

***Utilization Procedures
IGE/UP/1 Edition 2
Reprint with Amendments
August 2005
Communication 1716***

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

***Strength testing, tightness testing and
direct purging of industrial and commercial
gas installations***



Institution of

gas

Engineers & Managers

**Utilization Procedures
IGE/UP/1 Edition 2
Reprint with Amendments
August 2005
Communication 1716**

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

**Strength testing, tightness testing and
direct purging of industrial and commercial
gas installations**



Price Code: T6
© The Institution of Gas Engineers and Managers
Charnwood Wing
Ashby Road
Loughborough
Leicestershire, LE11 3GH
Tel: 01509 282728
Fax: 01509 283110
Email: general@igem.org.uk

CONTENTS

SECTION	PAGE
1 Introduction	1
2 Scope	5
3 Legal and allied considerations	9
4 Strength testing	10
• 4.1 Determination of MOP and MIP	10
• 4.2 Decision whether to strength test	11
• 4.2.1 New installations and extensions	11
• 4.2.2 Existing installations	11
• 4.3 Method, pressure, duration and test criteria for strength testing	11
• 4.4 Testing separate components or sub-assemblies	12
• 4.5 Procedures – pneumatic strength testing	13
• 4.6 Procedures – hydrostatic strength testing	15
5 Tightness testing	18
• 5.1 General	19
• 5.1.1 New installations and extensions	19
• 5.1.2 Existing installations	19
• 5.1.3 Dealing with installations containing sections at differing MOP	19
• 5.1.4 Dealing with creep when testing PE	20
• 5.2 Installation volume (IV)	20
• 5.2.1 General	20
• 5.2.2 Calculations	20
• 5.3 Tightness test pressure (TTP)	22
• 5.3.1 New installations and extensions	22
• 5.3.2 Existing installations	22
• 5.4 Selection of pressure gauges	23
• 5.5 Maximum permitted leak rate (MPLR)	24
• 5.5.1 New installations and extensions	24
• 5.5.2 Existing installations	24
• 5.6 Tightness test duration (TTD)	26
• 5.7 Procedures – tightness testing	29
• 5.7.1 By-passing components	29
• 5.7.2 Ambient conditions	29
• 5.7.3 Section and valve isolation	29
• 5.7.4 Testing	30
• 5.8 Completion	33
• 5.9 Appliance connector	33
6 Direct purging	37
• 6.1 General	37
• 6.2 Planning and supervision	38
• 6.3 Site precautions	39
• 6.3.1 Warning notices and labels	39

• 6.3.2	Electrical and fire	39
• 6.3.3	Noise	39
• 6.4	Designing and positioning purge points, hoses and vent stacks	39
• 6.5	Verification of purge velocity	41
• 6.6	Identification of purge gas cylinders	41
• 6.7	Gas detectors, oxygen measuring devices and other electronic equipment	41
• 6.8	Gas appliances	41
• 6.9	Determination of the purge volume, minimum purge flow rate and purge time	41
• 6.10	Vent gas testing	43
• 6.11	Purging procedures	44
• 6.11.1	Direct purging from air to gas i.e. commissioning	44
• 6.11.2	Direct purging from gas to air i.e. de-commissioning	45
• 6.12	Dealing with meters within pipework sections	46
• 6.12.1	Replacement meter with associated pipework maintained at a positive pressure	46
• 6.12.2	Replacement meter with associated pipework not maintained at positive pressure	48
• 6.12.3	Purging a new meter	48

APPENDIX

1	Glossary, acronyms and symbols	52
• A1.1	Glossary	52
• A1.2	Acronyms	54
• A1.3	Symbols	55
• A1.4	Subscripts/Suffices/Units	55
2	References	56
• A2.1	Legislation	56
• A2.2	ACOPs and Guidance Notes	56
• A2.3	British Standards (abbreviated titles)	56
• A2.4	IGEM Procedures and Recommendations	56
• A2.5	LP Gas Association (LPGA) Codes	57
3	Combining a strength and tightness test	58
4	Maximum permitted leak rates	59
• A4.1	Maximum permitted leak rate (MPLR)	59
• A4.2	Calculating the tightness test permitted leak rate when the test medium is not operating fuel gas and/or TTP is not OP	60
5	Tightness test calculations	61
• A5.1	Basic equation	61
• A5.2	Calculation of minimum duration of tightness test (TTD)	62
• A5.3	Calculation of leak rate from a measured pressure drop over a test time	62
• A5.4	Factors influencing the tightness test	63

