MASTER

ASPHALT SATURATION OF ROOFING FELT ON THE FELT MACHINE PHASE I

PROGRESS REPORT FOR THE PERIOD

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ABSTRACT

The asphalt roofing industry manufactures approximately 10 million tons of product annually. This requires an estimated 40 trillion BTU's in process heat and 4 million tons of asphalt having a fuel value of 140 trillion BTU's. Energy savings in a number of areas appear possible.

As an initial investigation, pilot equipment was installed on a commercial felt machine to determine whether saturation on the felt machine was feasible and whether energy savings would result.

Work to date has demonstrated a process by which adequate saturation levels can be achieved. Energy savings are estimated at 3.7 trillion BTU's per year on an industry-wide basis.

Further investigation requires evaluation of finished product and demonstration of the process on a commercial basis.

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SUMMARY

The objective of this investigation is to reduce energy consumption in the manufacture of asphalt roofing products. This progress report describes accomplishments from the start of the program in October 1978 through December 1979.

The specific hypothesis being investigated is that the asphalt saturation process which normally takes place at a roofing mill, where finished products are produced, can be better performed at the paper mill, where an intermediate, the roofing felt, is manufactured.

Paper mill saturation is expected to reduce energy consumption by utilizing the BTU's in the hot saturant to assist in moisture removal during felt manufacture. In addition, the roofing plant saturation utilizes large volumes of recirculating asphalt, which results in energy losses and the generation of pollutants. It is expected that paper mill saturation will improve on these energy and pollution aspects. Theoretical energy savings for felt mill saturation are estimated at 3.7 trillion BTU per year on an industry-wide basis.

Pilot equipment consisting of asphalt supply at 450°F, an asphalt recirculating loop, and 5 manifolds for application of asphalt, was designed and installed on a 12 ft. wide felt machine at Gloucester, N.J. The 5 manifolds applied asphalt to a 12" wide section of the felt at 5 locations located in the last quarter of the drum dryer section of the felt machine.

Seven trial runs have been made with this equipment on both 55 lb. shingle felt and 27 lb. built-up roofing felt. Test run objectives have been to produce felt with the required percentage of asphalt saturation. This has been accomplished by applying an apparent excess amount of asphalt, judging by the presence of unabsorbed asphalt on the surface of

the felt at wind-up. This unabsorbed asphalt soaks into the sheet during the 10-60 minute interval between reel wind-up and subsequent rewinding and slitting.

The basic objective of reaching specified saturant levels, uniformly distributed throughout the felt thickness, has been achieved and provides a basis for proceeding with additional steps in this program. These include manufacture and evaluation of finished products using the felt machine saturated felt, demonstration of the saturation process on the full twelve foot width of the felt machine and confirmation of the estimated energy savings.

INTRODUCTION

Asphalt roofing products protect the vast majority of homes and buildings in the United States. These products, for the most part, provide satisfactory in-service performance for 20 years, thus providing low life-cycle cost.

In 1978, U.S. production of roofing materials was 8 million tons of roofing shingles, 1 million tons of saturated felt products, and 1 million tons of roll roofing products. In common with most materials, rapidly increasing energy costs are increasing the cost of these widely used materials. In addition to substantial quantities of process heat used in their manufacture, asphalt roofing products utilize 4 million tons of asphalt (equivalent to 24 million barrels of oil) as a component in their manufacture. As a starting point in the reduction of process heat, it was decided to investigate a change in the asphalt saturation process.

PROCESS FOR MANUFACTURING ASPHALT ROOFING

There are basically three non-woven webs or felts used in the manufacture of asphalt roofing products. They are characterized by the type of fiber used in their manufacture; namely, organic (cellulosic fiber), asbestos (asbestos fiber), and glass (glass fiber). An estimated 80% of asphalt roofing products are made on organic felt. The use of asbestos is expected to decrease in future years, and the use of glass fiber is expected to increase. The saturation process investigated herein applies only to products produced from organic felt.

The current process for manufacturing asphalt roofing products from organic felt is shown schematically in Figure 1. Cellulose fibers such as those from paper and wood are processed into a dry felt, which is then saturated and coated with asphalt and surfaced with selected mineral aggregates appropriate to the finished product. These may be smooth roll roofings surfaced with mica or talc, or they may be mineral surfaced rolls or shingles, surfaced with slate, stone, or ceramic granules.

