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SUBJECT: Forwards comparison of draft STS w/snubber functional test sampling plan.

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April 3, 1980

Mr. H. K. Shaw
Engineering Branch, DOR
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Re: Snubber Functional Test
Sampling Plan

Dear Horace:

We have had an opportunity to review a draft Standard Technical Specification which includes a snubber functional test sampling plan which is somewhat similar to the plan I proposed to Mr. Dennis D. Davis on September 12, 1979.

The enclosed attachment is a comparison of these two plans, for your consideration. If you are not the right person to receive our comments, please pass this on and let us know who is.

If you have any questions concerning the attachment, please direct them to Larry Coggins who can be reached at 704-373-8249.

Very truly yours,

S. K. Blackley, Jr., Chief Engineer
Mechanical & Nuclear Division

DM Collings

D. M. Collings, Senior Engineer

LMC/asb

cc: C. Rosselle, EDS
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SNUBBER FUNCTIONAL TEST

SAMPLING PLAN EVALUATION

In evaluating the various sampling plans, two fundamental points should always be kept in mind:

1. The basis for acceptance of any sampling plan is a 95% confidence that 90-100 per cent of the snubbers are within calibration limits. This basis has broad acceptance and is used for both the Duke and draft plans.

2. Operability of the snubbers has already been established. The sampling plan is to provide confidence that the snubbers are within calibration limits.

Our goal is to explore the advantages and disadvantages of the draft plan versus those of the Duke plan. A brief description of the various plans follows.

The Duke plan requires an initial sample (n_1) of 35 with follow-on samples (n_f) of 17 for each out of calibration snubber, until the total number tested (n_t) equals 35 (1 + c/2) where c is the total number of out of calibration snubbers found.

There are two types of draft plans. The first requires a 10% sample plus follow-on samples of 10% for each out of calibration snubber. This plan is not considered workable for large populations and will not be discussed further. The second type of draft plan requires an initial sample of 35 (1 + c/2) plus follow-on samples of $35\,(1 + c/2)\left(\frac{2}{c + 1}\right)^2$ for each snubber above c not meeting the acceptance criteria. The plan requires preselection of an initial value of c, which we will call c_i.

A numerical comparison of these plans follows:

	Initial Sample (n_1)	Follow-on Samples (n_f)
Duke Plan	35	17
Draft Plan		
c_i = 0	35	140
c_i = 1	53	53
c_i = 2	70	35
c_i = 3	87	22
c_i = 4	105	17
c_i = 5	122	14
c_i = 6	140	12

The first-step in making an evaluation of these plans is to narrow the draft plan down to its viable alternatives. All initial values of c (c_i) greater than 4 have very large initial samples and do not provide adequate levels of protection if follow-on samples are required. Therefore, these c_i are not viable and will not be considered further. This relationship is shown in Figure 1.

Values of c_i of zero and one were also eliminated, based on the fact that even in very good populations there was a good chance of failing to pass the first test and with these large follow-on samples (140 and 53 respectively), the chance of passing the subsequent tests also was small. For example, if 2% of the population of 500 snubbers is out of calibration (that is, D/N - .02), a sample of 35 ($c_i = 0$) will be accepted 48% of the time, and if you find one bad snubber and test 140 more you will accept the second test only about three times in 100. Similarly, for $c_i = 1$, a sample of 53 will be accepted about 71% of the time, but if you find two bad snubbers in the first sample, you will accept the second sample only three or four times in 10. In our judgment, these two plans are too risky to consider viable.

Therefore, we have considered only draft plans with $c_i = 2$, 3, or 4 as being viable.

There are three overall objectives to be met by the sampling plan:

1. Reject bad lots.(1)

2. Accept good lots.

3. Minimize costs (downtime, testing costs, personnel exposure).

We will compare the draft plans versus the Duke plan to see how each stacks up against the three objectives.

