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BRITISH STANDARD

The design and construction of gas boosters used in association with combustion equipment – Specification

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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 12, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution.

This British Standard came into effect on 29 June 2007 and was prepared by Technical Committee GW/33, *Gas supply*. A list of organizations represented on the committee can be obtained on request to its secretary.

Supersession

BS 8487:2007+A1:2013 supersedes BS 8487:2007, which is withdrawn.

Information about this document

Text introduced or altered by Amendment No. 1 is indicated in the text by tags [A1] 〈A1〉. Minor editorial changes are not tagged.

Use of this document

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

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

Contractual and legal considerations

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

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

In particular, attention is drawn to the following statutory regulations:

Supply of Machinery Regulations 1992, as amended [1]

Provision and Use of Equipment at Work Regulations 1992 [2]

Dangerous Substances and Explosive Atmospheres Regulations [DSEAR] 2002 [3]

Electricity at Work Regulations 1989 [4]

Gas Safety (Installation and Use) Regulations 1998 [5]

Gas Safety (Installation and Use) Regulations (Northern Ireland) 2004 [6]

Gas Act 1986, as amended [7]

Introduction

This British Standard has been produced to address the growing use of centrifugal boosters on gas-fired plant. The boosters normally supply gas at pressures up to about 150 mbar, but almost identical units may also be used for combustion air duties.

The standard has been produced to enhance the advice provided by manufacturers with respect to the need for maintenance on gas boosters by competent persons. The sections on maintenance and commissioning within this standard will be of relevance to existing units.

1 Scope

This British Standard specifies the construction and maintenance requirements of indirectly and directly driven single-stage centrifugal booster assemblies (hereafter referred to as machines), working on first, second or third family gas, having an outlet pressure of not greater than 150 mbar.

This standard is not applicable to positive displacement gas and slide vane type compressors.

This standard is also applicable to machines with outlet pressures not greater than 150 mbar used on landfill gases or biogases or gas/air mixtures, provided that any additional design and safety issues have been incorporated.

Though applicable to single-stage machines only, this standard can be used as a basis for multi-stage machines where, in general, pressures higher than 150 mbar are achieved.

NOTE All pressures are gauge pressures. All pressure tests are performed with air under ambient conditions.

2 Normative references

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

BS EN 953, *Safety of machinery – Guards – General requirements for the design and construction of fixed and movable guards*

BS EN 1092 (all parts), *Flanges and their joints – Circular flanges for pipes, valves, fittings and accessories, PN designated*

BS EN 1515-1, *Flanges and their joints – Bolting – Part 1: Selection of bolting*

BS EN 10226-1, *Pipe threads where pressure tight joins are made on the threads – Taper external threads and parallel internal threads – Part 1: Dimensions, tolerances and designation*

BS EN 10255, *Non-alloy steel tubes suitable for welding or threading – Technical delivery conditions*

BS EN 60529, *Specification for degrees of protection provided by enclosures (IP code)*

BS EN 60730-1, *Automatic electrical controls for household and similar use – Part 1: General requirements*

BS EN ISO 228 (both parts), *Pipe threads where pressure-tight joints are not made on the threads*

BS EN ISO 10380:2003, *Pipework – Corrugated metal hoses and hose assemblies*

BS ISO 1940-1, *Mechanical vibration – Balance quality requirements for rotors in a constant (rigid) state – Part 1: Specification and verification of balance tolerances*

3 Materials and components

3.1 General

All materials used in the construction of the machine shall be suitable for their intended application and purpose, and shall not be liable to deterioration likely to cause a hazard within the intended design life of the machine.

All components shall be subject to defined quality control procedures; all castings shall be of good quality with no inclusions or porosity exceeding recognized good standards of engineering.

3.2 Design life

The machine shall be designed to have a life of at least 20 000 hours running and at least 3 years elapsed time.

NOTE Maintenance in accordance with the manufacturer's instructions is permitted during this period.

3.3 Mechanical strength

The mechanical strength of the machine shall be:

a) capable of containing 150% of the machine's maximum declared outlet pressure;

b) suitable for the intended application;

c) such that, when tested in accordance with Annex A, the vibrations in use do not lead to fatigue failure of the booster base plate or any integral castings during their declared design life;

d) such that the casing remains gas-tight in the event of failure of the rotating elements.

NOTE 1 This may be demonstrated by deliberately generating failure of the impeller blades.

