INTERNATIONAL STANDARD

ISO 17599

First edition
2015-01-15

Technical product documentation (TPD) — General requirements of digital mock-up for mechanical products

Documentation technique de produits (TPD) — Exigences générales de Digital mock-up pour les produits mécaniques

Reference number
ISO 17599:2015(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 10, *Technical product documentation*, Subcommittee SC 6, *Mechanical engineering documentation*.

Technical product documentation (TPD) — General requirements of digital mock-up for mechanical products

1 Scope

This International Standard specifies the requirements for the classification, composition, modelling, review, application, and management of digital mock-up.

This International Standard for mechanical products is applicable to the building, management, review, and application of digital mock-up.

2 Normative references

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

ISO 10007:2003, *Quality management systems — Guidelines for configuration management*

ISO 11442, *Technical product documentation — Document management*

ISO 16792:2006, *Technical product documentation — Digital product definition data practices*

3 Terms and definitions

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

3.1
digital mock-up (DMU)
digital specification given to a complete mechanical product or sub-system with an independent function, not only of the geometric properties, but also of its function and/or performance in a particular field

Note 1 to entry: The digital mock-up of the product is built at a design stage and is applicable to the whole life cycle of the product, including design, manufacture, marketing, and aftermarket. The digital mock-up could realize interference check, motion analysis, simulation of performance and manufacturing, technical training, advertising, maintenance planning, etc.

3.2
complete digital mock-up
digital specification given to all the information of a complete mechanical product or its systems

Note 1 to entry: The complete description pertains to mechanical components, system devices, function components, accessories, etc.

3.3
sub-system digital mock-up
digital specification of all the information of sub-systems based on the different functional divisions of mechanical products

EXAMPLE DMU of power, transmission, and control systems

3.4
scheme digital mock-up
part of the complete DMU, which includes the digital specification of product plan design

3.5
detailed digital mock-up
part of the complete DMU, which includes the digital specification of elaborate product design

3.6
manufacturing digital mock-up
part of the complete DMU, which includes the digital specification of product machining and assembling

3.7
geometry digital mock-up
subset of the complete DMU, providing digital information specification, geometrically emphasized, extracted from officially released DMU

3.8
function digital mock-up
subset of the complete DMU, providing a digital information specification, functionally emphasized, extracted from officially released DMU

3.9
performance digital mock-up
subset of the complete DMU, providing a digital information specification, based on performance, extracted from officially released DMU

3.10
special-purpose digital mock-up
description extracted or simplified from a complete product model of a digital mock-up for special purposes, such as simulation, technical training, and marketing

3.11
retrofit digital mock-up
DMU of a new product, built on the basis of an existing one

3.12
simplification
method which allows some features built without modelling or some parts (or components) without assembling during the modelling process

Note 1 to entry: Through simplification, the geometric detailed representation can be simplified and the model loading efficiency can be improved provided that the simplification does not incur ambiguous understanding or bring about inconvenience to the use of a model.

3.13
lightweight
method to extract patches from the product geometry model

Note 1 to entry: It reduces resource expenditure in model loading, and it is suitable for large assembly, assembly simulation, advertising, technical training, etc.

3.14
annotation
dimension(s), tolerance(s), note(s), text, or symbol(s) visible without any manual or external manipulation

[SOURCE: ISO 16792:2006, 3.1]

3.15
configuration
interrelated functional and physical characteristics of a product defined in product configuration information

[SOURCE: ISO 10007:2003, 3.3]

3.16
product configuration information
requirements for product design, realization, verification, operation, and support

[SOURCE: ISO 10007:2003, 3.9]

3.17
configuration management
coordinated activities to direct and control configuration

[SOURCE: ISO 10007:2003, 3.6]

4 Abbreviations

BOM bill of materials

CAD computer-aided design

CAE computer-aided engineering

CAM computer-aided manufacturing

CAPP computer-aided process planning

DMU digital mock-up

EBOM engineering bill of materials

FMEA failure mode and effects analysis

MBOM manufacturing bill of materials

PBOM process bill of materials

PDM product data management

QC quality control

TED theoretically exact dimension

5 Classification of digital mock-up

5.1 Development stage

According to the development or life cycle stage, digital mock-up is generally divided into scheme digital mock-up, detailed digital mock-up, manufacturing digital mock-up, etc.

5.2 Purposes

Digital mock-up can be established according to various special purposes, such as simulation, manufacture, technical training, marketing, and advertising. This classification is done in line with purposes.

5.3 Data format

Digital mock-up can be classified according to the software type or data format.

6 Composition of digital mock-up

6.1 Geometric information

The geometric information of DMU includes point, line, surface, body, and other relevant geometric information.

6.2 Constraint information

The constraint information of DMU includes the constraints between parts or components and between the internal and/or external reference information of DMU.

