HSE

Health and Safety Executive

Further guidance on emergency plans for major accident hazard pipelines

The Pipelines Safety Regulations 1996

This guidance is issued by the Health and Safety Commission. Following the guidance is not compulsory and you are free to take other action. But if you do follow the guidance you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.

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Part 1 - Emergency planning requirements

1.1 Introduction

1 The Pipelines Safety Regulations 1996 (PSR)[1] require a local authority to prepare emergency plans for pipelines which have the potential to cause a major accident. The Regulations also require a pipeline operator to establish emergency procedures for such pipelines.

2 The Health and Safety Executive (HSE) guidance booklet L82[2] provides advice on HSE's interpretation of the Regulations and how they will be enforced. The purpose of this document is to amplify that advice, especially in relation to the roles of local authorities and pipeline operators in preparing emergency plans.

3 This guidance document considers in more detail the nature of pipeline hazards, some technical aspects of major accident hazard pipelines and the likelihood and consequences of pipeline failure to assist and inform local authorities when preparing emergency plans.

1.2 General

4 Pipelines are considered a safe mode of transportation for conveying hazardous substances and are often safer than alternative methods, for example, by road and rail. However, there are occasions when pipeline failure results in loss of containment or accidental release of the pipeline contents. Emergency plans are required to provide an additional safeguard so that, in the unlikely event of an emergency involving a major accident hazard pipeline, protection could be provided to members of the public whose health and safety might be affected.

1.3 Pipelines Safety Regulations 1996

5 These Regulations apply to all relevant pipelines and are designed to ensure that pipelines are designed, constructed, operated, maintained and decommissioned safely.

6 Pipelines conveying 'dangerous fluids', defined in Schedule 2 of the Regulations, are referred to as major accident hazard pipelines (MAHP) and the following summarises the additional regulations which apply:

- requirements for emergency shut-down valves on certain major accident hazard pipelines connected to offshore installations (regulation 19);
- notification, by the pipeline operator, to HSE prior to construction, use, or change to a pipeline (regulations 20, 21 and 22);
- preparation of a major accident prevention document (MAPD) by the pipeline operator in which hazards are identified, risks assessed and where there are sufficient particulars to demonstrate that the safety management system is adequate (regulation 23);
- the pipeline operator to ensure that appropriate emergency procedures, organisation and arrangements are in place (regulation 24);
- **regulation 25 requires a local authority which has been notified by HSE of a major accident hazard pipeline to prepare an emergency plan;**
- **regulation 26 allows a local authority which prepares, reviews or revises a plan to charge a fee to the operator of the pipeline.**

Note: Regulations 25 and 26, together with extracts from the guidance to the Regulations (L82) are reproduced in Appendix 1.

7 Regulation 3 defines the meaning of 'pipeline'. An emergency plan has to apply to all parts of a major accident hazard pipeline - not just the buried pipe sections. For example, natural gas 'pipelines' will include block valve sites, pig trap sites, offtakes, pressure reduction stations and compressor stations. However, sites used for storage (eg gas holder stations) and gas terminals are not part of the 'pipeline'.

8 There is no explicit requirement in the Regulations to test an emergency plan drawn up under regulation 25 (but see also section 1.12). This was recognised as an outstanding issue by the Health and Safety Commission (HSC) when the Regulations came into force.

1.4 Scope of an emergency plan for pipelines

9 The Pipelines Safety Regulations, made under the Health and Safety at Work etc. Act 1974,[3] do not cover environmental consequences of pipeline failures. The Regulations only require an emergency plan to be prepared to deal with events involving a major accident hazard pipeline and which are a danger to the health and safety of people.

10 However, a local authority may elect to extend the scope of its emergency arrangements to cover environmental, economic and other consequences following the failure of a major accident hazard pipeline but any work undertaken in preparation for these parts of the plan cannot be charged to the pipeline operator under regulation 26 of PSR. Also, local authorities may take the view that certain kinds of environmental effects or damage have the potential to cause harm to people and should be included in the plan.

11 A local authority may elect to extend the scope of its arrangements to deal with those pipelines not defined as major accident hazard pipelines, for example, those carrying flammable liquids (eg gasoline, hexane, kerosene, diesel, dead crude oil, methanol etc), but no charge can be made to operators of these pipelines under regulation 26 of PSR.

12 The scope of emergency plans does not include actions to be taken in the event of loss of gas supply to gas consumers. These are matters covered by the Gas Safety (Management) Regulations 1996[4] which deal with the safe management of gas supply. Many of these kinds of events will probably involve the medium or low pressure gas distribution systems which operate at or below 7 bar gauge (ie 8 bar absolute) and fall outside the scope of the additional duties under PSR.

1.5 HSE's arrangements to notify a local authority

13 Pipeline operators have a duty under regulations 20 and 22 of PSR to notify HSE of their intention to construct, or make changes to, a major accident hazard pipeline and, in turn, HSE has to inform the relevant local authorities so that an emergency plan can be prepared or adjusted.

Note: If a pipeline is no longer to be a major accident hazard pipeline by virtue of a change in the conveyed fluid or fluid properties etc, then the pipeline operator shall notify HSE under regulation 22 of PSR. HSE will, in turn, inform the relevant local authority(ies) that an emergency plan for that pipeline is no longer required under the Regulations.

14 These notifications are made to the Hazardous Installations Directorate (HID) of HSE.

15 Local authorities are then informed of new pipelines or changes to pipelines via the HID Unit Inspection Teams which are located throughout the country (contact HSE's Infoline for details Tel: 0845 345 0055. Out of hours emergency contact number: 0151 922 9235). Receipt of the notification should act as a trigger for the local authority to prepare an emergency plan for a pipeline.

16 Normally, a notification to a local authority will be in the form of a letter (see Appendix 2 for an example), accompanied by the following information:

- the name of the pipeline operator;
- the contact details of the pipeline operator;
- the pipeline identifier, which may be a description or number;
- the name of the pipeline or the pipeline start and finish points; and
- the fluid to be conveyed.

17 A copy of the notification is sent by HSE to the pipeline operator.

18 If a local authority wishes to consult with HSE during the preparation of an emergency plan, or has any queries or requests for further information, advice or assistance, then contact should be made, in the first instance, with the local HID Unit Inspection Team (contact HSE's Infoline for details Tel: 0845 345 0055).

1.6 Aim of an emergency plan

19 For the purposes of PSR, the aim of an emergency plan can be described as: 'To detail action to be taken to minimise the consequences to the health and safety of people in the event of an emergency involving a major accident hazard pipeline'.

