Clean Steam in the Food & Drink Industry

Which grade of steam is right for your application?

Francisco Pedrosa, EMEA Business Development Manager - Clean Steam Specialist

There is a growing trend for steam users to switch to clean steam.

Plant steam is fine for applications where it doesn't come into direct contact with the product, as well as in many applications where the product would be unaffected by low levels of contamination. However, the possibility that water treatment chemicals or other contaminants such as flakes of rust or scale could end up in end product, for instance, is increasingly seen as unacceptable. Many food and drink manufacturers are therefore looking to up their game by switching to cleaner forms of steam. It's a move that other, high-purity operators such as pharmaceutical manufacturers, healthcare providers and electronics companies have already made, either for regulatory/guidance or product quality reasons.

This white paper looks at the different grades of steam available, including plant steam, filtered steam, clean steam and pure steam. It also considers where they might be most applicable. For instance, some food manufacturers are happy with filtered (culinary) grade steam, while others are opting for steam generated by a dedicated clean steam generator.

Finally, it considers the potential advantages of switching to clean steam, including reduced costs from product wastage and the ability to demonstrate the use of best practice to demanding customers such as supermarkets.

The demand for clean steam is growing

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Standard plant steam is a convenient and costefficient way for moving heat around a huge variety of processes and premises, from petrochemical sites to pharmaceutical plants. Yet there's a growing recognition that plant steam is simply not clean enough for some applications. While this has long been understood in pharmaceutical production, healthcare and electronics, demand for clean steam is now on the rise in other industries.

The most obvious is food and drink, where improved hygiene naturally promotes greater food safety. However, the quality of other products may sometimes benefit from the use of clean steam to prevent contamination, even where there is no regulatory requirement relating to steam quality. In fact, any process that has steam coming into direct contact with the product has some potential to benefit from a switch to clean steam, although industries such as food, drink, pharmaceuticals and healthcare will undoubtedly remain the biggest users.

Food and drink companies are waking up to clean steam

Food and drink are the industries where the trend towards clean steam is undergoing the biggest shift. This is partly because manufacturers want to avoid quality issues, expensive product wastage and even product recalls with the associated damage to their reputation. It's also partly because of pressure from customers such as the major supermarkets, who have their own responsibility to ensure the safety and quality of the products they sell.

There is no specific legislation governing the quality of steam in food and drink applications even though concerns over issues relating to taste and taint are becoming more prominent. However, manufacturers are legally bound to ensure the quality of the final product by identifying potential hazards and controlling them, typically by using a Hazard Analysis and Critical Control Point (HACCP) approach.

The Food Standards Agency (FSA)

Responsible for food safety and food hygiene in England, Wales and Northern Ireland. The FSA works with local authorities to enforce food safety regulations and standards.

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This means manufacturers should ensure suitable controls are established and adhered to for all possible hazards. Within a HACCP context, steam quality and safety could be described as a HACCP prerequisite or, if the steam is added directly into the product, as a stage in the food production process. The standards commonly referred to when considering food hygiene include:

UK:

- S.I. 2006 No. 14 - The Food Hygiene (England Regulation).
- Guidelines for the Safe Production of Heat Preserved Food – Department of Health.
- Hygiene and design of food factories, edited by J. Holah.

Europe:

- Regulation (EC) No 852 / 2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs. (Chapter VII, Section 5).
- Codex Alimentarious.
- European Hygienic Engineering and Design Guidelines (EHEDG).
- Regulation (EC) No 1935 / 2004 of the European Parliament and the Council of 27 October 2004 on materials and articles intended to come in contact with food and repeating Directives 80 / 590 / EEC and 89 / 109 / EEC.

USA:

- 3-A Accepted Practices for A Method of Producing Culinary Steam, Number 609-03.
- FDA Code of Federal Regulations, 173.310, Title 21, Volume 3, Revised as of April 1, 2005.
- National Organic Standards Board (NOSB), Steam Generation in Organic Food Processing Systems TAP Review.

International:

- ISO/TS 22002-1 Prerequisite programmes in food safety for food manufacturing.

The Food and Drug Administration (FDA)

The Food and Drug Administration (FDA) is a government agency established in 1906 with the passage of the Federal Food and Drugs Act.

Exerts strict control over the manufacture and commercial distribution of food and drink, cosmetics and pharmaceutical products, for products manufactured within the USA or manufactured outside of the USA for sale within.

