SAMPLING PLAN FOR VISUAL REINSPECTION OF WELDS

NOTICE

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1. INTRODUCTION

1.1 Background

The Nuclear Construction Issues Group (NCIG) was formed by several utilities for the purpose of developing a common approach to issues at nuclear power plant construction sites.

The first issue considered by NCIG covers visual acceptance criteria for inspection of completed structural welds. The resolution of that issue is contained in document NCIG-01, "Visual Weld Acceptance Criteria for Structural Welding at Nuclear Power Plants" (VWAC) and in the NRC letter to NCIG dated June 26, 1985. The development of VWAC involved the participation of a number of different Utility Companies and Architect/Engineers.

A Training Manual, NCIG-03, has been developed to provide a common basis for training of the Inspectors responsible for final acceptance inspection of completed structural welds using the NCIG-01 Acceptance Criteria.

The Acceptance Criteria of NCIG-01 and the guidelines and inspection principles contained in NCIG-03 are also applicable to reinspections of welds.

1.2 Purpose and Scope

The purpose of this Sampling Plan is to provide a uniform basis for conducting reinspections using the Acceptance Criteria of NCIG-01.

The Engineer[1] will identify the structures to which the NCIG-01 Acceptance Criteria will be applied in conjunction with this Sampling Plan. Examples of typical structures to which these criteria apply include, but are not necessarily limited to, steel components such as:

- Main building frame members and connecting members;
- Supports for equipment, components and piping,[2] cable trays and conduit, and HVAC ducts;
- Miscellaneous steel including bracing and stiffeners; embedments; stairways and handrails; doors and door frames; window frames, gratings; covers, etc.

1.3 Implementation

Each Project is responsible for reviewing NCIG-01 to assure that its use is consistent with the design and analysis of the structures to be reinspected. The Engineer is responsible for specifying the structures to which this Sampling Plan will be applied. The application and distribution of the Acceptance Criteria and this Sampling Plan shall be controlled in accordance with applicable document control procedures.

The Acceptance Criteria contained in NCIG-01 are intended to be used for final acceptance inspections and any later reinspections of completed structural welds. When approved by the Engineer, these Acceptance

(1) The Engineer, as used in this document, is the individual or the organization designated by the Owner as being responsible for the design of the structures being welded or inspected.

(2) Excluding component supports stamped in accordance with the ASME Code, Section III, Subsection NF.

Criteria are also applicable to the reinspection of welds which have been previously inspected using NCIG-01 or other acceptance criteria. With the concurrence of the Engineer, coated welds may be reinspected without removal of the coating for presence, location, length, size, profile and splatter. For reinspection of the other weld attributes in NCIG-01, the Engineer must evaluate the characteristics of the attribute being inspected in relation to the thickness and properties of the coating in developing a procedure or approach for the subject reinspections.

A reinspection procedure through coated welds must demonstrate the validity of the inspection method to provide acceptance of the coated welds. As an alternative to developing and qualifying an acceptance procedure for the reinspection of coated welds, the Engineer may specify that welds which exhibit the designated attribute shall have the coating removed and reinspected to determine acceptance. Welds which do not exhibit the attribute being reinspected shall be considered acceptable. A qualified procedure or removal of the coating is required for reinspection of cracks if the reason to reinspect for cracked welds occurred prior to the coating of the weld. Thick coatings for fire protection, architectural finishes, insulation or excessive dry film thickness which may mask the weld attribute shall be removed before the reinspection of the weld.

Visual weld reinspections are to be performed by qualified personnel. These reinspections are to be performed in accordance with Project Procedures and the Project Quality Assurance Program.

Other sampling plans using different approaches may also be suitable for reinspection of welds with the purpose of assessing the quality of a population of structural welds. It is not the intent of this document to preclude the development of other sampling plans.

1.4 Plan Summary

These Sampling Plans have been developed to provide a uniform method of reevaluating and accepting a large population of structural welds which have already been inspected and accepted, without the need to perform a 100% reinspection. The need to sample is based on the premise that someone (inspector, NRC, or other) has raised questions regarding the weld acceptability. The use of these plans will allow evaluation of the problem by review of a reasonable sample of the population in question.

Two sampling plans are recommended in this document: the single plan and the multiple plan. The sampling plan to be used is chosen before reinspection. Once sampling has commenced, the sampling plan cannot be changed during reinspection.

