DEVELOPMENT & TESTING OF FLOOR DRAIN WITH A VALVE TO BLOCK SEWER GAS FOR RESIDENTIAL APPLICATIONS

by: Bert Phillips, UNIES Ltd
for: Dranjer Corporation

June 1997

CMHC Project Officer: Peter Russell

This project was carried out with the assistance of a grant from Canada Mortgage and Housing Corporation under the terms of the Housing Technology IncentivesProgram (CMHC File 6521-29'94). The views expressed are those of the author and do not represent the official views of the Corporation.

Development and Testing of Floor Drain with a Valve to Block Sewer Gas for Residential Applications

Prepared by
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For
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Abstract

Dranjer Corporation patented the concept of a floor drain with a counterbalanced valve/seal assembly to prevent the flow of sewer gas if the conventional P-trap dries out. It was anticipated that this design would function as a backwater valve and that it could sufficiently reduce trap evaporation to eliminate the requirement for trap primers.

Field trial model XN-3 floor drains were produced for testing and monitoring. Testing and monitoring was done to assess the ability of the device to perform as a floor drain, meet the requirements of the proposed applications and to comply with the requirements of CSA Standard B79-94 "Floor, Area and Shower Drains, and Cleanouts for Residential Construction". Testing, monitoring and reporting were done by an "at arms length" engineering consultant.

Evaporation from a clean, properly functioning model XN-3 was less than 8% of that from a conventional trap and can maintain the trap seal for six years. Evaporation from an XN-3 in which the valve seal was significantly impaired was about 20% of that from a conventional trap. It is believed that evaporation rate can be used as a surrogate for estimating the reductions in sewer gas entry that would occur if the conventional P-trap dries out.

The XN-3 floor drain as tested is not a backwater valve. However, the product has been redesigned to make it function as a backwater valve. The redesign appears successful.

Executive Summary

Dranjer Corporation designed and patented a floor drain assembly with a counterbalanced valve/seal assembly to prevent sewer gas from infiltrating through the drain if the conventional P-trap dries out. The objective of this project was to evaluate the ability of this floor drain assembly to comply with Code requirements for floor drains and to assess its ability to perform as a floor drain, backwater valve and sewer gas block and to prevent or reduce evaporation from the trap. It is hoped that this design will be accepted as an alternative to trap primers. The benefits of this would be reduced water and sewer costs for homeowners and municipalities and improved protection from sewer gas entry.

A detailed testing program was developed to evaluate the performance characteristics of the assembly. Testing was done to assess compliance with CSA Standard B79-94 "Floor, Area and Shower Drains, and Cleanouts for Residential Construction", and to evaluate performance of attributes not addressed in the CSA standard.

Cover plates did not meet CSA loading criteria for light duty drain covers. Production covers will be manufactured from stronger material. Information from these tests will be used for design modifications to improve production model drain covers.

CSA watertightness tests showed that water leakage past the valve assembly generally complied with the requirements of a backwater valve, but in cases where some water leaked back into the floor drain catch basin, the float mechanism actuated, forcing the backwater valve open. This negated its usefulness as a backwater protection device. As a result, the valve assembly was redesigned. Preliminary testing indicate that the design changes have effectively eliminated the problem.

Tests were designed to evaluate the impact of operating in a dirty environment. When dirt passed through the drain, some stayed on the valve, slightly impairing the valve seal. This problem is common to other backwater valve/floor drain devices.

Tests were designed to assess the impact of dirt on the effectiveness of the valve as an alternative to a trap primer. Four Dranjer floor drains, each representing a different operating condition, were installed in a residential basement and connected to the city sewer system. The units included:

1) a conventional P- trap as a control unit;
2) a properly operating Dranjer;
3) a Dranjer with a wire wedging the valve slightly open, and;
4) a Dranjer which had household floor dust water poured through it to represent a dirty environment.

Water levels in the traps below each of the drains were measured on a regular basis over eight months.

Those tests showed that the Dranjer floor drains impaired with dirt and a wire significantly outperformed the conventional open trap. Over the eight month evaporation tests, water levels in the conventional floor drain trap fell 89 mm. Water levels in the dirty and wire impaired Dranjers fell 20 mm and 16 mm respectively, and in the clean Dranjer only fell 7 mm. These

water loss levels are compared to the Plumbing Code requirement for trap seal depths of not less than 38 mm.

Evaporation losses can be used as a conservative surrogate for sewer gas entry through traps.

The conclusion of the study is that the Dranjer can meet the CSA performance requirements for floor drains and backwater valves. It reduces evaporation thus extending the time before a wet trap dries out by more than a factor of four. In the event that the trap does dry out, the valve mechanism will block 75% or more of sewer gas entry, when compared to a conventional, open floor drain.

Résumé

La société Dranjer a conçu et fait breveter un avaloir de sol avec obturateur contrebalancé empêchant les gaz d'égout de s'infiltrer par l'avaloir si le siphon en P vient à s'assécher. L'objectif de la recherche consistait à évaluer la conformité de l'avaloir aux exigences correspondantes du Code de même qu'à évaluer sa tenue en service comme avaloir de sol, clapet anti-retour, obturateur de gaz d'égout et comme dispositif prévenant ou réduisant l'évaporation de la garde d'eau du siphon. La société Dranjer espère que cet avaloir sera admis comme solution de rechange au dispositif d'amorçage du siphon, puisque ce modèle présente comme avantages une réduction des coûts d'eau et d'égout tant pour les propriétaires que pour les municipalités et une meilleure protection contre l'infiltration des gaz d'égout.

Un programme d'essais détaillé a été mis au point dans le but d'évaluer la performance de l'avaloir. Les essais ont été menés en vue d'évaluer sa conformité avec la norme CSA B79-94, «Floor, Area and Shower Drains, and Cleanouts for Residential Construction», et d'évaluer la performance de certaines caractéristiques dont ne fait pas état la norme de la CSA.

Les plaques-couvercles ne satisfaisaient pas aux critères de mise sous charge de la CSA visant les plaques d'avaloir à service léger. Les plaques-couvercles du lot en production seront fabriquées d'un matériau plus résistant. Les résultats de ces essais serviront à apporter des modifications afin d'améliorer la plaque d'avaloir du modèle en production.

Les essais d'étanchéité à l'eau de la CSA ont indiqué que les fuites d'eau au-delà de l'obturateur répondaient aux exigences d'un dispositif antirefoulement, mais que dans les cas où une certaine quantité d'eau remonterait dans le pied de descente de l'avaloir, le flotteur s'activerait et ferait ouvrir le dispositif d'obturation. En conséquence, l'obturateur a fait l'objet d'une nouvelle conception. Les premiers essais indiquent que les modifications apportées ont efficacement remédié à la situation.

