

Reliability testing – compliance plans for success ratio

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American Society for Quality

AMERICAN NATIONAL STANDARD

Reliability Testing—Compliance Test Plans for Success Ratio

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Contents

	Page
Foreword.....	1
Clause	
1 Scope	2
2 Normative references	2
3 Other references	2
4 Definitions	2
5 List of symbols.....	3
6 Application	4
6.1 Reliability requirement.....	4
6.2 Repair and replacement	4
6.3 Types of test plans.....	4
6.4 General test procedure	5
7 General decision criteria.....	5
8 Truncated sequential test plans.....	5
8.1 Characteristics	5
8.2 Decision criteria	5
8.3 Operating characteristic curve	6
8.4 Expected number of trials to decision	7
9 Fixed trial/failure terminated test plans.....	10
9.1 Characteristics	10
9.2 Decision criteria	10
10 Design of trial or failure terminated test plans.....	12
10.1 Characteristics	12
10.2 Approach	12
10.3 Common cause	12
10.4 Other cases	13
10.5 Examples of application.....	13
10.6 Procedure to determine D and c or n and c	13
10.7 Decision criteria.....	14

Annexes

A Additional information on sequential test plans **23**

B Design of trial or failure terminated test plans—Examples..... **25**

C Design of trial or failure terminated test plans—Mathematical
procedures and formulas..... **27**

RELIABILITY TESTING

Compliance test plans for success ratio

Foreword

- 1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.
- 2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.
- 3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the test of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

This International Standard IEC 1123 has been prepared by IEC Technical Committee No. 56: Dependability.

This International Standard replaces IEC 605-5 (1982) including Amendment 1 (1987).

The text of this standard is based on IEC 605-5, first edition, including Amendment No. 1 and the following documents:

Six Months' Rule	Report on Voting
56(CO)144	56(CO)152

Full information on the voting for the approval of this standard can be found in the Voting Report indicated in the above table.

Annexes A, B and C are for information only.

Reliability Testing

Compliance test plans for success ratio

1 Scope

This International Standard specifies procedures for applying and preparing compliance test plans for success ratio or failure ratio.

The procedures are based on the assumption that each trial is statistically independent.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(191): 1990, *International Electrotechnical Vocabulary—Chapter 191: Dependability and quality of service*.

IEC 60605-1: 1978, *Equipment reliability testing—Part 1: General requirements*. Amendment 1 (1982).

3 Other references

IEC 60410: 1973, *Sampling plans and procedures for inspection by attributes*.

ISO 3534: 1977, *Statistics—Vocabulary and symbols*.

4 Definitions

Terms and definitions are in accordance with IEC 60050(191).

In addition, the following definitions are applicable for this International Standard:

4.1 success ratio: The probability that an item will perform a required function or that a trial will be successful under stated conditions.

NOTE—An observed success ratio is the ratio of the number of non-faulty items or of successful trials at the completion of testing, to the total number of test items or number of trials.

4.2 failure ratio: The probability that an item will fail or that a trial will be unsuccessful under stated conditions.

NOTE—An observed failure ratio is the ratio of the number of faulty items or of unsuccessful trials at the completion of testing, to the total number of test items or number of trials.

5 List of symbols

α nominal producer's risk (type I risk)

α' true producer's risk (type I risk)

β nominal consumer's risk (type II risk)

β' true consumer's risk (type II risk)

c acceptable number of failures or unsuccessful events during the test

NOTE— r_{RE} , number of failures for rejection in IEC 605-5, first edition (1982), corresponds to $c + 1$.

D nominal discrimination ratio, $D = p_1 / p_0 = (1 - q_1) / (1 - q_0)$

NOTE— D_R is the corresponding symbol in IEC 605-5, first edition (1982).