For the single plan, the sample size is 58 welded connections or components chosen at random from the population. The minimum sample size for the multiple plan is 64. For both plans, if all the sampled items meet the requirements of VWAC, the entire population is considered acceptable and sampling stops. For the single plan, if one or more VWAC discrepant items are found in the sample of 58, and for the multiple plan, if three or more VWAC discrepant items are found in the sample of 64, both an engineering evaluation of

discrepancies and their root cause analysis are required to determine population acceptance. A population is accepted if every discrepancy found is acceptable and the root cause analysis shows that there are no generic problems. Only for the multiple plan and when there are only one or two VWAC discrepancies in the sample of 64 is there the option of enlarging the sample and accepting the population by only evaluating the found discrepancies without doing a root cause analysis. Again in this case found discrepancies should be acceptable and the number of VWAC discrepancies should be less than three before the population is accepted. Not requiring a root cause analysis is reasonable in this case because of the limited number of VWAC discrepancies found in the cumulative sample.

The above description of the sampling plans is meant as a summary of these plans and does not contain all the details. For both plans the sampling procedure provides 95% confidence and 95% reliability when the population is accepted by using VWAC without any evaluation. When the VWAC inspection criteria are met, the design criterion is met. When discrepant welded items are evaluated by engineering analysis described in Paragraph 2.9 and found to be acceptable using a single plan, there is a 95% confidence that 95% of the items in the population meet the project design criteria. For the multiple plan, the reliability at 95% confidence level is even better than 95%.

1.5 Contents

This document contains three Sections and an Appendix. Section 2 defines the terms used in this

document. Section 3 contains the sampling procedure. Appendix A provides a commentary on the Sampling Plans.

2. DEFINITIONS

This section contains definitions of special terms used in the Sampling Plan.

2.1 Inspection Item

An inspection item is defined as either a welded connection or a component consisting of welded members and connections designed to carry loads.

2.2 Discrepant Weld, Discrepant Item

A discrepant weld is a weld that does not meet VWAC in one or more attribute(s) specified for reinspection. A discrepant item is an inspection item which has one or more discrepant welds.

2.3 Population, N

A population (lot) is a collection of the inspection items determined by the Engineer to be suitable for reinspection collectively under the Sampling Plan.

2.4 Cumulative Sample Size, n

The cumulative sample size is the portion of the population which is selected for reinspection pursuant to Paragraph 3.

2.5 Cumulative Number of Discrepant Items, d_n

This is the cumulative number of discrepant items observed in the sample n.

2.6 Percent Discrepant, p

The percent discrepant, p, is the proportion of discrepant items in the population expressed in percent.

2.7 Acceptance Number, a_n

This is the maximum cumulative number of discrepant items in the sample that permits acceptance of the population with no further sampling.

2.8 Rejection Number, r_n

This is the minimum cumulative number of discrepant items in the sample which does not permit population acceptance without engineering evaluation of discrepancies to determine population acceptability.

2.9 Engineering Evaluation

An evaluation made on individual discrepant items in the sample to determine acceptability of items to carry their loads. Depending on the nature of discrepancies, the scope of this evaluation varies from documenting judgment to carry loads within design allowables to detailed evaluations wherein actual loads, representative or actual material properties and detailed analysis are used.

2.10 Inaccessible Item

An inaccessible item is one for which excessive dismantling, access-related activities or radiation exposure would be required to perform a reinspection.

Inaccessibility is determined by the Engineer on a case-by-case basis.

If a portion of the population is coated and the coating is required to be removed by the Engineer before reinspection, the painted weld may be classified by the Engineer as inaccessible when other randomly selected welds are available.

2.11 Symbols

An alphabetical listing of symbols used is as follows:

a_n = Acceptance number

d_n = Cumulative number of discrepant items

N = Population size

n = Cumulative sample size

p = Percent discrepant

r_n = Rejection number

3. SAMPLING PROCEDURE

This section describes procedures for the specification of population and the selection of sampling plan type and gives details for implementing each of the selected sampling plans.