Les essais ont été mis au point dans le but d'évaluer l'incidence du fonctionnement de l'avaloir dans un environnement sale. Lorsque la saleté traversait l'avaloir, une certaine quantité demeurait sur l'obturateur et en gênait quelque peu le fonctionnement, situation courante pour tous les autres avaloirs de sol et clapets anti-retour.

Les essais ont été mis au point dans le but d'évaluer l'incidence de la poussière sur l'efficacité de l'obturateur à servir de solution de rechange au dispositif d'amorçage du siphon. Quatre avaloirs de sol Dranjer, chacun représentant un mode de fonctionnement différent, ont été installés dans le sous-sol d'un bâtiment résidentiel et raccordés au réseau d'égout municipal. Les appareils comportaient :

1) un siphon classique en P tenant lieu d'unité de contrôle;
2) un avaloir Dranjer fonctionnant bien;
3) un avaloir Dranjer avec un fil maintenant l'obturateur en position légèrement ouverte; et
4) un avaloir Dranjer dans lequel on a versé de l'eau contenant de la poussière provenant du plancher, dans le but de simuler un environnement sale.

Le niveau d'eau du siphon sous chacun des avaloirs a été mesuré périodiquement sur une période de huit mois.

Ces essais ont montré que les avaloirs Dranjer gênés par la poussière et le fil se sont beaucoup mieux comportés qu'un avaloir conventionnel ouvert. Au cours des tests d'évaporation menés au cours des huit mois, le niveau d'eau dans le siphon de l'avaloir de sol conventionnel est tombé de 89 mm. Le niveau d'eau dans les avaloirs Dranjer gênés par la poussière est tombé respectivement de 20 mm et de 16 mm, alors que celui de l'avaloir Dranjer propre n'est tombé que de 7 mm. Ces niveaux de perte d'eau se comparent à l'exigence du Code de plomberie pour un obturateur de siphon dont la profondeur de la garde d'eau n'est pas inférieure à 38 mm.

Les pertes par évaporation peuvent tenir lieu de substitut prudent à l'infiltration des gaz d'égout par le siphon.

En conclusion, l'étude établit que l'avaloir Dranjer est en mesure de satisfaire aux exigences de performance de la CSA en matière d'avaloir de sol et de clapet anti-retour. Il réduit l'évaporation, prolongeant par conséquent la période précédant l'assèchement du siphon par un facteur de plus de 4. Si le siphon s'asséchait, l'obturateur contrerait 75 % ou plus de l'infiltration des gaz d'égout, comparativement à un avaloir conventionnel ouvert.

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Background

Residential indoor air quality is of increasing concern in Canada and abroad. A common entry point for contaminants in indoor air is through floor drains which have lost their wet seal. Floor drains often lose their seals because of evaporation. As well, occasionally a blockage in sanitary system vents cause traps to siphon dry. In response to this concern, some jurisdictions require trap primers on floor drains.

A trap primer is typically a water feed into a trap. It may be designed to provide a continuous or an intermittent water flow to the trap. Operation and maintenance of trap primers are problematic. At one extreme, they plug up, so do not provide the intended protection. At the other extreme, some primers run continuously at excessive flow rates, placing undesired loads on water supply and sewage disposal systems. Maintenance or repair may be complicated by the fact that much of the apparatus is located in or under the floor slab.

Dranjer Corporation designed and patented a floor drain assembly that incorporates a counterbalanced valve/seal assembly to prevent the P-trap from drying out, and infiltration of sewer gas if the conventional P-trap does dry out. If the design is an effective alternative to trap primers, the product would provide protection from sewer gas entry without the cost and waste of increased water consumption. As well, in most situations this alternative's installed cost is less than a trap primer. Municipalities would benefit from reduced demands on water supply systems and reduced volumetric loads at sewage treatment plants.

Dranjer Corporation retained UNIES Ltd. to conduct tests assessing the impact of the valve/seal assembly on the evaporation rate from the floor drain P-trap. This report describes the performance evaluation and testing done by UNIES Ltd. on the Dranjer Corporation's field trial model XN-3 floor drain and presents the test results.

Project Objectives

The objectives of this project were:

1) Evaluate the product's ability to comply with CSA Standard B79-94 "Floor, Area and Shower Drains, and Cleanouts for Residential Construction"

2) Assess the device's ability to perform as a
   a) floor drain
   b) backwater valve
   c) sewer gas block

3) Assess the device's ability to prevent or reduce evaporation from the trap.

This work was performed in three phases:

- Phase One - define a testing and monitoring program to realize the project objectives

- Phase Two - carry out that testing and monitoring program

- Phase Three - analyze and report the test and monitoring data from Phase Two.

Description of the Dranjer Corporation's Field Trial Model XN-3 Floor Drain

Dranjer model XN-3 is a custom made field trial model for basement floors. The XN-3 is a patented floor drain with an integral backwater valve. The backwater valve also functions as a sewer gas check valve.

The design of this model is based on these concepts:

1. Floor drain traps tend to dry out because of infrequent use. Appliances like clothes washers are located for the convenience of the homeowner and not necessarily close to a floor drain where they could ensure the trap is kept wet. If the trap does dry out, it creates an open path to the main sewer. The mechanics of air circulation are such that, if the trap is open, the house tends to draw make-up air from this source, that is, to draw air from the sewer or storm water main. This is undesirable; therefore, plumbing codes often require trap primers to keep traps wet.

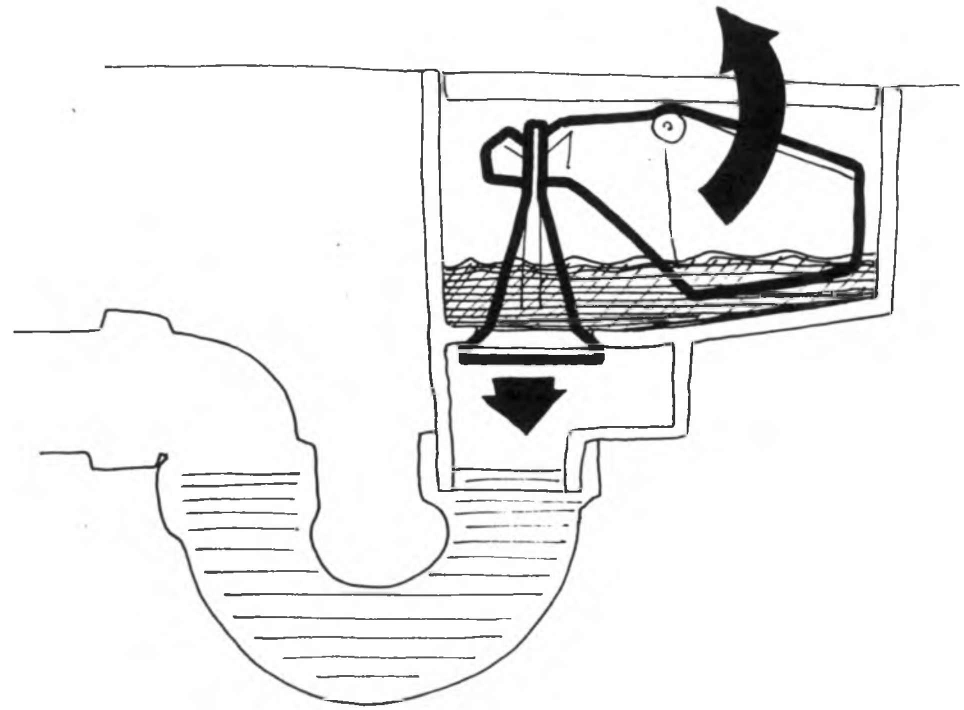
2. The Dranjer keeps the trap sealed. This: a) prevents the trap from drying out, and b) prevents sewer gas from entering the house even if it does dry out. It also functions as a backwater valve. The counterbalance keeps the valve shut under no flow conditions.

