THE QUEENSLAND STATE ARCHIVES FUMIGATION UNIT; ETHYLENE OXIDE/VACUUM FUMIGATION AS AN AID FOR THE PRESERVATION OF ARCHIVES AND MANUSCRIPTS

by

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Gaseous substances have been used for longer than most people can remember for the destruction of pests in confined spaces. They have proved invaluable for the preservation of stored products such as grains and dried fruits, textiles and clothing of historical importance, timber and wood work in all kinds of situations, museum and botanical collections, tightly compressed bales of tobacco and countless other items. The use of some of these substances for sterilisation purposes as opposed to disinfestation is not so well known.

Ethylene Oxide in particular, because of its properties, is now recognised as one of the few gases of practical importance in this field.

FUMIGATION HISTORY

By using Ethylene Oxide injected into an atmosphere of 95% vacuum the sterilisation and disinfestation properties are further enhanced although such a technique requires strictly controlled conditions and relatively expensive machinery.

Records show that the idea of using gaseous Ethylene Oxide for sterilising emerged very early and a German Patent for this was taken out in 1935. At that time such a process was not in demand and it was therefore not industrially exploited. It required the impetus of demands created by the second World War for re-awakening the interest in Ethylene Oxide disinfestation and cold sterilisation and since that time Ethylene Oxide has achieved ever increasing importance for such purposes as the sterilisation of medical preparations, instruments, plastic materials and plastic components of all types. It is also used for food stuffs, spices, dry egg powder and more recently records in the form of books and manuscripts of every conceivable kind.

It is now possible therefore for books, files, parcelled records and similar paper records in quantity to be wheeled into a vacuum chamber on a library trolley and without disturbance to be fumigated for a five or six hour period. Such treatment will at the one time account for all moulds, insects such as book mites and silverfish, cockroaches and some infectious organisms. Items so treated can be considered as sterile and if removed immediately with care to sterile storage areas no further treatment should be necessary until cross infestation or infection occurs.

It will be seen therefore that the process of collecting the records to be treated, the treatment of the records, the removal after treatment and the storage are all complementary and are actions which must be carefully planned to form a routine operation if the full value of the treatment is to be realised for the maximum period.

THE UNIT

The basic equipment for vacuum fumigation consists of one or more chambers of any convenient size coupled to a vacuum pump and included in the pipe work system, a measuring vessel for the fumigant, a vaporiser to convert the liquid fumigant to the gaseous state and filters for air, oil and water. The chamber or chambers should have doors opening across the whole width and height at either or both ends. They can be of any convenient size so as to permit hand loading, the wheeling in of trolleys, their inclusion in a small railway system or the manipulation of the load in and out of the chamber with a fork lift truck.

The vacuum pumps are very precisely engineered and require conscientious attention to their routine lubrication requirements. The connecting pipe work can be designed so that one pump can operate a number of chambers. This is a very practical proposition due to the exposure period of approximately five hours when the load in the chamber is undergoing treatment. Throughout this time the moving parts of the plant are idle and there is no manipulation of the controlling valves.

The photographs show the installation in the new Queensland State Archives Building at Annerley Road, Brisbane.* In this two chambers stand side by side and the doors are hinged so as to open towards the middle. The chambers are serviced by two vacuum pumps one of which has been installed as a standby unit and is only operated approximately once a month so as to keep it in running order. The internal dimensions of each chamber are approximately 4' x 5' x 4' and the whole plant fits into a room 12' x 14'.

Such an installation requires the supply of running water and a drain to remove this, three phase and single phase electricity, ventilation to the open air allowing good external clearance and a flow of fresh air preferably by wide doors leading directly from outside. All electrical installations need to be flash-proof.

USING THE EQUIPMENT

The chambers are normally free standing and once they have been precisely located the installation can be completed by a first class welder and plumber in approximately fourteen days. The operation of the plant is a relatively simple affair and in practice it has been found that this can be undertaken by Archives staff with no previous experience who are normally employed on other duties. The period of training is approximately one week during which time one or two chambers are used every day.

* Photographs reproduced on pp. 43-45 of this issue.

The plant in Brisbane like many others throughout the world is of German manufacture and was wholly imported through the Australian distributing agents. It is manufactured by a Company with a long history in the preparation and use of fumigation gases and application machinery.

SAFETY PRECAUTIONS

It is necessary for all those who are in any way associated with the operation of the plant to appreciate the explosion limits and inflammability of Ethylene Oxide. It will be seen from table 1 that the explosion limit has a low of only 4.3% by volume. This fact should not cause undue concern because the fumigant in liquid or gaseous form is always totally confined within the supply cylinder, pipe work or chambers and is never evacuated anywhere but through the discharge pipe installed for the purpose.

CHEMICAL AND PHYSICAL PROPERTIES.

