



# Maintenance Spells Extended Life for Chimneys and Stacks

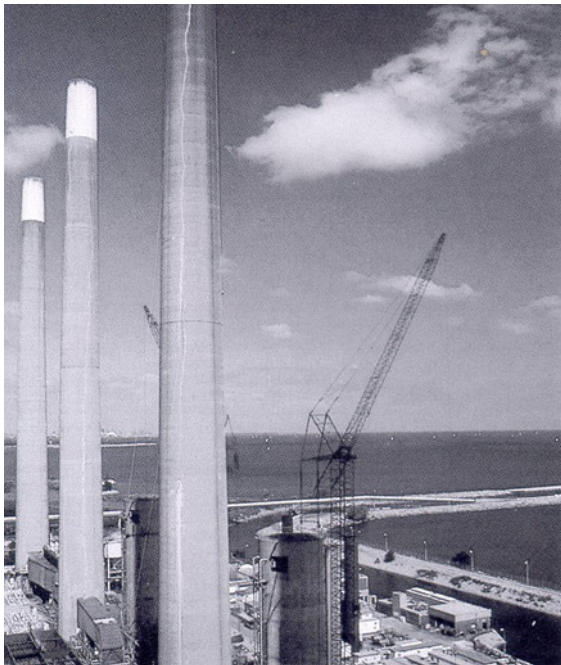
*These passive structures are often overlooked in maintenance schedules. When long-term neglect persists, expensive repairs and disruption of plant operations can result.*

By ARUN K BHOWMIK, Hamon Custodis

Chimneys are often overlooked when plant maintenance and repair programs are developed. Chimneys are basically passive structures with few mechanical parts that require maintenance attention to keep them functional. Because of this, it is easy to overlook them - but doing so can be costly.

Chimneys and stacks have only one function: dispersing flue gas into the atmosphere. In the process of fulfilling that function, they are exposed to harsh environments, both inside and outside. Flue gas, with its abrasive and corrosive characteristics, can damage the structural materials of the chimney or liner. Climatic conditions, ranging from high winds to extreme cold, place extreme stress on the structure itself.

Despite their common function, chimneys are not all the same. Each chimney is distinct, designed to operate effectively within specific constraints. A chimney in Arizona's dry climate will have different maintenance needs than a stack operating in Florida's humid environment, even though the industrial plants have similar operating conditions. Although these different conditions may not change the type of maintenance required, they can be expected to influence frequency of inspection and maintenance procedures needed if the chimney is to provide service for the typical 30-50 year life of a plant.



*Fig. 1. Concrete chimneys are constructed with various liner types. Common liners include independent or corbel-supported brick liners and base-supported steel liners. Inspection and maintenance varies with type.*

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## Chimneys and Liners

The most common types of chimneys are concrete, with independent brick liners; concrete, with corbel-supported brick liners; concrete, with independent base-supported steel liners; and radial brick (Fig. 1). Virtually all chimneys are vulnerable to chemical attack or corrosion resulting from condensation of the flue gases during cool down or service-related wear and tear.

Chimney shells, particularly the upper part of the outside, and chimney hoods are vulnerable to corrosion (from precipitation of flue gas or from acid rain) and disintegration (from variations of environmental temperature and humidity).

## Inspection

Regular inspection is the first step in an effective maintenance program. The components and frequency of inspections vary according to type of chimney, its materials of construction, the plant's operating conditions, and the location of the plant. For liners which are exposed to hot, dry flue gas, inspections should be conducted at least every three to five years after an initial inspection following the first year of operation. For chimneys exposed to wet-scrubbed flue gas, the liner and its appurtenances should receive annual inspections, at least during the first few years of operation. Both exterior and interior surfaces should be inspected and repaired when necessary (Fig. 2). The [accompanying table](#) lists basic areas of inspection.

## Nonroutine Maintenance and Repairs

Inside liners should be cleaned to minimize the buildup of deposits. When combined with moisture, deposits form harmful chemicals that deteriorate liner materials. In addition, deposits often become flaky, and when carried into the atmosphere by flue gas, they create both safety and regulatory problems.

Many problems are material specific. Chimneys with brick liners exhibit problems resulting from the impact of moisture and acidic flue gas on construction materials. These problems can manifest themselves over the entire height of a liner.

Debris allowed to collect at the chimney's base can mix with moisture and flue gas acid. Regular cleaning of the chimney floor prevents condensate collection and decreases its corrosive effect. If the liner near the floor is deteriorated, it should be replaced. If the floor is damaged, it must be repaired and a new, lead-pan floor installed over it.

Cracks in the brick liner allow flue gas to infiltrate the air space between the chimney and liner. If this flue gas is cold and contains acid particles, condensation is likely to occur, with subsequent corrosion of the lining band and other metal components including platforms and ladders.

