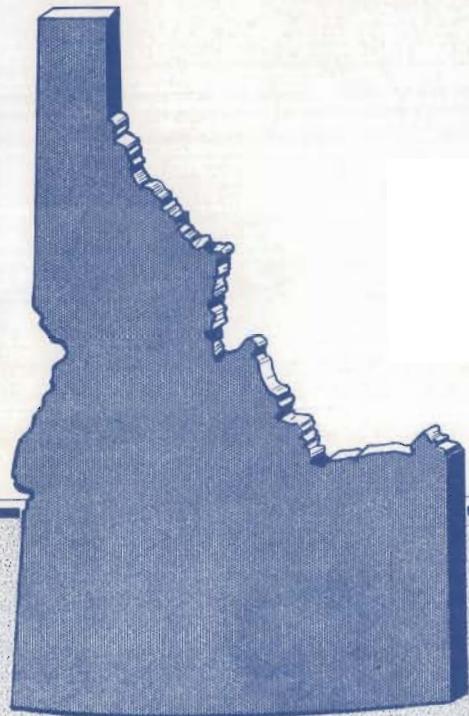


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AN INVENTORY OF THE SKID RESISTANCE OF IDAHO HIGHWAYS



APRIL 1972

RESEARCH PROJECT NO. 59

STATE OF IDAHO DEPARTMENT OF HIGHWAYS

AN INVENTORY OF THE SKID RESISTANCE
OF IDAHO HIGHWAYS

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SUMMARY

A locked wheel trailer meeting the specifications of ASTM E-274-65 was purchased in October 1970. During the summer and fall an inventory of the skid resistance of all highways on the State highway system was made. Skid numbers (coefficient of friction x 100) ranged in value from 10 to 78 with an average of 57. Testing followed the procedures established by ASTM. Tests were made on the average of every two lane miles, testing more frequently in non-uniform sections and less frequently in long, uniform sections.

A program for maintaining the inventory current will be pursued by testing new pavements as they are completed and retesting pavements at some designated interval of time.

ACKNOWLEDGEMENTS

Our thanks is extended to all who assisted in conducting this inventory. The Districts helped immensely by furnishing information about surfacing sections and conditions, and personnel to help in the actual testing. Marlene Voulelis and Phil Gardner of the Planning and Traffic ADP Section, wrote the computer programs for computing and listing the test data. Cliff Ragsdale, Materials and Research Programmer, worked with us in writing programs for analyzing the data. Barry Tyler, Engr. Tech. V, from the Materials Lab was responsible for organizing and conducting all the field work and for preparing the data for key punching. Dick Ruth, Engr. Tech. III assisted Barry at times and did the field work in District One. Especial thanks goes to Mrs. Nancy McConaughey for final checking of the data for form prior to submitting it for keypunching and for her assistance in compiling and typing the report.

The direction and encouragement of L. F. Erickson, Materials & Research Engr. and his review and criticism of the report are very much appreciated.

We are grateful to the National Highway Safety Bureau and to the State Traffic Commission for their assistance in conducting this skid test inventory.

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INTRODUCTION

Slippery pavements have been known to exist for more than four decades⁽¹⁾ and skid testing has been of interest to highway engineers for nearly that long. In recent years there has either been a real increase in skidding accidents, or an apparent increase due to more reliable accident reporting. In either case, there has developed an interest in skid resistance testing far outside the engineering society. This interest has manifested itself in safety organizations and in other citizen groups as well as in governmental agencies and the Congress of the United States.

In the National Cooperative Highway Research Program (NCHRP) Report No. 37-Tentative Skid Resistance Requirements for Main Rural Highways⁽¹⁾ the researchers explain that "pavement slipperiness is a relative term which attains physical significance only when other factors are specified." They explain that skidding accidents are not always caused by a slippery pavement, but that other factors such as excessive speed, unbalanced brakes, smooth tires, poor geometric design of the highway, and even the driver himself, are often causes of skidding accidents.

The authors state that "recent advances in the accuracy and reliability of friction test equipment are encouraging, but the present approach leaves much to be desired." This statement is based on three observations which they list as follows:

1. The accepted method of rating pavements for slipperiness, is skid resistance; the condition measured being skidding, precisely the condition it is sought to keep the motorist from becoming involved in.

(1) National Cooperative Highway Research Program (NCHRP) Report No. 37 - "Tentative Skid Resistance Requirements for Main Rural Highways".

2. The measurements, including those taken with the most accurate testors, have only relative significance because the measured friction values are influenced by test equipment design, tire characteristics, and operating conditions, in addition to the pavement.
3. The measurements are affected by conditions beyond the test engineer's control; that is, by factors which may vary from day to day without the operator's knowledge. Thus, a precise frictional comparison of several pavements measured with the same equipment, tire, and under (seemingly) identical conditions but on different days is, strictly speaking, not valid."

The authors also report, "Even if all these difficulties were eliminated, the measurement of pavement friction is, in itself, of limited value so long as the frictional needs of traffic are unknown. It is this need which provides the yardstick for the frictional rating of pavement surfaces as to skid resistance." In other words, before a label of slippery or skid resistant can be attached to a pavement surface, the frictional needs of traffic must be compared with the measured pavement friction. It is apparent, then, that "frictional requirements can never be fixed numbers, but are a function of highway layout, vehicle design, and driver habits."⁽¹⁾

In the fall of 1969, the Idaho Department of Highways applied for a National Highway Safety Bureau safety project through the Idaho Traffic Safety Commission for the purpose of conducting a skid resistance inventory of the State's highway system. This request included the purchase of a skid test trailer with towing vehicle and recording equipment. The safety project was approved April 3, 1970 and the equipment was received in early October the same year.

(1) National Cooperative Highway Research Program (NCHRP) Report No. 37 - "Tentative Skid Resistance Requirements for Main Rural Highways".

PURPOSE

The purposes of this project as cited in the Department's application to the National Highway Safety Bureau for a project are:

1. To obtain and maintain an inventory of skid resistance of the state highway system.
2. To check skid resistance of locations of frequent accidents, especially where skidding is reported to be a factor.
3. Investigate the variability of skid resistance with speed for different pavement surfaces.
4. Determine (monitor) loss of skid resistance of new pavements due to traffic wear.

CONCLUSIONS

1. The average Skid Number for all pavement types statewide is 57, with a low of 10 and high of 78. Of the approximately 6,750 tests analyzed about 3% were under skid number 30, with approximately 10% under skid number 40.
2. Even though the two sets of tests for each wheel did not indicate exact repeatability it is believed that with enough for analysis these results would be **statistically acceptable**.
3. **The skid number measured is an average for the test strip only and may not be representative of the skid number of the pavement on either side or those sections ahead or behind.**
4. **The skid number varies with speed, with the higher speeds giving low skid numbers and vice versa. (See Figure 1)**
5. Skid number values are only relative and are dependent upon a variety of conditions. No single number can be specified as a minimum above which you will be safe from skidding.

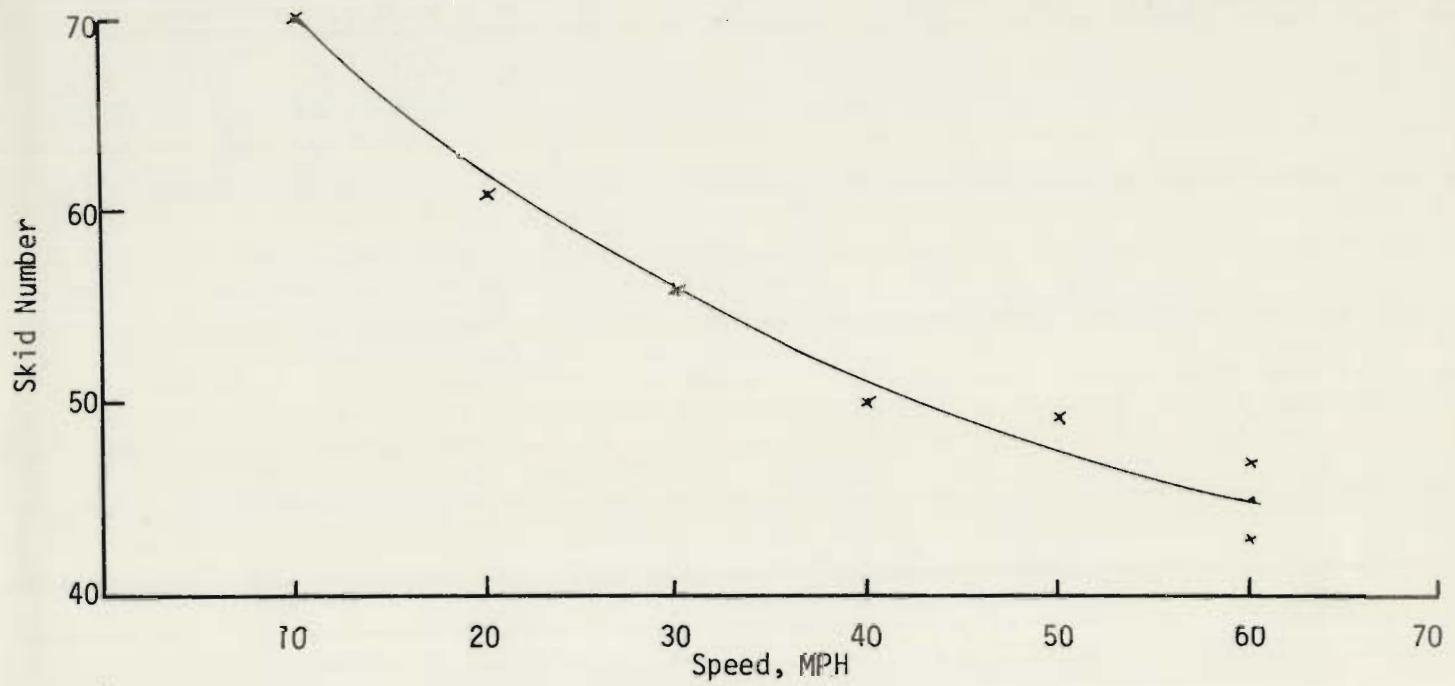


Figure 1 - Variable Speed Test - Made on Good Sealcoat

RECOMMENDATIONS AND IMPLEMENTATION

1. The data obtained during this project were furnished the Department's six Districts with the suggestion that they do what they can to improve the skid resistance of those sections of highway with low skid numbers. No minimum skid number was specified, as there was enough highway in each District which had extremely low numbers to keep them busy, if they started with the lowest sections and worked up. However, a skid number of at least 35 should be used as a minimum to achieve any improvement.
2. The Department should initiate a program for testing the skid resistance of every new pavement and surface treatment constructed, and for maintaining an inventory of the skid resistance of all highways.
3. Skid resistance information should be used in selecting the type of surface to place on a highway in any given area.
4. Skid resistance data should be studied as an aid in choosing sources of aggregate to be placed in the wearing surface.
5. The Maintenance Division and Districts should work together to improve skid resistance with the District taking immediate steps in the more urgent sections and the Maintenance Division programming the major projects, such as overlays and sealcoats, upon recommendations from the Districts.
6. The Materials and Research Division should assume the responsibility for the design of skid resistant pavements.
7. A follow-up report should be published which would discuss later testing and report corrective work which has been done as a result of the skid resistance testing.

8. Additional equipment testing should be performed to give us statistical confidence in test results.
9. Testing of city and county streets and highways should be initiated, possibly working through the Urban and Secondary Roads Engineers.

PROCEDURE

During 1968 some skid testing was done on selected routes using FHWA equipment as a demonstration of skid test equipment and procedures. Tests were generally made every two miles, with some variations, either testing more or less frequently on sections with apparent uniform or lack of uniformity of surface texture and skid resistance. Using this experience as a background, and with the help of our operating Districts, the state highway system was divided into test sections by routes and according to the surface type and condition. It was our intent, by dividing the highways into sections, to reduce the number of tests on long stretches of highway with uniform surface texture without reducing the value of the inventory. On stretches of variable surface texture additional testing was considered necessary to establish a range of values.

Tests were normally made at mileposts as a practical means of providing a reasonable degree of randomness for test locations. ASTM Standard Method of Test E 274-70, requires a minimum of five tests per section. This was not possible as time did not permit this frequency.

An exception to testing at mileposts was made by testing for skid resistance at reported wet pavement accident sites. The skid test data was placed on computer tapes for accessibility and to permit better analysis of the data. In addition to the safety aspects of skid resistance testing, and perhaps a corollary to it, is the possible use of the skid test data in setting priorities for resurfacing or sealcoat projects.

In addition to the inventory testing, several series of special tests were conducted to aid in the interpretation of the results. These included tests for

repeatability, for variation of skid number with speed, and for variability transversely across the pavement. The speed test and one transverse variability test were run on a good chip seal on SH-16. The other transverse variability test was run on SH-20 on a chip seal with nearly 100% chip loss in the wheelpaths. Repeatability tests were run on a good sealcoat on US-20 and a fair to poor sealcoat on SH-44. Results of these tests are discussed under "Results".

RESULTS

The skid test data have been placed on computer tapes and are accessible either as individual tests or as a printed tabulation of all tests, by District, highway section, or pavement type. Programs have been prepared for analyzing the data. One such program calculates and tabulates the frequency of occurrence of skid number values and the accumulated frequency in percent. Ogive, or frequency distribution curves have been drawn, graphically showing the percent of test values greater or smaller than any selected value for each type pavement by route, district and for all tests within each district, as well as statewide. These curves are shown in Figures A1-A27 in the Appendix. No distinction has been made between rural and urban. Most tests were made in rural areas because of the low speed limits which had to be observed in the urban areas.

The tabulation of results shows a high friction factor of 78 and a low value of 10 (Figure A1, Appendix). These values are typical for all districts. The mean value for the State is approximately 57; that is, 50% of all friction factors are above, and 50% are below 57. Usually values less than 35 or 40 are considered low. Values greater than about 50 are considered good and are "safe" at speeds up to 70 mph under most conditions.

Using the frequency distribution curves, it is possible to make a relative comparison of skid resistance values by surface types within each district. This may indicate surface types having generally better skid resistance values than other types. As an example, in District Three the ogive curve for Plantmix Pavement, Figure A13, shows that 5.0% of all tests were less than SN 40, while 11% of the tests on Seal Coats, Figure A16, were less than 40.

ACCIDENT SITE TESTING

Accident sites tested are noted in the remarks column of the computer tabulation. A search of wet pavement accidents records was made to find those in which skidding was considered a contributing factor. Accident sites selected for test were those, which in our judgment, could have been due to skidding as a contributing factor.

Table I shows the results of the accident site testing and raises the question as to whether many of these were really skidding accidents. The results are for only one test made in the wheelpath at the approximate accident site as determined from the accident report.

