Turning Ideas Into Reality

An Overview Of GPS

A Cost Saving Tool

First Edition
2005

Geometrical Product Specifications

Per Bennich
and
Henrik Nielsen

IfGPS
Institute for
Geometrical Product Specifications

IfGPS
Institute for
Geometrical Product Specifications

GPS - Geometrical Product Specifications
and the GPS-matrix system

Synopsis

GPS is the international symbol language for expressing tolerances in technical drawings. It is the only worldwide language available for communicating geometrical requirements on drawings. GPS is developed through cooperation by more than 60 countries and documented in ISO Standards issued by the International Organization for Standardization. GPS is a natural development of traditional tolerancing, or Geometrical Dimensioning and Tolerancing, GD&T as it is known in the US. What has been added is much more detailed definitions of the requirements. This allows designers to express functional requirements much more precisely than was previously possible. The potential benefit is a 15% reduction in manufacturing cost, and the payback time for the investment in training and updated documentation can be less than 2 years.

To realize these savings it is necessary to educate not only designers, but all personnel that use GPS to express and interpret geometrical requirements. It is also necessary to educate designers in the proper procedure and sequence for applying tolerances on drawings, so the tolerancing is unambiguous and truly expresses the functional requirements.

These skills are not taught at engineering schools or in basic tolerancing classes. Consequently, the vast majority of drawings used in industry today are ambiguous and do not communicate the true functional requirements of the parts. These drawings impose artificial constraints on manufacturing and in some cases allow non-functional parts to be accepted and passed on to assembly. The savings from implementing GPS comes from eliminating these types of waste.

While all companies involved in designing and manufacturing mechanical parts can benefit from implementing GPS, the advantages are greatest for those companies that subcontract or outsource the manufacturing of parts because these companies, more than any others, have a need for their drawings to be able to communicate functional requirements without further explanations.

What is GPS?

GPS in this context is the acronym for Geometrical Product Specifications. GPS is the modern and updated symbol language that is used for tolerancing and communicating requirements to part geometry in technical drawings. GPS is the common international tolerancing language and is used worldwide. The basis for GPS tolerancing is geometrical dimensioning and tolerancing (GD&T), but used in a new and different way.

The basis for GPS tolerancing is traditional geometrical tolerancing, but used in a new and different way.

Why this GPS document?

GPS is new and most companies are unaware of the significant savings and competitive advantages GPS can bring. The purpose of this pamphlet is to explain GPS in layman's terms and point out where the potential savings are, as well as outlining how you go about implementing GPS as the tolerancing language in your company.

The GPS advantage

You can gain technical, competitive, and economic advantages by implementing GPS as the tolerancing language in your drawings. Some companies report a payback of the investment in less than 2 years, primarily due to a reduction in manufacturing cost and a reduction in work stoppage due to non-functional parts jamming assembly lines or lack of functional parts idling production.

GPS is first and foremost about better, more detailed and precise communication amongst design, manufacturing, and metrology personnel. The savings come from fewer misunderstandings and getting it right the first time. A term that is key to understanding the advantage of GPS is specification uncertainty. It quantifies the ambiguity in a tolerance requirement when it is applied to a real part with form error and angular

An Overview of The GPS Matrix System

deviations. See figure 1. As tolerances have become tighter in recent years, the specification uncertainty in traditional tolerancing has become more significant. This is the motivation for the development of GPS.

A term that is key to understanding the advantage of GPS is specification uncertainty.

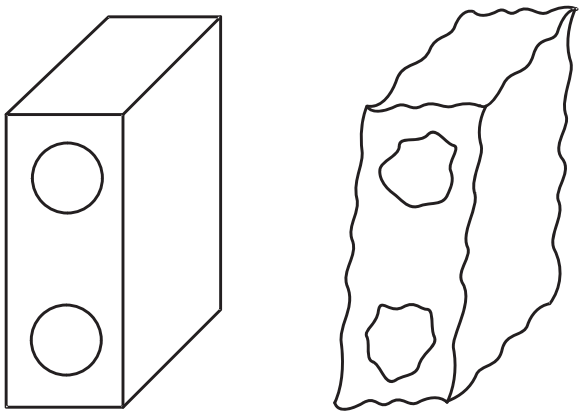


Figure 1: a) Nominal (perfect) part. b) Real part with form errors and angular deviations.

What are the signs that indicate my company would benefit from GPS?

There are a number of clear signs that a company would benefit from implementing GPS tolerancing. However, these signs are often misinterpreted, so companies think they have other problems, when in reality it is their product documentation and their tolerancing on the drawing that are insufficient.

These signs include:

- Your supplier delivers some parts that he has measured to be good, but when you measure them, you find them out of tolerance.
- You often use engineering deviations to use parts that are out of tolerance, but you know will work anyway.
- You use a purchased parts approval process (PPAP) to lock down the manufacturing processes used by suppliers instead of relying on the tolerances in your drawings to define the acceptability of parts.

