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CURRENT TRENDS IN WOOD HANDLING

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QUALITY BEGINS HERE. . . . .

Quality is a dominant theme in today's strategic planning and mill operation for almost every industry in the world and the pulp and paper industry is certainly no exception. Raw material from which a product is made is the starting point in any quality control program, but for the pulp and paper industry there are some unique challenges in developing, designing and operating fiber raw materials technology to achieve quality goals. First, wood is a biological material that has significant variability both within and between trees and tree species. Also, the variable form, size and shape of trees causes complex equipment design problems. The relatively new technology area of fiber raw material supply has drawn upon the several engineering disciplines, forestry, wood technology and computer science and with increasing success is meeting the goal of producing chips that meet the mill specific needs for chip quality (1).

The key chip quality factors are shown in Figures 1 and 2 a typical quality control "fish-bone" diagrams. Any discussion of a product quality issue where chips are a probable contributing cause should start with the use of this or similar mill specific and wood-type specific diagrams. Once the problem area has been isolated, a diagram like Figure 3 (a Paretto chart) is prepared to focus on the most likely solutions to the problem. The use of such quality control tools leads to the development, adaption and application of recent technology. The following is a review of some of the most significant developments in fiber raw material technology.

Wood Handling and Slashing

As the harvest age has decreased due to changes in forest management and rotation economics, the diversity of wood sizes and forms has increased. Many woodyards now handle a mixture of shortwood (1 to 3 meters long), longwood (3 to 8 meters long), tree-length (up to 20 meters long) and either whole, undelimbed trees or tree parts. In addition, the supply of solid wood product residuals is changing depending on the regional demands for lumber, plywood and other residuals generating products and the yield of these processes. The state-of-the-art in roundwood material handling in woodyards is large grapple gantry, bridge and circular cranes (Figure 4).

The higher productivity systems have been coupled with inventory management techniques to reduce the amount of wood stored at a mill to a level that minimizes deterioration due to drying and decay.

Debarking

While bark is required for tree growth, its presence in high amounts (6-15 by weight in most pulp roundwood flows), seasonal variation in bark adhesion and occasional inclusion inside the tree at branch and wound locations makes debarking of wood a key technology challenge. Mechanical debarking of stems and stem segments has become the dominant method as hydraulic systems faced tighter water treatment and environmental standards. The decrease in average stem sizes and emphasis on pulp quality has created renewed interest in drum debarker technology. One manufacturer has developed a small scale physical modeling and pilot size testing capability that feeds data and information to a computer model of drum debarker operation (2). A similar version of small scale physical models is used by almost all vendors to confirm that material flow designs will function without plug-ups and at high productivity with the specific raw material mix. Ring and other cambium shear debarkers are still used where stem sizes are large enough to maintain productivity, usually in lumber and plywood mills.

The seasonal changes in bark adhesions are well understood and technology developments are being applied to make bark removal more efficient in winter conditions (3).

Whole tree and forest residual chipping is a harvesting method that recovers more biomass, but the mixture of bark foliage, dirt and wood is unacceptable without considerable upgrading. Over the last 10 years, several technologies based on mechanical, hydraulic, pneumatic and optical properties have been evaluated and tested. Only the PAPRICAN "Paprifer" process is being actively marketed in North America (4).

A significant development in woodyard processes is the "satellite woodyard," a smaller scale system located away from the pulp mill (5). The drum debarkers used in these facilities are lighter-duty, but the system capacities approach those of full-scale woodyards. These systems produce clean chips that can be handled more cheaply than logs and can be economically transported longer distances than roundwood.

Portable mechanical debarking has been available for several decades, but has been limited to a single stem at a time. Some developments in chain flail debarking in conjunction with portable chipping show some promise in multiple stem processing at remote locations or to increment woodyard production.

Chipping

Once the cleanliness of chips has been assured through high efficiency debarking and in some cases, log washing, preparation of particles of uniform size distribution is accomplished through chipping. Not only should the distribution be uniform for stable pulping operations, but it should also be as narrow as possible to match the specifications of the pulping process.

In order to accurately assess chip size quality, the method of characterizing them must relate to pulp mill operations and economics. In Figure 5, the most commonly accepted size classification method that meets these criteria is illustrated (6). Characteristic distributions for several types of material chipped by various chippers are shown in Table 1.

The fundamentals of precision disk chipping have been clearly defined by Hartler (7) and a chipper system (infeed, wood/knife interface, chip discharge) can be designed to produce as narrow a distribution as possible given the size and shape of the wood pieces. It is not unreasonable to expect that roundwood chips would contain 80-90% acceptable chips without screening and wood products residuals, 80-85% accepts.

Chip Screening

To the extent that size distributions of chips received at a mill do not match the economic-based specifications of the pulping process and products, chip screening can be used to narrow distributions and reduce the variability of chip size.

Chip screening technology has advanced significantly in the last 10 years thanks to a change in the perceived value of chip quality. The basic relationships between chip size and pulping performance have been published for at least two decades (9), but the use of appropriate chip size test methods and economic interpretation created the incentive for vendors to develop improved gyratory screens for fines removal, disc screens for gross oversize scalping and for thickness control and slicers for precision overlength and overthick reduction. The systems have continued to become more precise and capital effective in the last five years (10-11). Specific implementation guidelines have been developed for these complex screen systems to insure high removal efficiency and system performance (11). While the fines rejected from chip screen systems should be sent to power boilers as fuel, the overlength and overthick chips should be reprocessed. The use of precision slicers adjusted to reduce chips down to 4 to 6 millimeter thickness are an integral part of a chip thickness screening system (13). Figure 6 shows a state-of-the-art configuration of a system utilizing preconcentration gyratory screens for concentrating oversize for subsequent precise disc screening and for fines removal. The slicers are protected by pneumatic rock separators. This process is patented and the equipment components can come from a wide range of equipment vendors (14).