Route	Milepost	Lane*	Skid Number
I-15	168.6	5	58
"	168.6	4	62
"	187.09**	5	44
"	187.09**	5	43
I-90	52.0	4	50
US-30	162.0	5	56
"	162.0	4	43
"	113.1	4	40
US-95	367.0	5	45
US-95A	390.0	5	60
SH-11	66.9	5	58
SH-24	49.65	5	63
"	49.65	4	62

Table I - Skid Test Results at Accident Sites

*Lane 5 - Driving lane traveling with increasing milepost; Lane 4 Driving lane traveling against increasing milepost.

**Site of skidding accident in which 6 people were killed. Two tests.

In order for skidding to occur the demand for friction must exceed the available friction required. An automobile can traverse a section of highway at a certain maximum speed because the tire and roadway conditions develop the friction needed to control the vehicle at that speed. Increase the speed a few miles

per hour and the frictional demand is greater, simultaneously reducing available friction, creating a condition which is favorable for a skidding accident.

TRANSVERSE VARIATION IN SKID RESISTANCE

It is very apparent with some pavement surfaces that there is a great variation in skid resistance across its width.

Two tests were made which show this variability. One test was on an obviously variable section, with nearly 100% chip loss in the wheelpaths.

The other was on a good sealcoat having the appearance of a fairly uniform skid resistance. Figures 2 and 3 show these results.

VARIATION IN SKID RESISTANCE WITH SPEED

One series of tests varying the speed was conducted, with the results shown in Figure 1. A single test was made at each speed, except two were made at 60 mph. Similar tests should be made on different surface types.

Figure 1 shows that as the speed increases, the skid resistance decreases. Other research has shown the slope of the curve will vary with the type of surface and its texture, temperature and with other factors.

SKID RESISTANCE LOSS OF NEW PAVEMENTS

One new concrete pavement was skid tested soon after it was opened to traffic in November 1970, and again during the inventory in July 1971. This is the only section on which such a comparison has been made. The average skid number in November 1970 was 55, while it was 43 in July 1971. This represents a significant loss of skid resistance. It is interesting that the surface texture depth of this same pavement was measured by the sand patch method prior to allowing traffic to use it, and again the following spring. This test revealed the loss

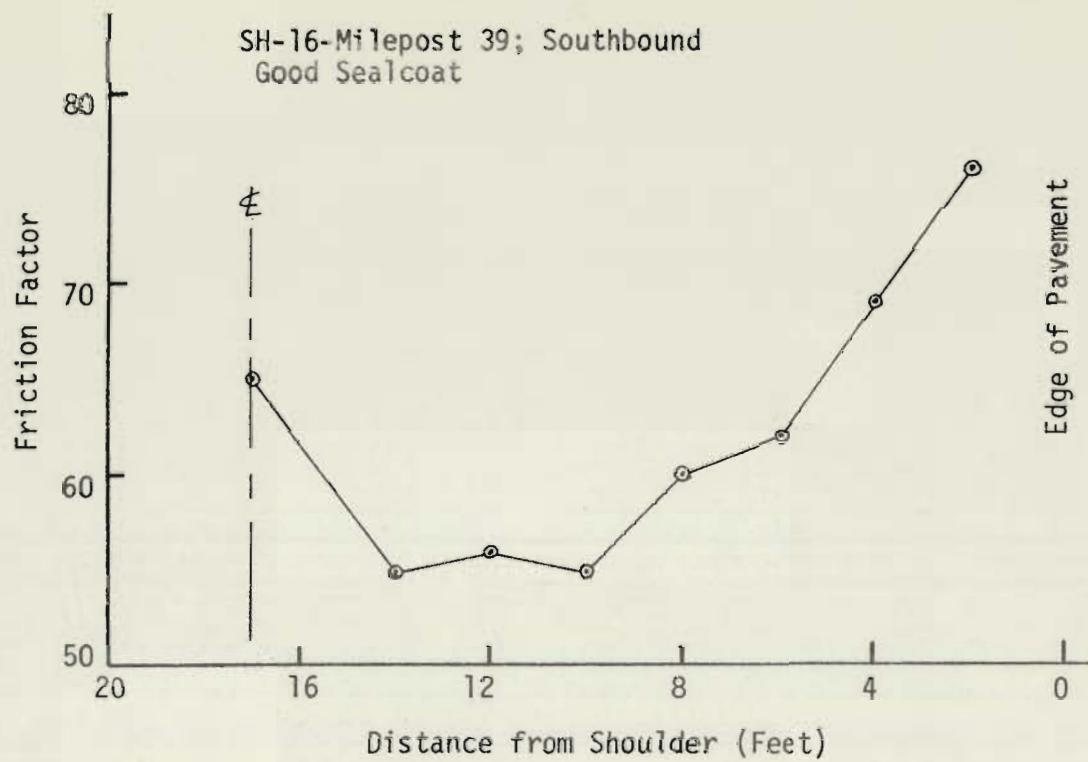


Figure 2 - Transverse Variability, Friction Factor

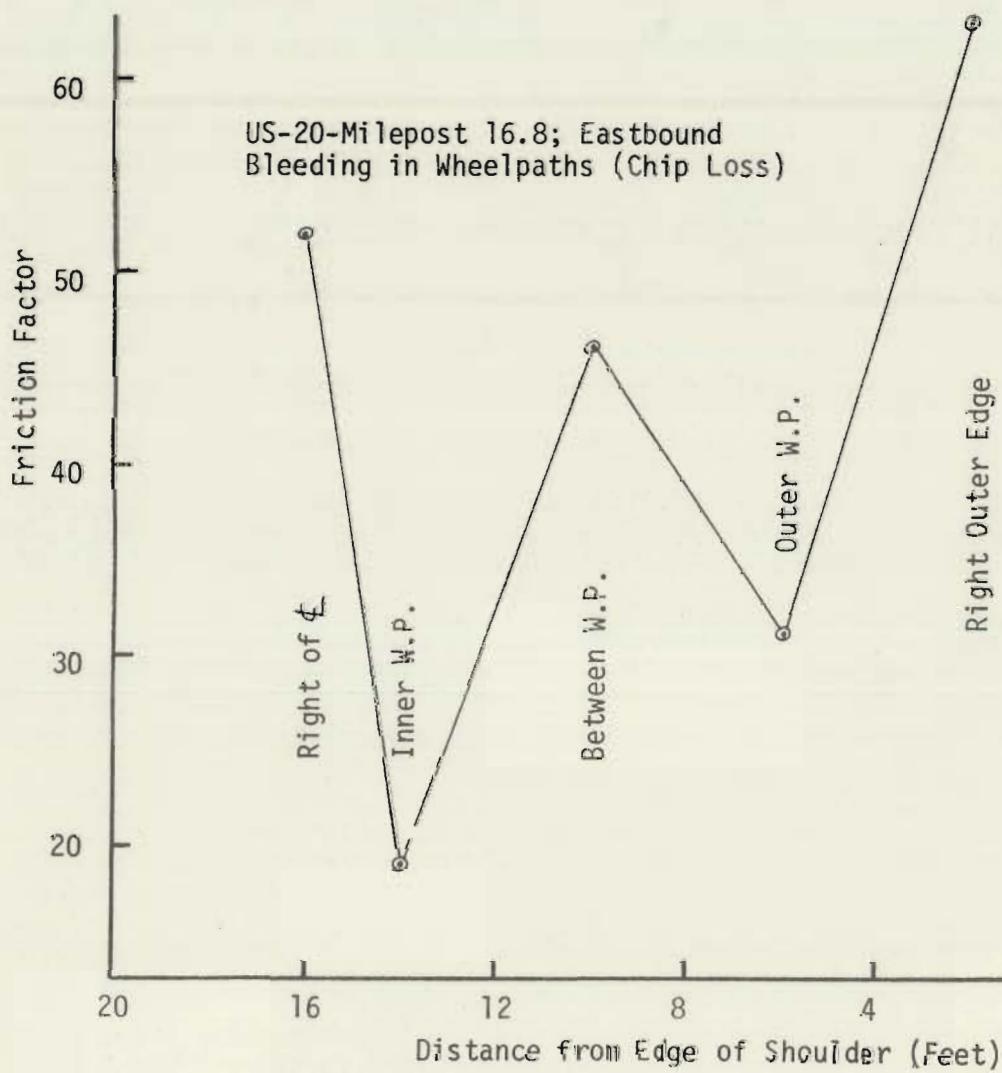


Figure 3 - Transverse Variability, Friction Factor

of much of the surface texture during the winter, probably due in part to the use of studded tires, as well as, the use of salt and sand in snow and ice control. The texture as constructed was an average of .057 inches in depth and in the spring was about .019 inches in depth.

REPEATABILITY TESTS FOR SKID RESISTANCE

Repeatability tests were conducted to determine the reliability of the equipment. These tests repeatedly skidded the test tire at the same spot so as to compare the results. This was done at two locations for both wheels of the trailer. Table II shows that the equipment does not repeat itself exactly; however, if enough tests are made it probably would be statistically acceptable.

Differences between tests may result from differences in the precise location of every other test. Other possibilities are that the equipment may not respond exactly the same each time. Any deviation in location, either transversely or longitudinally also alters results as shown in the test for transverse variation.

Test No.	SH-44		US-20	
	Left Wheel	Right Wheel	Left Wheel	Right Wheel
1	31	43	56	60
2	38	47	57	62
3	37	43	52	62
4	38	47	52	61
Ave.	36	45	54	61
Max.Diff.	7	4	5	2

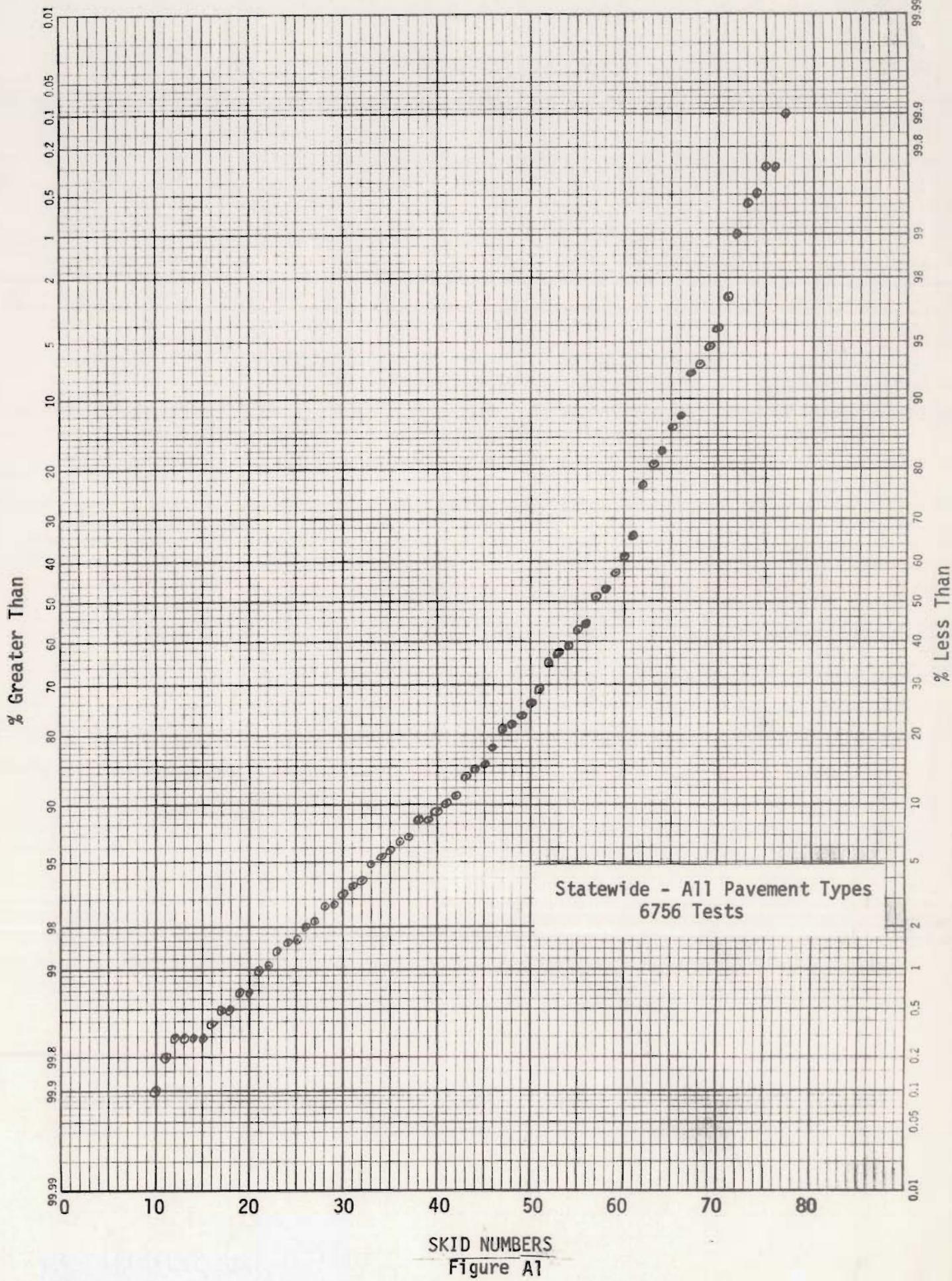
Table II - Repeatability Testing

COMPARISON WITH THE WASHINGTON
STATE HIGHWAY COMMISSION SKID TESTER

On August 25, 1971, the skid test crews and equipment from the Washington State Highway Commission and the Idaho Department of Highways made comparative tests for skid resistance on highways in both Idaho and Washington. Tests were made by both units at the same test sites on US-95 from Lewiston to Coeur d'Alene, on I-90 and US-10 from Coeur d'Alene to Washington State Line and on US-195 from Spokane to its junction with US-95 near Lewiston. One hundred nineteen duplicate tests were made. Plantmix, sealcoat and concrete pavements were tested.

It was hoped that there would be a close correlation between the two pieces of equipment. However, the Washington State equipment experienced difficulties on much of the route and they had to alter their test procedure. The expected correlation did not materialize probably due to the equipment difficulty.

