

Waste to Energy and Biomass Component Specifications

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1 SCOPE

The specifications provided in this document are aimed to ensure that WtE and Biomass Systems fit with a minimum set of technical characteristics that give the necessary quality. Specifications are mainly based on the use of international standards IEC and rules and guidelines given by IECRE-Renewable Energy. There are further standards which compliance is considered less important or addressed to specific applications. These are generically indicated as recommended and their compliance is left to the designer's choice.

Another important issue is the validity of the new standards, included those that replace the older ones. In most cases it is necessary to leave a sufficient time to manufacturer to adapt their products to the new standards. Moreover, certifications have a validity that may go well beyond the release of the new standards. For these reasons a time of 24 months is left from the date of release of each new standard before asking a full compliance.

1.1 Companion Documents

The documents listed hereinafter have to be considered a compendium of the current document. Therefore, they should be carefully read in addition to this.

[1] CESI_SEC-DREG Best Practice for designing a WtE and Biomass systems_v3.0 Final.docx
[2] CESI_SEC-DREG Connection Guidelines for WtE and Biomass_v3.0 Final.docx
[3] CESI_SEC-DREG Health and Safety Requirements for WtE and Biomass_v3.0 Final.docx
[4] CESI_SEC-DREG Inspection and Testing Checklists for WtE and Biomass_v3.0 Final.docx
[5] CESI_SEC-DREG Inspection and Testing Guidelines for WtE and Biomass_v3.0 Final.docx
[6] CESI_SEC-DREG Manual for the maintenance of WtE and Biomass_v3.0 Final.docx
[7] CESI_SEC-DREG Standards for Connection of Generator Based REG systems_v3.0 Final.docx

1.2 Glossary

EMC	Electromagnetic Compatibility
EN	European Standard
IEC	International Electrotechnical Commission
IECRE	IEC System for Certification to Standards Relating to Equipment for use in Renewable Energy Applications
KSA	Kingdom of Saudi Arabia
LV	Low Voltage (namely 220/127 V or 380/220 V or 400/230 V)
MV	Medium Voltage (namely 13.8kV or 33 kV)
SEC	Saudi Electricity Company
V	Voltage
WtE	Waste to Energy

2 REQUIREMENTS ACCORDING TO REFERENCE STANDARDS

All the components and equipment used in the Waste to Energy and Biomass (WtE/Biomass) system shall comply with applicable international and local standards and laws in force in the KSA. In particular, any WtE/Biomass components or equipment that may introduce harmful or hazardous conditions shall be rejected. Therefore, it is important to define a set of standards SASO, IEC, and EN, that shall identify the WtE/Biomass system components allowed for installation and to be connected in parallel to the distribution network in KSA.

3 WASTE TO ENERGY AND BIOMASS SYSTEMS

3.1 Technology standards

The WtE and Biomass systems (with the exception of biogas technology) do not have dedicated comprehensive technology standards, therefore the technical codes and standards for industrial and conventional power generation are normally used. This is due on one side to the technical complexity of such systems (which does not allow for a comprehensive coverage in dedicated standards), on the other side to the fact that most of the technologies used in WtE and Biomass systems are applications from other industries.

The following paragraphs list first the technological standards for biogas and then the organization and standards used as a reference from the conventional power generation industry.

3.1.1 Biogas systems

3.1.1.1 ISO 20675:2018 Biogas — Biogas production, conditioning, upgrading and utilization — Terms, definitions and classification scheme

ISO 20675:2018 defines terms and describes classifications related to biogas production by anaerobic digestion, gasification from biomass and power to gas from biomass sources, biogas conditioning, biogas upgrading and biogas utilization from a safety, environmental, performance and functionality perspective, during the design, manufacturing, installation, construction, testing, commissioning, acceptance, operation, regular inspection and maintenance phases.

