

SARS Transmission Through Plumbing –

Can Dry Floor Drain Traps Kill?

by Anne V. Sonner

Plumbing made the international news on April 17, 2003, when the Hong Kong Department of Health reported that the Severe Acute Respiratory Syndrome (SARS) virus was transmitted through the sewage system of a Hong Kong apartment complex. The outbreak resulted in 321 people infected with SARS and 65 deaths.

In spite of the size of this outbreak, most news stories devoted no more than a few paragraphs to the specifics of how the virus was spread through the plumbing. This article examines the Hong Kong Department of Health investigation, a report on a follow-up inspection, comments from people in China about the situation there, and, finally, the question: if the requirements of the Uniform Plumbing Code had been followed, could the outbreak have been prevented?

The SARS Epidemic

Believed to have emerged in November 2002 in the Guangdong Province of China, SARS apparently originated in animals, mutated, and was passed to humans. Symptoms of the disease include fever and coughing. After extraordinary detective work by several agencies in China, it was determined that the first person (index case) to start the global spread of SARS was a doctor from

Guangdong who visited a hotel in Hong Kong in February and infected at least 16 people there. SARS then spread from Hong Kong - an epicenter of air travel - to more than 30 countries within a month.

On March 12, 2003 the World Health Organization (WHO), the watchdog of the world's health, issued a worldwide alert and formed a war plan. For the first time in history the world's top microbiologists, from ten different countries, worked together to identify the cause of the disease - a new coronavirus, similar to the one that causes the common cold. Like the common cold, SARS is spread from person to person through airborne droplets, particularly from coughing and sneezing. SARS appears to be less transmissible than the common cold, but far more deadly. As of July 9, SARS had infected 8436 people and killed 812, according to statistics from WHO.

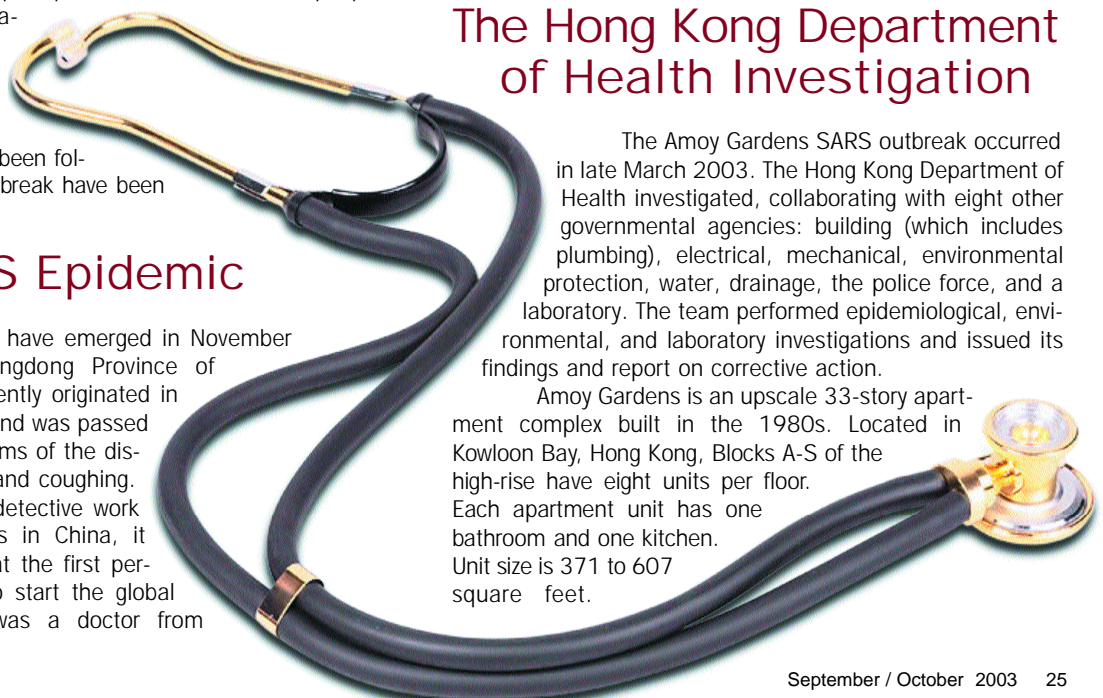
As SARS spread, WHO, the media, and the Internet informed the world. After initial panic, the world started pulling together. Residents of countries with SARS wore face masks and international travel was severely restricted. SARS outbreaks were handled by isolating cases, contact tracing and follow-up, and massive quarantine, especially in hospitals. Mass media public campaigns educated the public and, with the thermometer as a "key weapon," countless travelers were screened for fever, particularly at airports and other border points.