Earlier Dranjer models formed a double trap when installed over P-traps in conventional catch basin configurations. Double traps are not allowed in Plumbing codes. Initial attempts to design around the double trap restriction involved spring loaded valves. These designs encountered a back pressure problem. Water entering the drain would form a seal around the edge of the valve, preventing air from escaping. Water seepage past the valve would fill the drain tube between the valve and P-trap, compressing the air trapped in the drain tube. The resulting air pressure would push the valve more firmly into the closed position. This could prevent additional water from flowing through the valve until the water depth in the catch basin created enough downward pressure on the valve to overcome the closing force on the valve. When the valve opened, the resulting flow of water would be erratic if the valve did not open sufficiently to allow air to escape past the valve (i.e., to glub).

The Dranjer model XN-3 shown in Figure 1 has a float/counterbalance, designed to ensure a smooth flow of water through the device when the drain is in active use. As water fills the catch basin the float forces the valve to open, releasing air pressure that has built up under the valve (allowing it to glub). The float/counterbalance and valve seal assembly are easily removed to give access to the trap. The all plastic construction avoids problems with corrosion.

Dranjer Corporation believes the advantages of this product is cost (it will be cheaper than installing a trap primer), reliability (to be proven in the field trials), and reduced water usage. The reduced water usage will occur because a trap primer requires flushing water into the trap (this is normally fresh water to prevent the line to the trap primer from clogging with debris). The Dranjer product does not use any water.

FIGURE 1



NOTE: WHEN ASSEMBLED, THE SEAL SEATS THROUGH THE UNDERSIDE OF THE HOUSING - IN THE NORMAL POSITION FOR A BACKWATER VALVE.

THE FLOAT ACTS TO ENSURE THE SEAL OPENS PROPERLY FOR A SMOOTH FLOW OF WATER.

THE FLOAT ALSO ACTS AS A COUNTERWEIGHT TO KEEP THE VALVE CLOSED WHEN THE DRAIN IS NOT IN USE - PREVENTING SEWER GASSES FROM ENTERING THE HOME IN THE EVENT OF A DRY TRAP. THIS "SEWER GAS CHECK VALVE" FEATURE IS PROMOTED AS AN ALTERNATIVE TO A TRAP PRIMER. THE SEAL ACTS DIRECTLY TO KEEP OUT SEWER GASSES AND INDIRECTLY BY PREVENTING EVAPORATION FROM THE RESIDENTIAL SIDE OF THE TRAP.

Work Description

Dranjer Corporation designed and patented a floor drain assembly that incorporates a counterbalanced valve/seal assembly to prevent sewer gas from infiltrating through the drain if the conventional P-trap dries out. UNIES Ltd. was retained to conduct tests to evaluate the performance of the assembly as a floor drain, a backwater valve and sewer gas block and to measure its ability to reduce evaporation from the trap.

This section of the report describes the tasks undertaken to evaluate the field trial model XN-3 floor drain, describes the tests applied and presents the test results.

Define Testing and Monitoring

In Phase One, achieved the following:

- CSA Standard B79-94 "Floor, Area and Shower Drains, and Cleanouts for Residential Construction" was identified as the applicable standard for The System.

- A prototype Dranjer field trial floor drain model was reviewed with regards to its design and its intended applications.

- CSA Standard B79-94 "Floor, Area and Shower Drains, and Cleanouts for Residential Construction" was reviewed to determine its applicability to The System.

  Based on this review, it was proposed that The System be tested using the following sections of CSA Standard B79-94:

  - 6.1 Loading Test to determine Loading Classification
  - 6.2 Tightness Test using the Backwater Valve Test to determine ability of unit to meet the requirements of 5.6.3 Watertightness
  - 6.4 Joint Seal Test to ensure that the joints in the apparatus do not leak

- Preliminary testing was done on a field trial prototype to evaluate both the test methods and prototype performance.

- A testing and monitoring program to evaluate the performance characteristics of new Dranjer products was drafted.

  The Manitoba R-2000 Program Co-ordinator was asked and agreed to assist in identifying houses and installers for the monitoring program.

Testing

The detailed testing program developed in Phase One was conducted in Phase Two. Two types of testing were done, testing to assess compliance with CSA Standard B79-94 "Floor, Area and Shower Drains, and Cleanouts for Residential Construction", and testing to evaluate performance of attributes not addressed in the CSA standard. The following is a description of the test methods and results.

CSA STANDARD B79-94 TESTS

CSA Loading Test

Section 6.1 "Loading Test" of CSA Standard B79-94 "Floor, Area and Shower Drains, and Cleanouts for Residential Construction" describes the method and specifies the test load for floor drain covers. The load for a "Light Duty" loading classification is 3.92 kN (881 lbs.) on a 50 mm platen. Maximum deflection under load is not to exceed 10% of the largest transverse dimension of the grate (grate length is 185 mm) and permanent set is not to exceed 2%.

Three Dranjer field trial model XN-3 drain covers made of polyurethane were tested in a jig to simulate an "as built" field installation. A lever press was used to gradually load a platen at the centre of the cover plate. All three cover plates failed the test.

The polyurethane cover plates were very flexible, bending under load until the cover plate kicked through into the catch basin. In all cases, this occurred at a test load of about 1.5 kN (340 lb.), and at a maximum deflection of about 25 mm at the open end of the grate. It was the open end of the drain cover that collapsed into the catch basin. Within two hours of the test, the drain covers had almost completely recovered to their original shape.

CSA Tightness Test

This test determines the watertightness of the backwater valve in the Dranjer. In side view, the sewer gas valve and float mechanism assembly is asymmetrical; viewed from the front or back it is symmetrical. For this reason, two sets of the tilt test described in Section 6.2 "Tightness Test" of CSA Standard B79-94 were performed, one with the System tilted sideways and the other with it tilted front to back.

Installing the Dranjer Model XN-3 off level did not affect its performance as a backwater valve.

Some units tested were watertight; over the course of the Tightness Test, no water leaked up past the drain seal into the Dranjer catch basin in either the level or tilt tests.