<u>Rejecting Bad Lots</u>

Figure 2 shows the probability of accepting populations of 10% or more out of calibration snubbers for various initial values of c. The Duke plan corresponds to $c_i = 0$. As can be seen, the probability(2) of accepting bad lots decreases with increasing c_i. In <u>all</u> cases, the probability of accepting a bad lot is very small. For example, a population of 500 snubbers that is marginally acceptable (D/N = .10) will be accepted only about two times in 100 under the most liberal plan. A clearly unacceptable population with 20% out of calibration snubbers (D/N = .20) will be accepted only about three times in 10,000 under the most liberal plan.

Our conclusion is that all sampling plans reject bad lots with a high degree of confidence, but that the draft plans are marginally better at this than the Duke plan.

Accepting Good Lots

To have a reasonable chance of passing the first test under any plan, the population must be considerably better than the acceptance criteria. Figure 3 shows this relationship for the plans under consideration. For a population of 500 snubbers, to have a 50-50 chance of passing the first test, the population must have fewer than 4% out of calibration snubbers. For purposes of further comparison, we will take a "good" population as one with 2% out of calibration snubbers (D/N = .02).

Figure 4 plots the probability of acceptance versus the cumulative number of snubbers tested. The Duke plan exceeds the draft plan in probability of accepting good lots for $c_i = 2$ and $c_i = 3$, and appears to roughly coincide with $c_i = 4$ in this respect. (For information, an approximation of the 10% plus 10% sampling plan is included to show that it operates poorly on large populations.)

Our conclusion is that all plans under consideration are capable of accepting good lots with a high degree of confidence. However, for any given number tested, the Duke plan is somewhat more efficient than the draft plans.

Minimizing Costs

The cost of plant downtime is extremely high. The cost of excessive testing and unnecessary personnel exposure are also to be considered in evaluating the plans. Therefore, any sampling plan that requires more testing than is necessary to provide an acceptable level of protection is not justifiable.

Figure 5 shows the probability of testing exactly a given number for each plan under consideration. Using this information, Figure 6 has been developed which shows the expected average number of snubbers tested 96 per cent of the time. The remaining four per cent are those low probability cases requiring a large amount of testing. As can be seen from Figure 6, the Duke plan will average 48 snubbers tested while the draft plans require averages of 73, 84, and 105 respectively.

Our conclusion is that the Duke plan is considerably more effective than all of the draft plans in minimizing costs.

Summary

We have shown that all plans establish the required level of protection that was established as the basis for acceptance.

We have also shown that the draft plans require more testing that the Duke plan. The only observable benefit from this additional testing is a marginally lower chance of accepting a bad lot (Figure 2). This slim benefit does not justify testing an average of 1.5 to 2 times as many snubbers than is required, especially since the Duke plan achieves the acceptance basis.

Our final conclusion is that the Duke plan is the optimal plan because it requires only the amount of testing necessary to guarantee adequate protection.

NOTES:

(1) The term "lots," as used in this paper, should be taken to mean "population of snubbers."

(2) The probabilities in this paper are calculated from the basic laws of probability for the hypergeometric probability distribution. For more detailed explanation of the methods used, contact L. M. Coggins at 704-373-8249.

Form 184 (5-76)