As fewer new cases appeared, travel restrictions were gradually lifted in the affected countries. On July 5 WHO pronounced SARS to be "contained worldwide." Extensive research is underway at WHO labs to find a cure for SARS. While some initial studies are encouraging, a vaccine appears to be many years away. WHO urges continued vigilance to keep this dangerous new disease under control, stating, "The world is not yet SARS-free" and "SARS continues to threaten the world."

The Hong Kong Department of Health Investigation

The Amoy Gardens SARS outbreak occurred in late March 2003. The Hong Kong Department of Health investigated, collaborating with eight other governmental agencies: building (which includes plumbing), electrical, mechanical, environmental protection, water, drainage, the police force, and a laboratory. The team performed epidemiological, environmental, and laboratory investigations and issued its findings and report on corrective action.

Amoy Gardens is an upscale 33-story apartment complex built in the 1980s. Located in Kowloon Bay, Hong Kong, Blocks A-S of the high-rise have eight units per floor. Each apartment unit has one bathroom and one kitchen. Unit size is 371 to 607 square feet.



Soil and waste disposal for the bathrooms is through a vertical stack mounted on the external wall of the bathroom, serving the toilet, sink, bathtub, and floor drain in each unit. There are eight stacks for each block, collecting waste from the same unit of all floors. Each bathroom has an exhaust fan.

The index patient (the first case of this outbreak) was a man from mainland China who was visiting his brother, a resident of Block E. The visitor had diarrhea and used the toilet there. His brother, sister-in-law, and two hospital nurses subsequently developed SARS, presumably from direct personal contact. However, of the 321 SARS cases at Amoy Gardens, only 4% had had contact with SARS patients and only 8% had visited mainland China during the time of the Amoy Gardens outbreak. Further, there was “an obvious concentration” (41%) of the cases in Block E, which were the earliest cases in the outbreak and showed a “point-source type of distribution.” The spread appeared to be vertical – between apartments on top of each other. The report found that “given the unique distribution pattern of infected Block E residents and taking into account the contact with SARS patients and the reported large number of patients with diarrhea [which caused a high viral load in the sewage system], we observe that environmental factors played a major role in this outbreak.”

Findings

There were two significant environmental findings. First, a “large, visible crack” was found in a sewer vent pipe in Block E, which was a potential, but not certain, means of SARS transmission. Second, broken trap seals in bathroom floor drains allowed sewer gases laden with a heavy viral load from SARS victims’ diarrhea to escape and infect people in other apartment units.

Cracked Vent Pipe

The Department of Health reported, “In general, any leakage or seepage in the sewerage system is important as it could allow droplets carrying contaminated sewage to be ejected into the lightwell. By using an oil droplets test, the aerodynamics of the lightwell demonstrated a ‘chimney effect.’ The ‘puff’ of droplets was shown to rise inside the lightwell, expanding laterally as it traveled up the height of the building in a matter of minutes under certain wind conditions. This was further illustrated in quantitative terms using SF₆ as a tracer gas during the oil droplets test. However, it was not possible to quantify the amount of virus, if any, and the velocity of the emission of the droplets from the sewer vent pipe.”