6.3 Engineering attributes

The engineering attributes of DMU include BOM, material properties, boundary conditions, loads, failure criteria, lifetime performance, rigidity, strength, reliability, maintainability, safety, and other information.

7 Requirements of a digital mock-up model

7.1 General principles

Digital mock-up is the digital specification produced on a computer of a physical prototype, while the physical prototype is the materialized object of digital mock-up. The digital mock-up model shall

a) reflect the geometric attributes, functional characteristics, and performance properties of the physical prototype,

b) provide information representation required in the whole life cycle of a product with stability and completeness,

c) truly reflect the content of product characteristics where its forms may be various, and

d) be derivative, which can generate corresponding models depending on the different purposes.

7.2 Relationship between all kinds of digital mock-up

For relationships between all kinds of digital mock-up, see Figure 1.

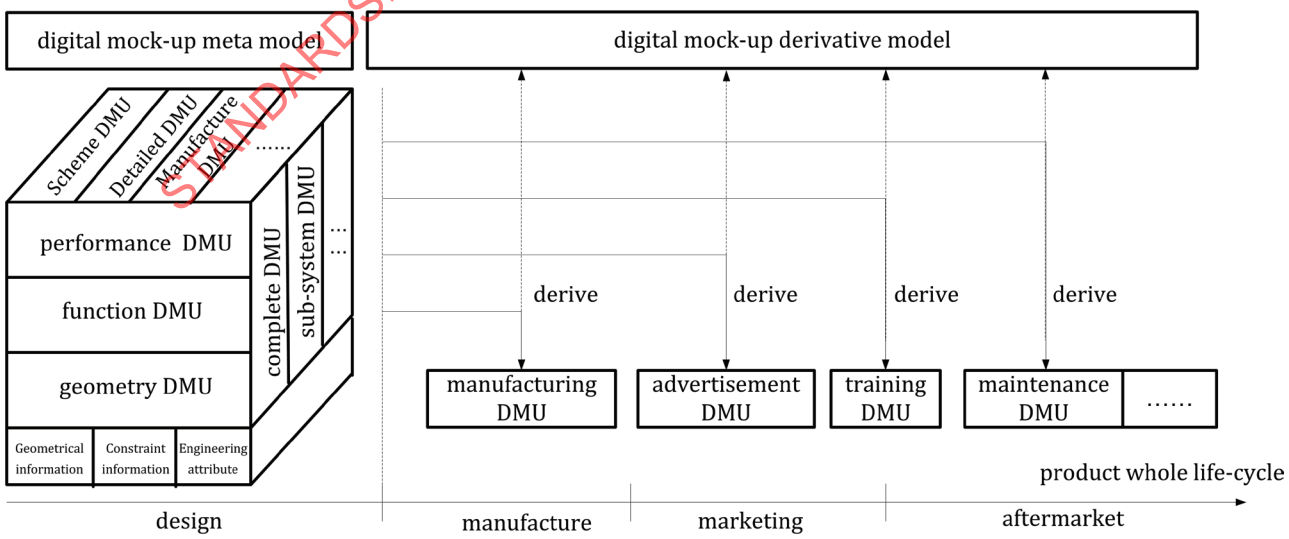

Figure 1 — Relationship between all types of digital mock-up

7.3 Requirements of complete digital mock-up

A complete digital mock-up shall be formed after the general assembly of each sub-system with each function modular included. It is a collective body involving information of a complete product in each field. It is also a system description of a product object in the computer. The complete DMU shall include, but not be limited to,

a) information which shall completely reflect product structure, layout, and position of each sub-system on the digital mock-up,

b) information which shall reflect the compatibility and maintainability on structure and system between a complete product and its sub-system,

c) information which shall reflect the working principles and the performance characteristics of one or each field concerned, and

d) complete information necessary for manufacturing, when the digital mock-up is transformed to physical prototype.

7.4 Requirements of sub-system digital mock-up

The sub-system digital mock-up is a description of the sub-system with a given function. It shall include, but not be limited to,

a) information which shall completely show the distribution and location of geometry, structure, and components,

b) information which shall reflect the working principles and performance characteristics in a certain field, and

c) information which shall contain complete manufacturing information to transform sub-system digital mock-up into a physical prototype.

7.5 Requirements of scheme digital mock-up

The scheme digital mock-up is formed at the scheme design stage. The definition and result of the scheme digital mock-up shall include, but not be limited to,

a) describing primary overall indicators of products and defining the primary product structural composition,

b) describing the product outline and carrying out industrial design evaluation,

c) establishment of basic parameters for each sub-system and enveloping space,

d) initial selection of standardized, purchased, finished parts, and equipment,

e) optimization of the scheme parameters and mechanism test models, and

f) carrying out overall layout design and scheme digital mock-up.