NOTE 2 A casing is that part of the machine forming a gasway and which normally contains the impeller and its drive shaft, seals and bearings. In a high-speed indirect drive machine it is typically of aluminium or cast iron.

NOTE 3 Pressure tests are performed at 150% maximum working pressure for 5 minutes on air, ensuring a maximum leakage rate of 100 cm^3/h.

The inlet and outlet connections shall conform to **12.2**.

3.4 Gas soundness

When tested for external gas soundness with air by pressurizing the machine to 150% of maximum working pressure, ensuring a maximum leakage rate of 100 cm^3/h when tested on air, the machine shall be gas-tight.

Parts of the housing which directly or indirectly separate a gas-carrying compartment from atmosphere shall either be made from metallic materials, or shall be such that, on removal or fracture of non-metallic parts other than O-rings, gaskets, seals and diaphragms, no more than 30 dm^3/h escapes at 150% maximum working pressure when tested with air.

NOTE It may be permissible to ventilate any leakage within a bearing housing to an external safe location if shown as part of the installation instructions.

4 Impeller and drive train

All components shall be designed to withstand the forces likely to be encountered in normal service, including cyclic loading which can cause fatigue damage [see **3.3**c)].

The security of any drive shaft shall be consistent with good engineering practice to ensure that the machine is capable of operating under intermittent or continuous use.

NOTE 1 The use of pinch bolts/grub screws on flat parts of shafts is not an acceptable method of securing an impeller or pulley wheel, if fitted.

The impellers and drive spindles shall be balanced in accordance with BS ISO 1940-1.

NOTE 2 For high speed indirectly driven machines, level G6.3 may be appropriate.

The impeller housing, any drive shaft and any drive wheel shall be matched in accordance with BS ISO 1940-1, taking account of temperature changes during normal use and any effect these might have on the tolerances.

Impeller shafts shall be designed to ensure that it is not possible to locate the impeller assembly incorrectly during maintenance or replacement. The impeller assembly, and drive pulley wheel if fitted, shall be securely located on the shaft such that movement is not possible from its correct location, e.g. by securing nuts and keyed fixings. When the machine is operated in the range of 5% to 100% flow within its design pressure lift envelope:

a) the machine shall have an outlet pressure that is stable within ±5% of the outlet pressure at its point of greatest instability;

   NOTE The use of anti-surge loops is permissible if specified in the installation instructions or included with the machine.

b) there shall be no noticeable audible surging;

c) any drillings, tappings or gasways within any casting shall not cause potential positions of weakness that might lead to failure (this includes fixing bolts and balancing methods);

d) fixings shall not become loose within the gasways leading to, and in close proximity with, the impeller assembly such that they could cause damage that might lead to failure of the assembly or the pressure casings.

The output performance of the machine shall be of an anti-surging design.

5 Shaft seals

The shaft seals selected for use in the machine shall:

a) be suitable for the applicable gas, the operating temperatures, the pressures and the control of gas leakage;

b) have a design operating life of 20 000 hours;

c) when the machine is installed according to the manufacturers' installation instructions and operated for two hours under no-flow conditions in an ambient temperature of 20 ± 5 °C, be able to operate continuously at a design temperature of not less than 80 °C.

The shaft seal assembly shall be designed to limit the amount of gas leakage into the space surrounding the booster. This shall be tested by operating the machine under normal conditions for two hours and then testing for external gas soundness with air by pressurizing the machine to 150% of maximum working pressure ensuring a maximum leakage rate of 100 cm^3/h.

6 Bearings

Bearings selected for use in the machine shall:

a) be suitable for the applicable gas, the operating temperatures, the pressures and the control of gas leakage;

b) have a design operating life of 20 000 hours;

c) when the machine is installed according to the manufacturers' installation instructions and operated for two hours under no-flow conditions in an ambient temperature of 20 ± 5 °C, be able to operate continuously at a design temperature of not less than 80 °C.

7 Temperature limitations

When the machine is installed according to the manufacturers' installation instructions and operated for two hours under no-flow conditions in an ambient temperature of 20 ± 5 °C:

a) the temperature of the bearings and shaft seals shall not exceed their manufacturers' recommendations; and

b) the temperature of the casings immediately adjacent to the bearings and shaft seals shall not exceed 80% of their design maximum temperature expressed in °C, unless a suitable device is fitted to cause the machine to proceed to non-volatile lockout at a casing temperature of not more than 80% of the maximum temperature expressed in °C.