6	Applying corrections for changes in atmospheric pressure and/or gas temperature during a prolonged tightness test	65
	<ul style="list-style-type: none"> ● A6.1 Temperature ● A6.2 Atmospheric pressure ● A6.3 Calculating the correction for temperature or pressure change during a test 	65 66 66
7	Tightness testing PE when TTP exceeds 1 bar	68
	<ul style="list-style-type: none"> ● A7.1 Tightness test pressure (TTP) ● A7.2 Tightness test duration (TTD) ● A7.3 Allowing for creep ● A7.4 Procedures 	68 68 69 71
8	Indirect purging with nitrogen	72
9	Purging heavier than air gases – risk assessment	74
	<ul style="list-style-type: none"> ● A9.1 Flammability range ● A9.2 Density (specific gravity) ● A9.3 Heavy ends ● A9.4 Steam purging 	74 74 74 74

FIGURES

1	Relative pressure levels	2
2	Algorithm to select testing and purging standards	2
3	Typical schematic NG installations	7
4	Flowchart/decision algorithm for strength testing	17
5	Flowchart/decision algorithm for tightness testing of new installations and extensions	35
6	Flowchart/decision algorithm for tightness testing of existing installations	36
7	Flowchart for direct purging of air to gas	50
8	Flowchart for direct purging of gas to air	51

TABLES

1	Selection of the method, pressure, duration and the test criteria for strength testing	12
2	Safety distances each side of pipework for pneumatic strength testing at STP exceeding 1 bar	14
3	Installation volume (IV) of meters	20
4	Volume of 1 m length of pipe	21
5	TTP for new installations and extensions	22

6	Selection of pressure gauges (typical data)	23
7	MPLR (new installations and extensions)	24
8	MPLR (existing installations) assuming TTP = OP	26
9	Calculation of minimum TTD – all metallic pipework and all PE pipework of MOP \leq 1 bar	27
10	Factor F1 to apply when calculating minimum TTD from Table 9	27
11	Factor F3 to apply when calculating leak rate (LR)	33
12	Minimum purge flow rate and velocity with recommended minimum purge point, associated vent and flare stack dimensions	43
13	Flammable limits and safe purge end points	43
14	MPLR (energy) at OP	59
15	MPLR (volume) for typical different fuel gases and pipework locations	59
16	Viscosity of various fuel gases and $\mu_w \mu_T^{-1}$ for air or nitrogen test	60
17	Change in pressure for 1°C change in temperature	65
18	TTP for new installations and extensions for tightness testing of PE at TTP > 1 bar	68
19	Factor F2 to apply when calculating TTD for new PE pipework of MOP > 1 bar	68
20	Soak time and creep allowance for PE 80 when TTP = 3 bar	70
21	Soak time and creep allowance for PE 80 when TTP = 6 bar	70
22	Soak time and creep allowance for PE 100 when TTP = 7 bar	70
23	Soak time and creep allowance for PE 100 when TTP = 10 bar	71
24	Minimum quantity of nitrogen per 10 m length of pipe	72
25	Flammability limits and safe purge end points for inert purge	73

SECTION 1 : INTRODUCTION

This Reprint with Amendments of IGE/UP/1 Edition 2 incorporates Amendments as issued in March 2005. It also includes enhancements issued in August 2005. It is essential that owners of the original Procedures i.e. those published in 2003 (Communication 1683), update those Procedures with the March 2005 Amendments (which are available to download from IGEM's website) but it is not essential for those Procedures to be updated with the August 2005 enhancements (which are available to download from IGEM's website if required but which have no influence on the requirements contained with the Procedures).