With other units, the valve and valve seat did not form a perfect seal and the unit leaked. When the water rose to a certain level in the catch basin, the float mechanism actuated, forcing the backwater valve open, thus negating any backwater protection provided by the valve.

CSA Joint Seal Test

In final form, the Dranjer body will be one piece ABS. As there will be no joints in the unit to leak, there was no need to test this criteria.

OTHER TESTS

Pressure Trap Tests

The Pressure Trap Tests were to determine if there were conditions which could result in a modest back pressure which would prevent the valve from opening when it should, or conditions that would result in the valve opening when it should remain closed. The performance failure observed during the CSA Tightness Test showed that the valve assembly in the floor drain could open during a backflow condition, if the catch basin filled with water.

Subsequent to those tests and that failure, the valve assembly was redesigned to circumvent the problem. Preliminary testing indicate that the design changes have effectively eliminated the problem.

Valve Sticking Tests

Valve sticking tests (to see if back pressure wedges the valve body into the valve seat) were conducted during the Tightness Tests. The valves tested opened normally after they had been exposed to significant (i.e., 3 metres water column) back pressures.

Flow Rate Capacity Tests

The writer did not find a reference within CSA to a flow rate test, but Sub-Section 5.3.4 of CSA Standard B79-94 specifies a minimum "grate free area" of 25 cm^2 for floor drains. Grate free area is the sum of the area of all unobstructed openings in the grate. Grate free area of the Dranjer field trial model XN-3 floor drain cover was more than 32 cm^2.

During the design process, KOR Product Design Inc. made a test rig and measured flow rate capacity for various drain configurations. They determined flow rate through the catch basin and drain was a function of the size and configuration of the components in the drain. They used this information to optimize the design of the unit.

Dirty Environment Tests

The impact of operating in a dirty environment was tested by dumping household dirt, laundry lint, etc. into the drain and then passing water through it. The effect that the dirt has on the ability to re-seat and reseal was inspected visually to see if the valve body is self cleaning.

When dirt passed through the drain, some stayed on the valve, slightly impairing the valve seal. In a backwater situation, water would seep up past the valve into the catch basin. With model XN-3 valve assembly, the float could force the valve open, negating its usefulness as a backwater valve. The valve assembly has been redesigned to address this problem.

In order to assess the impact of dirt on the effectiveness of the valve as an alternative to a trap primer, a Dranjer which had been loaded with an extreme amount of dirt was included in the evaporation tests. Those results, reported below, indicate that even with an impaired valve seal, the Dranjer significantly reduces the rate of evaporation from the floor drain trap.

Trap Evaporation Test

On July 7, 1996 four Dranjer floor drains with deep traps were connected to a sealed manifold which was attached to an extension on the sewer clean-out of a house connected to the municipal sewer system. Photos of this setup are presented in Figures 2, 3 and 4 (the colour photos from an earlier report). Each Dranjer floor drain was set up to represent a different operating condition:

1. control unit with the valve assembly removed (i.e., a conventional trap set up),

2. properly operating Dranjer,

3. a Dranjer with a 2.2 mm (0.090 inch) diameter wire between the valve and valve seat. This represents a (very large) broom straw dropped into the unit,

4. a Dranjer which had a mix of household and workshop floor dust and water poured through it prior to connection to the manifold. This represents operation in an exceptionally dirty environment as the quality of the seal was impaired by dirt between the valve body and the valve seat.

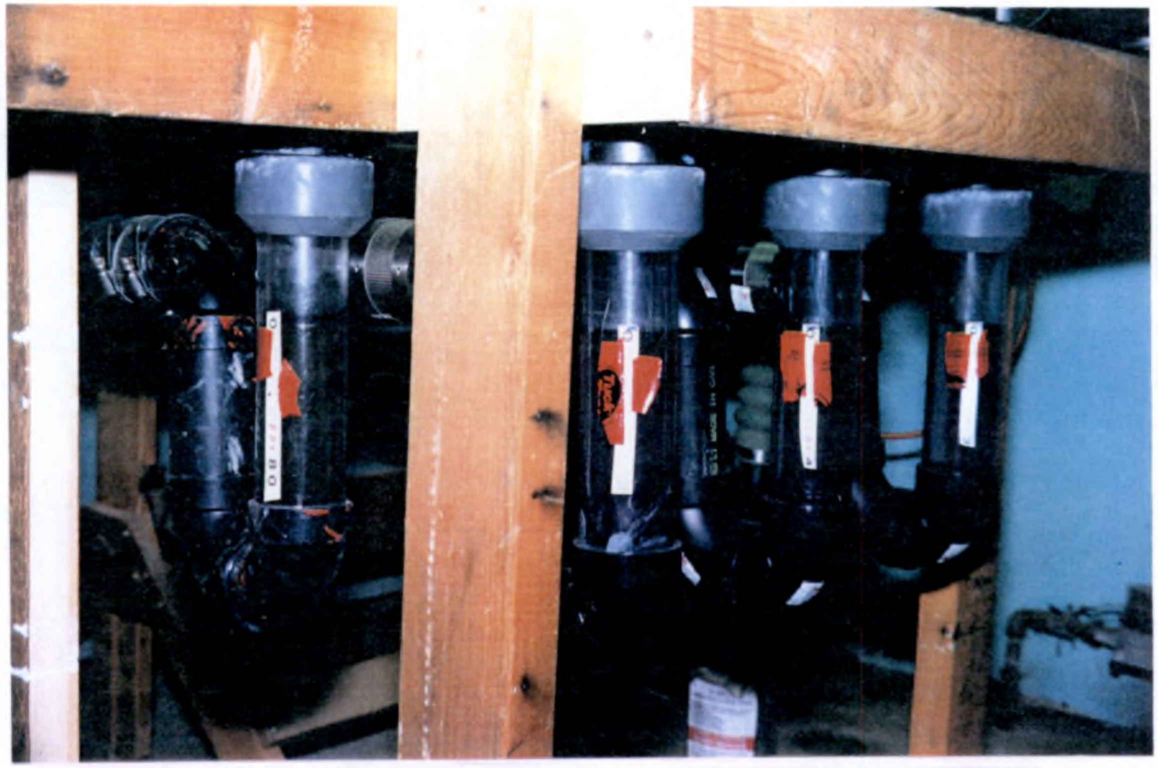
Each Dranjer was connected to a wet trap with a transparent tailpiece. A scale with the initial water level marked on it was secured to the outside of each tailpiece to allow visual inspection and measurement of water level depression. The set-up allowed each operating condition to be tested simultaneously. The downstream side of the traps were exposed to the air in the sewer lines, as would the floor drain in a normal installation. The traps were above grade and as such were warmer than an in-ground installation.

The tests were conducted in the basement of a house that is not air conditioned. Temperature and relative humidity were continuously monitored. The basement was ventilated at about 1 ACH by a continuously running exhaust fan from June through October. The exhaust fan was turned off from November to the end of the tests.