3.1 Population and Reinspection Attributes

On the basis of concerns necessitating a sampling evaluation of certain structural welds, the Engineer will define the population of welded connections or welded components which collectively constitute the population from which samples are to be taken. For example, all the horizontal to vertical welded connections in cable tray hangers constructed by a specific organization within a certain time span may be considered as a population. Alternatively, depending on the scope of concerns on the construction for the same situation of hangers, the Engineer may elect to consider individual hangers as the inspection items and describe the population by counting the hangers rather than specific connections in the hangers.

The Engineer will specify the specific attributes which are to be considered in the reinspection of samples from the population. The list of weld attributes to be reinspected need not include all weld attributes for which acceptance criteria are given in the VWAC.

3.2 Sampling Plan Type

Either the single sampling plan in Paragraph 3.3 or the multiple sampling plan in Paragraph 3.4 shall be used. Once sampling has commenced, the sampling plan shall not be changed.

3.3 Procedure for Single Sampling Plan

The flowchart for this sampling plan is given in Figure 1. The sample size n equals 58. The corresponding acceptance and rejection numbers are $a_{58} = 0$ and $r_{58} = 1$, respectively. The steps of the procedure are as follows.

Step 1

From the specified population N, select 58 inspection items at random.

Step 2

Reinspect the selected inspection items for specified attribute(s) using the acceptance criteria of VWAC. For each inspection item which is considered inaccessible for reinspection, another randomly selected alternative item shall be substituted in the sample. The number of discrepant items in this sample of 58 is identified as d_{58}.

Step 3

Compare the number of discrepant items d_{58} to the acceptance number zero.

a. If the number of discrepant items is zero, stop sampling and accept the population.

b. If the number of discrepant items d_{58} is one or more, an evaluation of discrepancies as described in Step 4 is necessary before population acceptability can be determined.

Step 4

Determine population acceptability by evaluating observed discrepancies.

a. If all d_{58} discrepancies are evaluated as acceptable and if a root cause analysis of these discrepancies does not indicate any generic problems, the population is accepted.

b. If any of the d_{58} discrepancies fail engineering evaluation or if any generic problems result from the root cause analysis of discrepancies, the population cannot be accepted on the basis of the present sampling reinspection. Appropriate corrective action shall be determined using Project Procedures. This may include 100% reinspection for unacceptable discrepant conditions and repair or evaluation on a case-by-case basis. If the root cause is determined to affect only a small portion of the original population, 100% reinspection may be limited to this portion of the population.

3.4 Procedure for Multiple Sampling Plan

This is a three-stage sampling plan. The cumulative sample size at each stage and the corresponding acceptance/rejection numbers are given in Table 1. Figure 2 exhibits the flowchart of the plan. The steps of the procedures are as follows.

Step 1

Identify 64 inspection items randomly selected from the population N. This process represents a Stage 1 sample in Table 1 where n = 64 and values of

acceptance/rejection numbers are $a_{64} = 0/r_{64} = 3$, respectively.

Step 2

Reinspect the selected inspection items for specified attribute(s) using the acceptance criteria of VWAC. For each inspection item which is considered inaccessible for reinspection, another randomly selected alternative item shall be substituted in the sample. The number of discrepant items observed in the first sample of size 64 is designated as d_{64}.

Step 3

Compare the number of discrepant items d_{64} to the acceptance and rejection numbers (0, 3) applicable to the first stage in Table 1.

a. If the number of discrepant items d_{64} is less than or equal to zero, stop sampling and accept the population.

b. If the number of discrepant items d_{64} is one or two, take one of the following actions.

   (i) Continue sampling by going to Step 5.

   (ii) Stop sampling and determine population acceptability by evaluating found discrepancies as described in Step 4.

c. If the number of discrepant items d_{64} is three or more, determine population acceptability by evaluating found discrepancies as described in Step 4.

Step 4

Determine population acceptability by evaluating d_{64} observed discrepancies.

a. If the engineering evaluation of d_{64} discrepancies finds all of them acceptable and if a root cause analysis of these discrepancies does not indicate any generic problems, the population is accepted.

b. If any of the d_{64} discrepancies fail engineering evaluation or if any generic problems result from the root cause analysis of d_{64} discrepancies, the population cannot be accepted on the basis of present sampling reinspection. Proceed to Step 9.

Step 5

Randomly select another 50 items from population N.

