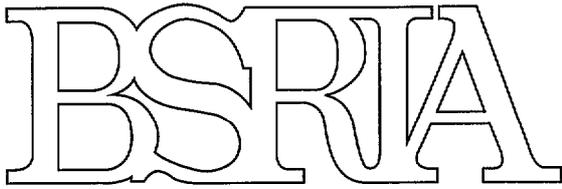


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DoE PROJECT 10B

WATER ECONOMY

Interim Report 11727/1

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Department of the Environment

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Appendix A1



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SUMMARY

There are many different types and designs of WC being installed around the world. These include models made of different materials, including for example stainless steel, and models with various flushing systems, some using little or no water.

The most important types are however water flushed vitreous china models. The most common flushing arrangement is for flushing water to be supplied from a cistern or tank, normally using the force of gravity. WCs are produced in different arrangements depending on consumer preferences / traditions in particular countries. The main types of arrangement are:

- close coupled arrangements with the cistern mounted on the pan;
- separate pans for use with separate or concealed cisterns or flushing valves;
- and, one piece toilets where the cistern is part of the same piece of china.

There are two main approaches to WC pan design:

- the wash down pattern, most common in Europe and areas of European influence, where the flushing water washes the bowl contents over a dam into the trap
- and, the syphonic pattern, used in North America and areas of American influence, where flushing is assisted by the creation of a syphon between the sump of the bowl and the trap.

The volume of water used for flushing has reduced in many countries over the past 10 years or so with greater attention being paid to water conservation. A 6 litre flush volume is becoming the norm in many European countries and is the maximum allowed for most installations in the U.S.A. and most of Australia and New Zealand.

The outlet from a cistern or tank, providing flushing water by gravity, is normally through a valve - a simple flap (or flapper) type in the U.S.A. and areas of American influence or a more complex drop valve in Europe and Australasia. The valveless syphon required in the UK is found in few other countries.

Pressurised flushing valves, often connected to the mains, are used in many countries, particularly for public toilets.

In North America a popular design uses mains water pressure to compress air which is then used to provide a "pressure assisted" flush.

Interruptible flush, which can provide a shorter flush where there are no solids, is common in a number of European countries. Dual flush is also available in some European countries and a two button dual flush mechanism has become the norm in Australia and New Zealand.

The performance of various designs which achieve a 6 litre flush volume will clearly be of interest. It will also be necessary to assess the reliability and tendency to water leakage of the flushing mechanisms used with these designs.

Product now being installed in Australia and New Zealand may be of particular interest because WC pan designs have been developed from those of British manufacturers.

1 INTRODUCTION

This interim report contains clarification and additional information as requested following submission of a draft report on the 9th November 1994.

This report forms part of Stage 1 of the project, world situation review, covering parts a and b.

The report aims to provide a clear picture of WC design worldwide, the state of technological progress and continuing developments. WC pan design and flushing mechanisms have been considered together because in many cases the design of one directly affects the other and usage patterns of particular combinations are closely related.

The objectives of this part of the study are:

- to identify the designs that might be used in the UK if regulations allowed alternatives to syphonic flushing apparatus;

- to assist in providing insight for UK exporters into the products necessary to penetrate important overseas markets.

Information has been assembled mainly through contact with manufacturers of sanitaryware and flushing mechanisms in the UK and throughout the world. Initial contact was generally made by fax, with telephone follow up, provision of literature and other relevant material, and some meetings. Appendix A.1 lists the organisations and companies contacted and the response received.

From these contacts the matrix of WC designs and flushing mechanisms (Table 3.1) was drafted and circulated to some 20 contacts around the world for comment and refinement. Considerable feedback has been received but some further input is expected.

Following discussion of the nature and extent of the testing phase of the project, recommendations will be made as to appropriate products for evaluation.

2 TYPES OF WC AND FLUSHING MECHANISM

The main types of toilet are water flushed vitreous china models. In addition, there are some special arrangements using little or no water, particularly for situations without mains drainage. Other materials, notably stainless steel, are also used for certain applications.

2.1 WC ARRANGEMENTS

Figure 1 illustrates a close coupled two piece toilet consisting of two separate pieces of vitreous china, the pan and the cistern, fastened together with a water tight closed seal between them. Most close coupled arrangements are floor standing (or pedestal) types but wall hung close coupled arrangements are made.

Figure 1 Close coupled WC suite

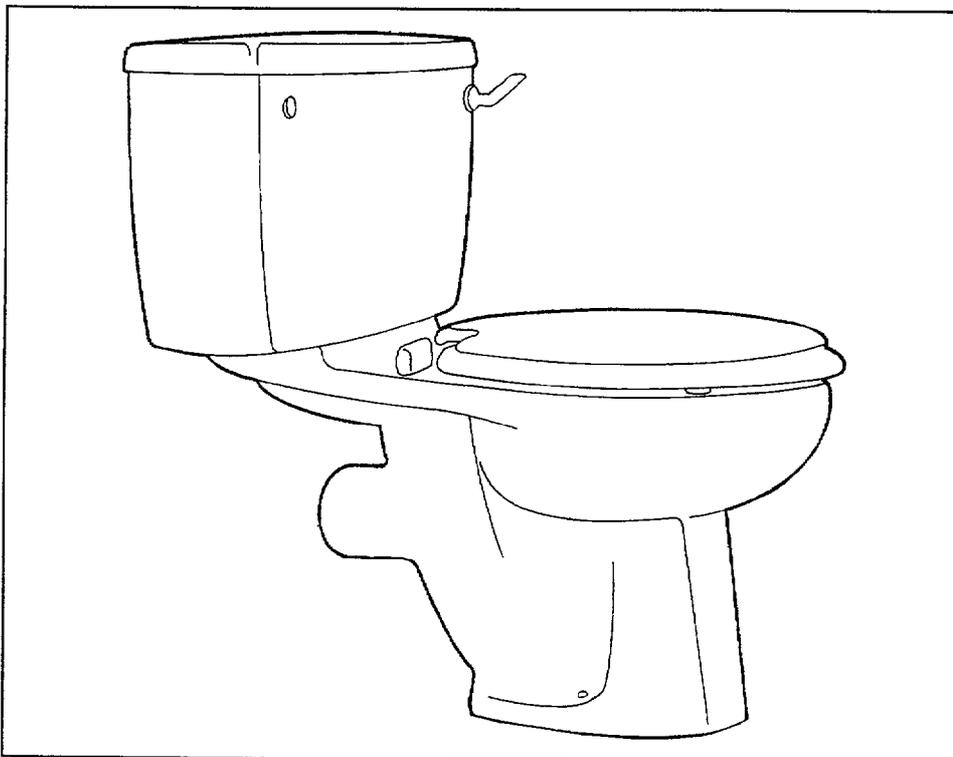


Figure 2 illustrates a number of different arrangements of separate WC pans. These can be wall hung or pedestal (floor standing). They may be used with a high level cistern (a), a low level cistern (b) or with the cistern or flushing valve concealed in or behind the wall (c and d). 'e' is the ultra low level cistern arrangement common in Australia and New Zealand.

