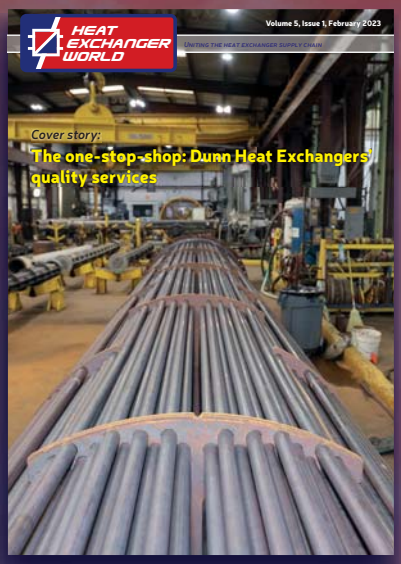
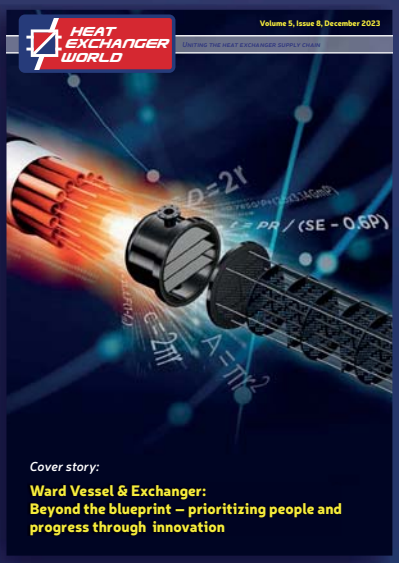
HEAT EXCHANGER WORLD 2023

YEAR IN REVIEW





Heat Exchanger World 2023: Year in Review

Heat Exchanger World is the global magazine connecting those working in the heat exchanger supply chain

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EDITORIAL

A year of progress!

2023 has been a year of growth for Heat Exchanger World. Following on from the success of our first ever European event in 2022, this year was about focusing our attention on what the industry needs and how we can be the best platform for sharing knowledge for the heat exchanger sector.

We engaged in more conversations than ever, travelling to Poland, the UK, Belgium, Spain, Italy and beyond to meet with our community and learn about the successes and challenges of the heat exchanger industry. At every opportunity, you showed us how innovative, enthusiastic, and dedicated the people of this community are, sharing your passions for complex problem-solving, for attracting new talent into the industry, and for anticipating the demands of the future energy scenario.

The purpose of the Heat Exchanger World Year in Review is to celebrate these qualities of our community. In this review, we have collated some of the most interesting and well-received articles from the 2023 publications. One article has been selected from each issue, covering new technologies, research, wider industry perspectives, and key projects.

Here, we also highlight the success of the fourth edition of Heat Exchanger World Americas Conference & Expo, held in Pasadena, TX, in October and organised by our Toronto team. The event offered a platform for profound technical discussions during the conference and exciting business propositions on the expo floor, all in an atmosphere that characterises our vibrant American community. You can read about the event on pages 4-6 of this review.

We can also take this chance to look forward to next year, as Heat Exchanger World Europe returns to Rotterdam in November 2024! We have big ambitions and we are working on the foundations laid in 2022, during which we collected feedback from a large number of visitors, exhibitors, and conference participants. On pages 34-37, you can find the Call for Papers which shares all information for those interested in participating in our 2024 European event. If you would like the chance to shape our conference programme, please submit your abstract and presentation ideas by Monday 5th February.

So, as 2023 approaches its close, it's clear to see that there are exciting things on the horizon for Heat Exchanger World! We extend a genuine thank you to all of our readers, contributors, presenters, exhibitors, and customers.

Wishing you a happy festive season and year end,

The Heat Exchanger World Team.

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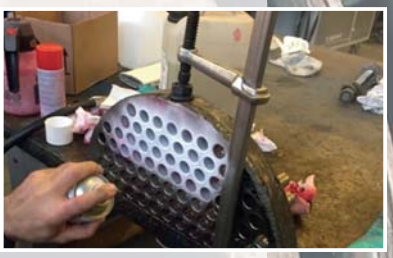
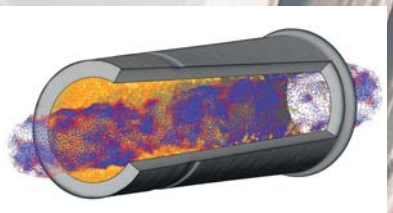




Heat Exchanger World Americas 2023: An Unprecedented Success!

Heat Exchanger World Americas 2023, held at the Pasadena Convention Center, exceeded all expectations and emerged as a resounding success. With over 1,300 registrations, this year's event provided a bustling platform for heat transfer enthusiasts to explore vendors, network, and stay updated on the latest industry developments and trends.

By Angelica Pajkovic

Sponsored by Brask Inc., Cust-O-Fab, Dunn Heat Exchangers, Elliott Tool Technologies, Flexitallic, Ohmstede, Superior Plant Rentals, TEADIT, Vahterus, and Ward Vessel & Exchanger, the 4th annual event served as a remarkable opportunity for companies to showcase their value propositions to a diverse community. Attendees forged crucial end user connections across various industries, including oil & gas, chemical, petrochemical, water & wastewater, and more.

Day one: engaging program

Manufacturers, suppliers, and distributors took centre stage during Day One of the exhibition, presenting their cutting-edge products, technologies, services, and capabilities. Simultaneously, they leveraged this gathering to initiate new business relationships and strengthen existing ones.

The technical conference ran parallel to the expo, featuring heat exchanger experts from diverse sectors who delved into a wide spectrum of topics relevant to the heat exchanger and heat transfer industries.

The conference kicked off with a keynote presentation by Chairman Bill Ashenhart from S&B Engineers & Constructors, on Meeting Constantly Changing Requirements in our Daily Activities. This Chairman's welcome was followed by an informative presentation by Ashley Hinojosa from HTRI, on Electric Heaters 101.

The morning session then transitioned to an interactive and engaging panel of industry experts who discussed Design & Specification with a focus on TEMA, API 660 & 661, PIP, ASME, ISO, PPC-1, and End User Specifications. The panelists provided an overview and discussed the good, the bad & the ugly of working with different heat exchanger standards & specifications.

After the lunch break, the conference broke down into two concurrently running Workshop Sessions.

"What impressed me the most about Heat Exchanger World Americas 2023 was the tremendous turnout. This industry has clearly spoken and demanded such an event. The event provides a forum for the entire heat exchanger community to meet, interact, and learn. I cannot wait to see what Heat Exchanger World Americas does in 2024."
Event Attendee

The first workshop focused on Maintenance, Cleaning & Antifouling, while the second workshop took a closer look at Design, Specification, & Testing. Presenters highlighted some of the typical challenges encountered by designers and fabricators while also showcasing some of the new technologies that can help to overcome these obstacles. Both presenters and attendees enjoyed plenty of discussion and interaction through several questions and conversations following the conclusion of the sessions.
The day concluded with an engaging happy hour, which transitioned into a dynamic cook-off abounding with great food and live entertainment. We would like to express our gratitude to all the companies that tantalized attendees' taste buds with their delectable offerings and to congratulate TEADIT for their cook-off victory. Attendees socialized and enjoyed each other's company, facilitating great future connections, all while listening to the amazing performance by The Spazmatics.

Day two

Day Two began with a dynamic keynote address on the Energy Transition – Net Zero by 2050, given by Naomi Jabbari from S&B Engineers & Constructors. This topic led seamlessly to the second keynote of the day, Adoption of New Technology – Don't be Resistant to Change, given by Fred Schweighardt from Airgas, an Air Liquide Company. The panel discussion between experienced engineers and attendees which followed provided a great opportunity to solve major heat transfer problems which are not covered by commercial standards. With a focus on Managing Aging Plants, Equipment Upgrades, & Best Practices, this panel discussed how to get the most out of the lifespan of heat exchanger equipment. It also provided a great platform for members of the audience to ask their questions, receive feedback, and even initiate debate within the community.
Rounding out the conference were four more concurrently running workshops. The first workshops of the day featured presentations on Bolted Joints, and Fabrication & Welding. The second cohort looked at Other Types of Heat Exchangers, and New Technologies & Material Selection. Each session allowed attendees to interact and learn from the compelling presentations, as well as ask questions and network before the conference's conclusion.

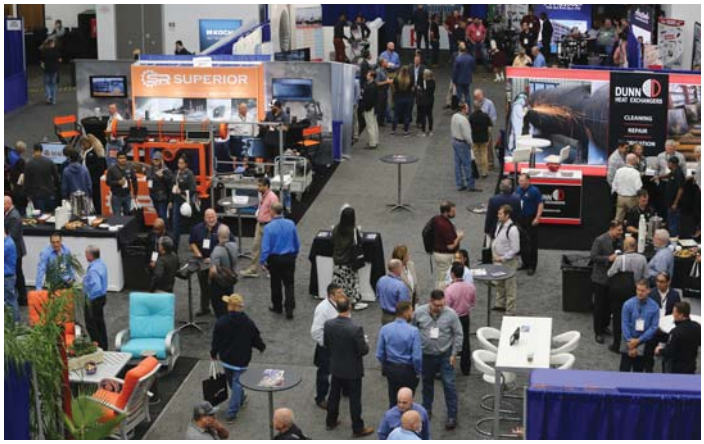
Networking on the expo floor

During the entirety of this two-day event, attendees had the opportunity to walk the expo floor and visit numerous vendors showcasing their new technology and latest product developments, all the while networking and forging connections.
Networking with industry peers is a vital aspect of the Heat Exchanger World Americas experience. The diversity and thought involved in each feature of the expo ensured that each of the attendees who partook in the event was left with an unforgettable experience.

Looking forward

The success of the Heat Exchanger World Americas Conference & Expo would not have been possible without the dedication and support of our sponsors, panellists, and presenters. We extend our heartfelt thanks to each one of them.
Looking ahead, mark your calendars for the next edition of the Heat Exchanger World Americas Conference & Expo, set to return to the NRG Center on October 15th and 16th, 2024. We eagerly anticipate your presence and invite you to participate in what promises to be another milestone event in the heat exchanger industry. ■

For more information, please visit https://heat-exchanger-world-americas.com/.
If you would like to participate in the conference or submit an abstract for a presentation, please contact Sara Mathov at s.mathov@kci-world.com.
For more information on how to become an exhibitor or to book your booth today, please contact Roger Caetano at r.caetano@kci-world.com.



The expo floor was packed with vendors showcasing their new technology and latest product developments.

The technical conference featured heat exchanger experts from diverse sectors who delved into a wide spectrum of topics relevant to the heat exchanger and heat transfer industries.

A panel of industry experts discussed Design & Specification with a focus on TEMA, API 660 & 661, PIP, ASME, ISO, PPC-1, and End User Specifications.

Networking is a key element of the Heat Exchanger World Americas event.

Attendees networked and enjoyed each other's company while listening to an energetic performance by The Spazmatics.

Heat Exchanger World Americas thanks its sponsors for their support:

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Pressing forward: Tranter's Vänersborg facility makes plates for the future

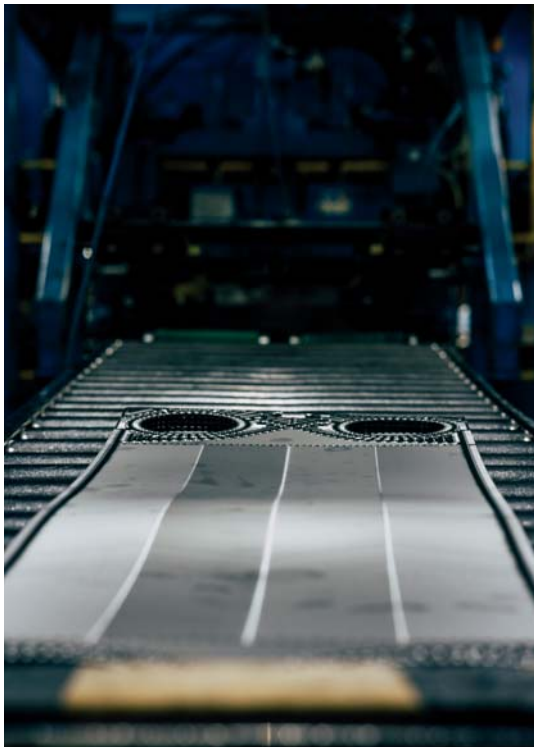
2023 stands before us all as a looming question mark. But with uncertainty comes possibility. If the well-known proverb tells us "necessity is the mother of invention," an unprecedented energy crisis, war in Europe, and urgency for meaningful environmental policies certainly classify as a time of necessity. Fortunately for our industry, the heat exchanger is a key piece of equipment for the most likely future energy scenarios.

By Ellie Pritchard, Heat Exchanger World

Tranter is a global manufacturer of gasketed and welded plate heat exchangers and a service provider, and the company's extensive reach and experience tells them that, for the heat exchanger industry, the future is bright. I was able to speak with the Tranter team about the trends they see in emerging applications and the unique technology of the company's manufacturing facility in Vänersborg (Sweden), which enables them to offer solutions for these new industries.
For a well-rounded insight, I spoke with Thomas Cassirer (Director of EPC & Energy), Van Aznavour (Sales Manager – Benelux & Germany), Madeleine Sestan Bach (Global Marketing Manager), and Tomas Örtendahl (Plant Manager – Vänersborg).

Emerging markets

Van Aznavour has been working for Tranter for five years and is the regional sales manager for capital sales in Germany and the Benelux region, as well as country manager for Germany. Amongst his many other responsibilities, Van focuses on new trends and applications and has a keen understanding of what his regional customers are calling for. "Geothermal is one very interesting and important application, not only in Germany, but all over the world," says Van. "There is still much to do and although much progress has been made over the past ten years, there are still many new possibilities for using geothermal energy for heating."
Thomas Cassirer holds a strategic global position observing current market trends and driving business in their direction. Thomas also works alongside EPC contractors to understand their needs and translate those into solutions. "Saving heat is a very important part of the energy situation right now. There are a lot of changes happening in the industrial sector in particular," Thomas confirms. "For example, we are seeing an increase in LNG projects due to the Russia-Ukraine war. High demand, combined with increased urgency, means an increased demand for fast-tracked products."
There has already been an increase in LNG projects with the majority appearing in Germany and the Netherlands. Although few and far between, the scale of the projects always results in huge opportunities where heat exchangers are concerned.



Unique pressing machines facilitate longer, deeper pressed plates which are ideal for largescale applications.

