

APPENDIX III

Removal of Asbestos Fibers by Pall 0.2 Micrometer Absolute (AR) and Coarser Ultipor (R) Membranes

Summary:

The ability of the Pall 0.2 μm^* (AR), 3 μm (AP), and 10 μm (AY) absolute filter membranes to remove asbestos was tested. The suspension of asbestos was prepared by homogenizing and sonicating asbestos fibers removed from a commercial pyrogen removal grade asbestos filter. This suspension was passed through the test membrane and all filtrate particles were collected downstream on 0.2 and 0.1 μm absolute analysis membranes. The analysis membrane was then examined for the presence of asbestos. In no case were asbestos fibers detected downstream from the 0.2 μm (AR) or 3 μm (AP) absolute membranes. Asbestos fibers were however detected downstream from the 10 μm absolute membranes. A theory accounting for the unexpectedly high removal efficiency of the 3 μm absolute membrane is presented.

Materials and Methods:

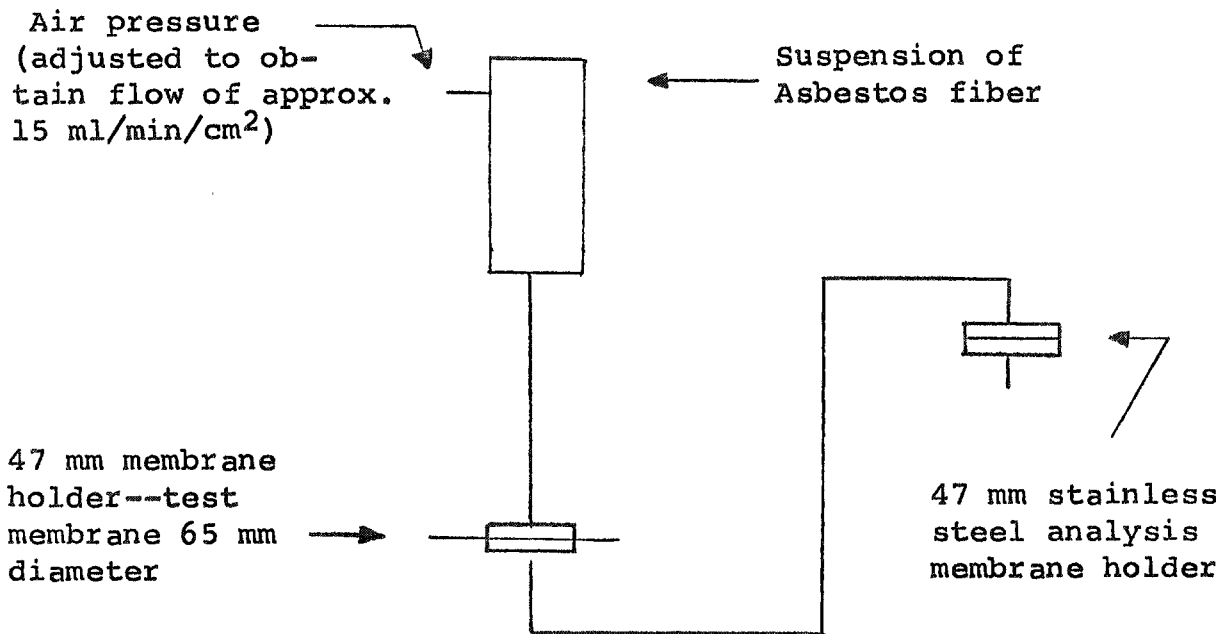
1) Asbestos:

Asbestos was removed from Ertel EO filters and placed in deionized water. The suspension was dispersed at 5000 RPM

* μm = micrometer

for 4 hours with a Gifford-Wood model FL6806 homogenizer comprising a close clearance rotor and stator. This was followed by sonication (using a high energy level Bendix 20 KC magnetostrictive unit) for 5 minutes and filtration through coarse wire mesh. The final suspension contained approximately 10 million fibers/ml, 0.1 to 0.5 μm in diameter and 0.2 to 5.0 μm in length.

