Brazed Aluminum Heat Exchangers

CHART®

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ANTONOV
INTERNATIONAL CARGO
TRANSPORTER

Chart has pioneered the fabrication of large brazed aluminum heat exchangers since the 1950s, and has produced over twelve thousand units.

Chart Energy & Chemicals , a wholly owned subsidiary of Chart Industries, Inc. (Nasdaq:GTLS), is a specialist in the design and manufacture of **Brazed Aluminum Heat Exchangers** (BAHX), which are mission critical for a wide variety of cryogenic processing applications where reliability and thermal efficiency are paramount.

Chart's heritage begins with the adaptation of the product from the aerospace industry in the 1950's, it incorporates the former Altec and Marston brands and includes a number of 'world firsts'. Chart's successful track record is unrivalled. Since pioneering the fabrication of large brazed aluminum heat exchangers in the 1950's and being the first manufacturer to introduce vacuum brazing in the 80's, Chart has produced over 12,000 units. Chart has fabricated more than 1,300 heat exchangers with a design pressure in excess of 69 barg (1,000 psig) and over 200 with a design pressure above 90 barg (1,300 psig).

Chart BAHX can be supplied as single units, manifolded assemblies or integrated solutions comprising fully assembled cold boxes including separator drums, vessels, interconnecting pipe work, valves, instrumentation and flanged connections for easy installation.

A site service team that can be deployed worldwide completes the picture.

Contents

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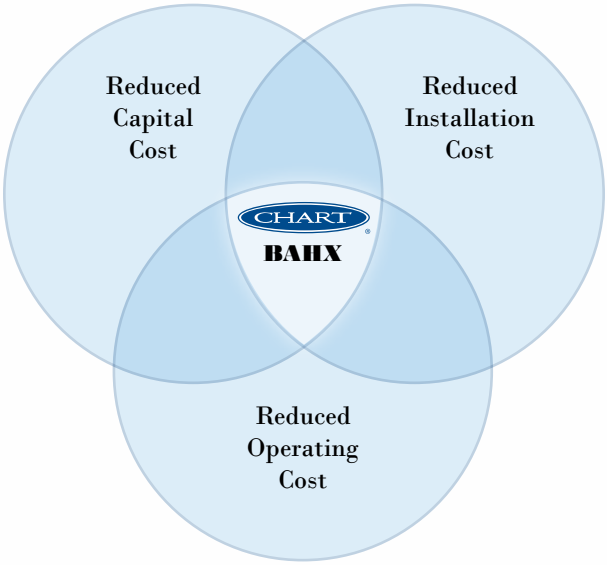
Superior Performance