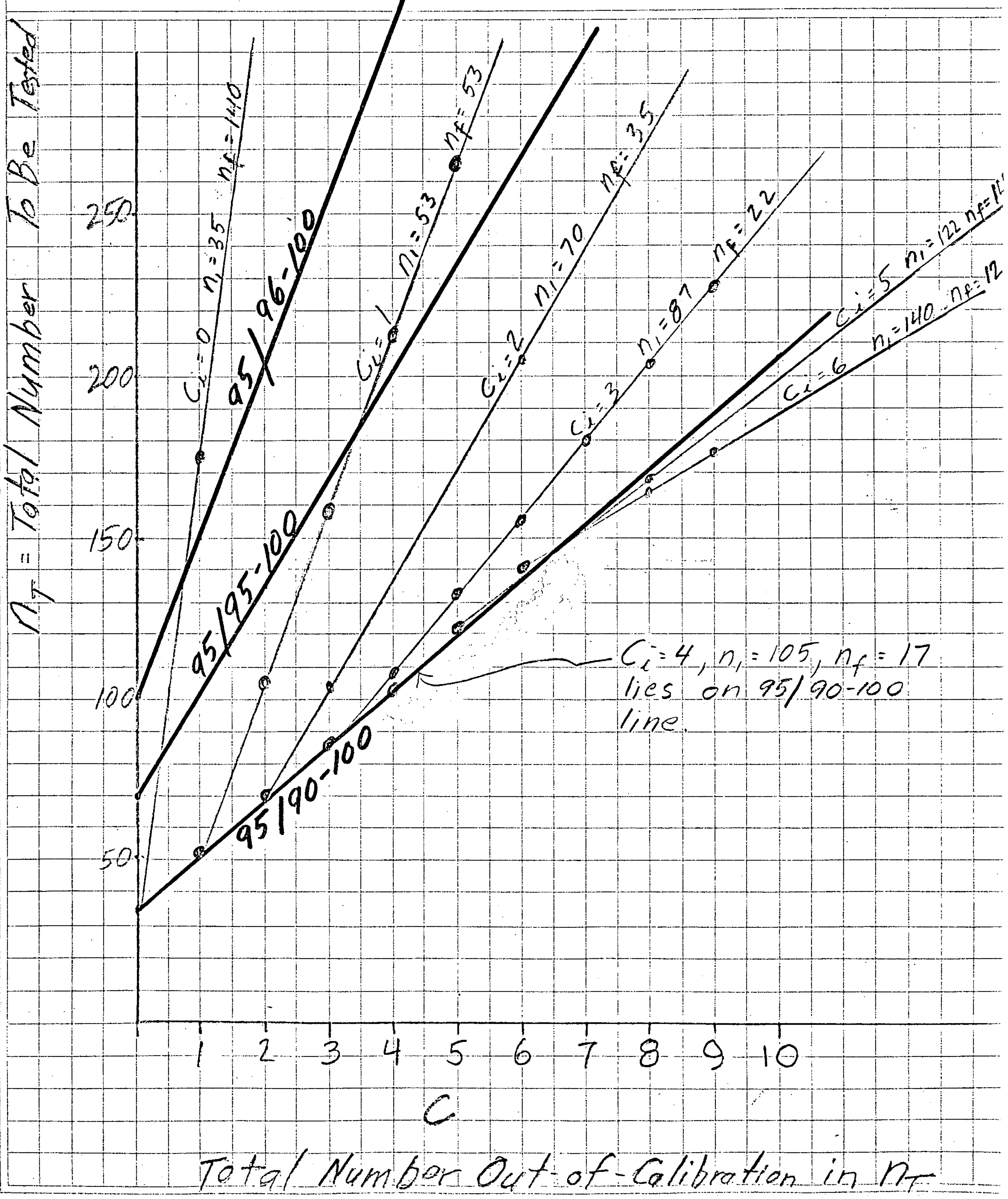
FIG. 1

Dev./Station ______ Unit ____ File No. ______

Subject: Confidence Limits of Sampling Plans

______ By ______ Date ______

Sheet No. ___ of ___ Problem No. ______ Checked By ______ Date ______



Form 134 (5-76)