2) Asbestos Removal Test Set Up:



3) Test Procedure:

The test membrane and set up (without the analysis membrane installed) were flushed with pre-filtered tap water flowing

at 3 liters/min. for 2 hours. An analysis membrane was installed and a blank taken with 250 ml of deionized water run through test set up shown above. The analysis membrane holder was disconnected and opened in a laminar flow HEPA filter fitted hood and the membrane was placed in a plastic petri dish. The set-up was reassembled with the membrane to be tested in place, and with a new analysis membrane, and 500 ml of asbestos slurry was run through the test set up at the same flow rate. The analysis membrane was then removed as described above. Flow rate used throughout the tests is 15 ml/min/cm², which is several times higher than flow rates typically used in actual filtration service.

4) Methods of Detection:

- a) Optical. The method used was that published in "Criteria for a Recommended Standard - Occupational Exposure to Asbestos", Report of Review Committee, National Institute for Occupational Safety & Health, Publication No. HSM 72-10257 (1972).
- b) Scanning Electron Microscope. A JEOL Model JSM-2 SEM was used, Resolution 150 Å (.015 um)
- c) X-Ray Dispersion. An EDAX 707A energy dispersion analyzer system was used, which provides qualitative, semi-quantita-

tive and quantitative information about the composition of the specimen.*

Results:

1) Optical Methods:

Three separate tests were run using 0.2 um Pall membranes as the test membranes. The HSM 72-10257 method was used to scan 30% of the area of analysis membranes. In each case the blanks and the tests showed no fisible asbestos fibers.

*The following is a capsule explanation of an X-ray energy dispersive analyzer system whose acronym XREDAS and other variations have been widely used. When added to the SEM electron column it provides chemical analysis "in situ" without destroying the specimen. When a specimen in the SEM receives energy from the electron beam it must release an equivalent amount of energy in some form. One way that it achieves this conservation of energy is by emitting X-rays, each of which has a particular energy that is determined by the structure of the atom from which it comes. Since all elements in the periodic table differ in atomic structure, it is possible to identify the elements present in the specimen by simply identifying the energies of the X-rays emitted. When an X-ray strikes the lithium drifted, silicon detector, it is converted to an electronic pulse whose heights is proportional to the energy of the X-ray. The pulse is then amplified and shaped by a preamp and amplifier before being counted and analyzed by a multichannel pulse height analyzer (MCA). The energy processing of each X-ray is completed in less than one microsecond, permitting sufficient data for multi-elemental analysis to be obtained in minutes. The pulses are counted and sorted according to their height by a special purpose hard-wired computer called a multichannel analyzer. The data output is in the form of a spectrum showing the number of X-rays that have been counted in each of the four hundred channels comprising the X-ray energy range. Interpretation of this spectrum provides qualitative, semi-quantitative and quantitative information about the multielemental composition of the specimen, an X-ray energy analysis system can be used to map the distribution of one or more selected elements or to perform a line scan showing how the concentration of a selected element changes from one region of the specimen to another.

2) SEM:

Table I shows the results we obtained using the Scanning Electron Microscope to examine the analysis membranes.

Between 1.5 and 3 hours was spent in examining each analysis membrane. No asbestos fiber was detected downstream from either the 0.2 or 3.0 um absolute Pall membranes (tests 1 - 5). Asbestos was, however, detected downstream when coarser pore size membranes were used; in test 6 we used a 10 um pore size membrane and were able to count asbestos fibers downstream; this grade of membrane removed more than 99.9% of the influent asbestos.

3) X-Ray Dispersion:

X-ray dispersion was used to identify all particles observed during scanning. This tool was extremely valuable since relying only on visual identification is often inconclusive and innaccurate.

Discussion: It will have been noted that the 3 um absolute element quantitatively removed asbestos fibers as fine as 0.1 um in diameter and 0.2 um in length. Normally, the 3 um graded filter removes over 90 to 99% of particles over about 1 um, but is not at all effective at 0.2 um. The reason for the effectiveness of this

filter in removing such fine asbestos particles is believed to be the following:

Asbestos (Chrysotile) is strongly positively charged in aqueous suspension. The fibers of which the filter is composed are strongly negatively charged. Removal efficiency is greatly enhanced by the opposing charges.

