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Geometrical product specifications(GPS) - Statistical tolerance - Part 5: Statistical quality indices of an assembly lot (hole/shaft fits)

产品几何技术规范（GPS） 统计公差 第5部分：装配批（孔、轴配合）的统计质量指标

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Table of Contents

1 Scope

This part of GB/Z 24636 specifies the statistical quality indices of an assembly lot (hole/shaft fit) and gives the fit quality indices, the related methods of analysis and the method of statistical tolerance design that guarantees fit quality.

This part applies to hole and shaft fit sizes that have two-sided specification limits and to which statistical process control is applied.

2 Normative references

The provisions of the following documents become provisions of this part of GB/Z 24636 through reference in it. For dated references, subsequent amendments (excluding corrections) or revisions do not apply to this part; however, parties to agreements based on this part are encouraged to investigate the possibility of applying the most recent editions. For undated references, the latest edition applies.

GB/T 1800.1-2009, Geometrical product specifications (GPS) - Limits and fits - Part 1: Bases of tolerances, deviations and fits (ISO 286-1:1988, MOD)

GB/Z 20308, Geometrical product specifications (GPS) - Masterplan (GB/Z 20308-2006, ISO/TR 14638:1995, MOD)

GB/Z 24636.1, Geometrical product specifications (GPS) - Statistical tolerancing - Part 1: Terms, definitions and basic concepts

GB/Z 24636.3-2009, Geometrical product specifications (GPS) - Statistical tolerancing - Part 3: Statistical quality indices of a part lot (process)

GB/Z 24636.4-2009, Geometrical product specifications (GPS) - Statistical tolerancing - Part 4: Statistical tolerance design based on a given confidence level

3 Terms and definitions

The terms and definitions given in GB/Z 24636.1 and the following apply to this part of GB/Z 24636.

3.1.1 fit capability - the measure of the distribution of the clearance or interference after fitting relative to the fit tolerance; the fit capability is six times the standard deviation of the clearance or interference after fitting, denoted 6 sigma-f. Note: sigma-f is the standard deviation of the clearance or interference after fitting, sigma-f being the square root of the sum of the squares of sigma-H and sigma-S, which are the standard deviations of the hole and shaft fit sizes respectively.

3.1.2 fit capability index (FCp) - the ratio of the fit tolerance Tf to the fit capability 6 sigma-f, expressed as FCp = Tf / (6 sigma-f) = (USLf - LSLf) / (6 sigma-f), where Tf is the hole/shaft fit tolerance, TH and TS being the hole tolerance and the shaft tolerance and Tf = TH + TS; USLf is the upper specification limit of the clearance or interference of the hole/shaft fit; and LSLf is the lower specification limit. [GB/T 1800.1-2009, definition 3.14.4] Note: FCp does not reflect the effect on assembly quality of the shift of the distributions of the hole and shaft fit sizes relative to the centres of their respective tolerance zones; it reflects only the potential capability of the final operation forming the hole and shaft fit sizes to meet the fit accuracy requirement, whereas the most important factor affecting the fit size is the distribution characteristic of the hole and shaft sizes.

3.1.3 fit shift parameter (kf) - the ratio of the shift of the mean value mu-f of the clearance or interference after fitting relative to the fit target value Mf to the half value of the fit tolerance, expressed as kf = (mu-f - Mf) / ((USLf - LSLf)/2) = delta-f / (Tf/2) = 2(delta-H - delta-S) / Tf, where mu-f is the mean clearance or interference after fitting; Mf is the fit target value of the assembly size; delta-f is the shift of the mean clearance or interference from the fit target value; delta-H is the shift of the mean of the hole from its target value; and delta-S is the shift of the mean of the shaft from its target value.

