HVAC&R Nation

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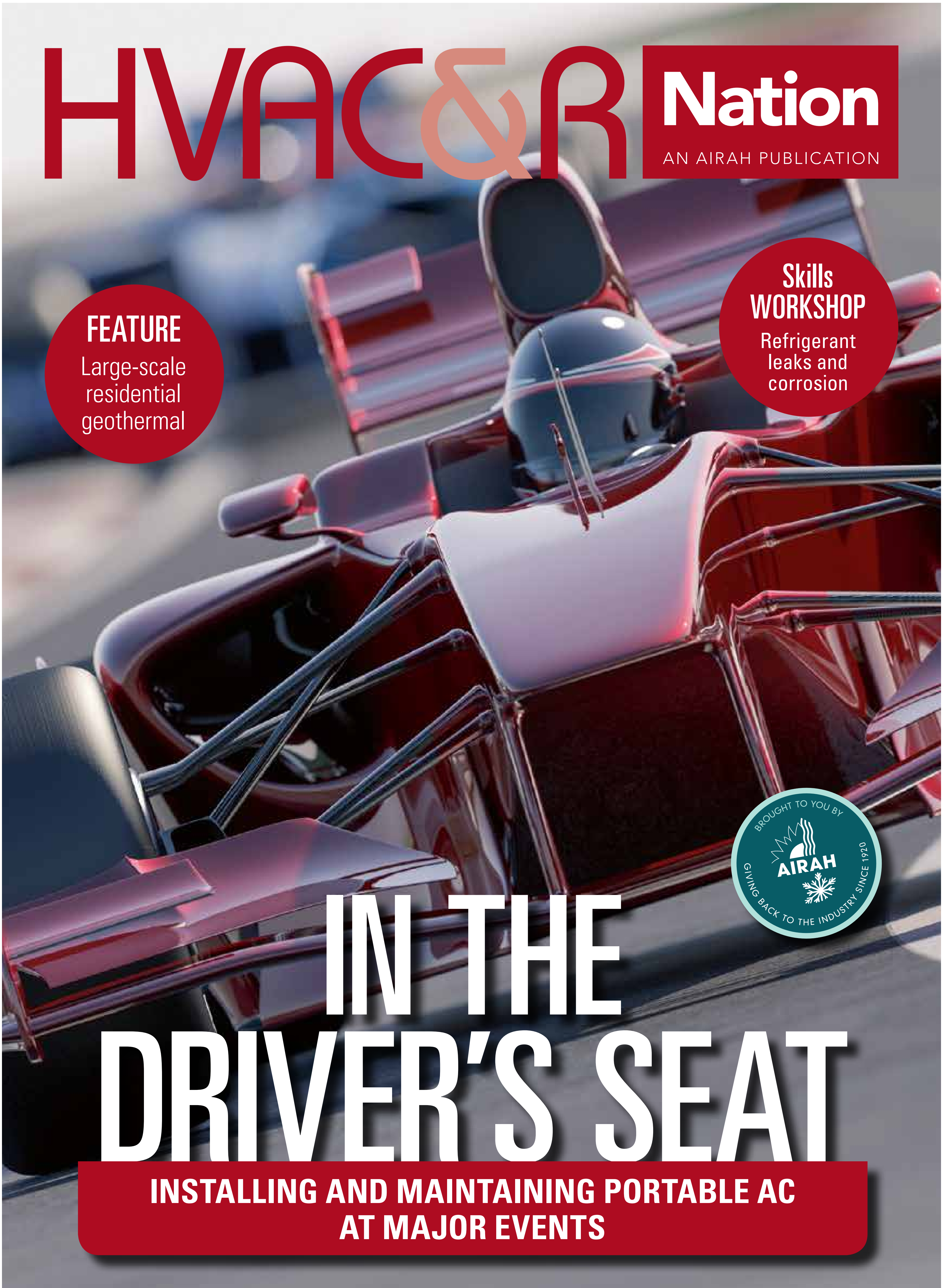

FEATURE
Large-scale residential geothermal

Skills WORKSHOP
Refrigerant leaks and corrosion

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INSTALLING AND MAINTAINING PORTABLE AC AT MAJOR EVENTS

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HVAC&R Skills Workshop

MODULE 97

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REFRIGERANT LEAKS – CAUSES, CURES, AND PREVENTION

Refrigerant leaks are one of the most widespread mechanical problems in the HVAC&R industry. Frustrating for customers and service techs alike, these leaks cost the industry billions, with the figures set to rise as the price of refrigerants increases. Aside from being costly, there is also an environmental impact as leaking systems expose refrigerant to the atmosphere. In this month's Skills Workshop, we will give you an overview of one the main causes of refrigerant leaks – corrosion – and how it can be cured and prevented.