This theory is supported by the observations that when separately suspended in water, both asbestos fibers and the filter medium fibers are well dispersed with little or no flocculation. If the two suspensions are mixed, heavy flocculation occurs - indicating strong interparticulate attraction.

TABLE I

ASBESTOS FIBER REMOVAL EFFICIENCY OF PALL ULTIPOR MEMBRANES

Test Membrane	Analysis Membrane Used		
	0.1 μ m Millipore	0.2 μ m Nuclepore	0.22 μ m Millipore
1. Pall AR (0.2 μ m) Test Membrane 1			
% Area of Analysis Membrane Scanned	0.4	0.4	
Magnification	10,000	10,000	
Results	No Asbestos	No asbestos	
2. Pall AR (0.2 μ m) Test Membrane 2			
% Area of Analysis Membrane Scanned	2.9	2.9	
Magnification	10,000	10,000	
Results	No asbestos	No Asbestos	
3. Pall AR (0.2 μ m) Test Membrane 3			
% Area of Analysis Membrane Scanned			0.1
Magnification			8,000
Results			No Asbestos
4. Pall AR (0.2 μ m) Test Membrane 4			
% Area of Analysis Membrane Scanned			0.1
Magnification			8,000
Results			No Asbestos
5. Pall UP (3.0 μ m) Test Membrane 1			
% Area of Analysis Membrane Scanned			0.1
Magnification			8,000
Results			No Asbestos
6. Pall 10 μ m Test Membrane			
% Area of Analysis Membrane Scanned			Random
Magnification			10,000
Results			Approx. 5,000 asbestos fibers on the analysis membrane. Note that the efficiency of filtration is greater than 99.9%

(1) PATENTS GRANTED IN THE UNITED STATES
TO DALL CORPORATION

File No.	Inventor	Patent No. and Date	Subject
12843	D.B.Fall	2,554,343 5/22/51	FSS Product and Process
13663	Fall et al.	2,819,209 3/7/58	POROUS TEFLON Product and Process
13663A	Fall et al.	3,048,537 8/17/62	POROUS POLYETHYLENE Process
14719	D.B.Fall	2,925,630 2/23/60	RIGIMESH Process
14749	D.B.Fall	3,049,790 8/21/62	RIGIMESH Product
14749B	D.B.Fall	3,061,917 11/6/62	SHIMMESH Process
14749C	D.B.Fall	3,241,693 3/22/66	SHIMMESH Product
15047	D.B.Fall	3,007,238 11/7/61	RIGIMESH Welded Cylinder Process
15047A	D.B.Fall	3,007,334 11/7/61	BUBBLE POINT Process
A15105	D.B.Fall	2,945,591 7/19/60	Automatic Shutoff
A15106 GIP	D.B.Fall	3,040,894 6/26/62	Automatic Shutoff
15619	D.B.Fall	3,057,481 10/9/62	CORRIGIMESH Process and Product
A15706	D.B.Fall	3,035,703 5/22/62	MAGNAMESH

Pat. No.	Inventor	Patent No. and Date	Product
155913 GIP	D.B. Pall	3,282,434 11/1/66	Filter with BELVALVE Washers
15837	D.B. Pall	3,037,570 11/1/61	RIGID-BOX Welded Cylinder Product
16074	D.B. Pall	2,942,572 6/28/60	DELTADYNE
16074A	D.B. Pall	3,077,854 2/19/63	DELTADYNE SWITCH
16074B	Pall et al.	3,077,326 2/12/63	DELTADYNE Magnetic Diaphragm
16074C	Pall et al.	3,209,721 10/5/65	DELTADYNE Non-Magnetic Diaphragm
2-016	Pall et al.	3,093,581 6/11/63	PALVALVE Sealing Element
2-017	D.B. Pall	3,083,834 4/2/63	Old LUTADYNE
2-018	Pall et al.	3,124,959 3/17/64	Primary Differential Pressure Sensing Element
2-019	Verrando, M.C. Jr.	3,109,809 1/5/63	Wash Filter Element
2-020	Pall et al.	3,164,164 1/5/65	BELVALVE Snap Through element
2-020A	Pall et al.	3,262,567 7/26/66	BELVALVE Filter Assembly
2-021 DIV.	Pall et al.	3,256,997 6/21/66	COALEX Separator
2-021A	Pall et al.	3,268,442 8/23/66	COALEX Process