3.1.1.2 ISO 22580:2020 Flares for combustion of biogas

ISO 22580:2020 applies to the design, manufacture, installation and operation of flares for the combustion of biogas. Test methods and performance requirements are also included.

3.1.1.3 ISO 24252:2021 Biogas systems — Non-household and non-gasification

ISO 24252:2021 applies for systems for biogas production by anaerobic digestion, biogas conditioning, biogas upgrading and biogas utilization from a safety, environmental, performance and functionality perspective, during the design, manufacturing, installation, construction, testing, commissioning, acceptance, operation, regular inspection and maintenance phases.

3.1.2 Boilers

ASME BPVC section I	Power boilers
ASME BPVC section VIII	Pressure vessels

3.1.3 Heat exchangers

TEMA	Tubular Exchangers Manufacturers Association
HEI	Heat Exchangers Institute

3.1.4 Process piping

ANSI B31.1	Power piping

3.1.5 Welding

ASME IX	Welding and brazing qualification

3.1.6 Valves and fittings

ANSI codes

3.1.7 Storage tanks

API 650	Welded steel tanks for oil storage
API 620	Design and construction of large, welded, low pressure storage tanks
AWWA D100	Steel tanks for water storage

3.1.8 Pumps

DIN	Deutsches Institut fur Normung
ASME	American Society of Mechanical Engineers
HI	Hydraulic Institute

3.1.9 Electrical

IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
ANSI	American National Standards Institute
ATEX	ATmosphèrs EXplosives directives

3.1.10 Instrumentation

IEC	International Electrotechnical Commission
ISA	International Society of Automation
ISO	International Organization for Standardisation
ASME	American Society of Mechanical Engineers
ANSI	American National Standards Institute

3.1.11 Corrosion

NACE	National Association of Corrosion Engineers

3.2 Fuel related standards

Fuel characterization and handling requirements/standards characteristic of the WtE/Biomass field are listed in the following paragraphs.

3.2.1 Solid recovered fuels

3.2.1.1 ISO 21637:2020 Solid recovered fuels — Vocabulary

ISO 21637:2020 defines terms for solid recovered fuels.

3.2.1.2 ISO 21640:2021 Solid recovered fuels — Specifications and classes

ISO 21640:2021 specifies a classification system for solid recovered fuels (SRF), and a template containing a list of characteristics for the specification of their properties, enabling trade and use of SRF supporting the protection of the environment.

3.2.1.3 ISO 21644:2021 Solid recovered fuels — Methods for the determination of biomass content

ISO 21644:2021 specifies three methods for the determination of the biomass content in solid recovered fuels: the 14C content method, the selective dissolution and the manual sorting methods.

3.2.1.4 ISO 21645:2021 Solid recovered fuels — Methods for sampling

ISO 21645:2021 specifies methods for taking samples of solid recovered fuels for example from production plants, from deliveries or from stock. It includes manual and mechanical methods.

3.2.1.5 ISO 21654:2021 Solid recovered fuels — Determination of calorific value

ISO 21654:2021 specifies a method for the determination of gross calorific value of solid recovered fuels at constant volume and at the reference temperature 25 °C in a combustion vessel calorimeter calibrated by combustion of certified benzoic acid.

3.2.1.6 ISO 21656:2021 Solid recovered fuels — Determination of ash content

ISO 21656:2021 specifies methods for the determination of ash content of all solid recovered fuels.

3.2.1.7 ISO 21660-3:2021 Solid recovered fuels — Determination of moisture content using the oven dry method — Part 3: Moisture in general analysis sample

This document specifies a method for the determination of moisture in a general analysis sample by drying the sample in an oven. This method is suitable for use for general analysis samples in accordance with CEN/TS 15414-1. It is applicable to all solid recovered fuels.

3.2.1.8 ISO 21663:2020 Solid recovered fuels — Methods for the determination of carbon (C), hydrogen (H), nitrogen (N) and sulphur (S) by the instrumental method

ISO 21663:2020 specifies the determination of total content of carbon, hydrogen, nitrogen and sulfur in solid recovered fuels by instrumental method. Depending on the amount of test portion, micro or macro instrumental apparatus are used.

