ENGINEERING STANDARD

FOR

RAIN AND FOUL WATER DRAINAGE OF BUILDINGS

ORIGINAL EDITION

JAN. 1995

This standard specification is reviewed and updated by the relevant technical committee on Oct. 1999(1), Dec. 2006(2) and Jan. 2016(3). The approved modifications are included in the present issue of IPS.

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FOREWORD

The Iranian Petroleum Standards (IPS) reflect the views of the Iranian Ministry of Petroleum and are intended for use in the oil and gas production facilities, oil refineries, chemical and petrochemical plants, gas handling and processing installations and other such facilities.

IPS are based on internationally acceptable standards and include selections from the items stipulated in the referenced standards. They are also supplemented by additional requirements and/or modifications based on the experience acquired by the Iranian Petroleum Industry and the local market availability. The options which are not specified in the text of the standards are itemized in data sheet/s, so that, the user can select his appropriate preferences therein.

The IPS standards are therefore expected to be sufficiently flexible so that the users can adapt these standards to their requirements. However, they may not cover every requirement of each project. For such cases, an addendum to IPS Standard shall be prepared by the user which elaborates the particular requirements of the user. This addendum together with the relevant IPS shall form the job specification for the specific project or work.

The IPS is reviewed and up-dated approximately every five years. Each standards are subject to amendment or withdrawal, if required, thus the latest edition of IPS shall be applicable

The users of IPS are therefore requested to send their views and comments, including any addendum prepared for particular cases to the following address. These comments and recommendations will be reviewed by the relevant technical committee and in case of approval will be incorporated in the next revision of the standard.

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GENERAL DEFINITIONS

Throughout this Standard the following definitions shall apply.

COMPAN:

Refers to one of the related and/or affiliated companies of the Iranian Ministry of Petroleum such as National Iranian Oil Company, National Iranian Gas Company, National Petrochemical Company and National Iranian Oil Refinery And Distribution Company.

PURCHASER:

Means the “Company” where this standard is a part of direct purchaser order by the “Company”, and the “Contractor” where this Standard is a part of contract document.

VENDOR AND SUPPLIER:

Refers to firm or person who will supply and/or fabricate the equipment or material.

CONTRACTOR:

Refers to the persons, firm or company whose tender has been accepted by the company.

EXECUTOR:

Executor is the party which carries out all or part of construction and/or commissioning for the project.

INSPECTOR:

The Inspector referred to in this Standard is a person/persons or a body appointed in writing by the company for the inspection of fabrication and installation work.

SHALL:

Is used where a provision is mandatory.

SHOULD:

Is used where a provision is advisory only.

WILL:

Is normally used in connection with the action by the “Company” rather than by a contractor, supplier or vendor.

MAY:

Is used where a provision is completely discretionary.

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0. INTRODUCTION

This Engineering Standard prescribes the limits of drains and sanitary pipework versus sewer lines and sets out general design consideration for drainage of foul water of buildings and houses and recommends minimum requirement for sanitation in places of employment.

Due to distinct placement level of the drains (below ground) and the sanitary pipework (above ground), this Standard is presented in two Parts:

BUILDING DRAINAGE	**(IPS-E-CE-390)**
SANITARY PIPEWORK	**(IPS-E-AR-342)**

1. SCOPE

This Standard sets out the minimum requirments for the design and layout of foul sanitary wastes and surface water drainage systems constructed in the ground under and around buildings, and their connection to sewers and open ditches separately and/or their connection to cesspools, soakaways or watercourses.

The structural design criteria are limited to drains not generally exceeding DN 300, although the other criteria are of general application.

Note 1:

This standard specification is reviewed and updated by the relevant Technical Committee on Oct. 1999. The approved modifications by TC were sent to IPS users as amendment No. 1 by circular No 98 on Oct. 1999. These modifications are included in the present issue of IPS.

Note 2:

This standard specification is reviewed and updated by the relevant Technical Committee on Dec. 2006. The approved modifications by TC were sent to IPS users as amendment No. 2 by circular No 297 on Dec. 2006. These modifications are included in the present issue of IPS.

Note 3:

This standard specification is reviewed and updated by the relevant Technical Committee on Jan. 2016. The approved modifications by TC were sent to IPS users as amendment No. 3 by circular No 473 on Jan. 2016. These modifications are included in the present issue of IPS.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

BSI	**(BRITISH STANDARDS INSTITUTION)**	
	BS 8301: 1985	"Building Drainage"
	BS EN 12056-3:2000	“Gravity Drainage System Inside Buildings. Roof drainage, Layout and Calculation”
IPS	**(IRANIAN PETROLEUM STANDARDS)**	
	IPS-E-GN-100	"Units"
	IPS-E-CE-380	"Sewerage and Surface Water Drainage System"
	IPS-E-CE-400	"Sewage Treatment"

3. DEFINITIONS AND TERMINOLOGY

For the purposes of this Engineering Standard the definitions of drainage terms used in Iranian Petroleum Industries’ Standards i.e. IPS-E-CE-380 and IPS-E-CE-400 are applicable here.

3.1 Drain

A pipe that takes foul sewage or surface water or both, from a single building or from any buildings or yards appurtenant to buildings within the same curtilage.

Note:

A drain becomes a sewer when it leaves the curtilage of the property and is connected to the public sewerage system or cesspool.

3.2 Blinding

Material that will fill the interstices and irregularities in the exposed trench bottom and, when adequately compacted will create a firm uniform formation on which to place the pipe bedding material.

Note:

Hoggin, sand, gravel, all-in-aggregate or lean concrete are commonly used.

3.3 Branch Drain

A line of pipes installed to discharge into a junction on another line or at a point of access, i.e. an access junction, inspection chamber or manhole.

3.4 Branch Vent

A ventilating pipe connected to one or more branch drains.

3.5 Discharge Unit

A unit of flow calculated for a drainage appliance so that the relative load-producing effect of its discharge can be expressed as a multiple of that unit.

Note:

The discharge unit load of an appliance depends on its rate and duration of discharge, the interval between discharges and the chosen criterion of satisfactory service. It is not a simple multiple of a rate of flow.

3.6 Inspection Chamber

A covered chamber constructed on a drain or sewer so as to provide access thereto for inspecting, testing or the clearance and removal of obstructions, and usually situated in areas subjected to light loading only.

3.7 Nominal Size (DN)

A numerical designation of the size of a pipe, bend or branch fitting, which is a convenient round number approximately equal to a manufactured dimension.

Note:

"Nominal bore" is the approximate internal diameter of a unit as declared by the

manufacturer. This quantity is quoted with units (mm) whereas nominal size (DN) is quoted without units.

3.8 Gutter

A channel alongside a road, or around the eaves of a building to collect and carry away surface water of roads, carparks and roof of building.

3.9 Gully

A drain fitting or assembly of fittings to receive surface water and/or discharge from waste pipes The top usually has a grating but may has a sealed cover.

4. UNITS

This Standard is based on International System of Units (SI) as Per IPS-E-GN-100, except where otherwise specified.

5. GENERAL DESIGN PRINCIPLES

5.1 Introduction

A drainage system should be designed, installed and maintained so as to convey and discharge its contents without causing a nuisance or danger to health, arising from leakage, blockage or surcharge.

5.2 Separate Discharge of Rainwater and Foul Water

In accordance with Iranian Petroleum Industries' code of practice, rainwater and foul water shall be discharged separately. No rainwater from roof areas shall be admitted into foul water branch discharge pipes, stacks or sewers or waste pipes for foul water, nor shall foul water be discharged via rainwater pipes or storm water sewers.