Step 6

Reinspect the selected items in Step 5 for the specified attribute(s) using the Acceptance Criteria of VWAC. For each inspection item which is considered inaccessible for reinspection, another randomly selected alternative item shall be substituted in the sample. The cumulative sample size at this stage is designated as n, and the number of discrepant items observed is designated as d_n. Determine the applicable acceptance and rejection numbers (a_n, r_n) from Table 1.

Step 7

Compare the number of discrepant items d_n to the acceptance and rejection numbers (a_n, r_n).

a. If the number of discrepant items d_n is less than or equal to a_n, take one of the following actions.

   (i) If an engineering evaluation of all d_n discrepant items finds them acceptable, accept the population.

   (ii) If any of the d_n discrepant items is found to be unacceptable, the population cannot be accepted on the basis of the present sampling reinspection. Proceed to Step 9.

b. If d_n is between a_n and r_n, take one of the following actions.

   (i) Continue sampling by going to Step 5; or

   (ii) Stop sampling and determine population acceptability by evaluating found discrepancies as described in Step 8.

c. If d_n equals or exceeds r_n, determine population acceptability by evaluating found discrepancies as described in Step 8.

Step 8

This is the same as Step 4 except that d_n is used instead of d_{64}.

Step 9

When the population cannot be shown to be acceptable on the basis of sampling reinspection, appropriate corrective action shall be determined using project procedures. This may include 100% reinspection for unacceptable discrepant conditions and repair or evaluation on a case-by-case basis. If the root cause is determined to affect only a small portion of the original population, 100% reinspection may be limited to this portion of the population.

TABLE 1

THREE-STAGE MULTIPLE SAMPLING PLAN

FOR VWAC-DISCREPANT ITEMS (a)

Sampling Stage	Cumulative Sample Size n	Cumulative Acceptance Number a_n	Cumulative Rejection Number r_n
1	64	0	3
2	114	1	3
3	164	2	3

(a) See Appendix A Section A.2 for a discussion of this plan.

