TESTING TIMES 'DOWN UNDER'

Does reduced flush volume have a negative effect of the performance in the drain line? One manufacturer was keen to find out.

The increasing practice of reducing the volume of water used to flush sanitary fixtures is raising some drain line performance questions across the plumbing world, and for good reason.

While fixture manufacturers focus on the performance of their products in the laboratory, we can't ignore what effect these new technologies are having on the overall performance of the plumbing system.

Reduced-flow, single-flush toilets began to appear in Europe in the 1970s, particularly in the Scandinavian region with products from Gustavsberg and Ifo.

Then, and even to this day, water authorities around the globe raised concern about lowering the volume of flush water, when they didn't know the effect such a reduction in quantity would have upon the flow within the associated drain lines.

Australia is the second-driest inhabited continent on earth and has major issues with maintaining adequate supplies of potable water in both city and country regions. Thus water conservation is considered very important for the nation's growing cities with their reliance on unsustainable water supplies.

In 2007, Australia has even more significant issues with its dwindling water supply due to the prolonged effect of a severe one-in-one-hundred-year drought affecting many parts of the country.

Australian sanitary manufacturer Caroma is the dominant supplier of sanitary fixtures to the Australian and New Zealand markets, which have a combined population of 25 million. In 1993 the company launched the first 6/3 dual-flush toilet, using just 6L (1.6 US gallons) for full flush and 3L (0.8 US gallons) for half-flush. This was the first instance when the technologies of both reduced-flush and variable-flush volumes were integrated.

Manager of Caroma's research and design department, Dr Stephen Cummings a leader in his field, has long held the view that while the involved and exacting process of designing and manufacturing toilet suites is of paramount importance, a critical issue is that the suite must be considered part of a 'balanced plumbing installation'.

"Much of the critical design and production process is based upon the need to retain as much of the energy of the flushing water for as long as possible within the pipeline system. This flow transportation performance can be easily impeded if the drainlines taking the waste discharge from the toilet bowl are incorrectly or poorly installed.

"The construction of pipe-work with correct workmanship, gradient, true bore, smooth jointing and quality materials are all essential factors that will significantly affect the overall performance," Dr Cummings says.

Dr Cummings initiated the design and construction of a pipeline test rig at the corporation's Sydney manufacturing centre several years ago. The elevated test platform, situated approximately 4m (12 feet) above ground level, allows toilet suites of various designs to be easily connected to 100mm (3.9 inches) and 80mm (3.1 inches) diameter

Manager of Caroma's research and design department Dr Stephen Cummings, accompanied by hydraulic consultant, Cliff Hensby, standing at the fixture changeover platform above Caroma's 60m (200 feet) long drain line test rig.

drain lines. These clear plastic drain lines, that extend for some 60m (200 feet) and form the longest test installation of its kind in the world, enable the test team to easily observe the waste flow performance from up to five of WCs set up on the rig using varying drain line grades configurations and low-flush discharges.

A number of intensive test programs were carried out over several years incorporating national and international Standards and procedures where applicable. The research program provided valuable information regarding the flow and behaviour of waste through the toilet bowl and the drain line when using various low-flush discharge volumes.

By using various low-flush volumes, combined with the introduction of synthetic solids and toilet paper, the researchers gained valuable information and a better understanding of the performance criteria required to achieve a 'balanced plumbing installation'.

Test rig supports and pipeline hangers have been designed and installed to replicate conditions experienced in the field. Gradients were accurately achieved initially by the use of a dumpy level, which proved to be very successful in achieving a continuous and correct gradient.

More recently, the researchers have utilized current electronic levelling devices to obtain an easier and even more accurate process of levelling. While adjustment is labour-intensive, the rig will allow a variety of tests to be carried out at a number of gradients, and differing pipeline sizes and fitting conditions can also be tested.

In 2004 Caroma again set a new low benchmark for the industry when it introduced the first 4.5L/3L (1.2/0.8 US gallons) dual-flush toilet system.

However, simply reducing the volume of water entering a cistern bowl can lead to issues and many researchers, suppliers and water authorities have invested time and resources in undertaking reviews.

The real science behind producing a reduced-flush performance toilet is in matching the flow of water from the cistern to the precisely designed configuration of the toilet bowl. In one action the flow from the cistern into the bowl needs to remove solids and paper as well as cleanse the bowl, but even then using ultra-low-flush volumes the task is not complete.

The characteristics of the head of water exiting the trap and flowing down the drain line is critical to the long-term performance of the complete plumbing system.

As Dr Cummings explains: "the key requirement between the WC and drain line is to fully discharge the waste from the bowl outlet using intial part of the flush and then to achieve steady flow conditions within a minimum distance within the drain line system in order for the waste to effectively clear the drain line. A significant amount of our development work has been involved in performance matching the bowl and sump configuration with the reduced flush volume discharged from the cistern. Importantly, the performance observed on the testing rig was validated in trials in the field with existing drain line installations.

Most Australians live in single-level housing, characterised by long-run drain lines. In single-level housing the performance of such drain lines is critical, whereas in multi-storey apartment blocks plumbing stacks are far more forgiving.

1. Caroma's impressive test-rig can simultaneously perform similar tests in differing pipe sizes.

2. This Caroma Smartflush simulation demonstrates how the characteristics of the head of water exiting the trap and flowing to the drain line is of critical importance.

3. (opposite page) Plumbing consultant Brett Mallinson (standing) and his CCTV operator Glen Ratter, review the drain line condition of one of the eight selected homes at a new housing estate in Christchurch, New Zealand.


