International Conference
1ST International Conference on Innovations, Recent Trends and Challenges in Mechatronics, Mechanical Engineering and New High-Tech Products Development
MECAHITECH'09
Bucharest, 8-9 October 2009

Proposals for Calculating the Gauges for Shafts and Bores Having Tolerance and/or Lomit Deviations Different from ISO System of Tolerances and Fits

Mircea-Bogdan ULEIA, P.E. MEng, PhD[1], Claudia Magdalena ULEIA MSc, Teacher 1-st deg.[2], Dragos-Nicolae ULEIA MEng[3]
[1]S.C. ISPE S.A Bucureşti, [2]Liceul Teoretic I.C. Vissarion Titu, [3]S.C. VULCAN S.A. Bucureşti

The need for the development of markets for the Romanian machine-building industry is a vital condition for its own survival. In this fight the main role is played by ensurance of an adequate competitiveness, related primarily to the product's quality, flexibility and economic efficiency.
To obtain an appropriate quality of the production that can be certified is imperative the introduction of total quality management system witch cover all aspects directly or indirectly connected to the production itself. Under this system a critical role comes up to the inspection of dimensional precision that for doing the tasks given, needs adequate means of inspection which can ensure both an high grade of adequate confidence and a sufficiently high universality on the one hand but also a satisfactory productivity under the condition of a satisfactory economic efficiency of the proposed goal. Among the means of dimensional inspection to these demands, they are also the gauges

1. Short presentation of the use of gauges

Usually the use of gauges is characteristic to mass and series production, because only in such conditions the gauges put their advantages in value: avoiding the wear of universal MCD that otherwise should be scrapped prematurely, increasing the productivity of control operations, improved the conditions for the running control, avoiding the errors in reading, indication, etc., inherent in the quantitative measurement of the dimensions and ensuring the interchangeability.

Checking with the gauges is only a review of classification of the deviations between the maximum and minimum limits, so only a qualitative, not quantitative verification but sufficient for adequate quality assurance of products. Checking with limiting fixed gauges also presents some risks, as shown in some works. Thus, the distribution of performance tolerances of the size of the active parties of the gauges is possible that sometimes the actual size to allow the acceptance of components which are not within the tolerance of execution or rejection of parts falling into it. The laws of distribution of deviations, these opportunities are still limited in practice and using gauges not revealed until now such cases which have had undesirable effects noticeable.

Checks are made for both dimensional deviations (cylindrical bores smooth, flat channel depth and width, the distance between holes or between a hole and an edge), for deviation of position (cotters channel position, deviations from symmetry, deviations from parallelism) and controls complex (smooth tapered surfaces, threaded cylindrical and conical surfaces, surfaces with grooves). Dimensional inspection of shafts and bores with smooth surfaces involves an shape control, too. Gauges-related advantages: simplicity, convenience and precision of control, especially to self-determination during manufacturing, lower cost than universal control means and a relatively wide range of uses.

2. Design issues of gauges

2.1 Methods for determining the dimensions, tolerances and deviations of active elements of gauges

A specific problem of gauges is calculating the dimensions, tolerances and deviations of active elements and determination of the parameters that occur in this calculation. It notes, for the full range of gauges, several situations. Thus it is possible to calculate the size of the active parts of gauges through prescriptions of calculating relationship depending on the type of gauge. Parameters of calculation are prescribed according in standards either depending on the range of nominal sizes and its deviations (in gauges for smooth cylindrical surface, also applicable for gauges for tapered surfaces smooth and flat fits flat, gauges for control assemblies with feathers and gauges for surfaces with grooves) or, usually, only for certain range of dimensions and only for certain deviations, usually for standardized tolerance fields or depending on the tolerance ranges (in gauges for threaded cylindrical and conical surfaces and gauges to verify the position of areas) but not in the latter case there is not possible the extension to other values. For some well defined role conical surfaces (cones Morse and metric) and certain types of threads standards directly prescribe nominally values and dimensional deviations of the active elements of gauges, starting for the inability to have other dimensions or tolerances than are prescribed by standards giving constructive information for verifying surfaces, too. The latter method sometimes may be a limitation of the range of verifiable dimensional sizes.