One example of such a project was carried out with Nederlands Gasunie through a UK based EPC company. Tranter was contracted to provide a dockside heat source for an LNG regasification plant in Eemshaven, the Netherlands. It was the company's EU-based production which ensured it could meet a tight 14-week deadline (from instruction to delivery), along with the coil stock and press capacity of the Vänersborg facility. The project contributes to the diversification of energy supply, an issue of global scale since the Russian invasion of Ukraine and the loss of Russian gas supply.
Both Thomas and Van, from their respective global and regional perspectives, see a shift in approach to heat recovery processes with heat now being seen for its valued energy potential. What used to be considered an idealist but expensive solution is now an obvious alternative to using expensive gas.
"Companies have much higher costs to calculate than before, so they can now see the sense in investing in more efficient heat recovery systems," says Van.

Predicting the near future

Looking to the coming years, both Thomas and Van see the traditional market sectors remaining stable but enjoying a boost from increased demand for renewable energy applications, such as geothermal due to a rise in district heating networks, hydrogen, LNG, and carbon capture systems (CCUS).
"Total growth rate (industry demand) for plate and frame heat exchangers is currently more than 5%," Thomas

Introducing automated processing methods to the facility, robots are used in the gluing process of the smaller plates.

confirms. "Industry demand for hydrogen is set to grow by 20-25% and we expect a similar growth for carbon capture systems. We aim to become a trusted advisor in these sectors."

"Developments in green and blue hydrogen are especially important in Asia Pacific and Europe, as well as renewable energy applications to produce the hydrogen," he adds. "These processes require multiple heat exchangers in their systems, so they are another good source business for us."

"In general, we also see an increased demand in CCUS applications, as the global focus has also become more environmentally conscious," says Van. "So, the key thing to understand is that the process industries have many different focuses at the moment: The environment, war, energy supply in general, and the cost of living. And carbon capture is one part of the solution to these global problems."

It is therefore clear that a holistic approach is needed – a variety of solutions are required to tackle a variety of challenges, and heat exchangers are necessary for many of these solutions. For many manufacturers, the challenge is ensuring that their product range is well-equipped to handle these new applications. This is where Tranter's Vänersborg facility plays its part.

"To face these demands, you of course first need the right product," Van explains. "For these applications, we normally need very high temperatures, very small logarithmic temp differences/very small temperature approaches, and high NTUs – that means that the temperature jump is very high and for this you need long plates/long thermal length. This is what Tranter does. Due to the high temperature deeper pressed plates can be advantageous, because those plates will be assembled with thicker gaskets which last longer."

Beyond this, both Thomas and Van acknowledge the importance of continuing a communicative relationship with customers. "Smart services are another new focus for us, helping to build lasting partnerships with customers. Ideally, they give us their operating process data so that we can analyse and help them reduce their downtime, by suggesting preventive maintenance, and so on," says Thomas. "Suppliers must take more responsibility for reducing the total cost of ownership."

Vänersborg facility

The Vänersborg facility is a vital part of the Tranter production line. Its unique pressing machines facilitate longer, deeper pressed plates which are ideal for large-scale applications. The process is unique in that sheets

The heat exchanger is a key piece of equipment for the most likely future energy scenarios.

The machines in the Vänersborg facility enable the easy switching of presses so that all designs can be produced in the longer lengths.

are fed through continuously, pressed and then cut, meaning that Tranter can provide plates of impressive scale at a fast rate - medium sized plates in 30 seconds, and large plates in minutes. All scrap material is collected and recycled, and the facility produces its own geothermal energy for heating, only purchasing renewable energy.

In addition to the deeper press, the plates also have application-specific formations such as hexagonal and chevron designs. The machines in the Vänersborg facility enable the easy switching of presses so that all designs can be produced in the longer lengths. Most plates are produced in stainless steel or, in cases of seawater cooling, titanium - for green hydrogen, nickel alloys or exotic materials are preferred.

The longest plates so far produced for a customer measured 3,5 metres in length, but the Vänersborg facility proudly displays a 6-metre-long plate in its workshop, a fun reminder to its team that anything is possible. "It is very unlikely that a customer will have a need for such large plates," Plant Manager Tomas Örtendahl admits with a smile. "But, should the opportunity ever arise, we are the only facility capable of producing plates to this scale."

Another feature of the facility is its automated processing, transitioning to a highly skilled workforce supported by digitisation. For example, robots are used in the gluing process of the smaller plates, whilst the larger plates require human hands to apply the glue. Madeleine explains that there is more focus on a lean but highly trained workforce. "Tranter sees a future in a workforce which is competent in a multitude of skills, and acknowledges that digitisation is part of the solution, but not the be-all-end-all answer to wider industry's challenges," says Madeleine. "For us, this begins with the implementation of a new ERP (enterprise resource planning) connected to a marketing automation system to be able to provide the ultimate customer experience."

To future-proof the company's problem-solving capabilities, a diversely trained workforce ensures that Tranter will be capable of answering the yet unknown issues in years to come.

"In general, we don't see ourselves as simply a components supplier. We have so many customers now that need more than that due to these new emerging technologies," Van states. "We need to work alongside them to learn more about how to tackle future challenges. They need alternatives, and to understand the reality of different options – In turn, we have to be informed and provide not only standard solutions, but intelligent ones." ■

Madeleine Sestan Bach (Global Marketing Manager) and Tomas Örtendahl (Plant Manager – Vänersborg) at Tranter's Vänersborg facility in Sweden.

Why we implemented ISO 14001 (and why it is important)

At Sterling TT, we wanted to have top-class environmental management systems in place. To make this happen, we sought certification for ISO 14001, the international standard for effective environmental management systems.

Being ISO 14001 certified demonstrates an ongoing commitment to improving environmental performance, such as reducing waste, saving energy, and minimising carbon footprint.

All text and images courtesy of Sterling Thermal Technology

We are fortunate that our top management is committed to improving Sterling TT's environmental performance. Our CEO, Emrah Gozturk, listed environment management at the top of his priorities in an interview with British Manufacturing Podcast. Getting our company ISO 14001 certified is part of his wish "to leave our children a better world." He does not only want to "help our customers to reduce their impact on the environment"; he also wants our company and employees to do so.

Lee Hatton, our Quality & Environmental Officer, has spearheaded this recent push. When Lee started at Sterling TT, there were some actions to protect the environment but no formal environmental management system in place. So, in today's world, where reducing environmental impact is crucial, we recognised our existing approach left a lot of room for improvement.

With the will to become a leader in eco-friendly heat exchanger manufacturing practices, Sterling TT has made exciting improvements in the last 12 months. This article explains the changes we made to comply with the standard, and the benefits we saw as a result.

What is ISO 14001?

ISO 14001 is an internationally recognised standard that maps out a framework for companies to set up an effective environmental management system (EMS). It helps meet environmental regulations and improve efficiency and environmental performance.

Being ISO 14001 certified demonstrates an ongoing commitment to improving environmental performance, such as reducing waste, saving energy, and minimising carbon footprint.

Each industry and company is different and the actions they can and should take also are. Therefore, ISO 14001 is not about meeting specific targets or taking particular actions. You must have an effective framework in place for compliance and improvement.

The structure of the standard is based on the cycle of the "Plan-Do-Check-Act" approach and includes clauses about leadership, documentation, and performance evaluation.

Areas of improvement for Sterling TT

Waste management

For us, one priority was waste management. As a manufacturing company, there will always be some quantity of raw materials that end up as waste, and processes that have the potential to create hazardous by-products, such as effluent. These can harm the environment if not controlled and disposed of properly.

To minimise our impact, we asked ourselves questions about our waste streams, such as:

- Where does our waste end up?
- Is it being disposed of correctly?
- Are the companies we are using registered waste handlers?
- Once it goes to them, how are they disposing of it?

"It was quite interesting to find out where our waste ends up. The companies that we currently use are good. There's nothing to landfill whatsoever. So, we're 100% on landfill diversion." Lee Hatton, Quality & Environmental Officer

By enhancing our recycling systems, we are contributing to the circular economy.

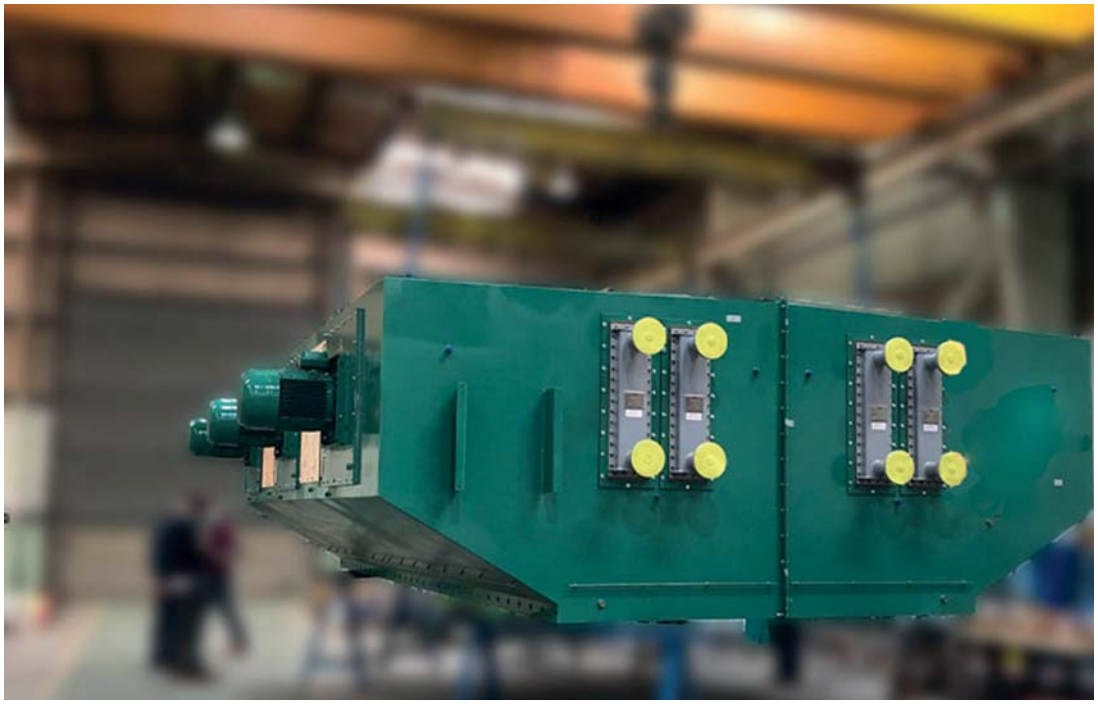
Energy usage

At Sterling TT, we always look at ways to reduce the amount of energy we use.

In the past, we failed to fully monitor our energy usage, but we're glad to say that we now do. We can look at where we use energy and where we can reduce its usage. The result is positive: we anticipate a significant energy usage reduction in 2022 compared to 2021.

We are also exploring ways to further improve on our energy use by implementing other energy sources such as solar panels, combined heat and power systems, battery storage, and voltage optimisation. We are also looking at updating machinery and equipment for more energy-efficient ones.

We're willing to investigate everything, whether it is a significant trendy change like installing solar panels or a mundane but effective one like replacing windows. A lot of heat can be lost from low-quality windows. If they haven't



CACW to equip a rotating stabiliser.

been replaced for a long time, it's an excellent opportunity to save energy.

Supply chain

The locations of our suppliers make a difference. Where possible, we only use UK or European suppliers to reduce the carbon emissions of transporting materials around the globe. We also have started checking our suppliers to see if they are ISO 14001 compliant. By ensuring they are, we know the positive impact on the environment doesn't stop at Sterling TT.

Heat exchangers

The main way to make a heat exchanger more environmentally friendly is by looking at the lifespan.

- Can we improve heat exchanger designs so that they last longer?
- Can we offer a refurbishment?
- How are these units disposed of?
- Do they contain hazardous material we need to make our customers aware of? Do we offer the best advice on how they dispose of it?

Of course, we already design heat exchangers to last as long as possible, and offer an aftersales service to our customers. But there is never a bad time to ask ourselves how we can make things even better.

Other changes

A thorough investigation of your processes can sometimes inspire changes that aren't obvious. For example, we discovered that grants are available for offering electric chargers on our premises for employees with electric cars.

There is no cost to our employees: they can come and charge their vehicles for free. It gives our staff an incentive to use electric cars. It might also facilitate a future electric car fleet for Sterling TT. We're always looking ahead.

How we implemented ISO 14001

Starting the certification process

We bought a copy of the ISO 14001 standard and investigated what we needed to do as a company to be certified. Then we selected TUV, a large and well-recognised certification body, to help go through the process. This part of the journey started with a pre-audit.

Engaging the company

A top-down approach is vital when it comes to significant company changes. We needed engagement from the management team to ensure they could provide support. With our management on-side, we worked from top to bottom. We organised training, monthly meetings and communication boards for the production members. We looked at systems at every manufacturing stage, from pre-production to after-production/post-production.

When new processes and procedures are in place, they must be filtered down to the shop floor.

Training

To kick off our new environmental management system with our staff, we presented an overview of the environmental fundamentals and how they apply to Sterling TT.

- What environment means
- The impact we could have on the environment
- Why it is beneficial to implement changes
- Why we should be more environmentally friendly
- How we can avoid pollution
- Where we should dispose of our waste
- How we can save energy in the company

Then, we made further training sessions that were more specific to people's job roles. For example, spill kit training and waste consignment note training. The goal was to make our staff aware of getting the correct documentation when moving hazardous waste.

Every month, we had a meeting in which we discussed anything that had cropped up in the month. We discussed any improvements and gave people a chance to contribute. How could Sterling TT do better? We included every department of the company, from the shop floor to the boardroom, so everyone knew what was happening. The advantage of these meetings was that we pulled in perspectives from across the company. Staff working in these departments could have seen something the environmental officer may have missed.

These meetings also kept all staff engaged and ensured they knew they could make a difference.

In addition, we created monthly notices. They provided data on how much waste we generated, how much energy we used, and even how much scrap metal we produced. That way, everyone knew where the company stood compared to its targets.

An ongoing process

ISO 14001 certification isn't a one-and-done situation. TUV will now come in once a year to audit our Environmental Management System to ensure we still comply with the standard.

That means continuing and improving our actions, training, and understanding legal requirements. Are there any new legislation, directives or messages from the Environment Agency that we should be aware of and consider?

You don't get complacent when it comes to environmental management.

The challenges we faced

Timescales

Sometimes being too eager can be challenging. It was the case with our original goals for ISO 14001 certification; we wanted it in place within six to nine months. The sheer effort and commitment that had to go into getting it in place in the time frame was quite something, but we managed to achieve it!

Legislation

There are a lot of legislation and regulations to get to grips with. We used the guidance of the Environmental Agency (EA) to help us put a legal register in place and make sense of the law. Still, even then, it was time consuming to determine what legislation was relevant to Sterling TT.

Changing perceptions and habits

As with any successful, long-running company, we are blessed with people who have been here for many years. They bring tremendous experience and institutional knowledge to the table, but some are set in their ways; they have been doing their work a certain way for many years.

We heard comments and questions such as: "I don't understand the point of doing this. It's less convenient." And even: "Why can't we chuck this down the drain?"

