

*Utilization Procedures*  
*IGE/UP/9 Edition 2*  
*Communication 1705*

*Founded 1863*  
*Royal Charter 1929*  
*Patron*  
*Her Majesty the Queen*

***Application of Natural Gas and fuel oil  
systems to gas turbines and  
supplementary and auxiliary fired  
burners***



# ***Application of Natural Gas and fuel oil systems to gas turbines and supplementary and auxiliary fired burners***



*Price Code: U5*  
© The Institution of Gas Engineers and  
Managers  
Charnwood Wing, Ashby Road  
Loughborough  
Leicestershire  
LE11 3GH  
Tel: 01509 272827  
Fax: 01509 283110  
Email: [general@igem.org.uk](mailto:general@igem.org.uk)

# CONTENTS

<b>SECTION</b>	<b>PAGE</b>	
1	Introduction	1
2	Scope	5
3	Legal and allied considerations	9
	• 3.1 European legislation	9
	• 3.2 UK legislation	9
	• 3.2.1 Health and Safety at Work, etc. Act (HSWA)	9
	• 3.2.2 Management of Health and Safety at Work Regulations (MHSWR)	9
	• 3.2.3 Provision and Use of Work Equipment Regulations (PUWER)	9
	• 3.2.4 Pressure Equipment Regulations (PER)	10
	• 3.2.5 Pressure Systems Safety Regulations (PSSR)	10
	• 3.2.6 Electricity at Work Regulations	11
	• 3.2.7 Noise at Work Regulations	11
	• 3.2.8 Gas Safety (Installation and Use) Regulations (GS(I&U)R)	11
	• 3.2.9 Confined Spaces Regulations	12
	• 3.2.10 Construction (Design and Management) Regulations (CDM)	13
	• 3.2.11 Supply of Machinery (Safety) Regulations	13
	• 3.2.12 UK Regulations under ATEX	13
	• 3.2.13 The Dangerous Substances and Explosive Atmospheres Regulations (DSEAR)	14
	• 3.2.14 Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR)	14
	• 3.2.15 Control of Substances Hazardous to Health Regulations (COSHH)	15
	• 3.2.16 Control of Asbestos at Work Regulations	15
	• 3.2.17 Gas Safety (Management) Regulations (GS(M)R)	16
4	Arrangement of plant	17
5	Gas and oil supply, pressure regulation and metering	19
	• 5.1 Gas and oil supply	19
	• 5.2 Pressure regulation	19
	• 5.2.1 Gas fired turbines	19
	• 5.2.2 Dual fuel turbines	20
	• 5.2.3 Fuel oil fired gas turbines	20
	• 5.3 Metering	20
6	Gas and fuel oil conditioning	21
	• 6.1 Gas and oil conditioning	21
	• 6.2 Filtration	21
	• 6.3 Fuel heating	22
7	Installation pipework	24
	• 7.1 Design	24
	• 7.1.1 General	24
	• 7.1.2 Pipework of MOP exceeding 16 bar	24
	• 7.1.3 Area classification	27
	• 7.2 Facilities for commissioning and de-commissioning	27

• 7.3	Facilities for testing and purging	28
• 7.4	Testing	28
• 7.4.1	Pipework of MOP not exceeding 16 bar	28
• 7.4.2	Pipework of MOP exceeding 16 bar	29
• 7.4.3	Gas tightness testing following maintenance of a turbine	30
• 7.4.4	Completion	31
• 7.5	Reporting	31
• 7.6	Monitoring	31
8	Valves	32
• 8.1	General	32
• 8.2	Safety shut-off valves (SSOVs) and gas vent valves	33
• 8.2.1	General	33
• 8.2.2	Gas valve proving systems	34
• 8.2.3	Specification for SSOVs for gas and oil	35
• 8.2.4	Specification for gas vent valves	35
• 8.3	Emergency block and vent valves for gas and oil	35
• 8.3.1	Specification for emergency block valves	35
• 8.3.2	Specification for emergency vent valves with emergency block valves	35
9	Venting	37
• 9.1	Design of gas vents	37
• 9.2	Lightning protection of gas vents	37
• 9.3	Oil vents and drainage	37
10	Purging of a turbine and its associated equipment	39
11	Air for ventilation and combustion	41
• 11.1	Ventilation of turbine enclosures	41
• 11.2	Ventilation of plant rooms	43
• 11.3	Turbine air intakes	43
12	Ancillary supplies	44
• 12.1	Electricity supplies	44
• 12.2	Control circuits	44
• 12.3	Electrical equipment	44
• 12.4	Fuel supply pipework	45
• 12.5	Plant	45
• 12.6	Instrument and control fluid supplies	45
13	Safety of turbine fuel gas and related systems	46
14	Safety of supplementary and auxiliary systems	47
15	Controls and operation	49
16	Commissioning	51
17	Operating instructions	52