2.2 Constructive designing of gauges

Gauges design involves, about determining the dimensions of the active elements, establish the general shape and the other dimensions, too. Usually this problem is solved by means of standards that prescribe exactly these elements. We illustrate this solution with the gauges for smooth cylindrical surface, for surfaces with cotters, for surfaces with grooves and many gauges for threaded surfaces, cylindrical and conical. Also complete definition of gauges in terms of constructive forms encounters in cone Morse and cone metric gauges. For gauges for smooth conical surfaces other than Morse and metric cones as well as for threaded cylindrical and conical surfaces that are not defined constructive elements may be used, at least guidance, applicable constructive elements from the standards for constructive dimensions of gauges for alike surfaces. For the gauges for flat fits and gauges for check surface position, because of differences in their form is not possible to make recommendations on constructive design. At the same time we can talk about limiting of range of sizes verifiable with gauges by limitations imposed by the standards of constructive forms of gauges, including by limiting the range of semi-product usable for gauges.

3. Deviations and tolerances controlled by gauges

Starting with how to use the gauges at first sight does not appear principled limitations on values dimensions, tolerances and deviations that can be checked with them, while respecting the areas of use. Furthermore, in terms of how the calculation, there are not theoretical reasons to limit the values of dimensions, deviations and tolerances verifiable by gauges. Limitations arise but related parameter values for calculation by the fact that their values are prescribed by discrete values depending on the values of tolerances and deviations verifiable or directly prescribed for a specific tolerance or deviation to a specific type of surface. In case of gauges for cylindrical and tapered metric thread, for cylindrical and conical threads for pipes with or without seal and for trapezoidal threads parameter values for computing parameters are prescribed for ranges of tolerance of thread, if size for cylindrical surfaces smooth and default conical smooth surfaces and flat fits the parameters of calculation are prescribed only for special tolerances and deviations, those prescribed by the ISO system for deviations, tolerances and fits.

4. Need of gauges for smooth cylindrical and conical surfaces with deviations and tolerances different for deviations and tolerances prescribed by ISO system

In the mechanical design is recommended practice fits, standard deviations and tolerances as prescribed by ISO, related to the benefits of using their known and presented in all literature.

However, there are also situations where these can not be used for objective reason, justifiable technical and/or economically. We will continue to exemplify such situations.

A prime example is solving of chains of dimensions for products made in series production.

Deviations and fits different from the standard design may appear thanks design calculations related, by example, to keeping character fits with temperature change in operating mode.

Technological calculations of such as assembly by relieving, the verification mangling degree of pipes, or intermediate size in manufacturing, lead, usually, to the occurrence of deviations and tolerances other than standardize.

Another issue is related to the economic aspect. Such deviations prescription ISO lead to numerical values that may be transferable to hundredths of millimeters or even microns[1] values, sometimes exaggerated view of the actual accuracy of functionally necessity. These values drive unnecessary costs related to the first "superprocessing" unnecessary and finishing operations involving the use of machinery, tools and devices with high precision and on the other side of "supercheking" related to special processes and also to equipment in terms of accuracy.

Sometimes overlooked, the psychological aspect has in its turn economic implications sometimes major. And this is related to the values of deviations showing hundredths of a millimeter and micron unnecessarily, which may lead the operator in some cases to excessive care and for precision of manufacturing and control process generating additional execution time and thus affect the growth unsustainable the price of that product.

Benefits of gauges presented in the first paragraph or impossible using other methods may require the use of gauges for dimensional inspection of dimensions showing such deviations. In these circumstances we consider demonstrated the need for gauges for smooth, cylindrical or conical surfaces with different deviations from deviations prescribed by the ISO.

5. Calculation of size of assets of gauges for smooth cylindrical surfaces

Relations for calculating gauges for checking parts with tolerances prescribed by standards general use SR EN 20286-1,2:1997 are those given in Table 1, taken from standard STAS 8222-68. We presented only the generalized relations for calculating the dimensions over 180 mm, which may be extended to smaller size by simply introducing value 0 for parameters α and α1.

