

APPLICATION OF FOAMS TO  
THE PROCESSING OF FABRICS

INTERIM REPORT

For Period October 1, 1977 to March 31, 1979

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OBJECTIVE

The primary objective of this project is to reduce the energy requirements for finishing fabrics by drastically reducing the water required to wet process the fabrics. Since less water is used, less energy is consumed in the evaporation of water. This is accomplished by replacing much of the water with air, making a foam and using it as the application medium. (Air requires no heat for dispersal).

For the first eighteen month's period (October 1, 1977 to March 31, 1979), UMRC's specific objectives were:

1. To complete up-grading of the UMRC finishing range to operating condition with commercial speed capability.
2. To optimize specific foam finish formulations to readiness for pilot plant fabric runs. Durable press, hand modification and water repellency type finishes were to be optimized. Pilot plant fabric finishing trials were to be run. Plant trials were to be run, including economic and energy evaluations, for the subsequent time period's commercial demonstrations.
3. To optimize specific foam dyeing formulations for selected dyes and fiber types for pilot plant runs. Fibers were polyester, nylon, acrylic, cellulose acetate, wool, cotton and rayon. Dye classes were disperse, acid, direct, cationic, reactive and pigments as applicable to specific fibers. Pilot plant dyeing trials were to be run. Plant trials were to be run, including economic and energy evaluations, for the subsequent time period's commercial demonstrations.
4. To optimize foam printing formulations for selected pigments and dyes for printing various substrates. Pigment formulations for cellulose, polyesters and their blends, acid dye formulations for nylon, vat dye formulations for cellulose and cationic dye formulations for acrylics were to be optimized. Pilot plant trials, including economic and energy evaluations, were to be made.
5. To determine the feasibility of foam fabric preparation including the operations of desizing, scouring and bleaching.

### SUMMARY

On April 1, 1978 when the first six month's work under the DOE/U. M. & M. contract was reported, the practicality of foam fabric finishing on a commercial basis had been established. Both U. M. & M.'s finishing plants and their chemical division's customers had processed limited yardage of fabrics equivalent in performance to conventionally wet finished fabrics. In these mill trials, a range of foam fabric finishes including softeners, hand builders, durable press and shrink resistant types were applied to cotton sheeting, corduroy and polyester/cellulosic blends, etc. In all cases, substantial energy savings were realized.

Since the issuance of the first and second interim reports, commercial practice of foam fabric finishing continues to grow with cumulative total estimated as approaching 200,000,000 yards. This figure is small compared with some 8 billions yards of fabrics finished annually but clearly emphasizes the effectiveness of energy conservation of foam processing. The textile industry, as true with other low profit, commodity industries, often accepts new technology on a slow, "show me" basis. In accepting this premise, we feel that growth of foam fabric finishing has been much faster than originally expected.

A number of companies are currently using foam fabric finishing as a commercial production process. Additionally the pilot range has been used to demonstrate foam fabric finishing to over twenty companies. The range has been used to demonstrate the foam acid dyeing of nylon carpets to several companies in this specialized area of textile processing. Active work still continues with these companies since the foam dyeing of carpets involves only about 1/5 the water used in the normal continuous dyeing of carpets. At the time of writing two carpet companies are actively working to evaluate foam dyeing on a mill scale. (NOTE: U. M. & M. does not commercially process carpets). Energy conservation is realized both from reduced steam consumption in steaming colors and less heat used for drying.

In the last eighteen months, we have established in actual commercial and pilot plant trials the following:

1. Substantial energy savings can be achieved by converting from regular to foam finishing. Additionally, in many instances, productivity can be increased by faster range speeds. It is also true in some cases that dryer efficiencies can be significantly improved with foam. This results from lower temperatures and higher speeds besides the obvious "less heat for less water to evaporate". These combined factors result in significant overall cost reduction.
2. In order to achieve maximum energy savings, the drying and curing steps should be separated. That is, the tenter frame should be used for drying only. When this practice is followed, it has been possible to both lower oven temperatures and double range speeds leading to as much as an 86% reduction in the energy consumption per unit of fabric dried.

Foam processing itself cannot lead to energy savings in the common thermal curing step since it involves dry fabric. If greater overall energy savings are to be achieved, new non-conventional energy efficient curing systems need to be coupled with foam processing. These could include low temperature curing systems, two package systems, "hot" catalysts, or more significantly, radiation curable systems. The demonstrated bench feasibility of hot catalysts for low temperature curing is being extended to the pilot plant.

3. Pile fabrics, such as carpets, flocked fabrics, woven velvets and sliver knits, have been successfully dyed in pilot trials on the UMRC range. These dyeings were achieved by knife application of foamed formulations onto one side, or "face", of the fabrics.

All of the foam dyeings described above can be considered ready for commercial practice. For flat goods, where equal shade is required for both sides, one side knife applications have led to front to back shading and occasionally to streakiness.

4. Foam printing has progressed much faster than originally programmed. Commercial scale trials with foam gravure type printing have shown reduction in both color and binder consumption. Foam printing, in some cases, will allow increased productivity by allowing higher speeds where drying capacity is fixed (i.e., steam cans). Three extended production printing trials have been completed. Two of the trials are discussed in the Foam Printing section on this report.

### BACKGROUND

In the period 1972 to October 1976, investigations at the United Merchants Research Center established that foam technology could be used to finish, dye and print a great variety of fabrics ranging from carpets and sliver knits to light weight goods such as 2 oz. per yard polyester/cotton sheeting. Foam finishing was used to apply softeners, durable press resins, water repellants and stain repellants to a variety of fabrics. Both natural and synthetic fibers and their blends were dyed with suitable dyestuffs. Disperse, acid, direct, cationic, reactive, sulfur, in fact, all known types of dyes and pigments were successfully adapted to foam application.

Fabrics were also printed with foams. Pigments, rapidogens and acid dyestuffs were among those coloring agents used to print fabrics with foams. The uniqueness of foam printing technology rests in the fact that auxiliary thickeners were not used to control the viscosity of the print paste. Instead the viscosity was controlled by the amount of air incorporated into the system. The side benefit of such a system is that no after-washing is required to remove the gums normally used in print pastes. Even where after-washing is needed to remove unfixed dyes as in the case of rapidogen and reactive dyes the absence of printing gums greatly facilitates the after-washing step.

The work done by UMRC during this period has resulted in the issuance of U. S. Patent No. 4,118,526 to U. M. & M.

## DISCUSSION

Data and discussion given covers contract work from October 1, 1977 to March 31, 1979.

### FORMULATION EVALUATION PROCEDURES

Overall foam evaluation begins in the laboratory using kitchen type planetary mixers to prepare the foams and knife coating of the foam onto test fabrics. Pilot plant trials, mill trials and commercial production follow sequentially with energy measurements being made in these three stages.

Initial formulation work consisted of taking a proven conventional formula for wet finishing, removing as much of the water of dilution as possible and then adding appropriate foaming agents and stabilizers. The solids multiplication governs the reduction of water - a "2X" solids type will be foam applied at one-half the normal wet pick-up. In a hypothetical mix containing 10% solids, 90% of the applied mix is water. When solids are doubled and wet pick-up is halved, only 40% of the applied mixture (foam) is water or a reduction of 55.6% of water applied. Other additives, such as foaming systems and stabilizers, will increase solids slightly and further reduce the water content.

The reformulated finish is initially checked for foamability and shelf stability. The latter is a critical test since the reactive ingredients are in a very concentrated form.

In a large number of cases, the foam finished fabric did not match the control especially with respect to esthetic properties such as handle, scroop, etc. The property alterations are due to the presence of foaming agents and foam stabilizers. The mixes were then modified so as to match the control.

Thus, it is evident that conventional finish systems can not be converted to foamable systems merely by removing water and adding a foaming agent.

Foam cell size is judged subjectively - fine, medium or coarse. This is quick and quite acceptable in textile technology - shade matching, hand evaluation and durable press ratings are considered precise and are routinely measured subjectively by trained personnel.

Foam consistency can be judged either subjectively or by measurement of its viscosity with a Stormer or Brookfield viscometer. The half life of a foamer is defined as the time required for half the foam volume to collapse. However, a more suitable measure of foam stability for this project is the determination of foam density and viscosity as a function of time. In the foam processing of fabrics, the foaming systems influence both foam characteristics (i.e., for effective coating) and fabric properties. Additionally, the foaming system will dictate the running conditions for the range foamer.

For example highly alkaline foaming systems can inhibit curing of the resin, while those containing certain nitrogen compounds can lead to fabric discoloration. The foaming systems also frequently alter the fabric handle.

A pilot study on the range Oakes foamer was run to establish those factors which influence the production of a satisfactory foam. A constant base formulation of glyoxal resin, melamine resin, catalyst and softener was made up with three different foaming systems. The first was a mixed anionic-nonionic of high alkalinity, the second was a nonionic of slight alkalinity (ring nitrogen) and the third was a neutral pH nonionic. None were applied to fabric since only foaming characteristics were determined.