All of these symptoms indicate that the tolerancing in your drawings does not correctly express the functional requirements of the part.

Are you subcontracting or outsourcing?

GPS based drawings provide an advantage when subcontracting or outsourcing the manufacturing of parts because GPS is a more precise language. Drawings based on traditional tolerancing typically give a lot of problems when manufacturing is outsourced, because your supplier does not share the common understanding built up over the years between your design department and your in-house manufacturing. The brutal truth is that most

The brutal truth is that most products function in spite of the tolerancing, rather than because of the tolerancing.

products function in spite of the tolerancing, rather than because of the tolerancing. The realities of modern manufacturing have made traditional tolerancing obsolete.

Correctly made scrap parts

The main problem is that traditional tolerancing is ambiguous. It always creates some level of doubt as to what exactly shall be manufactured. This ambiguity, or specification uncertainty, is often so large that parts can be made that live up to the tolerance requirements, but will not function correctly. This specification uncertainty creates both technical and economic problems, especially when the design and development departments and the shop that manufactures the part are far apart, as in the case of outsourcing, especially if they do not have a common spoken language. See example on figure 2.

Test your company's tolerancing

In the self-check form on page 11 you will find a number of examples of tolerance symbols and collections of symbols that you can compare to the drawings from your company or from your customers. This way you can determine what kind of tolerancing is used in each drawing.

You can use the form on page 11 to determine if you are using modern GPS tolerancing. If it turns out not to be a GPS based drawing, the consequence will often be that it contains significant specification uncertainty. This can create legal and economic problems if the drawing is used for subcontracting or outsourcing of manufacturing.

An Overview of The GPS Matrix System

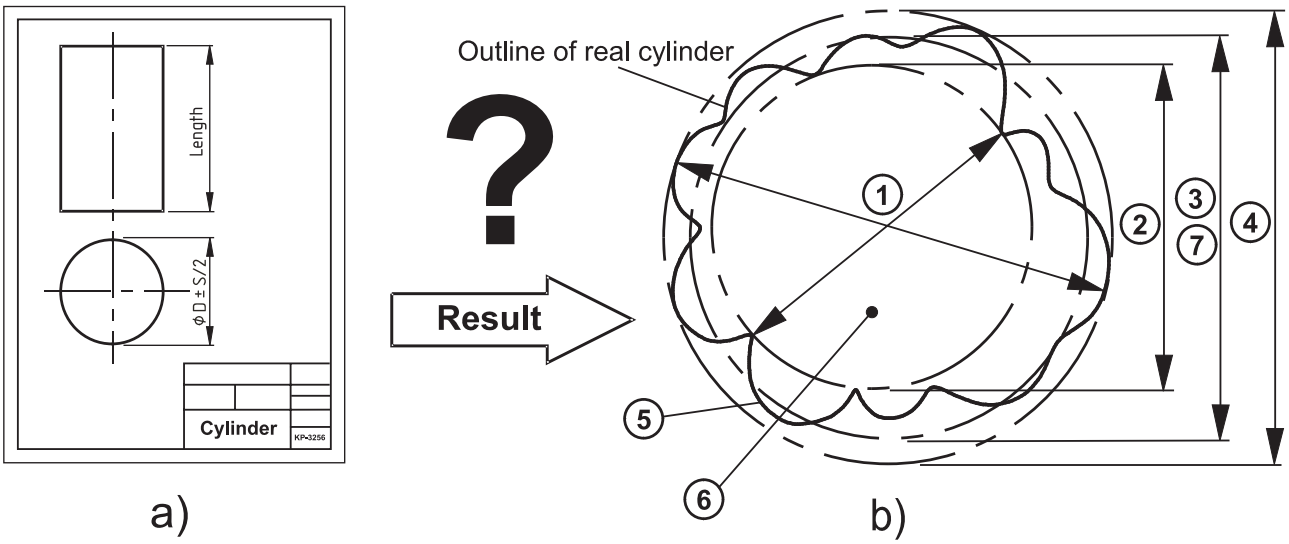


Figure 2: An example of specification uncertainty: ±tolerancing in the drawing a) is not defined on the real part. There are several different solutions (diameters) on the real part b).

Specification uncertainty can create significant legal and economic problems if the drawing is used for subcontracting or outsourcing of manufacturing.

The form on page 11 cannot provide any assurance that a drawing is correctly toleranced and has no specification uncertainty, but it can help in getting a rough first impression. Checking the tolerance symbols shown in the form does not require much technical knowhow since it only requires a visual comparison between the symbols in the table and the symbols in the drawing.

