BIOQUELL's CLARUS™ technology

Hydrogen Peroxide Vapour

Material Compatibility:

Issues and facts

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INTRODUCTION

The data in this paper is derived from a series of tests to ascertain the effect of hydrogen peroxide (H_2O_2) vapour on various commonly encountered materials which may be exposed to both dry and saturated H_2O_2 vapour during a gassing cycle.

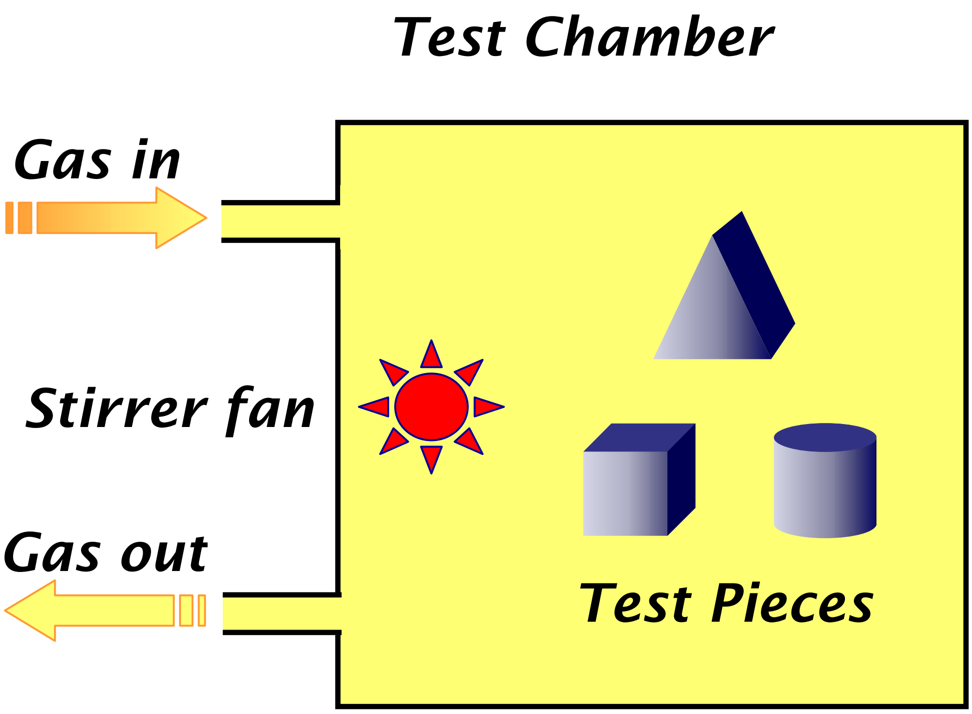
It is important to understand that the test cycles are intentionally designed to be generally more destructive than the actual gassing environment. They are intended to apply a severe exposure to the test material in order to ensure that, under normal gassing conditions, there is no likelihood of damage. Further, one-off gassing is far less likely to produce material compatibility problems as compared to repeated gassing on, say, a daily basis.

Certain materials have been deemed as problematic for gassing even at low doses and these are highlighted in the test notes. *For these materials the reader should note that practical experience shows that this damage is likely to occur regardless of whether the gassing is above or below the dew point.*

The list of materials described in this document is of course not comprehensive; if the reader is aware of other materials which may be exposed to hydrogen peroxide vapour it may be possible to perform further specific testing. To discuss such testing please contact BIOQUELL directly.

CONTENTS

Individual Material Tests: Test methodology



Test Conditions
Gas concentration : 1000 ppm
Exposure time : 140 hours
(variations noted in text)

Note: the maximum gas concentration in a room typically ranges from 500 to 750ppm

INDIVIDUAL MATERIAL TESTS:

Other items / assemblies cont.:

Hydrogen Peroxide Material Compatibility Data

Sheet 001

Material — **Aluminium 5251/H22**

Description — The sample material is 1.6mm thick and has a bright brushed finish on one side with a clean matt finish on the other.

Observations — The bright surface showed some signs of oxidation and discolouration, but no deterioration of the surface or loss of mechanical strength.

Conclusions — Unprotected aluminium is subject to oxidisation in normal atmospheric conditions. Hydrogen peroxide is an oxidising agent and some discoloration is thought to be expected. The initial oxidisation serves to protect the aluminium surface from further attack. The aluminium tested was of a grade commonly used in fabrication and machined parts.

Recommendations — Untreated Aluminium should not be used where possible, however if some surface oxidisation is acceptable then the aluminium should prove satisfactory.

Method of Testing — An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure.

The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected.

The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.

Date of Testing — 28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 002

Material **Aluminium Alloy, 'Niploy' Coated**

Description The sample provided was approximately 100 x 90 x 8 mm in size. No further details were provided. The finish appeared to be finely shot blasted and was matt in lustre.

Observations There was no obvious deterioration and no visible deposits on the surface.

Conclusions The material is satisfactory for use in a system with hydrogen peroxide at a concentration of 1500 ppm.

Recommendations The material is suitable for use and should prove satisfactory.

Method of Testing An enclosure of approximately 1 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. The sample was suspended inside the enclosure so as to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure even distribution of the hydrogen peroxide vapour.

The enclosure was sealed and the concentration and the sample subjected to the following:

70 hours exposure to hydrogen peroxide at a concentration of 1500ppm.

30 hours exposure to hydrogen peroxide at a concentration in excess of 1500ppm and up to 3500ppm.

10 hours exposure to Seppic 'Soproper'. For the test, 6ml/min fluid was evaporated into an airflow of 800l/min.

The inspection consisted of a detailed visual inspection.

Date of Testing 17.10.97

Hydrogen Peroxide Material Compatibility Data

Sheet 003

Material **Aluminium Bronze**

Description The sample provided was 50 x 32 x 8 mm in size. No further details were provided.

Observations There was no obvious deterioration and no visible deposits on the surface.

Conclusions The material is satisfactory for use in a system with hydrogen peroxide at a concentration of 1500 ppm.

Recommendations The material is suitable for use and should prove satisfactory.

Method of Testing An enclosure of approximately 1 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. The sample was suspended inside the enclosure so as to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure even distribution of the hydrogen peroxide vapour.

The enclosure was sealed and the concentration of 1500ppm was maintained for 170 hours after which time the sample was removed and inspected.

The inspection consisted of a detailed visual inspection.

