Cremation of Human Remains:
A Comparison of Alkaline Hydrolysis versus Combustion

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Background

The combustion of human remains is commonly known as cremation. It has served the funeral industry well for the last 100 years or so and will continue to do so for the foreseeable future. However, with a rapidly growing population and an ever increasing environmental awareness, the time has arrived to consider other alternatives for the disposition of human remains.
At the forefront of this consideration is the process of ***''High Pressure Alkaline Hydrolysis"***, also known as Bio Cremation™. This technology was originally developed for the decontamination and disposal of infected animal tissues and later reengineered to assist teaching hospitals with the disposition of donated cadavers.

Today, the alkaline hydrolysis process has been perfected as a commercially viable alternative to traditional cremation and burial. This article gives a basic description of the Bio Cremation process and evaluates the various environmental, social and logistical aspects of the technology in relation to traditional cremation.

Basic Description of the Process

Unlike traditional cremation which uses a combustion reaction to reduce the cadaver to bone fragments, the Bio Cremation process utilizes a reaction known as alkaline hydrolysis. Due to the extensive research and development to date, and the considerable knowledge attained through studies in both Europe and North America, this article primarily considers high pressure alkaline hydrolysis. Low pressure systems are also available but are generally deemed not to be commercially viable as an alternative to cremation due to the significantly longer processing times (up to 24 hrs), odor issues and lack of data/testing.

The alkaline hydrolysis process involves breaking down organic molecules to their basic components using a combination of water, alkali, heat and pressure. The cadaver is placed inside a stainless steel chamber which is then filled with water. A small amount of potassium hydroxide alkali (KOH) is then added and the contents heated to around 350°F. After a specified period of time the vessel is cooled and emptied leaving behind bone fragments that can be returned to the bereaved as with traditional cremation.

From start to finish the entire process is automated and controlled using a simple touch screen operator interface and PLC. The liquid from the process is a sterile aqueous solution of basic organic molecules and is directed to a water treatment facility, a topic covered in more detail later in this document.

Emissions and Carbon Footprint

The primary disadvantage associated with the combustion reaction used in traditional cremation is that it creates gaseous emissions, primarily in the form of carbon dioxide (CO_2), which are associated with global warming and climate change.

With growing awareness of climate change, regulators are coming under increased pressure to reduce CO_2 emissions in all areas of industry and as a result it has become more challenging to gain planning permissions and operating permits for crematoria. Although there are CO_2 emissions resulting from the Bio Cremation™ process (generating steam for heating), these are significantly less than for traditional cremation. In fact, looking at the both processes in their entirety, a recent UK independent study concluded that the carbon footprint associated with traditional cremation was approximately 4 times larger than that of Bio Cremation.

Other harmful emissions which can be created from the combustion of human remains include nitrogen oxides (NO and NO_2) which again contribute to climate change and, of particular concern in recent times, mercury vapor (Hg). Although less popular today, mercury has historically been a main component of the amalgam used in dental fillings. When exposed to the combustion temperatures involved in cremation this mercury will vaporize and travel into the atmosphere where it will mix with water vapor, cool, condense, and fall to the earth as rain. Recent studies have shown that even trace amounts of mercury can contaminate lakes and rivers and have toxic effects on fish and other animals or humans who consume them. In many parts of Europe this has led to the compulsory introduction of expensive filtration equipment to separate the mercury vapor from the other combustion gases prior to exiting the crematorium.

As for the Bio Cremation process, it operates at significantly lower temperatures than traditional cremation which prevents the mercury from vaporizing. Instead the amalgam is separated from the bone fragments in solid form at the end of the process.

As a result of the factors mentioned above the Bio Cremation technology has the potential to be installed in built-up commercial and/or residential areas without creating a nuisance or hazard to the surrounding population, something which would be strictly forbidden with traditional cremation due to strict zoning regulations.

