PULP AND PAPER MILLS

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1.0 SCOPE

This data sheet describes the overall processes involved in pulp and paper mills. Hazards and safeguards for individual processes are discussed in other data sheets dealing with the particular process described.

1.1 Changes

April 2016. Interim revision.

References to Data Sheet 5-7, *National Electrical Code that was made obsolete, were deleted.*

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Equipment and Processes

2.1.1 Wood Chip Preparation

For wood chip storage, see Data Sheet 8-27, *Storage of Wood Chips*.

2.1.1.1 Large quantities of combustible residue may be present around debarkers and chippers. Adequate maintenance and control of ignition sources, particularly cutting and welding, is important.

2.1.2 Chemical Recovery

For black liquor recovery boilers and associated processes, see Data Sheet 6-21, *Chemical Recovery Boilers*.

For lime kilns, see Data Sheet 6-17, *Rotary Kilns and Dryers*.

2.1.3 Bleaching

For chlorine dioxide equipment, see Data Sheet 7-58, *Chlorine Dioxide*.

2.1.4 Air Pollution Control

2.1.4.1 Arrange odorous vapor incineration equipment in accordance with Data Sheet 6-11, *Fume Incinerators*. Use the following order of preference in selecting incineration equipment:

a) A separate incinerator, designed exclusively for the intended use.

b) The plant lime kiln or similarly designed high temperature furnace.

c) A plant power boiler.

Avoid using a black liquor recovery boiler for vapor incineration, because of its importance to production and its other operating complications.

2.1.4.2 Arrange and protect exhaust duct systems in accordance with Data Sheet 7-78, *Industrial Exhaust Systems*.

2.1.5 Process Control

2.1.5.1 Protect grouped cables in accordance with Data Sheet 5-31, *Cables and Bus Bars*. Establish a program of electrical maintenance in accordance with the manufacturer's instructions and Data Sheet 5-20, *Electrical Testing*.

2.1.6 Powerhouse Area

2.1.6.1 Protect the powerhouse area in accordance with FM Global recommended practices as applicable:

For power boilers: Data Sheet 6-2, *Pulverized Coal-Fired Boilers*; Data Sheet 6-4, *Oil-and Gas-Fired Single-Burner Boilers*; and Data Sheet 6-5, *Oil-and Gas-Fired Multiple-Burner Boilers*.

For turbogenerators: Data Sheet 7-101, *Fire Protection for Steam Turbines and Electric Generators*; Data Sheet 13-3, *Steam Turbines*.

For transformers: Data Sheet 5-4, *Transformers*.

For switchgear: Data Sheet 5-19, *Switchgear and Circuit Breakers*.

For cooling towers: Data Sheet 1-6, *Cooling Towers*.

2.1.7 Paper Machines and Economizers

Paper machines and economizers should be protected in accordance with Data Sheet 7-4, *Paper Machines and Pulp Dryers*.

2.1.8 Airborne Pulp Dryers

Safeguards should be provided in accordance with Data Sheet 7-4.

2.1.9 Storage

Safeguards for pulpwood and wood chips are discussed in Data Sheet 8-27, *Storage of Wood Chips*. Roll paper storage is discussed in Data Sheet 8-21, *Roll Paper Storage*.

2.1.10 Pressure Vessels

Digesters and dryer rolls are discussed in Data Sheet 12-6, *Batch Digesters and Related Process Vessels*; Data Sheet 7-4, *Paper Machines and Pulp Dryers*.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 General

The loss record of the pulp and paper industry indicates that the major hazard areas are:

1. Log and chip piles.
2. Black liquor recovery boilers.
3. Paper machines.
4. Roll paper storage.
5. Process control centers and wiring.
6. Power and waste fuel boilers.
7. Turbogenerators.
8. Material handling systems.
9. Bleaching processes.

Critical factors governing loss prevention at a pulp and paper mill are:

1. Fire service water supply and distribution.
2. Automatic sprinkler protection.
3. Supervision and maintenance of equipment.
4. Fire brigade organization and training.
5. Building construction, separation, and cutoffs.

