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Beach, R. K.

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ABSTRACT

Current plumbing code requirements, behaviour of trap seals and related research are reviewed and revisions to plumbing code requirements suggested.

LES EXIGENCES FONCTIONNELLES DES SIPHONS DANS LES SYSTEMES DE DRAINAGE

par R.K. Beach

RESUME

Les auteurs passent en revue les exigences actuelles des codes de plomberie, le comportement des garde-eaux ainsi que les recherches connexes, et proposent des modifications aux exigences des codes de plomberie.

PERFORMANCE REQUIREMENTS FOR TRAPS IN DRAINAGE SYSTEMS

by

R.K. Beach

A sanitary building drainage system is required to carry waste from plumbing fixtures to the public sewer or a private sewage disposal system without permitting foul air to escape into the building. This is achieved by means of water seal traps, which are either integral with the fixtures or installed as close as is practical to the outlet from the fixtures. At one time traps were also installed on the sanitary building drain to prevent sewer air from entering the drainage system, but most plumbing codes now prohibit or advise against them because they create undesirable positive pressure conditions in the system and add to its cost.

Several factors affect the performance of traps in drainage systems, principally self-siphonage, induced siphonage and evaporation. As the first two depend on the air pressure in the drainage system, the venting system must be considered in conjunction with traps, and vice versa.

CONSEQUENCES OF A TRAP SEAL FAILURE

A factor that ought to be considered is the quality of the air in the drainage system. Is it a health hazard or just an unpleasant nuisance? When the water-borne system of handling night soil was introduced in the late 1800's, it was believed that sewer gas was harmful to health. Although accidental deaths may still occur, such as the recent asphyxiation of a man and a boy while cleaning a septic tank, some men, of necessity, are required to work indefinitely in areas where there is a concentration of sewer gas. They do so without apparent ill effect.

In the early 1950's, when research work was being carried out on the performance of traps, this subject was investigated (1, 2). The same conclusion was reached in both cases: that sewer gas does not transmit disease and that its composition differs little from that of outside air. Consequently, accidental discharge of air from a drainage system into a building is not likely to cause anything more than the annoyance of a temporary odour problem. There is no need to provide as large a factor of safety in the system design as there would be if the air in a drainage system presented a serious hazard to health.

TERMINOLOGY AND TYPES OF TRAP

It is well known that the configuration of a trap has an effect on its performance or operating characteristics. The three principal configurations are illustrated in Figure 1, which includes a diagrammatic presentation of the terminology used in this paper. In particular, it should be noted that the term, trap seal depth, always refers to the vertical distance between the trap dip and the trap weir. It is clear that each of the three types of trap will experience a different trap seal loss or have a different trap seal retention if subjected to the same suction pressure. Except for water closets, the most common type of trap is the tubular trap, which has the same diameter throughout. Most research to date has made use of this type because it simplifies investigations considerably. The present paper also uses the tubular trap as the basis for discussion, but the recommendations are applicable to all types of trap.

Depending upon its location in the drainage system, a trap will usually be subjected to either predominantly positive pressures or predominantly negative pressures, but not to both. The effect on its water seal will be different for the two cases because of the presence of the trap weir on the downstream leg.

EFFECT OF POSITIVE PRESSURES

Consider the trap shown in Figure 2(a). It is located in a positive pressure zone and has a seal depth of Z in. The air pressure on each side of it is equal to the atmospheric pressure, p_a. When the air pressure in the trap arm rises to $p_a + \Delta p$ owing to discharge of fixtures elsewhere in the system, the water rises in the fixture side of the trap until the water column, h, just balances the increase in pressure Δp (Figure 2(b)). As the trap has a uniform cross-section, the trap seal depression in the downstream leg is equal to the rise of water in the upstream leg. The change in water level in each leg, h/2, is therefore equal to $\Delta p/2$. (This simple U tube relation really does not hold true if one water level is near the trap weir or trap dip where the horizontal cross-sectional area changes slightly. The difference is small, however, and for practical purposes it can be ignored.)

When Δp and h increase to the point where they are equal to 2Z, (i.e., h/2 = Z) a tubular trap has reached its limit of protection against positive pressure. (This statement does not hold true for the other types of trap shown in Figure 1; there are significant differences in the size and volume of their upstream and downstream legs.) A slight overpressure is required to form air bubbles and to force them past the trap dip; if this happens a trap seal failure is deemed to have occurred.

When the pressure in the drainage system returns to atmospheric, the water will drain back into the trap and tend to return to the original seal height Z. A small quantity of water, however, will adhere to the sides of the trap and the fixture outlet pipe and will eventually evaporate. There is the further possibility that if the positive pressure is suddenly reduced to zero or to a negative value the momentum of the falling water in the trap will be sufficient to carry some of it over the trap weir. In practice, the amount of water lost by these occurrences will be very small and will not normally cause a problem.