The symbols have the following meanings in the table d_{min} [mm] minimum size of the part, D_{max} [mm] maximum size of the part, H [mm]-tolerance of execution for cylindrical plug gauges which may be H_s tolerance of execution for spherical plug gauges, H_1 [mm]-tolerance of execution for ring or fork gauges, H_p [mm]-tolerance of execution for plug

[1] To avoid confusion between micrometer measuring instrument, whose name is entered into everyday language and unit of measure representing sub-multiples of the order of 10^{-6} meter we propose that his name is, by exception "Micron" as is already entered in the language aware of storing the symbol [μm]. A precedent for this exception the name even if there are units for linear dimensions, Ångström unit, sub-multiples of the order of 10^{-10} meter, even with this specific symbol [Å]. Name micron can be found in standard STAS 10085/2-86 but use the symbol [μ].

gauging gauge for ring gauges, y or y ' [mm] limit of wear of the side "GO" of plug gauges cylindrical or spherical, situated beyond the limit "GO" of the part, y_1 or y'_1 [mm] limit of wear of the side "GO" of the cylindrical ring or fork gauge, located beyond the limit "GO "of the part, z [mm] distance between the center-field of tolerance of side" GO "of a new cylindrical or spherical plug gauge and limit the "GO" of the part, z_1 [mm]-distance between the center field of tolerance of "GO" side of a new ring or fork gauge, and limit "GO" of the part, α and α_1 [mm]-safety zones provided for plug gauges, respectively ring and fork gauge, with nominal diameter exceeding 180 mm, for to offset measurement errors, obviously having a value of 0 for dimensions less than 180 mm.

Schematic representation of calculus of gauges and gauging gauges, taken for the standard STAS 8222-68 too, can be traced in Fig 1 for plug gauges and in Fig. 2 for ring or fork gauges. In these pictures too, we have preferred to present the general case, the dimensions over 180 mm, for smaller eliminating the parameter α.

Table 1 Relations to calculate the size of the active elements for smooth cylindrical size [mm] [1]

Type of gauge	**Name of gauge**	**Dimension**
Plug	GO new	$(D_{min}+z)\pm H/2$
	GO worn	$D_{min}-y+\alpha$
	NOT GO	$(D_{max}-\alpha)\pm H/2$
Ring	GO new	$(D_{max}-z_1)\pm H_1/2$
	GO worn	$D_{max}+y_1-\alpha_1$
	NOT GO	$(D_{min}+\alpha_1)\pm H_1/2$
Gauging Plug	GO new	$(D_{max}-z_1)\pm H_p/2$
	GO worn	$(D_{max}+y_1-\alpha_1)\pm H_p/2$
	NOT GO	$(D_{min}+\alpha_1)\pm H_p/2$

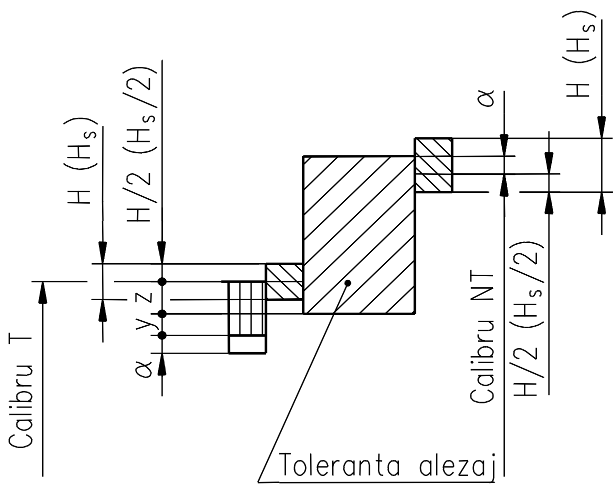
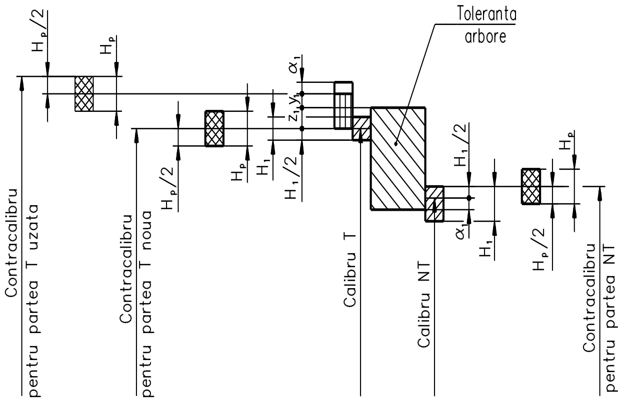


Figure 1 Scheme of calculation for smooth plug gauges [1]



F ig 2 Scheme of calculation for smooth ring gauges [1]

Relations, patterns and calculation parameters above can be used to calculate the height of steps GO, respectively NOT GO, for the gauges for the conical smooth surfaces.

