IGEM/GL/2
Communication XXXX

Founded 1863
Royal Charter 1929
Patron
Her Majesty the Queen

Planning of gas transmission and storage systems operating at pressures exceeding 16 bar

DRAFT FOR COMMENT

1 This draft Standard IGEM/GL/2 Edition 3 has been prepared by a Panel under the chairmanship of Paul Lawrence.

2 This Draft for Comment is presented to Industry for comments which are required by 29th June 2017, and in accordance with the attached comment form.

3 This is a draft document and should not be regarded or used as a fully approved and published Standard. It is anticipated that amendments will be made prior to publication.

Tom Bancroft
IGEM
IGEM House
26-28 High Street
Kegworth
Derbyshire, DE74 2DA
Tel: 0844 375 4436
Fax: 01509 678188
Email: thomas@igem.org.uk

IGEM
Institution of
Gas Engineers & Managers

Attached is the Draft for Comment of IGEM/GL/2 Edition 3 and the associated comment form.

We wish to make it as easy as possible for those of you representing industry bodies to issue the draft to your Members. You can either forward this email with attachment complete or forward it without the attachment and invite them to visit our website via where the Draft and http://www.igem.org.uk/technical-standards/standards-development/drafts-for-comment.aspx Comment Form are posted.

Organisations to which this Draft has been circulated:

ORG	**REP**
AIGT	JOHN BARRATT
Association of Register Gas Installers	TONY BRUNTON
BSI/GSE/30	GAVIN JONES
BPEC	Awaiting contact
BRITISH GAS	RICHARD HARPER
CAPITA	DAVID J SMITH
CIBSE	HYWEL DAVIES
CIPHE	TONI-LOUISE MATTHEWS
CITB	RAY EWART
DNO COLLAB FORUM	CHRIS CLARKE
EI	MARK SCANLON
ENA	CLARE CANTLE-JONES
EUSKILLS	IAN MOSS
GISG	MIKE LEPPARD
GAS SAFE REGISTER	JOHN STIRLING
HSE	ANDREW COX
HSE	MARGARET GREGSON
HSENI	JULIAN RICHMOND
B&ES (was HVCA)	RUSSELL MOTT
ICOM	ROSS ANDERSON
*Large Business Forum	TREVOR SMALLPEICE
MAMCoP Board	KEAVY LARKIN
NATIONAL GRID	HILARY BUXTON
NGN	MARTIN ALDERSON
NICEIC	CHRIS LONG
OFGEM	STEVE BROWN
Organisation of professional gas operatives	WIM RUTJES
PIG	CHERYL BURGESS
EUA (was SBGI)	STEVEN SUTTON
SGN	PAUL DENNIFF
UKLPG	RICHARD HAKEEM
WALES & WEST	CHRIS CLARKE
YPN	DAVID MCLEOD
<u>IGEM</u>	
COUNCIL	LESLEY ECOB
SPC	LESLEY ECOB
MEMB C	ROSS MCART
AUDIT C	CHRIS BIELBY
TCC	CHRIS GORMAN
GMC	VIC TUFFEN

ORG	REP
GUC	RICHARD MARROW
Industrial Affiliates	KEVIN RANSOM

IGEM
Institution of
Gas Engineers & Managers

IGEM/GL/2 Edition 3
Communication XXXX

Planning of gas transmission and storage systems operating at pressures exceeding 16 bar

Draft for comment

Founded 1863
Royal Charter 1929
Patron: Her Majesty the Queen

Institution of
Gas Engineers & Managers

IGEM/GL/2 Edition 3
Communication XXXX

Planning of gas transmission and storage systems operating at pressures exceeding 16 bar

Draft for comment

Price Code: C10H

IGEM House
26-28 High Street
Kegworth
Derbyshire, DE74 2DA
Tel: 0844 375 4436
Fax: 01509 678198
Email: general@igem.org.uk

ISBN 978 1 905903 XX X
ISSN 0367 7850
Published by the Institution of Gas Engineers and Managers

Previous Publications:
Communication XXXX (19XX) – 1st Edition
Communication 1927 (2007) – 2nd Edition

For information on other IGEM Standards please visit our website, www.igem.org.uk

CONTENTS

APPENDIX

FIGURES

SECTION 1 : INTRODUCTION

1.1 This Standard supersedes IGE/GL/2 Edition 2, Communication 1727, which is obsolete.

1.2 This Standard is part of a series of Institution of Gas Engineers and Managers (IGEM) publications providing requirements and guidance to support the Gas Safety (Management) Regulations (GS(M)R) and the Pipelines Safety Regulations (PSR). It has been drafted by an IGEM Panel appointed by IGEM's Gas Transmission and Distribution Committee, subsequently approved by that Committee and has been approved by IGEM's Technical Coordinating Committee on behalf of Council.

1.3 Requirements are provided for the planning of transmission and distribution systems so that as far as possible, continuity of gas supply is maintained to consumers on the system, and at a sufficient pressure that their appliances continue to operate at all times, unless load shedding has been initiated (through commercial agreements or in an emergency situation).

1.4 The relevant parts of this Standard may be cited in the gas transporter's (GT's) Safety Case, but the Health and Safety Executive (HSE) will need to satisfy itself that the parts are appropriate and have been properly applied in each case.

1.5 Terms such as Maximum Operating Pressure (MOP), and "operating pressure" (OP) reflect gas pressure terminology used in European standards. These terms will arise in all relevant IGEM Standards and possibly in other standards.

1.6 This Standard makes use of the terms "must", "shall" and "should" when prescribing particular procedures. Notwithstanding clause 1.9:

- the term "must" identifies a requirement by law in Great Britain (GB) at the time of publication
- the terms "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 HSE Approved Codes 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 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. People who initiated actions that caused or contributed to accidents might have acted in a more appropriate manner to prevent them.

To assist in the control of risk and proper management of these human factors, due regard should be taken of HSG48 and HSG65.

1.8 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.

1.9 Notwithstanding clause 1.7, this Standard does 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 this Standard being updated. Amendments to this Standard 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 this Standard in relation to matters within its scope but not precisely covered by the current text should be either:

- addressed to Technical Services, IGEM, IGEM House, High Street, Kegworth, Derbyshire, DE74 2DA; or
- emailed to technical@igem.org.uk.

These 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 imply acceptance of liability for the consequences and does not relieve the responsible engineer of any of his or her obligations.

SECTION 2 : SCOPE

2.1 This Standard contains advice on the planning and design of Natural Gas (NG) systems and any associated storage (hereafter referred to as "systems") of MOP exceeding 16 bar. The Standard does not encompass the availability of gas entering the system. Its purpose is to ensure that there is sufficient transportation capability in the system.

Note: Compliance with this Standard ensures that as far as is reasonably practicable, a system is able to maintain security of supply under the most onerous combinations of flow and pressure on the system, and that adequate arrangements are established to minimise the risk of a supply emergency (see Appendix 3).

2.2 This Standard includes the requirements for information exchange between different GTs and Network owners at system boundaries, to ensure the continuity of gas flow.

2.3 This Standard is intended to be used by persons involved in the planning of new systems and for the ongoing monitoring and reinforcement of existing systems, where appropriate.

2.4 This Standard applies to the planning of new systems and replacement of, or extension to, servicing, maintenance of existing systems. It is not retrospective, but it is recommended that existing systems be modified to meet this Standard, when appropriate.

Note: Standards rarely cover the retrospective issue of existing installations. They can, however, set a basis for consideration of performance upon which a risk assessment can be developed.