There are normally two plants or at least two separate machines required to manufacture the final roofing product. The first step or process is the production of the organic felt. A flow diagram of a typical felt mill or machine is shown in Figure 2. The U.S. roofing industry includes an estimated 50 felt mills.

Fig. 1. Processing Chart for Asphalt Roofing Products;
From Raw Materials to Finished Roofing

Fig. 2 - Flow Diagram of a Typical Organic Felt Mill.

Roofing felt is a special form of highly absorbent paper employing mostly recycled fibers. It is manufactured in different weights or calipers to meet end use requirements. The felt is usually formed on a single cylinder machine and dried over multiple, steam-heated, rotary drums where water content must be reduced from 50 to less than 8%. Frequently auxiliary heat must be added to the dryer section by either blowing high velocity hot air over the felt or by gas-fired infrared burners, or both. When dry, the felt is wound into large jumbo rolls and transferred to a roofing plant for the second processing step on a roofing machine.

The roofing machine is always a separate operation and is frequently located in a separate city or state. A flow diagram of a typical roofing machine is shown in Figure 3. The U.S. roofing industry includes an estimated 100 roofing machines. In addition, there are an estimated 50 machines that include only the saturator section of the roofing machine.

The roofing mills receive jumbo rolls of roofing felt in specific calipers depending upon the end item desired; i.e., saturated or coated roll roofing, mineralized roll roofing, waterproof membranes, and/or roofing shingles. The jumbo roll of roofing felt at ambient temperature with approximately 8% moisture is unwound into a "saturator" tank of hot asphalt at about 450°F. The felt may be preheated or a spray of asphalt may be applied just prior to the felt entering the tank. Saturant tanks or vats contain 10,000 to 15,000 gallons of hot asphalt. As the felt passes through the vats it absorbs the saturant and lowers the saturant temperature. The saturator maintains its heat by having fresh asphalt introduced from heated storage vessels and continual recirculation of the entire content through hot oil heat exchangers. The entire saturation tank area must be hooded to trap bituminous volatiles and entrained asphalt droplets. These fumes must be burned in a thermal oxidizer or passed through a condenser and

Fig. 3. Flow Diagram of a Typical Roofing Plant

precipitator.

After the material leaves the saturator, subsequent processing varies depending on the desired end product. The saturated felt may be cooled and wound up into rolls for sale as a finished product or the saturated felt may be coated with a high-melting point asphalt and surfaced with talc or granules to produce roll roofing products, or the granule-surfaced sheet cut to shapes to produce roofing shingles. Although the end products require different weights of felt the methods of saturation are essentially the same.

Asphalt roofing and siding products made from organic bases may be classified broadly in three groups: roofing shingles, roll roofing, and saturated felt.

1. Shingles - All shingles are surfaced with mineral granules. There are many weights and patterns of both individual and strip shingles, designed for new construction and reroofing.

2. Roll Roofing - Roll roofing is made by adding a coating of a more viscous, weather-resistant asphalt to the asphalt saturated organic felt. Some roll roofings are surfaced with mineral granules to produce a wide range of colors.

3. Saturated Felts - Saturated felts are used as underlayment for shingles, for sheathing paper, and for laminations in the construction of built-up roofs. They are produced from several weights of dry felt impregnated with an asphalt.

ENERGY SAVING PROCESS

The energy saving process under investigation includes the same basic operations as the current process, just described, but the energy intensive dip saturation step at the roofing plant would be replaced by spray saturation on the felt machine.

Energy savings are expected as follows:

- * The BTU's in the asphalt will assist in moisture removal from the damp felt, thereby reducing steam requirements in the drum dryers.
- * Only the quantity of asphalt needed for saturation will be heated, not the large excess needed for the dip tanks in the current process.
- * The felt mill saturation process, which expects to meter the required amount of asphalt onto the sheet, may eliminate oversaturation, thereby reducing asphalt consumption.

The felt mills are currently configured with large numbers of steam-heated, rotary dryer drums. In one plant, for instance, there are 66 of these drums used to reduce the moisture from 50 percent to less than 8%.

