SURVEY OF BURLINGTON INDUSTRIES, INC.
Burlington House Finishing Plant
Form Fabrics Plant
Durham Domestics Plant
Brookneal Finishing Plant

DATE OF SURVEY
November 6-9, 1974
December 3-4, 1974

SURVEY CONDUCTED BY
Troy Marceleno, P.E.
Ken Wallingford
Jack Proud
David Zeller

REPORT PREPARED BY
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Environmental Investigations Branch
Division of Field Studies and Clinical Investigations
National Institute for Occupational Safety and Health
December, 1974

PLACE VISITED:	Burlington Industries, Inc. P.O. Box 21207 3330 West Friendly Avenue Greensboro, N.C. 27420 Phone: (919) 379-2058
	1. Burlington House Finishing Plant Burlington, N.C. 27215 Phone: (919) 228-2371
	2. Form Fabrics Plant Greensboro, N.C. 27420 Phone: (919) 379-2024
	3. Durham Domestics Plant Durham, N.C. 27705 Phone: (919) 286-1201
	4. Brookneal Finishing Plant Brookneal, Virginia Phone: (703) 376-2311
DATE OF SURVEYS:	November 6-8, 1974 December 3-4, 1974
PERSONS CONTACTED:	Harold Imbus, M.D. John D. Neefus, Sr.
PURPOSE:	To conduct a survey of textile facilities that use formaldehyde based resins and ionic chloride compounds and to determine the presence and extent of bis-chloromethyl ether.

INTRODUCTION AND DESCRIPTION OF PLANT

The Division of Field Studies and Clinical Investigations (DFSCI), National Institute for Occupational Safety and Health (NIOSH) is conducting an investigation of possible bis-chloromethyl ether (BCME) formation in industrial, laboratory and other environments. This investigation has been initiated because of the known carcinogenic nature of BCME[1-8] and recent disclosures regarding its formation through the reaction of formaldehyde with hydrochloric acid or some other ionic chloride compound.[9-16]

The textiles industry uses formaldehyde resins and ionic chloride containing catalysts in permanent press treatment of fabrics. Sampling was deemed necessary at Burlington Industries finishing plants because they were using resins of high free formaldehyde content (carbamates) together with magnesium chloride catalysts. The combination was thought to enhance the formation of BCME as opposed to plants which use low free formaldehyde resins and zinc nitrate catalysts (or some other catalyst of low chlorides content). This was confirmed on October 8 and 9, 1974, in preliminary sampling conducted by Burlington Industries personnel who found BCME present in the padding area and at the exit end of tenters in two finishing plants located in Greensboro and Durham, North Carolina. The positive BCME findings of 1.6ppb, 0.5ppb and 0.9ppb were analyzed using the Rohm and Haas, high resolution mass spectrometric procedure.[15]

On November 5, 1974, DFSCI personnel including Troy Marceleno, Ken Wallingfo Jack Proud and David Zeller met with Burlington Industries staff representatives including Dr. Harold Imbus, Corporate Medical Director and John Keefe Sr., Corporate Industrial Hygienist, prior to beginning BCME sampling at two Burlington textiles finishing plants. Upon being informed of the prelim

BCME findings, the NIOSH survey was altered to accomodate two other Burlingto
plants located in nearby Burlington, North Carolina, and in Brookneal, Virgin

During the period November 6-8, 1974, 85 air samples were collected at the four plants above and analyzed for BCME. This included four blanks, 52 area and 29 personal breathing zone air samples.

On December 3-4, 1974, thirty-one additional air samples were collected at the Burlington and Durham, North Carolina plants. These included 20 area, 9 breathing zone and 4 blank samples. The resampling at the latter two plants was for the purpose of collecting duplicate samples at the Burlington plant for analyses by two independent laboratories. In the case of the Durham plant, it allowed retesting the plant after chloride free resins and a zinc nitrate catalyst designed to reduce the likelihood of BCME formation had been substituted in the manufacturing process.

PLANT BACKGROUND AND DESCRIPTION

General

Burlington Industries is the acknowledged world leader in textiles manufacturing. In the state of North Carolina alone, around eighty-eight of their plants are in operation.

Unlike another large textiles manufacturer surveyed recently by NIOSH,[17] Burlington Industries finishing plants are generally smaller (1050 to 55 persons for those plants sampled). Most were acquired by Burlington from other companies which produced specialty items, or one line of products, and consequently have only a few finishing frames (2 or 3). The largest finishing plant sampled (Burlington, North Carolina) had nineteen frames.