7.6 Requirements of detailed digital mock-up

Detailed digital mock-up is formed at the detailed design stage. The definition and result of the detailed digital mock-up shall include, but not be limited to,

a) carrying out the overall design of system and mechanism, primary simulation and optimization of system through CAE calculation, and getting a detailed design scheme,

b) carrying out calculations of detailed mass, performance, and load of the product and generally evaluating system reliability, maintainability, etc.,

c) carrying out the detailed assembly hierarchy division, space split, connection method, and interface definition of each sub-system and component model, and the calculation of envelope space of moving parts,

d) carrying out detailed product analysis,

e) verifying the parameters of overall design, including product function and performance, and modifying and optimizing partially if necessary, and

f) producing the assembly diagrams and engineering drawings of components and parts.

7.7 Requirements of manufacturing digital mock-up

Manufacturing digital mock-up is formed at the technological design stage. The definition and result of the manufacturing digital mock-up shall include, but not be limited to,

a) design of tools, clamps, and gauges,

b) simulation of the technological process of the product, including virtual machining, assembly, workshop (factory), etc., and

c) technological documents generation.

7.8 Requirements of geometry digital mock-up

The geometry digital mock-up of mechanical products shall include, but not be limited to,

a) information which can reflect each sub-system position in the digital mock-up,

b) information which can find the shape, dimension information, and geometric constraints of parts and components, and

c) product coordination, assembly, and fitting relations.

7.9 Requirements of function digital mock-up

Function digital mock-up of mechanical products shall include the following information, but not be limited to,

a) product working principles,

b) product hierarchical tree,

c) composition of parts and components, their state, and manual instructions,

d) coordinative harmony in the mechanical and function between sub-systems, and

e) information of product operation and maintenance.

7.10 Requirements of performance digital mock-up

Performance digital mock-up of mechanical products shall include the following information, but not be limited to,

a) performance indicators of product,

b) working characteristics of input and output,

c) sub-system indicators and performance coupling relations between sub-systems,

d) the safety factor and the stress and strain for the critical and important parts, and

e) lifetime performance and its reliability indicator.

7.11 Requirements of special-purpose digital mock-up

Special-purpose DMU shall be derived from the complete DMU and is subordinate to the complete DMU. It shall meet the following requirements:

a) When any change happens to the complete DMU, the derivative special-purpose digital mock-up shall also change correspondingly.

b) Any model information lost as a result of the derivation process from the complete DMU model shall not affect the use of the special-purpose DMU.

7.12 Requirements of retrofit digital mock-up

Retrofit digital mock-up shall meet the following requirements:

a) When retrofitting a new product, its complete digital mock-up shall be established.

b) As to partial modification, if the original product does not own the DMU model, the sub-system digital mock-up for the modified part shall be established.

8 Requirements of DMU building

8.1 General requirements

8.1.1 General principles

a) The digital mock-up shall provide the digital specification of the product, covering every stage of the life cycle of the mechanical product, while the information included by the digital mock-up shall improve gradually as the development process goes on.

b) Before the building of the DMU, full consideration of the modular design shall be taken into account, so as to facilitate the reuse, upgrade, and maintenance of the digital mock-up and ease the disassembly, recycling, and disposal when the product is scrapped.

c) DMU simplification and/or lightweight versions shall be permitted according to the product characteristics and places where the DMU is used.

d) The model of DMU shall be reviewed and appraised before its release.

8.1.2 Fundamental requirements

a) The DMU defines the nominal model. If the forms, orientation, and position of geometric elements are determined by the theoretically exact dimension (TED), DMU models should be built by the TEDs.

NOTE The scale of 1:1 is recommended to build the DMU.

b) The uniform unit shall be used in building DMU. If the length unit is not millimetre, it shall be an attribute of the model.

c) Before the modelling of a digital mock-up, a unified initial setting of modelling software shall be provided; usually, the setting items should include, but not be limited to, the start path of file loading, the initial screen and display environment, the initial modelling datum, the default view, layers, unit specification, design model precision, annotation format, basic model attributes, etc.

8.1.3 Identification of parts or components

The identification of parts or components of digital mock-up shall meet the requirements as follows:

a) Uniqueness: All parts or components shall have unique identification to avoid confusion during data storage, share, and release.

b) Unification: The identifications of parts or components shall be unified. Each enterprise or industry organization should have rules of their own according to their characteristics.

c) Readability: The identifications of parts or components shall observe the regulations made by each enterprise or industry organization and high readability facilitates the management of documents of digital mock-up model.

d) Extensibility: The identifications of parts or components shall be extendable to add new information according to different applications.

8.1.4 Definition and use of coordinate system

The definition and use of the coordinate system of the digital mock-up model shall abide by the following principles:

a) The coordinate system definition of the digital mock-up model shall be unified before product design, generally referring to the origin, orientation, naming of coordinate system, etc.

b) The coordinate system of the digital mock-up model should give concise and readable identifications.

c) The digital mock-up model shall have an absolute coordinate system and should establish a relative coordinate system during model building according to actual situation.