5.3 Frost Precautions Inside Buildings

Drainage systems and flushing equipment inside buildings shall be designed and installed so that they are neither damaged nor their function impaired by frost, assuming that they are used in the manner intended. See also Clause 3.6 of Part 2.

5.4 Considerations in Preparation of Drainage Layouts and Working Drawings

Access should be provided at all bends and junctions. Where a bend external to an inspection chamber or manhole is unavoidable, it should be adjacent and should provide a deviation of not more than 45°.

Bends, particularly in the smaller diameter pipes, should have a long rather than a short radius and in any case this should be sufficiently long to enable access for cleaning by the usual methods.

Inspection chambers and manholes should be sited so as to avoid the need for acute changes in direction of flow from branch drains (see Clause 6.3).

The routes selected should make full use of the natural slopes of ground or any adjustments thereto, so as to achieve design gradients with minimum excavation.

Common trenches for foul and surface water drains may prove economical in excavation. However, care is needed to ensure the stability of the shallower pipes and the spacing of pipelines should be adequate for the connections, including those which may be needed in the future. When deciding on trench arrangements the primary consideration, as in every aspect of the design process, should be the hydraulic effectiveness of the system.

5.5 Pipe Sizes

A foul drain should be of nominal size not less than DN 100 (see clause 6). A surface water drain should be of nominal size not less than DN 75, (refer to E-CE-380, Part 1). In certain cases a connection to a drain may be of smaller nominal size to suit the nature and volume of flow from a single appliance.

There may be situations where, for hydraulic reasons, a discharge pipe, designed in accordance with Part 2 of this Standard may need to be continued below ground without increase in bore to a position in a drainage system where the flow will prevent undesirable deposition of solids. Such a pipe should be laid direct to an inspection chamber or manhole without change of line or gradient.

5.6 Pipe Gradients

The choice of gradient should be such as to maintain self-cleansing velocity under normal discharge conditions (see 6.2.4.4).

5.7 Drains Laid Outside Buildings

For housing and small structures it is preferable for drains to be laid outside where provision can be made for ready detection of blockages and their removal. Pipework laid under the buildings should then be limited to short branches. A drain trench should not impair the stability of a building. When drains are laid parallel to the foundation, care should be taken that the foundations are not undermined.

Where the horizontal distance between the drain trench and the foundation is less than the depth from the underside of the foundation to the invert of the trench, the sides of the trench should be shored with members of sufficient strength to resist any horizontal or vertical movement of the foundation.

Trenches adjacent to load bearing walls within 1 m of the foundation of the wall should be filled with concrete to at least the level of the underside of the foundation. For distances greater than 1 m the concrete fill should be to a level below the underside of the foundation equal to the distance from it to the nearside of the trench, less 150 mm.

5.8 Differential Movement

Differential settlement should be accommodated by means of flexible joints. The risk of shear fracture is considerably reduced by the provision of a flexible joint located as close as practicable to the face of the structure. The length of the next pipe should not exceed 0.6 m. Where considerable differential settlement is anticipated several "rocker" pipes should be laid, and the gradient should if necessary be increased locally to reduce the likelihood of a back fall developing.

Where it is not necessary for a pipe to be built into a structure, the effects of differential movement may be overcome by the provision of a lintel, relieving arch or sleeve leaving a gap of not less than 50 mm around the pipe. To prevent the entry of gravel, rodents or gas through such gaps, glasswool or bituminized jute can be adopted.

6. FOUL DRAINAGE

6.1 Drainage to a Sewerage System

The outfall of a foul water drainage system should discharge into a foul water, but where such a sewer is not conveniently available and cannot economically be extended to a site, other methods of foul waste disposal will be necessary, either to treatment or to cesspool. For treatment methods or cesspool refer to IPS-E-CE-400.

6.2 Hydraulic Design of Foul Drains

6.2.1 Minimum sanitation requirement

a) In individual unit houses with private yard and in family dwellings within a housing complex, the minimum sanitation requirement in terms of discharge units of w.c., lavatory, shower etc. should conform with the requirements of owner.

b) In the buildings, planned as places of employment, the minimum number of toilet facilities to be provided shall be in accordance with Tables 1 and 2.

TABLE 1 - MINIMUM NUMBER OF TOILET

NUMBER OF EMPLOYEES	MINIMUM NUMBER OF SQUATTING TOILET	SITTING TOILET
1 to 9	1	1
10 to 24	2	-
25 to 49	3	-
50 to 74	4	2
75 to 100	5	2
Over 100	At least 5 and one extra for each additional 30 persons	At least 2 and one extra for additional 40 persons

TABLE 2 - MINIMUM NUMBER OF LAVATORIES

NUMBER OF EMPLOYEES	MINIMUM NUMBER OF LAVATORIES
1-50	1 For every 10 employees or portion thereof
51-100	At least10, and one extra for each additional 15 employees or portion thereof
Over 100	At least 14, and one extra for each additional 20 employees or portion thereof

6.2.2 Basic design principles

For determining drain size and gradient, the discharge unit method based on probability theory should be used for estimating a realistic peak flow so that the assessed design flow will seldom be exceeded.

6.2.3 Determination of flow

The flow rates, probability of discharge factors and discharge unit ratings of different appliances are given in Table 3. The same values are used also in Part 2 of this Standard.

TABLE 3 - FLOW RATES, PROBABILITY OF DISCHARGE FACTORS AND DISCHARGE UNIT RATINGS

APPLIANCES	CAPACITY	DISCHARGE DATA		RECURRENCE USE INTERVAL (FREQUENCY OF USE) T	PROBABILITY OF DISCHARGE $P = \frac{t}{T}$	DISCHARGE UNITS
		Flow Rate	Duration,			
WC (9L, high level cistern)	L 9	L/s 2.3	s 5	s* 1200 600 300	0.004 0.008 0.017	7♣ 14 28
Wash basin (32 mm branch discharge pipe)	6	0.6	10	1200 600 300	0.008 0.017 0.033	1♣ 3 6
Sink, double bowl (40 mm branch discharge pipe)	23	0.9	25	1200 600 300	0.021 0.042 0.083	6¨♦ 14 27
Mini tub (40 mm branch discharge pipe)	80	1.1	75	4500 (domestic) 1800	0.017 0.042	7¨♦ 18
Automatic washing Machine	180	0.7	300	15000	0.020	4
Shower	---	0.1	---	---	---	Use flow rate
Spray tap	---	0.06	---	---	---	Use flow rate
Urinal (per stall, automatic flushing)	4.5	0.15	30	1200 900	0.025 0.033	0.3

*** A use interval or recurrent interval (frequency of use) of 1200 s, corresponds to domestic use; 600 s, to commercial use; 300 s, to congested use such as in public toilets, schools and factories.**

♣ In domestic installations, the highest loading occurs during the morning peak period and is made up of the discharges from WCs, basins, and sinks. For this reason, a dwelling, is usually allotted a fixed number of discharge units for a group consisting of one each of these appliances. In this Standard 14 discharge units per dwelling is assumed (see Part 2 of this Standard).

♦ Some proportion of the total number of appliances may be assumed to be in simultaneous operation if considered appropriate.

6.2.3.1 Calculation for groups of similar appliances

The probability of discharge factor ($P = \frac{t}{T}$) can be found from Table 3 and then from Fig. 1 the probable number of similar appliances that within a group might be used simultaneously can be calculated.