In addition to the Food and Drug Administration's (FDA's) requirements, food business will be subject to other federal, state, and local requirements. These will vary depending on the product and the type of facility. When planning to operate a food business, companies may want to discuss their specific product and facility with the FDA District Office and the state and local regulatory agencies external Link Disclaimer that have jurisdiction.

What does 'FDA approved' mean?

"FDA approved" means that the agency has determined that the "benefits of the product outweigh the known risks for the intended use." Manufacturers must submit a premarket approval (PMA) application and the results of clinical testing in order to get approval.

The demand for clean steam is growing

Pharmaceutical and healthcare standards

The situation is more clear-cut in the pharmaceutical and healthcare industries, where clean steam has a long-established track record. Pharmaceutical operators should be working to current Good Manufacturing Practice (cGMP) guidelines, while healthcare providers in the UK operate sterilisation facilities according to the latest guidance from the Department of Health.

In addition, the Bioprocess Equipment (BPE) group of the American Society of Mechanical Engineers (ASME) provides a measurable way to design, manufacture, specify and purchase equipment for the biotechnology, pharmaceutical and personal care industries.

ASME-BPE guidance applies to:

- Any manufacturing system that is in contact with the product, raw materials, buffers for pH modification or product intermediates.
- Systems that are a critical part of product manufacture e.g. fermentation, separation, purification, intermediate, product storage, fill/finish equipment.
- Utilities that come in contact with manufacturing equipment for cleaning and sanitisation e.g. Water For Injection (WFI) used for rinsing, caustic fluids for Cleaning in place, clean/pure steam for sterilisation in place, gases used for blanketing or product movement.

Further guidance comes from the International Society for Pharmaceutical Engineering (ISPE) which publishes a number of best practice and framework books including its Good Automated Manufacturing Practice (GAMP) guide.

Electronics require extreme hygiene

While there is no consumer or patient health imperative to use clean steam in the electronics industry, the tiny scale and extreme fragility of electronic components demand the highest standards of hygiene during the production process in order to maintain product quality.

The European Medicines Agency (EMA)

A decentralised body of the European Union, the EMA's main responsibility is the protection and promotion of public and animal health, through the evaluation and supervision of medicines for human and veterinary use. Regulations are enforced by National Regulatory Agencies e.g. MHRA in the UK.

The four grades of industrial steam

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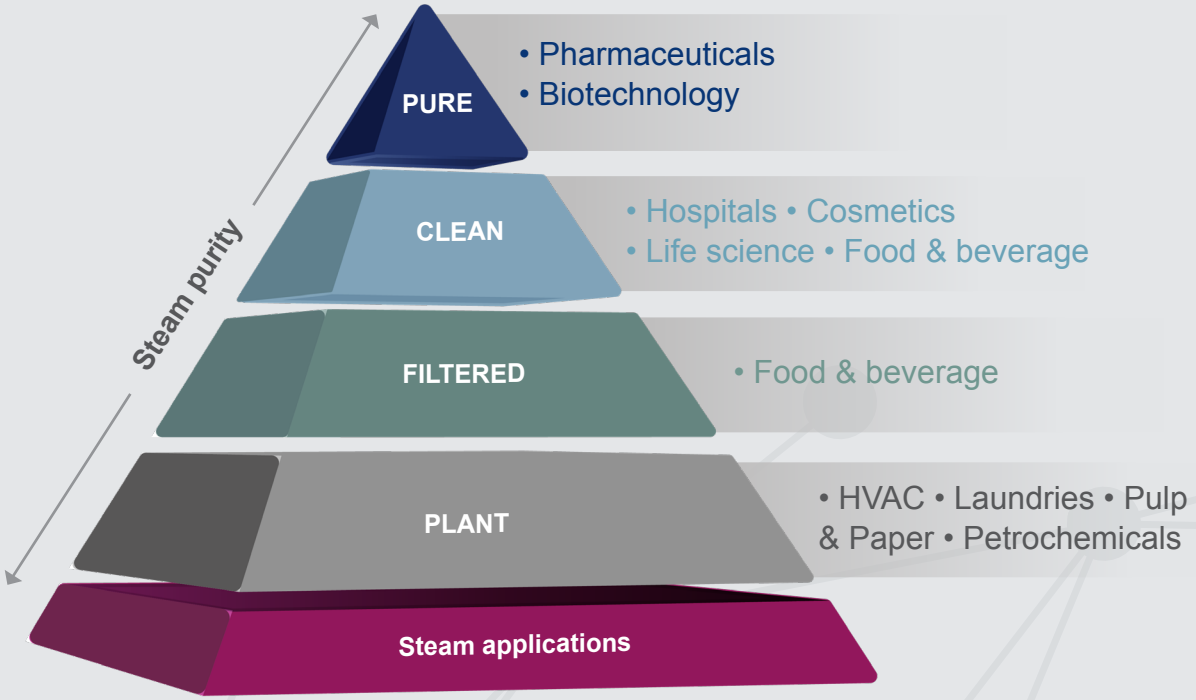