Figure 2 Separate WC pan arrangements

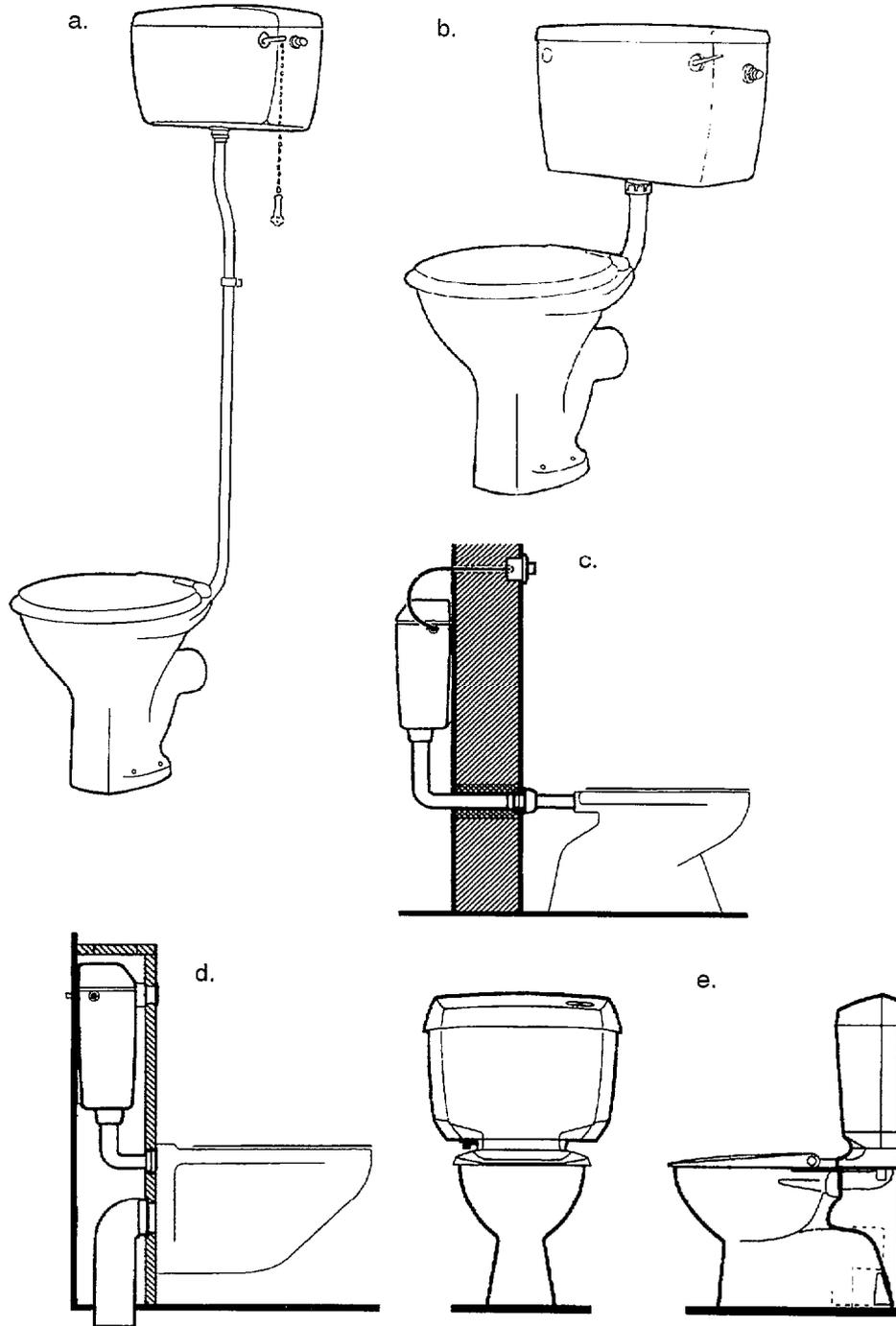


Figure 3 illustrates a one piece toilet where the cistern is included in one piece of vitreous china with the pan.

Figure 3 One piece toilet

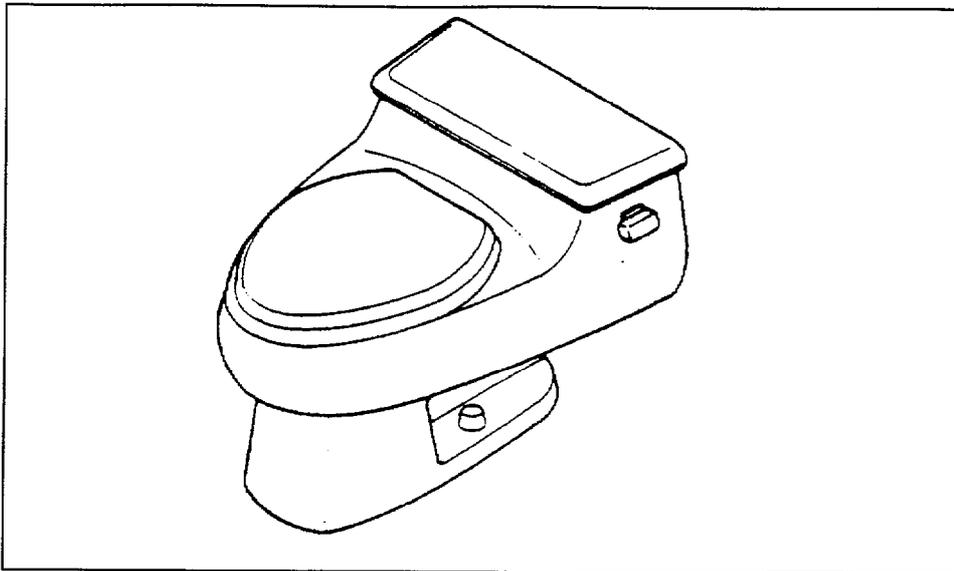
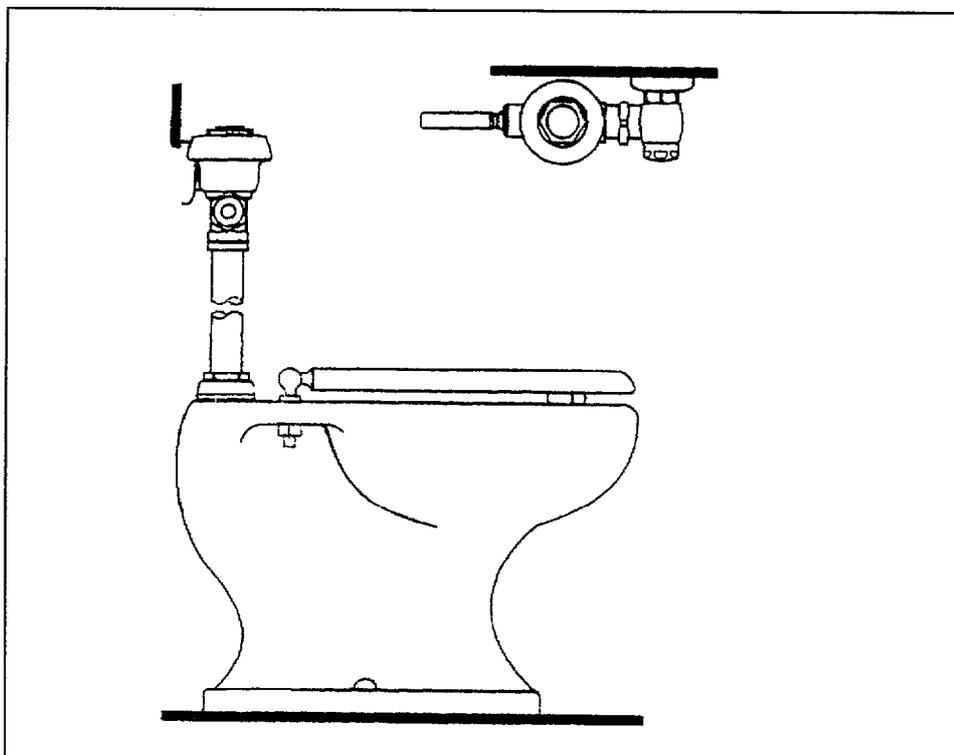


Figure 4 illustrates a WC pan with an exposed mains flushing valve.

Figure 4 WC with exposed flushing valve



2.2 WC PAN STYLE

Figure 5 illustrates a wash down pan where flushing water scours the sides of the pan and carries the bowl contents over a dam into the trapway. There are many variants of this arrangement with different bowl contours.

Figure 5 Wash down WC pan

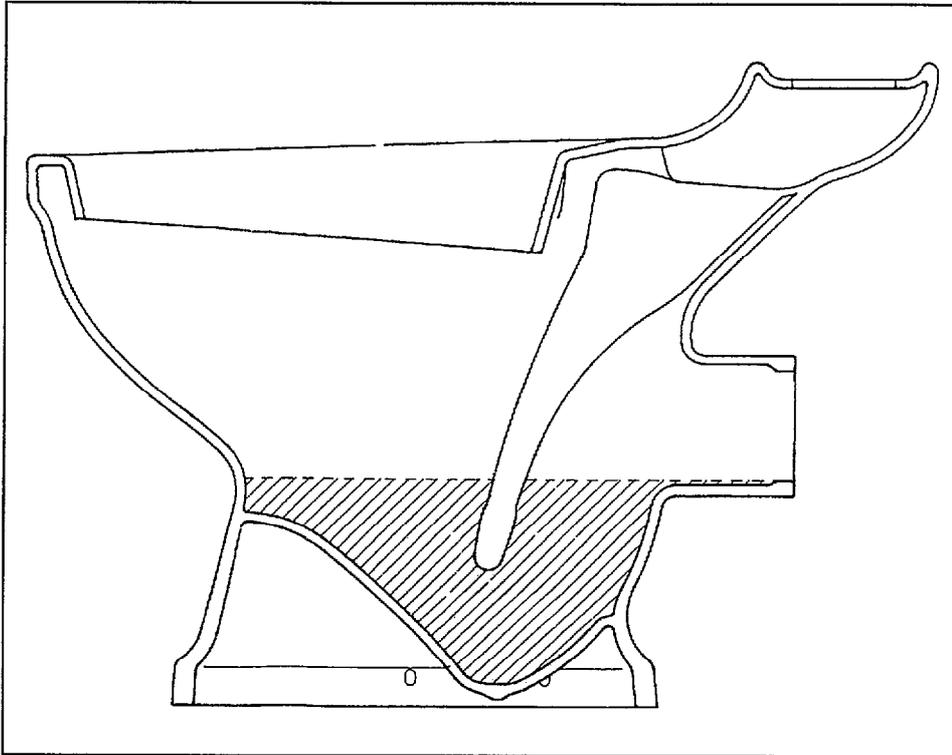


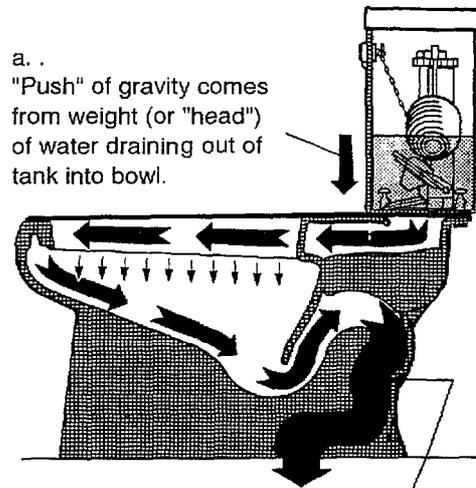
Figure 6 illustrates a number of syphonic pans. The flushing action is assisted by the creation of a syphon which empties the contents of the bowl and these designs have relatively narrow trap passageways.

