Keeping track of corrosion

A bracing walk in the salt spray along the beach is likely to do us some good, unlike breathing in polluted city air. However, both atmospheres have a similar effect in speeding up corrosion of metals — a problem that costs about $370 million a year in the Australian construction industry alone.

It's possible to correlate the quantities of pollutants in the air with the extent of corrosion they are likely to cause, but this involves expensive, continuous monitoring. A much cheaper method of measuring the corrosiveness of air is to expose metal specimens for a fixed term and measure the rate at which they corrode.

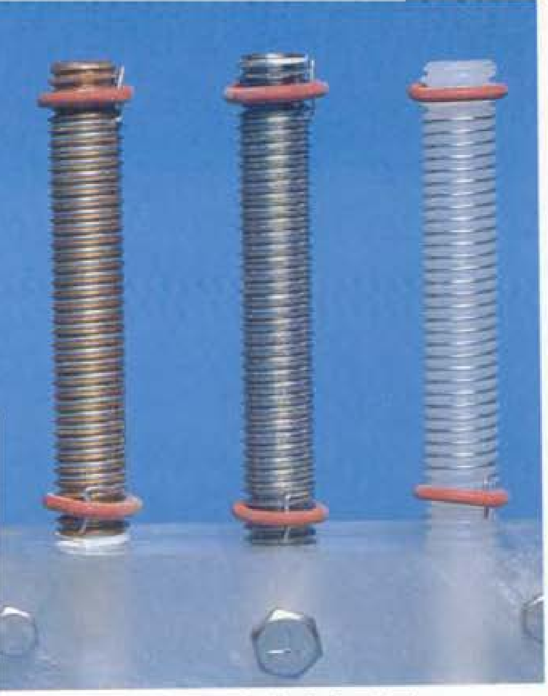
The procedure is widely used to measure the corrosivity of specific sites. It is also used to study the comparative performance of different metals, coatings, and finishes. When carrying out exposure studies, researchers usually select a range of environments representing rural, industrial, and marine.

In 1982, *Ecos* reported on a more unusual procedure — corrosivity mapping. Mr George King and Mr Keith Martin, of the Division of Building Research (now Building, Construction, and Engineering), and Mr John Moresby of the Division of Mineral Chemistry (now Mineral Products) had carried out a survey over 900 sq. km of the Melbourne metropolitan area using more than 300 sites on a 2-km grid. The corrosion map — the world's first of a metropolis — showed that corrosion rates were highest close to Port Phillip Bay and around the airports, an industrial plant, and a sewage-treatment works.

Mr Brian Carberry, a New South Wales Public Works Department architect, and Mr King are about to finish a similar project in Greater Newcastle. Using the standard Australian map grid covering an area of 1000 sq. km, they have placed steel specimens at 150 sites across a wide range of atmospheric environments. Mr King expects the high concentration of heavy industry — steelworks, smelters, and chemical plants — to make Newcastle's corrosion map look very different from Melbourne's. The survey is partly sponsored by several organisations, including BHP and James Hardie. Mr King hopes to receive similar support so that he can compile a corrosivity map of Sydney.

He has also conducted further studies in Melbourne in an attempt to understand what caused the higher corrosion rates at some sites in the first survey, and to compare the relative performances of a range of common building and cladding metals. He found that the greater corrosivity around the industrial plant was largely due to sulfur dioxide resulting from the sulfur-bearing brown coal it burnt in one boiler. High rates around the South-East-

Mr George King fixes specimens to a power-supply pole at one of the Melbourne beachfront sites.



This 'wire-on-bolt' device (to be manufactured by CSIRO under the name 'ATCORR') provides a simple, quick means of assessing corrosion rates.

ern Sewerage Purification Plant were due to extended periods of wetness in the low-lying flat terrain, combined with salt blown in from Port Phillip Bay.

Steels compared

To compare the performances of mild steel, low-alloy copper steel, galvanised steel, and aluminium-zinc-coated steel ('Zincalume'), Mr King selected 68 sites on a 2-km grid in the south-east of Melbourne to include a broad cross-section of conditions from 'moderately severe marine' to 'rural'. This approach lets him confidently establish the relative performances of different materials. He mounted specimens of each steel, so that they faced north, on brackets fixed 3·7 m above the ground on electric power-supply poles.