FIGURE 1 FLOWCHART FOR SINGLE SAMPLING PLAN

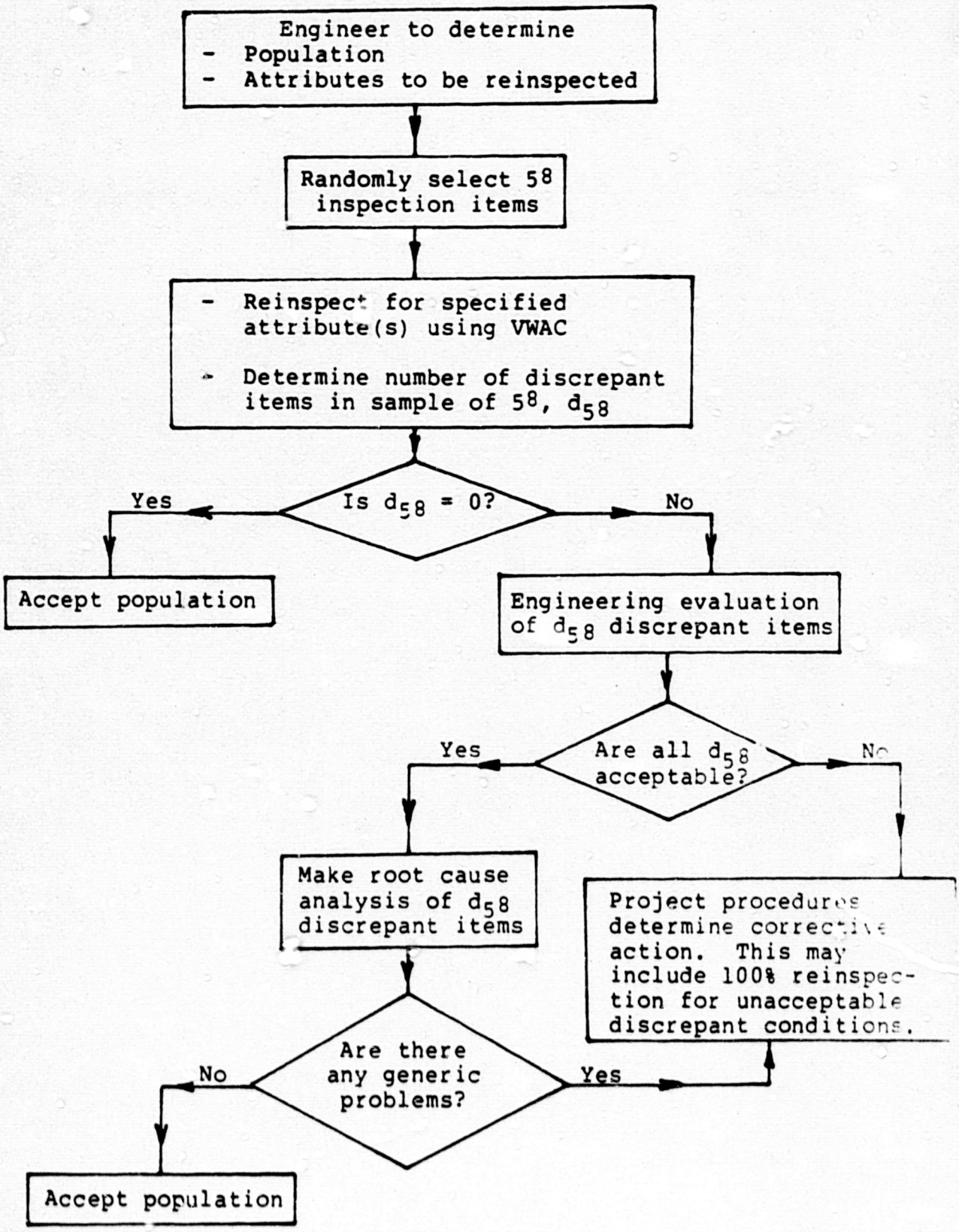

FIGURE 2 FLOWCHART FOR MULTIPLE SAMPLING PLAN