Durham Domestics Plant, Durham, N.C.

This plant began operations in 1898. It was purchased by Burlington Industries from Ervan Mills in 1961. The plant produces sheeting which is made into drapes, sheets, pillow cases, etc. Most of the essential operations for manufacturing the 50-50 polyester cotton blend material (yarning, weaving, bleaching, heat setting, finishing, cutting, sewing and preparation of distribution) are located here. Only the dyeing and screen printing of the fabric is done elsewhere.

Approximately 1300 persons are employed at this facility including forty who work in the finishing area. The finishing operation is housed separately in one of the five plant buildings and contains two finishing frames. Only one of these frames is used for resin/catalyst applications. The plant generally is well ventilated but is under slight negative pressure due to the large exhaust fans used to remove excess heat and moisture from the two finishing frames.

Burlington House Finishing Plant, Burlington, N.C.

This plant has been operating around twenty years. Its main function is the dyeing and finishing of 50-50 polyester cotton blend sheeting used to make pillow cases, sheets and draperies. It also produces material for mattress ticking and auto upholstery.

Approximately 330 people work in the plant, including 80 who work in the finishing area. The above operations are housed in one large building that is under slight negative pressure due to the exhaust fans from 19 frames located there. Resin/catalyst applications are performed on only three frames, however here.

Brookneal Finishing Plant, Brookneal, Virginia

This plant was bought by Burlington Industries from Pacific Mills. Originally it was used to produce worsted wool fabric but in 1971 was converted to produce the 50-50 polyester cotton blends. With the exception of yarning and weaving, it contains all the processes essential to producing the polyester cotton fabrics (bleaching, heat setting, dyeing, printing, finishing, cutting, sewing and preparing for distribution). The plant also performs dyeing and printing services for other Burlington Industries plants.

Approximately 1050 people work in the plant, including around 12 workers who operate the one finishing frame located there. The large building which houses all of the above operations is under slight negative pressure.

Formed Fabrics Plant, Greensboro, N.C.

This plant is used by Burlington Industries primarily as a pilot plant operation. Prior to 1971, it was used mostly to formulate textile additives (resins, catalysts, waxes, etc.)

Approximately 60 persons are employed at this facility including thirty who work in the finishing area where only one textile finishing frame is located (another is being constructed). Plant operations consist of dyeing, heat setting and finishing work, primarily on one product line utilizing formaldehyde, chloride catalysts and other chemical additives. The single building which houses the small operation is well ventilated but under slight negative pressure.

Medical Program

Burlington textile finishing plants are widely scattered throughout the country and medical services are provided mostly on an individual basis to employees through their private physician or through contract physicians located in the general vicinity of the plants. In most plants, nurses are on duty full time, normally during the first shift. Resource personnel, trained in first aid are also available to assist with cuts, abrasions and other minor problems.

All new employees are given pre-employment physicals. Spirometer tests are administered, as are SMA-12 blood tests.

Safety and Industrial Hygiene

Mr. John Neefus, Sr., the Corporate Industrial Hygienist for Burlington Industries is supported by two part time analytical chemists who help conduct general industrial hygiene services. To date, they have been primarily concerned with the byssinosis and vinyl chloride problems. Other problems being dealt with include those associated with noise, and the examination of all dye formulations to insure that these do not contain carcinogenic ingredients. In addition, most Burlington finishing plants have a technical chemicals coordinator who insures that materials and processes used in the plant are properly tested and utilized.

With respect to plant and industrial hygiene practices, all of the plants surveyed had separate eating facilities for their employees. All were well maintained and ventilated. On several occasions, however, employees were seen eating in the production area. Most employees normally are not issued uniforms but in some cases these are available for rental on an individual basis. Maintenance personnel are the exception; most have uniforms issued to them. Plant personnel generally are not required to shower before leaving the plant. In most cases, shower facilities were not available at the plant.

Ventilation

Most of the plants visited appeared to be properly ventilated. All were said to meet the OSHA requirements of six air changes per hour for manufacturing plants but time did not permit checking into this. Most were observed to be under slight negative pressure due to the large exhaust fans which are needed to vent the excessive moisture and heat in the drying and curing areas of the finishing frames.

DESCRIPTION OF THE OPERATION

General

Textiles manufacturing consists of several processes designed to convert raw materials (bales of cotton, etc.) into bed sheets or other products. These processes include yarning, weaving, preparation, dyeing, screen printing, finishing, sewing and packaging. Of the four plants surveyed, only the Durham and Brookneal plants performed the majority of these processes. The other two plants depended to a large extent on other Burlington plants for those services which they were not equipped to carry out.