The experimental conditions for foaming were:

- a.) A fixed rate of feed to the foamer - 0.85 lbs./min.
- b.) A fixed rotor speed in the foaming head - 750 rpm.
- c.) Line air pressure - 100 psig.
- d.) Air input - 0.2 and 0.3 cu. ft./min.
- e.) Delivery hose diameters - 0.25, 0.375, 0.5, 0.625 and 0.75 in.
- f.) Delivery hose length - fixed for all hoses at 50 feet.

The effect of varying conditions d and e on the quality of the foam was studied. In assessing the quality of a foam the following factors were considered:

- a.) Blow ratio - the ratio of the weight of the unfoamed liquid to the weight of an equal volume of foamed liquid.
- b.) Cell size.
- c.) Foam viscosity.
- d.) Blow-by - an undesirable condition in which the foam extruded from the foamer contains large air bubbles.
- e.) Back pressure - the pressure of the foam as it exits the foaming chamber.

The study lead to the following observations:-

1. Hose Diameter

Decreasing hose diameter leads to:

- a.) Increased back pressure
- b.) Higher foam viscosity at a given blow ratio
- c.) Finer cell size
- d.) Blow-by if decreased too far

2. Air Input

For a given hose diameter, increasing air input leads to:

- a.) Higher blow ratio
- b.) Increased back pressure
- c.) Minor improvement in foam stability

3. Back pressure should be kept between 20% and 70% of of the line air pressure in order to maintain stable foam formation.

4. For a given base finish and at equivalent back pressures during foaming, foam properties are independent of the foaming system used. However, fabric esthetics and physicals are strongly influenced by the type of foaming system used.

The one type of formulation evaluation not really available at a bench level is energy consumption which is an important factor. Previous reports have given energy data for production lots which ranged from runs of several thousand yards to over 50,000 yards. Obviously, the number and scope of experimental energy measurements in plants are limited to mainly those that do not disrupt or add to the cost of production. For this reason we have developed use of relatively short yardage runs on the range to determine energy consumption. Most textile dryers are individually designed and no two perform in the same manner. Therefore data from the UMRC range will be quite useful in setting optimum energy efficiencies in a plant dryer.

The techniques used are to precisely set up the critical parameters of wet pick-up, foam type, fabric type, application method, speed, oven temperature and oven air circulation pattern. The run is started and Polaroid pictures are taken of the gas meter at stop watch timed intervals. At the moment the run is stopped residual moisture, if any, is determined in the dried fabric.

From the data obtained simple arithmetic allows calculation of energy used per fabric unit-i.e., cubic feet of gas or B.T.U. per yard. Also, it is possible to calculate an efficiency figure for the dryer under the conditions used. As we use it we define oven efficiency as the theoretical energy required to evaporate the water on the fabric divided by actual energy used and expressed as per cent. Further discussion of and data for such measurements are included later in this report.

#### CHEMICAL FORMULATION - FABRIC FINISHING

As a starting point for the formulation of practical foamable finishes, an analysis of finish utilization at United Merchants' Clearwater Finishing Plant was made. In a printing and finishing plant such as Clearwater, literally hundreds of finish formulations are in their repetoiry.

Fifty-one foamable finishes suitable for about 35% of their 1977-78 fabric production were developed. If tinted versions of these finishes are included the figure is about 50% of total production.

The majority of finish components used are those manufactured by the Valchem division of U. M. & M.

For a typical foamable durable press finish the component breakdown is as follows:

Resin	6-10%
Softener	2-6
Hand Builder, Soluble	0-3
Hand Builder, Emulsion Polymer	0-10
Resin Catalyst	1-2
Foaming System	0.1 - 1.0

For foam finishes evaluated to date, the active materials have ranged from a high of 80% to a low of less than 10%. Some lower concentration mixes require thickeners or foam stabilizers for foam stability. Some typical agents of this type are cellulose ethers, alginates, polyethylene oxide polymers and ammonia activated acrylics.

The development of foamable finishes has followed two paths, a foamable fully compounded system to which only water is added at the mill location and mutually compatible foamable building blocks which the mill chemist or finisher can use to design his own systems. Some typical products are listed in Tables I and II.

TABLE I

FULLY COMPOUNDED SYSTEMS

1. Valfoam SF - a durable press, shrinkage control finish for polyester/cotton sheeting.
2. Valfoam CCF - a fabric stabilization finish for corduroys.
3. Valfoam P - a stabilization and hand building finish for light weight corduroys.
4. Valfoam 117 - a stabilization and softener finish for polyester/cotton flannels.

TABLE II

FOAMABLE BUILDING BLOCKS

1. Resins - Valrez FG-1, FG-2, 313-106, 291-143 and 313-74.
2. Softeners - Valsof FNS, FCS, PFC, FPE and 313-109.
3. Handbuilders - Valbond F-3, F-7, 313-107, PVF, 313-108 and 271-156.

An example of a special finish, a water repellent, soil release finish suitable for foam application to pile fabrics is shown in Table III.

TABLE III

WATER REPELLANT/SOIL RELEASE FINISH

	<u>%</u>
Scotchgard <sup>R</sup> FC-210	5.0
Valthic-70 (Acrylic acid copolymer latex)	3.0
Valmel-40 (An etherified methylol melamine)	2.0
Ammonium Chloride	0.05
Ammonium Hydroxide (28%)	0.5
Ammonium Stearate (33%)	3.0
Water	86.45

This finish was foamed to a 4:1 blow ratio and knife coated onto an acrylic/polyester sliver knit. The wet pick-up was 45%. The fabric after drying and curing met both water repellancy and soil release requirements.

A foamable napping softener for flannels was developed which could be applied at a 20-30% wet pick-up.

The plant trial results for many of these finishes will be discussed under "Fabric Processing".

It has been established that foam processing techniques can be utilized to actually eliminate intermediate drying steps by "Wet-On-Wet" application of foam.

Most fabrics are dyed in machines which deliver fabrics literally dripping wet. These are mechanically extracted, with padding or hydroextraction to a minimum water level. This is usually the same level as that to which a wet finished fabric is padded, i.e., 65-100% of fabric weight depending on fiber content. New high extraction pads are now available which reduce this level down to the 35-50% range.

In conventional finishing, these fabrics must be dried before they are finished by immersion in a finish bath, followed by padding, drying and curing.

Immersion of wet fabrics into a finish bath would lead to dilution of the bath by water on the fabric and often to bleeding of color into the bath.

In "Wet-On-Wet" finishing, a foamed finish can be applied to the fabric without an intermediate drying. Since the exact quantity of finish is applied directly to the fabric, there is no dilution of a finish bath. A very concentrated finish is foamed, applied to the wet fabric at low wet pick-up and the water already present helps to diffuse the finish after the foam is collapsed.

Carrying this wet-on-wet procedure one step further it is possible to foam dye, leave the fabric wet after steaming, foam finish and dry only once. This was demonstrated on the old UMRC range (at slow speed) by applying a foamed disperse/direct dye mixture onto a polyester/cotton blend, steaming, foaming on D.P. finish, drying and curing. Curing of the resin also thermosolled the disperse dye.

Three finishes have been evaluated in this foam wet-on-wet area. First, napping softener has been applied onto polyester/cotton blends for subsequent brushing or napping. Secondly, a non-polymeric dye fixative has been foam applied onto direct dyed wet cotton. Thirdly, D.P. finish was applied onto wet polyester/cotton. It was found that in this case less dry resin add-on was required to meet finished fabric specifications than would be required by conventional finishing.

Preliminary laboratory data had suggested that more effective utilization of finish occurred in foam finishing. This was the first plant trial that corroborates this. However, this needs to be confirmed in further trials.

The initial formulation approach of adding foaming systems to concentrated wet pad systems led to establishment of energy savings and validity of commercial foam finishing. However, many of the formulae were not optimized and required changes. Cost effectiveness improvement and correction of fabric property alterations have been accomplished in a number of instances:

- a.) A major portion of fabric finish types have been successfully formulated to increased solids foamable finishes.
- b.) Fabric physical and esthetic properties equivalent to those by conventional wet processes have been obtained via foam processing under mill production conditions.

#### FABRIC PROCESSING

The primary objective of the work under this contract is to demonstrate that foam processing is a commercially viable, energy conserving alternative to conventional wet processing.

When it became apparent that the pilot range would not be operational in the first six month's period, it was decided to run foam finishing trials on commercial ranges at U. M. & M.'s Clearwater and Old Fort Finishing Plants. These initial trials were sufficiently successful, that foam finishing was adopted as a commercial process by these plants on a limited number of styles.

The results from a number of finishing trials at both plants are summarized in the next thirteen tables. The foam trials were initially conducted by breaking into conventional finishing production runs (which served as controls) and applying the finish as a foam. The only dryer conditions varied were temperature and throughput. No attempts were made to optimize air flow or the degree of air recirculation.

