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THE
AIR AND VACUUM
DRYING
OF PRUSSIAN BLUE

THE UNIVERSITY OF LOUISVILLE

A DISSERTATION
SUBMITTED TO THE FACULTY
OF THE GRADUATE SCHOOL
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE
IN CHEMICAL ENGINEERING

By

DAVID B. ARDERN

1935

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INTRODUCTION

The purpose of this investigation was to determine the effect of varied drying conditions upon the rate and mechanism of the drying of a commercial solid by air and in vacuum.

Air drying of the solid was investigated at various conditions of temperature and humidity. The particular conditions chosen as to temperature and humidity were such as to check and complete previous experimental work performed by Schmied and Ardern (1). It was also desired to summarize the results of this and the previous work (1), and then compare the drying rate curves obtained with the theoretical curves of Newman (2).

The vacuum drying of the solid was studied under different conditions of temperature and vacuum. The data and curves obtained from the commercial solid were to be compared with the investigation of a theoretical inert solid made by Ridgway (3).

The solid used in all of these tests was commercial Prussian Blue paint pigment.

HISTORICAL

The practice of Chemical Engineering involves principally the carrying out of certain physical operations in the production of chemicals and many other similar products. These physical steps are called the unit operations.

The manufacture of products resulting from chemical reaction often involves a series of these individual unit operations. For example, in order to prepare a finished product, it may be necessary for the raw materials to be ground, screened, dissolved, filtered, and dried, while the by-products may be distilled, evaporated, and absorbed or crystallized.

The development of these unit operations has been in step with the rapid growth of the Chemical Engineering industries. The exact theoretical character of these operations has not in many cases been intently studied. However, recent investigations have indicated that the basic principles involved in any unit operation are the same, regardless of its application, or the method by which it is carried out.

One of these engineering operations is the unit process known as drying. "Drying commonly refers to the removal of a liquid from a solid, the liquid most frequently being water. The removal of water from a solid in solution is termed evaporation, but there is no distinction between evaporation and drying in crystallization processes. Ordinarily drying refers to the removal of water from a solid when the water is present in relatively small amounts" (4).

There are many types of dryers in commercial use, the kind varying widely according to the particular properties of the material to be dried. The actual classification of the machines used in this unit operation is difficult, but the simplest subdivision is into two classes, atmospheric air and vacuum dryers.

Air dryers are conveniently divided into three types (5):

1. The continuous automatic type. The material is conveyed mechanically through the dryer, or from compartment to compartment, while a transverse circulation of air is usually maintained.

2. The tunnel type. The material is passed through the dryer on trucks, while circulation of heated air is maintained in a direction opposite to the movement of the material. Construction permits the continuous feeding of material at one end and removal at the opposite end.

3. The compartment type. This dryer may be an entirely self-contained unit, as a dry kiln, all parts being furnished and set up in the building independent of the building construction. It may also be simply a room or compartment in the building, fitted with coils, fan, or other drying apparatus used in the drying process.

The continuous and tunnel dryers are efficient only if operated at uniform conditions over a long period of time. The compartment dryer adapts itself well to manufacturing batch units, where operation is not a twenty-four hour schedule.

The principle of operation of the air dryer is to pass heated air over the material being dried. In the case of the compartment dryer this

air is usually preheated by steam coils. In the continuous or tunnel dryer the flow of air may be either direct-current or counter-current. According to Nehbel (6) direct-current drying is theoretically more efficient than counter-current.

Increased efficiency may be obtained through more intimate contact of air and material according to J. Dom (7). Buck (5) warns against too rapid drying, which may result in warping, cracking, or discoloring of the material.

A wide variety of materials are handled in air dryers, the list containing such items as fruit of all kinds, clay products, cotton linters, films, furs, hides, paints, lumber, matches, rags, rubber, soap, tobacco, wallboard, pastes, textile materials, precipitates, filter cakes, etc.

Vacuum dryers may be divided into shelf dryers, for materials that do not need to be stirred while drying; rotary dryers, for material which must be continuously stirred; and drum dryers, for substances which readily acquire a dry film on the surface (8).

The vacuum dryer differs from the air dryer in that it operates at considerably reduced pressure. It gives a very high rate of drying, usually at low temperatures, and is used for materials which would undergo oxidation, decomposition, or discoloration in air dryers. A vacuum dryer will accomplish the same results as an air dryer of corresponding capacity in a much shorter period of time, and at much lower steam costs. However, the vacuum dryer has the higher cost of construction, and the added cost of operating a vacuum pump. Vacuum dryers are almost invariably operated intermittently, one notable exception being the Minton vacuum paper dryer (9).

Vacuum drying was first used commercially in 1881 (10), while the first report of a continuous belt type vacuum dryer was in 1906 (11). A study of the applications and limitations of vacuum dryers was made by Lavett and Van Marle (12), and of the mathematics of vacuum drying by Martin (13).

Vacuum dryers are adapted to the drying of such materials as rubber of all kinds, paints, dyes, extracts, pastes, glue, soap, salts, albumens,

starch, gluten, rosin, vegetables, fruits, sugars, chemicals, etc. (8).

Commercial Prussian Blue is the ferrocyanide of iron. To make it, a dilute solution of copperas (ferrous sulfate), acidified with sulfuric acid, is precipitated with potassium ferrocyanide solution. After decanting the liquor the white precipitate of ferrous-ferrocyanide is oxidized with nitric acid, bleaching powder and hydrochloric acid, or by exposure to air (14).

There are a number of varieties of Prussian Blue, all approximately the same composition, though slightly different in shade. They are made differently, and are known as Steel Blue, Milori Blue, Bronze Blue, Antwerp Blue, Chinese Blue, and Paris Blue (8).

A number of experimenters have disagreed as to the exact character of Prussian Blue. According to Hofman (15) and Mueller (16) the color is a ferrocyanide. Schmidt and Rassow (17) suggest that it is ferric ferrocyanide, containing some

potassium in place of the iron, two mols of water in intermolecular combination, and small quantities of hydrated ferric oxide in solid solution.

An X-ray analysis by Levi (18) failed to detect a difference in crystalline structure between ferrous and ferric ferrocyanides. Justin-Mueller (19) states that reactions with oxalic acid indicate the constitution to be ferric tri-ferroferrocyanide, while reactions with potassium hydroxide suggest a formula of ferrous diferroferricyanide.

Prussian Blue is an exceptionally strong and permanent pigment. It has extreme tinting powers, but its transparency decreases its covering ability. The pure dry pigment has a bronze tinge, which disappears with decreasing particle size. The intensity of color depends upon the concentration of acid, temperature of precipitation, and amount of oxidant used. The dry pigment is very hard to grind, and is insoluble in dilute acids and concentrated hydrochloric.

Morris (20) states that the drying of the press cakes is best carried out in a current

of hot air. The product is a stronger and less "cindery" one than that obtained from a vacuum dryer.

Besides extensive applications as a paint pigment, Prussian Blue is used in wallpaper and in the textile industry (8) (14). A recent application of the pigment has been in the processing of rubber (21), while it is also used in the printing industry (22) (23), and in the preparation of photographic color plates (24).

PART I**AIR DRYING**

THEORETICAL

For each different material, under specific conditions of temperature and humidity, there is said to be an equilibrium moisture content. This is the moisture content which the material will assume if left for a sufficient length of time in contact with air of those particular conditions.

If the initial moisture content is higher than the equilibrium, the difference between the two is called the free moisture content, and the removal of this free moisture is the unit operation known as drying.

The theoretical mechanism of the air drying of solids has been studied by Lewis (25), Sherwood (26), and Newman (2). According to their findings the drying of a solid takes place in two stages. The first may be termed the constant rate period, while the second is known as the falling rate period.

The constant rate period appears when the amount of free moisture present is relatively high. Water diffuses through the solid to the exposed surface, where the evaporation takes place

as rapidly as drying conditions permit. The principle resistance to the drying is in diffusion of water vapor through the air film on the surface of the solid. Since evaporation occurs on a surface which is kept wet, the temperature of the water and of the cake approaches the wet bulb temperature of the drying air. During this period the rate of drying remains a constant.

The point at which the constant rate period ends and the falling rate period commences is known as the critical water content. Below this critical water content the rate of drying curve is divided into the zone of unsaturated surface drying, and the zone where internal liquid diffusion controls.

The zone of unsaturated surface drying occurs when diffusion of liquid within the solid is no longer rapid enough to keep the entire surface wet. However, evaporation continues to take place at the surface, and the principle resistance is in the air film. If the effective wetted surface during this zone is a linear function of the water content, the drying rate curve will be a

straight line, though of a considerable negative slope as compared with the horizontal line of the constant rate period.

As the drying progresses, a second point is reached, beyond which diffusion through the solid is the controlling factor. The surface of the material having practically reached the equilibrium content, the air film resistance becomes negligible. The controlling factor, the diffusion resistance, increases as the amount of free moisture decreases, and the curve of the rate of drying is decreasingly negative as the solid approaches the equilibrium moisture content.

During the constant rate period and the unsaturated surface zone evaporation is occurring at the surface. But at the beginning of the internal diffusion zone the surface of the solid is practically dry. Therefore, it is conceivable that, if the temperature is high enough, the plane of evaporation may recede into the solid. If this happens, the rate of drying will be controlled not only by resistance to diffusion of liquid to the plane of evaporation, but also by resistance to diffusion of the vapors through the remaining solid and the air film.

Constant conditions in air drying mean constant temperature, humidity and air velocity. The effect of varying these conditions may be readily seen.

In most cases temperature has little to do with the final equilibrium moisture content. It will affect only the rate of drying. Increasing the temperature will hasten drying throughout, as both evaporation at the surface and diffusion within the solid will be affected.

Increasing the humidity decreases the differential between the water content of the solid surface and the air, thereby decreasing the driving force which is causing evaporation of the liquid at the surface. Therefore, an increased humidity will decrease the rate of drying during the constant rate period, and the unsaturated surface zone. It will not affect the zone of diffusion control.

The effect of increasing the air velocity will be to decrease the air film at the surface. Thus a higher air velocity will increase the rate of drying as long as the air film resistance is an

important factor, but will not affect the drying when diffusion controls. However, the increase in rate of drying as air velocity increases is not a linear function.

Some solids have a tendency to check and warp on drying. These properties are given a material by the fact that it undergoes unequal shrinkage if the drying is not uniform. Some solids also show case-hardening, the formation of a hard layer of dried material on the surface, which greatly hampers internal diffusion to the surface. These properties are usually increased by increased temperature and air velocity, but such tendencies may be decreased by increasing the humidity.

EXPERIMENTAL

A. APPARATUS and OPERATION

The dryer used in these tests was an "H - W" Conditioner, manufactured by the Industrial Dryer Corporation of Stamford, Connecticut. Fig. 1 is a photograph of the dryer, while a diagram is given in Figs. 2-A and 2-B.

In the operation of this dryer atmospheric air is drawn in through the inlet pipe A, Fig. 2, by the fan at B. Passing over four sets of steam coils in the heating chamber C, the air is brought to the desired temperature before passing under the baffle wall D, into the distribution chamber E. Through the slots F the heated air is blown over the material on the trays in the drying compartment G. From the outlet chamber H, the air may be exhausted through the stack J, or recirculated back through the dryer. The amounts of fresh and recirculated air are controlled by dampers K and L.

In order to maintain the drying air at the desired humidity it was necessary to mix the air with steam by means of the nozzle M. The steam was introduced just before the fan in order

FIGURE 2-A

Figure 1

"H - W" CONDITIONER

Diagrammatic Sketch of Drier

FRONT VIEW

FIGURE 2-A

DIAGRAMATIC SKETCH OF DRIER
FRONT VIEW

FIGURE 2-B

- A-ENTERING AIR PIPE
- B-FAN
- C-HEATING CHAMBER
- D-BAFFLE WALL
- E-DISTRIBUTION CHAMBER
- F-SLOTS
- G-DRYING COMPARTMENT
- H-OUTLET CHAMBER
- U-OUTLET AIR PIPE
- K-DAMPER
- L-DAMPER
- M-STEAM NOZZLE
- N-MOTOR

DIAGRAMATIC SKETCH OF DRIER
TOP VIEW

to be certain of thorough mixing as the air and steam passed through the fan.

Temperature and humidity data were obtained at the inlet and outlet of the dryer by means of wet and dry bulb thermometers. A Bristol Recording Psychrometer, Fig. 3, was used in controlling the conditions of the air. The psychrometer wet and dry bulbs were placed at the bottom of the distribution chamber E, Fig. 2, while the water fount and recording instrument were mounted on an instrument board at the rear of the dryer.

The percent recirculation of the air in the dryer was obtained by measuring the inlet air velocity with an anemometer when the dampers were set for zero recirculation, and then at any other desired setting.

Samples of the material dried were taken in the early parts of each run by means of a cork borer, until the material became too brittle, after which a knife was used. The samples were weighed on a chain-o-matic balance, and dried in a small electric drying oven. A large platform scale was

FIGURE 3

A - WET BULB THERMOMETER
A' - DRY BULB THERMOMETER
I - WATER INLET
O - WATER OUTLET
D - DRY BULB RECORDING PEN
W - WET BULB RECORDING PEN

BRISTOL RECORDING PSYCHROMETER

used for weighing the pans and material. Steam was obtained from a small gas fired boiler, which was part of the regular laboratory equipment.

B. MATERIAL

The material used in these tests was a standard commercial Prussian Blue, furnished by the Kentucky Color and Chemical Company of Louisville, Kentucky.

The pigment was manufactured by adding ammonium sulfate and sulfuric acid to ferrous sulfate, and then precipitating with sodium ferrocyanide. Oxidation was carried out with sodium chlorate at sixty degrees Centigrade. The resultant precipitate was washed by decantation over a period of three weeks, then filtered in a plate and frame filter press. Cakes from this press were used in these tests.

The filter cakes measured twenty-two inches square by about one and one-quarter inches thick. They had an initial moisture content of from forty-five to fifty percent water, and weighed about twenty-five pounds each when wet.

All color was returned to the Kentucky Color and Chemical Company after being dried.

C. EXPERIMENTAL WORK

A total of four runs were made at different temperature and humidity conditions, as shown in Table I. The first two runs were performed as a check on the work of Schmied and Ardern (1), while the last two were to obtain additional data.

For each run a total of twelve filter cakes were used, two on each of six trays. The trays were placed on alternate shelves in the dryer, with six empty trays occupying the intermediate shelves in order to satisfy the requirements of dryer construction.

In making each run the dryer was first brought to the desired conditions of temperature and humidity. The trays and material were weighed and placed in the dryer. Moisture samples were taken from each of the six trays at the start of the run, and at two-hour intervals thereafter throughout the run. They were weighed immediately, and then placed in the electric oven to dry for forty-eight hours at a temperature of seventy to eighty degrees Centigrade.

TABLE I

TEMPERATURE - HUMIDITY CONDITIONS OF RUNS

Run No.	Temperature °F.	Humidity %
1	180	2.9 (atmos.)
2	140	15
3	180	15
4	180	15

The dryer was kept at the desired temperature by controlling the steam in the coils. The necessary wet bulb temperature in order to give the desired humidity was determined from an humidity chart, and then this temperature maintained by recirculating the air and mixing it with steam. These control temperature were carefully watched on the recording psychrometer.

Readings of the room temperature and inlet and outlet wet and dry bulb thermometers were taken every two hours, and inlet air velocity readings made three or four times during each run. At the end of each run the trays and material were again weighed in order to determine the total moisture lost during the run. Each run lasted for a period of twenty-eight hours.

RESULTS

The data included in the Log Sheets and in the Moisture Content Tables was taken directly from data kept during the runs in the laboratory.

Some values given in the moisture content data are indicated as not being used in calculating the averages. Preliminary individual Moisture Content vs Time curves (not included) were plotted for each tray for each run. The values omitted were those which were found to be considerably off the general trend of the individual curves. These apparently incorrect values were attributed to the difficulty in always obtaining a representative sample.

In calculations for the rate of drying curves for the various runs, values of the percent moistures were read directly from the drying curves. The weights of the wet cakes at the beginnings of the runs were taken from their respective log sheets.

TABLE II

LOG SHEET

Run 1

Department of Chemical Engineering

Speed Scientific School

University of Louisville

DRYING OF PRUSSIAN BLUE

Psychrometer Chart No. 1

Date: 1/18/34

Plant Record Data

Laboratory Data

Name: Bronze Blue
 Rx. No.: 4002
 Slip No.: 607
 Batch No.: 12
 Date Struck: 1/12/34
 No. Trays Dried: 12
 Date In: 1/17/34

Batch Recd.: 1/17/34
 Batch Rtd.: 1/24/34

Drying Conditions

Temperature: 180°F.
 Humidity: 2.9% (Atmos.)

Inlet: Average Dry Bulb Temperature: 80°F.
 Average Wet Bulb Temperature: 65°F.
 Average Absolute Humidity: 42%

Outlet: Average Dry Bulb Temperature: 154°F.
 Average Wet Bulb Temperature: 129°F.
 Average Absolute Humidity: 43%

Average Room Temperature: 80°F.
 Inlet Air Velocity: 3069 ft./min.
 Percent Recirculation: None

Recorded Psychrometer Chart Temperatures: Dry Bulb: 180°F.
 Wet Bulb: 96°F.

Pan Data

Pan No.	Wt. of Cake Before Drying lbs.	Wt. of Cake After Drying lbs.	Wt. Moisture Lost lbs.
1	46.00	22.25	23.75
2	48.75	21.75	27.00
3	48.25	21.75	26.50
4	46.50	21.25	24.25
5	46.25	20.75	26.50
6	46.75	21.50	25.25
Totals	282.50	129.25	153.25

TABLE III
MOISTURE CONTENT DATA

Run 1

Sample No.	Tray No.	Wt. Wet Sample gms.	Moisture Lost gms.	Percent Moisture
1	1	5.078	2.578	50.7
	2	4.927	2.775	56.3
	3	4.908	2.657	54.1
	4	5.087	2.832	55.6
	5	5.141	2.811	54.7
	6	5.044	2.745	54.5
			Average	<u>54.3</u>
2	1	3.934	1.868	47.5
	2	4.570	2.345	51.2
	3	4.948	2.599	52.5
	4	3.836	1.904	49.7
	5	4.558	2.324	51.0
	6	4.443	2.278	51.3
			Average	<u>50.5</u>
3	1	5.022	2.137	42.6
	2	5.869	2.863	48.7
	3	5.671	2.882	50.8
	4	4.659	2.245	48.2
	5	4.889	2.445	50.0
	6	5.032	2.501	47.8
			Average	<u>48.1</u>
4	1	4.552	1.692	37.2
	2	4.652	1.849	39.8
	3	4.988	2.387	47.9
	4	4.386	1.897	43.3
	5	5.300	1.834	42.7
	6	4.889	1.879	38.5
			Average	<u>41.6</u>
5	1	6.101	1.884	30.9
	2	6.025	1.704	28.3
	3	3.566	1.399	39.2
	4	5.668	1.849	32.6
	5	5.748	2.091	36.5
	6	6.367	0.695	x13.0
			Average	<u>33.8</u>

x Value omitted in average.