Finishing

It is during the finishing process that the possibility exists for BCME formation. Here resins containing formaldehyde are combined with catalysts and cured in ovens at high temperatures to form the permanent press treatment of fabrics.

Several varieties of resins and catalysts are used in the textiles industry. Their application depends to a large extent on the effects desired in the finished product.

Resins - The carbamate and glyoxal type resins are the two in most prominent use today. Others include triazone, melamine, urea formaldehyde, ethylene urea and tetraset. They can be unbuffered or buffered depending on the need to control the Ph of the solution. This is done through the addition of buffer salts. Carbamate resins, such as those used at the Burlington plants surveyed, (one plant used glyoxal resins) usually have a high free formaldehyde content (2-7%). Generally, the carbamates give the fabrics a softer hand (feel) and are considered to make the fabric more durable than fabrics treated with the glyoxal resins. Their use is almost entirely restricted to sheeting manufacturing, however. Glyoxal resins most often are low in free formaldehyde (less than 1%). They give a "harsh hand" to the fabric but provide good durability and outstanding permanent press characteristics.

Catalysts - The two most commonly used catalysts are zinc nitrate and magnesium chloride. The latter variety is high in chlorides and is thought to be more conducive to BCME formation. The majority of the plants surveyed used this type of catalyst.

Figure 1 shows a schematic view of a typical finishing frame.

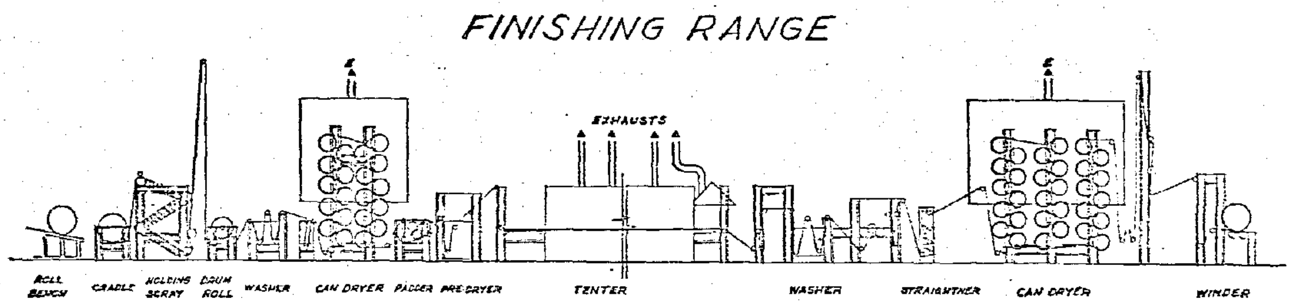

FIGURE I

Individual components in the finishing frame (or the order in which they are used) will vary, depending on the type of fabric being processed, and the quality or effect desired in the finished products. In general, however, the process is characterized by the following operations.

Mixing - This is usually accomplished in a "starch" room that is elevated above the frames. The resins and catalaysts are brought together in large stainless steel kettles, stirred and fed by gravity to the frames.

Pre-washing and padding - In the frame, the roll of fabric is unwound into a holding scray and then washed in different chemicals such as optical brighteners, blue tints, perboric or surfactants, depending on prior treatment or on subsequent processing. Next, the fabric is squeezed to remove moisture and dried by being threaded through sets of 10-20 heated "cans".

Moisture is removed by means of fans (8-10,000 cfm) and exhausted through vents in the roof. The fabric proceeds into a vat called a "padder", where the resin/catalyst mixture is added. From the "padder" the fabric moves rapidly into the curing phase.

C. Curing - This consists of passing the wet fabric through a predryer then through a curing oven (tenter). Temperatures range from 600°F in the predryer to between 350° to 400°F in the tenter. Normally the material moves at a speed of around 120 yards per minute. Curing time in the tenter is approximately 30 seconds. Predryers and tenters used in the curing process are of the gas-fired variety. The predryers have exhaust fans (around 10,000 cfm) which vent the heated gases (formaldehyde, etc.) directly to vents in the roof. The tenters also have three or more exhaust fans which are usually rated at 8,000 to 10,000 cfm each. Resin fixation (percent of cure) varies from place to place and from frame to frame but usually averages around 70 percent. The additional 30 percent curing takes place elsewhere after the fabric has been cut, sewn and final pressed.