EFFECT OF NEGATIVE PRESSURES

The effect of negative (suction) pressure on a tubular trap is shown in Figure 3. If a full trap (Figure 3(a)) is subjected to a steady suction pressure Δp_1, the water level in the upstream leg is depressed by atmospheric pressure p_a and water is forced over the trap weir and lost down the drainage system. This will continue until the difference in the water level, h_1, just balances the suction pressure Δp_1 (Figure 3(b)). When the pressure in the drainage system returns to atmospheric pressure, the trap will be found to have suffered a trap seal loss ℓ_1 equal to $h_1/2$ (Figure 3(c)). From this it may be seen that a tubular trap will prevent room air from bubbling into the drainage system as long as the steady suction pressure is less than the trap seal depth t, or twice the height of the trap seal retention Z, whichever is less.

If the trap in Figure 3(d) is then subjected to a steady suction pressure Δp_2 larger than t, water will be lost over the trap weir and air will bubble past the trap dip. This air replaces water in the downstream leg and this also is lost over the trap weir. The total amount of water ℓ_2 that can be lost in this manner is indicated in Figure 3(e), but it is highly variable, depending on the diameter of the trap, its trap seal retention at the start, the magnitude of the suction pressure and its steadiness and length of application.

PERFORMANCE CHARACTERISTICS OF TRAPS

The performance characteristics of traps in drainage systems have been studied in Denmark (3) and Belgium (4) and are currently under study at the Division of Building Research, National Research Council of Canada. Because of the characteristics of the traps, test methods, and pressures used in Europe, however, the information gained there can only be related to North American practice in a general way.

One European test consists of suddenly applying a negative pressure to the downstream side of the trap and measuring the trap seal loss after suction pressure has been removed. The test is repeated without refilling the trap and the results are plotted as shown in Figure 4. Curve III is of particular interest. It shows the sudden increase in trap seal loss that occurs once bubbling has started. With a test pressure of -1.68 in. (-420 N/m^2) water column the test had to be repeated nine times before bubbling occurred. More test repetitions would have been required if the differential test pressure had been smaller and fewer if the pressure had been larger. It is important to note that the suction pressure used in the tests was applied suddenly and that it was considerably higher than the 1-in. (250 N/m^2) negative pressure that could be expected in a North American system. It can be deduced that any trap that has a performance curve with a very small decrease in trap seal after the first one or two tests will probably perform satisfactorily; and that the performance of a trap in a drainage system can be determined by repeating the test only two or three times. The latter is an important practical consideration.

DRAINAGE SYSTEM CHARACTERISTICS

The entry of air into a drainage system is not a problem except for the noise that may be caused by bubbling. Once bubbling into the system has occurred, the trap will have a reduced capacity to provide protection from positive pressure since it will have lost a significant amount of seal. Fortunately, the characteristics of flow in a stack are such that a negative pressure tends to exist throughout the stack, except near the bottom. Here, as a result of change in the direction of flow, from vertical to horizontal, a positive pressure usually exists. The pressure gradient in a stack is fairly smooth, with a large increase in negative pressure occurring immediately below the fitting where waste enters the stack.

A typical stack pressure gradient for a British single-stack system is shown in Figure 5 (5). It is similar to that found in North American systems. The point where the pressure in a stack changes from negative to positive is indefinite, but it is always close to the base of the stack. The important thing is that although the pressure at a particular point in the stack will vary with flow, it will not normally change from a negative to a positive value, or vice versa, except near the point where the pressure is close to atmospheric. Thus a trap subjected to a large negative pressure may experience a large seal loss, but it is very unlikely that it will subsequently be subjected to a large positive pressure that could cause trap seal failure.

BEHAVIOUR OF TRAPS

The behaviour of individual traps with either full seal or reduced seal must be considered. It is known that positive pressure in a drainage system will not normally cause loss of seal, but that negative pressure and evaporation will. If the negative pressure acting on a trap is caused by discharge from the trap itself, it is called self-siphonage; if caused by the discharge of other fixtures, it is called induced siphonage.

Self-Siphonage

The phenomenon of self-siphonage can be explained by reference to Figure 6. Discharge from a fixture such as a lavatory consists of air and water; the two pass through the trap into the trap arm in such a way that slugs of water, or water and air, often fill the entire cross-section of the trap arm at points along its length (Figure 6(a)); that is, full-bore flow occurs intermittently in the trap arm. If such a slug is present in the trap arm near the end of the discharge period (Figure 6(b)), it produces a suction behind itself as it moves towards the stack. This suction may draw air through the trap and water out of it, as with induced siphonage.

As the last slug of water moves towards the stack, water sloughs off both ends of the slug. Some from the trailing end flows back towards the trap (Figure 6(c)). Water remaining in the trap aids this refill by applying a negative pressure equal to the difference in height of water in the two legs of the trap. If the slug is close to the trap, the backflow of water may be sufficient to refill it. If the slug is too far down the trap arm, however, the backflow will not reach the trap and the result will be a trap that is only partially filled (Figure 6(d)).