PULLOUT

A common problem with air conditioning, refrigeration and freezer systems is the loss of refrigerant gas, especially micro leaks. They can be very difficult to find and most people, even technicians, do not know the cause.

The two most common forms of external corrosion are pitting and formicary. Unfortunately, these two corrosive processes can occur in as little as a few weeks after installation. However, most of the time, corrosion will begin appearing between 1–4 years.

Telling the difference between general pitting and formicary (also known as "ant's nest") corrosion is often the first step to determining cause.

GENERAL PITTING CORROSION

- Aggressive anions (a-NYE-uns) attack copper tubes.
- Anions – are negatively charged chemical particles.
- Anions search for positively charged cations (kat-EYE-uns).
- Copper is an abundant source of cations.
- Large pits characterise general pitting.
- They can often be observed with the human eye.

EXTERNAL CORROSION

General pitting corrosion is caused by aggressive anion attack on the copper tube. An anion is a negatively charged chemical species. Due to this negative charge, anions aggressively search for positively charged species called cations.

Copper is an abundant source of cations. Large pits resembling bite marks characterise the footprint of general pitting. These pits can often be observed with the human eye. Chlorides are the most common source of the aggressive anions known to cause general pitting corrosion.

Pitting will eventually break through to the inside of the tubing and create a leaking condition.

CHLORIDES

Chlorides are the most common source of aggressive anions.

Common substances containing chlorides can include:

- Aerosol sprays
- Tub and tile cleaners
- Carpeting
- Vinyl fabrics
- Degreasing and detergent cleaners
- Vinyl flooring
- Dishwasher detergents
- Wallpaper
- Laundry bleach
- Fabric softeners
- Paint removers

FORMICARY CORROSION

Formicary corrosion is characterised by small pinholes in the copper tube walls. A lot of the time, formicary corrosion isn't visible to the naked eye, however, some black or bluish-grey deposits often can be seen on the surface.

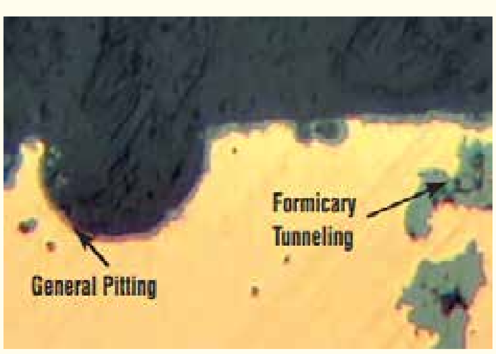
Examples of external copper corrosion.

Another key characteristic is a subsurface network of microscopic corroded tunnels within the tubing wall. These resemble ant nest-type structures, and are larger than the surface pinholes above them.

Organic acids such as acetic and formic acids are the primary cause of formicary corrosion. Acetic acids or the derivative acetate are found in a number of household products such as adhesives, panelling, particle board, silicone caulking, cleaning solvents, vinegar, foam insulation, and dozens of other commonly found products in the home or commercial/ industrial workplace.

Formic acid can be found in cosmetics, disinfectants, tobacco and wood smoke, latex paints, plywood, and dozens of other materials.

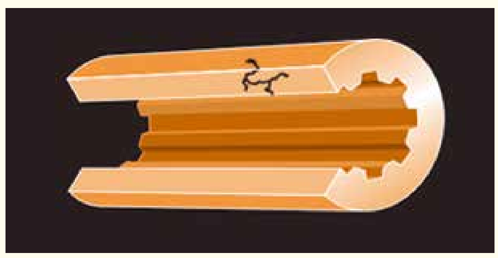
It is speculated that the rise in corrosion in recent decades may have been brought about by the emergence of tighter building construction methods, which inhibits outside air induction to dilute or clear away corrosive, indoor build-ups.