The most common type of syphonic pan has special jets, cast into the vitreous china, to direct a proportion of the flushing water straight into the trapway to prime the syphon. This is referred to as a syphon-jet type but a similar principle applies in the case of types referred to as reverse trap or syphon-wash which feature different bowl contours and water surface areas.

Another type of design is the syphon-vortex where water is not directed straight into the trapway. This type is associated with quiet operation and a large water surface and is often used in one piece toilets.

Syphonic action can be assisted by the use of a diaphragm in the trapway (b). The double trap syphonic type (c) was at one time popular in the UK and is still made in small quantities.

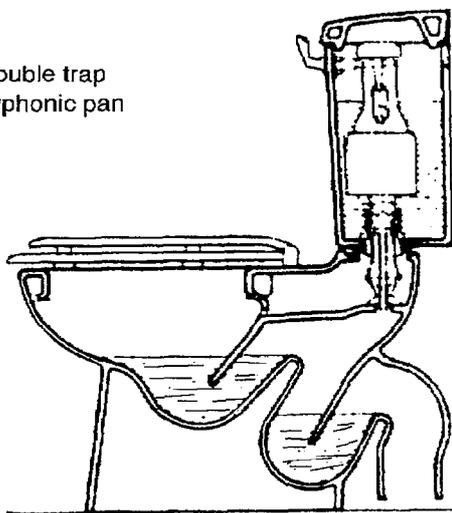
Figure 6 Syphonic WC pans



a. .
"Push" of gravity comes from weight (or "head") of water draining out of tank into bowl.

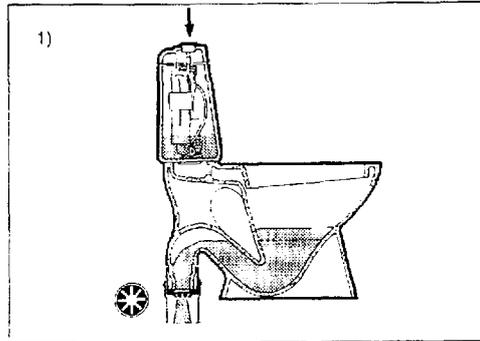
"Pull" of syphonic action... weight of water filling trapway creates suction that pulls water out of bowl, through trapway, out of drain.

c.
Double trap syphonic pan

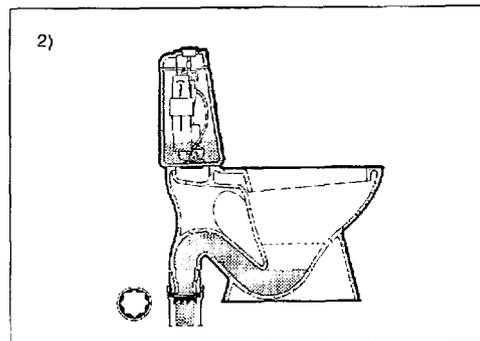


b.
WC 366 X

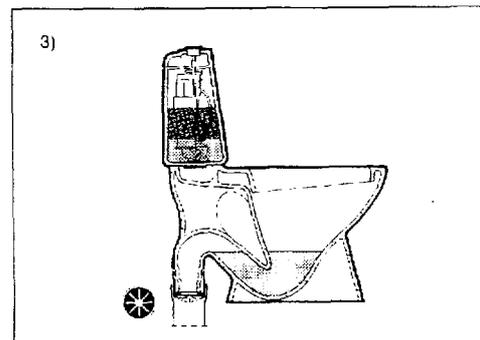
The WC is the first component. It is flushed out with 3.5 litres. Special fittings in the cistern plus a patented diaphragm in the outlet produce an extra push during the flushing sequence, which can be divided into three phases.



A delaying action.



Flushing with siphoning effect. "Secondary ventilation" takes place via the WC.

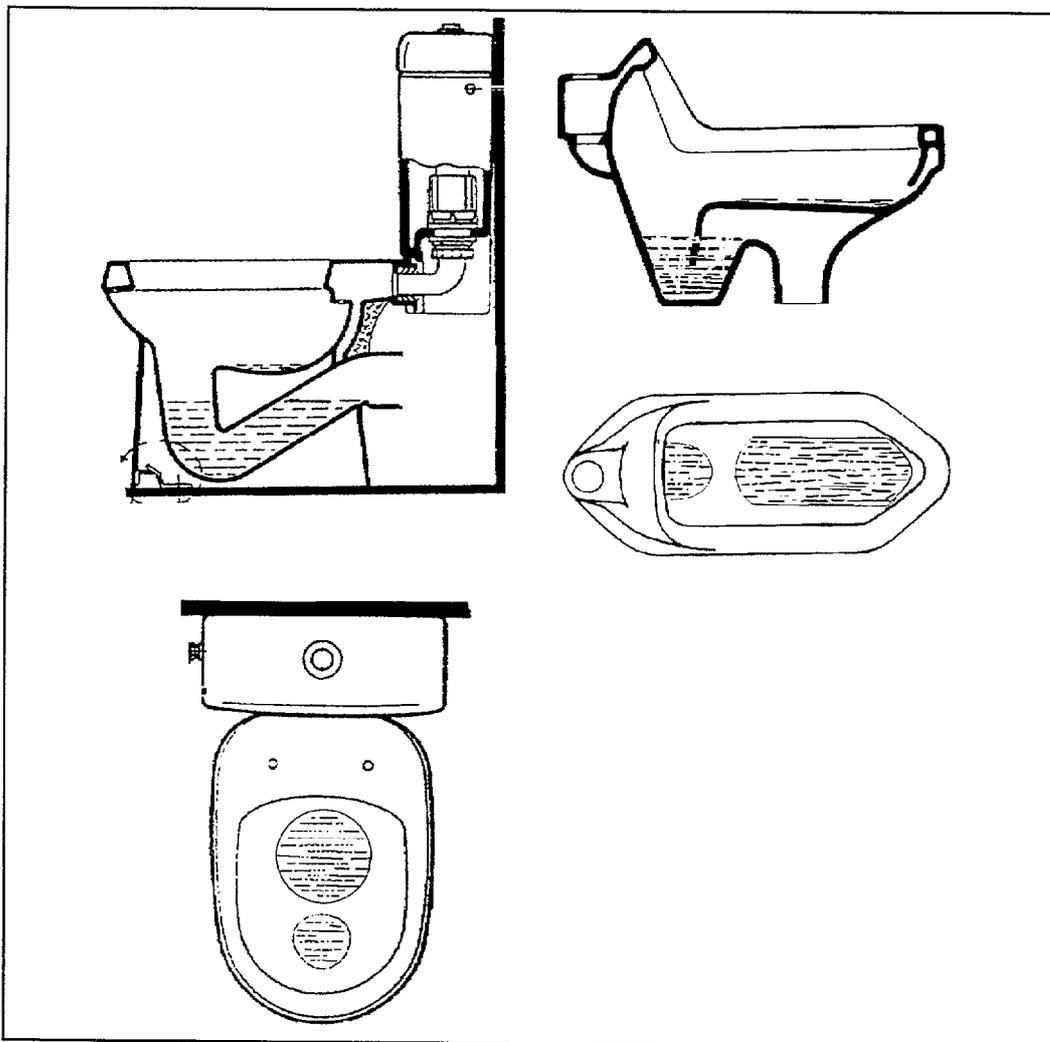


Refilling of water trap and cistern. The WC 366 X gives the same flushing efficiency, hygienic conditions and convenience as a conventional WC.

The surface area of the water remaining at the bottom of the pan can vary considerably between designs but, in general, syphonic pans have larger water surface areas than wash down types. This larger water surface is said to give better appearance and results in less fouling of the sides of the bowl with less need to use a brush. On the other hand the larger water surface results in a smaller "target area" for men, with greater likelihood of splashing, resulting in the development of up market variants of syphonic pans with elongated bowls. The narrow passageways of syphonic pans are also more susceptible to blockage.