Evaporation rate readings were taken on a regular basis between July 7, 1996 and March 17, 1997. Figure 5 (figure showing levels against time) shows depression of water levels due to evaporation in each of the drains over the test period, along with average space temperatures and humidities for those time periods. Over this period evaporation was:

- 89 mm (3.5 inches) from the open drain (i.e., control unit)
- 7 mm (0.27 inches) from the clean drain
- 16 mm (0.63 inches) from the drain with the wire
- 20 mm (0.79 inches) from the dirty drain

The results show that evaporation from the conventional (open) drain is four to five times that from those with dirt or a wire obstructing the seal and 12 times that of a clean, properly functioning unit. The properly functioning, clean trap had the lowest rate of evaporation. Evaporation rates increased during the winter months, with a fall in humidity levels in the basement.



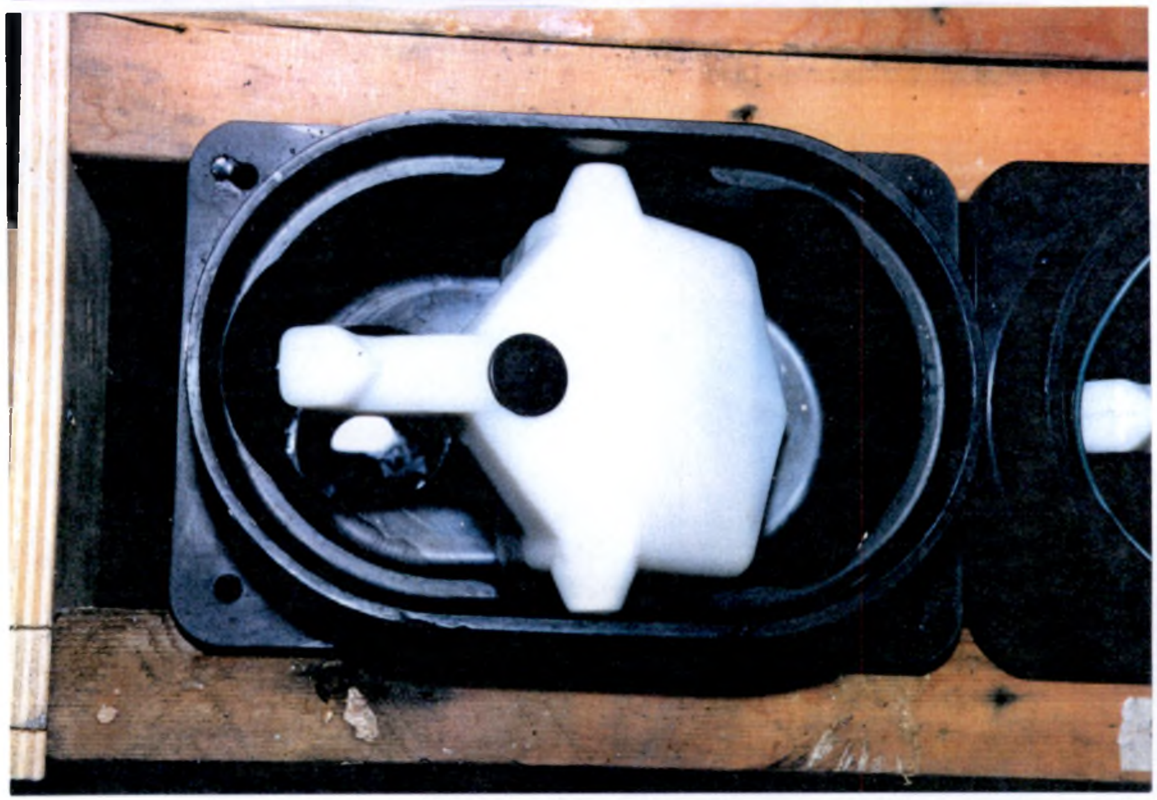


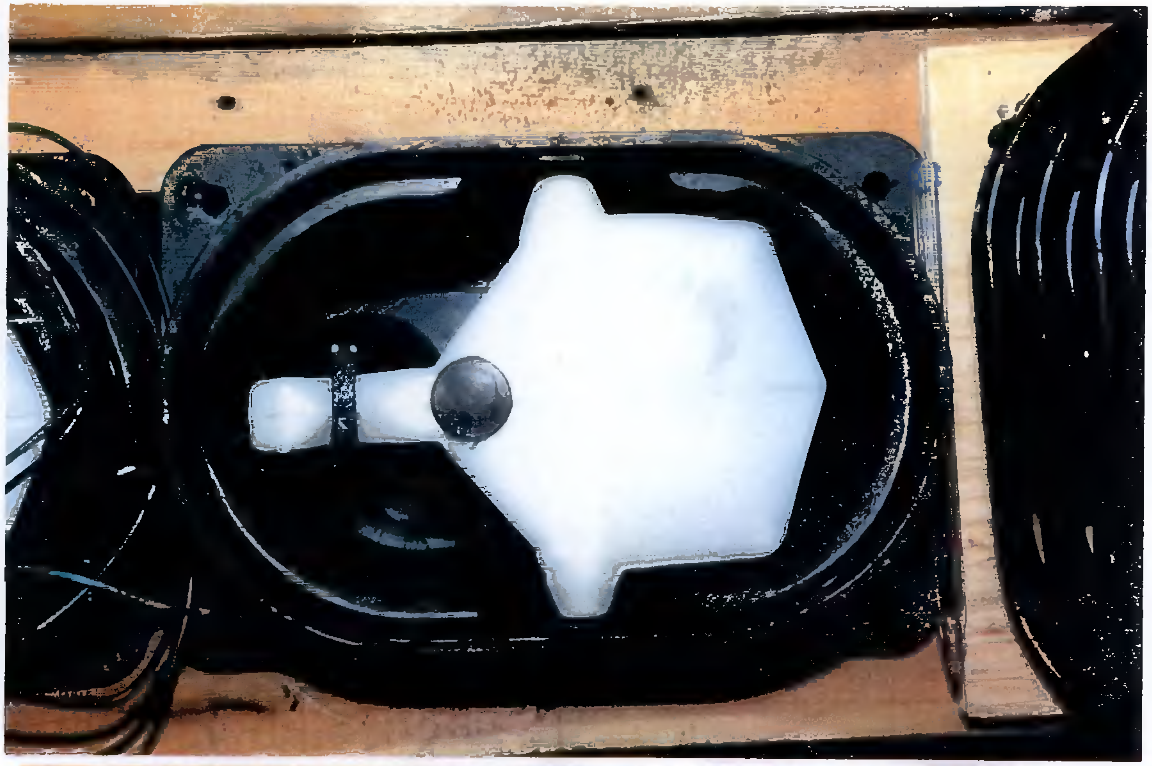
Figure 2

Above - Test rig set-up

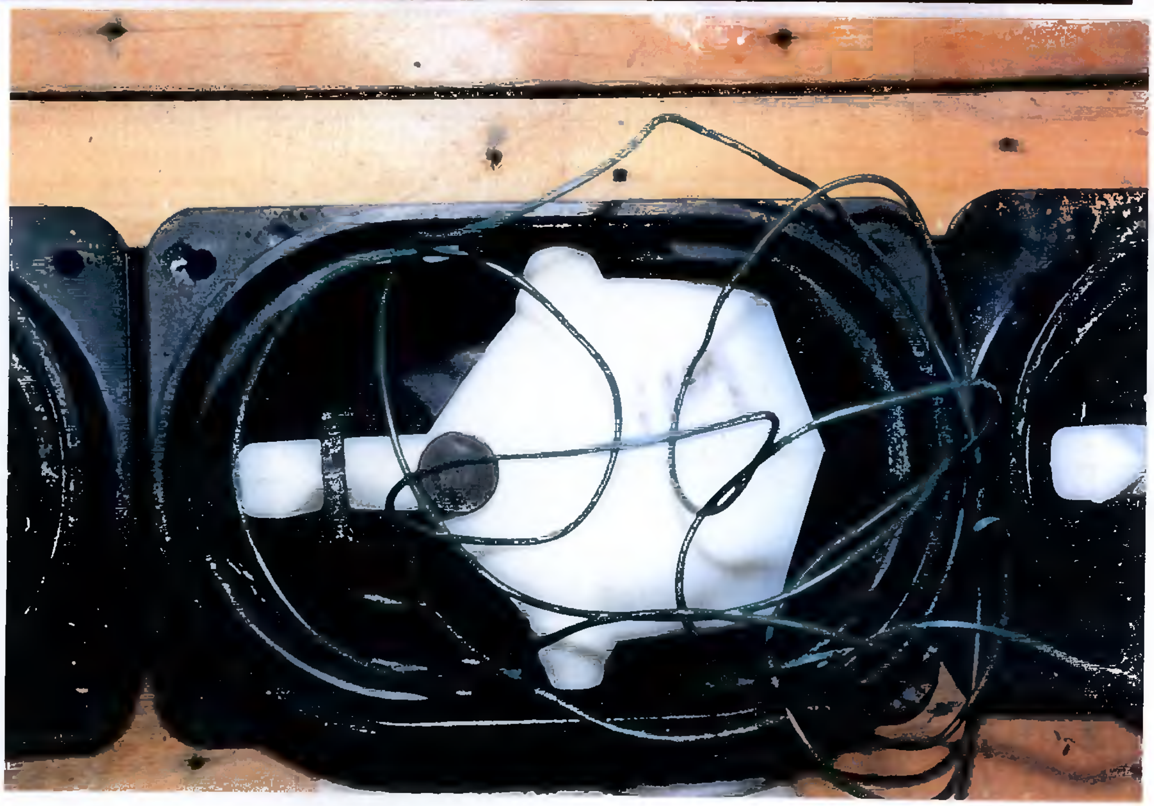
Above right - Transparent drains with level gauges

Right - Dranjer with valve removed

Figure 3



Above - Clean Dranjer with properly functioning valve



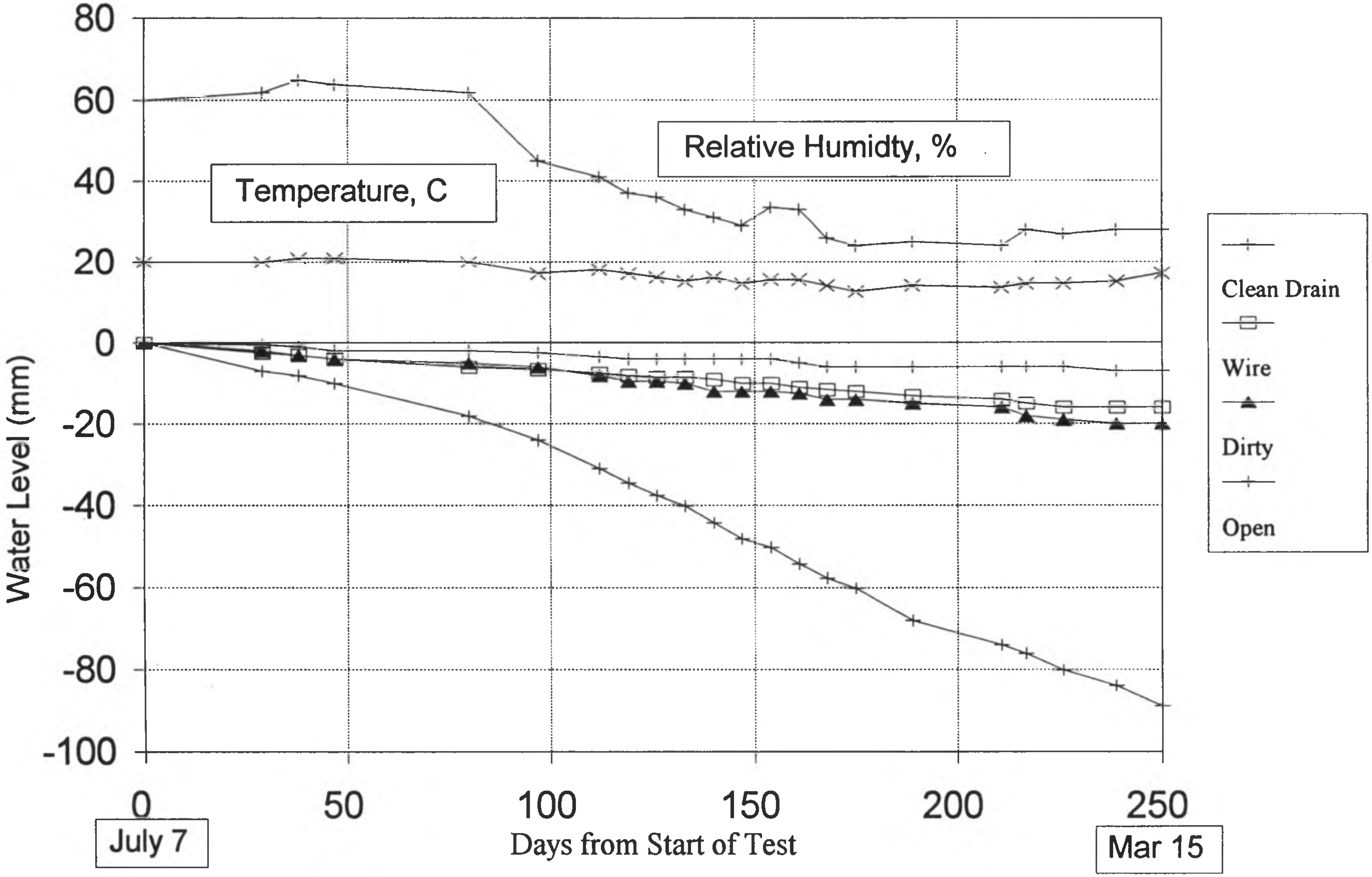
Below - Dranjer with 2,2 mm wire between valve and valve seat.