Standards for calculating the gauges (STAS 8221-68, 8222-68 STAS, STAS 8223-68) have prescribed values for maximum dimensions of 500 mm and have no relationship to extend the range covered account to other values of deviations.

Patterns and relations of the above is observed that the relations of calculation size of the active elements of gauges does not depend other value of tolerance area where size is calculated so that no restrictions can be applied to surfaces with different tolerances and the tolerances prescribed under the ISO.

6. Determination of parameters for calculating the size of the active elements of gauges for smooth cylindrical surfaces

From calculation parameter values presented in the above-mentioned standards can be seen that their values depend on the size value of surface for which is calculated the gauge and tolerance value of this surface, expressed by accuracy class. This raises the clear need to determine the calculation parameters for the different tolerances than the prescribed by ISO.

The values of these parameters are presented in standard STAS 8122-68, directly or indirectly (by indicating fundamental deviation IT) but only for well-established values of the usual fundamental tolerances (between IT 6 and IT 16) for each size range. There is one specific feature that is the fact that for different values of fundamental tolerance parameter values may be the same even in the same dimensional range.

Translating in the mathematical language we consider that are defined for each size range a number of functions (one for each parameter calculation) with discrete values, functions that have the field of definition on the lot of fundamental tolerances values for these accuracy classes and range values on the lot of parameters values. To find parameter values for different values of the ISO standard tolerances is required to establish relations of definition of the functions. Starting from the fact that functions are defined on a discrete set of values and the values in another set of discrete values in the same way they are presented the tabulated values trigonometric functions or logarithms, which we deem applicable method for finding the values of function which are not found in the set definition is interpolation method.

References [2] provides for the interpolation in technical measurements, so involved with tolerances and related calculations, the following methods

-graphic method
-linear method
-parabolic method

To establish a relationship between experimentally determined values of a parameter and the parameter values that varied in which varied during determination is usually use a polytropic relationship. We will discuss the possibility of this "interpolation", too.

Graphic method involves the graphical representation of the some pairs (*x, f (x)*) of the corresponding region of *x* tried and plot on graph paper the best curve corresponding function *y = f (x)*. Then read on the curve requested value of *y* for the argument *x* given. In addition to the fact what the graphical construction is laborious requiring a large scale suitable for an adequate precision, method is less accurate, depending on subjective factors for assessing the best curve. These deficiencies do it, both theoretically and practically, inapplicable for determining the parameters required for the gauge calculation.

Linear method assumes that between the values of *x* listed in table y varies linearly with x. according to relationship (1).

$$y = \sum_{i=0}^{n} A_i \; x^{i+1} \qquad (1)$$

In relation (1) y is the dependent size, A, B-coefficients, x-size given to determining dependency.

As a result, for the value of x located in the table between x_1 and x_2 values to their corresponding values y_1 and y_2 corresponds a value y given by (2)

$$y = y_1 + \frac{y_2 - y_1}{x_2 - x_1}(x - x_1) \qquad (2)$$

In relation (2) x is the function argument (in the case discussed fundamental tolerance value) and y is the value of function (in the case discussed the parameters of calculation that z, y, α, z_1, α1, H / 2, H_1 / 2, H_P / 2, as were defined in Table 1).

The method applies to a limited range of discrete values between which is the value for which we are to finding the values of this parameter leads to a low generalization links between function arguments and values as the main shortcoming of the method. On the other hand the method is relatively simple but with a good accuracy, identical to the general interpolation method used to calculate the tabulated values of trigonometric functions and logarithms before introducing electronic computing means, which gives a psychological advantage and can be implemented relatively easily.

