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PREVENTIVE MAINTENANCE, PLANNING AND ORGANIZATION

by

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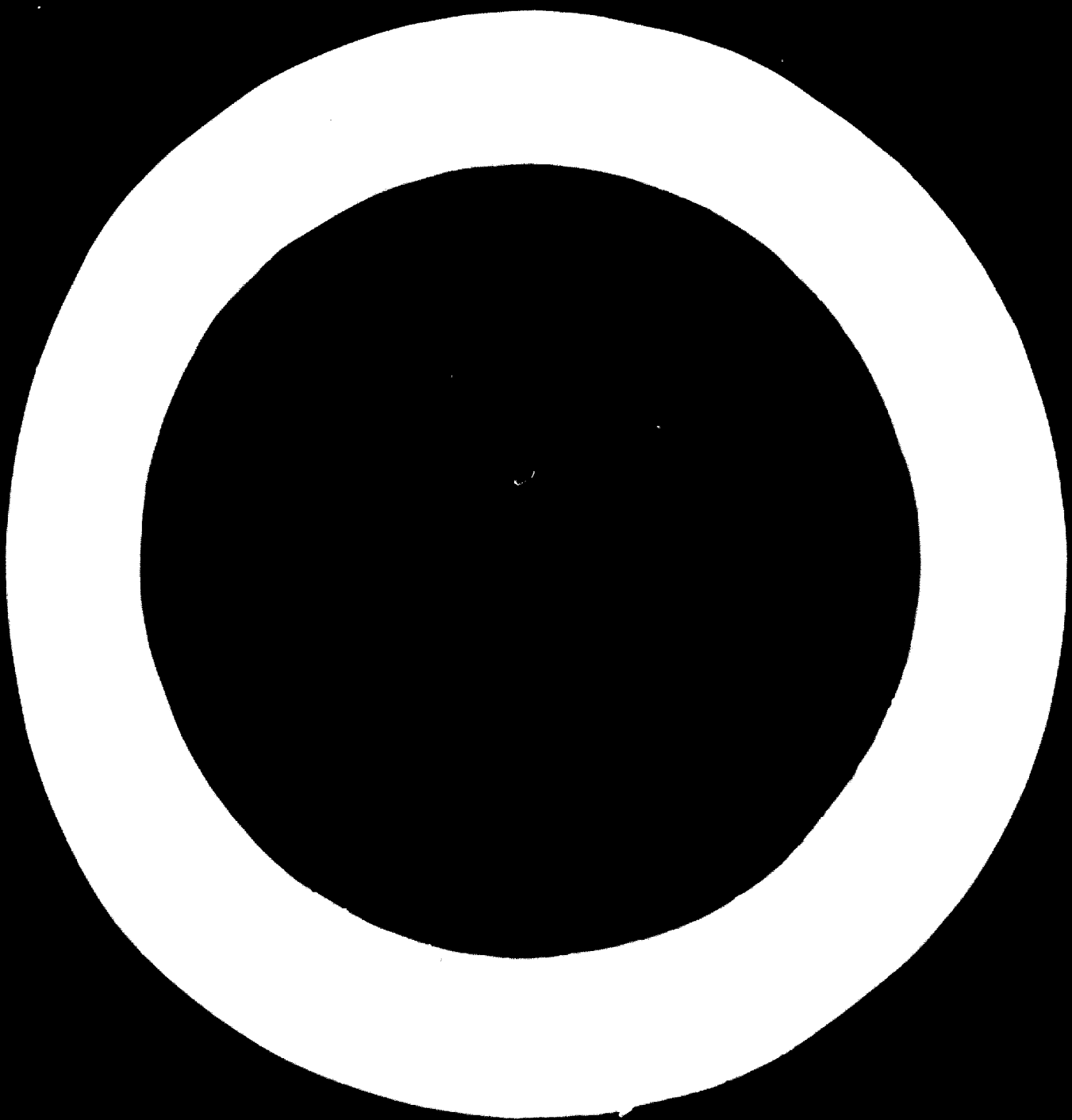


I. Measures, Concept and Nature of Preventive Maintenance

The term "preventive maintenance" comprises particular measures which in theory and in practice serve the maintenance of installations at regular intervals, i.e., measures which are taken in order to prevent breakdown and damage. Preventive maintenance measures may be classified as follows:

1. Direct measures of preventive maintenance
2. Indirect measures of preventive maintenance.

Direct measures of preventive maintenance are those included in maintenance and servicing intended to reduce wear on the one hand and measures intended to prevent wear on the other (preventive repair work).