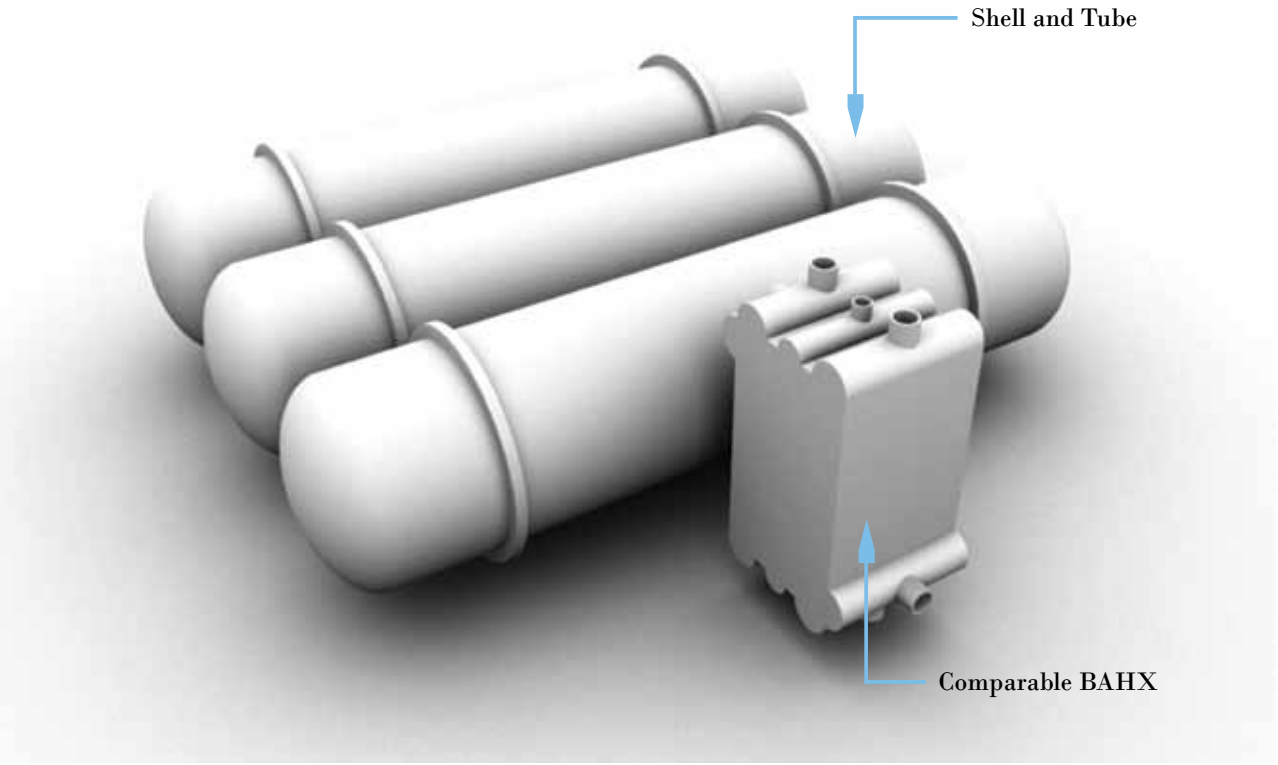
A BAHX is typically 20% the size of a shell and tube exchanger of comparable performance. Furthermore, the alternating plate fin construction offers multiple stream capability and simplifies a series of shell and tube units to a single compact structure.

Chart BAHX = Reduced Capital, Installation and Operating Cost versus Shell & Tube Exchangers

- All aluminum construction for maximum heat transfer and thermal conductivity
- High performance heat transfer fins
- Custom design for optimized thermal and hydraulic performance
- 6 to 10x greater heat transfer surface area/volume
- 10 to 20x more UA/volume
- Multi-stream capability
- 25 to 50% lower initial cost
- Up to 95% less weight
- Less plant space required
- Reduced ancillary costs – installation, insulation, foundation, transportation
- Reduced temperature approaches, as low as 2°F (1°C), result in reduced compressor horsepower

Chart BAHX Compared with Shell & Tube Alternative





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Applications

BAHX are at the heart of the cryogenic processes producing many of the industrial building blocks increasingly in demand throughout the world.

The industrial gas industry requires BAHX to produce the pure components of nitrogen, oxygen and rare gases in highly efficient cryogenic processes.

BAHX are incorporated into hydrocarbon processing applications for the production of important basic products such as ethylene, propylene, hydrogen and natural gas, which all require cryogenic processing.

Worldwide demand for natural gas, driven by its economic and environmental benefits versus other fossil fuels, is predicted to increase for the foreseeable future. BAHX play a fundamental role in its purification and liquefaction and also enable the extraction of valuable by-products such as helium and natural gas liquids (NGL).

Baseload LNG liquefaction facility

Small-scale LNG liquefaction plant

Propane dehydrogenation unit

Nitrogen rejection unit

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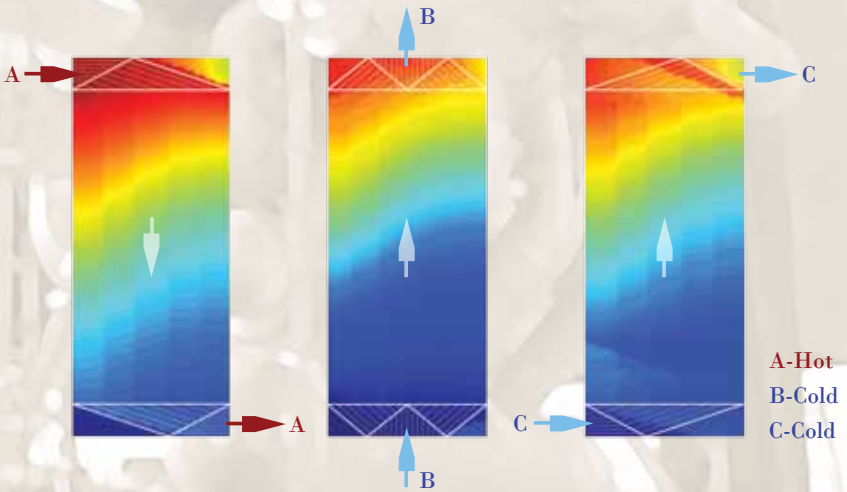
Custom Engineered