2.5 This Standard does not cover the physical design, construction, operation and maintenance of systems, or any routing and environmental considerations covered by legislation other than that referred to above. Refer to IGEM/TD/1 for further information on these requirements.

2.6 All pressures are gauge pressures unless otherwise stated.

2.7 Italicised text is informative and does not represent formal requirements.

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

SECTION 3 : LEGISLATION AND STANDARDS

This Standard is set out against a background of Legislation in force in GB at the time of publication (see Appendix 1). The devolution of power to the Scottish, Welsh and Northern Ireland Assemblies means that there may be variations to the Legislation described below for each of them and consideration of their particular requirements must be made. Similar considerations are likely to apply in other countries and reference to appropriate national Legislation will be necessary.

All relevant Legislation must be complied with and relevant ACoPs, official guidance Notes and referenced codes, standards, etc. shall be taken into account.

Care shall be taken to ensure that the latest editions of the relevant documents are used.

Appendix 1 lists legislation, guidance notes, standards etc. which are identified within this Standard as well as further items of legislation that may be applicable. Where standards are quoted, equivalent national or international standards etc. equally may be appropriate. Unless otherwise stated, the latest version of the referenced document should be used.

3.1 HEALTH AND SAFETY AT WORK ETC. ACT (HSWA)

HSWA applies to all persons involved with work activities, including employers, the self-employed, employees, designers, manufacturers, suppliers etc. as well as the owners of premises. It places general duties on such people to ensure, so far as is reasonably practicable, the health, safety and welfare of employees and the health and safety of other persons such as members of the public who may be affected by the work activity.

All persons engaged in the design, construction, commissioning, operation, testing, servicing, maintenance, alteration, disconnection and decommissioning of pipework must be competent to carry out such work. Competency is achieved by an appropriate combination of education, training, practical experience and exhibiting appropriate behaviours.

3.2 GAS SAFETY (MANAGEMENT) REGULATIONS (GS(M)R)

3.2.1 GS(M)R place specific duties on GTs, or their emergency service providers (ESPs), for dealing with gas escapes from pipes on their networks. Their primary duty is to make the situation safe. They are responsible not only for dealing with escapes from their own pipes, but also for dealing with leaks from gas fittings supplied with gas from pipes on their network. Action on discovery of gas leaking on consumer's premises is limited to turning off the gas supply at the emergency control valve (ECV) and advising the consumer to repair the source of the leaking by engaging a Gas Safe registered engineer to attend site and repair the leak if appropriate. In GS(M)R, the term "gas escapes" includes leaks or emissions of carbon monoxide (CO) from gas fittings.

Note: For further guidance on dealing with gas escapes see IGEM/SR/29.

3.2.2 GS(M)R place specific duties on GTs to set out in their Safety Case the arrangements the consumer has to put in place to prevent their plant or equipment producing a pressure of less than one atmosphere, or injecting extraneous gases (including air) into the GT's network. This may include the need to publicise that such equipment is to be fitted with anti-fluctuators or non-return valves.

3.2.3 Under certain circumstances, including where a "Landlord" distributes gas from the outlet of a bulk meter to consumers in a multi occupied building, a person may be deemed to be conveying gas in a network such that they have responsibilities under GS(M)R.

3.3 Pipelines Safety Regulations (PSR)

3.3.1 These Regulations apply to all pipelines, both onshore and offshore, but excluding pipelines that are:

- wholly within premises occupied by a single undertaking
- contained wholly within caravan sites
- contained wholly within land which constitutes a railway asset.

3.3.2 Generally, the Regulations place emphasis on pipeline integrity and have specific additional requirements for major accident hazard pipelines (MAHP) of MOP exceeding 7 bar, including the production and regular updating of a Major Accident Prevention Document (MAPD) and the requirement for the local authority to produce and revise emergency plans. The Regulations complement GS(M)R and include the:

- definition of a pipeline
- general duties for all pipelines
- need for cooperation between pipeline operators
- arrangements to prevent damage to pipelines
- description of a dangerous fluid
- notification requirements
- preparation and maintenance of a MAPD
- arrangements for emergency plans and procedures
- description of the pipeline safety management system.

Note: Notification of MAHPs enables HSE to set land use planning zones around the pipeline and associated above ground installations (AGIs). HSE provides each local planning authority along the pipeline route with 3 zone distances which are used to generate HSE's land-use planning advice in the vicinity of the pipeline. The requirement for notification applies to all pipelines operating at above 7 bar, including Polyethylene.

3.4 PRESSURE SYSTEMS SAFETY REGULATIONS (PSSR)

3.4.1 PSSR impose duties on designers, importers, suppliers, installers and users or owners to ensure that pressure systems do not give rise to danger. This is done by the correct design installation and maintenance, provision of information, operation within safe operating limits (SOL) and where applicable, examination in accordance with a written scheme of examination drawn up or approved by a competent person (as defined by PSSR).

Guidance on the selection of competent persons is given in L122. Users (or owners) of pressure systems are free to select any competent person they wish, but they have to take all reasonable steps to ensure that the competent person selected can actually demonstrate competence i.e. the necessary breadth of knowledge, experience and independence. In judging levels of competence, users or owners may wish to know that a national accreditation scheme has been developed by the United Kingdom Accreditation Service (UKAS) for bodies that provide services of this nature.

3.4.2 A pressure system would include bulk storage tanks, pressure vessels, pipework and protective devices. Once the pressure in the pipework drops below 500 mbar, and the user/owner can show clear evidence that the system does not contain, and is not liable to contain, a relevant fluid under foreseeable operating conditions, then that part of the system is no longer covered by PSSR. This is likely to be the case after the pressure relief valve associated with a pressure reducing valve which takes the pressure to below 500 mbar, for example at the entry to a building.

Note: A filter housing is considered to be a pressure vessel.

Note the special requirements placed on protective devices in such systems (see para 110b of L122). Pipelines and their protective devices where the pressure does not exceed 2 bar are exempt from PSSR (see Schedule 1 part 1 item 5 of L122).

More information is available in L122 and in the HSE free leaflets INDG 261 and INDG 178.

3.4.3 Inspection is the process that ensures that the installation is suitable for further operation within the design or performance limits specified by the designer or competent person.

3.4.4 It is required to determine whether an installation is within the scope of PSSR and if so, safe operating limits SOLs are to be specified and written schemes of examinations made available prior to commissioning.

SECTION 4 : OVERVIEW AND PLANNING PROCESS

4.1 OVERVIEW

Planning a system involves designing a suitable pipeline system to meet estimated forecasted consumer demands, given the consideration of limitations ~~of~~ any upstream system capability; this can include capacity, storage and pressure availability.

This principle is true for a single pipe or for a fully integrated system, when reinforcing or extending an existing system, and planning a new system.

4.1.1 Basic planning assumptions, for example input and output volumes and pressures, and the planning horizon, should be established from the outset (see Appendix 3).

Note 1: Normally, a period of 10 years provides a fair balance between the risk of over investment in plant and equipment, due to uncertainties in forecasting load growth or decline and the additional cost of replacing and increasing/decreasing equipment size at a later date. Sometimes, it may be justifiable to extend the planning horizon beyond 10 years, ~~say~~ for example up to 20 years, or to plan for load growth or decline. through to estimates of saturation. For example the inlet and outlet pipework of a pressure regulating installation (PRI) can be costly to replace and thus providing sufficient capacity at installation may be justified.

Note 2: Planning assumptions to take into consideration of the impact of renewable sources.