TABLE III (Cont.)
MOISTURE CONTENT DATA

Run 1

Sample No.	Tray No.	Wt. Wet Sample gms.	Moisture Lost gms.	Percent Moisture
6	1	5.590	1.316	23.5
	2	6.069	Lost	
	3	5.814	0.686	x11.8
	4	5.152	0.753	14.4
	5	7.482	4.048	x54.2
	6	4.862	1.096	22.6
			Average	<u>20.2</u>
7	1	5.569	0.884	15.9
	2	5.788	1.109	19.2
	3	5.857	1.776	30.3
	4	4.489	0.759	16.9
	5	5.389	2.165	x40.2
	6	5.277	0.590	11.0
			Average	<u>18.7</u>
8	1	3.424	0.226	6.6
	2	4.730	0.436	9.2
	3	5.286	1.205	22.8
	4	2.381	0.037	1.6
	5	4.985	1.316	26.4
	6	3.619	0.056	1.6
			Average	<u>11.4</u>
9	1	3.677	0.027	0.8
	2	3.496	0.038	1.1
	3	3.860	0.606	15.7
	4	3.659	0.119	3.3
	5	4.462	0.524	11.8
	6	3.030	0.035	1.2
			Average	<u>5.7</u>
10	1	2.460	0.105	4.3
	2	4.673	0.032	0.7
	3	3.480	0.043	1.2
	4	4.045	0.048	1.2
	5	6.002	0.482	8.0
	6	2.384	0.094	4.0
			Average	<u>3.2</u>

x Value omitted in average.

TABLE III (Cont.)
MOISTURE CONTENT DATA

Run 1

Sample No.	Tray No.	Wt. Wet Sample gms.	Moisture Lost gms.	Percent Moisture
11	1	4.045	0.001	0.0
	2	4.180	Lost	
	3	3.913	0.258	6.6
	4	5.576	0.349	6.3
	5	4.356	0.009	0.2
	6	3.992	0.032	0.8
			Average	<u>2.8</u>
12	1	2.842	Lost	
	2	3.727	Lost	
	3	3.786	0.022	0.6
	4	3.039	0.010	0.3
	5	3.040	0.012	0.4
	6	2.984	0.016	0.5
			Average	<u>0.5</u>
13	1	4.175	Lost	
	2	5.867	0.006	0.1
	3	4.662	0.597	x12.6
	4	3.951	0.303	7.7
	5	5.131	0.719	x14.0
	6	3.450	0.018	0.5
			Average	<u>2.8</u>
14	1	2.938	Lost	
	2	3.689	0.008	0.2
	3	5.340	0.052	1.0
	4	4.917	0.010	0.2
	5	4.611	0.046	1.0
	6	5.469	0.035	0.6
			Average	<u>0.6</u>
15	1	4.674	Lost	
	2	4.667	Lost	
	3	4.566	0.297	6.5
	4	4.407	0.040	0.9
	5	4.510	0.029	0.7
	6	4.567	0.017	0.4
			Average	<u>2.1</u>

x Value omitted in average.

DRYING CURVE I

TEMP. 180°F - HUM. 29%

RUN 1

PERCENT MOISTURE

TIME IN HOURS

TABLE IV
RATE OF DRYING DATA

Run 1

Sample No.	Percent Moisture (From Curve)	Wt. Wet Cake lbs.	Wt. Dry Cake lbs.	Moisture Present lbs.	Moisture Lost lbs.	Lbs. H ₂ O/ 100 lbs. Dry Solid	Lbs. H ₂ O Evaporated /hr./sq.ft/
1	53.8	283	131	152	-	116.0	- - -
2	51.0	266	131	135	17	103.2	0.211
3	47.2	248	131	117	18	89.3	0.233
4	41.8	224	131	93	24	71.0	0.298
5	34.3	199	131	68	25	51.8	0.310
6	20.3	164	131	33	35	25.2	0.434
7	18.7	161	131	30	3	22.9	0.037
8	10.8	146	131	15	15	11.4	0.186
9	6.4	140	131	9	6	8.9	0.074
10	4.4	137	131	6	3	4.6	0.037
11	3.1	135	131	4	2	3.1	0.025
12	2.2	134	131	3	1	2.3	0.012
13	1.6	133	131	2	1	1.5	0.012
14	1.4	132	131	1	1	0.8	0.012
15	1.3	132	131	1	0	0.8	0.000

RATE OF DRYING CURVE II

TEMP 180°F

HUM 29%

RUN 1

The drying conditions for Run 1 were a constant temperature of 180°F., and a humidity of approximately 2.9%. The supply of air was taken at atmospheric conditions from the room, without recirculation of humidification with steam.

Drying Curve I shows a rapid decrease in moisture content during the first ten hours of the run. The decrease during the next two hours was very low, after which the moisture content again decreased very rapidly for about four hours, and then approached an equilibrium condition with the drying air.

Rate of Drying Curve II indicates an increase in the rate of drying during the first twelve hours (a to b). During the next two hours the rate of drying decreases to a low value (b to c), again increases (c to d), and then drops to zero.

TABLE VI
MOISTURE CONTENT DATA

Run 2

Sample No.	Tray No.	Wt. Wet Sample gms.	Moisture Lost gms.	Percent Moisture
1	1	5.513	2.666	48.3
	2	5.381	2.546	47.9
	3	5.753	2.803	48.7
	4	4.787	2.723	47.1
	5	6.088	2.926	48.3
	6	5.453	2.477	45.4
			Average	47.8
2	1	6.038	2.090	51.2
	2	5.436	2.630	48.4
	3	5.439	2.581	47.4
	4	5.129	2.258	43.9
	5	5.707	Lost	
	6	5.233	Lost	
			Average	47.7
3	1	6.217	2.856	46.0
	2	5.126	2.231	43.6
	3	5.520	2.463	44.6
	4	5.423	2.399	44.3
	5	5.256	2.509	47.8
	6	4.693	2.036	43.4
			Average	45.0
4	1	6.304	2.647	42.0
	2	5.522	2.312	41.8
	3	5.625	2.269	40.0
	4	4.867	1.943	40.0
	5	5.417	2.541	46.8
	6	3.782	1.347	35.6
			Average	41.1
5	1	6.308	2.597	41.2
	2	5.426	2.283	42.1
	3	4.973	1.865	37.6
	4	5.343	2.014	37.7
	5	5.725	2.340	41.9
	6	6.407	2.091	32.6
			Average	38.9

TABLE VI (Cont.)
MOISTURE CONTENT DATA

Run 2

Sample No.	Tray No.	Wt. Wet Sample gms.	Moisture Lost gms.	Percent Moisture
6	1	7.228	2.688	37.2
	2	5.005	1.694	33.9
	3	4.992	1.697	35.0
	4	7.278	2.369	32.6
	5	6.891	2.320	33.7
	6	3.854	1.202	31.2
			Average	<u>33.8</u>
7	1	5.711	1.851	32.4
	2	6.001	1.973	32.9
	3	6.234	2.206	35.4
	4	7.184	2.790	x38.9
	5	6.189	2.488	x40.2
	6	6.189	2.488	x40.2
			Average	<u>33.8</u>
8	1	5.790	1.732	29.9
	2	4.081	1.183	29.0
	3	6.955	2.013	29.0
	4	5.094	1.259	24.8
	5	5.808	1.733	29.8
	6	5.093	1.167	22.9
			Average	<u>27.6</u>
9	1	5.739	1.507	27.3
	2	6.671	1.682	25.2
	3	5.981	1.336	22.4
	4	5.883	1.371	23.3
	5	6.852	1.894	27.6
	6	4.764	0.520	10.9
			Average	<u>22.6</u>
10	1	6.273	1.342	21.4
	2	6.972	1.275	18.3
	3	7.283	1.551	21.3
	4	6.144	0.676	11.0
	5	6.491	0.984	15.2
	6	5.460	0.598	11.0
			Average	<u>16.4</u>

x Value omitted in average.

TABLE VI (Cont.)
MOISTURE CONTENT DATA

Run 2

Sample No.	Tray No.	Wt. Wet Sample gms.	Moisture Lost gms.	Percent Moisture
11	1	4.426	0.903	20.4
	2	6.829	0.933	13.7
	3	3.857	0.601	15.6
	4	4.831	0.678	14.0
	5	5.688	1.075	18.9
	6	5.044	0.526	10.4
			Average	15.5
12	1	6.224	0.694	11.1
	2	7.539	1.104	14.7
	3	6.322	0.668	10.6
	4	5.409	0.498	9.2
	5	8.279	1.433	17.4
	6	4.744	0.262	5.5
			Average	11.4
13	1	6.830	0.655	9.6
	2	3.964	0.378	9.5
	3	6.162	0.550	8.9
	4	5.855	0.650	11.1
	5	5.742	0.898	15.6
	6	5.193	0.172	3.3
			Average	9.7
14	1	6.544	0.584	8.9
	2	6.274	0.567	9.0
	3	4.865	0.800	10.3
	4	3.173	0.085	x 2.7
	5	3.808	0.266	7.0
	6	4.544	0.134	3.0
			Average	7.6
15	1	5.856	0.488	8.3
	2	5.985	0.520	8.7
	3	4.643	0.383	8.3
	4	6.338	0.612	9.6
	5	6.157	0.896	x14.5
	6	4.495	0.120	2.7
			Average	7.5

x Value omitted in average.

DRYING CURVE III

TEMP. 140°F - HUM. 15%

RUN 2

TABLE VII
RATE OF DRYING DATA

Run 2

Sample No.	Percent Moisture (From Curve)	Wt. Wet Cake lbs.	Wt. Dry Cake lbs.	Moisture Present lbs.	Moisture Lost lbs.	Lbs. H ₂ O/ 100 lbs. Dry Solid	Lbs. H ₂ O Evaporated /hr./sq.ft.
1	47.8	296	154	142	-	92.2	- - -
2	47.3	293	154	139	3	90.2	0.037
3	45.0	281	144	127	12	82.4	0.149
4	41.7	265	154	111	16	72.1	0.198
5	38.1	249	154	95	16	61.7	0.198
6	33.8	233	154	79	16	51.3	0.198
7	33.8	233	154	79	0	51.3	0.000
8	27.5	213	154	59	20	38.3	0.248
9	21.8	197	154	43	16	27.9	0.198
10	16.3	185	154	31	12	20.1	0.149
11	15.4	182	154	28	3	18.2	0.037
12	11.4	174	154	20	8	13.0	0.099
13	9.1	170	154	16	4	10.4	0.050
14	7.8	167	154	13	3	6.4	0.037
15	7.2	166	154	12	1	5.8	0.012

RATE OF DRYING CURVE IV

TEMP 140°F HUM 15%

RUN 2

H₂O EVAP/H₂O/50 FT

H₂O / 100 # DRY SOLID

The drying conditions for Run 2 were a constant temperature of 140°F., and a humidity of 15%. The drying air was 63% recirculated and mixed with steam to the desired humidity.

Drying Curve III indicates a steady decrease in the moisture content during the first two hours. In the next two hours the loss is negligible, and the following six hours show a steady decrease. The next two hours show a slight decrease, after which the percent moisture slopes off toward the end of the run.

Rate of Drying Curve IV shows a rapid increase (a to b), followed by a period of constant rate (b to c), after which the rate drops to zero at d. It again increases (d to e), followed by a falling rate period (e to f). The rate of drying increases (f to g), and then decreases towards the end of the run.

TABLE VIII

LOG SHEET

Run 3

Department of Chemical Engineering

Speed Scientific School

University of Louisville

DRYING OF PRUSSIAN BLUE

Psychrometer Chart No. 3

Date: 2/15/34

Plant Record Data

Laboratory Data

Name: C. P. Blue
 Rx. No.: 4012
 Slip No.: 674
 Batch No.: A-1
 Date Struck: 2/13/34
 No. Trays Dried: 20
 Date In: 2/15/34

Batch Recd.: 2/14/34
 Batch Rtd.: 2/21/34

Drying Conditions

Temperature: 180°F.
 Humidity: 15%

Inlet: Average Dry Bulb Temperature: 78°F.
 Average Wet Bulb Temperature: 61°F.
 Average Absolute Humidity: 83%

Outlet: Average Dry Bulb Temperature: 151°F.
 Average Wet Bulb Temperature: 130°F.
 Average Absolute Humidity: 48%

Average Room Temperature: 79°F.
 Inlet Air Velocity: 198 ft./min.
 Percent Recirculation: 93%

Recorded Psychrometer Chart Temperatures: Dry Bulb: 180°F.
 Wet Bulb: 126°F.

Pan Data

Pan No.	Wt. of Cake Before Drying lbs.	Wt. of Cake After Drying lbs.	Wt. Moisture Lost lbs.
1	47.75	25.75	22.00
2	51.00	25.00	26.00
3	48.75	24.00	24.75
4	50.25	24.00	26.25
5	50.50	25.00	25.50
6	46.75	22.50	24.25
Totals	295.00	146.25	148.75

TABLE IX
MOISTURE CONTENT DATA

Run 3

Sample No.	Tray No.	Wt. Wet Sample gms.	Moisture Lost gms.	Percent Moisture
1	1	6.060	3.016	49.8
	2	6.009	3.254	54.1
	3	5.172	2.852	55.2
	4	6.170	3.296	53.4
	5	6.255	3.290	52.6
	6	5.416	2.884	52.5
			Average	<u>52.9</u>
2	1	5.827	2.822	48.4
	2	5.797	2.981	51.4
	3	4.991	2.724	54.5
	4	5.991	3.194	53.2
	5	5.851	3.039	51.9
	6	5.156	2.717	52.7
			Average	<u>52.0</u>
3	1	5.832	2.711	46.5
	2	5.864	3.019	51.1
	3	4.933	2.635	53.4
	4	5.895	3.027	51.3
	5	5.928	3.079	51.2
	6	4.300	2.132	49.1
			Average	<u>50.6</u>
4	1	5.784	2.596	44.8
	2	5.282	2.523	47.8
	3	4.511	2.345	52.1
	4	5.411	2.617	48.8
	5	5.644	2.745	48.7
	6	4.670	2.104	45.1
			Average	<u>47.8</u>
5	1	5.449	2.094	38.4
	2	5.438	2.510	46.0
	3	4.986	2.497	50.0
	4	5.335	2.306	43.2
	5	5.846	2.656	45.4
	6	4.986	1.979	39.7
			Average	<u>43.6</u>

TABLE IX (Cont.)
MOISTURE CONTENT DATA

Run 3

Sample No.	Tray No.	Wt. Wet Sample gms.	Moisture Lost gms.	Percent Moisture
6	1	5.250	2.016	38.4
	2	5.306	2.273	42.8
	3	4.343	2.024	46.7
	4	5.800	2.018	38.8
	5	5.525	2.441	44.2
	6	3.484	1.129	32.6
			Average	<u>40.6</u>
7	1	7.183	1.931	27.9
	2	5.308	2.017	38.0
	3	4.291	1.877	43.7
	4	8.919	2.605	29.2
	5	5.013	1.941	38.7
	6	7.117	2.133	29.7
			Average	<u>34.4</u>
8	1	9.022	2.327	25.8
	2	6.693	2.463	36.8
	3	6.516	2.453	37.7
	4	5.505	1.545	28.0
	5	6.719	2.635	39.2
	6	5.305	0.763	14.4
			Average	<u>30.3</u>
9	1	6.973	1.779	25.5
	2	5.982	1.261	21.1
	3	6.578	2.627	40.0
	4	5.438	2.984	18.1
	5	5.841	1.761	30.2
	6	4.532	0.538	11.9
			Average	<u>24.5</u>
10	1	5.688	1.274	22.4
	2	5.486	1.015	18.5
	3	6.598	1.653	25.0
	4	6.021	0.843	14.0
	5	6.660	1.306	19.6
	6	5.389	0.779	14.4
			Average	<u>19.0</u>

TABLE IX (Cont.)
MOISTURE CONTENT DATA

Run 3

Sample No.	Tray No.	Wt. Wet Sample gms.	Moisture Lost gms.	Percent Moisture
11	1	5.353	0.599	11.2
	2	6.173	0.633	10.2
	3	4.705	0.673	14.3
	4	5.051	0.551	10.9
	5	5.107	0.641	12.5
	6	4.551	0.148	3.3
			Average	<u>10.4</u>
12	1	3.248	0.089	2.8
	2	6.818	1.298	x19.1
	3	5.675	1.119	x19.7
	4	6.198	0.717	11.7
	5	5.684	0.383	5.9
	6	5.279	0.201	3.8
			Average	<u>6.1</u>
13	1	5.186	0.440	x 8.5
	2	6.132	0.559	9.1
	3	5.922	0.342	5.8
	4	6.637	0.470	7.1
	5	7.099	0.722	x10.2
	6	4.875	0.161	3.3
			Average	<u>6.3</u>
14	1	5.018	0.108	2.2
	2	7.053	0.129	1.8
	3	4.153	0.073	1.8
	4	5.916	0.158	2.7
	5	5.765	0.347	6.0
	6	5.089	0.154	3.0
			Average	<u>2.9</u>
15	1	3.247	0.034	1.1
	2	5.952	0.062	1.0
	3	4.486	0.059	1.3
	4	4.500	0.081	1.8
	5	4.776	0.118	2.5
	6	4.920	0.122	2.5
			Average	<u>1.7</u>

x Value omitted in average.

DRYING CURVE V

TEMP 180°F - HUM 15%

RUN 3

PERCENT MOISTURE

TIME IN HOURS

TABLE X
RATE OF DRYING DATA

Run 3

Sample No.	Percent Moisture (From Curve)	Wt. Wet Cake lbs.	Wt. Dry Cake lbs.	Moisture Present lbs.	Moisture Lost lbs.	Lbs. H ₂ O/ 100 lbs. Dry Solid	Lbs. H ₂ O Evaporated /hr./sq.ft.
1	52.8	295	139	156	-	112.2	- - -
2	52.3	292	139	153	3	110.0	0.037
3	50.5	281	139	142	11	102.2	0.137
4	47.5	265	139	126	16	90.7	0.198
5	44.1	249	139	110	16	79.2	0.198
6	40.1	232	139	93	17	66.8	0.211
7	35.2	215	139	76	17	54.7	0.211
8	30.2	199	139	60	16	43.2	0.198
9	24.8	185	139	46	14	33.1	0.174
10	18.6	171	139	32	14	23.0	0.174
11	11.3	157	139	18	14	12.9	0.174
11½	6.2	148	139	9	9	6.5	0.112
12	6.2	148	139	9	9 (0)	6.5	0.112 (0.0)
13	6.2	148	139	9	0	6.5	0.000
14	3.0	144	139	5	4	3.6	0.070
15	1.8	142	139	3	2	2.2	0.025

RATE OF DRYING CURVE III

TEMP 180°F HUM 15%

RUN 3

The drying conditions for Run 3 were a constant temperature of 180°F., and a constant humidity of 15%. The drying air was 93% recirculated, and mixed with steam to the desired conditions.

Drying Curve V shows a steady decrease in the percent moisture during the first twenty-one hours. For the next three hours the loss in moisture is practically zero, after which the percent moisture decreases till the end of the run.