Dry Floor Drain Traps

Bathroom floors at Amoy Gardens are customarily cleaned by mopping instead of flushing with water, and therefore do not charge the floor drain traps with water. The report stated, “The traps connected to most floor drains were likely to be dry and would not be functioning properly.”

This finding was corroborated by residents’ frequent complaints of foul bathroom odors. Tests done in a Block E apartment demonstrated that reflux of air from the soil stack through the floor drain into the bathroom occurred when the exhaust fan in the bathroom was switched on. The report stated, “The bathroom floor drains with dried-up ...traps provided a pathway through which residents came into contact with small droplets containing viruses from the contaminated sewage. These droplets entered the bathroom floor drain through negative pressure generated by exhaust fans when the bathroom was being used with the door closed.” The report also suggested moisture in the bathrooms facilitated the formation of contaminated water droplets, which could then have deposited the virus on various bathroom surfaces. The chance of a person’s exposure to the virus was increased given the small size of the bathrooms.

While SARS is generally spread through close personal contact, the Hong Kong Department of Health report explicitly attributed some of the cause of the Amoy Gardens outbreak to transmission through plumbing: “It is probable that the index patient initially infected a relatively small group of residents within Block E and subsequently to the rest of the residents in that block through the sewage system, person-to-person contact, and the use of shared communal facilities such as lifts and staircases. These residents subsequently transmitted the disease to others both within and outside Block E through person-to-person contact and environmental contamination.”

Corrective Action at Amoy Gardens

The following actions were taken to stop the spread of SARS at Amoy Gardens and other Hong Kong locations, and to prevent future outbreaks through the sewage plumbing.

First, residents of Block E were isolated within the building. They were not allowed to leave the building without permission, including for work, under threat of a fine or jail. As the disease spread, Amoy Gardens residents were removed from the building and quarantined outside of the area. While they were gone, the cracked sewer vent pipe was repaired and there was a comprehensive inspection of the drainage system of the entire complex. All the apartment units and common areas were disinfected, with particular attention to bathtub and kitchen fixtures. Tests showed the disinfecting of drainpipes was effective. Residents were given disinfectants along with guidelines on cleaning and were advised about keeping traps wet to ensure proper functioning.

These actions were extended to all buildings in Hong Kong where SARS patients lived. The Food & Environmental Hygiene Department made plans to inspect the buildings to ensure the guidelines were being followed. Also, a guide for the public was produced on cleaning, disinfection, and the proper functioning of trap seals.

The Hong Kong Building Department published Guidelines on Maintenance and Repair of the Drainage System and Sanitary Fitments, which was posted on their

Web site and distributed to all management companies and owners' corporations. It calls for "regular inspection" of all drain pipes, including soil pipes, waste pipes, ventilating pipes and underground drain pipes. Any leaks, blockages, or other defects "should be rectified immediately." Sanitary fittings [fixtures], including water closets, bathtubs, lavatory basins, shower trays, sinks and floor drains are to be inspected, "preferably once every three months," to ensure proper operation. Complaints of foul odors "should be investigated immediately" to determine the cause and correct any plumbing defects. Last, the guideline states, "Where there is a serious problem [with] leakage or blockage, or where the cause of a problem cannot be readily identified, it [is] necessary to seek advice from building professionals, i.e. authorized persons ... registered under the Buildings Ordinance..."

How Often Is SARS Transmitted Through Plumbing?

Amoy Gardens is the only place, at present, where it appears that SARS was clearly spread through plumbing, though it is possible there have been other unverified, unreported outbreaks where the virus was spread through sewer plumbing. On April 18 the Washington Post reported that Klaus Stohr, the chief SARS scientist at the World Health Organization, stated, "The possibility that the [SARS] virus could by aerosol move through a vertical pipe through other pipes... into the air and affect so many people, that's not comforting." However, Dr. Stohr believes SARS transmission through plumbing is rare. "If this would significantly contribute to the transmission of the virus, the epidemic would look different. It would spread faster. We'd have many more cases that we could not link to a SARS patient," he said.