4.0 REFERENCES

4.1 FM Global

Data Sheet 1-6, *Cooling Towers*.

Data Sheet 5-4, *Transformers*.

Data Sheet 5-19, *Switchgear and Circuit Breakers*.

Data Sheet 5-20, *Electrical Testing*.

Data Sheet 5-31, *Cables and Bus Bars*.

Data Sheet 6-2/12-63, *Pulverized Coal-Fired Boilers*.

Data Sheet 6-4/12-69, *Oil- and Gas-Fired Single-Burner Boilers*.

Data Sheet 6-5/12-70, *Oil- and Gas-Fired Multiple-Burner Boilers*.

Data Sheet 6-11, *Fume Incinerators*.

Data Sheet 6-17/13-20, *Rotary Kilns and Dryers*.

Data Sheet 6-21/12-21, *Chemical Recovery Boilers*.

Data Sheet 7-4, *Paper Machines and Pulp Dryers*.

Data Sheet 7-58, *Chlorine Dioxide*.

Data Sheet 7-78, *Industrial Exhaust Systems*.

Data Sheet 7-101, *Fire Protection for Steam Turbines and Electric Generators*.

Data Sheet 7-103, *Turpentine Recovery in Pulp and Mills*.

Data Sheet 8-21, *Roll Paper Storage*.

Data Sheet 8-27, *Storage of Wood Chips*.

Data Sheet 12-6, *Inspection of Digesters*.

Data Sheet 13-3, *Steam Turbines*.

APPENDIX A GLOSSARY OF TERMS

Roundwood: pulpwood in log form.

APPENDIX B DOCUMENT REVISION HISTORY

April 2016. Interim revision.

References to Data Sheet 5-7, *National Electrical Code that was made obsolete, were deleted.*

April 2010. Minor editorial changes were made for this revision.

May 2003. Minor editorial changes including deleting reference to Data Sheet 13-11, *Steam Turbines Driving Generators: Industrial Applications* which is now covered by the revised Data Sheet 13-3, *Steam Turbines*.

May 2000. This revision of the document has been reorganized to provide a consistent format.

APPENDIX C SUPPLEMENTARY INFORMATION

Cellulose is the most abundant and replaceable organic substance available in nature. It is converted to a wide variety of paper products in the pulp and paper industry.

Major paper products include newsprint, magazines, tissue, bags, cartons, food containers, wrapping paper, books, and writing paper. The conversion of paper into various end products may occur at or near the mill site. Processing at the mill normally ends with the winding, slitting, or coating of paper. Rolled and sheet paper or pulp is then shipped to a converting or processing plant located near the market.

Two distinct phases in the conversion of raw wood and other materials to finished paper are: 1) the manufacture of the various pulps, and 2) conversion of pulp to paper. Some plants produce only pulp and similar products; others produce only paper from pulp. Most carry out both phases of the processing operation.

C.1 Manufacture of Wood Pulp

Of all pulping production, the alkaline sulfate or kraft process accounts for about 72%, the acid sulfite 5%, semichemical 9%, groundwood 11%, and the remainder miscellaneous.

C.1.1 Wood Chip Preparation

Pulping operations begin with receipt of wood at the mill site. Pulpwood is supplied in log form (roundwood) or chips, as required by the mill. Roundwood is usually received with bark on, in four or eight foot lengths for convenient handling, although tree-length logs may be used in some mills. Softwoods are mainly used, but improvements in technology have permitted up to 20% hardwoods in some processes.

Former practice was to store the logs in the wood yard and process them into chips only a few hours before they were needed in the digester. An increasingly common practice is to convert the wood into chips immediately after receipt and store the chips in piles. (For wood chip storage, see Data Sheet 8-27.)

C.1.1.1 Mechanical Pulp

When the wood is ground without chemical digestion, the paper produced is low in strength. For better grades of paper, chemical pulp is mixed with the cheaper mechanical pulp.

