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Environmental Protection Technology Series

THOR V SOLVENTLESS METAL DECORATING FOR THREE-PIECE CANS
Background

Industrial Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
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THOR V SOLVENTLESS METAL DECORATING FOR THREE-PIECE CANS

BACKGROUND

by

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I. ABSTRACT

This is the first report of the Demonstration Project undertaken by Continental Can Company Metal Operations in agreement with the Environmental Protection Agency for the development and commercialization of a process to apply and cure an outside protective/decorative UV white base coating on flat sheets for the bodies of 3-piece cans. The Continental project is designated as Thor V.

The Thor V process is a single pass line wherein the UV white coating is applied, UV cured to a printable condition, two conventional inks and a trailing varnish are applied followed by baking in a gas-fired wicket oven. The conventional process is a 2-line operation. The first line applies the white coating followed by the oven bake. The second line then applies the two inks and varnish, again followed by an oven bake.

The Thor V process reduces total line length by 215 feet (65M) and total solvent emissions by approximately 66% as compared to the conventional process. Elimination of an oven and afterburner will also reduce new equipment costs by over $400,000, and save approximately 8,000,000 BTU/hour (2,000,000 Cal/hour) in gas consumption.

Along with background information, this report reviews the development work to date, describes the Continental Thor V line at our plant in Weirton, West Virginia, and describes the work needed to complete the project.

II. INTRODUCTION

A. Conventional Methods

At the present time, external protective and decorative conventional solvent coatings for flat metal sheets used for the bodies of 3-piece cans are applied by direct roll coating followed by baking in gas-fired wicket ovens at temperatures up to 430°F (221°C) for periods of six to ten minutes.

The outside can body coatings, usually white, are referred to as base coats since they most often become the background color and an integral part of the design which is completed by lithograph decoration (inks and varnish) on top of the base coating.

A schematic of the sequence of operations is shown in Figure 1.

B. Energy and Environmental Impact of Conventional Coating Methods

The conventional outside white coatings are applied in film weights in the range of 10 to 14 mgs/square inch (1.5 to 2.2 mgs/square cm). The wet coated sheets, approximately 35 inches x 41 inches (86 cm x 104 cm) are then transported on wickets through the baking oven at a rate of 85-95 sheets per minute. The decorative inks and trailing varnish are then applied and baked on a second line. A schematic of a direct externally fired (DEF) wicket oven for baking flat sheets is shown in Figure 1A.