There are four grades of steam commonly used in industry today, from basic plant steam, through filtered (culinary) steam, clean steam and pure steam. While plant steam is great for heat transfer applications in industries such as petrochemicals or pulp and paper, many food companies already use filtered steam, or even the clean steam favoured by hospital sterilisation departments and life science labs. Pure steam is the highest grade option and is required in pharmaceutical and biotech applications.

Steam purity versus steam quality

It's worth noting that steam purity and steam quality mean different things While steam purity is a measure of the dissolved solids, volatiles and/or particles in the steam, steam quality refers only to the amount of water in the steam. A more correct term is dryness fraction.

Dryness fraction = Mass of steam/(Mass of steam + entrained water)

The four grades of industrial steam
PLANT STEAM

Plant steam is the starting point for most steam users. It can certainly be used anywhere it doesn't come into direct contact with the process or product. If it is used directly, users should consider whether the quality and purity of the steam are fit for purpose or whether any possible contaminants could present a problem.

Contaminants can be chemical, physical or microbiological.

The most common source of chemical contamination in plant steam arises from treating the feed water as it enters the system. Boilers generate steam from water and that water is typically treated with chemicals to prevent a range of problems such as corrosion or the build-up of scaly deposits. Traces of those treatment chemicals can end up in the steam supply, especially if users do not follow best practice, which is available in standards such as BS 2486: 1997 and BS EN 12953 –10 2003.

If chemicals do end up in direct contact with the process, they have the potential to taint products with an unwanted taste or smell. In the case of food and drink applications, there may also be safety concerns or consumer perception issues associated with their presence.

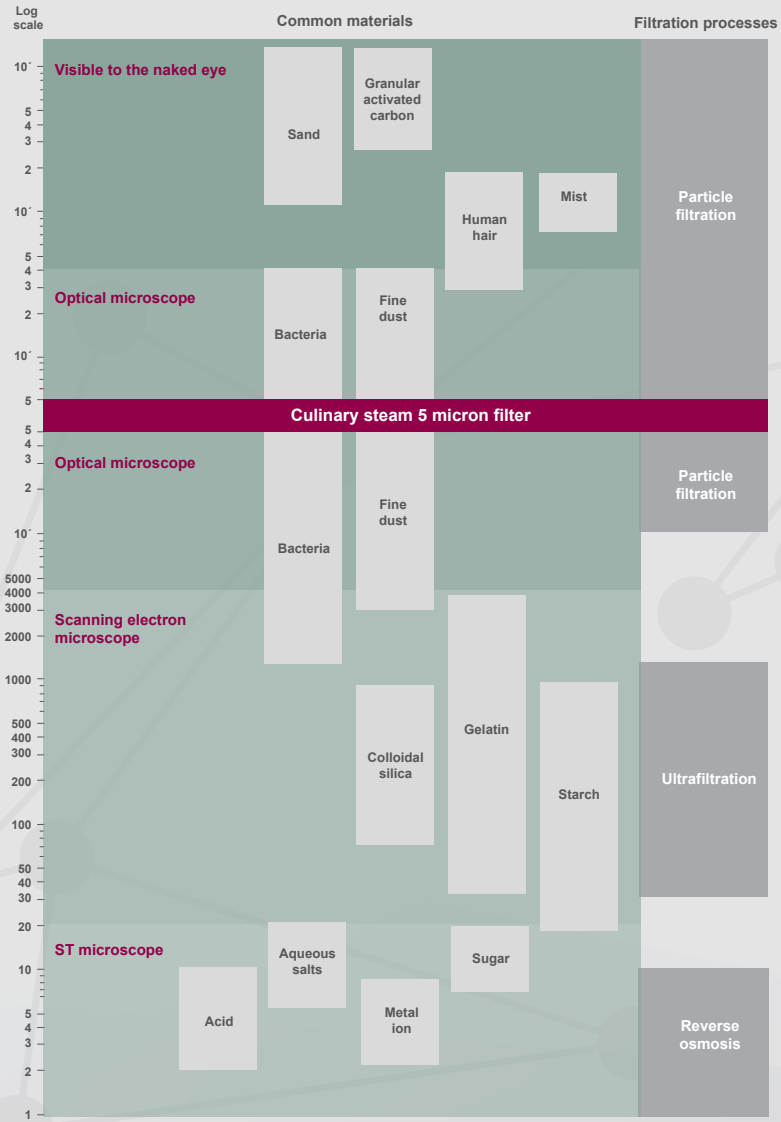
Carryover is another potential source of contamination. It may result from priming (where the distribution system draws off a large quantity of steam quickly and boiler water is entrained in the steam line) or foaming. Carryover can contain potentially high levels of water treatment chemicals.