A P P E N D I X



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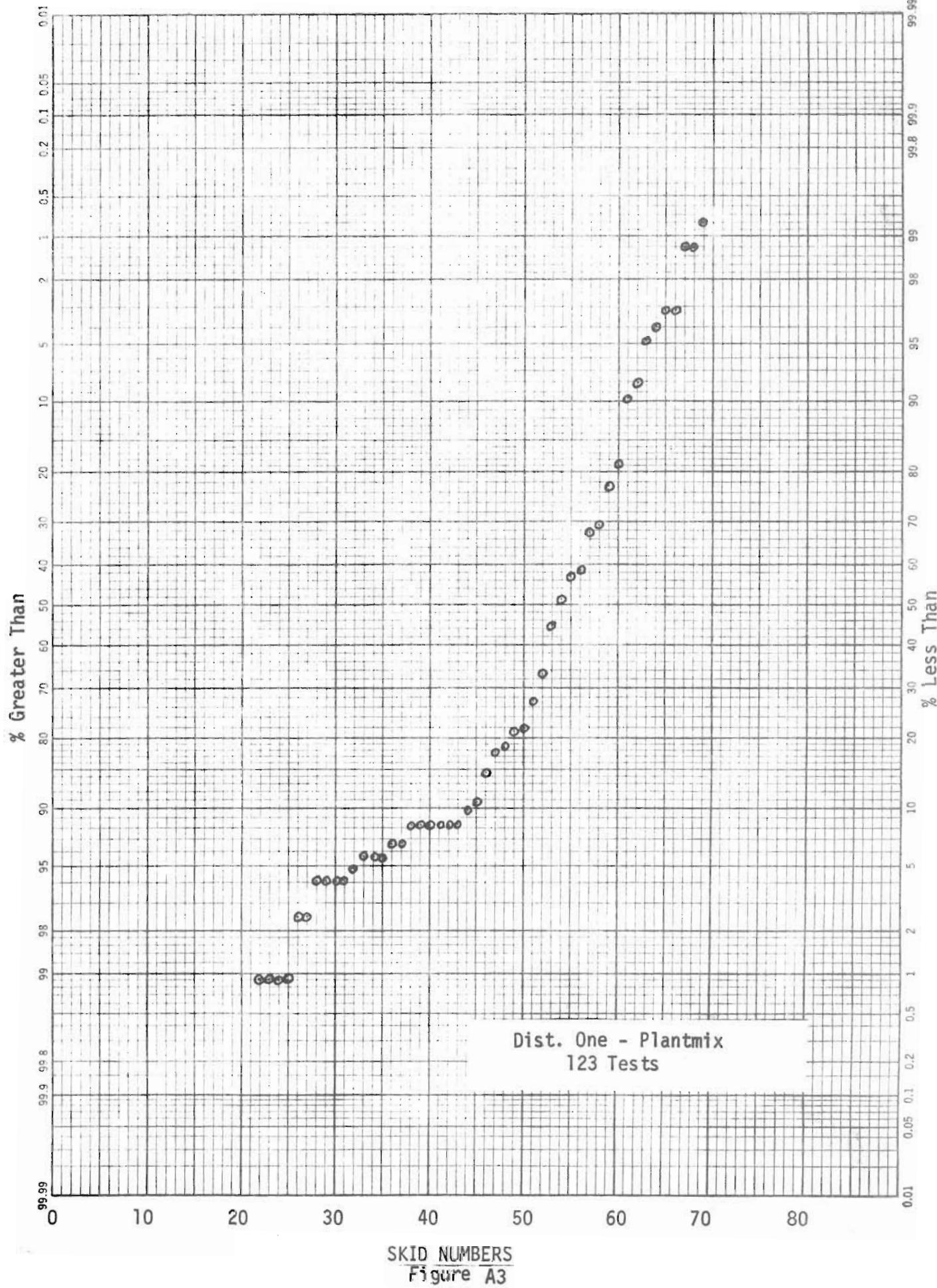
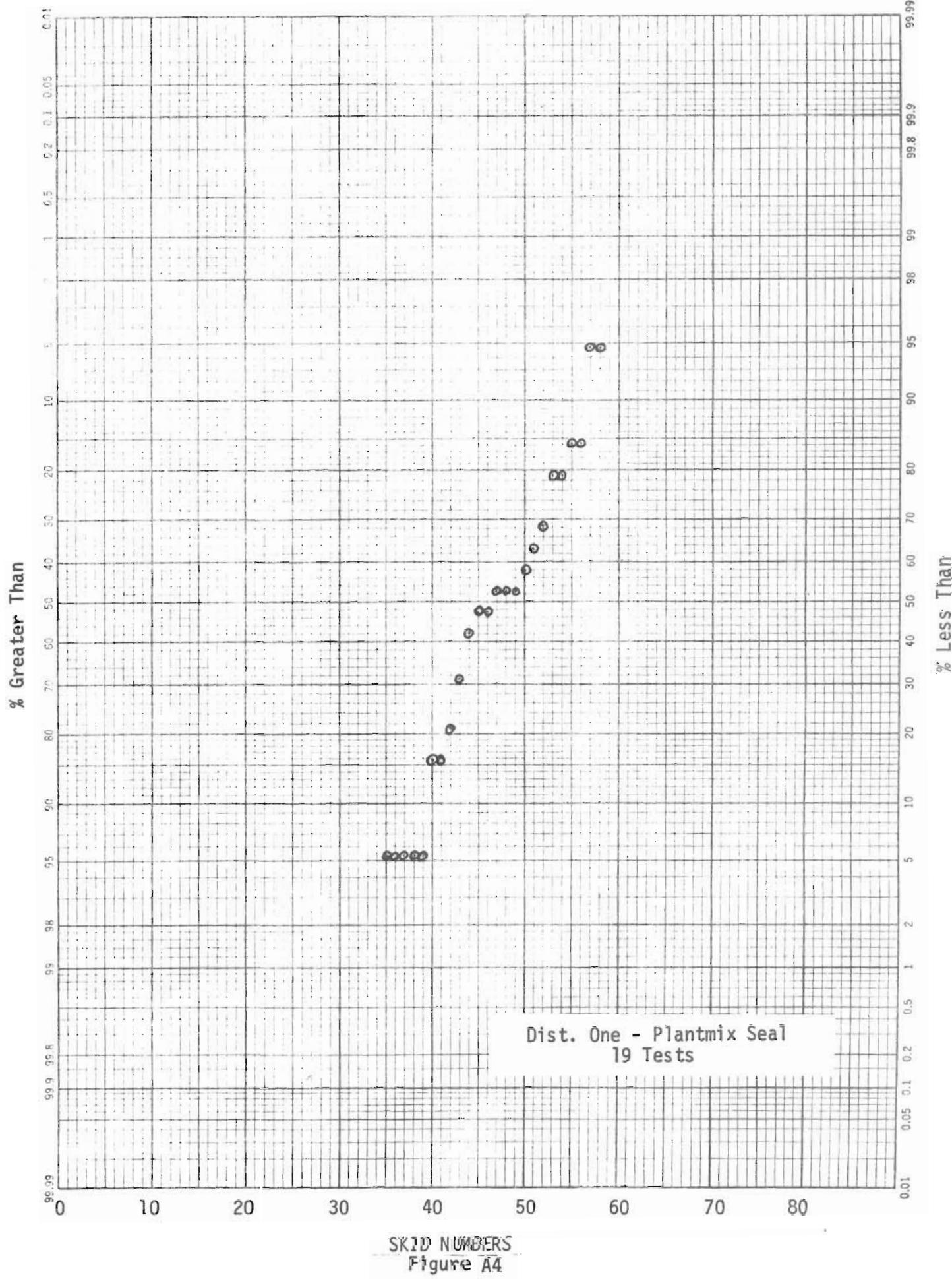
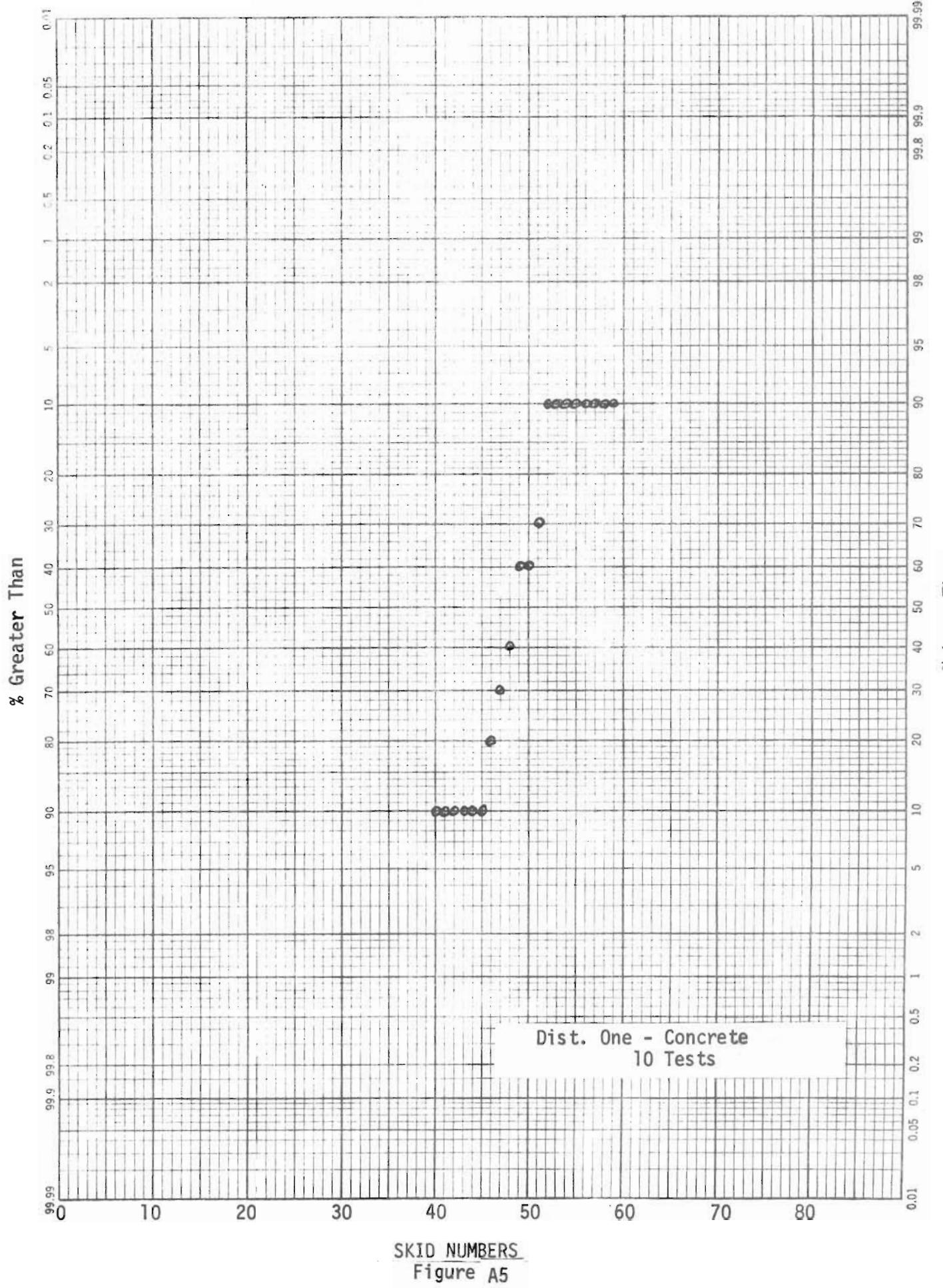


Figure A3





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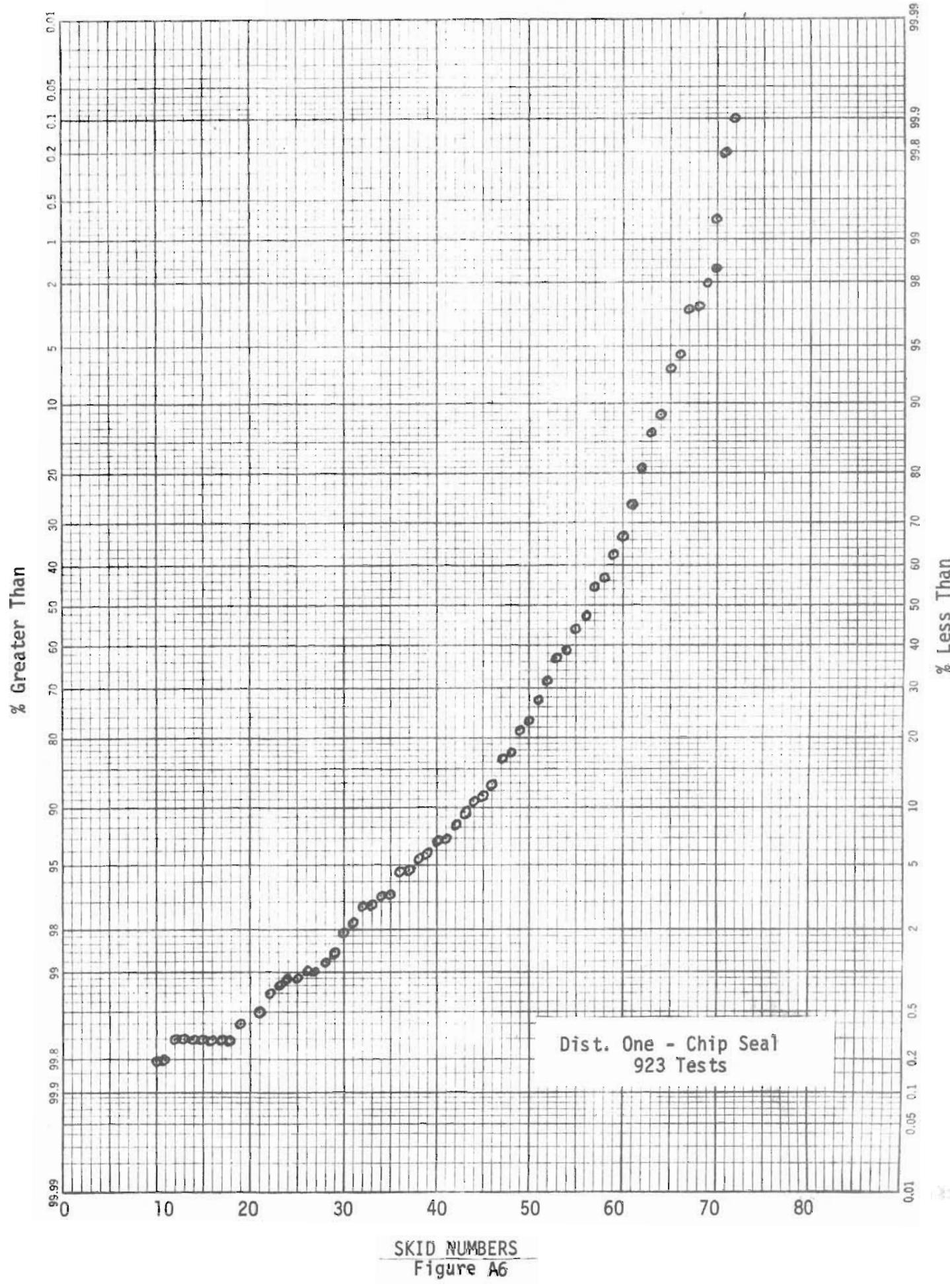