Note:

This method should not be used for mixed appliances to avoid unnecessary oversizing of pipes.

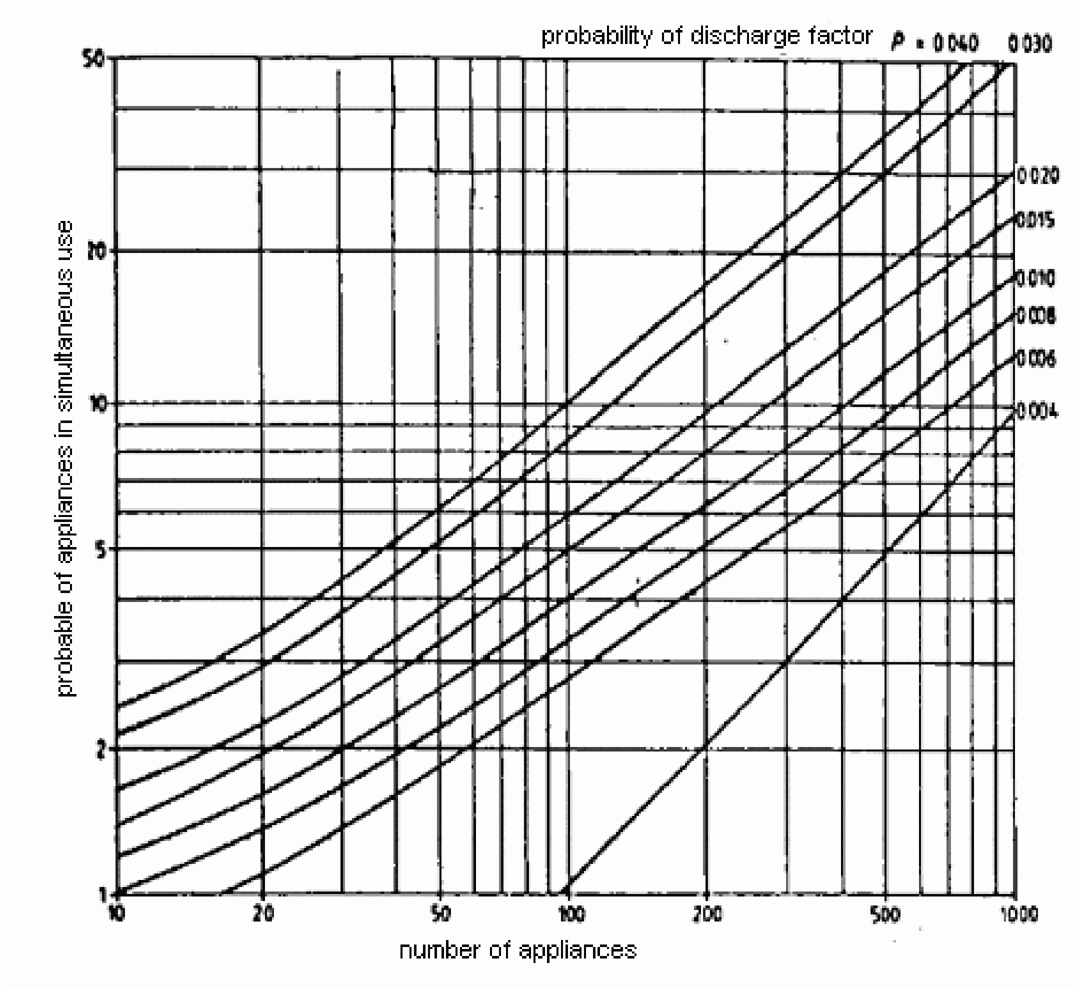
6.2.3.2 Calculation for groups of mixed appliances

For the calculations of flow in drains serving mixed appliances, discharge units are so chosen that the relative load producing effect of appliances can be expressed as multiples of the units. The discharge unit rating of an appliance depends on its rate and duration of discharge, on the interval between discharges and on the chosen "criterion of satisfactory service"*.

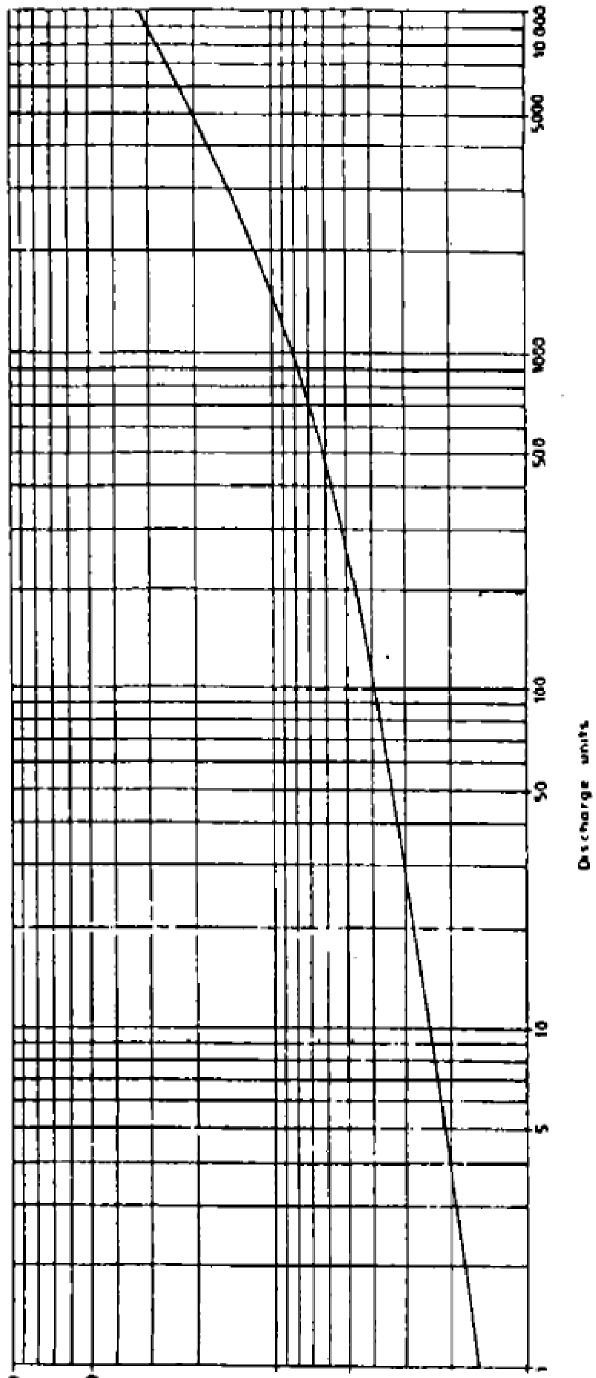
Discharge unit values for sanitary appliances in common use are given in Table 3. For other appliances the discharge unit value for each should be deduced from the data given in Table 3 for an appliance with the same trap diameter, and duration and rate of discharge.

The discharge unit values of all the appliances contributing to flow in the drain should be added, and the equivalent peak rate in L/s for this total obtained from Fig. 2. When the drain carries continuous flows from other sources, their rates can be added to the value obtained from Fig. 2.