It is not known why the Amoy Gardens outbreak was the only one, to date, transmitted through plumbing. A contributing factor was the unusually high viral load in the Amoy Gardens sewage system caused by diarrhea from the SARS patients. Also, some facts, which are under study, suggest the Amoy Gardens patients may have had a different strain of SARS. In the general population 10% of SARS patients have diarrhea. However, two-thirds of the infected residents of Amoy Gardens had diarrhea. Also, Amoy Gardens SARS patients were less receptive to treatment by certain drugs, and those who died were younger and initially healthier than SARS patients in the general population.

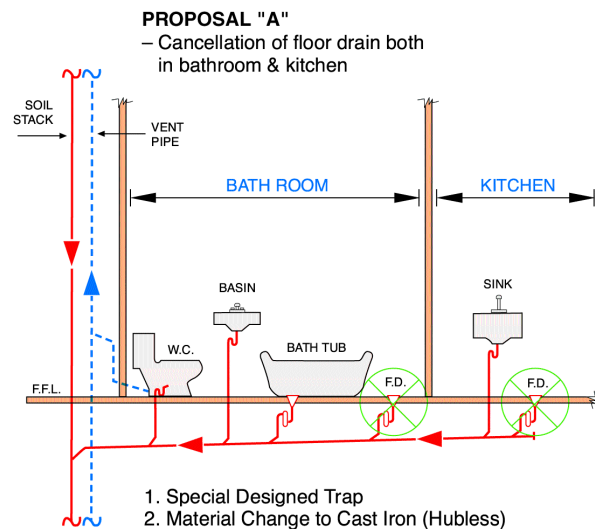
A Follow-Up Inspection

On May 1, two weeks after the Hong Kong Department of Health report was released, Henry Hung, owner of Ridgid Plumbing Limited in Hong Kong, Vice Chairman of the World Plumbing Council, and acting on

behalf of the Institute of Plumbing, inspected the plumbing at the Amoy Gardens apartments and made recommendations for changes. Coincidentally, a team of investigators from WHO were there the same day.

As he is a plumber, Mr. Hung's report contained additional specific information about the plumbing systems at Amoy Gardens, including the following: the traps in the apartment units were bottle-type re-sealing (anti-siphonage) and the single soil stacks for the bathrooms were 100 mm diameter uPVC. He found no plumbing problems: the traps had been charged with water, no foul odors were present, and no leakage from the soil pipes was observed.

However, due to the previous findings that the SARS virus had been spread through the sewage system, Mr. Hung gave extensive recommendations for changes. He prepared a "Proposal of Drainage Design to Reduce [the] Chance of Virus Infection Through [the] Plumbing System," including five possible redesigns, with diagrams:



Proposal "A" shown above, is one of the 5 proposals submitted by Henry Hung. This illustration is based on his original drawing.

- A - Eliminate the floor drains in the bathroom and kitchen; (see diagram above)
- B - Connect the fixture drains to the soil stack separately; add an extra trap to safeguard the loss of seal in the floor drain trap;
- C - Replace the single stack system with a two-pipe system (soil water stack and waste water stack);
- D - Connect the bathroom and kitchen floor drains to the sinks to make sure the traps are filled with water;
- E - Add an auto-cistern to safeguard the water seal in the bathroom floor drain.

Mr. Hung recommended a "special kind of waste valve in lieu of the traditional water seal trap." He also recommended the use of hubless cast iron for soil and waste pipe on external walls, rather than non-UV resistant uPVC pipe, which is commonly used in Hong Kong, unless the uPVC pipe is properly located (not exposed to sunshine), properly installed (with expansion joints

and sound workmanship), and properly designed (with optimal pipe sizing).