If saturation is done at the felt mills, approximately three-fourths of the drums would be used to reduce water content of the felt from 50 percent to 15 percent. Beginning at that point in the dryer line, hot asphalt is sprayed onto the sheet. The steam load to the remaining dryer drums diminishes. The saturation on the one side of the felt web will be accomplished with several spray bars configured to give a uniform coating of saturant at 450°F across the web and penetrating the felt forcing the moisture from the back side of the web. The process will be completed by 1 or 2 additional spray bars which are directed at the opposite side of the web covering the back and completing the saturation process. The saturated felt would be cooled and slit to the proper width and wound giving the finished

saturated felt product to be used at roofing mills.

In the proposed system, rolls of presaturated felt delivered to the roofing plants will be able to bypass the saturation vats and go directly to the coating operation. All saturators with their associated energy requirements, fume and heat losses would be eliminated at the roofing mills.

The areas of modification of both the felt machine and the roofing machine have been outlined in Figures 2 and 3. The saturator shown in Figure 3 would be eliminated along with the necessary vents. The dryer in Figure 2 would be modified to include the spray saturator and incinerator.

It has been calculated that a typical roofing shingle plant consumes between 50,000 and 110,000 MM BTU's per year in the operation of the roofing shingle machine. As outlined earlier, 50 percent of the roofing shingle plants have an additional saturated felt machine. It has been calculated that these machines consume 10,000 to 30,000 MM BTU's per year. The dry felt machine producing product for the roofing mills operates at approximately 190,000 to 380,000 MM BTU's per year.

These energy usage figures are for plants using electrostatic precipitators for fume control rather than the more energy intensive thermal oxidizers. A plant operating more hours per year at a faster line speed with inefficient equipment uses considerably more energy. Other plants may use less energy.

Under the proposed system, the energy requirements for an average roofing machine would be reduced by 44,000 MM BTU's per year and the saturated felt machines would no longer be required, thus eliminating consumption entirely. Because of the addition of the saturators to the felt mills, there is a slight increase in the energy use for these machines. The increase is not as high as one might expect because of the use of the more energy efficient spray saturation process. The estimated consumption

increase of energy at the modified felt machine has been calculated at 37,000 MM BTU's per year.

These energy consumptions and savings are summarized in Table 1, and the savings for an assumed average machine is extrapolated for the industry as a whole. Based on complete conversion, industry savings are 3.7 trillion BTU's. The savings are based on roofing plants using Electrostatic Precipitators for pollution control, since that is the industry trend. Potential savings from elimination of oversaturation are not shown since techniques to accomplish this are not yet demonstrated.

PILOT PLANT DESCRIPTION

The asphalt saturation pilot plant equipment was mounted on an existing commercial felt machine and is operated experimentally while the commercial machine is producing standard product.

Existing Felt Machine:

The sections of concern of the existing commercial felt machine are the typical dryer drums, calender stack and winder. These are shown schematically in Figure 4. This machine produces various calipers of 12 foot wide felt.

The felt is losing moisture as it is carried around the dryer drums, and when it enters the higher temperature (365°F) section at Drum #34, the felt has about 25% moisture. Figure 5 is a plot representing % Moisture vs. Dryer Drum Number for a typical run of 55 lb. felt. The felt is wound after the calender stack flexes and presses the felt for better surface finish. When a roll is wound and the next one is started, the felt is rewound, at a faster speed, while it is slit and trimmed to 3 or 4 foot widths for shipment to the roofing mills.

New Pilot Equipment:

The pilot installation is also shown in Figure 4. It basically consists of a roofers' kettle for heating and pumping the asphalt, a circulating line, and five spray manifolds.

The kettle is trailer mounted and has a capacity of 230 gallons. It is manufactured by Aeroil Products Co., Inc. - Model #KE-T-230P7. Its 7½ hp. pump engine as well as the heating torch are powered by LP gas for safety in a well ventilated indoor area. Optional safety equipment, such as thermostatic controls and an automatic gas shut-off, have been added. A dial

TYPICAL MANIFOLD

HOLE SIZE AND SPACING
FOR TRIAL RUN #1

FIG. 4

ASPALT SATURATION AT FELT MILL
PILOT EQUIPMENT

FIGURE 5

PERCENT MOISTURE OF SHEET
VS. DRYER DRUM NUMBER

thermometer directly reads the temperature of the saturant.

