
To provide the reliability in service which the operator needs, an antenna must be well designed, competently installed and properly maintained. This article examines the environment in which the antenna must operate and suggests standards of design, installation and maintenance.

## 1. The environment

An antenna installation is required to provide reliable communication over a link during the whole of the operational life of the system of which it is a part. It must maintain all the following parameters within definable limits in any climatic conditions which may be anticipated at its place of installation.

- (a) Forward gain
- (b) VSWR
- (c) Levels of side and rear lobes
- (d) Pointing direction of main beam
- (e) Polarisation
- (f) Level of internally generated noise
- (g) Power handling
- (h) Level of internally generated non-linear products

An antenna delivered by a competent manufacturer will be capable of meeting system requirements on each of these parameters in the conditions of an antenna test range. However, on being put into service it will be subject to a number of environmental influences which will tend to degrade its performance.

### Rain

The effect of rain, especially when contaminated with industrial pollutants or salt, is to accelerate the corrosion of metallic parts of an antenna. The materials used for an antenna must be corrosion resistant wherever possible. Unfortunately this is not an easy criterion to meet, although the author has seen antennas constructed entirely in stainless steel.

In practice the materials used are subject to corrosion and the object of design must be to cut down the rate at which it occurs. The most rapid corrosion will occur at points of connection between different metals, for example between brass and zinc or between stainless steel and aluminium. This corrosion is caused by the setting up of a small electrolytic cell in which one metal is dissolved away rapidly into solution. The rate of corrosion is determined by the 'contact potential' which may be determined from Table 1 for any pair of metals. In any pair the metal lower down the table will be corroded.

For outdoor service, no contact potential should exceed 0.25 volts. This restriction severely limits the permissible combinations available. Electroplating may be used to cover one metal with another giving an acceptable contact potential, but must be used with care as many platings are porous, adhere poorly to the parent metal, or are themselves subject to corrossion.

It will be seen from Table 1 that in no circumstances must aluminium alloys be joined directly to copper (used for coaxial cable conductors) or to stainless steel (used for fasteners). The unpleasant white mess to which aluminium is reduced in such situations is familiar to any one who has tried to mend a badly designed antenna. Even when water runs down a copper wire onto galvanised steel fittings, the galvanising is quickly stripped off and rusting rapidly sets in.

The rules which must be observed may be summarised:

(1) Make sure that contact potentials are less than 0.25 V.

(2) Hot dip any mild steel parts. Do not permit galvanised mild steel components to be drilled or sawn at the time of installation unless absolutely essential. Paint any exposed steel with zinc-rich primer and a top coat of micaceous iron oxide paint.

(3) Avoid water traps. Parts which cannot be sealed must be free draining. Make sure that parts are installed with drain holes downwards!

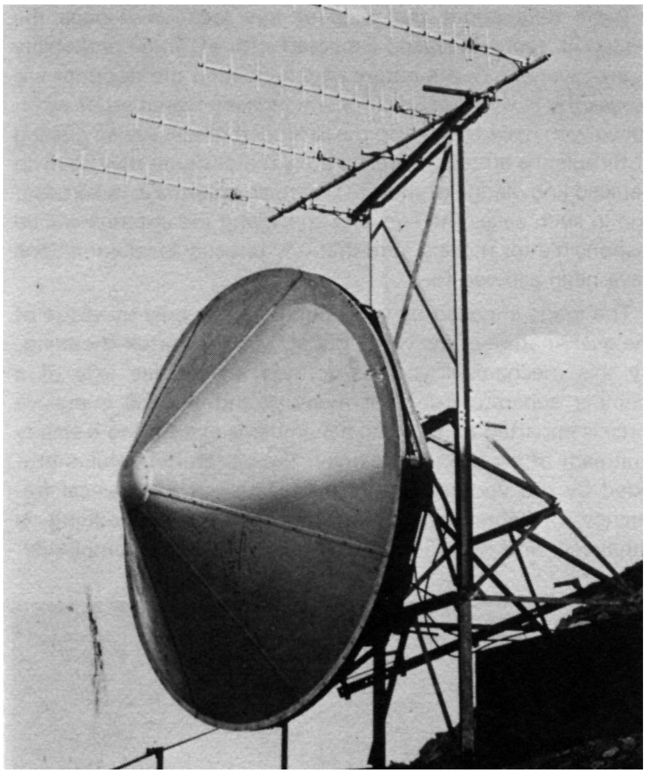
(4) Never expect an empty void to stay empty—water will always find a way in. If an empty space is essential and cannot be connected to a pressurised dry gas supply it should be provided with a seal at least equivalent to properly greased 'O' rings between smoothly machined metal faces.