3.2.1.9 ISO 21912:2021 Solid recovered fuels — Safe handling and storage of solid recovered fuels

ISO 21912:2021 provides principles and requirements for safe handling, treatment and storage of solid recovered fuels (SRF), prepared from non-hazardous waste, to be used for energy purposes. This document covers process stages from point of acceptance of material to point of delivery of SRF.

3.2.1.10 ISO/TR 21916:2021 Solid recovered fuels — Guidance for the specification of solid recovered fuels (SRF) for selected uses

ISO/TR 21916:2021 addresses the provision of background references that are helpful in defining a more detailed specification for SRF according to its specific end use for energy conversion (EfW plants) and to support the SRF market.

3.2.1.11 ISO 22167:2021 Solid recovered fuels — Determination of content of volatile matter

ISO 22167:2021 specifies the requirements and a method for the determination of volatile matter of solid recovered fuels.

3.2.1.12 ISO 22940:2021 Solid recovered fuels — Determination of elemental composition by X-ray fluorescence

ISO 22940:2021 specifies the procedure for a determination of major and minor element concentrations in solid recovered fuel material by energy-dispersive X-ray fluorescence (EDXRF) spectrometry or wavelength-dispersive X-ray fluorescence (WDXRF) spectrometry using a calibration with solid recovered fuel reference materials or solid recovered fuel samples with known content.

3.2.2 Solid biofuels

3.2.2.1 ISO 14780:2017 Solid biofuels — Sample preparation

ISO 14780:2017 defines methods for reducing combined samples (or increments) to laboratory samples and laboratory samples to sub-samples and general analysis samples and is applicable to solid biofuels.

3.2.2.2 ISO 16559:2022 Solid biofuels — Vocabulary

ISO 16559:2022 establishes a vocabulary for solid biofuels. This document only includes raw and processed material originating from

- forestry and arboriculture,
- agriculture and horticulture, and
- aquaculture.

3.2.2.3 ISO 16948:2015 Solid biofuels — Determination of total content of carbon, hydrogen and nitrogen

ISO 16948:2015 describes a method for the determination of total carbon, hydrogen and nitrogen contents in solid biofuels.

3.2.2.4 ISO 16967:2015 Solid biofuels — Determination of major elements — Al, Ca, Fe, Mg, P, K, Si, Na and Ti

ISO 16967:2015 describes methods for the determination of major elements of solid biofuels respectively of their ashes, which are Al, Ca, Fe, Mg, P, K, Si, Na, Ti. The determination of other elements such as barium (Ba) and manganese (Mn) is also possible with the methods described in ISO 16967:2015.

3.2.2.5 ISO 16968:2015 Solid biofuels — Determination of minor elements

ISO 16968:2015 is intended for the determination of the minor elements Arsenic, Cadmium, Cobalt, Chromium, Copper, Mercury, Manganese, Molybdenum, Nickel, Lead, Antimony, Vanadium, and Zinc in all solid biofuels. Further, it describes methods for sample decomposition and suggests suitable instrumental methods for the determination of the elements of interest in the digests. The

determination of other elements such as Selenium, Tin, and Thallium is also possible with the method described in this International Standard.

3.2.2.6 ISO 16993:2016 Solid biofuels — Conversion of analytical results from one basis to another

ISO 16993:2016 gives formulae which allow analytical data relating to solid biofuels to be expressed on the different bases in common use. Consideration is given to corrections that can be applied to certain determined values for solid biofuels prior to their calculation to other bases.

3.2.2.7 ISO 16994:2016 Solid biofuels — Determination of total content of sulfur and chlorine

ISO 16994:2016 describes methods for the determination of the total sulfur and total chlorine content in solid biofuels. It specifies two methods for decomposition of the fuel and different analytical techniques for the quantification of the elements in the decomposition solutions. The use of automatic equipment is also included in ISO 16994:2016, provided that a validation is carried out as specified and that the performance characteristics are similar to those of the method described in ISO 16994:2016.