8.1.5 Colouring and texture rendering requirements

Colouring and texture rendering of DMU shall meet the following requirements:

a) Easy to identify and operate.

b) For different purposes or at different stages; for example, when colouring DMU at the design stage, only 8.1.5 a) is observed; when the design is complete, the DMU models should assume the state of substantially dyed. When colouring the final DMU, either the product colour scheme or the colour of physical prototype or the user's practice and requirements should be taken into account.

c) When the texture rendering is given to DMU, the material properties of components shall be considered and the material texture shall be decided on.

8.1.6 Model state

a) For the mechanical product with kinematic pair, the submitted DMU model shall stay in stationary or stable state.

b) For the mechanical product with cyclic movement, the submitted DMU model shall stay in zero position in a motion cycle or keep stable under the effect of gravity.

c) Models of DMU with multi-status movement should be derived from the DMU model under stationary or stable state.

8.2 Detailed requirements of model building

8.2.1 Modelling of parts

8.2.1.1 Fundamental principles

a) The model of parts shall accurately express the design intent.

b) The model of a part shall not contain redundant elements. For example, it shall not comprise any geometry information which is not related to the model building result.

c) The modelling of a part should reflect that the design is for manufacturing and assembly, so as to enhance the manufacturability and ease of assembly.

d) The main frame of the model shall be built first, and then the detailed features of the model.

e) The parameterization to modelling of parts is recommended, and the inherent links and reference relations between data should be taken into account.

8.2.1.2 The general process of modelling of parts

The general process of modelling of parts is as follows:

a) Set the initial environment of modelling software.

b) Define examination rules for future DMU model validation.

c) Create DMU model file, and then copy and quote the reference relation if necessary.

d) Build the main frame.

e) Build part from detailed geometric features, such as rounds, chamfers, and small holes.

f) Create 2D engineering drawings, if required.

g) Add other information as necessary, such as annotation, attributes, analysis data, and material description as described in ISO 16792.

h) Examine and validate the DMU model.

8.2.1.3 Fundamental requirements

a) The model of parts shall include engineering information, for instance, performance indicator, analysis data, material description, etc.

b) Part-modelling features shall be fully constrained, neither should they be under-constrained nor over-constrained, unless otherwise specified.

c) Priority shall be given to the geometric constraint, such as parallel, perpendicular, and aligned. The dimension constraint is in the second consideration.

d) The outline surface of the part model shall be smooth and ruled surfaces should be adopted. Model data shall provide machining information, such as reference plane, technological holes, and positioning datum.

e) Priority shall be given to parameterized series family table when modelling the standardized parts.

f) Models of purchased parts should be provided by the supplier. If the supplier cannot do it, the parts model shall be set up by the user.

8.2.2 Assembly modelling

8.2.2.1 Fundamental principles

a) DMU models shall be assembled by hierarchy and by sub-systems (reflecting the physical sequences of assembly or disassembly of the product).

b) The assembly model shall include not only the information of parts or components but also the associativity between them.

c) The configuration status or released version of the DMU shall be recorded.

d) A complete assembly hierarchical tree shall be defined.

8.2.2.2 The process of assembly modelling

There are two modes in assembly modelling: design from top to bottom and that from bottom to top design. For the product with simple structure, the mode from bottom to top should be recommended; for the newly designed product with complex structure, the mode from top to bottom is recommended. These two design modes do not conflict with each other, and they may be used in combination sometimes.

The process from top to bottom is generally as follows:

a) Create top-level assembly model, and build layout model or skeleton model.

b) Define the assembly datum.

c) Create sub-assembly by the mode from top to bottom level by level, with the layout model as the design basis, until a complete assembly structure is formed.

d) Build the sub-assembly and models of parts.

e) Add relevant annotation and attribute description, as described in ISO 16792, including dimensional specification, geometrical specification with datum system or not, or surface texture specification or other types of specification and add when it is applicable, process capability index (or process performance index) and data. Refer to ISO 3534-2.

f) Create 2D engineering drawings as required.

g) Check the model according to the predefined inspection rules and modify any unconformities until the predefined requirements are met.

The process from bottom to top is generally as follows:

a) Carry out the bottom part or component modelling.

b) Create assembly model file for the upper level.

c) Set up the assembly datum and assemble the part or component model level by level until the complete assembly structure is formed.

d) Add relevant annotation and attribute description, as described in ISO 16792, including dimensional specification, geometrical specification with datum system or not, or surface texture specification or other types of specification and add when it is applicable, process capability index (or process performance index) and data. Refer to ISO 3534-2.

e) Make 2D engineering drawings as required.

f) Check model according to the predefined inspection rules and modify any unconformities until the predefined requirements are met.