Date of Testing 17.10.97

Hydrogen Peroxide Material Compatibility Data

Sheet 004

Material **Anodised Aluminium 30 Microns**

Description The test samples were from 2.5mm thick flat strip with clear soft anodised finish.

Observations There was no obvious deterioration of the surface or discoloration.

Conclusions Anodised aluminium should be an excellent material for use within an area to be sterilised with Hydrogen Peroxide. NB subsequent tests on certain anodised aluminium samples have given rise to discoloration so care should be taken when using this material.

Recommendations Anodised aluminium has shown a good result. Therefore we conclude that this material would be suitable. Hard Anodising should provide even better protection

Method of Testing An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure.

The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected.

The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.

Date of Testing 28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 005

Material **Brass**

Description

The samples used were 1.6mm thick brass sheet with one side bright. The other side had some surface defects due to storage.

Observations

There was some surface discoloration on the bright side, probably due to oxidisation and reaction with Hydrogen Peroxide. The structural integrity of the material did not seem to be adversely affected.

Conclusions

There will be cosmetic changes to brass items within an enclosure being gassed.

Recommendations

It is possible to use brass within an enclosure being gassed, however if brass is present it should be protected, if unprotected, some surface tarnishing could occur.

It is noted that copper/zinc materials act as a catalyst to hydrogen peroxide liquid and it is therefore essential that the liquid solution does not come into contact with brass.

Method of Testing

An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure.

The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected.

The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.

Date of Testing 28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 006

Material	**Copper**
Description	The material tested was 1.2mm thick half hard copper sheet with a bright finish on both sides
Observations	The copper had obviously been subjected to a surface change resulting from oxidisation from the Hydrogen Peroxide. This left the surface with a reddish hue but did not appear to affect the surface finish or strength of the material.
Conclusions	It is possible to use copper within an enclosure being gassed (e.g. water pipes) but if left uncoated there will be some cosmetic changes.
Recommendations	It is possible to use copper within an enclosure being gassed. It is recommended that copper pipes etc in rooms are coated with a suitable paint. It is noted that copper/zinc materials act as a catalyst to hydrogen peroxide liquid and it is therefore essential that the liquid solution does not come into contact with copper.
Method of Testing	An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure. The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected. The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.
Date of Testing	28.12.94

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Hydrogen Peroxide Material Compatibility Data

Sheet 007

Material	**Mild Steel**
Description	The samples were unpainted and unprotected with a thickness of 1.6mm.
Observations	The surfaces showed signs of rusting and shallow pitting.
Conclusions	Mild Steel is adversely affected by Hydrogen Peroxide. Therefore any breaks or defects in the surface protection will lead to localised corrosion and subsequent failure of any coating placed on mild steel.
Recommendations	Where possible mild steel should be avoided, if used the coating should be continuous and any defects repaired immediately.
Method of Testing	An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure. The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected. The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.
Date of Testing	28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 008

Material	**Stainless Steel**
Description	The test pieces were of 1.6mm thick-brushed polished stainless steel grade 316.
Observations	There was a slight discoloration of the polished finish; however, there was no deterioration of the material with regard to surface finish or mechanical properties. NB subsequent tests with isolators made from 316 stainless steel have not resulted in any discoloration – and c. 90% of all pharmaceutical isolators are now bio-decontaminated with hydrogen peroxide vapour and problems with stainless steel are not common.
Conclusions	Stainless Steel is a satisfactory material with which to manufacture enclosures or components for use within the system.
Recommendations	Stainless Steel is an ideal material for exposed surfaces but will also provide a suitable material for subsequent decorative finishes, e.g. Epoxy or Powder Coating.
Method of Testing	An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure. The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected. The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.
Date of Testing	28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 009

Material — **Brush Painted Mild steel**

Description

The sample was brush painted with Dulux Gloss Paint on mild steel pre-treated with a primer.

Observations

Severe blistering of the paint surface with subsequent flaking, occurred over the entire surface area

Conclusions

The brush painted surface is obviously absorbent to Hydrogen Peroxide which then reacted with the Mild Steel to form gas. This resulted in the bubbling of the painted surface. This damage began after a considerable exposure to high concentrations in the order of 1,000ppm. and may not prove a problem to short duration cycling.

Recommendations

Brush painted gloss mild steel is not a suitable method of protecting mild steel components within a Hydrogen Peroxide atmosphere. However further testing may be required to establish whether other items painted in this manner could be acceptable when a shorter exposure period is used.

Method of Testing

An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure.

The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected.

The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.

Date of Testing

28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 010

Material	**Epoxy Painted Mild Steel**
Description	Samples had a white 2 pack epoxy paint coat with a smooth finish.
Observations	Epoxy coated steel did not show any signs of deterioration or oxidation.
Conclusions	The Items tested appeared to be satisfactory, however it must be stressed that Epoxy paint varies significantly from manufacturer and type. Some deterioration over a long period may therefore be experienced.
Recommendations	Epoxy Coated Mild Steel should prove satisfactory for short duration exposures and epoxy coating appears to be a good choice for material protection.
Method of Testing	An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure. The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected. The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.
Date of Testing	28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 011

Material	**Galvonised steel**
Description	Air conditioning duct
Observations	Galvonised steel did not show any signs of deterioration or oxidation.
Conclusions	The item tested appears to be satisfactory.
Recommendations	Galvonised steel is commonly used in air conditioning systems. This material displayed no superficial or structural reaction to hydrogen peroxide vapour so can be recommended as a compatible material.
Method of Testing	A Clarus™ R Generator was placed inside a room of approximately 30 m^3. The sample was placed inside the room. The enclosure was sealed and the sample was subjected to 60 back-to-back cycles. A typical cycle achieved a concentration of >500ppm for 30 minutes, thus the sample was subjected to >500ppm for 30 hours. The sample was then removed and inspected. The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.
Date of Testing	19.09.03

Hydrogen Peroxide Material Compatibility Data

Sheet 012

Material	**Polyester Powder Coated Aluminium**
Description	The samples had Powder Coating to both surfaces with a smooth gloss finish.
Observations	There was no visible deterioration of the painted surface. The Powder Coating material is similar to that coating the mild steel but did not exhibit any bubbling or coating delamination.
Conclusions	The survival of the powder coating when applied to aluminium may be due to a number of factors; firstly, aluminium has to be etch primed to provide adhesion of the powder coating. Secondly, aluminium does not react with Hydrogen Peroxide and therefore gas production below the surface of the coating would not take place as with the mild steel samples.
Recommendations	Polyester Powder Coating would appear to be suitable for decorative finishes on aluminium components being exposed to Hydrogen Peroxide.
Method of Testing	An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure. The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected. The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.
Date of Testing	28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 013

Material **Stove Enamel Painted Mild Steel**

Description The samples had a white stove enamel coating on both sides with a smooth finish.