Slug action depends primarily on the length and slope of the trap arm. A trap arm set at a low slope tends to produce maximum refilling of the trap. The S trap, which is usually not permitted because it is highly susceptible to self-siphonage, shows the effect of a trap arm that can be considered to have either zero length or an infinite (vertical) slope. Increasing the diameter of the trap arm has the effect of reducing the chance of self-siphonage, but this is variable and depends on where the enlargement occurs. It has the further advantage of increasing the permissible length of the trap arm.

Another significant source of water for refilling a trap is the trail discharge from the fixture. Its size depends primarily on the area and slope of the bottom of the fixture; the hydraulic characteristics of the fixture outlet, strainer, and fixture outlet pipe have a secondary effect. Whether a trap is susceptible to self-siphonage in a particular installation, therefore, depends on the characteristics of the fixture and the actual arrangement of the piping.

Induced Siphonage

Induced siphonage is the mechanism whereby the operation of a fixture or fixtures elsewhere in a system creates a negative pressure that reduces the water seal in idle traps. Because of minor variations in manufacture or installation the effect of the same induced siphonage will vary slightly from trap to trap. In a particular installation one trap will tend to be more susceptible to failure than others, and when it does fail it will tend to protect the remaining traps by relieving the negative pressure in the system.

EVAPORATION

If a trap remains idle it becomes more susceptible to induced siphonage as it slowly loses its seal by evaporation, the total loss depending on the rate of evaporation and the period of idleness. Both are highly variable, but only the rate of evaporation lends itself to investigation. A study carried out at the Building Research Station (1) in England reports an evaporation rate of 0.15 in. per week for a 1-1/4-in. diameter trap with both legs exposed to room air whose temperature varied between 55 and 70 °F. This corresponds to a rate of about 0.08 in. per week where only one leg of the trap is exposed to room conditions. In the USA, the Housing and Home Finance Agency carried out a similar program that produced essentially the same results (2).

The American publication includes a method of estimating evaporation rate based on trap size, length of fixture outlet pipe, air temperature, and relative humidity. Vertical tubes and open traps were used so that, as for the British study, the test installations did not simulate actual installations very closely. Reference is made to the very low rates of evaporation reported by other workers and a comment is included that the actual evaporation rate may be less than that determined by the U.S. method. A lower rate can be readily attributed to the presence of strainers and mechanical wastes, which tend to restrict room air movement over the exposed water surface.

In the UK an evaporation rate of 0.1 in. per week is presumed, and this seems to incorporate a safety factor of about 1.25. As the rate of evaporation is highly variable, the same rate of evaporation, 0.1 in. per week, is tentatively recommended for use in North America. Where fixtures are expected to be subjected to long periods of idleness, either deep-seal traps or anti-siphon type traps can be used to provide added protection from loss by evaporation.

TESTING OF TRAPS

After the performance requirements for traps have been fixed there remains the matter of testing. It may be classified according to its purpose as follows:

- laboratory tests to establish the characteristics of a trap and determine whether it meets the requirements of the appropriate product standard, and

- site tests to prove out

  (i) the complete DWV (drain, waste, vent) system with regard to control of pneumatic pressure variations within the system, and

  (ii) the installed trap and its related piping with respect to self-siphonage.

It is relatively easy to establish suitable test methods, but it is not so easy to determine the number of times the test must be repeated to determine trap performance. As has been mentioned, only three repeated tests are needed to establish the performance of a trap subjected to the laboratory test procedure, and this would normally form part of the product standard. It is not so easy to establish whether three repeated tests are sufficient to establish the performance characteristics of a trap installed in a drainage system. In this case the suction test load is produced by discharging fixtures in the system. The number to be discharged should be determined on the same basis as that for establishing the sizing tables used in designing the system and contained in present plumbing codes. Owing to slight variations in fixtures and traps caused by the manufacturing process and the difficulty of repeating practical tests exactly, some variation in the individual test loads and results can be anticipated, but it should not be sufficient to obscure the difference between acceptable and unacceptable performance.

Another factor with a significant effect on the results of a test is the location of the fixtures that are discharged. It is common practice to select for testing fixtures that will apply the severest load on the system, generally those furthest upstream. Although a system must be able to withstand one application of a load of this nature, for it to withstand repeated applications without trap refill is a very severe requirement. The probability that specific fixtures will be found in operation together is considerably less than the probability that an equal number of any of the fixtures will be found in operation. It is suggested, therefore, that repeating the test three times without trap refill, using fixtures that apply the severest load, will establish whether the performance of the traps in a drainage system is adequate.

CURRENT REQUIREMENTS FOR TRAPS

The Canadian Plumbing Code 1975 (6) requires that traps have a minimum trap seal depth of 1-1/2 in. Most traps used in Canada, however, are manufactured to conform to the standards of the Canadian Standards Association and these generally require a trap seal depth of at least 2 in. The trap seal depth generally varies with the size, radius of curvature of the flow path, and the manufacturing process. In North America, traps for small fixtures are usually found to have a trap seal depth of between 2 and 3 in.

