

UNIVERSITY OF MICHIGAN
COLLEGE OF ENGINEERING
INDUSTRY PROGRAM

PROCESS ENGINEERING
MANUAL OF PROCEDURES

J. G. Lewis
H. A. Ohlgren
M. E. Weech
R. J. Annesser

April, 1955

IP-114

TABLE OF CONTENTS

	<u>Page</u>
<u>A - GENERAL DESCRIPTION</u>	1-3
A1.00 FOREWORD	1
1.1 CHEMICAL PROCESS DESIGN	1
1.2 FUNCTIONAL LAYOUT	1
1.3 OPERATIONAL ENGINEERING	2
<u>B - FLOW SHEET STANDARDIZATION</u>	4-24
B1.00 FOREWORD	4
1.1 INTRODUCTION	4
1.2 VALUE OF FLOW SHEET AND RELATIONSHIP TO DETAILED ENGINEERING	4
B2.00 INSTRUCTIONS FOR PREPARATION OF FLOW SHEETS	6
2.1 GENERAL INSTRUCTIONS	6
2.2 INFORMATION REQUIRED ON FLOW SHEETS	11
2.3 INFORMATION TO BE EXCLUDED FROM THE ENGINEERING FLOW SHEETS	12
2.4 DRAFTING PROCEDURES	12
2.5 ENGINEERING PROCEDURES	16
2.6 REVISIONS TO FLOW SHEETS	16
B3.00 FLOW SHEET SYMBOLS	18
4.00 INSTRUCTIONS FOR PREPARATION OF UTILITY FLOW SHEETS	22
5.00 PROCEDURE FOR REVISING FLOW SHEETS	24
<u>C - FLOW SHEET CODE SYSTEM</u>	25-87
C1.00 NUMBERING SYSTEM	25
1.1 FLOW SHEET NUMBERS	25
1.2 FUNCTIONAL LAYOUT NUMBERS	25
1.3 VESSELS	26
1.4 MECHANICAL EQUIPMENT	27
1.5 INSTRUMENTS	28
1.6 PIPING	29
1.7 STRUCTURAL	32
1.8 ELECTRICAL	33
C2.00 FLOW SHEET SYMBOLS	35
2.1 COLUMNS AND TOWERS	35
2.2 TUBULAR EQUIPMENT	38
2.3 AGITATED OR REACTION EQUIPMENT	40
2.4 MECHANICAL EQUIPMENT	44
2.5 TANKS	49

	<u>Page</u>
<u>C - FLOW SHEET CODE SYSTEM (Cont'd.)</u>	
2.6 INSTRUMENTS	51
2.7 PIPING	60
C3.00 ILLUSTRATION OF CODE SYSTEM USE	62
3.1 DESCRIPTION OF SAMPLE PROCESS	62
3.2 SAMPLE FLOW SHEET - CONCENTRATED NaBu SOLUTION	65
3.3 ITEM LIST	66
3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS	69
<u>D - EQUIPMENT DESIGN CALCULATIONS</u>	88-92
<u>E - FORMS</u>	93-98
E1.00 ITEM LIST	93
2.00 LETTER OF TRANSMITTAL FOR PRINTS	94
3.00 MASTER DISTRIBUTION LIST	95
4.00 LETTER OF TRANSMITTAL FOR PROJECT REPORT	96
5.00 REQUESTS FOR FLOW SHEET REVISIONS	97
6.00 COST DATA	98
<u>F - ABBREVIATIONS</u>	99-112
F1.00 SYMBOLS AND NOMENCLATURE OF CHEMICAL ENGINEERING	99
2.00 CHEMICAL ENGINEERING UNITS	108
3.00 SYMBOLS AND NOMENCLATURE OF RADIO CHEMISTRY	111
4.00 RADIO CHEMICAL UNITS	112

A. GENERAL DESCRIPTIONA1.00 FOREWORD

Chemical Process Engineers are composed functionally of three groups. The purposes and functions of these groups are outlined below:

1.1 CHEMICAL PROCESS DESIGN

Chemical Process Design Engineers carry through the details of the Process Engineering. These functions can be enumerated as follows:

- a - Evaluation of existing data, i.e., segregating "knowns" from "unknowns."
- b - Recommendation of tests to be conducted to gather additional data.
- c - Determination of priority for process tests needed.
- d - Evaluation of data applicable to process design.
- e - Development of engineering flow diagrams.
- f - Determination of heat and material balances.
- g - Establishment of utility requirements.
- h - Preparation of equipment and design calculations.
- i - Development of preliminary specifications.
- j - Preparation of design data for general engineering.
- k - Preparation of engineering reports.

1.2 FUNCTIONAL LAYOUT

Functional Layout Engineers are responsible for arrangement of equipment and system components to meet process requirements as determined from the engineering flow diagram. The Functional Layout Engineers perform the following duties:

- a - Preparation of plot plans showing the relative location of buildings and plant operations.
- b - Preparation of layout studies, based on engineering flow diagrams showing the relative location of the various items of equipment and comparison of relative construction and operating costs for such an equipment distribution.
- c - The Functional Layout Engineers shall construct models indicating plant arrangement when warranted by project studies.
- d - In the event perspective and plot analyses are required to illustrate plant arrangement in engineering reports, the Functional Layout Engineers are responsible for the preparation of such engineering studies.
- e - Functional Layout Engineers are responsible for the determination and evaluation of the equipment required for handling of bulk materials.
- f - Functional Layout Engineers are responsible for the conception and evaluation of remote operations systems required by the process.

1.3 OPERATIONAL ENGINEERING

The Operational Engineers are responsible for the following:

- a - Supervision of preparation of all manuals necessary for successful operation of units.
- b - Outlining the procedures necessary for obtaining data from mechanical tests and physical mock-ups.

- c - Tabulating those data and information that are received from the operation of mock-up facilities so that intelligent process designs can be effected.
- d - Training personnel required in new plant operation.

B. FLOW SHEET STANDARDIZATIONB1.00 FOREWORD

1.1 INTRODUCTION

To carry out efficiently the engineering and drafting operations for chemical process work, certain basic data and information must be produced in a logical and straightforward manner.

The presentation of a chemical process, in a schematic form, wherein the facts pertaining to the chemical engineering calculations and design, delineation of process flow, rates of all flow of materials and capacities, vessels, mechanical equipment, piping and instruments are shown, is the first detailed step in the creation of a process plant. From Process Engineering through General Engineering and Purchasing, the flow diagrams form the basis of all engineering activities. From this diagram, a tangible and workable unit to be operated must be made.

Knowing the importance of such a process flow sheet in our work, it is necessary that procedures, symbols and drafting technique are standardized. With this in mind, Standard B2.00 should act as a check list for assisting Process Engineering and General Engineering.

1.2 VALUE OF FLOW SHEET AND RELATIONSHIP TO DETAILED ENGINEERING

By having a properly formulated flow sheet, the Process Engineers and Detailed Engineers expedite their part of the program, thus assuring a well-balanced job.

1. Process Engineers will be aided in the development of the complete project.

2. Functional Layout Engineers can produce a correct and well-balanced plant assembly.
3. Vessel Engineers will be aided in formulating the technical features of all mechanical and structural designs for all vessels.
4. Mechanical Engineers will be assisted in the proper handling and specifications of all pumps, compressors, turbines, filters, conveyors, separators, etc.
5. Instrument Engineers will be helped in the design and specifications relating to the recording and controlling of temperatures, pressure, flow, liquid level, speed, etc.
6. Piping Engineers can arrange the pipe, valves and fittings in such a manner as to govern the flow of process materials and utilities, such as steam, air, water, etc., through the plant in a practical operating system.
7. Structural Engineers, although indirectly effected, can design for the necessary architectural appurtenances and designs of all building, structures, etc.
8. Electrical Engineers will be assisted in the design of power generation, transmission, distribution, lighting and problems of operation and application.

B2.00 INSTRUCTIONS FOR PREPARATION OF FLOW SHEETS

PURPOSE

To outline drafting procedure necessary to produce a PROCESS ENGINEERING FLOW SHEET.

SCOPE

These standards are intended to apply to the Process Engineering Flow Sheet only.

2.1 GENERAL INSTRUCTIONS

1. Scope of Flow Sheet

The flow sheet shall contain all basic engineering data relating to the materials, flow and equipment. The flow sheet, supplemented as called for below, shall contain all information necessary to convert the fundamental process design into engineering drawings, specifications and bills of material.

2. Responsibility

Chemical Process Engineers shall be responsible for the issuance of the flow sheet and accuracy of all information, with the exception of piping line numbers.

3. Checking

All flow sheets shall be checked before being issued.

4. Approval

When process and plant improvement are under way, or when new construction facilities are duplications of operations, the engineering flow sheet shall be submitted to the Operating

FLOW SHEET STANDARDIZATION
B2.00 INSTRUCTIONS FOR THE
PREPARATION OF FLOW SHEETS

7

Department; suggestions will be solicited and evaluated; authority to make final decisions will remain with Engineering.

5. Data

The flow sheet shall be accompanied by written detailed design data information. This design data information shall include the following:

a. Process Description

The flow sheet shall be accompanied by a written description of the process involved. It is intended that this description serve as a supplement to the flow sheet. It shall contain a brief description of the process involved. In addition, it shall explain in considerable detail those phases of operation which will effect the design and physical layout and yet are not subject to graphic portrayal on the flow sheet. Examples of these are explanations of lines shown on the flow sheet for starting up, standby equipment, sequence of operations in batch operation, probable length of run and probable shutdown period. The importance of completeness of such a supplementary description should be apparent when it is realized that only the department issuing the flow sheet is in a position to judge the importance of the information left off the flow sheet.

FLOW SHEET STANDARDIZATION
B2.00 INSTRUCTIONS FOR THE
PREPARATION OF FLOW SHEETS

8

b. Material Balance Summary

The flow sheet shall be accompanied by a comprehensive material balance that shows the quantity of material flowing from operation to operation and one piece of equipment to another in terms of mols per hour, pounds per hour, gallons per minute, or cubic feet per minute or hour. Such a material balance shall be tabulated in the form of stream flows. (See sample material balance sheet, page 9).

SAMPLE OF MATERIAL BALANCE

2.1 GENERAL (Cont'd.)

MATERIAL BALANCE

<u>Material</u>	<u>Mol%</u>	<u>Mols/Hr.</u>	<u>Lbs./Hr.</u>	<u>Gal/Min.</u>	<u>Vol%</u>
Feed:					
(n) C ₄	41.13	36.287	2,129	7.1	35.50
(i) C ₅	10.75	9.482	684	2.1	10.50
(n) C ₅	20.60	18.174	1,311	4.1	20.50
C ₆	12.90	11.383	981	3.0	14.00
C ₇	10.20	8.994	901	2.5	12.50
C ₈	4.42	3.902	446	1.2	6.00
	<u>100.00</u>	<u>88.222</u>	<u>6,452</u>	<u>20.0</u>	<u>100.00</u>
Bottoms:					
C ₆	2.97	.325	28	0.1	3.1
C ₇	61.29	6.694	671	1.9	37.5
C ₈	35.74	3.902	446	1.2	59.4
	<u>100.00</u>	<u>10.921</u>	<u>1,145</u>	<u>3.2</u>	<u>100.00</u>
Overhead Liquid Product:					
(n) C ₄	34.02	15.47	899	3.0	28.8
(i) C ₅	13.25	6.22	449	1.3	12.6
(n) C ₅	27.70	13.10	945	3.0	28.8
C ₆	20.41	9.81	845	2.6	25.0
C ₇	4.62	2.22	223	.5	4.8
	<u>100.00</u>	<u>46.82</u>	<u>3,361</u>	<u>10.4</u>	<u>100.00</u>
Overhead Vapor Product:					
(n) C ₄	68.33	20.82	1,210	4.1	64.1
(i) C ₅	10.70	3.26	235	0.8	12.5
(n) C ₅	16.64	5.07	366	1.1	17.1
C ₆	4.10	1.25	108	.3	4.7
C ₇	.23	.07	7	.1	1.6
	<u>100.00</u>	<u>30.47</u>	<u>1,926</u>	<u>6.4</u>	<u>100.00</u>
Reflux:					
(n) C ₄	34.02	46.41	2,697	9.0	28.8
(i) C ₅	13.25	18.66	1,347	3.9	12.6
(n) C ₅	27.70	39.30	2,833	9.0	28.8
C ₆	20.41	29.43	2,535	7.8	25.0
C ₇	4.62	6.66	667	1.5	4.8
	<u>100.00</u>	<u>140.46</u>	<u>10,079</u>	<u>31.2</u>	<u>100.00</u>

SAMPLE OF MATERIAL BALANCE

2.1 GENERAL (Cont'd.)

MATERIAL BALANCE

<u>Material</u>	<u>Mol%</u>	<u>Mols/Hr.</u>	<u>Lbs./Hr.</u>	<u>Gal/Min.</u>	<u>Vol%</u>
Total Overhead:					
(n) C ₄	37.98	82.70	4,806		
(i) C ₅	12.92	28.14	2,031		
(n) C ₅	26.40	57.47	4,146		
C ₆	18.59	40.49	3,488		
C ₇	4.11	8.95	899		
	<u>100.00</u>	<u>217.75</u>	<u>15,370</u>		

5. Data (Cont'd.)

c. Properties of Materials

The design data shall include a tabulation of the properties of materials for each of the various streams flowing through the plant. Such properties shall include the gravity, viscosity and any special properties which affect the selection of materials of construction or equipment.

d. Preliminary Equipment Specifications

The design data shall include data sheets on equipment, instruments and vessels. These data sheets shall supplement the data on the flow sheets which is necessarily graphic. It shall contain recommendations as to type, make and operating characteristics of pumps and instruments, if such are vital and not apparent from the flow sheet. Similarly, special equipment requirements shall be described

FLOW SHEET STANDARDIZATION
B2.00 INSTRUCTIONS FOR THE
PREPARATION OF FLOW SHEETS

11

in these specifications. Vessel data sheets shall contain the remaining necessary design information which is not shown on the flow sheet. Any apparent discrepancies between the flow sheets and design data shall be fully explained in the design data.