"We made ourselves available to answer any questions and concerns about new ways of working. We found that, as long as we explained the reasoning behind the changes, our colleagues adopted the changes quickly and smoothly," said Lee.

The benefits we have seen

We can talk about benefits in multiple categories:

- Benefits to the environment
- Benefits to our customers and suppliers
- Benefits to Sterling TT

Reducing waste, energy usage, and carbon emissions from transporting materials, as well as preventing pollution, are the obvious changes to implementing an effective Environmental Management System. Nevertheless, they result in a smaller carbon footprint for our company. A little less greenhouse gas spreads into the atmosphere.

Reducing our carbon footprint helps our customers to be more environmentally friendly too. For customers that integrate social and environmental concerns in their business operations and interactions with their stakeholders, it's crucial to work with suppliers that take actions to preserve the environment. Customers increasingly ask to fill out questionnaires to understand what we do to improve our environmental performance.

By obtaining ISO 14001, we prove to our customers that we are aware of our environmental impact and work on it to reduce it. Also, getting more environmentally friendly is aligned with Sterling TT's values.

Furthermore, failure to comply with environmental laws can result in significant fines for companies.

With an up-to-date legal register and systems in place to respond to changes in the law, we ensure Sterling TT does not get fined and is always compliant with legislation.

Finally, by reducing energy usage, we are saving money, which we can reinvest into our technology and processes, benefiting customers who purchase our heat exchangers or aftersales services.

What next?

So yes, we've got the 14001 certification, and that's a considerable achievement for Sterling TT. We're very proud of the progress we have made so far.

Now our company needs to keep up the good work. Part of the ISO standard says that to maintain certification, you need to show evidence of continuous improvement.

"There's always new technology coming out, and it's a case of where we can improve, how we do it, how much it is suitable for Sterling TT, and how quickly we can implement this to improve our environmental performance." Lee Hatton, Quality & Environmental officer at Sterling TT. ■

About the company

Sterling TT has been a pioneer in heat exchange innovation since 1904. It designs and manufactures customised heat exchangers. Besides, it has a robust aftersales department offering spares, TIR (test, inspection, and report), replacements, repairs, overhauls, offshore surveys, and maintenance services of existing heat exchangers. Sterling TT, located in the UK, delivers globally.

Mock-up of tube-to-tubesheet joints in shell and tube heat exchangers

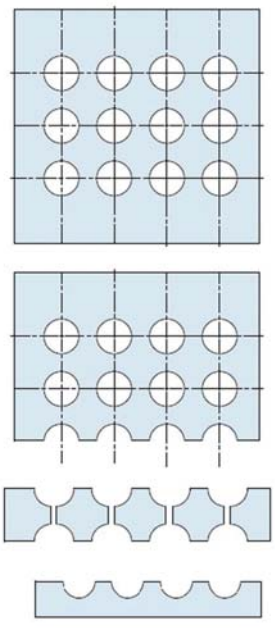
The tube-to-tubesheet joints in a shell and tube heat exchanger are critical locations which in many cases govern the life of the exchanger or call for unplanned outages in order to be repaired or plugged. There are many factors which should be considered in order to ensure long-lasting reliable joints.

By Baher Elsheikh, Lead Mechanical Engineer - SABIC

Those factors include the type of the joint (expanded only, welded and expanded, or welded only); design of the joint (weld size, expansion grooves size, configurations of the weld groove); method of application (mechanical expansion, hydraulic expansion, manual welding, orbital welding); and, quality control and inspection techniques used during fabrication (eg. tubesheet hole surface finish, bevel size, dye penetrant test for welding joint, hardness test, sensitive leak test by helium, hydrostatic test, tube expansion ratio measurement, ferrite content measurement, radiography examination); in addition to the qualifications of the joint through the applications of the mock-up.

A successful mock-up

A mock-up model is one of the important steps should be performed before the actual tube-to-tubesheet joint application, where confidence can be built for the design of the joint, quality of the tools and techniques applied, and qualification of the welder(s) and procedure.
To ensure the successful application of the mock-up, a detailed procedure should be prepared including the sequence of application, sketch and dimensions of the used material, testing to be applied, acceptance criteria and template for the output results report.



Mock up model for square layout.

General consideration and best practices to be considered while preparing the mock-up procedure:

- ASME BPVC Sec. IX QW-193 to be followed with additional requirements based on a case-by-case basis
- Mock-up required for each welding/procedure qualification
- The mock-up assembly should essentially duplicate the tube-to-tubesheet weld joint design to be used in production
- For tube-to-tubesheet welds to clad tubesheet, the cladding or overlay may be represented by a base material with a chemical composition that is essentially equivalent to the cladding composition
- The mock-up should consist of a minimum of 10 tubes for procedure qualifications and a minimum of 5 tubes for each welder qualification.
- Hardness testing to be considered for work with hardening materials (ex. DSS and Ti) or for service requirements (e.g sour service)
- It is advised that the dummy tubesheet is made from the same material of the production tubesheet, to ensure that HAZ in the mockup (dummy) tubesheet will provide representative results

All mock-up procedures should consider the following:

1. Check the conditions of the tubesheet holes and tube surface
2. Measure and record the actual diameter of the holes, Tubes' inner diameter, tube thickness for all tubes in four points with a micrometer to have accurate measurements.
3. Follow the same sequence of expansion and welding as agreed for the production.
4. The tool will be used for expansion (mechanical or hydraulic) and its model and applications steps to be mentioned in the procedure
5. Liquid penetrant for root pass and final pass

DPT for mock-up model.

Macro examination with 3.5% magnification of cladded tubesheet.

6. Visual examination: complete fusion, free of visual cracks, porosity indications, no evidence for tube burn through
7. Measure and record the actual tube ID after expansion and calculate wall reduction ratio for all tubes
8. Macro examination: section the mock-up through the centre and the 4 exposed surfaces to be smoothed or etched. Use magnifications 10 X to 20 X (preferred 20 X for better visibility) to check the following:
   - Minimum Leak Path (MLP)
   - No cracking
   - Complete fusion
   - Complete penetrations
9. Calculate and record the actual expansion ratio for each tube. All values should be tabulated and compared to the target expansion ratio
10. In hydraulic expansion the applied pressure should cause the tube to take exactly the shape of the hole including the grooves and the imperfections or scratches (should they exist)
11. Mechanical roller must be clean as well and free from scratches or imperfections. Its lubrications, temperature and performance should be monitored during application.

Tubesheet hole preparation

Holes to be drilled in the dummy tubesheet which will be used in the mock-up should have the same quality and fabrication requirements applied as the actual tubesheet holes drilling. Below is a list of the main requirements:

- Preparing the tube holes in the mock-up tubesheet must be done using the same technique to be used for drilling the actual tubesheet to have a clear representative view about the quality of the drilled holes
- Holes should be free from radial or longitudinal scratches or imperfections
- The inner surface of the tubesheet holes should be in as machined conditions (no need for polishing)
- Tube holes and tube external surfaces should be cleaned
- Longitudinal scratches are of higher risk as it would create leak pass across the joint, please check the schematic sketch for elaboration
- The outer tube surface at the interface with hole should be also free from scratches or imperfections

Minimum Leak Path (MLP)

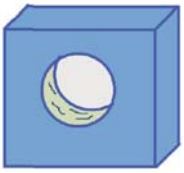
Minimum Leak Path (MLP) is an important parameter for the strength weld type tube-to-tubesheet joint. MLP is the minimum path where the media can leak and can be defined as the minimum distance in any direction from the root of the tube-to-tubesheet weld to the nearest surface.

MLP will depend on the type of the joint (fillet / groove / Fillet + groove / … etc.) and the actual shape of the applications (concave / convex / actual geometry / …etc.). In API 660, MLP is required to be no less than two-thirds of the nominal tube wall thickness. While in ASME BPVC section IX, it is required to meet the design, but there is no specific requirements for how to be identified.

The sketch below shows the MLP for different configurations of strength welded tube-to-tubesheet joints, colored red.

In order to achieve the requirement of ASME Sec. IX, below are two demonstrative examples where the strength weld size is calculated as per rules of ASME BPVC Sec. VIII div.1 – UW.20 and then to be used for calculating the MLP length, as defined in the red lined marked sketches. Calculated values will be compared with the two thirds of the tube thickness as per API 660.

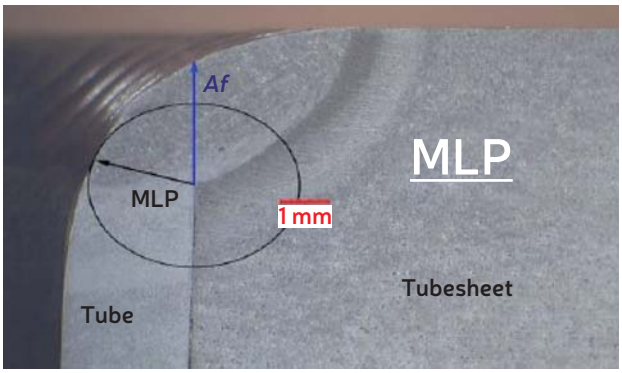
Longitudinal imperfections.



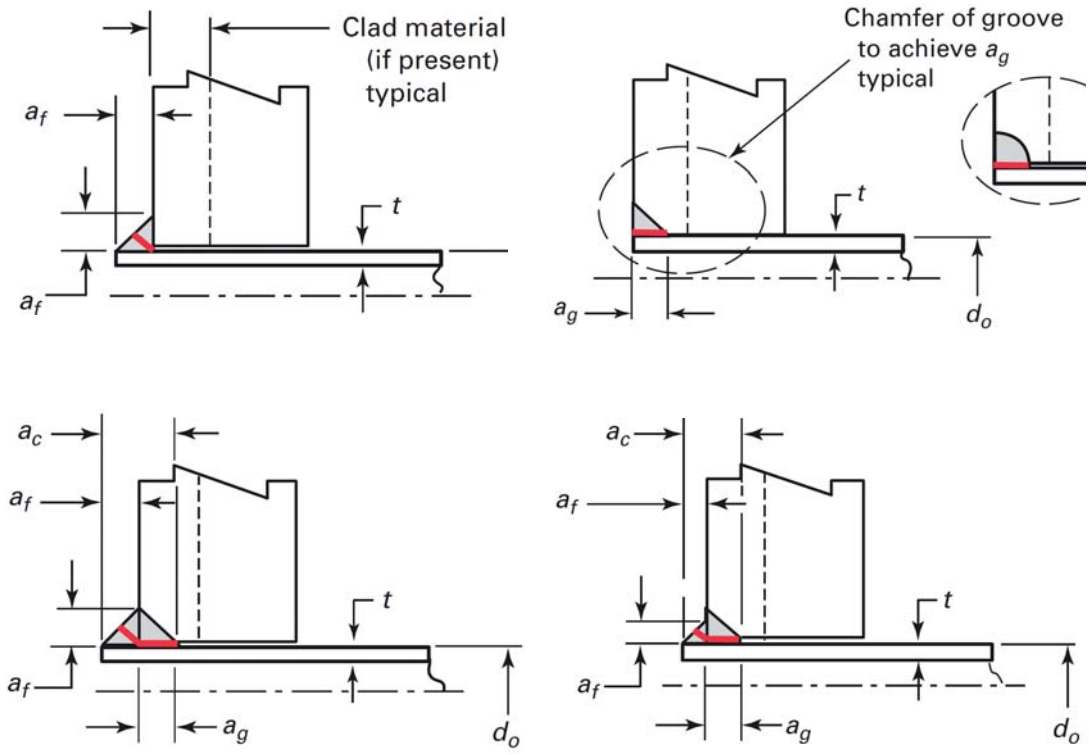
Radial imperfections.

Internal gauge measurement.

Internal three point expanding dial caliper.



MLP = the radius of the largest circle totally inscribed in the weld whose centre is situated at the root of the weld.



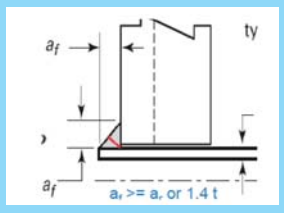
MLP for different ASME joints.

Key examples

First example: Fillet weld – full strength weld joint

$$a_r = \sqrt{(0.75d_o)^2 + 2.73t(d_o - t)f_w f_d} - 0.75d_o$$

Sa = 92.4 Mpa ….. Tube all. stress ASEM sec. II part D
St = 138 Mpa….. Tubesheet all. stress ASEM sec. II part D
Fw = Sa/Sw = 1 (Sw is smaller of Sa and St)
Fd = 1 for full strength weld



Example 1.

$$a_r = \sqrt{[(0.75 \times 19.05)^2 + 2.73 \times 2.018 \times (19.05 - 2.018) \times 1 \times 1]} - 0.75 \times 19.05$$

ar = 2.93 mm ……. 1,4t = 1.4 × 2.018 = 2.825 mm
af >= greater of ar or 1.4t …….. af = 2.93 mm
MLP Throught distance = af / 2 = 2.93 / 2 = 2.07 mm

Calculated MLP = 2.07 mm
MLP as 2/3 t = 1.405 mm …… per API 660

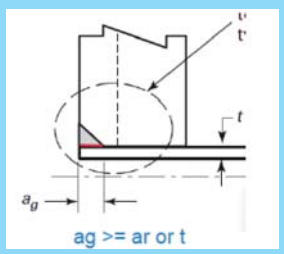
Second example: Groove weld – full strength weld joint

$$a_r = \sqrt{(0.75d_o)^2 + 1.76t(d_o - t)f_w f_d} - 0.75d_o$$

Sa = 92.4 Mpa ….. Tube all. stress ASEM sec. II part D
St = 138 Mpa….. Tubesheet all. stress ASEM sec. II part D
Fw = Sa/Sw = 1 (Sw is smaller of Sa and St)
Fd = 1 for full strength weld

$$a_r = \sqrt{[(0.75 \times 19.05)^2 + 2.73 \times 2.018 \times (19.05 - 2.018) \times 1 \times 1]} - 0.75 \times 19.05$$

ar = 2.93 mm …….
ag >= greater of ar or t …….. ag = 2.93 mm
MLP = depth of groove = ag = 2.93



Example 2.

Calculated MLP = 2.93 mm
MLP as 2/3 t= 1.405 mm …… per API 660

Please note the big difference between the calculated value considering the design calculations and the general rule form API 660.

In these examples, the following material and design data is assumed and will be used for both examples:

- Tube material: carbon steel ASME SA 179
- Tubesheet material: carbon steel SA 266 Gr.2
- Tube DO: 19.05 mm, tube thickness BWG 14 (2.108 mm)
- Design temperature (to be used for getting the material allowable stresses): 200°C

Conclusion

A mock-up of tube-to-tubesheet assembly is a vital requirement to achieve good quality, long life joints. The successful mock-up will represent the actual conditions of the production joints and provide required inputs to control all essential and important parameters controlling the quality of the joints depend on many aspects covering the dimensions control, tools to be used, procedure and sequence to be applied, quality checks and testing. The mock-up should be a reference point in the ITP (Inspection and Test Plan) of the exchanger.