Through use of process simulation, pilot trials and vigorous test procedures described by Brown and Lancaster (11), a system can be designed that can handle a wide range of chip quality levels and efficiently screen them to a target chip quality as illustrated by Figure 7.

Chip Storage and Handling

With the significant investment mills are making in quality control programs and technology to produce designed quality chips, chip handling and storage systems must be designed and operated to preserve quality. Chip conveying equipment should not treat chips to mechanical force that caused them to break into smaller pin chips and fines. Improperly designed and maintained pneumatic conveying equipment have more than doubled the fines content in some extreme situations. This can be avoided by designing system with chip quality as a key variable, not just capital and operating costs. In some cases, a belt conveyor for transporting chips long horizontal distances with numerous acute angle turns. However, there are short, steep conveyor runs best made by pneumatic systems carefully designed to avoid impact and damage.

On the storage pile, chip quality can be damaged by mechanical and biochemical deterioration. Frequent and unnecessary traffic of chip dozers creates higher fines and compacts the pile. A compacted and tall pile heats rapidly to temperatures that cause biochemical deterioration as shown in Figure 8 (15). These mechanisms of deterioration can be avoided by designing chip handling systems that use automated outstocking and conveying equipment that requires little or no tractor activity. These systems should be sized for low target inventory levels based upon a systematic modeling of the seasonal chip supplier and chip user relationship and trading off the costs of chip inventory with the risk of actually running out of chips (16).

Quality Management

The goal of producing target quality chips demands that a quality monitoring and control system be used in the chip production system. The tools for an effective chip quality control program are becoming available and being more quickly developed. Chip moisture sensing can be coupled to a belt weighing device to provide a reliable dry weight reading for chip purchase and digester control. Automated chip sampling devices, such as the one in Figure 9, are used to remove representative samples from chip flows for subsequent testing (17). Reliable chip test methods are essential and must directly relate to controllable and economically significant chip quality factors. Chip size distribution is one of the most important factors and manual and automated equipment is being marketed such as the ones shown in Figure 10 (18). The classification scheme used in such a classifier most commonly is the type shown in Figure 4 that gives an estimate of the amount of overlength, overthick, acceptable, pin chips and fines. These fractions relate directly to pulp mill operations and product quality, as must every quality control test. Automation of chip quality sampling and testing is being studied and developed.

Summary

The value of a forest-to-product view of chip quality must be clearly identified in the pulp mill operation and product quality. The largest single area of impact on a mill is variability. Figure 11 shows the potential impact of chip size extremes on Kappa number distributions and the consequent reduction in Kappa number variability as a result of complete chip screening. The more uniform unbleached pulp quality results in reduced bleaching costs, stronger and cleaner pulp and an opportunity to increase pulp yield. Similar examples in chip quality and variability reduction are bark content, wood specific gravity, species and chip age as shown in Figure 1. Each mill has unique chip quality needs and value relationships, but the technology to achieve these quality levels is available and being continuously improved.