Figure A6

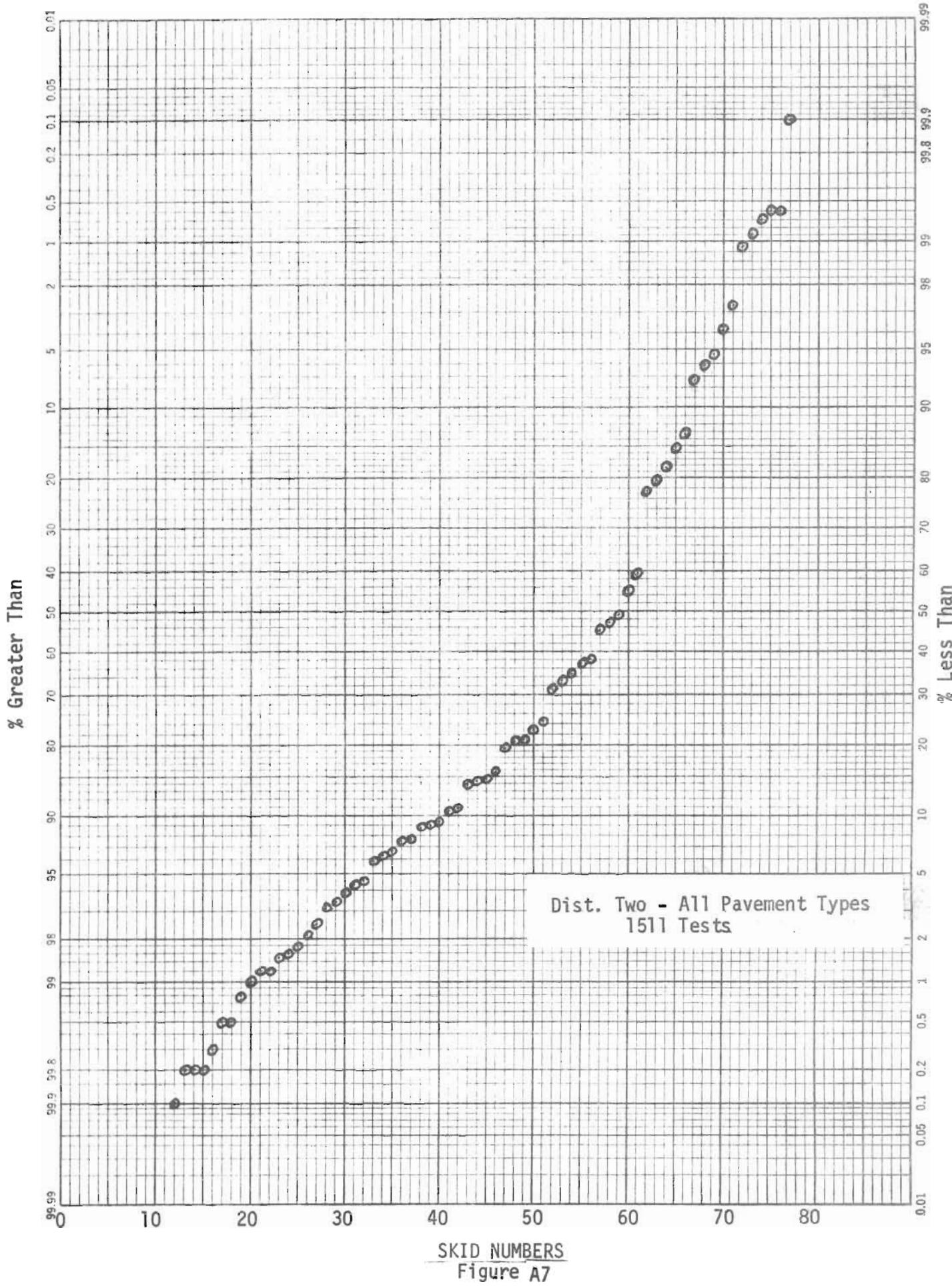
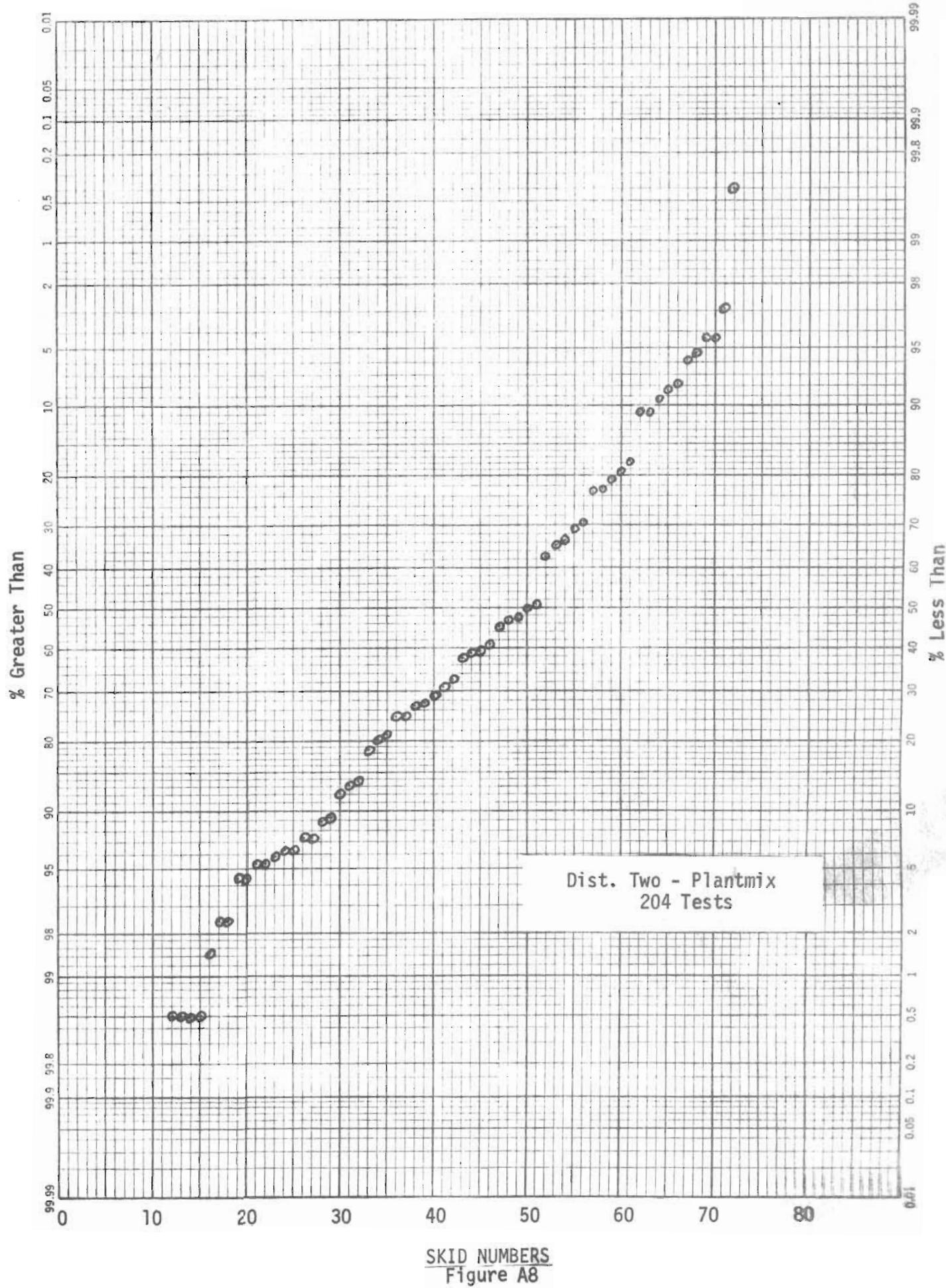


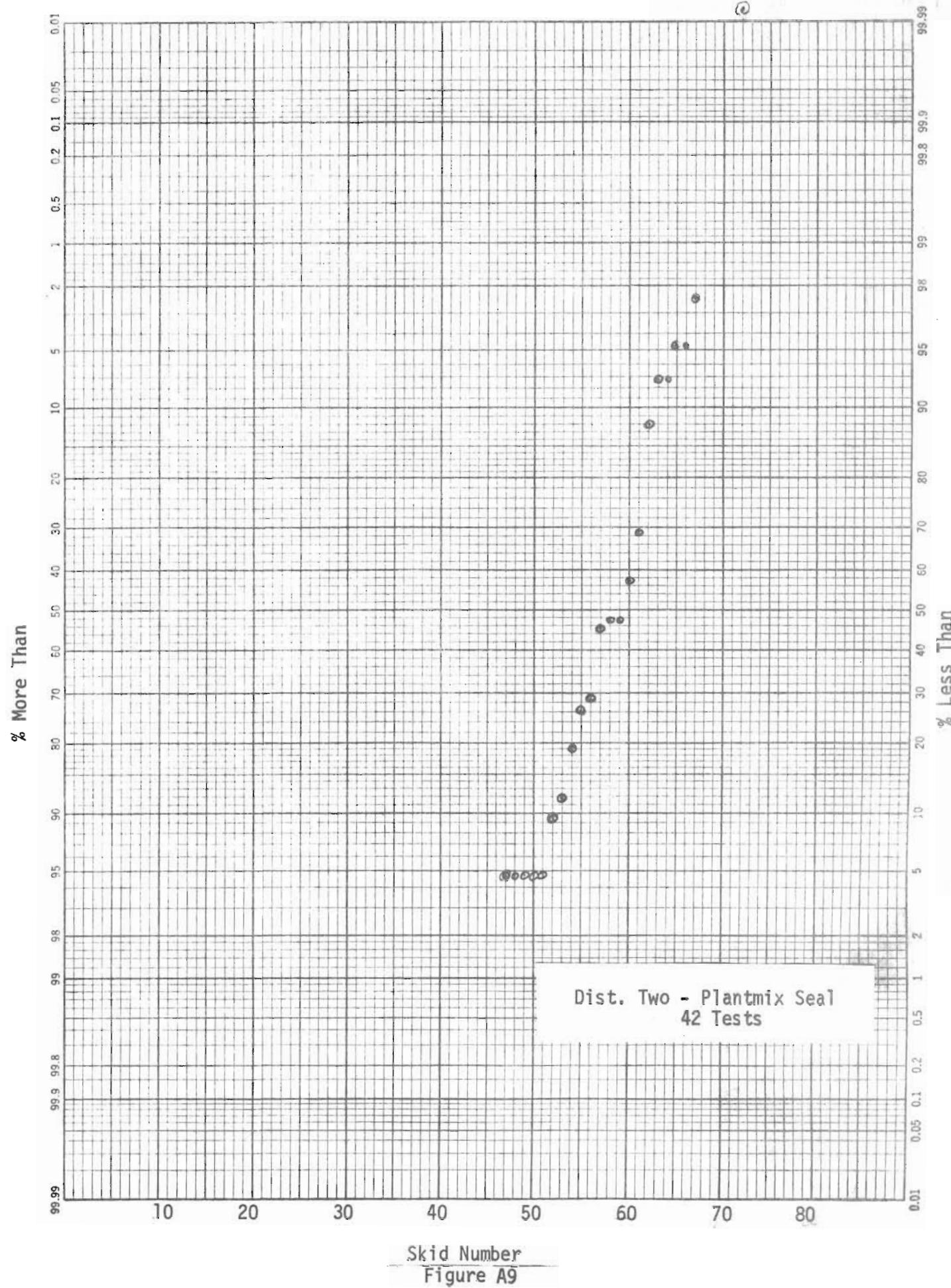
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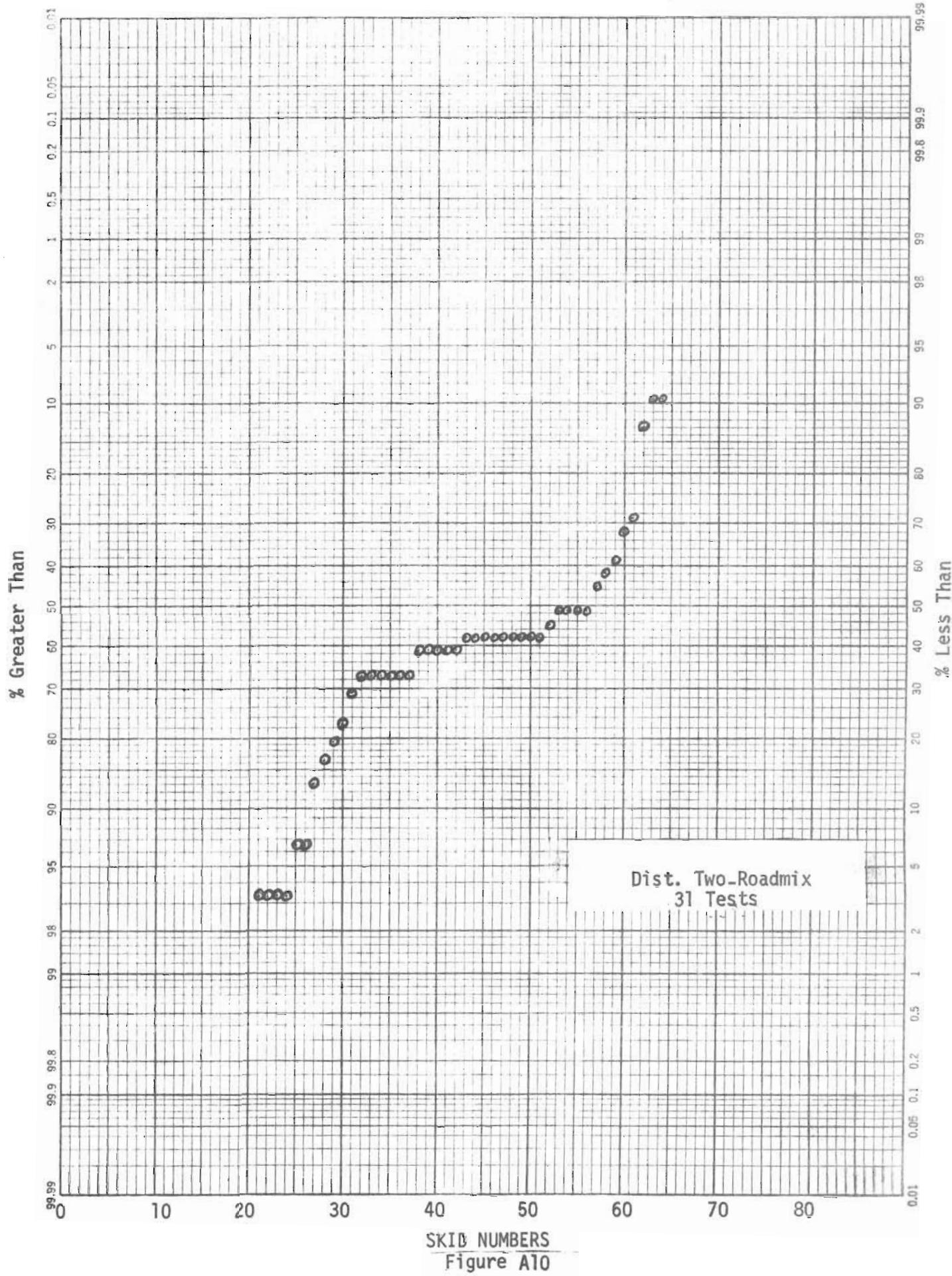
SKID NUMBERS
Figure A8