Observations There were slight signs of surface disturbance and some discoloration, however this was very slight.

Conclusions Stove enamel finished mild steel will give adequate protection in most instances however any damage leading to penetration of Hydrogen Peroxide to the steel substrate will result in flaking or bubbling of the paint.

Recommendations Stove Enamel Coating of Mild Steel will afford a reasonable protection, however, some bubbling or flaking may result from repeated cycles.

Method of Testing An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure.

The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected.

The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.

Date of Testing 28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 014

Material **ABS**

Description

The sample material was a light grey 2mm thick ABS plastic with a smooth side on one face and a textured finish on the other. This material is often used for vacuum forming and injection moulding of many plastic components.

Observations

The material showed no sign of deterioration and had no visible or discernible deposits on the surfaces. Structural strength appeared to be unchanged.

Conclusions

The material appears to be perfectly satisfactory for inclusion within a system to be sterilised with Hydrogen Peroxide. Outgassing from this material should not be a problem.

Recommendations

The material is suitable for use and should prove satisfactory.

Method of Testing

An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure.

The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected.

The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.

Date of Testing 28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 015

Material	**Acrovyn**
Description	The sample material was a 2mm charcoal Acrovyn sample with a smooth side on one face and a textured finish on the other. This material is often used for door and frame finishes.
Observations	The material showed no sign of deterioration and had no visible or discernible deposits on the surfaces. Structural strength appeared to be unchanged.
Conclusions	The material appears to be perfectly satisfactory for inclusion within a system to be decontaminated with hydrogen peroxide vapour. Out-gassing from this material should not be a problem.
Recommendations	The material is suitable for use and should prove satisfactory.
Method of Testing	A Clarus™ R Generator was placed inside a room of approximately 30m^3. The sample was placed inside the room. The enclosure was sealed and the sample was subjected to 64 back-to-back cycles. A typical cycle achieved a concentration of >500ppm for 30 minutes, thus the sample was subjected to >500ppm for 32 hours. The sample was then removed and inspected. The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.
Date of Testing	19.09.03

Hydrogen Peroxide Material Compatibility Data

Sheet 016

Material	**GRP (Glass Reinforced Plastic)**
Description	The samples tested had a smooth surface on one side with an exposed fibre on the other.
Observations	The sample did not show any signs of surface deterioration and the material strength appeared to be unaltered. However there is potential for gas absorption on the fibre lay up side.
Conclusions	GRP appears to be a satisfactory material, however the porosity of the fibre lay up side should not be exposed to Hydrogen Peroxide as degassing takes a long time.
Recommendations	GRP should prove to be as suitable material however, we would recommend careful consideration in its application.
Method of Testing	An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure. The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected. The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.
Date of Testing	28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 018

Material	**Machinable Nylube**
Description	The samples provided were of red nylube no further specification is available.
Observations	The material has been visibly affected by the hydrogen peroxide. The surfaces of the samples appear no longer as smooth. Bleaching of the colour has taken place when compared to the underside which was placed on the tray. The material appears to be structurally okay.
Conclusions	This grade of nylube is possibly suitable for use within a hydrogen peroxide system but there may be some surface changes.
Recommendations	None.
Method of Testing	An enclosure of 1 m^3 was connected to a BIOQUELL HyPer-Phase generator and set to operate at 1500 ppm. The sample of nylube was placed on a tray and a fan was provided to ensure gas circulation to all exposed surfaces. The enclosure was sealed and the concentration was maintained for 160 hours, after which time the nylube was visually and mechanically inspected to provide the above observations.
Date of Testing	11.07.96

Hydrogen Peroxide Material Compatibility Data

Sheet 019

Material **Neoprene**

Description The samples tested were black neoprene rubber, suitable for gasketing with a shore hardness of approximately 60.

Observations There was no sign of deterioration of the elasticity or strength of the materials. There was a slight surface powdering, however, this brushed and cleaned off to leave the material unaltered.

Conclusions The Neoprene sheet tested would appear to be a suitable choice for gaskets or gloves; natural rubbers will decompose quickly when exposed to Hydrogen Peroxide.

Recommendations Neoprene would be a suitable choice for gaskets, O rings or other items likely to come in contact with Hydrogen Peroxide vapours.

Method of Testing An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure.

The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected.

The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.

Date of Testing 28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 020

Material	**Perspex**
Description	The samples used were optically clear Perspex sheet, 6mm thick.
Observations	There was no deterioration of the material whatsoever. The optical clarity of the material appears to be unaltered.
Conclusions	From this original testing Perspex (clear Acrylic sheeting) should be suitable for manufacture of enclosure or vision panels. Perspex is slightly absorbent with respect to Hydrogen Peroxide which may marginally lengthen aeration times due to outgassing.
Recommendations	Perspex appears suitable for use in gassing applications – however our recommendation is to use polycarbonate sheeting as it has been extensively used as a room gassing interface panel with no detriment whatsoever.
Method of Testing	An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure. The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected. The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.
Date of Testing	28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 021

Material	**Polypropylene**
Description	Samples tested were semi-rigid ICI Polypropylene sheet with a shiny black surface.
Observations	The surface finish and material strength were unaltered.
Conclusions	This material appears to be suitable for use within systems exposed to Hydrogen Peroxide.
Recommendations	If this material is to be used for continuous exposure to Hydrogen Peroxide further testing may be required.
Method of Testing	An enclosure of approximately 0.3 m^3 was fitted to a BIQOUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure. The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected. The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.
Date of Testing	28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 022

Material	**Polythene**
Description	The samples used were a translucent semi rigid material similar to that used for packaging.
Observations	There was no visible deterioration of the surface or change in the translucent appearance of the material.
Conclusions	Polythene would appear to be compatible with the gas but readily absorbs Hydrogen Peroxide. Therefore the degassing time of the material will have to be taken into consideration.
Recommendations	This material would appear to be suitable for manufacturing components or enclosures but should not be used for long term exposure.
Method of Testing	An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure. The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected. The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.
Date of Testing	28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 023

Material	**PTFE**
Description	The samples were smooth finish 4mm thick PTFE sheet.
Observations	There was no deterioration of the surface or material strength at all.
Conclusions	PTFE is a suitable material for use with Hydrogen Peroxide in its vapour or liquid state.
Recommendations	PTFE could be used for tubing, or any machined or manufactured parts for use within a Hydrogen Peroxide atmosphere.
Method of Testing	An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure. The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected. The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.
Date of Testing	28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 024

Material **PVC**

Description The test pieces were of grey ICI extruded PVC sheet.