Did you know:

- The traditional tolerancing language has roots all the way back to 1930 and has evolved significantly over the last 10 to 15 years from a few standardized rules to a comprehensive symbol language (GPS), which can simulate part function.
- The GPS symbol language which has been developed in ISO with the input from experts from more than 60 countries is documented in over 100 international standards covering more than 2500 pages.
- The ISO GPS standards only function as the dictionary and grammar book of the GPS language. They do not contain much information about how the GPS system shall be applied.
- GPS allows critical tolerances in the drawing to be increased significantly.
- All CAD systems can be used for GPS tolerancing.
- GPS applies to 2D drawings as well as 3D CAD models.
- The CAD system cannot make a correct and unique tolerancing on its own ! It is only the human knowledge and experience that can make the tolerancing correct and unique using the CAD system as a tool.

Evaluate the tolerancing in your drawings by using the self-check form for tolerancing shown on page 11.

An Overview of The GPS Matrix System

What is the problem with traditional tolerancing?

The problem with traditional tolerancing is that when the manufactured parts have non-negligible form errors compared to the tolerances, the tolerancing becomes ambiguous and the reader of the drawing has to guess at exactly what the requirements are. See figure 2.

Tolerancing in drawings

The primary function of drawings of products and parts is to convey the design intent and the requirements of the part to those responsible for manufacturing the product or the part. This is done by focusing on the tolerancing that has been used in the drawing.

The tolerancing should communicate all the necessary prerequisites to ensure proper product function. Only those requirements that are indicated in the tolerancing in the drawing can be expected to be fulfilled.

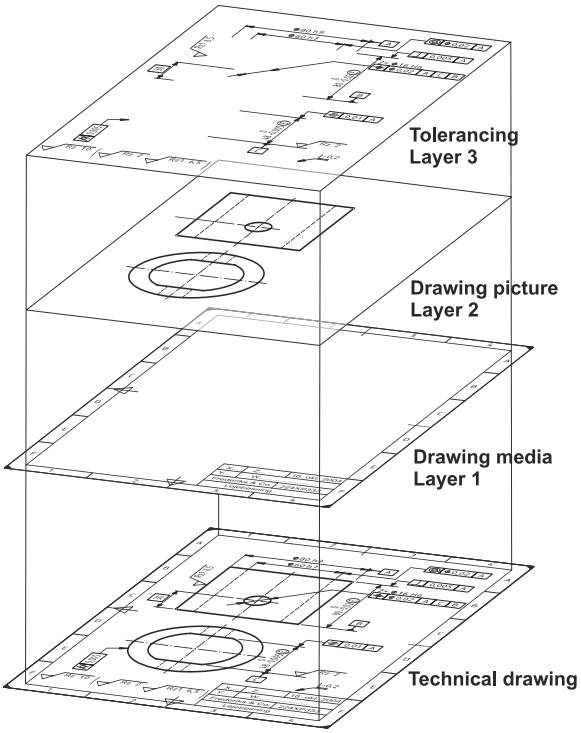


Figure 3: The drawing has 3 layers described in standards. Only layer 3 contains the GPS symbols and the specification requirements.

It is the tolerancing, i.e. the tolerance symbol language that is used and how it is applied, that is the important part of the drawing. See figure 3. This is because the tolerancing should communicate all the necessary prerequisites to ensure proper product function. Only those requirements that are indicated in the tolerancing in the drawing can be expected to be fulfilled. There are no hidden requirements. The drawing picture itself does not create requirements for the part. In particular, just because the drawing picture shows two sides of a part at a right angle to each other or a pattern of holes arranged symmetrically, it does not in itself create a requirement for the produced part. This often catches designers out. Because they are used to thinking based on the perfect geometry presented on the CAD screen or in the drawing, they often think there are such implied requirements.

It is important to realize that the tolerancing in the drawing is the single largest factor in determining the cost of manufacturing the product or the part.

It is important to realize that the tolerancing in the drawing is the single largest factor in determining the cost of manufacturing the product or the part. Unnecessarily tight tolerances drive up the cost of manufacturing. If the tolerancing is made with one particular manufacturing process in mind, it precludes the manufacturing engineer from using his expertise to find the most cost effective manufacturing process(es) that can make parts that will meet the functional requirements.

The tolerancing in the drawing becomes a contract or part of a contract when the drawing is given to another company. In this situation the tolerancing is a binding contract between the two parties.

Traditional and hybrid tolerancing

Traditional tolerancing is a tolerancing that primarily consists of dimensions and ±dimensional tolerances, supplemented with surface texture requirements. Hybrid tolerancing is a traditional tolerancing where a few geometrical tolerances have been added, but only as a supplement to the traditional tolerancing.

An Overview of The GPS Matrix System

Are the drawings in your company based on traditional or hybrid tolerancing?
If so, you can, without a doubt, make better and cheaper products by using GPS tolerancing in your technical drawings.

Ask in the design and development departments if GPS tolerancing is used in the drawings. If the answer is no, there is an unrealized development potential that can be unlocked by a relatively small investment in training of the relevant company staff in the use and interpretation of GPS tolerancing.