FIG. 2

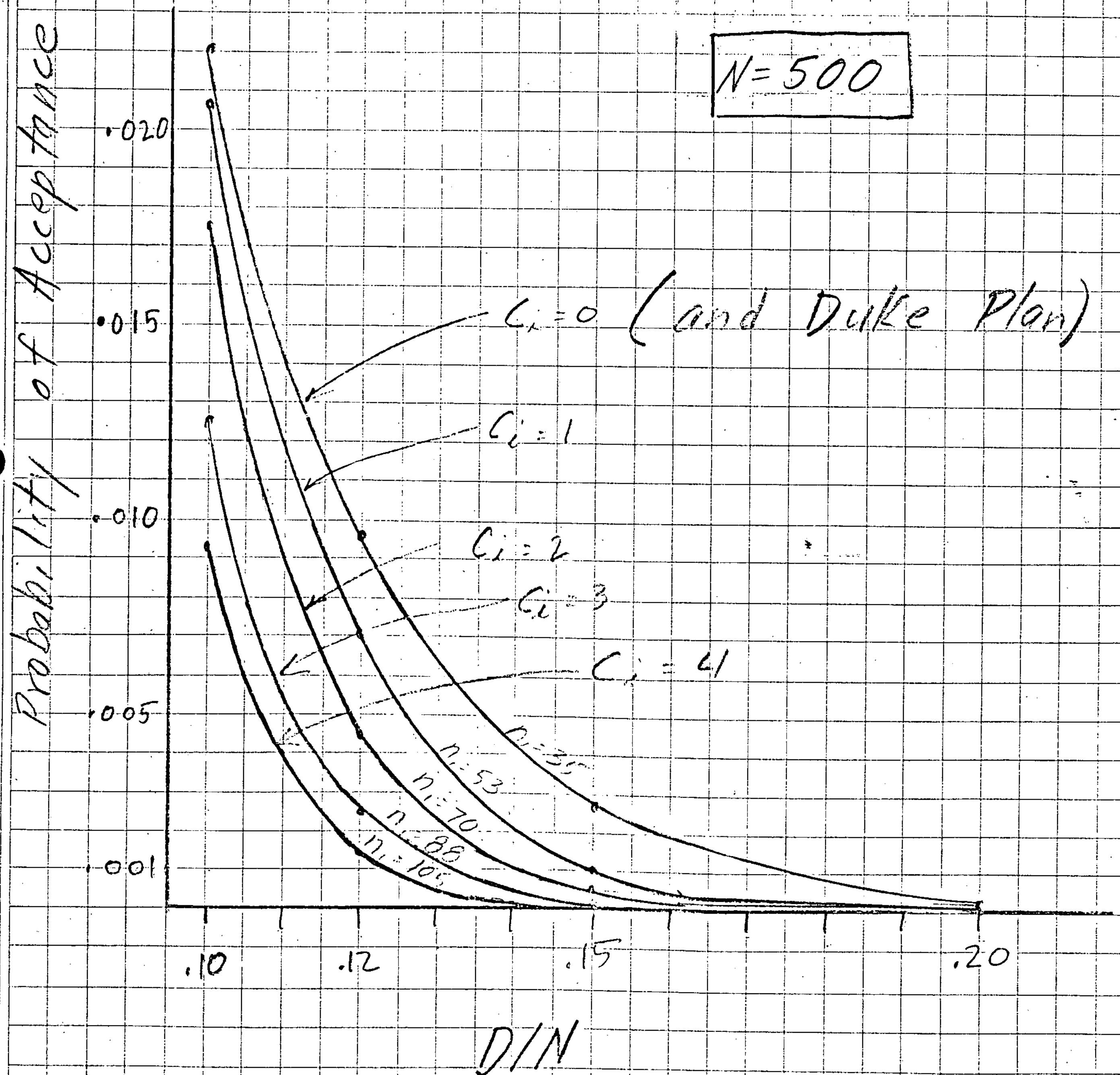
Dev./Station ____ Unit ____ File No. ____

Subject ____

By ____ Date ____

Sheet No. ____ of ____ Problem No. ____ Checked By ____ Date ____

Probability of Passing Bad Lot on First Test



Fraction of Out-of-Calibration Snubbers in the Population

Form 184 (5-76)