Current plumbing codes in Great Britain call for a minimum trap seal depth of 2 in., but the British Standard Code of Practice (7) states that traps 2 in. or less in diameter should have a trap seal depth of at least 3 in. This difference originated many years ago when the British changed from the two-pipe system of separate soil and waste stacks to the one-pipe system, so named because it uses the same pipe for both soil and waste (as in North America). Both the two-pipe and one-pipe systems require an additional pipe for venting. The single-stack system dispenses with the individual dry vent and vent stack generally used in North America and uses the soil-or-waste stack to fulfil both drainage and venting functions.

The old British two-pipe system used traps with 1-1/2-in. trap seal depths in the waste system and water closets with 2-in. trap seal depths in the soil system. The British were reluctant to permit traps with a 1-1/2-in. trap seal depth in the new one-pipe system and it was suggested that the minimum trap seal depth should be 3 in. The cost of redesigning water closets was considered to be so great, however, that they agreed to require only the small-diameter traps used in one-pipe systems to have a 3-in. trap seal depth. When the single-stack system was introduced the trap seal requirements of the one-pipe system were retained.

Model plumbing codes in the USA follow the recommendations of the Subcommittee on Plumbing of the Building Code Committee (8) that "Every fixture trap shall have a waterseal of not less than 2 in. and not more that 4 in." This is related to recommendations that self-siphonage and induced siphonage be limited to a loss of 1 in. and the maximum permitted pressure variation in the system to ±1 in. of water column. It was considered that a trap which lost 1 in. of seal by self-siphonage could still withstand an applied pressure of ±2 in. of water column and hence had a safety factor of 2. For a trap to be subjected to such a pressure, however, the venting system must have failed to limit the pressure to within the ±1-in. range. The wording of the requirements have changed in the USA over the years and it is now often expressed as "Trap seal retention shall be at least 1 in. or one half of the trap seal depth, whichever is greater". Although this covers the use of traps with trap seal depths greater than 2 in., it is inconsistent with the requirement that the venting system limit the pressure to a range of ±1 in. of water column.

PERFORMANCE REQUIREMENTS OF VENTING SYSTEMS

The performance requirements of traps and vent pipes in a sanitary drainage system are dependent on each other, the common factor being the variation in pneumatic pressure that occurs in the drainage piping. In general terms, traps are required to prevent the passage of air from the drainage system into the building when the pressure in the system is within the design range; the venting system is required to limit the pressure variation in the drainage system to that allowable range.

Current plumbing codes are invariably of the specification type, although they are often considered to be design manuals. As has been pointed out by Hunter (see Ref. 8, p. 142) "with any rules that may be applied generally with safety, many places will be found where we could go beyond the limits stated in the rules with perfect safety were there a competent authority to prescribe the limits for the condition encountered." The experience of the past 40 years has placed those involved in a better position to assess conditions under which rigid rules can be relaxed safely. This is reflected in the changes that have been made in current plumbing codes and the desire to move design details out of codes into supplementary design manuals, the detailed requirements to be replaced by performance requirements.

Without being identified as such, self-siphonage and induced siphonage are usually covered in current plumbing codes in the section on venting. The requirements governing self-siphonage and induced siphonage are based on original research by Hunter and by others at the National Bureau of Standards (8). In making his recommendations concerning self-siphonage Hunter considered many factors, including possible fouling of the piping, the shape of the bottom of the fixture, and the fact that the Subcommittee had agreed that the loss of seal from a trap with a seal depth of 2 in. should not exceed 1 in. In general, Hunter's original recommendation was that the maximum length of a trap arm should be 6 ft, except for washbasins and similarly shaped fixtures where it should be 4 ft. The U.S. Department of Commerce Subcommittee on Plumbing subsequently agreed on a maximum length of 5 ft for all trap arms.

Further research into self-siphonage carried out at the National Bureau of Standards (9) has provided an engineering basis for determining the maximum trap arm length. The Coordinating Committee responsible for the preparation of the American Standard National Plumbing Code, ASA-A40.8, considered the report but apparently did not find the engineering approach suitable for inclusion in the code. Instead a simple table was adopted of length versus fixture drain diameter that would be safe for all installations. This table, which may be found in most American model plumbing codes, is more restrictive than the present Canadian requirement for fixture drains with small diameters but less restrictive for those with large diameters. Actually, both tend to be overly restrictive and deal with only one of several equally important factors that affect trap seal loss due to self-siphonage. More work is required in this area, in particular in developing a practical design method based on the findings of BMS 126 (9), and the recommendations contained in this paper are a step in that direction. The proposals provide an easing of the dimensional requirement while maintaining the safety of the system. This, for the owner, means greater freedom in the layout of fixtures and reduced construction costs.

