BS EN 1591-4:2013

BSI Standards Publication

Flanges and their joints

Part 4: Qualification of personnel competency in the assembly of the bolted connections of critical service pressurized systems

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National foreword

This British Standard is the UK implementation of EN 1591-4:2013. It supersedes DD CEN/TS 1591-4:2007 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PSE/15/2, Flanges - Jointing materials and compounds.

A list of organizations represented on this committee can be obtained on request to its secretary.

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

ISBN 978 0 580 72905 8

ICS 03.100.30; 23.040.60

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2013.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 1591-4

August 2013

ICS 03.100.30; 23.040.60

Supersedes CEN/TS 1591-4:2007

English Version

Flanges and their joints - Part 4: Qualification of personnel competency in the assembly of the bolted connections of critical service pressurized systems

Brides et leurs assemblages - Partie 4: Qualification des compétences du personnel en charge du montage des assemblages boulonnés sur des systèmes sous pression en service critique

Flansche und ihre Verbindungen - Teil 4: Qualifizierung der Befähigung von Personal zur Montage von Schraubverbindungen in druckbeaufschlagten Systemen im kritischen Einsatz

This European Standard was approved by CEN on 22 June 2013.

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Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

This document (EN 1591-4:2013) has been prepared by Technical Committee CEN/TC 74 “Flanges and their joints”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2014, and conflicting national standards shall be withdrawn at the latest by February 2014.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes CEN/TS 1591-4:2007.

The detailed changes that have been made in converting CEN/TS 1591-4: 2007, a guidance document, to EN 1591-4: 2013, a European Standard containing requirements to be met, are too numerous to describe in detail. It is recommended that users of CEN/TS 1591-4:2007 study EN 1591-4:2013 in full in order to understand the differences between the two documents.

EN 1591, *Flanges and their joints*, consists of the following parts:

— EN 1591-1, *Flanges and their joints — Design rules for gasketed circular flange connections — Part 1: Calculation method*

— EN 1591-2, *Flanges and their joints — Design rules for gasketed circular flange connections — Part 2: Gasket parameters*

— CEN/TS 1591-3, *Flanges and their joints — Design rules for gasketed circular flange connections — Part 3: Calculation method for metal to metal contact type flanged joint*

— EN 1591-4, *Flanges and their joints — Part 4: Qualification of personnel competency in the assembly of the bolted connections of critical service pressurized systems* (the present document)

— CEN/TR 1591-5, *Flanges and their joints — Design rules for gasketed circular flange connections — Part 5: Calculation method for full face gasketed joints*

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Introduction

The competence of the bolting technicians is a key factor in the safe operation of a system containing pressurised bolted connections and in the achievement of the highest performance from a pressurised bolted connection. Design codes for pressurised bolted connections such as EN 1591-1 require controlled bolt tightening. Therefore, competent bolting technicians are needed so that the specified bolt load tolerances can be met and, where appropriate, the specified tightness requirement can be achieved.

Training and competence, experience and knowledge are often confused with each other. Training is no guarantor of competence, nor is experience a guarantor of knowledge and understanding. Training, experience, and assessment of the ability to apply knowledge are all required to achieve competence.

The essential elements needed to achieve competency are:

a) theoretical knowledge combined with practical experience gained on site or by simulated workshop activities;

b) assessment by a competent assessor to verify that the required knowledge, skill and ability has been gained and can be applied in accordance with an operating procedure.

These elements may be achieved through formal education and training, or experiential, work-based learning, or a combination of the two. Nevertheless, competency can only be demonstrated by the method indicated in this document. It sets out the training syllabi for not only the bolting technicians, who actually disassemble, assemble and tighten bolted joints that in service will be pressurised, but also the syllabi for the personnel who supervise those technicians, the responsible engineers.

Competency in the analysis of pressurised bolted connection failures is not required beyond use of knowledge gained during training.

A correctly assembled and tightened pressurised bolted connection that fails in service requires specialist knowledge to understand why the failure occurred and is outside the scope of this European Standard.

1 Scope

This European Standard is applicable to the bolting technicians, and their supervisors, the responsible engineers, who disassemble, assemble and tighten the bolted connections of whatever shape of critical service pressurised systems. A failure of a connection in such a system would endanger personnel, plant or the environment. A route for achieving competency in the skills required to safely and successfully disassemble, assemble and tighten pressurised bolted joints of any shape to a design bolt load using documented work instructions is given in this document. The aim is the establishment of a joint capable of maintaining a leak-free status throughout its' service life.

