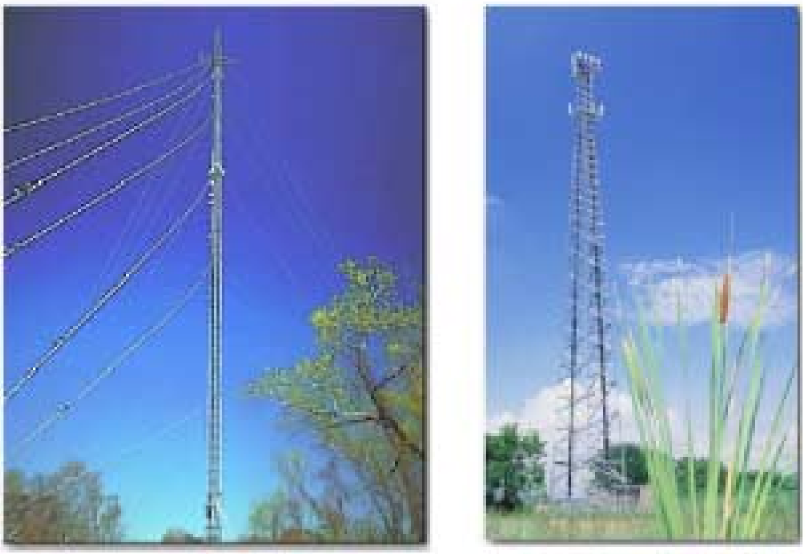
APPENDIX M

TELECOMMUNICATIONS



Transmission towers

Equipment shelter

Telephone

APPENDIX M

TELECOMMUNICATIONS

MICHIEL P.H. BRONGERS[1]

SUMMARY

The components that have an impact on corrosion of the telecommunications infrastructure in the United States include hardware, such as electronics, computers, and data transmitters, as well as the equipment shelters and towers used to mount antennas and dish-shaped transmitters and receivers. According to the U.S. Census Bureau, the total 1999 value of shipments of communications equipment was $84.6 billion.

Factors to be considered for the cost of corrosion are: materials of construction for towers and shelters and corrosion of grounding beds. No estimated cost of corrosion was determined for this rapidly changing sector due to lack of information. Many components are being replaced before physically failing because they become obsolete technology in a short period of time.

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[1] CC Technologies Laboratories, Inc., Dublin, Ohio.

SECTOR DESCRIPTION

This sector describes the impact of corrosion on the telecommunications infrastructure in the United States. The telecommunications infrastructure includes hardware such as electronics, computers, and data transmitters, as well as the equipment shelters and towers used to mount antennas and dish-shaped transmitters and receivers.

Wired communications systems include telephone and cable TV systems. Wireless communications systems include personal computer systems (PCS) and cellular telephones, broadcast and trunked radio systems, and a variety of other systems based on the transmission and reception of electromagnetic wave signals.

This sector description is limited to an identification of the areas expected to have the most corrosion problems. The telecommunications industry is relatively young and material replacement is often done because of technological changes rather than corrosion; therefore, no corrosion costs are reported in this sector.

Industrial Classification

The Standard Industrial Classification (SIC) system used by the U.S. Census Bureau(1) classifies the SIC 513 as "Broadcasting and Telecommunications Industries," which includes establishments providing point-to-point communications and the services related to that activity.

The SIC 5133 "Telecommunications" industry group comprises establishments primarily engaged in operating, maintaining, and/or providing access to facilities for the transmission of voice, data, text, sound, and full motion picture video between network termination points and telecommunications reselling. Transmission facilities may be based on a single technology or a combination of technologies. According to the 1997 Census, this industry group had 30,012 establishments, an annual revenue of $260.5 billion, an annual payroll of $47.5 billion, and approximately 1.0 million employees.

Size of Communications Equipment Sales

The U.S. Census Bureau reported that in 1999, the value of shipments for communications equipment totaled $84.6 billion(2) (see table 1). The Office of Telecommunications Technology, under the U.S. Department of Commerce, reported a comparable value for 1999 with $78.6 billion in total shipments.(3) Table 2 shows a list of typical telecommunications equipment.