PAVE No.	Inventor	PAVE No.	Inventor
2-043	Pall et al.	3,165,473	Corrugated Filter Element
2-049	Pall et al.	3,158,532	Tapered ULTIPOR Process
2-046	Pall et al.	3,238,056	UNITROL
2-046A	Pall et al.	3,246,767	ULTIPOR with angled fibers
2-048 CONT. D.B. Pall		3,199,520	SePALE Valve
2-048A CIP	D.B. Pall	3,229,817	SePALE Separator
2-048B	Pall et al.	3,181,895	SePALE Separation Unit
2-058A	D.B. Pall	3,332,557	SOLENTREX
2-072A	D.B. Rosenberg	3,144,850	Gas Detector
2-075	D.B. Pall	3,122,924	Manometer
2-079	Pall et al.	3,252,270	PETROSORB Filter
2-080 CIP	Pall et al.	3,372,743	Heat Exchanger
2-083	B.F. Silverwater	3,245,541	Filter for use under icing conditions

File No.	Inventor	Patent No. Iss. Date	Subject
2-084	Powerton et al.	3,354,028 11/21/67	Process for Coating Cylindrical Filters
2-089	D.B. Hall	3,257,315 6/21/66	Silver Sterilization of Water
2-091	D.B. Hall	3,246,920 4/19/66	Coupler for Filter Elements
2-093 CONT.	Pall et al.	3,407,852 10/22/68	Corrugated ULTIPOR
2-095 CONT. DIV.	Pall et al.	3,591,040 7/6/71	Corrugated ULTIPOR Div. of Patent 3,407,852
2-099	D.B. Hall	3,246,766 4/19/66	Sectional Filter Core
2-101	Pall et al.	3,283,902 11/3/66	Fluxal Filter in Parallel & Reserve
2-101A	Pall et al.	3,344,923 10/7/67	Fluxal Filter in Series and Reserve
2-102	Pall et al.	3,229,719 1/18/66	DRYATROL Control Valve
2-103	D.B. Hall	3,262,563 7/26/66	FLYING ULTIPOR-Boeing
2-103A	D.B. Hall et al.	3,262,564 7/26/66	FLYING ULTIPOR-DC 8
2-103B	B.F. Silvermaster	3,262,565 7/26/66	FLYING ULTIPOR-Verucal
2-105	Campolong, Jos.	3,187,711 6/3/65	DELTADYNE with Belleville Washer
2-109	D.B. Hall	3,327,859 6/27/67	SIPSTER

File No.	Inventor	Patent No.	Date	Description
2-110	D.R. Pall	3,617,616	9/12/72	Aspirator Compensator and Multi-layered Filter with Mesh Coating
2-113	Banger et al.	3,308,938	3/2/67	Filter with Aligned Core and Element
2-114	Pall et al.	3,327,866	6/21/67	Dutch REGIMES
2-115	E.F. Silverman	3,335,863	8/15/67	Flow Responsive Pressure Indicator
2-116	M.R.J. Silverman	3,140,633	7/21/64	BEHAVIOR with Filter
2-119	Pall et al.	3,336,055	8/18/67	Pipe Connector
2-120 Cont.	Pall et al.	3,500,560	7/6/71	CENTRIFUGAL Pall Filter
2-124	E. Kiser	3,463,870	9/23/69	Filter Media Coating Agent and Process
2-130	Pall et al.	3,520,114	7/24/70	CENTRIFUGAL Air Cleaner
2-133 CIP Cont.	David B. Pall	3,611,679		CENTRIFUGAL Air Cleaner
2-134	David E. Pall	3,448,038	6/3/69	Method and Apparatus Dehydration of Oil
2-136	Pall et al.	3,353,692	11/21/67	Fine and Coarse Filter ULTRAPOR
2-137 CIP	David B. Pall	3,592,767	7/13/71	Laminated Filter Sheet and Filter Elements
2-138	Pall et al.	3,457,339	7/22/69	Polypropylene End Capping