NOTE Non-volatile lock-out is the safety shut-down of the system, such that a re-start can only be accomplished by a manual reset of the system and by no other means.

8 Guarding

The machine shall be suitably guarded in accordance with BS EN 953.

9 Controls

The machine shall be fitted with a low-pressure switch [A1] or pressure transducer [A1] to be installed on its inlet, and wired such that non-volatile lockout occurs on failure under a low inlet pressure condition, or the installation instructions shall specify that such a switch [A1] or pressure transducer [A1] be installed [see Clause **14**b)].

The machine shall incorporate a visual means of indicating operation, e.g. a running lamp on a local control device/panel.

10 Electrical circuit

The electrical circuit and components of the machine shall conform to BS EN 60730-1.

All metallic parts of the machine shall be electrically continuous. An earth bond connection shall be provided for bonding to earth or the adjacent pipework.

The electrical earth circuit shall not depend upon the flexible gas connections.

11 Motor drive

The design of the drive shall be such that the design loadings of the bearings and the seal assemblies are not exceeded. The machine shall satisfy its design performance curve at declared voltage ±5%. It shall continue to operate safely with a voltage of +10% and –15% of its declared voltage range.

The degree of protection shall at least meet IP54 of BS EN 60529.

Where an indirect drive is used, means shall be provided to facilitate adjustment of belt tension. Access to such means shall require the use of commonly available tools (see also Note 2 to Clause **16**).

Motor assemblies shall be aligned to the impeller drive shaft assembly and checked after assembly to ensure they are true within specified tolerances.

12 Pipe connections and tappings

12.1 General

All main inlet and outlet connections shall be of a flanged design to meet the appropriate part of BS EN 1092. The minimum rating shall be PN6.

Pressure test points shall be incorporated to measure the inlet pressure and the outlet pressure.

Any tappings within gas containing parts of the machine body shall have a minimum material thickness equal to the outside diameter of the tapping. All threads in castings forming gas-containing parts of the machine shall be of parallel flat-faced type, using an appropriate seal, or shall seal on machined metal-to-metal faces. Threads on gas fittings not in castings shall conform to BS EN 10226-1.

When the machine is tested in accordance with Annex A, any holes within any casting shall not lead to failure.

Flexible connections provided with the machine shall conform to BS EN ISO 10380:2003, Type 1. Flexible connections shall contain a means to prevent the application of torque during assembly, e.g. union or slip ring type flanges.

〈A1〉 *NOTE Connections up to R2 may be threaded in accordance with BS EN 10226-1.* 〈A1〉

12.2 Torsion and bending

Machines shall be constructed in such a way that, when tested in accordance with Annex A, they have adequate strength to withstand likely mechanical stress to which they might be subjected during installation and service.

When tested in accordance with Annex A:

a) there shall be no permanent deformation of the machine which might lead to subsequent mechanical failure or gas leakage during normal operation, as determined by measurement;

b) the external leakage rate shall not exceed 100 cm^3/h when tested with air by pressurizing the machine to 150% of maximum working pressure.

13 Marking and data plates

A data plate shall be permanently affixed to the machine, clearly detailing the type and model.

The data plate shall also include the maximum inlet pressure, the maximum operating ambient temperature, the year of manufacture and the serial number for the machine. The data plate shall make reference to the manufacturer's instructions for gas types and specifications. This may be by the use of a symbol on the data plate.

Where belt tension is provided by the inherent weight of a motor, it is essential that any motor change is on a like-for-like basis. In such cases, warning instructions shall be displayed on the machine.

14 Installation instructions

The manufacturer's installation instructions shall be provided with the machine.

Advice shall be provided on compliance with the Gas Act [7] or the Gas Safety (Installation and Use) Regulations (GSIUR) [5 and 6] with respect to giving at least 14 days' notice in writing to the Gas Transporter of the intention to install the machine to operate with piped supplies of natural gas or LPG.