Users and owners should incorporate the application of a mock-up to ensure that detailed procedure is well-developed and reviewed including all the aforementioned aspects in addition to draft for the final report form. ■

About the author

Baher Elsheikh is a Mechanical Engineer at SABIC. He has twenty years of experience in the engineering, reliability, construction, commissioning and inspection management of pressure equipment, piping systems, fired heaters, and power boilers.

GeoHex project: Novel coatings for geothermal heat exchangers

An example of a geothermal power plant. Source: Dreamstime

Heat exchangers are critical components for geothermal applications but prone to damage from scaling and corrosion. The GeoHex consortium has been working to develop materials for heat exchangers that offer improvements in anti-scaling and anti-corrosion properties as well as heat transfer performance. These materials will afford improved efficiencies and reduced costs.

Text and images provided in collaboration with GeoHex

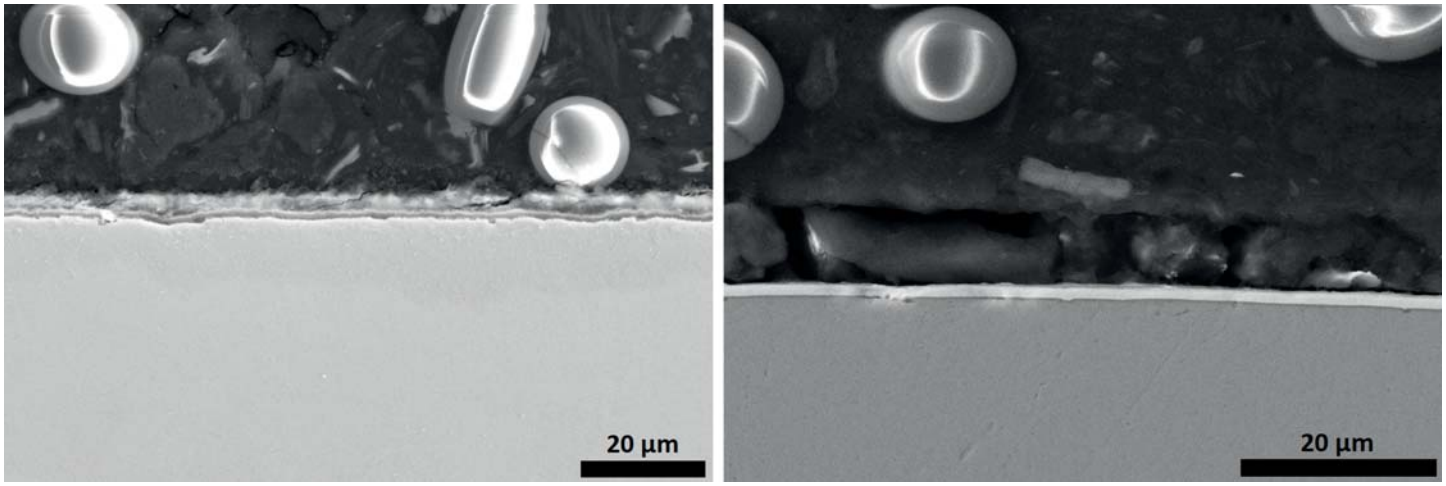
This project has received funding from the European Union's Horizon 2020 research and innovation programme. Grant agreement: 851917

The proposed way to realise the needed improvements is to use amorphous coatings. The initial challenge therefore lay in finding/developing coating materials which provide anti-corrosion and anti-scaling properties. This has led to the investigation of materials capable of not only providing the required anti-corrosion properties but also able to withstand the high temperatures associated with geothermal applications. GeoHex plans to achieve reduced scale formation in geothermal heat exchangers by using a variety of different coating types, including amorphous coatings. The project aims to take development from lab scale to full equipment scale; from working on small coupons, to heat exchanger test rigs, to relatively small but still representative heat exchangers, composing of proper geometry, corrugated plates, and pipes.

Project focus

The GeoHex project has centred its focus on Organic Rankine Cycle (ORC) powerplants due to their usability for low to medium thermal resources. In these applications, heat exchangers are used with a geothermal fluid on one side and a working fluid on the other. The working fluid is boiled and the vapour transfers energy to turbines to then generate electricity. The working fluid is then condensed to repeat a continuous cycle. The outcome of GeoHex's coating research intends to increase the heat exchanger performance for such applications, as well as to enhance anti-scaling and anti-corrosion properties. The project relies on work carried out by a consortium (see box text). Tæknisetur undertook single-phase testing analysis for multiple types of coatings manufactured using different processes, including:

- Thermal sprayed aluminium coating (TSA)
- Physical vapour deposition (Amorphous 1 & 2)
- Electroless nickel plated coatings (ENP)
- Chemical vapour deposition (MWCNT)
- High velocity oxygen fuel coatings (nanoporous)



Scanning Electron Microscope (SEM) image of tested samples. On the left side is a carbon steel substrate and on the right side is Amorphous 1 coated on stainless steel.

The Tæknisetur team assessed heat transfer performance and durability of each coating with an in-situ heat exchanger rig, installed at ON Power's Hellisheiði geothermal power plant, fitted with temperature and flow sensors, and performed microstructural analysis of tested samples using SEM/EDX and XRD, and pull-off adhesion tests.

Based on the heat transfer, microstructural analysis, and mechanical results, the following conclusions can be summarised for the single phase GeoHex coatings:

- Amorphous 1 shows great potential in silica removal where 80% of silica scaling was removed at 15.86 MPa but only 40-50% was removed on 245SMO and 316L at 27.03 MPa and 18.1 MPa respectively.
- TSA and ENP show a 45% and 35% increase in heat transfer coefficient respectively with low scaling accumulation compared to reference materials.
- 316L-Amorphous 2 sample had 4.9% lower heat transfer coefficient compared to the nanoporous-Amorphous 2 sample indicating better heat transfer performance, indicating better heat transfer performance by using the nanoporous coating.

Advantages of amorphous over crystalline structures

Amorphous materials do not have a well-defined crystalline structure, giving coatings based on them unique physical and chemical properties making them ideal for protective coatings. The lack of a crystalline structure means they can be deposited in a variety of ways (sputtering, ARC-deposition,), at mild and very scalable conditions giving precise control of thickness and properties.

Other advantages:

- Hardness and wear resistance
- Corrosion resistance
- Smoothness
- Can be designed to have enhanced properties, such as high or low reflectivity
- Electrical properties – can be designed to have high conductivity or insulation

David Ingvi Snorrason (R&D Engineer and Project Manager from GREIN research, another member of the GeoHex consortium) explains further: "Corrosion tends to occur on grain boundaries and amorphous materials lack such boundaries meaning that the oxide scale which inherently forms on the material is uniform which hopefully makes the coatings more

The image on the left is the experimental setup. The test rig is fitted with temperature, flow, and pressure sensors and the data was used to calculate the heat transfer coefficient of tested materials. On the right side is the heat exchanger where a plate is place into the slot as shown. During the test, a working fluid flows on one side and a geothermal brine on the other side.

corrosion resistant. Also, with regards to the polymeric reaction of silica scaling, the smoothness of metallic glass could potentially hinder formation of scaling and/or make it easier to get rid of silica scaling. The focus of this project is on heat exchangers, but we also see possible application in different parts of geothermal systems."

Future applications and overcoming issues

When asked about the future of such coatings, and prospects of their real-life application to geothermal heat exchangers, Baldur Gunnarsson of Tæknisetur explains that the "results for the amorphous coating show great potential for silica scaling removal and by using the nanoporous coating on the working fluid side shows an increase in heat transfer coefficient."

David of GREIN Research expands further: "The heat exchanger plates are where you need coatings with high thermal stability which our chrome coating can provide (up to 750 degrees C, which is beyond the requirement in geothermal power plants). But, we also considered other components of the geothermal system, such as the turbine blades or sensitive parts which might come into contact with more corrosive environments." The researchers believe that the coatings will be just as useful in these applications as for the heat exchangers.

Application of the coatings will require further testing, as this will involve hard to reach areas such as interior surfaces of pipework – physical vapour deposition techniques, for example, are difficult but not impossible to perform. Further analysis is also needed for cost predictions, although the team expects overall cost will be reduced as the coatings will provide superior protection, meaning lower cost materials can be used rather than austenitic stainless steels.

As with all research projects, the team did encounter some issues, such as delamination. "We saw delamination especially because the samples we produced initially for our first screening were mirror-finished," David explained. "So we saw some peeling in certain cases, but that's a problem that can be solved by using a better adhesion layer. In this case, we used a chromium adhesion layer, but there are other elements that can be used, titanium for example. So, if you do run into that problem where you're getting too much tension in the coating, the tension becomes too much for the adhesion and becomes an engineering problem generally which can be solved by using proper adhesion layers beneath the coating. We've not used fracture mechanics, but we do standard scratch tests and adhesion tests to assess the coatings. We are working to improve on this."

Regardless of how early these test results are, the GeoHex team is confident about the durability of its coatings. "The testing was only 200 hours for the long term testing, which is not a lot of time. So it would be good to test further for longer periods," said Baldur. "We saw some indication of corrosion in some of the coatings, thermal sprayed aluminium and nickel phosperous, but most did not show any signs of corrosion. So I can't yet commit to an exact number for lifetime assessment. But I assume that at one point for the heat exchanger, you would want to take disassemble the heat exchanger and clean it so we would have to assess the forces you can apply to the coating without damaging it. In general, we believe these coatings will have a long lifetime."

GeoHex global consortium

Iceland –	ON; University of Iceland; ICETEC; Grein Research
Norway –	Flowphys AS
UK –	TWI Ltd; Technovative Solutions; University of Leicester
France –	CEA; ENOGIA
Italy –	Spike Renewables
Romania –	Polytechnic University of Bucharest
Philippines –	Quantum Leap

Current status

By way of a conclusion, GeoHex is confident that amorphous metal coatings show a great potential for corrosion protection, but it can be challenging to find alloy compositions that form a stable amorphous structure. Combinatorial magnetron sputtering and X-ray analysis can be used to map out the phase space of TaSiM (M = Al, Cr, Fe, Ti) alloys and identify amorphous compositions. In a paper published in the 'Journal of Non-crystalline Solids', representatives from GREIN Research and the University of Iceland demonstrate how amorphous coatings are obtained at atomic percentages above 10-15% of each constituent; TaSiAl coatings are stable when annealed in air up to and including 550°C whereas TaSiFe, TaSiCr and TaSiTi remain amorphous up to and including 750°C. The research also shows that Ta35Si15Cr50 is almost unchanged at that temperature, and has a stable surface oxide shell less than 20 nm in thickness at 650 °C.

The stability of these materials at high temperatures means that they could be suitable for use as anti-corrosion coatings in high temperature applications, such as in geothermal. ■

Find out more

You can find out more about the GeoHex project through an interview with project leaders in Heat Exchanger World March 2022 issue: https://heat-exchanger-world.com/featured-story-the-geohex-project-anticorrosive-coatings-for-geothermal-heat-exchangers/

Learn more from the project's website: https://www.geohexproject.eu/

Recent paper produced by representatives from Grein Research and the University of Iceland, 'Structural stability and oxidation resistance of amorphous TaSi-based ternary alloy coatings': https://www.sciencedirect.com/science/article/pii/S2590159123000353?via%3Dihub

Predicting fouling: A brief introduction

Fouling is the deposition of unwanted material on surfaces. In liquid-solid interfaces, fouling is of particular interest, as it can have several deleterious consequences. Predicting where and how fouling occurs is critical to designing heat exchangers.

By Isaac Appelquist Løge and Benaiah U. Anabaraonye

Fouling is present in private households and industries. In homes, it manifests as the accumulation of dust, limescale in kitchen appliances, or biofilm on unwashed surfaces. In industries, fouling is a challenge for oil and gas production shipping, heat exchangers, membrane technologies, and food production. On ship hulls, the formation of crystals has been shown to severely increase the drag of a vessel, thereby increasing fuel consumption by up to 60 %. A layer as thin as 32 mm of fouling for heat exchangers can decrease the heat transfer efficiency by 25%. Membranes used for freshwater production can be entirely put out of operation if the channels are blocked, and more than 25% of operating expenses are spent on pretreatment to reduce fouling. Some common examples of fouling and its consequences are illustrated in Figure 1.

A new approach

Until 1929, fouling was not dealt with in the academic community, and empirical and anecdotal references were the primary source of information. The Tubular Exchangers Manufacturing Association (TEMA) developed an empirical approach based on the heat resistance across the hot and cold sides of a heat exchanger. The sum of these heat resistances could then be used to design the area of a heat exchanger. This method has been criticised widely due to its unphysical nature. Out of this criticism rose a new model developed by Kern and Seaton, which proposes a more mechanistic view of the underlying problem. They described mass accumulation over time as the difference between deposition and removal.

The Kern-Seaton model is the earliest approach in mechanistic fouling research and is still the basis of many models. In 1983, Epstein published a trendsetting paper summarising fouling in a 5×5 matrix.[1] Epstein classified fouling into five types (crystallite, particulate, chemical reaction, corrosion, and biological fouling) and five physical stages (initiation, transport, attachment, removal, and aging; see Figure 2).These stages have been used to expand the model of Kern and Seaton, where newer models consider initiation, transport, and attachment. We highlight key results from the main approaches in the literature.

Isaac Appelquist Løge and Benaiah U. Anabaraonye will be publishing regular articles as part of a Research Series across multiple issues of Heat Exchanger World. All articles will be available in our online archive: https://heat-exchanger-world.com/category/technical-articles/

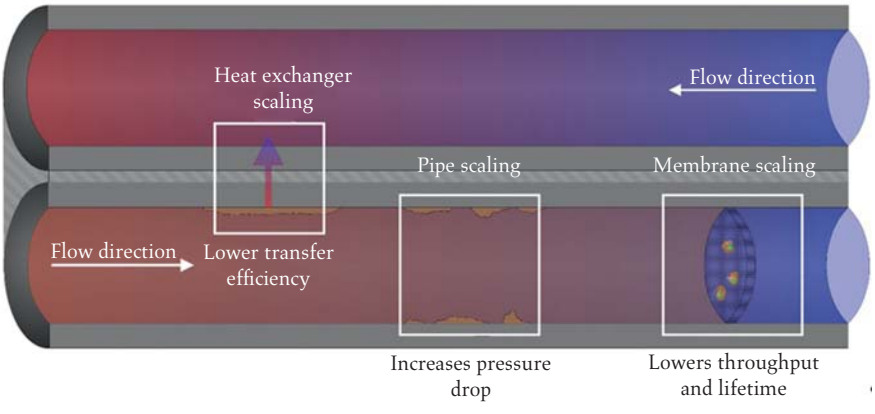


Figure 1: Common examples of fouling illustrated alongside its consequences.

