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PREVENTIVE MAINTENANCE

An Introductory Report Submitted by

the UNIDO Secretariat

Organized in co-operation with the German Foundation for Developing Countries and the Association of German Machinery Manufacturers (VDMA).

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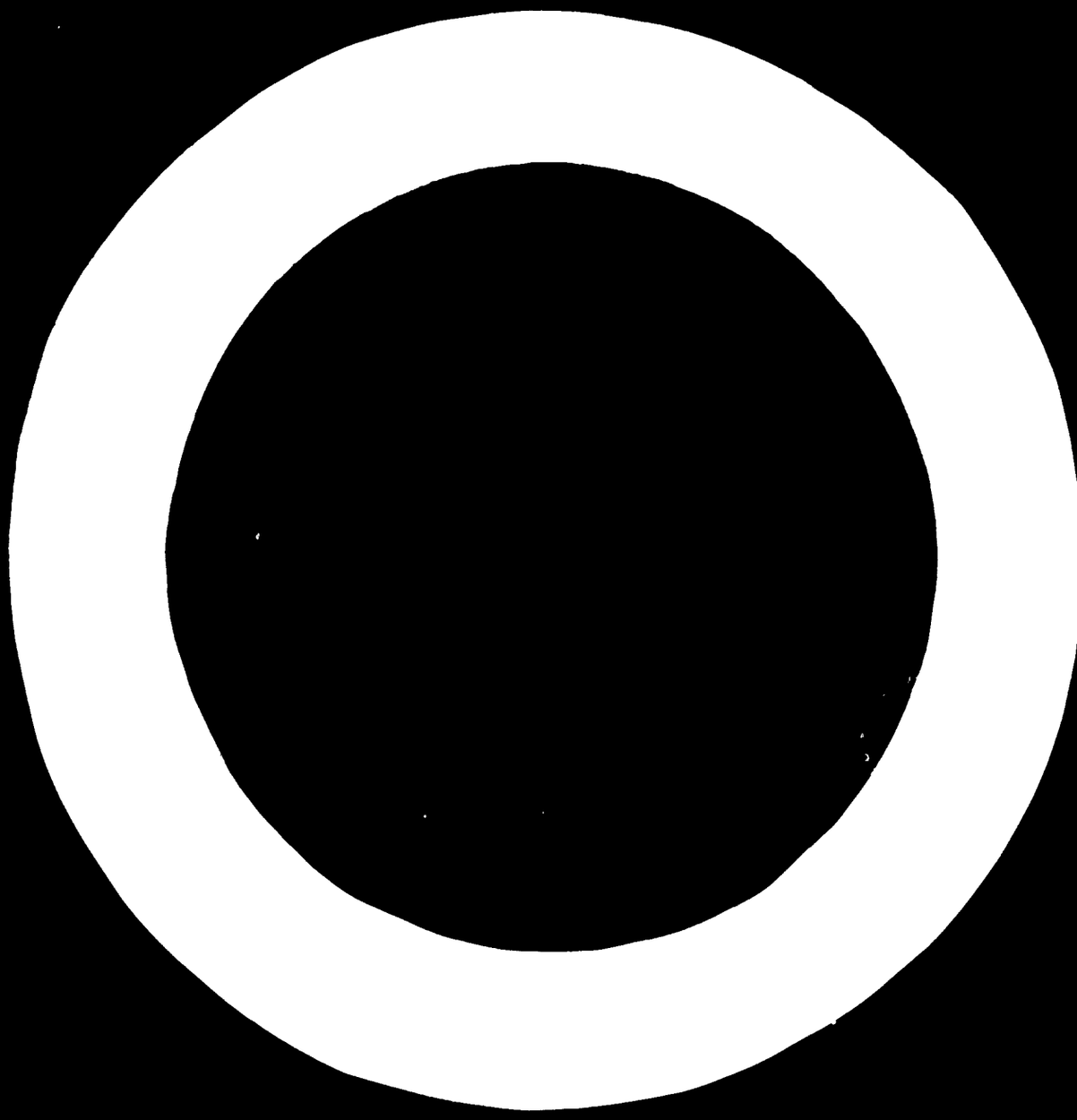


Introduction.

Production equipment is procured in order to obtain a pre-determined volume of production, of specific quantity and quality. In order to obtain this objective, such equipment must be fully supported in the field particularly in connection with the maintenance activity.

Maintenance is already an expensive item especially considering the complicated and sophisticated equipment of today. On the average, and under good conditions, the cost of maintenance of equipment during its lifetime is equal to or exceeds it purchase price. With some equipment this cost may reach two to three times the purchase price.