After 2 years Mr King took down the specimens and collected, for future analysis, the rust that had formed on the copper steel. He cleaned all the specimens in special solutions and used the difference in mass between the original and the corroded specimens to calculate corrosion rates in terms of thickness lost per year. After comparing these rates with locations, Mr King found a dramatic decrease in corrosivity within the first kilometre from the sea.

Surprisingly, galvanised steel performed poorly at beachfront sites, where its highest annual corrosion rate (7·3 μm) was 22 times greater than the lowest result — only 5·3 km inland. The equivalent ratio for mild steel and copper steel was just over 3. By contrast, aluminium-zinc-coated steel performed exceptionally well at the beachfront sites — five times better than galvanised

Cold corrosion

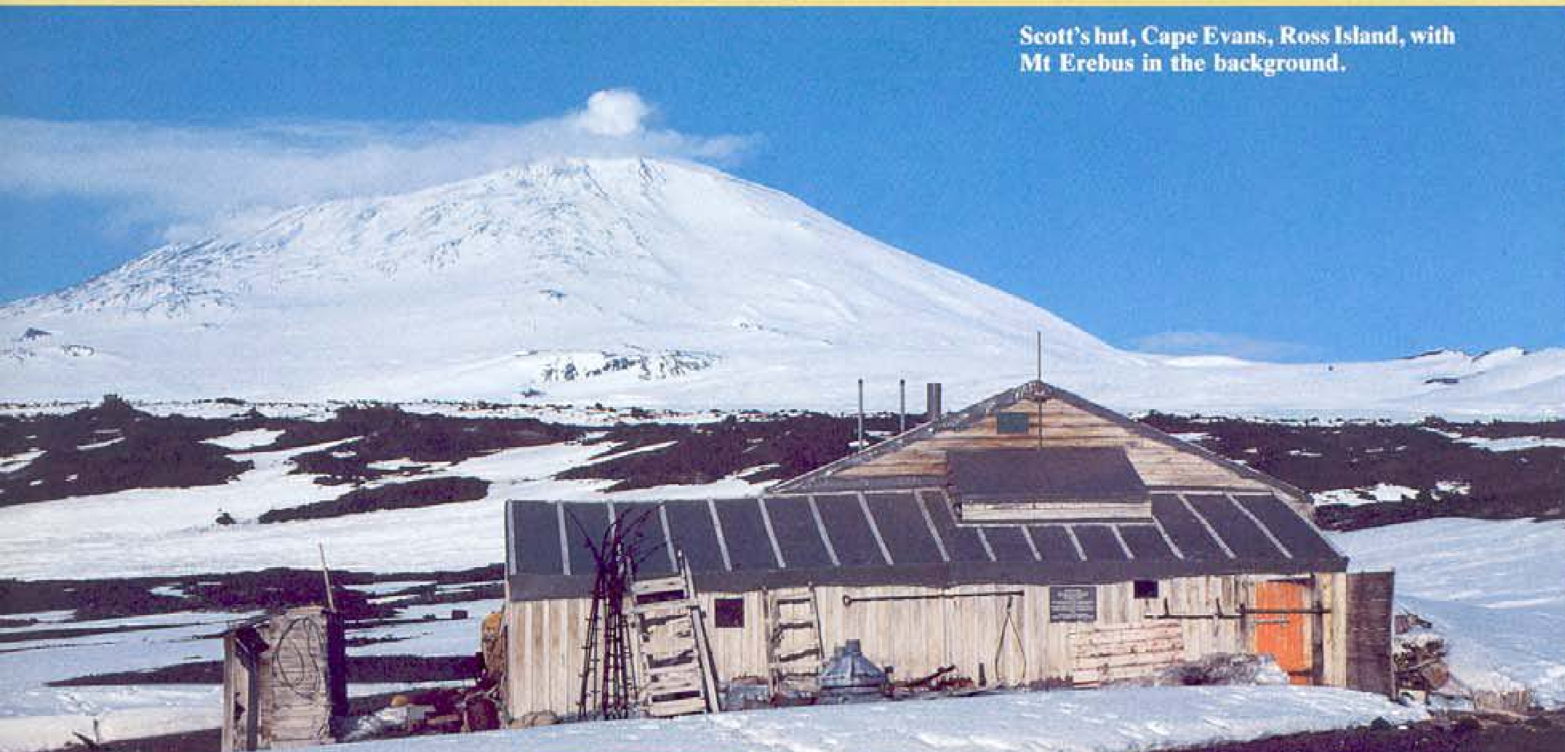
Accepted wisdom said that Polar regions have low corrosion rates because they are extremely cold and dry. So when, in 1960, snow and ice were removed from Scott's hut scientists were not surprised to find that most of the contents were still in excellent condition.

