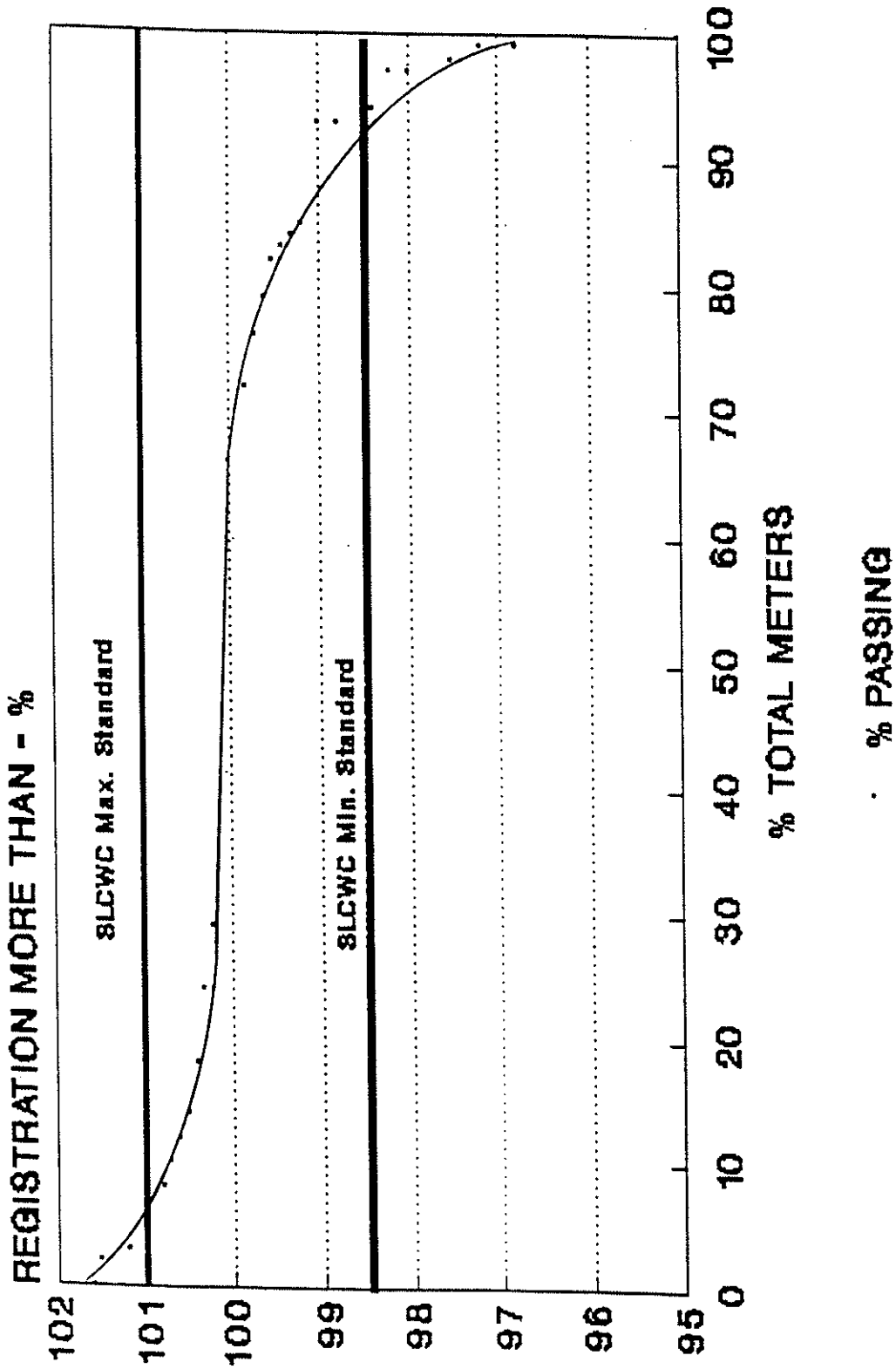


CHART 11 - NOVEMBER 1990

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

# 16 YEARS METER STUDY GROUP

## 1/8 G.P.M. TEST

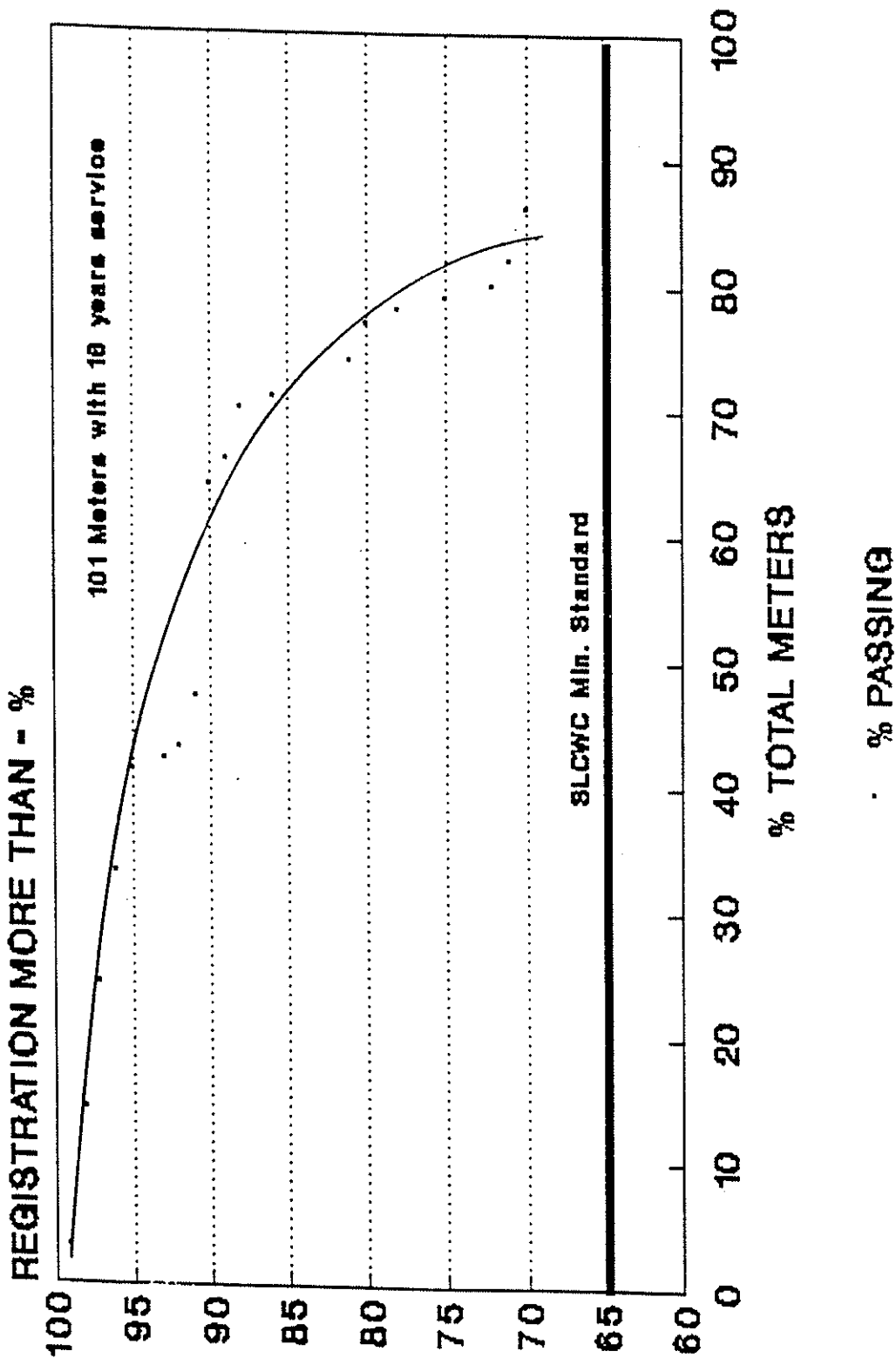


CHART 12 - NOVEMBER 1990

# 16 YEARS METER STUDY GROUP

## 2 G.P.M. TEST

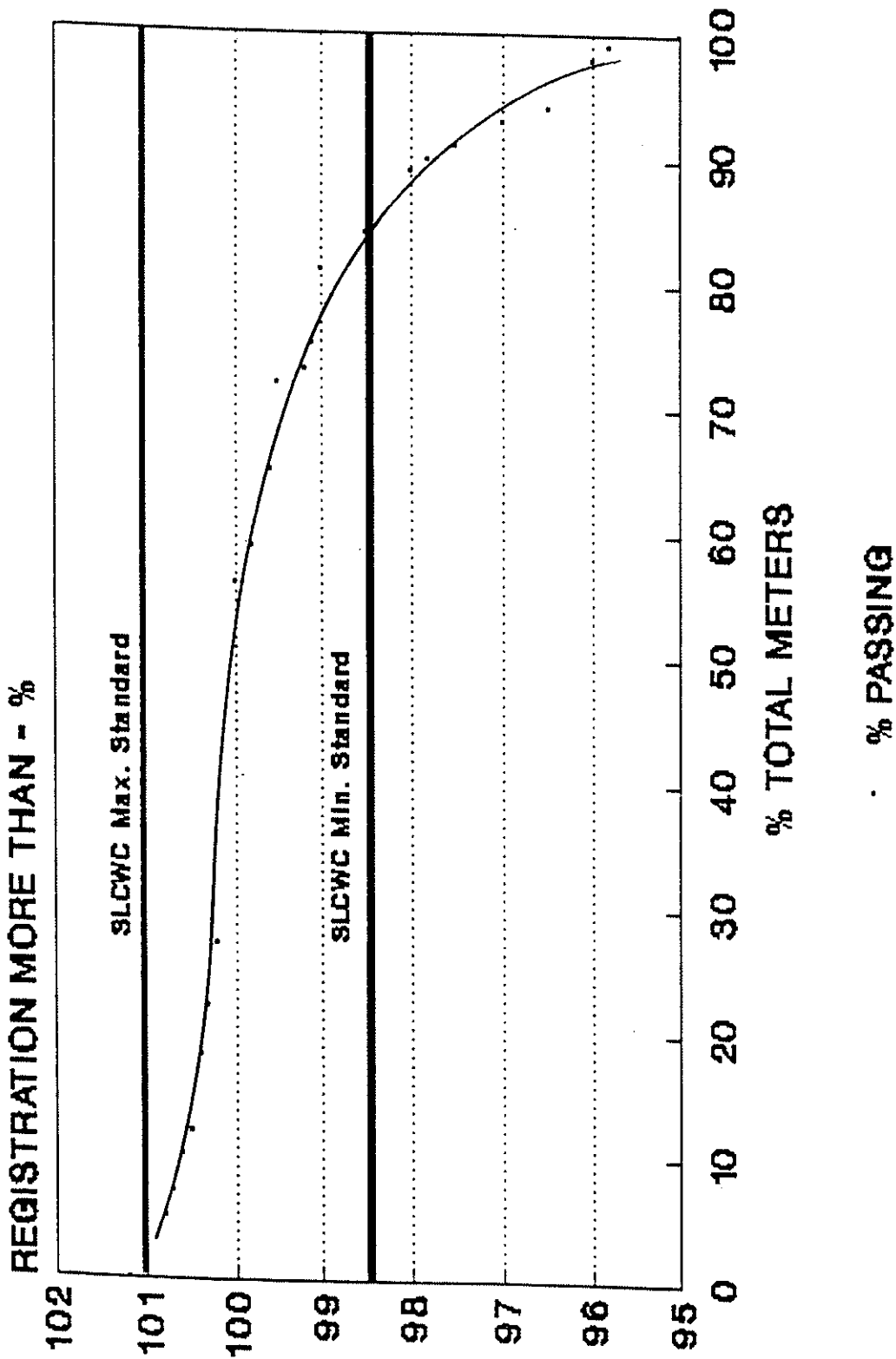


CHART 13 - NOVEMBER 1990

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<br>Meters | Cumulative<br>No. Meters | Summation<br>of Total<br>Tested - % | % Reg.<br>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