1.7 Objectives of an emergency plan

20 The objectives of an emergency plan are to:

- have simplicity and a clear structure to ensure all users understand the principles of its operation;
- reduce the risks to the health and safety of all those affected by an emergency (both immediately and potentially), including members of the public and emergency services personnel;
- identify those measures needed to contain the effects of the emergency;
- ensure a robust process is in place for the management of the emergency response following a pipeline accident and which clearly identifies the local authority, emergency services and pipeline operator responsibilities;
- manage the emergency to minimise the effects on the activities of those not directly affected, for example, traffic control to keep people out of the area and to prevent people congregating at the scene thereby putting themselves at risk;
- address in detail the communication requirements between the emergency services and pipeline operator;
- ensure rapid and appropriate restoration of those affected once the emergency is over;
- recognise the continuous 24-hour-a-day operation of pipelines and the multiplicity of potential incident locations. The plan should be flexible enough to provide emergency response at any time and at any location along the pipeline route;

- address in principle credible pipeline failures within the emergency planning distance but be flexible enough to take into account other events that are extremely unlikely and where the consequences may extend beyond the emergency planning distance (see section 2.6);
- be compatible with those drawn up for major accident hazard sites under the Control of Major Accident Hazards Regulations 1999 (COMAH) (as amended),[5,6] especially where pipelines are connected to such sites;
- deal effectively with pipelines which cross local authority boundaries - some longer pipelines may cross a large number of local authority areas.

1.8 Preparation of an emergency plan

21 Local authorities should consult with the pipeline operator, HSE and others as necessary.

22 In general, it will be the pipeline operator who will be able to provide the majority of the pipeline related information required for the preparation of a plan. The information provided by HSE when notifying local authorities is intentionally limited and does not include maps, details of the hazard range or emergency planning distance - it is designed to trigger a dialogue between the local authority and pipeline operator. The pipeline operator should be able to provide up-to-date information on the pipeline route and should, by virtue of its major accident prevention document, be able to provide sufficient details of pipeline hazards and the results of any risk assessment. This information will form the basis for determining both the hazard range and detailed emergency planning distance (see section 2.6).

23 **It is particularly important that early contact is made by the local authority with the pipeline operator to develop an understanding of the nature of the pipeline, the hazards and the consequences of potential failure, the emergency response management requirements and responsibilities and to identify what resources will be required by the authority to prepare the plan.** The scope, content and development cost of the emergency plan should be discussed and agreed with the pipeline operator. It is important that consultation and liaison with the pipeline operator are maintained during the preparation of the plan. This approach will also be helpful in resolving misunderstandings and reduce the possibility of disputes in relation to charging, especially where the use of existing general or generic pipeline plans are not considered appropriate by the local authority (see paragraph 27).

24 HSE may be able to provide additional advice and guidance, especially on technical matters concerning pipelines and their associated hazards and risks.

25 In the event of an emergency involving a major accident hazard pipeline, the following responses should be provided for in the plan:

- the control of the emergency location;
- assessment of the actual and potential consequences of the emergency;
- alerting the relevant authorities and organisations and the public;
- implementation of measures to mitigate the consequences of the emergency;
- restoring normal conditions.

26 The following should be considered when preparing a plan:

- the location of an emergency will not be known in advance - it may be in remote or rural areas; suburban or commercial areas; or heavily industrialised areas and, therefore, planning must be as flexible as possible;

- the varying times for the initial alert and the response by the emergency services and the pipeline operator;
- the population density can vary considerably at certain locations, eg open spaces, playing fields etc;
- although not required under PSR, emergency plans may take into account the environmental, economic or other consequences of emergencies involving pipelines (but see paragraphs 10 and 11).

27 In preparing emergency plans for pipelines, serious consideration should be given to extending existing general emergency plans or to providing generic pipeline plans which are integrated with general emergency plans. The approaches taken by local authorities for the preparation of a plan may differ, depending on the number and extent of pipelines and other local circumstances, for example:

- include major accident hazard pipelines in general emergency plans, but with specific references to each pipeline and pipeline operator, and show how emergency response arrangements for them are integrated into the general emergency plan;
- a generic plan for a number of pipelines, conveying the same fluid type and operated by the same pipeline operator, with specific references to each pipeline;
- a plan covering the pipelines of more than one operator, along a pipeline corridor or in the same area, with specific references to each pipeline and pipeline operator;
- a single plan covering all pipelines in a local authority area, with specific references to each pipeline and pipeline operator;
- a single plan for a pipeline passing through two or more local authority areas;
- an individual plan for a pipeline.

28 There are circumstances where a major accident hazard pipeline connects two immediately adjacent sites. In many cases these sites are industrial major accident hazard sites with their own emergency plan required under the COMAH Regulations. Although these pipelines are subject to the requirements of PSR and will be notified to local authorities by HSE, consideration should be given to incorporating such pipelines in one or other (or both) of the site emergency plans, rather than developing separate pipeline plans.

29 It is not necessary to submit an emergency plan for a major accident hazard pipeline to HSE for approval or acceptance.

1.9 Emergency arrangements, procedures and plans

30 Regulation 12 of PSR, which applies to all relevant pipelines, requires that a pipeline operator has adequate arrangements in place to deal with an accidental loss of fluid from a pipeline, or to deal with defects and damage to a pipeline or any other emergency affecting the pipeline.

31 Regulation 24, which only applies to major accident hazard pipelines, requires pipeline operators to have adequate emergency procedures, an appropriate organisation and effective arrangements to deal with an emergency involving a major accident hazard pipeline.

32 It is important that pipeline operator emergency arrangements and procedures and local authority emergency plans dovetail to provide a comprehensive and effective response to emergencies. Active co-operation and co-ordination between the pipeline operator and emergency services will be essential during the response to an emergency.

33 Many pipelines, by their very nature, may cross a number of local authority boundaries and it is important that adjacent local authorities co-operate with one another. They should strive to harmonise plans and develop standard structures, procedures, and plan-initiation arrangements.

34 The pipeline operator should specify the criteria and arrangements in emergency procedures for alerting the emergency services when it is known that there is an emergency involving a major accident hazard pipeline. Similar arrangements should be incorporated into local authority emergency plans to alert pipeline operators when an emergency is reported to the authorities or emergency services.