**APPENDIX**

1	Glossary and acronyms	53
2	References	57
3	Turbine and burner data gas flow enquiry form	62
4	Typical Natural Gas	63
5	Sizing of vents	65
6	Design of vents	66

**FIGURES**

1	Relative pressure levels	4
2	Typical CHP installations	6
3	Simplified gas fuel schematic for a typical turbine installation with a gas fired boiler	7
4	Simplified liquid fuel system schematic	8

**TABLES**

1	Purge velocities	28
2	Test procedures	29
3	Typical Natural Gas compositions	63
4	Compressibility factors for typical Natural Gas	64

## SECTION 1 : INTRODUCTION

- 1.1 These Procedures have been drafted by a Panel appointed by the Institution of Gas Engineers and Managers' (IGEM's) Gas Utilization Committee, subsequently approved by that Committee and published by the authority of the Council of the Institution.
- 1.2 These Procedures supersede IGE/UP/9, Communication 1652, which is obsolete.
- 1.3 These Procedures cover the application of Natural Gas (NG) and fuel oil systems for firing gas turbines and their interactions with gas and oil firing for supplementary and auxiliary fired burners.
- 1.4 The development and application of gas turbines as efficient and reliable power sources is now well proven throughout the world. The high temperature of the exhaust heat and its ability to support combustion of additional fuel with supplementary and auxiliary firing has led to considerable use of turbines in conjunction with waste heat recovery equipment such as boilers, dryers, etc. The rapid start-up process, enabling turbines to accept full load within minutes from a "cold start", and their very high power-to-weight ratio, has popularised their use as standby power and base load generators of electricity.
- 1.5 In contrast to other types of gas and fuel oil fired burners, the start-up, operation and shut-down procedures employed on a turbine are determined by many more factors than merely the need to establish, maintain and control a stable flame. In particular, the inter-dependence of turbine power and combustion air supply, the need to reach a self-sustaining speed rapidly to reduce the depletion of any starter motive power supplies, the avoidance of critical shaft or blade aerofoil resonance and the very rapid flame modulation needed to handle the sudden acceptance and shedding of loads, impose severe restrictions. These restrictions render many of the practices common on other large gas burners impracticable in this application. The high excess air quantities also provide considerable scope for safe deviation from practices used on other burners.
- 1.6 For gas firing, it is vital to consider the system as a whole, including the gas transporter's (GT's) network, meter installation, installation pipework, fuel gas compressor, turbine, supplementary/auxiliary fired burners and other gas users on site. Although, generally, NG is dry, the effect of pipeline conditioning, for example glycol fogging, on the dryness of the gas, needs to be taken into account. For oil firing, it is vital to consider the design of supply pipework, filtration, heating and pumping sets as a whole. No individual component can be specified or finalised in isolation from the rest of the system. Close liaison at an early stage with the fuel and electricity suppliers and between the various equipment suppliers is essential.
- 1.7 Supplementary firing can be by in-duct gas or dual fuel burners or by boiler-mounted dual fuel burners. These Procedures are not intended to cover the specific requirements for fuel oil firing for supplementary/auxiliary burner systems.

*Note: The ignition and subsequent operation of oil-fired systems are covered by BS EN 746 Part 2, BS EN 264, BS EN 267 and BS EN 293, as appropriate.*

The operating range of burners identified in these Procedures is likely to be wider than the range of operation required to meet emissions criteria. Consequently, tighter tolerances and smaller ranges may be required to meet regulations on emissions and, thus, will not affect gas safety. However, the additional complexities may require special consideration to be given in relation to safe operation.

Procedures for gas compressors and commissioning of gas plant are given in IGE/UP/6 and IGE/UP/4, respectively.