Fig. 3

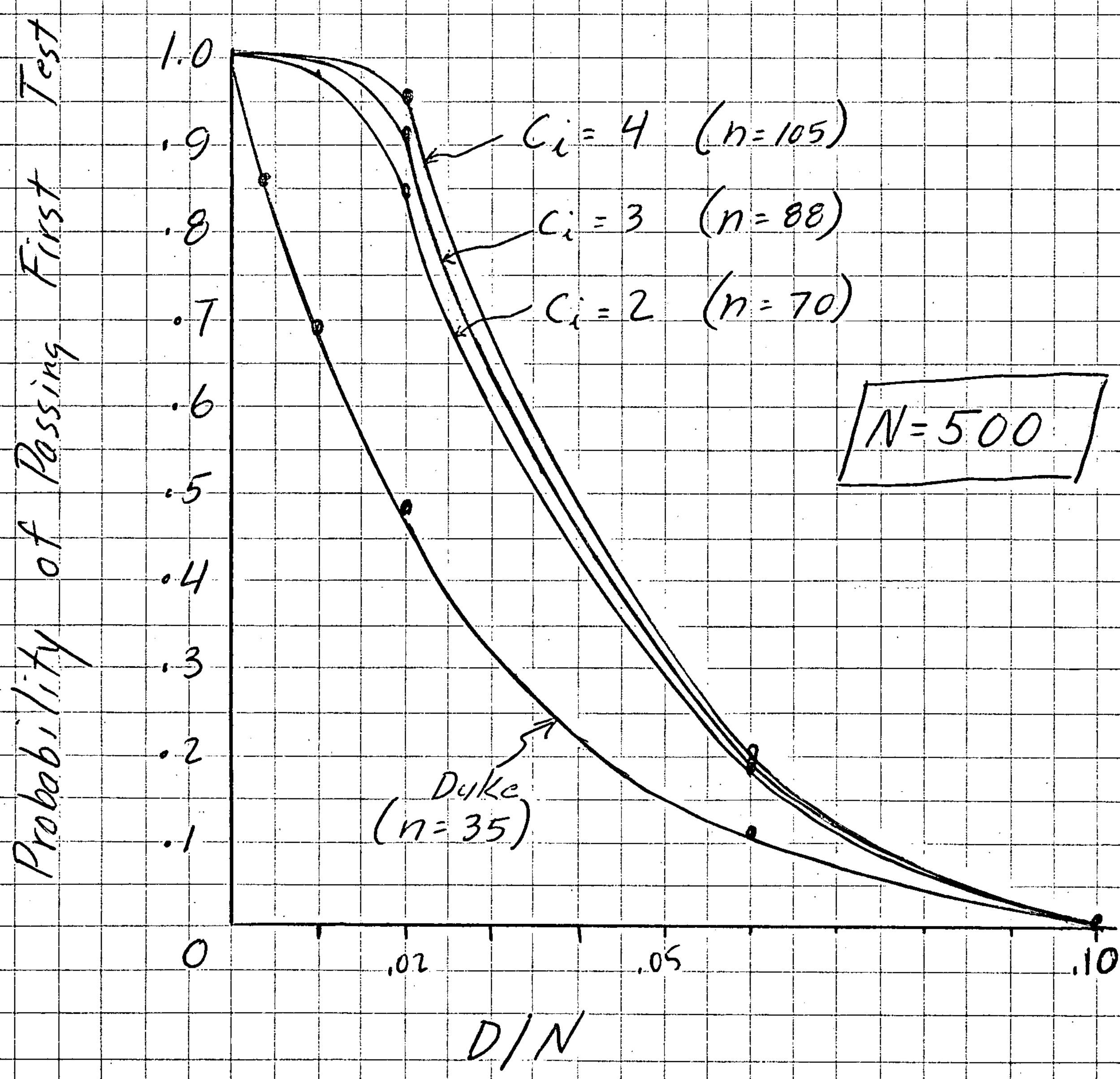
Dev./Station ______ Unit ______ File No. ______