But the clearing of the hut radically changed the micro-environment and, since then, the historic material has deteriorated. Inside the hut, tins of food that had bright, clean labels 30 years ago are now rusting and disintegrating. Outside, historic equipment and cases of the explorers' tinned provisions are showing signs of severe corrosion.

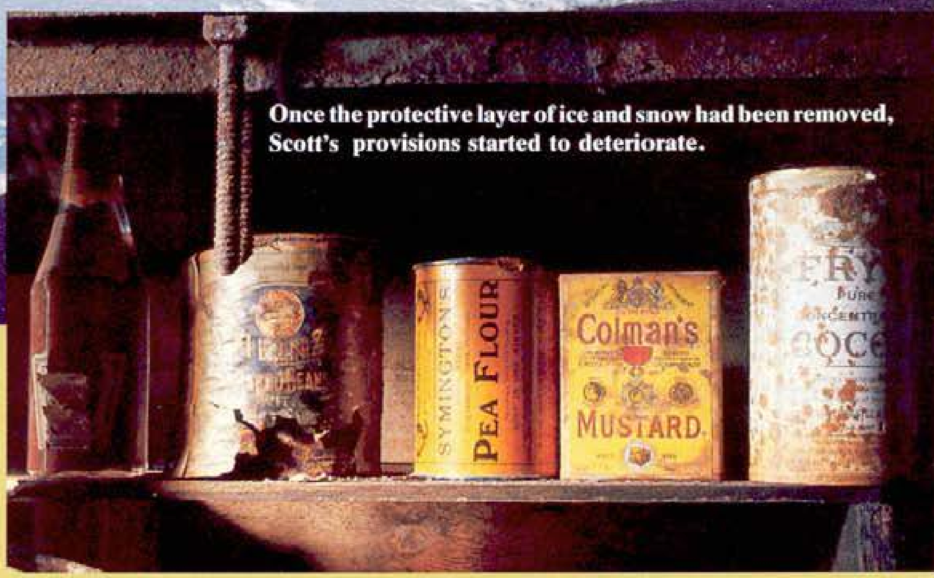
The Antarctic Heritage Trust and the Antarctic Division of the New Zealand Department of Scientific and Industrial Research (DSIR) have a continuing management program for the three historic huts built by Shackleton and Scott on Ross Island in the early 1900s. Contrary to earlier expectations, the environment at these sites appears to be severely corrosive and erosive — mainly due to the very strong winds that frequently blow salt-laden snow off the sea-ice and deposit it on the huts and equipment.

As part of the program to preserve these historic sites, Mr Gavin Dougherty, Mr Kerry Dalzell, and Mr Peter Dawson, from the DSIR, and Mr King installed standard copper steel specimens at Scott's hut, at Cape Evans (the coastal site), and at Vanda Station inland on the Antarctic continent opposite Ross Island. This station is located in Antarctica's 'dry valleys area'. Its strong, dry winds (speeds often in excess of 100 km per hour and a relative humidity of less

An archaeological dig inside one of the historic Antarctic huts.



Scott's hut, Cape Evans, Ross Island, with Mt Erebus in the background.



Once the protective layer of ice and snow had been removed, Scott's provisions started to deteriorate.

than 10%), very little snow, and virtually no rain make it one of the driest places on Earth. Temperatures range between −80 and +15°C.

After 12 months, corrosion at Vanda Station was only 0·9 μm, comparable to the levels obtained at Norman Wells in northern Canada — the benchmark for a site with low corrosivity. The site at Scott's hut told a different story. After 1 year, the level of corrosion (10·8 μm) was about the same as that measured in Melbourne's outer northern suburbs. But in the following 2 years the rate did slow more than Mr King expected. In a range of environments in mainland Australia, 3-year corrosion rates of mild steel are generally about 60% of that in the first year's exposure. At Cape Evans, the 3-year rate was about 40%. One explanation is that the corrosion products initially formed in the Antarctic may offer greater protection to the underlying metal.