This European Standard provides a modular training syllabus and an assessment process that can be used to determine the competency of personnel who disassemble, assemble and tighten bolted connections, whatever their shape, fitted to pressurised equipment containing a medium at any combination of temperature and pressure.

Bolting technicians have to assemble bolted connections of different levels of complexity. For this reason, training matrices dealing with bolted connections of various levels of complexity and for different types of pressurised bolted connections are given in this document. The modular structure created allows a bolting technician, once competency in the foundation level has been achieved, to obtain competency in higher levels as required.

Certification to this European Standard provides an attestation of general competency in accordance with the stated syllabi and assessments.

Certification to this European Standard does not represent an authorisation to operate, since this remains the responsibility of the employer, and the certified person may require additional specialised knowledge of employer-specific procedures, processes and equipment.

2 Normative references

Not applicable.

3 Terms and definitions

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

3.1
manufacturer
organisation that manufactures the device having the bolted connection

3.2
operator
organisation that is, or will be, responsible for the operation and maintenance of equipment

Note 1 to entry: This includes suppliers or contractors employed to disassemble, assemble and tighten bolted connections on pressurised equipment.

3.3
constructor
organisation that is or will be responsible for the construction and/or commissioning of a plant containing pipework and equipment

Note 1 to entry: This includes suppliers and contractors employed to disassemble, assemble and tighten bolted gasketed connections on pressurised equipment.

3.4
trainer/training provider
organisation or individual with the competence and capability to deliver the required training

3.5
assessor/assessment body
qualified person or organisation appointed to validate that the bolting technician, responsible engineer or technical authority is competent

3.6
bolting technician
person whose role is to disassemble, assemble or tighten the bolted connections of systems that will be pressurised in service

3.7
responsible engineer
person whose role is to plan and supervise the activity of bolting technicians

3.8
technical authority
person who, on behalf of the manufacturer, operator or constructor, is responsible for the technical aspects of the project that has resulted in the need for assembly of bolted connections

3.9
core topic
topic that requires a theoretical and/or practical understanding and the ability to apply that understanding safely and effectively

3.10
awareness topic
topic that requires an individual to retain sufficient knowledge about a subject for him/her to be conscious of its existence and its broad content

3.11
foundation level
level of training required, subject to assessment that the content has been assimilated, to ensure competency in the assembly of bolted connections whose bolts are capable of being tightened with hand operate torque wrenches

Note 1 to entry: Once competency at the foundation level has been achieved, further training and assessment for larger bolts and in specialist areas is possible.

3.12
critical service
any pressurised system where failure of the connection would result in danger to personnel or the environment

4 Qualification of trainer

The trainer shall be able to demonstrate a thorough understanding of the technical and practical aspects of the syllabus. For many institutions providing training, such as vocational technical schools, this shall be mandated in the school's quality plan.

5 Qualification of assessor

The assessor chosen shall be qualified as competent to be an assessor in the field of pressurised bolted connection related manual skilled vocations.

6 Personnel with work-based learning

Bolting technicians and responsible engineers who have acquired skills previously during employment can have acquired those skills by one of two routes:

a) practical and theoretical training as part of an apprenticeship or similar craft training based upon the syllabus of the following clauses below or an equivalent;

b) on-site practical learning by working with skilled technicians with no formal theoretical training.

In the case of those bolting technicians and responsible engineers who acquired the necessary skills by practical and theoretical training as part of an apprenticeship or similar craft training, they shall move directly to competency assessment as indicated in Clause 10 without the need for the training outlined below. If they fail the competency assessment then they shall undergo training as outlined below by a training provider before a second competency assessment as indicated in Clause 10.

In the case of those bolting technicians and responsible engineers who acquired their skills only by on-site practical learning by working with skilled technicians with no formal theoretical instruction, they shall undergo training as outlined below by a training provider before competency assessment as indicated in Clause 10.

7 Training location

Training shall either take place at a suitable training centre, within the framework of professional training or a craft apprenticeship or at the facility where the bolting technician normally works.

The location shall include both a suitable classroom and a suitably equipped workshop so that the personnel being trained gain both a theoretical understanding and practical experience with bolted connections that are representative of the different types present at the bolting technician’s normal place of work.

8 Training syllabi

8.1 Syllabi content

The relevant syllabi shall include as a minimum all pressurised bolted connections types that will be encountered by the bolting technicians when they return to their work site. For bolting technicians who are expected to work on a variety of sites, the content shall be sufficiently generic to cover all commonly encountered pressurised bolted connections. The manufacturer or operator requiring the training shall ensure the above requirement is met by the organisation selected to provide the training.