Observations The surface of the material appeared to be unaltered, there were no obvious signs of pitting or deterioration.

Conclusions The PVC material in this form would be suitable for use in providing enclosures or pipe work distributing Hydrogen Peroxide. It must be noted that the soft PVC will absorb Hydrogen Peroxide and degas slowly, however this rigid form of PVC shows little sign of adsorption of Hydrogen Peroxide. Further, components of the new Clarus range of bio-decontamination technology are made from PVC (and are repeatedly exposed to high concentrations of H_2O_2)

Recommendations Rigid PVC should be a suitable material for Hydrogen Peroxide systems.

Method of Testing An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure.

The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected.

The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.

Date of Testing 28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 025

Material **PVC Foam**

Description The samples consisted of a number of strips of black PVC foam gasketing, 3mm thick.

Observations There was no obvious deterioration of the samples with regard to surface, strength or resilience. Outgassing experienced.

Conclusions PVC foam would appear to be a suitable material for use when exposed to hydrogen peroxide vapours on a long or permanent basis.

Recommendations PVC foam would be a suitable choice for gaskets with high levels of hydrogen peroxide vapours. Note: Out gassing from exposed edges.

Method of Testing An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure.

The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples removed and inspected.

The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.

Date of Testing 28.12.94

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Hydrogen Peroxide Material Compatibility Data

Sheet 026

Material	**PVC Foam Sheet**
Description	The samples tested were manufactured by Norseal.
Observations	The gasket material did not have any surface defects, the elasticity and strength was unaltered.
Conclusions	This PVC foam gasket material would be suitable for seals but can only be used once. The recovery time is slow. It is absorbent to Hydrogen Peroxide vapour and will take time to de-gas, however, as only a small edge is likely to be exposed to the vapour, this should not prove a problem.
Recommendations	This material provides a cost effective solution for flat gaskets and should prove suitable for most applications.
Method of Testing	An enclosure of approximately 0.3 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure. The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected. The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.
Date of Testing	28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 027

Material **Silicone Rubber Seal**

Description The sample of seal was made from red silicone rubber extrusion moulded into a pea shape and was 43mm long with a sectional thickness of 3mm.

Observations There was no sign of deterioration to the surface, material strength or flexibility.

Conclusions The silicone rubber seal is suitable for use with hydrogen peroxide at concentrations of 1500 ppm.

Recommendations The silicone rubber seal can be used for any surface jointing throughout the system and may prove to be particularly useful for removable window seals.

Method of Testing An enclosure of approximately M/3 was connected to a BIOQUELL HyPer-Phase 310000 and set to operate at 1500 ppm. The sample of seal was placed on a tray and a fan was provided to ensure that gas was circulated to all surfaces. The enclosure was sealed in a concentration of 1500 ppm was maintained for 140 hours after which the sample was visually inspected to provide the above observations.

Date of Testing 11.07.96

Hydrogen Peroxide Material Compatibility Data

Sheet 028

Material	**Torlon**
Description	The sample provided was a 50mm diameter bar. No further details were provided.
Observations	There was no obvious deterioration and no visible deposits on the surface.
Conclusions	The material is satisfactory for use in a system with hydrogen peroxide at a concentration of 1500 ppm.
Recommendations	The material is suitable for use and should prove satisfactory.
Method of Testing	An enclosure of approximately 1 m^3 was fitted to a BIOQUELL HyPer-Phase Generator. The sample was suspended inside the enclosure so as to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure even distribution of the hydrogen peroxide vapour. The enclosure was sealed and the concentration of 1500ppm was maintained for 170 hours after which time the sample was removed and inspected. The inspection consisted of a detailed visual examination.
Date of Testing	17.10.97

Hydrogen Peroxide Material Compatibility Data

Sheet 029

Material **Viton**

Description

Viton synthetic rubber samples consisted of sheet material and a number of 'O' rings.

Observations

There was no obvious deterioration of the Viton samples with regard to surface or strength.

Conclusions

Viton synthetic rubber would appear to be a suitable material for use when exposed to Hydrogen Peroxide on a long or permanent basis.

Recommendations

Viton seems to be an ideal choice for Gaskets, 'O' rings or other items likely to come in contact with high levels of Hydrogen Peroxide vapours.

Method of Testing

An enclosure of approximately 0.3 m^3 was fitted to a BIQOUELL HyPer-Phase Generator. Inside this enclosure three samples measuring approximately 120mm by 50mm were suspended to allow full circulation of gas on all surfaces. The enclosure was provided with a circulation fan to ensure each sample received the same exposure.

The enclosure was sealed and the concentration of 1000ppm was maintained for 140 hours after which time the samples were removed and inspected.

The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.

Date of Testing 28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 030

Material **Desmopan**

Description The sample material was a cream timing drive belt, type DESMOPAN 10mm wide with 10mm drive pitch.

Observations The material showed slight signs of discolouration but had no visible or discernible deposits on the surfaces. Structural strength appeared to be unchanged.

Conclusions Providing the slight discolouration is acceptable, this material appears to be satisfactory for inclusion within a system to be sterilised with Hydrogen Peroxide. Outgassing from this material should not be a problem.

Recommendations This material appears to be suitable for use and in a Hydrogen Peroxide atmosphere

Method of Testing An enclosure of approximately 0.3 m^3 was fitted with a BIOQUELL Hydrogen Peroxide generator to produce a concentration of 1,000ppm. Inside this enclosure three samples measuring approximately 120mm by 50 mm of each sample material were suspended to allow full circulation of gas on all surfaces.

The enclosure was provided with a circulation fan to ensure each sample received the same exposure. The enclosure was sealed and the concentration was maintained for 140 hours after which time the samples were removed and inspected.

The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.

Date of Testing 28.12.94

Hydrogen Peroxide Material Compatibility Data

Sheet 031

Material **Domestic Smoke Alarm**

Description

A standard domestic smoke alarm was purchased from a local DIY store. The purpose of the test was to investigate the possibility that hydrogen peroxide might activate a simple smoke alarm.