Table 1. Value of shipments in 1999 for communications equipment, as reported by the U.S. Census Bureau.(2)

SHIPMENTS	VALUE OF SHIPMENTS	
	$ x billion	%
Communications systems and equipment	31.3	37.0
Other telephone and telegraph equipment	20.4	24.1
Telephone switching equipment	13.9	16.4
Carrier line equipment and non-consumer modems	9.1	10.8
Broadcast, studio, and related electronic equipment	3.9	4.6
Alarm systems	2.1	2.5
Other electronic systems and equipment	1.7	2.0
Vehicular and pedestrian traffic control equipment	1.0	1.2
Electronic teaching aids	0.7	0.8
Paging systems	0.3	0.4
Ultrasonic equipment	0.2	0.2
TOTAL	**$84.6**	**100%**

Table 2. U.S. telecommunications trade in 1998.[3]

PRODUCT		
NETWORK/TRANSMISSION EQUIPMENT	**CUSTOMER PREMISES EQUIPMENT**	**OTHER TELECOMMUNICATION EQUIPMENT**
Switches	Cellular telephones	Radio transceivers
Satellites	Videophones	Radio parts
Coaxial cable	Private branch exchange Switching apparatus (PBX)	Radio transmitters
Optical fiber/cable	Modems	Telegraphic apparatus
Line systems	Key systems	Radio receivers
Repeaters	Teleprinters	Antennas
	Handsets	Articles for instruments/networks
	Intercoms	Loudspeakers
	Wire with modular connectors	Earth stations
	Answering machines	Telephonic apparatus
	Pagers	Set-top boxes
	Facsimile machines	Television transmitters
	Telephone sets	
	Cordless telephones	

AREAS OF MAJOR CORROSION IMPACT

Hardware

Telecommunications hardware is the collective name for all the switchboards, electronics, computers, data transmitters, and receivers necessary to complete communications between people. Delicate electronic components must be protected from human and weather factors to be able to operate reliably over long periods of time. An expert in electronics manufacturing and corrosion contended that most failures of this type of equipment are caused by environmental factors. If electronics are not protected from moisture, corrosion of the delicate small parts will cause malfunctions.

It was found that most telecommunications hardware is placed and used inside buildings; therefore, it is expected that it will not be exposed to corrosive environments. In addition, electronic hardware becomes obsolete in just a few years. Therefore, the actual service life of consumer goods is often limited by rapid technological changes rather than by material degradation issues.

Telecommunications equipment with a longer design life includes the cables, connectors, and antennas used for the transmission and reception of electronic signals. These components may be placed outside and be buried so that they become exposed to environments such as soils and water, or they may be exposed to air and moist weather conditions. No data were found regarding the percentage of failures due to corrosion for each category.

A specific corrosion issue is a possibility at telephone facilities that maintain backup power systems in case of power outages. These facilities may have diesel fuel generators supplied by underground storage tanks (USTs). Leaking (UST) systems can cause contamination of groundwater supplies and can cause fires, explosions, and vapor hazards. Under the Resource Conversation and Recovery Act (RCRA), Subtitle I for Underground Storage Tanks, the owners and operators of underground storage tanks must have upgraded, replaced, or closed existing substandard

UST systems by December 22, 1998. Upgrading may involve adding spill, overfill, and corrosion protection to the UST system. More information about UST regulations is given in the sector that discusses hazardous materials storage.

Shelters

Telecommunications equipment is usually housed in a shelter in order to protect it from wind and weather. Shelters are structures without windows that can be climate controlled and contain large amounts of electronics, computers, and equipment, such as transformers.

Shelters are generally located in the immediate proximity of power stations and communications towers. Many antennas and towers are placed at high locations; therefore, a common place for shelters is on rooftops. Shelters are also placed at locations on the ground. Mobile telephony has created the need for many support antennas spread throughout the landscape. Along a major interstate highway, one can count approximately one communications tower per mile of road. Each tower has a shelter and a fence built around it, both of which protect this infrastructure.