Wear reduction measures are intended to reduce or at least slow down wear in equipment (i.e., the reduction of changes in the widest sense--arising from routine operation or a harmful environment--in the material and technical structure of equipment). They either serve to improve the resistance of the equipment concerned or reduce the strain on it.

It is a feature of preventive repair work that when wear appears it is dealt with in good time so that the equipment does not break down or damage does not occur. Technically, this may be achieved not only by preventive repair work on the worn component, but also by its preventive exchange, which contributes to attaining the original production capacity. Another feature of preventive repair work is that it may be subdivided into measures taken prior to breakdown, and those measures which--although taken after breakdown--are yet taken in good time before any damage arises. This kind of repair "in good time" is of practical importance only for equipment which is damaged during standstill time, and such equipment which may be replaced immediately by other equipment in case of breakdown.

Indirect measures of preventive maintenance include preventive inspections, performance tests, and the setting up of statistics on service life. Altogether, they supply the data required for the planning of direct preventive maintenance operations.

All these measures have one thing in common, namely, the ultimate aim of preventing or reducing breakdown of equipment and the damage involved. There is a fundamental difference between these measures and the repair and inspection work undertaken only when an enterprise has already suffered loss caused by the breakdown of a machine, a piece of apparatus or any other equipment. These measures do not fall under preventive maintenance.

II. The Most Important Advantages of Preventive Maintenance

If the advantages of preventive maintenance have so far been neglected in spite of the rapidly advancing mechanization and automatization of the means of production and the ever increasing integration of equipment into the production process, this is mainly attributable to the fact that the economic benefits of preventive maintenance have been underestimated.

It is therefore of particular importance to emphasize once more the numerous economic advantages of preventive maintenance of machines and other equipment, including the progress made in the field of rationalization which derives from preventive repair work.

The Most Important Advantages of Preventive Repair Work

1. Prevention of accidents and destruction of or damage to materials and equipment

2. Avoidance of immediate losses caused by unforeseen interruptions in production, e.g.,
   - losses incurred by non-delivery of goods urgently required for marketing or other purposes (additional costs);

- losses resulting from failure to meet the stipulated delivery date, e.g., decrease in profits due to delayed delivery, payment of compensation, penalty for non-performance; decrease in earnings, if the customer places no further orders;
- costs for standby machine operators who usually cannot immediately be given other work;
- additional costs resulting from the prolonged operating procedure;
- losses due to additional negative effects on other equipment and other departments of the enterprise.

3. Increase of the periodical capacity by the reduction of periods out of service due to damage

Advantages:

- repair work can be prepared more efficiently;
- time is no longer wasted in detecting defects;
- possibly, repair work can be started while the machine is still operating;
- execution of repair work during breaks, on Sundays and holidays, during works holidays, and out-of-season periods;
- concentration of different repair jobs.

In this way sales and profits are increased, viz., the costs of outside financing or capital expenditure for increasing the capacity are reduced.

4. Prevention of losses resulting from machinery breakdown

- costs due to rejection;
- costs resulting from the repair of faulty products;
- decrease in profits due to poor quality of the end product.

5. Reduction of actual repair costs

The repair costs can be reduced

- by combining several repair jobs (e.g., costs of preparatory measures are saved) and
- by better coordination of supplies (e.g., reduction of stocks in the spare part depot).

6. Other advantages

- elimination of disadvantages resulting from a decrease in machinery performance;
- a smaller number of spare parts is required;

- the intermediate stores (emergency supplies) can be reduced in size.

Measures intended to prevent wear have similar advantages. By intensifying the measures intended to prevent wear, not only frequency of damage, but the actual repair costs can be reduced because intervals between repairs can be extended.

III. Necessary Steps for the Introduction of Preventive Maintenance

Firms wishing to introduce preventive maintenance should have an idea of the type and extent of damage resulting from the breakdown of various types of machinery. They should therefore compile statistics of damage and disturbances. These should be subdivided according to the type of installation and parts, and according to department, because a decision for or against preventive maintenance cannot be taken for the entire machine park.

Apart from the statistical analysis, however, possible consequences of machine failure should also be analyzed theoretically. On this basis a type of priority list can be prepared which shows in what order the various machines require preventive maintenance.