At full load, the internal pump operates at 35 gallons per minute. It is connected to a 2 inch schedule 40 black iron circulating line which is steam traced and insulated. A pressure gauge is located just after the first header take-off. Normal operating pressure is about 5 psi. The original 0-200 psi gauge was replaced with a 0-15 psi unit after Run #3 to provide more accurate readings. Pressure is controlled with a flow valve where the asphalt returns to the kettle.

The five manifolds are made of 1" pipe with a series of drilled holes. The first four manifolds spray asphalt on the face of the sheet driving moisture out the back and then the fifth manifold sprays the back. The original manifolds contained five 1/8" holes, 3" center to center. To increase the circulating line to a more accurately measured pressure and minimize asphalt overflow from the ends of the dryer drums, new manifolds were drilled each having three 7/64" holes, 3" center to center. These were installed after Run #2. Figure 4 also shows the location where the additional asphalt was applied in Run #7. Figure 6 is a graph used to calibrate the flow of 450°F asphalt.

Operation of Pilot Equipment:

Many safety precautions are taken during each trial run. The asphalt is never heated within 100°F of its flash point. The asphalt trailer with its open flame is located in an open and accessible area. In addition to an existing sprinkler system, there is always an extra operator standing fire watch with a pressurized, extended fire hose whenever the asphalt is being heated. Also, several CO₂ and chemical fire extinguishers are in the area.

After the asphalt is heated to operating temperature (450°F), it is circulated through the preheated 2" line. The temperature drops a few

FIGURE 6

ASPHALT FLOW VS. PRESSURE

degrees, and it is then allowed to heat up again to 450°F.

Each trial run begins just after a jumbo production felt roll has been made and a new roll is started. The valves controlling each individual manifold are turned on in a timed sequence so that each manifold starts spraying on the same point on the moving felt. These times are determined by the machine speeds and are listed in the tables which give data for each trial run.

When more asphalt is applied at any given manifold than the felt can readily absorb, it forms a puddle as it is squeezed between the dryer drum and the felt a few feet downstream of each header. If this puddle increases in size, it spreads horizontally along the dryer drum and may overflow at the end of the drum. The excess asphalt is not absorbed into the sheet outside of the spraying area. This happens frequently after the third and fourth manifolds, where the sheet is already partially saturated. To minimize this problem, the flow at each manifold is adjusted individually. Also, application of some asphalt at the winder (as done in Test Run #7) cuts down on the need for high absorption rates at the dryer manifold areas.

EXPERIMENTAL PROGRAM

The overall objective of the experimental program is to demonstrate energy savings via felt machine saturation vs. roofing machine saturation. However, as a first step it was necessary to develop a specific process that would meet industry specifications for percent saturation. There are two basic felts weights used by the roofing industry; namely, No. 27 and No. 55. These felts weigh (prior to saturation) approximately 27 lbs./480 ft.² and 55 lbs./480 ft.². No. 27 felt is generally used for roll roofing products and No. 55 felt for shingle products. Specific specification levels for the minimum amount of asphalt impregnant (percent saturation) vary within the industry, but ASTM requirements (ASTM D-226 and D-225) are typical and call for minimums of 140% in No. 27 felt and 170% in No. 55 felt.

The experimental program conducted to investigate felt machine saturation can be divided into three phases: (1) exploratory tests run on the felt machine at Gloucester, (2) laboratory studies of saturation variables, and (3) trial runs at Gloucester using the pilot plant equipment. Each phase will be discussed below, along with the major conclusions from each investigation.

A. Exploratory Felt Machine Tests

Seven exploratory tests were conducted on a felt machine at Gloucester, N.J., during the last quarter of 1978. These tests were run to develop information pertinent to design of the pilot unit for spraying asphalt on the wet felt in the dryer section of the felt machine. In these tests, small amounts of hot asphalt were hand poured onto the wet felt at various points in the last quarter of the dryer section. The samples of felt were recovered directly after the dryer. Sections of the saturated and dry felt

for moisture determinations were obtained. Table 2 lists data and results from these tests.