4.1.2 Planning of a system should be based on:

- Maintaining flow into the system, as closely as possible at a constant flow throughout the day, irrespective of variations in consumer demand or
- matching the flow out of the system i.e. the daily fluctuation in demand (known as diurnal swing)
- a combination of the above depending on the dynamics of the system and the demands.

Where significant diurnal swing occurs, planning should take account of diurnal storage as well as transmission capacity.

4.1.3 The size of pipe and associated equipment should be determined. This may be a simple matter of applying a suitable pressure drop equation to a single pipe. However for more complicated systems a suitable network analysis computer program may be needed, particularly if high diurnal swing is encountered (see Section 4).

4.2 PLANNING PROCESS

4.2.1 Any system should be planned to meet the 1 in 20 planning criterion for all years up to the planning horizon which is normally 10 years.

Note 1: This is achieved by taking into account the optimum combination of pipeline capability and diurnal storage facilities.

Note 2: Planning criteria other than 1 in 20 may be used but in such cases HSE will request justification within a Safety Case under GS(M)R.

4.2.2 The process should reflect that a significant lead time for construction projects from conception to commissioning may be necessary, in order to carry out planning and to complete statutory/consultative requirements and construction. Plans for the system should be clearly established. The system capacity and proposed construction programme should be reviewed annually or more frequently if significant development is predicted, for example for a supply to a proposed power station.

Data should be sourced to understand the growth/ decline in demand across all market sectors to reflect anticipated changes for gas usage on the system. Where the data cannot be broken down by market sector, the changes to demand should be shared proportionally across the system.

4.2.3 Demand levels and profiles based on the latest available data, should be updated annually and incorporated in the network analysis model.

4.2.4 Consideration should be given to the requirement for and availability of diurnal and/or peak shaving/seasonal storage.

4.2.5 As far as possible any planning model should reflect the way in which the system is or will be operated. Any planning model should be validated against actual conditions.

SECTION 5: NETWORK ANALYSIS COMPUTER MODELLING TECHNIQUES

5.1 GENERAL

5.1.1 For integrated pipe systems and those that incorporate storage provision or include more than one compressor station, a computer based network analysis model representing the system should be used. However for simple low complexity pipe systems a model computer based network analysis program may be unnecessary.

5.1.2 For relatively constant pressure systems steady state network analysis is acceptable. Where a variable supply pressure is anticipated and/or diurnal storage is required from the pipe system, system planning should normally involve using a transient network analysis computer model.

5.1.3 The planning process should identify interruptible loads, which will have to be controlled by the operator of the system so that the security of supply through the system can be assured.

Note 1: Commercial requirements may change the way in which interruptible load is evaluated and contracted.

5.1.4 All network analysis model parameters etc. should be recorded and the records maintained.

5.2 NETWORK ANALYSIS MODEL PARAMETERS

5.2.1 Physical properties of gas

The model should be set up to reflect the actual condition of the gas being transported under the planning conditions. Thus the physical properties of the gas such as specific gravity, Joule Thompson coefficient, calorific value, compressibility and viscosity should be established. Reference should be made to gas quality specifications.

5.2.2 Temperature

5.2.2.1 Ground temperature should be established from records made at 1 m depth, at times of peak demand and a yearly profile if significant.

5.2.2.2 Gas temperatures from upstream systems should be modelled as accurately as possible. These should be provided by the upstream GT or producer.

5.2.3 Flow formula

A suitable flow formula should be selected which takes account of the system being modelled and the conditions under which it will operate.

5.2.4 Flow friction factors

The internal condition of transmission pipelines is assumed to be smooth, circular and free of debris. Generally the number of fittings on transmission pipelines is extremely low and efficiencies will therefore be high. Where possible tests should be carried out on pipelines to determine efficiencies.

Note: The efficiency factors used for older or small diameter 'unpiggable' pipelines may need to be adjusted to correspond with actual experience (see IGEM/TD/1).

5.3 SYSTEM COMPONENTS

5.3.1 **Pipe data**

5.3.1.1 The network analysis model should include all pipes operating at a pressure above 16 bar. Other pipes which have some impact on the above 16 bar system, or are considered for other reasons to be significant should also be included in the model.

Note: Some rationalisation may be undertaken to avoid short lengths of pipework or to simplify complicated connections or junctions.

Restrictions such as smaller diameter connections should be adequately simulated.

Pipelines that operate at 16 bar and below should be modelled in accordance with this Standard if their operation contributes towards the provision of linepack within the system. Reference should also be made to IGE/GL/1.

5.3.1.2 Dimensional accuracy is important. Particular care should be taken to ensure that the exact internal diameter is obtained, recognising that this will depend on the pipe specification.

5.3.2 **PRI modelling**

Some systems to be modelled may include more than one pressure level. The behaviour of those PRIs contained wholly within the system should be modelled as accurately as possible. For critical installations this may involve the simulation of individual streams with constraints on flow, inlet and outlet pressures and predicted minimum pressure differential at various flow rates.

5.3.3 **Compressor modelling**

Compressor operating parameters should be included in the network analysis model to permit accurate compressor simulation.

5.3.4 **Demand modelling**

Demand is sourced from the downstream system and the directly connected loads. Appropriate demand tags should be used in order that suitable demand profiles and/or load growth can be applied.

Note: ~~These~~ Directly connected loads could be a mixture of contractual obligation, and unconstrained consumer demands and accurately recorded flow information.

5.3.4.1 For downstream systems, the total demand for the day or period under investigation should be split in the ratio of demands imposed on each point, as required by the system downstream. Due to greater diversity on lower pressure systems, summed demands will probably exceed the total system demand. Demands should be scaled to the overall total appropriate to the day or period being modelled and applied to each demand point.

5.3.5 **Demand profiles**

5.3.5.1 Where possible, loads should reflect the different demand profiles informed by usage patterns.

Separate profiles should be established for storage and specific contracted demands.

System demand profile should be representative of the total network diurnal swing.

5.3.6 **Diurnal storage simulation**

Operation of storage installations may be simulated by a profile which reflects it's use. Filling/emptying rates are determined by the capacity and operating policy for that facility.

5.3.7 **Storage to and from the supplying system**

Storage drawn from upstream systems should normally, be taken as an increased rate above the average during times of high diurnal demand and as a decreased rate at times of low demand (usually at night).

Where necessary excess diurnal storage should be modelled to be transferred to the upstream system. For example on a large integrated transmission system, a storage deficit in one part of the downstream system could be compensated for by using a surplus from another part of the downstream system.

5.4 SIMULATIONS

5.4.1 Transient analyses should be carried out over a time period sufficient to establish stability of results.

5.4.2 Transient analyses should be carried out at suitable time intervals.

Note: An appropriate time interval is normally adequate for most purposes, for example 10 minutes etc. Some circumstances may necessitate shorter time intervals taken over a relatively small period, for example rapidly changing consumer loads or changes brought about by loss of plant. Similarly dynamic situations may be covered by longer time intervals.

5.4.3 Periods longer than one day may be required to simulate a particular planning condition properly.

5.5 SYSTEM VALIDATION

5.5.1 The network analysis model used for future planning should be validated against the actual operation of the system, as indicated by flow and pressure measurements.

5.5.2 The network analysis model should be set up to simulate the actual demand conditions and the results should be compared with the pressures and flows recorded.

5.5.3 Simulated results are sensitive to modelled changes in flows Simulated and actual recorded pressure and flows should be sufficiently well matched in line with the organisations procedures.

Note: As a guide the model is valid if the broad pattern of pressure distribution from the model is consistent with that experienced in practice and if the majority of individual modelled pressures are within 5% of actual pressures at the time of maximum pressure loss. The process of establishing the actual demands and associated profiles is the most likely source of any error.