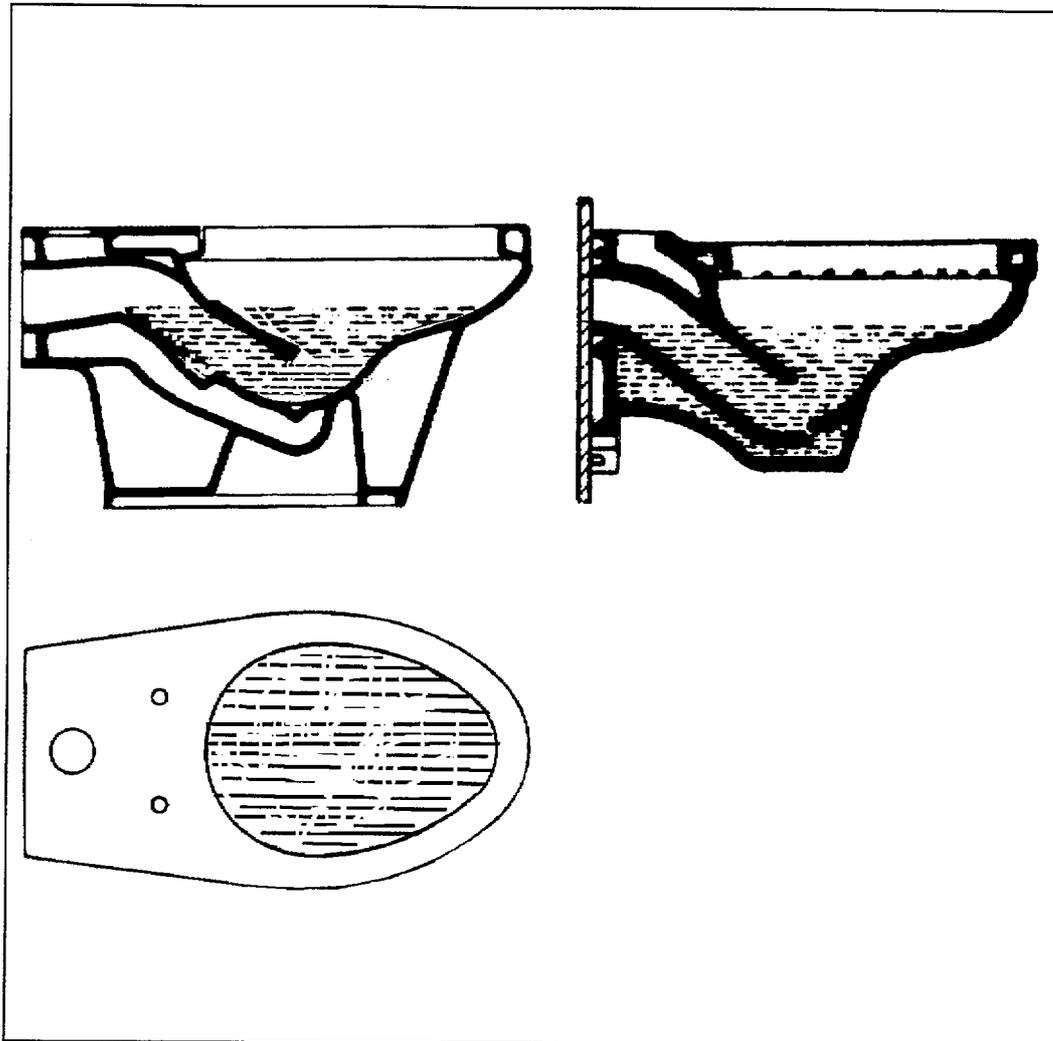
Figure 7 illustrates the wash out type of bowl. This is sometimes called a "display" toilet because the contents stay on the surface before the flush. This type generally operates using the wash down principle and is popular where users like to "see what they have done" as a check on health. This type of design is typical for squatting toilets common in China and Japan.

Figure 7 Wash out WC pans



Other types of bowl include blow out types (Figure 8) used in commercial/institutional settings with high water pressures provided mainly by flushing valves. These types are noisy and sometimes subject to splashing.

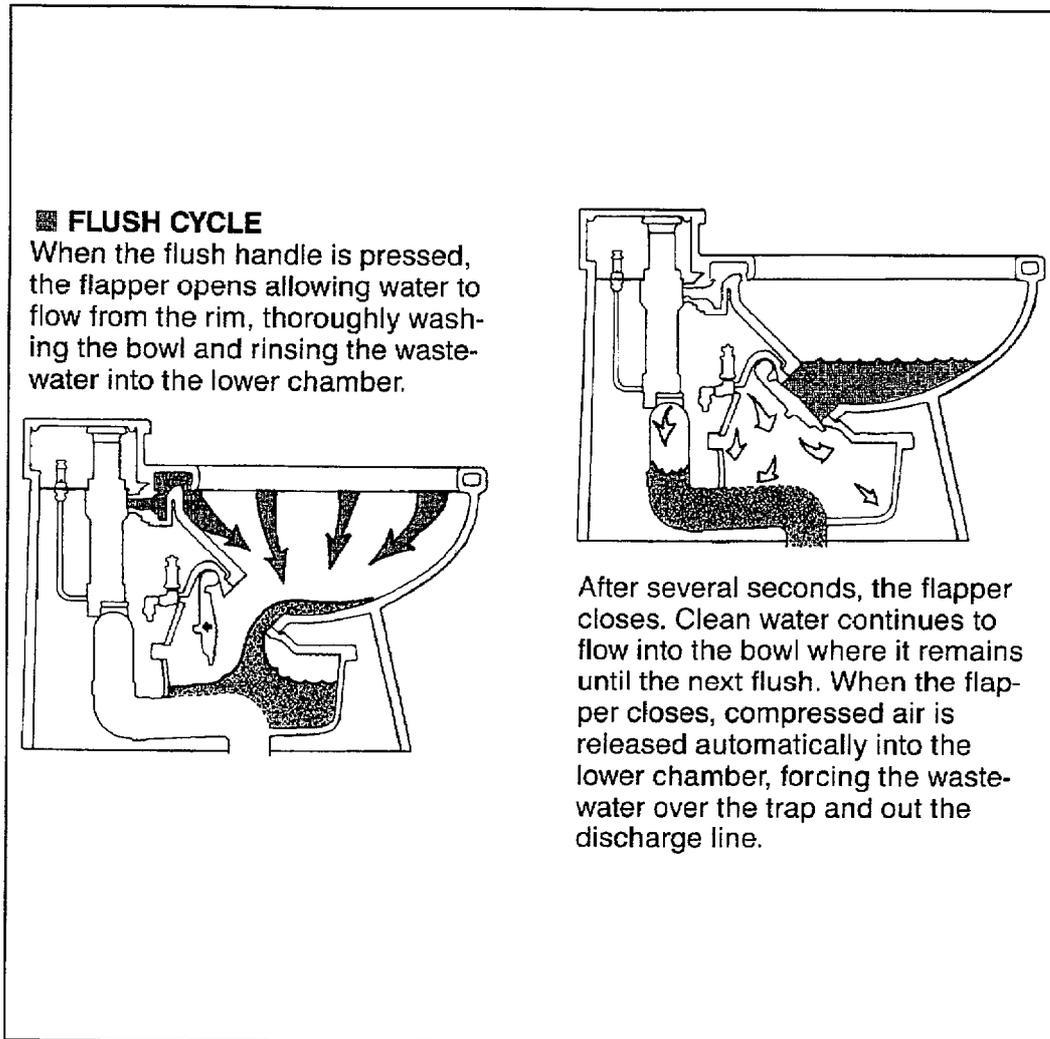
Figure 8 Blow out WC pans



Other types of arrangement use little or no water and are mainly used where mains sewerage is not available. These include arrangements using compressed air, a vacuum or a special pump to force or pull water and bowl contents out.

Figure 9 illustrates a compressed air system.

Figure 9 WC with water/compressed air flushing



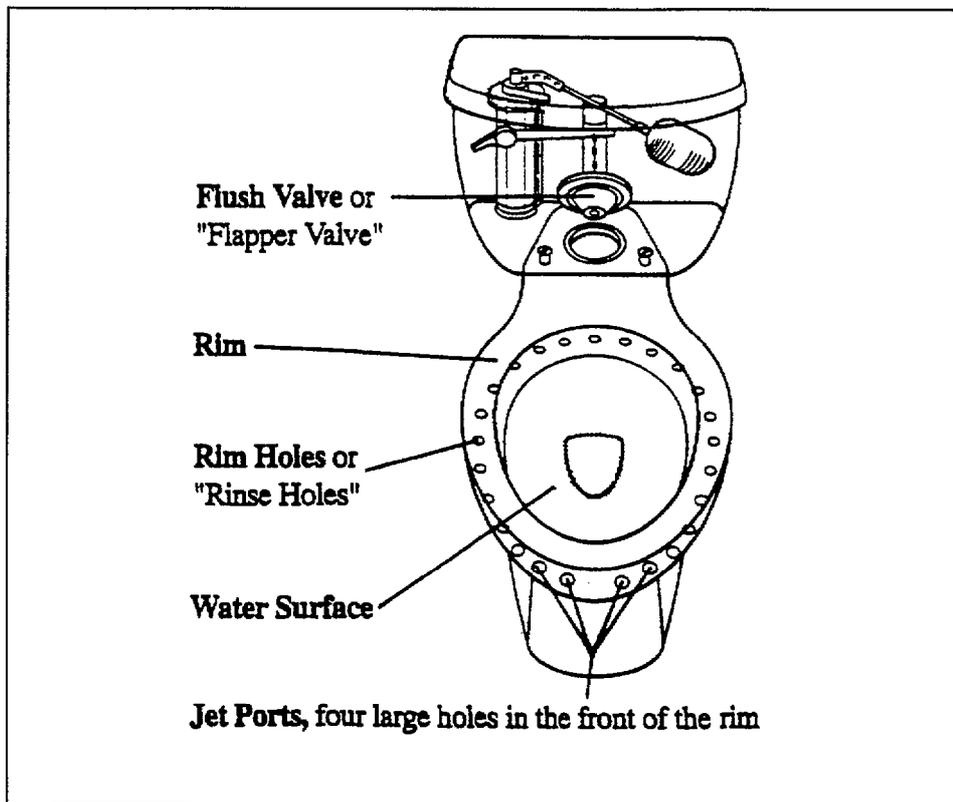
Other designs include flushing with foam and water and composting toilets.