The tests illustrated that hot asphalt applied to the wet felt in the dryer section can penetrate the felt without causing delamination or other obvious damage to the felt. Moisture content of the sections of felt on which the hot asphalt was applied was 1-2% lower than the untreated sections, indicating some drying produced by the hot asphalt. Percent saturations achieved were well below specification minimums, and excessive surface saturant was present on samples at the end of the dryer section.

Two additional exploratory tests were conducted on a felt machine in Dallas during the production of No. 27 felt. In Test #1, hot 450°F roll saturant was poured on felt containing 25% moisture. Saturation of the felt at the end of the dryer section was 91% with spotty asphalt penetration showing on the back of the felt. In Test #2, hot 450°F roll saturant was poured on felt containing 16% moisture. Saturation of the felt at the end of the dryer section was 81% with spotty asphalt penetration showing on the back of the felt. Samples from both tests showed surface saturation at the reel.

B. Laboratory Studies of Saturation Variables

Following the exploratory felt machine tests, a number of laboratory investigations were conducted to provide a further basis for design and operation of the asphalt spray system. These tests are not reported in detail, but a general summary of the variables identified and conclusions reached are listed below.

1. Viscosity - It was concluded that lower viscosities of the asphalt saturant were beneficial, particularly in the 200-225°F temperature range since damp felt does not exceed 212°F due to evaporative cooling. Asphalts with softening points in the 80-140°F range were examined.

TABLE 2

EXPLORATORY SATURATION TESTS ON GLOUCESTER FELT MACHINE

Column Number																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Test No.	Date	Mach. Speed FPM	Asphalt S.P.	Felt Wt.	Felt Kero.	Drum No.	Asphalt Applied - 450°F.					% H ₂ O Dry Felt	% H ₂ O Sat. Felt	% Sat.	Saturated Cross Section	
							% H ₂ O	Face-Back	Drum No.	% H ₂ O	Face-Back	Pen. %	Sat. %			
1	10/12	140	128	55	186	26	33.0	Back	--	----	----	7.7	5.7	56.0	49	135
2	10/12	140	128	55	186	31	26.4	Face	--	----	----	9.0	8.0	67.8	44	174
3	10/24	140	128	55	183	26	31.5	Back	31	26.4	Face	4.0	2.8	100.6	F 48 B 40	F 134 B 119
4	10/24	140	128	55	183	27	31.5	Face	31	26.4	Face	3.9	2.8	79.5	55	148
5	10/24	140	112	55	183	31	26.4	Face	--	----	----	3.9	3.0	75.1	57	134
6	11/7	140	127	55	184	25 27	31.5	Face	29 31	25.7	Face	5.8	4.2	86.0	38	192
7	11/7	140	127/117	55	185	26	31.5	127/ Back	31	25.7	117/ Face	6.3	6.5	131.0	F 40 B 38	F 167 B 155

Explanation of Columns:

- Col. 4 - Asphalt Softening Point (Ring and Ball)
- Col. 6 - Felt Kerosene Value
- Col. 7 - Location of first asphalt application.
- Col. 8 - Percent Moisture at point of application.
- Col. 9 - Application to face or back of sheet.
- Col. 10 - Location of second asphalt application.
- Col. 13 - Percent moisture in unsaturated felt at end of machine.
- Col. 14 - Percent moisture in saturated felt (unsaturated basis).
- Col. 15 - Percent asphalt saturation.
- Col. 16 - Depth of asphalt penetration into felt as percent of overall felt thickness.
- Col. 17 - Percent saturation in the saturated lamina of the felt.

2. Temperature - Since viscosity is temperature dependent, it was demonstrated that higher temperatures, 450°F vs. 300°F, improved saturation levels.

3. Time - Improved saturation levels were achieved by exposing the felt to asphalt for longer periods of time; e.g., 2 minutes vs. 30 seconds.

4. Pressure Differential - A pressure differential of 6 inches of asphalt applied to one surface of the felt reduced asphalt penetration time by two-thirds.

5. Felt Furnish - Fiber furnishes containing increased amounts of defibrated wood vs. paper fibers produced felts with improved asphalt penetration.

6. Moisture Content of Felt - Felts containing 15% moisture were more easily saturated than felts containing 30% moisture.

In general, the lab studies suggested that major changes would be needed on the felt machine in terms of lower machine speeds, higher drum temperatures, and more absorptive fiber formulations. As it turned out, the machine trials on the felt machine were more successful than lab work predicted. These trials are described below.