Chart BAHX are custom engineered to meet individual thermal and hydraulic performance requirements.

State-of-the-art software coupled with in-house engineering expertise and experience provide optimized design solutions incorporating all of the following:

- Achieve the required heat transfer performance for each process stream
- Work within the specified allowable pressure drops for each stream
- Incorporate multiple heat exchange duties into a single design
- Define the required number of process layers for each stream
- Produce the most efficient layer arrangement
- Specify component thicknesses according to mechanical strength requirements, operating conditions and the relevant design code
- Consideration of special customer requirements such as 2-phase distribution, thermosyphons, reflux condensing, transient operations
- Advanced transient thermal analysis capabilities to calculate the 3-dimensional internal fluid and metal heat exchanger temperatures. These analyses can be carried forward to predict potential fatigue damage and life expectancy of the equipment



As well as forming the basis of the comprehensive performance warranty, Chart design expertise adds another dimension to the customer's plant optimization by facilitating the evaluation of multiple cases and provides early equipment configurations and dimensional sketches for plant layouts.

Sophisticated 3D CAD modelling, FEA and dynamic thermal analysis software is employed by Chart.

Electronic data transfer completes the smooth and prompt interface between Chart equipment designs and the customer's plant layout.

Chart's proven software provides detailed information required to optimize designs and evaluate various operating conditions including transients.

Chart continues to develop its product and design capabilities through feedback and collaboration with various industry leaders and longtime, consistent users of BAHX.

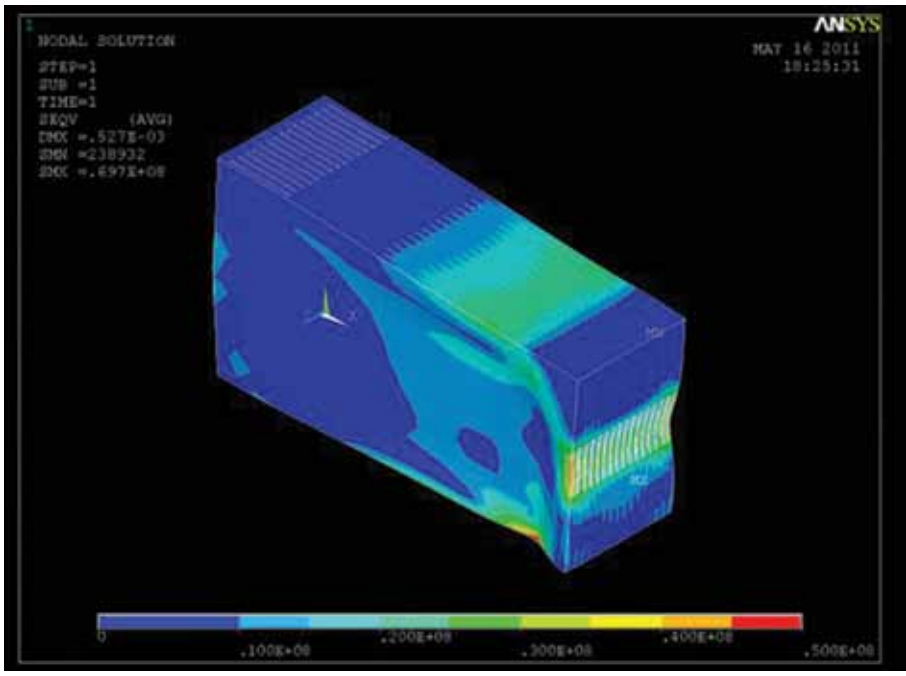
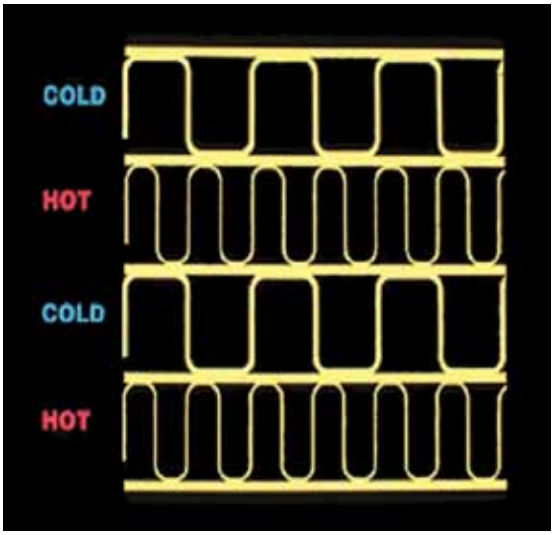


