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# Frequently Asked Questions (FAQs)

Rev. Feb-2019

## 1. What is a CPHX?

A Compact Platelet Heat Exchanger, or CPHX, is a device used to transfer energy in the form of heat from one or more fluid streams to another without any mixing of the fluids. Its name comes from its two distinct identifiers from other heat exchange devices. That is, CPHXs are typically 1/4 to 1/6 the size of traditional shell and tube exchangers for the same application. This is accomplished through the use of platelet technology which allows for small fluid passages that provide maximum heat transfer surface area in an extremely compact space; increasing exchanger effectiveness while minimizing its weight and footprint.

## 2. Who typically uses CPHXs?

The compact platelet heat exchanger excels in extreme environments, i.e. any process with very high operating pressures, extreme temperatures (hot or cold), and significant space (footprint) and/or weight constraints. A few examples of these applications are: offshore oil and gas plants, aerospace/flight components, or compact energy solutions such as naval propulsion systems or supercritical CO2 power cycles.

Compact platelet heat exchangers are not recommended for applications with modest operating conditions. For example, any process with low-range operating pressures and temperatures, or where space and weight savings are not at a premium. Also fluid streams containing an extremely large amount of particles and/or having extreme fouling tendencies, are not recommended for CPHX use.

## 3. Do CPHXs operate with gases or liquids?

HEXCES' CPHXs can be designed for any fluid type, i.e. liquid/liquid, gas/gas, or liquid/gas. Two phase flow is also possible in many applications.

## 4. What materials are used to make CPHXs?

There is a wide range of metals from which a CPHX can be fabricated. While stainless steel alloys are the most common, nickel, cobalt, copper, and titanium alloys are possible, and even refractory materials like molybdenum have been utilized. A combination of materials is also possible to optimize the overall design of the CPHX. The specific duty and operational requirements dictate the optimal material of construction.

### 5. What shapes can a CPHX take?

The basic rectangular shape is the most common, but HEXCES can tailor and optimize CPHX size and shape to the specified application to account for the available envelope. An example is our formed platelet liner CPHX used to cool the hot gas walls of combustion chambers and ducts that routinely see temperatures in excess of 1,600 °C.

### 6. Are there any size limitations on a CPHX?

With the modular approach taken by HEXCES for CPHX design and manufacture, the size is virtually unlimited; CPHXs can range from a few grams to multi-tonne assemblies. As the size increases, post fabrication logistics and handling become limiting factors.

### 7. Is fouling an issue with CPHXs?

The passageways of the CPHX are designed to minimize fouling by creating smooth passages with the absence of any “dead spots”. They are designed to operate in the flow regimes that are known to minimize fouling issues. Even so, the CPHXs do have small passages and should avoid streams that have extreme fouling tendencies. Solids that are larger than the passage ways can be filtered out of the streams using common filters or strainers – typically duplex filters are used so they can be cleaned or replaced without removing the heat exchanger from service. Particles and fibers that are smaller than the passage ways will pass through the heat exchangers and will not cause a problem as long as they are not too numerous, however these too can be filtered with proper system filtration design. By employing upstream filtration and a regular filter service regimen, CPHX service requirements are significantly reduced.

### 8. What if a CPHX becomes clogged or plugged?

In the event that the CPHX does become fouled or plugged, the exchanger can be cleaned. HEXCES offers onsite and offsite customer support for exchanger cleaning and maintenance operations. If requested by the customer, exchangers can be designed with additional access ports to allow for deep cleaning.

### 9. How is the general operation or health of a CPHX monitored?

The basic health of the CPHX and supporting filtration system are monitored using differential pressure readings. If desired, additional performance data can be collected by monitoring the inlet and outlet temperature and flow rate of each circuit of the exchanger. These data can then be used for predictive maintenance purposes to indicate when inspection and/or maintenance of the exchanger may be required.