C. Trial Runs at Gloucester Using the Pilot Equipment

The trial runs took place during the period of August-December 1979. Tables 3, 4, 5, & 6 list test run data and product data. In general, these runs demonstrated that the desired saturation levels could be reached if an apparent excess of asphalt was present on the surface of the sheet at wind-up. Soak-in occurs during the 10-60 minute period between initial wind-up of the felt and subsequent rewinding for trimming and slitting. During this period, roll temperatures are about 150-200°F. The softening point of the asphalt saturant is about 125°F, so migration of the asphalt from the surface of the sheet into the center of the sheet is understandable.

These trial runs were of limited duration, generally 1-3 minutes of asphalt application, so as not to interfere unnecessarily with production.

Run #1 - Asphalt was applied to face of sheet only, for 1 minute. Saturation was 85-109%. Surface saturation on sheet going into reel soaked in before slitting and rewinding on this and subsequent runs.

Run #2 - 2 minute run on 55 lb. felt to establish whether or not equilibrium had been reached in the one minute Run #1. Asphalt applied to face only. Saturation - 87-102%. Asphalt spread beyond edge of sheet and drip of asphalt off dryer drums was excessive.

Run #3 - Spray manifolds changed from five 1/8" holes, 3" O.C., to three 7/64" holes, 3" O.C. Two minute run on 55 lb. felt. 1st minute, 4 sprays on face only. 2nd minute, 4 sprays on face, one spray on back. Saturation with asphalt on face only - 72-102%. Saturation with asphalt on face and back - 124-141%. Maximum asphalt spread - 16½ inches. Asphalt drip minimal. Crush marks occurred in the calender stack that picked out on the idler roll ahead of the reel, causing the sheet to break.

Run #4 - One and one-half minute run made on 27 lb. felt with 3 hole manifolds and more precise 0-15 psi pressure gauge on asphalt circulating line, replacing 0-200 psi gauge. (Pressure determines flow rate.) Asphalt applied at three locations on face and one location on back. Saturation - 122-144%. Crush marks occurred at calender stack but no pickouts or breaks. Maximum asphalt spread - 10½". Asphalt drip minimal.

Run #5 - Same as Run #4 with increased asphalt application. Saturation - 123-154%. Crushing occurred in the calender stack causing pieces of saturated felt to be picked out on the idler roll ahead of the reel until the sheet broke. Maximum asphalt spread - 11 inches. Asphalt drip minimal. Moisture content of the saturated felt after 4 days was found to be 1.6% vs. normal 6-8% for unsaturated felt.

Run #6 - Two minute run made on 55 lb. felt in which the calender rolls were bypassed. Crush marks eliminated. Saturation - 97-150%. Asphalt on face spread out beyond edge of sheet and drip of asphalt off dryer drums was excessive. This spread out may be a function of sheet tension and warrants investigation in subsequent runs.

Run #7 - Two minute run made on 55 lb. felt. Calender rolls bypassed. Asphalt sprayed at four locations on face, and one on back in dryer. Flow was reduced from Run #6. An additional application of asphalt was made on the face by hand pouring asphalt on the sheet directly behind the idler roll at the reel at a quart per minute over a 6 inch width. Less asphalt spilled in the dryer section due to the lower flow there. The potential sticking problems during rewinding and unrolling did not develop.

Saturation averaged 150%, with a high of 162%. No adjustments were made in the sheet tension due to the expected difficulty in returning the machine to good operating conditions after the run. Asphalt applied to surface of the sheet at wind-up had soaked into the sheet when the reel was trimmed and rewound approximately 30 minutes later.

CONCLUSIONS & FUTURE RESEARCH

Based on experiments, to date, it appears possible to achieve specification levels of asphalt saturation in both shingle and built-up roofing felt on the felt machine. This is achieved by applying an apparent excess amount of asphalt to the surface of sheet. This surface saturant soaks into the partially saturated sheet after the felt is wound up in the reel during the 10-60 minute period prior to rewinding and trimming the finished roll of felt.

Further research is needed to establish that finished products produced from felt saturated on the paper machine function as intended in the field. The saturation process also has to be demonstrated on a full-scale basis for a sufficient period to establish thermal equilibrium, so that theoretical energy savings can be confirmed. A potential problem area involves residual moisture of about 2% in the saturated felt. The effect of this moisture on finished product performance requires investigation.