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Caroma's 4.5/3L SmartFlush™ technology was launched onto the market after an extensive field trial program was conducted in Melbourne in conjunction with Yarra Valley Water and other major water authorities in Australia.

The program included retrofitting 100 SmartFlush toilet suites into private homes that had previously been fitted with toilets of varying higher-flushing volumes. A number of locations were included of 'above average' difficulty, in terms of the length of the minimum grade line, varying grades along the line, old earthenware pipes, and toilets isolated from any assistance from upstream fixtures.

According to John Park of the Plumbing Industry Commission (PIC), 10 sites, with a range of drain materials from old earthenware to PVC, were selected for inspection by CCTV. "No blockages occurred during the trial, and to the best of our knowledge there have been no blockages since," he says.

The PIC protects consumers' health and safety by administering the licensing and registration system for plumbing practitioners, and promoting and enforcing plumbing standards in Victoria.

In addition to research into technical performance, Caroma also surveyed the homeowners, who confirmed their satisfaction with the performance of the new toilets, including bowl cleaning and removal of waste. The SmartFlush product was then unconditionally released to the market with the support of water companies and regulators nationally.

EXTREME TESTING AT MINIMUM GRADE

New Zealand's building code differs from that of Australia. A recently updated New Zealand drainage compliance document *(Acceptable Solution G13/AS2)* permits gradients on a DN 100 drain (nominal 100mm diameter, i.e. 4 inches diameter) to be significantly flatter than in most other parts of the world, down to a minimum gradient of 1:120 (0.83%).

This minimum gradient was based on evidence from several local authority regions where flat gradient drains had been permitted in order to overcome difficulties connecting to relatively shallow sewers in areas of flat topography.

The compliance document requires that at all times the drain be laid at the 'maximum practical gradient' (Grade of Drains: clause 3.5.2). In addition, the document also requires that where the grade of 1:120 is employed the relevant levels must be determined by 'verifiable levelling devices' with 'Laser or Dumpy Levels being recommended' (Construction: clause 5.2.2). It should be noted that at this gradient the maximum drain discharge unit loading is limited to 104 fixture units.

Caroma considered that a field trial under such conditions would provide an important further test of its SmartFlush product as part of a complete plumbing system, so a number of range models using the 4.5/3L technology were selected and installed.

Brent Mallinson, a plumbing consultant based in Christchurch on New Zealand's South Island, who runs Plumbing Design and Consultancy Ltd, was selected to manage and monitor the field trial. He chose eight new home sites that met the criteria, and with the assistance of builders and homeowners, arranged the installation of some 20 toilets.

Each site was CCTV-recorded before the homeowners took up residence and then on a monthly basis over the next year. The owners also completed user-satisfaction questionnaires before and after the trial.

The video inspection results produced some interesting observations. A number of the uPVC drain line installations were found to be poorly installed with rough and burred joints, use of excessive solvent cement, construction debris left in the pipe, and sections of pipe with negative grade.

These installation issues surprised the test team as New Zealand operates an extensive plumbing installer apprenticeship program and plumbing is a regulated industry.

Over the period of the inspections, any occasional waste build-up noticed on the CCTV reports was directly attributed to rough joints, builder's debris that had entered the drain during construction, or negative gradient sections. Importantly though, no drain blockage was reported by the occupants over the period of the trial, in conditions far more severe than was originally intended.

However, one thing that the trial did emphasize was that an important task that couldn't be neglected by any plumbing engineer/specifier was to ensure that the installation standards of contractors and their staff were regularly checked, as drain lines couldn't be expected to be as forgiving when attached to low-flow fixtures.

Regrettably, these problems have also occurred in Australia and elsewhere in the world. As societies come to grips with the ever-decreasing availability of water as a valuable commodity, it is the responsibility of everyone involved to realize that as the trade and industry 'pushes the boundaries' there is a need to apply good and safe practices at all times if we are to achieve the goal of reducing our water consumption.

From the toilet cistern to the authorities' sewer main, each component of the installation requires a 'matched performance' to ensure adequate and continuous energy exists to provide an efficient and water-conserving solution to the increasing problem of water consumption.

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BENEFITS OF FIELD TRIALS

Not only were the users satisfied with the performance, but the local authority was also satisfied that this extensive field trial proved the performance of the system outside of the traditional scope of testing in research laboratories.

Such field trials are important in demonstrating system performance to water authorities, which are often reluctant to allow new technologies even though water is in short supply – the health of the community is always of paramount importance.

Hydraulic consultant Cliff Hensby, who assisted with the research, believes the local authority made a courageous decision to allow the trial to proceed in the interests of valuable research.

"The intent was to provide new information regarding the performance of drain line flow at such minimal gradients. If extreme installation conditions exist on a site the trials could then assist those involved in making the correct decision as to whether or not such an installation was prudent and in everyone's interests. The grade is extreme and should not be viewed as the normal process and applied universally," Hensby says.

"The essential benefit from the research has been confirmation of Dr Cummings' contention that to achieve water conservation objectives the entire plumbing system should be of the highest standard and each element needs to be considered as part of a complete and balanced installation.

"Much of the information and benefits of the research are naturally introduced into Caroma's manufacturing programs. However, the broader industry also receives benefits as the lessons of the test program are fed back to the various relevant authorities and committees. Again, this is an example of a manufacturer working with the industry, and through those combined efforts, the entire community obtains real benefits."

CONTACTS

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