2.2 INFORMATION REQUIRED ON FLOW SHEETS

1. All vessels, heat exchangers, pumps and other equipment effecting the process shall be shown schematically.
2. All piping directly a part of the process shall be shown, including all by-passes, drains, flushing connections and other auxiliary piping.
3. All devices for the control or measurement of process variables shall be shown schematically.
4. Data or materials shall include the following at flow condition or conditions: composition, temperatures, pressures, rates of flow. The foregoing applies to simple, well-known materials on which physical data is readily available. When the materials on which physical data are difficult to obtain shall be shown on the flow sheet, the following additional data are required: specific gravity and viscosity in the cases of liquids and gases. In the case of slurries, percent of solids, required velocity and particle sizes should be given.

If it is considered too cumbersome to show all of the above

FLOW SHEET STANDARDIZATION
B2.00 INSTRUCTIONS FOR THE
PREPARATION OF FLOW SHEETS

12

information on the flow sheet, such data should be given in the design data issued concurrently with the flow sheet.

5. All special structures, such as brine pits, hot wells, pumps, flame traps, disposal pits, burning stacks, etc., directly entering into the process shall be shown schematically.
6. Utility requirements and disposal, at the points of utilization only, shall be shown.
7. Piping line numbers shall be added to the flow sheet after they are assigned by the Piping Engineers. This means the line and item numbers will not show on the original issue of the flow sheet but will be added to a reproducible by the Piping Engineers.

2.3 INFORMATION TO BE EXCLUDED FROM THE ENGINEERING FLOW SHEETS

Utility Headers, such as steam, water, gas, etc., shall not be shown on the flow sheet unless a circulating system, complete within the unit, is intended and this information incorporated only after detailed layout studies are prepared.

2.4 DRAFTING PROCEDURES

1. General Arrangement

a. Size of Drawings

All flow sheets shall be drawn where possible on standard size sheets with an overall maximum size of 24" x 36".

b. Flow Sheet Arrangement

Insofar as possible, the flow sheets shall be arranged in

FLOW SHEET STANDARDIZATION
B2.00 INSTRUCTIONS FOR THE
PREPARATION OF FLOW SHEETS

13

accordance with unit operations or unit processes. Match lines should also be shown. Thus it will be possible for the Project Engineers to make a continuous flow sheet by pasting the sheets together at the match lines. (NOTE: Match lines shall be at the sides, not the top or bottom of the sheets.)

c. Margins

All flow sheets shall have a margin of two inches, measuring from the left edge of the sheet. The margin shall be kept clear of all information so that it will not be covered by binder stocks.

d. Symbol Keys

Each flow sheet shall contain a key to the symbols for lines used on the sheet, shown preferably in the lower right hand corner.

e. Arrangement of Equipment on Drawings

The vessels and equipment shall, insofar as practicable, be arranged with due regard to their sequence of use in the flow or operations being performed. For example, if the equipment is to be housed in a multi-storied structure of relatively narrow width, it would be best to show the equipment with "up" at the left side of the sheet. If the equipment is housed in a low structure of wide expanse, then "up" should be towards the top of the sheet. The

FLOW SHEET STANDARDIZATION
B2.00 INSTRUCTIONS FOR THE
PREPARATION OF FLOW SHEETS

14

equipment should also be spaced on the drawing so that, in general, the flow is either from right to left or from left to right. By following the above, the general arrangement will be of assistance in the detailed layout studies performed by the Design Engineers.

f. Use of Base Lines

Consideration should be given to the feasibility of establishing a base line on the flow sheets. By this is meant a horizontal plane at grade or some other important level. Equipment and piping should be shown on their proper sides of the base line.

2. Drafting Details

a. Scale of Drawings

In general, adherence to a fixed scale is not necessary. However, vessels and equipment, etc., shall be shown in rough proportion to their relative sizes. For instance, a 10' x 30' cylindrical tank should be shown larger than one 5' x 15'. All instruments, valves and other small parts shall be shown at large enough scale to be readily readable.

b. Avoidance of Overcrowding

The drawings shall not be so crowded that room is not available for the addition of later information, such as line numbers and item numbers.

FLOW SHEET STANDARDIZATION
B2.00 INSTRUCTIONS FOR THE
PREPARATION OF FLOW SHEETS

15

c. Names of Equipment

All vessels, equipment, etc., shall have the name shown and also the item numbers. The item numbers are to be assigned by Process Engineering.

d. Symbols for Equipment and Instruments

All equipment and instruments shall be shown on the flow sheets, in accordance with the standard symbols accompanying this procedure. It should be borne in mind that simplification is of necessity, due to the expenditure of engineering man hours.

e. Symbols for Lines

Careful attention shall be given to the use of line symbols. Main process flow lines shall be heavy, solid lines. By-pass piping, lines for starting up, utility lines, etc., shall be light, solid lines. If the draftsman is in doubt, he shall consult the Layout Engineer regarding the function of a line in question, as to whether it shall be heavy or light.

f. Pipe Fittings

Pipe fittings shall not be shown on the flow sheet unless their presence is essential to the operation.

g. Flow Arrows

Direction of flow in lines shall be shown by liberal use of arrows. Arrows shall be used as follows: at or near the

junction of all lines with vessels, pumps, or other equipment; at each change of direction of the lines; and at not over ten-inch centers in long, straight runs.

h. Line Labeling

Where lines leave the area of the flow sheet and are shown as continued to storage or other units, each line shall be plainly labeled as to its eventual disposition.

2.5 ENGINEERING PROCEDURES

1. Consistency of Units

The flow sheets shall be consistent in the use of units for data. For instance, vacua shall be shown in the same units at all points on the flow sheet as millimeters of mercury. Do not show pounds per square inch in one place and inches of mercury in another. The above is not intended to imply that a single, consistent system such as the c.g.s. be used, but merely that there be no change-over of units on any one flow sheet.

2. Data for Line Symbols

The Layout Engineers shall see that the draftsman drawing the flow sheet is supplied with sufficient information so that he can comply with the regulations on line symbols. Particularly important is that information be complete on by-pass and start-up piping, etc.

2.6 REVISIONS TO FLOW SHEETS

Revisions should be shown in a definite manner, as follows:

Each revision of the flow sheet shall be accompanied by a detailed list of each change made during the current revision. This list must be

FLOW SHEET STANDARDIZATION
B2.00 INSTRUCTIONS FOR THE
PREPARATION OF FLOW SHEETS

17

2.6 REVISIONS TO FLOW SHEETS (Cont'd.)

sufficiently clear so that those using the flow sheet can find all changes without the necessity of comparing the old and new copies of the flow sheet.

B3.00 FLOW SHEET SYMBOLS

The following system of nomenclature shall be adopted for the preparation of engineering flow sheets. These symbols indicate the item numbers and the schedules to be used for indicating columns, tubular equipment, agitated vessels, equipment for unit operations and instruments. With reference to the symbols used for indicating instrumentation on the flow sheet, it should be noted that this list is representative only and is not complete. For that reason, the following explanations are given on the use of symbols and their combination and expansion to cover the entire field of fluid measurement and control.

For the purpose of explaining the use of symbols, automatic control may be considered to consist of a maximum of three essential parts, as follows:

1. A preliminary element, as for instance, an orifice.
2. A measuring and/or controlling device, as for instance, an indicating controller.
3. A final control element, as for instance, a control valve.

The symbols shown are so set up that any combination in actual practice, within the limits of fluid flow, can be properly shown. As pointed out under "design data", special requirements in instruments, not evident from the symbols, are to be explained in the design data sheets accompanying the flow sheets. Since, in some cases, a symbol represents a number of types of instrument, one of two courses must be followed by

3.00 FLOW SHEET SYMBOLS

the Process Engineers when formulating the flow sheets. Either this division must send data sheets with the flow sheets to explain fully the type or desired characteristics of the instruments required or it must leave the selection up to the Instrument Engineer. In explanation of the foregoing, the various groups of instruments are discussed below:

Temperature

A single symbol is used to portray all types of indicators. Any special requirements must be explained as noted above. Thermo-wells need not be shown on the flow sheet except where they are for use with a portable temperature indicator or when extra thermo-wells are desired.

Pressure

A single symbol is used to portray all types of indicators. Any special requirements must be explained as noted above.

Flow

Symbols for two types of flow rate indicators are shown: differential pressure and area types. These two symbols will take care of most cases occurring in our practice. Symbols for a number of primary elements are shown and are to be used in conjunction with the appropriate symbol for the measuring or controlling device. Symbols for FI, FR, FC, etc., as shown herein, are therefore, representative only.

No symbols are shown for flow totalizers or integrators. When such functions are required, no new symbols are necessary. Simply combine the proper instruments in symbol form and insert the letter "T" immediately after "F" in the label. Thus a positive displacement meter and a recorder

Flow (Cont'd.)

may be combined to make a "Flow Totalizer Recorder (FTR)."

Level

Due to the multiplicity of available primary elements for this purpose, only one symbol has been shown to cover the mechanical types. It will be necessary, therefore, for the data sheets to describe the desired type of instrument.

Analysers

This group is large and indefinite as is evidenced by the lack of precision in the word "analyser". As an aid to the placement of possible instrument functions in the proper category, the following list is given:

<u>Description</u>	<u>Labels</u>
a. Viscosity	(v)
b. Hydrogen Ion Concentration	(pH)
c. Electrical Conductivity	(ec)
d. Thermal Conductivity	(tc)
e. Calorific Value	(cv)
f. Explosibility and Inflammability	(e), (i)
g. Humidity	(h)
h. Color, Opacity, Turbidity, etc.	(c), (o), (t), etc.
i. Moisture Content	(m)
j. Composition Analysis	(ca)

The symbols shown for this group are schematic and conventional only. Therefore, the function of the instruments in question will necessarily need to be fully described in the "Data Sheets". However, as an aid to

Analysers (Cont'd.)

those using the flow sheet, the above listed labels of analysers shall be combined with the principal part of the label as shown on the symbol sheet.

(Viz. for a pH controller-AC (ph).)

B4.00 INSTRUCTIONS FOR PREPARATION OF UTILITY FLOW SHEETS

Utilities for the purpose under discussion are those fluids or other services required at one or more points of utilization in the process, yet the flow system of which may be made entirely independent of the process.

4.1 Under utilities, may be classed the following:

- | | |
|---------------------------------|---|
| 1. Process Steam | 11. Heating Water |
| 2. Heating Steam (Process) | 12. Steam Condensate |
| 3. Building Heating Steam | 13. Air For Power |
| 4. Power Steam for Prime Movers | 14. Air For Instruments |
| 5. Steam Tracings | 15. Air For Cleaning or Blowing Out Lines |
| 6. Cooling Water | 16. Fire Steam |
| 7. Drinking Water | 17. Inert Gases |
| 8. Chemical Make-up Water | 18. Evacuating Lines |
| 9. Process Water | 19. Blowdown Lines |
| 10. Flushing Water | 20. Various Gases used For Supplying Heat |

4.2 Utilities shall be shown on a separate flow sheet from the process.

The principal reason for this separation is that the layout of utility piping systems is dependent on the actual physical location of the equipment, and of the point of entry of the utility into the area.

Both of the foregoing are not determinable at the time the process flow sheet is made.

4.3 After the Process Engineering Flow Sheet is received by Detailed Engineers and coincidentally with the layout of the process piping, the Piping Engineers shall layout the utility piping system.

FLOW SHEET STANDARDIZATION

B4.00 INSTRUCTIONS FOR PREPARATION
OF UTILITY FLOW SHEETS

23

- 4.4 Sizing of lines shall be done by Process Engineers, based on the arrangement of piping laid out, requirements shown on the Process Engineering Flow Sheet and requirements of pumps, turbines, etc., as determined by the Mechanical Equipment Engineers.
- 4.5 All service connections shall be shown on the flow sheet.
- 4.6 The Utility Flow Sheet as completed above shall be submitted for approval before dependent design is continued.

B5.00 PROCEDURE FOR REVISING FLOW SHEETS

The Process Engineers are fully responsible for the Flow Sheets on all projects. After these drawings have been issued to the Detail Engineers, the different squads may find discrepancies or other things which of necessity require revisions. In order to systematize such revisions, the following procedure shall be followed:

- 5.1 Alterations are to be marked on the binder copy. Along with the marking of the prints, a "revision list" posted beside the print rack must also be noted with the Project Number, date, name of squad and signature of the individual.
- 5.2 All changes shall be marked with colored pencil and always initialed by the engineer making the changes.
- 5.3 Each engineer shall also mark the required revisions on his own copy of the flow sheet.
- 5.4 At appropriate intervals the revisions desired for the Flow Sheets shall be brought to attention of properly designated persons.

C. FLOW SHEET CODE SYSTEMC1.00 NUMBERING SYSTEM

The following is the method for assigning drawing and equipment numbers for the various types of work and equipment on all projects.

1.1 FLOW SHEET NUMBERS

Flow sheets are numbered according to project and sequence. For example, the third flow sheet drawn for a particular project might have the number (1006-92-03-1). This may be broken down as follows:

1006	Project Number
-92	Flow Sheet Designation
-03	Sequence Number
-1	Revision Number

The number 92 appears in all flow sheet numbers. The sequence number shall always be the last two digits of the third group. The revised number shall be changed each time the drawing is revised.