Important note: The pipeline operator's emergency procedures may refer to certain pipeline isolation valves at block valve sites or other above-ground installations in order to limit the loss of fluid at the location of an emergency. These valves may be operated remotely by signals from the (pipeline) control room or the site may have to be visited for manual valve operation. It must be stressed that these valves are under the control of the pipeline operator and local authority emergency plans should not include instructions to close any pipeline valve unless specific arrangements have been agreed with the pipeline operator.

1.10 Information in the event of an emergency

35 There are approximately 21 500 kilometres of major accident hazard pipeline in England, Scotland and Wales. The majority of this length passes through rural areas but a significant minority is routed through, or close to, higher population density, suburban areas.

36 Unlike major accident industrial sites (ie COMAH sites) the public has 'open access' to almost all parts of a pipeline route - only block valve sites, pumping stations and other above-ground installations tend to be securely fenced. Pipelines cross areas where varying numbers of people may be present at different times - in their homes or at pathways, roads, motorways, railways, rivers, playing fields, retail parks and other open spaces including farmland.

37 **The Pipelines Safety Regulations do not require information about a major accident hazard pipeline to be supplied to the public by the local authority or pipeline operator.**

Note: Local authorities and/or pipeline operators may elect to provide information to the public (for example, to those living or working within the emergency planning distance or those who have responsibility for particularly vulnerable groups in schools, hospitals and homes for the aged). Careful consideration should be given to the quantity, nature and form of information provided and advice should always be sought from the Police Industrial Security Officer when proposing to disclose (or otherwise put in the public domain) potentially sensitive information about pipelines and their associated installations.

38 In the event of an emergency involving a major accident hazard pipeline it is likely that prompt and appropriate information will have to be provided to members of the public who may be affected by the emergency. The emergency services and pipeline operator should agree who has the authority to activate any public warning, and under what circumstances. However, it must be remembered that pipeline incidents can occur suddenly and with little warning and the immediate consequences of the incident (eg an explosion) could be over before the emergency services and pipeline operator personnel arrive at the scene.

39 Arrangements should be made, using appropriate existing Police and local authority arrangements for co-ordinating public information, for the timely transmission of information to the media, members of the public and others during an emergency to keep people informed about what action is being taken and to provide guidance on what they should do to protect themselves. The plan should contain special guidance for sensitive or vulnerable groups. The pipeline operator should be prepared to make a formal announcement or statement soon after the emergency plan has been activated.

40 The emergency plan should take into account the possible concerns of the public living or working outside the emergency planning distance who may be alarmed by the visible or other consequences of an emergency, for example, smoke plumes. This may result in unnecessary alarm and important telephone links becoming jammed as the public seeks information about what is happening.

41 The following information should be held and readily available for transmission or distribution immediately following an incident:

- the common or generic name of the fluid in the pipeline and some indication of its principal acute or harmful characteristics in terms of people's health and safety;
- details of the nature of any pipeline release, consequences and knock-on effects (eg entry of flammable fluids into sewers and drains);
- protective measures to take (eg leave immediately, stay indoors and close all windows and doors etc); and
- details of evacuation arrangements.

1.11 Evacuation

42 Any proposals for the evacuation of the public must be very flexible and guidelines may have to be developed within the plan to assist the decision process by the emergency services on whether or not to evacuate. In many cases, evacuation would be considered a ‘last resort’.

43 The need for and scale of evacuation may be determined by a number of factors, for example:

- the probable release duration, the quantity and nature of any released fluid, eg a large release of toxic gas may require considerable numbers to be evacuated, especially those downwind of the emergency location;
- other consequences of a release, eg an explosion may render an area unsuitable for people to remain due to damage, loss of services etc;
- as a precautionary measure, in case of explosion or other escalation of the emergency, eg during an unignited release of flammable gas; and
- the make-up of the potentially affected population, eg the arrangements for children in school may differ from those for people at work.

1.12 Testing emergency plans and procedures

44 Although there is no explicit requirement in PSR, an emergency planning authority may decide, in conjunction with the pipeline operator (or a number of operators in its area), adjacent local authorities and others, to carry out exercises to test an emergency plan, or parts of it, from time to time. However, no charges may be made to the pipeline operator under these Regulations (see also paragraph 8).

45 In the absence of a requirement to test emergency plans, exercises carried out against other contingencies may be used to validate general arrangements for any incident, including pipeline emergencies.

46 Pipeline operators are required under PSR to test their own emergency procedures. If exercises are carried out these may involve the emergency services and, therefore, could test parts of the emergency plan as a result.

47 Communication is one of the most important elements of emergency procedures and plans. These links should be kept up-to-date and their validity regularly checked.

Part 2 - Emergency plans for pipeline failure

2.1 Planning for pipeline failure

48 An adequate plan detailing how an emergency relating to a possible major accident will be dealt with is required under regulation 25 of PSR.

49 There is no limit within the regulation as to the range of emergencies that must be catered for. The duty is an absolute duty and is conditioned only by the word 'possible'. Strictly speaking, everything is possible, even if only remotely probable. However, this may not be very helpful and a more practical approach is required.

50 There are a number of factors to consider when preparing an emergency plan involving a major accident hazard pipeline:

- pipeline design basis and routing;
- individual pipeline 'history';
- causes of pipeline failure;
- probability (or likelihood) of failure;
- size of failure (from pinhole leak to full-bore rupture);
- leakage release rate and duration of the release;
- effects (or consequences) of failure, including the behaviour of the pipeline fluid upon release;
- location of failure (relative to populated areas);
- 'external' factors, eg topography, 'drainage paths' (eg basements, sewers, drains and rivers), local weather patterns etc.

2.2 Causes of pipeline failure

51 Identifying the potential causes of pipeline failure should form part of the pipeline operator's hazard identification and risk assessment, ie as part of the major accident prevention document required under regulation 23 of PSR. An assessment of possible causes will help determine the likely modes of failure, eg a small leak or full-bore rupture.

52 No two pipeline incidents are completely alike but most can be categorised into a few principal causes of pipeline failure:

- third party activities (accidental or carelessness);
- corrosion, both internal and external;
- mechanical failure, including:
  - material defects;
  - construction defects, including weld defects;
  - fatigue;
  - operational errors;
  - maintenance problems;
- external hazards, including:
  - soil movement;
  - earthquakes;
- other external events, such as:
  - failure of adjacent plant or pipelines;
  - deliberate or malicious acts.