File No.	Inventor	Patent No. and Date	Subject
2-140	Pall et al.	3,513,158 3/3/71	Doctor Blade Forming of D. 1908
2-141A	Pall et al.	3,570,675 3/16/71	Back-Back Pressure Resistant Filter
2-142A DIV.	Pall et al.	Allowed & to Issue	Back Pressure Resistant Filter Element
2-142	D. Rosenberg	3,586,588 6/4/68	Hydraulically Actuated Pump
2-143	Cross et al.	3,428,253 2/18/59	Temperature and Pressure Responsive Valve
2-146	D.B. Pall	3,495,566 2/17/70	Delayed Response Pressure Indicator
2-144 DIV	D.B. Pall		
2-147 CIT	D. Rosenberg	3,650,093 3/22/72	Sterile Disposable Ad- ministration System
2-147 PAT. CIP	D. Rosenberg	3,710,947 1/16/73	Valve for Fluid Line & Structure Containing the same
2-148	D. Rosenberg	3,447,414 6/3/69	Syringe Pump
2-148 Design	D. Rosenberg	D219,414 12/8/70	Syringe Pump
2-148 CIP	D. Rosenberg	3,572,375 2/23/71	Twin Valve T-Connector
2-149	D.R. Pall	3,442,388 5/6/69	Artificial Kidney
2-153	Cocpor	3,508,657 4/27/70	Self-jacking Filter Housing Head
2-155	Riely et al.	3,503,497 3/31/70	Bag with Bacteria Filter Window
2-146 DIV. D.B. Pall		3,763,883 10/9/73	Pressure responsive devices having con- trolled response to flow surges

File No.	Inventor	Patent No.	Subject
2-156	Reedwell, C. A.	3,550,416 7/24/70	Paracranial Fluid Filter
2-157	Gross	3,558,837 6/13/72	Air Mixture
2-160	D. Rosenburg	3,523,468 8/11/70	Gas Separator
2-160 Design	D. Rosenburg	D218,310 8/11/70	Gas Separator Design
2-160 G1	D. Rosenburg	3,696,932 10/10/72	Disposable Filter Assembly
2-165	Riely et al.	3,631,051 1/8/72	Gas Purge Device
2-167 G12	Riely et al.	3,696,933 10/10/72	Inertial Filter
2-169	D. Rosenburg	3,610,848 10/5/71	Timer for Syringe Pump
2-169 LTV	D. Rosenburg	Allowed & to Issue	Timer for Syringe Pump
2-171	R.B. Cooper	3,564,175 2/16/71	Magnetic Switch
2-171 G12	R.B. Cooper	3,591,003 7/6/71	Differential Pressure Responsive Signalling Device and a Filter Assembly Having Same
2-172	R.E. Gross	3,633,612 1/1/72	Fail-Safe Valve
2-176	F. Riely	Allowed & to Issue	Microporous Non-Adherent Surgical Dressing
2-177	R. Gross	3,742,970 7/3/73	Flow sensitive sensing & shut-off device

APPENDIX IV

SELECTED LIST OF INDUSTRIES FOR COSMETIC, FOOD AND DRUG FILTRATION USING FINE LINE MEMBRANE FILTERS

- Note: 1) This list includes customers in the U.S., U.K., Germany, Austria, Switzerland and Russia where direct sales are made by Pall. Customers in Japan and throughout Europe are sold thru distributors the vice not included.
- 2) This list does not for all each particular fluid filtered. The fluids filtered can be categorized as follows:

PHARMACEUTICAL PREPARATIONS

Water: For preparation of drugs, ampule washing etc.
(and steam)

Air: For fermentation process and venting

Final Products: Various drugs, IV solutions

Solvents: For preparation of drugs and cleaning

Biologics: Serum and serum fractions, plasma vaccines,
culture media

MEDICAL DEVICES

Water for kidney machines, urological examination
devices etc.

