



**SAFE, RELIABLE AND COST EFFECTIVE SOLUTIONS FOR
EXTREME ENVIRONMENTS AND PROCESSES**



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Introduction

Now, more than ever, engineering firms are being asked to design equipment that can handle extreme process conditions and extreme environments. As this trend continues, the need for equipment that can endure and perform under extreme conditions will increase. This is especially true in the oil and gas, power generation and downstream/heavy industrial markets for a multitude of reasons, including:

- Oil and Gas market:
 - Arctic drilling
 - Deepwater discovery
 - Enhanced oil recovery (EOR) investments for further oil and gas production
- Power Generation market:
 - Advancements in higher pressure and temperature thermodynamic cycles for increased power efficiency
 - Technology development for further emissions control
 - New renewable technologies, such as molten salt Concentrated Solar Power (CSP) and advanced photovoltaic (PV) cell designs
- Downstream and Heavy Industrial markets:
 - Continued geographic expansion into emerging growth markets and countries with tropical, marine, desert, mountainous and arctic environmental conditions

Within all of these markets, extreme environments and processes bring a variety of challenges. Examples specific to extreme environments include:

- High and low temperatures ranging from -55°C to $+55^{\circ}\text{C}$
- Corrosive chemicals commonly used in industrial settings, including sodium and potassium compounds, and chlorides
- Explosive chemicals such as acetylene, hydrogen, ethylene, propane, methane, combustible dusts
- Salt air
- High humidity

And those specific to extreme processes include:

- Severe temperatures – ranging from cryogenic (-150°C and below) to 800°C
- Operational pressures on the order of 100 bar, 350 bar and above
- Corrosive liquids and gases
- High flow rates

Given the increased demand put on equipment by these environments and processes, reliability, sustainability and safety are incredibly important. Yet, equipment selection has become more challenging because many available solutions have not been specifically designed or fully tested for extreme environmental and process conditions. As such, the following challenges exist when working with extreme processes or in extreme conditions:

- Life expectancies of new technologies can be estimated, but have not been proven yet
- Equipment failure can be incredibly costly, especially when it relates to a critical process

- Equipment safety is paramount, especially in situations where operators are working in close proximity

Equipment maintenance in extreme conditions and processes is exceptionally costly; and corrosion and improperly designed equipment are usually the most costly aspects of maintenance. Corrosion, specifically, is often the root cause of failures and unplanned maintenance in extreme processes and environmental conditions. The cost of corrosion accounts for 60% of all maintenance costs, with price tags in the billions for the following industries:

- Oil and gas exploration and production, \$1.4 billion
- Petroleum refining, \$3.7 billion
- Chemical and petrochemical, \$1.7 billion (specifically \$0.40/barrel of oil)

Improperly designed equipment also equates to costly downtime. Equipment used in extreme process and environmental conditions must be specifically designed to address the elements of the application. If it is not, improper selection of materials, misunderstood flow conditions, and the lack of proper control and monitoring can all contribute to premature equipment failure from issues caused by material failure and overheating, which leads to expensive unexpected downtime.

With proper process design, controls and monitoring, conditional based maintenance can be performed early – when the potential for failure is identified as opposed to when actual failure occurs. On average, conditional based maintenance can save up to 15% per year in maintenance costs. For example, a 225,000-barrel per day petroleum refinery can save up to \$8 million per year when conditional based maintenance is performed before a failure occurs.

Selecting a practical heating technology partner for extreme industrial applications

Thermal engineering, and more specifically, the heating of materials and processes, is a critical part of most industrial facilities. Whether directly involved in the process or provided as ancillary equipment, heating systems are often relied upon to keep critical processes running, thereby minimizing downtime.

When engineering these systems, there are a multitude of variables to consider. When these systems are pushed to their limits (i.e., those dealing with extreme environments or processes), it becomes absolutely vital that every variable is understood and well maintained.

While there is typically more than one possible solution for each application, often there is only one optimal solution in which the benefits and performance exceed all other solutions.

Companies must prioritize benefits related to installation cost or equipment footprint, without yielding to shortcomings that might affect long-term performance.

There are several thermal technology providers and it can be difficult to find the right partner, especially given that each may offer a different solution with a particular set of benefits depending on your (or their) objectives. But when selecting the proper equipment for extreme applications, there are several specific factors that should be considered and questions that should be asked.