References

1. Fuller, W. S. TAPPI Vol. 70, No. 1:11 (1987).

2. Thompson, R. A. and Piggott, R. R. Proceedings of the TAPPI Pulping Conference (1986).

3. Hatton, J. V. Proceedings of the TAPPI Pulping Conference (1986).

4. Berlyn, R. and Simpson R. Proceedings of the CPPA Technical Conference (1986).

5. Williamson, D. R. Proceedings of the TAPPI Pulping Conference (1984).

6. Fuller, W. S. Proceedings of "Comminution of Wood and Bark", Forest Products Research Society (1984).

7. Hartler, N. TAPPI Vol. 69; No. 10:62 (1986)

8. Hartler, N. and Onisko, W. Svensk Paperstidning, Vol. 65; No. 22:905 (Nov. 30, 1962).

9. Christie, R. D. Pulp and Paper Canada, 87:9 (1986).

10. Christie, R. D. Proceedings of CPPA Western Joint Conference (1986).

11. Christie, R. D. Proceedings of the TAPPI Pulping Conference (1986).

12. Brown, R. A. and Lindsay, L. M. Proceedings of the TAPPI Pulping Conference (1985).

13. Artiano, A. TAPPI Vol. 69, No. 2:38 (1986).

14. U.S. Patent No. 4,376,042 (1983).

15. Fuller, W. S. TAPPI Vol. 68; No. 8 (1985).

16. Finke, G. F. Interfaces 14:5 (1984).

17. Fuller, W. S. Proceedings of the TAPPI Pulping Conference (1985).

18. Marrs, G. R. Proceedings of the TAPPI Pulping Conference (1986).

Figure 1
CHIP QUALITY FACTORS

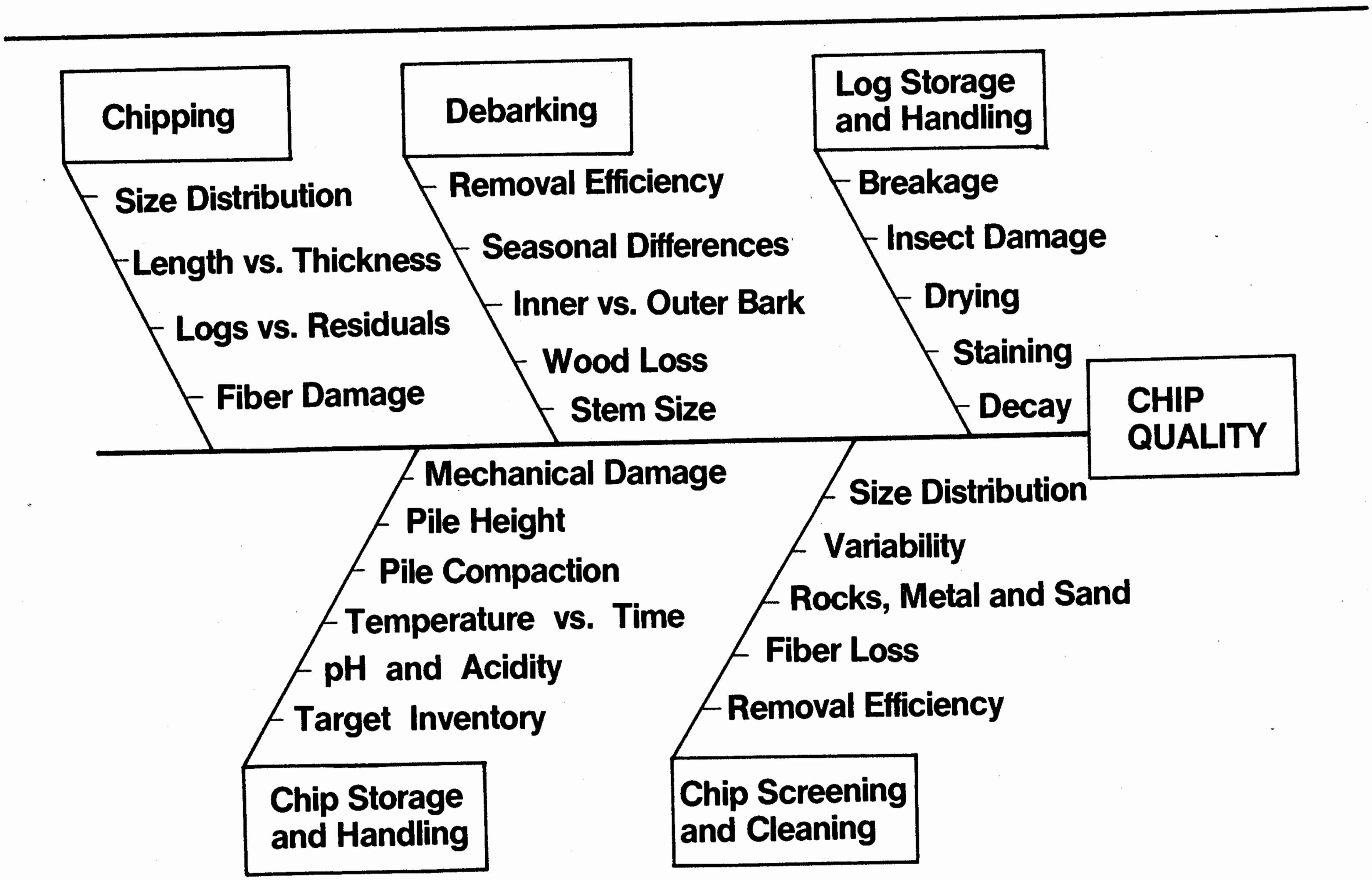


Figure 2
CHIP QUALITY FACTORS