Energy Consumption

Due to the high temperatures involved in traditional cremation (approximately 1500° – 1800°F), and the need to pre-heat the cremator chamber, it can be a highly energy intensive process. In contrast, the Bio Cremation chamber does not have a pre-heating requirement and operates at significantly lower temperatures (approximately 350°F). Studies have indicated that the combined electrical and gas energy requirement for the Bio Cremation process is approximately 85% less than traditional cremation.

Based on a rate of 40 cremations/month and natural gas consumption figures taken from an independent environmental study, the cost savings on gas achieved by adopting Bio Cremation™ over traditional cremation are in the region of $1,700 - $2,220 per month.

Efficacy and Sterilization

Both alkaline hydrolysis and high temperature combustion have been proven to be highly efficacious in the destruction of all pathogens, bacteria and viruses. Studies have shown that the corresponding wet and dry heats and exposure times involved in both processes ensure that the resultant products from each are sterile.

TSEs/Prions

Unlike other kinds of infectious disease which are spread by microbes, the infectious agent in TSEs is a specific protein called the prion protein. This makes them notoriously difficult to destroy/inactivate as they can survive much harsher conditions. Some examples of TSEs are BSE in cattle, Scrapie in sheep and CJD in humans.

The most common method for the destruction of TSE infected material is incineration (combustion). However in the last 10 to 15 years there have been numerous papers written by leading scientists in both the UK and the US stating that alkaline hydrolysis is a suitable alternative treatment in the destruction of TSE's. In Europe extensive research was commissioned by the European Scientific Steering Committee and carried out over a number years at the Roslin Institute in Scotland, one of the top research centers globally in this field.

Dr. David Taylor, a world leading expert in the field of TSE contamination, and a team of other researchers concluded that alkaline hydrolysis at elevated temperature and pressure was indeed a suitable method for the destruction of prion infected material. This is reflected in the official EU Animal By-Products Regulation (92/2005 amendment to 1774/2002) which lists alkaline hydrolysis as an acceptable method for the treatment of Category 1 (confirmed and high risk TSE) material. The USDA APHIS (United States Department of Agriculture Animal and Plant Health Inspection Service) also recognizes alkaline hydrolysis as an approved method for the disposal of prion infected material and in some cases has documented this as the preferred method to be applied.

Liquid

During a traditional cremation the combustion gases are emitted into the atmosphere. Once in the atmosphere much of this gas will mix with water vapor, cool, condense into liquid and fall as rain. During a Bio Cremation, the hydrolyzed liquid produced is typically sent to a water treatment facility. This liquid contains no DNA or genetic material but instead is a simple bio-chemical mix of small organic molecules.

Due to the nature of its origins, this liquid is obviously significantly higher in organic content (known as Biological Oxygen Demand or BOD) than the typical material flowing into the water treatment facility and is also typically higher in alkalinity (pH). Historically, when alkaline hydrolysis has been used on a larger scale in veterinary schools and research laboratories it has proven difficult on occasions to obtain permission from the water authorities to receive this liquid. However, where permission has been granted it has also been proven to have little or no effect on the operation of the water treatment facility.

In addition, given the process developments achieved in the new Bio Cremation™ system and the fact that the process is taking place on a smaller scale, the liquid produced from the Bio Cremation process will be less concentrated and of a much smaller volume than that of previous animal systems. As a result this liquid will not have any impact on an average sized water treatment facility. In addition the alkalinity (pH) of the liquid can be reduced to any desired level prior to discharge. The fact that the starting material is a human cadaver, rather than infected research animals will certainly make water authorities more amenable to accepting this liquid.
The viscosity of the alkaline hydrolysis liquid from animal systems has been an area of concern from water treatment companies in the past. It is essential that the liquid going to the treatment plant does not impede the flow through the pipes in any way. This concern has been raised due to the fact that older animal alkaline hydrolysis systems used sodium hydroxide (NaOH) as the alkali in the process which often resulted in a highly viscous liquid. As mentioned above, the newer Bio Cremation systems use potassium hydroxide instead of sodium hydroxide which prevents this viscous liquid being formed. In 2009 United Utilities (one of the largest water companies in the UK) carried out tests on the liquid derived from a potassium hydroxide based Bio Cremation. These tests demonstrated that there are no issues with viscosity and/or gelling of the liquid even when added to cold, raw sewage.