Polynomial method called parabolic unsuitable because parabolic method is a particular case of it when taking into account only two arguments, is to approximate the function *y = f (x)* with a polynomial of degree at most n where n is the number of arguments x known according the relationship (3)

$$y = \sum_{i=0}^{n} A_i \; x^{i+1} \qquad (3)$$

In relation (3), i is number of sizes to determining dependency, rest of symbols with meanings defined above for relation (1)

Polynomial can be written with Lagrange's formula (4)

$$y(x) = P(x) = \sum_{i=0}^{n} L_i(x)\; y_i \qquad (4)$$

where Li (x) has the expression given by (5) and takes values according to relationship (6)

$$L_i(x) = \frac{(x - x_0)(x - x_1)...(x - x_n)}{(x_i - x_0)(x_i - x_1)...(x_i - x_n)} \quad (5)$$

$$L_i(x_j) = \delta_{ij} = \begin{cases} 1 & pentru\ i = j \\ 0 & pentru\ i \neq j \end{cases} \quad (6)$$

In relations (4), (5), (6) P (x) is a polynomial, Li (x) a polynomial interpolation Lagrange,
δi j Kroneker's symbol, the remaining symbols with meanings defined above.

The method is laborious, difficult to apply to a large number of values [3], as is the present case. It can be used a simpler method resulting from this, the parabolic method witch is applied to a range of three values between witch they are the value for which they want to find the values of parameters. In addition with the uncertainty to location of the interval on the fact because the desired value can be either in range with lower values or higher range of values, the purely subjective choice may influence the results, the decreasing the number of taken intervals in discussion minimize considerably the main asset polynomial method, too, the relatively high degree of generalization of the links between the arguments and function values. Reducing of the depth of generalization of the link between the arguments and function values manifests if the number of these intervals is greater but under the maximum number of tabular values too, and uncertainty about the choice of these intervals is always where they are in odd number. Therefore, in our opinion, how laborious calculation is likely to lead to mismatches method, given that even the theoretical benefits are reduced.

Polyitropic method usually applied to a dependency on a large number of parameters, translated by a complex function as the relationship (7)

$$y = C \prod_{i=1}^{n} A_i\, x_i^{p_i} \quad (7)$$

In relation (7) C is a coefficient, p-exponent, the rest symbols as defined above.

When determining the value of the parameters mentioned above they starts from the premise that they must be done strictly in the range of sizes which belongs the size for witch mast be calculated parameters and thus the factors determining value is reduced to one, the basic tolerance and relation (7) is reduced to a polynomial type dependence of particular form (single term), which makes it unworkable.

Theoretical conclusions findings were experimentally validated. During the work the design of the authors, they do parallel calculations using linear interpolation and polynomial interpolation for a large number of gauges used to control parts having different tolerances of standard tolerances. In all cases, after rounding up results at 3 decimal places (precision at micron) under rules known differences between the two methods do not exceed a level of 30% of the tolerance level considered, as is customary used in design practice, acceptable to the checkers . Hence, trough experimental level too, from the experience of the authors, the same conclusion as was derived theoretically, the fastest method for determining the calculation parameters is linear interpolation method, which, on the other hand, ensure the required precision for the purpose for which is used.

And for linear interpolation may be taken into account the unequal influence factors hold two limits of the range that applies. Experimental studies on the influence of the weight limits of the interval for which the calculations are doing, were also made by the authors for a large number of cases.

For plug gauges was observed that increasing the influence of one of the limits lead to variations of dimensions of the diameter of plug gauge GO. If increased weight of limit on the left leads to increase of the values of diameter therefore to the growth of recoverable scrap, increasing weight limits on the right leads to reduction of the values of diameter therefore to reduction of recoverable scrap. Regarding the limit of wear in the first case an increase in its size and so decrease of the durability of gauge leads to increased of the risk of rejection of an adequate part, in the second case a decrease in diameter and a increased durability leads to an increased risk to accept the reject. Even in conditions in which differences between the various versions do not exceed a level of 30% of the tolerance level considered, as is customary used in design, acceptable to the checkers, we consider that these variants are unacceptable in terms of precision dimensional inspection leading to an occurrence of uncertainties.