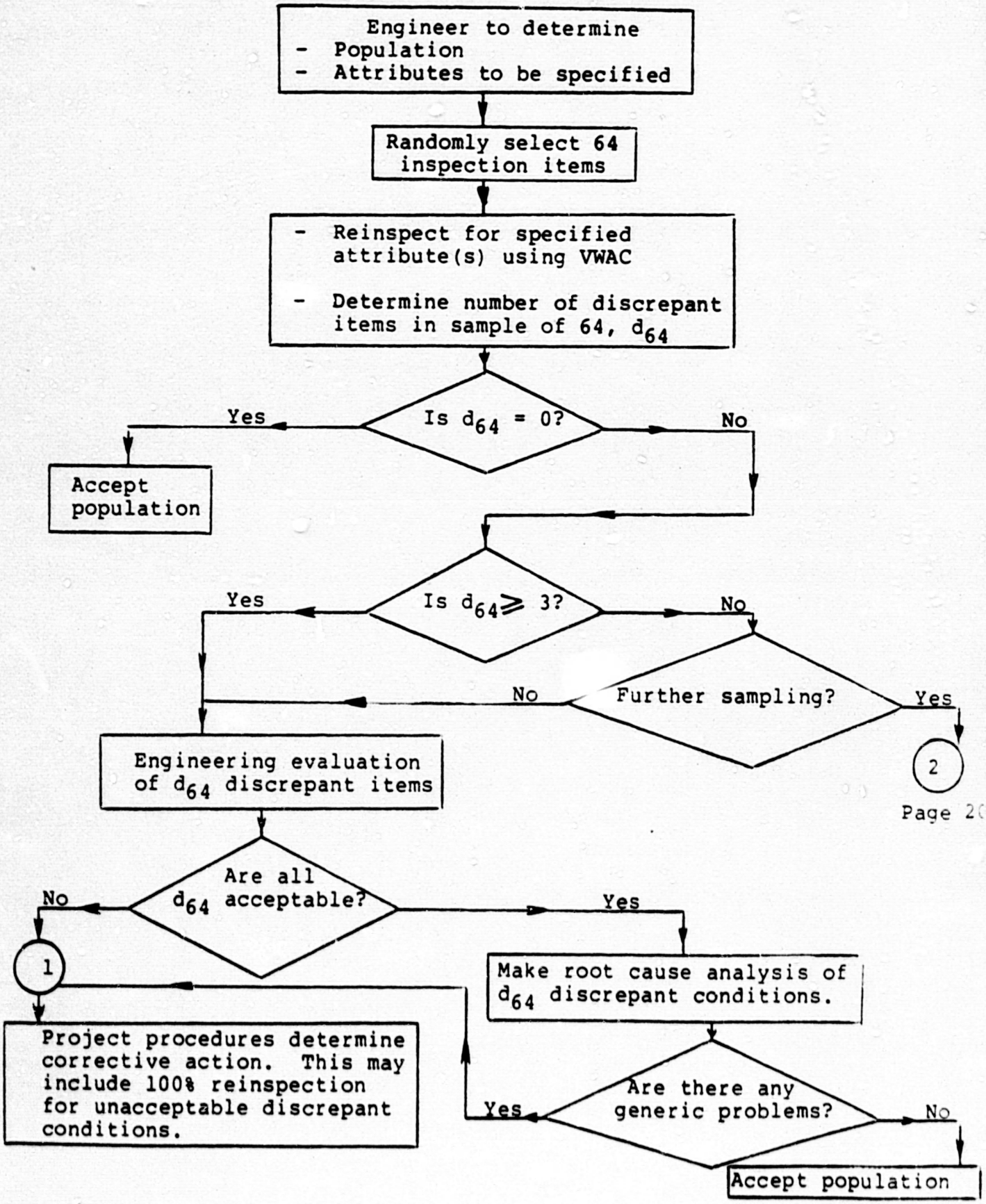

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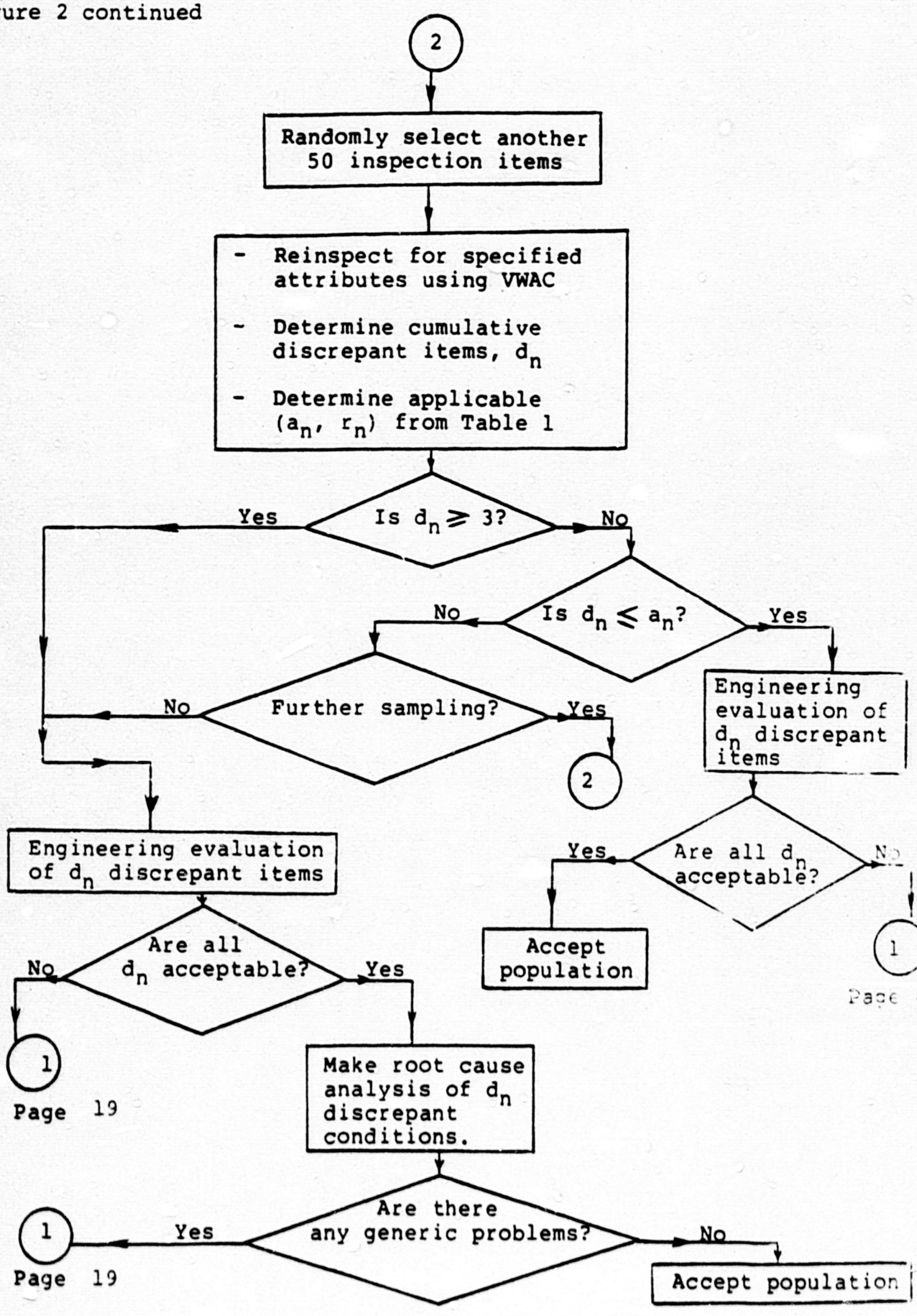
Figure 2 continued