8.2.2.3 Assembly constraints

8.2.2.3.1 Principles for constraint selection

a) The selection of the assembly constraint should reflect the constraint properties and motion relations of product object as truly as possible and selection shall be made about the constraint type which best reflects design intent. With regard to the moving product, the constraint shall truly reflect its mechanical motion characteristics.

b) Over-constraints or under-constraints shall be avoided.

c) According to design intent, the rational assembly datum shall be chosen and the assembly relations should be simplified as much as possible.

8.2.2.3.2 Model assembly without degree of freedom

For a model assembly without freedom, each component shall be completely constrained. The commonly used static constraint should include, but not be limited to, one coordinate system being fitted to another, one axis to another, one plane to another, and one surface tangent to another.

One constraint or a combination of several above constraints shall be used to give full constraints to a component.

a) one coordinate system being fitted to another

The position relations of components shall be constrained by the alignment or offset of coordinate systems. Each component should be constrained in the same coordinate system, in order to reduce unnecessary cross-referencing relationship between these components.

b) one axis being fitted to another

Axes of two components shall be constrained to be in superposition by alignment or insertion manner. This kind of constraint should be used commonly in fitting between the shaft and hole.

c) one plane being fitted to another

The position relations of components shall be constrained through alignment, matching or offset of plane to plane. If the normal direction of two planes is the same, this kind of constraint is called 'planes alignment'; if the normal direction of two planes is opposite, this kind of constraint is known as 'planes mate'; if the two planes are parallel and there is a certain offset distance between them, this kind of constraint is referred to as 'planes offset'.

d) one surface tangent to another

Two components position relationship shall be constrained by one surface tangent to another.

8.2.2.3.3 Model assembly with degree of freedom

For a three-dimensional model assembly with degree of freedom, assembly shall be done according to the actual mechanical kinematic pair type. Constraints affected shall correspond with the kinetic characteristics of actual mechanical kinematic pair. The common mechanical kinematic pair includes, but is not limited to, the revolute, sliding, cylindrical, planar, spherical connection and special moving pairs, or the combination of these kinematic pairs.

a) revolute pair

Also known as 'hinge'; it refers to the relative rotation of one component around an axis of another. The mobile component has one rotational degree of freedom.

b) sliding pair

It refers to the linear motion of one component relative to another along a straight line. The mobile component has one sliding degree of freedom.

c) cylindrical pair

One component affects a linear motion along a cylindrical plane relative to another, and rotates around the axis of the cylinder. The mobile component has two degrees of freedom, i.e. one sliding degree of freedom and one rotational degree of freedom.

d) planar pair

One component moves on a certain plane relative to another and rotates around the normal line of the plane. The moving component has three degrees of freedom, i.e. two sliding degrees of freedom and one rotational degree of freedom.

e) spherical connection pair

One component rotates in any direction around the centre of the sphere relative to another. The mobile component has three rotational degrees of freedom.

f) special moving pair

It refers to the movement constrained by special drive mechanism which usually includes gear, cam, belt, chain, coupler, and screw pairs.

8.2.3 Simulation modelling

8.2.3.1 Fundamental requirements

The simulation model is a subset of DMU and the digital specification expresses its capability necessary to show up product function and performance simulation.

According to application, different simulation models shall be built, such as assembly simulation model, kinematic simulation model, finite element model, and dynamic simulation model.

Full use shall be made of the existing geometric DMU to build simulation model, so as to reduce the work of model rebuilding.

8.2.3.2 Requirements of simulation modelling

The general process of simulation modelling based on the geometry model is as follows:

a) The initial setting of simulation software shall be made.

b) Simplification of geometry DMU should be carried out with detail features being deleted, provided it does not affect the simulation result. Take for example, when mechanical finite element analysis model is to be built, the detail features in the geometry DMU should be deleted, such as the chamfers, small holes, and turned edges, when the analysis model of multi-body dynamic is to be built, the several components, whose interacting load at connections can do without analysis, shall be looked upon as a single component.

c) If necessary, the characteristics of geometric DMU should be transformed to the element characteristics in the finite element analysis, such as rod, beam, and shell.

d) When the geometric DMU is to be input, it shall be checked. If there are any features affecting simulation, or any loss of information, the model shall be repaired, or other data transmission should be chosen and input again.

e) The input model should be partially adjusted according to the needs of simulation.

f) Other definition information should be added to the simulation model if necessary, and the simulation model should be improved gradually.

8.2.3.3 Detailed requirements

a) The existing geometric DMU, or the simplified model derived from the geometric DMU, shall be used as models of assembly simulation, and therefore the constraints on mass, motion, model assembly environment, measurement requirements, and output setting of key gap and distance should be supplied.

b) The existing geometric DMU, or the simplified model derived from the geometric DMU, should be used as models of kinematic simulation. Constraints on kinematic pair, drive type, load type, damp and friction co-efficient, measurement requirements, output setting, etc. should be supplied.

c) The mechanical finite element model should be simplified on the basis of the existing geometric DMU according to mechanics and the definition of meshing, load and boundary conditions, material and element attributes, solution, output setting, etc. should be supplied.

d) The dynamic analysis model should be simplified based on the existing geometric DMU to the largest extent according to the dynamic characteristics. The definition of the kinematic pair, dynamic constraint, load, solution, and output setting should be added.

e) The simulation model for other special fields shall be made from the existing DMU as the basis of the model.

