Engineered
Thermal Maintenance Systems for Urea Applications

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Controls Southeast, Inc. (CSI)
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Controls Southeast, Inc. is...

An Engineered Thermal Maintenance company that...

*Designs and develops heating systems for Refinery and Chemical Processes:*
  - Delayed Coking, asphalt, Solvent deasphalting
  - Sulfur, heavy resid
  - Urea, Caprolactum, polymers

*Consider all process variables:*
  - Process material, velocity of flow, specific heat, pipe material, environment, insulation, convection coefficients,

*Uses Finite Element and Computational Fluid Dynamic models*

*With unique heating products to*

...Provide thermal process guarantees
Range of Heating Products

TT
Freeze Protection

HΔT
Standard Product

CT
Engineered System

JP
Very tight Thermal range

Increasing heat requirement and/or temperature uniformity

\[ q = U \times A \times \Delta T \]
ControTrace

\[ q = U \times A \times \Delta T \]
ControHeat

- ControHeat for valves, pumps, instrumentation
ControHeat

- **Steel pressure chamber embedded in aluminum casting** for excellent heat transfer
- Designed, built, and tested in accordance with ASME Section VIII, Division 1
- Jacket for valves, pumps, meters, fittings, flanges – virtually any type of process equipment
Common Valve Heating Problems

- Poor heat transfer contact
- Uneven heating
- Required steam pressure is very high
- Can be tough to service valves
- No flow conditions result in plugs
- Require heat blankets, steam hoses, etc. to unplug
CSI Customer Examples

- Oil & Gas
  - bp
  - ConocoPhillips
  - Exxon
  - GS Caltex
  - SK Energy
  - Saudi Aramco
  - Suncor Energy
  - PEMEX
  - Valero
  - TOTAL

- Petrochemicals / Chemicals
  - BASF
  - Daikin Industries
  - DuPont
  - GE
  - Henkel
  - NatureWorks
  - PotashCorp
  - Toray Industries
  - ADNOC

- Engineering & Construction
  - KBR
  - Fluor
  - CBI
  - JGC
  - Jacobs
  - Alcoa
  - Aker Solutions
  - BEchtel
  - BHP Billiton
  - Cargill
  - CertainTeed
  - CORNING
  - Foster Wheeler
  - GAF
  - HERSHEY'S
  - Honeywell
  - United States Sugar Corporation

- Other
  - SNC-Lavalin
  - Technip
  - WorleyParsons

Urea Application Areas

- Carbamate vapor lines
- Vacuum Separators
- Liquid Urea lines
• **Thermal Objective:** Maintain bulk process between 132.7-140°C
  – Urea solidifies below 132.7°C
  – More Biuret is formed above 140°C
• Typical Line Sizes: 2-4”, typical lengths: 600-1200 ft
• Current Heating Method: Jacketed Pipe
• **Problems:** Cost, Cross-Contamination

**Benefit of ControTrace**

1. Less costly than Jacket Pipe
2. Eliminates Cross Contamination
3. Design time shorter – less stress analysis to run
4. Shorter Schedules – JP has longer lead times
Heating Needs – Carbamate Gas Lines

• **Thermal Objective:** Maintain pipe wall above 153°C
  – Carbamate condenses at 153°C
  – Condensed carbamate is corrosive
• Line Sizes: up to 16”, Length: 150-300 ft
• Current Heating Method: Steam Tube or Electric Tracing
• **Problems:** Corrosion, Use of costly alloys

<table>
<thead>
<tr>
<th>Benefit of ControTrace</th>
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<tbody>
<tr>
<td>1. Minimum Pipe wall temperature guaranteed</td>
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<td>2. No condensation, no corrosion</td>
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<td>3. Allows use of less expensive alloys for pipe material</td>
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<td>4. Less costly than current approaches</td>
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<td>5. Reliability of an Engineered system</td>
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Heating Needs - Evaporator

- **Function:** Separate water from urea
- **Thermal Objective:** Maintain bulk process between 133-140°C
  - Urea solidifies below 133°C
  - Polymerisation forms above 140°C
- **Typical Diameter:** 6-12 ft; **Height:** 6-12 ft.
- **Current Heating Method:** Electric or Tube Tracing
- **Problem:** Plugging / Fouling