- 1.8 These Procedures are intended to provide basic guidelines, highlighting the essential features necessary to ensure the safe and reliable use of gas turbines using NG or fuel oil as the principal, or as an alternative or participant, fuel. The very wide range of burner types and configurations employed on different designs necessarily dictates that no single specification can be prepared to cover the details of how these Procedures may be satisfied in all cases. Therefore, the aim is to establish the principal features of relevance to the safety of all installations, to deal in some detail with the techniques most commonly found in practice and, in so doing, to draw the reader's attention to the type of problem areas which may be encountered. In very many cases, the engineer involved will need to examine closely the individual installations with which they are concerned in order to ensure that safety, to an equal or better standard than that outlined, is provided. The details of how this is done are too varied to be specified rigidly and are, in many cases, subject to continuous revision by manufacturers in this very rapidly expanding field of technology. In addition to these Procedures, it is necessary to refer to the manufacturer's instructions.
- 1.9 These Procedures make use of the terms "should", "shall" and "must" when prescribing particular procedures. Notwithstanding Sub-Section 1.12:
- (a) The term "must" identifies a requirement by law in Great Britain (GB) at the time of publication.
  - (b) The term "shall" prescribes a procedure, which, it is intended, will be complied with in full and without deviation.
  - (c) The term "should" prescribes a procedure, which, it is intended, will be complied with unless, after prior consideration, deviation is considered to be acceptable.

Such terms may have different meanings when used in legislation, or HSE ACoPs or guidance, and reference needs to be made to such statutory legislation or official guidance for information on legal obligations.

- 1.10 It is now widely accepted that the majority of accidents in industry generally are in some measure attributable to human as well as technical factors in the sense that improper actions by people initiated or contributed to the accidents, or people might have acted in a more appropriate manner to avert them.

It is, therefore, necessary to give proper consideration to the management of these human factors and the control of risk. To assist in this, it is recommended that due cognisance be taken of HS(G)48.

- 1.11 The primary responsibility for compliance with legal duties rests with the employer. The fact that certain employees, for example "responsible engineers", are allowed to exercise their professional judgement does not allow employers to abrogate their primary responsibilities. Employers must:
- (a) Have done everything to ensure, so far as is reasonably practicable, that there are no better protective measures that can be taken other than relying on the exercise of professional judgement by "responsible engineers".
  - (b) Have done everything to ensure, so far as is reasonably practicable, that "responsible engineers" have the knowledge, skills, training, experience and personal qualities necessary for the proper exercise of professional judgement.

- (c) Have systems and procedures in place to ensure that the exercise of professional judgement by “responsible engineers” is subject to appropriate monitoring and review.
- (d) Not require “responsible engineers” to undertake tasks which would necessitate the exercise of professional judgement that is not within their competence. There should be written procedures defining the extent to which “responsible engineers” can exercise their judgement. When “responsible engineers” are asked to undertake tasks, which deviate from this, they should refer the matter to higher review.

1.12 Notwithstanding Sub-Section 1.11, these Procedures do not attempt to make the use of any method or specification obligatory against the judgement of the responsible engineer. New and improved practices may be adopted prior to these Procedures being updated. Amendments to these Procedures will be issued when necessary and their publication will be announced in the Journal of the Institution and other publications as appropriate.

1.13 Requests for interpretation of these Procedures in relation to matters within their scope, but not precisely covered by the current text, should be addressed to Technical Services, IGEM, Charnwood Wing, Ashby Road, Loughborough, Leicester, LE11 3GH. Such requests will be considered by the relevant Committee. Any advice given by, or on behalf of, IGEM, does not imply acceptance of any liability nor does it relieve any party of any of their statutory obligation.

1.14 Some of the procedures applied within the United Kingdom (UK) gas industry differ when the maximum operating pressure (MOP) exceeds 7 bar, compared to lower pressures. These reflect experience and data gained by custom and practice within the UK over many years.

European Directives and standards use pressure breaks of 100 mbar, 5 bar and 16 bar. IGEM continues to amend its technical publications to reflect these pressure breaks. For the purposes of IGE/UP/9 Edition 2, the pressure break has been increased from 7 bar to 16 bar but there remain specific changes in certain procedures at 7 bar.