1.2 FUNCTIONAL LAYOUT NUMBERS

Functional layouts are numbered according to project and sequence. For example, the third flow sheet drawn for Project 1006 might have the number 1006-91-03-1. This may be broken down as follows:

1006	Project Number
-91	Functional Layout Designation
-03	Sequence Number
-1	Revision Number

The sequence number shall always be the last two digits of the

1.2 FUNCTIONAL LAYOUT NUMBERS (Cont'd.)

third group. The number 91 appears in all functional layout numbers. The revision number shall be changed each time the drawing is revised.

1.3 VESSELS

Item Numbers

All vessels are placed in certain groups or series of Item Numbers according to their particular types or functions. For example, all columns and towers are placed in the 100 series; agitated or reaction equipment such as autoclaves, mixers, etc., in the 300 series, and all tanks such as receivers, decanters, storage tanks, etc., in the 500 series.

Types of vessels in the other series are represented by specific numbers. A particular vessel of any type is designated by a sequence number following the type number. For example, a particular finned tube heat exchanger might be represented by 202-3.

The Item Numbers are assigned on the flow sheet. No attempt is made to standardize on any of these numbers, but instead, they are assigned anew for each project.

B/M Numbers

The B/M Numbers and Item Numbers are always related in both Series and Sequence Numbers. For example, a certain column may be assigned Item No. 108-8. The B/M Number would be 196-08-8-1 and broken down as follows:

1	Column Designation
96	B/M Designation
-08	Type Designation (Column)
-8	Sequence No. (Eighth Column in that Group)
-1	Sequence No. (First B/M for that Column)

B/M Numbers (Cont'd.)

Or, a certain finned tube heat exchanger may be assigned Item No.

202-3. The B/M Number would be 296-02-3-2 and broken down as follows:

2	Tubular Equipment Designation
96	B/M Designation
-02	Type Designation (Finned Tube Heat Exchanger)
-3	Sequence No. (Third Exchanger in that Group)
-2	Sequence No. (2nd B/M for that Exchanger)

Drawing Numbers

All vessel drawing numbers are related directly to the Item Number. Example: Item 108 will be detailed by Drawing Number 108-1, the -1 indicating the first drawing related to that particular vessel. Item 202-3 will be detailed on Drawing Number 202-3-1 indicating the first drawing related to that piece of equipment, etc.

1.4 MECHANICAL EQUIPMENT

Item Numbers

All mechanical equipment is placed in the 400 series and all equipment assigned a particular number according to its type. For example: 404 is a Milton Roy Pump and to this is added a Sequence Number for each particular Milton Roy Pump. 404-1 would indicate the first Milton Roy Pump on a particular project.

B/M Numbers

The B/M and Item Numbers are always related in both Series and Sequence Numbers. For example: the Milton Roy Pump Item 404-1 referred to above would be covered by B/M No. 496-04-1, which is formed by merely inserting the standard B/M indication 96 and a dash between and 4 (for 400 series) and 04-1.

1.5 INSTRUMENTS

Item Numbers

All instrumentation is placed in the 600 series and each type of instrument is given a number in that series. For example, PRC 613 is a pressure recording controller. PRC 613-1 would indicate the first pressure recording controller on a particular project.

B/M Numbers

The B/M and Item Numbers are always related in both Series and Sequence Numbers. However, the Area Number in which the particular piece of equipment occurs also appears in conjunction with the B/M number. Example: B/M No. 696-513. The 696 indicates an instrument B/M (600 series and 96 standard B/M indication), the 5 indicates area 5, and the 13 signifies a pressure recording controller. If, for instance, Items 613-1 and 613-2 appear on the above example B/M and later it becomes necessary to order two more pressure recording controllers such as 613-3 and 613-4, the second B/M will have "A" appended to the B/M number. "B" for the third, etc. Accordingly, the B/M number will appear thus: 696-513-A. On projects not broken up into areas, it is assumed that all material is required in Area 1; hence B/M No. 696-113.

Drawing Numbers

All instrument drawings are in the 600 series and bear no relationship to either the B/M or Item Numbers. Instead Drawing Numbers are assigned by area or group numbers. Example:

Drawing Numbers (Cont'd.)

1000	Project Number
-6	Instrument Designation
-05	Area Number 5
-1	Sequence Number (First Drawing in that Group)

1.6 PIPING

Item Numbers

All piping material is placed in the 700 series and given definite group classifications. Basically, all piping Item Numbers consist of two sets of three digit numbers separated by a dash, thus 710-102-3, the first three numbers being the material group number and the second three identifying the particular item in the group. As for example:

7	Piping Indication
10	Material Classification
-1	Weight Classification Number (100 lb.)
02	Type Number (45-deg elbow)
-3	Sequence Number (Third elbow in that group)

Material Classification Numbers

Cast Iron	1
Steels	2
Alloys	3
Copper (including bronze)	4
High Silicon Irons (such as Duriron)	5
Porcelain (including glass, carbon)	6
Lead	7

Material Classification Numbers (Cont'd.)

Plastic (such as Saran)	8
Lined Pipe (glass or lastiglass)	9
Aluminum	10
Clay or Concrete	11

Weight Classification Numbers

100 lb. pipe or fittings	1
200 lb. pipe or fittings	2
300 lb. pipe or fittings	3
600 lb. pipe or fittings	4
2500 lb. pipe or fittings	5

Pipe Fitting Numbers

Straight Pipe	1
45-Deg. Elbow	2
90-Deg. Elbow	3
Tee	4
Union	5
Coupling	6
Streetell	7

A letter following the type number indicates the type of connection. For example:

7	Piping Indication
10	Material Classification Number (Aluminum)
-1	Weight Classification Number (100 lb.)
02	Type Number (45-Deg. Elbow)
A	Joint (Threaded)
-3	Sequence Number (Third Elbow in that Group)

Joints

- A. Threaded
- B. Welded
- C. Flared
- D. Bell

B/M Numbers

The piping B/M and Item Numbers are related to a certain extent. All piping B/M Numbers consist of three parts, the first being the standard designation for a piping B/M, the second identifying the material group, and the third the Sequence Number or Sequence and Area Number in combination. In view of the material group designation being used, a B/M will always contain items of the same material only. Thus, using the item number referred to above as an example, we would have B/M No. 796-10-8 broken down as follows:

7	Piping Designation
96	B/M Designation
-10	Material Classification No. (Aluminum)
-8	Sequence No. (Eighth B/M in that group)

Note: This B/M would apply to a project of only one general area. If the project were divided into numerous areas, the number would appear like this: 796-10-308, with the breakdown of the first two parts the same as explained above. The 308 would be divided thus:

3	Area No. 3
08	Sequence Number (Eighth B/M in that group)

Drawing Numbers

All piping drawings are in the 700 series and bear no relationship to either Item or B/M Numbers. Instead, they are assigned by Area or Group Number. Example:

1006	Project Number
-7	Piping Designation
04	Area No. 4
-2	Sequence Number (Second Drawing in that area)

1.7 STRUCTURAL

Item and Drawing Numbers

All structural items and drawings are in the 800 series with the Item Number being secondary or determined by the drawing number.

The drawing numbers are assigned according to Area or Group Number. Example 1000-802-18:

1000	Project Number
-8	Structural Designation
02	Area No. 2
-18	Sequence No. (Eighteenth Drawing in that area)

All items are generally divided into two classes, a complete unit or assembly designated by a letter and the detail parts of the unit designated by a numeral. Both in their entirety are derived from the drawing number on which they appear. Using the above drawing as an example, a foundation block shown on that drawing might carry Item Number 802-1A, the 802-1 identifying the drawing, and the A the item. Breakdown parts of that particular item might be identified as follows: 802-1-1 concrete, 802-1-2 anchor bolts, 802-1-3 reinforcing steel, etc.

Item and Drawing Numbers (Cont'd.)B/M Numbers

Structural B/M Numbers bear no relationship to the Drawing or Item. All structural B/Ms carry 896 as the structural B/M Standard Identification Number and a straight Sequence Number. Example, 896-1, 896-2, etc.

1.8 ELECTRICAL

B/M Numbers

All electrical items are placed in the 900 series. All electrical material is divided into groups and each group given a designation letter. For example, A for Conduit and Fittings, B for Wire, etc. Each group is then broken down according to its size or nature with a numeral designation. Thus conduit might be classified as A6, with A meaning conduit and 6 signifying 2" sherardized, while A7 might be 3" diameter in the same material, etc. However, all electrical item numbers as well as B/M numbers carry a 996 standard identification number so that the full item number would read 996-A6. The lettered group classification is standard, but the type number is set up especially for the particular requirements of each project.

As mentioned above, all electrical B/Ms carry the standard 996 Identification Number followed by a straight Sequence Number having no relationship to the Item Number, thus: 996-1, 996-2, etc.

Drawing Numbers

All electrical drawings are in the 900 series and bear no relationship to either Item or B/M Numbers. Instead they are assigned

Drawing Numbers (Cont'd.)

by Area or Group Number. Example 1005-901-1:

1005	Project Number
-9	Electrical Designation
01	Area No. 1
-1	Sequence Number (First Drawing in that area)

Note: All reference to drawing numbers herein deals with each squad's special use numbers and not with standard, sketch, or layout numbers.

C2.00 FLOW SHEET SYMBOLS

<u>Item No.</u>	<u>Equipment</u>	<u>Symbol</u>
-----------------	------------------	---------------

2.1 COLUMNS AND TOWERS

Each type of column or tower will be assigned a number in the interval 100-199.

Pulse Column

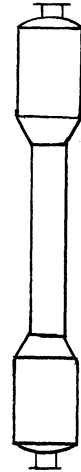


Plate Column



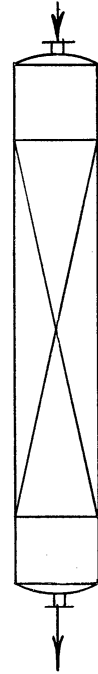
Item No.

Each type of column or tower will be assigned a number in the interval 100-199.

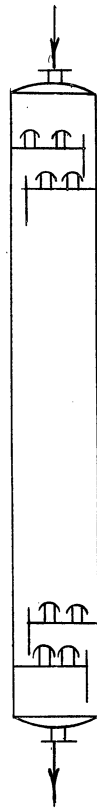
Equipment

Symbol

Packed Column



Bubble Cap Column



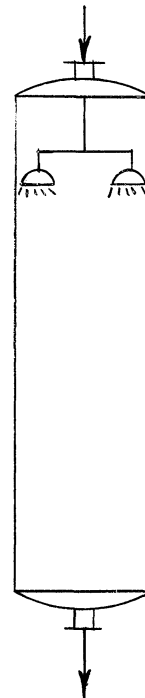
Item No.

Equipment

Symbol

Each type of column or tower will be assigned a number in the interval 100-199.

Spray Tower



Item No.

Equipment

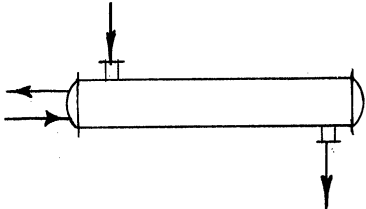
Symbol

2.2 TUBULAR EQUIPMENT

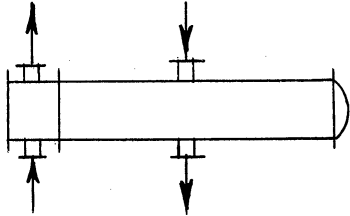
200

Shell and Tube
Heat Exchangers

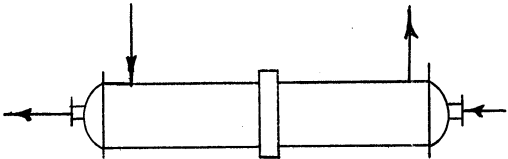
Heat Exchanger
With Fixed Tube Sheets



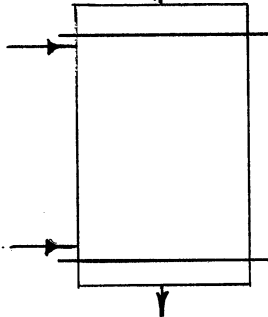
Floating Head
Heat Exchanger



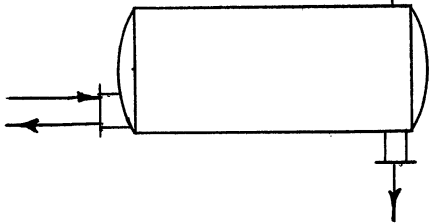
Condenser



Calandria



Reboiler



Item No.