(5) Where any corrosion risk exists between parts which may need to be adjusted or moved on a future occasion, use a suitable paste or tape to keep water out. (For example Densyl paste or Densotape).

Corrosion may reveal itself by gross effects such as the complete failure of an antenna or the physical collapse of some part of it. More subtle effects such as a rise in intermodulation products or noise may take longer to notice.

In addition to mediating corrosion, rain can give rise to a form of electrical disturbance known as precipitation static noise. This shows itself as an increased level of received noise during rain. Each raindrop carries an electrical charge which causes a small noise impulse when a drop falls onto the antenna. This effect is particularly noticed at frequencies below 100MHz and is countered by providing an insulating cover over the driven elements of an antenna.

## Ice and Snow



*A sectionalised fibreglass radome on a 4-m dish for protection against severe winter conditions*

If ice and snow build up on an antenna its performance will be degraded until the ice melts or is blown away. SHF dish antennas suffer particularly badly as VSWR, gain and cross polar performance are severely affected. A radome fitted to the antenna reduces the severity of the effects, but at some locations it is necessary to heat the radome surface to prevent the build-up of ice and snow if a link is to remain operational.

UHF ~ VHF antennas such as yagi arrays suffer a loss of gain and an increase in VSWR so, at severe locations, they are often fitted with heating elements inside the tubing.

The formation of hoar-frost deposits on HF antennas can cause their collapse by a combination of increased deadweight and increased wind load. When a site has a history of problems of this kind consideration should be given to providing automatic halyard tension correction~or the use of mechanical 'fuses to safeguard supporting structures.

The sheer weight of ice which builds up on an antenna can cause failure or bending, resulting in permanent offset of the line of fire of the antenna. Even worse, when the temperature rises and the ice begins to melt, large blocks of ice can fall from the structure or from antennas mounted on it. These create a hazard to personnel and are destructive of exposed antennas, feeders and even the roofs of equipment buildings. GRP or steel deflectors are sometimes mounted above the antennas exposed to this hazard. Feeders should be covered where they run horizontally and roofs suitably reinforced! Where falling ice is a known hazard it is obviously sensible to place the equipment building at a safe distance from the tower to reduce the hazard to staff.

Many efforts have been made to develop materials for radomes, ropes and other components which resist becoming coated with a build-up of ice. None of these appears to be adequate in the long term.

## Wind

For many types of antenna the dynamic pressure caused by wind exceeds the self-weight of the antenna. On VHF antenna towers the wind provides the only large horizontal load and on HF antennas the wind can increase the tensions in rigging wires and ropes many times over. Wind loads provide particular problems to the designer because they are transitory both in space and time and they produce oscillatory effects on objects on which they act.

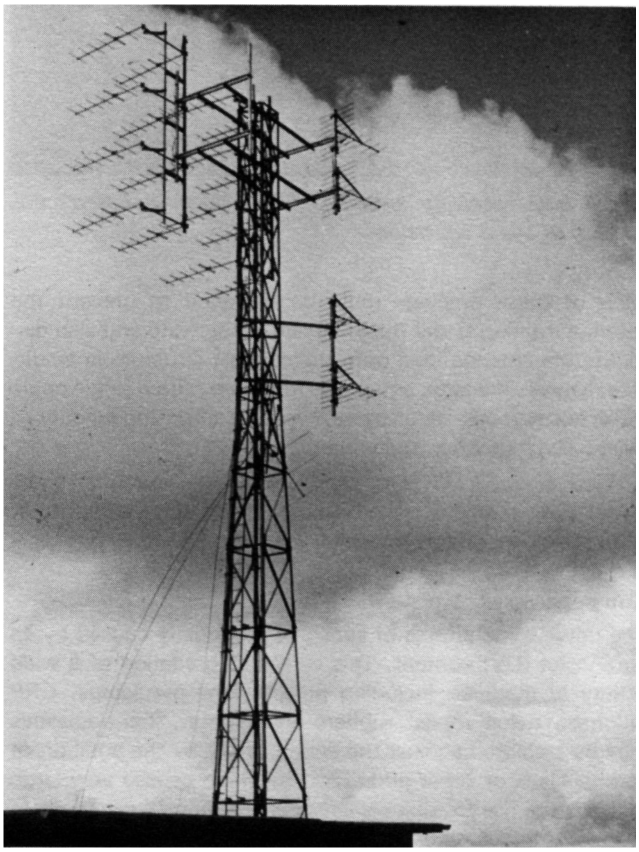
Basic data about the wind at any location defines the 3-second gust windspeed expected with a 1-in-50 probability in any year. From the nature of the location the designer will assess the likely wind shear characteristics (variation of windspeed with height) and also the likeiihood of any severe gusting or turbulence effects. Unfortunately the designer may have no detailed knowledge of the site where an antenna is to be used, and in such cases the engineer specifying the antenna will be responsible for making sure that any unusual local conditions have been allowed for.