9 Simplification and lightweight models of digital mock-up

9.1 Application

Simplification and lightweight models of DMU shall be handled according to product features, development stages, and application purposes. The possible application of simplification and lightweight models of DMU can be used in the following situations:

a) designing plans or principles;

b) designing large assemblies;

c) visualization;

d) simulation and/or optimization;

e) simplified expression of engineering drawings;

f) special situations, such as places, where commercial secrets are to be hidden.

9.2 General requirements

The following principles shall be observed when the DMU model is simplified or lightweight.

a) The identifier shall be added to the simplified or lightweight model, so as to be readily identified.

b) Misinterpretations shall be avoided.

c) The information expression of DMU at specific applications shall not be affected.

10 Requirements of management

10.1 General requirements

a) The management of the DMU shall include all stages of its life cycle of an assembly or a part.

b) There shall be agreement within the enterprise in DMU modelling, simulating, and managing software and its versions during the whole life cycle of products.

c) The manner and channels through which to exchange the data of digital model within, or between, enterprises shall be stipulated.

d) Assured software tools or normalized processes to manage the changes of the relevant DMU data produced at each stage of the whole life cycle shall be adopted.

10.2 Management of the whole DMU life cycle

10.2.1 General principles

The DMU life cycle includes the various stages of design, manufacture, marketing, and aftermarket. The whole DMU life cycle should meet following requirements:

a) At the initial stage of DMU development, all the activities and processes related to DMU at each stage of the whole life cycle should be planned.

b) The inter-relationships between the stages of the whole life cycle should be certain, and the same is true with the input and outputs, as otherwise, the process would be affected.

c) The standardization department should establish requirements of DMU at each stage of the whole life cycle.

10.2.2 Management of design stage

10.2.2.1 Management of scheme design stage

a) The design process of scheme DMU usually includes specifying requirements for the top-level design of the DMU, the top-level layout of the complete DMU, releasing the design requirements of the sub-system, the designing and simulating of the digital model of the sub-system, checking and acceptance of the sub-system, the assembly and simulation of the complete DMU, and its review.

b) Generally, it is the responsibility of the quality control (QC) department to inspect and check the DMU top-level design and supervise it.

c) It is the responsibility of the controlling design department to give an overall layout of the DMU, and delegate the requirements of the DMU designing to the sub-system.

d) Each sub-system design department should carry out designing and verifying the simulation of the scheme DMU according to the design requirements and the approved DMU should be presented to the controlling design department.

e) It is the responsibility of the QC department to inspect and check the scheme DMU of each sub-system.

f) It is the responsibility of the controlling design department to have the accepted DMU model assembled and its simulation verified, so as to have a wholesome DMU model.

g) It is the responsibility of the QC department to organize a review of the DMU model, and as for the requirements of specific review, see Clause 11.

10.2.2.2 Management of detailed design stage

a) The design process of detailed DMU generally includes the setting up and releasing of detailed DMU design requirements, detailed geometric DMU design and calculation, detailed function DMU design and simulation, detailed performance DMU design and verification, the collaborative design between mechanics and technology, detailed DMU review, and its release.

b) The QC department should determine the detailed DMU design and release specifications and be responsible for supervision.

c) The controlling design department should make detailed DMU design requirements based on scheme DMU, and then release them to the sub-systems.

d) Each sub-system design department should carry out sub-system detailed design and simulation based on detailed DMU design requirements.

e) The controlling design department should build a complete DMU based on the qualified and accepted sub-system DMU.

f) The controlling design department and sub-system design department should carry out engineering analysis, verification and optimization, simulation for test, etc.

g) The detailed DMU should include the following models: those of geometry, assembly, kinematic mechanism, static analysis, dynamic analysis, thermal analysis, electromagnetic analysis, ergonomics analysis, virtual assembly, logic control, etc.

h) The manufacturability of detailed DMU can be enhanced through the collaboration between the designing and technology departments.

i) The QC department shall organize the review of the detailed DMU, while it is the archives department's responsibility to officially release the qualified detailed DMU after review to manufacture department.

