



BS 6001 : Part 2 : 1984

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British Standard

Sampling procedures for inspection by attributes

Part 2. Specification for sampling plans indexed by limiting quality (LQ) for isolated lot inspection

Règles d'échantillonnage pour les contrôles par attributs

Partie 2. Plans d'échantillonnage indexés par qualité limite pour le contrôle de lots isolés — Spécifications

Verfahren zur Stichprobenprüfung anhand qualitativer Merkmale (Attributprüfung)

Teil 2. Stichprobenanweisungen unter dem Gesichtspunkt der rückzuweisenden Qualitätsgrenzlage für die Prüfung isolierter Lose

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Foreword

This Part of BS 6001 has been prepared under the direction of the Quality Management and Statistics Standards Committee in response to numerous requests for assistance received from both national and international technical committees that have experienced conceptual problems when attempting to specify acceptance criteria for small quantities of products delivered as 'isolated lots'. Many committees expressed the wish to see established a standardized series of sampling plans indexed in terms of limiting quality (LQ) as a measure of consumer protection. A variety of reasons was put forward as justification for not using the acceptable quality level (AQL) indexed plans given in BS 6001. These have been outlined in the introduction (see 0.1) for information.

Rather than develop a completely new series of sampling plans indexed by LQ, maximum use has been made of the existing plans given in BS 6001 : Part 1 in order to form a logical link with the fact that whereas the individual consumer may only be concerned with a particular lot received *in isolation*, the manufacturer is usually concerned with the production of a *continuing series* supplied to several customers, in various lot quantities.

Sampling involves risks irrespective of whether the sampling plans used utilize LQ or AQL for indexing purposes. These

risks cannot be completely eliminated, but they can be accurately controlled by use of this Part when the quality of lots of an isolated nature needs to be assessed.

Appendix A describes in detail two situations that illustrate the use of this Part.

Appendix B describes the extent to which procedures A and B of this Part are compatible with BS 6001 : Part 1.

This Part is based on ISO/DIS 7362, which was adopted by a large majority at the ISO Postal Ballot stage. In view of its particular relevance to consumer protection and the National Campaign for Quality, it was decided to publish this Part without waiting for the final English and French versions of ISO 7362, planned for 1984/85.

Acknowledgement is made for the development work on this Supplement to Dr D J G Farlie of the University of Essex, who is the Chairman both of ISO Technical Committee ISO/TC 69/SC 5, Acceptance sampling, of the International Organization for Standardization (ISO) and of the BSI Group of Statistical Methods Committees.

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Sampling procedures for inspection by attributes

Part 2. Specification for sampling plans indexed by limiting quality (LQ) for isolated lot inspection

0. Introduction

0.1 General. BS 6001 : Part 1 sampling plans indexed in terms of acceptable quality level (AQL), which is defined as a process average, were *primarily* designed for the assessment of a continuing series of lots. This enables *switching rules* to be employed that not only give protection to the consumer (by the switch to tightened inspection or discontinuation, where necessary) but also provide an incentive to the producer (by the switch to reduced inspection) by reducing testing and hence inspection costs (when consistently good quality is achieved). However, there is little doubt that in many industrial situations today the switching rules *are not* applied. This is for a variety of reasons or excuses, not all of which may be valid, including the following.

- (a) Individual BS 6001 : Part 1 plans are used without the switching rules, but AQL protection is still claimed or AQL redefined to suit so-called 'unique products'.
- (b) 'Our industry . . . product is *special*, so BS 6001 standard plans need not apply to us'.
- (c) Production is intermittent (not continuous).
- (d) Production is from several different sources in varying quantities i.e. 'job lots'.
- (e) Purchases are from stock-holders, i.e. no source data is available.
- (f) Lots are 'small', i.e. use of the hypergeometric distribution is required.
- (g) Lots are 'isolated'.
- (h) Lots are resubmitted after initial rejection.

Consequently, in certain of the above cases consumer protection may need to be attained or measured by other methods. This Part uses 'limiting quality' to measure consumer protection. It should be remembered, however, that prior information on the supplier's quality assurance system and its effectiveness may play a major part in deciding whether or not to accept a single lot.