Rate of Drying Curve VI indicates an increase in the rate of drying (a to b). The rate then remains constant from b to d, except for a slight dip at c. Next the rate of drying decreases sharply (d to e), again increases (e to f), and then decreases towards the end of the run.

TABLE XI

LOG SHEET

Run 4

Department of Chemical Engineering

Speed Scientific School

University of Louisville

DRYING OF PRUSSIAN BLUE

Psychrometer Chart No. 4

Date: 2/22/34

Plant Record Data

Laboratory Data

Name: C. P. Blue

Batch recd.: 2/21/34

Rx. No.: 4012

Batch Rtd.: 2/28/34

Slip No. 647

Batch No.: 3

Drying Conditions

Date Struck: 2/14/34

Temperature: 180°F.

No. Trays Dried: 20

Humidity: 20%

Date In: 2/21/34

Inlet: Average Dry Bulb Temperature: 75°F.
 Average Wet Bulb Temperature: 63°F.
 Average Absolute Humidity: 51%

Outlet: Average Dry Bulb Temperature: 151°F.
 Average Wet Bulb Temperature: 135°F.
 Average Absolute Humidity: 58%

Average Room Temperature: 76°F.
 Inlet Air Velocity: 170 ft./min/
 Percent Recirculation: 94%

Recorded Psychrometer Chart Temperatures: Dry Bulb: 180°F.
 Wet Bulb: 137°F.

Pan Data

Pan No.	Wt. of Cake Before Drying lbs.	Wt. of Cake After Drying lbs.	Wt. Moisture Lost lbs.
1	46.50	25.00	21.50
2	47.25	23.50	23.75
3	46.75	23.50	23.25
4	46.75	22.50	24.25
5	47.50	25.00	22.50
6	47.00	23.50	23.50
Totals	281.75	143.00	138.75

TABLE XII
MOISTURE CONTENT DATA

Run 4

Sample No.	Tray No.	Wt. Wet Sample gms.	Moisture Lost gms.	Percent Moisture
1	1	6.059	3.506	58.0
	2	5.902	3.597	60.9
	3	6.015	3.444	57.3
	4	6.187	3.633	58.8
	5	5.762	3.404	59.1
	6	6.085	3.548	58.2
			Average	<u>58.7</u>
2	1	5.592	3.216	57.5
	2	5.551	3.329	59.9
	3	5.520	3.157	57.2
	4	5.607	3.199	57.0
	5	5.517	3.269	59.3
	6	5.899	3.412	57.8
			Average	<u>58.1</u>
3	1	5.481	3.060	55.8
	2	5.829	2.255	57.5
	3	5.461	3.076	56.3
	4	4.881	2.747	56.2
	5	5.485	3.151	57.4
	6	5.538	3.125	56.6
			Average	<u>56.6</u>
4	1	5.534	3.032	54.6
	2	5.233	2.966	56.8
	3	5.119	2.829	55.3
	4	5.403	2.915	53.9
	5	5.809	3.374	58.0
	6	5.392	2.942	54.5
			Average	<u>55.6</u>
5	1	5.002	2.644	52.8
	2	5.397	2.990	55.4
	3	5.101	2.738	53.6
	4	4.687	2.431	51.8
	5	5.570	3.152	56.7
	6	5.009	2.658	53.0
			Average	<u>53.9</u>

TABLE XII (Cont.)
MOISTURE CONTENT DATA

Run 4

Sample No.	Tray No.	Wt. Wet Sample gms.	Moisture Lost gms.	Percent Moisture
6	1	4.645	2.362	50.8
	2	5.260	2.737	51.9
	3	5.073	2.628	51.9
	4	4.995	2.567	51.3
	5	5.298	2.993	56.4
	6	4.646	2.438	52.4
			Average	<u>52.4</u>
7	1	5.206	2.573	49.3
	2	5.182	2.715	52.3
	3	4.912	2.496	50.8
	4	5.079	2.421	47.7
	5	5.256	2.892	54.8
	6	4.625	2.234	48.3
			Average	<u>51.0</u>
8	1	4.410	2.051	46.6
	2	4.277	2.129	49.8
	3	4.819	2.372	49.2
	4	4.441	2.137	46.0
	5	4.851	2.628	54.2
	6	4.477	2.178	48.6
			Average	<u>49.4</u>
9	1	4.586	2.094	45.7
	2	5.044	2.223	44.2
	3	4.395	1.953	44.4
	4	4.347	1.743	40.1
	5	4.963	2.555	51.5
	6	4.562	2.085	45.8
			Average	<u>45.3</u>
10	1	4.749	1.994	42.0
	2	4.879	1.885	38.0
	3	4.732	2.125	44.8
	4	3.796	1.222	32.2
	5	4.760	2.325	48.2
	6	4.608	1.795	39.0
			Average	<u>40.8</u>

TABLE XII (Cont.)
MOISTURE CONTENT DATA

Run 4

Sample No.	Tray No.	Wt. Wet Sample gms.	Moisture Lost gms.	Percent Moisture
11	1	4.822	1.846	38.3
	2	3.816	1.297	33.9
	3	3.658	1.377	37.6
	4	4.738	0.852	18.0
	5	4.329	2.176	50.2
	6	4.590	2.174	x47.3
			Average	<u>35.6</u>
12	1	4.318	1.556	36.0
	2	4.451	1.514	34.0
	3	5.163	1.523	29.7
	4	6.056	1.560	x26.8
	5	3.606	1.743	48.4
	6	4.145	1.468	35.4
			Average	<u>36.7</u>
13	1	5.465	1.082	19.8
	2	6.672	1.599	23.9
	3	6.548	1.739	26.6
	4	5.464	0.505	9.2
	5	5.911	2.228	37.7
	6	6.693	1.118	16.7
			Average	<u>22.3</u>
14	1	7.121	1.569	22.1
	2	5.724	0.592	10.3
	3	6.121	0.702	11.5
	4	6.081	0.234	5.3
	5	7.145	1.861	26.0
	6	5.923	0.800	13.5
			Average	<u>14.8</u>
15	1	4.838	0.212	4.4
	2	4.434	0.435	9.8
	3	3.278	0.128	4.7
	4	4.614	0.214	4.6
	5	6.229	1.647	26.5
	6	5.587	0.295	5.2
			Average	<u>9.2</u>

x Value omitted in average.

TABLE XIII
RATE OF DRYING DATA

Run 4

Sample No.	Percent Moisture (From Curve)	Wt. Wet Cake lbs.	Wt. Dry Cake lbs.	Moisture Present lbs.	Moisture Lost lbs.	Lbs. H ₂ O 100 lbs. Dry Solid	Lbs. H ₂ O Evaporated /hr/sq.ft.
1	58.7	282	116	166	-	143.4	- - -
2	57.7	276	116	160	6	138.0	0.074
3	56.6	268	116	152	8	131.0	0.099
4	55.5	262	116	146	6	126.0	0.074
5	54.1	254	116	138	8	119.0	0.099
6	52.6	246	116	130	8	112.0	0.099
7	51.0	238	116	122	8	105.2	0.099
8	48.7	227	116	111	11	95.7	0.137
9	45.5	214	116	98	13	84.5	0.161
10	41.1	198	116	82	16	70.7	0.198
11	36.4	184	116	68	14	58.6	0.174
12	36.3	183	116	67	1	57.7	0.012
13	22.3	180	116	34	33	29.3	0.409
14	14.5	136	117	20	14	17.2	0.174
15	9.4	129	116	13	7	11.2	0.087

RATE OF DRYING CURVE VIII

TEMP 180°F

HUM 20%

RUN 4

H₂O / 100 # DRY SOLID

Drying Conditions for Run 4 were a constant temperature of 180°F. , and a humidity of 20%. The drying air was 94% recirculated and mixed with steam to the desired conditions.

Drying Curve VII indicates an increasing loss in moisture during the first twenty hours. For the next two hours the loss is practically zero, after which the loss is very rapid until the end of the run.

The Rate of Drying Curve VIII shows a slowly increasing rate (a to b). The rate next approaches zero (b to c), becomes very high (c to d), and then decreases rapidly until the end of the run.

SUMMARY

In summarizing the work on the air drying of Prussian Blue, it is well to include all of the work done, both in this investigation and in that performed by Schmied and Ardern (1). The curves (drying and rate of drying) resulting from these tests have similar characteristics with those of the previous work.

All of the tests give a drying curve which starts at approximately fifty percent moisture content, and drops off with a fairly steady slope for several hours. About midway on each curve there appears a "break", a period when the slope of the curve changes considerably, in some cases even becoming zero. After this "break" the drying continues steadily until the curve begins to level out parallel to the Time-axis.

The rate of drying curves are also similar to each other in character. During the early part of each run the curve shows an increasing or steady rate of drying. Corresponding to the "breaks" on the drying curves, the curves of rate of drying show an abrupt "dip", when for a period the drying rate is very low, or zero. After the

"dip" the rate of drying again becomes high, but decreases rapidly towards zero.

The rate of drying curves may be divided into two parts in the same manner as the theoretical drying rate curves. In Fig. 4 a typical rate curve of this investigation is compared with the theoretical curve of Newman (2). The first part of each of these curves corresponds to the theoretical constant rate period. During this part of the drying the cake is fairly soft, and evaporation of moisture at the exposed surface of the cake may be considered as the controlling factor in the drying.

That part of the drying curve containing and following the "dip" is equivalent to the theoretical falling rate period. The last portion of each curve following the dip, when the rate of drying is rapidly decreasing, is the zone where internal diffusion controls. During this part of the run the cake is dry, hard, and increasingly brittle, with a tendency to crumble.

The first and last portions of the Prussian Blue drying rate curves correspond well with the first period and the second zone of the second

FIGURE 4
COMPARISON OF RATE CURVES

THEORETICAL
SOLID

PRUSSIAN
BLUE

H₂O / 100 # DRY SOLID

H₂O EVAP / HR / SQ. FT.

period of the theoretical curve. However, the intermediate "dips" of the Prussian Blue curves are not as easily correlated with the theoretical zone of unsaturated surface drying. The question appears to be to explain these "dips".

It has been observed that the "dip" of the drying rate curve corresponds to the "break" on the drying curve. A comparison of the various drying curves is more easily obtained than of the different rate of drying curves. In order to obtain such a comparison, Table XIV has been prepared from the different drying curves of this investigation and of the previous work (1). It will be noticed that Runs 8 and 2-A each show two "breaks".

It is difficult to find any consistency about the moisture content at which "breaks" occur. It varies from six to thirty-six percent, the average being a little over twenty-two percent. There appears to be no correlation between temperature or humidity and the moisture content at the "break". Therefore, it may be concluded that the particular drying conditions have little to do with the occurrence of these "breaks".

TABLE XIV
COMPARISON OF AIR DRYING CURVES

Run No.	Temp. °F.	Humidity %	Time Hrs.	Initial Moisture Content %	Avg. Moist. Content at Break %	Final Moisture Content %
1	120	6.3	28	49.0	34.0	23.0
2	140	4.6	28	48.4	27.4	7.6
5	140	10	28	47.2	34.9	8.7
8	140	15	28	47.0	28.2 & 21.0	10.8
2-A	140	15	28	48.0	33.7 & 15.8	7.3
3	160	6.3	28	49.0	28.3	8.2
6	160	10	28	43.3	21.9	2.4
9	160	15	28	46.4	22.5	9.7
10	160	20	28	45.2	20.3	16.0
4	180	2.7	20	51.5	20.4	16.6
1-A	180	2.9	28	53.6	19.4	1.4
7	180	10	28	43.4	26.0	7.2
3-A	180	15	28	52.5	6.2	1.6
4-A	180	20	28	58.7	36.4	9.3

Runs Nos. 1-A, 2-A, 3-A, and 4-A from this investigation.
Other data from work of Schmied and Ardern (1).

The possibility that these "breaks" might signify a thermal decomposition of the Blue presented itself. The products of such a decomposition would be hydrogen cyanide, cyanogen and ammonia gases. Qualitative tests for these gases were made on the outlet air, and they were found present in minute quantities only in the very earliest part of the constant rate period.

It is suggested that the "break" is caused by a physical change rather than a chemical one. The constant rate period lasts until the residual free moisture in the pigment is removed. Then the drying becomes very slight, or ceases entirely, while the material undergoes a rearrangement of physical structure, with the resultant liberation of more or less water of crystallization.

Removal of this newly liberated moisture causes an increase in the rate of drying, but as the exposed surface is quite dry, internal resistance is the controlling factor in this drying, therefore the rate of drying decreases as the resistance increases.

The wide discrepancy in the occurrence of the "break" is believed due entirely to the chemical preparation of the blue, and is not dependent upon the particular conditions under which it is dried.

From Table XIV it will be observed that for any particular temperature, the final moisture content increases as the humidity increases. Also, for any humidity, the final moisture content decreases as the temperature increases. These facts may be explained from the fact that the higher the humidity the higher the equilibrium moisture content. But for any particular humidity, the higher the dry bulb temperature, the greater the driving force between wet and dry bulb temperatures, and therefore the lower the final moisture content.

Further investigations are now being conducted in these laboratories with the view of determining, if possible, the exact character of the "breaks" and "dips" of the drying and rate of drying curves in this study.

One series of tests are being conducted in the dryer, similar to the runs previously

discussed. In these runs thermocouples are placed above, below, and in various parts of the cake. The hypothesis is that the difference between the temperature of the cake itself and of the air above the cake will depend upon the rate of drying. The actual cake temperature should be much more nearly equal to the control temperature at the bottom of the "dip", when the drying rate is near zero, than on either side of it, when the drying is taking place more rapidly. Similarly, as the cake approaches its equilibrium moisture content, the drying rate diminishes, and there should be a corresponding rise in the cake temperature.

There is no agreement among previous investigators as to the amount of water of crystallization in Prussian Blue. Since an explanation of the drying rate "dips" on the basis of the breaking off of water of crystallization has been offered, it appeared desirable to endeavor to determine the exact water of crystallization content of Prussian Blue.

A series of tests for this water of crystallization are being conducted by drying a

small quantity of Blue rapidly by means of electric heat in an open crucible. A thermometer is placed in the center of the cake, and the crucible suspended on a balance, so as to read constantly the temperature and the loss in weight of the sample.

Other tests for this water of crystallization are being conducted by means of a closed pressure bomb. A sample of wet pigment is sealed in the bomb, which is then immersed in an oil bath and slowly heated. Readings of both temperature and pressure are made at regular short intervals.

It is believed that these additional investigations may be successful in better understanding the exact character of the unusual "dips" occurring throughout the rate of drying curves.

Sherwood (26) has proposed an extensive mathematical interpretation of the theoretical rate of drying curve. No mathematical discussion is offered here for the curves obtained in this investigation as the equations must necessarily be derived from the experimental work. Before obtaining such equations it is necessary to

determine exactly the character of the rate of drying curves, and the factors upon which the "dips" are dependent.

PART II**VACUUM DRYING**

THEORETICAL

The vacuum drying of solids constitutes one of those unit operations of Chemical Engineering about which very little is known. Only a small amount of work has been done towards the investigation of the theory of vacuum drying.

Ridgway (3) conducted a study of the vacuum drying of an inert solid sil-o-cel. He concluded that the drying took place in two divisions. The first consisted of a constant rate period, during which the loss in moisture progressed at a constant rate. The second was a falling rate period, during which the rate of drying was decreased.

The conclusions offered by Ridgway (3) are that during the first period water is actually boiling out of the solid, and the drying is fairly uniform throughout the cake. A point is reached at which the surface is fairly dry, after which evaporation takes place principally in the interior of the cake. This is the falling rate period, when diffusion of vapor through the cake is the controlling factor. The assertion that actual boiling occurs during the early stages of vacuum drying is also made by Berthold Block (27).

In his experimental work Ridgway (3) determined the actual temperature within the cake during the drying. The results indicated that the temperature throughout the cake remained constant until the solid was fairly dry. The cake temperature then rose rapidly, approaching the actual dryer temperature.

During the constant temperature period the cake temperature was equal to the temperature at which water would boil under the pressure existing within the dryer. When the cake became fairly dry throughout the raising of the cake temperature until it was equal to the control temperature of the dryer indicated that the solid had reached equilibrium and that the drying had ceased.

In this investigation it was desired to study the mechanism of the drying of Prussian Blue in vacuum, and to compare the drying of this commercial solid with the drying of the inert solid, sil-o-cel. It was proposed that the phenomena regarding cake temperatures would be the same for the two solids, provided the Prussian Blue cake dried in the same manner as the inert material.

It was further suggested that, if the drying curve in vacuum showed the same "bump" as that found in air drying, a period when little or no drying was taking place, there would appear a corresponding rise in the cake temperature, followed by a decrease when the evaporation was resumed.

EXPERIMENTAL

A. APPARATUS and OPERATION

The apparatus used in this investigation consisted of a standard vacuum shelf dryer, with its auxiliary equipment, and other apparatus necessary in obtaining the experimental data.

The dryer was a commercial four-tray unit constructed by the Buffalo Foundry and Machine Company of Buffalo, New York. Fig. 5 is a photograph of the dryer.

The drying compartment was a single heavy cast-iron shell supported on four legs. The front of the dryer was a heavy door, fastened by screw clamps, and sealed by a gasket between it and the dryer shell. In the door were two glass port-holes for observing the action within, and a valve for breaking the vacuum.

Material to be dried was placed on four shallow pans, twenty-four inches square. One of these rested on the bottom of the dryer shell, the others on three shelves. These shelves were steam-jackets, connected through manifolds to inlet steam and exhaust lines, and were the source of heat for the dryer.

Figure 5

VACUUM DRYER

At the time the vacuum dryer was used, the individual copper-constantan cold junctions were placed in a thermos bottle in order to maintain them at constant temperature. The copper leads from the

The standard auxiliary equipment for the dryer consisted of a water-jacketed surface condenser mounted on a liquid receptacle, and a water-cooled vacuum pump. The condenser was located between the dryer and the pump.

A steam pressure gauge on the outlet manifold aided in maintaining constant drying temperature. An U-tube manometer was utilized in measuring the vacuum. Both steam and vacuum were controlled by means of needle valves.

In order to obtain data on actual temperatures within the dryer ten Copper-Constantan thermocouples were used. Fig. 6 illustrates the method in which these couples were brought from the inside of the dryer, through an air-tight seal, to the instrument board. This seal was formed passing the thermocouple wires through a rubber stopper wedged into the branch of the pipe through which the vacuum was maintained.

At the instrument board the ten individual Copper-Constantan cold junctions were placed in a thermos bottle in order to maintain them at constant temperature. The copper leads from the

FIGURE 6
SKETCH OF VACUUM DRYER

cold junctions were connected to two switches, from which copper wires ran to a Leeds and Northrup Potentiometer Indicator. This instrument had a manual cold-end compensator for correcting the thermocouple cold-end temperature in the thermos bottle to zero degrees Centigrade, whereby it was possible to obtain directly the temperature from the millivolt reading by means of a conversion table (28).

