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Objectives and learning outcomes for BS 8888 training

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Contents

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Foreword

Publishing information

This Published Document is published by BSI and came into effect on 30 April 2011. It was prepared by Subcommittee TDW/4/6, *Technical product realization – Education and training strategy*, under the authority of Technical Committee TDW/4, *Technical product realization*. A list of organizations represented on this committee can be obtained on request to its secretary.

BSI Subcommittee TDW/4/6 takes collective responsibility for its preparation. The Subcommittee wishes to acknowledge the contribution of the Institution of Engineering Designers.

Relationship with other publications

The need for this Published Document grew out of the publication of BS 8888 and the establishment of training courses to introduce its requirements to practising engineers, designers and technicians.

Presentational conventions

The provisions in this Published Document are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a Published Document cannot confer immunity from legal obligations.

1 Scope

This document sets out the recommendations for training programmes in Technical Product Specification (TPS) based on the BS 8888.

It provides guidance for the definition of content and learning outcomes of training courses and is aimed primarily at course developers. It is intended for training courses targeted at practising engineers, designers and technicians.

It does not provide training materials, assessment methods or certification mechanisms.

NOTE 1 Examples of technical product specifications include engineering drawings and 3D CAD models used for conveying engineering intent.

NOTE 2 A scheme based on this document is provided by the Institution of Engineering Designers.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 8888, *Technical product specification*

BS EN 22768 (all parts), *General tolerances*

3 Terms and definitions

For the purposes of this Published Document, the following terms and definitions apply.

3.1 core outcome
necessary content of courses at the level specified

3.2 reader
person who interprets the technical product specification

NOTE The reader uses the drawings and associated documentation to support downstream applications such as manufacturing.

3.3 specifier
person who produces the technical product specification

NOTE The specifier generates drawings and associated documentation, usually in design.

3.4 supplementary outcome
additional content of courses at the level specified, according to the training needs

3.5 verifier
person who confirms that the requirements given in the technical product specification have been satisfied

4 Objectives and learning outcomes for BS 8888 training scheme

Trainees should have some familiarity with technical product specifications and engineering drawing practices and should be proficient in the following:

- types of standards (BS, ISO and ASME);
- drawing sheet sizes;
- drawing sheet and title block requirements;
- orthographic projections;
- scales;
- line types;
- cross-section and detail views;
- representation of screw threads etc.;
- dimensions;
- dimension schemes and rules of dimensioning;
- linear tolerances;
- limits and fits.

In addition, specifiers should be able to:

- lay out a drawing sheet;
- select a suitable sheet size and scale;
- select and show suitable views;
- apply dimensions.

NOTE Work roles are expected to fall into three categories: specifiers, readers and verifiers. The training in each of these categories is set out at two levels.

- *Level 1: Basic, for those who are taking on such roles and require to gain, or regain, familiarity with TPS documentation in a BS 8888 environment.*
- *Level 2: Advanced, for those already familiar with TPS documentation, who need to have a more advanced interpretation of details appropriate to their industry and role.*

The minimum level of expertise needed for Level 1 courses should be part of the initial education and training of designers (see Annex A).

The course provider should certify the successful completion of the core, and any other supplementary, material.

5 Level 1 training

5.1 Objectives

Upon completion of a Level 1 course a specifier should be able to produce technical product specifications for manufactured components that conform to British and ISO standards and to use GPS specification methods.

NOTE This can be achieved with supervision and guidance from a specifier at Level 2 or equivalent.

Readers should be able to correctly interpret technical product specifications produced to the standard of a Level 1 specifier.

Verifiers should be able to verify technical product specifications produced to the standard of a Level 1 specifier.

5.2 Core outcomes

5.2.1 Core outcomes – specifiers

After completing Level 1, a specifier should be able to:

- understand the six degrees of freedom of a rigid body in three-dimensional space;
- select appropriate data and an appropriate datum hierarchy;
- correctly mark data on a 2D or 3D TPS;
- identify features-of-size;
- apply size tolerances;
- apply the Envelope Requirement where appropriate;
- select appropriate geometrical tolerances;
- correctly mark geometrical tolerances on a 2D or 3D TPS;
- apply the Maximum Material Requirement;
- calculate bonus tolerance;
- calculate the Virtual Condition size of a feature;
- be aware of the principles behind allocating tolerance values;
- recognize surface texture symbols;
- recognize the following indications: Ⓛ, Ⓟ, Ⓕ, CZ, "TOLERANCING ISO 8015, ASME Y14.5".