5.5.4 If even after critical examination of all possibilities validation is not achieved, it may be appropriate to consider using different pipe efficiency factors in some parts of the system. However any new factors used should be within reasonable tolerance of those expected for the size, material and history of the pipeline in question.

5.6 SYSTEM REINFORCEMENT

Reinforcement of the system for extra transmission or storage capacity may be accomplished by a variety of means which may include:

- additional pipe length
- additional compression
- load management
- uprating pressure or increasing operating range
- upgrading or new sources
- additional storage facilities.

All options should be assessed. Following implementation of these options the model should be revalidated.

SECTION 6: CONNECTIONS AND INTERFACES

This section describes the arrangements and agreements required between different GTs and/or those exempt from a GT license agreement (hereafter referred to as 'parties' in this Section), at system boundaries to ensure continuity of gas flow. System interfaces may be either controlled or uncontrolled.

6.1 GENERAL

6.1.1 The system connection should be designed in accordance with appropriate current standards and in line with the agreement of the parties.

6.1.2 The parties should liaise regarding the SOLs of both the upstream and downstream systems.

Note: Attention is drawn to the requirements of relevant legislation, such as PSSR and PSR.

6.1.3 The parties shall liaise on pressure and volume profile data and agree on the anticipated variation of these parameters at the interface point, following connection of the proposed new load.

6.1.4 The provision of any metering equipment at the system interface should be determined by agreement between the parties. Whether or not metering is permanently installed, consideration should be given to providing a suitable means for recording gas flow and pressure for analysis purposes. Data obtained should be made accessible to the parties involved.

6.2 REMOTE CONTROLLED INTERFACES

6.2.1 Pressure regulating apparatus, isolation valves and control equipment should comply with IGEM/TD/13.

6.2.2 Allocation of responsibility for operation and maintenance of interface equipment should be agreed between the parties.

6.2.3 A formal agreement should be drawn up between the parties specifying, in addition to any commercial considerations, the following where appropriate:

- the maximum volume (flow rate) of gas to be supplied at the interface point
- MOP and design minimum pressure (DmP)
- typical daily profiles and associated seasonal variations
- the design criteria used to determine the flow and pressure at the interface point
- alternative supplies available to the system being connected
- gas quality
- gas flow limiting devices.

Note: The list is not exhaustive.

6.3 NON-REMOTE CONTROLLED INTERFACES

6.3.1 The system connection should be designed in accordance with appropriate current standards and with the agreement of the parties.

6.3.2 Consideration should be given to the installation of suitable isolation valves at readily accessible points, to allow the systems to be physically isolated from each other.

6.3.3 Ownership of the isolation valves, responsibility for maintenance and access for its operation should be agreed between the parties.

6.3.4 Arrangements to ensure the operational security of isolation valves should be considered at the design stage.

6.3.5 Consideration should be given to whether flow limiting devices are required at the interface to protect the upstream system from excessive demand.

6.3.6 A formal agreement should be drawn up between the parties specifying in addition to any commercial considerations:

- MOP and DmP
- the maximum flow rate (volume) of gas to be supplied at the interface and at requested time intervals for example hourly, daily etc.
- rate of change of flow
- the design criteria used to determine the flow and pressure at the interface point
- alternative supplies available to the system being connected if applicable.

SECTION 7: SYSTEM PLANNING

7.1 FLOW CONSIDERATIONS

7.1.1 Consideration should be given to demands on the system and the way gas is supplied into the system. There may be a variety of ways in which the system is supplied, varying between two extremes of pressure control and volumetric control. Storage used to a diurnal profile may relieve peak demands on the transmission system or cover for other system imbalances. This should be taken into account in the planning process.

7.1.2 A view should be taken of the overall demand level to be supplied. This should take account of commitments to downstream operators. Where several exit points are involved a view should be taken on diversity between the exit points. This may be done by assessing historical exit point requirements from similar situations.

7.2 PRESSURE CONSTRAINTS

7.2.1 Attention should be paid to the requirements of relevant Regulations, such as PSSR and PSR.

7.2.2 Where storage is critical, the maximum available operating pressure range should be used, so as to release the maximum available linepack from the system.

7.2.3 MOP is pre-determined by operating stress levels, the appropriate planning limits for proximity criteria and population density; and may be commensurate with any upstream restrictions in accordance with IGEM/TD/1.

7.2.4 DmP and minimum operating pressure should be determined having regard to the lower pressure tiers supplied and should be as low as possible if the requirement is to maximise the linepack available.

7.2.5 Pressure cycling for utilisation of linepack should comply with the appropriate design limitations for the fatigue life of the pipeline in accordance with IGEM/TD/1.

7.2.6 In planning a system care should be taken to meet conditions under normal operation without imposing constraints which are difficult to manage, having regard to day-to-day operation and maintenance. Where extensions to existing systems are being considered, comprehensive information on existing plant capacity and operational restrictions should be obtained and information on planning data and projected requirements updated, so that the system can be operated to design requirements.

7.2.7 A variety of DmPs for planning purposes may apply to critical points on a system and these should be determined by the present and future inlet pressure requirements to regulators supplying downstream systems.

Note: For example it is possible for critical points to be prescribed by inlet pressures to regulators supplying downstream systems, or by pressure requirements for specific large end users.

7.2.8 In anticipation of future system development plans appropriate DmPs should be maintained at specific points on the system.

Consideration should be given to downstream capability and/or requirements when designing systems where pressure drops are large.

Note: For example a 19 bar system operating down to 3.5 bar at peak would require only an additional 1.6% of daily demand, or the start pressure to drop to 18.7 bar, to cause terminal pressures to fall below 2 bar.

7.2.9 Consideration should be given to gas velocity in accordance to IGEM/TD/1 across the whole operating range of a system particularly when there is an increased risk of contaminants, for example dust.

7.3 OPERATING MARGINS

Design margins should be considered to cater for the possibility of forecasting error, storage outage, equipment malfunction and other operational failures. These may be determined by a percentage increase of peak flow or by individual specific simulations.

7.4 SECURITY OF SUPPLY

7.4.1 Security measures are intended to minimise the consequences of system failure.

The cost of failure may be considered against the cost of additional resilience but, security of supply must be maintained at all times. Any decision to accept a lower level of security of supply should be justifiable by a risk assessment.

7.4.2 Where system enhancements are being considered, account should be taken of security benefits in the various options that may be available.

7.5 CONTINGENCY PLANNING

7.5.1 General

7.5.1.1 Contingency planning should be undertaken to identify appropriate actions and procedures to safeguard supplies in the event of plant or equipment failure. As it is not possible to cover all events and occasions on which there may be an incident, care should be taken in choosing a representative selection.

7.5.1.2 It should be recognised that some items of equipment can fail, with secondary and multiple consequences. For example the loss of diurnal storage facility would increase the peak load on the supply systems, increasing plant throughput and reducing linepack.

7.5.2 Major failures

Contingency planning for major failures may require liaison with other GTs to establish whether or not additional capacity and/or storage is available from other systems. In these circumstances it should be confirmed that increased pressure, flow rates and/or storage can be transmitted and utilised effectively within the supply system.

7.5.3 Electricity supply failures

Loss of public electricity supply depresses consumer gas demand for the duration. On restoration of supply, gas demand may show a sudden increase over anticipated peak levels. Systems are not required to meet such abnormal loads. However loss of plant due to electricity failure should be considered under contingency planning.

