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Although Taylor early had greatly emphasized the importance of the maintenance of standards, very little was done in this field of activity until quite recently, except in those plants in which he and his associates were working.

A real contribution to the literature on maintenance was made in May, 1917, when the Taylor Society published a paper by H. K. Hathaway, entitled "Maintenance of Machinery and Equipment as Part of the Taylor System of Management."⁵ In this paper the method used by Taylor and his associates for maintaining standards of machinery and equipment was outlined and briefly explained.

Within recent years much more interest has been shown in the subject of maintenance of standards. That interest, however, can by no means be called widespread as yet, although there are in the country a number of companies which recognize maintenance of standards as an important problem and have well-developed methods of handling it.

The subject, maintenance of standards, is such a broad one that it will not be possible here to go into a detailed and exhaustive discussion of the maintenance of all possible standards; nor is it the purpose of this paper to give the detailed technique of the operation of every department responsible for maintaining a standard. The discussion will, therefore, be confined to the maintenance of standards of plant and equipment, tools, raw materials, worked materials, finished product and what has been called "plan of organization" and its mechanisms. It is proposed to discuss what might be called the fundamentals of the maintenance of each of the standards set forth above, and by examples to illustrate how some of these fundamentals have been successfully applied.

Maintenance of Standards of Plant and Equipment

Proper maintenance of plant and equipment has always been important, but it is only within recent years that any considerable number of manufacturing establishments have given the problem the same careful thought and attention which they have applied to other management problems, even though proper maintenance was often an integral part of the problems.

⁵Bulletin of the Taylor Society, Vol. III, No. 3, p. 6.

they were attempting to solve. There are many reasons that might be advanced to account for the increasing interest of the manufacturing community in the more effective handling of plant and equipment maintenance. It will be well to mention a few of these reasons at this point in order that some of the methods and details which will be described later in this paper may be better understood. Among these reasons are the following: (1) increased mechanization, (2) greater investments in machinery and equipment, (3) greater emphasis upon working conditions, (4) greater emphasis upon quality, (5) greater use of incentives and (6) greater use of cost accounting and budgeting.

1. *Increased Mechanization.* The rapidity with which industry at the present time is progressing in the direction of complete mechanization is remarkable. Many operations which only a few years ago were largely dependent upon individual workers both for quality and quantity of production are now to a great extent being performed by machines. Where production is dependent largely upon the performance of a machine the importance of making certain that the machine will perform consistently, in order to obtain high production, is apparent. Moreover, the failure of a machine or other piece of equipment becomes much more serious under our present methods of production. The failure of a conveyor being used in connection with the assembly of a radio set or an automobile does not merely result in the idleness of one worker. It causes every worker along that line to be idle and results in no work whatever being performed. The failure of a single machine under older methods of production merely resulted in the loss of production of one worker.

2. *Greater Investments in Machinery and Equipment.* Increased mechanization results in larger capital expenditures, so that now the amount of money invested in machinery and equipment in American factories is tremendous. Whether or not these investments will prove profitable will depend, among other things, upon whether or not the machinery can be kept in continuous operation. If this equipment is not kept in operation there will be losses because of heavy fixed charges as well as from the very rapid rate of obsolescence of many types of modern machinery. Because of this high rate of obsolescence many manufacturers insist that new equipment pay for itself in two years, and in some cases even in one year. If this is to be done this equipment cannot be permitted to stand idle for any reason which it is possible to prevent.

3. *Greater Emphasis Upon Working Conditions.* Another important reason for the present emphasis upon maintenance is the fact that American manufacturers are beginning to realize, as they never did before, the importance of good physical working conditions, if both high production and high quality are to be obtained. Good lighting, a clean workshop, proper air conditions, are factors which promote healthy shop conditions and directly result in greater production and higher quality of work.

4. *Greater Emphasis Upon Quality.* Every year in American industry greater emphasis is being placed upon quality of product. In order to obtain quality from machines it is necessary that they do more than merely run well enough to obtain production. They must be so well maintained and adjusted that production of high quality from them is not only possible but certain. Thus again the maintenance of standards becomes of increasing importance.

5. *Greater Use of Incentives.* The importance of proper maintenance is emphasized when one considers it in connection with the utilization of incentive systems of wage payment. The failure to maintain standard conditions on a job, after the time study has been made and the rate set, has caused no end of hard feeling on the part of the workers toward the management, and the total failure of many an incentive system of wage payment which might otherwise have resulted in increased wages to the worker and increased profits to the management. It is unfair, for example, to set a rate on a machine when it is operating at a definitely predetermined standard speed and then insist that that rate stand when at some future time, because of poor maintenance, the machine only operates, for example, at 85 per cent or less of the standard speed.

6. *Greater Use of Cost Accounting and Budgeting.* Another reason why maintenance of standards of plant and equipment has assumed its present important role is because two of the mechanisms of modern management, cost accounting and budgeting, have exposed the costliness of any program which does not provide adequately for proper maintenance. Through properly developed factory cost accounting the great losses resulting from improper maintenance are exposed. Modern budgeting has brought forcefully to the attention of those in control the great sums which are spent for maintenance and has emphasized the necessity of having this work performed in a more scientific manner and at reduced cost.

Prevention

As was said before, there is relatively little which is really new in the present methods of maintaining standards, and this is particularly true with reference to the maintenance of standards of plant and equipment.

The basic idea in back of all modern maintenance is prevention. As it was pointed out earlier in this paper, Taylor as early as 1893 had written on this subject and, even before that time, was practicing preventive maintenance at the Midvale Steel Works in Philadelphia. In many organizations, even at the present time, the responsibility for the condition of machinery, equipment and buildings, is left entirely to the superintendent or foreman. While a repair department may exist, it acts only upon orders of a superintendent or a department head. It does not take the initiative in maintaining equipment to any set standard. Consequently machinery is often permitted to operate long after the time it stopped producing economically, and many times so long that serious breakdowns, resulting in expensive repairs and long, costly production delays, occur. Often no action is taken to have the machine repaired or adjusted as long as the machine is able to turn out some production, no matter how little. The costliness of such a method, in terms of excessive repair cost and expensive production delays, is apparent, as is the fact that such a method of repair of equipment is absolutely incompatible with scientific management, which is necessarily based on carefully developed standards. Under scientific management the entire shop management is based upon the idea that every machine will operate under the greatest practicable load, and failure to maintain the machine in a condition which will make this possible immediately makes impossible the highest type of shop management.

The idea of preventive maintenance is worked out by centralizing the responsibility for the condition of machinery and equipment. Instead of having every foreman responsible for the condition of his machinery, a maintenance department takes over this responsibility and assumes the initiative in seeing that the established standards are maintained. This is done by means of regular scheduled inspections, by means of which difficulties are anticipated and the machines always kept in standard condition. The attitude of the modern maintenance department is not to permit a considerable lowering of the established standard to occur, and then