A drawing with GPS tolerancing is well suited for outsourcing of manufacturing regardless of where in the world the manufacturing is to take place and what language the manufacturer speaks.

The use of modern GPS tolerancing is one of the largest and cheapest developments that has taken place in the manufacturing of mechanical products in recent years. The use of GPS will make your drawings unambiguous and you can use tolerances in your future drawings that are larger than the tolerances that you are using in your drawings today. Finally, a drawing with GPS tolerancing is well suited for outsourcing of manufacturing regardless of where in the world the manufacturing is to take place and what language the manufacturer speaks.

Evaluate the tolerancing in your drawings by using the self check form for tolerancing shown on page 11 in this document.

How is GPS different?

In GPS, the symbol language has become much more detailed and specific. It gives the designer the ability to make the tolerancing unambiguous and allows much more flexibility to modify tolerance indications to express precisely what the functional requirements are.

Additionally, by applying GPS specifications according to the 8-step tolerancing process developed by the Institute for Geometrical Product Specifications (IfGPS), a joint venture between PB Metrology Consulting in Denmark and HN Metrology Consulting in the US, the designer can ensure that all the tolerances are tied together in one coordinate system and not allowed to "float" relative to one another. This is key, because it allows tolerances to be increased by the amount of "float" eliminated, which often can be substantial. However, although this 8-step tolerancing process is very important, it is not defined in standards.

GPS tolerancing gives better profitability and better products.
The symbol language that is used for tolerancing in drawings has been expanded, modernized, and internationalized over the last 10 to 15 years. The modernization and internationalization have taken place to meet new requirements based on technological developments and the needs that have emerged in the globalization of subcontracting and outsourcing of part manufacturing.

GPS is a natural development of the traditional way the drawings have been toleranced for half a century. The basis for GPS tolerancing is geometrical tolerancing (GD&T), but used in a new and different way.

Why do we have to implement GPS in my company?
GPS is necessary to ensure that the drawing can express the design intent unambiguously. Unambiguous tolerancing has become more critical because tolerances have become tighter and drawings increasingly are used for subcontracting and outsourcing of manufacturing.

Traditional tolerancing is only unambiguous and only works well when the parts that are being manufactured have negligible form error and all angles in the part are virtually perfect, compared to the size of the tolerances. GPS has been developed to overcome this shortcoming. GPS tolerancing maintains its uniqueness when applied to the manufactured part even if the part has significant form error and angular deviations.

The basic advantage of GPS is that it allows tolerances to be expressed more precisely and with more detail. This means that GPS tolerancing can simulate part function very closely. With GPS the designer can include much more information in the drawing. This information can be used by the manufacturing engineer to choose the technically and economically optimal manufacturing method.
The requirements of the measurement method are also built into the GPS tolerancing. This allows the metrology function to make intelligent choices about what measurement method and

technology to use to get the right uncertainty and the right sensitivity in the measurement. This means that the existing measurement technology can be used much more effectively and with smaller uncertainty.

Lower manufacturing costs

The use of GPS gives a number of advantages both technically and economically. Parts that are manufactured according to drawings that are toleranced using GPS generally have lower manufacturing cost. GPS also gives much better assurance that the product will function according to the design intent, especially when the manufacturing of the parts is being subcontracted or outsourced domestically or across the world. This is because GPS tolerancing gives more information and is more precise.

Take advantage of larger tolerances

Experience has shown that traditional tolerancing forces the designer to use smaller tolerances to make the part function, far smaller tolerances than if GPS had been used in the drawing. This is the economic consequence of traditional tolerancing and it often leads to completely unnecessary manufacturing and measuring problems.

GPS tolerancing - a technical necessity

It is crucial that readers clearly and unambiguously understand the drawings and what the design intent is. This is the whole purpose of tolerancing!

It is most likely that your company is tolerancing in the traditional way that we all learned during our education or later on in training courses and seminars. In this case, your drawings are primarily based on dimensional tolerancing for diameters, distances, angles etc. In some cases drawings may be "spiced up" with a few geometrical tolerances and surface finish requirements based on the surface roughness parameter Ra as a supplement to the dimensional tolerancing to create what we call hybrid tolerancing.

GPS allows critical tolerances in the drawing to be increased significantly.

What does my company gain by using GPS?

Some of the tolerance symbols that today are part of the GPS system are already in use in the traditional drawing. There is a risk that the produced result is quite different from what was intended by the drawing if these symbols are used without knowledge of the correct meaning that they have today. When the symbols in the drawing are read correctly according to the GPS rules, the intent of the tolerancing will be misunderstood by those who know the current GPS rules and follow them correctly. Of course, you do not get the advantages that are built into the GPS system when the symbols are not used in accordance with the modern GPS meaning and not used systematically based on the GPS philosophy.