Molecular weight		44
Freezing point		$-111^{o}C$
Density of gaseous ethylene oxide		1.52 (air=1)
Density of liquid ethylene oxide		0.896 ($20^{o}C$)
Explosion limits when mixing with air:		
	low	4.3 vol %
	high	60.4 vol %

Smell in weak concentrations: resembling chloroform.

The correct operation of the plant is a foolproof procedure but in the event of an emergency arising due to perhaps a fractured pipe, although this is most unlikely, the risk of an accident is minimal. This is because of the installation of an extract fan which is in constant operation and the provision of flashproof switches, fuses and motors. Smoking of course is not allowed nor is the introduction of any room heating equipment, floor polishers, electric drills, torches or other devices which create sparks. It is preferable for the staff to wear rubber soled shoes and to avoid wearing clothing which may create static electricity sparks. In the unlikely event of a leak occurring it is possible for the bulk of the gas to be removed from the fumigation chambers and to be discharged into the open air within five minutes and if a pipe fracture were to occur the valves can be manipulated in such a way that the fracture may be by-passed whilst the gas is being removed.

As the whole unit is under vacuum any fractures in the system or leak in the valves will result in an intake of air into the plant rather than a discharge of gas into the atmosphere surrounding the unit. Over night fumigation treatment is not recommended unless the operator of the plant is in attendance at all times. Safety precautions include the flushing of each chamber prior to opening the doors with fresh air three or four times after the initial charge of gas has been

withdrawn and discharged into the open air by the vacuum pump. These flushings involve the filling of the chambers with fresh air and the drawing of a 95% vacuum after each air intake. It is a relatively lengthy procedure but one which cannot be avoided in the correct operation of the plant.

To-day pure Ethylene Oxide as a fumigant is only used in experimental work. The commercial product which is readily available in Australia is a mixture of 90% Ethylene Oxide and 10% carbon dioxide. This is an inflammable and explosive mixture but the introduction of the 10% carbon dioxide results in a much greater safety factor than would be the case if pure Ethylene Oxide was employed. It is perhaps worth noting that no serious accident has been reported amongst the hundreds of plants of the type described which are in operation throughout the world.

REQUIREMENTS FOR EFFICIENCY

Assuming that a 95% vacuum is drawn for each operation of the chamber the success of the operation still depends upon three factors. These are: –

(a) The concentration of gas used which is controlled by the basic quantity injected into the evacuated chamber.
(b) The temperature within the chamber at the time of operation and
(c) The period of exposure for each chamber load.

Tables 2, 3 and 4 illustrate the results which may be expected.

It will be noted from table 2 that it will be comparatively easy to kill Clostridium var. Bact. Coli., whereas for the staphylococci var., larger quantities of Ethylene Oxide have to be used for the same purpose. Only a low concentration is required to kill mould fungus.

TABLE 2
EFFECT OF ETHYLENE OXIDE AT VARYING CONCENTRATIONS
Exposure period: six hr.
Temperature approx. 25°C.

	Concentration: g./cu.m.						
	150	250	350	500	750	1,000	1,250
Bact. coli ...	X	X	X	O	O	O	O
Streptoccocc. sp: ...	X	X	X	O	O	O	O
Staphylococc. var. ...	X	X	X	X	X	O	O
Clostridium var. ...	X	X	O	O	O	O	O
Bac. anthracoides ...	X	X	X	X	O	O	O
Flavobact. ...	X	O	O	O	O	O	O
Oidium lactis ...	X	X	O	O	O	O	O
Penicill. gl. ...	X	O	O	O	O	O	O
Aspergill. niger ...	X	O	O	O	O	O	O
Mucor mucedo ...	X	X	O	O	O	O	O

Explanation of Signs: X growth O sterile – not tested

Table 3 illustrates the great influence the temperature has on the success of the operation for the control of organisms. Mould can be destroyed at a temperature of less than 20°C whereas the bacteria are satisfactorily dealt with only at a temperature above 20°C.

TABLE 3
EFFECT OF ETHYLENE OXIDE AT VARYING TEMPERATURES

Concentration: 500 g./cu.m.
Exposure period: six hr.

	Temperature °C.				
	14	18	20	25	30
Bact. coli	X	X	O	O	O
Staphylococc. var.	X	X	X	X	X
Streptococc. sp.	X	O	O	O	O
Clostridium var.	X	X	O	O	O
Bac. anthracoides	X	X	X	X	X
Flavobact.	X	O	O	O	O
Oidium lactis	O	O	O	–	–
Penicill. gl.	O	O	O	O	–
Aspergill niger	O	O	O	–	–
Mucor mucedo	O	O	O	–	–

Explanation of signs: X growth O sterile – not tested

For this reason it may be necessary when considering the installation of a plant to design an acceptable heating system to work both in the room in which the plant is installed and the area in which the records to be collected are stored prior to treatment. Cold records placed in a cold chamber are not likely to be subject to a temperature rise of any significance after the chamber door has been shut even though room heating may be introduced into the chamber area for the period of the exposure.