FOOD AND BEVERAGE

Product Filtration: Alcoholic (beer, gin, etc.) and
soft drinks, syrup

Air: Sterile vent filters for storage tanks

COSMETICS

Water, lotions, perfumes, etc.

COMPANY	LOCATION	COUNTRY
Abbott Labs	N. Chicago, Ill.	U.S.
Allergan Pharm.	Santa Anna, Calif.	"
Alcon Laboratories	Fort Worth, Texas	"
McGaw Labs	Glendale, Calif.	"
Armour Pharm.	Chicago, Ill.	"
Astra Pharm.	Worcester, Mass.	"
Ayerst Labs	Rouses Pt., New York	"
Baxter Labs	Morton Grove, Ill.	"
Berkman-Massengill	Piscataway, New Jersey	"
Bristol Labs	Syracuse, New York	"
Cutter Labs	Berkeley, Calif.	"
Ciba Pharm.	Summit, New Jersey	"
Dow	Yionsville, Indiana	"
Hoffman-LaRoche	Nutley, New Jersey	"
Johnson & Johnson	New Brunswick, New Jersey	"
Schering	Kenilworth, New Jersey	"
Eli Lilly	Indianapolis, Ind.	"
Pfizer	Groton, Conn.	"
Elkin Sinn	Cherry Hill, New Jersey	"
Endo Labs	Garden City, New York	"
F. Fougere & Co.	Hicksville, New York	"
Holland Rantos	Piscataway, New Jersey	"
John Hopkins Univ.	Baltimore, Md.	"

COMPANY	LOCATION	COUNTRY
N.K.B.	Bethesda, Md.	"
Lederle Lab.	Pearl River, N.Y.	"
Mord Johnson & Co.	Evansville, Ind.	"
Warner Lambert	Titity, Pa.	"
Warner Chilcott	Morris Plains	"
Wilson Pharm. & Chem. Corp.	Chicago, Ill.	"
Miles Lab.	Elkhart, Ind.	"
"	Clifton, N.J.	"
Knoll Pharm.	Orange, N.J.	"
S.B. Penick & Co.		
Riker Labs, Inc.	Northridge, Calif.	"
Upjohn Co.	Kalamazoo, Mich.	"
E.R. Squibb & Sons		
Richardson Merrill	Hatboro, Pa.	"
Wyeth Labs	Westchester, Pa.	"
Geigy	Macclesfield	U.K.
Fisons Pharm.	Holmes Chapel	"
I.C.I. Pharm.	Macclesfield	"
Calmic (div. of Wellcome)	Crewe	"
Glaxo	Ulverston	"
Elida Gibbs	"	"

COMPANY	LOCATION	COUNTRY
Sandoz	Ulverston	U.K.
3M (Riker Labs)	"	"
Bista (subsidiary of Eli Lilly)	"	"
Dylac	Liverpool	"
Evans Medical	"	"
E.R. Squibb	"	"
Colgate Palmolive	"	"
Allied Breweries	"	"
Beechams	Irvine	"
Flow Labs	"	"
Roché products (Hoffman LaRoche)	"	"
I.C.I. Agricult- ural div.	Billingham	"
Winthrop Labs	"	"
Glaxo	Bernard Castle	"
I.C.I. Grangemouth	"	"
Various breweries including Vaux, Tennants, Scottish & Newcastle & Coca-Cola	"	"
Beecham	Worthing	"
Roussel	Swindon	"
Cancer Research Institute	London	"