10.2.2.3 Management of technological design stage

a) The manufacturing DMU shall be built on the basis of the detailed DMU and its design process generally includes fixture design, technological simulation, designing of technological file, review and release of manufacturing DMU.

b) The technological design department should engage in simulations of virtual machining, assembling and factory (or workshop) through the manufacturing DMU, so as to obtain and provide basic data for technological designing.

c) The technological design department should carry out the conversion from EBOM to PBOM and test and verify the rationality of technological design on the basis of technological simulation of DMU.

d) The technological design department should carry out the work of designing fixtures on the basis of PBOM, the conversion from PBOM to MBOM, to create a manufacturing DMU that can be used in the work place.

e) The QC department should organize the review of the manufacturing DMU, while it is the archives department's responsibility to officially release the qualified manufacturing DMU to the work place.

10.2.3 Management of manufacture stage

a) The manufacturing department shall carry out manufacturing activities with the manufacturing DMU, which has been officially appraised and released.

b) The manufacturing department should carry out materials preparation, the work of machining and assembly operation instructions, product inspection, etc. on the basis of the manufacturing DMU.

10.2.4 Management of marketing and aftermarket stages

a) The marketing department should engage itself in product advertising, bidding, technical training, product service, recycling, remanufacturing, etc. with special-purpose DMU.

b) The special-purpose DMU can be simplified or aesthetically enhanced, but shall not deviate from the DMU nature, and it shall meet the requirements in actual use.

10.3 Requirements of data management

a) PDM should be used to carry out the management of DMU, and seamless integration should be realized between PDM and CAD/CAE/CAPP/CAM.

b) The DMU data of products at each stage of the whole life cycle shall be managed in a centralized manner, including geometry and simulation models, simulation result, correlation, etc.

c) The DMU data at each stage shall be managed according to hierarchy, type and version and the mechanism of index, and interrelation should be established, so as to guarantee the interrelatedness and uniformity.

d) The simulation model and simulation result of DMU at each stage should be managed and the correlation with geometry DMU should be kept.

e) The DMU basic model, including those of standardized parts and general parts, shall be stored and managed in a centralized mode to ensure uniformity.

f) The product data management department shall periodically check up the safety, integrity, and validity of the data of DMU.

g) The management mechanism of the safety authority of DMU data shall be established and periodically backup the data, and store the data of DMU used in routine operation in different computers, and back them up in different media, to avoid data missing or damage caused by natural or human factors.

h) Document management related to DMU shall be performed according to ISO 11442.

10.4 Configuration management

a) The configuration management of DMU shall include activities such as configuration management planning, configuration identification, change control, configuration status accounting, and configuration audit as described in ISO 10007.

b) Configuration management planning of DMU shall include plans of design, acceptance, review, release, archiving of the DMU.

c) Configuration identification of DMU shall be performed according to ISO 11442.

d) Stage identification should be established for DMU, to show the current stage where the DMU stays now.

e) Engineering change management of DMU shall be performed according to ISO 10007.

f) Keep detailed record of the change process of DMU of each type.

g) Establish the baseline, which has a compulsory nature, and stage information of DMU for the qualified DMU after review at each stage and archive DMU, according to the baseline.

h) The QC department shall periodically carry out the audit for the changes of the configuration of the scheme DMU, detailed DMU, manufacturing DMU, etc.

11 Requirements of review

11.1 Purposes and aims of review

The main aims of DMU reviewing are to ensure

a) applicability of the product,

b) conformity of the design,

c) coordination of all the sub-systems, and

d) manufacturability of the product.

11.2 Foundations of reviewing

Reviewing is based on the following considerations:

a) product R&D contracts;

b) R&D task statement of product;

c) overall R&D technology programme of product;

d) reliability programme of products and all sub-systems;

e) maintainability programme of products and all sub-systems;

f) quality assurance programme of products and all sub-systems;

g) standardization programme of products and all sub-systems;

h) product model norms and standards;

i) building requirements and specifications of DMU of products.

11.3 Materials of review

The relevant materials submitted for review shall include

a) foundations to rely on for reviewing,

b) DMU and its demonstration environment,

c) review items, including demonstrations and inspection items,

d) relevant materials, including models, pictures, lantern slides, video screen, software, models, etc., and

e) technical reports on DMU.

11.4 Contents to be reviewed

To be reviewed are such items as the scheme DMU, detailed DMU, and manufacturing DMU at their respective stages. For specific review requirements, see Figure 2.