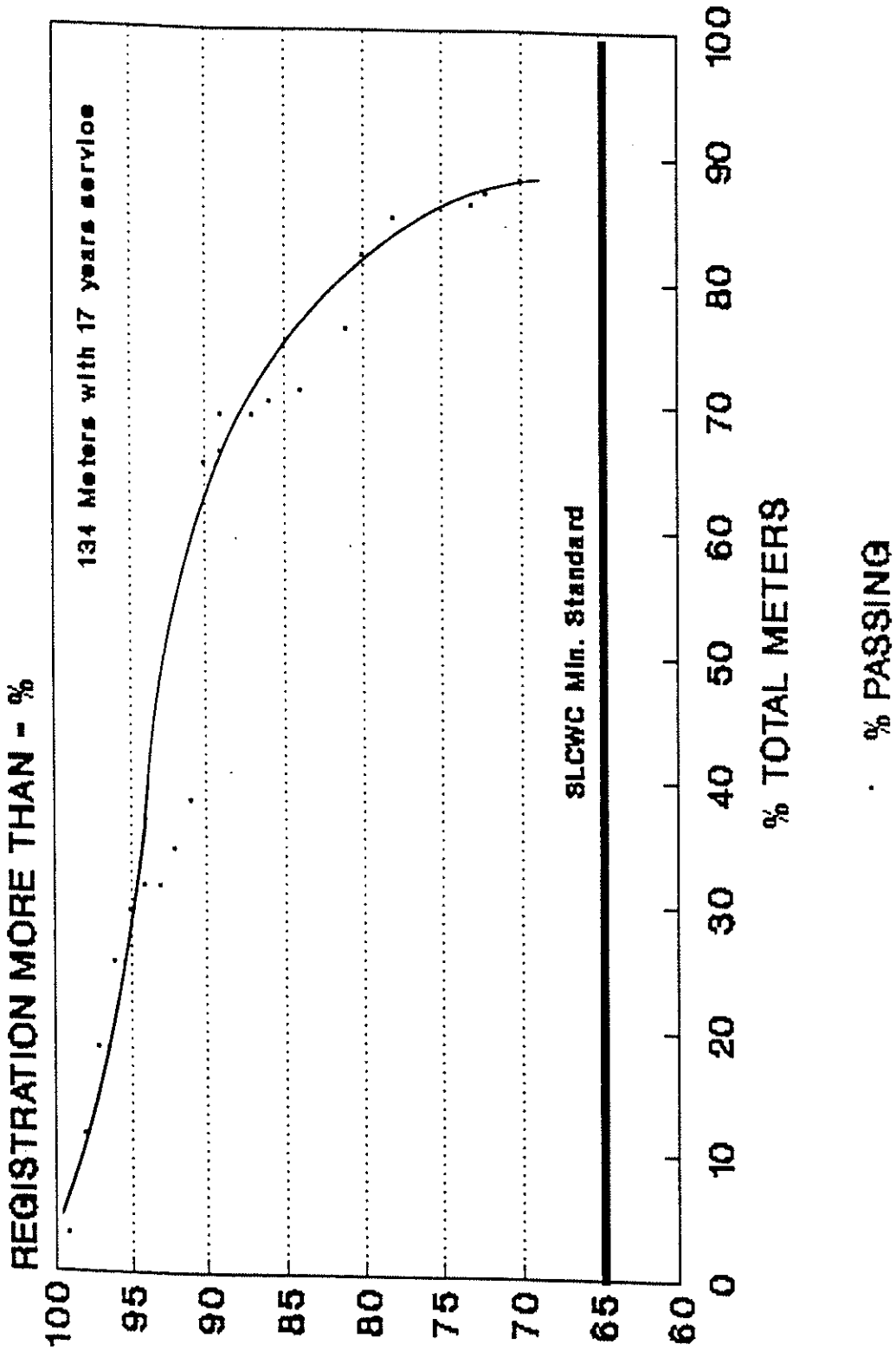


CHART 14 - NOVEMBER 1990

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

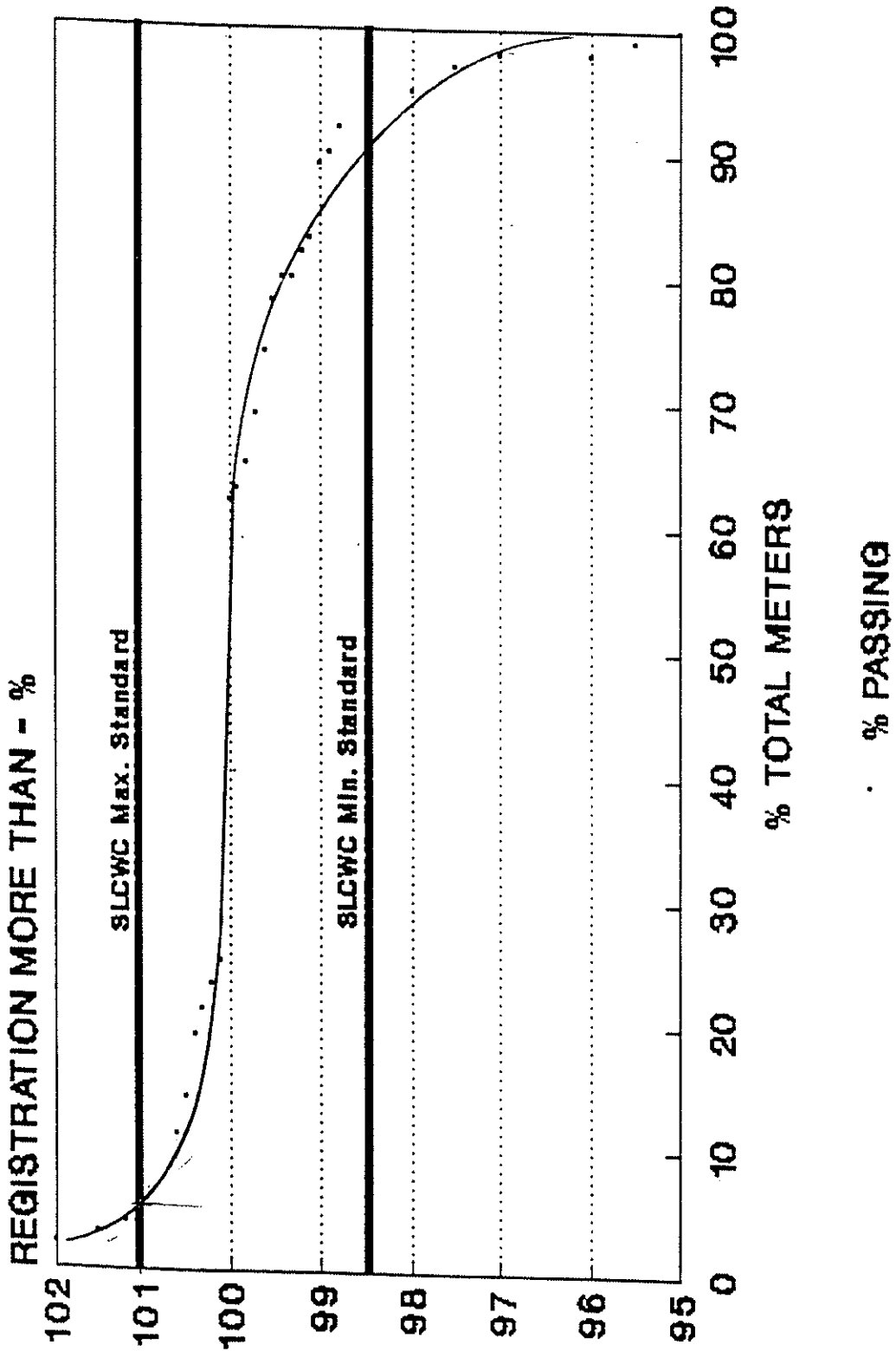


CHART 15 - NOVEMBER 1990

17 YEAR STUDY GROUP - 1990  
1/8 GPM FLOW

| Number of Meters | Cumulative No. Meters | Summation of Total Tested - % | % 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 65%. Average registration for this group was 44.5%

17 YEAR STUDY GROUP - 1990  
2 GPM FLOW

| Number of<br>Meters | Cumulative<br>No. Meters | Summation<br>of Total<br>Tested - % | % Reg.<br>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

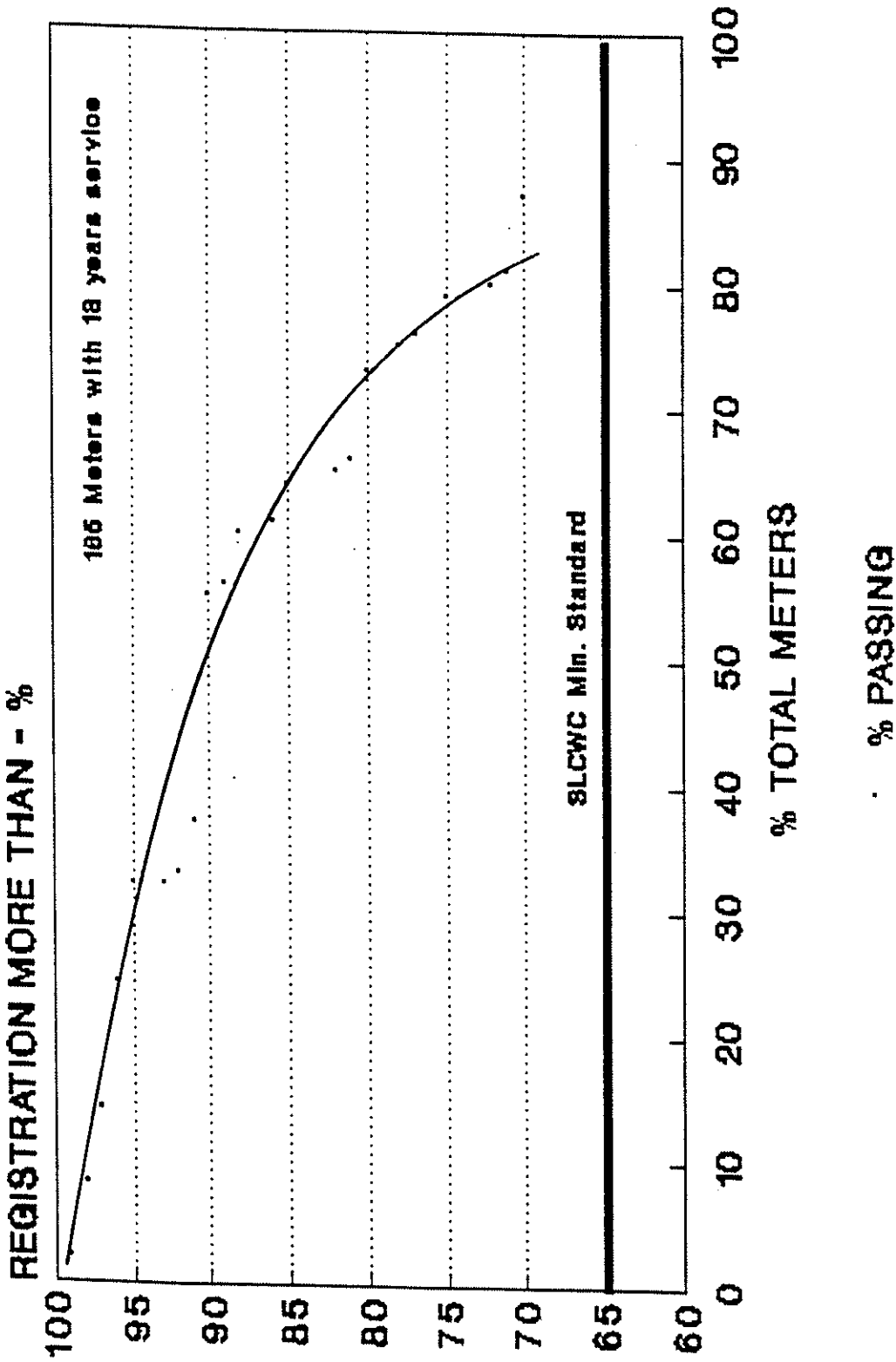


CHART 16 - NOVEMBER 1990

# 18 YEARS METER STUDY GROUP

## 2 G.P.M. TEST

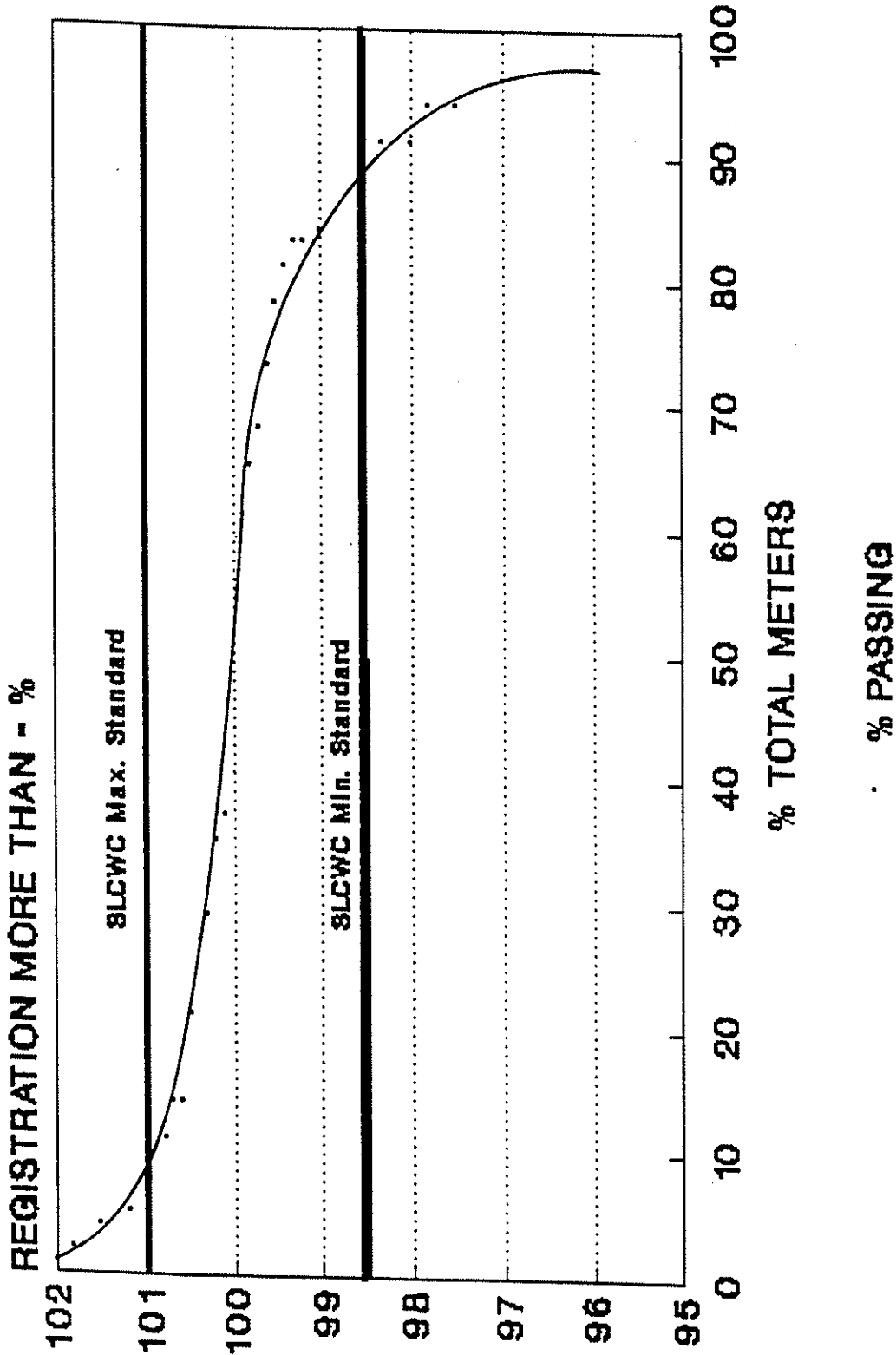


CHART 17 - NOVEMBER 1990

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                            | 75               |
| 3                | 124                   | 75                            | 77               |
| 12               | 121                   | 73                            | 78               |
| 2                | 109                   | 66                            | 80               |
| 2                | 107                   | 65                            | 81               |
| 5                | 105                   | 65                            | 82               |
| 1                | 100                   | 64                            | 85               |
| 6                | 99                    | 61                            | 86               |
| 2                | 93                    | 60                            | 88               |
| 30               | 91                    | 56                            | 89               |
| 7                | 61                    | 55                            | 90               |
| 1                | 54                    | 37                            | 91               |
| 1                | 53                    | 33                            | 92               |
| 13               | 52                    | 32                            | 93               |
| 16               | 39                    | 32                            | 95               |
| 10               | 23                    | 24                            | 96               |
| 10               | 13                    | 14                            | 97               |
| 3                | 3                     | 8                             | 98               |
|                  |                       | 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