COMPANY	LOCATION	COUNTRY
Lister Institute	Elstree	"
Animal Virus Research Institute	"	"
Glaxo	Greenford	"
Smith & Nephew	Komford	"
Merck Sharpe & Dohme	Hoddesdon	"
Microbiological Research Est.	Porton	"
Wellcome Foundation	Pirbright	"
Pfizer	Sandwich	"
J & S	Carlisle	"
Larsons	Chesham	"
Beechams Soft Drinks	Brontford	"
Schweppes	"	"
Showerings	Somerset	"
Coates cider	"	"
Gordon's Gin	London	"
Booth Gin	"	"

COMPANY	LOCATION	COUNTRY
Dr. Thoma & GmbH	795 Biberach Postfach 720	Germany
Farbwerke Hoechst AG	623 Frankfurt/M. Hoechst Postfach	"
Biochemie GmbH	A-625 Kundl	Austria
Deutsche Welcome GmbH	3006 Glessburgwedel Im langen Felde	Germany
Kali - Chemie	3057 Neustadt a. Rübenberge	"
Bacillolabfabrik Dr. Boede & Co.	2000 Hamburg 54 Melanchthonstrasse 27	"
Chemische Fabrik von Heyden	84 Regensburg - 2 Donaustrasserstr. 378	"
Farbwerke Hoechst AG	623 Frankfurt/M.-Hoechst Postfach	"
Marbert GmbH	4 Dusseldorf 16 Bonner Str. 155	"
Eau de Cologne	5 Köln - Ehrenfeldt Postfach 4711	"
MMM GmbH	8 München 75 Implerstr. 18	"
Euroclinic, Schuck u. Co.	8 München 55 Sauerbruchstrasse 10	"
Webecke u. Co. GmbH	2407 Bad-Schwartau Nuhlenstrasse 38	"
Stiefenhofer KG	8 München 12 Postfach 79	"
DMR - Apparatebau	62 Wiesbaden Saarbrucker Allee 3	"

COMPANY	LOCATION	COUNTRY
Miles Kali-Chemie	307 Nienburg	Germany
E. Melch	61 Darmstadt 2 Postfach 4119	"
Avon Kosmetika GmbH	8051 Neufahrn	"
Roehm GmbH	61 Darmstadt Mainzer Str. 42	"
Farbwerke Hoechst AG	623 Frankfurt/H-Hoechst Postfach	"
Bayer	509 Leverkusen	"
Ciba-Geigy AG	CH-4002 Basel Postfach	Switzerland
Sandoz AG	CH-4002 Basel Lichtstrasse 3.	"
Biochemie	A-625 Rendl	Austria
Techmashimport	Moskau-G 200 Smolenskaja pl.	Russia
Biogal		Hungary
Rudolf Müller u. Co.	6301 Watztenborn-Steinberg Giessener Strasse 75	Germany
Schering AG	4619 Bergkamen Postfach	"
Frankenbrunnen Hufnagel OHG	8532 Bad Windsheim Illersheimer Strasse	"
Teutoburger Mineral- brunnen	4812 Ummeln Brockhagener Strasse	"
Gatzweilers Alt- Brauerei OHG	4000 Dusseldorf-Oberkassel Postfach 128	"
Rudolf Rieder	Getränkefabrikation 8404 Wörth/Donau	"

<u>COMPANY</u>	<u>ADDRESS</u>	<u>COUNTRY</u>
Farbwerke Hoechst AG	623 Frankfurt/H-Hoechst Postfach	Germany
Lager AG	56 Wuppertal-Elberfeld	Austria
Asta Werke	4812 Brackwede Postfach 109	Germany
Pfizer GmbH	75 Karlsruhe Postfach 4949	"
Sandoz AG	85 Nurnberg Postfach	"
Dortmunder Union- Schultheiss-Brauerei AG	47 Dortmund Postfach 965	"
Hansen Alt-Brauerei	4156 Witten Postfach 80	"
Kaake Beck AG	28 Lienen Gronenstrasse 60	"
Stern Brauerei, Carl Funke AG	43 Essen Dellinghauser Strasse 1	"
Lowenbrau AG	8000 Munchen 40 Clemensstrasse 83	"

APPENDIX IV

1. Annual Reports 1972-1973.
2. List of Pall Patents.
3. List of customers in the pharmaceutical and related industries.