The manufacturer's installation instructions shall:

a) detail the maximum inlet pressure and the gas pressure v flow characteristics of the machine; the type of gases that the machine is suitable for, the maximum ambient temperatures, the rated voltage, single- or three-phase, the running and starting currents, the drive ratio if applicable, the electrical drawing number, and appropriate approval data if applicable;

NOTE Landfill gases and biogases can be wet, dirty and corrosive, so materials of construction for machines have to be selected specifically for the composition of the gases. Particular attention should be paid to any hydrogen sulfide (H_2S) content, which can be highly corrosive.

b) detail the requirements for low pressure inlet protection to satisfy GSIUR [5 and 6] (see Clause **9**);

c) include a graph of the performance [pressure lift v flow] of the machine based on air and/or the gas being handled;

d) state that the machine shall be installed in accordance with the manufacturer's instructions and the requirements of IGE/UP/2, paying particular attention to rigid pipe supports adjacent to the inlet and outlet flexible connections to the machine and the need for suitable fresh and cooling air for ventilation in the area/housing where the machine is installed;

e) provide information on noise levels together with advice regarding the use of personal protective equipment, e.g. hearing protection;

NOTE Reference should be made to HSE L108 [8] and INDG 362 [9].

f) detail any requirements for the use of anti-vibration mountings (AVMs) or resilient mountings;

g) state that the inlet and outlet connections of the machine are to be made using flexible connections (supplied by either the manufacturer or the installer) and specify the limits of position and orientation;

h) specify the correct design and length of flexible pipe at the inlet/outlet connections;

i) provide advice on the provision and use of an interlock with the downstream combustion equipment to prevent the machine from overheating when there is no demand for gas flow;

NOTE Cooling loops may be an acceptable alternative or additional means of control for low-flow and no-flow conditions to limit temperature rise.

j) indicate that there has to be provision for accessibility for maintenance and routine inspections and specify that, where the machine is installed in a remote location, suitable access has to be provided without the need for special access equipment;

k) indicate that ventilation has to be provided in the booster area and recommend that the ventilation provisions specified by the manufacturer are followed;

l) recommend that the machine is serviced by a competent person at the intervals recommended by the machine manufacturer or his agent;

m) include information on the sizing of anti-surge loops;

n) include recommendations on the external wiring system; specifically, that the electrical installation be in accordance with BS 7671, and additional instructions on:

   i) the use of, and wiring diagrams for, low-pressure cut-off switches [A1] and pressure transducers; [A1]

   ii) the application of overheat protection systems, where required;

   iii) the application of, and wiring diagrams for, "appliance running" interlocks;

   iv) the application and limitations of variable speed drives, where appropriate;

o) provide advice on compliance with DSEAR [3] [A1] and a booster machine risk assessment for the user to incorporate in a site risk assessment. Further information on DSEAR compliance is given in IGEM/UP/16; [A1]

p) specify the type of any in-service lubricant required for bearings and the frequency and method of application (see Clause **6**).

15 Commissioning instructions

Commissioning instructions shall be provided by the manufacturer, indicating that, after installation, a competent person shall perform commissioning of the machine and that the final inspections shall include at least:

a) correct matching with the pressure and flow rate demands, if practicable;

b) mechanical damage;

c) the manner in which the machine has been installed and controlled in accordance with the manufacturer's instructions;

d) the gas soundness of the unit and the complete assembly;

e) correct operation of the safety devices and systems;

f) belt tension, where fitted; and

g) adequate ventilation.

16 Servicing and maintenance

Servicing and maintenance instructions shall be provided by the manufacturer, detailing:

a) the maximum recommended service interval;

b) the methods of replacing parts A1, including any special advice for work on parts displaying an Ex marking; A1

c) which parts should be replaced in pairs, i.e. only in conjunction with another particular new part;

d) which parts should be replaced after a specified running period, regardless of condition;

NOTE 1 Stainless steel flexible connections might require replacement on a 5-yearly basis.

e) which operations, if any, the manufacturer or his agent should perform off-site;

f) manufacturer's parts references for items such as bearing assemblies, shaft seals, drive belts, motors and electrical equipment which might be required as part of regular maintenance.

NOTE 2 Where belt tension is provided by the inherent weight of a motor, it is essential that any motor change is on a like-for-like basis. In such cases, warning instructions need to be displayed on the machine.

Annex A (normative) Test method for mechanical strength (see 3.3) and torsion and bending (see 12.2)

A.1 Install the machine to a rigid base plate.

A.2 Fix to the machine pipes conforming to BS EN 10255, medium series, with a length of at least 300 mm (as shown in Figure A.1), applying the appropriate tightening torque to flange bolts associated with any flanged sections (used for the inlet or outlet machine connections) to BS EN 1515-1 from the values in Table A.1. The ends of these pipes shall be left free but shall be sealed in such a way as to allow pressurization of the machine.