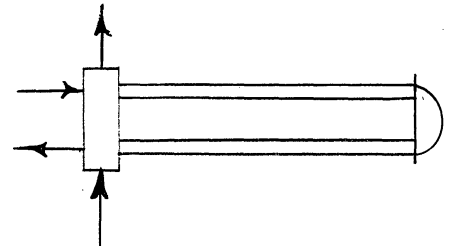
Equipment

Symbol

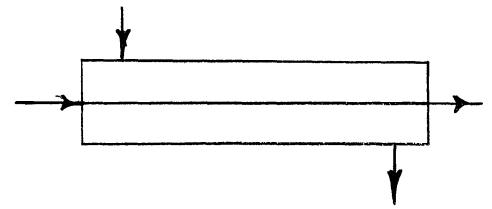
210

Pipe or Finned Tube
Heat Exchangers

Finned Tube
Heat Exchanger



Double Pipe
Heat Exchanger



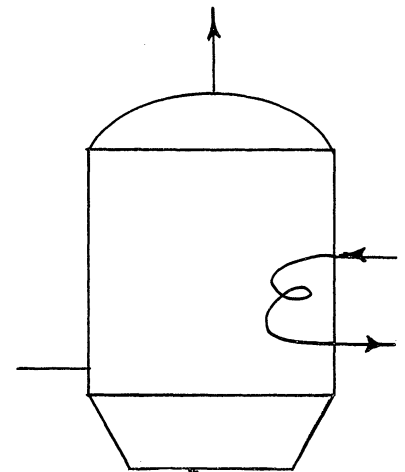
Heater



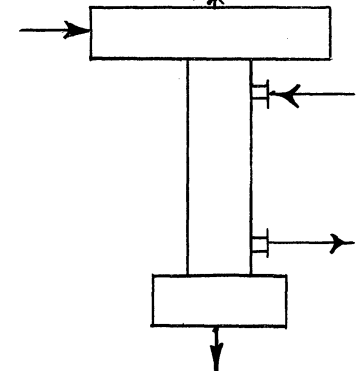
220

Evaporators

Single Effect
Evaporator
With Internal
Heating



Falling Film
Evaporator



<u>Item No.</u>	<u>Equipment</u>	<u>Symbol</u>
220 (Cont'd.)	Evaporators	
	Thermal Cycle Evaporator	
230	Crystallizers	
	Vacuum Crystallizer	
240	Kilns	
	Rotary Kiln	
2.3 AGITATED OR REACTION EQUIPMENT		
300	Mixer Settler	
310	Agitated or Reaction Tank	
	Tank with Mechanical Agitator	

<u>Item No.</u>	<u>Equipment</u>	<u>Symbol</u>
310 (Cont'd.)	Agitated or Reaction Tank	
	Tank with Sparger	
	Tank with or without Mechanical Agitator and Jacket as shown	
	Tank with Sparger and Jacket	
320	Autoclave	
	Autoclave	
330	Infinitely Safe Agitated or Reaction Tank	
	Infinitely Safe Tank with Sparger	

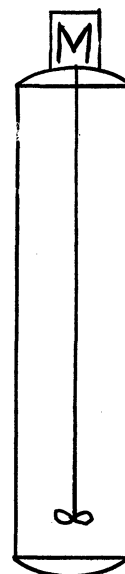
Item No.

Equipment

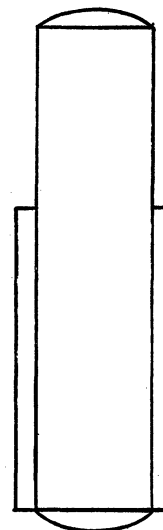
Symbol

330 (Cont'd.)

Infinitely Safe Tank with
mechanical Agitator



Infinitely Safe Tank with
Jacket



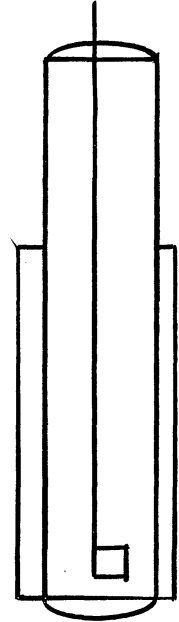
Item No.

Equipment

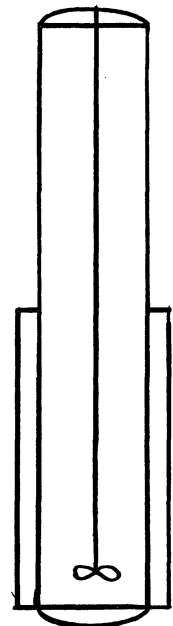
Symbol

330 (Cont'd.)

Infinitely Safe Tank with
Jacket and Sparger



Infinitely Safe Tank with
or without Jacket and
Mechanical Agitator as shown



Item No.

Equipment

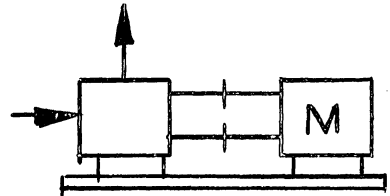
Symbol

2.4 MECHANICAL EQUIPMENT

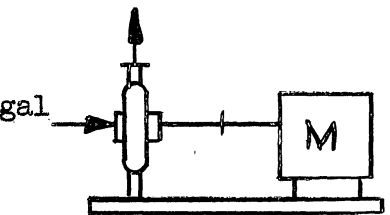
400

Pumps

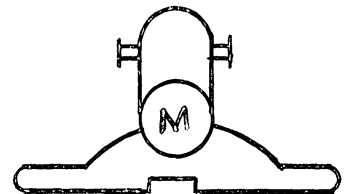
Diaphragm or Re-
ciprocating Pump



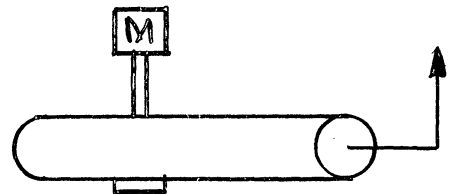
Rotary or Centrifugal
Pump



Gear Pump

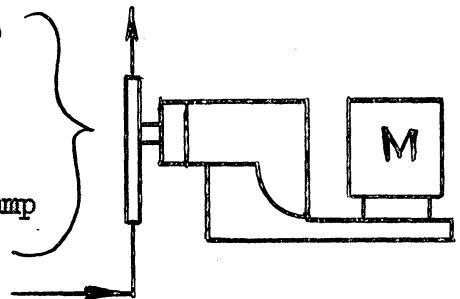


Sump Pump

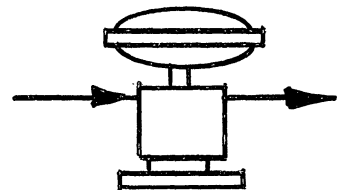


Measuring Pump

Remote Head Pump



Air Operated
Diaphragm Pump



FLOW SHEET CODE SYSTEM

C2.00 FLOW SHEET SYMBOLS

45

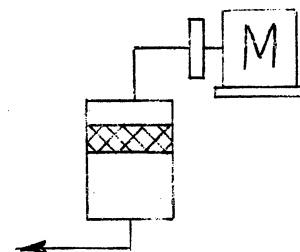
Item No.

Equipment

Symbol

410

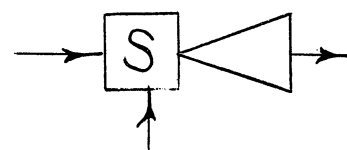
Pulse Generator



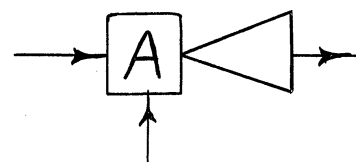
420

Jets

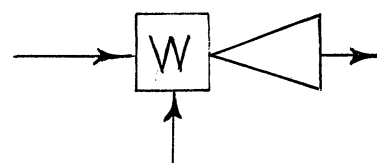
Steam Jet Eductor



Air Jet Eductor



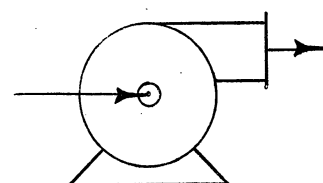
Water Jet Eductor



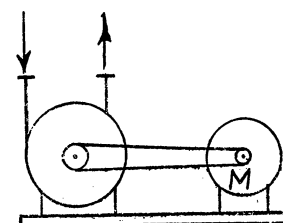
430

Mechanical Gas Moving
Equipment

Blower



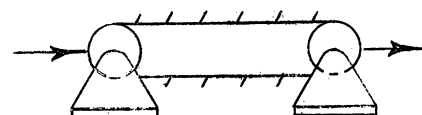
Compressor or Vacuum Pump



440

Mechanical and Conveying
Equipment

Conveyor



Item No.

Equipment

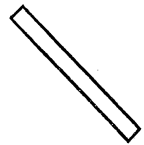
Symbol

440 (Cont'd.)

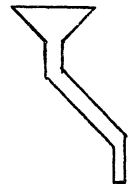
Gear Reducer



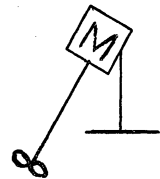
Chute



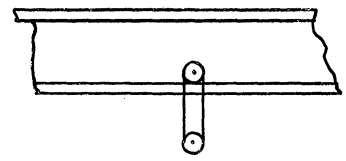
Slug Chute



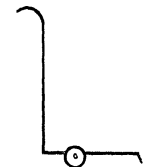
Portable Agitator



Hoist



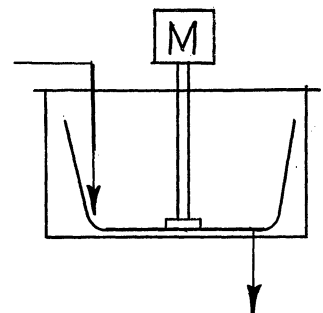
Hand Trucks



450

~~Separations Equipment~~

Centrifuge



FLOW SHEET CODE SYSTEM

C2.00 FLOW SHEET SYMBOLS

47

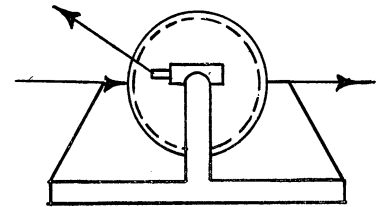
Item No.

Equipment

Symbol

450 (Cont'd.)

Rotary Filter



Filter Press

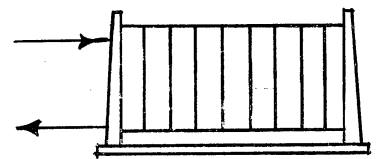
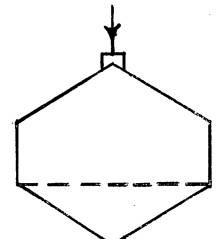
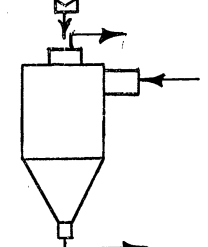


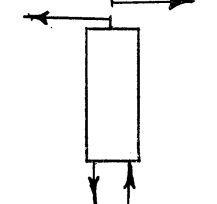
Plate Filter



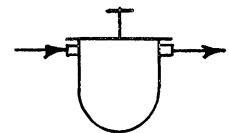
Cyclone Separator



De-entrainer



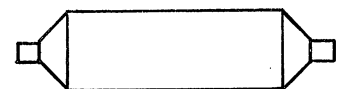
Strainer



460

Dryers

Drum Dryer



Item No.

Equipment

Symbol

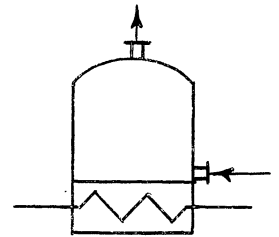
470

Generators

Gas Generator



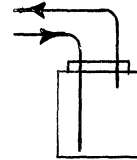
Steam Generator



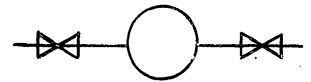
480

Special Equipment

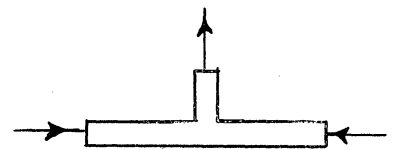
Sampler



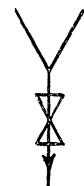
Gas Sampler



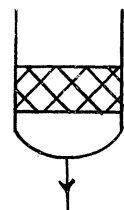
Mixing Tee



Addition Funnel



Sintered Filter



Item No.

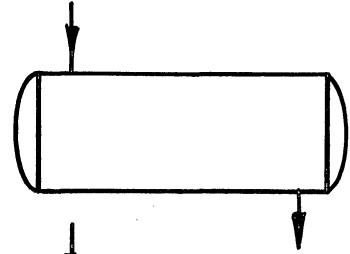
Equipment

Symbol

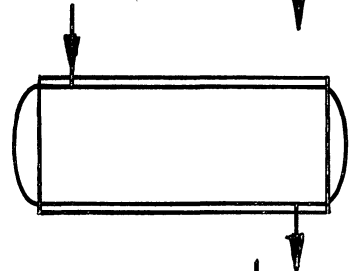
2.5 TANKS

500

Storage Tanks
Tank

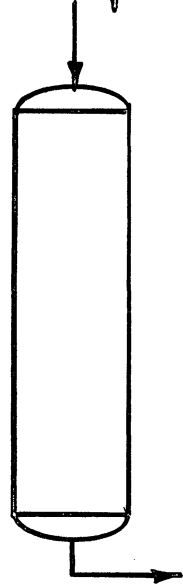


Tank with Jacket



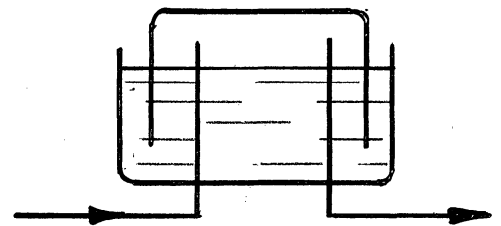
510

Infinitely Safe
Storage Tank



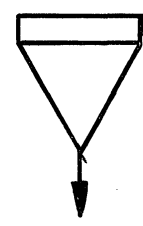
520

Gas Holder



530

Bin or Hopper



FLOW SHEET CODE SYSTEM

C2.00 FLOW SHEET SYMBOLS

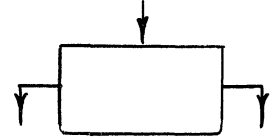
Item No.