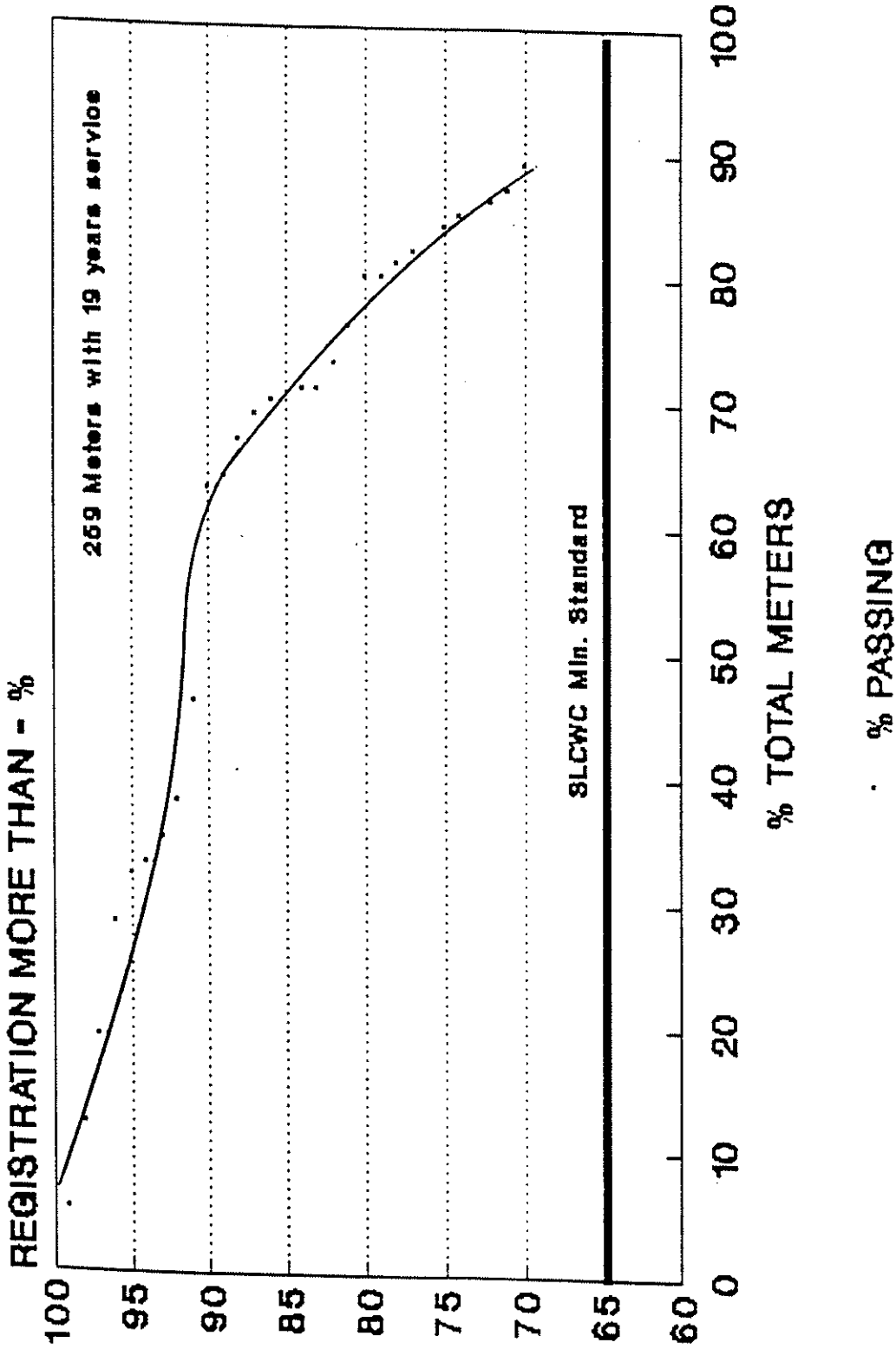


CHART 18 - NOVEMBER 1990

# 19 YEARS METER STUDY GROUP

## 2 G.P.M. TEST

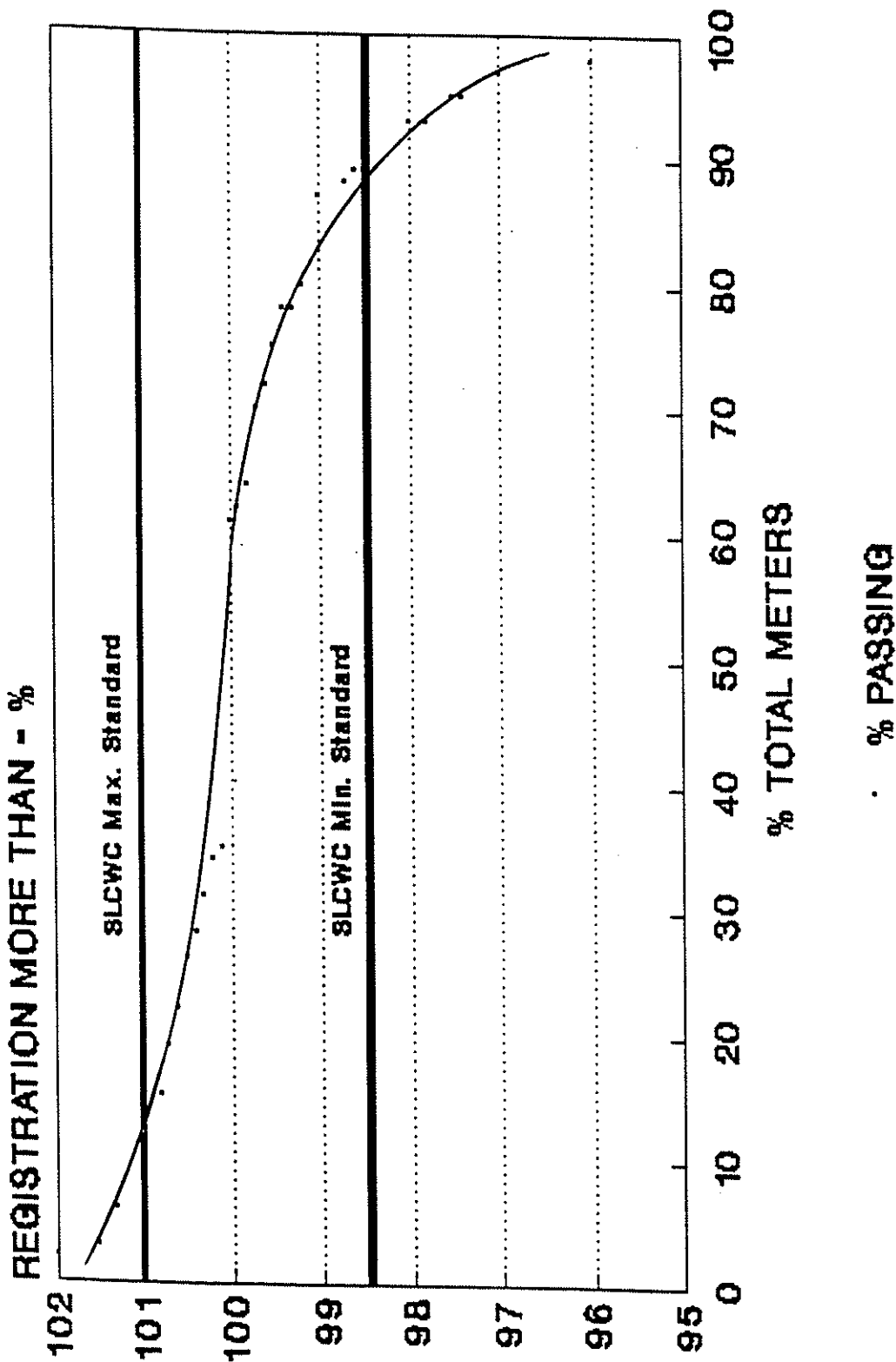


CHART 19 - NOVEMBER 1990

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<br>Meters | Cumulative<br>No. Meters | Summation<br>of Total<br>Tested - % | % Reg.<br>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