The procedure for calculating per cent oven efficiency has been applied to energy data on foam finished production runs.

Previously these data were presented showing savings (percentage) of gas when the wet pad process was converted to a foam process. The savings varied from 26% (low) up to 86% (high) and reflect a savings in all cases for the effect of a lower water load on the dryer for the foam systems. However, when the oven efficiencies (energy for water evaporation divided by total energy input) are calculated, they ranged from a low of 6% to a high of 90%.

The operation of tenter frames is not simply use as a dryer but often other functions of finishing are present. Some typical examples, all requiring elevated temperatures, are curing of resins, heat setting of thermoplastic fibers and thermosoling of dyes. Some years ago a major textile school surveyed industrial tenter frame efficiencies and put 30% as a "good practice" overall mill figure.

In the design of tenter frames it is now customary to specify a minimum drying capacity. With continuous operation of burners delivering a specified number of B.T.U.'s per hour, the frame must evaporate a specified amount of water. Customarily, also, the conditions state a given fabric at a specific wet pad moisture pick-up and frame temperature. For some years U. M. & M.'s engineers require design drying capacity minimum that calculates in 40-45% oven efficiency range. The UMRC range calculates to about 52-53% even with its short length of 21 feet.

A study of dryer conditions to optimize energy savings utilizing foam is in progress on the UMRC range. Some data from the study's first stage will follow presentation of the plant finishing energy data.

Table IV compares the composition of a conventional durable press finish with its foamable counterpart. Table V summarizes the plant data where this finish was applied to a 3 oz./sq. yd. printed polyester/cotton fabric. In the first and second trial (Columns 1 and 2), the oven temperature was maintained at 350 F. solely to overcome a heat set put into the fabric during a high temperature curing of the printed pigments. In the next trial (Column 3), where the oven was only used for drying, it was possible to operate the oven at its lowest temperature and still increase range speed. The increase in energy savings achieved by lowering the temperature was quite dramatic. The oven efficiencies are directly related to the indicated operating conditions.

TABLE IV  
DURABLE PRESS FINISH

<u>Wet Process</u>	<u>Foam Process</u>	
Valbond-6061	Valbond F-74	
Valrez 99H	Valrez F-T4	
Valcat AH	Valcat F-A4	
Valsof G-2	Valsof FNS	
Valsof PE	Modified Starch	
Modified Starch		
Valwet P-35		
Wet-Pick-Up (on wt. of fabric)	60%	30%
Calculated Water Pick-Up	55.9%	26.5%

TABLE V  
DRYER DATA  
50/50 Polyester/Cotton  
(Wt. 3 oz./yd.<sup>2</sup>)

	<u>Conventional</u>	<u>Foam</u>	<u>Foam</u>
Finish Pick-Up on wt. of fabric	60%	30%	30%
Calculated Water Pick-Up	56%	26%	26%
Oven Temperature F.	350	350	225 (1)
Speed, yds./min.	92	98	115 (2)
% Speed Change		+6.5	+25
Nat. Gas Consumption (ft. <sup>3</sup> /yd.)	1.38	0.71	0.39
BTU/yd.	1428	734	403
Energy Savings		47.6%	73.6%
Oven Efficiency, %	10%	9%	16%

- (1) Minimum operating temp.  
(2) Maximum speed

The same finish (Table IV) was applied to a heavier (6.6 oz./yd.<sup>2</sup>) polyester/cotton fabric. Again, it was possible to reduce oven temperature and increase range speed and demonstrate significant energy savings. The data are summarized in Table VI, and show with "drying only" how oven efficiency, productivity capacity and energy savings are all significantly increased.

TABLE VI  
50/50 Polyester/Cotton  
(Wt. 6.6 oz./yd.<sup>2</sup>)

	<u>Conventional</u>	<u>Foam</u>
Finish-Pick-Up on Weight of fabric	60%	30%
Calculated Water Pick-Up	56%	26%
Oven Temperatures F.	350 F.	250 F.
Speed, yds./min.	57	110
% Speed Change	- -	+93%
Natural Gas Consumption (ft. <sup>3</sup> /yd.)	2.26	0.31
BTU/yd.	2339	326
Energy Savings	- -	86%
Oven Efficiency, %	12.7%	43%

The next three Tables (VII, VIII & IX) summarize the results of a number of trials in which a durable press, fabric stabilization finish was applied to polyester/cotton fabrics of various weights. The major conclusion drawn from this work is that while productivity (range speed) was significantly improved by switching to foam finishing, energy savings, while reasonable, were disappointing. Energy savings calculated on the basis of reduced water pick-up should be about 54%. In all three of the runs oven efficiencies actually drop in going from wet pad to foams. Energy savings are realized but are below the expected levels.

In explanation these runs were from the first significant yardages (350,000) of foam finishing run within U. M. & M. in 1977. At the time we did not realize the full value of simultaneously increasing speed and decreasing temperature in foam processing to get the highest energy savings. Frame temperatures were not dropped but speeds were roughly doubled. Actually, although energy was saved total oven efficiency dropped (Tables VII, VIII & IX) due to heat losses from the dryer. The mill was quite happy at that time since both gas was saved and labor and overhead cut (by doubling speed.) Similar finishing is now being run in the particular mill at lower dryer temperatures.

TABLE VII

50/50 Polyester/Cotton

(Wt. 4.0 oz./yd.<sup>2</sup>)

	Conventional	Foam
Finish-Pick-Up on Weight of fabric	60%	30%
Calculated Water Pick-Up	56	26
Oven Temperatures F.	320/350/360*	320/350/360
Speed, yds./min.	46	94.6
% Speed Change		+105%
Liquid Propane Consumption (ft. <sup>3</sup> /yd.)	.0018	.0011
BTU/yd.	1231	752
Energy Savings		39%
Oven Efficiency, %	14%	11%

\*Three zone dryer

Table X, compares the composition of a conventional top softener for cotton flannel and its foamable counterpart. Such a finish is dried only.

As is again demonstrated in Table XI, high energy savings are achieved when increased range speed is coupled with reduced oven temperatures.

Also, the oven efficiency of the foam system shows a high degree of optimization for both energy savings and productivity (top speed of machine).

TABLE VIII

50/50 Polyester/Cotton

(Wt. 7.5 oz./yd.<sup>2</sup>)

	<u>Conventional</u>	<u>Foam</u>
Finish-Pick-Up on Weight of fabric	60%	30%
Calculated water Pick-Up	56%	26%
Oven Temperatures F.	330/370/380	330/370/380
Speed, yds./min.	40	80.7
% Speed Change		+101%
Liquid Propane Consumption (ft. <sup>3</sup> /yd.)	.0021	.0013
BTU/yd.	1437	889
Energy Savings		38%
Oven Efficiency, %	23%	17%

TABLE IX

50/50 Polyester/Cotton

(Wt. 2.5 oz./yd.<sup>2</sup>)

	<u>Conventional</u>	<u>Foam</u>
Finish-Pick-Up on Weight of fabric	60%	30%
Calculated water Pick-Up	56	26
Oven Temperatures F.	320/340/340	320/340/340
Speed, yds./min.	51	89.5
% Speed Change		+75%
Liquid Propane Consumption (ft. <sup>3</sup> /yd.)	.0017	.0012
BTU/yd.	1163	821
Energy Savings		29%
Oven Efficiency, %	9%	6%

TABLE X

FLANNEL TOP SOFTENER FINISH

	<u>Wet Process</u>	<u>Foam Process</u>
	Valsof G-2	Valsof FNS-43
	Valwet RW	Valsyl F-40
	Syton DS	
Wet Pick-Up	68.4%	25%
Calculated Water Pick-Up	67.6%	24.4%

TABLE XI

DRYER DATA

COTTON FLANNEL

(Wt. 4.2 oz./yd.<sup>2</sup>)

	<u>Conventional</u>	<u>Foam</u>
Finish-Pick-Up on Weight of fabric	68.4%	25%
Calculated Water Pick-Up	67.6%	24.4%
Oven Temperatures F.	345/380	260/265
Speed, yds./min.	60	107
% Speed Change		78.3%
Natural Gas Consumption (ft. <sup>3</sup> /yd.)	0.409	0.089
BTU/yd.	423	92
Energy Savings		78.2%
Oven Efficiency, %	54%	90%

A foamable hand builder/fabric stabilization finish was formulated (Table XII) for application to 100% cotton print cloth. In this trial, the oven was used to both dry and cure the fabric.

TABLE XII

HAND BUILDER/FABRIC STABILIZATION FINISH

<u>Wet Process</u>	<u>Foam Process</u>
Glovez FN	Valrez UFF
Valcat AH	Valcta 4-AF
Valbond-54	Valbond VAF-4
Valsof-421	Valsof F-421
PVA	PVA

Again, the data of Table XIII clearly illustrates that the use of the same oven for drying and curing even with the foam system is energy wasteful.