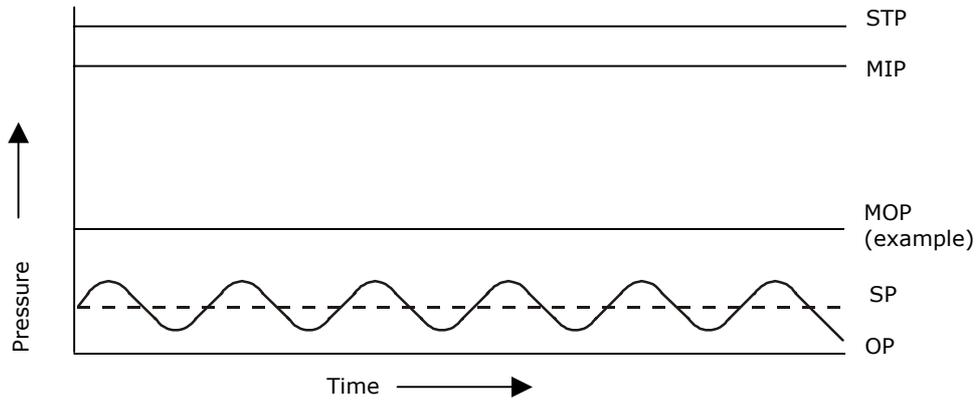
*Note: “MOP” and other new terms such as operating pressure (OP) have been introduced to reflect gas pressure terminology used in European standards. Appendix 1 defines these terms and it is possible to equate them to terms used in Edition 1. These terms will arise in all relevant IGEM technical publications in future and, possibly, in other standards.*

*Referring to Figure 1, note how OP is shown to oscillate about the set point (SP).*

*For a new system of installation pipework, the onus is on the designer to establish both the maximum incidental pressure (MIP) and MOP. For an existing system of installation pipework, the onus is on the designer/owner of the system to ensure that any increase in pressure within the system will not result in OP exceeding MOP of the system and on the gas transporter/meter asset manager (GT/MAM) to ensure that any change in their pressure regimes due to fault conditions will not jeopardise the safety of the downstream system. This involves effective communication between the GTs/MAMs and system designers/owners.*

1.15 These Utilization Procedures were published on 1st October 2004.

They may be used rather than the procedures given in IGE/UP/9 Edition 1 immediately but a lead-in period is allowed permitting the use of Edition 1 until 1st January 2005.



- STP = Strength test pressure
- MIP = Maximum incidental pressure
- OP = Operating pressure
- MOP = Maximum operating pressure
- SP = Set point of the regulator.

Note: This is extracted from IGE/TD/13 and simplified for the purposes of IGE/UP/9 Edition 2.

**FIGURE 1 - RELATIVE PRESSURE LEVELS**

## SECTION 2 : SCOPE

2.1 These Procedures cover the essential safety aspects of the engineering, start-up, operation and shut-down of NG and fuel oil fired gas turbines and associated equipment (typical arrangements are shown in Figures 2, 3 and 4). They are not intended to provide a complete specification for such equipment.

2.2 These Procedures apply to normally distributed NG (a 2<sup>nd</sup> family gas as defined in BS 1179) and oil fuels as used for firing gas turbines (such fuels as meeting BS 2869 or ASTM D396-80).

They may be used for other gases, for example "landfill gas", "mines gas", "digester gas", liquefied petroleum gas (LPG), LPG/air, refinery gases, etc. and chemical feed-stocks and highly volatile fluids such as naphtha, etc. providing due account is taken of the differences between the fuels and of any related safety issues.

*Note: Appendix 4 gives details of the constituents of typical Natural Gas.*

2.3 These Procedures apply to fixed and to mobile gas turbines for continuous and standby duties, for example in factories, power stations and gas compression systems.

Turbines used for vehicular propulsion or used offshore are not covered. However, the general principles outlined in these Procedures may be used as guidance.

2.4 These Procedures apply to:

- both single and multi-shaft turbine types  
*Note: In this context, "shaft" relates to the turbine and not to the alternator. The term "spool" is a commonly used alternative.*
- both single and multiple burner types
- turbines exhausting to heat recovery equipment, with or without supplementary and/or auxiliary fired burners, which may or may not have air supplies other than the engine exhaust. Those having independent air supplies are also considered as auxiliary fired.

2.5 These Procedures apply to gas turbines supplied directly from a "high" pressure gas supply and to those supplied via a gas compressor.