Washing - Excess formaldehyde is washed from the fabric after it is cured, by simmering it in large vats. Following this, the material is threaded through drying cans where the moisture content is reduced to around 2 to 3 percent. The exhaust fans over these units are rated at around 11,000 cfm each.

SURVEY PROCEDURES

A total of 5 frames were surveyed at the four Burlington plants. This included one each at the Durham, Brookneal and Greensboro plants and two (Nos. 5 & 6) at the Burlington plant. In most cases, the frames were running the usual product line and represented current finishing practices.

The sampling protocols employed were developed in consultation with various industry personnel. Later they were perfected by means of pilot and in-plant sampling.[16,17]

Long-term (3 and 4 hours) personal and area air samples were collected using Sipin Lo Flow pumps equipped with Porapak Q sampling tubes (50-80 mesh size macroreticular, polymer absorber beads inserted in 7 cm, 9mm diameter glass tubes). The pumps were individually set to collect around 10 or 15 liters each over the 3 or 4 hour sampling period.

Short-term (10 and 15 minutes) area air samples also were collected. These made use of Bendix Model C115 personal monitoring pumps, with sampling flow rates of 1 liter per minute. They also utilized the Porapak Q tubes.

The long-term area (and in some cases breathing zone) air samples were collected in the starch room, padders, alongside the tenter frame and at the delivery end of the tenter. The short-term air samples were collected in the areas above, from stacks above each frame, and in the starch room. Stainless steel permeation drying tubes were employed ahead of the Porapak Q samplers in areas where excessive heat and moisture would hinder BCME uptake by the Porapak Q. These tubes were primilarly used in stack sampling where exhaust gases were in excess of the 80°F recommended ceiling for Porapak Q use. Moisture in the drying tubes was removed by attaching a Bendix Model C115 pump to the inlet side of the tube. To insure that the sample was guarded against dilution of the BCME in the stack with the ambient air, stainless steel probes were inserted into the stack at least 2 feet below the stack opening, ahead of the drying tubes.

Samples collected during the November 6-8, 1974 survey were sent to the Rohm & Haas Company and analysed by high resolution mass spectroscopy/gas chromatography (MS/GC). This procedure has a capability for measuring BCME at the 0.1 ppb level in air as described by Collier.[15] Samples collected during the December 3-4, 1974 survey, also were analyzed at the Rohm & Haas labs. However, duplicate samples were collected at the Burlington, North Carolina plant and sent to the Dow Chemical Analytical Laboratory in Midland, Michigan for analysis by MS/GS magnetic separation and by their new proprietary technique.

DISCUSSION OF RESULTS

Table 1 shows a correlation of area to personal samples collected during the initial November 6-8, 1974 survey. Table 2 shows similar data for the December 3-5, 1974 follow-up survey. A total of 85 samples were collected during the initial survey while 31 were collected later.

Initial Survey

Six samples collected during this initial survey were positive for BCME by means of mass spectroscopy analysis. Two of these (samples 122 & 131) were

TABLE 1

CORRELATION OF AREA TO PERSONAL SAMPLES
BURLINGTON INDUSTRIES, INC.

