CASE STUDY

Optimization of a bio-decontamination process: atomized hydrogen peroxide new cycle development method

Risk-based cycle development, considering not only the required decontamination level but the type of load and cycle total time

By Guillem Martínez Lorente, IonHP+ Technology Specialist, & Maria Santafe, Head of Process Laboratory, respectively, at Telstar

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ABSTRACT

Atomized hydrogen peroxide requires a methodical positioning of the load to achieve a correct decontamination.

According to GMP regulations, it is recommended to develop a recipe for each load and register every load pattern used. Changes on load pattern can reduce efficacy or efficiency in the cycle.
To ensure effectiveness in bio-decontamination cycles, a specific cycle development for the target load is required.

Customer issue

The IonHP+ decontamination system is a robust decontamination technology. However, there are several environmental and recipe dependent factors that directly affect the bio-decontamination process: temperature, RH, concentration, liquid/air flow rate and dwell time are some of the most important variables to be considered when developing a new process. There are also production related factors which significantly impact bio-decontamination, such as size, quantity, placement, and composition of the load.

In this case, after a development and validation of the decontamination process of one type of load, the customer changed the production procedure and decided to introduce a different load inside an isolator. The new load was more abundant, larger, and composed of different type of material cover (plastic bags and double Tyvek).

The client tried to start production, but sterility controls always showed growths. To avoid contamination, the customer attempted to design a new recipe increasing biocide concentration, but contaminations still appeared in sterility controls. Also, they found excessive condensation and puddles on the isolator ground which increased aeration times up to 8 h.

Solution

A new cycle development service developed by Telstar, which is a decontamination process study with the target load, was performed. During this service, the company conducts a risk-based study, assessing the composition and the placement of the load and identifies the critical points to decontaminate, but also optimizing the recipe and aeration phase cycle times, to achieve the decontamination level required by customer.

How do we achieve the solution?

Basic concepts

IonHP+ is a hydrogen peroxide-based decontamination technology which uses liquid and gas phases to reduce microbiological population. Hydrogen peroxide distribution, hydrogen peroxide concentration and physical conditions are particularly important to ensure good decontamination performance.

As previously mentioned, there are key parameters that must be adjusted to correctly decontaminate using ionHP+ technology. The RH interacts with H2O2 due to water and the hydrogen peroxide molecules similarity. RH should be lower than 80% to achieve a correct distribution.

Higher temperatures promote larger hydrogen peroxide gas phase (vapour pressure equilibrium at that specific temperature), nevertheless, ionHP+ process requires a specific ratio in between gas and liquid and therefore, a larger gas phase does not necessarily mean that the process is more effective. Thus, even if the environmental temperature could be in between 18 and 30ºC a specific study should be considered for each temperature step.

Load patterns are defined considering the size and composition of materials. For instance, absorbent materials like Tyvek retain a certain percentage of H2O2 inside, so, the general concentration should be adapted to compensate this loss of free H2O2. Also, plastic covers with wrinkles increase the area to decontaminate and can raise difficulties in decontamination. The good placement of load to improve distribution and the adjustment of the recipe are key concepts in HP decontamination.

Assessment results

The cycle development was divided into 4 parts:

- Micro-condensation distribution
- Chemical evaluation
- Microbiological evaluation
- Cycle time optimization

Micro-condensation distribution evaluation

First tests were used to correctly place the load inside the isolator, allowing the correct dispersion of hydrogen peroxide spray and avoid obstructions.

Figure 1: Micro-condensation sensor used to measure the impact of liquid hydrogen peroxide

Using a micro-condensation sensor, micro-droplet distribution was evaluated. Studied positions were selected according to the load distribution in each chamber, always ensuring H2O2 impact in all areas even not having load.