Cross contamination is also a possibility, since most manufacturers will recover condensate from around the factory in order to save water and energy. If there are any pinholes or other leaks in the system, the returning condensate may be contaminated by process media or by the chemicals used for cleaningin-place, for instance.

Although effective water treatment should minimise problems such as scale and corrosion if carried out correctly, plant steam may still carry solid contaminants, such as flakes of rust or residual scale from inside the boiler and steam distribution system.

Of course, the temperature and pressure of steam kills common microbial hazards such as Salmonella, Listeria or E. coli. In fact, heat is a most effective and convenient physical control agent for destroying microbes, which is why clean steam is used to sterilise medical instruments, for example. Even so, dead microbiological debris (pyrogens) can still induce an adverse reaction if injected, which is why many pharmaceutical applications demand pure steam. In addition, any solid residue deposited by plant steam as it contacts the process or product could potentially provide a home for future microbiological growth once the product has cooled down.

The four grades of industrial steam
FILTERED STEAM



Filtered or culinary steam is plant steam that has passed through a filter, typically 5 microns. This removes 95% of all particles larger than 2 microns. A pre-filter (typically 25 microns) is placed upstream of any 5 micron filter to prevent rapid blinding (blocking) of the main culinary filter.

While EU Regulation (EC) No. 852 / 2004 says: ‘Steam used directly in contact with food is not to contain any substance that presents a hazard to health or is likely to contaminate the food’, it doesn’t specify the acceptable quality or purity of steam. In practice many European operators refer to the US 3-A practices for producing culinary steam.

3-A Accepted Practices for a Method of Producing Culinary Steam, Number 609 - 3, is the US standard that establishes requirements for producing culinary steam. It stipulates the materials used, surface finishes, installation and boiler operation with regard to the use of culinary steam.

Note that water treatment, boiler carryover and cross contamination still pose a risk, because the filter may not remove all the potential contaminants. In fact, the 3-A Practice specifically stipulates that boilers should be ‘operated in such a manner as to prevent foaming, priming, carryover, and excessive entrainment of boiler water into the steam’.