November 6-8, 1974

Sample No. & Type *	Plant Sampled **	Sampling Rate ***	Vol. Liters	AREA SAMPLED FRAME NO.	1 MIXING	2 PADDER	3 BEHIND PADDER	4 ENTRANCE TO OVEN	5 ALONG OVEN	6 EXIT OVEN AREA	7 WASHER AREA	8 STACK AREA	9 ALL PLANT	10 OTHER	Result ppb ****
101 A	BD	63 cc/m	10.6	2						X					<LOD
102 A	BD	61 cc/m	16.1	1						X					<LOD
103 P	BD	61 cc/m	11.5	-									X		<LOD
105 P	BD	61 cc/m	18.1	2						X					<LOD
106 A	BD	63 cc/m	12.6	2	X										<LOD
107 P	BD	63 cc/m	14.0	1						X					<LOD
108 P	BD	63 cc/m	10.1	2										X	<LOD
109 P	BD	63 cc/m	13.9	1				X							<LOD
110 A	BD	63 cc/m	9.9	2		X									<LOD
111 P	BD	63 cc/m	9.5	-									X		<LOD
112 A	BD	82 £m	12.0	2								X			<LOD
113 P	BD	63 cc/m	10.6	-									X		<LOD
114 P	BD	63 cc/m	9.6	2										X	<LOD
116 P	BD	61 cc/m	13.4	2										X	<LOD
133 P	BD	63 cc/m	14.3	1						X					<LOD
134 P	BD	63 cc/m	10.9	2				X							<LOD
135 A	BD	63 cc/m	13.7	2			X								<LOD
136 A	BD	8 lpm	13.0	2				X							<LOD
140 A	BD	63 cc/m	16.3	2						X					<LOD
130 P	BHF	63 cc/m	8.2	6										X	<LOD
132 P	BHF	63 cc/m	9.5	6										X	<LOD
153 P	BHF	62 cc/m	9.9	5										X	<LOD
156 P	BHF	62 cc/m	10.6	5										X	<LOD
164 P	BHF	62 cc/m	9.5	5&6										X	<LOD
[illegible] P	BHF	62 cc/m	9.4	5&6										X	<LOD
[illegible] P	BHF	63 cc/m	14.5	5&6				X							<LOD
128 P	BHF	63 cc/m	9.6	5&6				X							<LOD
[illegible] P	BHF	61 cc/m	8.5	5&6	X										<LOD
131 P	BHF	61 cc/m	8.3	5&6	X										2.7
1[illegible]4 A	BHF	63 cc/m	2.8	5		X									<LOD
127 A	BHF	63 cc/m	9.2	5		X									<LOD
161 A	BHF	63 cc/m	9.6	6		X									<LOD
149 A	BHF	63 cc/m	9.9	6		X									<LOD
137 A	BHF	63 cc/m	9.0	5&6										X	<LOD
160 A	BHF	62 cc/m	10.3	5						X					<LOD
151 A	BHF	62 cc/m	10.5	5						X					<LOD
162 A	BHF	63 cc/m	10.2	6						X					<LOD
152 A	BHF	63 cc/m	11.1	6						X					<LOD
104 A	BHF	63 cc/m	8.1	6	X										<LOD
157 A	BHF	63 cc/m	8.2	5	X										<LOD
125 A	BHF	63 cc/m	8.8	5	X										<LOD
123a A	BHF	63 cc/m	9.1	5						X					<LOD
159 A	BHF	61 cc/m	8.2	6						X					<LOD

TABLE 1 (continued)

Sample No. & Type *	Plant Sampled **	Sampling Rate ***	Vol. Liters	AREA SAMPLED: FRAME NO.	1 MIXING	2 PADDER	3 BEHIND PADDER	4 ENTRANCE TO OVEN	5 ALONG OVEN	6 EXIT OVEN AREA	7 WASHER AREA	8 STACK AREA	9 ALL PLANT	10 OTHER	Result ppb ****
155 A	BHF	63 cc/m	12.8	5&6								X			< LOD
159 A	BHF	1 lpm	11.0	5&6								X			< LOD
127A P	BHF	61 cc/m	9.3	6										X	< LOD
128 P	BHF	62 cc/m	9.5	6										X	< LOD
126 P	BHF	63 cc/m	9.2	6				X							< LOD
122 P	BHF	63 cc/m	9.3	6	X										1.6
125A A	BHF	1 lpm	10.0	6										X	< LOD
124 A	BHF	1 lpm	10.0	6		X									< LOD
123 A	BHF	1 lpm	10.0	6						X					< LOD
121 A	BHF	1 lpm	10.0	6						X					< LOD
12[illegible] A	BHF	1 lpm	10.0	6								X			< LOD
11[illegible] A	BHF	1 lpm	10.0	6	X										< LOD
115 A	BB	1 lpm	12.0			X									< LOD
117 P	BB	63 cc/m	13.5		X										< LOD
129 A	BB	63 cc/m	17.4											X	< LOD
137 A	BB	1 lpm	22.0		X										< LOD
138 A	BB	1 lpm	22.0												< LOD
139 A	BB	1 lpm	22.0									X			0.4
142 A	BB	1 lpm	9.0									X			< LOD
143 A	BB	1 lpm	22.0					X							< LOD
181 A	BB	61 cc/m	16.3							X					< LOD
183 A	BB	63 cc/m	14.9		X										< LOD
185 A	BB	63 cc/m	16.0				X								< LOD
186 P	BB	61 cc/m	27.3											X	< LOD
187 A	BB	63 cc/m	15.8							X					< LOD
188 A	BB	1 lpm	22.0							X					< LOD
190 P	BB	61 cc/m	15.4											X	< LOD
192 P	BB	63 cc/m	17.1							X					< LOD
193 A	BB	62 cc/m	16.2			X									[illegible].6
194 A	BB	61 cc/m	18.4			X									< LOD
195 A	BB	62 cc/m	27.7					X							< LOD
19[illegible] A	BB	63 cc/m	23.4											X	< LOD
17[illegible] A	BG	1 lpm	1[illegible].0		X										< LOD
174 A	BG	1 lpm	15.0			X									< LOD
[illegible] A	BG	1 lpm	15.0											X	< LOD
179 A	BG	1 lpm	15.0					X							< LOD
171 A	BG	1 lpm	15.0							X					< LOD
177 A	BG	1 lpm	15.0							X					< LOD
141					BLANK SAMPLE										
144					BLANK SAMPLE										
1[illegible]4					BLANK SAMPLE										
191					BLANK SAMPLE										