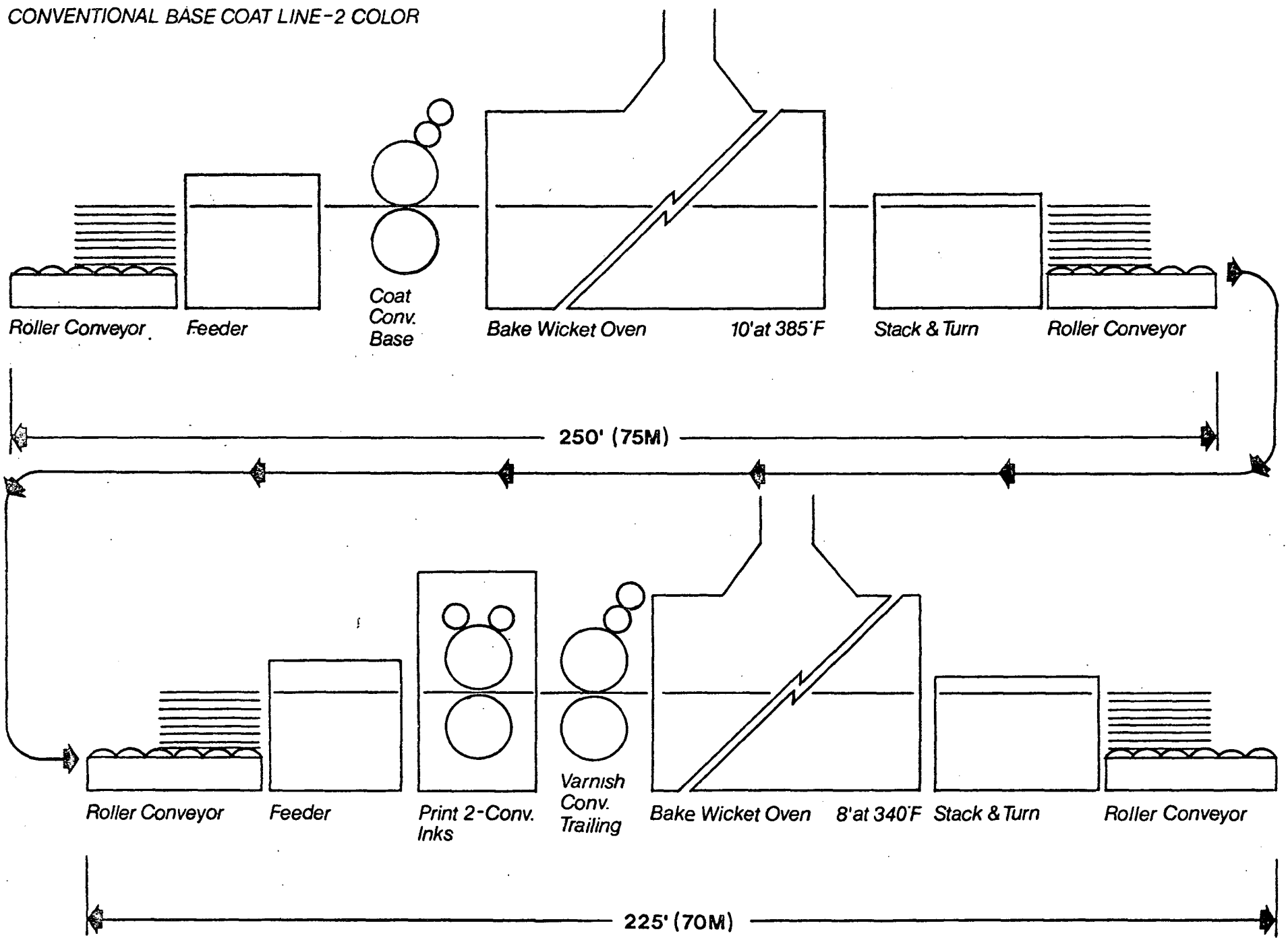
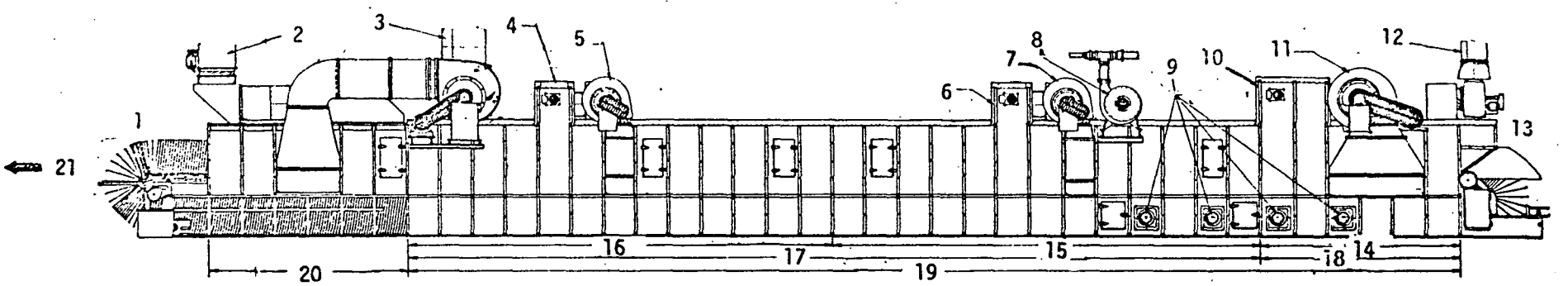

CONVENTIONAL BASE COAT LINE-2 COLOR
Roller Conveyor
Feeder
Coat Conv. Base
Bake Wicket Oven
10'at 385°F
Stack & Turn
Roller Conveyor
250' (75M)
Roller Conveyor
Feeder
Print 2-Conv. Inks
Varnish Conv. Trailing
Bake Wicket Oven
8'at 340°F
Stack & Turn
Roller Conveyor
225' (70M)

FIGURE 1.