Chart helps customers understand the effects of severe operating conditions through detail stress analysis



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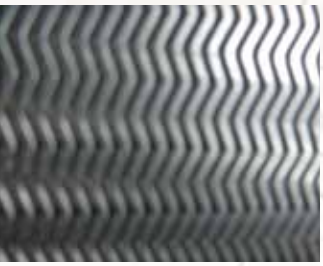


Maximum Heat Transfer Performance

Heat is transferred between layers across the parting sheets (primary heat transfer surface) while the fins provide an enhanced secondary heat transfer surface.

Chart has developed 4 primary fin types each offering different thermal and hydraulic performance characteristics.

For maximum design versatility the height and density of each fin type can be varied resulting in a multitude of performance characteristics.

Different fin types can be combined in a single stream. This approach is common when the heat transfer duty requires a phase change e.g. an incoming fluid is boiled and then superheated.

The hydraulic and thermal performance characteristics of all Chart fins is based on extensive laboratory testing and over 40 years of successful field operation.

Construction

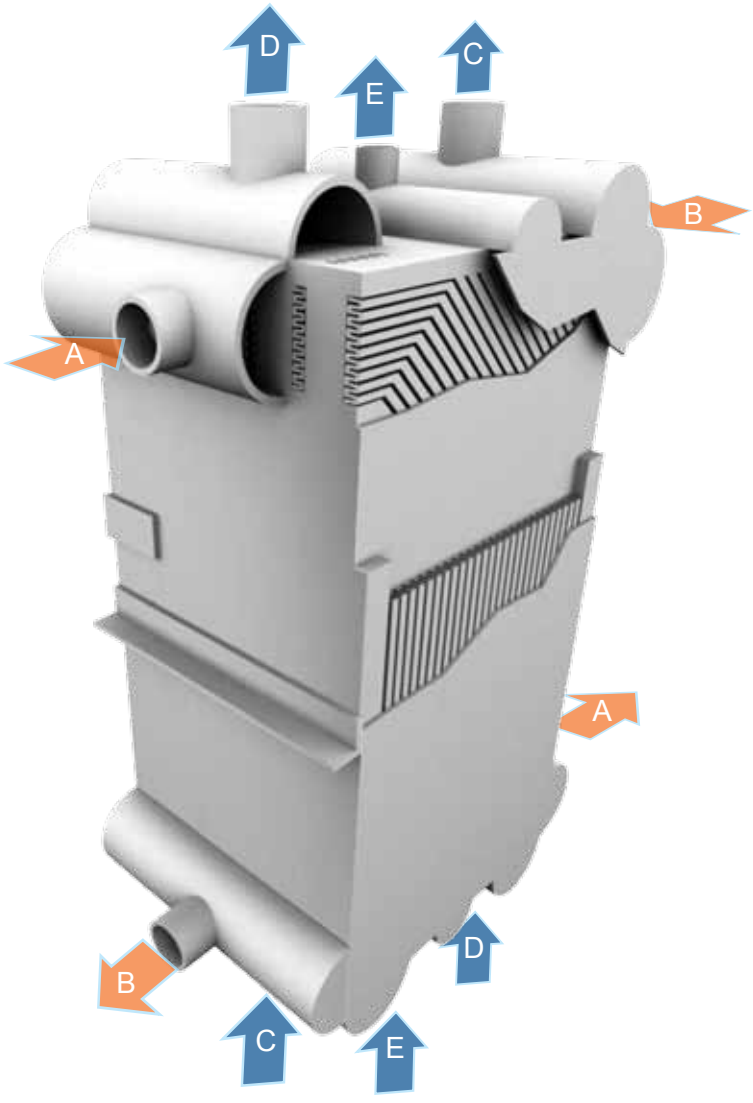
Chart BAHX owe their inherent versatility and high performance characteristics to their aluminum plate-fin construction.