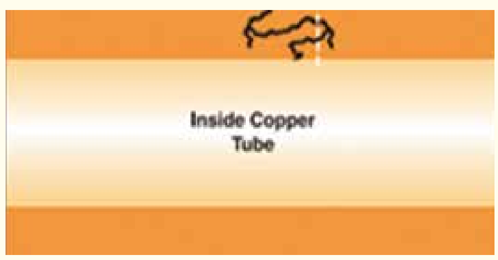
Formicary corrosion tunneling.

GENERAL PITTING AND FORMICARY CORROSION

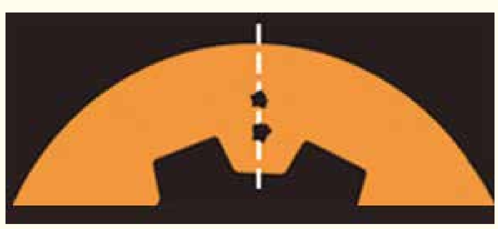
General pitting and formicary corrosion need oxygen and water to take place. While limiting oxygen is basically impossible in most cases, it will come as no surprise that limiting moisture will go a long way to fighting corrosion.



A 3D representation of corrosion through a tube.



Side view of a leak.



Cross-section showing portion of corrosion (leak).

FORMICARY CONDITIONS

There are three conditions required:

- The presence of oxygen.
- The presence of chemically corrosive agent (organic acid).
- The presence of moisture.

With multiple corrosive agents present, multiple corrosion occurs.

INTERNAL CORROSION PREVENTION

How can you neutralise the acids or deal with them? First step is to test the level of acid with a reliable pH test.

If it is not too acidic, you can use a high quality acid neutraliser to balance things out. If it is too acidic, then the system will need flushing, and driers and the lubricant will need replacing. At the same time, add a neutraliser to deal with any residue remaining.

In the case of outdoor condensing coils, corrosion can be prevented with periodic cleaning. Existing corrosion and build-up can be removed with an acid-based or alkaline-based coil cleaner. In some cases, pure filtered water can also be used. Do not use softened water as it contains salt which will corrode coil fins.

It is important to avoid leaving behind coil cleaner chemical residue. This residue has the potential to initiate the corrosion process, even if they are labelled as "non-acid". Like acid-based cleaners, alkaline cleaners also need to be rinsed thoroughly as alkaline residue can also corrode aluminium and other materials.

Coils located in certain conditions will require more frequent cleaning, most notably, heavy industrial areas that experience acid rain or coastal areas where ocean salt is present.

It is not possible to prevent all failures due to corrosion, but these best practices can help:

- Low-static MERV filtration and ERVs for fresh air.
- Ventilate new buildings during first year.
- Annual indoor coil rinsing.
- Special coatings in some environments.

INTERNAL CORROSION CAUSES

The main cause of the internal corrosion is the presence of moisture. Improper evacuation causes moisture to be left in the system, which results in:

- Increased head pressure.
- Increased discharge temperature.
- Increased compression ratio.
- Loss of efficiency.

Here is a little bit of science to explain what also goes on:

Humidity is inevitably introduced into a system in small amounts via the lubricant, the refrigerant, and by poor servicing practices.

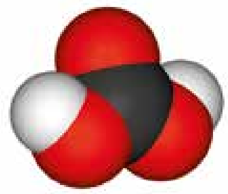
Integrated driers and accumulators can become oversaturated, especially when they are not serviced or changed. Who hasn't come across that one?

We all know that moisture is a problem but why?

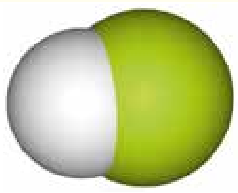
Fluorinated A/C refrigerant gases contain the chemical fluorine, moisture reacts with fluorine present in the refrigerant creating highly corrosive hydrofluoric acid that attacks all system components including aluminium, copper, solder, seals, plastic and rubber. These acids work their way around a system and are often concentrated in coil bends where many micro leaks occur.

Other acids are also created due to the presence of moisture, these include hydrochloric acid, carbonic acid created by CO_2, and fatty Acids created by lubricant degeneration.

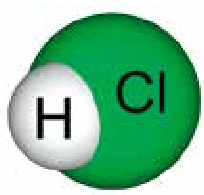
Carbonic acid (H_2CO_3)



Hydrofluoric acid (HFL).



Hydrochloric acid (HCL).