Such expense is justified only if it helps in attaining the main objectives of maintenance i.e. increased productivity of equipment and decreased downtime and overall cost of production, and safeguarding the equipment itself. This can only be achieved if maintenance is planned carefully and rationally. Under haphazard maintenance, not only the cost of maintenance will increase with the resulting increase in total production cost, but the main objectives of maintenance will not be reached in spite of the cost increase. The lifetime of equipment will be shortened, downtime will increase and production will be reduced both in quantity and quality.

It is generally agreed toda, that unplanned maintenance, or what is generally termed "Fire-fighting technique" should be completely avoided. The main theme of discussions in maintenance circles today is how the planning of maintenance should be carried out.

Definitions and Objectives of Preventive Maintenance.

Within the sphere of planned maintenance many definitons are heard, such as planned maintenance, scheduled maintenance, corrective maintenance, predictive maintenance, productive maintenance, preventive maintenance and

maintenance prevention. These terms are understood and conceived very differently even among the maintenance experts. This is particularly true in the case of preventive maintenance.

Definitions are made to outline a particular activity so that it becomes clear what the activity entails and how to go about it. What is important is not the understanding of the definitions themselves, but an understanding of the different phases and aspects of maintenance activities, the aim of each phase and how these aims are attained. It would be thus appropriate to explain and clarify just the different maintenance activities, hoping that this will lead to a rationalization of definitions.

Planned Maintenance.

The term planned maintenance does not describe a particular type of maintenance, but it implies that maintenance is planned in advance as against haphazard or unplanned maintenance. It is agreed today that all maintenance should be planned and this implies that all maintenance activities should come under planned maintenance. Breakdowns will always occur unexpectedly and handling of such breakdowns is called emergency maintenance. Such emergency operations should be planned to a large extent in advance. The reporting of breakdowns; the rapid diagnosis of the failure; the speedy allocation of task to a specialized repair gang; the support of this repair gang, particularly concerning the speedy spare part delivery and availability of repair tools and equipment; the speedy attendance to the failure; all should be organized and planned to the greatest possible extent. Although the stoppage of equipment due to the failure is not planned, what we mean here by planning is that when the failure occurs, everyone concerned would know what to do; where spare parts and repair tools are to be obtained; how to diagnose the failure quickly; and how the repair experts are transported with the necessary equipment to the location of the failure. This is the opposite to haphazard handling of emergency failures where everyone is running all over the place without achieving a great deal. No one knows who does what or where the repair equipment or parts are. However, such maintenance could be classified as emergency repair and it is understood that it cannot be completely planned.

Apart from emergency maintenance, all other maintenance activities come under the following headings for phases or aspects:

a) Maintenance Prevention: This first aspect or phase covers all measures to be taken in order to avoid maintenance completely. This takes place in two distinct steps. The first is when the equipment is being designed and ordered, by paying attention to the maintainability of equipment thus reducing the maintenance effort required during the lifetime of the equipment. This aspect or phase is called Maintenance Prevention. The second step is sometimes called Corrective Maintenance and it usually takes place when the equipment is actually in operation by studying failures and change design, materials or working conditions to avoid the repetition of these failures. It does not entail any operations where the repair or replacement of a part brings it back only to the original condition without the abovementioned changes. It is interesting to notice that training of maintenance personnel and machine operators could be considered as part of corrective maintenance.

b) Routine Maintenance: This entails all operations which are necessary to keep the production equipment going efficiently. It includes lubrication, periodic inspection, adjustment, cleaning, periodic overhaul, repair, replacement, etc. All these operations are carried out either while equipment is running or during pre-planned shut-downs. All such operations can be included in one maintenance plan with timing of operation and the personnel to which each operation is assigned. This phase of maintenance forms the bulk of continuous maintenance activity during the lifetime of the equipment.

c) Preventive Maintenance: Although operations coming under this title could as well form a part of routine maintenance, they entail a philosophy and a conception which differentiate them from other routine maintenance operations. The idea behind preventive maintenance is based on the fact that it is difficult to determine accurately the lifetime of an equipment or when it will breakdown. When the breakdown of an equipment or part of an equipment has grave consequences, a safety measure is introduced. In an American publication, preventive maintenance is defined as the maintenance undertaken before the need develops to minimize the possibility of an unanticipated production interruption and breakdown and this is the nearest to the conception of Preventive Maintenance in this paper. The equipment or part of the equipment in question is changed before the end of its lifetime is reached. This, in fact, entails the sacrifice of part of the lifetime of the equipment for safety; the magnitude of the part sacrificed depends on the consequences of the failure if it occurs prematurely. There should be, of course, a balance between the cost to the enterprise of the part of the life of the equipment sacrificed and the cost of the possible damage which would occur if this part fails unexpectedly in service. A typical example is the aeroplane. Changing the blades of a turbine or a bearing of a compressor before the expected end of their life may cost a few hundred dollars. This is insignificant compared to the money-loss incurred and the loss of life if the engine fails in the air. Another example is that in a continuous process plant where a small pump, for example, is needed in the operation of the whole plant. The failure of such a pump will stop the whole plant with possible damage to other bigger and more expensive parts of the plant and to the