The syllabi shall include a number of key topics to ensure a comprehensive understanding and appreciation of the pressurised bolted connections. The topics shall be divided between those that require awareness and core topics requiring an in-depth understanding.

Awareness topics shall ensure bolting technicians appreciate the engineering principles that underpin the core topics requiring in-depth understanding. Core topics shall be understood thoroughly by bolting technicians. For example, bolting technicians shall be shown and understand how the relationship between torque and bolt load is impacted by the coefficient of friction, before being taught torque tightening of a bolted joint.

The matrices in 8.2 and 8.3 provide the mandatory minimum syllabi for the various levels of training. By agreement between the manufacturer/operator/constructor and the training provider, additional topics of local importance shall be added to meet the requirements of the manufacturer/operator/constructor. At all times, bolting technicians shall be trained using procedures and work instructions deemed most suitable by the manufacturer/operator/constructor.

Any additional topics added to the mandatory minimum syllabi shall be listed on the syllabus information supporting any certificate awarded, see 10.3.

The training shall be formatted to include both classroom and practical sessions. The duration of the training shall be agreed between the training provider and the operator, constructor or manufacturer and shall take into account the previous experience of the personnel being trained.

8.2 Qualification level

8.2.1 General

Various levels of speciality above the foundation level exist within the population of bolting technicians and these are represented by the content of the tables given below.

Once training in the foundation level (see Table 1) has been undertaken and the subsequent assessment has demonstrated the achievement of competency, bolting technicians may elect to achieve competency in one or more of the higher levels. The training matrices for these higher levels are given in Tables 2, 3, 4, 5, 6, 7, 8, 9 and 10 below.

Competency at the foundation level shall be demonstrated before training and competency assessment at higher levels is undertaken.

8.2.2 Foundation level

Table 1 — Foundation level training matrix

Topic	Core	Awareness
Types of bolted connections		X
Functionality of gaskets		X
Types of gaskets and their relative features		X
Relationship between bolt elongation (strain), bolt load and gasket stress		X
Common causes of the failure of gasketed bolted connections		X
Bolt load loss and implications		X
Applied and residual bolt loads		X
General health and safety precautions	X	
Safe joint disassembly	X	
Seal face preparation	X	
Identification of defects and faults	X	
Face alignment and gap uniformity	X	
Gasket storage, handling, preparation and placement	X	
Effect of thread friction on load when using torque tightening	X	
Importance of using the specified thread lubricant	X	
Bolt tightening methods and their relative accuracies		X
The need for bolt tightening patterns	X	
Bolt tightening patterns	X	
Tightness level		X
Requirement to meet a specific class of tightness	X	
Manual torque tightening	X	
Maintenance and calibration of manual torque wrenches	X	
Requirements for hydraulic torqueing and tensioning		X
Confirming that joint can return to service	X	
Recording of work carried out	X	
Reporting of variance or irregularity	X	
Emission monitoring and leakage management		X

8.2.3 Hydraulic tension tightening

Table 2 — Training matrix for hydraulic tension tightening

Topic	Core	Awareness
Permanently installed hydraulic tensioning nuts	X	
Fundamentals of hydraulic tensioning	X	
Understanding when to use hydraulic tensioning equipment	X	
Types of hydraulic tensioners	X	
Methods of hydraulic tensioning	X	
Maintenance of pump and hydraulic tensioner	X	
Calibration of hydraulic tensioners	X	
Hose configuration	X	
Methods of calculating correct bolt load and associated formulae	X	
Understanding gross load/residual load	X	
Number of hydraulic tensioners, percentage cover and effect on load loss	X	
Hydraulic tensioning pressure/load conversion	X	
Hydraulic tensioning procedures	X	
Hydraulic tensioning tightening patterns	X	
Tool fit and clearance issues	X	
Bolt coatings and their effect on thread security in both nut and puller sleeve	X	

8.2.4 Hydraulic torque tightening

Table 3 — Training matrix for hydraulic torque tightening

Topic	Core	Awareness
Safe use and handling of hydraulic hoses	X	
Correct socket usage, wear/damage of sockets	X	
Risk of pressure injection injuries – avoidance and action	X	
Good working practices to avoid finger/hand pinch points	X	
Safe use of a backing wrench	X	
Types of hydraulic torque wrenches	X	
Selection of tool pressure to provide required torque for a particular tool	X	
Use of single and multiple tools to tighten a joint	X	
Numbering of bolts when single and multiple tools are used	X	
Understanding when to use hydraulic torque equipment	X	
Fundamentals of hydraulic torqueing	X	
Tool fit and clearance issues	X	
Identifying good reaction points	X	
Torque tightening patterns	X	
Importance of lubrication and control of friction	X	
Effects of bolt coatings	X	