*Note 1: Procedures for gas compressors are provided in IGE/UP/6.*

*Note 2: Procedures for spark ignition and dual fuel reciprocating engines are provided in IGE/UP/3.*

2.6 Metric standard conditions apply, unless otherwise specified.

2.7 All pressures are gauge pressures, unless otherwise stated.

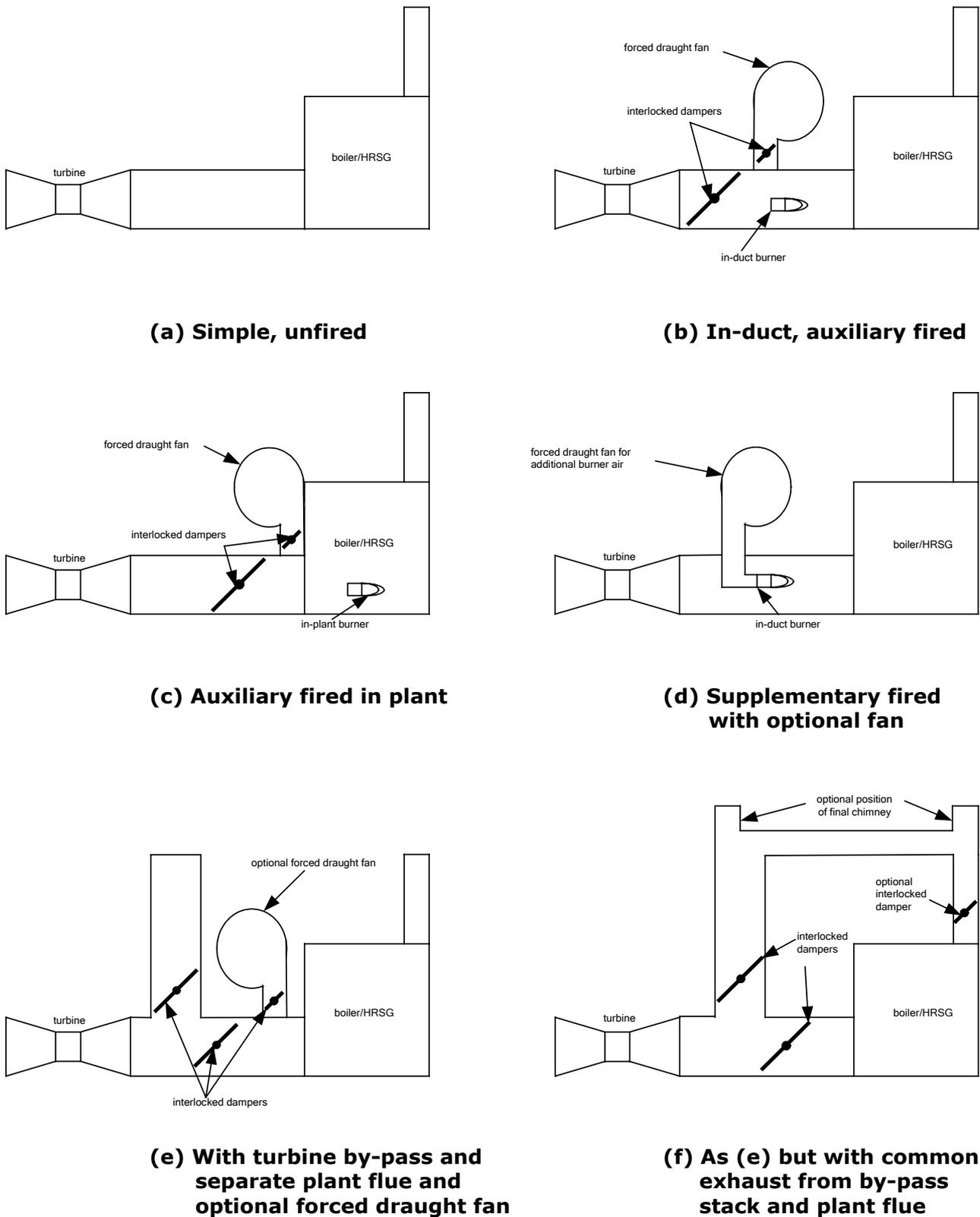
2.8 All fuel inputs are given net unless otherwise stated.