TABLE 3 - TRIAL RUNS NO. 1 AND 2 USING PILOT EQUIPMENT

	Run 1 - 8/10/79		Run 2 - 8/27/79	
	Time - On	Time - Off	Time - On	Time - Off
Spray #1 - Drum #36	0:00	1:00 minute	0:00	2:00 minute
Spray #2 - Drum #40	0:22	1:22	0:22	2:22
Spray #3 - Drum #42	0:31	1:31	0:31	2:31
Spray #4 - Drum #46	0:52	1:52	0:52	2:52
Asphalt Temp. °F	445-448		450	
Line Pressure - psi	4		4	
Approx. Asphalt Flow on Sheet - Gal./Min.	5		5	
Felt Kerosene No.	178		185	
Asphalt R&B S.P. °F	117		120	
Line Speed - fpm	140		140	
Felt Weight - Lb./480 Ft. ²	55		55	

TABLE 3a

<u>Run 1</u>				<u>Run 2</u>			
<u>Feet</u> <u>From</u> <u>Start</u>	<u>Width of</u> <u>Asphalt</u> <u>on Face</u>	<u>% Black</u> <u>Back</u> <u>Surface</u>	<u>Percent</u> <u>Saturation</u>	<u>Feet</u> <u>From</u> <u>Start</u>	<u>Width of</u> <u>Asphalt</u> <u>on Face</u>	<u>% Black</u> <u>Back</u> <u>Surface</u>	<u>Percent</u> <u>Saturation</u>
20	17	60	85	20	18	50	102
40	17	95	93	40	22	70	98
60	17	95	99	60	28	80	85
80	21	99	105	80	35½	80	82
100	26	99	108	100	39*	87	93
120	30½	99	109	120	39	90	93
120+	32	85	66	140	39	90	87
				160	39	97	96
				180	39	98	97
				200	39	97	94
				220	39	95	91
				240	39	97	95
				260	39	85	90
				280	39	80	56

* Roll width - actual spread was greater.

TABLE 4 - TRIAL RUNS NO. 3, 4 AND 5 USING PILOT PLANT EQUIPMENT

	<u>Run 3</u> <u>9/7/79</u>	<u>Run 4</u> <u>9/27/79</u>	<u>Run 5</u> <u>9/27/79</u>
Sprays	Three 7/64" holes 3" OC	Three 7/64" holes 3" OC	Three 7/64" holes 3" OC
Line Pressure	3-4 psi	4.3-5.0 psi	6 psi
Asphalt Flow	2.9 gal./min.	2.45-3.25 gal./min.	4.2 gal./min.
Asphalt Temp.	450°F	450°F	450°F
Asphalt S.P.	121°F	125°F	125°F
Felt Kerosene	180	175-180	175-180
Machine Speed	140 fpm	280 fpm	280 fpm
Felt Wt.-Lb./480 Ft. ²	55	27	27

<u>Spray</u> <u>No.</u>	<u>Drum</u> <u>No.</u>	<u>ON</u>	<u>OFF</u>	<u>ON</u>	<u>OFF</u>	<u>ON</u>	<u>OFF</u>
1	36	0:00	2:00	0:00	1:30	0:00	1:00
2	40	0:22	2:22	0:12	1:42	0:12	1:12
3	42	0:31	2:31	0:16	1:46	0:16	1:16
4	46	0:52	2:52	--	--	--	--
5	46*	1:56	2:56	0:30	2:00	0:30	1:30

* Back of Sheet.