Artificial intelligence

Artificial intelligence is applicable in many scientific fields. Recent studies looked into the usefulness of neural networks in determining the fouling rate on heat exchangers. In a 2018 study, an artificial neural network was used as an alternative to complex and time-consuming experiments.[2] The researchers trained and validated their neural network against a databank of 11,626 datasets to estimate the fouling in a system, based on variables such as density, velocity, fluid and surface temperature, oxygen concentration, the hydraulic diameter of the passage, and time.

Through their model, they obtained results with a slight deviation from the datasets used for validation, which shows the practicalities of such a mathematical tool, and raises the questions of whether such tools could be implemented for design optimisation of heat exchangers. The limitations of this approach are that the physiochemical principles at play are not addressed and that it merely reproduces and extrapolates from already existing data.

Molecular dynamics

Molecular dynamics (MD) allows for a detailed investigated of the forces between particles and surfaces, and is well suited for fouling studies. In desalination, where thin-film reverse osmosis membranes play a crucial role, fouling is also a common problem, causing membranes to lose functionality over time. An MD study was performed on the antifouling performance of a polyamide-coated membrane.[3] The researchers simulated the degree of crosslinking in the axial direction of the membrane to obtain a reactive, grafted surface through which the transport dynamics of water molecules could then be determined. Two fouling agents were introduced in the flow, namely 1-ethyl-2-methyl benzene and n-decane, and through the membrane's mean force, the surface's inertness could be characterised. Furthermore, through trajectory analysis of the fouling agents, they could relate the membrane's inertness to the pollutant's size, hydrophobicity, and polyamide coverage ratio of the membrane. This study highlights the opportunities to gain mechanistic information on the surface-adsorbent interaction through molecular dynamic simulations.

Computational flow dynamics

Computational flow dynamics (CFD) is a versatile tool, which have been widely used in fouling studies. CFD provides opportunities to study the physical interplay of surface stresses, flow velocity, and rheological properties. Figure 3 illustrates how mixing and transport processes could be understood through CFD in combination with results from experiments. CFD algorithm for heat exchanger systems must solve equations for mass transport, heat transfer, and chemical reactions in both the solution and on the surface, all while having a system that is evolving in time. Depending on the

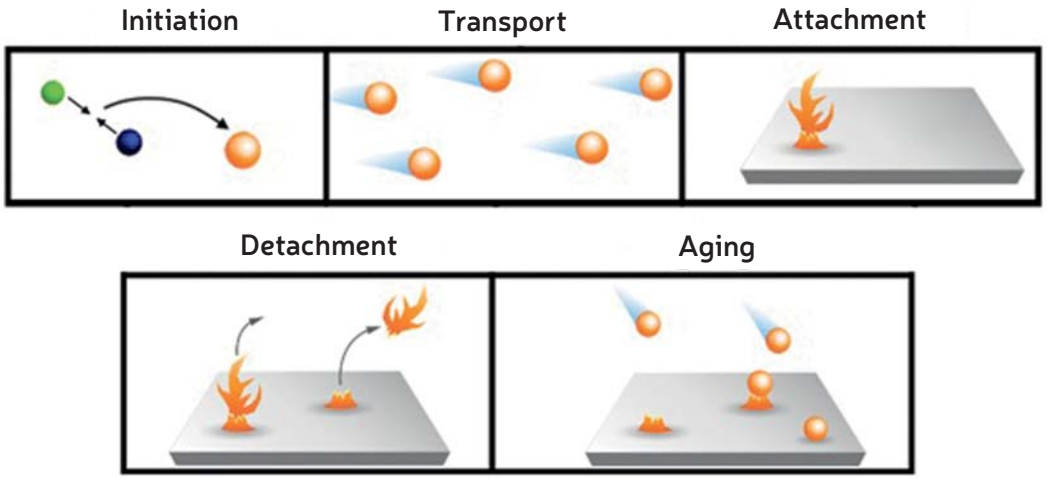


Figure 2: The five stages of fouling.

model's complexity, multiple stages of the fouling process can be incorporated, ranging from complex nucleation schemes to temporal evolution of the properties of the fouling layers. Johansen and coworkers developed a model that aims to change how surface fouling is usually modelled.[4] They challenge the popular two-step model, which calculates the transport to the surface and then the surface adsorption. Instead, they proposed a wall function where the deposition is simulated as a mass sink at the walls. This model has been validated and showed good agreement compared to the traditional models. Due to the coarse mesh used in this model, it shows good promise for usage in industrial-scale applications where the system is of high complexity. One critical assumption in this model is that the wall acts as a mass sink, and therefore the inner diameter of the tube is unchanged with deposition. When reactions would occur over a long period, it is unlikely that the model would accurately describe reality. As more and more deposition would occur, the hydraulic diameter would shrink, effectively increasing the shear forces and thereby the contribution and importance of detachment.

Conclusion

AI, MD, and CFD can give insights into the mechanisms governing the rate of fouling. However, none of the published models have a detailed, unified description of all the five steps described in Epsteins 5x5 matrtix, and there exists experimental evidence suggesting that fouling is even more complex than previously anticipated.

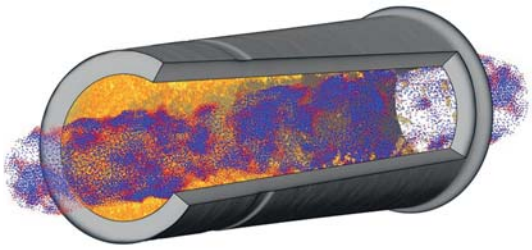


Figure 3: Example of combined experimental and CFD studies of crystallisation fouling.

We have shown that surface properties, saturation state, and flow velocity can influence detachment and aging in previously unreported ways.[5-8] We have also shown that the interplay between all five stages of fouling for processes occurring over a longer time is not entirely understood. In the coming issues, we will present novel research on detachment and aging, and in the last issue, we will discuss the critical areas of opportunity for the modeling of fouling processes. ■

About the authors

Benaiah U. Anabaraonye is a research scientist and Program Manager at the Danish Offshore Technology Centre. He has a PhD in Chemical Engineering from Imperial College London.

Isaac Appelquist Løge completed a Ph.D. on crystallisation fouling, using novel methods to visualise fouling formation. He is currently researching what makes fouling detach and what makes it stick.

References

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IOGP-JIP33: Standardising equipment procurement specifications

The IOGP JIP33 program has been a great success in the short time it has been active, and is now actively engaging with operators and EPCs to further adoption across the industry.

By Adri Postema, Engineering and Standards Director & JIP33 Programme Director IOGP; and David Harris, Specifications Manager JIP33, IOGP

The basic premise for JIP33 procurement specifications is to have standardised technical, quality and information requirements that overlay a recognised industry standard (Figure 1). JIP33 specifications also have a standardised Data Sheet for each specification that should increase efficiency and help simplify communication between purchaser and supplier regarding requirements and product configuration.

Case studies performed by equipment suppliers on behalf of JIP33 have shown that standardisation of quality and information requirements is as impactful on cost and schedule for the manufacturer as are the technical requirements.

Of the 54 JIP33 specifications published, 24 have API as a parent standard, 8 have IEC as a parent, 9 have no parent standard, and the remaining are to various other Standards Development Organizations.

The content of IOGP specifications will be offered for consideration to be included in the underlying parent standards once these get updated. This reduces the overall maintenance activity of JIP33 specification and ensures wider use of the JIP33-specific requirements.

Since 2019 JIP33 has included the digital aspects of specification development and publication. Developing specifications as digital data files, using digital requirement management tools, provides an opportunity for quick feedback loops for users of the JIP33 specifications.

Changing the future of specifications

Both the move to authoring specifications to a defined set of digital rules, as well as publishing the specifications so they can be incorporated into a company's business system, is a journey that Standards Development Organisations (SDO) are all embarking on. The IOGP has had a Task Force looking at standardising Requirements for Digitization since 2018 and JIP33 is an early adopter sharing experiences in digital specification writing and using digital exports of the JIP33 specifications for importing into a company's established systems. JIP33 are actively sharing the best practices with the SDOs with the aim that there will be a common set of rules for digital requirements in the future.

This digitisation, as well as the cultural and behavioural mindset that standardised procurement specifications needs, requires strategic management of change within organisations. Subject Matter Experts and engineers have the opportunity to think and work in a significantly more efficient way than how the industry has traditionally operated for decades. Given the fact that the twelve sponsoring operating companies who are actively participating in JIP33 development have their own business, organisational systems and cultural differences, getting them all to move in the same direction and compromise their traditional practices has been a transformational change for the industry.

Figure 1: Base structure of JIP33 specifications

Within the 12 JIP33 sponsoring companies, there has been strong leadership from the top, setting a consistent set of expectations of 'using JIP33 specification without change' throughout an organisation. Successful JIP33 implementation is beyond engineering, and requires involvement from the company's supply chain organisation and adaptation from information and quality functions.

Managing these expectations has been best shown by introducing Key Performance Indicators (KPI) through the organisational structure that align with the company's overall strategy and objectives. This helps drive the engagement and cultural change needed. As the JIP33 program has developed, the KPIs used by the sponsoring companies have also developed, and they are now looking at pushing the KPIs further into the supply chain.

Supply chain & stakeholders

The oil & gas supply chain for capital projects is complex, as it tends not to have a direct purchase-supplier structure. Instead, requirements go from an owner/operator to an EPC, then a packager and finally to manufacturers (and sometimes their sub-suppliers). This means that recognising and maintaining the integrity of a JIP33 specification through the supply chain is not simple, especially when requirements are imported into a company's business system. This can make gathering KPIs on how JIP33 implementation is evolving both internally and externally complex. Setting up expectations and systems to collect the necessary data for KPIs should be done at the beginning of a company's implementation journey. This should extend to company expectations on gathering relevant data from their supply chain.

Initial KPIs for JIP33 sponsoring operating companies' focus were leading in nature and focused on the level of implementation of specifications within the owner/operators, from the adoption of the specification through to purchasing (Figure 2).

Now that implementation is maturing in most of the sponsoring operating companies, the program is looking

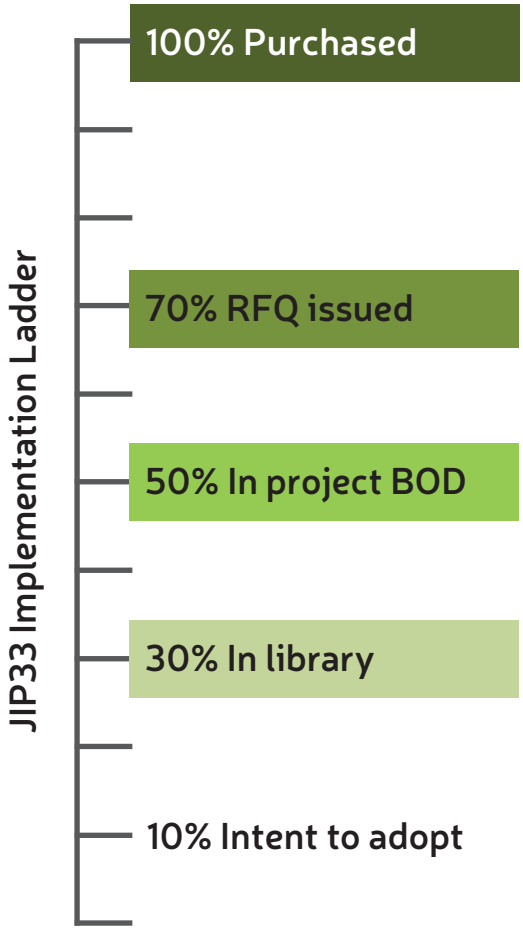


Figure 2: Adoption staircase

Heat exchangers installed at an oil refinery. Source: Dreamstime

to establish more result-focused KPIs on the volume of equipment purchased (Figure 3), projects utilising JIP33 specifications, and the percentage of value captured. The sponsoring operating companies are now asking their EPC partners to track and monitor comparable data within those organisations to demonstrate how JIP33 specifications adoption is expanding.

The KPIs are intended to show JIP33 adoption throughout the supply chain, but it is also possible to monitor the value derived from JIP33 implementation. Due to supply chain complexity, market fluctuations and oil price, baselining cost and demonstrating the cost impact of JIP33 can be challenging. However, what can be determined are the engineering hours required to issue a Request for Quotation (RFQs) for a standardised product, as well as tracking the reduction in clarifications that result in issuing standardised requirements. For manufacturers, having standardised requirements and Data Sheets means there should be less administration needed in responding to RFQs.

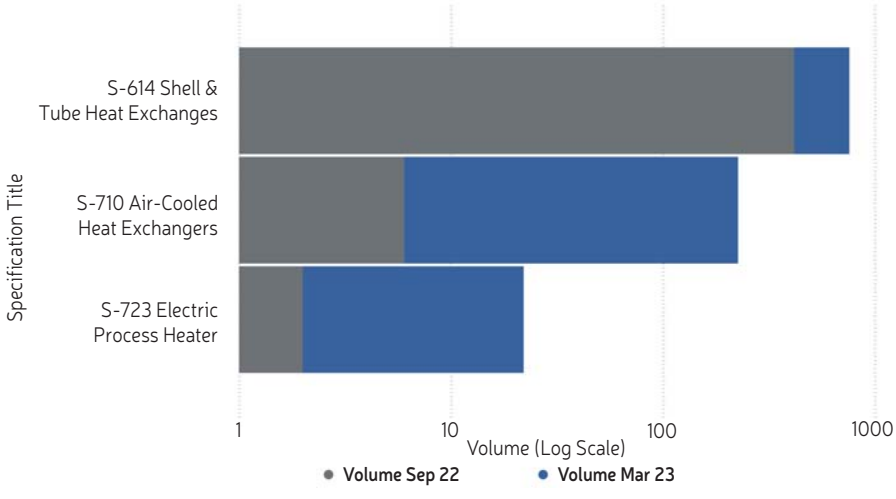


Figure 3: Volume of equipment procured by sponsoring operating companies using JIP33 specifications

Over the years, JIP33 has organised industry events to discuss the initiatives with key supply chain stakeholders. Recent engagement activities include inviting senior management from regional suppliers, EPCs and non-sponsoring Operating Companies to the IOGP Engineering Leadership Council to discuss their real-world experience with JIP33 to date and to discuss recommendations on driving adoption further. JIP33 has a communication plan for more in-person events and webinars, and will continue this outreach throughout the coming years.

Implementation guides and training videos have been developed to help companies better understand the JIP33 process and how best to implement the specifications. Increased engagement with supplier partners has improved the overall JIP33 development process and the quality of the specifications. Initially, supplier input was limited to the draft specification public review. That has now evolved significantly, and there is more opportunity for suppliers, EPCs and non-sponsoring companies to actively contribute to the JIP33 process. Supplier questionnaires and user feedback reviews on current specifications are being used as input to the process. In addition, there are public reviews of draft specifications and post-review town halls to provide feedback to commenters on the changes made to the document. For certain specifications, suppliers even actively participate in shaping the draft specification where anti-competition rules allow.