Table A.1 **Tightening torque for flange bolts**

Nominal size DN	6	8	10	15	20	25	32	40	50	65	80	100	125	⩾150
Torque N·m	20	20	30	30	30	30	50	50	50	50	50	80	160	160

A.3 Before testing, determine by measurement the base-line as fitted dimensions that might be required for comparison during subsequent deformation/bending tests; e.g. inlet and outlet gas connections, shaft locations

A.4 Operate the machine for two hours under no-flow conditions in an ambient temperature of 20 ± 5 °C. Disable any low inlet gas pressure switch necessary to allow the machine to run as specified for this Annex.

A.5 With the machine operating at 150% of its maximum design pressure, apply to the pipes (see **A.2**) the force for the required bending moment given in Table A.2 for 900 s and at least 300 mm from the inlet and outlet flanged connections.

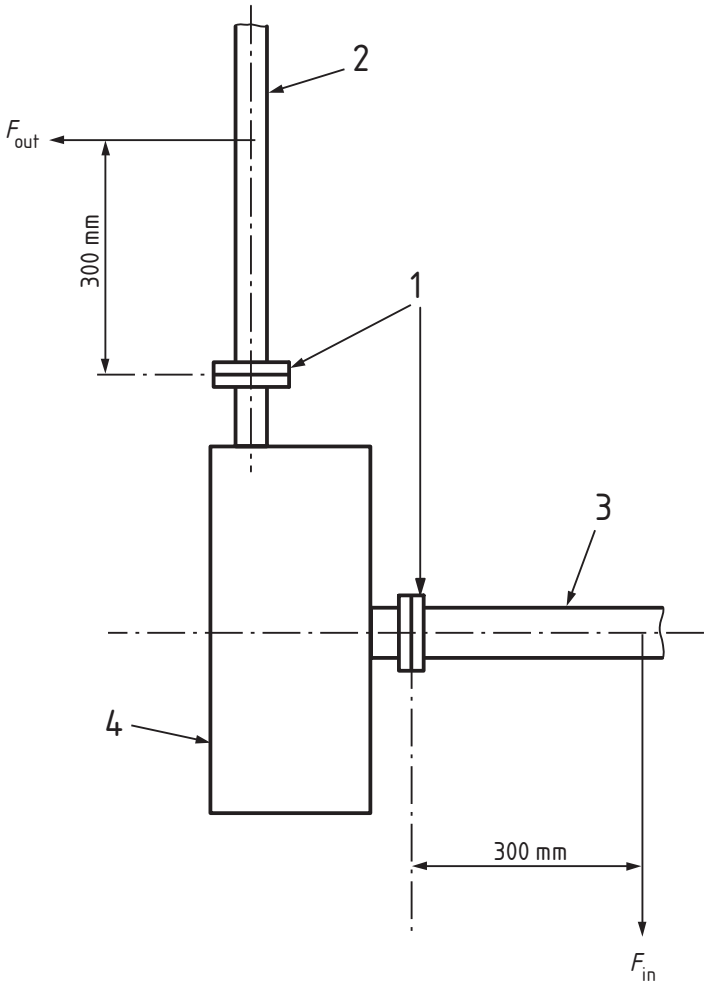
Table A.2 **Bending moments**

Inlet or outlet connection nominal size DN	**Bending moment at connection face *F*** Nm
> 15	40
20	50
25	80
32	130
40	175
50	260
65	315
80	390
100	475
125	500
< 150	550

A.6 With the machine not operating and the force still applied, test for external gas soundness with air by pressurizing the machine to 150% of maximum working pressure and verifying that the external leakage rate does not exceed 100 cm^3/h.

A.7 On completion of the testing, determine by measurement whether there is any permanent deformation of the machine which might lead to subsequent mechanical failure or gas leakage during normal operation.

Figure A.1 **Bending moment test**



Key

1 Connection face of flanges
2 Outlet machine pipe
3 Inlet machine pipe
4 Booster

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Standards

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BS 7671, *Requirements for electrical installations – IEE Wiring Regulations*

BS EN 60730-1, *Automatic electrical controls for household and similar use – Part 1: General requirements*

IGE/UP/2, *Gas installation pipework, boosters and compressors on industrial and commercial premises*

〈A1〉 IGEM/UP/16, *Design for Natural Gas installations on industrial and commercial premises with respect to hazardous area classification and preparation of risk assessments* 〈A1〉

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[8] HSE L108 *Reducing noise at work: A guide to the Noise at Work Regulations 1989*.

[9] HSE INDG 362 *Noise at Work.*

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