For information, the enhancements have been made to 1.3 (Note 4, 2nd paragraph), Figure 1, 2.1 (Note 2), Section 5 (Acronyms), Note to Table 6, 5.1.2.5, 5.3.2, 5.4.2 (note to 6th bullet) 5.9.1, Figure 5, Figure 7 and Figure 8.

The Amendments have been made to Figure 2, 2.2, 2.7, 3.4, Page 10, 4.2.1, Table 1, 4.5.15, 4.6.1, 4.6.13, Figure 4, Section 5, 5.1.2.6, 5.2.2(d), 5.4.2, 5.5.2.7, 5.7.4.1(c), 5.7.4.1(d), 5.7.4.2(d), 5.7.4.2(e), 5.7.4.2(f), 5.8.2, 5.9.2, 5.9.3, 6.2.5, 6.7, 6.9.1, 6.11.2(d), 6.11.2(g), A2.3, A4.2, A7.3.2, Table 21, A8.3, Table 24, A8.9.

- 1.1 These Procedures supersede IGE/UP/1 Edition 1, Communication 1583, which is obsolete.
- 1.2 The term "tightness testing" is now used in European standards. For the purposes of these Procedures, the terms "soundness testing" (as used in IGE/UP/1 Edition 1) and "tightness testing" have an identical meaning.
- 1.3 IGE/UP/1 Edition 2 deals with all aspects of strength and tightness testing and direct purging of selected 1st, 2nd and 3rd family gases (see Sub-Section 2.2) within its wide scope. For example, for Natural Gas (NG), it covers pipework downstream of the emergency control valve (ECV) on industrial and commercial premises, of maximum operating pressure (MOP) not exceeding 16 bar.

Note 1: The principles of IGE/UP/1 Edition 2 may be applied for MOP exceeding 16 bar. However, parameters such as the duration of a test may be impracticable. Alternative test methods and criteria may be more appropriate.

In addition, the higher risks associated with testing at such higher pressures would need to be taken into account.

Note 2: Strength testing has been introduced for new pipework and extensions to ensure that pipework can withstand, with respect to integrity, the pressures it could experience under fault conditions. A result of carrying out a strength test is that the subsequent tightness test is carried out at operating pressure (OP) and not at higher pressures as was the case with Edition 1.

In some cases, the strength and tightness tests may be combined.

Note 3: More information has been included for the testing of polyethylene (PE) systems, including an appendix dealing with creep at higher pressures.

Note 4: "MOP" and other new terms such as "maximum incidental pressure" (MIP) and 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.

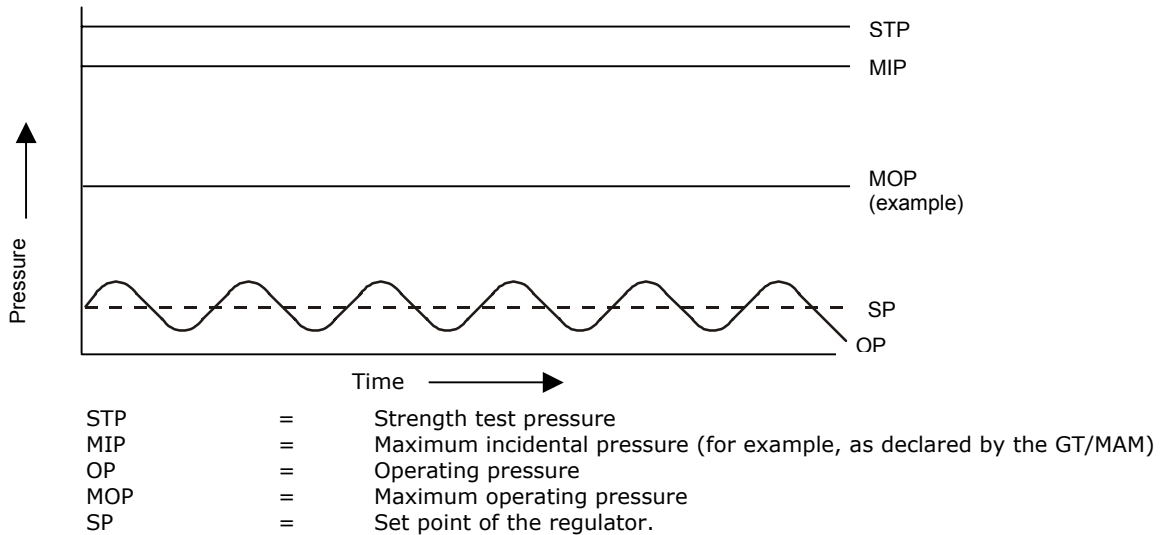
Referring to Figure 1, note how OP is shown to oscillate about the set point (SP). Note also that MOP can be declared at any value from OP upwards to a limit below MIP. The strength test pressure (STP) has to be at least 110% MIP and in many cases (see Table 1) will be greater.