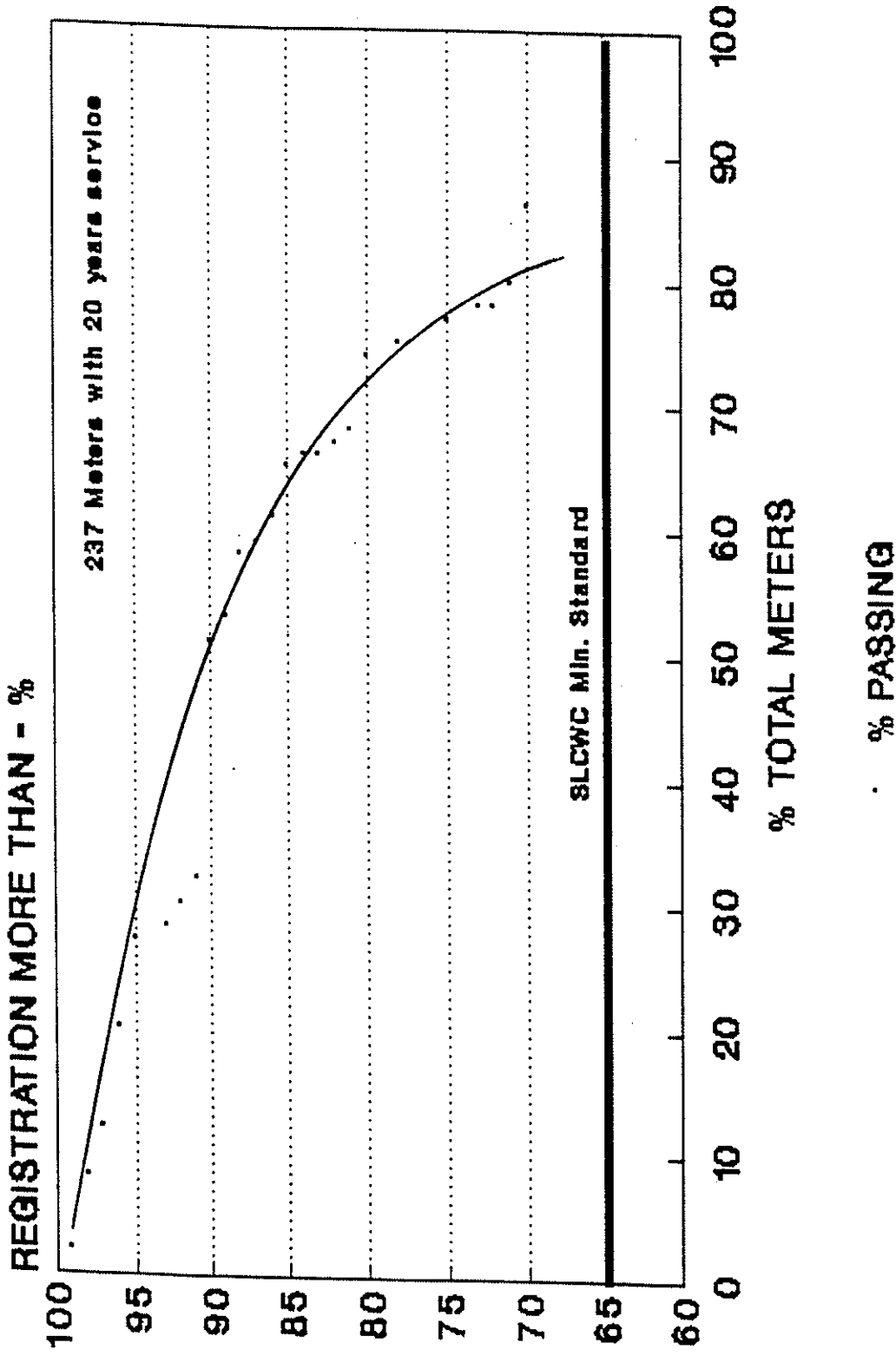


CHART 20 - NOVEMBER 1990

# 20 YEARS METER STUDY GROUP

## 2 G.P.M. TEST

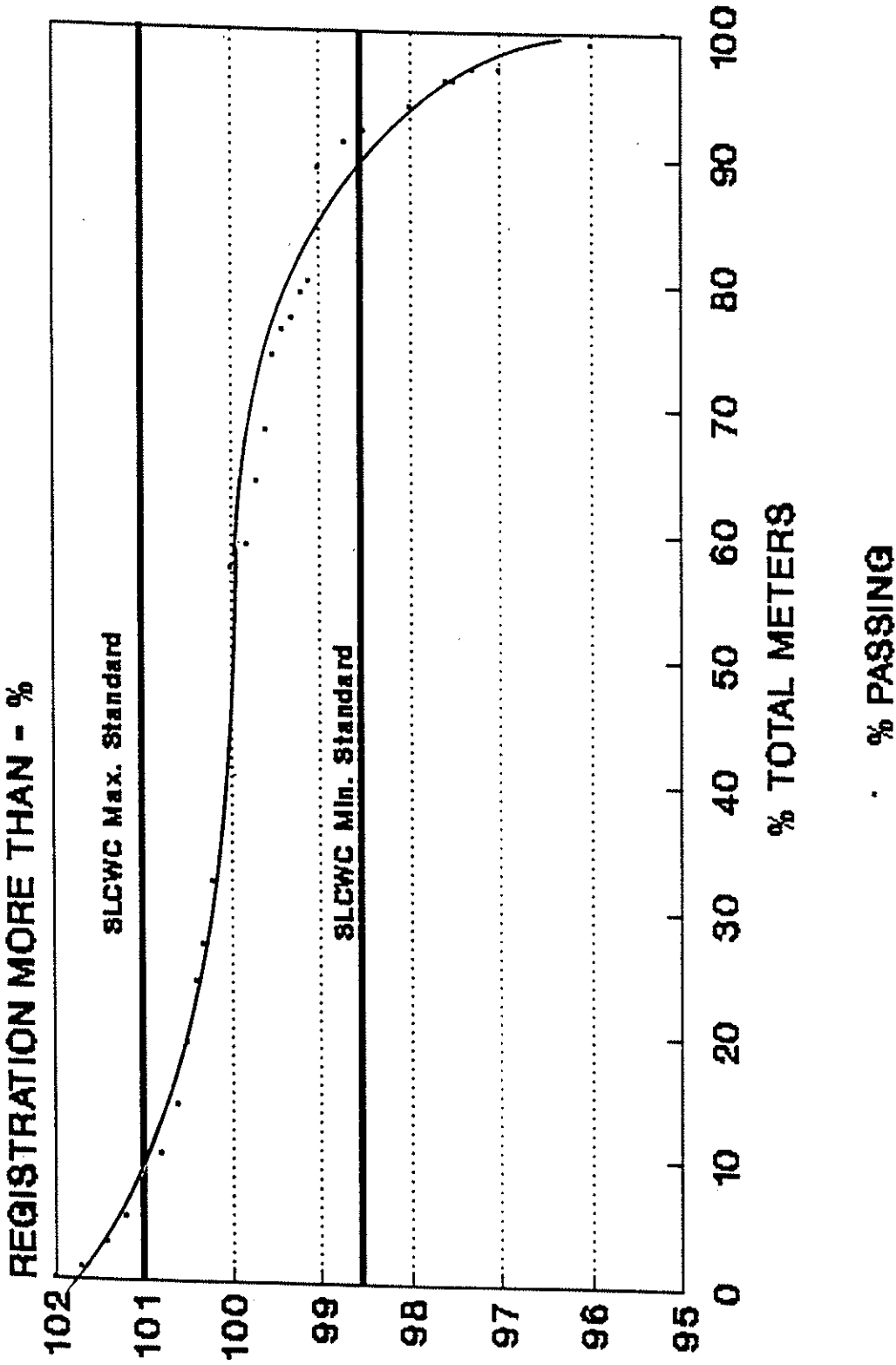


CHART 21 - NOVEMBER 1990

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%

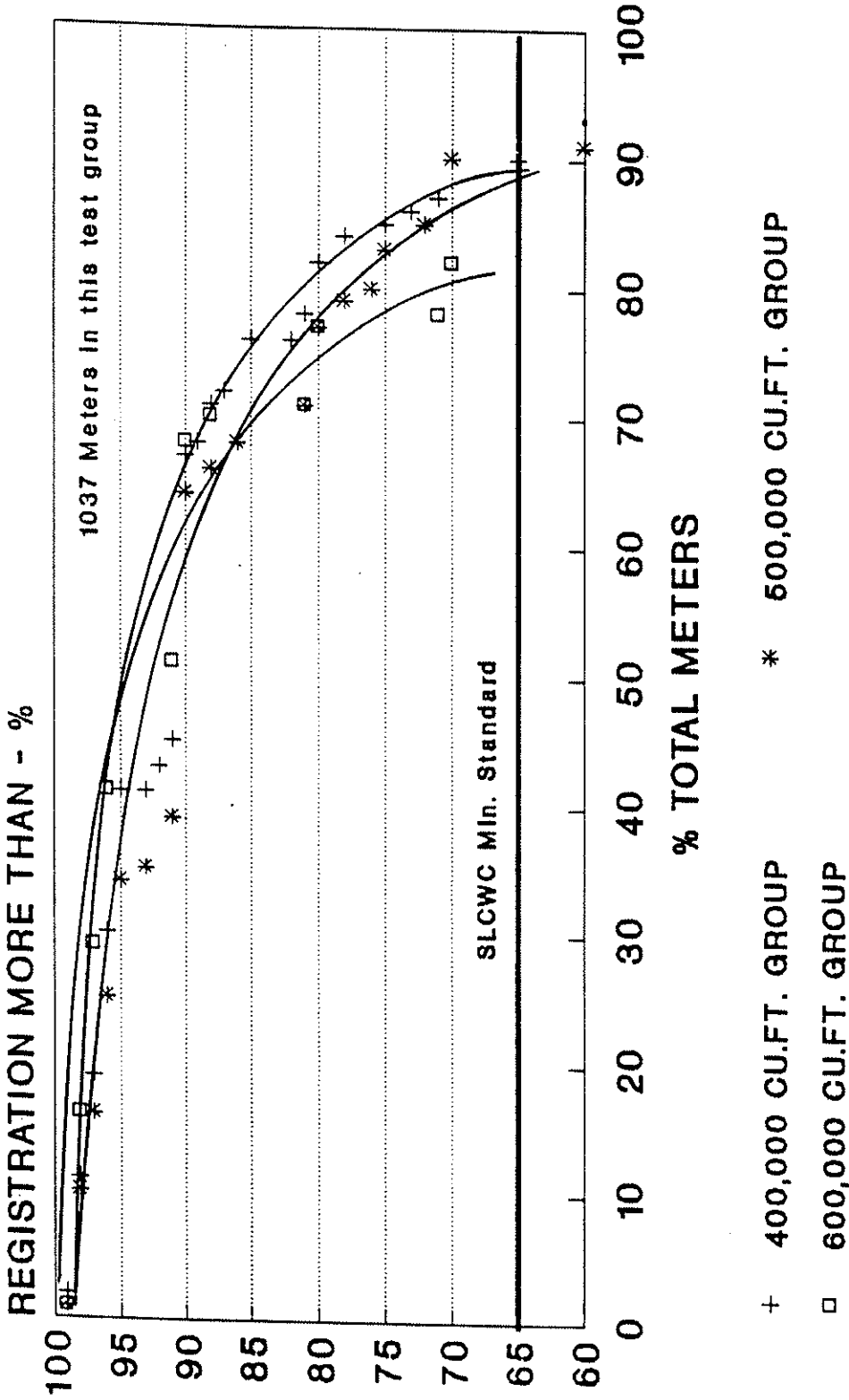


20 YEAR STUDY GROUP - 1990  
2 GPM FLOW

| 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

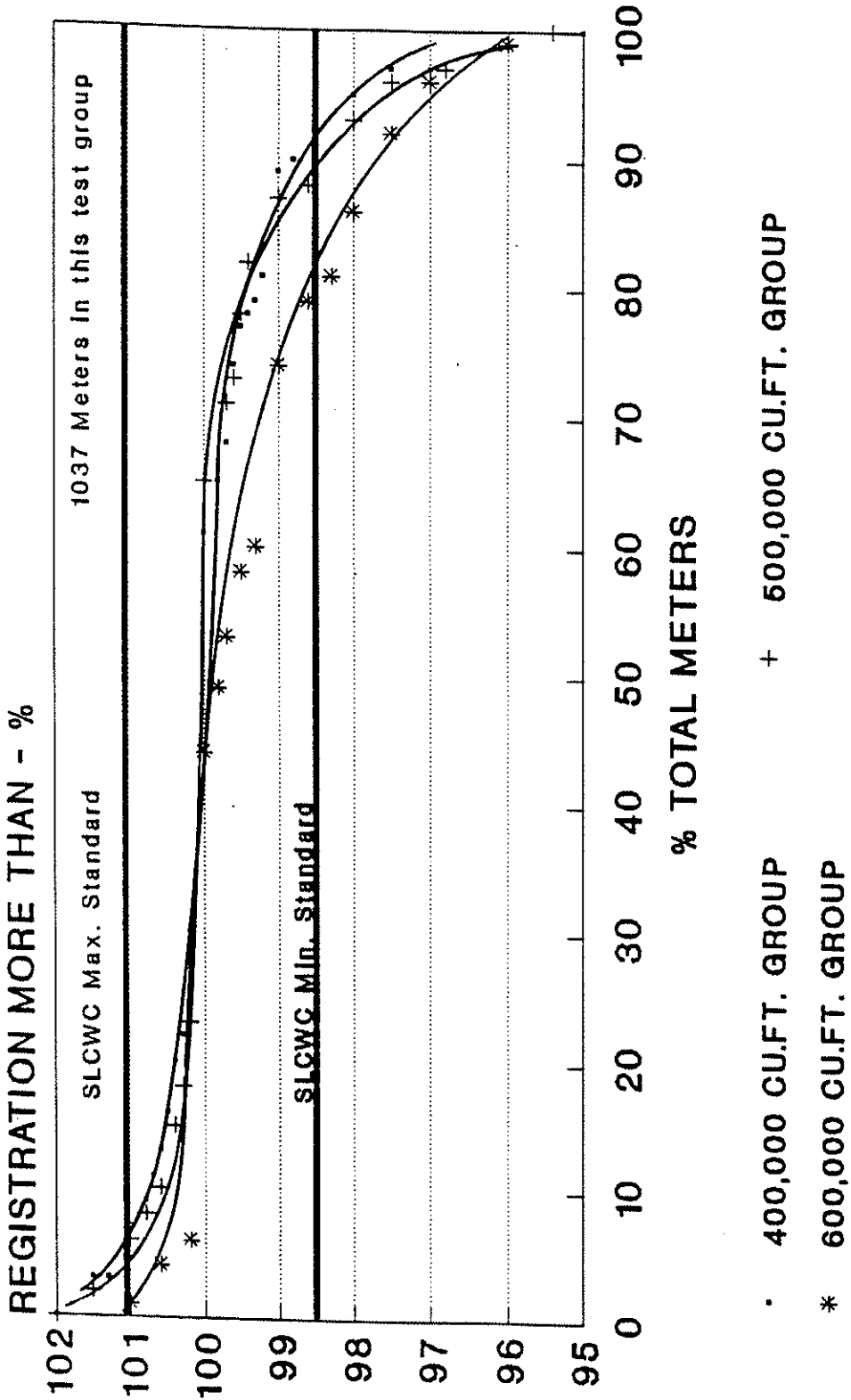


ACCEPTABLE RANGE: OVER 65%

CHART 22 - NOVEMBER 1990

# 400/500/600,000 CU.FT. USAGE STUDY GROUP

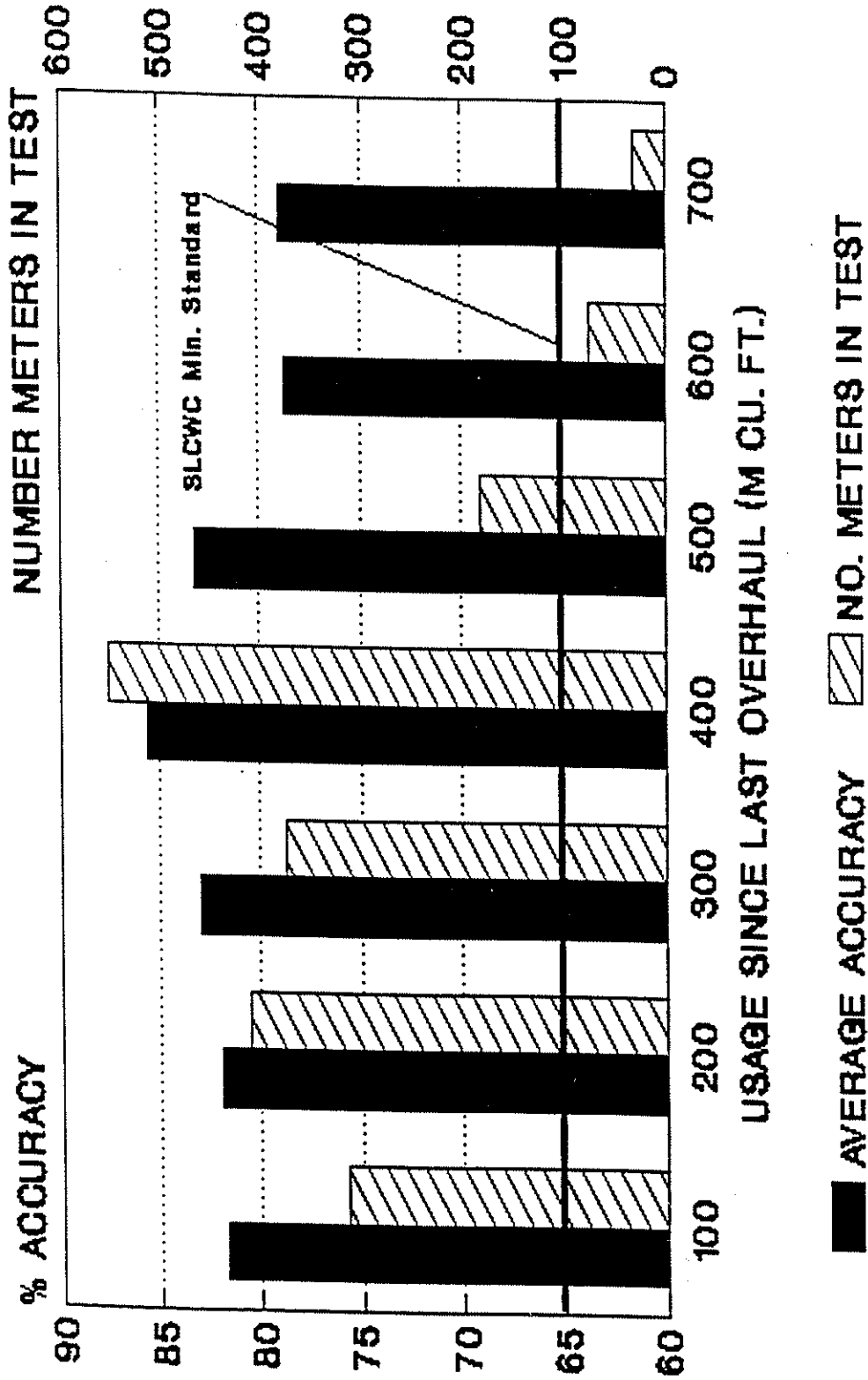
## 2 G.P.M. TEST



ACCEPTABLE RANGE: 98.5% - 101%

CHART 23 - NOVEMBER 1990

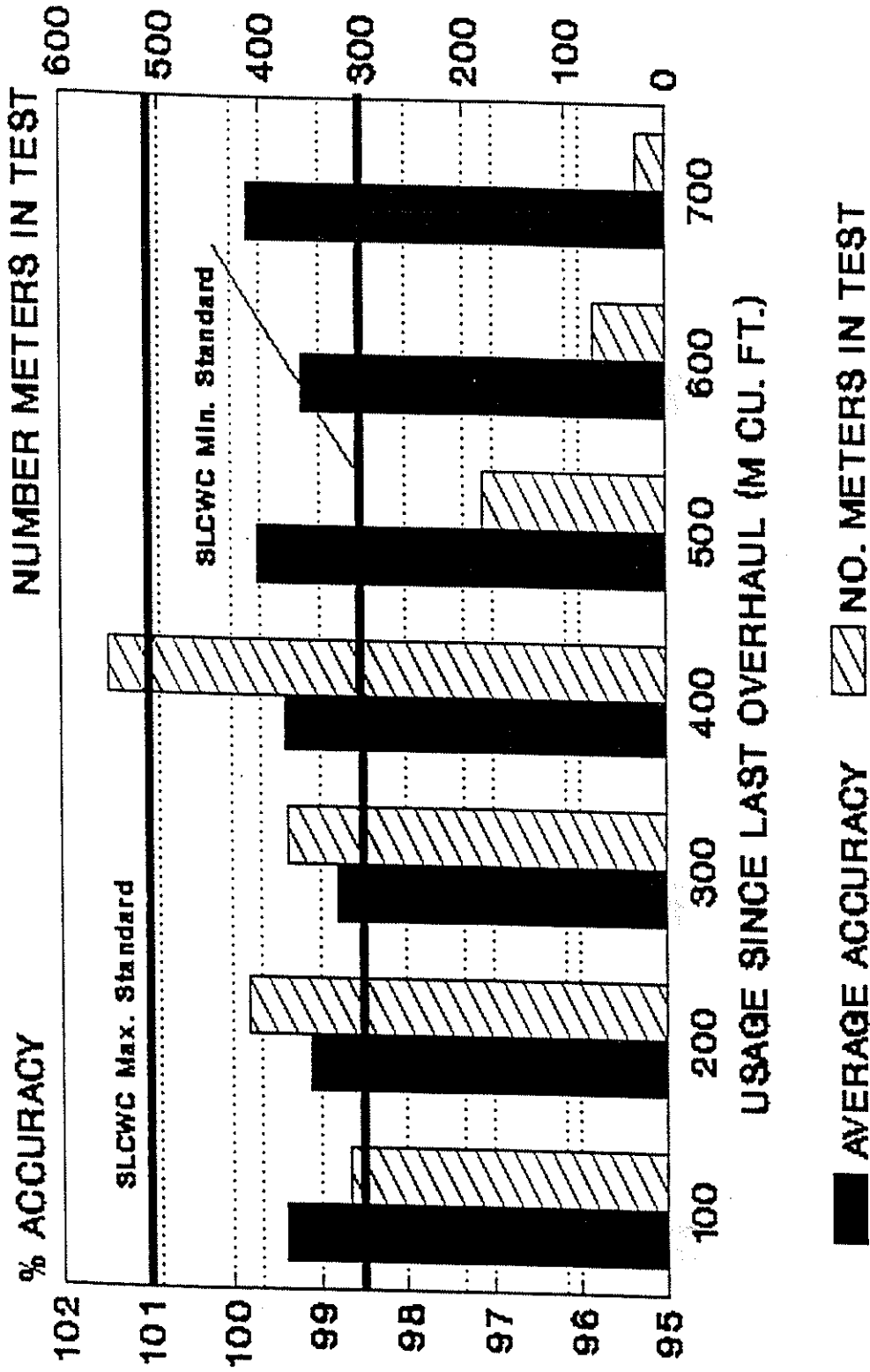
# USAGE COMPARED TO AVG. % ACCURACY 1/8 G.P.M. TEST