Before introducing preventive maintenance the types of breakdown should also be analyzed to discover which occur most frequently in the various machines or machine elements, because not all failures can be anticipated by preventive maintenance. Some breakdowns are due to age or accident, others occur quite early in the service life of a machine. Preventive repairs can forestall only breakdowns caused by normal, gradually advancing wear and at best some of the breakdowns caused by accident.

In practice the type of damage will often suggest the reason for the machine failure. Therefore the damage statistics should, if possible, also state the technical "diagnosis" of the damage. The statistics often clearly reflect to what extent the three

types of breakdown are relevant. Such statistics can also be used for planning the repair schedule.

IV. Preventive Repair Procedure

Repair work after breakdown and preventive maintenance differ insofar as the latter is carried out at regular intervals. The repair schedule is based mainly on

1. type, frequency and date of the preventive repairs;
2. type, frequency and date of preventive inspections, and
3. type and extent of wear reduction measures.

In this connection the planning of the inspection schedule is of particular importance, especially with regard to preventive repairs. Both in theory and practice different procedures have been developed for planning such measures, i.e., schedules which indicate on what date and for what reason a particular measure has to be taken. We want to discuss here the procedure applied in case of sudden breakdown of a machine or machine part, i.e., the sort of machine that, after remaining fully operational (despite constant wear), suddenly breaks down completely once a critical stage of wear is reached. Such equipment can be preventively repaired especially when it is of the type which breaks down because of wear.

The least degree of preventive repair planning is involved in planning based on occasional inspections. Long-term preventive repair planning is involved when it is decided to preventively repair a machine once a certain degree of wear is noticeable. When this procedure is applied inspections are also required. As such control measures are in some cases difficult to carry out, and often very expensive, the repair work is scheduled without direct examination of the machinery.

In these cases planning can be based only on the expected service life. Such information can be gained by keeping a record of expected service life for each machine, making spot checks on the wear characteristics of test equipment,

evaluating the experience of other firms, or by obtaining information from the manufacturer of the equipment concerned. If such data are available and are representative of what can be expected in future, it is advisable to carry out preventive repairs on a machine once it has reached a certain age. According to the factors determining machine wear, the service life is measured in different ways, e.g., output, number of hours, weeks, months, etc., the equipment has been in operation. When establishing criteria for repair cycles, the average life of the various machines should by no means be taken as a basis, because the service life differs considerably even if breakdowns early on in service life and accidental breakdowns are both infrequent. On the other hand it is in no way always advisable to carry out the preventive repair before the earliest possible date of breakdown. A certain risk of breakdown must be taken. To what extent the service life can determine the repair cycle must be analyzed by means of a profitability calculation. If the intervals between the repairs are shorter, more repairs have to be carried out, but machine breakdown and resulting damage are less frequent.

Similar considerations apply when deciding to introduce a strictly periodical repair cycle. In this case repairs are carried out at fixed intervals, not according to the amount of time elapsed since the last repair. A problem arises when a machine breaks down between these fixed intervals. In such a case it is difficult to realign repair periods with the long-term repair schedule, unless the equipment concerned is repaired again at the appointed time.

It will often be economical to coordinate repair jobs on similar machinery. By means of such economical repair procedure considerable time and costs can be saved, especially if vital production equipment is concerned which can be repaired only when out of service. This is especially important in enterprises working to full capacity because the reduction of periods out of service due to repairs will make it possible to increase the production and sales volume.

V. Inspection Procedures

This section deals with installations and installation elements that break down suddenly. Inspection procedures for this sort of plant and equipment are determined by the aims that are being pursued. If preventive inspections concentrate only on normal, gradually increasing wear, a sequential inspection procedure is to be recommended. The main feature of this sort of procedure is that the length of time allowed to elapse between inspections is dependent on the findings of the previous inspection. Sequential planning is therefore involved.

If inspection is to reveal in good time unusual wear relative to the age of the installation, it is advisable to carry out inspections at regular intervals. The handbooks recommend such regular inspections as a measure for the discovery of failure in equipment that should always be ready for use and where failure is not immediately noticeable, e.g., alarm systems, fire extinguishers, lightening conductors, military equipment, etc. Regular inspection is recommended only if accidental circumstances occurring while the equipment is not in use can cause failure.