*** The criterion of satisfactory service referred to in this Standard is 99.5 % and is defined as the percentage of time that the design discharge flow loading will not be exceeded. A graph, based on this figure, showing the number of appliances likely to be in simultaneous use for a given total is shown in Fig. 1 for different values of appliance probability of discharge (P) figures.**

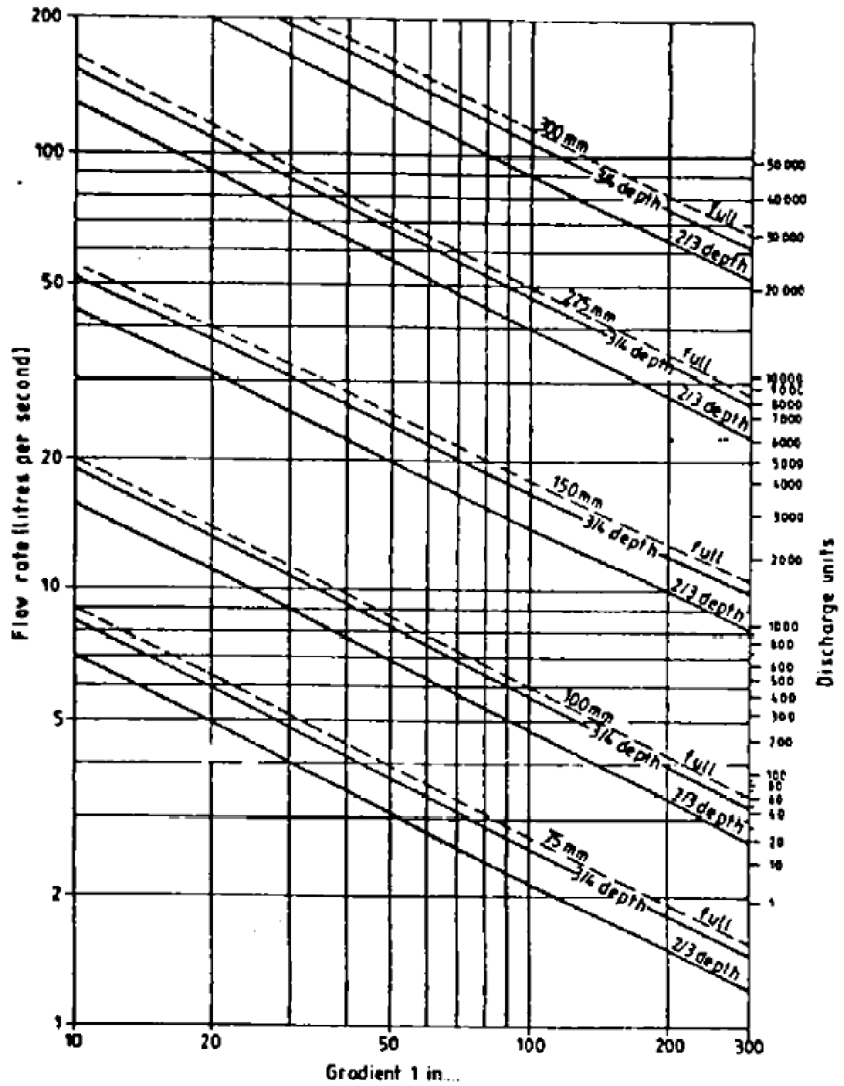


PROBABILITY GRAPH FOR NUMBER OF APPLIANCES DISCHARGING SIMULTANEOUSLY
Fig. 1



DESIGN FLOWS FOR FOUL DRAINS: CONVERSION OF DISCHARGE UNITS TO FLOW RATES

Fig. 2



DISCHARGE CAPACITIES OF DRAINS RUNNING FULL, 3/4 AND 2/3 PROPORTIONAL DEPTH: USED PIPES IN GOOD CONDITION (HYDRAULIC ROUGHNESS, k = 0.6 mm)

Fig. 3

6.2.4 Determination of Pipe Size and Gradient

6.2.4.1 General

Fig. 3 shows the discharge capacities of drains, from 75 mm to 300 mm diameter, when flowing full, and at 0.75 and 0.67 proportional depth. Using Fig. 3 and the likely peak flow rate, the designer should select a pipe diameter and gradient taking account of the factors in 6.2.4.2 and 6.2.4.3.

The design curves in Fig. 3 are based on a hydraulic roughness of 0.6 mm as defined for the Colebrook-White equation. This roughness should be suitable for intermittently used drains of all pipe materials.

Note:

For used pipes in poor condition refer to BS 8301.

6.2.4.2 Design for minimum blockage

Blockages may occur because of misuse but the risk of recurring blockages during normal use can be minimized by ensuring a high standard of drain and manhole construction throughout the system and that pipes are not unacceptably oversized.

6.2.4.3 Choice of pipe size and depth of flow

Foul drains should be of minimum size DN 100, but where waste water only is conveyed DN 75 is considered acceptable. (Excepting special bore requirements, e.g. for hospitals min. size DN 150 is preferred).

For foul drains, the size of the pipe and the gradient (see 6.2.4.4) at which it is to be laid should be so chosen that at peak flow the risk of induced trap siphonage is minimized by ensuring adequate air movement in the drain. This is usually achieved by not exceeding a proportional depth of 0.75.

6.2.4.4 Choice of gradients

Choice of gradients should be such as to maintain self-cleansing velocity under normal discharge conditions.

To achieve a satisfactory installation, diameter and gradient should be adequate for the maximum flow and competent supervision should be provided to ensure a high standard of pipe quality, laying, jointing and workmanship. This is particularly important when pipes are laid to flat gradients.

The following guidelines on gradients should be observed.

a) For flows of less than 1 L/s, pipes not exceeding 100 mm nominal bore at gradients not flatter than 1:40 have proved satisfactory.

b) Where the peak flow is more than 1 L/s, a 100 mm nominal bore pipe may be laid at a gradient not flatter than 1:80, provided that at least one WC is connected.

c) 150 mm nominal bore pipe may be laid at a gradient not flatter than 1:150, provided that at least five WCs are connected.

d) Experience has shown that for gradients flatter than those given in items (a) to (c), a high standard of design and workmanship is necessary if blockages are to be minimized.

Where this has been achieved, gradients of 1:130 for 100 mm nominal bore pipes and 1:200 for 150 mm nominal bore pipes have been used successfully.

6.3 Connections to Foul Drains

6.3.1 General

A connection to a foul drain from a sanitary appliance, a discharge stack, a gully or branch drain should, where convenient and practicable, be made to an inspection chamber or manhole. However, provided that effective access to all pipe runs is achieved for maintenance, removal of blockages and testing, it may be made to a junction.

However made, it should be so arranged that the discharge is swept in the direction of flow at the point of connection. The length of a connection from an appliance should preferably not exceed 6 m and that from a group of appliances 15 m (see clause 10).

6.3.2 Connections

For all kind of connectional details to inspection chambers or manholes, to junctions, discharge stacks etc. refer to relevant Standard Drawings.

6.3.3 Connections to an existing drain

Where it is impracticable to construct an inspection chamber or manhole for a connection to an existing drain, a junction should be inserted. Where this is impracticable a saddle may be used providing the receiving drain is at least one size larger than the branch drain and the saddle connection is made so that the flow enters above the horizontal diameter.

6.3.4 Connection to manhole

A branch connection should have an angle of entry not greater than 90 at the internal face of a manhore. Where practicable it should be installed at half pipe level of the main channel to provide a cascade entry. Where the invert level at an incoming drain is more than 60cm, a back drop to be used.

6.4 Connections to Septic Tanks, Settlement Tanks or Cesspools

Where a drain or private sewer is connected to a septic or settlement tank, the entry velocity should be restricted so as to ensure that quiescent conditions within the tank are disturbed as little as possible. In the case of an incoming drain of up to 150 mm diameter this is usually achieved by adopting a gradient not steeper than 1:50 for a length of at least 12 m immediately upstream of the tank.

