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Highly Efficient, Medium-Voltage Process Heating Solutions

Sponsored by: Chromalox

Permitting and pollution costs associated with fossil-fired fuels have driven large-scale oil and gas operations, petrochemical plants and power generation facilities to explore alternative process heating solutions as they scale operations to address increased energy demands. Traditional low-voltage electric process heating solutions are highly efficient, provide precise temperature control and carry a low carbon footprint. However, implementing high heat duty low-voltage systems carries significant overhead. Chromalox introduced DirectConnect™ technology to address installation and life cycle costs of multi-megawatt electric heating systems.

Figure 1: On-site medium voltage power distribution.

Electric process heating provides on-site pollution-free operation, which eliminates the need for costly pollution control devices and heat recovery systems.

What is DirectConnect™ Technology?

Chromalox's DirectConnect medium-voltage control panels and electric heating systems are a revolutionary technology that capitalizes on the advantages of electric process heating while addressing the pitfalls of low-voltage, high-amperage designs.

Electric process heating provides on-site pollution-free operation, which eliminates the need for costly pollution control devices and heat recovery systems. Electric process heating allows for direct heating of process fluids and elimination of waste heat, and provides precise temperature control delivering heat on demand. The unprecedented repeatability and set-point accuracy of electric heat allows operators to realize efficiency gains and eliminate excess overruns traditionally supplied by a fuel-fired system. Electric

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systems also enable near-perfect heating efficiency across the entire operational range and large turndown ratios, which are significantly higher than possible with fuel-fired equipment.

Traditionally, the trade-off for implementing operationally efficient low-voltage electric heating systems is the significant increase in installation and operating costs, which reduces the return on investment as the power requirements reach a megawatt or more. Chromalox's DirectConnect process heating solutions are designed to minimize those operating expenses and installation costs. They deliver unprecedented efficiencies while reducing installation costs, maintenance costs and power losses — an ideal solution for applications greater than ~1 MW (~3-4 MMBtu/hr).

Lowers Installation Costs

Installation costs for process heating systems are a function of the number of circuits, the wire gauge and the associated infrastructure needed to support the cabling. Medium-voltage systems utilize higher voltages, eliminating the need for costly step-down transformers. In addition, they provide the same power density but with fewer circuits, greatly reducing the number of wires and connections made, which in turn drastically reduces labor and installation costs.

Reduces Maintenance and Life Cycle Costs

The maintenance and life cycle costs of a process heating system include the costs of inspections, heater element replacements and the downtime while these operations are carried out. DirectConnect technology reduces the number of circuits in operation by a factor of 10. There are fewer contactors and solid state switching devices. Chromalox's medium-voltage process heaters also allow for the ability to replace individual heating elements or sub-circuits.

Facility managers are now presented with an economical solution for inspection, installation and maintenance operations. They benefit from reduced downtime and operate at a fraction of the cost of maintenance of a low-voltage, high-amperage design.

Increases Efficiency

An electric heater's efficiency is typically specified by power losses that are a function of the electrical current. Medium-voltage systems deliver the same power density over a lower amperage circuit. This effectively minimizes heat generation, wire losses over transmission lines, heater bussing losses and panel losses, achieving operational efficiencies as high as 99.2 percent.

Case Study: 5.0 MW Electric Process Heating System

The growth of global markets has increased the complexity of modern refineries, gas processing facilities and power generation facilities. To curb increased energy demands, operators have invested in low-voltage process heating solutions. However, as electric process heaters scale to address increased load requirements, complex multi-megawatt electric heating systems were formed and life cycle costs have become a greater issue.

Chromalox's DirectConnect process heating solutions have a lower total cost of ownership when compared to a low-voltage, multi-megawatt electric heating system. A prime example of realized savings is illustrated by a review of an engineering, procurement and construction (EPC) project for a 5.0 MW electric fuel gas process heating system installed at a gas-fired combined cycle power plant.

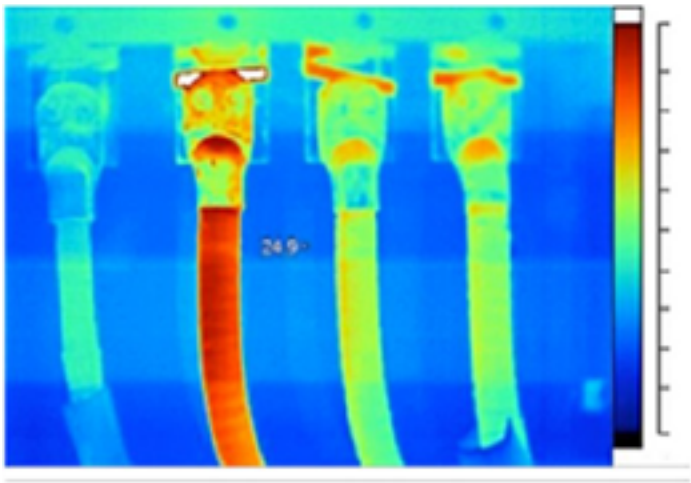

Figure 2: Energy losses affecting efficiency are a function of amperage (the I in the I2R). Source: Chromalox