D' true discrimination ratio

h intercept values of the accept and reject lines on the vertical axis of the sequential test diagram (see figure 1)

n number of items, number of trials, number of events, sample size

n_f number of items, number of trials, number of events, sample size required for acceptance

n_s accumulated number of trials in a sequential test plan

n_t number of items, number of trials, number of events, sample size at truncation

p true failure ratio, $p = 1 - q$

p_0 specified acceptable failure ratio, corresponding to acceptable quality level (AQL)

p_1 unacceptable failure ratio, corresponding to limiting quality (LQ)

p_a probability of acceptance

q true success ratio, $q = 1 - p$

NOTE— R is the corresponding symbol in IEC 605-5, first edition (1982).

q_0 specified acceptable success ratio, $q_0 = 1 - p_0$

q_1 unacceptable success ratio, $q_1 = 1 - p_1$

r number of relevant failures or relevant unsuccessful events

r_t number of relevant failures or relevant unsuccessful events at truncation

s slope of accept and reject lines in the sequential test diagram (see figure 1)

6 Application

6.1 Reliability requirement

The requirement is assumed to be specified as:

- acceptable failure ratio, p_0 or
- acceptable success ratio, q_0 ($p_0 = 1 - q_0$).

These test plans are based on the assumption that each trial is statistically independent and that the probability of success (or failure) is constant, i.e. the binomial distribution assumptions apply. The true producer's and consumer's risks for the test plans differ from the nominal characteristics α and β due to the necessary approximations to whole numbers and to the truncation of the sequential tests.

6.2 Repair and replacement

The test plans given in this standard are applicable to reused as well as non-reused (one-shot) items. Reused items may be repaired between successive trials, provided that the state and performance are the same at the start of all trials. For non-reused items, a separate test item is used for each trial.

6.3 Types of test plans

Test plans are given for three types of tests:

- truncated sequential tests (see clause 8);
- fixed trial/failure terminated tests (see clause 9);
- designed trial/failure terminated tests (see clause 10).

The detailed reliability test specification shall state which type of test and which test plan are to be used. Guidance for the choice of type of test is similar to that given in IEC 605-1, 7.3.1, for truncated sequential and time/failure terminated tests for the case in which the reliability measure is a function of time.

6.4 General test procedure

The test items shall be subjected to the number of trials according to the relevant test plan. For reused, replaced or repaired items, the detailed reliability test specifications should preferably state the number of test items as well as the maximum number of trials for each test item.

A trial is defined as the operation or cycle as described in the detailed reliability test specification.

7 General decision criteria

All test plans and decision criteria are based on either:

- an acceptable number of relevant failures for a specified number of trials; or
- an acceptable number of trials for a specified number of relevant failures.

The numbers of trials and relevant failures (see IEC 605-1, 9.2) are counted and compared with the decision criteria of the test plan.

The detailed decision criteria for the three types of test plans are given in 8.2, 9.2 and 10.7, respectively.

8 Truncated sequential test plans

8.1 Characteristics

Sequential test plans are characterized by decision rules for accepting or rejecting compliance, or for continuing testing, after any number of trials. They are determined by selected values of risks and discrimination ratio. In order to implement a test plan, q_0 has to be specified (or derived).

Associated operating characteristic curves and values of the expected relevant number of trials to decision are included.

Table 1 presents the appropriate test plans for various values of the specified q_0 , D , α and β . The table contains parameter values of h , s , n_t and r_t for each test plan (see figure 1).

NOTE—The truncation affects the values of α' and β' . However, the truncation values of table 1 are chosen so that the maximum values of α' and β' are less than 0.055; 0.105; 0.205 and 0.305, for values of α and β 0.05; 0.10; 0.20 and 0.30 respectively. The truncation values were obtained from a computer program which calculated α' and β' for increasing values of n_t and r_t until the maximum values were within the above stated bounds.

8.2 Decision criteria

The decision criteria are as follows:

- accept if $sn_s - h > r$;
- continue if $sn_s - h < r < sn_s + h$;
- reject if $r > sn_s + h$.

The sequential test plans shall be truncated at lines based on the values given in table 1. The truncation gives rise to the following additional criteria:

- accept if $n = n_t$ and $r < r_t$;
- reject if $r > r_t$.

The accumulated results are checked against the criteria after each trial and a decision is made whether to accept, continue or reject.