ACCEPTABLE RANGE: OVER 65%

CHART 24 - NOVEMBER 1990

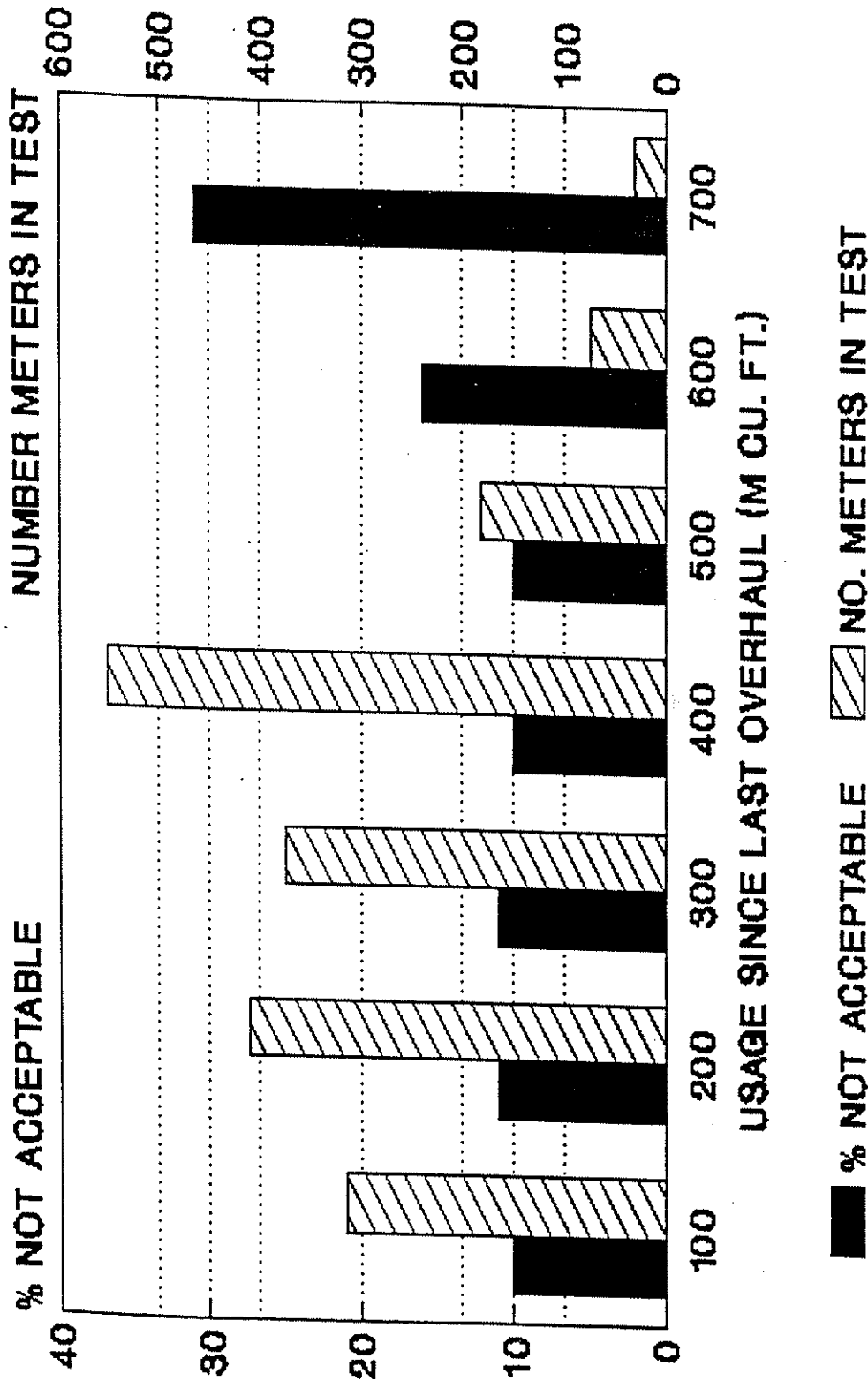
# USAGE COMPARED TO AVG. % ACCURACY 2 G.P.M. TEST



ACCEPTABLE RANGE: 98.5% - 101%

CHART 25 - NOVEMBER 1990

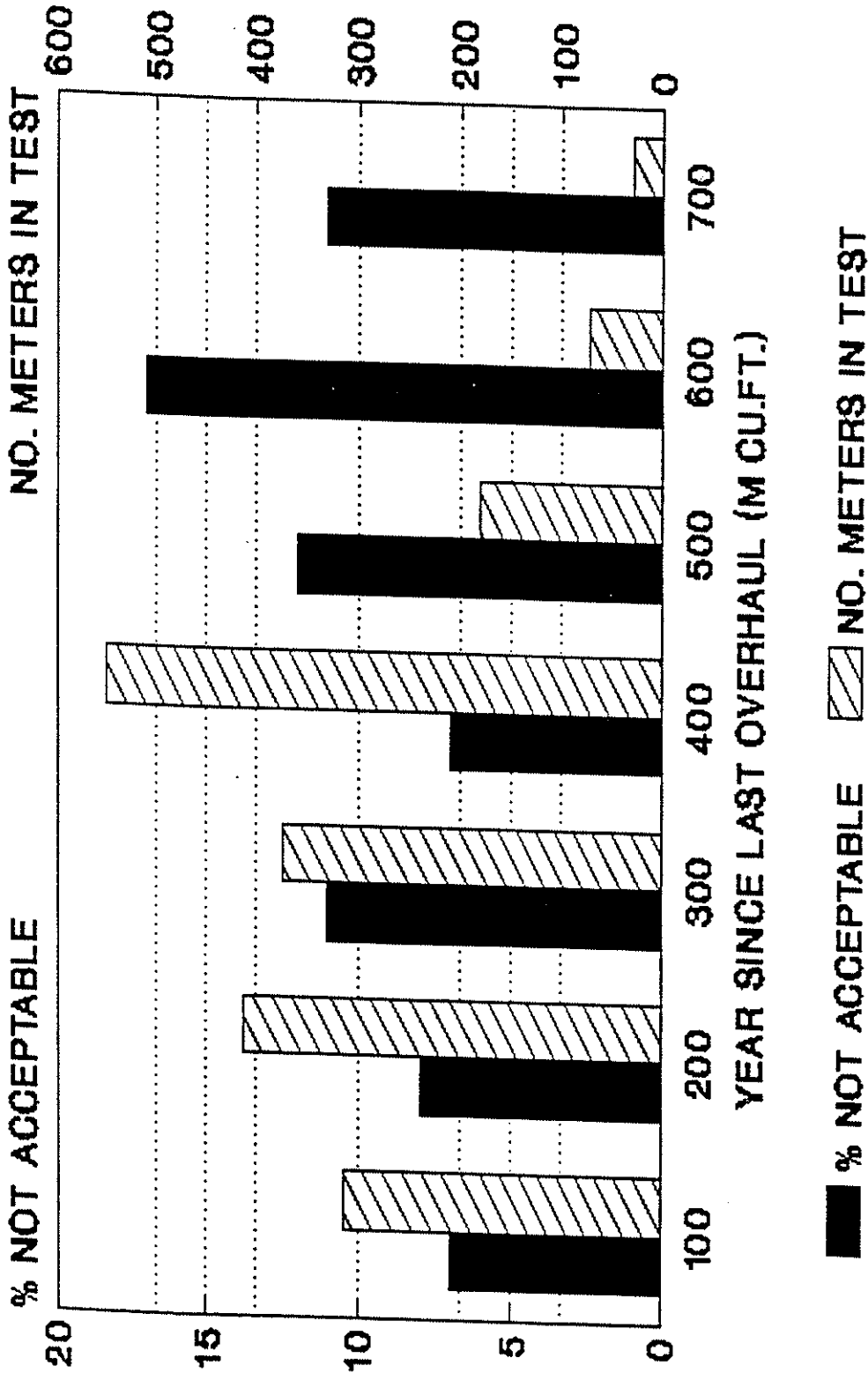
# USAGE COMPARED TO AVG. % ACCURACY 1/8 G.P.M. TEST



METERS UNDER 65%

CHART 26 - NOVEMBER 1990

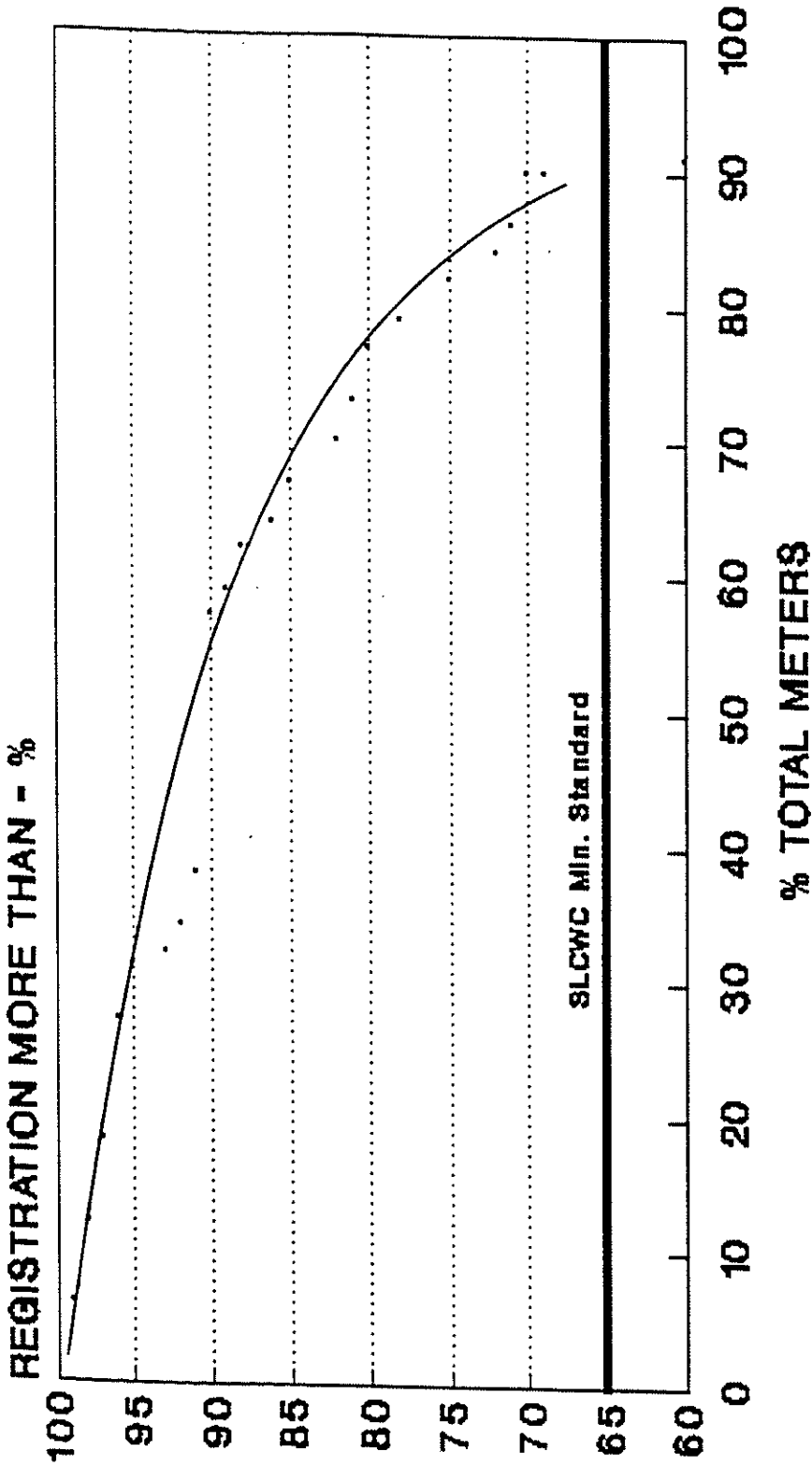
# USAGE COMPARED TO AVERAGE % ACCURACY 2 G.P.M. TEST