In a drying operation, large volumes of air are heated to carry off the water and fumes. Once dried, however, only the fabric needs to be heated to effect cure and clearly to use the drying oven to effect cure will be an energy inefficient process.

The reduction in oven efficiency and rather modest energy savings for this finish plus no speed or temperature advantages sharply contrast with the "dry only" gains on the cotton flannel (Table XI).

Even as a separate curing operation, heating a fabric to 300 F. to 400 F. is wasteful of energy. There is a need to couple foam finishing with non-conventional methods of curing such as radiation curing which is a room temperature process.

TABLE XIII

100% COTTON  
(Wt. 2.7 oz./yd.<sup>2</sup>)

	<u>Conventional</u>	<u>Foam</u>
Wet Pick-Up on Weight of fabric	69.9%	30%
Calculated Water Pick-Up	68.5	28.7
Oven Temperature F.	350	350
Speed, yds./min.	121	118
Gas Consumption, (ft. <sup>3</sup> /yd.)	0.234	0.173
BTU/yd.	242	179
Energy Savings		26%
Oven Efficiency, %	61	35%

A detailed study of energy consumption as a function of wet pick-up, range speed and oven temperatures is underway on the UMRC pilot range. The first objective was to determine if short yardages runs correlate with production energy data. To do this with the technique described earlier we applied a foamable softener onto 3.2 oz./yd.<sup>2</sup> 50/50 polyester/cotton print cloth. Low level, non-reactive solids are deliberately used to avoid effects such as chemical crosslinking and finish migration in the dryer. Typical data from the early trials are shown in Table XIV.

TABLE XIV

PILOT TRIALS

<u>Wet Pick-Up</u>	<u>Type</u>	<u>Range Speed</u>	<u>Temp. F.</u>	<u>Ft.<sup>3</sup> of gas/yd.</u>	<u>Residual Moisture</u>
85%	Conventional	20 ypm.	350	0.420	dry*
81.4	Conventional	25	350	.442	7.6%
35	foam	59	350	.169	dry
32	foam	40	225	.081	dry
28	foam	59	225	.080	4.9%

\*Residual moisture less than 4%.

In the determination of dryer energy data to date on the UMRC range one exploratory run is quite thought provacative. The temperature was set at 175 F. (37 F. below the boiling point of water), the lowest controllable set point on the burners. At 28% wet pick-up and 20 yards/minute speed the fabric dried and the oven efficiency calculated at 100.4%. From a thermal standpoint this is not possible due to radiant and mechanical heat losses from the chain, the dryer walls, air exhaust and exiting fabric. Then it was realized the recycle air of 30,000 cfm. could be effecting some of the drying. If time permits, this area of mechanical (i.e. electrical drive) evaporation will be explored.

FOAM DYEING

The two principle processes in dyeing fabrics are beck dyeing and continuous dyeing. In beck dyeing, a small amount of dyestuff and auxilliary additives are dissolved or dispersed in large amounts of water and the dyestuff is exhausted onto fabrics. Thus, per pound of fabric, 40-50 pounds of water are consumed for the dyeing and scouring cycles in a beck. At least 98% of this water is waste water which must be processed before returning it to the stream.

In the Sancowad<sup>R</sup> process, there is considerable reduction in the amount of water used at least through the dye cycle.

In conventional continuous dyeing of fabrics, a small amount of dye is dissolved or dispersed in large amounts of water and is applied by impregnation and padding. Then the fabric is subjected to color fixation followed by a washing operation. Thus per pound of fabric, 20-25 pounds of water is consumed in continuous dyeing, of which only approximately 4% is evaporated and the remaining 96% of water adds to waste effluents.

In contrast, for continuous foam dyeing, water consumption can be less than one-half pound per pound of fabric in those cases where no after-washing is required. Virtually all of this water is removed by evaporation thereby largely eliminating waste effluents. Since the major portion of energy consumed in the dyeing of fabrics is associated with the heating and evaporation of water, then significant reduction in water usage leads to corresponding reduction in energy consumption.

Because continuous foam dyeing resembles continuous dyeing, it will be well to describe the two processes pointing out the similarities and differences.

In continuous dyeing, the dyes and auxilliary additives are dissolved or dispersed in large volume of water and the fabric is impregnated and padded. The wet pick-up of dye liquor on fabrics in continuous dyeing is of the order of 70-100% for woven and knits and up to 300-400% for high pile fabrics such as carpets. Then the fabric is subjected to color fixation either by steaming and drying or by drying and thermofixing depending on the dyestuffs.

The essential steps in continuous foam dyeing are summarized as follows:

- Prepare Foamable Composition
- Foaming the Composition
- Applying the Foam
- Collapsing Foam and Distributing Dyestuff
- Fixation of Dye

The wet pick-up of foam dye application ranges from 20-50%, the proper amount being dictated by the fabric construction, weight of fabric and the depth of shade desired. The various fibers and fabric constructions foam dyed and the corresponding dyestuffs are listed below.

<u>Fiber Type</u>	<u>Dye Types</u>	<u>Fabric Construction</u>
Polyester	a,b	Pile fabrics, flat goods, knits non-wovens
Nylon	c,d,a	Carpets, woven, non-woven, flocked
Cellulosics	e,f,g,h,j,b	Corduroy, flocked goods, flannels, wovens
Acrylic	i	Carpets, sliver knits, knits
Modacrylic	i,b	Sliver knits, non-woven blankets
Acetate	a	Wovens, knits
Qiana	a	Knits

a - Disperse; b - Pigments; c - Acids; d - Premetallized; e - Directs;  
f - Reactive; g - Sulfur; h - Vats; i - Cationic; j - Rapidogen (Azoics)

The following factors determine the depth of dye shade in foam dyeing.

- Dye Concentration in the foamable mixture
- Blow Ratio
- Amount of foam applied

The wet pick-up is determined by the blow ratio and amount of foam applied to the fabric. The foam density decreases as the blow ratio increases. Increase in blow ratio dilutes the dye concentration, the diluent being air. The viscosity of foam also increases as the blow ratio increases.

In dyeing fabrics by the foam method, the blow ratio is partially dictated by the weight and fabric construction. The range of blow ratios used for various fabric constructions are given in Table XV. In dyeing a very open construction, a higher blow ratio with its higher viscosity would be used. For heavier weight fabrics or those of tight construction, a lower blow ratio is used.

TABLE XV

FABRIC CONSTRUCTION VS. BLOW RATIO

<u>Fabric Construction</u>	<u>Blow Ratio Range</u>
Woven	6:1 -- 12:1
Knits	6:1 -- 12:1
Sliver Knits	4:1 -- 10:1
Carpets	4:1 -- 10:1
Flocked/Loop	6:1 -- 10:1
Upholstery	4:1 -- 8:1
Open Weave (Drapes)	8:1 -- 15:1
Non-Woven	4:1 -- 8:1

After the dye application, both foam and traditional continuous dyeing methods use the fixing conditions which are appropriate for the dyestuff in question. For example, disperse dyes are fixed on polyesters by thermofixation or by high temperature steaming.

With direct dyes, a continuous steam fixation procedure is used. The reactive dyes may be fixed by continuous steaming or thermosoling or by cold batching depending on dye and catalyst steam used. For cationic dyes on acrylics, continuous steaming is used for dye fixation.

Where the dyestuff has to be developed by a subsequent chemical treatment, we have found that the dye developing agent can also be applied by the foam process. For example, cotton corduroys can be first impregnated with formulated reduced sulfur dye and then after steaming, oxidized with foamed hydrogen peroxide without an intervening drying step. Azoics which have been applied to fabrics as a foam have been developed with acetic or formic acid also in foamed form, thus eliminating the need of an acid ager. As has been stated before, in most dyeings, light to medium shades do not require an afterwash. However, on occasions, a foamed detergent after-clearing operation has been found to be beneficial.

To date, in the majority of our dyeing work, the foamed composition has been knife coated onto the fabric. The fabric is then passed over a vacuum slot which partially collapses the foam. Following vacuuming, the fabric is passed through a pair of pad rolls which completely collapses the foam bubbles and distributes the dye liquor uniformly across the face of the fabric. The knife coating method works particularly well with pile fabrics such as carpets, sliver knits, corduroy, and flocked goods. However, with knits, wovens, non-wovens, and particularly in the heavier weights, the back of the fabric is dyed lighter than the front.

In an effort to overcome this back to front shading problem, we have attempted to apply the foam to both sides of the fabric on a modified commercial horizontal padder which will be described later. Unfortunately, most of dyeing work on horizontal padder has resulted in non-uniform application of the dyestuffs. We believe that the primary problem here is in the method of distributing the foam onto the padder.

Furthermore, there is an indication that density of the foam confined to the nip rolls of the padder changes with time. Work is continuing on overcoming the above cited problems. In addition, alternate ways of applying the foam to both faces of the fabric are being explored.