**Benefit of ControTrace**

1. Reliability of an Engineered system
2. Fouling problems eliminated
Heating Needs – Urea Solution Storage Tanks

- **Function of Vessel**: Storage of urea solution
- **Thermal Objective**: Maintain bulk process at or above 80°C
  - Urea “falls out” of solution below 80°C
- **Current Heating Method**: Electric or Tube Tracing
- **Problems**: External corrosion, solidification, cost

**Benefit of ControTrace**

1. Reliability of an Engineered system
2. Less expensive than current approach
ControTrace for Tanks

1. Keeps material molten
2. No internal coils – eliminates need to ever go into tank
3. Don’t have to drain the tank to maintain heating system
4. Eliminates corrosion in or on tank
5. An engineered solution guaranteed to work
CSI Urea Customer Examples

- Molten Urea handling, Carbamate vapor lines
- ControTrace and ControHeat
BENEFITS OF CONTRO TRACE™
IN HEAT TRACING SYSTEMS

For over 30 years, the refining and petrochemical industries have enjoyed operational success using ControTrace™ and ControHeat™ engineered bolt-on jacketing in lieu of jacketed piping and conventional steam tracing. The use of Contro Trace™ has gained recognition for preventing corrosion and plugging issues in vapor applications, which are common recurring problems when using conventional steam or electrical tracing. ControTrace™ and ControHeat ™ engineered bolt-on jacketing have been proven to be more reliable with lower CapX and OpX costs than jacketed piping on most liquid applications. An additional benefit to ControTrace™ and ControHeat™ systems is a significant reduction in the quantity of steam supply and condensate traps required versus jacketed piping or conventional steam tracing. Importantly, Controls Southeast is the only company that provides single-source capability to design, manufacture, and guarantee the heating system for both the piping and in-line process equipment. The specific, detailed, 3D construction drawings provided with every bolt-on jacketing system designed by Controls Southeast give a clear, to-scale representation of every component with its orientation and location specified; this enables Operations and Maintenance to know specifically what is beneath the insulation (see attached reference drawings).
General Benefits:

1. CSI provides a completely engineered system. (See attached reference drawings)
2. Thermal design is based on finite-element modeling rather than look-up tables and/or generic specifications. Modeling results are provided to support system design.
3. Uniform distribution of heat, required jacket coverage, and detailed evaluation of piping supports, flanges, and in-line process equipment are all considered as required by the application.
4. Location of supply/return points are determined by hydraulic analysis rather than generic specifications to ensure performance and optimize utilities infrastructure (steam traps).
5. Specific, detailed, 3D installation drawings are produced to ensure high quality and accurate installation and to eliminate any ambiguity with respect to decisions in the field.
6. The 3D drawings document visually and accurately each component and its location for ease of field inspection and long-term maintenance and operability once the system is insulated.
7. Detailed steam consumption is produced for each steam circuit and considers not only heat loss to ambient but also heat gain to process; this enables adequate steam supply and steam piping sizing.
8. CSI provides a thermal guarantee of system performance.

Specific Benefits over Jacketed Piping for Liquid Processes:

1. More Reliable
   a. Bolt-on jacketing eliminates the risk of cross-contamination.
   b. ControTrace™ and ControHeat™ systems can be designed so that the performance of the system is less susceptible to steam trap failure (i.e., maintain flow despite steam trap failure).
   c. System engineering, design, and component integration are completed by a thermal maintenance specialist who considers every detail that may affect performance.
   d. Hydraulic analysis and resulting steam routing are accomplished by a thermal maintenance specialist and designed to minimize the quantity of steam traps.
2. Less Expensive
   a. System results in lower CapX and OpX costs (2X-8X less steam consumption).
   b. Less effort is required for the EPC:
      i. Piping for bolt-on jacketing system can be engineered and designed as un-jacketed system.
      ii. Less rigid system, resulting in fewer expansion loops, less piping, less time to stress analyze.
      iii. Easier to field modify.
   c. Excess flanges are eliminated, resulting in lower cost and maintenance.
Specific Benefits over Tube Tracing for Vapor Processes:

1. More Reliable
   a. Greater heat transfer surface contact area and 3-mm wall thickness increase robustness.
   b. Finite-element modeling considers pipe wall temperature gradients to ensure temperature maintenance above process dew-point to reduce corrosion/plugging potential.
   c. A detailed evaluation determines the need for jacketing piping supports, flanges, and in-line process equipment to eliminate localized cold spots.
   d. System engineering, design, and component integration are completed by a thermal maintenance specialist with 30 years of successful experience who considers every detail that may affect performance.
   e. Hydraulic analysis and resulting steam routing completed by a thermal maintenance specialist and designed to minimize steam traps (2X-10X difference versus conventional steam tracing depending on application).