Traditional low-voltage, three-phase systems in North American markets are powered by a 480 V line voltage, while the standard for medium voltage equipment is 4,160 V. Implementation of a 5 MW medium-voltage system eliminates the need for costly step-down transformers, requires fewer conduit runs and reduces labor costs.

Project Cost Breakdown — 5,000 kW (17 MMBtu/Hr)

480 V CONSTRUCTION — 70 Circuits	
Product	
Process Heater	$465,900
Power Control Panel	$483,000
Start Up Service	$21,400
Product Sub-total	$970,300
Installation	
Transformer	$237,900
250 ft Run to Panel	$346,500
450 ft Run to Heater	$623,700
1,230 Labor Hours	$116,900
Install Sub-total	$1,325,000
$2,295,300	

4,160 V CONSTRUCTION — 6 Circuits	
Product	
Process Heater	$623,500
Power Control Panel	$572,200
Start Up Service	$8,500
Product Sub-total	$1,204,200
Installation	
Transformer	-
250 ft Run to Panel	$31,500
450 ft Run to Heater	$56,700
110 Labor Hours	$10,500
Install Sub-total	$98,700
$1,302,900	

Figure 3: Project cost breakdown for a 5 MW heater installation. Source: Chromalox

Installation savings alone offset equipment costs. The project immediately realized $992,400 in savings by utilizing medium-voltage services, while the full impact was modeled for cost of ownership with annual returns as well as a 20-year life cycle.

COST OF OWNERSHIP	480 V	4,160 V	SAVINGS
Installation	$2,295,100	$1,302,700	$992,400
Operating	$4,842,600	$531,600	$4,311,000
Maintenaince	$199,500	$34,200	$165,300
10 yr Life Cycle Repacements	$370,500	$44,400	$326,100
20 Year Costs	$7,707,700	$1,912,900	$5,794,800
Annualized Costs	$385,385	$95,645	$289,740

Figure 4: Chromalox medium voltage electric heating systems offer a lower total cost of ownership when compared to low-voltage high-amperage systems with savings compounded annually. Source: Chromalox

Second-generation Systems

Chromalox is now expanding the capabilities of their DirectConnect product portfolio to further support next-generation infrastructure. They have increased the voltage range and received third-party certifications and patents while addressing the requirements of international markets.

Increased Voltage Range

North American markets have modeled savings by switching from standard 480 V three-phase, high-amperage circuits to medium-voltage systems operating at 4,160 V. Chromalox's second-generation systems support capacities up to 7.2 kV with an increased voltage differential that yields even greater savings.

Third-party Certifications and Patents

Third-party certifications are a vital requirement before a system can be considered for implementation. Chromalox DirectConnect electric heaters and control panels have been tested and approved by independent, internationally recognized third-party laboratories. They have received ETL, IEC and UL certification for their heating elements and medium-voltage control technology with a maximum rating up to 7.2 kV. An ATEX/IECEex certification mark was also received for heating assemblies operating in hazardous locations.

Chromalox's advanced DirectConnect technology has been awarded patents in the U.S., China, Canada, Italy, Spain, Germany, France and the U.K. They have also obtained Patent Cooperation Treaty status globally, bringing the world within reach of Chromalox's medium-voltage control panels and electric heating systems.

International Markets

Chromalox's in-house solutions are designed to support industry standard voltages. The introduction of DirectConnect technology in North America was centered on 480 V and 4,160 V (low voltage and medium voltage). International markets operate at slightly different voltage ranges centered on 380 V and 6,600 V. Chromalox's second-generation systems operate at voltages up to 7.2 kV, and with the recently acquired IEC and CE certifications they have set the stage to enter international markets.

Environmentally Responsible and Sustainable Operations

Facilities are actively looking at ways to reduce their carbon footprint and become more environmentally responsible. At the same time, management must still consider the impact to their bottom line. The conversion away from carbon-emitting heating sources needs to be done in a cost-effective manner and the fact that Chromalox's DirectConnect technology enables zero-emissions and near-perfect efficiency for large point-of-use heating systems in a facility's process generates tremendous interest globally.