At regular intervals throughout each run samples were taken from the dryer for the purpose of obtaining moisture content data. In the early stages of the runs a cork borer was used in obtaining these samples, until the cake had hardened to the point where a knife was necessary. These samples were placed on watch glasses, weighed and dried in an electric oven before final weighing.

Steam for all of these runs was obtained from a small laboratory boiler. The material used in these tests was a commercial Prussian Blue pigment manufactured by the Kentucky Color and Chemical Company, as described in Part I.

B. EXPERIMENTAL WORK

A total of twelve experimental runs were made at different conditions of temperature and vacuum, as indicated in Table XV. No runs were longer than twelve hours duration, while at those conditions at which the material dried in less time than that the run was terminated when the cake temperatures indicated the material was completely dry.

Two cakes, each equal to one-fourth of a standard filter cake were used in each run. These cakes measured eleven inches square, by about one and one-fourth inches thick.

Temperatures were obtained within the dryer by the placing of ten thermocouples as indicated in Fig. 6. No. 1 was placed between the top tray and the dryer shelf, and was used as the control point for maintaining constant temperature. Nos. 2, 3 and 4 were placed at the top, middle, and bottom respectively of the top cake, and Nos. 5, 6 and 7 in corresponding positions in the lower cake. No. 8 was placed in the vapor space between the top of the lower cake and the bottom of

TABLE XV

TEMPERATURE - VACUUM CONDITIONS OF RUNS

Run No.	Temperature °C.	Vacuum " Hg.
1	100	18
2	110	18
3	120	18
4	130	18
5	100	22
6	110	22
7	120	22
8	130	22
9	100	26
10	110	26
11	120	26
12	130	26

the dryer shelf above. No. 9 was in the outlet pipe leading to the condenser and pump, while No. 10 gave the temperature of the top of the dryer shell.

Temperature readings on these thermocouples were taken every fifteen minutes throughout each run. The millivolt readings were converted to temperatures by the conversion table (28), allowances made for the known correction factors (3), and the correct temperatures in degrees Centigrade recorded directly in the data book.

Samples for the determination of the moisture contents were taken from each tray at half-hour intervals, weighed immediately, dried for forty-eight hours at a temperature of seventy to eighty degrees Centigrade, and weighed again. From the weight of the dry sample and the weight of moisture lost, the grams of moisture per gram of dry solid was calculated for each sample.

The filled trays were also weighed before and after each run in order to determine the total moisture lost by the entire cake.

It was necessary to break the vacuum in order to obtain the moisture content samples. This was done by opening the valve in the door of the dryer. The total operation of getting the samples and returning the dryer to the correct vacuum required from three to five minutes for each sampling.

RESULTS

The information contained in the Log Sheets was taken directly from the records made of each run in the laboratory. In particular, the Plant Record Data was the record kept by the Kentucky Color and Chemical Company on the pigment used. The figure for the Average Control Temperature was an average of the quarter-hour readings on the control thermocouple between the top tray and the shelf.

Tables of Cake Temperature Data are a record of readings made on thermocouples in the top, middle and bottom of each cake. Individual plottings of each thermocouple (not included) were made, and were the basis for the elimination of a few values before calculation of the average temperatures for each tray. From these average temperatures the Cake Temperature Curves were plotted.

Data in the Moisture Content Tables were obtained from the small samples taken off each tray at half-hour intervals. Weights of these samples were expressed as grams moisture per gram dry solid, from which the Drying Curves were plotted.

TABLE XVI

LOG SHEET

Run 1

Department of Chemical Engineering

Speed Scientific School

University of Louisville

DRYING OF PRUSSIAN BLUE

Date: 4/25/34

Temperature: 100°C.

Vacuum: 18"Hg.

Plant Record Data

Laboratory Data

Name: Steel Blue

Batch Recd.: 4/25/34

Rx. No.: 4006

Batch Rtd.: 4/27/34

Slip No.: 731

Batch No.: 4

Date Struck: 3/29/34

Avg. Control Temp: 99.93°C.

No. Trays Dried: 1

Date In: 4/25/34

Tray Data

Tray No.	Wt. of Cake Before Drying lbs.	Wt of Cake After Drying lbs.	Wt. Moisture Lost lbs.
1	5.50	2.75	2.75
2	6.00	2.75	3.25
Total	<u>11.50</u>	<u>5.50</u>	<u>6.00</u>

TABLE XVII
CAKE TEMPERATURE DATA

Run 1

Time Hrs.	Temperature in °C.							
	#2	Tray 1 #3	#4	Avg.	#5	Tray 2 #6	#7	Avg.
0.25	37.5	34.5	32.0	34.7	34.5	35.5	38.0	36.0
0.50	44.5	44.0	41.5	43.3	43.0	45.5	48.0	45.5
0.75	56.0	54.5	53.0	54.5	54.0	55.5	57.0	55.5
1.00	63.0	62.5	62.0	62.5	62.0	61.5	63.0	62.2
1.25	67.0	66.5	68.0	67.2	68.5	68.0	67.5	68.0
1.50	68.0	69.0	70.0	69.0	71.0	70.5	71.0	70.8
1.75	70.0	70.0	71.0	70.3	71.0	70.5	70.0	70.5
2.00	71.0	71.5	71.5	71.3	71.0	70.5	70.0	70.5
2.25	71.0	71.0	71.0	71.0	70.5	70.0	70.0	70.2
2.50	71.0	71.0	72.0	71.3	71.0	70.5	70.0	70.5
2.75	71.0	71.0	72.0	71.3	71.0	70.0	70.5	70.5
3.00	73.0	72.5	73.5	73.0	70.0	68.5	68.5	68.7
3.25	72.0	72.0	72.0	72.0	70.0	68.0	67.5	68.5
3.50	73.0	72.5	73.0	72.8	69.0	68.5	67.5	68.3
3.75	73.5	73.0	73.0	73.2	69.5	67.0	67.0	67.8
4.00	73.0	73.0	73.0	73.0	69.0	67.5	67.0	67.8
4.25	72.5	72.0	72.0	72.2	68.0	67.0	67.0	67.2
4.50	71.5	71.5	71.5	71.5	67.5	66.0	65.5	66.3
4.75	71.0	71.0	71.0	71.0	68.0	66.0	65.0	66.3
5.00	69.0	69.0	69.0	69.0	69.0	69.0	68.0	68.6
5.25	70.0	70.5	70.5	70.3	69.0	68.5	67.5	68.3
5.50	71.0	71.0	70.5	70.8	70.0	69.0	68.5	69.2
5.75	71.0	70.5	70.0	70.5	68.5	67.5	67.0	67.6
6.00	71.5	71.5	71.5	71.5	69.0	67.0	68.0	68.0
6.25	72.0	72.0	71.5	71.5	70.0	68.5	68.5	69.0
6.50	71.0	71.5	71.0	71.2	70.0	69.5	68.5	69.3
6.75	72.0	72.0	71.5	71.8	70.0	68.5	68.5	69.0
7.00	72.0	72.0	71.0	71.6	70.0	68.5	68.5	69.0
7.25	72.0	72.0	70.5	71.5	71.0	68.5	68.0	69.2
7.50	70.0	71.5	69.0	70.2	69.0	67.5	66.0	67.5
7.75	68.0	68.0	68.0	68.0	66.0	65.5	64.5	65.3
8.00	72.0	71.5	71.0	71.5	69.0	67.5	66.5	67.3
8.25	72.0	71.5	72.0	71.8	72.0	69.5	71.0	70.8
8.50	73.0	72.5	73.0	72.8	72.0	71.0	71.0	71.3
8.75	71.0	70.5	71.0	70.8	71.0	69.5	68.5	69.7
9.00	71.5	72.0	72.0	71.8	72.0	71.0	71.0	71.3

TABLE XVII (Cont.)
CAKE TEMPERATURE DATA

Run 1

Time Hrs.	Temperatures in °C.							
	Tray 1				Tray 2			
	#2	#3	#4	Avg.	#5	#6	#7	Avg.
9.25	72.0	71.0	71.5	71.5	71.5	70.5	71.5	70.8
9.50	72.0	71.0	71.5	71.5	71.5	70.5	69.5	70.5
9.75	71.5	70.5	71.5	70.8	70.5	71.0	70.5	70.7
10.00	72.0	71.0	71.5	71.5	71.5	70.5	71.5	70.8
10.25	71.0	71.5	71.0	71.2	71.0	69.5	70.0	70.2
10.50	72.0	72.0	72.5	72.2	71.5	70.5	71.0	71.0
10.75	71.0	70.5	72.0	71.2	70.0	68.5	68.5	69.0
11.00	72.5	72.0	72.0	72.2	71.5	70.0	70.0	70.5
11.25	72.0	71.5	72.0	71.8	69.0	67.0	67.0	67.7
11.50	73.0	72.0	71.5	72.2	71.0	70.5	70.5	70.8
11.75	67.0	66.5	64.5	66.0	68.0	68.5	68.5	68.5
12.00	68.0	66.0	64.5	66.2	69.5	70.0	70.5	70.0

CAKE TEMPERATURE CURVE IX

TEMP 100°C.

VACUUM 18" Hg.

RUN 1

TABLE XVIII
MOISTURE CONTENT DATA

Run 1

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist. per Gm. Dry Solid
0	1	4.56	2.21	2.35	1.063
	2	6.20	2.96	3.24	1.094
0.5	1	5.20	2.46	2.74	1.113
	2	4.74	2.37	2.37	1.000
1.0	1	5.10	2.57	2.53	0.985
	2	5.08	2.55	2.53	0.992
1.5	1	4.97	2.51	2.46	0.980
	2	5.35	2.68	2.67	0.997
2.0	1	4.57	2.42	2.15	0.888
	2	4.50	2.33	2.17	0.932
2.5	1	4.51	2.40	2.11	0.879
	2	4.62	2.46	2.16	0.878
3.0	1	7.42	4.26	3.16	0.742
	2	5.56	3.16	2.40	0.759
3.5	1	5.48	3.17	2.31	0.728
	2	7.42	4.08	3.34	0.818
4.0	1	5.74	3.49	2.25	0.645
	2	6.67	3.82	2.85	0.746
4.5	1	6.18	3.83	2.35	0.614
	2	4.43	2.55	1.88	0.737
5.0	1	7.98	4.63	3.35	0.724
	2	6.8	3.42	2.76	0.808
5.5	1	6.80	3.96	2.85	0.718
	2	4.44	2.49	1.95	0.783
6.0	1	6.67	3.91	2.76	0.706
	2	6.56	3.92	2.64	0.673

TABLE XVIII (Cont.)

MOISTURE CONTENT DATA

Run 1

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist. per Gm. Dry Solid
6.5	1	6.25	3.78	2.47	0.653
	2	7.32	4.54	2.78	0.612
7.0	1	6.45	3.83	2.62	0.683
	2	7.78	4.31	3.47	0.805
7.5	1	6.70	4.53	2.17	0.478
	2	5.87	3.39	2.48	0.731
8.0	1	5.10	3.93	1.17	0.399
	2	4.86	3.17	1.69	0.533
8.5	1	4.54	2.95	1.59	0.539
	2	5.51	3.39	2.12	0.625
9.0	1	3.27	2.25	1.02	0.453
	2	5.82	3.88	1.94	0.500
9.5	1	2.35	1.89	0.46	0.244
	2	6.27	4.31	1.96	0.455
10.0	1	5.11	4.25	0.86	0.202
	2	3.51	2.37	1.14	0.488
10.5	1	2.99	2.03	0.94	0.458
	2	4.54	3.27	1.27	0.388
11.0	1	6.41	4.99	1.42	0.284
	2	5.75	4.20	1.55	0.369
11.5	1	7.00	5.50	1.95	0.386
	2	7.10	5.26	1.84	0.350
12.0	1	3.41	2.55	0.86	0.298
	2	6.18	5.48	0.70	0.128

DRYING CURVE X

TEMP 100 °C VACUUM 18" Hg.

RUN 1

TABLE XIX

LOG SHEET

Run 2

Department of Chemical Engineering
 Speed Scientific School University of Louisville

DRYING OF PRUSSIAN BLUE

Date: 4/28/34

Temperature: 110°C.

Vacuum: 18" Hg.

Plant Record Data

Name: Steel Blue
 Rx. No.: 4006
 Slip No.: 731
 Batch No.: 4
 Date Struck: 3/29/34
 No. Trays Dried: 1
 Date In: 4/27/34

Laboratory Data

Batch Recd.: 4/27/34
 Batch Rtd.: 4/30/34
 Avg. Control Temp: 109.91°C.

Tray Data

Tray No.	Wt. of Cake Before Drying lbs.	Wt. of Cake After Drying lbs.	Wt. Moisture Lost lbs.
3	7.50	4.00	3.50
4	7.25	4.00	3.25
Total	14.75	8.00	6.75

TABLE XX
CAKE TEMPERATURE DATA

Run 2

Time Hrs.	Temperatures in °C.							
	#2	Tray 1 #3	#4	Avg.	#5	Tray 2 #6	#7	Avg.
0.25	35.5	35.0	34.0	34.8	33.0	34.0	33.5	33.5
0.50	51.5	50.5	51.0	51.0	46.5	47.5	47.5	47.2
0.75	61.0	61.5	63.0	61.8	58.0	58.0	59.5	58.5
1.00	68.0	68.0	69.0	68.3	65.0	65.5	65.5	65.3
1.25	72.0	71.5	71.0	71.5	69.0	69.0	68.0	68.7
1.50	72.0	71.5	71.5	71.7	70.5	69.5	68.5	69.5
1.75	73.0	73.0	72.0	72.7	72.0	71.5	71.5	71.7
2.00	73.0	73.0	72.0	72.7	72.0	71.5	71.5	71.7
2.25	73.0	73.0	72.0	72.7	72.0	71.5	71.5	71.7
2.50	73.0	73.0	72.0	72.7	72.0	71.5	71.5	71.7
2.75	73.0	72.0	72.0	72.7	72.0	71.0	71.0	71.7
3.00	73.0	73.0	72.0	72.7	72.0	71.5	71.5	71.7
3.25	73.0	73.0	72.0	72.7	72.0	71.5	71.0	71.5
3.50	73.0	73.0	72.0	72.7	72.0	71.5	71.5	71.7
3.75	72.0	70.5	72.0	71.5	72.0	72.5	72.5	72.3
4.00	73.0	69.5	72.5	71.7	73.0	73.5	72.5	73.0
4.25	73.0	71.5	72.5	72.3	73.0	72.5	72.5	72.7
4.50	73.0	72.5	72.5	72.8	73.0	72.5	72.5	72.7
4.75	73.5	71.5	72.0	72.3	74.0	72.5	72.5	73.0
5.00	73.0	72.0	72.5	72.5	73.0	72.0	73.5	73.0
5.25	73.0	71.5	72.0	72.2	73.5	73.0	71.5	72.5
5.50	73.0	72.0	72.0	72.3	74.0	73.0	73.0	73.3
5.75	73.0	71.5	73.0	72.5	74.0	72.5	72.5	73.0
6.00	73.0	72.0	74.0	73.0	74.5	73.0	72.5	73.3
6.25	73.0	72.0	73.0	72.7	75.0	73.5	73.0	73.8
6.50	75.0	71.5	73.0	73.2	75.0	74.0	73.5	74.2
6.75	72.0	70.0	70.0	70.7	74.0	72.5	72.5	73.0
7.00	75.0	72.0	72.5	73.2	73.0	72.5	73.5	73.0
7.25	72.5	70.0	72.0	71.5	74.0	73.5	72.5	73.3
7.50	72.5	72.5	73.0	72.7	76.0	74.5	73.5	74.8
7.75	72.5	71.0	73.0	72.2	76.0	73.5	73.5	74.3
8.00	74.0	72.5	74.0	73.5	77.0	75.5	74.5	75.7
8.25	74.0	73.0	74.0	73.7	77.0	74.0	75.0	75.3
8.50	76.0	73.5	76.0	75.2	77.5	75.5	75.5	76.2
8.75	73.0	71.5	74.0	72.8	75.5	74.5	73.5	74.5
9.00	75.0	74.0	74.0	74.3	77.5	75.5	74.5	75.8

TABLE XX (Cont.)
CAKE TEMPERATURE DATA

Run 2

Time Hrs.	Temperatures in °C.							
	#2	Tray 1 #3	#4	Avg.	#5	Tray 2 #6	#7	Avg.
9.25	73.5	72.5	73.0	73.0	77.0	75.0	75.5	75.8
9.50	75.0	74.0	74.0	74.3	76.5	73.0	74.5	74.7
9.75	73.0	71.5	72.0	72.2	76.0	74.5	74.0	74.8
10.00	74.0	72.5	73.5	73.3	75.5	74.0	73.5	74.3
10.25	72.0	70.5	71.5	71.3	73.0	73.5	72.5	73.0
10.50	74.0	73.5	73.0	73.5	74.0	74.0	73.0	73.7
10.75	72.5	71.5	72.5	72.2	73.0	72.5	73.0	72.8
11.00	74.0	73.0	73.5	73.5	74.0	73.0	73.5	73.5
11.25	73.5	73.5	73.0	73.3	74.5	72.5	72.5	73.2
11.50	73.5	73.0	73.0	73.2	74.0	73.5	73.5	73.7
11.75	74.0	73.5	72.0	73.2	74.0	73.5	73.5	73.7
12.00	75.0	76.0	73.7	73.7	75.5	73.5	73.0	74.0

CAKE TEMPERATURE CURVE XI

TEMP 110°C. VACUUM 18" Hg.

RUN 2

TABLE XXI
MOISTURE CONTENT DATA

Run 2

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist. per Gm. Dry Solid
0	1	5.386	2.770	2.616	0.944
	2	5.732	2.802	2.930	1.047
0.5	1	4.870	2.635	2.217	0.835
	2	5.958	3.207	2.751	0.857
1.0	1	6.091	3.792	2.299	0.607
	2	5.031	2.751	2.280	0.828
1.5	1	6.788	3.791	2.997	0.791
	2	5.620	2.899	2.721	0.938
2.0	1	7.251	4.171	3.080	0.738
	2	7.325	3.986	3.337	0.837
2.5	1	6.424	3.613	2.811	0.778
	2	5.963	3.377	2.586	0.767
3.0	1	6.614	3.988	2.626	0.658
	2	5.006	2.921	2.085	0.714
3.5	1	6.813	4.077	2.736	0.671
	2	8.754	5.055	3.699	0.732
4.0	1	7.697	4.803	2.894	0.603
	2	7.659	4.706	2.953	0.628
4.5	1	9.100	5.753	3.347	0.582
	2	6.186	3.909	2.277	0.581
5.0	1	6.695	4.264	2.431	0.570
	2	6.210	3.961	2.249	0.568
5.5	1	7.710	4.896	2.814	0.575
	2	10.048	6.534	3.514	0.538
6.0	1	8.457	5.788	2.669	0.461
	2	8.927	6.044	2.883	0.478

TABLE XXI (Cont.)
MOISTURE CONTENT DATA

Run 2

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist. per Gm. Dry Solid
6.5	1	6.671	4.608	2.063	0.448
	2	6.024	4.051	1.973	0.487
7.0	1	6.701	5.401	1.300	0.241
	2	5.341	3.905	1.436	0.367
7.5	1	6.694	5.318	1.376	0.259
	2	7.717	5.683	2.034	0.358
8.0	1	3.795	3.131	0.664	0.313
	2	6.574	5.329	1.245	0.234
8.5	1	6.922	5.951	0.971	0.163
	2	4.603	3.967	0.636	0.160
9.0	1	7.450	5.964	1.486	0.249
	2	6.435	5.271	1.164	0.221
9.5	1	6.792	5.817	0.975	0.168
	2	5.078	4.243	0.835	0.197
10.0	1	4.901	4.200	0.701	0.167
	2	6.206	4.936	1.270	0.257
10.5	1	5.722	5.025	0.697	0.139
	2	8.519	6.952	1.567	0.225
11.0	1	6.212	5.471	0.741	0.135
	2	6.508	5.409	1.099	0.203
11.5	1	6.383	5.889	0.494	0.084
	2	5.374	4.790	0.584	0.122
12.0	1	6.932	6.380	0.552	0.087
	2	5.286	4.749	0.537	0.113

DRYING CURVE XII

TEMP 110 °C VACUUM 18 "Hg

RUN 2

TABLE XXII

LOG SHEET

Run 3

Department of Chemical Engineering

Speed Scientific School

University of Louisville

DRYING OF PRUSSIAN BLUE

Date: 5/3/34

Temperature: 120°C.