Figure 4

Above - Dranjer treated with household and workshop dirt

Below - Household and workshop dirt mixed with water which was poured into above Dranjer

Figure 5
Data from Evaporation Rate Tests



Venting Failure

Between the December 30 readings and January 6, 1997, a blockage in the plumbing stack caused water levels in the test drains to drop 50 mm below the initial (i.e., July 7, 1996) water level. It is the writer's opinion that a combination of heavy snowfalls and extremely cold temperatures in December and early January caused the plumbing vent to freeze over. After that, a major water flow in the house's sanitary drainage system (e.g., toilet flush) caused 100 mm of water column negative pressure in the drains, which resulted in the observed drop in water levels.

Sewer vent stack ice blockages which cause wet traps to siphon are common in Winnipeg during very cold weather and are a reason that vents are insulated in attics and that roof vent terminations are increased in size. This event is described in more detail in the Appendix.

Monitoring Program

As part of the monitoring program, Dranjers were installed in the basement slab of a new house in Dauphin, Manitoba and in two houses in Toronto. The plumber for the Dauphin house stated the installation was routine. Separate inspection of the installation by the writer and by the local plumbing inspector did not indicate any problems.

Two units were provided to the owner/builder of the Toronto Healthy House, Rolf Paloheimo. These were installed in the mechanical rooms in two houses. Mr. Paloheimo stated that there were no product-related problems with the installation. One unit got plugged when activated carbon spilled from the house air purification system and was washed into the catch basin. This problem was easily remedied. Mr. Paloheimo was positive about the benefits and potential for this product.

Analysis and Results

CSA Loading Test

The three cover plates that were load tested did not meet the CSA criteria for light duty drain covers. Cover plate deflections of magnitude observed prior to the cover plate kicking into the catch basin would damage the float mechanism. It is expected that production drains and covers will be made of ABS, a more rigid material. Changing to ABS will likely reduce cover plate deflection. The information from these tests can provide guidance for design modifications to improve the strength of the production model drain covers.

CSA Tightness Test

If the valve and valve seat of the Dranjer field trial model XN-3 did not form a "perfect seal", leakage into the catch basin could actuate the float and open the valve. This operating characteristic meant that the Dranjer field trial model XN-3 design could not be relied upon to provide backflow protection. This realization stimulated a re-design of the valve mechanism. Preliminary tests indicate that mode of failure has been eliminated and that the redesigned valve mechanism performs satisfactorily as a backwater valve.

There is a significant possibility that debris entering the catch basin during or after installation will impair the seal and allow some leakage. This problem is not unique to the Dranjer design, but is common to all backwater valves.

Dirty Environment Tests

The tightness and evaporation test results indicated that passing a lot of debris through the Dranjer field trial model XN-3 adversely affected its ability to prevent trap evaporation. However, a dirty unit significantly outperformed a conventional open trap.

Trap Evaporation Test

The water in the trap of a conventional floor drain provides a barrier against the entry of sewer gas. This barrier against sewer gas can be lost through evaporation or as a result of a venting failure in the plumbing system. The trap evaporation tests demonstrated that the valve mechanism in the field trial model XN-3 floor drain provided two levels of protection against sewer gas entry: it significantly reduced evaporation thus ensuring that the trap would remain wet for a longer time period, and; in the event that the water seal was lost, the valve would significantly reduce the amount of sewer gas entering through the drain.

Clause 2.3.1(1)(a) in the 1990 Canadian Plumbing Code states every trap shall "have a trap seal depth of not less than 38 mm". In practice, most nominal 2 and 3 inch floor drains have trap seal depths of 50 mm to 60 mm. Over the eight month test period of the evaporation tests, evaporation from the conventional floor drain trap was 89 mm.

Evaporation from the floor drains equipped with the Dranjer valve mechanism was 7 mm to 20 mm over the same time period. Based on this, one may expect a conventional open floor drain to lose its trap seal due to evaporation in as little as three months while the wet seal in a floor drain equipped with the Dranjer valve mechanism would remain effective at least four times as long.

Venting Failure

The incident related to a frozen plumbing vent highlighted the fact that evaporation is not the only factor that causes wet traps to lose their seal. In addition to ice blockages, leaf and debris blockages are possible. Strong or gusty winds may pressurize the house and/or depressurize the roof vent termination, causing enough water to siphon out of a trap to lose the wet seal. The Dranjer could not be expected to prevent water from being siphoned from the trap, and still allow water to freely drain past the valve, given the level of depressurization that a trap may experience. However, the Dranjer would provide a second line of defence against the entry of sewer gas if a floor drain wet trap is siphoned out by such an incident.

Impact on Sewer Gas Entry

The evaporation test results were used to indicate the impact that the valve mechanism would have on sewer gas entry if the wet seal is lost. For this analysis, the following assumptions are made:

- sewer gas movement through the floor drain assemblies would be similar to the movement of water vapour, i.e., evaporation rate can be used as a surrogate for soil gas entry;
- water vapour pressure differentials from the wet trap to the basement was similar for all four floor drain assemblies;
- all water loss from the floor drains being tested was evaporation to the basement.

If these three assumptions are valid, the evaporation rates for each of the floor drain assemblies in the evaporation tests represent the rate of sewer gas passage through the floor drain. Based on the results of the evaporation tests, the Dranjer floor drain assembly could reduce sewer gas entry by 76% to 92%, in the event that the wet seal was lost.

The second two assumptions understate the benefits of the valve mechanism. Relative humidity in the space enclosed between the water surface in the trap and the valve mechanisms will be higher than in the trap above the drain without a valve. Higher relative humidities mean higher vapour pressure differentials driving water vapour past the valve assembly.

Evaporation would occur from both sides of the wet seal in the trap (i.e., some water would evaporate to the sewer and some would evaporate to the house side of the trap) and wind pressures may have caused some spillage from the drains early in the test cycle. Evaporation losses from the sewer side of the traps should be the same for all units being tested, as they are exposed to the same conditions on the sewer side. Assuming evaporation only occurs to the house side of the trap makes the units with lower rates of evaporation appear less favourable relative to the unit with the highest rate of evaporation. The other extreme would be to assume that the 7 mm of evaporation in the "clean" unit represented the losses of all four units to the sewer side. The losses to the house side would then be 0, 9, 13 and 82 mm. If these evaporation rates are proportional to sewer gas entry rates, the field trial model XN-3 would reduce soil gas entry rates by 84% for the dirty Dranjer to 100% for the clean Dranjer.

An Alternative to Trap Primers?

