CONCEPT

HTRI MEMBER

ENABLING APPLICATION SPECIFIC HEAT TRANSFER ENHANCEMENT IN

LNG Regasification Heat Exchangers For FGSS Systems

VorTX Wire Turbulators

VorTX Spiral Turbulators

Twisted Tape Turbulators

Rigid Soldered Turbulators

Wire Wound Fin Tubes

Finding the right turbulator for an application is an exercise we are equipped to handle.

We make a bunch of different turbulator types and many different geometries within those types.

And it's because we make the entire spectrum of turbulator types and have data on where they stand that we can rank them in order of performance without letting bias creep in.

Rigid Soldered Turbulator

The highest performing turbulator there is as in addition to turbulation it also increases the internal surface area of the tube anywhere between 2x to 4x because of the solder bond effect. It makes drastic size (and cost) reduction in viscous fluid coolers possible.

It is also a gamechanger in gas coolers where the surface area extension is the dominant play other than simply turbulation as gas is naturally turbulent anyway. A 4x increase in internal surface area at 75% bond efficiency would still give a 3x bump in heat transfer coefficient.

Wire Turbulator

vortx enabled

Wire turbulators offer the flexibility of easy insertion and the second highest performance profile in our range. Second only to rigid soldered turbulators. Their performance and pressure drop correlations are mapped into our VorTX DLL. Wire Turbulators are ideal for cases where tubeside limitation is severe.

Spiral Turbulator

vortx enabled

Spiral Turbulators sit in between the performance of tight L/D Twisted Tape and Low Dense Wire Turbulators. A sweet spot in terms of pressure drop penalties. Spiral Turbulators also have their performance and pressure drop correlations mapped into our VorTX DLL. Spiral Turbulators are ideal for viscous and semi-viscous applications where pressure drop allowance is tight and twisted tapes can't give enough performance.

Twisted Tape

CEI Twisted Tapes have perfect L/D conformance and can be made in a wide range of materials and sizes. Even the L/D range that we can make these in is large giving a lot of flexibility in terms of design choices.

What VorTX is.

VorTX is Concept Engineering International's dynamic link library (DLL) developed by HTRI under proprietary contract with Concept Engineering International.

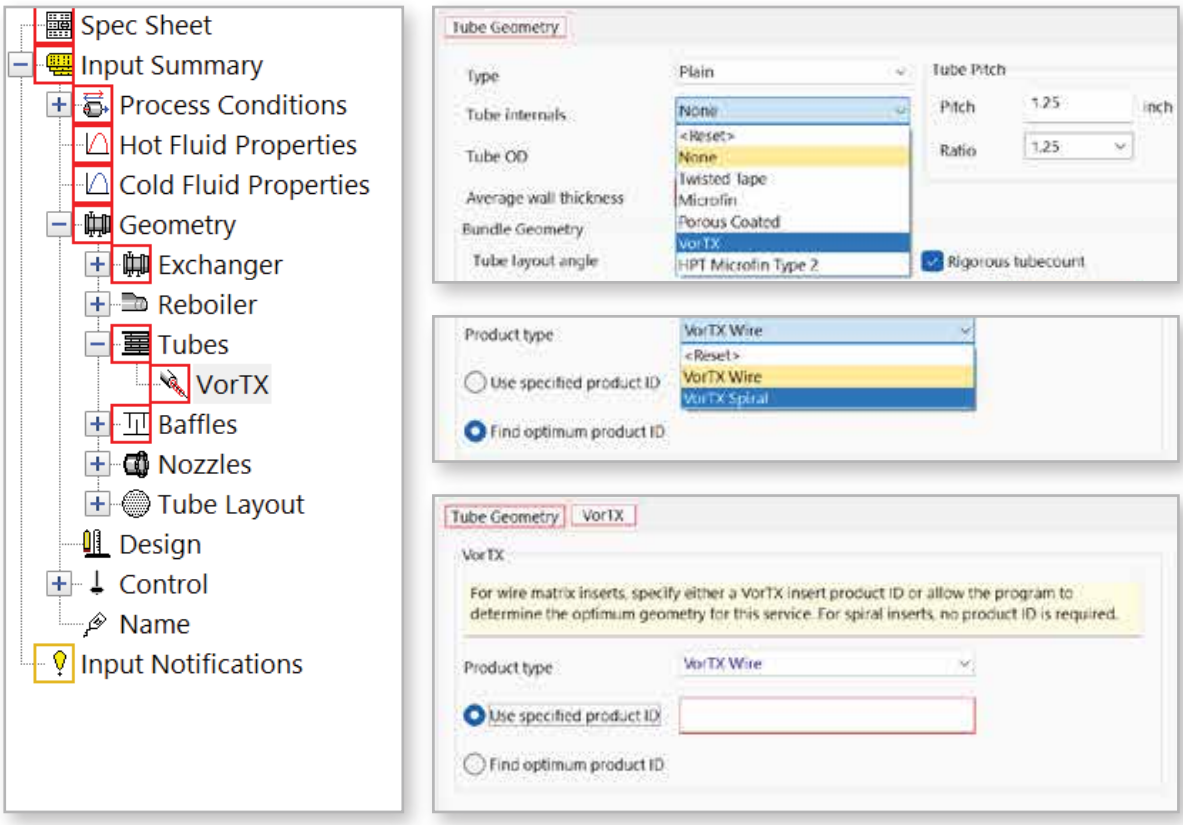
Multiple Concept Engineering International turbulators (wire and spiral tube inserts) were tested at HTRI's Research and Technology Center in Navasota, Texas, USA.