The four grades of industrial steam
CLEAN STEAM

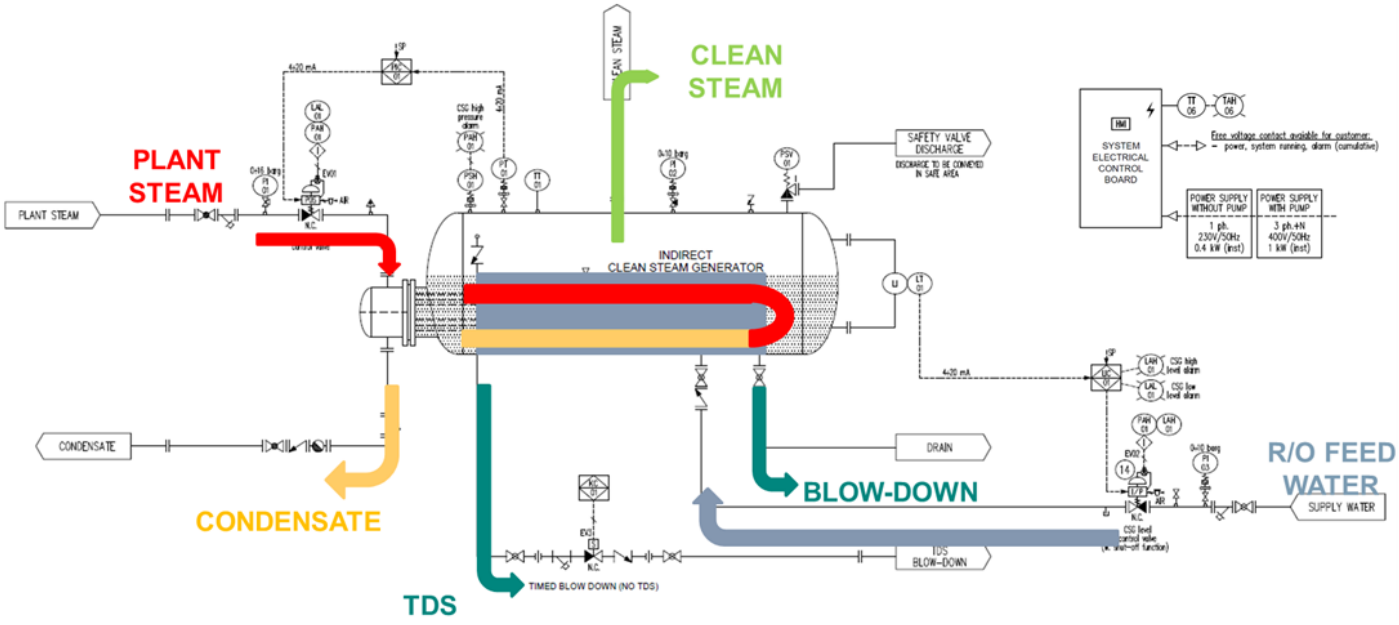
Clean steam is different because it relies on a secondary generator and tightly controlled feed water quality to eliminate many of the potential issues already outlined.

It's critical to start with the right water quality. Raw water is not adequate and will require pre-treatment. Reverse osmosis (RO), deionised/ demineralised (DI) and continuous electrodeionised (CEDI) water are all good possibilities. They all remove the need for chemical treatment by removing most of the particulates, inorganics and dissolved solids at the pre-treatment stage. The risk of water treatment chemical contamination is therefore eliminated when using clean steam.

In addition to the quality/purity of the clean steam leaving the generator, there are other factors that should be considered when installing a clean steam system.

Clean steam is very aggressive, so grade 316 or 316L stainless steel is typically used on contact surfaces throughout the system to protect against rouging. In addition, even though the temperature of the steam will keep most bacteria at bay, the surface finish of equipment should minimise any crevices that could encourage microbial growth. Similarly, a clean steam distribution system should be designed to good engineering practices. Guidance can be sought from 3-A Sanitary Standards.

Clean steam is often used in applications such as sterilisation not only to eliminate contaminants, but also to ensure the quality control of critical attributes such as dryness, superheat and production of noncondensable gases, all of which could adversely affect the process and equipment.



The four grades of industrial steam
CLEAN STEAM CASE STUDY

With partners including global companies and offering a variety of services including product development, ingredient sourcing, process advice and pack design, no challenge is too big for Natural Fruit & Beverage Co. To help a leading baby food manufacturer differentiate itself in a crowded market, the team at Natural Fruit & Beverage Co. embarked on a project to transition to clean steam generation for the packing process. All the while, minimising the risk of contamination to meet strict investor requirements.

The food and beverage industry might be a vibrant and thriving scene, but as one of the fastest moving industries, its highly competitive nature has also added considerable pressure to operating margins across the supply chain. In response, many organisations focus on identifying areas for improvement in the quality of products and processes. As one of the UK's leading packers of food products into resealable pouches, Natural Fruit & Beverage Co. did just that.

In late 2017, Jamie Walker, Manufacturing Manager at Natural Fruit & Beverage Co. was approached by a key customer looking to enhance the quality of their product - baby fruit puree sachet pouches. Ultimately, they wanted to differentiate themselves from their competitors and win future supermarket contracts.

CO_2 problems

Until then, the customer had been using CO_2 for purging and cleaning excessive residue before capping the product. It was becoming apparent that while competitor products were improving in quality, CO_2 was offering no room for improvement, and was also an expensive resource.

With CO^2 restricting progression, an alternative method had to be sourced. Jamie sought advice from existing suppliers and peers in the industry to see what alternatives were available. After speaking to a number of experts, he decided to follow up on the recommendation to use steam.

Clarity on steam

Jamie's initial findings unearthed a common misconception around the use of steam in food processing and he discovered that there is far more to understand than simply opting for one type of steam. With the need to understand which steam type would be best for their process, Natural Fruit and Beverage Co. called upon steam specialists, Spirax Sarco to guide them in the right direction.