And for fork or ring gauges can be observed that increasing the influence of one of the limits results variations of sizes GO-NOT GO. If increased weight of the left limit leads to a decrease of the values of limit GO and increase of the values of limit NOT GO so to the growth of the unrecoverable reject and the diminution of recoverable reject, increased weight of the right limit leads to increased limits GO and reduce the values of limits NO GO respectively to the growth of recoverable reject and to the diminution of recoverable reject. Regarding the limit of wear in the first case an can observe an increase in its size and so decrease of the durability of the gauge and an increase of the risk of rejection of a adequate part in the second case a decrease of limit and a growth of the durability but also the a risk to be accepted the reject. In this case too, even in conditions in which differences between the various versions do not exceed a level of 30% of the tolerance level considered, as is customary used in design, acceptable to the checkers, we consider that these variants are unacceptable in terms of precision dimensional inspection leading to an occurrence of uncertainties.

As a conclusion of all those listed in this paragraph and linking the theoretical with the practical applications we consider that, to determine parameters required for sizing active elements of limiting smooth gauges, optimal calculation of all points of view is dimensional linear interpolation in the range of dimensions in which frames the checking dimension and in fundamental tolerance range falling left and right to control the size tolerance. Interpolation will be taking equal weight to both limits.

7. Practical method for determining the size of the active elements of cylindrical gauges for size with different deviations and / or t tolerances from ISO system tolerances and fits

Practical method for the determination of the parameters for calculating of the gauges for cylindrical smooth surfaces and apply equally to shaft and bores involves the following steps

1. Establishing baseline data the nominal size value to verify, its upper and lower deviation values, or the value of nominal size, maximum size and minimum size. The values of maximum deviation and minimum deviation are calculated with relations (8) and (9). Further examples of calculations will be made for shafts, for bores are identical calculations, assuming only a change of symbols in lowercase to uppercase.

$$es = d_{max} - d \quad [mm] \tag{8}$$

$$ei = d_{min} - d \quad [mm] \tag{9}$$

In relations (8) and (9) d [mm] is the nominal size, d_{max} [mm] maximum size and d_{min} [mm] minimum size, es [mm] upper deviation, ei [mm] lower deviation. Deviations are introduced in calculations including the sign preceding it.

2. From initial data element will be calculated the basic element to determine the parameters, the tolerance which we call conventionally actual and, where appropriate, minimum and maximum values for size

The calculation for actual tolerance is made with relation (10), for the maximum size with the relation (11) and for the minimum size with relation (12)

$$T_e = es - ei = d_{max} - d_{min} \quad [mm] \qquad (10)$$

$$d_{max} = d + es \quad [mm] \qquad (11)$$

$$d_{min} = d + ei \quad [mm] \qquad (12)$$

In relations (11), (12), (13) T_e represents actual tolerance, remaining symbols have the meaning above.

If necessary the actual tolerance value to be prescribed in micron processing is performed according to the known relationship (14). Also relation (14) indicates the transformation of values to calculate from microns in millimeters for maximum and minimum deviations.

$$1\,\mu m = 0{,}001\,mm \quad 1\,mm = 1000\,\mu m \qquad (14)$$

Consider the symbols commonly used in relation (14) known.

3. Nominal size will be framing a size range reflecting their of SR EN 20286-1,2:1997. It will retain the values that limits of range, we will note the conventional D_m and D_M [mm] for bores, d_m and d_M [mm] for shafts, the index m indicating the minimum and maximum value indicating the index M.

4. To apply interpolation is necessary first to determine the margins of the interval in which it is made. This objective requires, because of the indication of the parameters depending on the amount of tolerance through class accuracy, finding of the actual precision class (with the surface to checking is performed).

A simple method involves comparing the actual tolerance value for the size of checking surface with the values of standard steps of tolerances for the range of dimensions in which the dimension of checking surface is framed. By comparison may frame the actual tolerance of the dimension of the surface to checking among the two steps of standard tolerances.

Another method, applicable to any computer program requires the determination of the class of precision through precision coefficients depending of the step precision. Starting from the calculation of standard tolerances steps in accordance with SR EN 20286-1:1997 with additional explanations [4, 5, 6, 7, 8, 9, 10] actual coefficient value is calculated with relationship (15) for sizes below 500 mm and the relationship (16) for size over 500 mm

$$k_e = \frac{T_e}{0{,}45\sqrt[6]{d_m d_M} + 0{,}001\sqrt{d_m d_M}} \qquad (15)$$

$$k_e = \frac{T_e}{0{,}0004\sqrt{d_m d_M} + 2{,}1} \qquad (16)$$

In relations (15) and (16) k_e is the coefficient of precision actually presented before the rest of the symbols having meaning above.