Clause 4.5.5 "Trap Seal" in the 1990 Canadian Plumbing Code states "Provision shall be made for maintaining the *trap* seal of a floor drain by the use of *trap* seal primer, by using the drain as a receptacle for an *indirectly connected* drinking fountain or by equally effective means."

Floor drain primers are noted for being unreliable, and in the event of a failure, the floor drain trap primer would be totally ineffective. The Dranjer valve mechanism by itself will not be as effective as a wet trap seal. However, the Dranjer valve mechanism can be expected to maintain the wet seal in typical residential floor drain traps for at least one year, and up to six years in clean environments. In the event that the trap does dry out, the Dranjer would prevent the entry of 75% or more of soil gas, compared to an open floor drain. If statistics on the failure rate of trap primers were available, an evaluation could be made of the relative effectiveness of the Dranjer and trap primers.

The matrix in Table 1 compares cost and performance of conventional floor drains, floor drains with trap primers and the Dranjer. For example, if 25% of trap primers fail within the first two years of operation, on average, Dranjers would be more effective than trap primers.

Table 1

Comparison of Trap Alternatives

Alternative	Conventional P-Trap	P-Trap with Trap Primer	Dranjer with Soil Gas Valve
Incremental first cost	$0 (base case)	$100	$35
Operating cost	$0	Up to 10,000 litres of water per year. Up to $15/year for water.[1]	$0
Expected time before loss of wet seal in a dry environment	150 days	150 days after primer stops	600 to 2000 days
Consequence of losing the wet seal	free flow of soil gas through trap	free flow of soil gas through trap	Limited soil gas flow. Valve blocks 75% to 100% of soil gas flow.

1. Up to 25 litres of water/day at $1.50/1000 litres.

Summary and Conclusions

With modifications, the Dranjer floor drain trial model XN-3 can meet the CSA Standard B79-94 "Floor, Area and Shower Drains, and Cleanouts for Residential Construction" requirements for floor drains. This would involve a change in materials from the trial model with possibly some redesign of the cover plate to reduce deflection under load.

The Dranjer floor drain trial model XN-3 with the float/counterbalance mechanism could not be relied upon to meet the requirements in CSA Standard B79-94 "Floor, Area and Shower Drains, and Cleanouts for Residential Construction" for backwater valves. A redesign of the valve mechanism to address this issue appears successful.

The Dranjer floor drain trial model XN-3 valve mechanism reduced evaporation from the trap by more than 75%. The evaporation rates observed indicate conventional floor drains could lose their wet trap seals within 100 days, while floor drains equipped with the Dranjer valve mechanism should maintain their wet trap seal for more than a year in exceptionally dirty environments, and up to 6 years in clean environments.

If the water seal in a trap is lost, the Dranjer valve mechanism should reduce soil gas entry 75% or more, compared to a conventional, open floor drain.

Follow up was done on three Dranjer floor drains installed in houses. The installing plumbers were not given special instruction or advice on the product installation. Installation was seen as routine by the plumbers, no problems were encountered. Because the installations did not require any special skills, knowledge or instruction, further field testing to evaluate the potential for installation problems was not pursued.

On average, Dranjers are probably as effective as trap primers at preventing the flow of soil gas flow. In order to make a quantitative comparison of the effectiveness of the Dranjer valve mechanism relative to trap primers, data on trap primer failure rates are needed.

Appendix

Venting Failure

Re: A Hick-Up in the Trap Evaporation Tests on Dranjer Floor Drains

Background

The Dranjer Corporation has designed and patented a floor drain assembly which incorporates a valve/seal assembly to prevent soil gas from backing up through the drain in the event that the conventional wet trap dries out. UNIES Ltd. has been retained by the Dranjer Corporation to conduct tests to assess the impact of the valve/seal assembly on the rate of evaporation from the conventional trap floor drains.

On July 7, 1996 four Dranjer floor drains (Dranjers) with deep traps were connected to a manifold connected to the sewer clean-out of a house. Each of the Dranjer floor drains is set up to represent a different operating condition. These are:

- a properly operating Dranjer,
- a Dranjer with a 2.2 mm (0.090 inch) diameter wire between the valve and valve seat,
- a Dranjer which had a mix of household and workshop floor dust and water poured through it prior to connection to the manifold, to represent operation in an exceptionally dirty environment (the quality of the seal was impaired by dirt between the valve body and the valve seat), and
- a control unit with the valve assembly removed (i.e., a conventional trap set up).

Each Dranjer is connected to a wet trap with a transparent tailpiece to allow the water level in the trap to be sighted and compared to the initial water level. The set-up allows tests at each operating condition to be run simultaneously. During the tests, the downstream side of the traps "see" the air in the sewer lines, as do floor drains in normal installations. Water levels were measured, recorded and plotted on a regular basis.

Test Results and Discussion

Floor drain water levels measured between July 7 and December 30, 1996 are shown in Figure 1. Over this period, the rate of evaporation from the open trap was significantly greater than from the other three traps. The properly functioning, clean trap had the lowest rate of evaporation. Evaporation rates increased during the winter months. This corresponds with a fall in the relative humidity in the basement and absolute water vapour pressures on both the house side and sewer side of the drains.

Over the 175 day test period, the water level in the open drain (i.e., control unit) fell 60 mm (2.36 inches); water in the drain with the wire fell 12 mm (0.47 inches); water in the dirty drain fell 14 mm (0.55 inches), and; the water level in the clean drain fell 6 mm (0.24 inches). Between the December 30 readings and January 6, 1997, an event occurred causing water levels in the test drains to drop 50 mm below the initial (i.e., July 7, 1996) water level.

It the writer's opinion that this sudden change in water levels was the result of a blockage in the plumbing stack vent at the roof of the house. The blockage was caused by the combination of heavy snowfalls and cold temperatures in December and early January.

Once a vent is iced up, any major water flow into the house's sanitary drainage system can cause a negative pressure in the drains between the blockage and water slug flowing through drains. (Vents are installed in plumbing systems to prevent the water in wet traps from being siphoned out.) The negative pressure in the drains would pull the water level in each of the drains down to the same pressure differential (i.e., 100 mm of water column).

Water would siphon out of the three traps during the depressurization, but the open drain would have required a greater negative pressure (i.e., over 120 mm or twice the 60 mm of water level depression observed) before any water would be siphoned from it. In support of this theory are the fact that a guest in the house occasionally commented about a sewer smell at the kitchen sink, indicating the drain may have been siphoned enough to loosen the seal of the wet trap. Furthermore, sewer vent stack ice blockages which cause wet traps to siphon are common in Winnipeg during very cold weather and are a reason that vents are insulated in attics and that roof vent terminations are increased in size.

This incident highlights the fact that evaporation is not the only factor that causes wet traps to dry out. The Dranjer could not be expected to prevent water from being siphoned from the trap, and still allow water to freely drain past the valve, given the level of depressurization experienced in this incident. However, the Dranjer would provide a second line of defence against the entry of sewer gas if a floor drain wet trap is broken by such an incident.