Lessons learned

Besides needing strategic management of change and associated KPIs to monitor adoption, some other fundamental principles have been identified to successfully adopt and implement JIP33 specifications. These include ensuring that the 'brand' visibility of the JIP33 specification is maintained as it moves through the supply chain so that it will be recognised, and suppliers

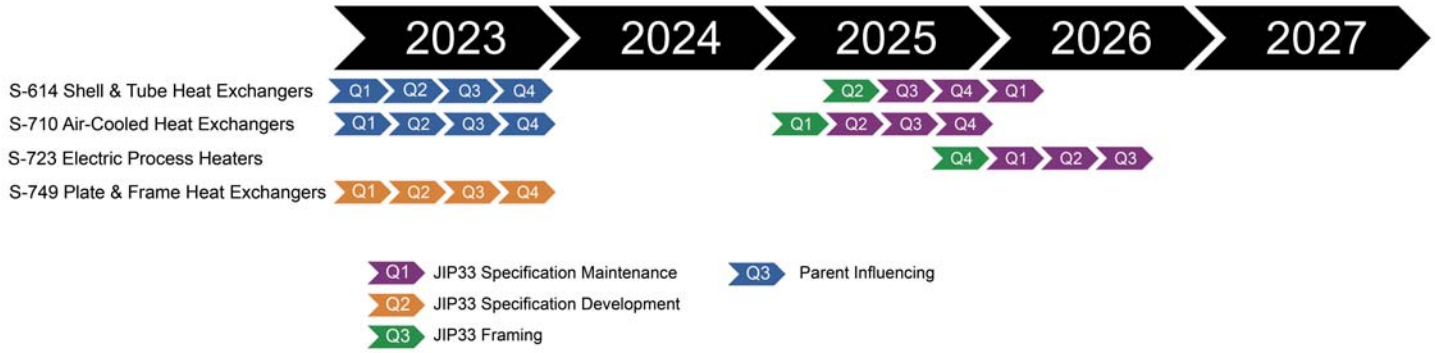


Figure 4: Provisional roadmap for the development of JIP33 specifications for heat transfer equipment

can respond appropriately. It is also important that the specifications are being used 'as-is'; overlaying or modifying the JIP33 specifications will erode their value. JIP33 is continually updating its processes, including how to minimise overlays to specifications when maintaining or expanding the scope of existing specifications.

Looking forwards

The application of JIP33 specifications is not limited to greenfield upstream capital projects. The specifications are also being actively used in brownfield and low-carbon applications. One of the selection criteria recently added for development topics was low carbon/energy transition applicability. This helps broaden the application past the traditional oil & gas usage into new businesses that many in the sector are now active in.

For the flow control industry, this means that standards will need to meet environmental objectives such as:

- Address the reduction of fugitive emissions and define the respective quality requirements
- Include data requirements that certify the carbon footprint of flow control equipment
- Include information requirements to mitigate material fraud in the energy sector
- Define new scope to cover applications in Hydrogen and CCUS
- Leave space for further innovation (like additive manufacturing)

These elements will be covered in JIP33 in new and existing specifications as long as they form existing gaps in industry standards. A provisional roadmap for developing JIP33 specifications for valves is shown in Figure 4.

Conclusion

JIP33 has been a great success in the short time it has been active. The JIP33 Program is now actively engaging with additional operators and EPCs to further adoption across the industry. A large number of projects are now using JIP33 specifications, and large volumes of equipment specified by JIP33 have been procured since the oil & gas industry started to recover from the pandemic. While there is still a journey for many companies to go through to get the full cultural and behavioural changes required throughout their organisation, there is the full support of executives from the major international and national oil & gas companies driving this program and making it go from strength to strength. The program continues to welcome increased participation of suppliers in the program, welcomes their input at all stages of the process, and actively encourages those who wish to know more to reach out to the JIP33 Project Team in this exciting endeavour. ■

JIP33 beyond oil & gas

David Harris has been the Specifications Manager of the JIP33 project at IOGP since 2020. He highlighted how the project is having a positive effect well beyond the oil & gas industry.

"When JIP33 was set up, it was aimed at large upstream oil & gas projects that, in terms of global expenditure, are second only to aerospace. However, it's now also being applied to the maintenance and upgrades of existing facilities."

"Beyond oil & gas, the program is also relevant to low-carbon projects, from the electrification of existing facilities to carbon capture. JIP33 specifications have already been applied to some publicly announced carbon capture projects in the UK and Europe, and several of our new topics will have applications for net zero and low carbon projects. For example, specifications for power cables to offshore oil & gas facilities have applicability to offshore wind farms. New energy projects will benefit from the standardisation, experience and competency present in traditional oil & gas engineering. While they may have a different economic base and risk profile, much of the subsea knowledge required for e.g. carbon capture is well-known within oil & gas. Notably, for new energy projects to succeed, they need to operate long-term, and the oil & gas industry understands long-term engineering reliability very well."

David Harris

"An important advantage of JIP33 and the IOGP, in general, is that we can publish best practices and guidelines in a reasonably short period of time. We're happy for these to be picked up by international standards organisations to form the basis for international standards. There's a lot of exciting innovation in the global low-carbon energy industry, and some of the foundational principles from big oil & gas projects also apply to them. We have a thorough understanding of operational integrity and excellence."

Image © Alfa Laval

Green hydrogen as beacon of hope: Overcoming technological challenges together

Innovative technologies that optimize energy efficiency will play a critical role in reducing the energy demand of numerous applications, thereby lowering the overall projected demand and meeting the Paris climate goals. One forward-looking example is the use of industrial waste heat generated during the production of green hydrogen and fed directly back into the manufacturing process.

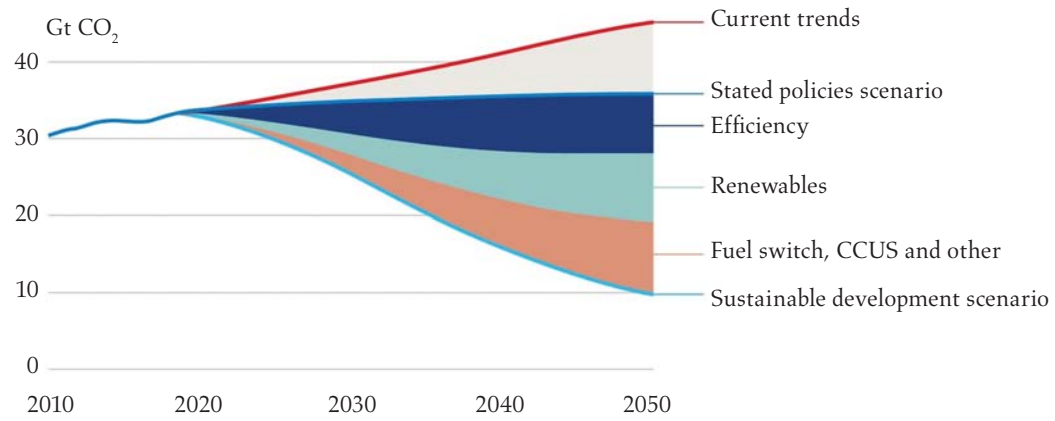
By Sven Schreiber - Managing Director, Alfa Laval Mid Europe

The world is currently facing a double challenge. On the one hand, global energy demand is constantly rising due to economic growth, and, according to the projections of the International Energy Agency (IEA), it will be 54% higher than today as early as 2050.[1] On the other hand, society must drastically reduce carbon consumption and emissions to avoid severe environmental consequences in line with the Paris Climate Agreement.

There is no 'one' simple solution to reducing carbon emissions. Instead, it requires the implementation of numerous new technologies and fuels across all sectors of the economy. A major contribution will come from energy efficiency, which means realizing as much output as possible with minimal input. Energy efficiency, combined with access to renewable energy sources such as solar and wind, and a transition from fossil fuels to new energy sources such as biofuels and green hydrogen, is essential to a successful transition toward sustainability. In those industries that cannot do without fossil fuels, carbon capture technology must be used. So currently, we are indeed on the brink of an energy revolution in both industry and society, moving away from fossil fuels and embracing new environmentally friendly technologies.

Driving innovative technologies forward

Most of the technologies needed to halve emissions by 2030 are already available today. However, achieving the goal of net-zero emissions by 2050, as enshrined in the European Climate Change Act, will be more challenging. According to the IEA, half of the emissions reductions will rely on technologies that are still in the prototype or demonstration phase. Green hydrogen, carbon capture, long-term energy storage – all will require large investments to become reality. To accelerate decarbonization, a two-pronged strategy is needed. Firstly, more investment must go into deploying the technologies that are already available and commercialized to make industry more sustainable. Simultaneously, efforts must be made to drive the development of new technologies for a long-term energy transition and the establishment of an efficient circular economy. Sustainable partnerships play a crucial role in achieving these goals. Collaboration across countries, industries, and sectors is essential for making a meaningful impact. It is about rethinking and developing new business models to achieve climate goals while maintaining company visibility.



Transition to clean energy: There is no single or simple solution for achieving decarbonization. Image © Alfa Laval, data according to IEA[1]

Energy efficiency as a key factor

The issue of energy efficiency is crucial in achieving the targets set by the Paris Climate Agreement. According to IEA forecasts, 40% of emissions reductions could be achieved through energy efficiency by 2040. There is enormous potential. The technology is there, we just need to use it. Energy efficiency should be at the top of the agenda in every context. After all, there is nothing more sustainable than energy that is not consumed in the first place.

One example of collaboration to accelerate the development as well as the implementation of energy-efficient technologies is the Energy Efficiency Movement, launched as an open platform by Swiss technology company ABB and now gaining momentum. Alfa Laval is the first member to join the movement. Together, the participants want to draw attention to the topic of energy efficiency and promote its implementation.

Energy efficiency is not only important for existing industries and applications but also for the development of new climate-friendly technologies ranging from green hydrogen and power-to-X to energy storage, carbon capture, and biofuels. Efficient solutions are urgently needed everywhere to increase the scalability of these technologies and thus accelerate the transition to a carbon-free future.

Green hydrogen as a clean energy carrier

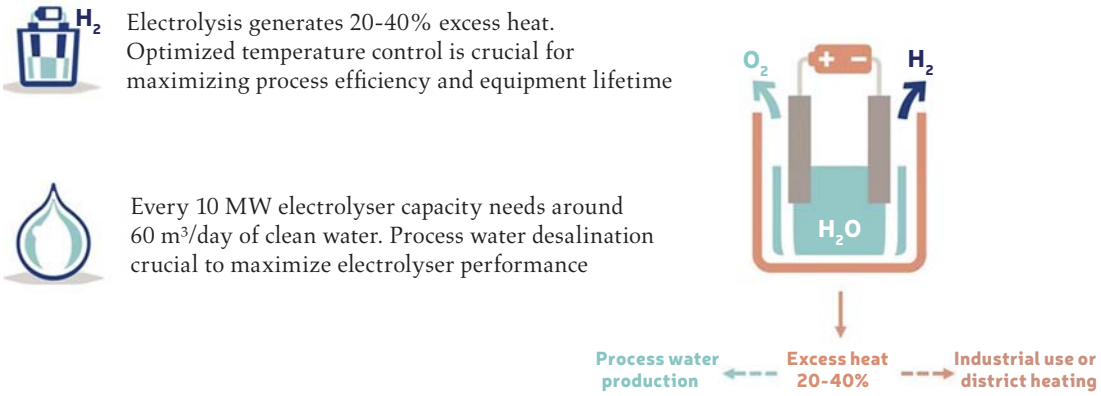
One energy carrier with particularly great potential in the future energy landscape is hydrogen. In the net-zero scenario, for example, 22% of the world's energy needs could be met by clean hydrogen by 2050.[2] This includes both green hydrogen produced through electrolysis and blue hydrogen. In the latter, carbon capture is added to conventional production based on natural gas or coal. Overall, the hydrogen economy will grow significantly in the long run.

However, to make this a reality, we still face several challenges related to technology deployment, scalability, and commercialization. These challenges span the entire hydrogen value chain, from the production of green hydrogen to its final application as a molecule or energy carrier. Hydrogen can be used in many ways, including as a feedstock for industrial processes such as ammonia, methanol, and steel production, as a power source in fuel cells, and as a fuel in the transportation sector. While there are numerous possibilities, investments are needed to make the coming hydrogen economy a reality. The future is likely to witness a mix of centralized and decentralized solutions, both on a small and large scale. To achieve the full hydrogen economy needed for the net-zero emissions scenario by 2050, green hydrogen production must be scaled

Heat transfer needs:

1. Electrolyte cooling
2. Gas cooling
3. Process water desalination
4. Post-treatment cooling
5. Overall plant cooling
6. Waste heat recovery
7. End-use applications

Efficient cooling and heat recovery are at the heart of optimized water electrolysis. Image © Alfa Laval



Green hydrogen production insights. Image © Alfa Laval

up, appropriate infrastructure built, and reliable balancing ensured.

It is important to consider scaling at the development stage. This means investing in solutions that are also cost effective in the long term. When it comes to heating and cooling, optimal heat transfer is necessary in almost every industrial process – including the hydrogen value chain.