Specific factors and questions include:

- *Reliability:*

- Does this equipment manufacturer have a proven record of successfully providing equipment into extreme applications?
- Do they have an experience list that includes similar applications?
- Do they go above and beyond the minimum requirements (i.e., do they provide long-term testing)?
- *Materials of construction:*
 - Do they understand the complexity of material science when it comes to material compatible with the environment or process medium?
- *Quality:*
 - Do they have processes in place to ensure that the equipment will be defect free when it arrives on-site?
- *Conformance to Industry Standards:*
 - Has the equipment been tested and approved by a third party agency?
- *Service Offering:*
 - If my equipment needs maintenance or repair work, will someone help troubleshoot or conduct an on-site audit or maintenance?
- *Control System:*
 - Does the equipment have the proper controls in place to prevent failure due to conditions like overheating and low flow rates?
 - Do the controls have monitoring that allows for condition based maintenance (i.e. can I tell if the equipment is operating within acceptable limits)?
- *Design:*
 - Does the design address all of my concerns for corrosion, temperature, pressure, and hazardous conditions?

Solution: a platform specifically designed for extreme environmental and process conditions

Chromalox has the answers when your company is asking these questions. The Chromalox XtremeDuty™ Platform is the industry's first product platform specifically designed for extreme environmental and process conditions.

Leveraging nearly 100 years of applications experience in areas like aerospace, oil and gas, and petrochemical, Chromalox has developed a product platform that utilizes engineering, material and control technologies that specifically address pain points such as risk, downtime, maintenance, operating costs and safety, which are common in extreme environmental and process applications.

Chromalox incorporates the latest thermal spray and fluoropolymer coatings to prevent and delay effects of corrosion and uses thermal modeling and body of knowledge to select optimal designs in high-temperature and high-pressure applications.

Chromalox uses a vast array of application knowledge allowing for the selection of specific materials that will produce an optimal solution from both an application and cost standpoint; and beyond that, having in-house test labs featured equipment allows for long-term reliability testing.

In addition, Chromalox has relationships with several third party certification agencies, including Intertek, Underwriters Laboratory and Factory Mutual, allowing Chromalox to obtain product certifications to both North American and International standards, such as CE, IEC, ATEX, UL, CSA, FM, DNV and EAC.

The XtremeDuty™ Platform provides a multitude of solutions to extreme conditions and process heating needs, including:

- **XtremeDuty unit heaters** installed on the exposed deck of an offshore drilling platform in the Oil and Gas Exploration market
- **Heat trace cables and connection kits** that help maintain the flow of hydrocarbons in a pipeline and are certified for Class I, Division 2 and Zone 2 locations
- **Insertion style cartridge heaters** used to maintain a fluidized bed reactor at temperatures up to 1500°F (815°C)
- **Cast circulation heaters** used for seal gas drying that are designed for pressures up to 7,500psi (500 bar)
- **Control panels** that can maintain precise temperatures in petrochemical refining and are designed for Class I, Division 2 and Zone 2 locations

Real life application: Arctic Liquid Natural Gas (LNG) Facility

A company engineering equipment for an arctic LNG facility faced several challenges. First, in order to maintain efficient operations in arctic temperatures, heat was required for nearly the entire facility and - in some instances - the heating systems needed to be started at temperatures as low as -52°C. In addition to the cold temperatures, the facility was located close to the sea, which posed the potential for salt air corrosion. The remote location of the facility meant that any unplanned equipment maintenance would be costly and, in some instances, impossible, which meant equipment needed to be incredibly reliable. Some of the equipment would also be located in hazardous locations, resulting in the potential for explosive gases and dusts in the air, thereby requiring the equipment to meet stringent third party standards.

Leveraging the XtremeDuty product platform, Chromalox provided solutions to multiple applications, including:

- Pre-heating a gas compressor compartment using an explosion proof fan **forced air heater** certified to -55°C
- Drying out sea air in a gas compressor with a **cast block circulation heater** capable of heating air at pressures in excess of 100 bar
- Preventing ice build-up in piping using **heat trace cable** certified to zone 2 hazardous locations

In the end, the Chromalox XtremeDuty Platform was able to address several of the challenges that can cost the customer time and money by helping to extend time between planned maintenance, minimizing unplanned maintenance, and protecting critical equipment from unexpected failure.

Conclusion

When it comes to extreme environments and processes, new technologies and innovations in thermal engineering, material technologies and testing have made it possible to design more reliable, safe and cost effective heating systems.

Given the risk and costs involved, it is vital that you partner with an equipment provider who has the knowledge and experience required to design and build equipment going into extreme conditions.

By designing features that address specific environmental and process conditions, the Chromalox XtremeDuty™ Platform provides a safe, reliable and cost effective solution for your extreme environment and process needs.

About Chromalox:

Chromalox is a thermal technology company. We engineer thermal solutions for the world's toughest industrial heating applications. Our Heat Trace segment delivers temperature management solutions for piping systems, valves, and tanks. Our Industrial Heaters and Systems segment delivers process heating solutions for revenue-generating industrial processes, and our Component Technologies segment delivers component heating solutions for industrial equipment manufacturers. Chromalox was founded in 1917 and is headquartered in Pittsburgh, PA.

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