LEFT SIDE VIEW OF COMPLETE DEF OVEN



1	Rear
2	Cooling Exhaust
3	Cooling Intake
4	No. 3 Burner Box
5	No. 3 circulating Fan
6	No. 2 Burner Box
7	No. 2 circulating Fan
8	Combustion Air Blower
9	Conveyor Preheat Circulating Fans
10	No. 1 Burner Box
11	No. 1 Circulating Fan
12	Main Exhaust
13	Front
14	Zone 1
15	Zone 2
16	Zone 3
17	Maintaining Section
18	Heating Section
19	Baking Section
20	Cooling Section
21	To Oven Unloader

FIGURE 1A

For the system described (white base coat, two colored inks, varnish), the typical oven solvent emissions are as follows:

Material	Solvent per hour Lbs	Kgms	% of total emissions
White base coat	118	53.6	66
Two inks	2.5	1.1	1
Varnish	59	26.8	33

It is evident from the above figures that two-thirds of the solvent emissions in the conventional system come from the high film weight white base coating, approximately one-third from the varnish, and only a trace from the inks.

Oven operation for baking the white coating will typically consume 4.2MM BTU/hour (1.0 MM Cal/hour) of natural gas energy. An afterburner, if one is needed, will consume an additional 3.8 MM BTU/hour (0.95 MM Cal/hour).

C. Environmental Control Alternatives

In Priority I Air Quality Regions, as designated by the Environmental Protection Agency, conventional coating materials cannot be run on existing coating lines beyond mid-1975.

Dependent upon control regulations promulgated by the states, counties, and municipalities, several, but not consistently applicable, hydrocarbon control techniques can be used. The principle techniques permitted include the following:

a) The formulation of conventional coatings with "exempt solvents," i.e., solvents generally considered to have no or low photochemical reactivity.

b) The use of low solvent concentration high solids or water based coatings.

c) The use of afterburners.

Dependent upon the applicable state, county, and municipal regulations, the use of these types of coatings may also require substantial modification of existing ovens to provide no contact of the air-solvent mixture with oven burners. This particular provision can add up to 30 or 40% increase in the natural gas requirement to heat the oven. The technical validity of this energy intensive requirement is highly questionable when the actual air flow characteristics of the direct fired flat sheet metal decorating ovens are understood.

In many state, county, and municipal regulations the use of afterburners is mandatory if the above mentioned alternatives are not available or have not been developed and fully tested by mid-1975. This alternative for oven exhaust controls can be characterized as follows:

a) The capital cost of the afterburner can range from 50% to 125% of the capital cost of the oven to be controlled.

b) The additional gas consumption for the afterburner can be equivalent to the amount of natural gas to operate the oven.

D. Energy and Economic Impact of Environmental Control Alternative

Each of the environmental control alternatives are characterized for their economic and energy impact in the following table.

TABLE 1

Type of control	Capital cost $	Operating cost $	Energy requirement
Afterburner	+ 100%	+ 100%	+ 100% natural gas
Exempt solvent	0	+ 15%	No change
Low solvent	0	+ 25-40%	No change

These data show that a long term solution must be directed toward a reduction in energy usage and solvent concentration in the coating material.

E. The Ultraviolet System Alternative

For the past decade, Continental Can's Research and Development departments have explored many alternate processes and materials which would minimize or eliminate the solvents in the coating materials. Additionally, discreet energy input processes were investigated with the objectives of energy reduction and potential increase in overall productivity through elimination of the requirements for wicket ovens.

In the course of those exploratory studies, experimental and analytical evaluations of electron beam, X-ray, gamma ray, ultraviolet, fused powder, and infrared, as examples, were undertaken.

From these evaluations, ultraviolet light combined with coating materials sensitive to "curing" by UV evolved as the system with the preferred techno-economic potential resulting in an approved, specific research project in October 1972.

Concurrent with this coating system research, Continental developed and commercialized the first UV litho ink flat metal sheet decorating system which gave further credence for focusing its research and development on UV coating systems.

By October 1973 sufficient development data had been derived to initiate a project for installation of a full scale experimental system in a manufacturing facility (see Figure 2). The Continental Mark I UV dryer shown in Figure 2 contains nine medium pressure mercury vapor UV lamps rated at 200 watts/ inch (78.7 watts/cm).