7.6 COMPRESSION

7.6.1 Networks may have compressor stations within the pipeline systems and if present or planned as part of capacity provision then they need to be modelled effectively.

The exact requirements or specification should be incorporated into the network analysis model using the principal factors:

- maximum and minimum flow rate
- pressure lift required
- inlet gas temperature.

7.6.2 Compression adds energy to the gas resulting in higher gas temperature. If several compressor stations are installed on the same pipeline, the temperature of the gas may increase substantially which will adversely affect the integrity of the downstream pipework and pipe wrapping or coating material. If the gas temperature exceeds the maximum design temperature of the pipeline, aftercoolers should be installed unless a safety study is undertaken to justify their exclusion.

7.7 BOUNDARY CONTROL TECHNIQUES

7.7.1 General

As outlined in Sub-Section 6.2 various pressure constraints may arise during the life of a system. The effects should be modelled as part of the planning process. Several techniques exist for minimising such effects and maximising the system storage and transmission capacity (see clauses 6.7.2 to 6.7.4).

With conventional PRIs, pressures or flow rates are set to maintain minimum acceptable pressures at the extremities of the system supplied under predicted peak conditions. However it is often possible to increase system transmission or storage capacity at off peak and/or peak conditions by designing a control system to maximise potential of the pipeline system, either upstream or downstream of the controlling device.

Safety and security of supply are of paramount importance in planning and in the use of techniques described in this Section. System planners should also be aware that these techniques may require control and monitoring from an appropriate centre.

Planning of such installations should comply with IGEM/TD/13.

7.7.2 Minimising PRI pressure loss

Pipelines operating with different MOPs will be separated by a PRI. In order to maximise the linepack in the upstream system, the regulators should be designed to operate with minimum pressure differential. Consideration may be given to the installation of a by-pass arrangement, which operates at pre-determined low pressure to ensure minimum pressure drop and maximum use of linepack with suitable controls to safeguard the downstream pipeline.

7.7.3 Remote set point control

Where a pipeline operating pressure is limited at a particular location, for example an IGEM/TD/1 proximity constraint it may be achieved by remotely controlling the upstream regulator. The pressure at the critical point should be sensed and fed back to the regulator, via a suitable communications link such that the desired remote set point is achieved.

Note: This solution for maximising linepack and transmission capacity is appropriate where a significant pressure drop occurs between the control point and the source regulator.

The technique may also be used to satisfy other objectives, for example limiting the inlet pressure to a downstream installation to avoid pre-heating.

7.7.4 Switched boundary control

Normally switched boundary control is applicable to pressure controlled systems where the linepack storage is limited, for example small diameter pipelines. Storage should be released by switching the regulator from local to remote control at the appropriate time, such that the setting is determined by the terminal pressure of the pipeline.

Note: In certain circumstances the upstream supply system pressure may also be allowed to decay after the time of peak demand, allowing additional linepack to be released.

7.7.5 CHANGES IN PLANNING PARAMETERS

The impact of any changes to an operational system which may result in a change to the system design parameters should be assessed before implementation. Any proposed change to previously agreed planning parameters should be discussed between upstream and downstream GTs (see Section 5). As a consequence, it may be necessary to revisit the complete planning cycle.

SECTION 8: STORAGE MODELLING

8.1 THEORETICAL LINEPACK AVAILABILITY

8.1.1 The volume of stored gas available for release from linepack should be determined to estimate the total storage available in a system.

8.1.2 Two conditions should be established to calculate the maximum theoretical amount of linepack available:

- the state at which the maximum stored volume occurs and
- the state at which the minimum stored volume occurs.

The maximum linepack available is the difference between the maximum and minimum stored volumes.

8.1.3 While maximum storage requirements may occur well down the load curve, a storage requirement at or close to the maximum is possible when extremely high demand conditions occur. Such conditions will approach or may even exceed peak day demand.

Note: In practice lower level days are difficult to define as they are subject to wide variation of demand profiles throughout the day, and are almost certain to show higher diurnal swing than theoretical peak day values. This will result in linepack availability at peak and at lesser conditions being of very similar magnitude. Therefore calculation of the theoretical maximum linepack should be based on conditions occurring near to planning peak.