2.3 WATER DISTRIBUTION

Most WC pans have a rim which may have an open bottom (open rim) or a closed bottom with holes (box rim). Open rim designs are such that water to wash the sides of the bowl falls from the rim but much of the water is forced to the front of the bowl. Some open rim designs have plastic inserts which result in more consistent water distribution than could be achieved within the manufacturing tolerances of vitreous china. These inserts have been used for many years and typically are made of polypropylene. Manufacturers not using plastic inserts claim that the plastic is attacked by chemicals used for cleaning, particularly chlorine.

Figure 10 illustrates a box rim design. Water to wash the sides of the bowl is directed through holes underneath the rim and for syphon-jet models larger holes at the front to direct water to the trap to prime the syphon.

Figure 10 Syphonic WC pan with box rim



Another variant is the so called "rimless" pattern which has a fully glazed roll over rim without an internal waterway. Water is forced up under the rim to scour the sides of the bowl. This type is used because of ease of cleaning.

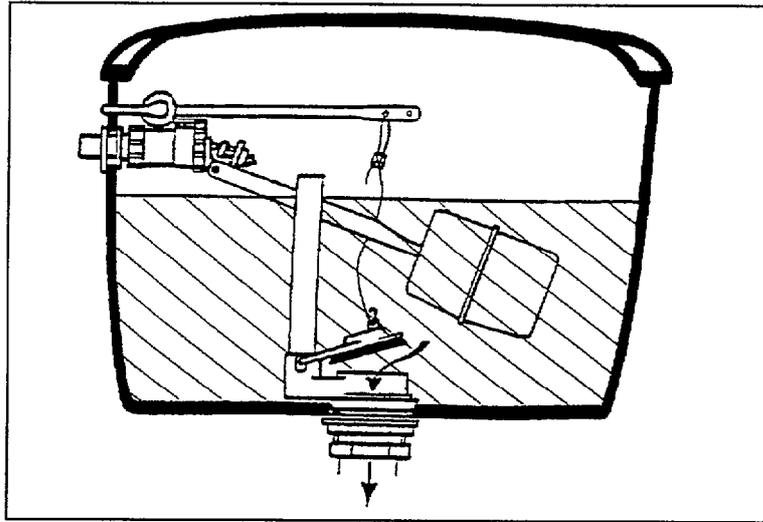
Box rim designs are more expensive to produce than open rim patterns because the former are normally cast in two pieces and joined together before firing. Box rims are used in most syphonic pans and in up market wash down pans.

2.4 FLUSHING MECHANISMS

The most common type of flushing mechanism is a cistern or tank, filled by means of a float (or ball) valve and using the head of water to provide the flow. The cistern is emptied using a valve or syphon.

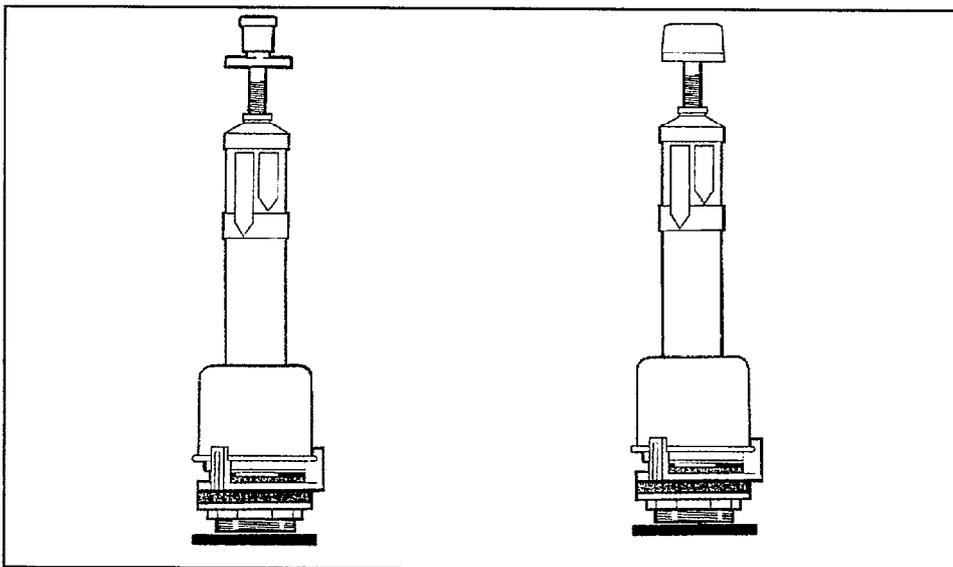
The simplest type of valve is the flap valve (figure 11). This is tripped open to initiate the flush, is kept open by the flow of water and reseals when the cistern is empty.

Figure 11 Simple flap valve in cistern



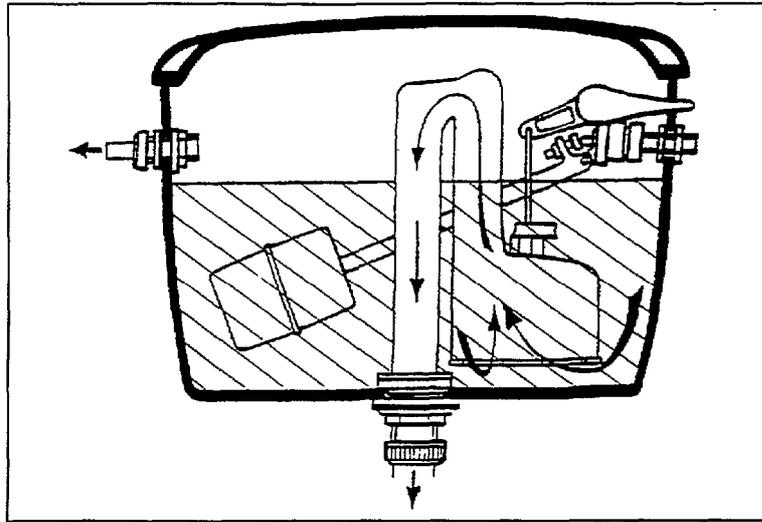
A more complex arrangement is the drop valve (figure 12) which may be pull or push operated. the valve drops closed when the cistern is emptied.

Figure 12 Pull and push drop valves for cisterns



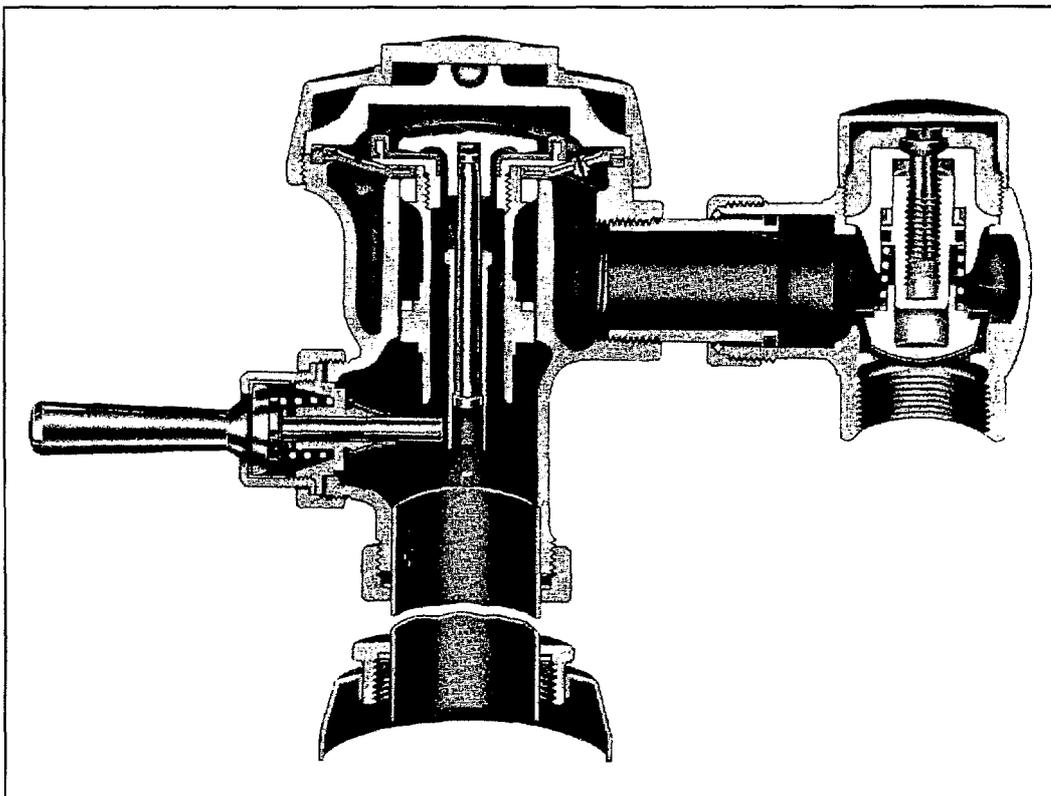
The valveless syphon or waste water preventer (figure 13) uses a piston to prime the syphon and initiate the flush. The syphon stops when the cistern is emptied.