8.2.5 Heat exchangers and pressure vessels

Table 4 — Training matrix for heat exchangers and pressure vessels

Topic	Core	Awareness
Types of exchangers/TEMA designations	X	
Interaction of seals during assembly	X	
Gasket types	X	
Confined gaskets	X	
Handling and storage of gaskets	X	
Bolting load requirements	X	
Joint configuration and terminology	X	
Flange surface inspection	X	
Gap measurement	X	
Bundle and channel orientation	X	
Damage risks	X	
Tube sheet considerations	X	
Tightening shoulder type bolts	X	
Alignment of primary and secondary seals prior to tightening	X	
Tightening method preference relative to bolt length and tool access	X	

8.2.6 Flanges made form brittle materials

Table 5 — Training matrix for flanges made from brittle materials

Topic	Core	Awareness
Types of brittle flanges	X	
Brittle flange materials		X
Interaction of seals during assembly	X	
Gasket types	X	
Handling and storage of flanges and gaskets	X	
Load requirements	X	
Tightening methods for brittle flanges	X	
Joint configuration and terminology	X	
Flange surface inspection	X	
Gap measurement	X	
Tightening method preference relative to bolt length and tool access	X	
Safe disassembly of brittle flanges	X	

8.2.7 Bolt load determination after assembly

Table 6 — Training matrix for bolt load determination after assembly

Topic	Core	Awareness
Methods of measuring bolt load post assembly	X	
Measuring bolt load by extension measurement	X	
Measurement of bolt load by Torque application	X	
Measurement of bolt load by Tension application	X	
Measurement of bolt load by Ultrasonic measurement	X	
Proprietary devices for bolt load indication (indicating rod type and indicating washer type)	X	
Measurement of bolt load using extensometer	X	

8.2.8 Compact flanges

Table 7 — Training matrix for compact flanges

Topic	Core	Awareness
Compact flange types	X	
Assembly requirements for each type of compact flange	X	
Identification of seal ring types and materials	X	
Bolt load determination	X	
Tightening methods	X	
Tightening patterns	X	
Inspection of components pre assembly	X	
Inspection of flange post assembly	X	
Gap measurement	X	
Safe disassembly of compact flanges	X	

8.2.9 Clamp connectors

Table 8 — Training matrix for clamp connectors

Topic	Core	Awareness
Clamp connector types	X	
Assembly requirements for each type of clamp connector	X	
Identification of seal rings and materials	X	
Bolt stress and load determination	X	
Tightening method	X	
Tightening patterns	X	
Inspection of components pre assembly	X	
Inspection of connectors post assembly	X	
Safe disassembly of clamp connectors	X	

8.2.10 Special connectors

Table 9 — Training matrix for special connectors/flanges

Topic	Core	Awareness
Special connectors/flanges and types of special connectors/flanges	X	
Assembly of special connectors/flanges	X	
Identification of gaskets, seal rings and materials	X	
Bolt stress and bolt load determination	X	
Tightening method	X	
Tightening patterns	X	
Inspection of components pre-assembly	X	
Inspection of components post assembly	X	
Safe disassembly of special flanges	X	

8.2.11 Bolted connections for small bore tubing connections

Table 10 — Training matrix for small bore tubing conections

Topic	Core	Awareness
Types of small bore tubing connections	X	
Seals and Gasket types	X	
Inspection of components pre assembly	X	
Assembly of small bore flanged connections	X	
Identification of pressure ratings and seal materials	X	
Tightening methods for specific small bore fittings	X	
Avoidance of over-tightening flanges on small bore tubing.	X	
Importance of avoiding stress within tubing and on fittings.	X	
Inspection of components post assembly	X	
Safe disconnection of flanges on small bore tubing	X	

8.3 Responsible engineer

The responsible engineer shall be certified as competent to all the levels of competence held by the bolting technicians he is responsible for on the site and, in addition, the topics detailed in the responsible engineer syllabus given in Table 11.