The loads imposed by wind fluctuate not only by virtue of the gusty nature of the wind, but also by the vortex-shedding. By this mechanism vortices formed on the lee side of a member separate from the member and a small impulsive force is imparted to it. When a member is exposed to a steady airstream of a particular velocity, the vibratory stimulus provided by the vortices occurs at the natural mechanical frequency of vibration of the member; vortex-shedding is enhanced and vibration builds up to a larger amplitude.

Vibration induced in this way may be damped by the use of suitable dampers or by changing the aerodynamic behaviour of the member, for example by changing its section or adding helical strakes.

The oscillatory nature of wind-induced loads is very important. The instantaneous maximum value of stress is higher than it would be for a static condition and the life of the structure is reduced by the effects of fatigue. Fatigue is particularly important in aluminium structures, in which it is almost universally responsible for fracture failures. To minimise the stress in long antenna booms, they should be centre mounted or provided with rope stays.

Wind loads imposed on any antenna are transferred to the supporting structure by the mounting brackets. The configuration of these brackets must be designed to prevent the antenna rotating under the influence of the wind and also distribute the antenna load onto the support structure in a suitable manner. If a large antenna is mounted onto a single angle tower leg member—even a heavy one—a surprising amount of twist will occur when the wind blows.



*Complex Yagi arrays in East Africa. In a windier location they would need staying*

Wind induced vibration tends to shake screw fasteners loose: they should always be retained by self-locking nuts, spring washers or screw locking adhesive.

**Sunshine**

The unwelcome effects of sunshine are mostly caused by its ultra-violet (UV) content. This causes degradation of a wide variety of materials including polyethylene mouldings, GRP radomes, nylon ropes, rubbers and paints. Thermoplastics may be stabilised against the action of UV by the addition of carbon black or other additives. Sunshine causes very large temperature rises in objects left openly exposed, especially in tropical latitudes, and the RF power ratings of coaxial cables and components is reduced. It may be possible to provide sunshades for critical components such as ferrite cored baluns, but in other cases the exposed components must be derated. Badly designed devices may suffer because of the effect of thermal expansion.

## 2. Installation

The previous section has indicated some of the ways in which antennas may suffer as a result of exposure to the weather. It is well worth while checking over a new antenna at the time of installation to spot any obvious design defects or omissions such as missing drain holes or loose fittings. Erect the antenna in accordance with the manufacturer's instructions but be prepared to use Densyl paste or thread locking compound where required.

HF antennas need careful tensioning, and may need adjustments making if the site is not level. No fibre ropes should be used less than 3 m above ground level if the site is grazed by animals: the lower ends of halyards or tensioning stays being exchanged for wire rope to avoid the risk of being bitten through.

A VHF antenna installation will look much more professional if care is taken to ensure precise alignment of all elements and booms. Feeders should be cleated tidily underneath tower members to avoid the risk of damage or hazard when the tower is climbed.

*Active loop receiving antennas using fibreglass-encased conductors to avoid corrosion*

Coaxial connectors should be protected by wrapping with self-amalgamating (polyisobutylene) tape and over-wrapping with Densotape. Any drip-shrouds provided on the cable should first be cut off.

In severe environments antennas can be painted at the time of installation, using a zinc chromate or calcium plumbate primer followed by a micaceous iron oxide top coat. This paint should not be applied to radomes or other insulating materials.

### Maintenance

The engineer who maintains an installation sees the effects of design shortcuts or errors at the time of erection. He should first consider the installation as a whole, ensuring that its appearance is as it should be and that no parts have become detached. This should be followed by an examination of rigging tensions, groundwork and feeders. Finally he should check the site: that safety fencing is intact, that no damage is being caused by animals and that the grass is being kept short so as not to present a fire hazard.

At intervals of three years, it is prudent to lower HF arrays and examine for local corrosion, broken wires, cracked insulators or other danger signs.

VHF antennas are generally more accessible and may be examined for corrosion without dismounting.

A useful method of detecting electrical deterioration is to make a frequency-swept measurement of the VSWR of an antenna at the time of its installation. Measurements made at maintenance visits can be compared with the original figures, allowing problems such as water ingress to be detected early.

**General**

The achievement of high reliability over a long service life requires careful design combining good engineering practice with the results of experience. First class design is not cheap, and it is regrettable that the last few years have seen a decline in the engineering standards to be seen in many antennas. CS A has many years of experience in designing reliable antennas for broadcasting and aerocomms: this article has indicated some of the problems which are regularly encountered and for which solutions are continuing to be found.

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