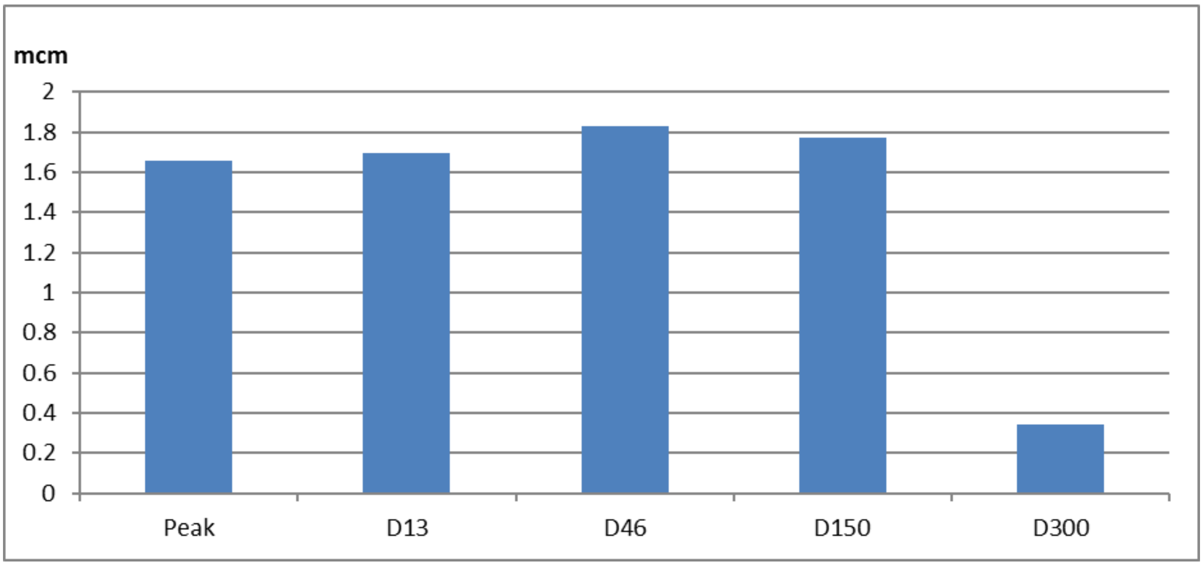


FIGURE 1 – STORAGE AVAILABLE AT VARIOUS DEMAND LEVELS

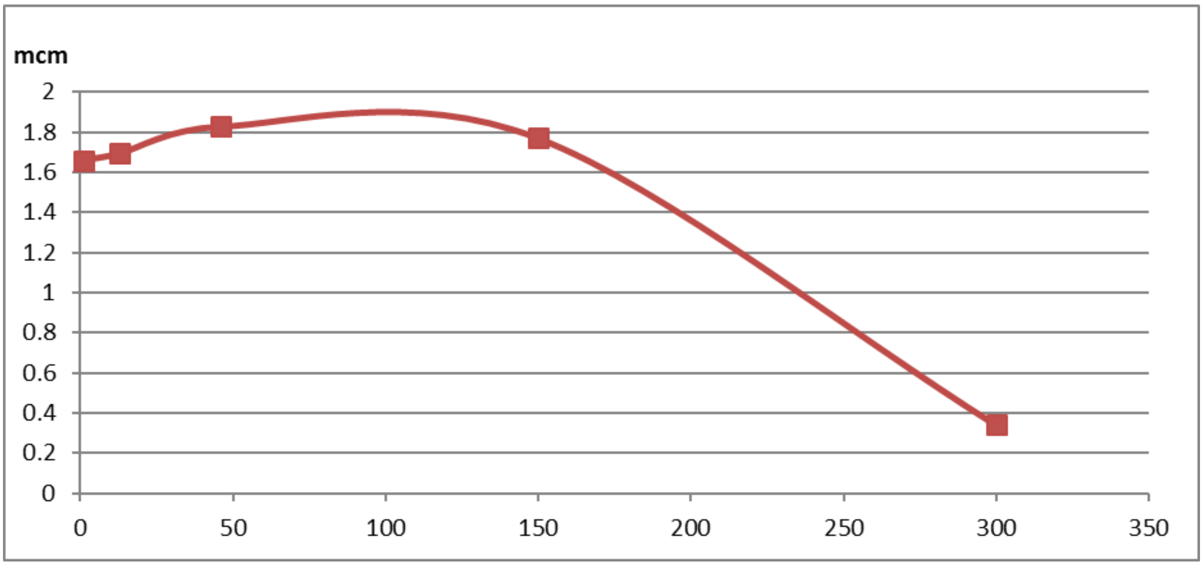


FIGURE 2 - STORAGE AVAILABLE BY DAY NUMBER

Note: Storage planning is based on ensuring that sufficient storage is available to meet the requirements across the range of demands experienced in a year. The storage plan will take account of the following factors:

- *Impact of level of demand: linepack systems have less storage capacity at high demands*
- *Ability to vary the input rates to the storage pipelines enabling pipeline to cycle over the full pressure range.*
- *Availability of non-pipeline storage (e.g. holders): Reduction in availability away from high demand periods and plant maintenance during summer months*

8.2 ASSESSING IF SUFFICIENT LINEPACK IS AVAILABLE

Analyses of days requiring the maximum 1 in 20 storage requirement should be carried out to assess whether the system is capable of supplying adequate amounts of storage under all conditions commensurate with the 1 in 20 year criterion.

Note: The method is to analyse pre-determined sets of circumstances in a prescribed way. For example such a day might be a high swing, moderate forecast error day when the forecast error remained undetected until early afternoon, which would be simulated with appropriate control operator actions. On other days there may be large forecast errors, perhaps with earlier error detection or the day may start with low stocks.

8.3 TAKING STORAGE FROM UPSTREAM SYSTEMS

8.3.1 There is interaction between storage taken from an upstream system and available linepack. Both the quantity taken and the way in which it is taken will have an effect. Iterative analyses should be carried out to establish the right combination of supply system storage, linepack and other storage to achieve the correct overall volume matching the theoretical storage requirement.

Note 1: The times at which the theoretical maximum and minimum stored volume values occur may differ significantly from a system which uses no upstream storage.

Note 2: This will be attained when the system operates between its maximum pressure at all supply points and the minimum planning pressure at all terminal points, or as many of these as may be achieved in practice.

SECTION 9: PRI DESIGN PARAMETERS

9.1 GENERAL

PRIs form an integral part of a transmission system. The planning engineer should provide the design engineer with sufficient information to enable the system to operate efficiently, the main parameters to include:

- maximum and minimum volumetric flow
- maximum and minimum pressure
- daily pressure profile
- daily volumetric flow profile
- velocity
- maximum and minimum temperature.

On the basis of these parameters, the detailed design should be prepared in accordance with IGEM/TD/13.

9.2 PLANNING HORIZON

The future flow and pressure requirements of the site should be ascertained to determine the relevant parameters for the design of pressure regulating equipment, based on supply and demand forecast for the downstream systems. The planning horizon identified in clause 3.1.2 should be used.

9.3 CAPACITY

As part of the planning process, all PRIs should be checked for capacity utilisation on a regular basis to ensure that the planned duty is achievable. A programme of modification or replacement should also be agreed with system operations managers.

SECTION 10: SUPPLIES TO LARGE USERS

10.1 Network planning issues should be included in discussions for supply to large users to ensure that the aspirations of all parties involved may be met.

10.2 The modelling of ramp rates should reflect the capability of equipment to be connected to the system. The system modelling should take account of the actual conditions that could be imposed on the system by the large load.

10.3 Information on ramp rates, equipment trips and downstream equipment should be supplied by the shipper or relevant parties to the GT.

APPENDIX 1 : GLOSSARY, ACRONYMS AND ABBREVIATIONS

A1.1 GLOSSARY

All definitions are given in IGEM/G/4 which is freely available by downloading a printable version from IGEM's website www.igem.org.uk.

Standard and legacy gas metering terms are given in IGEM/G/1 which is freely available by downloading a printable version from IGEM's website.

A1.2 ACRONYMS AND ABBREVIATIONS

AGI	Above ground installation
ACoP	Approved Code of Practice
CO	Carbon monoxide
DmP	Design minimum pressure
GB	Great Britain
GS(M)R	Gas Safety (Management) Regulations
HSWA	Health and Safety at Work Act
ECV	Emergency control valve
ESP	Emergency service provider
GT	Gas transporter
HSE	Health and Safety Executive
IGEM	Institution of Gas Engineers and Managers
MAPD	Major accident prevention document
MAHP	Major accident hazard pipelines
MOP	Maximum operating pressure
NG	Natural Gas
OP	Operating pressure
PRI	Pressure regulating installation
PSR	Pipelines Safety Regulations
PSSR	Pressure Systems Safety Regulations
SOL	Safe Operating Limits
UKAS	

APPENDIX 2 : REFERENCES

This Standard is set out against a background of Legislation in force in GB at the time of publication. Similar considerations are likely to apply in other countries where reference to appropriate national Legislation is necessary. The following list is not exhaustive.

Where British Standards etc. are quoted, equivalent national or international Standards etc. equally may be appropriate.

A2.1 LEGISLATION IN GREAT BRITAIN

This sub-appendix lists Legislation referred to in this Standard as well as Legislation not referenced but which may be applicable.

- Gas Act 1986 (as amended by the Gas Act 1995)
- Utilities Act 2000
- Health and Safety at Work etc. Act 1974
- New Roads and Street Works Act 1991
- Pipelines Act 1962
- Construction (Design and Management) Regulations 1994
- Electricity at Work Regulations 1989 and Memorandum of Guidance 1989
- Gas Safety (Management) Regulations 1996
- Management of Health and Safety at Work Regulations 1999
- Noise at Work Regulations 1989
- Pipelines Safety Regulations 1996
- Pressure Systems Safety Regulations 2000.

A2.2 HSE APPROVED CODES OF PRACTICE

L122	Pressure Systems Safety Regulations 2000. ACoP
HSG48	
HSG65	
INDG 261	
INDG 178	

A2.3 IGEM STANDARDS

• IGEM/TD/1 Edition 4	Steel pipelines for high pressure gas transmission
• IGEM/TD/13	Pressure regulating installations for transmission and distribution systems
• IGEM/G/1	Defining the end of a Network, a meter installation and installation pipework
• IGE/GL/1 Edition 2	Planning of gas distribution systems of MOP not exceeding 16 bar
IGEM/SR/29	Dealing with gas escapes

APPENDIX 3 : EXPLANATORY NOTES OF DEFINITIONS

A3.1 GAS DEMAND SIMULATIONS

The daily gas demands in a supply network may be simulated by examining the temperature/weather patterns over a long series of years, using known temperature/demand relationships. Variations in gas demands during the day may be modelled from previous experiences. From these simulations, statistics may be derived for the planning of peak capacities of the transmission and storage systems. These are normally expressed as peak day demand (see A3.2 or A3.4) and diurnal swing (see A3.2 and A3.3).