3.2.2.8 ISO 16995:2015 Solid biofuels — Determination of the water-soluble chloride, sodium and potassium content

ISO 16995:2015 describes a method for the determination of the water-soluble chloride, sodium and potassium content in solid biofuels by extraction with water in a closed container and their subsequent quantification by different analytical techniques.

3.2.2.9 ISO/TS 16996:2015 Solid biofuels — Determination of elemental composition by X-ray fluorescence

ISO/TS 16996:2015 specifies the procedure for a determination of major and minor element concentrations in biomass material by energy dispersive X-ray fluorescence (EDXRF) spectrometry or wavelength dispersive X-ray fluorescence (WDXRF) spectrometry using a calibration with biomass reference materials. A semi-quantitative determination may be carried out using matrix independent standards.

3.2.2.10 ISO 17225-1:2021 Solid biofuels — Fuel specifications and classes — Part 1: General requirements

ISO 17225-1:2021 determines the fuel quality classes and specifications for solid biofuels of raw and processed materials originating from:

a) forestry and arboriculture.
b) agriculture and horticulture.
c) aquaculture.

3.2.2.11 ISO 17225-2:2021 Solid biofuels — Fuel specifications and classes — Part 2: Graded wood pellets

This document determines the fuel quality classes and specifications of graded wood pellets for non-industrial and industrial use. This document covers only wood pellets produced from the following raw materials (see ISO 17225-1:2021, Table 1):

- 1.1 Forest, plantation and other virgin wood.
- 1.2 By-products and residues from wood processing industry.
- 1.3.1 Chemically untreated used wood.

3.2.2.12 ISO 17225-3:2021 Solid biofuels — Fuel specifications and classes — Part 3: Graded wood briquettes

ISO 17225-3:2021 determines the fuel quality classes and specifications of graded wood briquettes. This document covers only wood briquettes produced from the following raw materials (see ISO 17225-1: 2021, Table 1):

- 1.1 Forest, plantation and other virgin wood
- 1.2 By-products and residues from wood processing industry
- 1.3.1 Chemically untreated used wood

3.2.2.13 ISO 17225-4:2021 Solid biofuels — Fuel specifications and classes — Part 4: Graded wood chips

ISO 17225-4:2021 determines the fuel quality classes and specifications of graded wood chips. This document covers only wood chips produced from the following raw materials (see ISO 17225-1:2021, Table 1):

- 1.1 Forest, plantation and other virgin wood.
- 1.2 By-products and residues from wood processing industry.
- 1.3.1 Chemically untreated used wood.

3.2.2.14 ISO 17225-5:2021 Solid biofuels — Fuel specifications and classes — Part 5: Graded firewood

This document determines the fuel quality classes and specifications of graded firewood. This document covers only firewood produced from the following raw materials (see ISO 17725-1:2021, Table 1):

- 1.1.1 Whole trees without roots.
- 1.1.3 Stem wood.
- 1.1.4 Logging residues (thick branches, tops etc.).
- 1.2.1 Chemically untreated by-products and residues from wood processing industry.

3.2.2.15 ISO 17225-6:2021 Solid biofuels — Fuel specifications and classes — Part 6: Graded non-woody pellets

This document determines the fuel quality classes and specifications of graded non-woody pellets. This document covers only non-woody pellets produced from the following raw material (see ISO 17225-1:2021, Table 1):

- 2 Herbaceous biomasses
- 3 Fruit biomass
- 4 Aquatic biomass
- 5 Biomass blends and mixtures

3.2.2.16 ISO 17225-7:2021 Solid biofuels — Fuel specifications and classes — Part 7: Graded non-woody briquettes

This document determines the fuel quality classes and specifications of graded non-woody briquettes. This document covers only non-woody briquettes produced from the following raw materials (see ISO 17225-1:2021, Table 1):