Skid Number
Figure A9

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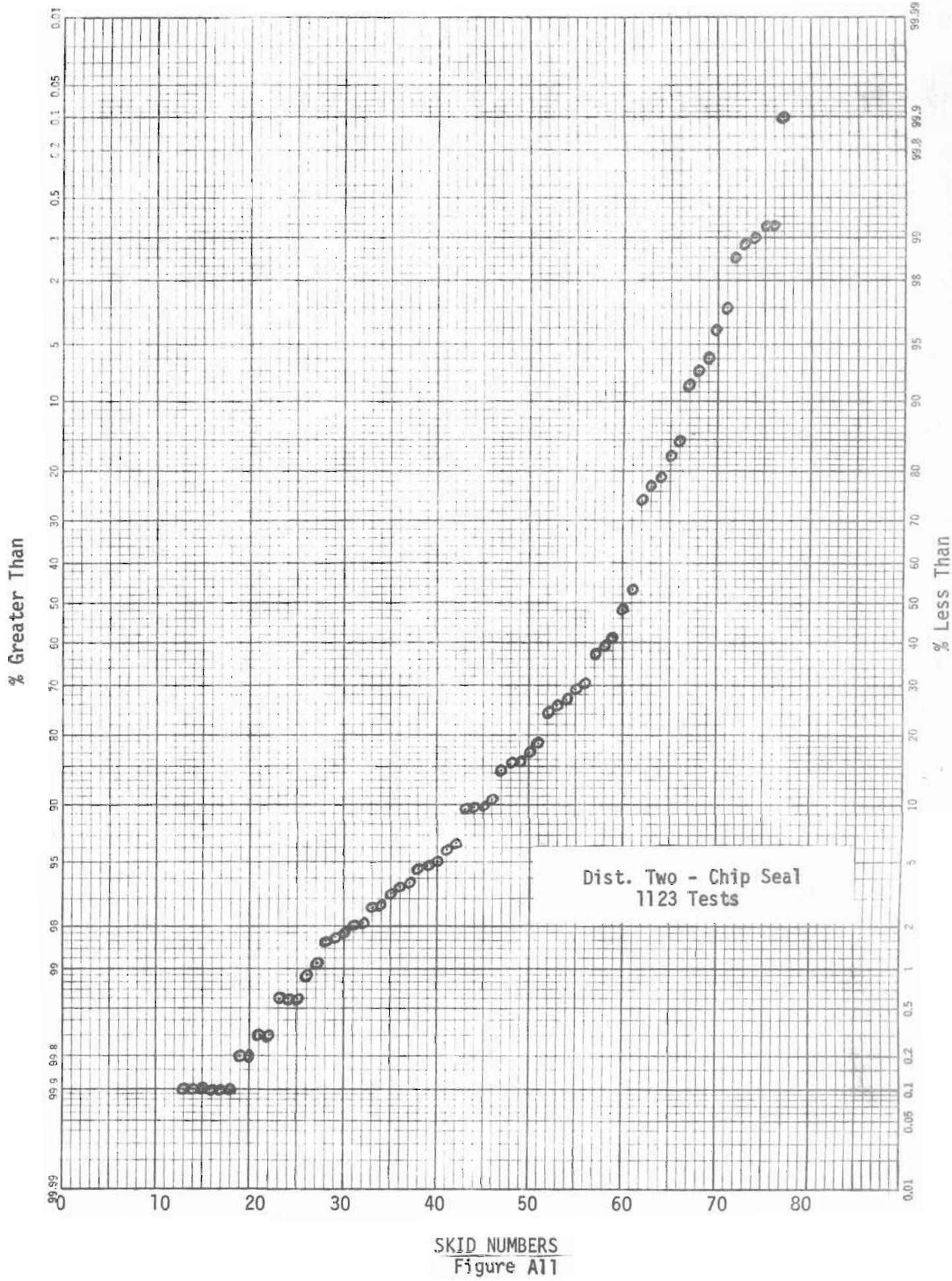
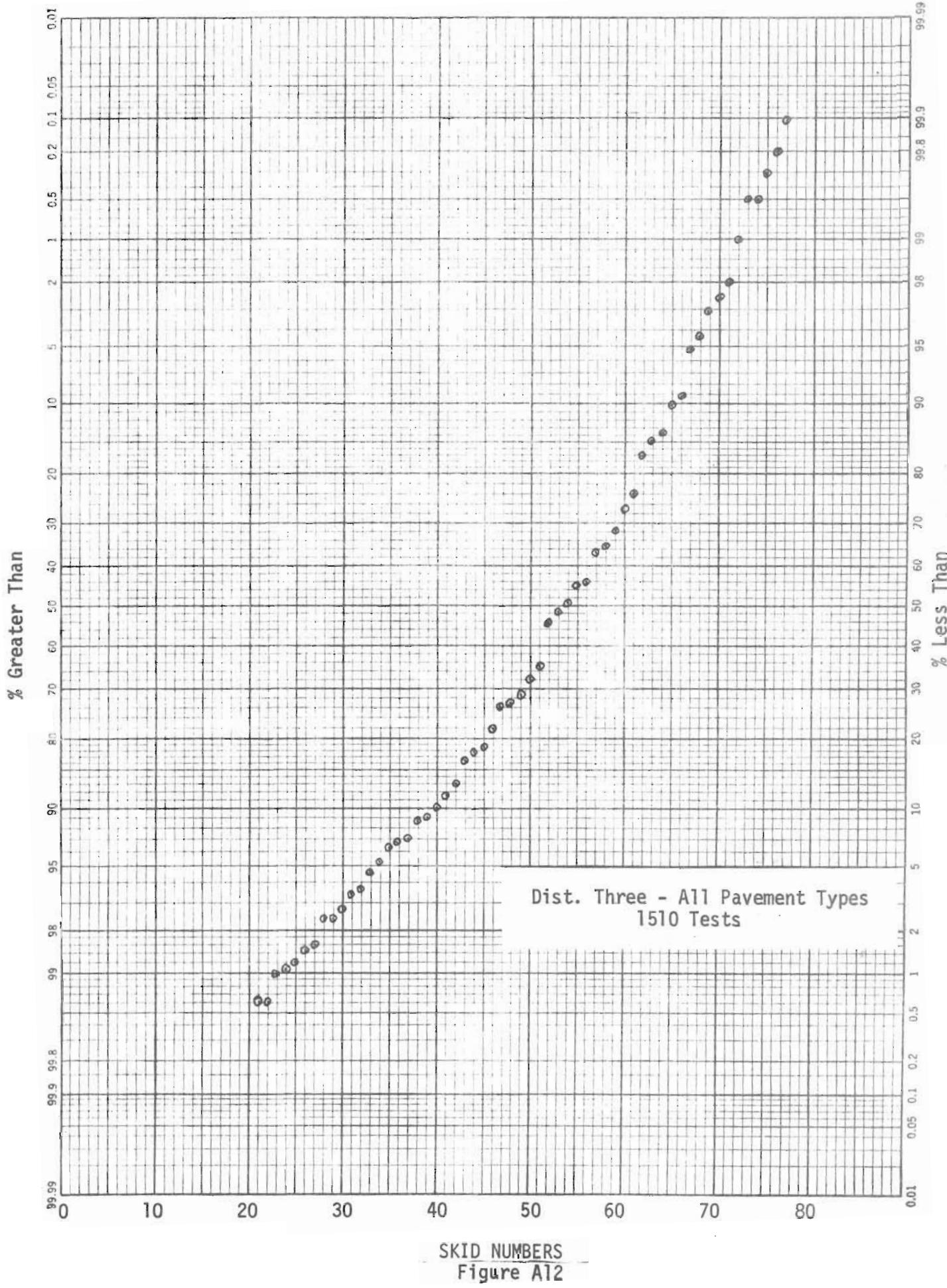
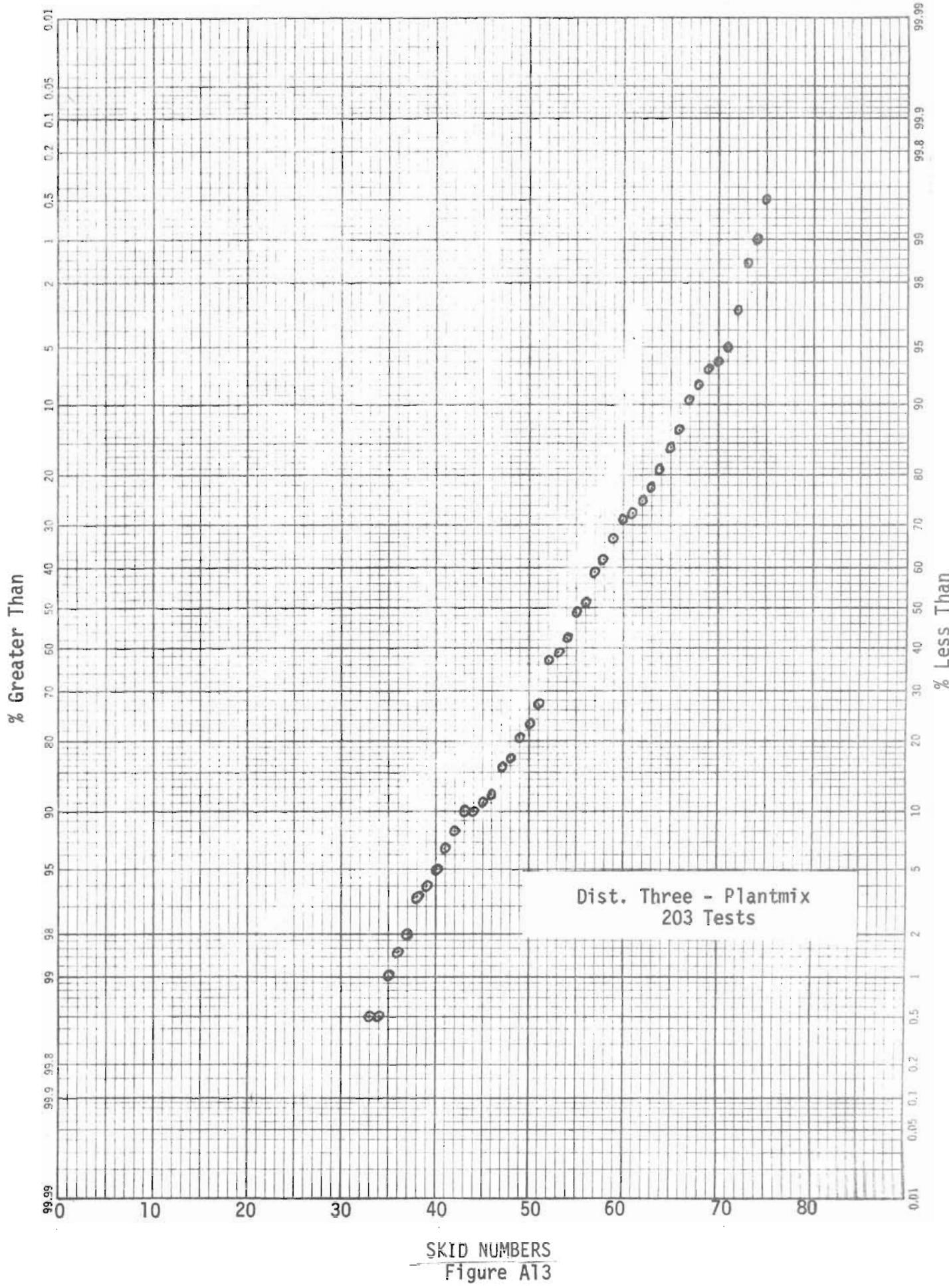