## ENERGY CONSERVATION

Up to now, only short yardage work has been done on dyeing carpets and other fabrics on the new pilot range. As a consequence, no effective data on energy consumption has been compiled. Work has been started on obtaining such information. In the meanwhile, some theoretical estimates on energy savings obtained by foam dyeing are discussed below.

Let us first consider fabrics which must be dried and then subjected to curing or thermofixation. Where the wet pick-ups, are less than one-half of conventional wet pick-ups, energy savings in drying is greater than 50% by adapting the foam process. Thus for foam dyeing of polyester fabrics with disperse dyes, and for pigment dyeing where fabric is first dried and then subjected to curing; energy savings are realized.

Now let us consider fabrics which have to be wet steamed for color fixation. The energy required to heat up wet nylon carpet in the steamer from 70 to 212 F. for acid dye fixation by conventional and foam methods are compared in Table XVI. At 300% wet pick-up by conventional dyeing, the energy requirements in steaming are  $7\frac{1}{2}$  times higher than in foam dyeing at 40% wet pick-up. For other types of fabrics such as woven, knit, flock or upholstery fabric where the wet pick-ups are less than one-half of conventional, the energy required for wet steaming in the steamer would also be less than 50% of the conventionally dyed substrates.

TABLE XVI

NYLON CARPET: STEAM

FIXATION - ENERGY COMPARISON

CONVENTIONAL VS. FOAM

<u>Description</u>	<u>Conventional</u>	<u>Foam</u>
Nylon Carpet Weight	25 oz./sq. yd.	25 oz./sq. yd.
% Wet Pick-Up O.W.G.	300%	40%
Energy required to heat up from 70 - 212 F. for color fixation*	667.5 BTU/sq. yd.	89 BTU/sq. yd.

\*For the conventional dyeing the energy required for color fixation is 7½ times higher than foam dyeing.

The energy requirements in drying conventional and foam dyed carpets are compared in Table XVII. The relative energy requirements calculated are lower than actual values because drying ovens are only 30-35% efficient. Absolute energy savings in foam dyeing will be higher than calculated values.

TABLE XVII  
ENERGY REQUIRED IN DRYING

FOAM VS. CONVENTIONAL

<u>Description</u>	<u>Conventional</u>	<u>Foam</u>
Nylon Carpet Weight	25 oz./sq. yd.	25 oz./sq. yd.
% Wet Pick-Up O.W.G.	80%*	42%**
Energy required to raise carpet temperature from 70 - 212 F.	190 BTU/sq. yd.	- - - - -
Energy required to raise temperature from 180-212 F.***	- - - - -	20 BTU/sq. yd.
Energy for evaporation of water	1216 BTU/sq. yd.	638 BTU/sq. yd.
Total Energy in Drying	1406 BTU/sq. yd.	658 BTU/sq. yd.

\*After washing and vacuum extraction

\*\*In foam after steaming including 2% gain

\*\*\*Temperature drop as carpet passes from steamer to dryer

Because the dictating factor in the thorough-put of most continuous dyeing ranges is the drying capacity of ovens, adoption of the foam dyeing process with its low wet pick-ups can lead to significant increases in productivity.

With our new pilot plant range we will be able to actually measure and compare the energy consumption in the dyeing of carpets by both foam dyeing and by the conventional dyeing process.

The mechanism of foam dyeing is postulated as follows: Foam as applied to pile fabric resides on the surface of the pile. When the foam collapses, its viscosity drops precipitously and the now very fluid dye liquor flows down the fibers resulting in uniform dye application from face to back. However, because of the small amount of dye liquor present, there is only sufficient liquor to sheath the fibers and no liquid for bridging fibers or for draining through the backing.

The selection of foaming aids and stabilizers for foam dyeing is very critical. In fabric dyeing the foam must be sufficiently stable to permit knife coating application or during horizontal pad application without premature collapse; but susceptible to collapse subsequent to application to fabrics. The additives should have no adverse effect on crocking, light fastness, soiling and flammability, since in most cases, there is no back-washing of foam dyed fabrics.

Typical formulations for the foam dyeing of fabrics are given below:

1. Nylon Carpets - Acid Dyes

<u>Foamable Formulation</u>	<u>Shades</u>		
	<u>Light</u>	<u>Medium</u>	<u>Dark</u>
Acid Dyestuff (a)	1%	3%	6%
Foam Concentrate (b)	3%	3%	3%
Water	96%	94%	91%
pH (adjusted with acetic acid)	5.5	5.5	5.5
Blow Ratio	10:1	8:1	6:1
Wet Pick-Up	30%	40%	50%

a.) Acid dyestuffs evaluated include Acid Blue 25, Acid Blue 40, Acid Red 226, Acid Red 337, Acid Yellow 198, Acid Orange 152, Acid Red 278, Acid Blue 277, and Acid Black 172.

b.) Foam concentrate is compounded from Valdet CC and small amount of cellulosic thickener.

2. Polyester Carpets - Disperse Dyes

<u>Foamable Formulation</u>	<u>Shades</u>		
	<u>Light</u>	<u>Medium</u>	<u>Dark</u>
Disperse Dyestuff (a)	1%	2%	4%
Foam Concentrate (b)	7%	7%	7%
Carrier	2%	3%	4%
Water	90%	89%	87%
pH Adjusted to	8.0	8.0	8.0
Blow Ratio	10:1	8:1	6:1
Wet Pick-Up	30%	40%	50%

a.) Disperse dyestuffs evaluated included Disperse Blue 56, Disperse Red 60, Disperse Blue 81, Disperse Yellow 93, Disperse Orange 66, Disperse Brown 1 and Disperse Yellow 56.

b.) Foam concentrate is compounded from synthetic thickener and anionic surfactants.

3. Cotton Corduroy - Sulfur Dyes

<u>Foamable Formulations</u>	<u>Shades</u>		
	<u>Light</u>	<u>Medium</u>	<u>Dark</u>
Reduced Sulfur dye liquid (Sodyesul liquid Blue 4GBCF)	3%	6%	10%
Reducing Agent (a) (Sodyefide B)	3%	6%	10%
Foam Concentrate (b)	7%	7%	7%
Water	87%	81%	73%
pH	12	12	12
Blow Ratio	6:1	4:1	4:1
Wet Pick-Up	30%	40%	40%

Steam -- Atmospheric Steaming

Oxidation -- Apply foam hydrogen peroxide

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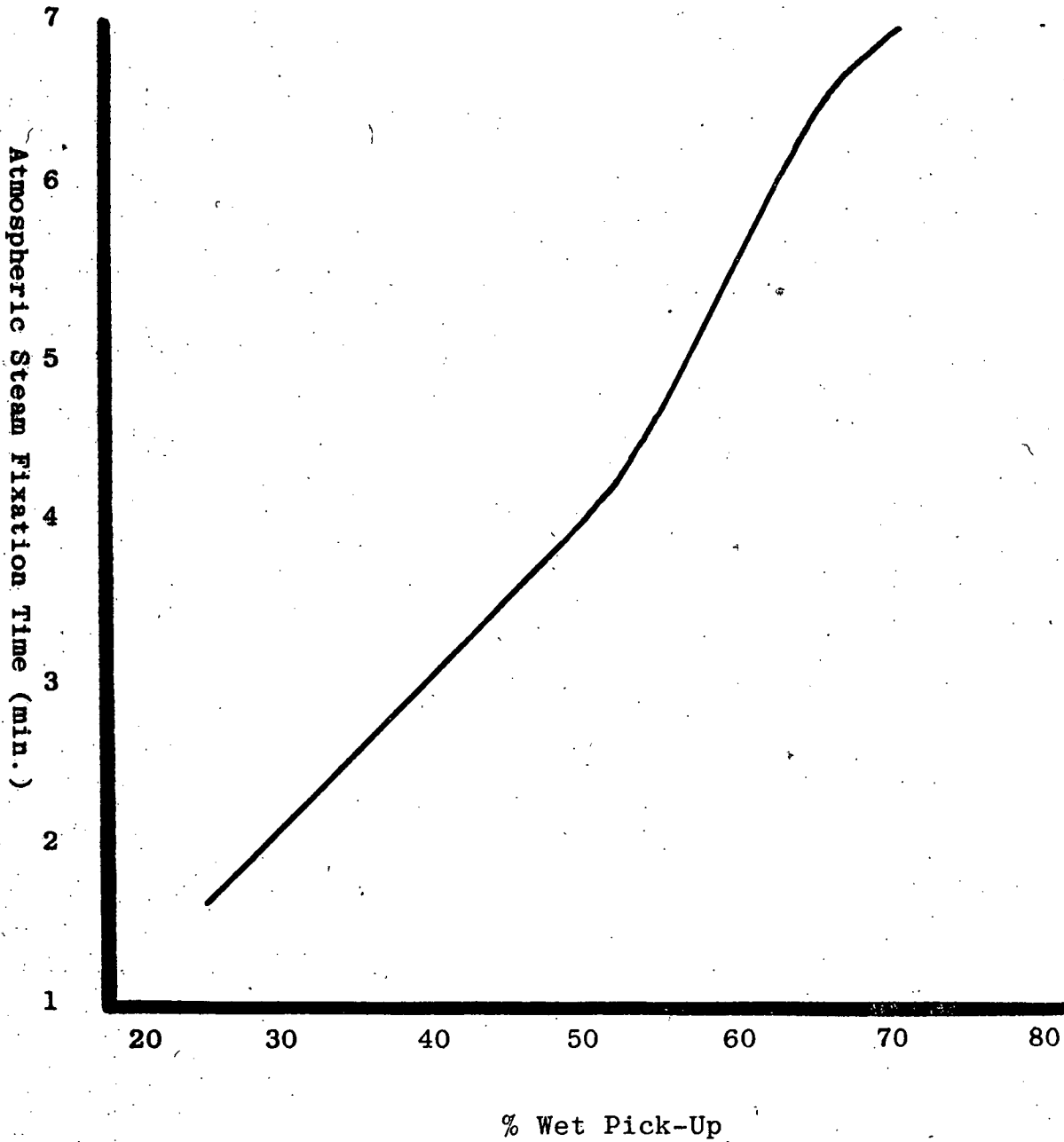
\*Good color fastness was obtained for light and medium blue shades without after-washing.