Vacuum: 18" Hg.

Plant Record Data

Laboratory Data

Name: Steel Blue
 Rx. No.: 4006
 Slip No.: 731
 Batch No.: 4
 Date Struck: 3/29/34
 No. Trays Dried: 5
 Date In: 4/30/34

Batch Recd.: 4/30/34
 Batch Rtd.: 4/12/34
 Avg. Control Temp: 120.41°C.

Tray Data

Tray No.	Wt. of Cake Before Drying lbs.	Wt. of Cake After Drying lbs.	Wt. Moisture Lost lbs.
3	6.25	3.25	3.00
4	6.75	3.25	3.50
Total	13.00	6.50	6.50

TABLE XXIII
CAKE TEMPERATURE DATA

Run 3

Time Hrs.	Temperatures in °C.							
	#2	Tray 1 #3	#4	Avg.	#5	Tray 2 #6	#7	Avg.
0.25	35.0	33.5	36.5	35.0	36.0	37.5	37.5	37.0
0.50	51.5	53.0	59.5	54.7	50.0	50.0	52.0	50.8
0.75	71.0	71.0	71.0	71.0	66.0	66.5	68.0	66.8
1.00	72.0	72.5	74.0	72.8	70.5	73.5	74.0	72.7
1.25	73.0	74.0	74.0	73.3	71.0	73.5	74.0	73.0
1.50	74.0	74.0	74.0	74.0	72.5	74.0	73.5	73.3
1.75	74.0	74.0	74.0	74.0	73.0	73.5	74.0	73.5
2.00	74.5	74.5	74.0	74.3	72.5	74.0	73.5	73.3
2.25	74.0	74.5	74.0	74.3	72.5	73.5	73.5	73.2
2.50	74.0	75.0	74.0	74.0	72.5	74.0	73.5	73.3
2.75	74.0	74.5	74.0	74.2	73.0	74.0	73.5	73.5
3.00	74.0	74.0	74.0	74.0	73.0	74.0	73.5	73.5
3.25	74.0	74.5	74.0	74.2	73.0	74.0	73.5	73.5
3.50	74.0	74.5	74.0	74.2	73.0	74.0	73.5	73.5
3.75	74.0	74.0	74.0	74.0	73.0	73.5	73.5	73.3
4.00	74.0	74.0	74.0	74.0	73.0	73.5	73.5	73.3
4.25	73.5	73.5	73.5	73.5	73.5	73.0	73.0	73.2
4.50	74.0	74.0	74.0	74.0	74.0	74.5	73.5	74.0
4.75	74.0	74.0	74.0	74.0	74.0	74.5	73.0	74.0
5.00	74.0	74.0	74.0	74.0	74.0	74.5	73.5	74.0
5.25	74.0	74.0	74.0	74.0	74.0	74.5	73.0	73.8
5.50	75.0	73.5	74.0	74.2	74.0	75.5	73.5	74.0
5.75	74.0	74.5	74.0	74.5	74.0	75.5	74.5	74.7
6.00	75.0	75.5	74.0	74.8	75.0	76.5	73.5	75.0
6.25	75.0	74.5	74.0	74.5	74.0	74.5	73.5	74.0
6.50	75.0	74.5	74.0	74.5	74.5	75.5	74.5	74.7
6.75	76.0	76.0	75.5	75.8	76.0	75.5	79.5	77.0
7.00	77.0	77.5	77.5	77.3	76.5	77.5	77.0	77.0
7.25	76.5	76.0	77.0	76.5	74.0	73.5	75.5	74.3
7.50	75.0	74.5	74.0	74.5	74.0	74.0	74.5	74.2
7.75	75.0	75.0	74.0	74.3	74.0	74.0	75.5	74.5
8.00	75.0	75.0	74.0	74.3	74.0	74.0	75.5	74.5
8.25	75.0	74.5	74.0	74.5	74.0	73.5	75.5	74.3
8.50	74.0	73.0	73.0	73.3	72.0	70.5	74.0	72.2
8.75	75.0	73.0	74.0	74.0	72.0	71.5	74.0	72.5
9.00	77.0	74.0	78.0	76.3	72.0	72.5	70.0	71.5

TABLE XXIII (Cont.)

CAKE TEMPERATURE DATA

Run 3

Time Hrs.	Temperatures in °C.							
	Tray 1				Tray 2			
	#2	#3	#4	Avg.	#5	#6	#7	Avg.
9.25	83.0	77.5	89.0	83.2	77.0	76.0	78.5	77.2
9.50	85.0	85.5	97.0	89.2	81.0	81.5	87.0	83.2
9.75	88.0	91.5	101.0	93.5	83.0	85.5	91.0	86.5
10.00	95.0	99.5	107.0	100.5	90.0	93.5	98.0	93.8
10.25	105.0	106.5	110.5	107.3	98.5	100.5	102.5	100.5
10.50	112.5	114.0	117.0	114.5	103.0	106.5	107.0	106.2
10.75	114.5	113.5	113.5	113.8	107.0	107.5	108.5	107.7
11.00	118.0	116.5	117.0	117.2	113.0	113.0	113.5	113.2
11.25	120.0	120.0	118.5	119.5	116.0	115.5	115.0	115.5
11.50	121.0	120.5	120.5	120.7	119.0	118.5	118.0	118.5

CAKE TEMPERATURE CURVE XIII

TEMP. 120 °C

VACUUM 18" Hg.

RUN 3

TABLE XXIV
MOISTURE CONTENT DATA

Run 3

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist per Gm. Dry Solid
0	1	5.509	2.732	2.777	1.018
	2	4.756	2.375	2.381	1.002
0.5	1	3.691	1.910	1.781	0.932
	2	3.826	1.954	1.872	0.958
1.0	1	5.638	3.046	2.595	0.860
	2	3.824	2.095	1.731	0.828
1.5	1	5.847	3.267	2.580	0.789
	2	7.216	3.859	3.357	0.869
2.0	1	4.334	2.650	1.684	0.635
	2	6.496	3.155	2.341	0.742
2.5	1	6.754	3.954	2.800	0.708
	2	6.466	3.579	2.887	0.807
3.0	1	5.672	3.472	2.200	0.634
	2	5.275	3.212	2.063	0.643
3.5	1	7.727	5.047	2.680	0.531
	2	6.046	3.662	2.384	0.652
4.0	1	5.327	3.656	1.671	0.457
	2	5.416	3.426	1.990	0.580
4.5	1	6.324	4.458	1.866	0.418
	2	6.721	4.905	1.816	0.370
5.0	1	6.039	4.584	1.455	0.318
	2	7.844	5.293	2.551	0.482
5.5	1	5.059	3.574	1.485	0.416
	2	6.351	4.409	1.942	0.441
6.0	1	4.736	4.022	0.714	0.178
	2	5.186	3.733	1.453	0.390

TABLE XXIV (Cont.)
MOISTURE CONTENT DATA

Run 3

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist. per Gm. Dry Solid
6.5	1	4.001	3.676	0.325	0.088
	2	4.934	3.661	1.273	0.348
7.0	1	5.193	4.638	0.555	0.120
	2	5.843	4.556	1.287	0.282
7.5	1	6.229	4.824	1.405	0.292
	2	4.467	3.634	0.833	0.230
8.0	1	6.244	5.021	1.223	0.244
	2	5.595	4.806	0.789	0.164
8.5	1				
	2	5.366	4.781	0.585	0.122
9.0	1	5.086	4.248	0.838	0.197
	2				
10.0	1	5.152	4.945	0.207	0.042
	2				
11.5	1	4.862	4.299	0.563	0.131
	2				

DRYING CURVE XIV

TEMP 120 °C VACUUM 18 "Hg

RUN-3

TABLE XXV

LOG SHEET

Run 4

Department of Chemical Engineering

Speed Scientific School

University of Louisville

DRYING OF PRUSSIAN BLUE

Date: 5/9/34

Temperature: 130°C.

Vacuum: 18" Hg.

Plant Record Data

Name: Steel Blue
 Rx. No.: 4008
 Slip No.: 731
 Batch No.: 4
 Date Struck: 3/29/34
 No. Trays Dried: 5
 Date In: 4/30/34

Laboratory Data

Batch Recd.: 4/30/34
 Batch Rtd.: 5/12/34
 Avg. Control Temp: 130.53°C.

Tray Data

Tray No.	Wt. of Cake Before Drying lbs.	Wt. of Cake After Drying lbs.	Wt. Moisture Lost lbs.
1	6.25	3.00	3.25
2	5.50	2.75	2.75
	<u>11.75</u>	<u>5.75</u>	<u>6.00</u>

TABLE XXVI
CAKE TEMPERATURE DATA

Run 4

Time Hrs.	Temperature in °C.							
	Tray 1				Tray 2			
	#2	#3	#4	Avg.	#5	#6	#7	Avg.
0.25	37.0	36.0	39.0	37.3	44.0	49.5	76.5*	46.7
0.50	50.5	47.0	51.1	49.5	65.0	67.5	74.0*	66.7
0.75	72.0	69.5	74.0	71.8	74.0	74.0	74.5	74.2
1.00	77.0	75.0	75.5	75.8	75.0	74.5	74.5	74.7
1.25	78.0	76.0	75.5	76.5	76.0	75.0	73.5	74.8
1.50	77.0	76.5	75.0	76.2	74.5	75.5	74.5	74.8
1.75	77.0	76.0	74.0	75.7	74.5	74.0	73.5	74.0
2.00	75.0	74.5	74.0	74.5	75.0	73.5	72.5	73.7
2.25	76.0	75.5	75.0	75.5	76.0	74.5	72.5	74.3
2.50	78.0	76.5	76.0	76.8	76.5	75.5	75.5	75.8
2.75	76.0	73.5	74.0	74.5	73.0	74.5	73.5	73.7
3.00	74.5	73.0	74.0	73.8	73.5	73.5	74.0	73.7
3.25	74.0	72.0	74.0	73.3	72.5	73.0	71.5	72.3
3.50	74.0	72.5	74.0	73.5	72.0	73.5	72.5	72.7
3.75	75.0	73.0	73.5	73.8	74.0	73.5	73.5	73.7
4.00	75.0	74.5	74.0	74.5	74.0	75.0	74.0	74.3
4.25	75.0	74.5	74.0	74.5	74.0	75.0	74.0	74.3
4.50	75.0	74.5	74.0	74.5	74.0	75.0	78.5	75.8
4.75	74.0	74.5	74.0	74.2	75.5	76.5	89.5	80.5
5.00	75.0	74.5	74.0	74.5	78.0	78.5	100.0	85.5
5.25	75.0	74.5	74.0	74.2	91.0	84.5	112.5	96.0
5.50	75.0	74.5	74.0	74.2	103.5	98.5	122.5	108.2
5.75	75.0	74.5	74.0	74.2	122.0	120.5	130.0	124.2
6.00	75.0	74.5	74.0	74.5	130.0	130.0	130.0	130.0
6.25	75.0	74.5	81.0	76.8	132.0	131.0	132.0	131.7
6.50	75.0	74.5	88.0	79.2	138.0	139.0	140.0	139.0
6.75	78.0	75.0	98.0	83.7	138.0	139.0	140.0	139.0
7.00	82.5	75.0	105.5	86.0	138.0	139.0	140.0	139.0
7.25	94.5	94.5	113.0	100.7	135.0	134.0	134.0	134.3
7.50	109.5	109.5	122.0	113.7	140.0	139.5	139.5	139.8
7.75	117.5	117.5	123.5	119.5	134.0	136.0	132.5	134.2
8.00	123.0	123.0	130.5	125.2	136.0	135.5	135.5	135.7

* Value omitted in average.

CAKE TEMPERATURE CURVE XV

TEMP. 130 °C VACUUM 18" HG

RUN 4

TABLE XXVII
MOISTURE CONTENT DATA

Run 4

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist per Gm. Dry Solid
0	1	4.066	3.108	0.948	0.308
	2	4.977	2.483	2.494	1.002
0.5	1	5.336	3.838	1.498	0.391
	2	4.726	2.619	2.107	0.805
1.0	1	6.248	3.388	2.860	0.844
	2	6.544	3.825	2.719	0.711
1.5	1	5.663	3.140	2.523	0.804
	2	6.074	2.673	3.401	1.273
2.0	1	5.714	2.871	2.843	0.992
	2	4.677	3.241	1.436	0.443
2.5	1	4.865	2.711	2.154	0.794
	2	4.375	3.043	1.332	0.438
3.0	1	5.476	3.202	2.274	0.710
	2	5.186	4.596	0.590	0.128
3.5	1	5.310	3.288	2.022	0.614
	2	4.010	3.365	0.645	0.192
4.0	1	5.507	3.485	2.022	0.580
	2	5.713	5.181	0.532	0.103
4.5	1	5.537	3.653	1.884	0.517
	2	4.287	3.920	0.367	0.094
5.0	1	6.097	4.175	1.922	0.460
	2	4.246	4.204	0.042	0.010
5.5	1	7.087	5.411	1.676	0.310
	2	5.569	5.527	0.042	0.008
6.0	1	6.210	4.859	1.351	0.278
	2	5.093	5.086	0.007	0.001

TABLE XXVII (Cont.)
MOISTURE CONTENT DATA

Run 4

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist per Gm. Dry Solid
6.5	1	4.547	3.674	0.873	0.238
	2	3.605	3.595	0.010	0.003
7.0	1	6.066	5.152	0.914	0.178
	2	3.708	3.703	0.005	0.001
7.5	1				
	2	4.818	3.873	0.945	0.242
8.0	1	5.565	5.559	0.006	0.001
	2	4.435	4.442		

DRYING CURVE XVI

TEMP 130 °C Vacuum 18" Hg

RUN 4

TABLE XXVIII

LOG SHEET

Run 5

Department of Chemical Engineering

Speed Scientific School

University of Louisville

DRYING OF PRUSSIAN BLUE

Date: 5/5/34

Temperature: 100°C.

Vacuum: 22" Hg.

Plant Record Data

Name: Steel Blue
 Rx. No.: 4006
 Slip No.: 731
 Batch No.: 4
 Date Struck: 3/29/34
 No. Trays Dried: 5
 Date In: 4/30/34

Laboratory Data

Batch Rcd.: 4/30/34
 Batch Rtd.: 5/12/34
 Avg. Control Temp: 100.55°C.

Tray Data

Tray No.	Wt. of Cake Before Drying lbs.	Wt. of Cake After Drying lbs.	Wt. Moisture Lost lbs.
4	6.75	3.00	3.75
3	6.75	3.25	3.50
Total	13.50	6.25	7.25

TABLE XXIX
CAKE TEMPERATURE DATA

Run 5

Time Hrs.	Temperatures in °C.							
	Tray 1				Tray 2			
	#2	#3	#4	Avg.	#5	#6	#7	Avg.
0.25	55.0	54.5	51.0	53.5	45.0	45.5	48.5	46.3
0.50	65.5	64.5	63.0	64.3	58.0	56.5	59.5	58.0
0.75	64.0	64.5	64.0	64.2	64.0	63.5	63.5	63.7
1.00	62.0	62.0	61.0	61.7	62.0	59.5	60.5	60.7
1.25	63.0	62.5	62.0	62.5	61.0	59.0	60.0	60.0
1.50	62.0	61.5	61.0	61.5	60.0	58.5	59.0	59.2
1.75	64.5	62.5	64.0	63.5	62.0	65.5	64.5	64.0
2.00	64.0	62.5	62.0	62.8	62.0	61.5	61.7	61.7
2.25	65.0	64.5	64.5	64.7	64.0	64.5	63.5	64.0
2.50	64.5	63.5	63.0	63.7	64.0	62.5	62.5	63.0
2.75	65.5	64.5	64.5	64.8	64.5	64.0	63.5	64.0
3.00	63.0	62.5	62.0	62.5	62.5	61.5	61.5	61.8
3.25	65.0	63.5	63.0	63.8	63.5	63.0	63.5	63.3
3.50	63.5	63.5	62.5	63.2	63.5	62.0	62.0	62.5
3.75	63.5	62.5	63.0	63.0	63.5	63.5	63.5	63.5
4.00	66.0	64.5	64.5	65.0	65.0	64.5	64.5	64.8
4.25	65.0	65.5	64.5	65.0	64.0	64.0	64.5	64.2
4.50	65.5	65.5	65.0	65.3	64.5	65.5	64.0	64.7
4.75	66.0	65.0	64.5	65.2	64.5	64.5	64.5	64.5
5.00	65.5	65.5	65.0	65.3	65.5	64.0	64.0	64.5
5.25	65.5	65.0	65.0	65.2	65.0	64.5	64.0	64.5
5.50	66.0	65.5	65.0	65.0	65.0	65.0	64.5	65.0
5.75	65.5	65.0	65.0	65.8	65.0	64.5	64.0	64.5
6.00	66.0	65.5	65.0	65.5	65.0	65.0	64.5	64.8
6.25	65.5	65.0	64.5	65.0	65.0	64.8	64.0	64.5
6.50	65.5	65.0	64.5	65.0	65.0	64.5	64.5	64.7
6.75	65.5	65.0	64.0	65.0	64.0	64.5	64.5	64.3
7.00	66.0	65.5	65.0	65.5	65.0	64.0	65.5	64.8
7.25	64.0	64.0	62.0	63.3	65.0	64.5	65.5	65.0
7.50	64.5	65.5	65.0	65.0	65.0	64.5	65.5	65.0
7.75	65.0	65.5	64.0	64.8	63.0	63.5	64.5	63.7
8.00	67.0	66.5	66.0	66.5	66.0	65.5	65.5	65.7
8.25	67.0	63.5	63.0	64.5	63.0	62.0	61.0	62.0
8.50	66.0	63.5	62.5	64.0	62.0	61.5	61.5	61.7
8.75	62.0	63.5	61.0	62.2	61.0	60.5	60.5	60.7
9.00	64.0	62.0	61.0	62.3	60.5	61.0	61.0	60.8

TABLE XXIX (Cont.)
CAKE TEMPERATURE DATA

Run 5

Time Hrs.	Temperatures in °C.							
	#2	Tray 1 #3	#4	Avg.	#5	Tray 2 #6	#7	Avg.
9.25	63.0	62.5	61.0	62.2	61.5	61.5	62.0	61.7
9.50	64.5	63.5	62.0	63.3	62.0	62.5	62.5	62.7
9.75	65.5	62.5	61.5	63.0	64.0	62.5	63.5	63.3
10.00	68.0	64.5	64.0	65.5	64.0	62.5	64.5	63.7
10.25	69.0	61.0	63.0	64.3	65.0	65.5	65.5	65.3
10.50	70.0	62.5	62.0	64.8	64.0	64.5	65.5	64.7
10.75	73.0	62.0	61.0	65.3	65.0	67.5	69.5	67.4
11.00	74.0	63.0	61.0	66.0	65.0	74.0	73.5	70.8
11.25	76.5	62.5	62.0	67.0	67.0	76.0	75.5	72.2
11.50	81.0	66.0	62.0	69.8	65.0	81.0	81.0	75.7
11.75	85.0	68.0	62.0	71.7	70.0	87.0	88.0	81.7
12.00	89.0	72.5	64.0	75.2	70.0	91.0	89.5	83.5

CAKE TEMPERATURE CURVE XVII

TEMP 100°C. VACUUM 22" Hg.