2. Less Expensive
   a. System results in lower CapX and OpX costs considering installation, steam traps, and associated infrastructure.

ControHeat

1. More uniform conductive heating to valve or instrument
2. Can be cast to match any shape
3. Easy to remove and replace for maintenance actions
Integrally jacketed piping systems and components have long been the preferred method used with processes that require elevated temperatures for efficient in-plant transfer of products such as sulfur, bitumens, phthalic anhydride, DMT and polymers. Pumpability, product quality, flow properties and reliable equipment operation for many of these processes depend on viscosity ranges controlled by temperature.

Integral jacketing offer the advantages of unit construction, high rates of heat transfer from the heating medium to the process, and the ability to maintain processing temperatures within close tolerances.

The disadvantages of integrally jacketed systems are the limited selections available for jacketed components, relatively long deliveries for these components, and inconsistencies of quality of the jacketed components due to the lack of industry-wide fabrication standards.

The CSI Bolt-On Heating System is comprised of products that respond positively to the disadvantages cited for integral jacketing. The bolt-on system provides thermal performance necessary to meet narrow-envelope processing. The product heating options are versatile, ranging from the primary function of temperature maintenance to more thermally complex applications of heat-up and melt-out, and, infrequently, heat exchanger duty of process heating or cooling.

The CSI Bolt-On Heating System consists of two basic product groups which are discussed in more detail on subsequent pages:

- **ControHeat Bolt-On Jackets** for valves, pumps, meters and other components.
- **ControTrace Heating Elements** for piping, tanks and vessels.

This brochure outlines the products and services offered by CSI to help designers and engineers optimize performance and value for specific bolt-on heating systems.
Benefits of the CSI Bolt-On Heating System

There are several benefits that accompany the CSI Bolt-On Heating System. The major ones are:

Component Selection Versatility. Because components of the system most often are line-size components, project engineers can select from a very broad range of standard products. The base component, of course, must be able to operate at elevated design temperatures. More than 3500 typical processing components are represented in the ControHeat Jacket pattern inventory. Several new patterns are added to this inventory each week.

No Cross-Contamination. Defects in castings or cracks in core piping cause cross-contamination. The double-wall design of the bolt-on heating system eliminates the possibility of cross-contamination. The heating fluid can’t reach the process, and the process can’t flood the heating system.

Economical Temperature Control. Depending on the thermal requirements of the process, the CSI Bolt-On Heating System can offer significant cost savings compared to a fully jacketed processing system. In general, the cost of the clamp-on system increases as the required temperature of the process approaches the temperature of the heating fluid. When the design temperature envelope is very narrow, say 2-4°F, designers must carefully analyze potential chill spots to determine the optimum heat coverage.

Low Maintenance Costs. Practically any piece of equipment or process component can be economically heated with a bolt-on jacket. Because standard line-size components can be used throughout the system, the replacement of individual components like a valve can be made without concerns for long lead times and “crises” expediting.
ControHeat Jackets Cover Valves

CSI makes ControHeat Bolt-On Jackets for virtually any valve. Generally, there are two types of jacket construction offered: One-piece jackets, called UniJackets, for valves sizes 3-inch and smaller; and two-piece jackets for valves sizes 4-inch and larger. Very large valves like 20-inch gate valves may utilize more than two pieces to accommodate ease of installation.

Here’s How The ControHeat Jacket Works:

1. Pressurized heating fluid enters the pressure chamber embedded in the aluminum casting. The pressure chamber may be either carbon steel or stainless steel.

2. The pressure chamber is designed, manufactured and tested in accordance with the ASME Boiler and Pressure Vessel Code, Sec. VIII, Div.1.

3. The aluminum casting, which never contacts the pressurized heating fluid, rapidly transfers heat from the pressure chamber to the external surface of the valve.