A3.2 SPECIALISED TERMS ASSOCIATED WITH DIURNAL SWING

diurnal swing volume	The theoretical minimum storage capacity needed to supplement a perfectly forecast supply of constant flowrate in order to satisfy varying demands at each instant throughout a day.
diurnal swing	The diurnal swing volume requirement divided by the total demand for the day expressed as a percentage. Diurnal swing is a useful measure because demands of a similar nature but different size may have similar swings and the variation in swing for a large area from year to year is unlikely to change significantly.
diurnal swing storage	The volume of gas required to meet consumer demands above the average daily flow rate on any particular day. Storage facilities are provided to absorb surplus gas when demands are low and then release it when demands are high.
diurnal storage requirement	The theoretical minimum storage capacity needed to support the combination of diurnal swing volume requirements and operating margins.
diurnal storage provision	The minimum storage used to support a given value of diurnal storage requirement. The requirement and provision could be different because it may not be possible in reality to refill some plant to the same extent as may theoretically appear possible during a day and thereby use it more than once.

A3.3 CALCULATION OF DIURNAL SWING VOLUME

A3.3.1 To determine the diurnal swing volume for a given gas network, a graph of demand versus time for a complete day is produced (Figure 1 provides an example). The example shown is a typical domestic load but the method is applicable to any demand profile. The diurnal swing volume in the example is Area A plus Area B minus Area C. Area C represents the ability to refill storage within the supply day. The accuracy of this calculation is improved with smaller time intervals.

A3.3.2 An alternative method of displaying the same information is to plot accumulative demand (Figure 2 provides an example). The average demand is represented by the line of constant slope. The diurnal swing volume is represented by the greatest absolute vertical deviation from the average line. If part of the deviation to the average is negative, the absolute value (of the greatest negative) is added to the greatest positive deviation to give the total diurnal swing volume.

A3.3.3 A further method of displaying diurnal swing is to plot the difference between instantaneous and average demand over the complete day, at appropriate time intervals (Figure 3 provides an example) from an initial storage volume (stock level). For a particular demand profile the maximum and minimum stock levels and times of occurrence are clearly illustrated. The diurnal storage volume is the difference between the maximum and minimum levels. In a linepack storage network a plot of pressure versus time has the same profile, stored volume being directly proportional to pressure.

A3.4 PEAK DAY DEMAND

A3.4.1 In determining the level of peak demand the following assumptions may be made:

- the total load in each winter of the series is standardised such that it is the same for each year of the series
- although the 1 in "n" demand level may only be exceeded in one winter in "n", within that particular winter the 1 in "n" demand level may be exceeded more than once. Such occurrences need not be on consecutive days.

A3.4.2 Sufficiently detailed historical weather data is available for GB, to enable each winter day demand to be calculated on the basis of the current demand/weather/day of week/date relationship.

A3.4.3 Consider for example and simplicity the 60 year period 1928-1987. The 1 in 20 demand would be that which would be exceeded only in 3 years. If the four largest demand days occurred in the years with demands as shown below.

1928	**1947**	**1962**	**1977**
1002 999	1021 1016 1012 995	1041 1035 1033 1014 1008 999	1000

The 1 in 20 demand will be 1000 as it will be exceeded only in 1928, 1947 and 1962. There would be only one demand of that level in a weather year like 1928. However in the weather year 1947, the 1 in 20 level would be exceeded 3 times and in 1962 5 times.

A3.5 LOAD DURATION CURVE

A3.5.1 The load duration curve is a graphical representation of the number of days on which the gas load exceeds a given demand threshold over a particular period. For example an annual load duration curve the values for Figure 5 can be derived for the weather pattern of a particular year, using a demand profile graph (see Figure 4 as an example).

A3.5.2 Load duration curves can be simulated from annual temperature/weather statistics over a long series of years. From these statistics a 1 in "n" load duration curve can be derived, which represents the probability of demand above a given threshold being exceeded in only one out of "n" years.

A3.6 **DIVERSITY**

A3.6.1 Diversity is best illustrated by reference to domestic users. A single user will, as a peak demand use the total appliance rated quantity. However a neighbour will not have completely coincidental gas usage. Clearly as more customers are added together this coincidence of peak usage lessens and, although the total peak load will continue to grow as the size of the consumer group increases, the average peak consumption per consumer will continue to decrease.

A3.6.2 This phenomenon extends beyond domestic customers. For example diversity will arise between other market sectors between different parts of a town and between towns to varying degrees.

A3.6.3 The effect of this is that calculated peak loads by distribution system will if added together exceed the total system demand, i.e. the sum of the parts does not equal the whole. It is therefore necessary to apply a diversity factor.

A3.6.4 Because of diversity the peak supply to any group of customers will be lower than the sum of the individual peak demands of all the customers.

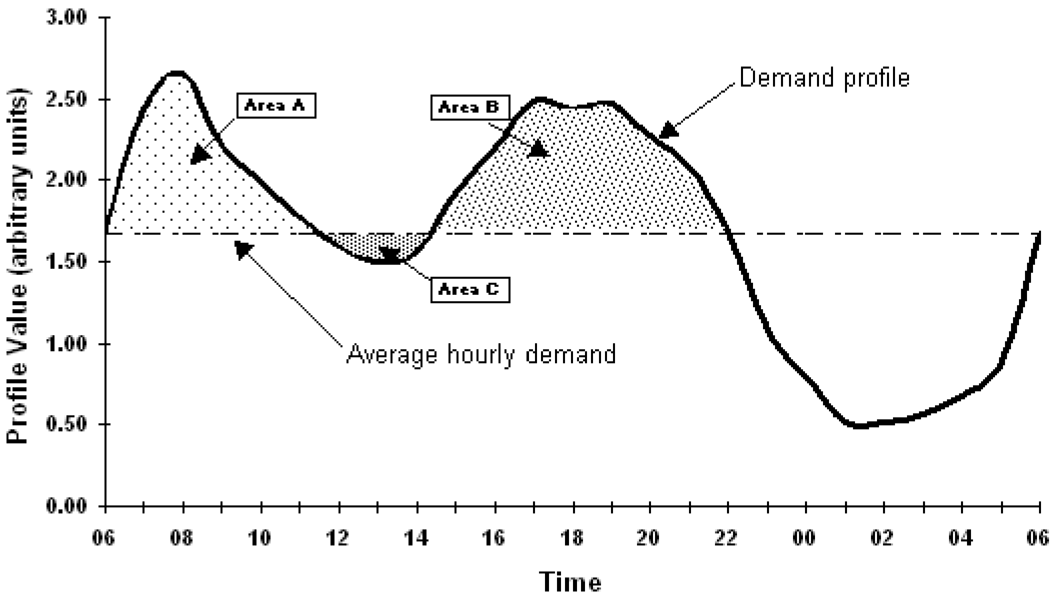
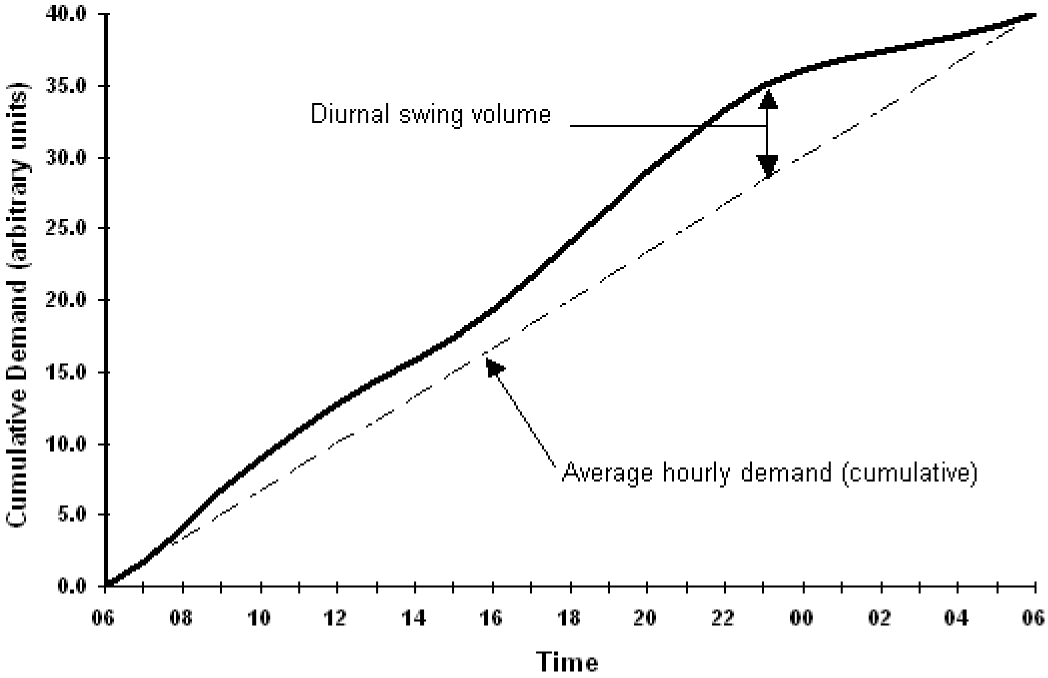