Mr. Hung stressed the need for good plumbing design and practices. The size of the ventilating stack should be calculated properly. Hong Kong has many high-rise buildings, due to limited land space and "maximization of economic effectiveness." He explained that momentum forces from multiple floors create negative pressure in the pipeline which can break the water seal in the traps where there are no anti-siphonage devices installed or operating properly. Also, good maintenance to the drainage system is vitally important. There have been reported cases where bathtub traps were removed by "cowboy" (the local term for "unlicensed") plumbers during renovations.

Mr. Hung further recommended plumbers be licensed to install drainage systems. Under the current regulations in Hong Kong, plumbers must be licensed to install water piping systems, but not drainage systems.

Plumbing in China – Information from IAPMO Staff

Wu Si Min from IAPMO's Beijing office gave the following information: "The Chinese government issued some special regulations for hospital buildings during the SARS outbreak regarding plumbing. It emphasized the importance of air ventilation in buildings – the exhaust ventilation system should be in good operating condition and the use of central air conditioning was prohibited in the hospitals that receive SARS patients. It also stressed that all sewer plumbing should be good quality and kept in good operating condition."

Regarding codes, Jin Luo, Senior Director of IAPMO's Asia Pacific Program Development, explained that the Uniform Plumbing Code is not officially adopted in China, but is used as "a reference by the local code-writing people when developing their own local codes." Jin added, "A person I know in Shanghai told me once that he uses the UPC frequently in his work when developing and updating the plumbing codes there." On the practice of installing floor drains in residential bathrooms in China, Jin said, "I believe it is to handle unpredicted flooding to prevent costly damages, especially in multi-floor buildings."

In a related note, IAPMO honorary member George Kauffman observed problems with traps in China over 20 years ago. George traveled to

Trade Tech. Chuck recalled George said there were floor drains in all the bathrooms - and some bathrooms were shared by over 25 families. Also, the trap arms did not vent to the floor drains, making a "dirty arm" (unvented trap arm) connection. "The traps were also 'oversized' for the trap arms, still another violation of our UPC," Chuck said. If George were still alive, he probably would be very interested in the current plumbing situation in China.

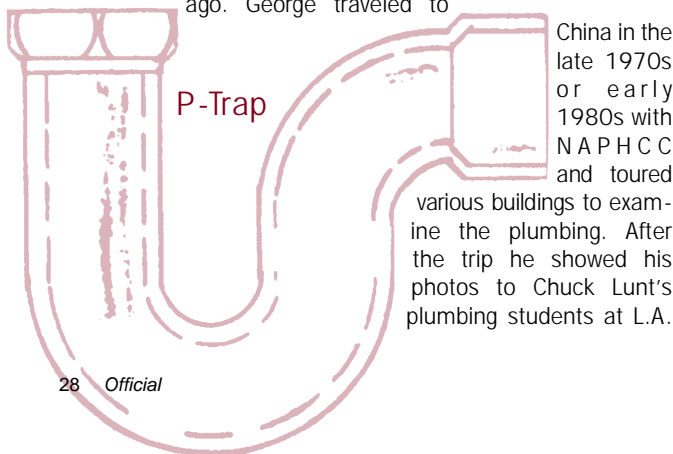
Can SARS Be Spread through Plumbing in the U.S.?

Several American plumbing experts said they have seen situations where sewer gas escaped from dry traps, but they think the requirements of the Uniform Plumbing Code are adequate to protect from SARS transmission through plumbing.

Roger Rotundo, plumbing/mechanical inspector III for the city of Phoenix, Arizona, said he thinks the UPC does a good job of protecting the public from sewer gas and subsequently from SARS. He described situations he has seen where sewer gas escaped plumbing installations: "With the exception of one instance, they were all UPC code violations. The majority involved traps on floor drains where the contents of the trap had evaporated. UPC Sec. 1007.0 requires traps used infrequently to have an automatic means of maintaining the seal. Another instance was when an inexperienced installer drilled a vent pipe to use the newly created opening for an air conditioning condensate line (a code violation, UPC Sec. 801.1). Every time the AC unit operated it sucked sewer gas into the suite. I witnessed one incident where an indirect waste receiver was concealed in a mechanical chase, the trap seal evaporated and the sewer gas was picked up by the air handling system. They evacuated the building! This is a violation of UPC Sec. 804.1."