4. Normally, heat transfer cement is used with the jacket to minimize any air gap between the casting and the valve body. The cement promotes efficient heat transfer.
Control valves with integral jackets often require very long lead times for deliveries. Sometimes the long delivery times force instrument engineers to sacrifice performance for availability. ControHeat Jackets allow you to select the optimum valve for the process without concern for the jacket.

Designed for hot-oil vapor service, this two-piece ControHeat jacket with flanged connections and extended coverage for mating flanges is used in 650°F service on a 20-inch ball valve in a polymer reactor operation.

Any ControHeat Valve Jacket can be designed to heat mating pipe flanges as shown on these plug valve jackets used in BPA service.

This UniJacket on an off-the-shelf sampling valve keeps the valve plug-free, ready to operate at all times.

Three-way ball valves are easily heated with ControHeat Jackets. Various styles of actuator brackets can be accommodated.

UniJacket installed on ball valve. CSI insulated flexible jumpovers connect the jacket to ControTrace Elements heating adjacent piping.
ControHeat Bolt-On Jackets are widely used throughout the processing industry to improve pump efficiencies, prevent motor burnout and promote uniform processing temperatures. Some critical metering pump applications require jacketing to assure accurate throughput. Certain gear pump applications require jacketing to minimize degradation of polymers and other products that are shear sensitive. The barrels of progressive cavity pumps may need to be heated for foodstuffs such as chocolate, syrups and dairy products. In some batch-type operations, pump jacketing may be needed during start-up only. In pumping applications like sulfur, phthalic anhydride, or DMT, not only does the pump casing need to be heated at all times, the backplate also may need heating. When pump manufacturers do not offer jacketed backplates, CSI offers both fabricated bolt-on heating jackets as well as ControHeat Jackets.

Two Metering Diaphragm Pumps with ControHeat Jackets. The jackets cover four pump heads as well as check valve assemblies.

High-Pressure Piston Pump with 3-phase electric ControHeat Jacket.

Gear Pump with Mag Drive and External Relief Valve totally jacketed for hot-oil application. ControHeat Jacket on mag drive used for heating.

Progressive Cavity Pump for use in CIP service for foodstuffs.
ControHeat Jackets for Meters & Instruments

Accurate process data and process performance often depend on instruments, meters and safety devices operating at elevated process temperatures. CSI makes jackets for many types of meters, instruments and related equipment: DP cells, vortex shedding meters, rupture discs, coriolis flow meters, viscometers, tank vents, level indicators and chemical tees. Few of these components are available with integral jackets. The ControHeat Jacket has a history of successful service with these components. In fact, several manufacturers of these products have standardized on the ControHeat Jacket to complement their product lines.

Coriolis Meter used in high temperature service of pre-polymer process. Jacket is hot-oil heated and maintains meter at 600° F.

Liquid Level Indicator used in palm oil storage application. Jacket completely covers all process-wetted surfaces.

Condensables in gas streams can collect and choke the flow in flame arrestor passages. ControHeat Jackets keep the passages clear.

Pulsation Dampeners with ControHeat Jackets in high-temperature applications provide critical service for downstream instruments and meters. The jacket keeps the stagnant process fluid under the dampener’s gas pad molten.

ControHeat Jacket on a Brookfield Viscometer increases the instrument’s operating range and longevity, as well as improving accuracy of data collected.
ControTrace Heating Elements have performed very well in diverse applications from chocolate to polyester resin. Numerous plants have drastically curtailed their use of jacketed pipe, preferring to use ControTrace on process piping for DMT, rosins, sulfur, cyanuric chloride, acrylic acid, hot melts and numerous bottoms recirculating lines. Some of these plants fabricate the elements in the field. Others depend on CSI for the complete service of design, fabrication and installation of the bolt-on heating system.

ControTrace Elements are formed from carbon steel, SA178 Gr. A boiler tubing. The elements are pressure rated in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, Div.1.

The most popular size of ControTrace is a 1"x 2" rectangular shape with the pipe-side surface formed to match the outside diameter of the pipe on which it will be placed. Normally, a non-drying heat-transfer cement is used to promote heat transfer between the element and the pipe wall. For nominal pipe sizes of 1½" and less, a smaller size of ControTrace (½"x1½") is available. Other element sizes may be ordered on a custom basis. Stainless steel ControTrace is also offered for very aggressive environments.