product itself. In this case the cost of changing the whole pump periodically before the end of its lifetime would be very small compared with the cost of possible damage if it fails. It is generally accepted that preventive maintenance should be considered when corrective maintenance cannot be justified, predictive maintenance cannot be applied and as required maintenance, i.e., maintenance after failure occurs, cannot be tolerated.

This distinction between preventive maintenance and routine maintenance, although both contain a series of planned operations carried out according to a pre-planned schedule, is necessary because of the following: All routine operations are carried out on all equipment and there is no scope for determining and deciding whether the operation is economically necessary or not. All equipment requires lubrication, periodic overhaul and there is no question of suppressing such operations on economic bases. Without them equipment will not go on producing and maintenance operations become costly and unorganized, and the life of the equipment will be shortened. On the other hand, preventive maintenance operations become necessary only as a safety measure against possible risk. With preventive maintenance each case should be studied and a decision is made on whether to carry out the preventive maintenance operation or not and the part of the lifetime of the equipment or part of the equipment to be sacrificed according to economic and safety considerations. This insinuates that preventive maintenance, as outlined here, may be a waste if adopted. In other words if the lifetime of equipment parts and the exact time when failure is expected is accurately known, then there will be no need for preventive maintenance as outlined in this paper, while routine maintenance will still be required.

d) Predictive Maintenance: Maintenance prevention, routine maintenance and preventive maintenance need fact-finding activities to help in their planning. It is necessary and useful to know what is happening to different parts of equipment under actual working conditions. This will help in obtaining a better estimation of the lifetime of the different parts of the equipment for the preventive maintenance, or in a better assessment of the frequency of routine maintenance or to know beforehand if an unexpected deterioration is taking place in certain parts. Many techniques are being developed for this purpose such as noise and vibration measurement. This phase of maintenance is composed of auxiliary operations which help in better planning of the other phases

The distinction between the different phases of maintenance is useful since it draws attention to different approaches leading to different aims. However, all are necessary for a successful maintenance operation.

Unfortunately in many serious text books and technical articles on maintenance, preventive maintenance is defined in different ways, for example, in one technical book preventive maintenance is defined as "Its purpose is to minimize breakdowns and excessive depreciation resulting from neglect". This is the main aim of maintenance activity as a whole. In another publication preventive maintenance is defined as the "Planned maintenance of plant and equipment resulting from periodic inspections that disclose faulty conditions". This definition also is not complete since there are many routine maintenance and preventive maintenance operations which are based on past-equipment history. Again it does not include the safety measure stipulated in this paper. Another definition for preventive maintenance is that it is the maintenance of production means in the non-failed state with the objective to prevent or reduce failur . This

involves routine maintenance, routine adjustment and non-destructive or non-stoppage testing. This definition is also too drastic and entails operations of maintenance prevention and predictive maintenance.

Planning and Installation of a Preventive Maintenance Programme.

Whether preventive maintenance is conceived in the narrow sense stipulated in this paper or in the very broad sense of being a synonym to planned maintenance, the steps to be taken for and the requirement of the installation of a preventive maintenance programme are the same. These will be explained briefly in the following:

The first requirement for the success of a preventive maintenance programme is that equipment must be in a good condition to start with. It is extremely difficult to install a successful programme if the equipment, due to neglect and lack of planned maintenance in the past, has reached such a state that breakdown or emergency maintenance has become the prevailing activity. As a rule of thumb, if the enterprise is spending between 50% to 70% or more of its maintenance effort on breakdowns, then it will be extremely difficult to install a preventive maintenance programme. Under such conditions, such a programme will be extremely difficult to implement and will become very costly without giving the enterprise the anticipated advantages.

The first step would thus be to start with a programme of overhauling and putting in good condition all equipment. This is, of course, quite costly, but this is the price the enterprise has to pay for past neglect and lack of organized maintenance. However, if such a step is not carried out because of the expense incurred, the conditions will continue to worsen and an almost complete plant shut-down will be the price to be paid for such a policy.