RUN 5

TABLE XXX
MOISTURE CONTENT DATA

Run 5

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist. per Gm. Dry Solid
0	1	3.445	1.743	1.702	0.975
	2	4.428	2.250	2.178	0.969
0.5	1	5.177	2.425	2.752	1.133
	2	3.628	1.912	1.716	0.897
1.0	1	4.755	2.308	2.447	0.061
	2	4.839	2.538	1.981	0.774
1.5	1	5.296	2.786	2.510	0.900
	2	4.915	2.815	2.100	0.746
2.0	1	6.631	3.419	3.212	0.939
	2	4.960	2.950	2.010	0.682
2.5	1	3.653	2.055	1.598	0.778
	2	5.314	3.066	2.248	0.733
3.0	1	5.164	3.058	2.106	0.688
	2	6.521	3.887	2.634	0.677
3.5	1	6.084	3.436	2.648	0.771
	2	6.771	4.177	2.594	0.622
4.0	1	6.572	3.869	2.703	0.698
	2	6.596	4.398	2.198	0.500
4.5	1	4.618	2.975	1.643	0.553
	2	6.988	4.605	2.383	9.518
5.0	1	6.389	4.172	2.217	0.531
	2	6.612	4.376	2.236	0.512
5.5	1	6.380	4.055	2.325	0.573
	2	5.077	3.738	1.339	0.358
6.0	1	6.281	4.086	2.195	0.537
	2	5.205	3.853	1.352	0.351

TABLE XXX (Cont.)
MOISTURE CONTENT DATA

Run 5

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist per Gm. Dry Solid
6.5	1	6.085	3.925	2.160	0.550
	2	6.828	5.225	1.603	0.307
7.0	1	4.726	3.446	1.280	0.371
	2	5.389	4.473	0.916	0.205
7.5	1	6.532	4.557	2.175	0.499
	2	4.721	4.066	0.655	0.161
8.0	1	5.193	4.063	1.130	0.279
	2	4.470	3.761	0.709	0.189
8.5	1	5.742	4.106	0.636	0.398
	2	4.562	4.009	0.553	0.138
9.0	1	3.874	3.290	0.585	0.178
	2	4.381	4.214	0.167	0.040
9.5	1	4.510	3.966	0.544	0.137
	2	5.345	4.780	0.565	0.118
10.0	1	4.528	4.128	0.400	0.097
	2	4.468	4.020	0.448	0.111
10.5	1	5.898	4.785	1.113	0.233
	2	5.528	4.484	0.044	0.010
11.0	1	5.141	5.118	0.023	0.004
	2	5.049	4.723	0.326	0.069
11.5	1	4.998	4.996	0.002	0.000
	2	4.789	4.616	0.173	0.037
12.0	1	4.697	4.570	0.127	0.028
	2	6.057	6.003	0.054	0.009

DRYING CURVE XVIII

TEMP 100 °C VACUUM 22 "Hg

RUN 5

GMS MOISTURE / GM DRY SOLID

TIME IN HOURS

TABLE XXXI

LOG SHEET

Run 6

Department of Chemical Engineering

Speed Scientific School

University of Louisville

DRYING OF PRUSSIAN BLUE

Date: 5/7/34

Temperature: 110°C.

Vacuum: 22" Hg.

Plant Record Data

Name: Steel Blue
 Rx. No.: 4006
 Slip No.: 731
 Batch No.: 4
 Date Struck: 3/29/34
 No. Trays Dried: 5
 Date In: 4/30/34

Laboratory Data

Batch Red.: 4/30/34
 Batch Rtd.: 5/12/34
 Avg. Control Temp: 110.54°C.

Tray Data

Tray No.	Wt. of Cake Before Drying lbs.	Wt. of Cake After Drying lbs.	Wt. Moisture Lost lbs.
1	6.25	2.50	3.75
2	6.00	2.75	3.25
Total	12.25	5.25	7.00

TABLE XXXII
CAKE TEMPERATURE DATA

Run 6

Time Hrs.	Temperatures in °C.							
	#2	Tray 1 #3	#4	Avg.	#5	Tray 2 #6	#7	Avg.
0.25	63.0*	35.5	37.0	36.3	44.0	43.5	41.5	43.0
0.50	70.0*	53.0	56.0	54.5	53.0	61.5	61.5	58.7
0.75	82.0*	66.0	65.0	64.5	65.0	64.5	65.5	65.6
1.00	86.5*	65.0	65.0	65.0	65.0	65.5	65.5	65.3
1.25	66.0	65.5	66.2	66.2	65.0	65.0	65.5	65.2
1.50	66.0	65.5	66.0	65.8	65.0	65.0	65.5	65.2
1.75	66.0	65.5	65.0	65.5	65.0	65.0	65.0	65.0
2.00	66.0	65.5	65.0	65.0	65.0	65.0	65.0	65.0
2.25	66.0	65.5	65.0	65.0	65.0	65.0	65.0	65.0
2.50	66.0	65.5	65.0	65.5	65.0	65.0	65.0	65.0
2.75	66.0	65.0	65.0	65.3	65.0	65.0	65.0	65.0
3.00	65.5	65.0	64.5	65.0	65.0	65.0	65.0	65.0
3.25	65.5	65.0	65.0	65.2	65.0	65.0	65.0	65.0
3.50	65.5	65.0	65.0	65.3	65.0	65.0	65.0	65.0
3.75	65.5	65.0	65.0	65.2	65.0	65.5	65.0	65.2
4.00	65.5	64.5	65.0	65.3	65.5	66.0	65.0	65.5
4.25	66.0	64.5	65.0	65.2	66.0	65.0	65.0	65.3
4.50	66.0	64.5	65.0	65.2	66.0	65.0	65.0	65.3
4.75	66.0	66.0	66.0	66.0	66.0	66.5	66.0	66.2
5.00	66.0	66.0	66.0	66.0	66.0	66.5	66.0	66.2
5.25	66.0	65.0	65.5	65.5	66.0	66.0	65.5	65.8
5.50	66.0	65.5	65.0	65.5	67.0	66.5	66.0	66.5
5.75	66.5	66.5	67.0	66.7	66.5	67.0	66.5	66.7
6.00	66.0	65.5	66.0	65.8	66.5	66.0	66.0	66.2
6.25	68.5	67.5	67.5	67.8	68.0	67.5	68.0	67.3
6.50	68.0	67.0	67.0	67.3	67.0	67.5	67.0	67.2
6.75	68.0	67.5	67.5	67.7	67.0	67.0	67.0	67.0
7.00	68.0	67.5	67.5	67.7	67.0	66.0	66.0	66.3
7.25	68.0	67.5	67.0	67.5	68.0	69.0	66.5	67.8
7.50	68.0	65.5	66.0	66.5	68.0	69.5	67.5	68.3
7.75	68.0	67.5	67.0	67.5	68.0	72.0	67.0	69.0
8.00	67.5	67.0	66.5	67.0	68.5	78.5	70.5	72.5
8.25	68.0	67.5	67.5	67.7	70.0	83.5	83.5	79.0
8.50	68.0	67.5	68.0	70.5	70.5	88.5	83.5	80.8
8.75	68.5	67.5	67.5	67.8	72.0	93.0	89.5	84.0
9.00	68.0	65.5	67.0	66.8	78.0	99.5	97.5	91.7

* Value omitted in average.

TABLE XXXII (Cont.)

CAKE TEMPERATURE DATA

Run 6

Time Hrs.	Temperatures in °C.							
	#2	Tray 1 #3	#4	Avg.	#5	Tray 2 #6	#7	Avg.
9.25	66.0	66.0	67.0	66.3	87.0	104.5	104.0	95.2
9.50	68.0	67.0	66.5	67.2	93.0	104.5	104.0	100.5
9.75	65.5	64.5	64.5	64.8	96.5	104.5	104.5	101.8
10.00	64.0	62.5	64.0	63.5	101.0	106.5	105.5	103.7
10.25	64.0	63.5	64.5	64.0	103.0	106.5	105.5	105.0
10.50	64.5	64.0	64.5	64.3	110.0	112.0	110.0	110.7
10.75	64.0	62.5	65.0	63.8	105.5	108.0	105.0	106.2
11.00	66.0	62.5	68.0	65.5	112.0	111.5	110.5	111.3
11.25	69.5	62.5	73.0	68.3	110.0	110.5	109.5	110.0
11.50	72.5	64.5	79.5	72.2	113.0	114.5	113.0	113.5
11.75	73.5	64.5	81.5	73.2	110.0	108.5	107.0	108.5
12.00	77.5	71.0	89.0	79.2	110.0	111.0	111.0	110.7

CAKE TEMPERATURE CURVE XIX

TEMP 110 °C. VACUUM 22 " Hg.

RUN 6

TABLE XXXIII
MOISTURE CONTENT DATA

Run 6

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist per Gm. Dry Solid
0	1	5.704	2.587	3.117	1.202
	2	4.300	2.010	2.290	0.140
0.5	1	3.461	1.703	1.758	1.032
	2	3.510	1.792	1.718	0.958
1.0	1	5.006	2.545	2.461	0.967
	2	5.702	2.881	2.821	0.979
1.5	1.011	6.011	3.141	2.870	0.913
	2	4.566	2.434	2.132	0.875
2.0	1	6.025	3.102	2.923	0.943
	2	4.269	2.413	1.865	0.769
2.5	1	6.901	3.861	3.040	0.787
	2	3.826	2.304	1.522	0.659
3.0	1	5.675	3.247	2.438	0.747
	2	4.814	3.033	1.781	0.588
3.5	1	7.010	4.099	2.911	0.710
	2	5.340	3.356	1.984	0.592
4.0	1	6.864	3.854	3.010	0.782
	2	6.754	4.389	2.355	0.536
4.5	1	7.461	4.756	2.705	0.598
	2	6.933	4.504	2.429	0.540
5.0	1	4.917	3.201	1.716	0.536
	2	6.054	4.152	1.902	0.458
5.5	1	6.754	4.501	2.243	0.498
	2	5.793	4.130	1.663	0.403
6.0	1	7.209	4.908	2.301	0.468
	2	5.085	3.610	1.475	0.008

TABLE XXXIII (Cont.)

MOISTURE CONTENT DATA

Run 6

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist per Gm. Dry Solid
6.5	1	4.549	2.946	1.603	0.544
	2	5.111	4.234	0.877	0.208
7.0	1	5.025	3.414	1.611	0.472
	2	5.448	4.256	1.192	0.280
7.5	1	4.556	2.889	1.667	0.577
	2	4.474	3.895	0.579	0.149
8.0	1	5.956	4.778	1.178	0.247
	2	4.540	4.136	0.404	0.098
8.5	1	4.939	3.791	1.148	0.303
	2	4.839	4.216	0.623	0.148
9.0	1	4.680	3.794	0.886	0.234
	2	4.185	3.846	0.339	0.088
9.5	1	6.541	5.421	0.920	0.170
	2	4.208	4.226		
10.0	1	5.196	4.668	0.528	0.113
	2				
10.5	1	4.034	3.667	0.367	0.100
	2				
11.0	1	4.814	4.796	0.018	0.004
	2	4.367	4.361	0.006	0.001
11.5	1	4.041	3.958	0.083	0.021
	2				
12.0	1	5.438	5.279	0.159	0.030
	2				

DRYING CURVE XX

TEMP 110 °C VACUUM 22 "Hg

RUN 6

TABLE XXXIV

LOG SHEET

Run 7

Department of Chemical Engineering
 Speed Scientific School University of Louisville

DRYING OF PRUSSIAN BLUE

Date: 5/8/34

Temperature: 120°C.

Vacuum: 22" Hg.

Plant Record Data

Laboratory Data

Name: Steel Blue
 Rx. No.: 4006
 Slip No.: 731
 Batch No.: 4
 Date Struck: 3/29/34
 Date In: 4/30/34
 No. Trays Dried: 5

Batch Recd.: 4/30/34
 Batch Rtd.: 5/13/34
 Avg. Control Temp: 120.38°C.

Tray Data

Tray No.	Wt. of Cake Before drying lbs.	Wt. of Cake After drying lbs.	Wt. Moisture Lost lbs.
3	6.75	3.00	3.75
4	5.75	2.50	3.25
Total	12.50	5.50	7.00

TABLE XXXV
CAKE TEMPERATURE DATA

Run 7

Time Hrs.	Temperatures in °C.							
	Tray 1				Tray 2			
	#2	#3	#4	Avg.	#5	#6	#7	Avg.
0.25	35.5	33.5	34.0	34.3	35.0	33.5	33.5	34.0
0.50	68.0*	48.5	51.0	49.7	48.0	44.0	47.0	46.3
0.75	85.0*	63.5	62.0	62.7	63.0	64.0	62.5	63.2
1.00	86.0*	67.0	67.5	67.2	67.0	67.0	67.0	67.0
1.25	87.0*	68.0	67.0	67.5	67.0	67.0	67.0	67.0
1.50	85.0*	67.0	67.0	67.0	65.0	63.0	63.0	63.7
1.75	65.0	64.5	64.0	64.5	64.5	64.0	64.0	64.2
2.00	65.0	64.5	64.0	64.5	64.0	64.0	64.0	64.0
2.25	66.0	65.5	65.0	65.5	66.0	65.5	65.0	65.3
2.50	66.0	65.5	65.0	65.5	65.5	65.0	65.0	65.2
2.75	66.0	65.5	65.0	65.5	65.5	65.0	65.0	65.2
3.00	66.0	65.5	65.0	65.5	65.5	65.0	65.0	65.2
3.25	65.5	65.0	65.0	65.2	65.0	65.0	64.5	64.8
3.50	65.5	65.0	65.0	65.2	65.0	65.0	64.5	64.8
3.75	65.5	65.0	65.0	65.2	65.0	65.0	64.5	64.8
4.00	65.5	65.0	65.0	65.2	65.0	65.0	64.5	64.8
4.25	65.5	65.0	65.0	65.2	65.2	65.2	64.5	64.8
4.50	66.0	65.0	65.5	65.5	65.0	65.0	65.0	65.0
4.75	66.0	65.5	65.0	65.5	66.5	65.0	65.0	65.2
5.00	66.0	65.5	66.0	65.8	66.0	65.0	65.0	65.3
5.25	66.0	65.5	66.0	65.8	66.0	65.0	65.0	65.3
5.50	65.5	65.0	65.5	65.3	65.5	64.5	64.5	64.8
5.75	65.0	65.0	64.0	64.7	65.0	64.0	64.0	64.3
6.00	65.0	65.0	63.5	64.5	64.5	63.5	63.0	63.7
6.25	65.0	65.0	65.0	65.0	64.5	64.5	64.0	64.3
6.50	65.5	64.5	65.0	65.0	65.5	64.0	64.0	64.5
6.75	66.0	65.5	65.0	65.5	65.0	64.5	64.0	64.5
7.00	66.0	65.5	65.0	65.5	65.0	64.5	64.0	64.5
7.25	66.0	65.5	65.0	65.5	65.0	64.0	64.0	64.0
7.50	66.0	65.5	65.5	65.7	65.0	63.5	64.5	64.3
7.75	66.5	65.5	66.0	66.0	65.0	63.5	64.0	64.2
8.00	67.0	66.5	70.0	67.8	67.0	64.5	64.0	65.2
8.25	70.0	66.5	78.5	71.7	69.0	64.0	65.5	66.2
8.50	74.0	80.5	94.0	82.8	73.0	65.0	78.5	68.8
8.75	81.0	90.0	102.0	91.0	80.0	66.0	74.0	73.3
9.00	93.0	101.0	112.0	102.0	84.0	69.0	81.0	78.0
9.25	103.0	106.0	115.0	108.0	88.0	75.0	86.0	83.0
9.50	113.0	114.0	118.0	115.0	97.0	85.0	95.0	92.3
9.75	112.5	113.5	115.0	113.7	102.5	95.5	99.5	99.2
10.00	119.5	118.5	120.0	119.3	112.0	115.5	118.0	115.2

* Value omitted in average.

CAKE TEMPERATURE CURVE XXI

TEMP 120 °C VACUUM 22" Hg.

RUN 7

TABLE XXXVI
MOISTURE CONTENT DATA

Run 7

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist per Gm. Dry Solid
0	1	4.431	2.122	2.309	1.087
	2	4.283	2.109	2.174	1.030
0.5	1	3.372	1.696	1.676	0.988
	2	3.631	1.818	1.813	0.997
1.0	1	4.393	2.392	2.001	0.837
	2	5.978	3.311	2.667	0.807
1.5	1	6.101	3.255	2.846	0.874
	2	5.912	3.276	2.636	0.805
2.0	1	7.848	4.348	3.500	0.804
	2	4.565	2.646	1.919	0.724
2.5	1	5.918	3.374	2.544	0.755
	2	6.152	3.899	2.253	0.578
3.0	1	5.573	3.362	2.211	0.658
	2	5.250	3.340	1.918	0.574
3.5	1	7.732	5.004	2.728	0.546
	2	5.422	2.534	1.888	0.534
4.0	1	5.894	3.995	1.899	0.475
	2	6.891	4.631	2.260	0.488
4.5	1	6.123	4.245	1.878	0.442
	2	4.980	3.946	1.034	0.262
5.0	1	7.367	5.302	2.065	0.390
	2	7.598	5.731	1.867	0.326
5.5	1	5.566	3.985	1.581	0.397
	2	6.192	4.577	1.615	0.393
6.0	1	4.694	3.520	1.174	0.334
	2	4.932	4.022	0.910	0.226

TABLE XXXVI (Cont.)
MOISTURE CONTENT DATA

Run 7

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist per Gm. Dry Solid
6.5	1	4.505	3.507	0.998	0.285
	2	3.022	3.851	1.171	0.304
7.0	1	3.762	3.166	0.602	0.190
	2	3.423	2.834	0.589	0.208
7.5	1	5.033	4.491	0.542	0.121
	2	4.319	3.531	0.788	0.223
8.0	1	4.751	4.431	0.326	0.074
	2	4.574	4.106	0.468	0.114
8.5	1	4.053	3.790	0.263	0.069
	2	4.303	3.836	0.467	0.122
9.0	1	3.704	3.530	0.174	0.049
	2	4.060	3.926	0.134	0.034
9.5	1	6.028	6.028	0.000	0.000
	2	3.820	3.817	0.003	0.001
10.0	1				
	2	4.142	4.137	0.005	0.001

DRYING CURVE XXII

TEMP 120 °C VACUUM 22 "Hg

RUN 7

TABLE XXXVII

LOG SHEET

Run 8

Department of Chemical Engineering
 Speed Scientific School University of Louisville

DRYING OF PRUSSIAN BLUE

Date: 5/9/34

Temperature: 130°C.