Figure A11



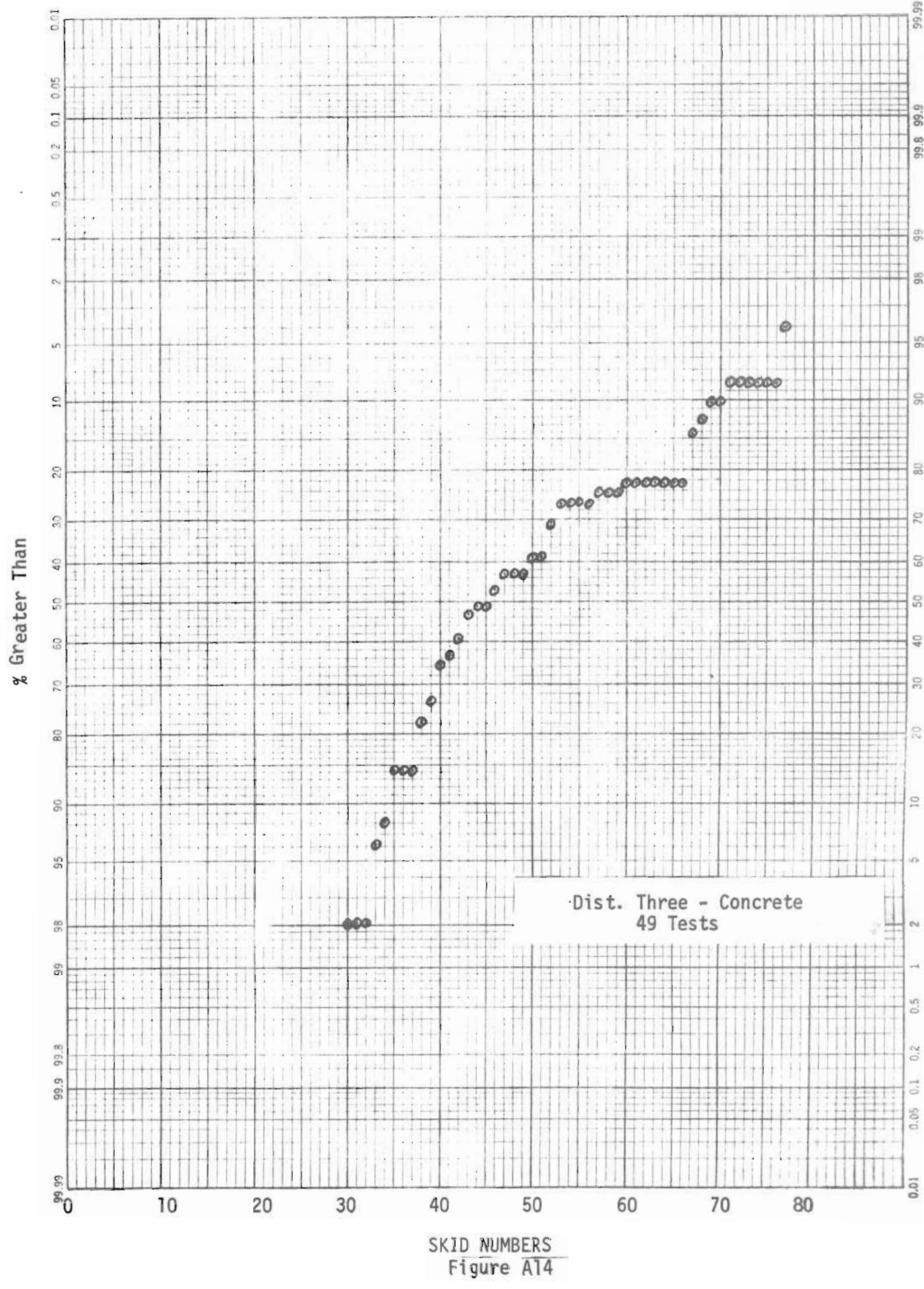
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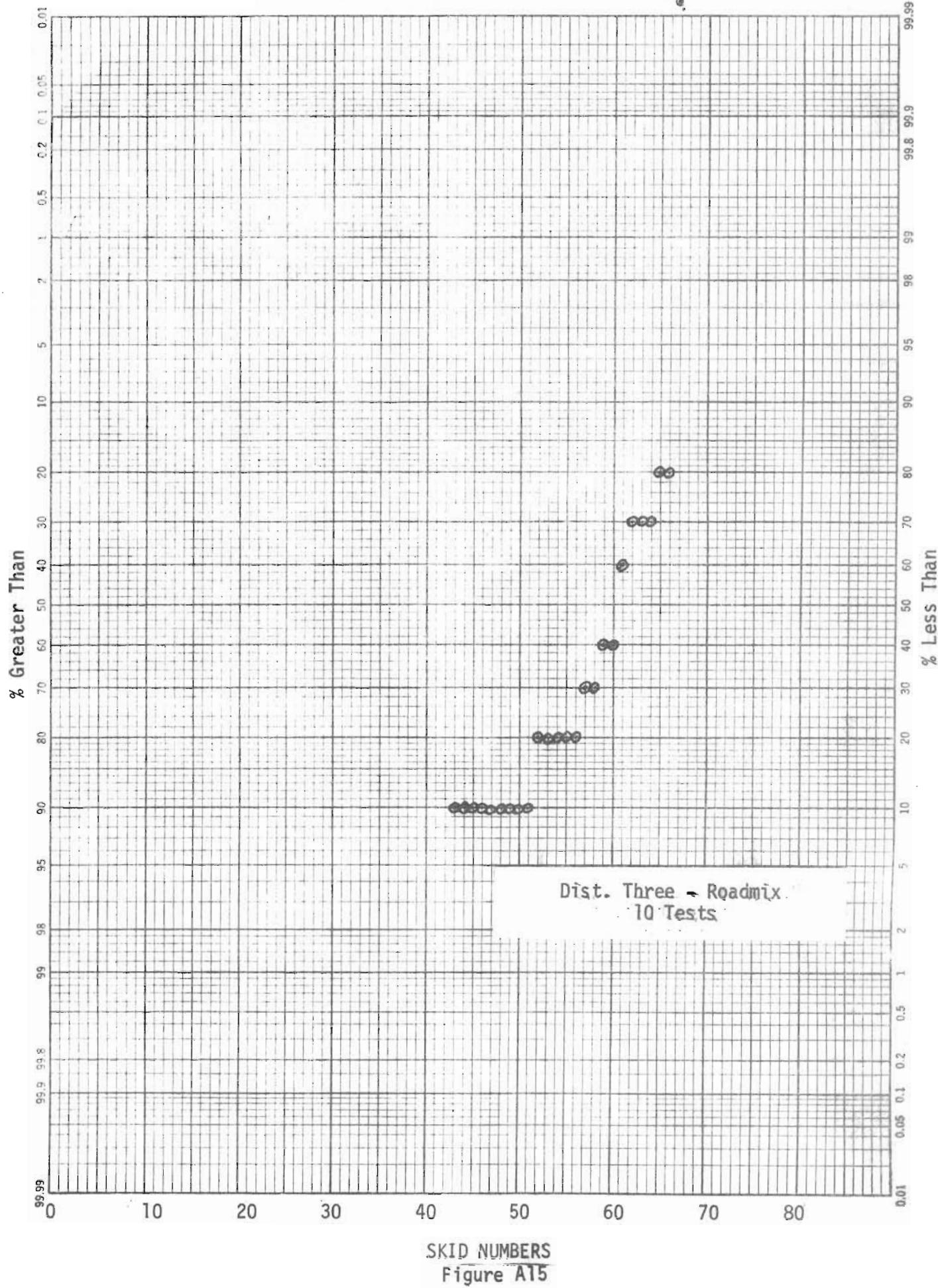
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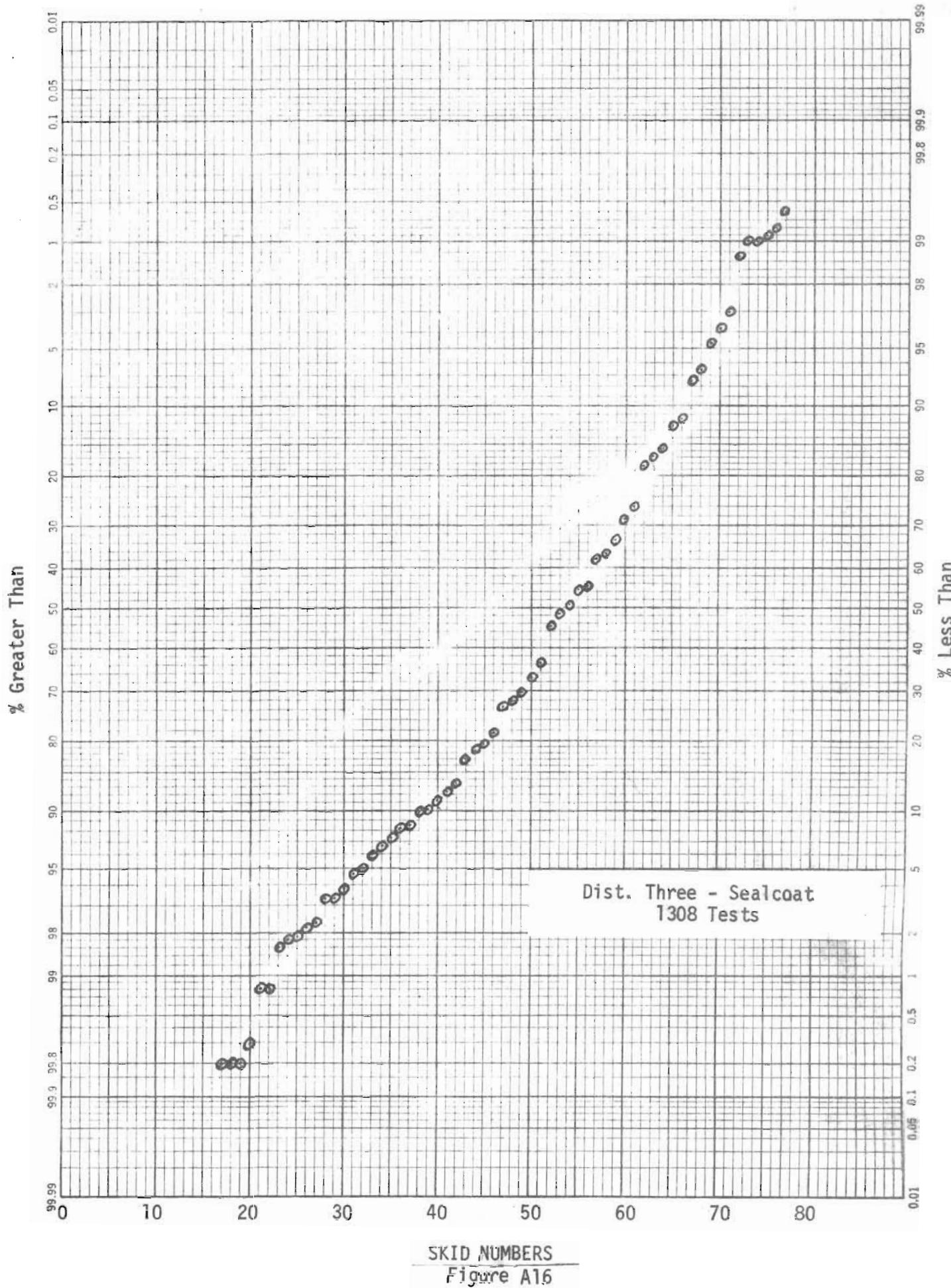
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SKID NUMBERS
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% Greater Than

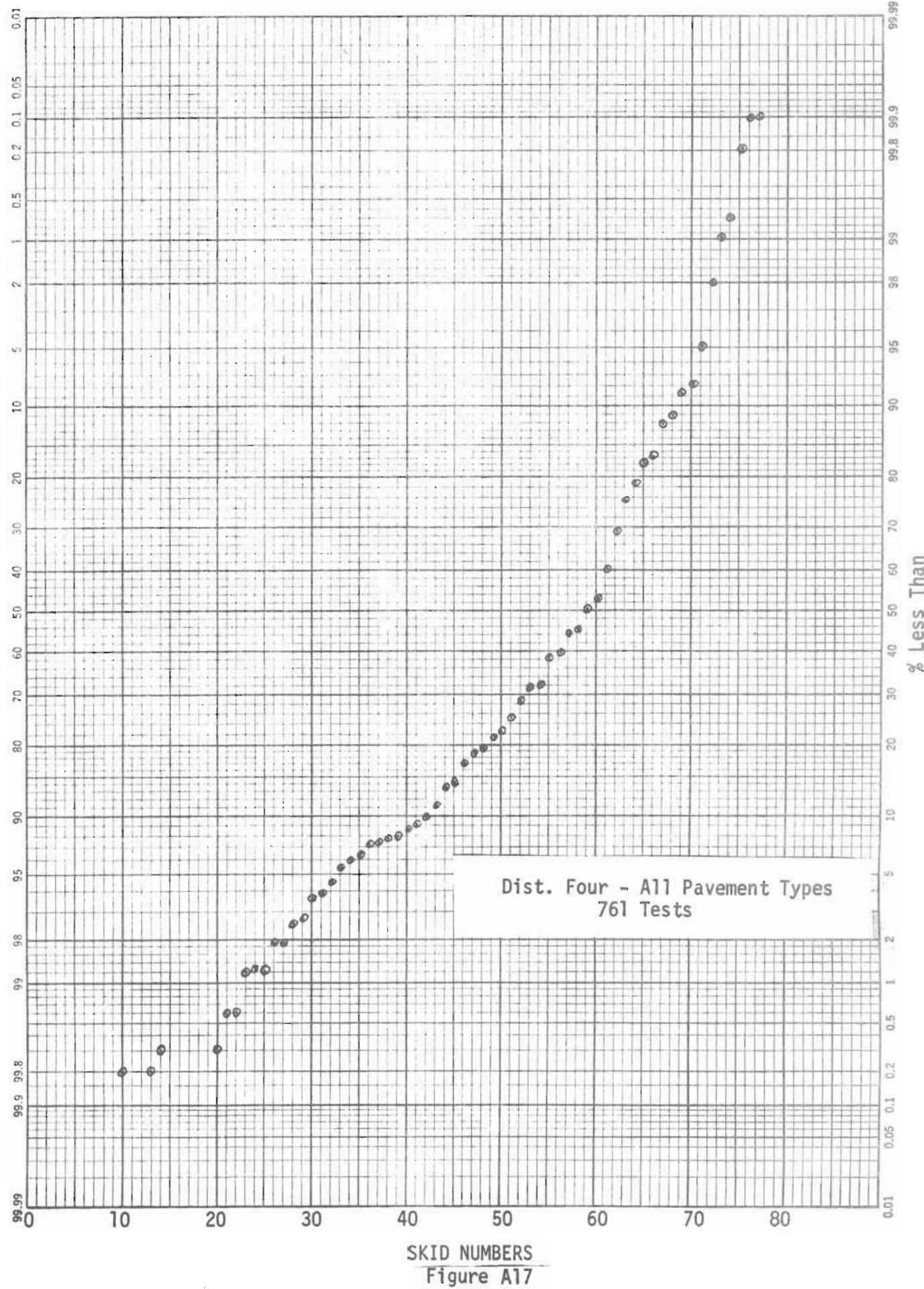
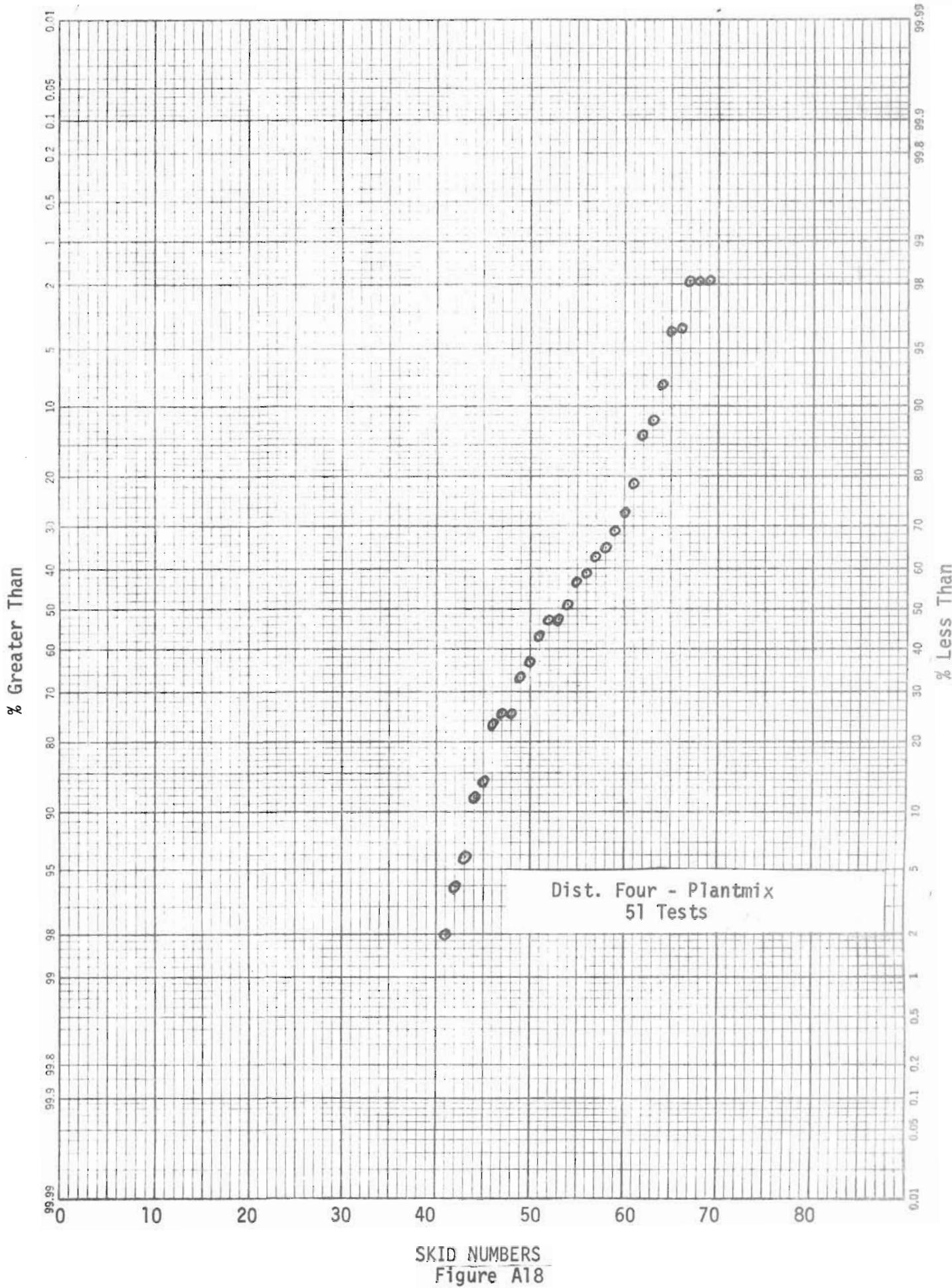