Figure 13 Valveless syphon in cistern



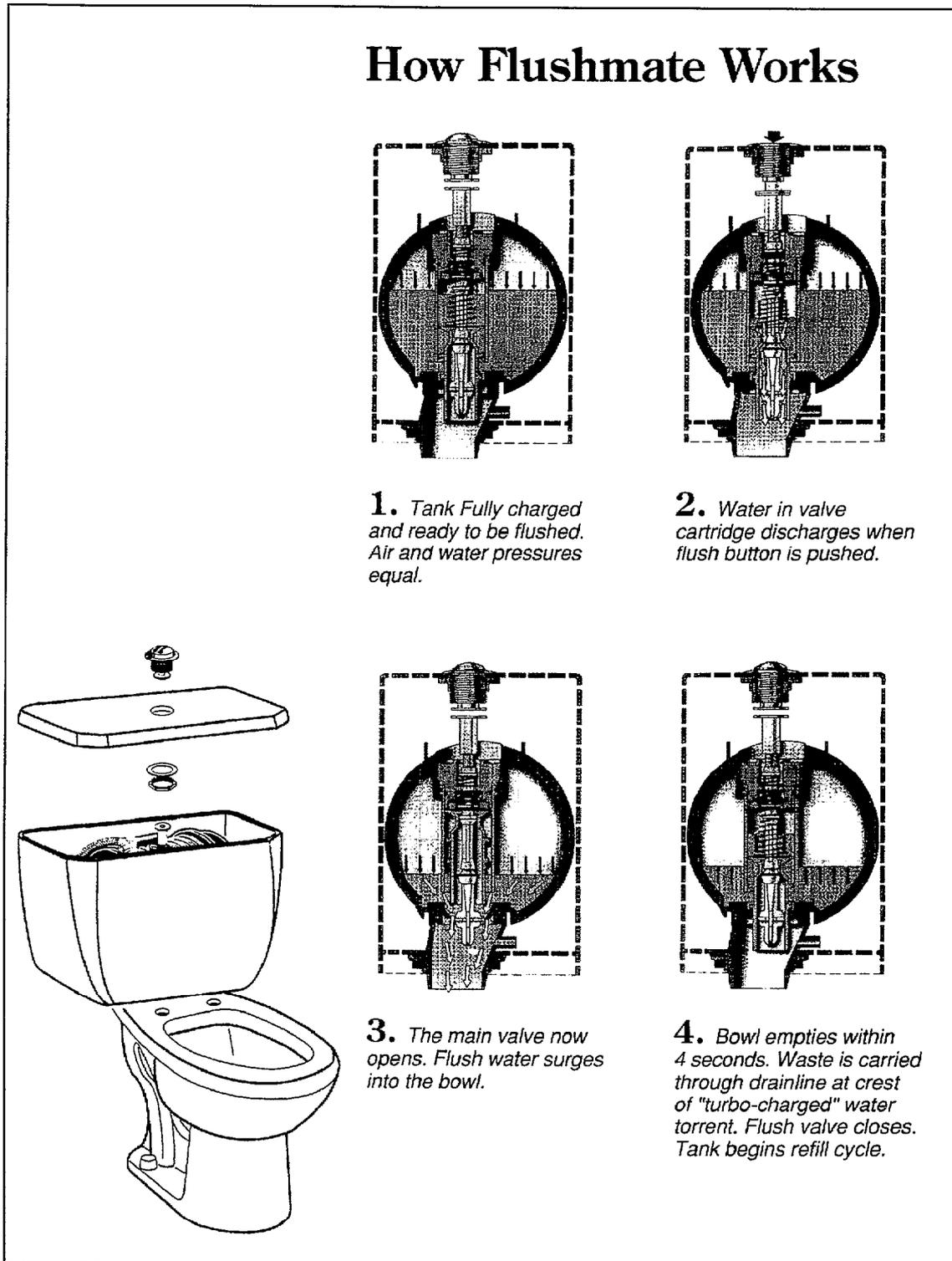
Flushing valves (figure 14) operating on mains or pressurised water supplies deliver measured amounts of water, normally at high flow rates. These are particularly suited to applications where heavy usage might not allow a cistern to fill up between uses.

**Figure 14 Flushing (Flushometer) valve
(diaphragm type)**



A pressure assisted flush (figure 15) uses incoming water pressure to compress air in a tank. When flushing takes place the compressed air provides a boost to the water flow.

Figure 15 Pressure assisted flush



2.5 DUAL AND INTERRUPTIBLE FLUSHING

When the toilet is used for liquid only it should not be necessary to flush with the same quantity of water. Arrangements have been devised to provide two different flush volumes or to allow the flush to be stopped before the tank is emptied.

Dual or interruptible flushing is difficult to achieve effectively with syphonic WC pans because of the minimum quantity of water required to make the syphon work and the need to refill the trap after the flush.

Dual flush has been achieved with specially designed syphons, where a single press of the flushing lever results in a partial flush and the lever must be held down to achieve a full flush. This has been said to result in water wastage because users unfamiliar with the arrangement initiate a partial flush first and then a full flush, using 50% more water. As a result this arrangement is no longer supplied in significant quantities.

A twin flap valve arrangement has been devised and this is sometimes used with an electronic control which decides on the size of the flush based on the time spent on the toilet by the user.

A two button drop valve arrangement perhaps provides the most "user friendly" and effective dual flush arrangement.

Interruptible flush is provided by a very simple and cheap modification to the design of the leading push operated drop valves. The first push initiates a full flush, a second push stops the flow. Effective use of this facility requires familiarity (and perhaps skill).

3 TYPES CURRENTLY BEING INSTALLED WORLDWIDE

3.1 OVERVIEW

Table 3.1 presents a summary of the types of WC and flushing mechanism currently being installed around the world. This represents the current situation and does not attempt to reflect the designs installed in the past. Usage of different designs are classified as "Most Common", "Popular" or "Some Significant Use" in each country. Most common will generally be over 50% of the particular market, popular would be more than 5 to 10% of the market and some significant use over around 1% of the market.

In general there are two basic approaches to WC pan design and flushing mechanisms reflecting either American or European influence. The American approach is normally a syphonic pan flushed using a cistern fitted with a simple flap valve. The European approach is normally a wash down pan flushed using a cistern with a more complex drop valve. There are also pockets of distinctly British influence, extending to the use of the waste water preventer (valveless syphon) flushing mechanism.

Mains flushing valves are used in some countries in commercial and institutional applications. In North America pressure assisted flushing is quite popular in residential applications.

Interruptible flush is fairly common in most European countries as an almost cost free by product of typical drop valve designs.

In Australia and New Zealand a "user friendly" two button dual flush system is used. A recent variant of this arrangement incorporates an interlock with the inlet valve to the cistern. The inlet valve will not open unless the toilet has been flushed, preventing the wastage of more than a cistern full of water should the outlet valve leak.

Table 3.1 Summary of WC types and flushing mechanisms currently being installed worldwide

a) European Union	WC arrangements					WC pan style				WC water distribution			Typical flushing volume (litres)	Flushing mechanisms				Dual/stop	
	CC	SEP	OP	Oth	WD	SYP	WO	Oth	OR	BR	Oth	Gravity tank/cistern			MFV	Oth	DF	IF	
												FV		DV					VS
UK/Ireland	M	P			M	S ¹			M	P	S ²		X	X	M ³	X			
Germany	P-	M ⁺			P+	S-	M-		M	P				M		P		P+	
France	M	P			M	S			M	P				M		S	S ⁵	P+	
Italy	M	P ⁺			M	P			M	P				M		S	S	S	
Spain	M	P			M				M	P				M		S		P	
Netherlands	M	P			P		M-		M	P				M		S		S	
Belgium/Luxembourg	M	P			M				M	P				M		S		S	
Greece	M	P			M	P			M	P				M		S	S ⁵	S	
Portugal	P	M			M				M	S				M		P		S	
Denmark	M	P			M				M					M		S		S	

- Notes: 1. Double trap syphonic - only like for like replacement, flushed with 9 litres;
 2. Rimless for special applications.
 3. Cistern with external overflow required in UK, internal overflow (into pan) often used in Eire.
 4. Mainly concealed cistern (in wall)
 5. Flushing valve fed by pressurised cylinder.
 6. 3.5/4 litre flush sometimes requires special flow booster syphon in waste system.

Key: M = Most common; P = Popular; S = Some significant use; X - not allowed; + growing in use; - declining in use.
 CC = Close coupled; SEP = Separate WC pan (wall hung or floor standing; high/low level cistern or concealed cistern/flushing valve);
 OP = One piece; Oth = Other (see notes); WD = Wash down; SYP = Syphonic; WO = Wash out;
 OR = Open rim (including types with plastic inserts to improve water distribution); BR = Box rim;
 FV = Flap (or flapper) valve; DV = Drop (pull or push operated) valve; VS = Valveless syphon; MFV = Mains (pressurized) flushing valve;
 DF = Dual flush; IF = Interruptible flush.