3.1.4 fit capability index (FCpk) - the smaller of the two ratios of the distance from the mean of the fit characteristic to each of the two-sided specification limits to the half value of the fit capability, expressed as FCpk = min{(USLf - mu-f)/(3 sigma-f), (mu-f - LSLf)/(3 sigma-f)}; the equivalent formula is FCpk = FCp (1 - |kf|), with 0 <= |kf| <= 1.

3.1.5 fit capability index (FCpm) - the ratio of the fit tolerance to the particular statistic 6 tau-f, expressed as FCpm = Tf / (6 tau-f) = (USLf - LSLf) / (6 times the square root of (sigma-f squared plus (mu-f - Mf) squared)) = FCp / the square root of (1 + delta-f squared), where tau-f is the positive square root of the mathematical expectation of the square of the deviation of the fit characteristic (clearance or interference) from its target value, and delta-f is the standardized shift of the distribution of the assembly size, delta-f = (mu-f - Mf) / sigma-f. Note: the FCpm index reflects in a combined way the effect on assembly quality of both the fluctuation of the hole and shaft operations and the shift from the fit target value,

and may be used as an index measuring the centring of the assembly size.

3.2.1 superior degree percentage of hole/shaft fit (PC(f)) (percentage of clearances or interferences in the defined middle zone of the fit tolerance) - the ratio of the number of clearances or interferences of the assembly lot that lie within the middle zone (superior zone) of the fit to the number in that assembly lot, expressed as a percentage. The superior degree percentage PC(f) is calculated in the following two cases: a) the middle zone (superior zone) of the fit is the middle third of the fit tolerance zone: PC(f)(Mf plus or minus Tf/6) = {Phi[FCp(1 - 3kf)] - Phi[-FCp(1 + 3kf)]} x 100 %; b) the middle zone (superior zone) of the fit is the middle half of the fit tolerance zone: PC(f)(Mf plus or minus Tf/4) = {Phi[1.5 FCp(1 - 2kf)] - Phi[-1.5 FCp(1 + 2kf)]} x 100 %. Note: to simplify application and to promote the raising of fit quality, the index PC(f)(Mf plus or minus Tf/6) is recommended in preference.

3.2.2 fraction of average fit quality loss (Pql(f)) - the average quality loss caused to society and to the user by the deviation of the clearance or interference of the assembly lot from the target clearance or target interference, expressed as a percentage: Pql(f) = [1/(3 FCp) squared + kf squared] x 100 %.

4 Relation between the statistical quality indices of an assembly lot (hole/shaft fit) and the statistical parameters of the two (hole and shaft) fit sizes

4.1 General. The relation between the statistical quality indices of the assembly lot (hole/shaft fit) and the statistical parameters of the two (hole and shaft) fit sizes is the basis of statistical tolerance design oriented to the fit quality indices, and is also the main basis for predicting the statistical quality indices of the assembly lot (hole/shaft fit) from the statistical parameters of the two fit sizes. The relation between the statistical quality indices and the statistical tolerances of the two fit sizes is the embodiment of the relation between the statistical parameters under the particular condition that the statistical parameters of the hole and shaft fit sizes all reach the limiting values of the statistical tolerances.

4.2 Relation between the fit capability index FCp and the process capability indices of the two fit sizes. FCp = Tf / (6 sigma-f) = (TH + TS) / (6 sigma-f) = 1 / the square root of (1/Cp(H) squared + (1/(r Cp(S))) squared) plus 1 / the square root of (1/Cp(S) squared + (r/Cp(H)) squared), where r is the ratio of the hole tolerance to the shaft tolerance, r = TH/TS.

4.3 Relation between the fit shift parameter kf and the shift parameters kH and kS of the two fit sizes. kf = delta-f / (Tf/2) = 2(delta-H - delta-S) / (TH + TS) = (r kH - kS) / (1 + r). Note: when the hole/shaft tolerance ratio r = 1, kf = 0.5(kH - kS); when r = 1.6, kf is approximately 0.615 kH - 0.385 kS.

4.4 Relation between the superior degree percentage PC(f) and the process capability