Band corrosion weakens splice bolts and reduces the effective cross-section of the lining band. Sudden increases in temperature can trigger band expansion, causing weakened bands to fail in tension or the splice bolts to fail in shear.

***“Regular inspection is the first step in an effective chimney and stack maintenance program”***

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*Fig. 2. Exterior repairs normally do not require interruptions in plant process and, despite the heights involved, are simpler to perform than interior repairs. Here, maintenance personnel pressure inject epoxy into a structural crack.*

Routine repair of cracks in liner brick-work is required to minimize infiltration of flue gas. If penetrating flue gas has weakened the liner bands, they must be replaced. Stainless steel bands are recommended for harsh environments. Liner bolt shear strength also should be checked. Corroded and weakened bolts should be replaced.

Mortar deteriorates with age and exposure. Loose mortar should be removed and tuck-pointed. Repairs can be finished by applying a flash coat of acid-resistant gunite material. Because flash coatings require regular inspection and periodic repair, installation of gunite with suitably anchored wire mesh is the preferred finish method. Selection of repair material should be based on its ability to withstand specific flue gases.

Extremely cold weather can cause ice to form on the chimney's rain hood. Ice buildup damages rain hoods and allows chunks of ice to fall from it. Replacing the hood with one designed to prevent ice falling on the outside of the chimney may resolve the problem. Formation of ice in the annulus can also be minimized by providing hot air circulation where ice formation is anticipated.

### Advanced Repairs

Some independent brick liners have shown a tendency toward leaning (shifting of the liner from a concentric position with the outer shell). Leans as great as 30 in. have been reported. If the liner and shell are too close, impact between liner bricks and concrete shell can take place during deflection caused by wind or seismic events. Dislodged bricks may be the result. Falling bricks pose a danger to platforms and chimney components as well as to personnel.

The potential for leaning has been traced to unsymmetrical temperature, moisture, and acid conditions in the mixing zone that are caused by dividing scrubbed and bypass gases. Subsequent increases in moisture and salt growth in brick and mortar contribute to liner lean.

***“Repairing chimney lean should be attempted only by qualified personnel”***

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To prevent leaning, it is recommended that over/under breaching arrangements (commonly used in chimneys that handle both scrubbed and unscrubbed gases) be eliminated. Ducting should be arranged to establish a single chimney entrance for mixed gases. Baffle walls should be eliminated, because they tend to prevent mixing of gas streams and aggravate temperature differentials across the liner.

When nonuniform operating conditions exist, or where an abnormal thermal shock or chemical explosion can be anticipated, a sacrificial target wall to absorb these impacts should be constructed. The target wall may be base or corbel supported and should be flashed at the top to prevent condensate from entering the air space between the wall and liner.

To repair an existing lean, a segment of liner at the top of the chimney should be removed and rebuilt to recenter it. The degree of lean determines the amount of removal and replacement. An alternate method of repairing a lean is to force the liner back to its original position and secure it to prevent it from shifting again. Both techniques are major repairs and should be attempted only by qualified personnel.

Corbel-supported brick liners are vulnerable to severe structural problems when confronted by high flue gas velocities that create positive pressure inside the liner, cyclic chimney operation that promotes acid condensation, and highly acidic condensate resulting from the use of high sulfur-content fuel.

Corbel-supported liner deterioration is caused by penetration of flue gas into the air space through cracks in the brickwork. Penetrating gas saturates the insulation in the air space, eventually deteriorating the corbel joints and the brick lining. Gas also corrodes the reinforcing steel and interior face of the concrete shell, creating leaks through the joints of the shell. Problems of this type often go undetected until damage is significant.

Simple maintenance procedures cannot eliminate these problems. Liner replacement is usually required under these conditions. Independent base-supported brick, fiber glass reinforced plastic, or insulated steel liners are the best suited to these conditions. Although liner replacement is expensive and time consuming, it can be performed without a major shutdown of the chimney by using a temporary bypass stack.

In cases where plant operations can be modified to eliminate hostile flue gas conditions, repairs can be made to corbel-supported brick liners. After obtaining access to the air space through a partial removal of the liner, workers must clean the interior of the column, reinforce weakened rebar, apply mortar to protect interior concrete, clean and repair the corbel, and rebuild the liner.

Application of an ordinary gunite lining to the inside surface of the concrete may not be an acceptable repair alternative. Noninsulating gunite allows a large thermal gradient through the concrete shell which can cause vertical stress relief cracks to form in the outer shell. Crack patching, grouting, and installation of exterior tension bands can be used to repair these cracks, but these repairs are expensive, time consuming, and less dependable than the recommended method.

## Steel Stacks

Like brick or concrete chimneys, steel stacks are vulnerable to a number of common problems, including atmospheric corrosion and weathering on outside surfaces, corrosion due to acid condensation on interior surfaces, and fly ash or particulate collection at the base, false bottom, or roof cap. Steel stacks are also affected by acid infiltration of the insulation, corrosion of anchor bolts, deformation due to thermal stress and wind or seismic loads, and fatigue cracking.