Subject ______

By ______ Date ______

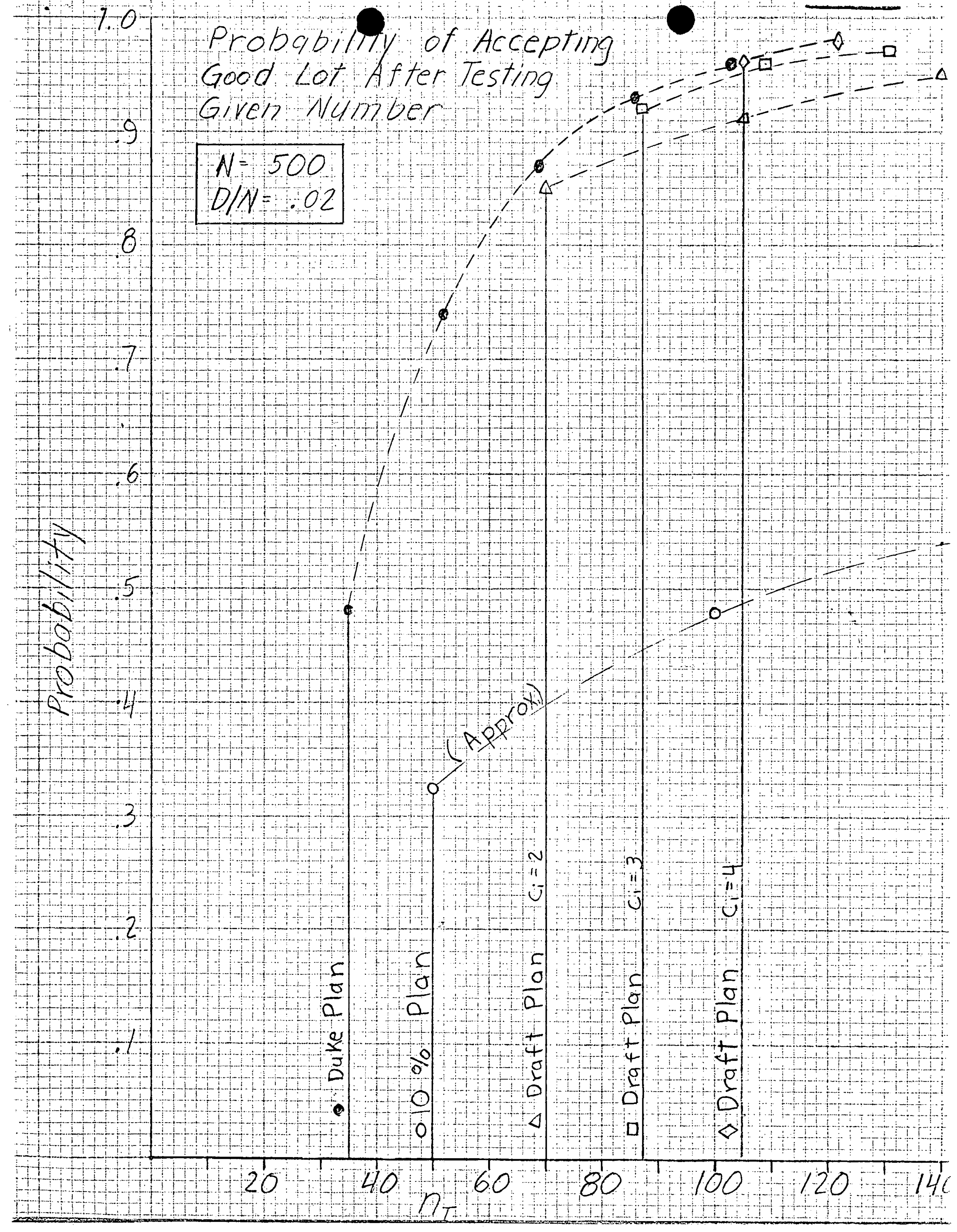
Sheet No. ___ of ___ Problem No. ______ Checked By ______ Date ______

Probability of Accepting Good Lots on First Test



Fraction of Out-of-Calibration Snubber in Population

FIG. 4



Probability of Accepting Good Lot After Testing Given Number
N = 500
D/N = .02
Probability
n_T
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
20
40
60
80
100
120
140
(Approx.)
● Duke Plan
○ 10 % Plan
△ Draft Plan $c_1 = 2$
□ Draft Plan $c_1 = 3$
◇ Draft Plan $c_1 = 4$

Form 184 (5-76)