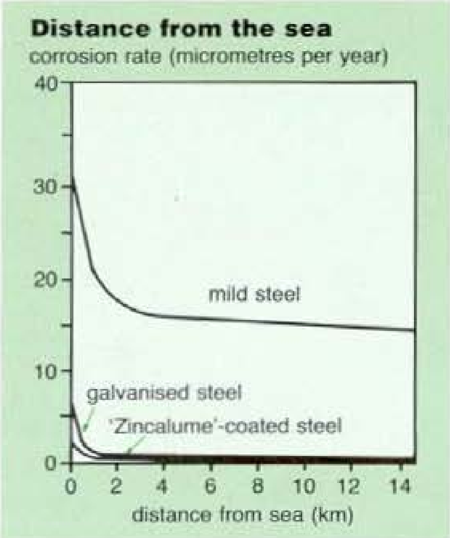
Recently, Ms Janet Hughes of the Australian National Maritime Museum in Sydney has examined Australia's historic Antarctic site (Mawson's hut at Commonwealth Bay in the Australian Antarctic Territory) and found corrosion to be a serious problem. Noting the shortage of accurate data on the general rates of corrosion in the region, Ms Hughes and Mr King are planning to carry out a survey that will help them produce a corrosion map of Antarctica.

They will use standard copper-steel specimens exposed at seven sites — Rothera (U.K.), Fossil Bluff (U.K.), Vanda (N.Z.), Amundsen–Scott South Pole (U.S.A.), Vostok (U.S.S.R.), Mawson (Aus.), and Macquarie Is. (Aus.). The scientists expect that the results from Vostok, due to its high altitude, distance from the sea, and record low temperatures (−90°C), will establish it as the world's least corrosive location.

The results from this survey will indicate the levels of corrosion protection required for structures in various areas of Antarctica. They will also assist in predicting what will happen if ice and snow are cleared from historic sites, and thereby help in their management.

Assessing atmospheric corrosivity in Antarctica. G. A. King, G.J. Dougherty, K.W. Dalzell, and P.A. Dawson. *Corrosion Australasia*, 1988, **13**, 13–15.

The problems of preservation in a polar climate: the conservation of Sir Douglas Mawson's hut at Commonwealth Bay, Antarctica. J. Hughes. *ICCM Bulletin*, 1988, **14**, 1–32.



Mr King found a dramatic decrease in the rate of corrosion within the first kilometre from the sea. Because of this, he believes the Australian Standard Classification of a 'severe marine environment' should be limited to 2 km from the coast rather than the present 7 km.

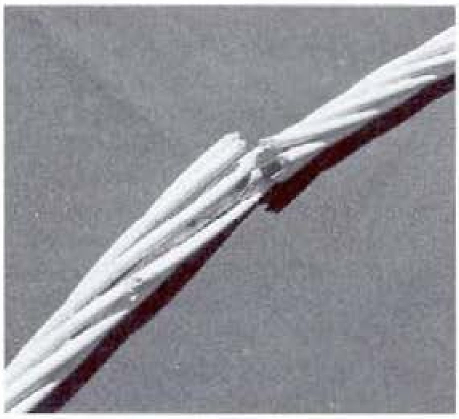
steel, although their performances matched very much more closely at sites further from the sea.

Interestingly, the results of the study do not support the Australian Standard classification of a severe marine environment as one within 7 km of the southern coast of Australia. Based on his research, Mr King believes that 2 km would be a more appropriate distance.

Corrosion close to the sea

Mr King is now undertaking a long-term study on the comparative performance of different classes of metal products in marine environments, with specimens made from about 30 products from the United States of America, Japan, West Germany, New Zealand, and Australia. The International Lead Zinc Research Organisation, BHP, and Comalco are supplying materials and have committed funds totalling more than $170 000 for the project.