For a new system of installation pipework, the onus is on the designer to establish both 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 (GT)/meter asset manager (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.

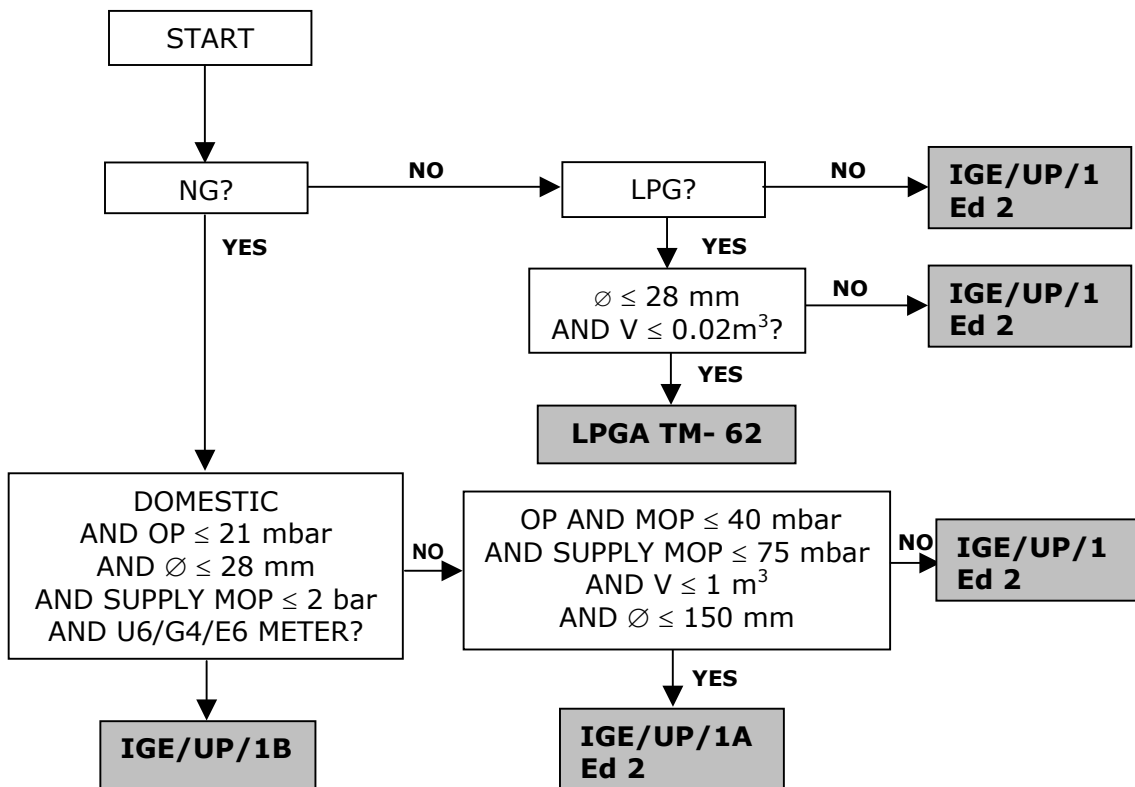
IGE/UP/1A Edition 2 deals with tightness testing and direct purging of small low pressure NG installations of volume not exceeding 1 m³ and diameter not exceeding 150 mm on industrial and commercial premises.

IGE/UP/1B deals with tightness testing and purging of domestic-sized NG installations.