Observations

During the test the output from the alarm was continuously monitored and at no time did the system activate. On completion of test the smoke alarm was inspected, tested and found to be working.

Conclusions

Testing confirmed that hydrogen peroxide vapour would not affect the smoke alarm. It is reasonable to suppose that industrial smoke alarms would be more robust than domestic units.

Recommendations

Smoke alarms will be neither damaged nor activated by exposure to high concentrations of hydrogen peroxide vapour.

Method of Testing

The smoke alarm was placed into a 22m³ environmental chamber. A single BIOQUELL HyPer-Clean nozzle was placed on a tripod in the centre of the chamber with a small discharge nozzle fitted. The smoke alarm was placed approximately 2 m from the nozzle discharge. At this point it would be subject to high velocity air\gas (approximately 25m\sec.) The positioning ensured that high concentration gas would be injected into the smoke alarm. The nozzle was connected to a HyPer-Phase gas generator programmed to run continuously. Generator set parameters were as follows:

Airflow	500 l/min.
Hydrogen peroxide injection	6g/min.
Gassing time	18 hours.

Date of Testing 20 March 1999

Hydrogen Peroxide Material Compatibility Data

Sheet 032

Material **Door-closer**

Description The fixtures and fittings required to fit a door-closer (as pictured, below)

Observations None of the materials showed any signs of structural degradation. The passivated steel used to make the lock mechanism and lock shield became discoloured, due to oxidation by the hydrogen peroxide gas.

Conclusions Hydrogen peroxide vapour has no apparent effect on the function of the door closing mechanism. The discolouration of a small number of the components of the door-closer would not affect the function of the equipment. The lock mechanism would be encased inside the door so would be shielded from the hydrogen peroxide vapour.

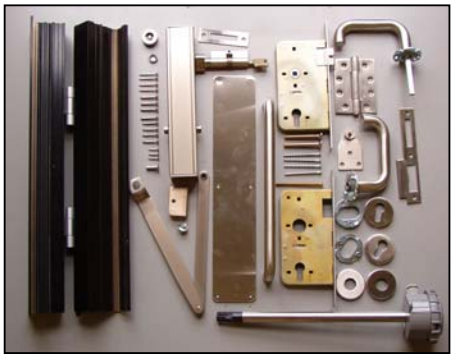
Recommendations The materials used to make this door-closer are suitable for use in a room regularly decontaminated by hydrogen peroxide vapour.

Method of Testing A Clarus™ R Generator was placed inside a room of approximately 30 m^3. The door-closer components were placed inside the room.

The enclosure was sealed and samples were subjected to 74 back-to-back cycles. A typical cycle achieved a concentration of >500ppm for 30 minutes, thus the samples were subjected to >500ppm for 37 hours. The samples were then removed and inspected.

The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.

Date of Testing 19.09.03



Hydrogen Peroxide Material Compatibility Data

Sheet 033

Material **Ceramic tiles**

Description Five STONHARD ceramic tiles, used for wall and flooring were tested (as pictured, below)

Observations None of the tiles showed any signs deterioration or visible deposits on the surfaces

Conclusions Hydrogen peroxide vapour has no apparent effect on ceramic tiles.

Recommendations Ceramic tiles are recommended as suitable materials in a room regularly decontaminated by hydrogen peroxide vapour.

Method of Testing A Clarus™ R Generator was placed inside a room of approximately 30 m^3. The ceramic tiles were placed inside the room.

The enclosure was sealed and samples were subjected to 85 back-to-back cycles. A typical cycle achieved a concentration of >500ppm for 32 minutes, thus the samples were subjected to >500ppm for 43 hours. The samples were then removed and inspected.

The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.

Date of Testing 19.09.03

Hydrogen Peroxide Material Compatibility Data

Sheet 034

Material **Computer System with Monitor**

Description

The test computer was a 486 DX 2 system operating Windows 3.1 and included a 17-in. monitor. The keyboard was extended to allow operation of the computer from outside the test area in order to confirm the computer's operational status during the test run.

Observations

During the continuous gassing the computer performed correctly. On subsequent inspection of the internal components no fault was found. The 3.5-in. diskette functioned correctly and there was no corruption of data. Testing the computer confirmed all operational functions were correct.

Conclusions

This system is suitable for use in an enclosure being gassed.

Recommendations

Electronic and computer systems should be left powered on as this will ensure that the internal fans distribute gas within the PC. NB subsequent tests with computers and other electronics have shown no adverse effect from exposure to hydrogen peroxide vapour.

Method of Testing

The computer was placed into a 22m³ environmental chamber. A single BIOQUELL HyPer-Clean nozzle was placed on a tripod in the centre of the chamber with a small discharge nozzle fitted. The computer was placed approximately 1.5 m from the nozzle discharge. At this point it would be subject to high velocity air\gas (approximately 30 m\sec.) The positioning ensured that high concentration gas would be injected into the computer system. The nozzle was connected to a BIOQUELL HyPer-Phase gas generator programmed to run continuously. Generator set parameters were as follows:

Airflow	500 l/min.
Hydrogen peroxide injection	6g/min.
Gassing time	18 hours

Date of Testing

28 March 1999

Hydrogen Peroxide Material Compatibility Data

Sheet 035

Material	**Linear Bearing**
Description	Approximate size 38 x 35mm with a 15mm linear slide.
Observations	The bearings showed no signs of deterioration and had no visible deposits on the surface. One set of ball bearings appears to be slightly discoloured, however this may be due to lubricant. The second set of ball bearings appear to have three bearings missing. This may be by design or due to disassembling prior to receipt of the unit.
Conclusions	The bearing should be satisfactory for use in a system with hydrogen peroxide at a concentration of 1500 ppm.
Recommendations	This type of bearing should prove to be serviceable for inclusion in a system to be exposed to H_2O_2. The discoloration of the lubricant may be due to some interaction with the hydrogen peroxide and this may require further consideration.
Method of Testing	An enclosure of 1 m^3 was connected to a BIOQUELL HyPer-Phase 310000 and set to operate at 1500 ppm. The bearings placed on a tray and a fan was provided to ensure good gas circulation to all surfaces of the bearing. The test isolator was sealed and the concentration was maintained for 160 hours. A visual inspection was then carried out allowing the above assessment to be made.
Date of Testing	11.07.96

Hydrogen Peroxide Material Compatibility Data

Sheet 036

Material **Rubber floor tiles**

Description Six 2mm Noraplan rubber floor tiles were tested (as pictured, below)

Observations None of the tiles showed any signs deterioration or visible deposits on the surfaces.