A clean steam solution

The Spirax Sarco experts were invited to present to the The Spirax Sarco experts were invited to present to the management team at Natural Fruit & Beverage Co. Here they explained the various types of steam, the concept of clean steam as an ingredient and how it applies in relation to a Hazard Analysis and Critical Control Point (HACCP). The team of specialist engineers explained that despite the food and drinks manufacturer having made use of filtered steam in the production process, consistency in taste, colour and quality of the end product could be achieved by choosing clean steam.

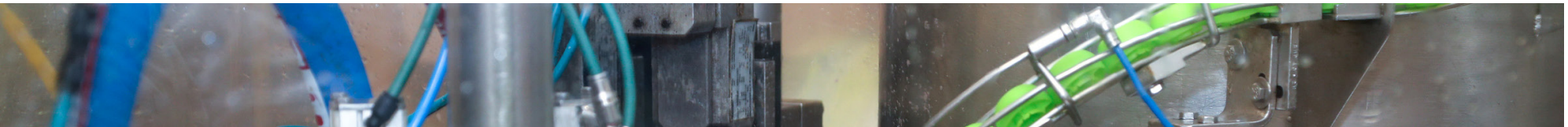
Generating and using clean steam within a process means controlling feedwater quality at the source. Rather than relying on a filtration process to extract particulates, the production of clean steam utilises a secondary steam generator with the ability to control chemical-free feedwater quality.

Based on this explanation, Natural Fruit & Beverage Co. went ahead and introduced an electric compact clean steam generator 50 kW (50 kg/h @ 3 bar) with preheating capability and the ability to control feedwater quality.

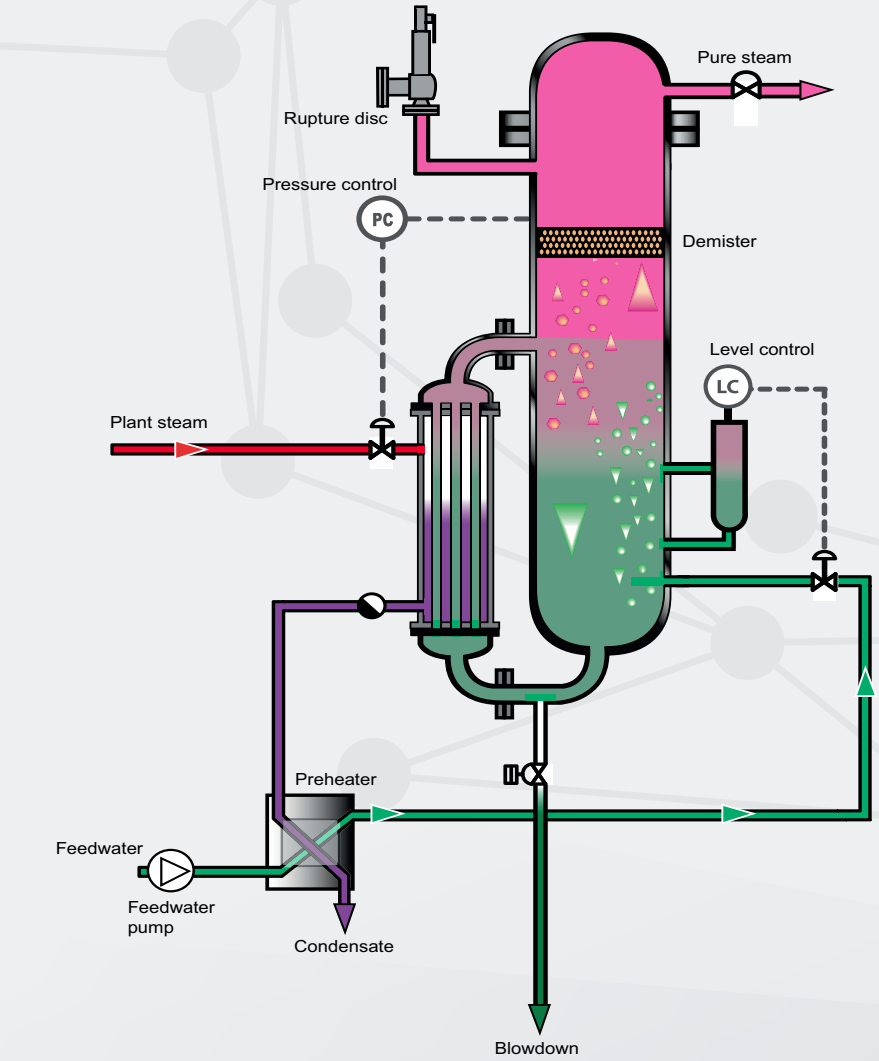
Overall Jamie was impressed with the service he received. He commented: "The Spirax Sarco team gave me the confidence and security that they knew the subject well enough to introduce a clean steam generator rather than filtered steam."