/continued

Table 3.1 Summary of WC types and flushing mechanisms currently being installed worldwide

	WC arrangements				WC pan style				WC water distribution		Typical flushing volume (litres)	Flushing mechanisms				Dual/stop			
	CC	SEP	OP	Oth	WD	SYP	WO	Oth	OR	BR		Oth	Gravity tank/cistern			MFV	Oth	DF	IF
													FV	DV	VS				
b) Other Europe																			
Austria	P	M			P		M		M	P				M		S			S
Finland	M	S			M			S ⁷	M	P				M		S			
Norway	M	S			M			S ⁷	M	P				M					
Sweden	M	S			M	S ⁸		S ⁷	M					M					
Switzerland	P	M			M		P		M	P				M					
Poland	P	M			M		P		M					M					S
Czech/Slovak Republics	P	M			P		M		M					M					
Slovenia/Croatia/Bosnia/Yugoslavia	M	P			M		S		M					M					
Hungary	P	M			P		M		M					M					
Bulgaria/Romania	P	M			M		P		M					M					

Notes: 6. 3.5/4 litre flush sometimes requires special flow booster syphon in waste system.

7. Special (including composting etc.) WCs for non main sewerage;

8. Special low flush volume versions with diaphragm in the outlet;

Key: M = Most common; P = Popular; S = Some significant use; X = not allowed; + growing in use; - declining in use.

CC = Close coupled; SEP = Separate WC pan (wall hung or floor standing; high/low level cistern or concealed cistern/flushing valve);

OP = One piece; Oth = Other (see notes); WD = Wash down; SYP = Syphonic; WO = Wash out;

OR = Open rim (including types with plastic inserts to improve water distribution); BR = Box rim;

FV = Flap (or flapper) valve; DV = Drop (pull or push operated) valve; VS = Valveless syphon; MFV = Mains (pressurized) flushing valve;

DF = Dual flush; IF = Interruptible flush.

/continued

Table 3.1 Summary of WC types and flushing mechanisms currently being installed worldwide

c) Americas	WC arrangements				WC pan style			WC water distribution			Typical flushing volume (litres)	Flushing mechanisms				Dual/stop			
	CC	SEP	OP	Oth	WD	SYP	WO	Oth	OR	BR		Oth	Gravity tank/cistern			MFV	Oth	DF	IF
													FV	DV	VS				
USA	M		P	P ⁹		M		S ¹⁰	S	M			M			P			P ¹²
Canada	M		P	P ⁹		M		S ¹⁰	S	M			M			P			P ¹²
Mexico	M		P	S ⁹		M		S ¹⁰	P	M			M			S			S ¹²
Central America	M		S			M			M	P			M			S			
Caribbean	M	S	S		S	M			M	P			M	S	S	S			
Brazil	M	S	S		P	M			M	P			M	P		X			
Argentina	M	S	S		P	M			M	P			M	P		S			
Columbia	M	S	S		P	M			M	P			M	P		S			
Venezuela	M	S	S		P	M			M	P			M	P		S			
Other South America	M	S	S		P	M			M	P			M	P		S			

Notes: 9. Single units with exposed mains flushing valve;
 10. Special vacuum and compressed air WCs for non mains sewerage;
 11. Federal law requires (as from 1/1/94) 6 litre maximum flush for residential use; this will be extended to cover commercial/institutional use from 1/1/97;
 12. Pressure assisted flush.

Key: M = Most common; P = Popular; S = Some significant use; X - not allowed; + growing in use; - declining in use.
 CC = Close coupled; SEP = Separate WC pan (wall hung or floor standing; high/low level cistern or concealed cistern/flushing valve);
 OP = One piece; Oth = Other (see notes); WD = Wash down; SYP = Syphonic; WO - Wash out;
 OR = Open rim (including types with plastic inserts to improve water distribution); BR = Box rim;
 FV = Flap (or flapper) valve; DV = Drop (pull or push operated) valve; VS = Valveless syphon; MFV = Mains (pressurized) flushing valve;
 DF = Dual flush; IF = Interruptible flush.
 /continued

Table 3.1 Summary of WC types and flushing mechanisms currently being installed worldwide

d) S E Asia & Pacific	WC arrangements					WC pan style				WC water distribution			Typical flushing volume (litres)	Flushing mechanisms					Dual/stop	
	CC	SEP	OP	Oth	WD	SYP	WO	Oth	OR	BR	Oth	Gravity tank/cistern			MFV	Oth	DF	IF		
												FV		DV					VS	
																				FV
Japan	M	S	S+	P ⁹	P	M	S ¹³	S ¹⁴	P	M			M		P ¹⁶	S ¹⁷	S	S		
China	P	M	S		P	M	P ¹³		M	S			M	P	S	S		S		
Taiwan	M	S	P	S ⁹	S	M		S ¹⁴	M	P			M	S	S	S				
Hong Kong	M	P	S		M	S			M	P			S ¹⁸		M					
Singapore/Malaysia	M	P	S		M	P			M	P			P	M	S	S		S		
Indonesia	M	P			M	P			M	P			P	M		S		S		
Thailand	M	P	S		M	P			M	P			P	M	S	S		S		
Vietnam/other Indo-china	M	P			M	P			M	S			S	M		S				
Korea	M	S	S		S	M			M	P			M	S		S		S		
Philippines	M		P		S	M			M	P			M	S		S				

- Notes: 9. Single units with exposed mains flushing valve;
 13. Mainly squatting type;
 14. Blow out for use with flushing valves;
 15. 8 litres is minimum allowed;
 16. Including electronic sequence valves;
 17. Special foam flushing WCs for non mains sewerage;
 18. Flap valve used when flushing with seawater and (illegally?) for refurbishment work.

Key: M = Most common; P = Popular; S = Some significant use; X - not allowed; + growing in use; - declining in use.
 CC = Close coupled; SEP = separate WC pan (wall hung or floor standing; high/low level cistern or concealed cistern/flushing valve);
 OP = One piece; Oth = Other (see notes); WD = Wash down; SYP = Syphonic; WO = Wash out;
 OR = Open rim (including types with plastic inserts to improve water distribution); BR = Box rim;
 FV = Flap (or flapper) valve; DV = Drop (pull or push operated) valve; VS = Valveless syphon; MFV = Mains (pressurized) flushing valve;
 DF = Dual flush; IF = Interruptible flush.

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Table 3.1 Summary of WC types and flushing mechanisms currently being installed worldwide

e) Middle East & Africa	WC arrangements				WC pan style				WC water distribution			Typical flushing volume (litres)	Flushing mechanisms				Dual/stop		
	CC	SEP	OP	Oth	WD	SYP	WO	Oth	OR	BR	Oth		Gravity tank/cistern			MFV	Oth	DF	IF
													FV	DV	VS				
Turkey	M	P			M	P	S		M	P		6 - 9		M		S			
Lebanon/Syria	M	P			M				M			6 - 9		M		S			
Israel	M	P			P	M			M	P		6 - 13		M	P	S			
Iran	M	P			M				M			6 - 9		M		S			
Iraq	M	P			M				M	P		9		S	M	S			
Saudi Arabia	M	P			P	M			M	P		6 - 9		S	M	S		S	
Other Gulf states	M	P			M	S			M	P		6 - 9		S	S	M			
Egypt/Libya Tunisia	M	P			M	P			M	P		6 - 9		M			S		
Algeria/Morocco	M	P			M				M	P		6 - 9		M			S	S	
South Africa	M	P			M				M			9		S	S	M	S		
Other Africa	P	M			M				M			9		S	S	M	S		

Key: M = Most common; P = Popular; S = Some significant use; X - not allowed; + growing in use; - declining in use.
 CC = Close coupled; SEP = Separate WC pan (wall hung or floor standing; high/low level cistern or concealed cistern/flushing valve);
 OP = One piece; Oth = Other (see notes); WD = Wash down; SYP = Syphonic; WO - Wash out;
 OR = Open rim (including types with plastic inserts to improve water distribution); BR = Box rim;
 FV = Flap (or flapper) valve; DV = Drop (pull or push operated) valve; VS = Valveless syphon; MFV = Mains (pressurized) flushing valve;
 DF = Dual flush; IF = Interruptible flush.

/continued.....

Table 3.1 Summary of WC types and flushing mechanisms currently being installed worldwide

f) Other countries	WC arrangements					WC pan style			WC water distribution			Typical flushing volume (litres)	Flushing mechanisms				Dual/stop		
	CC	SEP	OP	Oth	WD	SYP	WO	Oth	OR	BR	Oth		FV	Gravity tank/cistern		MFV	Oth	DF	IF
														DV	VS				
Russia & former Soviet Union	P	M			M		S		M				M		S				
Australia	P	M ¹⁹			M				M	P			M		S		M ²⁰		
New Zealand	P	M ¹⁹			M				M	P			M		S		M ²⁰		
Burma	P	M			M				M			M	S	S	S				
India	P	M			M				M			M	S	S	S				
Pakistan	P	M			M				M			M	S	S	S				
Bangladesh	P	M			M				M			M	S	S	S				
Sri Lanka	P	M			M				M			M	S	S	S				

Notes: 19. Mainly separate pan with ultra low level plastic cistern (appearance similar to close coupled).
 20. 6/3 litre dual flush now mandatory in most areas.