This illustrates another very important point. Because GPS is such a precise language, the need to apply revision control and quality assurance to keep track of which standards apply to which drawings is much more significant than it is for traditional tolerancing. It takes ongoing awareness and training to keep track of revisions to standards and properly implement the changes as they occur.

It often becomes possible to more than double the tolerance that is indicated in the drawing when GPS is used compared to the tolerance value that can be used in the traditional drawing.

The introduction of GPS in the company will generally provide both an economic and a technical improvement because the specification uncertainty can be eliminated completely and the correlation uncertainty (a measure for how well the tolerancing simulates the intended function of the part) can be reduced significantly. That should be sufficient motivation for actively implementing GPS here and now in your company.

The specification and correlation uncertainty which is eliminated by using GPS can be used to either improve the function of the part or to increase the tolerance that is indicated in the drawing or both. It often becomes possible to more than double the tolerance that is indicated in the drawing when GPS is used compared to the tolerance value that can be used in the traditional drawing.

An Overview of The GPS Matrix System

Examples of the advantages of GPS:

- There is no doubt about what the requirements are for the part. The specification uncertainty is low. The drawing is unambiguous. You can communicate unambiguously and without problems with suppliers both domestically and abroad even when you do not have a common spoken language.

- The tolerances can be made more functionally correct. The requirements in the drawing can be differentiated in more detail.

- Since the tolerancing can simulate the part function very closely, the correlation uncertainty is low.

- The drawing becomes much more valuable for product development for the next version of the product since the GPS drawing contains much more unambiguous information about the geometrical requirements of the part function.

- The tolerances are larger. Both the "saved" specification uncertainty and the "saved" correlation uncertainty can be used directly to increase the "traditional" tolerance. Larger tolerances give a better relationship between process variation and tolerance and between measurement uncertainty and tolerance.

- The GPS drawing contains much more information that can be used for more qualified choices of manufacturing processes, machining sequences, fixturing, alignment methods, etc. This means that in many cases there is no need for subsequent measurements of the part requirements, because the requirements in the drawing are automatically fulfilled!

- The designer no longer has to consider the capabilities of manufacturing or measurement methods, but only has to concentrate on tolerancing based on function. This is the consequence of the GPS conformance principle.

- The specification operator, which is the definition of the tolerance symbol, determines directly the theoretically correct measurement method. The task for the measurement function now consists of avoiding use of the often very expensive, slow, and complicated correct measurement method and equipment. Instead, the measurement function can focus on designing and qualifying a cheaper, faster, and simpler measurement method that can perform the measurement "well enough". "Well enough" is based on a measurement uncertainty evaluation and the economic consequence of the uncertainty.

How do I implement GPS in my company?

The GPS language must be implemented in the company based on a management decision and GPS must be used and understood by everybody throughout the company (or within a particular product team), otherwise it will not work. This is why it is important that management is informed about GPS and understands why it is so important to make this strategic decision.

How is GPS to be used?

GPS should first and foremost be used for the critical tolerances and requirements in a drawing. These are the tolerances that primarily influence the function and the manufacturing cost of the part. It is less important that other requirements in a drawing are unambiguous.

GPS is like a tool box: The designer can take only the tools that he needs and leave the rest alone. This allows the designer to learn the various specification tools of the GPS system as they become necessary for him, once he has the basic overview of what types of tools are available and how the overall GPS system works.

How do we implement GPS in our company?

GPS can only be used effectively after the relevant staff has been trained to use and interpret the symbol language. A pilot project covering the team responsible for a new product is a good way to start and to gain some experience. GPS should primarily be used for new drawings and new projects. Only the problematic ones amongst the old drawings should be considered for translation into GPS.

How is GPS implemented in a company?

The decision to implement GPS in a company must be a strategic decision made by top management. The decision has to be very visible to the staff as a requirement to them. Resources