a.) Liquid sodium sulfide reducing agent from SODYE CO.

b.) Foam concentrate is compounded from synthetic thickener and an anionic surfactant.

Figure I shows the fixation time for acid dyes on nylon carpet as a function of wet pick-up. It is postulated that the shorter fixation time is a result of foam dyed carpets reaching the fixation temperature in a much shorter time.

Figure I



For the last six months our research in foam dyeing has been concentrated in evaluating application techniques in order to produce commercially acceptable dyeings.

In the dyeing of substrates that require color application to only one side, such as carpets, it has been verified that the best method of color application is to apply the foamed color with a knife-over-roll applicator, induce color penetration into the carpet pile with vacuum extraction, and collapse the foam with pad extraction. This is followed by color fixation and drying. On most shades no after wash is required to get satisfactory wash and crockfastness.

On short pile fabrics such as nylon flock fabric the same dyeing, fixation and drying procedure as described for nylon carpets (above) gives good results. Since the pile on nylon flock fabric is much shorter than that on nylon carpet, vacuum extraction prior to pad extraction is not necessary.

The dyeing of flat woven fabrics requires even dyeing on the face and back of the fabric as well as side-to-side. We still do not have a completely adequate method of applying foamed color to flat woven fabrics to produce commercially acceptable dyed fabric.

In one series of dyeing trials the floating knife, knife-over-roll and vertical pad were evaluated for dyeing flat woven fabrics. In all trials the same foamed pigment dye formula was used. The results are given below:

Floating Knife - Even color application to the face of the fabric was obtained, but color penetration was poor. Pick-up is generally lower by this method and generally results in a "one-side" dyeing.

Knife-Over-Roll - Even color application to the face of the fabric was obtained. Foam color application was increased over that obtained by the floating knife method by adjusting the height of the knife over the roll. After the foam color was applied the fabric was run through the vertical pad to collapse the foam and increase penetration (essentially the same procedure as used in dyeing pile fabrics). This method was judged best, but still not commercially acceptable because of some face to back shading.

Vertical Pad - Two separate trials were run on the vertical pad in an effort to get even color application. On one trial foamed color was fed to the color through at the nip of the pad rolls. Color application was uneven, and the fabric showed color streaks and a face to back shading. On the second trial the color pan was filled with foamed color, and the fabric was passed through the color pan into the pad rolls. On this trial the pick-up was extremely high, around 70%. Even with high pick-up the evenness of application was poor.

During our experimental foam dyeing trials we have learned that the use of a second "doctor" knife, adjustable for angle and height, greatly improves evenness of foam application for both dyeing and finishing foam systems.

Studies are continuing on improved delivery of foam systems to the foam applicators.

The application of foam dyeing systems by horizontal pad is beginning. This should greatly improve the face-to-back shading conditions we have seen in knife applications of foam dye systems as foam can be applied to both sides of the fabric simultaneously.

Two carpet manufacturers are actively investigating our foam dyeing systems for carpet dyeing. We will have more to report on this in our next interim report.

## FABRIC PROCESSING - FOAM PRINTING

Foam printing has progressed at a more rapid pace than projected in the proposed timetable. Formula optimization work has yielded print foam systems which, in pilot trials, have been successfully printed by both intaglio and screen printing techniques on production equipment.

The desired stability of a foaming system for textile processing is dictated by the function of the system. For foam finishing and dyeing, the foamed system need only have a stability (half life) on the order of minutes. In both cases the foam is consumed as rapidly as it is formed.

On the other hand, foamed printing systems in the context of textile printing operations must have a minimum useable life of 8 to 10 hours. The criteria of useability is that the printing system after being foamed shows no significant change in blow ratio or viscosity for the desired period of time.

Typical viscosity stability curves for acceptable and unacceptable foamed printing systems are illustrated in Figure II. Whereas the blow ratios of both foams were unchanged over the six hour period, in the control there was a coalescing of the bubbles from an initial size of 50 to 100 microns in diameter to about 400 microns. The viscosity of a foam is inversely proportional to its cell size.

In order to maintain good print definition and uniform cover, a 50 to 100 micron cell size is needed. Printing with a 400 micron foam leads to a motely appearance.

The foamed print systems must be stable to transfer from reservoir to the applicator by positive displacement pumps.

One problem encountered in rotary screen printing with foams was the appearance of streaks in the printed area of the fabric. These streaks were in the machine direction and were due to premature collapse of the foam inside the rotating screen. The foam is subjected to different mechanical action in the stenciled and unstenciled areas of the screen. This has been corrected by mechanical devices inside the rotating screen.

Foam print trials were successfully run with the same foam on cotton terrycloth by both screen and gravure printing techniques. The foam was specially tailored for softness of hand and maximum penetration down the fabric surface loops.

The print system used, after foaming, had a blow ratio of 1.6 to 1 and a viscosity of 1800 centipoises (Brookfield #6 spindle at 20 rpm.). The foam had a useful life of about 24 hours. The print was a single color pattern with about 40% cover.

Gravure printing was run on a roll of ".0075 - .0080" engraving depth of speeds from 10-50 yards/minute. Drying was on steam cans @ 250 F. The resulting hand was quite soft, color penetration was excellent and no streaks were observed.

The same foam was run on a 40 mesh rotary screen at 20 yards/minutes. Print quality and softness of hand were excellent. Penetration was quite acceptable but not as good as in gravure printing.

In addition to pigment printing, foam printing with acid, disperse and rapidogen colors has also been successfully carried out in pilot trials.

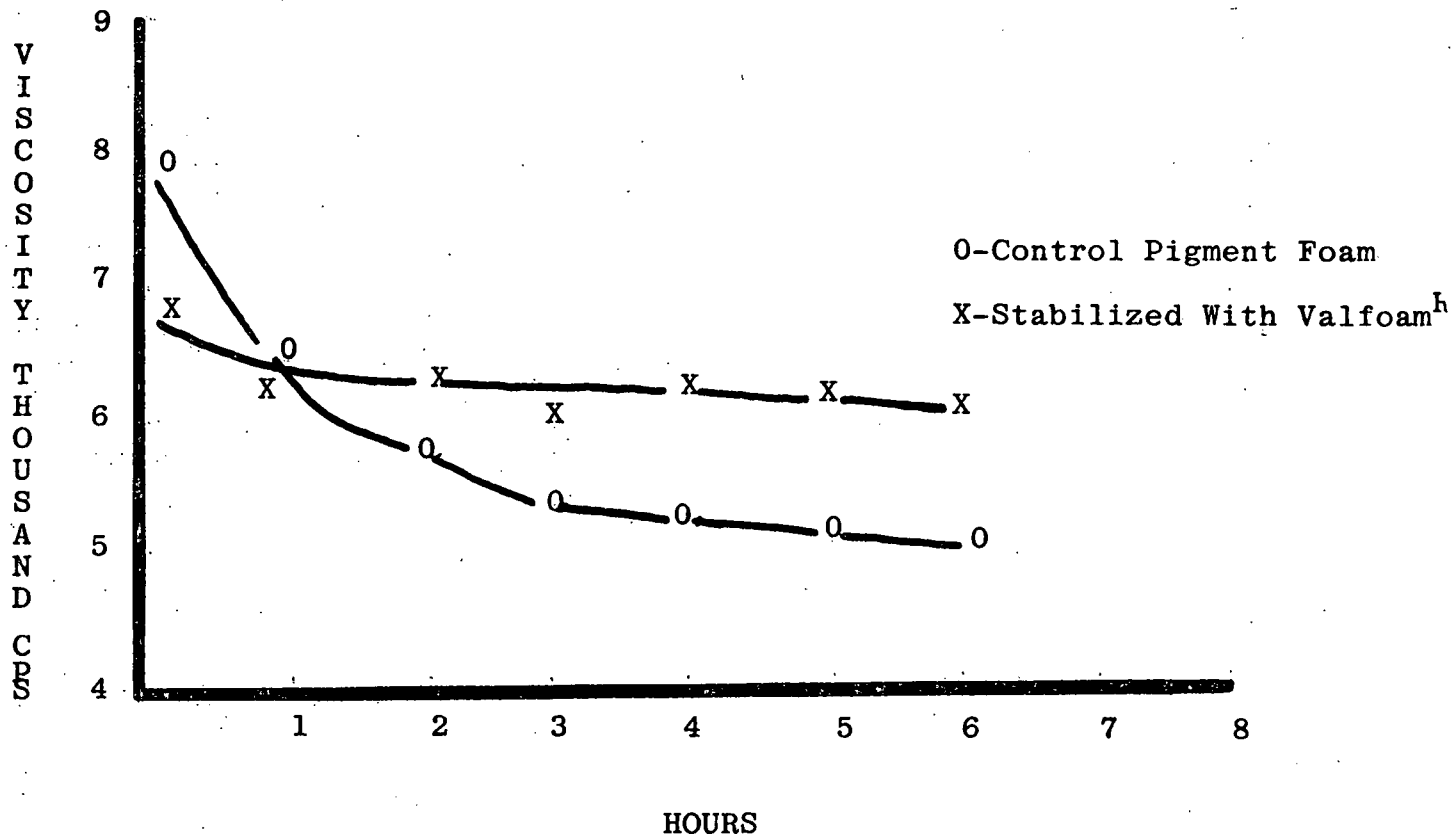
Energy measurements have not been made yet but are planned. A rotary screen is to be introduced into the pilot range for studies.