Fig. 5

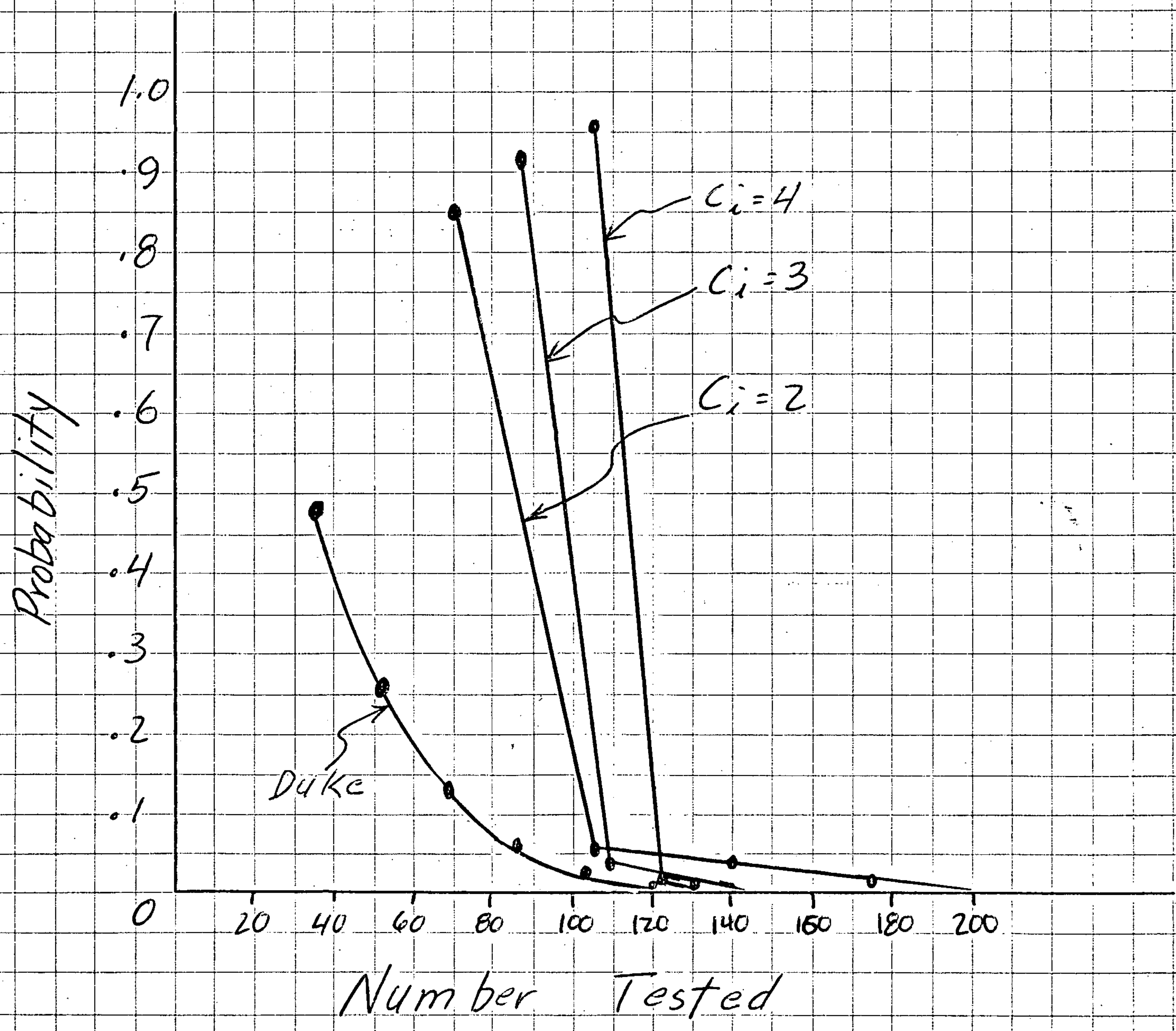
Dev./Station ______ Unit ______ File No. ______

Subject ______

______ By ______ Date ______

Sheet No. ___ of ___ Problem No. ______ Checked By ______ Date ______

Probability of Testing Exactly a Given Number



Form 134 (5-76)