Four construction materials are commonly used for communications shelters: steel, aluminum, fiberglass, and concrete. Wooden blocks or concrete blocks are used for their foundations. The capital cost for a shelter can range from $5,000 for a small metal box to $500,000 for a secured concrete building with steel doors. Prefabricated steel shelters for cellular telephone companies typically cost $20,000.(4)

Carbon steel shelters need to be painted to be protected from corrosion. Stainless steel shelters would not need painting; however, the initial material costs are higher than for painted steel. Elsewhere in this report, a full description is given on the cost of paint and its application and the cost comparisons of stainless steel versus carbon steel; therefore, no further details are given here.

Aluminum is mainly selected due to its favorable weight-to-strength ratio. On rooftops and on other mounted structures, the dead weight of the shelter can be important for structural purposes. Aluminum is generally considered to be corrosion-resistant in non-marine environments. The initial material costs are higher than that for carbon steel; however, surface painting is not necessary. For aesthetic appearances, an owner may select coated aluminum with a different color.

The wall construction of fiberglass shelters consists of a foam core with two skins of fiber-reinforced plastic. The fiberglass exterior is corrosion-resistant and, therefore, requires relatively low maintenance. However, the price of fiberglass shelters is generally higher than that of painted carbon steel and aluminum. The fiberglass surface may be molded for a better appearance (for example, using a brick pattern). Standard widths vary between 1 and 5 m (4 and 16 ft), and standard lengths vary between 2 and 7 m (6 and 24 ft). An advantage of fiberglass shelters is that they can be delivered pre-assembled.

The largest and strongest shelters are those constructed using concrete. They are usually secured shelters with steel doors. Montee of the AT&T Tower Group(4) stated that all concrete shelters have temperature- and humidity-controlled environments; therefore, corrosion is not an issue for the equipment place inside.

Heat and Humidity

For cellular telephone equipment, a refrigerator-sized cabinet can be placed near an antenna. The cabinets can be made of steel or aluminum. Corrosion protection is applied for cosmetic purposes because this type of technology generally becomes obsolete and is replaced before corrosion becomes a structural issue. Terry Keating of Lucent Technologies(5) explained that they apply a double system of galvanizing and painting for corrosion protection of their steel cabinets. Surface preparation through grinding and the application of zinc chromate primer is essential for galvanizing. The outdoor cabinets are built more robustly (of thicker gauge material) than the indoor cabinets and can cost twice as much. Cabinets in the range of $1,000 to $10,000 have an estimated corrosion cost of approximately 20 percent, according to Keating.

Significant effort is put forward to protect the equipment contained in the cabinets from moisture. The cabinets are sealed and cooled using passive air-to-air heat exchangers. Only in extreme cases do these cabinets have the more expensive active air-conditioning units.

Nationwide, an estimated 4,000 cabinets for cellular telephone equipment are in use. Their average price is around $5,000, and the estimated cost for corrosion protection for this type of cabinet is 20 percent; therefore, their estimated corrosion costs are approximately $4.0 million (4,000 x $5,000 x 0.20).

Towers

The transmission of signals is done best from antennas mounted at high places. To achieve this, four types of towers have been developed: (1) towers with guidewires, (2) self-supporting wireless towers, (3) tapered steel monopoles, and (4) aesthetic towers. The design, erection, inspection, and maintenance of telecommunications towers is a growing industry because more and more people have portable telephones that require a large number of relatively small towers to be constructed around the country.

Montee[(4)] explained that the large majority of telecommunications towers are of the self-supporting type. These towers have been constructed since the early 1960s and are made using hot-dipped galvanized steel. Now, 40 years later, negligible corrosion is observed on these towers. Up until the late 1980s, many of the self-supporting towers were painted red and white for daytime visibility and have a red beacon for nighttime. During that period, paint was reapplied every 7 years at a cost of $15,000 to $20,000 per tower; however, this was not for corrosion protection. Today, towers less than 152 m (500 ft) tall and equipped with strobe lights are not required to be painted.

