Use of hydrogen peroxide vapor (HPV) is a recognized and recommended solution for the decontamination of small aseptic processing enclosures. Due to the historic limitations and lack of understanding of this technology, other larger scale applications have often not been considered. However, over the last 20 years Bioquell has developed world leading expertise in the bio-decontamination of large areas including hospitals, biomedical facilities, pharmaceutical production areas and bio-containment facilities. This paper discusses a service-based approach to large scale decontamination and the benefits hydrogen peroxide vapor technology can offer.
Choosing the right bio-decontamination technology

Different market sectors and different companies have different criteria for implementing new bio-decontamination technology. When deciding on the best process to employ, particularly for large scale operations, the following issues should be evaluated. These will help to ensure that any systems implementation provides a sensible, operational and financial basis for change:

1. **Verification**. The ability to independently verify that a bio-decontamination process has been carried out successfully is an important issue to address. The system chosen should provide the ability to intrinsically meet the requirements of the regulatory body without risk to the process. This applies not only to the disinfectant application but also its removal. For example, a manual system, however implemented, monitored and documented, will only be as good as the operators performing the task. Environmental sampling and monitoring will help ensure that critical control points are within acceptable limits but will not ensure that all areas have been exposed to the correct cleaning regime.

2. **Risk reduction**. Bio-decontamination processes carry inherent risks that can directly affect human health as well as financial performance. It is important that these different risks are assessed. It is also important to review the steps the manufacturers have put in place to help mitigate these risks. For example, any process which requires a person to manually perform a task has inherent risk especially where this task is repeated. By automating parts of the process, these types of risks can be minimized. Another example is where the bio-decontamination process is uncontrolled or unmonitored. Here there is a risk that the target area has not been bio-decontaminated fully or the active disinfectant has not been sufficiently removed/neutralized at the end of a decontamination cycle. In this situation, as well as the obvious risk to human health, it also offers a potential delay in the release of the area back to full production.

3. **Down time reduction**. Whether restarting operations after a planned shutdown or a microbiological excursion, the time taken to reinstate the facility back to full production will be a critical factor to the overall cost of the intervention. Removing residues or waiting for the chemicals to be below regulated limits can cause substantial time loss and prevent reinstatement.

4. **Cost reduction**. Cost reduction should be reviewed directly and indirectly. As a result of bio-decontamination, the removal of other process steps (including preparation, application, removal, sampling and reporting) can help with direct cost reduction. Indirectly, a reduction in risk, resources and verification processes usually lead to longer term cost reductions. However, it is clear that any cost comparison must include the process as a whole to get a fair and equitable comparison between technologies.

An overview of the main bio-decontamination techniques

Many different bio-decontamination approaches have been used in the pharmaceutical industry. These can be typically categorized as spray and wipe, formaldehyde fumigation, chemical foggers and hydrogen peroxide vapor (HPV) technology:

- **Spray and wipe**: A simple process but one that can lead to contamination reservoirs. These reservoirs allow the development of chemical resistant characteristics despite the stringent use of chemical rotation techniques. The spray and wipe process is also inherently manual and hence suffers from a lack of validation and control. The removal, and proof of removal, of disinfectant residues only adds to the variation in the process which inevitably manifests itself in additional time and cost.

- **Formaldehyde fumigation**: For both small and large scale applications, formaldehyde has historically been the default choice for bio-decontamination fumigation. However, the downsides of time, lack of process control, residues, health and safety implications and mounting legislation regarding its health risks are now challenging its primary advantage of being cheap to deploy.

- **Chemical foggers**: By emitting a nebulized / atomized spray of a particular disinfectant, these units are finding some small scale bio-decontamination uses. However, the manual nature of operation, the lack of good distribution, the possibility for residues and the lack of an active chemical removal system pose serious questions about their safety and use in anything but uncontrolled or unregulated environments.

- **HPV**: Hydrogen peroxide, when flash evaporated forms a vapor that acts like a gas. This homogeneous vapor is distributed onto all surfaces, providing a complete 3 dimensional coverage. When implemented correctly, HPV decontamination is extremely effective at eliminating biological contamination. The process is residue-free, quick, and safe to use on sensitive electrical equipment.

**HPV technology description**

HPV, as a large-scale bio-decontamination process, has been commercially available (as both equipment purchase or a managed service option) since 2003. It provides a rapid, residue-free technology, able to decontaminate large buildings in under 24 hours without the need for a lengthy residue removal step. The HPV process can be
validated with *Geobacillus stearothermophilus* biological indicators\(^1\) to demonstrate a 6-log sporicidal reduction within the target area. The gaseous vapor-phase hydrogen peroxide bio-decontamination process, including biological indicator verification, has been accepted by international regulators as a method of achieving ‘surface sterilization’.

Most importantly, when compared to manual disinfection or formaldehyde fumigation\(^2\), HPV is not ‘wet’. The excellent process verification, low contact time (and hence fast cycle time) and excellent materials compatibility (including sensitive electronics) mean that HPV offers a number of advantages over more conventional methods.

**Bioquell HPV bio-decontamination service options**

For very high frequency / low volume decontamination requirements, equipment purchase is clearly advantageous.

For other larger or less regular bio-decontaminations, a service provision affords a number of key advantages:

1. **Scheduled shut down:** Most production or aseptic processing areas require planned maintenance periods, either at a set time intervals or between campaigns.

   Manual wipe down or formaldehyde ‘fogging’ takes up a disproportionate amount of time compared to the results achieved with Bioquell HPV. Aerosolized hydrogen peroxide (aHP) although relatively rapid, does not provide the level of efficacy associated with Bioquell HPV\(^1\). Bioquell’s room bio-decontamination service (RBDS) can be deployed rapidly over a large area (e.g. 8,000m\(^3\) in 16 hours including all set-up activities) and still achieve a high level 6-log spore reduction. The time saving afforded by this service is typically between 2–7 days on any given volume of production or research area when compared with traditional techniques.

2. **Emergency requirement:** If environmental bio-burden reaches alarm limits, either by gradual increase or spike, the remediation process needs to ensure that all environmental reservoirs are removed. Bioquell offers a number of different ways to deploy its room bio-decontamination service in this situation with the preferred method based around a pre-planned deployment model. Even without a pro-active consultancy visit, the Bioquell RBDS team are able to react to any given emergency. Clearly the more planning which has been carried out in advance, the more efficient this process will be.

3. **Remediation planning:** Most companies rely on carefully constructed and audited processes to ensure that the risk from a contaminant is minimal. However, accidents do happen, such as the introduction of contaminated consumables. A rapid remediation plan is essential to ensure limited interruptions to a facility’s output. Bioquell’s RBDS project managers are able to provide detailed project plans and guidance to customers ensuring that, should a rapid response be required, the process is smooth and efficient with limited impact.

**Conclusion**

HPV, especially as a large volume service provision, offers a number of key benefits in terms of speed, efficacy, safety and operational flexibility. With no post process cleaning procedures required, it enables the reinstatement of activities faster and more efficiently than otherwise possible. This leads to cost reduction and improved efficiency.
References