Induced siphonage, which relates to the negative pressure that may occur in a drainage system, is covered in most plumbing codes by specification of where vent pipes are required and provision of tables that give the maximum allowable length of vent pipe, depending on size, hydraulic load served, and size of soil-or-waste stack. A limited amount of wet venting is provided for by including clauses that are, in effect, exceptions to the basic requirement of the North American system that all fixtures must be individually vented.

The tables are based on Hunter's work (8, p. 114) in which he assumed that "no positive or back pressure greater than 1 in. or no negative pressure or partial vacuum less than 1 in. of water, measured from atmospheric pressure as the zero, is to be developed in any branch drain connecting to the stack above the house drain." He continued with the very important statement: "It should be kept in mind that pressure variations in the stack which cannot possibly be transmitted to a fixture trap have no bearing on the problem. We are only concerned with the pressure effects in the branches, whether vented or unvented."

The presence of the ±1-in. requirement in a plumbing code has little effect, however, since the venting systems must be designed in accordance with the vent sizing tables contained in the code. There is ample evidence that in many cases these tables result in the oversizing of vent pipes and venting systems. As traps with trap seal depths greater than 2 in. are readily available, a requirement that the pressure in a drainage system be limited to ±1 in. of water column is also overly restrictive. It is therefore proposed that the basic requirement of a venting system should be to limit the pneumatic pressure variation that can act on a trap to a maximum design value that is consistent with the capabilities of the traps used in the system.

The present vent sizing tables are applicable in cases where the design pressure variation is ±1 in. of water column and the traps being used have a trap seal depth of 2 in. Although this will be the most common situation, tieing the pressure limitation to the trap seal depth of the traps being used eases the restrictions on properly designed systems. Such a change will not increase the possibility of a trap seal failure nor reduce the safety of the system.

DETERMINATION OF TRAP PERFORMANCE REQUIREMENTS

The performance requirements of a trap must be expressed in terms of induced siphonage, self-siphonage, evaporation and the maximum permitted variation from atmospheric pressure that may occur in the system. These represent loads that may be applied to the trap in any sequence, so that performance requirements must be based on the worst possible sequence of events. That sequence of loads is as follows: induced siphonage or self-siphonage, evaporation and, finally, application of the maximum deviation from atmospheric pressure that the venting system may permit. These may be expressed by the following equations

$$A \geq B_1 + C + B_3 \qquad (1)$$

$$A \geq B_2 + C + B_3 \qquad (2)$$

where A = trap seal depth,

B_1 = trap seal loss caused by induced siphonage resulting from the effect of D, the maximum deviation from atmospheric pressure that may occur in the system in accordance with the performance requirements of the venting system,

B_2 = trap seal loss caused by self-siphonage,

B_3 = minimum depth of seal required to prevent the passage of air through the trap under the effect of D, the maximum deviation from atmospheric pressure that may occur in the system in accordance with performance requirements of the venting system,

C = minimum allowance for evaporation.

The relations of these variables for tubular traps are shown in Figure 7.

When the level of water in a tubular trap is in mid-range, the trap will behave like a simple U tube: if pressure is applied to the water in one leg, the surface will be depressed and the same volume of water will flow into the other leg to raise the surface by the same amount. Thus, the depression of the first surface is equal to the elevation of the second, and both changes in elevation are equal to half the applied pressure in inches of water. If either or both surfaces approach the trap dip or trap weir, this relation will change slightly because the horizontal cross-section of the trap will increase as it changes shape from round to oval; and in order to keep the displaced volume the same there will be a change in height. For tubular traps with small radii of curvature the deviation from a simple U tube is small. As may be seen in Figure 7, the radius of curvature of the trap will cause B_1 and B_3 to be slightly smaller than D/2. The result is that both errors add additional depth of seal to the evaporation allowance C. Although assuming that $B_1 = B_3 = D/2$ causes some difference between calculated and actual values, it simplifies calculations considerably. As the error involved is small and not critical, it will be assumed for tubular traps that

$$B_1 = B_3 = D/2 \tag{3}$$

Thus, substituting in equation (1) and simplifying, gives

$$A \geq C + D \tag{4}$$

and equation (2) becomes

$$A \geq B_2 + C + D/2 \qquad (5)$$

Equation (4) applies to all traps in a system and covers any combination of occurrences of evaporation and induced siphonage. Those traps in the system that are susceptible to self-siphonage must also comply with equation (5). The loss of seal from induced siphonage and self-siphonage is not cumulative. A trap that loses some seal by self-siphonage will not lose any seal by induced siphonage unless it is exposed to suction pressure with a value greater than twice that of the seal already lost. Conversely, a trap that provides protection from induced siphonage pressures equal to D/2 will provide the same protection from self-siphonage. Setting minimum values for C and D in equation (4) automatically sets the minimum value of B_2 in equation (5) at D/2 for traps whose trap seal depth, A, equals C plus D.