Roger continued: "The instance that was not a UPC violation was a UMC code violation. This occurred at a restaurant where the kitchen hoods had inadequate make-up air. The vacuum created in the restaurant by the hoods actually caused the floor drain traps to bubble sewer gas. The smell only happened in the morning - once the restaurant opened for business at lunch (opening doors and drive-thru windows), the smell went away. The openings reduced the negative pressure in the building so the traps were able to do their job. Took me a while to figure that one out! You can imagine the thoughts of the employees seeing a man with his ear to the floor drain, yelling at people to 'Shut that door!'"

Chuck Lunt, plumbing instructor at L.A. Trade Tech, also discussed the dry trap problem. "Are there floor drains in the U.S. with dry traps that allow sewer gas to escape? Yes. While Americans don't typically have floor drains in their homes, except perhaps in a laundry room, floor drains are required in locations of many commercial buildings." Floor drains are required by UPC Sec. 412.2 to be installed in non-residential bathrooms with two or more toilets or urinals, in commercial kitchens, and in commercial laundry rooms. This



China in the late 1970s or early 1980s with N A P H C C and toured various buildings to examine the plumbing. After the trip he showed his photos to Chuck Lunt's plumbing students at L.A.

is a minimum requirement – more floor drains can be installed if desired by the architect/designer, mechanical engineer, or homeowner, Chuck explained. He recalled that prior to the 1960s, the UPC required floor drains in all restrooms in commercial or public buildings.

Chuck also commented on the UPC Sec. 1007.0 requirement on trap seal protection. "To install trap-primers in areas of infrequent use is the answer, but with California in such financial disaster, don't look for it to happen everywhere soon." Chuck says the city of Los Angeles does require trap primers on all floor drain traps. "Many engineers require a trap primer to be installed anywhere there is a possibility of the trap becoming dry (back-pressure, siphoning or evaporation causing the trap to empty)," Chuck said. "Many buildings in the L.A. area have had the problem of traps drying out after tenants moved out and a period of time passed before new tenants moved in. Also, L.A. Unified Schools had this problem while I was supervising their plumbing. Restrooms were closed down and used for storage areas and the traps dried out, allowing sewer gases to enter the building. We solved this problem by adding heavy oil – 90 weight – to the traps that would not be used."

Regarding UPC Sec. 1005.0, which requires fixture traps to have a water seal of two to four inches, Chuck says the minimum and maximum are to allow for "optimum condition of assurance that the trap seal will neither evaporate, nor will it siphon out." Extensive tests to determine these numbers were made at the Los Angeles Mechanical Testing Lab many decades ago when the UPC was in its infancy.