* Type: A-Area; P-Personal
** Plant Sampled: BD-Durham; BHF-Burlington; BB-Brookneal; BG-Greensboro
*** Samples Collected at 61-63 cc/minute utilized Sipin Lo Flo pumps. Those at 1 liter per minute were collected by Bendix C118 pumps.
**** LOD - Level of detection is 0.1 ppb (v/v).

TABLE 2

CORRELATION OF AREA TO PERSONAL SAMPLES
BURLINGTON INDUSTRIES, INC.
DECEMBER 3-4, 1974

Sample Number and Type*		Plant Sampled **	Sampling Rate ***	Sample Volume (liter)	SAMPLING LOCATIONS										Result (ppb) ****
					Frame No.	1 Starch Room	2 Padder	3 Behind Padder	4 Entrance to Oven	5 Outside Oven	6 Oven Exit	7 Wash Area	8 Stack Area	9 Other	
211	A	BD	63 cc/m	14.1	2								X		<LOD
246	P	BD	63 cc/m	18.2	2	X	X	X	X	X					<LOD
249	A	BD	63 cc/m	17.7	2	X									<LOD
255	A	BD	63 cc/m	19.4	2		X								<LOD
258	P	BD	63 cc/m	15.4	2	X									<LOD
259	A	BD	63 cc/m	18.8	2			X							<LOD
261	A	BD	63 cc/m	19.2	2				X						<LOD
262	A	BD	63 cc/m	17.8	2						X				<LOD
266	P	BD	63 cc/m	14.0	2		X	X	X	X					<LOD
201	A	BHF	63 cc/m	6.5	5	X									<LOD
202	A	BHF	63 cc/m	5.1	5			X							<LOD
204	P	BHF	63 cc/m	5.3	5		X	X	X	X					<LOD
205	A	BHF	63 cc/m	4.6	5			X							<LOD
206	A	BHF	63 cc/m	6.8	5	X									<LOD
207	P	BHF	63 cc/m	6.3	5	X									<LOD
208	P	BHF	63 cc/m	6.4	5	X									<LOD
209	P	BHF	63 cc/m	13.5	6	X									<LOD
210	P	BHF	63 cc/m	14.6	6	X									<LOD
213	A	BHF	63 cc/m	12.4	6	X									<LOD
214	A	BHF	63 cc/m	15.2	6	X									<LOD
216	A	BHF	63 cc/m	14.7	6	X									<LOD
217	A	BHF	63 cc/m	13.1	6	X									<LOD
218	A	BHF	63 cc/m	15.0	6		X								<LOD
220	A	BHF	63 cc/m	15.0	6		X								<LOD
245	A	BHF	1 lpm	18.0	5		X								<LOD
247		BHF			BLANK SAMPLE										<LOD
248	A	BHF	63 cc/m	5.5			X								<2.7
252	A	BHF	63 cc/m	4.5			X								<LOD
254		BHF			BLANK SAMPLE										<LOD
260	P	BHF	63 cc/m	5.3	5		X	X	X	X					<LOD
268	A	BHF	1 lpm	15.0	5	X									<LOD
				RTI SAMPLER RESULTS											
Tenax #1	A	BHF	12 lpm	1.2m³	5		X								<LOD
Tenax #2	A														
a.		BHF	12 lpm	1.2m³	5		X								<LOD
b.		BHF	12 lpm	1.2m³	5		X								<LOD
c.		BHF	12 lpm	1.2m³	5		X								<LOD
Tenax #3	A	BHF	12 lpm	1.2m³	5		X								>5-8
Tenax #4	A	BHF	12 lpm	1.2m³	5		X								INDEF
Porapak #1	A	BHF	12 lpm	1.2m³	5		X								INDEF
Porapak #2	A	BHF	12 lpm	1.2m³	5		X								INDEF