- 2 Herbaceous biomasses
- 3 Fruit biomass
- 4 Aquatic biomass
- 5 Biomass blends and mixtures

3.2.2.17 ISO/TS 17225-8:2016 Solid biofuels — Fuel specifications and classes — Part 8: Graded thermally treated and densified biomass fuels

ISO/TS 17225-8:2016 determines the fuel quality classes and specifications of graded densified solid biofuels produced from thermally treated biomass for non-industrial and industrial use. This document covers pellets and briquettes produced from the following raw materials (see ISO 17225-1:2014, Table 1):

- 1.1 Forest, plantation and other virgin wood.
- 1.2 By-products and residues from wood processing industry.
- 1.3.1 Chemically untreated used wood.
- 2. Herbaceous biomass.
- 3. Fruit biomass.
- 4. Aquatic biomass.

Subcategories of the above stated raw materials are included.

3.2.2.18 ISO 17225-9:2021 Solid biofuels — Fuel specifications and classes — Part 9: Graded hog fuel and wood chips for industrial use

This document determines the fuel quality classes and specifications of graded hog fuel and wood chips for industrial use. It covers only hog fuel and wood chips produced from the following raw materials (see ISO 17225-1, Table 1):

- 1.1 Forest, plantation and other virgin wood.
- 1.2 By-products and residues from wood processing industry.
- 1.3 Used wood.
- 1.4 Blends and mixtures.

This document covers *hog fuel* that has pieces of varying size and shape, produced by crushing with blunt tools such as rollers, hammers, or flails, and *wood chips* which are defined as chipped woody biomass with a sub-rectangular shape and a typical length of 5 mm to 50 mm typically in the form of pieces with a defined particle size produced by mechanical treatment with sharp tools such as knives.

3.2.2.19 ISO 17827-1:2016 Solid biofuels — Determination of particle size distribution for uncompressed fuels

ISO 17827-1:2016 Part 1 AND 2 specifies a method for the determination of the size distribution of particulate biofuels

3.2.2.20 ISO 17828:2015 Solid biofuels — Determination of bulk density

ISO 17828:2015 defines a method of determining bulk density of solid biofuels by the use of a standard measuring container. This method is applicable to all pourable solid biofuels with a nominal top size of maximum 100 mm.

3.2.2.21 ISO 17829:2015 Solid Biofuels — Determination of length and diameter of pellets

ISO 17829:2015 specifies the methods for the determination of diameter and length of pellets.

3.2.2.22 ISO 17830:2016 Solid biofuels — Particle size distribution of disintegrated pellets

ISO 17830:2016 aims to define the requirements and method used to determine particle size distribution of disintegrated pellets. It is applicable for pellets that fully disintegrate in hot water.

3.2.2.23 ISO 17831 Solid biofuels — Determination of mechanical durability of pellets and briquettes

ISO 17831-1:2015 and 2 define a determination method for testing the mechanical durability of pellets and briquettes. The mechanical durability is a measure of the resistance of compressed fuels towards shocks and/or abrasion as a consequence of handling and transportation

3.2.2.24 ISO 18122:2015 Solid biofuels — Determination of ash content

ISO 18122:2015 specifies a method for the determination of ash content of all solid biofuels.

3.2.2.25 ISO 18123:2015 Solid biofuels — Determination of the content of volatile matter

ISO 18123:2015 aims to define the requirements and method used to determine the volatile matter content of solid biofuels. The volatile matter content is determined as the loss in mass, less that due to moisture, when solid biofuel is subject to partial pyrolysis under standardized conditions.

3.2.2.26 ISO 18125:2017 Solid biofuels — Determination of calorific value

ISO 18125:2017 specifies a method for the determination of the gross calorific value of a solid biofuel at constant volume and at the reference temperature 25 °C in a bomb calorimeter calibrated by combustion of certified benzoic acid.