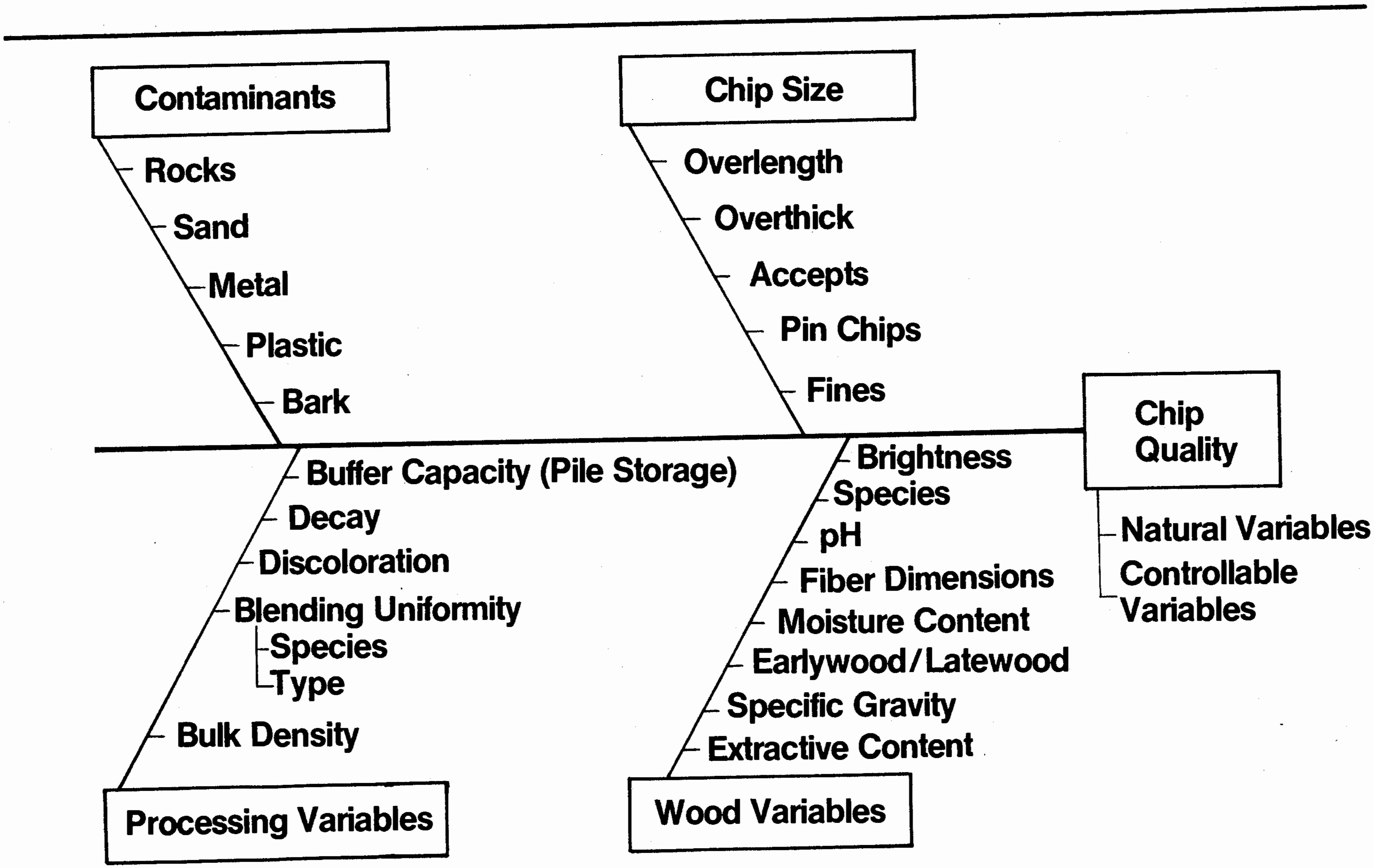


Figure 3
PARETTO CHART OF PULP QUALITY DEFECTS — CHIP QUALITY IS ALWAYS A FACTOR

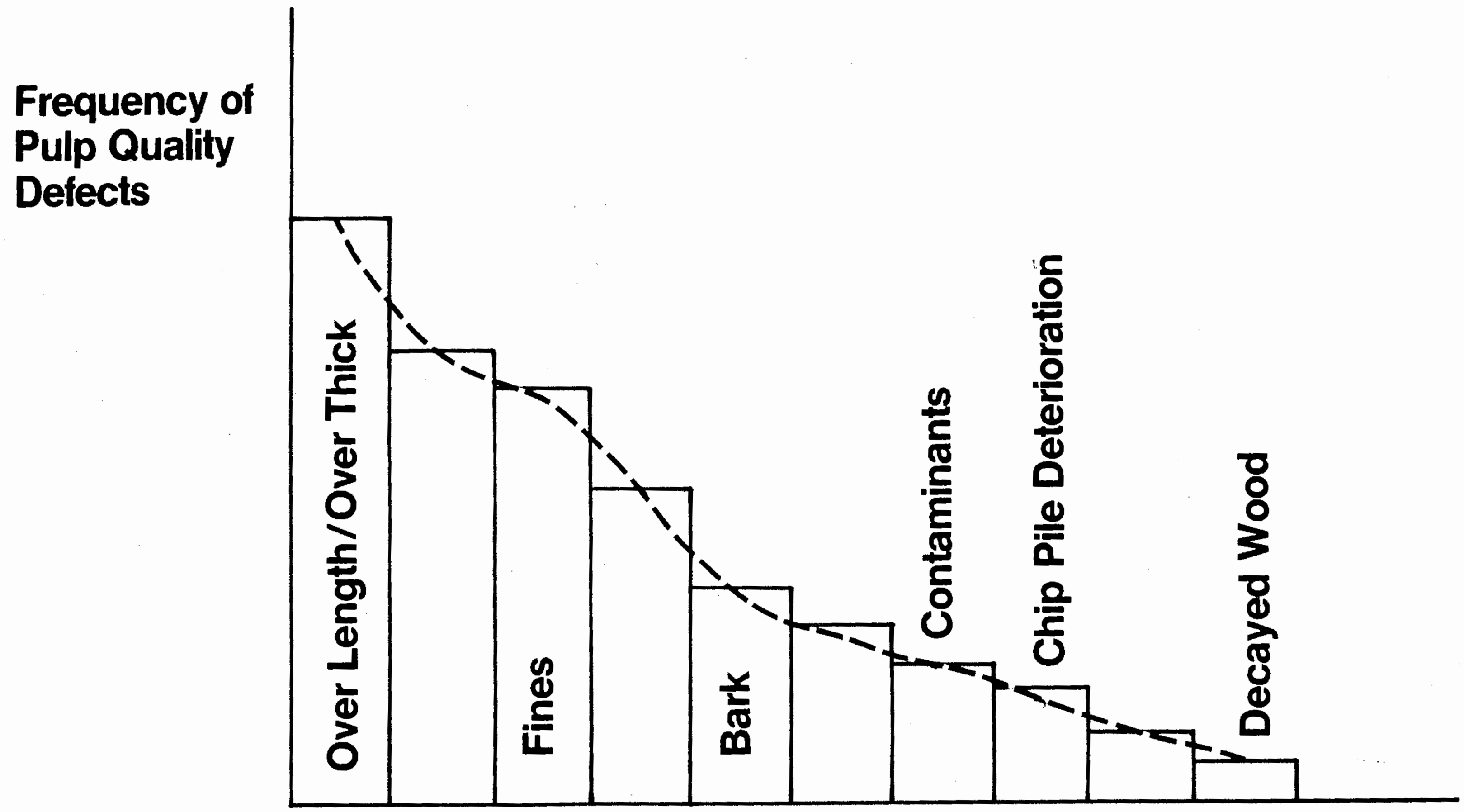


Figure 4
LOG HANDLING CRANES

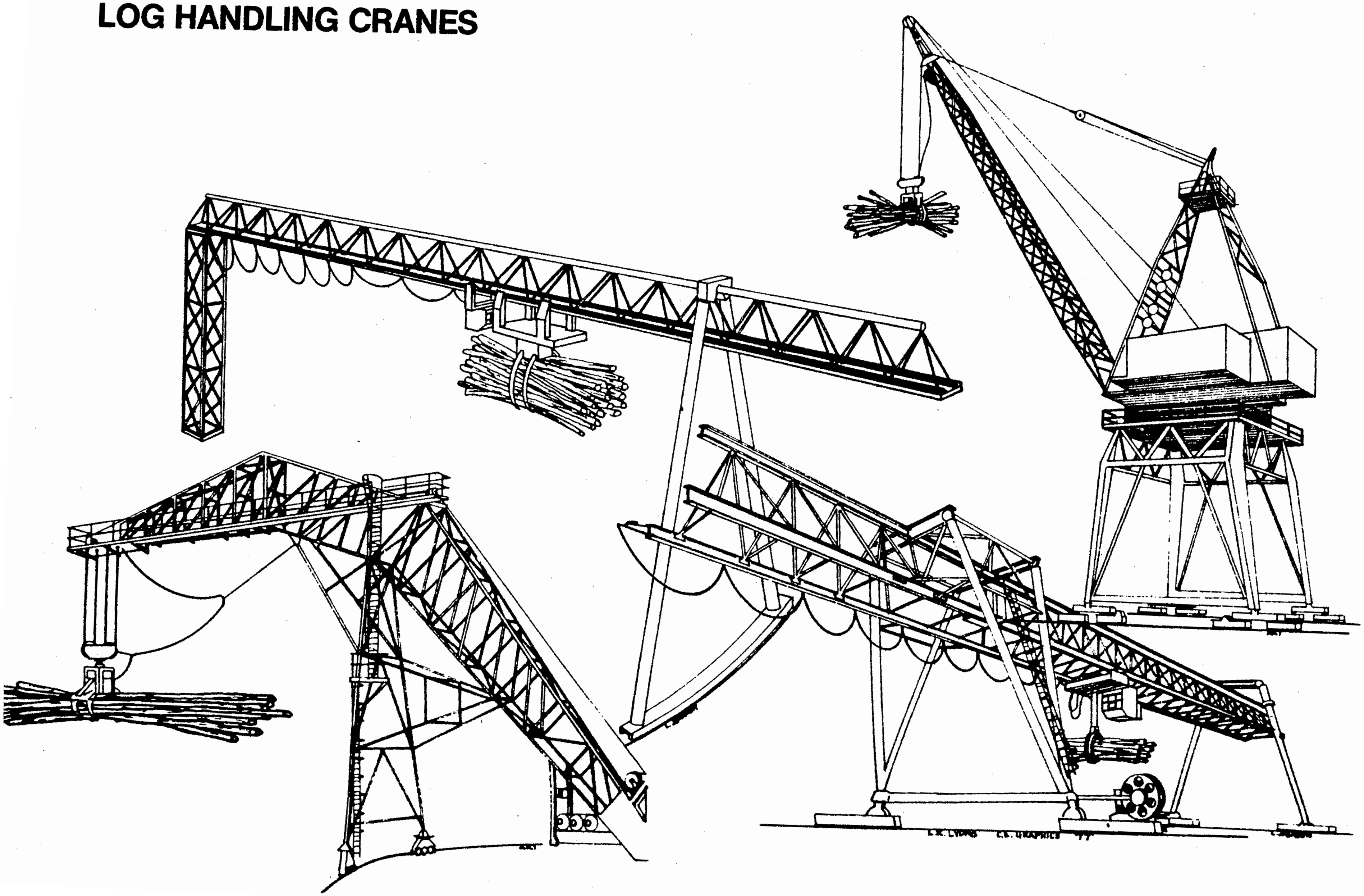


Figure 5
STALSVETS CLASSIFICATION

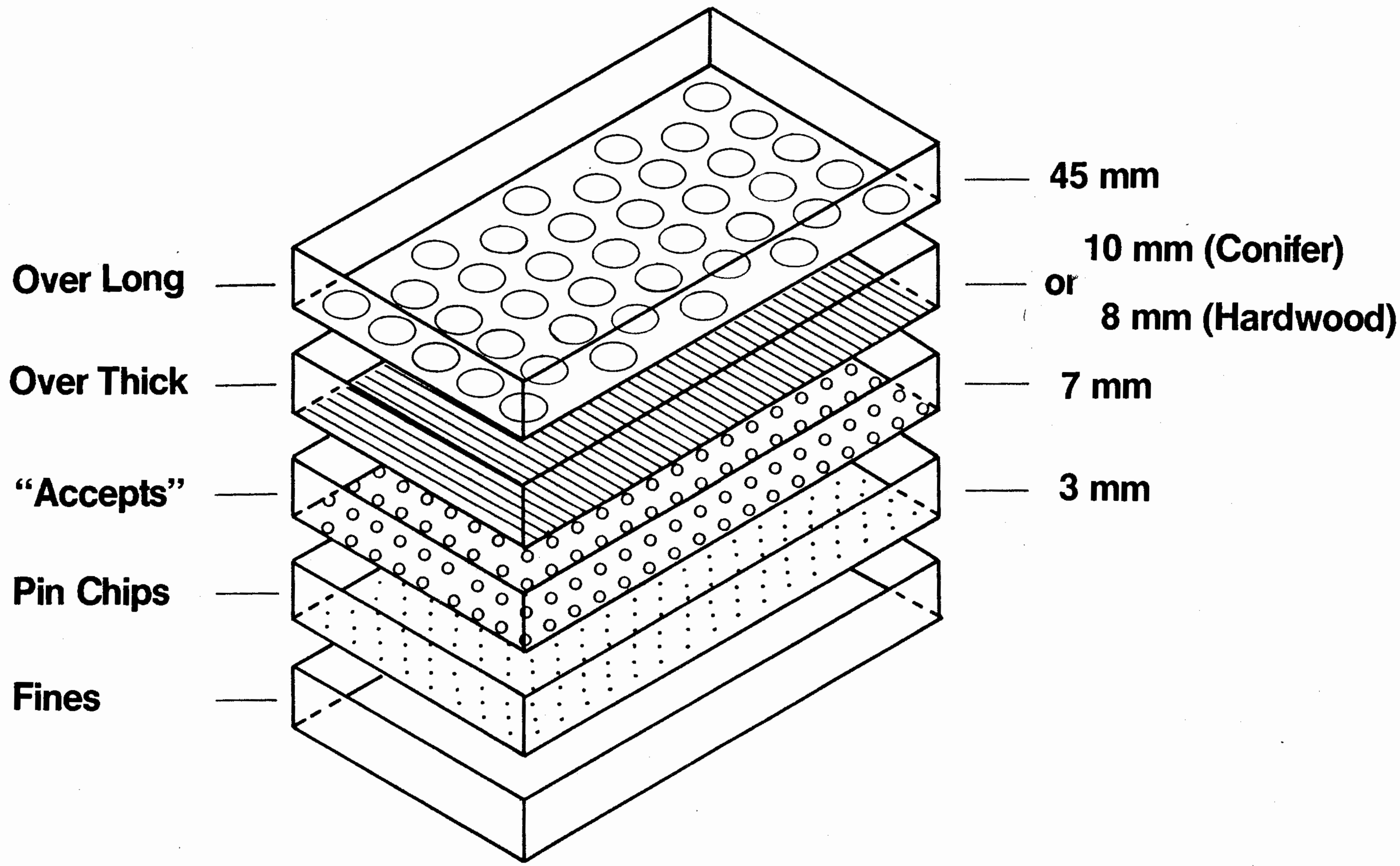


Figure 6
GYRATORY — DISK CHIP SCREEN SYSTEM

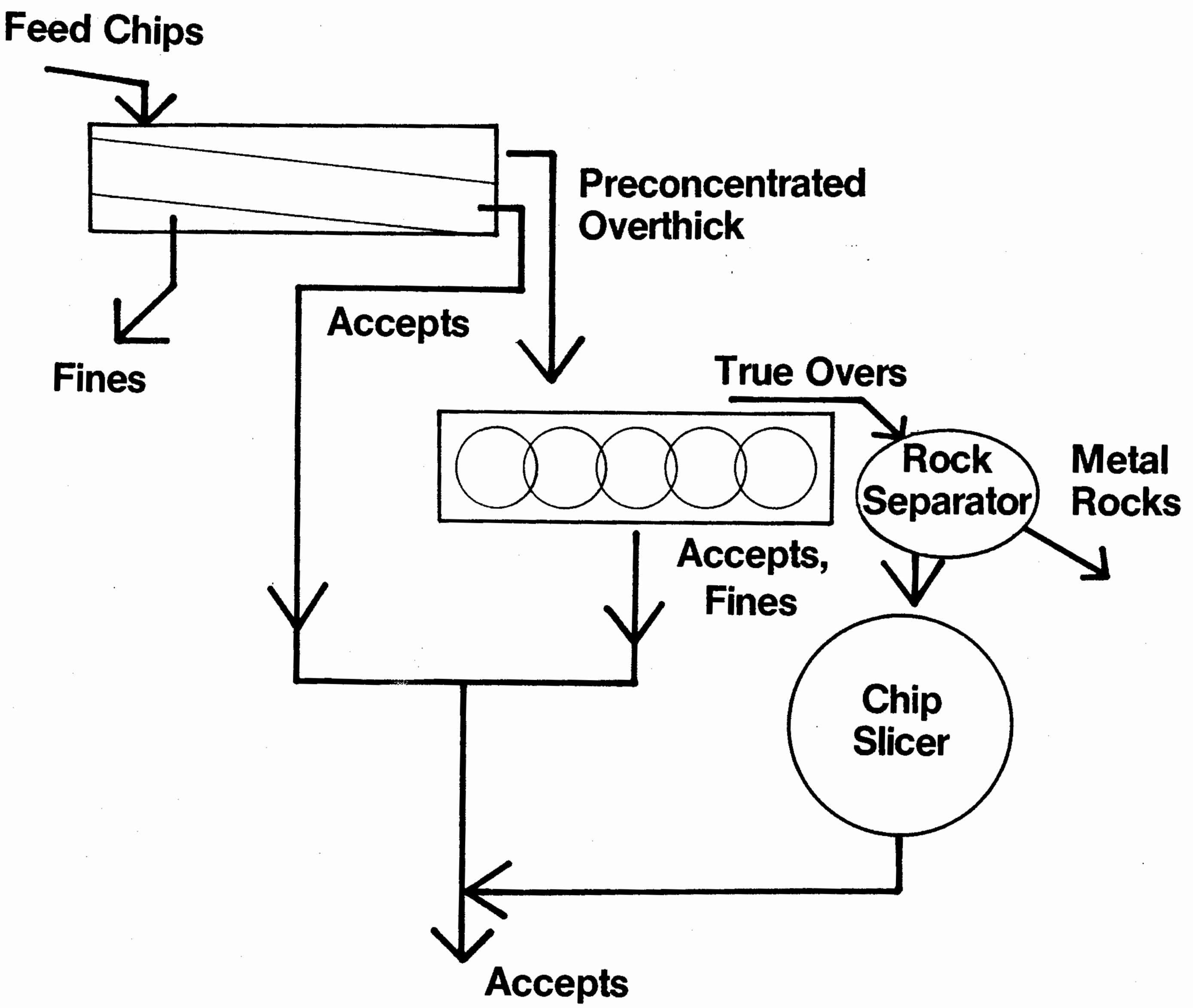
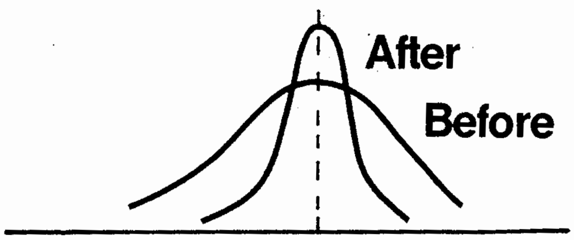