Step accuracy can be determined based on the actual accuracy rate by comparing it with precision coefficients dependent from step precision presented in Table 2, in which we presented only the precision values for the steps between 6 and 16 for which is usually calculated gauges according to existing data from standard STAS 8222-68 on the calculation gauge.

Table 2 Precision coefficient values according to the steps of precision

n	6	7	8	9	10	11	12	13	14	15	16
k_n	10	16	25	40	64	100	160	250	400	640	1000

in the table 2 n is the step of precision and k_n is accuracy factor for that step precision.

After determining the effective precision step this is framed between two accuracy classes according to SR EN 20286-1,2:1997 noted n_i respectively n_s where index i indicates the lower accuracy class and the s the upper

5. For dimensional range corresponding to the nominal size of the part to check is determined tolerance values labeled Te and basic calculation parameters for sizes according to STAS 8222-68 labeled as appropriate z, H / 2, y, α for plug gauges respectively z_1, H_1 / 2, y_1, α_1 for ring gauges for both accuracy class lower to effective precision class, highlighted by the index i, and upper accuracy class to effective precision class highlighted by the index s.

6. Knowing the values for lower, upper and effective tolerance and calculating parameter values for upper tolerance and lower tolerance is to determine the parameters for calculating for the actual tolerance related by linear interpolation.

Values thus obtained are used to calculate the size of the active elements of the gauge.

The method is applicable both for conical and flat smooth fits.

8. Constructive elements of size for smooth cylindrical surfaces

Because standards for shape of gauges for smooth cylindrical surfaces not restrict their application in relation with tolerance of checking part can be used without problems to the definition of the constructive elements not related to active dimensions, in accordance with limitations related to checking part. To determine the shape and dimensions (tail cone diameter, overall length, bore diameter, the diameter of the ring, etc.) for constructive unfunctional elements is used the indications of Romanian standards STAS 2981/1-80, 2981/2-80, STAS 3634-80, STAS 2991-80, STAS 3507-80, STAS 4350-88 and STAS 12896-90.

9. Conclusions

1. The need to ensure total quality of production in economic conditions require the use of means of inspection to ensure good dimensional accuracy, good productivity and a cost price leading to profitability
2. Gauges have numerous advantages in this direction and thus are applicable in many situations.
3. Gauges calculation for smooth cylindrical surface is limited to parts with tolerance and fits according to ISO.
4. The calculation of such gauges does not impose restrictions related to values of tolerances of checked pieces. The only restrictions are imposed by the lack of calculation parameters for different tolerances that prescribed tolerances according to ISO
5. The fact that the values of parameters for calculating the size for smooth cylindrical are prescribed for tolerance discrete values allowed their determination for other values of tolerance by linear interpolation.
6. Practical experience of the authors on the calculation, implementation and use of the gauges calculated according to indicated methodology which utilization in dimensional inspection did not affect the acceptability of the parts constitute a confirmation of the viability of calculation methodology

10. References

[1] ***-Standardele române (SR EN, STAS) menționate în text-Editura tehnică, Bucureşti
[2] Ştețiu, .C. E., Oprean, C.-Măsurări geometrice în construcția de maşini-Editura Ştiințifică şi Enciclopedică, Bucureşti.1988
[3] Olaru, V., Halanay, A., Turbatu, S.-Analiză atematică- Editura didactică şi pedagogică, Bucureşti, 1983
[4] Dragu, D.-Toleranțe şi măsurători. Manual pentru licee cu profilurile de mecanică,