Conclusions Hydrogen peroxide vapour has no apparent effect on rubber floor tiles.

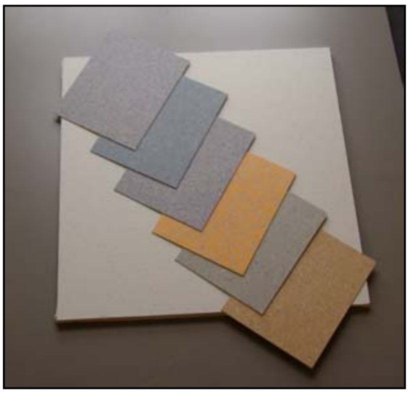
Recommendations Rubber floor tiles are recommended as suitable materials in a room regularly decontaminated by hydrogen peroxide vapour.

Method of Testing A Clarus™ R Generator was placed inside a room of approximately 30m^3. The tiles were placed inside the room.

The enclosure was sealed and samples were subjected to 64 back-to-back cycles. A typical cycle achieved a concentration of >500ppm for 30 minutes, thus the samples were subjected to >500ppm for 32 hours. The samples were then removed and inspected.

The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.

Date of Testing 19.09.03



Hydrogen Peroxide Material Compatibility Data

Sheet 037

Material	**Window frame (double glazed)**
Description	Two double glazed plastic window panes and their associated coated aluminium frame (as pictured, below)
Observations	Neither the plastic windows nor the frame showed any signs deterioration or visible deposits on the surfaces. No glazing was evident on the window panes.
Conclusions	Hydrogen peroxide vapour has no apparent effect on double glazed windows or frames.
Recommendations	Double glazed windows are recommended as suitable materials in a room regularly decontaminated by hydrogen peroxide vapour.
Method of Testing	A Clarus™ R Generator was placed inside a room of approximately 30m^3. The window frame was placed inside the room. The enclosure was sealed and the sample was subjected to 64 back-to-back cycles. A typical cycle achieved a concentration of >500ppm for 30 minutes, thus the sample was subjected to >500ppm for 32 hours. The samples were then removed and inspected. The inspection consisted of a detailed visual inspection and a mechanical inspection to ascertain whether the material had been adversely affected during the exposure.
Date of Testing	19.09.03

Room material testing (including fixtures and fittings)

BIOQUELL's Clarus™ decontamination equipment can be used to decontaminate entire rooms and suites. A wide variety of equipment, fixtures and fittings will be repeatedly exposed to high levels of hydrogen peroxide vapour during room gassing. Individual material tests have proven that hydrogen peroxide vapour has few material compatibility problems. Materials that will commonly be encountered in rooms were tested in a small test gassing room.

MATERIALS TESTED

The materials tested are pictured below:

Additional material tested included: taps (plastic and metal), Perspex, PVC and neoprene samples, fabric and polyester laminator cloth, work bench surfaces, cupboard doors, wire racks (coated and uncoated metal), rubber seals and a ceiling fluorescent light fitting.

METHODS:

A Clarus™ R generator was put in a 30m^3 room. The materials were positioned in the room so as to maximise the surfaces exposed to the hydrogen peroxide vapour. Two Clarus R2 units were included in the room to catalytically convert the hydrogen peroixde at the end of the cycle.

CYCLE PARAMETERS:

At least 80 back-to-back gassing runs were conduced with the following cycle parameters:
Typical temperature/relative humidity: 20°C / 40%
Conditioning time: 10mins
Gassing time: 45mins
Aeration time: 200min
The materials were exposed to a gas concentration of in excess of 500ppm for 30minutes on each cycle. ***Thus the materials were exposed to >500ppm for 40 hours.***

RESULTS

Passivated (coated) metal materials showed a slight discolouration. This is shown by the face on which the component has been resting still has a shiny finish whilst the exposed sides have lost their glossy finishes. Similarly, discolouration of copper was noted. These purely aesthetic changes are due to the strong oxidising properties of hydrogen peroxide vapour.
All other materials showed no signs of degradation and were free of viable residues.

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Equipment testing case study

INTRODUCTION

BIOQUELL have carried out extensive testing to demonstrate that whilst using the Clarus™ range of gas generators, used for the bio-decontamination of small enclosures and rooms, sensitive electronics are not effected by the hydrogen peroxide (H_2O_2) vapour.

A range of instruments have been tested both dormant and powered without any failures

Test 1

Sensitive electrical equipment was placed within the chamber of a Microflow 1metre class II biological safety cabinet. All equipment within the cabinet was disconnected from the power supply.

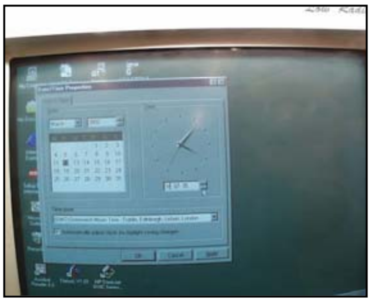
A typical gassing cycle was selected with the following parameters: -
Conditioning time 20 minutes
Gassing time 30 minutes
Aeration time 150 minutes

During the gassing phase concentrations of gas recorded within the chamber reached in excess of **1000** ppm. Slight fogging was visible upon the cabinet viewing panel due to the hot gas coming into contact with the cold glass and condensing.
The delivery temperature of the H_2O_2 gas was approx. 60˚C, elevating the chamber temperature by a maximum of +12ºC above the ambient room temperature.

This was then repeated on a back to back basis for a **further three cycles**. Once the final aeration was complete the equipment was removed, powered on and tested for faults. All of the equipment exposed to the gas functioned correctly and showed no signs of deterioration.

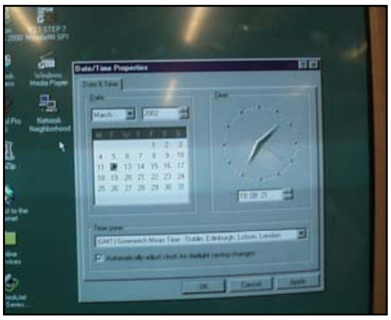
The following equipment was tested:-
Computer VDU, oscilloscope, power supply, solar powered calculator, lap top computer, telephone.