Thermomechanical pulp is a relatively new development, but the cost and pollution potential of chemical treatment is reduced and it produces a better pulp than the groundwood process. In thermomechanical pulping, chips are ground in a refiner by attrition from disks, at high temperature and pressure, in a steam atmosphere. (See Fig. 1.)

C.1.2 Chip Digestion

Chip digestion or cooking is accomplished in a batch or continuous digester. A chip digester is a large vessel provided with raw-chip feed and cooked-chip discharge ports, and equipped with means for heating and maintaining its contents at a specified temperature and pressure for the required length of time. Operating temperatures, pressures, and time vary with the type of process (kraft, sulfite, or semichemical). The digester material of construction also varies for corrosion resistance.

C.1.2.1 Acid Sulfite Process

In the acid sulfite process (Fig. 2) the typical digester liquor is an aqueous solution containing calcium or magnesium bisulfite and an excess of sulfur dioxide. The digesters are cylindrical steel vessels with a lining of cement, crushed quartz, and acid-resisting brick, for corrosion resistance.

In preparing the sulfite liquor, sulfur is burned to form sulfur dioxide, which is cooled and absorbed in a water spray tower where calcium or magnesium compounds are converted to the bisulfite with an excess of sulfur dioxide absorbed. The digester is usually heated with direct steam. Recently developed digesters have an external stainless-steel heat exchanger where the cooking liquor is heated. Cooking liquor is then circulated through the digester by means of pumps. This provides more uniform temperatures and prevents dilution of the liquor by steam condensate. Cooking conditions vary, depending on the nature of the wood and composition of the cooking liquor. The pressure varies from 70 to 160 psi (480 to 1570 kPa, 4.8 to 15.7 bar). The time and temperature range from 6 to 12 hours and from 340° to 350°F (171° to 175°C). After cooking, the pulp is discharged into a blow tank and then washed with fresh water. At this point, the lignin or binding components in the wood have been dissolved and the cellulose fibers have been separated into pulp.

C.1.2.2 Semichemical or NSSC Pulping

Semichemical, also known as chemimechanical pulping, involves both chemical digestion and mechanical grinding to produce the pulp. This process uses smaller chips and more hardwoods than the chemical processes. The main semichemical process is the NSSC (neutral sulfite semichemical). The cooking liquor used is sodium sulfite buffered with sodium carbonate. Digestion takes place at 100 to 160 psi (690-1570 kPa, 6.9-15.7 bar), 320° to 360°F (160°-182°C) for only 12 to 48 minutes. Mechanical treatment completes separation of the wood fibers into pulp. Stainless steel protection is normally needed on the digestion equipment to control corrosion problems.

Pulp Screening and Washing. In the semichemical or NSSC process, the chips are mechanically disintegrated and converted into pulp by disk refiners. The pulp is then washed, as in the acid sulfite and sulfate processes, to separate it from the cooking liquor. The pulp then passes over screens to separate it from larger undigested particles. Metal is removed and knots and undigested fibers are usually returned for another pass through the digester.

C.1.2.3 Sulfate Process

Sulfate or kraft pulp is an alkaline process using a solution of sodium hydroxide and sodium sulfide, or *white liquor*, in the digesters (Fig. 3). Large batch digesters have been used, but continuous digesters are increasing in use also.