APPENDIX A

COMMENTARY

A.1 General Comments on Sampling Plan Implementation

A.2 Parameters of Recommended Sampling Plans

A.3 Comments on Treatment of Inaccessible Items

A.1 General Comments on Sampling Plan Implementation

The Sampling Plan is one method used to demonstrate that a population of welded connections or components is adequate. It is to be used to verify that items which have been previously inspected and accepted are adequate. The Sampling Plan is not to be used for first line inspection or as a system of accepting welds which have not been inspected to the requirements of VWAC or some other visual weld acceptance criteria.

Because the items in the population have already been inspected and accepted, the review of the welded items in the sample representing the full population is intended to be applied to the questionable attribute(s) and not to each weld attribute for which acceptance criteria are given in the VWAC. For example, if there is a question as to the size of welds in a population of welded connections, the Inspector reviewing the representative sample would only consider the size of the welds.

It is management's responsibility to select the random sample representing the population of welded connections. To be considered representative, consideration should be given to:

1) The organization making the welds

2) The organization inspecting the welds

3) Weld procedures used

4) Inspection procedures used

5) Configuration similarity

6) Welding accessibility

7) Inspector accessibility

8) Welding position

9) Shop vs. field welds

10) Material product, type and form

When the Engineer performs an engineering evaluation of the observed discrepancies, it is permissible to use:

1) Allowable stresses based on specified, actual or representative physical properties

2) Specified or actual loads

3) More refined stress analysis

A.2 Parameters of Recommended Sampling Plans

The operating characteristic curve of each of the single and multiple sampling plans is shown in Figure A1. The population percent discrepant in Figure A1 refers to VWAC discrepancies. If a population has 5% VWAC discrepancies, Figure A1 shows that the probability of this population being accepted by the single sampling plan is 5.1%. The corresponding value for the multiple sampling plan is 5.04%. Therefore, both plans at reliability of 95% provide nearly 95% confidence; they are 95/95 plans for acceptance using VWAC without further engineering evaluation. The curve for the single sampling plan in Figure A1 also shows that for percent discrepant values smaller than 5% (higher values of reliability), the single sampling plan is more

conservative. This means that the multiple plan has a higher probability of accepting the population.

When engineering evaluation is used to accept the population using sampling results, percent discrepant will refer to its failure to meet engineering evaluation. The sampling procedures in this document have a zero discrepant acceptable condition for this type of discrepancy. This means that whether the single or multiple plan is used, every discrepancy found must be acceptable through engineering evaluation before the population is accepted. The operating characteristic curve for the single sampling plan in this case is again the same as the one shown in Figure 1. When the multiple plan is used, the sample size at which engineering evaluation is made could be either 64, 114, or 164. For this reason, the construction of the operating characteristic curve for this case is not directly available. However, since the sample size will be at least 64 and a zero discrepant acceptable condition is being used, the operating characteristic curve for this use of the multiple plan procedure should be more conservative than for the single plan. Consequently, the use of the multiple plan will provide better than 95% reliability at 95% confidence when an engineering evaluation is used.