The VorTX DLL contains tube side single phase heat transfer and pressure drop correlations for modeling Concept Engineering International's products which were developed under proprietary contract with HTRI using Concept Engineering International's proprietary data.

HTRI used laminar flow CFD results to supplement empirical testing measurements at Reynolds numbers under 500.

The VorTX DLL can be used with HTRI Software for the following purposes:

1. Identifying an optimal Concept Engineering International product from those supported by the VorTX DLL based on utilizing the maximum amount of pressure drop allowed.
2. Evaluating the performance of a Concept Engineering International product supported by the VorTX DLL that resembles the geometry of those tested by HTRI.



What VorTX enables.

Data really drives every enhancement decision we make.

We're looking for the best operating window for our products from a Reynolds standpoint.

We're diving deep into wall correction factor impact of our geometries in software outputs.

We're looking at the additional hydraulic load of each geometry. Small tweaks in angles of attack.

How much the shear stress is when you pit turbulator vs bare tube.

What the impact on fouling is likely to be because of that additional wall sheer stress.

How we can disrupt film boiling to move over to nucleate boiling, arrest mist flow and reduce bubbles down to size.

These are questions that only data has the answer for.

Our turbulator range (multiple geometries) has been tested for a hard data mining operation.

Post that, the data has been analyzed and curve fitted and then modeled into correlations along with a test report for each insert geometry.

We've also done supplemental CFD work via a proprietary contract to home in on more accuracy.

To completely integrate into software platforms, we've also had developed the **VorTX.DLL** plugin that will hold this data and allow you, the user, to design your exchangers using our products in a matter of seconds if you're using compatible software.

If you're an end-user like a refinery who uses a performance monitoring software, we're also looking at hard coding our mined data in software such as this to see the impact we can have on refinery exchangers to mitigate fouling by looking at shear stress increases and what that will mean for overall CO2 emissions reduction.

High-Performance Heat Transfer for LNG Regasification & FGSS Systems

As marine and industrial sectors transition toward cleaner fuels, Fuel Gas Supply Systems (FGSS) must deliver absolute reliability under extreme conditions. LNG regasification operates across severe temperature gradients (down to −162 °C) and high pressures, leaving no margin for thermal inefficiency.

Our heat transfer enhancement technologies are engineered to vaporize LNG efficiently and predictably—ensuring your FGSS delivers gas at precisely controlled temperature and pressure for engine injection and downstream processes.

Engineering the Cryogenic Boundary

Regasifying LNG from cryogenic conditions is where conventional heat exchangers struggle. Our enhancements are specifically designed to maximize thermal throughput while minimizing equipment size—critical for space-constrained marine engine rooms, FSRUs, and modular land-based installations.

By increasing effective heat transfer coefficients, we enable:

- **Shorter exchanger lengths**
- **Reduced skid footprint**
- **Lower capital cost per unit of regasification capacity**

Rigid Soldered Turbulators

The Cryogenic Standard for High-Pressure FGSS Applications

Rigid soldered turbulators represent the definitive solution for high-pressure LNG vaporizers and gas heaters. By creating a direct metal-to-metal thermal bridge between the insert and tube wall, they eliminate the insulating air gap inherent in conventional inserts—delivering maximum thermal conductivity at cryogenic temperatures.

Key Advantages

- **Thermal Integrity:** High-quality solder bonding ensures stable performance through extreme thermal cycling and differential contraction.
- **Compact Design:** Enables significant reduction in shell-and-tube vaporizer length, saving valuable deck or skid space.
- **Pressure-Capable:** Designed for the high pressures typical of FGSS vaporizers.