Recovery of excess heat

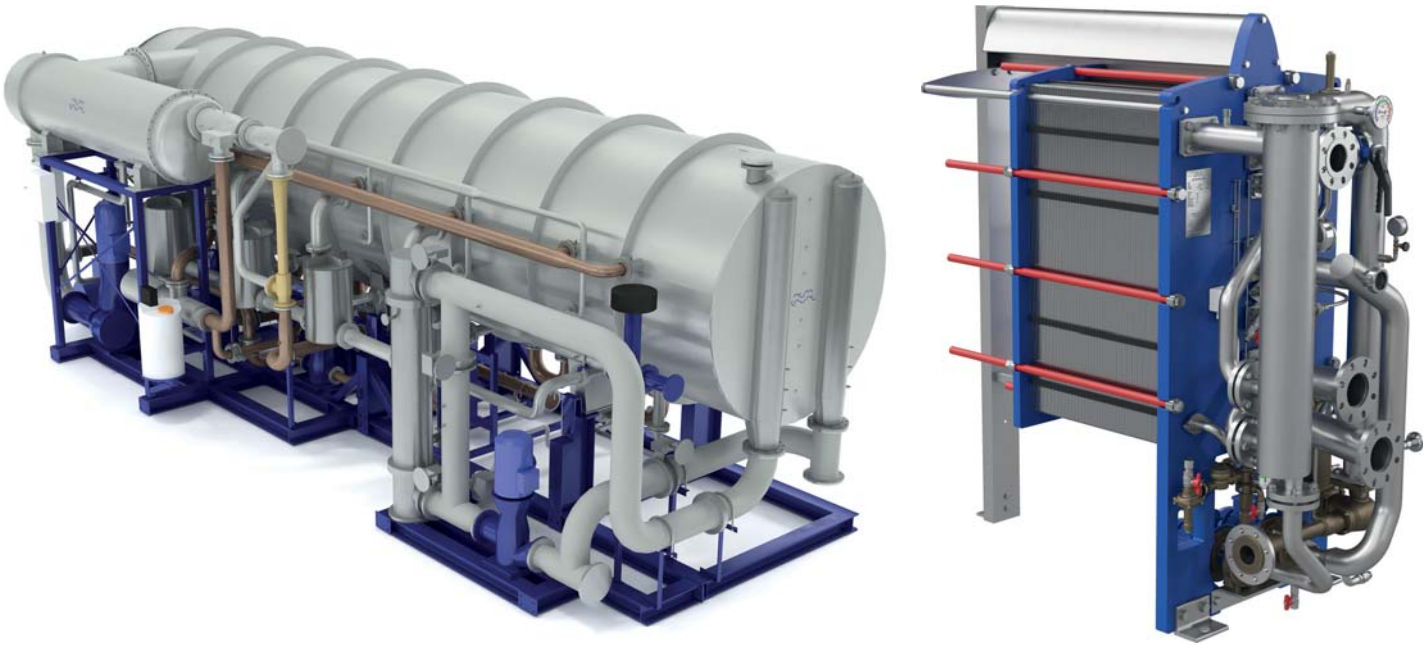
One example is the production of green hydrogen. Currently, the most mature electrolysis technologies are PEM electrolyzers and alkaline electrolyzers, which are expected to remain dominant in the market for the next few years. They operate at temperatures approximately between 50 and 80°C. Regardless of the specific technology used, temperature control is paramount to ensure both maximum productivity and efficiency of the electrolyzer, as well as maximum equipment lifespan.

During the electrolysis process, approximately 20–40% of the electrolyzer's capacity is converted to excess heat. Despite the relatively low operating temperature, this heat should not be wasted. The use of heat recovery technologies allows this energy to be absorbed and used elsewhere. As a rule, recovered waste heat should be integrated back into the process in a suitable way. Alternatively, if the infrastructure allows, the heat can be sold and used on neighboring sites, for industrial processes or in the district heating network. It is also possible to use it for heat conversion processes such as the production of chilled, distilled, or hot water, as well as electricity.

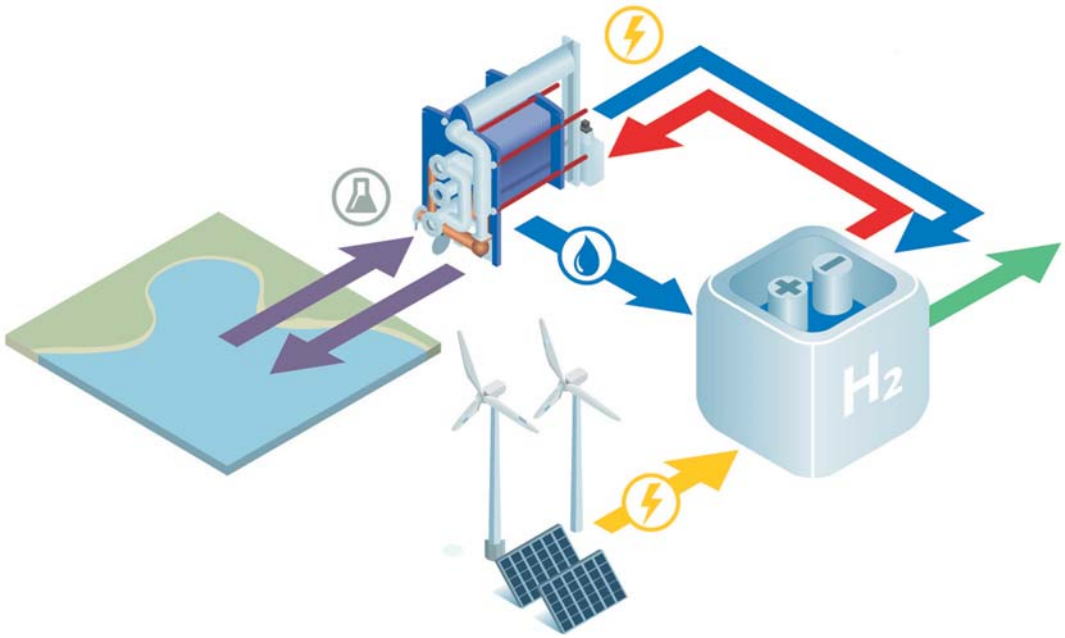
However, options are limited with the low-temperature heat generated during green hydrogen production. Current projections indicate a potential electrolysis capacity of 90 GW by 2030,[2] which would generate 18–36 GW of waste heat. As more countries adopt hydrogen economy strategies and technologies continue to evolve, capacity is expected to further increase. To stay on track for the net-zero emissions target by 2050, we would need a capacity of 200-250 GW by 2030.[2] In order for green hydrogen production to be energy efficient and cost competitive in the long term, it is important to consider waste heat as a valuable resource.

Direct waste heat utilization in hydrogen production

A simpler solution for utilizing waste heat is to integrate it directly into the green hydrogen production process. For every 10 MW of electrolysis capacity, approximately 50–60 m³ of clean water is required, highlighting the importance of efficient water recovery. With a projected capacity of 90 GW by 2030, this translates to a global demand of up to 540,000 m³



The freshwater generation systems HyDuo MEP (left) and HyDuo AQUA (right) simultaneously cool the electrolyzer and generate high-quality water. Image © Alfa Laval



Reusing excess heat is the most sustainable solution for water purification in green hydrogen production. Image © Alfa Laval

of water per day, roughly equivalent to the daily water consumption of the city of Los Angeles.

The treatment of the supplied water depends on its quality, which varies depending on the water source. In most cases, however, purification is necessary. The most common process for purifying water for electrolysis is reverse osmosis using chemicals. An alternative solution is vacuum evaporation, which uses the waste heat from the electrolyzer to demineralize the water and achieve the required quality for electrolysis. This process allows for direct reintegration of waste heat into hydrogen production.

With Alfa Laval HyDuo, two processes can be done at the same time: electrolyzer cooling, ensuring the right temperature of the hydrogen production process, and water purification, producing the right water quality for electrolysis. Utilizing waste heat as an energy source in the water purification process comes with many advantages, including lower dosage of chemicals, smaller footprint, greater reliability, and lower electricity consumption. Moreover, it improves process efficiency by up to 27%.

Using excess heat to produce pure water

First, feed water enters the evaporation section of the plate pack, where the plates are warmed by the hot water that comes from the electrolyzer. This causes the water to evaporate at around 30–65°C in a vacuum of 75–99%, which is maintained by the brine/air ejector. (The exact temperature and vacuum ranges depend on the model of the freshwater generator and the temperature of the electrolyzer's hot water). This means that only clean freshwater vapor reaches the condenser section of the plate pack, which is cooled by a flow of seawater. Here the vapor is condensed into fresh water, which is pumped out of the freshwater generator. The vapor produced during the evaporation stage rises into the separator section, where any droplets of entrained seawater are removed. Gravity causes these droplets to fall back into the brine sump at the bottom of the freshwater generator.

Thermal desalination processes have long been used on offshore oil and gas platforms to produce fresh water from seawater. This method can therefore be directly applied to hydrogen production and is particularly advantageous offshore and in areas where fresh water is scarce. With this technology, the required water quality can be achieved in most cases without additional post-treatment.

In contrast, traditional desalination systems typically rely on membrane-based solutions where various chemicals are essential for ensuring smooth operation (e.g., biocides, activated carbon, anti-scaling). This is due to the sensitivity of membranes to variations in water impurities. However, when using a thermal solution, the need for chemicals is dramatically reduced, with their use limited to anti-scaling purposes. In some cases, the anti-scaling chemicals can even be avoided if operations run using lower hot-water temperature.

Establishing economical and scalable solutions

Until now, the industry has primarily focused on dissipating the heat generated during hydrogen production, for example through methods like sea cooling or ventilation. However, to increase the overall efficiency of the process, the waste heat must be recovered and used. The most obvious use is in other internal processes or in district heating. Sector coupling can also be considered. As shown, there is also the possibility of integrating the waste heat directly back into the process itself through the recovery of clean water.

The key now is to establish the required technologies in the market and scale them up for larger capacities. Innovative heat transfer technologies are critical to making hydrogen processes energy efficient and competitive - across the entire green hydrogen value chain.

Collaborative projects and partnerships aimed at finding new solutions and business models will be key drivers in enabling high-performance hydrogen solutions for a decarbonized future. ■

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About the author

Sven Schreiber has been the Managing Director of Alfa Laval Mid Europe GmbH, the Alfa Laval subsidiary responsible for Germany, Austria and Switzerland, since 2019. The company is a global leader in key technologies for heat transfer, separation, and fluid handling. Since January 2023, he has also served as a board member of the Power-to-X for Applications working group at the German Engineering Federation (VDMA), with the aim of accelerating the transformation process to achieve climate protection targets.

Additive manufactured cold plates

How Conflux Technology is improving thermal performance for Advanced Air Mobility

In 2021, over 6,850 orders were made for AAM aircraft, equating to around EUR 24 billion in sales. Image courtesy of Joby Aviation.

The concept of Advanced Air Mobility (AAM) is a catch-all term for lightweight passenger and freight air transport, often in the urban environment. This emerging industry is growing rapidly, attracting EUR 6.5 billion in new investment in 2021, with orders for approximately 6,850 aircraft worth over EUR 24 billion.[1]

By Ben Batagol, Head of Business Development, Conflux Technology

At the heart of these electric Vertical Take Off and Landing (eVTOL) vehicles lies the electric powertrain. This consists of a lithium-ion battery along with high performance motors and inverters which generate the necessary lift and propulsion. There are a variety of different powertrain concepts currently being developed, however they all share the same thermal management challenges that come with high power and high voltage electronics.

The importance of thermal management in eVTOL aircraft

Managing the waste heat generated by electronic components in an aircraft propulsion system is crucial to performance, a characteristic shared with electric vehicle powertrains in the automotive world. Battery systems only work efficiently within a narrow window of operating temperatures and so require both pre-heating and cooling. Furthermore, the resistance and hysteresis losses within motors generate heat which can cause damage to the magnets and windings, while the silicon carbide in the inverters can also degrade if too hot.

For aircrafts, particularly small, lightweight eVTOLs, mass and propulsion system efficiency are essential to achieving a high range and payload capacity. Therefore, these electric powertrain components need to be effectively cooled with thermal management systems that are extremely lightweight and compact.

There are two approaches to cooling electronics; direct and indirect cooling. Direct cooling is where a fluid is in direct contact with the electrical components, which are submerged in a dielectric fluid. This allows heat to be extracted immediately from the source and there is no thermal resistance. However, flooding the electronics significantly increases weight, which is undesirable in an aircraft.

Indirect cooling on the other hand uses metallic heat sinks that contain channels of fluid and are attached to electronic components. This is typically how components within PCs and laptops are cooled using a fan to circulate air through a heat sink.

"However, the amount of heat you can dissipate with air cooling is quite limited and requires a high mass flow rate," explains Dr Jason Velardo, Thermal Engineer at Conflux Technology. "Whereas liquid is denser than air which increases its cooling capacity."

"The heat transfer performance of water in particular, along with its low viscosity makes it the best coolant for electronic devices. It has typically double the heat capacity of dielectric fluids, which is why indirect cooling solutions such as cold plate liquid cooling with water are much more effective at dissipating heat, without adding too much mass."

What is a cold plate heat exchanger?

Liquid cold plates are metallic heat sinks that consist of a closed-circuit liquid cooling system which pumps water through miniature channels within the cold plate and then

on to a heat exchanger. They can be attached directly to the cells of a battery or stator of the motor and allow heat to be transferred from the component, through the metallic structure, to the coolant, which is often water or a water-glycol mixture.

Cold plates are particularly suited to electronics because they allow the heat capacity benefits of water to be exploited whilst keeping the fluid in a sealed system, avoiding short circuits. The internal and external geometries can also be designed to minimise thermal resistance and reduce pressure drop in a compact package, something that additive manufacturing technologies are revolutionising.

How are cold plates manufactured?

Traditionally, cold plates are manufactured from aluminium due to its low weight and good thermal properties. The cooling channels within the plates are generally formed by stir welding together two plates in which the required flow detail has been pressed or machined. However, these welded joints increase the risk of leakage and are also thermally inefficient as inhomogeneous joints can lead to air gaps which act as an insulator, rather than a conductor.

"The welded structure is one of the challenges with traditional cold plates," explains Dan Woodford, Conflux Technology's Chief Commercial Officer. "The risk of leakage is problematic, and you are unable to create complicated internal structures. Whereas with additive manufacturing techniques, there is no welding or brazing and so you have one monolithic part with no joints and therefore no leaks."

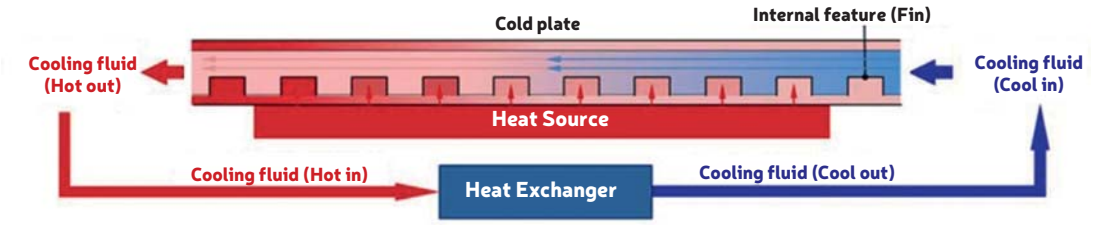
Conflux Technology use a Laser Bed Powder Fusion (LBPF) additive manufacturing process to create aluminium cold plates with complex geometries that are impossible to manufacture with traditional methods. The process uses a fibre laser to selectively melt a layer of fine metal powder. The build plate is then lowered, and another layer of powder is applied. The laser melts the powder again and layer by layer, the part gradually builds up into a full 3D geometry.

Electronic components are typically air-cooled with a fan and a heat sink, but for hotter applications, such as gaming PCs and electric powertrains, indirect liquid cooling is used. Image courtesy of Avadirect.