3.2.2.27 ISO 18134 Solid biofuels — Determination of moisture content

ISO 18134 codes describe the method of determining the total moisture content of a test sample of solid biofuels by different methods.

3.2.2.28 ISO 18135:2017 Solid Biofuels — Sampling

ISO 18135:2017 describes methods for preparing sampling plans and certificates, as well as taking samples of solid biofuels, for example, from the place where the raw materials grow, from production plant, from deliveries, e.g. lorry loads, or from stock. It includes both manual and mechanical methods.

3.2.2.29 ISO 18846:2016 Solid biofuels — Determination of fines content in quantities of pellets

ISO 18846:2016 specifies a method for determining the amount of material passing through a sieve with 3,15 mm diameter round hole.

3.2.2.30 ISO 18847:2016 Solid biofuels — Determination of particle density of pellets and briquettes

ISO 18847:2016 specifies the method for determining the particle density of compressed fuels such as pellets or briquettes.

3.2.2.31 ISO 19743:2017 Solid biofuels — Determination of content of heavy extraneous materials larger than 3,15 mm

ISO 19743:2017 specifies a method for the determination of content of heavy extraneous materials larger than 3,15 mm by the use of sink-and-float separation combined with elutriation. This document is applicable to woody biomass in accordance with ISO 17225-1:2014, Table 1.

3.2.2.32 ISO 20023:2018 Solid biofuels — Safety of solid biofuel pellets — Safe handling and storage of wood pellets in residential and other small-scale applications

ISO 20023:2018 provides principles and requirements for the safe handling and storage of wood pellets in residential and other small-scale applications. It covers the supply chain from loading of the delivery truck, requirements of delivery trucks, connections to the end-user's store and the delivery process. It

also covers the design and construction of pellet storage systems. This document addresses risks of fires, dust explosions, off-gassing, oxygen depletion, damage to appliances and buildings through swelling of pellets and other health risks. It is applicable to wood pellets according to ISO 17225-2.

3.2.2.33 ISO 20024:2020 Solid biofuels — Safe handling and storage of solid biofuel pellets in commercial and industrial applications

ISO 20024:2020 provides principles and requirements for safe handling and storage of solid biofuels pellets in commercial and industrial applications. This document is using a risk-based approach to determine what safety measures should be considered.
Facilities with a storage capacity <100 t are covered by ISO 20023. Generally, for end-user facilities with a storage capacity of <1 000 t, ISO 20023 could also be applicable if storage principle and facility complexity is in-line with the objectives of ISO 20023.
This document covers the handling and storage process of pellets in the following applications:

— at a pellet production plant from the outlet of the cooler unit until loaded for transportation.
— at a commercial distributor from the receiving station until loaded for transportation; and
— at an industrial end-user from the receiving station until fed into the fuel preparation or combustion process.

Although unloading and loading of e.g. vessels, trains or trucks are included in the operational envelops defined above, the safety aspect of the transportation itself is beyond the scope of this document.
This document also gives specific guidance on detection and suppression systems and preparatory measures to enable safe and efficient firefighting operations. Guidance on the management of fire and explosion incidents is also specified.

3.2.2.34 ISO/TS 20048 1:2020 Solid biofuels — Determination of off-gassing and oxygen depletion characteristics

ISO/TS 20048 1:2020 defines a method for determination of off-gassing (permanent gases) and oxygen depletion from woody as well as non-woody biomass, including densified materials such as pellets and briquettes, as well as non-densified materials such as chips. The method is also applicable for thermally treated materials, including torrefied and carbonized materials.