**Custom Fabrication Options:** Customers may opt for one of three methods to use when installing a heated piping system that utilizes ControTrace Elements.

1. CSI can turnkey the complete heated piping system. CSI provides the front-end engineering and drawings, fabricates the pipe and ControTrace (securing the ControTrace on the pipe), and installs the system in your plant. Another frequently used option is production by CSI of both the piping and ControTrace Elements, installing the elements on the pipe, insulating the finished assemblies, and shipping the system to the field for installation by others. We have the flexibility, of course, to provide only specified portions of the project.

2. Based on isometric drawings provided by the customer, CSI spools the elements and, with the customer’s approval, fabricates finished ControTrace pieces, tests them, and ships them to the field, ready for installation on the pipe by others.

3. CSI provides individual components that owners use to fabricate on site their own bolt-on heating systems.
ControTrace coverage of elbows, even in smaller pipe diameters, as shown here, can be accomplished on both the throat and the heel. Side coverage of elbows also is frequently used.

ControTrace is used successfully on piping in refineries, terminals, barges and acid plants. Combined with ControHeat jackets, as on the ball joints in this application, uniform heat can be provided to the the entire system very economically.

ControTrace Elements can be fabricated to uniformly heat complex piping shapes like the cross, reducer and lateral shown here.

In the application depicted in the accompanying photo, ControTrace Elements proved to be a cost saving alternative to all-stainless steel jacketed pipe. With no external pressure, core piping was selected based on internal process requirements. This allowed a thinner pipe wall and saved money.

The design of the ControTrace coverage on a particular piping run depends on the process thermal requirements, pipe schedules, and the type and thickness of insulation used. In this application CSI designers determined that heating elements placed normal to the process flow would provide the most uniform coverage.
Storage tanks and vessels up to 25 feet in diameter are in service with ControTrace elements providing uniform heat over their entire surfaces.

The ControTrace Element configuration can be designed for liquid or vapor heating media. A key benefit of ControTrace is that elements can be dispersed evenly around the vessel, assuring the uniform heat coverage. Jackets can be fabricated for conic heads as well as elliptical heads. Generally, systems that utilize a liquid heating medium are designed in a serpentine configuration. Systems that use a vapor heating medium are usually constructed for parallel medium flow. When parallel flow must be used on a liquid system, flow diverters can be placed inside the ControTrace assemblies to channel the liquid.

ControTrace Elements were utilized in this phthalic anhydride storage facility because the product could provide economical, uniform temperature maintenance in critical service.

CSI has developed special fabrication techniques to achieve uniform heat coverage of vessel heads, allowing for various sizes of nozzle penetrations.

When liquid heating media are used, jacket elements are fabricated in a serpentine design to provide even heat distribution. Where non-condensables may cause vapor locks, bleed vents are added at strategic jacket locations.

Conical vessel bottom with ControTrace.
A major segment of CSI’s total business is the design and fabrication of jacketed piping systems. The continuing evolution of CSI Bolt-On Heating Systems is linked directly to the knowledge and experience we gain in jacketed piping, because the same engineers and designers who manage jacketed piping projects also design and manage projects for bolt-on heating systems. The singular focus of this cumulative experience, from initial quotations through process start-up, is a satisfied customer that likes doing business with CSI.

Two Computer Tools

1. To assist customers in determining the right amount of bolt-on heat coverage, CSI has developed a computer program that allows inputs of up to five process variables. These variables are type and thickness of insulation, process temperature, heating medium temperature, ambient design temperature, and nominal pipe or tank sizes. Several values may be selected for each variable. The data produced from these variables is used to determine the optimum system. Results of the program tell designers the number of ControTrace Elements to be used, the energy loss per hour per foot of pipe and the consumption of heating fluid used per hour per foot of pipe.

2. The second computer program, more sophisticated than the first, uses finite difference modeling to profile the cross-sectional thermal performance of the bolt-on heating system. The results yield a detailed temperature profile of the piping system at equilibrium, the heat lost to the atmosphere through the insulation, and the net heat input to the process. This program considers the thermal conductivities of the system components as well as film coefficients of both the process and the heating fluid.
ControTrace elements on this rail car solved a critical maintenance problem for a major producer of caprolactam.

For additional information and quotations, please write or call:

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Polymer additive skid with 450°F bolt-on heating system.