**10. Can you tell me more about platelet technology and where else is it used?**

The basic processes making up platelet technology have been around for a very long time and while somewhat esoteric, are very mature. Photochemical machining (PCM) in the form of patterned metal etching is traceable back to at least the middle ages where it was used on metal armour and other art. The first patents for photochemical etching (machining) appeared in the mid 1800's. Use of the process as a production tool, mainly for printed circuit board and television screen photomask fabrication, began in the 1950's. Today PCM is used for making everything from Christmas tree ornaments to integrated circuit lead frames and EMI shielding. HEXCES style platelets have been used for highly complex liquid rocket engine and gas generator injectors, and for chemical reactors and heat exchangers.

Diffusion bonding, the solid state joining process used to assemble CPHXs, also has roots that are centuries old. Essentially a high-tech form of an early blacksmith's weld, development of the modern process began in earnest in the 1950's to support cold war technology needs for joining difficult or previously impossible to join materials. Today, diffusion bonding is used to make things as mundane as bimetallic strips in thermostats, to jet engine and fuselage components.

The marriage of these two basic fabrication processes in the form of "platelet technology" was first accomplished by Aerojet, an American rocket and missile propulsion company, in the mid-1960s to address liquid rocket injector design and fabrication needs. Over the next 40+ years the nuances of designing and fabricating platelet devices were developed and the technology branched into other areas including thermal management devices. HEXCES, through its aerospace heritage, now leads the field in this highly mature technology.

**11. Can a CPHX be made using 3D printing?**

While a growing and highly intriguing technology, capable of producing relatively small heat exchangers, metal 3D printing has limitations that make it unattractive for many CPHX applications. Of the available metal 3D printing methods, the most applicable are those employing lasers and powder bed technologies. While capable of achieving comparable basic feature size, they suffer from gravity effects on horizontal channels affecting shape and tolerance control. Metal 3D printing also produces high residual stress, can produce non-homogenous material properties and has a low deposition rate. Currently, material choice and equipment size are limited. There is also the problem of removal of the residual powder from the inherently long and small cross section CPHX passage ways. Assuming most of these limitations are overcome with continued process development, including, say, a tripling of the deposition rate, it would still take over 52 weeks of continuous 24/7 printing to produce the cores for a typical 11 tonne CPHX assembly. Platelet technology produces a finished CPHX assembly of this class in a fraction of the time.

**12. What sets HEXCES apart from the competition?**

There are a few things that set HEXCES apart from the competition.

First, HEXCES design and engineering capabilities and breadth of knowledge are unmatched by any other known company. HEXCES personnel have been developing CPHXs for over 35 years and have a combined experience in platelet device design, analysis, manufacture, and test in excess of 200 years. In fact, HEXCES' heritage is directly traceable to the inception of the CPHX, first developed in the aerospace industry in the mid-1970s, and the invention of platelet technology in the mid-1960s.

Second, HEXCES development capabilities far exceed that of the competition. Not only do we take advantage of the most advanced programs for computer aided design, such as computational fluid dynamics (CFD) and finite element analysis (FEA), but our manufacturing and process engineers are on the cutting edge of relevant process development, having successfully developed many of the processes used in the fabrication of CPHXs and other platelet devices. In addition, HEXCES has multiple dedicated performance test beds, capable of small-scale to full-scale operation of the exchangers under actual operating conditions. This allows us to certify one or every CPHX produced, depending upon customer requirements.

Finally, our commitment to quality, safety, and customer satisfaction. As an ISO 9001:2015 certified company, we have proven processes in place to ensure quality products are delivered to our customers every time, on time. We strive to constantly improve our products and services by continually reviewing results, policies, procedures, and customer feedback. To support our customers HEXCES offers services to cover every stage of the CPHXs life cycle, from our applications engineers who ensure the right product is supplied to each unique application, to our field services team who support installation, commissioning, inspection, maintenance, and decommissioning of our products. As an example of our commitment to our customers, we recently launched our filtration design and supply service to ensure long life and minimized maintenance of our CPHXs.

**13. What certifications does HEXCES hold?**

HEXCES, through its parent company, Clean Energy Systems, Inc., holds the following certifications: ISO 9001:2015 and ASME Boiler and Pressure Vessel Code (BPVC) U and R Stamps.