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## Inspection of Stacks

Factors that influence frequency of inspection include: climate, construction materials, type of construction, and the nature of use. Generally, stacks should be inspected annually for the first three years of operation. Results of the initial inspections should determine the frequency of future inspections. Steel stacks are particularly vulnerable to corrosion caused by sulfur and chlorine compounds present in flue gas. These compounds combine with moisture and other flue gas constituents to form a highly aggressive, corrosive environment.

Steel under stress exhibits increased vulnerability to corrosion. This heightened vulnerability is particularly notable in steel stacks. Corrosion sharply decreases the number of cycles to failure in fatigue loading. Detection of corrosion in a steel stack may indicate serious degradation of structural strength. Immediate evaluation of shell stress is usually indicated at this point. Various nondestructive methods, such as ultrasonic testing, may be used.

## Routine Maintenance

Like chimneys, steel stacks can also experience serious deterioration from collection of condensate on the stack floor. Routine cleaning of the floor is critical to prevent this. Severe corrosion of shell plate and anchor bolt material requires their replacement.

Stacks can be protected from corrosion by applying a suitable elevated-temperature, acid-resistant lining to protect the steel surface. Application of properly selected insulation with metal cladding to the outside of the stack is also effective for stacks with specific operating conditions.

In dual-wall stacks, corrosion of the inner liner is not usually a problem. However, damp conditions between the outer and inner shells can promote corrosion in this area. Protected vents can be installed at the bottom of the outer stack to allow air circulation in this annular space.

## Combating Stack Vibration

Steel stacks, particularly those without linings, can vibrate perpendicular to wind direction. Known as resonant vibration, this condition is caused by vortex shedding wind forces. Depending on mass, critical frequency, and damping characteristics of the stack, wind velocity at which resonance occurs can be less than 30 mph. At resonant conditions, stacks are subject to total reversal of stresses under steady wind, leading to early failure of welds and loosening of anchor bolts.

***“Stacks should be inspected annually for the first three years of operation”***

Several methods have been developed to respond to dynamic wind vibration. Aerodynamic methods (use of helical strakes to break up the vortices) and damping methods (use of mass dampers, foundation-preformed fabric pads, or hanging chains) can be used. Particular care should be exercised when applying any of these techniques. Drag factors in the area of the helical strakes increases almost twofold, resulting in a subsequent increase in both shear stress and moments. Improperly designed damping methods can accelerate fatigue and promote cracking of the steel shell and welds. Consultation with a structural expert familiar with stack dynamics is recommended if resonant vibration is a problem.

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<b>Recommended Inspection Procedures For Chimneys and Stacks</b>	
<b>Masonry Chimneys and Liners</b>	<b>Concrete Chimneys</b>
<p><b>Inspect for:</b></p> <ul style="list-style-type: none"> <li>- Existence of cracks</li> <li>- Uniform wall thickness</li> <li>- Spalling of brickface</li> <li>- Existence of loose bricks</li> <li>- Evidence of localized bulging</li> <li>- Existence of pressurized air space in caps, seals, fans, and gauges</li> <li>- Outer shell clearance, especially near top of chimney</li> <li>- Softening of mortar</li> <li>- Softening of brick</li> <li>- Condition of liner bands</li> <li>- Corrosion of lintel beams</li> </ul>	<p><b>Inspect for:</b></p> <ul style="list-style-type: none"> <li>- Spalling</li> <li>- Imperfections in concrete</li> <li>- Surface softness</li> <li>- Evidence of sulfur attack</li> <li>- Reinforcement corrosion</li> <li>- Adequate concrete cover</li> <li>- Crack formation</li> <li>- Existence of carbonation</li> <li>- Evidence of chloride attack</li> </ul>
<b>Steel Stacks</b>	
<p><b>Inspect stack exterior for:</b></p> <ul style="list-style-type: none"> <li>- Uniform shell thickness – ultrasonic devices for non-destructive thickness testing, or core samples and drill tests for destructive testing</li> <li>- Condition of finish</li> <li>- Condition of access system – ladders, ladder anchors, cages, safety climb devices, platforms, painter’s trolleys, and trolley rails</li> <li>- Condition of lightning protection systems</li> <li>- Condition of support systems – braces, guy wire anchors, guy cables, and guy fittings</li> <li>- Condition of anchor bolts</li> <li>- Condition of electrical system</li> </ul> <p><b>Inspect stack exterior for:</b></p> <ul style="list-style-type: none"> <li>- Uniform shell thickness</li> <li>- Condition of lining</li> <li>- Condition of insulation</li> <li>- Evidence of particulate accumulation</li> <li>- Condition of general items – stack gap and seals, expansion joints</li> </ul>	

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