Vacuum: 22" Hg.

Plant Record Data

Laboratory Data

Name: Steel Blue
 Rx. No.: 4006
 Slip No.: 731
 Batch No.: 4
 Date Struck: 3/29/34
 No. Trays Dried: 5
 Date In: 4/30/34

Batch Recd.: 4/30/34
 Batch Rtd.: 4/12/34
 Avg. Control Temp: 130.06°C.

Tray Data

Tray No.	Wt. of Cake Before Drying lbs.	Wt. of Cake After Drying lbs.	Wt. Moisture Lost lbs.
3	5.75	2.75	3.00
4	6.50	3.25	3.25
Balance	<u>12.25</u>	<u>6.00</u>	<u>6.25</u>

TABLE XXXVIII
CAKE TEMPERATURE DATA

Run 8

Time Hrs.	Temperatures in °C.							
	#2	Tray 1 #3	#4	Avg.	#5	Tray 2 #6	#7	Avg.
0.25	49.0	52.0	60.0*	50.0	43.0	43.0	43.5	43.2
0.50	63.0	63.5	63.0	63.2	62.0	63.0	64.0	63.0
0.75	64.0	64.0	63.5	64.0	63.0	63.5	64.5	63.7
1.00	63.0	63.0	63.0	63.0	63.0	63.0	62.0	62.7
1.25	63.0	63.0	63.0	63.0	63.0	63.0	62.0	62.7
1.50	63.0	63.0	63.0	63.0	63.0	63.0	62.0	62.7
1.75	64.0	63.5	63.0	63.5	63.0	63.5	64.0	63.5
2.00	65.0	65.0	64.5	64.8	64.0	64.5	64.5	64.3
2.25	65.0	65.0	64.5	64.8	65.0	64.5	64.5	64.7
2.50	65.0	64.5	64.5	64.7	64.5	64.5	64.5	64.5
2.75	66.0	65.5	65.0	65.5	64.0	64.5	64.5	64.3
3.00	66.0	65.5	65.0	65.5	64.0	64.5	64.5	64.3
3.25	66.0	65.0	65.0	65.3	65.0	65.0	64.0	64.7
3.50	66.0	65.0	65.0	65.3	65.0	64.5	64.5	64.7
3.75	66.0	65.0	65.0	65.3	65.0	64.5	64.5	64.7
4.00	66.0	65.0	65.0	65.3	65.0	64.5	64.5	64.7
4.25	66.0	65.0	65.0	65.3	65.0	64.5	64.5	64.7
4.50	66.0	65.0	65.0	65.3	65.0	64.5	64.5	64.7
4.75	66.0	65.0	65.0	65.3	65.0	64.5	64.5	64.7
5.00	66.0	65.0	65.0	65.3	65.0	64.5	64.5	64.7
5.25	66.0	65.5	64.5	65.3	65.0	64.0	64.0	64.3
5.50	67.5	66.5	67.0	67.0	65.0	65.5	64.5	65.0
5.75	70.0	67.5	69.0	68.8	66.5	65.5	65.5	65.8
6.00	74.0	69.5	74.0	72.5	65.0	67.0	66.0	66.0
6.25	82.0	73.0	88.0	81.0	67.5	67.5	66.5	66.8
6.50	94.0	88.5	106.0	96.2	67.0	67.0	66.5	66.7
6.75	107.5	107.5	114.0	109.7	66.5	68.5	66.5	67.2
7.00	120.0	119.0	122.5	120.5	66.5	70.5	66.5	67.8
7.25	126.5	124.5	126.0	125.7	67.9	73.5	70.5	70.3
7.50	132.5	131.0	131.5	131.7	74.0	86.5	82.5	81.0
7.75	132.0	131.0	129.5	130.8	88.0	99.0	99.0	95.3
8.00	134.0	134.0	134.0	134.0	104.0	112.5	112.5	109.7
8.25	133.0	132.0	129.0	131.3	114.0	116.5	117.0	115.8
8.50	134.0	133.0	132.5	133.2	122.0	123.0	123.0	122.7
8.75	131.0	131.0	130.0	130.7	124.0	125.5	123.5	124.3
9.00	133.0	131.5	131.0	131.8	128.0	128.0	127.5	127.8

* Value omitted in average

CAKE TEMPERATURE CURVE XXIII

TEMP. 130 °C

VACUUM 22 "Hg.

RUN 8

TABLE XXXIX
MOISTURE CONTENT DATA

Run 8

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist. per Gm. Dry Solid
0	1	4.023	1.869	2.154	1.150
	2	4.786	2.521	2.265	0.899
0.5	1	5.426	2.857	2.569	0.900
	2	5.846	3.392	2.454	0.723
1.0	1	4.512	2.561	1.951	0.762
	2	5.990	3.451	2.539	0.735
1.5	1	6.673	3.835	2.838	0.739
	2	4.902	2.912	1.990	0.684
2.0	1	6.387	4.085	2.303	0.563
	2	4.976	3.540	1.436	0.406
2.5	1	5.928	3.729	2.199	0.589
	2	2.856	1.037	1.799	0.443
3.0	1	5.566	3.684	1.882	0.511
	2	5.474	3.906	1.566	0.401
3.5	1	6.915	4.771	2.144	0.449
	2	5.659	3.830	1.829	0.478
4.0	1	4.171	3.249	0.922	0.284
	2	4.127	3.437	0.690	0.201
4.5	1	3.593	3.169	0.424	0.134
	2	4.128	3.532	0.596	0.169
5.0	1	4.820	4.090	0.730	0.178
	2	5.821	4.663	1.158	0.248
5.5	1	4.385	3.863	0.522	0.135
	2	3.767	3.053	0.714	0.234
6.0	1	3.521	3.217	0.304	0.095
	2	4.340	3.617	0.723	0.200

TABLE XXXIX (Cont.)

MOISTURE CONTENT DATA

Run 8

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist per Gm. Dry Solid
6.5	1	3.989	3.821	0.168	0.044
	2	5.090	4.255	0.835	0.197
7.0	1	2.435	2.447	0.008	0.003
	2	4.641	4.077	0.564	0.138
7.5	1	5.326	5.309	0.017	0.003
	2	5.145	4.641	0.504	0.109
8.0	1				
	2	4.696	4.306	0.390	0.091
8.5	1				
	2	3.686	3.679	0.007	0.002

DRYING CURVE XXIV

TEMP 130 °C. VACUUM 22 " Hg.

RUN 8

TABLE XL

LOG SHEET

Run 9

Department of Chemical Engineering
 Speed Scientific School University of Louisville

DRYING OF PRUSSIAN BLUE

Date: 4/27/34

Temperature: 100°C.

Vacuum: 26" Hg.

Plant Record Data

Name: Steel Blue
 Rx. No.: 4006
 Slip No.: 731
 Batch No.: 4
 Date Struck: 3/29/34
 No. Trays Dried: 1
 Date In: 4/27/34

Laboratory Data

Batch Recd.: 4/27/34
 Batch Rtd.: 4/30/34
 Avg. Control Temp: 99.91°C.

Tray Data

Tray No.	Wt. of Cake Before Drying lbs.	Wt. of Cake After Drying lbs.	Wt. Moisture Lost lbs.
1	6.50	3.25	3.25
2	6.75	3.25	3.50
Total	13.25	6.50	6.75

TABLE XLI
CAKE TEMPERATURE DATA

Run 9

Time Hrs.	Temperatures in °C.							
	#2	Tray 1 #3	#4	Avg.	#5	Tray 2 #6	#7	Avg.
0.25	20.0	20.0	19.5	19.8	19.0	21.5	21.5	20.3
0.50	25.0	22.5	22.5	23.2	25.0	22.0	22.5	23.2
0.75	35.0	34.5	31.5	33.7	37.0	34.0	32.5	34.5
1.00	44.0	43.5	43.0	43.5	47.0	45.0	45.0	45.7
1.25	50.0	49.5	49.0	49.5	49.0	48.5	47.5	48.3
1.50	50.0	49.5	49.0	49.5	49.5	48.5	49.0	49.0
1.75	50.0	49.5	49.0	49.5	49.0	48.5	48.5	48.7
2.00	50.0	49.5	49.0	49.5	49.0	48.5	48.5	48.7
2.25	50.0	49.5	49.0	49.5	49.0	49.0	48.5	48.7
2.50	50.0	49.5	49.0	49.5	49.0	48.5	48.5	48.7
2.75	50.0	49.5	49.0	49.5	49.0	48.5	48.5	48.7
3.00	50.0	49.5	49.0	49.5	49.0	48.5	48.5	48.7
3.25	50.0	49.0	48.5	49.2	49.0	49.0	47.5	48.5
3.50	49.5	48.5	48.0	48.5	49.5	48.5	48.5	48.8
3.75	50.0	49.0	49.0	49.3	49.0	48.5	48.5	48.7
4.00	50.0	49.5	49.0	49.5	49.0	48.5	48.5	48.7
4.25	50.0	49.5	49.0	49.5	49.0	48.5	48.5	48.7
4.50	50.0	49.5	49.0	49.5	49.0	48.5	48.5	48.7
4.75	50.0	49.5	49.0	49.5	49.0	48.5	48.5	48.7
5.00	50.0	49.5	49.0	49.5	49.0	48.5	48.5	48.7
5.25	50.0	49.5	49.0	49.5	49.0	48.5	48.5	48.7
5.50	50.0	49.5	49.0	49.5	49.0	48.5	48.5	48.7
5.75	50.0	49.5	49.0	49.5	49.0	48.5	48.5	48.7
6.00	50.0	49.5	49.0	49.5	49.0	48.5	48.5	48.7
6.25	50.0	48.0	48.7	48.7	48.0	47.5	47.5	47.7
6.50	51.0	50.0	49.5	50.2	48.5	49.5	49.0	49.0
6.75	51.0	50.0	49.5	50.2	49.5	50.5	49.5	49.8
7.00	54.5	56.5	55.0	55.3	55.5	55.5	54.5	55.2
7.25	54.0	53.5	52.0	53.2	52.5	52.5	52.0	52.3
7.50	52.0	51.5	51.0	51.5	51.0	51.0	52.0	51.3
7.75	54.5	53.0	53.0	53.5	53.0	52.5	51.5	52.3
8.00	53.0	52.5	52.0	52.5	52.0	52.0	51.5	51.8
8.25	52.0	51.5	52.0	51.8	51.0	51.5	51.5	51.3
8.50	52.0	51.5	52.0	51.8	52.0	51.5	51.5	51.7
8.75	53.0	52.5	52.0	52.5	52.0	52.5	52.5	52.3
9.00	52.0	54.5	52.0	52.8	52.0	51.5	52.5	52.0

TABLE XLI (Cont.)
CAKE TEMPERATURE DATA

Run 9

Time Hrs.	Temperatures in °C.							
	#2	Tray 1 #3	#4	#vg.	#5	Tray 2 #6	#7	Avg.
9.25	52.0	56.5	52.0	53.5	52.0	52.5	52.0	52.2
9.50	52.0	60.0	55.5	55.7	54.0	56.0	56.0	55.3
9.75	52.0	59.0	52.0	54.3	57.0	61.0	56.0	58.0
10.00	52.0	61.0	54.0	55.7	63.0	55.0	58.0	58.7
10.25	56.0	58.0	56.0	56.7	63.0	57.0	58.5	59.5
10.50	55.0	61.0	58.0	58.0	67.5	61.0	60.5	63.0
10.75	53.0	62.0	61.0	58.7	73.0	68.0	65.5	68.8
11.00	52.0	61.5	58.0	57.2	79.0	72.5	70.5	74.0
11.25	54.5	61.5	60.0	58.7	80.5	78.5	74.5	77.8
11.50	55.0	61.5	59.0	58.5	86.5	82.0	78.5	82.3
11.75	58.0	65.0	61.5	61.2	89.0	86.5	84.5	86.7
12.00	60.0	67.0	64.5	63.8	92.0	89.5	88.5	90.0

CAKE TEMPERATURE CURVE XXV

TEMP 100°C

VACUUM 26" Hg

RUN 9

TABLE XLII
MOISTURE CONTENT DATA

Run 9

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist. per Gm. Dry Solid
0	1	5.435	2.810	2.625	0.935
	2	4.561	2.288	2.273	0.993
0.5	1	5.243	2.781	2.462	0.886
	2	4.966	2.656	2.334	0.885
1.0	1	5.950	3.175	2.775	0.874
	2	5.374	2.934	2.440	0.832
1.5	1	5.230	3.045	2.185	0.718
	2	5.911	3.323	2.588	0.780
2.0	1	5.838	3.169	2.669	0.842
	2	5.544	3.399	2.145	0.632
2.5	1	3.817	2.212	1.605	0.727
	2	7.066	4.299	2.767	0.644
3.0	1	6.277	3.854	2.423	0.630
	2	7.664	4.578	3.086	0.674
3.5	1	6.981	4.454	2.527	0.588
	2	4.531	2.810	1.721	0.612
4.0	1	6.164	4.047	2.117	0.523
	2	5.884	3.798	2.086	0.550
4.5	1	5.720	3.678	2.042	0.555
	2	7.472	4.907	2.565	0.523
5.0	1	5.494	3.556	1.938	0.455
	2	8.537	5.872	2.665	0.453
5.5	1	7.486	5.621	1.865	0.332
	2	6.400	4.531	1.949	0.396
7.0	1	6.053	4.351	1.702	0.392
	2	6.383	5.078	1.305	0.257

TABLE XLII (Cont.)
MOISTURE CONTENT DATA

Run 9

Time Hr.s	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost gms.	Gms. Moist. per Gm. Dry Solid
8.5	1	5.863	4.703	1.160	0.247
	2	5.395	4.761	4.634	0.133
10.0	1	6.057	5.287	0.770	0.146
	2	6.003	5.665	0.338	0.060
11.5	1	6.004	5.701	0.303	0.053
	2	5.026	4.902	0.124	0.023
12.0	1	5.109	4.755	0.354	0.074
	2	4.509	4.481	0.028	0.006

DRYING CURVE XXVI

TEMP 100°C VACUUM 26" HG

RUN 9

TABLE XLIII

LOG SHEET

Run 10

Department of Chemical Engineering

Speed Scientific School

University of Louisville

DRYING OF PRUSSIAN BLUE

Date: 5/2/34

Temperature: 110°C.

Vacuum: 26" Hg.

Plant Record Data

Name: Steel Blue
 Rx. No.: 4006
 Slip No.: 731
 Batch No.: 4
 Date Struck: 3/29/34
 No. Trays Dried: 5
 Date In: 4/30/34

Laboratory Data

Batch Recd.: 4/30/34
 Batch Rtd.: 5/12/34
 Avg. Control Temp.: 109.10°C.

Tray Data

Tray No.	Wt. of Cake Before Drying lbs.	Wt. of Cake After Drying lbs.	Wt. of Moisture lost lbs.
1	5.50	2.25	3.25
2	7.00	3.25	3.75
Total	12.50	5.50	7.00

TABLE XLIV
CAKE TEMPERATURE DATA

Run 10

Time Hrs.	Temperatures in °C.							
	#2	Tray 1 #3	#4	Avg.	#5	Tray 2 #6	#7	Avg.
0.25	21.0	20.5	20.0	20.5	20.0	19.5	19.5	19.7
0.50	32.0	32.5	34.0	32.8	42.5	38.0	41.5	40.7
0.75	50.0	49.5	48.0	49.2	48.0	48.5	47.5	48.0
1.00	50.0	49.5	49.0	49.5	49.0	48.5	48.5	48.7
1.25	49.5	49.5	49.0	49.3	49.0	49.0	48.5	48.8
1.50	49.5	49.0	48.0	48.8	49.0	48.5	48.5	48.7
1.75	49.0	48.5	49.0	48.8	49.0	49.5	49.5	49.3
2.00	49.0	49.0	48.0	48.7	49.0	48.5	48.5	48.7
2.25	50.0	49.5	48.5	49.3	49.0	49.0	48.5	48.7
2.50	50.0	49.5	48.5	49.3	49.0	49.0	48.5	48.7
2.75	50.0	49.0	49.0	49.3	49.0	49.0	49.0	49.0
3.00	50.0	49.5	49.0	49.5	49.0	49.0	49.0	49.0
3.25	50.0	49.5	49.0	49.5	49.0	49.0	49.0	49.0
3.50	50.0	49.0	49.0	49.3	49.0	48.5	49.0	48.8
3.75	50.0	49.0	49.0	49.3	49.0	49.0	49.0	49.0
4.00	50.0	49.5	49.0	49.5	49.0	49.0	49.0	49.0
4.25	50.0	49.5	49.0	49.5	49.0	49.0	49.0	49.0
4.50	50.0	49.5	49.0	49.5	49.0	49.0	49.0	49.0
4.75	50.0	49.5	49.0	49.5	49.0	49.0	49.0	49.0
5.00	50.0	49.5	49.0	49.5	49.0	49.0	49.0	49.0
5.25	49.5	49.0	49.0	49.2	49.5	50.0	50.0	49.8
5.50	50.0	49.5	49.0	49.5	49.0	49.5	49.5	49.3
5.75	51.0	50.5	50.0	50.5	51.0	51.5	50.0	50.8
6.00	50.0	49.5	49.0	49.5	49.0	51.5	49.5	50.0
6.25	49.0	50.5	49.5	49.7	51.0	55.0	52.0	52.7
6.50	63.0	65.0	65.0	64.3x	64.0	63.5	57.0	61.2x
6.75	63.0	65.0	65.0	64.3x	64.0	63.5	57.0	61.2x
7.00	49.0	49.0	49.0	49.0	59.0	61.5	57.5	59.3
7.25	50.0	51.5	51.0	50.8	65.0	69.5	65.5	66.7
7.50	50.0	51.5	54.0	51.8	66.0	73.5	67.5	69.0
7.75	51.5	53.5	62.0	55.8	72.5	78.5	73.5	74.7
8.00	55.0	58.5	75.0	62.8	85.0	89.0	84.5	86.2
8.25	61.0	66.5	89.5	73.0	94.0	95.0	91.5	93.5
8.50	68.0	77.5	98.0	81.5	101.5	101.5	98.5	100.5
8.75	77.0	85.5	98.0	86.8	102.0	102.0	100.0	101.3
9.00	88.5	96.0	104.0	96.2	108.0	106.0	104.5	106.2
9.25	97.0	99.0	103.0	99.7	106.0	105.0	104.5	105.2
9.50	104.0	105.0	108.5	105.8	107.5	108.5	106.5	107.5
9.75	106.5	105.0	107.0	106.2	108.5	108.5	107.0	108.0
10.00	108.0	107.5	108.5	108.0	108.5	108.0	108.0	108.2

x Value omitted in plotting cake temperature curve.