matematică-fizică şi matematica-mecanică, clasa a XI-a-Editura didactică şi pedagogică, Bucureşti, 1978
[5] Dragu, D., Bădescu, Gh., Militaru, C., Sturzu, A., Popescu, I.-Toleranţe şi măsurători tehnice-Editura didactică şi pedagogică, Bucureşti, 1980
[6] Lăzărescu, I., Şteţiu, C. E.-Toleranţe, ajustaje, calcul cu toleranţe, calibre-Editura tehnică, Bucureşti, 1984
[7] Sturzu, A.-Toleranţe şi măsurători tehnice-Universitatea Politehnică Bucureşti, Bucureşti, 1993
[8] Sturzu, A., Popescu, E. N.-Tehnologii şi echipamente de control (T.E.C.)-Universitatea Politehnică Bucureşti, Bucureşti, 2000
[9] Şteţiu, C. E.-Control tehnic-Editura didactică şi pedagogică-Bucureşti, 1979
[10] .Uleia, M. B.-Stadiul actual al asigurării calităţii pieselor de dimensiuni mari-Referat 1 al studiilor doctorale-Universitatea Politehnica din Bucureşti, 1999

ANNEX 1 (Informative)
EXAMPLE OF CALCULATION

A1 size determination limit buffer size for checking bore $Ø100^{+0,100}_{+0,050}$

Initial data [1]
D 100 mm
ES +0,100 mm
EI +0,050 mm
Is calculated according to the relations of § 6
Te=0,100-0,050=0,050 mm=50 μm
D_{max}=100+0,100=100,100 mm
D_{min}=100+0,050=100,050 mm
According to SR EN 20286-1:1997 Table 1 to obtain employment dimensional field [1]
D_m = 80 mm, D_M = 120 mm
Is calculated according to the relations of § 6

$$k_e = \frac{50}{0,45\sqrt[6]{80\times120}+0,001\sqrt{80\times120}} = 23,0146$$

According to Table 2 § 6 tolerance falls between rungs of tolerance IT7 and IT8
From Table 1 SR EN 22768-2:1997 and Tables 2 and 3 STAS 8222-68 results [1]

n	ITn	H	z	y	Shape tolerance
7	0,035	IT3=0,006	0,005	0,004	IT2=0,004
8	0,054	IT3=0,006	0,008	0,006	IT2=0,004

By linear interpolation according to the actual tolerance value is obtained

T_e	H/2	z	y	Shape tolerance
0,050	0,003	0,007	0,006	0,004

According to § 5 identical to Table 1 STAS 8222-68 to obtain [1]
GO new = (100.050 0.007) = 100.057 ± 0.003 ± 0.003
GO worn = (100,050-0,006) = 100.044

NOT Go = 100.100 ± 0.003
Form plug gage will be in accordance with Fig. 1 and Fig. 2 of standard STAS 2981/2-88 dimensional range between 90 and 100 mm. The handle used to be the type A30 according to STAS 2992/2-85. [1]

A2 size determination of the size limit for checking tree fork Ø200 $^{+0,200}_{-0,100}$

Initial data [1]

D 200 mm
Es +0,200 mm
Ei -0,100 mm

Is calculated according to the relations of § 6
Te=0,200-(-0,100)=0,300 mm=300 μm
Dmax=200+0,200=300,200 mm
Dmin=200-0,100=199,900 mm
According to SR EN 20286-1:1997 Table 1 to obtain employment dimensional field [1]
d_m = 180 mm, d_M = 250 mm
Is calculated according to the relations of § 6

$$k_e = \frac{300}{0,004\sqrt{180 \times 250} + 2,1} = 104,9$$

According to Table 2 § 6 tolerance falls between rungs of tolerance IT11 and IT12
From Table 1 SR EN 22768-2:1997 and Tables 2 and 3 STAS 8222-68 results [1]

n	ITn	H_1	z_1	y_1'	α_1	Shape tolerance
11	0,290	IT5=0,018	0,040	0,010	0,010	IT4=0,012
12	0,460	IT5=0,018	0,045	0,015	0,015	IT4=0,012

By linear interpolation according to the actual tolerance value is obtained

T_e	$H_1/2$	z_1	y_1'	α_1	Shape tolerance
0,300	0,009	0,040	0,010	0,010	0,012

According to § 5 identical to Table 1 STAS 8222-68 to obtain [1]
GO new = (200,200-0,040) = 200.160 ± 0.009 ± 0.009
GO worn= (200.200 +0,010-0,010) = 200.200
NOT GO = (199.900 0.010) = 199.910 ± 0.009 ± 0.009
Form size fork will be in accordance Fig. 2 of standard STAS 2991-80 dimensional range between 180 and 200 mm. [1]