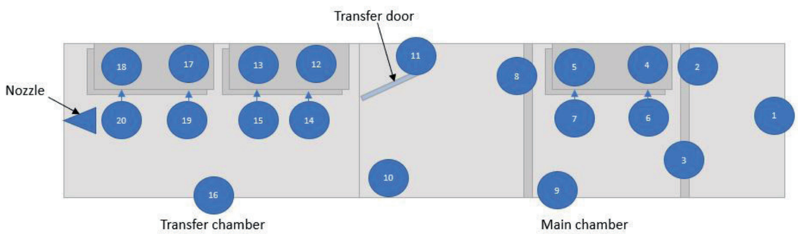

Figure 2: Isolator drawing, and positions selected

Transfer chamber and main chamber positions were selected to achieve 6-logarithm reduction on the load and the most significant surfaces of the isolator.

Using a concentration recipe (20mL), micro-condensation achieved the optimum range in all positions (between 2500 and 15000ng/mm2).

Chamber	Position	Max Impact(ng/mm^2)
Main chamber	1	3115
	2	2855
	3	3640
	4	6400
	5	7555
	6	2700
	7	3650
	8	10520
	9	12750
	10	14230
	11	7860
Transfer chamber	12	9555
	13	10855
	14	4235
	15	3810
	16	14520
	17	9180
	18	7970
	19	5685
	20	4725

Table 1: Micro-condensation results

Chemical evaluation

Gas impact was evaluated through the use of chemical indicators (CIs). CIs were placed in each position studied to determine the correct impact of biocide.

Results confirm that position 6 is a critical point and the most difficult point to decontaminate.
Other positions received a good biocide impact with a preliminary recipe.

Figure 3: Chemical indicators after being exposed to a hydrogen peroxide cycle

Biological evaluation

Like a critical point was detected using a conservative recipe, it was decided to begin a battery of tests from 20 mL to 60mL. Puddles were observed at 60mL injection, so this volume was discarded.

Exposure time used was increased 10 minutes as low micro-condensation impact points required more gas impact to achieve correct decontamination levels. Longer exposure time would improve distribution and effectiveness of the biocide.

Biological indicators were positively deactivated with hydrogen peroxide volumes of 30ml, 40ml and 50ml, achieving in every case a 6-log reduction, and in all studied positions. Thus, the optimized recipe was 30ml.

Figure 4: Biological indicators in disc format

Cycle time optimization

Aeration flow was adjusted at the maximum flow which the H14 filters allowed. It was increased by 54% from the initial flow. This increase in air change renovations (ACH) is a crucial factor to decrease aeration times.

Final aeration times were reduced from 8 h to 1,25 h due to ACH increase, total injected hydrogen peroxide volume was reduced and load pattern was optimized, which also implied elimination of puddles and excessive condensation.

Conclusions

After the service, the process effectiveness was checked according to customer requirements (6-log reduction in all surfaces of the load and equipment). Growths were not detected in sterility tests after the cycle development.

Finally, the injection volume was reduced (avoiding puddles) and load placement was optimized according to the injection and exposure process,allowing the hydrogen peroxide to reach all the points of the isolator without an excess of biocide injection. ACHs were also increased up to 54% during the aeration phase. These improvements significantly reduced the cycle times (from 8h to 1,25h).

References

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The authors

Guillem Martínez Lorente, IonHP+ technology specialist and Pharma and Vacuum R&D Project Engineer, holds a MEng in Biotechnology from Universitat de Vic-Universitat Central de Catalunya (Uvic-UCC) together with a Msc in Bioengineering from the Institut Químic de Sarrià (IQS). Guillem joined Azbil Telstar in 2020, actively participating in different emerging technologies development. Currently, he is focused on R&D of Life Science Industry process related projects, as well as providing support to laboratory services related to sterilization process.

Maria Santafé Villarroya holds a MEng in Chemical Engineering from the Universitat Autònoma de Barcelona (UAB), Spain. After more than five years of studying Lyophilization technology as a Process Laboratory Engineer, he is from 2020 the Head of Process Laboratory at Telstar thus leading all customer projects in this field. In addition, and as part of the R&D team, she actively contributes with her expertise in all R&D process related projects.

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