ACCEPTABLE RANGE: 98.5% - 101%

CHART 27 - NOVEMBER 1990

**100,000 CU. FT. USAGE STUDY GROUP  
1/8 G.P.M. TEST**



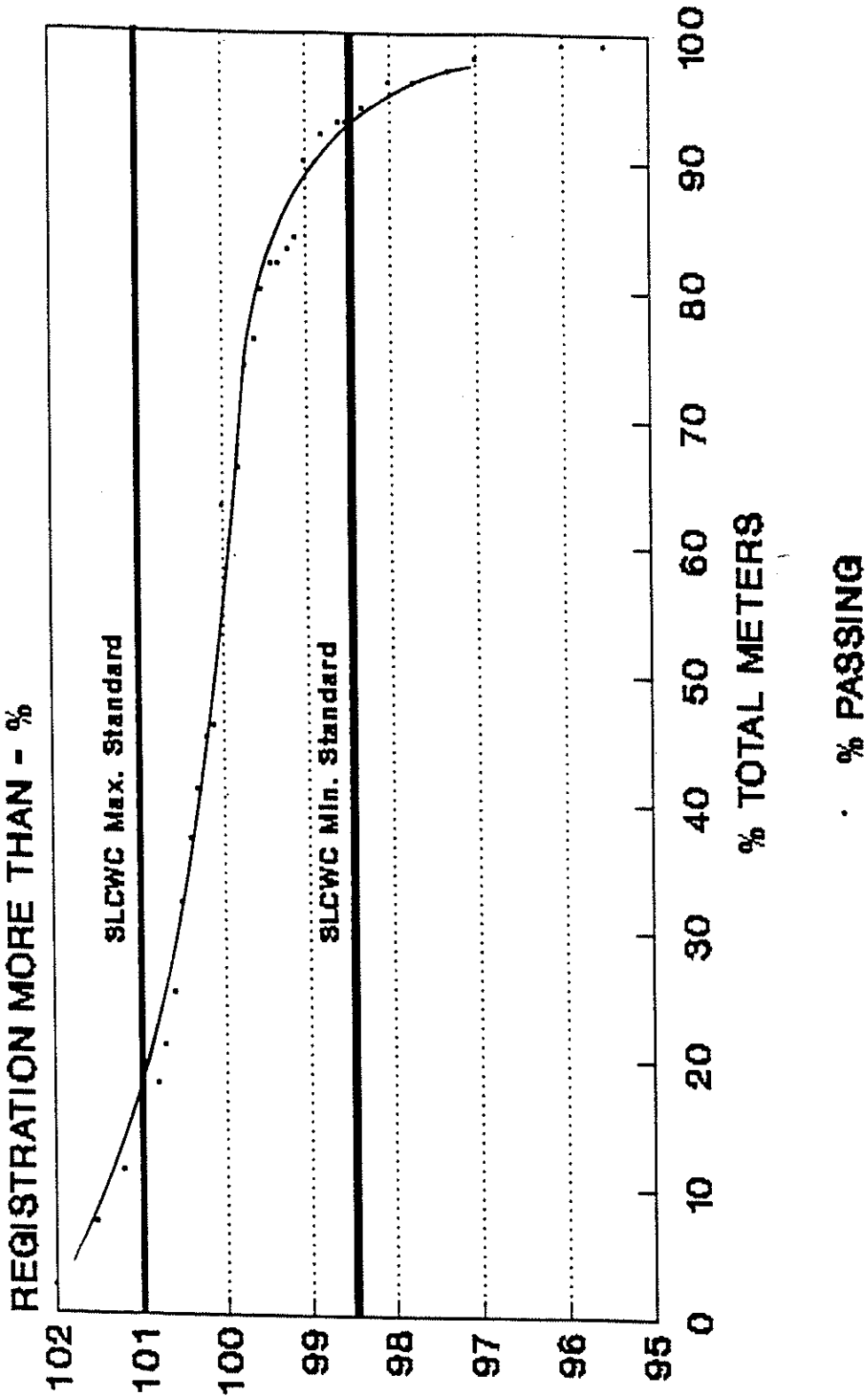
· % PASSING

**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

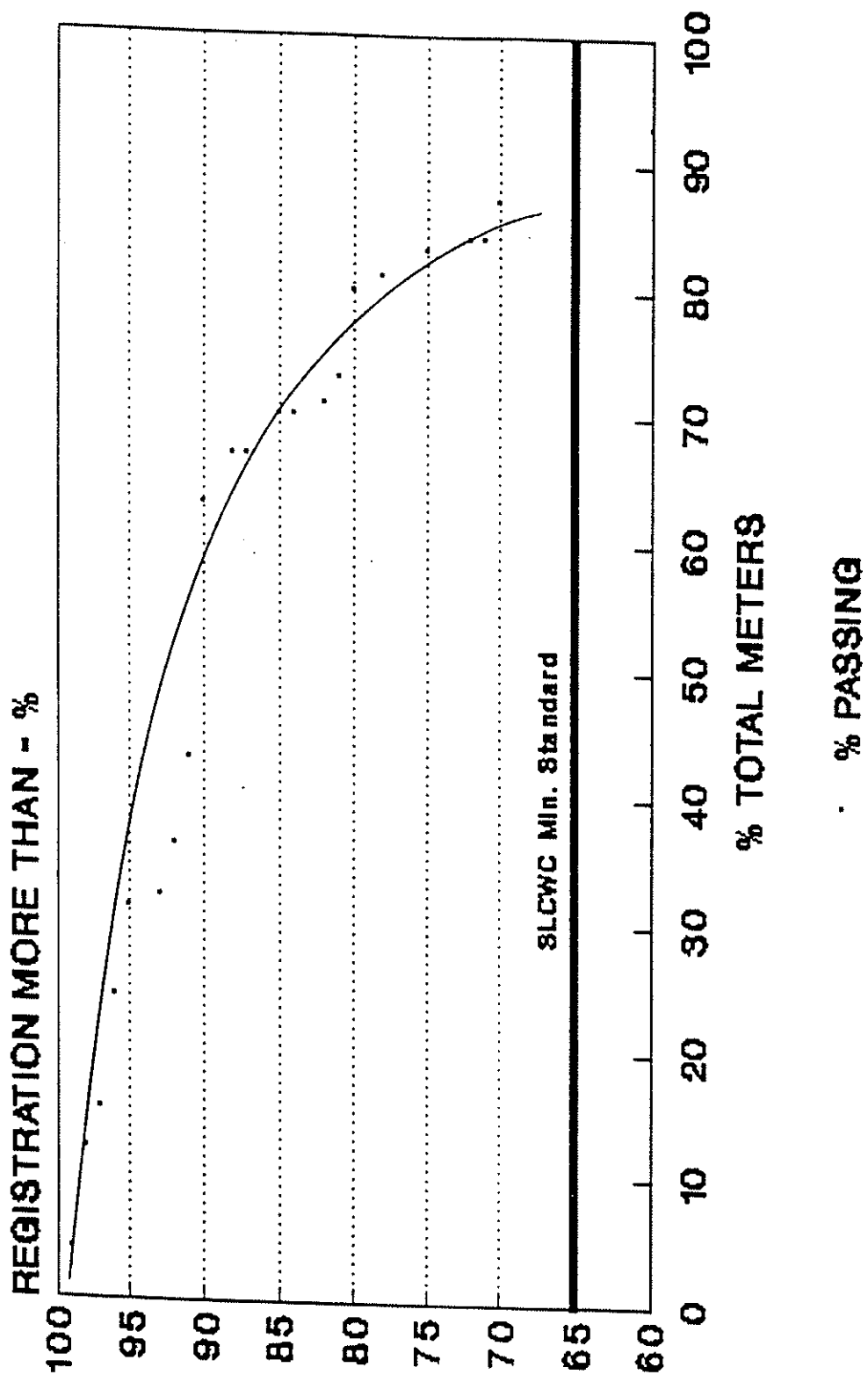
| Number of Meters | Cumulative No. Meters | Summation of Total Tested - % | % Reg. More Than |
|------------------|-----------------------|-------------------------------|------------------|
| 2                | 313                   | 100                           | *                |
| 1                | 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