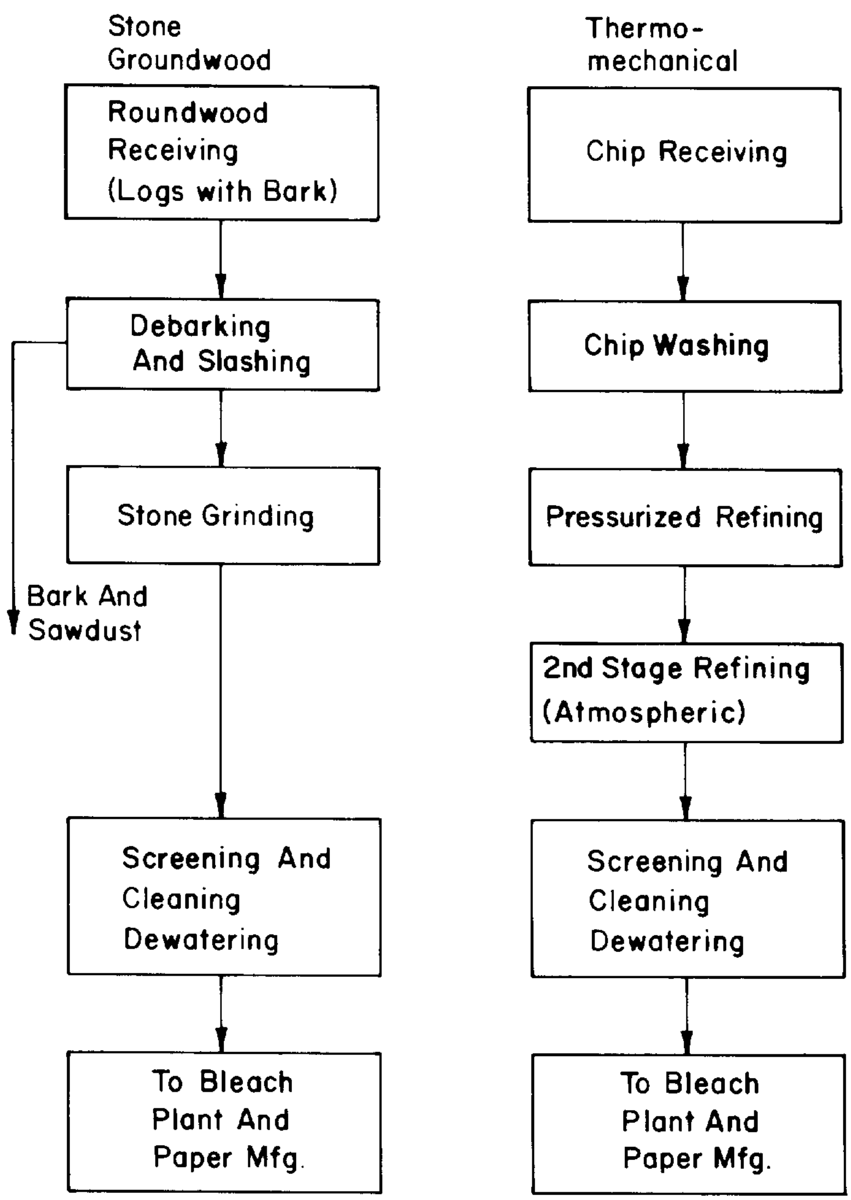

Fig. 1. Flowchart of alternative mechanical pulping techniques.

Continuous digesters of the horizontal and inclined tube designs move the chip charge through the digester by mechanical screw or bucket conveyors. Vertical digesters accomplish chip movement by gravity in downflow digesters, or by a lifting mechanism in upflow digesters. The most common design is the continuous downflow digester, described as follows.

Chips are conveyed from storage and blended, if hardwood and softwood chips are to be cooked together. The chips are fed through a chip meter, the speed of which determines chip flow rate to the digester. This also determines the cooking liquor flow rate and pulp discharge rate.

The metered chips are discharged into a steaming vessel, at about 15 psi (103 kPa, 1.03 bar), where the chips are preheated and air is expelled. Chips and cooking liquor are then fed into an impregnation zone,