Figure 7
CONTROL OF CHIP SIZE DISTIRUBITON
WITH HIGH EFFICIENCY CHIP SCREEN SYSTEMS



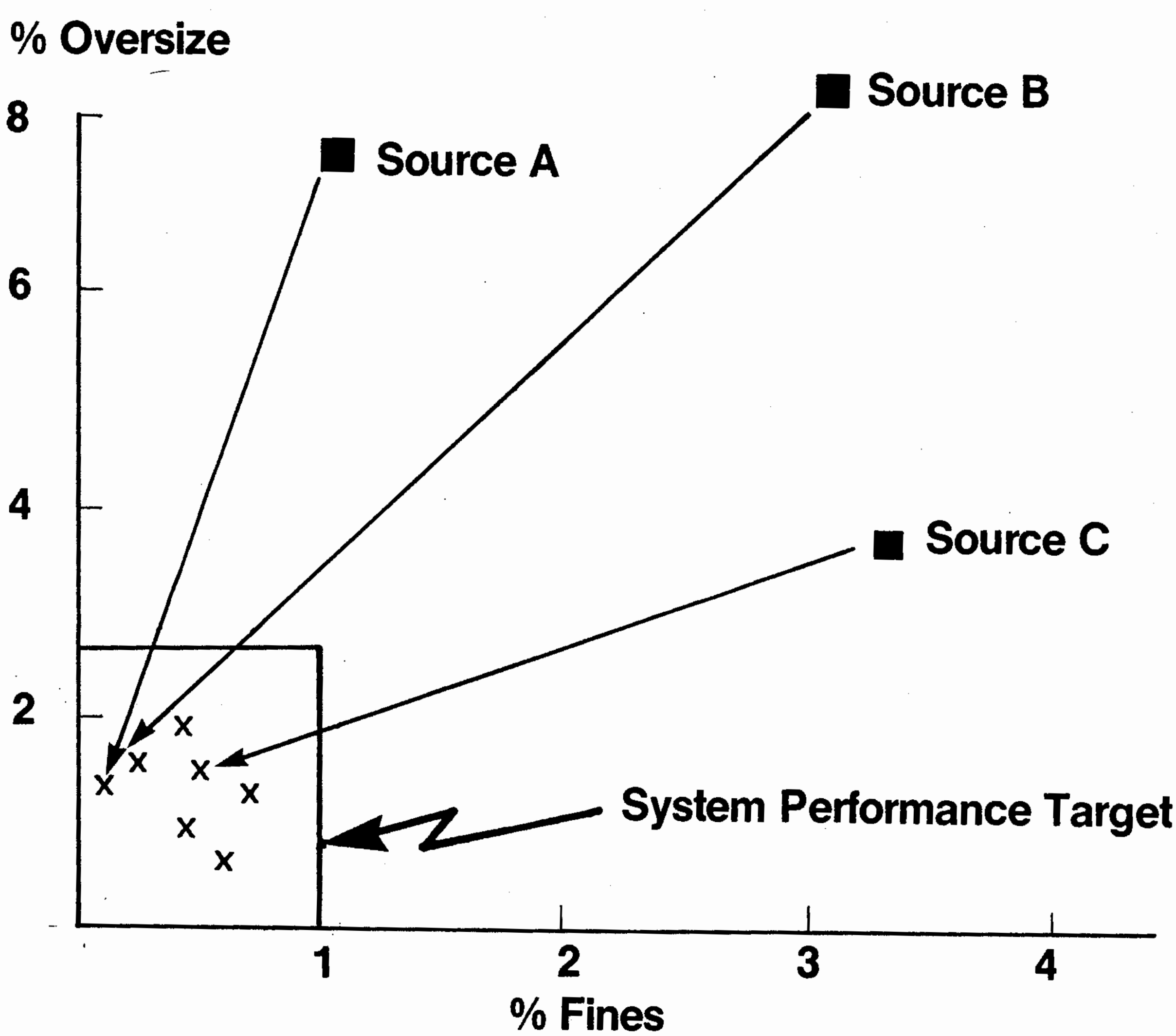


Figure 8
SEQUENCE OF CHIP PILE DETERIORATION

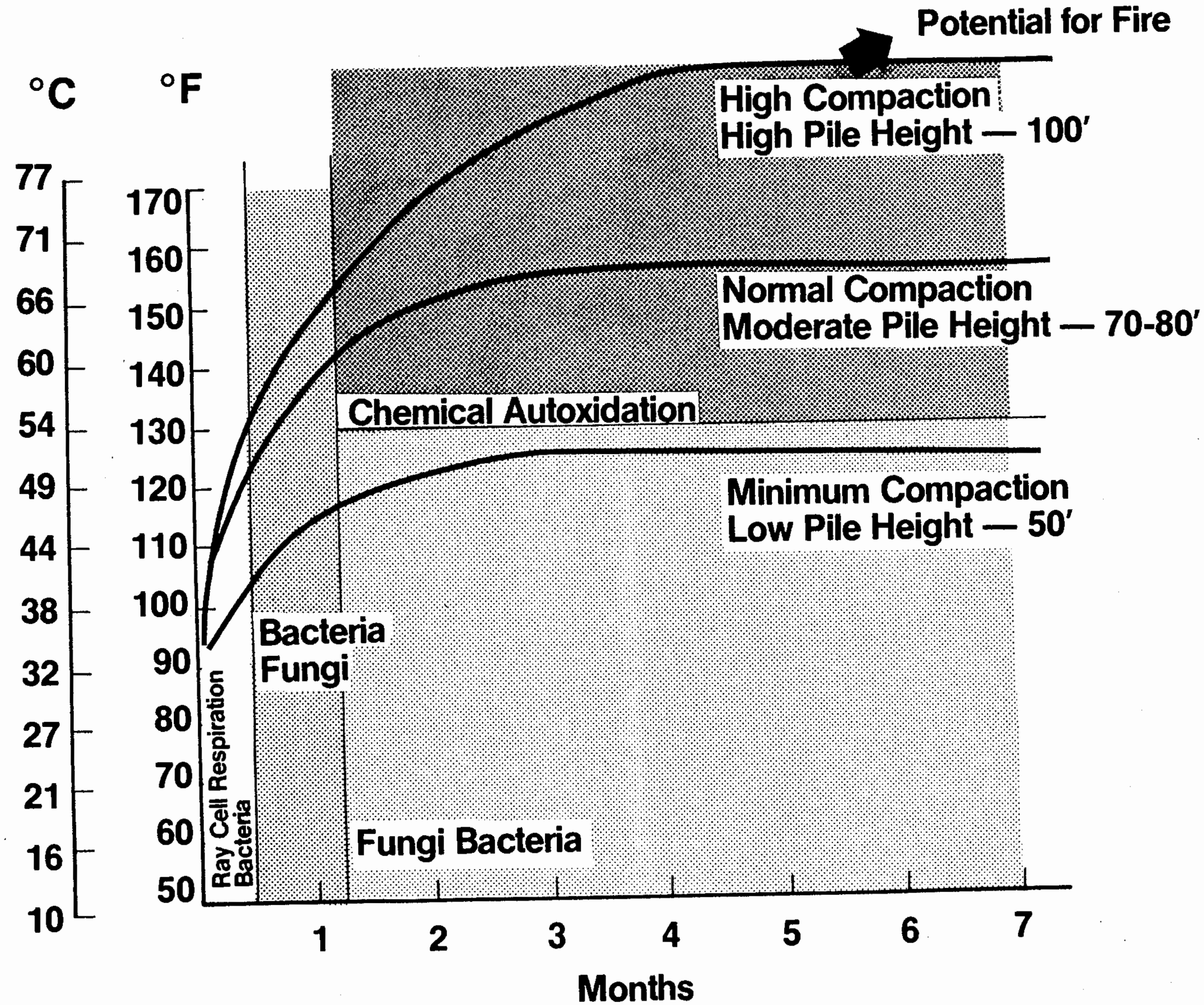