Target Applications

- **High-pressure LNG vaporizers**
- **Boil-Off Gas (BOG) heaters**
- **Trim heaters for:**
  - **ME-GI**
  - **X-DF**
  - **Dual-fuel engines**

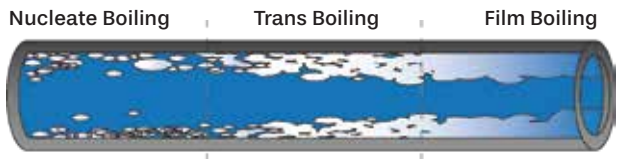
Wire Turbulators

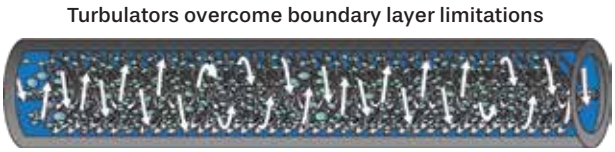
Engineered for Two-Phase LNG Heat Transfer

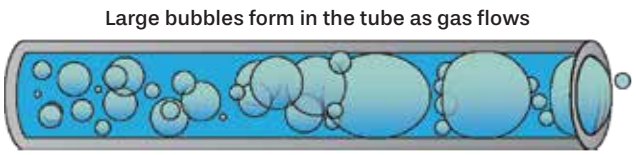
Wire turbulators are specifically designed to address the dominant performance limitations in LNG regasification, where film boiling, mist flow, and large vapor bubbles degrade heat transfer.

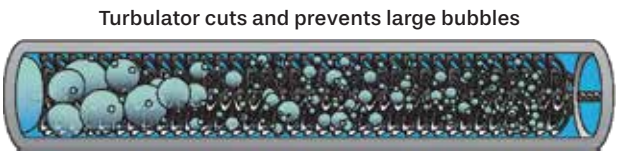
Performance Benefits

- **Film Disruption:** Continuously breaks the insulating liquid film at the tube wall, sustaining high local heat transfer coefficients.
- **Mist Flow Mitigation:** Prevents performance collapse associated with mist flow regimes, maintaining heat transfer effectiveness along the full tube length.
- **Bubble Size Control:** Breaks large vapor bubbles into smaller structures, increasing effective wetted area and enabling further vaporization.



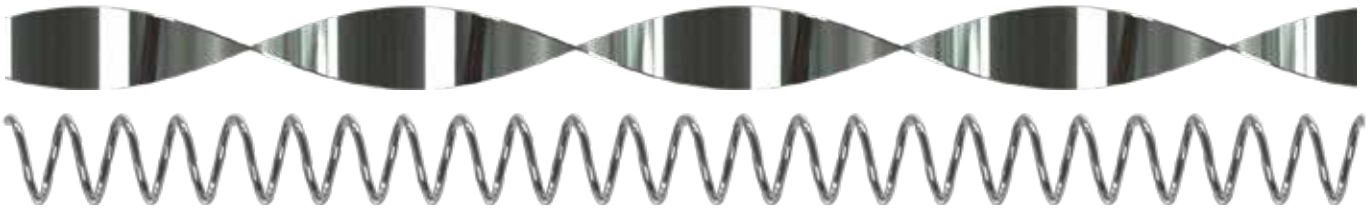






Spiral & Twisted Tape Turbulators

Optimized for Low-Pressure Regasification Stages



In low-pressure sections of FGSS, pressure drop management becomes the primary design constraint. Spiral and twisted tape turbulators are optimized to enhance heat transfer while maintaining predictable hydraulic performance.

Key Features

- **Flow Stabilization:** Helps maintain stable flow regimes during liquid-to-gas phase transition, reducing vibration and flow-induced instability.
- **Predictable Performance:** Manufactured to tight geometric tolerances, ensuring pump and compressor lift requirements are met with confidence.

Target Applications:

- **Low-pressure BOG compressors**
- **Fuel gas heaters for auxiliary engines**
- **LNG bunker station heat exchangers**

Specialized FGSS Solutions Across the LNG Value Chain

Our heat transfer enhancement technologies are purpose-built for the unique demands of LNG infrastructure:

- **Marine Dual-Fuel Systems:** Reducing regasification unit size to fit within tight ME-GI and X-DF engine room footprints.
- **FSRUs & Floating Assets:** Maximizing heat transfer density where weight and space are at a premium.
- **LNG Truck Loading Terminals:** Enhancing trim heaters to deliver precise gas temperatures despite wide ambient variations.

Materials Engineered for Cryogenic Service

LNG service leaves no room for material fatigue or thermal failure. All inserts are available in cryogenic-grade alloys, including **SS316L**, ensuring:

- Mechanical integrity at sub-zero temperatures
- Resistance to thermal cycling and contraction
- Long-term corrosion resistance in LNG environments

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