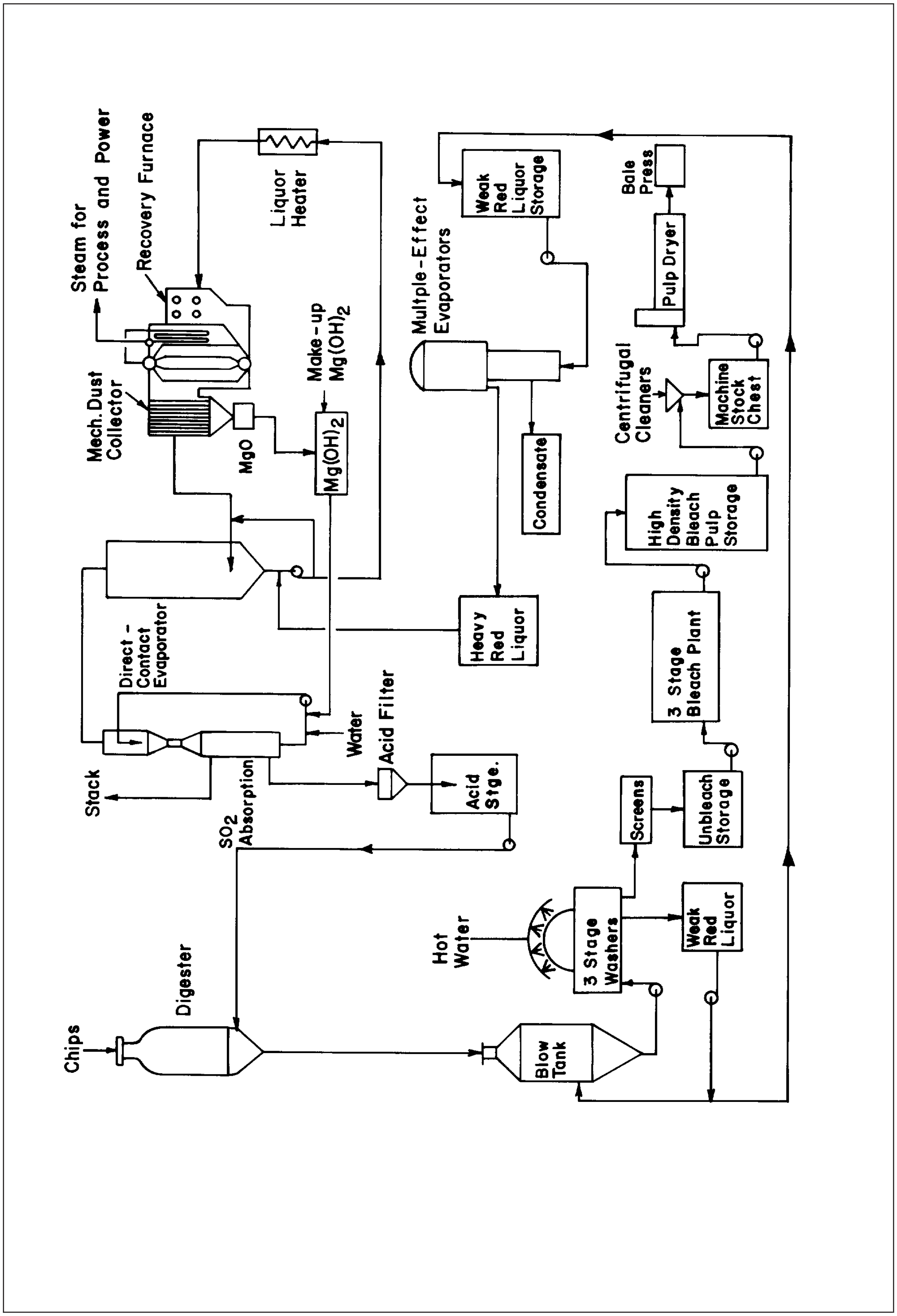

Fig. 2. Flowchart of magnesium sulfite acid pulping and magnesium oxide recovery.

which may be a separate vessel or the upper portion of the digester itself. This area is maintained at a