Provision should be made for effectively rodding the incoming drain and its connection to a septic tank.

Information on the design of small sewage treatment works and septic tanks is given in IPS-E-CE-400.

7. SURFACE WATER DRAINAGE OF PAVEMENTS

For design of surface water drainage system beyond the curtilage of building complex property, see Part One of IPS-E-CE- 380.

8. THE STRUCTURAL DESIGN OF DRAINAGE

8.1 General

For design basis and methods of beddings for rigid and flexible pipes refer to IPS-E-CE-380.

9. PROVISION OF GULLIES AND GREASE TRAPS

For engineering and constructional details refer to standard drawings for gullies, IPS-D-CE-232 and for grease traps, IPS-D-CE-233.

10. ACCESS TO DRAINS

10.1 General

Access is required to drainage installations for testing, inspection, maintenance and removal of debris. Access to drains allowing rodding in both directions can be provided by inspection chambers and manholes, and by some access fittings whereas rodding eyes allow for rodding downstream only.

10.2 Provision of Access to Drains

The guiding principle is that every drain length should be accessible for maintenance and rodding without the need to enter buildings. Access should be provided at the head of each run of drain and at changes in direction, gradient or pipe diameter*.

Table 4 indicates the recommended maximum distance between rodding eyes, access fittings, inspection chambers and manholes. These are based on standard rodding techniques and the need for removing debris.

Where a branch drain joins another drain without the provision of an inspection chamber or manhole at the junction, access should be provided on the branch drain within 12 m of the junction.

*** For drains larger than DN 300 see IPS-E-CE-380.**

TABLE 4 - MAXIMUM SPACING OF ACCESS POINTS

DISTANCE TO	FROM ACCESS FITTING		FROM JUNCTION OR BRANCH	FROM INSPECTION CHAMBER	FROM MANHOLE
	1	2			
	m	m	m	m	m
Start of external drain**	12	12	----	22	45
Rodding eye	22	22	22	45	45
Access fitting (1) min. 150 mm × 100 mm or 150 mm Dia.	---	----	12	22	22
Access fitting (2) min. 225 mm × 100 mm	----	----	22	45	45
Inspection chamber	22	45	22	45	45
Manhole	22	45	45	45	90

**** See 6.3.1 for distance of first access point from start of drain, i.e. stack or ground floor appliance outlet.**

10.3 Rodding Eyes and Access Fittings

10.3.1 General

Rodding eyes and access fittings provide limited access and should be used in accordance with clause 10.2 and with the maximum spacing recommendations given in Table 4.

10.3.2 Rodding eyes

A rodding eye provides access at surface level for the clearance in one direction only of obstructions and debris using normally accepted manual rodding techniques. It should be constructed in pipework preferably of the same diameter as the drains it serves and should connect to the drain at an angle not steeper than 45° from the horizontal. It should preferably be carried up to ground level at the same angle to permit easy rodding and to reduce resistance to the passage of rods.

10.3.3 Access fittings

Access fittings provide for rodding in more than one direction and for testing. On a buried drain they are used in three ways:

a) as an opening in the top of the drain having a sealed cover and separate cover bedded at surface level;

b) with a raising piece terminating with a suitable cover at surface level;

c) with a sealed cover located within an inspection chamber or manhole, in which case spacings in Table 4 should be as for an access fitting.

10.4 Inspection Chambers and Manholes

10.4.1 General

Inspection chambers and manholes should be resistant to water penetration, be durable and be designed to minimize the risk of blockage. Provision to prevent flotation may be necessary.

Preformed and precast units should be installed strictly in accordance with manufacturer's instructions.

10.4.2 Dimensions

Dimensions depend on the size of the main drain and on the number, size and position of branch drains entering. The size of inspection chambers should be such that the drain can be cleaned from the surface. The design of manholes should permit entry without restricting operational space.

Subject to the minimal given in Table 5 internal dimensions for manholes with a number of branches may be estimated as follows:

a) Length

The length should be 300 mm for each DN 100 or DN 150 branch on the side having most branches plus an allowance at the downstream end for the angle of entry.

b) Width

The width should be the sum of the widths of the benching, plus 150 mm or the diameter of the main drain, whichever is the greater. The benching width should be 300 mm where there are branches or 150 mm where there is no branch.

Where manholes or inspection chambers with curved channels cannot be avoided, their dimensions should be based on the foregoing principles.

TABLE 5 - MINIMUM DIMENSIONS FOR RODDING EYES, ACCESS FITTINGS, INSPECTION CHAMBERS AND MANHOLES

TYPE OF ACCESS	DEPTH TO INVERT	Min. INTERNAL DIMENSIONS		Min. NOMINAL COVER SIZE		
		Rectangular length and width	Circular diameter	Rectangular length and width	Circular diameter	Remarks
	m	mm	mm	mm	mm	
Access fitting	0.6 or less except where situated in a chamber (see Clause 10.3)	(a)150× 100 (b)225× 100	150 ----	150 × 100 225 × 100	150 ----	The depth restriction is imposed because of the limited access afforded by these items and is based on the ability to manipulate a stopper at arm's length from the surface.
Inspection chamber *	0.6 or less	----	190 mm dia. for drains up to 150 mm dia.	----	190	The depth restriction is imposed as for the access fitting.
	1.0 or less	450 × 450	450	450 × 450	450♣	The extra internal size enables manipulation of a stopper from the surface at the increased depth.
Manhole♥	From 1.2 to 2.4	1200 × 750	1050	600 × 600	600	Larger size required for shallow manholes.
	Greater than 2.4	1200 × 750	1200	600 × 600	600	Generally in accordance with safe working in sewers and at sewage works'.
Manhole shaft (where applicable)	Greater than 2.7	900 × 840	900	600 × 600	600	Minimum chamber width 840 mm.
Rodding eye		Preferably same size as drain, but not less than 100 mm diameter		---	----	

*** A covered chamber constructed on a drain or sewer so as to provide access thereto, for inspecting, testing or the clearance and removal of obstructions, and usually situated in areas subjected to light loading only.**

♣ In the case of clayware and plastics inspection chambers the clear opening may be reduced to 430 mm in order to provide proper support for the cover and frame.

♥ A working chamber with cover constructed on a drain or sewer within which a person may inspect, test or clear and remove obstructions in safety.

Ø Minimum ¥ height of chamber in shafted manhole 2 m from crown of pipe to underside of reducing slab.

¥ The term "minimum" as used in this table refers to the smallest acceptable nominal dimension and does not exclude normal negative manufacturing tolerance below the nominal size.

11. SEWERAGE AND SURFACE WATER LIFTING INSTALLATION

Sewage lifting may become necessary where the levels of a building or site make it impracticable to provide a gravity connection to a suitable outfall or where a gravity drain would be subjected to unacceptable surcharge from the sewer. For sewage lifting installations in which the diameter of the delivery main does not exceed 150 mm refer to BS 8301:1985, Section three, but for large installations refer to IPS-E-CE-380.

APPENDICES

APPENDIX A
DRAINAGE OF ROOFS AND WALLS

A.1 SCOPE
This Appendix-A deals with the drainage of surface water from roofs and walls and recommends acceptable methods of designing gutters, gutter outlets, rainwater pipes, and inlets to gullies and discharge stack, providing the climatological conditions of the project site such as the possibilities and frequency of frosting is taken into account by the designer in the choice of the type of the roof and its rainwater (including melted snow) drainage system.