5.2.2 Core outcomes – readers

After completing Level 1, a reader should be able to interpret:

- datum indicators;
- a size tolerance;
- the Envelope Requirement;
- a limit and fit code;
- a position tolerance;
- a perpendicularity tolerance;
- a flatness tolerance;
- the Maximum Material Requirement and calculate bonus tolerance.

5.2.3 Core outcomes – verifiers

After completing Level 1, a verifier should be able to:

- understand the six degrees of freedom;
- understand the concept of uncertainty of measurement;
- interpret datum indicators;
- verify a size tolerance;

- verify the Envelope Requirement;
- verify a limit and fit code;
- verify a geometrical tolerance;
- calculate bonus tolerance when Maximum Material Requirement is used;
- verify the Virtual Condition boundary of a feature.

NOTE For the verifier modules there is a clear connection with the metrology training provided by the National Physical Laboratory (NPL). It is envisaged that the verifier modules could be developed with NPL, and become a product with joint ownership and delivery.

5.3 Supplementary outcomes

5.3.1 Supplementary outcomes – specifiers

At Level 1, the supplementary outcomes for specifiers should be to:

- have an awareness of BS EN 22768 (all parts)
- recognize a surface texture specification;
- recognize an edge tolerance specification;
- have an awareness of measurement methods.

5.3.2 Supplementary outcomes – readers

At Level 1, the supplementary outcomes for readers should be to:

- recognize a surface texture specification;
- recognize other geometrical tolerance symbols.

5.3.3 Supplementary outcomes – verifiers

At Level 1, the supplementary outcomes for verifiers should be to:

- recognize a surface texture specification
- recognize an edge tolerance.

5.4 Assessment

5.4.1 Assessment for specifiers

At Level 1, an assessment for specifiers should include multiple choice and simple calculation questions, and written or verbal descriptions of key concepts.

Specifiers should also be able to identify 7 out of 10 errors on test drawings.

5.4.2 Assessment for readers

At Level 1, an assessment for readers should include a test paper with multiple choice questions.

5.4.3 Assessment for verifiers

At Level 1, the assessment for verifiers should be as defined in **5.4.1**.

6 Level 2 training

*COMMENTARY ON CLAUSE **6***
Trainees at Level 2 are assumed to have met all the requirements of Level 1.

6.1 Objectives

Upon completion of a Level 2 course a specifier should be able to produce technical product specifications for manufactured components that conform to British and ISO standards and to use GPS specification methods without supervision.

Readers should be able to correctly interpret technical product specifications produced to the standard of a Level 2 specifier.

Verifiers should be able to verify technical product specifications produced to the standard of a Level 2 specifier.

6.2 Core outcomes

6.2.1 Core outcomes – specifiers

After completing Level 2, a specifier should be able to:

- understand the difference between a datum, a datum feature and a simulated datum feature;
- understand the difference between an ideal feature, a real feature, an extracted feature and an associated feature;
- use a second datum reference to orientate an orientation tolerance zone;
- apply the Maximum and Least Material Requirement;
- apply Ⓜ to a datum reference in a geometrical tolerance;
- calculate a datum shift allowance;
- explain principles behind allocating tolerance values;
- identify whether the specification for an elementary assembly will permit a clash;
- define a projected tolerance zone;
- relate uncertainty of measurement to the allocation of tolerances.

6.2.2 Core outcomes – readers

After completing Level 2, a reader should be able to:

- correctly interpret all geometrical tolerances;
- correctly interpret the Maximum Material Requirement;
- calculate bonus tolerance;
- understand material condition applied to datums and datum shift;
- derive manufacturing methods from a TPS.

6.2.3 Core outcomes – verifiers

After completing Level 2 a verifier should be able to:

- understand the difference between a datum, a datum feature and a simulated datum feature;
- understand the difference between an ideal feature, a real feature, an extracted feature and an associated features;
- verify an orientation tolerance zone with two datums;
- calculate bonus tolerance when Least Material Requirement is used;
- verify a geometrical tolerance when Ⓜ or Ⓛ is applied to a datum reference.

NOTE For the verifier modules there is a clear connection with the metrology training provided by the National Physical Laboratory (NPL). It is envisaged that the verifier modules could be developed with NPL, and become a product with joint ownership and delivery.

6.3 Supplementary outcomes

6.3.1 Supplementary outcomes – specifiers

At Level 2, the supplementary outcomes for specifiers should be to:

- be able to specify an Ra value for a machined surface with a specified lay pattern requirement;
- be able to specify an edge tolerance;
- be able to have a deeper awareness of measurement methods;
- have an understanding of BS EN 22768 (all parts).

6.3.2 Supplementary outcomes – readers

At Level 2, the supplementary outcomes for readers should be to:

- be able to recognize a surface texture requirement;
- be able to recognize an edge tolerance.