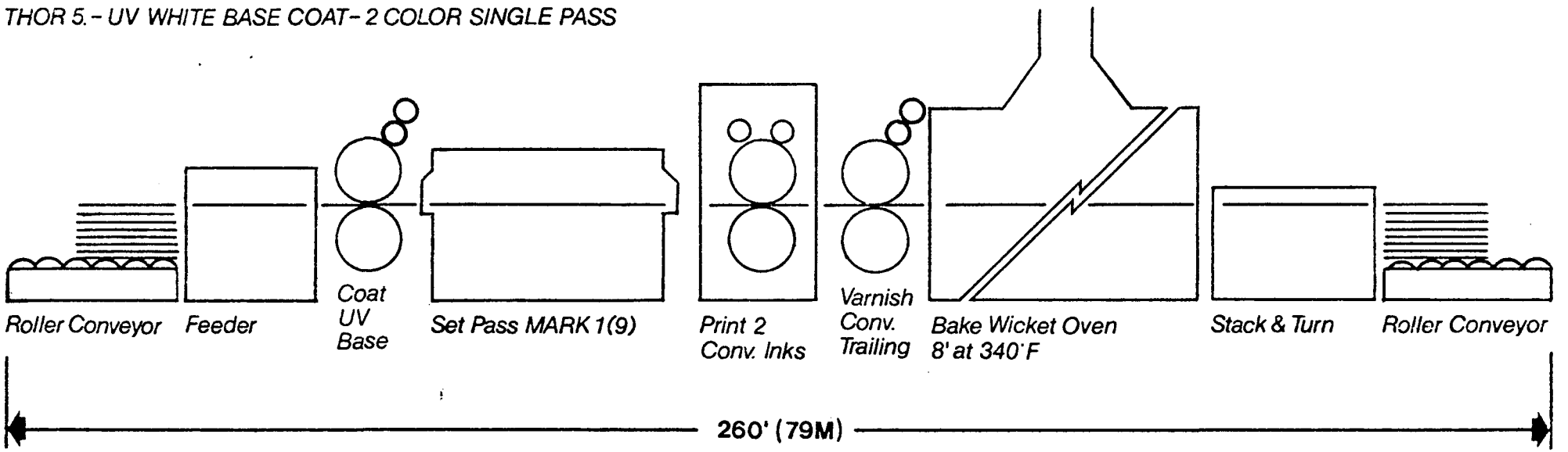

THOR 5.- UV WHITE BASE COAT- 2 COLOR SINGLE PASS
Roller Conveyor
Feeder
Coat UV Base
Set Pass MARK 1(9)
Print 2 Conv. Inks
Varnish Conv. Trailing
Bake Wicket Oven 8' at 340°F
Stack & Turn
Roller Conveyor
260' (79M)

FIGURE 2.

III. PROJECT OBJECTIVES

The purpose of this project is the development of a system for 3-piece can decoration to apply a UV white base coat, one or two conventional inks and a trailing varnish, in a single pass operation.

Commercialization of this system will eliminate the following:

a) One oven and afterburner (where needed) for curing the white coating

b) 4 to 8 million BTU/hour (1 to 2 million Cal/hour) of natural gas energy

c) 30% of the conventional system electrical demand

d) White coating solvent

IV. RESEARCH AND DEVELOPMENT TO DATE

A Pert Chart listing the major tasks in the complete Thor V program is shown in Figure 3. Work to date has essentially covered the tasks up to container fabrication evaluation. None of the materials tested to date has warranted a customer performance evaluation.

A. Laboratory

In laboratory testing, the test coatings are applied to various metal substrates, including tinplate, TFS (tin free steel), and QAR (quality as rolled) plate, using a laboratory Wagner roll coater. The white coating is set on a Continental designed laboratory UV dryer using one medium pressure mercury vapor UV lamp rated at 200 watts per inch. Conveyor speed can be adjusted from approximately 5 feet (1.5 m) per minute to over 100 feet (30.5 m) per minute. The coated panels are then baked in a laboratory gas fired oven to complete the cure of the white coating.