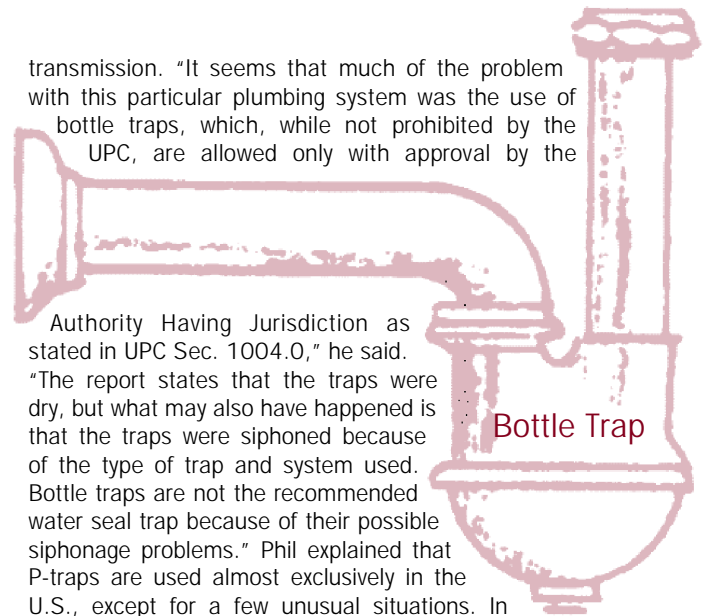
Tom Lehane, retired chief plumbing inspector for the city and county of San Francisco, stated, "The UPC protects against floor drain trap problems as long as the traps are maintained properly." Traps need to be kept continuously primed, but since they may not be, Tom thinks every trap should be self-primed. He has seen situations in commercial toilet rooms where the traps dried out, sewer gas came back into the room, and complaints were made about the odor. One "trick of the trade" is to pour mineral oil into infrequently used traps as it doesn't evaporate like water does. In the U.S., unlike in Hong Kong, there are almost never floor drains in residential bathrooms, so a problem like the one in Amoy Gardens cannot happen here, Tom noted.

Tom said in the past U.S. floor drains were more common, as there were hose bibbs in some bathrooms for washing the floors by flushing the area with water. The code has changed to reflect that now most floors are dry-mopped and floor drains are for emergency overflows.

Tom has traveled to Asia many times to teach plumbing code seminars. He said it is common practice in some regions for a person to bathe by dumping buckets of water over himself and to wash clothes in bathrooms, causing lots of water splashed around the room. This might be one explanation for the prevalence of bathroom floor drains in China.

Phil Campbell, training coordinator of the Pipe Trades Joint Apprenticeship and Journeymen Training Committee for Southern Nevada, U.A. Local 525, reviewed the information in this article on the Amoy Gardens situation and suggested another possible explanation of the SARS

transmission. "It seems that much of the problem with this particular plumbing system was the use of bottle traps, which, while not prohibited by the UPC, are allowed only with approval by the



Authority Having Jurisdiction as stated in UPC Sec. 1004.0," he said. "The report states that the traps were dry, but what may also have happened is that the traps were siphoned because of the type of trap and system used. Bottle traps are not the recommended water seal trap because of their possible siphonage problems." Phil explained that P-traps are used almost exclusively in the U.S., except for a few unusual situations. In fact, in his 25 years in plumbing he has never seen a bottle trap, other than a picture in a book. He believes that an anti-siphonage device on a bottle trap will sooner or later break, as do all mechanical devices, and is not an adequate substitute for using the correct trap.

Phil commented on venting at Amoy Gardens: "It also seems that the system had no individual vents for each fixture as is required under UPC Sec. 1002.1, given that the reports cited in this article referred to the system as a "single stack drainage system," in other words with no vent stacks or branches. UPC Sec. 311.4 prohibits these systems for this very reason - the traps may siphon. We must remember that indoor plumbing systems and the vent which made this possible have been with us for roughly only 120 years. We have become used to our system of plumbing, which protects and serves us so well. However, products and systems are continually being recommended for use solely because they save money, not because they provide the highest form of protection of the building occupants from the atmosphere in the plumbing system. Now that we can see the harm that can happen with the use of these types of systems, plumbing system designers will take more care in their designs."

Last, IAPMO Executive Director Russ Chaney commented on SARS and the UPC: "IAPMO is proud to be a world leader in protecting public health through safe, sanitary plumbing. We believe that if every country and jurisdiction adopts and enforces the Uniform Plumbing Code, the threat of SARS spreading through plumbing would be virtually eliminated."

Will a cure be found and can the SARS genie then be put back into its bottle? Or, like the common cold, will the SARS virus ebb and flow but never go away? Regardless of the ultimate outcome, continued vigilance is needed to keep SARS under control and the plumbing industry must do its part to prevent any further outbreaks through sewer piping. Plumbers and inspectors know their work protects public health. The SARS epidemic proved that point to the world. 