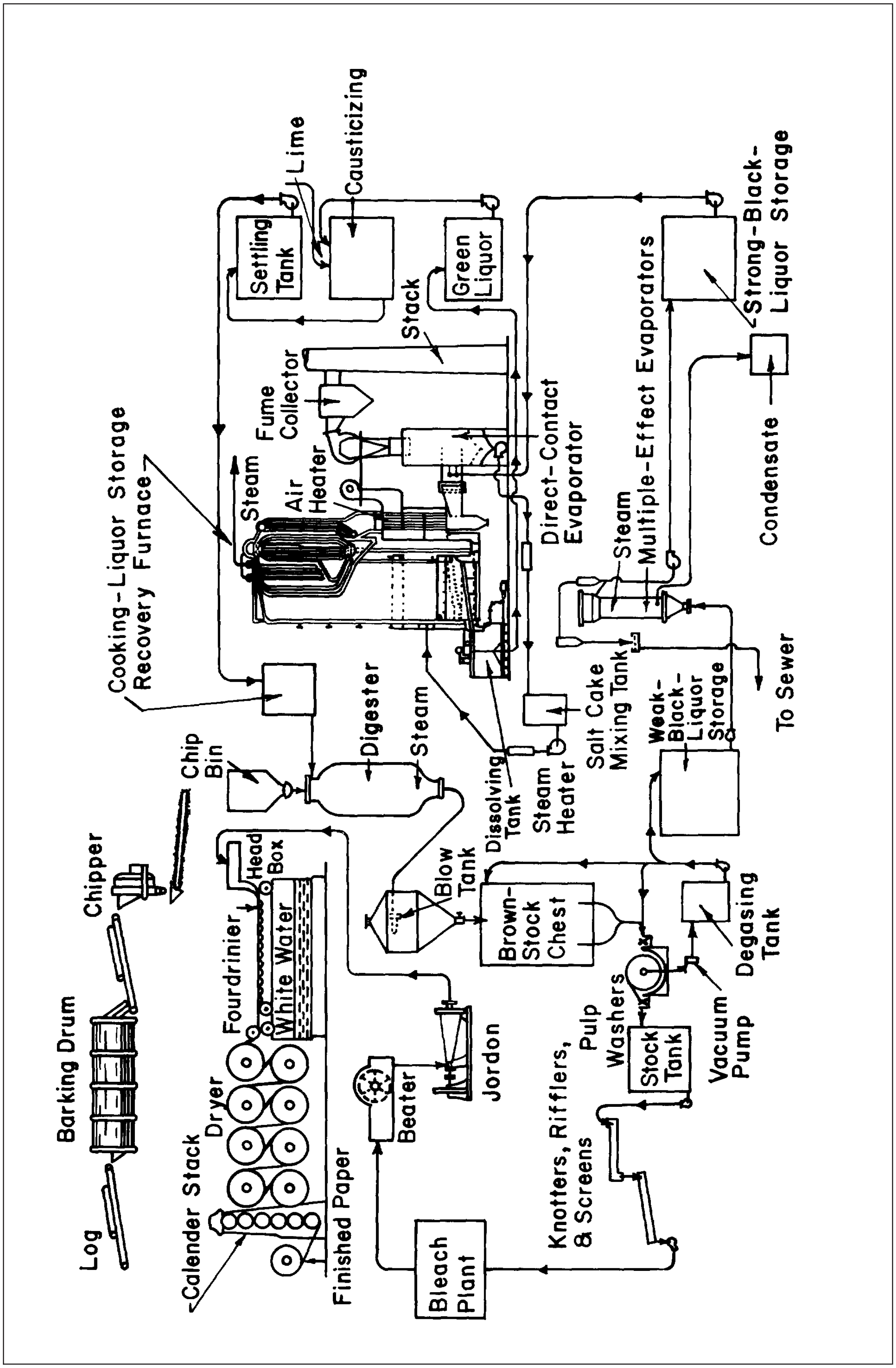

Fig. 3. Flowchart for kraft or sulfate pulping, with liquor recovery and re-use.

temperature 20°F (11°C) lower than that in the digester cooking zone (340°F [170°C]). The impregnated chips enter the cooking zone after about 20 minutes in the impregnation zone.