CAKE TEMPERATURE CURVE XXVII

TEMP 110°C

VACUUM 26" Hg.

RUN 10

TABLE XIV
MOISTURE CONTENT DATA

Run 10

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist per Gm. Dry Solid
0	1	4.704	2.273	2.431	1.067
	2	5.092	2.683	2.409	0.898
0.5	1	3.903	2.076	1.827	0.881
	2	3.313	1.761	1.552	0.882
1.0	1	5.280	2.825	2.455	0.868
	2	6.669	3.637	3.032	0.833
1.5	1	6.085	3.562	2.523	0.709
	2	3.897	2.329	1.568	0.673
2.0	1	5.895	3.584	2.311	0.644
	2	7.079	4.413	2.666	0.604
2.5	1	5.825	3.494	2.332	0.667
	2	6.356	4.443	1.913	0.431
3.0	1	5.562	3.509	2.053	0.585
	2	6.588	4.436	2.152	0.485
3.5	1	7.761	5.149	2.612	0.507
	2	6.392	4.579	1.813	0.396
4.0	1	6.812	4.690	2.122	0.453
	2	6.264	4.830	1.434	0.298
4.5	1	5.305	3.813	1.492	0.391
	2	3.734	3.137	0.597	0.191
5.0	1	4.316	3.506	0.810	0.231
	2	4.825	4.283	0.542	0.137
5.5	1	6.100	5.012	1.088	0.217
	2	5.693	5.061	0.632	0.125
6.0	1	5.898	5.155	0.743	0.144
	2	6.312	5.573	0.739	0.133

TABLE XIV (Cont.)
MOISTURE CONTENT DATA

Run 10

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist. per Gm. Dry Solid
6.5	1	7.675	6.920	0.755	0.109'
	2	6.239	5.998	0.241	0.040
7.0	1	4.487	4.044	0.433	0.109
	2	4.661	4.454	0.207	0.047
7.5	1	5.188	4.757	0.431	0.091
	2	5.015	4.841	0.174	0.037
8.0	1	6.216	6.166	0.050	0.008
	2	5.703	5.691	0.012	0.002
8.5	1	5.480	5.106	0.374	0.073

DRYING CURVE XXVIII

TEMP 110 °C VACUUM 26 "Hg

RUN 10

GMS. MOISTURE / GM. DRY SOLID

TIME IN HOURS

TABLE XLVI

LOG SHEET

Run 11

Department of Chemical Engineering
 Speed Scientific School University of Louisville

DRYING OF PRUSSIAN BLUE

Date: 5/4/34

Temperature: 120°C.

Vacuum: 26 " Hg.

Plant Record Data

Name: Steel Blue
 Rx. No.: 4006
 Slip No.: 731
 Batch No.: 4
 Date Struck: 3/29/34
 No. Trays Dried: 5
 Date In: 4/3/34

Laboratory Data

Batch Red.: 4/30/34
 Batch Rtd.: 5/13/34
 Avg. Control Temp: 119.57°C.

Tray Data

Tray No.	Wt. of Cake Before Drying	Wt. of Cake After Drying	Wt. Moisture lost
1	6.00	3.25	2.75
2	6.00	3.00	3.00
Total	12.00	6.25	5.75

TABLE XIV II
CAKE TEMPERATURE DATA

Run 11

Time Hrs.	Temperatures in °C.							
	#2	Tray 1 #3	#4	Avg.	#5	Tray 2 #6	#7	Avg.
0.25	33.5	31.5	31.0	32.0	33.0	31.5	30.5	31.7
0.50	48.5	48.0	46.5	47.7	48.0	47.5	47.5	47.7
0.75	50.0	49.0	50.0	49.7	50.5	50.0	50.0	50.2
1.00	50.5	50.0	48.5	49.7	50.0	48.5	48.5	49.0
1.25	51.0	49.5	49.0	49.8	50.0	48.5	48.5	49.0
1.50	52.0	50.0	49.5	50.5	53.0	50.5	50.5	51.3
1.75	52.5	50.5	50.5	51.2	53.5	51.0	51.0	51.5
2.00	51.0	49.5	49.5	50.0	53.0	50.5	50.5	51.3
2.25	53.0	49.5	49.0	50.5	59.0	50.0	50.0	53.0
2.50	54.0	51.5	49.5	51.7	61.5	50.0	50.0	53.8
2.75	58.5	50.0	49.0	52.5	61.0	50.0	50.0	53.8
3.00	59.0	50.0	49.0	52.7	62.0	50.0	49.5	53.8
3.25	60.5	50.0	49.0	53.2	62.0	60.0	49.5	53.8
3.50	62.0	50.0	49.0	53.7	62.5	50.0	49.5	53.8
3.75	65.0	50.0	49.0	54.7	62.0	50.0	49.0	53.7
4.00	67.0	50.0	49.0	55.3	62.5	50.0	50.0	54.2
4.25	63.0	50.0	49.0	54.0	60.0	50.0	53.0	54.3
4.50	65.0	50.0	49.0	54.7	63.0	50.0	57.0	56.8
4.75	68.0	50.0	49.0	55.7	64.5	57.0	67.5	63.0
5.00	68.0	50.0	49.5	55.8	67.0	67.0	75.0	69.7
5.25	70.5	48.5	48.5	55.7	71.5	83.0	88.0	80.8
5.50	68.0	49.0	53.5	56.8	72.0	93.5	98.5	88.0
5.75	69.0	49.5	56.2	56.2	80.5	102.5	107.5	96.8
6.00	71.0	49.5	48.0	56.5	87.0	107.5	111.5	102.0
6.25	75.0	49.5	49.5	58.0	97.0	111.5	115.5	108.0
6.50	76.0	49.5	49.0	58.2	105.0	115.5	117.5	112.7
6.75	84.0	50.5	49.0	60.8	116.0	117.5	120.0	117.8
7.00	85.5	51.5	50.5	62.5	118.0	121.5	121.0	120.2

CAKE TEMPERATURE CURVE XXIX

TEMP. 120°C.

VACUUM 26" Hg.

RUN 11

TABLE XLVIII
MOISTURE CONTENT DATA

Run 11

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist. per Gm. Dry Solid
0	1	3.523	1.749	1.774	1.014
	2	3.741	2.066	1.675	0.810
0.5	1	5.148	2.508	2.640	1.052
	2	3.589	2.058	1.531	0.743
1.0	1	5.171	2.823	2.348	0.831
	2	5.908	3.550	2.358	0.664
1.5	1	7.224	4.014	3.210	0.800
	2	6.117	3.879	2.238	0.577
2.0	1	6.199	3.617	2.582	0.779
	2	3.993	2.649	1.344	0.507
2.5	1	6.178	3.586	2.592	0.722
	2	6.195	4.333	1.862	0.430
3.0	1	5.992	3.756	2.236	0.595
	2	5.921	4.313	1.608	0.373
3.5	1	6.637	4.336	2.301	0.532
	2	5.293	4.201	1.092	0.260
4.0	1	5.800	4.552	1.248	0.274
	2	5.322	4.223	0.099	0.260
4.5	1	7.056	4.995	2.061	0.412
	2	4.164	3.576	0.588	0.164
5.0	1	5.511	4.085	1.426	0.349
	2	5.024	4.598	0.426	0.093
5.5	1	6.019	4.720	1.299	0.275
	2	4.158	3.888	0.270	0.070
6.0	1	4.401	3.609	0.792	0.220
	2	3.734	3.513	0.221	0.063

TABLE XLVIII (Cont.)
MOISTURE CONTENT DATA
Run 11

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist. per Gm. Dry Solid
6.5	1	4.383	3.716	0.667	0.180
	2	3.675	3.654	0.021	0.006
7.0	1	5.339	3.665	0.674	0.144
	2	3.945	3.940	0.005	0.001

DRYING CURVE XXX

TEMP 120°C. VACUUM 26" Hg.

RUN 11

GMS. MOISTURE / GM. DRY SOLID

TIME IN HOURS

TABLE XLIX

LOG SHEET

Run 12

Department of Chemical Engineering
 Speed Scientific School University of Louisville

DRYING OF PRUSSIAN BLUE

Date: 4/25/34

Temperature: 130° C.

Vacuum: 26" Hg.

Plant Record Data

Name: Steel Blue
 Rx. No.: 4006
 Slip No.: 731
 Batch No.: 4
 Date Struck: 3/29/34
 No. Trays Dried: 5
 Date In: 4/30/34

Laboratory Data

Batch Recd.: 4/30/34
 Batch Rtd.: 5/12/34
 Avg. Control Temp.: 130.25° C.

Tray Data

Tray No.	Wt. of Cake Before Drying lbs.	Wt. of Cake After Drying lbs.	Wt. Moisture lost lbs.
1	6.75	2.75	4.00
2	5.25	2.25	3.00
Total	12.00	5.00	7.00

TABLE L
CAKE TEMPERATURE DATA

Run 12

Time Hrs.	Temperatures in °C.							
	#2	Tray 1 #3	#4	Avg.	#5	Tray 2 #6	#7	Avg.
0.25	50.0	49.5	49.0	49.5	49.0	48.5	48.5	48.7
0.50	51.0	50.0	49.0	50.0	49.5	48.5	48.5	48.8
0.75	50.0	53.0	51.0	51.3	52.0	48.5	48.5	49.7
1.00	50.0	50.5	49.0	49.8	49.0	48.5	48.5	48.7
1.25	64.0*	50.5	49.0	49.7	48.0	47.0	47.5	47.5
1.50	72.5*	50.0	49.0	49.5	49.0	48.5	47.5	48.3
1.75	75.0*	50.0	49.0	49.5	49.0	48.5	48.5	48.7
2.00	75.0*	50.0	49.0	49.5	49.0	48.5	48.0	48.8
2.25	80.5*	50.0	49.0	49.5	49.0	48.5	48.0	48.5
2.50	82.0*	50.0	49.0	49.5	49.0	48.5	48.0	48.5
2.75	82.0*	50.5	49.5	50.0	49.5	49.0	48.0	49.0
3.00	82.0*	50.0	50.0	50.2	49.0	50.0	49.0	49.3
3.25	95.0*	51.5	50.0	50.7	50.0	50.0	49.5	49.8
3.50	94.0*	51.0	50.0	50.5	50.0	50.0	48.5	49.5
3.75	62.0*	50.5	50.0	50.8	50.0	49.5	49.5	49.7
4.00	65.0*	51.0	50.0	50.5	50.0	49.5	49.5	49.7
4.25	79.0*	51.0	50.0	50.5	50.5	49.5	49.5	49.8
4.50	80.5*	51.0	50.0	50.5	50.5	49.5	49.5	49.8
4.75	80.0*	52.0	51.0	51.5	51.0	50.0	50.0	50.3
5.00	82.0*	52.0	51.0	51.5	53.0	50.0	50.0	51.0
5.25	84.0*	52.0	52.0	53.5	55.0	50.0	50.0	51.7
5.50	85.0*	52.0	62.0	57.0	58.0	50.0	51.5	53.5
5.75	89.0*	58.0	72.0	64.0	64.0	50.0	54.5	56.2
6.00	95.0*	66.0	81.0	73.5	73.0	53.5	64.5	63.7
6.25	96.0*	81.0	91.0	86.0	85.0	60.0	78.0	74.3
6.50	103.0	94.5	102.5	100.0	104.5	88.5	102.0	98.3
6.75	106.5	107.5	101.5	108.3	114.0	108.0	112.5	111.5
7.00	111.5	115.5	119.5	115.5	123.0	119.5	123.0	121.8
7.25	116.0	120.5	123.5	120.0	122.0	121.5	121.5	121.7
7.50	121.0	124.5	127.0	124.2	128.5	128.5	126.0	127.7
7.75	124.0	124.5	128.0	125.5	126.0	125.5	125.0	125.5
8.00	128.0	127.5	130.0	128.5	129.0	126.5	128.5	128.0

* Value omitted in average.

CAKE TEMPERATURE CURVE XXXI

TEMP. 130°C.

VACUUM 26 "Hg.

RUN 12

TABLE LI
MOISTURE CONTENT DATA

Run 12

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist. per Gm. Dry Solid
0	1	5.272	2.537	2.735	1.078
	2	5.220	2.479	2.741	1.104
0.5	1	4.104	2.075	2.029	0.978
	2	3.892	1.896	1.996	1.052
1.0	1	4.087	2.209	1.878	0.849
	2	5.162	2.712	2.450	0.904
1.5	1	4.421	2.437	1.984	0.815
	2	3.610	2.039	1.571	0.771
2.0	1	4.639	2.741	1.898	0.692
	2	5.041	3.046	1.995	0.654
2.5	1	6.065	3.953	2.112	0.534
	2	5.524	3.699	1.825	0.493
3.0	1	5.942	3.885	2.057	0.529
	2	6.047	4.250	1.797	0.422
3.5	1	4.126	2.932	1.194	0.407
	2	4.618	3.532	1.086	0.308
4.0	1	4.724	3.513	1.211	0.345
	2	5.296	4.369	0.927	0.212
4.5	1	5.940	4.552	1.388	0.305
	2	3.685	3.377	0.309	0.091
5.0	1	3.811	2.946	0.865	0.294
	2	3.959	3.697	0.262	0.071
5.5	1	4.667	3.678	0.899	0.239
	2	4.710	4.725		
6.0	1	5.001	4.607	0.394	0.086
	2				

TABLE LI (Cont.)
MOISTURE CONTENT DATA

Run 12

Time Hrs.	Tray No.	Wt. Wet Sample Gms.	Wt. Dry Sample Gms.	Moisture Lost Gms.	Gms. Moist. Per Gm. Dry Solid
6.5	1	4.468	4.097	0.371	0.090
	2				
7.0	1	4.265	4.193	0.072	0.017
	2				
7.5	1	4.403	4.399	0.004	0.001
	2	4.641	4.641	0.000	0.000
8.0	1	4.326	4.326	0.000	0.000
	2				

DRYING CURVE XXXII

TEMP 130 °C VACUUM 26 " Hg

RUN 12

GMS MOISTURE / GM DRY SOLID

TIME IN HOURS

SUMMARY

A number of worthwhile conclusions regarding the vacuum drying of Prussian Blue may be drawn from this work. It is reasonable to believe that in general these conclusions may apply to other similar solids as well.

In his study of an inert solid, Ridgway (3) found a period of constant drying rate, represented by a drying curve of steady slope, down to a moisture content of about 0.8 gms. moisture per gm. dry solid. From that point, the rate of drying was changing, as indicated by a drying curve of decreasing slope as the material approached dryness.

The results of this investigation agree with the theoretical solid. All of the runs performed at either a temperature of 130°C. or a vacuum of 26" Hg. show an initial period of constant drying rate, followed by a falling rate period, when the rate of drying is decreasing as the moisture content approaches zero.

However, the point at which the first period ceases and the second commences is not well defined, as it varies from 0.5 to 4.0 gms. moisture

per¹⁰ gm. dry solid. The curves at lower temperatures and vacuums are more peculiar to Prussian Blue, and less in agreement with the theoretical curves.

Ridgway (3) concluded that the amount of vacuum had little effect on the drying time, but that the time was inversely proportional to the temperature.

In this investigation it was found that for a constant vacuum of 26" Hg., each ten degree rise in temperature decreased the drying time approximately seventeen percent, while the decrease at 22" Hg. amounted to about nine percent per ten degree temperature increase. At 18" Hg. increasing the temperature has a very noticeable effect on the drying time, but it is difficult to estimate this, as at lower temperatures the twelve hour period here used did not bring the solid to its equilibrium moisture content.

Vacuum, likewise, was found to have an effect on the drying time. At a constant temperature of 100°C. a vacuum of 18" Hg. did not dry the solid in twelve hours, but vacuums of 22" and

26" Hg. each brought the solid almost to a moisture content of zero in twelve hours. At constant temperatures of 110, 120 and 130°C. each four inch increase in the vacuum decreased the drying time by about seventeen percent.

The curves of cake temperatures all show the same characteristics. The cake is heated up to the temperature at which water boils at the pressure existing inside the dryer. The temperature remains fairly constant at this value, until, as the moisture content approaches zero, the cake temperature rises toward the constant control temperature. When the cake temperature levels out at the control value, it indicates the cake is thoroughly dry.

It is interesting to observe that the time at which the cake temperature starts to rise does not in several cases correlate with the time at which the change from constant to falling rate of drying occurs. Instead, the cake temperature begins to rise at a moisture content of about 0.1 gm. moisture per gm. dry solid. This suggests the

probability that the change from constant to falling rate of drying occurs gradually rather than suddenly.

It is observed that the drying curves at lower temperatures and humidities show "breaks" similar in character to those of the air drying study. However, in the case of the vacuum drying, the curve through the area of the "break" is much smoother. There is no abrupt cessation and resumption of drying, as was found in the air drying.

There are at this time no new suggestions regarding the cause of these "breaks", further than were made in the discussion of the air drying. The cause may possibly be thermal decomposition of the pigment, the sudden breaking off of water of crystallization, or a molecular rearrangement of the pigment structure.

The fact that the "breaks" are not observed when the run is at a temperature of 130°C. , or a vacuum of 26" Hg., is believed attributable to the very rapid rate of drying under these conditions. If a "break" does occur at these conditions, it is of such short duration that the method of sampling used did not detect it.

Before performing the experimental work, it was suggested that if a "break" similar to that of the air drying occurred while drying in vacuum, the cake temperature should show a considerable rise, due to the stopping of the drying, and that the temperature of the cake would return to that of boiling water under the existing pressure as the evaporation was resumed.

This was hypothesized on the basis of the very abrupt "breaks" and zero rate of drying of the air drying investigation. The results of this investigation did not produce evidence in support of this hypothesis. This is believed due to the fact that the "breaks" found were not abrupt in character, and drying did not entirely cease. Although the rate of drying decreased, the evaporation continued, and therefore the cake temperature remained at the temperature of water evaporating at the pressure existing within the dryer.

From the data of the individual thermocouple readings it may be observed that the cake temperature was the same through the entire cake during the greater part of the run, indicating

that evaporation was taking place through the whole of the cake, not at the surface alone.

This data further indicated that the top surface of the cake became fully dried only very slightly in advance of the center and lower edges. When the cake was fully dry the temperature rose very rapidly to the existing dryer temperature.

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