Figure 9
RECIPROCATING DEFLECTOR AUTOMATIC MECHANICAL CHIP SAMPLER

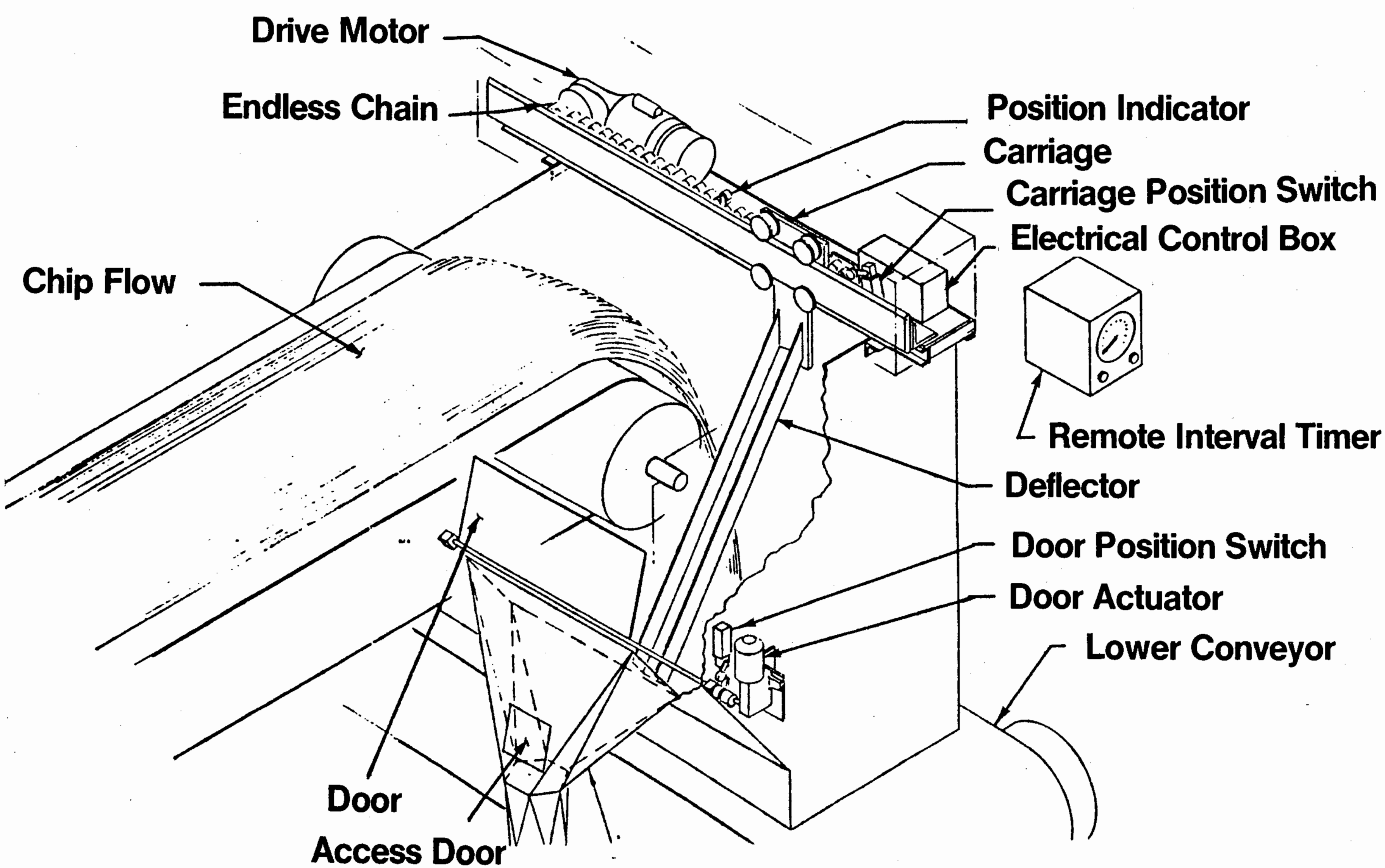


Figure 10

GRADEX™
PARTICLE SIZE ANALYZER

Figure 11
INFLUENCE OF CHIP SIZE
DIGESTER VARIABILITY — KAPPA NUMBER