Figure A17



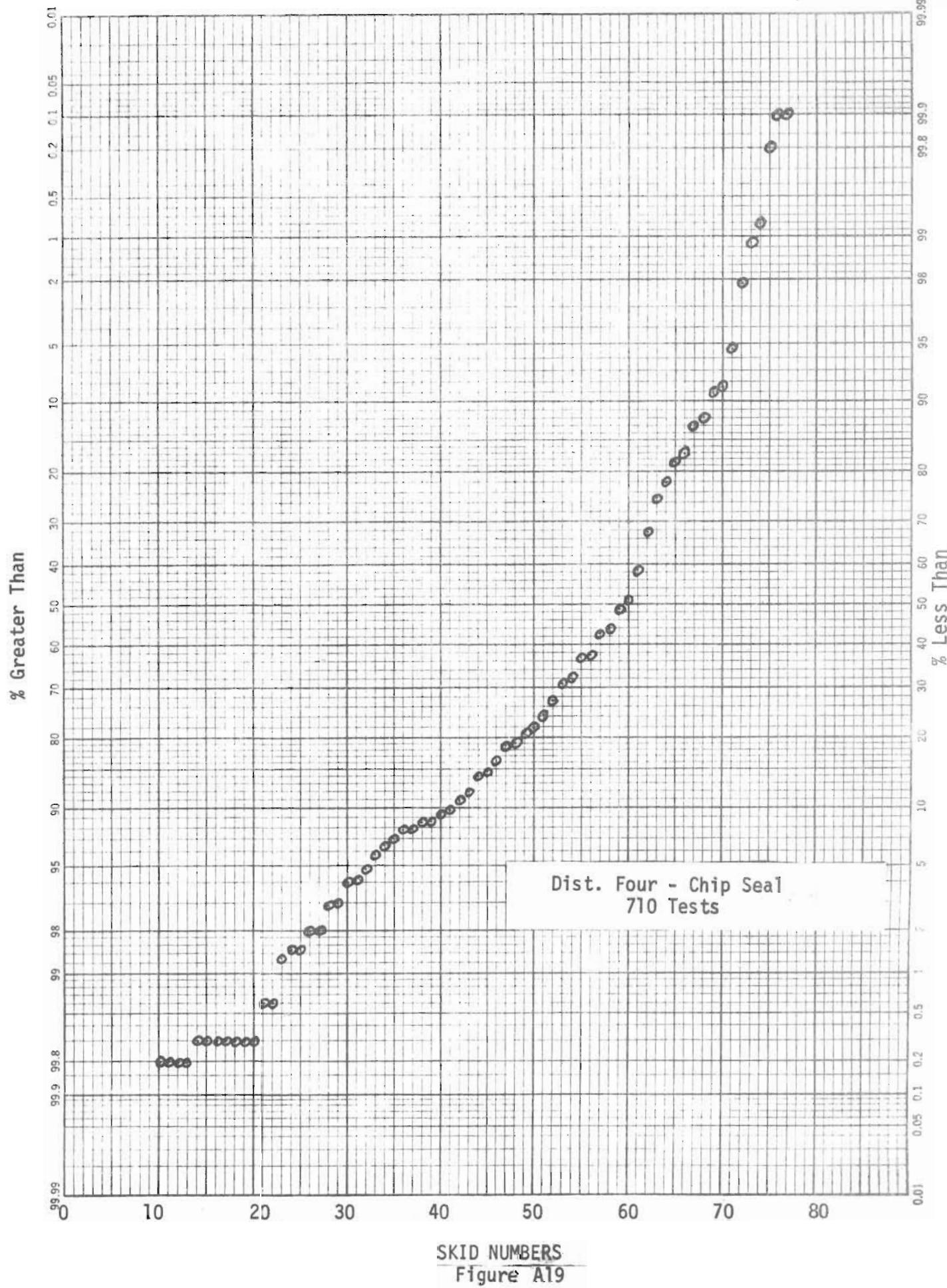
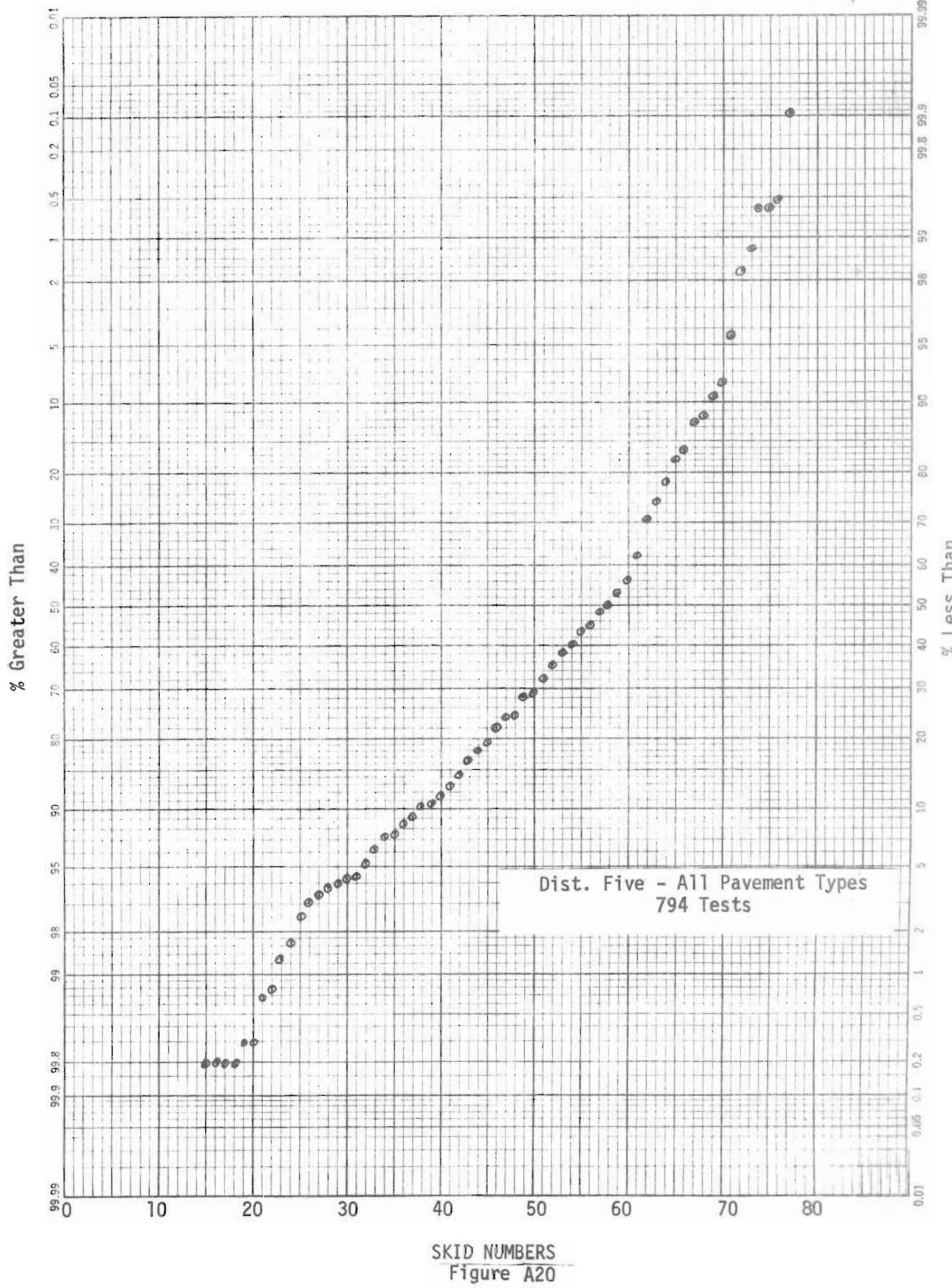
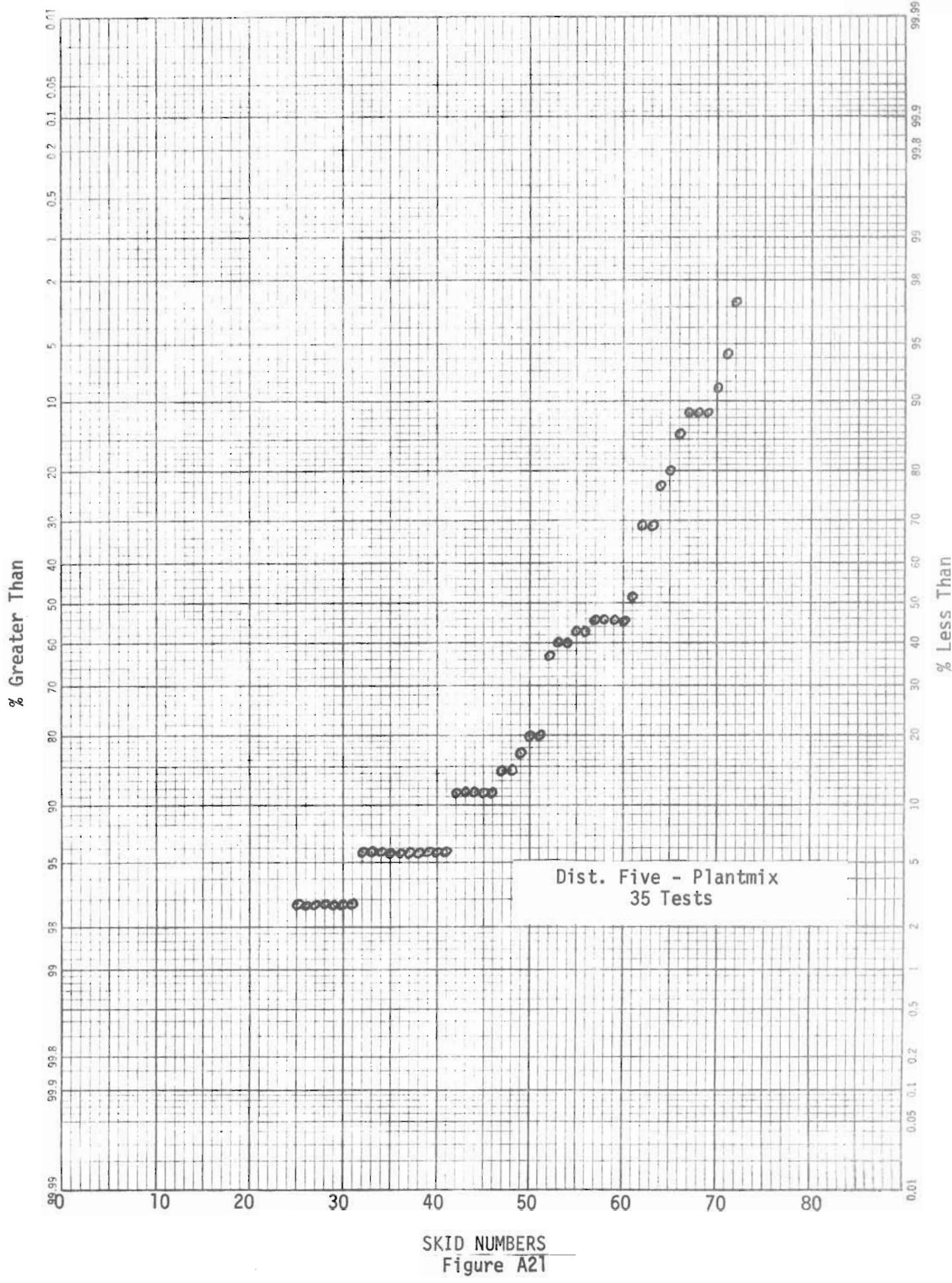