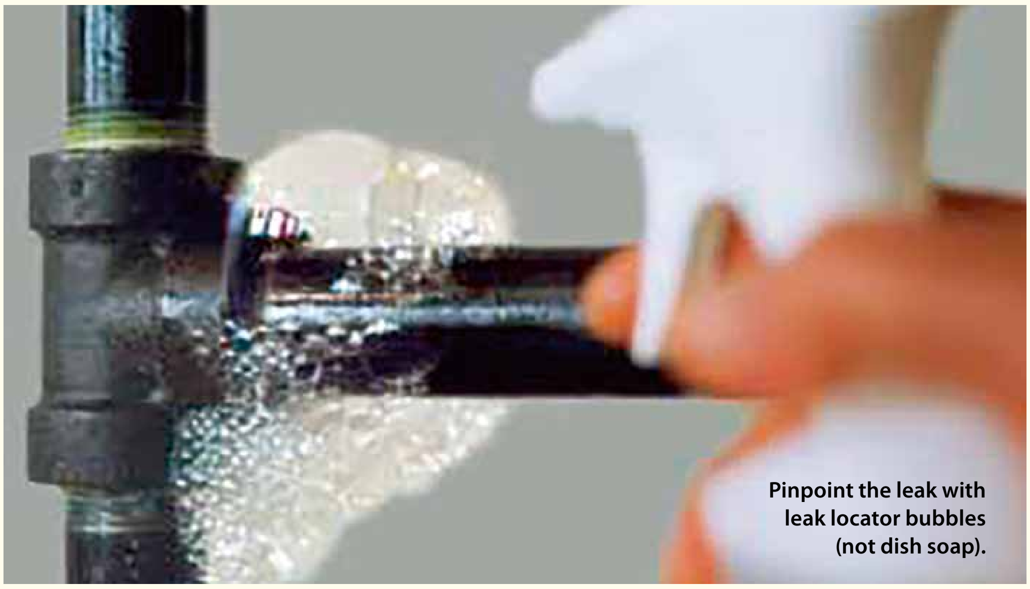


AVOID ACID!

- Acids suspended in oils etch copper, creating pinhole leaks.
- Acid attacks motor windings, stripping away vital winding insulation and copper wiring. This leads to compressor burnout.
- Acids can attack valve seats and cause wire drawing to occur, causing temparatures as high as 750°C causing valve and lubricant failure. (most AC lubricants boil above 400°C)
- Acids can vortice in coil U-bends, concentrating the corrosion.
- Etched copper particles lodge on the crank shaft causing binding, leading to the need for hard start kits and premature compressor failure.

Even small levels of acids initiate catalytic reactions. Acid first reacts by dissolving metals. Although acid takes time to accumulate, when critical concentrations are reached, the destructive process rapidly accelerates.

PULLOUT



Pinpoint the leak with leak locator bubbles (not dish soap).

FURTHER PREVENTION

Some best-practice methods to prevent internal corrosion include:

- Neutralising acid after a burnout.
- Flushing refrigerant lines when doing major repair or component replacement.
- Proper evacuation.
- Change the oil!
- Using a non-polymer leak sealant product to stop or prevent micro leaks.

Polymeric leak stop products aren't recommended as they tend to travel with the refrigerant in the system and must be installed with a drying agent. They also use dangerous chemicals such as toluene and have a low flash point of 36°C. Poor evacuation or repair practices involving polymer can cause internal chemical reaction, which has the potential to clog metering devices, tools, equipment, and compressor discharge valves.

In contrast, non-polymer leak sealants are oil-based and travel safely with the lubricant.

They do not react with moisture or air (non-hygroscopic), but react at the leak point, creating thin layers until the leak stops. On top of this, they have a high flash point and are non-toxic to skin.

LEAK DETECTION

Here is a basic checklist for detecting leaks:

- Use a good electronic leak detector to find the area.
- Pinpoint the leak with leak locator bubbles (not dish soap).
- The first leak you find may not be the only leak, so keep searching.
- Leak locator dyes are an option in some cases.
- Clean the dye from system surfaces after locating and repairing leaks.

To the purist that say "nothing but refrigerant and oil in a system" – with the fine line between a healthy system and an unhealthy system lubricants and refrigerants need safe fully tested and proven additives to keep a system balanced, especially when chemical reactions occur due to the presence of moisture and the inevitable creation of acids. ■

MORE INFORMATION

This month's Skills Workshop has been put together by Geoff Russell and James Bowman from Rectorseal Australia.
Go to www.rectorseal.com.au

Geoff Russell

James Bowman

Next month: Standards Update