Equipment

Symbol

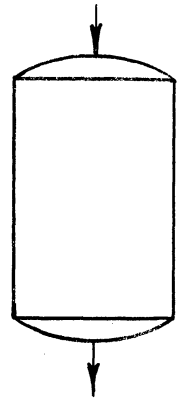
540


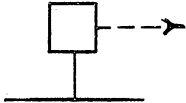
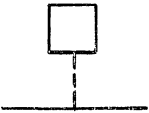
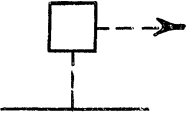
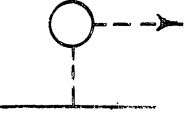

Decanter

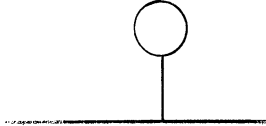
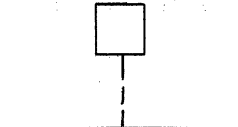
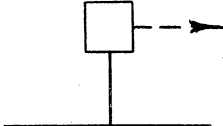
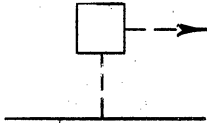
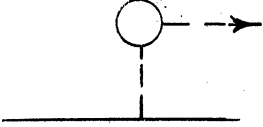


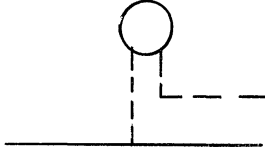
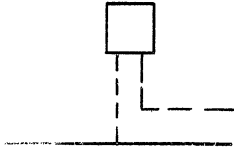
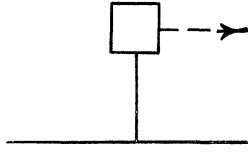
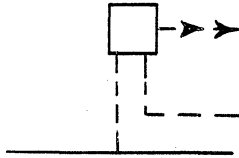
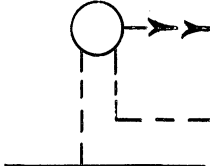
550

Receiver, Run-down,
Feed Tank



<u>Item No.</u>	<u>Instrument Function</u>	<u>Symbol</u>	<u>Label</u>
2.6 INSTRUMENTS	(An "A" in the label accompanying any symbol indicates that the instrument has an alarm.)		
600-609	Temperature Instruments		
	Temperature Indicator		TI
	Temperature Controller - Non-Indicating		TC
	Temperature Recorder		TR
	Temperature Recording Controller		TRC
	Temperature Indicating Controller		TIC
	Thermo - Well		TW

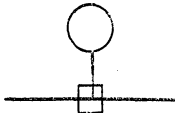
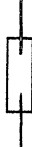
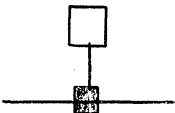
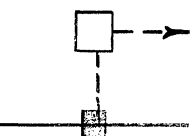
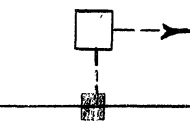
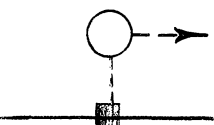
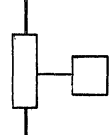
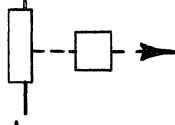
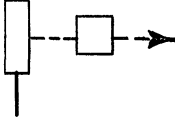
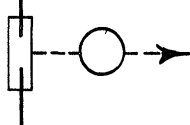
<u>Item No.</u>	<u>Instrument Function</u>	<u>Symbol</u>	<u>Label</u>
610-619	Pressure Instruments		
	Pressure Indicator		PI
	Pressure Recorder		PR
	Pressure Controller - Non-Indicating		PC
	Pressure Recording Controller		PRC
	Pressure Indicating Controller		PIC

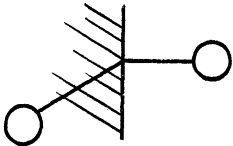
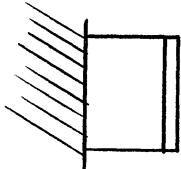
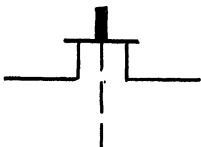
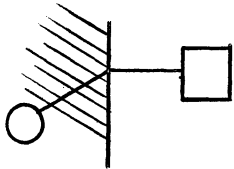
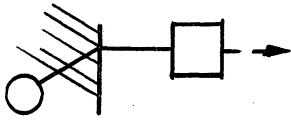
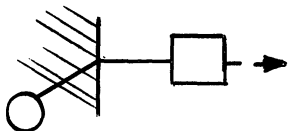
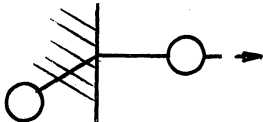
<u>Item No.</u>	<u>Instrument Function</u>	<u>Symbol</u>	<u>Label</u>
	Pressure Difference Indicator		PDI
	Pressure Difference Recorder		PDR
	Pressure Difference Controller- Non-Indicating		PDC
	Pressure Difference Recording Controller		PDRC
	Pressure Difference Indicating Controller		PDIC

FLOW SHEET CODE SYSTEM

C2.00 FLOW SHEET SYMBOLS

54

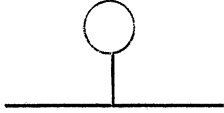
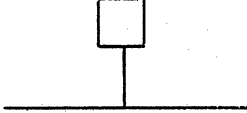
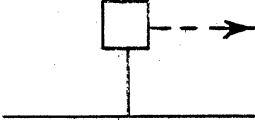
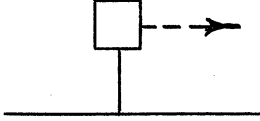
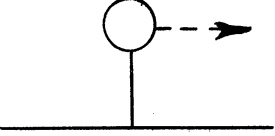
<u>Item No.</u>	<u>Instrument Function</u>	<u>Symbol</u>	<u>Label</u>
620-629	Flow Instruments		
	Flow Rate Indicator (Differential Type)		PFI
	Flow Rate Indicator (Area Type)		AFI
	Flow Rate Recorder (Differential Type)		PFR
	Flow Rate Controller (Differential Type)		
	Flow Rate Recorder Controller (Differential Type)		PFRC
	Flow Rate Indicating Controller (Differential Type)		PFIC
	Flow Rate Recorder (Area Type)		AFR
	Flow Rate Controller (Area Type)		AFC
	Flow Rate Recording Controller (Area Type)		AFRC
	Flow Rate Indicating Controller (Area Type)		AFIC

<u>Item No.</u>	<u>Instrument Function</u>	<u>Symbol</u>	<u>Label</u>
630-639	Level Instruments		
	Level Indicator (All Types except gauge cols. and gauge sticks)		LI
	Level Indicator (Gauge Column)		LI
	Level Indicator (Gauge Stick)		LI
	Level Recorder		LR
	Level Controller		LC
	Level Recording Controller		LRC
	Level Indicating Controller		LIC

FLOW SHEET CODE SYSTEM

C2.00 FLOW SHEET SYMBOLS

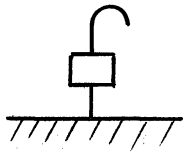



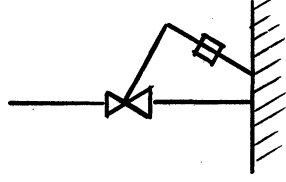


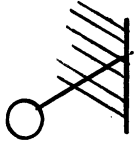

56

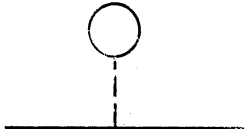
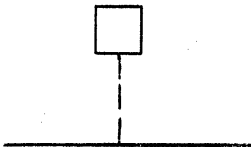
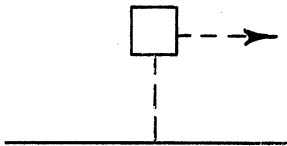
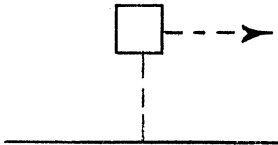
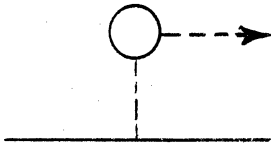
<u>Item No.</u>	<u>Instrument Function</u>	<u>Symbol</u>	<u>Label</u>
640-649	Analysing Instruments		
	Analysing Indicator		AI
	Analysing Recorder		AR
	Analysing Controller		AC
	Analysing Recording Controller		ARC
	Analysing Indicating Controller		AIC


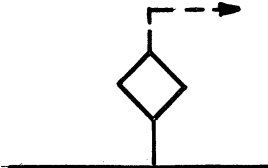
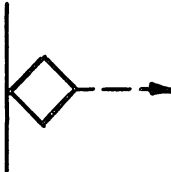

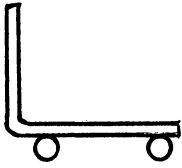

FLOW SHEET CODE SYSTEM

C2.00 FLOW SHEET SYMBOLS

57

<u>Item No.</u>	<u>Instrument Function</u>	<u>Symbol</u>	<u>Label</u>
650-659	Safety Devices		
	Flame Arrestor		FA
	Rupture Disc		RD
	Relief Valve		RV
	Control Valve		RVC
	Fusible Link Safety Valve		FL
	Indicator		I
	Recorder		R
	Level (Primary element)		
	Indicating Controller		IC

<u>Item No.</u>	<u>Instrument Function</u>	<u>Symbol</u>	<u>Label</u>
660-669	Specific Gravity Instruments		
	Specific Gravity Indicator		GI
	Specific Gravity Recorder		GR
	Specific Gravity Controller Non-Indicating		GC
	Specific Gravity Recording Controller		GRC
	Specific Gravity Indicating Controller		GIC

<u>Item No.</u>	<u>Instrument Function</u>	<u>Symbol</u>	<u>Label</u>
670-679 Miscellaneous Instruments			
	Controller (Non-Indicating or Recording)		C, RC
	Pressure Switch		PS
	Limit Switch		LS
	Noise Alarm		NA
	Platform Scale		
	Radiation Monitor		RM

FLOW SHEET CODE SYSTEM

C2.00 FLOW SHEET SYMBOLS


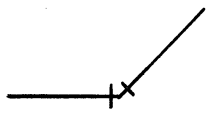
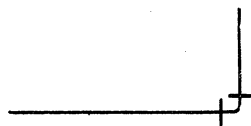
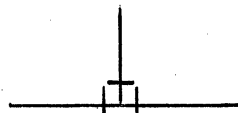
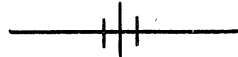


60

Item No.

Pipe Fitting




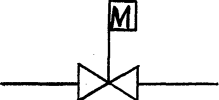
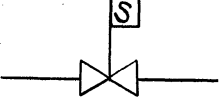
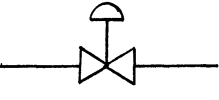

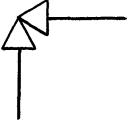


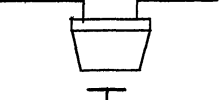

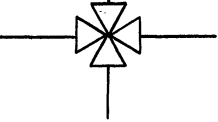
Symbols

2.7 PIPING

(1)	Straight Pipe	
(2)	45-Deg. Elbow	
(3)	90-Deg. Elbow	
(4)	Tee	
(5)	Union	
(6)	Streetell	
(7)	Reducer	

FLOW SHEET CODE SYSTEM

C2.00 FLOW SHEET SYMBOLS

<u>Item No.</u>	<u>Pipe Fitting</u>	<u>Symbols</u>
	(An "R" below the symbol for any valve indicates that the valve is remotely controlled)	
(20)	Gate Valve	
(21)	Globe Valve	
(22)	Plug Valve	
(23)	Motor-Operated Valve	
(24)	Solenoid Valve	
(25)	Diaphragm-Operated Valve	
(26)	Diaphragm Valve (Saunders Patent)	
(27)	Angle Valve	
(28)	Check Valve	
(29)	Three-Way Valve	
(30)	Steam Trap	
(31)	Pressure Reducing Valve (Manual)	
(32)	Multi-port Valve	

C3.00 ILLUSTRATION OF CODE SYSTEM USE

The accompanying process description and flowsheet presents a part of an organic process and is shown to illustrate use of equipment numbering and the relation of this to engineering flowsheets. The following are presented:

- 3.1 Process Description
- 3.2 Engineering Flowsheet
- 3.3 Equipment Itemizing
- 3.4 Preliminary Equipment Specification

3.1 DESCRIPTION OF SAMPLE PROCESS

A slurry of calcium carbonate is made up in Dissolvers, Item Nos. 301-1 and 301-2, using recovered calcium carbonate and water. The slurry is sterilized by live steam admitted directly to the Dissolvers. The slurry is then pumped into one of the Fermenters, Item Nos. 303-1, 303-2, 303-3 and 303-4, at the boiling point by Fermenter Feed Pump, Item No. 401-7, by-passing Solution Coolers, Item Nos. 200-1 and 200-2.

Seven (7) charges of corn sugar, water, and culture food are made up in the dissolvers. Live steam is admitted directly into the solution until it boils (approximately 220° F.). The solution is then pumped through solution coolers, where it cools to 83° f. into the Fermenter. A portion of the cooling water from Solution Cooler, Item No. 200-2, is used to make up the next charge of sugar solution. The fermenters are seeded with a charge from Culture Tanks, Item Nos. 301-3 and 301-4, pumped by Fermenter Feed Pump, Item No. 401-7. When seven (7) charges of cooled sugar solution and one (1) charge of carbonate slurry are thoroughly mixed in the Fermenter, a temperature

3.1 DESCRIPTION OF SAMPLE PROCESS (Cont'd.)

of 100°F. in the mixture will be attained. Throughout the fermentation period of thirty (30) days, this temperature is maintained by water at 100°F., flowing through fermenter jackets. Constant temperature water is maintained by the admission of extra steam or water by means of Mixing Tee, Item No. 442-1, to the flow from Circulating Pumps, Item Nos. 401-1 and 401-2. Recording Temperature Controller, Item No. 603-1, controls the extra steam or water requirements. After passing through the fermenter jackets, constant temperature water returns to Constant Temperature Tank, Item No. 500-1. During fermentation, sufficient air flows through the reaction mass to maintain bacteria life and complete the fermentation.