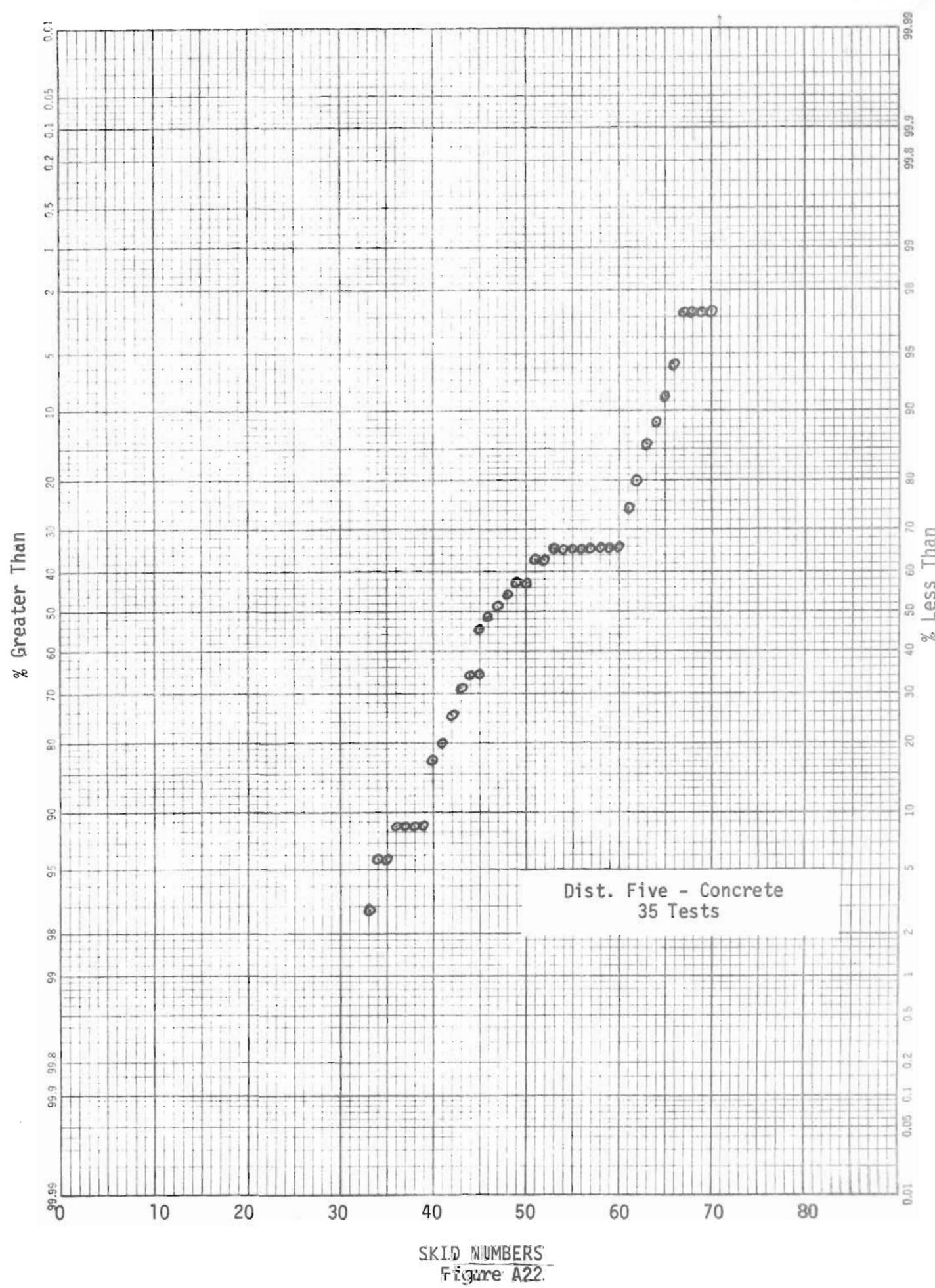
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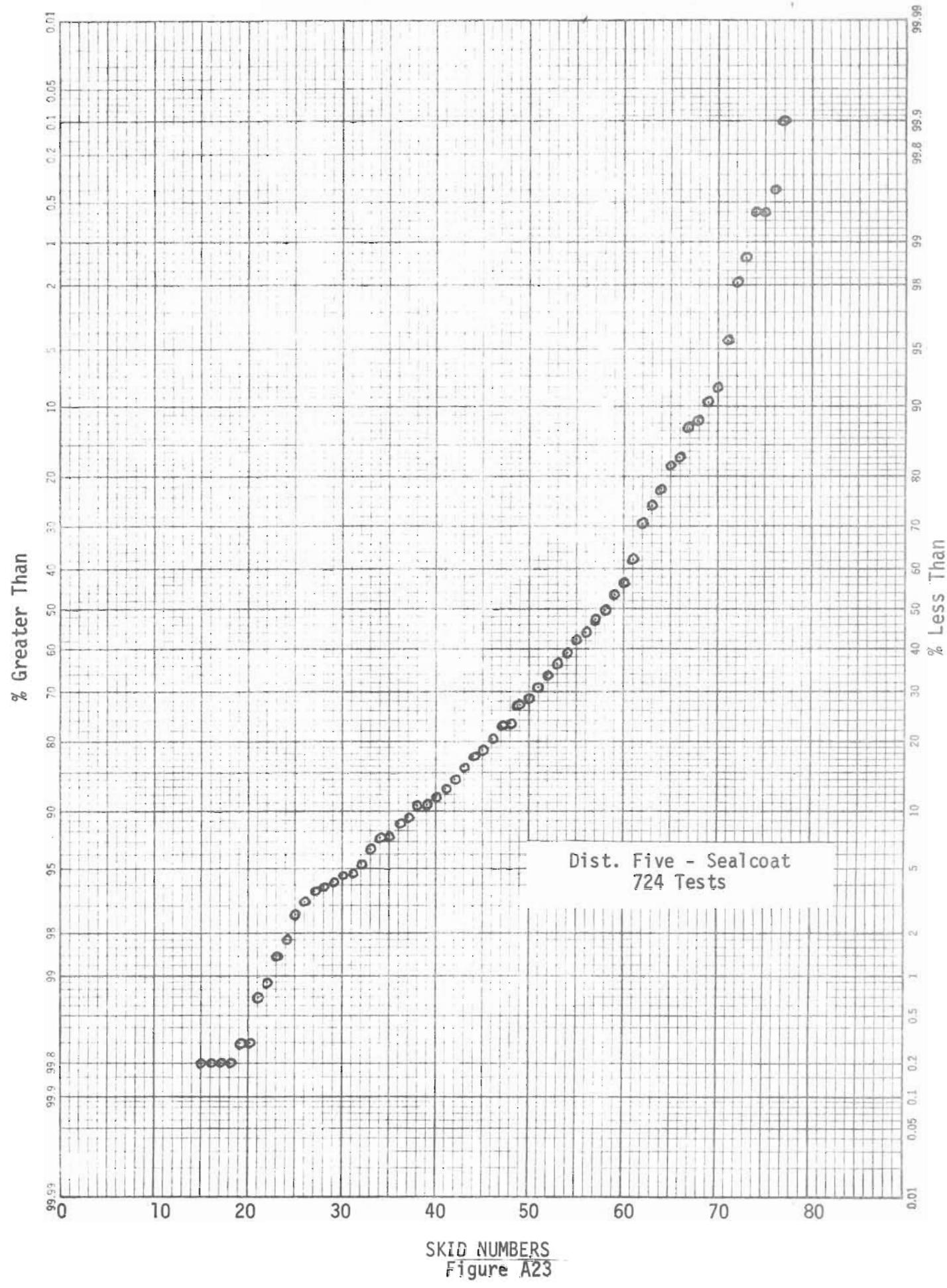
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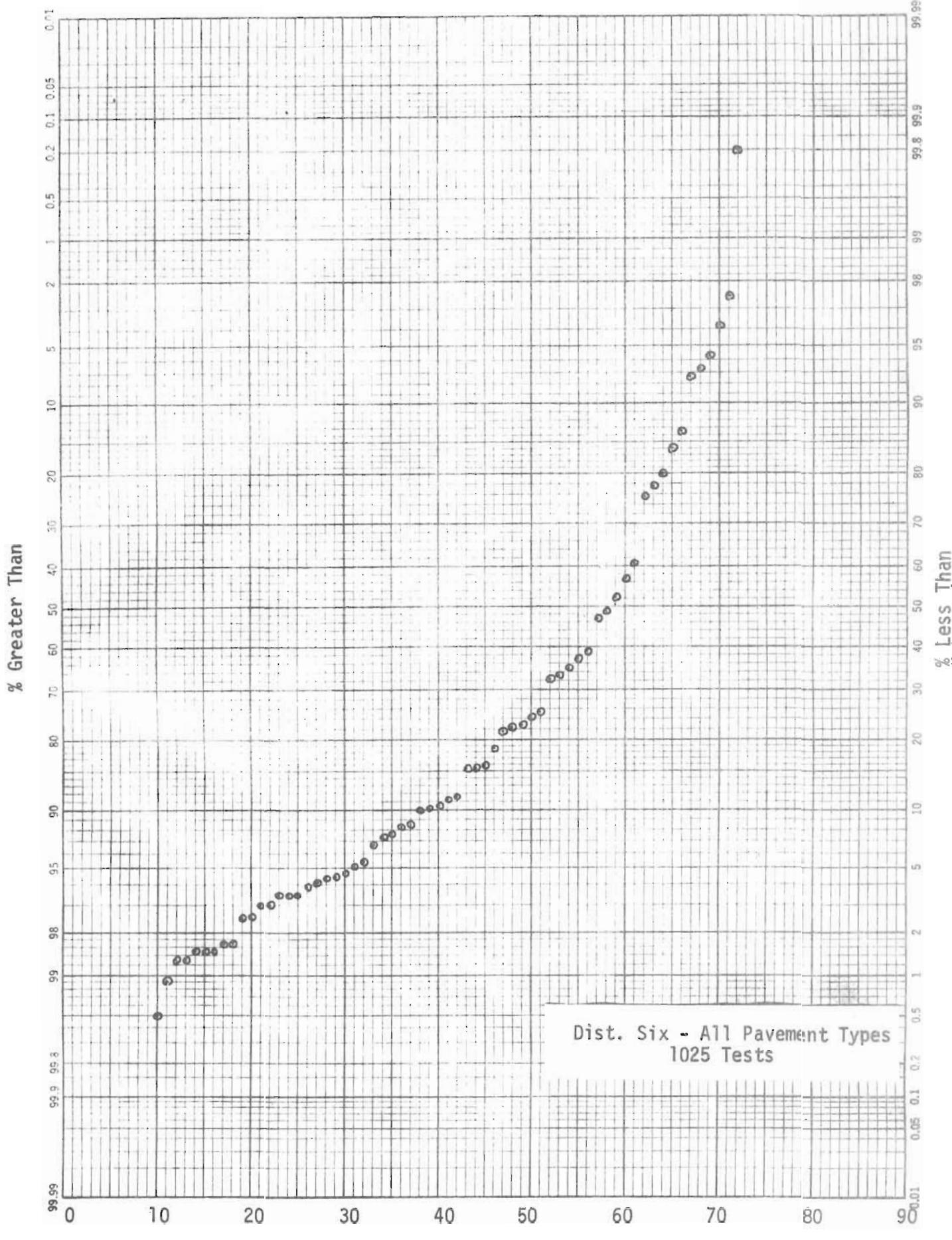
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SKID NUMBERS
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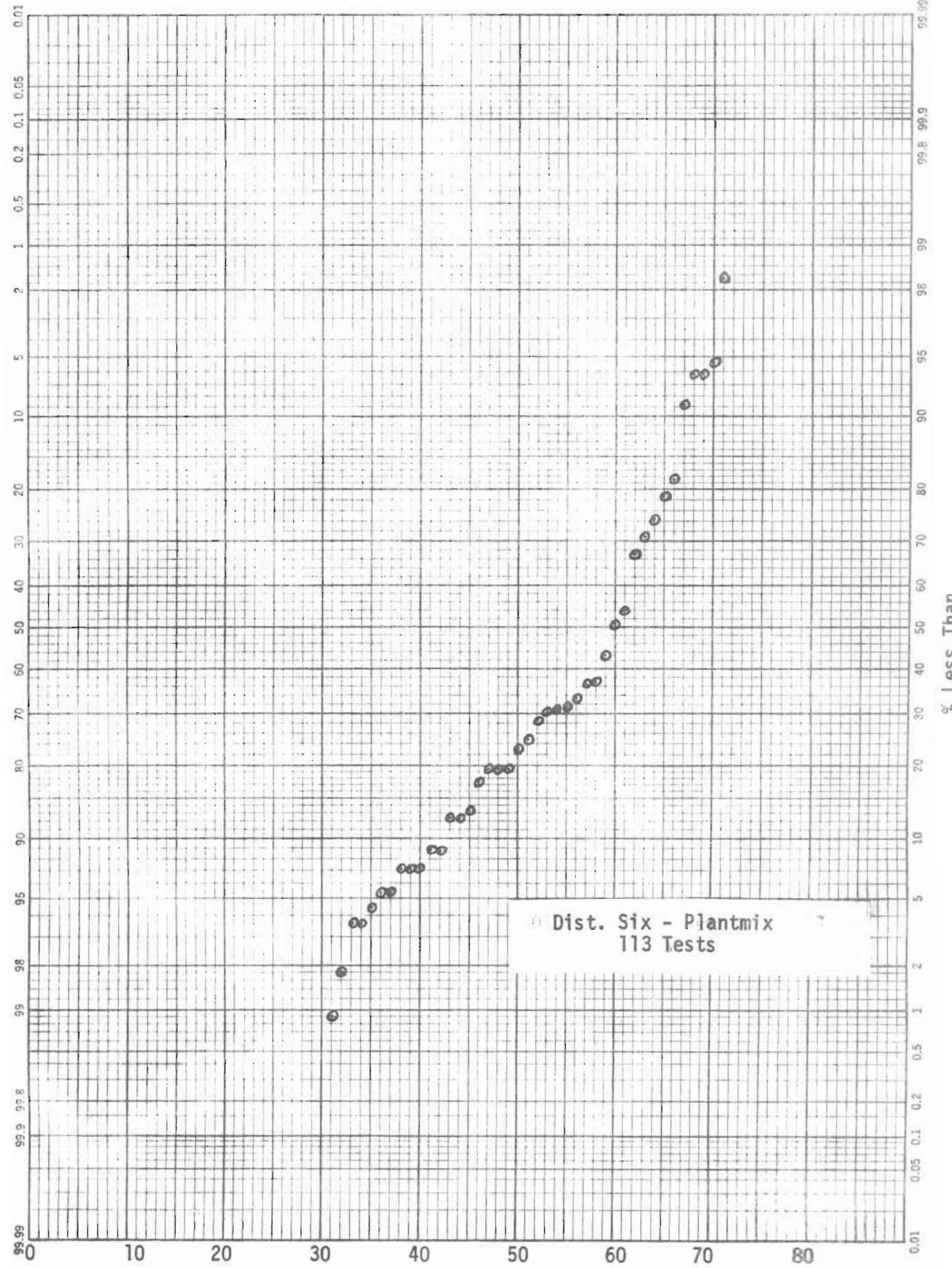


Figure A25