6.3.3 Supplementary outcomes – verifiers

At Level 2, the supplementary outcomes for verifiers should be to:

- be able to verify a surface texture specification which includes an Ra value for a machined surface with a specified lay pattern requirement;
- be able to verify an edge tolerance;
- be able to derive verification methods from a TPS;
- be able to understand the following indications: "GENERAL TOLERANCES ISO 2768-mK" (where 'mK' could be any of the permissible code indications).

6.4 Assessment

The assessment methods at Level 2 should be as set out in **5.4**.

Annex A (normative) Recommendations for TPR content of initial engineering and product design qualifications

A.1 Introduction

There have been two major changes in recent years, which have affected the perception of Engineering Drawing as part of the initial academic qualifications of professional engineers, CEng, IEng & Eng Tech, and of Product Designers. The first is the gradual growth in the use of CAD systems, initially as 2D drawing aids and, more recently, as solid modelling systems able to link with a range of manufacturing and analysis options. As a result, the use of drawing boards has virtually disappeared in both industry and academia, although the traditional orthographic drawing remains the major means of communicating design information to the manufacturer. Students are less familiar with the details of such communications, being less able to produce or read such drawings.

The second change has been the introduction of the Geometric Product Specification (GPS) system, internationally. This is specified in the UK by BS 8888. It has now been joined by the closely related BS 8887 (all parts) and BS 8889. These three are together referred to as covering Technical Product Realization (TPR).

There is currently no specific guidance available from either the Engineering Council or the appropriate engineering and product design professional bodies on the requirements for accredited course content in this area. Since there is no mandate to set any standards in engineering or product design courses, the following is a recommendation to the professional bodies and the course providers for the minimum level of understanding, by a new graduate, of the documentation required to specify a product to be manufactured.

A.2 Definitions

In making these recommendations the following definitions have been adopted according to the current practice in engineering accreditation documentation.

a) *Knowledge* is information that can be recalled.

b) *Understanding* is the capacity to use concepts creatively, for example in problem solving, in design, in explanations and in diagnosis.

c) *Skills* are acquired and learned attributes which can be applied almost instinctively.

d) *Know-how* is the ability to apply learned knowledge and skills to perform operations intuitively, efficiently and correctly.

e) *Awareness* is general familiarity, albeit bounded by the needs of the particular discipline.

Since Chartered Engineers and Product Designers have less need to be aware of the details of TPS, the recommendations for them are the baseline, with enhanced requirements for IEng and Eng Tech.

A.3 Chartered engineers and product designers

A.3.1 General

In general, these recommendations refer mainly to the scope of BS 8888. Courses with a strong manufacturing emphasis might also wish to refer to BS 8887 (all parts) and BS 8889 as appropriate.

A.3.2 Knowledge

Chartered engineers and product designers should have knowledge of a basic range of tolerance symbols in use in their industrial field and their meaning.

A.3.3 Understanding

Chartered engineers and product designers should understand:

a) how engineering drawings form the basic language by which the unambiguous detailed specification, resulting from the design process, is communicated to the manufacturer(s);

b) the basis of the GPS system and the necessity of proper tolerance specification as they affect manufacturing costs;

c) orthographic projection and the way in which the various views of an artefact are generated, including oblique views and sections, with particular reference to third-angle projection.

A.3.4 Skill

Chartered engineers and product designers should have the skill to read a set of engineering drawings and correctly interpret their meaning as to the geometry of the artefact they represent, even if they do not fully appreciate all of the detailed tolerance requirements.

A.3.5 Know-how

Chartered engineers and product designers should have the know-how to manufacture a simple artefact from the information contained in an engineering drawing.

A.3.6 Awareness

Chartered engineers and product designers should be aware of:

a) the limitations of their expertise in this field (although they may gain familiarity as their career progresses), and the need to defer to more knowledgeable practitioners when the situation requires it;

b) sources of the necessary information to expand their expertise as needed.

A.4 Incorporated engineers

A.4.1 General

Courses for incorporated engineers are likely to be more focused on specific areas of engineering expertise, so these recommendations should be interpreted as they apply to those areas.

A.4.2 Knowledge

Incorporated engineers should have knowledge of the full range of tolerance symbols in use in their industrial field and their implications on the organization of the manufacturing processes.

A.4.3 Understanding

Incorporated engineers should understand:

a) engineering drawing language, including the detailed use of orthographic projection, and be proficient in its use to communicate an unambiguous detailed engineering specification of a product;

b) the importance of the GPS system in transmitting engineering information unambiguously, even between designers and manufacturers who do not speak the same language.