An Overview of The GPS Matrix System

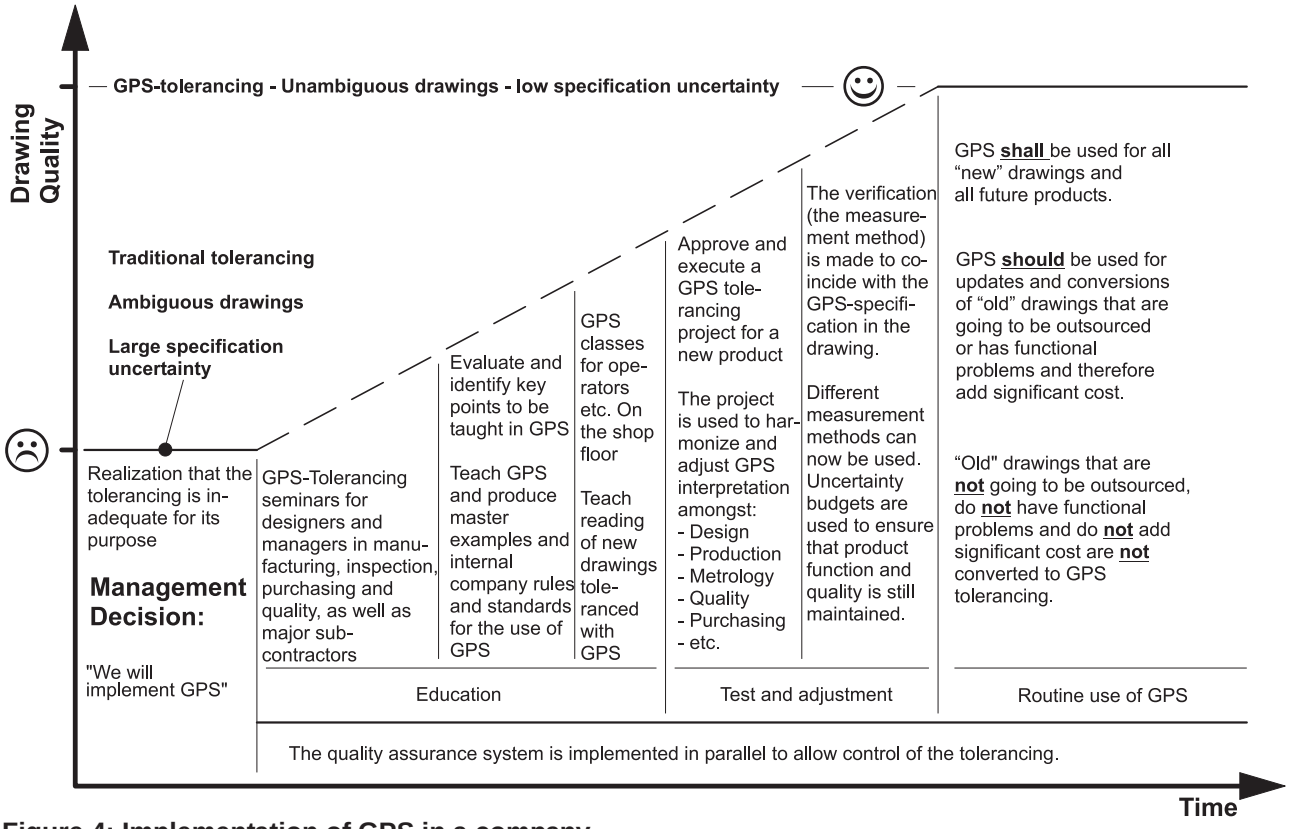


Figure 4: Implementation of GPS in a company.

have to be allocated because it takes time, but the results will quickly be visible!

A pilot project covering the team responsible for a new product is a good way to start and to gain some experience.

Reprogramming

The implementation of GPS (see figure 4) cannot be done in pieces and one person or one department at a time. It is necessary once and for all to create a common "language" and a common understanding amongst all technical functions and staff within the company so they can communicate unambiguously with each other by using GPS. It normally requires a total reprogramming or reeducation of all the technical staff within the company when the existing normal tolerancing level and the GPS tolerancing language scope and possibilities are taken into consideration. In short, it is necessary to start over.

It cannot be expected that people that come directly from the education system have a sufficient knowledge of the use of GPS. Most educational institutions have not yet added GPS to their programs and spend very few hours on tolerancing rules and symbols in the first place.

Two choices

There are two ways to conduct the GPS implementation process:

- self-study for everybody or in a core group which then educates and informs the rest of the staff.

- all staff participate in external seminars or seminars are set up internally in the company with external instructors that create the foundation, followed by "language" training with practical tolerancing examples in the form of completed part drawings and designs.

The first option is more theoretical than real. It requires too many resources and experience shows that there is a significant risk that major parts of the tolerancing rules will be misunderstood.

Internal seminars are a better solution that give the necessary foundation of common understanding for the implementation of GPS. This approach

An Overview of The GPS Matrix System

leads to the desired goal much faster and with a much higher probability of success than the self-study method.

Teaching GPS based on the company's own drawings

Experience shows that there is a need for a concentrated basic GPS seminar of at least 25 - 30 hours of effective instruction time. It can consist of a review of the GPS's Toolbox (the GPS system, the tolerancing rules and symbols) that takes up 75-80% of the instruction time and should be finished with a lot of examples of how to change the company's own existing drawings from traditional tolerancing to GPS tolerancing. The use of the company's own drawings as examples is necessary because the GPS tolerancing, much more than traditional tolerancing, requires a very detailed knowledge of the use and function of the part in the product.

Experience shows that there is a need for a concentrated basic GPS seminar of at least 25 - 30 hours of effective instruction time.

Old problems become new solutions

As part of the seminars, gather the participants from the company in teams around a group of products/parts and the related problems that they know and work with every day. The participants in the teams should be combined from several functions within the company (design, production, sales, purchasing, quality, measurement, etc.). This way the participants will experience during the seminars how they can now communicate better with more details and less ambiguity by using GPS. The participants will also learn that they are able to solve part requirement problems in drawings that have not previously had a good and unique solution.