Note: This is extracted from IGE/TD/13 and simplified for the purposes of IGE/UP/1 Edition 2.

FIGURE 1 - RELATIVE PRESSURE LEVELS



*≤ is less than or equal to
 Ø is nominal diameter
 V is volume.*

Note: This shows the most suitable standard for a particular situation. If IGE/UP/1A Edition 2 or IGE/UP/1B or LPGA TM-62 are not indicated, then it is essential that IGE/UP/1 Edition 2 is used. If it is preferred (it is not recommended, as it is more complex to follow) IGE/UP/1 Edition 2 can be used rather than IGE/UP/1A Edition 2 or IGE/UP/1B or LPGA TM-62. At the time of publication, neither IGE/UP/1B nor LPGA TM-62 require strenath testina.

It is necessary to check the scope of referenced standards before proceeding.

FIGURE 2 - ALGORITHM TO SELECT TESTING AND PURGING STANDARDS

LPGA TM-62 deals with tightness testing of domestic-sized liquefied petroleum gas (LPG) pipework (volume not exceeding 0.02 m³). For greater volume, IGE/UP/1 Edition 2 applies.

Figure 2 will assist in selecting the appropriate standard.

- 1.4 It has been recognised that certain activities outlined in IGE/UP/1 Edition 2 are only required for “large” installations and/or higher pressures and/or gases other than NG. By removing some of the procedures to the Appendices, procedures for the more routine activities i.e. on smaller, lower pressure NG installations, are much simpler to identify.

In addition, the Procedures attempt to highlight the process for the majority of installations by the use of black text with blue for less common situations. Typically, black text would apply for a pipework section of MOP not exceeding 100 mbar, to operate on NG, using a water gauge or low resolution electronic gauge requiring a short test where correction for temperature and pressure is not required, and not removing any meter. However, before ignoring the remaining (blue) text, the user has to ensure that none of the test parameters fall outside those indicated by the black text. Therefore, it is important to be familiar with all the contents of the book.

Green text is used for examples illustrating individual procedures.

Note: The above does not apply to diagrams, where the colours used do not follow these principles.

- 1.5 There are several reasons why it was necessary to introduce a 2nd edition of IGE/UP/1, including:

- to take into account changes in technology and application since IGE/UP/1 Edition 1 was published

Note: This is particularly important with the increasing use of PE pipe, higher pressures and developments in gauge technology.

The test procedures may have to vary for PE compared to steel pipework due to the creep properties - these variations are explained in detail.

- to simplify the decision making and calculations while retaining the same standards of safety. The basic concept of ensuring a maximum safe energy release remains
- comments had been made suggesting the layout of Edition 1 could be improved. Important data needed for each calculation was in the Appendices rather than in the main body of text. The vision for Edition 2 was a document where the user progresses through the pages logically, finding the information they need for the calculations as they go, rather than having to refer to Appendices. This principle holds for the majority of installations and circumstances (see Sub-Section 1.4). In some instances, there will be a need to use the more complex guidance given in the Appendices.

- 1.6 These Procedures make use of the terms “should”, “shall” and “must” when prescribing particular procedures. Notwithstanding Sub-Section 1.9:

- the term “must” identifies a requirement by law in Great Britain at the time of publication
- the term “shall” prescribes a procedure which, it is intended, will be complied with in full and without deviation
- 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 Health and Safety and Executive (HSE) Approved Code of Practice (ACoPs) or guidance,

and reference needs to be made to such statutory legislation or official guidance for information on legal obligations.