Fig. 6

Dav./Station ______ Unit ____ File No. ______

Subject ______

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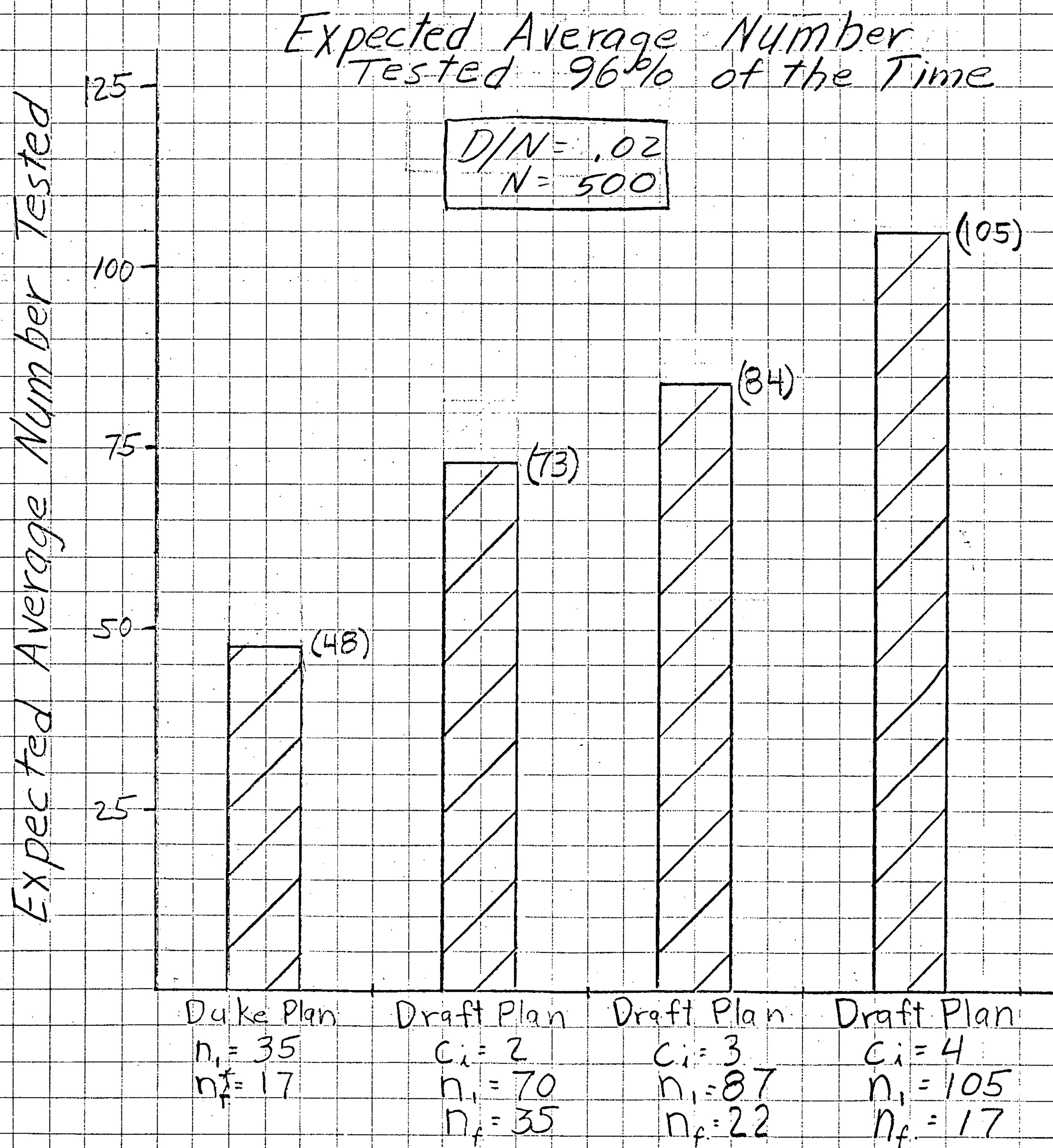

* n_f = follow-on sample size