53 The most likely cause of pipeline failure is due to third party activity (in the order of 50-60% of all incidents). Until recent times, corrosion was the most common cause but better coatings, the use of cathodic protection and the use of 'intelligent pigs' to inspect for corrosion has reduced the proportion of failures due to corrosion. These two modes of failure taken together probably account for around 70-85% of all pipeline failures.

54 Third party damage can result in a pipeline being so severely damaged to require prompt action to be taken by the pipeline operator, eg initiating a total shutdown, partial or total reductions in operating pressure, fitting temporary repair clamps etc. There is always the danger that any resultant gouge on the pipe can fail due to cracking at some time in the future. If the pipeline is punctured the most likely result is a substantial leak but, for pipelines operating at high stress levels (or high design factors), a full-bore rupture could result. Puncture-leaks caused by mechanical digging equipment, or similar, may be quickly repaired by fitting repair clamps but this operation can still take many hours.

55 Corrosion normally results in small holes developing through the pipe wall - some may only be the size of pin-holes. It would be highly improbable for corrosion to develop sufficiently to cause a full-bore rupture rather than failure by leakage.

56 Mechanical failures are becoming rarer due to better material specifications, improved manufacturing controls and routine application of non-destructive examination of field welds.

57 External hazards such as ground or soil movement may be a problem in mining areas where subsidence can occur or where the pipeline route is close to mineral extraction sites and quarries.

58 During the preparation of the major accident prevention document the pipeline operator should take into account the possible knock-on effects of failure of adjacent pipelines or other plant. The failure of one pipeline in a pipeline corridor - especially those above ground - can cause damage to adjacent pipelines due to projectiles, fire or collapse of supporting structures. When preparing a plan for two or more pipelines in a corridor, it may be appropriate for the local authority to assume that the most hazardous pipeline will fail - either as the 'initiating event' or as a result of failure of an adjacent pipeline.

2.3 Probability of pipeline failure

59 The amount of reliable data on pipeline failure varies depending on the accuracy of recording past incidents and the approach taken by the pipeline operator, ie only recording loss of containment incidents or logging 'near misses' as well. However, comprehensive company based or industry specific databases do exist which can be used by pipeline operators as a basis for statistical assessment of pipeline incidents.

60 There is no single, comprehensive database that is applicable to all pipelines in England, Scotland and Wales. Much of the information used in risk assessments and safety evaluations has to be inferred from databases developed in the USA and Europe. It would not be appropriate to place too much reliance on absolute values when considering probabilities of failure, especially when looking at small populations of pipelines carrying specific fluids.

61 For these reasons, it may be more appropriate for the pipeline operator to provide the local authority with a combination of the results of statistical assessments and qualitative judgement, based on experience, and which takes into account the particular features and circumstances of the pipeline and its route.

2.4 Size and duration of pipeline leaks

62 There is only one kind of failure that is relevant - a leak (whether it has already happened or threatened by, for example, severe external damage or a fire acting on a pipeline). However, the magnitude of any leak is crucial and may range from a pin-hole to rupture of a pipeline (a full-bore rupture or full-bore equivalent rupture).

63 The potential fluid loss and duration of the leak may be influenced by a number of factors, including the extent of damage, the nature of the fluid (eg a compressible gas or an incompressible liquid), pipeline dimensions, location of shut-off valves (but see 'Important Note' after paragraph 34), the topography of the pipeline route and time for pipeline operator personnel to be mobilised and arrive on site.

64 When a high pressure gas pipeline fails, immediate and rapid depressurisation (over a matter of seconds) is followed by relatively stable flow as the pipeline 'unpacks' due to the leak, and the continued pumping of gas into the pipeline, which may last for some hours.

65 For flammable gases there can be a sequence of events starting from immediate ignition, to delayed local ignition, through delayed remote ignition, to no ignition at all. Each can have different consequences, hazard ranges and durations but there is an inter-dependency and for this reason time-scale and sequence should be considered.

2.5 Hazards and effects of pipeline failure

66 The following considers the more likely hazards and effects or consequences of pipeline failure but an incident may involve a combination of two or more of these effects, eg the failure of a high pressure, toxic, flammable gas pipeline.

2.5.1 Fire and explosion

67 The majority of major accident hazard pipelines carry fluids which are flammable. The ignition of any release can have serious effects and may involve little opportunity for escape. People indoors may be shielded from the effects of the thermal radiation, but the radiation levels may be sufficiently large to cause buildings to catch fire.

68 Any failure of such pipelines carries the risk of ignition of the fluid but experience has shown that in the majority of cases ignition does not occur.

69 If a release of a gas or vapour is not ignited immediately it will form a cloud which may disperse over large distances. As it disperses it will be diluted with air, the concentration will fall below the lower flammability limit, and then will no longer present a fire hazard. The distance over which such a release may disperse depends on the type of release and the prevailing weather conditions. Concentrations and duration may be estimated using computer models which combine a plausible physical description of cloud behaviour with data obtained from experiments and actual events.

70 If a developed cloud is ignited it may burn as a flash fire back to the point of failure. If a release is ignited immediately it may burn as a jet flame or pool fire. Techniques are available for estimating the quantity of fluid released over time and the size and expected thermal radiation from jet fires and pool fires.

71 Vapour cloud explosions, following a massive release of volatile fluid or a boiling liquid expanding vapour explosion (BLEVE) are low probability, severe consequence events which may occur with certain fluids under certain conditions. Methods are available for estimating the size of a vapour cloud explosion or BLEVE fireball and the levels of thermal radiation at various distances from the fireball. The blast over-pressure and its effects on people and buildings can be calculated.

72 A number of scenarios may have to be considered:

- lighter than air and heavier than air releases;
- immediate ignition of the escaping fluid (explosion/flash fire/jet fire);
- delayed ignition (explosion);
- gas/vapour cloud migration; and
- thermal radiation effects on people and buildings, including duration of exposure.

2.5.2 Toxic effects

73 The consequences of toxic releases may be more difficult to predict than those of flammable releases because they are more time dependent and variable according to distance and weather conditions. Pipeline operators should be able to estimate the concentrations and durations of toxic gas and vapour clouds at various distances downwind of the release point for a range of different leak sizes. This information may then be used with hazardous dose data to deduce the distances at which toxic effects might be expected and hence the area in which appropriate emergency response would be needed.