The Thor V process, by definition, uses conventional inks and a trailing varnish. A normal varnish bake is 8 minutes at 340°F (171°C). Consequently, most tests were conducted at this bake. The normal laboratory application and curing sequence is, therefore, as follows:

1) Apply UV white coating at a film weight of 10 to 12 mgs/square inch (1.5-1.9 mgs/square cm)
2) UV set white coating at speeds of 20 to 60 feet per minute (6.1 to 18.3 meters per minute) which is equivalent to a full size sheet speed of approximately 10 sheets per minute.

PERT CHART - THOR V PROGRAM

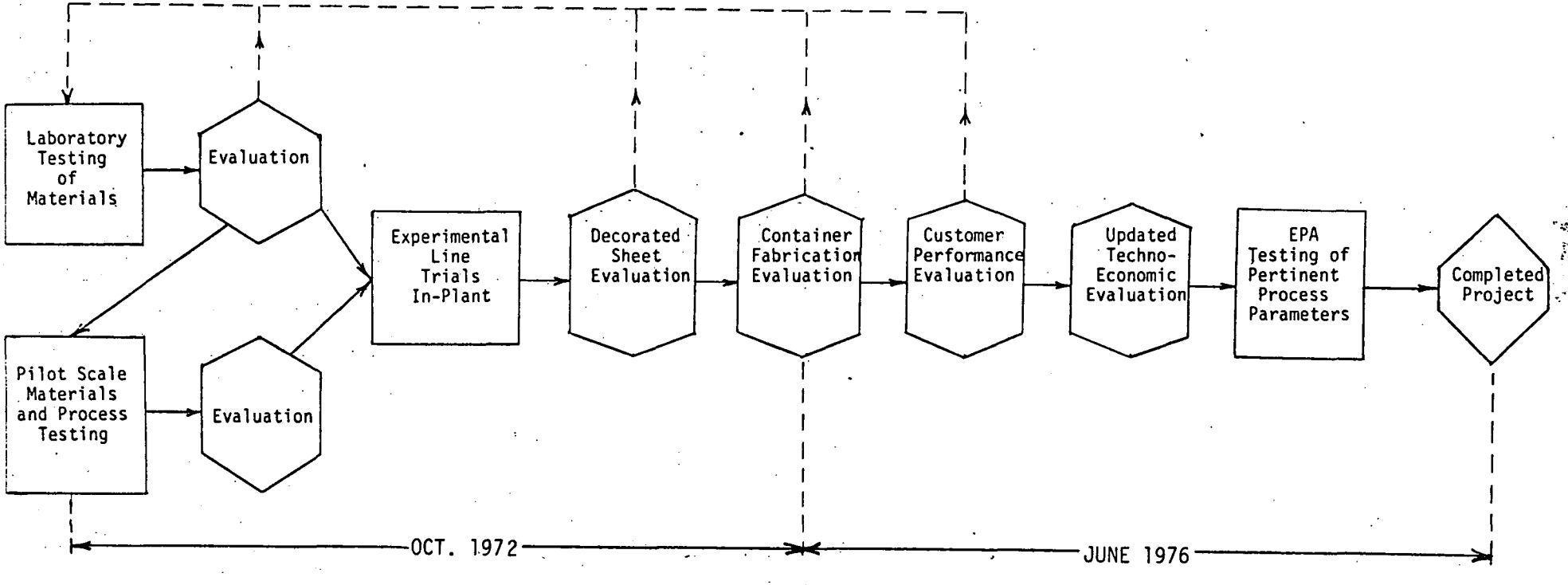


FIGURE 3

3) Apply Conventional ink

4) Apply conventional varnish over wet ink

5) Bake panels for 8 minutes at 340°F (171°C)

The coated and cured panels are then subjected to standard litho evaluation which includes tests for the following properties:

1)	Flow	6)	Adhesion
2)	Gloss	7)	Fabrication
3)	Color	8)	Blocking
4)	Hiding	9)	Mobility
5)	Odor	10)	Pasteurization resistance

B. Pilot

The pilot scale testing has been done on a UV pilot line for flat sheet coating located at the Chicago Technical Center. The line has over ten UV lamps available for curing the UV test coatings, and can handle sheet sizes up to approximately 24 inches (61 cm) long by 30 inches (76 cm) wide at speeds up to over 100 sheets per minute. Evaluation of the coated sheets is the same as described above in the standard litho evaluation procedure.