The second point is that a successful planned maintenance or preventive maintenance programme cannot be implemented over night. This will require from several months to several years according to the type of plant, available past maintenance records, type of maintenance carried out before

etc. Usually a rough programme is determined first according to the suggestions explained below. Then such a programme is modified and re-planned continuously on the basis of records and figures fed back to it from the factory until it reaches a stage where it becomes suitable to the conditions prevailing in the factory.

The third point to be noted is that any degree of sophistication can be built into a preventive maintenance plan. Establishing a PM programme should not become an end in itself, but it should be always looked at as a means of attaining certain desired objectives for the enterprise as a whole. Over-planning and over-sophistication should be avoided especially at the early stages of installing the programme. Such a programme should be designed to suit conditions of the enterprise and should not be just an imitation of a programme installed somewhere else. It is generally recommended to start with a simple programme which would gradually be built up to a complete one. Consensus is that it is also too big a bite to start the work by applying a PM programme to the entire plant at once. It is better to start with certain machines or a department and then extend it gradually. The advantage of building up the programme gradually and start with one department is to give a chance for the training of personnel and for all concerned to absorb and get acquainted with the procedures to be followed. In many instances it was found that the main reason for the failure of a PM programme is that the personnel concerned were not given a fair chance to understand and get acquainted with the programme. Building up the team of personnel who will carry out the programme is a most important step and should be given the necessary effort and consideration.

The initial step in establishing a first and rough preventive maintenance programme is to establish an equipment identification system. Information such as machine make, place and date of purchase would be recorded on a card or a file or similar system. Each machine should also be given a code number. Such identification system is essential for the PM programme and also for the inventory system.

The next step is to establish for each machine a history card, with records of all breakdowns and length of time required for repair. Such a record is essential for organizing the details of the work required in the programme. It is also advisable to include in the history card the cost of all maintenance and repair operations carried out on this machine during a certain period. This should include labour, material and spare part costs separately. It is very important, particularly at the early stages of introducing a PM programme, to follow up progress. A base should thus be established to measure progress and equipment history cards are an essential element for such a base. Usually in an enterprise, there is some information available on past repairs and breakdowns of equipment, but this is usually scattered in a way that is of very little value. It is essential to collect such available information in a understandable form such as equipment history cards, etc.

The third step is to organize all technical information, such as manuals, pamphlets, etc. on equipment in a form which makes them easily accessible. Such technical documents are usually laid in different places so that it becomes difficult for personnel concerned to get hold of them when they are needed. An equipment service library could be established and documents arranged and classified with the help of the machinery code number.

Next an inventory of all maintenance and repair operations required for all machinery is compiled. Equipment manufacturers technical documents and recommendations, equipment history cards and information obtained from other enterprises using the same type of equipment should form the basis of such inventory.

A work programme is then established with timing of every operation and the personnel required to carry it out. The programme should be constructed to have a more or less even work load in the maintenance departments. From the work programme the maintenance personnel force is estimated and steps should be taken to employ and train them in advance. The necessary equipment should also be procured. Competent personnel and adequate equipment is a necessity to the success of the programme.

It should be remembered that a PM programme does not entail only maintenance operations, but also stoppage of production equipment for maintenance. Thus such a programme should be established with the full co-operation and understanding of the production department. This will also create a precedent of co-operation between the production and maintenance departments which is essential for a successful maintenance.

Introducing the Programme.

Once the programme is planned, great care must be paid to how it is introduced. The programme must be sold to all concerned. A series of meetings should be arranged with both production and maintenance personnel and the programme, its procedures and aims should be fully discussed.

It is only natural that the introduction of such a new activity in the enterprise will be watched carefully by all concerned, especially the top management. They will be anxious to watch whether the programme is really worthwhile and if it is giving the expected results. No preventive maintenance programme will give immediate results, but it will take some time before a tangible outcome is obtained. The programme of introducing the system should be realistic and factual, otherwise, the result will be only frustration. It would be a damaging blow to the programme if enthusiasm and sympathy were lost by both top management and personnel because of unjustified expectation and frustration. As a matter of fact, since preventive maintenance does not show results in reducing repair load maintenance cost except after some time, the programme will pass through a phase where there is no reduction in maintenance work while the cost of personnel and equipment carrying out the programme will be added to the normal running maintenance cost of the enterprise. This temporary increase in maintenance cost is natural and must be expected. This should be explained fully to management. Starting the programme gradually department by department will help enormously in passing through this critical phase comfortably.