0.2 Objectives. In an attempt to reconcile the somewhat diverse requests for assistance made over the period preceding publication of this Part by committees of the International Electrotechnical Commission (IEC), the International Organization for Standardization (ISO) and the European Committee for Standardization (CEN) representing various product sectors, this Part has been drawn up with the following features.

- (a) The new LQ plans can be easily integrated with the existing AQL plans in BS 6001 : Part 1.
- (b) The LQ indexing uses a rationalized series of values that cannot be confused with the preferred series of AQL values.
- (c) The five basic numbers associated with a single sampling plan, i.e. lot size, sample size, acceptance number, AQL (or quality accepted with probability 0.95) and LQ, appear in the same table whenever possible.

0.3 Summary. The problems associated with acceptance sampling inspection involve defining the following unambiguously:

- (a) the criteria used to judge discrete individual items supplied in quantity;
- (b) the quality level expected from the manufacturing process;
- (c) the discrimination offered by the plans; and
- (d) the procedure to be followed when a lot is not accepted.

Above all, however, it is necessary to design the sampling scheme so that it may easily be invoked in a purchasing contract. The plans in this Part make maximum use of the established plans given in BS 6001 : Part 1 : 1972, so that 11.6 of that standard (see 1.1) can be made directly operational by providing a rationalized series of plans indexed in terms of limiting quality.

1. Scope and field of application

1.1 Scope. This Part of BS 6001 establishes sampling plans indexed by limiting quality and procedures for inspection by attributes compatible with BS 6001 : Part 1 that can be used when the switching rules of that standard are not applied. The plans are primarily intended for use with single lots (procedure A) or lots of an isolated nature (procedure B) where quality can be expressed in percent nonconforming. They do not cover the case where quality is expressed in nonconformities per hundred units.

The plans in this standard are indexed by a rationalized series of limiting qualities with a consumer's risk usually below 10 %, but always below 13 %. This method of indexing permits the *ad-hoc* procedure mentioned in 11.6 of BS 6001 : Part 1 : 1972* to be implemented as a standard procedure.

*In 11.6 of BS 6001 : Part 1 : 1972 it is stated that '... if the lot or batch is of an isolated nature, it is desirable to limit the selection of sampling plans to those, associated with a designated AQL value, that provide not less than a specified limiting quality protection. Sampling plans for this purpose can be selected by choosing a limiting quality (LQ) and a consumer's risk to be associated with it. The plans give values of LQ for the commonly used consumer's risks of 10 % and 5 % respectively'. This Part establishes rationalized values for LQ and allows the consumer's risk to vary as indicated in 11.6 of BS 6001 : Part 1 : 1972.

NOTE. The plans in BS 6001 : Part 1 are indexed by a preferred series of AQL values and inspection levels. During the inspection of a continuing series of lots, the application of switching rules helps to ensure that the process average in that series of lots is kept below the specified AQL. Limiting quality does not have the same direct relationship with the process average (see 3.5.1).

1.2 Field of application. Alternative procedures are provided in this Part to cater for two situations often met in practice, practice.

(a) **Procedure A** is to be used when the supplier and consumer both wish to regard the lot in isolation. The tables are based on random sampling from finite lots for both consumer and producer risks. **This procedure is to be used unless there is a specific instruction to use procedure B.**

(b) **Procedure B** is to be used when the supplier regards the lot as one of a continuing series but the consumer considers the lot received in isolation. The tables are based on random sampling from a finite lot for the consumer's risk at the limiting quality, but random sampling from a process for the producer's risk, and the tabulated values of the operating characteristic (OC) curves. The plans employed are a selection of the plans available in BS 6001 : Part 1 so that a producer can maintain consistent procedures for customers whether or not they receive individual lots or a continuing series of lots. This procedure is suitable for inclusion in product standards or specifications that contain sampling clauses. **The manufacturer will be concerned with all of his production but the individual consumer only with the particular lot received.**

NOTE. The title of the publication referred to in this Part is given on the inside back cover.

2. Definitions

For the purposes of this Part of BS 6001, the definitions given in BS 6001 : Part 1 apply.

3. Choice of sampling plan

3.1 Specifying a sampling plan. Procedure A shall be used unless procedure B is specified by the contract or specification.