VI. Wear Reduction Procedure

There is a choice of wear reduction procedures. Wear causes changes in the material and technical characteristics of plant and equipment and reduces its usefulness; in principle, these changes can be reduced in different ways or even be completely eliminated.

Summary of the Most Important Wear Reduction Measures

1. Improving wear resistance
   (Measures should be taken at the design and production stages.)
   - the use of materials, or combinations of materials, that are especially wear-resistant;
   - use of protective layers;
   - creation of a favourable shape of surface;

- selection of materials having complementary properties wherever friction occurs between materials;
- careful repairs;
- thorough quality control at the end of the production process or repair process.

2. Wear reduction

Reduction of normal wear

- preventive measures against harmful environmental conditions (e.g., elimination of harmful waste gases, dust, etc.);
- guarding against harmful environmental effects with coats of paint, coverings, protective layers, sheeting, and other anti-corrosion measures;
- choosing a location where conditions are favourable from the start.

Reduction of wear occurring during periods out of service

- taking care of plant and equipment, e.g., greasing, covering, etc.;
- storage in special storage space under particularly favourable conditions.

Reduction of "chemical wear" whilst equipment is in use

- improving the characteristics of the material to be processed and/or stored, e.g., pre-cooling or pre-heating, advance removal of harmful substances, advance addition of wear-reducing substances;
- creation of favourable production conditions and storage conditions, e.g., favourable temperatures;
- lining production containers and storage containers.

Reduction of "mechanical" wear whilst equipment is in use

- taking measures against dust and other forms of air pollution;
- taking measures to prevent any foreign bodies—dust, emery dust, swarf, etc.—from entering between two sliding surfaces, e.g., by sealing bearings, filtering air intakes of combustion engines and compressed air tools, fuel filtering, frequent cleaning, etc.;
- use of lubricants suitable for the degree of movement and material properties of the moving parts;
- frequent lubricant changes;
- establishing a favourable production rate;
- avoiding frequent changes of speed and load;

- drawing up of operating instructions, bringing them to the operators' attention, and controlling regularly whether they are adhered to;
- careful selection and training of operators;
- awarding bonuses to careful machine operators;
- taking constructive measures to make it impossible to overload plant and equipment (taking precautions against overloading, e.g., the fitting of slipper clutches, lead seals on machines, etc.).

In practice several of the measures listed above can be applied at the same time. Indeed, many of them can be applied, but some less actively than others. Those responsible for keeping plant and equipment in order should not strive to attain technical optimum values. It is not worthwhile to apply the whole range of wear reduction measures, because they usually entail certain costs which must be compared with the economic advantages expected from wear reduction. These advantages are primarily that repair and replacement cycles are shortened, whereby the costs of repair and replacement can be reduced. In the case of equipment which, even in a state of advanced wear, remains fully operative until it suddenly breaks down, this planning must aim at minimizing the sum of additional wear reduction costs and replacement and repair costs. As long as the service life of the plant in question is unknown all efforts should be made to keep average total costs per unit of time down to a minimum.

VII. Final Remarks and Bibliography

The planning and organization of preventive maintenance raises many problems of economy. These become more complex, when more thought is given to economic requirements in planning different preventive maintenance measures for simultaneous application. Numerous models that aid decision-making have been developed in Anglo-American and German publications, however, permitting an approach to be made towards an optimal solution of a large proportion of these problems, if the necessary information can be obtained. The most important German language publications as regards practical maintenance planning are listed below:

Bussmann, Karl F., Mertens, Peter (Editors), Operations Research und Datenverarbeitung bei der Instandhaltungsplanung, Stuttgart 1968, Poeschel Verlag.

