FORREST
Technical Coatings

High-Temperature Corrosion:
When Heat Changes the Rules





Corrosion is often associated with moisture, humidity, and wet environments. At elevated temperatures, however, corrosion behavior changes significantly. In these conditions, corrosion can occur even in the absence of liquid water, driven instead by direct chemical reactions between metals and gases in the surrounding atmosphere.

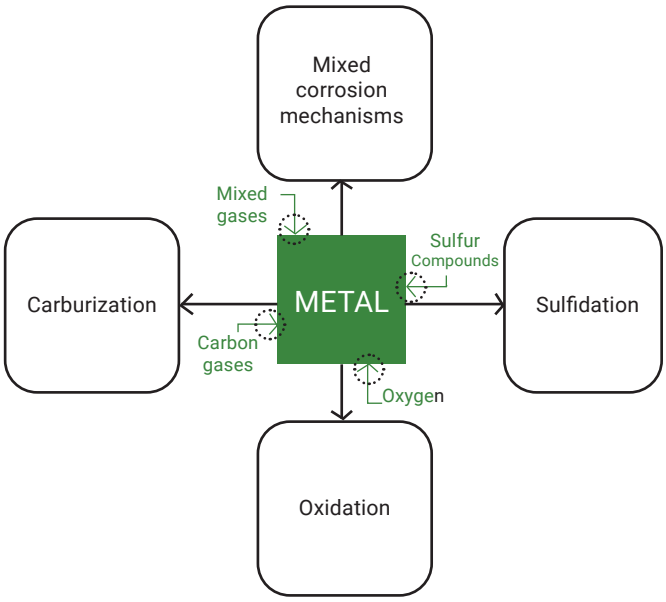
This form of attack is commonly referred to as high-temperature corrosion.

How High-Temperature Corrosion Is Different

Unlike atmospheric corrosion, high-temperature corrosion does not require a liquid electrolyte. Instead, metals react directly with gaseous species such as oxygen, sulfur-containing compounds, or carbon-bearing gases.

These reactions can result in:

- Oxidation
- Sulfidation
- Carburization
- Mixed corrosion mechanisms



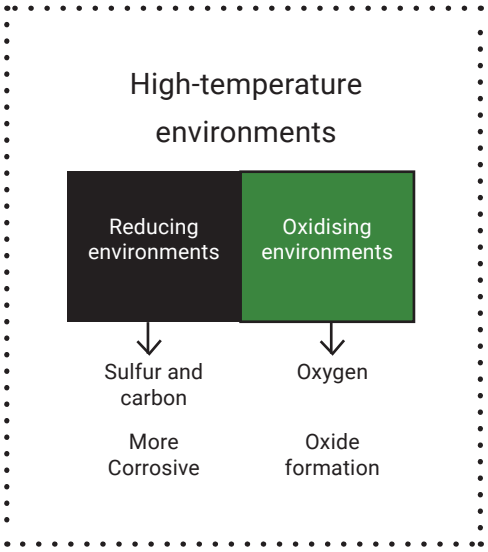
Because moisture is not required, corrosion can continue at temperatures where conventional electrochemical corrosion would otherwise slow or stop.

No Moisture Required
High-temperature corrosion can occur in dry environments through direct metal gas reactions.

Oxidizing and Reducing Environments

High-temperature environments are often described as either oxidizing or reducing, based on oxygen availability.

- **Oxidizing environments** contain excess oxygen, promoting the formation of oxide scales on metal surfaces.
- **Reducing environments** lack available oxygen and may contain sulfur or carbon compounds that attack metals more aggressively.



Reducing environments are generally more corrosive because protective oxide layers are less likely to form or remain stable.

Oxygen Can Be Protective
At high temperatures, controlled oxidation can form protective scales that slow further corrosion.



The Role of Protective Oxide Scales

Many heat-resistant alloys rely on the formation of thin, stable oxide layers to protect the underlying metal. When these oxide scales remain intact, they act as barriers that slow further chemical attack.

However, oxide scales can fail due to:

- Thermal cycling
- Mechanical stress
- Chemical instability in certain atmospheres
- Differences in expansion between metal and scale

Once a protective scale breaks down, corrosion accelerates rapidly.





Temperature Thresholds and Corrosion Severity

While definitions vary, high-temperature corrosion is typically associated with service temperatures above approximately 650 degrees Celsius. At these temperatures, corrosion rates increase dramatically and material selection becomes critical.

In many applications, corrosion damage occurs not only during steady operation, but also during:

- Startup
- Shutdown
- Cooldown

During these transitions, temperature changes and exposure conditions can destabilize protective layers and accelerate attack.

Thermal Cycling Matters
Repeated heating and cooling can be more damaging than steady high-temperature operation.

Industries Affected by High-Temperature Corrosion

High-temperature corrosion is a widespread challenge across many industries, including:

- Power generation
- Refining and petrochemical processing
- Thermal processing and heat treatment
- Combustion-adjacent equipment
- Waste and biomass processing



In these environments, conventional coatings and materials often fail prematurely if not specifically designed for elevated temperature exposure.



Implications for Corrosion Control at High Temperatures

Because high-temperature corrosion mechanisms differ from atmospheric corrosion, protection strategies must also change. Effective control depends on:

- Understanding the service atmosphere
- Accounting for temperature and cycling
- Selecting materials and coatings compatible with high heat
- Ensuring adhesion and stability at operating temperatures

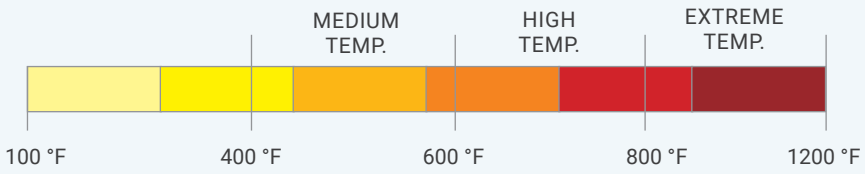
Coatings designed for ambient conditions rarely perform well when exposed to sustained high temperatures or reactive gases.

Heat Changes the Strategy
Corrosion control methods effective at ambient temperatures may fail when exposed to high heat.

Why Understanding High-Temperature Corrosion Matters

High-temperature corrosion often progresses out of sight and can lead to rapid material loss once protective mechanisms fail. Because damage may not be immediately visible, failures are frequently unexpected and costly.

Understanding how heat alters corrosion behavior allows for more informed material and coating decisions, improved service life, and reduced operational risk.





Key Takeaway

High-temperature corrosion follows different rules than moisture-driven corrosion. When heat and reactive gases dominate, corrosion can proceed rapidly without visible warning. Effective protection requires a clear understanding of service temperature, atmosphere, and material behavior under heat.

About Forrest Technical Coatings

For more than 50 years, Forrest Technical Coatings has manufactured specialty coating systems designed to perform in demanding service environments. Based in the United States with a global customer footprint, Forrest works closely with equipment manufacturers, engineers, and operators to address corrosion, heat, and environmental exposure challenges across a wide range of industries.

Forrest's portfolio includes industrial and high-temperature coating systems for applications such as biomass processing, exhaust and thermal equipment, power generation, and other corrosion-prone environments. Products such as the INFERNEX® high-temperature coating systems are engineered to withstand elevated temperatures, aggressive atmospheres, and real-world operating conditions.

As a manufacturer, Forrest focuses on understanding how the environment, substrate, and service conditions interact, and on formulating coatings that align with those realities.

FORREST
Technical Coatings

Forrestpaint.com | info@forrestpaint.com