74 Theoretical predictive processes tend to err on the side of safety and may over-estimate the consequences. In practice a high proportion of the people apparently at risk may not be seriously harmed because:

- gas concentrations indoors are less than those out-of-doors, unless the exposure is prolonged;
- any upward draught may cause the gas cloud to dissipate rapidly, especially if the release is accompanied by a fire; and
- physical features along the pipeline route, eg a hill between the pipeline and nearby populated areas, may reduce the risk by interfering with the gas travel. Tall vegetation may absorb gases (eg chlorine) and also increase the dispersing turbulence in the air.

75 A major failure resulting in the release of a large quantity of a toxic gas is a low probability event but the consequences could be very severe for people living close to the incident and in the path of the cloud. The role of the emergency services would be rescue, treatment of the injured, making safe the affected area etc.

76 The major difference between releases of toxic and flammable fluids is that toxic clouds tend to be hazardous down to a much lower concentration than flammable clouds and, therefore, may remain hazardous over greater distances, while travelling with the wind - some toxic gases may travel several kilometres from the point of leakage before becoming sufficiently diluted not to adversely affect people nor to be noticeable (eg hydrogen sulphide can be detected at extremely small concentrations). The best course of action might be NOT to attempt evacuation, with people in the area being kept indoors, with windows and doors closed until the toxic cloud has passed. They should then be told to open all doors and windows and to go outside. However, for those exposed to a prolonged release, the chances of survival would diminish with the passing of time.

2.5.3 Blast effects and projectiles

77 The pressure-blast at the time of failure can be significant in close proximity to the pipeline but its serious effects may quickly diminish with distance. In the event of a major failure the pipeline cover material, including soil, rocks, hard-core etc, will be thrown at high velocity into the air. There is also the possibility of considerable damage to window glass due to blast effects.

78 The stored energy in pipelines conveying gas can be an important factor in the hazard potential of the fluid. The failure of a pipeline carrying a liquid will have a much lower blast effect owing to the incompressible nature of liquids. Gases conveyed as liquids and liquids with dissolved gases will have an intermediate effect.

2.5.4 Cryogenic effects

79 The sudden release of certain fluids (eg ethylene) may cause severe local cooling of the atmosphere and any person caught in the cloud of released gas may suffer ‘cold burns’ or damage to the lungs. However, these kinds of release can be highly visible and people are not likely to enter the affected area.

2.5.5 Asphyxiation

80 The release of large amounts of gas or vapours (even non-toxic substances) at high concentrations could cause asphyxiation due to the exclusion of oxygen. However, these conditions may only exist in close proximity to the point of failure.

2.5.6 Noise

81 The release of high pressure gas creates a great deal of noise, which can be very intense and may cause damage to people's hearing, albeit temporarily. A major failure of a high pressure gas pipeline in a suburban area may result in large numbers of people seeking medical attention for hearing problems. High noise levels can be very disorientating and may cause unexpected behaviour in people affected in this way.

2.6 Hazard range and emergency planning distance

82 Hazard range is the maximum distance from the pipeline within which the surrounding population could suffer a specified level of harm in the event of a release of pipeline fluids following a pipeline failure.

83 The definition of hazard range does not take into consideration the probability or likelihood of an event occurring and, although the full hazard range need not be taken into account for detailed emergency planning, the emergency services should be advised of the possible need to extend the emergency response and to ensure, where necessary, they can summon extra assistance and other resources for very low frequency major accidents.

84 The emergency planning distance is that distance where a detailed emergency plan has to be prepared for the worst credible, or reference, accident and should be agreed by the local authority and pipeline operator.

85 Pipeline operators will provide emergency planners with an indication of hazard ranges and emergency planning distances as a result of preparing the MAPD.

86 The pipeline operator should provide information on the risks to an individual of a specified level of harm for which a detailed emergency plan would be required. However, it is recognised that not all major accident hazard pipelines may have had full quantified risk assessments carried out.

Note: The individual risk for a specified level of harm is set at 1.0 cpm (chances per million) of receiving a 'dangerous dose' (see Glossary), or worse, (or in the region of 0.3 cpm, which is the reference value for vulnerable or large populations) suggested by HSE[7] as the level of risk below which risks are considered trivial and for which detailed emergency plans need not be prepared.

87 For suburban or thick-walled pipelines, which generally would not be likely to rupture but could leak, the use of risk assessment may not provide an adequate emergency planning distance. These areas should be discussed with the pipeline operator and the emergency services and for them to consider the nature of the substance and its behaviour on release, even in small quantities.

88 Local authorities, in discussion with pipeline operators and the emergency services, may advocate a 'generic' approach to detailed emergency planning distances and use a multiple of the proximity distance as defined in IGE/TD/1[8] for rural pipelines conveying dry natural gas or PD 8010 Part 1[9] for other substances.

Note: Access to relevant information from references 8 and 9 (also see paragraph 93) can be obtained by the local authority from the pipeline operator.

89 All the above highlights the importance of the liaison between the operator and the local authority over details such as the nature and characteristic behaviour of likely pipeline releases of various types which can be specific to the fluid and its physical properties, its pressure and temperature in the particular pipeline.

2.7 Worst credible, or reference, accidents

90 Pipelines should be designed, built and operated to reduce, to as low as reasonably practicable, the risks of failure. In general, pipelines are built to recognised codes and standards, for example British Standards Institution Codes of Practice, Institution of Gas Engineers Recommendations and Institute of Petroleum Model Code of Safe Practice.

91 However, even if a pipeline is designed, built and operated properly there remains a residual risk of a major accident which is due to the potential release of large quantities of dangerous fluids which are carried in the public domain. This risk is present along the whole length of the pipeline, although it may vary considerably, depending on location, pipeline design specification and whether or not special safety measures have been taken.

92 Wherever possible, pipeline routes are selected to be remote and away from areas of high population density, particularly when the transported fluid is a flammable or toxic gas. However, many pipelines do pass through suburban areas which may include extensive development such as residential estates, schools and shops. Historically, gas pipelines in suburban areas, or areas where there may be a greater concentration of people (eg at road and rail crossings), are designed to operate at lower stress levels than in rural areas. Typically, the stress is kept below a level where it would be very unlikely that a pipeline rupture would occur if the pipeline became damaged or otherwise deteriorated.