It is a good idea to invite key personnel from major suppliers to participate in the company's seminars.

This will motivate the supplier and facilitate later communication and cooperation to everyone's benefit.

Getting to an operational level

The level that can be reached with such a basic GPS seminar is not especially high nor especially operative. It is certainly no "nerd level" that is reached after 25-30 hours of instruction. The level after this basic language class is just enough for an experienced designer to begin using GPS in simple part drawings for simple part functions.

The amount of material and the number of new things in GPS is simply too great. But after this seminar, the routine and the operational level is reached by systematically applying GPS.

The seminar described is appropriate for designers and leading personnel from other technical functions in the company. Operators from the production and measurement areas should be taught GPS in a more limited seminar.

The process is expanded

It is an advantage to establish a cross functional GPS group within the company. In the GPS group, the new tolerancing culture can then be developed after the basic seminar(s).

It is crucial that a common understanding is developed within the company of what the critical requirements for the parts are, because these are the requirements where GPS must be applied.

It is advantageous to have follow-up meetings after the basic seminar with participation of the external instructor.

This can take place when there is a need in the GPS group to clarify questions about details in new drawings that are created with GPS tolerancing. A more advanced discussion of the new drawings and the understanding of the more complex and more advanced GPS use can take place at these follow-up meetings.

It is an advantage to establish a cross functional GPS group within the company. In the GPS group, the new tolerancing culture can then be developed after the basic seminar.

An Overview of The GPS Matrix System

The results become visible

As it turns out, the GPS group will also lead to the development of internal company standards based on the new knowledge. Company standards assist in collecting and documenting existing special tolerance knowledge and tolerance needs. Company standards also help in reducing the complexity of the individual drawing. Company standards are envisioned in the ISO-GPS system as a necessary supplement. International standards cannot and will not cover all possibilites and details.

It is common that a need for specialized advanced seminars for smaller groups arises, for example, seminars in surface finish specification and measurement, form specifications and measurements, datum and datum systems, estimation and use of measurement and specification uncertainty.

Going live

The last chance for informing all personnel, customers, and suppliers about GPS is when the first new GPS drawings go into production. Of course, it should ideally happen much earlier.

It is important that suppliers and personnel in the company's own production departments realize that there are now different and new symbols and rules in the drawings and especially that the rules for proving conformance and nonconformance now are different from what they were and that it is now necessary to provide proof of the level of measurement uncertainty.

Putting up GPS posters throughout the company to support and inform about the new things that happen help in raising awareness. You might also want to send posters and information to suppliers.

Hand out GPS pocketbooks to all staff (see the overview of GPS publications that can support GPS implementation in the company on the last page of this pamphlet). You can also send a GPS pocketbook written in their own language to foreign customers and suppliers.

Do not make it harder than it has to be.

When GPS is initially implemented in the company, stay away from "old" drawings. Leave them as they are. Start using GPS in a new product project. When experience with using GPS has been built up, then you can consider translating and updating "old" problem part drawings to GPS.

Always review old drawings from a GPS and specification/correlation uncertainty point of view before they are outsourced and sent to a supplier. Update to GPS as necessary.

Maintain an overview

When GPS is implemented, you should also implement a procedure for technical quality assurance of the tolerancing in the drawings. It is necessary to keep track of which and when GPS standards and GPS rules are implemented, both now and in the future, and which drawings and projects they apply to.

For most companies it is a new situation that the tolerance symbol language changes, develops, and improves all the time and therefore, has to be subject to quality assurance.

For most companies it is a new situation that the tolerance symbol language changes, develops, and improves all the time and therefore has to be subject to quality assurance.

Some advice for the future

It is necessary to have at least one complete collection of ISO and/or national GPS standards in the company. A collection that has to be kept up-to-date all the time. It should be just as natural to have a complete and updated collection of GPS standards as it is to have a dictionary in the company. Standards are not there to teach, but only to give rules and tools.

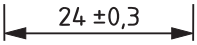
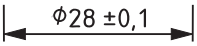
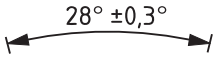
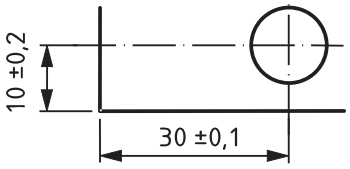
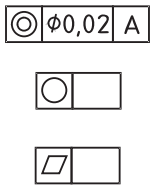
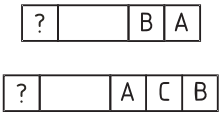
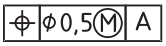
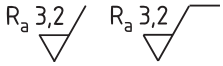
The guidance and education in the use of GPS standards must be maintained by following the developments, for example, by participating in conferences or buying relevant literature or having regular scheduled follow-up seminars with external or internal instructors.