- 1.7 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:
- have done everything to ensure, so far as it is reasonably practicable, that “responsible engineers” have the skills, training, experience and personal qualities necessary for the proper exercise of professional judgement
 - have systems and procedures in place to ensure that the exercise of professional judgement by “responsible engineers” is subject to appropriate monitoring and review
 - 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 professional judgement. When “responsible engineers” are asked to undertake tasks which deviate from this they should refer the matter for higher review.
- 1.8 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 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 regard be paid to HS(G)48.
- 1.9 Notwithstanding Sub-Section 1.7, these Procedures do not attempt to make the use of any method or specification obligatory against the judgement of the responsible engineer. Where new and better techniques are developed and proved, they should be adopted without waiting for modification to these Procedures. 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.
- 1.10 Requests for interpretation of these Procedures in relation to matters within their scope, but not precisely covered by the current text, should be addressed in writing to Technical Services, The Institution of Gas Engineers and Managers (IGEM), Charnwood Wing, Ashby Road, Loughborough, Leicestershire, LE11 3GH and will be submitted to the relevant Committee for consideration and advice, but in the context that the final responsibility is that of the engineer concerned. If any advice is given by or on behalf of IGEM, this does not relieve the responsible engineer of any of his or her obligations.
- 1.11 These Utilization Procedures were published on 30th June 2003. They may be used rather than IGE/UP/1 Edition 1 immediately but a lead-in period is allowed, permitting the use of Edition 1 until 31st September 2003.
- 1.12 Italicised text is informative and does not represent formal Procedures.
- 1.13 Appendices are informative and do not represent formal Procedures unless specifically referenced in the main sections via the prescriptive terms “should”, “shall” or “must”.

SECTION 2 : SCOPE

2.1 These Procedures apply to any section of pipework including any appliance/plant pipework:

- for NG, from the outlet of the ECV (fitted on the end of the gas service that is owned by the GT)
Note: This does not include a gas service (see IGE/TD/4).
- for LPG, from the outlet of the bulk storage vessel or cylinder valve (as appropriate)
Note: This does not include a gas service (see the Gas Safety (Installation and Use) Regulations (GS(I&U)R)).
- for other gases (see Sub-Section 2.2) on customers' premises, from the outlet of the isolation point from a distribution system

Note 1: This includes any primary or secondary meter installation (see Appendix 1).

Note 2: These Procedures may be applied for risers and laterals.

Note 3: The diversity of industrial and commercial gas installations is such that it is inappropriate to provide detailed guidelines for all types of installation covered by the scope of these Procedures. It is recognised that special circumstances may occur, on an installation, for which some of these Procedures cannot be applied. In such a case, for example where the volume of pipework cannot be readily calculated, whether testing or purging, a specific testing or purging procedure needs to be developed that has a comparable sensitivity and level of safety. The procedure needs to be developed by personnel of adequate competency and experience.

2.2 These Procedures cover strength testing and tightness testing, and direct purging, of pipework containing NG, Butane, Propane, LPG/Air (SNG and SMG) and Coal Gas.

Note 1: GS(I&U)R (see Section 3) define "gas" to include 1st, 2nd and 3rd family gases as well as other gases. The principles of IGE/UP/1 Edition 2 may be used for gases other than those above but suitable adjustments to stated parameters and procedures will need to be considered by a competent person.

Note 2: IGE/SR/22 deals with purging of certain other fuel gases not listed above.

Note 3: See Sub-Section 2.7 regarding the principles adopted for the detection of leakage.

2.3 These Procedures cover pipework of MOP not exceeding 16 bar.

Note: Provided suitable precautions are taken, and subject to a risk assessment, these Procedures may be used as a basis of a written procedure for testing of pipework of MOP exceeding 16 bar.

The scope does not cover installations where the upstream system MOP exceeds 75 mbar without a meter inlet valve (MIV) fitted between the regulator/PRI and any meter.

Note : The principles of IGE/UP/1 Edition 2 may readily be applied for such installations.

2.4 These Procedures apply to strength testing and/or tightness testing pipework of any diameter in the following circumstances:

- new pipework
- alteration to, replacement of, re-use of, or upgrading (for example increasing OP) existing pipework
- new extensions to existing pipework
- prior to any work (see Appendix 1) on existing pipework
- where there is a known or suspected gas leak in pipework
- where there has been a complete loss of pressure for any reason

Note: The closure of a valve, for example the ECV, can result in a complete loss of pressure which necessitates tightness testing and purging before resumption of supply.

- routine testing of existing pipework

- immediately before purging pipework (except when taking pipework permanently out of service).

Note: If considering strength testing of existing pipework, refer to clause 4.2.2.

Typical schematic NG installations are shown in Figure 3 which illustrates the differences between new and existing pipework and meters and the implications for strength and/or tightness testing.