FIGURE 3- TYPICAL DEMAND PROFILE
(values chosen are for demonstration only)



Note: *The Diurnal Swing Volume is the maximum deviation between the average demand line and the actual demand line*

FIGURE 4 - CUMULATIVE DEMAND THROUGHOUT THE DAY

(values chosen for demonstration only)

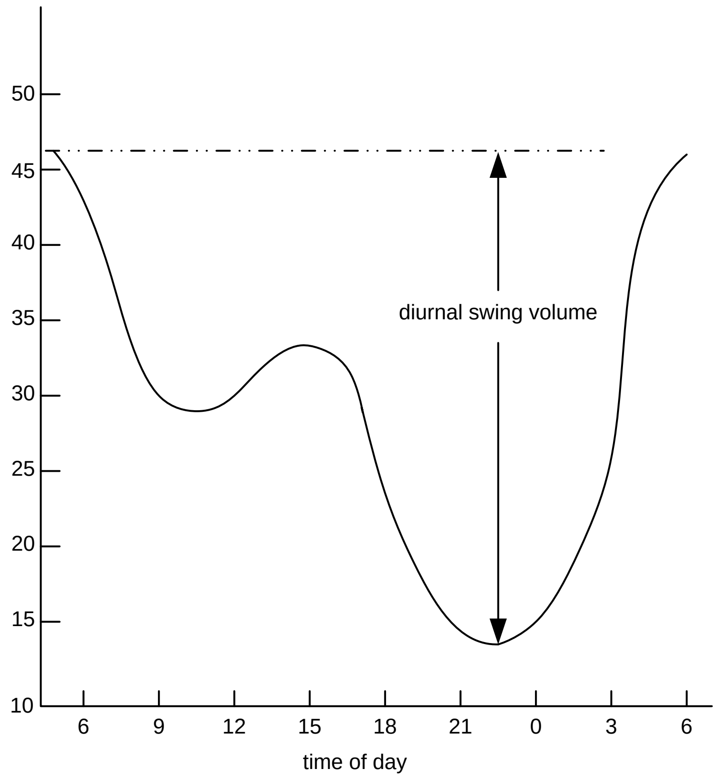


FIGURE 5 - STOCK LEVEL THROUGHOUT THE DAY

(values chosen for demonstration only)

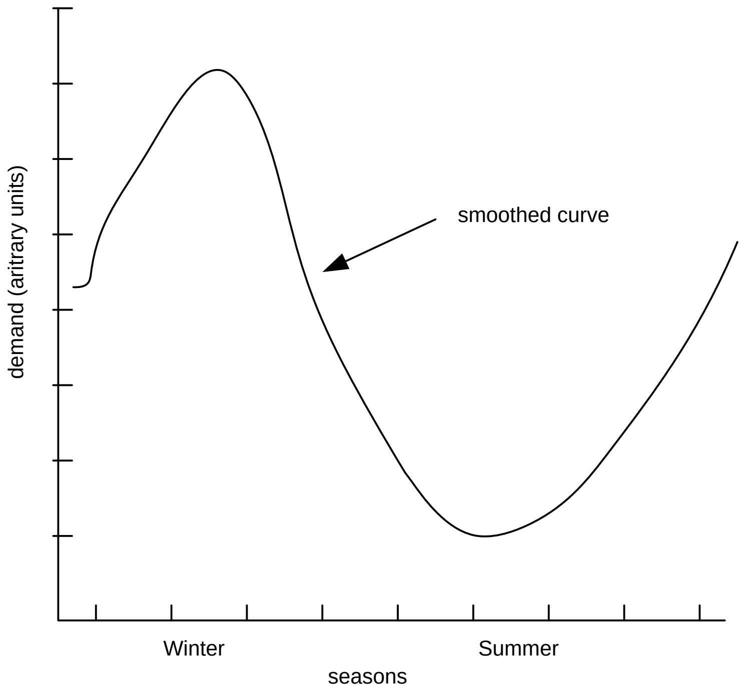


FIGURE 6 - ANNUAL DEMAND PROFILE
(values chosen for demonstration only)

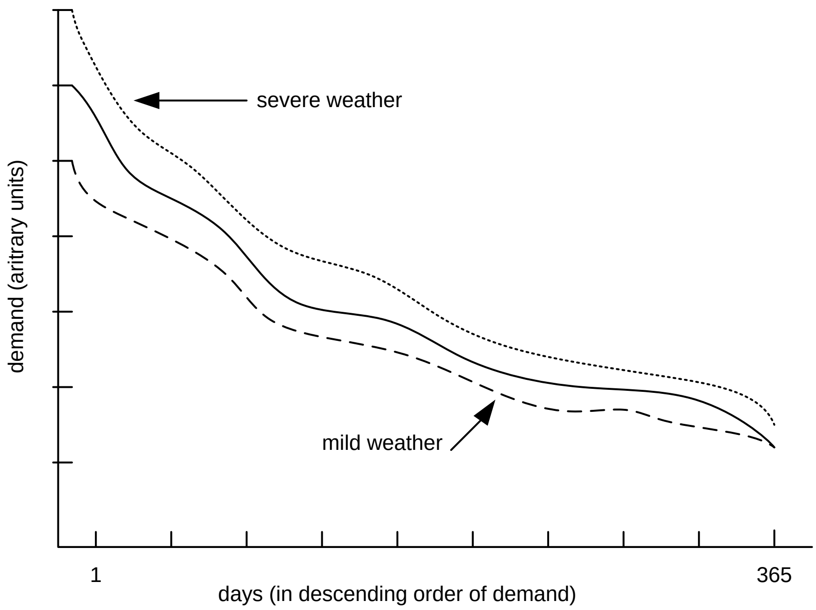


FIGURE 7 - LOAD DURATION CURVE
(values chosen for demonstration only)

BLANK PAGE