Table 11 — Training matrix for responsible engineer

Topic	Core	Awareness
Health and safety considerations	X	
Generation of safety rules	X	
Generation of work instructions	X	
Methods of determination of the gasket stress for a given tightness class	X	
Provision of bolt load/gasket stress, value for a flange/gasket combination	X	
Confirmation that a bolted connection can be returned to operation	X	
Tightness measurement and leakage management		X

8.4 Technical authority

The person acting as the technical authority does not have to be trained, examined, assessed and accredited in the manner required of the bolting technicians and responsible persons on the site. However, it is recommended that the Technical Authority completes the relevant courses if the required knowledge and awareness has not been obtained previously during his or her career.

9 Effectiveness of training

The manufacturer, operator or constructor shall develop a method for verifying the effectiveness of the training provider and shall document it within their quality management system. Possible methods include bolting technician questionnaires and trainer performance reviews.

10 Competence assessment

10.1 General

The assessor and the trainer shall be different people.

The assessment of competence shall be undertaken by a qualified assessor and consist of two parts: a theoretical question paper and a practical assessment.

The assessor shall have been assessed as competent both as an assessor and in bolted connection of pressurised systems of the relevant type.

10.2 Method of assessment

10.2.1 Theoretical question paper

The pass mark shall be set at such a level as the assessor thinks necessary to be sure that the bolting technician has retained the required level of awareness and understanding.

10.2.2 Practical assessment

The bolting technician shall demonstrate to the assessor at either the training location or at the work site that they can work safely and efficiently in accordance with the relevant operating procedures. The demonstration shall take place using bolted connection types that are representative of the different types on the work site. Throughout the assessment, the bolting technician shall explain what he is doing and its importance in safety terms and for good connection security. After the demonstration of assembly and tightening, the bolted connection shall be inspected to demonstrate correct assembly and bolt tightness. To this end the bolted connection shall be tested, if practicable, for leak tightness and shall then be disassembled to allow demonstration of the disassembly technique and to allow the gasket to be inspected for evidence of good installation.

10.3 Certificate

After competence has been successfully demonstrated, the competence certification shall indicate the date and place of the assessment and that competence to the relevant level (Foundation, Heat Exchangers and Pressure Vessels etc.) has been achieved. In all cases, the training syllabus, indicating any locally agreed extra syllabus items, shall be attached to the certificate.

The certificate shall clearly show the name of the training provider, the assessor and assessment body and the date of the assessment.

11 Competence management

11.1 Record keeping by the manufacturer, operator or constructor

Manufacturers, operators or constructors shall develop and include a procedural framework within their quality management system to meet the requirements of this standard. Such a framework needs to address:

a) identification of a competent training provider;

b) evaluation of the effectiveness of the training for each person undergoing training;

c) assessment of competence of personnel; and

d) register of date that competency was achieved.

NOTE For examples, refer to EN ISO 9001:2008, 6.2.2.

The manufacturer, operator or constructor initiating the training or employing a certified competent bolting technician shall create and maintain a register of site personnel competencies.

The register shall include each individual's date of training and assessment and an indication of how frequently the individual has worked with gasketed bolted connections.

The manufacturer, operator or constructor shall not employ any bolting technician whose certification has expired.

11.2 Record keeping by the assessor

The assessor shall keep a record of the place and date of the assessment of people who have been certified as competent and the employment details of the competent person as supplied by that person. These records shall be kept available for consultation by potential employers of the competent person.

11.3 Information to be supplied by the competent person

The competent person shall ensure that the assessor is informed of any changes in employer so that the starting and finishing dates of all employments as a bolting technician or a responsible engineer are recorded.

12 Period of validity of certification

12.1 Initial certification

The validity of the certification of the bolting technician begins on the date that the competency examinations have been passed. The period of validity is five years provided that both of the following conditions are fulfilled:

a) the bolting technician has had no interruption in bolted flange work for a period exceeding six months;

b) there are no specific reasons to question the ability, skill or knowledge of the bolting technician in the application of bolted flange connections.

If either of these conditions is not fulfilled, the certification shall be withdrawn.

12.2 Prolongation

The validity of the bolting technician's or responsible engineer's certification may be extended for a further five year period every five years by competence re-assessment as indicated in Clause 10. If the outcome of the re-assessment is failure then the bolting technician or responsible engineer shall undergo full re-training before another competence assessment.

Bibliography

[1] EN 1591-1, *Flanges and their joints — Design rules for gasketed circular flange connections — Part 1: Calculation method*

[2] EN ISO 9001:2008, *Quality management systems — Requirements (ISO 9001:2008)*

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