3.2 Choice of sampling procedure. Although procedure A is based on the hypergeometric distribution for sampling results, this distribution is well approximated by the binominal distribution for plans with non-zero acceptance numbers in procedure A. Hence, the OC curves for these plans are well approximated by the tabulated performance of the same plans in procedure B. However, procedure A uses plans with acceptance number zero and with sample sizes based on the hypergeometric distribution of sampling results while procedure B excludes accept-zero plans, replacing them by 100 % inspection.

The choice between the procedures is dominated by the attitude towards accept-zero plans. Procedure A uses accept-zero plans linking the sample size and the lot size by the hypergeometric distribution until the proposed plan corresponds to the accept-zero plan in BS 6001 : Part 1 corresponding to that limiting quality. Thereafter the progression of sampling size and acceptance number with lot size is based on the inspection levels available in BS 6001 : Part 1. The overall effect of procedure A resembles inspection level II for limiting quality less than 8 % and level I for limiting quality greater than 8 % with 8 % being intermediate between these levels.

Procedure B provides greater flexibility in the choice of inspection levels. The tabulated OC curves are based on the probability of producing a nonconforming unit so they are approximately correct for small sampling fractions but as the sampling fraction increases the curves (and tables) underestimate the probability of acceptance for good quality and underestimate the probability of rejection for poor quality. For sufficiently small lots procedure B requires 100 % inspection.

Both procedures treat the limiting quality as the actual percent nonconforming units in the lots submitted. The probability of acceptance at this limiting quality can be found in table 2 for procedure A (for which table 1 shall be used) or tables 3 to 12 for procedure B. Procedure B is indicated as the appropriate procedure if the manufacturer is concerned with a continuing series of lots; whether or not these go to the same consumer. Procedure A is indicated as the appropriate procedure when the lot is a single lot and shall be used if accept-zero plans are required to be part of the sampling scheme.

3.3 Procedure A. Plans shall be identified by their lot size and limiting quality.

With the specified lot size and limiting quality as indexing values, the sample size, n , and acceptance number, A_c , shall be as given in table 1.

NOTE. Although the primary index to these tables is the limiting quality, the producer/supplier needs guidance on the quality level required if lots are to have a high probability of acceptance. Information on the producer's risk point is contained in table 1. Information on the probability of acceptance of relatively good lots by accept-zero plans is given in table 13.

3.4 Procedure B. Plans shall be identified by the lot size, the limiting quality and the inspection level. Unless otherwise specified in the contract or specification, level II shall be used.

The specified limiting quality shall be used to select the appropriate table from tables 3 to 12. Within each table the specified lot size and inspection level indicate the appropriate sample size, n , and acceptance number, A_c . Although the primary index to the table is the limiting quality, the producer/supplier needs guidance on the quality level required if lots are to have a high probability of acceptance. Each table gives information on the equivalent AQL and details of the OC curves. The OC curves are indexed by the sample size code letter used in BS 6001 : Part 1 and the acceptance number.

The OC curves given under tables 3 to 12 are based on the Poisson/Binominal distribution. The actual operating characteristic will be more discriminating than these curves because it accepts with greater probability when the indicated probability is greater than or equal to 0.90 and with a smaller probability when the indicated probability is less than 0.10.

3.5 Choice of parameters for the sampling procedures

3.5.1 Limiting quality. Unlike the AQL, which provides a guide for the producer on the level or quality he needs to produce so that he can satisfy the acceptance criteria most of the time, the limiting quality does not provide a reliable guide for the consumer as to the true quality of the accepted lots. For this reason the limiting quality should be chosen realistically at a minimum of three times the desired quality.

This enables the producer/supplier to provide lots of the desired quality and still have a reasonable probability of

acceptance for the submitted lots, at least for acceptance numbers 3, 5, 10 and 18. For acceptance number 1 plans, the lots have to have a quality better than $LQ/10$ and for acceptance number zero plans the lots have to be perfect or nearly perfect before the probability of acceptance rises to 0.95 or greater. The limiting values are restricted to a set of rationalized values and the plans are intended to be used with these rationalized values. If these plans are introduced where a non-standard limiting quality is already specified, the plans should be entered with the rationalized value of LQ corresponding to the interval containing the non-standard value (L) listed in column 4 of table 14. Columns 2 and 3 of table 14 contain information on the consumer's risk qualities found in tables 3 to 12 for consumer's risks of 10 % and 5 %.