IfGPS
Institute for
Geometrical Product Specifications

An Overview of The GPS Matrix System

The Self Check Form

The self check form below contains a number of examples of tolerance symbols and collections of symbols that you can compare to the drawings from your company or from your customers. This way you can determine what kind of tolerancing is used in each drawing. The form can be used to determine if you are using modern GPS tolerancing. If it turns out not to be a GPS based drawing, the consequence will often be that it contains significant specification uncertainty. This can create legal and economic problems if the drawing is used for subcontracting or outsourcing of manufacturing.The form cannot provide any assurance that a drawing is correctly toleranced and has no specification uncertainty, but it can help in getting a rough first impression.

Question	Tolerancing Symbol	GPS Comment
Are ±tolerances used for other dimensions than diameters and features of size in the drawing?		± tolerances are generally not unambiguous on the real part. There is specification uncertainty. To be replaced by a position tolerance as an improvement.
Are ±tolerances used for diameters without using a modifier, for example Ⓔ in the drawing?		A diameter without the use of a modifier is not unambiguous on the real part (see figure 2). The specification modifiers shall be used as an improvement.
Are ±tolerances used for angles in the drawing?		± tolerances for angles are generally not unambiguous on the real part. There is specification uncertainty. Shall be replaced by an angularity tolerance (geometrical tolerance) as an improvement.
Are ± tolerances used for coordinates of e.g. hole centers in the drawing?		± tolerances used for coordinate tolerancing are not unambiguous on the real part. There is a very large specification uncertainty. Shall be replaced by position tolerances with reference to a datum system as an improvement.
Are geometrical tolerances used in the drawing?		If geometrical tolerances are not used, the tolerancing is solely based on dimensional tolerancing. There is significant specification uncertainty. Shall be replaced by GPS tolerancing as an improvement.
Are datum systems used in the drawing?		The function of the part cannot be expressed unambiguously if datum systems are not used. There is probably significant specification uncertainty. A functionally correct datum system shall be established as an improvement.
Is the maximum material requirement Ⓜ used in conjunction with position tolerances for e.g. holes in the drawing when the required function is to enable assembly with the adjacent part in the design?		If this is not the case, parts that exceed either the diameter tolerance or the position tolerance, but still function as intended (assembly possible) will be rejected. Use the maximum material requirements as an improvement.
Is the 1965 version of the surface finish symbol used in the drawing?		Very significant specification uncertainty - up to 300%. Use the current GPS symbol as an improvement.
Is the 1991 version of the surface finish symbol used in the drawing?		Large specification uncertainty - up to 30%. Use the current GPS symbol as an improvement.
Is the edge symbol used in the drawing?		If the symbol is not used, the edges are not controlled. This creates specification uncertainty. The edge symbol shall be used as an improvement.

The GPS Pocket Books

The GPS Pocket Book gives a brief presentation of the most important and the most frequently used tolerance symbols in GPS tolerancing. It contains 36 pages of fine print in A6 (148 mm x 105 mm) format.

The GPS Pocket Book also presents the most common rules and the most basic grammar related to the GPS symbol language.

The GPS Pocket Book is not intended for stand alone use. It does not give a complete and exhaustive presentation of GPS. The purpose of the GPS Pocket Book is to be a memory aid for people who are using GPS in their daily work.

The GPS Pocket Book is intended for use together with the numerous GPS standards issued by ISO.

The GPS Pocket Book is available in English, Spanish, German, Chinese, Swedish and Danish as of early 2005. Additional language versions are planned.

The GPS Pocket Book is an excellent aid for discussing Geometrical Product Specifications with colleagues, clients, and suppliers around the world. Graphics and text are laid out so the same information is in the same place on the same page in all language versions. So you can have the English version in front of you and your supplier in China can have the Chinese version in front of him and you can easily communicate.

The GPS Pocket Book is published by the Institute for Geometrical Product Specifications, a joint venture between PB Metrology Consulting and HN Metrology Consulting, Inc. To purchase the GPS Pocket Book, go to www.IfGPS.com where you can also find more information about the GPS Pocket Book and other GPS related materials as they are developed.

This document can be freely distributed in its entirety. Quotations can be used with indication of the source.

See additional information about GPS on:

Institute for Geometrical Product Specifications
www.ifGPS.com

ifGPS

Institute for Geometrical Product Specifications

Or contact:

In Europe:

www.bennich.dk

Per Bennich
PB Metrology Consulting
Birkevej 11
DK-3500 Vaerloese
Denmark

per@bennich.dk
+45 44 47 01 04

Outside Europe:

www.HN-Metrology.com

Henrik Nielsen
HN Metrology Consulting, Inc.
10219 Coral Reef Way
Indianapolis, IN 46256
USA

hsnielsen@HN-Metrology.com
+1 317 849 9577

An overview of GPS - A cost saving tool
1st edition