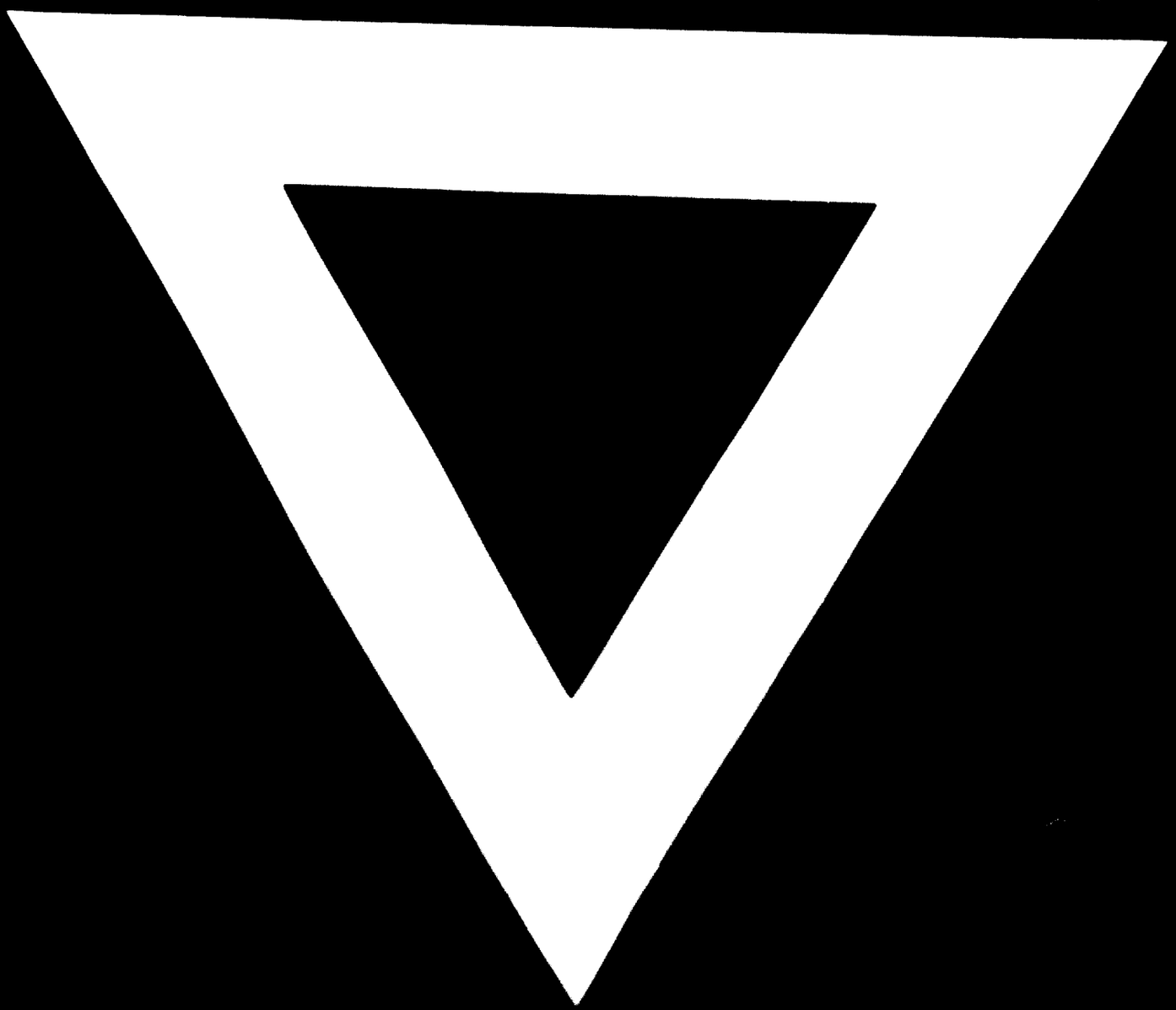
Männel, Wolfgang, Wirtschaftlichkeitsfragen der Anlagenerhaltung, Wiesbaden 1968, Betriebswirtschaftlicher Verlag Dr. Th. Gabler.

Männel, Wolfgang, Vorbeugende Instandhaltung - Eine Einführung und Bibliographie, in the Series "Arbeitsvorbereitung," Number 6, published by Ausschuss für wirtschaftliche Fertigung e.V., Frankfurt am Main 1970 (being printed).

Opfermann, Klaus, Kostenoptimale Zuverlässigkeit produktiver Systeme - Ein Beitrag zur Planung der Abwehr von Störungen des Betriebsprozesses, Volume 5, Schriften zur theoretischen und angewandten Betriebswirtschaftslehre, edited by Prof. Dr. Ludwig Pack, Wiesbaden 1968, Betriebswirtschaftlicher Verlag Dr. Th. Gabler.

In this short paper I have tried to show you not only the importance and advantages of preventive maintenance, but more especially to give you an introduction to organization and planning.

You are now called upon in your turn to take up the idea of preventive maintenance and to introduce it as far as possible within your spheres of influence.



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