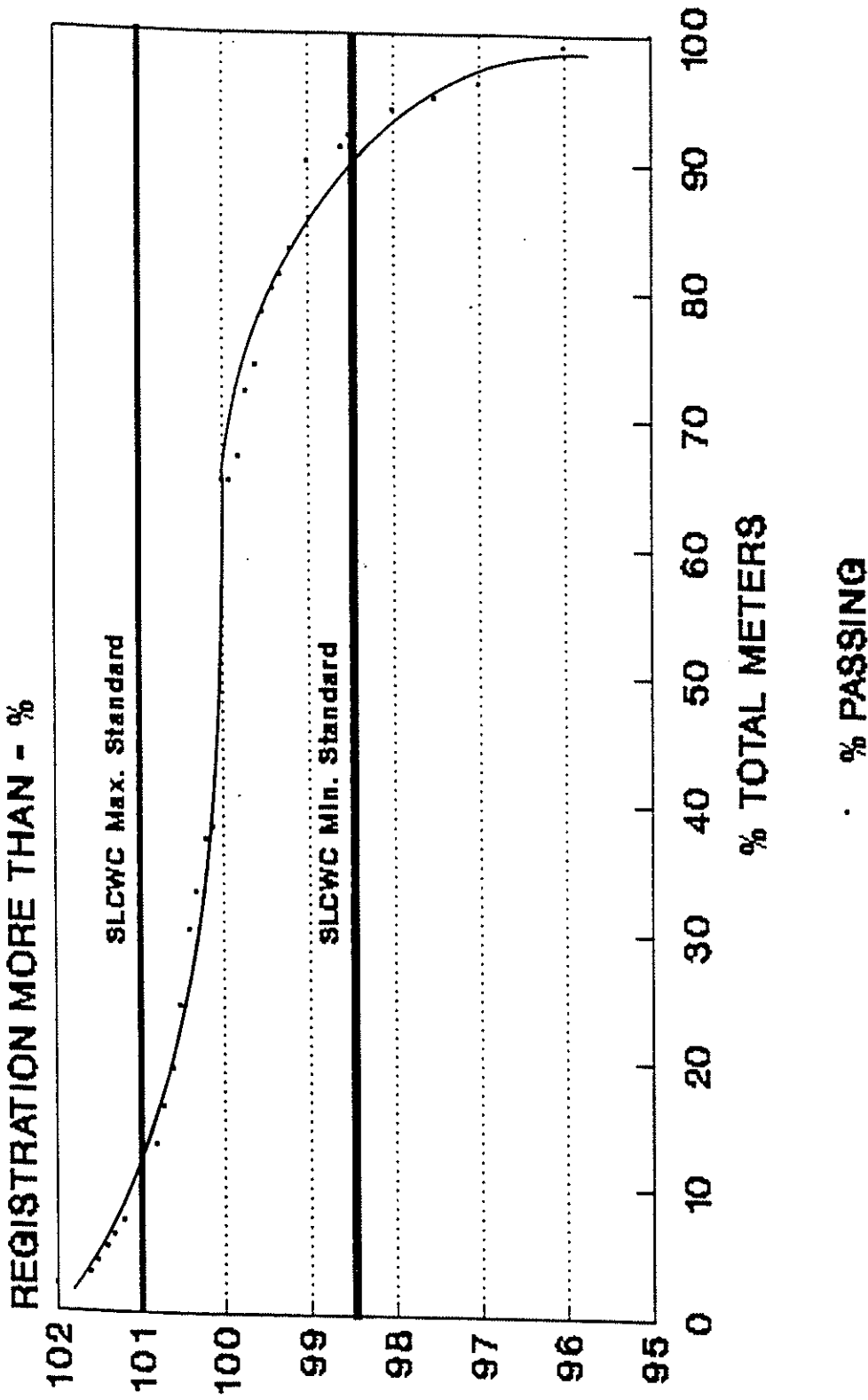
## 1/8 G.P.M. TEST



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              |

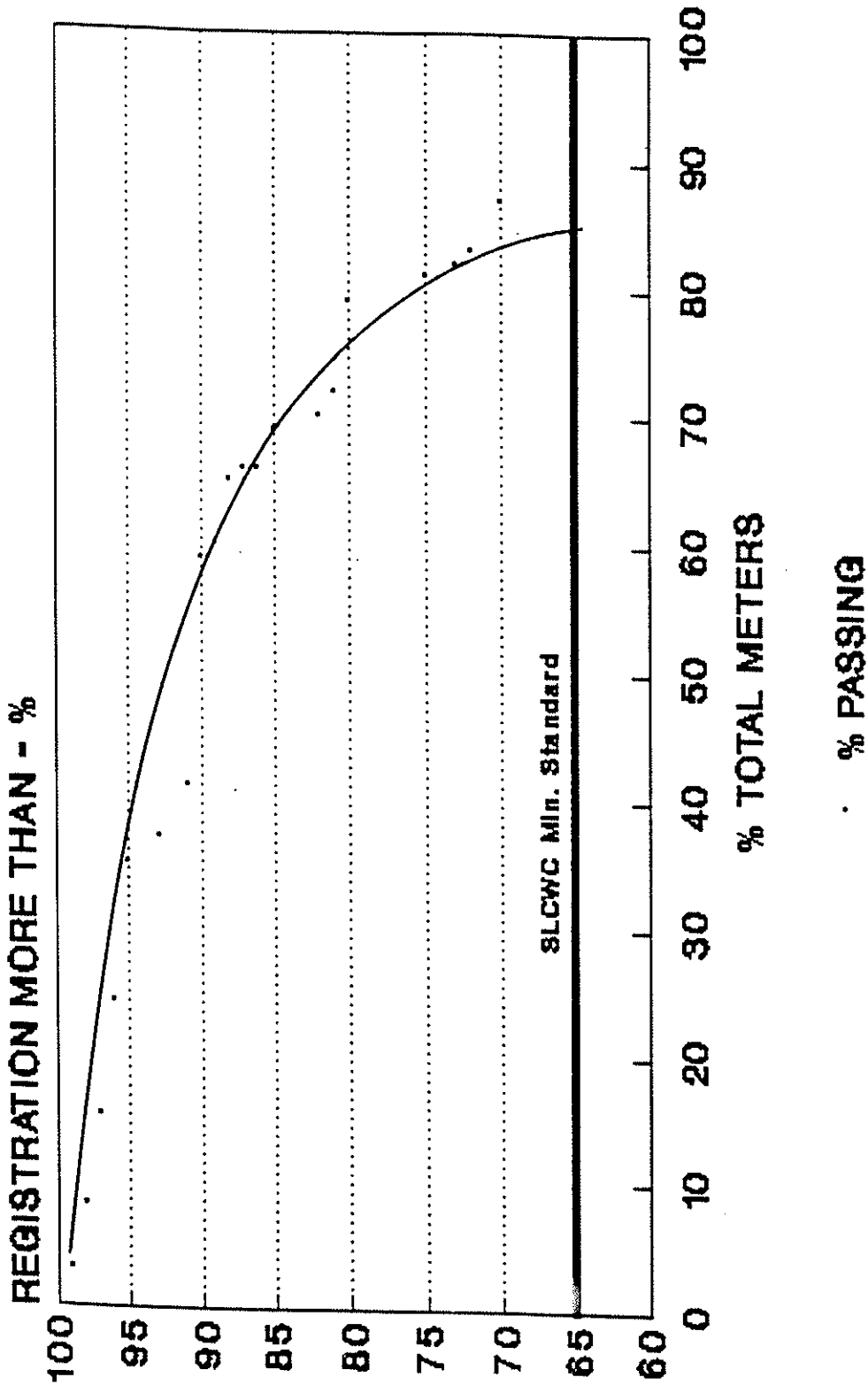
92%

\* 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

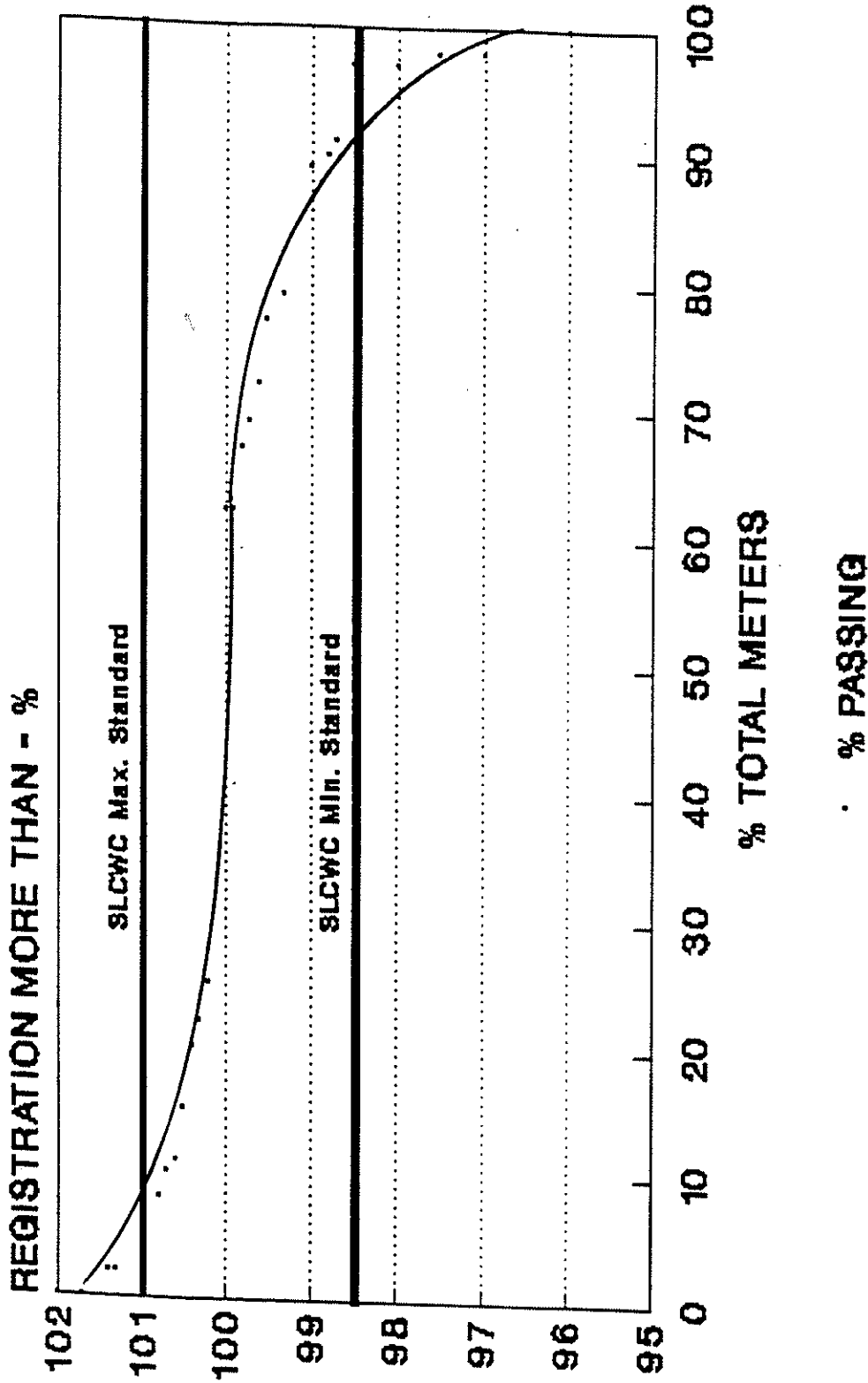


ACCEPTABLE RANGE: OVER 65%

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

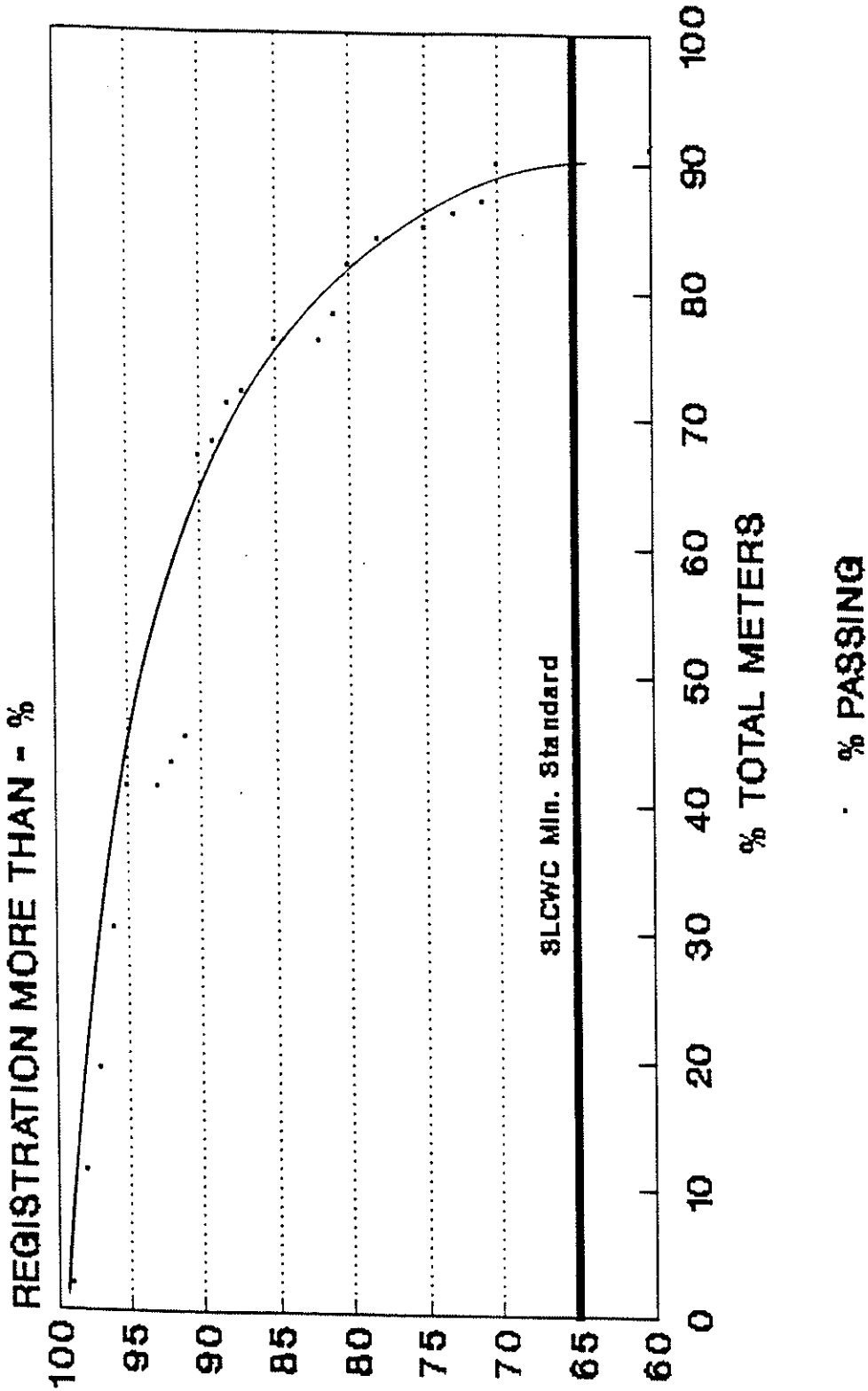
| Number of Meters | Cumulative No. Meters | Summation of Total Tested - % | % Reg. More Than |
|------------------|-----------------------|-------------------------------|------------------|
| 1                | 374                   | 100                           | *                |
| 7         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

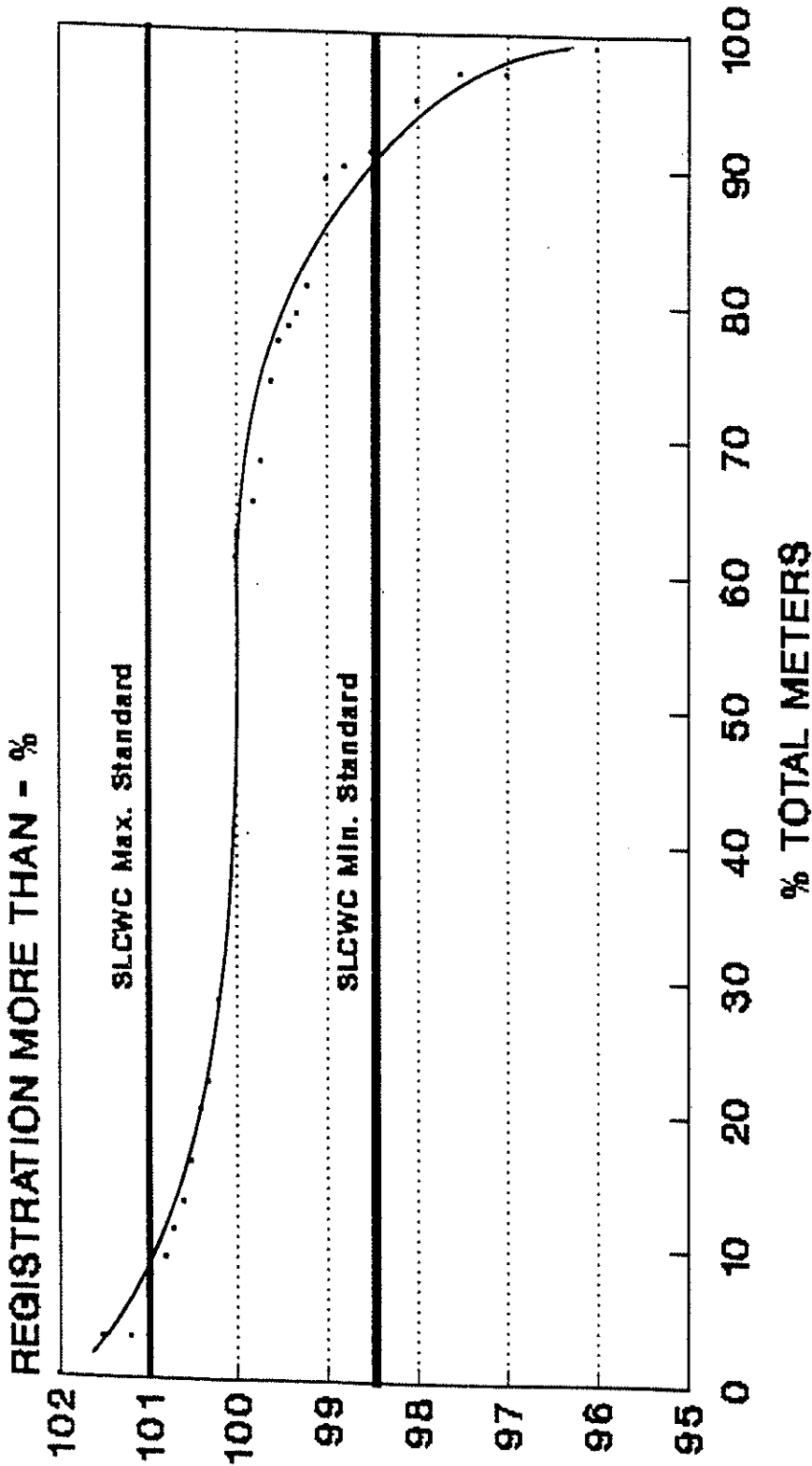


Down

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%

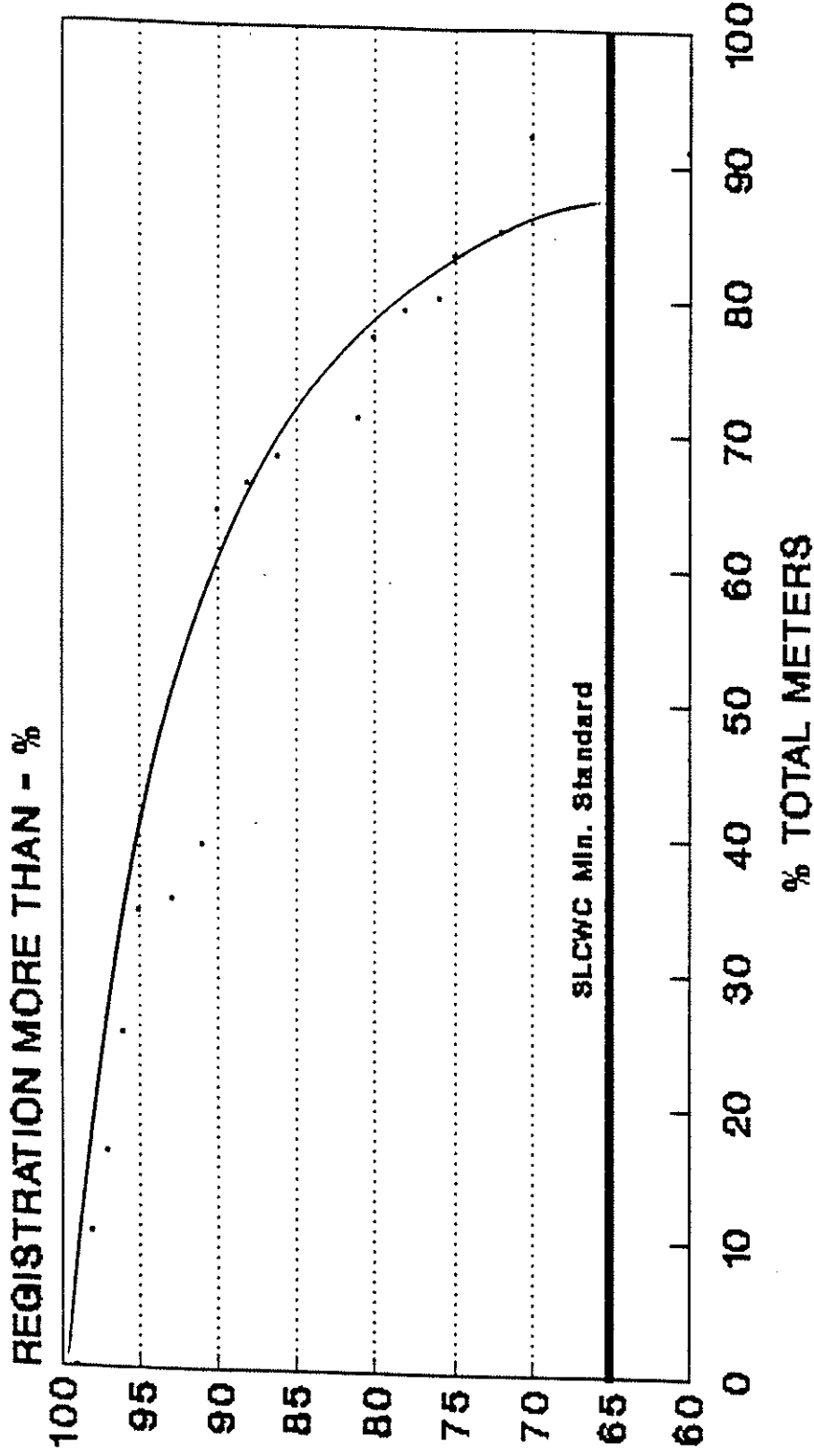
400,000 CU. FT. USAGE STUDY GROUP - 1990  
2 GPM FLOW