A.2 METEOROLOGICAL ASPECTS OF DESIGN
The capacity of roof and paved area drainage systems should be adequate to dispose of intense seasonal rains that usually occur in thunderstorms. Allowance should be made, where necessary, for the effect on the drainage capacity of wind concurrent with rain.

A.2.1 Design Rates of Rainfall and Categories of Risk
For drainage design of paved areas such as paved roofs,car parks or playgrounds, on which ponding can be tolerated during a heavy storm and for a few minutes after the storm has ceased, except when overflow from them will present undue risk to persons or property a design rate of rainfall of 50 mm/h is recommended.
The probability, Pr, of exceeding the chosen rate of rainfall may be assigned a value between 0.0, representing assured safety, and 1.0, representing certainty that the rate will be exceeded. For values of the return period equal to or greater than 5 years, Pr and T are approximately related by the equation:

$$P_r = 1 - \left(1 - \frac{1}{T}\right)^{L_y} \quad (\text{for } T \geq 5 \text{ years})$$

where:

- P_r is the probability of exceeding the chosen rate of rainfall;
- T is the return period (in years) of the chosen event;
- L_y is the anticipated life of the building or the period for which the contents need to be protected (in years), whichever is being used as the drainage design criterion.

For a given return period, the maximum rate of run-off will result from a storm whose duration is equal to the time of concentration, which is the minimum time for the whole area of the roof to contribute flow at the point of discharge. A time of concentration of 2 min. is considered typical for many roofs.
The designer should choose the rate of rainfall that at the chosen location has a return period equal to or greater than the recommended return period. For more design guidance refer to BS EN 12056-3:2000.

A.2.2 Wind
The recorded rates of rainfall on rain gages take no account of the driving effect of wind concurrent with the rain. Allowance for the effect of the wind is not required when designing drainage for horizontal surfaces, or for other surfaces protected from the wind by nearby objects, but such an allowance should be considered where sloping or vertical surfaces occur that are freely exposed to the wind. The angle of descent of wind-driven rain can safely be taken to be 26 to the vertical.
For method of determining the effect of wind on the run-off from pitched roofs and vertical surfaces refer to BS EN 12056-3:2000.

A.2.3 Snowfall
Although precautions are often required to prevent undue accumulation of snow on roofs, it is not necessary to allow for the removal of melted snow in sizing gutters and rainwater pipes as the maximum run-off resulting is less than the minimum recommended design rate of rainfall. Gutters and outlets may, however, become blocked by frozen snow but this can be avoided by the use of snowboards, the openings of which may be bridged by snow during heavy falls.

A.2.4 Thermal Movement for Gutters and Rainwater Pipes
Supports and fixings to gutters and rainwater pipes should allow thermal movement to take place

without leakage and, in addition, expansion joints may be necessary. The spacing of expansion joints depends upon the flexibility of the jointing material used, the method of jointing and supporting, and the coefficient of expansion of the material of which the gutter is made. For further design guidances refer to BS EN 12056-3:2000.

A.2.5 Effective Catchment Area of Run-off

The effective catchment area of a sloping or vertical surface depends upon the angle of descent of the rain. It may normally be assumed for purposes of design that the rain falls at an angle of one unit horizontal to two units vertical (26° to the vertical), and that its direction is such as to produce the maximum rate of run-off to each length of gutter.

A.2.5.1 Flat roofs and paved areas

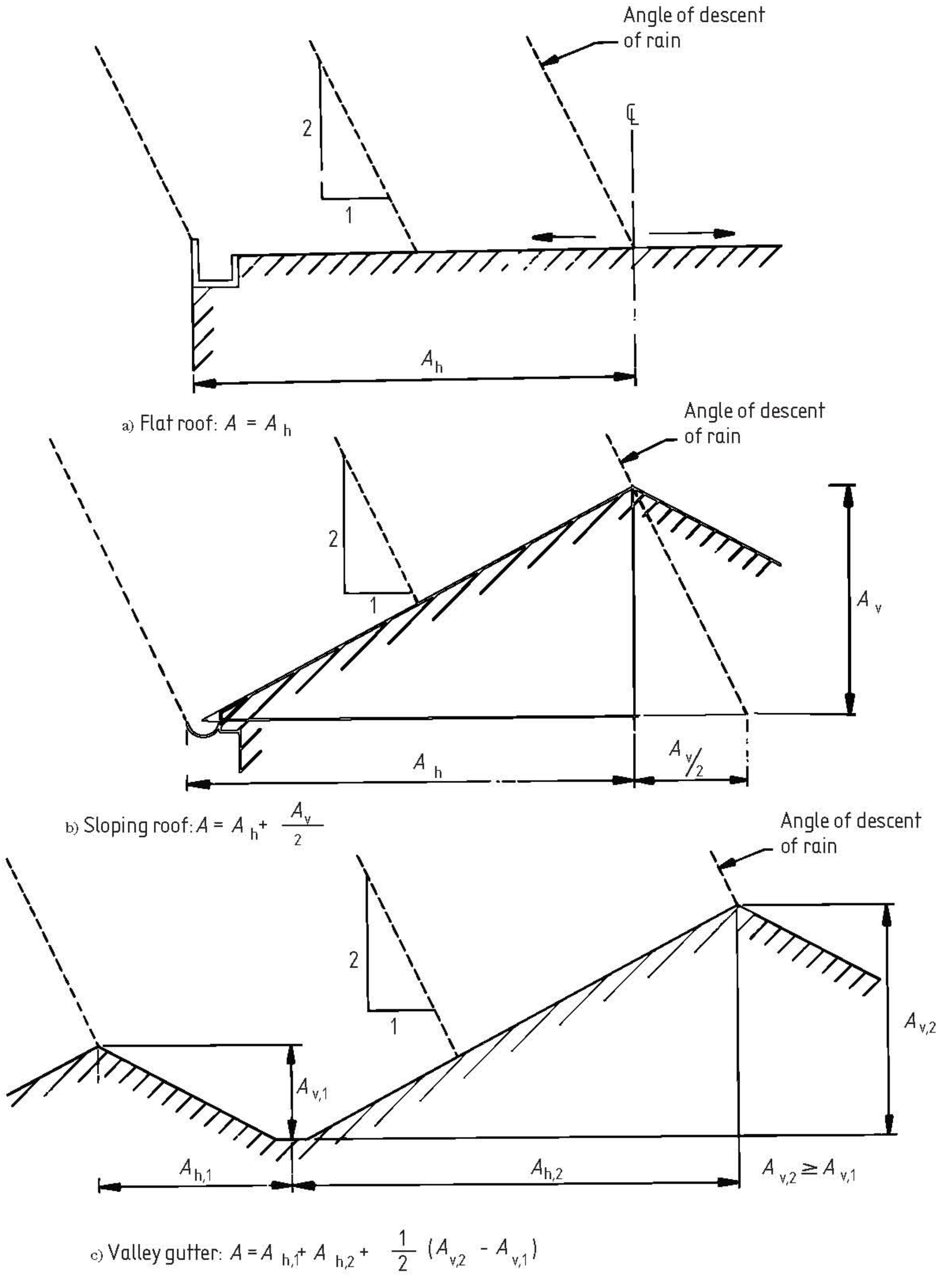
The effective catchment area, Ae, of a freely exposed horizontal surface is equal to the plan area of the surface (see Fig. 4 (a)). Where sloping or vertical surfaces drain to a flat roof or paved area, the additional area of catchment should be calculated as described in A.2.5.2 and A.2.5.3.