Slight fogging occurred during the gassing phase as vapour condenses on the cold glass



Test 2

A similar test was carried out with the equipment connected to a power supply and switched to the **'on'** position. Again levels of gas reaching **over 1000ppm** were recorded within the chamber with slight fogging on the glass-viewing panel. BIOQUELL's tests showed that the high voltage VDU used functioned normally throughout the duration of testing period and also thereafter.



At the end of the aeration period the equipment is still functioning normally

RESULTS

In both cases the results were conclusive that the introduction of hydrogen peroxide gas at 60ºC had no effect on the functionality of the electrical equipment. Also **no surface distortion/discoloration was found with the casing**. Fogging on cold surfaces only occurred during the gassing phase and dissipated soon after the aeration cycle began.

Due to the unique dual circuit technology utilised by the Clarus™ generators, a total of 25ml of 30% H_2O_2 liquid was used for each gassing cycle (an adequate amount to reach a full biological kill, comprising a 6-log reduction of Tyvek pouched *Bacillus stearothermophilus* biological indicators within the enclosure).

Separately, BIOQUELL have also completed some 860 cycles on a safety cabinet, with no effects to the airflow sensors, capacitors, pressure transducers or electrical service points all located within the cabinet and subject to exposure (see following page).

ROOM BIO-DECONTAMINATION

Room bio-decontamination represents a major part of BIOQUELL's ongoing research and development programme. Throughout all of the testing programs, electronics have been present during the gassing trials and maintained full functionality. This in turn has enabled room gassing to be performed with the gas generator located inside the room being bio-decontaminated. Other room bio-decontamination material tests are contained in this paper.

CONCLUSION

Throughout BIOQUELL's trials it has been demonstrated that bio-decontamination with H_2O_2 vapour does not appear to be detrimental in any way, effecting operational aspects or aesthetics of sensitive electronic equipment.

BIOQUELL would recommend that any electrical equipment that houses a fan whilst running is left switched on. This is to ensure that gas can be drawn through the equipment where biological contamination could be present.

Corrosion testing

860 gassing cycles over a 4 month period

- No electronic failures
- Electrical wiring undamaged
- Stainless steel unaffected
- Painted mild steel unchanged
- Exposed PCB not damaged

Standard paint trials

INTRODUCTION

BIOQUELL has already conducted trials with various substrate-paint combinations, the results of which can be seen in Material Compatibility Data Sheets 013-017. The aim of this trial is to evaluate the effects of repeated room bio-decontamination (RBDS) using hydrogen peroxide vapour on a standard "off the shelf" trade paint.

MATERIALS AND METHODS

The materials chosen as substrates were:

Galvanised Steel (600mm x 600mm)
Mild Steel (600mm x 600mm)

Materials were procured from local suppliers and had no prior preparation other than that stipulated by the paint application instructions.

Paint

The paint was purchased from a local builders merchant. The products were:

Undercoat: ICI Dulux Trade Undercoat, Brilliant White.
Topcoat: ICI Dulux Trade High Gloss, Dark Grey
Varnish: Rustins Clear Varnish, extra tough polyurethane gloss.

Substrate Paint Combinations

The substrates and paint were matched to produce 4 combinations:

	Substrate	Undercoat	Topcoat	Varnish
1	Galvanised steel	✓	✓	X
2	Galvanised steel	✓	✓	✓
3	Mild steel	✓	✓	X
4	Mild steel	✓	✓	✓

All paints were applied as per instructions printed on the side of the tin using normal paint brushes. Paints were left to dry at room temperature for 24 hours between coats (drying period stated on the tin was 6-16 hours minimum).

Hydrogen peroxide exposure and room parameters

The gassing enclosure was a small square approximately 20m^3 room.

The gassing cycle was as follows:

Conditioning: 20 minutes (extended conditioning was needed to heat the room air temperature above the minimum level)
Gassing: 25 minutes at low rate
Dwell: 5 minutes at zero injection
Aeration: approx 5 hours

The cycle was repeated 50 times.

RESULTS

The paints that did not have the additional varnish coating did show a small amount of bubbling around the extreme edges of the substrate. The bubbling started to appear after eight cycles. This effect was more prevalent on the galvanised substrate than the mild steel base material. The substrates with a varnish coating showed no signs of bubbling.

Before and after pictures showing comparisons of the substrates, including close up views of any bubbling witnessed are included on p49-50.

CONCLUSION

The trade paint does bubble around the edges when subjected to multiple hydrogen peroxide vapour exposures. The bubbling was not apparent on the flat painted surfaces of the materials. This provides evidence that the bubbling is caused by hydrogen peroxide vapour diffusing under the painted surface at the edges, decomposing to liberate oxygen and hence causing an expansion effect on the paint surface. Bubbling was much more prevalent on the galvanised steel substrate than the mild steel. This would lead to the conclusion that there is a better adherence of the paint to the mild steel than the galvanised steel, limiting the diffusion of the hydrogen peroxide into the paint.

The samples coated in polyurethane varnish showed no adverse effects due to the hydrogen peroxide vapour. It seems likely that the varnish seals the exposed edges of the paint, thus preventing the diffusion of hydrogen peroxide vapour underneath the paint.

In conclusion, standard trade gloss paint has a good resistance to hydrogen peroxide vapour, however exposed painted edges may be sites of limited bubbling after multiple (>8) gassing runs. The substrate does influence the amount of paint bubbling but the bubbling effect can be completely prevented on galvanised steel and mild steel by coating the gloss paint topcoat in varnish.

Below are before and after pictures showing comparisons of the substrates, including close up views of any bubbling witnessed.

No.1 (galvanised steel with undercoat and topcoat) before and after gassing

(a) Before

(b) After

(c) (left) Close-up of bubbling on the edge of the paint sample

No.2 (galvanised steel with undercoat, topcoat and varnish) before and after gassing

No bubbling was witnessed on this substrate / paint combination

No.3 (mild steel with undercoat and topcoat) before and after gassing

(a) Before

(b) After

(c) (left) Close-up of bubbling on the edge of the paint sample. Bubbling was extremely fine – very hard to pick up with a camera.