Example:

The limiting quality has previously been set at 3.5 %. This is not a rationalized value, and the tables should be entered by using the nominal limiting quality $LQ = 3.15 \%$, since 3.5 % lies in the range $2.5 \% \leq LQ < 4.0 \%$.

3.5.2 Inspection level. In the BS 6001 : Part 1 procedures, increased sample size corresponds to a greater protection for the consumer. In this Part consumer protection is held approximately constant and the effect of increasing sample size is to permit the supplier greater latitude in the permitted process averages. If the consumer is satisfied by the protection provided against an occasional poor lot by the limiting quality, then the inspection level is primarily of interest to the supplier, especially if the costs of sampling inspection are borne by him. A process average well below the limiting quality (better quality) would enable the use of smaller sample sizes. Conversely, if the consumer is concerned with actual rather than limiting quality, or if he pays for the sampling costs, then greater inspection levels are not necessarily advantageous. For this reason, inspection level III provided by BS 6001 : Part 1 has not been incorporated in this standard for limiting qualities greater than 5 %. When sample sizes have to be kept small and other considerations are secondary, specifying level S-2 has the effect of providing a fixed sample size for all lot sizes, the sample size depending only on the limiting quality.

4. Rules for acceptance and non-acceptance

4.1 Sampling and inspection. The sampling plan having been determined as in clause 3, the specified sample units shall now be drawn at random from the lot, and all units in the sample inspected.

4.2 Acceptance. If the number of nonconforming units found in the sample is equal to or less than the acceptance number, A_c , specified in the plan, the lot shall be accepted except that any nonconforming units found during inspection, whether forming part of the sample or not, shall not be accepted.

4.3 Non-acceptance and resubmission. If the number of nonconforming units found in the sample is greater than the acceptance number, A_c , the lot shall not be accepted. An unacceptable lot shall not be resubmitted for inspection unless

- (a) the responsible authority agrees; and
- (b) all units in the lot have been re-examined or retested and all nonconforming units have been removed or replaced by good units or nonconformities corrected.

If the responsible authority agrees to the resubmission of a lot that has not been accepted, the responsible authority shall specify the method of acceptance inspection to be applied (i.e. LQ value and/or inspection level, and whether reinspection shall include all types or classes of nonconformities or only those that caused the initial rejection).

5. Double and multiple sampling plans

Tables 15 and 16 provide the sample sizes and acceptance patterns for the double and multiple sampling plans in BS 6001 equivalent to the single sampling plans given in tables 3 to 12. The sample size code agrees with that in BS 6001 : Part 1 equivalent to the single sampling plans given in tables 3 to 12. The sample size code agrees with that in BS 6001 : Part 1 and the acceptance pattern code with the acceptance number in the corresponding single size plans. Since procedure A and procedure B plans have similar OC curves for non-zero acceptance numbers, these double and multiple plans can also be used in procedure A to replace the corresponding single sampling plan. The user is referred to 10.1.2 and 10.1.3 of BS 6001 : Part 1 : 1972 for the operation of these double and multiple sampling plans.

Table 1. Single sampling plans indexed by limiting quality (procedure A)

Lot size		Limiting quality (nominal)									
		0.5 %	0.8 %	1.25 %	2.0 %	3.15 %	5.0 %	8.0 %	12.5 %	20 %	32 %
16 to 25	n Ac	→	→	→	→	→	25* 0	17* 0	13 0	9 0	6 0
26 to 50	n Ac	→	→	→	50* 0	50* 0	28* 0	22 0	15 0	10 0	6 0
51 to 90	n Ac	→	→	90* 0	50 0	44 0	34 0	24 0	16 0	10 0	8 0
91 to 150	n Ac	→	150* 0	90 0	80 0	55 0	38 0	26 0	18 0	13 0	13 1
151 to 280	n Ac	200* 0	170* 0	130 0	95 0	65 0	42 0	28 0	20 0	20 1	13 1
281 to 500	n Ac	280 0	220 0	155 0	105 0	80 0	50 0	32 0	32 1	20 1	20 3
501 to 1200	n Ac	380 0	255 0	170 0	125 0	125 1	80 1	50 1	32 1	32 3	32 5
1201 to 3200	n Ac	430 0	280 0	200 0	200 1	125 1	125 3	80 3	50 3	50 5	50 10
3201 to 10 000	n Ac	450 0	315 0	315 1	200 1	200 3	200 5	125 5	80 5	80 10	80 18
10 001 to 35 000	n Ac	500 0	500 1	315 1	315 3	315 5	315 10	200 10	125 10	125 18	80 18
35 001 to 150 000	n Ac	800 1	500 1	500 3	500 5	500 10	500 18	315 18	200 18	125 18	80 18
150 001 to 500 000	n Ac	800 1	800 3	800 5	800 10	800 18	500 18	315 18	200 18	125 18	80 18
> 500 000	n Ac	1250 3	1250 5	1250 10	1250 18	800 18	500 18	315 18	200 18	125 18	80 18