In remote locations or where it is not possible or desired to release to the water treatment plant there are other potential routes for the liquid. It can be collected and sent to an anaerobic treatment plant where it will be converted into a soil nutrient for land application and biogas for green energy production. This option has many benefits for the environment and is likely to become more popular as the anaerobic treatment technology becomes more available across the US. There is also the potential to apply the liquid directly onto cemetery/memorial gardens to fertilize the ground as the liquid is rich in potassium, nitrogen and phosphorus, the nutrients essential for plant life. However further research is required for this option to determine where it may be suitable, in what quantities and the benefits/overall environmental impact.

Worker Safety

Worker safety is a key consideration for all employers and crematoria operators are no different. The primary dangers associated with traditional cremation are exposure to the extreme heat and light (infrared/UV) involved in the process as well the potential to inhale harmful dust/emissions. These workers are supplied with Personal Protective Equipment (PPE) such as heatproof gloves, face shields and dust masks and given the necessary training to use the equipment safely.

Similarly, workers in a Bio Cremation™ facility will also be required to be trained in the safe use of the equipment and given suitable PPE chemical resistant gloves and aprons to protect them from exposure to alkali.

Potentially dangerous chemicals are used in many industries and must always be treated with care and all OSHA guidelines followed regarding spill procedures, Material Safety Data Sheets (MSDS) etc. However, as the Bio-Cremation unit is fully automated, manual handling of the alkali is not required at any time during normal operation and when the alkali supply does need to be replenished this can often be carried out by the supplier, not the equipment operator.

Materials That Can Be Processed

The Bio Cremation technology generally does not allow for synthetic fabrics to be processed. Therefore the bodies of the deceased are dressed in respectful gowns made from organic fibers such as silk or wool.

Unlike traditional cremation, pacemakers do not have to be removed prior to the process and medical implants such as titanium hip or knee joints are not damaged or charred in any way. Another advantage of Bio Cremation is that items of jewelry can be recovered in pristine condition following the process.

Remains

In traditional cremation the body is converted to bone fragments via the process of combustion. It is then crushed and returned to the bereaved.

Similarly, in Bio Cremation the body is also converted to bone fragments and is crushed and returned to the bereaved in exactly the same way. The only difference is that bio-cremated bone fragments have a smaller particle size and are pure white in color.

Caskets

Unlike traditional cremation a wooden casket is not used in the Bio Cremation process. Instead a silk or wool container is preferred offering a sustainable option for the environment and further reducing carbon emissions to the atmosphere.

As with traditional cremation a wooden rental/transfer casket can be used for the purposes of the ceremony and viewing.

Funeral Ceremony

There is little change, if any in the funeral service for a Bio Cremation™ versus traditional cremation. Both are dignified and respectful. The differences between the two processes only occur after the body is committed from public view.

Costs

In North America the capital cost of a Bio-cremation unit can be significantly greater than that of a traditional cremator.

In Europe, where mercury filtration is mandatory, the cost of the Bio-Cremation is typically less than that of traditional cremator plus filtration equipment.

Overall operating costs for the Bio-cremation unit are expected to be similar, if not less than that of a traditional cremator.

Company Information

Resomation Ltd was formed in Scotland in early 2007 to promote Resomation as a real alternative to burial and cremation. The basic technology behind the resomation process has been well established for many years. However, the vision of Resomation Ltd, to make the process widely available to all is relatively new. Resomation Ltd have expanded and developed the resomation process to make it useable and potentially available to all.

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