*Note: The ratio of gross to net input is, approximately, 1.1:1, 1.09:1 and 1.08:1 for appliances on Natural Gas/Towns Gas, propane and butane respectively. For the purposes of these Procedures, where gross heat inputs represent requirements of existing Standards, they are converted to net using a conversion factor of 1.1 in all cases. For example, 600 kW gross input =  $600 \div 1.1 = 545$  kW net input for Natural Gas.*

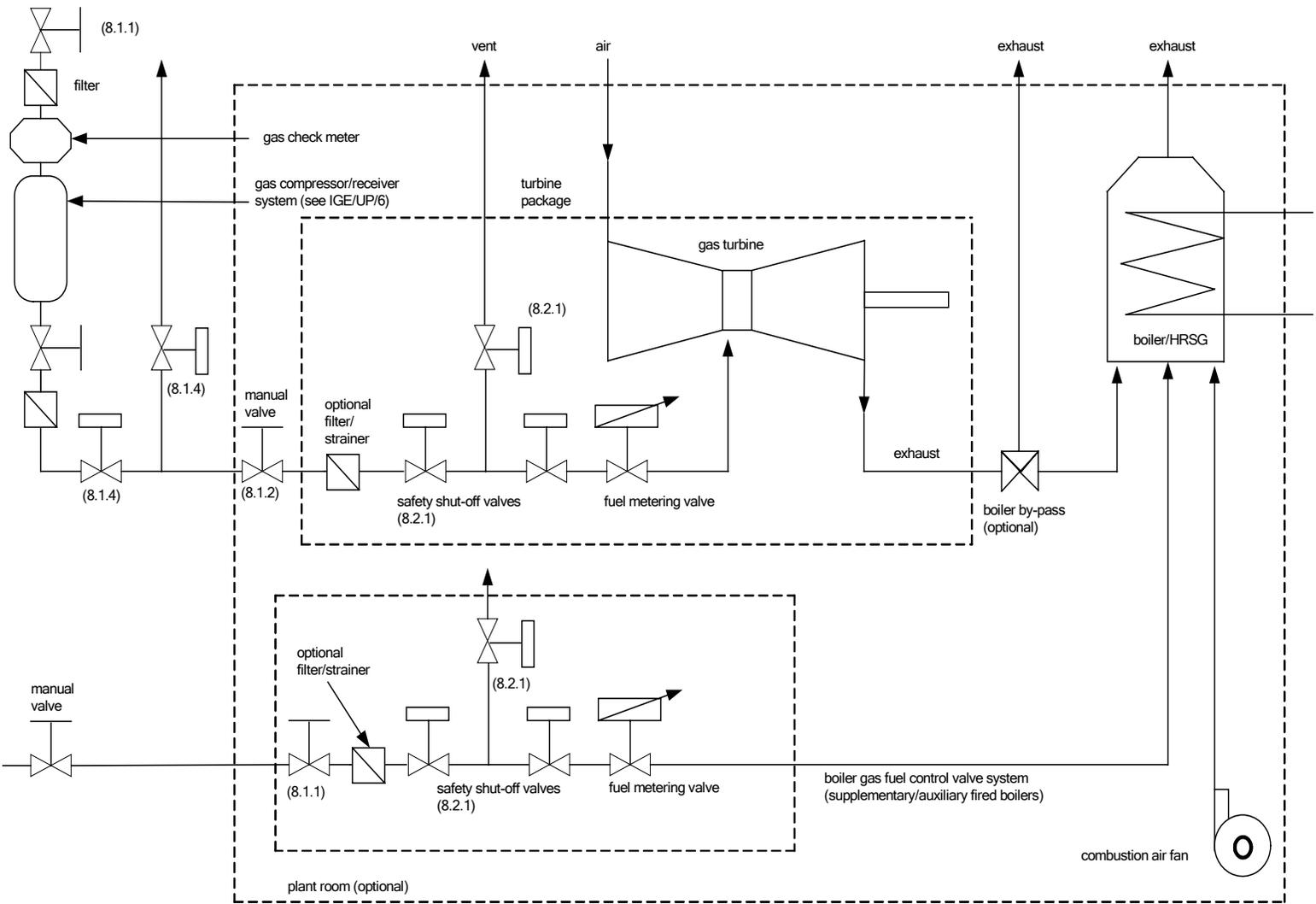
2.9 The term "turbine(s)" refers to "gas turbine(s)" throughout, unless otherwise stated.

2.10 Italicised text is informative and does not represent formal Procedures.

2.11 Appendices are informative and do not represent formal Procedures unless specifically referenced in the main sections via the prescriptive terms "should", "shall" or "must".