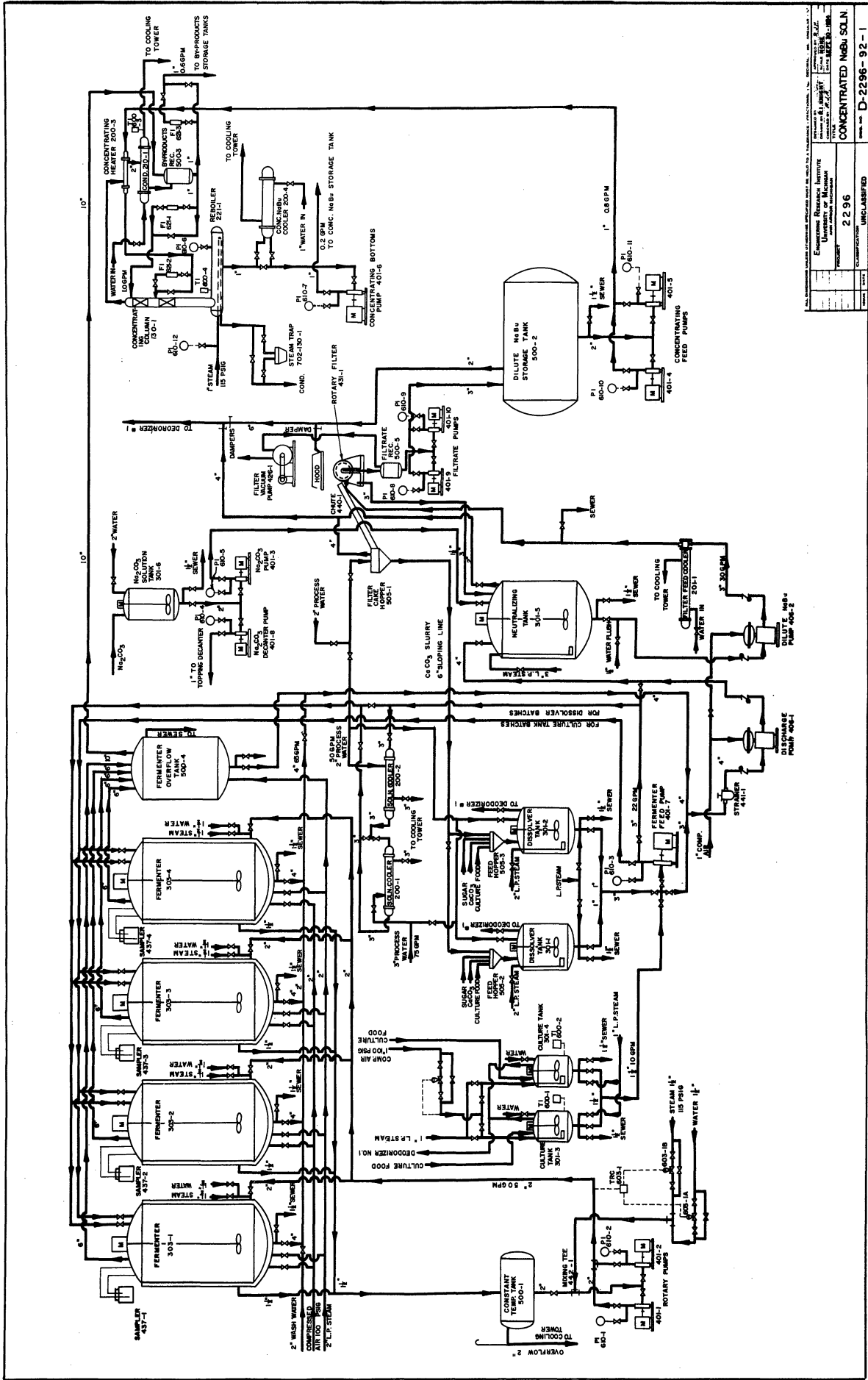
All vessels and lines used in setting a Fermenter are provided with steam out connections and drains.

After fermentation is complete, the batch is pumped into Neutralizing Tank, Item No. 301-5, by Discharge Pump, Item No. 406-1. Sodium carbonate solution is added from Sodium Carbonate Solution Tank, Item No. 301-6, by means of Sodium Carbonate Pump, Item No. 401-3. When this mixture is boiled by the admission of live steam, calcium salts of organic acids are replaced by sodium salts and calcium carbonate is regenerated. Dilute Na Bu Pump, Item No. 406-2, pumps the slurry through Filter Feed Cooler, Item No. 201-1, to Rotary Filter, Item No. 431-1. The calcium carbonate cake from Rotary Filter is collected in Filter Cake Hopper, Item No. 505-1, and washed back into dissolvers for reuse. Filtrate is collected in Dilute Na Bu Storage

3.1 DESCRIPTION OF SAMPLE PROCESS (Cont'd.)

Tank, Item No. 500-2. Overflow from Filter returns to the Neutralizing Tank.

Concentrating Column, Item No. 130, is fed continuously by Concentrating Feed Pumps, Item Nos. 401-4 and 401-5. The feed interchanges heat with vapor from the column in Concentrating Heater, Item No. 200-3, which also serves as partial condenser for the overhead stream. Reboiler, Item No. 221-6, supplies heat for the concentration, driving off water and volatile by-products of fermentation reaction. Overhead vapors are completely condensed in Condenser, Item No. 210-1, collected in By-Products Receiver, Item No. 500-3 and drained to By-Products Recovery System. Bottoms from Reboiler are cooled by Cooler, Item No. 200-4 and pumped by Concentrating Bottoms Pump, Item No. 401-6, to Concentrated Na Bu Storage Tanks. (Not shown as sample flow sheet.)



Equipment Reference Inventory Project: 2296 Title: CONCENTRATED NEBU SOLN Date: 11/22/54 Drawn: [Signature] Checked: [Signature]	
2296	UNCLASSIFIED
Form No. D-2296-92-1	

3.3 ITEM LIST

<u>Item No.</u>	<u>Description</u>
130	Concentrating Column
200-1	Solution Cooler
200-2	Solution Cooler
200-3	Concentrating Heater
200-4	Concentrated Na Bu Cooler
201-1	Filter Feed Cooler
210-1	Condenser
221-1	Reboiler
301-1	Dissolver
301-2	Dissolver
301-3	Culture Tank
301-4	Culture Tank
301-5	Neutralizing Tank
301-6	Sodium Carbonate Sol. Tank
303-1	Fermenter
303-2	Fermenter
303-3	Fermenter
303-4	Fermenter
401-1	Circulating Pump
401-2	Circulating Pump
401-3	Sodium Carbonate Pump
401-4	Concentrating Feed Pump

FLOW SHEET CODE SYSTEM

C3.00 ILLUSTRATION OF CODE SYSTEM USE

67

3.3 ITEM LIST (Cont'd.)

<u>Item No.</u>	<u>Description</u>
401-5	Concentrating Feed Pump
401-6	Concentrating Bottoms Pump
401-7	Fermenter Feed Pump
401-8	Sodium Carbonate Decanter Pump
401-9	Filtrate Pump
401-10	Filtrate Pump
406-1	Discharge Pump
406-2	Dilute Na Bu Pump
426-1	Filter Vacuum Pump
431-1	Rotary Filter
440-1	Chute
441-1	Strainer
442-1	Mixing Tee
500-1	Constant Temperature Tank
500-2	Dilute Na Bu Storage Tank
500-3	By-Products Receiver
500-4	Fermenter Overflow-Tank
500-5	Filtrate Receiver
505-1	Filter Cake Hopper
505-2	Feed Hopper
505-3	Feed Hopper

3.3 ITEM LIST (Cont'd.)

<u>Item No.</u>	<u>Description</u>
<u>Thermometers</u>	
600-1	Culture Tank, Item No. 301-3
600-2	Culture Tank, Item No. 301-4
600-3	Condenser, Item No. 210-1
600-4	Reboiler, Item No. 221-1
<u>Recording Temperature Controller</u>	
603-1	Constant Temperature Tank, Item No. 500-1
<u>Pressure Gauges</u>	
610-1	Circulating Pump, Item No. 401-1
610-2	Circulating Pump, Item No. 401-2
610-3	Fermenter Feed Pump, Item No. 401-7
610-4	Sodium Carbonate Decanter Pump, Item No. 401-8
610-5	Sodium Carbonate Pump, Item No. 401-3
610-6	Reboiler, Item No. 221-1
610-7	Concentrating Bottoms Pump, Item No. 401-6
610-8	Filtrate Pump, Item No. 401-9
610-9	Filtrate Pump, Item No. 401-10
610-10	Concentrating Feed Pump, Item No. 401-4
610-11	Concentrating Feed Pump, Item No. 401-5
610-12	Steam to Reboiler, Item No. 221-1
612-1	Compressed Air to Culture Tanks, Item Nos. 301-3 and 301-4

3.3 ITEM LIST (Cont'd.)

<u>Item No.</u>	<u>Description</u>
<u>Rotameters</u>	
621-1	Condenser, Item No. 210-1, to Concentrating Column, Item No. 130
621-2	Feed to Column, Item No. 130
621-3	Overhead Product from Column, Item No. 130

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS

1. Vesselsa. Concentrating Column - Item No. 130

Number Required	- One (1) - New
Size	- 1' - 6" ID x 6' - 0" straight shell
Type	- Packed - 1" carbon raschig rings
Design Pressure	- Atmospheric
Design Temperature	- 250°F.
Material of Construction	- Carbon Steel
Packed Sections	- 2 - 2" - 0" sections
Heads	- Flat flanged
Nozzles	- 1 - 4", 1 - 1 1/2", 2 - 1"

b. Solution Coolers - Item Nos. 200-1 and 200-2

Number Required	- Two (2) - Existing
Customer's Vessel	

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

c. Reboiler - Item No. 221-1

Number Required	One (1) - New
Type	- U-Tube bundle
Number of Passes	- Shell - 1 - Tubes - 2
Shell Size	- 14" ID x 10' - 0" long
Tube Bundle Size	- 10" diameter x 8' - 0" long
Tube Size	- 1" OD carbon steel
Number of Tubes	- 12 - U-tubes
Baffles	- None
Surface	- 48 sq. ft.
Duty	- 482, 680 Btu/Hr.
Working Temperature	- Shell - Inlet - 220°F. Outlet - 220°F. Tubes - Inlet - 338°F. Outlet - 338°F.
Design Pressure	- Shell - 15 psig Tubes - 250 psig
Material of Construction	- Shell - carbon steel Tubes - carbon steel

d. Concentrating Heater - Item No. 200-3

Number Required	- One (1) - New
Type	- Fixed head plus expansion joint
Number of Passes	- Shell - One (1) Tubes - One (1)

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

Shell Size	- 6" ID x 4' - 0" tube length
Tube Size	- 1" OD
Number of Tubes	- 14
Baffles	- None
Surface	- 14.7 sq. ft.
Duty	- 28,760 Btu/Hr.
Working Temperature	- Shell - Inlet 212°F. Outlet 212° F. - Tubes - Inlet 70°F. Outlet 190°F.
Design Pressure	- Shell - 30 psig Tubes - 30 psig
Material of Construction	- Shell - carbon steel Tubes - carbon steel
e. <u>Condenser - Item No. 210-1</u>	
Number Required	- One (1) - New
Type	- Fixed head plus expansion joint
Number of Passes	- Shell - One (1) Tubes - One (1)
Shell Size	- 8" diameter x 6' - 0" tube length
Tube Size	- 1" OD
Number of Tubes	- 31
Baffles	- None
Surface	- 49 sq. ft.
Duty	- 412,880 Btu/Hr.

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

Working Temperature - Shell - Inlet - 212°F.
 Outlet - 210°F.
 Tubes - Inlet - 80°F.
 Outlet - 105°F.

Design Pressure - Shell - 60 psig
 Tubes - 60 psig

Material of Construction - Carbon steel

f. Filter Feed Cooler - Item No. 201-1

Number Required - One (1) - New
 Type - Fixed head plus expansion joint
 Number of Passes - Shell - 1
 Tubes - 6
 Shell Size - 16" diameter x 12' tube length
 Tube Size - 3/4" OD
 Number of Tubes - 186
 Baffles - Cut 10 rows past center line horizontally on 4" pitch
 Surface - 438 sq. ft.
 Duty - 1,440,000 Btu/Hr.
 Working Temperature - Shell - Inlet - 80°F.
 Outlet - 105°F.
 Tubes - Inlet - 216°F.
 Outlet - 120°F.