Since installing the new solution, Spirax Sarco has supported the Natural Fruit & Beverage Co. with regular site visits which has helped Jamie in gaining a better understanding of how their steam system is working.

Francisco Pedrosa, Clean Steam Specialist at Spirax Sarco added: "There are many companies across the country that use the same processes as Natural Fruit & Beverage Co., and yet do not realise the full potential of clean steam. Should their story spark an interest with any like-minded manufacturers, we would be more than happy to offer a consultation to advise on where they might be able to improve."



The four grades of industrial steam
PURE STEAM



Schematic of a pure steam generator

Pure steam must be pure, dry and pyrogen-free. When it condenses it should comply with international pharmacopoeia requirements for water for injection (WFI). In other words, it must be pure enough to be injected into the human body with no ill effects.

Again, a supply of highly purified feed water is essential, using the same principles as for clean steam. However, this time the standard is higher, with the resulting condensate again meeting WFI standards. A dedicated pure steam generator then distils the water either once or multiple times to produce the purity of steam required.

Because you'll find most pure steam being used in pharmaceutical applications, all the equipment and processes should meet cGMP, as enforced and regulated by national agencies such as the US FDA and Pharmacopoeia.

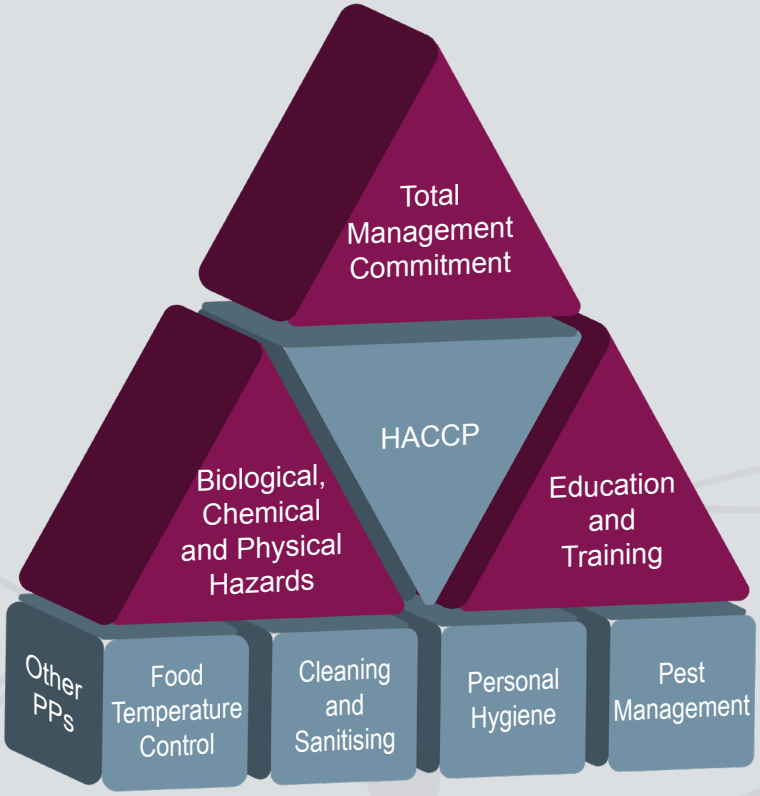
Why opt for cleaner steam?

The direct benefits of opting for steam with a higher standard of purity than plant steam vary, depending on the industry and the particular application. In industries such as pharmaceuticals, healthcare and electronics, the patient safety, regulatory and product quality requirements make the decision to use highpurity steam extremely clear-cut. Quite simply, it's an essential prerequisite for a successful operation.

On the other hand, some operators in the food and drink industries still view the use of clean steam as discretionary because of the lack of concrete regulatory requirements. However, it can be crucial in helping manufacturers to demonstrate that they are applying an effective food safety regime according to HACCP principles. This is increasingly a requirement from major retailers who, along with manufacturers, are responsible for ensuring the safety and quality of the products they sell.