93 During the preparation of a detailed emergency plan it would be appropriate to consider the following as examples of worst credible, or reference, accidents:

- a pipeline in Class 1 locations (PD 8010 Part 1) or Type R areas (IGE/TD/1) with a design factor of 0.72 or less, operating at its maximum allowable operating pressure and which could fail catastrophically, ie by rupturing. In this case, the emergency planning distance could be defined by an individual risk level of 1 cpm of receiving a dangerous dose, or worse, for a population density not exceeding 2.5 persons per hectare and 0.3 cpm for vulnerable populations;
- a pipeline in Class 2 locations (PD 8010 Part 1) or Type S areas (IGE/TD/1) with a design factor of 0.3, or less, operating at its maximum allowable operating pressure, which is unlikely to fail catastrophically by rupturing but may leak through a hole in the pipewall. In this case, the emergency planning distance could be defined by an individual risk level of 0.3 cpm of receiving a dangerous dose, or worse.

Appendix 1

Extracts from Pipeline Safety Regulations 1996 and Guidance Publication L82

To assist the reader, regulations 25 and 26 from the Pipelines Safety Regulations 1996 (PSR) are reproduced below, together with extracts from the relevant sections of the supporting guidance document L82.

Regulation 25 - Emergency plans in case of major accidents

(1) A local authority which has been notified by the Executive that there is, or is to be a major accident hazard pipeline in its area shall before the pipeline is first used or within 9 months of such notification, whichever is later, and subject to paragraph (5), prepare an adequate plan detailing how an emergency relating to a possible major accident in its area will be dealt with.

(2) In preparing the plan pursuant to paragraph (1) a local authority shall consult the operator of the pipeline, the Executive and any other persons as appear to the authority to be appropriate.

(3) A local authority which has prepared a plan pursuant to paragraph (1) shall, as often as is appropriate and, in any case, at least every three years review the plan and make such revision as is appropriate.

(4) The operator of a major accident hazard pipeline shall ensure that every local authority through whose area the pipeline will pass is furnished promptly with such information as it may reasonably require in preparing the plan referred to in paragraph (1).

(5) It shall be deemed to be sufficient compliance with the requirement in paragraph (1) as to the time by which a plan is to be prepared, where such time is exceeded by reason of waiting for information referred to in paragraph (4) which has been promptly required.

(6) Where a pipeline passes or is to pass through the areas of two or more local authorities the duties under this regulation may be discharged by them where they prepare a single plan.

Extract from Guidance L82

Local authorities at county or equivalent level, once notified of a pipeline by HSE, are required by this regulation to prepare an emergency plan for each major accident hazard pipeline passing through their area. The requirement under these Regulations is for emergency plans which should specifically relate to the protection of the health and safety of people, not environmental damage.

Though local authorities will already have general emergency plans, it will be necessary to have either pipeline specific plans or to include specific reference to each major accident pipeline and how their emergency arrangements are integrated into the existing emergency provisions in the area covered by the authority.

It is intended that emergency plans should only be drawn up or amended after consultation with bodies who may be able to contribute information or advice. In all cases this will include the emergency services (fire, police and ambulance), hospitals, the pipeline operators and HSE. Other bodies to be consulted will depend on

circumstances and could include adjacent local authorities through whose area the pipeline passes, government departments dealing with agriculture, the Environment Agency or its Scottish equivalent, the Scottish Environment Protection Agency, and companies providing water services.

Full liaison and effective two-way flow of information is required between the pipeline operator and the local authority. Information from the pipeline operator is needed to enable the authority to draw up the emergency plan, and information from the authority should be available to the pipeline operator to assist in the preparation of the pipeline emergency procedures so as to achieve dovetailing between the pipeline emergency procedures and the local authority's emergency plan.

The pipeline operator should provide information about the type and consequences of possible major accidents and the likely effects. Information should also be provided on the route of the pipeline, the fluid conveyed and the operating conditions, location of shut-off valves and emergency control arrangements.

In the event of an incident involving a pipeline, it is important there is effective communication between the emergency services and pipeline control centre.

The emergency plan should be a written document, in a format which can be used readily in emergencies, and kept up to date to reflect changes in risk, procedures, hardware and personnel. The authors of the plan must address all relevant aspects including the following:

(a) the types of accidents to people to be taken into account;
(b) organisations involved including key personnel and responsibilities and liaison arrangements between them;
(c) communication links including telephones, radios and standby methods;
(d) special equipment including fire-fighting materials, damage control and repair items;
(e) technical information such as chemical and physical characteristics and dangers of the fluids conveyed;
(f) information about the pipeline including route of the pipeline, location of shut-off valves and emergency control arrangements;
(g) evacuation arrangements;
(h) contacts and arrangements for obtaining further advice and assistance, eg meteorological information, transport, first aid and hospital services, water and agricultural information;
(i) arrangements for dealing with the press and other media interests.

Since an incident involving a pipeline could occur at any point along its length, it is often inappropriate to provide location-specific advice along the whole length of the pipeline. The plan is likely to focus on those parts of the pipeline which are vulnerable to damage such as road, rail and river crossings and other areas of higher risk. Pipeline plans for this reason are likely to be generic and flexible in nature.

In discharging their duties, local authorities must take reasonable steps to ensure that they are preparing plans which will prove adequate in the event of major accidents. This will involve checking and testing the various components of each plan during its development.

The local authority shall review, and where necessary, revise and update the plan at suitable intervals so that it can be relied upon to work effectively in an emergency. The maximum interval for review should be every three years.

For existing pipelines, local authorities are allowed 18 months from notification of the pipeline to prepare the major accident hazard emergency plans (see regulation 27(6)).

For all new pipelines, the plan is required before the pipeline is brought into use, or within nine months of notification of the pipeline to the local authority by HSE, whichever is the later.

Regulation 26 - Charge by the local authority for a plan

(1) A local authority which prepares, reviews or revises a plan pursuant to paragraph (1) or (3) of regulation 25 may charge a fee, determined in accordance with paragraphs (2) to (4), to the operator of the pipeline to which the plan relates.

(2) A fee shall not exceed the sum of the costs reasonably incurred by the local authority in preparing, reviewing or revising the plan and, where the plan covers pipelines of which there are more than one operator, the fee charged to each operator shall not exceed the proportion of such sum attributable to the part or parts of the plan relating to his pipelines.

(3) In determining the fee no account shall be taken of costs other than the costs of discharging functions in relation to those parts of the plan which relate to the protection of health or safety of persons and which were costs incurred after the coming into force of these Regulations.

(4) The local authority may determine the cost of employing a graded officer for any period on work appropriate to his grade by reference to the average cost to it of employing officers of his grade for that period.

(5) When requiring payment the local authority shall send or give to the operator of the pipeline a detailed statement of the work done and costs incurred including the date of any visit to any place and the period to which the statement relates; and the fee, which shall be recoverable only as a civil debt, shall become payable one month after the statement has been sent or given.