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

- Design Pressure - Shell - 15 psig
Tubes - 50 psig
- Material of Construction - Carbon steel
- g. Concentrated Na Bu Cooler - Item No. 200-4
- Number Required - One (1) - New
- Type - Use a jacketed 1" U-tube carbon steel pipe 10 feet long
- Duty - 8,950 Btu/Hr.
- Working Temperature - Shell - Inlet - 85°F.
Outlet - 104°F.
Tubes - Inlet - 212°F.
Outlet 120°F.
- Design Pressure - Shell - 50 psig
Tubes - 15 psig
- Material of Construction - Carbon steel
- h. Fermenters - Item Nos. 303-1, 303-2, 303-3, 303-4
- Number Required - Four (4) - Existing
- Customer's Vessels
- Agitator:
- Number Required - Four (4) - New
One (1) per vessel
- Type - Top entering vertical double turbine
- Material of Construction - Stainless shaft and turbine
- Mixing Time - Continuous

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

Material	- Slurry of 10% CaCO_3 in corn sugar solution
Viscosity	- 1.2 cp. @ 100°F.
Motor	- Explosion proof, 440 volt, 3 phase, 60 cycle

i. Dissolvers - Item Nos. 301-1, 301-2

Number Required	- Two (2) - New
Type	- Vertical
Design Pressure	- 60 psig
Design Temperature	- 350°F.
Size	- 5' - 0" diameter x 7' - 0" straight shell
Heads	- Dished
Material of Construction	- Carbon steel
Nozzles	- 1 - 16"; 1 - 12"; 1 - 4"; 1 - 3"; 1 - 2"; 5 - 1"

Agitator:

Number Required	- Two (2) - New One (1) per vessel
Type	- Top entering vertical single turbine
Material of Construction	- Stainless shaft and turbine
Mixing Time	- 20 minutes
Material	- (1) 50% CaCO_3 in water (2) 20% corn sugar in water

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

- Motor - Explosion proof, 440 volt, 3 phase
60 cycle
- j. Neutralizing Tank - Item No. 301-5
- Number Required - One (1) - Existing
- Customer's Vessel
- Agitator:
- Number Required - One (1) - New
- Type - Top entering vertical single turbine
- Material of Construction - Stainless shaft and turbine
- Mixing Time - 90 minutes
- Material - 10% CaCO_3 in solution of organic salts and water
- Viscosity - 1.5 cp @ 100°F.
- Motor - Explosion proof, 440 volt, 3 phase,
60 cycle
- k. NaCO Solution Tank - Item No. 301-6
- Number Required - One (1) - New
- Type - Vertical
- Design Pressure - Atmospheric
- Design Temperature - Atmospheric
- Size - 6' - 0" diameter x 10' x 0" straight
shell
- Heads - Top - Open
Bottom - Dished

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

Material of Construction	- Carbon steel
Nozzles	- 2 - 3" 2 - 1"
Agitator:	
Number Required	- One (1) - New
Type	- Vertical single turbine
Material of Construction	- Carbon steel
Mixing Time	- 30 minutes
Material	- Saturated solution of sodium carbonate in water
Motor	- Explosion proof, 440 volt, 3 phase 60 cycle
1. <u>Culture Tanks - Item Nos. 301-3 and 301-4</u>	
Number Required	- Two (2) - New
Type	- Vertical
Design Pressure	- 15 psig
Design Temperature	- 300°F.
Size	- 3' - 0" diameter x 5' - 0" straight shell
Heads	- Flanged and dished
Material of Construction	- Stainless steel
Nozzles	- 1 - 12"; 2 - 4"; 2 - 2"; 2 - 1"
Agitator:	
Number Required	- Two (2) - New

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

- | | |
|--------------------------|--|
| Type | - Top entering - gear drive - dual propeller |
| Material of Construction | - Stainless shaft and propellers |
| Mixing Time | - Continuous |
| Material | - Skim milk |
| Motor | - Explosion proof, 440 volt, 3 phase, 60 cycle |
- m. Filter Cake Hopper - Item No. 505-1
- | | |
|--------------------------|---|
| Number Required | - One (1) - New |
| Design Pressure | - Atmospheric |
| Design Temperature | - Atmospheric |
| Size | - 6' - 0" x 1' - 0" x 1' - 6" deep
at one end sloping to 2' - 0" other end |
| Heads | - Flat top and bottom |
| Material of Construction | - Carbon steel |
| Nozzles | - 2 - 6"; 1 - 4"; 1 - 2" |
- n. Constant Temperature Tank - Item No. 500-1
- | | |
|--------------------|---|
| Number Required | - One (1) - New |
| Type | - Horizontal |
| Design Pressure | - 15 psig |
| Design Temperature | - 212°F. |
| Size | - 3' - 6" diameter x 6' - 0" straight shell |
| Heads | - Dished |

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

- Material of Construction - Carbon steel
- Nozzles - 1 - 12"; 3 - 4"; 1 - 1"
- o. By-Products Receiver - Item No. 500-3
- Number Required - One (1) - New
- Type - Vertical
- Design Pressure - 15 psig
- Design Temperature - 250° F.
- Size - 1' - 0" diameter x 2' - 0" straight shell
- Heads - Dished
- Material of Construction - Carbon steel
- Nozzles - 1 - 4"; 2 - 2"; 1 vent to suit
- p. Dilute Na Bu Storage Tank - Item No. 500-2
- Number Required - One (1) - Existing
- Customer's Vessel
- q. Fermenter Overflow Tank - Item No. 500-4
- Number Required - One (1) - Existing
- Customer's Vessel
- r. Feed Hoppers - Item Nos. 505-2 and 505-3
- Number Required - Two (2) - New
- Design Pressure - Atmospheric
- Design Temperature - Atmospheric
- Size - 3' - 0" x 3' - 0" height to be determined by layout characteristics with

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

top to be 16" above first floor. Bottom opening 12" diameter centered on 16" manhole of Dissolvers, Item Nos. 301-1 & 301-2. Sides sloped to allow free flow of material 45° and 60°.

Material of Construction - Carbon steel

2. Mechanical Equipmenta. Rotary Filter - Item No. 431-1

Number Required - One (1) - New
 Type - Continuous
 Capacity - 30 GPM
 Slurry - 9% CaCO₃ in organic aqueous solution
 Size - 3' - 0" diameter x 6' - 0" length
 Working Temperature - 180°F.
 Working Pressure - 100 mm
 Note - Equipped with filtrate receiver, vacuum pump, hood and filtrate pump

b. Mixing Tee - Item No. 442-1

Number Required - One (1) - New
 Type - Liquid to liquid or gas to liquid
 Size - To suit
 Liquid Rate - 50 GPM
 Cooling Liquid Rate - 10 GPM

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

- Steam Rate - 50 #/Hr.
- Material of Construction - Carbon steel
- c. Circulating Pumps - Item Nos. 401-1 and 401-2
- Number Required - Two (2) - New
- Type - Centrifugal
- Fluid Handled - Water
- Viscosity - 1.0 cp @ 60°F.
- Specific Gravity - 1.0 @ 60°F.
- Hours of Service - 24
- Operating Temperature - 100°F.
- Capacity - 50 GPM
- TDH - 75 feet
- Suction Head - Flooded
- Construction - Cast iron case and impeller with
carbon steel shaft
- Motor - 440 volt, 3 phase, 60 cycle, explo-
sion proof
- d. Fermenter Feed Pump - Item No. 401-7
- Number Required - One (1) - New
- Type - Centrifugal
- Fluid Handled - 21.5% corn sugar in water
- Specific Gravity - 1.075 @ 220°F.
- Hours of Service - 8
- Operating Temperature - 220°F.

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

- | | |
|---|--|
| Capacity | - 50 GPM |
| TDH | - 75 feet |
| Suction Head | - Flooded |
| Construction | - Cast iron case and impeller
with carbon steel shaft |
| Motor | - 440 volt, 3 phase, 60 cycle,
explosion proof |
| e. <u>Dilute Sodium Butyrate Pump</u> - <u>Item No. 406-2</u> | |
| Number Required | - One (1) - New |
| Type | - Oliver Diaphragm |
| Fluid Handled | - 7% solids in suspension with 10%
organics in water solution |
| Hours of Service | - 6 |
| Operating Temperature | - 220°F. |
| Capacity | - 30 GPM |
| TDH | - 50 feet |
| Suction Head | - Flooded |
| Construction | - Rubber lined |
| Note | - Complete with solenoid, timer,
and pressure gauge |
| f. <u>Concentrating Feed Pumps</u> - <u>Item Nos. 401-4 and 401-5</u> | |
| Number Required | - Two (2) - New |
| Type | - Turbine |
| Fluid Handled | - Dilute Na Bu solution |

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

Viscosity	- 5 cp @ 60°F.
Specific Gravity	- 1.2 @ 60°F.
Hours of Service	- 24
Operating Temperature	- 100°F.
Capacity	- 1.0 GPM
TDH	- 80 feet
Suction Head	- Flooded
Construction	- Cast iron case and impeller with carbon steel shaft
Motor	- 440 volt, 3 phase, 60 cycle, explosion proof
g. <u>Concentrating Bottoms Pump</u> - <u>Item No. 401-6</u>	
Number Required	- One (1) - New
Type	- Turbine
Fluid Handled	- Aqueous Na Bu solution
Viscosity	- 5 cp @ 60°F.
Specific Gravity	- 1.2 @ 60°F.
Hours of Service	- 24
Operating Temperature	- 230°F.
Capacity	- 1 GPM
TDH	- 50 feet
Suction Head	- Flooded
Construction	- Cast iron and impeller with carbon steel shaft

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

- Motor - 440 volt, 3 phase, 60 cycle,
explosion proof
- h. Discharge Pump - Item No. 406-1
- Number Required - One (1) - New
- Type - Oliver diaphragm
- Fluid Handled - 4% solids suspended in 13% organics
in water solution
- Hours of Service - 2
- Operating Temperature - 100°F.
- Capacity - 60 GPM
- TDH - 60 feet
- Suction Head - Flooded
- Construction - Rubber lined
- Note - Complete with Solenoid, timer,
and pressure gauge
- i. Sodium Carbonate Pump - Item No. 401-3
- Number Required - One (1) - New
- Type - Centrifugal
- Fluid Handled - 25% solution of sodium carbonate
- Operating Temperature - 100°F.
- Capacity - 50 GPM
- TDH - 50 feet
- Suction Head - Flooded
- Construction - Cast Iron case and impeller with
carbon steel shaft

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

Motor	- 440 volt, 3 phase, 60 cycle, explosion proof
j. <u>Sodium Carbonate Decanter Pump</u> - <u>Item No. 401-8</u>	
Number Required	- One (1) - New
Type	- Turbine
Fluid Handled	- 25% sodium carbonate in water
Operating Temperature	- 100°F.
Capacity	- 1 GPM
TDH	- 50 feet
Suction Head	- Flooded
Construction	- Cast iron case and impeller with carbon steel shaft
Motor	- 440 volt, 3 phase, 60 cycle, explosion proof

3. Instruments

All recording temperature controllers are of the electronic potentiometer type with proportional and automatic reset.

Temperature recorders shall be multiple point with an electronic potentiometer measuring system.

Recording flow controllers shall be the pneumatic proportional type.

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

4. Piping

Service	- High Pressure Steam - 125 psi High Pressure Condensate Boiler Feed Water - 175 psi
Pipe	- 2" and Smaller - Steel - Schedule 40 - Screwed Joints with 300# M. I. Fittings 2 1/2" and Larger - Steel - Schedule 40 - Welded Joints with 150# F. S., Slip-on or Welding Neck Flanges Schedule 40 - Steel Butt Weld Fittings
Valves	- 2" and Smaller - 200# Screwed Brass 2 1/2" and Larger - 150# Flanged, Cast Steel, O. S. & Y.
Service	- Low Pressure Steam Low Pressure Condensate Process Water - Above Ground Cooling Water - Above Ground Compressed Air Instrument Air Fuel Oil - Above Ground Vents
Pipe	- 2" and Smaller - Steel - Schedule 40 - Screwed Joints with 300# M. I. Fittings

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

- 2 1/2" and Larger - Steel - Schedule
40 - Welded Joints with 150# F. S.
Slip-on or Welding Neck Flanges
- Valves - 2" and Smaller - 200# Screwed Brass
2 1/2" and Larger - 125# Standard
Flanged, IBBM, O. S. & Y.
- Service - Calcium Butyrate Slurry
Calcium Carbonate Slurry
- Pipe - All sizes - Steel - Schedule 40 -
Welded Joints with 150# F. S. Slip-
on Flanges (or 125# Std. C. I. Screwed
Comp. Flanges)
- Note: For changing direction of
Slurry Lines, use Flanged Tees
or crosses with Blind Flanges
for Rodding Clogged Lines.
- Valves - All sizes - 125# Std. Flanged, All
Iron O. S. & Y., except on Slurry
Lines. For Slurry Lines, use Cast
Iron Plug Valves, Flanged.
- Service - Peppermint Oil - Crude
Glycerine
Ether

3.4 PRELIMINARY EQUIPMENT SPECIFICATIONS (Cont'd.)

Culture Food

Sodium Carbonate Solution

Dilute Sodium Butyrate

By-Products

Amyl Alcohol

Caustic Soda

Pipe

- 2" and Under - Steel, Schedule 40 -
Screwed Joints, 300# M. I. Fittings
- 2 1/2" and Up - Steel, Schedule 40 -
Welded and Flanged - 150# Slip-on
Flanges, Schedule 40 - Butt Weld
Fittings - Steel - Schedule, 40 Pipe

Valves

- 2" and Smaller - 125# Clamp Type,
All Iron
- 2 1/2" and Over - 125# Flanged,
All Iron O. S. & Y.

D. EQUIPMENT DESIGN CALCULATIONS

The following outline is recommended for setting up calculations.

Volume 1 should consist of the following:

- Part I - Conference Notes
- Part II - Basis of Design
- Part III - Material Balance
- Part IV - Process Engineering Calculations

Volume 1. should be kept in a three-ring notebook so that additions can readily be made.

Since a large number of groups are working on several different projects and since projects may be transferred from one person to another, or one group to another, it is important that all calculations be set up in the same manner. A sample of the form to be used is attached hereto. It is expressly requested that calculations be set up under this procedure. Your cooperation in this respect will be appreciated.

The following is a recommended outline to be used in setting up calculations in the future:

1. Calculations should be made on all vessels and mechanical equipment according to flow sheets. This is important since flow sheets are discussed as a complete unit.
2. Calculation breakdown should be such that insertions or removal of items will not upset the entire calculation system.
3. Each new set of equipment should be started on a new page with a complete centered heading.