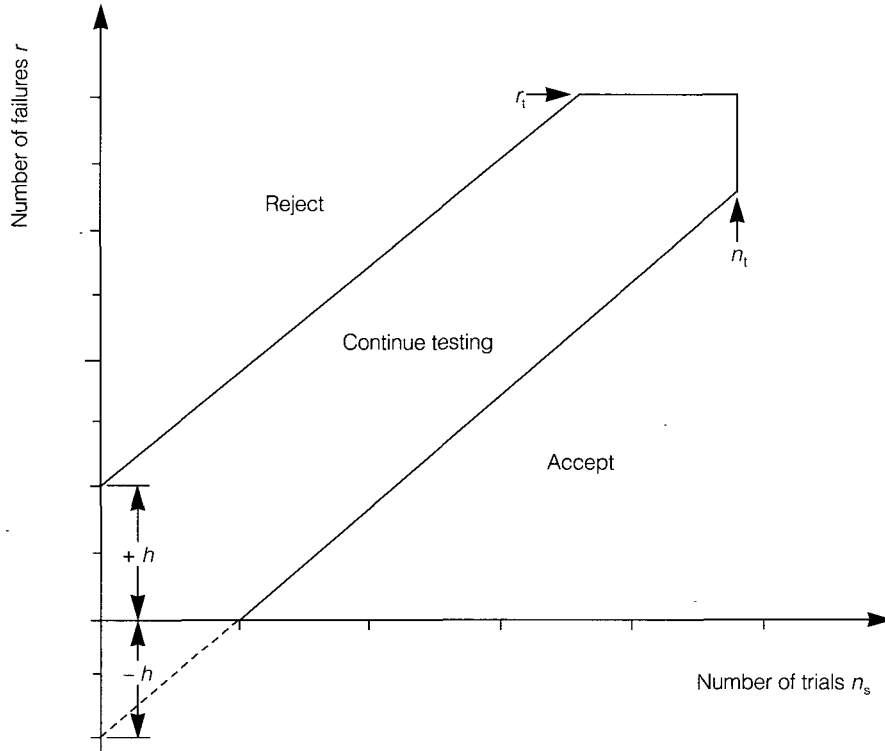


Figure 1—Truncated sequential test

8.3. Operating characteristic curve

For any of the truncated sequential tests, the following approximate points on the operating characteristic curve are given:

q	P_a
1.0	1.0
q_0	$1 - \alpha$
$1 - s$	0.5
q_1	β
0.0	0.0

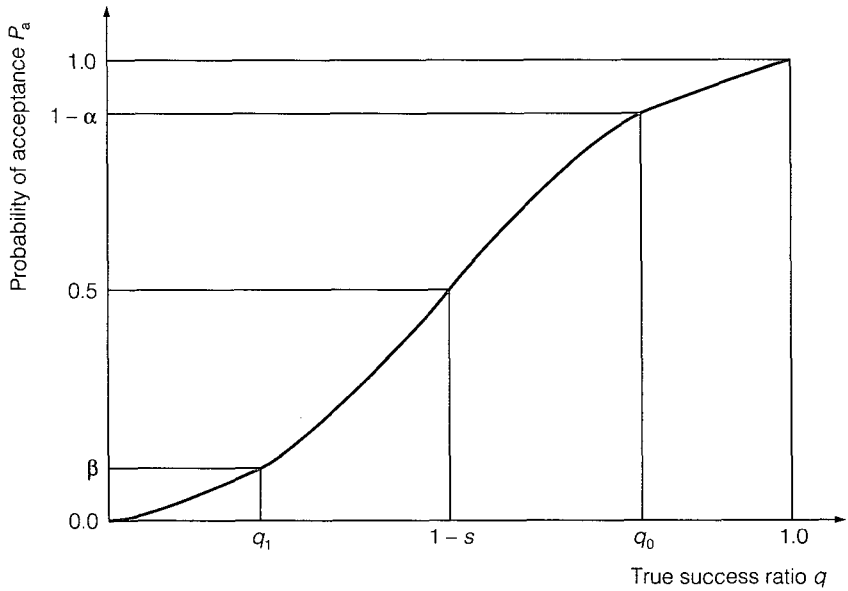


Figure 2—OC curve

8.4. Expected number of trials to decision

For any of the truncated sequential test plans, the following approximate points can be determined for the curve of the expected number of trials to decision versus the true success ratio:

q	n_s
1.0	$\frac{h}{s}$
q_0	$\frac{h(1-2\alpha)}{s-(1-q_0)}$
$1-s$	$\frac{h^2}{s(1-s)}$
q_1	$\frac{h(1-2\beta)}{(1-q_1)-s}$
0.0	$\frac{h}{1-s}$

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