Both equations (4) and (5) are useful in showing the benefits that can be obtained by having traps available with varying trap seal depths. These benefits may be gained at the design stage or at the installation stage, but the greatest benefit accumulates at the design stage. The designer has freedom to use larger values for B_2, C and D in the design of the system as long as he specifies that the traps have a trap seal depth A equal to or greater than that determined by equations (4) and (5). The value of D will apply over the whole system, but values for B_2 and C can be varied to suit particular situations. It is anticipated that most designers will not take advantage of this opportunity, but present plumbing codes specifically prohibit the minority from taking any advantage of special traps and traps with large trap seal depths.

The owner enjoys additional benefits when trap seal depths greater than that required by both the plumbing code and the designer's requirements are installed. The excess depth is available as increased protection from any load that may occur in the system; that is, all safety factors have been increased. The user also gains a similar benefit when the maximum individual load represented by C and B_2 or D is lower than the minimum design level required by the plumbing code or the designer. The "unused" safety factor is available as added protection from other loads. Because of this fortuitous arrangement the individual values specified in the plumbing code for B_2, C, and D need not include a large factor of safety. Setting minimum values for B_2 and C and a maximum value for D in the code ensures that the designer and owner will be able to use special traps such as deep seal traps and anti-siphon traps to their best advantage while still ensuring that the system is safe.

A further use for equations (4) and (5) is to prove the safety and acceptability of actual installations. The present dimensional limitation in codes placed on trap arms to prevent self-siphonage is still valid in that any installation that conforms will comply with equations (4) and (5). An installation that does not conform to the present dimensional limitations will probably require testing to ensure that it complies with equations (4) and (5).

The test involved is very simple: fill the fixture and then discharge it. This should be repeated several times and the maximum value of trap seal loss used to determine compliance with the requirement for self-siphonage. Much of this testing was carried out and reported by the National Bureau of Standards in BMS 126 (9), but it needs to be brought up to date by additional laboratory and on-site tests. If this is done a table of piping arrangements "deemed to satisfy" equations (4) and (5) can easily be developed.

RECOMMENDATIONS

Present plumbing code practice is to specify a minimum value for A. Equation (4) clearly shows that it is preferable to specify minimum values for C and D. In Canadian plumbing codes where the minimum value for A is 1-1/2 in. the corresponding values to be substituted would be 1/2 in. for C, the evaporation allowance, and 1 in. for D, the maximum pneumatic pressure variation limited by the venting system. D/2 sets the absolute minimum value for B_2, the loss of seal by self-siphonage, so that the minimum value recommended for B_2, C and D/2 is in each case 1/2 in. As Canadian plumbing codes require that traps conform to recognized product standards and these generally require that traps have a minimum trap seal depth of 2 in., the same as the present minimum value for "A" in American plumbing codes, the additional 1/2 in. of trap seal depth constitutes an added margin of safety over and above that provided by individual factors.

CONCLUSION

These recommendations do not reduce the inherent safety of drainage and venting systems. They incorporate the same minimum safety factors, but the factors are expressed in a way that shows the relation between them. There is no need to provide large individual safety factors because these combine to make up the full depth of water seal that reacts to the individual load.

There are many benefits to be gained from including these recommendations in plumbing codes. Restrictions on system design will be eased, while still retaining the inherent safety of present requirements. This will allow greater freedom in fixture layout and piping arrangements and will in many cases result in lower installation costs. The recommendations also establish a basis for testing new and existing systems to determine whether, in fact, they are safe.

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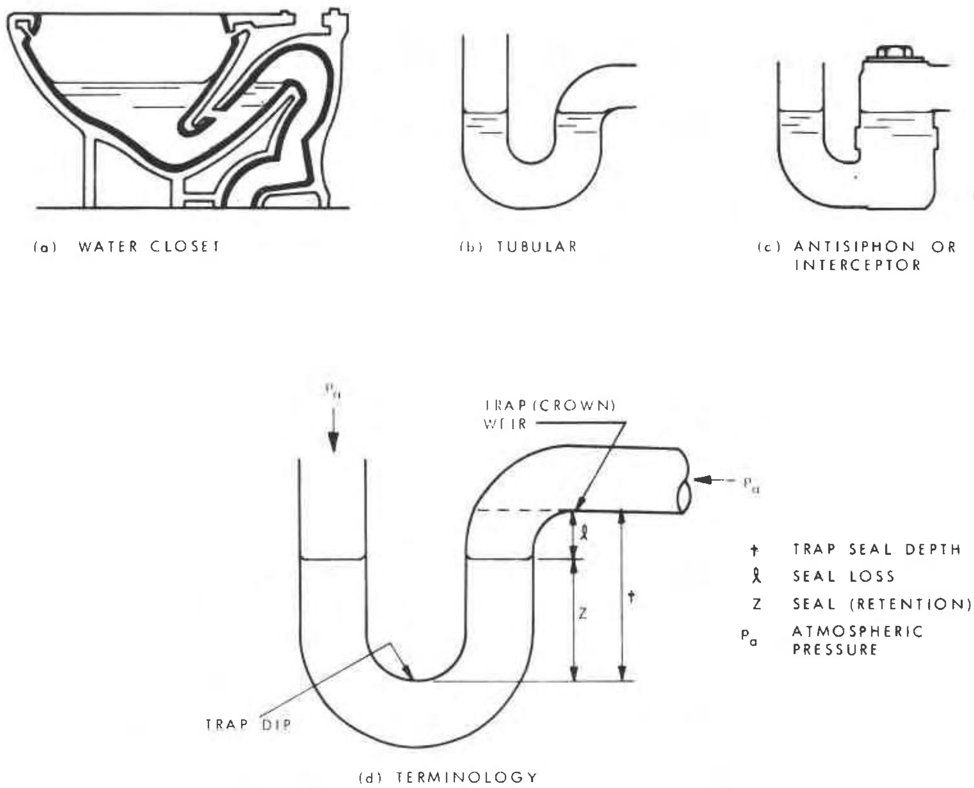