Specimens will be exposed at three sites — severe marine, moderate marine/rural, and mild marine/residential — for up to 10 years. Each specimen has features that simulate the types of 'distress' to which metals are subjected during fabrication and building, such as various-radius bends, cut-outs, domes, and dimples. Some of the specimens are mounted on specially designed racks with a glass roof — protecting them from rain, but not from salt spray and dust. The roof allows partial transmittance of ultraviolet light. Previous experience has shown that, in marine environments, metal not regularly washed will often deteriorate more rapidly.



Corroding electricity conductors are a major problem for electricity authorities. Mr King is working with the Electricity Trust of South Australia to find out in which parts of that State the transmission/distribution system is most susceptible.

New devices showing promise

As part of the Division's search for more rapid assessment procedures, Mr King and his colleagues have been looking at other approaches to corrosion measurement, including modifications to CLIMAT (CLassification of Industrial and Marine ATmospheres) testers, developed at the Alcan laboratories in Canada. These units consist of 1-m lengths of aluminium wire wound tightly into the threads of nylon, steel, and copper bolts mounted vertically on a perspex block. They are generally exposed for 3 months and the percentage weight loss on each wire is expressed as a corrosion index.

CLIMAT tests have been carried out at hundreds of locations throughout the world, and correlations have emerged between the indices developed and the service records in existing installations. The wire's high ratio of surface-area to weight, together with a bi-metallic effect that speeds up corrosion, results in the high sensitivity of the device.

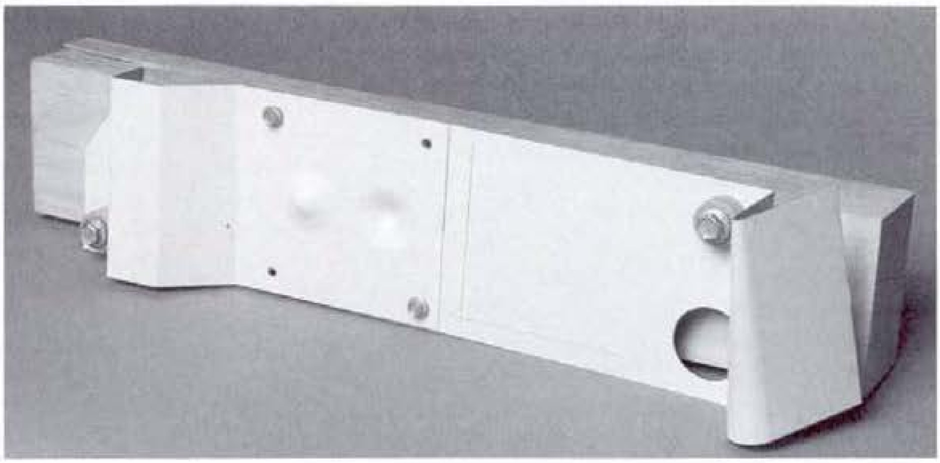
In the more recent Melbourne survey, as well as the metal specimens attached to the power poles, Mr King used the Division's versions of these 'wire-on-bolt' units. They were changed quarterly during the 2-year survey period. He found strong correlations between the indices from the units, the distance from the sea, and the corrosion rates of the metals and coatings tested.

As a service to industry the devices are to be manufactured and marketed by CSIRO under the name 'ATCORR' (from ATmospheric CORRosion). It's hoped that ATCORRs will provide a simple means of assessing the level of atmospheric corrosivity at any location in just 3 months.

In a further development, Mr King and Mr Jim Kapetas, an engineer from the Electricity Trust of South Australia (ETSA), have just begun a collaborative survey sponsored by ETSA. Initially, they are placing ATCORR units in the Victor Harbour district to assess the various corrosion indices inland from the coast. Eventually they will place 200 units (along with standard steel specimens) in a range of atmospheric environments throughout the State. The results will show ETSA which areas along its transmission/distribution system are most susceptible to corrosion.

David Brett

The metal specimen's strange shape, and its lumps and dimples, have a purpose. They simulate the types of 'distress' to which metals are subjected during fabrication and building.



More about the topic

- A corrosivity survey on a grid of sites ranging from rural to moderately severe marine. 1. Steel, galvanised steel, and Zincalume coated steel. G.A. King. 2. ATCORR indices. G.A. King and P. Gibbs. *Corrosion Australasia*, 1988, **13**, 5–14; 1990, **15**, 5–8.
- A corrosion map of Melbourne. A. Bell. *Ecos* No. 33, 1982, 10–12.