Each BAHX consists of alternating layers of corrugated fins separated by parting sheets.

Apart from the fluid entry and exit points to each layer the edges are sealed with bars that contribute to the structure's mechanical strength and contain the fluids, preventing them from leaking to the atmosphere.

This sandwich construction of layers continues in accordance with the layer stacking arrangement defined for the design until the heat exchanger block (or matrix) is complete.

The multi-stream capability of the BAHX is achieved by altering the entry and exit points of each process stream. It is common for BAHX to have more than 10 different process streams in a single design allowing the process designer to optimize the cooling curves for maximum process efficiency.



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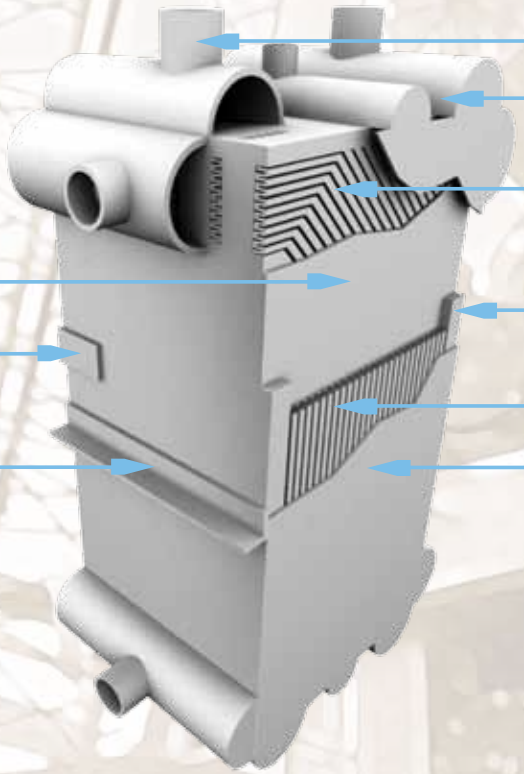
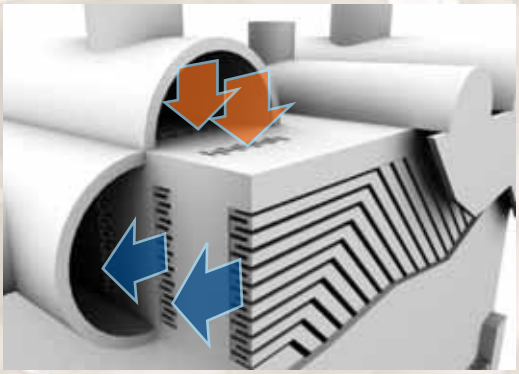
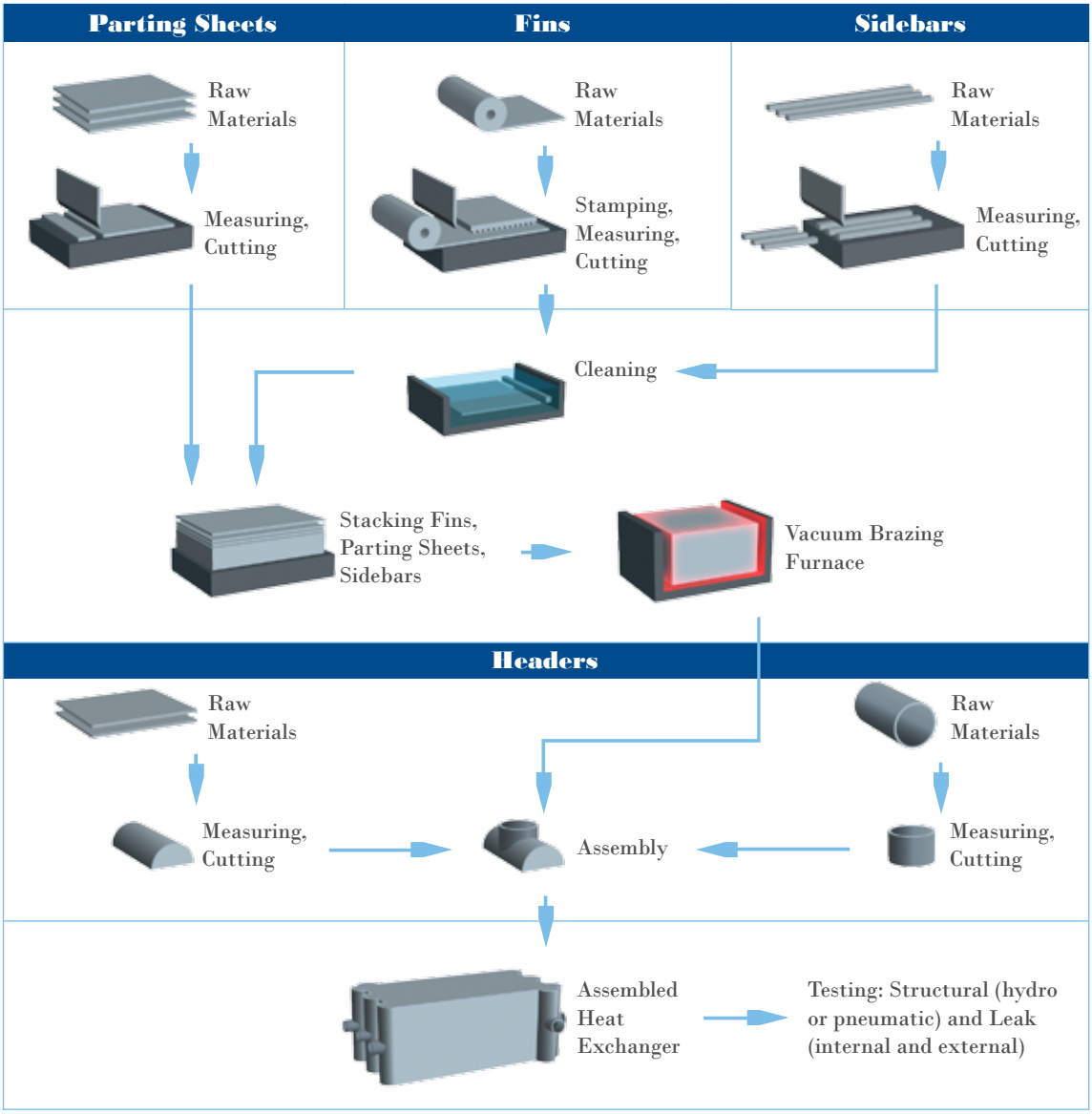


The matrix assembly is brazed in a vacuum furnace. The brazing process is highly complex and rigorously controlled to ensure a bond between each fin and corresponding plate. Even in a small heat exchanger that means millions of brazed joints. Each one is formed through capillary action as the brazing alloy on the surface of each plate melts during the high temperature operation and fuses to the parts in contact with it.



Following brazing, BAHX construction is completed with the welding of the header and nozzle assemblies over the fluid entry and exit ports. Support angles, pedestal base, wear plates, lifting lugs and other items that aid lifting, handling and installation are also welded to the unit after brazing.

From incoming raw materials to the shipment of finished product, all manufacturing processes are rigorously controlled and monitored to ensure total quality.



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Specialized Chart Expertise - High Pressure Capability

Chart currently offers BAHX in excess of 160 barg (2,320 psig). Through a relentless research and development program Chart continues to expand the pressure limits and the maximum block sizes at which these elevated pressures can be reached. Chart boasts an experience list for high pressure BAHX which is unmatched by its competitors and is a demonstration of Chart quality and reliability.