The second largest group of towers is the guided (wire) towers. These towers have been in service for some time. Historically, guided towers were constructed using regular carbon steel and were sandblasted and repainted regularly. The continued operation of these existing, aging guided towers is a major corrosion concern because corrosion of the steel members may affect the structural integrity of the towers.

In recent years, wireless communications have emerged as a large industry with continued growth. Many cellular telephone companies are using monopole towers because they are less noticeable in the landscape and cities than self-supporting and guided towers. Additionally, the cost for monopoles with a height up to 46 m (150 ft) is comparable to that of self-supporting towers. A disadvantage of monopoles is that they cannot be expanded or strengthened after construction; however, that is a possibility for steel-framed towers.

The number of aesthetic towers is relatively low due to their added finishing costs; therefore, this type of tower is only used when other options would be unacceptable.

The antennas that are mounted to towers do not have significant corrosion problems, according to Montee.[(4)] Dish antennas are made from aluminum and are painted. Cellular telephone panel antennas have not yet shown problems; however, they were placed only a relatively short time ago. The whip antenna, which is 5.5-m (18-ft), 76-mm- (3-in-) diameter pole, is typically used for emergency 911 calls. The whip antenna has no corrosion problems but is prone to damage from lightning strikes.

One tower attachment engineer stated that the single largest corrosion problem in the telecommunication industry is the degradation of buried grounding beds and grounding rings around towers and shelters. These copper grounding systems are consumed over time by corrosive soil. Problems occur when the electrical connection between the grounding bed and the structure is interrupted, or when the corrosion advances so much that the electrical resistance of the bed becomes too great. To prevent electrical disconnection between the grounding and the structure, the traditional mechanical connections must be replaced with CADWELD® connections [American Welding Society (AWS) designation: Termit Welding (TW) process]. Galvanic corrosion due to connections between dissimilar metals is another factor related to copper ground beds.

The copper cables used for the telecommunications industry's electrical supply are encapsulated in plastic to prevent electrical shorts. The plastic also provides corrosion protection to the wires.

CASE STUDIES

Case Study 1. Inspection of Telecommunications Towers

The components and elements of a telecommunications network require regular maintenance. One of the most important parts is to ensure the structural integrity and safety of the telecommunications towers. On their website,(6) CGTI Pylones[2] specifies details for a maintenance and inspection program for telecommunications towers. The amount of maintenance is greater for towers with guidewires than for self-supporting towers.

The principal action is to regularly perform a visual inspection of the tower's external condition. The inspection must be done regularly during the life of the structure, for each installation of an additional loading, and after each important climatic event (tempest, hurricane, etc.) As a minimum, the first checking visit of each tower should be done, at the latest, 6 months after its installation and erection, while subsequent maintenance visits should be done each year. Based on the results of the inspection, maintenance and other such interventions can then be carried out.

CGTI Pylones reports the following detailed checklist for inspection visits (see table 3). For the current report, the corrosion-related items are italicized. The list shows that water traps, problems with grounding systems, and structural hazards from corroded areas are the most common problems. If the items are counted and the relative time spent on each of the tasks in a normal inspection is estimated, the inspection time spent on corrosion issues is calculated at approximately 25 percent.

Table 3. Checklist for inspection visits to telecommunications towers with guidewires, as reported by CGTI Pylones.(6)

MAIN STRUCTURE:
Check that there are no structural components missing.
Check that bars are neither warped nor holed nor split. In that case, defective part(s) shall be replaced.
Check that structural components are not oxidized.
Check that draining holes (pipe leg members, pipe lattice parts) are not blocked.
GUIDEWIRES:
Check guidewires and accessories.
Check that each cable that is part of the guidewire is neither broken nor warped.
Measure the tension of each guidewire by a strand dynamometer and to compare the result with the value stated in the manufacturer's files.
Check guidewire corrosion.
Check that the guidewire tightening system is properly greased.

[2] CTGI Pylones is a French company that designs, constructs, maintains, and inspects telecommunications towers.