 n is the sample size; Ac is the acceptance number.*Where n exceeds the lot size, 100 % inspection with zero acceptance number is to be used.→ Nominal limiting quality implies less than one nonconforming item in the lot. The first available plan for higher LQ is to be used.

Table 2. Summary of sampling plan properties for procedure A

NOTE: The layout of the cells in the table is as follows:

Sample size/acceptance no. (n/Ac) Probability of acceptance at the limiting quality* (PLQ)
 Percent nonconforming (p) Probability of acceptance at quality p (P_a)

Lot size	Limiting quality (nominal)										
	0.5 %	0.8 %	1.25 %	2.0 %	3.15 %	5.0 %	8.0 %	12.5 %	20.0 %	32.0 %	
16 to 25						Inspect every item	17/0 0 1.0	13/0 0 1.0	9/0 0 1.0	6/0 0 1.0	0.070 1.0
26 to 50				Inspect every item	Inspect every item	28/0 0 1.0	22/0 0 1.0	15/0 0 1.0	10/0 0 1.0	6/0 0 1.0	0.085 1.0
51 to 90			Inspect every item	50/0 † 0 1.0	44/0 0 1.0	34/0 0 1.0	24/0 0 1.0	16/0 0 1.0	10/0 0 1.0	8/0 0 1.0	0.040 1.0
91 to 150		Inspect every item	90/0 † 0 1.0	80/0 0 1.0	55/0 0 1.0	38/0 0 1.0	26/0 0 1.0	18/0 0 1.0	13/0 0 1.0	13/1 2.67	0.041 0.96
151 to 280	Inspect every item	170/0 0 1.0	130/0 0 1.0	95/0 0 1.0	65/0 0 1.0	42/0 0 1.0	28/0 0 1.0	20/0 0 1.0	20/1 1.79	13/1 2.86	0.044 0.95
281 to 500	280/0 0 1.0	220/0 0 1.0	155/0 0 1.0	105/0 0 1.0	80/0 0 1.0	50/0 0 1.0	32/0 0 1.0	32/1 1.0	20/1 1.80	20/3 7.20	0.072 0.95
501 to 1200	380/0 0 1.0	255/0 0 1.0	170/0 0 1.0	125/0 0 1.0	125/1 0.250	80/1 0.417	50/1 0.667	32/1 1.08	32/3 4.42	32/5 8.50	0.029 0.95
1 201 to 3 200	430/0 0 1.0	280/0 0 1.0	200/0 0 1.0	200/1 0.188	125/1 0.281	125/3 1.13	80/3 1.75	50/3 2.78	50/5 5.38	50/10 12.9	0.042 0.95
3 200 to 10 000	450/0 0.010	315/0 0.010	315/1 0.110	200/1 0.180	200/3 0.690	200/5 1.32	125/5 2.12	80/5 3.32	80/10 7.92	80/18 16.1	0.041 0.95
10 001 to 35 000	500/0 0.009	500/1 0.071	315/1 0.111	315/3 0.437	315/5 0.834	315/10 1.97	200/10 3.99	125/10 5.01	125/18 10.2	80/18 16.1	0.041 0.95
35 001 to 150 000	800/1 0.044	500/1 0.071	500/3 0.273	500/5 0.524	500/10 1.23	500/18 2.50	315/18 3.99	200/18 6.31	125/18 10.2	80/18 16.1	0.041 0.95
150 001 to 500 000	800/1 0.044	800/3 0.170	800/5 0.328	800/10 0.771	800/18 1.56	500/18 2.50	315/18 3.99	200/18 6.31	125/18 10.2	80/18 16.1	0.041 0.95
≥ 500 001	1250/3 0.109	1250/5 0.209	1250/10 0.494	1250/18 1.00	800/18 1.56	500/18 2.50	315/18 3.99	200/18 6.31	125/18 10.2	80/18 16.1	0.041 0.95

* The stated probability of acceptance is the maximum for lots of nominal limiting quality in the size range and the minimum for lots with percent nonconforming p . These probabilities are based on the hypergeometric distribution. The producer's risk point is (p , P_a); the consumer's risk point is (LQ , PLQ).