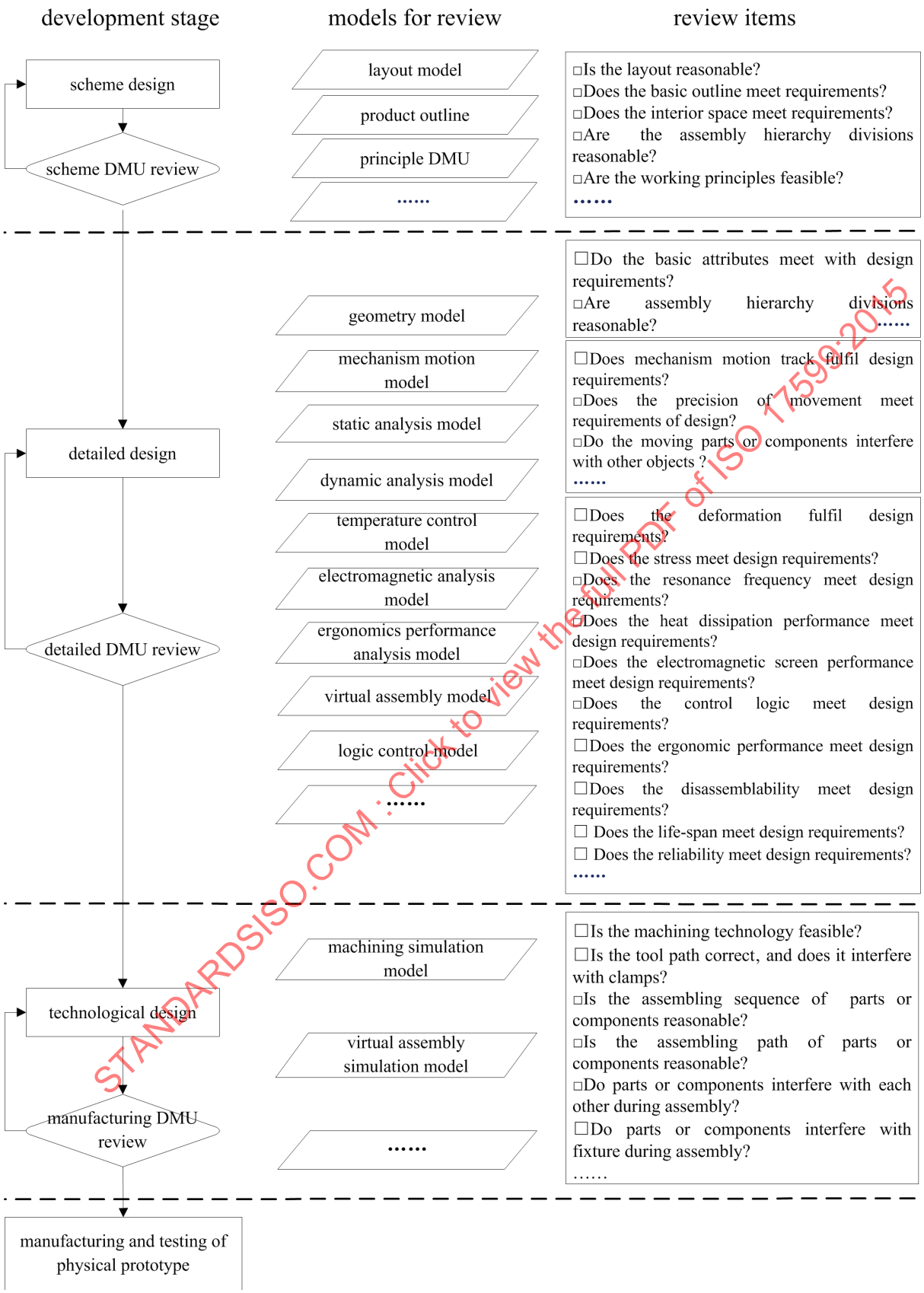

Figure 2 — Review of objects and items at each development stage

11.4.1 Review of scheme digital mock-up

The objects for review of scheme DMU shall at least include

a) a clear diagram of product and each sub-system,

b) layout model of product and each sub-system, and

c) principal DMU model of product and each sub-system.

The contents for review of scheme DMU shall at least include the following items:

a) Do the product outlines, colours, and materials meet requirements?

b) Does the interior space meet requirements?

c) Is the overall layout reasonable?

d) Are the assembly hierarchy divisions reasonable?

e) Does the mechanism motion meet requirements?

f) Are the working principles feasible?

11.4.2 Review of detailed digital mock-up

The objects for review of detailed DMU shall at least include the following:

a) three-dimensional geometric models of parts or components of product and each sub-system;

b) assembly models of product and each sub-system;

c) mechanism motion models of product and each sub-system;

d) static analysis models of product and each sub-system;

e) dynamic analysis models of product and each sub-system;

f) temperature analysis models of product and each sub-system;

g) electromagnetic analysis models of product and each sub-system;

h) ergonomic analysis models of product and each sub-system;

i) virtual assembly models of product and each sub-system;

j) logic control models of product and each sub-system.

The review of the detailed DMU shall include at least the following considerations:

a) Do the basic attributes (including mass, volume, shape dimensions, rotary inertia, etc.) meet design requirements?

b) Are the assembly hierarchy divisions reasonable?

c) Does the mechanism motion track fulfil design requirements?

d) Does movement precision meet design requirements?

e) Do the parts or components interfere with other objects while in motion?

f) Does deformation fulfil design requirements?

g) Does stress meet design requirements?