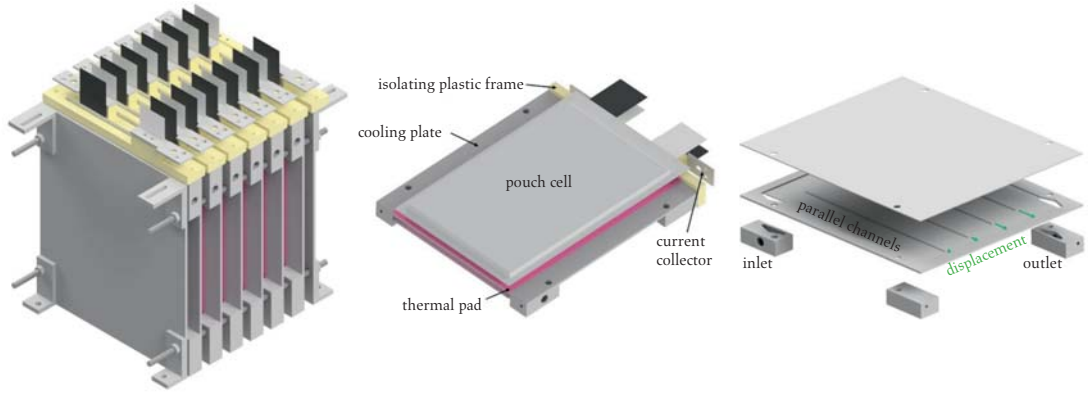
Designing an effective cold plate

Achieving high heat transfer efficiency

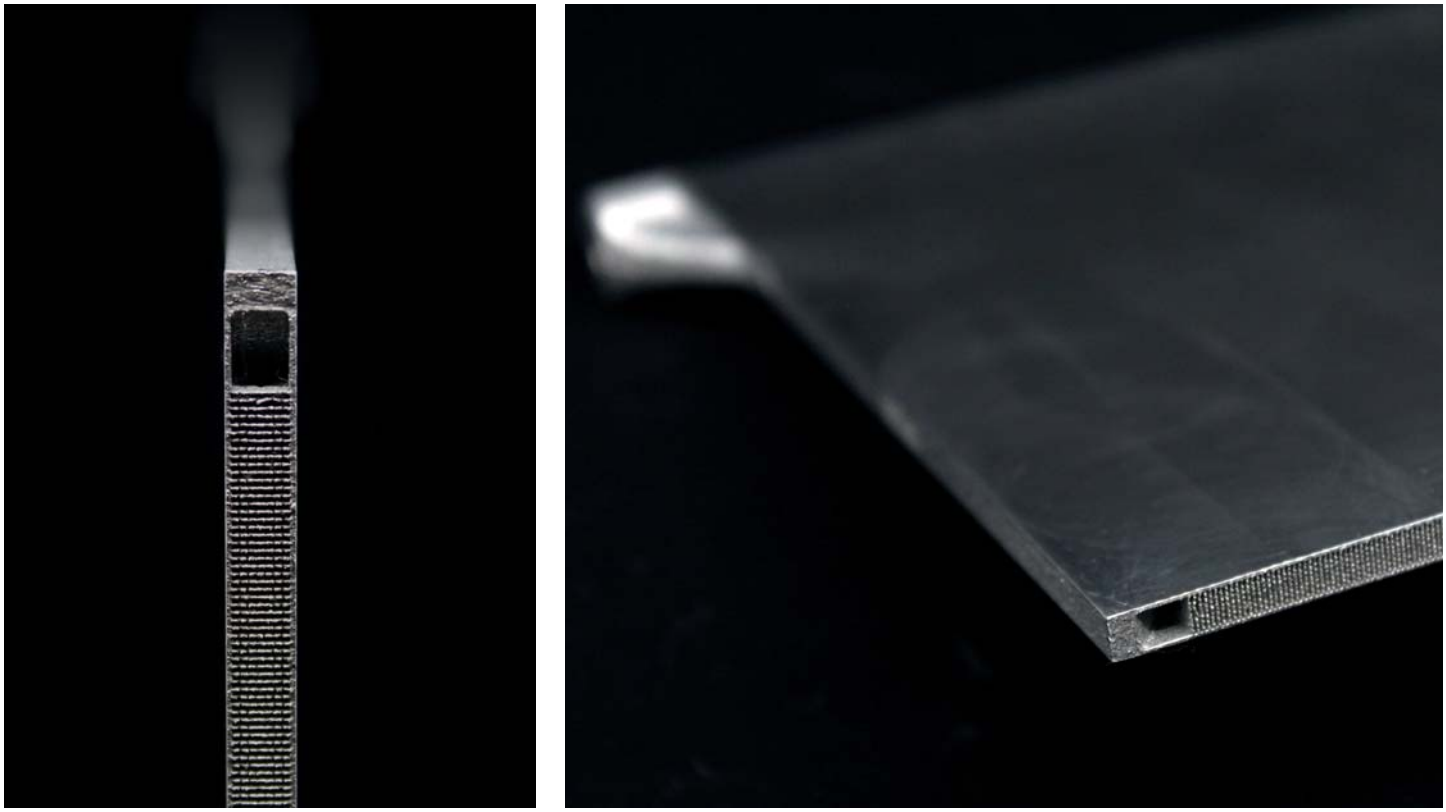
Key to the performance of a cold plate design is thermal resistance. This determines how well heat is transferred across a system.[2] For a cold plate, the aim is to reduce the thermal resistance of the metallic structure so that the maximum amount of heat is transferred from the source to the coolant.



Cold plates are metallic heat sinks that flow liquid coolant through channels. Image courtesy of Compelma.



In a lithium-ion battery, the non-structural pouch or cylindrical cells within a module are often bonded to cold plates which offer both support and direct cooling. Image courtesy of MDPI.



Conflux Technology creates advanced additive manufactured cold plates for electronics and battery cooling. Additive manufacturing allows complex internal geometries which help direct and mix the flow as well as increase surface area.

Dan Woodford, Chief Operating Officer, Conflux Technology.

Jason Velardo PhD, Thermal Engineer, Conflux Technology.

"Theoretically, minimum thermal resistance requires zero thickness of your cold plate structure," says Velardo. "But in reality, the cold plate is providing structure as well as cooling, so you need as thin a wall as possible within the limits of strength, stiffness, and manufacturability. One of the advantages of traditional manufacturing methods is that they can produce extremely thin walls via machining or skiving techniques but Conflux's additive manufacturing technology is now getting very close to achieving the same wall thicknesses."

"Additive manufacturing also has the benefit of creating novel shapes with complex internal geometries that are impossible to create any other way," continues Velardo. "This allows the internal structure of the cold plate to be designed to increase surface area and compensate for the thermal resistance of the walls."

Fins, pins and gyroid structures[3] can all be incorporated within the cold plate design to not only increase the surface area, and therefore heat rejection, but also to optimise the behaviour of the flow. "By directing the flow and using geometry to initiate turbulence, we can channel the coolant to hotter areas such as busbar junctions whilst also mixing the flow to dissipate heat more effectively," says Woodford.

Minimising pressure drop

The internal design of the cold plate has a direct effect on other elements of the cooling system. The pressure drop across the liquid coolant circuit defines the size and energy requirements of the pump. An efficient design means a smaller pump, lower mass and a lower energy drain on the battery system.

"Conflux has the thermal design expertise and the simulation capability to create highly accurate CFD simulations of internal flow," explains Woodford. "These simulations, together with additive manufacturing means we can rapidly prototype and test new designs far more quickly than if we were using conventional press tools or machining."

Compact packaging

Electronic components are often located in confined environments and therefore require compact and inventive thermal management solutions. This is particularly important in the restricted space of small eVTOL aircraft.

"Additive manufacturing can create unique shapes that are very difficult to achieve with traditional methods," highlights Woodford. "For cooling high-power electronics, we can design and manufacture bespoke cold plates that wrap around components such as inverters. We can also form ports and connections for the coolant circuit in any geometry or location to best package the whole assembly within the vehicle."

"Overall, the capabilities of additive manufacturing is moving cold plate cooling technology forwards to meet the new demands of the Advanced Air Mobility sector," concludes Woodford. "Our expertise in thermal management and additive manufacturing allows us to design, simulate, prototype and correlate bespoke cold plate designs much faster than has been possible before."

References

[1] R.R., A.E., 2022. *A milestone year for future air mobility* [Online]. McKinsey and Company.

[2] *The thermal resistance of microchannel cold plates* [Online]. Advanced Thermal Solutions Inc.

[3] A.S., 1970. *Infinite periodic minimal surfaces without self intersections* [Online]. NASA. ■

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The Heat Exchanger World team welcomes our community back to Rotterdam on 6th & 7th November for our Conference & Exhibition 2024. Having grown almost twice the size, the 2024 event will be hosted at the Rotterdam Ahoy where even more of the heat exchanger industry can come together.

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Our 2024 Conference will provide a stage for professionals across the heat exchanger industry to present on the challenges, successes, and key topics concerning heat exchangers. Aided by a panel of experts, we will select the most relevant and engaging presentations for the 2024 conference programme.

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The Heat Exchanger World Conference 2024 will provide a dedicated meeting ground for professionals working in the heat exchanger supply chain to address key issues in the industry from design and manufacture, through purchasing to usage and maintenance. It will enjoy an atmosphere of information sharing, connection, and learning in a relaxed and informative atmosphere.

Do you have an idea for a presentation which addresses a key topic in the heat exchanger industry? We invite you to submit a 150 word abstract by **Monday 5 February**. This will then be assessed by our Heat Exchanger World Steering Committee.

SUBMISSION DETAILS

Submit your 150 word presentation abstract to Heat Exchanger World in Word format to Conference Coordinator, Ms Joanne McIntyre at j.mcintyre@kci-world.com.

Explain the outline of your presentation as clearly as possible, include key topics and keywords.

DEADLINE: Monday 5 FEBRUARY

Conference contact:

Joanne McIntyre,
Conference Coordinator
Tel: +31 575 585 298
Email: j.mcintyre@
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Suggested topics:

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- Corrosion and fouling – Prevention and protection
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- And more...

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Heat Exchanger World Conference & Expo Europe 2024

Heat Exchanger World Conference 2024 Steering Committee

Our 2024 Conference will be headed by a panel of experts, representing the heat exchanger industry from end users to manufacturers to service providers. With their combined knowledge and experience, the Heat Exchanger World Steering Committee will work to ensure that the conference programme is engaging, topical, and full of technical insights.

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Aeishwarya Chaudhari – *Lead Mechanical Engineer, BASF (Mumbai)*
Barinder Ghai – *Director Technical Marketing, Alleima*
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Showcase your expertise!

This is a niche networking event where every attendee is part of the Heat Exchanger World community. Presenters are recognised as leading experts on the design, manufacture and use of heat exchangers.

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Heat Exchanger World Conference & Expo Europe 2024

Event information

Heat Exchanger World Conference & Expo will be held at the Rotterdam Ahoy event space in Rotterdam, the Netherlands.

LOCATION:

Rotterdam Ahoy
Ahoyweg 10
3084 BA Rotterdam
The Netherlands
Phone: +31 10 293 3300
Website: www.ahoy.nl/en/

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The Heat Exchanger World Expo 2024 will be a meeting ground for those working in every field of the heat transfer industry. It will be tailored toward providing direct business-to-business and networking opportunities, and will welcome the diversity of global knowledge from exhibitors, visitors and conference delegates, further generating the understanding and knowledge necessary for future industry growth.

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Expo contact:
Sjoerd Hesseling,
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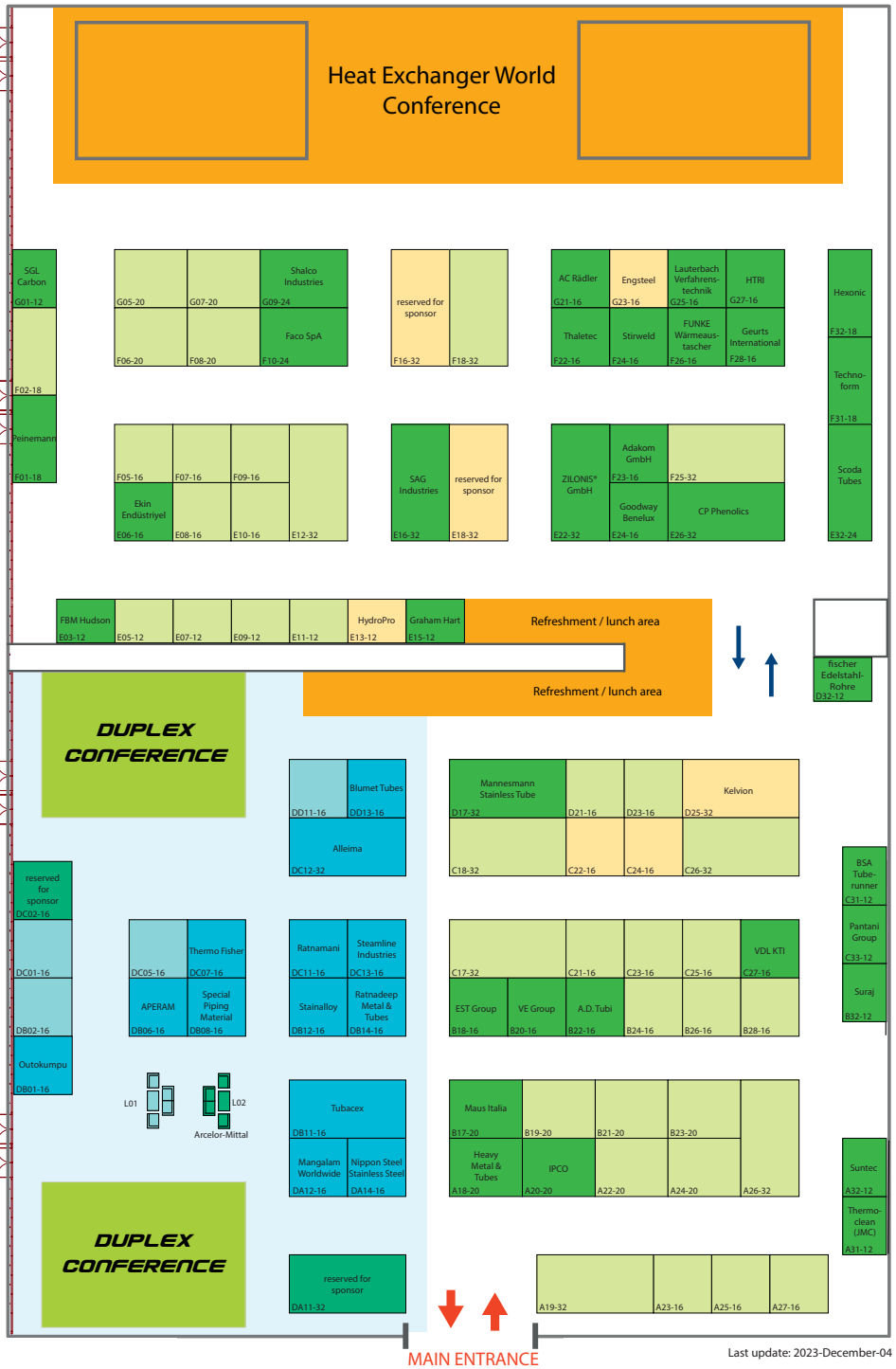

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