A.4.4 Skill

Incorporated Engineers should have the skill to read a set of engineering drawings and correctly interpret their meaning as to the geometry of the artefact they represent, appreciating the full meaning of the tolerance requirements.

A.4.5 Know-how

Incorporated engineers should have the know-how to:

a) manufacture an appropriate artefact from the information contained in an engineering drawing, correctly interpreting the tolerance requirements;

b) advise design teams on ways to improve the efficiency of manufacture by using more appropriate tolerance specifications in their documentation.

A.4.6 Awareness

Incorporated engineers should be aware of:

a) the limitations of the range of application of their expertise, and the need to defer to practitioners in other fields when the situation requires it;

b) sources of the necessary information to expand their expertise as needed.

A.5 Engineering technicians

A.5.1 General

Engineering Technician courses are likely to concentrate on the requirements of a specific industry or engineering task, so these recommendations should be interpreted as they apply to that industry or task. Two sets of requirements could be identified, for those mainly involved in the design process, and those in manufacturing. Those in design should concentrate more on the scope of BS 8888, while those in manufacture should refer more to BS 8887 (all parts) and BS 8889 as appropriate.

A.5.2 Engineering technicians (design)

A.5.2.1 Knowledge

Engineering Technicians in design should have knowledge of a significant range of tolerance symbols in use in their industrial field, although, at the point of graduation, they might not yet appreciate the detailed use of some.

A.5.2.2 Understanding

Engineering technicians in design should understand the engineering drawing language as it applies in their industry, including the detailed use of orthographic projection, and be proficient in its use to communicate an unambiguous detailed engineering specification of a product.

A.5.2.3 Skill

Engineering technicians in design should have the skills to read a set of engineering drawings and correctly interpret their meaning as to the geometry of the artefact they represent, appreciating the meaning of the tolerance requirements.

A.5.2.4 Know-how

Engineering technicians in design should have the know-how to:

a) appreciate the manufacturing implications of the tolerance methods in use in their industry;

b) advise the design team on ways to improve the efficiency of manufacture by using more appropriate tolerance specifications in their documentation.

A.5.2.5 Awareness

Engineering technicians in design should be aware of:

a) the limitations of the range of application of their expertise, and the need to defer to practitioners in other fields when the situation requires it;

b) sources of the necessary information to expand their expertise as needed.

A.5.3 Engineering technicians (manufacture)

A.5.3.1 Knowledge

Engineering technicians in manufacture should have knowledge of a significant range of tolerance symbols in use in their industrial field, although, at the point of graduation, they might not yet appreciate the detailed use of some.

A.5.3.2 Understanding

Engineering technicians in manufacture should understand the interpretation of the engineering drawing language as it applies in their industry, to communicate an unambiguous detailed engineering specification of a product.

A.5.3.3 Skill

Engineering technicians in manufacture should have the skill to read a set of engineering drawings and correctly interpret their meaning as to the manufacturing processes they imply, appreciating the meaning of the tolerance requirements.

A.5.3.4 Know-how

Engineering technicians in manufacture should have the know-how to query the tolerance specifications in the documentation if they unnecessarily constrain the mode of manufacture.

A.5.3.5 Awareness

Engineering technicians in manufacture should be aware of:

- the limitations of the range of application of their expertise, and the need to defer to practitioners in other fields when the situation requires it;
- sources of the necessary information to expand their expertise as needed.

A.6 Suggested teaching routes

With the virtual demise of the drawing board and the rise of solid modelling software, the need has arisen for new approaches to teaching TPR to be developed. The following are some possible approaches which have been suggested. They are by no means an exhaustive list and are given here purely as a way of provoking new thinking in this area.

- Encourage students to sketch their design ideas by hand before producing a computer-based solid model. Basic instruction in sketching makes their solid modelling work more efficient.
- Give students an orthographic drawing of a simple component and ask them to produce an accurate solid model of the object, perhaps finding its weight, centre of mass, or other property as a check on their accuracy.
- For Design, Make and Test projects early in the course, each design group could pass their design drawings to another group for manufacture. The manufacturing group would be marked on how well they match the drawing, and on how many genuine errors they spot. The originating group eventually gets the part back for testing, so have to live with the results of any drawing errors.
- Have a range of engineering drawings of recognizable parts available for students to gain familiarity. If possible, the real product could also be on display.
- For major project work later in the course, engineering drawings should be required and marked. For projects where this is not appropriate, reasonable quality sketches should be required.

Bibliography

Standard references

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 8887 (all parts), *Design for manufacture, assembly, disassembly and end-of-life processing (MADE)*

BS 8889, *Technical product verification – Inspection of size, form and surface texture in relation to function – Specification* [1)]

1) In preparation.

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