Mercury Tolerant Construction

As well as being the first manufacturer to incorporate fabrication techniques into the construction of BAHX, which can make them tolerant to exposure to mercury, Chart recognized and identified the conditions at which mercury contamination could be harmful to its heat exchangers.

Chart has continued to refine and supplement its proprietary mercury tolerant capability and the resultant unique features reaffirm its position as the reference standard for the industry.

Specialized Chart Expertise - Cold Boxes and Manifold Assemblies

As well as stand alone exchangers Chart offers fully assembled and tested manifolded batteries and complete cold boxes.

Typically plate fin heat exchangers are housed in internally insulated carbon steel enclosures called cold boxes that also contain inter-connecting pipework, process separation vessels and associated instrumentation and valves. Flanged terminations at the box wall facilitate quick and easy connection to process pipework.

Chart's primary manufacturing locations for these assemblies are the Chart Coastal Fabrication facility in Louisiana that provides direct access to the US intercoastal waterway and the Gulf of Mexico and a similarly equipped shop in Wuxi, China.

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Specialized Chart Expertise - Core-in-Kettle® Heat Exchangers

Chart's Core-in-Kettle heat exchangers are designed to replace shell-and-tube heat exchangers with the direct benefits of lower installation costs, reduced operating costs, less replacement time and reduced horsepower requirements.

The high performance of Chart Core-in-Kettle heat exchangers will greatly improve the efficiency and economy of chillers, vaporizers, reboilers and condensers.

The Core-in-Kettle design is capable of achieving tight temperature approaches down to 2°F thereby increasing plant capacity and reducing horsepower requirements.

Enhanced performance through:

- Reduced temperature approach (down to 2°F/1°C) with resulting savings in power
- Up to 10 times greater heat transfer surface area per unit volume than conventional shell and tube units
- Multi-stream capabilities in a single construction

Cost savings through:

- Smaller vessels resulting in lower installation costs
- Smaller site plan, foundations and support structure
- Reduced refrigerant inventory
- Reduced process power requirements enabling a smaller compressor and lower operating costs

Applications

Petrochemical	Ethylene Propylene Ethane Butane Propane	C2, C3, C4 splitters Feed chilling train Heat pump distillation columns Columns Cascade refrigeration
Natural Gas Processing	Expanding plant LP-Gas NGL	Propane chillers Cascade refrigeration Liquid fractionation
Gas Liquefaction	LNG Nitrogen Hydrogen	Cascade refrigeration Feed chilling train

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World Class Quality, Environmental & Safety Programs

Chart heat exchangers are typically designed, built and tested according to ASME VIII Div. 1 code requirements; although Chart's global experience ensures compliance with all applicable international rules and regulations as required.

ISO 9001:2008 | ASME 'U' | National Board 'R' | National Board Registration | TUV Certificate | Chinese Mfr. License

Gost 'R' | GTTN | DNV Mfg. Approval | Korean Mfr. Registration | ISO 14001:2004

In addition to the headline quality certifications e.g. ISO 9001, ASME, PED, Chart holds a number of international accreditations including those for Russia, China and Korea.

After Sales and Support

Chart can provide supporting documentation, consultation, and on-site services for installation and trouble-shooting needs.

From thermal and hydraulic performance reviews, repair of fouled or damaged exchangers to site installation, Chart's engineering expertise is at your service worldwide.

Chart is a founding member of the Aluminum Plate-Fin Heat Exchanger Manufacturers' Association (ALPEMA).

To download our Installation, Operation and Maintenance manuals for BAHX and cold boxes as well as other product specific literature please visit www.chart-ec.com.

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Operational Facilities

Chart serves its global BAHX markets through its headquarters and principal engineering and manufacturing facility in La Crosse, Wisconsin USA, with an additional manufacturing facility in Wuxi, China and a European sales, marketing and engineering office in Wolverhampton, England.

A handpicked sales network in key territories throughout the world supplement the two sales offices and provide local support for customers.

Chart's manufacturing facilities for large assemblies and cold boxes are in New Iberia, Louisiana USA and Wuxi, China.