A recommended approach to applying HACCP involves the following steps:

1. Conduct a hazard analysis of the plant and process areas.
2. Identity critical control points to eliminate the risks.
3. Establish critical limits .
4. Create monitoring processes.
5. Establish correction actions and solutions
6. Define verification procedures.
7. Keep records.



FOOD SAFETY MANAGEMENT IMPLEMENTATION PYRAMID

Spirax Sarco clean steam solutions

As well as being the leader in general-purpose steam, Spirax Sarco is also very active in delivering filtered, clean and pure steam systems for more specialised applications.

Filtered steam – Spirax Sarco offers a range of clean steam filters that will remove 95% of particles from plant steam, such as a 5 micron filter element that is designed to remove 95% of all particles larger than 2 microns and is acknowledged in the 3-A Accepted Practices for a Method of Producing Culinary Steam (when used in conjunction with FDA chemical standards). This solution should be combined with optimised water treatment and good plant maintenance in order to minimise the chances of contamination.

Clean steam – Spirax Sarco also offers dedicated systems for generating clean steam. For example, our reverse osmosis (RO) technology can remove almost 99% of the dissolved solids from raw feed water, without the use of chemical treatment. Our dedicated clean steam generators typically use plant steam to generate a source of clean steam that's suitable for a vast majority of hygienic environments, including food and drink manufacture and healthcare.

Pure steam – Pure steam generators from Spirax Sarco are coupled with high-purity distribution systems designed to ASME-BPE and meet cGMP requirements. All the contact parts are 316L stainless steel, complete with certified surface finishes. Supporting documentation provides full material traceability, surface finish, elastomer FDA and USP Class VI compliance, complete with a certificate of conformance.

Global brewer relies on Spirax Sarco clean steam

A major brewer uses two Spirax Sarco Clean Steam Generators and a Spirax Sarco Reverse Osmosis water treatment system to provide clean steam for beer keg sterilisation. Directly injecting clean steam into the beer kegs ensures that the process will not taint the product's taste, which could happen if only plant steam was used.

The Spirax Sarco generators were supplied as pre-assembled compact skid mounted packages for minimal installation time. The systems included precision automated controls, PLC control with a touch-screen interface and remote monitoring capabilities. They were built for low maintenance with all wetted secondary parts in stainless steel 316L and are supported by a support service with 24-hour response.

Spirax Sarco is now the brewer's preferred supplier for its other global facilities.

Spirax Sarco clean steam solutions

Spirax Sarco offers a range products and services for clean and pure steam applications:

Clean steam generators

All Spirax Sarco clean steam generators are supplied with a certification as standard to demonstrate they are manufactured in accordance with legislation requirements that avoids the risk of corrosion or contamination of clean steam supply and the PED directive.

Compact Modular Design Clean Steam generator (CSG - FB)
The CSG-FB is a compact modular design system made to fit through plant room doors and save on floor space. The pre-assembled, skid-mounted package arrives ready to be connected to your utilities with an option of multiple units side by side. The CSG - FB unit is equipped with EC 1935/2004 declaration of conformity.

The standard range covers clean steam duties up to 1600 Kg/hr @ 5bar g. It comes with a programmable control panel and colour touch screen mounted on the control panel, for easy parameter setting, monitoring, remote diagnosis and maintenance, providing reliable operation and low cost of ownership.

High Capacity Clean Steam Generator (CSM-K)
The CSM-K is ideal for use on larger loads where steam purity and quality consistency is critical to the process. The pre-heat degassing system is separate on this model and circulates the feedwater, ensuring the removal of soluble gases prior to entering the boiler.

The standard range of outputs is up to 5000 kg/hr @ 3bar g but also manufacture to client requirements and needs.

Clean & Pure Steam Components
Spirax Sarco is natural partner to help design and provide solutions and components for your clean and pure steam requirements. These include our sanitary range of products, heat exchangers and control systems to provide the efficient and safe steam distribution of steam to the point of use.

Services

Steam Quality Testing
A steam quality test can advise on the best quality of steam for an application. Improving the quality and purity of steam can cut energy costs, improve productivity and product quality, minimise risk and reduce maintenance workload.

Clean and Pure Steam Systems Training
This training course provides knowledge on all aspects of filtered, cleans & pure steam and associated water quality.

For more information or to request a steam quality assessment, please contact the Spirax Sarco team at **hello@uk.spiraxsarco.com**

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