Further formulation optimization of foamable printing systems, both pigment and wet color systems, will be conducted in the next six month period.

Figure II

SHELF STABILITY

Pigment Foams



Three extended roller printing trials have been completed. Two of them are discussed below:

Trial #1 - Three thousand yards of cotton flannel were printed with a four color pattern-three peg colors and a blotch color. All four colors were printed with foamed pigment colors.

Approximately 90% of this print trial was graded printing seconds. The primary reason for the seconds was that we were unable to dip the blotch color fast enough to print without missing color. The secondary reason for printing seconds was that a very low consumption, outline color eventually dried out and would not pick-up on the furnisher brushes.

Fastness properties and physical properties of the foam printed fabric was equal to or better than that printed with regular pigment colors.

A savings in color cost of 15-20% was shown for foamed pigment colors.

To insure complete drying of cotton flannel printed with regular pigment color, print machine speeds are reduced to about 35 ypm. With the foamed pigments we were able to print in excess of 60 ypm. with complete drying.

Trial #2 - Thirteen thousand yards of cotton flannel were printed with a three color pattern-two peg colors and a blotch color. For this trial only the blotch color was printed with foamed pigment color. The blotch color was fed to the print machine by pumping, and no problem was encountered with missing color during printing.

Inspection of this 13,000 yard print trial has been completed. Approximately 600 yards of seconds were directly attributable to the foam printed blotch. In regular production printing, print seconds are 2-4%.

Fastness properties and physical properties of this foam printed fabric was equal to or better than that printed with regular pigment colors.

Again, a savings in color cost of 15-20% was shown for foamed pigment colors.

We were unable to verify increased printing speeds on this trial because the printing was done on the UMRC print machine which has a maximum speed of 40 ypm.

A third 13,500 yard printing trial which used foamed pigment color for the blotch has been completed without difficulty. We are awaiting Clearwater's inspection report on this trial.

These and other printing trials have shown that the stability of foamed pigment colors is better than anticipated. In one instance we have used color that was foamed eight days prior to printing.

GENERAL

Given below is a listing of papers presented by U. M. & M. personnel, papers published and patents issued to United Merchants and Manufacturers on Textile Foam Processing:

Papers Presented On Textile Foam Processing

I. By: Mr. C. G. Namboodri

A. Experimental Foam Printing System Development

1. AATCC Printing Symposium, New York City 1/11-1/13/78
2. Printing Symposium, Clemson University 4/4-46/78

B. Continuous Foam Dyeing Of Carpets

Carpet Technology Symposium, Clemson University 2/14-2/15/78

C. Foam Dyeing

Chemistry Of Dyeing Seminar, Clemson University 5/30-6/1/78

D. Foam Finishing Cotton Textiles

Natural Fiber Textile Conference, Atlanta, 9/26-9/28/78

E. Foam Dyeing Of Carpets

Carpet Technology Symposium, Clemson University  
2/79.

II. By: Dr. R. S. Gregorian

A. The Use Of Foams In The Wet Processing Of Textiles

Energy Workshop, N. C. State University 1/24-1/25/78

B. The Utilization Of Foams In The Wet Processing Of Textiles

American Chemical Society, National Meeting, Miami  
9/11-9/14/78

C. The Utilization Of Foams In The Wet Processing Of Textiles

DOE International Conference On Energy Conservation  
And Solar Energy, Milan, Italy 3/27/79

III. By: Dr. R. A. Bafford

A. The Use Of Foams In The Wet Processing Of Textiles

D.O.E./Georgia Tech/Clemson Energy Symposium, Atlanta,  
2/14-2/15/78

B. Foam Processing Route To Energy Conservation In The  
Textile Industry

AATCC Meeting, Florida State University 2/22/79

C. Utilization Of Foam In Wet-Processing Of Textiles

Graduate Seminar, Florida State University 2/23/79

IV. By: Mr. R. Lyons

A. Foam Processing Of Textiles

AATCC Regional Meeting (Rhode Island) Seckonk, Mass.  
2/28/78

B. Processing Of Textiles With Foam Systems

ATMI-Engineering Sub-Committee On Energy-Hilton Head, S. C.

C. Foam Processing Of Textiles

Seminar on "Innovations In Textile Processing", North  
Carolina State University 8/10-8/11/78

D. Processing Textiles With Foam Systems

Palmetto/Piedmont AATCC Sections, Rock Hill, S. C.  
10/14/78

Publications On Foam Processing

I. Air In, H<sub>2</sub>O Out In Wet Processing - R. S. Gregorian and  
C. G. Namboodri, Textile Industries, pp. 61-65,  
October, 1977

II. Continuous Foam Dyeing Of Carpets - C. G. Namboodri  
and R. S. Gregorian, American Dyestuff Reporter,  
67, pp. 27-34 (1978)

III. An Experimental Foam Printing System - C. G. Namboodri,  
J. Johnson and R. S. Gregorian, Textile Chemist &  
Colorist, 10, pp. 213/19 - 214/20 (1978)

IV. Processing Textiles With Foam Systems - Thomas W. Carter,  
American Dyestuff Reporter, 67, #12, 48-57 (1978)

V. Foam Finishing Of Cotton-Containing Textiles - C. G.  
Namboodri and Marshall W. Duke, Textile Research  
Journal, 49, 156-162 (1979)

Patents On Foam Processing

I. U. S. Patent 4,118,526 Method Of Treating Fabrics,  
R. S. Gregorian & C. G. Namboodri 10/3/78

APPENDIX

UP-GRADED PILOT DYEING AND FINISHING RANGE

The up-graded range is capable of running a wide variety of foam and conventional processes. Figure III schematically shows the layout of present components. Some components are fixed and others variable as outlined in Appendices 1, 1A and 2. Some can be optional depending on the particular process under study.

To illustrate the range's versatility the following operations can be performed:

1. Finish or Dye Application

- a.) Knife Over Roll - This is a knife applicator with a supporting bottom roll. In processing substrate travels between knife and bottom roll. Chemical application is to one side of substrate.
- b.) Floating Knife (one or two) - This is a knife applicator with height adjustments (for tension control only). Substrate travels unsupported under the knife. Chemical application is to one side of substrate.
- c.) Horizontal Pad - Except for some tubular knit finishing, horizontal pads are not normally used in textile pad finishing or pad dyeing applications. This type pad can be used for foam application and foam collapsing.
- d.) Vertical Pad - This type pad is normally used in textile wet processing. It can be used to collapse foam previously applied to substrate.

2. Extraction

Vacuum Slot - This type extraction is not normally used in textile pad finishing or pad dyeing applications. It can be used to increase penetration of foam applied to one side of substrate (as with knife over roll application).

3. Steamer

Some dyes (acid dyes, for instance) require steaming for dye fixation. UMRC's steamer will be used primarily in dyeing trials in our pilot range.

4. Drying (Tenter Frame)

Tenter frame drying is normal to fabric finishing methods. Fabric is held to finish width while being transported through the dyeing zone(s).