2.5 These Procedures apply to direct purging in the following circumstances:





- new pipework
- alteration to, replacement of or re-use of, existing pipework
- new extensions to existing pipework
- where there has been a complete loss of pressure for any reason
Note: The closure of a valve, for example the ECV, can result in a complete loss of pressure which necessitates tightness testing and purging before resumption of supply.
- where there is the possibility of air being present in pipework
- where pipework is to be taken out of service temporarily or permanently.

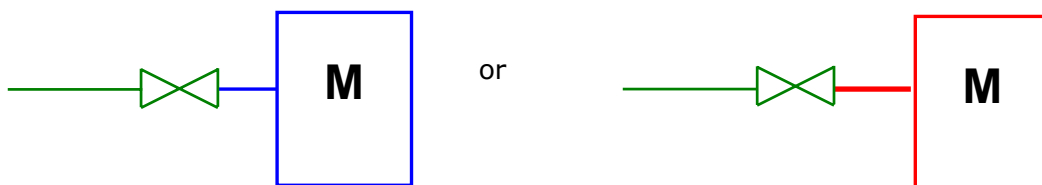
The Procedures apply when purging pipework of diameter not exceeding 150 mm of any length, and for pipework of diameter exceeding 150 mm limited to the maximum lengths given in relevant tables.

2.6 All pressures quoted are gauge pressures unless otherwise stated.

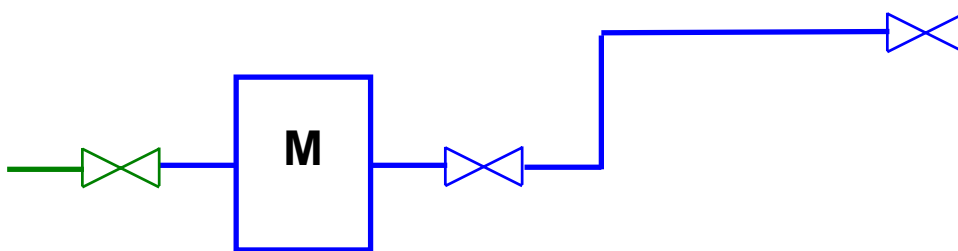
2.7 IGE/UP/1 Edition 2 adopts the concept of “gauge readable movement (GRM)”. When using a water gauge, it may be possible to reduce the duration of tests for new installations and extensions by adopting the concept of “no perceptible movement”. This will lower test times in many cases but has to be subject to a thorough analysis, by the responsible person, of the complex fluid mechanics and mathematics involved.

KEY

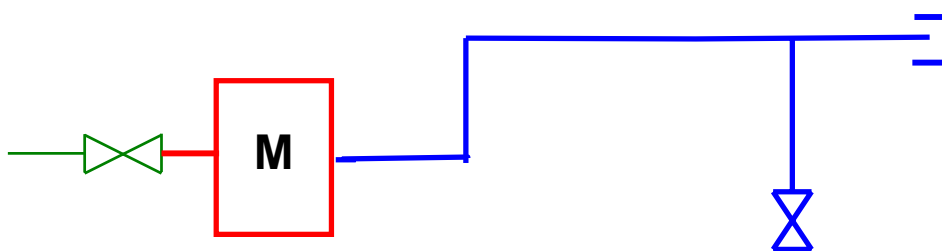
-  Existing and test is NOT required
-  New
-  Existing
-  Capped end