* Type: A - Area; P - Personal
** Plant Sampled: BD - Durham; BHF - Burlington
*** Samples collected at 63 cc/minute utilized Sipin Lo Flo pumps. Those at 1 liter per minute were collected by Bendix C118 pumps. The RTI samples collected at 12 liters per minute with an RTI high volume sampler.
**** LOD - Level of detection is 0.1 - 0.2 ppb depending on volume sampled. Those analyzed by Dow Chemical have a LOD of 1 ng and 5ng depending on procedure used.

breathing zone samples from workers who performed essentially the same duties (but worked on different shifts) in the starch room at the Burlington, North Carolina plant. Samples 193 and 139 were collected in the padding area and from a roof stack at the Brookneal plant. The last two positive samples (174 and 136) were collected from the padding area at the Greensboro, North Carolina plant, and at the entrance to the tenter in the Durham plant. The latter two samples were at or slightly below the level of detection (LOD) for BCME (0.1ppb) and were therefore discounted. Samples 122, 131 and 193 were confirmed later as BCME by gas chromatographic retention time, unit resolution mass spectral features and isotropic Cl distribution on Gas Chromatographic/Mass Spectrometric (GC/MS) computer system. Samples 139 (0.4ppb) was below the level (1ppb) which can be recaptured in the mass spectrometer for later GS/MS confirmation following the initial mass spectral analysis.

Follow-Up Survey

As was indicated earlier, the December 3-4, 1974 survey was undertaken to check the effect of changes made in the finishing process at the Durham, North Carolina plant and also to varify the positive findings at the Burlington, North Carolina plant. Duplicate samples collected at the Burlington plant were analyzed by GC/MS electron capture, GC/MS magnetic separation and also by the new Dow proprietary technique.

The survey performed at the Durham, North Carolina plant consisted of nine long term samples collected on Porapak Q tubes with Sipin Lo Flow pumps as described earlier. All samples were found to be below the LOD for BCME. These probably reflected the changes made earlier in the finishing process where the carbamate resins were altered to reduce the chloride content and zinc nitrate catalysts were substituted for the magnesium chloride catalysts.

The survey performed at the Burlington, North Carolina plant was only partially successful. This was primarily because only a 1-1/2 hour production run was possible with the materials on hand which were needed to duplicate the conditions surveyed on November 6, 1974. This resulted in only 4.5 - 6.5 liter samples being collected with the Lo Flow Sipin pumps rather than the 15 liters desired.

Additional samples using other samplers were also collected at this time. Two samples were collected on Porapak Q tubes with Bendix C118 pumps at 1 liter per minute. In addition, a high volume sampler developed by the Research Triangle Institute (RTI), Research Triangle Park, North Carolina was also used. It collected six air samples simultaneously at 12 liters per minute. The RTI samples were taken on large cartridges of Porapak Q and Tenax (using 3 grams each of 35-60 mesh size beads per tube). Sampling volume for these samples was 1.2 cubic meters each.

The long term (1-1/2 hours) samples were submitted to Rohm and Haas and also to Dow Chemical for analysis by high resolution MS procedure. Samples 208, 204, 268 and 245, submitted to Rohm and Haas were found to be negative for BCME. Duplicate samples submitted to Dow Chemical for analysis by GC/MS magnetic separation and by their new proprietary method (samples 207, 201, 206, 252, 260 and 202) also were negative for BCME. Only sample 248 was found positive for BCME. This sample was analyzed by the Dow GC/MS method with a detection limit of 1 ng and was found to contain 70+ 7 ng or 2.7 ppb of BCME. Its duplicate sample (252) had been analyzed earlier by Rohm and Haas and had been found to be negative.

The samples collected by the high volume sampler were split between RTI and Dow for analysis. RTI kept four cartridges (2 Tenax and 2 Porapak Q) while Dow received two Tenax cartridges. RTI began its analysis within the first week after sampling and found that breakthrough had occurred in the Porapak Q cartridges to such a degree that they discounted the sample.

During analysis by RTI of the first sample containing Tenax, it was found that breakthrough had occurred in the cartridge but to a lesser degree than that found earlier with the Porapak Q sample. Also, because of the high amount of BCME present in the Tenax sample, the detector became saturated (electrons available for capture had been exceeded). A subsequent analysis using one-eighth of the sample size resulted in a BCME estimate of at least 5 to 8 ppb. Analysis of the second Tenax cartridge conducted ten days later showed what appeared to be BCME but at a substantially reduced level. Positive confirmation was not possible due to the low concentration level and to the presence of an interfering hydrocarbon.