Chips pass downward through the cooking zone, replacing those discharged. Normal passage time through the cooking zone is 90 to 120 minutes. Liquor in the cooking zone is withdrawn for heating and recirculated. Pressure is 100 to 135 psi (690-930 kPa, 6.9-9.3 bar). As cooked chips reach the bottom zone of the digester, they are mixed with filtrate from the pulp washer for cooling and dilution purposes. Cooked chips are cooled to a temperature of 250° to 260°F (120°-127°C) and forced by digester pressure through an adjustable orifice valve, through a blowline to a blow tank at atmospheric pressure.

C.1.3 Chemical Recovery

C.1.3.1 Sulfite Liquor

The sulfite liquor from the digestion process, called *weak red liquor*, is evaporated to a heavy red liquor and burned in a boiler to produce magnesium oxide and sulfur dioxide. The red liquor boiler differs from a black liquor boiler in that there is no smelt bed. The magnesium oxide is carried through the boiler exhaust and recovered through a collection system. It is then slaked to magnesium hydroxide and mixed with regained and make-up sulfur dioxide to produce fresh bisulfite liquor. Other byproducts that may be recoverable from the waste sulfite liquor are lignin, vanillin, tanning material, road binders, special cements, core binders, plastics, and food yeast.

C.1.3.2 Semichemical Liquor

Liquors from the semichemical process are recovered in black liquor recovery boilers. This process is similar to the sulfate process. (See Data Sheet 6-21, *Chemical Recovery Boilers*.)

C.1.3.3 Sulfate Liquor

Black liquor washed from the pulp, at a solids content of 12 to 15%, is sent to multiple effect evaporators and concentrated to a 45 to 50% soluble solids content. The liquor is further concentrated to 62 to 65% solids content in an evaporator of the cascade, concentrator, or cyclone type and burned in a recovery boiler for generation of process steam and conversion to sodium carbonate and sodium sulfide, leaving the furnace as smelt. See Data Sheet 6-21 for further details.

C.1.4 Bleaching

Bleaching wood pulp is an extension of the pulping process. Dyes are formed from the tannin in the wood during the digestion process. The bleaching agents oxidize and destroy the dyes. They also dissolve and remove the remaining lignin in the pulp, leaving the pure cellulose fibers.

Typically, there is a series of steps in the bleaching process. In kraft pulp, for example, a bleaching sequence would be C-E-H-D. Translated, this means the pulp is treated with chlorine (C), followed by extraction (E) with sodium hydroxide, treatment with calcium or sodium hypochlorite (H) and treatment with chlorine dioxide (D).

C.1.5 Air Pollution Control

A modern development in paper mills is the institution of a fume incinerator system to remove the harmful fumes that pollute the air and create an odor problem. Vapors and noncondensable gases are recovered from process tanks associated with pulp digestion and chemical treatment. These include dimethyl and hydrogen sulfides, mercaptanes, alcohol, and turpentine. See Data Sheet 7-103 for further details on turpentine recovery systems.

Condensable vapors may be recovered and the noncondensable gases are incinerated, either in a separate incinerator or in a kiln or boiler. If the mill has an associated electrolytic chlorine plant, the hydrogen byproduct may be incinerated as a noncondensable gas to save energy. The hazards are a concentration of flammable gases or vapors within the explosive range and the effect of a possible explosion on vital production equipment.

C.2 Manufacture of Paper

C.2.1 Paper Machines

Paper machines are expensive, complex units essential to plant production. The dryer ends of paper machines combine the fire hazards of a highly combustible product, lint deposits, oily residues, and paper scraps in the presence of such ignition sources as overheated bearings, dryer flames, mechanical sparks, friction, and electrical equipment. Complete automatic sprinkler protection over the dryer end of the machine, including hoods and economizers, high housekeeping standards, and proper lubrication and maintenance procedures reduce the hazard to a reasonable level. Data Sheet 7-4 discusses paper machines and economizers.

C.2.2 Airborne Pulp Dryers

One of the major items of production equipment in most modern kraft pulp mills is an airborne pulp dryer. These dryers remove water from the pulp leaving the pulp machine, reducing the water content from 40% to 10 to 18%. Their steam consumption is high. These are discussed in Data Sheet 7-4.