FIGURE 1

BASIC TRAP TYPES AND TERMINOLOGY

BR 5266-1

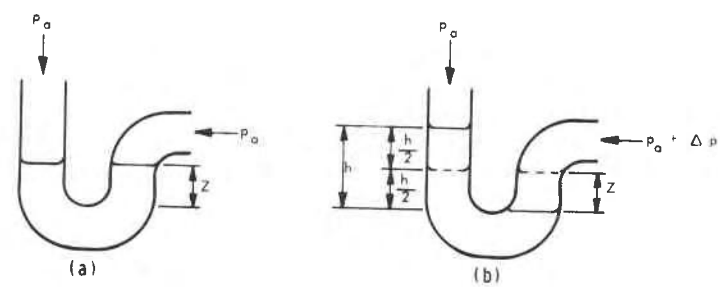

FIGURE 2

TRAP SEAL BEHAVIOUR UNDER POSITIVE PRESSURE

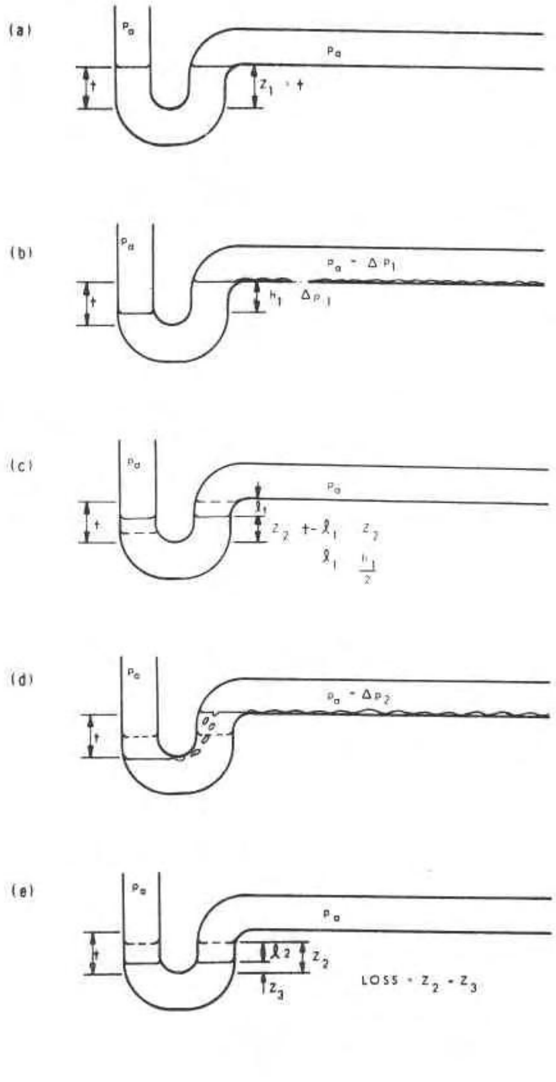

FIGURE 3
TRAP SEAL BEHAVIOUR UNDER NEGATIVE PRESSURE

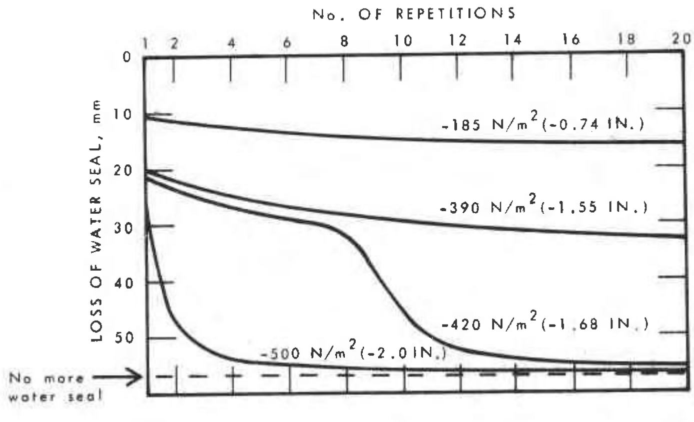

FIGURE 4

CUMULATIVE TRAP SEAL LOSS AT VARIOUS SUCTION PRESSURES (3)