Any new PM programme needs modifications and alterations until it reaches a standard suitable for the enterprise. An efficient follow up system is necessary in order to be aware of the necessary modifications and

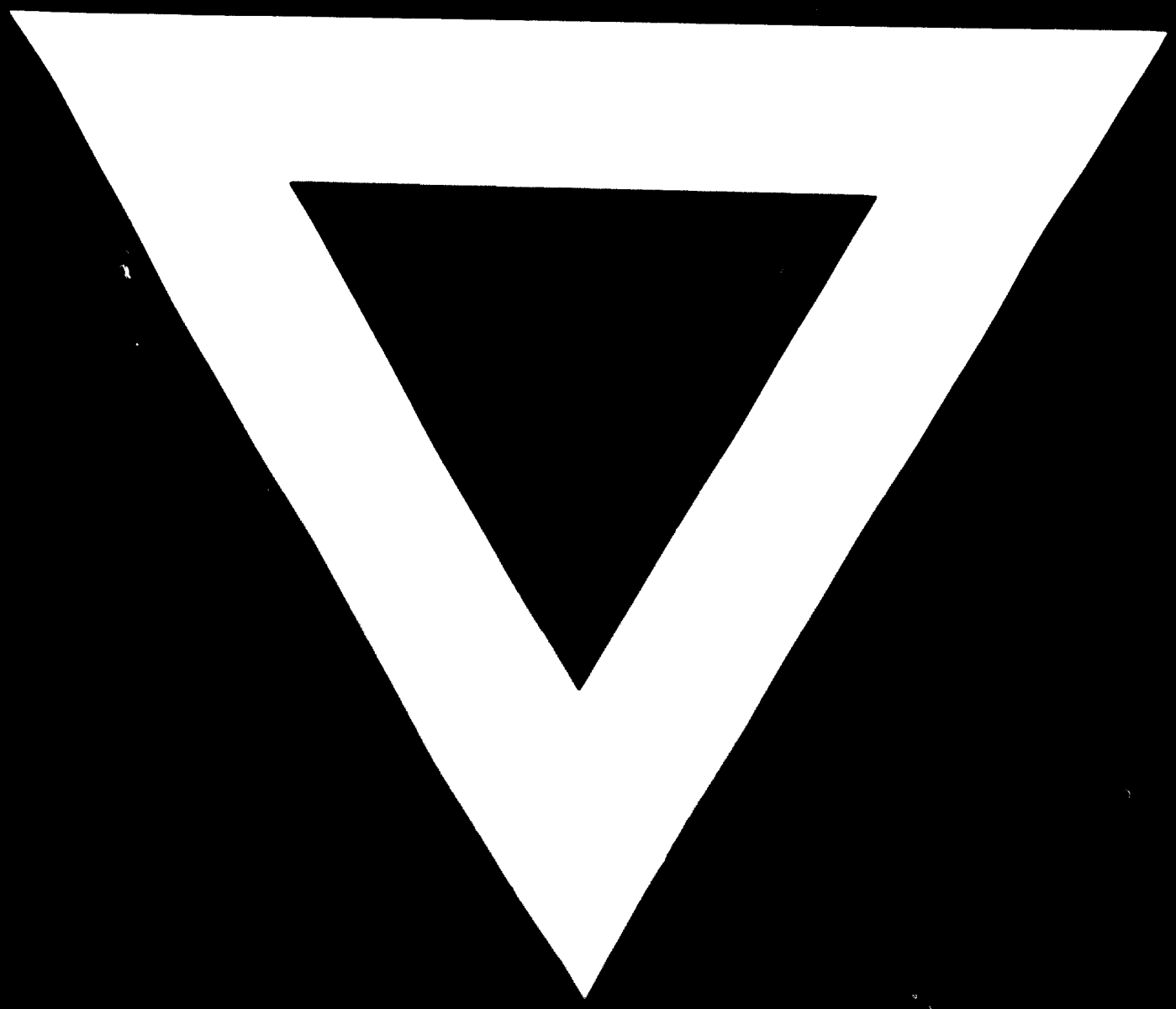
to make sure that the programme is progressing along the right lines. The responsibility of this follow-up system should be clearly defined and should not be delegated to certain personnel who already have other responsibilities and are engaged in other activities. It is usual that when urgent work crops up within their other areas of responsibility, such personnel will forget completely about the programme and the follow-up system and concentrate on handling this urgent work.

A monthly report should be prepared showing the number of operations scheduled, number of services completed and behind schedule, and also failures which have stopped occuring after introducing this programme.

Conclusion.

Planned and preventive maintenance is a system which certainly results in lowering production costs, safeguard equipment and increase in both the quality and quantity of production. This is the view of almost everybody who has introduced such a system in a plant.

However, planned and preventive maintenance programmes should be carefully planned, skillfully introduced and should be given time to show the expected results.



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