A.3 Comments on Treatment of Inaccessible Items

Step 2 in Paragraph 3.3 describing implementation of a single plan and Steps 2 and 6 in Paragraph 3.4 for a multiple plan permit the use of a randomly selected alternative when the initially selected item is not physically accessible due to reasons determined as acceptable by the Engineer. This should not introduce bias in sampling when concerns which led to the decision of performing sampling are not related to inaccessibility.

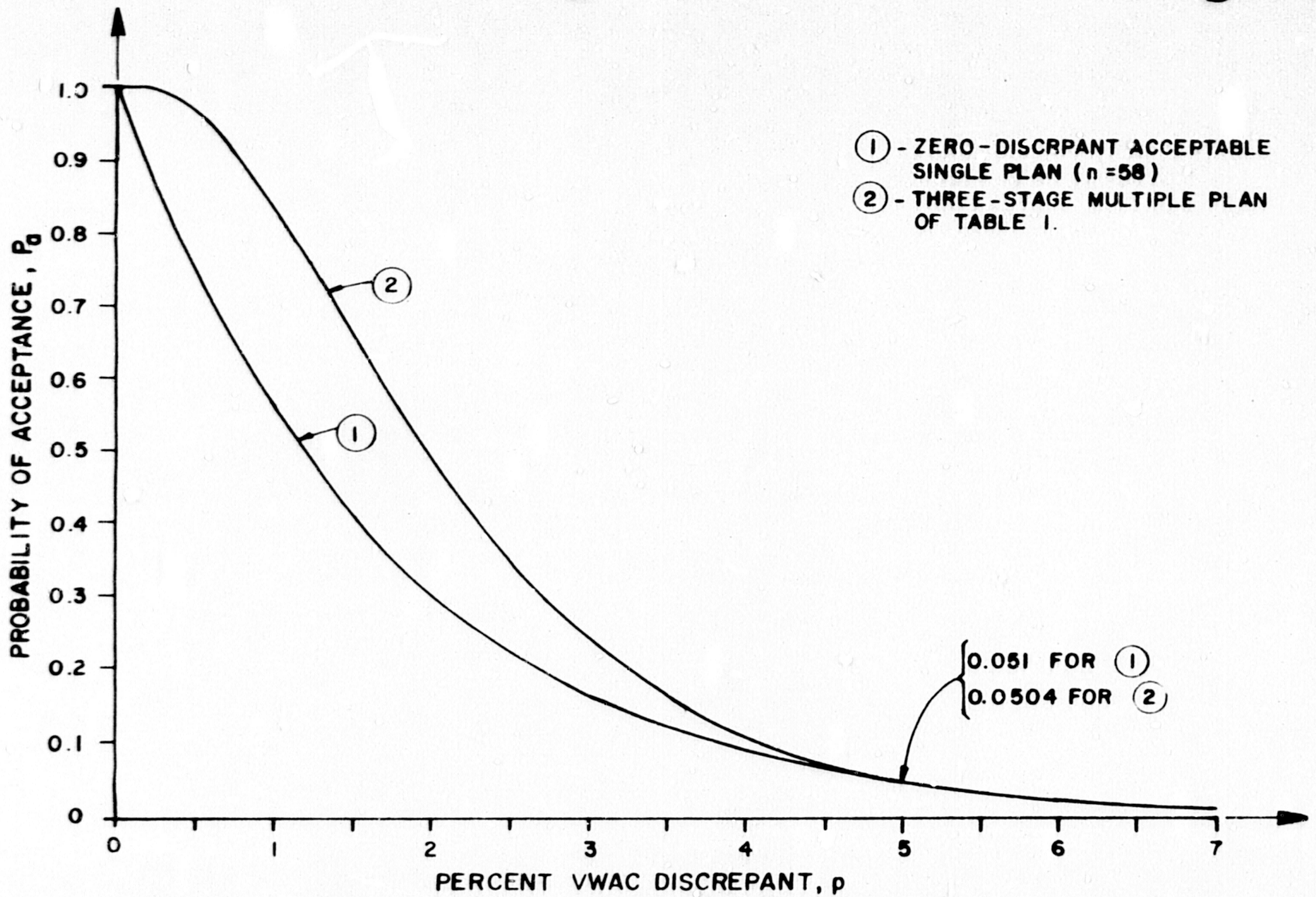


FIGURE A1 - OPERATING CHARACTERISTIC CURVES FOR RECOMMENDED SINGLE AND MULTIPLE PLANS