Volume 1. - Process Engineering Design
Part IV - Process Engineering Calculations
Flow Diagram - ????-92-1

A - Towers

Absorber - Item No. 101

1. Feed

- a - _____
- 1) _____
- a) _____
- (1) _____
- (a) _____
- (1) _____
- (a) _____

2. Absorber Size

- a - _____
- 1) _____
- a) _____
- (1) _____
- (a) _____
- (1) _____
- (a) _____
- ((1)) _____
- ((a)) _____

NOTE: A separate page should be started for each new item.

Volume 1. - Process Engineering Design
Part IV - Process Engineering Calculations
Flow Diagram - ????-92-1

A - Towers

Stripper - Item No. 102

1. Feed

a - _____

1) _____

a) _____

(1) _____

(a) _____

(1)) _____

(a)) _____

((1)) _____

((a)) _____

Volume 1. - Process Engineering Design
Part IV - Process Engineering Calculations
Flow Diagram - ????-92-1

B - Heat Exchangers

Condenser - Item No. 210-1

- 1. _____
- a - _____
- 1) _____
- a) _____
- (1) _____
- (a) _____

Volume 1. - Process Engineering Design

Part IV - Process Engineering Calculations

Flow Diagram - ????-92-1

Repeat the same system for Agitated Vessels, Tanks and Mechanical Equipment as follows:

A - Towers

B - Heat Exchangers

C - Agitated Vessels

D - Tanks

E - Mechanical Equipment

When any of the above groups are not required, that letter should be used for the next group or equipment.

FORMS

E2.00 LETTER OF TRANSMITTAL

94

E2.00 LETTER OF TRANSMITTAL FOR PRINTS

Dear Sir:

Attached herewith are prints of the following drawings which have been issued by _____ . These prints are for your record and file.

Very truly yours,

E3.00 MASTER DISTRIBUTION LIST

MASTER DISTRIBUTION

MASTER DISTRIBUTION - Total of _____ Copies

PROJECT NO. _____

Custodian

- Copy No. 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18
- 19
- 20

Distributed by: _____

Date: _____

FORMS

E4.00 LETTER OF TRANSMITTAL
FOR PROJECT REPORT

96

E4.00 LETTER OF TRANSMITTAL FOR PROJECT REPORT

DATE _____

SUBJECT _____

Dear Sir:

Enclosed please find Copy No. _____ of _____
copies on a report for Project No. _____

Will you please affix your signature as indicative
of having received this issue and return to the writer.

Very truly yours,

Signature _____

FORMS

E5.00 REQUESTS FOR FLOW SHEET REVISIONS

97

E5.00 REQUESTS FOR FLOW SHEET REVISIONS

REQUESTS FOR FLOW SHEET REVISIONS				
Location	Flow Sheet Number	Description	Requisitioned By	Date

E6.00 COST DATA

COST DATA					
Item No.	Project Number	Item Description FOB or Freight Allowed	Purchase Date	Price	Remarks

ABBREVIATIONS

F1.00 SYMBOLS AND NOMENCLATURE
OF CHEMICAL ENGINEERING

99

F. ABBREVIATIONS

F1.00 SYMBOLS AND NOMENCLATURE OF CHEMICAL ENGINEERING

Absorptivity (for radiation)	α	(alpha)
Acceleration	a	
Acceleration of gravity standard value	g g_0	
Activity	a	
Activity coefficient, molal bases	γ	(gamma)
Angle	α θ ϕ	(alpha) (theta) (phi)
solid	ω	(omega)
Angular velocity	ω	(omega)
Aperture	a	
Area	A	
Base of natural logarithms	e	
Bottoms, residue, waste	W, B	
Breadth, width	b	
Coefficient		
activity, molal basis	γ	(gamma)
discharge	C	
distribution	m	
expansion		
linear	α	(alpha)
volumetric	β	(beta)
friction	f	
heat transfer		
individual	h	
over-all	U	

ABBREVIATIONS

FL.00 SYMBOLS AND NOMENCLATURE
OF CHEMICAL ENGINEERING

100

Coefficient (Cont'd.)

mass transfer		
gas film	K_G	
individual	k	
liquid film	k_L	
over-all	K	
gas film basis	K_G	
liquid film basis	K_L	
resistance	C	
Compressibility		
cake, exponent of	s	
factor	z	
Concentration, volumetric	c	
of extract	c_E	
of raffinate	c_R	
Conductance, thermal	C	
Conductivity, thermal	K	
Constant		
equilibrium, $y = Kx$	K	
gas, universal	R	
Stefan - Boltzman	σ	(sigma)
Cross section	S	
Density	ρ	(rho)
Depth	y	
Diameter	D	
Difference, finite	Δ	(capital delta)
Differential operator	d	
Diffusivity, thermal	α	(alpha)
Diffusivity of vapor	D_V	
Distance		
above datum plane	Z	
in direction of flow	x	

ABBREVIATIONS

FL.00 SYMBOLS AND NOMENCLATURE
OF CHEMICAL ENGINEERING

101

Distillate rate	D	
Distribution ratio	m	
Efficiency	η	(eta)
Emissivity (for radiation)	ϵ	(epsilon)
Energy		
Free, Gibbs, (H-TS)	G	
general	E	
internal	U	
internal, per unit weight	u	
Enthalpy	H	
of saturated liquid, per unit weight	h_f	
of saturated vapor, per unit weight	h_{fg}	
per unit weight	h	g
Entrainment ratio	E	
Entropy	S	
per unit weight	s	
Equilibrium		
curve, slope of	m	
constant, $y = Kx$	K	
value, mole fraction in vapor	y^*	
Equivalent resistance of cloth	r	
Evaporation		
latent heat of	λ	(lambda)
per unit weight	h_{fg}	
Expansion		
linear, coefficient of	α	(alpha)
volumetric, coefficient of	β	(beta)
Exponent of compressibility of cake	s	
External work	W_e	
Extract rate	E	
Fanning friction factor	f	

ABBREVIATIONS

F1.00 SYMBOLS AND NOMENCLATURE
OF CHEMICAL ENGINEERING

102

Feed	thermal condition of $(L_m - L_n)/F$ rate	q F	
Film	mass transfer coefficient liquid	K_L	
	gas thickness, effective	K_G B	
Flow	rate, mass volumetric, rate of weight rate per unit of breadth	w q Γ	(capital gamma)
Force, total load		F	
Free energy	Gibbs (H-TS) Helmholtz (U-TS)	G A	
Free Moisture content		W	
Fraction	mol in extract in liquid in raffinate in vapor volume weight	y x x y x_v x_v	
Friction	coefficient of energy balance factor, Fanning	f F f	
Fugacity		f	
Function		ϕ ψ χ	(phi) (psi) (chi)
Gas	constant, universal	R	

ABBREVIATIONS

F1.00 SYMBOLS AND NOMENCLATURE
OF CHEMICAL ENGINEERING

103

Gravity		
acceleration of		g
standard value, acceleration of		g_0
Heat		
capacity		
at constant pressure		C_p
at constant volume		C_v
humid		c_s
latent		
of fusion		λ_f
of vaporization		λ
per unit weight		h_{fg}
mechanical equivalent of		J
quantity of		Q
specific		c
at constant pressure		c_p
at constant volume		c_v
ratio of	c_p/c_v	k
transfer		
coefficient		
individual		h
over-all		U
factor		j
rate of		q
Height		Z
equivalent to a theoretical plate, "H.E.T.P."		H_p
of transfer unit, "H:T.U."		H_t
Henry's Law constant, c/p		H
Humid		
heat		c_s
volume		v_H
Humidity		H
relative		H_R
Hydraulic radius		R_H
Inertia, moment of		I
Length		L

ABBREVIATIONS

FL.00 SYMBOLS AND NOMENCLATURE
OF CHEMICAL ENGINEERING

104

Liquid	L
rate	L
above feed	L_n
below feed	L_m
Logarithms, base of natural	e
Mass	m
flow rate	w
transfer coefficient	
gas film	k_G
individual	K
liquid film	k_L
over-all	K
gas film basis	K_G
liquid film basis	K_L
velocity	G
of liquid	L
Matter, quantity of, weight	W
Mesh	m
Moisture content, free	W
Mol	
fraction	
in extract	y
in liquid	x
in raffinate	x
in vapor	y
equilibrium value	y^*
ratio	
in extract	Y
in liquid	X
in raffinate	X
in vapor	Y
Molecular weight	M
Moment of inertia	I
Newton law of motion, conversion factor	g_c
Number in general	N

ABBREVIATIONS

FL.00 SYMBOLS AND NOMENCLATURE
OF CHEMICAL ENGINEERING

105

Plates, number of	N_p	
Power	P	
Pressure	P	
Production rate	R	
Radiation, intensity of	N	
Radius	r	
hydraulic	R_H	
Raffinate flow rate	R	
Rate		
extract	E	
flow, volumetric	q	
heat transfer	q	
liquid, above feed	L_n	
liquid, below feed	L_m	
raffinate	R	
rotation	n	
transfer	N	
vapor	V	
Ratio		
mol in extract	Y	
mol in liquid	X	
mol in raffinate	X	
mol in vapor	Y	
reduction	R_r	
reflux	R	
Reduction ratio	R_R	
Reflux ratio	R	
Relative		
humidity	H_R	
volatility	α	(alpha)
Residue, waste, bottoms	W, B	
Resistance		
cake, specific	α	(alpha)
cloth, equivalent	r	

ABBREVIATIONS

FL.00 SYMBOLS AND NOMENCLATURE
OF CHEMICAL ENGINEERING

106

Resistance (Cont'd.)

coefficient thermal	C R
Rotation, rate of	n
Slope of equilibrium curve	m
Solid angle	ω (omega)
Solubility	S
Solvent present	H_e
Specific	
heat	c
at constant pressure	c_p
at constant volume	c_v
heats, ratio of, c_p/c_v	k
surface	s
volume	v
Stefan-Boltzmann constant	σ (sigma)
Surface	
per unit volume	a
Specific	s
tension	σ (sigma)
Temperature	t
absolute	T
Theoretical plate, equivalent, height of, "H.E.T.P."	H_p
Thermal	
condition of feed $(L_m - L_n) / F$	q
conductance	C
conductivity	k
diffusivity	α (alpha)
resistance	R
Thickness, film effective	B
Time	θ (theta)
Tractive force per unit area	τ (tau)

ABBREVIATIONS

FL.00 SYMBOLS AND NOMENCLATURES
OF CHEMICAL ENGINEERING

107

Transfer			
	rate of		N
	unit, "H.T.U.", height of		H_t
	units, number of		N_t
Vapor			
	mol ratio		Y
	rate		V
Vaporization, latent heat of			λ (lambda)
per unit weight			h_{fg}
Velocity			
	acoustic		V_a
	angular		ω (omega)
	average		V
	local		u
	mass		G
	of liquid		L
Viscosity			
	absolute		μ (mu)
	kinematic		ν (nu)
Volatility, relative			α (alpha)
Volume			
	fraction		x_v
	humid		v_H
	specific		v
	total or per mol		V
Waste			
	bottoms, residue		B,W
Weight			
	fraction		x_w
	quantity of matter		W
	rate of flow per unit of breadth		Γ (capital gamma)
Width, breadth			b
Work			
	external		W_e

ABBREVIATIONS

F2.00 CHEMICAL ENGINEERING UNITS

108

F2.00 CHEMICAL ENGINEERING UNITS

(Abbreviations are the same for plural as for singular form)

A ^o	angstrom unit
amp	ampere
atm	atmosphere
bbl	barrel
Btu	British thermal unit
°C	degree centrigade
cal	calorie
Ctu	Centigrade thermal unit
cm	centimeter
cm ²	square centimeter
cm ³ or cc	cubic centimeter
cm Hg	centimeter of mercury
cp	centipoise
°F	degree Fahrenheit
ft or	foot
ft ²	square foot
ft ³	cubic foot
ft-lb	foot pound
gm	gram
gal	gallon
g-cm	gram centimeter
g-mol	gram mol

ABBREVIATIONS

F2.00 CHEMICAL ENGINEERING UNITS

109

h.p or hp	horse power
hr	hour
in. or "	inch
in. ²	square inch
in. ³	cubic inch
in. Hg	inch of mercury
kg	kilogram
kv	kilovolt
kw	kilowatt
l	liter
lb	pound
lb-mol	pound mol
m	meter
m ²	square meter
m ³	cubic meter
M	molar
mg	milligram
Max.	Maximum
Min.	Minimum
min	minute
ml	milliliter
mm	millimeter
ppm	parts per million
psi	pounds per square inch
psia	pounds per square inch absolute

ABBREVIATIONS

F2.00 CHEMICAL ENGINEERING UNITS

110

psig	pounds per square inch gage
rpm	revolution per minute
sec	second
v	volt
w	watt

Note - Parenthesis should be used in combinations of units to separate units that are not otherwise separated. For example:

$\text{Btu}/(\text{hr})(\text{ft}^2)(^{\circ}\text{F})$

ABBREVIATIONS

F3.00 SYMBOLS AND NOMENCLATURE
OF RADIOCHEMISTRY

111

F3.00 SYMBOLS AND NOMENCLATURE OF RADIOCHEMISTRY

Absorption coefficient, over-all	σ	(sigma)
absorption, alone	σ_a	
scattering	σ_s	
total	σ_t	
Activity	a	
Atomic number	Z	
Disintegration constant	λ	(lambda)
Half life	t 1/2	
Half thickness	x 1/2	
Mass number	A	
Radiation, types	α	(alpha)
	β	(beta)
	γ	(gamma)

ABBREVIATIONS

F4.00 RADIOCHEMICAL UNITS

112

F4.00 RADIOCHEMICAL UNITS

b	barn
c	count
c/min	count per minute
mev	million electron volts
γ -curie	gamma curie, 3.71×10^{10} disintegrations per second

UNIVERSITY OF MICHIGAN



3 9015 03483 8063