C. In-Plant

Following promising test results at the Chicago Technical Center and encouraged by the success of our commercial UV ink operations, it was decided to install a full scale experimental line in a Metal Operations plant and, consequently, the Thor V line was installed at our Plant 446

in Weirton, West Virginia. The line (No. PC-7) was completed and initial testing began in March of 1974. The line layout is described in Section II of this report and is shown in Figure 2.

Since March 1974, a number of coating tests have been conducted on the Thor V line at Weirton with experimental UV white coatings. A normal testing sequence consists, essentially, of the following (assuming satisfactory results at each operation:

1) Adjust entire line to run at 85 sheets per minute (feeder-coater-press-oven-conveying equipment).
2) Using inside enameled plate, apply outside UV white base coat on standard 15-inch Wagner roll coater.
3) Feed plate directly into Continental Mark I UV dryer to cure white coating sufficiently to accept inks in next operation.
4) Apply one or two conventional inks on Hoe Y press and apply a wet roll coated conventional trailing varnish.
5) Bake decorated plate in standard wicket oven.

None of the UV white coatings run on the line to date (August 1975) have been fully acceptable. The primary problem common to all materials tested thus far is coating rheology--ability to achieve a smooth film comparable to that obtained with conventional solvent base white coatings. Poor adhesion and discoloration of the white coating after baking have also been problems.

Work is also currently being done to improve flow through possible engineering modifications to the standard commercial roll coater. If, however, the coating formulation changes and/or coater modifications do not result in satisfactory flow conditions, it may be necessary to go to a different, more costly, application method.

V. FUTURE RESEARCH AND DEVELOPMENT PROGRAM

Referring to the Pert Chart in Figure 3, once a satisfactory UV white coating is developed from the standpoint of application properties and decorated sheet evaluation, the next phase of testing will be container fabrication. For this, the decorated plate will be shipped to a can manufacturing plant since only enameling and decorating is done at Weirton.

The plate will be slit to body blank size and then fabricated into necked-in Conoweld cans. During can manufacture, the test litho will be carefully watched for scratching, adhesion, fabrication, and can mobility through the assembly operations.

If all prior test results are satisfactory, the next step will be to submit cans to a customer, or customers, for their evaluation. While litho appearance will be of primary concern, customer testing will also include mobility, double seaming of the end on the body, pasteurizing and product flavor testing. During this phase of the program, we will also update our technical data and economics based on the then current manning, energy, equipment, and coating material costs. If these analyses are favorable, a large scale run will be made during which the Federal Environmental Protection Agency and Continental will measure the pertinent process parameters affecting energy usage and environmental control.

Finally, we will begin XP production (commercial production on an experimental basis) leading to standardization of the UV white coating and the Thor V process.

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16. ABSTRACT The report gives the background of a demonstration project to develop and commercialize the Thor V process to apply and cure an outside, protective/decorative, UV-cured white base coating on flat sheets used for the bodies of three-piece cans. The Thor V process is a single-pass line: the UV white coating is applied and UV-cured to a printable condition; and two conventional inks and a trailing varnish are applied, followed by baking in a gas-fired wicket oven. The conventional process is a two-line operation: one line applies the white coating, followed by the oven bake; the other applies the two inks and varnish, again followed by an oven bake. The Thor V process reduces total line length by 215 ft (65M) and total solvent emissions by about 66%, compared to the conventional process. Elimination of an oven and afterburner also reduces new equipment costs by over $400,000 and saves about 8 million Btu/hr (2 million Cal/hr) in gas consumption. The report also reviews development work to date, describes the Thor V line at a plant in Weirton, West Virginia, and describes work needed to complete the project.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Air Pollution	Solvents	Air Pollution Control	13B	11K
Metal Finishing	Photochemical Reactivity	Stationary Sources	13H	
Cans		Thor V Process	13D	07E
Metal Protection	Ultraviolet Equipment	Metal Decorating	11C	14B
Coating Processes				
Coatings				

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