In table 4 the importance of an adequate exposure time is emphasised. In most cases five or six hours at an efficient dosage of Ethylene Oxide will give satisfactory sterilisation. However if the dosage is too small even prolonged exposure will not give a satisfactory result.

TABLE 4
EFFECT OF ETHYLENE OXIDE AT VARYING PERIODS OF EXPOSURE

Concentration: 500 g./cu.m.
Temperature approx. 25°C.

	Exposure period in hours						
	2	4	5	6	7	10	14
Bact. coli	X	O	O	O	O	O	O
Staphylococc. var.	X	X	X	X	X	X	X
Bac. anthracoides	X	X	X	X	X	X	X
Streptococc. sp.	X	X	O	O	O	O	O
Clostridium var.	O	O	O	O	O	O	O
Flavobact.	O	O	O	O	O	O	O

Supplementary information, by R.C. Sharman

The building which houses the fumigation plant was designed in the knowledge that such a plant would be necessary (See Archives and Manuscripts, volume 3, no. 7, November 1968, pp 24-35). This is important, for few existing buildings are likely to have a room suitably placed to house such a heavy and demanding piece of equipment. Obviously the strength of the floors – required to take the weight of two large chambers and ancilliary equipment – had to be borne in mind. Mr. Woodhouse's article points out the need to have three-phase and single-phase electricity supply, running water and easy access to the atmosphere to enable exhaust gases to disperse. It was also desirable to have the plant in such a position that the cylinders of fumigant can be stored outside the main walls (yet under cover) but so that they would not be very far from the vaporiser, to which the liquid fumigant is brought by means of a pipeline. Thus a cupboard (to which access is gained from the loading bay) holds the cylinders of fumigant, and this is just through the wall from the fumigation room.

The building is so designed that the incoming archival materials, unloaded under cover in a loading bay, can be moved through a set of double doors straight into the fumigation room. A door leads off from the Fumigation room to the sorting room. This enables archival material to be fumigated immediately on its arrival at the Archives building, and after fumigation to be taken to the sorting room for further processing.

The fumigation plant was supplied through the firm of Houghton and Byrne, Brisbane, which firm has since been incorporated into Powell's Pest Control Pty. Ltd. The most of the equipment, including the technical part of the installation, was $17,670 (one must remember that this is a two-chamber plant, and that a single chamber one would cost considerably less); in addition, some additional $400 was allocated by the State Works Department for minor installation costs. These minor costs included the supplying of ramps to enable the trolleys to be wheeled into the chambers.

The removal of a huge quantity of archives and intermediate records from the old State Archives building in William Street, Brisbane, to the new building in Annerley Road, Dutton Park, could not be slowed down by the necessity to fumigate each load of records as it arrived. This meant that both archives and intermediate records had to be moved into the intermediate records section of the building (which section was designated a "dirty area") and the archives area (air-conditioned, and designated a "clean area") was not occupied when the building first came into use. In any case, the fumigation plant, at that stage (June – August 1968) had not been installed.

This enabled the Archives staff to fumigate the records in accordance with a pre-determined plan, and no outside factors were present to force a

haste upon the operation which might have been hazardous to its success. Material designated as permanently-valuable archives was removed, trolley load by trolley load, from the intermediate records section to the fumigation plant, fumigated, and re-shelved in the archives area. At the time of writing, this process has proceeded fairly satisfactorily, with only minor delays. About 10,000 linear feet of records have so far been treated.

Special trolleys have been designed, 3'6" in length, with three shelves each side. Three of these trolleys can be placed in a chamber at one time – the first two being wheeled in, end first, to rest at the far end of the chamber, and the third one being placed sideways, at the near end. This means that 63 linear feet of records can be fumigated in each chamber at one time. As each chamber is loaded once a day, records can be processed at the rate of about 126 linear feet per day.

The main running expense is, of course, the cost of the fumigant. The cylinders are returnable to the supplier when empty, and the cost of a re-fill (140 lbs) is $75.00. One of these cylinders lasts for 19 chamberfuls of records – that is, on the present program, a cylinder lasts for nearly two weeks.

It may well be remarked that the cost of protecting archival materials from infestation is high, and it would be feasible only for large organizations, having documentary material of great value, to allocate so much money towards the capital costs involved. However, in a climate such as Brisbane's it seems that an archives institution has little option but to make some provision for the fumigation of material such as that housed in the Queensland State Archives. In time, other archives institutions may well follow Queensland's lead. The State which was the first in Australia to erect a separate building for State archives has also been the first to provide a fumigation plant for archival materials, and the public officials responsible for the provision of these amenities will doubtless be glad to share their expertise with their colleagues in the rest of Australia.