Key: M = Most common; P = Popular; S = Some significant use; X - not allowed; + growing in use; - declining in use.
 CC = Close coupled; SEP = Separate WC pan (wall hung or floor standing; high/low level cistern or concealed cistern/flushing valve);
 OP = One piece; Oth = Other (see notes); WD = Wash down; SYP = Syphonic; WO - Wash out;
 OR = Open rim (including types with plastic inserts to improve water distribution); BR = Box rim;
 FV = Flap (or flapper) valve; DV = Drop (pull or push operated) valve; VS = Valveless syphon; MFV = Mains (pressurized) flushing valve;
 DF = Dual flush; IF = Interruptible flush.

3.2 WC ARRANGEMENTS BEING INSTALLED

Close coupled WC suites are by far the most popular arrangement in developed countries and are gaining in use in less developed countries. Separate pans with high or low level cisterns are declining in use but concealed cistern arrangements are gaining in popularity in Europe. One piece toilets are an attractive up market product in the U.S. and Canada and are becoming popular in Japan and other countries in S.E. Asia.

The movement towards close coupled arrangements results in less head of water available to power a gravity flush. One piece toilets, although not used to any significant extent in Europe, have an even lower head of water.

3.3 CURRENT WC DESIGN

The cheapest product is the wash down pan with open rim water distribution. This is generally the most popular product in Europe and areas subject to European influence. In these countries up market designs are usually box rim wash down pans. A wide range of styles are produced with different bowl contours, water surface areas, sump volumes and presumably flushing characteristics.

The typical American design is a syphonic pan with box rim water distribution. Use of this type of design has extended to Japan and areas where American and Japanese companies have been active. Cheaper syphonic pans with open rim water distribution are made in some Latin American and S E Asian countries.

The "European" and "American" influenced markets tend to be kept very separate, partly due to consumer preference and familiarity but perhaps more importantly due to plumbing practice and dimensional differences.

The typical American WC has a bottom outlet 12 inches from the wall. The most popular European arrangement is a horizontal outlet which can be connected through the wall or through the floor by means of a separate "P" or "S" trap. The S trap normally results in a bottom connection nearer to the wall.

UK manufacturers often claim that bottom outlet arrangements are not permitted under UK Water/Building Regulations but there seems to be little, if any, legal justification for this, provided the appliance can be removed to clear blockages. One possible reason why bottom outlet and "solid to wall" arrangements are not generally used in the UK may be associated with a requirement, at one time applicable in Inner London, for all connections to be visible. A more important problem is likely to be associated with the internal diameter of the trap found on syphonic (American style) WC pans, particularly those designed for lower flush volumes; this is very likely to be smaller than the minimum dimensions considered necessary to meet the Building Regulations requirement to minimise the risk of blockage.

In the United States itself WC design has undergone a revolution in the past five years with the introduction of legislation restricting the flushing volume to 1.6 U.S. gallons (6 litres). Manufacturers have retained the syphonic principle and many have tried to achieve water surface areas approaching those available with earlier products designed for much greater flush volumes.

Special WC designs using little or no water are installed particularly in areas where there is no mains drainage. In North America designs using compressed air or a vacuum to push or pull out bowl contents are sold in significant quantities. In Japan, where 50% of dwellings are not connected to mains sewerage systems, foam and water flushing systems are used. Composting toilets are used in Scandinavia.

3.4 FLUSHING VOLUMES

In most countries of the developed world flushing volumes have reduced considerably over the past ten or twenty years. This movement has been tempered by concern not only about the ability of a reduced water volume to provide an effective flush but also about the quantity of water needed to carry solids through the drains.

In Japan a minimum volume of 8 litres is required for a full flush. In Sweden on the other hand special arrangements have been devised to carry solids through the drains following a 3.5 litre flush. In most countries around 6 litres seems to be accepted as a sensible minimum and where water conservation is a high priority this is also being introduced as a maximum volume.

The most dramatic change in recent years has occurred in the United States. Ten years or so ago many toilets were being flushed with 18 or 20 litres of water and "water saving" models flushed with 13 litres. From the beginning of 1994 all toilets installed in residential premises must flush with 6 litres or less and this requirement will be extended to the commercial/institutional sector from the beginning of 1997.

3.5 FLUSHING MECHANISMS USED

By far the most common type of flushing arrangement is a cistern or tank with the flow of water provided by gravity. Gravity cisterns used in the Americas, Japan and much of SE Asia are fitted with simple flap or flapper outlet valves. Push operated drop valves are most common for this application in Western Europe and Australasia. Simpler pull operated drop valves are most popular in Central and Eastern Europe and are still used in Western Europe. The valveless syphon is used in the UK, Ireland, Hong Kong and to some extent in some other countries influenced by British practice.

Flapper and drop valve arrangements generally incorporate an overflow pipe discharging into the pan. In the UK water byelaws require the use of the valveless syphon with a warning pipe (external overflow) to provide a visible indication of

inlet valve failure. These requirements also apply in Hong Kong and in the area served by the Dublin Water Works, the largest undertaking in Ireland. In Eire some of the country is not subject to regulations and although the valveless syphon is generally used, plumbers find it easier and neater to install WC cisterns with internal overflow, even where (as in Dublin) this contravenes the regulations. UK manufacturers supply special low height syphons to allow for internal overflow to the Irish market and other areas where the external warning pipe is not a requirement.

One of the main justifications for the valveless syphon and warning pipe is to prevent water wastage due to leakage of inlet and outlet valves. In a study on residential water conservation carried out for the U.S. Department of Housing and Urban Development in the early 1980s, nearly 20% of toilets tested were found to leak and water wastage due to this was estimated at over 4 US gallons per capita per day ie. over 5,500 litres per capita per year (over 11% of average total water usage per consumer in the UK). Valves may have improved in quality and the European style of drop valve would be expected to be more reliable but it can be said that valves will eventually leak.

In order to meet these arguments the leading Australian manufacturer has recently developed an arrangement which interlocks the outlet valve with the inlet valve. A linkage prevents the float operated inlet valve from operating unless the flush button has been pressed. If a valve is leaking the cistern will not refill and the user is alerted when the flush button does not work immediately. This effectively prevents the wastage of more than a cistern full of water should a valve leak.

Mains or pressure flushing valves are used in many countries. These devices require high water flows and hence large pipe sizing not normally found in domestic situations. Although pressurising tanks are available to allow wider application of this type of valve, usage is generally confined to non residential applications (particularly public toilets).

Pressure assisted flushing is used for 10 to 15% of WCs installed in the residential sector in the U.S., despite a price premium. This type of design is said to have benefited from problems alleged to have been experienced with new 6 litre gravity flush designs.

3.6 VARIABLE FLUSH VOLUMES

Most push operated drop valves and many pull operated drop valves as used in Europe are offered in versions that allow the flush to be stopped. Some makers of drop valves have also developed dual flush versions but these have yet to become popular in Europe.

An Australian developed two button dual flush drop valve is now the norm in Australia and New Zealand.

The leading Japanese manufacturer has developed a twin flapper valve arrangement to provide a dual flush. This is at present only used in fairly sophisticated and expensive products, some of which include electronic controls.

APPENDIX A1
WATER ECONOMY - LIST OF CONTACTS

APPENDIX A1 Country	WATER ECONOMY - LIST OF CONTACTS Organisation/Company
Australia	Caroma Industries Ltd Hardie Bathroom Products Master Plumbers Association of Victoria
Belgium	Ideal Standard Europe
Denmark	Danish Building Research Institute
France	Clara Fabrications Sanitaires Griffon S P M P - division of M P M P sanitaire
Germany	Abu-Plast D A L Sanitärtechnologie Jomo Pagette Geberit GmbH Villeroy & Boch
India	Hindustan Sanitaryware Industries
Ireland	Dublin Water Works
Italy	Esseti srl Ceramica Dolomite SpA
Japan	Nepon Company Ltd Toto Ltd
Netherlands	Wisa BV
New Zealand	BRANZ Caroma Sales Ltd James Hardie Building Products
South Africa	National Building Research Institute
Spain	Roca S A
Sweden	Gustavsberg VVS AB

APPENDIX A1 Country	WATER ECONOMY - LIST OF CONTACTS Organisation/Company
Sweden	Ifö Sanitär AB Södermelms Rostfria Svenska Toa-Throne AB
Switzerland	Geberit AG
Thailand	Karat Sanitaryware
Turkey	Elmor Tesisat Malze mesi Tic AS
UK	Armitage Shanks Brausch & Co. (UK) Ltd British Bathroom Council Caradon Bathrooms Ltd NRA, Demand Management Centre Opella Ltd Shires Bathrooms WRc Evaluation & Testing Centre
USA	American Standard Inc Coast Foundry Eljer Industries Envirovac Inc Kohler Company Mansfield Plumbing Products Microphor Inc. Sloan Valve Company Stevens Institute of Technology