† No lot in this size range can have the nominal limiting quality, hence there cannot be a probability of acceptance for this quality.

Table 3. Single sampling plans for limiting quality 0.5 % (procedure B)

Lot size for given inspection level				BS 6001 : Part 1 single sampling plan (normal inspection)			Code letter	Submitted quality accepted with given probability* (quality as percent nonconforming)					Acceptance probabilities† (limiting quality)	
S-1 to S-3	S-4	I	II	III	AQL	n		0.95	0.90	0.50	0.10	0.05	Max.	Min.
> 800#	> 800#	> 800#	801# to 500 000	801# to 150 000	0.065	800	P	0.0444	0.0665	0.210	0.486	0.593	0.091	0.000
			> 500 000	150 001 to 500 000	0.10	1250	Q	0.109	0.140	0.294	0.534	0.620	0.129	0.129
				> 500 000	0.10	2000	R	0.131	0.158	0.284	0.464	0.526	0.066	0.066

AQL is the acceptable quality level;

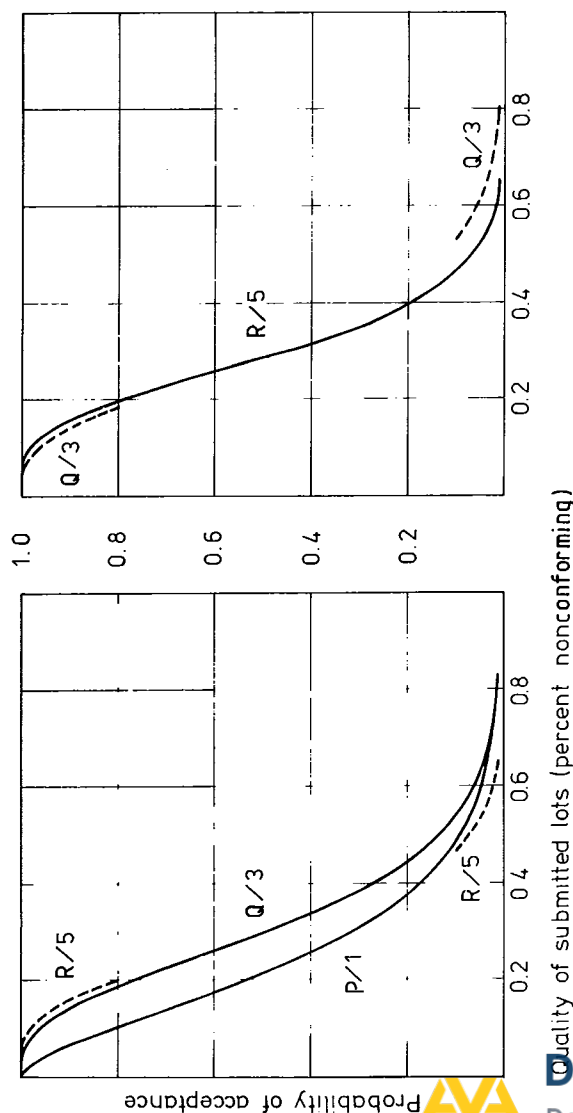
n is the sample size;

Ac is the acceptance number.

*Probability calculated by the Poisson approximation.

†The exact acceptance probabilities calculated from the hypergeometric distribution vary with lot size. The maximum and minimum values attained for permitted lot sizes are given for each plan.

#For fewer than 801 in the lot, the lot is to be 100 % inspected.



Quality of submitted lots (percent nonconforming)

NOTE. Curves are identified by sample size code and acceptance number.

Operating characteristic curves for single sampling plans (LQ = 0.5 %)