Difficulties were also experienced with the Tenax samples submitted to Dow Chemical for analysis. Because of mailing and other time delays, analyses were not begun until the latter part of the second week after sampling. Also, the Tenax cartridges were of such large diameter that standard fittings were not available for convenient hookup to the Dow sample elution assembly. This was resolved by using a set of Teflon R caps that were fitted with 1/4 inch stainless steel tubing that could be adapted to the assembly. Upon being heated, however, the Tenax #1 sample, developed leaks. They were quickly detected and appropriate adjustments made so as to prevent any BCME loss. The GS/MS examination of this tube disclosed that no BCME was present.

Prior to analysis of the Tenax #2 sample, Dow contacted RTI for specific instructions for handling the larger cartridge. The problems experienced earlier were resolved by removing the packing from the cartridge, mixing the Tenax beads thoroughly and repacking the Tenax aliquot into a smaller diameter tube. Three aliquots were taken after careful mixing and analyzed for BCME. All were found to be negative using GC/MS and the new proprietary technique.

The vast difference between the BCME levels found in the sample analyzed by RTI and the absence of BCME in those samples analyzed by Dow most likely reflect the waiting period before the latter samples were analyzed. It may also reflect the need for further research to explain why side by side sampling sometimes results in positive and negative samples being collected simultaneously.

CONCLUSIONS AND RECOMMENDATIONS

Selective sampling of four Burlington Industries plants has confirmed the presence of BCME in the textiles finishing area. BCME was found in area samples and in some cases personal, breathing zone samples which were collected in the starch room and padding areas, around the tenter frame and in the exhaust stacks leading from the tenter frame. The findings, although not substantial (only one tenth of the samples where BCME was thought to exist were found to be positive), nevertheless are considered significant. This is because in the past, resins of greater formaldehyde content have been in prevalent use. When used in combination with magnesium chloride catalysts they conceivably gave rise to larger concentrations of BCME.

The parameters for BCME formation are not entirely understood at this time. The effect on the human body from low BCME levels also is uncertain. Laskin[3] in 1971 found carcinomas in half of the rat population (LC_{50}) exposed to BCME concentrations of 0.1 parts per million. This, however, is around 100 times higher than the readings found in textiles operations. Both of the items require extensive research by NIOSH and others.

Pending more extensive investigations that are designed to shed more light on BCME formation in textiles and other industrial operations, the following recommendations should be seriously considered in the interest of effecting worker safety, especially in those operations where high free formaldehyde resins and magnesium chloride (or some other ionic chloride containing catalysts) have been used.

1. Textiles Processing - Zinc nitrate or some other low, ionic chloride containing catalyst should be used whenever possible instead of magnesium chloride catalysts. Also, low free formaldehyde resins should be used instead of those that have a high free formaldehyde content.

2. Medical - Sputum cytology examinations should be conducted on all employees who have worked or are working in areas for more than five years where ionic chloride containing catalysts were or are being used. The examinations should be conducted according to Saccomanno[18,19] (or equivalent). For employees whose readings are equal to or more than 2A on a scale of 1 to 5, a more active medical surveillance program is recommended including:

a. Repeating sputum cytology examinations on a ˀ months interval

b. X-ray examination if not done recently

c. Cessation of smoking and other activities which would aggravate pulmonary diseases

d. Conducting bronchoscopy examinations if reading is 3 or above.

Victor E. Archer, M.D., whose address is shown below*, can provide medical consultation on sputum cytology examinations, as time permits.

3. Engineering - Exhaust vents leading from starch rooms, predryers and tenter frames should be separated from fresh air intake systems by at least a 10 foot vertical separation to insure that contamination of incoming air does not take place.

4. Industrial Hygiene - If not already in effect, a program of industrial hygiene should be established in each plant which will, at a minimum:

a. Examine the nature and toxic effect of chemicals being used in the plant and insure that employees who handle these materials are properly protected through the use of protective clothing, footwear, gloves, respirators, etc.

b. Prohibit workers from eating, smoking, etc., in production areas.

c. Require showers and a uniform or work clothes change before departing for home to insure that others are not unnecessarily exposed to chemicals from clothing that is being laundered at home.

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d. Sample air for BCME in finishing areas where formaldehyde resins are used. These samples can be collected on Porapak Q, or equivalent, and analyzed by gas chromatography - mass spectroscopy or similar techniques which are sensitive to 0.1 ppb. Further information can be obtained from Troy Marceleno, P.E., whose address is shown below.**

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