No.4 (mild steel with undercoat, topcoat and varnish) before and after gassing

No bubbling was witnessed on this substrate / paint combination

Compatibility of paint finishes

Oil based paints, e.g. gloss and eggshell, are now largely based on alkyd resins, which have been modified by oils such as linseed or soya. The drying process for such oil-based paints is a two-stage process – firstly the **evaporation of the solvents leaving the resin**, which is then followed by an **auto-oxidation process i.e. the absorption of oxygen from the atmosphere to harden the resin**. The solvent evaporation occurs within a matter of hours but the oxidation process then continues for a minimum of two weeks before full hardening occurs and could be considerably longer depending on conditions. This oxidation process then slows down but will continue with time and the further oxidation eventually embrittles the paint and surface deterioration occurs, which is why repainting eventually becomes necessary.

If the natural auto-oxidation drying process is modified in any way then hardening may not occur properly and surface deterioration may become evident. Because hydrogen peroxide is a strong oxidising agent, if paintwork has not been fully cured, then exposure to hydrogen peroxide vapour is likely to cause damage to surfaces.

Will hydrogen peroxide cause long-term damage to oil-based paint even if it has fully dried?

The answer to this is yes, but it is a matter of degree and frequency of gassing. For example, in our own Research & Development facilities, we have a room of approximately 100m^3 that we use for bio-decontamination gassing trials on a very frequent basis. Part of the wall surfaces have oil-based paint finish. Deterioration of these surfaces has occurred after about 20 gassing cycles where very aggressive gassing conditions have been used, but the paint had been applied several years ago.

By comparison, recently we conducted a gassing trial on a Category III containment laboratory for a client at a hospital in the UK. The room had gloss paintwork around window and doorframes. The cycle run was a very heavy peroxide cycle to test efficacy against a range of pathogenic cell cultures. At the end of the cycle there was absolutely no sign of any surface deterioration to these finishes (or to any other finishes or equipment in the room).

A biologics manufacturer ran a set of trials over recent months in their facility using hydrogen peroxide. The first set of trials involved about six gassing runs using a Clarus™ C generator in a room with oil based painted surfaces. At the end of these trials there was no significant evidence of surface finish damage. They then started a set of trials using a generator from another manufacturer. After the first gassing cycle with this equipment significant deterioration of the surfaces was observed. These painted surfaces were not new. The customer drew the conclusion that it was the second manufacturer’s equipment that had caused the problem – which may well have been the case – however, a proportion of the problem will have been related to the hydrogen peroxide molecules which are a source of free radicals which bio-deactivate micro-organisms but which are also a strong oxidant.

Our experience is that if oil based paintwork has fully cured and the exposure to hydrogen peroxide is infrequent then it is reasonably safe to gas these surfaces a few times per year with only a small risk of deterioration. However for more frequent or prolonged applications then this material is not compatible with the hydrogen peroxide gassing process. Eventually the surface will oxidise and deteriorate although the precise timing of this is clearly variable.

Are there suitable alternatives to oil-based painted finishes?

There is a wide range of surface finishes that can be used and it is not appropriate to consider all in this response. However, regarding manually applied painted finishes, the Paint Research Association of the UK has indicated to us that in their opinion a two-pack polyurethane paint finish should be highly resistant to hydrogen peroxide. We currently utilise urethane in the manufacture of HEPA filter components at our factory and we have experience that this material is unaffected by hydrogen peroxide vapour even at very high levels of exposure.

We would be happy to discuss questions about appropriate paint finishes in further detail.

Eye goggle test

OBJECTIVE

To test sample sets of eye safety goggles for materials compatibility with H_2O_2 and measure absorption rates / out gassing on completion of the gassing cycle

TEST METHOD

A Pharmaceutical customer was investigating the feasibility of using the Clarus™ L hydrogen peroxide gas generator and a Microflow Peroxide safety cabinet for the bio-decontamination of eye safety goggles.

The purpose of the tests were:
1) To investigate if the eye safety goggles were manufactured from a suitable material to withstand multiple gassing cycles of hydrogen peroxide vapour.
2) To check for any out-gassing after the completion of the gassing cycle. To ensure that an operators eyes were not subjected to high levels of H_2O_2 from out-gassing from the goggles.

EQUIPMENT REQUIRED:

Test No.1
Clarus™ C with test chamber for material compatibility test

Test No.2
Clarus™ L with Microflow Peroxide safety cabinet for out-gassing measurements

SUMMARY OF RESULTS

Test No.1: Materials Compatibility

Two pairs of eye safety goggles (Uvex with Orange/Grey headband and Uvex with Blue/Pink headband) were placed in a flexible film test chamber and were subjected to 20 gassing cycles using a Clarus™ C gas generator. After the gassing cycle had been completed the eye safety goggles were visually inspected showing no deterioration of materials. Each pair of goggles was then placed in individually sealed bags and left overnight. After a period of time a hand held H_2O_2 detector was used to measure the level of H_2O_2 within the sealed bags to check the level of out-gassing.

Uvex with Orange/Grey headband – 2.4ppm
Uvex with Blue/Pink headband – 4ppm

The goggles showed low levels of out gassing as they were subjected to 20 continuous gassing cycles

Eye goggles positioned in safety cabinet for gassing

Test No.2: Simulation of typical gassing cycle with Clarus™ L

Two pairs of new eye safety goggles (Uvex with Orange/Grey headband and Uvex with black band) were placed in a Microflow 0.96m Peroxide safety cabinet and gassed using a Clarus™ L hydrogen peroxide gas generator.

The goggles were subjected to a standard gassing cycle with the following parameters:
Conditioning time:10 minutes
Gassing time: 18 minutes
Dwell time: 10 minutes
Aeration Time: 180 minutes
H_2O_2 Volume: 25ml

On completion of the gassing cycle the goggles were placed on a mannequins head. A hand held H2O2 detector was then used to measure the H_2O_2 levels in the goggles with the following results:

Uvex with Orange/Grey headband – 2.0ppm
Uvex with black band – 2.3ppm

The goggles were then placed on the work area of the safety cabinet and aerated for 45 minutes with the safety cabinet working under normal operating conditions. The goggles were then removed from the safety cabinet and placed on the mannequin head. Further measurements were then taken with the following results:

Uvex with Orange/Grey headband – 0.1ppm
Uvex with black band – 0ppm

CONCLUSION

The above test results indicate that the eye safety goggles are manufactured from materials that are compatible with H_2O_2 as there was no indication of deterioration after 20 continuous gassing cycles.

The second set of tests showed that the goggles required additional aeration to the standard gassing cycle to ensure that out gassing is minimised. It is recommended that a procedure be developed to aerate the goggles in the safety cabinet for a time after the gassing cycle has been completed.

Out-gassing measurement taken from eye goggles in position of normal use