Table 3. Checklist for inspection visits to telecommunications towers with guidewires, as reported by CGTI Pylones.[6]

BOLTING PARTS:
Check that there are neither bolts and nuts nor other bolting parts (washers, pins) missing. In that case, immediate corrective action is required.
Check bolt tightening.
Check that bolts are not oxidized.
Check anchorage rod in the concrete.
VERTICALITY AND ALIGNMENT:
Check structure verticality with the appropriate devices (such as theodolite).
Measurements should be made in two different planes with a 90° angle difference.
ANTENNAS AND ACCESSORIES:
Check that antennas and antenna supports are in good condition.
Check that coaxial cables are in good condition.
Check that fixing clamps are in good condition.
SAFETY COMPONENTS:
Check that access ladder is in good condition.
Check that all safety components are existing and complete.
Check the functioning of the fall arrestor system.
For a fall arrestor system with cable, check that the cable has not been overtightened (for instance, due to a fall).
Check the functioning of the anti-climbing door.
LIGHTNING AND EARTHING SYSTEM:
Check that all lightning and earthing components are existing and complete, including lightning arrestor, copper strip, and connection plate.
Check the earthing connection of coaxial cables.
Measure the resistivity of the earthing system.
NIGHT BEACONING:
Check that all beaconing components are existing.
Check condition and functioning of beaconing components (light bulb, energy cables, fixing parts, photoelectric cell, connections).
Check earthing of the night beaconing.
ANTI-CORROSION PROTECTION:
Check galvanization condition.
Check paint condition.
Check oxidization of the structure, bolting parts, and accessories.
For masts with guidewires, check oxidization of wires.
TOWERS IN SALTY ENVIRONMENTS:
Check the condition of the tower structure when located in a salty environment.
If rains are not sufficient to clean the tower of salt settlings, a regular wash of the tower structure shall be carried out.

Table 3. Checklist for inspection visits to telecommunications towers with guidewires, as reported by CGTI Pylones.[6]

CONCRETE BLOCKS:
Check the condition of aboveground concrete block parts. There must not be any stagnant water.
Check the condition of anchor setting in the concrete block.
TOWER LOADING:
Report types, numbers, and heights of antennas currently installed on the tower.
Compare the result with the initial loading that has been considered in the structure design.

Case Study 2. Example of a New $3,000,000 Digital Television Facility

In February 1999, the Leblanc group announced the new construction of a digital television facility, which will be constructed on top of Farnsworth Peak in Lafayette, Colorado.[7] The total value of this new construction was $3,000,000, which was to be spent on the different components by the respective subcontractors. The contract included the tower, foundations, antennas, transmission lines, combiners, switching systems, and emergency power systems.

The contracting group was a consortium of eight stations, consisting of five commercial and three public broadcasters. The new 73-m (240-ft) tower, topped by a 22-m (72-ft) antenna system, provides a center of radiation approximately 1,500 m (5,000 ft) above Salt Lake City, Utah. In addition to the 8 digital television station antennas, 16 microwave dishes would be installed on the tower.

The tower selected in this case was a rugged, heavy self-supporting type. It was designed to withstand forces created by 250 km per hour (155 mi per hour) winds simultaneously with 7.6 cm (3 in) of radial ice. The base foundation was designed to withstand strong uplift forces. The legs at the tower base are fabricated from 25-cm- (10-in-) diameter solid round high-strength steel, and the face width at the top is 3.0 m (10 ft).

The main antenna was mounted inside a 1.5-m- (5-ft-) diameter glass-reinforced plastic (GRP) cylinder 22 m (72 ft) tall. The GRP cylinder has the advantage of significantly reducing the wind, while at the same time providing for easy access and maintenance regardless of the severe weather conditions incurred at the site.

In the design phase of this tower and antenna, no specific corrosion cost analysis was reported. However, it is obvious that the presence of the glass-reinforced cylinder is a choice of materials to protect the antenna from moisture and therefore corrosion. In this case, the cost of this corrosion protection could be estimated from the cost of the fiberglass construction, which is possibly 10 percent ($300,000) of the total construction costs.

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