CASE 1: NEW OR EXISTING METER FITTED WITH NO OUTLET PIPEWORK CONNECTED

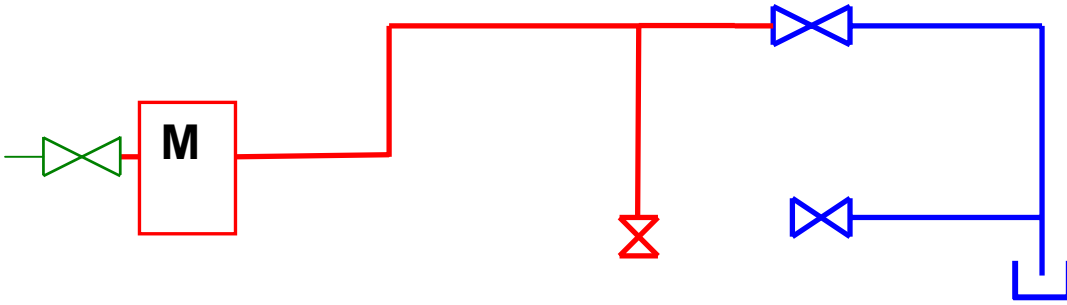


CASE 2: NEW METER AND NEW PIPEWORK



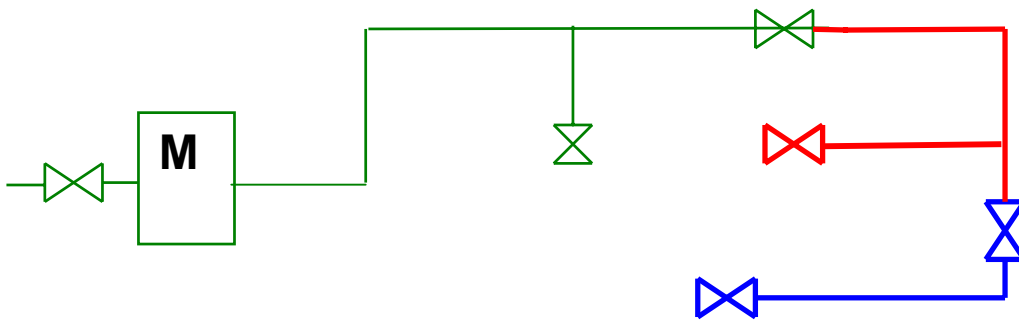
CASE 3: EXISTING METER AND NEW PIPEWORK

FIGURE 3 - TYPICAL SCHEMATIC NG INSTALLATIONS



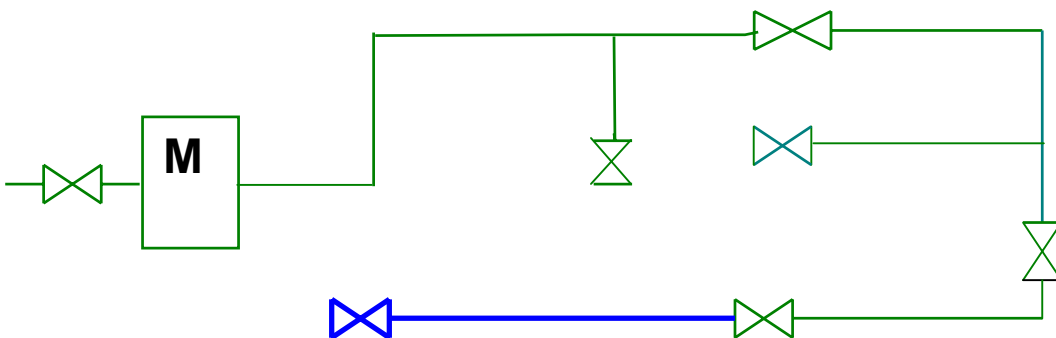
*New section of pipework.
Existing meter and pipework.
No valve was fitted at end of leg to be extended, so all existing pipework is de-pressurised to allow new valves and pipework to be installed.*

CASE 4: EXISTING METER AND PIPEWORK. AN EXTENSION TO THE PIPEWORK IS ADDED



*New section of pipework.
No valve fitted at end of leg to be extended, but the last section of existing pipework can be isolated from the rest.
Only the existing last section needs to be depressurised to allow new valve and pipework to be installed.*

CASE 5: EXISTING METER AND PIPEWORK. AN EXTENSION WAS ADDED THEN, AT A LATER DATE, A FURTHER EXTENSION IS ADDED



*New section of pipework.
A valve is fitted at end of the leg to be extended so new pipework can be added without de-pressurising the existing installation.*

CASE 6: AS CASE 5 THEN, AT A LATER DATE, A FINAL EXTENSION IS ADDED

FIGURE 3 (cont) - TYPICAL SCHEMATIC NG INSTALLATIONS