Advanced Process Development

The unique combination of technology, cost savings, efficiency and zero-emissions operation contained within the DirectConnect platform allows for newly conceived processes. For example, multi-megawatt heating systems play a vital role in unlocking, extracting and transporting oil and natural gas. From downhole heaters that warm viscous oil deposits to circulation heaters used in steam-assisted gravity drainage and carbon dioxide treatment, precision-engineered multi-megawatt heating systems are enabling enhanced oil recovery (EOR) processes that were previously not possible.

Modeling Savings

Chromalox has modeled the potential savings when switching from a low-voltage, high-amperage system operating at 380 V to a medium-voltage system that operates at 6,600 V. The greater voltage differential allows operators to achieve an even greater reduction in installation costs, maintenance costs and power losses when compared to a 480 V/4,160 V conversion.

Project Cost Breakdown — 5,230 kW (11 MMBtu/Hr)

380 V CONSTRUCTION — 63 Circuits	
Product	
Process Heater	$270,000
Power Control Panel	$302,000
Start Up Service	$19,000
Product Sub-total	$591,000
Installation	
Transformer	$165,000
250 ft Run to Panel	$328,600
450 ft Run to Heater	$547,700
1,230 Labor Hours	$120,700
Install Sub-total	$1,162,000
$1,753,000	

6,600 V CONSTRUCTION — 3 Circuits	
Product	
Process Heater	$427,000
Power Control Panel	$384,000
Start Up Service	$7,800
Product Sub-total	$818,800
Installation	
Transformer	-
250 ft Run to Panel	$30,800
450 ft Run to Heater	$51,300
110 Labor Hours	$6,700
Install Sub-total	$88,800
$907,600	

Figure 5: Project cost breakdown for a 3.23 MW electric process heating system. Source: Chromalox

The modeled savings for a 3.23 MW electric process heating system provides for immediate installation savings of $845,400, with a 20-year return on investment of 427 percent. Reduced operating costs were the largest factor contributing to a lower cost of ownership while maintenance and life cycle replacements also contributed to a considerable

reduction. Key takeaways from the modeled savings include:

- Elimination of costly step-down transformers (400 kVA NEMA 1: approximately $20,000; 1 MW NEMA 1: approximately $40,000)
- Reduced labor costs for installation (1,270 labor hours compared to 70 labor hours)
- Fewer conduit runs (50 compared to 9)
- A drastic reduction in the number of wired circuits (63 separate 380 V circuits compared to three 6,600 V circuits)
- Significant increases in operational efficiency (85.0 percent compared to 99.2 percent)
- A reduction in maintenance costs ($237,850 compared to $39,898)

The 3.23 MW electric process heating system requires only three circuits versus the 63 that are required for a three-phase 380 V system. Load requirements are accommodated by implementing medium-voltage circuits with comparable amperage. The additional cost per foot for a suggested increased wire gauge from 6 to 4 AWG was largely offset by drastic reductions in the number of circuits in operation, as well as a lower conductor resistance.

Power losses are substantially lower due to the lower impedance of the thicker gauge wires and a reduced number of circuits in operation. Efficiency of the system is effectively boosted to 99.2 percent for an associated annual savings of $192,511.

COST OF OWNERSHIP	380 V	6,600 V	SAVINGS
Installation	$1,753,000	$907,600	$845,400
Operating	$4,070,400	$220,100	$3,850,300
Maintenaince	$179,600	$17,100	$162,500
10 yr Life Cycle Repacements	$237,900	$39,900	$198,000
20 Year Costs	$6,24,800	$1,184,600	$5,056,200
Annualized Costs	$312,040	$59,230	$252,810

Figure 6: Chromalox has increased the voltage range and received third-party certifications and patents while addressing the requirements of international markets. Source: Chromalox

Inspection time for three versus 63 circuits decreases maintenance hours by nearly 90 percent while heater element and circuit replacement costs also saw drastic reductions, even when accounting for a higher replacement factor. The result is a substantial reduction in maintenance costs coupled with significantly less downtime when implementing a 380 V/6,600 V conversion.

Conclusion

Chromalox's patented DirectConnect medium-voltage systems allow industrial facilities to scale operations in a way that is both innovative and sustainable. Operators are able to capitalize on potential savings with Chromalox's multi-megawatt electric heating systems through installation, maintenance and operational cost reductions. Their industry-leading design has addressed the disadvantages of implementing a low-voltage, high-amperage heating solution with the proven success of their medium-voltage systems in petrochemical, power generation and large-scale oil and gas operations.

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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, USA.

Online at: **www.chromalox.com/en/technologies/directconnect**