TABLE 4a

Feet From Start	Run 3			Run 4			Run 5		
	Width Asphalt On Face	Back Surface % Black	% Sat.	Width Asphalt On Face	Back Surface % Black	% Sat.	Width Asphalt On Face	Back Surface % Black	% Sat.
20	9½"	50	78	White Lines Face & Back			8-3/4"	100	123
40	9-3/4"	60	82	8-3/4"*	90	136**	9¼"	100	130
60	9-3/4"	60	82	8-3/4"*	100	124	9½"	100	135
80	10"	65	86	9'*	100	131	10"	100	121
100	10"	70	110	9-3/4"	100	138	10"	100	135
120	10¼"	85	102	9½"	100	132**	10"	100	131
140	10"	100*	124	9"	100	129**	10½"	100	138
160	12"	100	127	9½"	100	122	10½"	100	153
180	14½"	100	124	9-3/4"	100	131	10"	100	145
200	16½"	100	141	9-3/4"	100	126	11"	100	135
220	16"	100	134	9-3/4"	100	121**	11"	100	154
240	16½"	100	130	9-3/4"	100	140**			
260	16"	100	136	10"	100	128			
280				10"	100	141			
300				10"	100	144			
320				10¼"	100	136			
340				10½"	100	142**			
360				10½"	100	137**			

* Start of Back Spray

* White Streaks

Crush Marks
Throughout Run220 foot Sample
Split & Desaturated

** Crush Marks

Face 135% Sat.
Back 128% Sat.

TABLE 5 - TRIAL RUN NO. 6 USING PILOT PLANT EQUIPMENTRun #6 10/25/79

Spray Manifolds	Three 7/64" holes, 3" O.C.
Initial Line Pressure	5 psi (Reduced to 4.5 psi after the asphalt spread beyond the edge of sheet.)
Initial Asphalt Flow	4.1 gal./min.
Asphalt Temperature	450°F
Asphalt Softening Point	126°F
Felt Kerosene No.	189
Machine Speed (FPM)	140
Felt Weight (Lb./480 Ft. ²)	55

Asphalt Application

<u>Spray No.</u>	<u>Drum No.</u>	<u>ON</u>	<u>OFF</u>
1	36	0:00	2:00
2	40	0:24	2:24
3	42	0:33	2:33
4	46	0:55	2:55
5	46*	1:00	3:00

* Back of Sheet.

Felt Temperatures

Williamson 600 Infra Red Temperature Detector

	<u>Dry Felt</u>	<u>Saturated Felt</u>
Exit from Dryer	220-235°F	250°F
Reel Roll	145-155°F	200°F

TABLE 5a

Run #6 10/25/79

<u>Feet From Start</u>	<u>Width Asphalt On Face</u>	<u>Width Asphalt On Back</u>	<u>% Saturation</u>
20	12	5½	127
40	14-3/4	7	126
60	20	7	97
80	25	5½	107
100	32	5	121
120	36*	5½	122
140	36*	10½	133
160	36*	5	121
180	36*	8	150
200	36*	5	121
220	36*	12	107
240	36*	12	121
260	36*	10	119
280	36*	13**	94

* Asphalt Spread Beyond Edge.

** Spotty - Not Solid Black.

No crushing or pick-out at idler roll.

TABLE 6 - TRIAL RUN NO. 7 USING PILOT EQUIPMENT

Run #7

Sprays	Three 7/64" holes, 3" O.C.
Line Pressure	4.5 psi
Asphalt Flow	3.4 gpm
Asphalt Temperature	450°F
Asphalt Soft. Pt.	128°F
Felt Kero.	185 (calendered)
Machine Speed	140 fpm
Felt Wt. - Lb./480	55

<u>Spray #</u>	<u>Drum #</u>	<u>Time - On</u>	<u>Time - Off</u>
1	36	0:00	2:00
2	40	0:24	2:24
3	42	0:33	2:33
4	46	0:55	2:55
5	46 (back)	1:00	3:00
6	Reel*	on for 75 sec. from start	

<u>Feet</u>	<u>Width</u>	<u>Width</u>	<u>%</u>
<u>From</u>	<u>Asphalt</u>	<u>Asphalt</u>	
<u>Start</u>	<u>On Face</u>	<u>On Back</u>	<u>Saturation</u>
20	9-1/2	8	145.2
40	11-3/4	9-1/2	161.7
60	11-1/2	11	148.2
80	15-1/4	11	144.9
100	20	10	154.3
120	27-3/4	11	133.4
140	32-1/2	11-1/2	149.4
160	36+	11	159.6
180	36+	10-1/4	144.1
200	36+	10-1/4	139.0
220	36+	11	135.1
240	36+	9-3/4	121.8
260	36+	9	120.3

(Calender Bypassed)

* Asphalt hand poured on sheet at reel (1 qt./min. over 6 inches wide).