| 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**



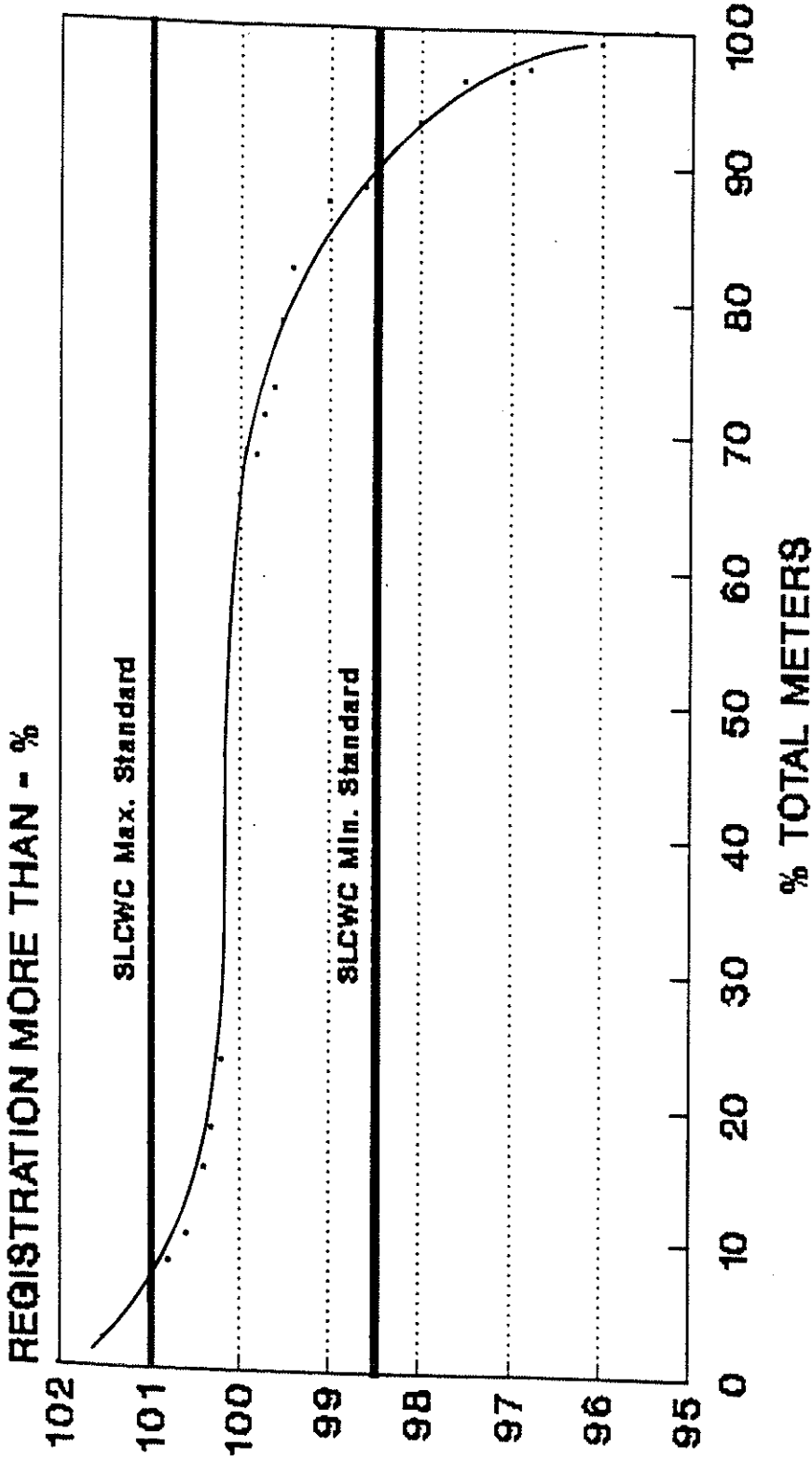
· % PASSING

**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

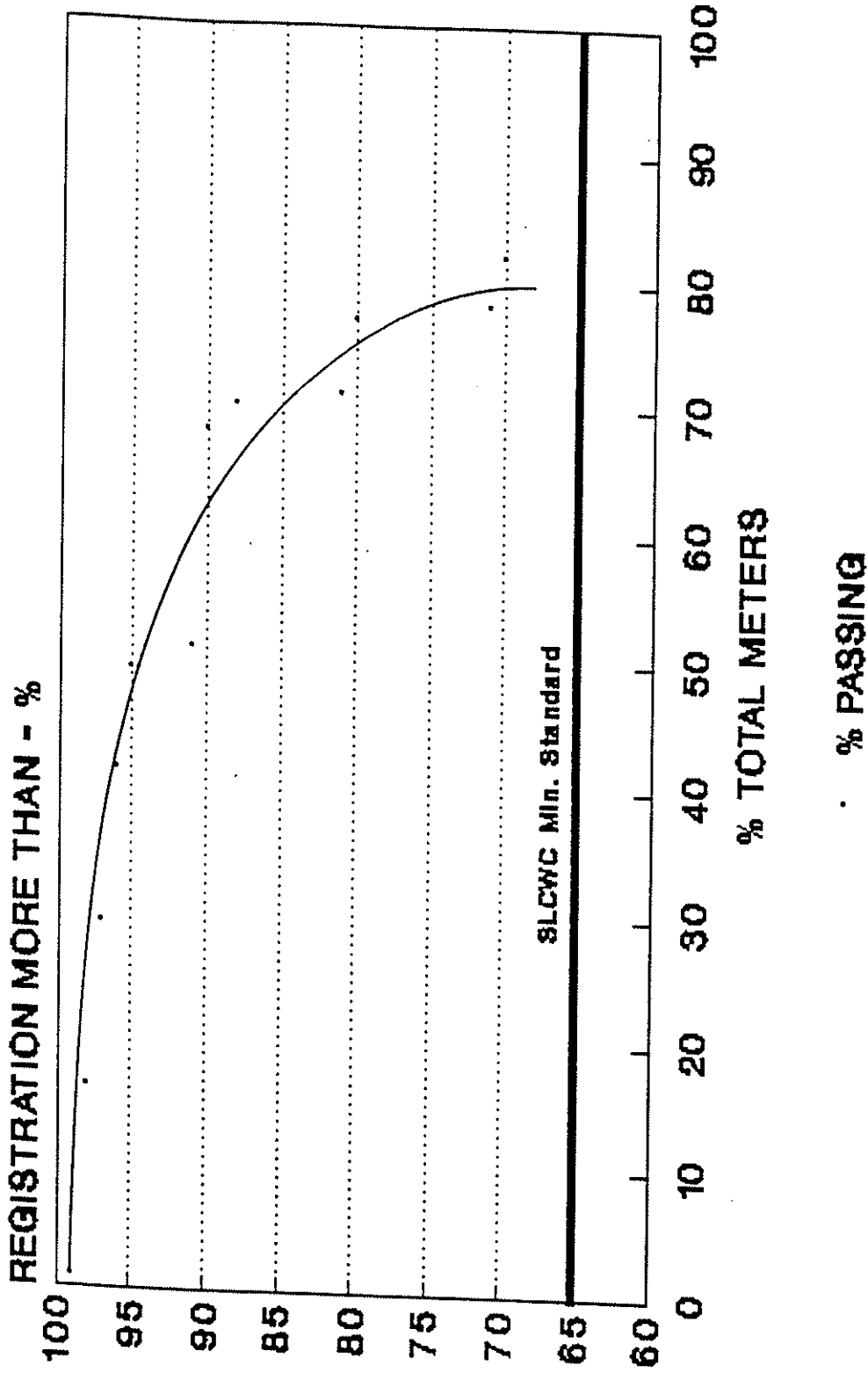
15 Meters registered less than 65%. Average registration for this group was 38.92%

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%

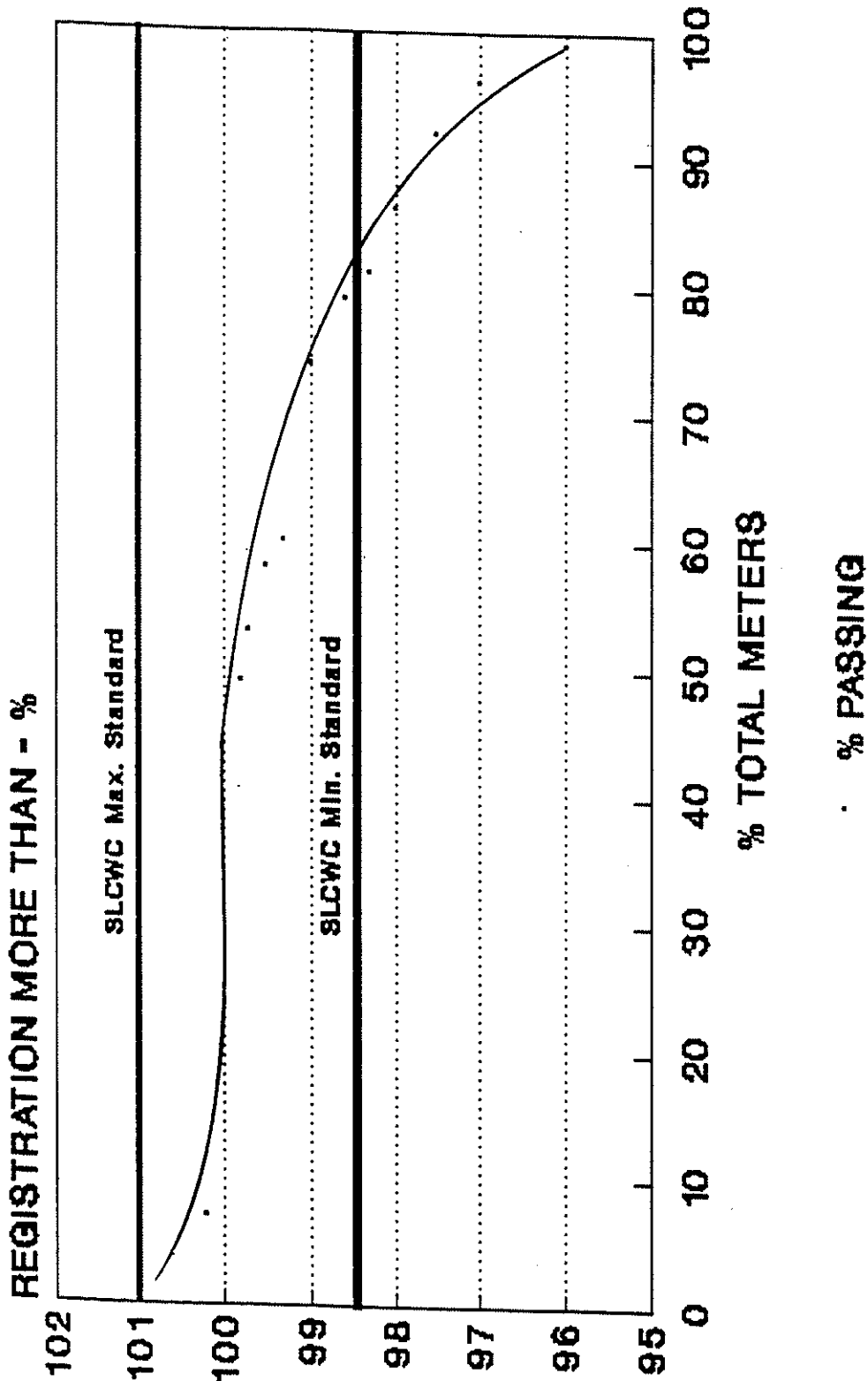
**600,000 CU. FT. USAGE STUDY GROUP**  
**1/8 G.P.M. TEST**



**CHART 38 - NOVEMBER 1990**  
**ACCEPTABLE RANGE: OVER 65%**

# 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<br>Meters | Cumulative<br>No. Meters | Summation<br>of Total<br>Tested - % | % Reg.<br>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%

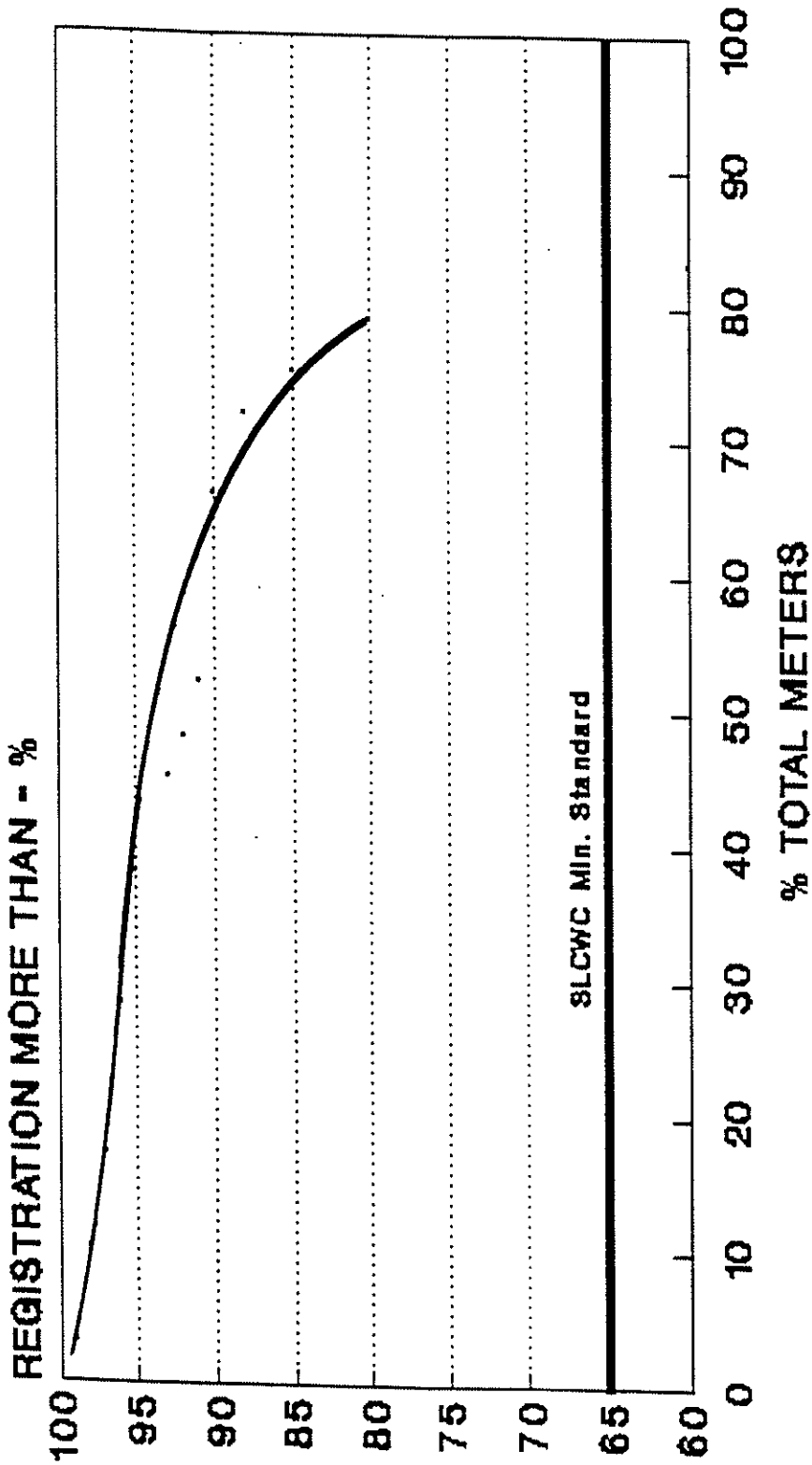
600,000 CU. FT. USAGE STUDY GROUP - 1990  
2 GPM FLOW

| 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**



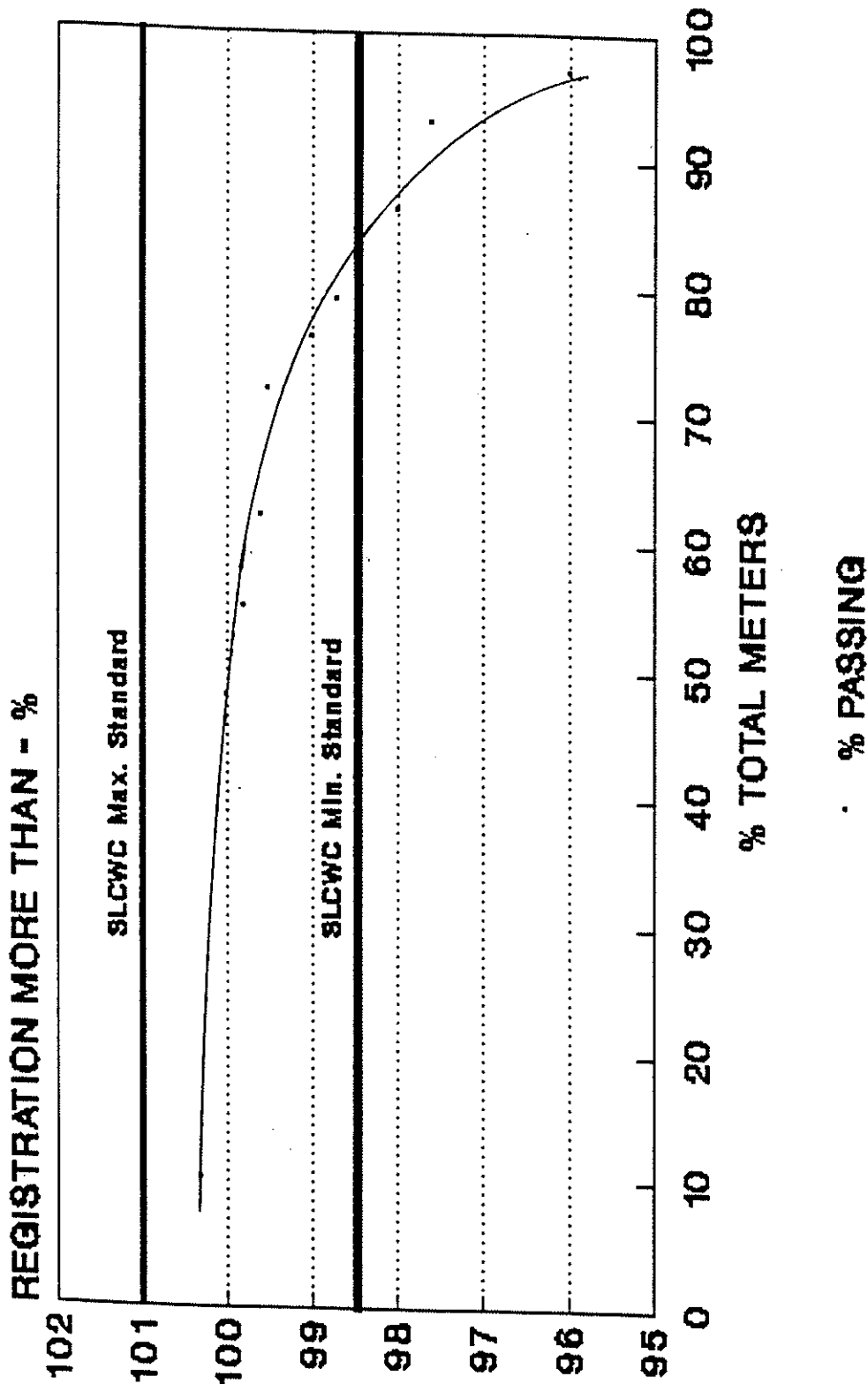
• % PASSING

**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<br><i>446</i>  | 101<br><i>999</i>  | 134<br><i>999</i> | 165<br><i>817</i> | 259<br><i>747</i> | 237<br><i>496</i> | 1096<br><i>5004</i> |
| Mileage (M Cu. Ft.) | 100                | 200                | 300               | 400               | 500               | 600               | 700                 |
| No. of 5/8" Meters  | 313<br><i>2047</i> | 412<br><i>1756</i> | 374<br><i>778</i> | 552<br><i>311</i> | 181<br><i>79</i>  | 73<br><i>33</i>   | 1934<br><i>5004</i> |

**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% - <sup>102%</sup>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<br>In Service<br>As of Jan. 1 | Meter<br>Growth<br>During Year | Changes<br>Made<br>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                         |