Extract from Guidance L82

This regulation enables the local authorities who are responsible for preparing and keeping up-to-date emergency plans required under regulation 25 to recover the cost of undertaking this work from the pipeline operator.

The local authority may only recover costs that have been reasonably incurred. There may be locations where several pipelines are co-located, so the local authority may decide to prepare one emergency plan covering all the pipelines. In such an event each pipeline operator should be charged for only that part of the costs which can be attributed to the pipeline under his control.

The charge made may only be for the cost of preparing the plan itself, and of any changes necessary to keep it up to date. It does not cover the cost of emergency equipment (eg fire appliances) considered necessary for the operation of the plan. Furthermore, the charge should relate only to those parts of the emergency plan concerned with the health and safety of people, not with environmental damage.

The charge made should be based on the time spent by officers of appropriate grades. The average costs of their employment overheads as well as salary may be taken into account.

In presenting a charge to a pipeline operator, the local authority should provide an itemised, detailed statement of work done and cost incurred. Any dispute arising over the charge has to be decided in the civil courts. HSE has no enforcement role for the recovery of cost incurred by a local authority in respect of emergency planning.

Appendix 2

Sample format of letter used to notify local authorities of a pipeline

HAZARDOUS INSTALLATIONS DIRECTORATE
Unit: (to be inserted) - Head of Unit: (to be inserted)

To: County (or Regional) Emergency Planning Officer (as appropriate)

Your Ref:

Our Ref:

Date:

Dear Sir

HEALTH AND SAFETY AT WORK ETC ACT 1974
THE PIPELINES SAFETY REGULATIONS 1996, SI 1996 NO. 825
REGULATION 25: EMERGENCY PLANS IN CASE OF MAJOR ACCIDENTS

Regulation 25 of the Pipelines Safety Regulations 1996 (PSR) places a duty on each local authority (as defined) to prepare an adequate emergency plan relating to major accident hazard pipelines within its area. To help you in discharging that duty, I am enclosing details of a major accident hazard (MAH) pipeline which is to be constructed in your area.

The enclosed details are copied from information supplied to HSE by the pipeline operator, as required by regulations 20 and 22 of PSR.

We have supplied the name of the pipeline, the fluid for which the pipeline is notified, the operator's name and address and a contact within the operator's organisation.

We advise you to contact the pipeline operator for the further details necessary to be able to draw up an emergency plan as required by regulation 25 of PSR.

If you have any queries about the pipeline information enclosed, or about your duties under the Regulations, please contact the undersigned. HSE guidance on the Regulations has been published as L82 *A guide to the Pipelines Safety Regulations 1996*. In addition, you may find the following guidance booklet of help (although not written specifically with pipelines in mind): HSG191 *Emergency planning for major accidents*. Both priced publications are available from HSE Books, PO Box 1999, Sudbury, Suffolk CO10 2WA.

HSE's website **www.hse.gov.uk** has additional information on MAH pipelines, and further guidance on emergency plans for these, on its Pipelines Topic page.

Confirmation of this notification is being sent to the pipeline operator.

Yours faithfully

<>

HM Principal Inspector of Health and Safety

Appendix 3

Content and structure of pipeline emergency plans - an example

The following gives an example of the structure and kinds of information that may be included in a pipeline emergency plan. Emergency planners should consider this as a guide only and may choose alternative layouts and adjust the content to suit their own policy, approach (eg generic plans for pipelines) and other local circumstances. It is recognised that some local authorities will have already addressed many of the issues listed below - in a wide variety of structures and planning approaches. Provided suitable cross-referencing is included it should not be necessary to repeat such details in pipeline plans themselves (see paragraphs 23 and 27 in the main text).

Documentation

A pipeline emergency plan should include:

- a title page;
- the plan copy number;
- amendment details;
- distribution list;
- contents page.

Plans should be kept up to date and arrangements should be in place to update and amend the documentation as necessary.

Introduction

The introduction should cover:

- the legislative background;
- the aims and objectives of the plan;
- how the plan interfaces with adjacent local authority plans if a pipeline crosses borders and with pipeline operator emergency procedures.

Pipeline or pipeline system details

This section should include:

Pipeline operator details:
- name of the operator;
- address;
- contact name;
- control centre address and contacts;
- key personnel and their roles, including contractors used by the pipeline operator;
- organisation chart.

Pipeline details:
- pipeline route maps;
- name of the conveyed fluid;
- location of above-ground sections, where appropriate;
- pipeline operating pressure;
- pipeline diameter;
- name and location of industrial sites (eg COMAH sites) connected by the pipeline, where appropriate.

Hazard and risk

This section should contain details of the nature of the hazard and risk including:

- a description of the conveyed fluid, how it is conveyed (as a liquid, gas or mixture) and its physical and chemical properties (together with details of access to emergency chemical advice);
- the range of possible major accidents together with an assessment of the likelihood of their occurrence and their effects;
- relevant topographical features and meteorological information and their effects in the event of a pipeline failure, where appropriate.

Plan activation

This section should explain how to activate an emergency plan, including:

- the likely mechanisms for initial alerts, eg pipeline operator, members of the public, farmers etc;
- an 'alerting' flow chart or list of actions to be followed;
- the mechanism for triggering the plan;
- any action to be taken by:
  - the pipeline operator;
  - the fire service;
  - the police, including traffic control;
  - the ambulance service;
  - the health authority;
  - local authorities;
  - etc;
- any stand-down procedure.

Organisation

This section should give details of:

- the command structure;
- roles and responsibilities of the pipeline operator, police, emergency services, local authorities, health authorities, HSE, utilities, port authorities, Meteorological Office etc;
- any co-ordination arrangements, including arrangements with the pipeline operator and other local authorities;
- any implementation procedures.

Incident control points and communications

The plan should:

- describe how emergency service rendezvous points, incident control points and forward control points would be selected in the event of a pipeline emergency;
- describe the communication facilities available to the emergency services, local authorities, pipeline operator etc, for example:
  - government telephone preference system;
  - access overload control;
  - communication charts;
  - radio facilities etc;
- detail any known communication 'blind spots'.

Support services

This section should give details of all support services and resources available from:

- the pipeline operator, its contractors and industry-pooled resources;
- local authorities;
- voluntary organisations;
- government departments and agencies eg:
  - Health and Safety Executive;
  - Department for Environment, Food and Rural Affairs;
  - Environment Agency;
- the utilities, eg gas, electricity, water, sewage, drainage, telephone etc;
- the Association of British Insurers.