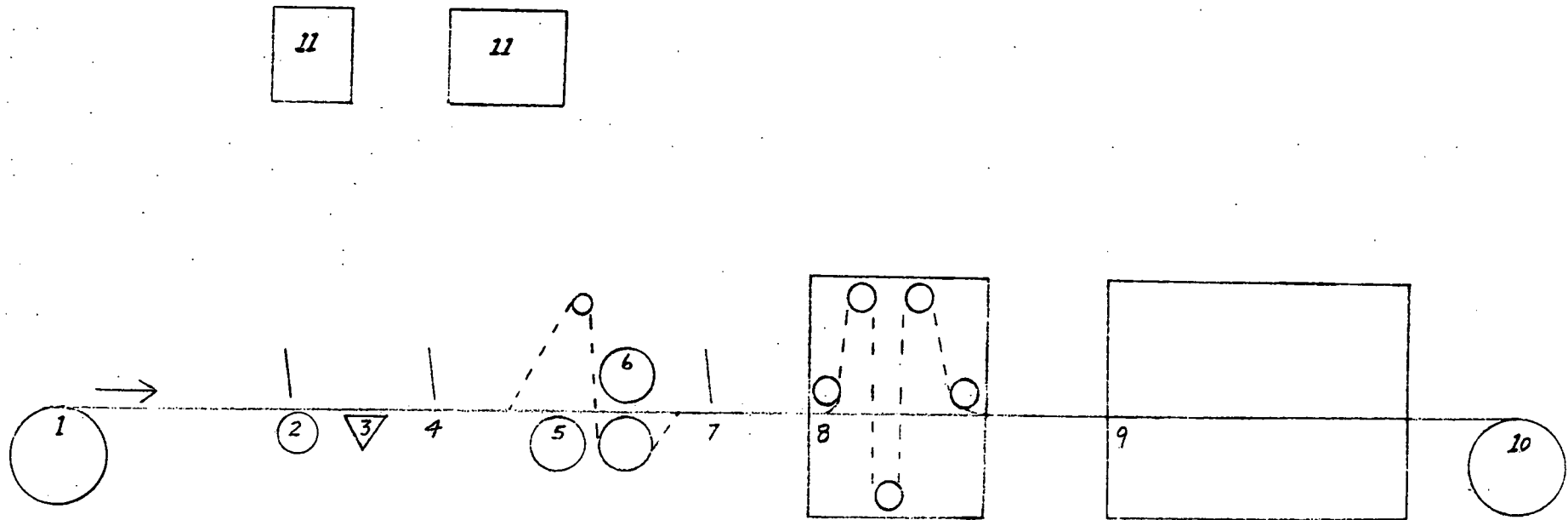
### 5. Foamers (Two)

We have two foam generating units for use with the Pilot Plant Range. With two foamers we can apply foam to two different applicators (floating knives, for instance) at the same time.

The main function of the up-graded range is to demonstrate the commercial feasibility of foam dyeing and finishing processes and demonstrate that energy savings are feasible with these processes.

As outlined, the range was designed to fulfill this function by being versatile and subject to easy modification. A major need will be the development of foam application systems to uniformly apply color. Some work will go into foam delivery devices to supply the applicators.

The use of the range for demonstration purposes is most helpful in developing trade acceptance of the foam processes. Outside company representatives have observed both flat goods and carpet processing under several range conditions. In addition, other representatives have observed at U. M. & M.'s Clearwater and Old Fort Finishing Plants foam finishing applications. However, these applications have been restricted to use of horizontal pads. Since completion of the up-graded UMRC range, we have been able to demonstrate other foam applications such as knife over roll and floating knife.



1. Fabric Let Off
2. Knife-Over-roll Coater
3. Vacuum Slot (can be re-located)
4. Floating Knife
5. Horizontal Pad
6. Vertical Pad
7. Floating Knife (can be re-located)
8. Steamer
9. Tenter Dryer
10. Fabric take-up
11. Foamers (2)

FIGURE III

APPENDIX 1

FIXED COMPONENTS OF UMRC RANGE

Fabric Feed

Roll let-off, scray, fabric straightners and tension devices.

1

(See Appendix 1-A)  
(See Appendix II)

Vertical Pad

Five ton, bottom roll metal, top roll fiber.

2

(See Appendix II)

Steamer

Twenty-three yards capacity, variable and metered steam supply. Can be by-passed.

3

(See Appendix 1-A)  
(See Appendix II)

Tenter Frame

Twenty foot, two zone-Room temperature to 400 F. (204 C.). Pins and clips on chain variable internal air flow and exhaust.

Incinerator burners. Fractional up to 60 yards/minute.

Fabric Take-Up

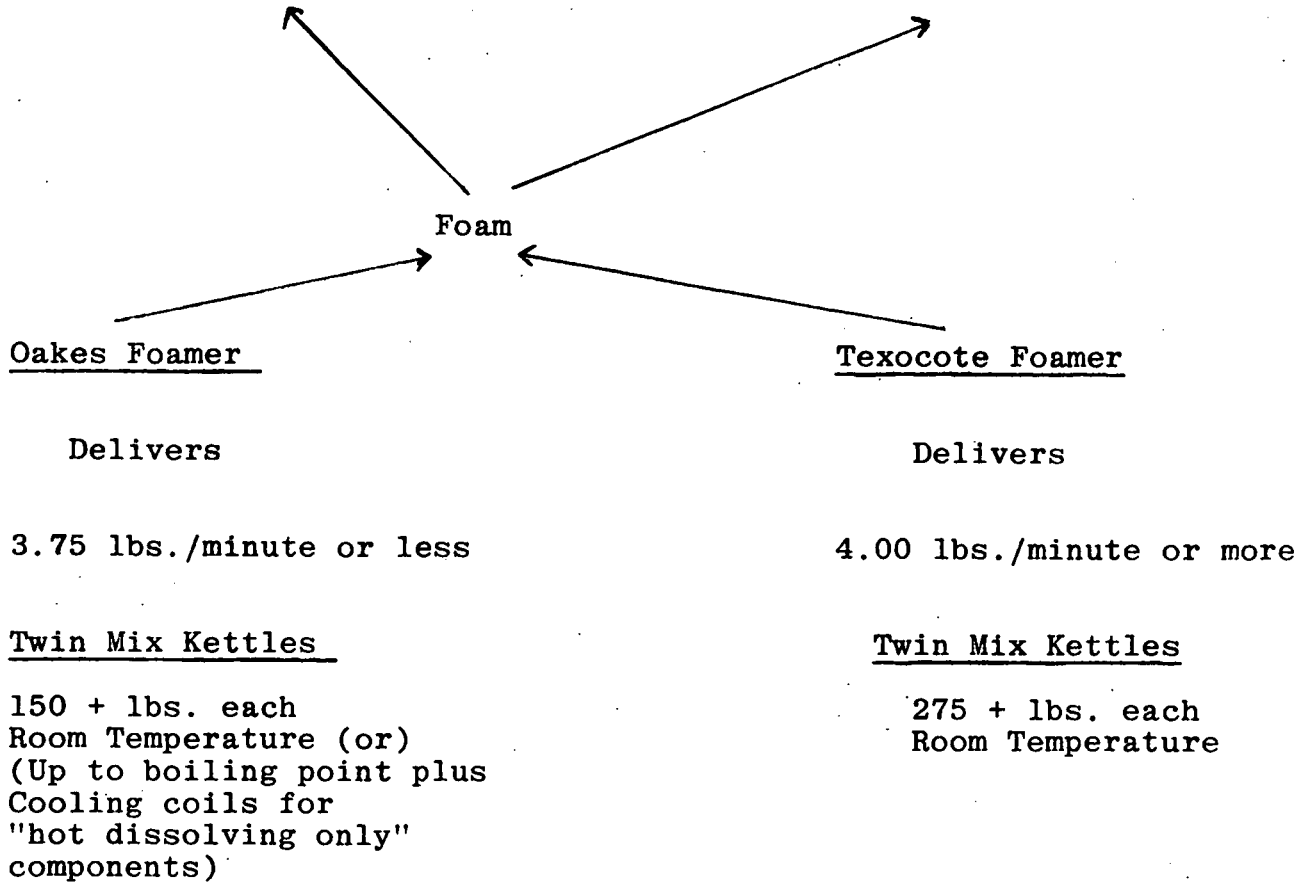
"Pre-set", but variable, tension-Any speed.

APPENDIX 1-A

FOAM MAKE-UP SYSTEMS

1. (Delivery to either point)

3. (Figure III)



APPENDIX 2

PROJECTED VARIABLE COMPONENTS OF UMRC RANGE

1. Foam Applicators - Knife over roll and vertical pad. Various foam delivery devices - slotted tube, fixed pipes, oscillating pipe, sprays, etc.

Vacuum Slot - Optional dependent on fabric construction.

2. Wet Fabric Take-Up - For cold batching processes.

Fabric Invertor - Device for reversing (face side up) fabric - i.e., knife coat at I, reverse, knife coat back side at III.

3. Knife Coater - Floating knife type. Movable to position I.