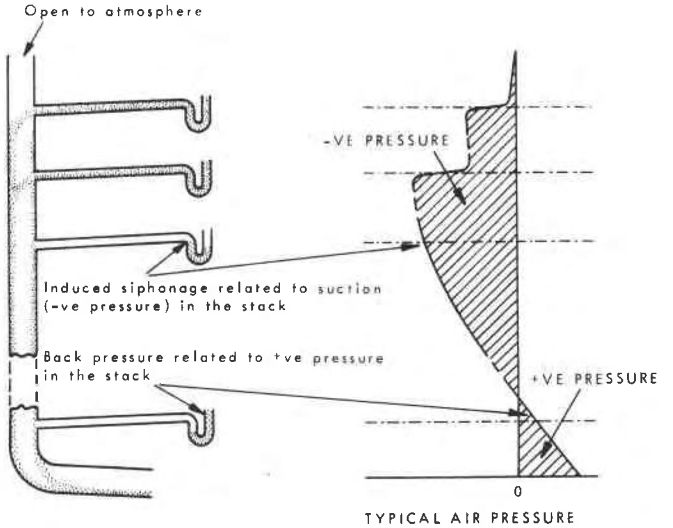

FIGURE 5

PRESSURE VARIATIONS IN A STACK (5)

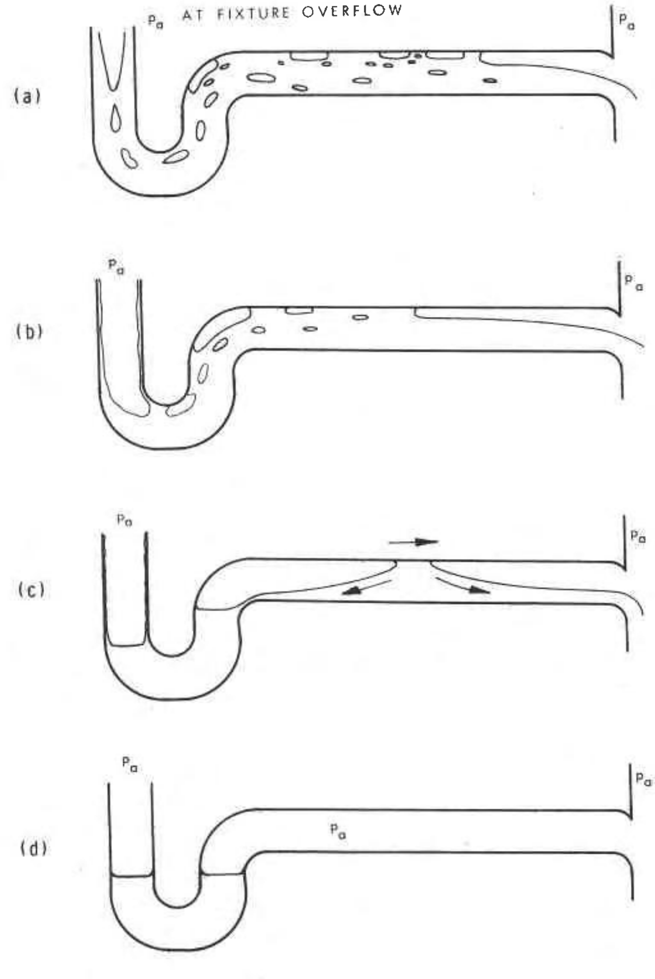

FIGURE 6
SELF-SIPHONAGE TRAP ACTION

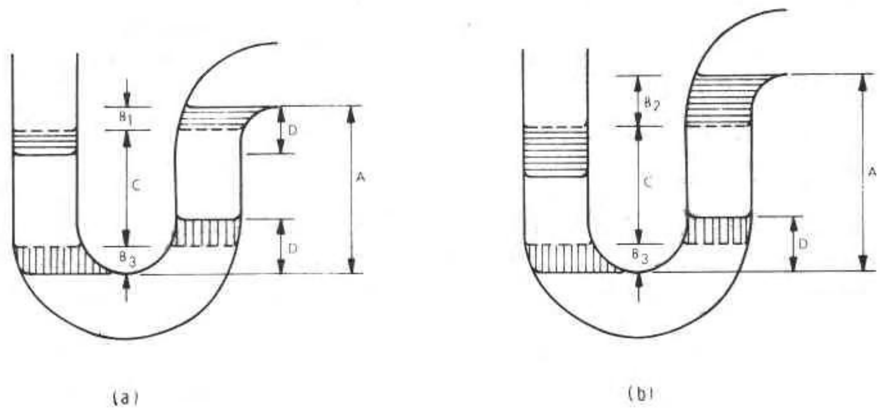

FIGURE 7
TRAP PERFORMANCE REQUIREMENTS