A.2.5.2 Sloping roofs

The effective catchment area, Ae, of a freely exposed roof draining to an eaves or parapet wall gutter is equal to the plan area of the roof, plus half its maximum area in elevation (see Fig. 4(b)).
In a valley gutter, one side of the roof will tend to be exposed to the wind and the other side will tend to be sheltered; the method of calculating the effective catchment area is illustrated in Fig. 4(c).
Run-off from any vertical walls should be allowed for (see A.2.5.3).

A.2.5.3 Vertical surfaces

Wind-driven rain will cause run-off from walls and other vertical surfaces that are freely exposed to the wind to reach a paved area. Such run-off from vertical surfaces will only need to be considered where flooding of the paved area cannot be tolerated.
Although not all the rain approaching a wall will reach a paved area however.
In designing wall-drainage the total rain approaching the wall may be used, bearing in mind that the resulting figure will normally have a large margin of safety. For the method of calculating Ae see the illustration in Fig. 5.



CALCULATION OF EFFECTIVE CATCHMENT AREA, Ae, FOR ROOFS

Fig. 4

A.2.6 Rate of Run-Off

Run-off from roofs, paved areas and vertical surfaces should be calculated assuming that the surfaces are impermeable.

The rate of run-off, Q (in L/s), is given by the equation:

$$Q = r.A_e C$$

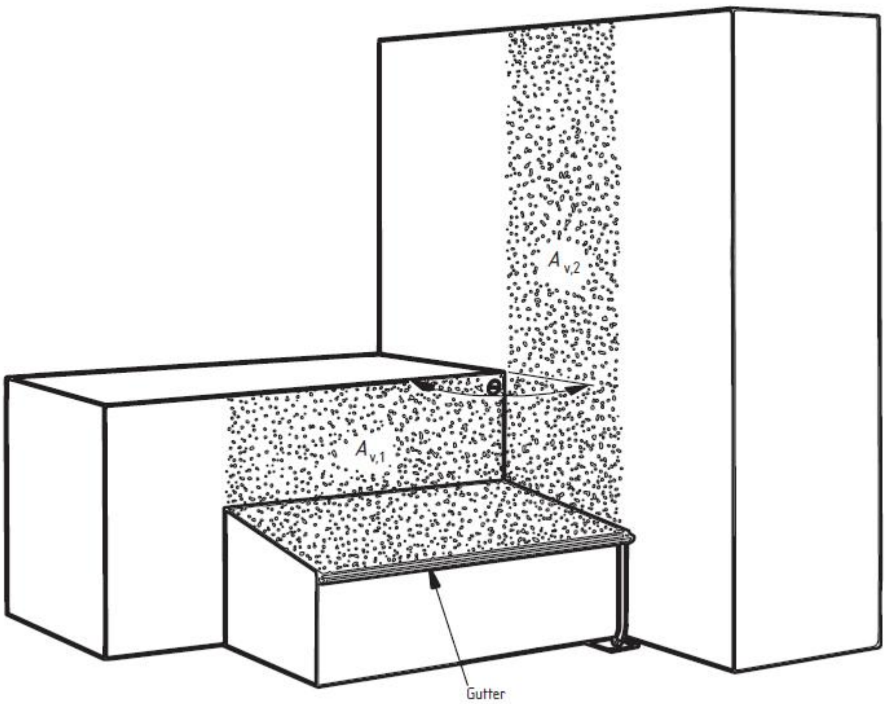
Where:

A_e is the effective catchment area in square meters (see Clause A.2.5);

r is the rainfall intensity, in liters per square meters. $(\frac{lit}{Sec.m^2})$ (see clause A.3.4.4);

C is a runoff coefficient (taken as one unless national and local regulations and practice state otherwise), dimensionless.

Any run-off occurring from unpaved areas, should be prevented from draining on to paved areas.



$$A = \frac{1}{2}\sqrt{\ }(A^2_{v,1} + A^2_{v,2} - 2A_{v,1} \cdot A^2_{v,2} \cos\theta)$$

where $A_{v,1}$ and $A_{v,2}$ are areas of the vertical walls, as shown, contributing to the flow of the gutter

CALCULATION OF EFFECTIVE CATCHMENT AREA, Ae, FOR VERTICAL SURFACES

Fig. 5

A.3 HYDRAULIC DESIGN OF ROOF DRAINAGE

A.3.1 General Principles

A roof drainage system, whether flat or pitched generally comprises of three parts:

a) the gutter or channel that collects the flow from the roof;

b) the outlet into which the flow from the gutter or channel discharges;

c) the pipework that conveys the flow from the outlet to the below-ground drainage system.

Note:

In the design practice of flat roof drainage systems, adoption of gutter can be omitted for catchment areas of up to approximately 1000 m^2, by provision of more outlets and rain water down-pipes that are installed inside the building perimeter.

The three parts of the drainage system can be designed separately if the outlet and the pipe work are made large enough for the flow to discharge freely from the gutter.

Gutters and down pipes may be omitted from a roof at any height provided that it has an area of 6 m^2 or less and provided that no roof or other surface drains on to it.

A.3.2 Method of Design of Gutters

The method of design adopted in this Standard is based on the following assumptions:

a) the gutter slope is not steeper than 1 in 350 (i.e. it is nominally level);

b) the gutter has a uniform cross-sectional shape;

c) the outlets are large enough to allow the gutter to discharge freely;

d) the distance between a stop end and an outlet is less than 50 times the upstream water depth, or the distance between two outlets is less than 100 times the water depth.

Eaves gutters should wherever possible be designed to discharge freely. For the method of calculation of flow in gutters and its other design aspects refer to BS EN 12056-3:2000.

A.3.3 Rainwater Pipes

The vertical rainwater pipes for standard eaves gutters or valley and parapet wall gutters, should have the same nominal bore as the gutter outlets to which they are connected. The horizontal lengths of rainwater pipe should where possible be given a small fall to prevent the ponding of water. Long runs of pipework need to be designed according to standard hydraulics principles for steady flow in pipes. For further details refer to BS EN 12056-3:2000.

A.3.3.1 Warming of rainwater pipes

Where the temperature of the air falls and remains below zero for appreciable times during winter season, it is recommended to warm-up the rainwater pipes and gutters by circulating hot air along its length and or to run hot water return pipes adjacent to rainwater pipes to avoid frosting and blockage of rainwater drainage system.

Note:

As far as possible use of exposed rain water down pipes should be avoided in such areas.

A.3.4 Flat Roofs

A.3.4.1 General

For the purposes of this Standard, a flat roof is defined as one having a pitch of 10 or less to the horizontal. Flat roofs should be so designed that pools of water do not remain on the roof after rainstorms.

A.3.4.2 Layout of roof

Flat roofs may be drained in two ways:

a) Towards the outer edges of the roof with falls provided by the construction of the roof.

b) Towards channels or towards several outlets within the perimeter of the roof with falls provided by screeding.

Falls are required in both cases, and minimum values should not be less than 1 in 70 in the case of (a) and 1 in 80 in the case of (b).

A.3.4.3 Location of outlets

The location of outlets of rainwater in flat roofs, preferably should be at the sunny side in order to avoid frosting of melted snow at the mouth of outlets.

In general an economic scheme will include few outlets, but the number needed may often be determined by the plan shape of the roof rather than by the area to be drained.