3.2.2.35 ISO 20049-1:2020 Solid biofuels — Determination of self-heating of pelletized biofuels — Part 1: Isothermal calorimetry

ISO 20049-1:2020:

- specifies a general test procedure for quantification of the spontaneous heat generation from solid biofuel pellets using isothermal calorimetry.
- specifies a screening test procedure for wood pellets using an instrument temperature of 60 °C.
- establishes procedures for sampling and sample handling of solid biofuel pellets prior to the analysis of spontaneous heat generation; and
- gives guidance on the applicability and use of isothermal calorimetry for calculation of the net reaction rate of the heat producing reactions of solid biofuel pellets.

3.2.2.36 ISO 20049-2:2020 Solid biofuels — Determination of self-heating of pelletized biofuels — Part 2: Basket heating tests

ISO 20049-2:2020 specifies basket heating tests for the characterization of self-heating properties of solid biofuel pellets. The described methods can be used for other substances than solid biofuel pellets (e.g. wood chips).

3.2.2.37 ISO 21404:2020 Solid biofuels — Determination of ash melting behaviour

ISO 21404:2020 specifies a method for the determination of the characteristic temperatures for the ash melting behaviour of solid biofuels.

3.2.2.38 ISO/TS 21596:2021 Solid biofuels — Determination of grindability — Hardgrove type method for thermally treated biomass fuels

ISO/TS 21596:2021 describes a method for determination of grindability of graded thermally treated and densified biomass fuels such as classified in ISO/TS 17225-8, for the purpose of preparing fuels with a defined particle size distribution for effective combustion in pulverized fuel boilers. The grindability characteristics determined by the test method provide guidance as to the pulverizing mill performance when utilizing such fuels.

3.2.2.39 ISO 21945:2020 Solid biofuels — Simplified sampling method for small scale applications

This document describes simplified methods for taking samples of solid biofuels in small scale applications and storages including preparation of sampling plans and reports. The main focus is on storages with a size of ≤100 t.

3.2.2.40 ISO 23343-1:2021 Solid biofuels — Determination of water sorption and its effect on durability of thermally treated biomass fuels — Part 1: Pellets

ISO 23343-1:2021 specifies a method for the determination of water sorption in a laboratory setting and provides a measure for how the durability is impacted as a result of immersion in water.

3.2.2.41 ISO/TR 23437:2020 Solid biofuels — Bridging behaviour of bulk biofuels

This document summarizes current knowledge concerning a test method and its technical implementation, and existing knowledge about the bridging performance of biofuels.
The document consists of three parts, as follows:

- Part I: Method for direct determination of bridging behaviour, to make it available for research and development purposes (see Clause 4).
- Part II: Implementing the measurement principle, to assist in the construction of test apparatus and to illustrate the performance of a bridging test (see Clause 5).
- Part III: Experience and results from bridging tests, to provide typical results on bridging for a wide range of biofuels already tested (see Clause 6).

3.3 Performance testing standards

3.3.1 ASME PTC 46 – Overall plant performance

This Code applies to any plant size. It can be used to measure the performance of a plant in its normal operating condition, with all equipment in a clean and fully functional condition. This Code provides explicit methods and procedures for – among others – solid fuelled Rankine cycle plant.

3.3.2 ASME PTC 17 – Reciprocating Internal-Combustion Engines

This Code provides rules for testing, and for the computation and tabulation of the results of tests for all types of reciprocating internal combustion engines, in order to determine power and fuel consumption. This Code is applicable to biogas and syngas fed WtE/Biomass plants.

3.3.3 ASME PTC 34 – Waste Combustors with Energy Recovery

The object of this Code is to provide a test procedure for evaluating the performance of waste fuel combustors with energy recovery using the boiler as a calorimeter. These procedures apply when the variability and waste fuel composition results in a lack of confidence in obtaining representative samples for laboratory analysis.

3.3.4 ASME PTC 19.10 – Flue and Exhaust Gas Analyses

This Document specifies methods, apparatus, and calculations which are used in conjunction with Performance Test Codes to determine quantitatively, the gaseous constituents of exhausts resulting from stationary combustion sources (among which WtE and Biomass plants).