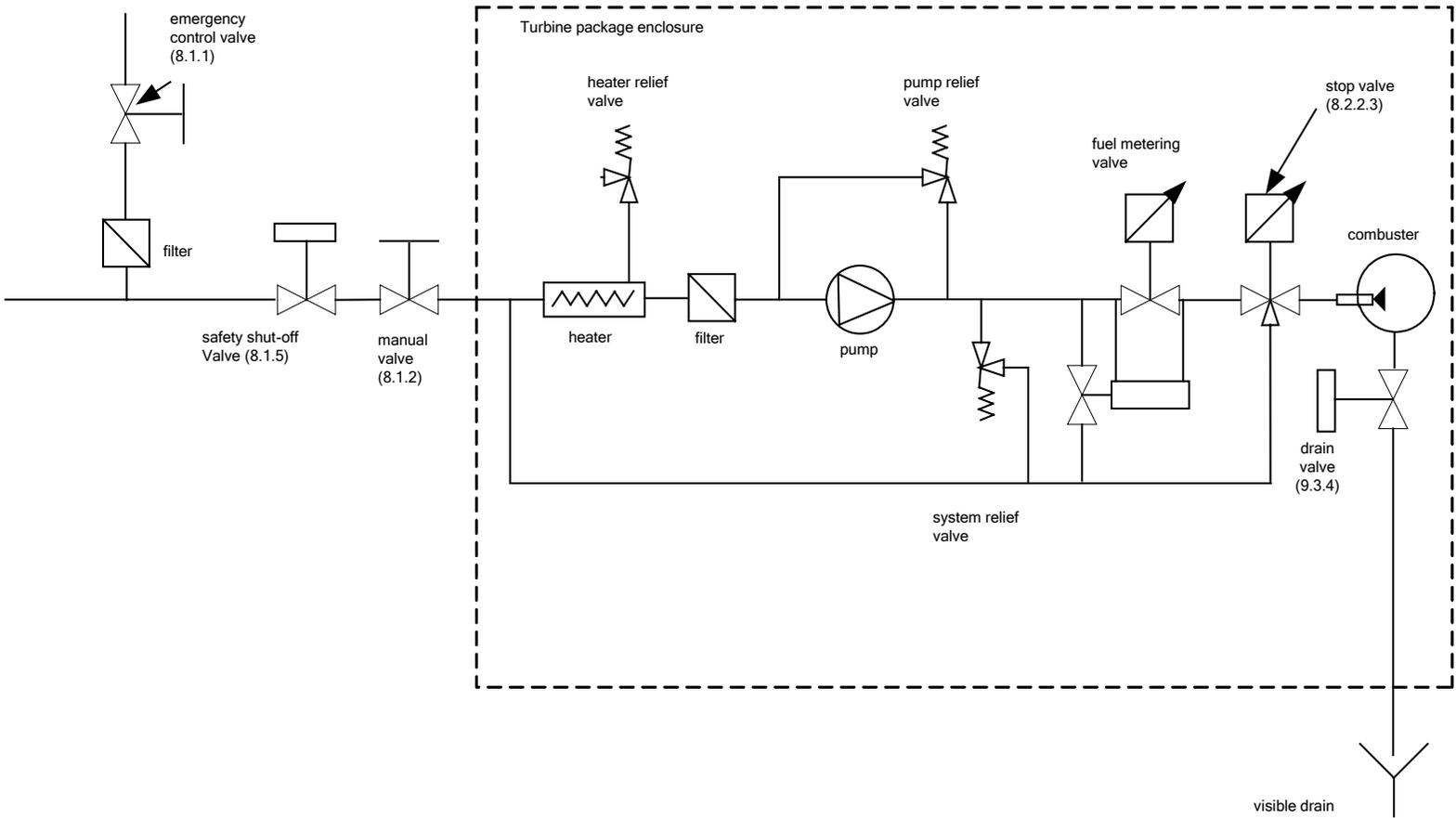


**FIGURE 2 - TYPICAL CHP INSTALLATIONS**



Note: Cross references denote related clause in these Procedures

**FIGURE 3 - SIMPLIFIED GAS FUEL SCHEMATIC FOR A TYPICAL TURBINE INSTALLATION WITH A GAS FIRED BOILER**



Note: Cross references denote related clause in these Procedures.

**FIGURE 4 - SIMPLIFIED LIQUID FUEL SYSTEM SCHEMATIC**