Medical facilities and response

This section should detail the medical facilities and responses that may be required, in agreement with the ambulance service. Information on the pipeline fluids and potential effects on people's health and safety should be distributed to designated hospitals. Reference should be made to arrangements for temporary mortuaries or body-holding areas.

Public information and protection

In this section areas at risk along the pipeline route should be identified and the following considered:

- areas of special concern, eg schools, hospitals, homes for the aged etc;
- how warnings are given, paying attention to possible panic, distress, confusion, language barriers etc;
- cross-references to local rest centre plans and evacuation plans.

Informing the media

This section should explain the arrangements for informing and handling the media, including the issuing of statements. The importance of this aspect must not be under-estimated. Poor liaison can cause serious difficulties during any incident and may lead to unfavourable comment.

Environment

Although the requirement for emergency plans under the Pipelines Safety Regulations is specifically directed towards protecting the health and safety of people, consideration should be given, by local authorities, to possible environmental consequences of a major pipeline accident and which may be addressed in the plan. Arrangements should be in place to alert or inform those who have responsibilities for the protection of the environment, water supplies etc.

Appendices to the plan

These may include:

- a telephone directory for the pipeline operator(s), emergency services and their control centres, other local authorities, utilities, government departments and agencies, HSE offices, port authorities, water authorities, railway companies, media contacts, Meteorological Office, Association of British Insurers Mobile Emergency Unit etc;

- a list of all major accident hazard pipelines covered by the plan;
- maps of the pipeline route with details of emergency planning distances, hazard distances, potentially vulnerable locations etc;
- details of the arrangements for obtaining lists of streets and roads, where appropriate;
- locality details, including:
  - significant places and contact details, eg schools, hospitals, homes for the aged etc;
  - industrial premises contact details;
  - population figures and other relevant data;
- organisation charts;
- weather information and local details;
- sample of the public information package; and
- proformas, events log etc.

Glossary

Boiling liquid expanding vapour explosion (BLEVE) - this may occur if a pipeline carrying gas in liquid form is engulfed in fire. If a section of the pipeline is isolated the pressure may rise as the liquid boils. If the pipe wall weakens due to heat and ruptures then the pipeline contents will be explosively released. If the fluid is flammable, instantaneous ignition occurs, producing a fireball.

Dangerous dose - a result of heat, toxic gas or vapour, or explosive over-pressure which gives rise to all of the following effects:

- severe distress to almost everyone;
- a substantial fraction of the affected population requiring medical attention;
- some people seriously injured; and
- some susceptible people may be killed.

Design factor (f) - as with most engineering systems a factor of safety is applied to pipelines - this is known as the design factor - and may have a significant contribution when deciding on the route of a pipeline.

The design factor is the relationship between the maximum stress allowable at a particular location and the specified minimum yield strength of the pipe material. [The specified minimum yield strength of a pipe is not the point at which a pipe section would fail catastrophically, ie the ultimate tensile strength, but that stress which would cause a section of pipe material to elongate by 0.5% of its original length. For example, for most steels used in gas transmission pipelines the ultimate tensile strength is between 15%-70% greater than the specified minimum yield strength.]

For most pipelines on land the calculation of stress levels in the pipe wall is generally confined to those stresses resulting from the internal pressure of the fluid.

Currently, the design factor for pipelines in open country (or 'rural') is limited to a maximum of 0.72. Where pipelines approach built-up areas this generally reduces to 0.3 for gas pipelines but higher values up to 0.5 may be allowed for gas pipelines designed to IGE/TD/1[8] if the nominal wall thickness is not less than 19.1 mm or if additional external protection is afforded or if a safety evaluation is carried out. Pipelines in heavily built-up areas (ie town and city centres) are limited to 7 barg operating pressure and the design factor becomes almost irrelevant.

The 0.3 design factor was selected by analysis of experimental data obtained from pipeline failure tests. It was found that pipelines with a design factor of 0.3 or less would generally not fail by long-running fractures - they would tend to leak rather than rupture (the 'leak before break' principle).

Easement - a right of way for the construction, maintenance and operation of a pipeline.

Emergency planning distance - is that distance within which detailed emergency plans are prepared.

Fireball - the burning of a flammable gas or vapour cloud, the bulk of which is initially over-rich (ie above the Upper Flammable Limit). The buoyancy of the hot combustion products may lift the cloud from the ground, forming a mushroom-shaped cloud. Combustion rates are high and the hazard is primarily due to thermal effects.

Flash fire - the burning of a flammable vapour cloud at very low flame propagation speed. Combustion products are generated at a rate low enough for expansion to take place easily without significant over-pressure ahead of or behind the flame front - the hazard is, therefore, primarily due to thermal effects.

Hazard - the potential to cause harm.

Hazard range - the distance from the pipeline within which the surrounding population could suffer a specified level of harm in the event of release of pipeline fluids following loss of containment. The hazard range may be a function of a variety of factors including the pressure in the pipeline, the nature of the fluid, local topography and weather conditions and magnitude of the failure.

Proximity distance [also known as building proximity distance or minimum building distance] - is the distance from the pipeline within which it is recommended that there are no occupied buildings. It is assumed that no occupied development will be permitted upon the easement - the easement or wayleave being the land over which the pipeline operator has contractual control. The proximity distance may be related to the pipeline maximum allowable operating pressure, pipeline diameter, pipe wall thickness (in suburban areas) and the results of a safety evaluation.

Risk - a function of the probability (or likelihood) of harm actually occurring and the severity of its consequences.

Risk assessment - the identification of the hazards present and an estimate of the extent of the risks involved, taking into account any precautions that may have been taken or other mitigation measures.

Rural area - an area through which a pipeline passes where the average population density is 2.5 persons per hectare or less.

Suburban area - an area through which a pipeline passes where the average population density exceeds 2.5 persons per hectare and which may be extensively developed with residential properties, schools, shops etc.

References

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8 *Recommendations on transmission and distribution practice. Steel pipelines for high-pressure gas transmission* IGE/TD/1 (Fourth edition) Institution of Gas Engineers 2001 ISBN 0 7177 0118 2

9 PD 8010-1:2004 *Code of practice for pipelines. Steel pipelines on land* British Standards Institution 2004 ISBN 0 580 43951 8

10 *Emergency planning for major accidents: Control of Major Accident Hazards Regulations 1999 (COMAH)* HSG191 HSE Books 1999 ISBN 0 7176 1695 9

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