A.3.4.4 Rainfall intensity, r

If recorded rainfall intensities are not available, the recommended design rate of rainfall for such a roof is 0.021 $^{lit}/_{Sec.\,m^2}$ (75 mm/h), but adoption of higher rates may be required by owner if it is necessary to reduce the risk of flooding in very sensitive buildings, however more than 0.15$^{lit}/_{Sec.\,m^2}$ is not required.

The design rate of run-off from a roof should be calculated assuming that the roof is impermeable.

Allowance should be made for water that drains from adjacent roofs and vertical surfaces.

A.3.4.5 Discharge at edge of roof

Run-off from a flat roof may be discharged into:

a) An eaves gutter (see Fig. 6 (a)).

b) A chute connected to a hopper head (see Fig. 6 (b)).

The eaves gutter should be designed according to the method described in A.3.2. The entrance to a chute acts as a weir and the width that is required can be estimated from Table 6.

TABLE 6 - CAPACITY OF OUTLET WEIRS FOR FLAT ROOFS

DEPTH OF FLOW ABOVE INVERT OF WEIR	DISCHARGE PER MILLIMETER LENGTH OF WEIR Qx	AREA DRAINED PER MILLIMETER LENGTH OF WEIR AT DESIGN RATE OF RAINFALL OF 75 mm/h
mm	L/s	m^2
5	4.66×10^{-4}	2.24×10^{-2}
10	1.32×10^{-3}	6.32×10^{-2}
15	2.42×10^{-3}	11.6×10^{-2}
20	3.73×10^{-3}	17.9×10^{-2}
25	5.21×10^{-3}	25.0×10^{-2}
30	6.85×10^{-3}	32.9×10^{-2}

A.3.4.6 Discharge within perimeter of roof

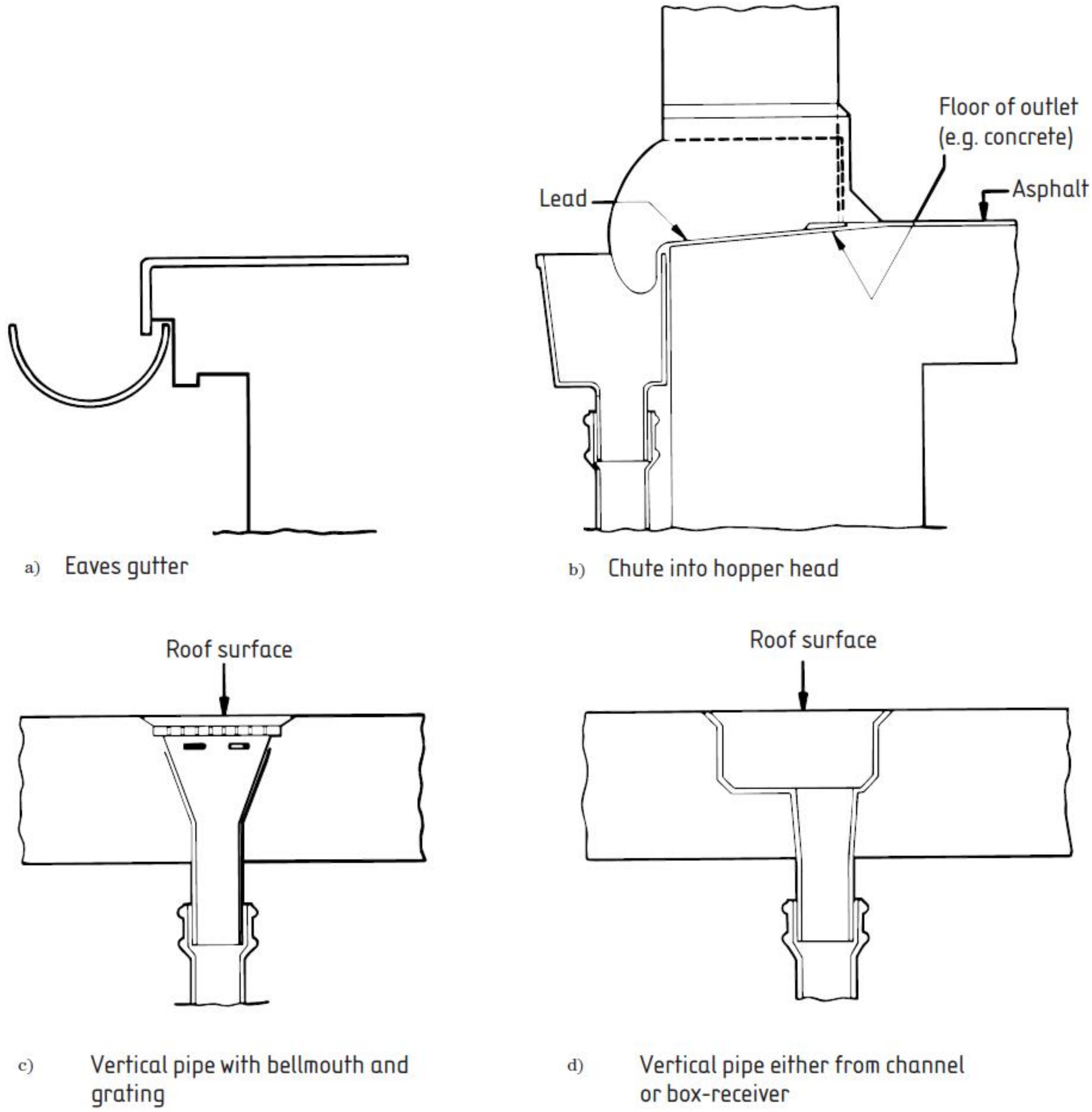
Run-off from a flat roof may discharge to:

a) a channel formed within or by the roof (see Fig. 6 (d));

b) a sump containing an outlet;

c) an outlet draining the roof directly (see Fig. 6 (c)).

Roof channels and their outlets should be designed in the same way as valley gutters. Sumps and roof outlets normally act as weirs, and should be sized so as to limit the depth of water on the roof to 30 mm or less. The depth of a sump is determined by the capacity of the outlet that drains it, and should be not less than h+25 mm where h is the depth of water above the outlet. Design procedures for sumps and roof outlets are given in BS EN 12056-3:2000.



DRAINAGE FROM FLAT ROOFS: TYPES OF OUTLET

Fig. 6

A.3.4.7 Design of roof outlets

Some types of outlets that are suitable for asphalt roofs are illustrated in related IPS-D-CE-217. Approximate areas that can be drained by these outlets at a rainfall intensity of 75 mm/h are given in Table 7.

TABLE 7 - ESTIMATED CAPACITIES OF OUTLETS FOR FLAT ROOFS

OUTLET TYPE	PIPE SIZE	AREA DRAINED AT RAINFALL INTENSITY OF 75 mm/h AT DEPTH OF WATER ABOVE OUTLET:					
		5 mm	10 mm	15 mm	20 mm	25 mm	30 mm
	mm	m^2	m^2	m^2	m^2	m^2	m^2
Square flat grating	100	17	49	90	135	190	250
Circular flat grating	50, 65	4.5	12	23	36	51	67
	75,90, 100	9.6	27	50	77	105	140
Circular flat grating with horizontal pipe	50	4.5	12	23	36	51	67
	75, 100	7.1	20	37	57	80	105

A.4 DRAINAGE OF PAVED AREAS

For surface water drainage in catchment areas refer to IPS-E-CE-380.