La Crosse, Wisconsin USA

Wolverhampton, England

New Iberia, Louisiana USA

Wuxi, China

Experience Counts

>60 Years since Chart brazed the first large BAHX for an industrial application

>200 Chart fabricated cold boxes in service
Chart BAHX with mercury tolerant features in service
Chart BAHX with design pressure >1300 psig (90 barg) in service

>400 Chart Core-in-Kettle® in service

>1,300 Chart BAHX with design pressure >1000 psig (69 barg) in service

1982 Chart introduces vacuum brazing

1989 Chart manufactures the first Core-in-Kettle®

1998 Unification of Altec and Marston providing over 100 years combined BAHX design and manufacturing experience

2014 Expansion of the La Crosse facility and opening of a purpose built manufacturing plant in Wuxi, China

>2,300 psig (159 barg). Chart's proven high pressure capability

>12,000 Chart manufactured BAHX

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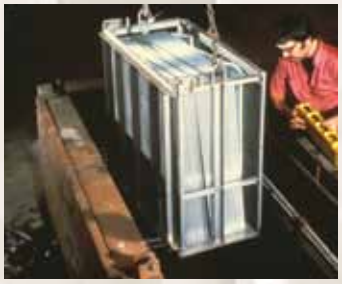
Dedication to the Core
60 Years of Manufacturing Heritage

A selection of images from our archives



General

	1 Cubic Meter of LNG	1 Metric Tonne of LNG	1 Cubic Meter of Gas	1 Cubic Foot of Gas	1 Million Btu	1 Therm	1 Gigajoule	1 Kilowatt Hour	1 Barrel Crude
Convert From:	Multiply By:								
1 Cubic Meter of LNG	1	0.405	584	20631	21.04	210.4	22.19	6173	3.83
1 Metric Tonne of LNG	2.47	1	1379	48690	52	520	54.8	15222	9.43
1 Cubic Meter of Gas	0.00171	0.000725	1	35.3	0.036	0.36	0.038	10.54	0.0065
1 Cubic Foot of Gas	0.00005	0.00002	0.0283	1	0.00102	0.0102	0.00108	0.299	0.00019
1 Million Btu	0.048	0.0192	27.8	981	1	10	1.054	292.7	0.182
1 Therm	0.0048	0.00192	2.78	98.1	0.1	1	0.105448	29.27	0.0182
1 Gigajoule	0.045	0.018	26.3	930	0.95	9.5	1	277.5	0.173
1 Kilowatt Hour	0.000162	0.000065	0.0949	3.3	0.003415	0.03418	0.0036	1	0.00062
1 Barrel Crude	0.261	0.106	153	5390	5.5	55	5.79	1612.9	1

Temperature

	Celsius	Fahrenheit	Kelvin
Convert From:	Multiply By:		
Celsius	1	F=Cx1.8+32	K=C+273.15
Fahrenheit	C=(F-32) / 1.8	1	K=(F+459.67) / 1.8
Kelvin	C=K-273.15	F=Kx1.8-459.67	1

Pressure

	Atmosphere	Bar	Kg/cm²	Kg/m²	Megapascal	Millibar	PSI (lb/in²)
Convert From:	Multiply By:						
Atmosphere	1	1.01295	1.03325	10332	0.10132	1012.95	14.696
Bar	0.9872	1	1.02	10197	0.1	1000	14.504
Kg/cm²	0.9678	0.9804	1	10000	0.09804	9.804×10^{2}	14.223
Kg/m²	9.678×10^{-5}	9.807×10^{-5}	0.0001	1	9.807×10^{-6}	0.09806	0.00142
Megapascal	9.86923	10	10.1972	101972	1	10000	145.04
Millibar	9.872×10^{-4}	0.001	1.02×10^{-3}	10.197	0.0001	1	1.45×10^{-2}
PSI (lb/in²)	0.068046	0.068948	7.031×10^{-2}	703.07	0.00689	68.948	1

Volume

	Cubic Centimetre	Cubic Metre	Cubic Inch	Cubic Foot
Convert From:	Multiply By:			
Cubic Centimetre	1	1×10^{-6}	0.06102	3.531×10^{-5}
Cubic Metre	1×10^{6}	1	61024	35.315
Cubic Inch	16.387	1.639×10^{-5}	1	0.00057
Cubic Foot	28317	0.02831	1728	1

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Innovation. Experience. Performance.®